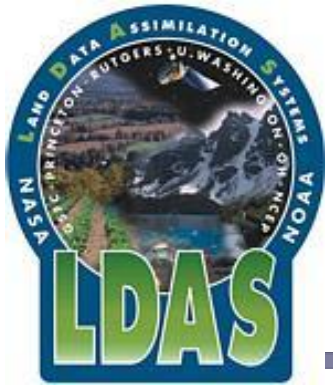
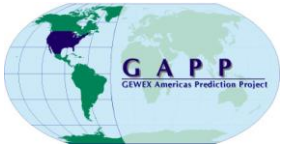


Evaluation of N-LDAS Land Surface Models with Observed Surface Fluxes, Soil Moisture, and Soil Temperature

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



THE STATE UNIVERSITY OF NEW JERSEY
RUTGERS

LDAS Goals

1. Test state-of-the-art land surface models for use in data assimilation.

2. Once we have a good model, develop a real-time land surface data assimilation system that uses in situ and remotely-sensed soil moisture, skin temperature, and snow to produce (in real time and later in a reanalysis) an accurate soil moisture data set that can be used for
   a) retrospective land-memory predictability studies, and
   b) real-time coupled model predictions of weather and seasonal climate

We are still in phase 1 of the project.

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)**

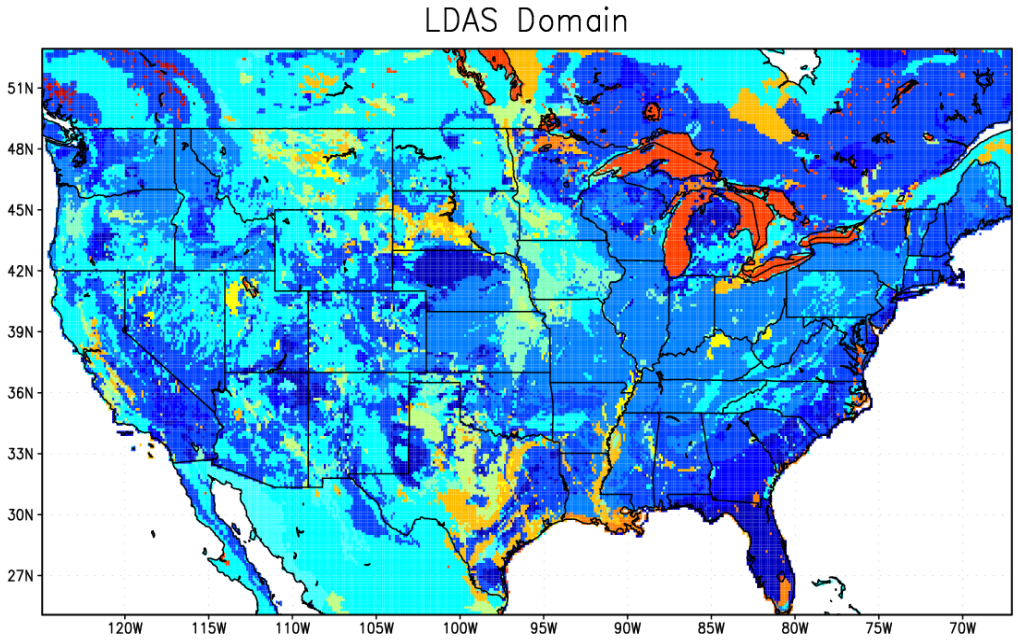
3. **Evaluate results with all available observations, including soil moisture, soil temperature, and fluxes.**

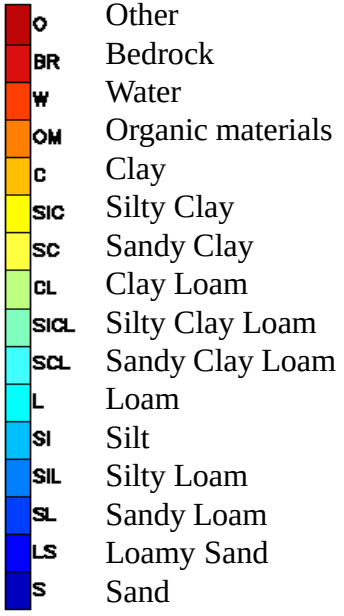
GAPP
GEWEX Americas Prediction Project

THE STATE UNIVERSITY OF NEW JERSEY
RUTGERS

Introduction

Predominant soil type





- **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.

LDAS Evaluation Issues

For model evaluation, we must deal with the following issues:

- Vegetation
- Vertical resolution
- Soil type

} Differences between observations and models

- Precipitation
- Radiation

} Differences in forcing between observations and models

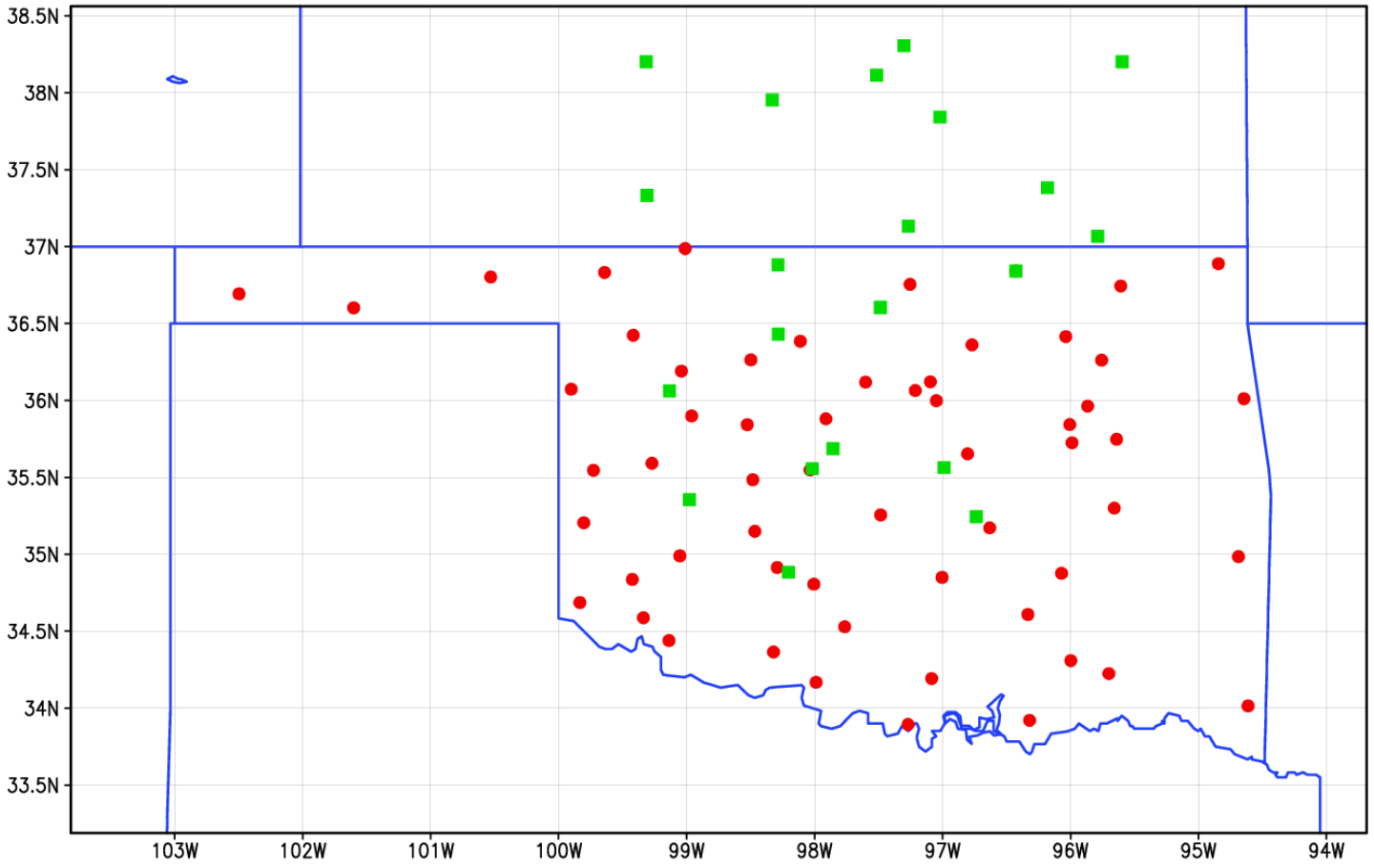
- Spatial and temporal scales of soil moisture variations
- Averaging soil moisture from a mosaic tiling approach
- Interpreting soil moisture from variable infiltration approach

GAPP
GEWEX Americas Prediction Project

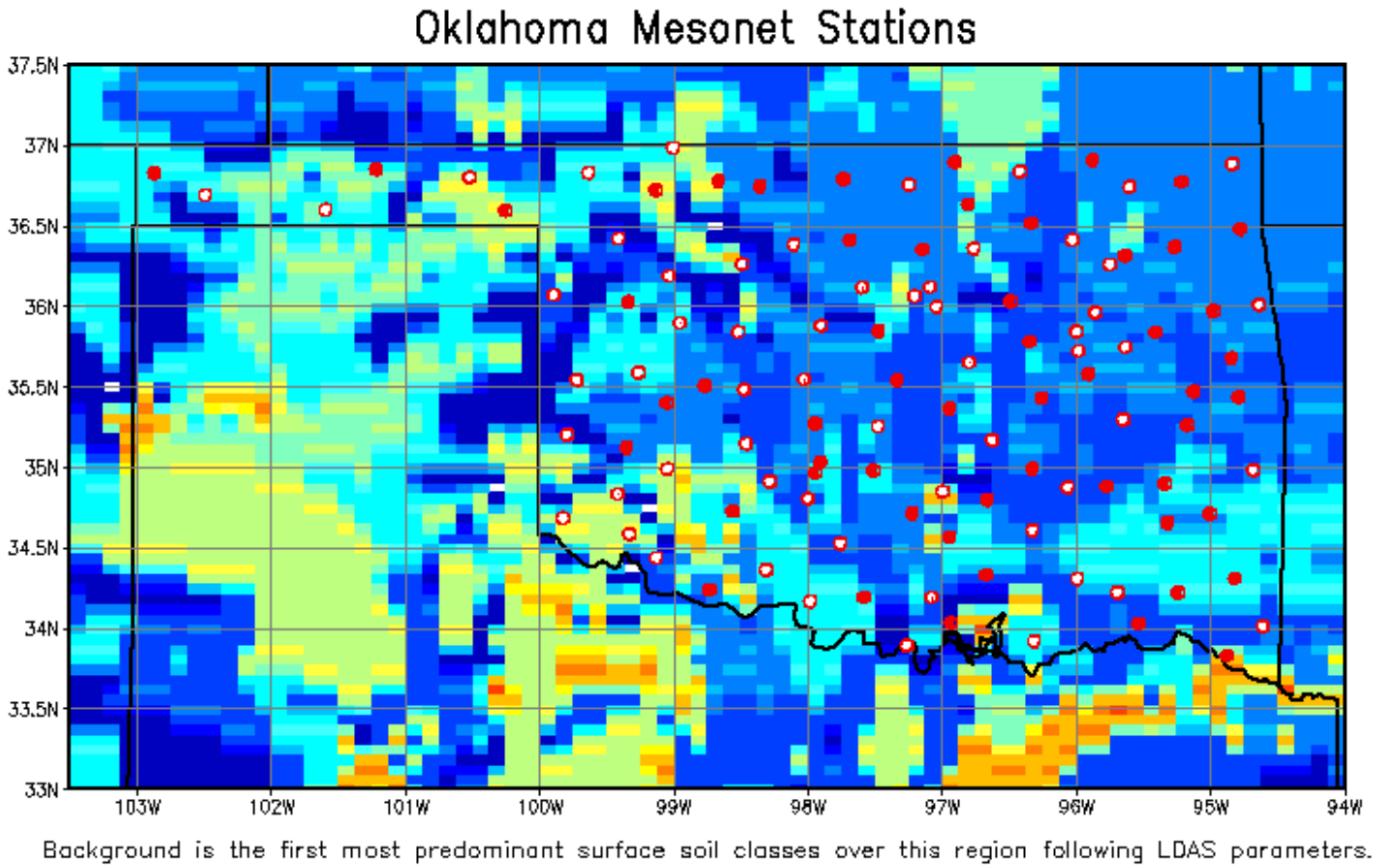
THE STATE UNIVERSITY OF NEW JERSEY
RUTGERS

Soil Moisture Observations

- ARM/CART sites
- Oklahoma Mesonet sites



Oklahoma Mesonet



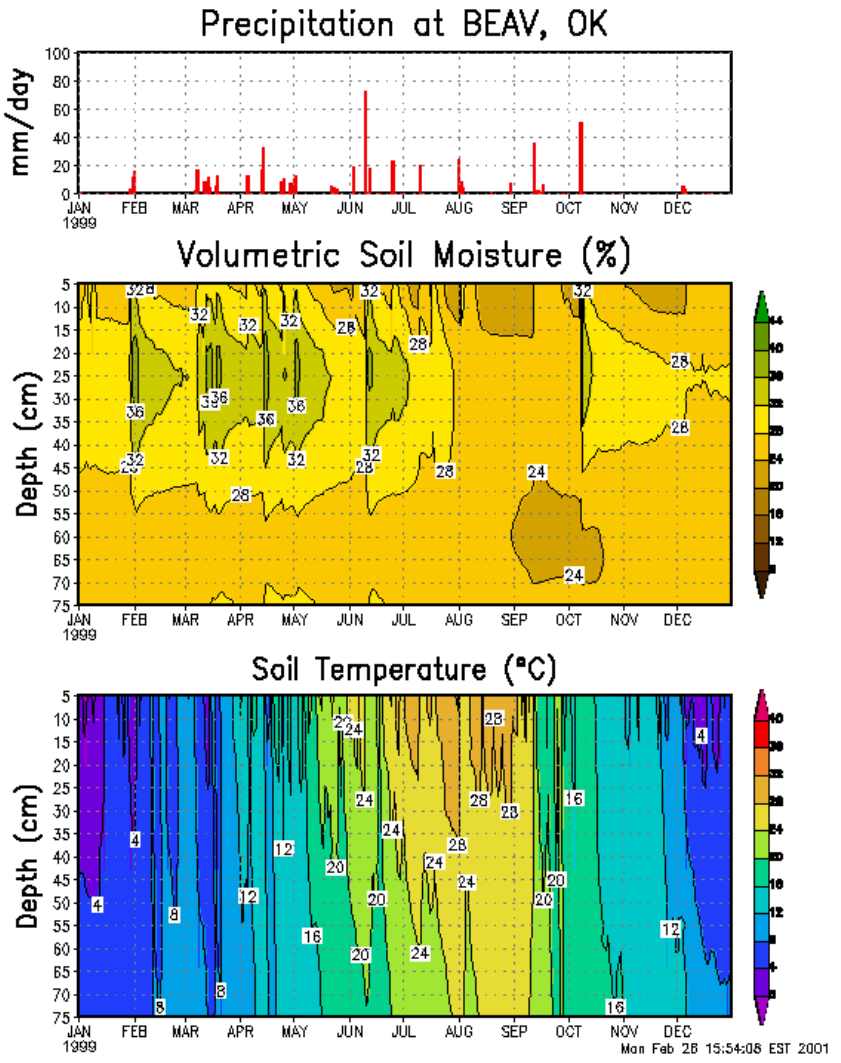
Background is the first most predominant surface soil classes over this region following LDAS parameters.

Predominant soil type

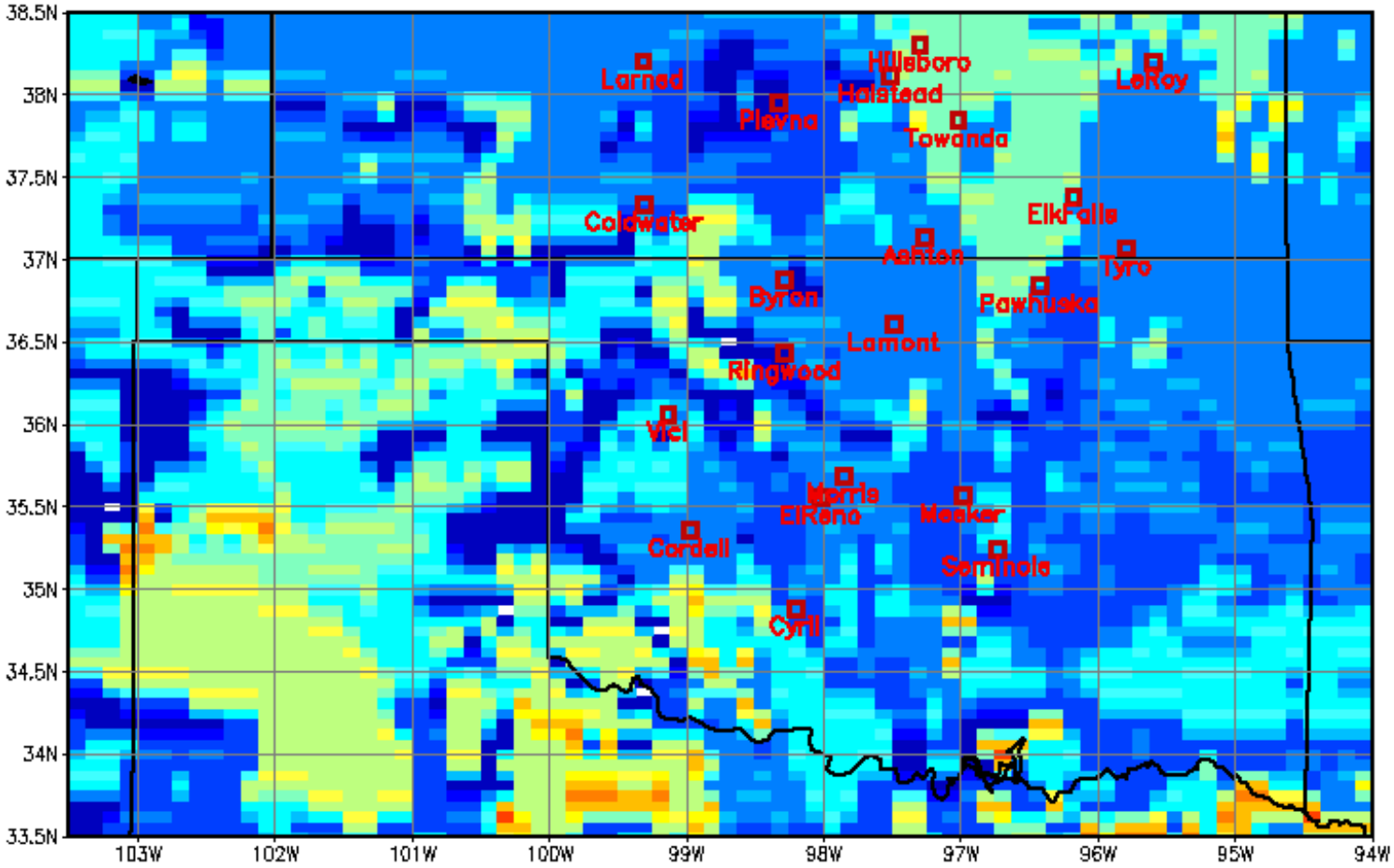
O	Other
BR	Bedrock
W	Water
OM	Organic materials
C	Clay
SIC	Silty Clay
SC	Sandy Clay
CL	Clay Loam
SICL	Silty Clay Loam
SCL	Sandy Clay Loam
L	Loam
SI	Silt
SIL	Silty Loam
SL	Sandy Loam
LS	Loamy Sand
S	Sand

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



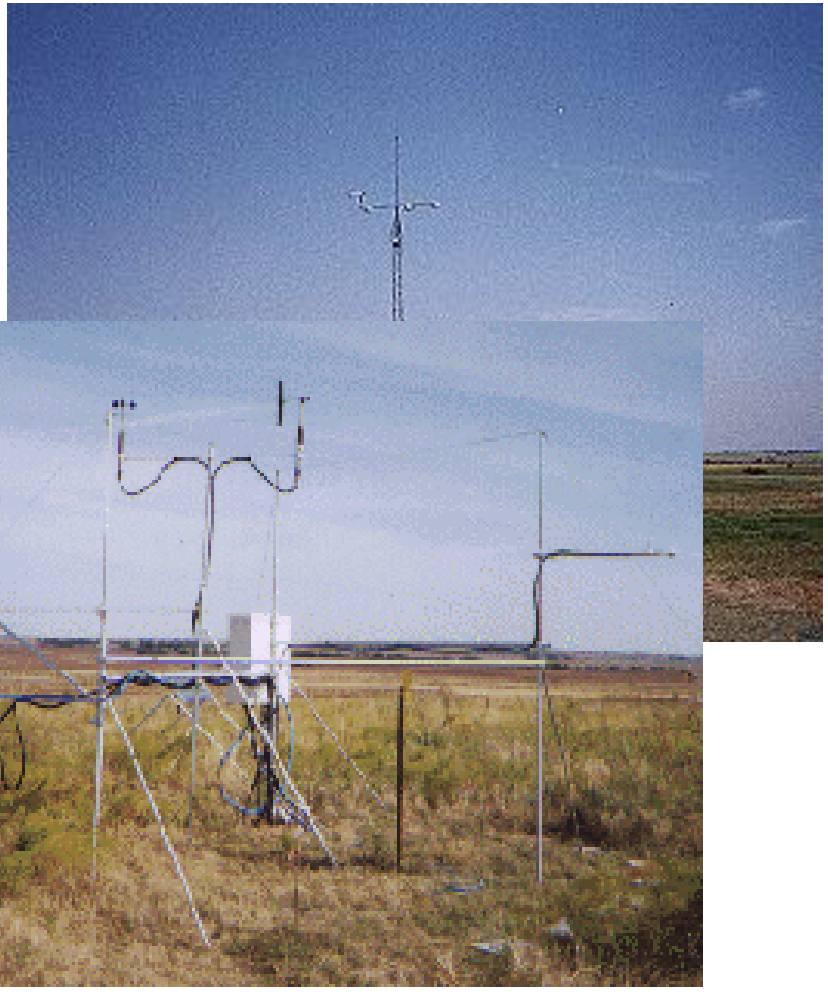
Background is the first most predominant surface soil classes over this region following LDAS parameters.

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

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*

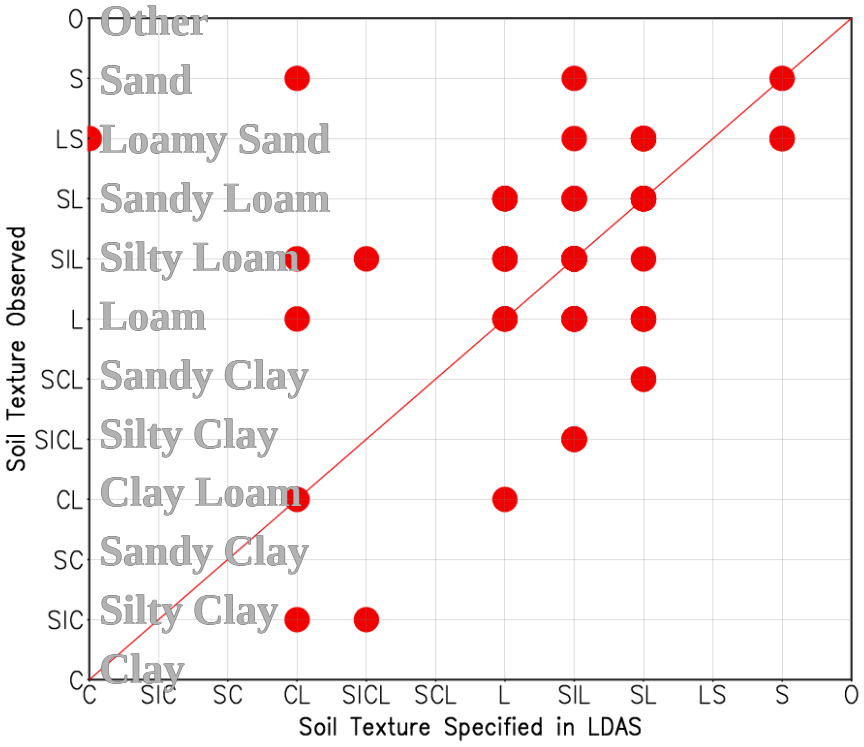


ARM/CART

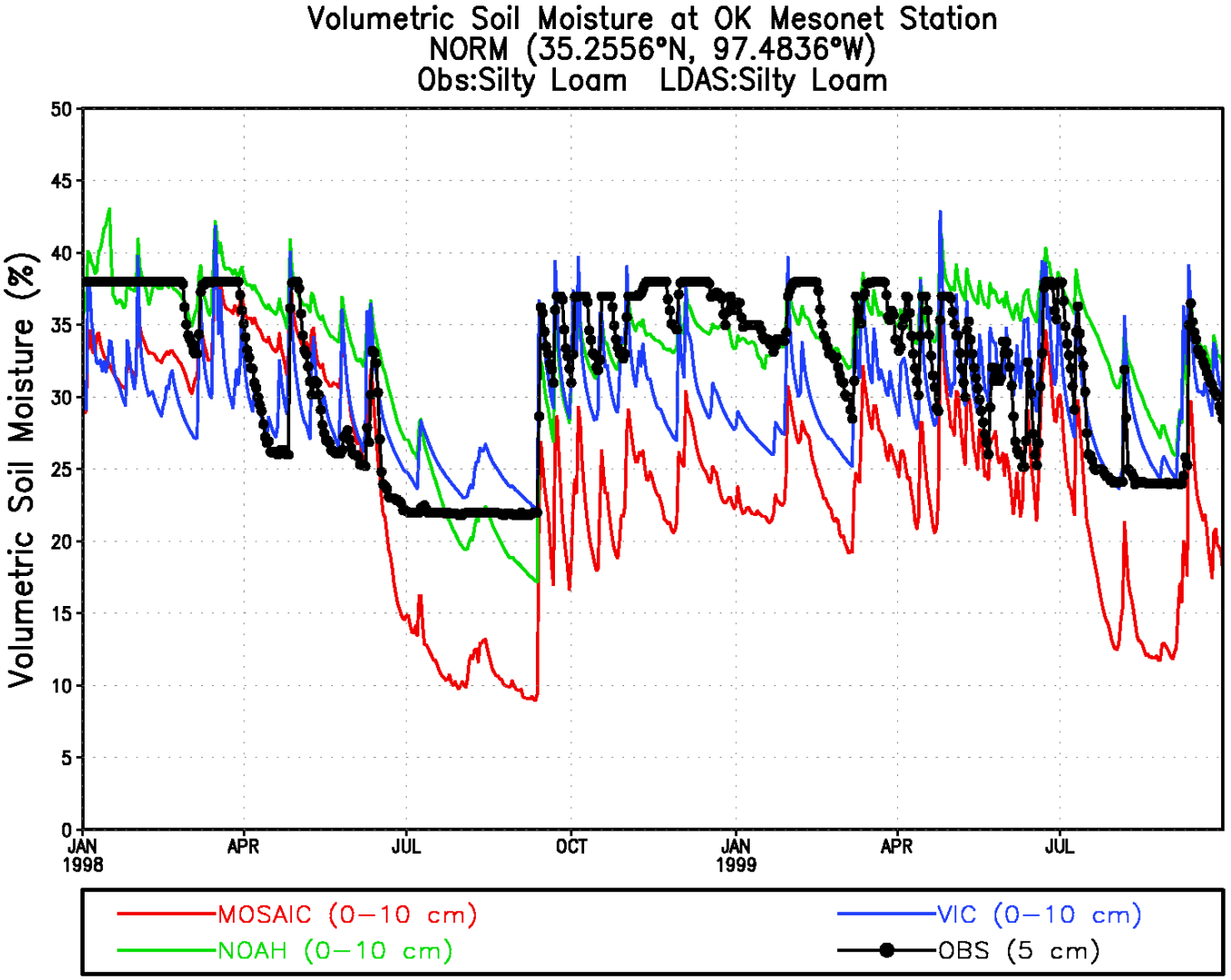
- **Solar Infrared Radiation Stations (SIRS)**
  - *Downward longwave radiation*
  - *Downward shortwave radiation*
  - *Upward longwave radiation*
  - *Upward shortwave radiation*
- **Soil Water And Temperature System (SWATS)**

Soil Texture Comparison

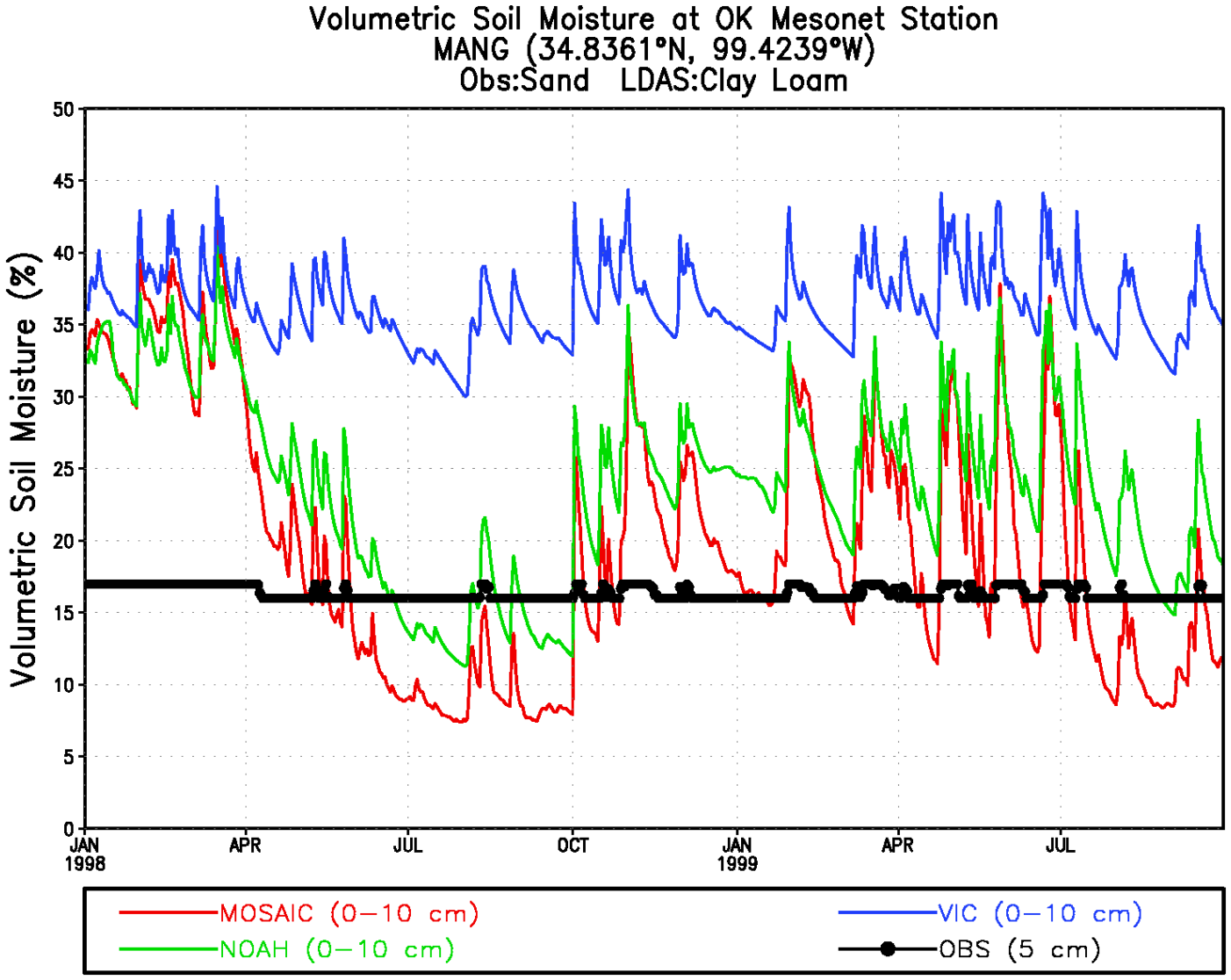
- Soil texture is as important as vegetation in the land surface model simulations.
- Soil texture data set used by LDAS is based on 1 km Penn State STATSGO and 5 min ARS FAO data.
- At Oklahoma Mesonet and ARM/CART stations, soil texture information is also available.
- The actual station observations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



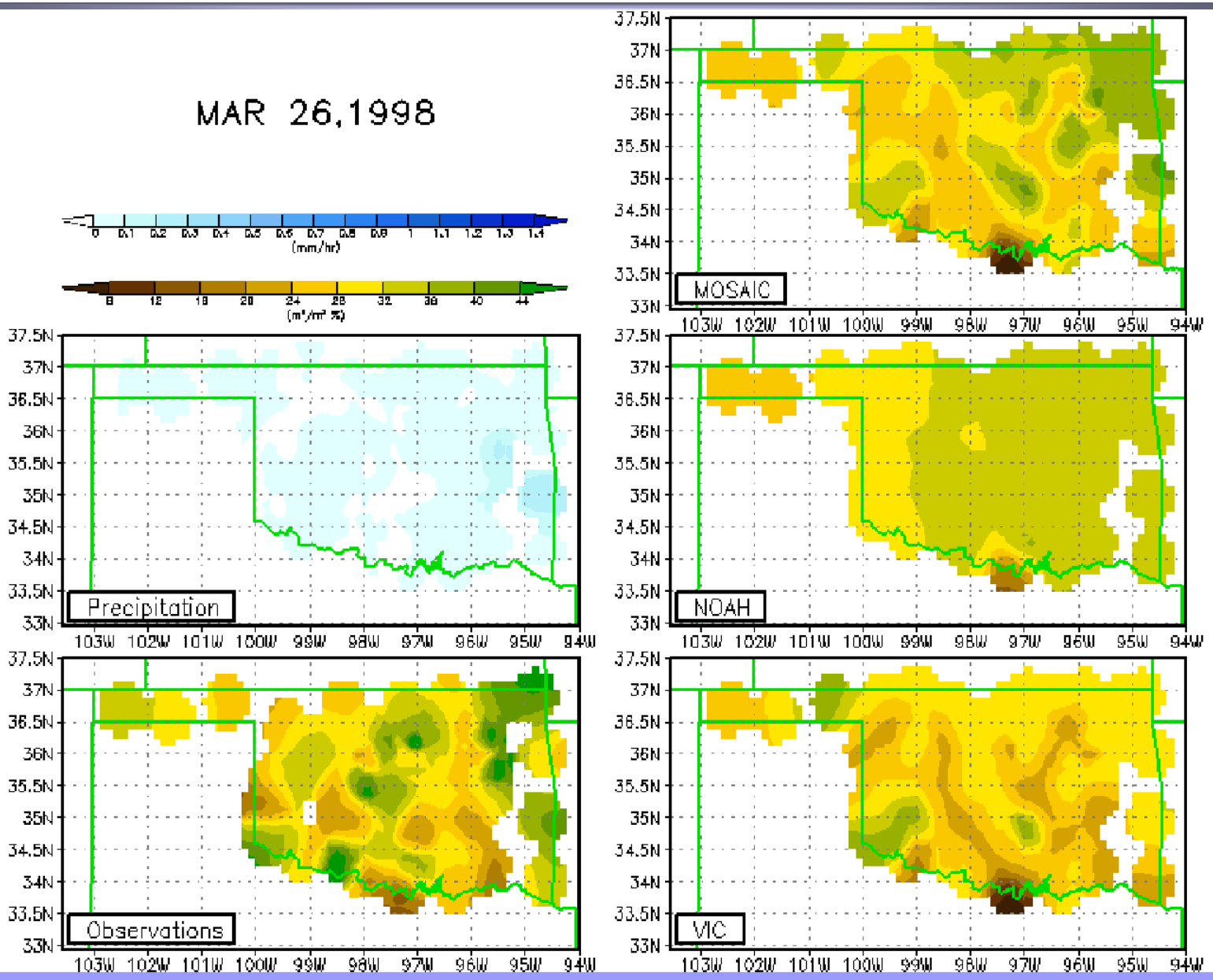
Simulation with Matching Soil



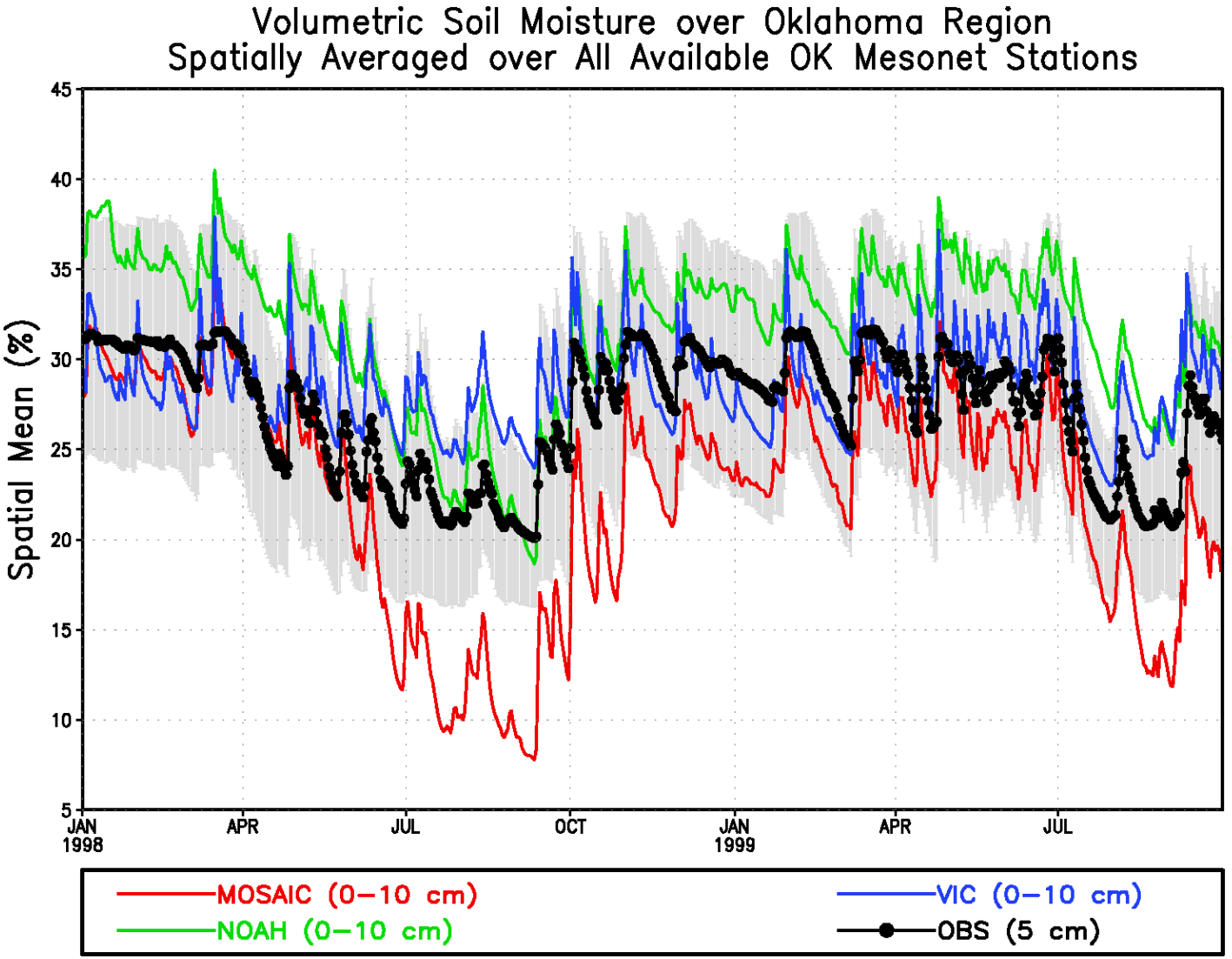
Simulation with Different Soil



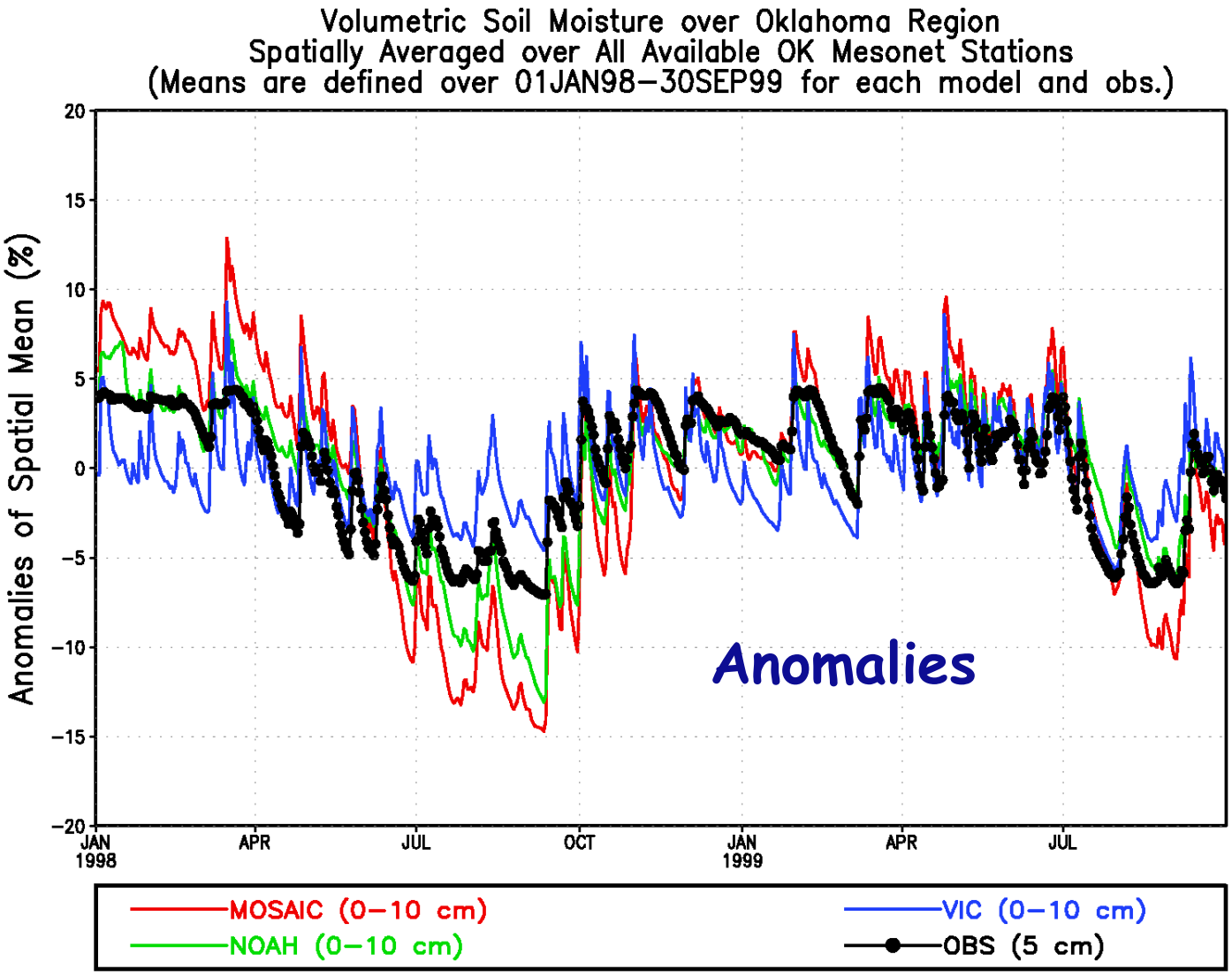
Soil Moisture



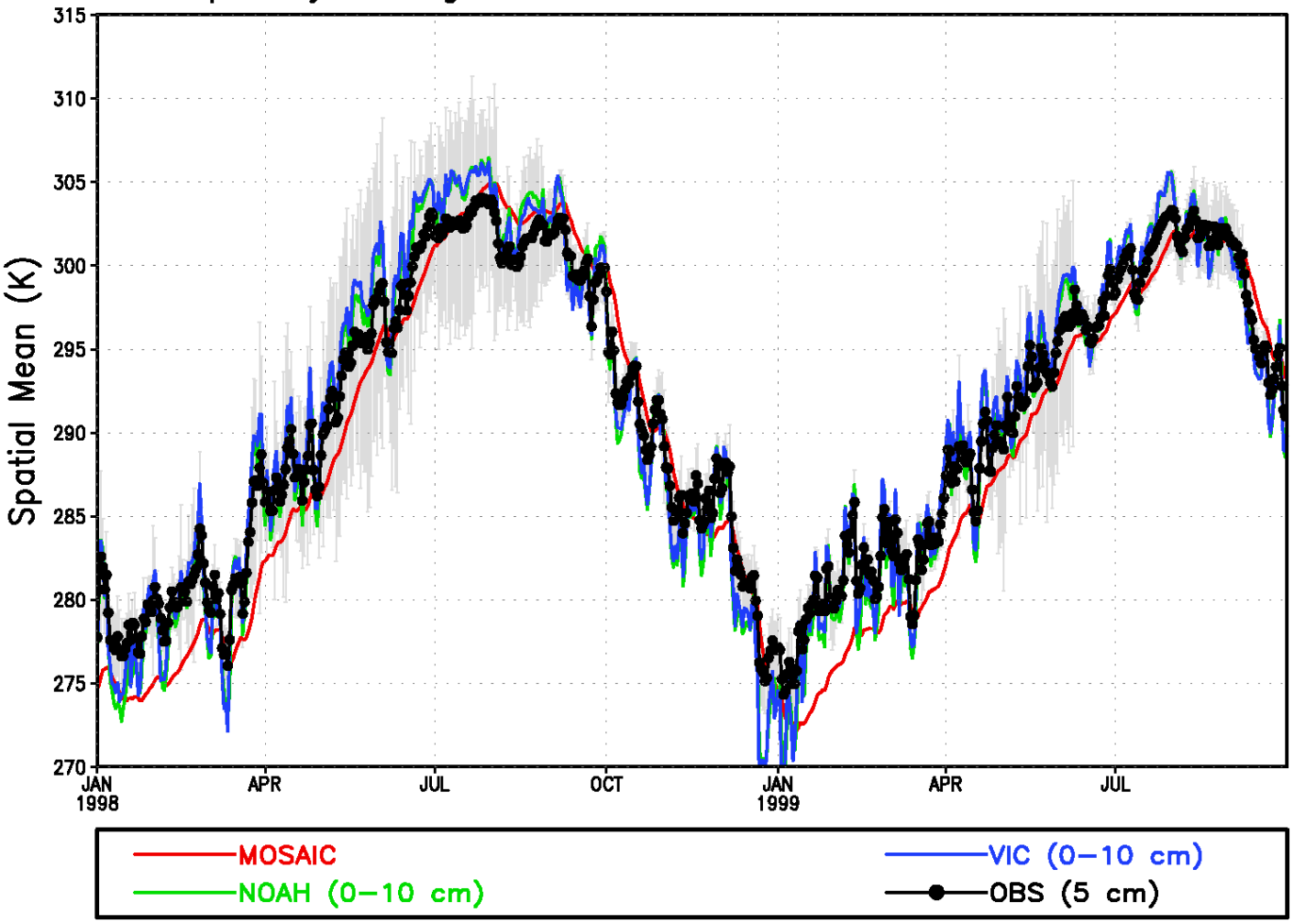
Soil Moisture



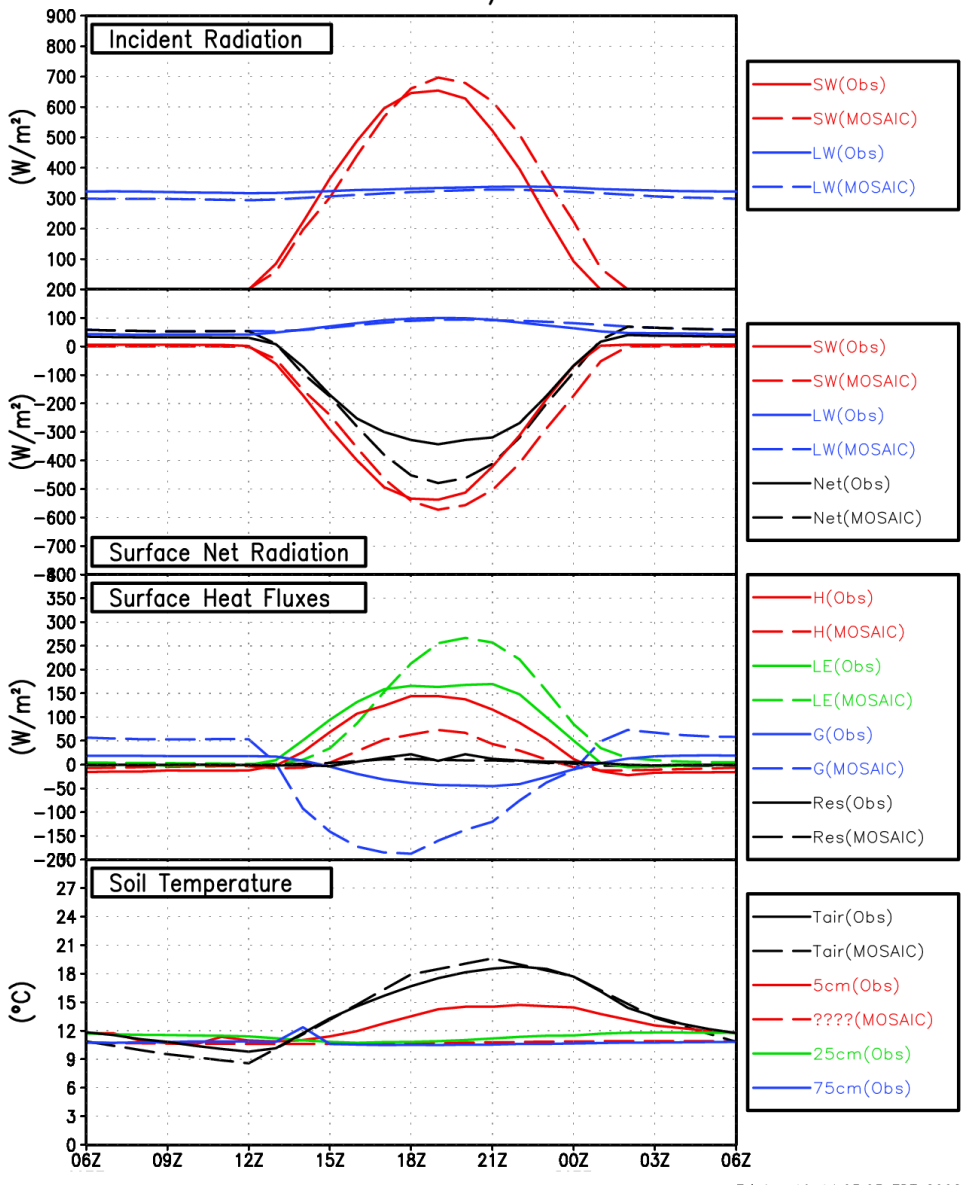
Soil Moisture Anomalies

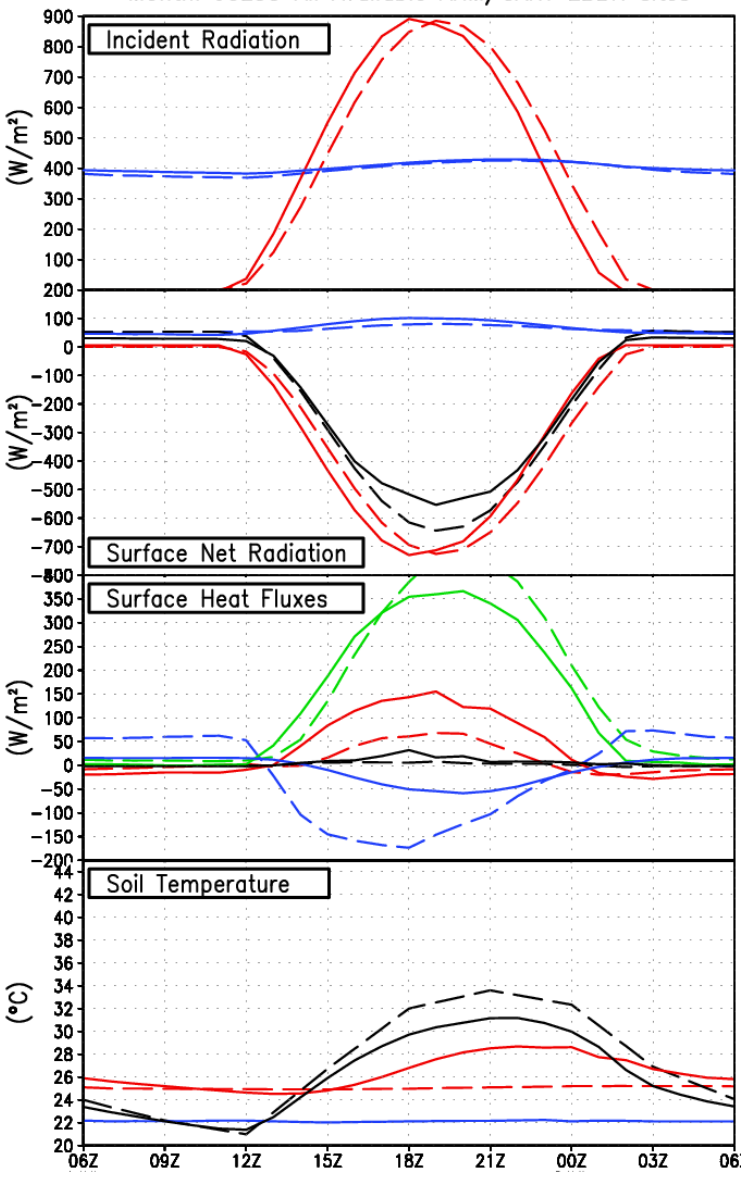


Soil Temperature

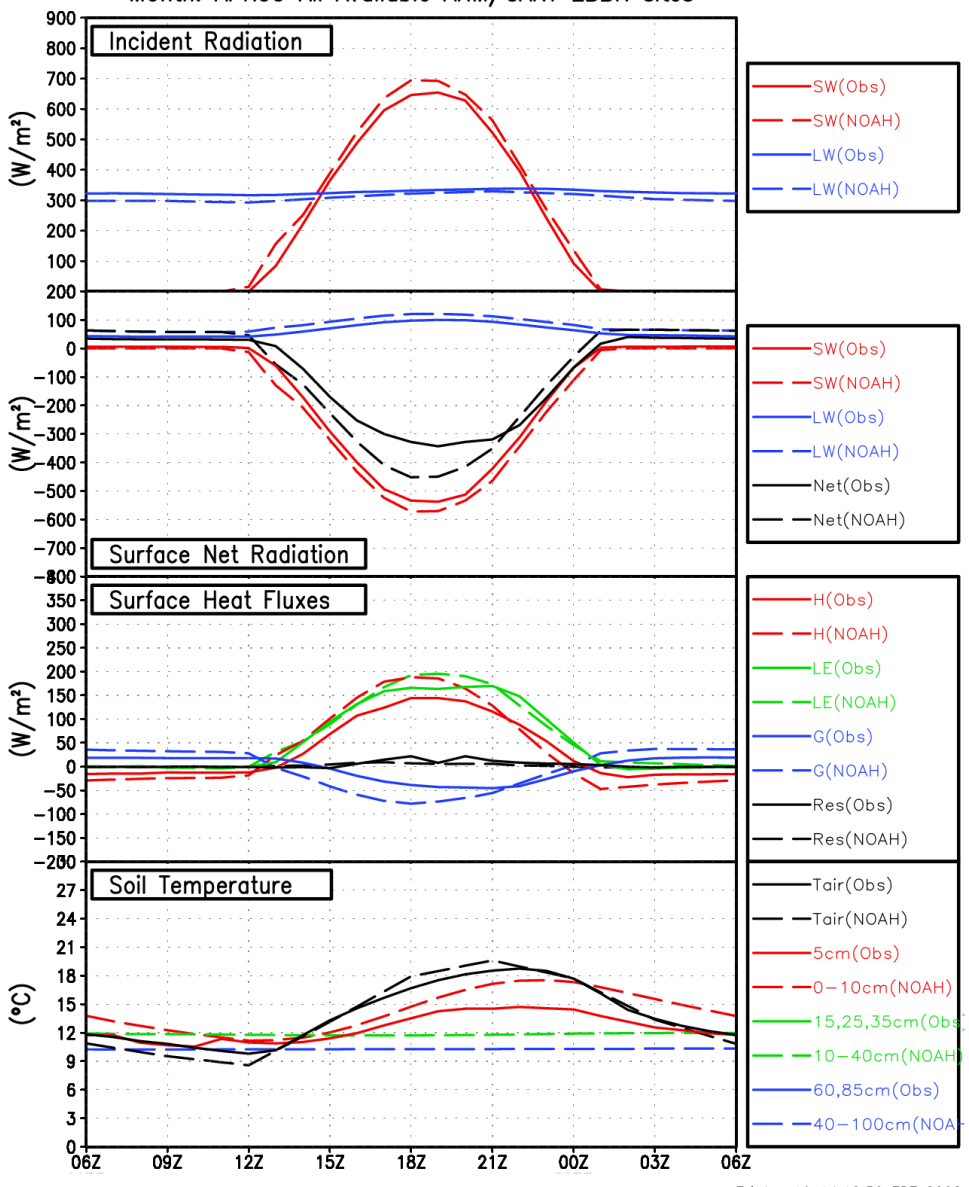


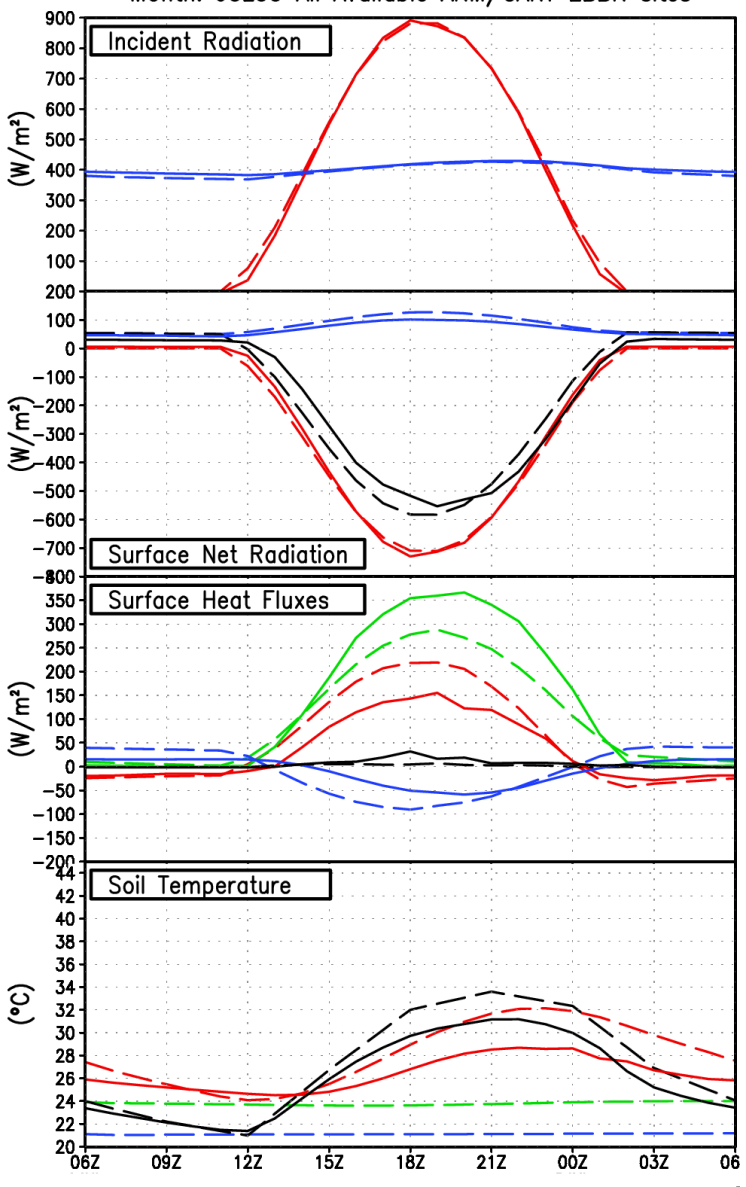
Diurnal Energy Fluxes: MOSAIC



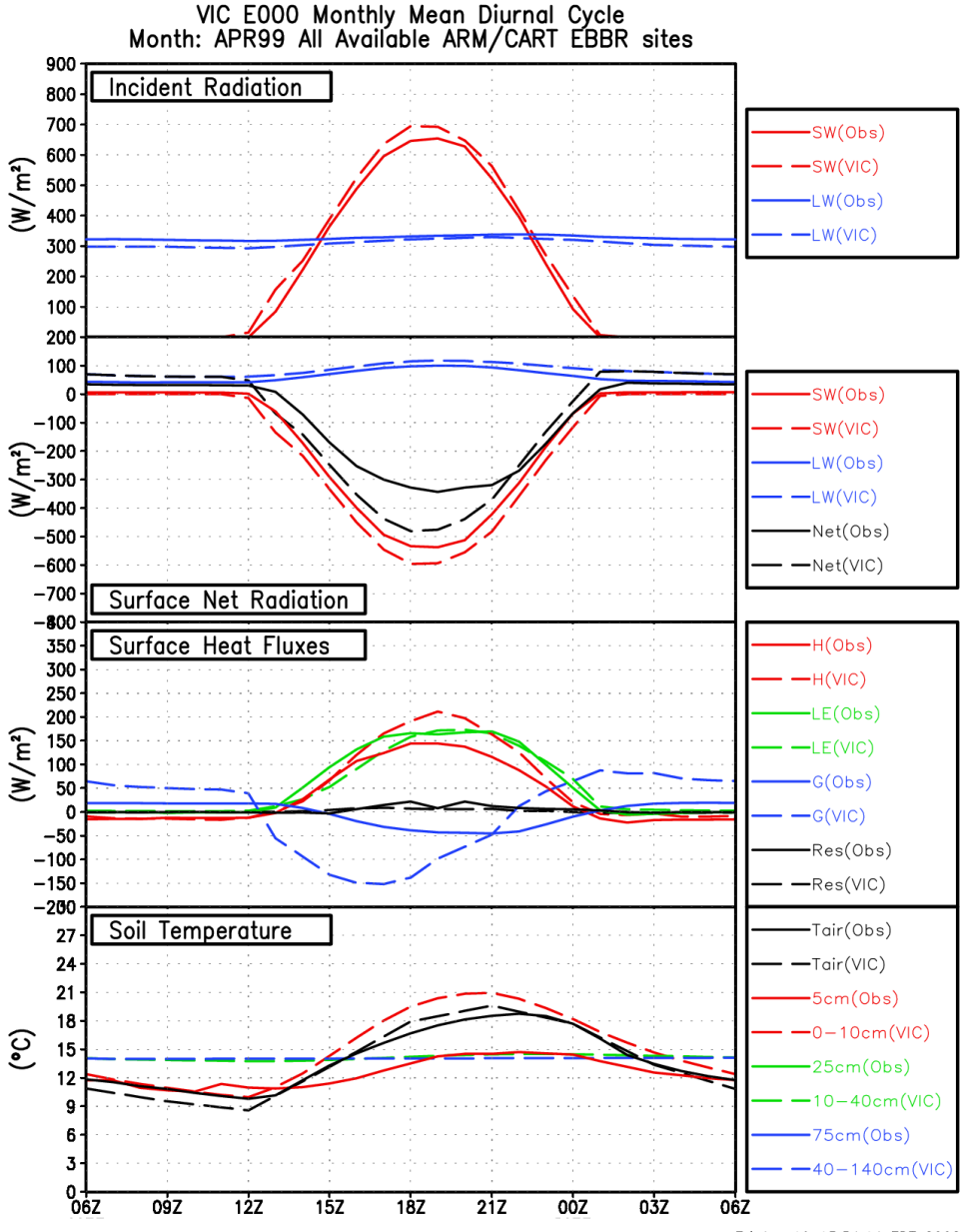


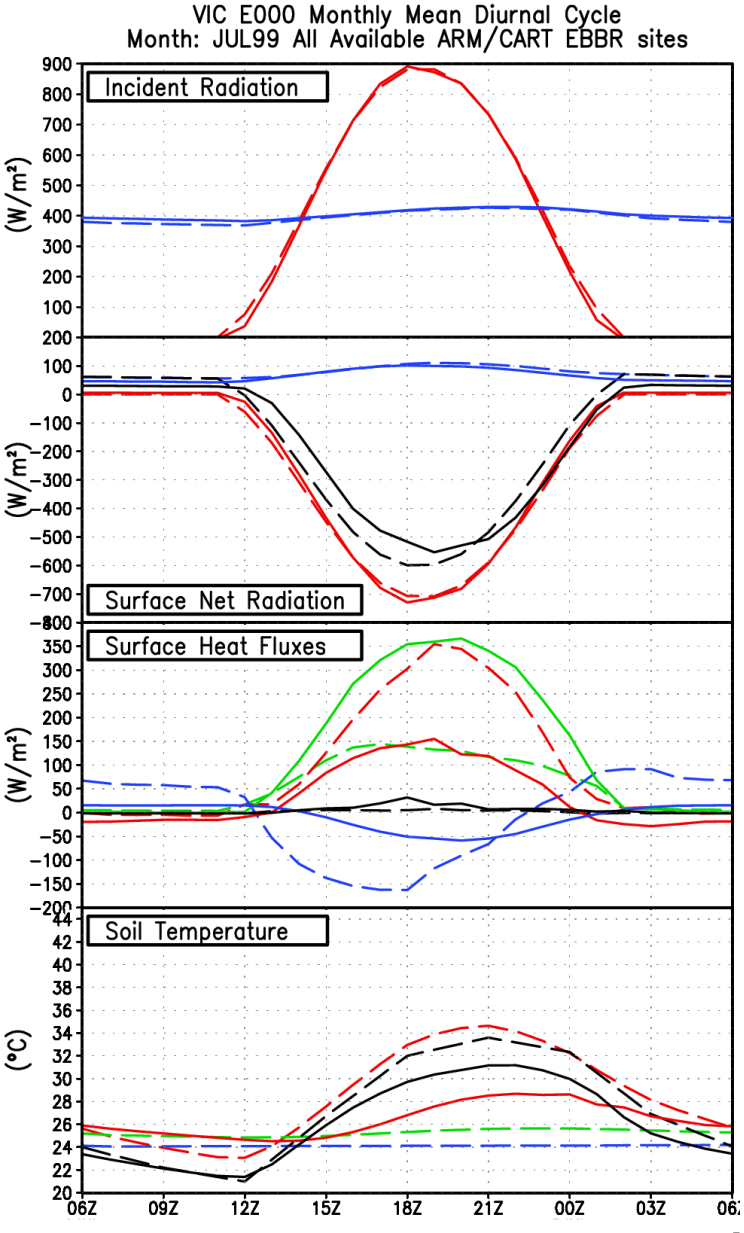
Diurnal Energy Fluxes: NOAH





Diurnal Energy Fluxes: VIC





Answers: LDAS Scientific Questions

1. Can land surface models forced with observed meteorology and radiation accurately calculate soil moisture? Not yet

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? ?

GAPP GEWEX Americas Prediction Project

THE STATE UNIVERSITY OF NEW JERSEY RUTGERS

Conclusions

- Models simulations of soil moisture show reasonable, but imperfect, simulations of soil moisture and temperature to Oklahoma observations.
- Differences between model output and observations exist, especially in the surface flux terms.
- These difference 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.
- Validation with actual observations is crucial to model improvement.