Investigating a possible contribution of land surface processes on extreme hot event in Northeast Eurasia in recent summer

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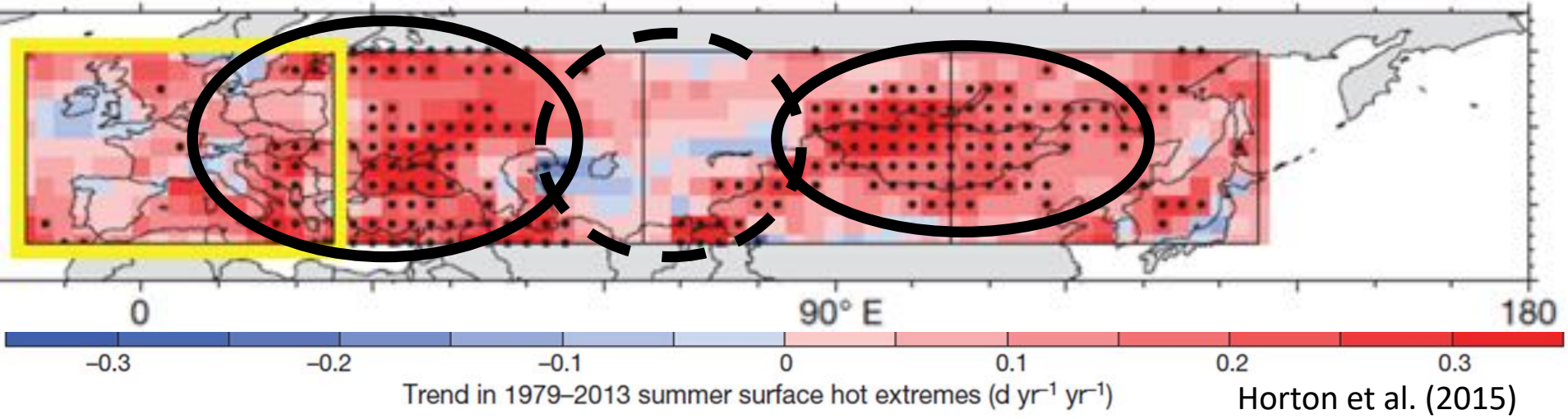
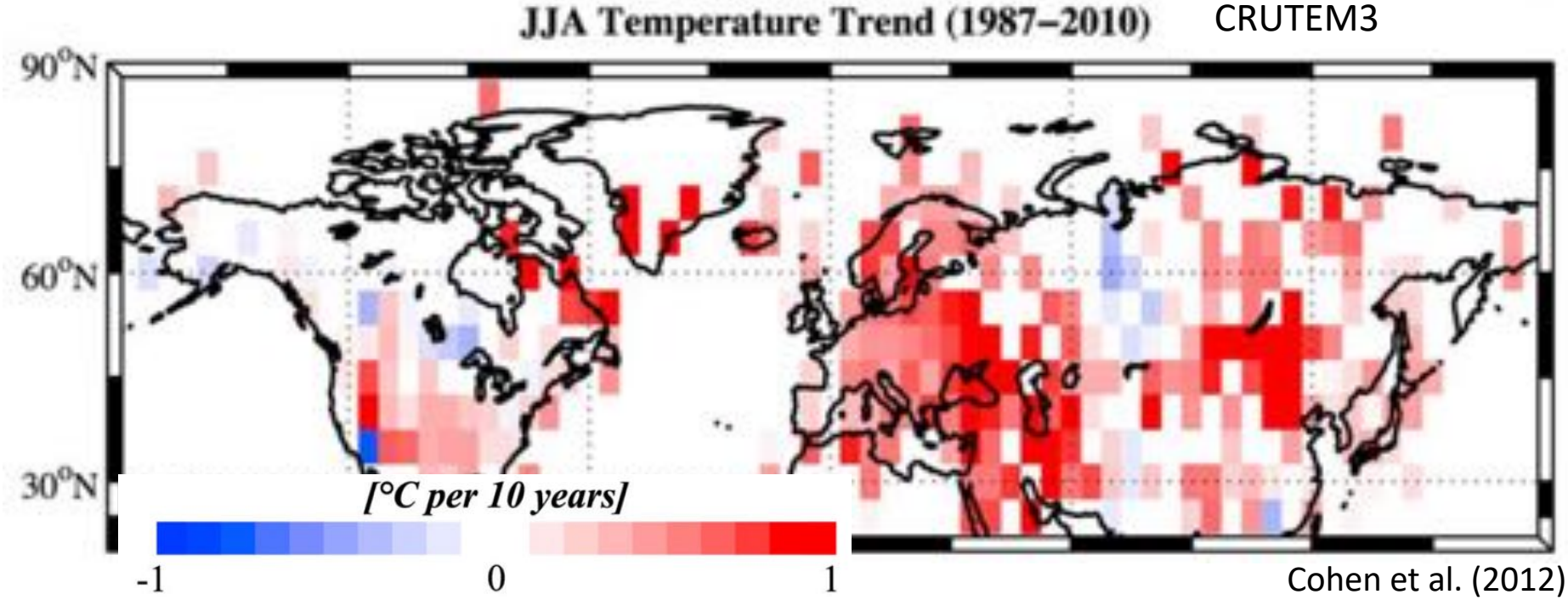
•Erdenebat, E. and T. Sato, 2016: Recent increase in heat wave frequency around Mongolia: role of atmospheric forcing and possible influence of soil moisture deficit.
Atmos. Sci. Lett., **17**, 135-140, DOI: 10.1002/asl.616

•Sato, T. and T. Nakamura, 2018: To be submitted.

Recent increase in mean and extremely high temperature over Eurasia

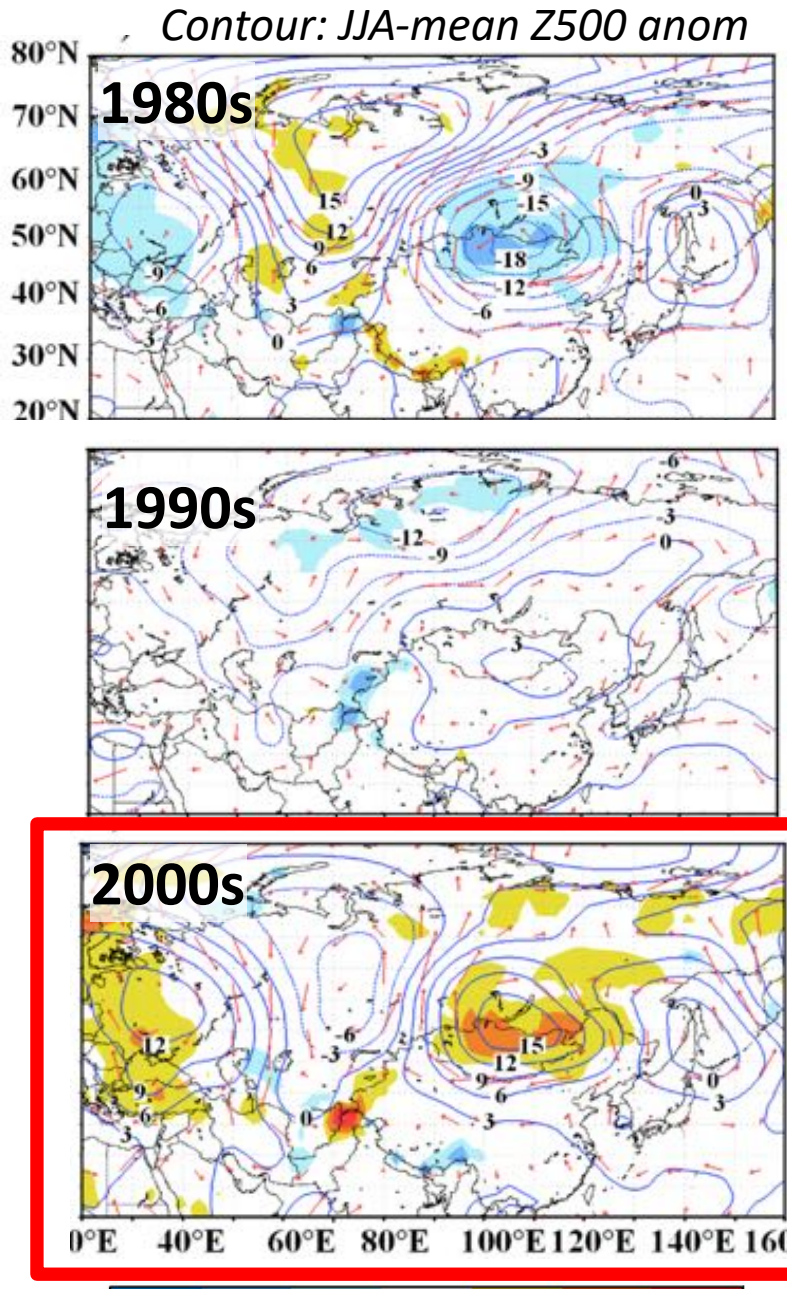


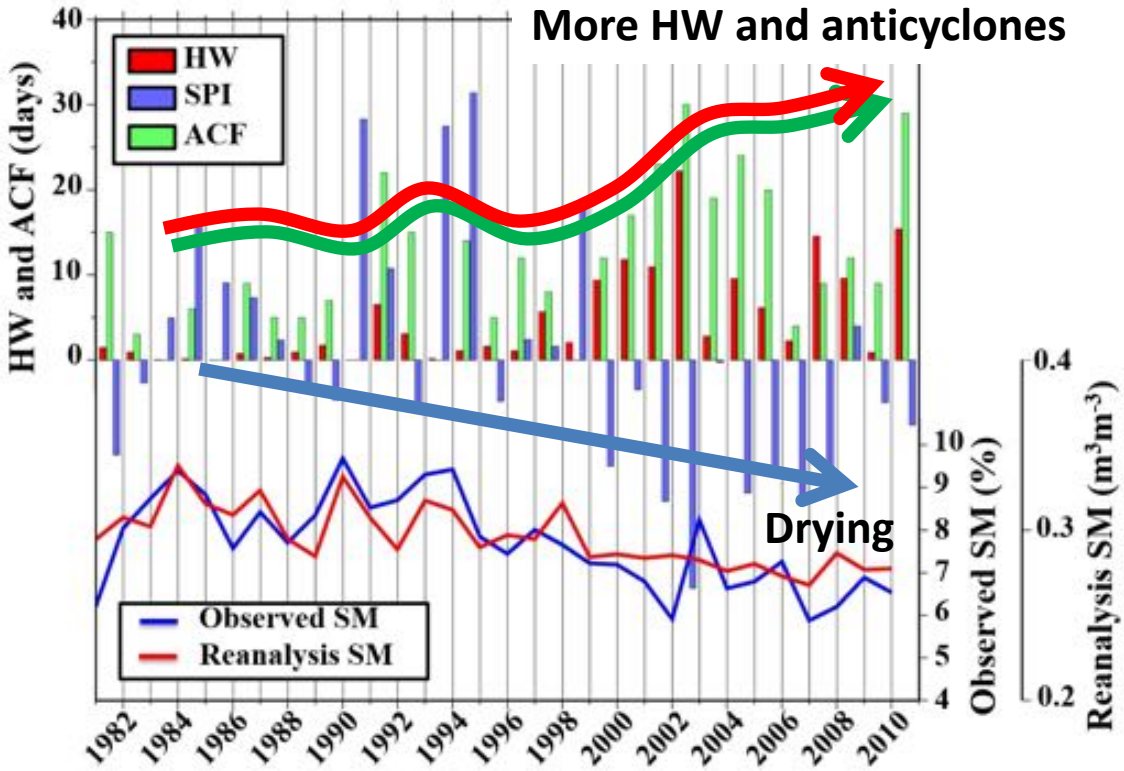
Horton et al. (2015)



CRUTEM3

Cohen et al. (2012)



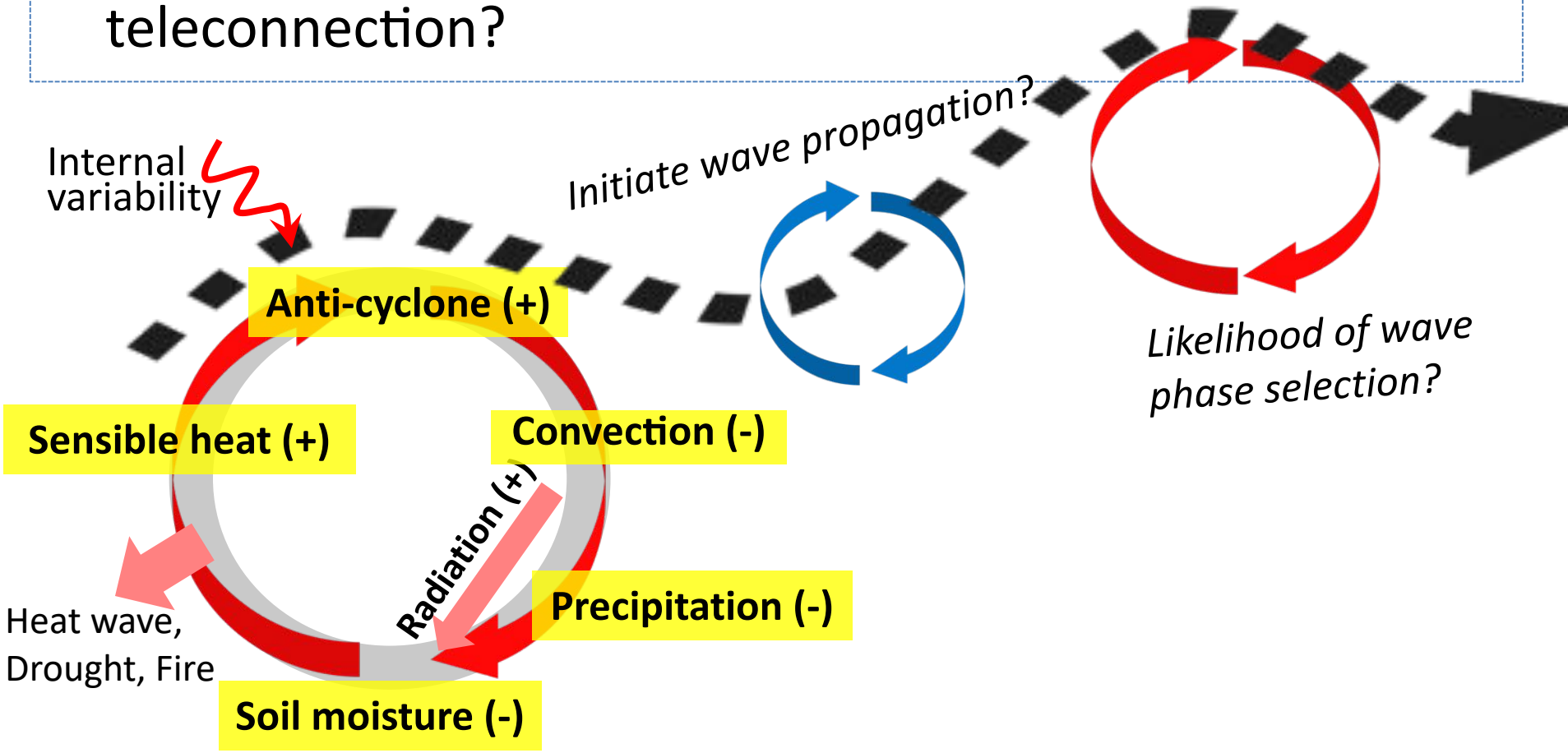


Erdenebat and Sato (2016, ASL)

- Recent warming accompanies wave-train (circumglobal teleconnection; Ding and Wang, 2005)
- Stronger anticyclone and drier soil intensify local L-A interaction

Question

- Is there possible role of surface anomalies for inducing wave-train patterns over Eurasia?
  - Koster et al. (2016, JCLI) examined for North America
- Do surface anomalies affect the sign of circumglobal teleconnection?



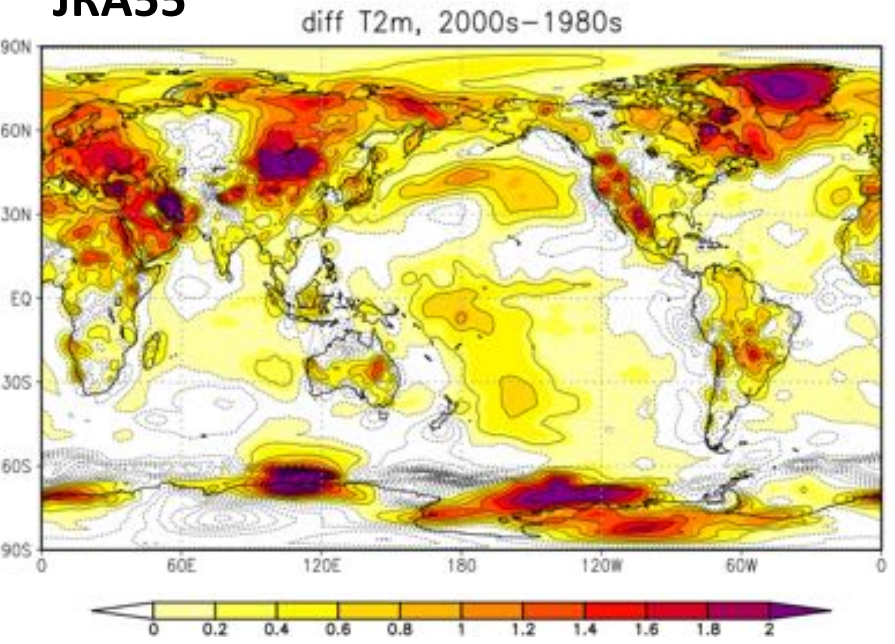
Data: Large ensemble exp. output

- Database for Policy Decision making for Future climate change, **d4PDF**) (Mizuta et al., 2017, BAMS)
  - 60km MRI-AGCM3.2 (driven using observed monthly SST, sea ice, and external forcings)
  - 60yrs (1951-2011) × 100 ensemble members =6,000yrs

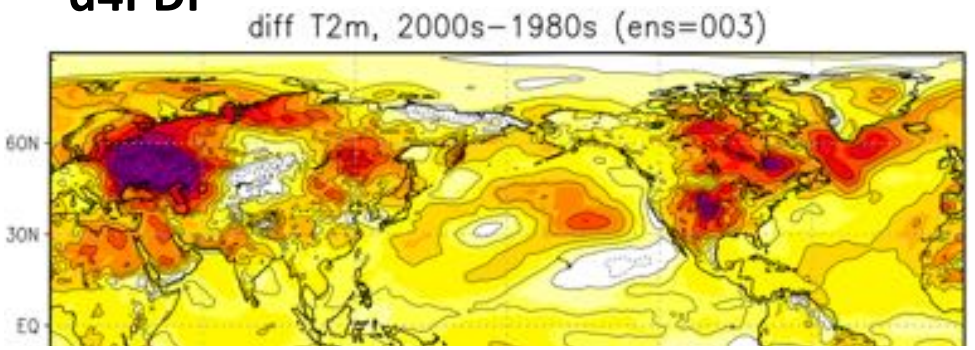
  - Experiment: Historical simulation
  - Interval: Monthly output

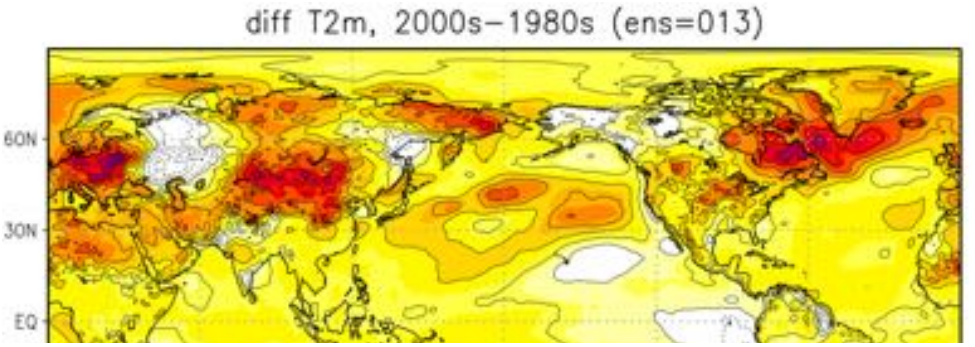
Similar wavy patterns in decadal change
(2000s minus 1980s)

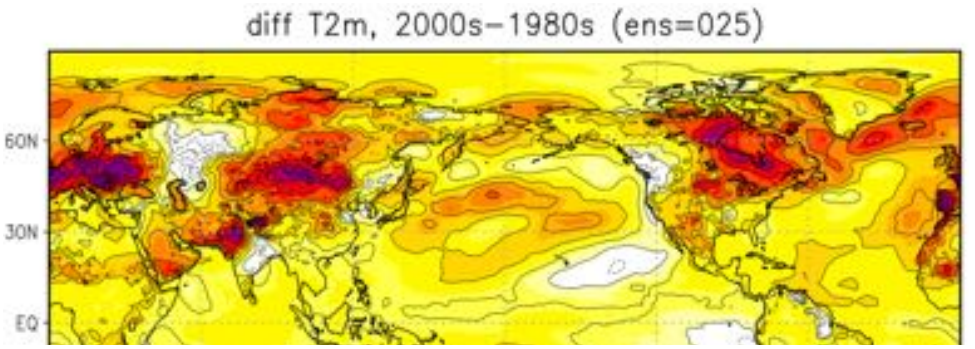
JRA55



d4PDF



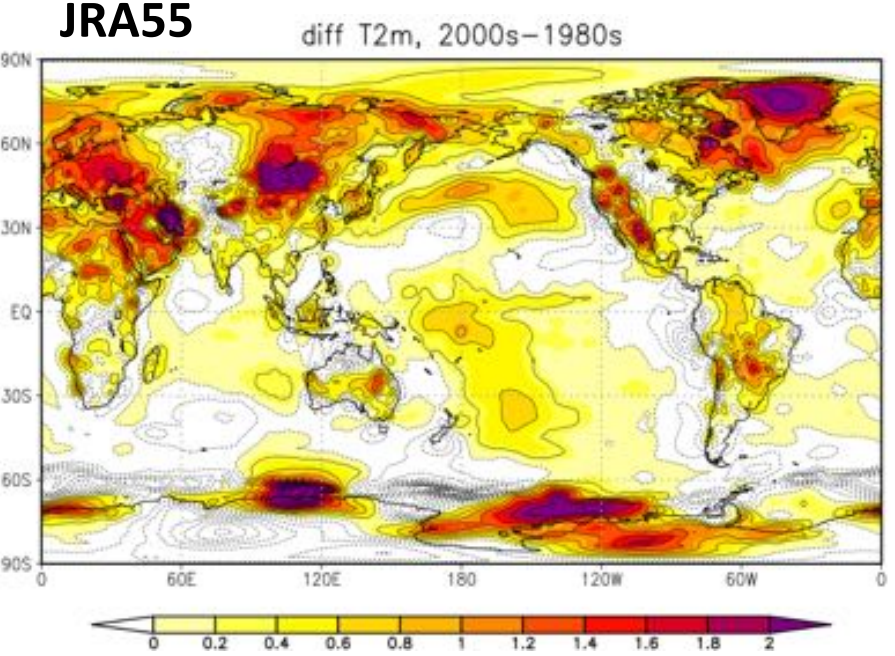




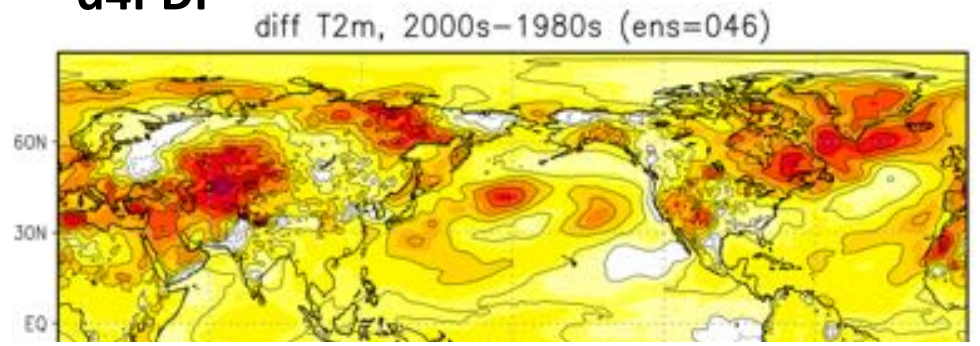
- Some members simulated the realistic T2m change over Eurasia.

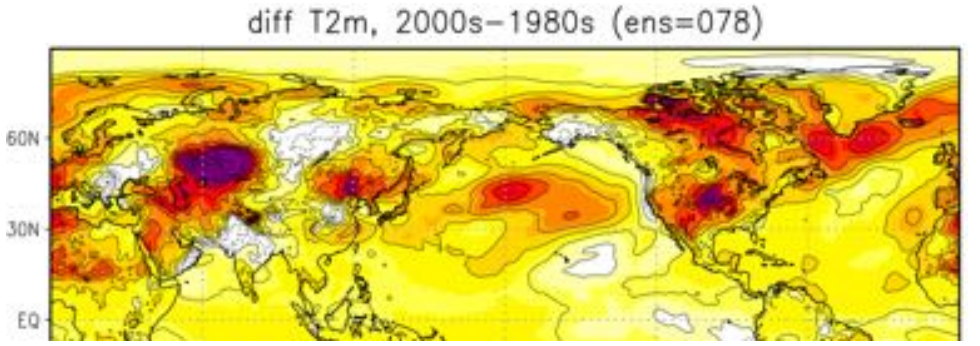
Similar wavy patterns in decadal change
(2000s minus 1980s)

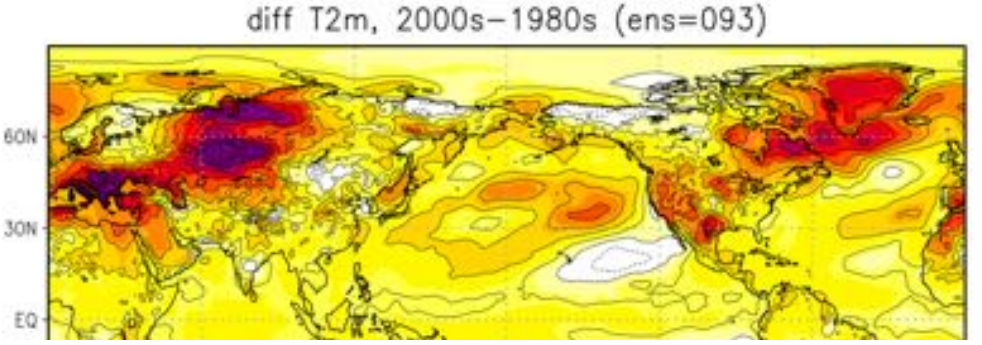
JRA55



d4PDF

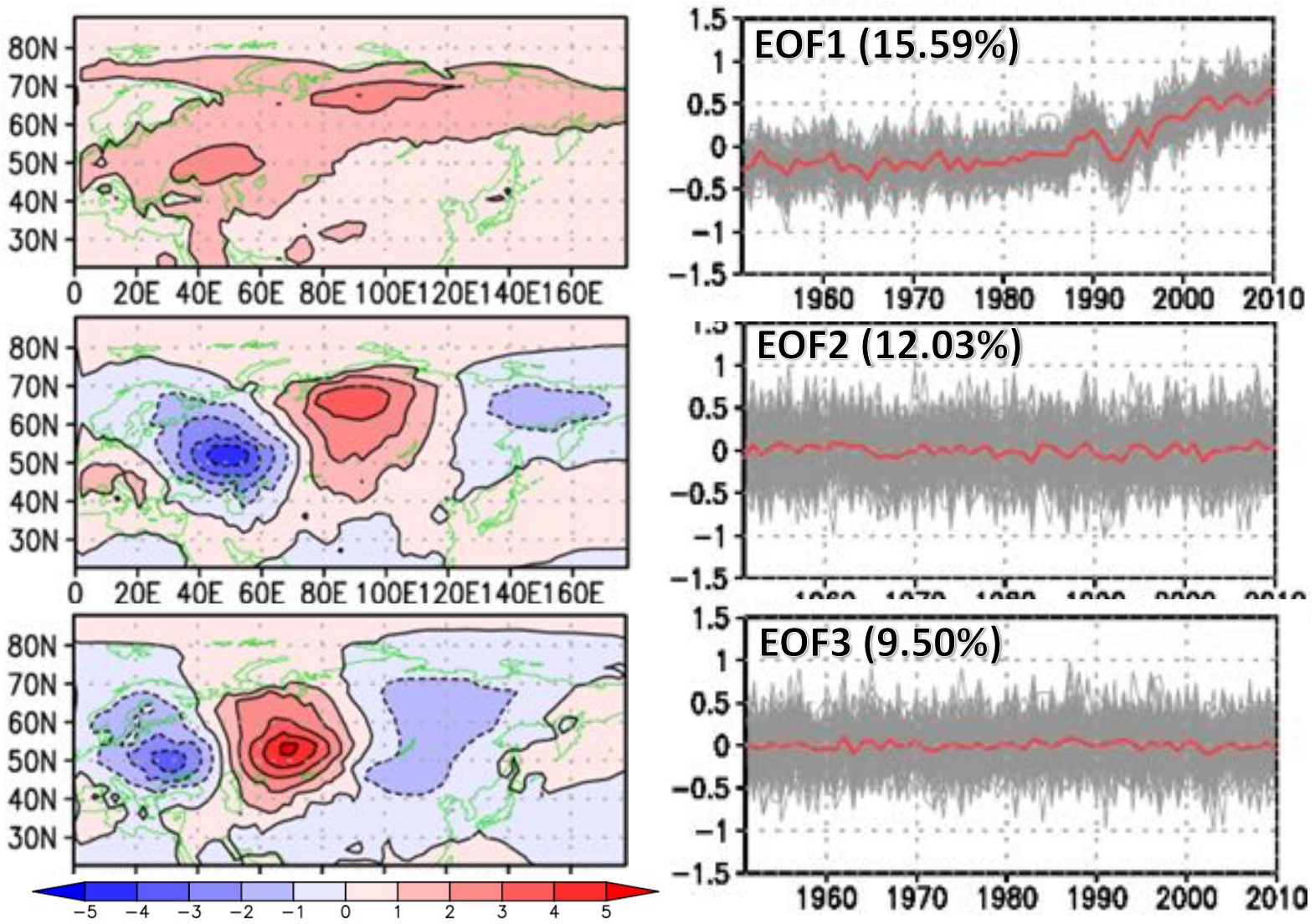






- Atmospheric wave-induced T2m change in decadal timescale is commonly seen, but the phase is diverse.
- The recent T2m change pattern can occur independently from SST.

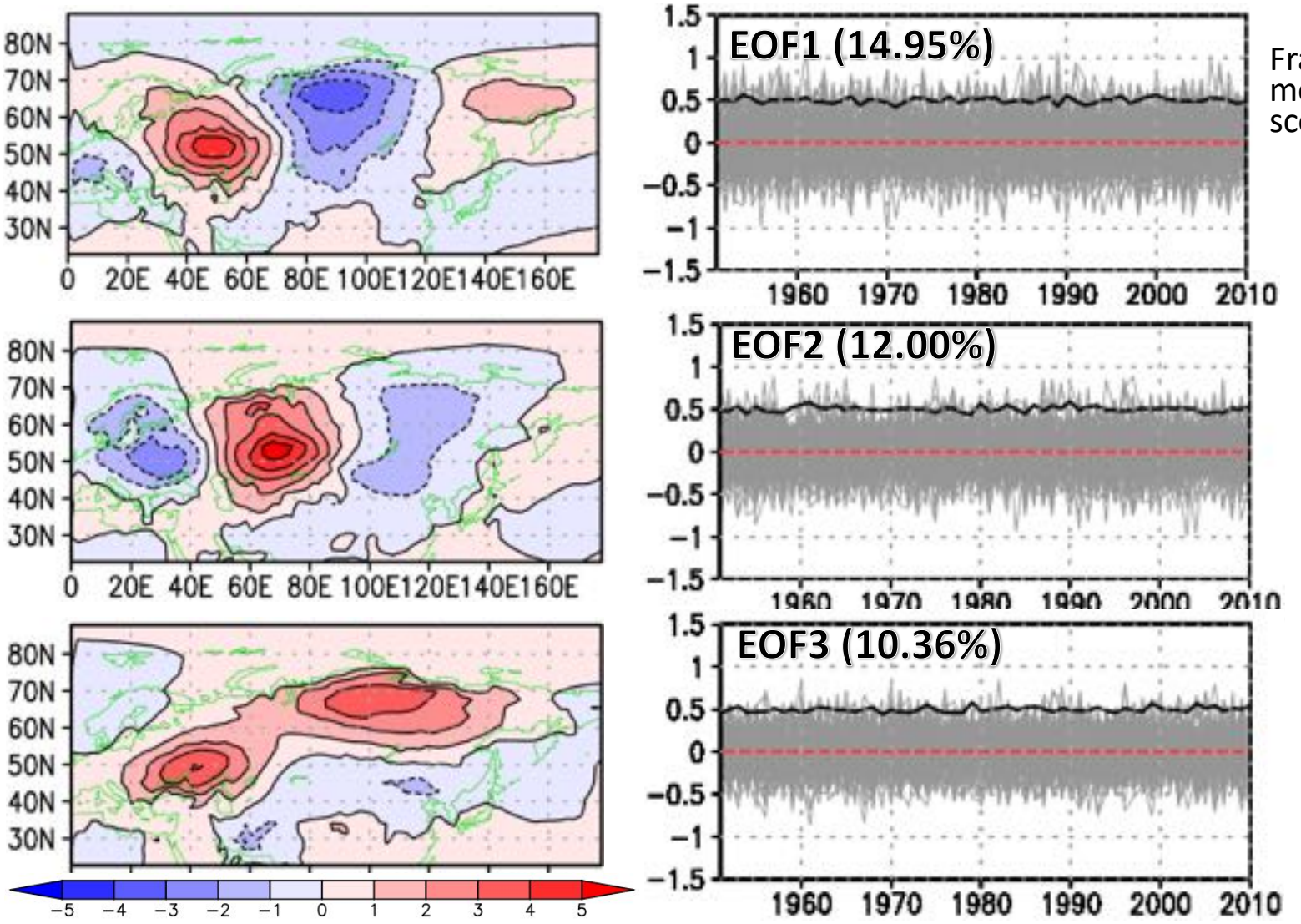
N=6000 (60yrs x 100member), JJA-mean T_{2m}



•EOF1: recently-enhanced warming trend centered over western and northern Eurasia.
→associated with global climate change (SST and external forcings)

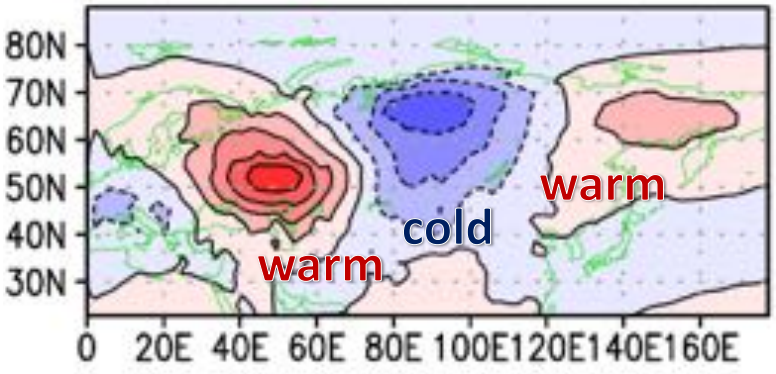
•EOF2&3: wave-train pattern that occurs almost randomly with time.
→associated with atmospheric internal variability (independent from SST)

N=6000 (60yrs x 100member), T_{2m}(JJA) deviation from ensemble mean

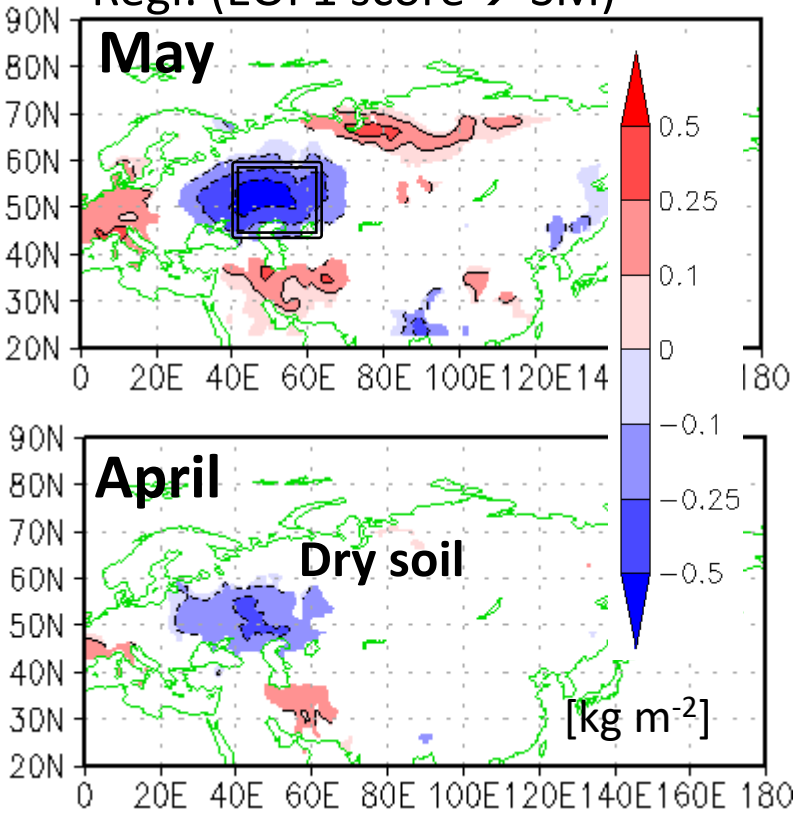


•EOF1, 2: Wave pattern is a primary mode for among-member spread

EOF1 T_{2m}(JJA)



Regr. (EOF1 score→ SM)

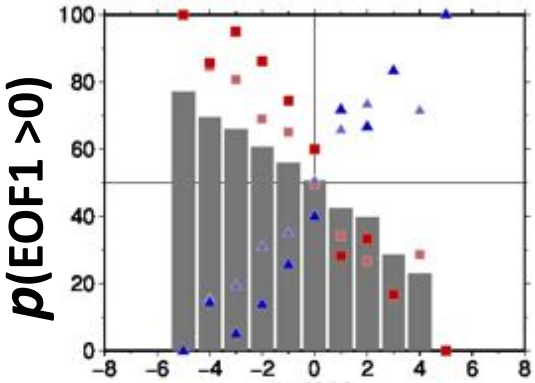


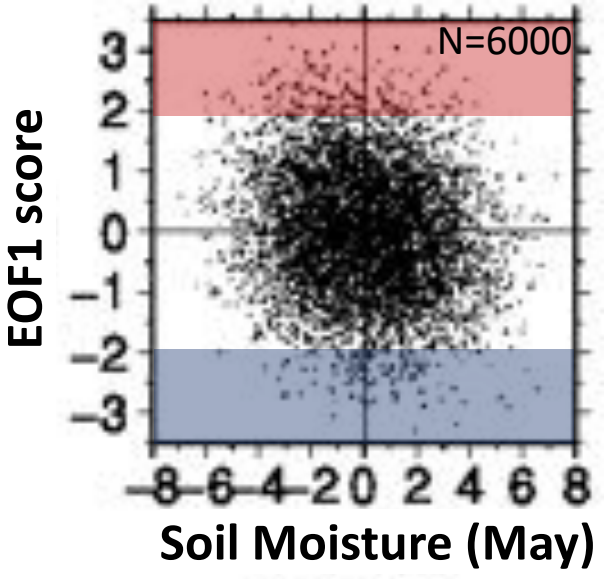
Referenced domain: 40-60E, 45-60N

JJA T_{2m} pattern vs Spring Soil Mois.

W-C-W

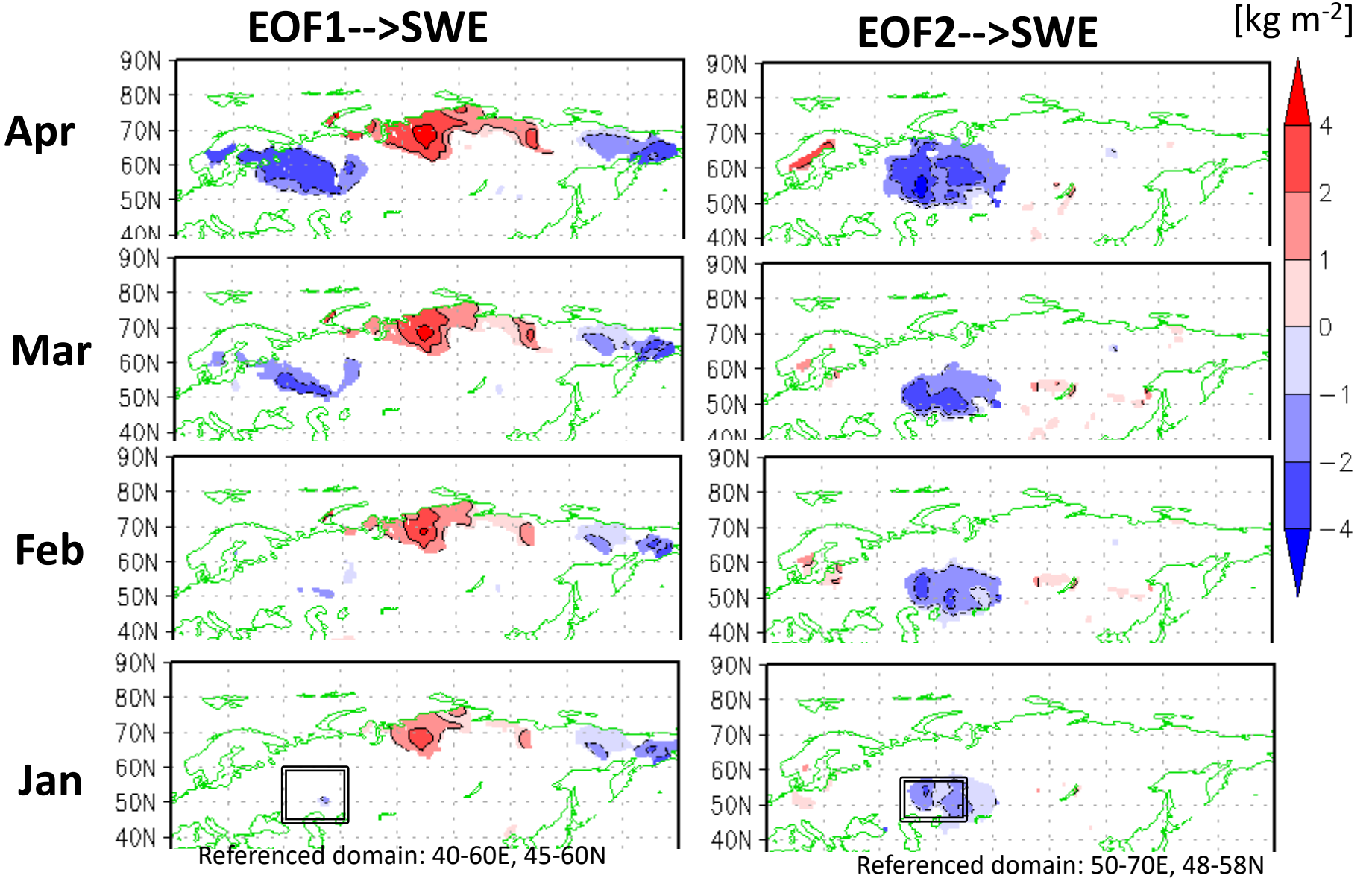
C-W-C





- EOF1 score is correlated with spring SM over Kazakhstan-Russia-Ukraine region.
- The likelihood of sign selection for wave propagation is modulated by SM.

JJA T_{2m} pattern vs Winter snow water



- EOF1: Snow water anomalies over western and central Siberia
- EOF2: Persistent snow water anomalies over Kazakhstan-Russia-Ukraine region.

Summary

- We analyzed huge ensemble AGCM experiment to study the effects of land surface processes on the formation of Eurasian summer temperature anomalies.

- **Wave pattern in T_{2m} occurs randomly with time.**

  →T_{2m} anomaly pattern can be generated independently from SST, suggesting the importance of atmospheric internal variability and L-A interaction.

- **Soil moisture anomaly around Kazakhstan-Russia-Ukraine region in spring affects the likelihood of sign selection of the EOF score.**

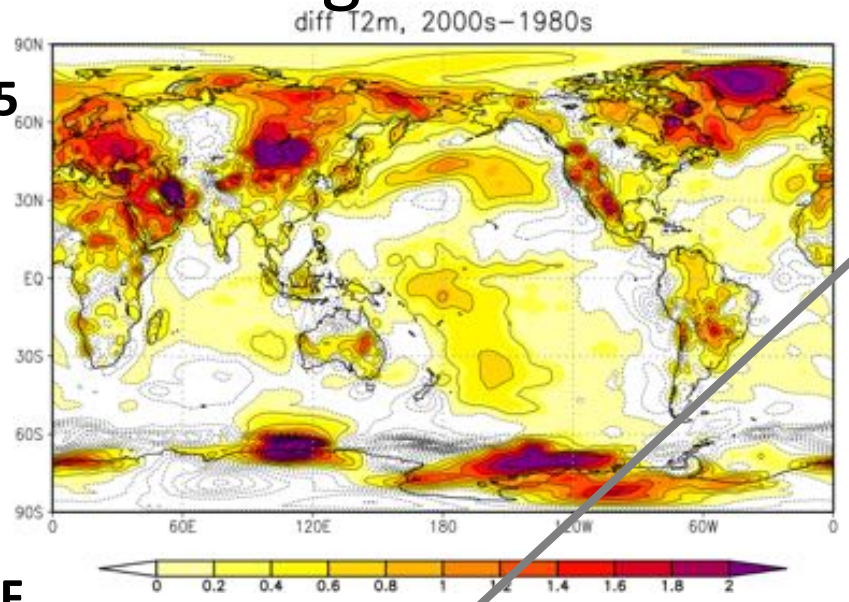
  →e.g., higher SM in May prefers warm-cold-warm T_{2m} anomaly pattern over Eurasia in summer.

  – Snow water equivalent affect the SM in snow melting season.

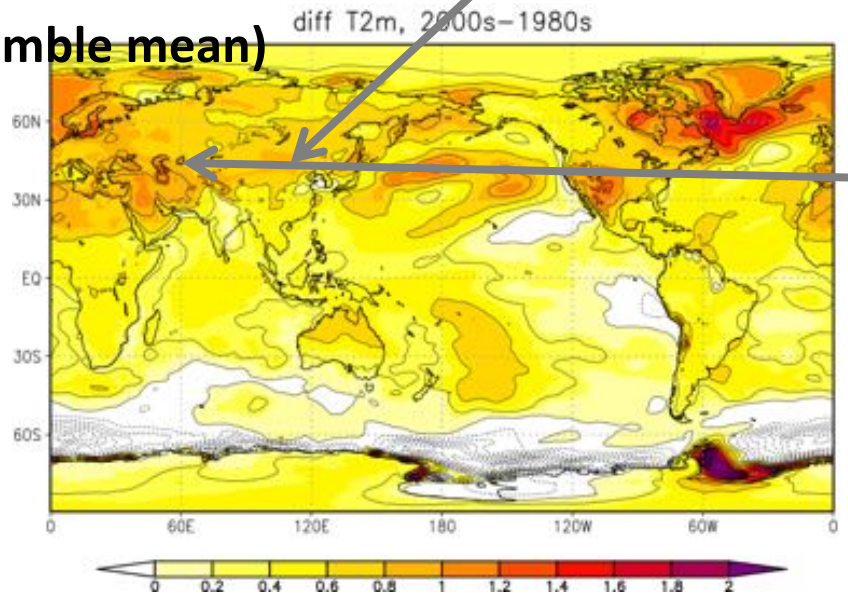
- **These findings encourage the idea that L-A interaction is important for seasonal prediction over northern Eurasia.**

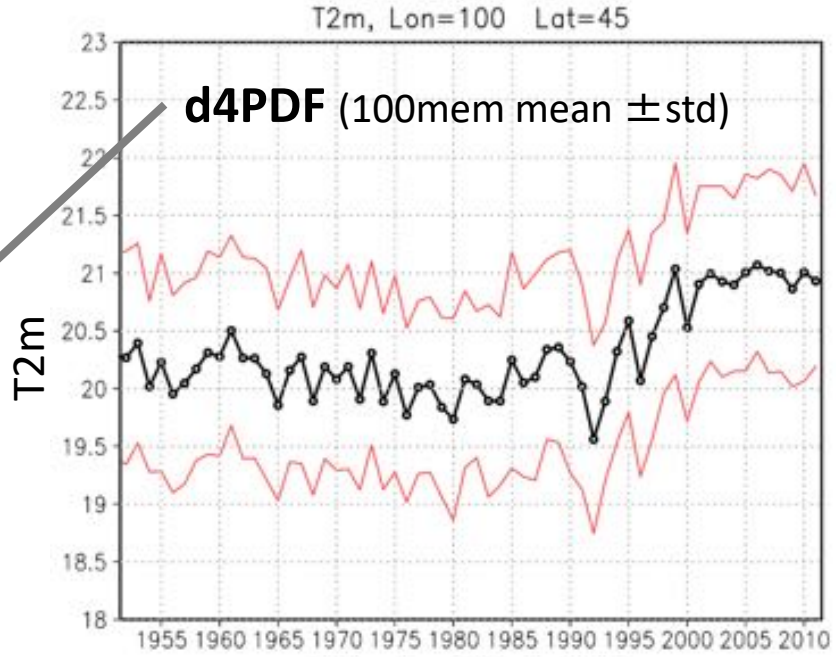
JJA T2m changes

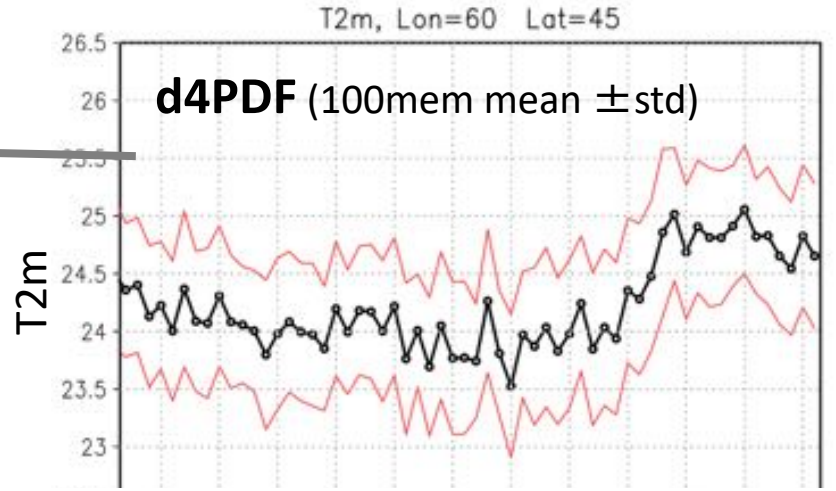
JRA55



d4PDF
(ensemble mean)

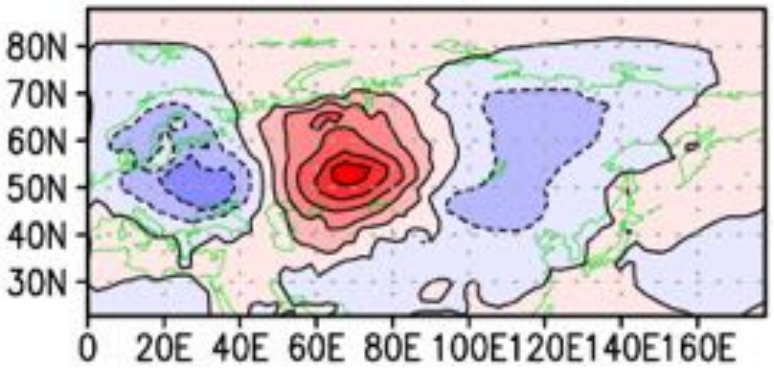




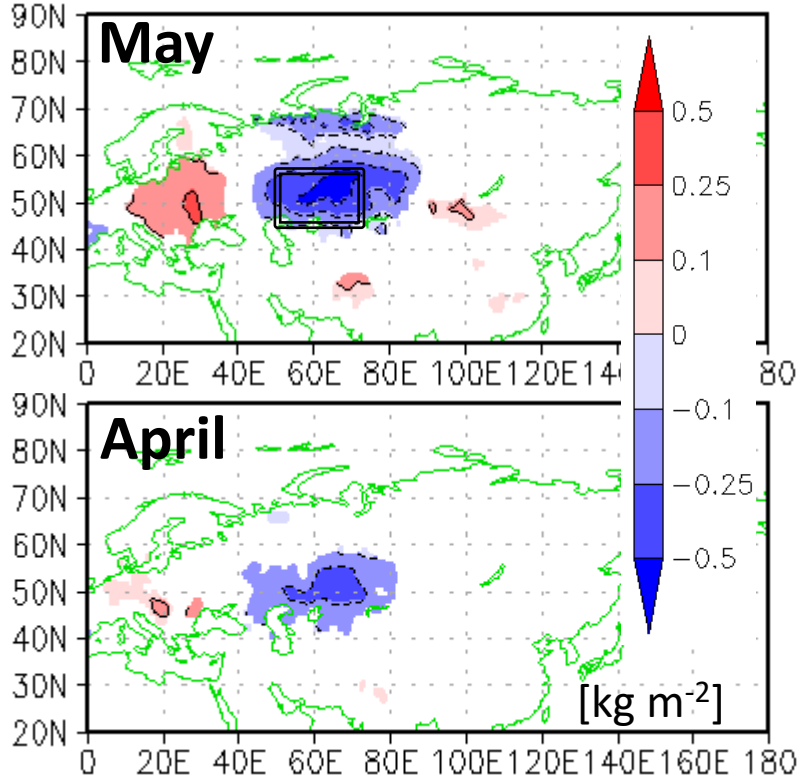


- T2m jump over mid-latitude was simulated regardless of ensemble members (SST forcing)
- T2m change in d4PDF (ensemble) is more uniform than JRA55 (due to 100 member average)

EOF2 T_{2m}(JJA)

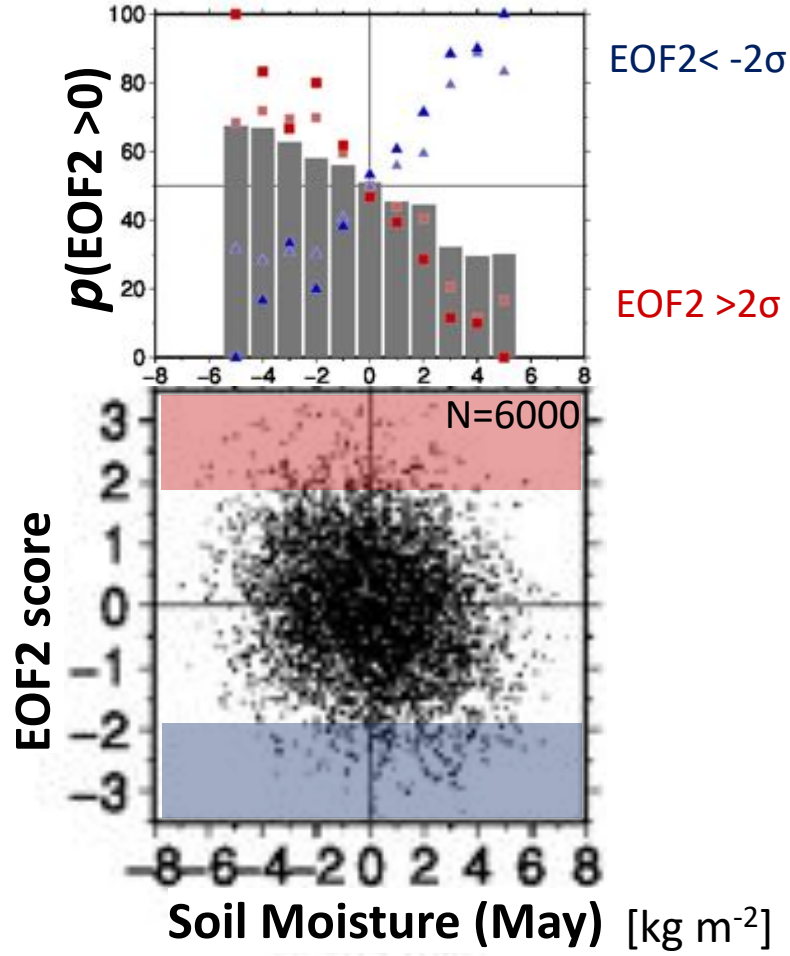


Regr. (EOF2 score→ SM)



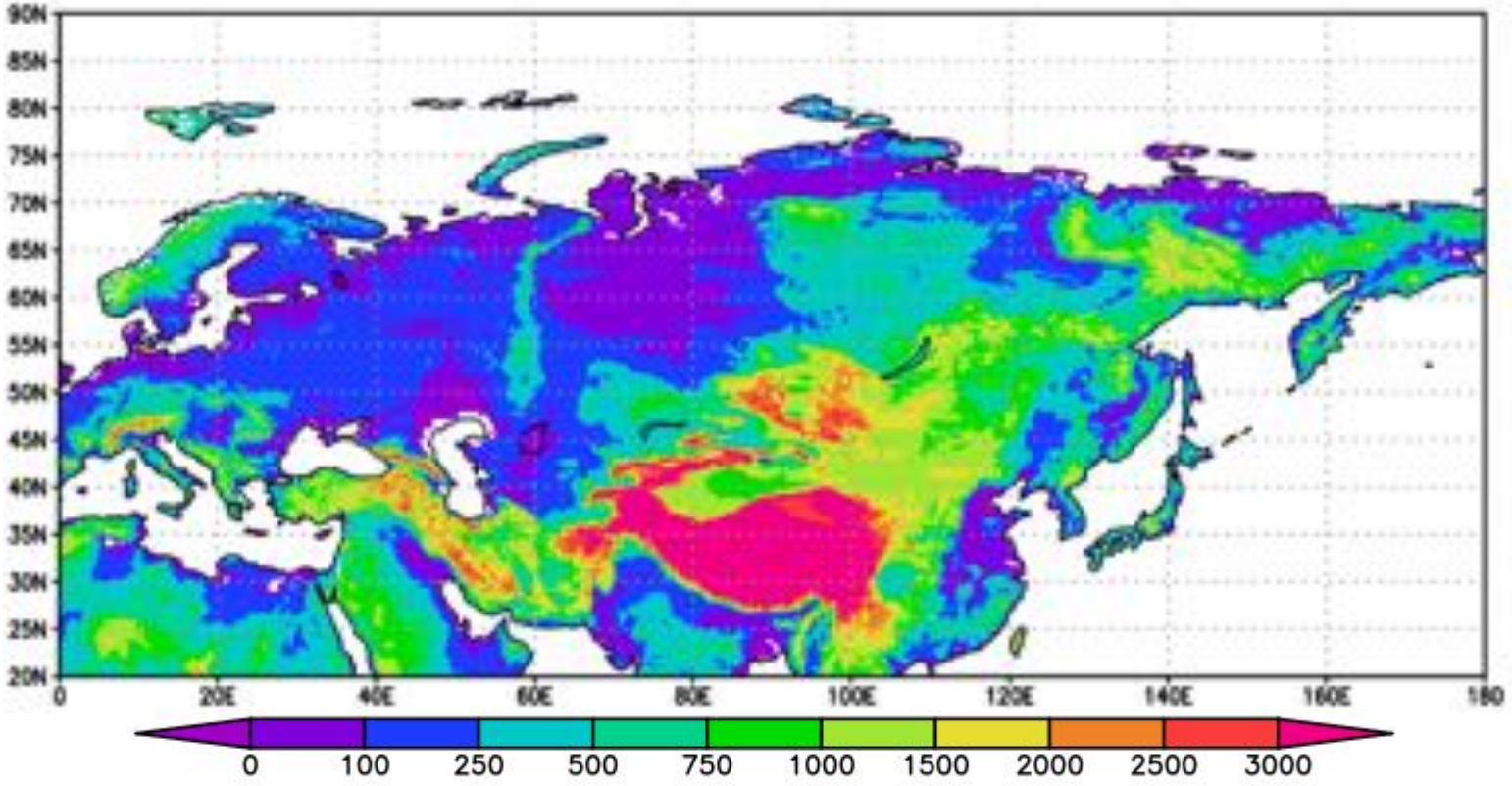
Referenced domain: 50-70E, 48-58N

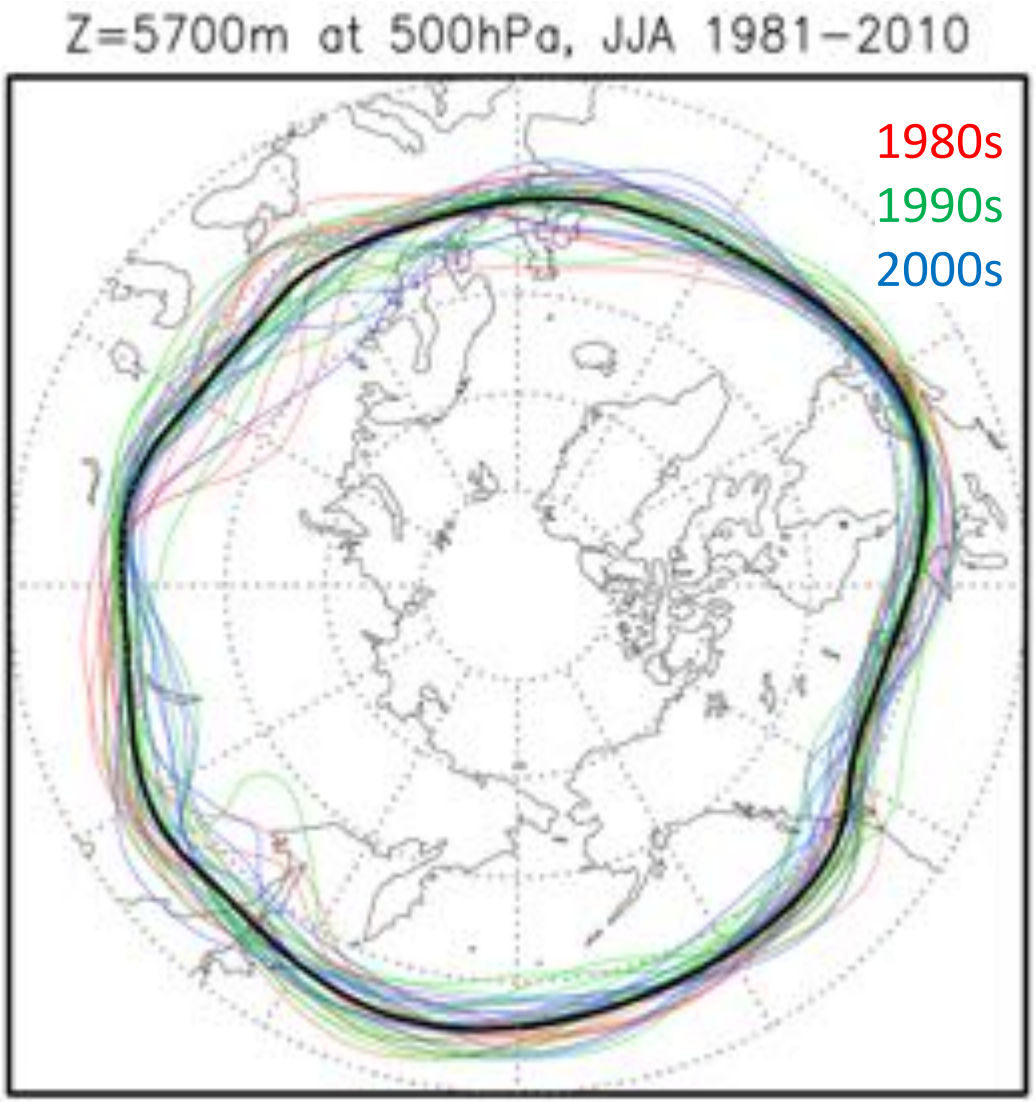
JJA T_{2m} pattern vs Spring Soil Mois.

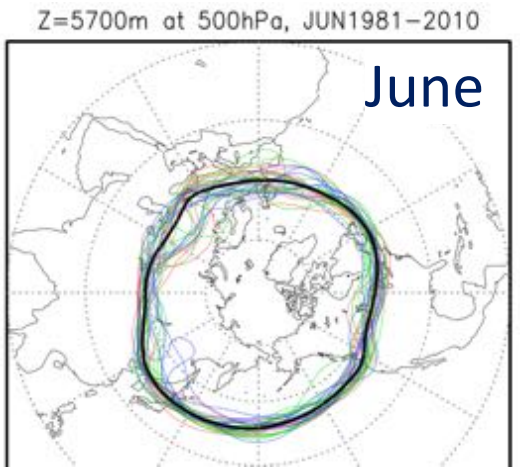


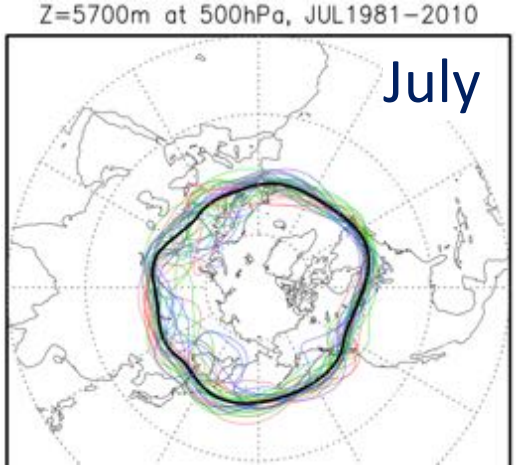
- Similar result with EOF-1.

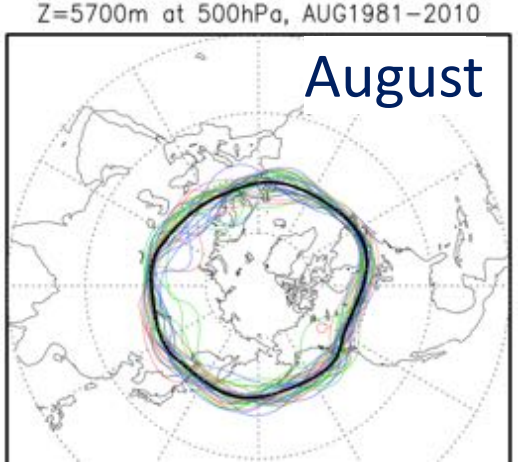
Supporting material: Topography



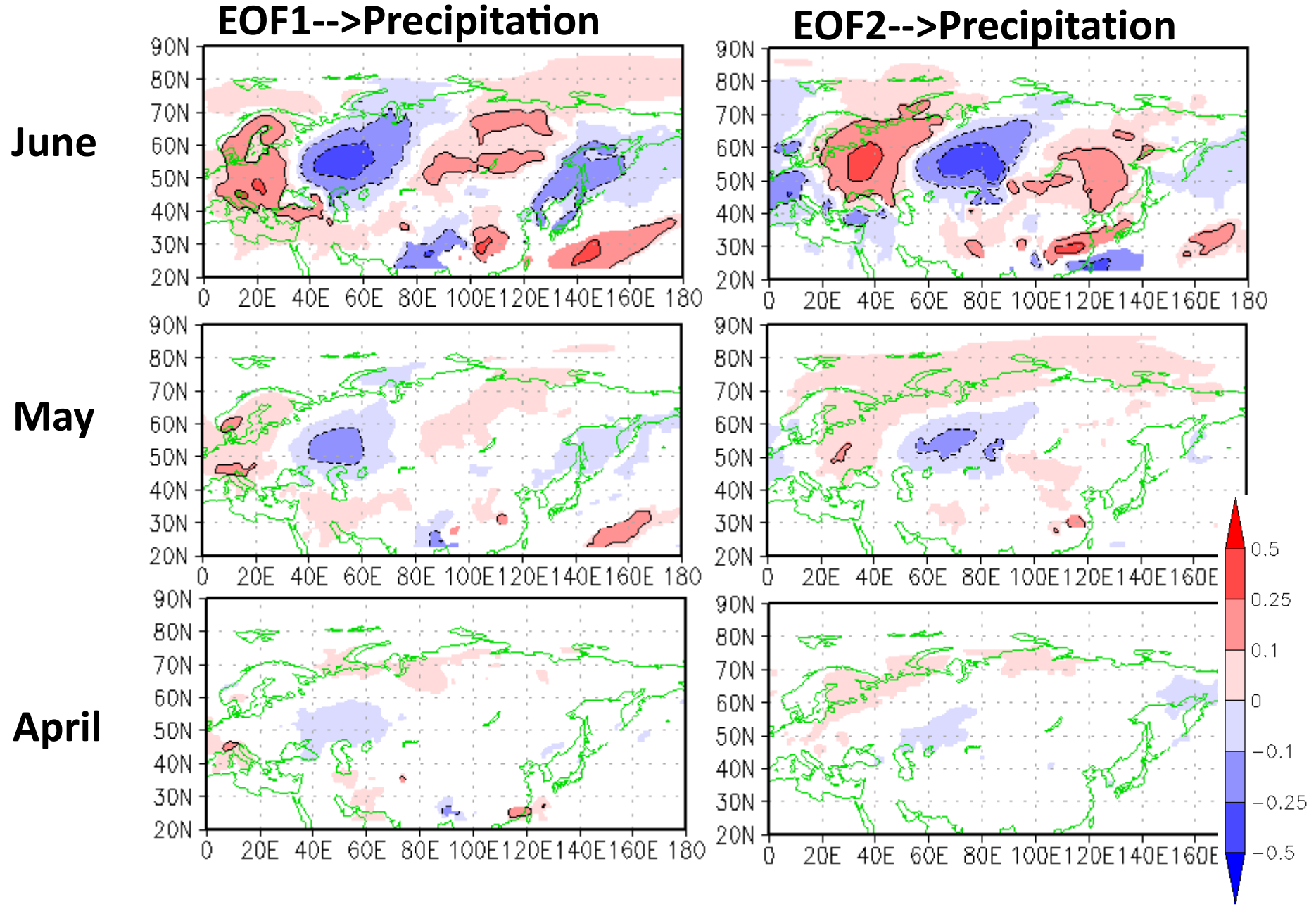




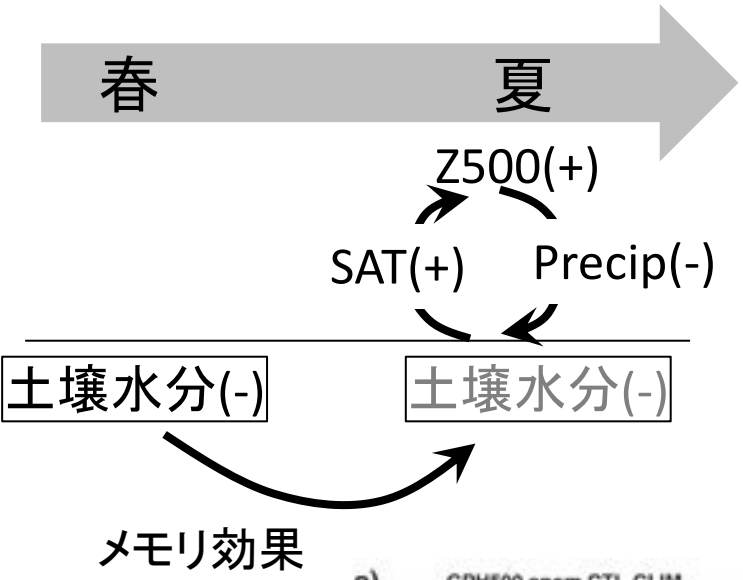


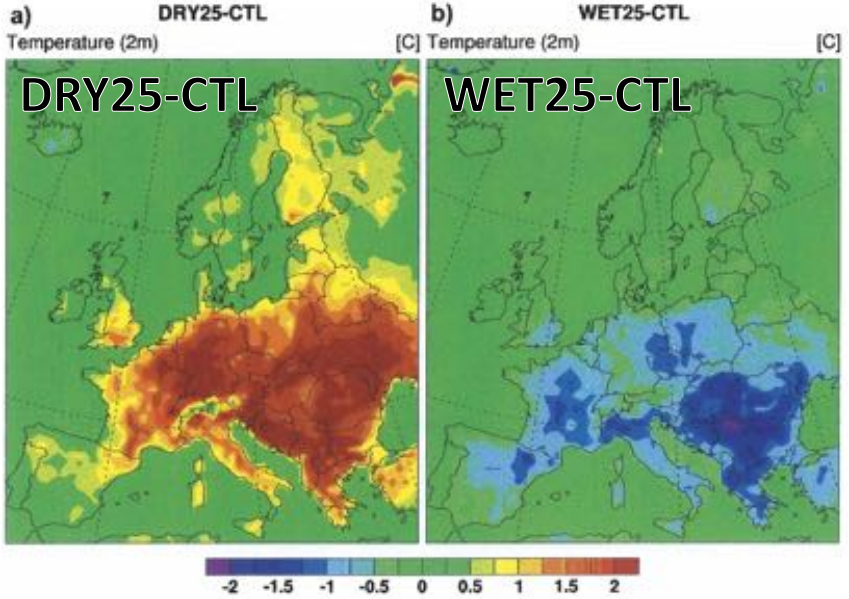


- The location of the jet is determined dynamically by internal variability. The jet meanders largely over Eurasia during summer.
- Is there contribution of land processes?

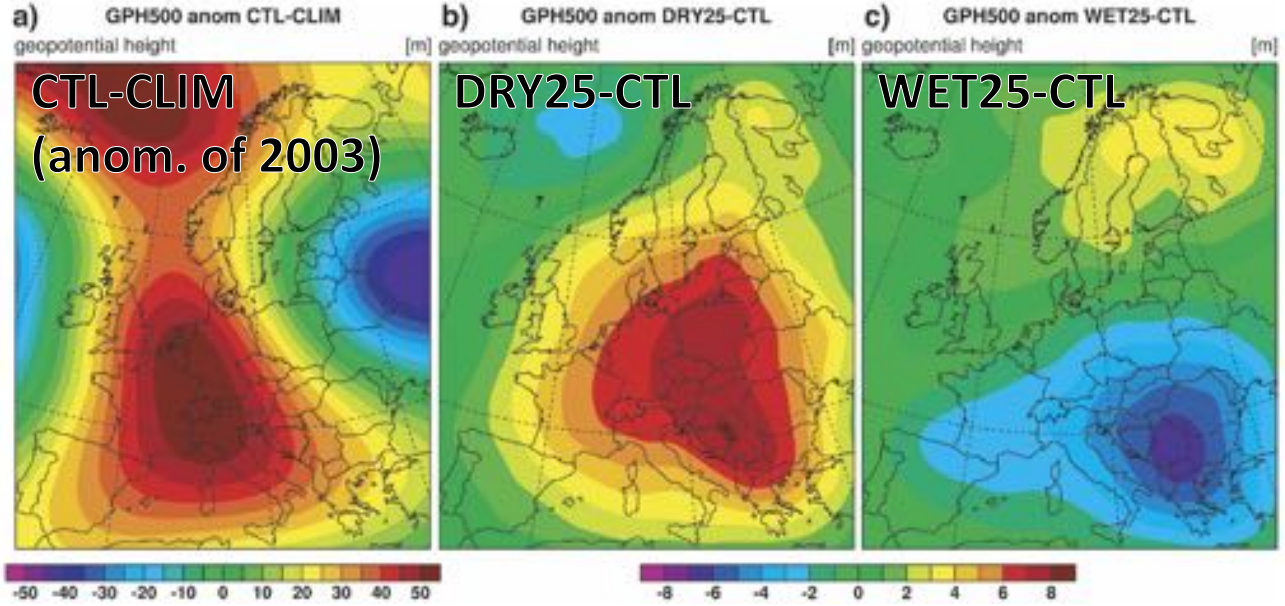

EOF1-->Precipitation
EOF2-->Precipitation
June
May
April
90N
80N
70N
60N
50N
40N
30N
20N
0
20E
40E
60E
80E
100E
120E
140E
160E
180
0.5
0.25
0.1
0
−0.1
−0.25
−0.5

2003 European Heat Wave





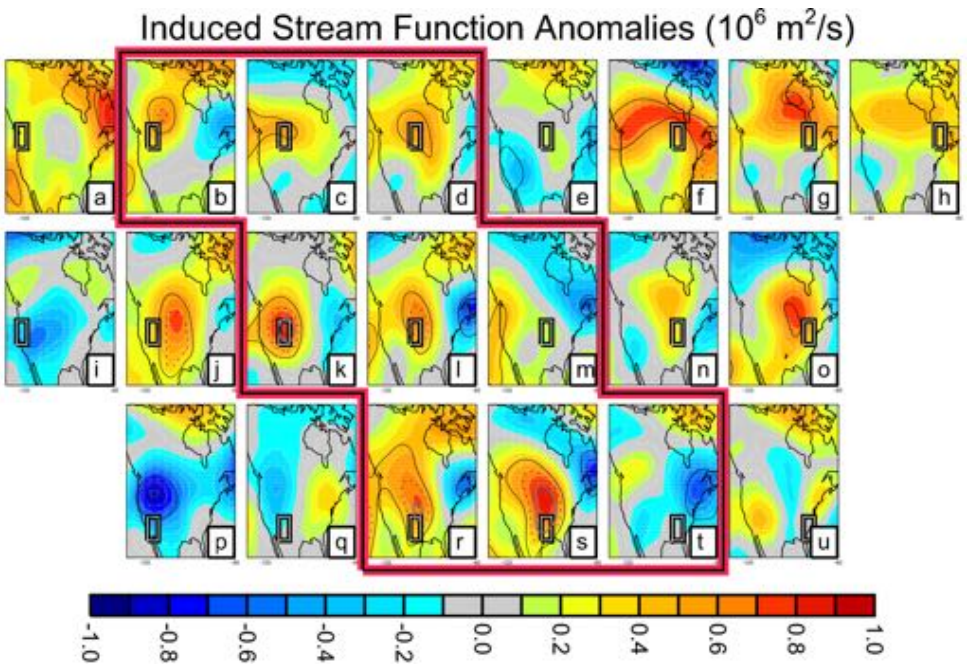
SAT



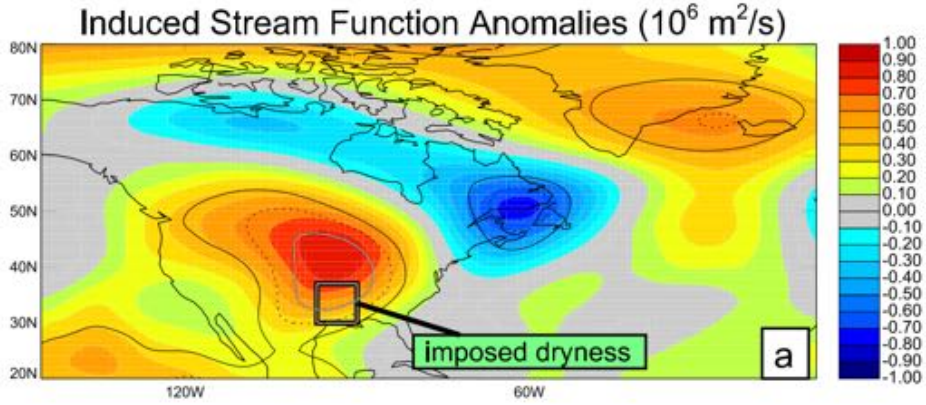
Z500

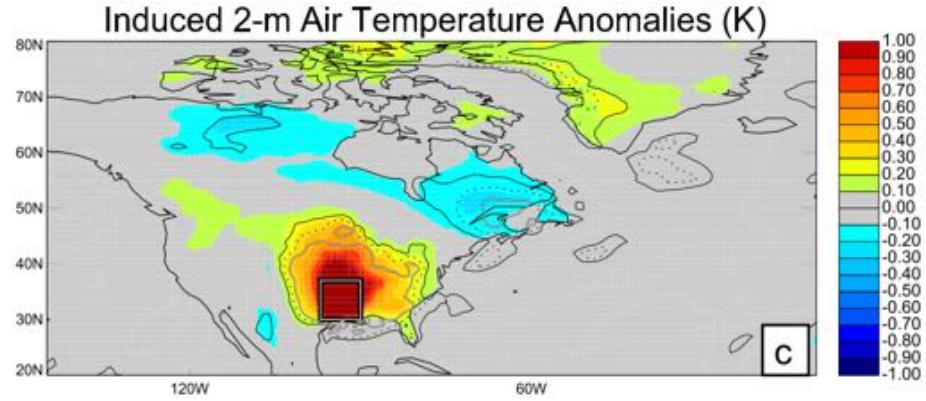
Fischer et al. (2007)

Response of upper-air circulation to SM anomaly



(Koster et al., 2016 JCLI)





- SM anomaly imposed at slightly different locations emerge a common synoptic circulation anomaly which can propagate remotely.
- It is unclear whether there are similar SM effects in Eurasia.