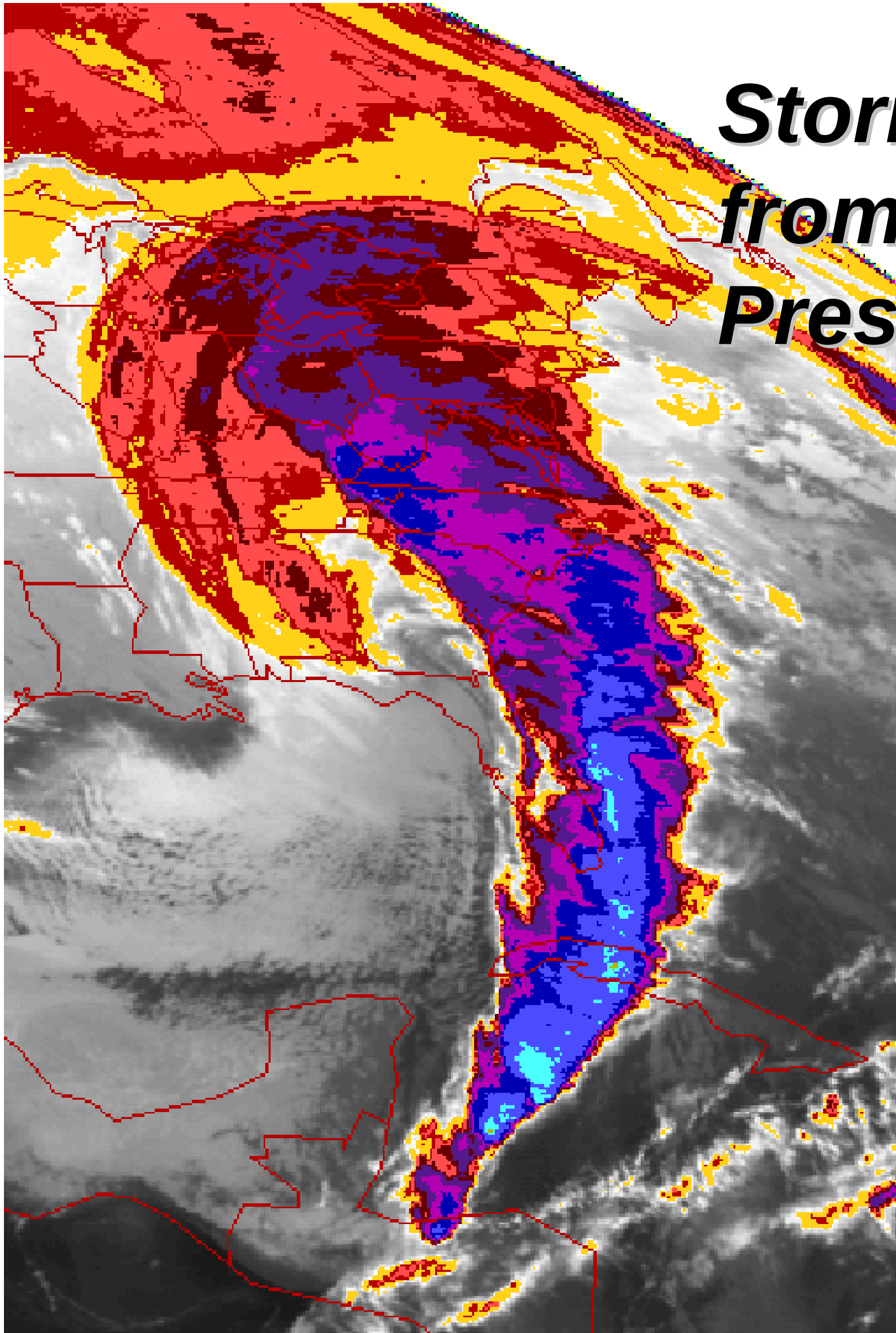

Storm Track Analysis from CCSM3: Present and Future Climate

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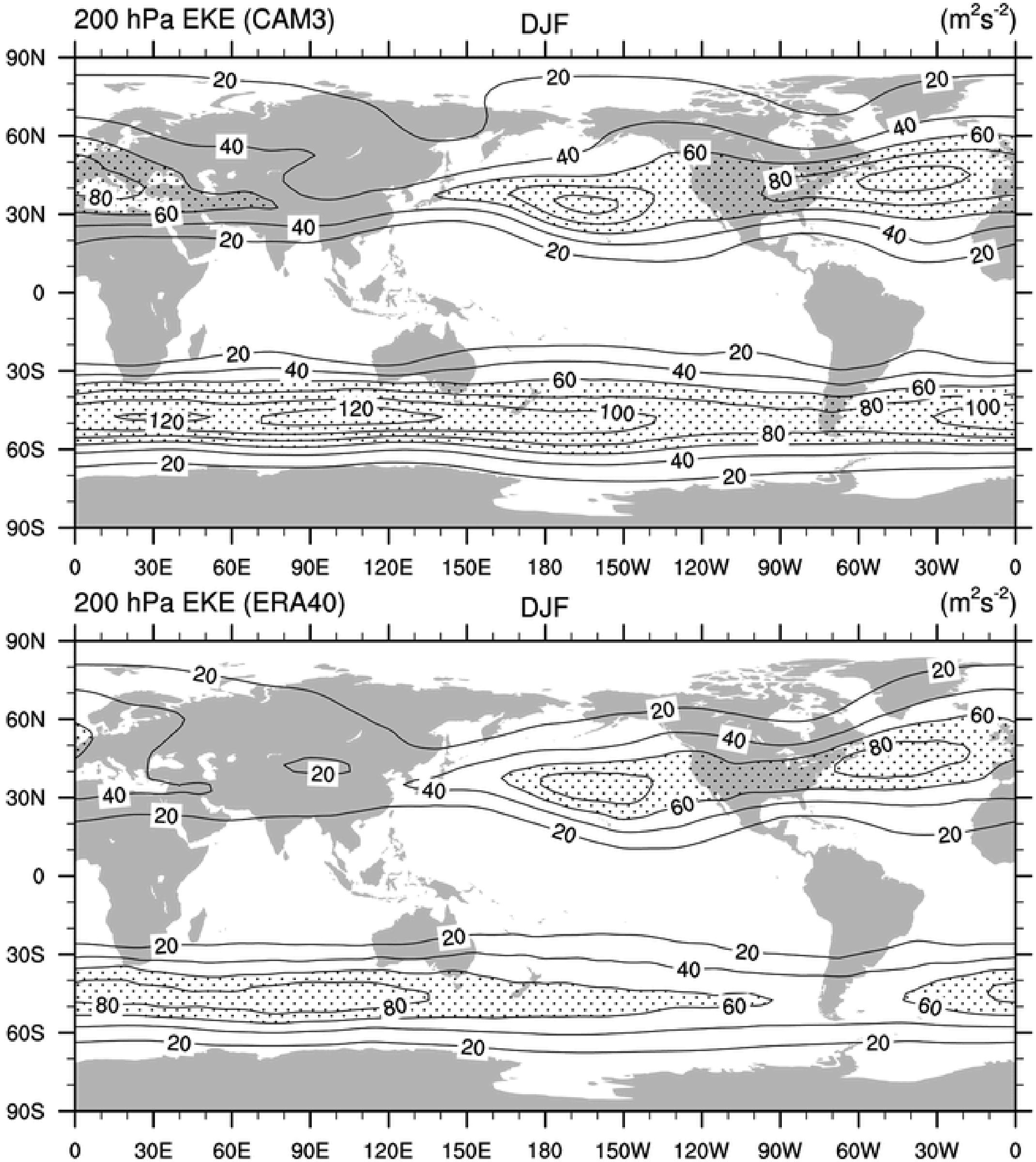


CAM3

ERA40

Fig. 18. Mean 200-hPa transient eddy kinetic energy (DJF) from (top) CAM3 and (bottom) ERA-40. The contour interval is 20 m2 s−2, and values greater than 60 m2 s−2 are stippled. (Hurrell et al. 2006)

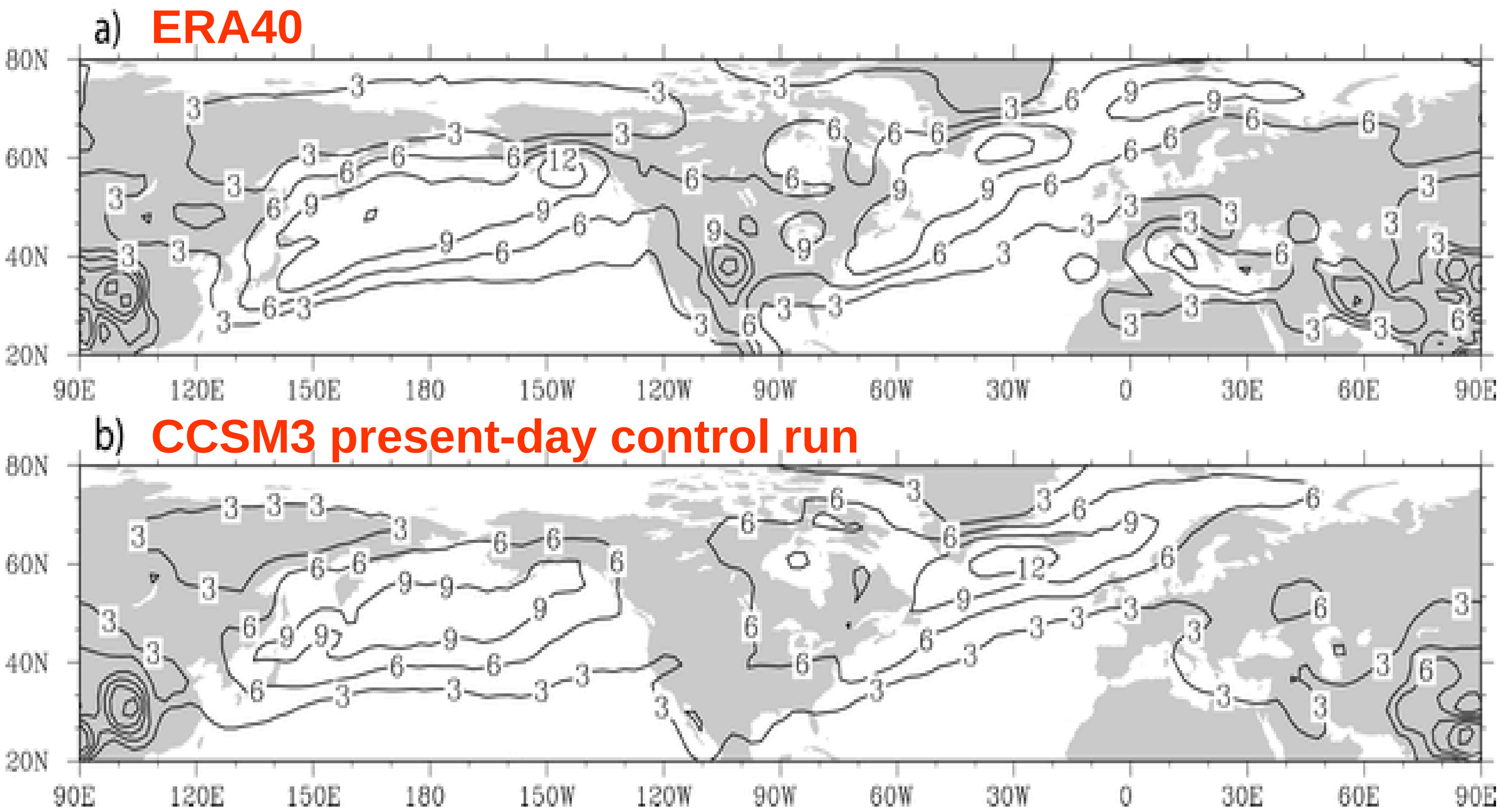


Fig. 1. Cyclone trajectory counts during DJFM for (a) ERA-40 for years 1958–2000 and (b) CCSM3 for years 501–540. The contour interval is every three cyclones per year within a 500-km distance of a given point. (Alexander et al. 2006)

Storm Track Methodology

Second-moment statistics of filtered meteorological variables

Serreze 1995, Serreze et al. 1997, Hodges 1994, Koenig et al. 1993, Blender et al. 1997, Sinclair 1997, Simmonds and Keay 2000, Gulev et al. 2001, Eichler and Higgins 2006, Lambert and Fyfe 2006, Bengtsson et al. 2006

Cyclone tracking

Vorticity tracking: Sinclair 1997, Simmonds and Keay 2000, Rudeva and Gulev 2007, Greeves et al. 2007

Resolution of the tracking variable: Blander and Schubert 2000, Jung et al. 2006

Map projection of the tracking variable: Zolina and Gulev 2002

Our Cyclone Tracking Algorithm

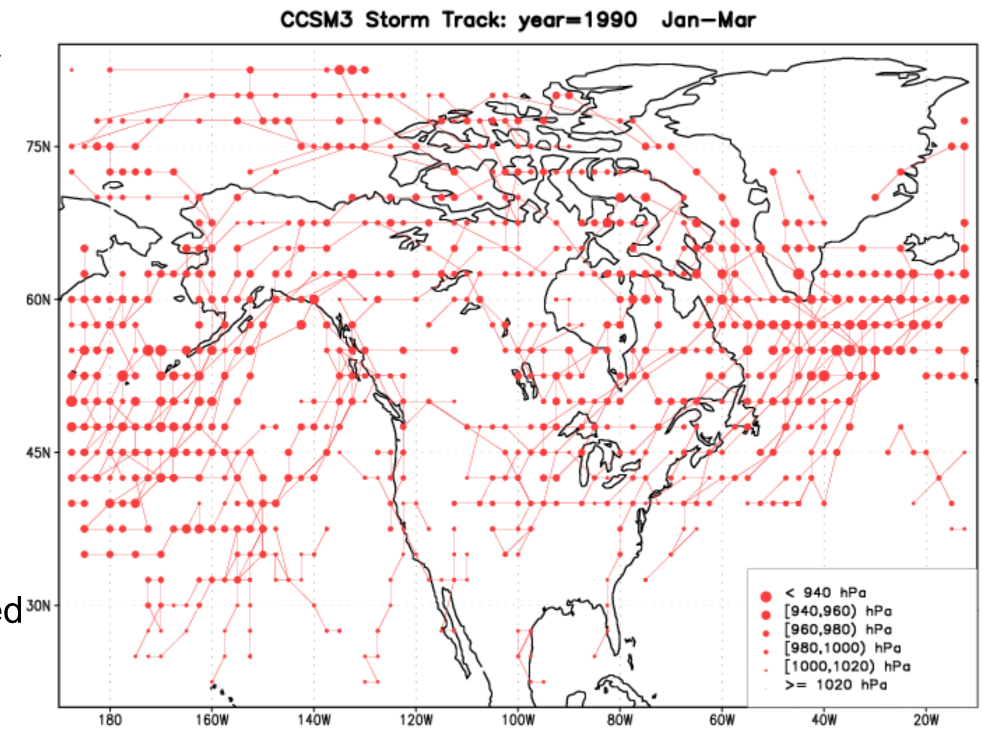
Data: 6hrly SLP
CCSM3 historical run
and A1B

Step1:

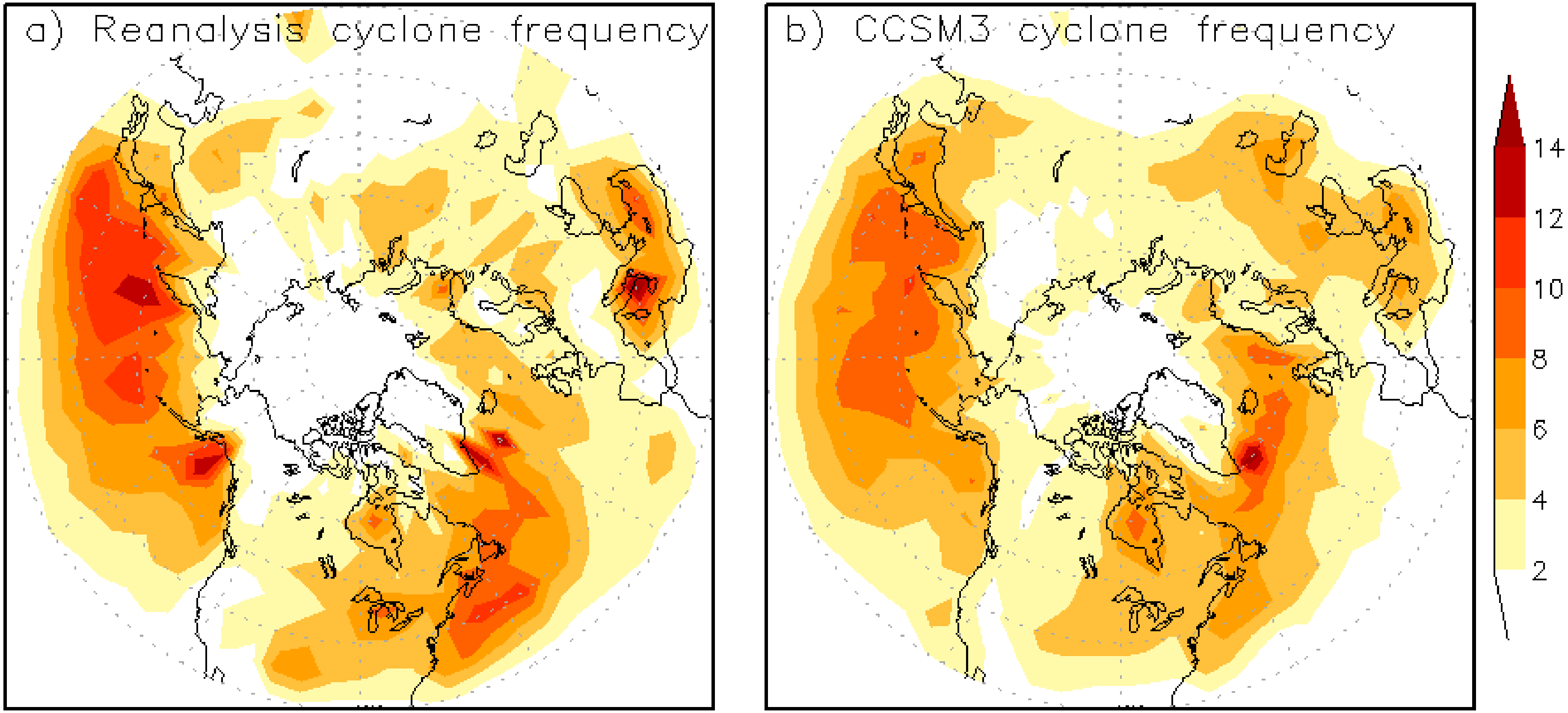
- the SLP of a cyclone candidate is lower than all eight surrounding grid points
- the SLP gradient between the cyclone candidate center and its eight surrounding grids is no smaller than 0.15 hPa/100km
- the pressure gradient between the four surrounding grid points and their outside adjacent grid points must be negative inward
- if there are more than one low pressure systems within 1200 km, the grid point with lower SLP is considered as the cyclone center

Step2:

- cyclone genesis occurs when there is no recorded cyclone within a radius of 700 km 6 hours earlier
- cyclones should last longer than 2 days



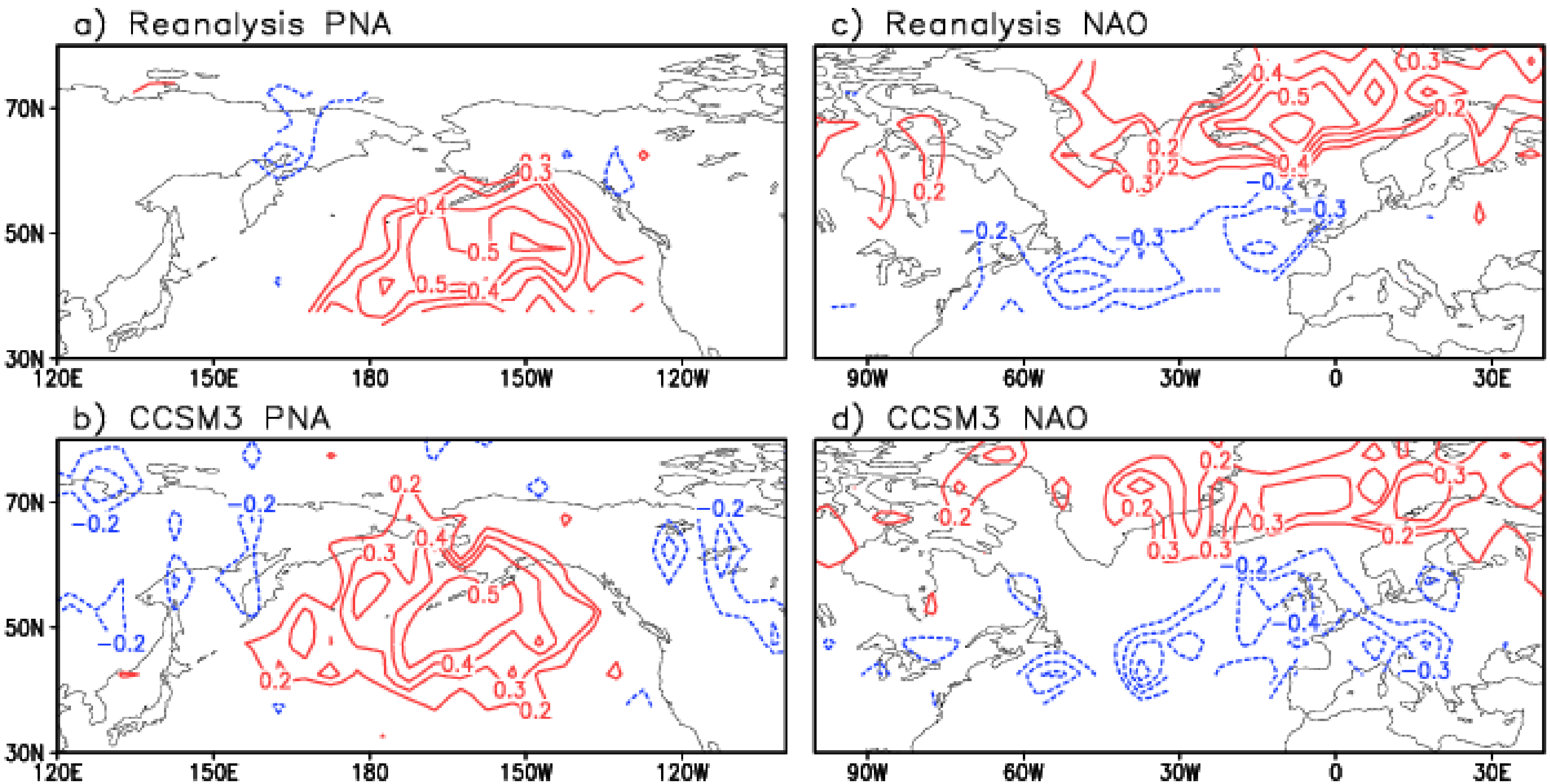
JFM Cyclone Frequency Climatology 1950-1999



Events/5x5 degree

Correlation between the frequency of the intense cyclone (slp <980 hPa)
And

PNA (Pacific) **NAO (Atlantic)**



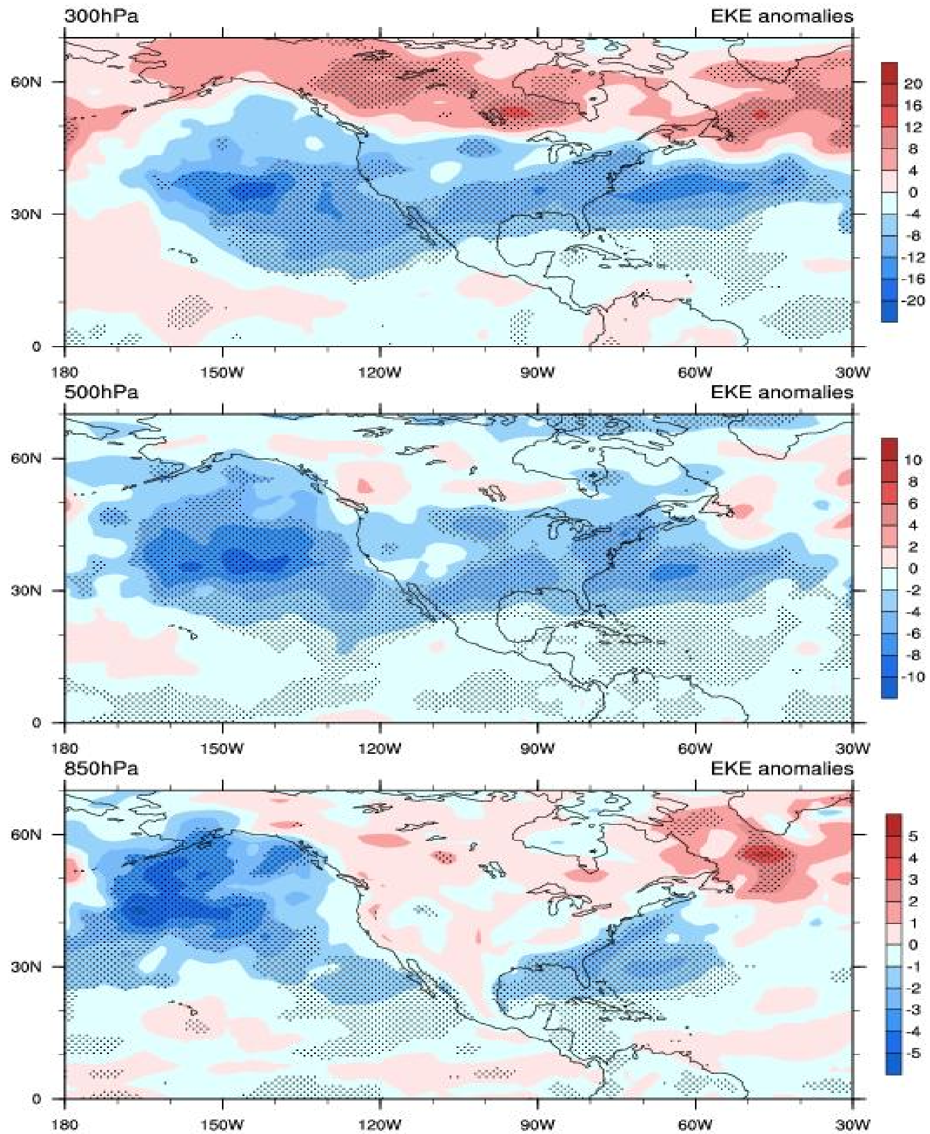
Consistent with Gulev et al. (2001)

Future change in JFM CCSM3 A1B 2-8-day EKE (2080-2099 relative to 1980-1999)

300 hPa

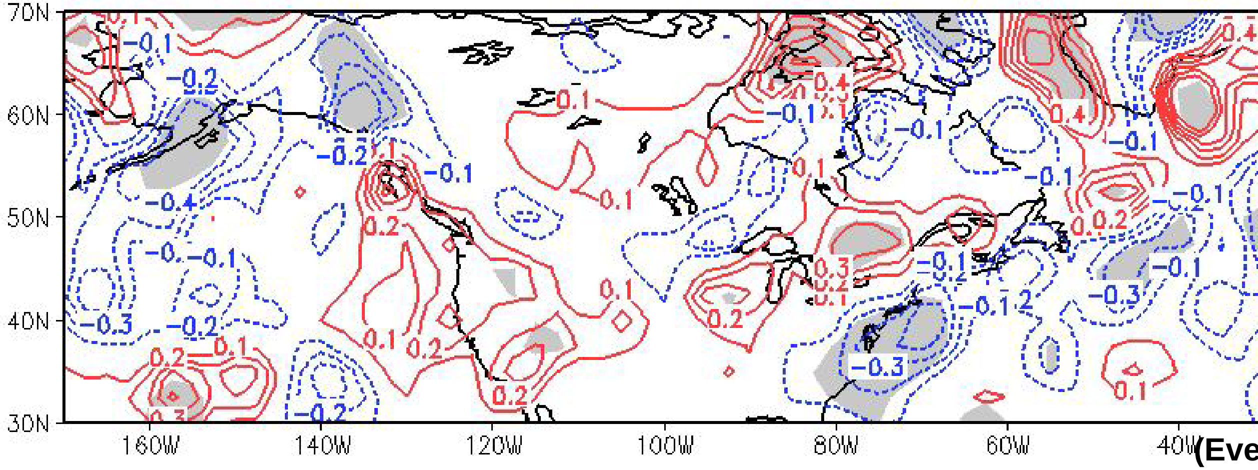
500 hPau

850 hPa



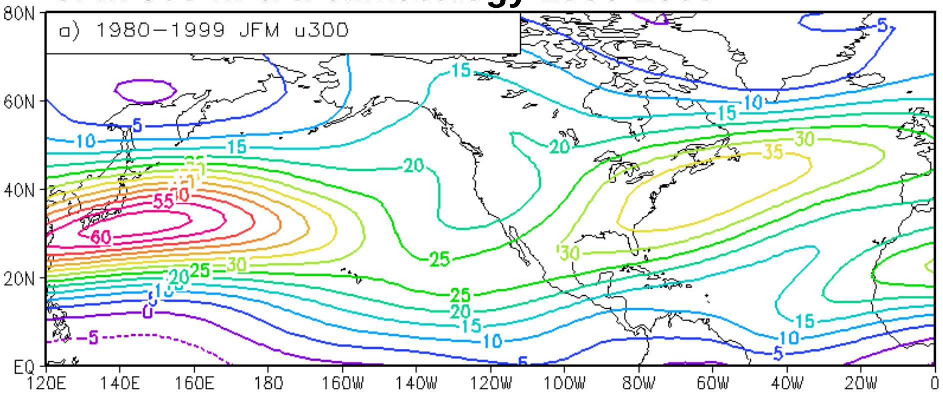
Poleward shift of the storm tracks (Yin 2005)

CCSM3 JFM cyclone frequency anomalies 2080-2099 relative to 1980-1999



(Events/2.5x2.5 degree)

JFM 300 hPa u climatology 1980-1999



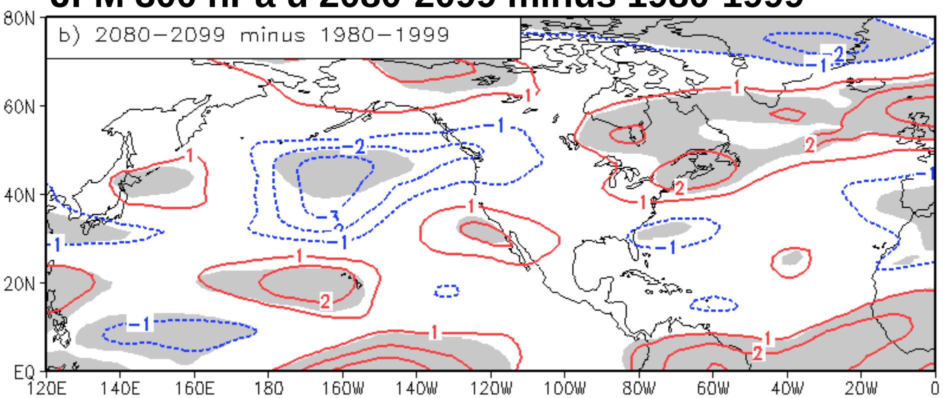
Baroclinicity parameter:

Eady growth rate maximum at 780 hPa

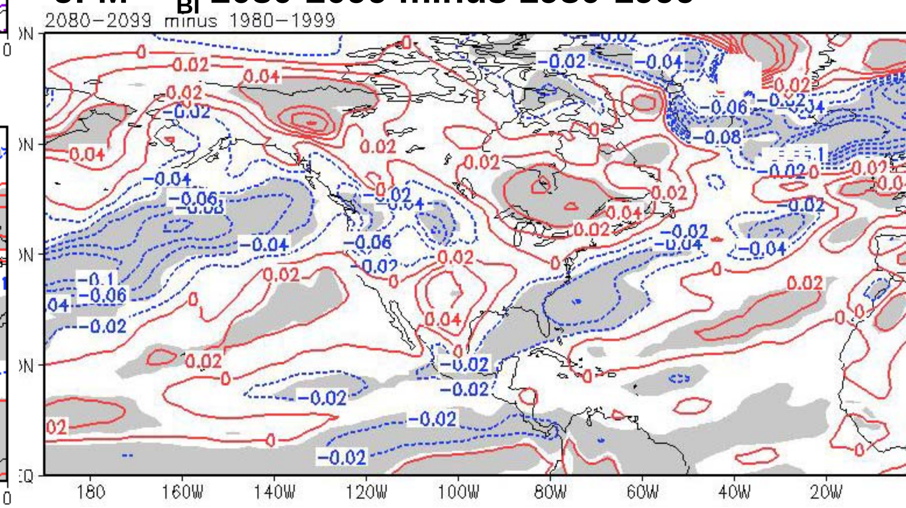
Lindzen and Farrell (1980) and Hoskins and Valdes (1990)

$$\sigma_{BI} = 0.31f\,|\,\partial \mathbf{V}/\partial Z\,|\,N^{-1}$$

JFM 300 hPa u 2080-2099 minus 1980-1999

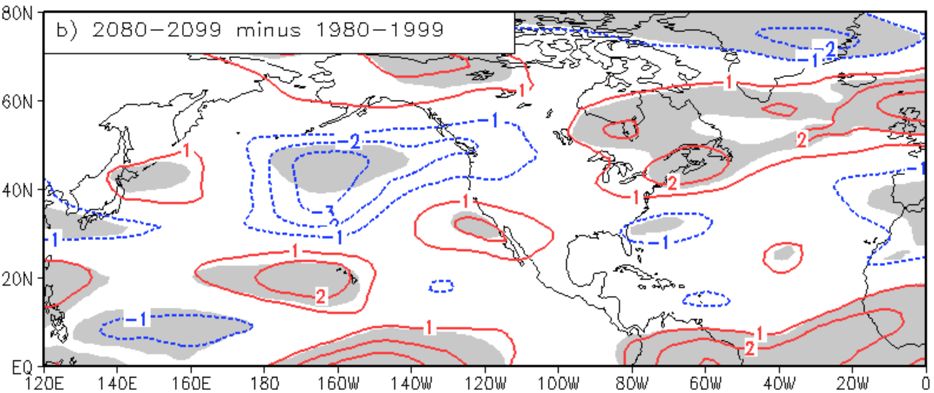


JFM σ_{BI} 2080-2099 minus 1980-1999

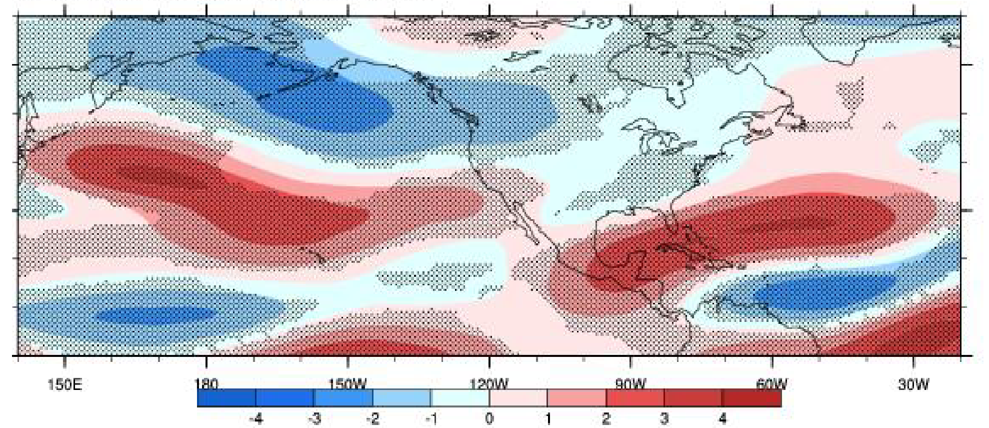


Mean state change: one member vs. 9 members

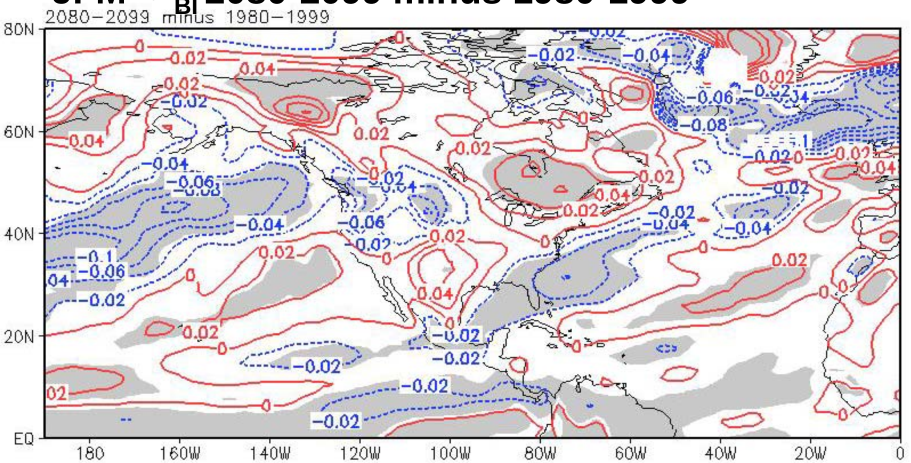
JFM U300 2080-2099 minus 1980-1999



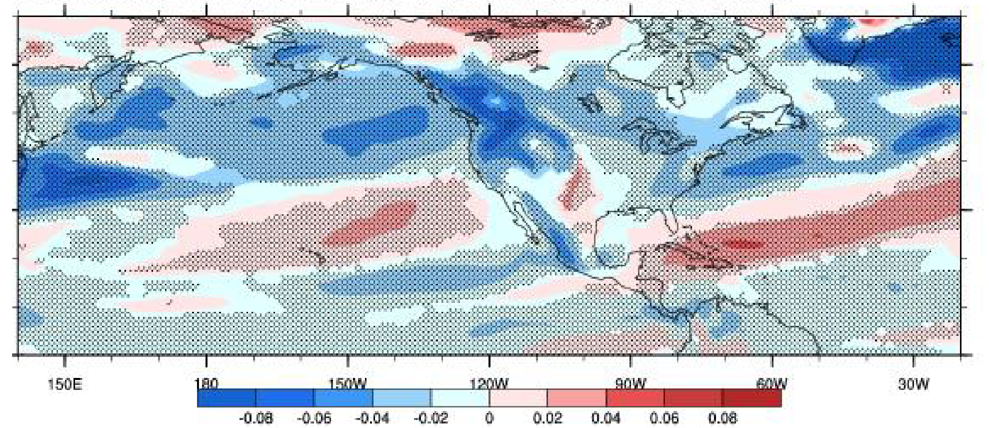
a) 9-member JFM u300 anomalies(m/s)



JFM σ $_{BI}$ 2080-2099 minus 1980-1999



b) 9-member JFM 780mb Eady growth rate maximum anomalies (1/day)



Shading indicates significant population difference at the 90% confidence level.

Stippling indicates at least 6 out of the 9 members agree on the sign of the anomalies.

Conclusions

- One CCSM3 21st century A1B scenario realization indicates there is a significant increase in the extratropical cyclone frequency on the US west coast and decrease in Alaska. Meanwhile, cyclone frequency increases from the Great Lakes region to Quebec and decreases over the US east coast, suggesting a possible northward shift of the Atlantic storm tracks under the warmer climate.

- The cyclone frequency anomalies are closely linked to changes in seasonal mean states of the upper-troposphere zonal wind and baroclinicity in the lower troposphere.

- Due to lack of 6-hourly outputs, we cannot apply the cyclone tracking algorithm to the other 8 CCSM3 realizations. Yet based on the linkage between the mean state change and the cyclone frequency anomalies, it is likely a common feature among other ensemble members that cyclone activity is reduced on the East Coast and in Alaska as a result of global warming.