Space-Time Variability of AMSR-E and Modeled Soil Moisture

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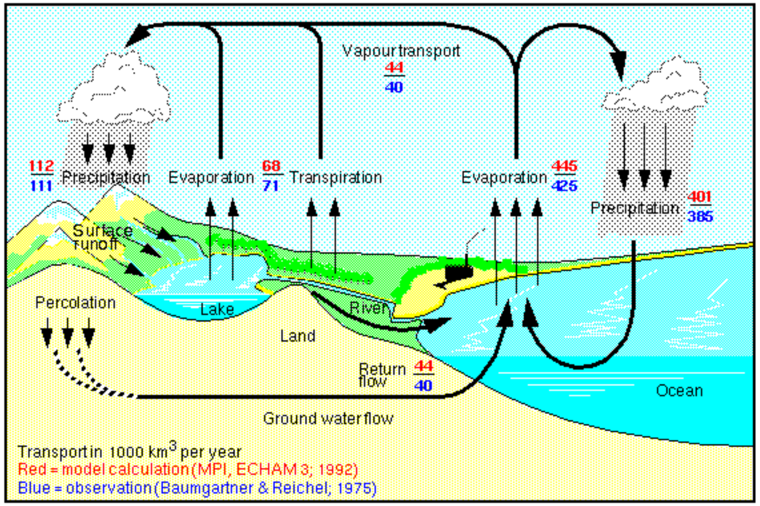
AMSR-E Soil Moisture Applications:

- Weather and Climate Model Initialization
- Flood and Drought Monitoring
- Soil Moisture Dynamics and Global Water Balance



Rate of change of water stored in the root zone can be expressed as:

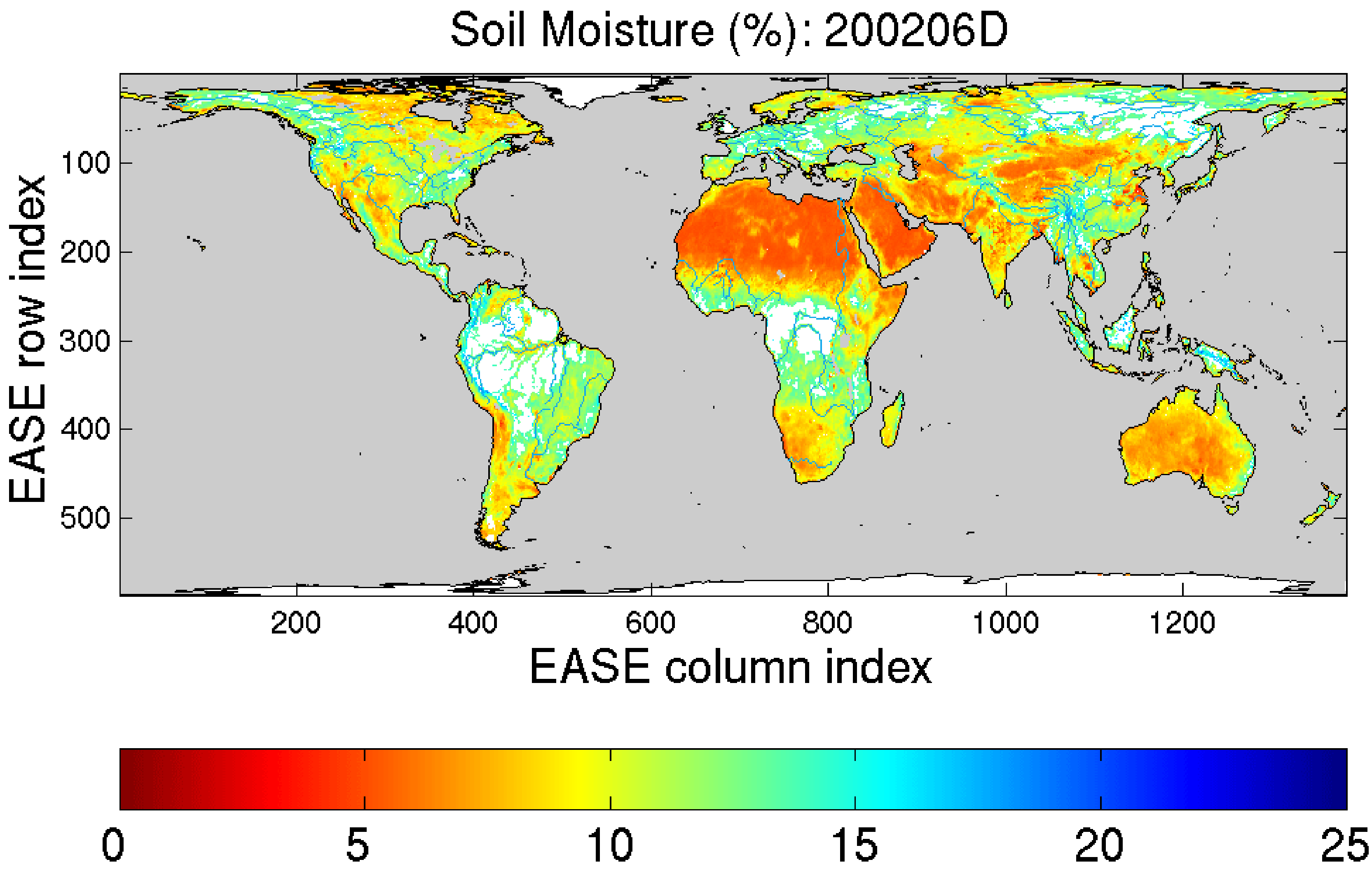
$$nZ_r \frac{ds(t)}{dt} = R(t) - I(t) - Q[s(t)] - E[s(t)] - L[s(t)] \qquad \text{(mm/day)}$$

s = relative soil moisture ($0 < s < 1$) averaged over the root zone
n = porosity
Z_r = root zone depth
$R(t)$ = precipitation
$I(t)$ = interception
$Q[s(t)]$ = runoff
$E[s(t)]$ = evapotranspiration
$L[s(t)]$ = leakage

Background:

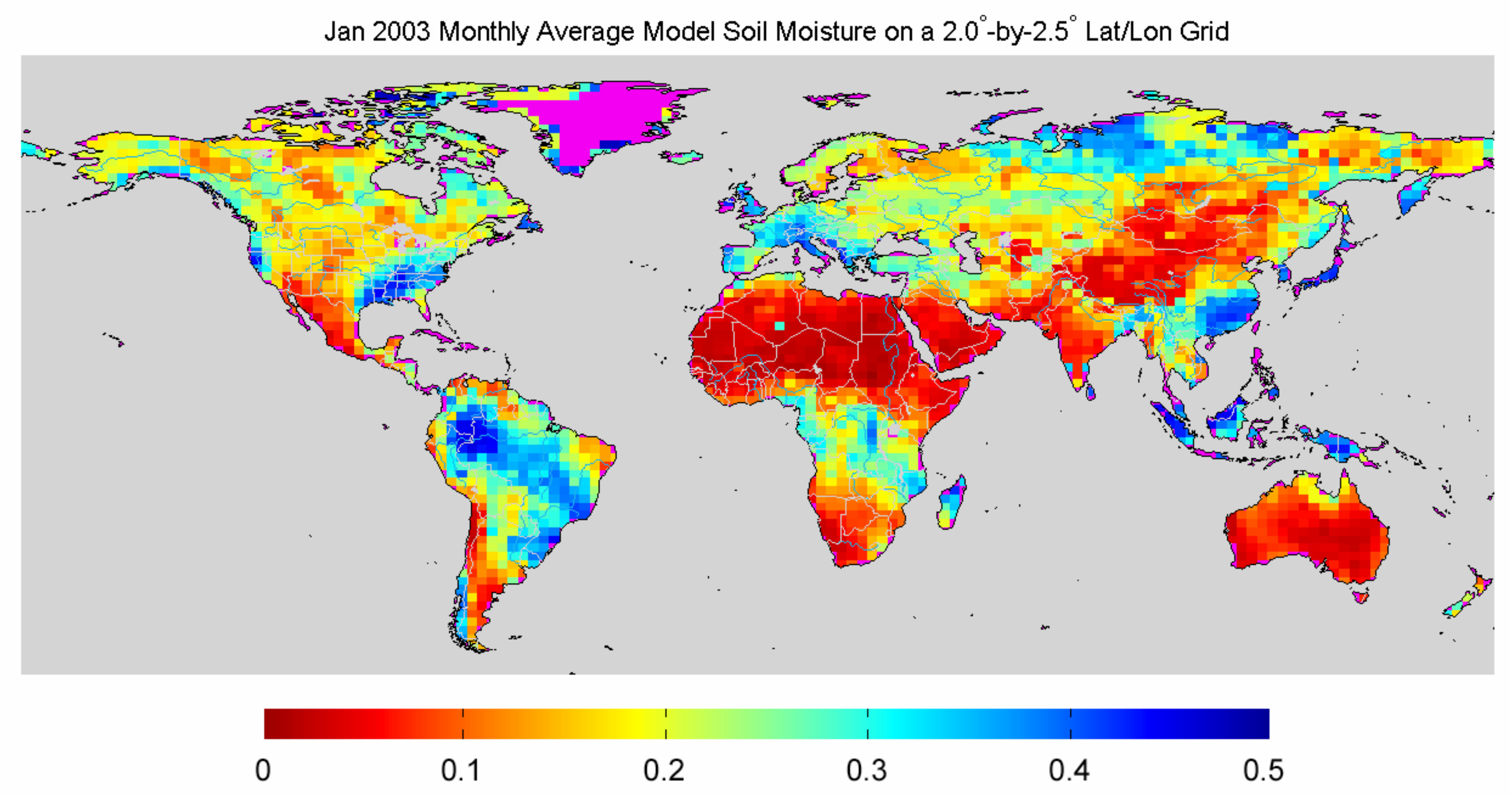
- AMSR-E has provided global observations of brightness temperature and soil moisture (over sparsely-vegetated land) since June 2002 (~4 years of data available for analysis)
- Retrieval algorithms for soil moisture are based on microwave models calibrated using observational data (from a variety of sources) over different terrain types
- In situ soil moisture data, often used for validation, are typically representative of:
  - top ~5-cm, ~1-m spatial extent, ~30 minute temporal sampling (with automated sensors)
- Statistics of soil moisture observed by in situ sensors can be quite different from those observed by satellite radiometers such as AMSR-E which respond to soil conditions in:
  - top ~1 cm, ~60-km spatial extent, ~2-3 day temporal sampling (global coverage)
- Land surface models used to define surface boundary conditions for weather and climate forecasts typically stratify the soil into layers ~2-10 cm at the surface, and may not represent aggregated physical processes accurately at the 60 km scale
- Statistics of soil moisture distributions from different sources have implications for calibration of AMSR-E soil moisture observations

AMSR-E Monthly Soil Moisture



NASA Catchment Land Surface Model Soil Moisture
(Koster, Reichle et al.)

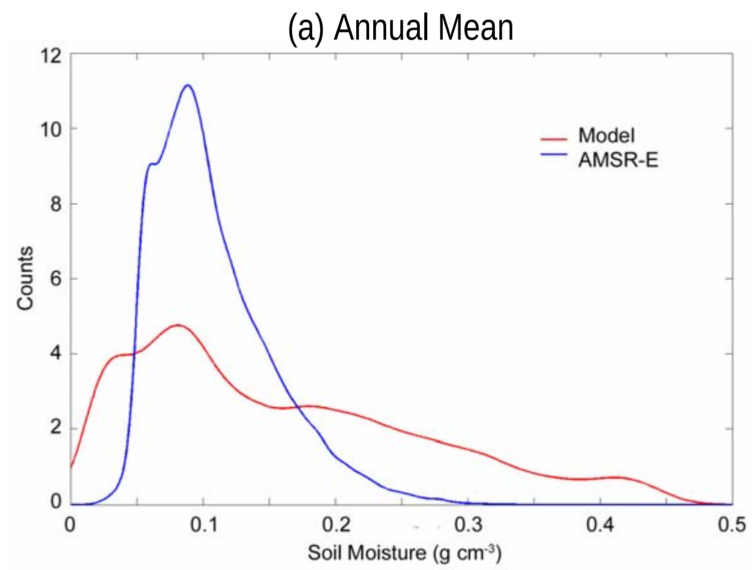
Top two layers are 2 cm and 1 m

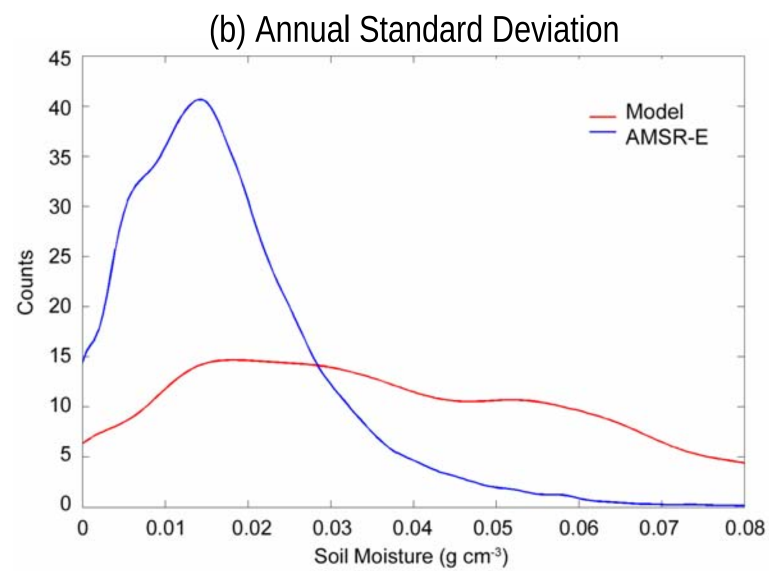


2-cm layer soil moisture

AMSR-E and NASA Catchment Model Soil Moisture Annual Statistics (2004)

- Global maps of annual means and standard deviations of soil moisture were generated for AMSR-E and Catchment Model data
- PDFs of the spatial distributions were computed for each map
  - (a) **Top Panel**: PDFs of annual mean soil moisture (2004)
  - (b) **Bottom Panel**: PDFs of annual standard deviation of soil moisture (2004)
- AMSR-E retrievals show much less spread than modeled values in the annual mean and seasonal variability of soil moisture across the globe

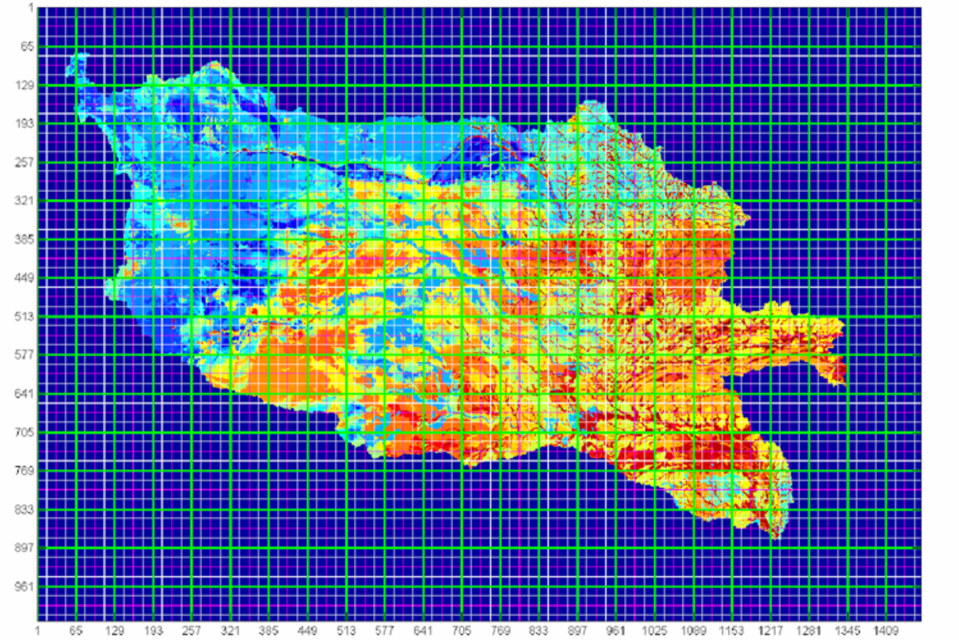




Effect of Aggregation on Modeled Soil Moisture Distributions in SGP

- Study domain: Red-Arkansas river basin in U.S. Southern Great Plains
- High resolution (1 km) geophysical fields were generated by Crow et al. using the TOPLATS hydrological model
- Two water balance layers - top layer 5 cm
- Period analyzed: May 26 through Jun 28, 1994 (33 days) - output saved twice daily (Hydros OSSE simulation)
- Number of 1-km land pixels: 473,828

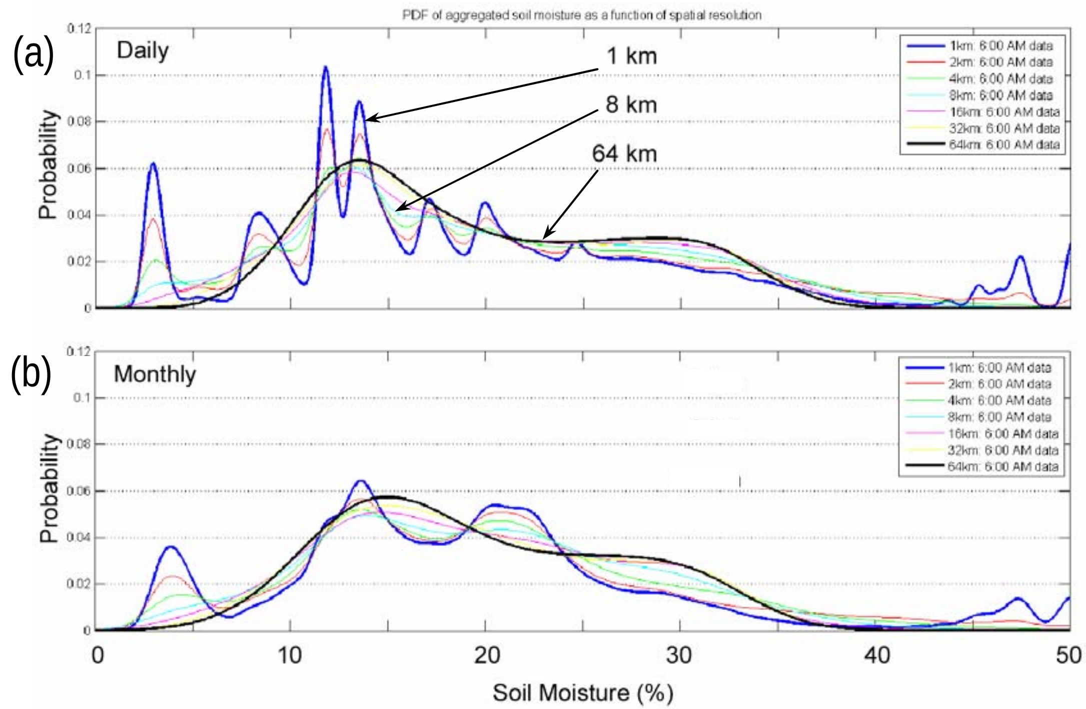
Red-Arkansas River Basin - Nesting of Multiscale Grids (16 km, 32 km, 64 km)



- Within the study domain there are 107 distinct 64-km x 64-km grid cells on which all other higher resolution grids (1km, 2km, 4km, 8km, 16km, and 32km) overlay with no missing pixels.

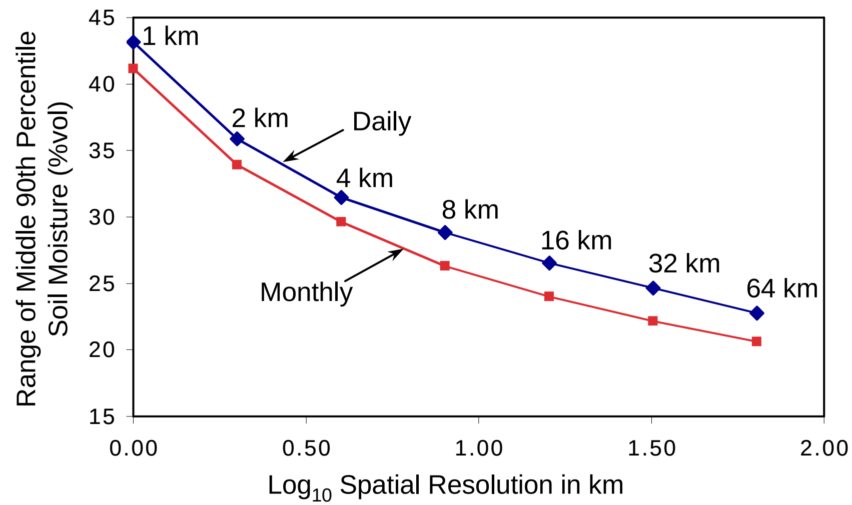
PDFs of Aggregated Soil Moisture at 1 km to 64 km Resolutions

(a) Daily
(b) Monthly



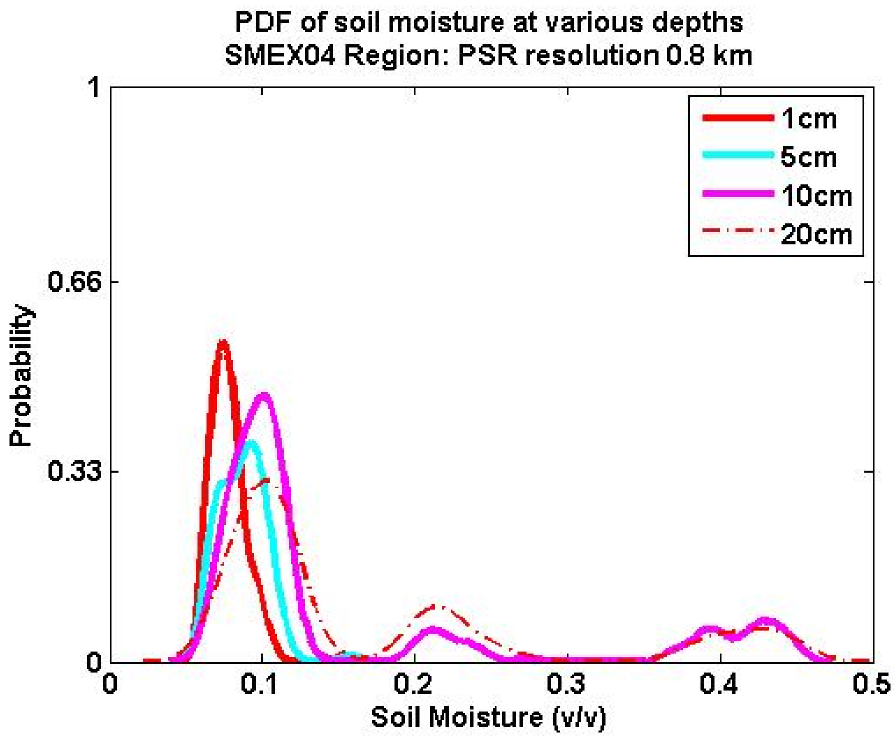
- Spread of soil moisture PDF decreases as spatial and temporal aggregation increases

- Quantitatively, the range of the middle 90th percentile of the soil moisture PDF decreases by about a factor of two from 1 km to 64 km

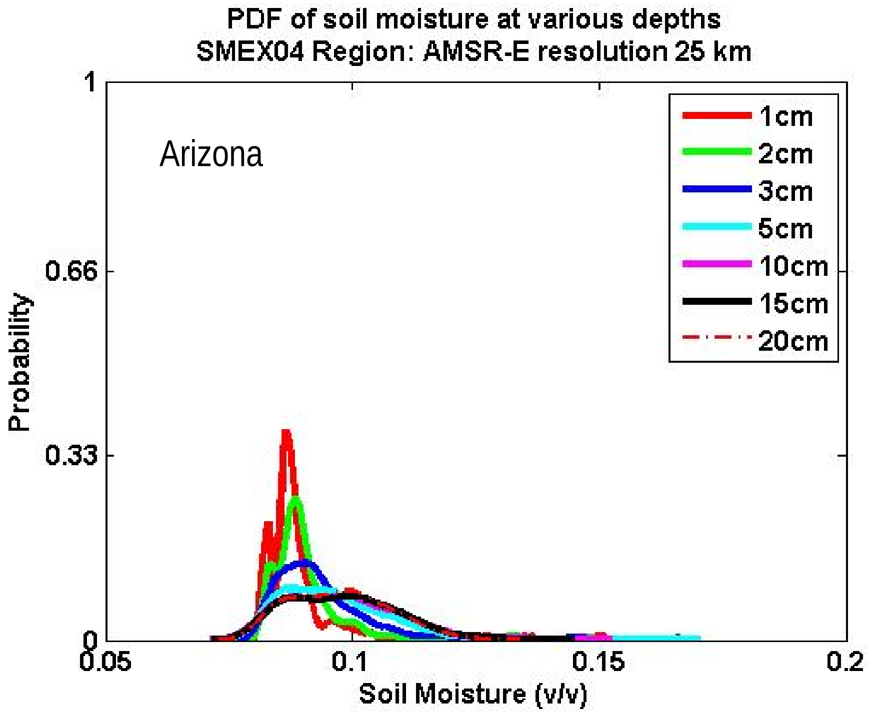


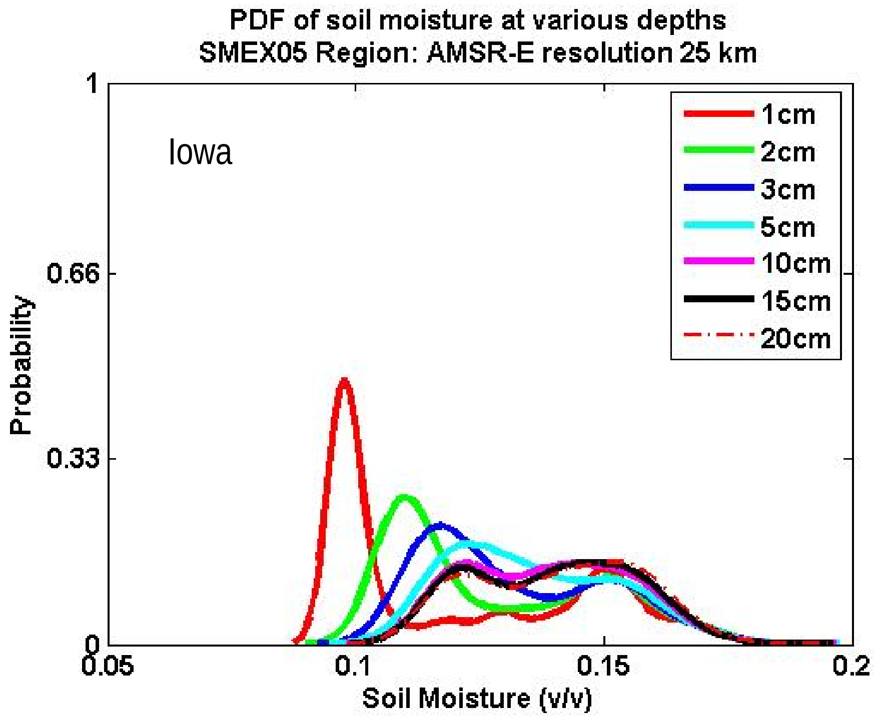
Effects of Aggregation Over Vertical Profile: Simulations Using Hydrus-ET Model (with Mohanty et al., TAMU)

- Process-based 1-D fine vertical scale hydrology model (Hydrus-ET, Mohanty et al.) run at local scale and aggregated to remote sensing pixel scale, with outputs at daily time step
- Forcing by daily precipitation from TRMM or ground observation stations in SMEX04 (Arizona) and global precipitation database in SMEX05 (Iowa) regions
- PDFs of soil moisture generated by aggregating to different depths for PSR (800 m) and AMSR-E (25-Km) footprint resolutions
- Simulation for PSR resolution (SMEX04 region) run for one month during SMEX04 period, and full year for AMSR-E (SMEX04 and SMEX05 regions)



Effects of Aggregation (Contd.)





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