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

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Outline

- Motivation and Objectives
- Methodology
- Storm Track Properties
- Storm-related Precipitation
  - Reanalysis vs Observations
- Summary

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

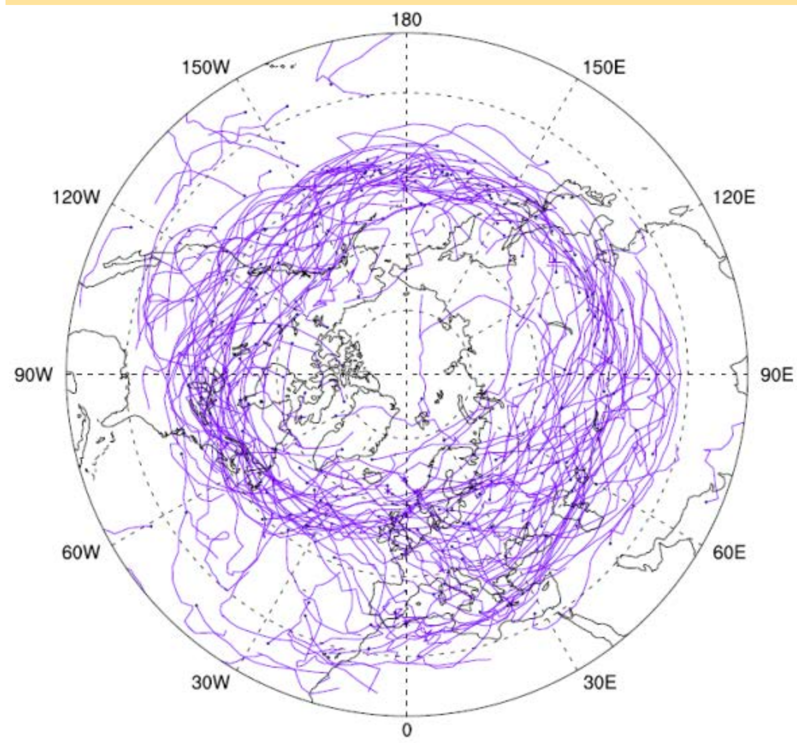
By analyzing Northern Hemisphere mid-latitude storm tracks and their influences on winter precipitation, we hope to provide guidance in seasonal forecasting and to further the development of climate prediction in conjunction with the mission of NOAA's Climate Prediction Center.

Methodology

A cyclone-tracking approach is used to identify and track individual storms from Potential Vorticity (PV) anomalies on the θ=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 θ in an adiabatic frictionless flow, so they must propagate along isocontours of isentropic PV.

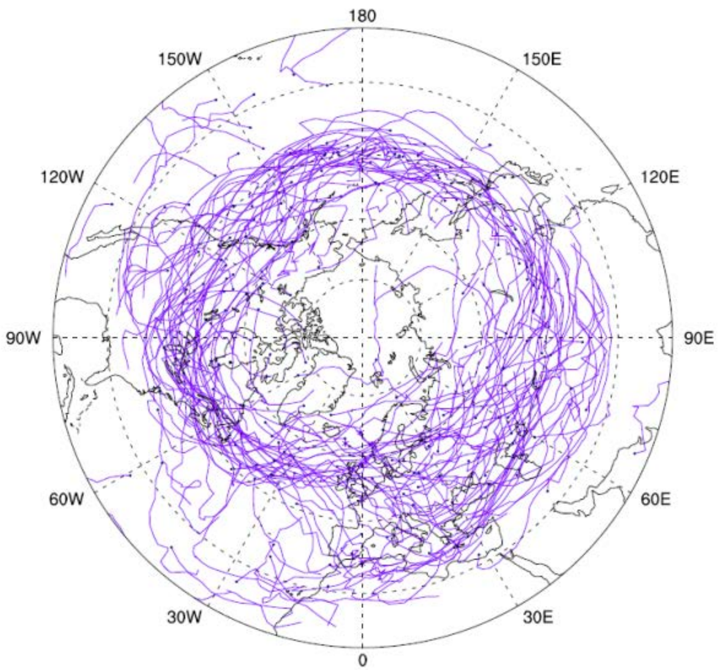
Isentropic Potential Vorticity storm trajectories DJF 1999



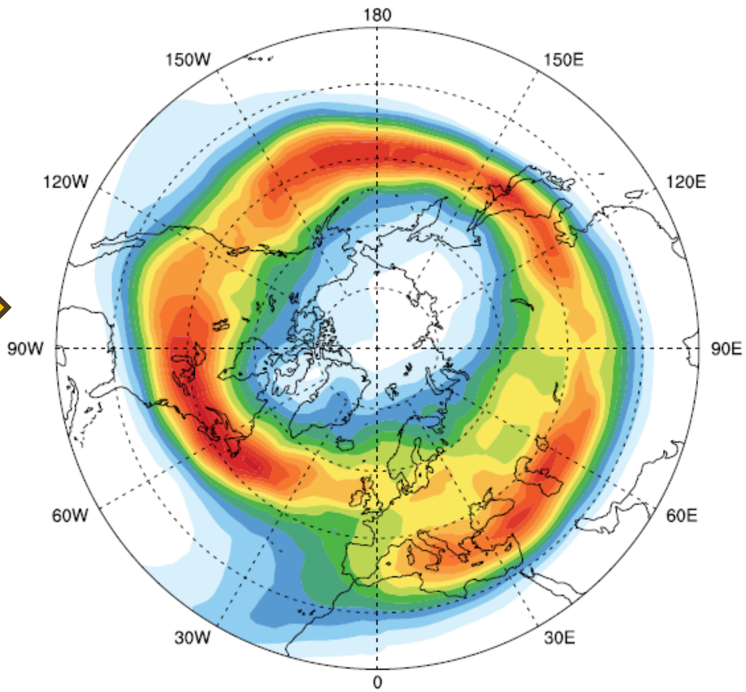
Methodology

- 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.

Storm Trajectories 1999



Storm Track Density 1980-2010



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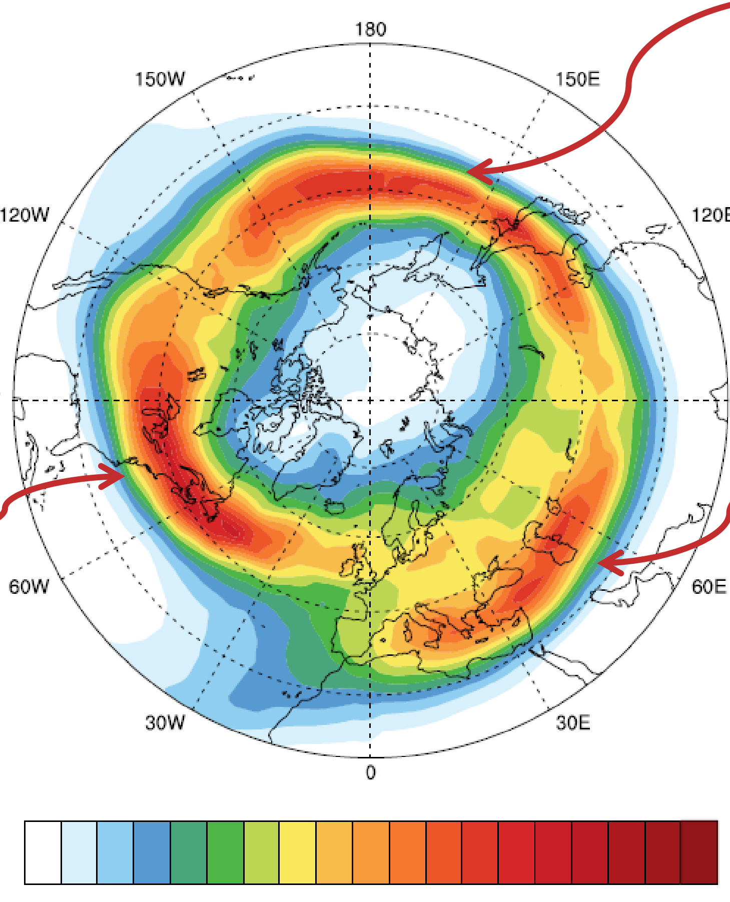
Storm Track Properties

Three storm tracks are easily identified.

Storm Track Density 1980-2010



Pacific Storm Track

North American-Atlantic (NAA) Storm Track

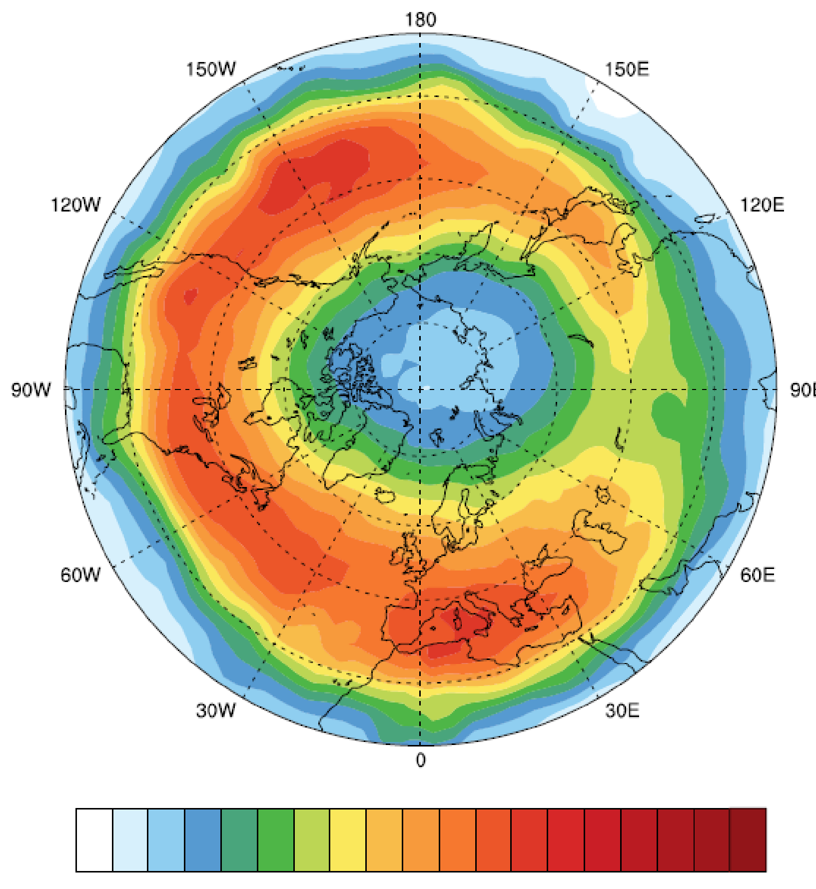
Mediterranean Storm Track

Contour interval is 1.0 cyclone per 10^6 km^2 per month.

Storm Track Properties

Storm tracks are strongest over large water basins.

Mean Storm Track Intensity 1980-2010

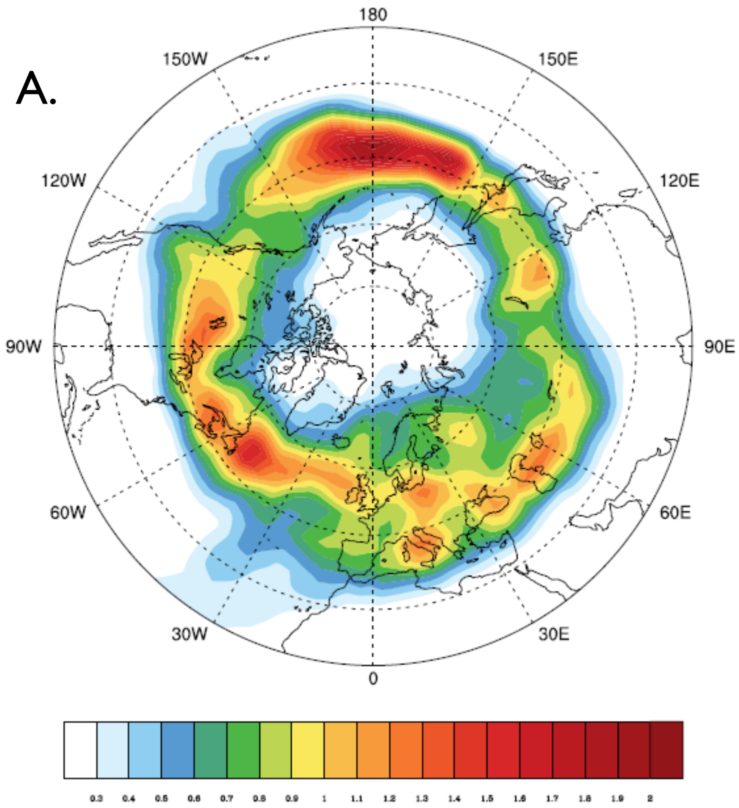


Contour interval is 0.25 PVU.

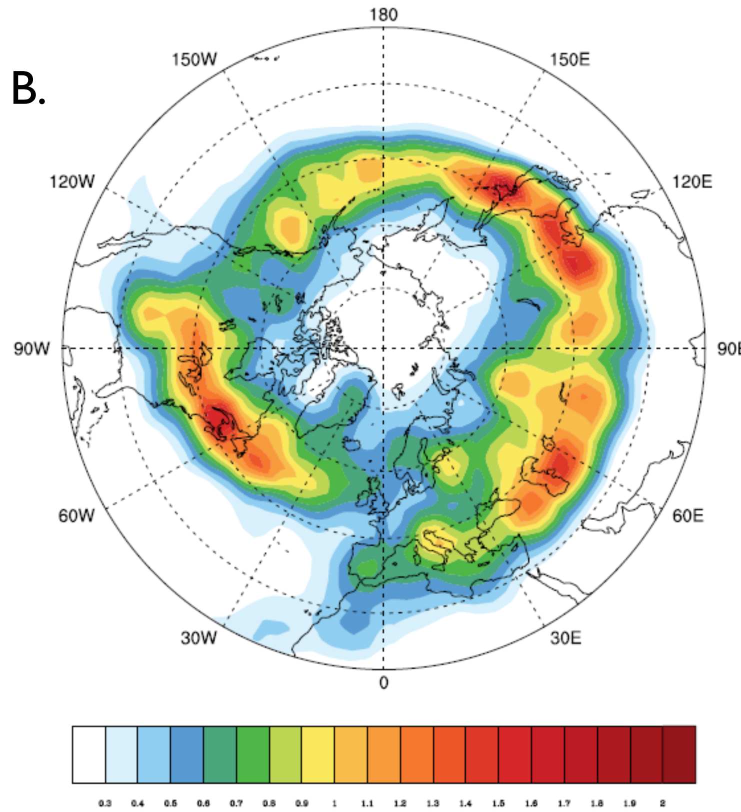
Storm Track Properties

Regions of cyclogenesis and cyclolysis are revealed.

Cyclogenesis Density 1980-2010



Cyclolysis Density 1980-2010

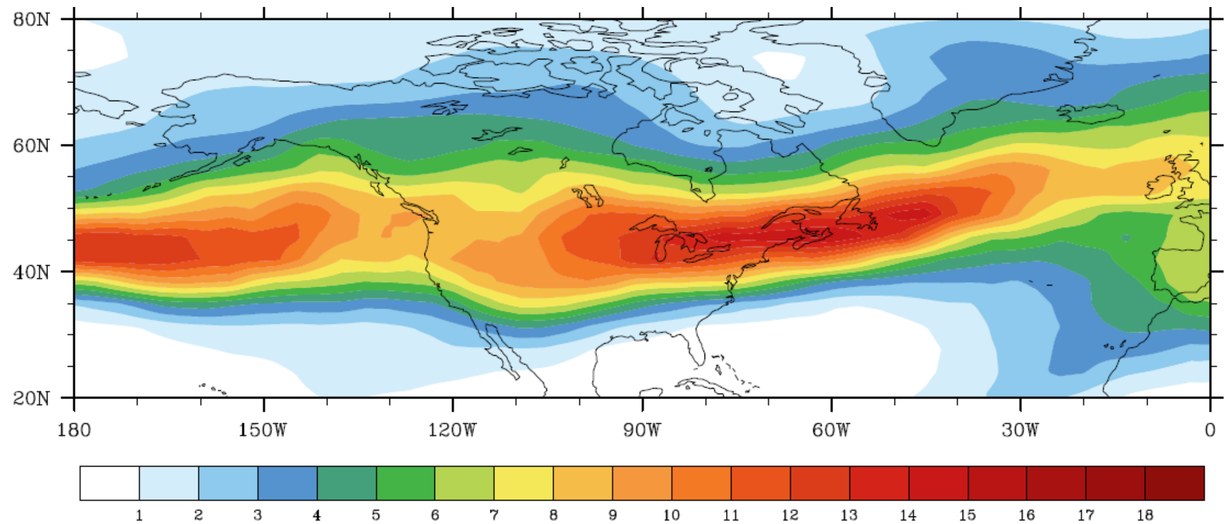


Contour interval is 0.1 cyclone per 10^6 km^2 per month.

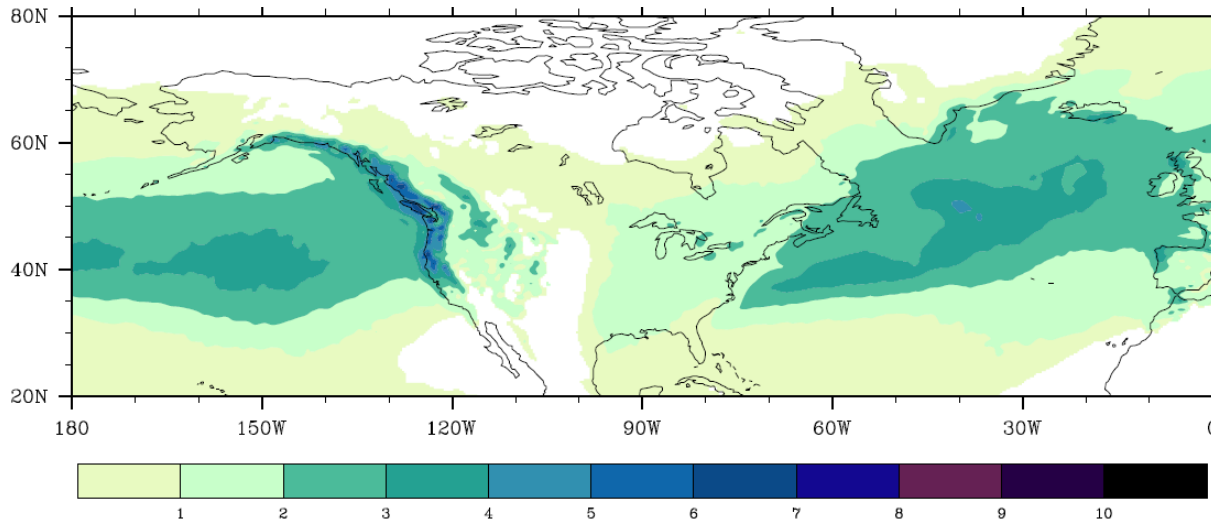
Storm-related Precipitation

1980-2010

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.

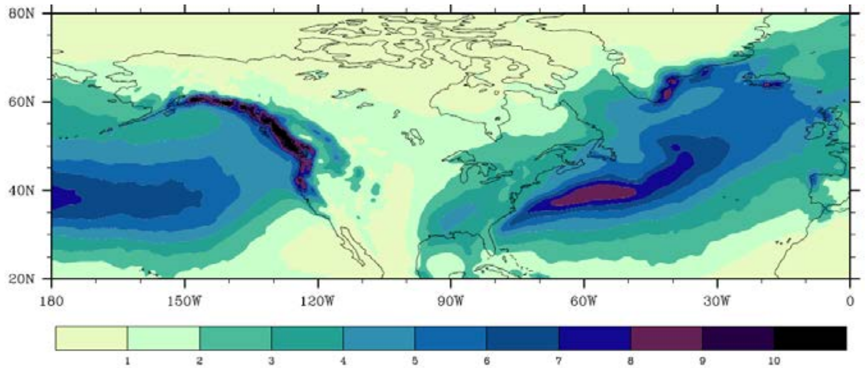


Storm-related Precipitation

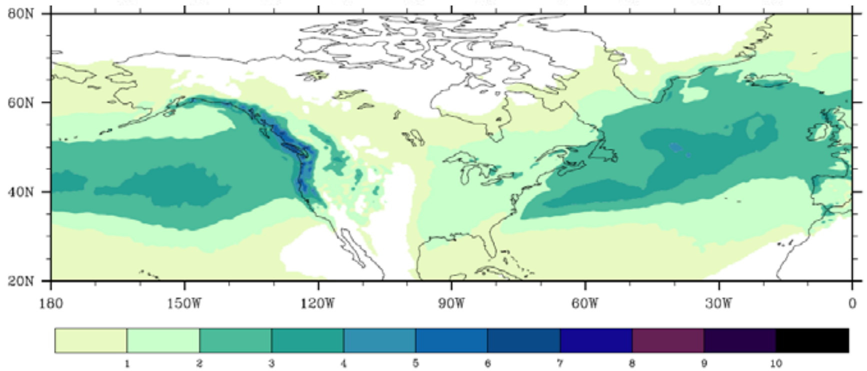
1980-2010

Storms produce ~50% of the total CFSR precipitation over the oceans, and up to 70% over North America.

Total PR

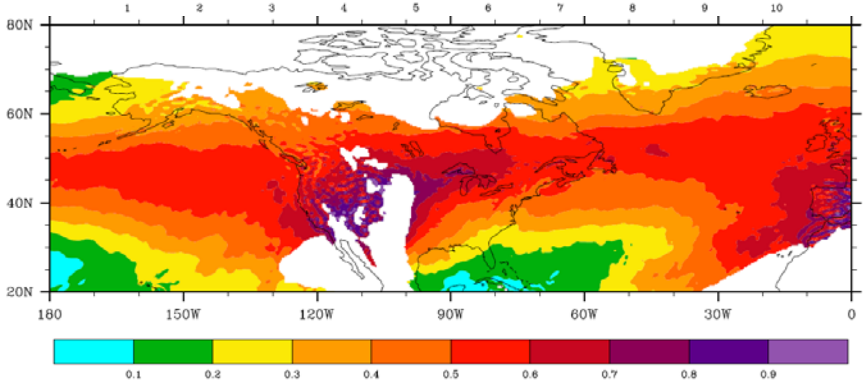


Storm PR



Contour interval is 1.0 mm day^{-1}.

PR Ratio



Contour interval is 0.1, or 10%.

Reanalysis vs Observed Precipitation

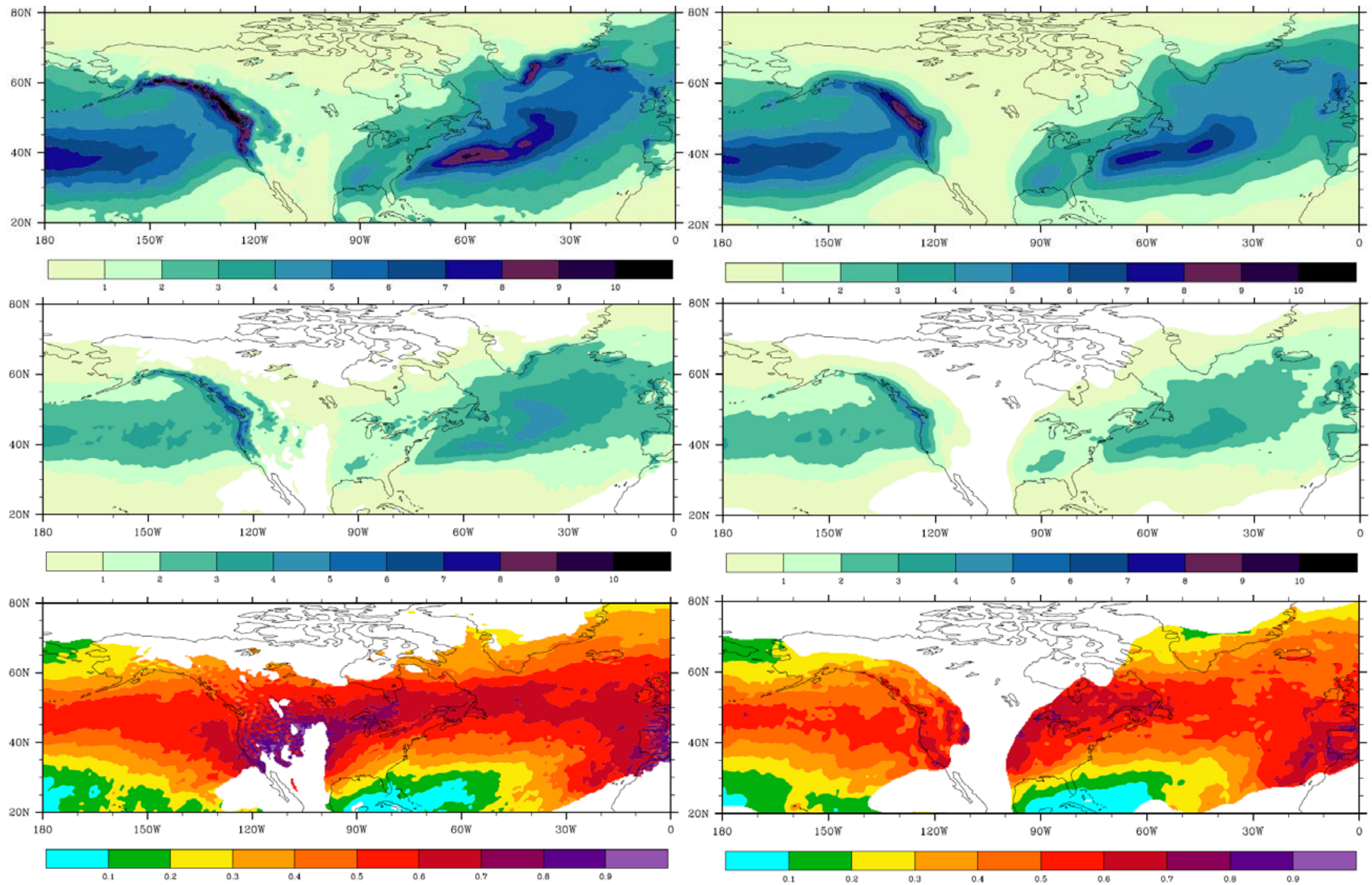
1999-2010

CFSR | GPCP

Total PR

Storm PR

PR Ratio



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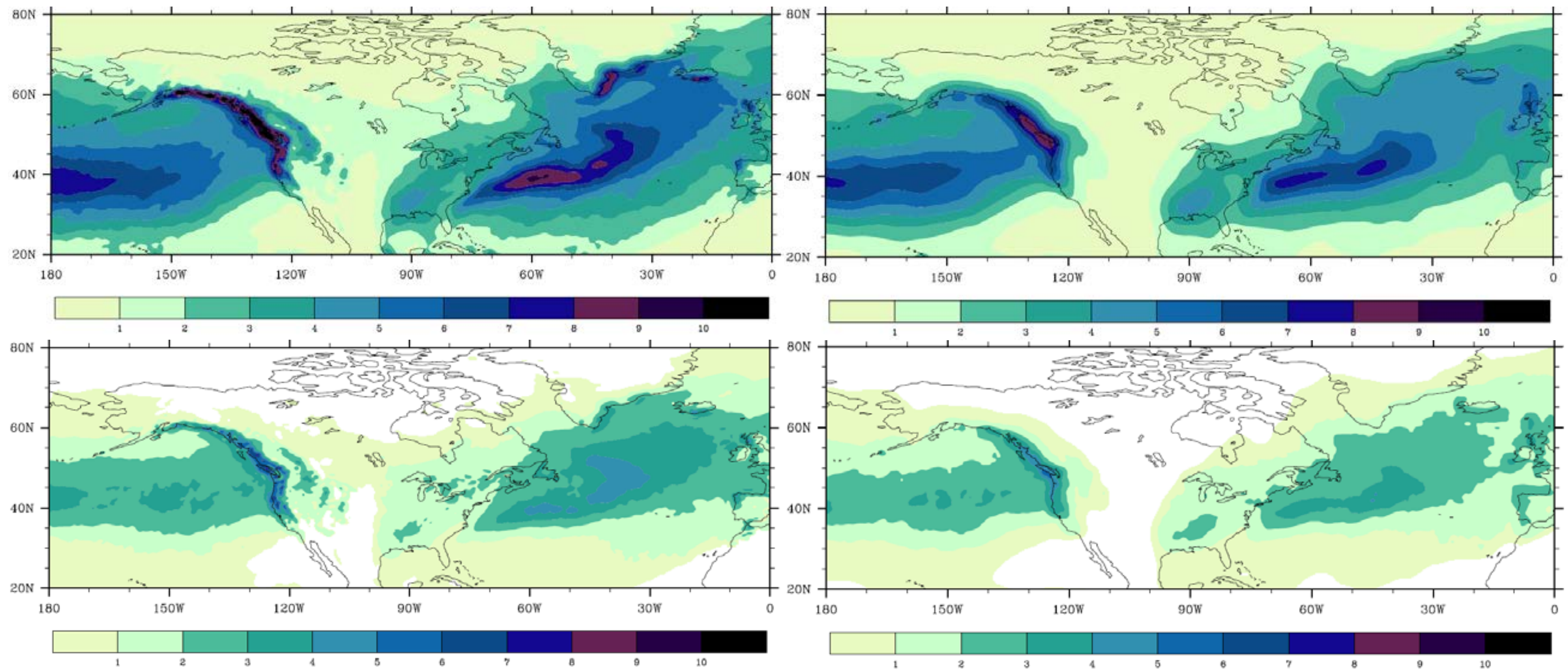
Reanalysis vs Observed Precipitation

1999-2010

CFSR | GPCP

Total PR

Storm PR



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

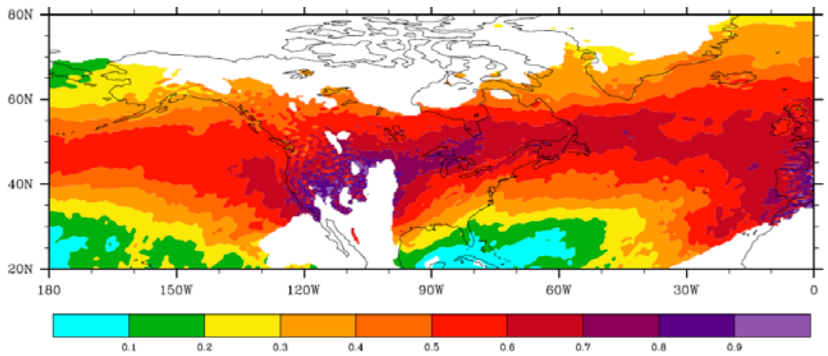
- Reanalysis and observed storm precipitation tend to agree in the Pacific.
- Reanalysis shows more intense storm precipitation in the Atlantic than is observed.

Reanalysis vs Observed Precipitation

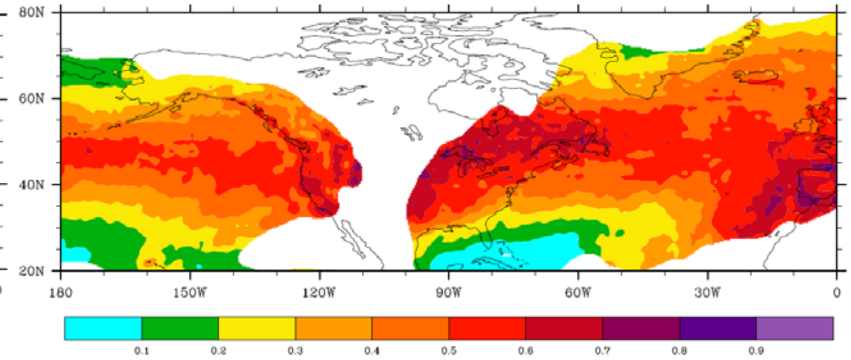
1999-2010

PR Ratio

CFSR



GPCP



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:

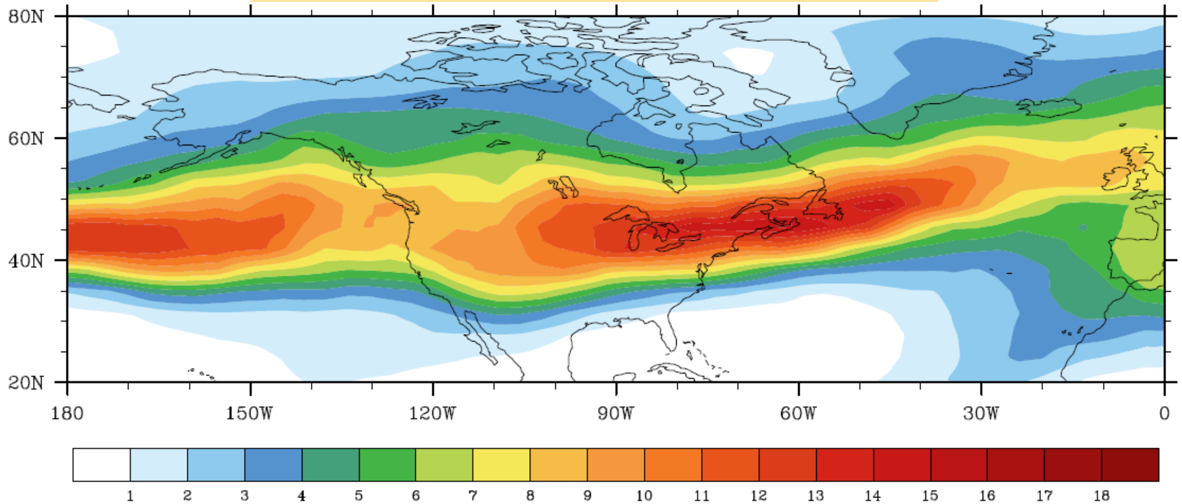
Hawcroft, M. K., L. C. Shaffrey, K. I. Hodges, and H. F. Dacre, 2012: How much Northern Hemisphere precipitation is associated with extratropical cyclones? *Geophys. Res. Lett.,* 39, L24809.

Holton, J. R., 2004: An introduction to dynamical meteorology, Edition 4th. *Elsevier Academic Press.*

Hoskins, B. J., and K. I. Hodges, 2002: New perspectives on the Northern Hemisphere winter storm tracks. *J. Atmos. Sci.*, 59, 1041-1061.

Supplemental Info

Storm Tracks DJF **1980-2010**



Storm Tracks DJF **1999-2010**