Impact of soil moisture initialization on AMIP-type simulations in JSBACH

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FONA Decadal Climate Prediction BMBF
MiKlip
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Project background

MiKlip

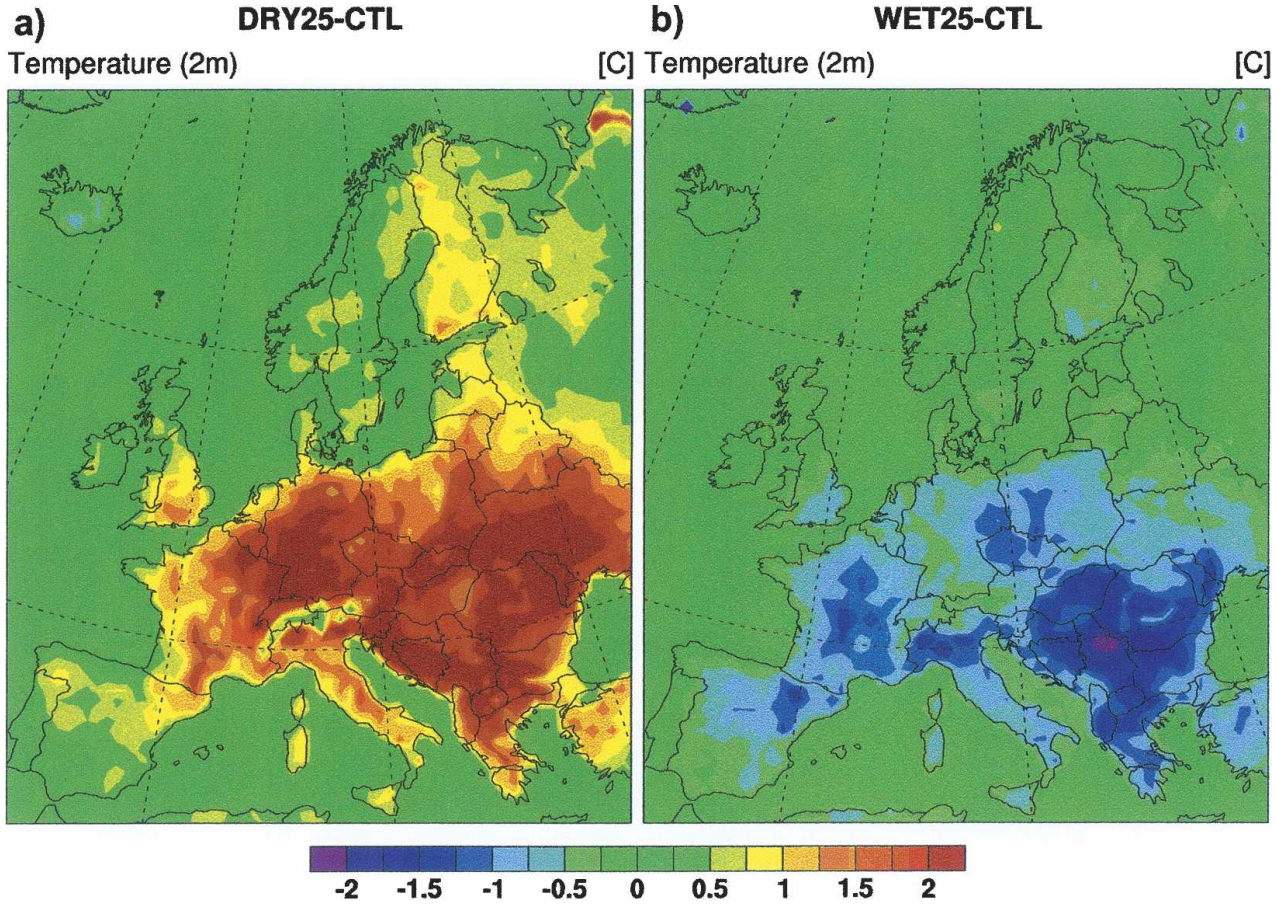
- MPI-ESM setup suitable for seasonal to decadal climate predictions
- Assimilation of ocean, atmosphere and land surface data
- Prototype setup is currently in development

PastLand Module

- Identify regions and time scales of land surface memory
- Gather land surface data suitable for assimilation
- Development of a variational assimilation system for optimal parameter and state estimation of the land and biosphere

Do we need land surface initialization?

Summer 2003 temperature anomaly due to spring soil moisture perturbation of (a) -25% and (b) +25% (Fischer et al., 2007).



Do we need land surface initialization?

Research questions:

- Does soil moisture initialization improve the model skill for seasonal/decadal predictions?

➔ Hindcast ensemble simulations with fully coupled prototype system

- What is the lifetime (memory) of extreme soil moisture states in a climate model?

➔ Initialization experiment

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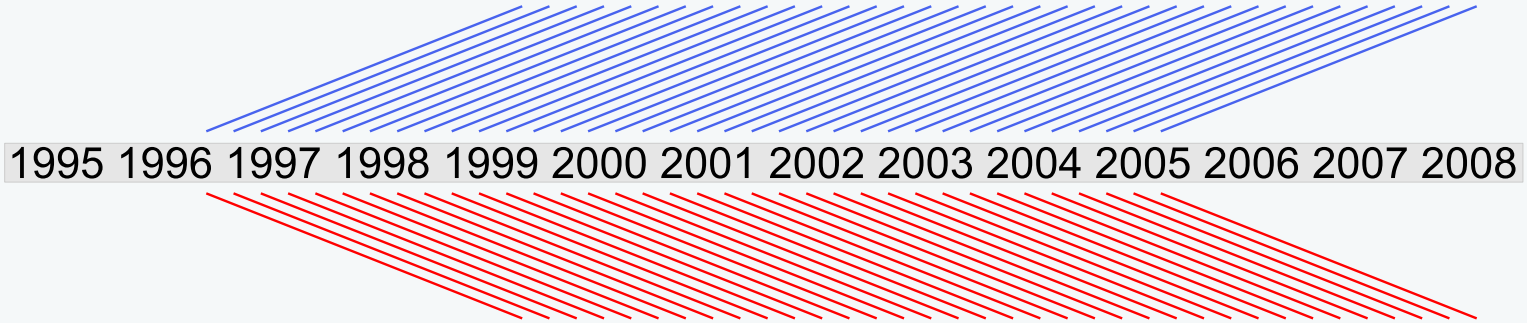
Soil moisture initialization experiment

Model setup

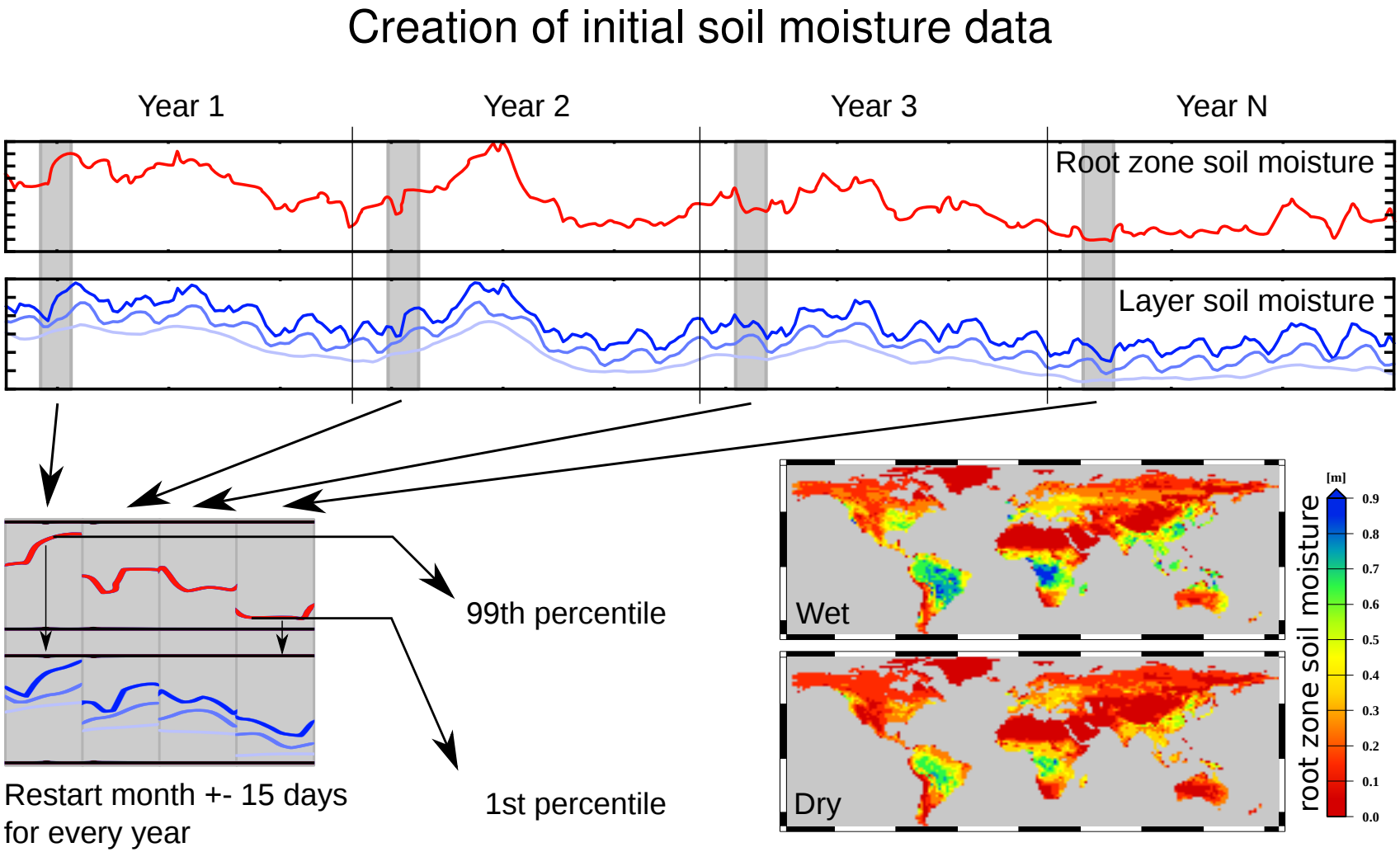
- AMIP-type ECHAM6/JSBACH (prescribed ocean surface)
- Resolution T63L47 ($\approx$1.8°), Period 1995–2008, 6h output
- New soil hydrology scheme (Hagemann & Stacke, *subm.*)

Initialization ensemble



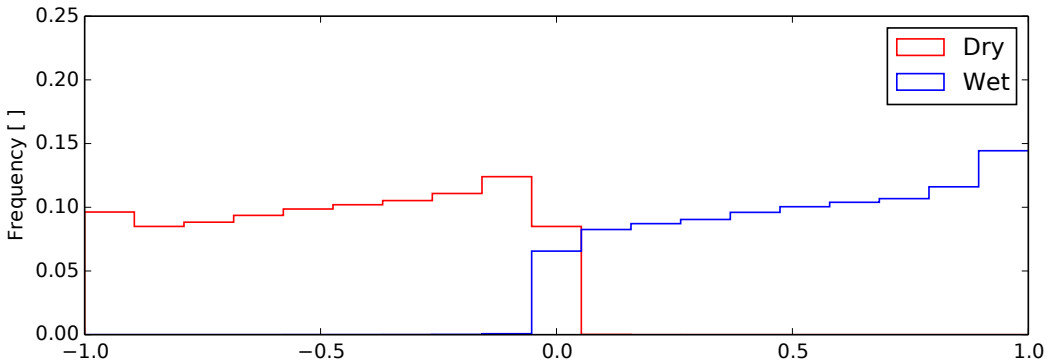
- Initialization with extreme wet and dry soil state
- free run for 3 years
- $2 \times 4 \times 9$ simulations $\equiv$ 216 simulation years

Soil moisture initialization experiment

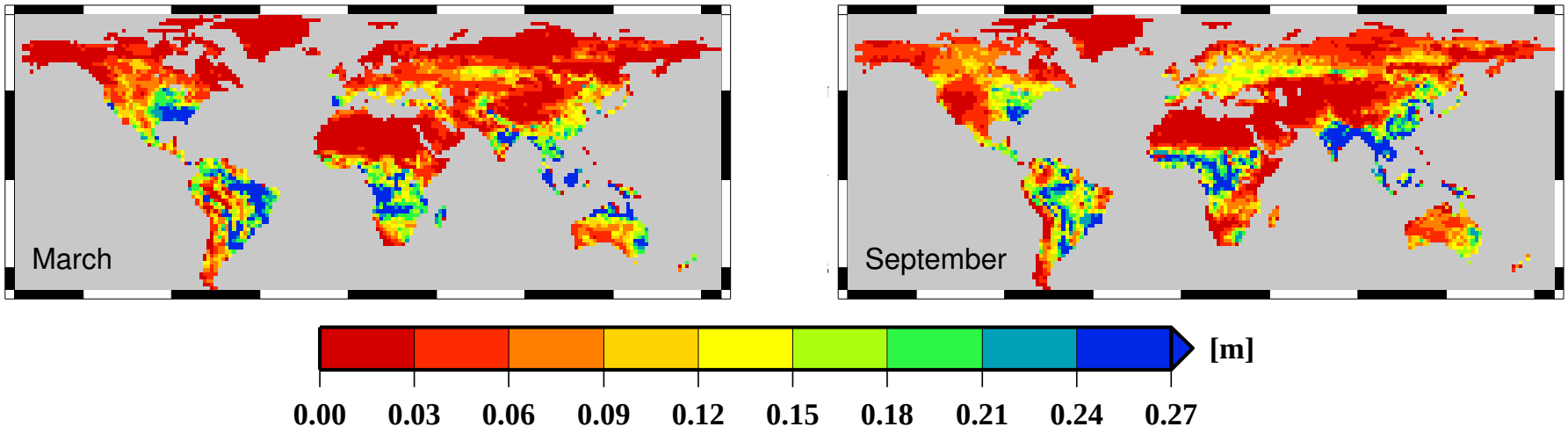


Soil moisture initialization experiment

Histogram of relative root zone soil moisture perturbation



Difference between extreme wet and dry initial conditions



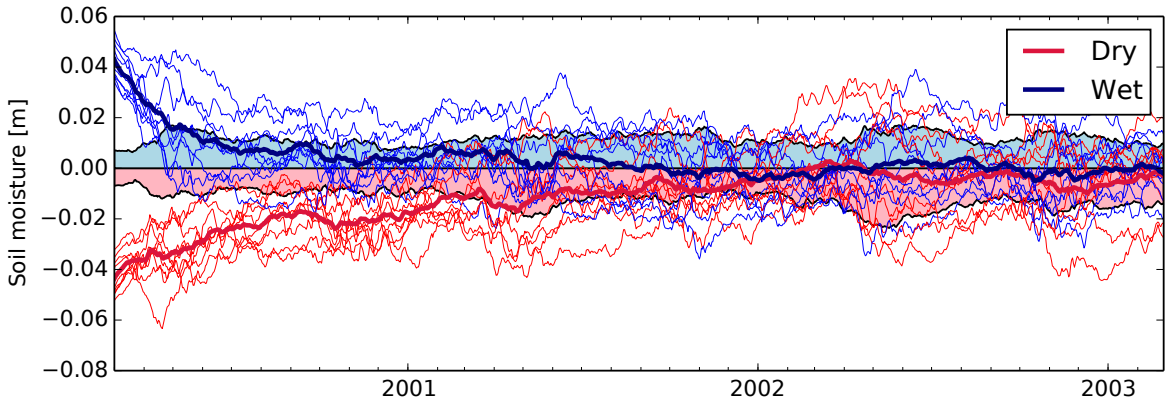
Analysis method

Perturbation length τ

$$SNR(t) = \frac{E\left[\Delta\theta_i(t)\right]}{\sqrt{E\left[\left(\Delta\theta_i(t) - E\left[\Delta\theta_i(t)\right]\right)^2\right]}} \quad (1)$$

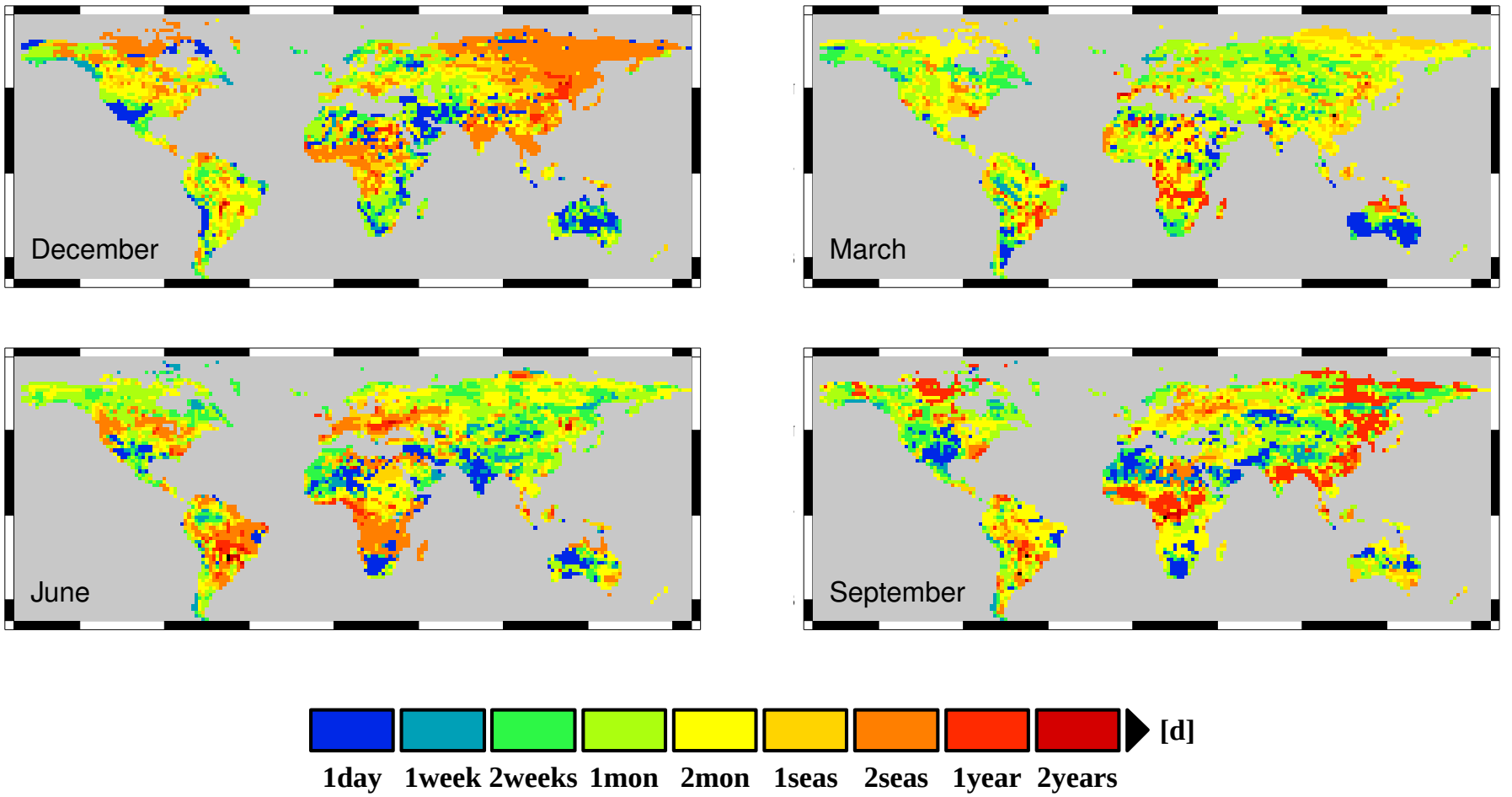
$$\tau = \min_{i=1..n} \left(i : SNR(t) \leq 1\right) \quad (2)$$

Soil moisture anomaly and ensemble standard deviation



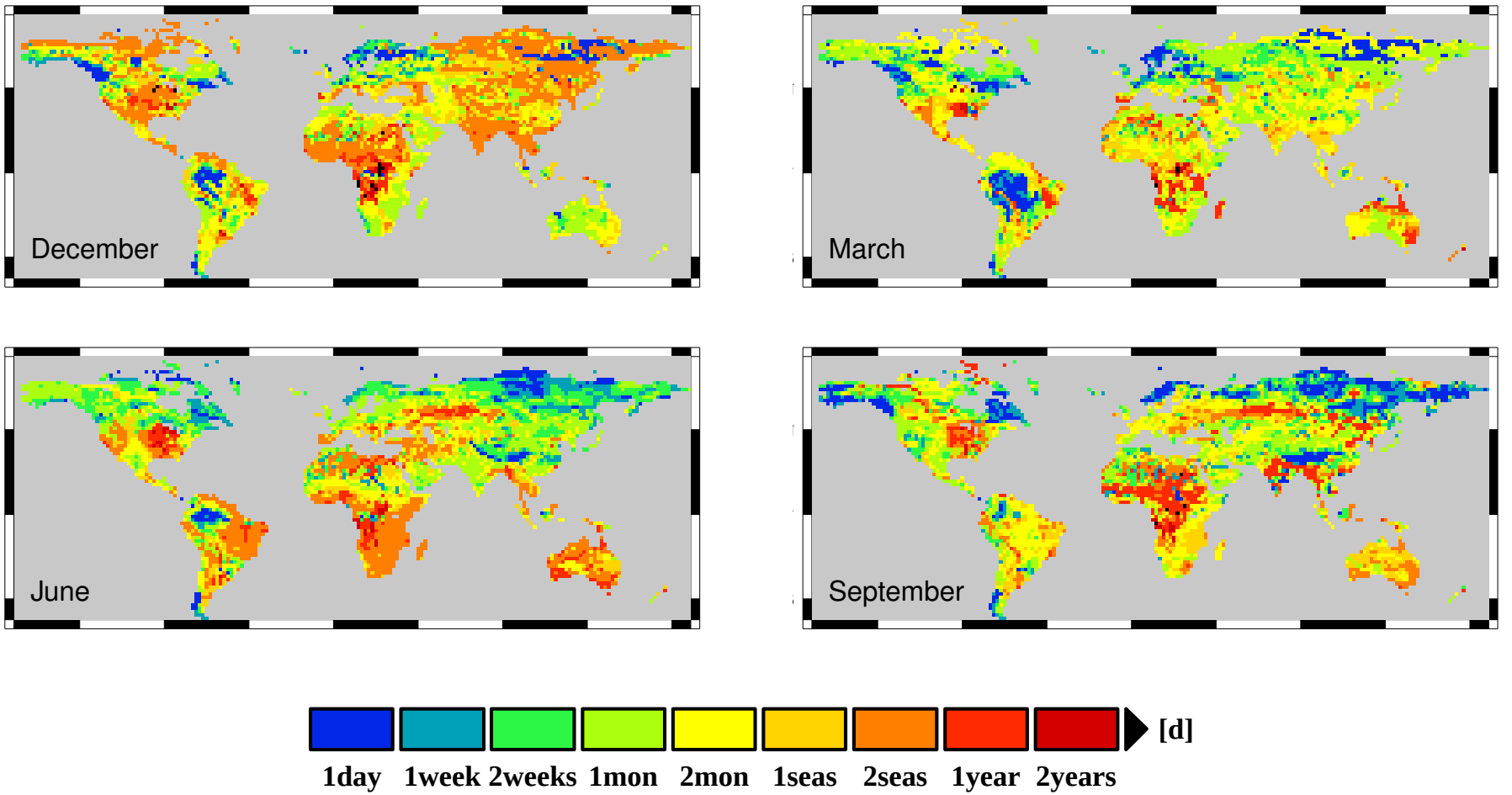
Global Analysis

Perturbation length τ for extreme dry initial state

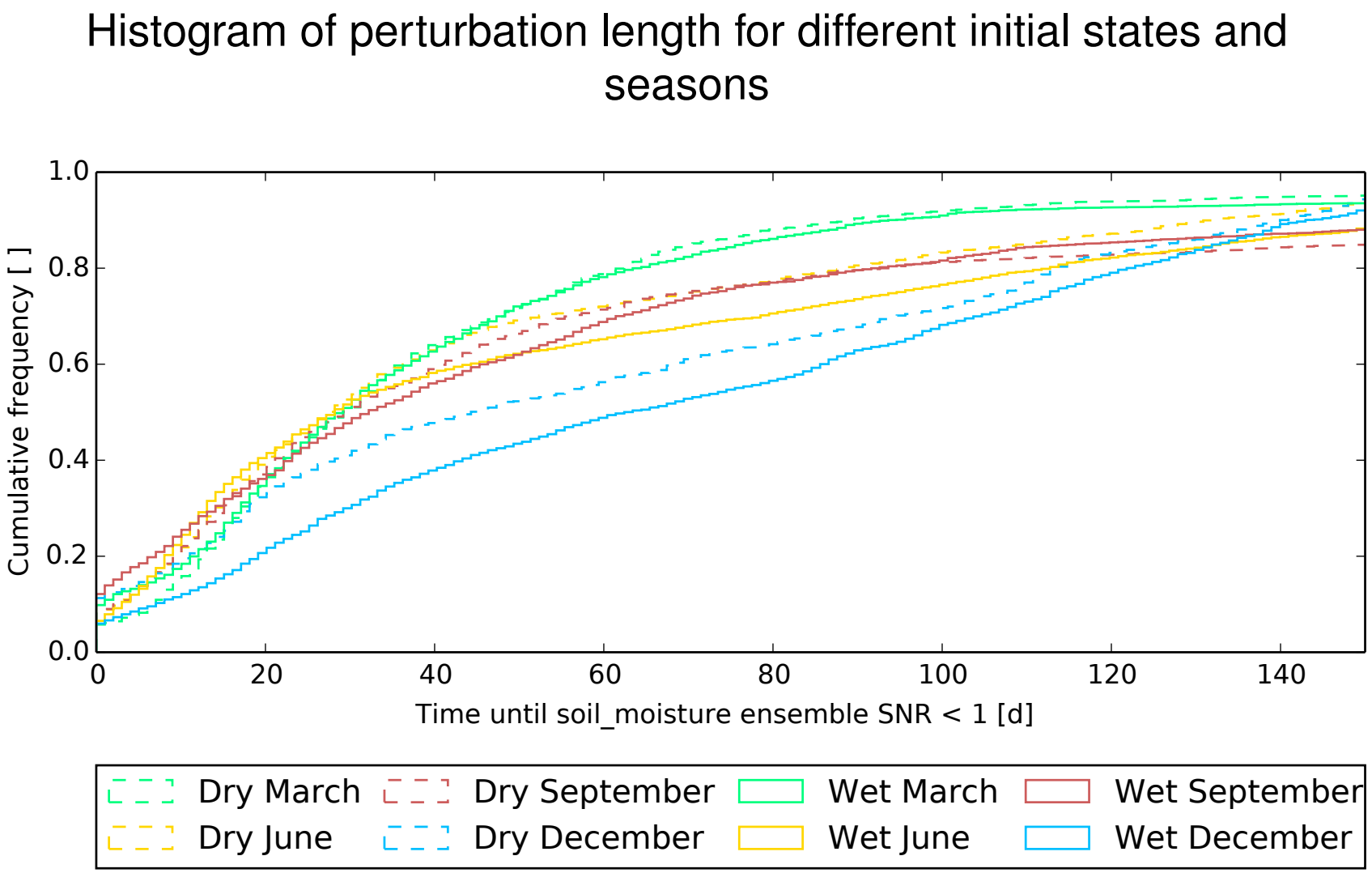


Global Analysis

Perturbation length τ for extreme wet initial state

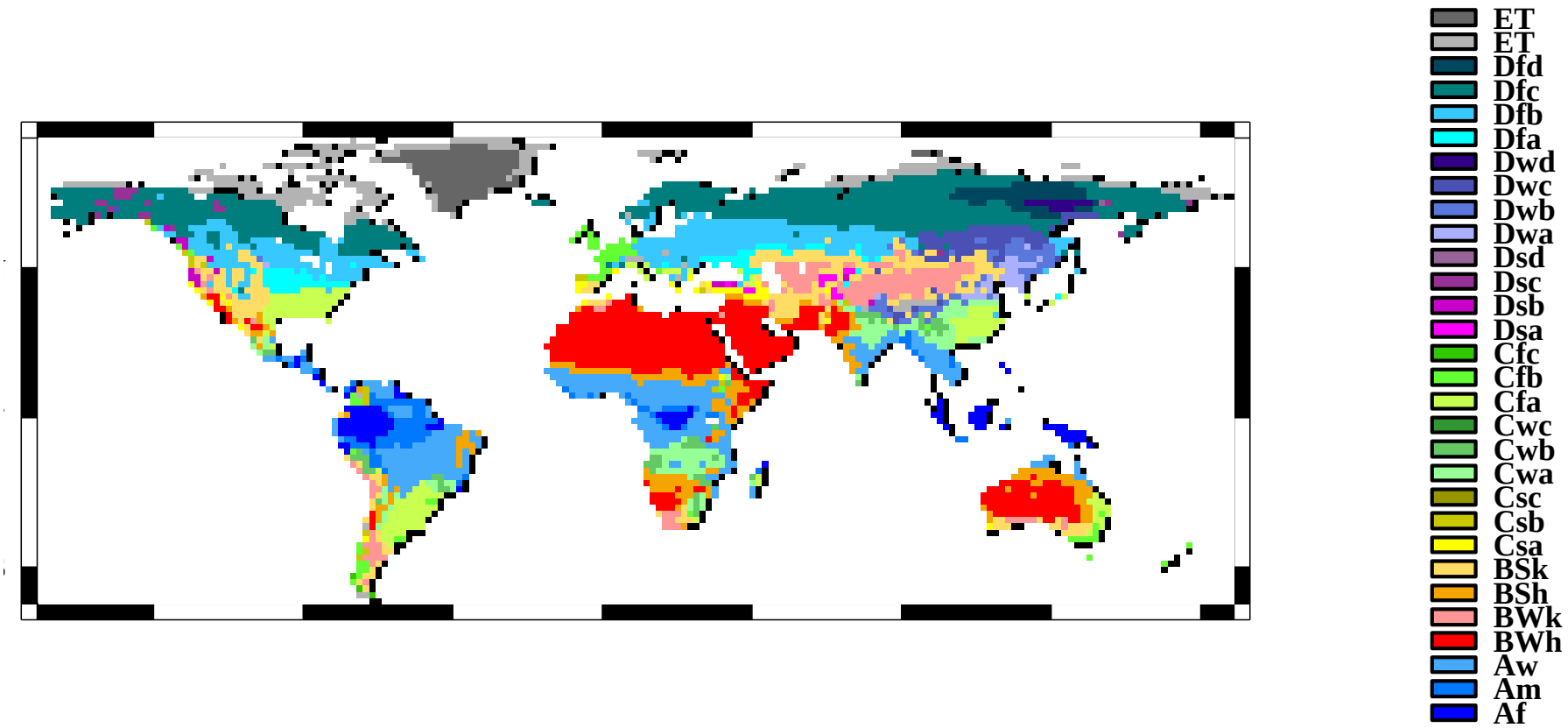


Global Analysis

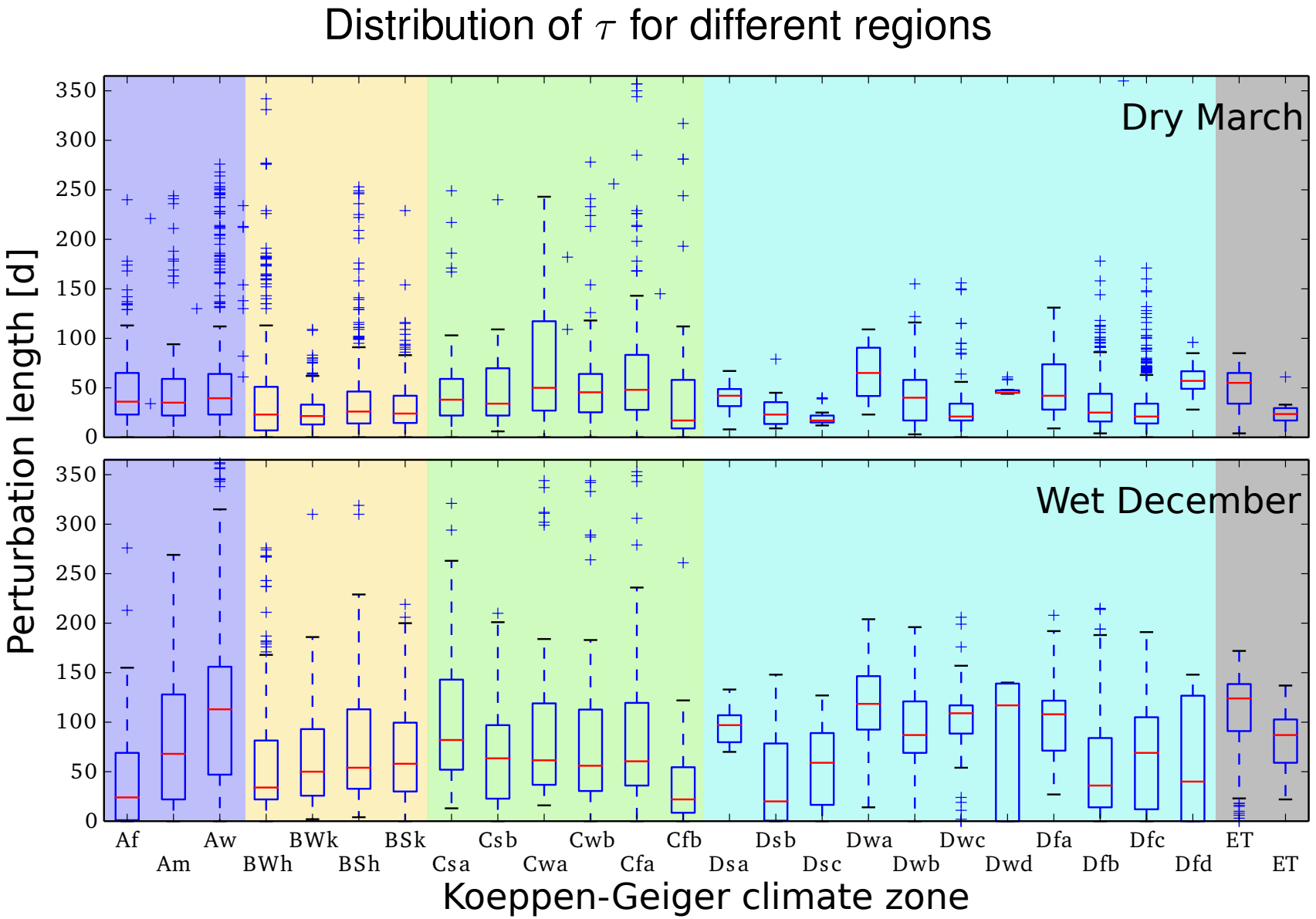


Regional Analysis

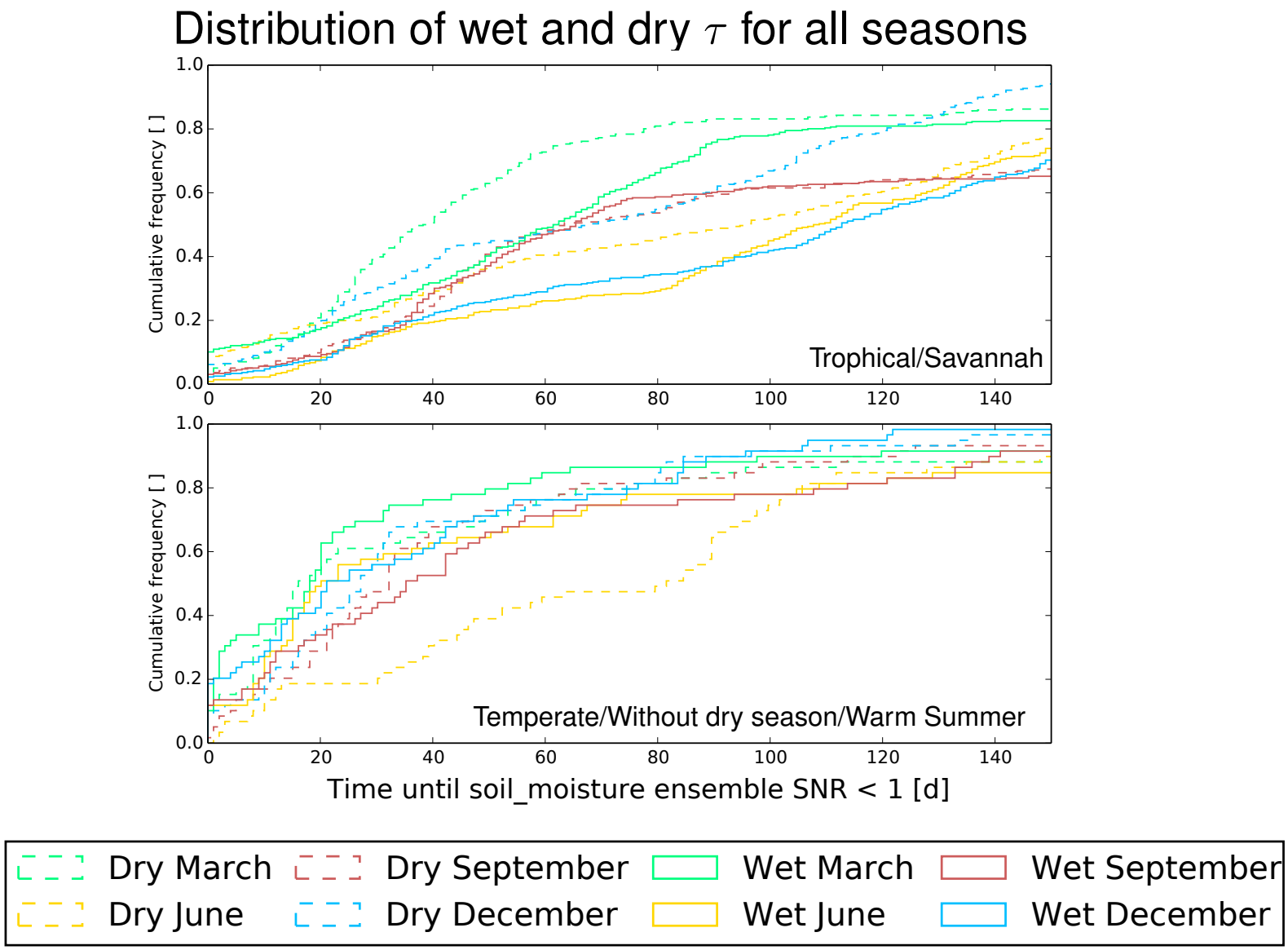
World map of the Koppen-Geiger climate classification at T63



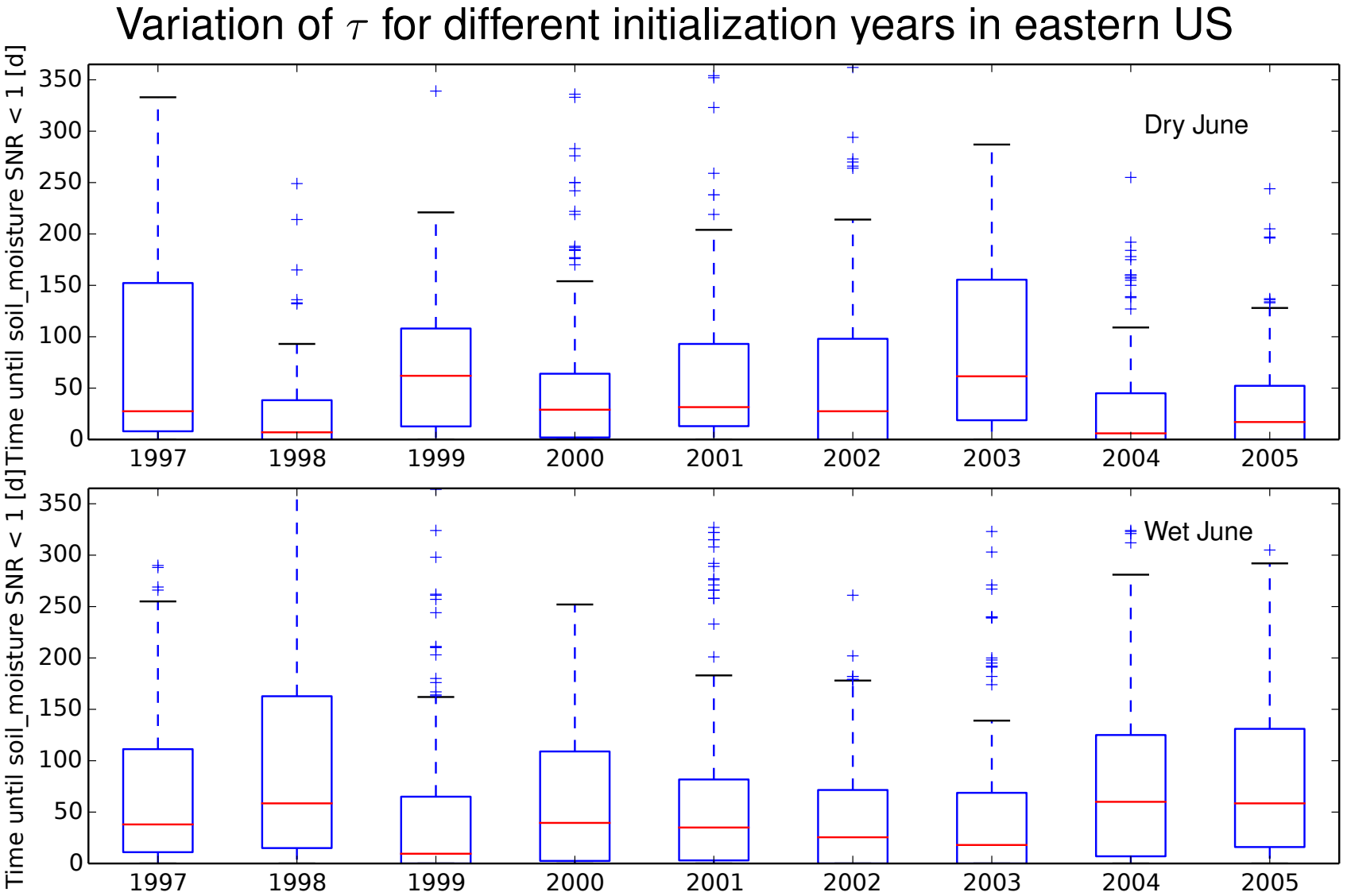
Regional Analysis



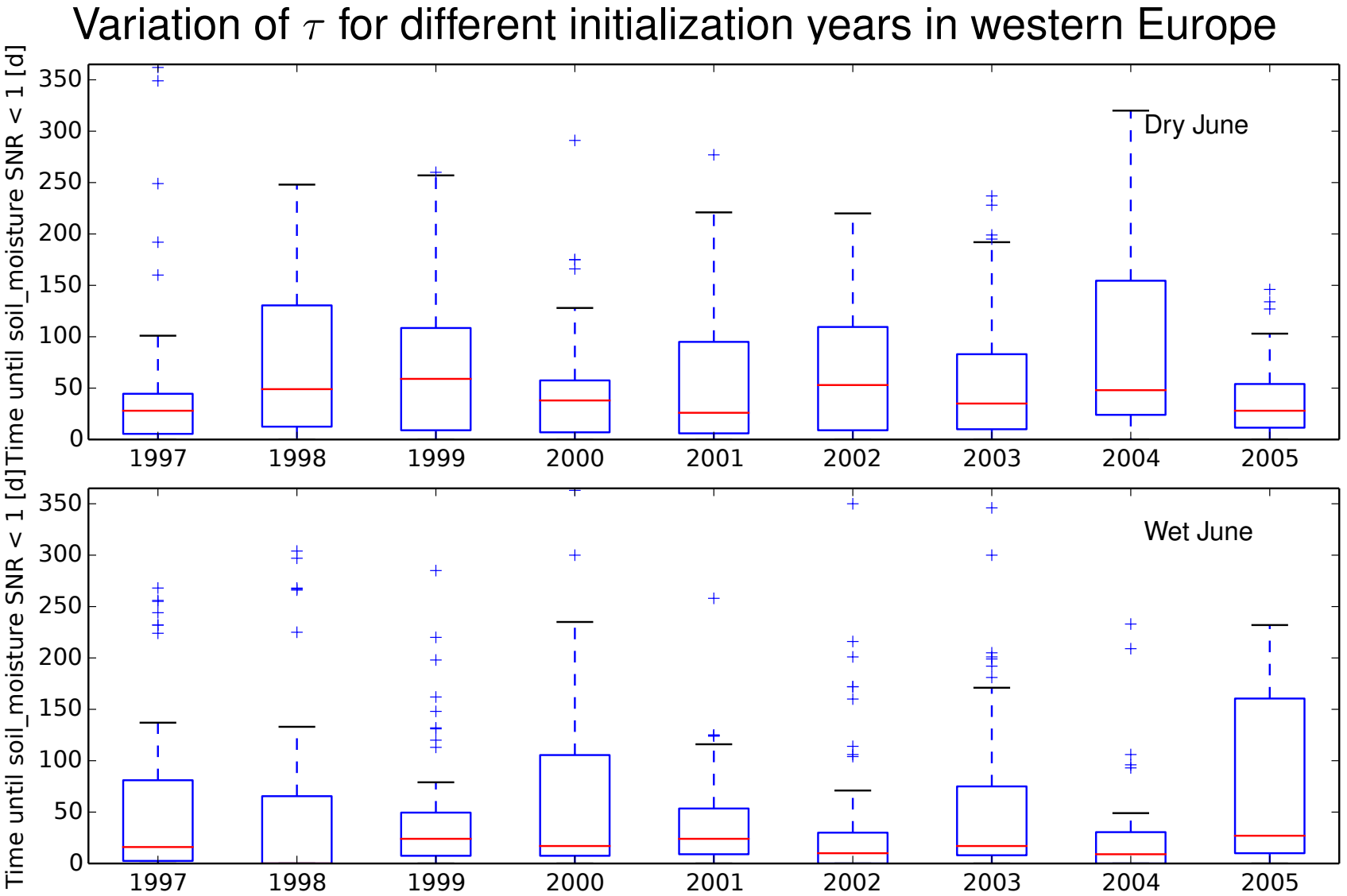
Regional Analysis



Ensemble member analysis

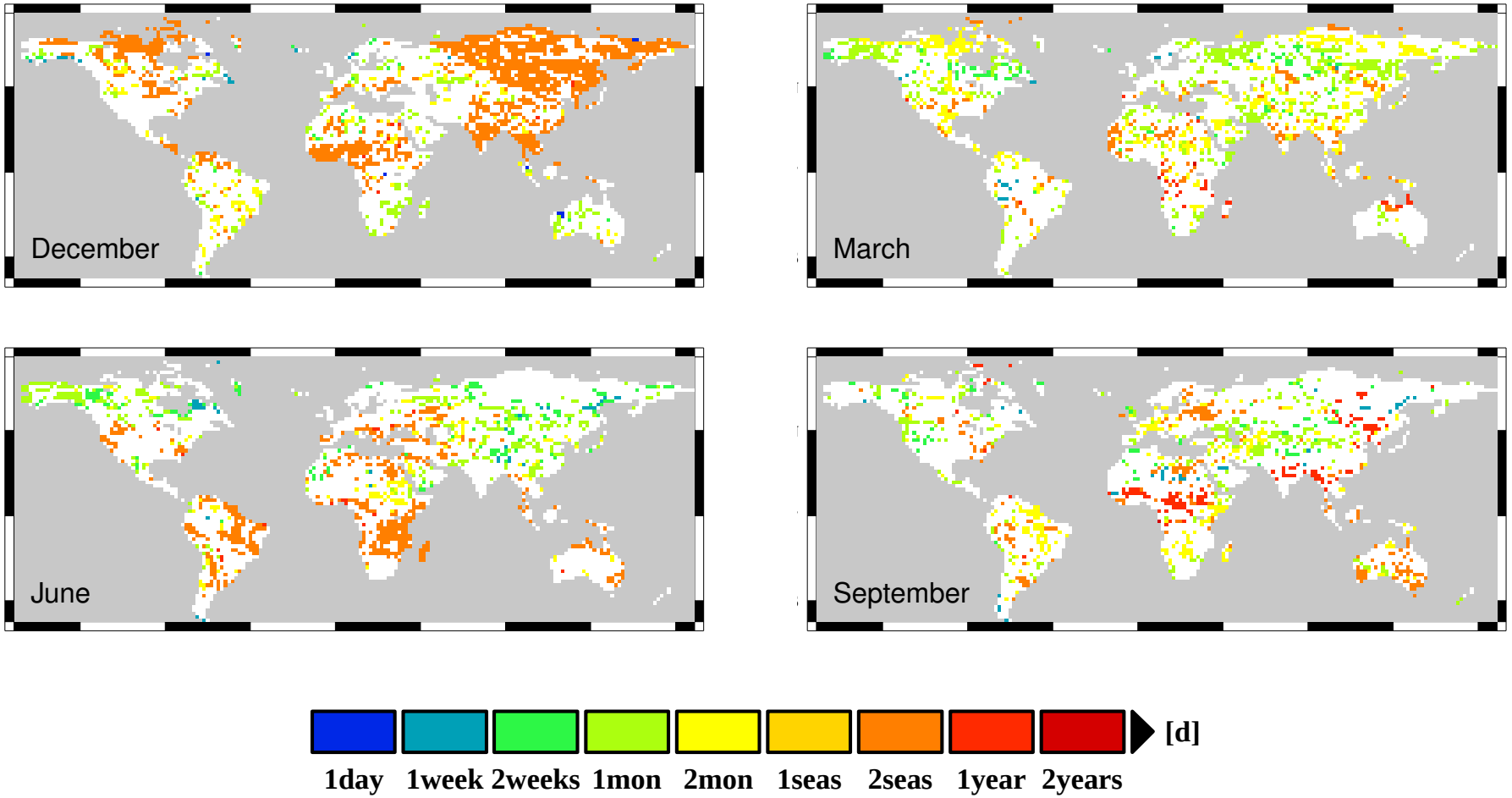


Ensemble member analysis



Ensemble member analysis

Regions with similar perturbation length for wet and dry initial state



Summary

- Ensemble of AMIP simulation initialized with extreme dry and wet soil moisture states
- Memory varies between few days up to two seasons
- Strongest effects for wet initialization (Winter) and humid/cold regions

Conclusion

- Memory is modified by climate state
- Memory exists for seasonal time periods

Outlook

- Correlation of soil moisture initialization and temperature/precipitation anomalies
- Comparison with offline simulations