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

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• 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)
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)

• Some members simulated the realistic T2m change over Eurasia.
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

Fraction of members score>0
EOF1 $T_{2m}$ (JJA)

JJA $T_{2m}$ pattern vs Spring Soil Moist.

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

Regr. (EOF1 score $\rightarrow$ SM)

- EOF1 < -2σ
- EOF1 > 2σ

Referenced domain: 40-60E, 45-60N
• 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

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

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?
2003 European Heat Wave

Fischer et al. (2007)

Z500

SAT

CTL-CLIM (anom. of 2003)

DRY25-CTL

WET25-CTL

春

夏

メモリ効果

土壌水分(-)
Response of upper-air circulation to SM anomaly

- 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.

(Koster et al., 2016 JCLI)