

Extratropical Ocean Warming and Winter Arctic Sea Ice Cover since the 1990s

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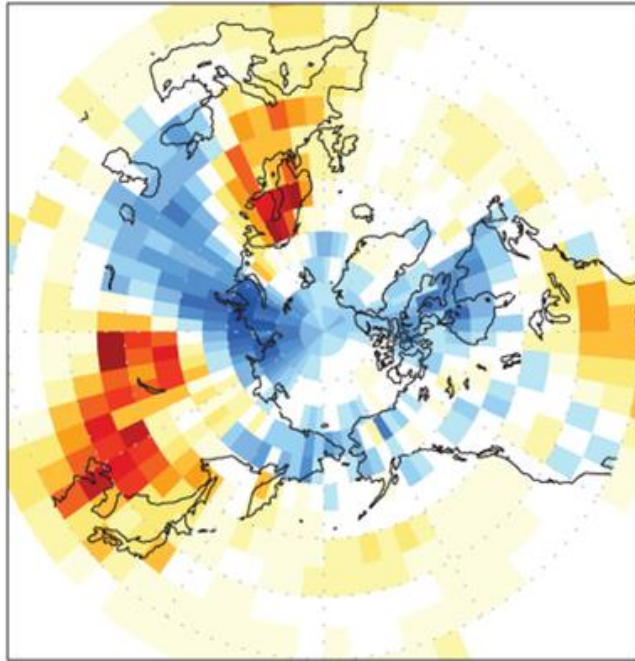


Arctic Warming (Amplification)

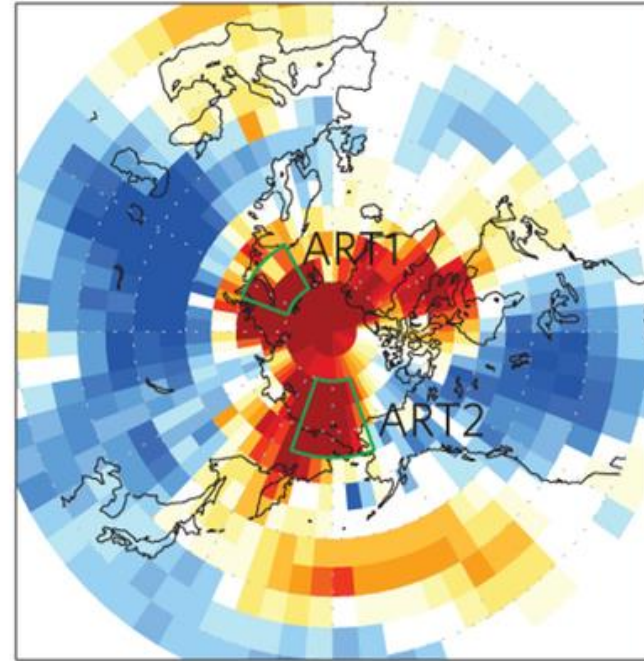
- ✓ **Sea ice**
- ✓ **Heat and moisture transport**
- ✓ **Inflows of Atlantic and Pacific waters**
- ✓ **Local radiative effect**
- ✓ **Increased emittance of blackbody**
- ✓ **Reduced air pollution**
- ✓ **Phytoplankton**

Surface Temperature (Arctic)

a Trend (1979–1997, DJF)



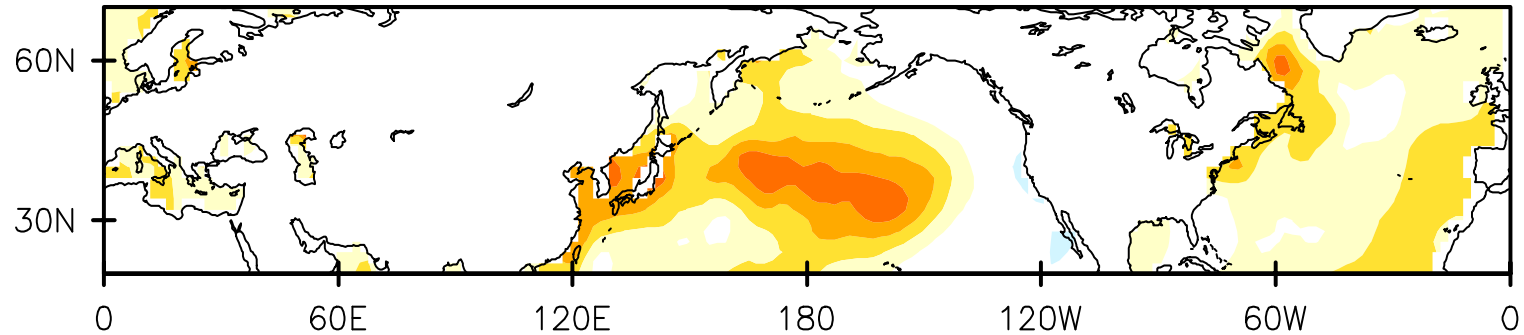
b Trend (1998–2013, DJF)



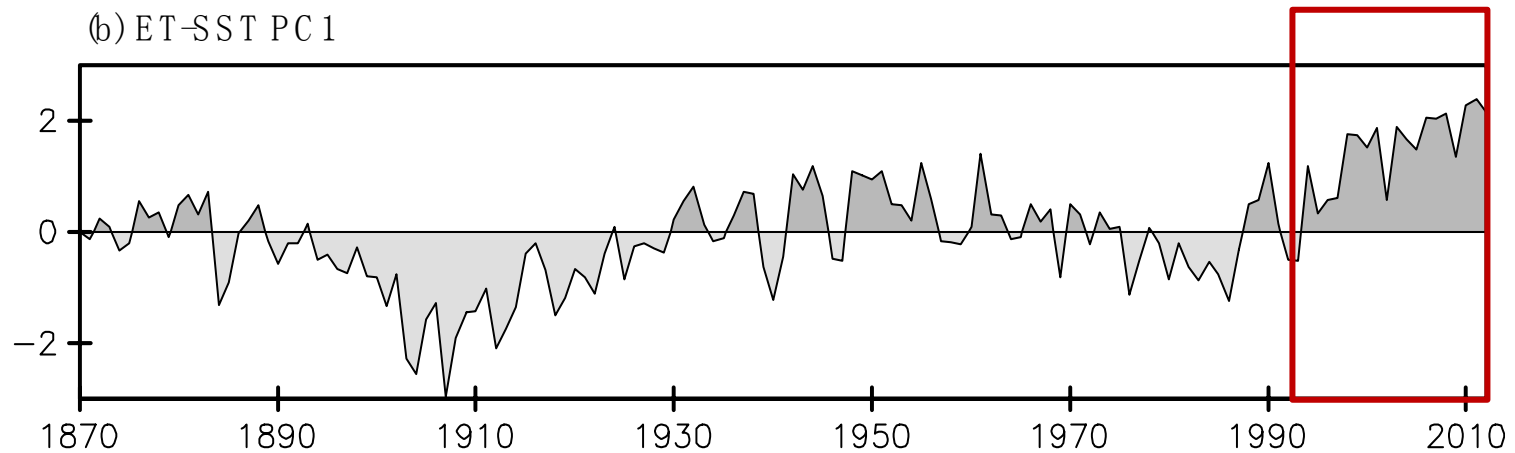
Kug et al. 2015.

Motivation

(a) ET-SST EOF1 (1870-2012)



(b) ET-SST PC1



The period from 1994 to 2013

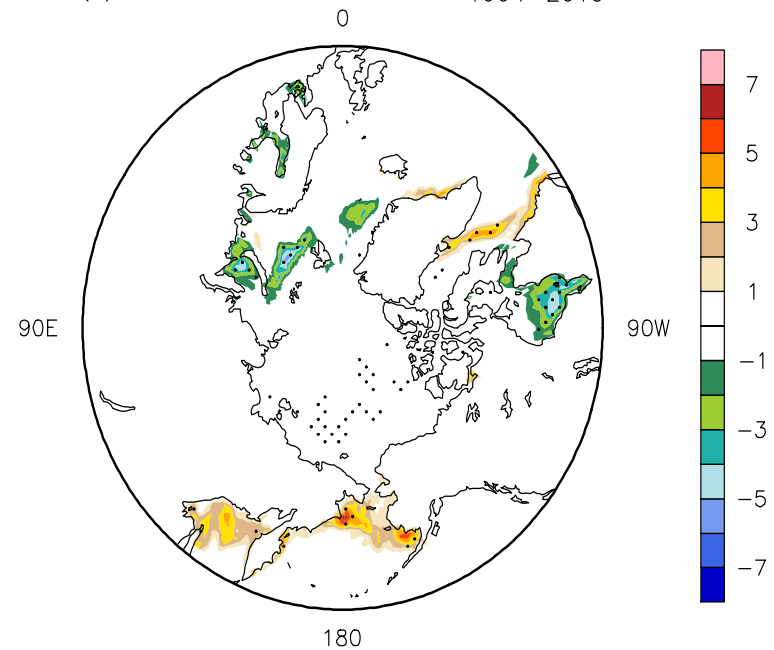
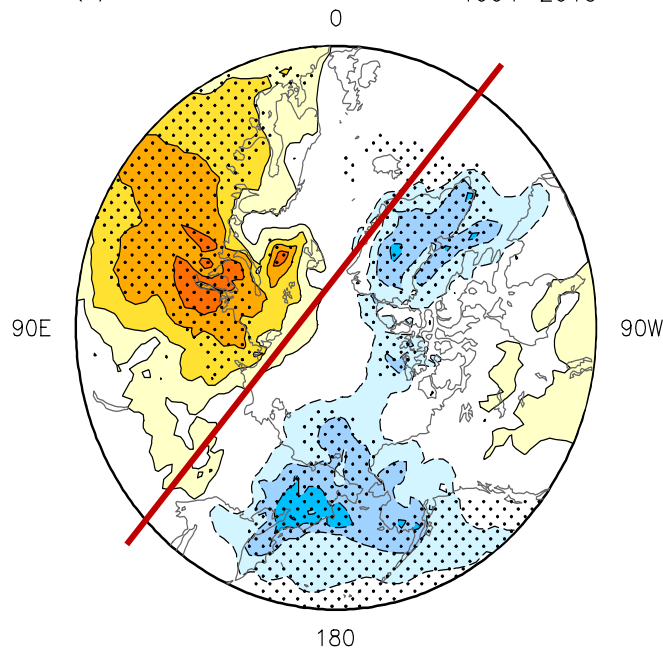
Teleconnection of ET warming (detrended)

Air temperature at 2 m

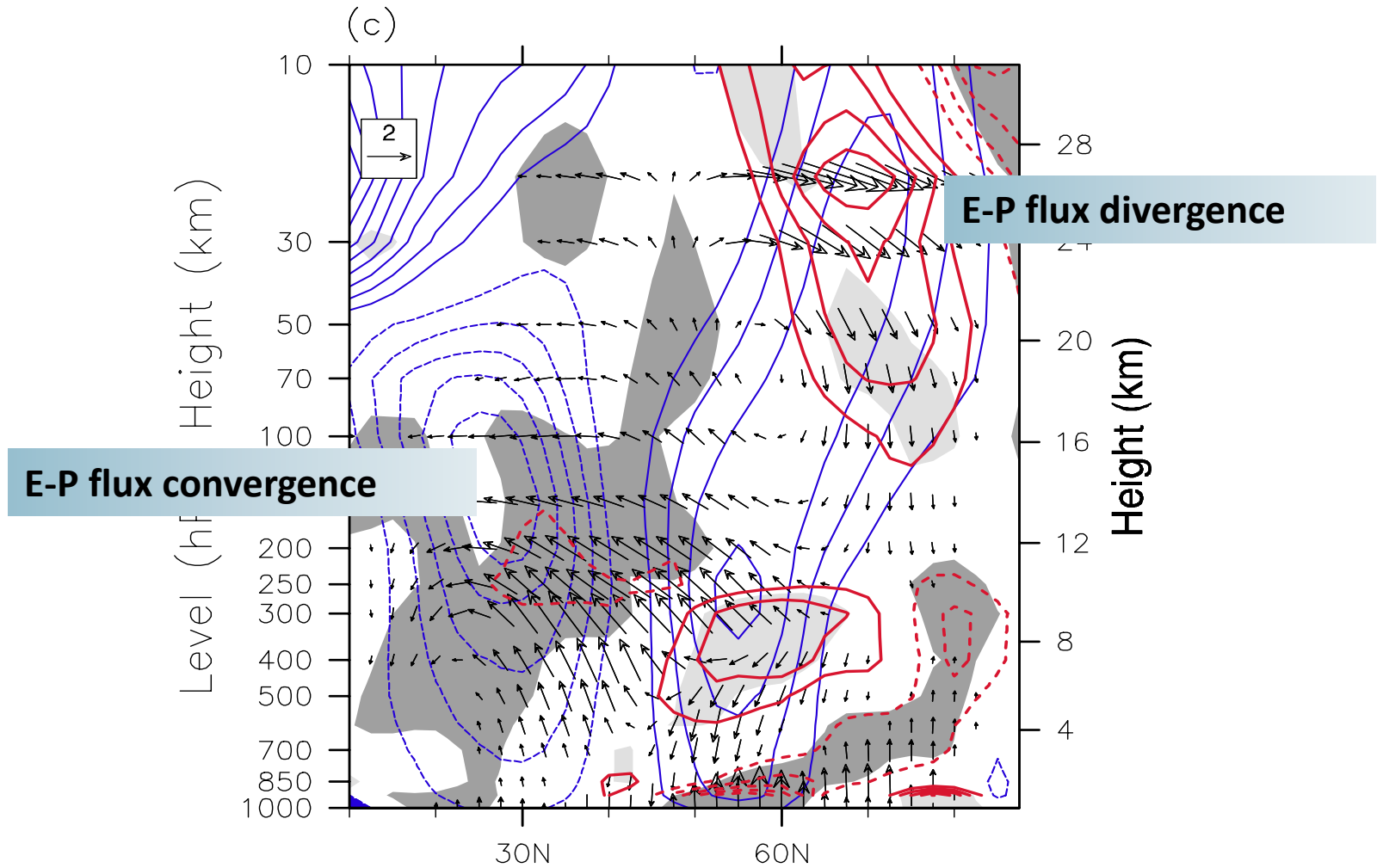
Arctic sea ice cover

(a) T2m 1994–2013

(b) ASIC 1994–2013



Differences in zonal wind (blue contours), E-P flux (vectors), and its divergence (red contour). between high and low ET-SST PC-1



NCAR-CAM₃

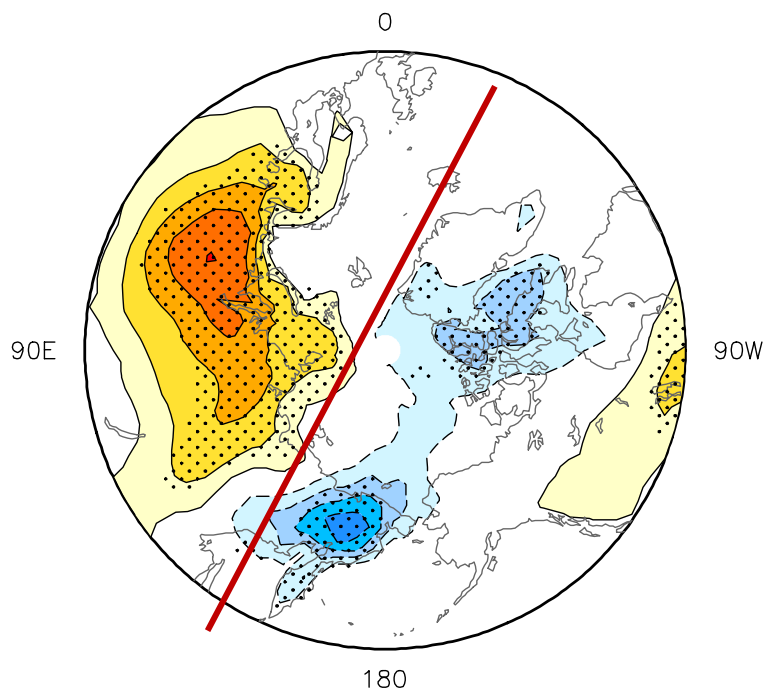
Experimental design (Exp.1)

- 1 **CAM₃ is forced by climatological and monthly-mean SST and sea ice (1979–2010)**
- 2 **For extra-tropical oceans (20°N–70°N), the model is forced by the observed 35-yr (from January 1979 to December 2013, 35 × 12 months).**
- 3 **10 members**

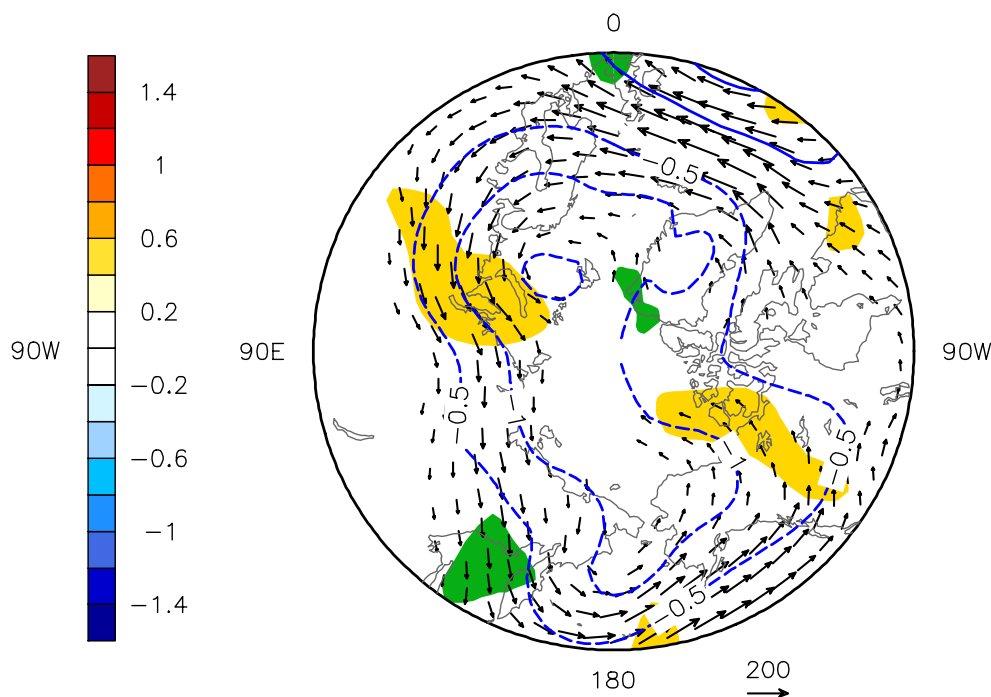


Simulated quantities regressed to ET-SST PC-1 during 1994–2013

Surface air temperature



850-hPa horizontal heat flux



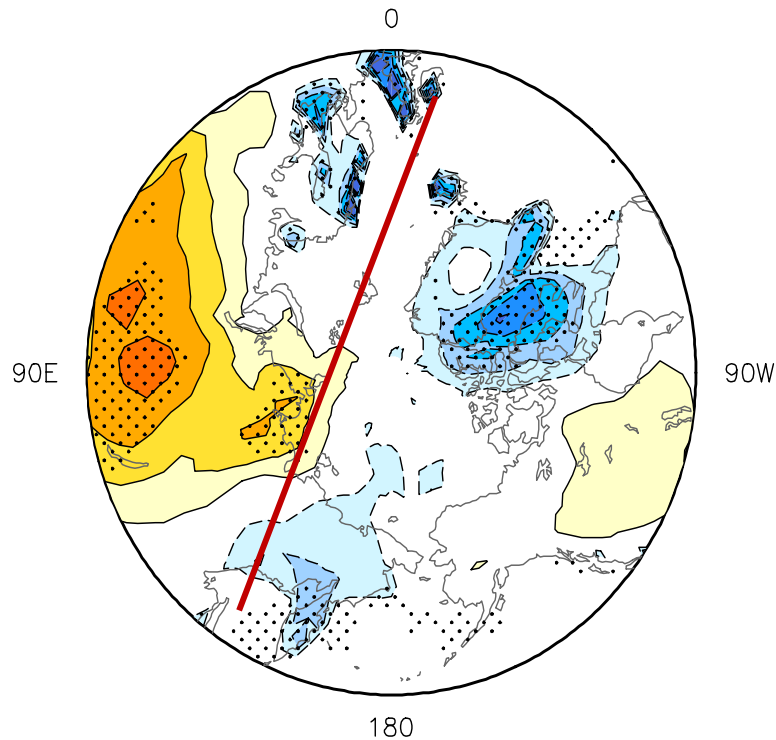
NCAR-CAM₃

Experimental design (Exp.2, 3 and 4)

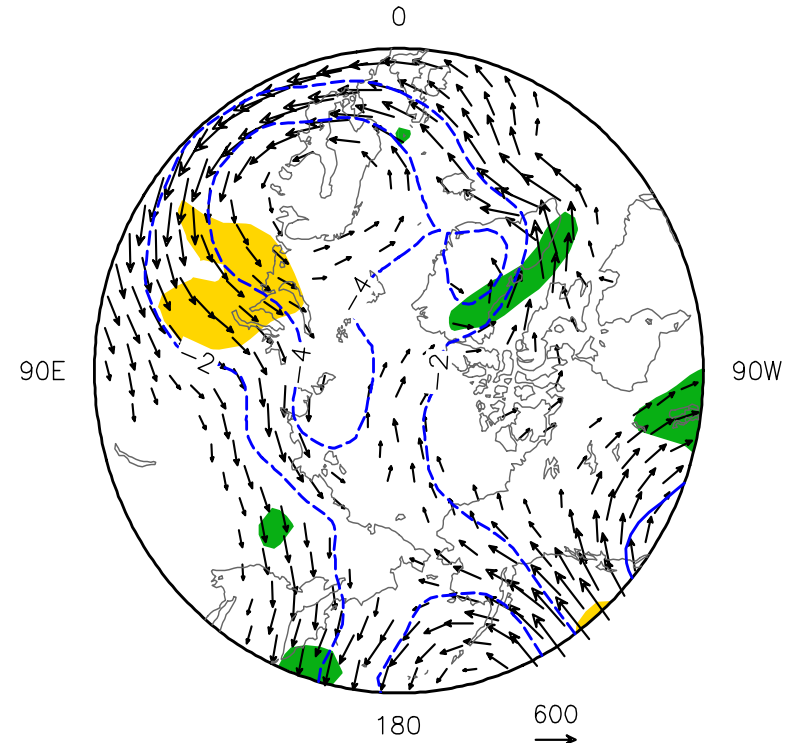
- **Exp.2, control simulations in which CAM₃ is forced by climatological monthly mean SST and sea ice (1979–2010)**
- **Exp.3, sensitivity simulations in which CAM₃ is forced by perturbed winter ET-SST (20°N–70°N)**
- **Exp.4, sensitivity simulations in which CAM₃ is forced by perturbed winter NP-SST (110°E–110°W, 20°–70°N);**

Simulated impact of ET-SST (Exp.3 minus Exp.2)

(a) SAT ET-SST RUN



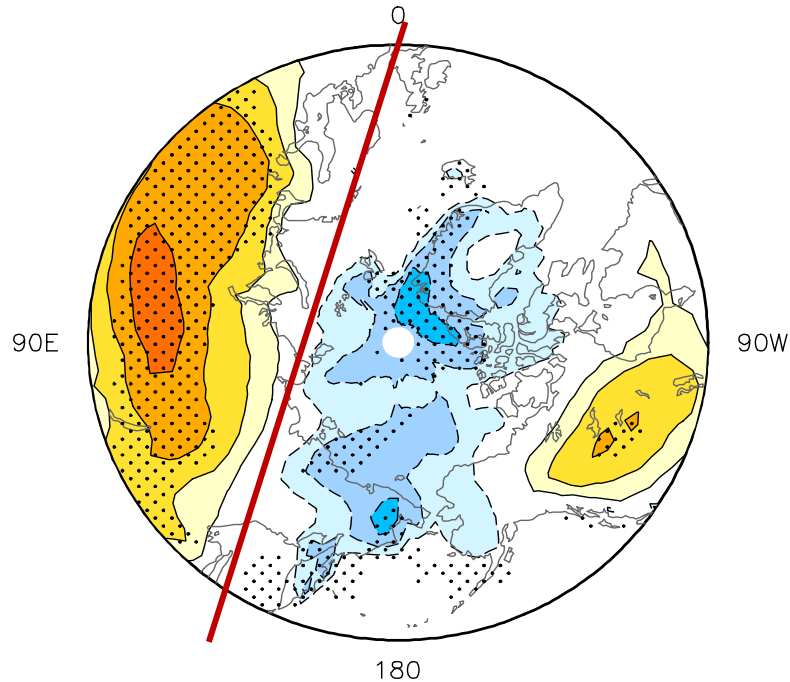
(b) SLP/HHF850 ET-SST RUN



Simulated impact of NP-SST (Exp.4 minus Exp.2)

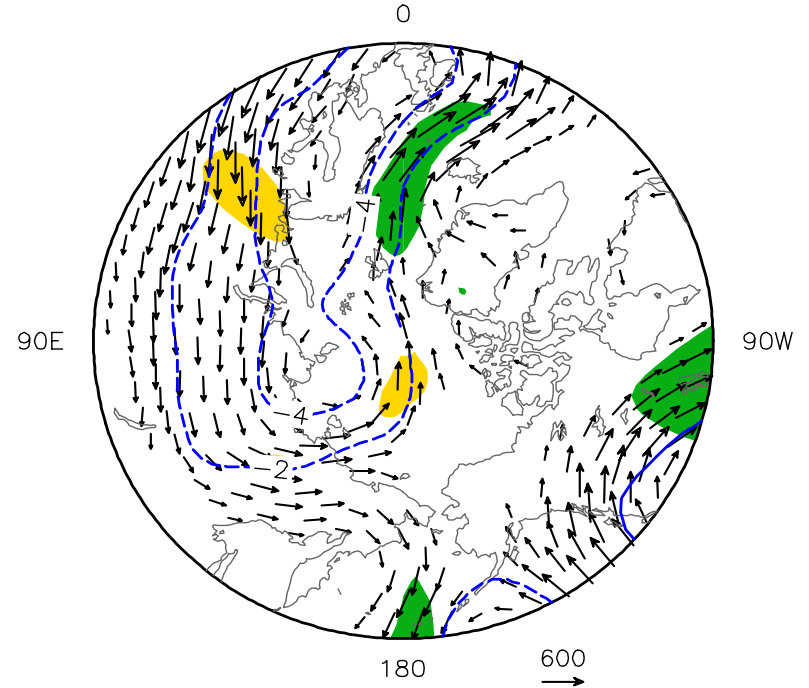
(a) SAT

NP-SST RUN



(b) SLP/HHF850

NP-SST RUN



Conclusion

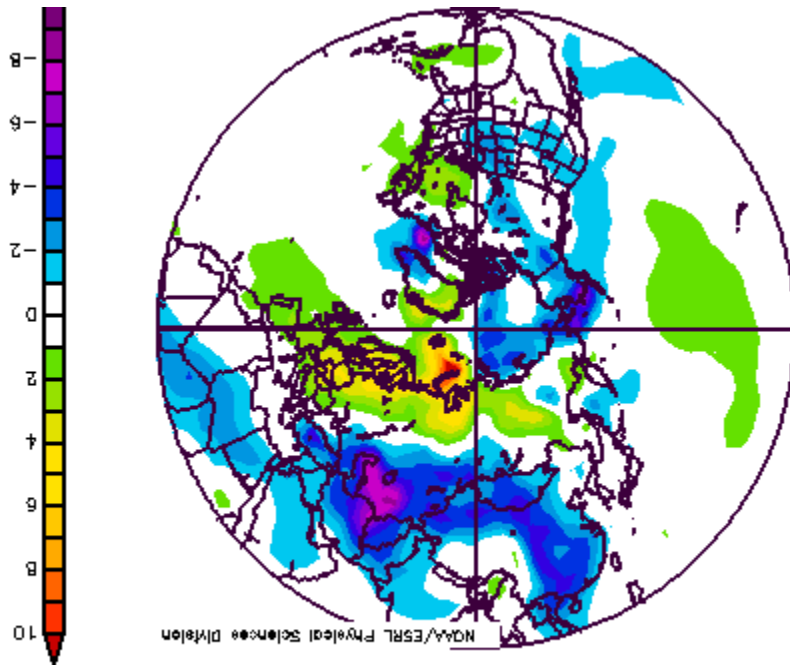
- **The winter extra-tropical warming (in particular, the warming in the Pacific) can influence the winter Arctic warming by strengthening the polar vortex and modulating the near surface atmospheric heat and moisture transport.**

Li, F., Wang, H.J., Gao, Y.Q., 2015, Journal of Climate

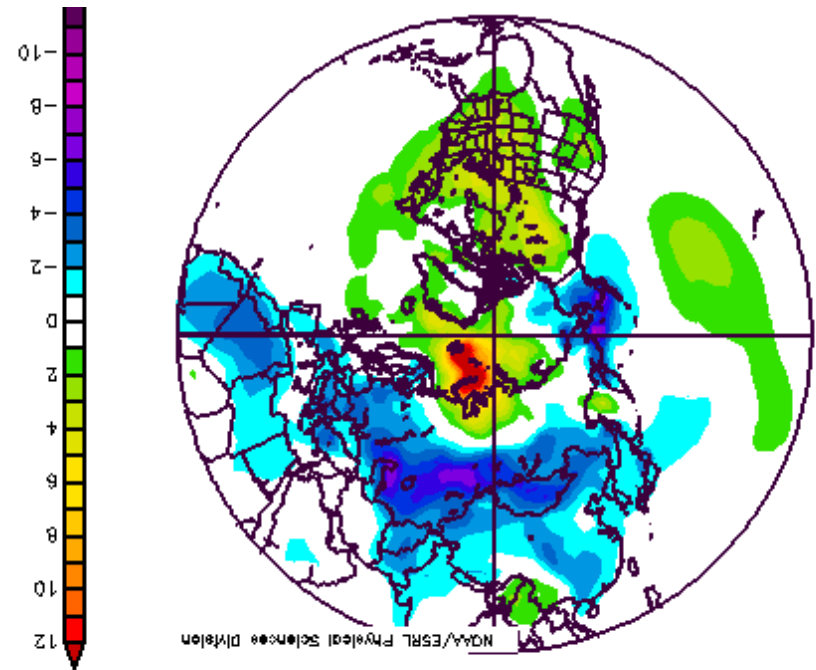


Surface Air Temperature Anomaly

Jan-Feb 2008

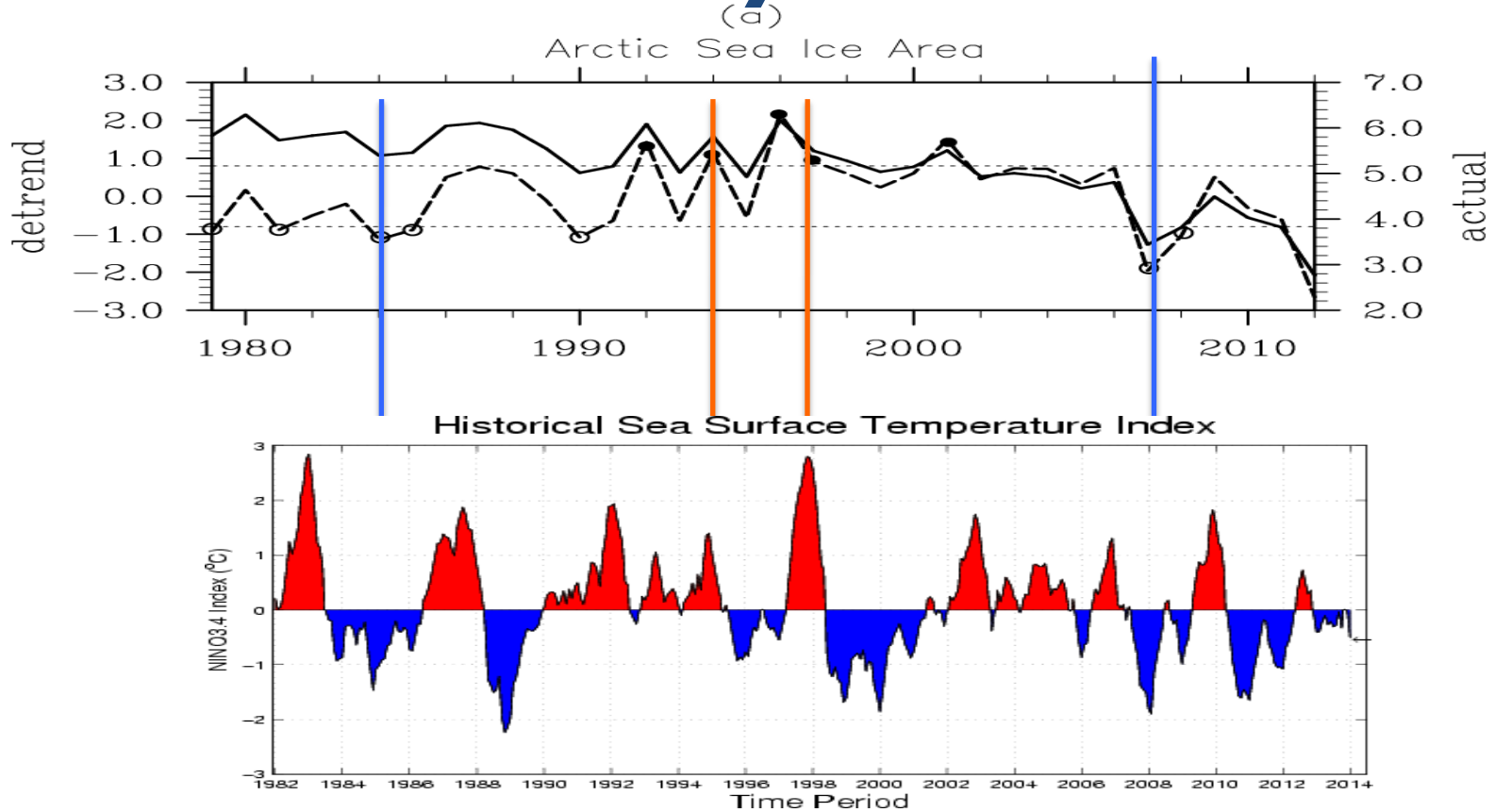


Jan-Feb 2012



Courtesy of Shuanglin LI

Sea Ice Anomaly and ENSO



Han Z., Li S.L., Liu J.P., Gao Y.Q., Zhao P. (2016) Journal of Climate