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Assessing the ability of isotope-enabled General Circulation Models to simulate the variability of Iceland water vapor isotopic composition

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During the fall of 2010 we installed an autonomous water vapor spectroscopy laser (Los Gatos Research analyzer) in a lighthouse on the Southwest coast of Iceland (63.83°N, 21.47°W). Despite initial significant problems with volcanic ash, high wind, and attack of sea gulls, the system has been continuously operational since the end of 2011 with limited down time.

The system automatically performs calibration every 2 hours, which results in high accuracy and precision allowing for analysis of the second order parameter, d-excess, in the water vapor. We find a strong linear relationship between d-excess and local relative humidity (RH) when normalized to SST. The observed slope of approximately -45 o/oo/% is similar to theoretical predictions by Merlivat and Jouzel [1979] for smooth surface, but the calculated intercept is significant lower than predicted.

Despite this good linear agreement with theoretical calculations, mismatches arise between the simulated seasonal cycle of water vapour isotopic composition using LMDZiso GCM nudged to large-scale winds from atmospheric analyses, and our data. The GCM is not able to capture seasonal variations in local RH, nor seasonal variations in d-excess.

Based on daily data, the performance of LMDZiso to resolve day-to-day variability is measured based on the strength of the correlation coefficient between observations and model outputs. This correlation coefficient reaches $\sim$0.8 for surface absolute humidity, but decreases to $\sim$0.6 for δD and $\sim$0.45 d-excess. Moreover, the magnitude of day-to-day humidity variations is also underestimated by LMDZiso, which can explain the underestimated magnitude of isotopic depletion. Finally, the simulated and observed d-excess vs. RH has similar slopes. We conclude that the under-estimation of d-excess variability may partly arise from the poor performance of the humidity simulations.