Storm Tracks and Low-Frequency Variabilities in AFES-LETKF Experimental Ensemble Reanalysis 2 (ALERA2)

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Summary

- Large-scale atmospheric fields including storm tracks in the upper troposphere of Northern Hemisphere in ALERA2 show good agreement with those in JRA-25 reanalysis.
- Distribution of the analysis ensemble spread in the upper troposphere is large over the Pacific and the Atlantic, which are in part related to storm-track activities.
- Near the times when the ensemble spread takes maxima or minima over Pacific or Atlantic regions, similar weather patterns tend to appear over or just downstream of the regions.

Introduction

- AFES-LETKF experimental ensemble reanalysis 2 (ALERA2, Enomoto et al. 2013) is an atmospheric reanalysis dataset based on AFES (AGCM for the Earth Simulator) and the local ensemble transform Kalman filter (LETKF).
- Two streams are conducted as ALERA2 (Figure 1).

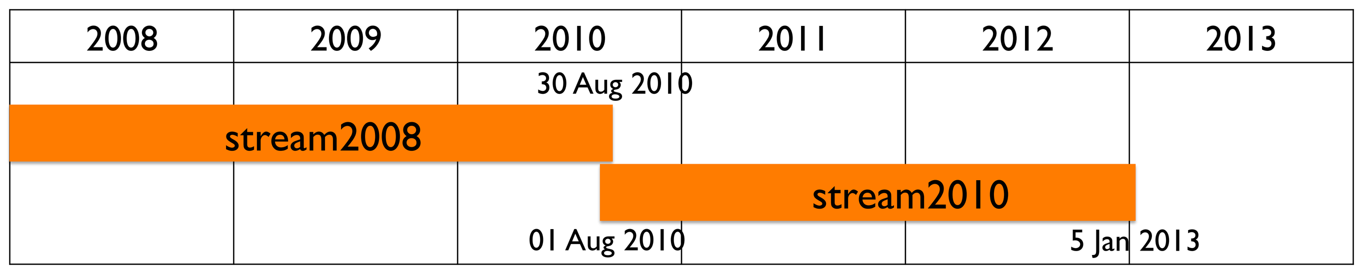
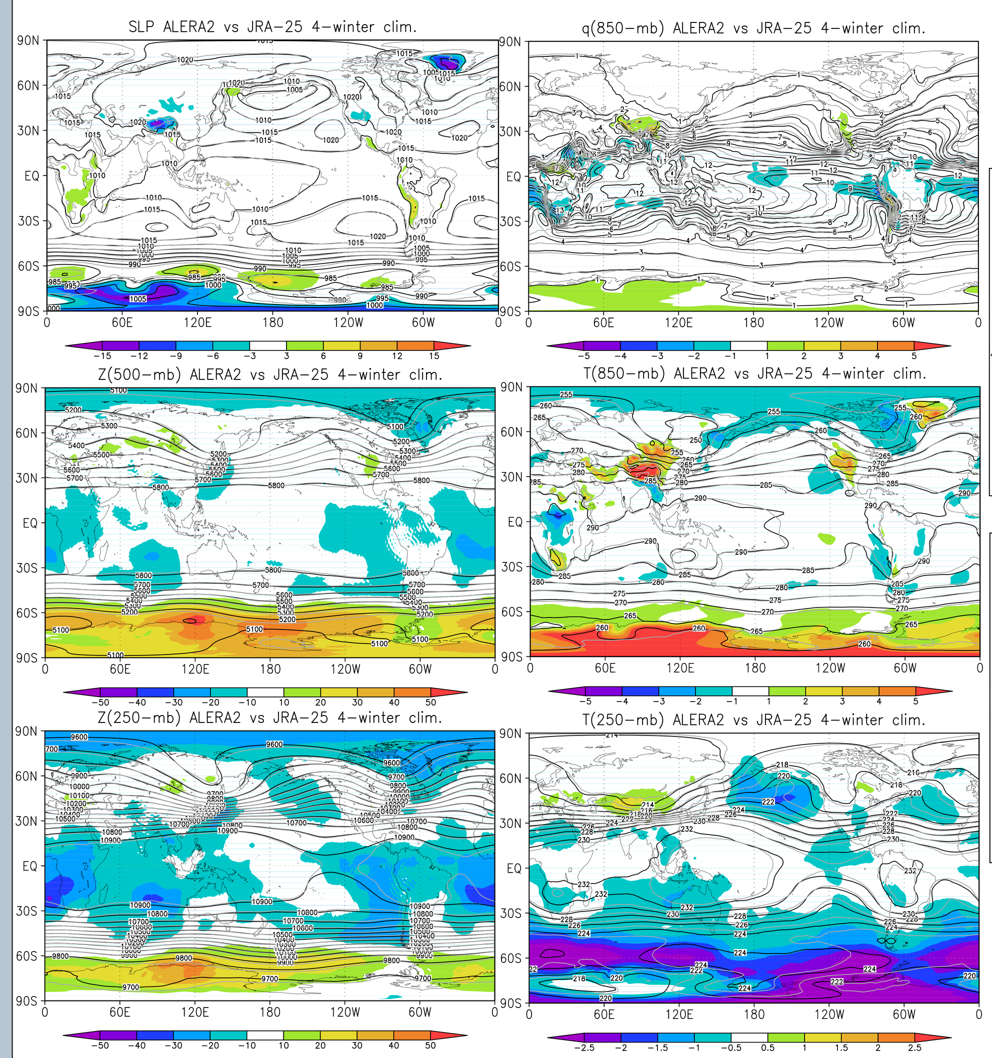


Fig 1: Two streams conducted as ALERA2.

- Large-scale phenomena of intraseasonal variabilities, low-frequency variabilities, in midlatitudes can be related to the variability of the analysis ensemble spread, because it is reported that the spread in ALERA (a predecessor to ALERA2) takes maximum prior to some low-frequency variabilities in the tropics or the stratosphere (Enomoto et al. 2010).
- The low-frequency variabilities, including atmospheric blocking, are closely related to storm-track activities and they cause various weather extremes. However, they are difficult to predict for medium-range weather forecasting; for example, blocking is still not accurately reproduced by numerical models, even using advanced modeling techniques (e.g., Pelly and Hoskins 2003).
- Four wintertime (Dec-Feb, 2008-2012) low-frequency and storm-track variabilities in ALERA2 are investigated in terms of the distribution and time evolution of the analysis ensemble spread that is related to the ensemble forecasting. Also, winter synoptic fields in ALERA2 are compared with those in one of the operational reanalysis datasets, JRA-25/JCDAS (Onogi et al. 2007).

Performance of ALERA2



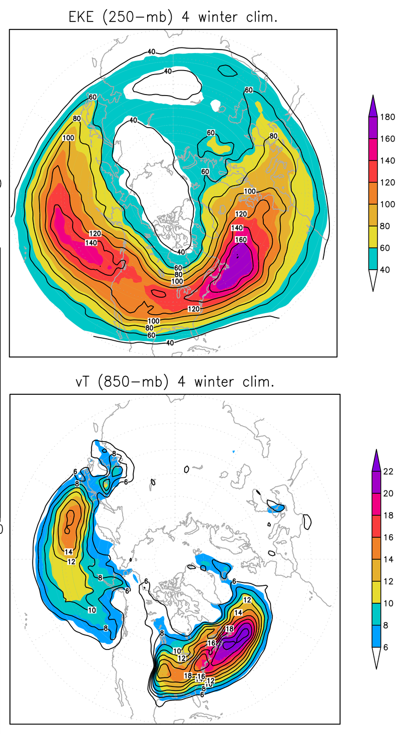


Fig 3: The winter-averaged eddy kinetic energy [m^2/s^2] on 250 hPa and meridional eddy heat flux [K m/s] on 850 hPa in ALERA2 (shades) and JRA-25 (contour).

Fig 2: Four winter-averaged values in ALERA2 (the grey-shaded lines), JRA-25 (the black lines), and their difference (shades; ALERA2 − JRA-25). The values are SLP [hPa], geopotential height (Z, [m]), specific humidity [g/kg], and temperature [K].

- ALERA2 well reproduces the winter climatological fields in midlatitudes of Northern Hemisphere to investigate synoptic-/large-scale phenomena.
- Activities of synoptic eddies (2-8 day band-pass-filtered component), storm tracks, in ALERA2 also show good agreement.

Distribution of the ensemble spread

- The ensemble spread in the upper troposphere is large near the westerly jet (storm tracks) in every years, especially over Pacific and Atlantic regions.
- Interannual variability of the spread looks large but may not correlates with that of the storm-track activity.

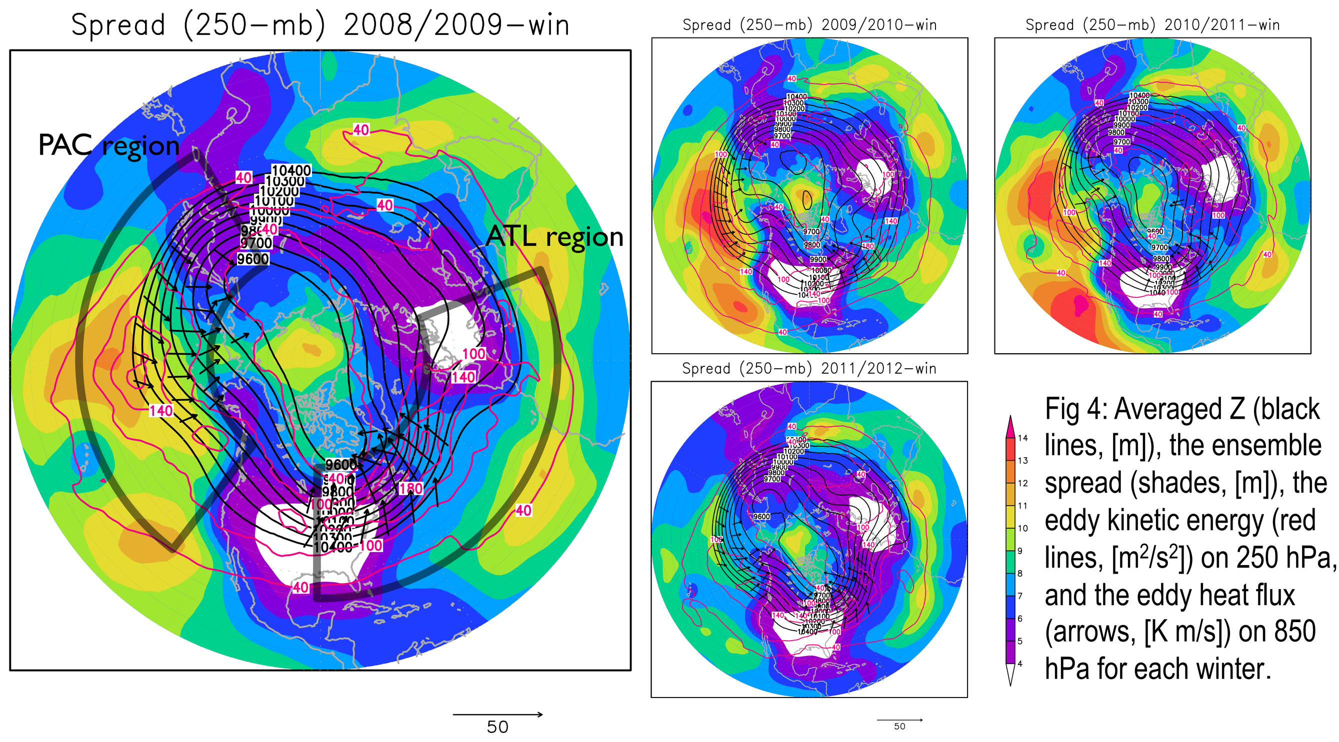


Fig 4: Averaged Z (black lines, [m]), the ensemble spread (shades, [m]), the eddy kinetic energy (red lines, [m^2/s^2]) on 250 hPa, and the eddy heat flux (arrows, [K m/s]) on 850 hPa for each winter.

Temporal evolutions of the ensemble spread

Relationship between the spread, zonal index (Z(30N) -Z(60N)), and Eady growth rate (Simmonds and Rudeva 2012) for each winter is shown.

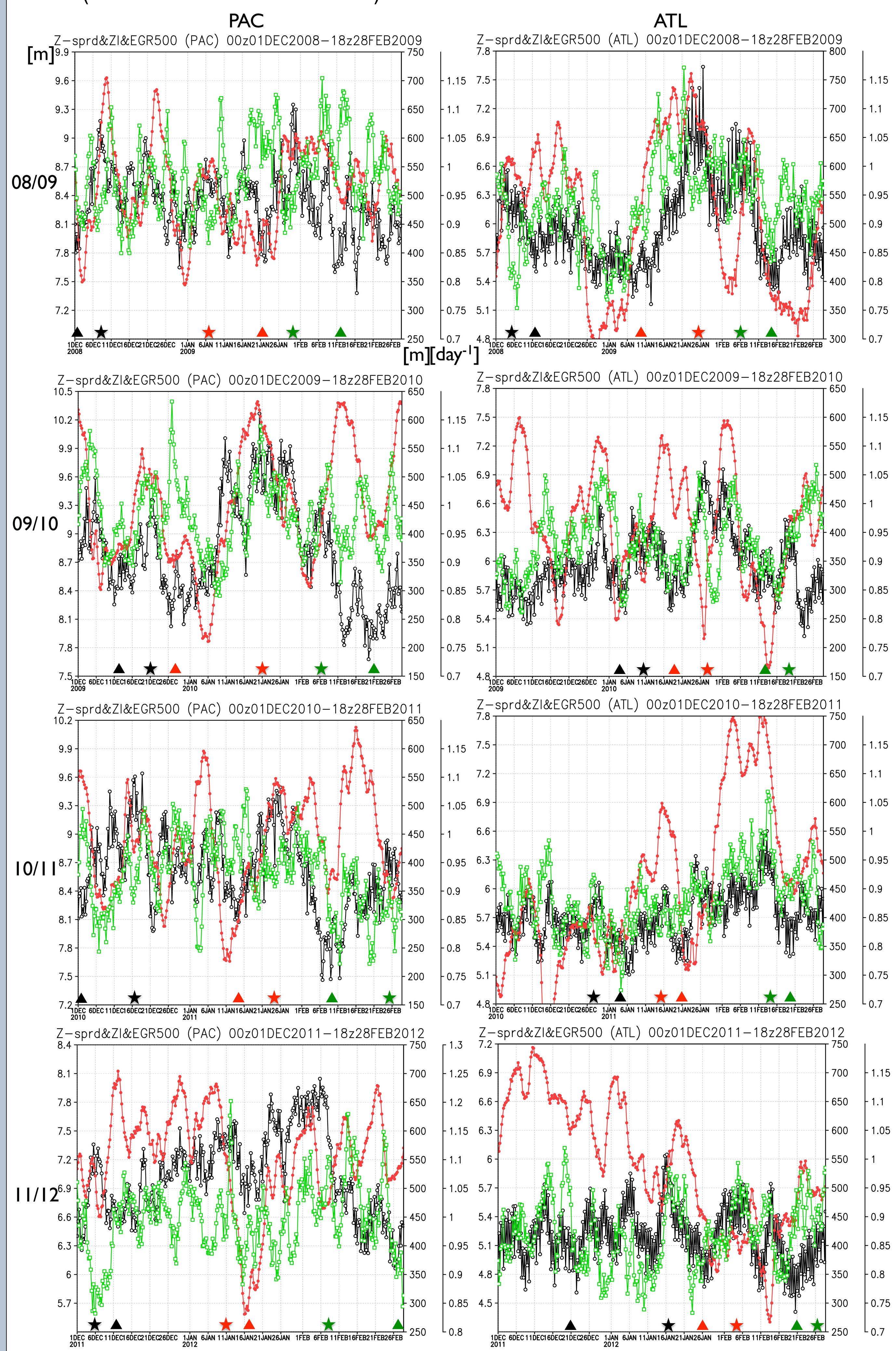


Fig 5: Time changes of the area-averaged ensemble spread (black, [m]) on 250 hPa, the zonal index (red, [m]) on 500 hPa, and the Eady growth rate (green [day^{-1}]) over the PAC or ATL region. The ★ and ▲ signs are tags for dates used in Figures 7 and 8.

- Correlations are in part found between the ensemble spread and the Eady growth rate and/or the zonal index.
- There is a relationship between the spread variability, low-frequency variabilities, and storm-track activities.

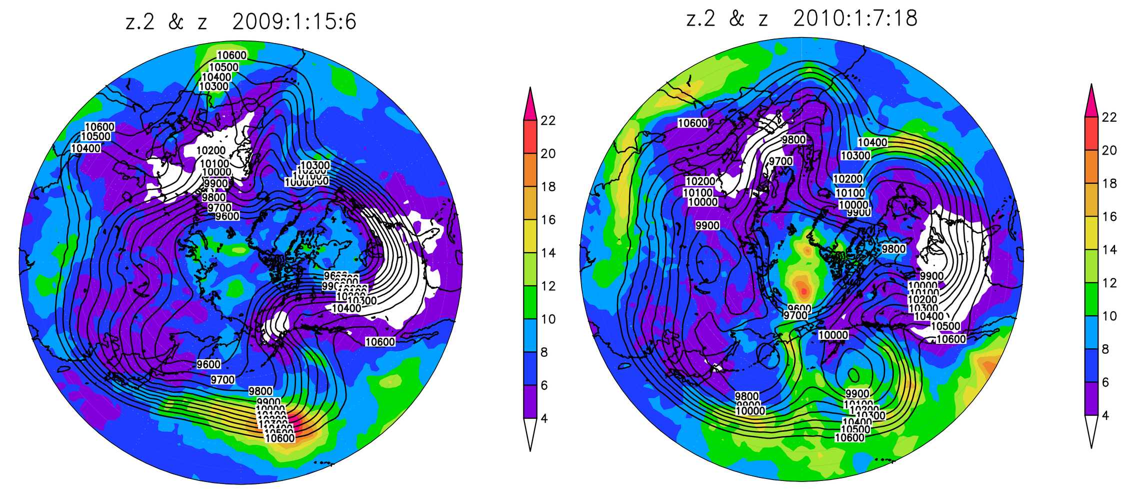


Fig 6: Snapshots of Z (black lines, [m]) and the ensemble spread (shades, [m]) on 250 hPa.

Some snapshots show that the ensemble spread increases along strong jet streams partly associated with low-frequency and storm-track variabilities.

Low-frequency variabilities related to the spread valiability

Z fields at maximum (minimum) dates of the spread tagged by ★ (▲) in Figure 5 over the PAC and ATL regions are displayed.

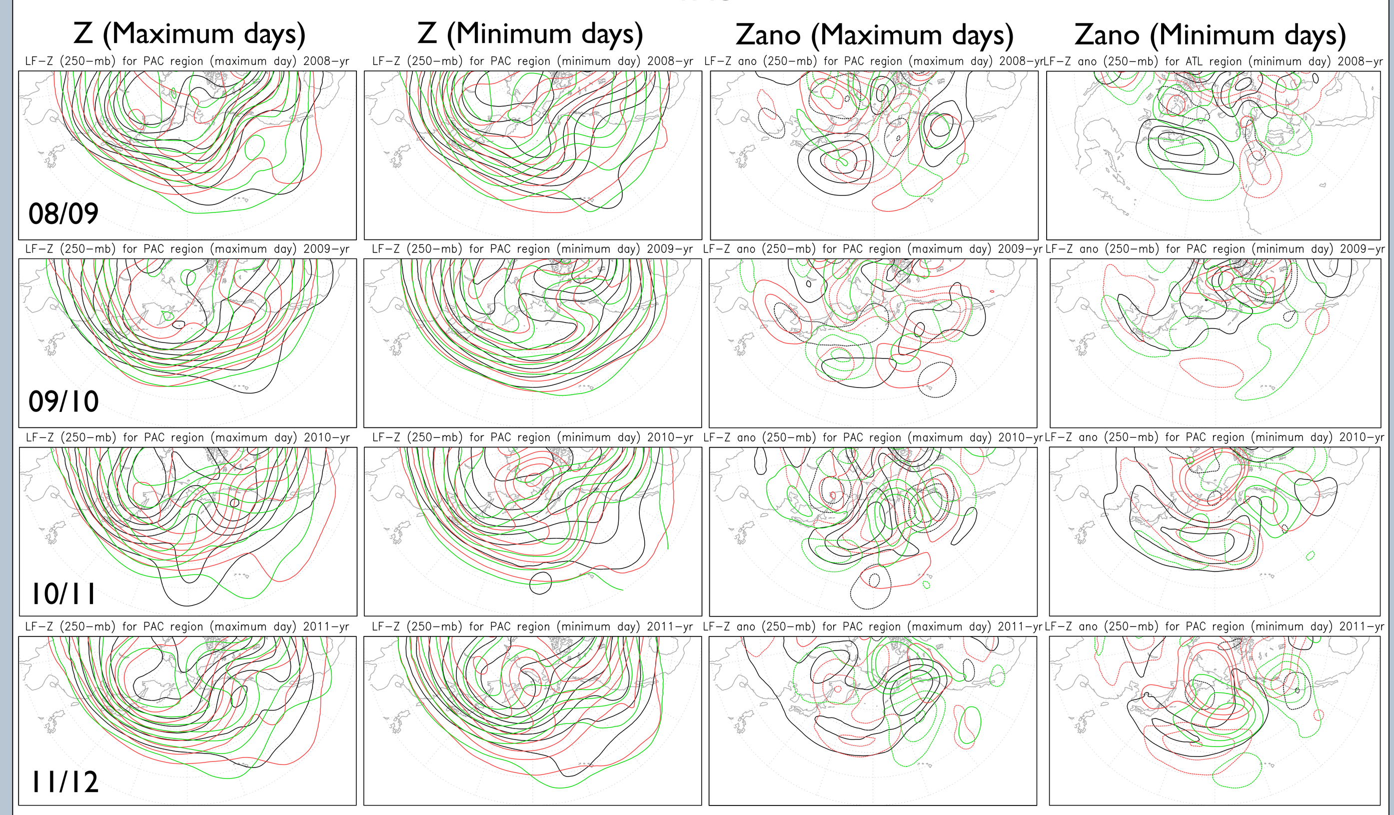


Fig 7: Snapshots of the 8 day low-pass-filtered Z and Z anomaly (deviation from each winter-averaged Z) on 250 hPa at maximum and minimum dates for the PAC region. The contour interval for the filtered Z (Z anomaly) is 80 (100) m. Colors of the contours correspond to those of the tags.

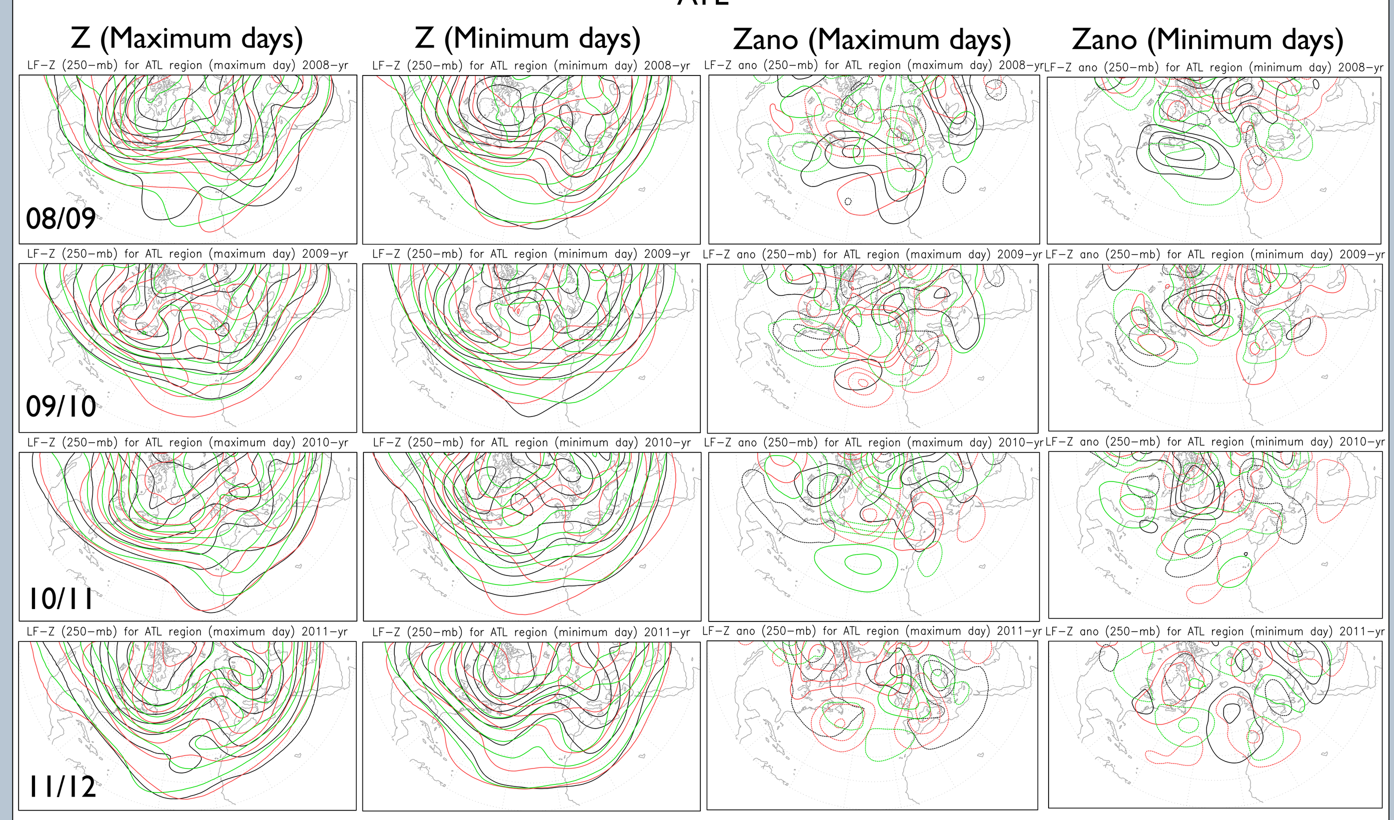


Fig 8: Same as Figure 7 but for the ATL region.

- Similar weather patterns, especially blocking-like or strong zonal-flow patterns, tend to appear at maximum or minimum dates of the ensemble spread averaged over the storm-track regions.
- Some of dominant low-frequency variabilities may be related to variability of the ensemble spread.

References

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