Dynamic root status and impacts on productivity and evapotranspiration

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Motivation

- Roots have been static for far too long
- The exponential distribution of roots agrees well with global observations, but does not allow changes in root distribution from changes in water or nutrients, nor does it capture the rooting profile of ecosystems in arctic or arid regions.
- At a minimum, root profiles should include time varying structure.

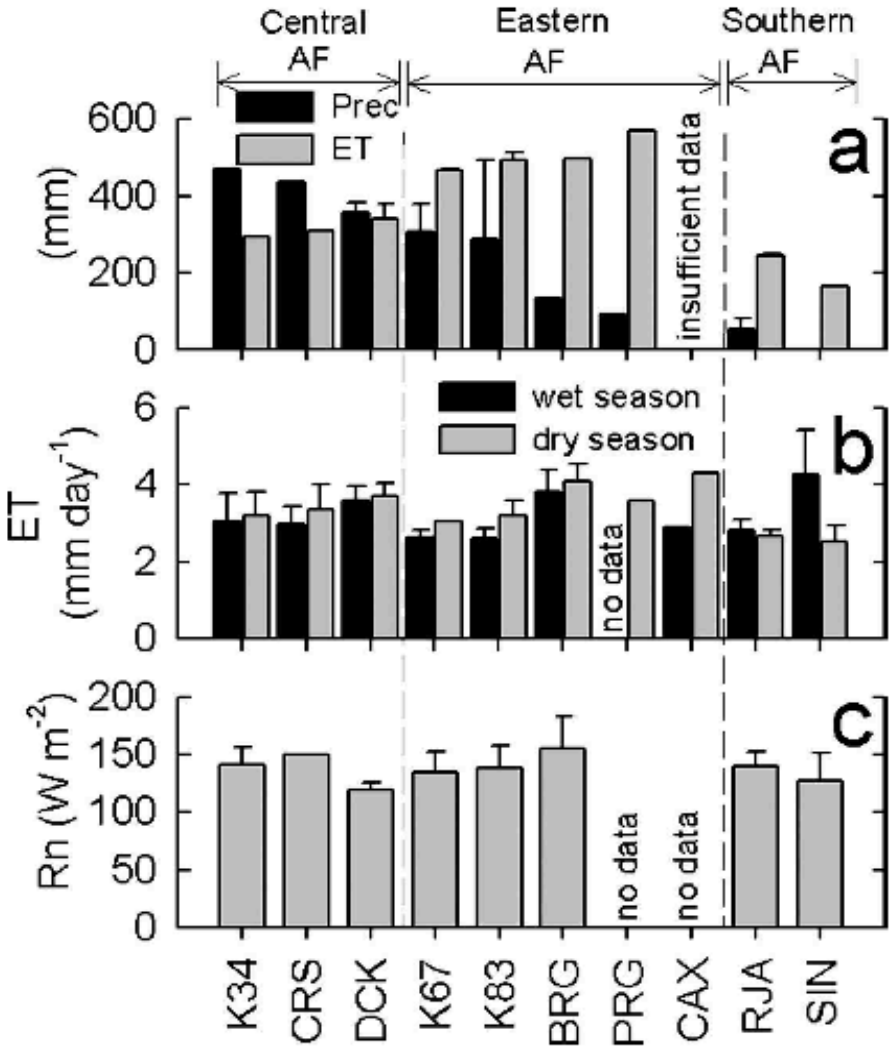


FIG. 7. (a) Total precipitation (Prec: mm) and ET during dry season; (b) average daily ET during the dry and wet seasons, respectively; and (c) averaged dry season surface net radiation (R_n) for different sites in the Amazon Forest (AF).

Juárez et al., 2007

Dynamic roots are designed to optimize water and nitrogen uptake

Add new root carbon to each soil layer weighted by water and nitrogen availability:

$$\rho_j = C * fr + C_{new} * ((1 - w_{limit}) * \frac{rswa}{\sum rswa} + w_{limit} * \frac{rsmn}{\sum rsmn}) - C_{lost} * fr$$

where

$$w_{limit} = \sum \frac{\log\left(\frac{minpsi}{psi}\right)}{\log\left(\frac{minpsi}{maxpsi}\right)} * fr$$

Water availability in the root zone

$$rswa_j = \frac{\log\left(\frac{minpsi}{psi}\right)}{\log\left(\frac{minpsi}{maxpsi}\right)}$$

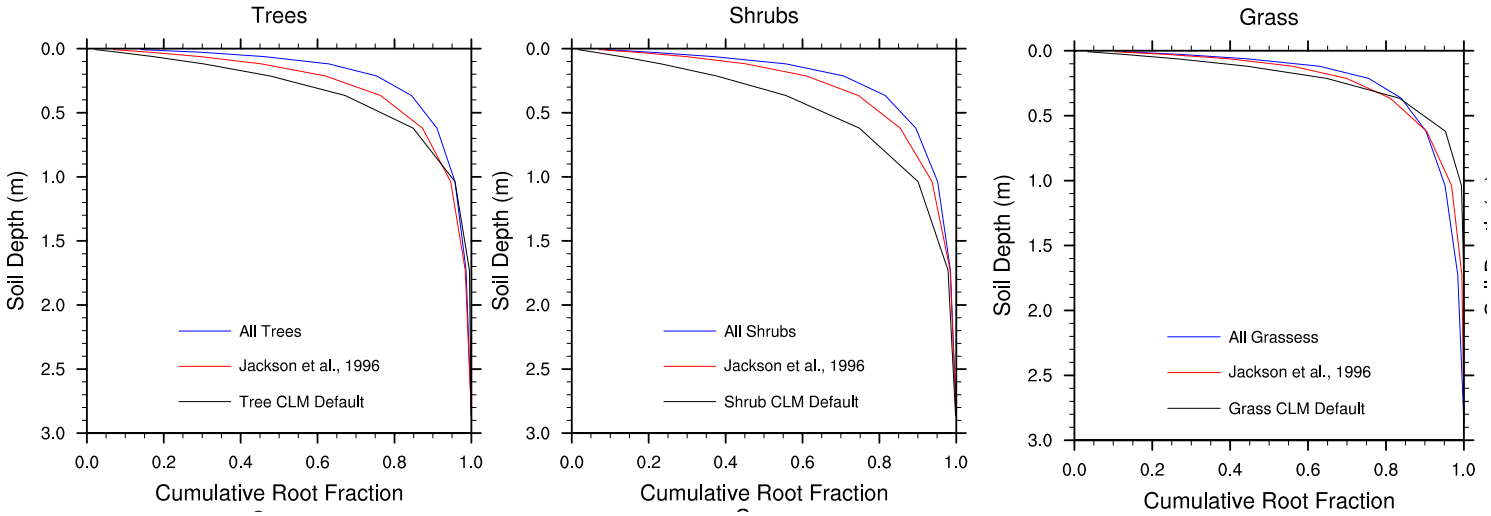
Water availability in each soil layer

$$rsmn_j = sminn\_vr_j$$

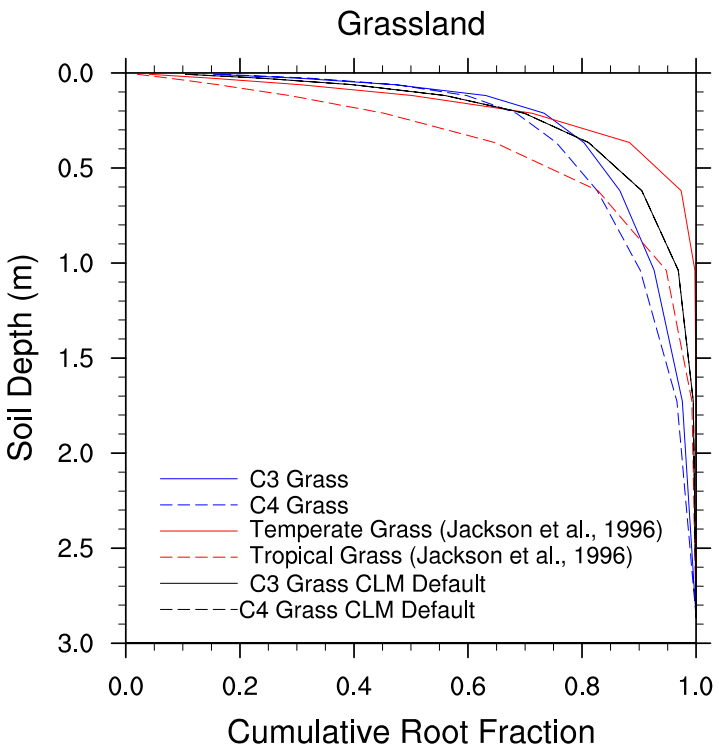
Nitrogen availability in each soil layer

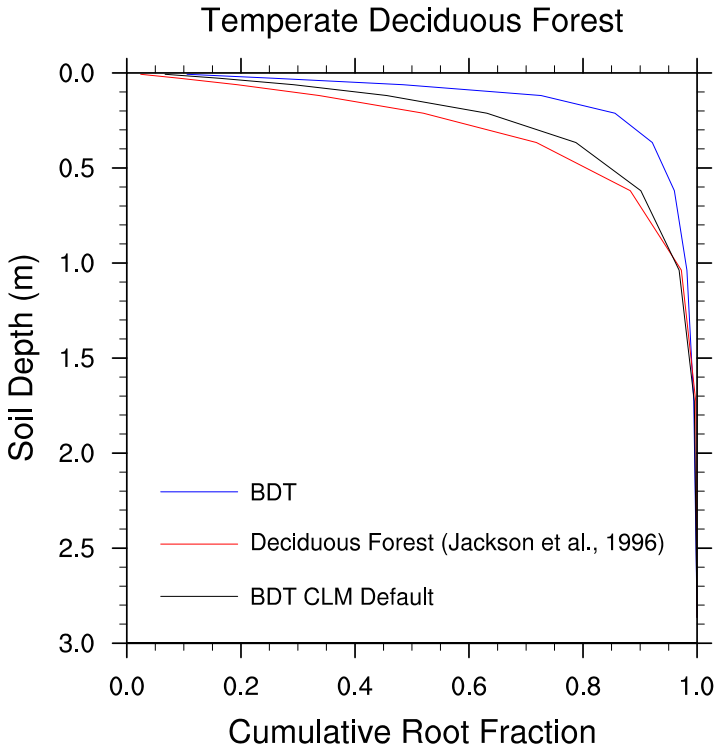
Status

- Longer spinup times, possibly from an increase of root fraction at depth
- A correction to dynamic roots:
  - Redefine the boundaries of maximum and minimum water availability
  - Don’t allow roots to grow in saturated soils

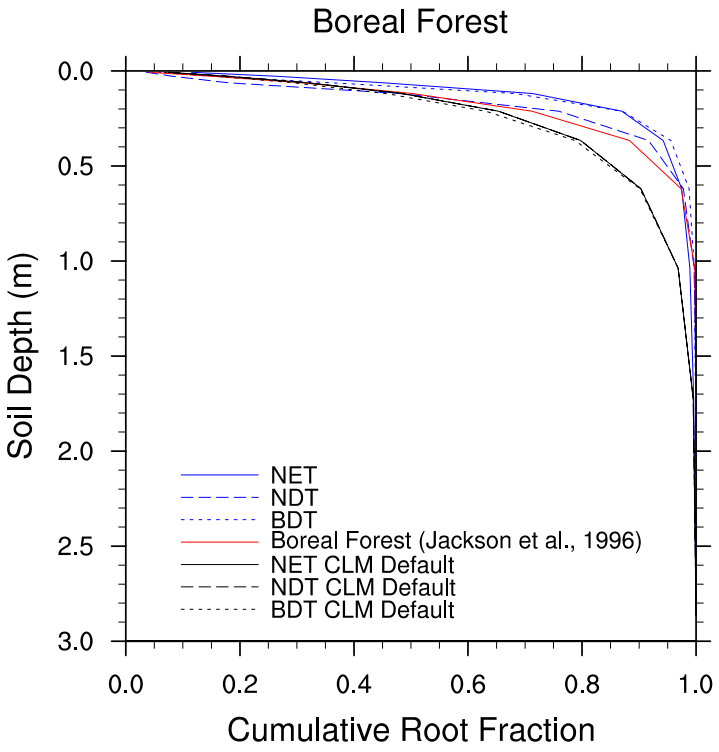


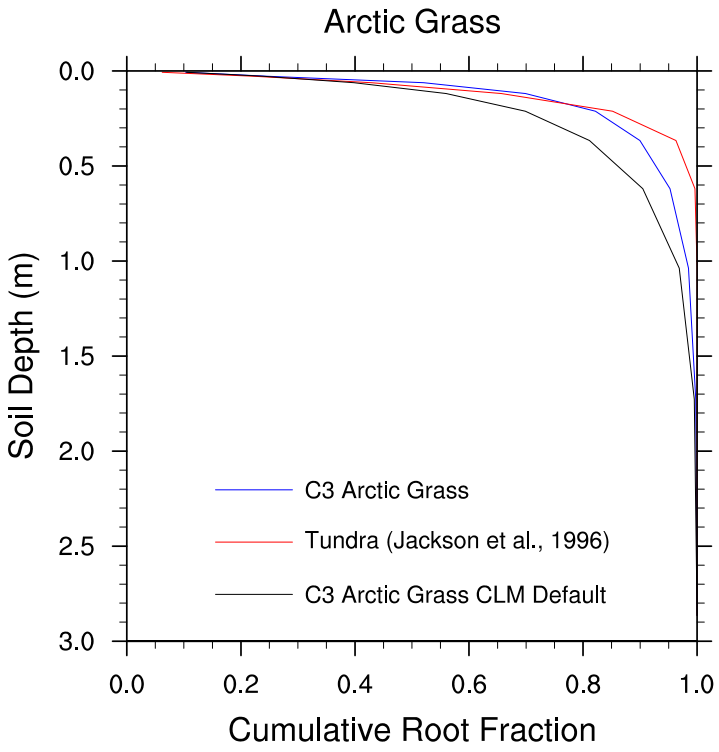
But there are still some problem areas





But some vegetation does do well

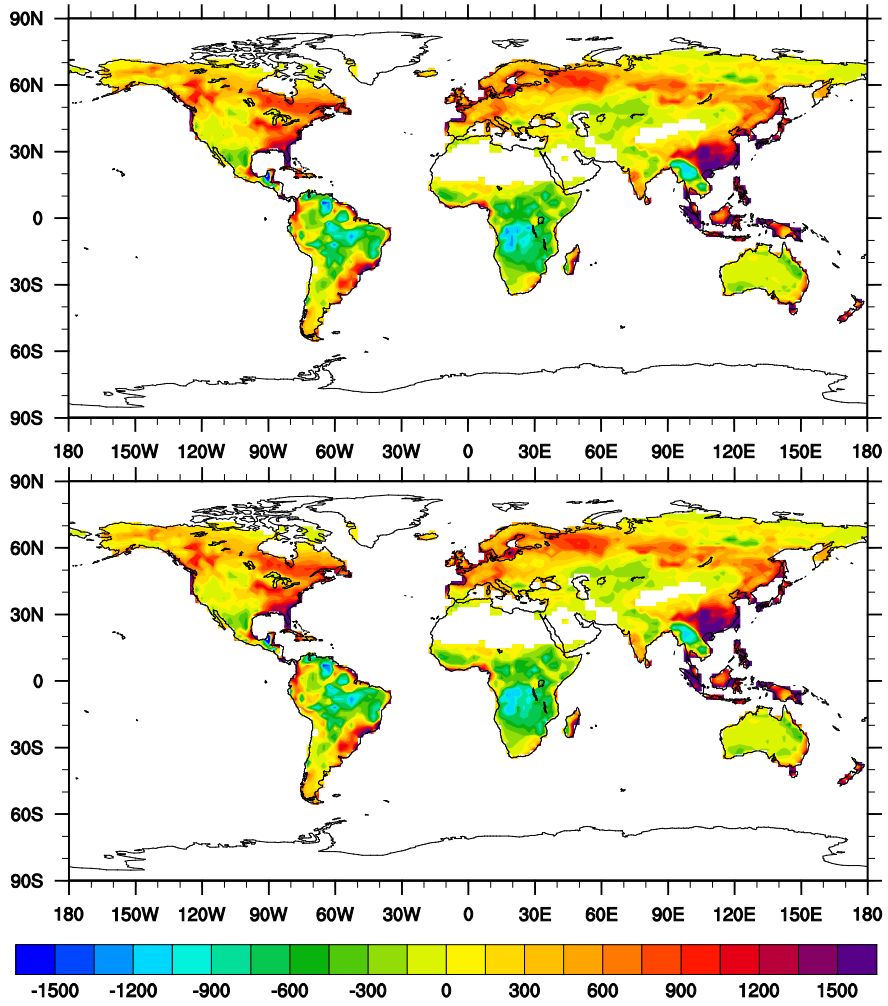


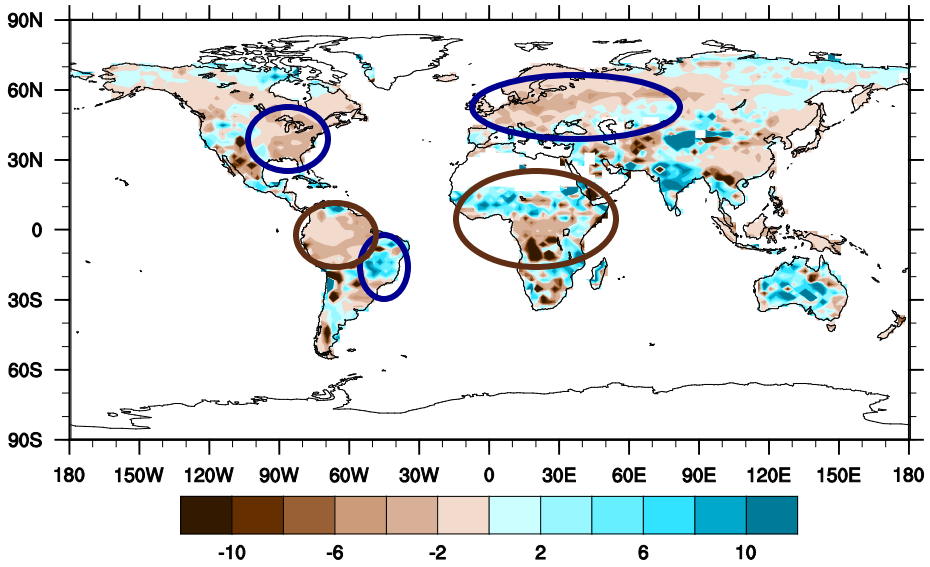


Some general observations

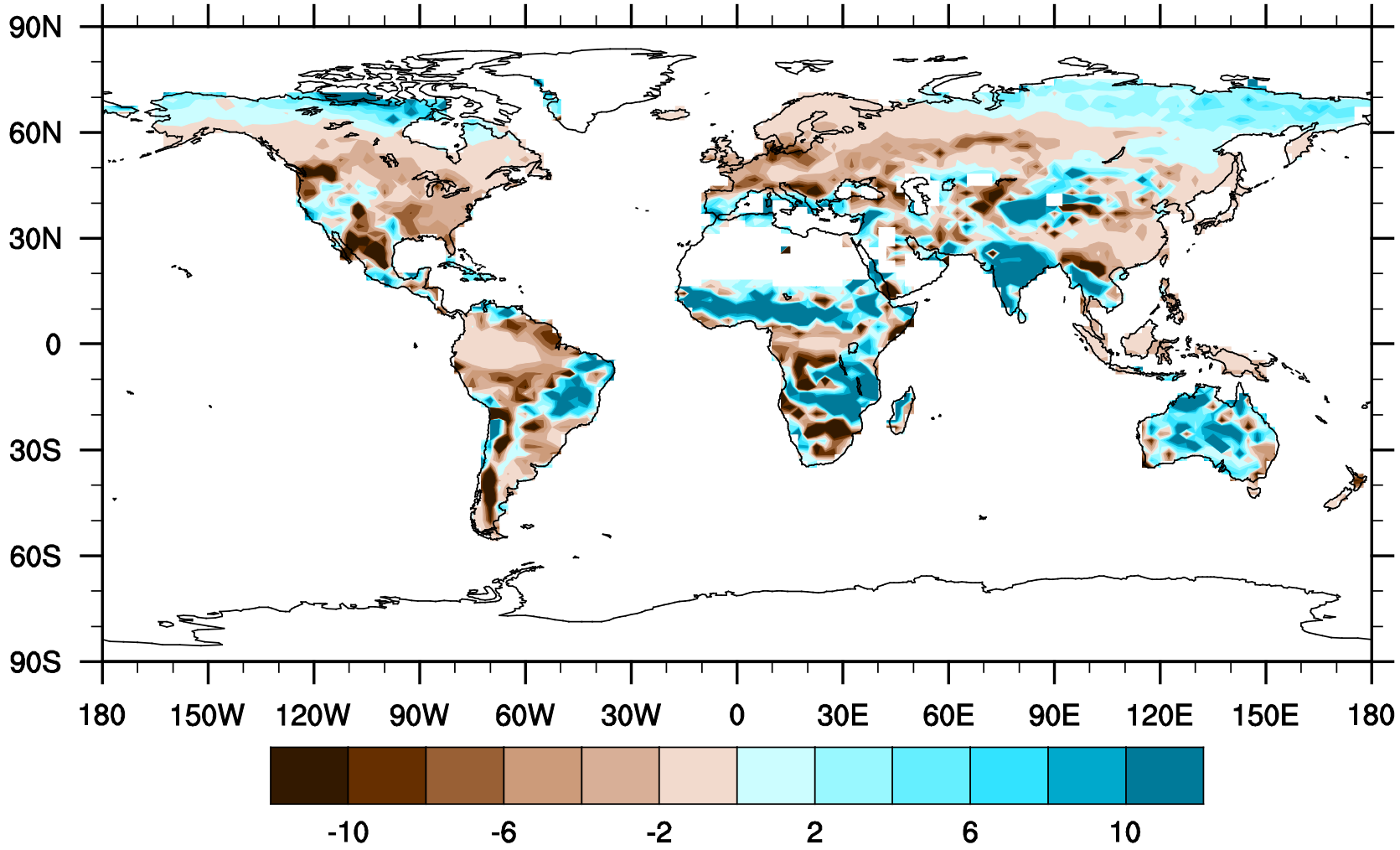
- “Odd” root profiles tend to appear in:
  - Dry and mountainous regions
  - The edges of a PFT boundary or climate zone
  - When PFT occupies a small fraction of grid cell
- Evergreen vegetation tends to follow nitrogen more strongly
- Grasses perform the worst
- All vegetation tend to have deep roots in dry regions
  - Could be due to increasing water with depth
- In wet regions (Amazon), roots follow nitrogen profile

GPP

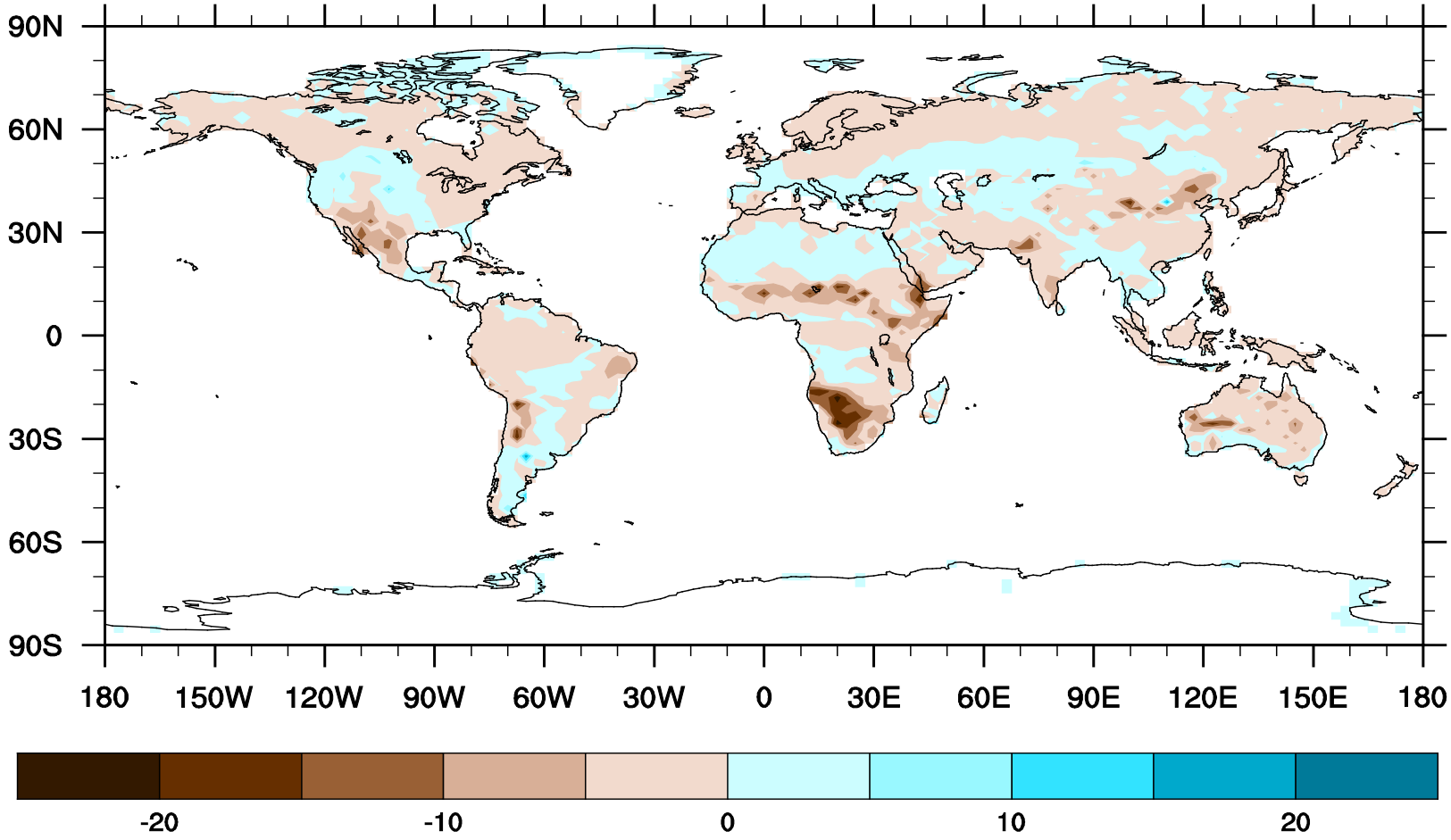

90N
60N
30N
0
30S
60S
90S
180 150W 120W 90W 60W 30W 0 30E 60E 90E 120E 150E 180
-1500 -1200 -900 -600 -300 0 300 600 900 1200 1500


90N
60N
30N
0
30S
60S
90S
180 150W 120W 90W 60W 30W 0 30E 60E 90E 120E 150E 180
-10 -6 -2 2 6 10

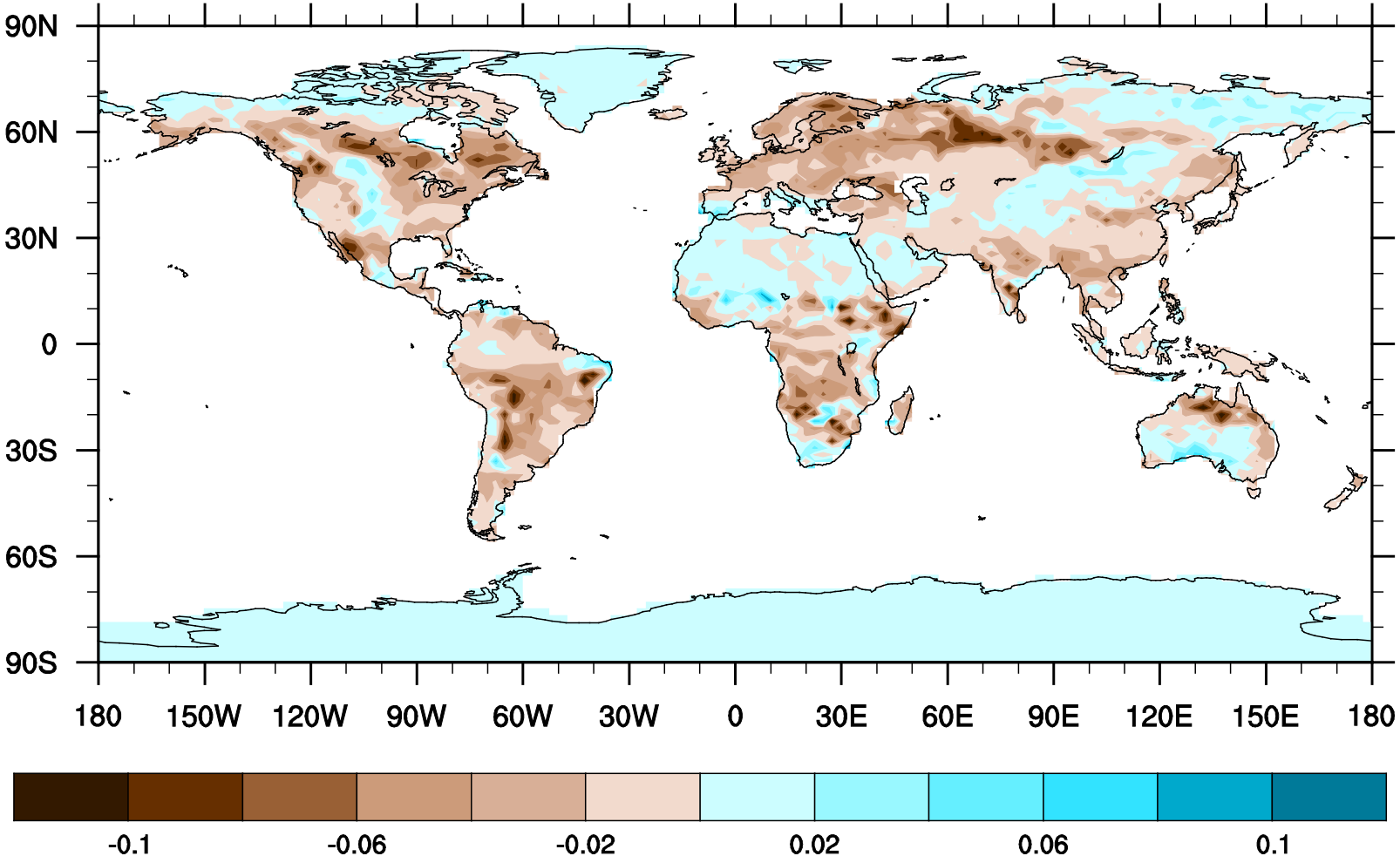
Transpiration



Percent difference of water in the soil column



Difference in BTRAN



Conclusions

- Dynamic roots are still a work in progress
- Unclear if behavior is wrong – lacking evidence and data on root distribution

- Additional modifications to root module:
  - Don't change root structure during onset period
    - But do count new growth that would go to storage (stress and deciduous vegetation)
  - Use a more generic nitrogen profile
  - Work with other components such as variable soil depth to bedrock, flexible CN, and plant hydraulics