Assessing global model hydrology with simulations from the Stable Water-isotope Intercomparison Group

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The atmospheric water cycle in climate models has developed far beyond the pioneering scheme by Manabe *et al.* (1965) to now include elaborate land surface exchange, sophisticated cloud physics and convection. While present generation climate models credibly reproduce the observed distribution of water vapour, there remains a question as to whether this results from the correct balance of contributing processes. Indeed the different ways various models reach hydrologic balance is likely key to understanding the range of climate sensitivities found in model intercomparisons. The Stable Water-isotope Intercomparison Group (SWING) brings together modeling groups with GCMs capable of simulation the isotopic composition of water to deduce differences in the atmospheric hydrology and exchange processes in climate models though isotope simulations.

Figure 1 shows the June-July-August mean isotopic composition of water vapour at 700 hPa from the three models participating in the SWING Phase 1 experiment (Hoffmann *et al.* 1998, Noone and Simmonds 2002, Schmidt *et al.*, 2005). The experiment protocol includes prescribed climatological sea surface temperatures and greenhouse gas concentrations set to 1990s levels. Each of the models simulates the isotopic composition of precipitation very well, yet there are substantial biases in the simulation of tropospheric vapour. The models agree that vapour is more depleted at higher latitudes where condensation has preferentially removed heavy nuclides. The model simulations are less similar in locations where convection is common. The models show more depletion in regions of intense convection where condensation processes dominate, but show local enrichment where convection acts to loft non-depleted vapour from the boundary layer. The degree to which these affect the simulated hydrology is seen in the isotopes. One model has less depleted water in the tropics which is linked to excessive convective transport, while another model has more localized features where convection is more closely tied to the geography. These model results can be compared to measurements derived from the Tropospheric Emission Spectometer (Worden *et al*., 2007). This is the first global tropospheric survey of isotopic composition and provides an unprecedented and important ground truth for isotope models. The difference between the all models and the observations is larger than the difference between any two models. Some of this discrepancy is associated with sampling biases and resolution differences between the models and the observations; however, the mismatch also indicates that the way in which each of the models achieves hydrologic balance is through a different combination of contributing processes (evaporation, transpiration, boundary layer mixing, large-scale advection and condensation). As such, we have demonstrated the independent information provided by isotopes has great utility in ensuring the atmospheric water balance in models is obtained for the right reasons.

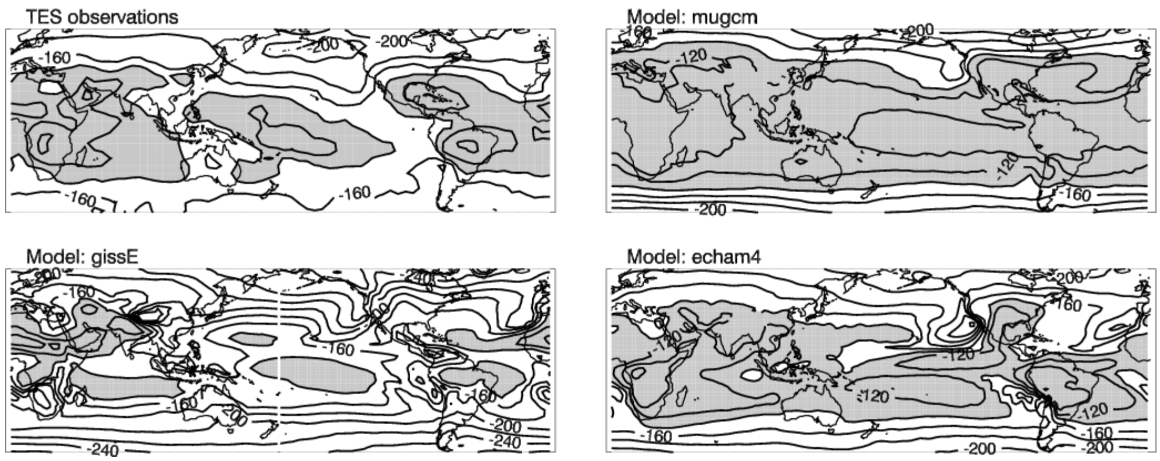

Figure 1: June-July-August mean isotopic composition of water vapour (δHDO) at 700 hPa from the Tropospheric Emission Spectrometer, and simulated by three general circulation models. Values are shown as a normalized difference from the isotopic composition of ocean water. Contour interval is 20 permil, and values larger than -140 permil are shaded.

References

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SWING data archived and available at http://atoc.colorado.edu/~dcn/SWING