Synoptic-Dynamic Climatology of the Stratospheric Aleutian Anticyclone

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Motivation

- The "Aleutian High" (AH) is a normal, climatological feature of the wintertime Northern Hemisphere stratospheric circulation (See Fig. 1).
- Although the climatology of the AH has been documented by Harvey and Hitchman (1996), its existence and dynamics have not been explained.
- It is worth studying because its anomalous intensification and poleward expansion can coincide with distortions of the stratospheric polar vortex and lower tropospheric cold air anomalies (Fig. 1)

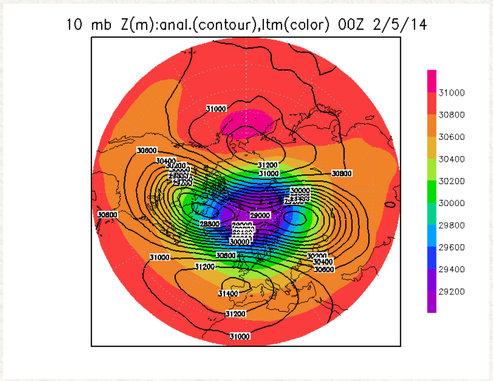
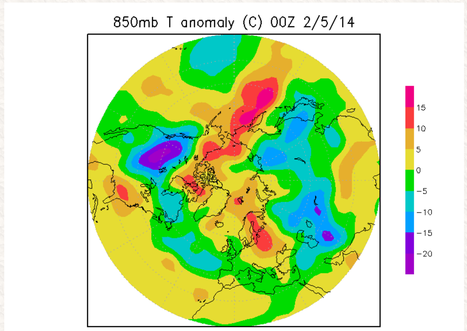


Figure 1. Above: analyzed (contours) and long-term (1981 – 2010) daily mean (colors) 10-mb geopotential heights (m) and right: 850-mb temperature anomalies (C), all valid 0000 UTC 5 February 2014.

Climatology

- Using MERRA data (Rienecker et al. (2011) and the moments technique of Ehrmann and Colucci (2017), an AH was defined by a closed 31.2 km contour on 10 mb, within 40-80N, 120E-100W, 1 October through 31 March, covering $1.84X10^6$ km^2, and persisting for at least five days.
- 68 events (each separated by at least 15 days) were identified in 35 winters (1980 – 2014) or almost two events per winter (Fig. 2).

Figure 2. AH events (blue shading, with each onset date marked with a black circle), as a funtion of day relative to January 1 (Day 0) during 1980 – 2014 winter seasons.



Dynamics

- The onset of each AH event was investigated by inverting the quasigeostrophic potential vorticity tendency to obtain the geopotential height tendency due to mechanical (vorticity) and thermal forcings in the troposphere (1000 – 200 mb) and stratosphere (200 – 10 mb), following Ehrmann and Colucci (2017).
- Analyzed and calculated height tendencies were averaged under each AH and composited over all events.
- Composite 10-mb height tendencies at AH onset are mostly due to thermal and mechanical forcings in the stratosphere, but with a non-negligible contribution from mechanical forcing in the troposphere (Fig. 3).

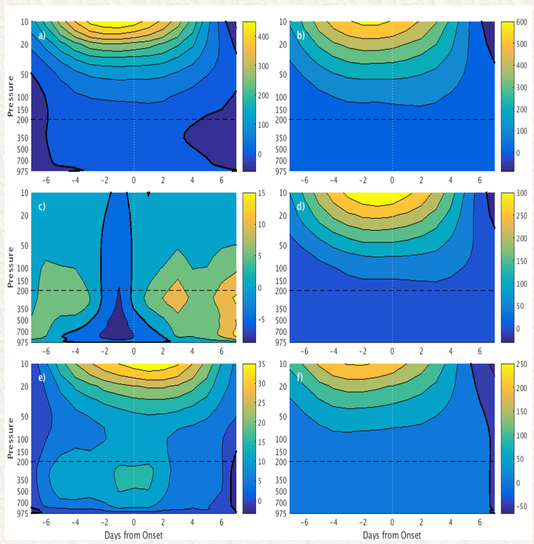


Figure 3. Geopotential height tendencies (m/10d) as a function of pressure and day relative to AH onset (Day 0): (a) analyzed, (b) total calculated, (c) thermal troposphere, (d) thermal stratosphere, (e) mechanical troposphere and (f) mechanical stratosphere.

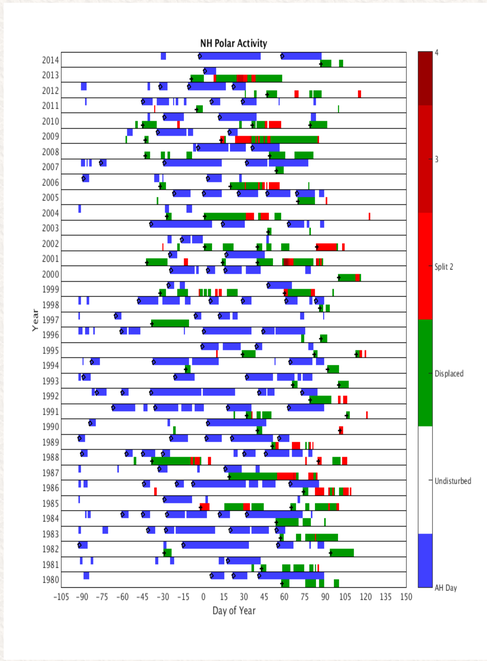


Figure 4. As in Figure 1 but including the polar vortex disturbance events from the Ehrmann and Colucci (2017) catalog.

Conclusions

- There were roughly two AH events per winter during the 1980 – 2014 winter seasons.
- AH onset is of mostly stratospheric origin, with roughly equal contributions from mechanical and thermal forcings.
- There is a non-negligible contribution to AH onset from mechanical (vorticity) forcing in the tropospere, possibly from upward propogating blocking anticyclones.

Questions

- Do polar vortex disturbances coincide with AH intensification (Fig. 4)?
- What causes the demise of AH events?
- What are the dynamics of stratospheric anticyclones in other locations (North Atlantic, Australia)?
- Is there a relationship between tropospheric blocking and the AH?

References

- Ehrmann, T. S., and S. J. Colucci, 2017: Tropospheric cooling as a mechanism for stratospheric polar vortex disturbances. Submitted to *J. Atmos. Sci.* Available upon request.
- Harvey, V. L., and M. H. Hitchman, 1996: A climatology of the Aleutian High. *J. Atmos. Sci.,* **53**, 2088-2102.
- Rienecker, M. M., and Coauthors, 2011: MERRA: NASA's modern-day retrospective analysis for research and applications. *J. Clim.,* **24**, 3624-3648.