Some Emergent Constraints and Metrics on Model Evaluations over Land

Xubin Zeng, William Lytle,
Patrick Broxton, Nick Dawson
University of Arizona

Aihui Wang
Chinese Academy of Sciences

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Outline

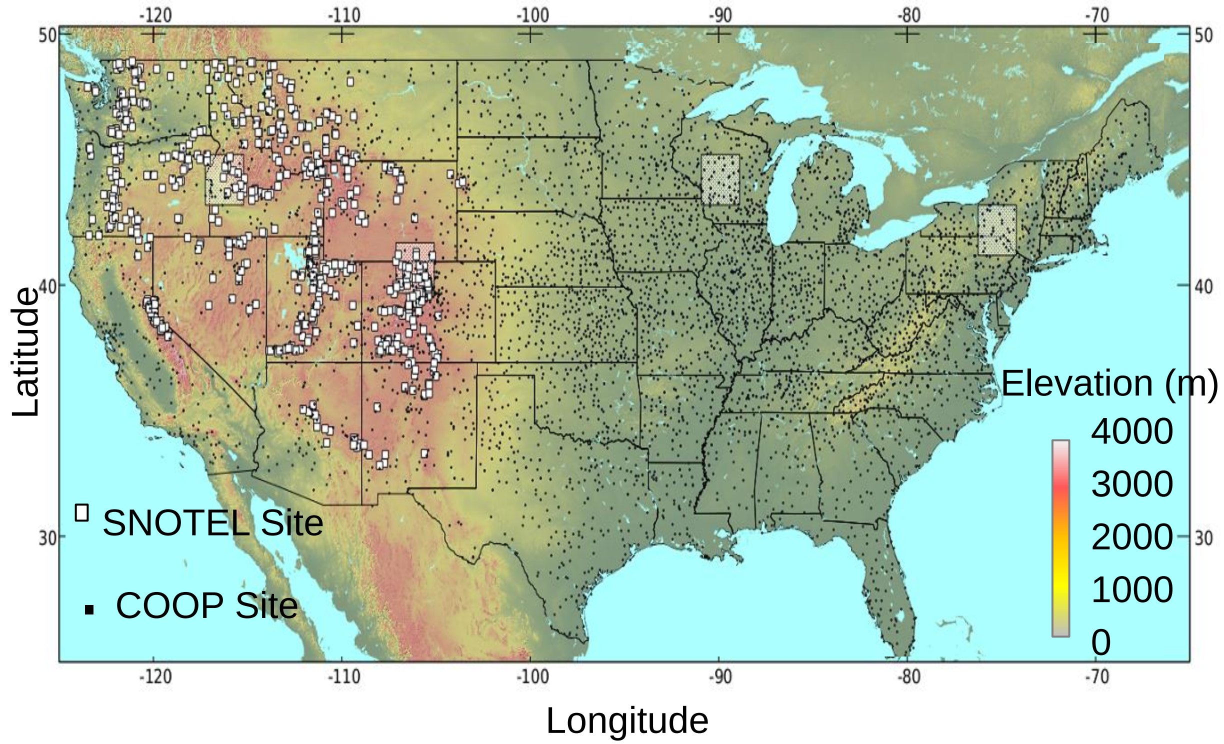
- Our daily snow water equivalent dataset over CONUS
- Our global hourly air temperature (T2m) datasets
- Flux tower data analysis
- Land-precipitation coupling strength

1. Snow water equivalent (SWE) and depth

They are difficult to measure from satellite remote sensing or to upscale from in situ point measurements to area averages

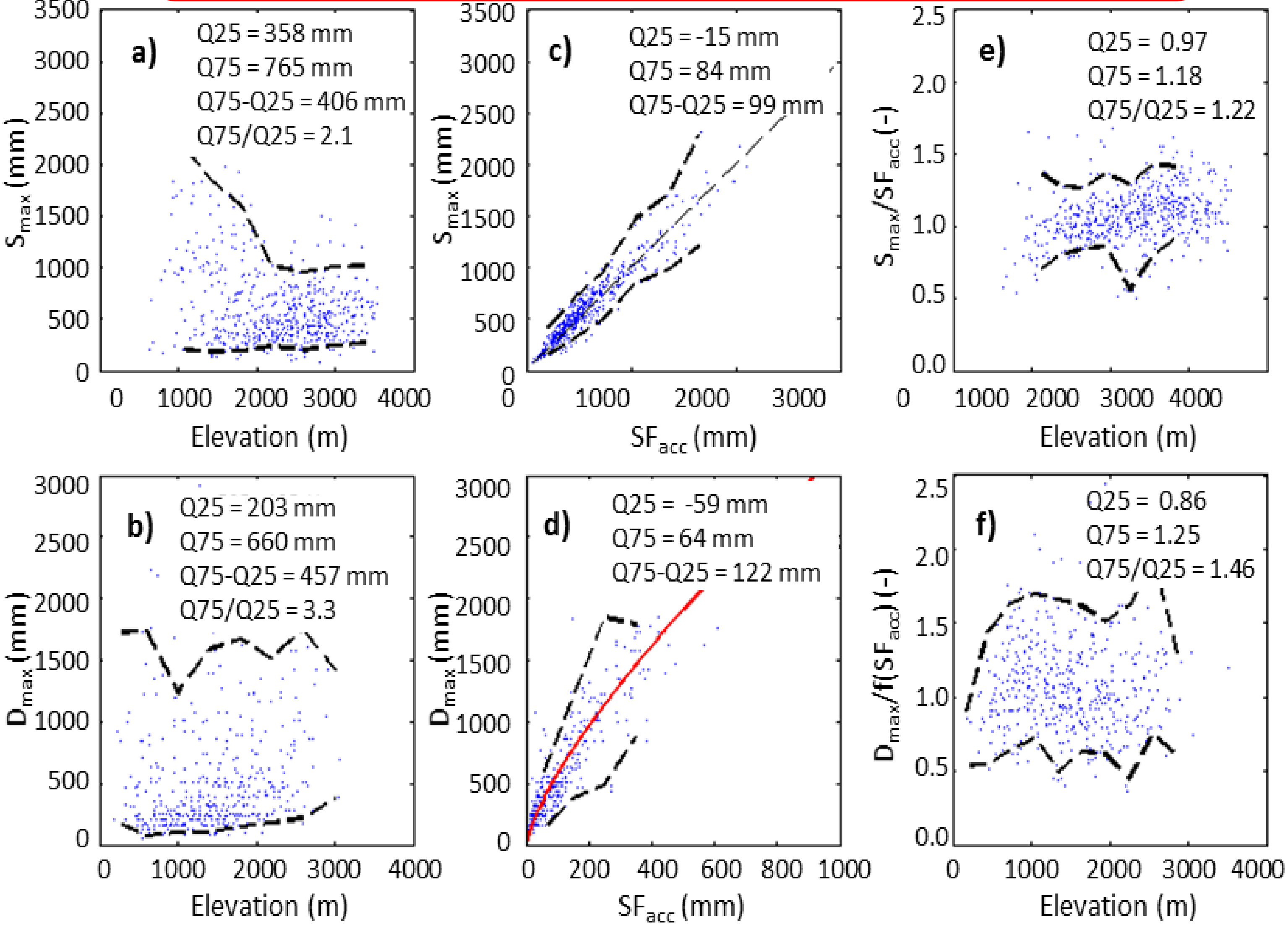
hundreds of SNOTEL sites: SWE and snow depth data;

thousands of COOP stations: snow depth data



Q: How do we upscale snow measurements from points to area averages?

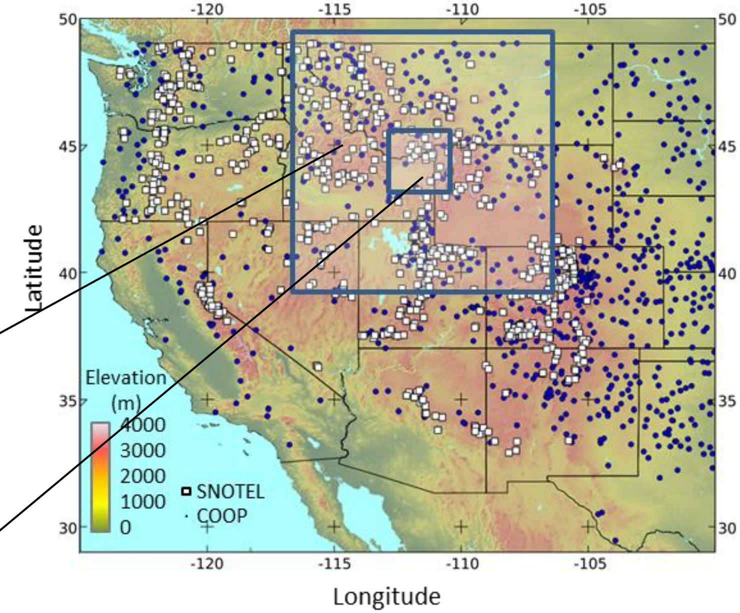
Our simple and obvious, yet effective approach: spatial interpolation based on the ratio of SWE over accumulated (snowfall – snowmelt/sublimation)

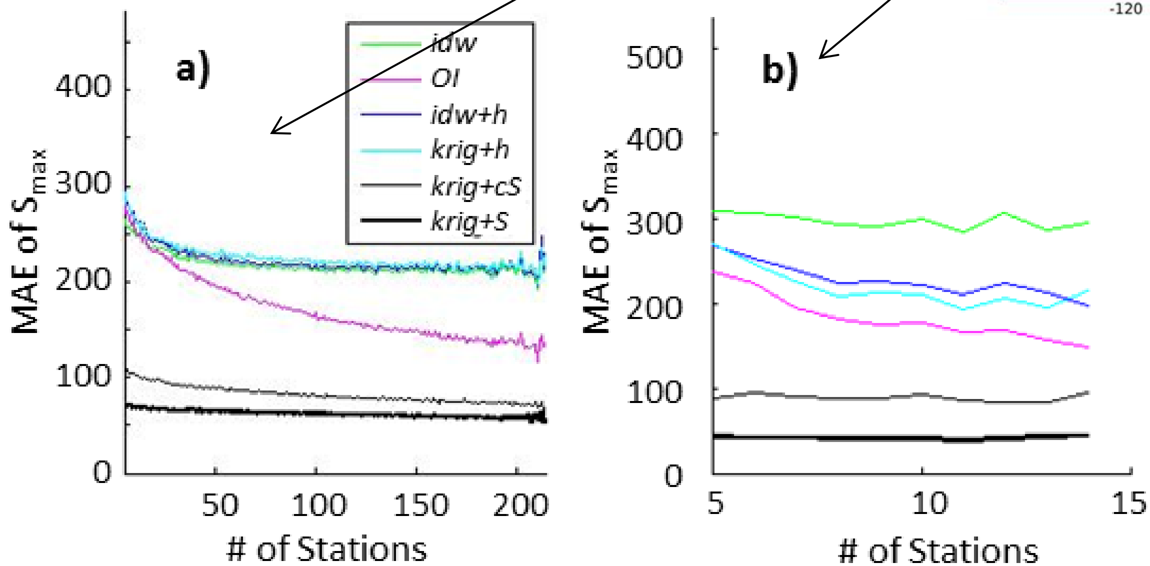


Broxton et al. (2016a)

PRISM precipitation and temperature data is combined with SWE and snow depth data from thousands of COOP and SNOTEL stations

We have generated daily 3 km SWE and snowfall datasets over CONUS

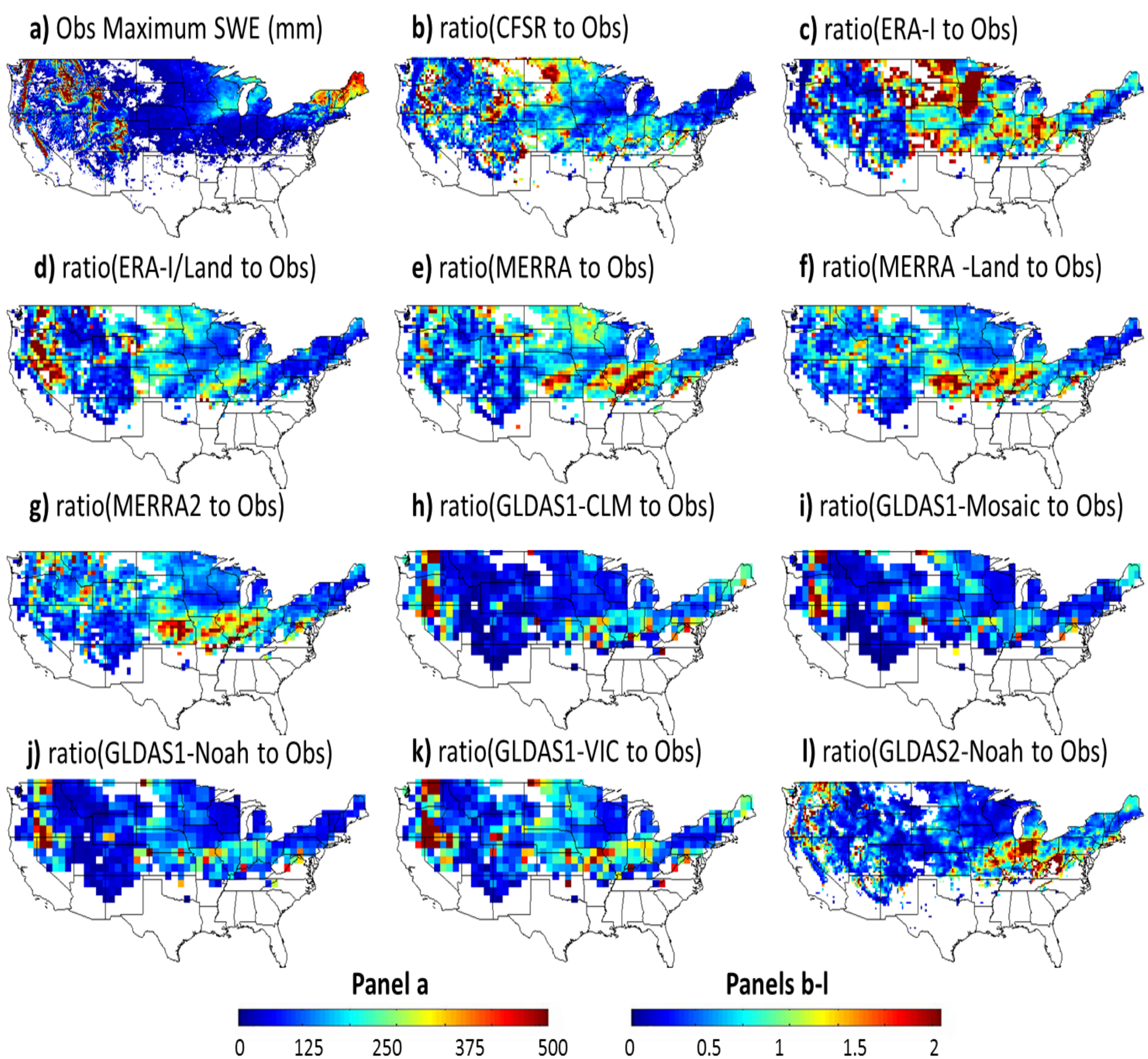




Our method based on SWE/accumulated snowfall is much better than four previous methods based on SWE itself

Panel a) max SWE according to our dataset ("OBS"), Other panels: ratios between reanalysis/GLDAS max SWE and OBS

- SWE in reanalyses and GLDAS is too low over much of CONUS



Question:

What is the main reason for this underestimate?

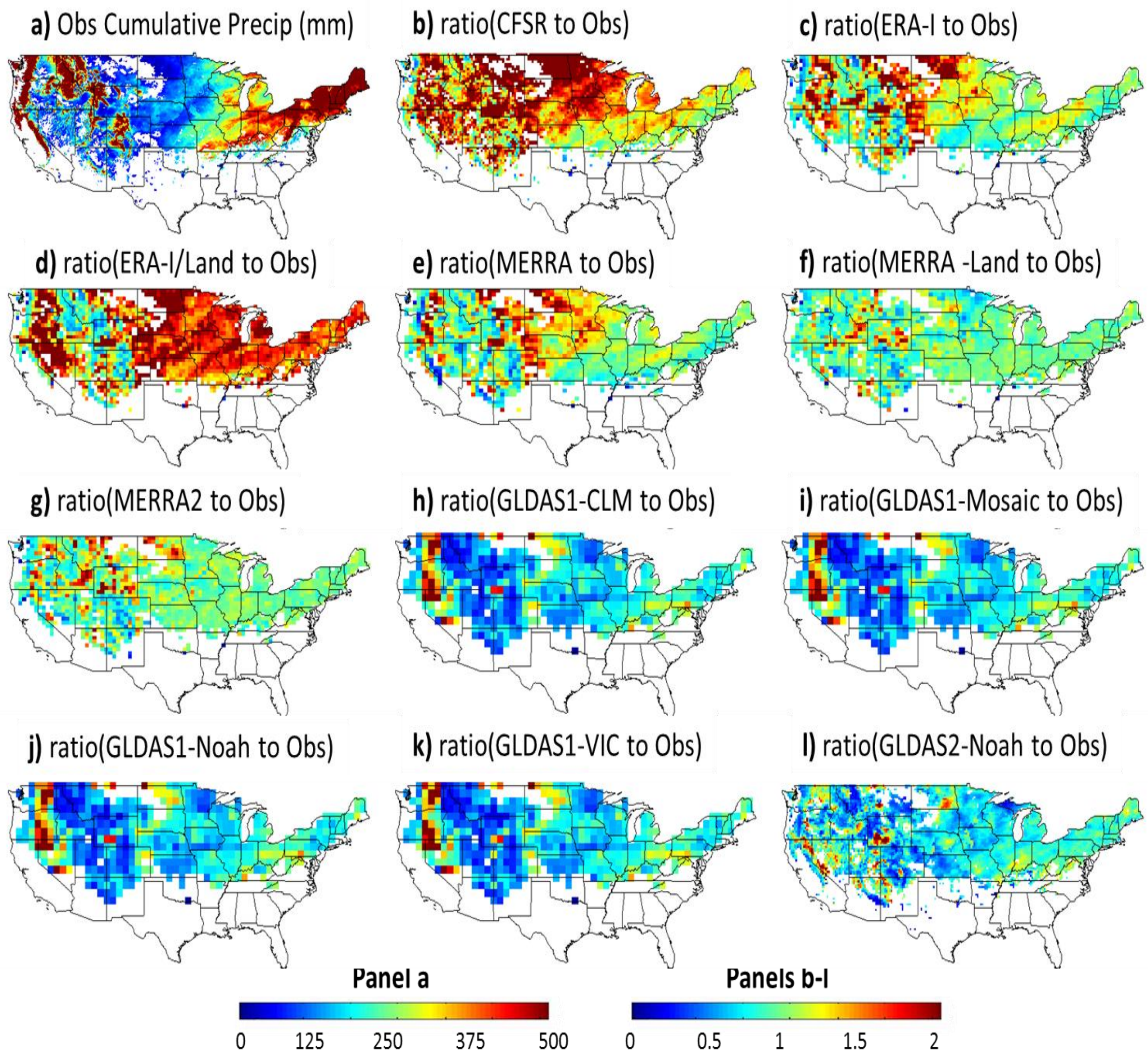
- Atmospheric forcing deficiencies?
- deficiencies in land models and snow data assimilation?

Broxton et al. (2016b)

- Some products have too much precipitation or snowfall and some have too little
- However, nearly all products have too little maximum SWE (previous slide)

Point:

- Deficiencies in atmospheric forcing data cannot explain this widespread underestimation of SWE.

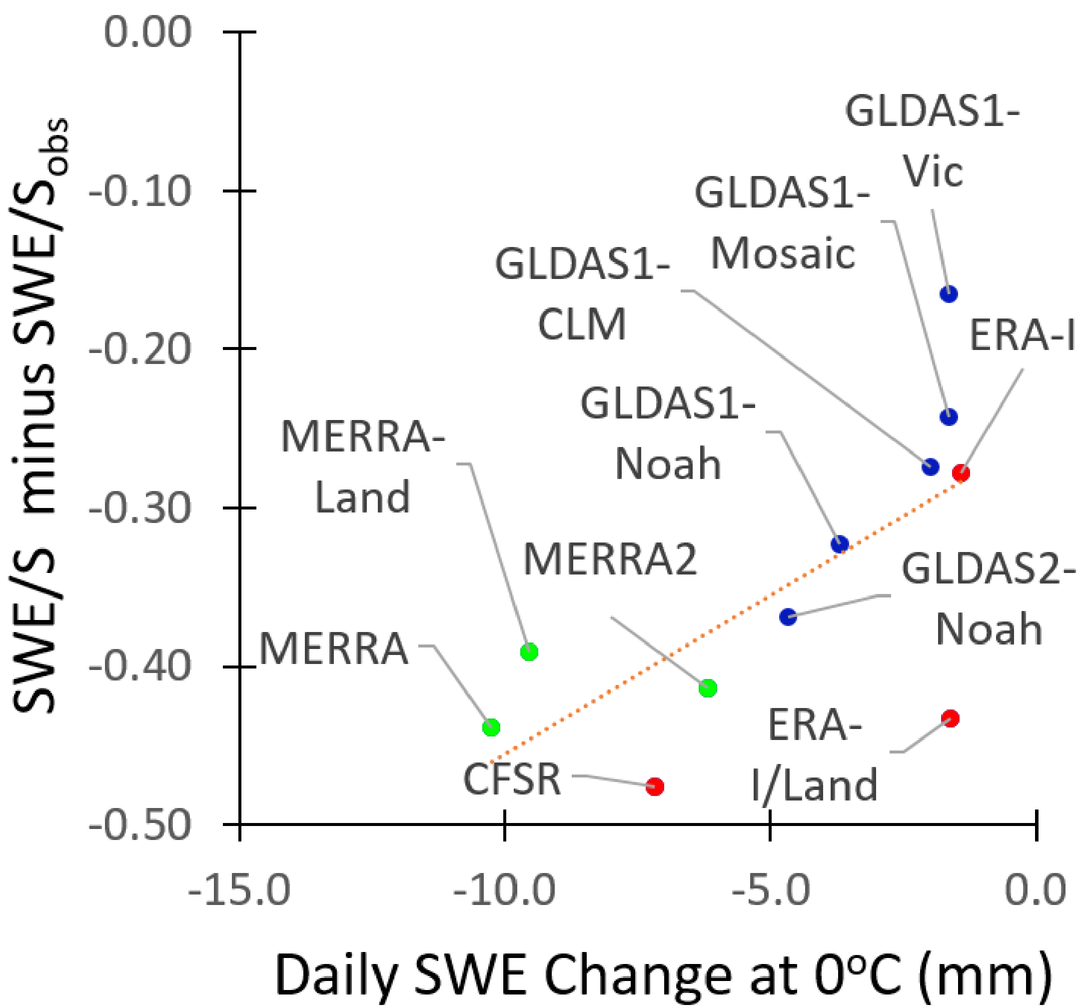


a) Cumulative snow season precipitation ("OBS"), b-l) ratios between reanalysis/GLDAS cumulative snow season precipitation and OBS

- SWE is under-predicted more severely for reanalysis products that ablate more snow near freezing point temperature

Point:

- SWE underestimation in reanalysis/GLDAS is primarily caused by deficiencies in land model (particularly snow ablation near freezing point) and snow data assimilation



Based on these results, one emergent constraint is suggested:

- evaluation of model daily SWE and its ratio over the accumulated snowfall

Our daily 3 km SWE dataset over CONUS could also be used directly for ILAMB

We will also try to develop the global SWE and snow depth data in the near future

Animation:
http://www.atmo.arizona.edu/~broxtopd/Snow%20Movies/

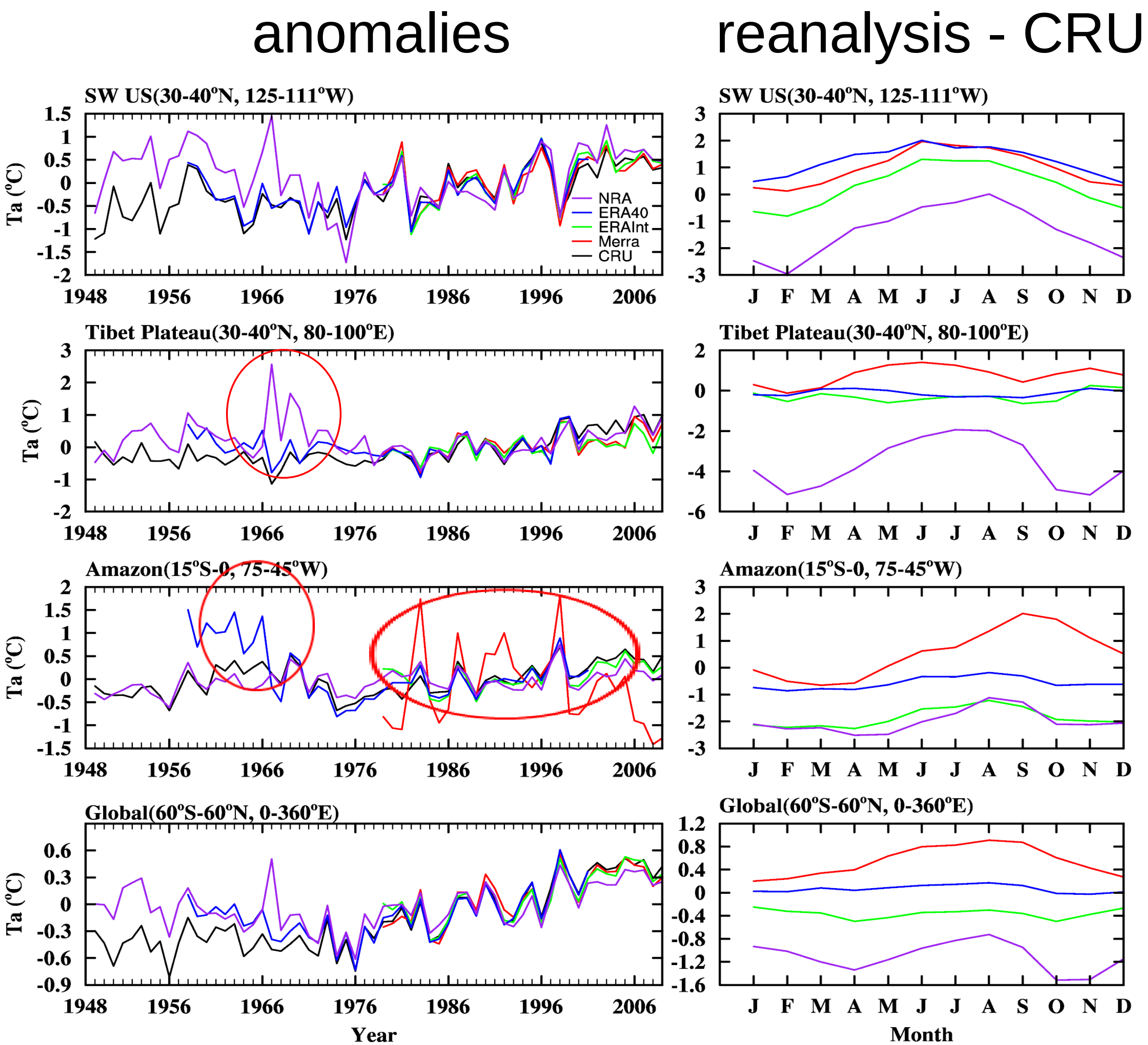
2. Our global 0.5° hourly T2m data

We have developed global 0.5°x0.5°, hourly land surface 2m temperature data sets by merging the in situ data (CRU) with various reanalyses (MERRA, ERA-Int, ERA-40, NCEP) (Wang and Zeng, 2013).

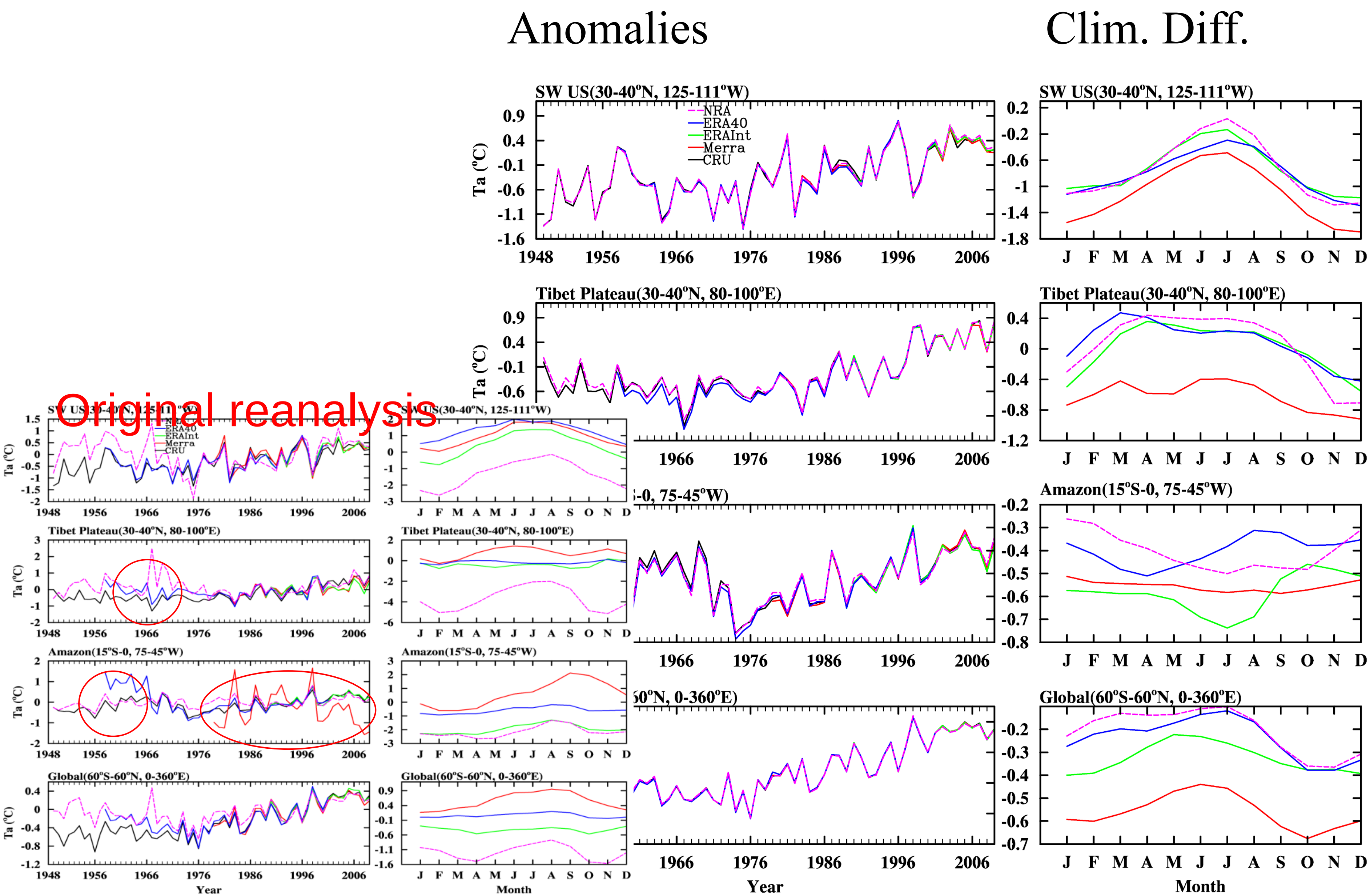
Our value-added data sets have exactly the same monthly mean values of daily maximum (Tx) and minimum (Tn) temperatures as those from CRU.

rda.ucar.edu/datasets/ds193.0/.index.html

How realistic and consistent are reanalysis Ta?

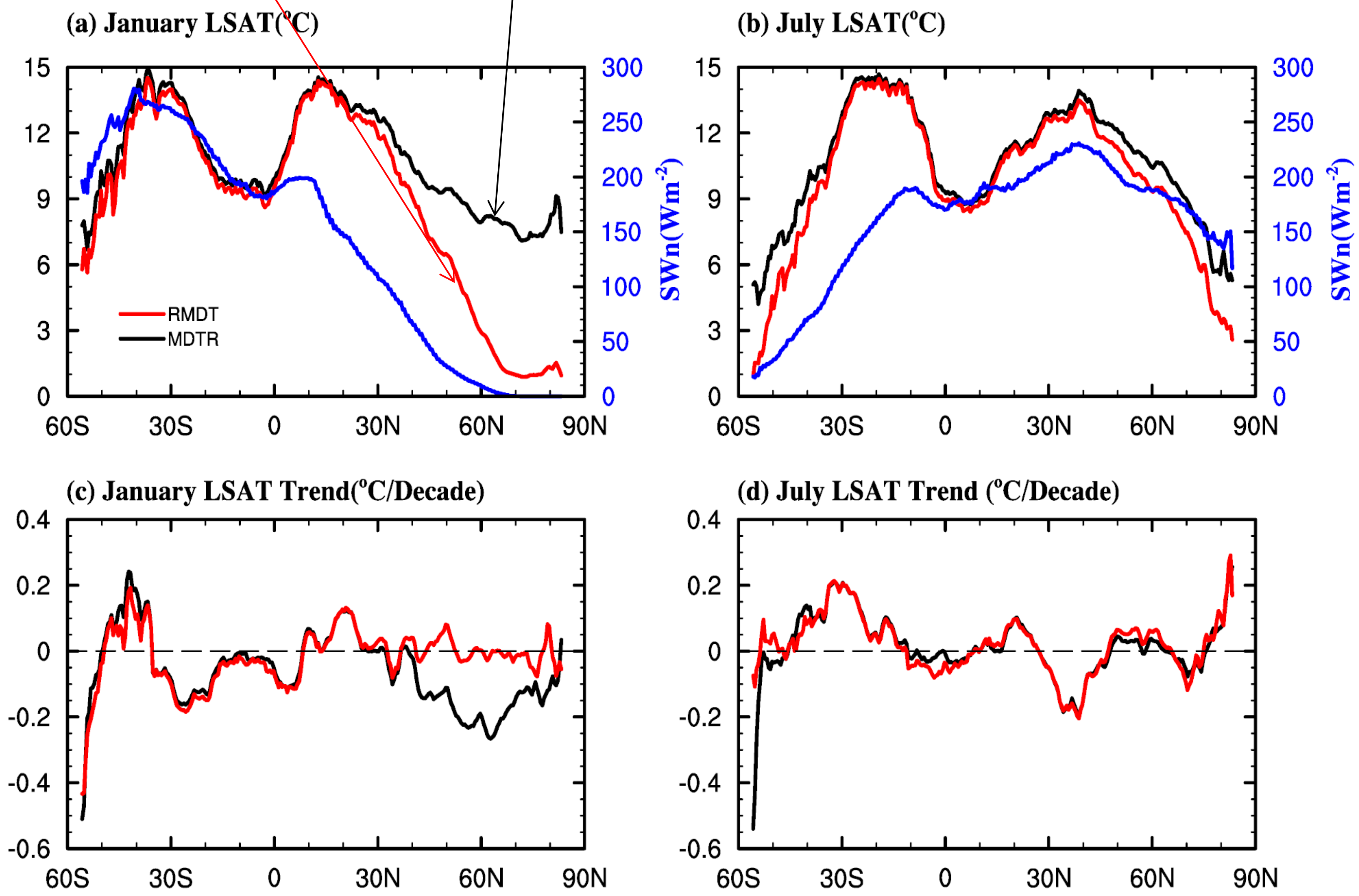


After our adjustment using CRU data
(Clim Diff also represents the Tm24 versus Tm)



MDTR (based on daily Tx and Tn)

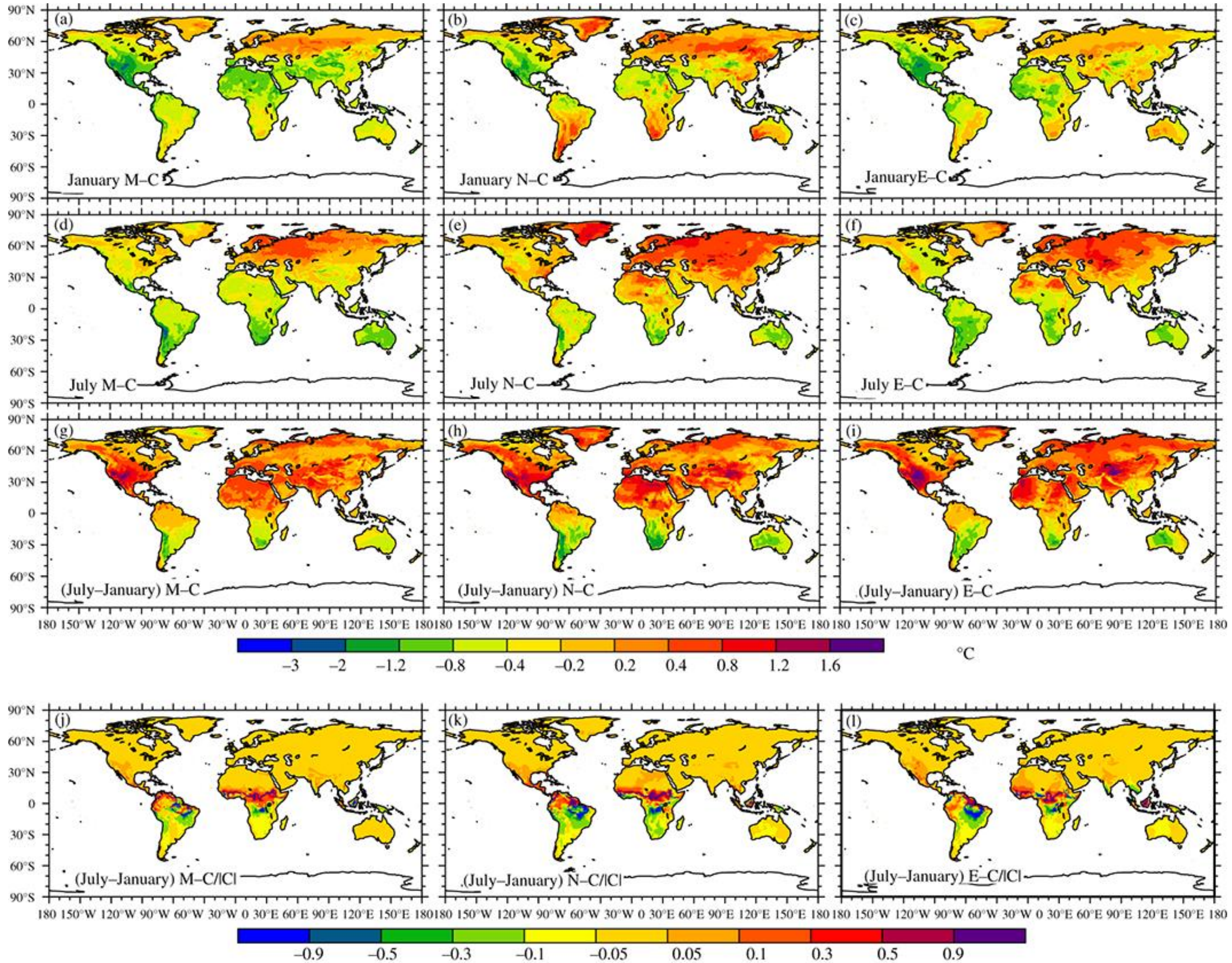
RMDT (based on monthly-averaged diurnal cycle)



http://rda.ucar.edu/datasets/ds193.0/

Wang and Zeng (2014)

Tm24 –
(Tx + Tn)/2



Wang and Zeng (2015)

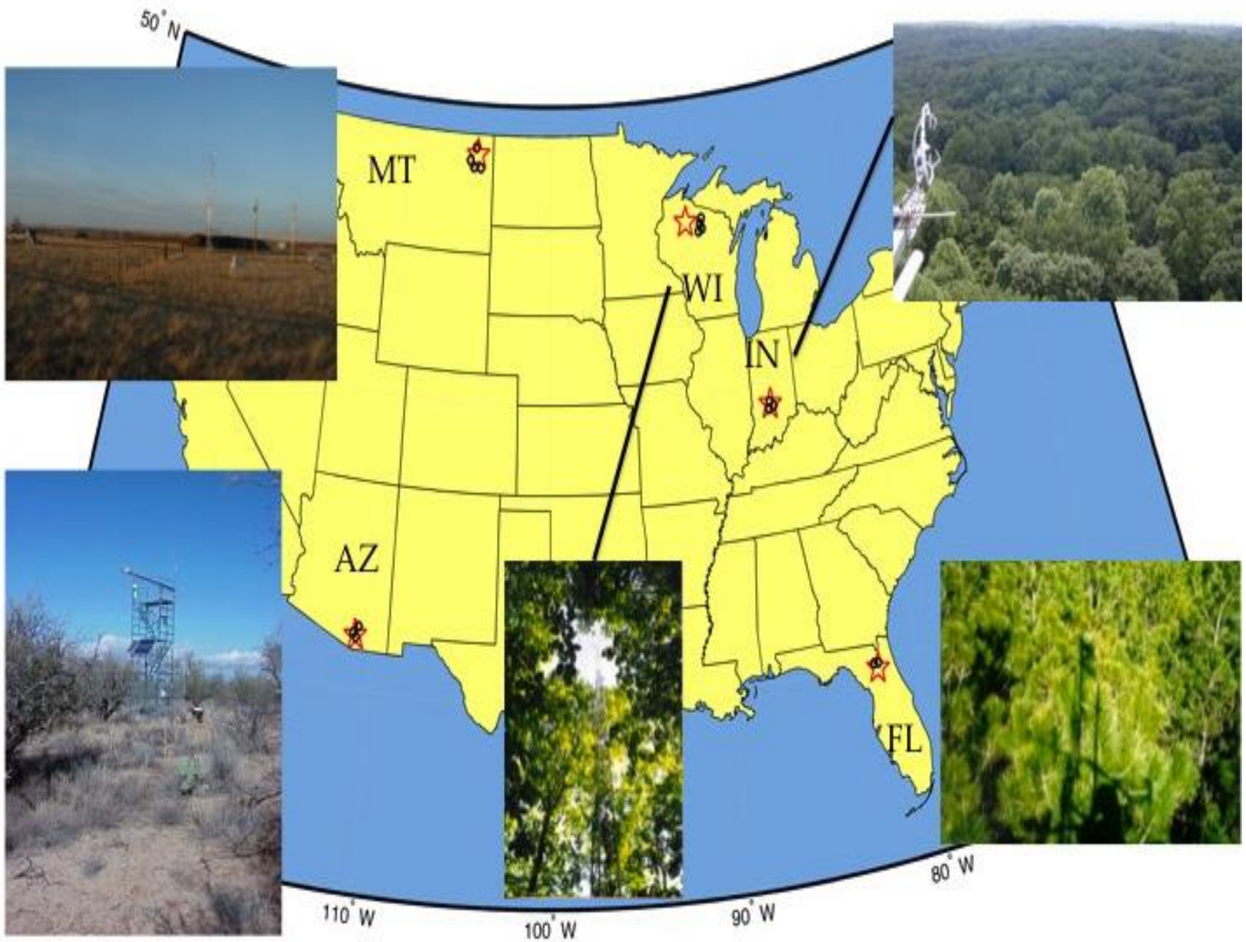
Based on these results, we make two suggestions for model land surface T2m evaluation metrics:

- To evaluate model monthly mean temperature, which is averaged over all time steps, using the true monthly mean based on 24 hourly values from our datasets, rather than using Tm = (Tx + Tn)/2

- To save monthly averaged diurnal cycle from models and compare its range with that based on our datasets, rather than using DTR = Tx - Tn.

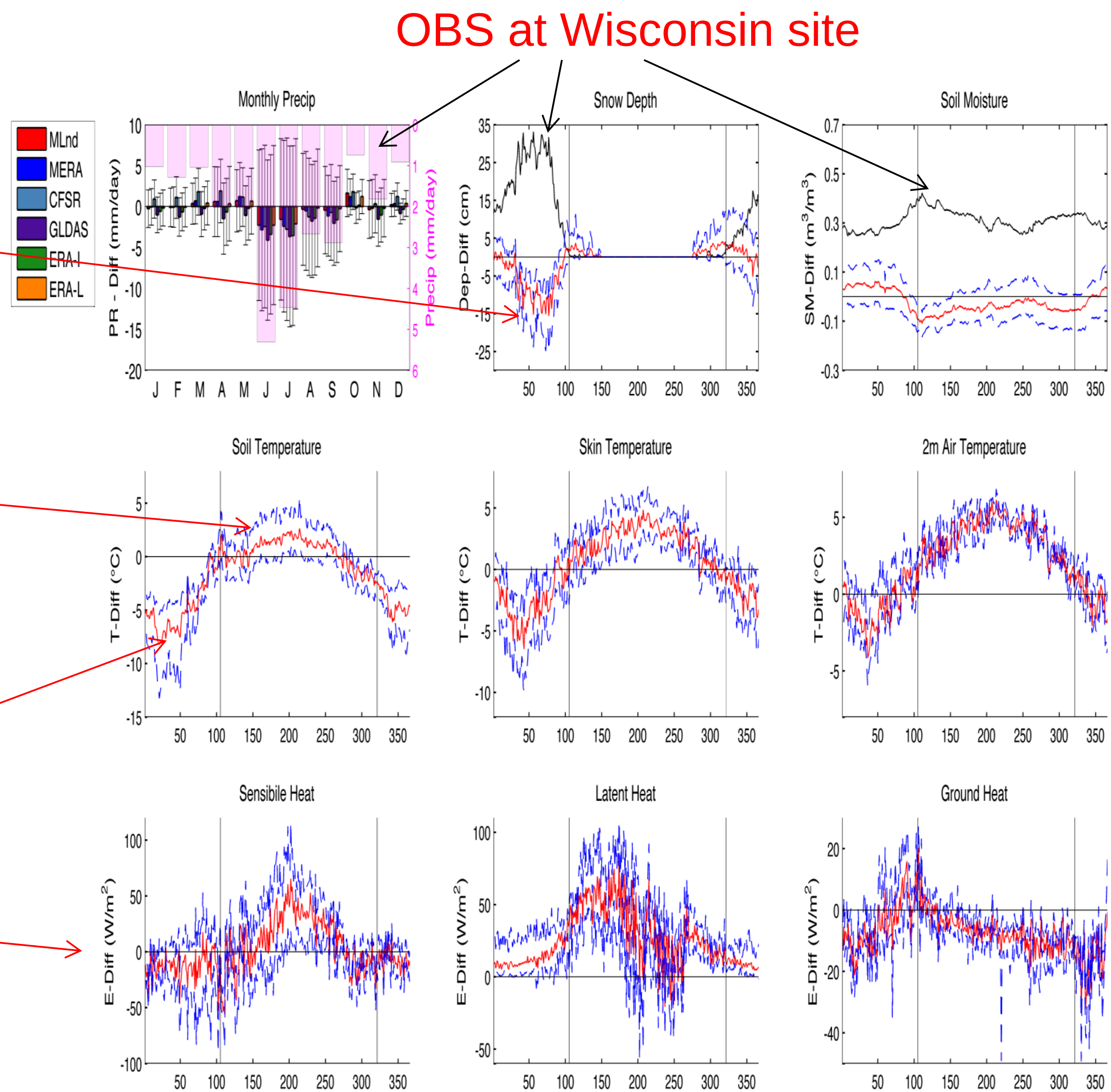
See our poster for more details.

3. Above- and below-ground processes over five flux tower sites and COOP snow depth data



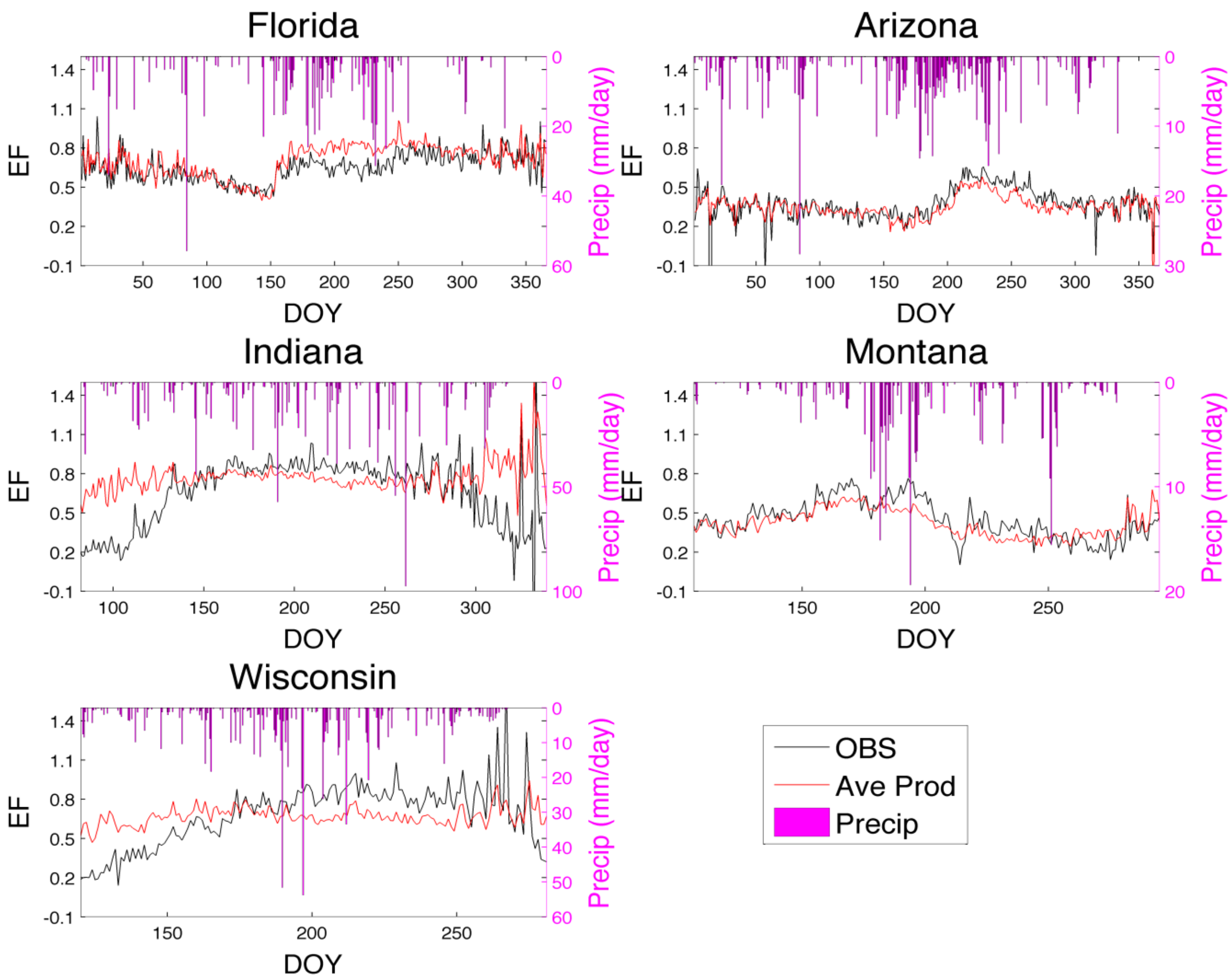
Lytle and Zeng (2016)

- Reanalyses underestimate snow depth
- Summer soil and skin T is driven by Tair
- Winter soil T errors are larger than Tair and Tskin errors
- Larger errors in SH and LH than G



MERRA, MERRA_Land, GLDAS (CLM, Mosaic, Noah)
ERA-Int, ERA-Int_Land, CFSR

- Over AZ, MT, and FL, reanalyses agree well with OBS
- Over IN and WI, good agreement occurs in summer only



Black: daily EF = LH/(SH + LH) from observations (snow free)
red: mean daily EF across all products
Magenta histogram: observed precipitation

Based on these results, two emergent constraints are suggested:

- coupled evaluation of model daily air, skin, and soil temperatures, particularly over regions with seasonal snow cover

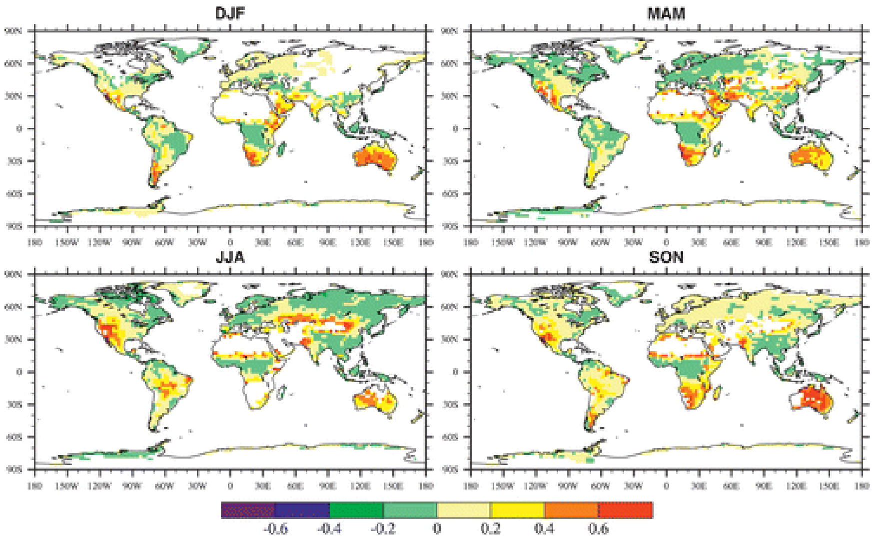
- Evaluation of the model evaporation fraction EF = LH/(SH + LH) over the seasonal cycle

4. Monthly land-precipitation coupling strength parameter Γ

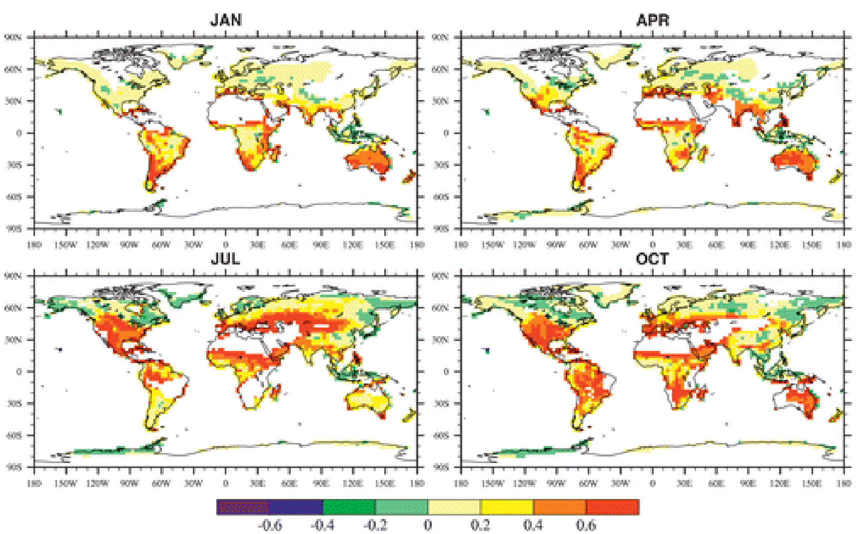
It is easy to compute and insensitive to the horizontal scales used.

A relatively high Γ is a necessary condition for a relatively strong coupling.

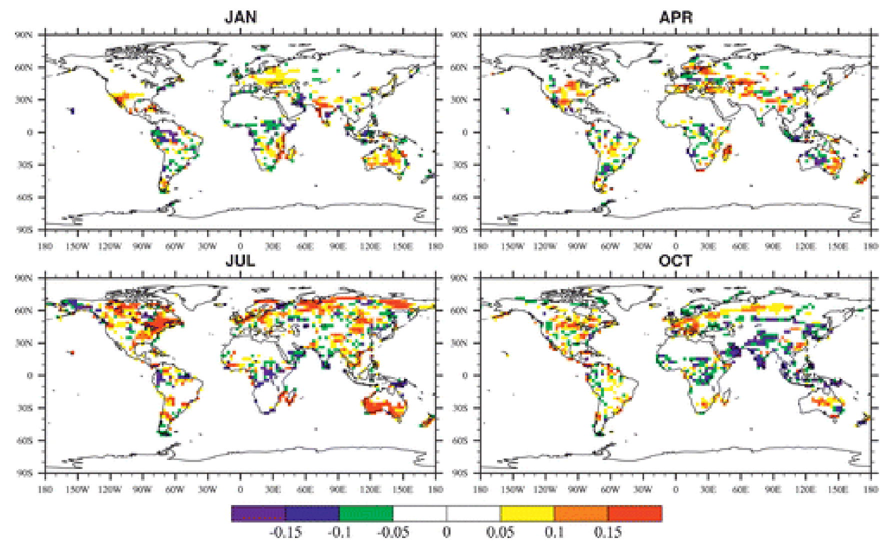
$$\Gamma = \sum_{i=1}^{N} P_i' E_i' \Big/ \sum_{i=1}^{N} P_i'^2 . \qquad (4)$$



ECMWF Reanalysis



CCSM3



$2[CO_2]–[CO_2]$

Zeng et al. (2010)