Stable Water-isotope Intercomparison Group (SWING)

URL: http://atoc.colorado.edu/~dcn/SWING
Coordinator: David Noone

Objectives

SWING aims to use water isotope information to understand water cycle processes and to quantify their role in climate and climate feedbacks. SWING incorporates an intercomparison of current state-of-the-art water isotope general circulation models and related observational isotope data. It brings together scientists with a common wide range of interest in both modelling and measuring stable water isotopes ($H_2{}^{18}O$, HDO) and its application to earth system problems with a special focus on atmospheric hydrologic balance and water movement in the land surface.

Status

During 2006, SWING coordination was transferred from the Max Plank for Biogeochemistry in Jena to the University of Colorado in Boulder, with successful migration of the model and observation database and web site to the new location. Four modeling groups have contributed to the archive (contributing models are MUGCM, GISS, ECHAN, NCAR-CAM) with three additional groups expected to contribute as their internal validation is competed. The Phase 1 simulations include a 20 year simulation with climatological SSTs, and a simulation with transient SST from 1870 to 2002.

With the extensive archive of data now in existence and with public access to the 125 gigabyte volume of model results, community members are beginning to use the SWING isotopic data for constraining analysis of biospheric and atmospheric processes. To increase visibility and publicize the activity, SWING continues to report core science results at scientific meetings (American Geophysical Union and European Geophysical Society meetings). The first summary publication of SWING phase 1 experiments is in preparation, with a target publication date of early 2007.

Acquisition of new observations has opened avenues for new types of analysis of hydrologic cycles with isotopes and more comprehensive validation of model isotope simulations. In addition to the IAEA/WMO Global Network for Isotopes in Precipitation, a new IAEA coordinated observation network (Moisture Isotopes in the Biosphere and Atmosphere - MIBA) aims to measure near isotopic composition of surface atmospheric vapour, water in leaves and soil and offers new opportunities for SWING to examine global and regional distributions of surface exchange processes. In the last 12 months three different space-based instruments have been used to develop isotopic datasets from hyperspectral infrared satellite observations. Observed spectra from the IMG instrument on Japan's ADEOS satellite was used to derive zonal mean tropospheric values, while the MIPAS instrument on the European Space Agency's Envisat was used to derive HDO and $H_2{}^{18}O$ from the upper troposphere to the lower mesosphere. Perhaps the most promising of these new datasets for the use in understanding tropospheric hydrology derives from the Tropospheric Emission Spectrometer on NASA's Aura spacecraft. As part of standard operations NASA has begun operationally processing global datasets of HDO between 850 hPa and 300 hpa with a 2-day repeat frequency. Use of this new and exciting data has become a key part of the SWING activity.

New Directions

With SWING Phase 1 experiments complete, initial planning for a Phase 2 experiment sets is underway. Due to availability of new high quality satellite data, the scope of the experiment can extend naturally to more detailed analysis of cloud processes. The Phase 1 experiments focused on mean quantities as basic validation of isotopic modeling and capturing primary aspects of the hydrologic cycle. The Phase 2 experiments aim to target understanding the isotopic hydrology under perturbed conditions and in associated with variability in cloud and surface exchange processes.

One underutilized feature of isotope models is the ability to trace water from predefined water sources to the distribution of precipitation of that water. Future experiments will be performed making use of this capability to provide estimates of recycling rates and evaluation of horizontal and vertical transport pathways in the models. Some non-isotopic modeling groups also have this analytical capability and will be encouraged to participate.

Additionally, in response to requests from users of the existing archive data, SWING will strive to make simulations available for both warming scenarios (double CO_2) and for glacial periods. These simulations will satisfy the need to use model isotope output as constraints on global and regional water budget calculations for these epochs.

Key results

Based on analysis of the new TES satellite data, it has been determined through isotopic analysis that the terrestrial biosphere is a significant source of tropospheric water. Much of this water is derived from local soil evaporation and transpiration, as can be determined by the distinctly enriched isotopic signature relative to water of oceanic origin. This water is removed from the boundary layer by strong continental convection, which contrasts with the oceanic convection which tends to be weaker and less efficient in transporting water vapour out of the boundary layer. The SWING models all exhibit the same behavior although the strength in the resulting isotopic anomalies is much smaller, and reflects the differing formulation of water transport by convection in the models. Ongoing analysis is likely to show that the model-observations mismatch is also due to in accurate modeling of soil hydrology and evapotranspiration.

Summary

SWING aims to use water isotope simulation and analysis to improve understanding of key hydrologic exchange processes, the distribution of water sources, and the ability to model the hydrology. New opportunities have emerged due to availability of high quality satellite data. Planning has begun for second phase experiments that target key atmospheric and surface processes, and address variability rather than mean state.

Key publications

Payne, V. H., D. Noone, C. Piccolo, R. G. Grainger and A. Dudhia, 2006: A global view of the deuterium content of upper tropospheric/stratospheric water vapour from satellite measurements, *submitted*, July, 2006.

Worden, J. R., K. Bowman, D. Noone and TES Team Members, 2006: TES observations of the tropospheric HDO/H2O ratio: retrieval approach and characterization *Journal of Geophysical Research*, 111(D16), D16309, 10.1029/2005JD006606

Worden, J. R., D. Noone, K. Bowman and TES Team Members, 2006: Global hydrologic cycles seen with water isotope measurements from space, *submitted*, January, 2006.

Zakharov, V. I., R. Imasu,K. G. Gribanov, G. Hoffmann and J. Jouzel, Latitudinal distribution of the deuterium to hydrogen ratio in the atmospheric water vapor retrieved from IMG/ADEOS data. *Geophysical Research Letters* 31, L12104, doi: 10.1029/2004GL019433, 2004.