Boreal Winter Storm Tracks and Related Precipitation in North America: A Potential Vorticity Perspective

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Motivation

- Large narrow bands of extratropical cyclonic activity (i.e., storm tracks) impact the climate by contributing to shifts in tropospheric jets, altering global atmospheric flow patterns.

- Storm tracks can influence the climatological intensities and spatial distributions of nonlinear quantities like precipitation.

Objectives

By analyzing Northern Hemisphere mid-latitude storm tracks and their influences on winter precipitation, we hope to provide guidance in seasonal forecasting and to further the development of climate prediction in conjunction with the mission of NOAA’s Climate Prediction Center.
A cyclone-tracking approach is used to identify and track individual storms from Potential Vorticity (PV) anomalies on the $\theta=320K$ surface, with a minimum cyclogenesis intensity threshold of 0.5 PVU.

- PV acts as a dynamical tracer for storms because parcels (i.e., cyclones) conserve PV and $\theta$ in an adiabatic frictionless flow, so they must propagate along isocontours of isentropic PV.
Methodology

- Storm tracks are represented by the track density of all identified cyclones that fit a set of minimum spatial and temporal criteria.
- Small-scaled features are captured.
- Cyclones and anticyclones are differentiated.
Three storm tracks are easily identified.

Contour interval is 1.0 cyclone per $10^6$ km$^2$ per month.
Storm tracks are strongest over large water basins.

Mean Storm Track Intensity 1980-2010

Contour interval is 0.25 PVU.
Regions of cyclogenesis and cyclolysis are revealed.

Contour interval is 0.1 cyclone per $10^6$ km$^2$ per month.
Storm tracks leave strong precipitation footprints over the Pacific and Atlantic Oceans.

Precipitation from eastward propagating Pacific storms shows an enhanced signal over the west coast of North America due to orographic effects.
Storms produce ~50% of the total CFSR precipitation over the oceans, and up to 70% over North America.
Reanalysis vs Observed Precipitation
1999-2010

Total PR

Storm PR

PR Ratio
The total reanalysis and observed precipitation generally agree over the oceans, although the reanalysis is more intense than observations in the Atlantic Ocean.

- Reanalysis and observed storm precipitation tend to agree in the Pacific.
- Reanalysis shows more intense storm precipitation in the Atlantic than is observed.
The **Pacific storm track** yields up to 70% of the total reanalysis and up to 60% of the total observed precipitation over the west coast of North America.

The **NAA storm track** produces 50-70% of total reanalysis precipitation and 50-60% of the total observed precipitation in eastern North America.
Summary

Three mid-latitude storm tracks are revealed following the evolution of PV perturbations.

Storm tracks leave conspicuous precipitation footprints where they are strongest (i.e., over the oceans), producing about half of the total precipitation there.

Storm tracks leave enhanced precipitation signals over the North American west coast in both reanalysis and observations.

The reanalysis overestimates the observed storm precipitation over the North American west coast by 2 mm day$^{-1}$ and in the Atlantic Ocean by 10%.
Thank you

Questions?

References:


Supplemental Info

Storm Tracks DJF 1980-2010

Storm Tracks DJF 1999-2010