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Surface studies of water isotopes in Antarctica for quantitative interpretation of deep ice core data

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Polar ice cores are unique climate archives. Indeed, most polar ice cores have a continuous stratigraphy and present high temporal resolution of many climate variables in a single archive. While water isotopic records (dD or d18O) in ice cores are often taken as reference for past atmospheric temperature variations, they are also associated with a large uncertainty in the quantification of past temperature changes. Several reasons are invoked to explain the limit of such an approach; in particular, post-deposition effects are especially important in East-Antarctica because of the low accumulation rate there. The strong influence of post-deposition processes highlight the need for surface polar programs in addition to deep drilling programs.
We present here new results on water isotopes from several recent surface programs, mostly over East Antarctica. Together with previously published data, the new data presented in this study have several implications for the climatic reconstruction based on ice core isotopic data:
1- It has been shown that the spatial relationship between mean surface temperature and mean isotopic composition of precipitation can be explained quite straightforwardly using simple isotopic models tuned to d-excess vs [U+F064]18O evolution in transects on the East Antarctic sector. The spatial slopes deduced from the transects are however quite high ($\sim$ 0.7-0.8 ‰°C-1 for [U+F064]18O vs temperature) compared to the temporal slopes derivedat the annual scale from precipitation sampling at sites from East Antarctica like Vostok and Dome C (slope between d18O and temperature of 0.35 to 0.46 ‰°C-1). Such a difference may well be explained by the vanishing inversion layer in summer (Landais et al., 2012; Casado et al. 2016).
2- Post-deposition effects linked to exchanges between the snow surface and the atmospheric water vapor lead to an evolution of d18O in the surface snow in the absence of any precipitation event. This evolution preserves the positive correlation between d18O of snow and surface temperature but is associated with a much slower d18O vs temperature slope than the slope observed in the seasonal precipitation.
3- Post-deposition effects clearly limit the possible archiving of high resolution (seasonal) climatic variability in the polar snow but we suggest that sites with an accumulation rate larger than 7-8 cm eq water yr-1 record a seasonal cycle.