Stable Water Isotopes and Water Tracers in CAM5

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Paleoclimate and Climate Variability and Change Working Group Meeting

Thanks to many people

- David Noone
- Chuck Bardeen
- Esther Brady
- Tony Wong
- Anne-Katrine Faber
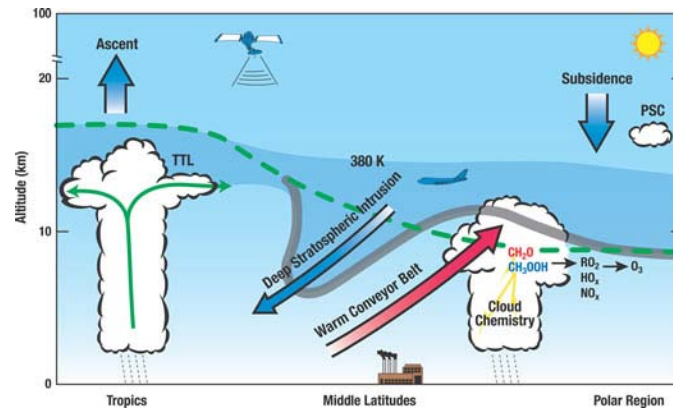- Bette Otto-Bliesner
- Many More!

Why Water Isotopes

The addition of water isotopes into CESM can help with numerous scientific problems, including:

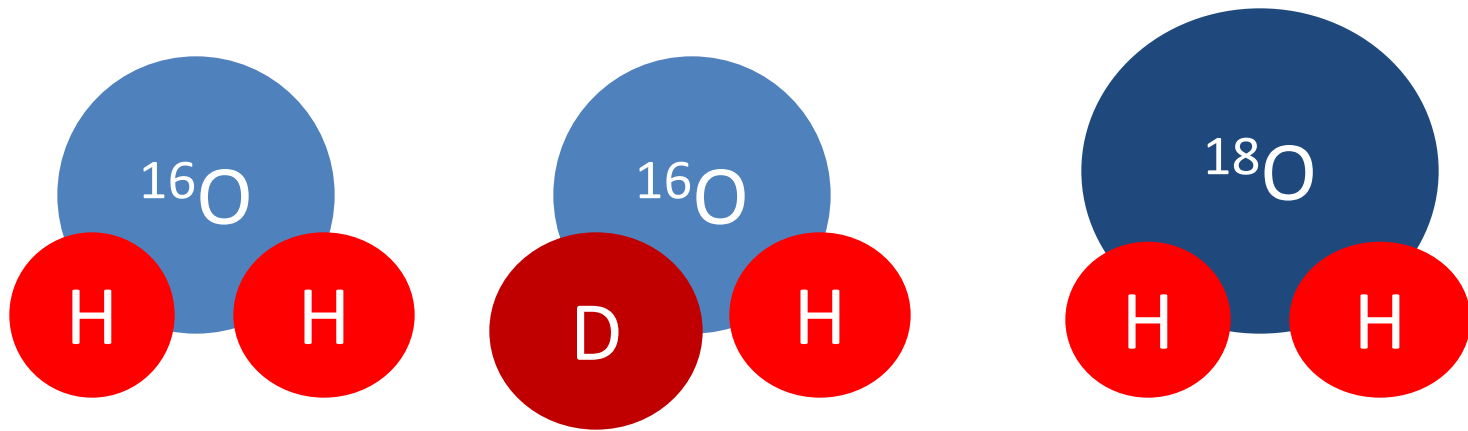Model/Proxy
Comparisons:

Atmospheric
Hydrology

Parameterization
development

Isotope Basics

Three different isotopic species (isotopologues) of water are currently simulated:

All numbers shown in this presentation are "delta" values (δD), in units of permil:

$$R = \frac{X}{H_2O}$$

$$\delta X = \left(\frac{R}{R_{std}} - 1 \right) * 1000$$
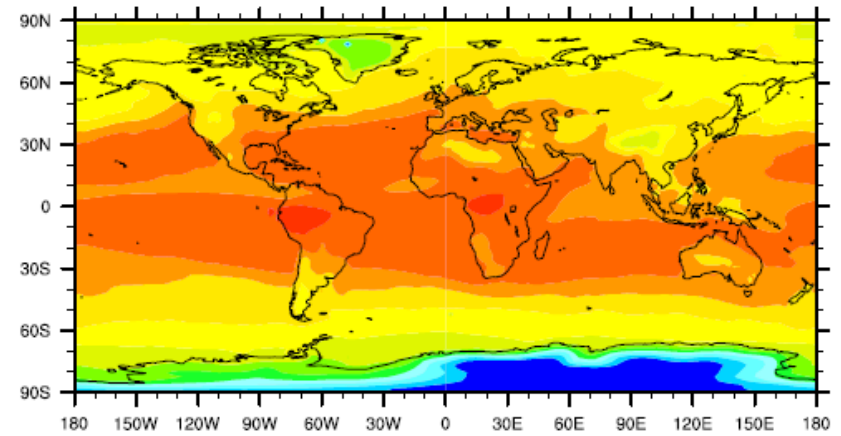
CAM5 simulations

- 1.9 x 2.5 degree FV run

- Forced with 1995-2012 Boundary conditions (including prescribed SSTs and Sea Ice).

- Simple bucket model used to deal with isotopic land and sea ice surface fluxes (will eventually be replaced by iCLM4/iCICE4).
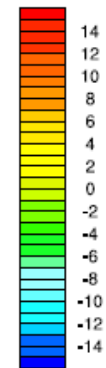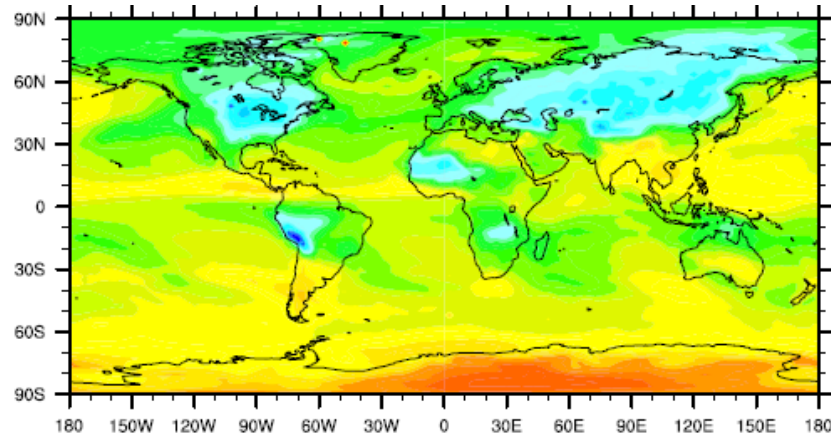
- Let's look at some results!
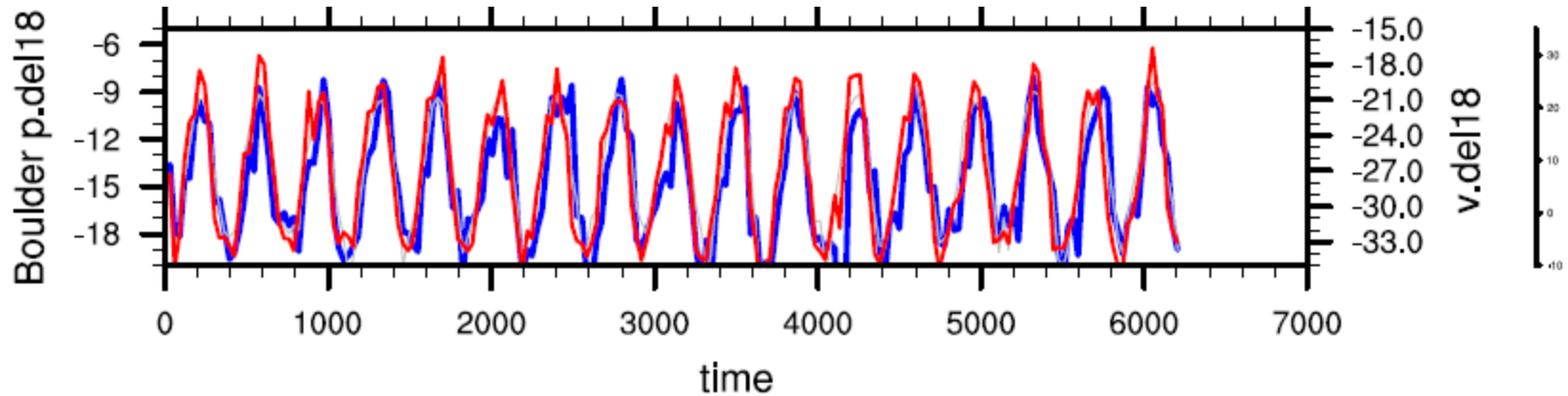
δ^{18}O Precipitation

DJF
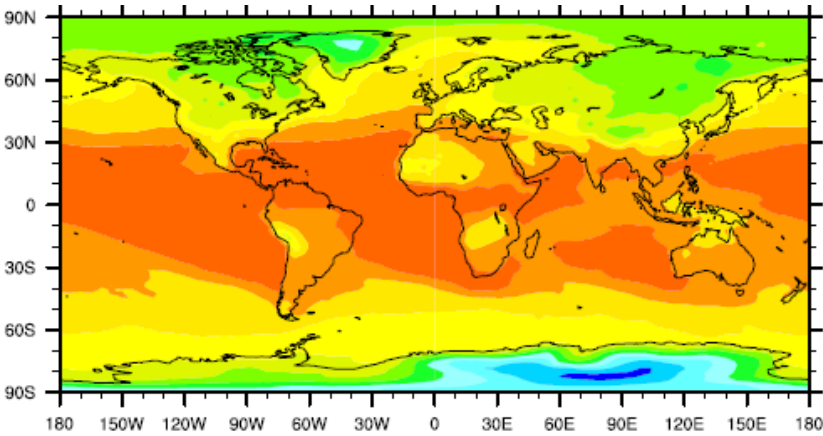
JJA

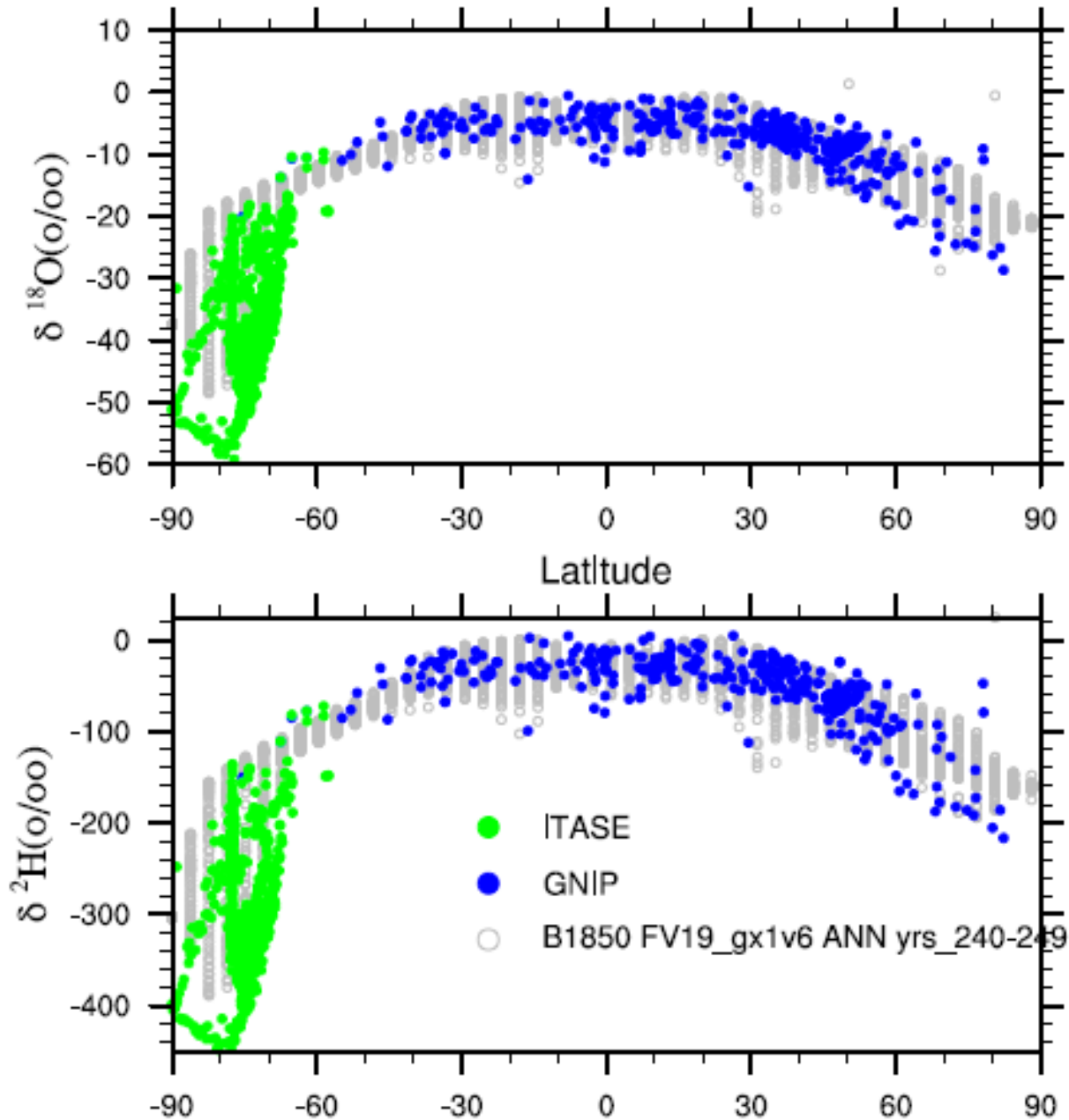## DJF-JJA

δ¹⁸O Precipitation

Observed Precipitation seasonal cycle: 6-23 permil
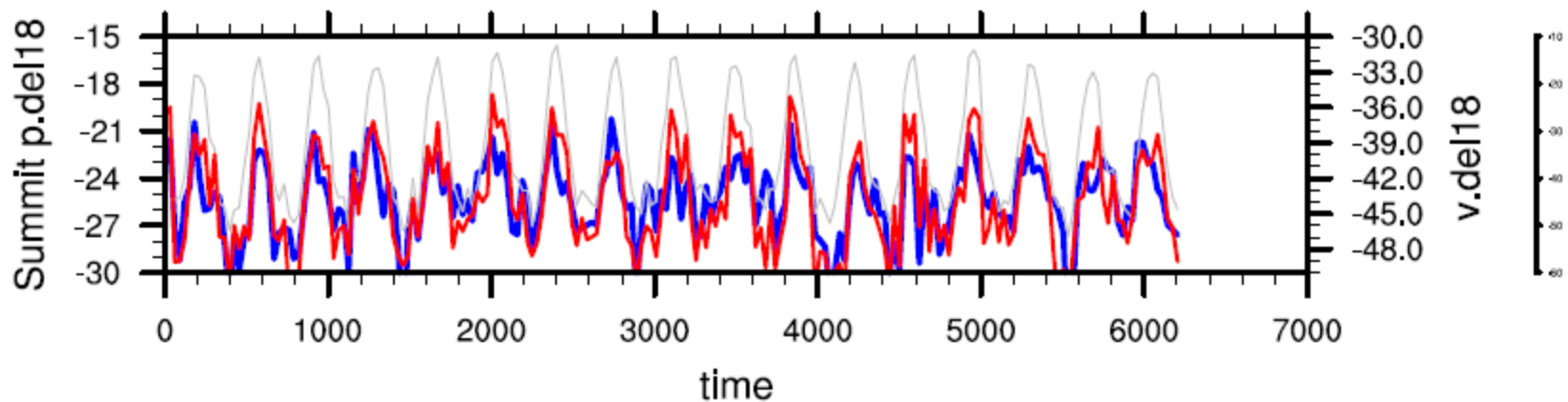
Observed Precipitation seasonal cycle: 7-10 permil

Plots from Anne-Katrine Faber

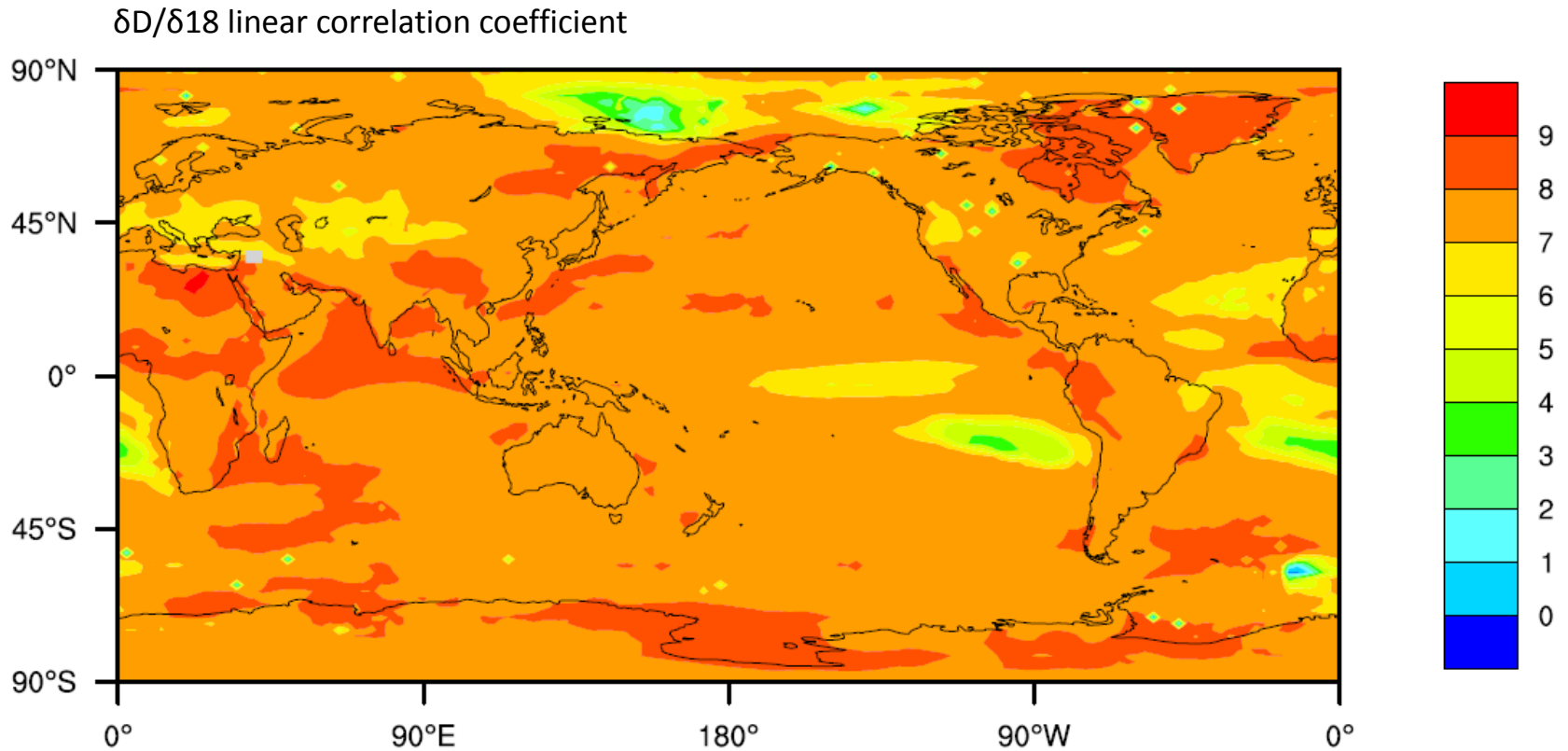# iCAM5 vs. Obs.

Plots from
Esther Brady

CAM5 simulations

The Meteoric Water Line is the slope of the δD/δ18 values in precipitation

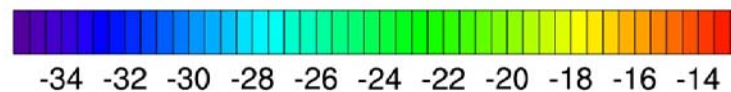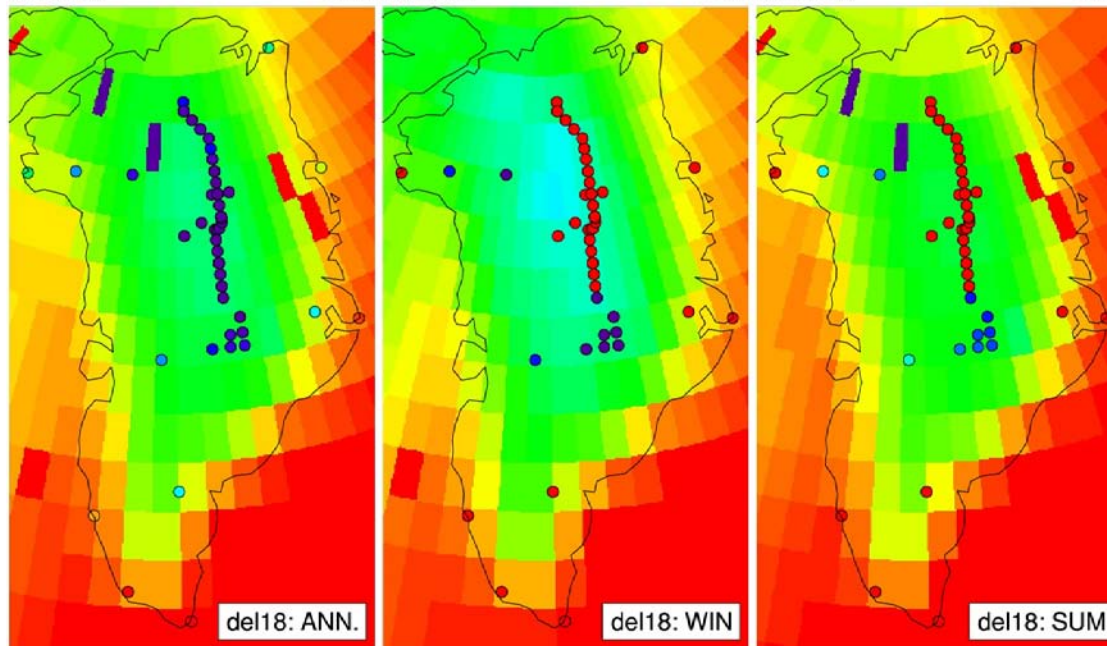δD/δ18 linear correlation coefficient

Global Theoretical value = 8   Simulate Global Average = 7.6

Research example: Greenland

Greenland Is important because numerous ice cores have been drilled there, and it is a region with many isotopic measurements to compare with the model.

Plot from Anne-Katrine Faber

Research example: Greenland

What controls the isotopic values of precipitation in Summit, Greeland (72°N, 38°W)?

Try multi-linear regression:

$$\delta^{18}O_{summit} = A*T_s + B*RH + C*R_{lnd/ice}$$

T_s = Surface Air Temperature anomalies

RH = surface Relative Humidity anomalies

$R_{lnd/ice}$ = Land and Sea Ice Moisture Tag/Total Moisture anomalies

Water Tracers/Tags

Water tags are water isotopes in CAM5 that don't fractionate, thus allowing one to create a second hydrologic cycle in the model that is de-coupled from the climate. This allows for one to modify moisture sources and sinks without changing the climate or circulation.
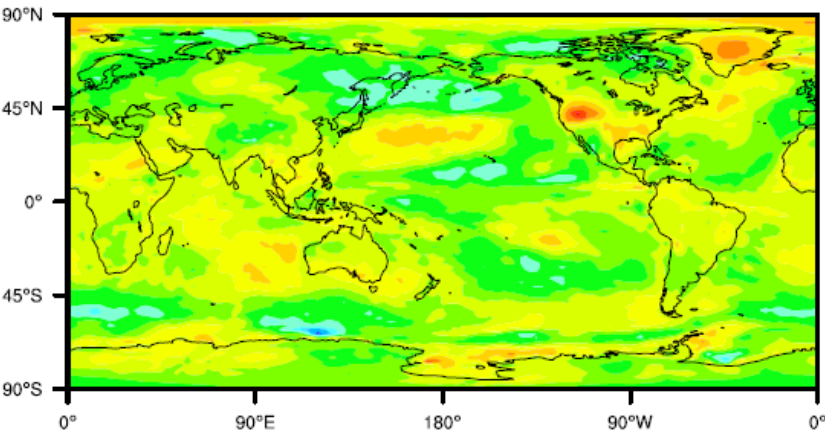
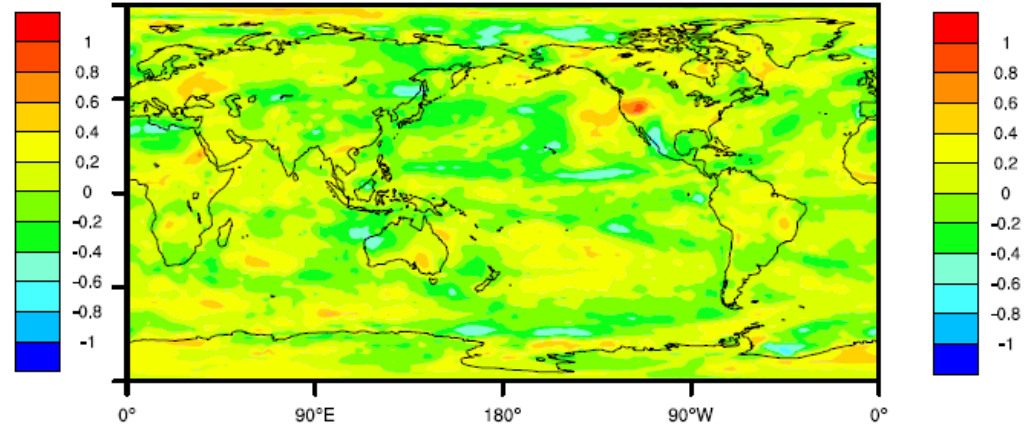Blue = North Pacific moisture, Green = North Atlantic moisture, and Red = Land moisture
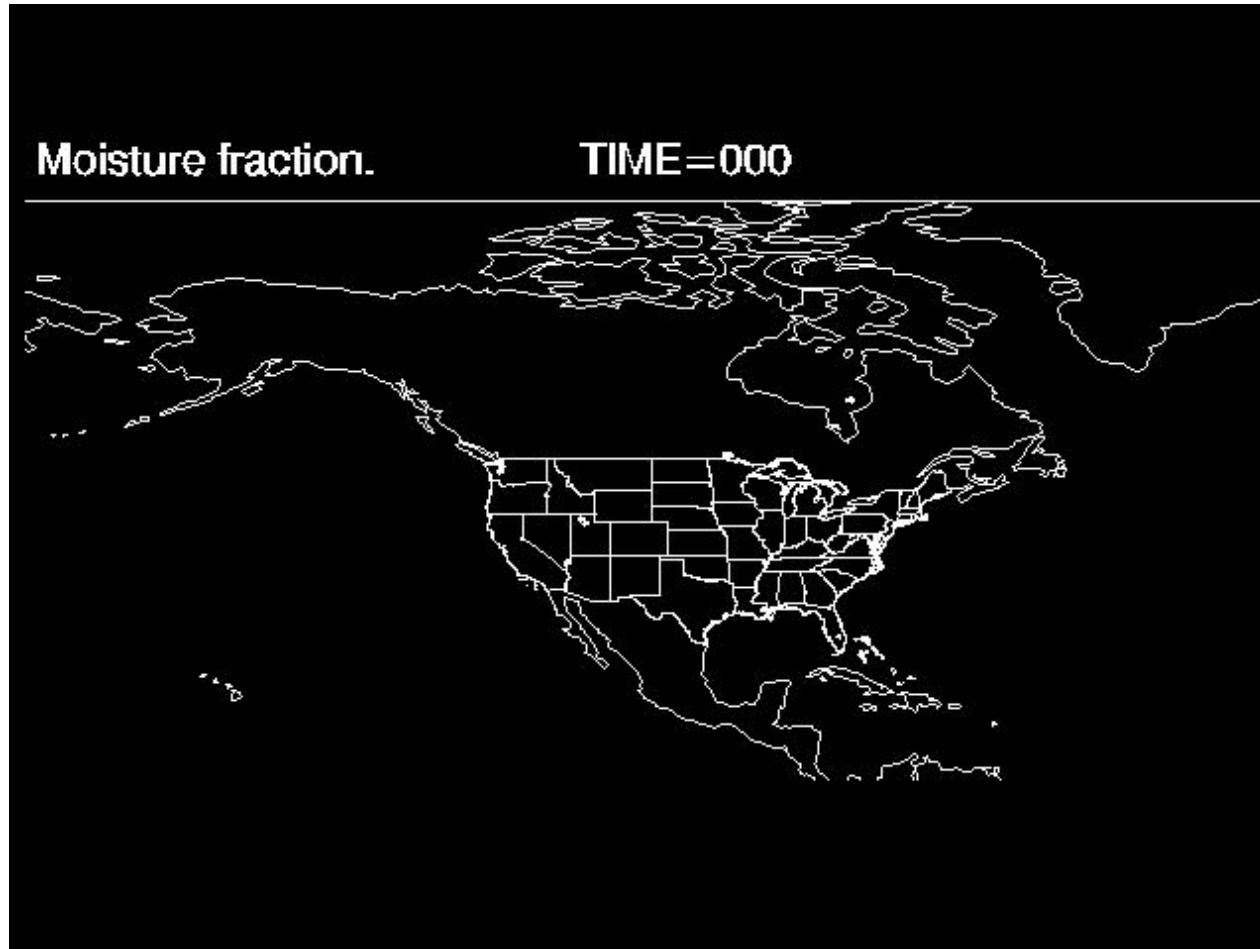
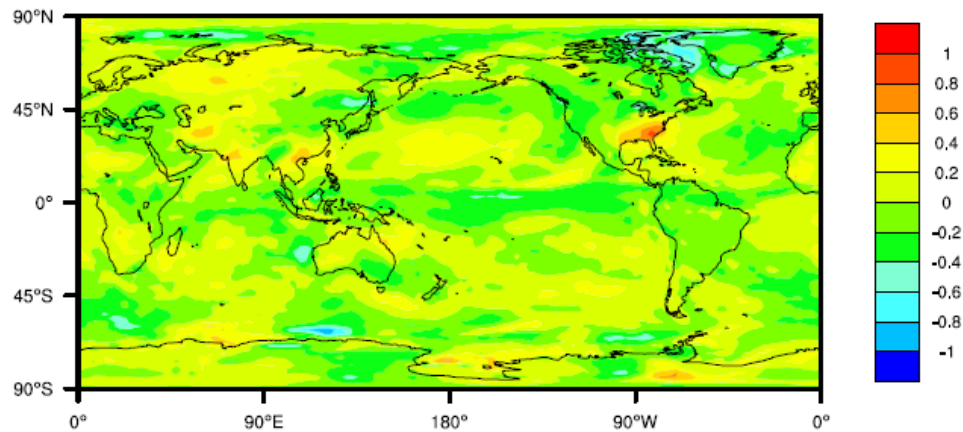
Animation from David Noone

Research Example: Greenland
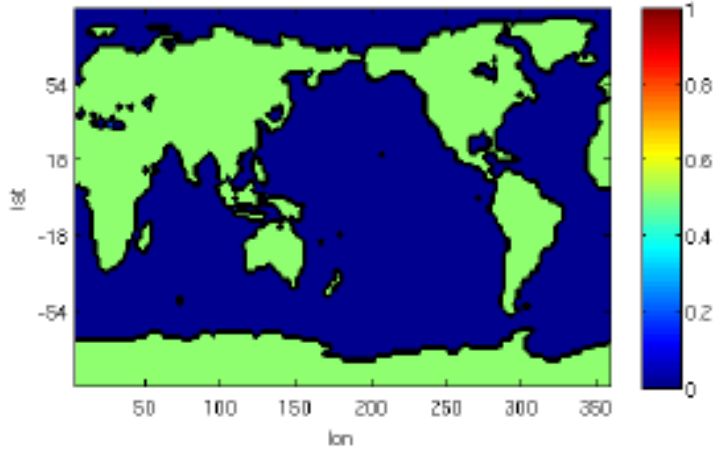
Surface Temperature
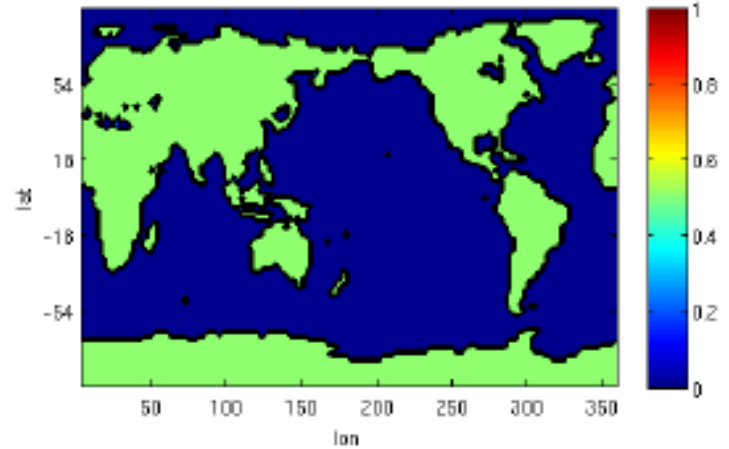

Relative Humidity

Land/Sea Ice Moisture Ratio
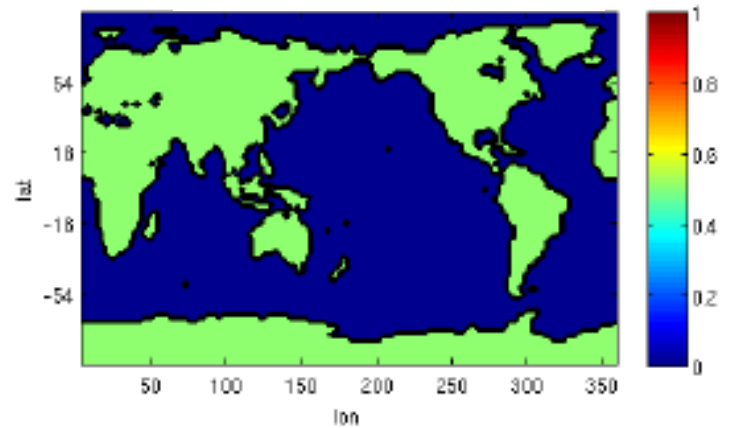
iCLM4 development

Surface Water

Canopy Vapor

Shaded Leaf Water

Sunlit Leaf Water

Plots from Tony Wong
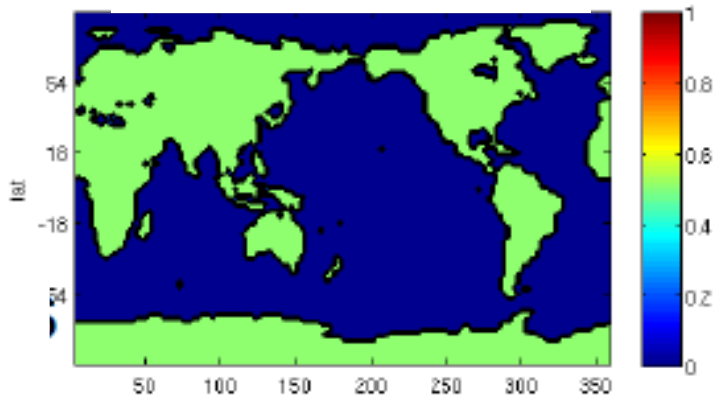
Conclusions

- Major iCAM5 Software development is complete.

- Now currently doing model tuning, validation, and minor-debugging (particularly to improve seasonal cycle).

- Also in the process of being coupled to other isotope-enabled components

- Should be ready to do scientific quality simulations by this summer.

Questions?

Thanks for Listening!