Blocking

Outline

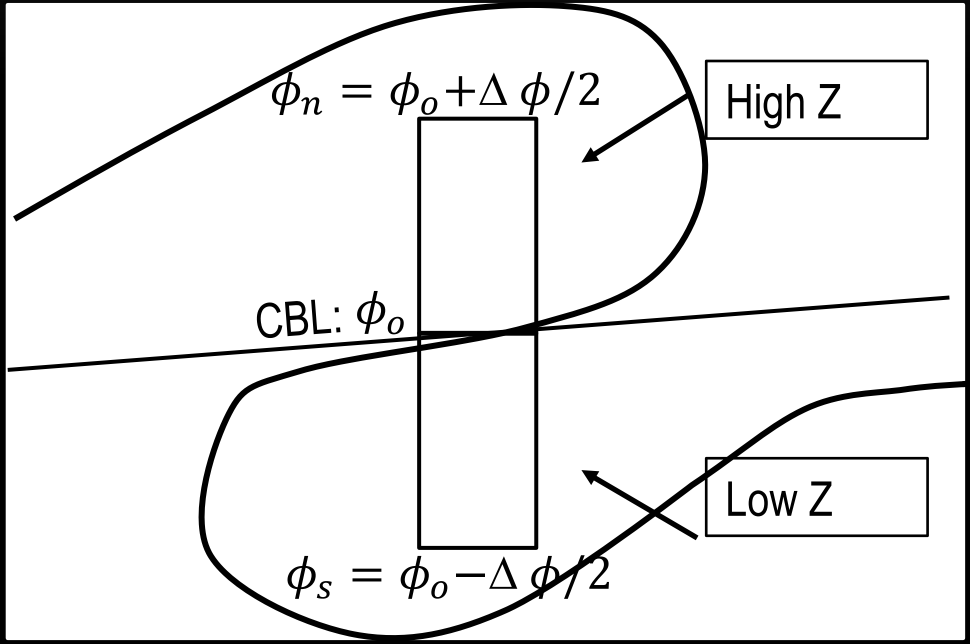
- What is blocking?
- How do we detect blocking?
- What are the typical types of blocking?
- Impacts of blocking
- Variability and Prediction

What is blocking?

- Blocking denotes the breakdown of the prevailing midlatitude westerly flow. It is often associated with a quasi-stationary anticyclone at high latitude and a split or meridional displacement of the zonal jet. It is called “blocking” because the normal westerly flow and the eastward progression of weather systems are temporarily disrupted by a strong meridional type of flow.
  - Blocking may be identified as a weather regime in some regions.
- Blocking patterns typically exist over the same location for 3-5 days and on rare occasions may persist for weeks. Long-lasting blocking will induce persistent anomalous weather conditions, including extreme temperatures and droughts.
  - persistent blocking over Europe in summer 2003 led to extreme heat waves
  - a blocking anticyclone over North America in winter 2013/14 resulted in warm anomalies in the west coast and cold anomalies in the eastern US.
- The persistence of blocking implies: i) association with extreme weather; ii) a potential to improve the extended-range predictability

Blocking Detection I: An Anomalous High

- Identify blocking as an anomalous anticyclone or as the reversal of the meridional geopotential height gradient at 500 hPa.
- Blocking can be searched along the “central blocking latitude” (CBL), which is often defined based on the midlatitude storm track.
- Blocking highs are different from synoptic ridges. Additional thresholds are required to constrain the duration and spatial scale:
  - Duration threshold (e.g., > 3, or 5 or 7 days)
  - Quasi-stationary threshold: (e.g., the displacement of the center longitude less than 45 degrees in one day, Barnes et al. 2012)
  - Spatial scale threshold (e.g., blocked longitude needs to be contiguous for at least 15-degrees)



For example, Lejenäs and Økland (1983) required that

$$Z_{\phi_0 - \Delta\phi/2} - Z_{\phi_0 + \Delta\phi/2} < 0$$

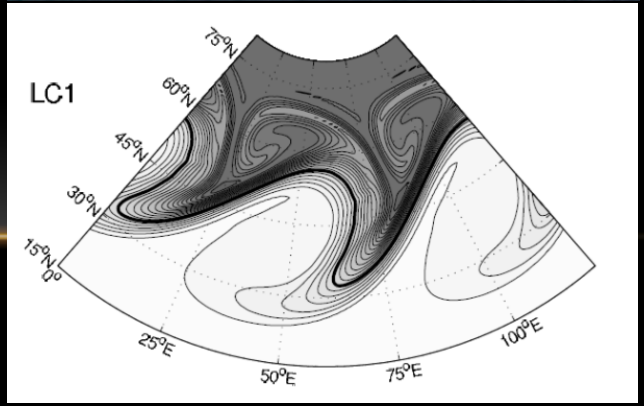
What does the blocking identification algorithm imply for the zonal wind?

Blocking Detection II: Rossby Wave Breaking

- Blocking is detected based on its Rossby wave breaking (RWB) feature.
- Blocking is detected based on the reversal of the potential temperature gradient on potential vorticity surfaces.
- The essence of the formation of a block is that a substantial mass of subtropical air, with its low potential vorticity on an isentropic surface, is advected poleward.

What is Rossby wave breaking?
Similar to ocean wave breaking, RWB is characterized by the rapid and irreversible overturning of potential vorticity (PV) contours (McIntyre and Palmer 1983)

Wikipedia



Simulated with GFDL Dry Dynamic Core, Polvani and Esler (2007)

Blocking Detection II: Rossby Wave Breaking (cont'd)

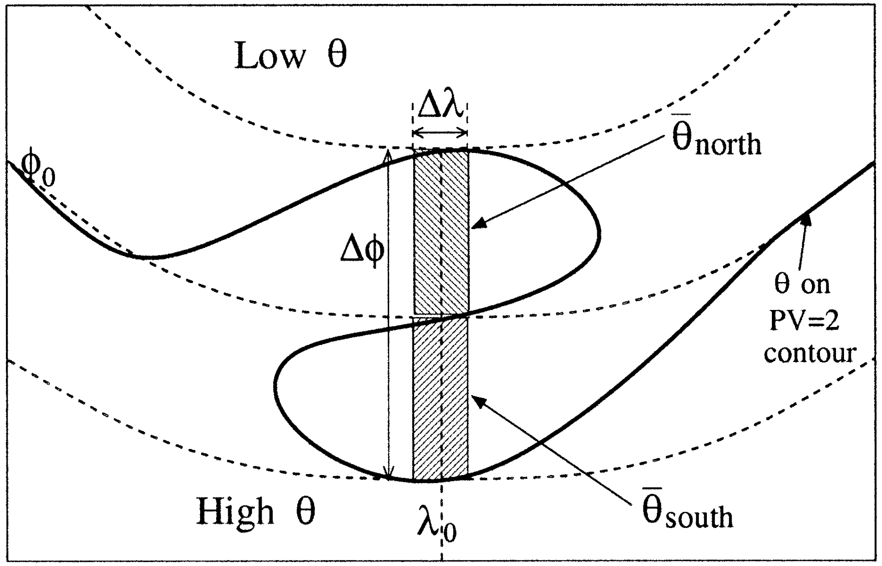


FIG. 2. A schematic representation of the relevant parameters for calculating the PV–θ blocking index $\mathcal{B}$ at a given longitude λ_0. The thick line is a representative θ on PV = 2 contour during a blocking event centered at λ_0 in this case.

Blocking Index is defined on potential vorticity surfaces

$$\mathcal{B} = \frac{2}{\Delta\phi}\int_{\phi_0}^{\phi_0+\Delta\phi/2} \theta \, d\phi - \frac{2}{\Delta\phi}\int_{\phi_0-\Delta\phi/2}^{\phi_0} \theta \, d\phi.$$

A longitude could be said to be blocked if *B>0*, indicating that there is high potential temperature to the north and low potential temperature to the south (reversal of the meridional theta gradient).

1D Blocking Index vs. 2D blocking Index

- 1D blocking:
  - Search for blocking along a fixed latitude, such as 50N
  - Search for blocking along the storm track, which varies with longitude and season
- 2D blocking:
  - Search blocking at all latitudes within a latitude range
  - It thus identifies large-scale wave breaking events at higher latitudes that do not block the core of the westerly jet

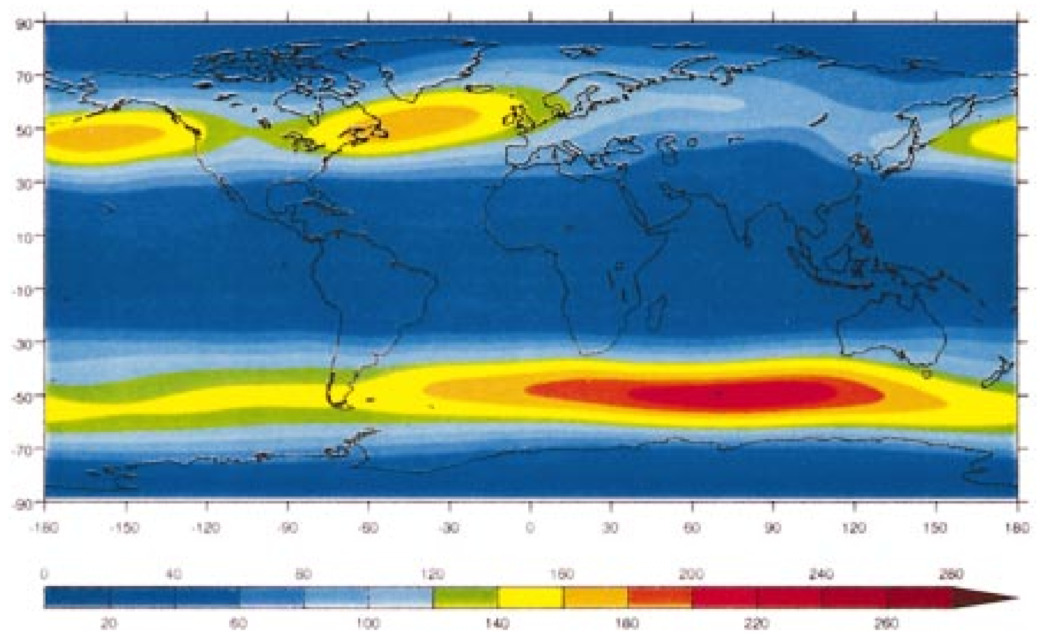
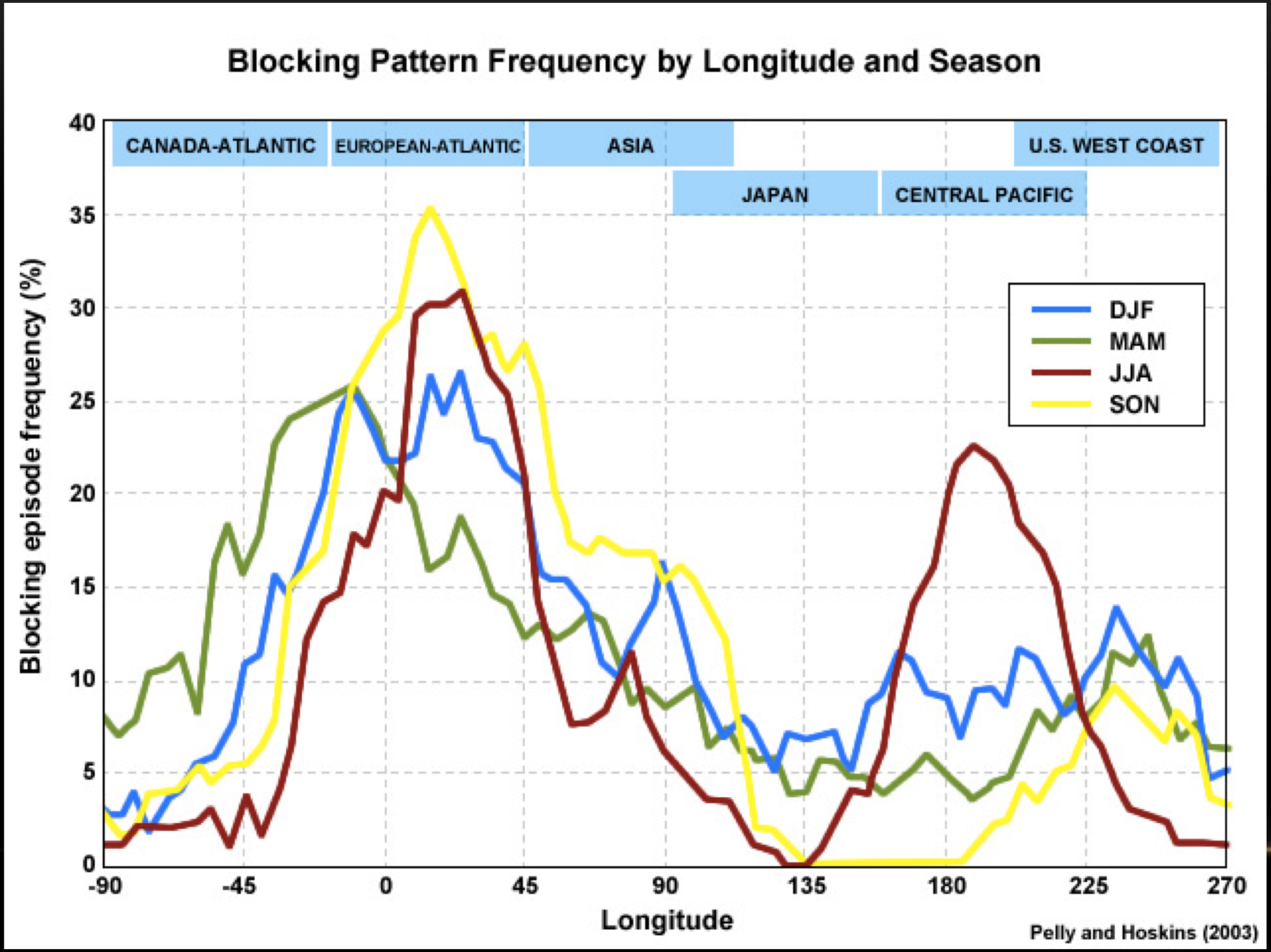


FIG. 3. Annual mean high-pass transient EKE ($m^2 s^{-2}$) at 300 hPa taken from the ERA-15 dataset (1979–93 ECMWF Reanalysis). Spectral filtering has been applied at truncation T21.

1D Blocking: Freq in Diff. Seasons



- Two peaks: one peak over the Atlantic and one over the Pacific.
- Over the Pacific blocking occurs more frequently in summer and the peak is close to the dateline, while blocking peaks over the East Pacific in the other seasons.

2D Blocking Distribution (winter)

Three blocking centers:

- The Pacific sector, north of the jet core
- Near Greenland, north of the jet core
- Near Scandinavia, south of the jet core

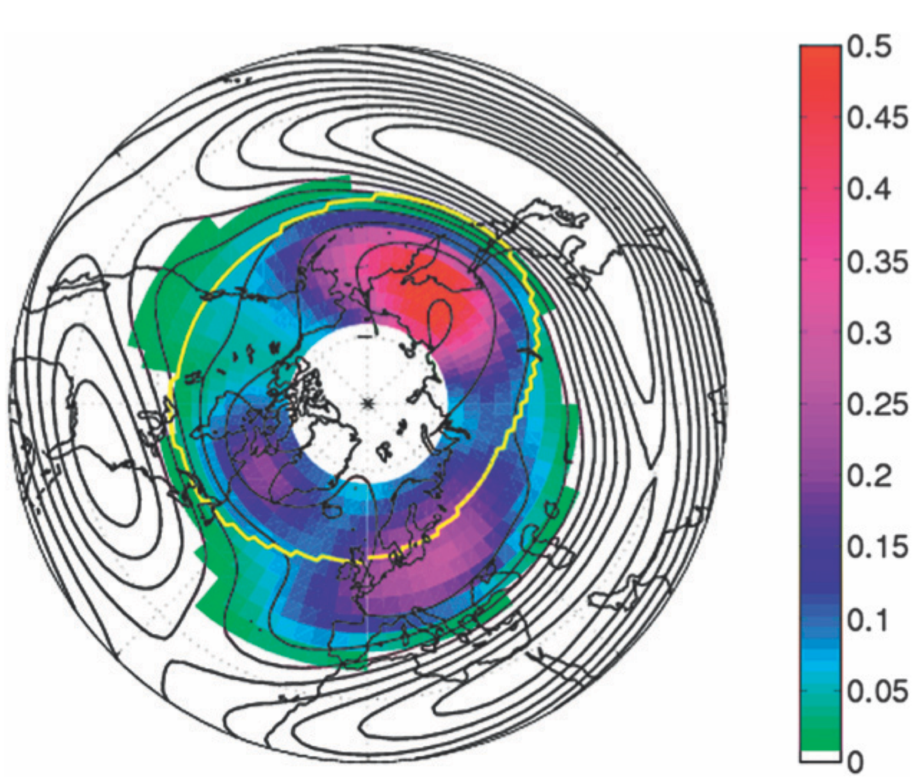


FIG. 2. Relative frequency of blocking as derived by using the 2D approach (shading). For each day in which blocking is identified, all grid points (around the blocking center) that exhibit a positive *B* are counted. These are then summed up and rescaled for the total number of days (90 × 44 seasons). The black contours display the mean of *B*, with values from −50 (the jet-stream core over the Pacific) and every 5 units. The yellow line represents the CBL used in M11.

References

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- Pelly, J. L., and B. J. Hoskins, 2003: How well does the ECMWF ensemble prediction system predict blocking? Quart. J. Roy. Meteor. Soc., 129, 1683–1702.
- Tibaldi, S., and F. Molteni, 1990: On the operational predictability of blocking.*Tellus* , **42A**, 343-365.