Water Table Depth Simulations in CLM and the Impact on Soil Memory

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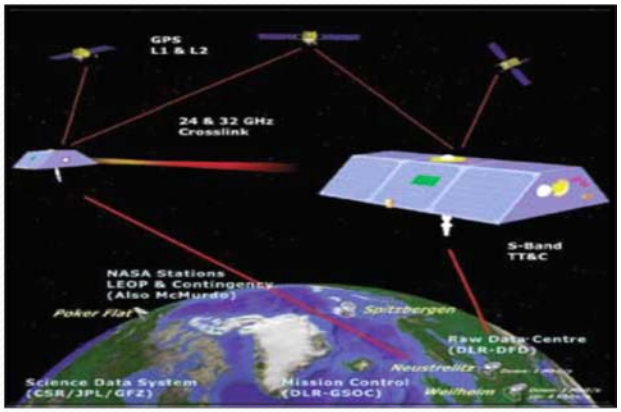
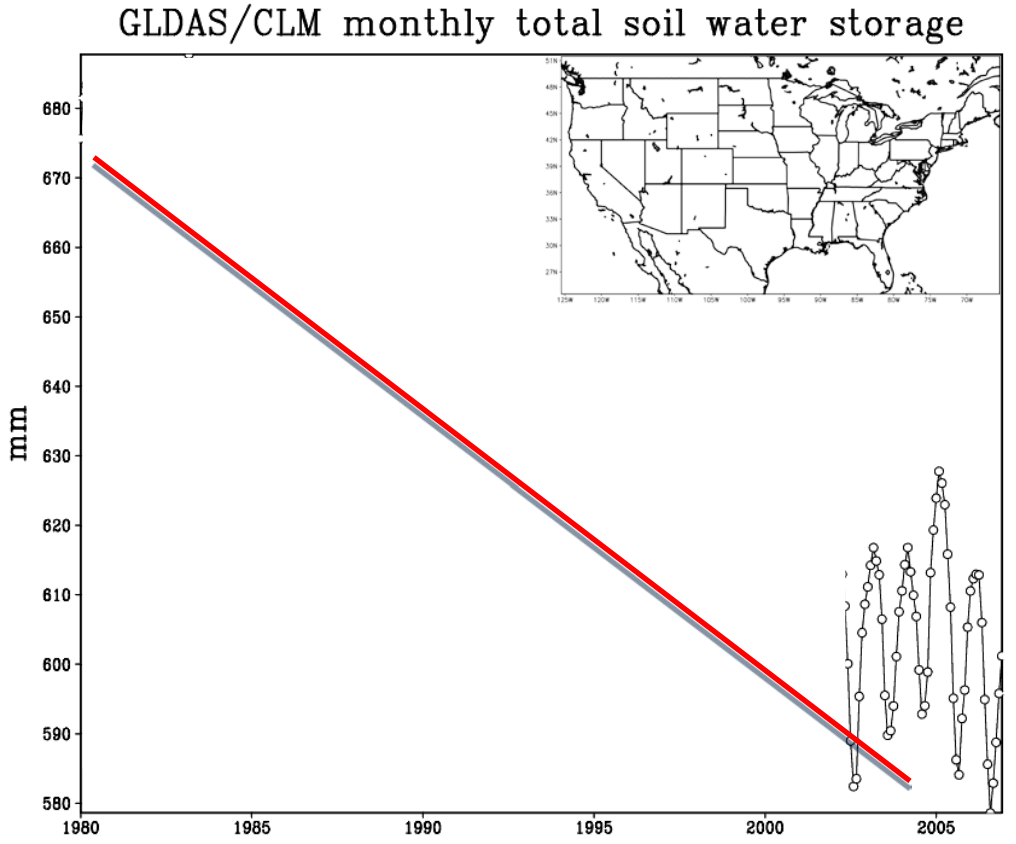
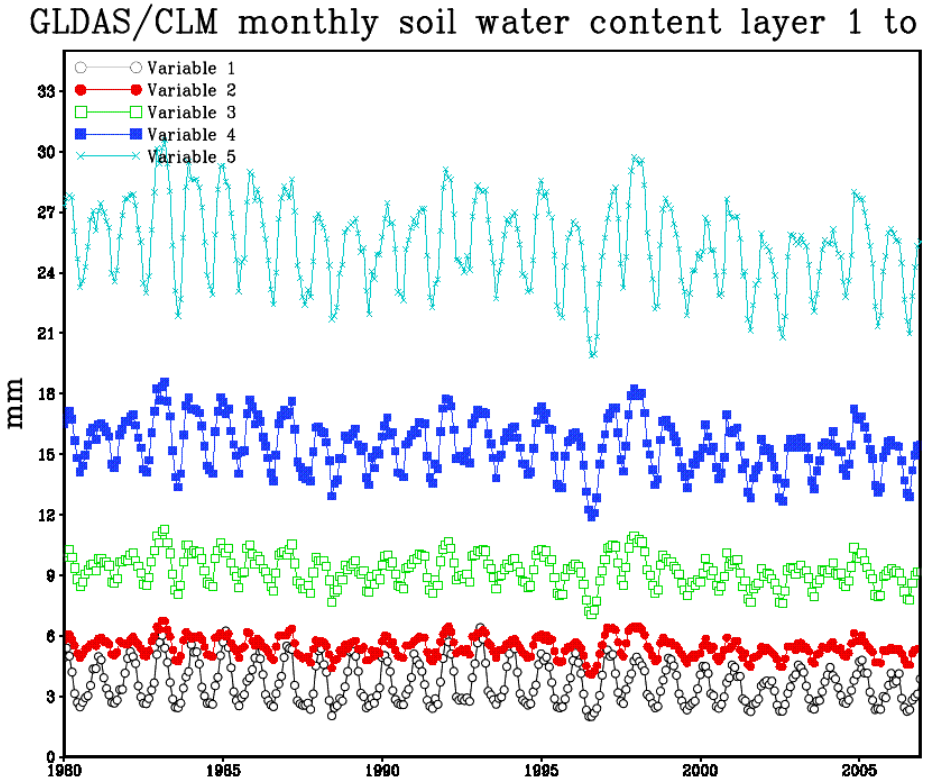
Total Water Storage in LSM

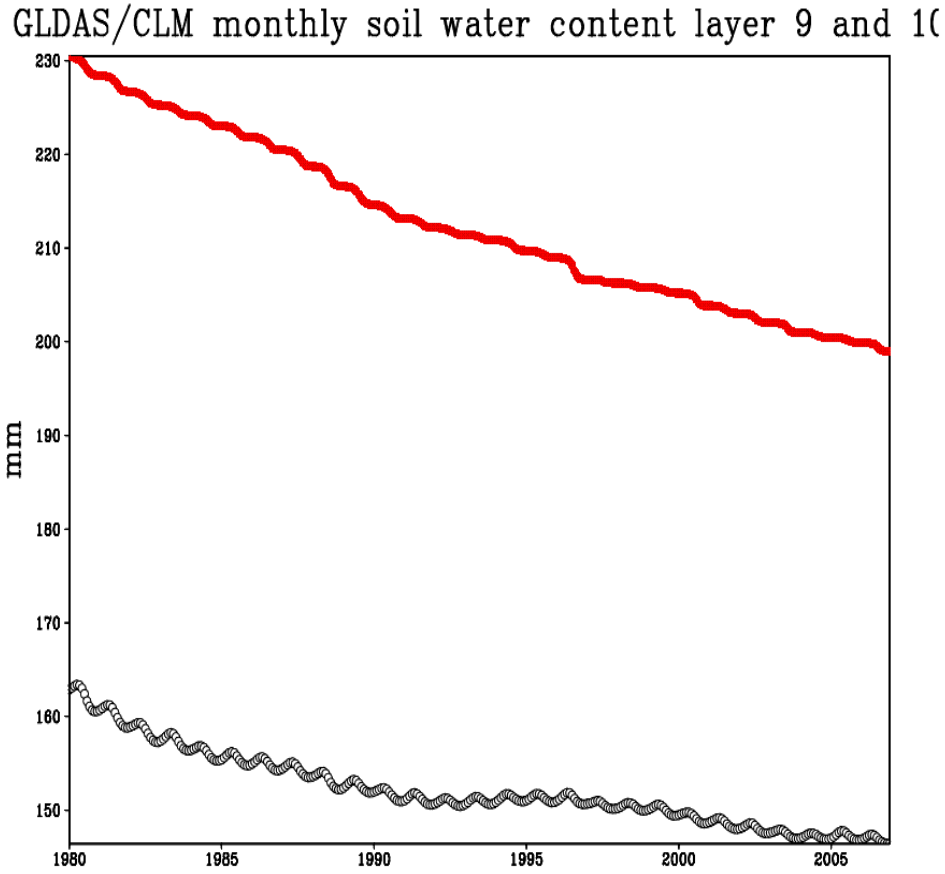
GRACE-TWS





Soil water in different layers





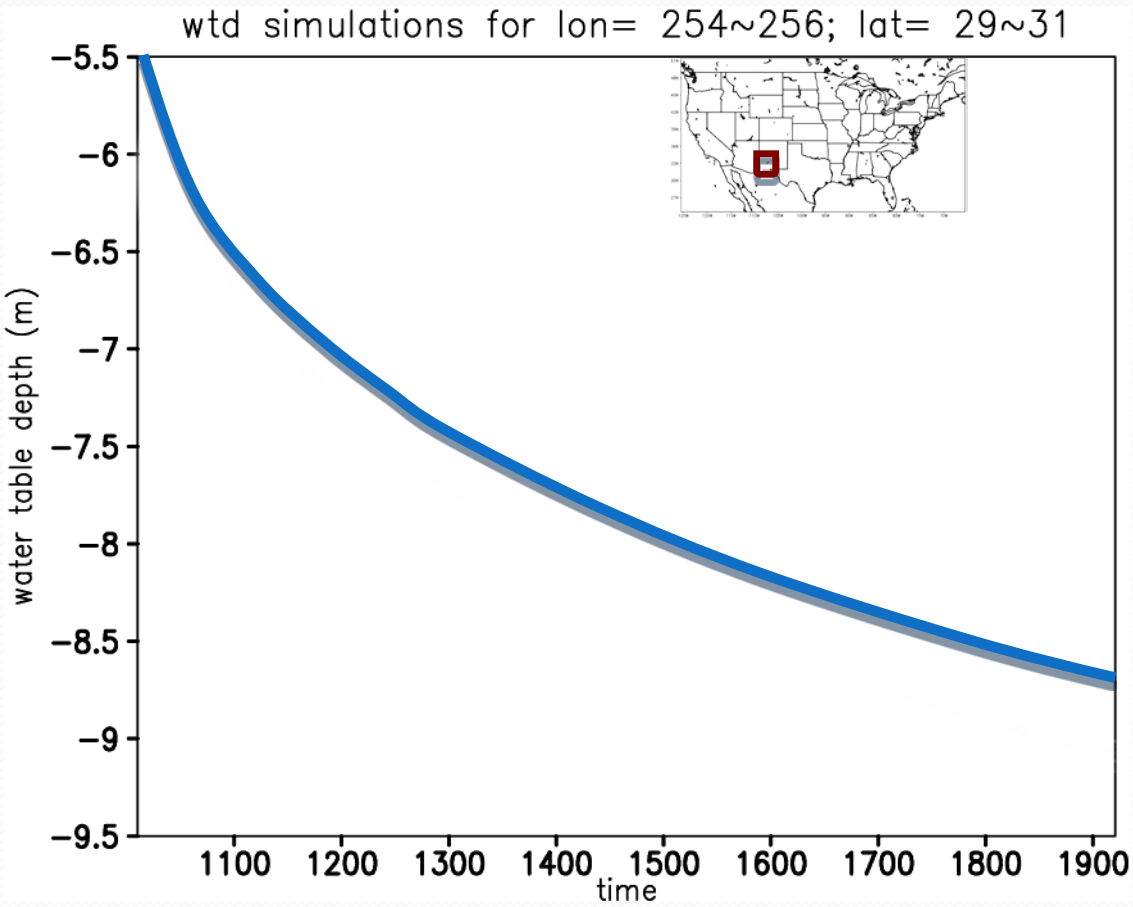
Why does it need such long time to reach Equilibrium?

a) There are no plants in deserts to extract wetness from the deeper layers.

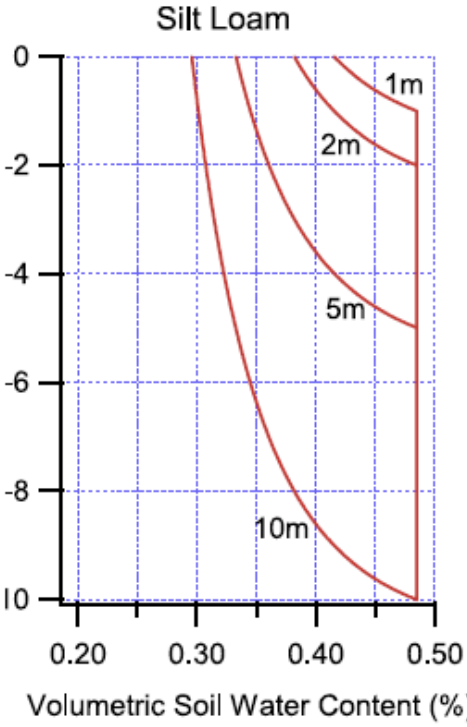
b) Therefore, after gravity drainage ceases, water in those deep layers will diffuse upwards and eventually evaporate, which takes longer time.

➔ It takes a very long time for deserts to reach equilibrium when they are initialized with wet or even average-wetness soils. (250 years, Niu et al., 2007)

How long does CLM3.5 reach Equilibrium WTD?



How WTD affects the soil moisture profile



From Fan et al., 2007

Suggestions:

a) provide the EWTD as I.C. for the CLM4

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Niu et al., [2007] proposed an efficient way to obtain the EWTD

$$z_{\nabla,\mathrm{eq}} = z_{\mathrm{bot}} - \psi_{\mathrm{sat}} s_{\mathrm{bot}}^{-b}$$

Obtaining soil moisture profile I

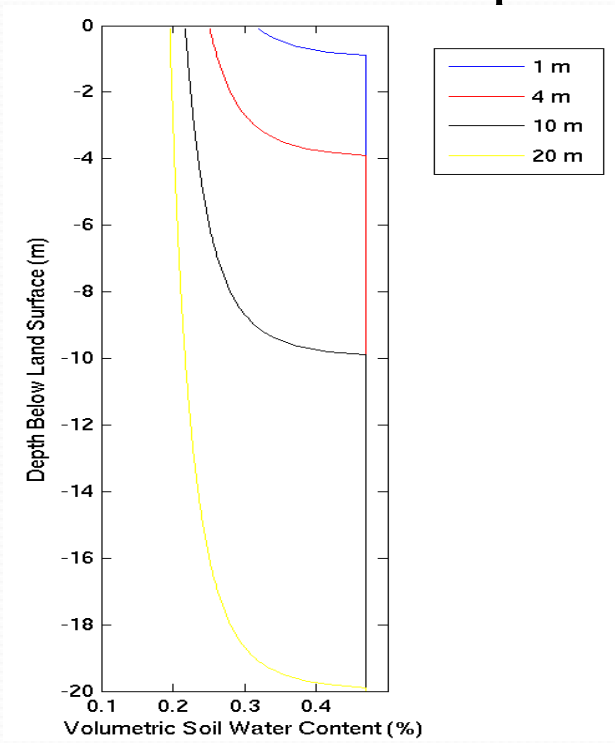
Soil moisture profile can be determined from the Brooks and Corey [1964] soil moisture characteristic relationship

$$\theta(\psi) = \theta_r + (\theta_s - \theta_r)(\frac{\psi_c}{\psi})^B$$

$$\psi(\text{matric head}) = WTD - Z$$

B = pore size distribution index

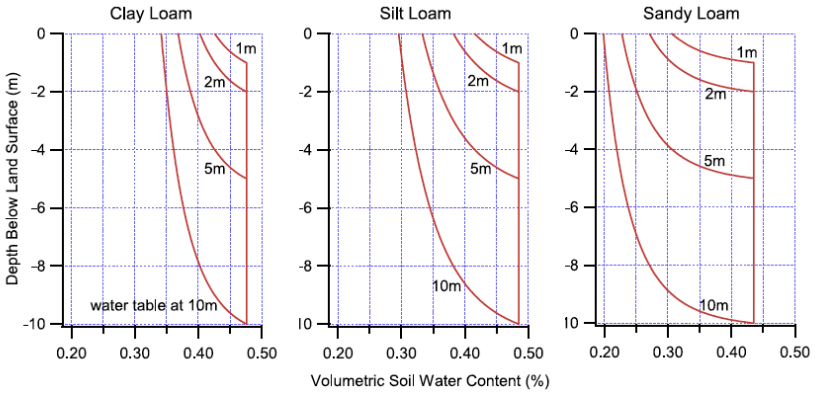
ψ_c = height of the capillary fringe



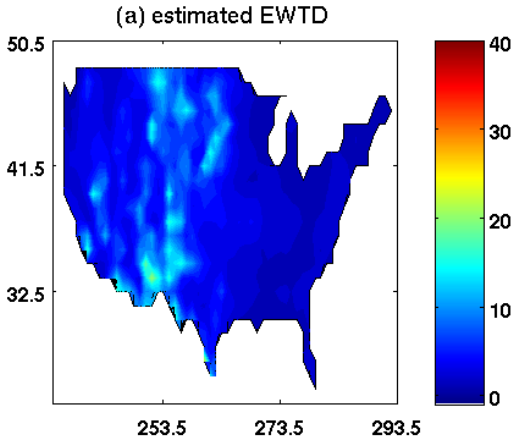
Obtaining soil moisture profile II

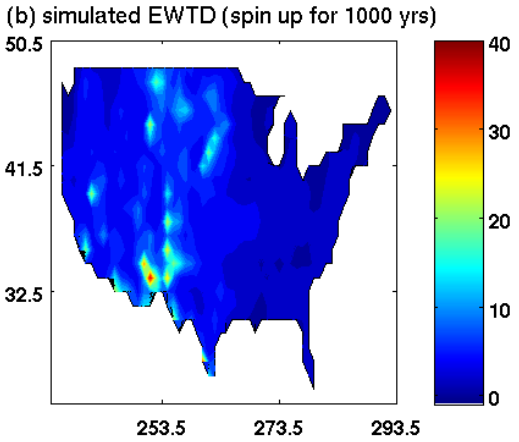
Using water table as lower boundary condition to solve the Richards' Eq. numerically [Fan et al., 2007]

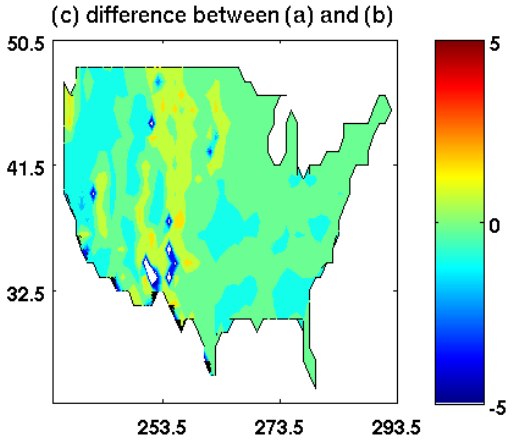
$$q = K_\eta \left(\frac{\partial \psi}{\partial z} - 1 \right), \quad K_\eta = K_f \left(\frac{\eta}{\eta_f} \right)^{2b+3}, \quad \psi = \psi_f \left(\frac{\eta_f}{\eta} \right)^b$$

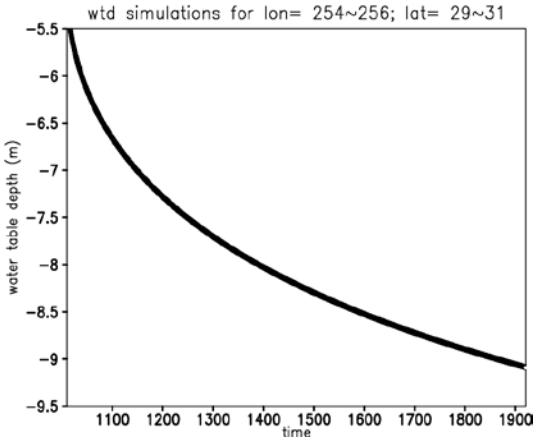


Estimate Equilibrium WTD







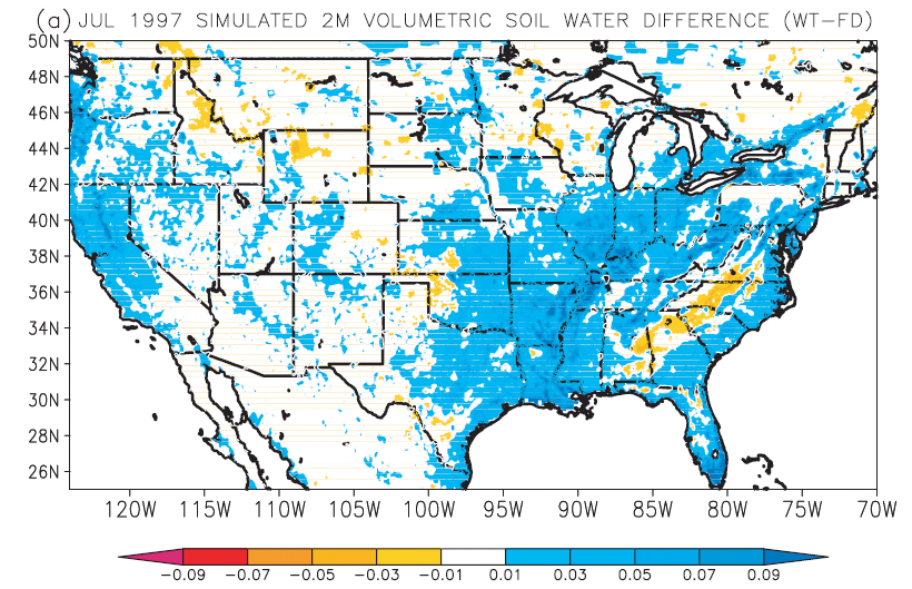


With the equilibrium WTD and SM as I.C. for the CLM4, the GW table and soil moisture in deeper soil layers can be treated correctly.

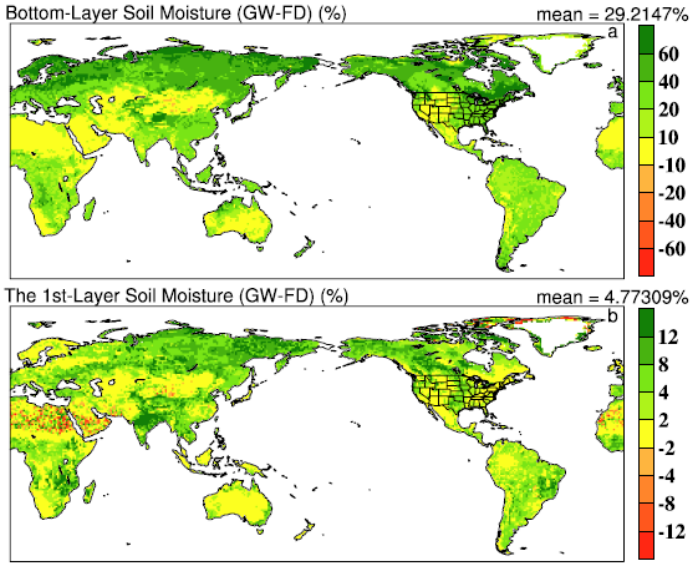
Provide more reasonable total water storage simulations and comparisons with GRACE.

Impacts of Groundwater on the Soil Moisture Memory

Impacts of Groundwater on the Soil Moisture Content

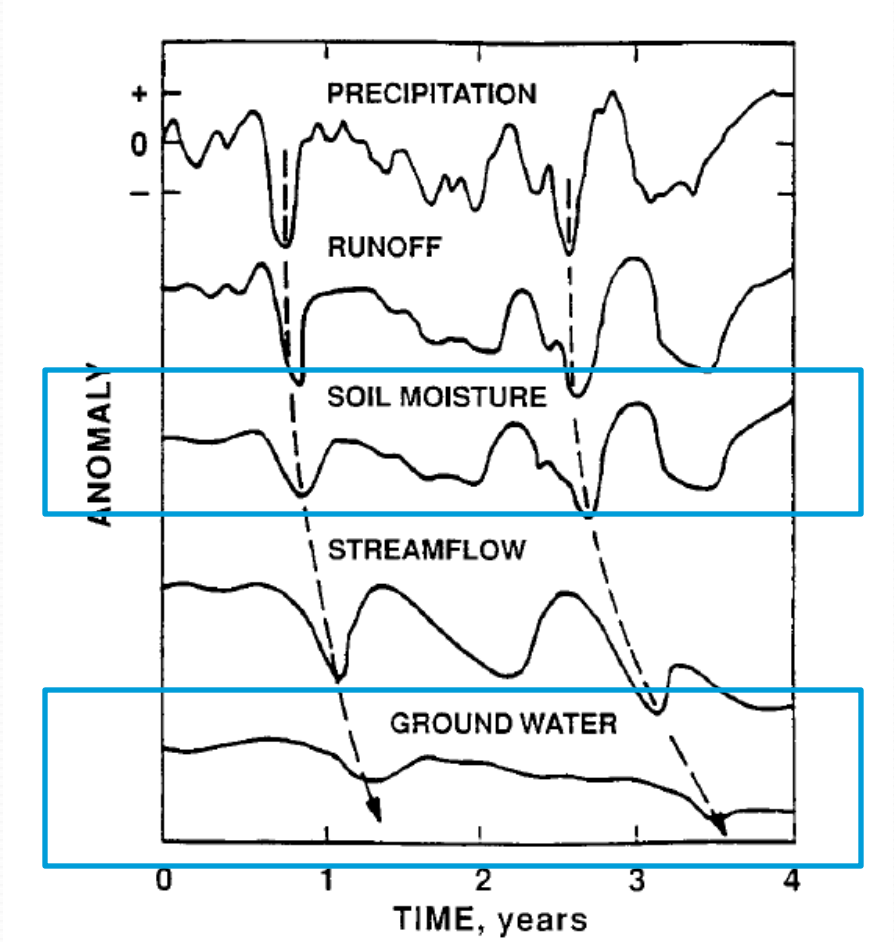


From Anyah et al., 2008



From Niu et al., 2007

Atmospheric forcing anomalies propagate to deeper soil layers



From Changnon ,1987

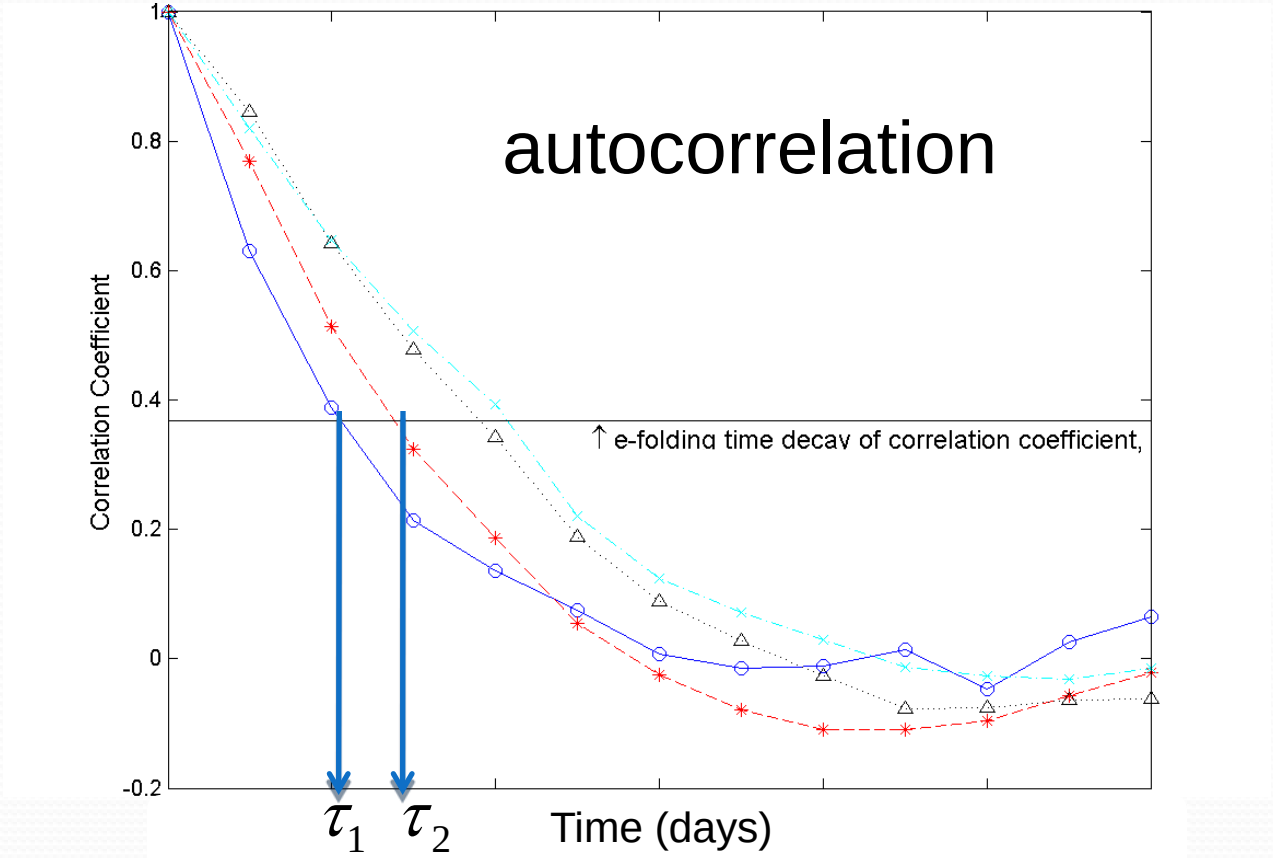
Examine the Soil Moisture Memory

two simulations:

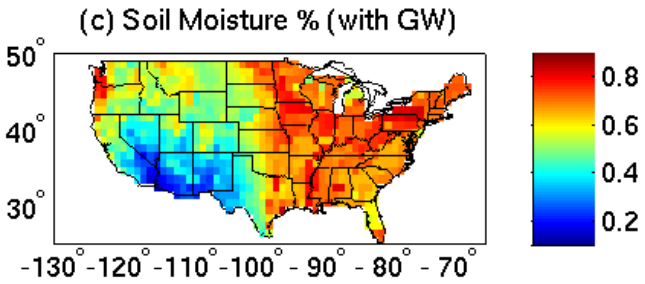
(a) control run (default CLM3.5)

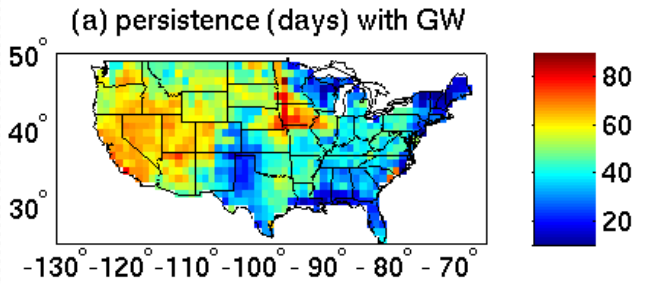
(b) no GW run (no capillary flux from GW)

Using daily soil moisture to estimate the memory (persistence)



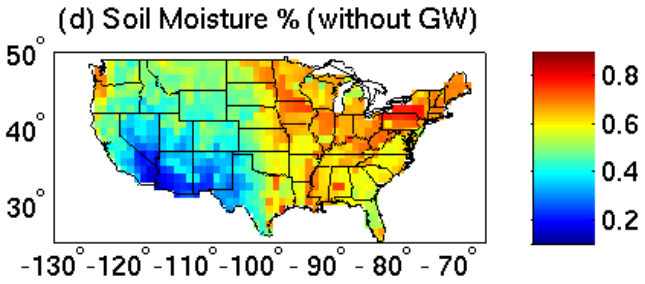
Soil moisture content and persistence for GW and no GW

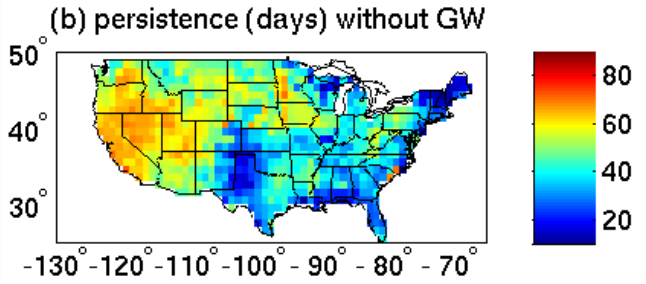




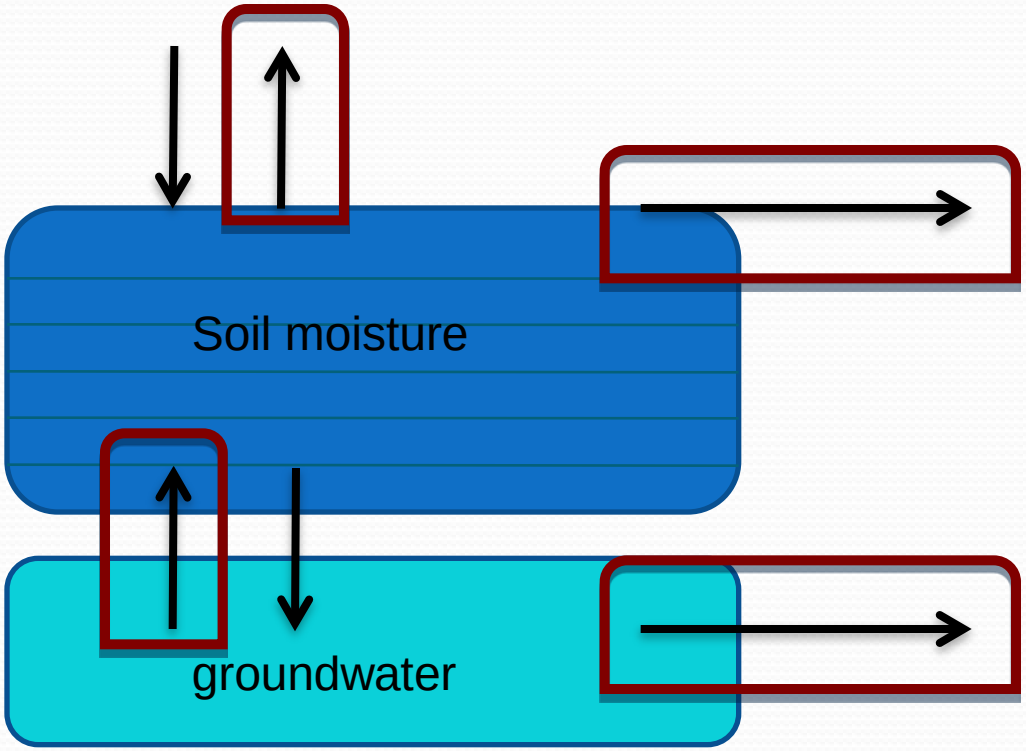
Soil moisture content

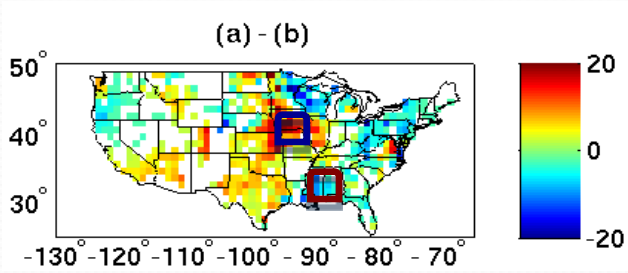
persistence

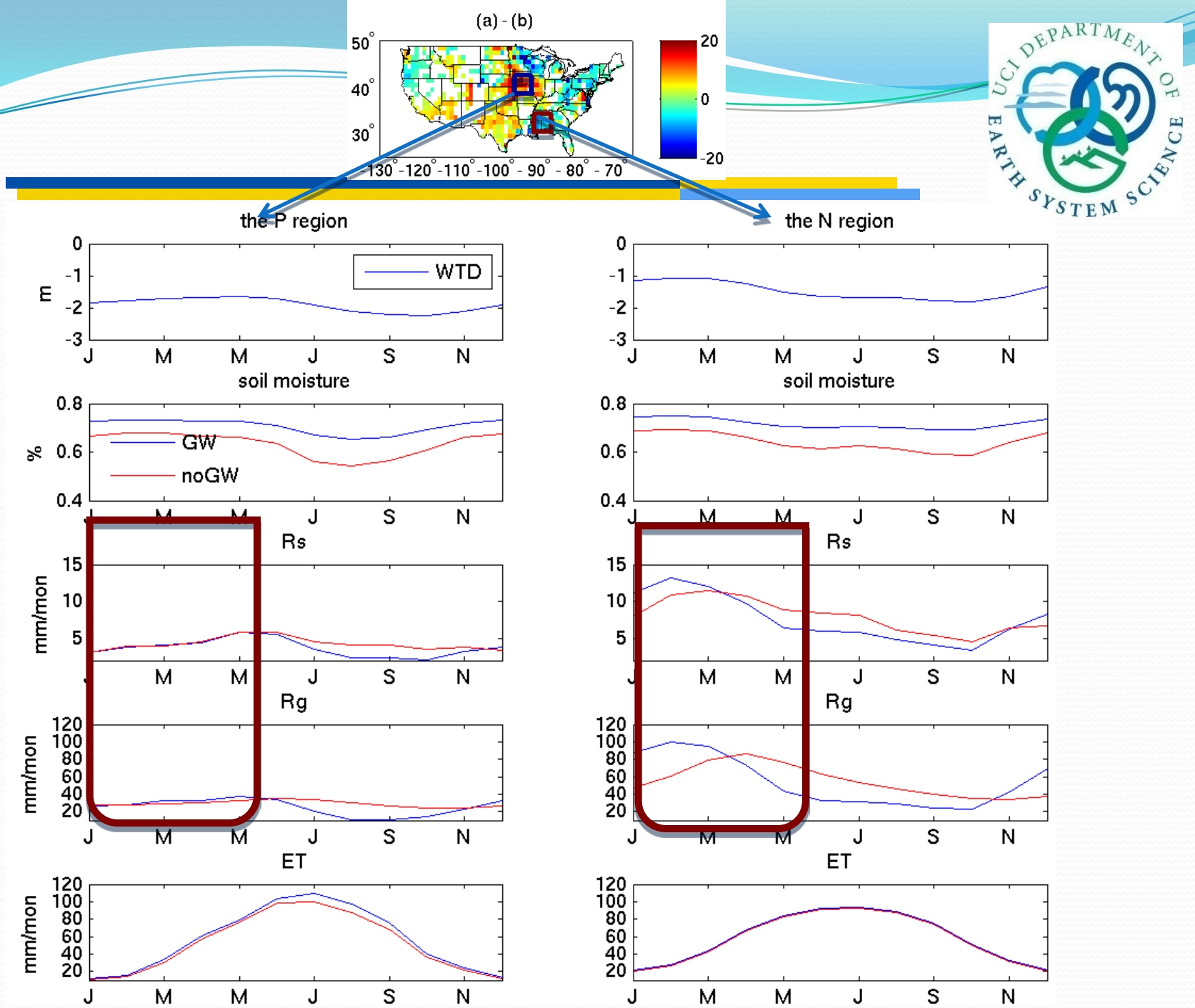




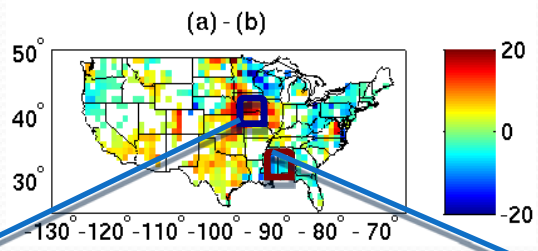
Schematic of water budget in CLM

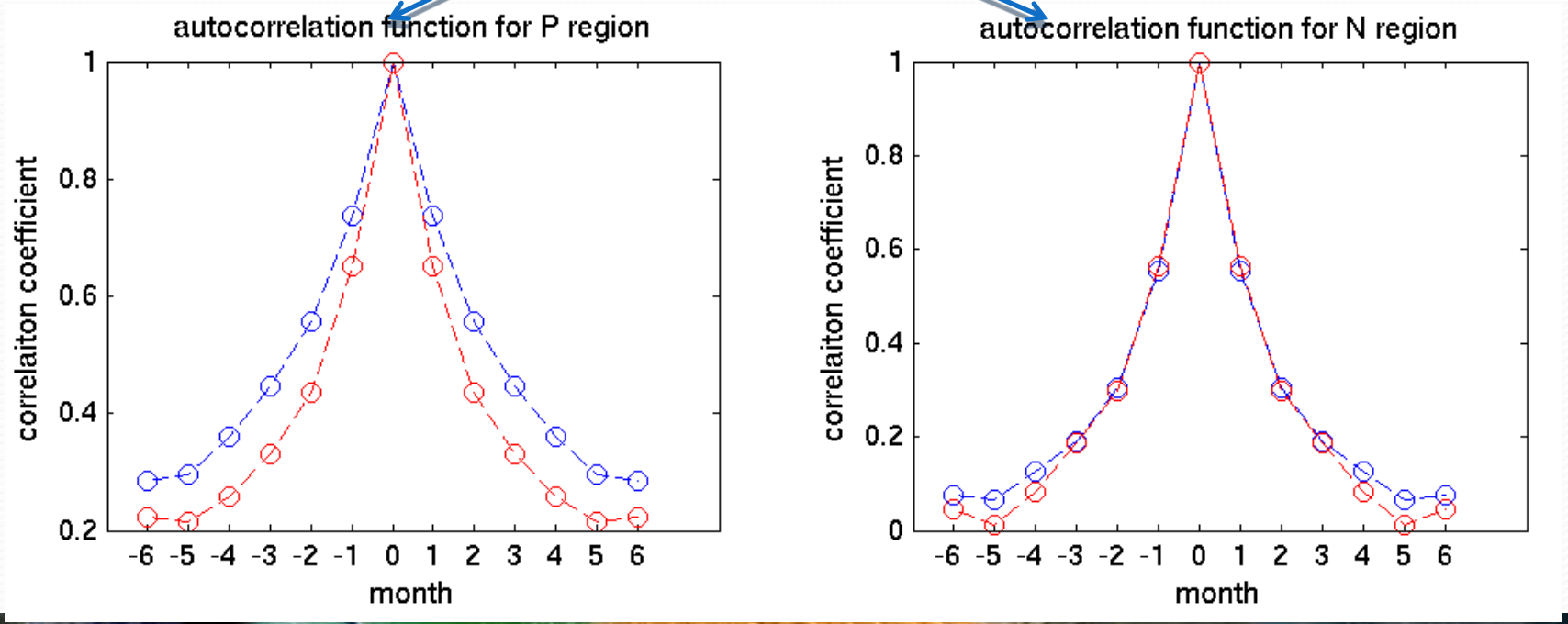





(a) - (b)
50°
40°
30°
-130° -120° -110° -100° - 90° - 80° - 70°
20
0
-20
the P region
the N region
WTD
m
soil moisture
GW
noGW
%
Rs
mm/mon
Rg
ET
J M M J S N

soil moisture autocorrelation function





Summary:

- Preliminary results show that soil moisture memory does not always increase after adding GW model. Due to other fluxes' effect on the soil memory.
- Further analyses are necessary – which flux is important in some specific region, and how this result changes after coupling to the AGCM will be the next step.