

On the Relation Between North American Winter Precipitation and Storm Tracks

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Outline:

- Motivation and objectives
- Eulerian view of storm tracks
- Lagrangian view of storm tracks
- Storm tracks and precipitation

Motivation:

- Individual storms strongly influence weather.
- Storm tracks can impact the climate by contributing to shifts in tropospheric jets.

Objective:

 To better understand the relationship between North American precipitation and the intensities and spatial patterns of storm tracks in the boreal winter.

Eulerian Method:

- Represents storm tracks as regions of high variability as estimated, e.g., by the standard deviation of the meridional wind at 200 hPa.
 - Areas of high standard deviation indicate areas of strong storm development.
- This method cannot distinguish between cyclones and anticyclones.



Eulerian Method:



Standard deviation of vort at 850mb for DJF 1979-2010

CFSR

Fig. 1: Eulerian storm track patterns represented as standard deviations of (left) meridional wind at 200 hPa in units of m/s, and (right) band-pass-filtered vorticity at 850 hPa in units of 1/s.

Eulerian Method:



Results from Eulerian Method:

- The Eulerian storm track at 200 hPa is displayed as one large track that spans the entire globe.
 - Small spatial scales are not captured at this pressure level.
- The Eulerian vorticity pattern at 850 hPa shows 2 distinct tracks, one over the North Atlantic Ocean and the other over the North Pacific Ocean.
 - This pattern captures some small-scale features.
- Regression maps produce wave trains exhibiting basic characteristics of synoptic waves along the storm track.



Lagrangian Method:

- Examines the filtered vorticity field at 850 hPa and follows maxima of vorticity to identify individual cyclones.
 - Storm track density is then estimated, and from it the genesis and lysis of storm tracks is determined.
- Low-level vorticity can identify low pressure systems earlier in their life cycles.
- This method can separately identify cyclones and anticyclones.

1980 DJF vorticity trajectories



Fig. 3: Individual storm tracks that lasted at least 2 days and traveled further than 1000 km in the 1980 DJF season. Blue dots mark the beginning of each track. Produced using the Lagrangian approach.

Lagrangian Method:

Fig. 4: Lagrangian statistical representations of (left) storm tracks from single estimation points for each track, and (right) mean intensity in units of 1.0e-5 1/s.



Lagrangian Method:

Fig. 5: Lagrangian statistical representations of (left) cyclogenesis from the starting points of each track, and (right) cyclolysis from the end points of each track.

180 180 150W 150E 150W 150E 120W 120E 120W 120E 90W 90E 90W 90E 60E 60W 60E 60W 30E 30W 30E 30W 0 0

1979-2010 DJF Genesis Density

1979-2010 DJF Lysis Density

Results from Lagrangian Method:

- The Lagrangian track density pictures 4 separate Northern Hemisphere tracks with greater detail than either Eulerian pattern.
- The Lagrangian track density captures the extensions into the lower latitudes of the Mediterranean and Pacific storm tracks, both of which are missed by the Eulerian vorticity pattern.



Eulerian and Lagrangian views

Left column: Eulerian storm track patterns at (a) 200 hPa, and (b) 850 hPa.

Right column: Lagrangian (c) storm track pattern, and (d) mean storm track strength in units of s^{-1} .



1979-2010 DJF Track Density





Early Precipitation Analysis:

Standard deviation of v at 200mb for DJF 1979-2010 Eulerian 150W 150E 120W 90W 1979-2010 DJF Track Density Lagrangian 150\/ 120W 90V 90F 60W 60F 30V 30E



Regression of v on sfc precip at 200hPa for DJF 1979-2010



TRACK Regression of vort on sfc precip at 850hPa for DJF 1979-2010



-1 -0.8 -0.6 -0.4 -0.2 0 0.2 0.4 0.8 0.8 1 1.2 1.4

Concluding Remarks:

- Track density from the Lagrangian method highlights the Northern Hemisphere winter storm tracks with greater detail than the traditional Eulerian method.
- Regressions of Lagrangian vorticity on surface precipitation reveal detailed small-scale features, contrasting regressions using Eulerian variables.

Future Work:

- To further study relationships between storm tracks and North American precipitation.
 - Use extended EOFs to determine covariance.
 - Ascertain statistical significance.
 - To investigate the impacts of lower frequency modes of variability, such as the Madden-Julian Oscillation (MJO), on storm tracks and extreme precipitation events over North America.
- Aid in clarifying how storm tracks modify precipitation patterns over North America in support of CPC/NOAA activities.



Thank you for your attention!

