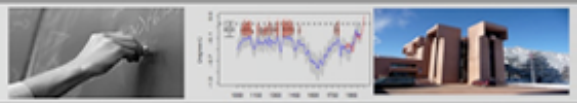
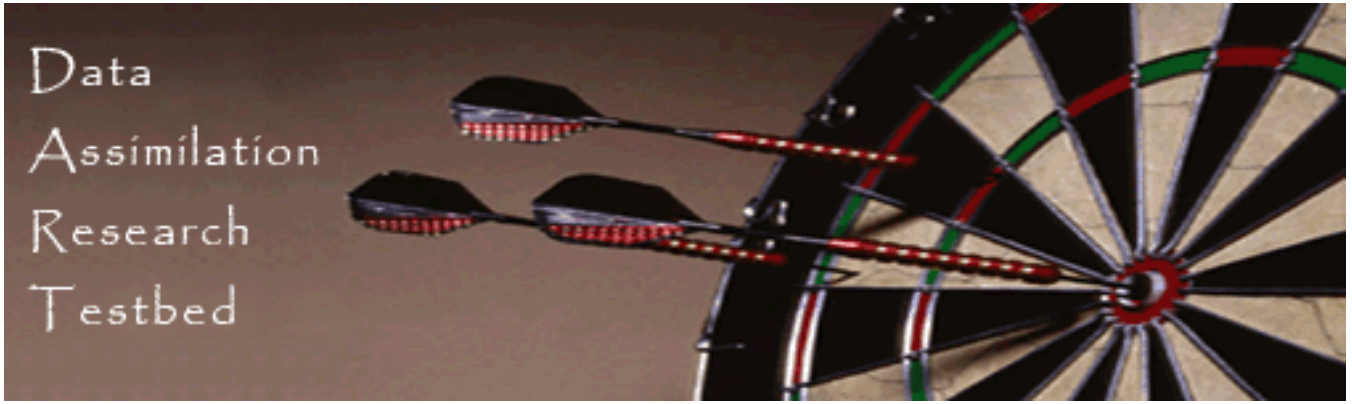


CESM, CLM, Observations, and Assimilation



Tim Hoar: *NCAR*

as well as DAReS and CSEG



Climate Modeler's Commandments

by John Kutzbach (Univ. of Wisconsin).

1. Thou shalt not worship the climate model.
2. Thou shalt not worship the climate model, but thou shalt honor the climate modeler, that it might be well with thee.
3. Thou shalt use the model that is most appropriate for the question at hand.
4. Thou shalt not change more than one thing at a time at first.
5. In making sensitivity experiments, thou shalt hit the model hard enough to make it notice you.
6. Thou shalt not covet fine-scale results with a coarse-scale model.
7. Thou shalt follow the rules for significance testing and remember the model's inherent variability.
8. Thou shalt know the model's biases and remember that model biases may lead to biased sensitivity estimates.
9. Thou shalt run the same experiment with different models and compare the results.
10. **Thou shalt worship good observations of the spatial and temporal behavior of the earth system. Good models follow such observations. One golden observation is worth a thousand simulations.**



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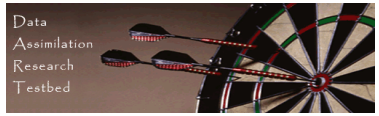
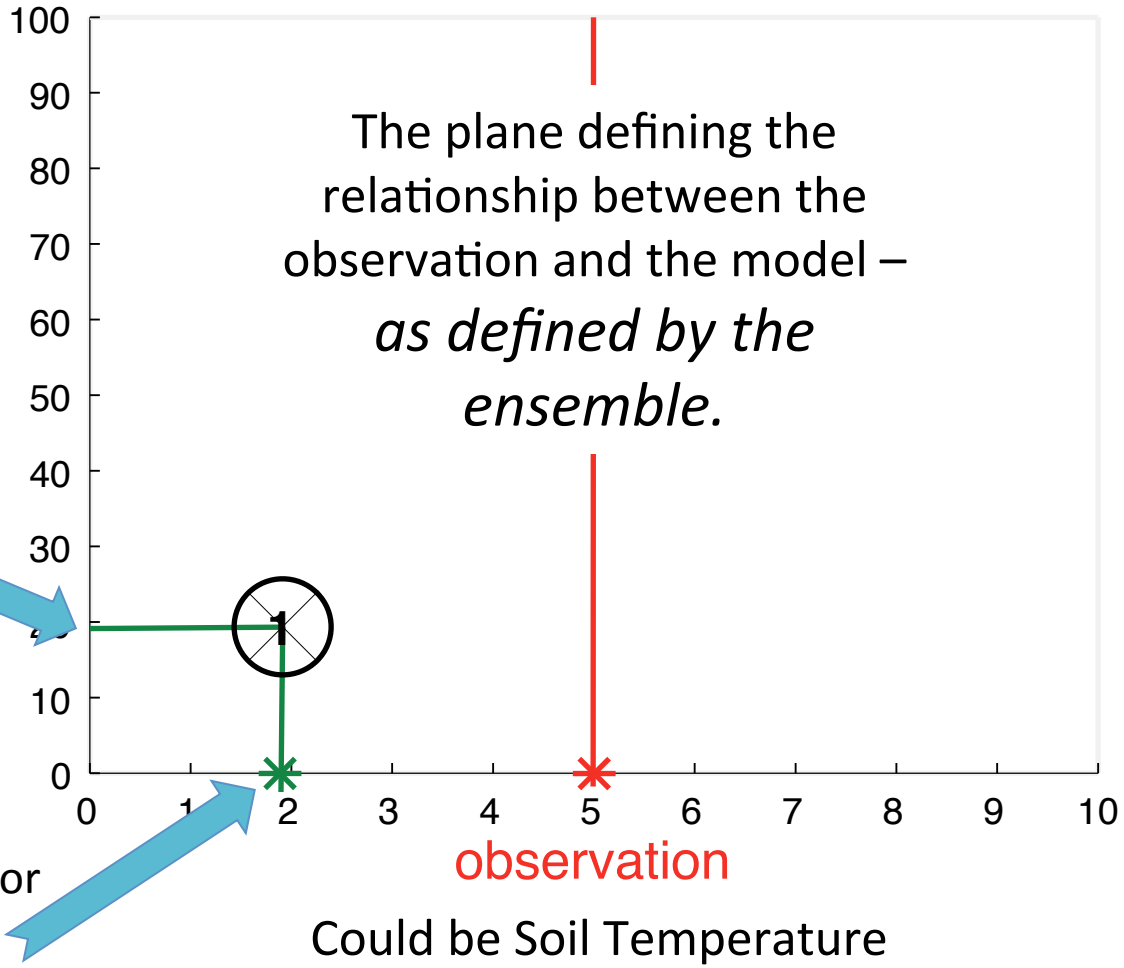
Amen Brother!



Visual Guide to Ensemble Data Assimilation

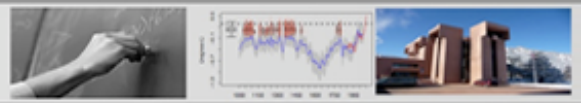
Some unobserved state variable. e.g. live root carbon, dead root carbon, canopy water …



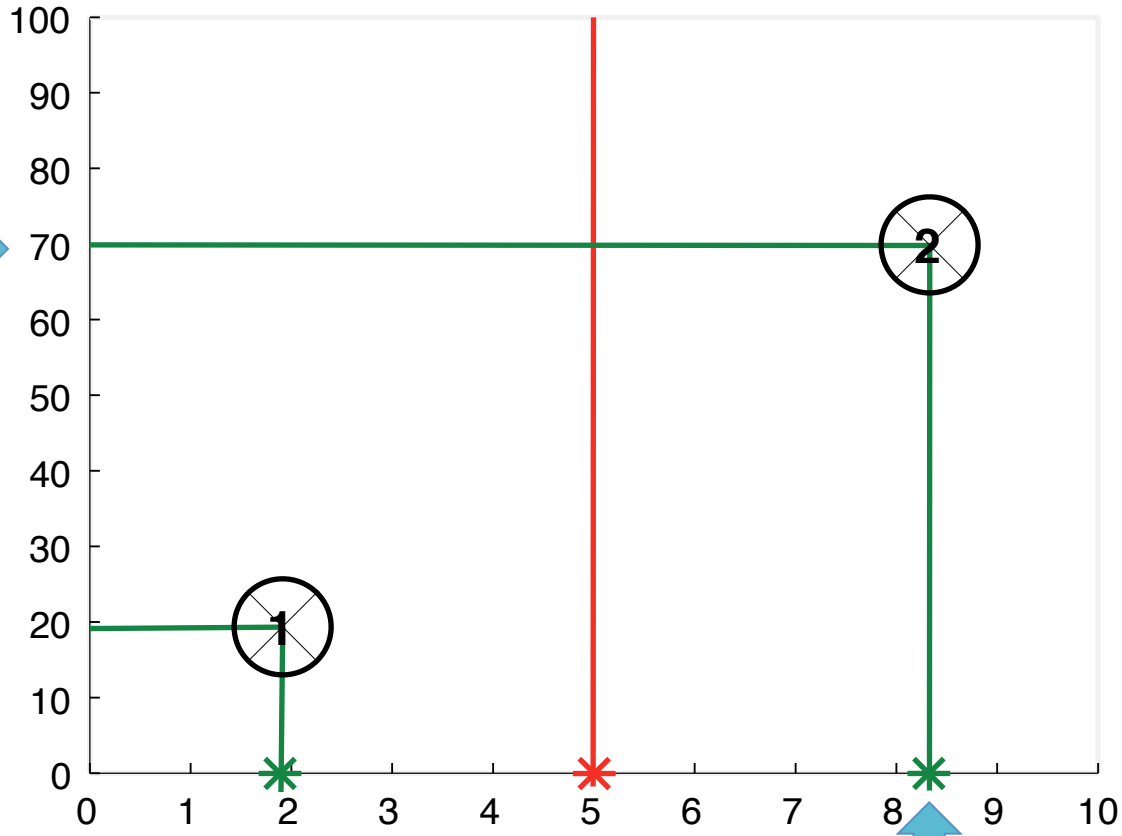
Directly from ensemble member 1

Result of the forward observation operator for ensemble member 1

Could be Soil Temperature

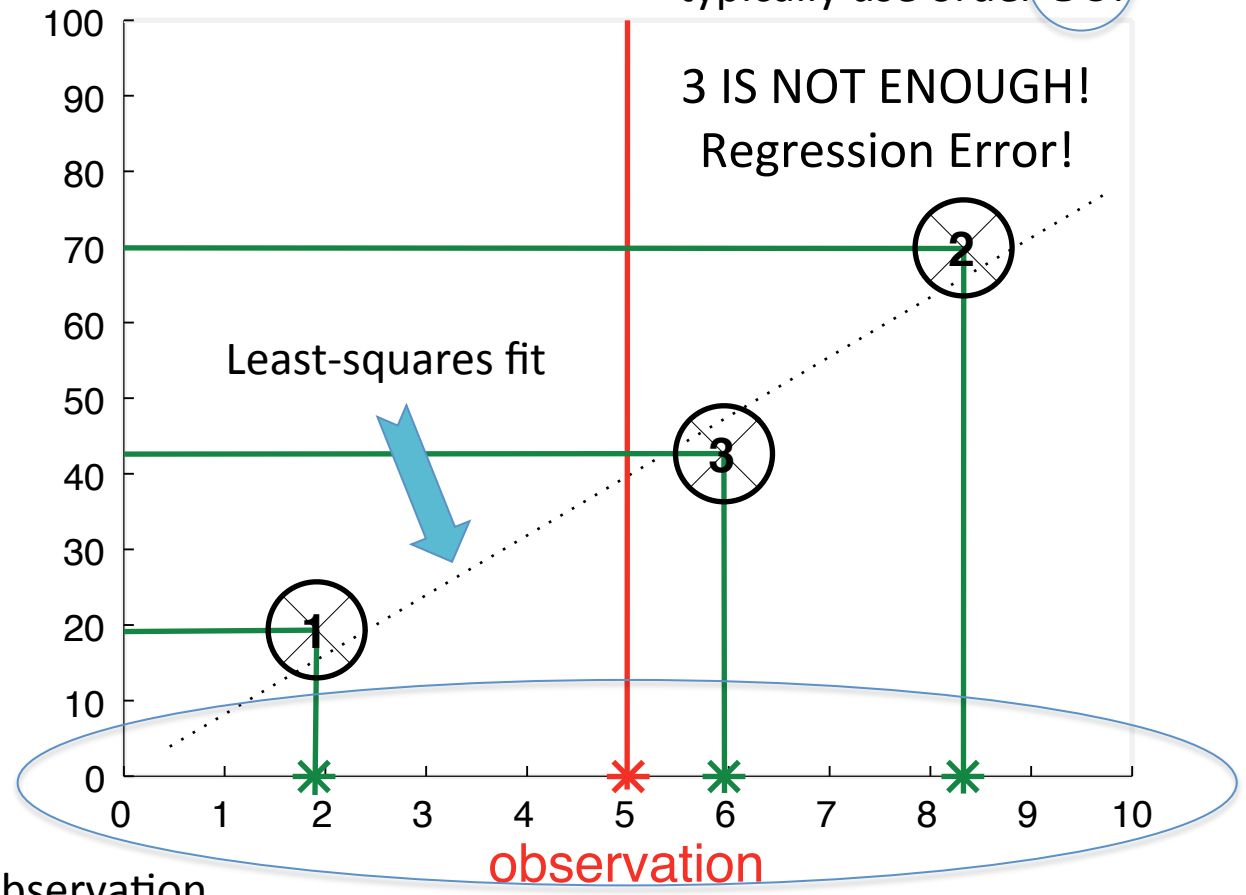


Directly from ensemble member 2



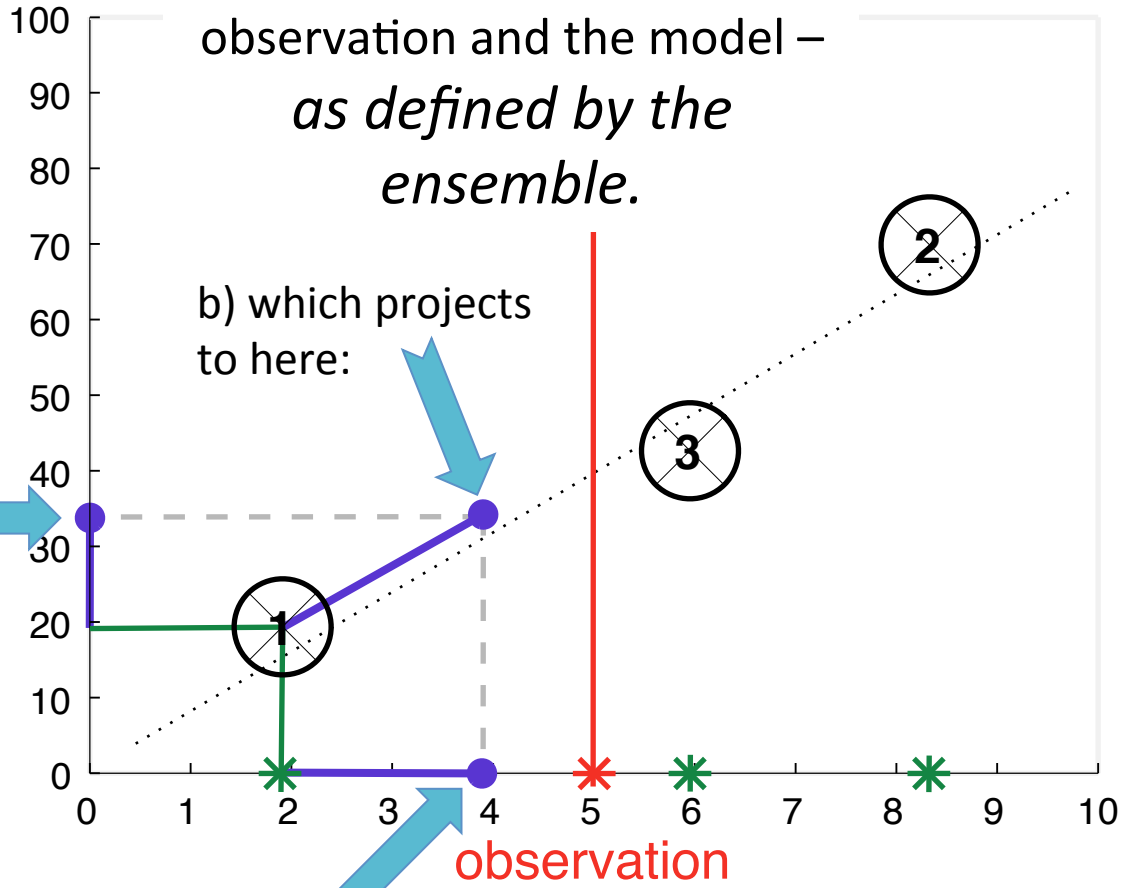
"observation" from ensemble member 2

In our assimilations, we typically use order 80.



Now, we can calculate out observation increments any way we want.

The plane defining the relationship between the observation and the model – *as defined by the ensemble.*



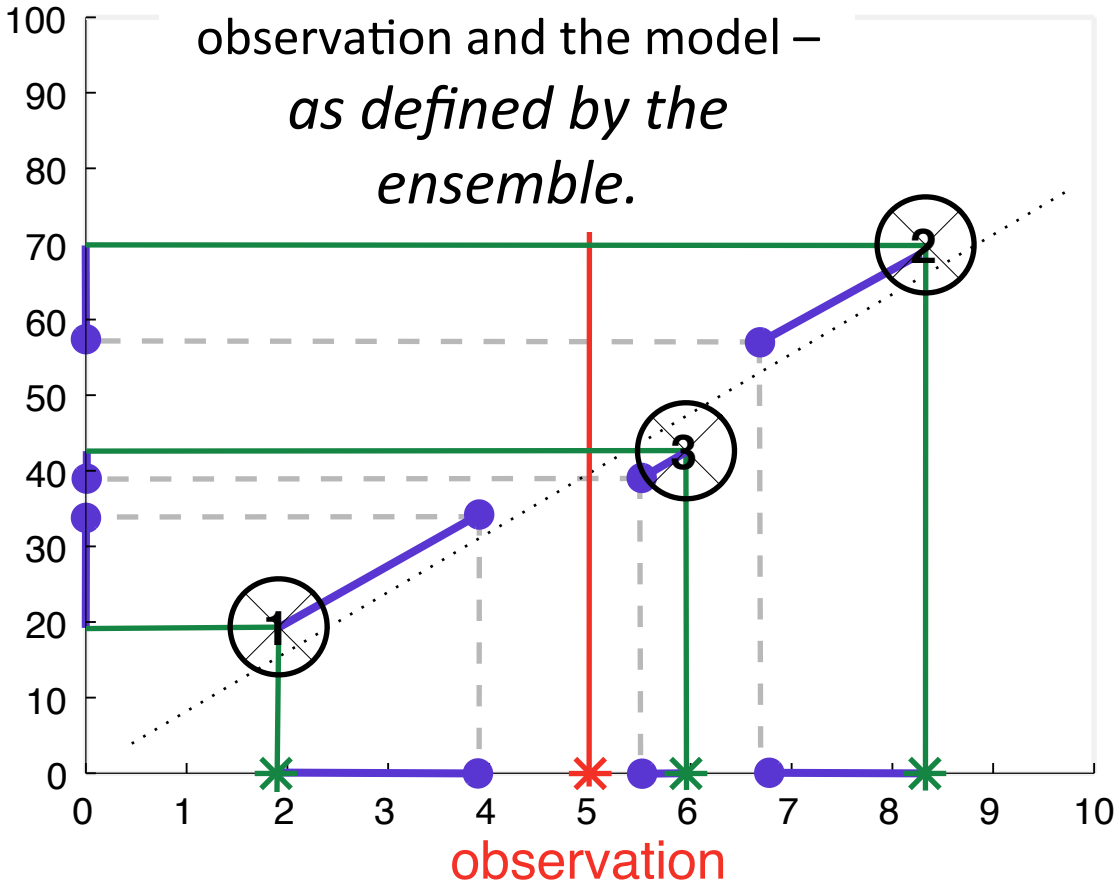
c) Which means the unobserved Posterior should be:

b) which projects to here:

a) The "observation" Posterior for member 1

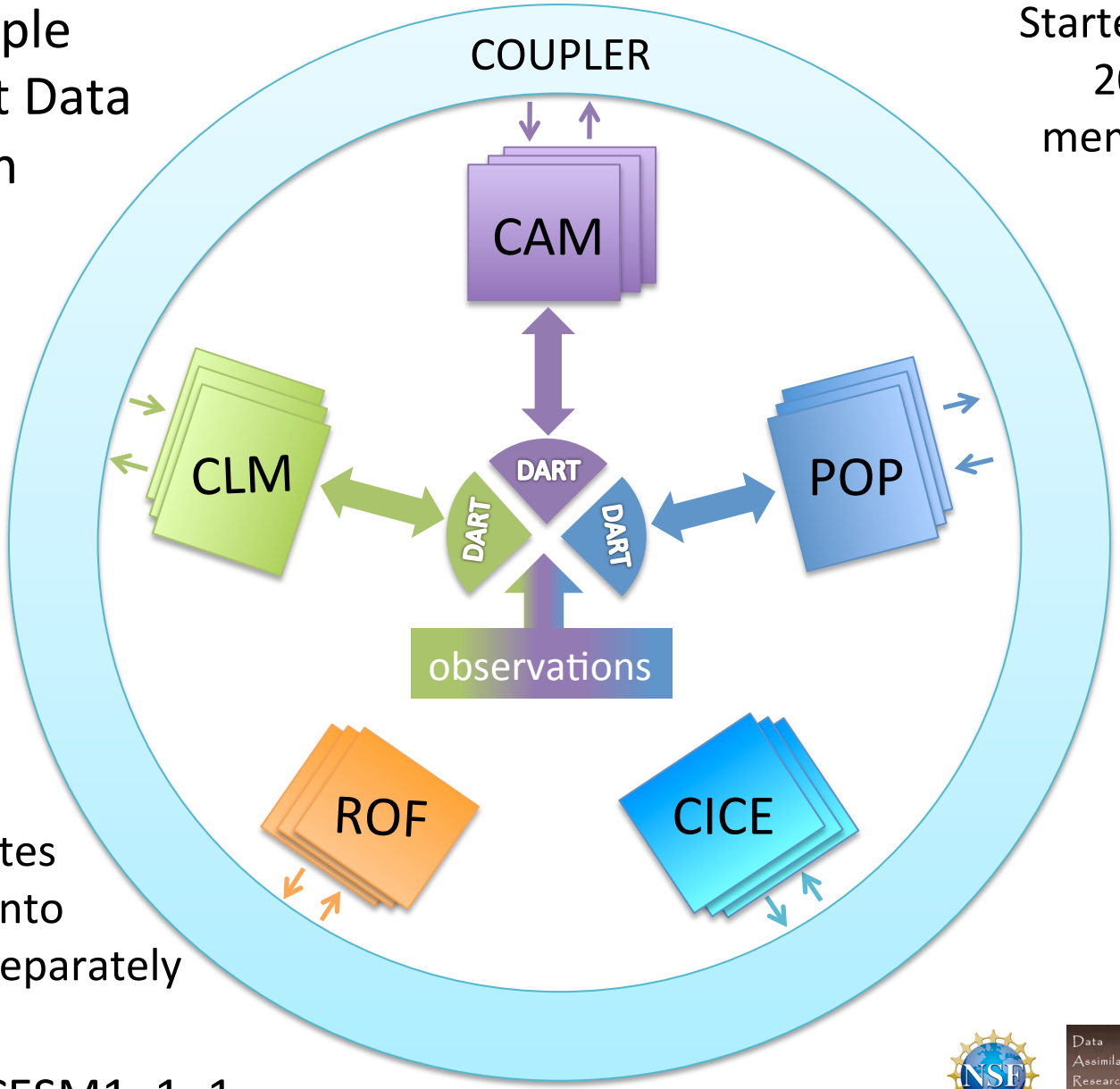
Any part of the model:
snow cover fraction,
root carbon,
canopy water …
Could even be a model parameter!

The plane defining the relationship between the observation and the model – *as defined by the ensemble.*



Could be Soil Temperature

DART Multiple Component Data Assimilation



Started with CCSM4 20th Century 30-member ensemble for all model components

Important! There are *multiple* instances of each model component.

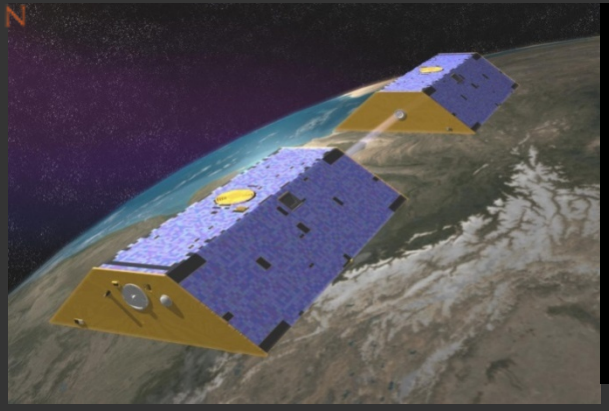
Abhishek Chatterjee is doing this now!

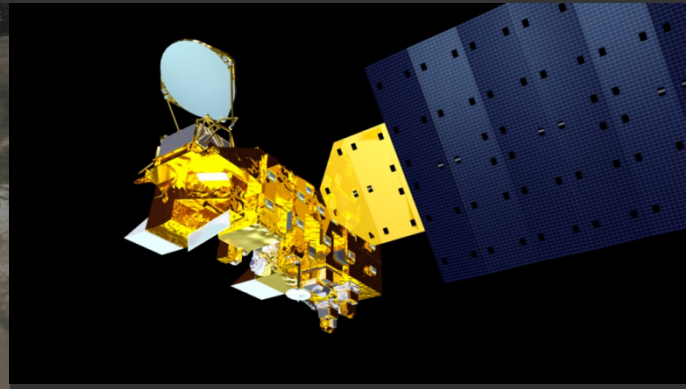
DART assimilates observations into components separately

B compset CESM1_1_1

Some of the researchers using CLM/DART

- **Yong-Fei Zhang** (UT Austin)
  - multisensor snow data assimilation
- **Andy Fox** (NEON)
  - flux observations/state estimation
- **Hanna Post** (Jülich)
  - assimilation & parameter estimation
- **Raj Shekhar Singh** (UC Berkeley)
  - groundwater
- **Long Zhao** (UT Austin)
  - AMSR-E radiances, empirical vegetated surface RTM, soil moisture (SMAP)
- **Ally Toure** (NASA-Goddard USRA)
  - brightness temperatures
- **Yonghwan Kwon** (UT Austin)
  - sensitivity of assimilation of brightness temperatures from multiple radiative transfer models on estimates of snow water equivalent.





Improving Estimates of Snowpack Water Storage in the Northern Hemisphere Through a Newly Developed Land Data Assimilation System

Yong-Fei Zhang[1], Zong-Liang Yang[1,2], Yonghwan Kwon[1], Tim J. Hoar[3], Hua Su[1], Jeffrey L. Anderson [3], Ally M. Toure [4,5], and Matthew Rodell [5]

[1]Jackson School of Geosciences, University of Texas at Austin, Austin, TX, United States.

[2]Key Lab of Regional Climate-Environment for Temperate East Asia (RCE-TEA), Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing, China.

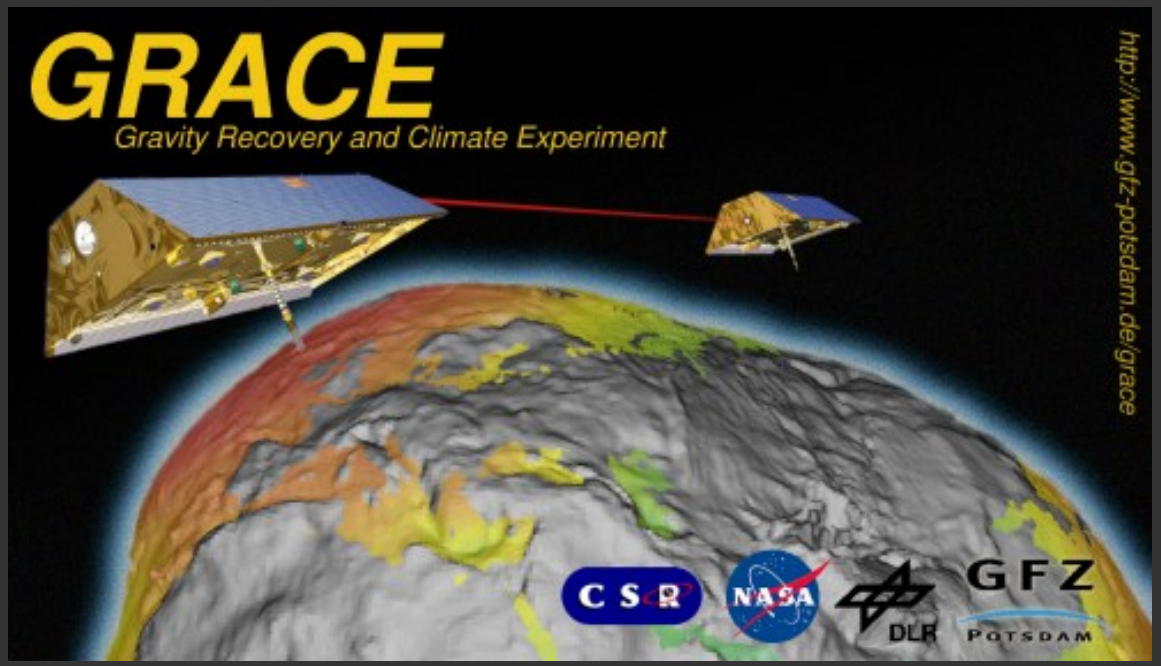
[3]The National Center for Atmospheric Research, Boulder, CO, United States.

[4]Universities Space Research Association (USRA), Columbia, MD, United States.

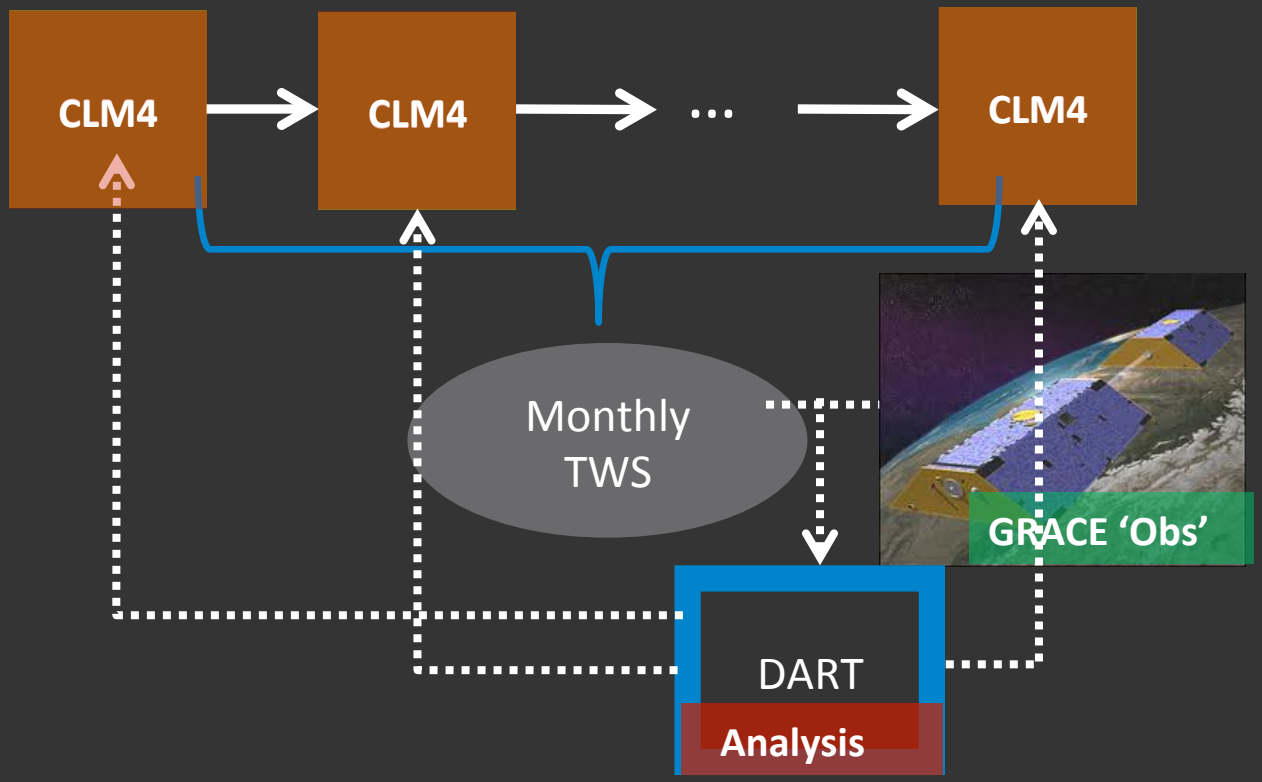
[5]NASA Goddard Space Flight Center, Greenbelt, MD, United States.

GRACE satellite data

- Different from MODIS that measures radiances, GRACE measures the distance between two satellites and retrieves gravitational anomalies. One of the products is a change in monthly total water storage (TWS).



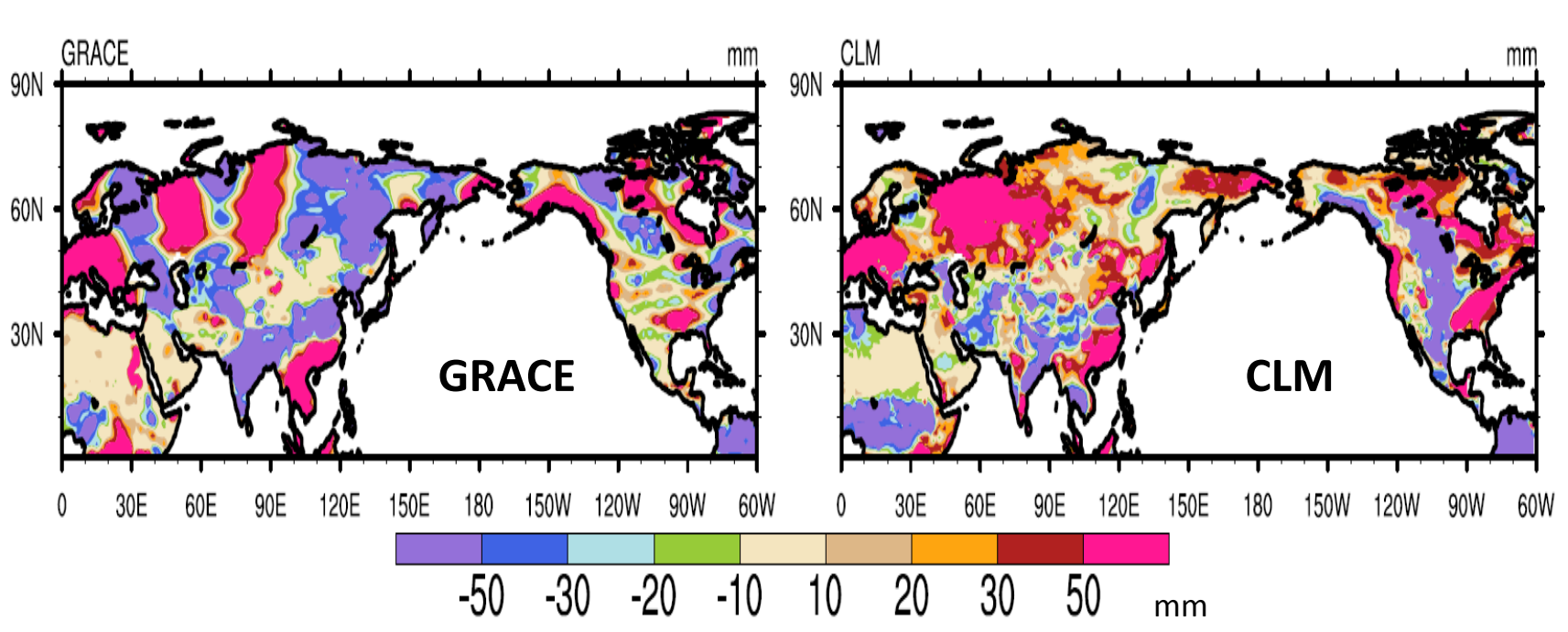
Two passes in GRACE data assimilation



1 Run CLM for one month to be able to calculate change in monthly total water storage.
2 Re-run CLM with data assimilation.

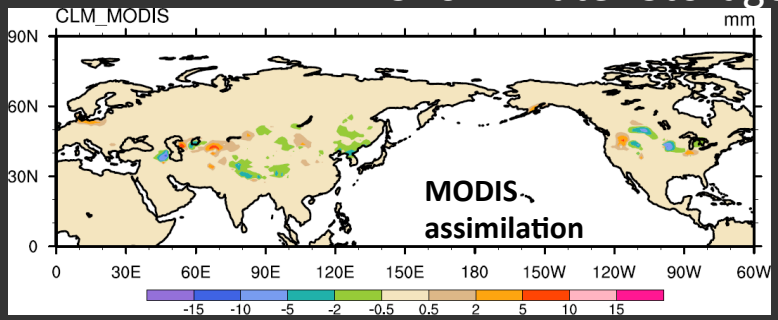
Total Water Storage change Jan 2003

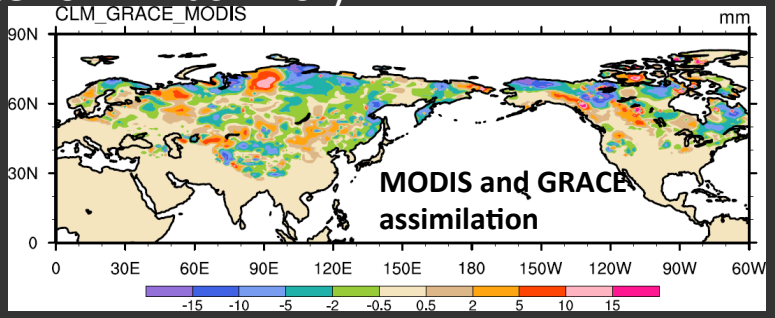
No assimilation.

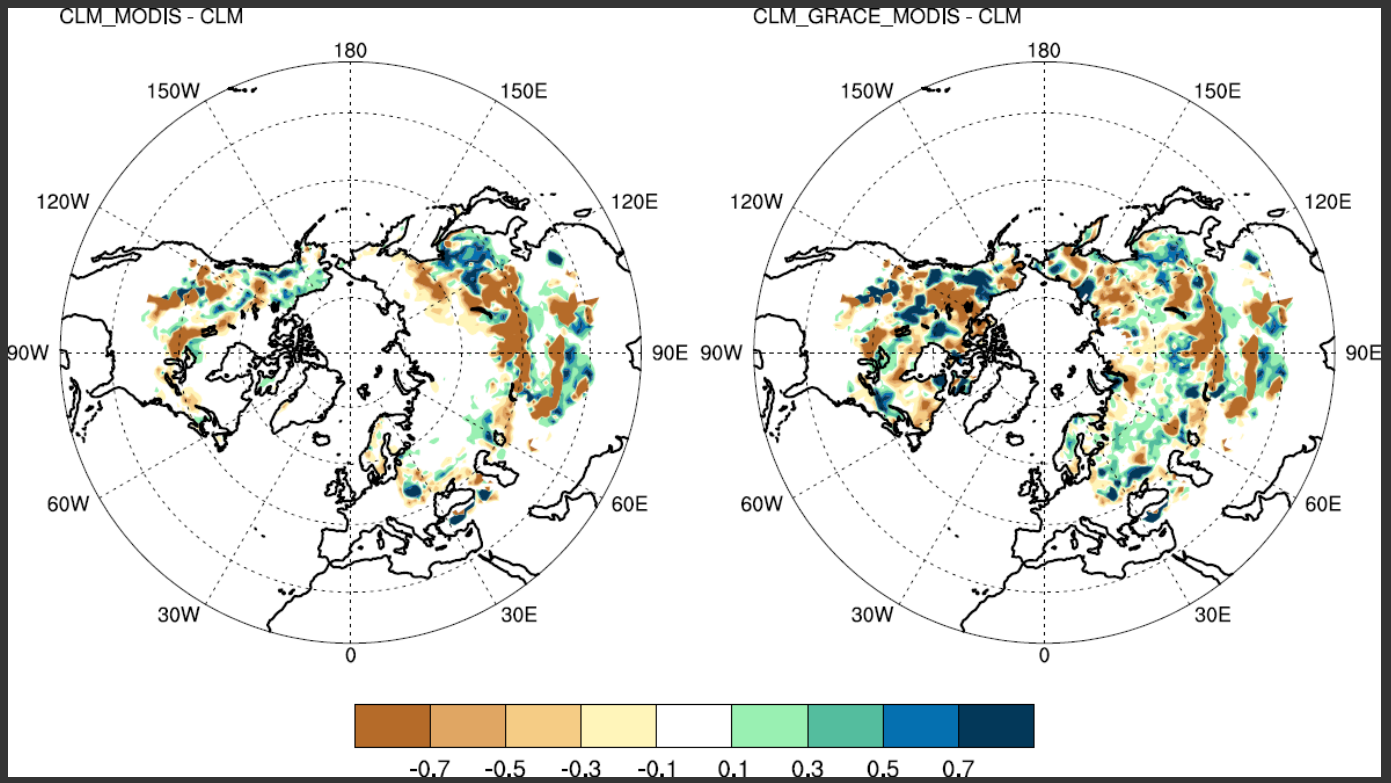


Assimilation Results

Snow Water Storage (Posterior minus Prior)



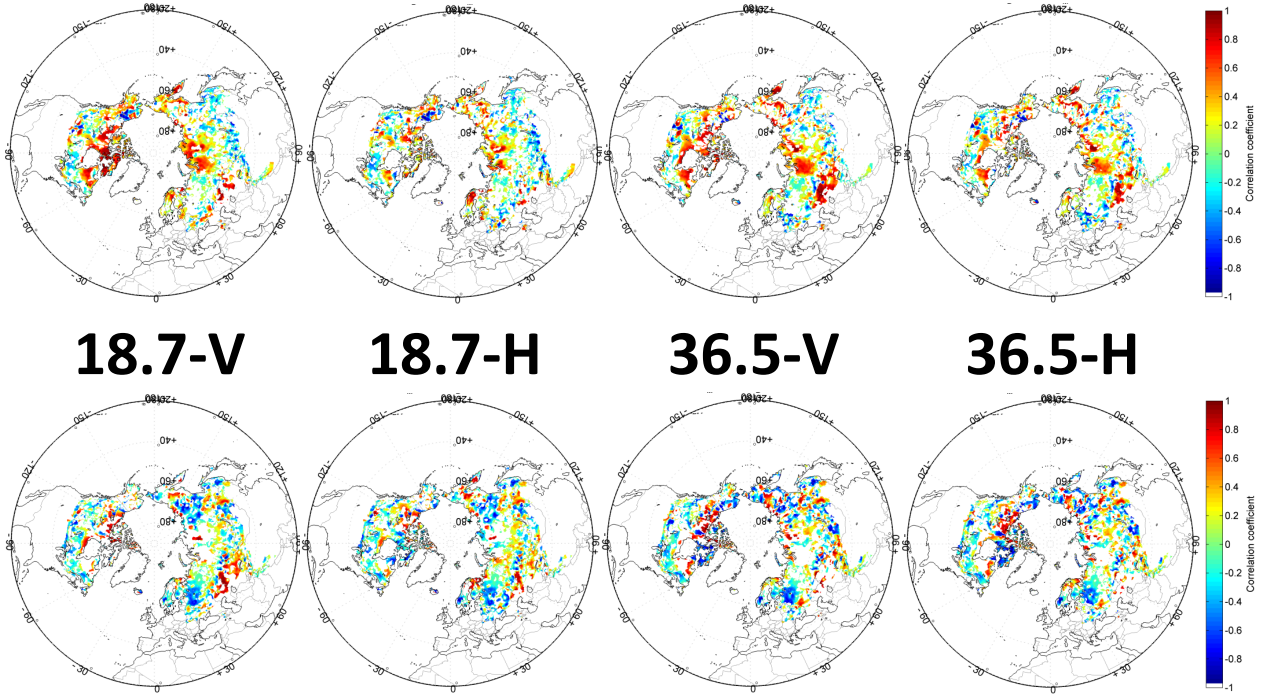




Multi-RTM ensemble approaches in SWE assimilation.

Yonghwan Kwon, UT Austin

Develop an advanced radiance assimilation scheme to estimate SWE at continental scale by using multiple snowpack RTMs: Microwave Emission Model for Layered Snowpacks (**MEMLS**) and Dense Media Radiative Transfer – Multi Layers model (**DMRT-ML**).



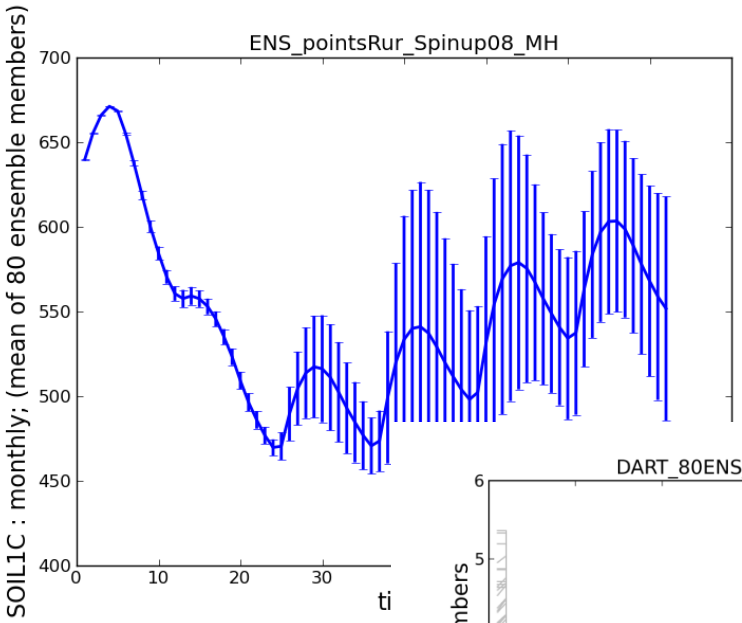
CLM4 & MEMLS

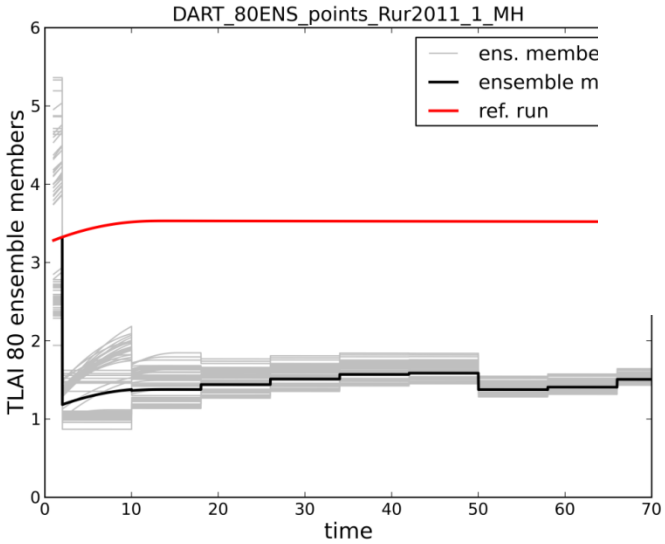
Correlations between:

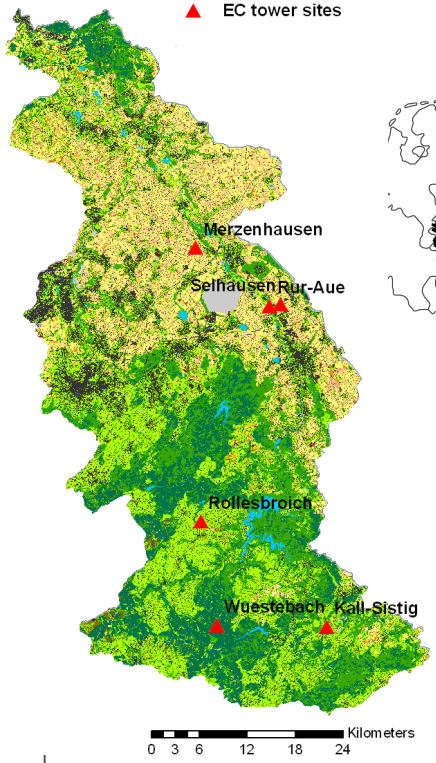
CLM4 & DMRT-ML

MEMLS; Wiesmann and Mätzler, 1999
DMRT-ML; Picard et al., 2013

Assimilation of eddy covariance fluxes & MODIS LAI data and CLM upscale NEE from plot to catchment scale



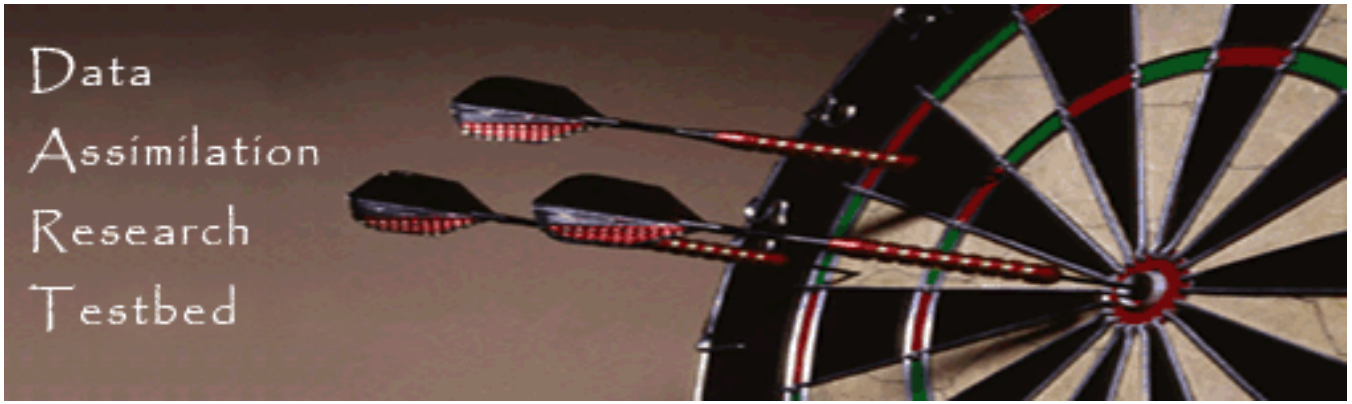




Hanna Post visited Gordon Bonan, Andy Fox and me for 3 months earlier this year.

For more information:

CAM GITM WACCM WRF CLM POP AM2 BGRID COAMPS NOAH MPAS_ATM MITgcm_ocean COAMPS_nest SQG NAAPS MPAS_OCN TIEGCM PBL_1d CABLE NCOMMAS PE2LYR



www.image.ucar.edu/DAReS/DART

dart@ucar.edu