Earth system model of INM RAS as an instrument for future decadal prediction of climate changes

Volodin E.,
Marchuk Institute of Numerical Mathematics RAS, Moscow
volodinev@gmail.com

Climate system model of INM RAS includes:

1. **Atmospheric general circulation model;**
2. **Oceanic general circulation model;**
3. Carbon cycle;
4. Atmospheric chemistry;
5. Aerosol block;
6. Oceanic biogeochemistry;
7. Ice sheet model;
8. Parameterization of some electric phenomena.

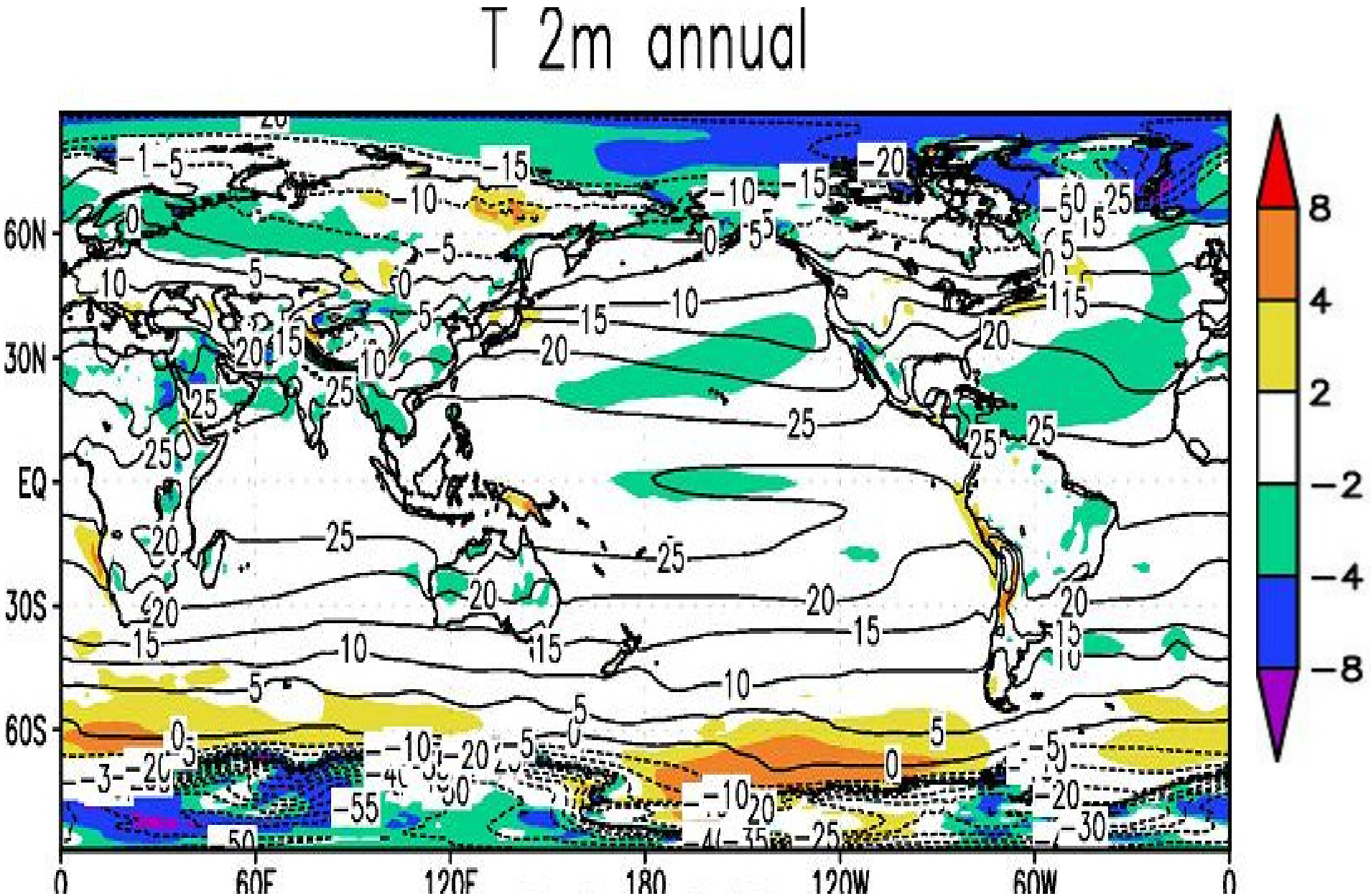
Frequently used model configurations

1. **Atmosphere 5x4 degrees in longitude and latitude, 21 levels up to 30 km. Ocean: 2.5x2 degrees, 33 levels.** For educational purposed (workshops for students).
2. **Atmosphere 2x1.5 degrees in longitude and latitude, 21 levels up to 30 km. Ocean: 1x0.5 degrees, 40 levels.** For CMIP6, PMIP, ISMIP,….
3. **Atmosphere 2x1.5 degrees in longitude and latitude, 73 levels up to 60 km. Ocean: 0.5x0.25 degrees, 40 levels.** For CMIP6, seasonal and decadal prediction.
4. **Atmosphere 0.67x0.5 degrees in longitude and latitude, 73 levels up to 60 km. Ocean: 0.167x0.125 degrees, 40 levels.** For HIRESMIP.

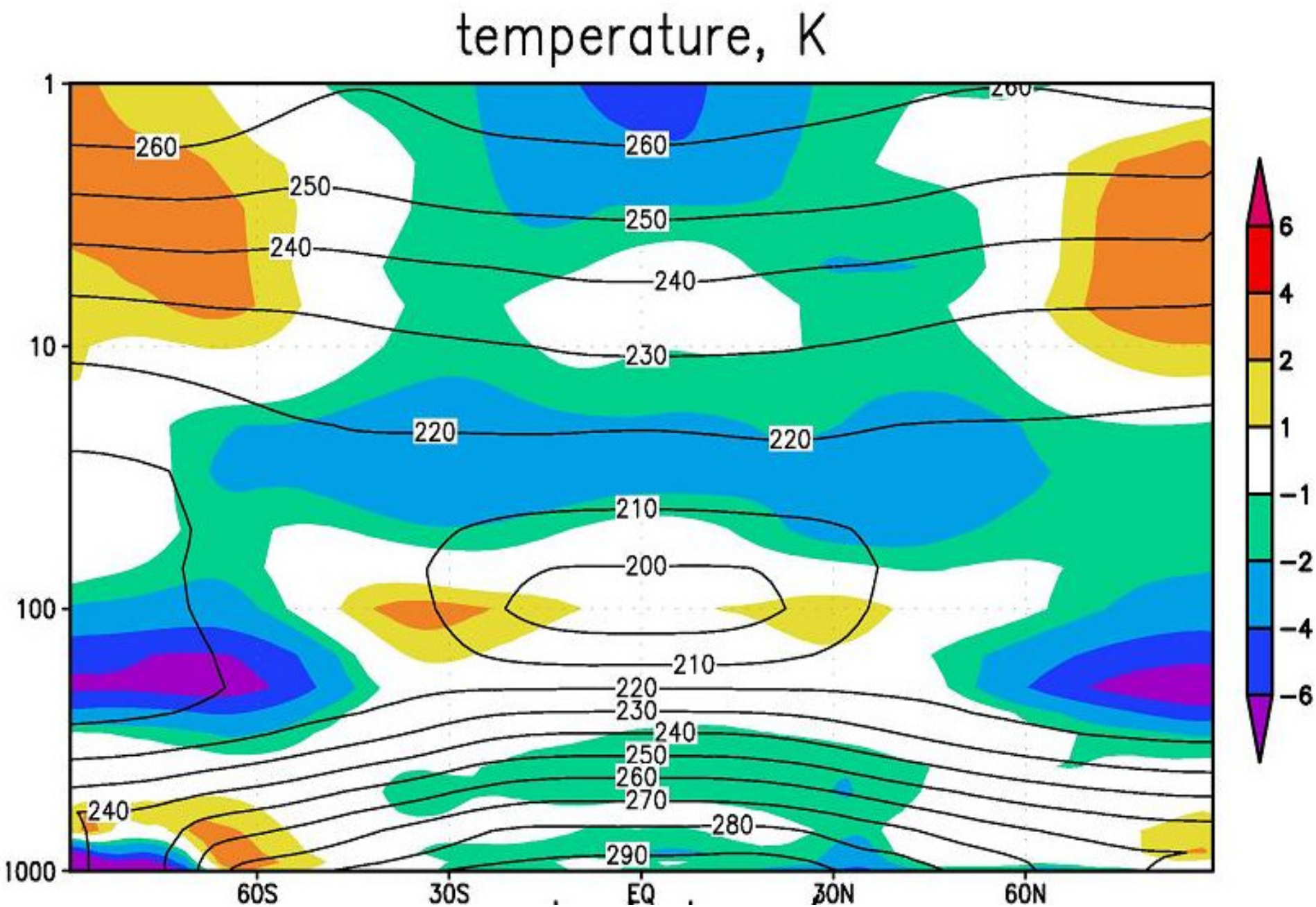
Plan:

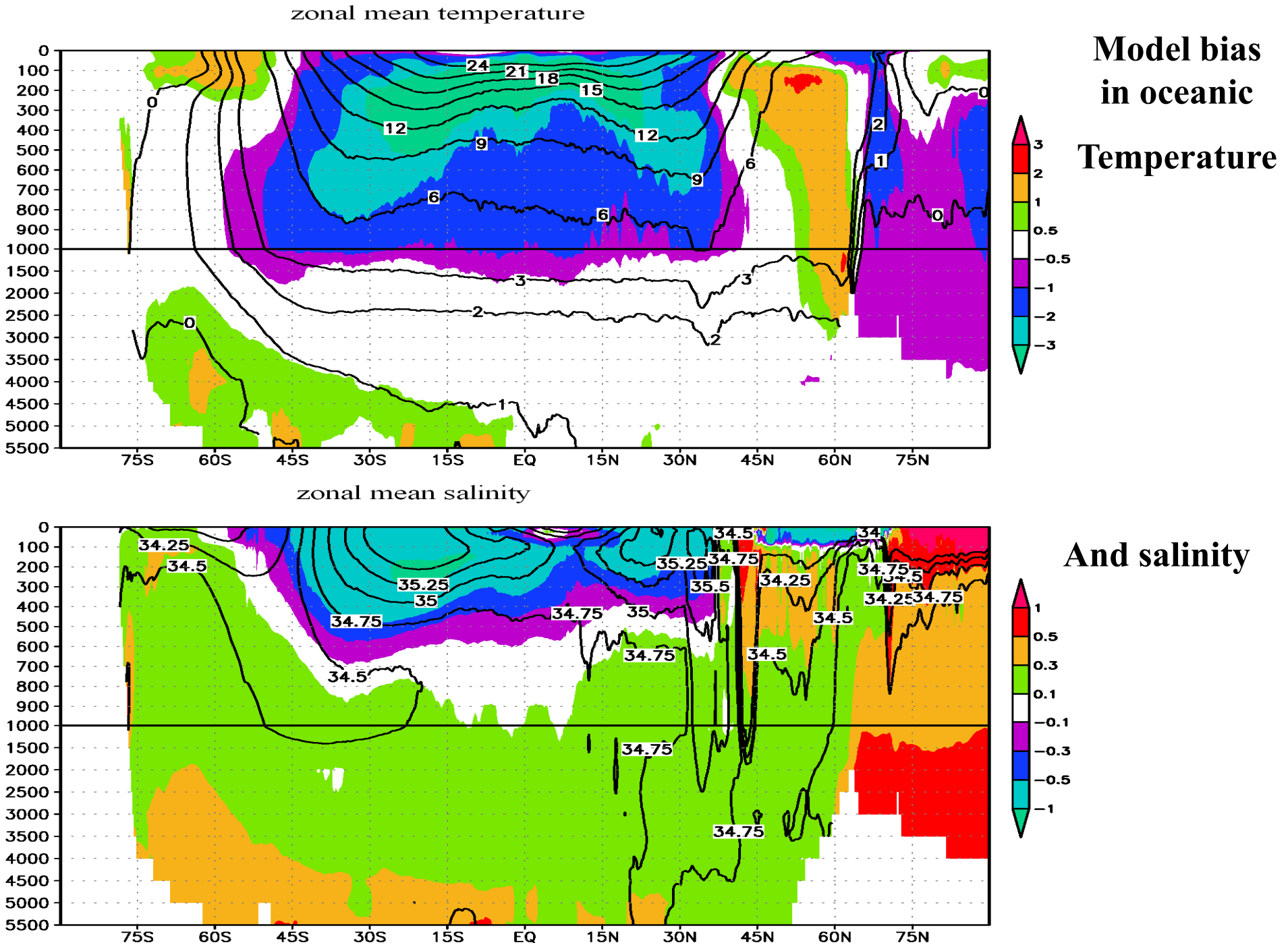
1. Simulation of mean state
2. Simulation of climate changes in 1850-2100
3. Some modes of natural variability from seasonal to multidecadal time scales
4. Plans for future

Model bias in annual mean temperature at 2m with respect to ERA-Interim



Annual mean model bias in air temperature





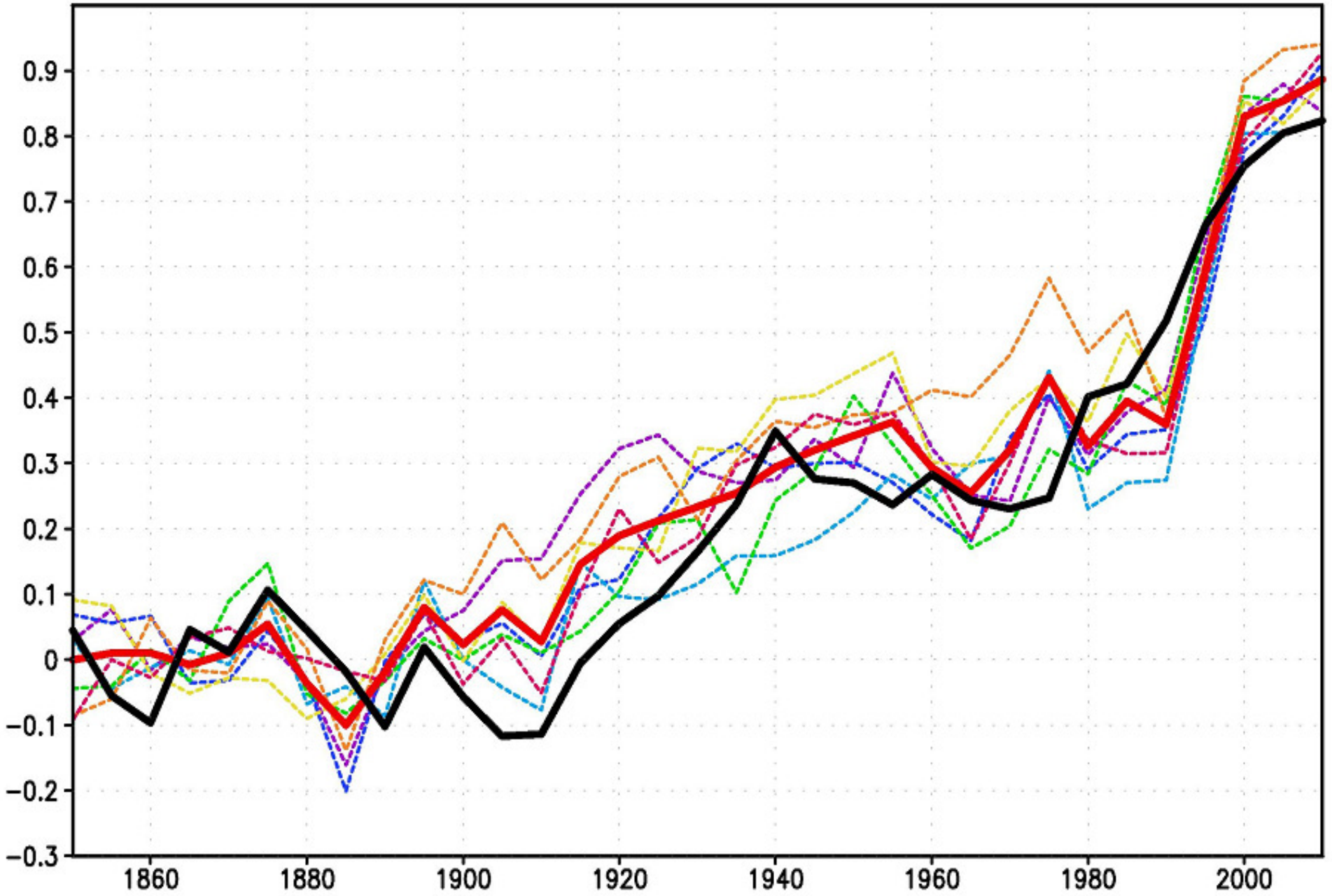
Model bias in oceanic Temperature

And salinity

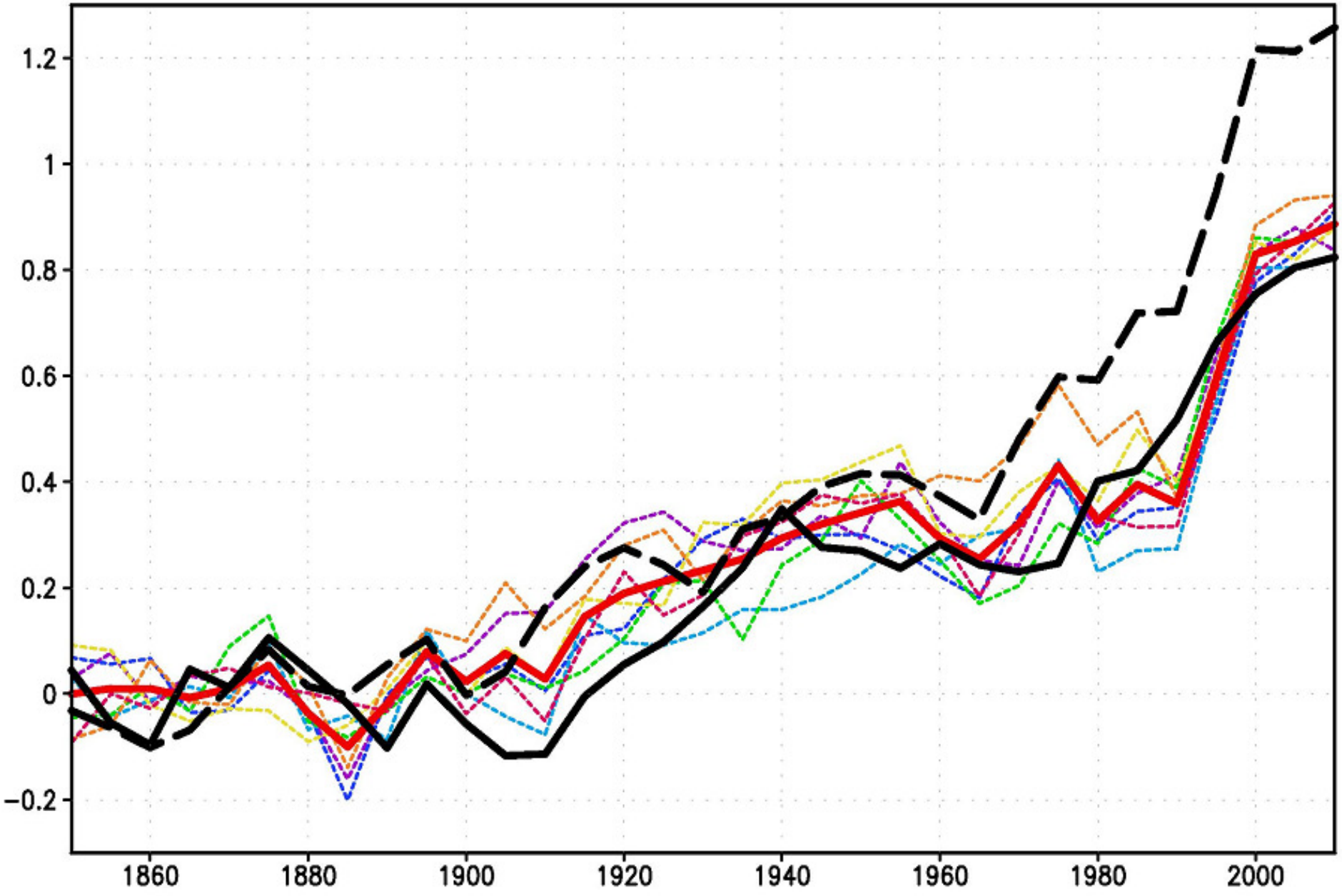
Climate changes in 1850-2014 for CMIP6.

Ensemble of 10 model runs with observed forcing and different initial conditions was performed.

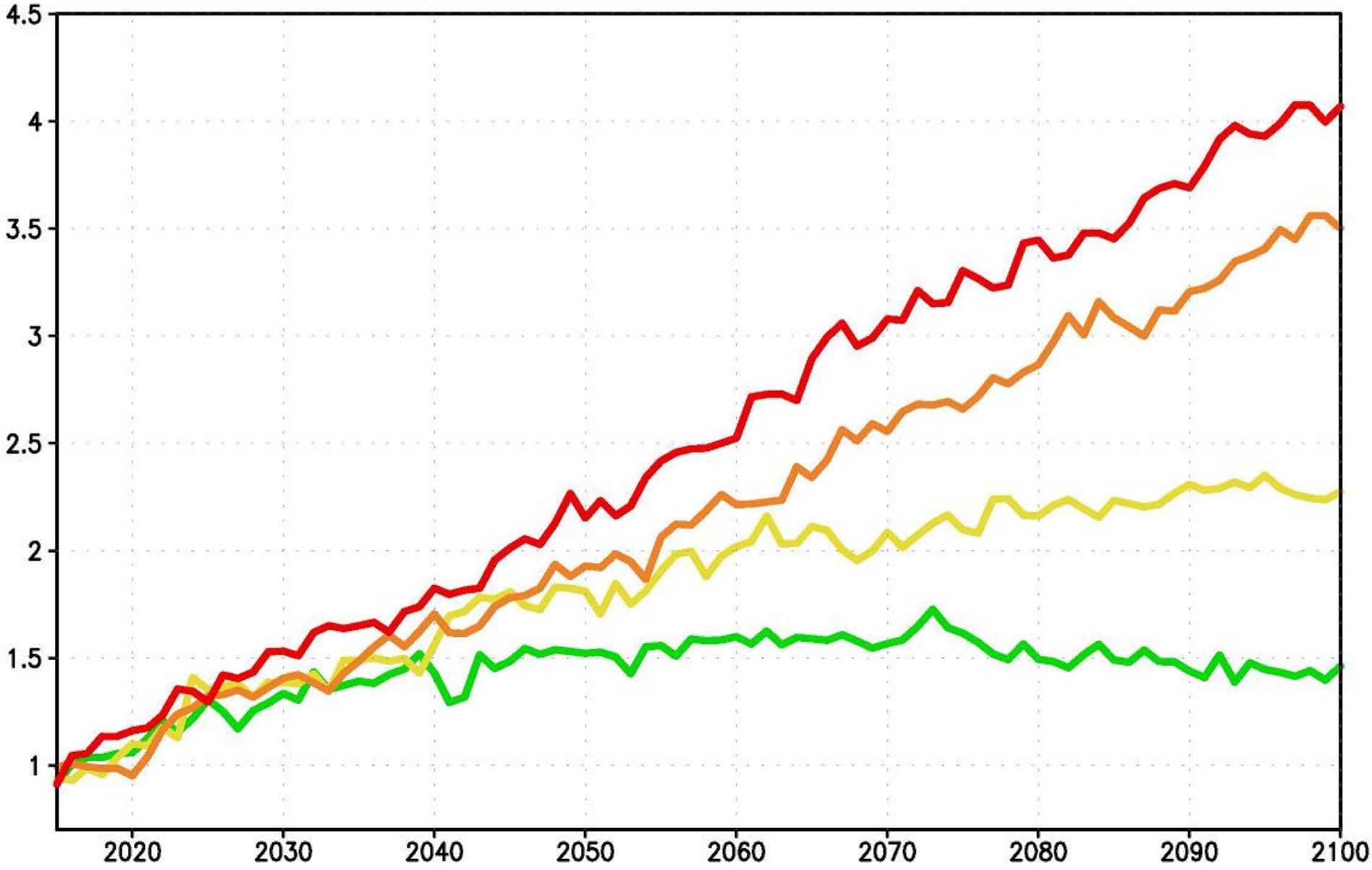
5-year mean near surface temperature in the observations (black), model mean (red) and individual model runs (dashed color lines).



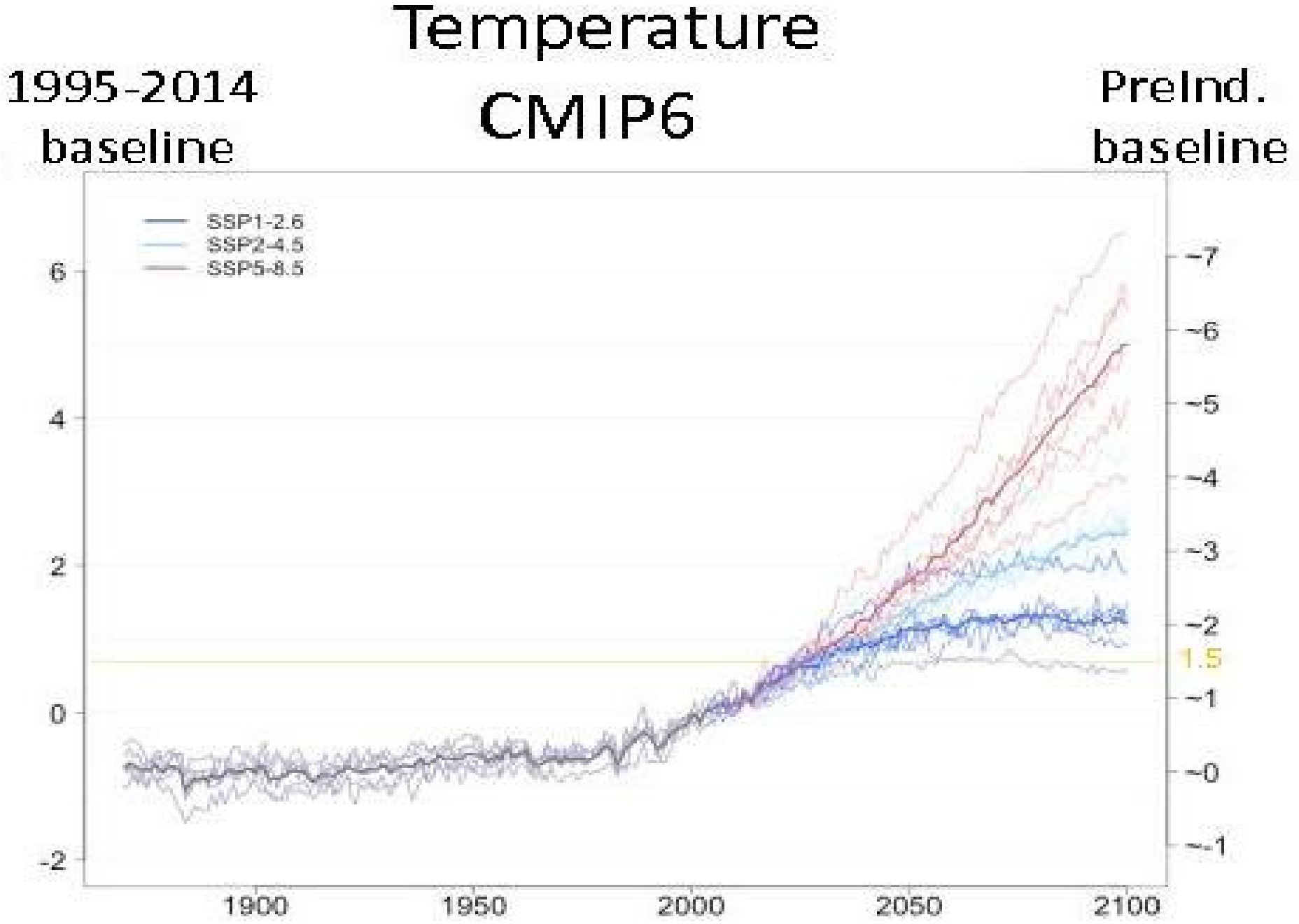
The same, but data of experiment added where anthropogenic aerosol emission is fixed at a level of year 1850 (black dashed).



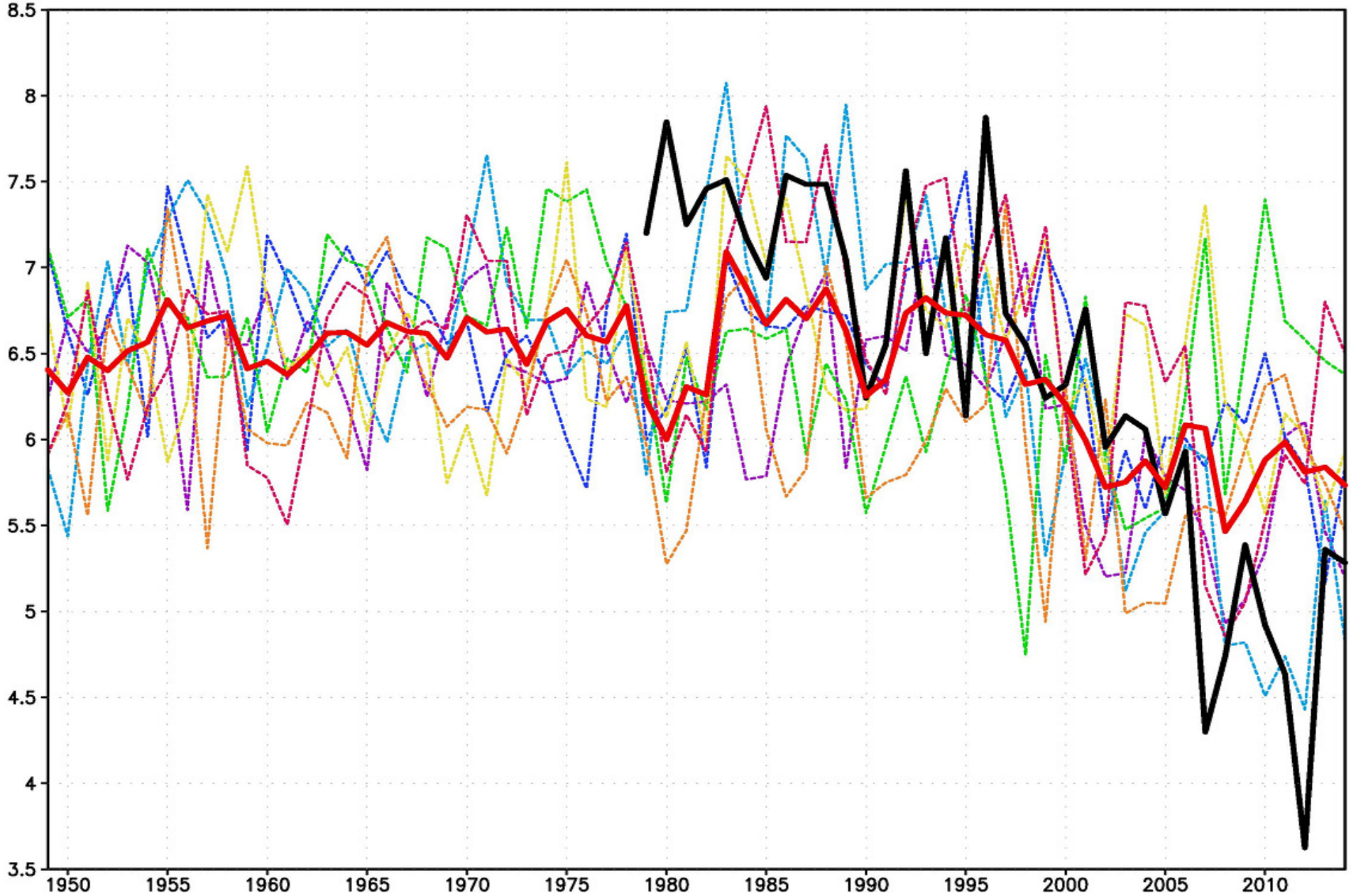
Surface temperature change in 2015-2100 in INM-CM4-8 model for scenarios ssp1-2.6, ssp2-4.5, ssp3-7.0, ssp5-8.5

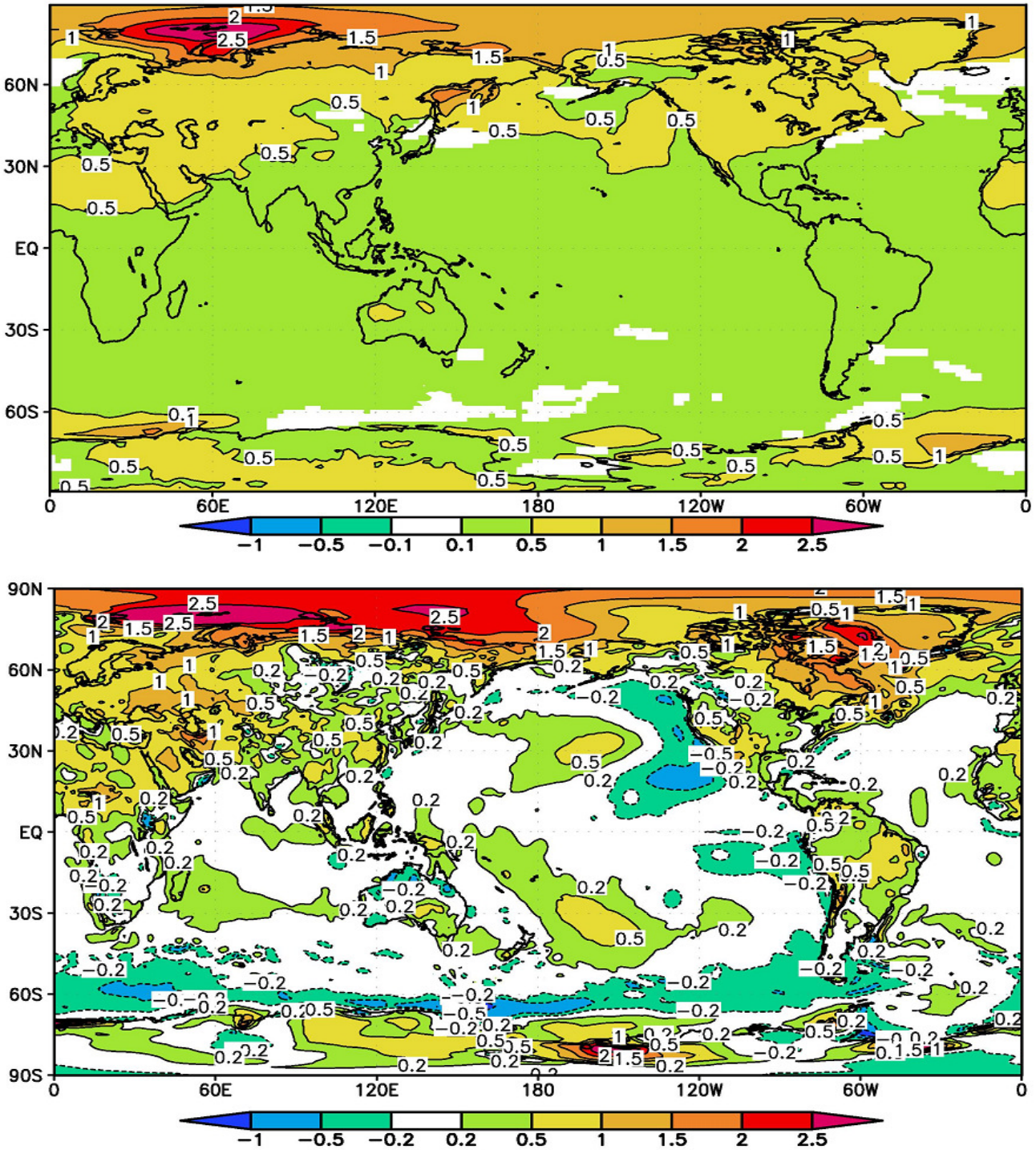


Surface temperature change in 2015-2100 in other CMIP6 models

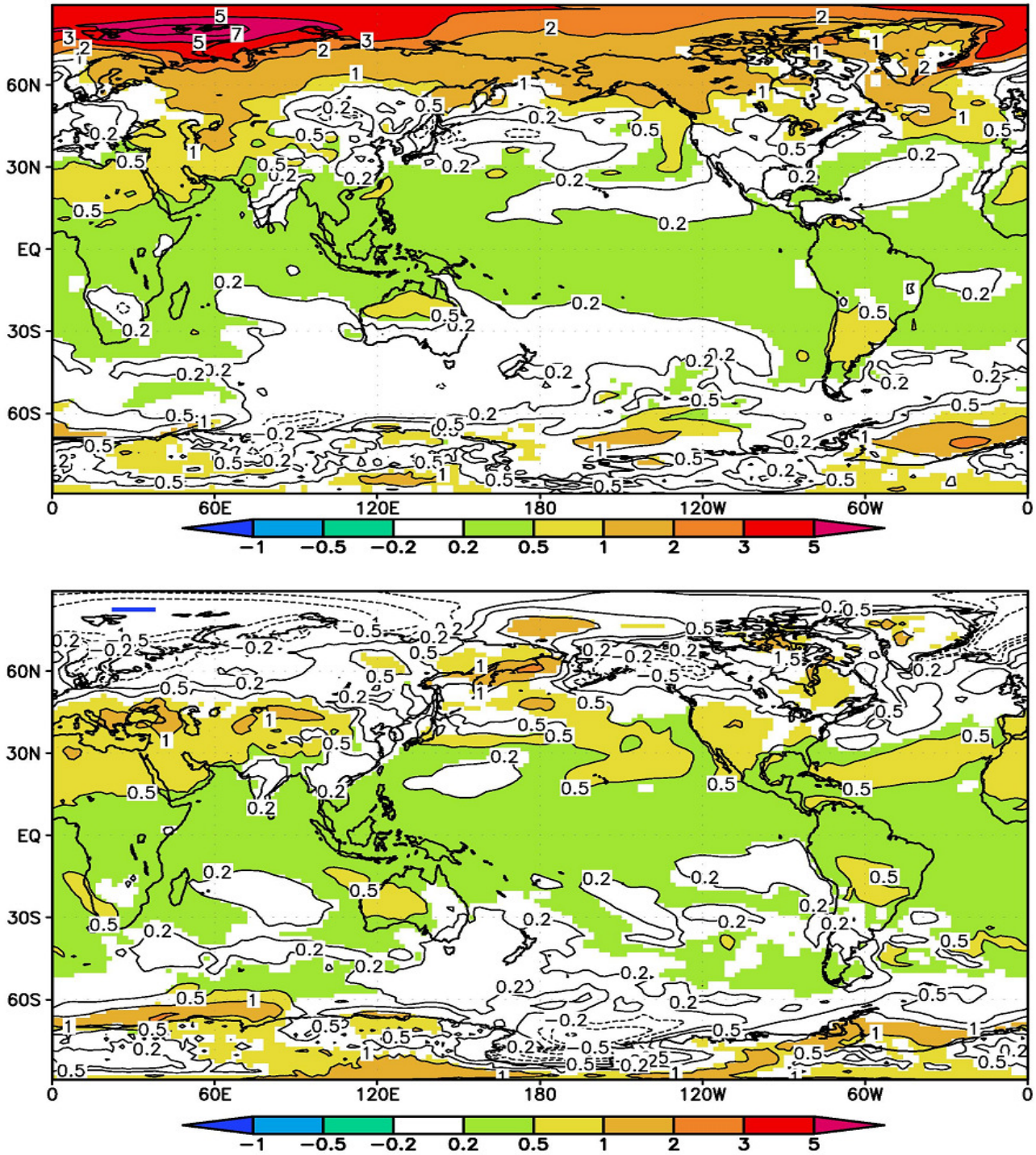


Arctic sea ice area in September in the observations (black), model mean (red) and individual model runs (dashed color lines)





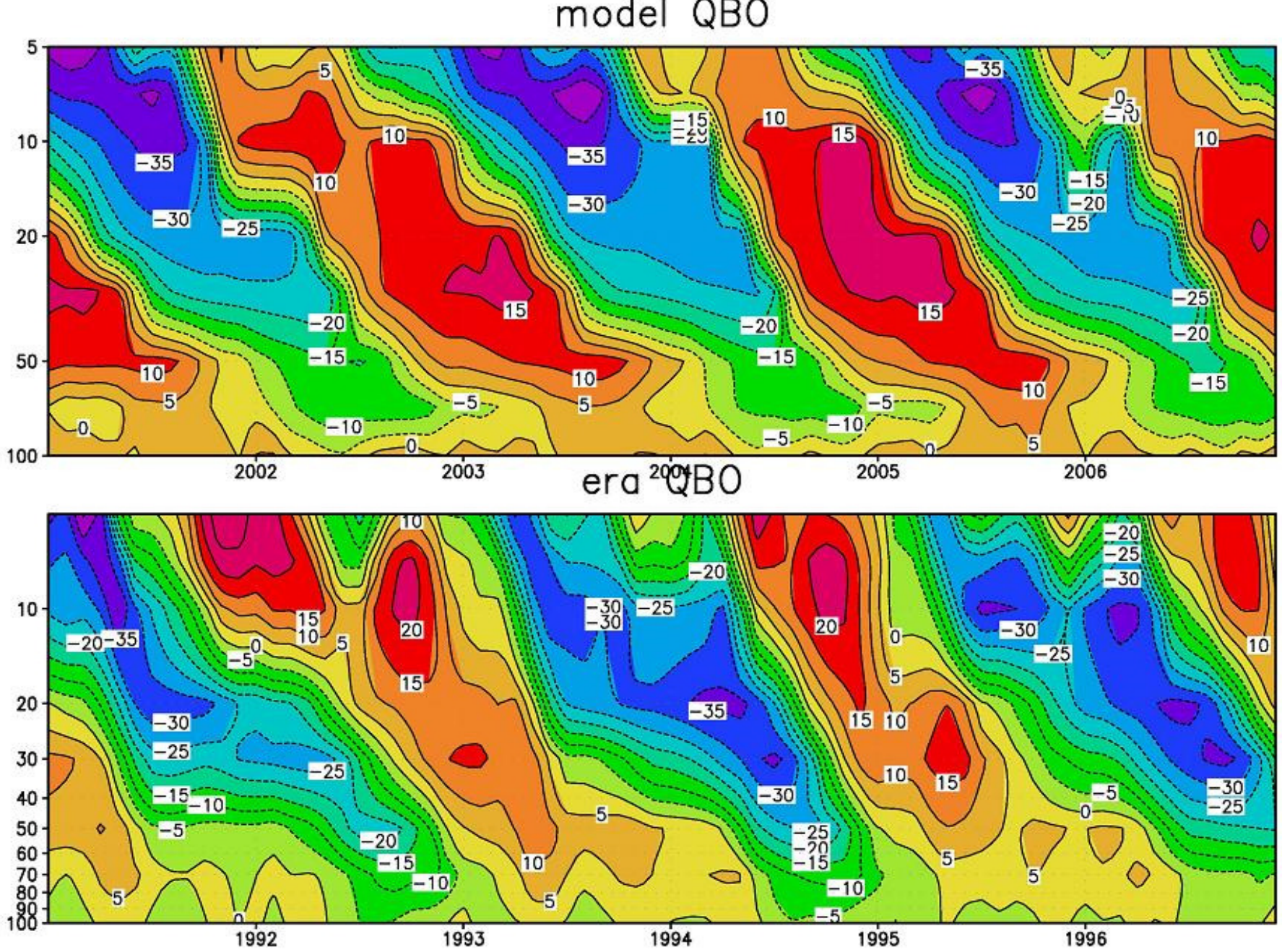
Surface temperature in 2000-2014 minus 1985-1999 for model ensemble (top) and ERA-Interim (bottom)

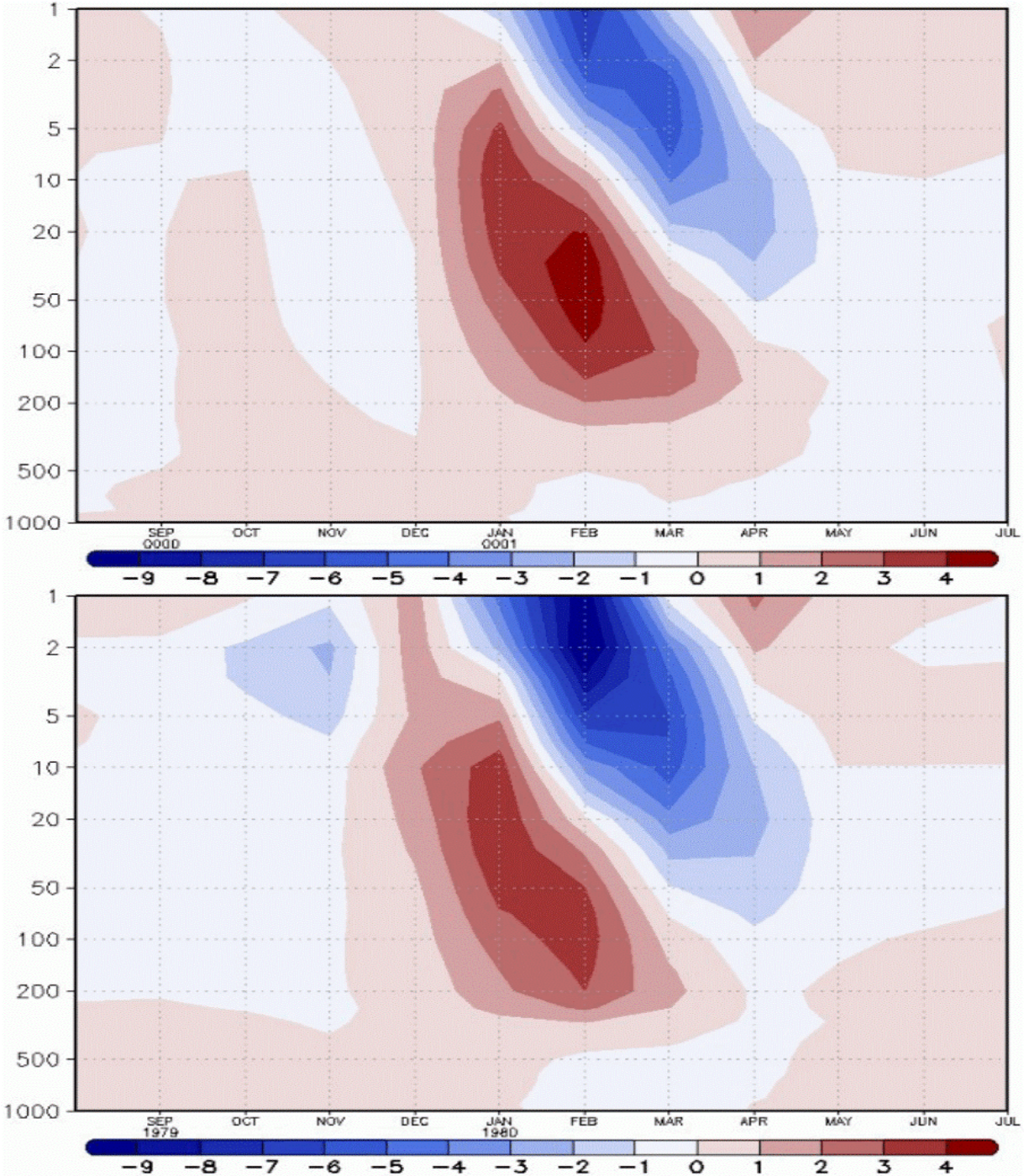


Temperature in 2000-2014 minus 1985-1999 in model run with highest and lowest Arctic warming

Model natural variability at time scales from seasonal to multidecadal

Quasibiannual oscillation in the model and reanalysis

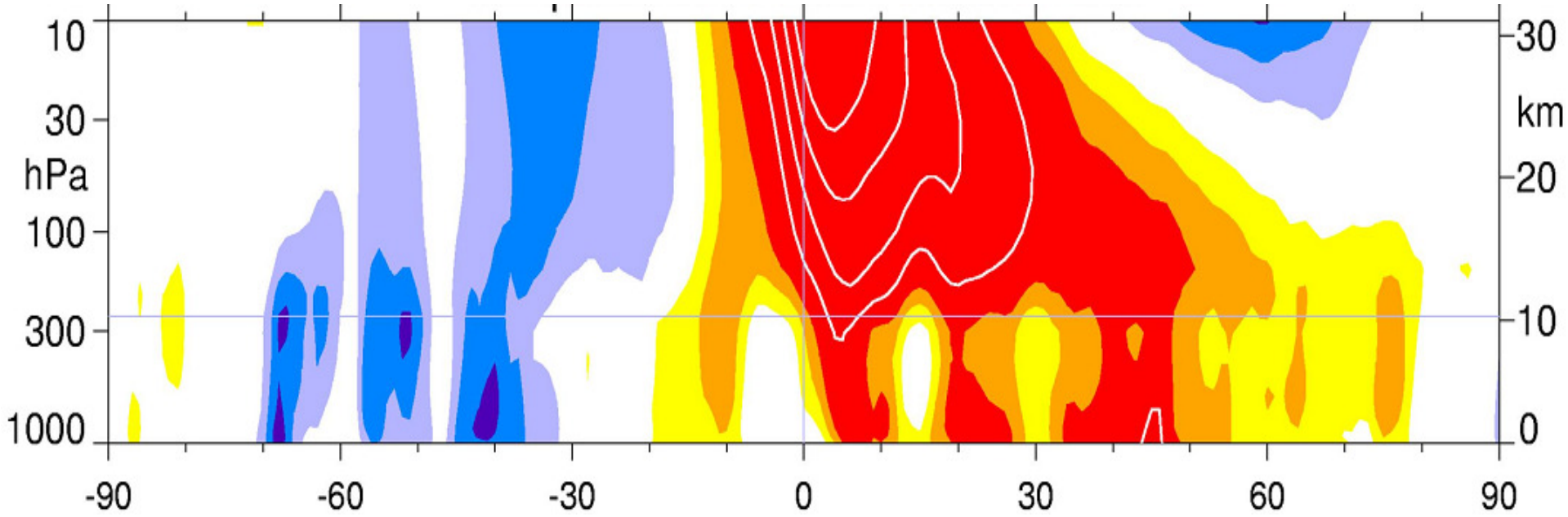




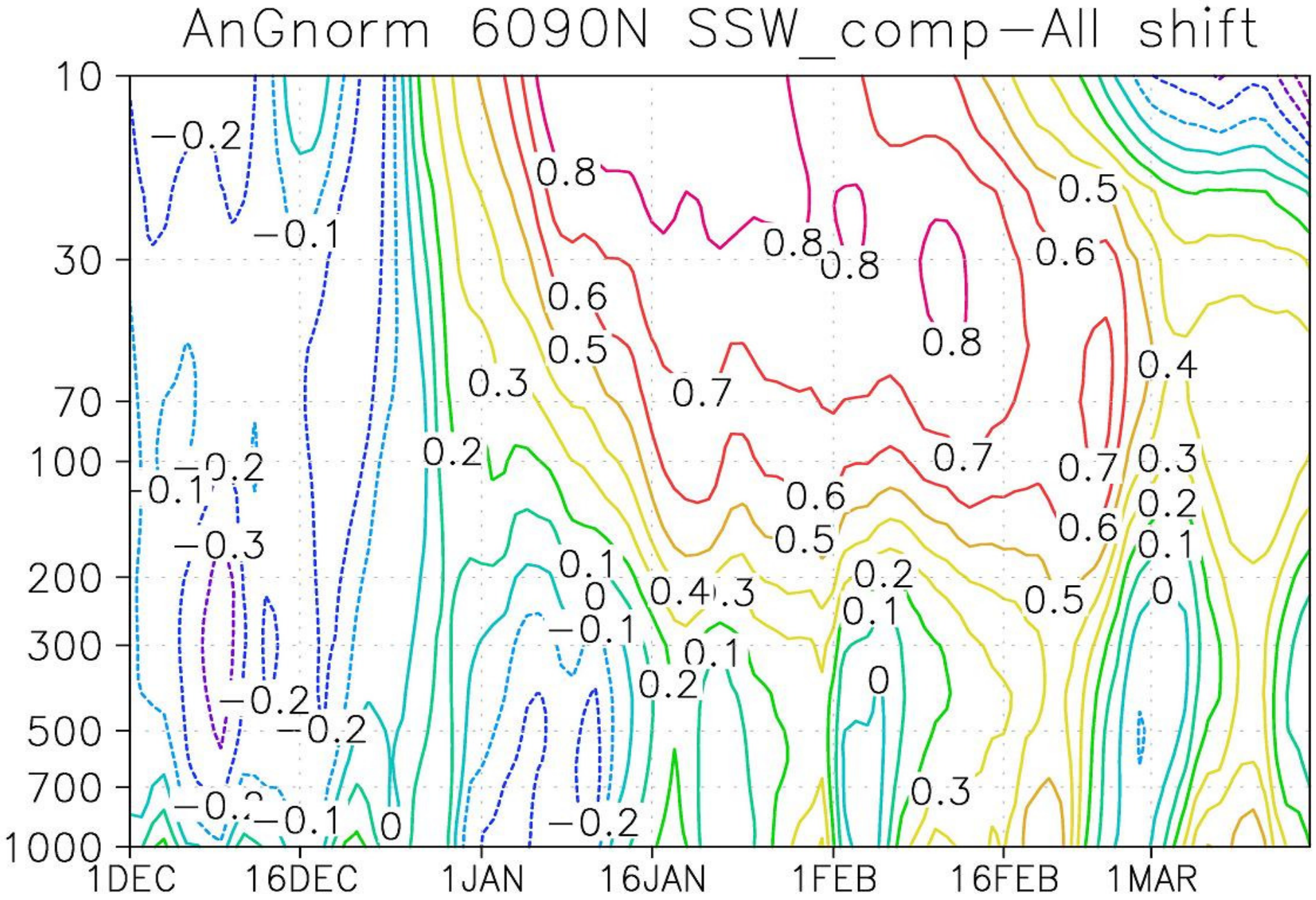
EOF-1 of zonal interannual variability in zonal mean temperature in the model (top) and reanalysis (bottom). Data are averaged over 60N-90N.

Anomaly of geopotential at 70-90N normalized by RMS for all stratospheric warmings

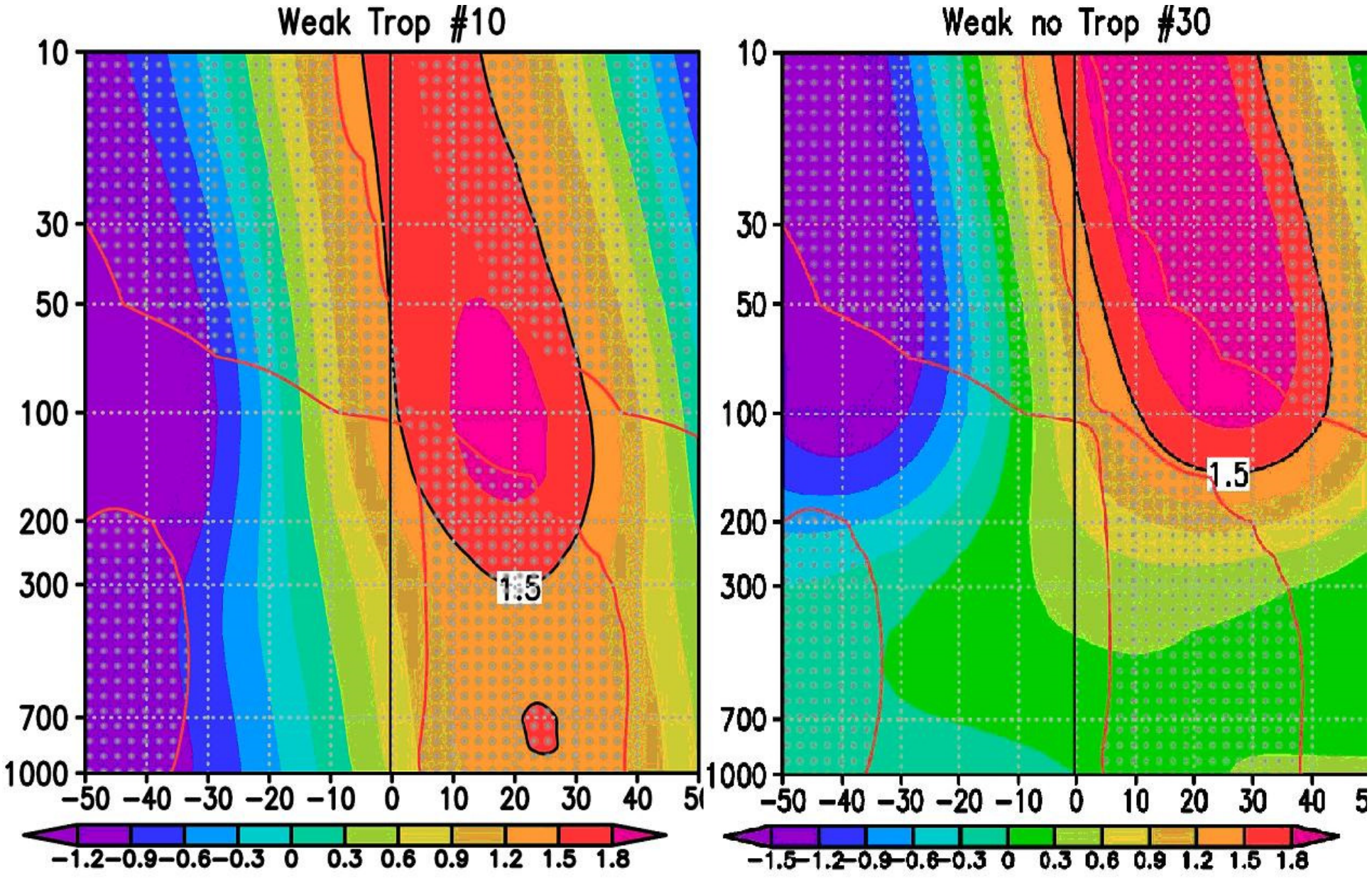
From: Baldwin, M.P., Dunkerton T.J. Downward propagation of the Arctic Oscillation from the stratosphere to the troposphere, J. Geophys. Res.1999, V104, P.30937-30946.



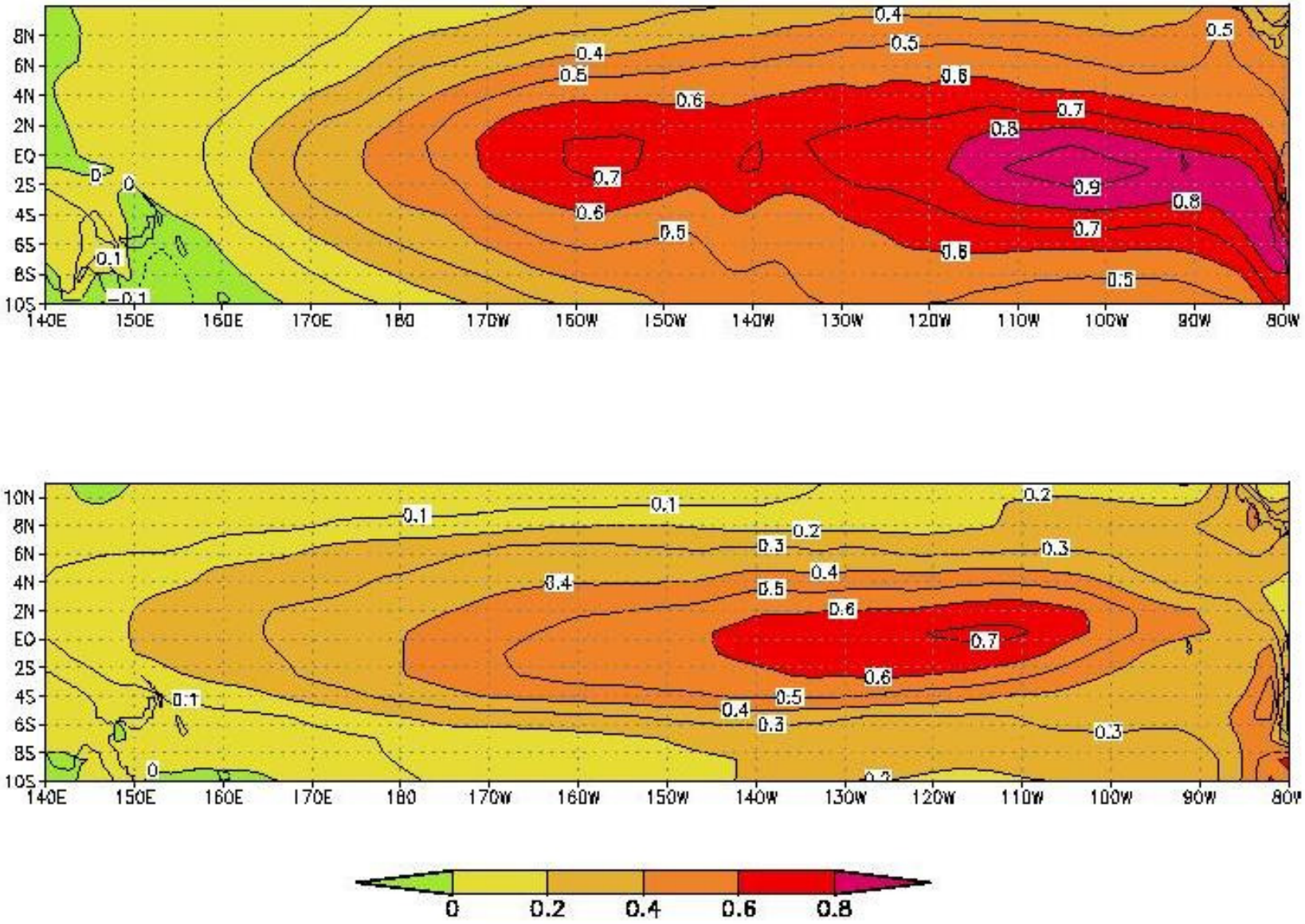
The same for model data



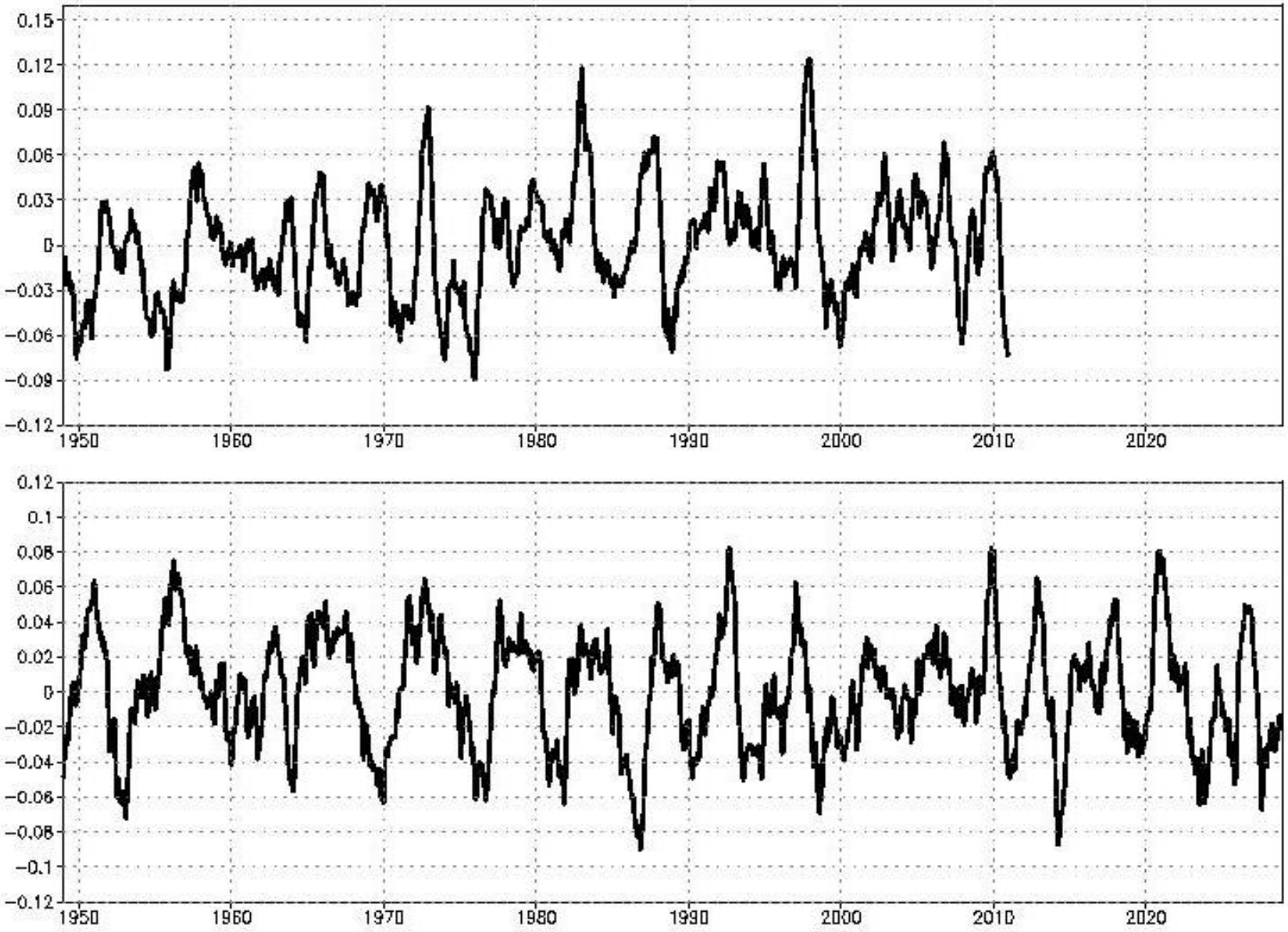
Composites of geopotential anomalies for stratospheric warmings with strong (left) and light (right) effect on troposphere.



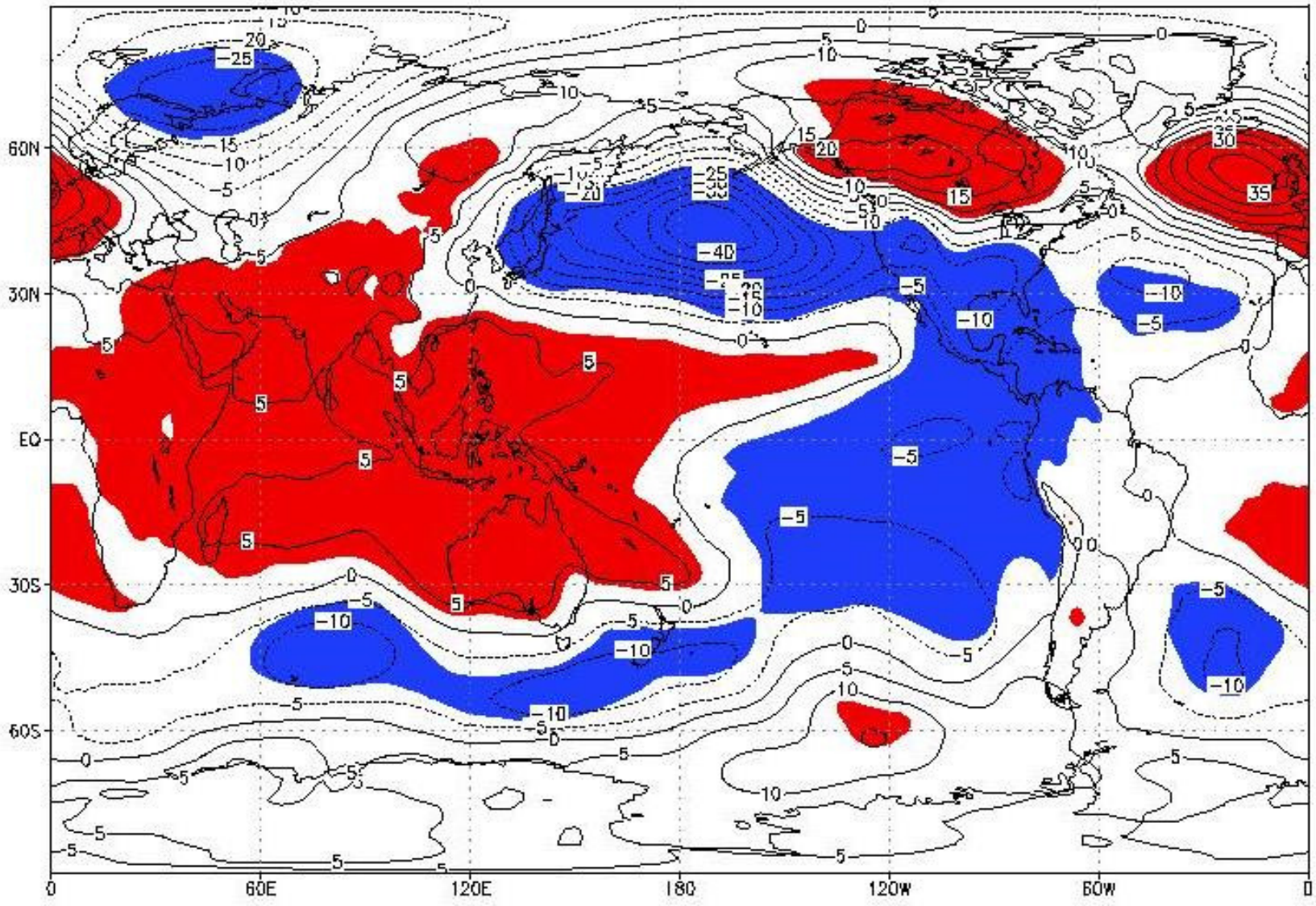
EOF-1 of Tropical Pacific SST. NCEP reanalysis (top), model (bottom)



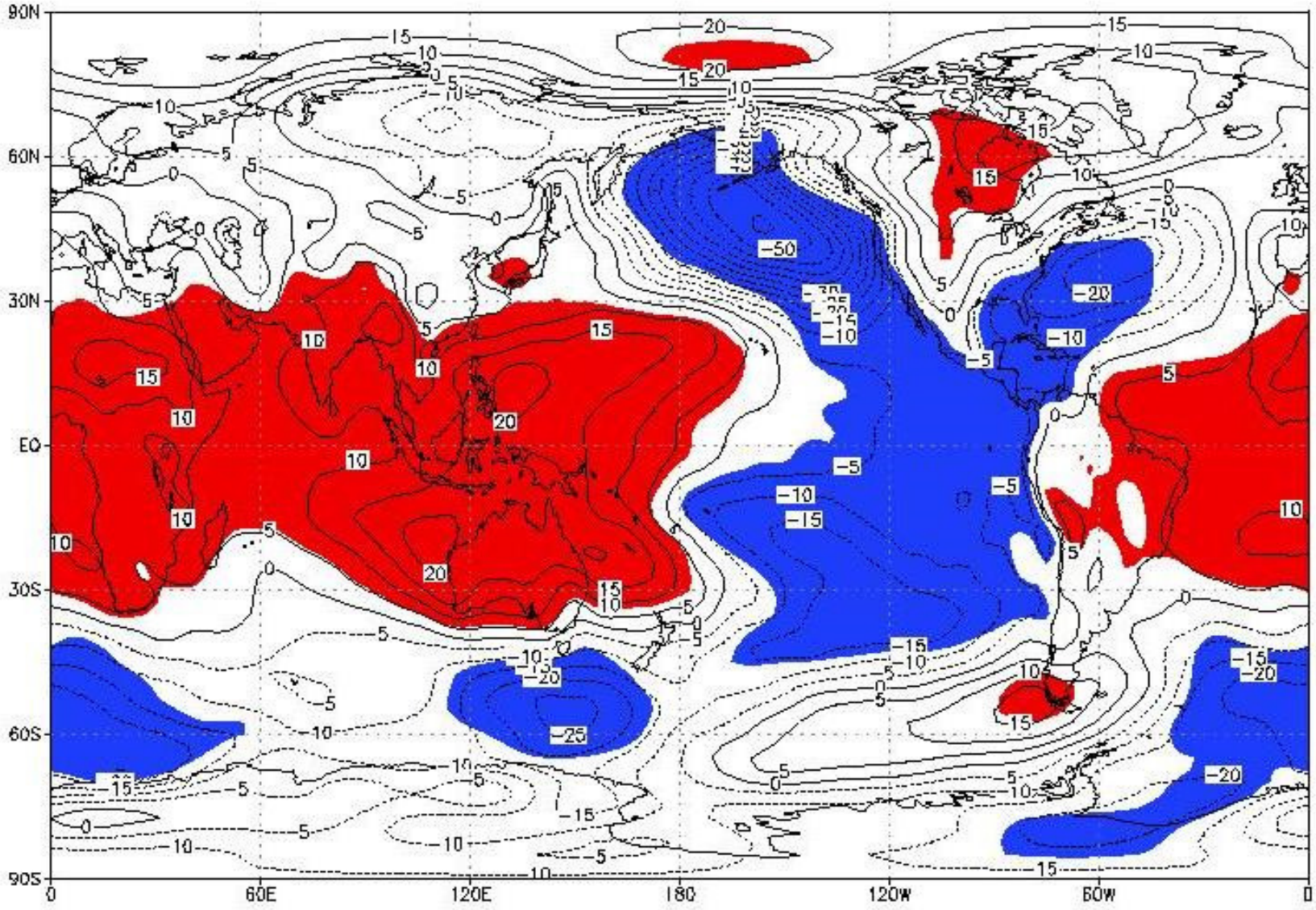
Time series of expansion coefficient in OBS (top) and MODEL (bottom)



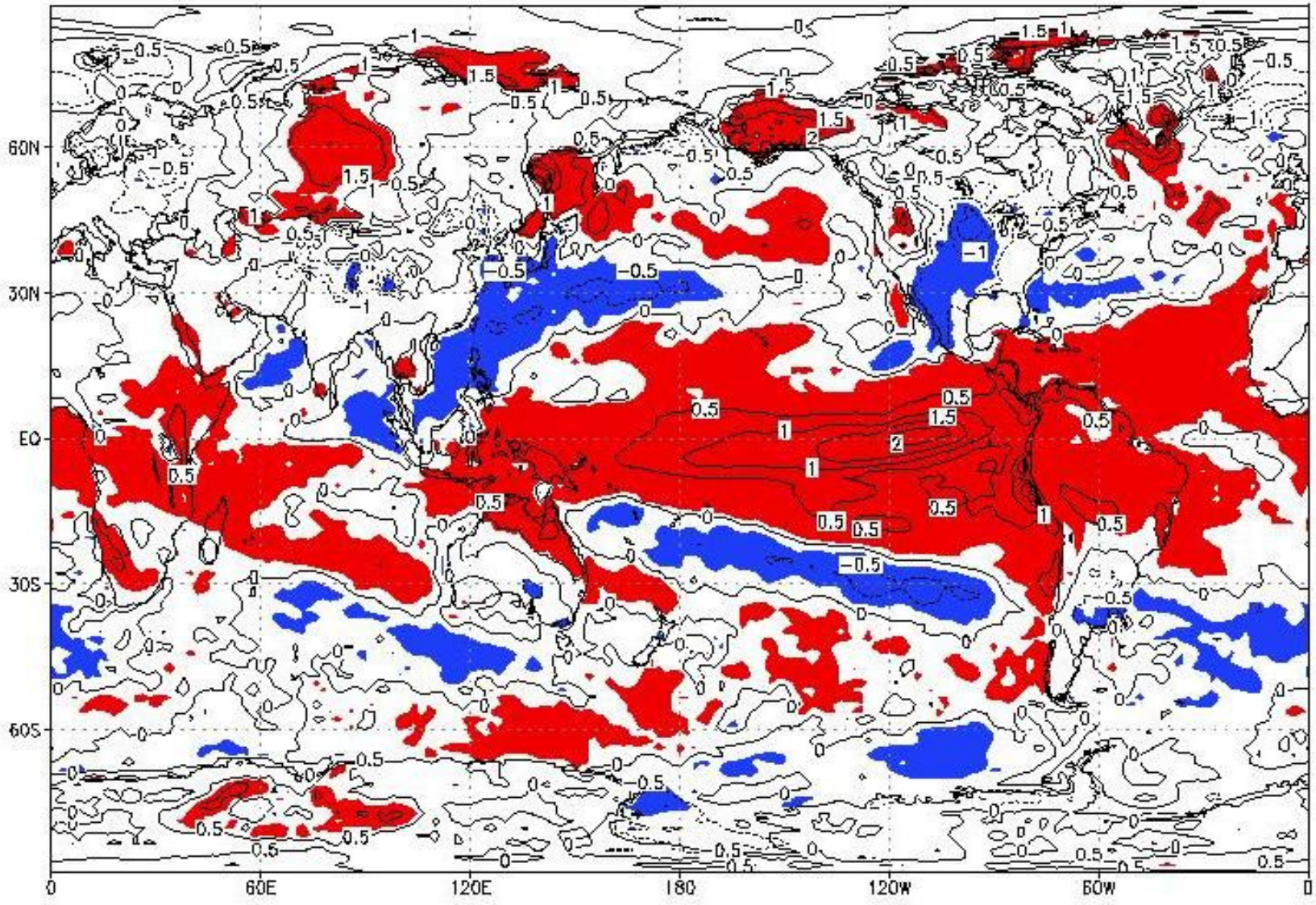
JFM anomaly of geopotential at 1000 mb for El-Nino (model)



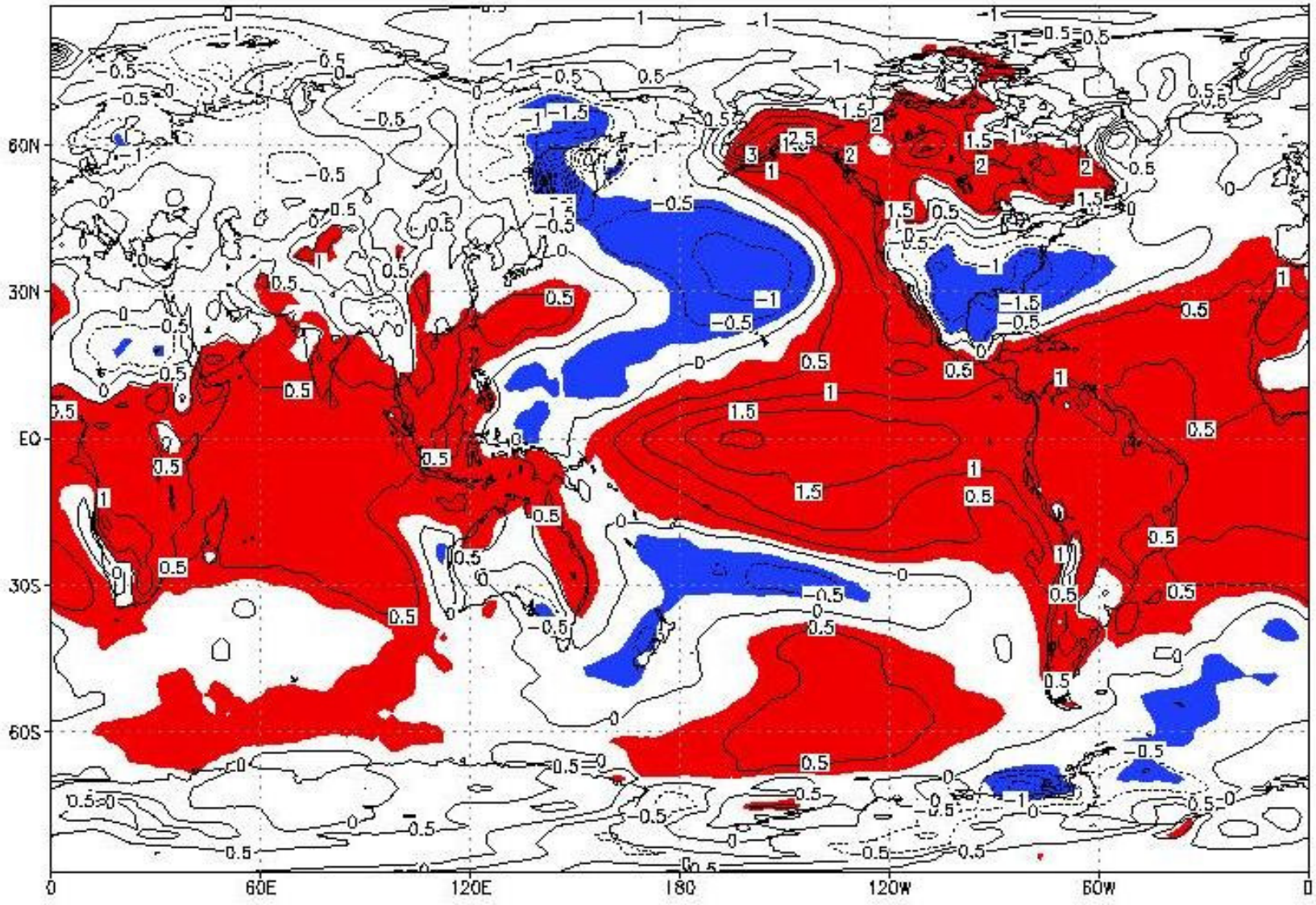
JFM anomaly of geopotential at 1000 mb for El-Nino (NCEP)



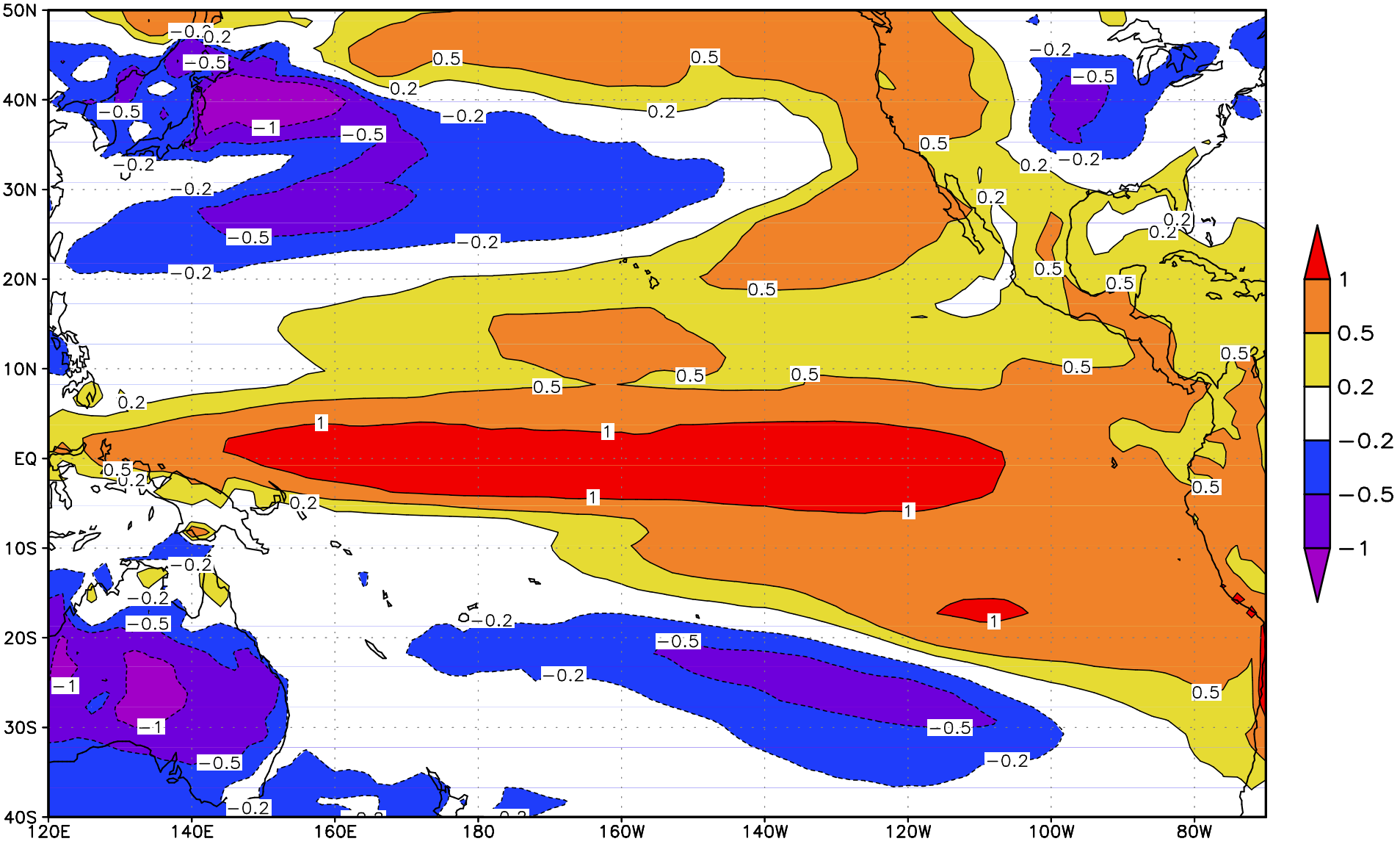
Composite of JFM surface temperature anomaly for El-Nino (model).



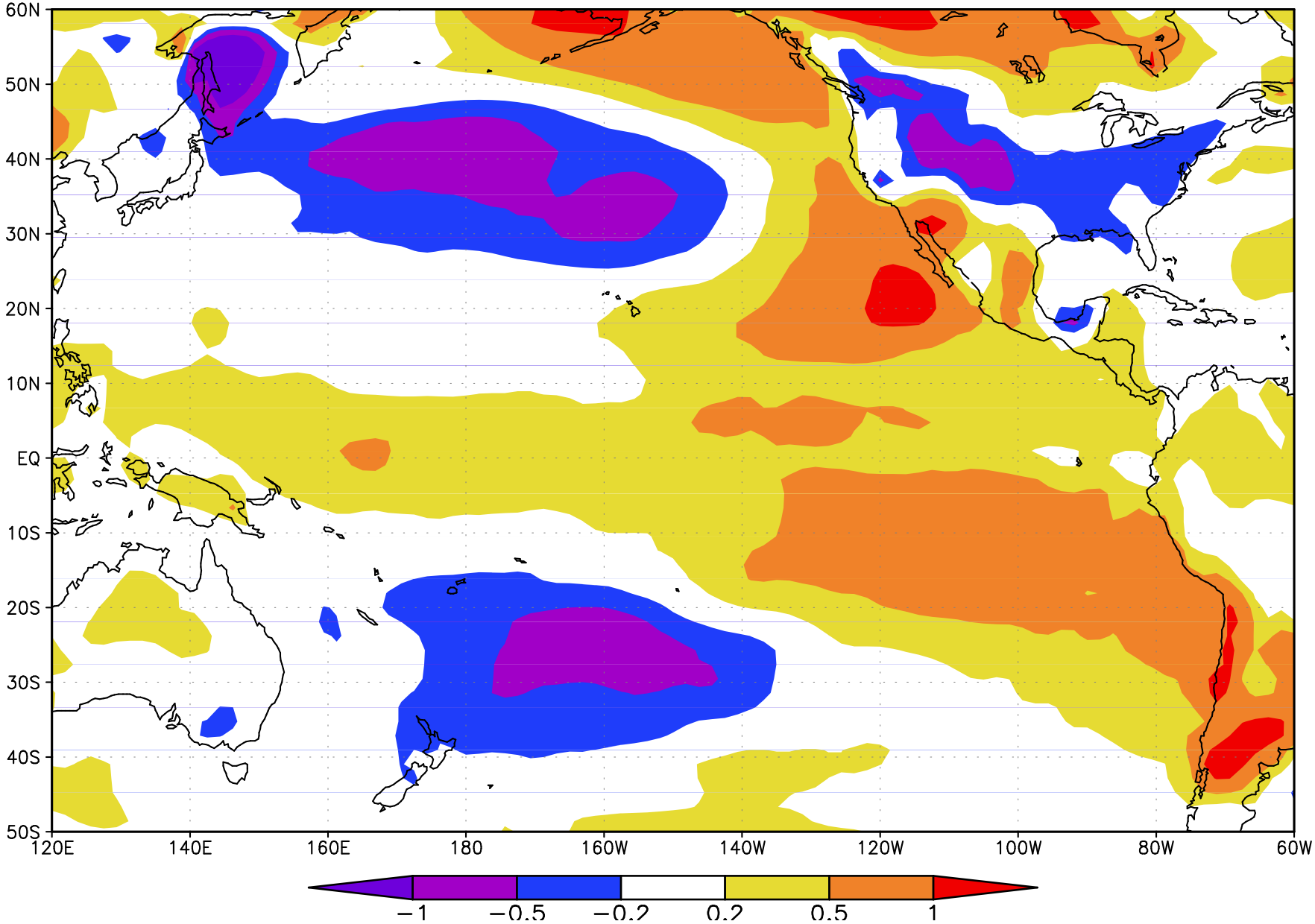
Composite of JFM surface temperature anomaly for El-Nino (NCEP).



EOF-1 of SST in INMCM4, 500 years. Model pattern of Pacific Decadal Oscillation

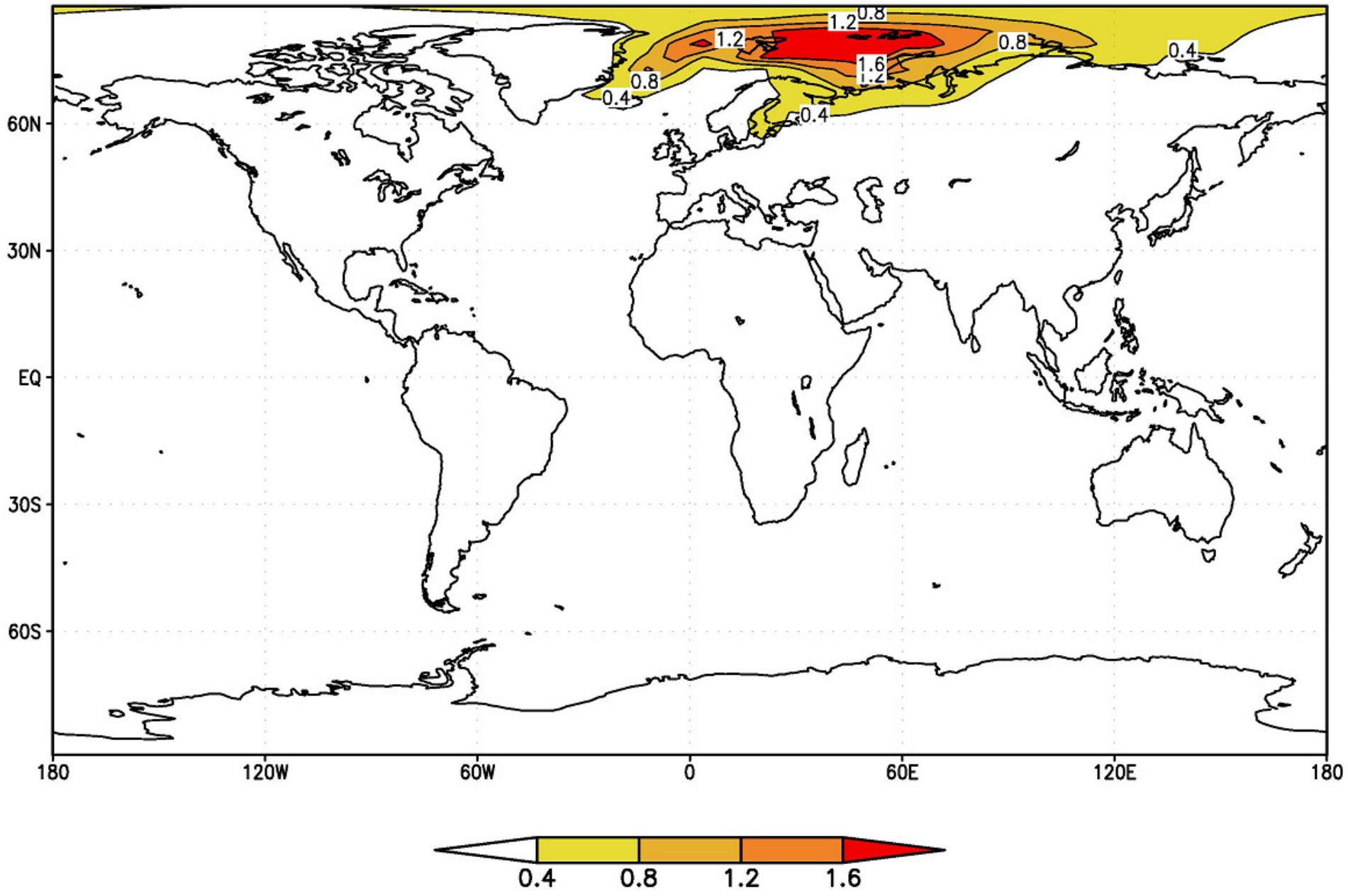


PDO in the observations: (1979-1989)-(1967-1976)

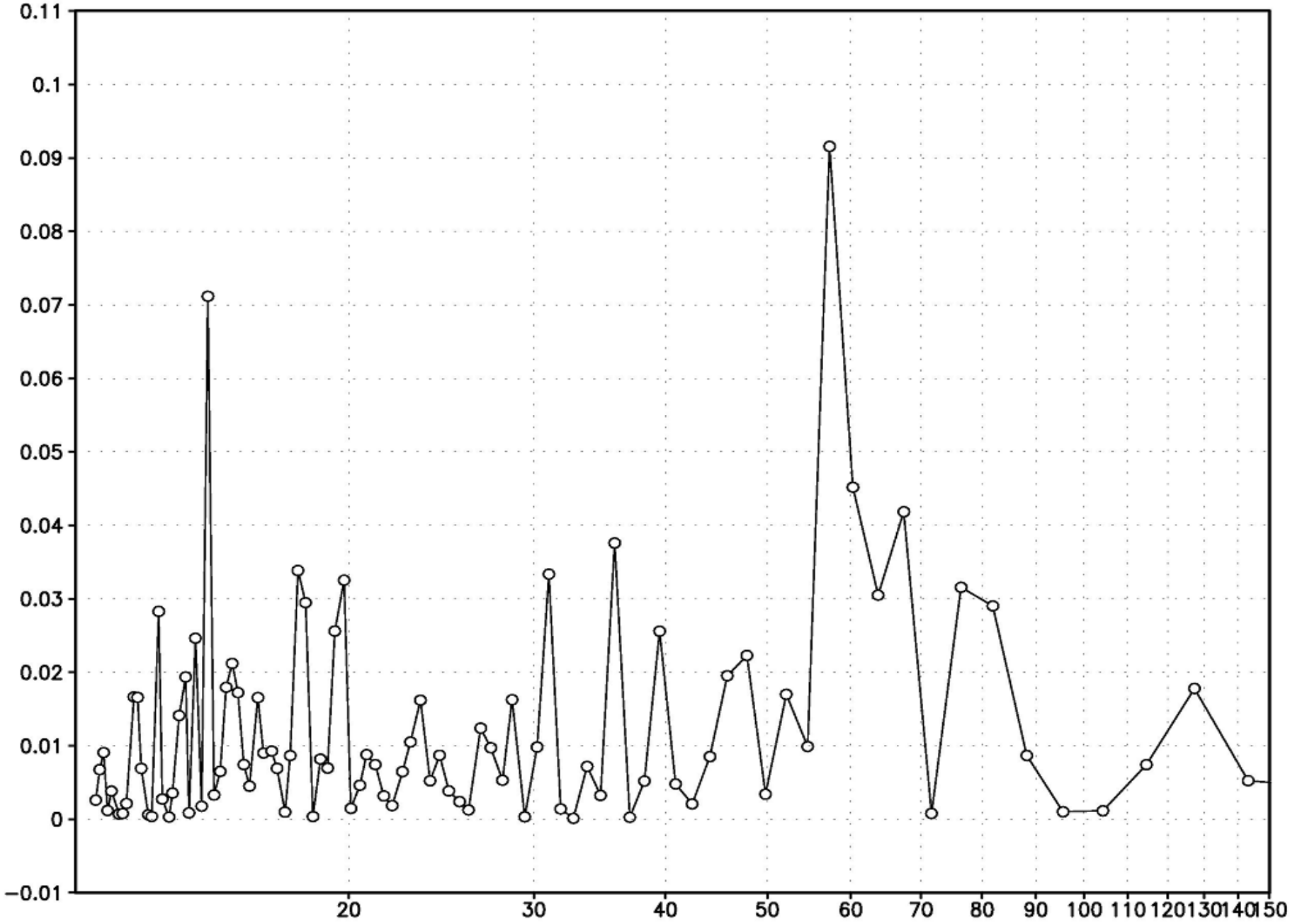


Температура в Арктике (60-90N) на различных высотах в ансамбле экспериментов, стартовавших с начальных условий 1 декабря, когда поток тепла на север был большим.

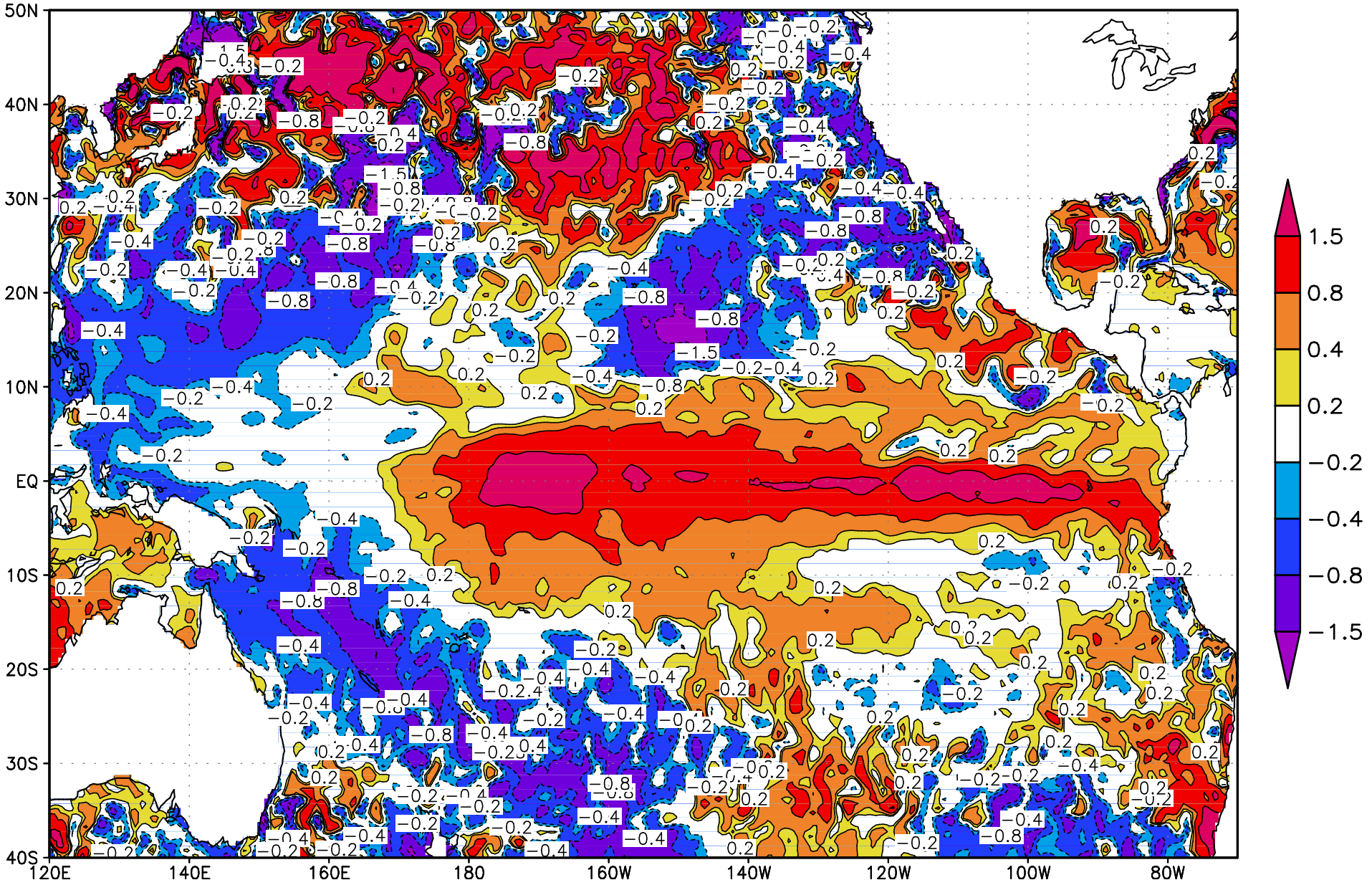
EOF-1 of 5-year mean temperature is localized in Arctic



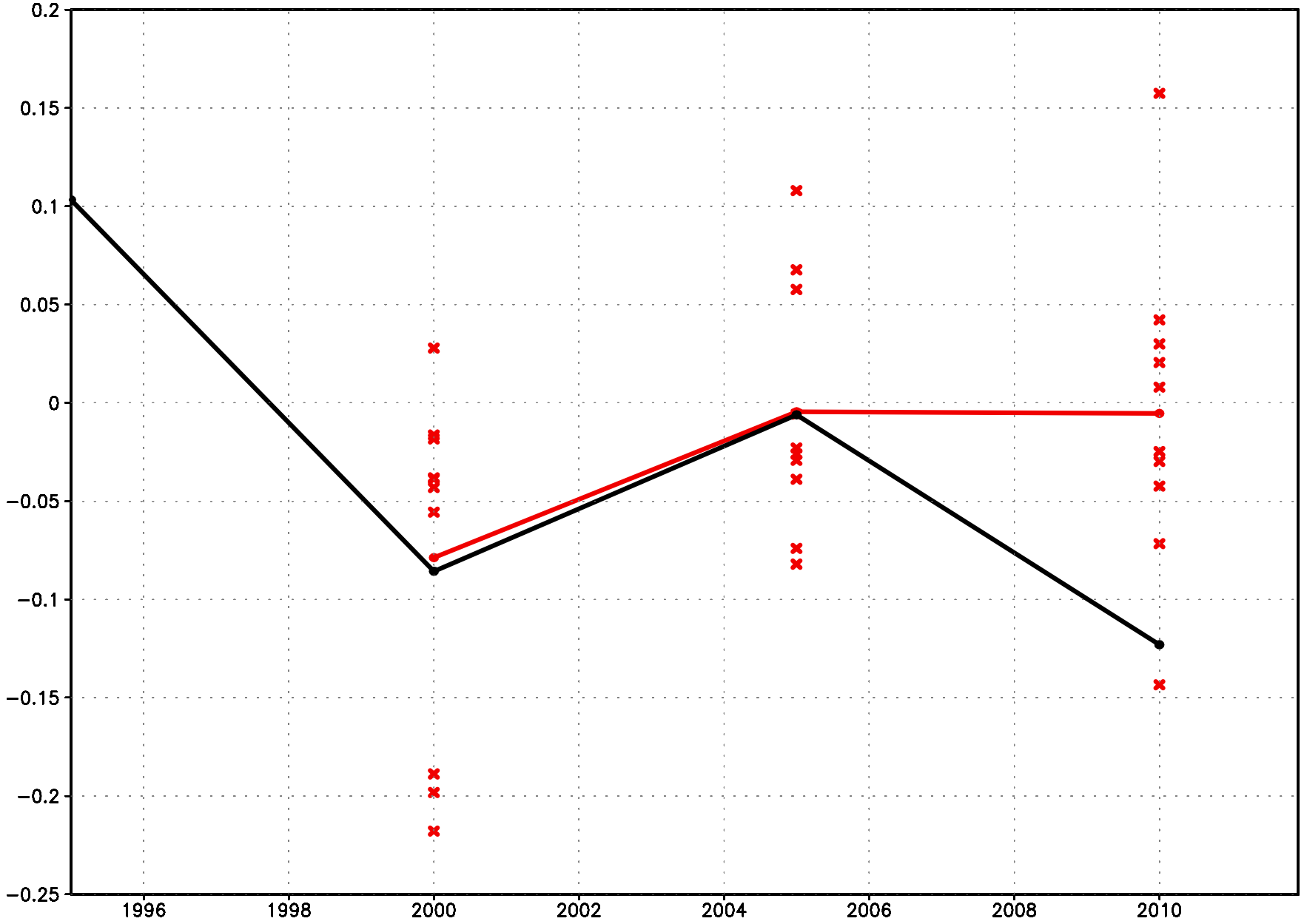
Time spectrum of expansion coefficient



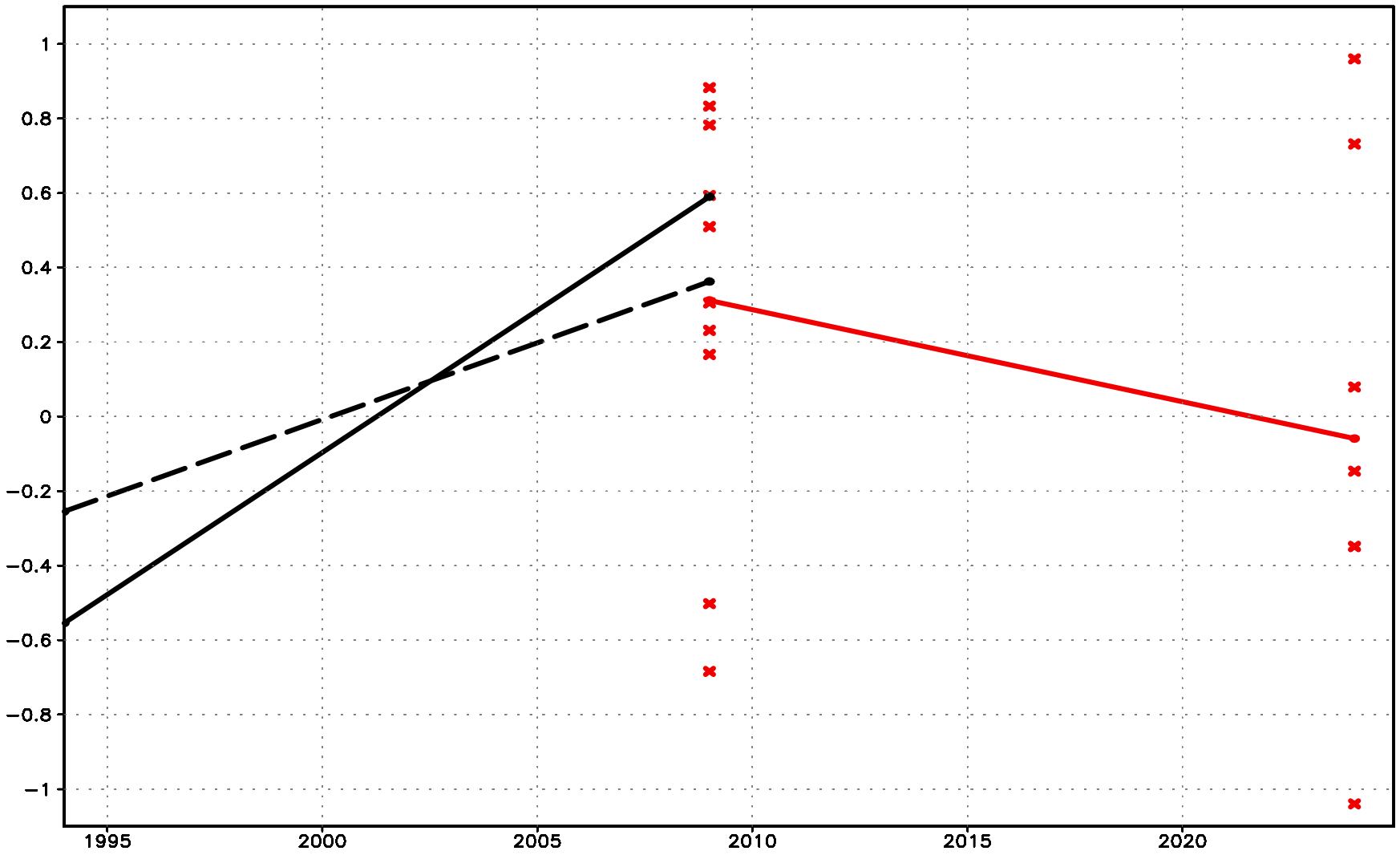
Initial SST anomaly in Jan 1995



5 year mean PDO index for NCEP (black) and model (red)



15 year mean surface temperature anomaly in region 70N-88N, 20W-80E in MERRA (dashed black), NCEP (solid black), individual forecasts (red crosses) and ensemble mean (red solid line)



Future plans:

1. Seasonal forecasts for 1980-2019.
2. Decadal forecasts for some cases.