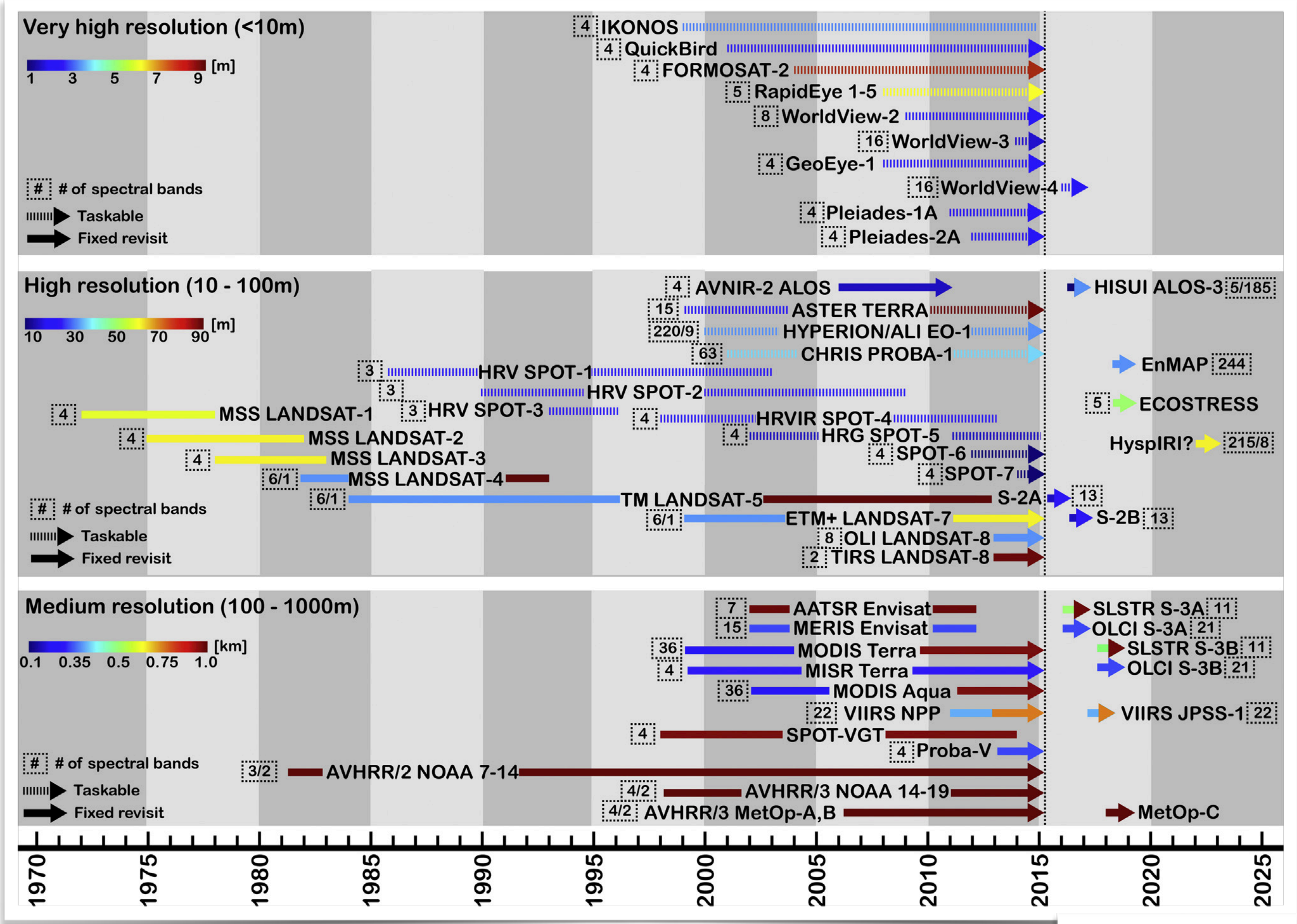
Assimilation of vegetation optical depth retrievals from passive microwave radiometry

Sujay Kumar, Thomas Holmes, Rajat Bindlish,
Richard de Jeu, Christa Peters-Lidard

Hydrological Sciences Laboratory, NASA Goddard Space Flight Center, USA
Vandersat, The Netherlands

Historically, multi- and hyper spectral optical and thermal satellite sensors are used to provide retrievals of vegetation (LAI, NDVI, fPAR, SIF, …)

- high resolution
- acquisition primarily limited to cloud-free days



Houborg et al. (2015)

Microwave remote sensing provides all weather measurements, albeit at a coarser resolution

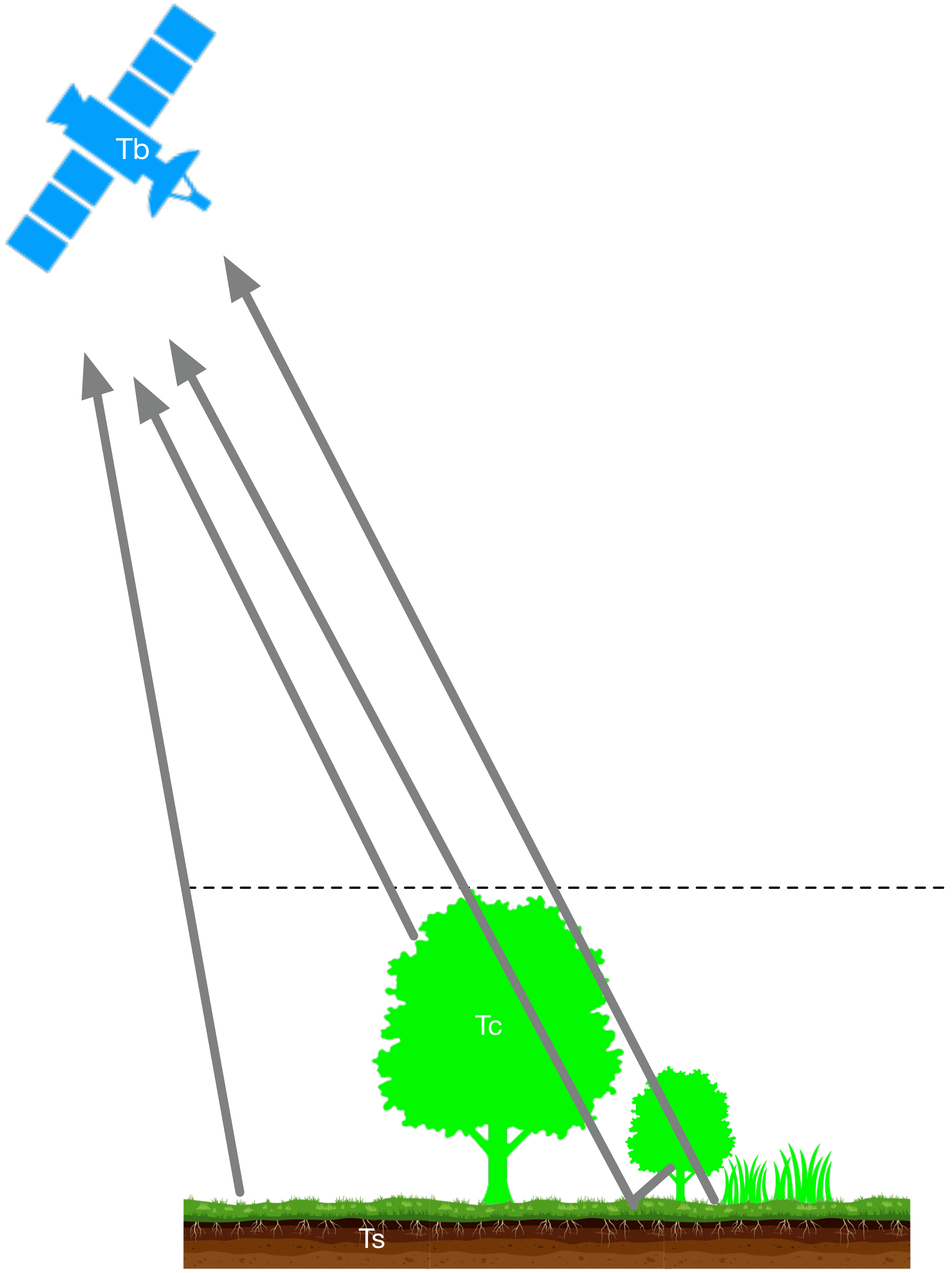
Vegetation optical depth (VOD) is an integrated measure of the vegetation structure and water content.

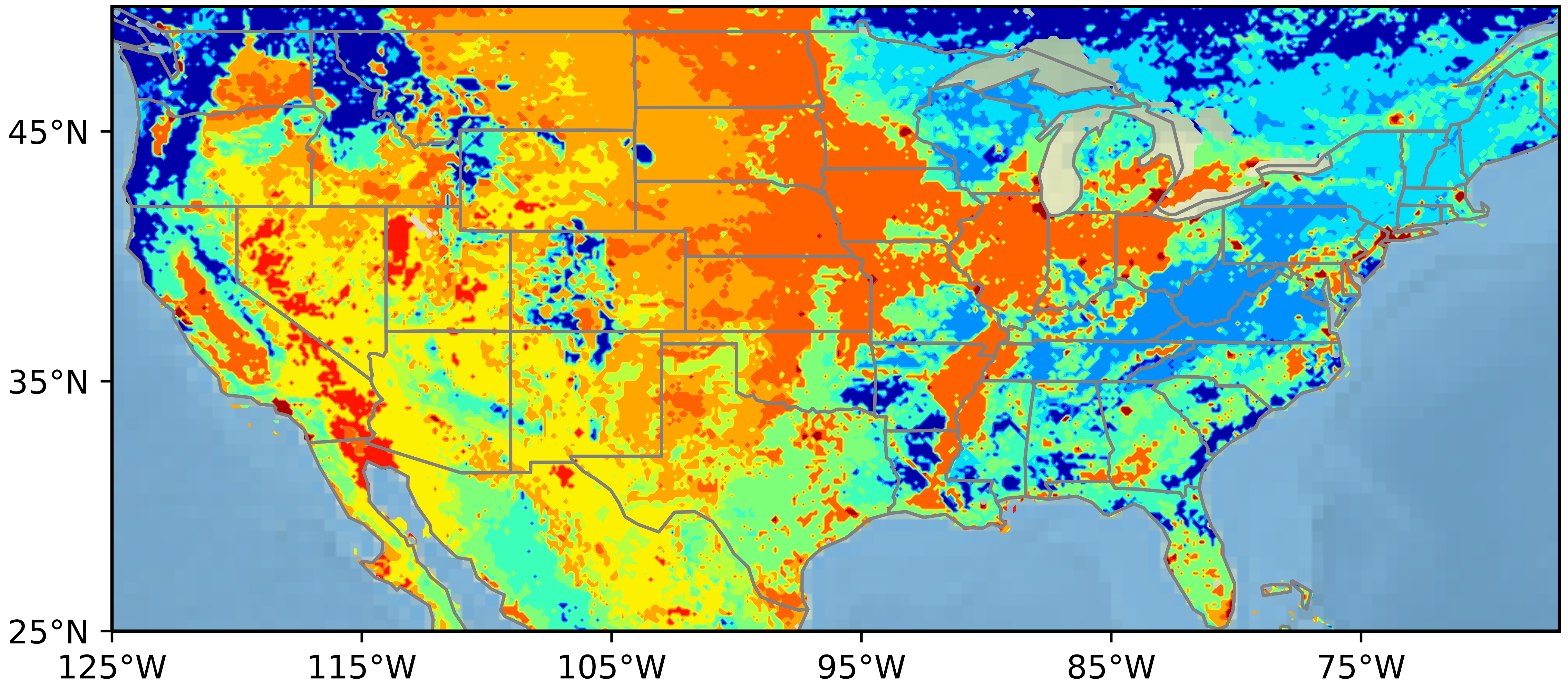
Estimated as part of the radiometric soil moisture retrieval approach based on the first order tau-omega model.

Two parameters in the tau-omega model account for the influence of vegetation on the emissions from the soil and vegetation

omega - volume scattering effects within the vegetation layer

tau - attenuation of the microwave emission by the vegetation layer (VOD)





Experiment configuration: NLDAS2 domain (CONUS at 1/8th degree spatial resolution), NLDAS2 forcing, Noah-MP (3.6) land surface model and HyMAP streamflow routing model.

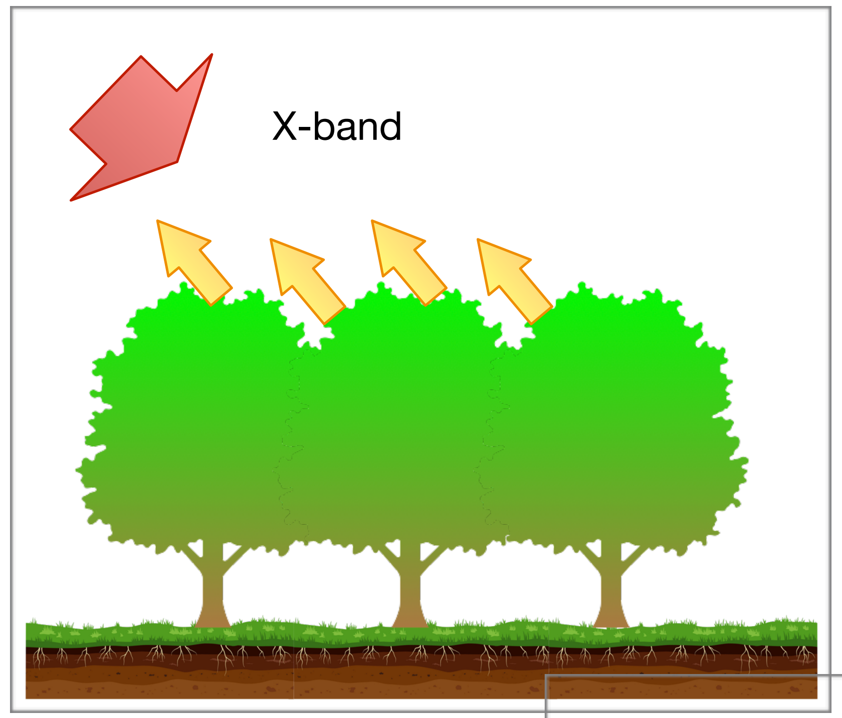
VOD retrievals for assimilation:

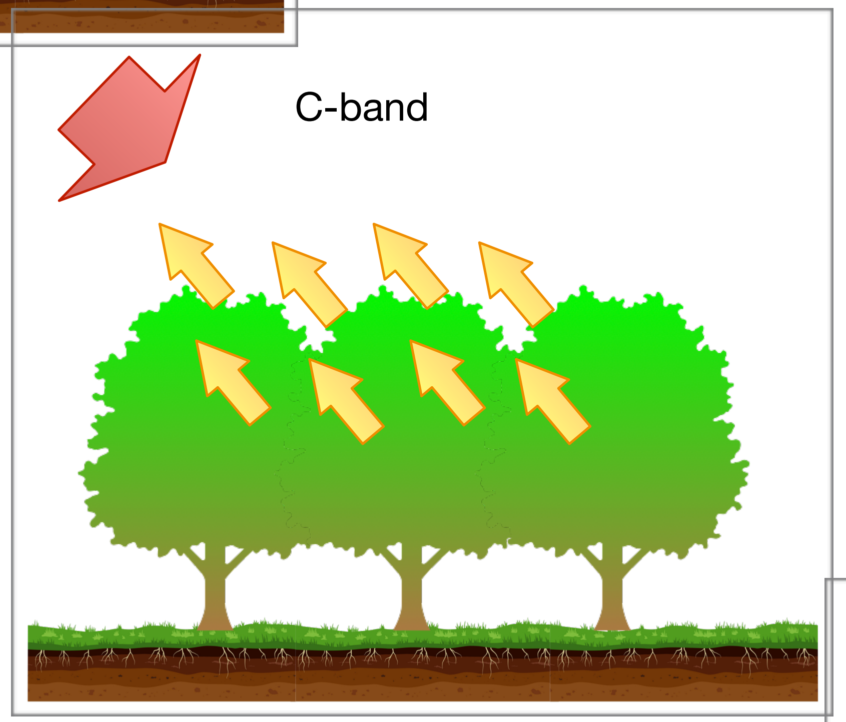
X-band and C-band VOD retrievals from the Land Parameter Retrieval Model (LPRM), using data from AMSR-E and AMSR2 instruments.

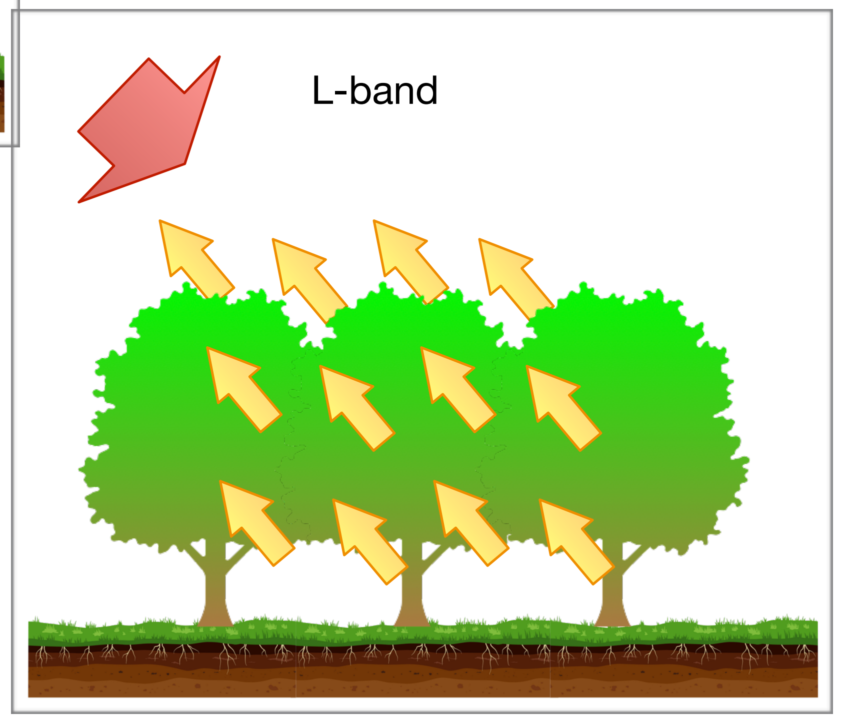
Less sensitive to cloud water content, more sensitive to vegetation, but prone to RFI contamination.

L-band VOD retrievals from NASA SMAP mission.

Less RFI contamination, more sensitivity to deeper canopy layers.



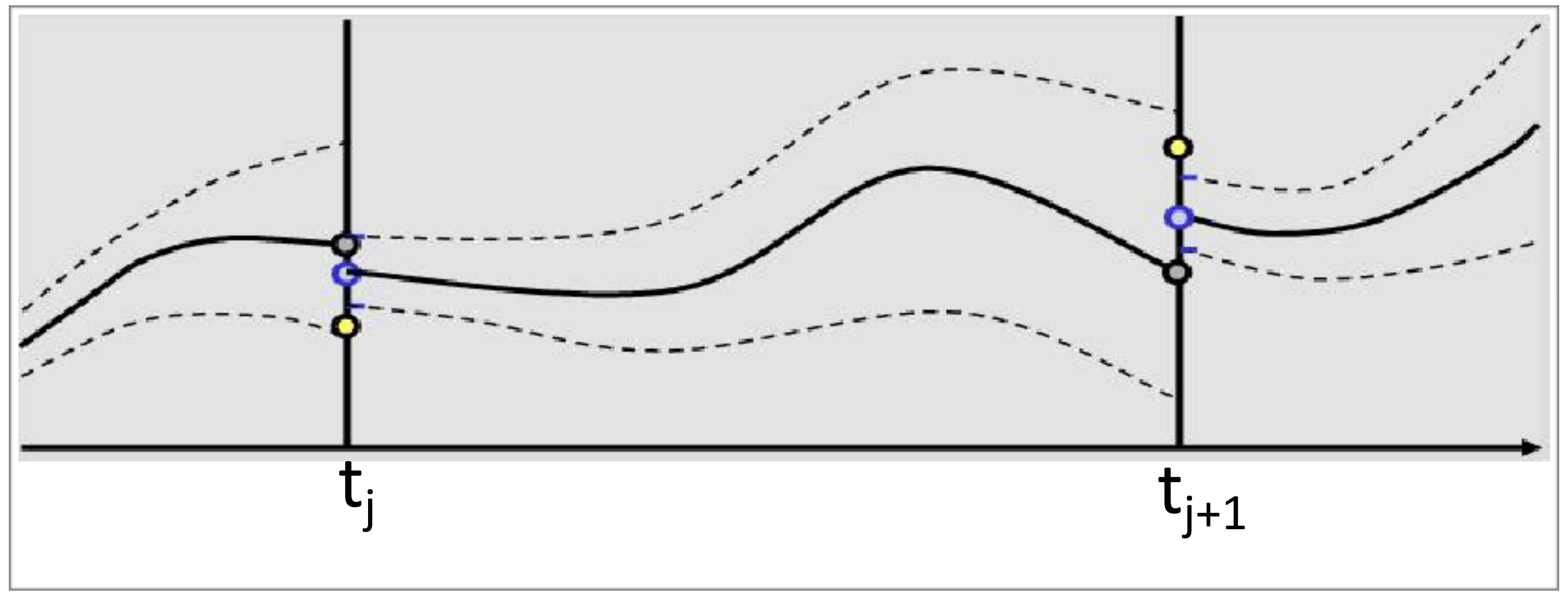




VOD retrievals are assimilated using a 1-d Ensemble Kalman Filter (EnKF) algorithm)

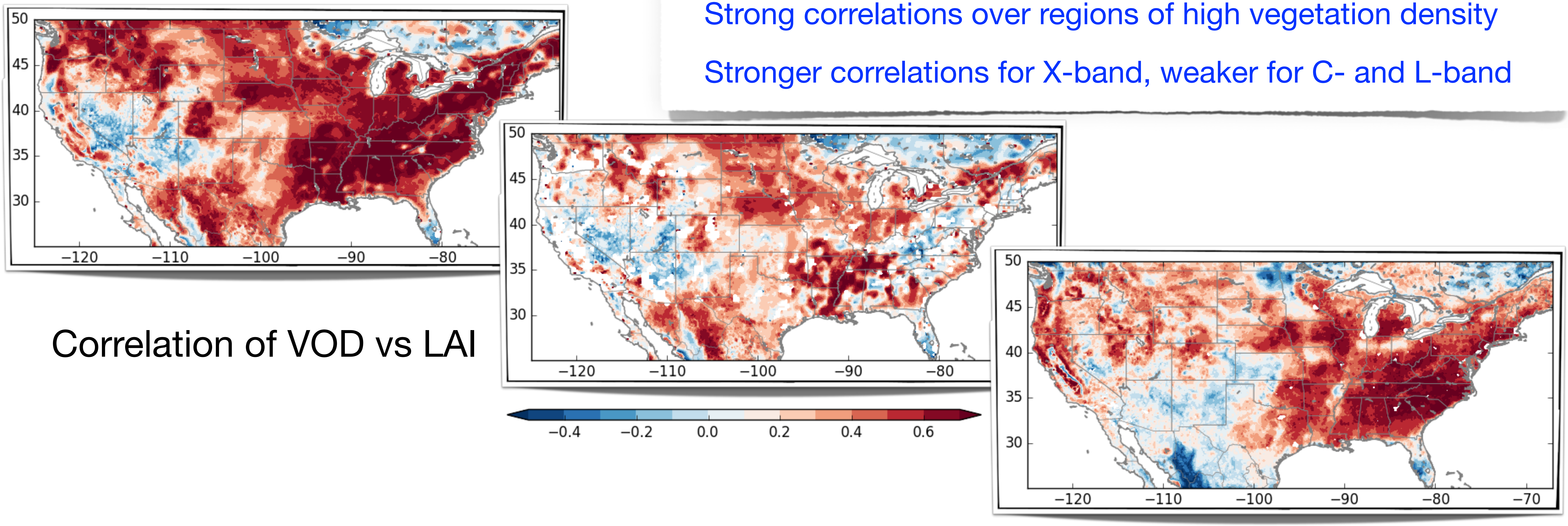
The assimilation is performed by rescaling the VOD retrievals into the LAI space, as the LSM doesn't include a prognostic VOD variable.

VOD retrievals are rescaled using CDF matching to the MODIS-based LAI retrievals. [Previous study (Kumar et al. 2019) shows that MODIS LAI assimilation significantly improves the representation of water and carbon budgets.]

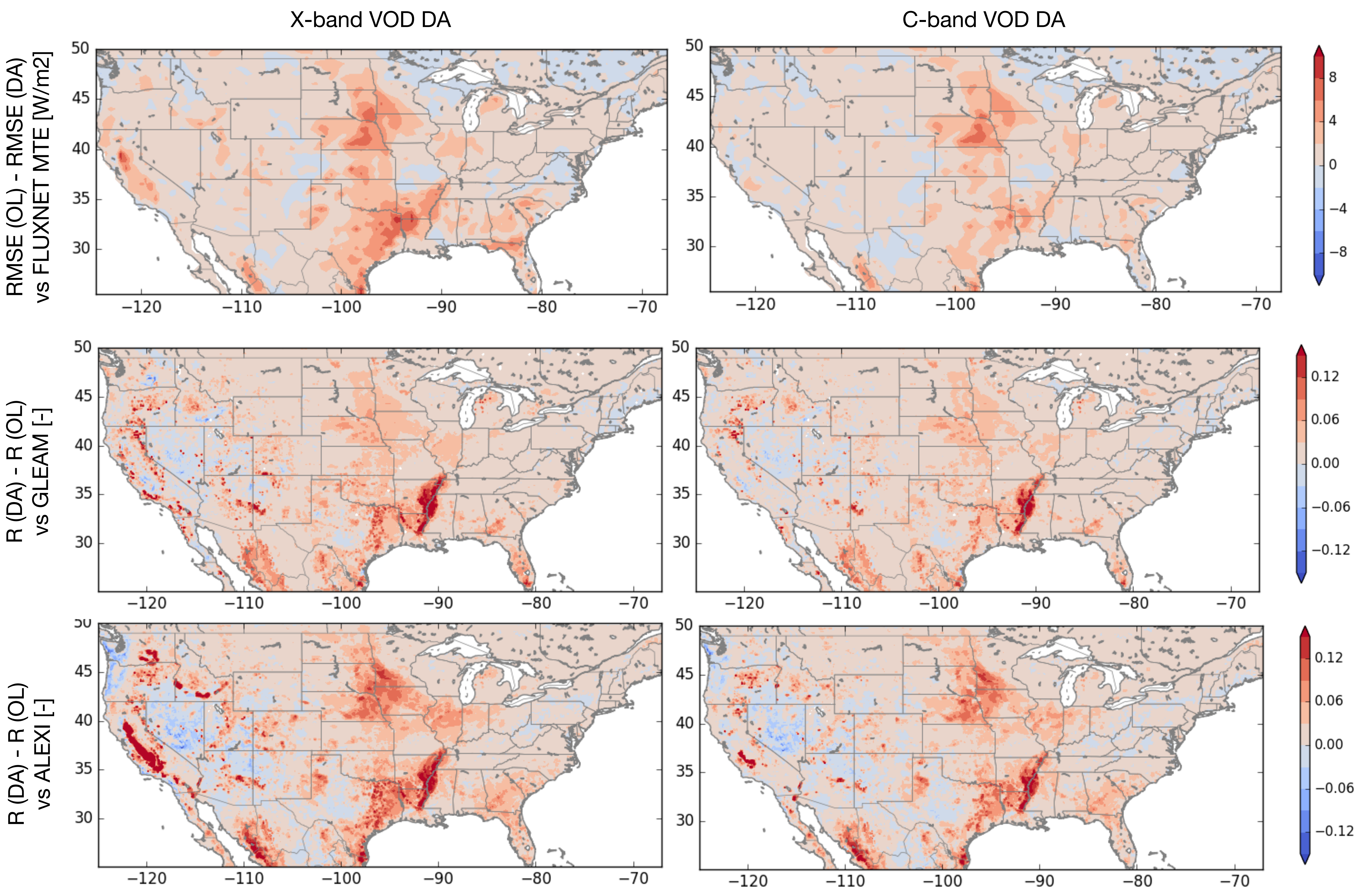


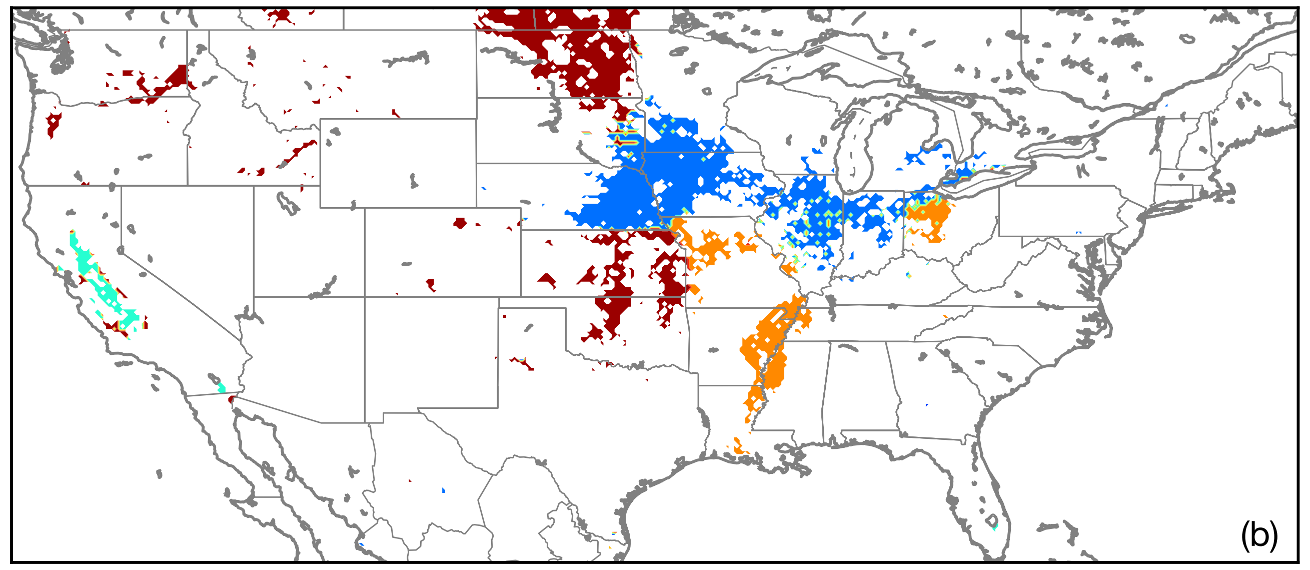
Strong correlations over regions of high vegetation density

Stronger correlations for X-band, weaker for C- and L-band



Correlation of VOD vs LAI

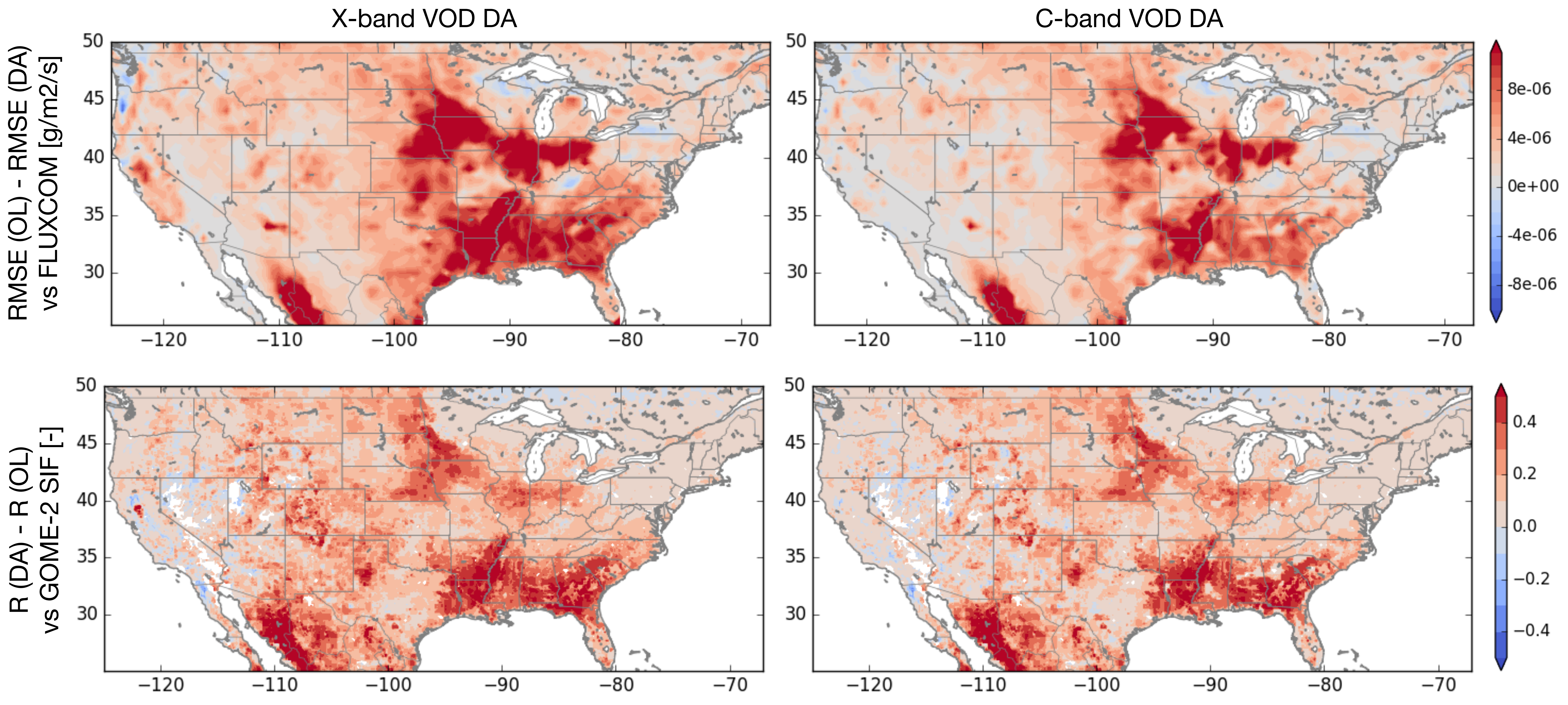




Similar spatial patterns of improvements from X-and C-band assimilation; Larger improvements with X-band

Strong improvements over the Central Plains, lower Mississippi, parts of the Southeast (over agricultural areas of maize and soybean)

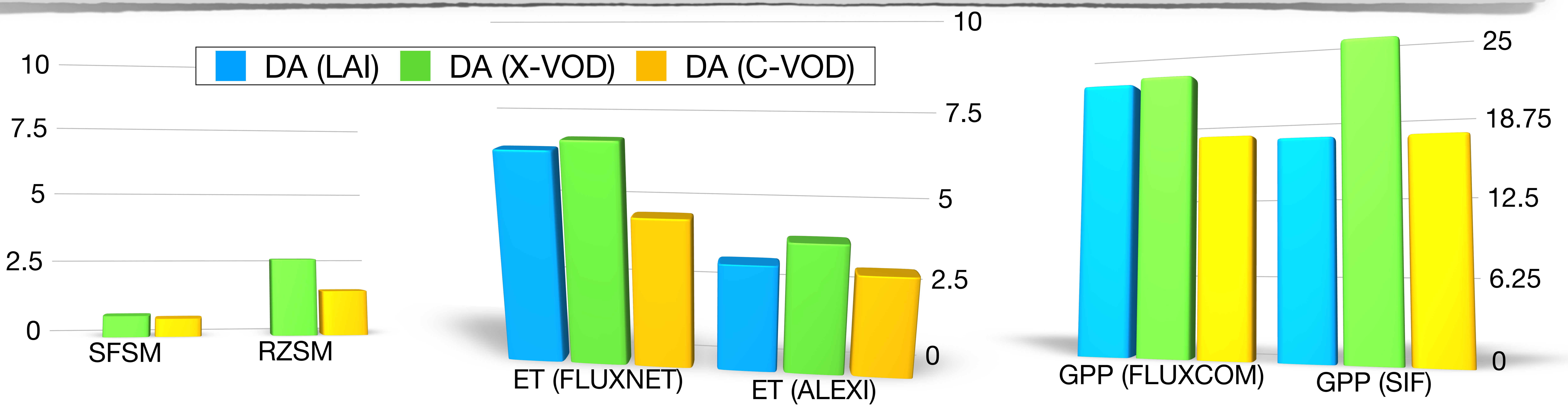
Change in ET RMSE (W/m2) /R (-); Warm colors indicate improvements and cool colors indicate degradations from DA

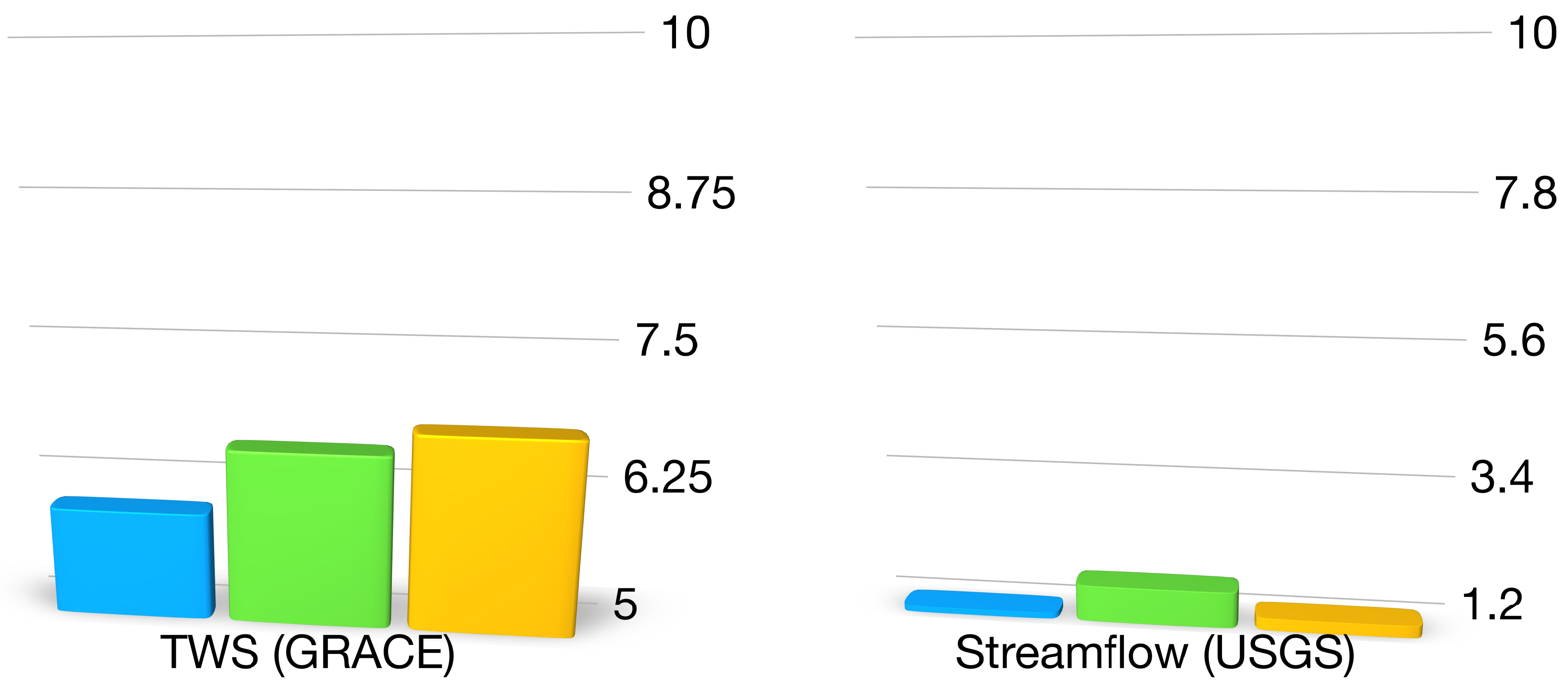


GPP estimates are evaluated against the FLUXCOM data (developed through upscaled tower measurements) and SIF retrievals from GOME-2 instrument aboard the MetOp-A satellite

Strong improvements in the GPP estimates from VOD-DA, particularly over the agricultural areas.

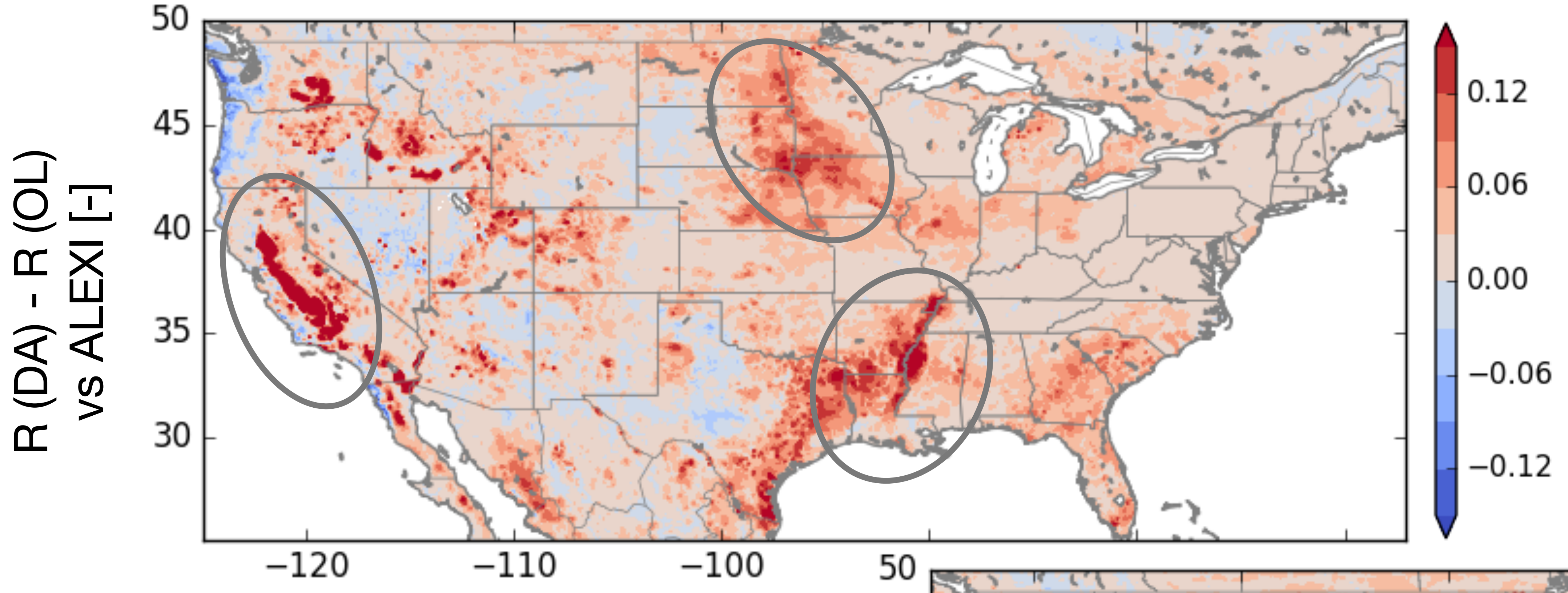
Comparing the impact of passive microwave-based VOD-DA to optical sensor-based LAI-DA



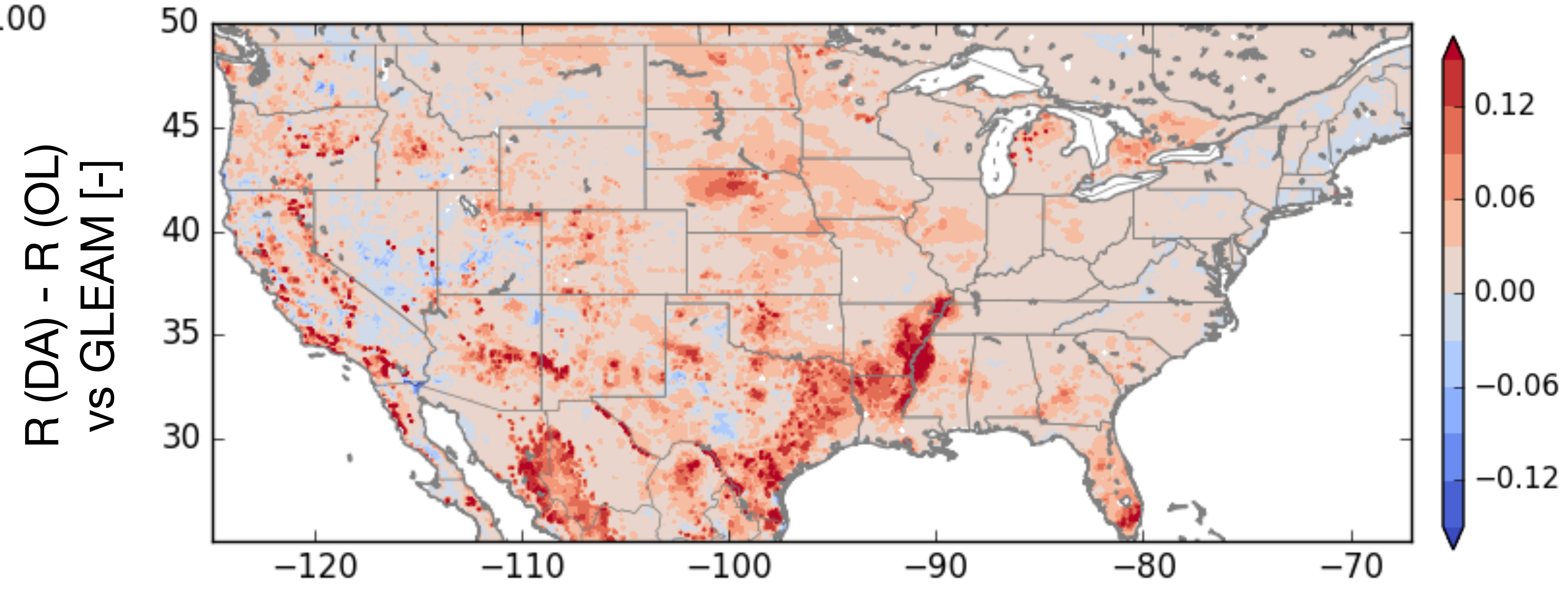


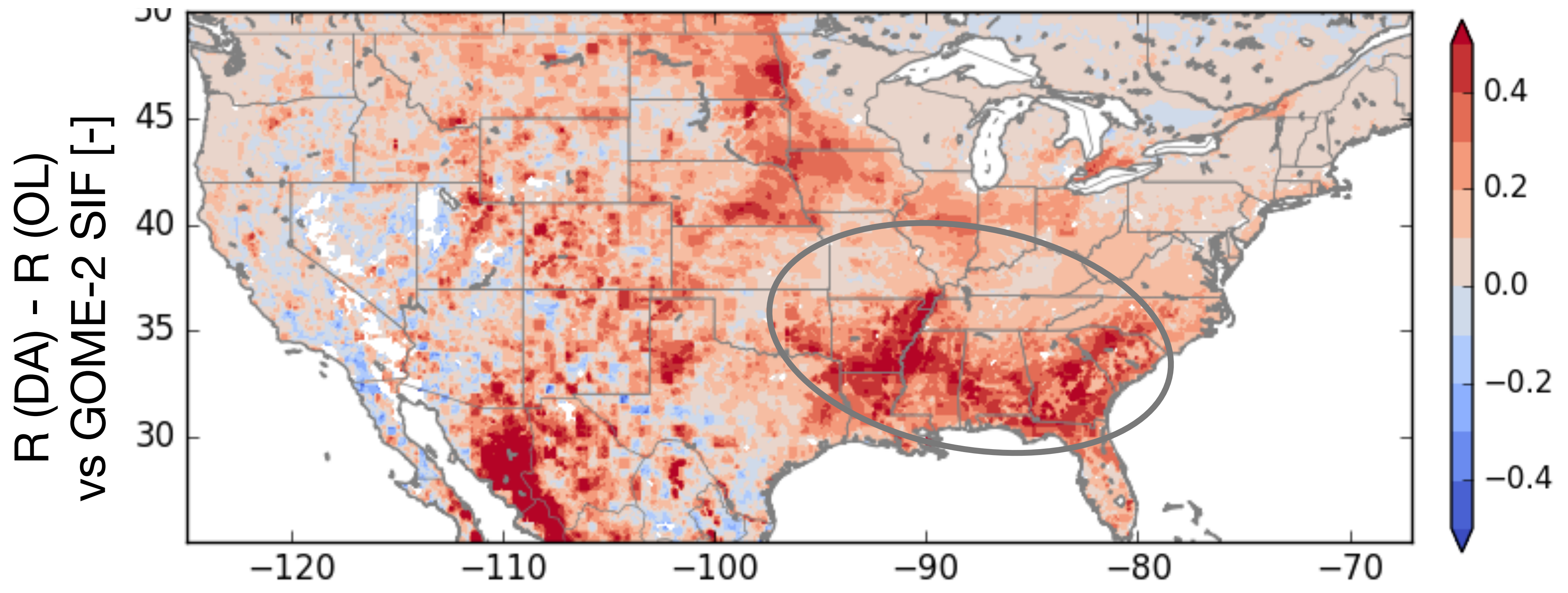
The level of improvements from VOD-DA are comparable to those from LAI-DA.

Assimilation of both types of measurements will allow minimizing the sensing, coverage, and spatial resolution limitations of each sensor.

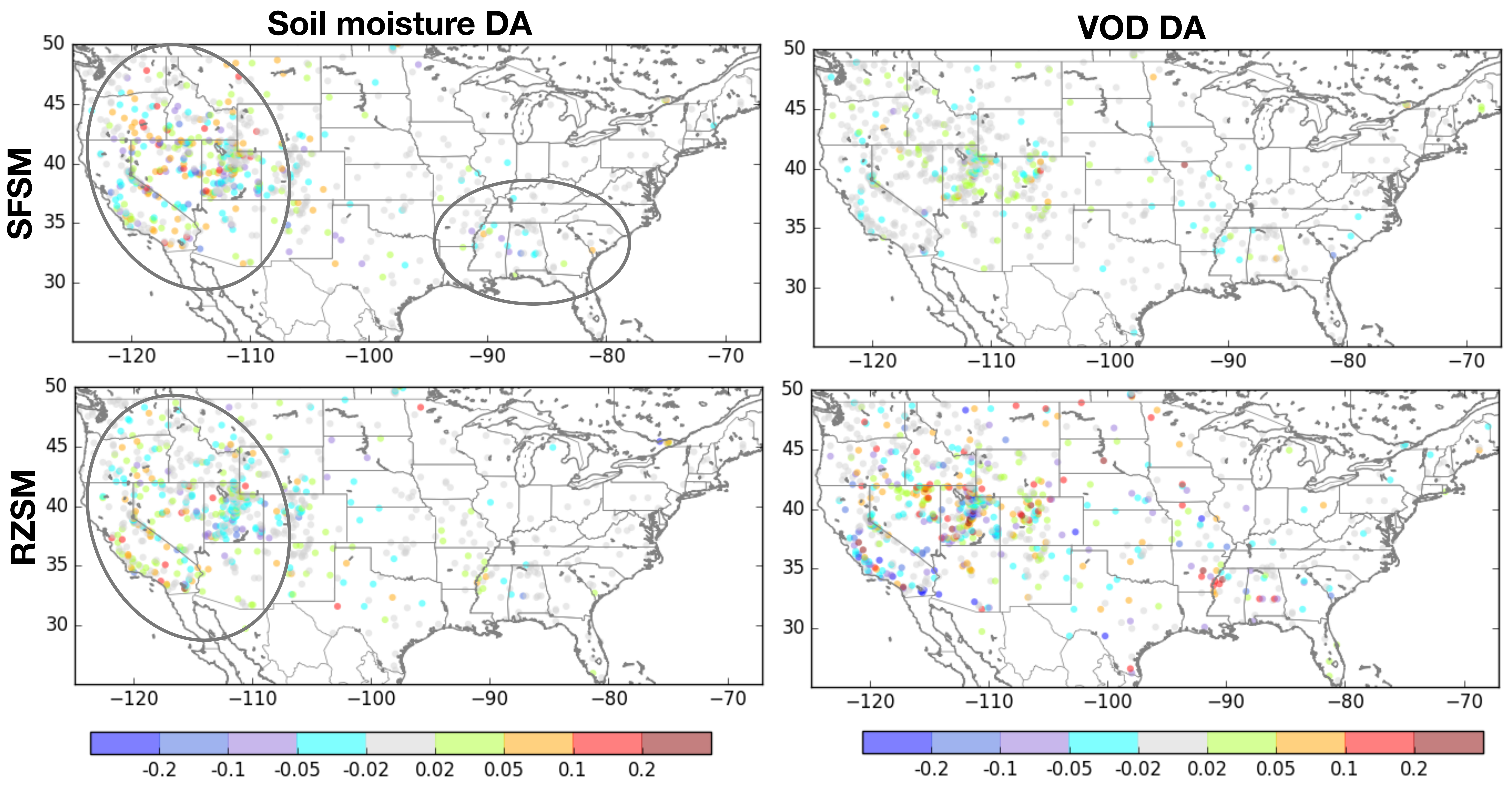


SMAP VOD DA provides systematic improvements in the simulated ET and GPP.

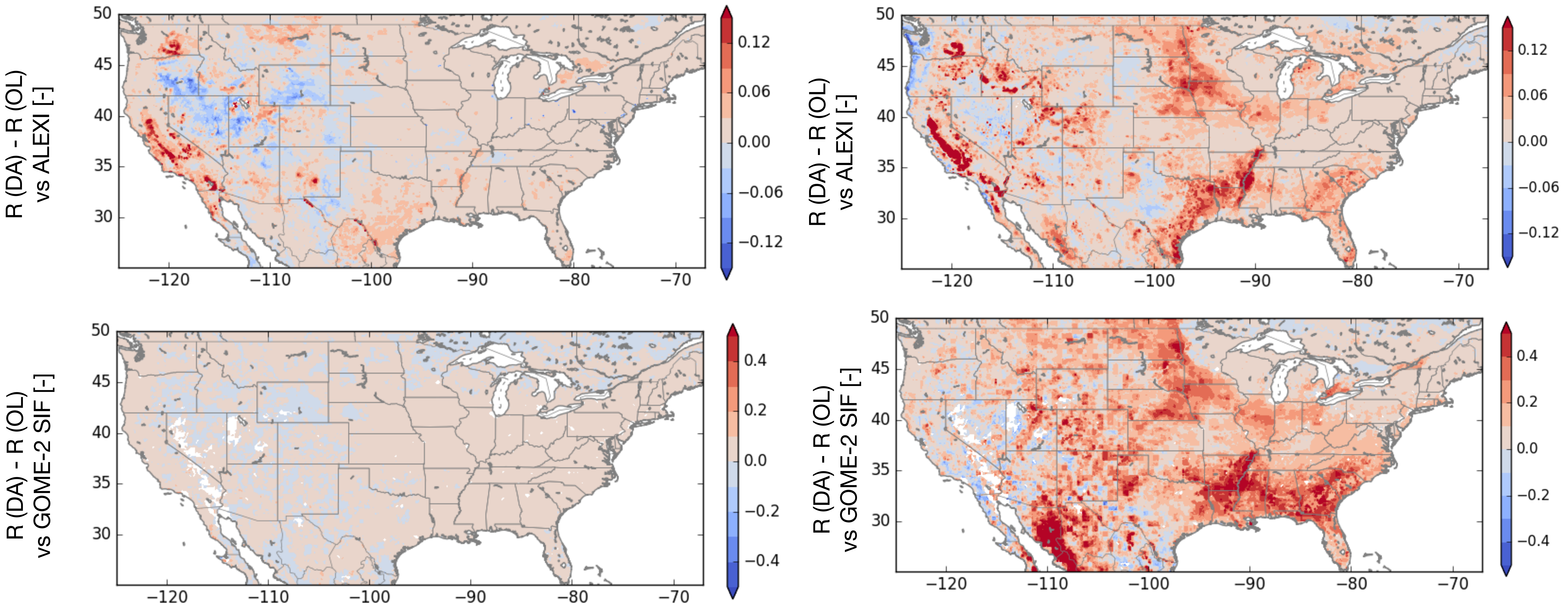




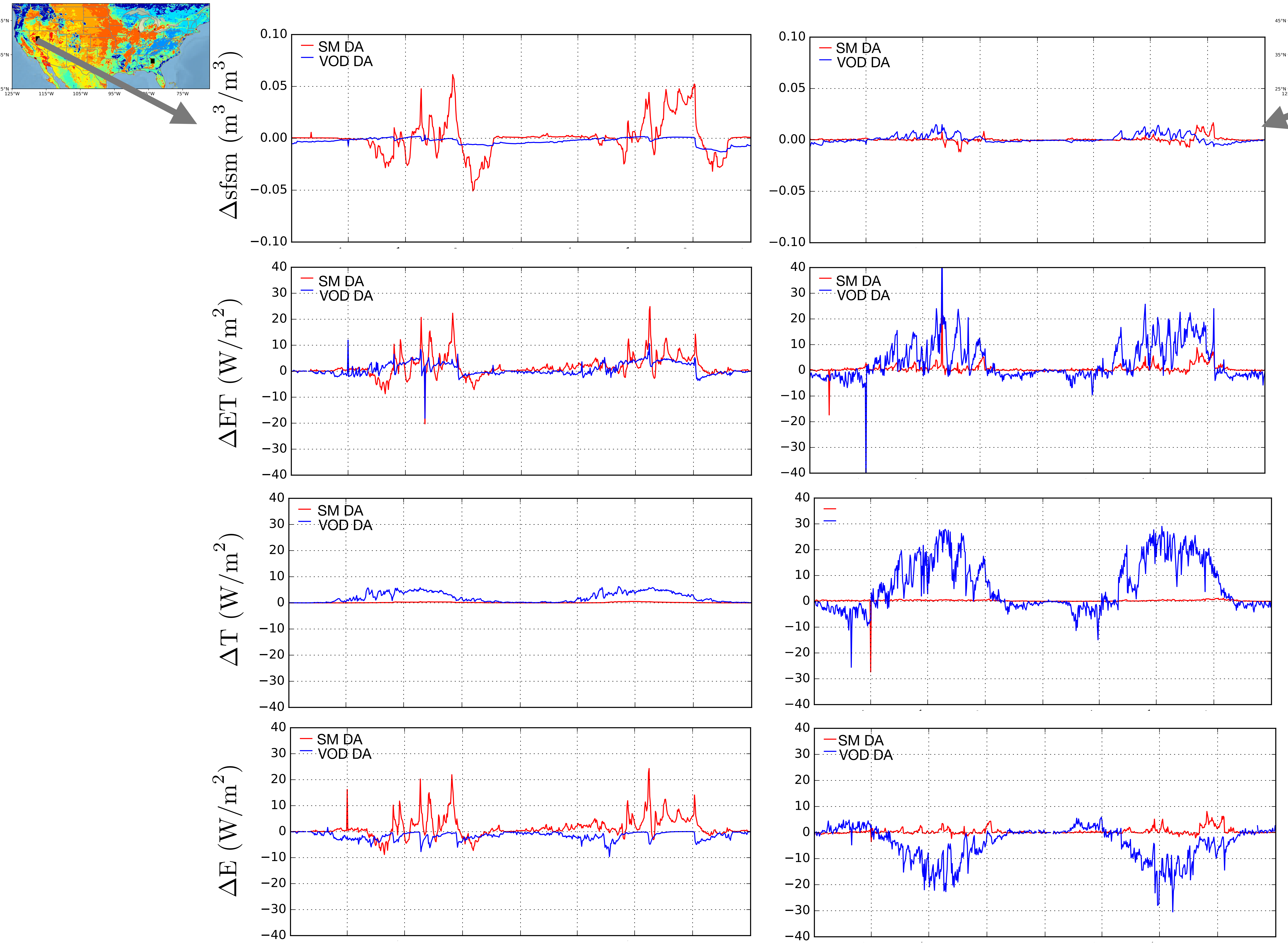
Is there independent information in the soil moisture and VOD retrievals from SMAP?



Positive impacts on soil moisture from soil moisture DA, smaller impacts from VOD-DA



Little impact on ET from soil moisture DA, significant improvements in ET from VOD-DA

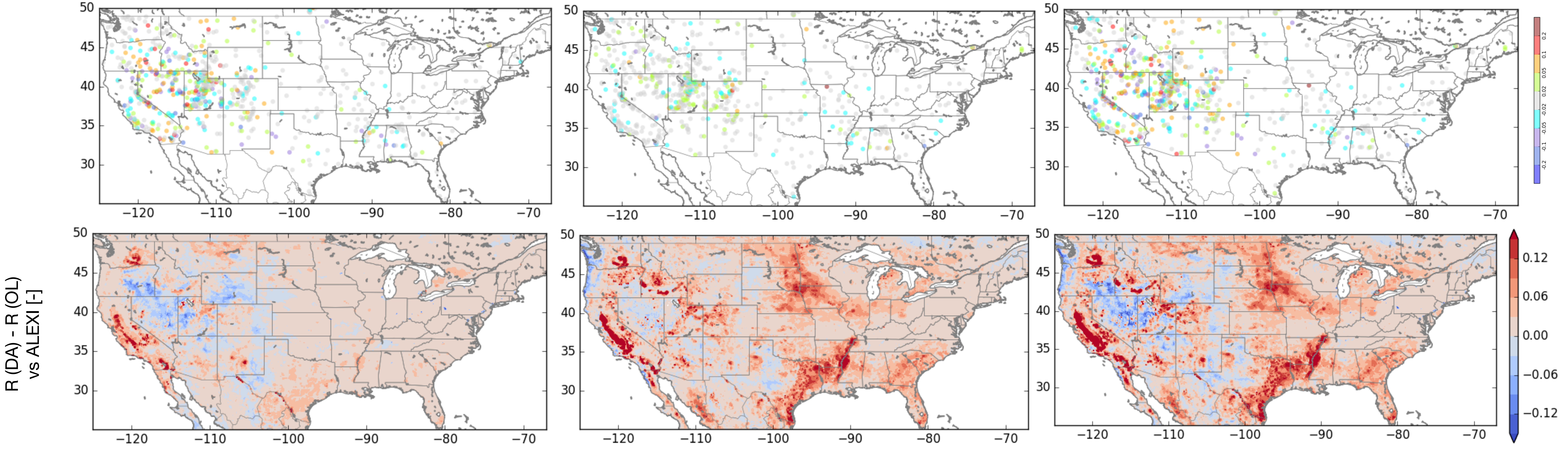


Over the arid location, soil moisture is the primary control on ET. Changes in ET are more connected to the bare soil evaporation

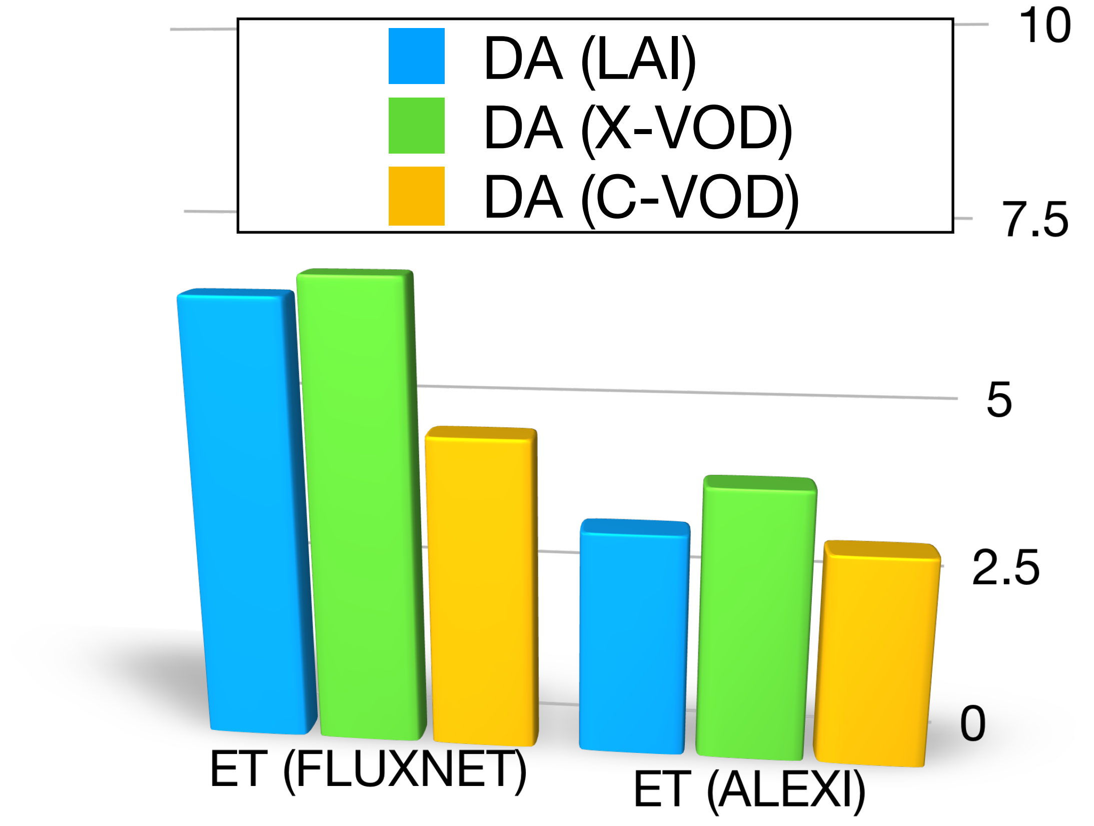
Soil moisture DA drives the changes in ET

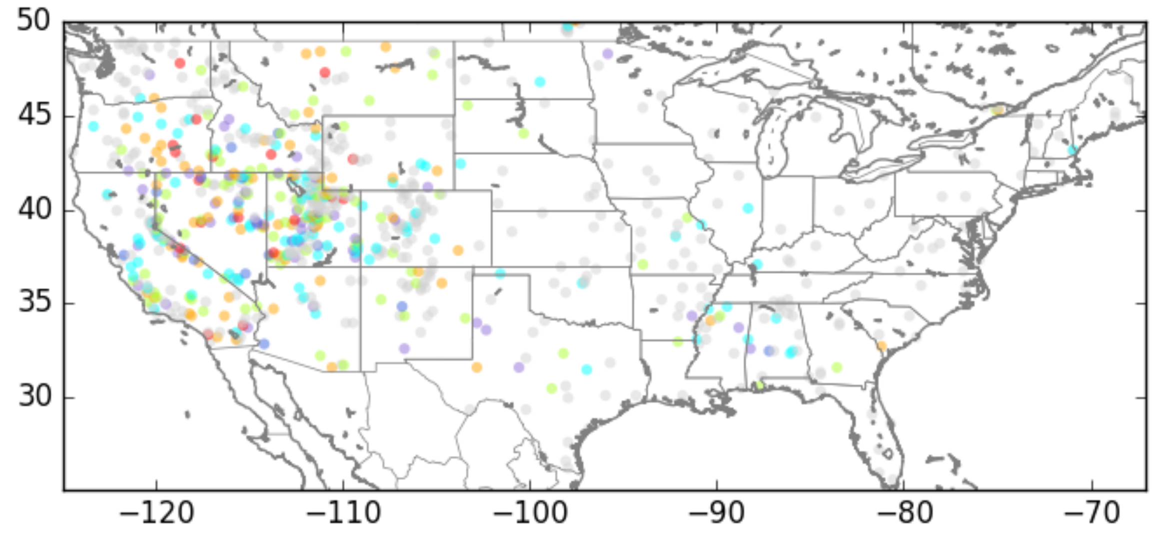
Over the wet location, VOD DA changes LAI and transpiration, which drives the changes in ET.

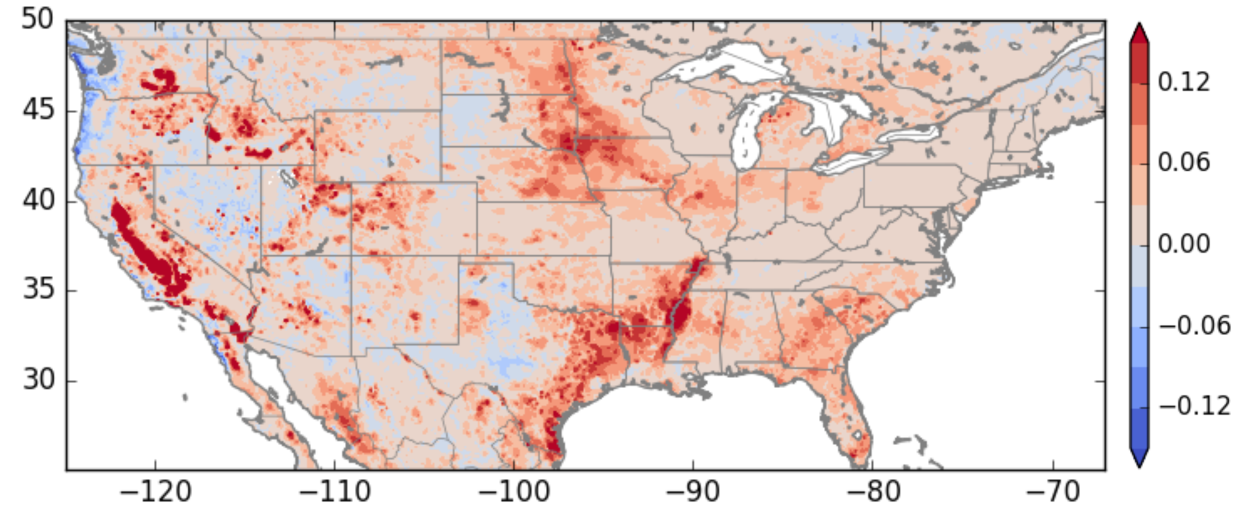
Joint assimilation of SMAP soil moisture and VOD



Little impact on ET from soil moisture DA, significant improvements in ET from VOD-DA







Assimilation of VOD from passive microwave sensors provides beneficial and comparable impacts to those obtained from the assimilation of optical sensor-based data.

Soil moisture and VOD retrievals from SMAP contain independent information that can be exploited within data assimilation. Soil moisture information is more useful for developing improvements in water budget fluxes over water limited domains and VOD is more useful over energy limited areas.