PARALLEL SESSIONS

13:55 | WEDNESDAY 21 SEPTEMBER

Mitigation Options | Chair: Professor Nick Eyre

13:55	Introduction by the Chair	
14:00	Global Warming and Cities: The Implications of Global Warming for Urban Planning and Decision-making.	Professor David Dewar
14:15	What does 1.5°C mean for aviation and shipping?	Professor Alice Bows Larkin
14:30	1.5°C and 10 billion: How to Feed the World while Mitigating Climate Change A nested scenario exercise about the future of food and agriculture under the Paris Agreement	Dr. Monika Zurek
14:45	Negative emissions - near term deployment opportunities	Henrik Karlsson
15:00	Closing the carbon cycle with air capture	Dr. Klaus Lackner
15:15	What role for solar geoengineering in meeting a 1.5°C target?	Dr. David Keith

ABSTRACTS: PARALLEL SESSIONS

Professor David Dewar | Global Warming and Cities: The Implications of Global Warming for Urban Planning and Decision-making

There is widespread recognition that towns and cities are important contributors to global warming and climate change, generating, as they do, between 60 and 70% of total greenhouse gas emissions. Clearly, urban planning and policy must be part of any mitigation strategy. It is also widely recognised that urban structure and form have implications for greenhouse gas emissions. What there is less clarity about are the precise characteristics of structure and form which urban planners and decision-makers should be seeking to achieve, in order to maximise efficiencies in terms of reducing emissions. This paper seeks to contribute to filling the gap. It does so under a number of heads of argument: size of hinterland for inputs and outputs; the urban footprint; densities; structure of the space economy; land use mix; scale and grain; connectivity and permeability; building form and height; carbon sinks; industrial ecology; and hazard avoidance. The arguments developed under these heads are then summarised to identify the urban model which decision-makers and planners should be seeking to achieve. However, urban decisions cannot be made on the basis of greenhouse gas emissions alone. The model is then tested against the criteria of liveability and the challenges posed by other interrelated emerging international tendencies: economic globalisation and increasing structural unemployment; food security; water scarcity; and fossil fuel dependence. The emphasis throughout is on the urban challenges faced by developing countries, but much of the argument is applicable to all cities.

Professor Alice Bows-Larkin | What does 1.5C mean for aviation and shipping?

Authors: Michael Traut, Kevin Anderson, Maria Sharmina, Ruth Wood, Amanda Lea-Langton, Conor Walsh and Alice Bows-Larkin. All at: Tyndall Centre for Climate Change Research, School of Mechanical, Aerospace and Civil Engineering, University of Manchester, UK

Over the past decade, the aviation and shipping sectors have drawn research interest for three principal reasons. Firstly, emissions released in international airspace and waters, even if connected to activities of 'Annex 1' citizens, were omitted from national targets set for Annex 1 nations within the Kyoto Protocol, and go unmentioned in the Paris Agreement. Secondly, the international organisations given a mandate to develop mitigation measures targeting these sectors – the International Civil Aviation Organisation (ICAO) and the International Maritime Organisation (IMO) – have made slow progress compared with other sectors (relating to Annex 1 mitigation). Finally, aviation and shipping face very different CO2 mitigation challenges and opportunities from each other. With both estimated to be contributing a share of annual global CO2 emissions equivalent to a top ten emitting nations, constraining further CO2 growth is an important research area, even under a 2°C goal. The long lead-times for technological deployment governed by the capital intensive nature of aircraft, ships and related infrastructure, coupled with rising demand, raises serious questions around the ability of these sectors to be able to respond, at least technically, to constraints posed by a 1.5°C budget. Here, the 1.5°C goal is interpreted for the aviation and shipping sectors, assuming these sectors deliver a "proportionate response" to the challenge. The constrained proportional budget is contrasted with existing industry and other demand-side projections. These will include consideration of where fossil fuel transportation is necessarily minimized in line with 1.5°C, global off-setting and opportunities for virtual conferencing to substitute for travel, to illustrate the gap between the Paris ambition and industry expectations. Finally, technical expertise around available biofuel options, coupled with an interrogation of more radical decarbonisation possibilities and their deployment timeframes is synthesised to draw conclusions regarding the ability of these sectors to 'fit' within 1.5°C constraints.

Dr Monika Zurek | 1.5 degrees C and 10 billion: How to Feed the World while Mitigating Climate Change. A nested scenario exercise about the future of food and agriculture under the Paris Agreement

Authors: Monika Zurek, ECI University of Oxford, Petr Havlik, IIASA

In December 2015 the majority of the world's governments agreed in the so-called 'Paris Agreement' on a renewed commitment to reduce GHG emissions. At the same time, while the global population is still increasing diets in many parts of the world are changing as people are becoming richer and more urbanized and move towards a more 'Western' diet, rich in meat and dairy products and processed foods. Nevertheless, about 800 million people continue to go hungry and 2 billion people suffer from micronutrient deficiencies. Thus, how to feed the world in 2050 or 2100 is still a complex puzzle to solve. And this puzzle will only get more complicated when considering the role that agricultural production and food systems should, and can, play in contributing towards climate change mitigation in order to reach the new 1.5 degrees C target. Today, Agriculture, Forestry, and Other Land Use (AFOLU) account for about a quarter of all anthropogenic emissions, out of which most is directly or indirectly related to agricultural production. The described likely changes in diets and lifestyles have the potential to increase food system emissions. Thus there is an immanent need for the food sector to develop mechanisms to allow the sector to better balance food and nutrition security goals with other societal targets. The global food system will be asked to contribute to the ambitious targets in several ways. A nested 2-phased scenarios exercise is currently exploring the future of food and agriculture under the Paris Agreement. Much more transformative polices as well as new technologies are needed to close the mitigation gap that has to be bridged in order to reach the Paris Agreement.

Henrik Karlsson | Negative emissions – near term deployment opportunities

Authors: Henrik Karlsson, Biorecro AB, Sweden.

The IPCC 5th Assessment Report showed a need for large scale deployment of negative emission technologies such as BECCS for meeting the 2 degree target. Meeting the 1.5 degree target will require even more negative emissions and particularily an earlier start and faster deployment rate. However, there is a severe mismatch between the deployment rates associated with the 2 and 1.5 degree targets and the current trend. There is only one large scale demonstration facility of BECCS globally. There are no dedicated incentives for BECCS to drive innovation and deployment. Even though several countries and regions are already including negative emissions with BECCS as part of their long term climate mitigation strategies, examples being the UK and Sweden, there are no clear implementation plans on how this will be realised. Considering the diminuitive carbon budget remaining for a 1.5 degree target in relation to current emissions, there is an urgent need for immediate deployment of BECCS. If no early deployment, before 2025, of BECCS can be achieved, it will not be possible to scale the technology in time to meet the 1.5 degree target and avoid excessive overshoot. Still the current debate on negative emissions and BECCS is solely focused on how such technologies will affect land use and how much biomass that could be sustainably produced globally in the second half of this century. To deploy negative emissions with BECCS in time, early opportunites need to be examined. Such opportunities include storing CO2 from ethanol production facilities, pulp plants, waste-to-energy facilities and existing biomass CHP plants. The combined capacity of these facilities in no less than 350 MtCO2/y. If these low hanging fruits are not picked, the theoretical capacity of large scale BECCS deployment will be irrelevant and the 1.5 degree target out of reach.

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Dr Klaus Lackner | Closing the carbon cycle with air capture

The 1.5 degrees C goal cannot be reached without balancing the carbon budget. Not only does this require the global annual emissions to reduce by 8% per year over the next 40 years, but then stopping emissions or negating them. Ultimately, a balanced climate demands every ton of fossil based carbon that we add to the atmosphere to be put away. This can only be achieved by negative emissions technologies in concert with sustainable carbon neutral energy systems. The capture of CO2 from ambient air, air capture for short, is an enabling technology that can contribute to balancing carbon in three important ways. First, it provides a means of canceling CO2 emissions without the need for co-operation from the emitter, enabling the enforcement of regulations on all emissions from all sources. Air capture will set the marginal cost of canceling CO2 emissions and thus encourage technological change that in many situations can accomplish the same goal more cost-effectively. Air capture can drive change; even if it only collects a small fraction of emissions expected under business-as-usual scenarios. Second, air capture can collect at a sequestration site more CO2 than is emitted, thereby creating negative emissions. Third, air capture can help close the anthropogenic carbon cycle by providing the carbon feedstock for sustainable, synthetic fuels. Value generation is not limited to the fuel, but includes the stabilization of inherently intermittent renewable energy source.

Dr David Keith | What role for solar geoengineering in meeting a 1.5 degree target?

What role might solar geoengineering, also known as albedo modification or solar radiation management, play in meeting the 1.5°C target? In a crude technical sense, it appears highly likely that solar geoengineering could ensure that the world stayed under a 1.5°C target. This does not require that solar geoengineering be implemented, but rather that the option to deploy and monitor it be developed. Given the stubbornly persistent uncertainty in climate sensitivity—the "likely" range is now back to 1.5-4.5°C, where it has been over 35 years ago—one can argue that the ability to do solar geoengineering is the only way to be confident of meeting a 1.5 target. But, of course, the temperature target is only a proxy for limiting a range of climate impacts, and the pertinent question is how useful is solar geoengineering to limiting climate risks, such as increased storms, increased droughts, extreme temperatures, sea-level rise, and ocean acidification. I will review the emerging evidence about the efficacy (or lack thereof) of solar geoengineering to limit specific climate risks. The ability of solar geoengineering to reduce risks depends, in part, on the method employed. I will review a range of methods and present new work showing how some solid aerosols could both reduce radiative forcing and restore the stratosphere ozone. The hardest questions about solar geoengineering are not about the technology but about its governance in a divided world. I will briefly review emerging literature on international politics of solar geoengineering, including research on coalition formation and liability regimes. Finally, I will speculate about how solar geoengineering fits into a range of strategies for reducing climate risks, including (most importantly) emissions mitigation but also carbon removal and adaptation.

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Sensitivity of Natural Systems | Chair: Dr. Daniel Mitchell

13:55	Introduction by the Chair	
14:00	On the difference in regional climate impact indicators under 1.5°C and 2°C warming above pre-industrial levels	Dr. Carl-Friedrich Schleussner
14:15	What difference does 0.5°C make for terrestrial biodiversity, and where does it matter the most?	Dr. Jeff Price
14:30	The Impact of 1.5°C warming on the wheat production in Tunisia	Karim Bergaoui
14:45	Differential climate impacts in Europe in 1.5°C, 2°C, and 3°C worlds	Dr. Paul Bowyer
15:00	Rain-on-Snow and Tundra Reindeer Nomadism in Arctic Russia under 1.5°C of Warming	Professor Bruce Forbes
15:15	The response of the polar regions in CMIP5 models: an assessment of RCP2.6	Dr. Emily Shuckburgh
15:30	Large ensemble climate simulations for 1.5°C and 2.0°C warmer worlds: preliminary results	Dr. Michael Wehner

Dr Carl-Friedrich Schleussner | On the difference in regional climate impact indicators under 1.5°C and 2°C warming above pre-industrial levels

Authors: Carl-Friedrich Schleussner[1,2], Tabea K. Lissner[1,2], Erich M. Fischer[3], JanWohland2, Mahé Perrette[2], Antonius Golly[4,6], Joeri Rogelj[3,5], Katelin Childers[2], Jacob Schewe[2], Katja Frieler[2], Matthias Mengel[1,2], William Hare[1,2], and Michiel Schaeffer[1,7]

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The 2015 Paris Agreement includes the long term global average temperature limit of 1.5oC that represents a strengthening of the below 2°C limit that was applied in previous decisions of the UNFCCC. Despite the prominence of these two temperature limits, a comprehensive overview of the differences in climate impacts at these levels of global mean warming has so far been outstanding. Here we provide an assessment of key climate impact indicators at warming levels of 1. 5°C and 2°C, including extreme weather events, water availability, agricultural yields, sea-level rise and risk of coral reef loss. By analyzing changes in indicators for 26 world regions as applicable, we find substantial differences between a 1.5°C and 2°C warming. From our analysis, regional hot-spots of change emerge with tropical regions bearing the brunt of the impacts of an additional 0.5°C warming. Our findings highlight the importance of regional differentiation to assess both future climate risks and different vulnerabilities to incremental increases in global-mean temperature.

Dr. Jeff Price | What difference does 0.5°C make for terrestrial biodiversity, and where does it matter the most?

Authors: Dr. Jeff Price, School of Environmental Sciences, University of East Anglia, Norwich UK; Professor Rachel Warren, Tyndall Climate Change Centre, University of East Anglia, Norwich, UK; Dr. Jeremy VanDerWal, Centre for Tropical Biodiversity and Climate Change, James Cook University, Townsville, Australia

The Wallace Initiative has developed models examining the potential impacts of climate change on 80,000 terrestrial plants, birds, mammals, reptiles and amphibians at projected global temperature changes of 1.5° to 7° C, a global resolution of ~20 km by ~20 km, for 21 climate models, under several potential dispersal scenarios. As part of a larger examination of the potential impacts of climate change on biodiversity in World Wildlife Fund Priority Places we examined what difference 0.5°C would make between 1.5° C and 2°C, and where the differences (benefits) are greatest. Specifically, we looked at which areas remained "refugia" (i.e., remained climatically suitable for >75% of the species studies) to determine which areas of the World might be least or most sensitive to 1.5° versus 2°C of warming. We found that that many of the areas that apparently had large benefits at 1.5°C were not necessarily those that had the greatest impact at 2° or even 4°C. Overall, across the five taxa, plants appeared to benefit the most and reptiles the least from holding the temperature rise to 1.5°C rather than 2°C. Regionally, Coastal East Africa appeared to benefit the most, with an average (across all five taxa) of a 22% increase (benefit) in the area of the priority place that would require reduced adaptation to climate change to maintain current biodiversity under these models. The African Rift Lakes and the Orinoco River (South America) region were second with an approximate 21% benefit followed by Madagascar and

the Namib-Karoo (Africa) with a 20% benefit. In fourth place are the Mekong, Miombo and Southeast River and Streams (U.S.). The degree to which dispersal (and corridors) can benefit biodiversity depends on how the 1.5°C target is achieved, especially which types of mitigation (e.g., biofuels), are used.

Karim Bergaoui | The Impact of 1.5 C warming on the wheat production in Tunisia

Authors: Karim Bergaoui ICBA; Makram BelhajFraj ICBA; Adla Khalaf; Rashyd Zaaboul ICBA; Giuio Carelotti ICBA; Rachael McDonnell ICBA

Wheat is the main staple crop in North Africa region and contributes the most to food security. It is almost entirely grown under rainfed conditions and its yield is highly impacted by the climate variability, e. g. dry winters, a late autumn or late spring. The irregular rainfall or drought events, lead mainly to both early and terminal wheat stresses and high inter-year variation in yield. The goal of this study is to use a large ensemble of regional climate models (>50) with the CMIP5 weighted multi-model mean of the projected SST and to integrate two different scenarios (1.5°C and 2°C warming above the pre-industrial levels). This study will reply to the answer: if the ambitious climate change mitigation efforts succeed in stabilizing temperatures at 1.5°C, what will be the impact on cereal production in a Northern African country? Tunisia was chosen among the region for its wide diversity in biophysical and farming conditions and for data availability on a wide range of wheat management systems from subsistence farming systems to highly mechanized agribusinesses. We calibrated and validated a dynamical crop model, DSSAT, to simulate the national wheat production and to understand the impact of drought on growth and development that causes yield variation. DSSAT simulations were driven by CHIRPS and ERA-Interim reanalysis data as daily climate forcings. The simulations were validated in a set of farmer fields which were representative of the dominant cropping systems in the country. Then, the model was validated with 10 years state-level production data. Finally, we forced the crop model with the two climate change scenarios using all the regional climate models and we assessed the impact of each scenario on the wheat production at the national level.

Dr Paul Bowyer | Differential climate impacts in Europe in 1.5, 2, and 3 degree worlds

Authors: Daniela Jacob, Paul Bowyer, Lola Kotova (GERICS/Helmholtz Zentrum Geesthacht), and the IMPACT2C team

Additional motivation and incentives for drastically reducing carbon emissions to meet the 1.5oC ambition set at COP21, is provided by describing the differences in climate impacts, between different possible future worlds. The EU FP7 project IMPACT2C addressed this question to look at differential impacts in Europe and a selection of highly vulnerable areas outside of Europe, in 1.5, 2, and 3 degree worlds. Using multiple global and regional climate models, simulations were carried out using three different emissions scenarios namely, RCP2.6, RCP4.5, and RCP8.5. In order to investigate differential impacts, IMPACT2C developed a methodology to determine the time period when a given global warming threshold was crossed. In addition to the use of multiple climate models, where possible, multiple impact models were used, to analyse impacts in different economic sectors. Accordingly, the approach used in IMPACT2C permits a robust quantification of uncertainty in the different climate impacts. This presentation will provide a summary of some of the differences between 1.5, 2, and 3 degree worlds, with respect to changes in climate variables and a selection of key climate indicators. In addition, an exploration of some climate impacts under different possible future worlds will be presented for a number of economic sectors, including water, agriculture, ecosystem services, and tourism.

Prof. Bruce Forbes | Rain-on-Snow and Tundra Reindeer Nomadism in Arctic Russia under 1.5°C of Warming

Authors: Bruce C. Forbes[1], Timo Kumpula[2], Nina Meschtyb[1], Roza Laptander[1], Marc Macias-Fauria[3], Pentti Zetterberg[4], Mariana Verdonen[2], Anna Skarin[5], Kwang-Yul Kim[6] and Linette N. Boisvert[7]

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Sea ice loss is accelerating in the Barents and Kara (BK) Seas under 1.5°C of warming in recent decades. Assessing potential linkages between sea ice retreat/thinning and the region's ancient and unique socialecological systems is a pressing task. Tundra nomadism continues to be a vitally important livelihood for indigenous Nenets and their large herds of reindeer. Warming summer air temperatures have been linked to more frequent and sustained summer high-pressure systems over West Siberia, but not to sea ice retreat. At the same time, autumn/winter rain-on-snow (ROS) events have become more frequent and intense. What is driving this increase is not clear. Here we review evidence for cold season atmospheric warming and precipitation increases over Arctic coastal lands in proximity to BK sea ice loss. A major ROS event during autumn/winter 2013-14 led to the starvation of 61,000 reindeer out of a population of ca. 275,000 animals on Yamal Peninsula. Historically, this is the region's largest recorded mortality episode. Fieldwork with migratory herders has revealed that the ecological and socio-economic impacts from this single extreme event will unfold for years to come. If sea ice loss is driving increasingly severe ROS events and high reindeer mortality, it has serious implications for the future of tundra Nenets nomadism.

Dr Emily Shuckburgh | The response of the polar regions in CMIP5 models: an assessment of RCP2.6

Authors: Emily Shuckburgh, Tom Bracegirdle, Emma Boland and Andrew Meijers, British Antarctic Survey

The response of the polar regions through the twenty-first century to low-end emissions and radiative forcing pathways is structurally different to the rest of the global and hence of particular interest. Key aspects of the southern hemisphere atmosphere-ocean-ice dynamics are mediated through the tropospheric jet, which responds both to greenhouse forcing and to ozone recovery. This means that the impact of RCP2.6 is not simply characterised by a weaker version of RCP4.5/8.5: there are significant differences in both the first and second halves of the century as ozone recovery progresses. In particular this has important implications for Southern Ocean heat and carbon uptake. In the Arctic too the response is complex, here due to the sea ice response, however robust conclusions are limited by the wide spread among models in terms of their sea ice projections. We present a comprehensive assessment RCP2.6 compared with RCP4.5/8.5 for both polar regions and highlight the global-scale implications.

Dr Michael Wehner | High resolution climate model simulations of stabilized 1.5 and 2 degree warming scenarios

Authors: Michael Wehner, Daithi Stone, Jeffery Johnson, Burlen Loring, Hari Khrishnan Lawrence Berkeley National Laboratory

We present very high resolution global climate model simulations of a stabilized 1.5C and 2C warmer climate as envisioned by the Paris COP21 agreement. Changes in extreme weather, including tropical cyclones, will be discussed. Differences between the two scenarios compared to simulations of the present will be shown. The resolution of this global climate model (25km) is significantly higher than presently available in the public CMIP5 database. Because of this high-resolution, severe storm systems are much more realistically represented and the simulation of tropical cyclones up to Category Five on the Saffir-Simpson scale are routinely simulated. Output data from these simulations will be made freely available to all interested parties and should prove a useful resource to those interested in studying the impacts of anthropogenic warming stabilized at these levels.

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Human Impacts of 1.5˚C | Chair: Professor Michael Oppenheimer

13:55	Introduction by the Chair	
14:00	1.5˚C for the Hindu Kush Himalaya: impacts on people and adaptation	Dr. Arthur Lutz
14:15	Impact of 1.5˚C on the climate extremes, water resources, agriculture and food security of Bangladesh	Professor Saiful Islam
14:30	The Health Burden of Climate Change in US: Evidence from Influenza-Like Illness	Dr. Shouro Dasgupta
14:45	Would 1.5˚C avoid significant macroeconomic losses? A country-level investigation of the macroeconomic consequences in the period 2015-2050 of scenarios leading to 1.5˚C, 2.0˚C and 4.5˚C by 2100.	Dr. Michiel Schaeffer
15:00	Key risks at 1.5˚C to 2˚C: the IPCC WGII AR5 assessment	Dr. Katharine Mach
15:15	Extending the scientific basis for assessing of the impacts of 1.5˚C of global warming – The ISIMIP framework	Dr. Katja Frieler

Dr Arthur Lutz | 1.5 degrees for the Hindu Kush Himalaya: impacts on people and adaptation

Authors: A.F. Lutz, FutureWater, Wageningen, The Netherlands; H. Biemans, Alterra, Wageningen, The Netherlands; W.W. Immerzeel, FutureWater, Wageningen, The Netherlands; A.B. Shrestha, International Centre for Integrated Mountain Development, Kathmandu, Nepal; A. Syed, Bangladesh Centre for Advanced Studies, Dhaka, Bangladesh; P. Wester, International Centre for Integrated Mountain Development, Kathmandu, Nepal

The HI-AWARE research consortium aims to enhance the climate resilience and adaptive capacities of the poor and vulnerable people living in the Indus, Ganges and Brahmaputra basins. What does a global temperature rise of 1.5 degrees mean locally for the people living in this major climate hotspot? In this regional study we have selected a representative ensemble of climate models and investigated the local impact of a 1.5 degree scenario. Apart from showing changes in main climate indices, like mean annual temperature and precipitation, we specifically look at impacts that are directly relevant to the poor and vulnerable people in this region in different sectors. We make an analysis of changes during critical moments and exceedance of critical thresholds for health and agriculture. An example of a relevant indicator for health is the number of nights above 30 degrees Celsius, because this is the temperature human bodies need to recover from heat during the day. An example for the agricultural sector is the change in pre-monsoon precipitation, because this will affect the transplantation of rice. We show that climate change impact analysis tailored to the needs of stakeholders can reveal patterns of change that would not be detected by conventional analyses. This visualization of relevant impacts will stimulate a more concrete discussion towards the design of case-specific effective adaptation measures.

Professor A.K.M. Saiful Islam | Impact of 1.5 degree on the climate extremes, water resources, agriculture and food security of Bangladesh

Authors: A.K.M. Saiful Islam, G.M. Tarekul Islam, Sujit Kumar Bala, Md. Jamal Uddin Khan, Mohan K. Das, Ahmed Sajid Hasan, Mustasim Billah, Sudipta Adhikary, Md. Nasir Uddin, Md. Md. Golam Rabbani Fahad, Alfi Hasan and Supria Paul

The changes of climate have substantial impact on climatic extremes, agricultural production and food security, water resources management and overall economy of a country. Temperature and precipitation extremes and their potential future changes are evaluated. Climate projections from eleven regional climate models (RCM) are used to examine the extremes temperature and precipitation over Bangladesh in the recent past (1971–2000) and in future scenarios (2020s, i.e. 2011-2040, 2050s, i.e. 2041-2070 and 2080s i.e. 2071-2100) under RCP 8.5 representative concentrations pathway scenarios. Uncertainties due to model biases in the RCM have been overcome by using a new approach called Multi-segment statistical bias correction (MSBC) method. Study indicates moderate increase in precipitation during the pre-monsoon period (MAM) ranging between 125mm and 615mm. Significant increase precipitation in post-monsoon period (i.e. October) up to 220mm for 2080s is also evident. . Results from the RCMs exhibits 2°C and 4°C or more temperature rise relative to pre-industrial period (1861-1880) during 2050s and 2080s over Bangladesh. Both precipitation and temperature exhibit greater extreme over Bangladesh in 2080s than other two future periods (i.e., 2020s and 2050s). Brahmaputra-Ganges-Meghna river systems carries the third largest fresh water discharge and Brahmaputra carries about 67% total annual flow of Bangladesh. Climate Change will expected to alter the hydrological cycles and the flow regime of these basins. A physically based model, Soil Water Assessment Tool (SWAT), has been set up over the Brahmaputra basin, which has been calibrated and validated using the observed daily flow data at Bahaduarabad gauge station during the period from 2001 to 2009. Most of the RCMs show increasing tendency of the discharge of Brahmaputra River at Bahadurabad station during monsoon when flood usually occurs in Bangladesh.

However, the hydrological droughts will become less frequent in the future, though their magnitudes will become greater. Bangladesh is a low lying flat delta where elevation ranges from 1 to 5m. Global warming will cause the sea level rise though the variation of the rise is not same everywhere. The coastal region of Bangladesh is comprised of morphologically dynamic river network, sandy beaches and estuarine system. The interactions of huge fresh water inflows and sediment loads coming from the upstream river system and saline waterfront penetrating inland from the sea are the key factors for a vulnerable coastline. A widely used flow simulation model, Delft3D, has been set up for the complex Bangladesh delta to investigate the inundation patterns of the coastal region of Bangladesh under different sea level rise conditions. It has been found that additional 4.3%, 8.4% and 11.32% of coastal area will be inundated and additional 2.5, 6 and 8 million people will be affected if sea level rise is 0.5m, 1m and 1.5m, respectively. Agriculture contributes to 35% of the GDP and 70% of the labor force in Bangladesh. Boro rice is the leading rice producer variety of Bangladesh. Impact of climate change on production of Boro rice in Bangladesh has been evaluated using the DSSAT 4.5 crop modelling system. After calibration using BR29 variety for the period 2001-2005 and validated for 2006-2010, the impact of future climate is analyzed for 23 regions of Bangladesh. Most of the regions, the yield of Boro rice is negative, reaching over 20% decrease in some regions. The maximum temperature rise exceeds 1.5°C in 2020s which will adversely impact the yield of the crop.

Dr Shouro Dasgupta | The Health Burden of Climate Change in US: Evidence from Influenza-Like Illness

Authors: Shouro Dasgupta, Junior Researcher, Fondazione Eni Enrico Mattei (FEEM) and Centro Euro-Mediterraneo per i Cambiamenti Climatici (CMCC); Ian Sue Wing, Associate Professor, Boston University Department of Earth and Environment

The role of weather and climate in epidemiology and transmission of disease has been studied in a variety of ways and with varying complexity. Exposure to extreme temperatures and/or humidity levels increases the risk of mortality mainly through impacts on our cardiovascular and respiratory systems. In this paper, we utilize a city-by-week level dataset over a span of 40 years for 122 cities in the US - significantly larger than those used in the existing literature. The weekly influenza mortality data comes from the Centers for Disease Control and Prevention's Morbidity and Mortality Weekly Report. These observations were matched to temperature and specific humidity data from the Global Land Data Assimilation System forcing files. Combining these datasets, we utilize non-parametric Generalized Additive Models to investigate the relationship between climatic exposure and influenza mortality rates and find robust non-linear effects of both temperature and specific humidity on influenza mortality rates in the US. Our results provide empirical support to epidemiological experiments under laboratory conditions which showed that the highest risk of influenza is at extreme low and high temperatures ranges and at specific humidity levels between 4 g/kg and 12 g/kg. The smoothed splines from our analysis also demonstrate that the risk of influenza mortality varies across temperature and humidity ranges. Finally, using a bias corrected methodology; we provide projections of influenza mortality for the course of the 21st century, which suggest that a 1.5°C warming by mid-century will increase influenza mortality by more than one percentage point while warming of more than 2°C will increase influenza mortality by as much as 3% in some areas of the US. There also seems to be a spatial shift of influenza mortality from the West and Southwestern parts of the US to the South and Southeastern regions during the 21st century.

Dr. Michiel Schaeffer | Would 1.5C avoid significant macroeconomic losses? A country-level investigation of the macroeconomic consequences in the period 2015-2050 of scenarios leading to 1.5C, 2.0C and 4.5C by 2100

Authors: Florent Baarsch - Climate Analytics / CESifo (Munich) / PIK (Potsdam); Paola A. Yanguas Parra - Climate Analytics; Jessie Granadillos - Climate Analytics; Michiel Schaeffer - Climate Analytics / University of Wageningen

Knowledge of the future macroeconomic effects of climate change is still limited. Current models are offering limited insights in the effects of extreme weather events on countries' development trajectories. The evidence basis for the effects of climate change in a 1.5C scenario is even thinner, compared to higher levels of warming. This research aims at estimating the macroeconomic consequences at the country-level of climate change from the present to 2050, in a 1.5C scenario, in comparison to a 2C scenario, and a 4.5C scenario by 2100. The projections are derived from a two-step method. The first step relies on a non-linear econometric model (Burke et. al., 2015 and Baarsch et al., forthcoming). The objective of these approaches is to infer climate

analogues for different levels of intensity of temperature extremes, called climate-economy elasticity, for the period 1980-2015. Regressions are performed in pooled panels for each continent – and several subcontinental regions. The optimal sets of elasticities per continent are selected using a Monte-Carlo based randomization-filtering method. In the second step, an ensemble of 5 models from the CMIP5 database, in three different warming scenarios representative of the 1.5C, 2C and 4.5C warming trajectories, is used to compute future country-level exposure to temperature intensity. The historical analysis shows that countries and continents have different optimal temperature, reflecting different adaptation patterns and economic structure across regions and countries. The results point out that even in the first half of the 21st century, significant benefits arise from keeping global mean temperature increase well below 2C towards 1.5C in comparison to a scenario leading to 4.5C by 2100. The research also calls for more detailed model runs for a 1.5C scenario, which would include all climate stressors and particularly precipitation as hydro-meteorological extremes are the main drivers of long-term negative macroeconomic consequences.

Dr. Katharine Mach | Key risks at 1.5°C to 2°C: the IPCC WGII AR5 assessment

Authors: Katharine J. Mach Senior Research Associate, Carnegie Science Department of Global Ecology Co-Director of Science, WGII AR5 Technical Support Unit; Christopher B. Field Director, Carnegie Science Department of Global Ecology; Melvin and Joan Lane Professor for Interdisciplinary Environmental Studies, Stanford University Co-Chair, WGII AR5

The IPCC's AR5 identified key risks in a changing climate to inform judgments about danger from climate change. Its comprehensive stock taking evaluated changing risk levels and potential for risk reduction for 142 key risks across sectors and regions. Sectors ranged from human security, health, and livelihoods, to urban and rural areas, to water resources and ecosystems. Regions spanned all continents, small islands, and the ocean. The key risk assessment underpinned our IPCC conclusion that increasing magnitudes of warming increase the likelihood of severe, pervasive, and irreversible impacts. In this presentation, we will introduce and analyze the key risk assessment. We will describe, in particular, its implications for 1.5°C to 2°C global temperature increase above preindustrial levels. The focus will be differential risks resulting, for example, from extreme events and sea level rise, food and water insecurity, and ecosystem and biodiversity loss. These increasing risks across 1.5°C to 2°C warming were a key input to the UNFCCC Structured Expert Dialogue on the long-term global goal, where we and other IPCC authors presented the current status of scientific understanding. This compelling but incomplete scientific foundation points to key priorities moving forward. In building from the

WGII AR5 and subsequent research, the IPCC 1.5°C Special Report will need to grapple with limitations in available evidence especially at regional scales, while addressing complex interactions, persistent uncertainties, and diverse societal objectives relevant to understanding and communicating risks. Effectively tackling these core challenges in both research and assessment will empower ambitious responses.

Dr. Katja Frieler | Extending the scientific basis for assessing of the impacts of 1.5°C of global warming – The ISIMIP framework

Authors: Katja Frieler, Veronika Huber, Stefan Lange, Sebastian Ostberg, Christopher Reyer, Jacob Schewe, Miodrag Stevanovic, Lila Warszawski, Fang Zhao, Potsdam Institute for Climate Impact Research

The Inter-Sectoral Impact Model Intercomparison Project (ISIMIP) is the largest community-driven research project of its kind allowing for a consistent synthesis and aggregation of climate impacts across different sectors at different levels of global warming. However, there are still some important gaps in the available impact simulations hindering a comprehensive assessment of "the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways". Here we describe the model simulations planned within ISIMIP to fill these gaps and provide tailored input to the planned 1.5°C IPCC Special Report. The protocol is designed to 1) generate a pre-industrial reference simulation of impacts indicators, which allows for a quantification of the full range of impacts of 1.5°C of global warming, 2) allow for an exemplary quantification of impacts of low levels of global warming that manifest instantaneously and over a long time period up to 2300, and 3) allow for an assessment of mitigation trade-offs induced by land use changes due to increased bioenergy production as one important option to reach a low emission scenario. To this end a range of impact models from different sectors (global and regional hydrological models, global gridded crop models, global vegetation models, regional forestry models, global and regional marine ecosystem and fisheries models, global and regional coastal infrastructure models, global and regional energy models, health models, and agro-economic models) will be forced by a common climate input and a consistent socio-economic story line to provide the scientific basis for an aggregation of impacts across sectors and an analysis of cross-sectoral interactions potentially damping or amplifying sectoral impacts. .

13:55 | WEDNESDAY 21 SEPTEMBER

Implications of a 1.5˚C target for adaptation | Chair: Dr. Debra Roberts

13:55	Introduction by the Chair	
14:00	Delta Hotspots under 1.5˚C: Case studies of the Ganges-Brahmaputra, Mahanadi and Volta Deltas	Professor Robert Nicholls
14:15	Adapting Agriculture and Foods Systems to a 1.5˚C World: Towards a Coordinated Global and Regional Assessment	Professor John Antle
14:30	Building resilience or managing change? Managing for biodiversity and ecosystems in a changing climate	Dr. Mike Morecroft
14:45	Adapting to a 1.5˚C warming; An Inherent Vulnerability based Approach	Professor Nijavalli Ravindranath
15:00	Forecast-based Financing to build adaptive capacity to extreme weather events in a +1.5˚C world	Meghan Bailey
15:15	It's all about the implementation: Lessons from the boundaries of adaptation	Patrick Pringle

Prof Robert Nicholls | Delta Hotspots under 1.5°C: Case studies of the Ganges-Brahmaputra, Mahanadi and Volta Deltas.

Authors: Robert J Nicholls (University of Southampton), M. Rahman (BUET, Dhaka), M. Salehin (BUET, Dhaka), H. Sugata (Jadavpur University Kolkata), T. Ghosh (Jadavpur University Kolkata), S. Codjoe (University of Ghana, Accra), K. Appeaning Addo (University of Ghana, Accra), E. Tompkins (University of Southampton), C. Hill (University of Southampton), and A. Lazar (University of Southampton)

Deltas are seen as one of three vulnerability hotspots to climate change within the Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA) research programme, building on 30 years of impact research. This paper will examine the vulnerabilities of the three deltas that are being considered in the DECCMA project under climate stabilisation under 1.5oC and 2.0oC. These are: (1) the Ganges-Brahmaputra delta, Bangladesh/India; (2) the Mahanadi delta, India; and (3) the Volta delta, Ghana. Sea-level rise is the least responsive climate factor to climate stabilisation: hence climate-induced sea-level rise will continue, but at a slower and non-accelerating rate of rise. In addition, deltas are subject to other important stresses and are a major focus for development. Factors such as human-induced deltaic subsidence and human-induced catchment changes remain a major concern as these can cause substantial relative sea-level rise due to nonclimatic processes (sediment starvation and land subsidence). There are also other important influencing factors such as urbanisation and changes to agriculture and wider ecosystem services. The paper will review the impacts and adaptation needs for the three deltas under a 1.5oC and a 2.0oC world. There will be a strong focus on sea-level rise linked to a multiple driver framework of relevant nonclimatic changes. In particular, we will contrast the different sea-level rise trajectories between these two scenarios. It will consider the potential adaptation needs and their timing. We find that many adaptation approaches are occurring in the three deltas today such as building cyclone shelters, embankment construction, changes in agriculture practice, along with migration (due to multiple drivers). The suitability of these existing approaches or the need for new approaches under the 1.50C and 20C worlds will be considered. The wider implications for other deltas will be reviewed.

Professor John Antle | Adapting Agriculture and Foods Systems to a 1.5° C World: Towards a Coordinated Global and Regional Assessment

Authors: John M. Antle, Professor of Applied Economics. Oregon State University

Modeling studies suggest a 1.5° C world would prevent large climate impacts on agricultural systems. However, available research indicates that the mitigation and food policies needed to achieve this target are likely to require a large contribution from agriculture and the wider food system to facilitate major changes in global food production and consumption. This presentation will describe key methodological challenges to global and regional agricultural and food system assessments including: the incorporation of proposed mitigation and food policies into global and regional assessments; evaluation of their implications for sustainable food security and nutrition; and impacts on vulnerable rural and urban populations. The presentation will conclude with the plan by the Agricultural Model Inter-comparison and Improvement Project (AgMIP) to implement a 1.5° C assessment within its ongoing Coordinated Global and Regional Assessment of agriculture and food systems.

Dr Mike Morecroft | Building resilience or managing change? Managing for biodiversity and ecosystems in a changing climate

Authors: Mike Morecroft, Simon Duffield, Sarah Taylor, Humphrey Crick, Nick Macgregor (Natural England)

Building resilience to climate change is a frequently cited aspiration in nature conservation. It has a variety of formal definitions, but building resilience tends to imply a desire to maintain species and ecosystems in where they currently occur. Ecosystems and species can persist in a range of conditions so, up to a point, this makes sense. If the 1.5 degree target is achieved, there are realistic prospects of avoiding 'dangerous' impacts on biodiversity and ecosystem services by enhancing resilience, particularly restoring degraded ecosystems and re-establishing natural processes. However, some changes are inevitable, even at 1.5 degrees and as the magnitude of climatic change increases, tipping points will be crossed and adaptation would increasingly need to focus on how to manage ecological change rather than prevent it. Resilience has long been a topic of theoretical interest in ecology. The empirical evidence base has been small, but is growing and we can begin to assess how much difference the way we manage the land makes to vulnerability to climate change. Adaptation policies have also started to get to a level of detail which can galvanise planning and action rather than simply stating ambition. Drawing on science, policy and practical experience I will assess what difference a 1.5 degree target really makes to adaptation and the balance between building resilience and managing change.

Professor Nijavalli Ravindranath | Adapting to a 1.5 C warming; An Inherent Vulnerability based Approach

Authors: N H Ravindranath, and Rajiv Chaturvedi are from Indian Institutenof Science, Bangalore; Jagmohan Sharma, is a Senior Forest Officer from Karnataka State Forest Department, Bangalore

The global mean temperatures have already risen by about 10C since the pre-industrial times, impacting the natural and production systems across the world. At the Paris climate conference the world community agreed to limit warming to below 20C and to pursue efforts to limiting warming to 1.50C. According to IPCC (2014) "a first step towards adaptation to future climate change is reducing vulnerability and exposure to present climate variability". In this context an 'Inherent Vulnerability' based approach incorporating 'non-climatic stresses/drivers' under current climate is suggested, as addressing such nonclimatic socio-economic and environmental stresses contributes to long-term resilience. Firstly, the impact of climate change on production and natural systems will be determined not merely by the magnitude of climate change, but also by the socio-economic and environmental status and stresses. Secondly, assessment of impact or vulnerability using climate model projections involves multiple models and multiple scenarios and is associated with large uncertainties. Attempting to deal with the vulnerabilities or developing adaptation strategies based on future climate models would necessitate development of multiple adaptation strategies - one corresponding to each model-scenario output. There is no way to attach probability of occurrence to a particular model-emission scenario and therefore any adaptation choice made would be completely arbitrary. Thus, reducing vulnerability by addressing the drivers of 'Inherent Vulnerability' is a robust approach to build resilience of communities and ecosystems in anticipation of an uncertain future climate. The development of adaptation strategies for 'Inherent Vulnerability', would contribute to adaptation to potential climate change impacts associated with 1.5 C warming, since communities and ecosystems are already exposed to such conditions under current warming and climate variability. The concept of 'Inherent Vulnerability' based adaptation strategy development will be demonstrated by using case studies from India.

Meghan Bailey | Forecast-based Financing to build adaptive capacity to extreme weather events in a +1.5 degree world

Author: Meghan Bailey, University of Oxford and Red Cross Red Crescent Climate Center; Catalina Jaime, Red Cross Red Crescent Climate Center; Erin Coughlan de Perez, Red Cross Red Crescent Climate Center

The 1.5 degrees goal of the Paris Agreement is expected to reduce the threat of climate-induced extreme weather events as compared to warmer scenarios. Even so, extreme weather events associated with a +1.5 degree world pose substantial risks to populations in developing countries and small islands states and will require adaptation at both the community and institutional level. One method to build adaptive capacity to extreme weather events is to use early warning to provide timely support in advance of an anticipated event, such as a flood, drought, or cyclone. The Red Cross Red Crescent Climate Centre and its partners have developed a novel form of early warning early action entitled Forecast-based Financing (FbF), which releases humanitarian funding for specific pre-disaster actions in anticipation of an extreme event. The proposed presentation would outline the method of FbF and how this has worked in practice for Red Cross Red Crescent national societies and other humanitarian actors around the world. In particular it will focus on identifying thresholds of impacts, which outstrip the coping capacity of local populations, and how these thresholds can be linked with forecasts to produce triggers for action. It will highlight real-world examples where the concept has been piloted as well as future areas of high-potential application. New applications of FbF covered will include actions in anticipation of lesser-served hazards such as frost, heat waves and coral bleaching. The presentation aims to highlight the potential of using scientific forecasts embedded within broader adaptation and disaster risk reduction programming to reduce the loss and destitution associated with extreme weather events. Living well in a +1.5 degree world will require careful consideration of the avoidable losses associated with likely future disasters, as well as targeted use of limited humanitarian funds and a willingness to innovate within the climate adaptation space.

Patrick Pringle & Mr Roger Street | It's all about the implementation: Lessons from the boundaries of adaptation

Authors: Roger B Street, UKCIP; Patrick Pringle, UKCIP

The 2015 Paris Agreement places unprecedented emphasis on the need to adapt to the impacts of climate change and for greater clarity regarding national level adaptation efforts. To date much of the focus of adaptation efforts has been on adaptation policy and planning processes and securing finance. Following Paris, there is a growing recognition of the need to rapidly progress these nation plans to large scale adaptation implementation. We need to consider what is needed create an enabling environment for adaptation action, and examine the often overlooked capacities and functions that link research, policy and practice. Recent discussions at the UNFCCC Technical Expert Meeting on Adaptation in Bonn highlighted the critical role of enhancing knowledge exchange and communication between science, adaptation plans, and policies and practice on the ground. National climate action plans are collectively becoming the global roadmap to tackling the adaptation challenges, however practical support and guidance are necessary. This presentation will highlight how to meet the UN adaptation goal of 'enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change' through particular emphasis on the role that boundaries organisations play in these. With the knowledge and experience of implementing adaptation, it is the boundary organisation that becomes the necessary 'glue' to bring together valuable yet sometimes disparate efforts between research, policy and practice communities; bridging, translating, synthesising, facilitating collaboration and exchanging knowledge. Valuing the linkages of science, policy and practice that boundary functions can support to build capacity and increase impact of climate adaptation finance is so vital in a post-Paris world. In this presentation we shall illustrate this critical role with specific examples.

13:55 | THURSDAY 22 SEPTEMBER

Mitigation Pathways | Chair: Dr. Joeri Rogelj

13:55	Introduction by the Chair	
14:00	Interpretation of the 1.5°C goal	M J Mace
	How to contain undesirable side effects of a 1.5°C mitigation target?	Dr. Oliver Geden
14:20	Allowable emissions for a peak vs. long-term 1.5°C target	Dr. H. Damon Matthews & Professor Pierre Friedlingstein
14:40	Decarbonization bottlenecks and the 1.5°C limit: What determines the lower limit of achievable climate targets?	Dr. Gunnar Luderer
	Challenges for 1.5°C mitigation scenarios & modelling	Dr. Charlie Wilson
15:05	How to move from INDC to 1.5°C: the insights from comparison study based on various allocation schemes	Professor Fei Teng
	Equitable contributions to achieve the Paris Agreement commitments	Yann Robiou du Pont
15:25	Cross-sectoral assessment of the policies required to meet a 1.5°C target	Dr. Neil Edwards
	What does the 1.5°C limit mean for coal plans in the OECD, China and the European Union?	Dr. Marcia Rocha

M J Mace | Interpretation of the 1.5 degree C goal

Authors: M.J. Mace, Independent Consultant, Legal Advisor to Saint Lucia in the negotiating process, guest lecturer at University of London- SOAS on climate change law and policy LLM course.

Article 2 of the Paris Agreement moves beyond the "below 2 degree" ambition of 1/CP.16 to embed a 1.5 degree long-term temperature increase limitation squarely in the 'purpose' article of a legally-binding treaty. The 1.5 degree goal can be seen as a ceiling that should not be exceeded, or be seen as a longer-term target after a temporary overshoot, while all the time remaining "well below" 2 degrees C, as referenced in Article 2. Regardless, no longer is a budget acceptable that "may" limit temperature rise to 2 degrees with a some degree of likelihood. Articles 2 and 4 now provide the dirction of travel for collective and individual action - peaking as soon as possible, rapid reductions thereafter, net zero emissions in the second half of the century, in pursuit of the 1.5 degree limit. From these elements, consistent emission reduction pathways can be drawn, and an emissions budget can be determined. This presentation will consider: the legal significance of the 1.5 degree limit; its operationalization through Article 4; the determination of an emissions budget and the relevance of threshold avoidance budgets; the importance of the timing of reductions within any budget envelop and the relationship of timing to impacts; Parties' recognition in Article 2 that reaching these goals "would" significantly reduce the risks and impacts of climate change; Article 8's reference to the importance of averting, minimizing and addressing loss and damage associated with climate change; the significance of the reference in decision 1/CP.21, para. 17 for the first time to quantified markers for emission pathway consistency and related mitigation gaps for both 2 and 1.5 degrees; the notion of a duty of care under international law; and the legal, institutional and political tools available to ramp up mitigation ambition under the Agreement to close the current gap.

Dr Oliver Geden | How to contain undesirable side effects of a 1.5C mitigation target?

The inclusion of the 1.5 °C target into the Paris Agreement is usually seen as a major climate policy success. But while the UNFCCC's 1.5 °C decision recognizes climate risks that will emerge far ahead of 2C and might help to create a new benchmark for 'loss & damage' claims, it is unclear if it will really be able to accelerate mitigation action. From a perspective that takes prevalent political rationales and common practices in climate policymaking into account it can be argued that temperature targets lack many of the features necessary to effectively guide national governments and other key actors: being precise, evaluable, attainable and motivating. By failing to state explicitly what individual countries are required to deliver, 1.5 and 2 °C allow leaders to support ambitious targets, while pursuing mitigation efforts that are in reality insignificant (see current INDCs and insufficient rules for ratcheting-up commitments until 2030). So far, carbon budgets have not influenced climate policymakers and high-level politicians as intended, and they most likely never will. Instead, climate economists have started to stretch the remaining budgets by introducing vast amounts of carbon dioxide removal (CDR) into their models, effectively masking political inaction. Furthermore, budgeting 1.5 °C will catalyze the concept of temporary 'temperature overshoot' that has been almost absent so far in the 2 °C debate, allowing for even more conceptual flexibility, and thus political 'hypocrisy'. Last but not least, the 1.5 °C target will be used to accelerate the policy debate on the need for solar radiation management (SRM). Taking the rules and procedures of real-world climate policymaking into account, the presentation will show ways to contain undesirable side effects of the 1.5 °C target decision, mainly by introducing complementing elements (e.g. policy strategies for CDR/SRM) and a new hierarchy between temperature and zero emissions targets.

Dr H. Damon Matthews | Allowable emissions for a peak vs. long-term 1.5°C target

Authors: H. Damon Matthews (Concordia University, Canada) and Kirsten Zickfeld (Simon Fraser University, Canada)

Recent global temperature increases indicate that we may be rapidly approaching 1.5 degrees of global warming. Using estimates of human-attributable warming and the climate response to cumulative emissions, we have calculated that a continuation of recent CO2 emission trends would take us past 1.5°C in about a decade and a half (see visualization of this calculation at: www.countdown2degrees.com). This is consistent with the few estimates of allowable emissions for 1.5°C that exist in the literature, all of which suggest a very short window of time before this carbon budget is consumed. While CO2-induced warming is largely irreversible, much of the anticipated near-term warming will likely result from emissions of short-lived non- CO2 gases. This non-CO2 warming is therefore likely to be reversible on timescales of longer than a few decades given the potential for mitigation of these short-lived emissions. The timing of a 1.5°C climate target, and in particular whether this target is applied to peak or long-term warming, is therefore a crucial determinant of estimates of allowable emissions. In this presentation, we will argue that while near-term (peak) warming of 1.5 °C may be extremely difficult to avoid, taking a longer-term perspective on 1.5°C would make this a much more realizable climate target. Such a long-term perspective would also be consistent with efforts to avoid climate impacts such as sea level rise and ocean acidification that manifest fully on timescales of centuries to millennia.

Dr. Gunnar Luderer | Decarbonization bottlenecks and the 1.5°C limit: What determines the lower limit of achievable climate targets?

Authors: Gunnar Luderer, PIK; Elmar Kriegler, PIK; Volker Krey, IIASA; Keywan Riahi, IIASA; Bert Saveyn, IPTS; Massimo Tavoni, FEEM; Detlef Van Vuuren, PBL; Zoi Vrontisi, IPTS and represantatives from participating modeling teams

This talk will present results from a first-of-its kind analysis of the intended nationally determined contributions (INDCs) and implications for the achievability of the 1.5°C goal. The study is conducted in the context of the EU FP7 ADVANCE project and based on an ensemble of eight integrated energy-economyclimate models. Limiting global warming to below 2°C with a high likelihood limits the remaining CO2 emissions to ~800 GtCO2. For a medium chance of returning to below 1.5°C by 2100 this quota is even reduced to ~200 GtCO2 (medium chance of <1.5°C). We here estimate the lower limit of fossil-based CO2 emissions for 2016-2100 to be of the order of 1000 GtCO2 [NUMBERS ARE ALL VERY PRELIMINARY!], even under very optimistic assumptions about ratcheting up in the near-term. If nations follow the climate policy ambition of the currently intended nationally determined contributions (INDCs) until 2030 without ratcheting-up this lower limit will increase by another 150-250 GtCO2. We also find that electricity supply has the greatest potential for near-term emission reductions, but also holds the greatest risk of further carbon lock-in. The transportation and buildings sectors, by contrast, emerge as more difficult to decarbonize. These two sectors account for the bulk of residual long-term CO2-emissions in deep decarbonization scenarios. Our results have important implications for the negative emissions requirements under alternative long-term climate goals. They also help inform about priorities for near-term emission reductions and long-term mitigation technology development.

Dr Charlie Wilson | Challenges for 1.5oC mitigation scenarios & modelling

Authors: Charlie Wilson, Tyndall Centre for Climate Change Research, UK; Glen Peters, CICERO, Norway; Joeri Rogelj, International Institute for Applied Systems Analysis (IIASA), Austria

Scenarios are a method for exploring the future possibility space. Models enrich scenario storylines with quantitative detail. Over 100 modelled scenarios in the IPCC AR5 database characterize uncertainties for 2°C mitigation from part of the current technological and policy option spaces. The 1.5°C target will generate a new wave of scenarios ratcheting up the transformation effort in energy, land-use, and economic systems. Three limitations with 2°C scenarios and modelling will constrain new insights if extended in their current form to 1.5°C analysis. First, mitigation scenario storylines do not systematically sample the full future possibility space. As examples, 2°C scenarios are systematically skewed towards ever-improving efficiency (doing more with less) rather than reaching sufficiency (having enough), and cumulative incremental change rather than radical, disruptive change. 1.5°C scenarios should explore a wider set of possible futures including discontinuities from historical experience. Second, the mapping of scenario storylines into model inputs and assumptions is constrained by models' stylised representation of real-world phenomena potentially important for 1.5°C mitigation. Examples include non-financial attributes valued by end-users, and sector-specific non-economic policy instruments. Modelling analysis for 1.5°C scenarios should account for real-world dynamics potentially relevant for rapid transitions. Third, the evidence from observed transitions emphasizes social, institutional, and political contingencies. Although these drivers of change may be depicted in scenario storylines and/or interpreted from modelling results, this is often limited. For example, scenarios that delay implementation of a global carbon price are used as a coarse placeholder for a wide range of questions about political feasibility. 1.5°C scenarios and modelling should better internalise non-technical drivers of change. Unless these limitations are addressed, we see new policy-relevant insights on the challenge of 1.5°C mitigation as coming from empirical studies and meta-analysis of observational evidence for rapid transitions, including social and political science.

Professor Fei TENG | How to move from INDC to 1.5 degree: the insights from comparison study based on various allocation schemes

Authors: Fei TENG, Institute of Energy, Envirnoment and Economy, Tsinghua University

Responding to the call for INDC submission, more than 180 countries and regions have already prepared and submitted their INDCs to the UNFCCC before the Paris climate conference at the end of 2015. Those INDCs formed a firm basis for implementation of Paris Agreement in the post-2020 period. However, the scientific assessment also indicated that the aggregation of those bottom-up submitted INDCs is still not enough to meet the 2 degree target which national political leaders agreed in Copenhagen and reaffirmed in Paris, and also far from the 1.5 degree target emerging from the Paris. The existence of the emission gap is largely due to a lack of common agreed standard of equity, then it is not surprised that countries will select various interpretations which they tend to favor. Therefore, the inconsistent choose of equity standards lead to the overuse of global carbon budget and giga tons emission gap. To close the gap and also move to 1.5 degree, it is important to understand the underpinning equity principles and standards behind each submitted INDCs. However, only few submissions linked the INDC with quantifiable equity standards, thus the picture of equity issues behind each INDC submission is still vague. To resolve this issue, this paper propose an excise to explore the underpinning equity principle behind country's submission through comparing INDC with carbon budget allocation under different effort sharing schemes. There are dozens of effort sharing schemes have been proposed in the literatures and summarized in the recent IPCC AR5 assessment report. This study will use those effort sharing scheme as a reference to understand the consistency of INDCs with 2 degree target under various effort sharing schemes and the possibility to move towards a 1.5 degree future.

Yann Robiou du Pont | Equitable contributions to achieve the Paris Agreement commitments

Authors: Yann Robiou du Pont [1], M Louise Jeffery [2], Johannes Gütschow [2], Peter Christoff [3] and Malte Meinshausen [1,2]. [1] Australian-German Climate & Energy College, University of Melbourne, Parkville 3010, Victoria, Australia; [2] Potsdam Institute for Climate Impact Research(PIK), Telegraphenberg, D-14412 Potsdam, Germany; [3] School of Geography, University of Melbourne, Parkville 3010, Victoria, Australia

With the Paris agreement, the international community has committed to net-zero emissions in the second half of the century, to limiting global warming to 2°C, and to best efforts to limit warming to 1.5°C. However, current aggregate emissions reduction targets are not consistent with these long term commitments and the question of how to equitably achieve these global goals remains. We identify global cost-optimal emissions scenarios in line with these temperature and mitigation targets and allocate their emissions to countries according to five equity approaches ('capability', 'equal per capita', 'Greenhouse Development Rights', 'equal cumulative per capita' and the 'constant emissions ratio') representative of the five equity categories presented in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Countries' submitted Intended Nationally Determined Contributions (INDCs) are compared with the calculated national allocations to assess their fairness and consistency with the long-term Paris goals. China's INDC is weaker than any allocation approach in line with 2°C, the USA's lies within two, and the EU's and India's within three. Of these countries, only India is in line with 1.5°C under some equity approaches. A benchmark 2030 emissions level consistent with the 1.5°C target is 32.6 GtCO2e, 7.1 GtCO2e lower than the 39.7 GtCO2e needed for 2°C. Based on the average equitable allocations, G8 and China as a group would together need to reduce their 2030 emissions by an additional 21 percent of their 2010 emissions under the 1.5°C case as compared to the 2°C case. All other countries together are allocated 2030 emissions only 9% higher than 2010 levels for 1.5°C consistent scenarios, whereas for 2°C consistent scenarios allocations are 48% above 2010 in 2030. However, over the century, equitable national allocations in line with the 1.5°C goal do not reach lower levels than for 2°C for almost all countries.

Neil Edwards | Cross-sectoral assessment of the policies required to meet a 1.5°C target

Authors: Jean-Francois Mercure, Heleen de Coninck, Radboud University, Netherlands; Hector Pollitt, Unnada Chewpreecha, Cambridge Econometrics Ltd, UK; Neil R. Edwards, Philip B Holden The Open University, UK; Pablo Salas, Jorge E. Vinuales, University of Cambridge, UK

In this paper we use an advanced modelling approach to develop and assess a set of real-world policies that, if implemented, would put global greenhouse gas emissions on a pathway that is consistent with a 66% chance of meeting the 1.5°C target for limiting global temperature change. We apply a novel highly disaggregated dynamical Integrated Assessment model to carry out the analysis and build up an emissions reduction scenario based on a mixture of regulatory and market-based instruments. In contrast to much of the existing analysis that has been carried out for the IPCC and others, our assessment approach is entirely simulation-based and model responses to specific policy inputs are based on observed behavioural relationships. We combine the highly detailed macro-econometric model E3ME with the FTT model of technology diffusion in the power and transport sectors to construct a fully path-dependent scenario in which policies are combined to drive strong emission reductions. This emissions profile is used with emulators of carbon cycle and climate system models to estimate the impact on global temperature change and other climate impacts. The analysis finds that carbon pricing on its own would not be sufficient to meet the 1.5°C emission reduction target. Other policies, including regulation on energy efficiency, incentives for the adoption of new technologies and a series of sector-specific regulations are required. The modelling finds that the global economic impact of implementing the measures over the period out to 2050 would be small but there are potentially very large distributional impacts, both between sectors and

countries. The costs to the economy of fast decarbonisation take primarily the form of stranded physical capital assets (e.g. coal power plants), the cost of which becomes reflected in commodity prices (e.g. electricity), reducing household disposable income.

Dr Marcia Rocha | What does the 1.5°C limit mean for coal plans in the OECD, China and the European Union?

Authors: Marcia Rocha*, Niklas Roming*, Fabio Sferra*, Jasmin Cantzler*, Paola Parra*, Michiel Schaeffer*, Andrzej Ancygier*, Alain Coimbra*, Bill Hare*

*Climate Analytics

The scientific literature suggests that CO2 emissions from coal use need to be zero globally around 2050 to limit warming to 1.5°C. Given the potential lock-in that emissions-generating assets with a long economic lifetime (40+ years) may imply, we investigate what the 1.5°C limit means for the currently operating and planned coal power plants in the OECD, in the European Union and in China. In a first step we employ the Simplified Integrated Assessment Model with Energy System Emulator (SIAMESE) to compute regional coal emissions pathways in line with an emissions scenario from the Integrated Assessment Model (IAM) MESSAGE consistent with limiting warming to 1.5°C with 50% probability in 2100. SIAMESE allows for flexible spatial resolution while keeping results consistent with full scale IAMs like those applied for IPCC's AR5. Next, we calculate cumulative lifetime emissions resulting from existing and planned coal fired power plants contained in the Global Coal Plant Tracker database using technology/coal type specific efficiencies, load factors, emissions intensities and lifetimes. We conduct a sensitivity analysis regarding these parameters to ensure robustness of the results. Cumulative coal-related emissions in line with 1.5°C are compared with emissions resulting from existing and planned coal power plants. Preliminary results suggest that for OECD, for the EU and for China, coal power plants presently operating will emit considerably more CO2 than what would be in line with a least-cost budget in line with 1.5°C derived from SIAMESE; emissions from planned coal power plants would surpass this budget significantly. This is due to the relatively high remaining economic lifetime of these assets. These results clearly rule out new coal power plants coming online and point to the urgency of developing economic, political and social avenues to retire coal plants before end of lifetime.

13:55 | THURSDAY 22 SEPTEMBER

Financing 1.5°C | Chair: Professor Cameron Hepburn

13:55	Introduction by the Chair	
14:00	When the elephant meets the mouse: modeling the impact of fossil fuels and renewable energy subsidies on macro-economic and financial stability	Dr. Irene Monasterolo
14:15	Energy Storage - The Role Of The Capital Markets In Financing The Transition	Jessica Williams
14:30	The role of 'green' State Investment Banks in addressing the finance gap for deep de-carbonization	Professor Tobias Schmidt
14:45	Unlocking climate finance: driving action on the ground	Noémie Klein
15:00	Legal issues in energy and climate finance: European offshore wind	Jaap Waverijn
15:15	Financing 1.5°C: How to leverage low-carbon investments in rapidly developing economies?	Dr. Luigi Carafa

Dr Irene Monasterolo | When the elephant meets the mouse: modeling the impact of fossil fuels and renewable energy subsidies on macro-economic and financial stability

Authors: Irene Monasterolo, Boston University; Eric Kemp-Benedict, Stockholm Environmental Institute; Emanuele Campiglio, London School of Economics; Elena Dawkins, Stockholm Environmental Institute; Antoine Godin, Kingston University

Costs of renewables are falling, green investment is expanding, and the climate negotiations appear to be reinvigorated with the most emitting countries having signed the COP21 agreement. These trends suggest that there is a growing risk to holding equity in fossil fuel companies and fossil reserves could become unburnable (Carbon Tracker Initiative, 2014) – the assets may abruptly lose their value, and become stranded (Battiston et al., 2016). Yet there are risks to shifting away from fossil fuels, as well. For instance, existing electricity markets and grids are not well suited to heavy reliance on intermittent renewables; policy standards and regulation are evolving and a key source of uncertainty for investors; a trained workforce is still in the making and would require specific investments in education while governments struggle with growing public debt; R&D facilities are geared toward existing technologies. Drawing on Schumpeterian models of technological transformation, the literature on socio-technological regime transitions, and the results of different modeling exercises carried out by the authors, we discuss the risks and uncertainties tending toward or away from continued reliance on fossil fuels. We explore three sources of risk for investments in renewables:

- lock-in, whether institutional, in the form of policy regulation and standards that favour investment in non-renewable technologies, or technological, influencing public and private investments:

- policy environments that undermine investment in renewables, such unstable fiscal policies in the US and the persistence of fossil fuels subsidies;

- credit bottlenecks that negatively affect access to capital thus mining investments in renewables, which work on a different business model as compared to fossil fuels energy and require high initial capital investments.

We discuss policies targeting consumers, firms, and the financial sector in shifting the balance toward low carbon investment by looking at the international policy agenda and multilateral development banks.

Jessica Williams | Energy Storage – The Role Of The Capital Markets In Financing The Transition

Authors: Michael Wilkins, Managing Director & Head of Environmental & Climate Risk Research Standard & Poor's Ratings Services; Jessica Williams, Research Assistant, Environmental & Climate Risk Research Standard & Poor's Ratings Services

Energy storage is key to being able to use renewable energy to its full potential, indeed current grid systems struggle to utilise beyond 20-30% renewable energy without it, due to the unpredictability and intermittency of wind and solar. IRENA has estimated that the world will need 150 GW of battery storage by 2030 if it is to meet the desired target of 45% of power generated from renewable sources. Battery pack price has fallen from $1,000 per kWh in 2010 to $350 per kWh today, which makes battery storage increasingly commercially viable. Now that the costs and technology risk are plummeting the last barrier to these transformational technologies is the financing. Debt financing will inevitably make up a large percentage of the transition bill but how exactly, is yet to be seen. How could large scale project financings for innovative technologies such as storage work? How are developers de-risking and structuring such projects and how would a credit rating agency such as Standard & Poor's assess the risks? In the case of storage, a lot can be learnt from the solar, wind and energy efficiency project financing in terms of applicable models. These technologies all share the same barriers of high upfront costs and long payback periods. However, unlike these technologies energy storage has

the potential for multiple use applications within a given project enabling various revenue streams (balancing, back up, meeting peak demand, off taking / reducing generation curtailing, uninterrupted power supply). This increased flexibility serves as both an opportunity for creative project development and a risk to realizing full revenue projections.

Prof. Tobias Schmidt | The role of 'green' State Investment Banks in addressing the finance gap for deep de-carbonization

Authors: Tobias Schmidt, Energy Politics Group, ETH Zurich; Anna Geddes, Climate Policy Group and Energy Politics Group, ETH Zurich

The Paris agreement implies that the development and diffusion of low-carbon technologies (LCTs), such as renewable energy technologies (RETs), will have to be accelerated substantially to reach the 2- and the even more ambitious 1.5-degree targets. But there is a significant 'financing gap' for the projects required and many are concerned that investments for the large-scale diffusion of LCTs will not materialise. Public support and utilities' balance sheets are currently constrained and, given the necessary scale of investment, private finance is required. However other capital sponsors are deterred by the high (perceived) risks of low-carbon technology projects. In recognition of these issues, some governments have appointed 'green' State Investment Banks (SIBs) to help fill the finance gap. For example, the UK's "Green Investment Bank" and Australia's "Clean Energy Finance Corporation" were both founded in 2012, independently but with similar goals: to assist their country's transition towards a greener economy by accelerating the diffusion of low carbon projects by leveraging in private finance. We performed a qualitative analysis of the role of these SIBs in addressing the finance bottleneck for the innovation and diffusion of RETs. Our findings show that SIBs can play a much wider role than simply providing capital and taking risk; they also act as knowledge brokers and standard setters, and can incentivize capability building. We do however see a gap in support for the higher risk needs of smaller developers and community scale renewables projects. Overall our current findings lead to the conclusion that – if designed well – SIBs can successfully tackle a range of systems failures faced by RET developers, leveraging additional private finance into the sector and enabling the diffusion and innovation of renewables. However, depending on the terms of their remit, for some sub-sectors SIBs can also introduce technology and firm selection bias.

Noémie Klein | Unlocking climate finance: driving action on the ground

Mr Jaap Waverijn | Legal issues in energy and climate finance: European offshore wind

Authors: Jaap Waverijn, LLM (Cambridge) - Research fellow, Groningen Centre of Energy Law, University of Groningen and Coordinator North Sea Energy Law Programme (part-time LLM for energy professionals by the universities of Groningen, Oslo, Aberdeen and Copenhagen)

Law and policy should stimulate investments by IFIs, the private financial sector and citizens. In addition, government should financially support the road to economic viability of promising technologies. Currently, that is not always the case. Issues include, firstly, that policy uncertainty is an important reason for institutional investors to decide against investing (see, eg, FS UNEP reports). Secondly, in some cases essential financial matters are not provided for by law. The European offshore wind sector provides an example of these issues. Through subsidies on the electricity produced, public funding allows the sector to mature and reduce costs to try and become economically viable. For these large scale projects, which can cost as much as €3bn, legal and policy certainty is paramount to attract institutional investors. Around half of the offshore wind farms are financed wholly by utilities. In the other half, the project developers attract capital from a consortium of public and private financial institutions. The public financial institutions, such as the EIB and ECAs, are essential in closing these deals. In addition to policy certainty, financial institutions require financial

security for their loan to the project company. Therefore, both the subsidy and license the project company holds should be able to be pledged, allowing them to be transferred to a third party in case of insolvency, benefiting the lenders. This is currently not possible in many jurisdictions as it is not legally allowed. In addition, mortgage or pledge on the physical installations cannot be established beyond territorial waters in any European jurisdiction as a result of a range of legal problems. These problems include that beyond territorial waters property laws do not automatically apply, public registers do not extend to the sea and ownership problems occur because of the 'ownerless' status of the seabed beyond the territorial sea.

Dr Luigi Carafa | Financing 1.5 degrees: How to leverage low-carbon investments in rapidly developing economies?

Authors: Dr Luigi Carafa, Energy and Climate Change Programme, Barcelona Centre for International Affairs

The effective mitigation of climate change requires investment flows to be shifted from high-carbon to low carbon technologies. Global climate finance reached USD 391 billion in 2014 (with more than 60% coming from private investors, and the remaining part coming from public finance). Developed countries stay committed to provide 100 billion a year to developing countries by 2020. Although the low-carbon shift has already started, there is a compelling need to massively increase low-carbon investment flows in order to stay well below 2°C and try to stay below 1.5°C – as established in the landmark climate agreement approved in Paris in December 2015. Under business as usual, global carbon emissions will increase by almost one-third by 2035 compared to today's level – with rapidly developing economies accounting for all of this increase. While emissions in OECD countries are on the decline, emissions in rapidly developing economies are skyrocketing due to population growth, economic development and raising living standards. By 2035, we will need $54 trillion to meet the rising global energy demand with low-carbon technologies. But can we shift fast enough to prevent a climate crisis? Crucially, in developing economies low-carbon investments are discouraged by high risks associated to regulatory, technical, and financial barriers. As a result, low-carbon project financing costs are over 40% higher than in developed economies on average. This presentation will shed light into (a) critical barriers for low-carbon investments in rapidly developing economies; (b) the policy signals that Paris Agreement gives to the market; and (c) areas of effective policy intervention that can reduce investment risks and leverage private investments in rapidly developing economies.

13:55 | THURSDAY 22 SEPTEMBER

Societal and development implications of the Paris Agreement | Chair: Professor Benito Müller

13:55	Introduction by the Chair	
14:00	Different development pathways are needed to get well below 2°C	Professor Harald Winkler
14:15	What did IPCC say about the 1.5°C temperature long-term goal? Could IPCC say more, without being prescriptive?	Professor Jean-Pascal van Ypersele
14:30	Building Equity In: Challenges and Opportunities for Representing Equity in Climate Policy Modeling Analyses	Dr. Sonja Klinsky
14:45	Bottom-up push to 1.5°C	Professor Claude Henry
15:00	Climate change and 1.5°C: how to communicate to raise awareness and promote a change of action after the Paris Agreement	Tais Gadea Lara
15:15	Zero hunger/zero net emissions: marching in step or falling between two stools? What research needs to do to deliver the twin goals.	John Magrath
15:30	Meeting the 1.5°C target: Implications for the Fossil Fuel Industry and Civil Society	Dr. Peter Frumhoff

Image: [CC0 Public Domain] COP/Paris via Flickr

Prof Harald Winkler | Different development pathways are needed to get well below 2°C

Authors: Harald Winkler, Energy Research Centre, University of Cape Town

It is politically and symbolically signifcant that the Paris Agreement aims well below 2 degrees, and pursues efforts to 1.5 °C.1 The question of 1.5 degree is not, on its own, the most important, but only when understood together with the imperative to "eliminate poverty, in all its forms, everywhere". 2 Conceptually, this will require thinking about different development pathways,3 as well as ramping up climate actions. The deep decarbonsiation pathways project (DDPP) was based on national modeling by 16 country research teams, and showed that it is technically possible for these countries to contribute to 2 °C.4 An ERC study of South Africa (SA) used energy-economy-environment modeling,5 with the 2 °C imperative stretching what might be possible in SA's political economy. Remaining within 14 Gt energy emissions from 2010 to 2050 means rapid move away from coal, decarbonising electricity. The scenarios assume fundamental developmental shifts.6 We had to envision an economy that SA does not have, and a population with skills beyond those our education system delivers. Even then, unemployment is reduced only by 25-50%, failing to meet the challenge of zero poverty and zero emissions.7 Running the same modeling framework for 1.5 °C would not add qualitatively different information. ERC undertook work to ask which actors and social forces in SA would either support or oppose a DDP. Modeling is complemented by political analysis of the interests of coalitation of incumbents –coal-based electricity, energy-intensive electricity users, coal to liquids, mining (incl coal), as well as emerging actors with interests in a low-carbon economy, e.g., the renewable energy industry. 8 Beyond political analysis, we need to reimagine development pathways. Paris and the SDGs require new thinking and the IPCC special report will hopefully assess new research on development pathways that can both pursue 1.5°C and make poverty history.

Prof. Jean-Pascal van Ypersele | What did IPCC say about the 1.5°C temperature long-term goal? Could IPCC say more, without being prescriptive?

Authors: Jean-Pascal van Ypersele, Université catholique de Louvain (Belgium), Former IPCC Vice-Chair

Information about the implications of the different temperature goals, including 1.5°C, is not always easy to find in the successive IPCC reports. This paper will review the evolution of the IPCC discourse about those goals and discuss its policy-relevance. The analysis will start from the notion of "dangerous anthropogenic interference with the climate system" at the heart of UNFCCC Article 2, cover the evolution of the "reasons for concern" framework from AR3 to AR5, and discuss some aspects related to the 1.5°C goal in the (never published) Box devoted to Article 2 and due to be part of the AR5 Synthesis Report. The paper will end with a discussion of the limits of the IPCC mandate in the context of the 1.5°C goal.

Dr Sonja Klinsky | Building Equity In: Challenges and Opportunities for Representing Equity in Climate Policy Modeling Analyses

Issues of equity have long been central to climate policy for three primary reasons: unequal historical contributions of greenhouse gases; existing and profound inequities in human wellbeing; and differences in vulnerability to climate impacts. All three elements of equity intersect and are central to climate policy decision-making both for ethical concerns about human wellbeing and because perceived inequities feed directly into the political challenges faced by many climate policy efforts. As such, equity considerations must be factored into analyses of possible pathways for a 1.5C world. Without comparative information about who is likely to face which kinds of costs, benefits and trade-offs and what the implications of these will be for their well-being, it is difficult to evaluate the ethical dimensions of policy proposals and or to provide early insight into the political challenges posed by particular policy designs. However, modeling equity as a multidimensional element of climate policy is not straightforward, and many IAMs do not easily lend themselves to providing accessible insights into the equity dimensions of policy choices. This paper starts with an articulation of the multi-dimensional challenges of equity in climate policy and compares this with current approaches for representing equity in IAMs. It then assesses the capacity of models to integrate more nuanced and politically salient elements of equity and lays out a series of possible pathways for expanding our ability to take equity seriously in modeling when examining potential pathways to a 1.5C world.

Professor Claude Henry | Bottom-up push to 1.5°C

In a game-theoretical spirit, Vasconcelos et al., in Nature Climate Change (2013), report results that "clearly suggest that a polycentric approach involving multiple institutions is more effective than that associated with a single, global one, indicating that such a bottom-up, self-organization approach, set up at a local scale, provides a better ground on which to attempt a solution for such a complex and global dilemma", i.e. climate change. That might sound overly optimistic. Nevertheless this perspective of contagion and progressive coordination of initiatives is to an encouraging extent vindicated by actual moves involving a variety of actors, be they imaginative and determined activists, investors reoptimizing their portfolios with respect to the "climate risk" recently recognized on financial markets, banks reorienting their lending activities for similar reasons, cities sharing best mitigation and adaptation practices, nation states and regional authorities (Canadian provinces, US states, Chinese megacities) implementing one or another form of carbon pricing, indigenous communities proving the best managers of tropical forests, …. In L'Ancien Régime et la Révolution, Livre III, Alexis de Tocqueville shows how mushrooming new visions and actions converged from many different horizons to overthrow the Old Regime and generate a new order. The proposed paper examines whether a similar pattern might be developing today with the perspective of a revolution, that is, as it was, the only way out of inextricable problems.

John Magrath Mr | Zero hunger/zero net emissions: marching in step or falling between two stools? What research needs to do to deliver the twin goals

Authors: Gore, T; Kreiser, I; Magrath. J; Oxfam international

There is an urgent need to better understand the implications of simultaneous efforts to achieve two major goals of international policy – to end hunger, and to curb greenhouse gas emissions: the 'zero hunger/zero net emissions' agenda. The Sustainable Development Goals adopted a target of zero hunger by 2030 but despite undeniable progress, that target will not be met without a gear-shift in policies and practices. Paris adopted a target of net zero emissions in the second half of the century, and the 1.5-degree 'stretch goal' implies both net zero fossil fuel emissions by mid-century and net zero GHG emissions by 2060-2080. These targets too are in grave danger of not being met. Research is urgently needed on how to achieve these goals at the same time, and sustain the achievements. Both imply radical transformations of socio-economic systems, potentially with major equity considerations. Therefore it is vital to understand the potential complementarities and possible tensions between these two goals and articulate the matters that arise for policy deliberation. Research must deliver on several key axes including land use, low carbon energy choices, emissions reductions from agriculture and genuine 'zero hunger/zero net emissions' policy options that can unleash development co-benefits of low-carbon investments. We will raise key questions and propose a framework to help guide research.

Dr Peter Frumhoff | The Role of the US Supreme Court in Achieving the Paris Agreement's Long-term Temperature Targets

Authors: Ken Kimmell, Union of Concerned Scientists, Cambridge MA USA; Rachel Cleetus Union of Concerned Scientists, Cambridge MA USA; Peter Frumhoff Union of Concerned Scientists, Cambridge MA USA*; Alden Meyer, Union of Concerned Scientists, Washington DC USA. *Speaker

Because the world has waited so long to address climate change, we face an exceedingly difficult challenge to lower emissions sufficiently to meet the Paris Agreement goal of limiting global temperature increases to well below 2°C above pre-industrial levels, with an aim to limit the increase to 1.5 °C. As the world's largest source of cumulative carbon dioxide emissions, the United States has a particular responsibility to provide leadership in climate mitigation. Carbon dioxide emissions from power plants account for nearly 40 percent of total C02 emissions in the United States and are easiest and most costeffective target for lowering emissions. Cutting power-plant emissions under the federal Clean Power Plan is a cornerstone of the U.S. pledge under the Paris Agreement to reduce national emissions 26 to 28 percent below 2005 levels by 2025. Recognizing that the near-term emission reductions pledged in that agreement are not sufficient to meet its long-term temperature goal, the Paris Agreement requires all nations to review their existing pledges every five years and for each to increase its level of ambition to the maximum extent feasible. Were the Supreme Court to strike down or remand the Clean Power Plan, it would make it more difficult for the United States to meet and exceed its current pledge, and even harder for it to offer a more ambitious pledge in five years. And, if the United States fails to meet its commitments under the Paris Agreement, other countries may rethink their commitments as well. Given uncertainties over a Supreme Court ruling, it may fall to US cities, states, businesses and community leaders to accelerate emissions reductions at sub-national levels and demonstrate to other nations clear resolve to meet and exceed US federal emissions reductions commitments, on a path consistent with achieving the Paris Agreement's temperature targets.

POSTER PRESENTATIONS

In alphabetical order:

Andie Stephens | 1.5°C target for BT

Professor Carlo Aall & Karen Morben | Household preferences for radical reductions of their direct and indirect greenhouse gas emission

Authors: Carlo Aall, Western Norway Research Institute, Karen Richardsen Moberg, Western Norway Research Institute

A number of studies comparing the development of production and consumption related GHG emissions reveal that many rich countries have experienced a reduction in production-related emissions whereas the opposite is the case for consumption related GHG emissions. Having a likely chance at keeping below 1.5°C warming implies that rich countries also need to address consumption related GHG emissions – including indirect emissions that originates outside of the territory of the country in question. This forms the background for the project "Household preferences for reducing greenhouse gas Emission in four European High Income Countries" (HOPE) that investigates household preferences for reducing GHG emissions in four countries (Norway, Sweden, Germany and France) and four medium sized cities (Bergen, Umeå, Mannheim and Communauté du Pays d`Aix). We have started the project by assessing to what extent current climate policies address direct or indirect household consumption related emissions. We have then asked 75-150 households in each city case to imagine they are forced to reduce their emissions by 50 per cent within 2030 – thus implying that reducing such emissions should be at least on par with the ambition level in current EU climate policies that are aiming primarily at production related and to some extent direct consumption related emissions. In this state of mind, we ask them to rank a number of pre-defined actions that would reduce emissions related to transportation, housing, food and other consumption until the household has managed to cut their emissions by 50 per cent. In collaboration with local and national decision-makers in each country, we develop proposals for amending and supplementing the current climate policy that might enable reductions in consumption related GHG emissions in accordance with the household preferences revealed in the city cases. We present the preliminary findings from our ongoing research.

Professor Nigel Arnell | Estimating global-scale impacts at 1.5°C using damage functions

Authors: Nigel Arnell (University of Reading), Jason Lowe (Met Office Hadley Centre), Rachel Warren (University of East Anglia)

Most assessments of the impacts of climate change use scenarios constructed from climate model simulations, most recently using the CMIP5 ensemble. However, even the lowest forcings in the CMIP5 ensemble result in an increase in temperature greater than 1.5oC by 2100. Until new climate model runs are available with low forcings, it is necessary to estimate impacts in a 1.5oC world using some means of

interpolation of existing model runs. This presentation will show the impacts across the global domain at a temperatures between 1.5 and 5oC above pre-industrial levels by 2100, for a range of sectors and considering a range of metrics of impact, including the risk of impacts exceeding specific thresholds. It is based on the use of damage functions, constructed by applying spatially-explicit impacts models with scaled CMIP5-generation climate model scenarios. The presentation will demonstrate how the difference in impacts between different levels of forcing varies between indicator (and region), making it difficult to generalise about the benefits of limiting the rise in temperature to 1.5oC. The presentation will also discuss methodological issues relating to the interpolation of model output to estimate impacts under low forcing pathways.

Dr. Richard Bailey

Sophie Blackburn | Deliberate transformation in a 1.5°C warming world: What are we aiming for?

Scholars working at the climate-development nexus have made increasingly urgent calls for a shift in focus for a 1.5 degree warming world. Beyond mitigation and incremental adaptation, what we need – they argue – is a fundamental transformation in social and society-environment relationships (Pelling 2010, O'Brien et al 2013, Pelling et al 2015). They argue transformation offers not only an escape from catastrophic outcomes of global environmental change, but an opportunity to renegotiate power relationships across scales and redraw current trends of global inequality, poverty and injustice. Whilst disasters scholars have already documented the role of extreme events in stimulating non-linear 'tipping points' in social-political systems (Pelling and Dill 2010), climate change literature has increasingly called for proactive or 'deliberate' transformation (O'Brien 2012). Embedded in both are normative visions of transformations that upset and reconfigure inequitable value systems, norms and power relations which produce vulnerability and poverty, permitting the emergence of more equitable, just and

empowering development trajectories. However here we face a stumbling block: what sort of deliberate transformation should the world be aiming for? Whose world is transformed, how, and who decides? Policy-makers (even those meaningfully engaged with the radical notion of deliberate transformation) currently face an empirical vacuum of evidence demonstrating exactly what 'good' or 'proper' transformation looks like, and how to 'do' it in practice. This paper explores this challenge, using a case study of post-tsunami transformation in the Andaman Islands (South India) to demonstrate the contradictions, complexities and opportunities of transformation in action. It documents the catalytic role of tsunami rehabilitation in stimulating local political engagement, activism and representation, yet at the same time counter-evidence of transformation at the individual and local scale. Given these challenges and uncertainties, the paper asks whether it is realistic, practical, or even desirable, to try and 'do' deliberate transformation?

Dr. Brenda Boardman | The cost of energy efficiency

More energy efficiency is a key component of the Paris Agreement, but what is the cost and whose money is it? There are many answers to this question, depending on the policy approach that is taken. For instance, some routes to greater energy efficiency can be at nil cost, to everyone, if backed by regulation and timing that fits with design cycles – that is the lesson from product policy. If the funding of new energy supply results in extra costs being passed on to consumers, then they are deprived of the expenditure they need to invest in their own properties – rising demand becomes an inevitable prophecy. To overcome the split incentive in rented properties, the property owner is more likely to invest in greater energy efficiency if it is perceived to increase the value of the property. What policies would link property value with greater energy efficiency? These lessons are clearest in the developed world, but have parallels in developing countries. The Chinese Government wanted its people to have a higher standard of living as a result of buying fridges. The only models available were energy-inefficient requiring excess new electricity supply to be built to supply this inefficient demand. The policy lessons are explored, so that high levels of energy efficiency can contribute both to improved standards of living while restricting the demand for energy supply and easing the way to compliance with global carbon targets.

Camilla Born | Impact politics: aligning the politics of climate action

Despite the vulnerable countries triumph in anchoring a 1.5C temperature target at the heart of the Paris Agreement, worsening climate impacts are being experienced today. Impacts are not linear, nor are they isolated from other compound risks. Those communities most exposed to increasingly interconnected and protracted global vulnerabilities – including inequality, urbanisation, demographic shifts, political instability and conflict – are predicted to experience the worst impacts of climate change. 1.5C cannot be seen as a safety net and communities everywhere must begin preparing and adapting to high-risk scenarios. The Paris Agreement sets a tall order: countries and communities must prioritise climate action to decarbonise their economies whilst dealing with climate impacts. The politics of climate action have to date been largely disconnected from lived-experience and often driven by science and duty. However it is unlikely this will be enough to secure climate resilience which requires deep and broad reform. In the coming years the experience of climate impacts will provide new inputs to the political debate. Over each 5 year cycle, the technologies and impact-driven demand for action will need to be harnessed to secure 1.5C compatible action. Aligning the politics of climate action will be essential to maintaining agency to build resilience in tandem with mitigation action.

Dr. Sally Brown | Adapting for sea-level rise at 1.5°C: A case study of the Maldives

Authors: Sally Brown, Matthew Wadey, Robert J Nicholls, Faculty of Engineering and the Environment, University of Southampton / Tyndall Centre for Climate Change Research; Maurice McCabe, University of Manchester; Ivan Haigh, Ocean and Earth Science, University of Southampton / Tyndall Centre for Climate Change Research

Small island developing states lobbied and were granted under the Paris Agreement, special consideration for climate change adaptation, even at 1.5°C. For the world's lowest lying nation, the Maldives (with a mean elevation of 1m above mean sea-level), adaptation to sea-level rise is required on a national scale. Even with successful climate change mitigation leading to the stabilisation of surface temperatures, sea-levels will keep on rising due to the commitment to sea-level rise. Hence, impacts are delayed, but not totally avoided. This increases the uncertainty of the magnitude of rise, but also provides valuable planning time to cope with impacts. The Maldives is undergoing rapid development, with large numbers of people migrating to the capital city. To relieve population pressure in the capital, a new artificial island, Hulhumalé, was built in the late 1990s with a mean elevation of 2m above mean sea-level. Using hindcast wave data with bathymetric and topographic measurements in an overtopping model, extreme water levels were analysed with incremental sea-level rise. Results indicated that the sooner a

1.5°C rise in mean sea-level rise occurs, the less likely the island is to experience periodic flooding. When a 1.5°C first occurs, the consequences of flooding could be reduced through local level adaptation. However, over longer timescales (e.g. > century) where temperatures may stabilise, but where sea-levels keep rising, larger-scale government led adaptation would be required. Given the large uncertainty in sea-level rise, incremental adaptation planning for Hulhumalé is advised. At a national scale, adaptation is complex due to cultural ties, legislation and wider development issues, and requires careful consideration and planning from the Maldivian government and international community. Climate change mitigation helps provide time to achieve this.

Dr. Peter Carter | An illustrated guide to the 1.5°C and 2°C policy target options

Authors: 1. Dr. Peter Carter, Climate Emergency Institute, Canada. 2. Paul Beckwith, Department of Geography, Environment and Geomatics, University of Ottawa, Canada

This poster presentation shows policy-relevant aspects of a global average surface temperature increase of 1.5°C and 2°C at 2100 and at equilibrium warming on environmental (human population) health, relying on the IPCC assessments. We provide (professionally rendered) graphs and charts of the following as a one-stop general resource:

- Comprehensive charts of impacts and risks at 1.5°C and above with adaptation (including oceans and the Arctic), sourced from the IPCC assessment. Risk of "runaway carbon dynamic" (IPCC 2001) is included as a hazard to all populations and ecosystems, with a chart of amplifying feedback sources. The fixed climate sensitivity with long duration of warming for risk on environmental population health is considered.
- Up-to-date recent annual global temperature increases by latitude and monthly increase maps compared to 1900, sourced from NASA GISS and NOAA (to July 2016).
- Temperature increases projected from updated aggregate national emissions targets (INDCs) for 2100 and equilibrium.
- IPCC AR5 crop model projections showing latitude yield changes correlated with global temperature increases from pre-industrial (food security under the UN convention).
- Risks to ecosystem services of projected global temperature increases from pre-industrial, to ecosystems

(with ocean ecosystems included) and to species (ecosystem safety under the UN convention).

- Risks of global temperature increase commitment to environmental population health, derived from the atmospheric CO2 equivalent and radiative forcing sourced from the IPCC AR5.
- The stringent range of the IPCC AR5 best-case scenario (RCP2.6) as the best (if not only) chance of the 1.5°C limit. This is the best mitigation and adaptation policy relevant response regarding disastrous to catastrophic impacts on large human populations and security of all future generations. Our presentation shows how time is of the essence for recommending this response.

Martin Chilcott | The power to drive sustainable business outcomes across complex value chains through digital collaboration platforms.

Authors: Martin Chilcott and 2degrees

The need for 'greater collaboration' is referenced as the primary call-to-action in response to tackling global sustainability challenges. We hear this from multilateral institutions, global corporations and industry groups. In response, and as digital collaboration experts, 2degrees are able to offer unique insight on how to make this call-to-action a reality, helping to build greater understanding among diverse audiences.

Context:

The greatest challenge that corporations face today is to survive and thrive in a time of unprecedented turbulent change. How can a population due to reach 9 billion people live well and sustainably on a single planet with finite natural resources, particularly when the challenges are exacerbated by climate change? Like many business leaders, we believe companies can only answer this challenge by adopting the principles of sustainable business and using them to transform the resilience and competitiveness of their value chain. Fortunately, most of the knowledge and capability needed to do this already exists, albeit isolated and hidden in pockets of best practice: in a supply-base, operations or amongst a businesses customers. What is required therefore, are new forms of collaboration that make the exceptional normal and so enable far greater economic efficiency, drive innovation, manage environmental and social risks, protect brands and create shared value. "It is time to take climate action to the next level. We need to accelerate the speed, scope and scale of our response, locally and globally… it is about solutions – innovation and imagination; collaboration and partnerships between the public and private sectors…" Ban Ki-moon, Secretary-General, United Nations. "We find the goal of a better life with a healthy planet to be an inspiring ambition. But navigating the necessary transitions will require extraordinary and unprecedented coordination, collaboration and leadership across all sectors of society." Ben van Beurden, CEO, Royal Dutch Shell plc.

Dr. Rachel Cleetus | Analyzing pathways to power sector deep decarbonization in the United States

Authors: Rachel Cleetus, Union of Concerned Scientists; Alison Bailie, Union of Concerned Scientists; Steve Clemmer, Union of Concerned Scientists

The power sector is the single biggest source of carbon emissions in the United States, responsible for 30 percent of total greenhouse gas emissions. Cutting these emissions is therefore critical to reaching net zero emissions by the middle of the century or before, in line with climate goals. Our research analyzes pathways to cut US power sector emissions by 90 percent or more by 2050, under different technology cost assumptions. We also show that the power sector can contribute to economy-wide reductions through increased electrification of many energy end-uses, including in the transportation, residential, commercial and industrial sectors. The insights from our analysis are broadly instructive for global decarbonisation efforts. In 2015, US energy-related carbon dioxide emissions were 12 percent below 2005 levels, driven in large part by a shift away from coal toward cheaper, lower carbon electricity generation resources like natural gas and renewable energy, along with increased energy efficiency. While this is an encouraging trend, the reality is that much deeper cuts in emissions are needed. Furthermore, an overreliance on natural gas poses significant challenges because it is still a fossil fuel that produces both carbon dioxide and methane emissions. Robust policies will be required to reduce emissions, accelerate the shift to zero and low carbon technologies, and encourage clean energy innovation. We model the impact of a carbon price as one effective way to drive these changes. Under a range of scenarios, we find renewable energy and energy efficiency to be the biggest contributors to decarbonization. Depending on technology cost and performance assumptions, natural gas with carbon capture and storage and nuclear power can also make a modest contribution. Emission reduction pathways with greater cumulative reductions provide additional space for other sectors to develop innovative solutions and our analysis helps identify conditions that support such reductions.

Mairi Dupar | Mainstreaming climate compatible development

Dr. Brenda Ekwurzel | Arctic relevance to the Paris agreement ambition of a 1.5°C world

Authors: B. Ekwurzel[1], R.M. Holmes[2], S. Pfirman[3], R. Pomerance[4], and P. Schlosser[5]. [1] Union of Concerned Scientists; [2] Woods Hole Research Center; [3] Barnard College, Columbia University; [4] Arctic 21; [5] Columbia University

One goal of this conference is to understand the impacts of the 2015 Paris Agreement to hold 'the increase in the global mean surface temperature (GMST) to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C.' However, a 2°C GMST above pre-industrial, would likely mean that Arctic temperature rises around 5°C GMST above pre-industrial (Collins et al., 2013). This temperature change would have major impacts on the Arctic system, which depends on ice. Even a 2°C GMST increase above the 1986-2005 period, could mean a nearly ice-free Arctic Ocean in September (Collins et al., 2013. Under the RCP 2.6 (~2°C GMST), the mean regional air temperature over the Greenland Ice Sheet is around 4 °C increase above 2000 level by 2100 (Fürst et al., 2015). The associated regional atmospheric warming and the oceanic warming are projected to contribute 2.4-6 cm sea level equivalent (s.l.e.) by 2100 from the Greenland ice sheet (Fürst et al., 2015). Further investigations are needed to reduce the uncertainties with the permafrost feedback into the carbon cycle but as high as ca. 100 Gt C cumulative emissions from Arctic permafrost is possible by 2100 with 2°C GMST above pre industrial (Schaefer et al., 2014). These Arctic changes will in turn impact global temperature, sea level, etc. Successful implementation of the Paris Agreement will not be sufficient to halt degradation of the Arctic cryosphere: we need to know the regional and global implications of a very different Arctic and what choices are available to society.

Dr. Luis Fernández | And justice for none? Social prospectives of an unavoidable future

Authors: Dr. Luis Fernández, Climate Change Research Programme, UNAM

Although the Paris Agreement strives to achieve a stabilization of temperature "well below 2 °C above preindustrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels", many scientists affirm this goal is simply not feasible and even go as far as affirming that we are already overdrawn. Even if there is still a small possibility of stabilization at 1.5C, our pledges are not enough. In this way, the Paris Agreement "hopes" to achieve what it cannot deliver: justice. Now, we are overdrawn and in the Paris Agreement, it is now established that Loss and Damage mechanism will never "involve or provide a basis for any liability or compensation". In conclusion, we are betting on a voluntary commitment by all nations, using an infeasible goal and providing no compensation mechanisms and no reference to human rights other than in the preamble with no legal force, to deliver a better future to all. Being

overdrawn warrants complete injustice for the most vulnerable and the least responsible. In the present we face an unfair world even if we do not consider climate change, as the migrant crisis in Europe shows. As such, it is very important that we start to ask what, where and how is this guaranteed unfairness going to be reflected? What are the mechanisms of social pressure that will likely be used for protest as a counterforce against the forces that made a 1.5 goal unfeasible? How will civil disobedience play out when reaching this grim scenario? In short, what are the implications and possible societal repercussions of a complete lack of distributive/compensatory/intergenerational injustice spread throughout the world? These and other questions will be explored in this presentationz

Dr. Rebecca Ford | Decarbonising Electricity Systems and Integrating Renewable Energy

Authors: Malcolm McCulloch, Sarah Darby, Rebecca Ford, Cameron Hepburn, John Rhys, Nick Eyre. All authors from the University of Oxford

Reaching a 1.5-degree target requires rapid deployment of renewable energy generation assets and the electrification of heat and transport. In many nations, wind and solar are of particular interest due to their abundant availability and declining costs. However, integrating renewable energy sources with high levels of variability presents four key challenges that must be overcome to transition to a 1.5-degree pathway. The first challenge results from the high capital but low operating expenses of wind and solar compared to traditional generation assets. This raises questions around how to incentivise investment in assets with short run marginal costs that increasingly approach zero, and how future markets should be structured to achieve this. The second challenge relates to the ability to provide power to end-users when and where it is needed. The engineering requirement to balance electricity networks at all points in time implies that demand side flexibility is needed to cope with the increased supply side variability of wind and solar. This could be provided by demand response, storage, and/or long distance interconnects, but the most effective combination is not yet understood. The third challenge stems from the electrification of heat and transport. This will increase energy and power constraints on the system, which need to be accounted for when incentivising effective investment and operation. Electrification of heat also introduces seasonal variability that current technologies and markets have not yet addressed. The final challenge is due to the increase of locally owned distributed energy resources. This will require greater engagement of actors traditionally viewed as passive consumers, and raises questions about how to manage networks and markets to cope with these additional agents. In this presentation we explore these challenges in greater detail, and identify a range of social, technical, market and regulatory implications for a 1.5-degree mitigation pathway.

Chris E. Forest

Dr. Jan S. Fuglestvedt

Dr. James Glynn | Bridging the gap between INDCs and Paris ambition

Authors: Professor Brian Ó Gallachóir - University College Cork; Professor Socrates Kypreos - Paul Scherrer Institute; Dr Franck LeCocq – CIRED; Dr Frédéric Ghersi - CIRED

Bottom Up (BU) techno-economic models often times give insights into the technical possibilities to Climate Change mitigation without representing the macroeconomic transition pathways with sufficient realism and feedback. Top down (TD) macroeconomic models give greater macroeconomic realism of the long term dynamics that drive the global energy system, but suffer from a lack of technical realism. What are the financial mechanisms required invest in radical infrastructure role out? What are the requirements upon the labour force for training and employment to implement the transition? What are the achievable rates of decarbonisation without driving the global economy into recession? This abstract outlines collaboration between CIRED and University College Cork which hybridises ETSAP-TIAM - a technology rich BU global energy systems model - with a reduced form 2 sector multi region macroeconomic (CIRED-KLEM) TD model. We explore the feedbacks to energy service demand and economic growth in a deeply decarbonising energy system under the perspective of new global macroeconomic reality of slower than expected growth, while aiming to move from INDC pledges towards 1.5C mitigation pathways. As with other analysis of Intended Nationally Determined Contributions (INDCs), such as the IPCC, IEA, UNEP, and PBL analyses, the hybridised results show the current pledges will not go far enough to reach a 2C or a 1.5C trajectory, only slowing the rate of increase of emissions from fossil fuel and industry BASE case, with long term uncertainty beyond 2030 actions. The INDC cumulative emissions far exceed the 2C budget of 1000 GtCO2 or 550 GtCO2 for 1.5C between 2020 – 2100 for greater than 50% chance of meeting the 1.5C target. This work points to the significant loss of consumption, regional inequity and regional economic losses between 0.5% GDP to 6% GDP. 1.8C is the lowest feasible temperature target in 2100 in this hybrid framework.

ABSTRACTS: POSTERS

Martin Haigh | A Better Life with a Healthy Planet, Pathways to Net-zero Emissions

"A Better Life with a Healthy Planet" is a supplement to the Shell New Lens Scenarios (NLS) published in 2013. Scenario-building is part of an ongoing process, used in Shell for more than 40 years to challenge executives' perspectives on the future business environment. We base them on plausible assumptions and quantification, and they are designed to stretch management to consider a wide range of outlooks, including events that may be only remotely possible.

The NLS scenarios – Mountains and Oceans – considered alternative ways influence in society could evolve and described different routes for the future evolution of the global energy system. Our latest work illustrates choices, challenges and ideas for society to decarbonise the global economy in a way that might address both the challenge of climate change and the desire for broader economic growth.

A Better Life with a Healthy Planet takes the most optimistic features of Shell's 2013 scenarios and combines them with individually plausible further shifts in policy, technology deployment, circumstances, and events that might move the world onto a new, even lower-emission trajectory, resulting in net-zero emissions on a timescale consistent with global aspirations.

Our work has led us to conclude that society's goal of providing the necessary energy to support the lives and livelihoods of a world nearing 10 billion people by the end of the century, in the context of net-zero CO2 emissions, is technically feasible. But it will be very challenging.

To achieve net-zero emissions requires the transformation of the entire global economy, especially in four foundational areas where a significant proportion of energy-related emissions of CO2 occurs: power, industry, transportation and buildings.

Successful and orderly energy transitions will require a combination of urgency and long term vision in policy making and leadership. Critically, sound policy must recognise environmental objectives but also economic development; encouraging a range of solutions to include both cleaner hydrocarbons as well as renewables.

Above all, success will require the active cooperation of millions of citizens, policymakers, civil society leaders, and businesses across the planet.

www.shell.com/scenarios

Edward Hanrahan | Opportunities for delivering climate and social impacts through integrated projects

Authors: Edward Hanrahan, CEO ClimateCare

With the new SDGs for the first time, the link between achieving sustainable development objectives and climate objectives has not only been acknowledged but brought centre stage. To all it should be clear: the one cannot be met without the other. ClimateCare is a certified B Corporation with over 19 years experience creating, securing finance for and delivering integrated Climate+Care programmes that cut carbon and improve lives. It has won numerous awards - including Best Project Developer Public Health for four consecutive years. Working with Governments and International Corporate partners it has cut 20.6 million tonnes of carbon and at the same time improved life for 16.5 million people. Edward will share his experience of what makes a successful climate and development project, the challenges, the role he feels these types of integrated project can play in meeting the 1.5 target.

Dr. Bill Hare | Impacts of climate change on conditions for human well-being and development: differences at 1.5°C and 2°C of warming

Authors: Tabea K. Lissner (Climate Analytics, Potsdam Institute for Climate Impact Research); C.-F. Schleussner (Climate Analytics, Potsdam Institute for Climate Impact Research); Serdeczny, O. (Climate Analytics); M. Schaeffer (Climate Analytics, Wageningen University); B. Hare (Climate Analytics, Potsdam Institute for Climate Impact Research)

Global datasets on biophysical impacts of climate change are becoming more and more detailed and sophisticated. Analyses of human impacts, however, are often conducted at local to regional scale and lack comparability. In addition, such bottom-up studies often insufficiently consider climate and impact signals and the uncertainty associated with model projections. As a result, global assessments of climate impacts on conditions for human well-being remain insufficiently explored, especially with regard to understanding the human implications of the 1.5° C temperature limit in the long-term temperature goal of the Paris

Agreement. In this contribution we apply the AHEAD Index (Adequate Human Livelihood conditions for Well-being and Development, Lissner et al. 2014, ESD) globally at a country scale. AHEAD provides an aggregate, quantitative measure of conditions for human well-being based on 16 components, conceptually rooted in influential approaches to measure human

well-being and livelihoods and applying a fuzzy logic algorithm. We show how changes in individual biophysical determinants of AHEAD affect overall AHEAD values at 1.5° and 2°, respectively, by exploring the effects of different levels of warming on both, the single components of AHEAD as well as on the aggregate index. Drawing on the full range of impact data available through the ISI-MIP (Inter-Sectoral Impact Model Intercomparison Project) archive, we also assess the relevance of uncertainties in the context of AHEAD. Our results provide a first step in understanding the relevance of the long-term global goals for overall human well-being. By including a range of determinants of both tangible as well as intangible resources, AHEAD also provides a way forward in addressing climate-related non-economic losses (NELs) and helping to guide the mobilisation of international climate finance for adaptation and loss and damage.

Dr. Karsten Haustein | Tracking progress to 1.5°C : an up-to-date index of human-induced warming

Dr. Nathan Hultman | Making Paris Work: Accelerating Ambition beyond 2025 through Improved Global INDC Practice

Authors: Nathan Hultman, Center for Global Sustainability, University of Maryland

The Paris Agreement present an unprecedented opportunity to address global energy, environment and development challenges with practical and robust solutions grounded in research and empirical analysis. Realizing the potential for transformational change will require development of new research approaches, capacity building, and network development to encourage maximum transparency and future ambition. The architecture in the Paris Agreement establishes a structure for nationally determined contributions and process for encouraging increasing ambition over time. The eventual success of this approach depends on national implementation of the INDCs and the global acceleration of decarbonization rates to historically high levels in the periods after 2030. The new cycle of national target setting and implementation requires analytical and institutional capacity to develop and evaluate INDCs. After an eventful 2014-2015 in which most countries had to develop a new system to generate national targets, there is now an opportunity for a review and analysis of what worked well, and what needs improvement, for future rounds of target-setting. In particular, discussions on how to construct a target as well as how to evaluate the stringency of targets internationally can help develop a set of good practices and conventions for this new field. I describe an integrated approach to generating and evaluating targets, including national circumstances, current government challenges and opportunities, mitigation potential by technology, costs, and normative considerations. In addition, I describe an approach to build global capacity in this area. Many countries have an interest in further developing their analytical capacity more systematically. This can be pursued in four dimensions: building their capacity within government, increasing the quality and scale of links to non-governmental research and analytical organizations domestically, supporting development of expertise within domestic institutions, and networking into a global community of practitioners and analysts.

Dr. Matthew Ives | Systems-based infrastructure modelling of options for pathways to 1.5°C in the UK

Authors: Ives, M., Thacker, S., Cao, Yue, Hall, J.

Meeting the demands of the UK's 2008 Climate Change Act and futher ambitions for meeting 1.5 degree goals will require much of the heavy lifting in GHG reductions will need to be undertaken by changes to our infrastructure systems, particularly the energy industry. The Infrastructure Transitions Research Consortium has developed a national scale systems-based infrastructure modelling capability that has been used in collaboration with the National Infrastructure Commission to assess alternative pathways for meeting UKs Climate Change goals. This work has shown there are a number of alternative paths that can reduce emissions from the infrastructure sectors by over 90%. However, there are significant costs involved in each pathway and implications involving interdependencies between the transport and energy and the energy and water systems.

Dr. Rachel James | What difference does half a degree make? A review of methods for modelling regional climate responses to global warming targets

Authors: Rachel James1,2*, Richard Washington2, Carl-Friedrich Schleussner3,4, Joeri Rogelj5,6, Declan Conway7. 1Environmental Change Institute, University of Oxford | 2Climate Research Lab, Oxford University Centre for the Environment | 3Climate Analytics | 4Potsdam Institute for Climate Impact Research | 5Energy Program, International Institute for Applied Systems Analysis | 6Institute for Atmospheric and Climate Science, ETH Zurich | 7Grantham Research Institute on Climate Change & the Environment, London School of Economics | *rachel.james@ouce.ox.ac.uk

A key issue for the IPCC 1.5°C Special Report is the difference between impacts at 1.5°C and 2°C. Until recently, there has been little attention to the methodological challenges associated with identifying regional climate signals at specific warming levels. This paper, in review for WIRES climate change, reviews alternative approaches for identifying regional climate signals associated with global temperature targets, and evaluates the extent to which they constitute a sound basis for impacts analysis and policy decisions. Four methods are outlined, including comparing data from different greenhouse gas scenarios, sub-selecting climate models based on global temperature response, pattern scaling, and extracting anomalies from transient experiments at the time of each global temperature increment. These methods have rarely been applied to compare 2°C with 1.5°C, but some demonstrate potential avenues for useful research, notwithstanding the methodological challenges associated with the use of existing climate model experiments, which are not generally designed to model the impact of specific temperature targets. Novel approaches are encouraged: to address the challenge of differentiating between half degree warming increments in the light of sources of uncertainty; to examine mechanisms of regional climate change including the potential for nonlinear responses; and to explore the relevance of time-lagged processes in the climate system and declining emissions, and the resulting sensitivity to alternative mitigation pathways. These represent important areas for enhanced research efforts, which could provide fundamental evidence for the upcoming special report on 1.5°C, and inform policy discussions.

Linda Johnson-Bell | Water or Wine? The Viability of Irrigation in Viticulture

Authors: LJ Johnson-Bell CEO / Founder, The Wine and Climate Change Institute (www.twacci.org) Associate, Global Climate Adaptation Partnership (www.climateadaptation.cc)

Climatologists love wine. The vitis vinifera is the crop most susceptible to changes in climate, and its harvest conditions and migration patterns serve as models for future climate scenarios. It is interesting then, that this thirsty $300 billion international industry and its water emergency has not come into sufficient focus. Swathed in historical and mythical cultural allegories, wine is protected from scrutiny in discussions of water competition: when in fact, there are regions (ex. South Australia) where local water licenses are allocated to wineries rather than to agricultural crops and livestock and where irrigation accounts for 99% of blue water use. For, when the vitis vinifera is grown outside its indigenous regions, irrigation is necessary. The Water Footprint Network reports that it takes 29 gallons (131 litres) of water for a glass of wine (comprising blue, green and grey). With more erratic harvest conditions existing within increasing temperatures (weather vs climate), the majority of the world's viticulturists are under threat from drought. And irrigation has become the accepted global adaptation technique, even while water prices are crippling and over-irrigation leads to soils too-heavily salinated to sustain any further agriculture. Irrigation is viticulture's number one adaptation ally, whilst it is mitigation's number one foe. Irrigating food crops is one thing, but should we re-examine irrigation use for this luxury crop and maintain wine grape production to more sustainable climates? This paper is concerned with investigating the comparative use of blue water (irrigation) amongst the principal wine regions and examines the outcomes of mitigating viticultural irrigation.

Dr. Mikiko Kainuma | Action plans for a low carbon and sustainable development in Asia

Authors: Mikiko Kainuma*, Rahul Pandey, Toshihiko Masui***, Shuzo Nishioka*, Shinichiro Fujimori***. * Institute for Global Environmental Strategies; ** IGSA Labs; *** National Institute for Environmental Studies**

World leaders agreed to pursue efforts to limit the average global temperature increase to 1.5 oC above preindustrial levels. For this purpose, realization of a low carbon and sustainable development in Asia is imperative where greenhouse gas emissions (GHG) are expected to be about half of the global emissions in 2050 in the business as usual scenario and major efforts are required for sustainable development. Collaborating with researchers in different Asian countries, the Asia-Pacific Integrated Model (AIM) team has developed various regional, national and local scale scenarios of GHG emissions and options to mitigate them. These scenarios have offered valuable insights for a Low Carbon Society (LCS) policy design and implementation. Early mitigation actions are a necessity in all Asian countries to avoid high carbon lock-in from long-life energy technologies. However, at the same time, domestic developmental priorities in individual countries, such as poverty eradication, cutting local pollution, achieving energy and water security, are crucial. Therefore, a pragmatic strategy in early periods is to take actions within overriding domestic and sector level goals of a nation. GHG mitigation actions aligned within the agenda of domestic and sector level developmental objectives in the short run could seamlessly yield to integrated, cross-sector and drastic actions within explicit and mainstreamed LCS agenda in the medium- and long- run. AIM team has contributed to developing LCS scenarios in Asia through capacity building over twenty years. Some action plans by AIM have already been implemented in several cities such as Kyoto (Japan) and Iskandar (Malaysia). They emphasize several efficiency improvement measures and behavioral changes in end-use sectors of residential, commercial, transportation and industry as well as renewable energy options. These activities could enhance science and policy linkages and provide feasible pathways to a LCS.

Professor David Kanter | Pathways to Nitrogen's Planetary Boundary – and the Implications for a 1.5°C World

Authors: David R. Kanter - Department of Environmental Studies, New York University; Jeffrey D. Sachs - The Earth Institute, Columbia University

Nitrous oxide (N2O) is the largest remaining threat to the ozone layer and the third most important greenhouse gas, responsible for 6% of global greenhouse gas emissions. Consequently, efforts to limit global mean temperature increases to 1.5 degrees need to include strategies for reducing non-CO2 greenhouse gases such as N2O. N2O is also a key component of nitrogen pollution, an issue that contributes to a suite of environmental impacts – from air and water pollution to biodiversity loss – and one of two planetary boundaries that humanity has exceeded. Nevertheless, it has yet to garner the attention from the policy community that it deserves. Moreover, emerging calls for a coordinated international response to nitrogen pollution need to be reconciled with the reality that solutions, particularly in the agricultural sector, are often locally specific. This is the goal of the new "Pathways to Nitrogen's Planetary Boundary" project (PNPB): disaggregating nitrogen's planetary boundary into several regional boundaries, and developing pathways to reach these boundaries using regionally-tailored nitrogen use efficiency strategies. This new form of regional integrated assessment aims to provide a roadmap for policy-makers to better address nitrogen pollution. The regional teams (East Asia, South Asia, East Africa, Eastern Europe, Latin America and North America) have already been formed as part of the International Nitrogen Management System initiative. Their focus on improving understanding of regional nitrogen flows is a crucial first step for developing the regional boundaries and pathways. PNPB would provide a forum for sharing methods, tools, data, and results among the teams, and ultimately aggregate the pathways to determine the extent to which they meet nitrogen's planetary boundary. This project is central to translating emerging nitrogen science into actionable policy recommendations, thereby increasing the likelihood of staying below 1.5 degrees given N2O's climate impacts.

Dr. Jasmin Kemper | The role of carbon capture and storage technologies in a carbon-constrained world

Authors: Jasmin Kemper, IEAGHG; Tim Dixon, IEAGHG; John Gale, IEAGHG

The aim of this presentation is to review the role of carbon capture and storage (CCS) technologies in climate change mitigation scenarios and, in particular, what implications a 1.5°C scenario, as warranted by COP21, will have for these technologies. Most of these scenarios cannot achieve a 2°C or lower target without including CCS. The discussion will focus on two special, highly relevant topics relevant to CCS pathways: (1) negative emission technologies (NETs) and (2) the 'unburnable carbon' concept. In current mitigation scenarios which are based upon integrated assessment models (IAMs), e.g. in reports by the IPCC, IEA and others, one NET already figures very prominently as it can result in net removal of CO2 from the atmosphere: bioenergy in combination with CCS (Bio-CCS or BECCS). This presentation will discuss the status of CCS and Bio-CCS, including their feasibility and current deployment, and address the related challenges and opportunities, e.g. the food-water-energy-climate nexus of bioenergy. Another topic that is subject to intensive research and discussion is the 'unburnable carbon' concept, i.e. the global carbon budget in emission scenarios for climate change mitigation implies that a certain amount of fossil fuel reserves should not be used and their resulting greenhouse gases not emitted to the atmosphere. As CCS is a technology that prevents or reduces the emissions of CO2 to the atmosphere, it has the potential to enable use of fossil fuels in carbon-constrained scenarios. This presentation will thus review recent publications on this topic, some of which concluded that CCS technologies have a material impact on 'unburnable carbon.'

Tim Kruger | Negative Emissions – Distilling the Hope from the Hype

Authors: Tim Kruger, Oxford Martin School, University of Oxford

Mitigation is not enough. While it is necessary – indeed essential – to rapidly reduce emissions of greenhouse gases, it is not sufficient. Achieving the ambition of the Paris Agreement will require not only steep reductions in emissions of greenhouse gases, but also the removal of carbon dioxide from the atmosphere. That is the conclusion reached by the IPCC in its Fifth Assessment Report and is reflected in the models that climate negotiators used in Paris late last year. Almost all the scenarios that restrict the rise in global mean temperatures to between 1.5°C and 2°C require the deployment of technologies that currently do not exist. We simply do not know whether such proposed techniques could be deployed at the scale required in a way that is technically possible, environmentally sound and socially acceptable. This talk will seek to distil the hope from the hype – exploring what we know and what we do not know – about negative emissions. It will also map out what work we would need to undertake to fully understand what potential negative emissions techniques may have and what the implications would be if the reality of such techniques does not conform with the ambition assumed in the models.

ABSTRACTS: POSTERS

Professor David Lee | Aviation in a temperature constrained world

Authors: Lee D. S (MMU) et al.

Aviation emissions are projected to grow strongly over the next decades with only a small possibility to mitigate CO2 emissions through improved technology and operations. Alternative lower-C fuels may contribute, but these are as yet not available in sufficient quantities and depend on other market issues. Market-based measures are being negotiated at the international level, but the success and reductions will be modest for total global aviation. So, how much of a slice of the 1.5 degree CO2 emissions can aviation be expected to have? We explore this issue against a baseline of the latest projections and mitigation measures as discussed by ICAO.

Penehuro Lefale | The Paris Agreement's 1.5°C target: Observations from Tokelau

Authors: P.F.Lefale1, P. Faiva1, C. Anderson2, F. Tauafiafi1 and H. J. Diamond3

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Climate change threatens the sustainability of Tokelau. Reducing and managing the risks of climate change are critical to ensuring the future viability of Tokelau as a nation. Tokelau faces a future that is dependent on the actions of other governments, especially the actions of those in developed countries which are also the biggest greenhouse gas emitters. The Paris Agreement is considered by Tokelau as the most realistic step by the international community towards stabilising greenhouse gas emissions at a level that would mitigate dangerous interference with the climate system. One of the outcomes of the Paris Agreement was the call for Parties to hold "the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change." The inclusion of the 1.5°C target was a surprise to many in the scientific community. Not only does it go against latest scientific understanding of climate change (as documented in the IPCC AR5), but it puts the onus on the scientific community to review and assess whether that goal is even possible as well as to assess what the impacts of such a global warming goal of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways might be. This paper will explore some options on how to possibly achieve the 1.5°C target and evaluate the possible consequences of these options from Tokelau's perspective.

Professor Jason Lowe | Uncertainty in global carbon budgets, overshooting and the challenge of limiting warming to 1.5°C above pre-industrial levels.

Authors: J A Lowe(1), D Bernie(1), A Gambhir(2), A Wiltshire(1), S Smith(3) and C Huntingford(4). 1=Met Office; 2=Imperial College London; 3=Committee on climate change; 4=CEH

The cumulative global anthropogenic carbon emissions compatible with 1.5C of global average near surface warming above pre-industrial level remains uncertain. A major source of uncertainty comes from not being able to precisely quantify the value of the transient climate response (TCR). Low values of TCR correspond with higher allowable carbon budgets for 1.5C, whereas high TCR values limit the global carbon budget too smaller values. Using different estimates of the uncertainty distribution of TCR leads to different median carbon budget estimates and, importantly from a risk assessment perspective, different spreads in the allowable carbon budget. A second major source of uncertainty comes from the additional climate forcing that is expected to result from a range of Earth system processes, such as additional carbon released by thawing permafrost. At present many of these processes are omitted from the most complex modelling studies. Here we show how these uncertainties could combine to affect the scale of the challenge to limit warming to below 1.5C. Many current emission pathways produced by integrated assessment models that aim to limit warming to low temperatures in 2100 rely on a temporary overshoot of the atmospheric CO2 concentration and of the near surface temperature above both present-day and the 2100 target values. We look at the viability of overshoots of different sizes based on our understanding from general circulation models and show that it is necessary to combine this with our findings on allowable carbon budget uncertainty in order to optimise the 21st century response if the lowest temperature targets are to be reached. This research builds on activities in AVOID2, EU Ampere and a project for the Committee on Climate Change.

Dr. Yuge Ma | Enabling Opportunity Spaces for Transformation towards Sustainability in Global Megacities: Comparative evidence from Shanghai and Istanbul

Authors: Thomas F. Thornton; Diana Mangalagiu, Yuge Ma,

Dina Hestad, School of Geography and the Environment, Environmental Change Institute, University of Oxford.

Cities account for about 75% of global energy consumption and up to 80% of global anthropogenic emissions (Hoornweg et al. 2011). While thousands of cities across the world are undertaking climate action plans, these are not always designed and implemented in synergy with other policy goals, both in the developed and developing world. At the same time, city governments around the world are forming new networks to join forces to advance sustainability, while remaining sensitive to cultural and place values. These cities can play an important role in climate action strategies. GREEN-WIN, a European Union Horizon 2020 project, seeks to discover opportunities for societal development while avoiding dangerous climate change can be realised. Major emphasis is placed on urban transformation, which holds the promise of highest impact in reducing carbon emissions (mitigation) and effecting sustainable responses (adaptation) to the effects of anthropogenic climate change in large, growing cities. Opportunities for adaptation can be found in locating and aligning cultural models of human – environment relations within evolving knowledge systems and communities of practice in enabling environments within what we term adaptation opportunity spaces. These spaces include especially critical urban systems which are currently unsustainable, but show capacity for innovation towards adaptation. In this paper we focus on the fast-growing housing and urban renewal sector in Istanbul, Turkey and the mobility sector in Shanghai, China. We identify key cultural orientations toward sustainability and climate change, emerging knowledge systems, and communities of practice in each sector, and assess the enabling environment (bottom-up and top-down) for adaptive transformation towards sustainability. The analytical framework is further evaluated for general analysis of urban transformation against UNFCCC targets for limiting anthropogenic climate change.

Douglas MacMartin | Meeting 1.5°C using a portfolio of options: reducing carbon emissions, negative carbon emissions, and solar geoengineering?

Authors: Douglas MacMartin, Cornell University; Katherine Ricke, Cornell University; Richard Millar, Oxford University; Jane Long, EDF

Most proposed pathways for meeting even a 2C global mean temperature target rely on some "negative emissions" technology. However, no such approach has yet been demonstrated at sufficient scale, and thus the maximum potential remains unclear. Negative emissions approaches will be even more essential in meeting a 1.5C target, either with or without temperature overshoot. We explicitly separate and decouple the rate of decarbonization from assumed negative emissions in existing mitigation pathways. Given the climate change risks if targets are exceeded, combined with uncertainty on whether targets can be met through mitigation alone, solar geoengineering could also be considered as an additional element of a comprehensive strategy for managing risk. We evaluate trade-offs between these three different elements of a strategic portfolio, including the associated implications on the amount and duration of geoengineering that would be required as a function of different choices on the rate of decarbonization, and different assumptions on future availability of negative emissions technology. The former strongly influences the peak overshoot (or maximum solar geoengineering to maintain 1.5C), while the latter strongly influences the duration of the overshoot. Including solar geoengineering as part of the portfolio of options may increase the ability to achieve 1.5C, but the risks of geoengineering would need to be evaluated against the risks of climate change without geoengineering.

Krishna Malakar | Making the Indian marine fishing community climate ready: Assessing adaptation and its determinants

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Climate change is projected to adversely impact marine fishing livelihoods. Multiple environmental and human-induced stressors such as extreme weather events and pollution also contribute to its vulnerability. Adaptation to changes is pertinent for sustaining livelihoods of coastal fishing communities. In this paper, an empirical assessment of the levels of adaptation in the coastal states of India has been done. Adaptation in the form of using motorized and mechanized boats, and Global Positioning System (GPS) is highly desirable. Additionally, adopting safety equipments during fishing trips is of paramount importance. Differences in implementation of adaptation strategies in the coastal states have been evaluated using statistical analyses: Mann-Whitney U test and Theil index. Further, the determinants of adoption of these strategies have been identified and analyzed through Akaike Information Criterion and ordinary least squares regression. According to Sustainable Livelihoods Approach, capitals, namely human, physical, natural, economic and social can influence adaptive capacity. Hence, proxies of these capitals have been assessed for their influence on levels of adaptation in the marine fishing sector in India. The analysis consists of data on 71 coastal districts collected from the Marine Fisheries

Census 2010. It is observed that the levels of adoption of different strategies among the districts are quite unequal. Again, since the vulnerability of the east and west coast to extreme weather events differs, they also differ in their adaptation levels. It is found that mostly human, social and economic capital dictate adaptation in Indian marine fishing. Human capital like access to education, and social and economic capital like access to fishing cooperatives can induce adaptation. Such assessments of adaptation levels and their drivers can be helpful in understanding the barriers to adaptation. Consequently, this can assist in enhancing the adaptive capacity of the community and planning adequate livelihood interventions, in preparation of 1.5°C warming.

Dr. Philippe Marbaix | Exploring the role of baseline scenarios from the SRES, AR5, and post-AR5 era in assessing very ambitious mitigation targets.

Authors: Philippe Marbaix, Université catholique de Louvain, Georges Lemaître Centre for Earth and Climate Research, Belgium; Andrew Ferrone, Department of Environmental Research and Innovation, Luxembourg Institute of Science and Technology (LIST), Luxembourg; Jean-Pascal van Ypersele, Université catholique de Louvain (Georges Lemaître Centre for Earth and Climate Research), Belgium

Baseline scenarios are future projections for the anthropogenic drivers of climate change in the absence of explicit climate policy. Baselines are important for most scenario analysis, as the feasibility, costs, and possible risks involved in reaching a mitigation goal (such as 2.0 or 1.5 °C above pre-industrial) may strongly depend on these references. IPCC AR4 (2007) described baseline scenarios as generally falling into one of the following categories: 1) continuation of present-day trends and behaviour, 2) a set of comprehensively different assumptions (storylines), and 3) probabilistic approaches. Scenarios from the IPCC SRES (2000) report are based on storylines, and were widely used including in AR5 (2014). For AR5, Working Group III relied on a new database of scenarios. In this database, baselines appear broadly consistent with a continuation of recent trends, although a subgroup includes improvement in the energy intensity of economic output. However, at the same time, a new set of alternative assumptions was developed under the name "Shared Socio-economic Pathways" (O'Neill et al. 2013, Climatic Change). Socio-economic and emission data corresponding to these SSPs were developed and made available for public review in 2015 (by IIASA). Here we compare the main features of scenarios from these databases using a new analysis tool (allowing e.g. scenario selection based on criteria). Preliminary results suggest that AR5 baseline scenarios cover a range extending more towards high emissions than the SRES, but less towards low emissions. In particular, the differences between SRES and AR5 baselines do not appear to come from differences in the world final energy consumption, but the development of non-biomass renewable energies differ between these databases. Having explored the differences between scenarios developed over almost 20 years, we discuss the potential links between these different baselines and the achievability and challenges of very ambitious mitigation targets such as 1.5°C.

Dr. Ben Matthews | An interactive model for exploring options and uncertainties influencing pathways towards a 1.5°C goal.

Authors Dr Ben J. H. Matthews

Scenario analysts interpret the 1.5C UNFCCC goal as aspiring to lower the global temperature after a higher peak, aiming to reduce specific impacts such as sea-level rise from melting icecaps, ecosystem losses, etc. Without a common agreement regarding specific impacts to avoid, or the extent of overshooting, the range of interpretations is broader than for <2C scenarios. Modeling challenging low scenarios requires diverse options. While models focused on energy supply technologies suggest negative emissions, considering demand-side lifestyle and planning changes opens other pathways. Land use change, minor gases and aerosols, and international transport become more important. Any shared vision including changing lifestyles must also consider equitable access to sustainable development.

The interactive integrated assessment model JCM helps compare thousands of 1.5C pathways. An iterative inverse approach, calculating a range of policy options consistent with defined temperature pathways, helps distinguish differing interpretations of the goal, from uncertainties about society and climate systems.

Since its application in 2003 to the first probabilistic analysis of <2C scenarios, JCM is being updated, combining insights from other models and scenarios (including new SSPs). Parameters influencing demography, economy, energy preferences, equitable sharing policies, land use change, minor gases and aerosols, and uncertainties in carbon cycle and climate system response, are systematically varied.

Combining these in spaghetti plots, shaded bands, or probability statistics is not the best way to communicate insights. An interactive model enables stakeholders to explore the relative sensitivity to many factors and distinguish scientific uncertainties, from flexibility in policy options. Choosing goals implies balancing impacts and effort across regions, generations, diverse sectors, and risk level (likely vs extreme outcomes). Such integration requires complex models, but includes value judgements which should be transparent. Interactive tools provide an interface to the ultimate integrated assessment model which remains the global network of human heads.

ABSTRACTS: POSTERS

Professor Jim McAdam | The response of a small island state to 1.5°C climate change – the example of the Falkland Islands

Authors: Professor Jim McAdam OBE, Agri Food Biosciences Institute and Queens University of Belfast; Michael Poole, Member of Legislative Assembly, Falkland Islands Government (Environment Portfolio); Nicholas Rendall, Environmental Planning Department, Falkland Islands Government

Small oceanic islands are particularly vulnerable to climate change given their isolation, biodiversity and self reliance. Climate change predictions for the Falkland Islands (12,000km2 , 52°S pop 2,800) are for 1.3-2.2°C increase in temperature over the next 100 years. The islands have the highest proportion of peat cover in any of the UK Overseas Territories and given the dry (400-800mm), windy climate and shallow soil cover, are susceptible to erosion and loss of soil carbon. They have a small population density, important biodiversity and a sustainably managed fishery. The Falkland Islands Government (FIG) has supported an EU project to determine the potential impact of and risk associated with a temperature increase in the order of 1.5°C. Following extensive public consultation, key risks identified were: changes in soil moisture and drying; changes to invasive plants, pests and diseases; plants unable to shift ranges; increased fire risk; changes in soil organic carbon; changes in yield and quality of forage species planted. Scientific evidence was accumulated, reviewed and presented to FIG to inform Government in its willingness to demonstrate a sound evidence base to identify risk and underpin policy. FIG will now consider the evidence base from a risk analysis to formulate policy. The islands already invest heavily in renewable energy technologies, nationally over 50% of energy is generated from wind and all renewable resources (wind ,sun, rainfall) are mapped for incorporation into business plans for individual settlements to select best possible options. We propose that the Falkland Islands are an exemplar of climate change risk assessment and potential adoption into a government policy which is underpinned by the best scientific evidence available to mitigate impacts across a range of scenarios. Even though it is a small country, the Falklands is recognising its glo

Dr. Dann Mitchell | Realizing the impacts of a 1.5 °C warmer world

Authors: Daniel Mitchell(a), Rachel James(a), Piers M. Forster(b), Richard A. Betts(c,d), Hideo Shiogama(e) and Myles Allen(a)

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Impacts of a global warming of 1.5oC will be dominated, in many regions, by changing risks of extreme weather events exceeding critical thresholds (e.g. for human health). Relatively small ensembles of coupled model integrations, as requested by CMIP, are primarily suited to the assessment of expected changes in mean climate, not weather extremes. To quantify these changes, both high atmospheric resolution and large initial-condition ensembles are required. Here we present the methodology of the Half a degree of Additional warming; Projections, Prognosis and Impacts (HAPPI; www.happimip.org) project, which allows for such an experimental design. One of the issues of impacts in a 1.5-degree world is that of signal-to-noise. The attribution community has been using large ensembles to deal with these sorts of problems for over a decade, and their methodology is directly applied to this climate projection problem. To directly address impact differences between a 1.5 and 2-degree world, climate modellers have run large ensembles (>50 members) of 10-year periods for recent observed and 1.5°C and 2°C warmer worlds, using projected changes in sea surface temperatures drawn from existing coupled model simulations. The use of 10-year time slices allows for the assessment of long-lived extreme events, such as droughts, while still allowing for large ensembles. The use of >50 ensemble members of a 10-year analysis period allows for statements to be made regarding policy-relevant return times such as 50-100 years. The resultant probabilistic assessment of climate allows for any clear and tangible differences to be detected between small changes in global temperature. This analysis, built on the HAPPI framework, begins with work on the attribution of human health metrics to past climate, then focuses on applying these methods to changes in human habitable zones under 1.5 degree and 2 degree warming scenarios.

Robert Mostyn | A methodology of citizen empowerment: how resource accountability can be automated and used to inform consumers on sustainable lifestyles.

Authors: Robert Mostyn (independent), Dr. Justus von Giebler (Wuppertal Institute)

The myEcoCost consortium has developed a proof-of-concept software module between 2012 and 2015 that effectively accounts for resources exploited at each stage in a product's life cycle. The accounting includes all inputs and outputs and can be used to provide meaningful indicators to all economic actors. In particular, individual consumers! In this paper we explain how automated, resource accounting can be used to address the data quality issue currently hindering effective business and policy

decision making. And in doing so, inform individuals to what degree they are leading a sustainable lifestyle using the Material Footprint. The approach includes a gamification element to entice people to engage with the measurement, with self-determined goals and timelines. You will see how modern technology can be used to inform of one's sustainable lifestyle as easily as reading a watch. Such information could influence consumer behavior and in doing so, dramatically accelerate humanity's opportunity to adapt lifestyles, and therefore social consumption, to sustainable levels, that could limit our global warming to 1.5 degrees.

Maliha Muzammil | The Political Economy of Low Carbon Climate Resilient Development in Least Developed Countries

Scenarios and Policy Researcher for the CGIAR Research Programme on Climate Change, Agriculture and Food Security (CCAFS) at the Environmental Change Institute, University of Oxford. Also a doctoral student at SOAS, University of London. My research examines the opportunities and barriers for low carbon, climate resilient pathways in least developed countries using a political economy approach. The research aims to identify the co-benefits of linking adaptation and mitigation strategies and trade-offs that low carbon, climate resilient development trajectories will bring for Bangladesh, the case study country.

The presentation will discuss if it is it possible to achieve a 1.5°C target whilst also meeting Least Developed Countries' (LDC) development objectives by implementing the three main policy agendas of low carbon, climate resilient development (LCCRD): adaptation, mitigation and development simultaneously through integrated policy processes. The presentation will explore the many socio-political-economic factors driving integrated policy processes in LDCs in recent times, and the benefits and trade-offs associated with such processes with a focus on Bangladesh. Case studies on LCCRD from Bangladesh will include the Solar Home System (SHS) and Solar Irrigation Pumps (SIP) Programmes and will discuss if such initiatives can feed into the broader country targets of emission reduction adhering to their INDCs.

Professor Mark New | The biophysical and human consequences in semi-arid hot-spots at 1.5°C and 2.0 °C of global warming

Authors: Mark New, African Climate and Development Initiative, University of Cape Town Modathir Zaroug, African Climate and Development Initiative, University of Cape Town; Jagdish Krishnaswamy, Ashoka Trust for Research in Ecology and the Environment , India Milind Bunyan, Ashoka Trust for Research in Ecology and the Environment, India; Fahad Saeed, Sustainable Development Policy Institute, Pakistan Chris Jack, Climate System Analysis Group, University of Cape Town; Piotr Wolski, Climate System Analysis Group, University of Cape Town

Semi-arid regions (SARs) of the sub-tropics and tropics are widely considered to be hot-spots of climate change risk. They combine two key features of risk: high exposure, being hot and dry, coupled with high interannual rainfall variability; and large numbers of highly vulnerable people. Climate model projections indicate SARs will warm faster than the global average, and will generally receive reduced rainfall.

Consequently, SARs might experience significant differential impacts between 1.5 and 2.0 degrees of global warming. We build on previous assessments of exposure and vulnerability to climate change across SARs of Africa and Asia in the CARIAA Research Programme, to assess the differential effects of impacts-relevant climate indices under 1.5 and 2.0 degrees of global warming, using a combination of CMIP5 and CORDEX global and regional model ensembles. We show that there are statistically significant differences in the projected frequency of heat extremes critical to human and animal health across nearly all areas in each SAR. We do not detect widespread significant differences in drought intensity, duration and frequency, because of high pre-existing background variability, and fairly large differences between ensemble members; however, the data suggest a trend towards increased intensity and duration of drought. Our results suggest that there will be differences in potential biophysical and human impact of climate change in SARs between 1.5 and 2.0 degrees of global warming. However, the realisation of these impacts depends on the effectiveness of measures to reduce vulnerability. Evidence from our research in SARs suggests that structural drivers of existing vulnerability will be need to be removed to avoid widespread human impacts at both 1.5 and 2.0 degrees of global warming.

Dr. Friederike Otto | Historical responsibility for the impacts of a warming world at 1.5°C

Authors: Friederike E.L. Otto(1), Ragnhild B. Skeie(2), Jan S. Fuglestvedt(2), Terje K. Berntsen(2), Myles R. Allen(1). (1) Environmental Change Institute (ECI), University of Oxford, Oxford, UK. (2) Center for International Climate and Environmental Research Oslo (CICERO), Norway.

It is well-established which regions of the world are responsible for the largest share of historical greenhouse gas emissions. While the actual numbers and uncertainty margins in estimated climate responses of these emissions change depending on decisions of, for example, how to include emissions from trading or whether or not to include aerosols, the magnitude, mix and timing of emission determine the historic contribution to global mean average temperature increase. However, the impacts of this temperature increase on society today and in a 1.5-degree

world will be dominated by extreme weather events. We propose two different methodologies of estimating individual region contributions on historic extreme weather events and thus assigning historical responsibility of the major economic regions of the world by combining the methodologies of extreme event attribution and accounting for historic emissions. In particular we highlight the assumptions leading to the largest differences in attributable historic responsibility. Demonstrating that apart from the decision on the start date of emissions counting towards a historic responsibility share (e.g. the whole industrial period vs. the last decades since anthropogenic climate change was recognised in the first IPCC reports) necessarily ambiguous methodological decisions and the exact definition of an extreme event are crucial. With this work we show for the first time exemplarily whether and to what extend quantitative scientific evidence is available to objectively discuss questions of climate justice not necessarily in the context of liability and compensation which has been explicitly excluded from the Paris agreement but in particular with respect to recognition and reconciliation. Looking forward these methods can also be applied to assess how commitments made, e.g., in INDCs alter the share of responsibility for individual classes of extreme events.

Emilie Parry | Time to Look Beyond the Development Model? Alternative Approaches for Catalyzing Climate Change Action & Innovation in Asia

The 2015 Sustainable Development Goals (SDGs) include wide-ranging mandates for action on climate change and its impacts. It is encouraging to see the siloed walls of the development field become more porous and comprehensive. Nevertheless, this urgent context of interconnected global complexities necessitates creative innovation to address the many facets of climate change. It is vital to explore other ways of doing, knowing and relating around climate action, outside of the existing international development paradigm. In this paper, I deconstruct and challenge the notion of development and growth as an acceptable vehicle for addressing climate change or community wellbeing and sustainability. I examine alternative Asian models for building climate change action and resilience with shifting values to define new parameters of climate sensitive markets, communities, food- and eco-systems. The paper explores strategies to catalyze behaviour change, and approaches to leveraging scale of impact without formulaic top-down replication. A key to igniting a global level of appropriate and sustainably effective climate change mitigation and adaptation may reside within lessons from E.F. Schumacher's Burmese-inspired "Small is Beautiful"—from the region and communities where his ideas were first born and nurtured.

Valentino Piana | Implementing Paris: which more ambitious Nationally Determined Contributions can promote innovation in the transport system with sufficient urgency to contribute to 1.5°C-consistent global greenhouse gas emission pathways

Authors Valentino Piana, Director of the Economics Web Institute

Transport emissions and their rising trend are key obstacles to very rapid decarbonisation scenarios. Urgently reversing trend is necessary (Rogelj et al., 2015) and the Paris Agreement (PA) established the architecture to ratchet up action. This paper bridges UNFCCC processes, including PA, and cutting-edge socio-economic-institutional research on transport sector and specifically on electric mobility, which may represent a wild card, if propelled by national and international policies and especially when powered by renewable energies. Pathways of short- to mid-term drastic reduction in global emissions are generated and made dependent on discrete policy events, whose tracking constitutes a significant part of the PA implementation (art. 4, 6, 13). The paper proceeds as follows: first, it reviews literature on electric mobility and low carbon transport since AR5 (WGIII), highlights key drivers and success factors, delivers a list of potential statements to be inserted in future Nationally Determined Contributions (art. 4, 6), transport-related NAMAs, and NAZCA pledges. Then a taxonomy of PA countries is proposed, based on current and perspective INDC, energy mix, transport sector features, and electric mobility constraints. The attribution of each country to a cell in the taxonomy generates quantitative values for the effects of the statements. We identify how international supporting mechanisms (art. 6, 9, 10, 11, 12) can build upon such matrices of countries / statements, with synergetic and transformational effects. By attributing a certain probability to inclusion in future waves of NDCs, leveraging NAMAs and NAZCA pledges, we compute aggregate emissions pathways, embedded in open-source computer code that can be used to track how the scenario is getting real or quickly becomes unattainable. All this will be summarised in formats helpful for global stocktaking (art. 14) and facilitative dialogue among Parties in 2018 (FCCC/CP/2015/10/Add.1, point 20). The methodology can be applied to further sectors beyond transport.

Yann Quilcaille | Analysis of the IPCC AR5 transformation pathways with a new compact Earth system model

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For the IPCC AR5, a large quantity of emission scenarios was collected from integrated modelling teams. The climate impacts of these transformation pathways were estimated with a single model named MAGICC (AR5 WG3 Chapter 6). This reduced-form model is calibrated on CMIP3 and C4MIP models. It was shown to produce consistent climate projections when concentration-driven (AR5 WG1 Chapter 12). However, its carbon-cycle – and therefore its ability to be emission-driven – was shown slightly biased (AR5 WG1 Chapter 6). A large fraction of non-CO2 forcings – as expected in low-carbon scenarios – also makes its projections span a narrower range than that of complex models (AR5 WG1 Chapter 12). Here, we use a new Earth system model to analyze the AR5 WG3 transformation pathways. OSCAR v2.2 (Gasser et al., 2016; see also Li et al., 2016), is calibrated on the latest complex models intercomparison exercises (CMIP5, TRENDY, ACCMIP, CCMVal2, WETCHIMP). It features a more advanced carbon-cycle representation, its atmospheric module covers the wide range of results in non-CO2 modeling by complex models, and it includes more interactions and feedbacks than most existing Earth system models.

Our analysis aims at detecting and understanding the cause of any systematic bias induced by using only one reduced-form model. We compare the two assessments of the transformation pathways, especially the trajectories towards 1.5 or 2°C of global warming. Ultimately, the use of two compact Earth system models, instead of a single one, will help the analysis of socio-economic scenarios to gain in reliability, and will therefore improve the next IPCC special report on the 1.5°C target.

Morien Rees | Raising awareness of the existence of climate change will have little effect if there is no creation of processes for social and behavioural change. How can the museums sector contribute?

195 countries have committed themselves to pursuing the 1,5 degree scenario, investors are circling fossil free technology, polls point to a growing awareness of the challenges of climate change, fewer disputing the facts. We all know, all we need to know about climate challenges. Yet despite the clamour around the Paris conference, it appears life goes on more or less unchanged for most of us. This is a conundrum. And while perceived political inertia together with the vested interests of the fossil fuel companies are important factors, this presentation has a different focus: It concentrates on the general public and the role of museums in attempting to resolve the conundrum. Museums are equipped with tools that suggest they are capable of contributing to the task of activating the public. Museums are perceived as being an impartial actor in society, guardians of the truth. Museums can also claim to transcend boundaries in both space and time and have established successful patterns of international cooperation - an essential requisite in the task of meeting the challenges of the global nature of climate change. Museums erase borders in other ways, between disciplines within museums, in research and dissemination projects, between museums and other sectors of society; a precondition for successfully dissimilating the complex nature of the problems in climate change. The presentation investigates Dr Juan Salazar's proposition that museums should focus on the differences between information about, and the communication of, the challenges of climate change. Salazar maintains that raising awareness of the existence of climate change will have little effect if there is no creation of processes for social and behavioural change. He suggests moving beyond the notion of informing visitors (vertical flow of messages) to engage with communicating with visitors (horizontal process of dialogue and participation), thereby leading to action.

Dr. Katharine Ricke | The dynamics of temperature target overshoot

Authors: Katharine Ricke, Cornell University; Richard Millar, University of Oxford; Doug MacMartin, California Institute of Technology

As the climate science and policy communities begin to assess the feasibility and benefits of a 1.5°C or 2°C temperature target, understanding the implications of potential limits on sustainable decarbonization and carbon dioxide (CO2) removal rates for the chances of avoiding temperature overshoots will be an important contribution of the scientific community. Drawing upon results from the mitigation literature and the IPCC Working Group 3 (WG3) scenario database, we examine the global mean temperature implications of independent pathways for the decarbonization of energy supply and for the capture of atmospheric CO2 (negative emissions). We find that within the range of decarbonization and negative emissions futures considered by WG3, the most ambitious rates of decarbonization and deployment of negative emissions technologies are required for a 50% chance to avoid an overshoot of 1.5°C altogether. The magnitude of temperature overshoot is primarily determined by the rate of decarbonization, but limiting the duration of overshoot to less than two centuries requires ambitious deployment of both decarbonization and negative emissions technology.

ABSTRACTS: POSTERS

Ruksana Haque Rimi | Impacts of 1.5°C Global Warming on Changing Risks of Extreme Weather Events in South Asia, Bangladesh

Authors: - Ruksana Haque Rimi, DPhil Candidate, Environmental Change Institute, Oxford University Centre for the Environment; Dr Karsten Haustein, Postdoctoral Researcher, Environmental Change Institute, Oxford University Centre for the Environment; Emily Barbour, Researcher, Member of the Oxford Water Network, Member of the Climate Systems and Policy research cluster; Professor Myles R. Allen, Professor of Geosystem Science in the School of Geography and the Environment, Leader, Climate Research Programme in the Department of Physics

The Paris agreement of 2015, on "Holding the increase in the global average temperature to well below 2°Cabove pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C", needs strong support from research on the nature, benefits and feasibility of a 1.5 degree world. While assessing both risks and vulnerabilities to incremental increases in global mean temperature, the regional differentiation is very important. For instance, highly unusual heat extremes would affect around 15% of land area in South Asia under 1.5°C and around 20% of land area under 2°C warming. The increase in heavy monsoon rainfall intensity for South Asia is projected to be 7% under 1.5°C and 10% under 2°C warming. Here, populations largely depend on the stability of the monsoon, which provides water resources for the agricultural production. Disturbances to the monsoon system and rising peak temperatures put water and food resources at severe risk. A small South Asian country, Bangladesh is potentially a hotspot of impacts as it is vulnerable to a combination of increasing challenges from extraordinary temperatures, extreme river floods, more intense tropical cyclones, and rising sea levels. The changing risks of extreme weather events in many regions, is likely to be dominated by impacts of a global warming of 1.5°C, and the impacts avoided by stabilising temperatures at 1.5 instead of 2°C. To quantify these changes, both relatively high atmospheric resolution and large initial-condition ensembles are required. With the support from HAPPI project, this study will conduct experiments specifically designed to quantify the relative risks associated with 1.5°C and 2°C of warming, focusing on extreme weather and the relative risks of low-probability extreme weather events for Bangladesh. Finding from this study is expected to quantify the implications of the Paris Agreement of 2015, particularly for this highly climate vulnerable region.

Niklas Roming | How can the Green Climate Fund trigger a global energy system transformation? The potential multiplier effect of steering banks' portfolios towards 1.5°C compatible investment pathways

Authors: Bianka Kretschmer, Niklas Roming, Fabio Sferra, Felix Fallasch, Carl-Friedrich Schleussner, Climate Analytics

The implementation of the Paris Agreement requires a rapid global decarbonisation of the world's energy system. Given the long lifetime of energy assets, today's investment decisions will have a strong impact on future emissions and risk locking-in a high carbon path incompatible with the 1.5°C temperature limit in the Paris Agreement. The GCF (Green Climate Fund) is an important instrument to promote low carbon investments. However current and projected governments contributions to the GCF are not sufficient to directly leverage the energy transition towards 1.5°C. Commercial banks and key actors in the financial system need to be engaged in steering away investments from fossil fuels towards low-carbon technologies. Three such banks have recently been accredited to the GCF. As partner institutions of the GCF, these banks are expected to shift their overall investment portfolios towards low carbon technologies to be in line with the climate fund's envisioned paradigm shift. Our research explores the relevance and potential of these large commercial banks to align their investment portfolios with the 1.5°C temperature target in the context of the GCF's mandate to promote transformational change. We provide benchmark pathways for global investments into coal under a 1.5°C temperature target and apply the constraint of these benchmark pathways to the three banks' portfolios. Result are presented on how these portfolios will have to evolve to be in line with 1.5°C compatible investment pathways. For this task, we draw from Integrated Assessment Models' scenarios to assess investment benchmark portfolios under a 1.5°C target at the individual bank level. We show that if the GCF Board indeed would be successful in implementing a policy framework to induce change in its partner institutions' investment structure, this could make a significant contribution towards a transformational change well beyond the Fund's own investment capacities into climate change projects.

Tara Schmidt | Global Energy Outlook to 2035: can we accelerate current trends toward a 1.5°C world?

Picture this: a world powered on zero-carbon energy. Solar and wind become the most competitive energy sources, everywhere. Everyone powers their homes, businesses and industries with renewables, while transport goes electric. The energy companies that thrive are the ones that went green… back in 2016. Is it completely unfathomable? Today zero-carbon energy sources are already competing against fossil fuels, with substantial opportunity for growth. Despite coal and oil prices being at multi-year lows, over half of global power capacity additions in 2015 came from wind, solar, hydro and nuclear. And in December, the UN Climate Conference delivered a global climate accord – hailed as a "historic turning point" by COP21 President Laurent Fabius. Although carbon-cutting targets are nowhere even near the agreed 2C goal, many energy companies expect progressively stringent policy to stimulate more investment into renewables and energy storage. While renewables continues to grow, the fossil fuel industry is facing more challenging times ahead. Over the next 15 years, Wood Mackenzie forecasts demand growth for coal and oil demand to slow to just half of what it is today, with significant downside risks. Increasing pressure from governments, investors and fossil fuels divestments could further dampen demand. And the risk of 'lower-for-longer' prices is mounting. Consequently, there is a risk energy prices will not fully recover any time soon (if ever). Never before has there been more of an impetus for the world's largest energy companies to focus on low carbon energy and clean energy technologies. In our presentation, Wood Mackenzie will look at how these trends could be accelerated for a 1.5C world - comparing our forecasts to 2035 with BP, ExxonMobil and the International Energy Agency.

Tobias Schultz | The Climate Stabilization Council

Authors: Tobias Schultz, SCS Global Services; Stan Rhodes, SCS Global Services

The climate impacts already occurring makes clear the urgency of stabilizing the global climate immediately, preventing temperatures from passing 1.2°C in the next few years, and buying critical time to keep temperatures below 1.5°C in the long run. Exciting, practical and cost effective project options for solving this problem are currently available. These projects are based on protocols developed from the updated science in the IPCC Fifth Assessment Report, which are in the process of standardization through the American National Standards Institute and the International Organization for Standards. Among the projects that could be deployed in the next 10 years are: Projects to combat atmospheric brown clouds in developing countries, methane abatement projects, technologies to enhance the natural cooling cycles linked to marine clouds, and technologies to enhance the natural venting of Earth radiation into space. The mission of the Climate Stabilization Council is to promote a platform to implement projects that can immediately slow global warming and stabilize the global temperature below +1.5°C. By using the most updated climate science and advanced life cycle assessment protocols, the Climate Stabilization Council will: research and evaluate the ability of projects to achieve climate stability, launch working groups to develop implementation protocols for these projects, providing required best practice guidance and a mechanism to verify project's ability to achieve the stated stability goals, and connect potential funders with project proponents. Leading climate scientists have already agreed to help inform and develop protocols to ensure the scientific credibility of each project. The Climate Stabilization Council ensures a science-based roadmap to achieve 1.5°C climate stability.

Fabio Sferra | Towards optimal 1.5°C emission pathways for individual countries: a UK case study

Authors: Fabio Sferra (Climate Analytics), Mario Krapp (Climate Analytics), Niklas Roming (Climate Analytics) , Michiel Schaeffer (Climate Analytics), Marcia Rocha (Climate Analytics), Bill Hare (Climate Analytics)

IAMs (Integrated Assessment Models) play a crucial role in assessing mitigation options and key characteristics of long-term mitigation pathways under the IPCC Working Group III. IAMs determine optimal energy mix and emission pathways consistent with a temperature limit, while minimising global costs. For individual countries, however, a key limitation of IAMs, being computational expensive, is their limited regional resolution, which focuses on 10-20 main regional aggregates. The goal of this paper is to downscale the results of IAMs at the country level by using a simplified model: SIAMESE (Simplified Integrated Assessment Model with Energy System Emulator) with the aim of providing useful insights for policy makers to consider cost-effective mitigation options. SIAMESE compares well with IAMs on the regional level and its simplicity allows for a reasonable downscaling to individual countries within a specific region. Because Siamese is essentially a reduced-complexity IAM its application to downscale regional results is more sophisticated than simple downscaling according to socio-economic indicators, such as GDP, and preserves more of the key indicators of national energy-system structure. Like other IAMs, SIAMESE employs a welfare-maximisation approach to determine optimal emission pathways. A Negishi-Weighting procedure ensures an optimal

allocation of energy resources among all the countries. With SIAMESE we analyse the implications of a 1.5°C global warming limit, as referenced in the Paris Agreement, for the United Kingdom. We show that CO2 emissions from the energy sector would need to decline rapidly and estimate the time emissions would need to reach zero, as well as when individual primary energy carriers would need to be phased out, in particular coal and oil. This paper argues that the current level of ambition of UK's emission target for 2050 would need to be enhanced if it were to be aligned with least-cost reduction strategies consistent with an optimal 1.5C pathway.

Alison Smith | Co-benefits of climate mitigation action for development objectives

Authors: Alison Smith (University of Oxford, Environmental Change Institute) and Alison Pridmore (Aether).

Strong international co-operation will be essential to achieve the 1.5°C target, and this will involve engaging with countries that have different motives and capacities for climate action. The IPCC's 5th Assessment Report highlighted that many actions to control greenhouse gases not only reduce climate change impacts, but also affect the achievement of other development objectives, such as those relating to air quality, energy security and food security. Stronger climate mitigation action to meet the 1.5°C target could have significant positive impacts on these other goals, providing a powerful additional motive for climate action, but could also exacerbate certain negative impacts. Increased understanding of these co-benefits and adverse side effects is thus vital. This paper explores the outcomes of a four month scoping study on the co-benefits and possible adverse side-effects of climate mitigation, focusing on the evidence related to China, India, Indonesia, Brazil, the Middle East and Africa. Key priorities and concerns for these regions are identified, with the research being placed in the context of the INDCs. For example, in China the evidence base currently focuses on air quality co-benefits, driven by severe urban pollution. For India and South Africa, energy security is also a major concern. In Brazil and Indonesia, land use change and associated mechanisms to reduce deforestation currently dominate the literature. Research gaps and next steps are then identified. These include: development of improved tools and indicators to ensure that co benefits can be included in decision-making; incorporating co-benefits into climate finance mechanisms where appropriate; developing case studies at the city level; and using dissemination networks to raise awareness of the extent of co-benefits offered. These measures can help to ensure that countries can fully exploit the opportunities for synergies between climate mitigation, climate adaptation and the achievement of longer term sustainable development goals.

Dr. Ana Solorzano | Can social protection increase resilience to climate change? A case study of the CCT Oportunidades programme in rural Yucatan, Mexico

This presentation will examine the linkages between social protection and resilience to climate change among poor rural households. To date there is a very limited understanding of the potential role of social protection programmes in contributing to an increase in resilience of the rural poor with respect to climate change. An improved understanding of these links can help to build the knowledge base that is needed to help the poorest members of the society to adapt to the impacts of climate change. This gap in understanding is addressed in this presentation through a case study of the conditional cash transfer programme Oportunidades in two rural communities in Yucatan, Mexico, a region highly exposed to hurricanes and droughts. Qualitative and quantitative data were collected by means of household surveys, life-history interviews, key informant interviews, group discussions and participant observation. The research found that the main role of Oportunidades is to provide a regular and predictable safety net that protects households from short-term risk, thus increasing households' coping capacity. The impact on the adaptive

capacity of households is indirect and differentiated according to their respective poverty profiles. Furthermore, the research shows that certain features of the theory of change of Oportunidades, and its design, reduce the potential impact of the programme, creating trade-offs between coping and adaptive capacities. The research concludes by making a case for social protection to be complemented by other interventions in a systemic approach that should explicitly consider climate change, in order to increase resilience and achieve sustainable poverty reduction.

Peter Stevenson | The role of food and farming in meeting the 1.5°C target

Studies show that our diets alone – with their high levels of meat and dairy consumption – will take us over the 1.5°C target. Indeed on a business-as-usual basis agriculture's emissions are set to increase. Emissions from agriculture can only be reduced by a 50% decrease in food waste and a move to healthy diets which in many (but not all) parts of the world involves substantial reductions in meat and dairy consumption. In West Europe this would involve a 60% and 23% decrease in meat and milk consumption respectively. The decrease in East Europe would be lower: a 45% and 4% reduction in meat and milk consumption respectively. Halving the consumption of meat, dairy products and eggs in the EU would achieve a 19–42% reduction in GHG emissions. Governments are apprehensive about this issue.

However, studies with focus groups indicate a general belief that it is the role of government to spearhead efforts to address unsustainable consumption of meat and that Governments overestimate the risk of public backlash. A reduction in meat and dairy consumption would deliver co-benefits regarding food security, the state of natural resources (e.g. soil, water and biodiversity) human health and animal welfare.

Professor Fubao Sun | Changes in climatic extremes and possible consequence to human and economic system of China

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In the 2015 Paris Agreement, "to limit the temperature increase to 1.5°C above pre-industrial levels" becomes one effort to be pursued. Therefore it is vital to evaluate possible consequences to human and economic system if the temperature increases to 1.5 °C regionally. In this study, we will evaluate possible changes in climatic, hydrological extremes and possible consequence to human and economic system of China based on cmip5 climate models, long term historical observations. In this presentation, we will introduce a proposal for assessing risk of human-economic system under global climate change, that is to initiate soon and continue for five years in China. The risk is defined as the interaction of physical hazards and the vulnerability of exposed elements. The research plan and some recent progress investigating the climate change risk of human-economic system in China presented in this study will help understand the regional case of China when the temperature increases to 1.5 °C above pre-industrial levels.

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Professor Jozef Syktus | Comparing the impacts of mitigated versus non-mitigated scenarios on heat stress in tropical regions

Projected changes in temperature and humidity over the course of the 21st century will contribute to increased heat stress on human populations living in many tropical and sub-tropical regions. Heat stress, arising from a combination of high temperature and humidity, directly impacts human health and wellbeing. Here, we evaluate the impact of different climate scenarios, based on the Representative Concentration Pathways (RCPs), on heat stress conditions during the 21st century in tropical and sub-tropical regions using the Wet-Bulb Globe Temperature (WBGT) heat stress index. The projected changes in WBGT were combined with projected changes in human population to derive the spatial and temporal extent of changes in exposure to heat stress during this century. We found that, by 2100 under the high-emission RCP8.5 scenario, there are unprecedented increases in the number of extreme heat stress conditions ("black flag days"), with parts of West Africa, Central America, the Indian sub-continent and maritime southeast Asia experiencing over 300 days per year of extreme heat stress. Under the moderate RCP2.6 scenario, the number of black flag days by 2100 is significantly lower compared with RCP8.5, with a magnitude and distribution similar to RCP8.5 at 2050. The population exposed to extreme heat increased more than eightfold over current levels by 2100 for RCP8.5 under the high population growth scenario in tropical and subtropical regions of Asia and Africa. Under the RCP2.6 scenario, there was a substantial reduction in population exposure in Central and South America and Africa compared with RCP8.5. However, in Asia there was still more than a four-fold increase over current levels at 2100. These projected changes in population to heat stress pose a significant risk to human wellbeing and workforce productivity during the 21st century.

Kiyoshi Takahashi | Comparing risks for aiming at 1.5°C, 2.0°C and 2.5°C targets with climate uncertainties

Authors: Seita Emori, Kiyoshi Takahashi, Yoshiki Yamagata (National Institute for Environmental Studies), Shinjiro Kanae (Tokyo Institute of Technology), Shunsuke Mori (Tokyo University of Science), Yuko Fujigaki (University of Tokyo) and ICA-RUS project members

We have assessed risk-management implications of setting 1.5, 2.0 or 2.5 degree targets at about 50% probability. Process based impact models for multiple sectors are used for future projections of impacts based on climate scenarios from selected 5 CMIP5 models, 4 RCP levels and 3 socio-economic scenarios. Results are interpolated according to global mean temperatures to estimate impacts for each target. Sectors covered are agriculture, terrestrial ecosystem, water resources, floods, health, marine bio-geochemical cycles and ecosystem (17 variables in total). The results show that the difference in impacts between any two targets is generally smaller than that between any target and BaU and also than the range of impacts caused by climate uncertainty. Therefore, from the impact perspective, making progress toward a target without fail and dealing with climate uncertainties are more important than the choice of target. Note, however, that a more comprehensive assessment could alter this finding. Especially, probability of crossing certain threshold temperature could be very different for different target. We have also assessed the portfolios of mitigation options and associated

economic impacts for achieving emission pathway for each target, employing multiple integrated assessment models. Within the scope of this study, impacts are generally less sensitive to a change in target than mitigation costs, which might support a less ambitious target, if one focuses on globally aggregated economic values. Further work is needed to quantify impacts in monetary terms to complete a cost-benefit analysis. Note, however, that using a global scale cost-benefit analysis is a choice itself, reflecting value judgments. In the study, we have also found that setting 2.0 and 2.5 degree targets at about 80% probability, as more risk-averse strategies, roughly translates into setting 1.5 and 2.0 targets at about 50%, respectively.

Kit Vaughan

Martha-Marie Vogel | Amplification of land versus global temperature increase controlled by soil moisture feedbacks

Authors Martha-Marie Vogel, René Orth, Zürich and Sonia I. Seneviratne, Institute for Atmospheric and Climate Science, ETH Zürich, Switzerland

Temperatures on land will increase by more than 1.5°C, even if the global temperature increase with respect to pre-industrial levels can be limited to 1.5°C. This difference between land versus global mean temperatures is even more pronounced in the case of extreme hot temperatures (Seneviratne et al. 2016). Land-atmosphere interactions contribute to the development of these extremes. To improve the understanding of the role of soil moisture-temperature feedbacks for extreme temperatures we analyse global climate model experiments with soil moisture fixed to present-day levels and compare them with fully coupled simulations. We find that soil moisture is an essential control of the additional warming over land, and in the case of hot extremes. In particular in central Europe the additional future warming of extreme temperatures can be largely explained by a long-term soil moisture drying.

Seneviratne, S.I. et al., 2016. Allowable CO2 emissions based on regional and impact-related climate targets. Nature, 1870, pp.1–7

Dr. Gernot Wagner | Tipping elements, tipping points, and economic catastrophes: Pathways for integrated assessment

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Key Points:

- Potential thresholds in climatic and social systems play an important role in estimates of climate damages.
- 'Tipping points' as broadly understood involve positive feedbacks and abrupt change, but not all climatic thresholds cause abrupt change.
- Some possible climate-influenced economic catastrophes involve tipping points, but not all do.

The literature on the costs of climate change often draws a link between climatic 'tipping points' and economic catastrophes. The use of the phrase 'tipping point' in this context is less restrictive than in popular and social scientific discourse. Whereas 'tipping points' generally involve abrupt changes, for some climatic ones, the commitment to a change may occur abruptly, but the change itself may take centuries or longer to realize. Additionally, the connection between climatic 'tipping points' and economic losses is tenuous, though emerging empirical and process-model-based tools provide pathways for investigating it. We propose terminology to distinguish 'tipping points' in the sense popularized by Gladwell from climatic 'tipping elements' (in the sense introduced by Lenton and colleagues), as well as from economic catastrophes. We illustrate our proposed distinction by surveying the literature on climatic tipping elements, climatically-sensitive social tipping points, and economic catastrophes, and we propose a research agenda for investigating all three.

Dr. Rachel Warren

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Abstract: This new analysis quantifies the benefits of mitigation for climatic change induced range loss for biodiversity globally. It extends a previous analysis, which indicated that 60% of range losses could be avoided by constraining warming to 2C above pre-industrial levels compared to a baseline without climate change mitigation. The new analysis, which incorporates 80,000 species globally at a resolution of 20x20km, shows the additional benefits of constraining warming to 1.5C, but warns that these will only be realised if mitigation to 1.5C is achieved with careful attention to land management, since extensive biofuel cropping

could result in large scale habitat loss and deforestation.

Dr. Brian Walsh | Algal feedstock as the key to ambitious climate targets

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Net carbon sinks capable of avoiding dangerous perturbation of the climate system and preventing ocean acidification have been identified, but they are likely to be limited by resource constraints. Land scarcity already creates tension between food security and bioenergy production, and this competition will intensify as populations and the effects of climate change expand. Despite research into microalgae as a next generation energy source, the land-sparing consequences of alternative sources of livestock feed have been overlooked. Here we use the FeliX model to quantify emissions pathways when microalgae is used as a feedstock to free up to 2 billion hectares of land currently used for pasture and feed crops. Forest plantations established on these areas can conceivably meet 50 % of global primary energy demand, resulting in emissions mitigation from the energy and LULUC sectors of up to 544 ± 107 PgC by 2100. Further emissions reductions from carbon capture and sequestration (CCS) technology can reduce global atmospheric carbon concentrations close to preindustrial levels by the end of the present century, well below the levels necessary to limit warming below 1.5C. Though previously thought unattainable, carbon sinks and climate change mitigation of this magnitude are well within the bounds of technological feasibility.