Precipitation variability in the Peruvian Andes under future climatic conditions – Assessment and implications

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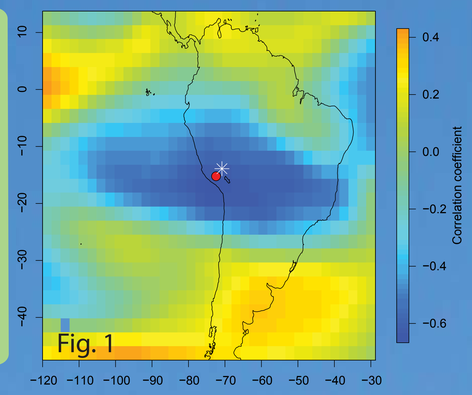
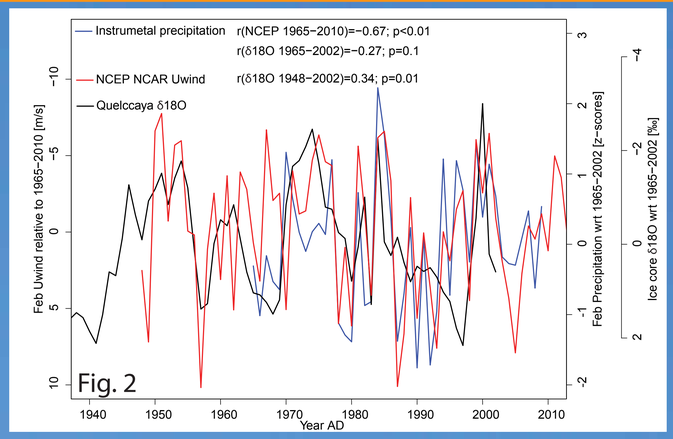
1 Introduction

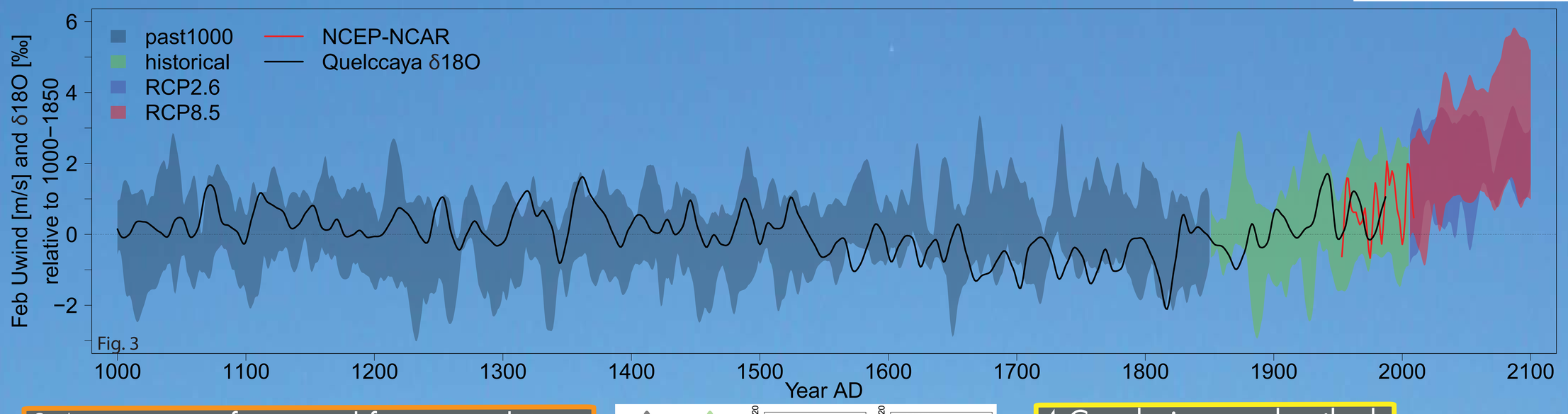
In the high Andes, agriculture but also other economic sectors such as hydropower production, strongly depend on water availability, and are therefore sensitive to changes in future precipitation regimes. Recent work suggests that the zonal flow in the mid- to upper troposphere is the best large-scale predictor for summer rainfall over the altiplano (e.g. Ref. 1). The enhanced westerly flow identified in many simulations of future climate is therefore interpreted to result in drier conditions on the altiplano. Here,we provide a first assessment of the relationship between summer precipitation in the south-eastern Peruvian altiplano, 200mbar zonal wind and oxygen isotope ratios in a nearby ice core in a multi-centennial context using new CMIP5 model simulations.



2 Observational data

We use a composite of three instrumental precipitation stations from south-eastern Peru (red circle in **Fig. 1**, data standardized over 1965-2010 before averaging). In summer (Feb), this record shows a clear negative relationship to 200mbar zonal wind strength (Uwind; NCEP-NCAR reanalysis): Spatial correlations over 1965-2010 are indicated by shading colors in Fig. 1. **Fig. 2** shows a time series comparison using average Uwind in the domain 68°-73°W / 15°-20°S. Oxygen isotope ratios (δ18O) recorded in the Quelccaya ice core covering the years AD 470-2002 (white asterisk in Fig. 1; Ref. 2) are related to both precipitation and zonal wind (Fig. 2; δ18O and Uwind are inverted).

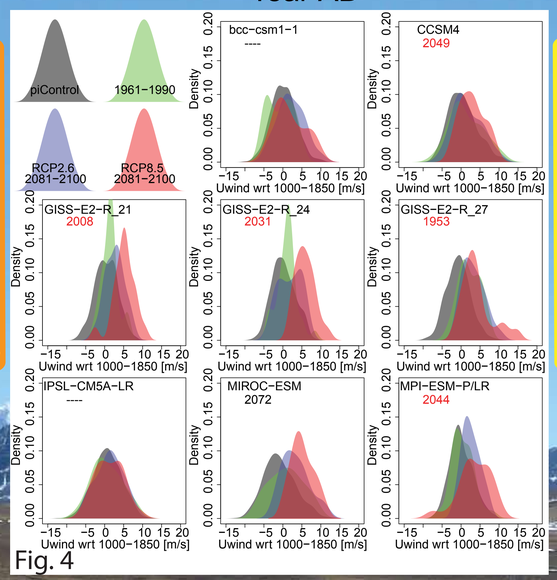




3 Assessment of past and future conditions

Fig. 3 shows the evolution of zonal wind strength, averaged over the area 68°-73°W / 15°-20°S as simulated by GCMs over the period AD 1000-2100. The shaded areas enclose the 5th-95th percentiles over the 8 CMIP5 simulations available over this period. The figure represents 30-year loess filtered data. NCEP-NCAR time series shown in red and δ18O values from Quelccaya in black.

Fig. 4 shows the distribution of unfiltered historical (1961-1990) and RCP2.6 and 8.5 scenario (2081-2100) zonal wind, compared to the pre-industrial control simulation for each model run. The numbers at the top-left of each panel indicate the year, after which 30-year filtered zonal wind continuously exceeds natural variability (control-run, 90% bounds) in the RCP8.5 scenarios (values <2050 in red; – means no exceedance).



4 Conclusions and outlook

- Most of the available model simulations suggest an increase of westerly flow at 200mb. Assuming a linear relationship, the median increase of 2.9 m/s between 1981-2000 and 2081-2100 in the strongest warming scenario (RCP8.5) represents a decreaese of approximately 17% in precipitation at the study sites.

- 5 out of 8 models project that decadal-scale zonal wind speed over the altiplano will exceed the levels of natural variability before 2050 (RCP8.5), stressing the necessity for implementing adaptation already in the near future.

- The simulations are able to capture the decadal-scale variabilty and the 20th-century increase of Quelccaya δ18O values. In contrast, the long-term δ18O-decrease in the pre-industrial period is not captured by the simulations.

- Further assessments of instrumental, paleoclimate and model data are required to better understand the mechanisms and teleconnections driving precipitation variability in the Peruvian altiplano.

References:
(1) Minvielle, M. and Garreaud, R. D. (2011). Projecting Rainfall Changes over the South American Altiplano. Journal of Climate 24 (17): 4577-4583.
(2) Thompson, L., *et al.* (2006). Abrupt tropical climate change: past and present. Proceedings of the National Academy of Sciences 103 (28).

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