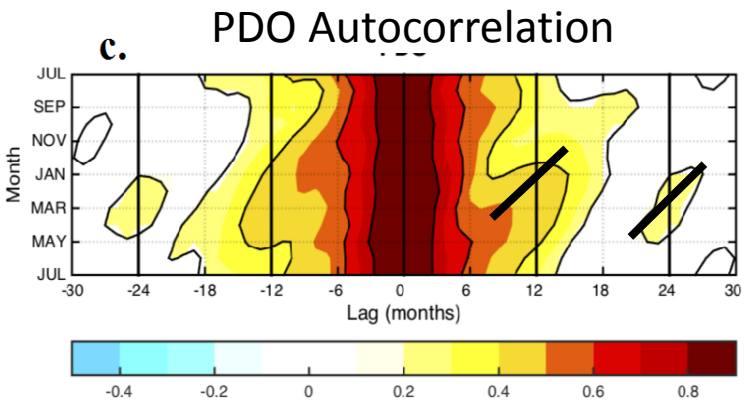
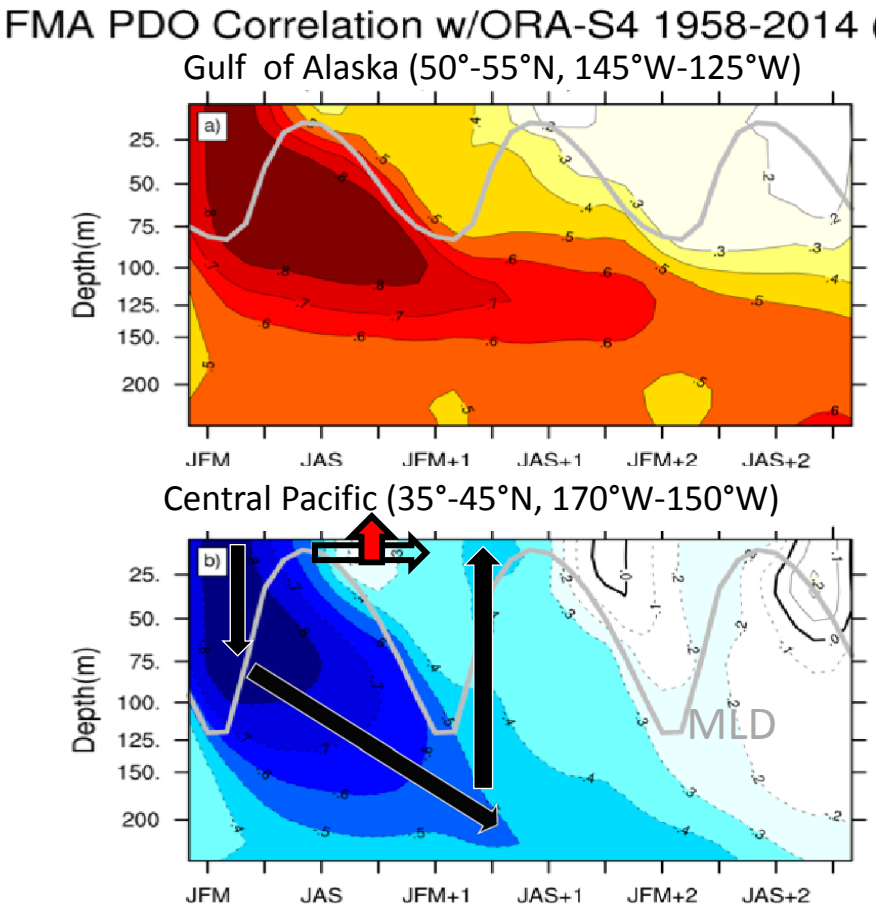
Potential re-emergence of seasonal soil moisture anomalies in North America

Matthew Newman[1,2], Yan Wang[1,2], Sanjiv Kumar[2,3], and Benjamin Livneh[1,4]

[1]CIRES/University of Colorado [2]NOAA/ESRL/PSD [3]National Research Council [4]Department of Civil, Environmental, and Architectural Engineering/University of Colorado

Re-emergence in the North Pacific





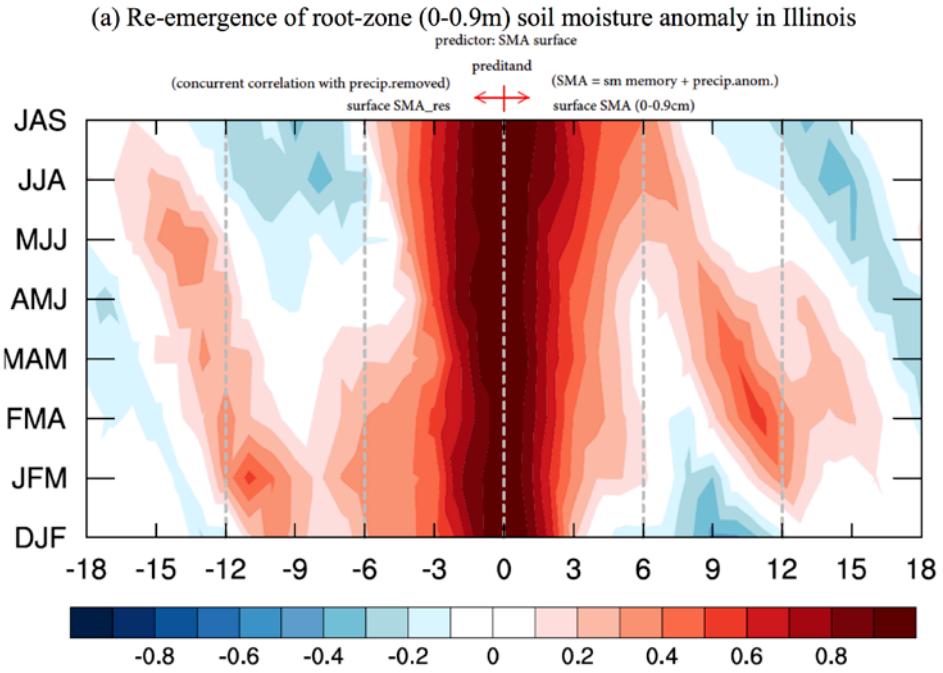
- Winter SST anomalies recur through re-emergence
- Acts to redden ENSO & random atmospheric forcing
- Drives pronounced PDO "re-occurrence"

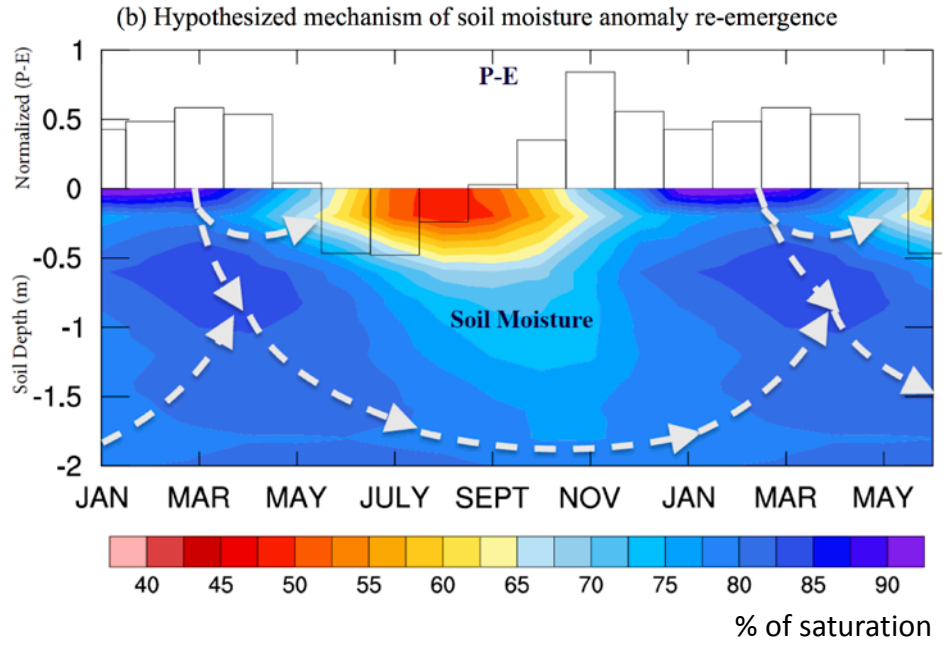
Soil moisture re-emergence in Illinois

Illinois Climate Network (ICN) observations (1983-2004)

Top: autocorrelation of surface (0-0.9m) soil moisture anomaly showing "re-occurrence"

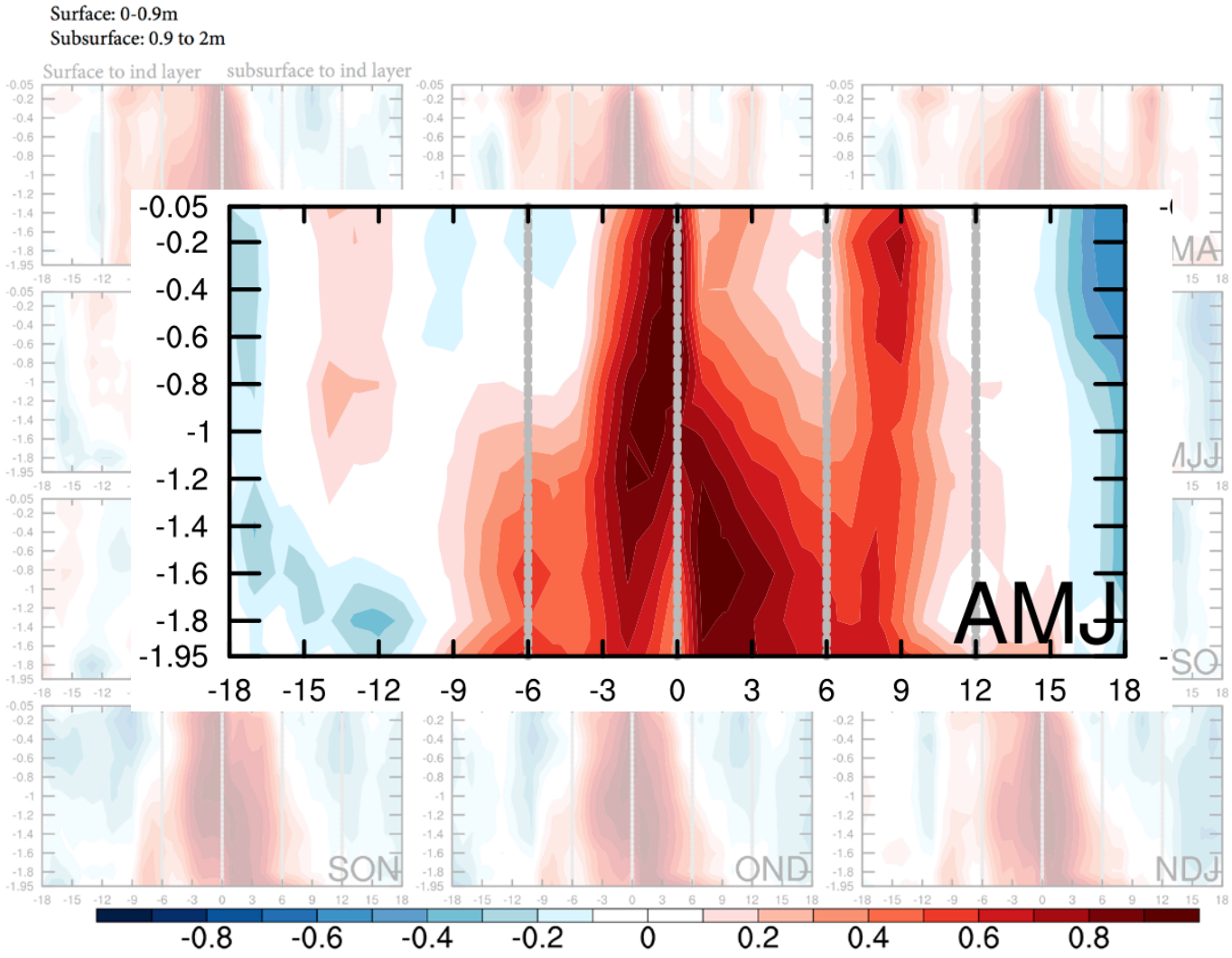
Bottom: Climatological soil moisture, with hypothesized "re-emergence" pathways





Potential re-emergence

Subsurface soil moisture anomaly appears to lead surface anomaly in certain seasons



Negative lags: correlation with base season **surface** (0-1m) soil moisture anomaly

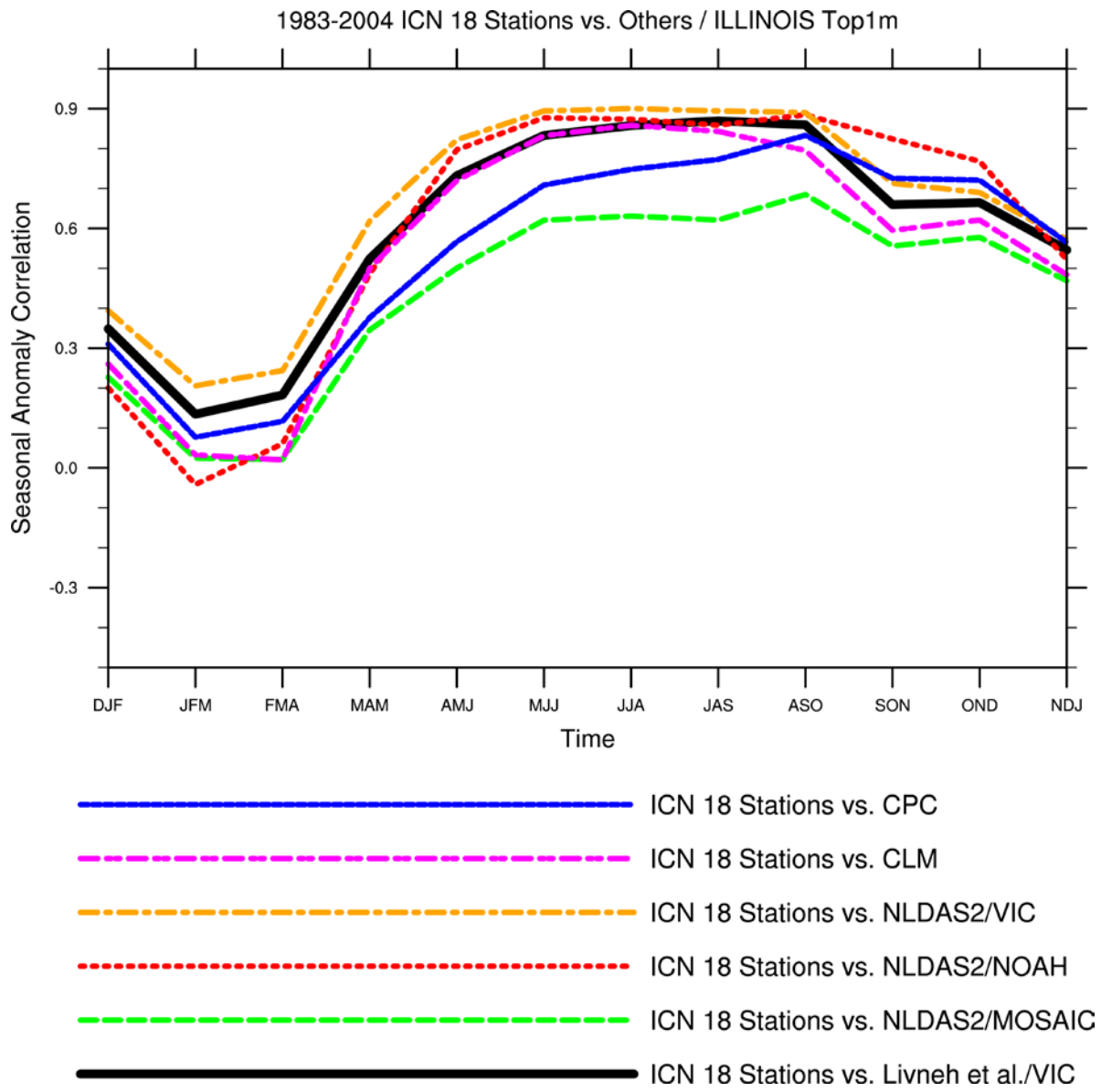
Positive lags: correlation with base season **subsurface** (1-2m) soil moisture anomaly

Soil moisture datasets

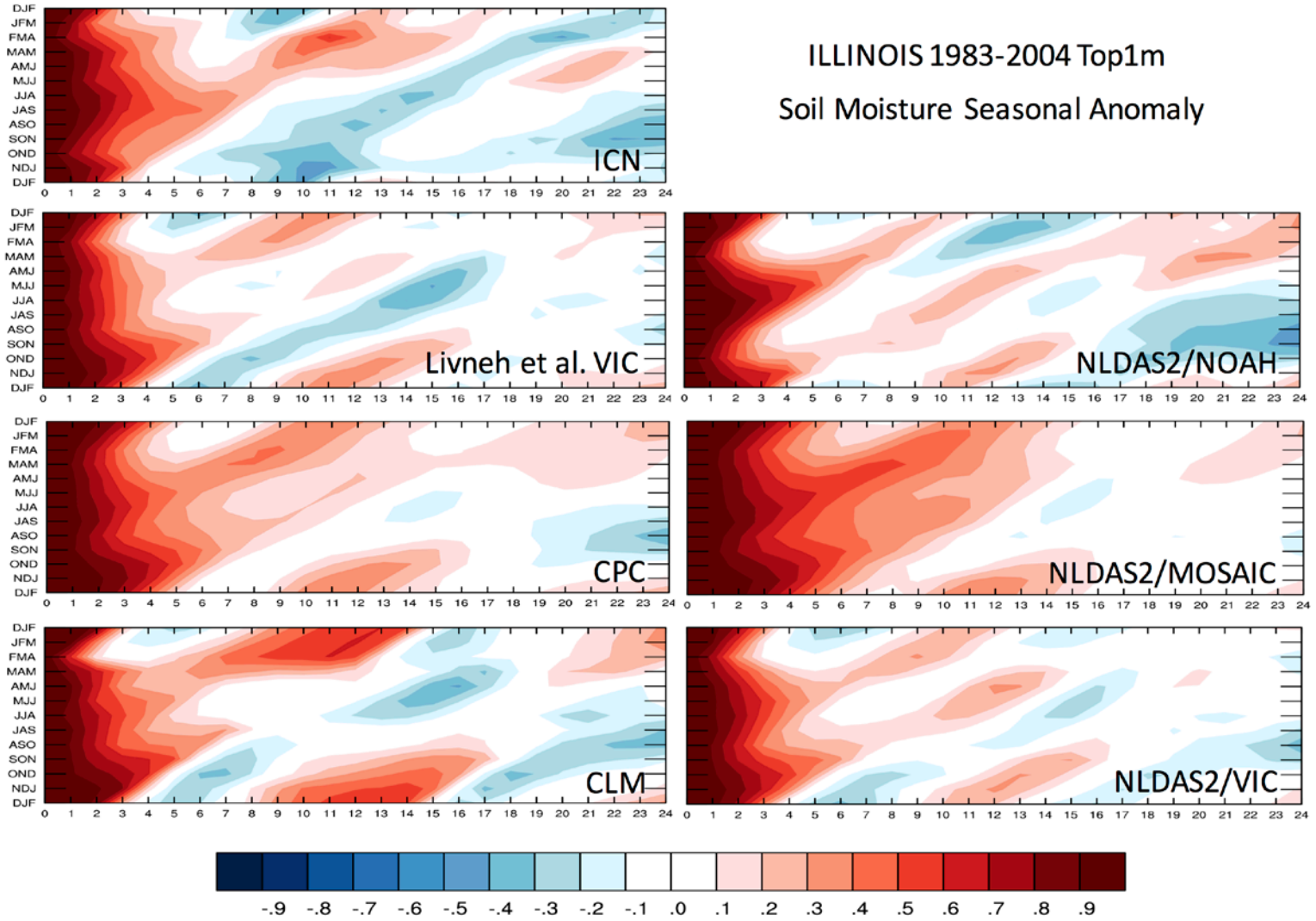
Dataset	Years	Forcing	Notes
VIC (Livneh et al.)	1950-2010	**Hydrologically consistent dataset (ie, calibrated from observed runoff)** for the conterminous United States, gridded at ½° latitude/longitude, derived from daily temperature and precipitation observations from approximately 20 000 NOAA Cooperative Observer (COOP) stations (Livneh et al 2013).	Three-layer (variable depth) variable infiltration capacity (VIC) model, run at 1/16° resolution in 3-hourly increments.
CPC (V2)	1950-2010	Monthly data over the globe from CPC PRECipitation REConstruction over Land (Chen et al. 2002) and CPC Global Land Surface Air Temperature Analysis (Fan and van den Dool 2008)	One-layer hydrological model ("leaky bucket") with spatially constant parameters (Huang et al. 1996; van den Dool et al. 2003). Constant depth 1.6m, run at ½° resolution, monthly
NCAR CLM	1950-2010	CRU3.2+NCEP R1 temperatures/precipitation (CRUNCEP; Viovy 2011)	NCAR Community Land Model (CLM) v4.5, 17 layers, constant depths, run at 1° resolution, 6-hourly increments (Oleson et al. 2013)
NOAH (NLDAS2)	1979-2010	NLDAS2 forcing fields (NARR/PRISM, plus various corrections)	Land model used in NCEP operational models. Four layers, constant depths
VIC (NLDAS2)	1979-2010	Same as for NOAH	Similar model to Livneh et al, but not balanced with runoff (also, different forcing, variable levels are not the same)
MOSAIC (NLDAS2)	1979-2010	Same as for NOAH	Land model originally used in NASA GCM
Illinois Climate Network (ICN)	1983-2004	None (soil moisture measurements)	18 station average. **Measurements are 1x monthly except 2x monthly in growing season.**

"LDAS" (land data Assimilation system)

Correlation of soil moisture datasets with ICN

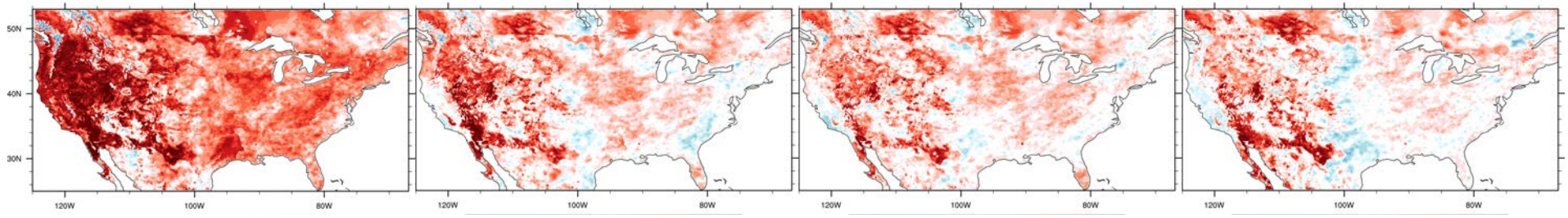


Autocorrelation of soil moisture anomalies

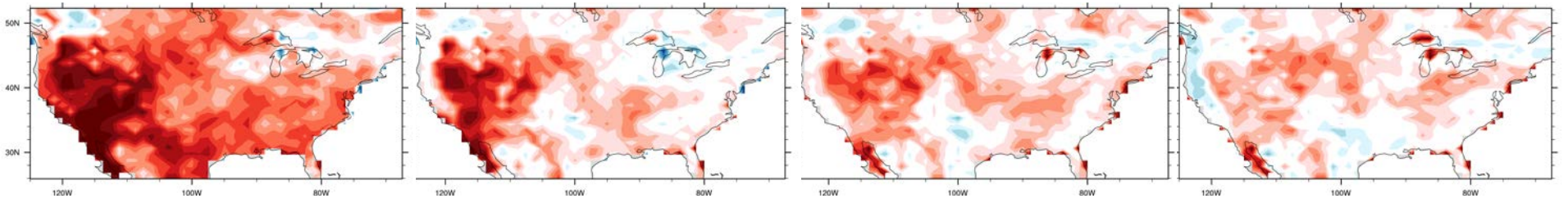


Autocorrelation for AMJ base season, top 1m soil moisture layer, 1950-2010

Lag 3 Lag 6 Lag 9 Lag 12

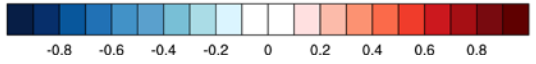


VIC (Livneh et al)

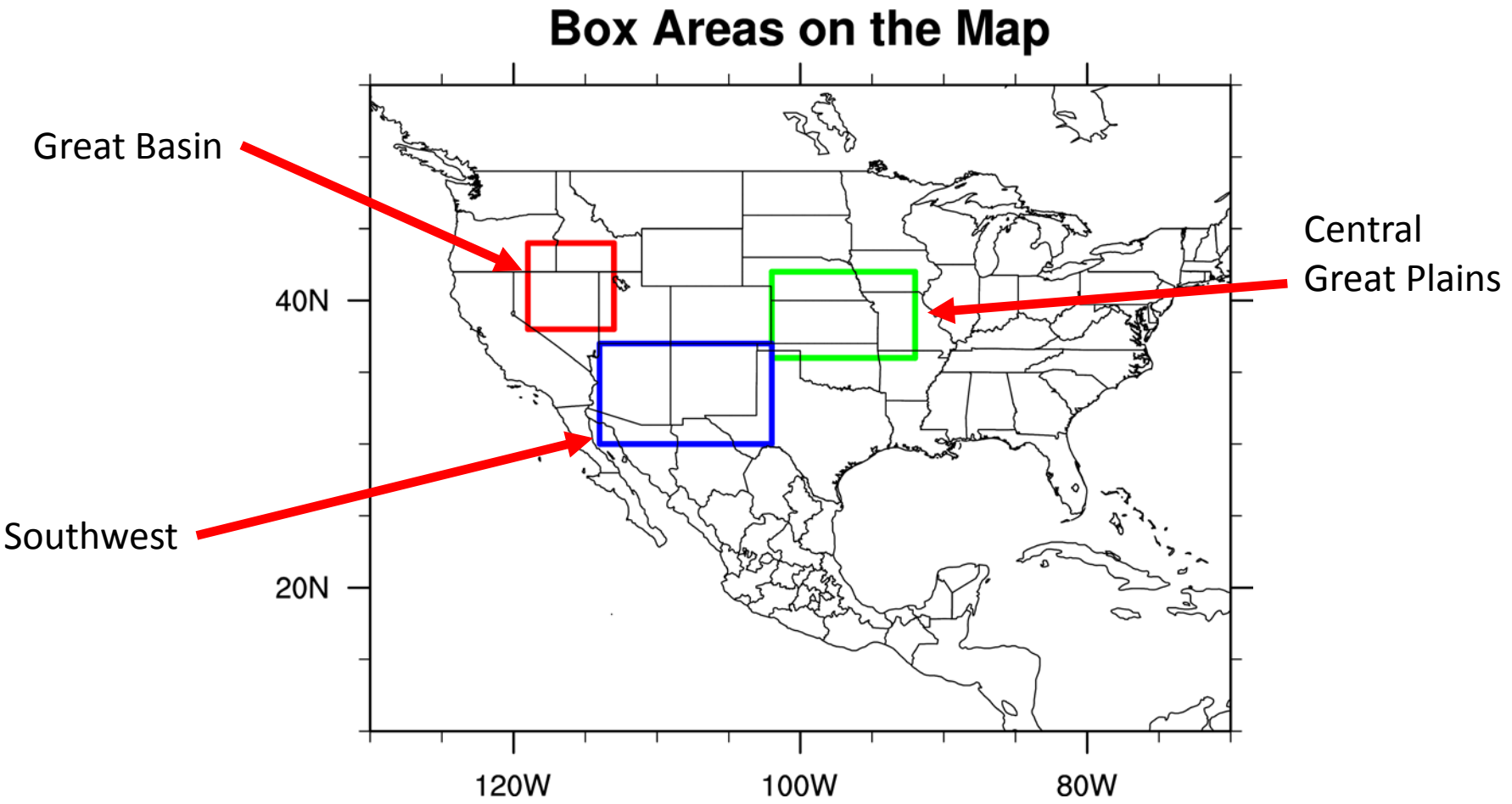


CLM 4.5 (Oleson et al)

[All datasets detrended from now on]

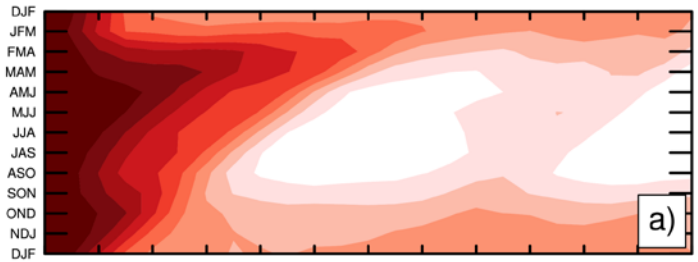


Regional soil moisture indices

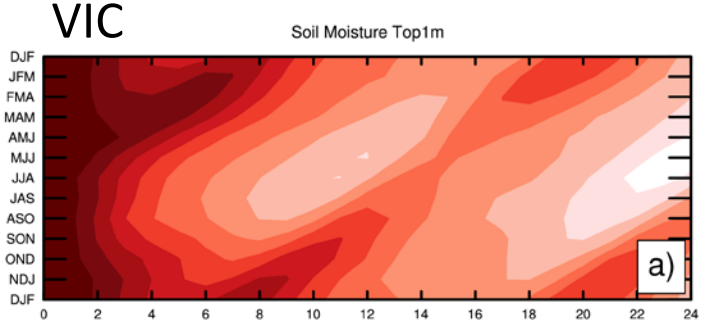


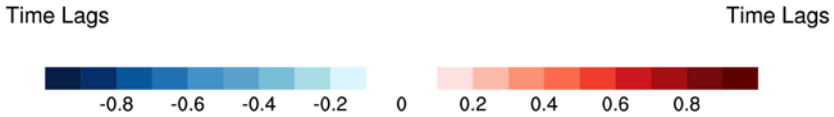
Great Basin

Soil moisture (top 1m)



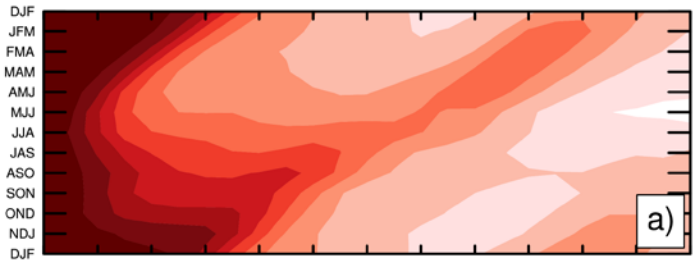
VIC



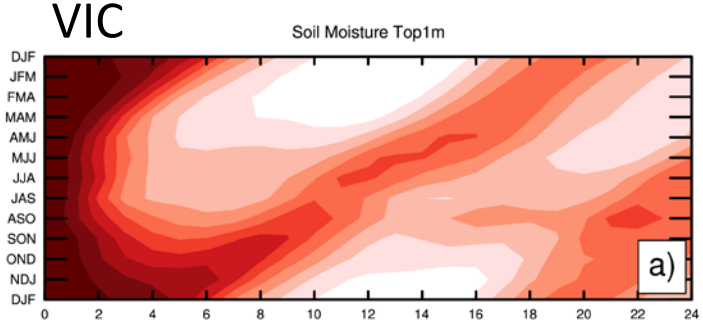


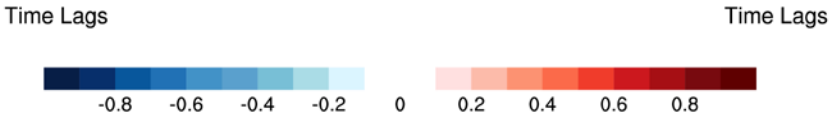
Southwest

CLM Soil moisture (top 1m)

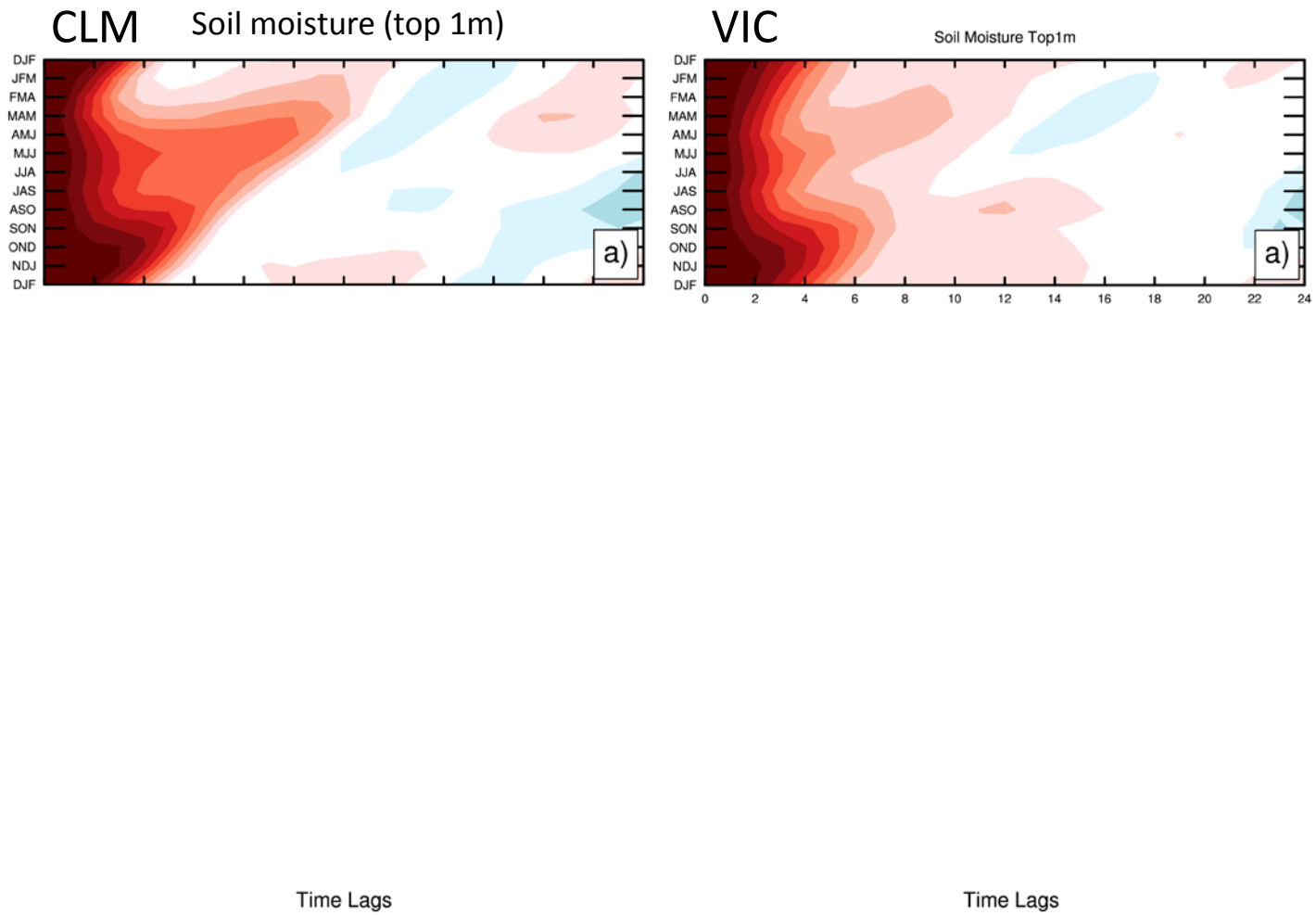


VIC

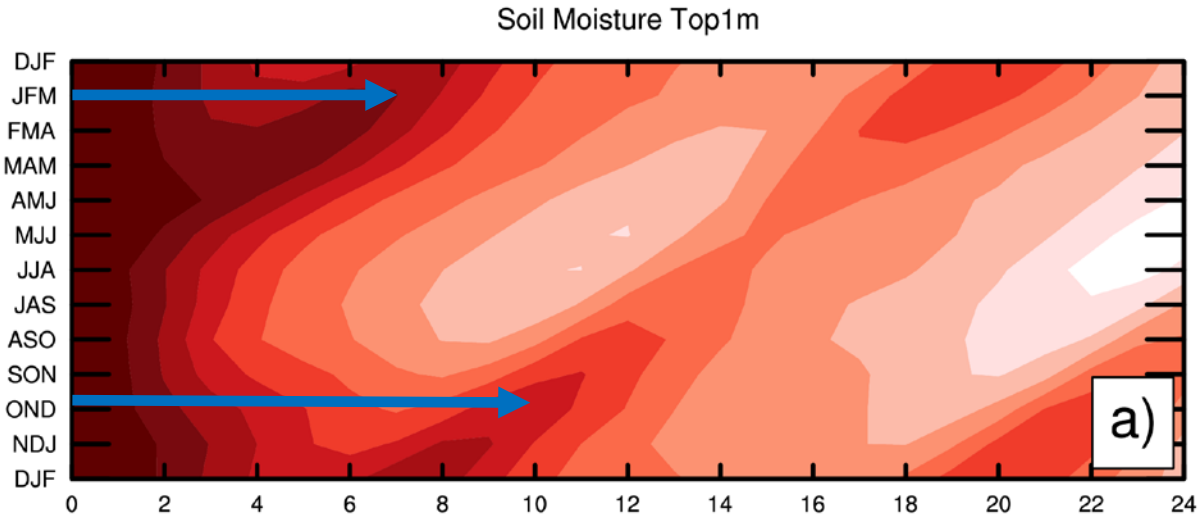




Central Great Plains



Maximum re-occurrence maps



lag (months) at maximum re-occurrence (secondary maximum of autocorrelation)

JFM = 7 months OND = 10 months

Shading: lag autocorrelation value at lag of maximum re-occurrence

JFM = 0.8 OND = 0.65

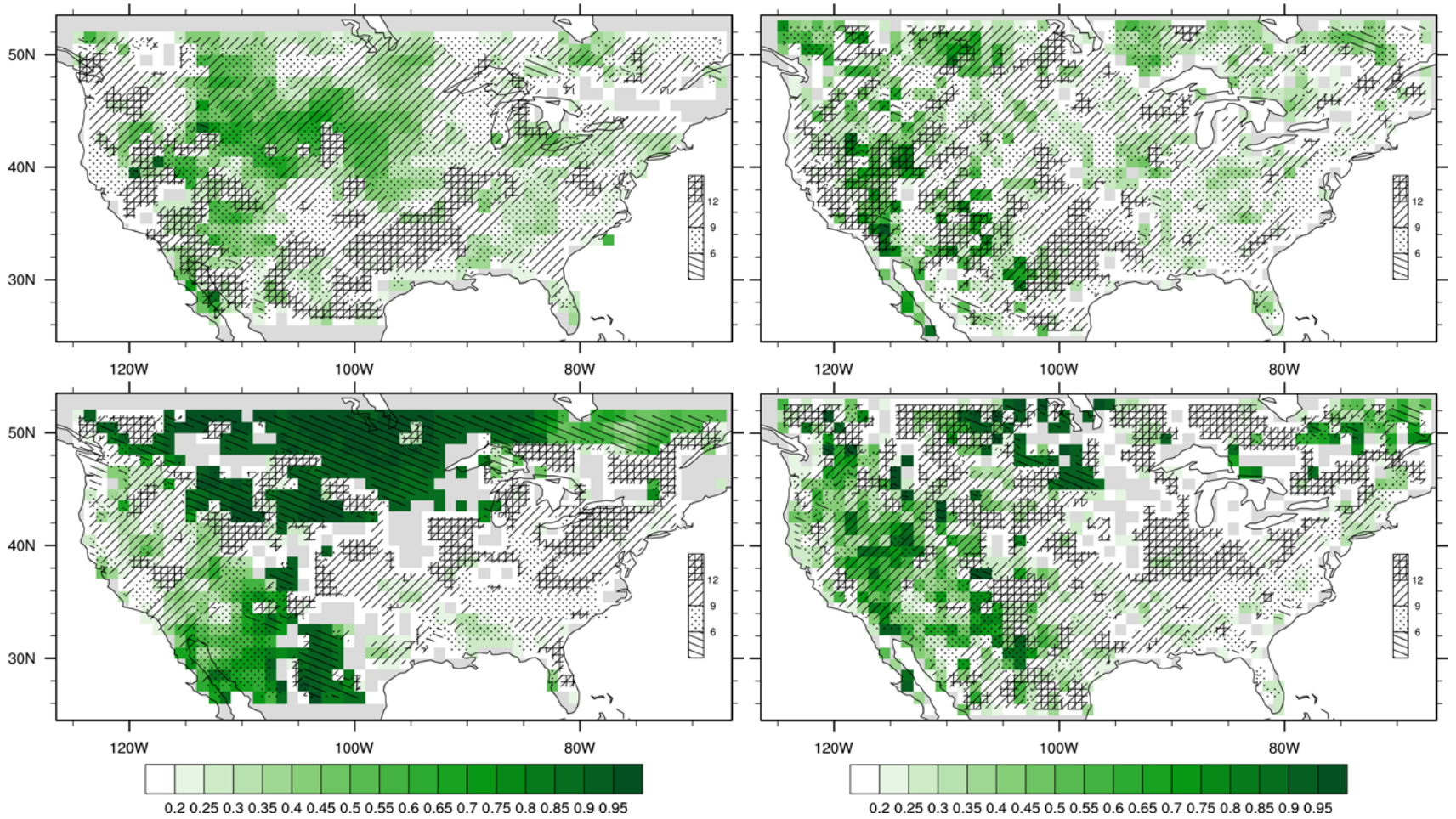
Maximum re-occurrence maps

CLM

VIC

AMJ base season

SON base season



Hatching: lag (months) at maximum re-occurrence (secondary maximum of autocorrelation)

Shading: lag autocorrelation value at lag of maximum re-occurrence

Concluding remarks

- There is pronounced seasonal and spatial variation of soil moisture anomaly autocorrelation
  - Secondary maxima may yield long-lead predictability in some seasons
- Comparison of surface and subsurface anomalies is suggestive of a “re-emergence” mechanism
  - Some preliminary analysis suggests atmospheric forcing variations does not explain these results
- Substantial uncertainty in “LDAS” soil moisture anomalies, vs. limited observations, limits confidence in these results