CEOP Cross Cut Studies

Isotope Cross Cut Studies (ICCS)

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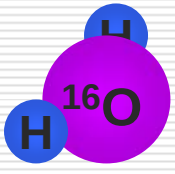
08/20/2009@Melbourne

Stable Water Isotopes

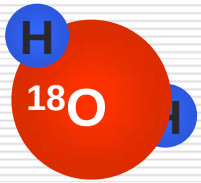
- Proxy of integrated records of phase changes during hydrologic cycles.

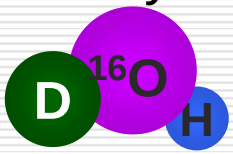


('Light' Water)
Easy to evaporate

H_2O

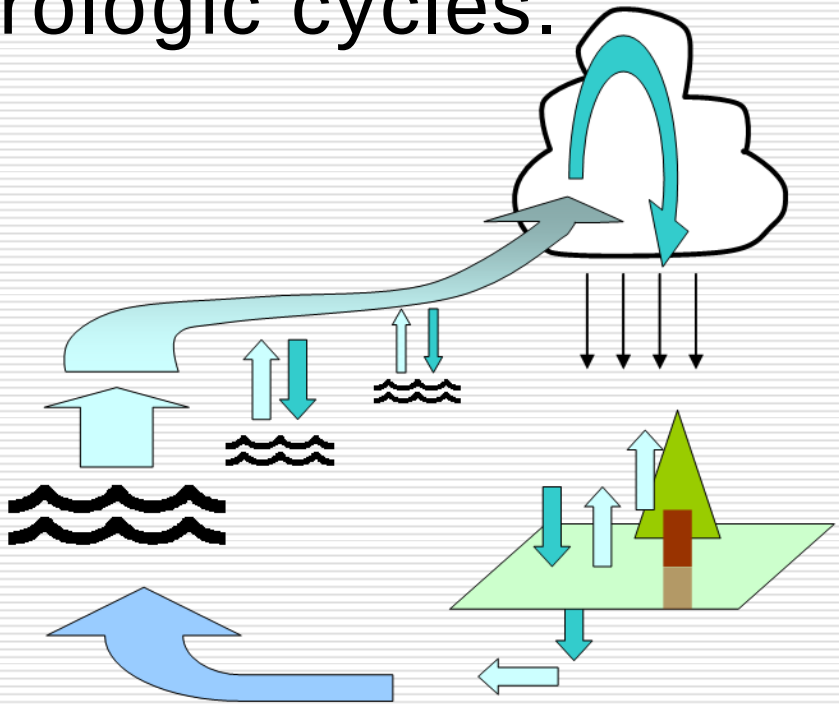
('Heavy' Water)
Easy to condense





$H_2{}^{18}O$ **0.20%**

HDO **0.016%**



"Fractionation" causes large spatial and temporal variability in isotope distribution.

ICCS Objectives:

- Facilitate isotope studies with modeling, in situ and remote sensed observations, and integration with other CEOP Elements.
- Understand isotopic processes in the hydrologic cycles and allow non isotope studies within GEWEX/CEOP to be enhanced by knowledge of isotopic constraints.
- Improve facilitation access to isotopic data (in-situ observations, and remote sensing data, and model simulation results) from other CEOP Elements.

Key Results in 2008-09

- SWING-2 workshop was held in November 2008.
  - Several model simulation results for present and paleoclimates were archived, and preliminary analysis started.
- Mauna Loa observation campaign was held in October to November 2008.
- TES/Aura HDO measurement for 2004-present were retrieved.
- SCIAMACHY/Envisat HDO measurement was emerged.
- HDO profiles were measured by ground-base FTS for late 90s to present.

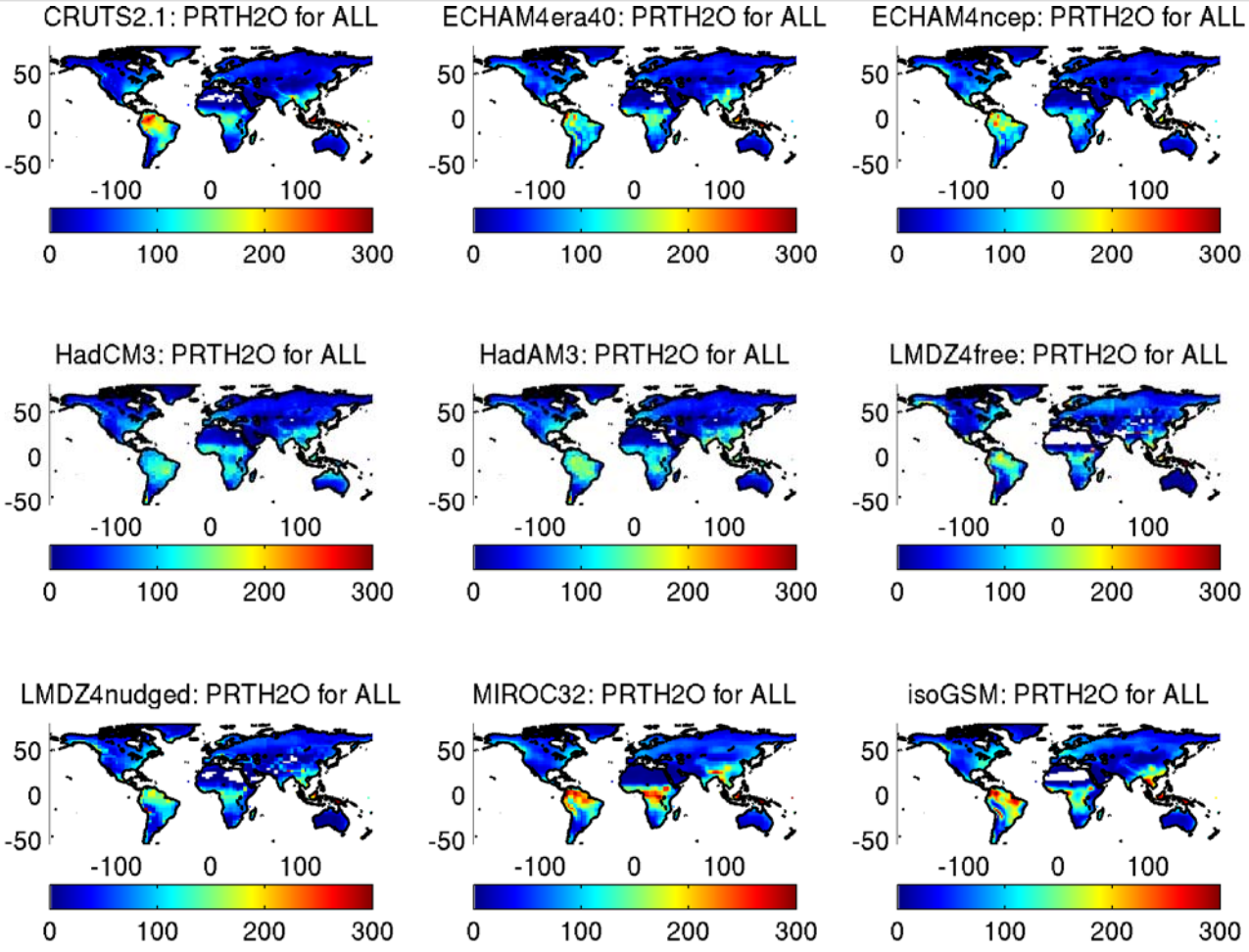
SWING-2

- Kick-off in 17-19 November 2008 in IAEA HQ; chaired by C. Sturm, K. Yoshimura & D. Noone.
- More isotopic AGCMs (at least 9) and 2 isotopic RCMs.
- Add nudging experiments to focus on only isotopic parameterizations and on more realistic reconstruction of isotopic variations.
- More focused on hydrologic cycle than climatology

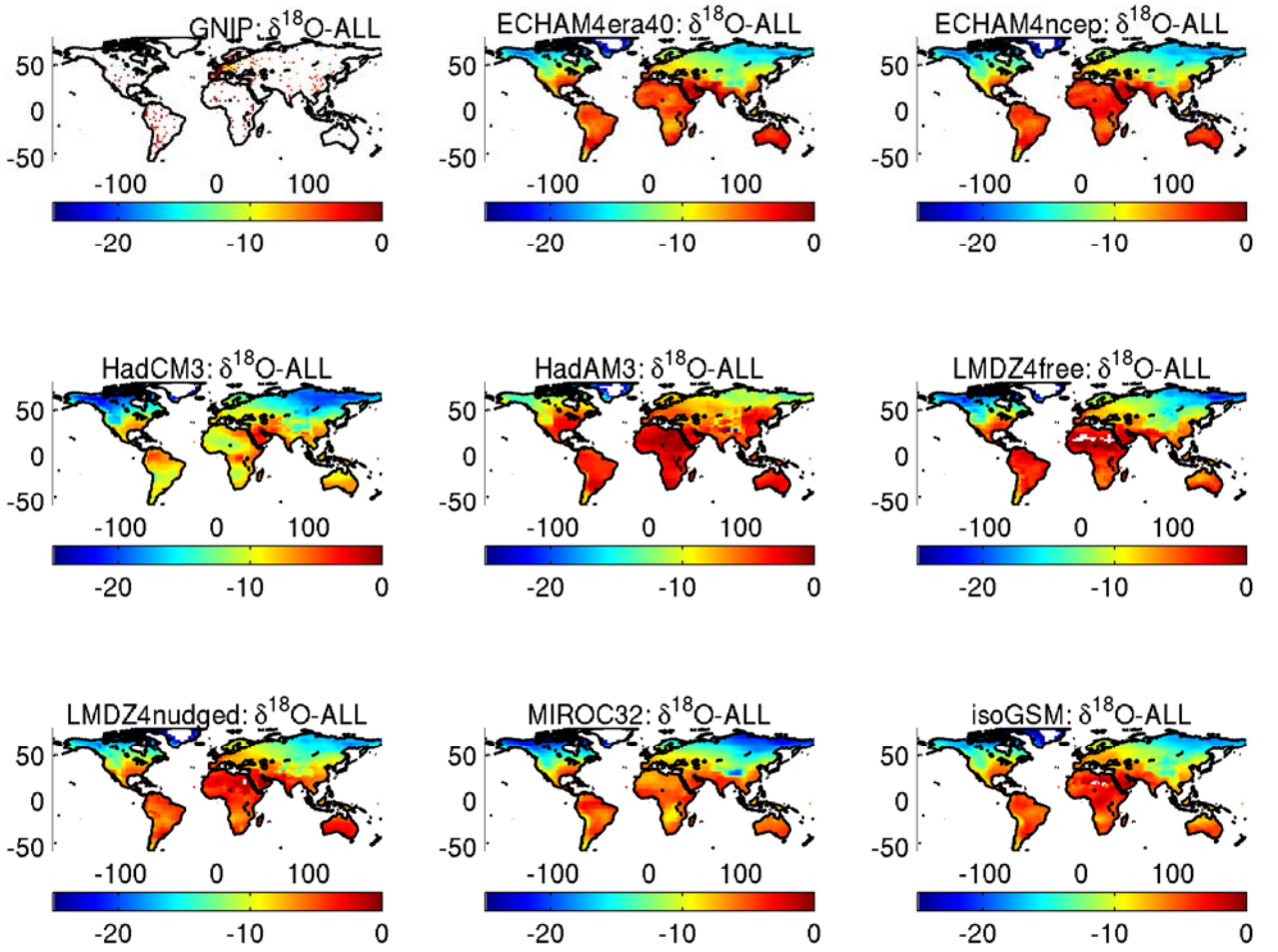
Objectives of SWING-2

- Evaluate the capability of climate models to represent the spatial and temporal variability of water isotope composition in precipitation
- Spatially and temporally interpolate the GNIP (Global Network of Isotope in Precipitation, IEAE/WMO since 1960's) dataset by applying the nudging technique or something else.
- Deliver an optimal reconstruction of monthly gridded maps of water isotopes in precipitation, by merging simulations and observations
- Assess the uncertainties and confidence intervals of the above gridded data-set (for all approved methods)

Preliminary Result of SWING2

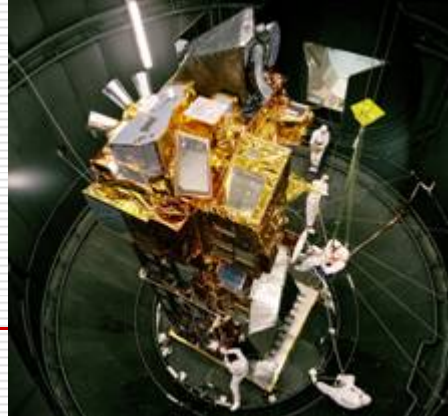


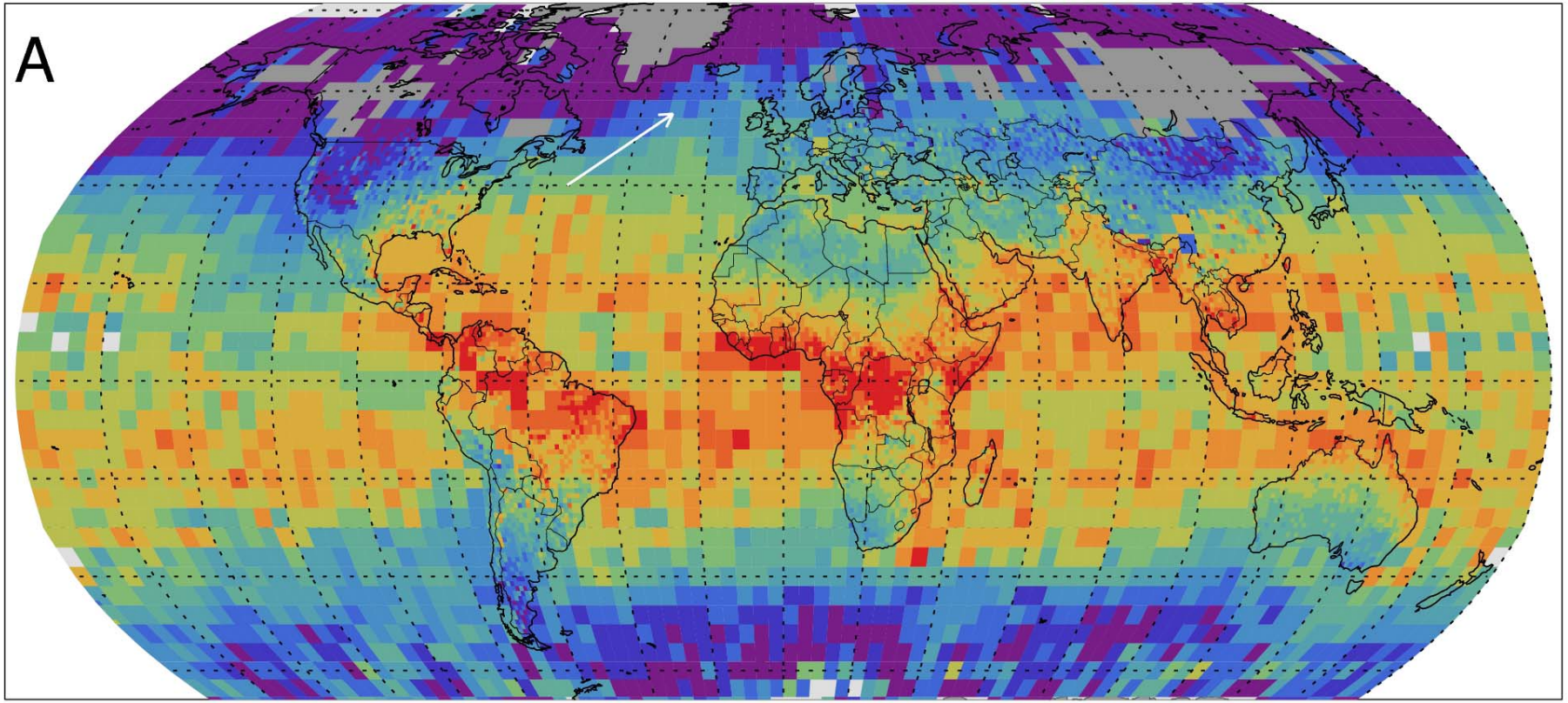
Preliminary Result of SWING2



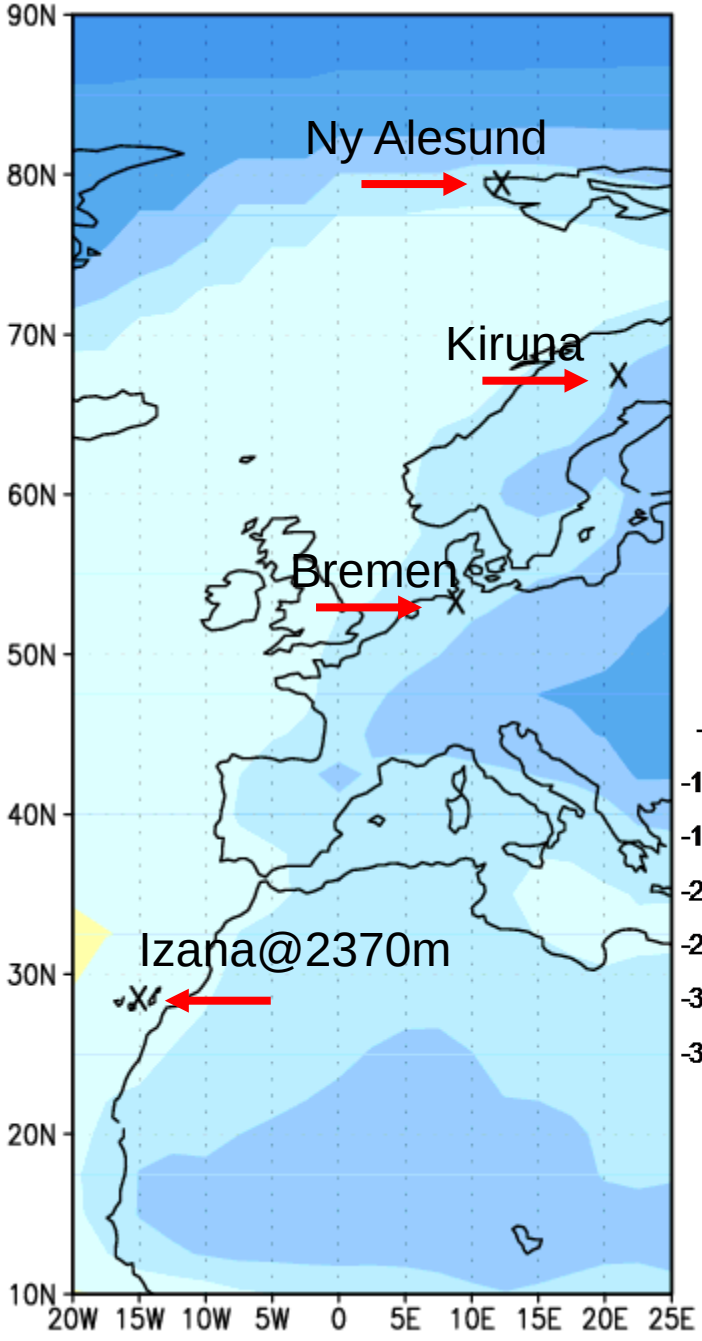
Annual mean column dD by SCIAMACHY on Envisat

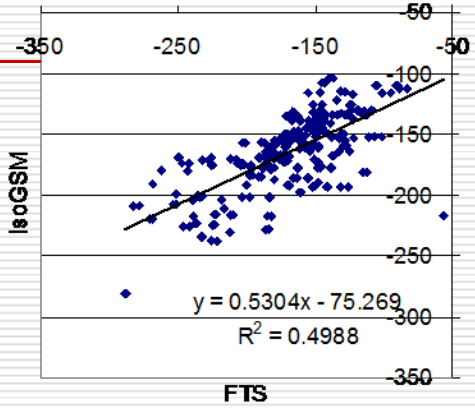
(Frankenberg, Yoshimura, et al., *Science*, in print)

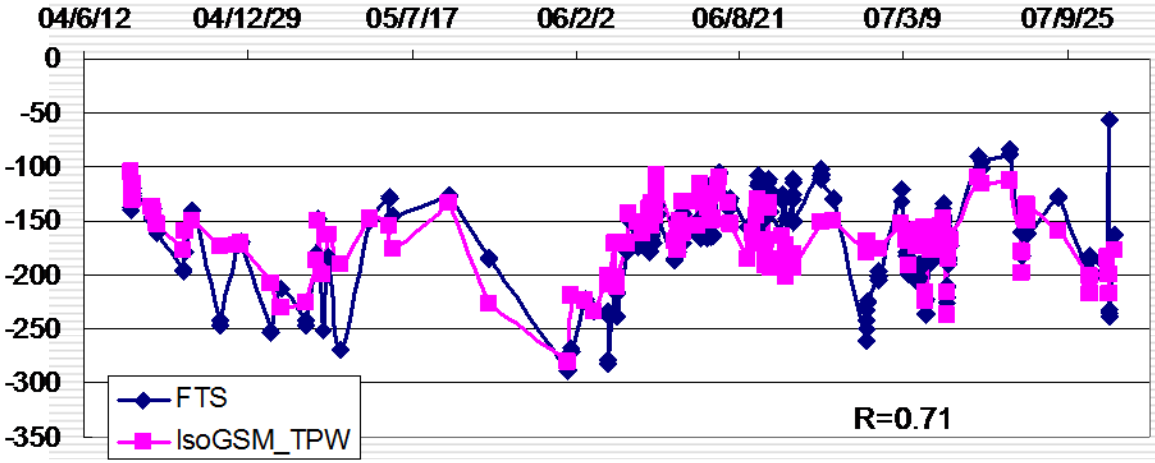




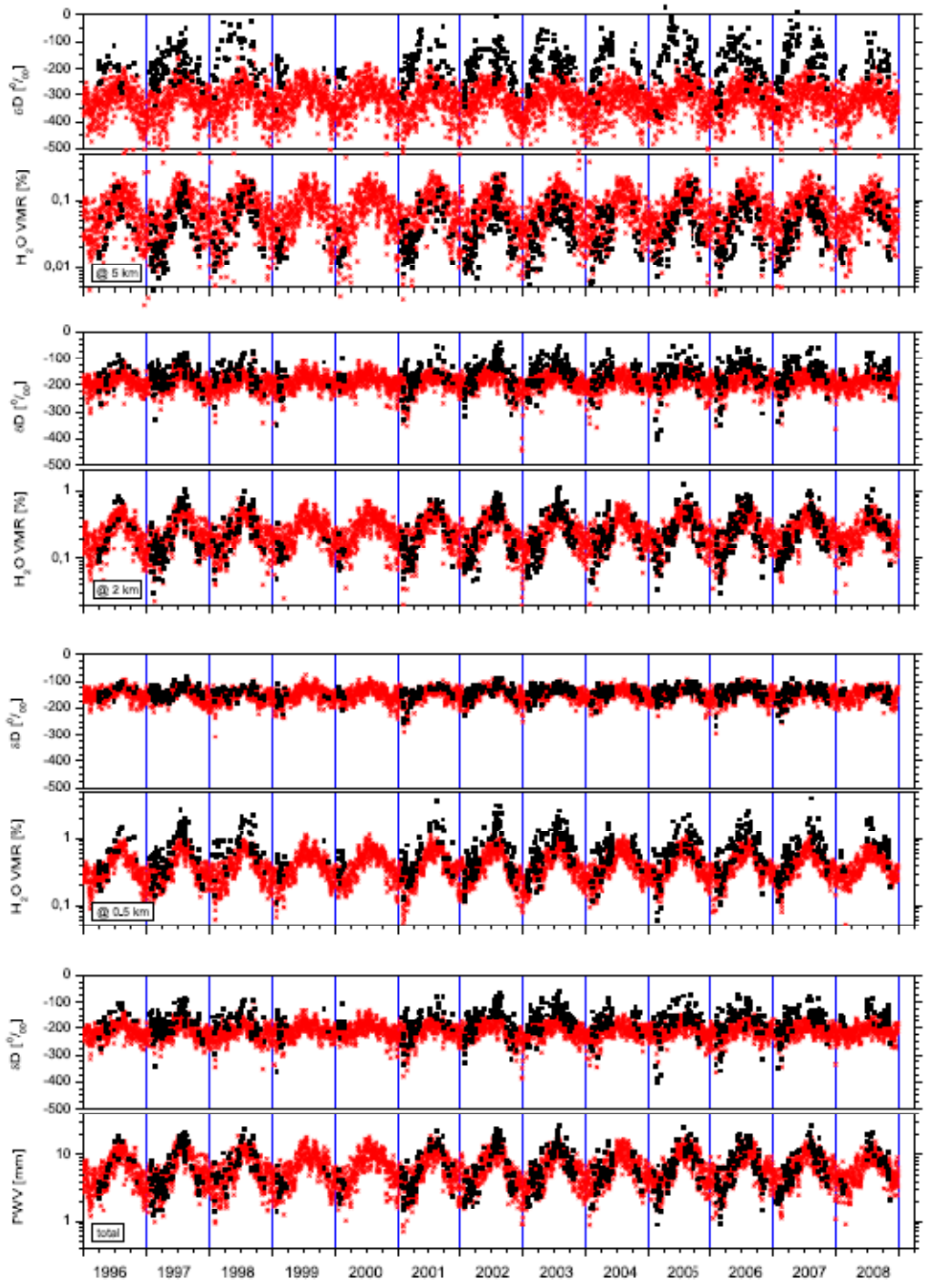
Ground-based FTS observations





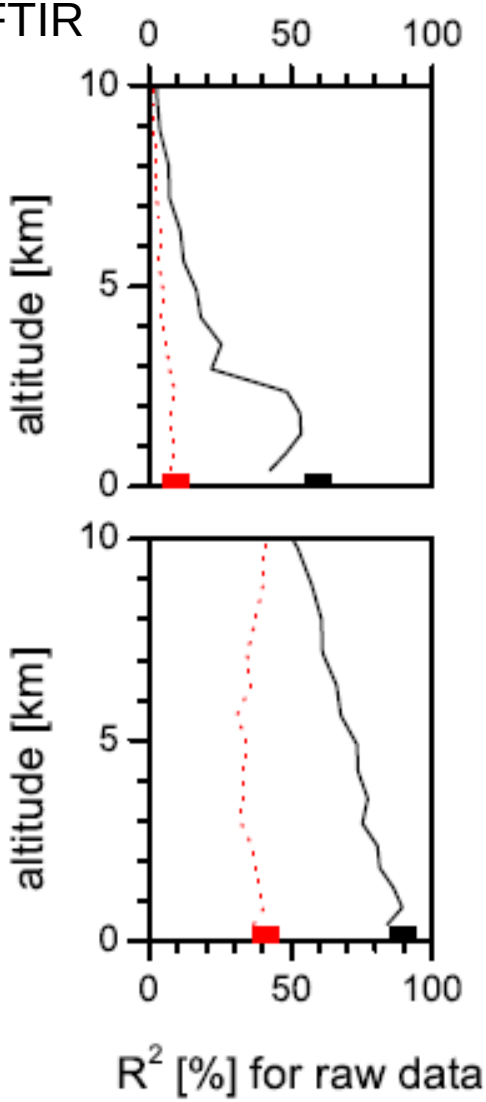


http://www.iup.uni-bremen.de/ftir/index.php?section=STATIONS&subsec=BREMEN



Red: IsoGSM
Black: FTIR

@Kiruna/Sweden



Red: Free run
Black: Nudged run

Schneider et al. (2009)

Challenges & Future Plans

- SWING2: On going development of “model-data fusion” product for the 20th century, especially 1958 onward.
  - GNIP-SWING2 deliverable: September 2009
  - Focus on special scientific interests: 2009-2010
  - Preparation of GCMiso intercomparison for selected CMIP5 experiments: 2010
- “Isotope Reanalysis” – The first isotope data assimilation
- Developing framework for new regional scale isotope models likely to be available in next few years.

Coplen et al. (2008)

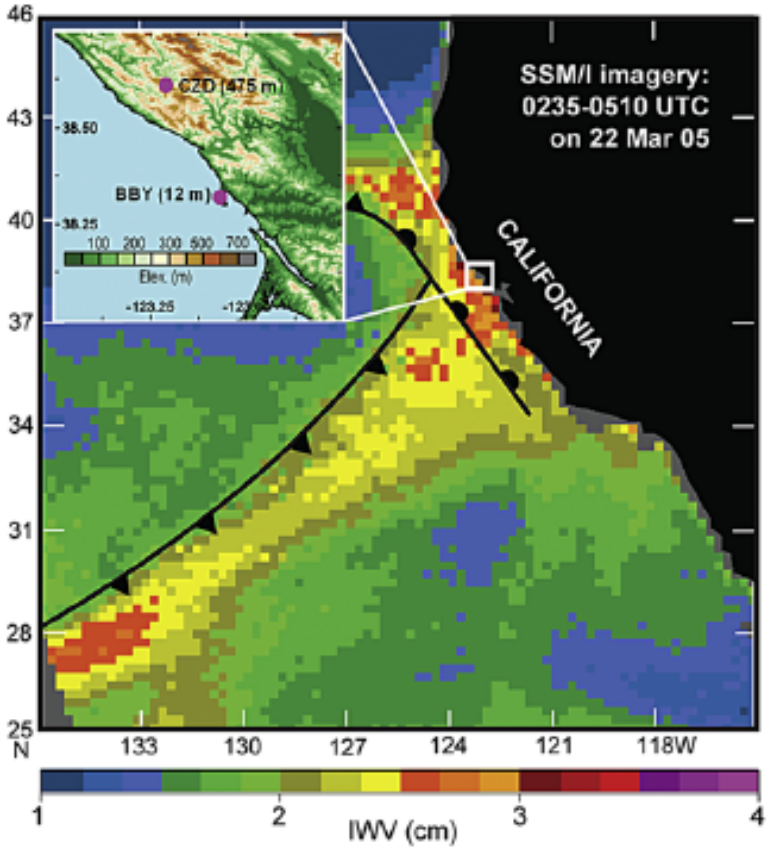
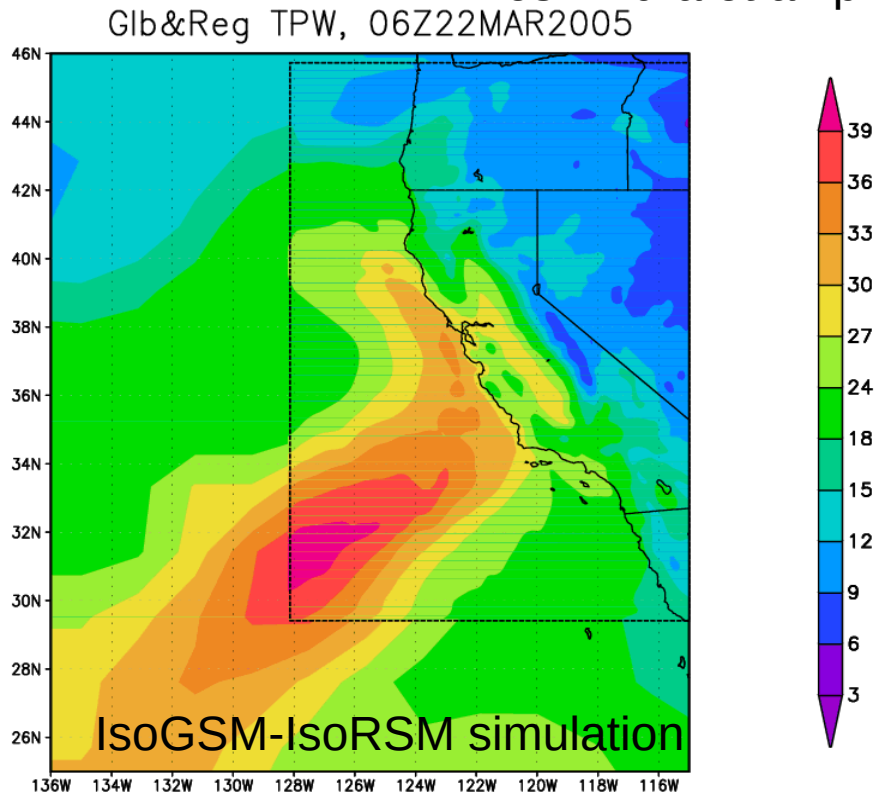
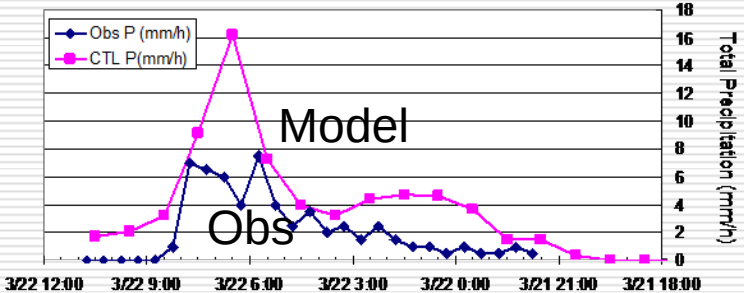


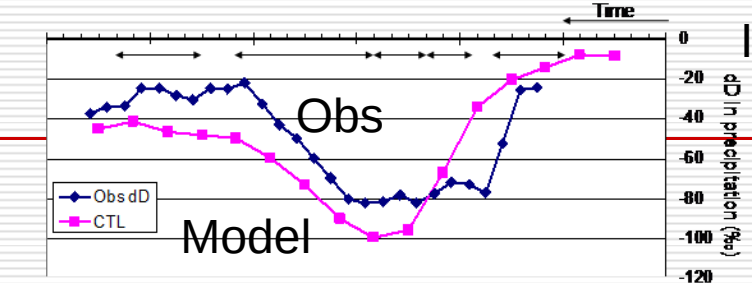
Figure 1. Composite Special Sensor Microwave/Imager satellite image of integrated water vapor (IWV, cm; color bar at bottom) constructed from polar-orbiting swaths between 0235 and 0510 UTC 22 March 2005. Approximate frontal positions are shown at 0300 UTC 22 March. The white box corresponds to the inset terrain base map showing the observing sites at Bodega Bay (BBY) and Cazadero (CZD).

Yoshimura et al. prep.





Prcp



Isotope

Example of regional isotope modeling and experiments

Possible CEOP Collaborations

- HE: Snow/glacial isotope data, climate reconstruction by proxy
- RHP: In-situ sampling networks (e.g., Asian Monsoon), regional simulations
- Satellite: HDO retrievals
  - Ground-base FTS HDO profiles
- Model and Data: Various global and regional isotope climate models and simulation outputs
- Land: Post-iPILPS experiment ? Separating evaporation and transpiration from total ET

Thank you so much.

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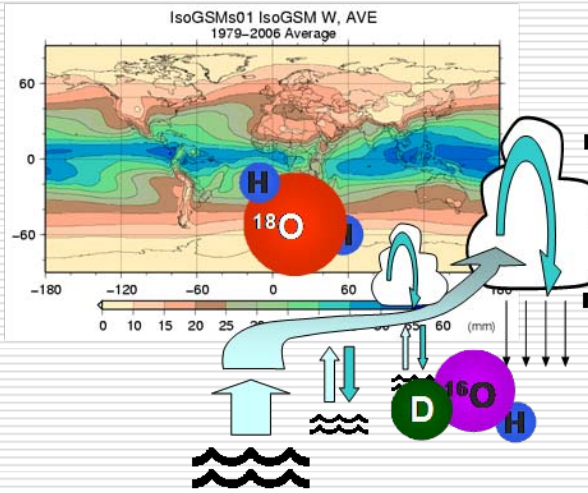
30-yr “Isotope Reanalysis”

(http://meteora.ucsd.edu/~kyoshimura/IsoGSM1)



Surface evaporation (MJ79)

$$R_E = \alpha_{k\_sw}\frac{\alpha_e R_{sea} - hR_a}{1-h}$$

$$\alpha_{k\_sw} = \begin{cases} 1-A & \cdots V < 7(\text{m/s}) \\ 1-(B\times V + C) & \cdots V \geq 7(\text{m/s}) \end{cases}$$

Ice crystal formation (JM84)

$$\alpha_{df} = \alpha_{k\_jm}\alpha_e$$

$$\alpha_{k\_jm} = \frac{S}{\alpha_e (D/D')^n (S-1)+1}$$

$$S = 1 - 0.003T \cdots T < -20°C$$

Rain drop evaporation (S75)

$$m\frac{dR_r}{dm} = \beta(R_r - \gamma R_v)$$

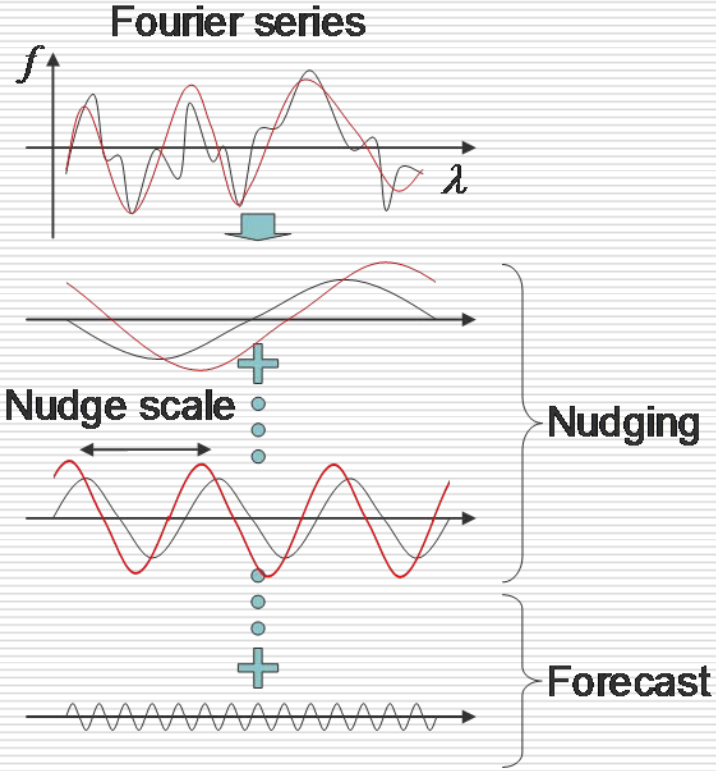
$$\beta = \frac{1-\mu}{\mu},\ \gamma = \frac{\alpha_e h}{1-\mu},\ \mu = \alpha_e (D/D')^n (1-h)$$

$$R_r = \varepsilon\left[(R_{r0} - \gamma R_{v0})(m/m_0)^\beta + \gamma R_{v0}\right] + (1-\varepsilon)R_{r0}$$

$$R_v = \left[q_0' + (m_0' - mR_r)\right]/q$$

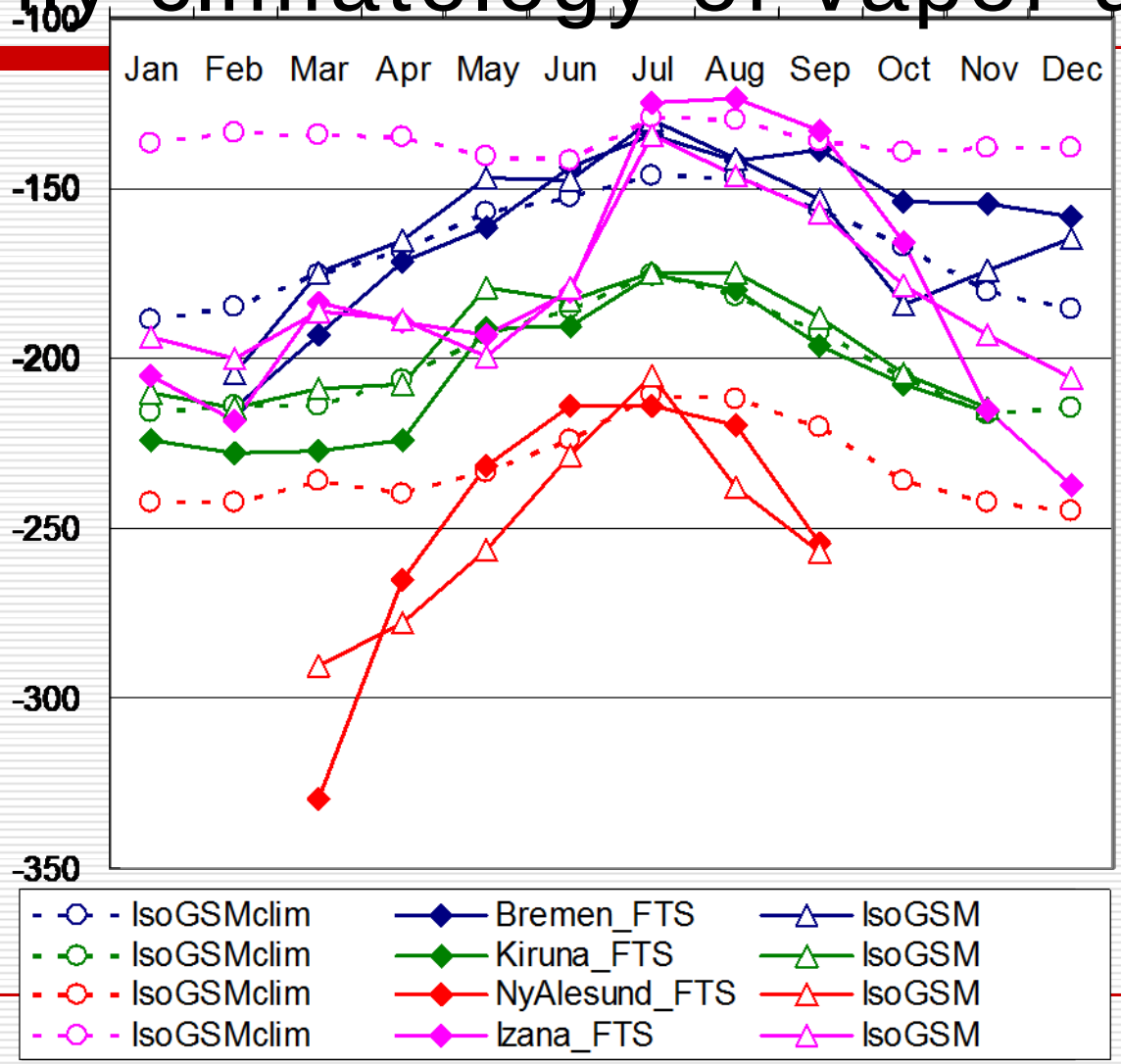
IsoGSM

SIO/UT Isotopic Global Spectral Model



Use large scale (>1000km) winds to constrain dynamical field and try to reproduce global isotope fields in daily to inter-annual time scales.

Monthly climatology of vapor dD



Frankenberg et al. (2009)

ICCS Objectives corresponded to the GEWEX's

- Objective 1: Data
  - Provide to the community isotope datasets from models and associated compiled observations.
- Objective 2: Understanding
  - Find an alternate view of model errors, and give insight to the mechanisms controlling variability.
- Objective 3: Prediction
  - The SWING contributes to understand the differences in model hydrology though the isotopic information, which might help to improve the prediction skill.
- Objective 4: Applications
  - Many opportunities to work with other groups, which are not presently being exploited. Studies on cloud processes and surface exchange are typical examples.