A Downscaled Surface Atmospheric Forcing Dataset for Land Surface Modeling

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Abstract

In this study, we have developed a hyper-resolution land-surface forcing dataset (temperature, pressure, humidity, wind speed, incident longwave and shortwave radiation) from coarse resolution products using a physically-based downscaling approach. These downscaling techniques rely on correlations with landscape variables, such as topography, temperature lapse rate corrections, surface roughness and land cover. A proof-of-concept has been implemented over the Oklahoma domain, where high-resolution observations are available for validation purposes. The hourly NLDAS (North America Land Data Assimilation System) forcing data at 0.125° have been downscaled to 500m resolution over the study area during 2015. Results show that correlation coefficients between the downscaled forcing dataset and ground observations are consistently higher and biases are lower than the ones between the NLDAS forcing dataset at their native resolution and ground observations. Results are therefore encouraging as they demonstrate that the 500m forcing dataset has a good agreement with the ground information and can be adopted to force the land surface model for land state estimation. The Noah-MP land surface model is then forced with both the native resolution NLDAS dataset and the downscaled one to simulate surface and root zone soil moisture. Model outputs are compared with in situ soil moisture observations and SMAP (Soil Moisture Active Passive Mission) products at different spatial resolutions. This work will result in a radical improvement over the current state-of-the-art forcing data and will move into the era of hyper-resolution land modeling.

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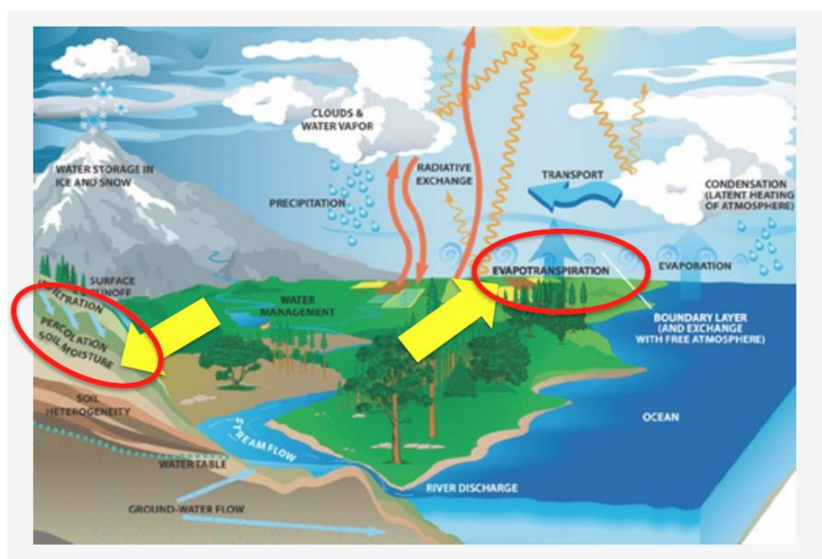
Motivation

Why soil moisture?

- Soil water content has influence on cloud coverage, precipitation, runoff and evapotranspiration
- A realistic soil moisture improves weather and climate prediction, hazard mitigation (floods and droughts), agricultural planning and water resources management



How much water is there?

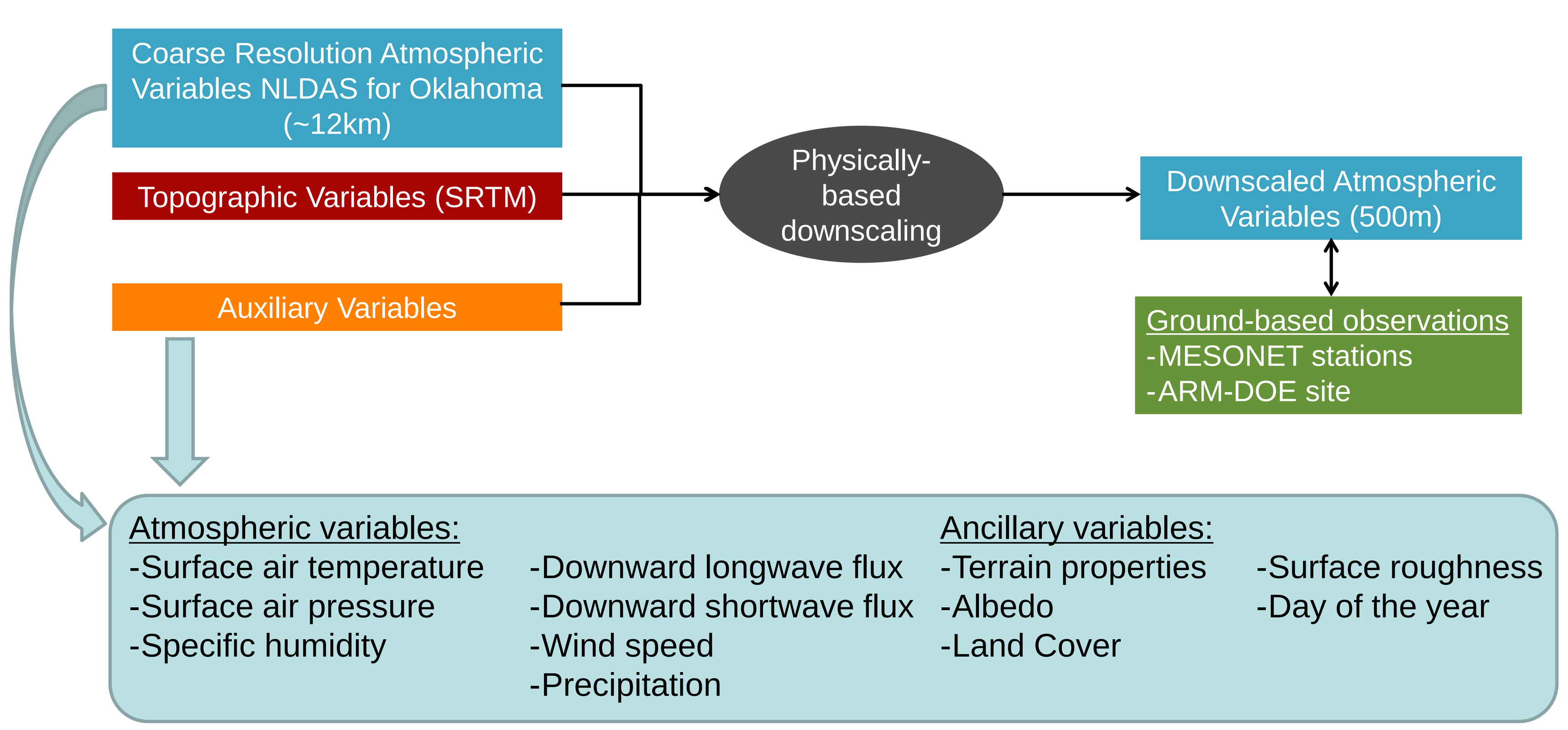
Component	USGS	UNESCO (1990)
Oceans	97.09%	93.93%
Glaciers	1.99%	1.65%
Groundwater	0.62%	4.12%
Atmosphere	0.29%	0.001%
Lakes	0.012%	0.016%
Soil moisture	0.004%	0.005%
Rivers	0.0001%	0.0001%
Total	100%	99.72%

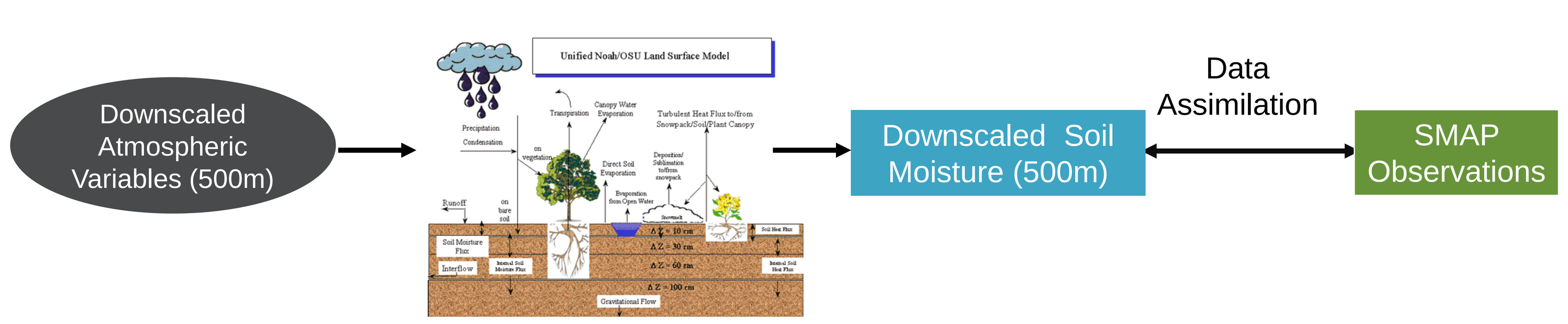
Source: Applied Remote Sensing Training Program

- Availability of in-situ soil moisture measurements is scarce
- NASA Soil Moisture Active Passive (SMAP) mission provides information on surface soil moisture (top 5 cm of the soil column)
- SMAP soil moisture is limited by course resolution (36 km)

Methodology

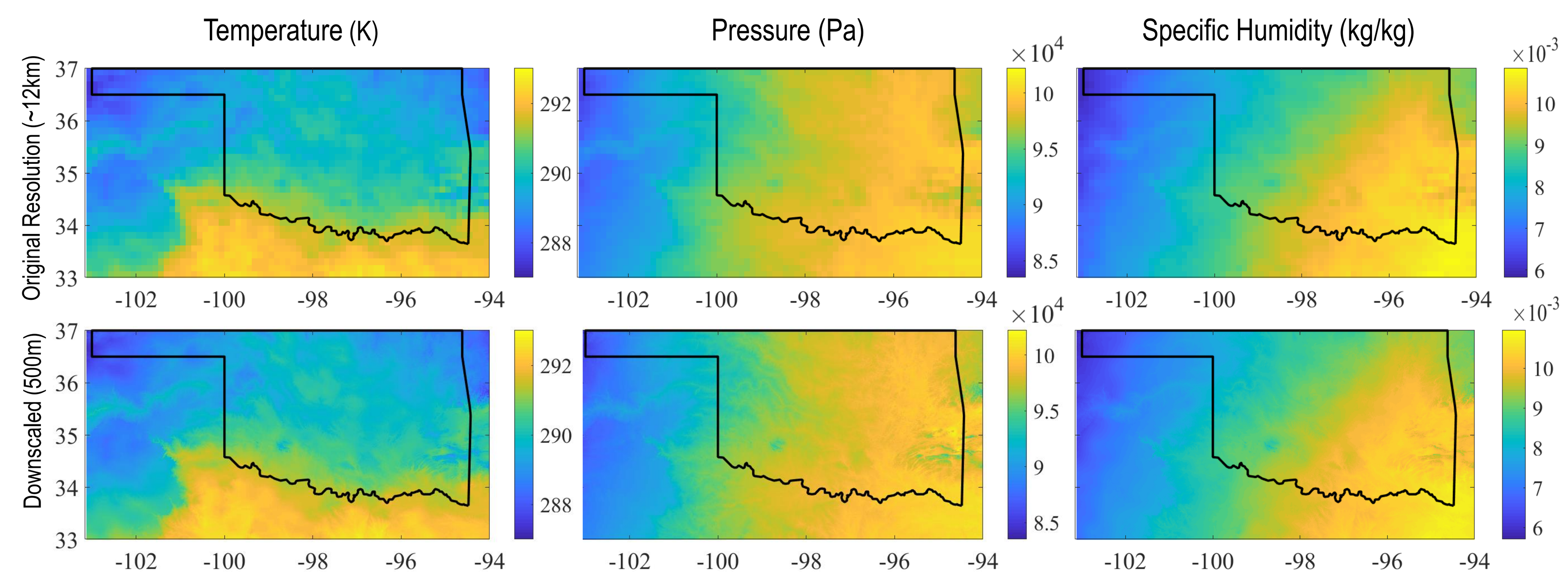
Physically-based surface meteorology downscaling are developed to study surface flux, storage, and water balance changes and investigate the causality of these changes at the regional to local scale.



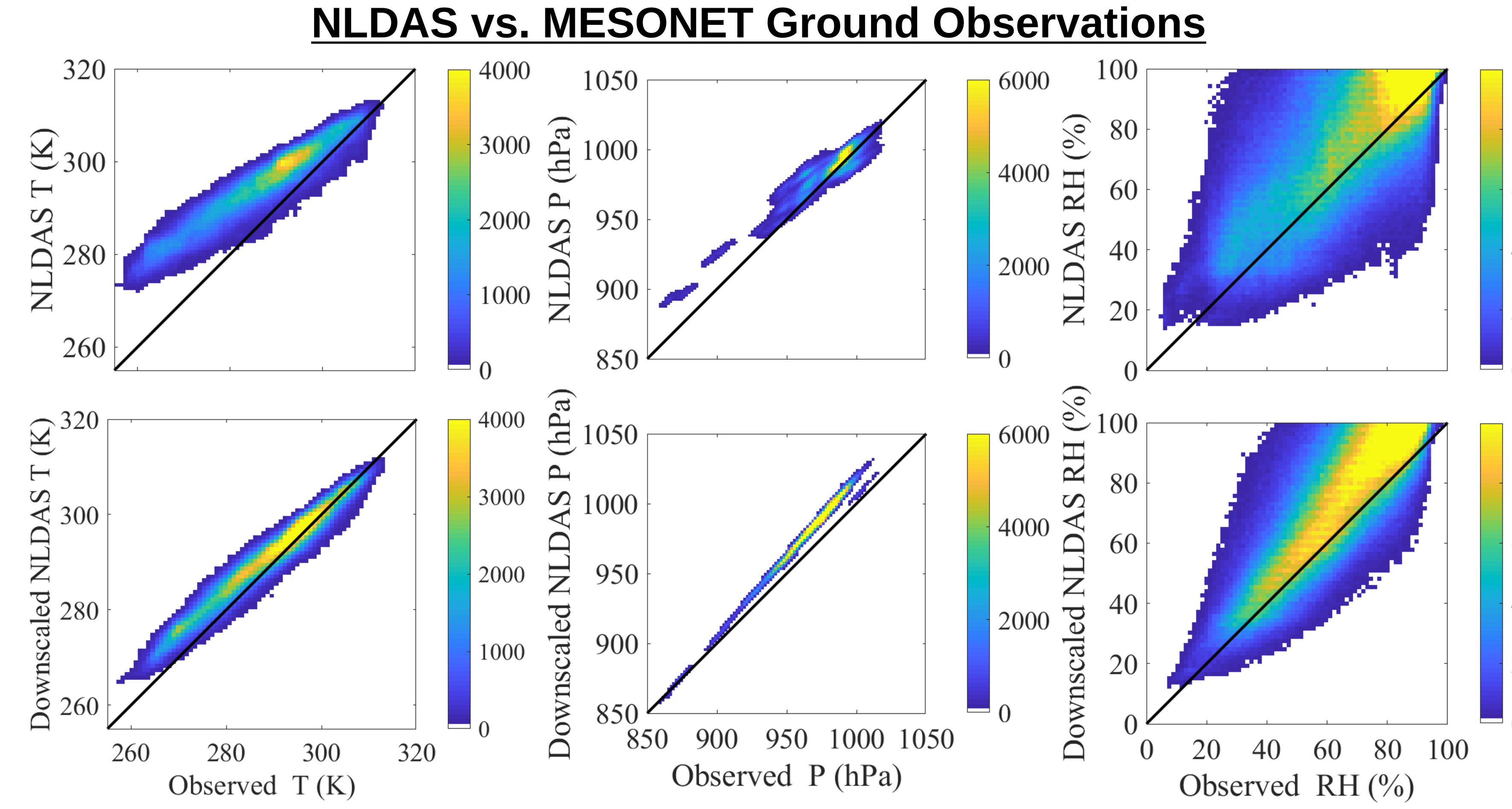


Validation

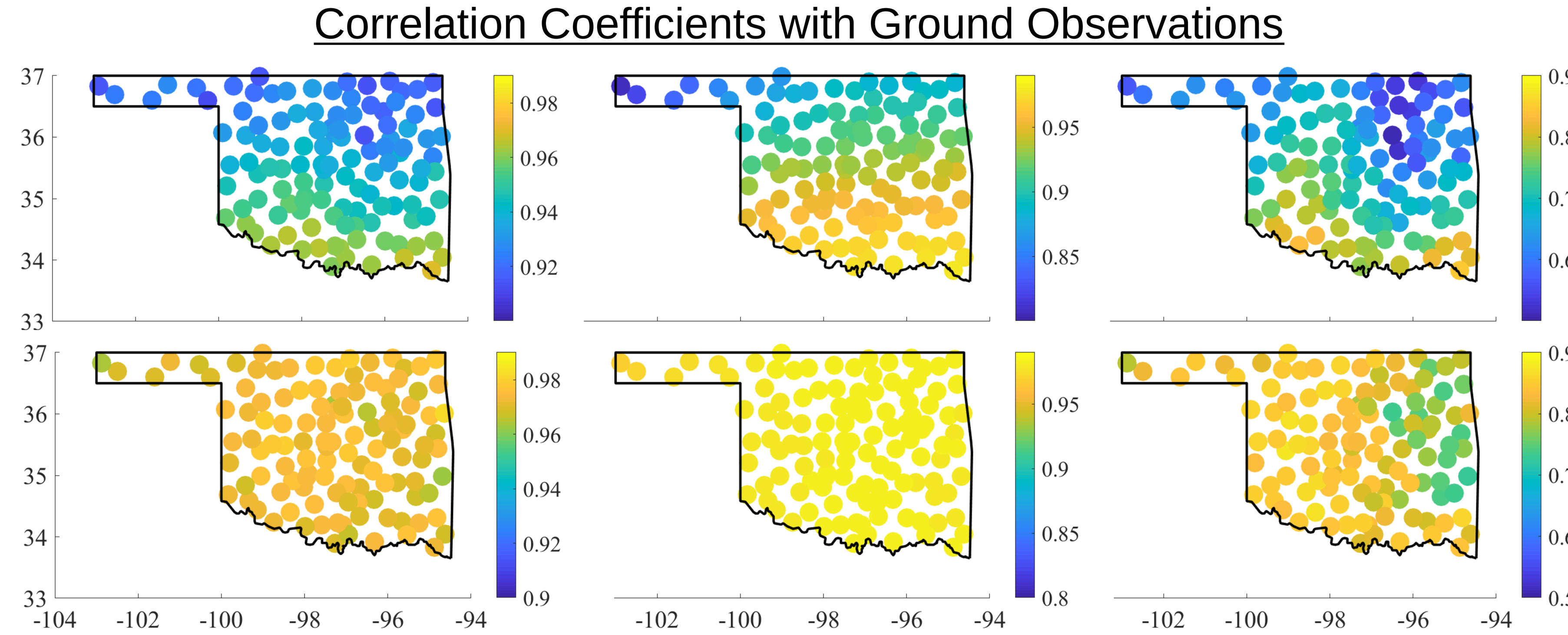
Average NLDAS Atmospheric Variables during 2015



NLDAS vs. MESONET Ground Observations



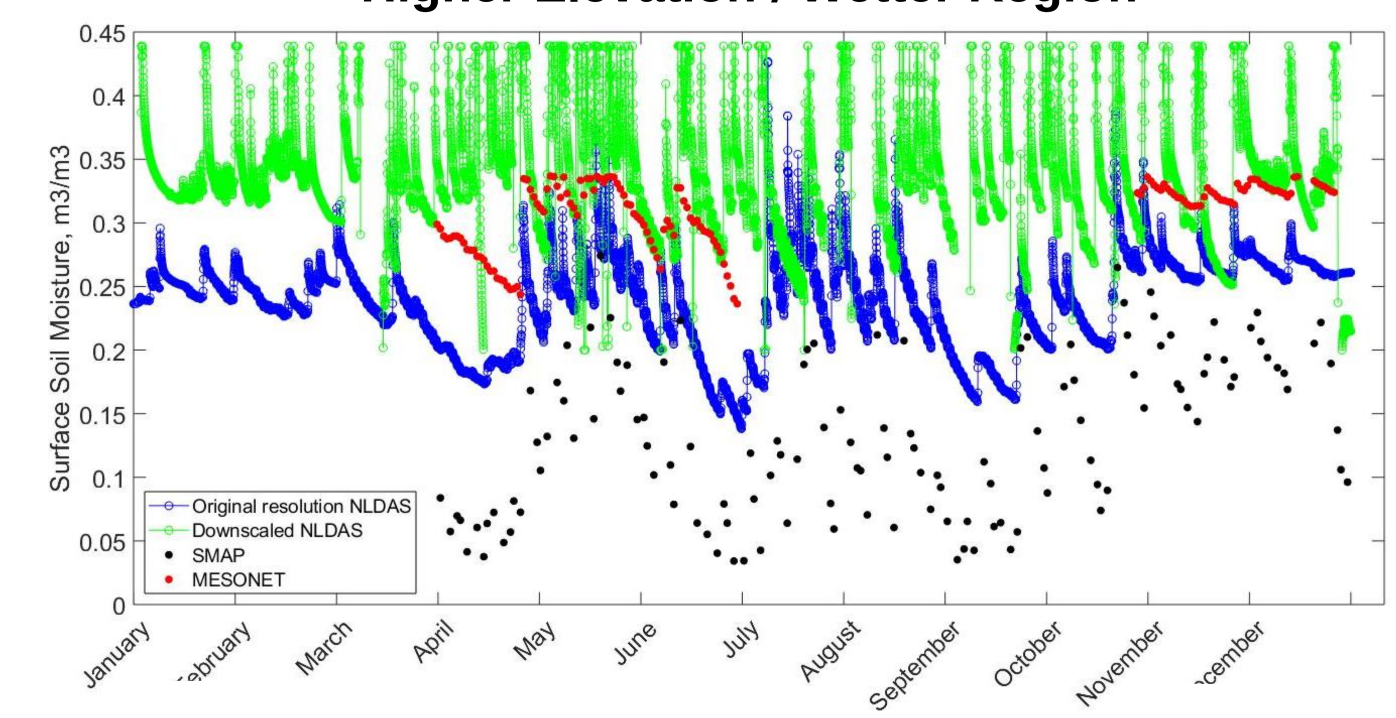
Correlation Coefficients with Ground Observations



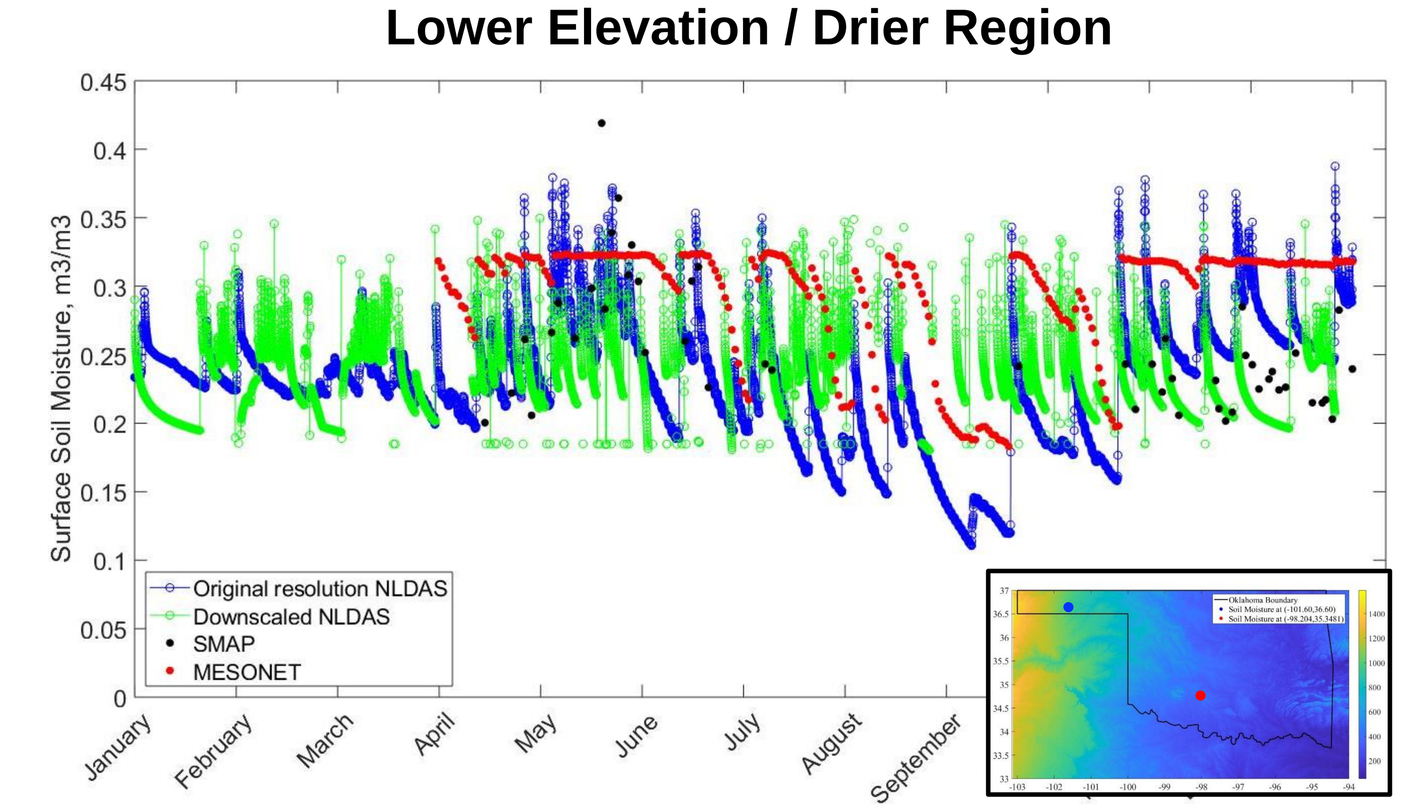
	Original/Downscaled		
	Correlation	RMSE	MRE
Temperature (K)	0.94/0.97	5.09/2.69	0.01/0.00
Pressure (hPa)	0.94/1.00	13.8/2.75	0.12/0.00
Relative Humidity (kg/kg)	0.69/0.92	17.1/12.6	0.21/0.16
Longwave Radiation (W/m²)	0.73/0.82	49.4/36.9	0.12/0.09
Shortwave Radiation (W/m²)	0.91/0.86	119/158	-1.3/0.47
Wind Speed (m/s)	0.70/0.70	2.22/2.21	-1.5/1.9

LSM Simulations

Higher Elevation / Wetter Region



Lower Elevation / Drier Region



Conclusions

- Surface meteorological downscaling techniques were developed and validated in Oklahoma.
- Validation show good downscaling performance:
  - Correlation coefficients (biases) between the downscaled dataset and observations are consistently higher (lower) than the native resolution and the reference.
  - The downscaled forcing dataset has a positive impact on LSM soil moisture simulations.
- Next steps:
  - Investigate SMAP soil moisture data assimilation in downscaled hyper-resolution land surface modeling
  - Perform bias adjustment before assimilating SMAP observations
  - Validate the hyper-resolution surface and root zone soil moisture products against the MESONET ground-based observations

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