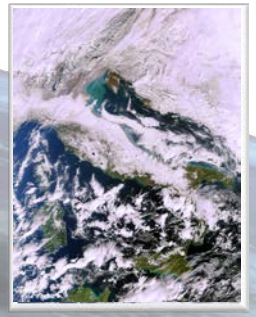
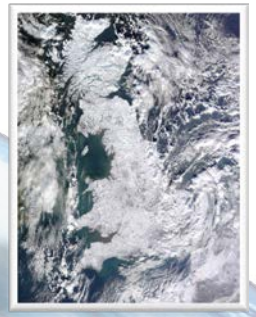
Arctic Change and Possible Influence on Mid-latitude Climate and Weather – Workshop Summary

J. Cohen, X. Zhang, J. Francis, T. Jung, R. Kwok and J. Overland

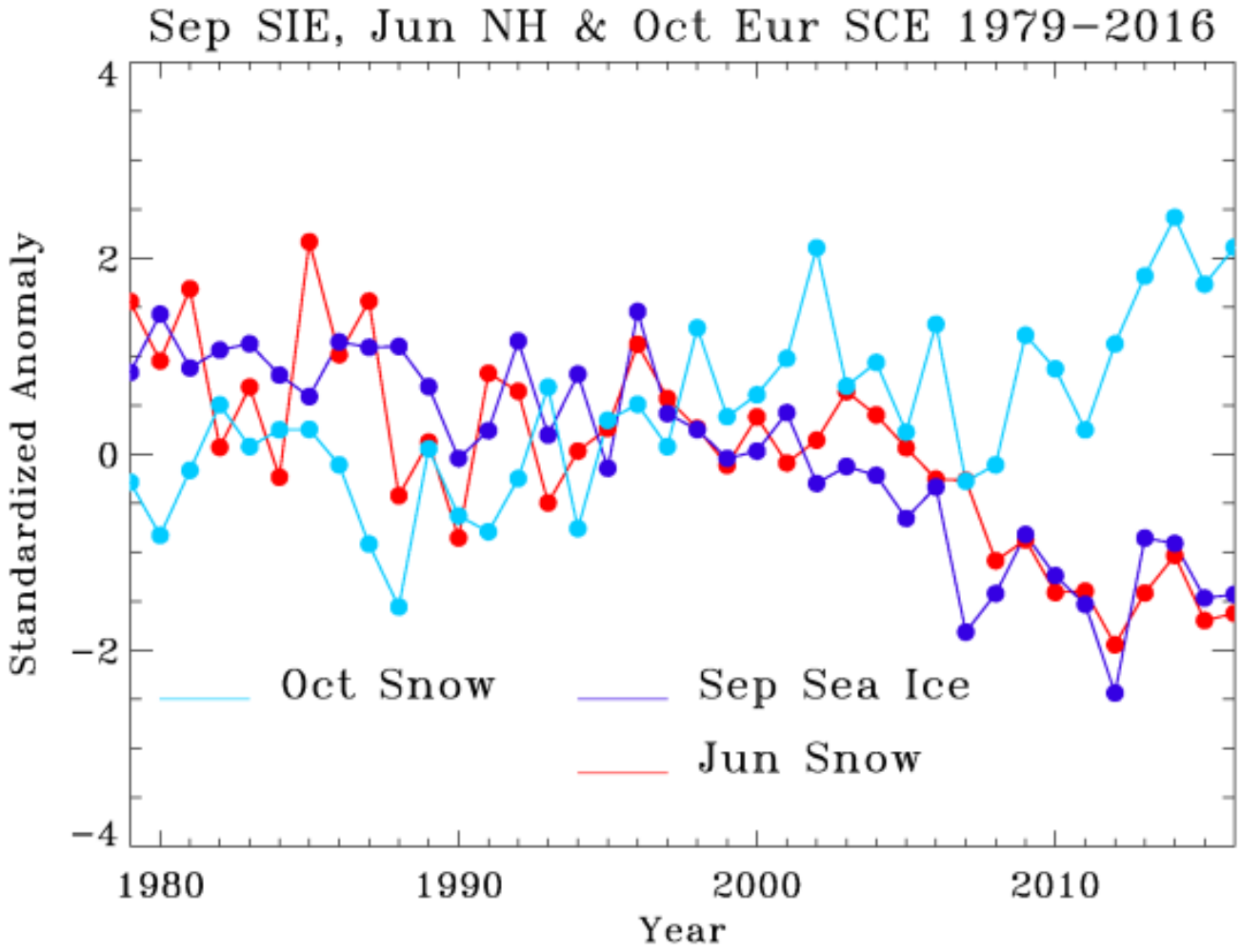
February 14, 2017



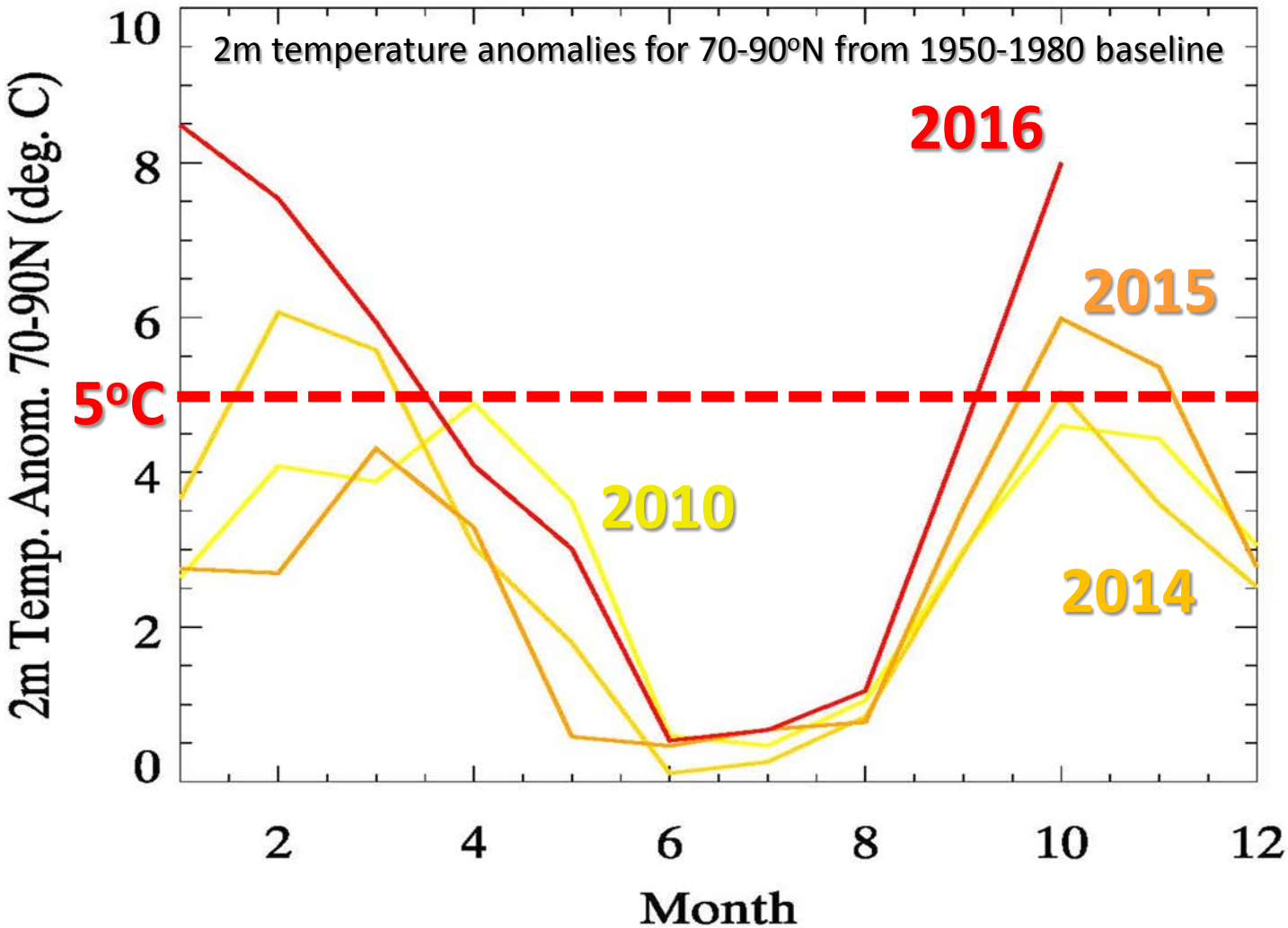


ARCTIC AMPLIFICATION

Sea Ice and Snow Cover Decline



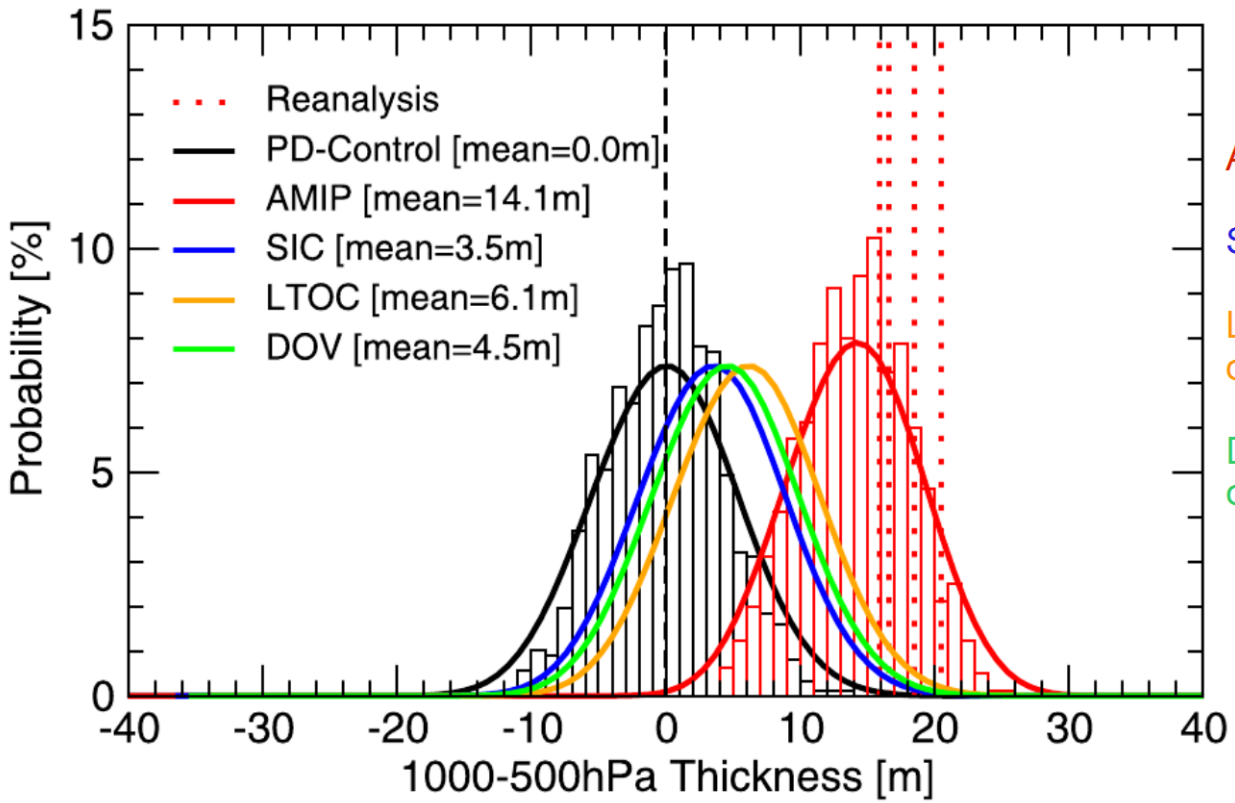
Annual Cycle of Arctic Temperatures



data from NCEP reanalysis/ESRL

Sea Ice loss and full AA

Role of SIC vs decadal ocean variability and internal variability



AMIP : SST + sea ice

SIC : sea ice only

LTOC : long-term oceanic trend

DOV : decadal oceanic variability

Perlwitz et al. (2015)

Sea ice loss is not the only contributor to AA

"local vs remote"? is a difficult question

they are not independent of each other

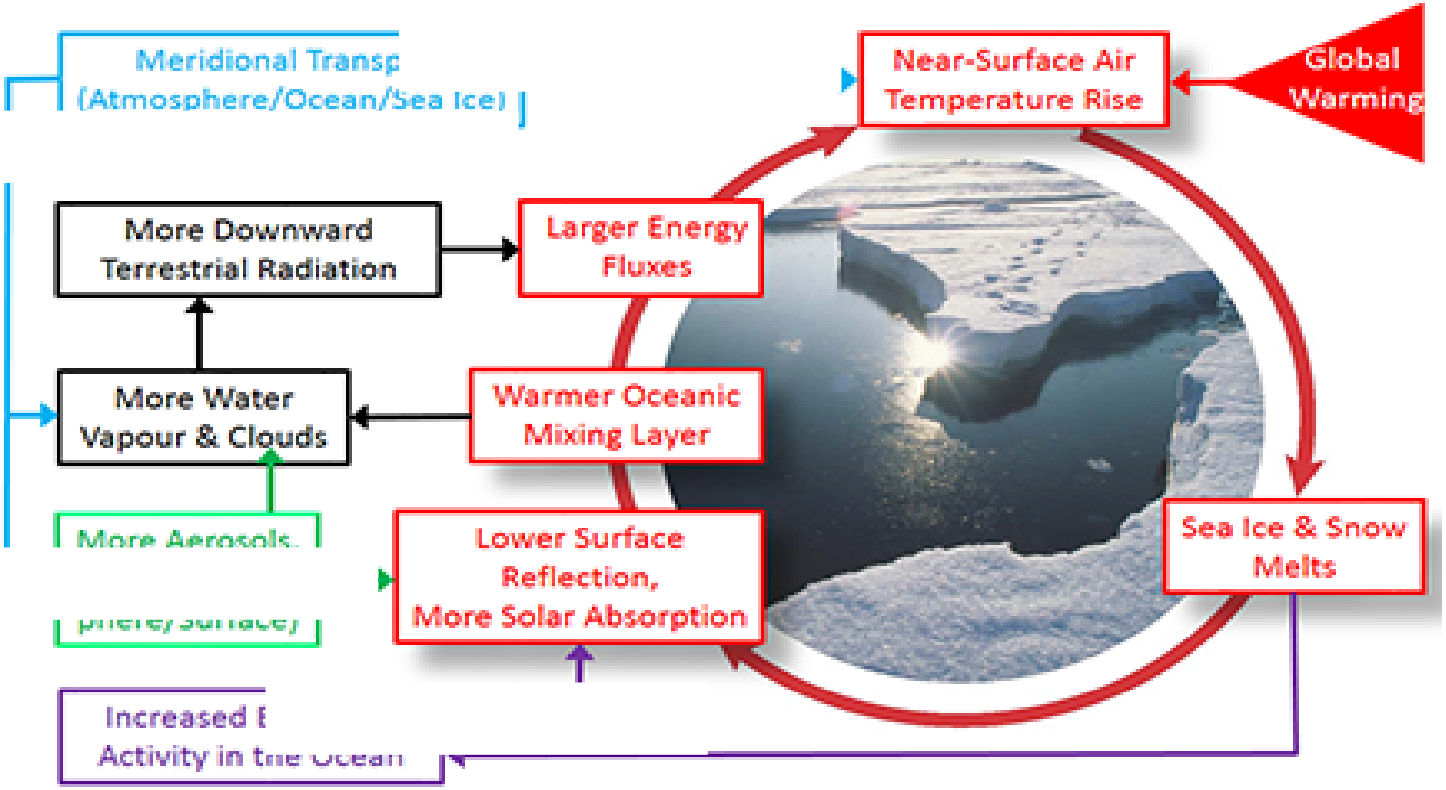
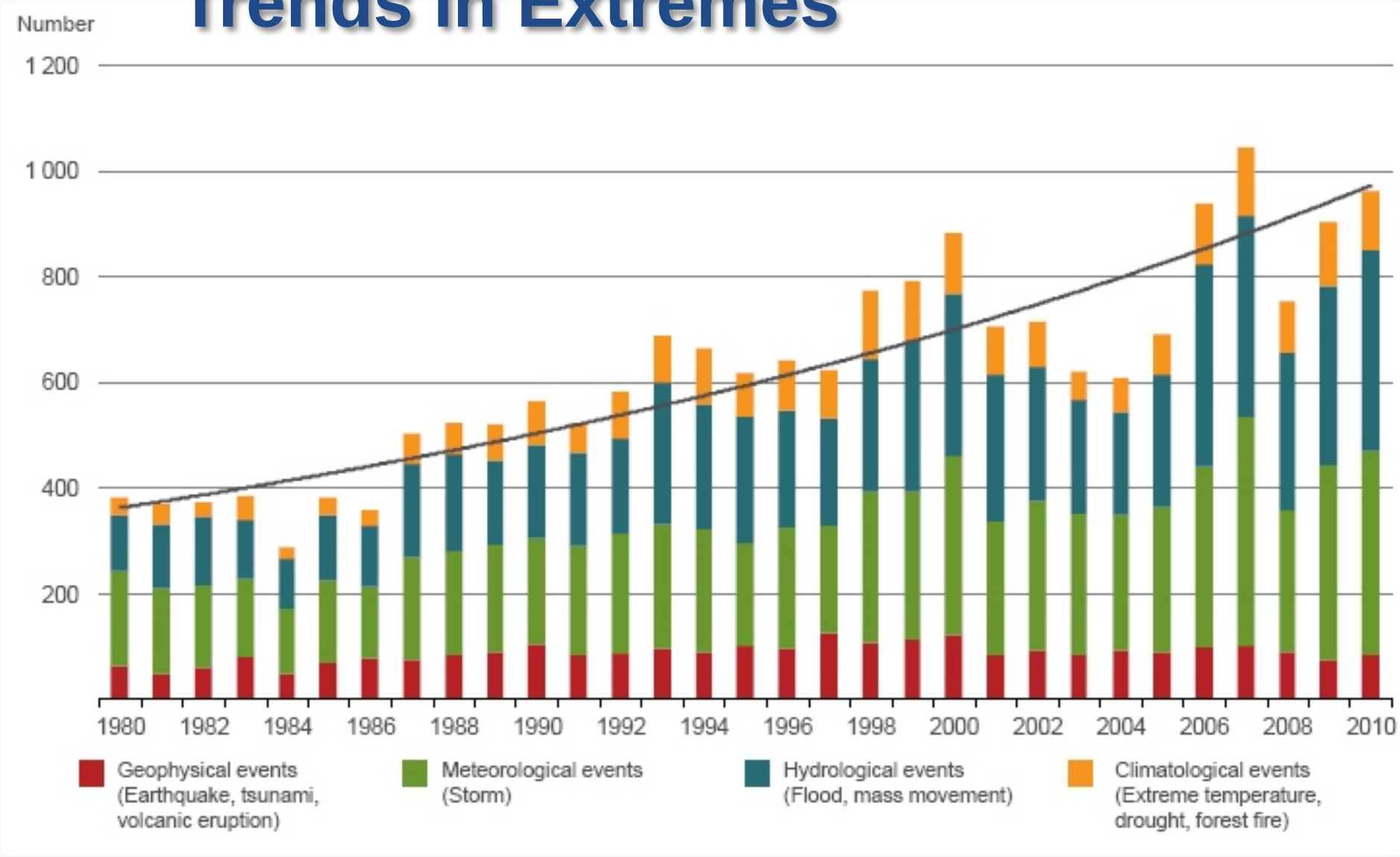


Fig. 2. Examples of feedback processes that amplify an initial near-surface air temperature rise caused by global warming. Red, surface albedo effect; blue, changes in north–south atmospheric and oceanic transport; black, effects of water vapor and clouds; green, effects of aerosol particles; purple, increased oceanic biological activity.

Source: Wendisch, M., et al. (2017), Understanding causes and effects of rapid warming in the Arctic, Eos, 98, doi:10.1029/2017EO064803. Published on 17 January 2017.

EXTREMES

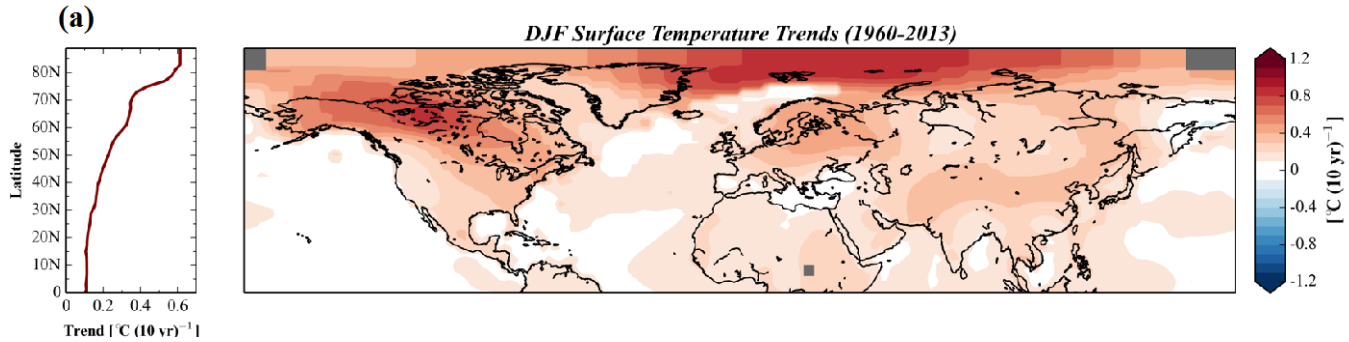
Trends in Extremes

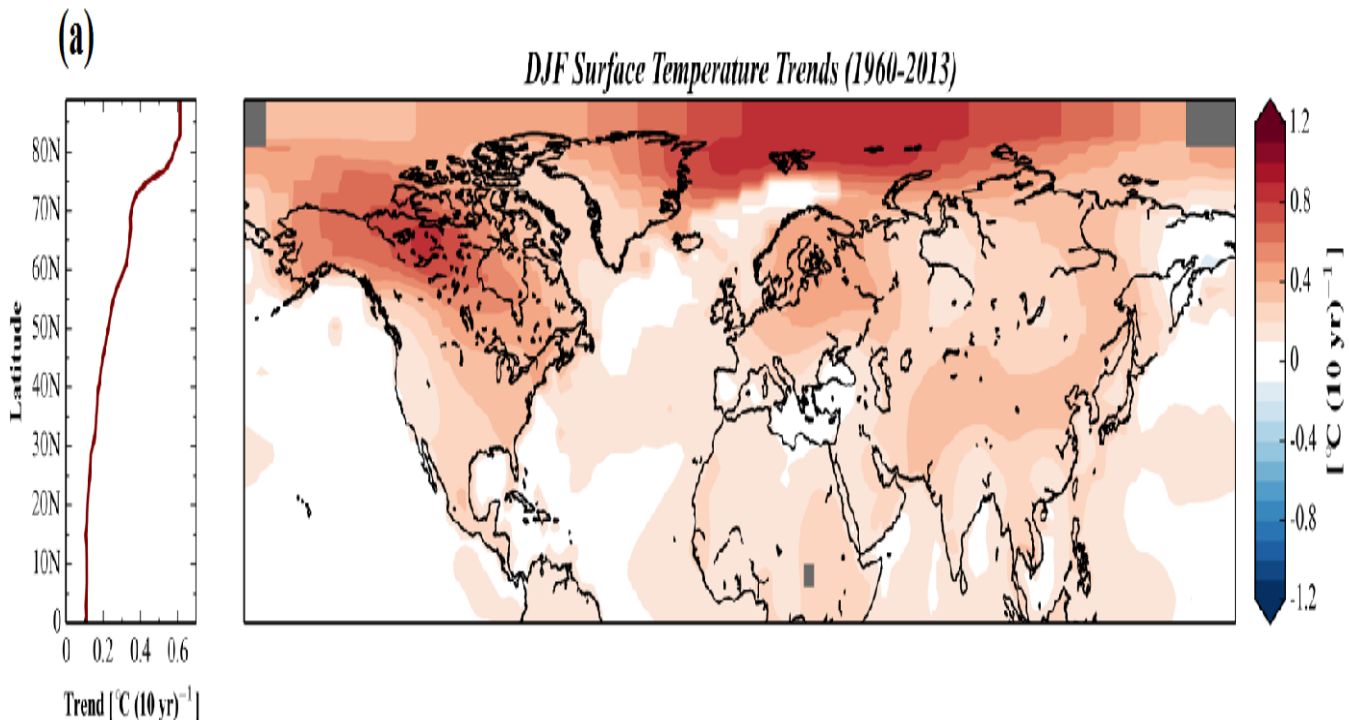


Source: MunichRe

WARM ARCTIC/COLD CONTINENTS

Arctic Amplification



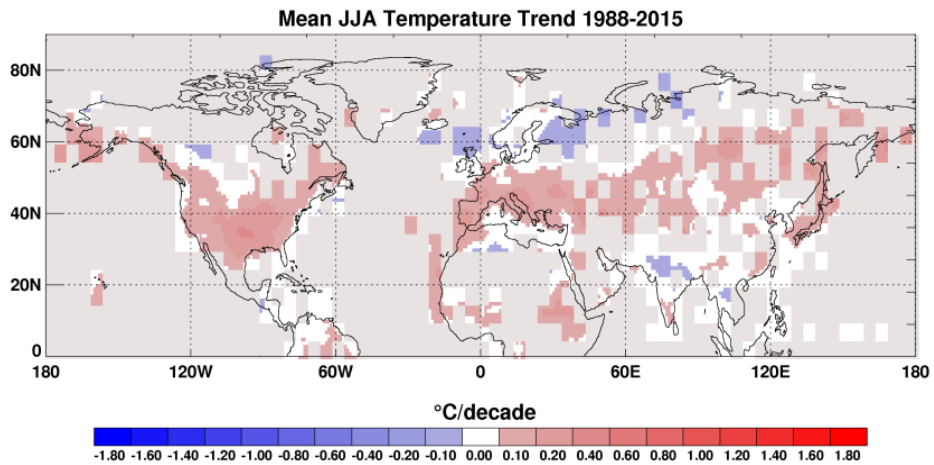


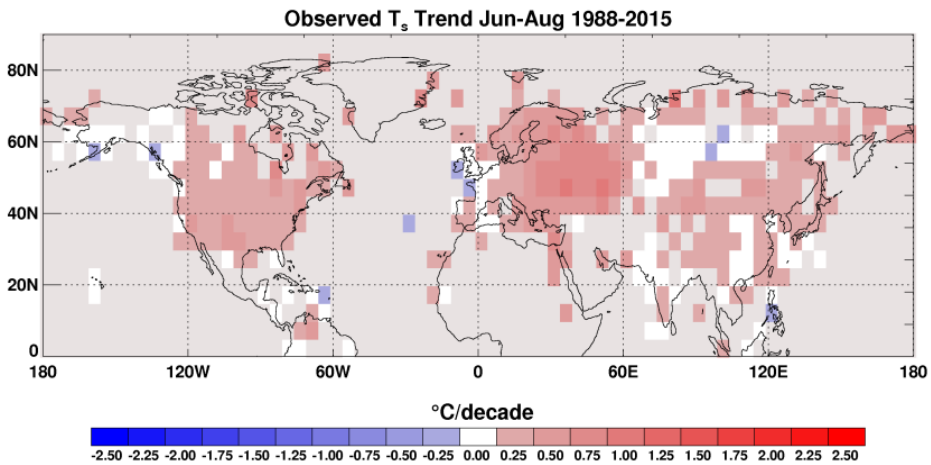
Cohen et al. 2014 Review paper

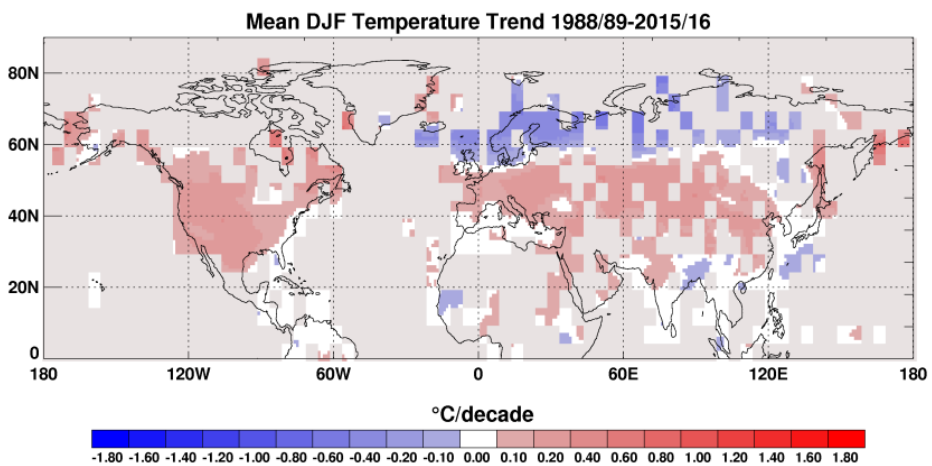
Seasonal Forecast Trends

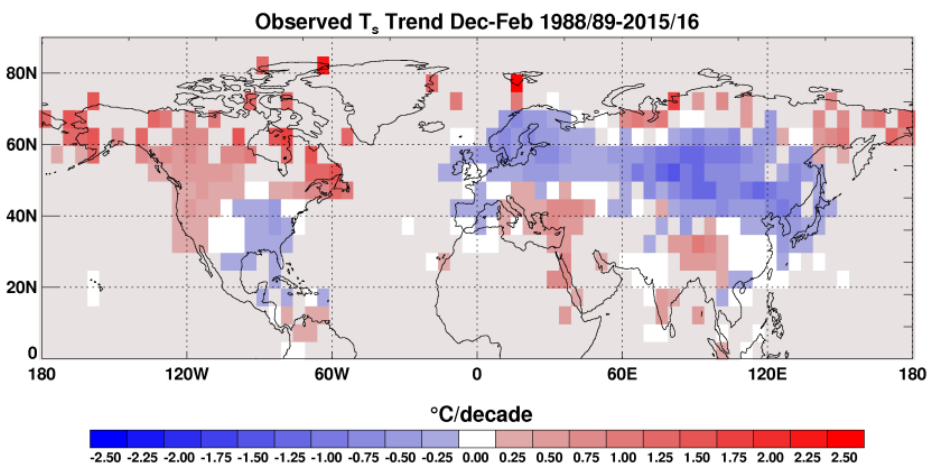
CMIP3

Observations







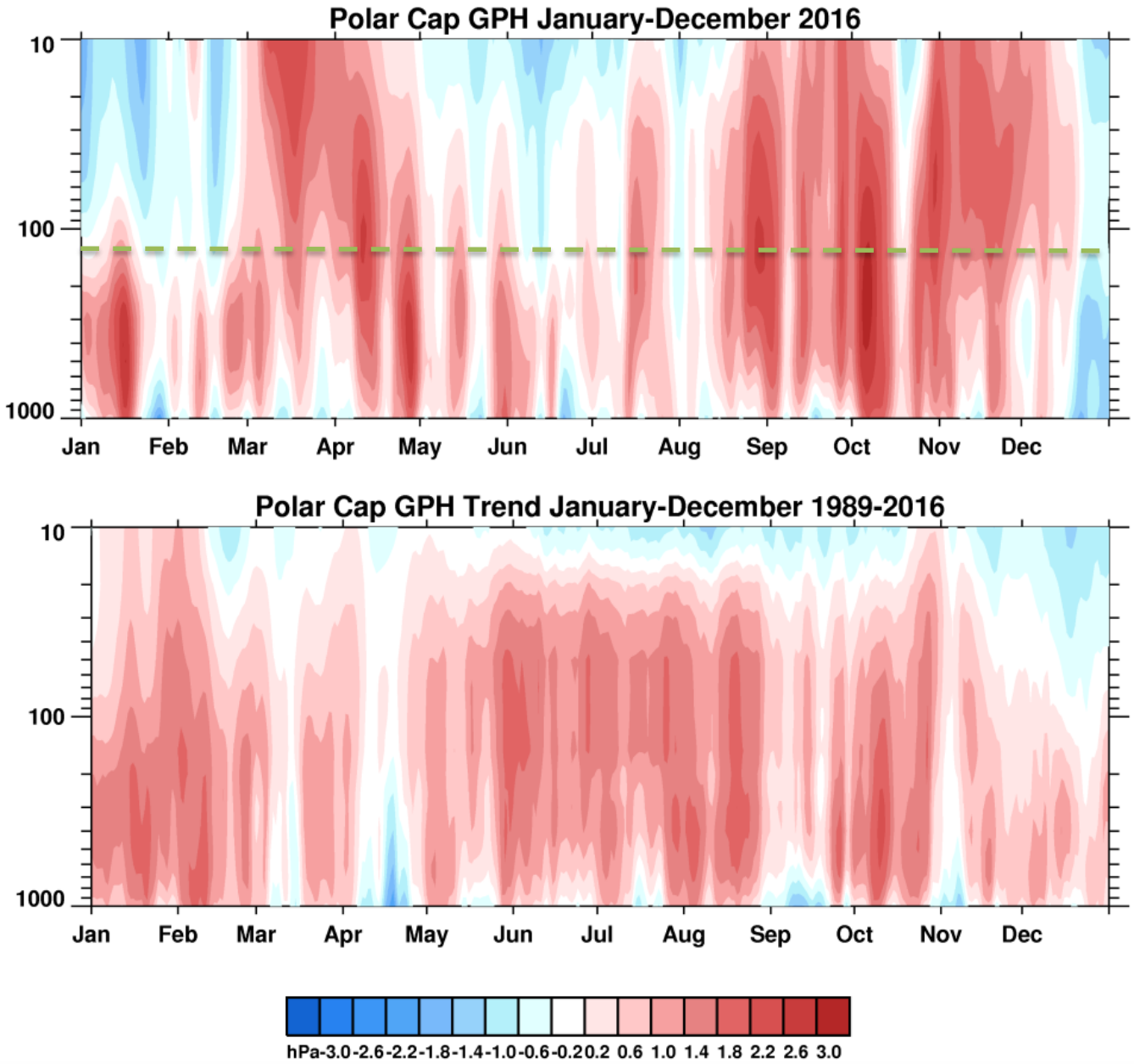


ARCTIC AMPLIFICATION AND MID-LATITUDE WEATHER

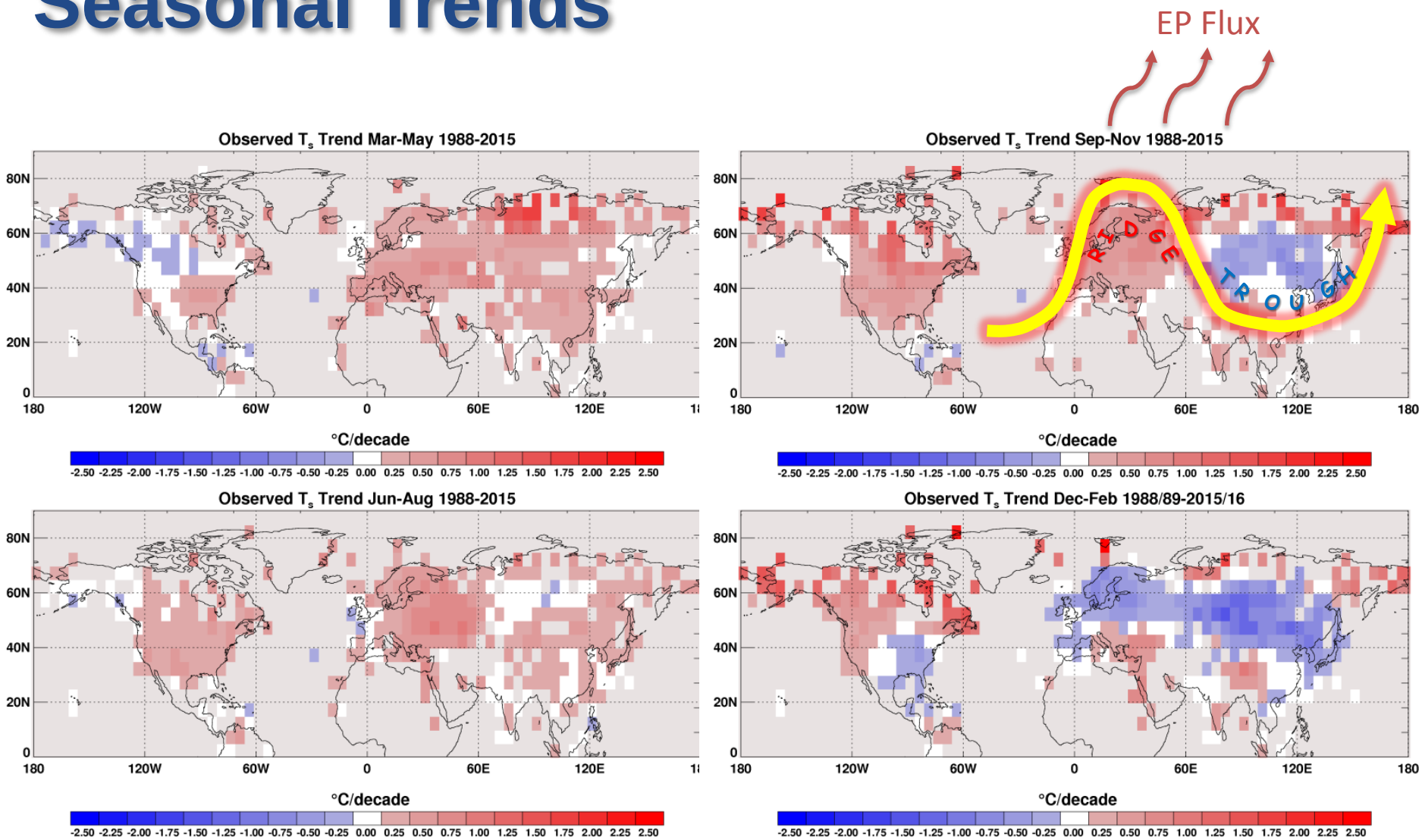
Theories linking AA to Mid-latitude Weather

- Changes to latitudinal temperature gradient
- Changes to the Jet Stream/blocking/wave speed
- Changes to atmospheric waves:
  - Planetary waves (winter)
  - Synoptic scale waves (summer)
- Changes to troposphere-stratosphere coupling
- Support of these theories are conditional and challenged by imperfect observations and models

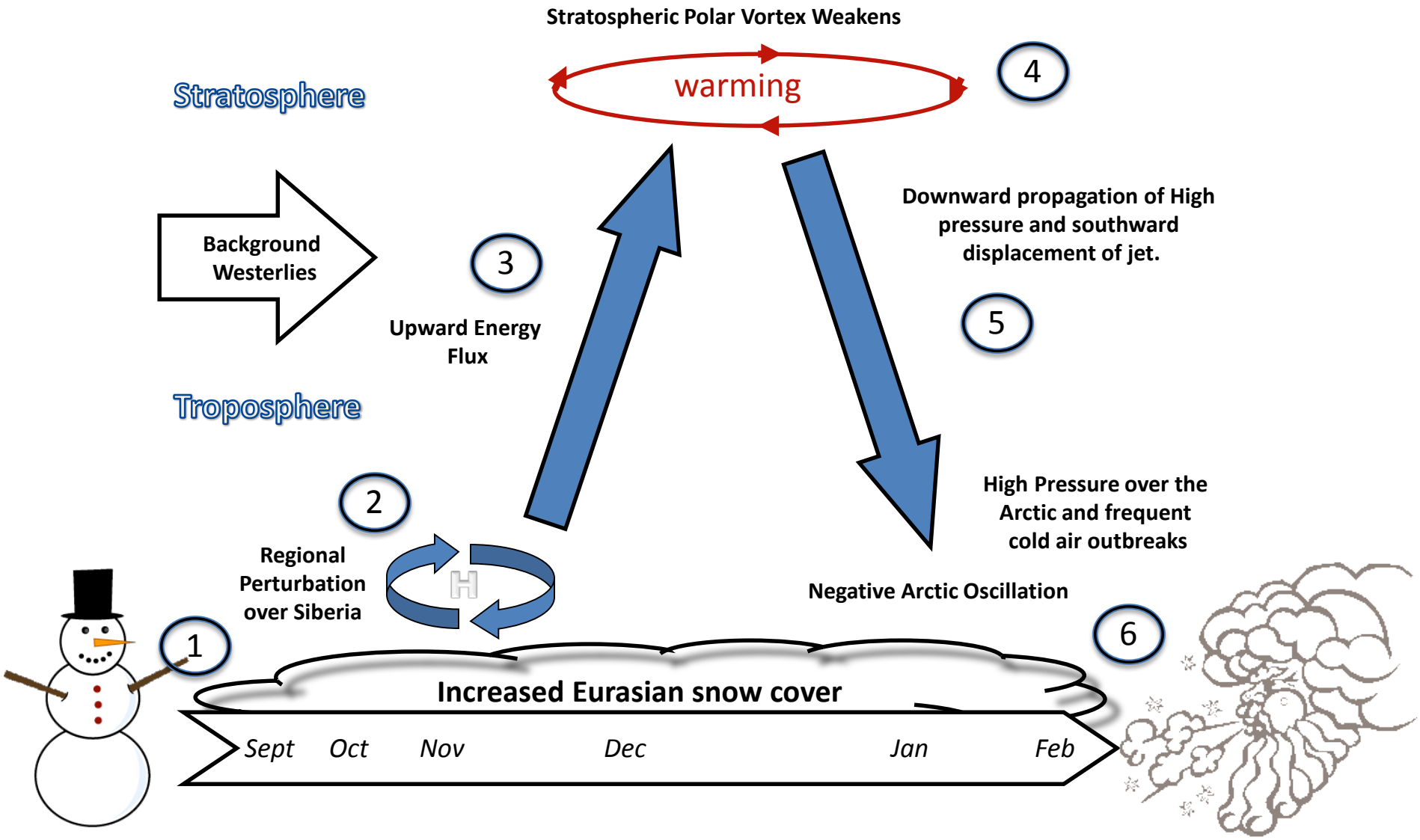
Arctic Warmth reaches to the Stratosphere



Seasonal Trends

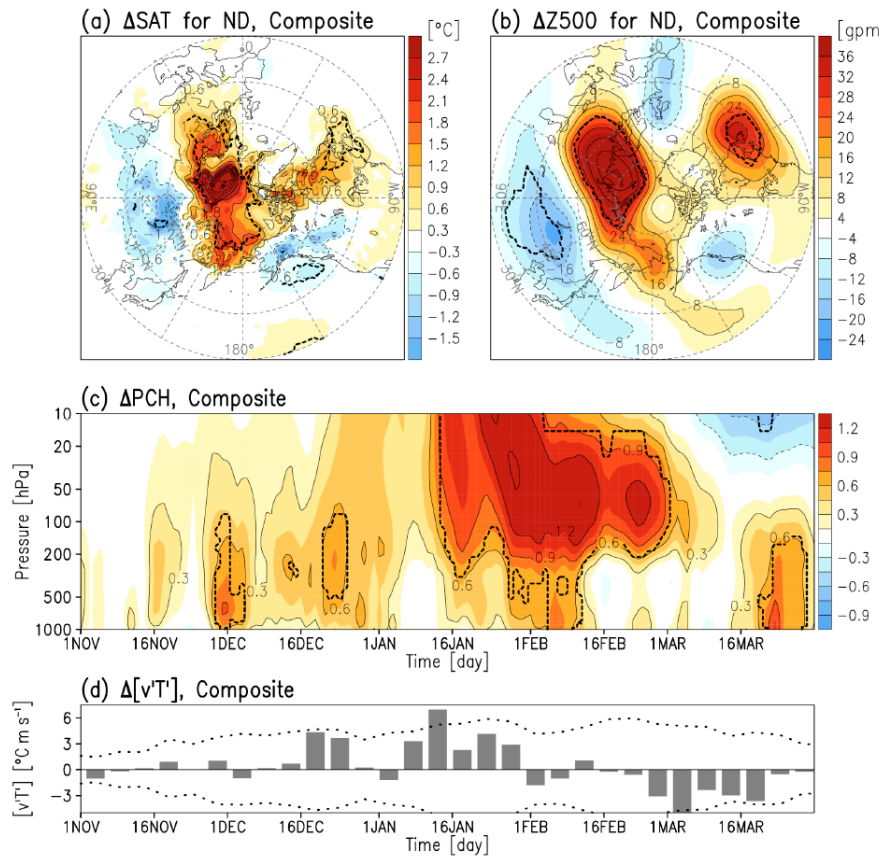


Extensive Snow Forced Cold Signal

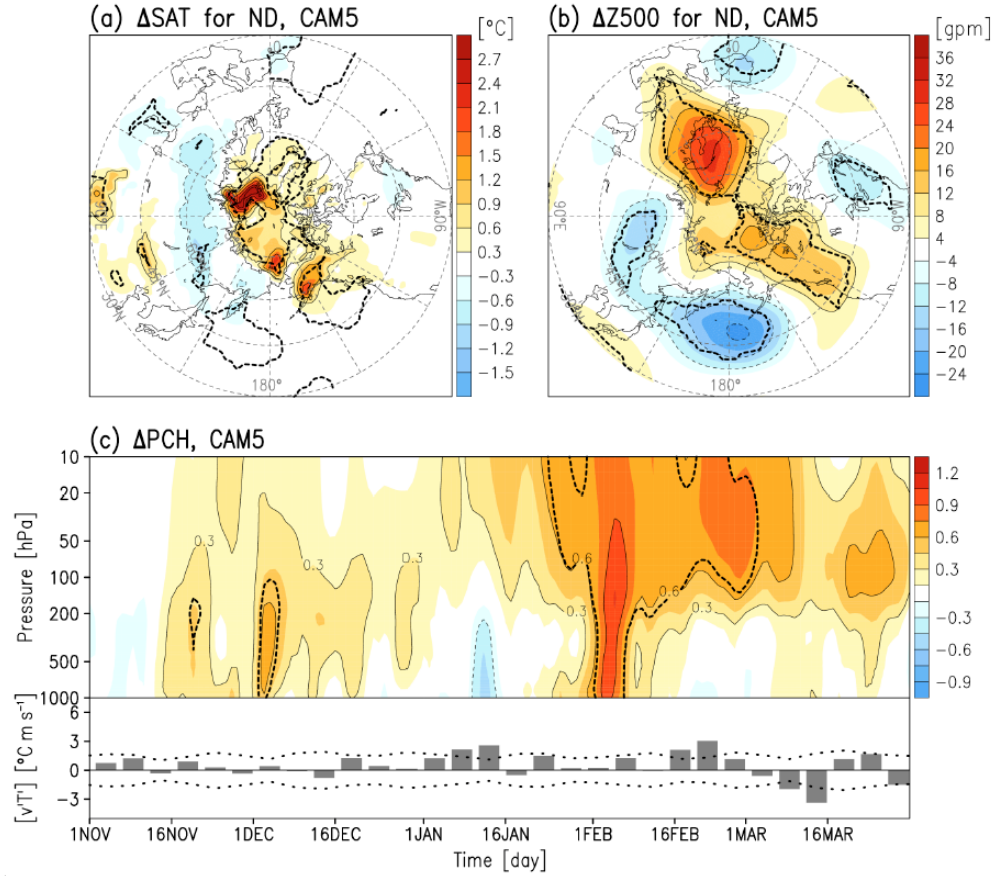


Reduced Sea Ice Forced Cold Signal

observations



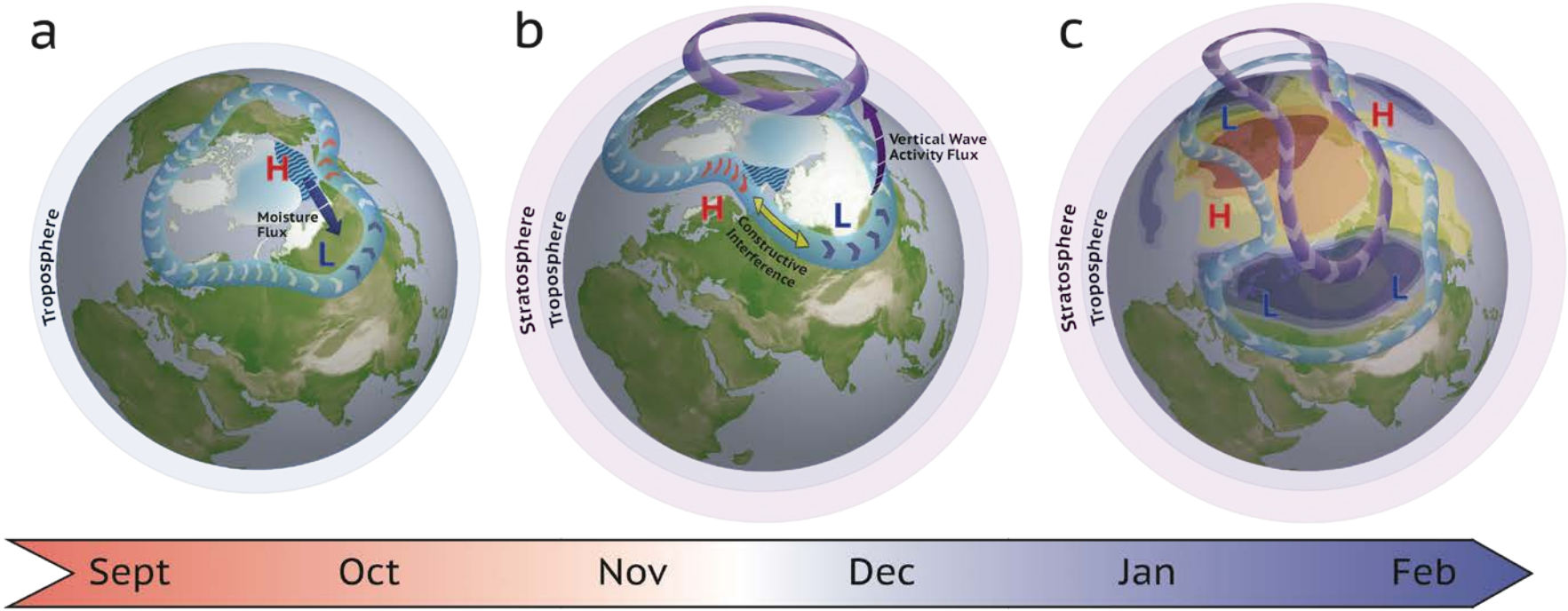
model



Some model runs forced with low sea ice have been able to simulate atmospheric response as observed.

Kim et al. 2014

Synthesis of Sea Ice and Snow Cover



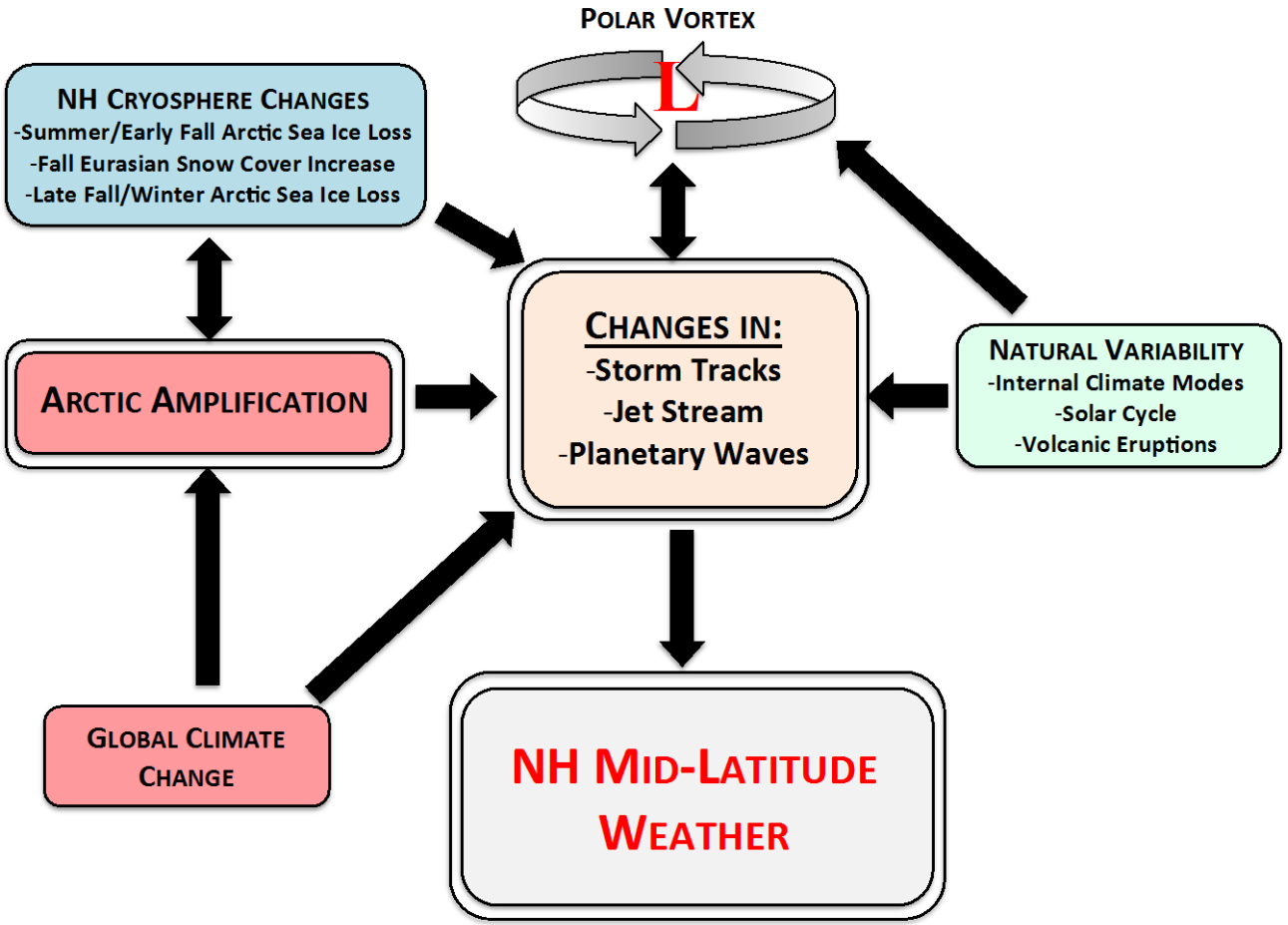
Cohen et al. 2014 Review paper

CHALLENGES- THEORY, OBSERVATIONS AND MODELS

Challenges with Data and Models

- Short time series in observations since AA
- Model deficiencies
- Uncoordinated modeling studies
- Biases and uncertainties in metrics for quantitative analysis
- Still more and more observational and modeling studies argue that a changing Arctic is influencing mid-latitude weather

Mid-latitude Weather is Complicated



Cohen et al. 2014

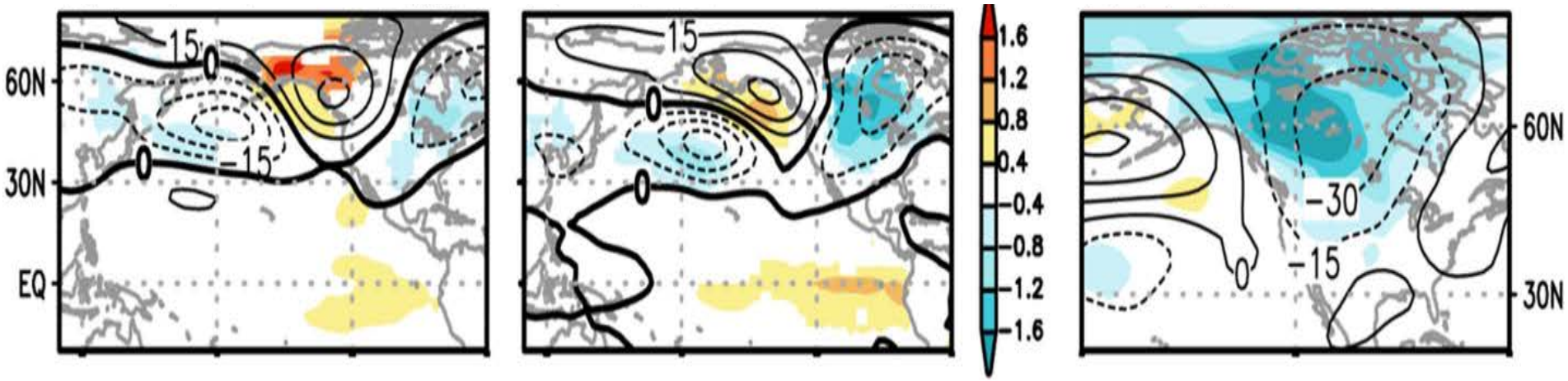
Dependence of Teleconnections on Background State

Response of Autumn-Winter 300 hPa Heights

PDO Influence when Chukchi Sea is cold

PDO Influence when Chukchi Sea is warm

Different in PDO Influence warm minus cold



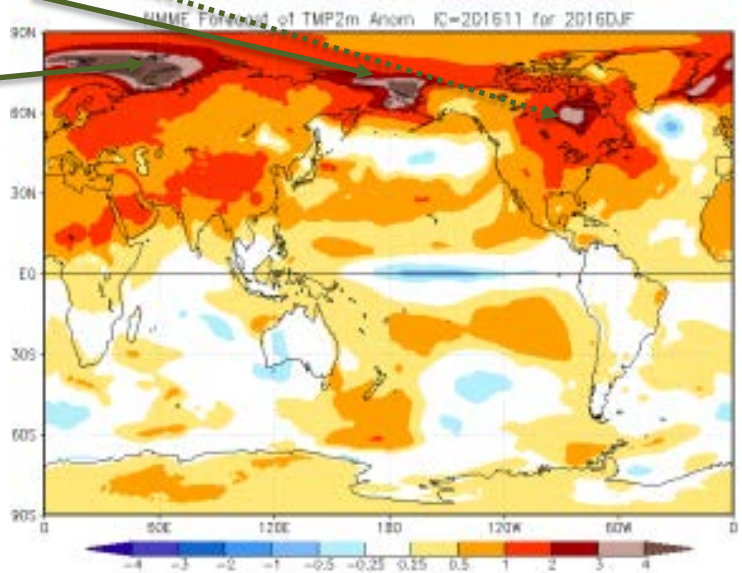
Sung et al. 2016,
Overland et al. 2016

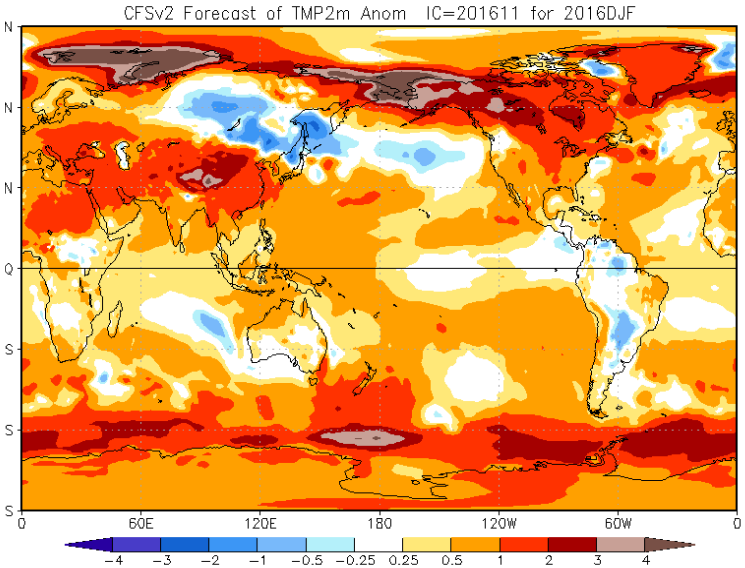
NATURAL VARIABILITY

Dynamical Winter Forecasts 2016/17

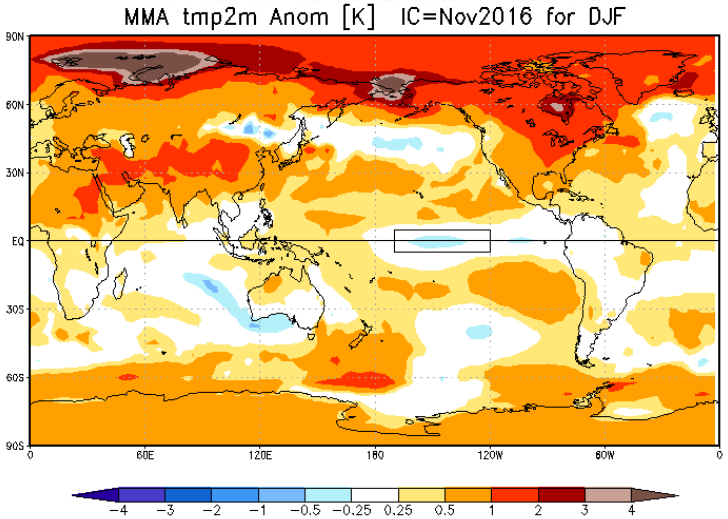
Triggers for/out of phase with continental temperature anomalies

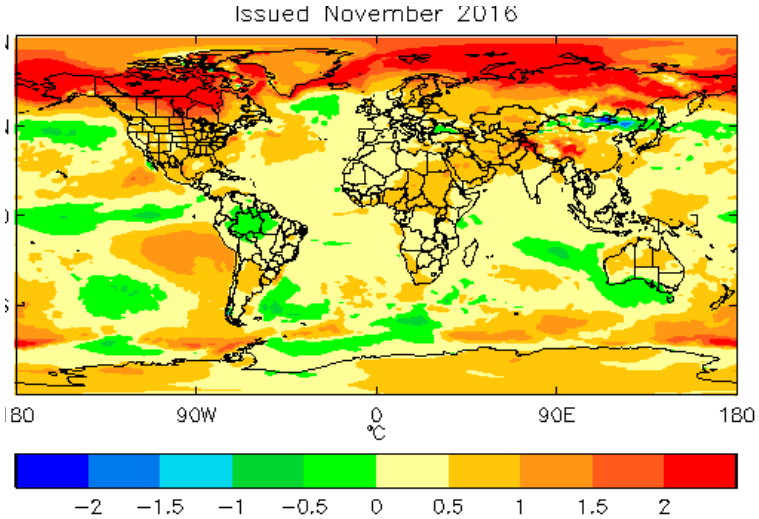
US Models



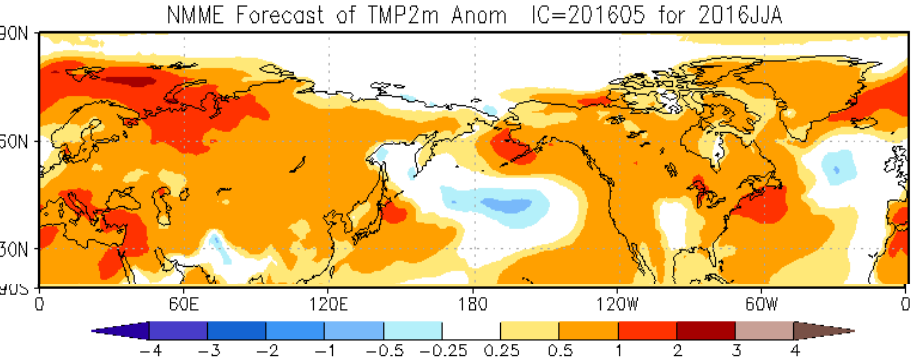


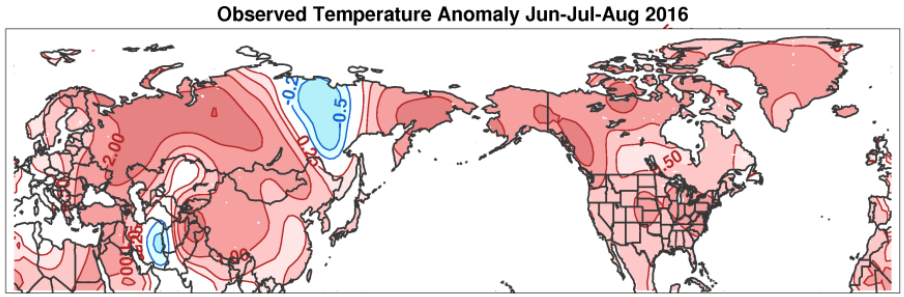
International/ European Models

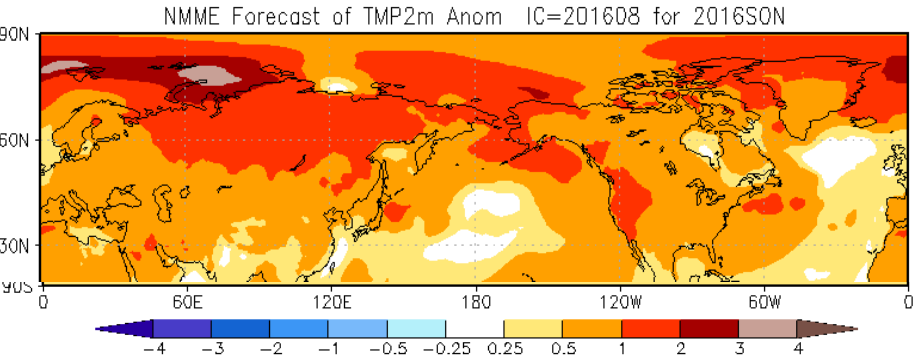


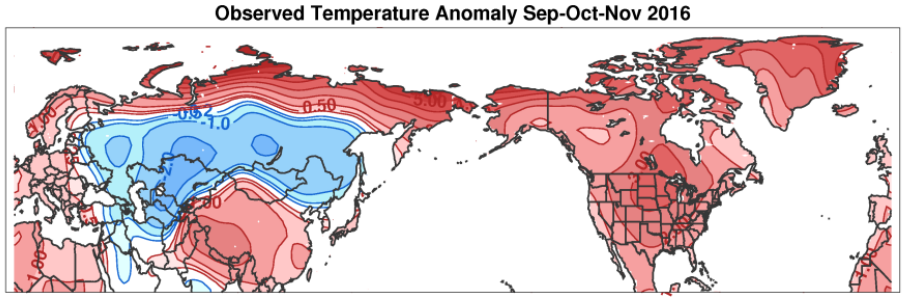


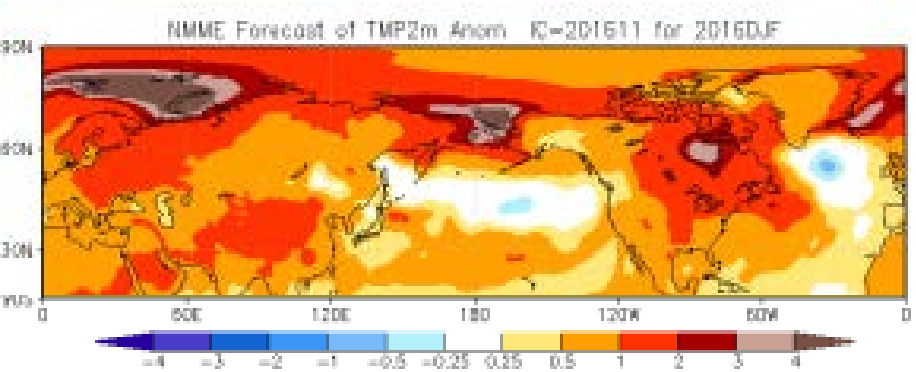
Dynamical Winter Forecasts 2016

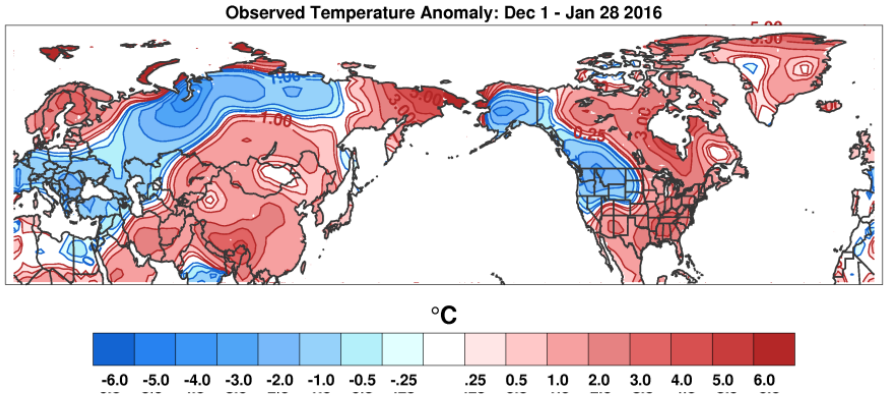




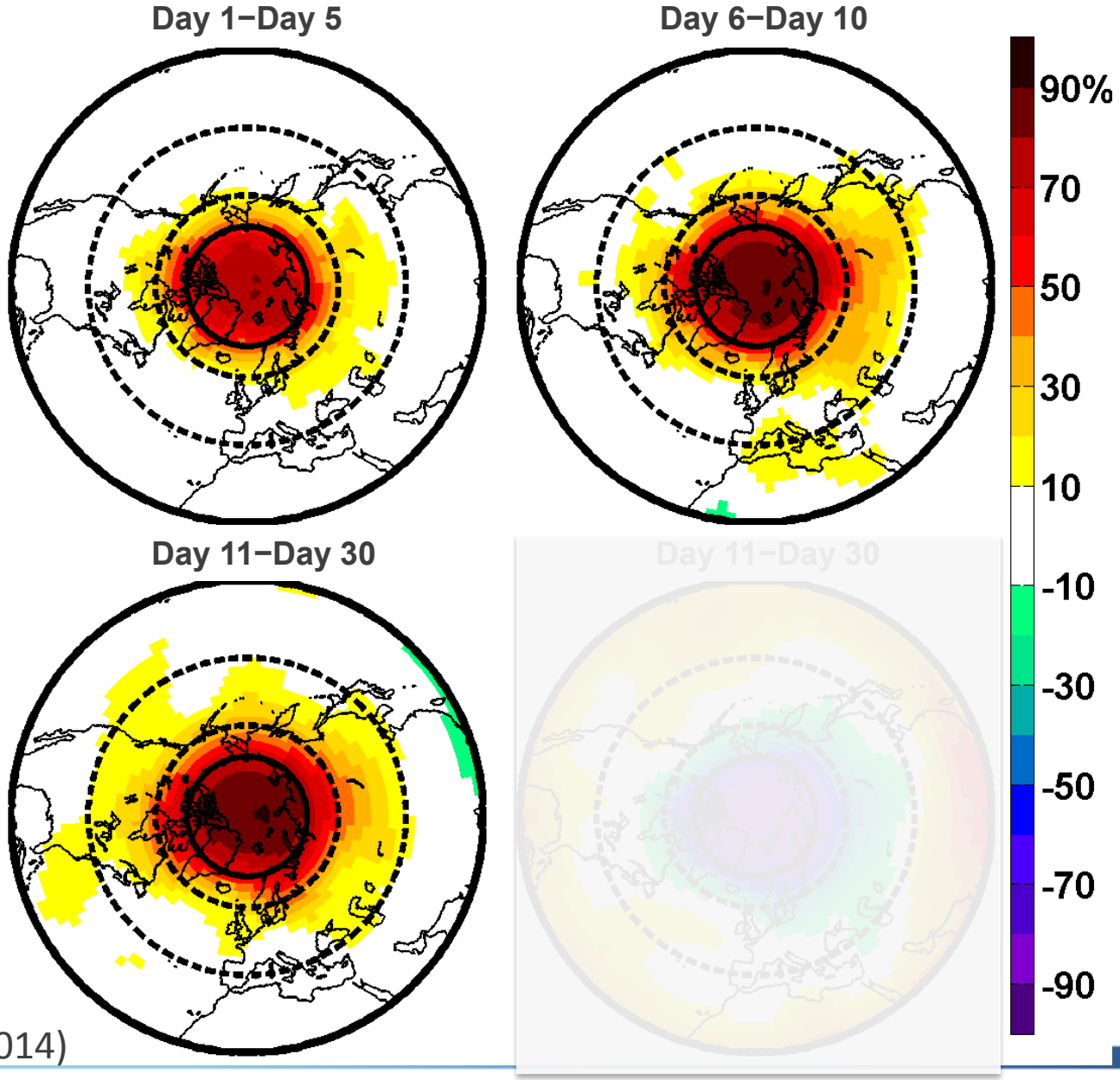








Arctic relaxation



Jung et al. (2014)

END

Recent Cold Winters not Well Simulated

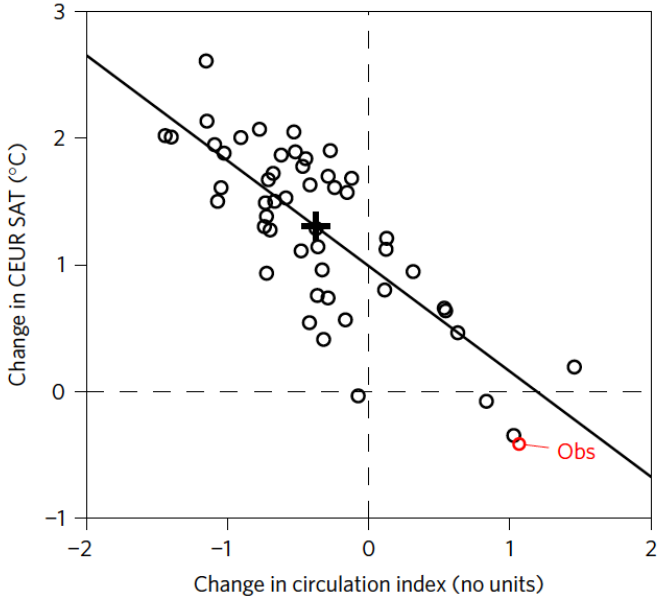


Figure 3 | Relationship of changes in observed and simulated circulation index to CEUR SAT changes. Changes from 1979–1989 to 2002–2012 for each AOGCM simulation (black) and for observed changes (red) in circulation index, ΔZ (ref. 25), and SAT[1]. The cross indicates the forced response (AOGCM mean), and the line indicates the AOGCM linear regression ($r = -0.77$ and $p < 0.0001$).

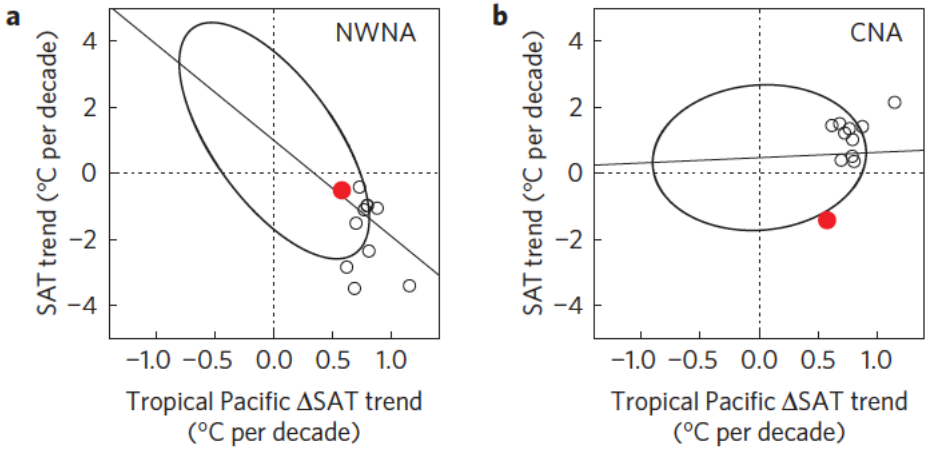


Figure 3 | Simulated and observed winter trends from 2001–2002 to 2013–2014 in North American SAT and the tropical Pacific SAT gradient. **a**,**b**, SAT trends averaged over northwest North America (**a**) and central North America (**b**) versus trends in the tropical Pacific ΔSAT. The red dot represents the observations. The trends in the ensemble of fully coupled model simulations are depicted by the ellipses (encompassing 95% of the ensemble members) and the straight line (representing the best linear fit). The open circles denote the trends in the pacemaker simulations.

Central Asia (McCusker et al 2016)

Central N America (Sigmond et al 2016)