Assessing Models with Flux Stations:

Some overarching lessons

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Land Surface Validation Lesson Themes

- **What governs model soil moisture levels**
  - Amplitude of seasonal cycle
  - Absolute value of annual mean
- **Evaluate model surface forcing biases**
  - Model forcing versus local forcing
- **Model land properties vs station land properties**
  - Soil type, vegetation class, soil class
- **Assessing local flux station representativeness**
  - Complement with satellite skin temperature validation
  - Augment with annual water budget determined from observed precipitation and observed streamflow

NLDAS Design
(An Uncoupled Approach)

1. **Force models with 4DDA surface meteorology (Eta/EDAS), except use actual observed precipitation (gage-only daily precip analysis disaggregated to hourly by radar product) and hourly downward solar insolation (derived from GOES satellites).**

2. **Use 4 different land surface models:**

   - NOAH (NOAA/NWS/NCEP)
   - MOSAIC (NASA/GSFC)
   - VIC (Princeton U./ U. Washington)
   - Sacramento (NOAA/OHD)

3. **Evaluate results with all available observations, including soil moisture, soil temperature, surface fluxes, satellite skin temperature, snow cover and runoff.**

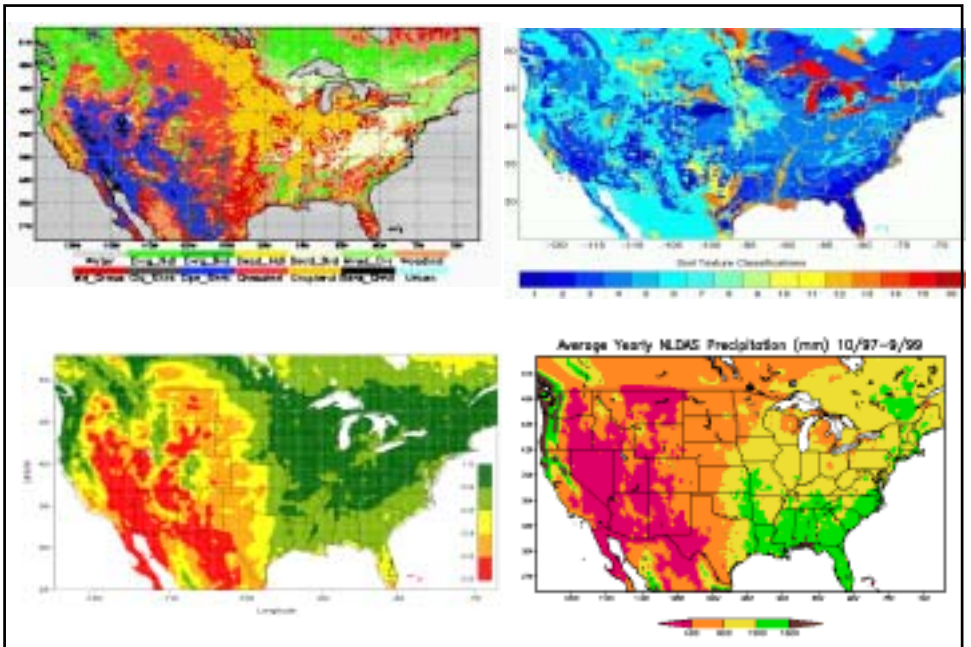


Fig. 1 Top row: Map of NLDAS predominant class of vegetation type (A) and soil type (B) Bottom row: Climo Jul green veg (C) from Gutman et al and avg annual precip total in mm (D)

LDAS Run Modes:
1) Realtime, 2) Retrospective

1) **REALTIME: 15 Apr 1999 to 15 Dec 2001**
   -- **NCEP realtime forcing**
2) **RETROSPECTIVE: 01 Oct 1996 to 30 Sep 99**
   -- **Mandated largely by spin-up issues**
   -- **NASA-assembled retrospective forcing**
      --- Higgins NCEP/CPC reprocessed precipitation forcing:
         ---- more gages obs, more QC
      --- Pinker U.Md reprocessed solar insolation forcing
         ---- better cloud screening, more QC

Rutgers University compared the soil moisture, soil temperature, surface flux results from the retrospective LDAS runs to observations over Oklahoma/Kansas for last retro year.

Multi-scale and Multi-source Validation work in NLDAS

- Forcing data (surface met, radiation, precip): Rutgers U., Princeton U., NASA, NCEP
- Snow cover and Snow water equivalent: Princeton University, NCEP
- Water balance at surface: NCEP
- Streamflow/runoff: NCEP, NWS-HRL, University of Washington
- Soil moisture Rutgers University, NWS-HRL
- Energy balance at surface: Rutgers U., NCEP
- Skin temperature: NCEP, NESDIS, Rutgers

- **What governs model soil moisture levels ?**
  - **Amplitude of seasonal cycle?**
  - **Absolute value of annual mean?**

The Land Surface Water Budget

$$dSM/dt + dSN/dt + dSG/dt = P - E - R$$

SM = soil moisture storage
SN = snowpack storage
SG = groundwater storage

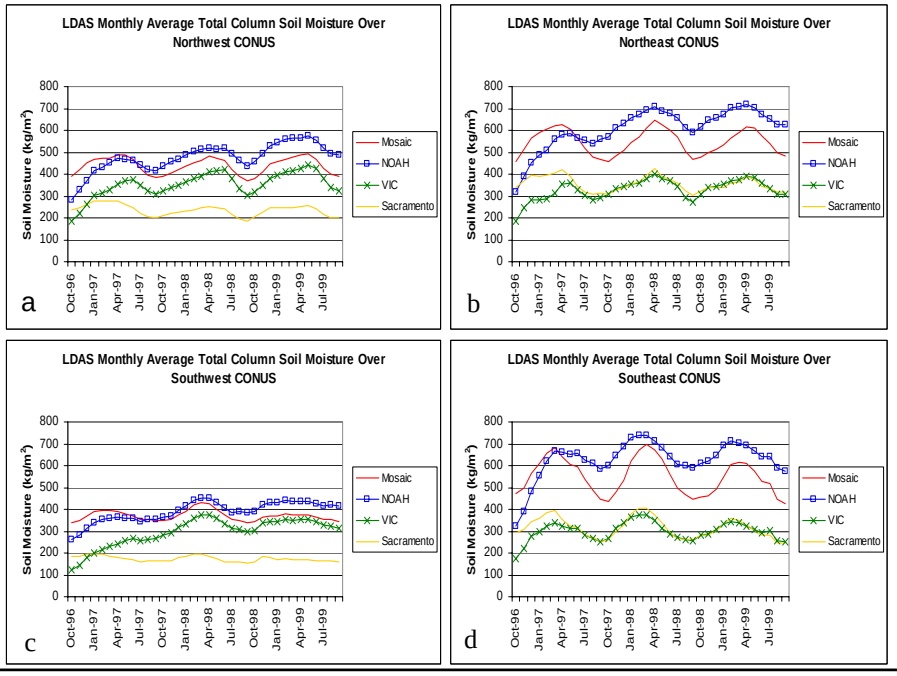
The forcing controls only the rate of change of surface water storage, e.g. the amplitude of the annual cycle of the soil moisture storage.

On an annual cycle basis the storage changes are small compared to the annual accumulations of P, E, and R, hence:

$$0 = P - E - R \quad \text{or}$$

$$E = P - R \quad \textbf{(ANNUAL BUDGET)}$$

NLDAS: Time series of monthly total column soil moisture, by CONUS quadrant.

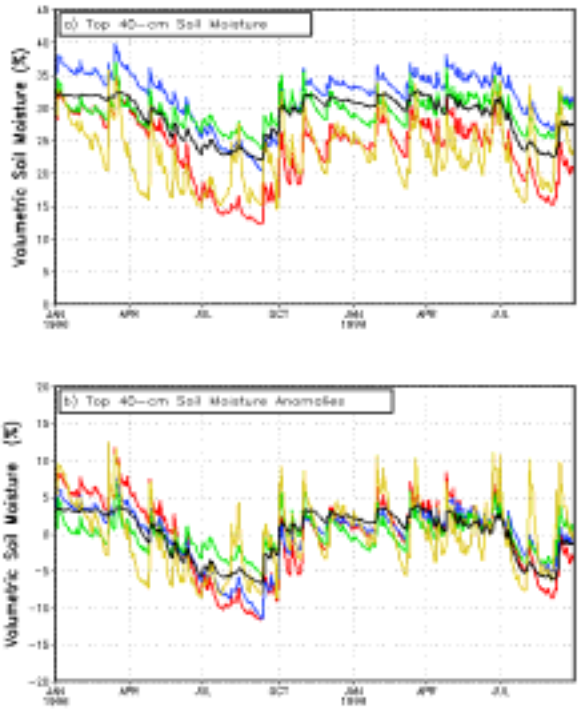


NLDAS soil moisture in top 40 cm averaged over the OU Mesonet

(Robock et al., 2003)

TOP:
Absolute value

BOTTOM:
Departure from annual mean



Lesson from Koster and Milly (1999)

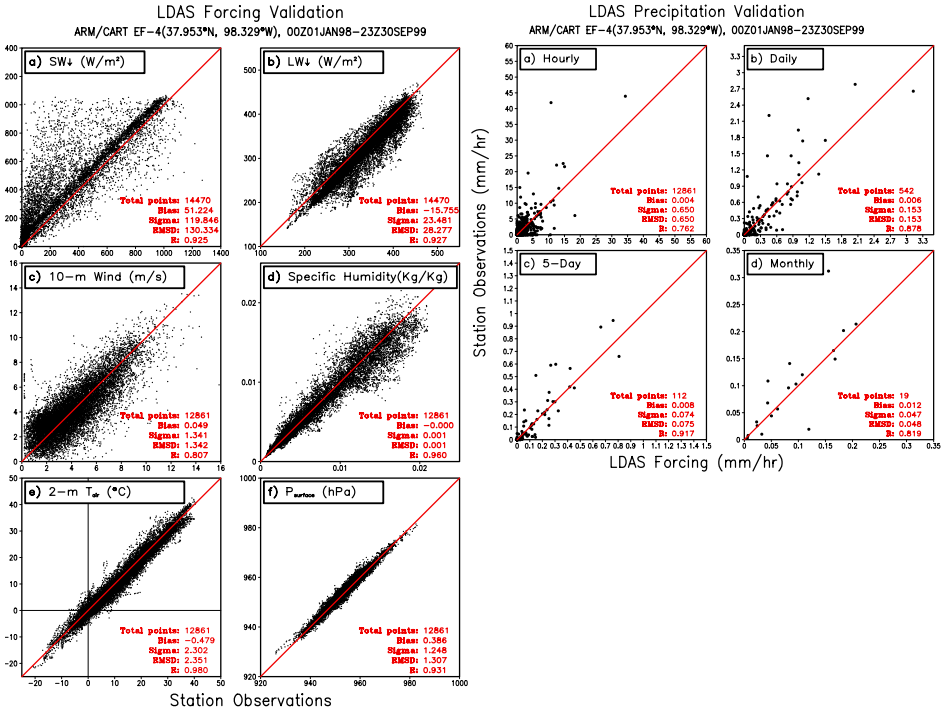
The range of soil moisture in a given land model is largely determined by three factors:

1) Maximum soil water holding capacity of the active soil column.

2) Functional form ("slope") and critical thresholds ("intercepts") of the function governing **surface infiltration** as a function of soil water content

3) Functional form ("slope") and critical thresholds ("intercepts") of the function governing **surface evaporation** as a function of soil water content.

- **Evaluate model surface forcing biases**
  - **Model forcing versus local forcing**

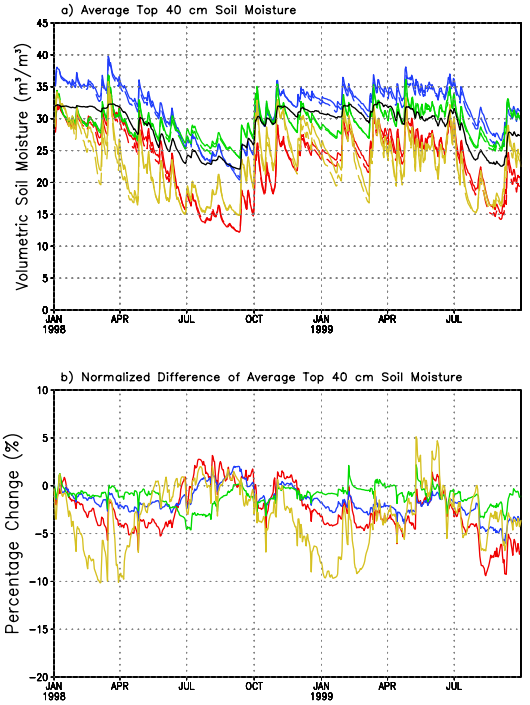


NLDAS soil moisture in top 40 cm averaged over the OU Mesonet

(Luo et al., 2003)

TOP:
From model forcing (solid) versus local station forcing (dashed).

BOTTOM:
Percent difference of local Station-driven result from model-driven control.



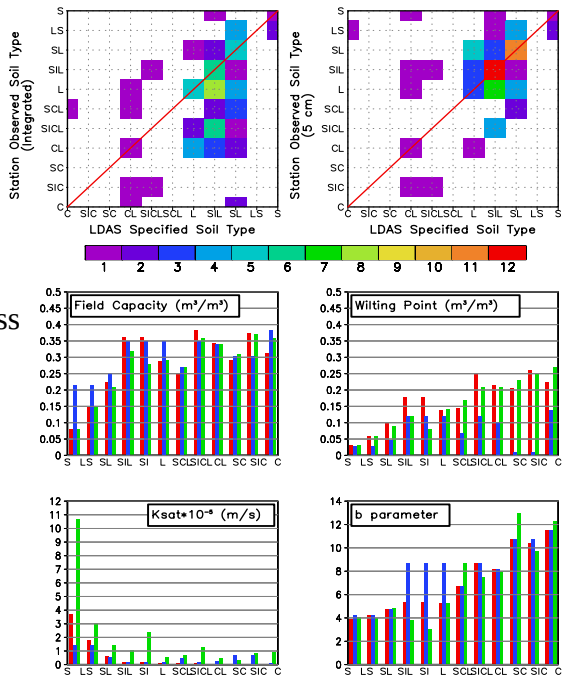
- **Model land properties vs station land properties ?**
  - **Soil type, vegetation class**

NLDAS soil class and soil parameters.

(Robock et al., 2003)

TOP:
Model assigned soil class versus local flux station soil class.

BOTTOM:
For given soil class, comparion of assigned soil parameters among three SVAT models.

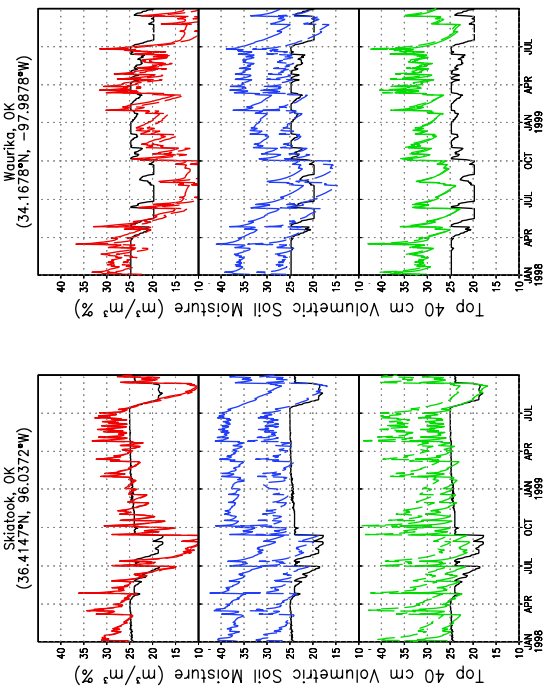


NLDAS soil moisture sensitivity to soil class. (Robock et al., 2003)

TOP:
At OU Mesonet Station A - Soil moisture of Control run (solid) vs that with local soil class (dashed).

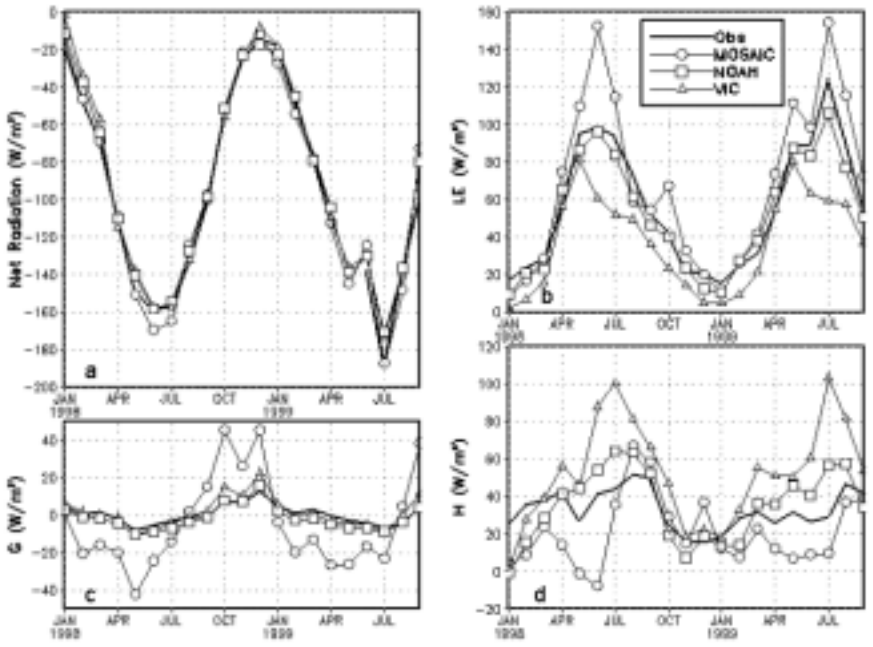
BOTTOM:
As in top panel, but for OU Mesonet station B.

LESSON: Local class aids Non-calibrated LSM but Hurts calibrated LSM.



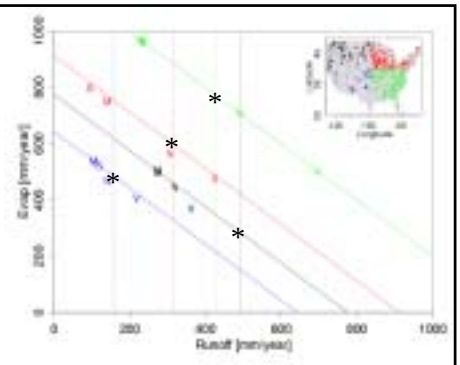
- **Assessing local flux station representativeness ?**
  - **Augment with annual water budget determined from observed precipitation and observed streamflow**
  - **Complement with satellite skin temperature validation**

NLDAS: Monthly mean surface energy fluxes over 21 months (Jan 98 – Sep 99)

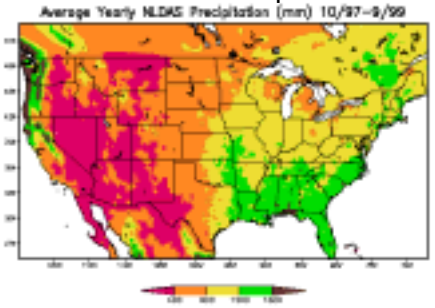


E = P – R **(ANNUAL BUDGET)**

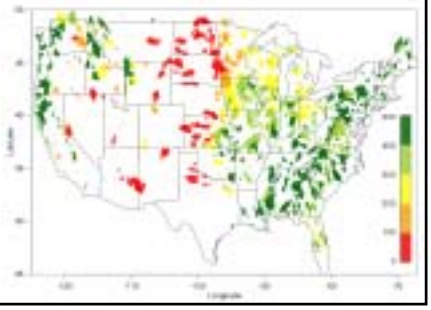
Evaporation inferred from the annual water budget using the observed precipitation and runoff.



Observed Precipitation (mm/yr)



Observed Runoff



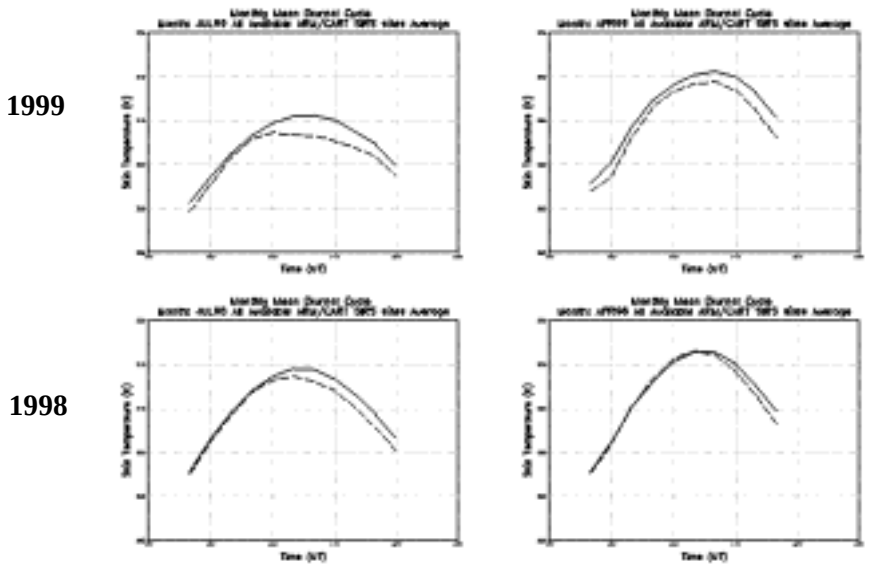
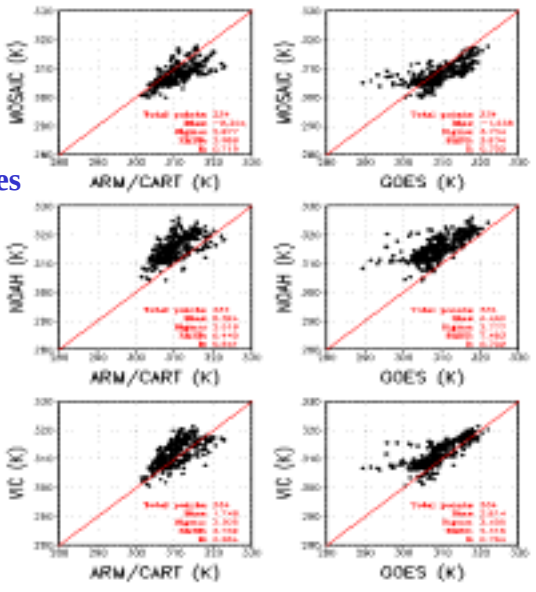


Fig. 27 Monthly & Multi-Station Mean Diurnal Cycle: Surface Skin Temperature ARM-Station Observations (solid) vs Coincident GOES-based Retrievals (dashed)

Measured LST
vs
Model LST

At 21 ARM SIRS sites

July 1999

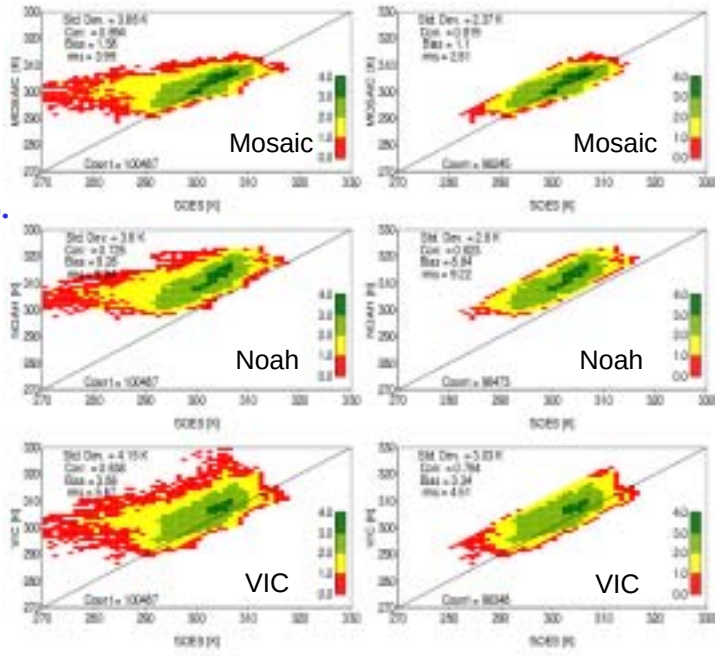


Model vs ARM **Model vs GOES**

GOES LST
vs
Model LST

Midwest U.S.

July 1999



Model vs (unscreened) GOES **Model vs (screened) GOES**