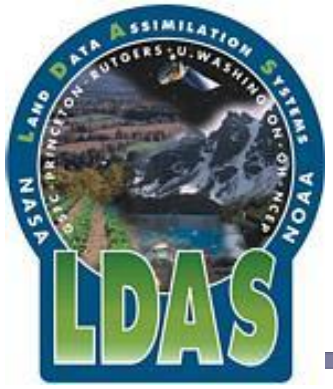
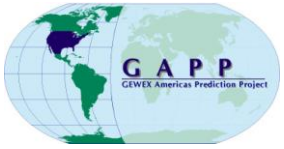


Evaluation of N-LDAS Land Surface Models with Observed Forcing and Hydrology

Alan Robock[1], Lifeng Luo[1], Kenneth Mitchell[2], Paul R. Houser[3], Eric F. Wood[4], John Schaake[5], Dennis Lettenmaier[6], Brian Cosgrove[3], Qingyun Duan[5], Dag Lohmann[2], Justin Sheffield[4], Wayne Higgins[7], Rachel Pinker[8], Dan Tarpley[9], Kenneth Crawford[10], and Jeffrey Basara[10]

[1]*Department of Environmental Sciences, Rutgers University*
[2]*NOAA/NWS/NCEP/EMC*
[3]*Hydrological Sciences Branch, NASA/GSFC*
[4]*Department of Civil Engineering, Princeton University*
[5]*NOAA/NWS/OHD*
[6]*Department of Civil and Environmental Engineering, University of Washington*
[7]*NOAA/NWS/NCEP/CPC*
[8]*Department of Meteorology, University of Maryland*
[9]*NOAA/NESDIS/ORA*
[10]*Oklahoma Climatological Survey*



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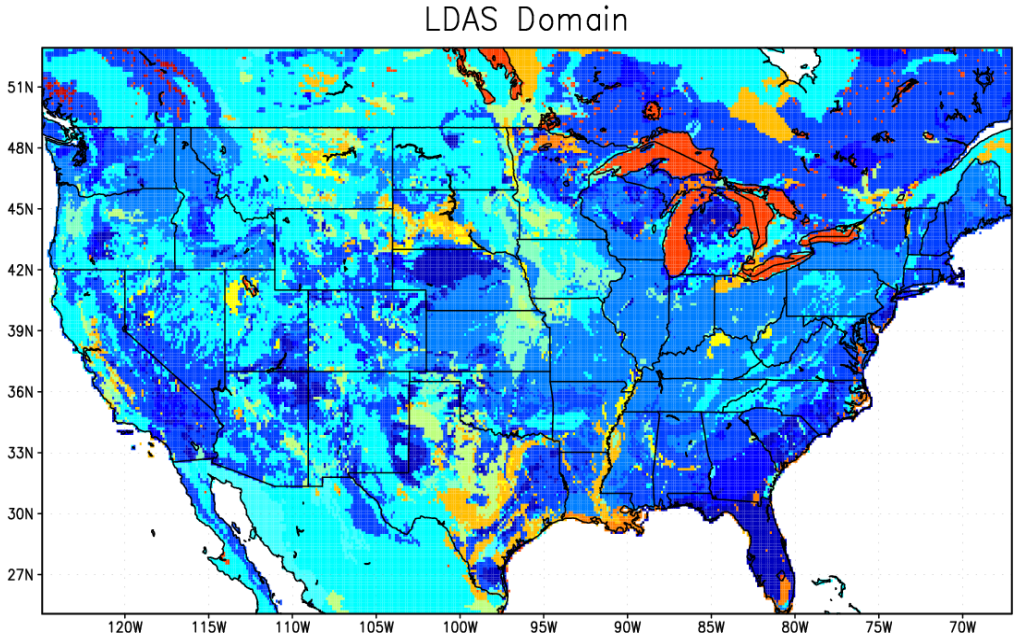
LDAS Design

1. **Use 4 different land surface models:**
   - MOSAIC (NASA/GSFC)
   - NOAH (NOAA/NWS/NCEP)
   - VIC (Princeton University/University of Washington)
   - Sacramento (NOAA/OHD)

2. **Force models with Eta model analysis (EDAS) meteorology, except use actual observed precipitation (Stage IV radar product merged with gages) and downward solar radiation (derived from satellites)**

3. **Evaluate results with all available observations, including soil moisture, soil temperature, and fluxes.**

Introduction



Predominant soil type

O	Other
BR	Bedrock
W	Water
OM	Organic materials
C	Clay
SIC	Silty Clay
SC	Sandy Clay
CL	Clay Loam
SICL	Silty Clay Loam
SCL	Sandy Clay Loam
L	Loam
SI	Silt
SIL	Silty Loam
SL	Sandy Loam
LS	Loamy Sand
S	Sand

- **Domain**
  - 125°W-67°W, 25°N-53°N
- **Resolution of Model Simulations**
  - 1/8° ≈ 14 km x 11 km

LDAS Scientific Questions

1. Can land surface models forced with observed meteorology and radiation accurately calculate soil moisture?
2. If not, what are the relative contributions to the differences between models and observations of errors in the soil moisture observations or of the differences between model and observed:
    a. Forcing?
    b. Soil properties?
    c. Vegetation?
    d. Scales?
    e. Vertical resolution?
    f. Tiling or variable infiltration assumptions?

LDAS Retrospective Runs

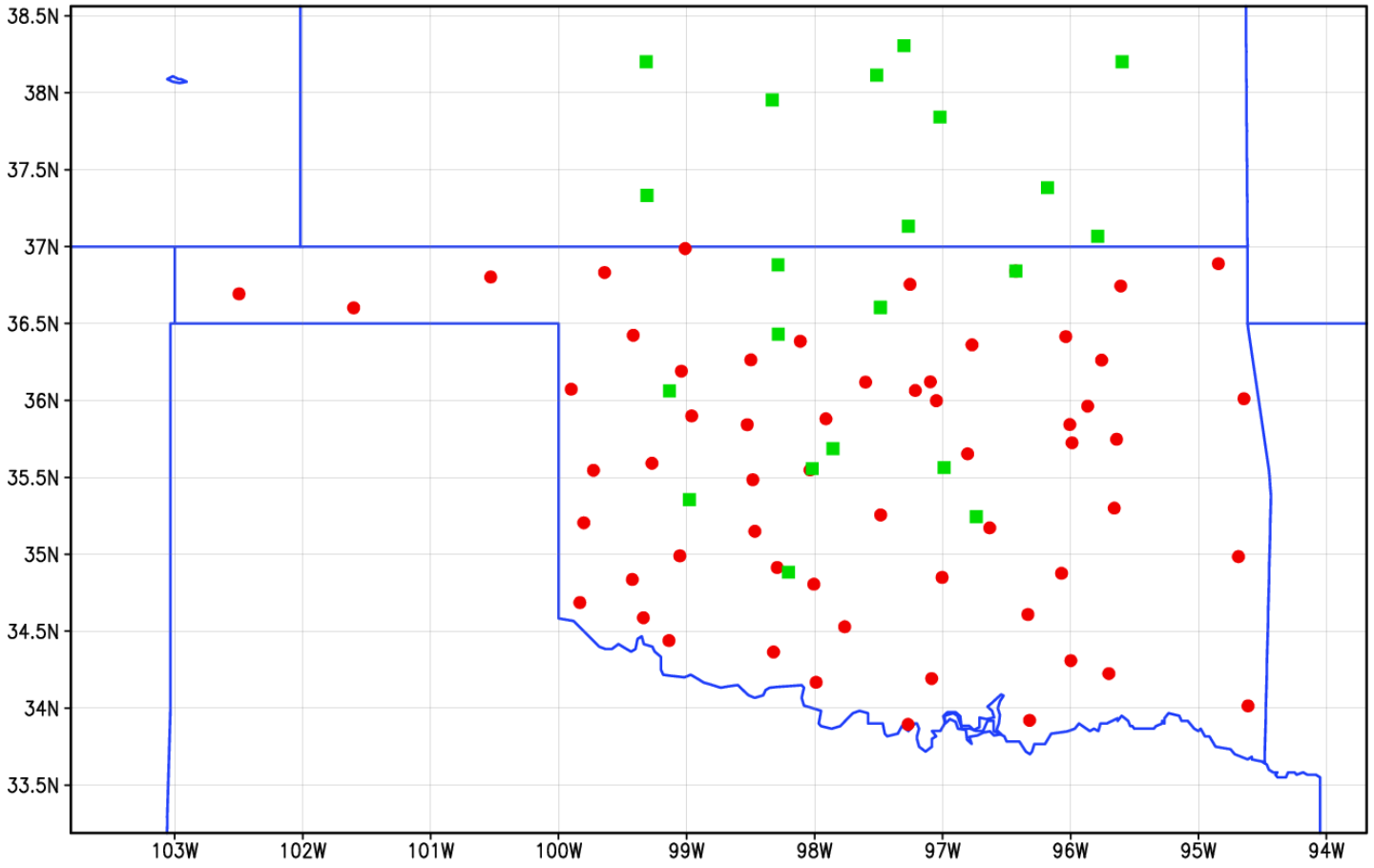
The four LDAS land surface schemes were run for the period from October 1, 1997 through September 30, 1999, with a one-year antecedent spinup (October 1, 1996 - September 30, 1997).

We compare the soil moisture results from these runs to observations from the dense observational networks of the Oklahoma Mesonet and ARM/CART networks.

We also performed experiments with different forcing and model parameters.

Soil Moisture Observations

- ARM/CART sites
- Oklahoma Mesonet sites



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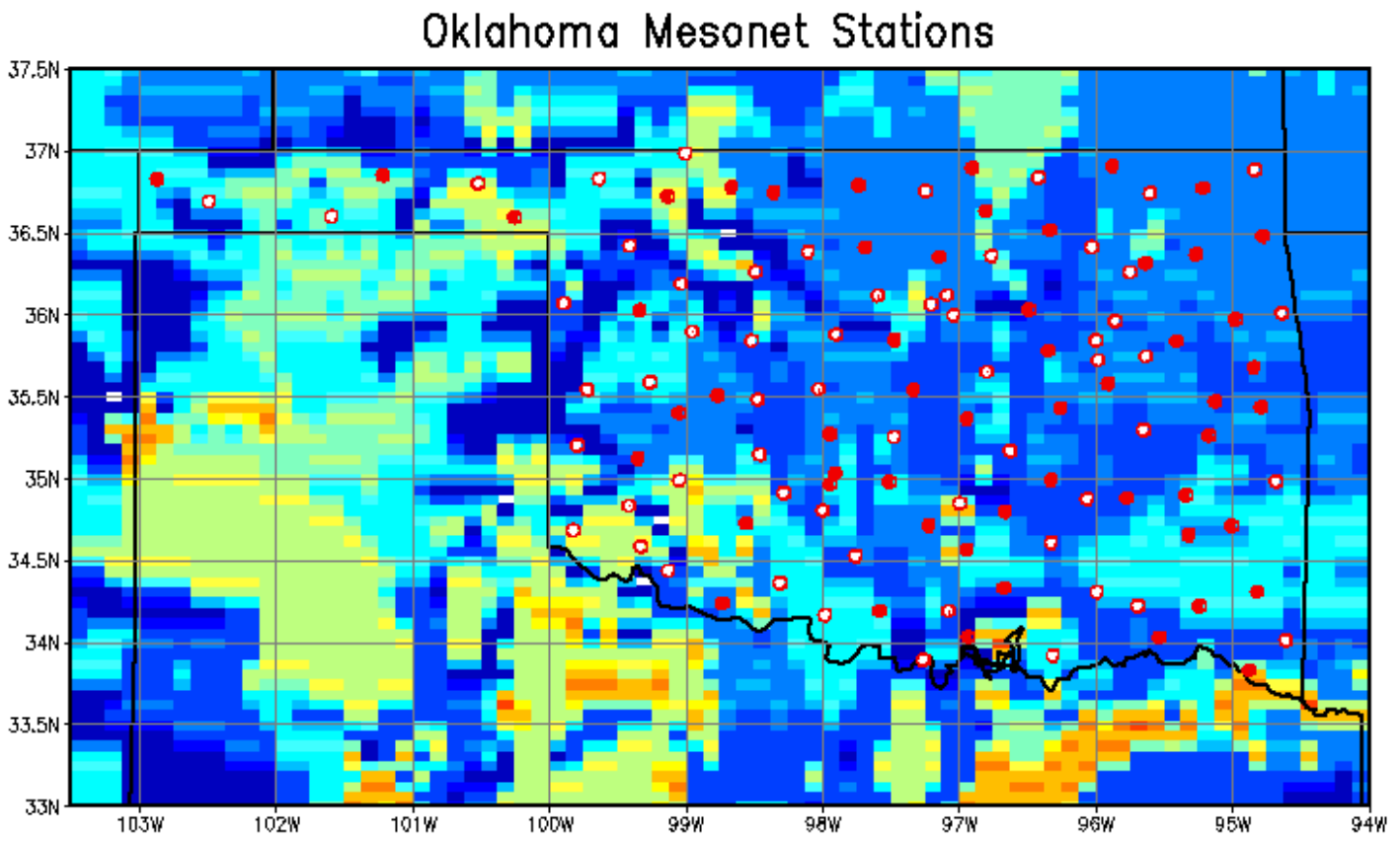
Oklahoma Mesonet



Background is the first most predominant surface soil classes over this region following LDAS parameters.

Predominant soil type (upper 5 cm)

O	Other
BR	Bedrock
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OM	Organic materials
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SIC	Silty Clay
SC	Sandy Clay
CL	Clay Loam
SICL	Silty Clay Loam
SCL	Sandy Clay Loam
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SIL	Silty Loam
SL	Sandy Loam
LS	Loamy Sand
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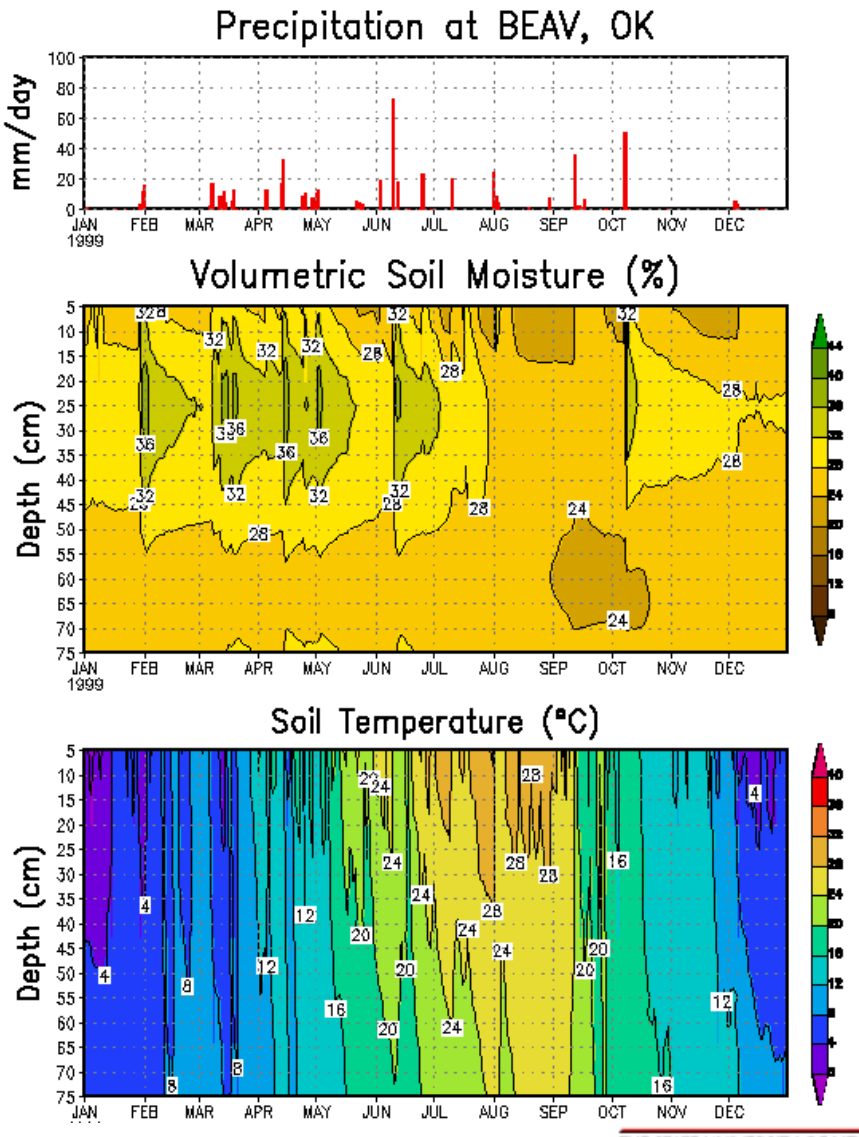
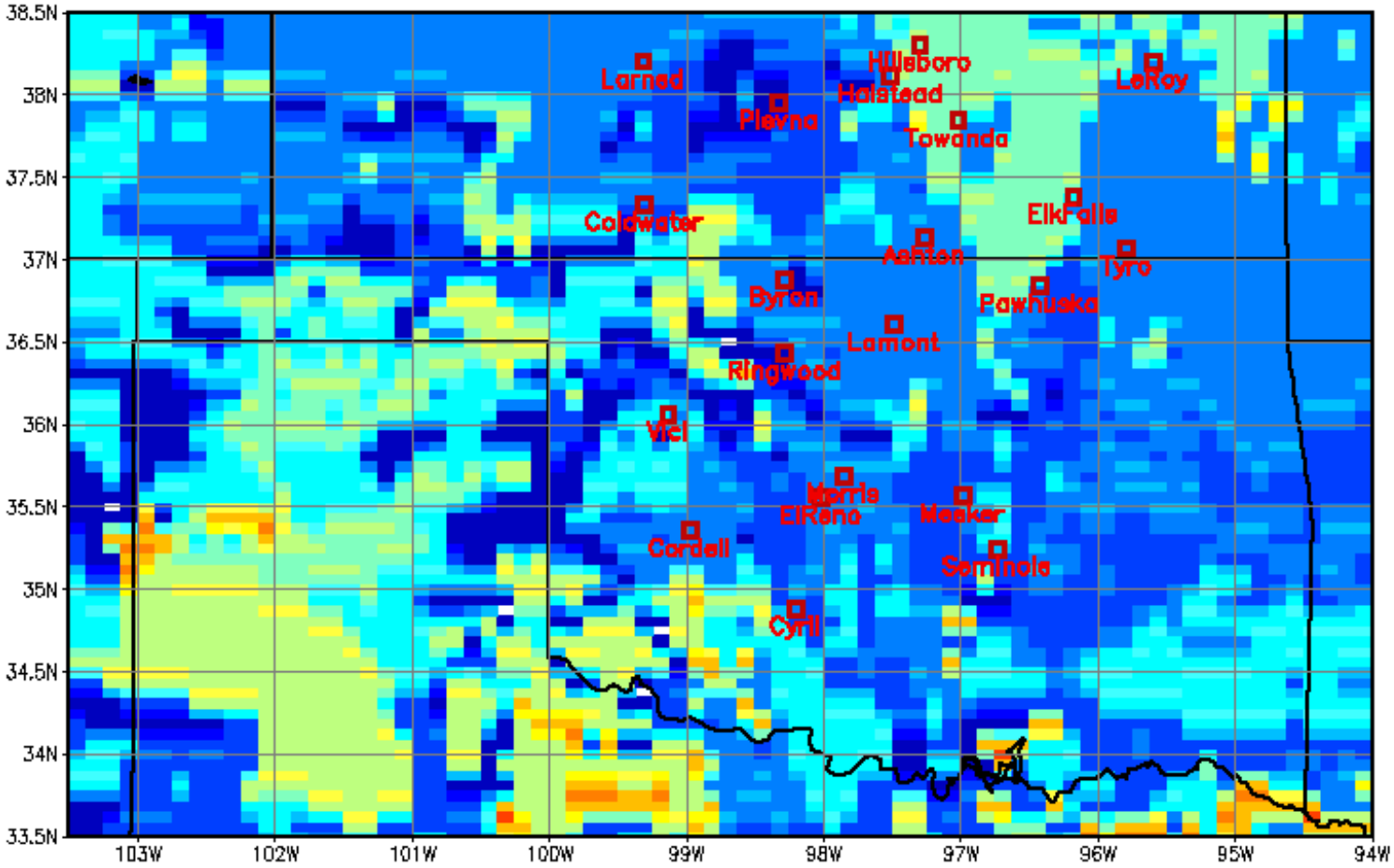
Oklahoma Mesonet

- 115 Mesonet stations covering every county of the state
- Meteorological observations are taken at 5 min intervals:
  - *Relative Humidity at 1.5 m*
  - *Air Temperature at 1.5 m*
  - *Average Wind at 10 m*
  - *Precipitation*
  - *Station Pressure*
  - *Solar Radiation*
- 72 stations have soil moisture and soil temperature observations taken at 15 min intervals.



ARM/CART

Predominant soil type (upper 5 cm)



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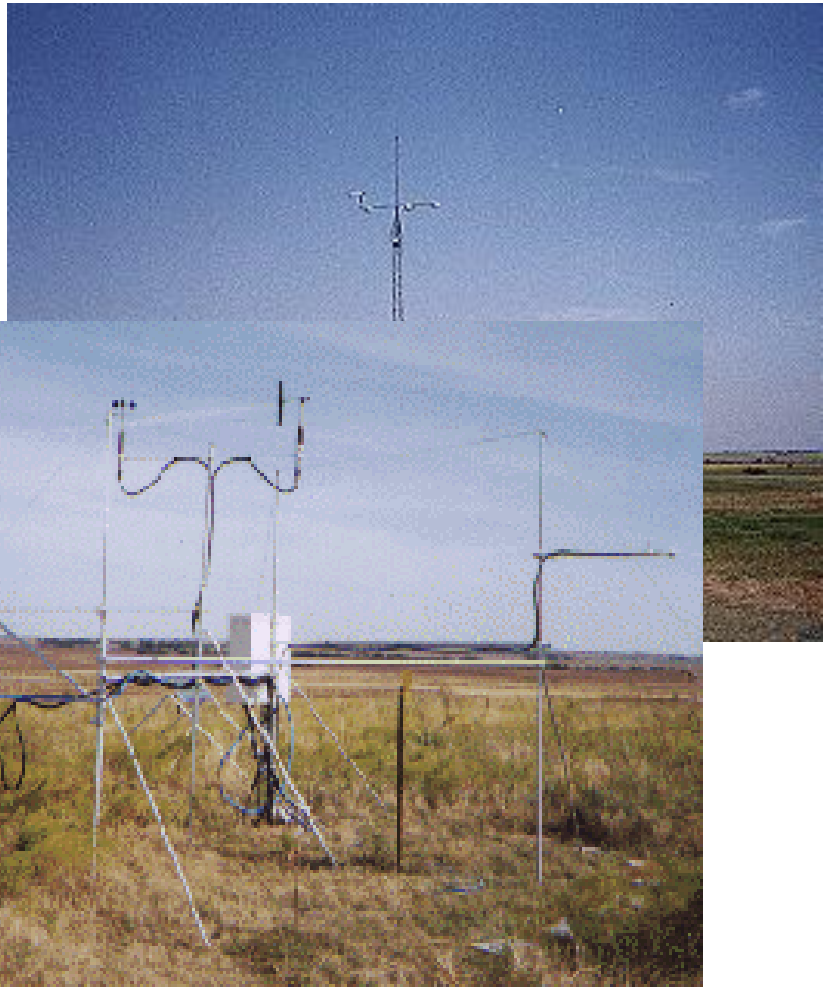
SIL	Silty Loam
SL	Sandy Loam
LS	Loamy Sand
S	Sand

Background is the first most predominant surface soil classes over this region following LDAS parameters.

ARM/CART

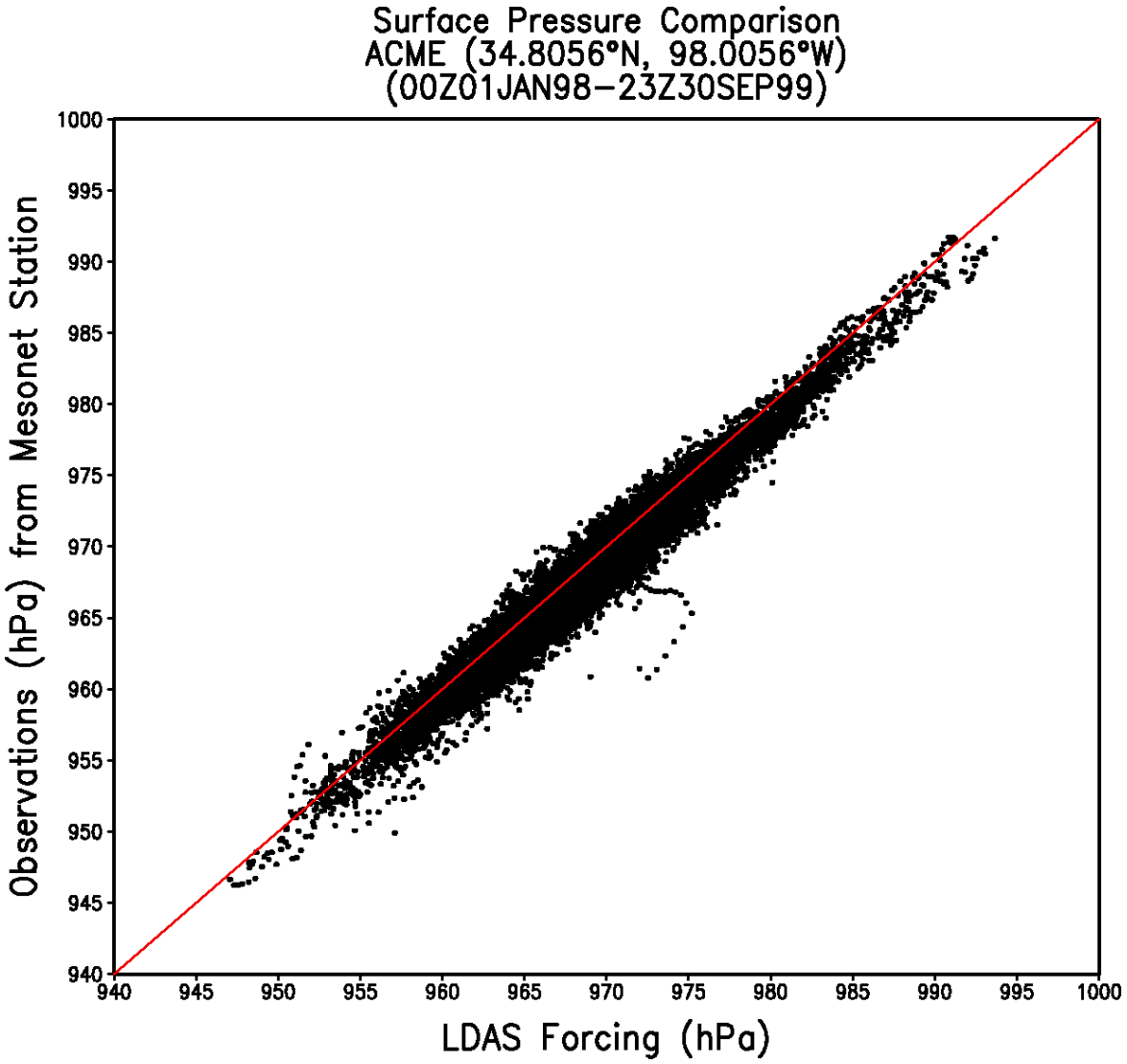
- **24 Extended Facilities (EF)**
- **14 Surface Meteorological Observations System (SMOS) stations**
  - *Surface pressure*
  - *Precipitation*
  - *Air temperature*
  - *Humidity*
  - *Wind*
- **14 Energy Balance Bowen Ratio (EBBR) stations**
  - *Latent heat flux*
  - *Sensible heat flux*
  - *Net radiation*
  - *Ground heat flux*



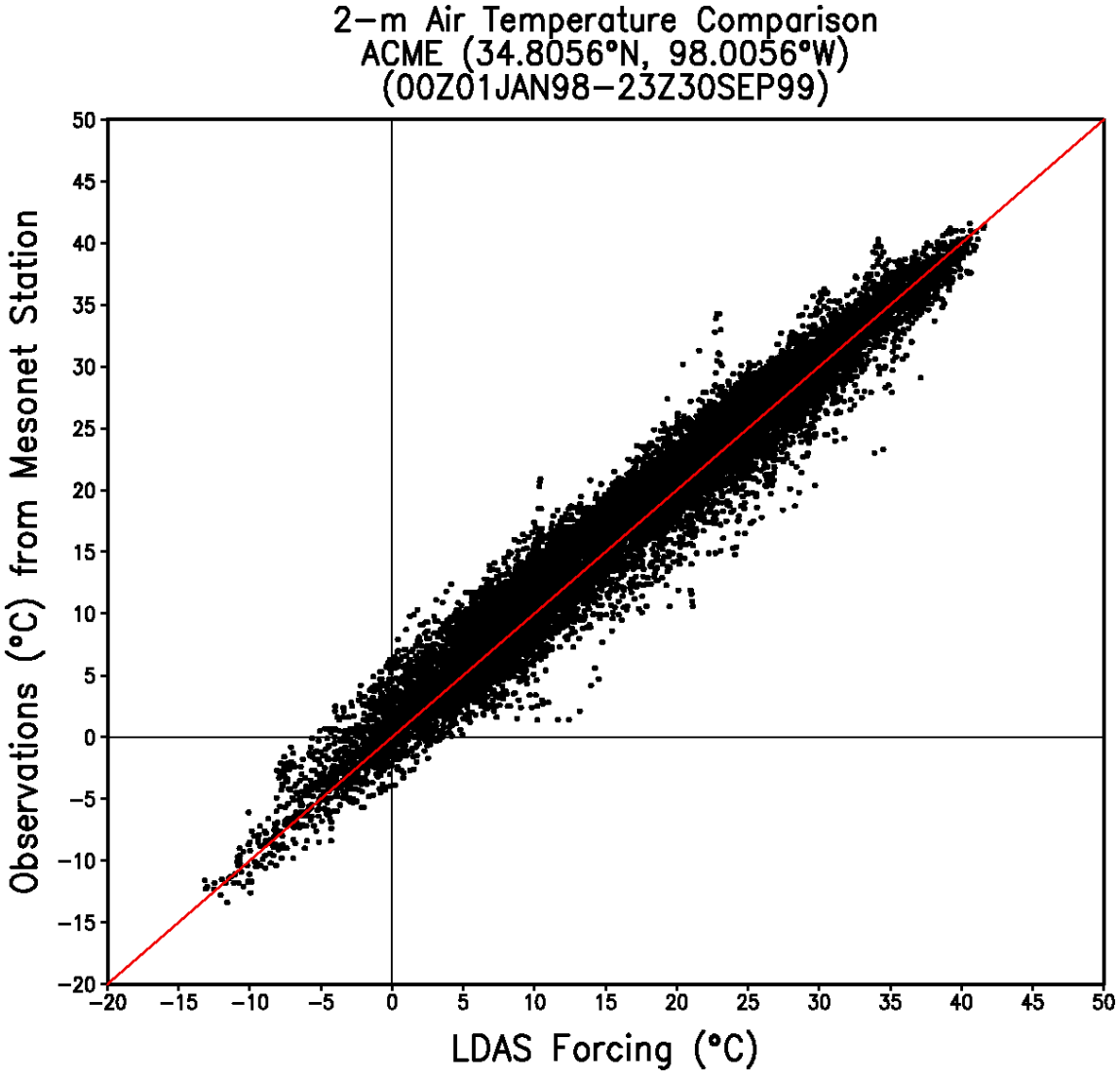
ARM/CART

- **Solar Infrared Radiation Stations (SIRS)**
  - *Downward longwave radiation*
  - *Downward shortwave radiation*
  - *Upward longwave radiation*
  - *Upward shortwave radiation*
- **Soil Water And Temperature System (SWATS)**

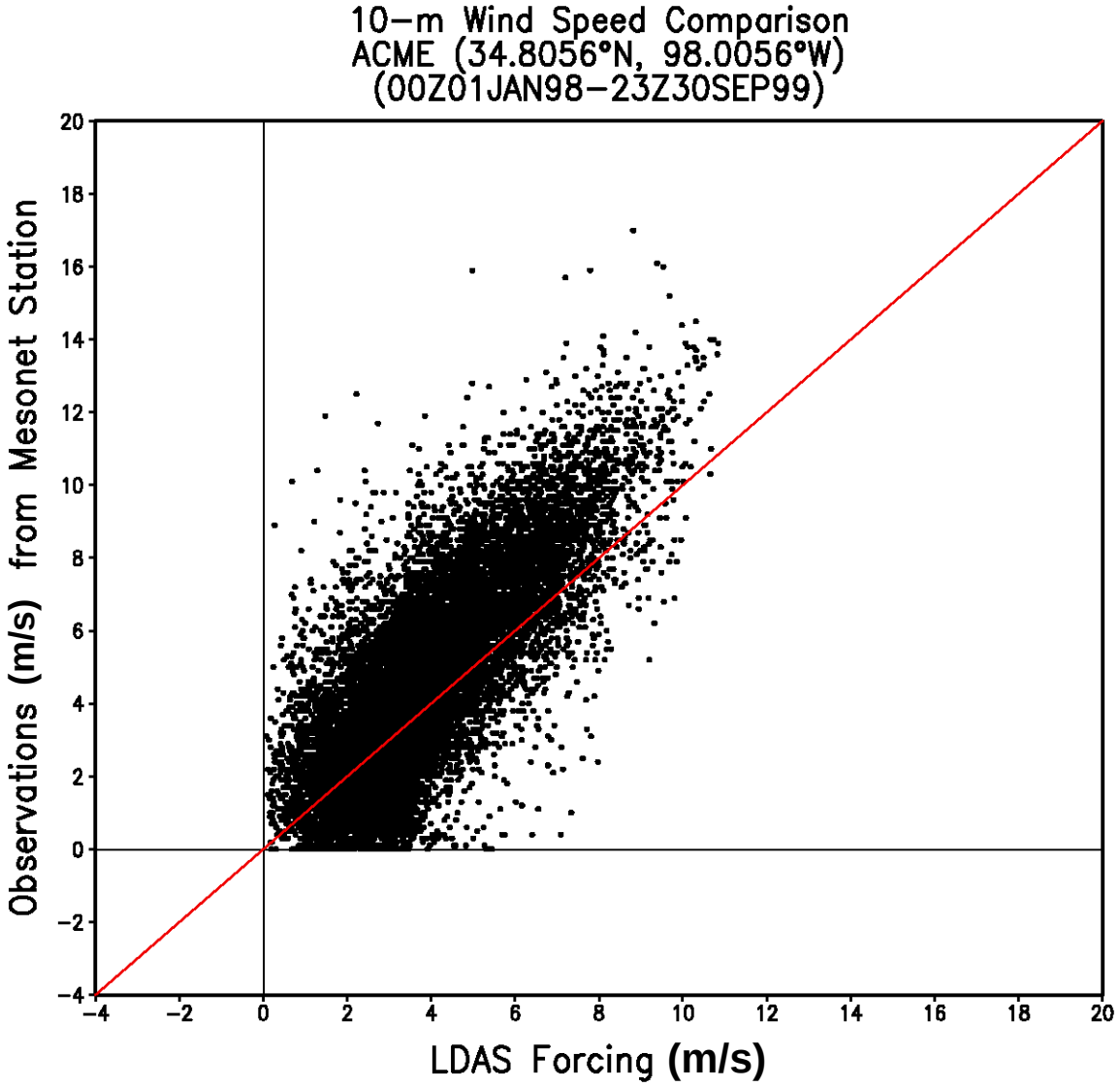
Forcing Validation: Pressure



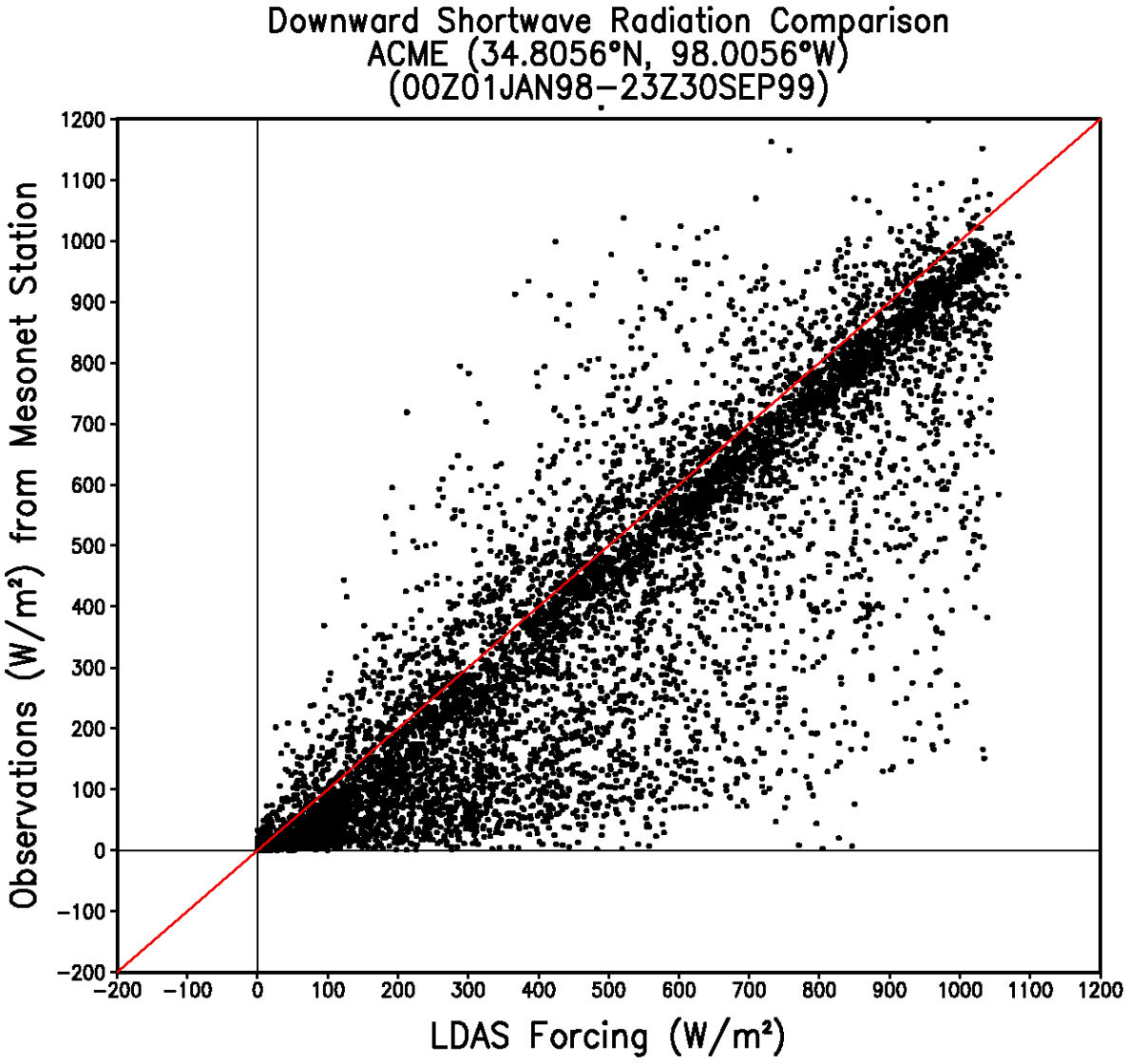
Forcing Validation: Temperature



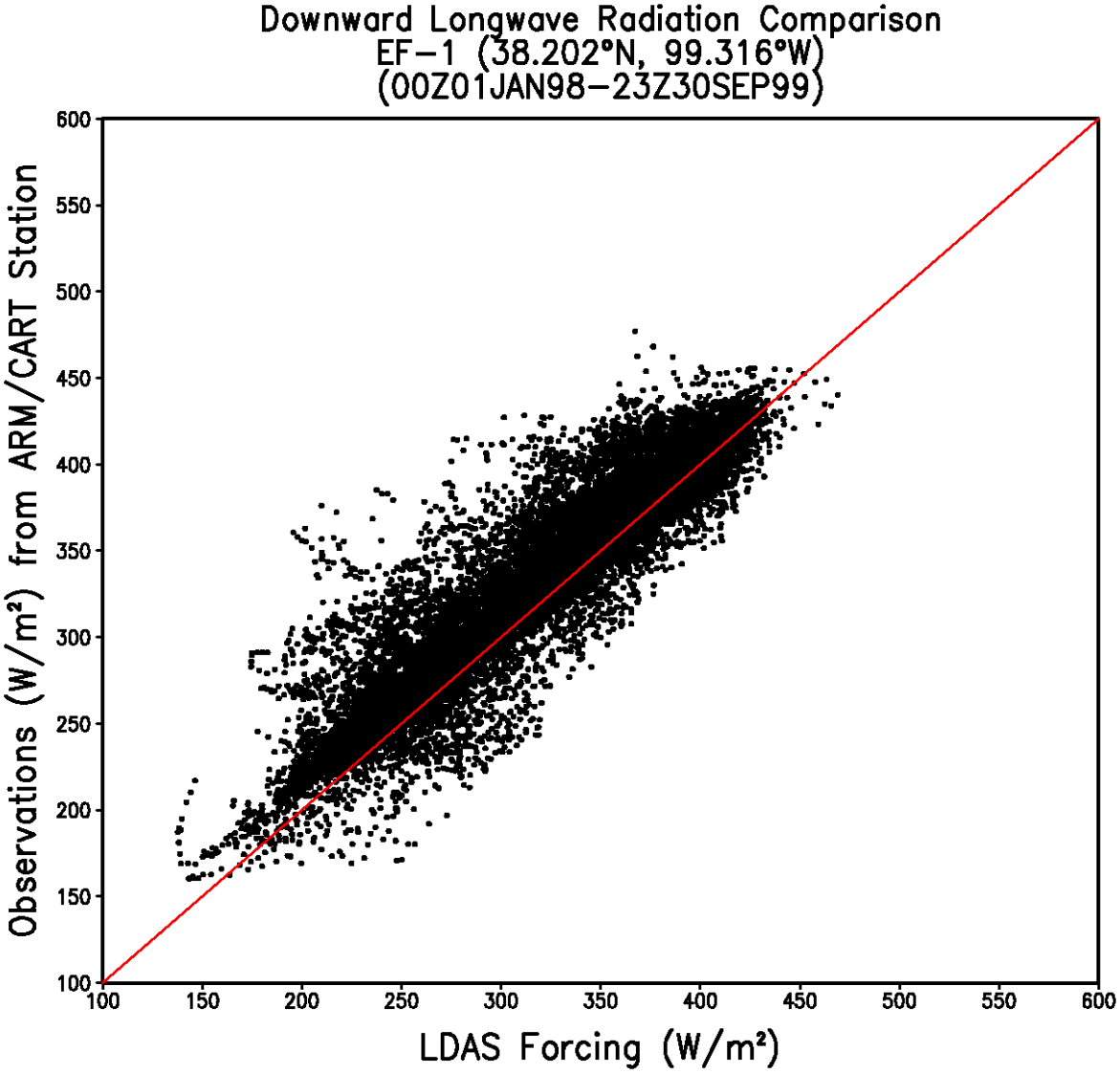
Forcing Validation: Wind Speed



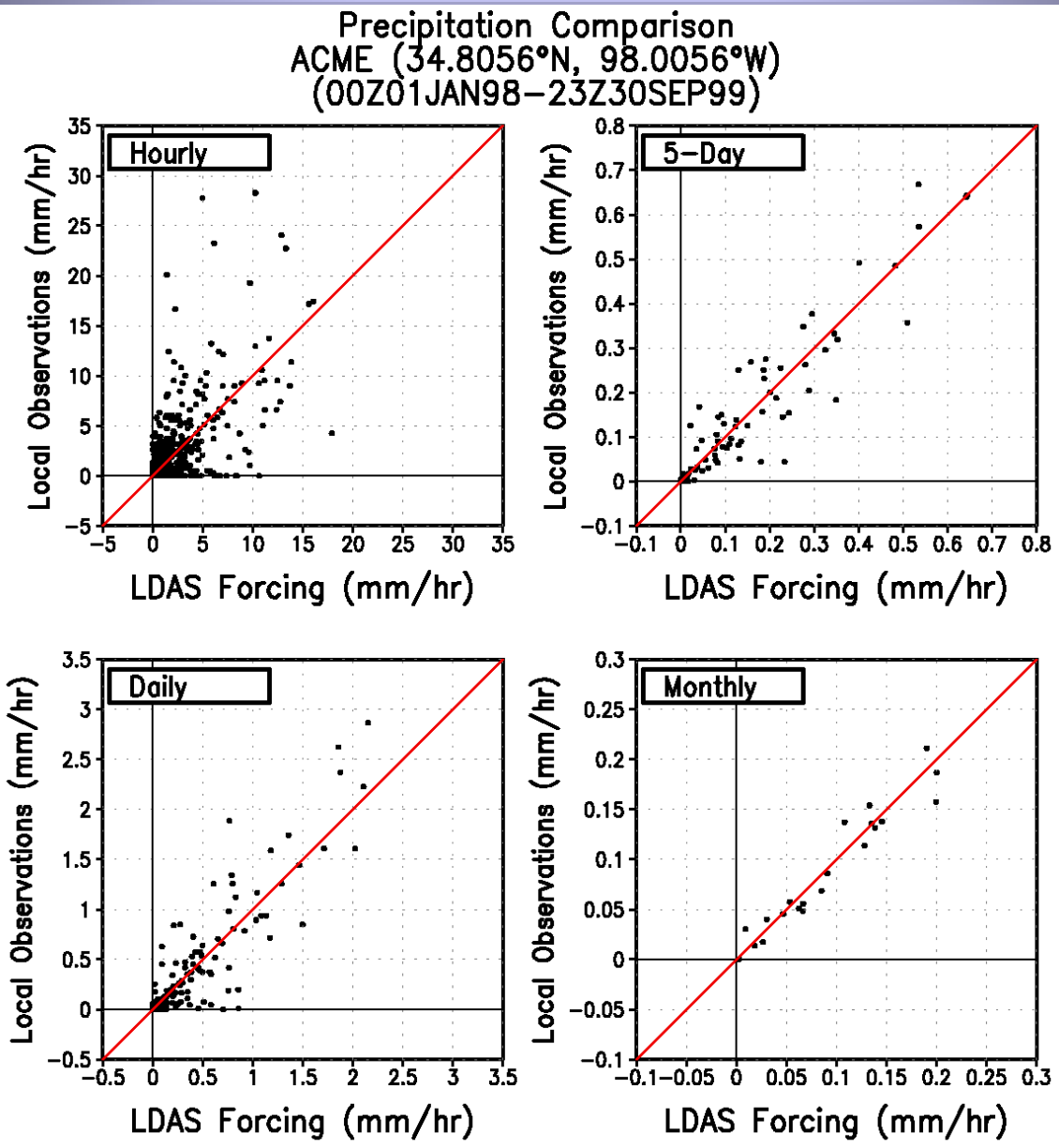
Forcing Validation: Downward Shortwave



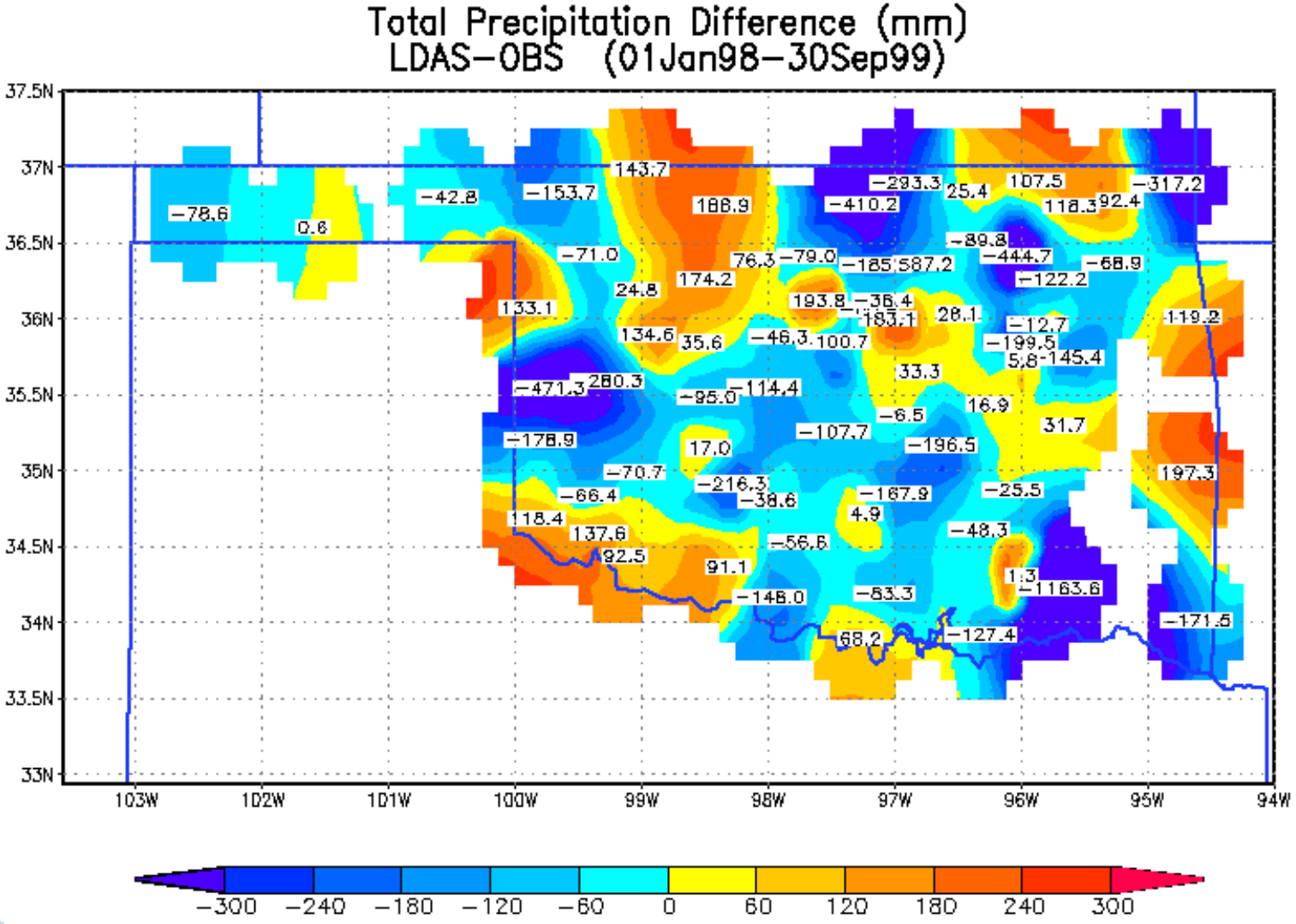
Forcing Validation: Downward Longwave



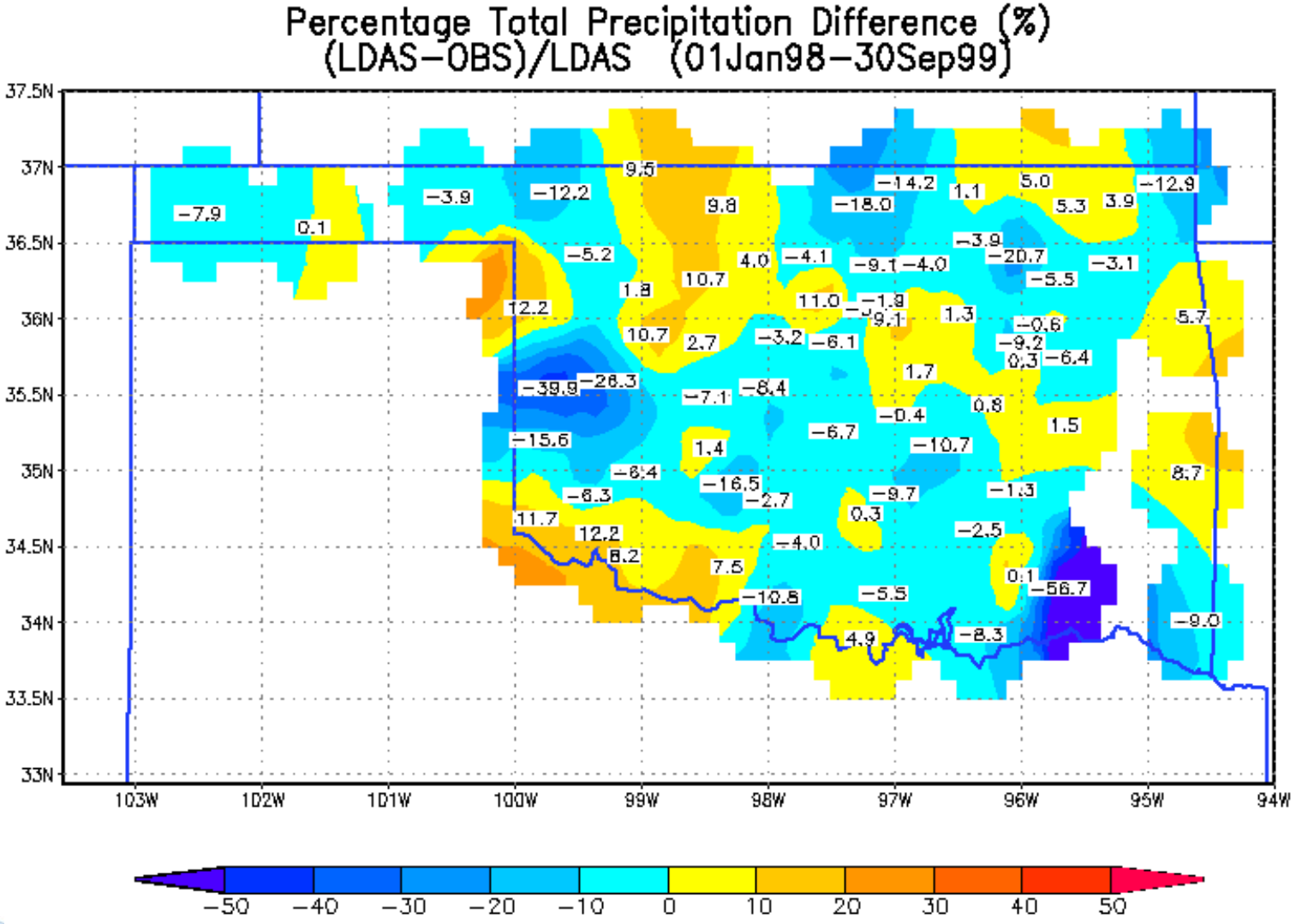
Forcing Validation: Precipitation



Forcing Validation: Precipitation



Forcing Validation: Precipitation

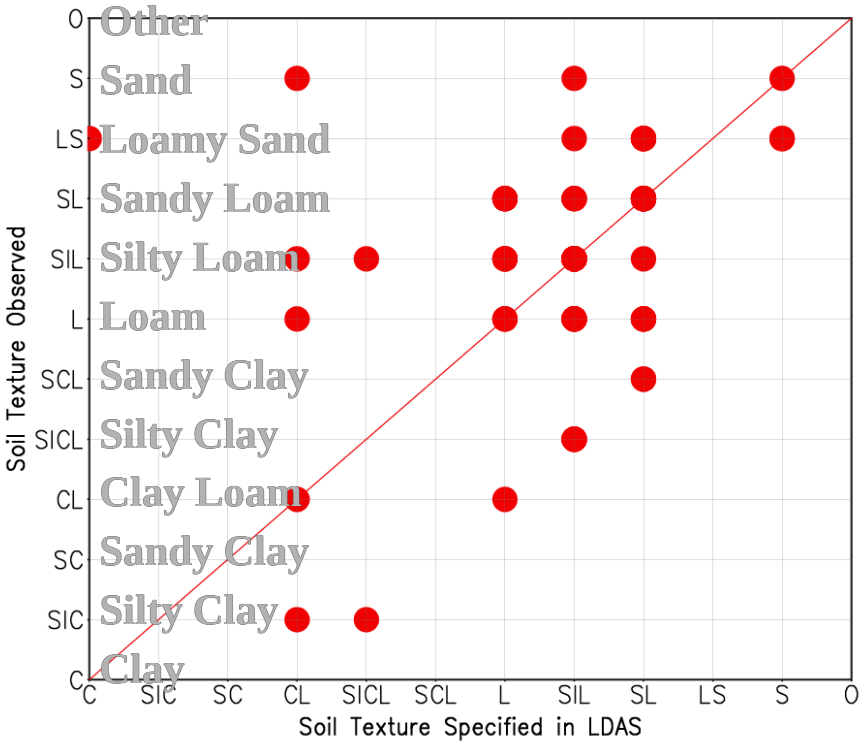


Forcing Experiments

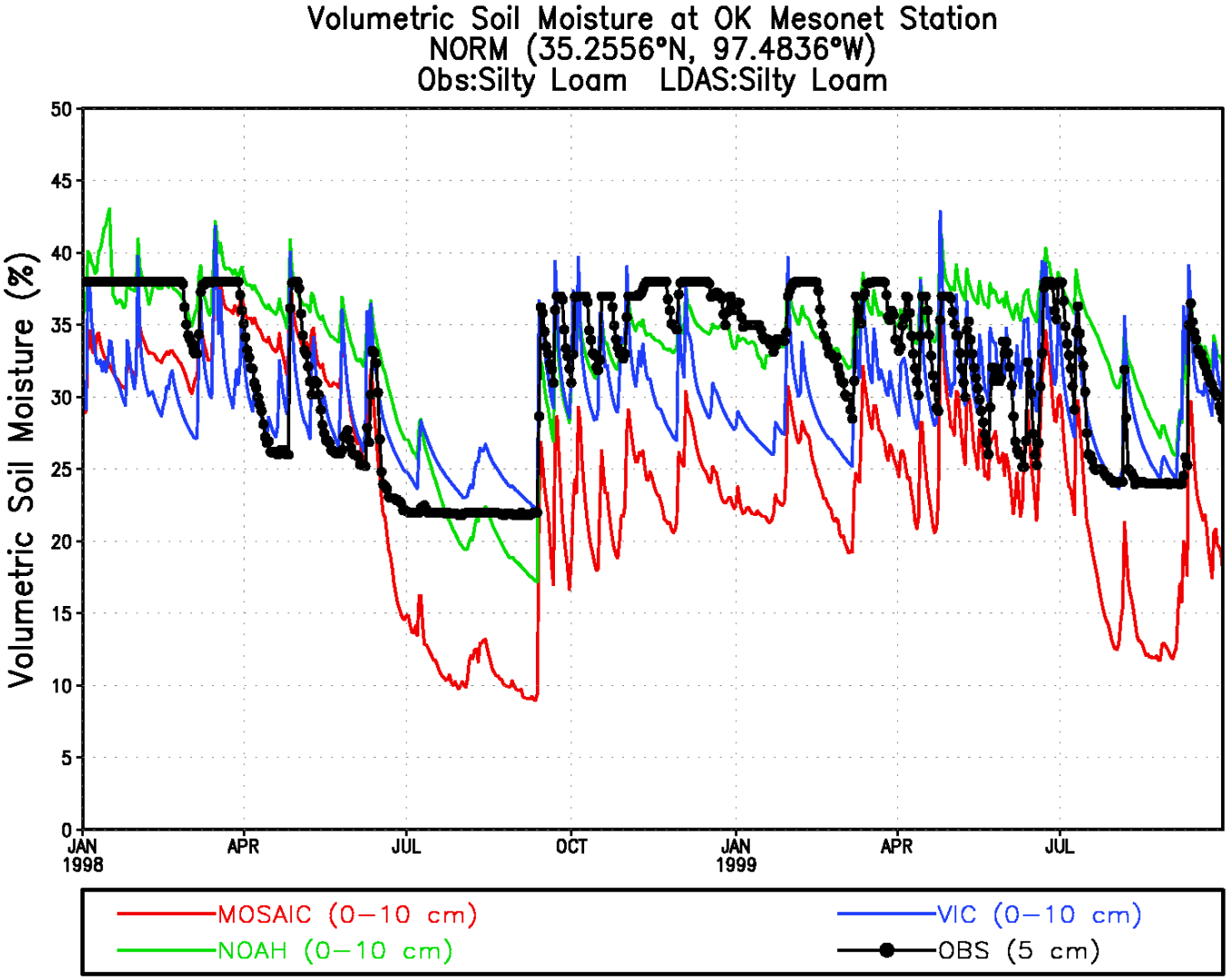
- **Control**
  - *Original LDAS simulation*
- **Local Forcing**
  - *Using all available local observed atmospheric forcing at OK Mesonet and ARM/CART stations*
- **Local Soil**
  - *Original LDAS forcing, but local soil properties observed at the stations*

Soil Texture Comparison

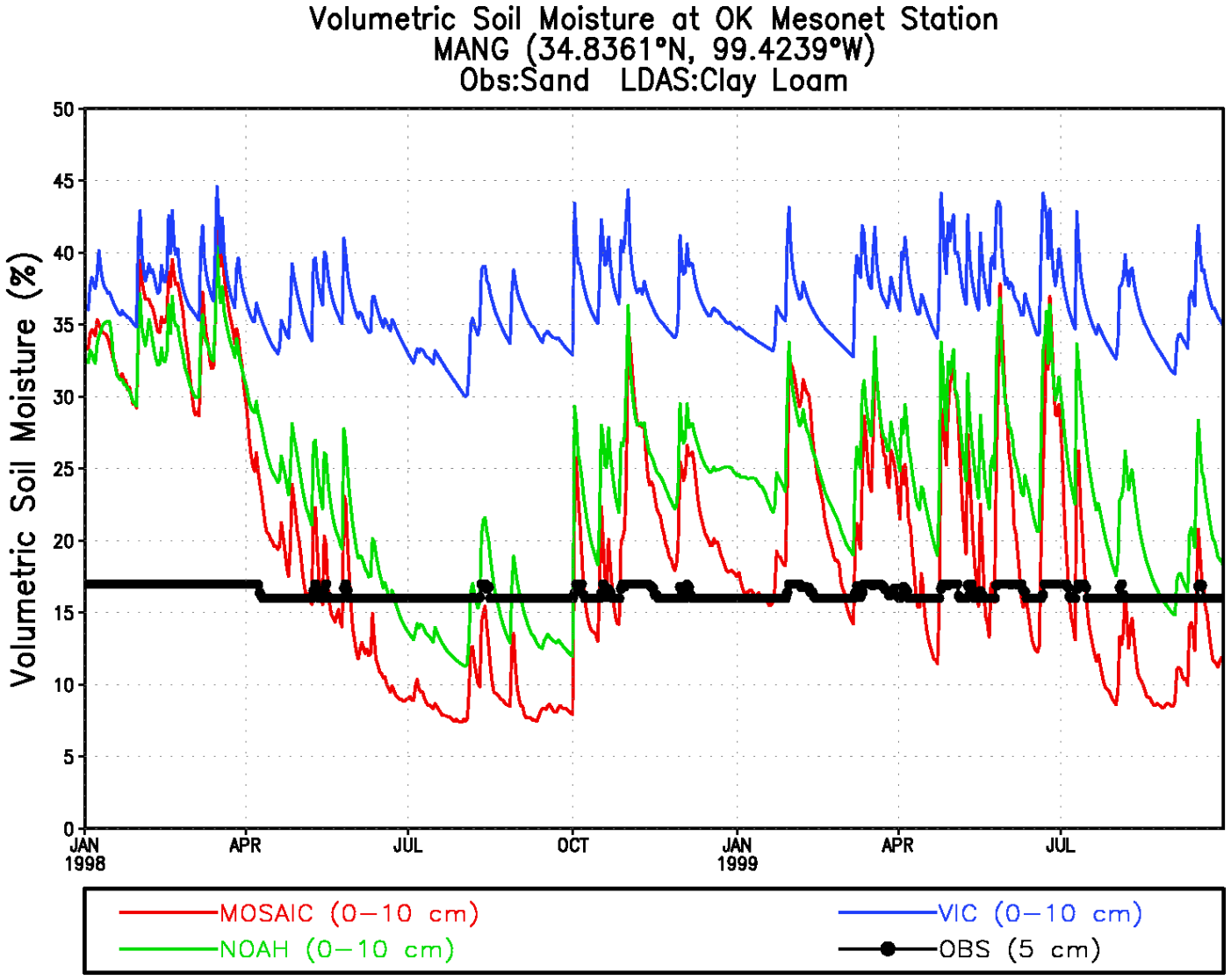
- Soil texture is as important as vegetation in the land surface model simulations.
- Soil texture data set used by LDAS is based on 1 km Penn State STATSGO and 5 min ARS FAO data.
- At Oklahoma Mesonet and ARM/CART stations, soil texture information is also available.
- The actual station observations do not agree very well with those specified for the LDAS models.



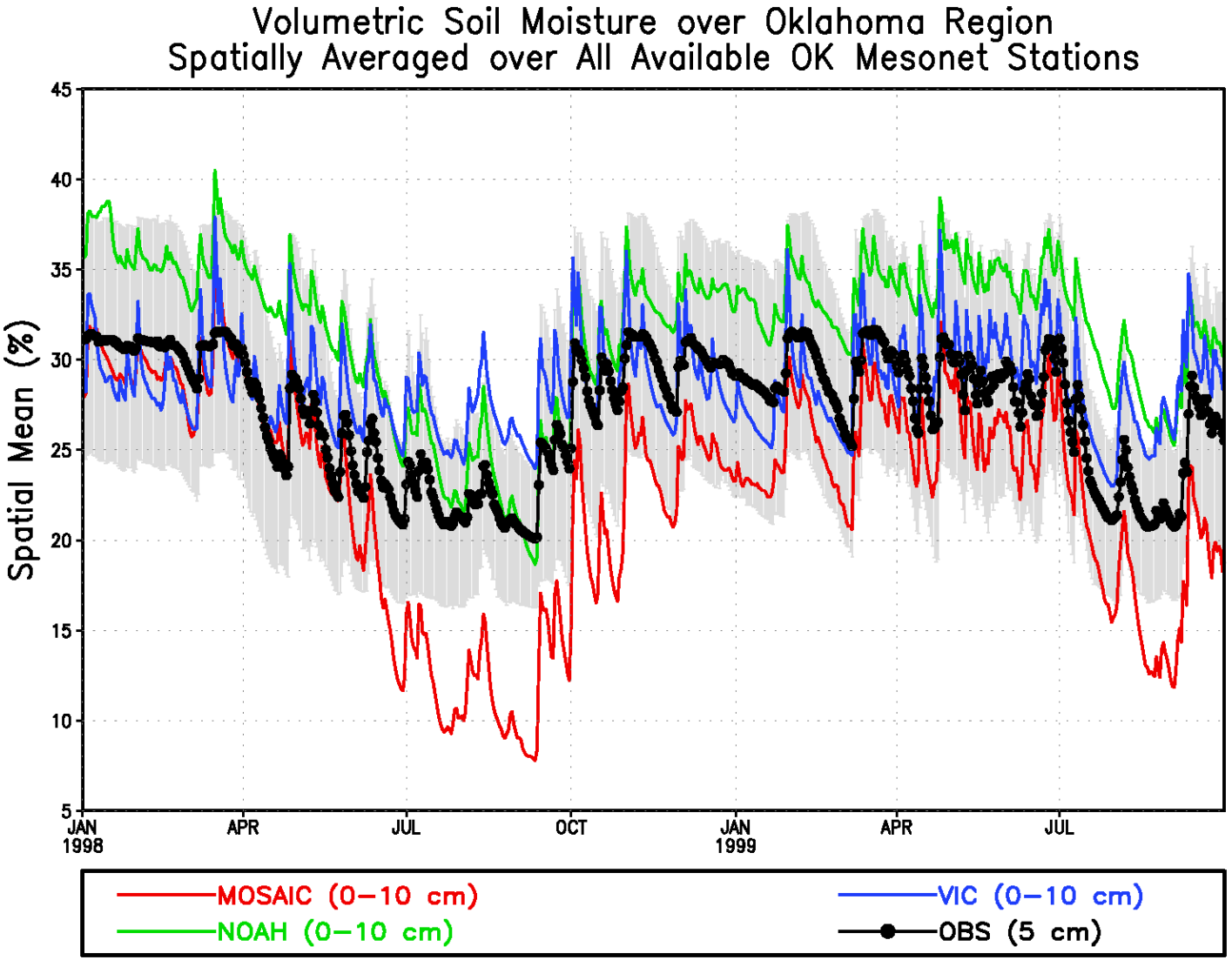
Simulation with Matching Soil



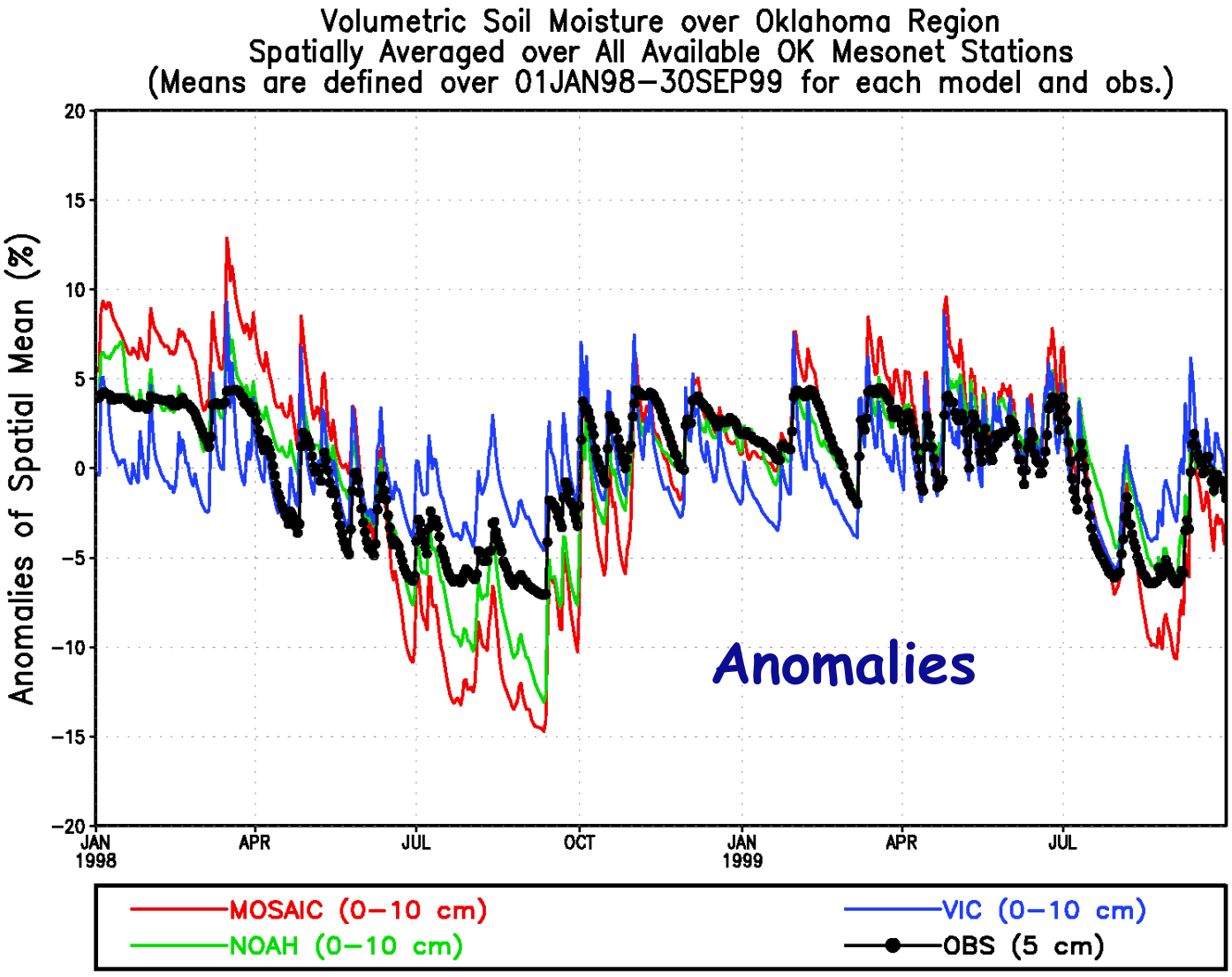
Simulation with Different Soil



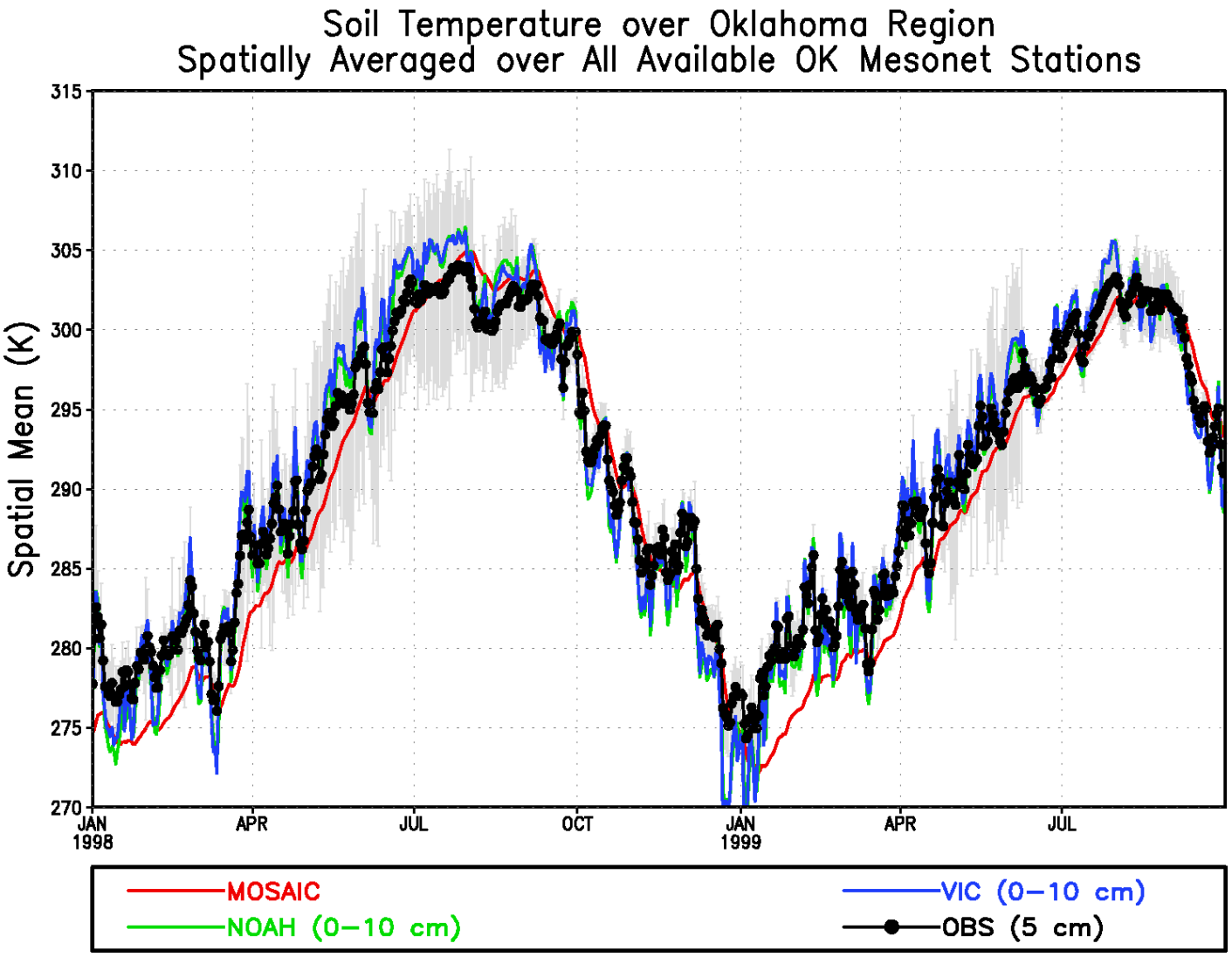
Control Soil Moisture



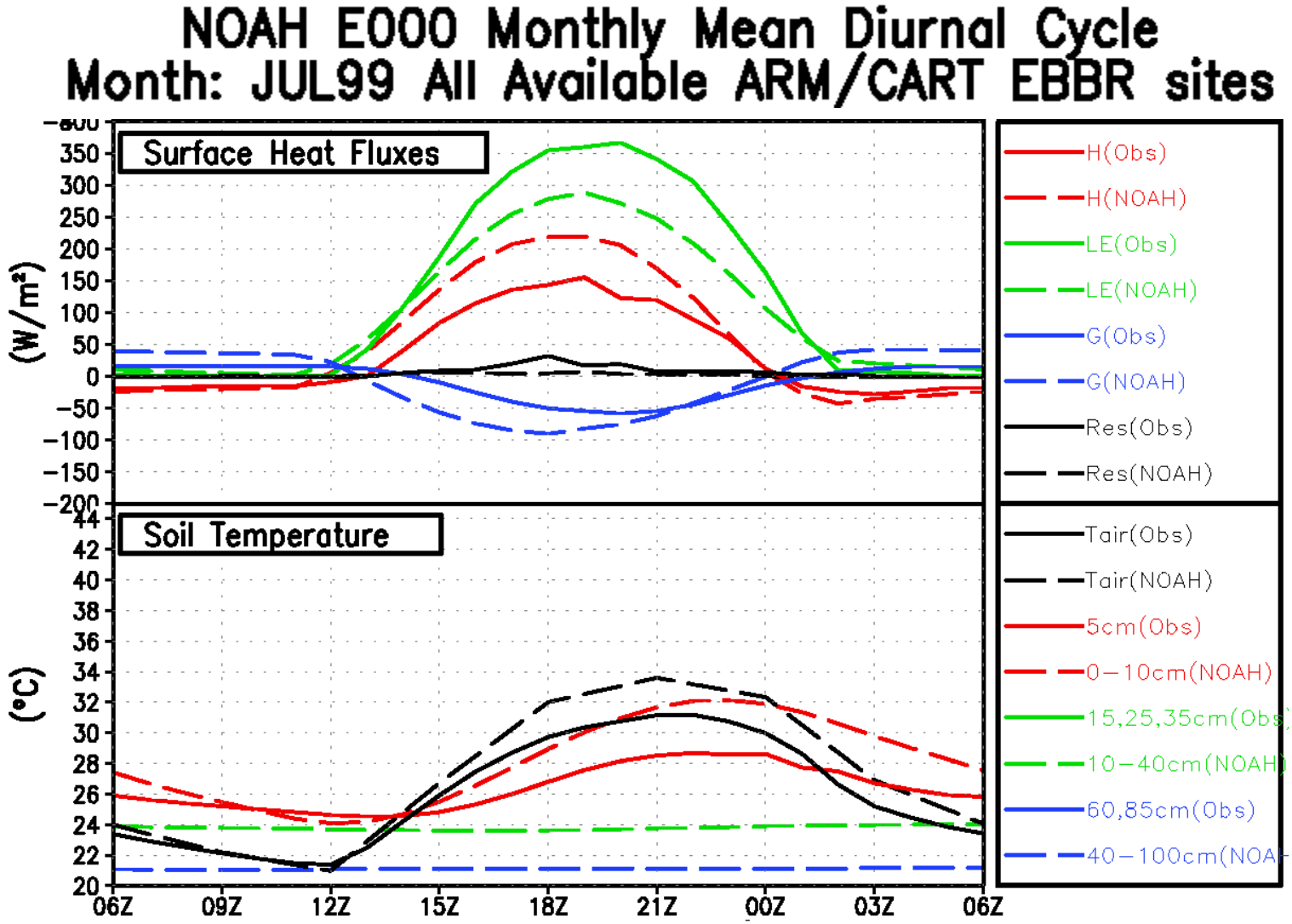
Control Soil Moisture



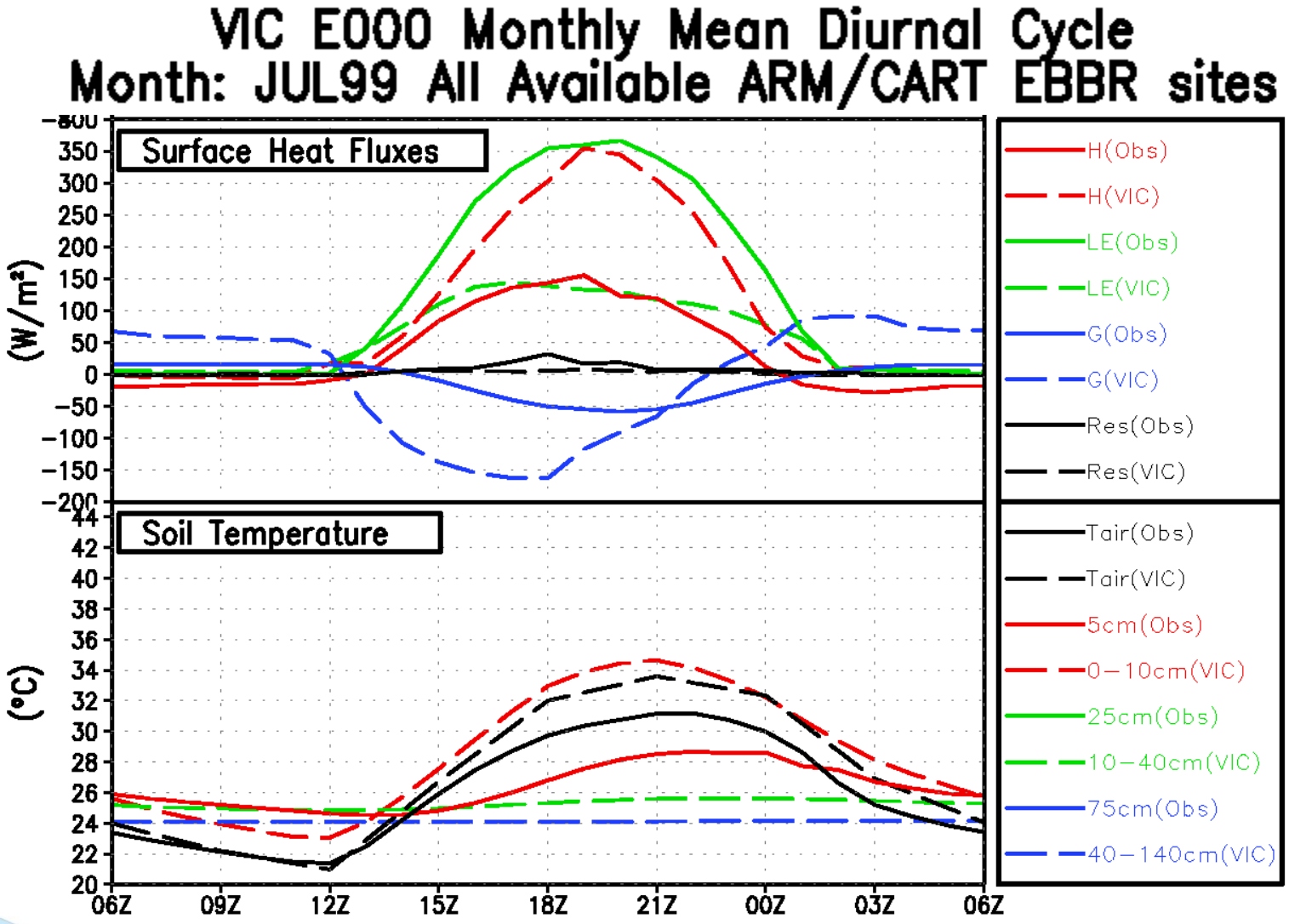
Control Soil Temperature



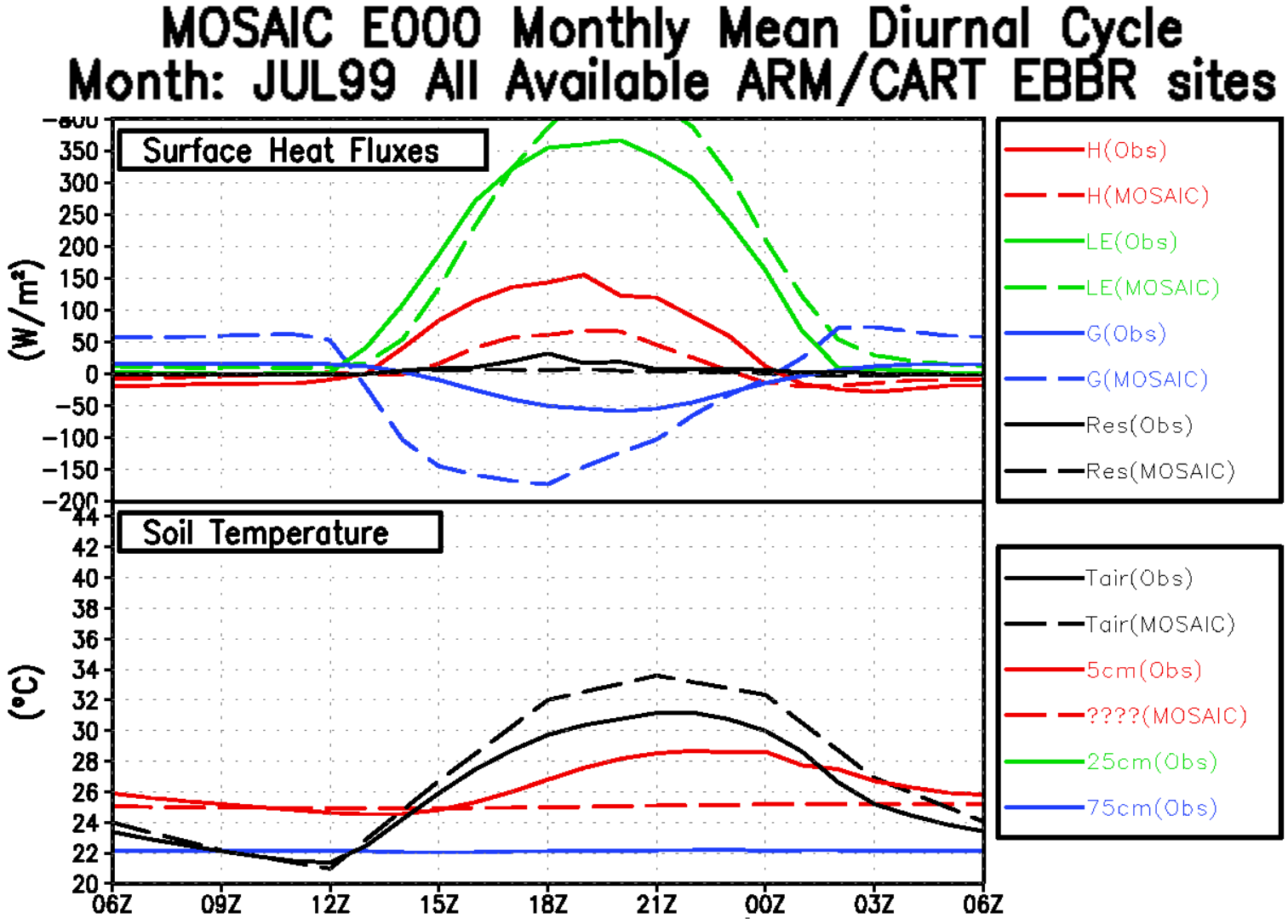
Control NOAH Fluxes



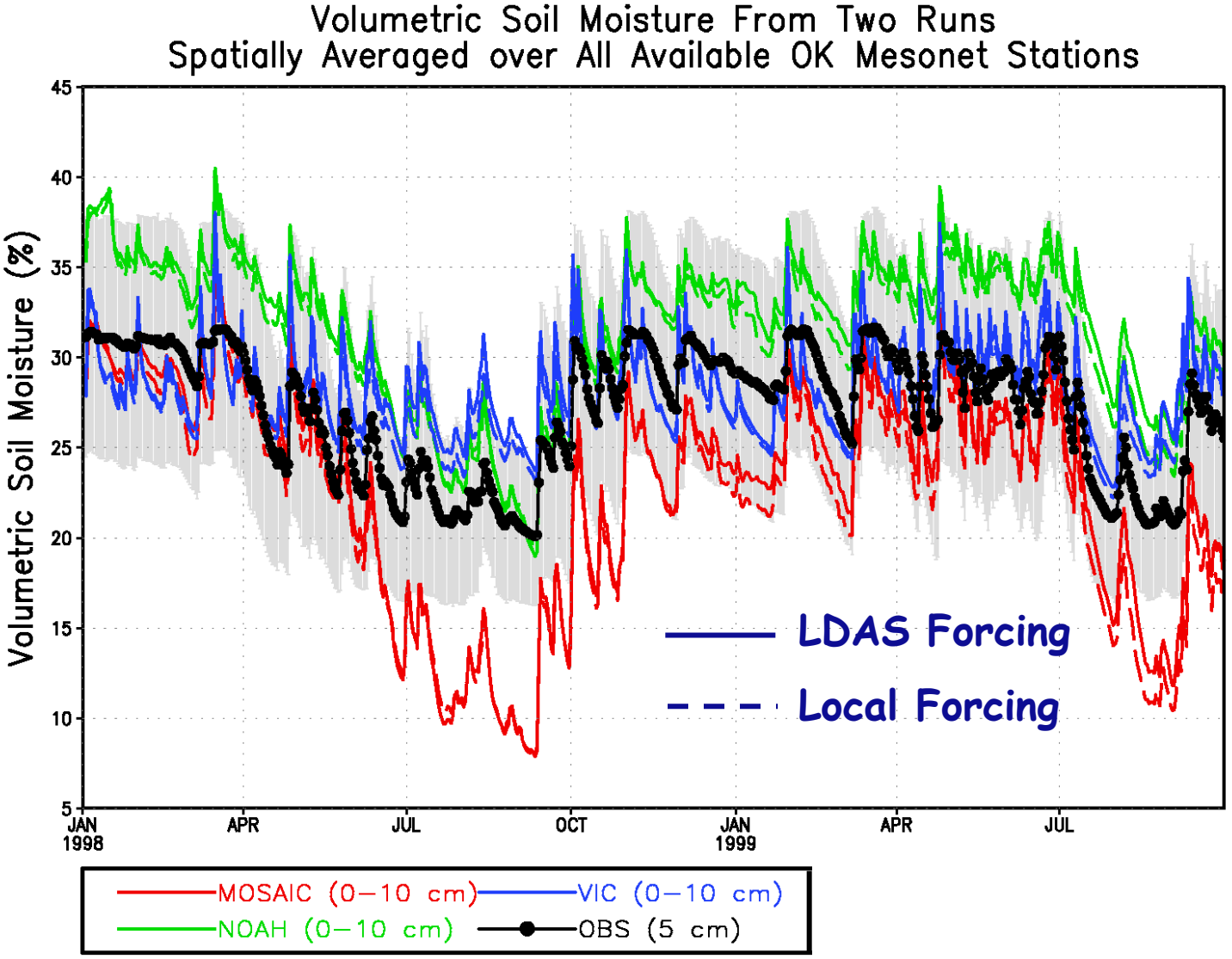
Control VIC Fluxes



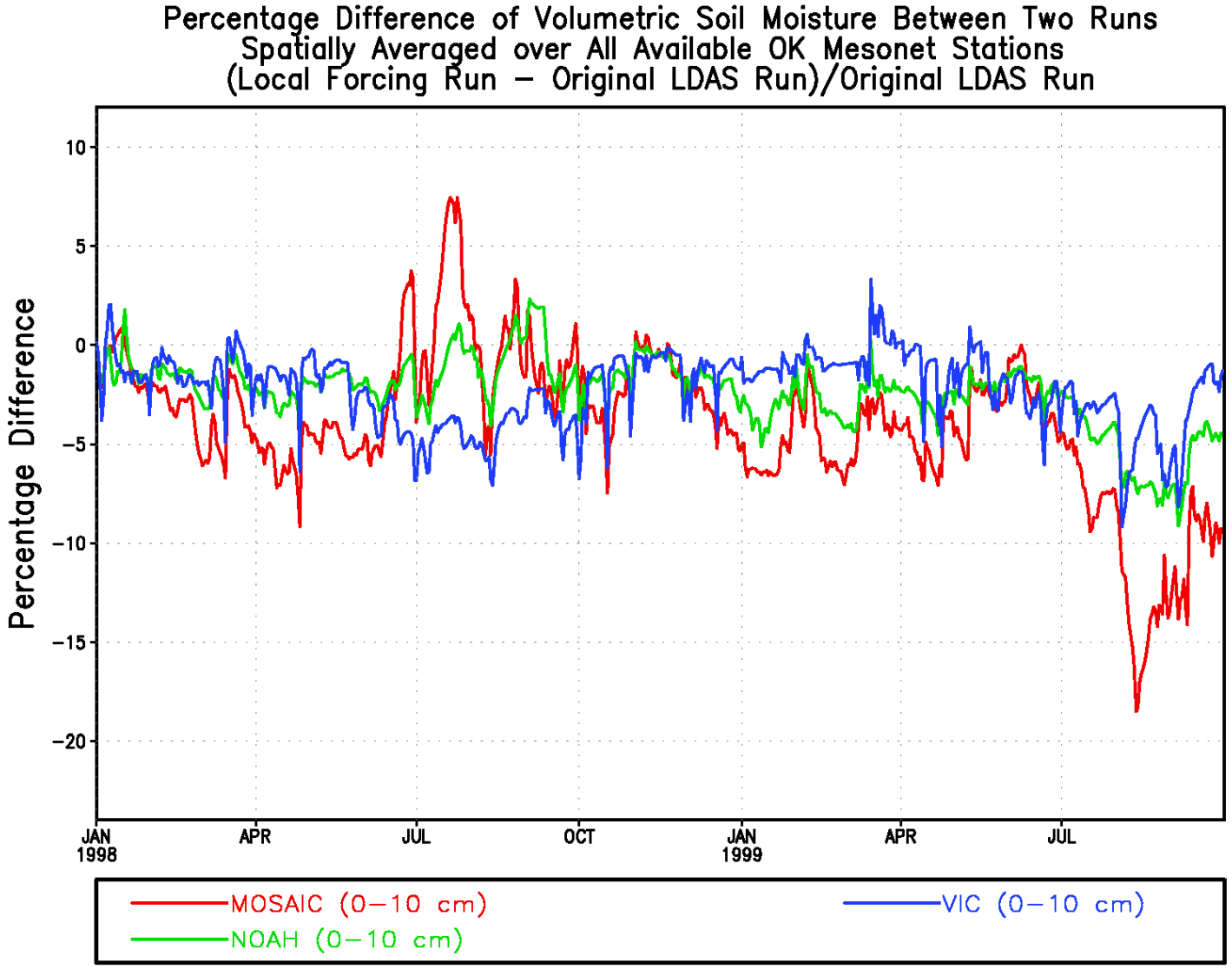
Control MOSAIC Fluxes



Local Forcing Soil Moisture



Local Forcing Soil Moisture



Answers: LDAS Scientific Questions

1. Can land surface models forced with observed meteorology and radiation accurately calculate soil moisture? Probably

2. If not, what are the relative contributions to the differences between models and observations of errors in the soil moisture observations or of the differences between model and observed: No

   a. Forcing? No
   b. Soil properties? Yes
   c. Vegetation? Probably
   d. Scales? No, if using spatial average
   e. Vertical resolution? Probably not
   f. Tiling or variable infiltration assumptions? ?

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Conclusions

1. LDAS simulations of soil moisture show reasonable simulations of soil moisture and temperature and fluxes compared to Oklahoma observations.
2. Differences between model output and observations are not due to differences between actual and LDAS-specified forcing or random observational errors, but are likely due to soil or vegetation differences and model assumptions.

- Conducting these experiments is very difficult, given the task of assembling and quality controlling the complex combination of disparate forcings and the validation observations, the massive amounts of output generated, and typical computer problems, but coordination between the LDAS team members has worked extremely smoothly.
- Validation with actual observations is crucial to model improvement.