Impacts of sea ice / SST changes for the observed climate change — GREENICE project —

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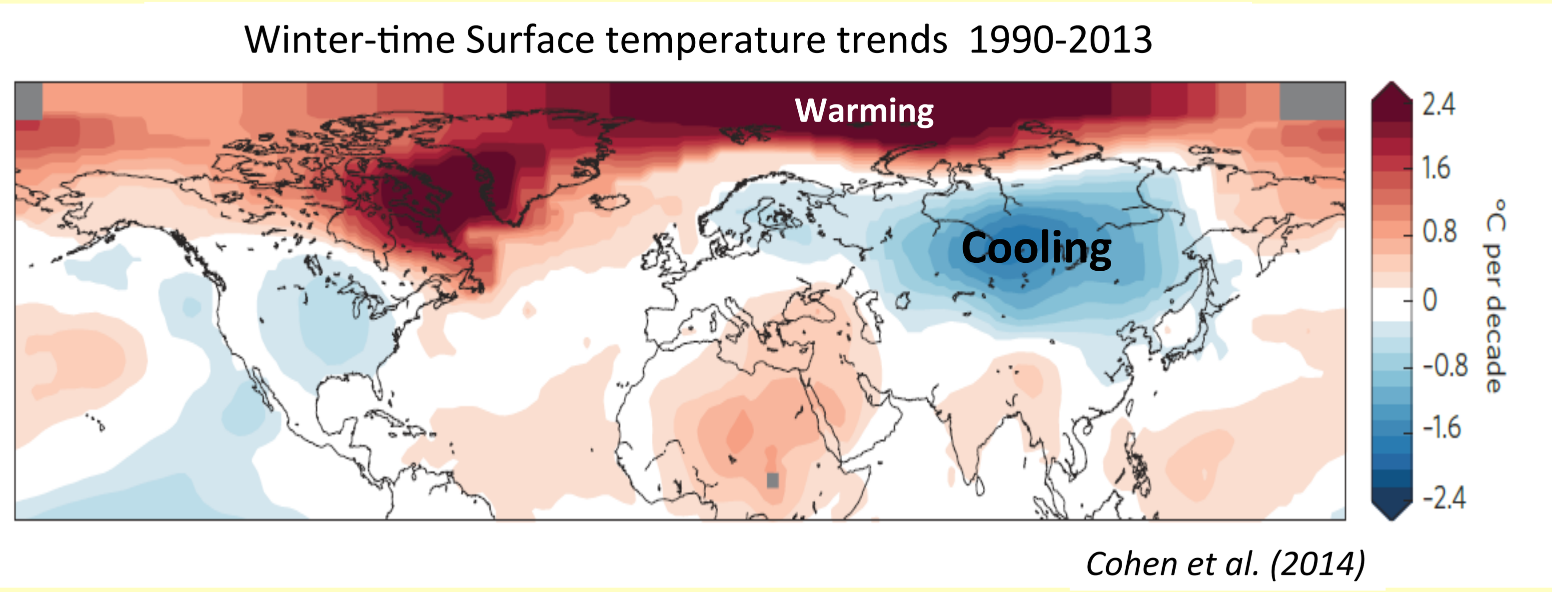
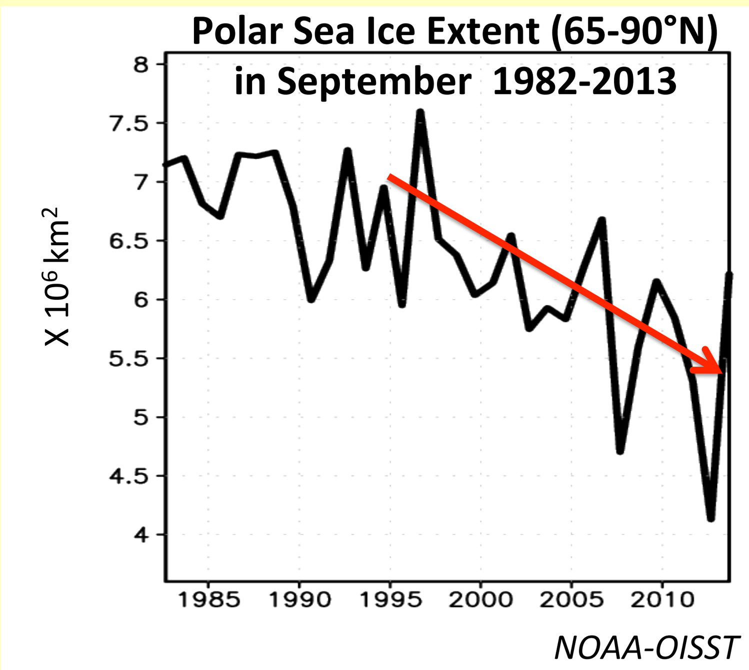
1. Sea-ice reduction and its possible impacts

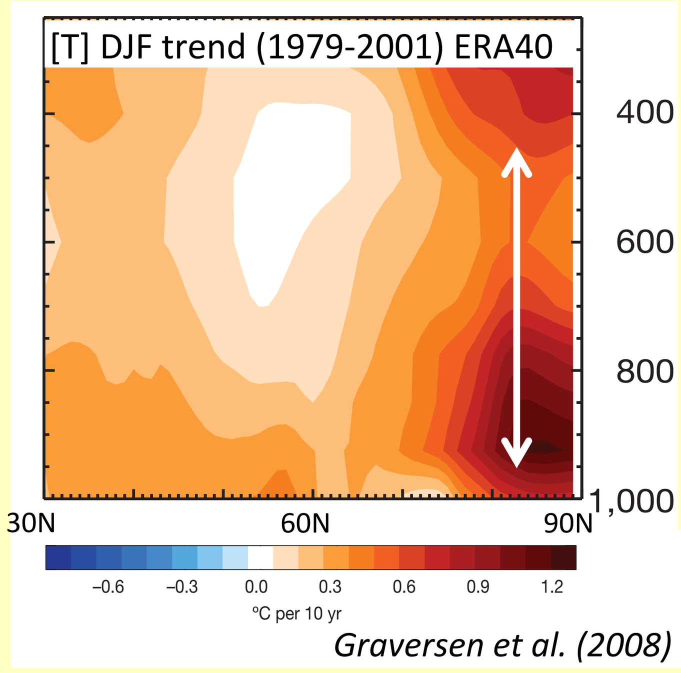
Arctic amplification of global warming



Sea Ice reduction



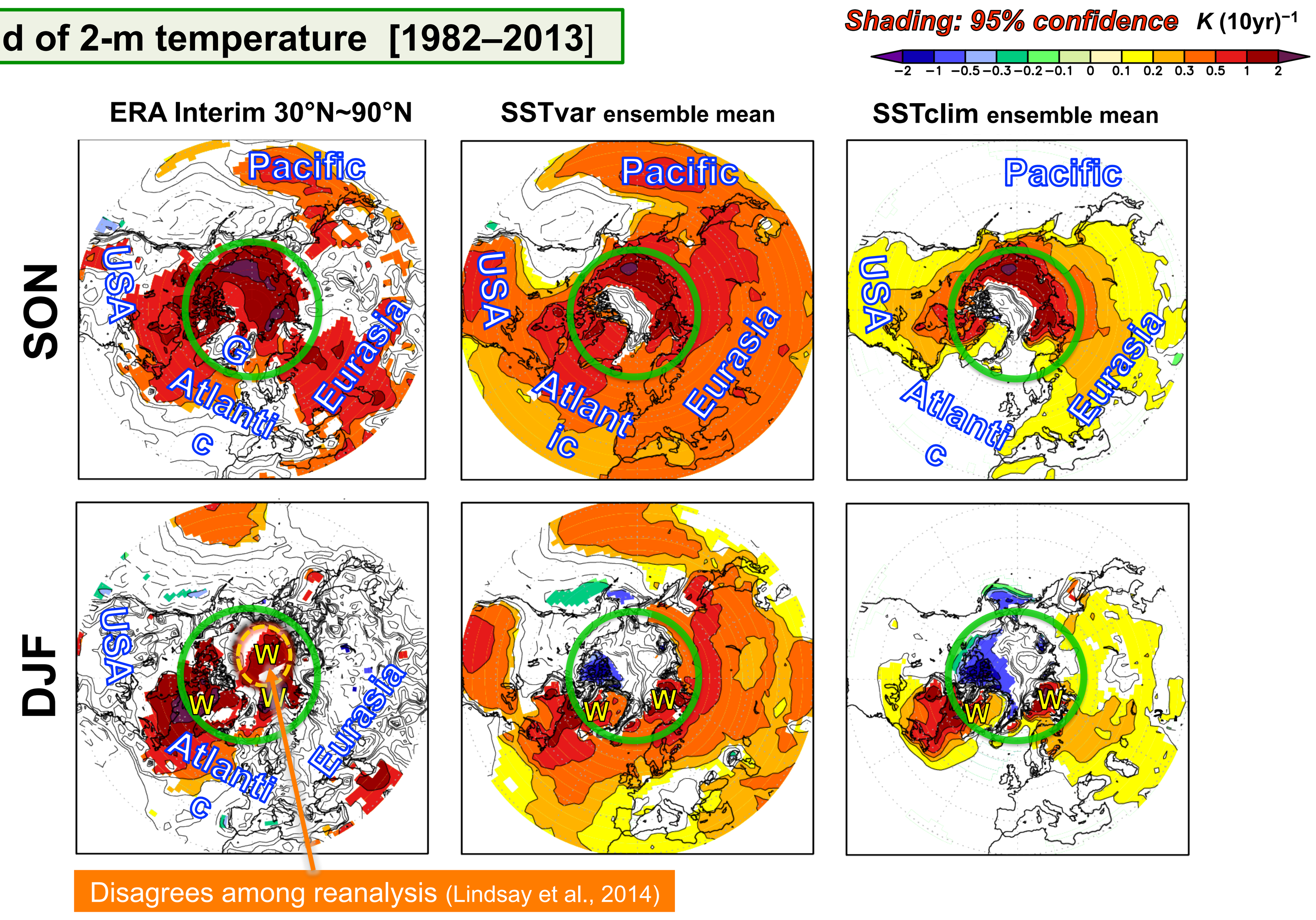
Upward extended warming



- The arctic region has warmed more than twice as fast as the global average. (*Cohen et al., 2014*).
  - Impact of Sea-ice reduction *(Screen et al. 2012; 2013)*
  - Poleward energy flux by atmospheric internal dynamics *(Graversen et al., 2008)*
  - Greenland warming response to tropical SST change *(Ding et al., 2014)*
- Mid-latitude winter is getting severer (Cohen et al., 2014), especially in Siberia.
  - Sea-ice reduction may have influenced (Mori et *al., 2014*)
  - No evidence of Sea-ice impact (McCusker et *al., 2016*)

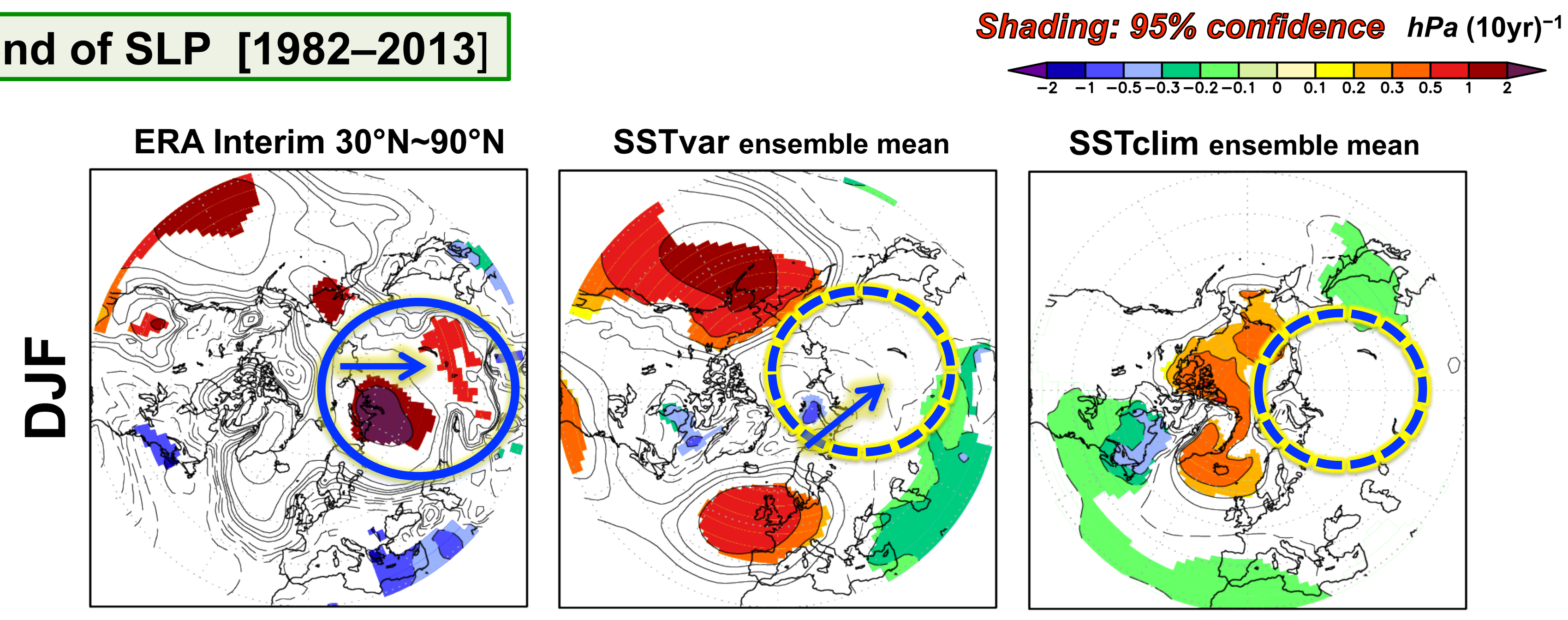
... need to be addressed for sustainable-growth of society (= "green-growth").

Trend of 2-m temperature [1982–2013]



- Significant polar surface warming pattern is similar to reanalysis in both experiments.
  → dominance of the sea ice impact.
- Greenland warming can be reproduced without SST change.
  → Tropical SST change (Ding et al., 2014) seems not required.
- Both of the experiments simulate warming trends in Siberia.
  → The siberian cooling is not likely to be driven by sea ice changes.

Trend of SLP [1982–2013]



- No positive SLP trend → No Siberian cooling (McCusker et al., 2016)

2. Experiments and results from GREENICE project

Coordinated AGCM experiments to assess the robustness of atmospheric response to SIC & SST changes

Forced with observed SST and SIC changes, considered separately and together

Two ensembles

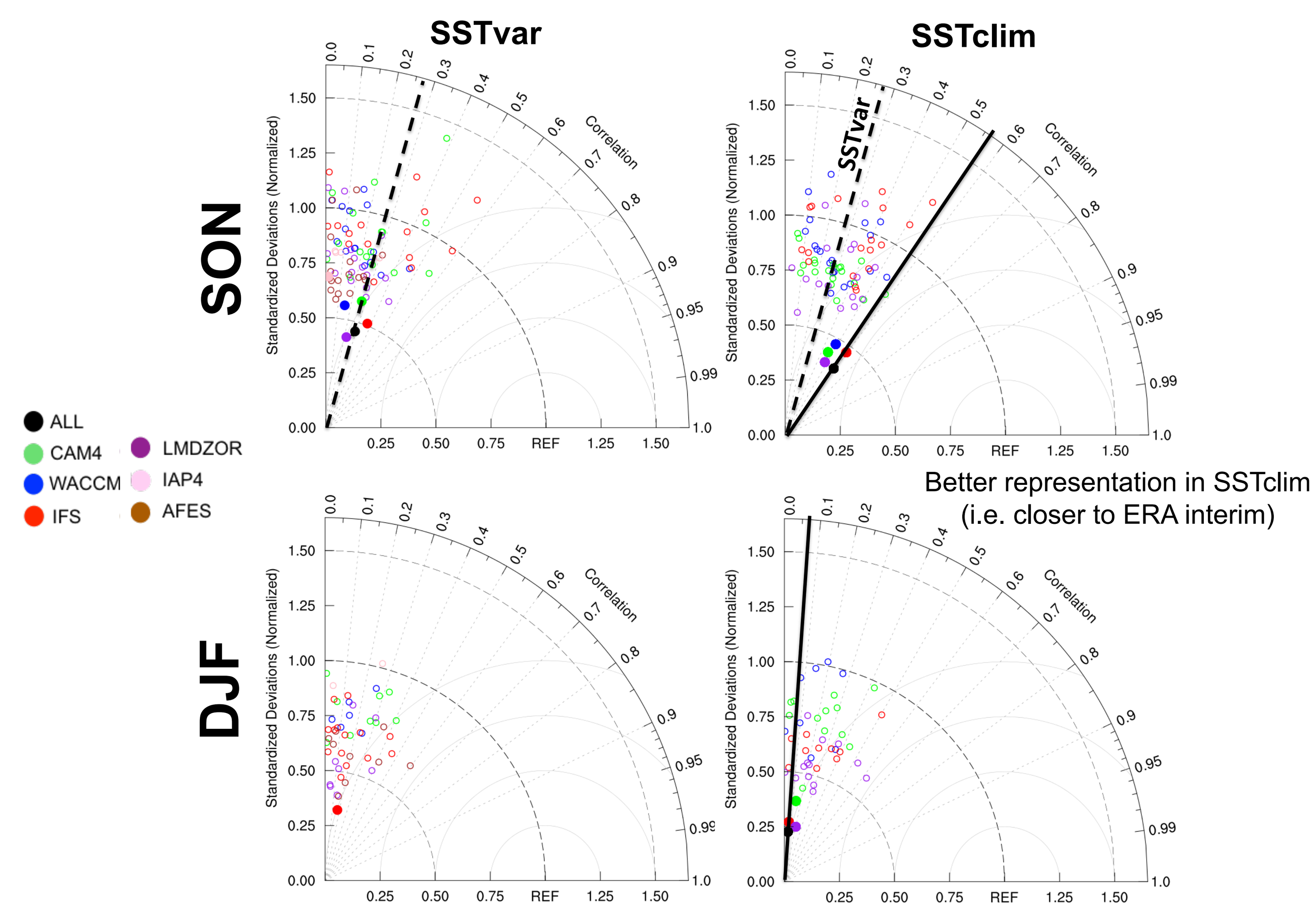
– Hindcast experiment ("**SSTvar**")
- 1982-2013
- CMIP5 protocol (RCP8.5)
- NOAA OI satellite derived data
- Full daily variations in SIC and SST
- 7 different models

Model	Resolution	SSTvar	SSTclim
CAM4	1° x1 °, L26	20 members	20
WACCM	1° x1 ° L66	20	20
IFS	T255 L91	20	20
LMDZOR	2.5°x1.25°L39	20	20
IAP	T85L19	9	-
AFES	T79 L56	30	-

– SST climatology experiment ("**SSTclim**")
- Full daily variations in SIC (same as above)
- SST is replaced to daily climatology (adapted from Screen et al., 2013)

Similarity of t2m trend with ERAI (over 30°- 90°N Land)

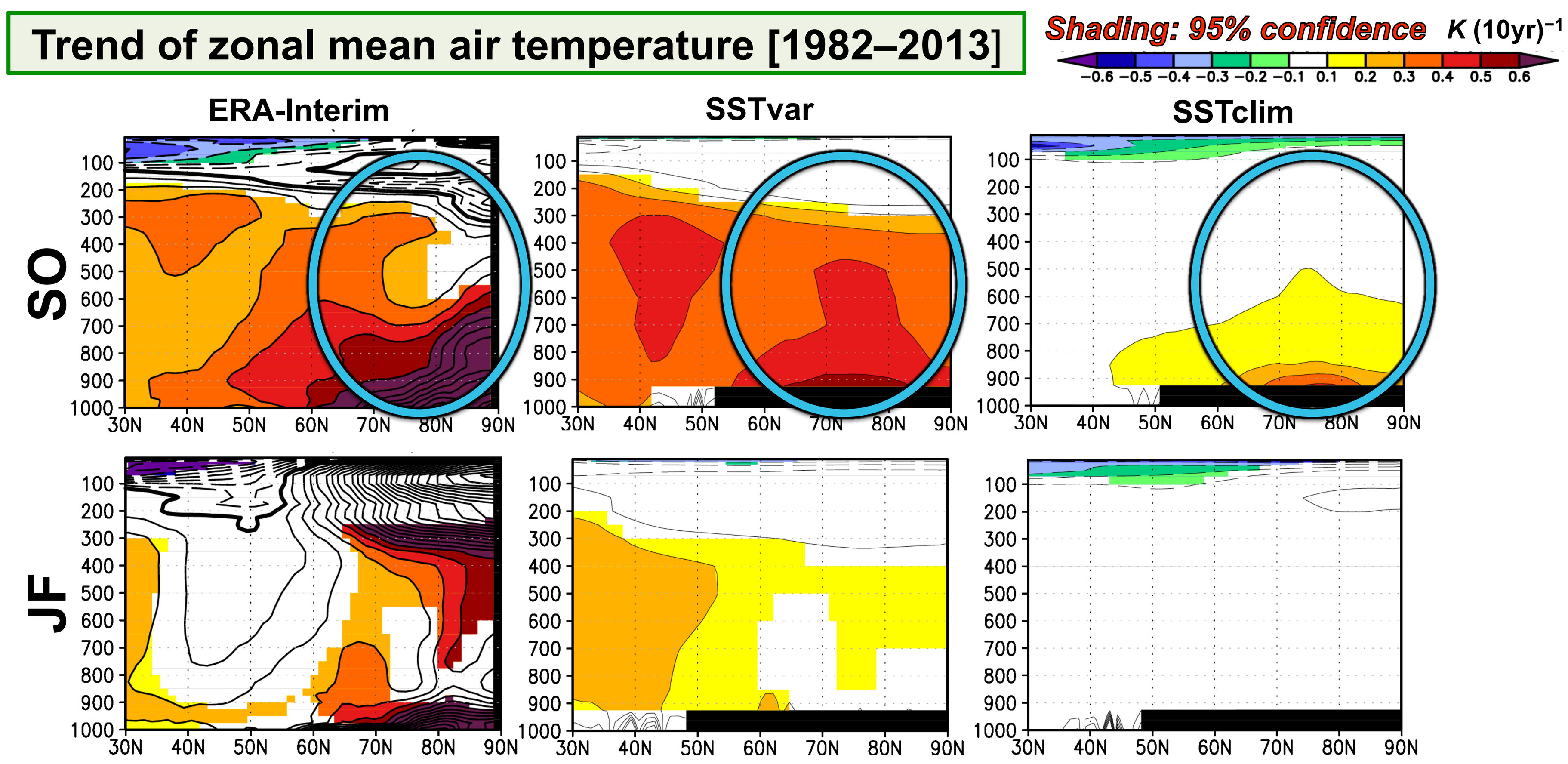
*** Observation is one realization



3. Summary

- The arctic amplification of the surface temperature warming in polar latitudes seems mostly due mostly to the sea Ice changes both in autumn and winter.
- In winter, the Greenland surface warming can occur without tropical SST changes. (opposing to Ding et al., 2014)
- Siberian cooling seems to be caused by internal atmospheric variability instead of SIC and SST. (supporting McCusker et al., 2016)
- The impact of sea Ice changes on arctic amplification is confined near the surface; warming aloft is mainly due to SST (supporting Screen et al., 2012; 2013).

Trend of zonal mean air temperature [1982–2013]



Observed arctic amplification extends upward.

The upward extention was reproduced with SST changes.

The extention reduced without SST changes. (Screen et al., 2012)

References

Cohen et al., 2014, NGEO, 7, 627-637.
*Ding et al., 2014, Nature, **509**, 209-212.*
*Graversen et al., 2008, Nature, **451**, 53-56.*
*Lindsay et al., 2014, J. Climate, **27**, 2588-2606.*
*McCusker et al., 2016, NGEO, **9**, 838-842.*
Mori et al., 2014, NGEO, 7, 869-873.
*Screen et al., 2012, GRL, **39**, L10709.*
*Screen et al., 2013, J. Climate, **26**, 1230-1248.*