Using wavelet analyses on water level time series to detect glacial influence in mountain hydro systems

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INTRODUCTION:
- Determining the glacial influence of streams is of critical importance to evaluate potential impact of glacier retreat on water quality and aquatic biota.
- Worldwide, glacial runoff exhibits repeated cyclic fluctuations at the daily time-scale during the ablation period.
- We proposed a new method based on wavelet analyses on water level time series to determine the glacial influence in mountain hydro systems.
- We applied our method at 15 stream sites in two glacierized catchments, in the tropical Andes (Ecuador).

METHODS:
- The local wavelet power spectrum gives the magnitude of the variance in the series at a given scale and location time => permit to detect diurnal variation (glacial signal).
- The scale average wavelet power spectrum at 24-h scale permits to visualize the fluctuation of the diurnal flow variation power throughout the year.
- To compare quantitatively the glacial influence among all stream sites we defined three metrics:
  - The diurnal variation power: integration of the scale-averaged wavelet power curve corrected by the 95% confidence level
  - The diurnal variation frequency: frequency of days with significant diurnal flow variations in the time series
  - The diurnal variation temporal clustering: number of hydrological state changes (days with and without significant diurnal flow variation) divided by the total number of days in the time series minus one

RESULTS:
- Glacier-fed streams presented a significant power at the 24h scale corresponding to the daily glacial flood (B).
- Diurnal flow variations occurred continuously between January and May while seldom significant after May (C).
- We found no significant diurnal flow variation in sites with no glacier cover in their catchments (E & F).
- The diurnal variation power was significantly positively correlated with the percentage of glacier cover in the catchment.
- One site presented high diurnal variation power although no glacier cover in its catchment: Detection of glacial meltwater resurgence
- High frequency (>0.45) => diurnal flow variations were significant about half of the year
- High temporal clustering (>0.85) => glacial floods were clustered

CONCLUSION:
Our method based on wavelet analyses on water level time series permits to:
- Identify glacial influence at any stream sites (diurnal flow variation)
- Identify seasonal pattern of the diurnal flow variation
- Compare quantitatively glacial influence among streams sites (power, frequency and temporal clustering)
- Detect glacial meltwater reemergence

Using long time series, our method could also be very useful to track climate change impact on hydro systems draining glacierized catchments.