Reply to Reviewer #1

Based on climate model simulations and sensitivity experiments, this study shows that the PNA was largely distorted or broken at the LGM, which was attributed to a split of the westerly jet stream over North America induced by the thick Laurentide ice sheet. It further indicates that ENSO had little influence on North American climate at the LGM. The results are intriguing and the mechanism proposed is convincing. I would recommend a minor revision to address the comments below.

We thank the reviewer for the reviews. Replies to the comments are as follows. All our replies are in blue.

1. If the PNA is defined as the leading EOF of the 500hPa geopotential height, the results would change or not?

We have done analysis, using different methods. The results are almost the same as our correlation analysis.

Figure R1 shows the geographic distributions of the Rotated Empirical Orthogonal Function (REOF) analysis of 500 hPa height in NCEP/NCAR reanalysis. The second REOF mode well represents the loading pattern of the PNA. The second REOF in the PIC simulation of PMIP2 CCSM3 also shows the PNA pattern (Figure R2).

However, the second REOF in the LGM simulation of the PMIP2 CCSM3 does not show the PNA pattern (Figure R3). The third and fourth modes indicate connections between the North Pacific and Arctic.

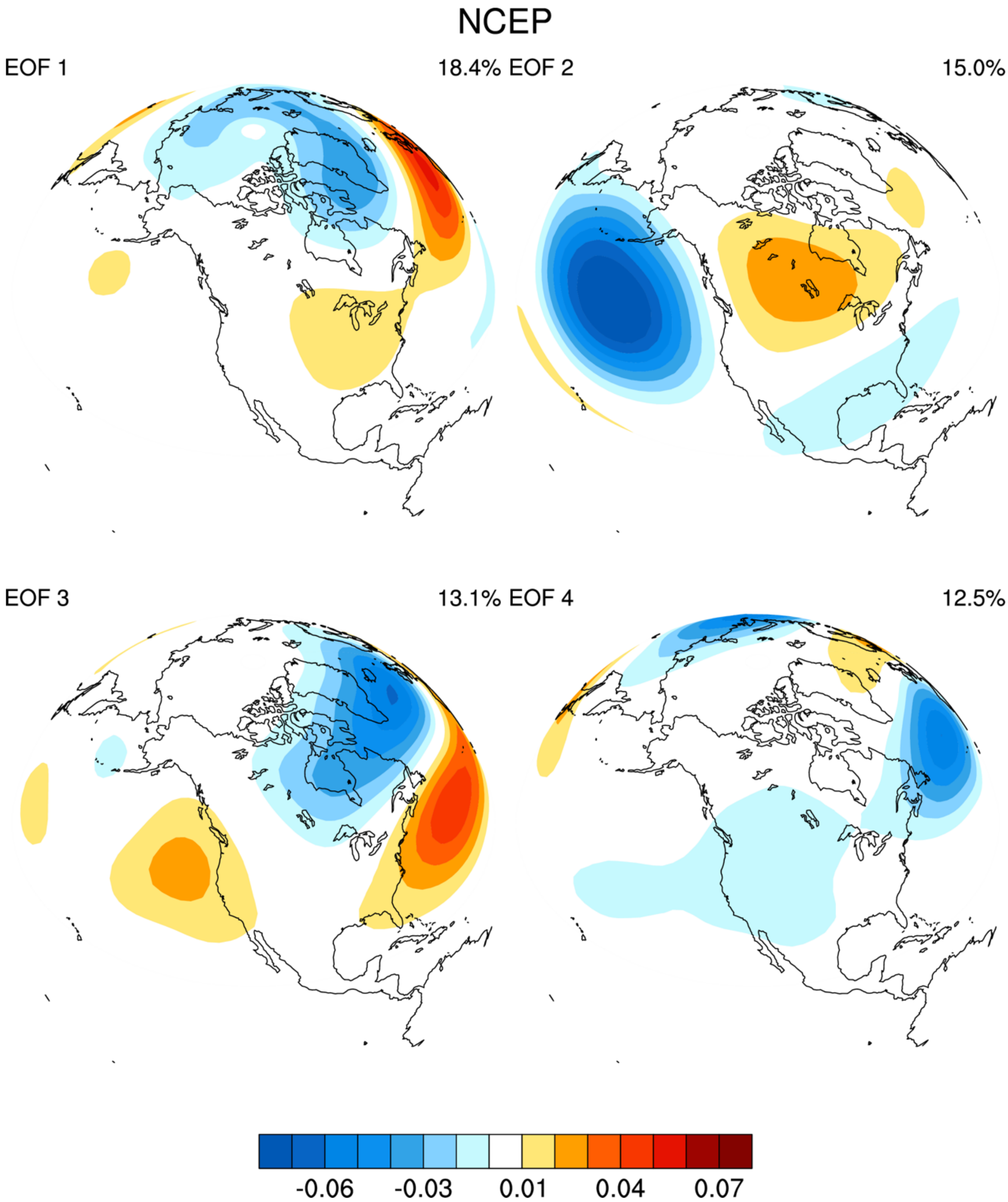


Figure R1. Spatial patterns of the Rotated Empirical Orthogonal Function (REOF) analysis of 500 hPa height in NCEP/NCAR reanalysis.

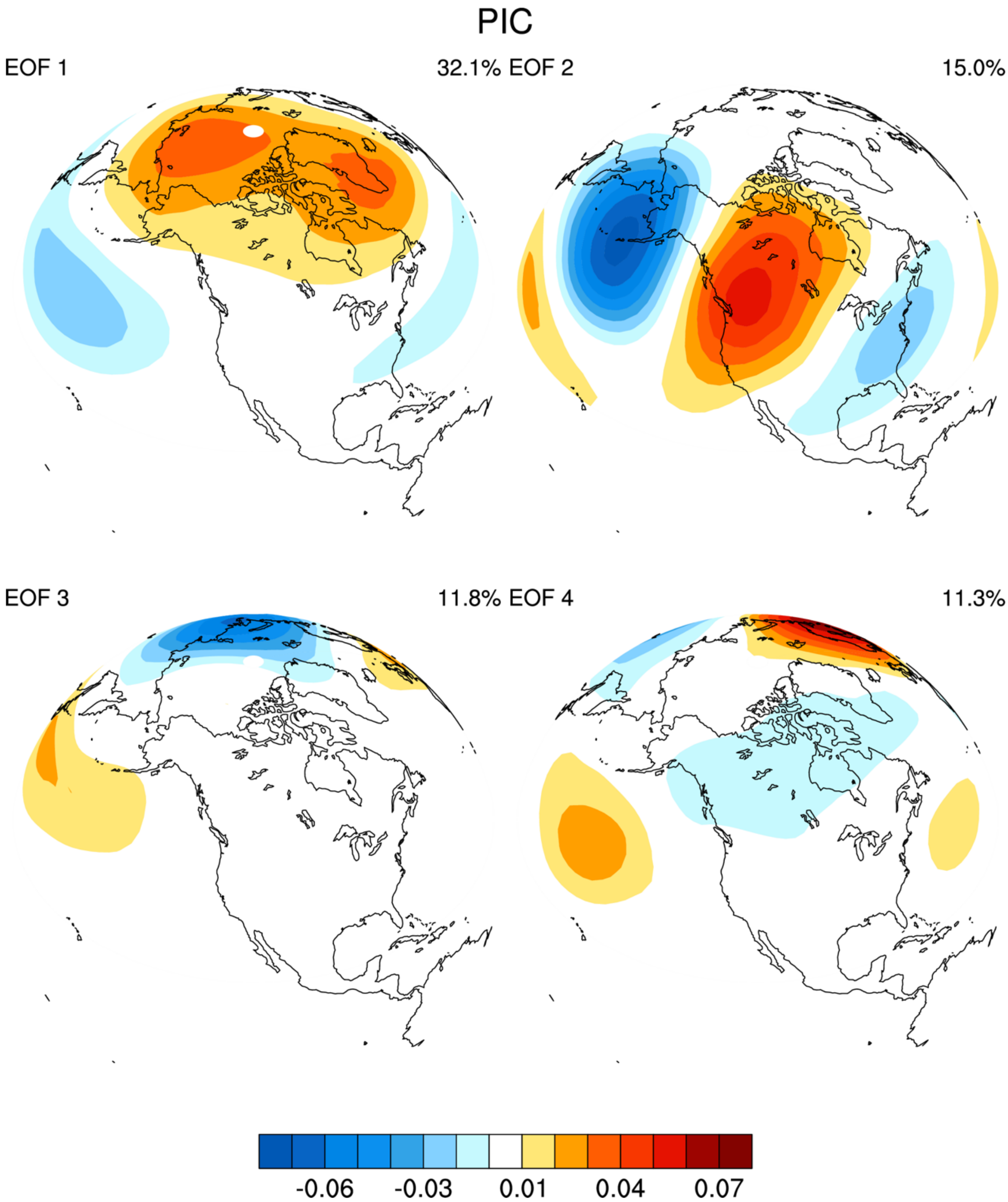


Figure R2. Spatial patterns of REOFs of 500 hPa height in the PIC simulation of PMIP2 CCSM3.

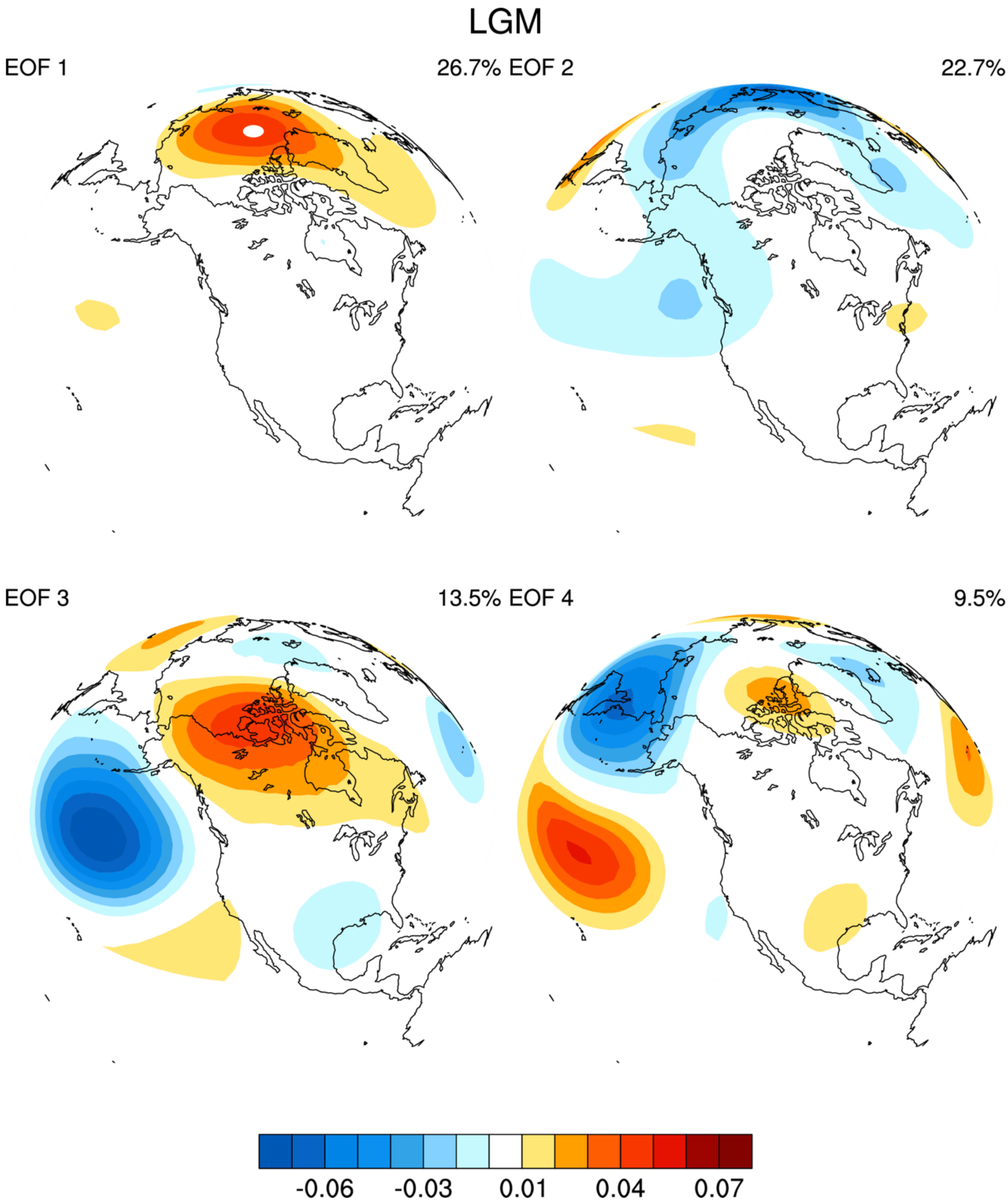


Figure R3. Spatial patterns of REOFs of 500 hPa height in the LGM simulation of PMIP2 CCSM3.

2. It is better to replace Figs. 6d-f with the meridional temperature gradient, and present a figure showing the sensitivity simulation result that meridional temperature gradient become sharper with increasing ice sheet thickness. This would clearly illustrate how a split of the westerly jet stream over North America is connected to the thick ice sheet through the thermal wind relation.

Thanks for the suggestion. We have replaced Figs. 6d-f with the meridional temperature gradient. As shown in the updated figure, we can clearly see that the subtropical temperature gradients in the LGM simulation are stronger than those in NCEP/NCAR reanalysis and the PIC simulation.

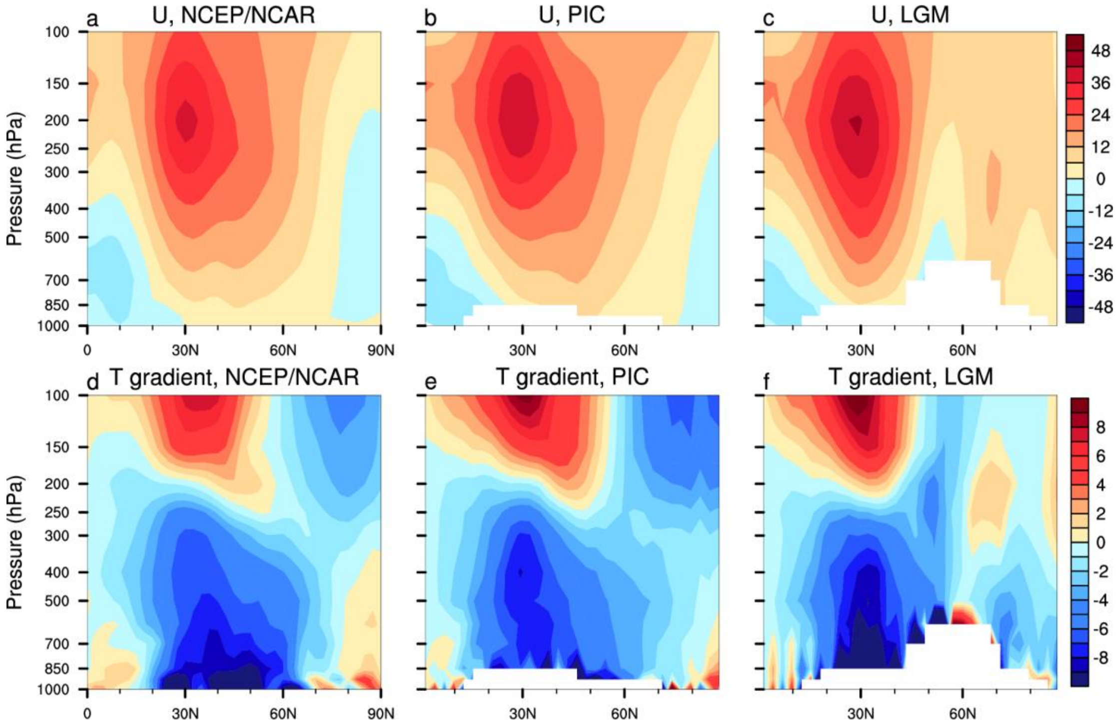


Fig. 6. Vertical cross sections of DJF zonal winds and meridional temperature gradients along the longitude of 100 °W in the NCEP/NCAR reanalysis and PMIP2 CCSM3 simulations. Top panels: zonal winds, and bottom panels: meridional temperature gradients. Left panels: NCEP/NCAR, middle panels: PIC, and right panels: LGM. Zonal-wind unit is ms^{-1}, and temperature gradient unit is K/(1000 km).

A new figure will be added to the papers to how meridional temperature gradients change with increasing ice-sheet thickness (Figure S4). The figure shows that subtropical temperature gradients becomes stronger with increasing ice sheet thickness, which leads to the strengthening of the subtropical jet.

Figure S4 also shows that positive temperature gradients occur above the ice sheet as ice sheet thickness reaches 80%. It is consistent with the occurrence of easterly winds.

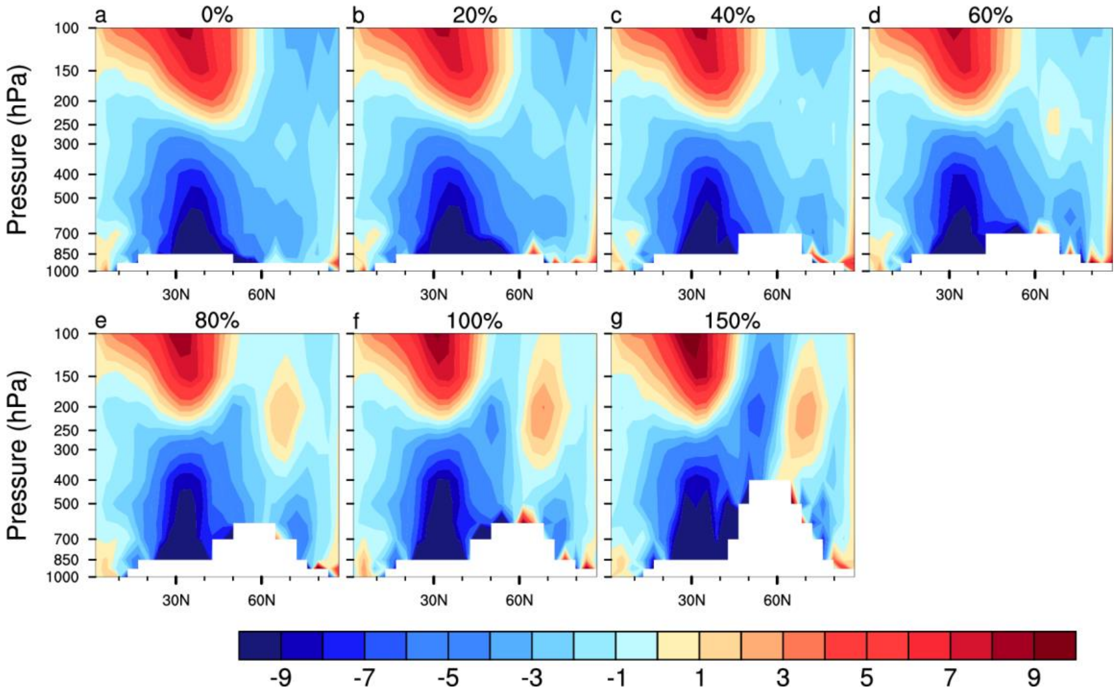
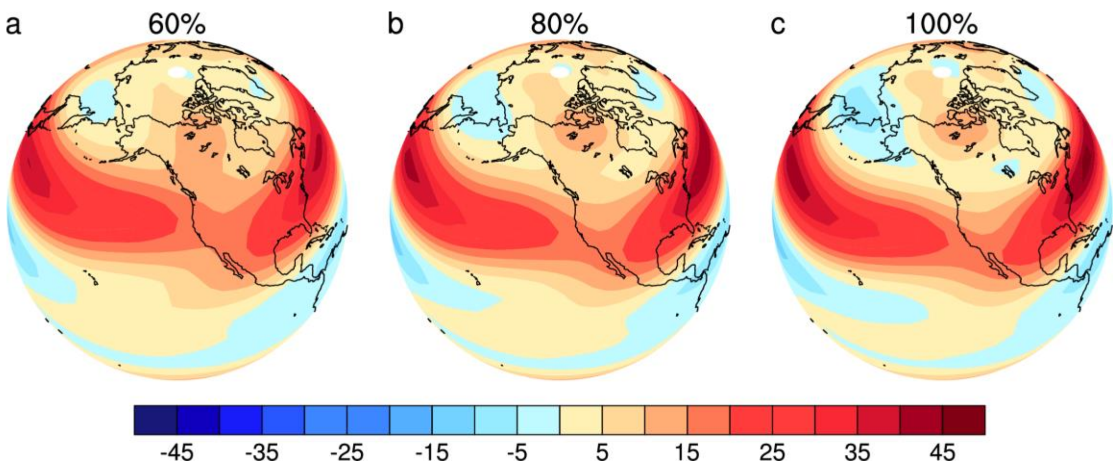


Figure S4. Vertical cross sections of DJF meridional temperature gradients along the longitude of 100 °W in sensitivity simulations with different ice sheet thicknesses. (a) 0%, (b) 20%, (c) 40%, (d) 60%, (e) 80%, (f) 100%, and (g) 150%. The color interval is 1 K/(1000 km) .

3. Fig. 8 is kind of needless. Instead, the zonal wind in the 60%, 80%, 100% thickness simulations can be added to Fig. 7 to show the occurrence of easterly winds over the Laurentide ice sheet.

Yes, zonal winds in the 60%, 80%, and 100% thickness simulations will be added to Fig. 7. It is shown below.

It is better to keep Figure 8, we feel. Readers shall have some intuition of how the geopotential field and winds respond to increasing ice sheet thickness.



4. How are the wave activity flux and stationary wavenumbers calculated?

The three-dimensional wave activity fluxes are calculated using equation 7.1 in Plumb (1985), which is cited in the paper.

The stationary wavenumbers are calculated using equation 6.29 in Held (1983), which is also cited in the paper.

5. The temporal span used for the individual simulations of PMIP2 and PMIP3 should be clarified. What is the degree of freedom used for the correlation coefficient of 0.35?

Thanks for your suggestion! We used the last 30-year simulations for each model of PMIP2, PMIP3, and our sensitivity simulations. The degree of freedom used for the correlation coefficient of 0.35 is 30.

6. L189: Alberta->North Pacific

Revised.

References:

Held IM (1983) Stationary and Quasi-stationary Eddies in the Extratropical Troposphere: Theory. in B. J. Hoskins, Pearce RP (eds.) Large-scale Dynamical Processes in the Atmosphere. Academic Press, pp. 127–168.

Plumb RA (1985) On the Three-Dimensional Propagation of Stationary Waves. Journal of the Atmospheric Sciences 42:217-229.