1D5.1

Large-Scale Precursors to Major Lake-Effect Snowstorms Downwind of Lake Erie

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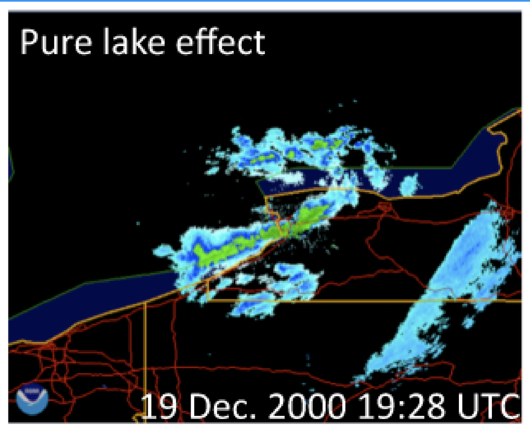
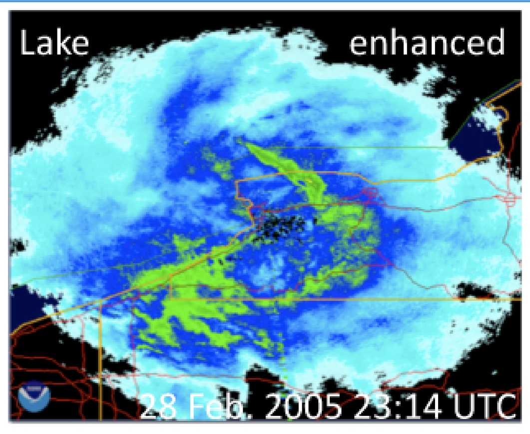
Motivation and Methodology

Motivation for this study

- Interested in identifying a dominant large-scale weather pattern in the days prior to major lake-effect snow events lee of Lake Erie
- Improve lake-effect snow forecasts with a 6-10 day lead time



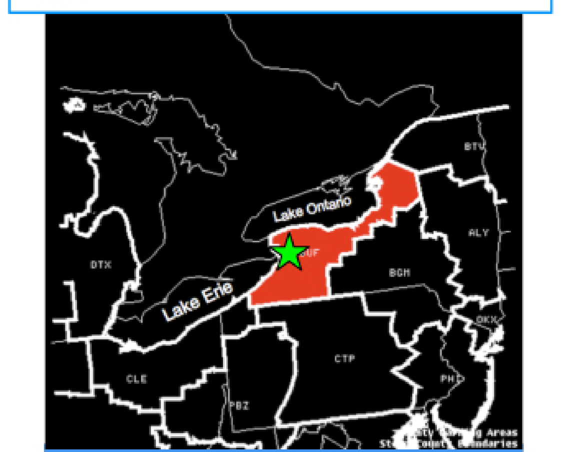


Case Categories (1998-2011)

- All (31 cases)
- Length
  - 24-42 h (20 cases)
  - **>42 h (11 cases)**
- Time of year
  - Jan., Feb., March, April (15 cases)
  - Oct., Nov., Dec. (16 cases)
- Phase of AO at Onset
  - **pos. AO (15)**
  - **neg. AO (16)**

Criteria for a storm to be included in this study:

- Produce at least 12 in of snow in 24 h
- Purely lake-effect (not associated with large scale snowstorm)
- Occur within Buffalo County Warning Area and off of Lake Erie



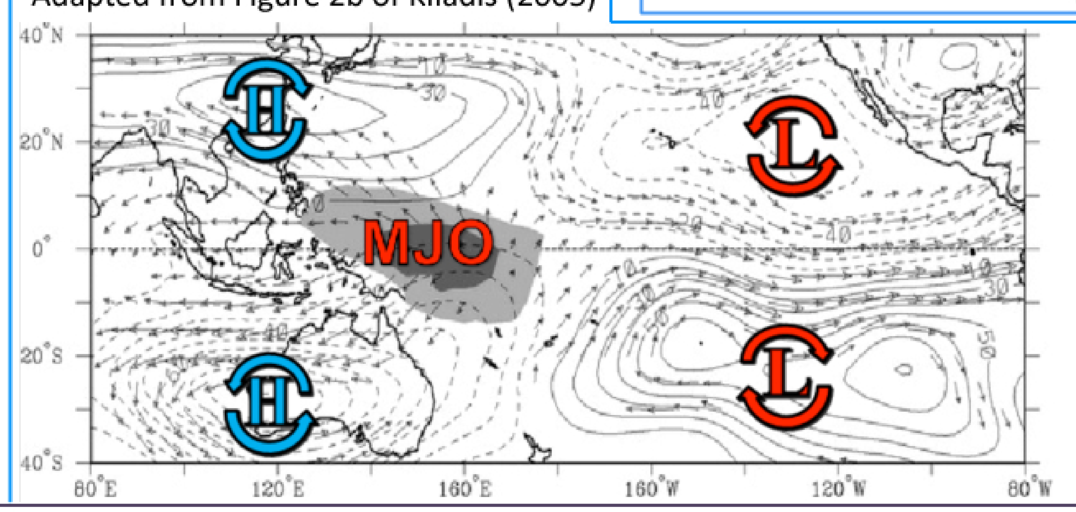
NWS Buffalo County Warning Area. The green star marks the city of Buffalo

Background

Madden-Julian Oscillation (MJO)

- Describes an eastward moving "pulse" of equatorial convection.
- A typical cycle lasts 30-60 days
- Influences the weather in the tropics and the midlatitudes

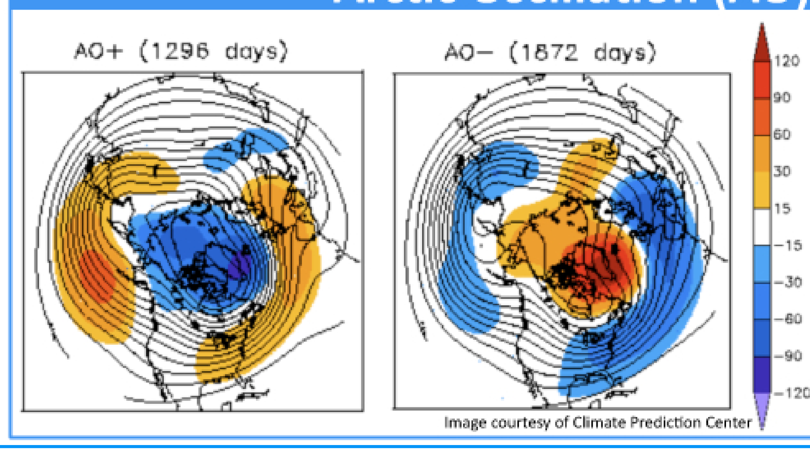
Adapted from Figure 2b of Kiladis (2005)



300-hPa streamfunction (contoured every 10 x 10^5 m^2 s^{-1}) total wind (vectors in m s^{-1}), and MJO-filtered Outgoing Longwave Radiation (OLR) anomaly (shaded < -16 W m^{-2}).

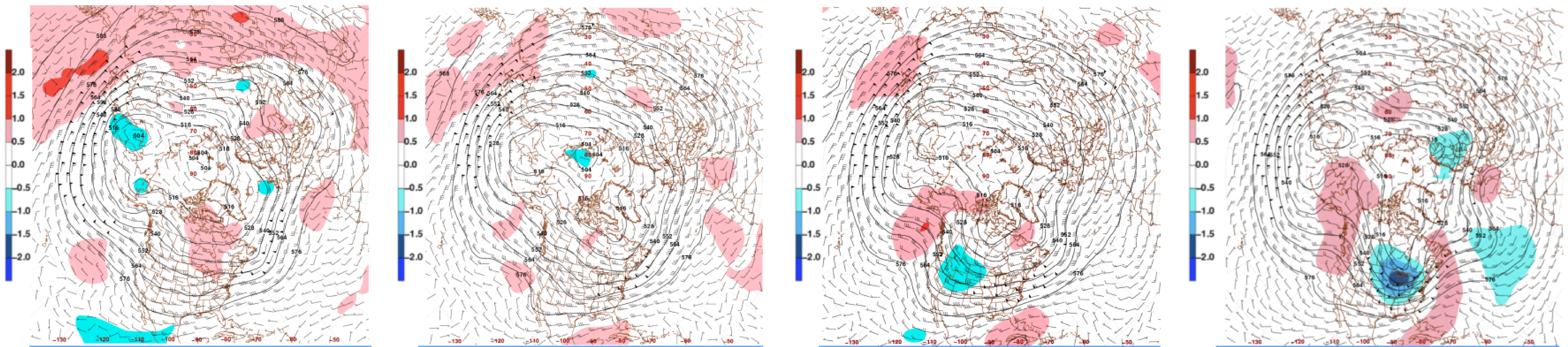
MJO convection at the equator is associated with anticyclonic circulation at upper levels to the north and south of the convection

Arctic Oscillation (AO)



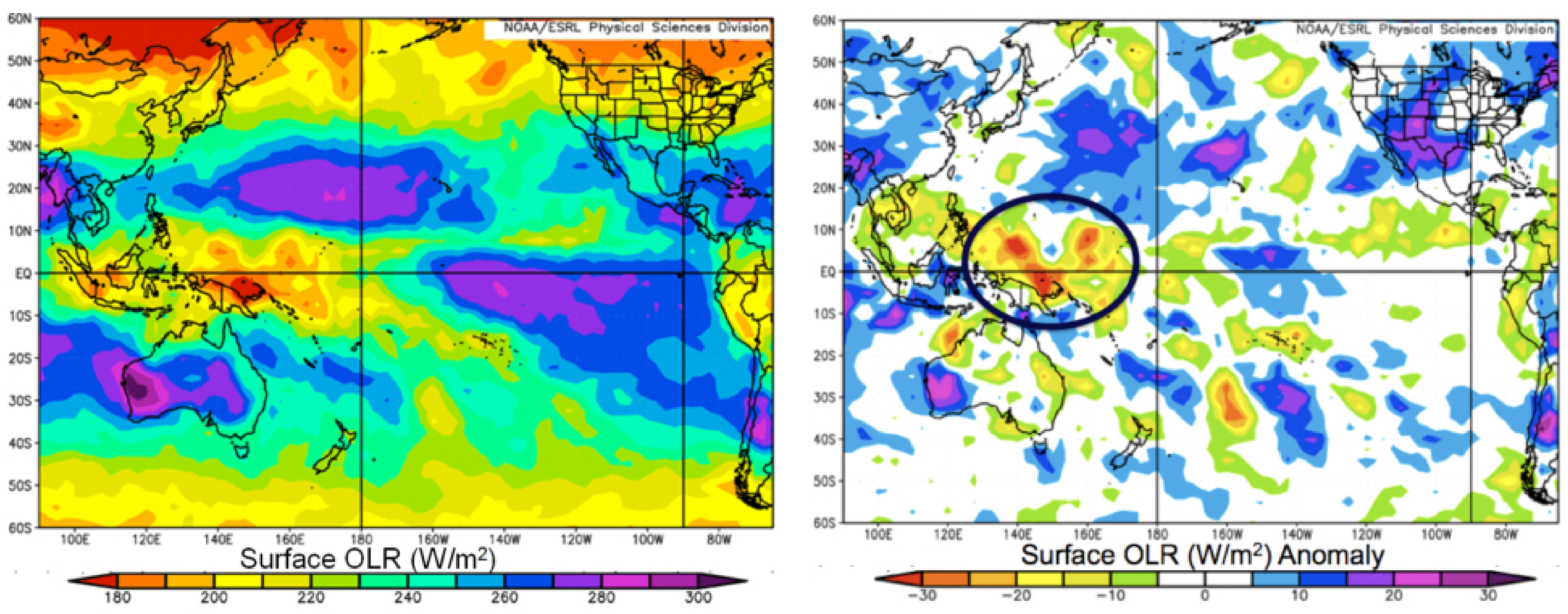
500-hPa height (m) and anomaly pattern for the positive and negative phase of the AO. The blue (red) indicates negative (positive) height anomalies

Composite Analysis of Lake-Effect Snowstorm Cases that Last > 42 h



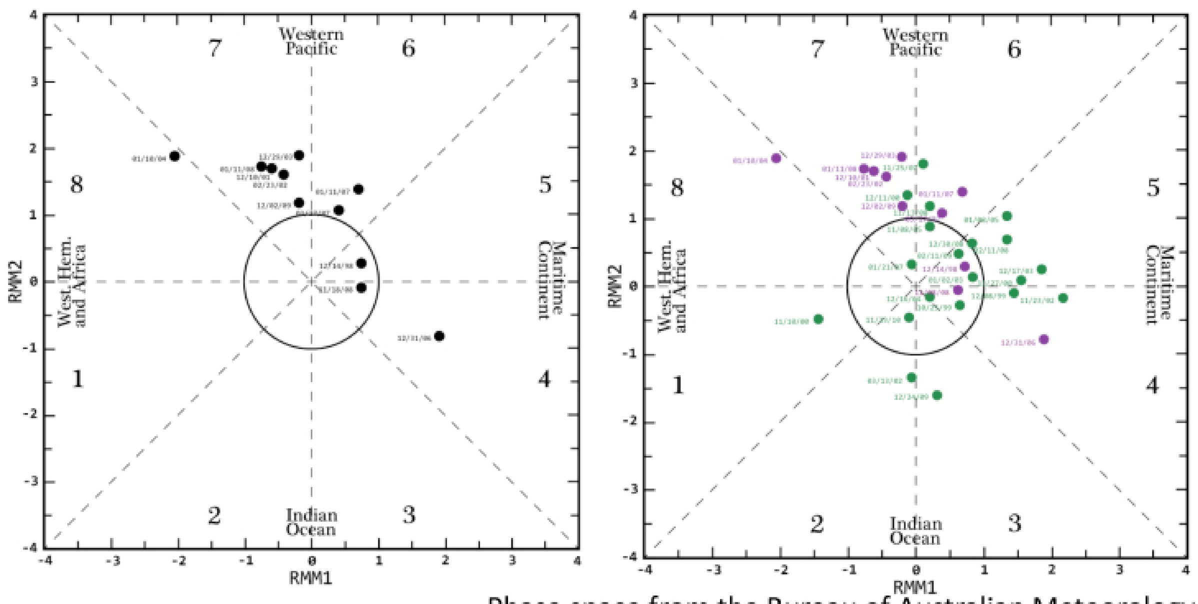
500-hPa geopotential height (dam), wind (kts) and standardized height anomalies. The red (blue) indicates anomalously high (low) heights

These maps are the composite analysis of the 500-hPa height pattern of the 11 lake-effect snow cases that lasted > 42 h. 8 days prior to onset there are anomalously high heights in the Western Pacific. This is associated with convection at the equator which is likely associated with the MJO as discussed below. This induces a Rossby wave train leading to anomalously high heights (ridge) over the Eastern Pacific 3 days prior to onset and anomalously low heights (trough) over the Eastern United States during lake-effect snowstorm onset. This trough is a necessary ingredient in lake-effect snowstorms.



Outgoing Longwave Radiation (OLR)

- Left: Composite map of OLR 8 days prior to onset.
- Right: Composite map of OLR anomalies 8 days prior to onset
- The anomalously low OLR at 140 E is indicative of convection likely associated with the MJO



Phase space from the Bureau of Australian Meteorology

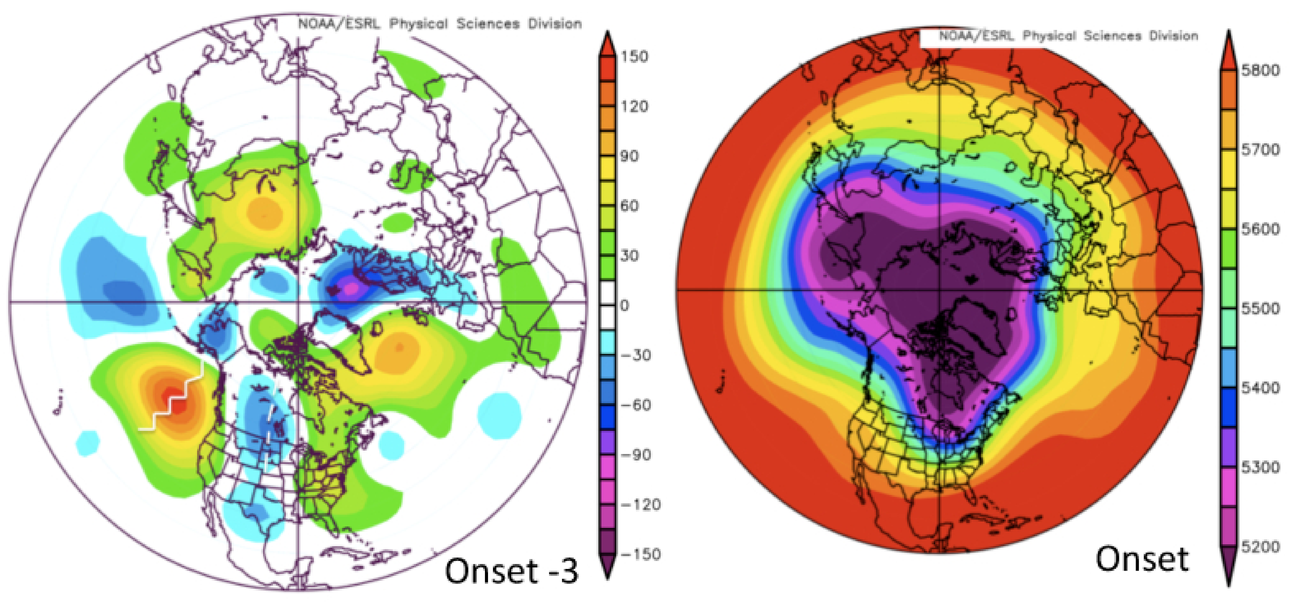
The MJO phase space diagrams describe the location of the MJO, which begins in Phase 1 and travels counterclockwise around the phase space ending at phase 8. Plotted on the left is the location and strength of the MJO 8 days prior to onset for the cases that lasted > 42 h. Important to note is the clustering of cases in phases 6 and 7. On the right, all 31 cases included in this study are plotted. In green are cases that lasted 24-42 h and in purple are cases that lasted >42 h. The shorter cases have a clustering around phase 5, although there are many outliers indicating that there is less confidence in this signal.

Significance of MJO on NE U.S.

- AO favors a negative tendency when MJO is in phases 6 and 7
- MJO in phases 7 and 8 influences midlatitude temperature and height anomalies in a way that resembles the negative phase of the AO (L'Heureux and Higgins (2007)

Negative phase of the AO is more conducive for cold air outbreaks in the northeast United States (CPC 2012)

+AO at Onset Composite

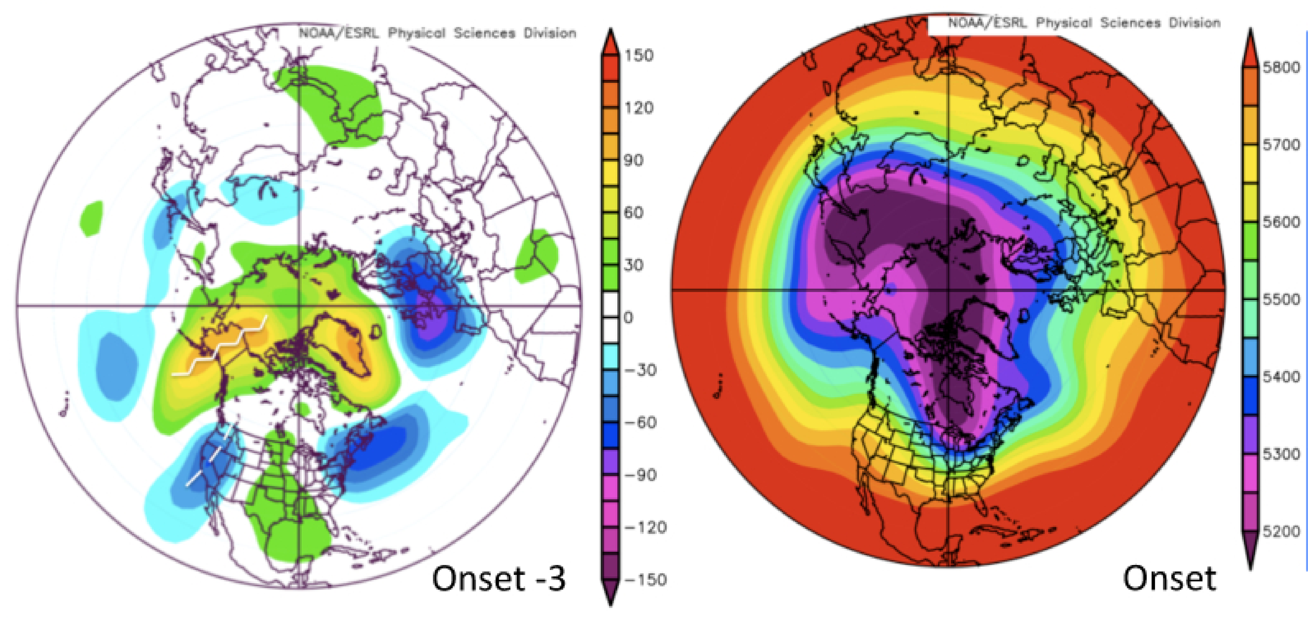


n=15

- Left: Composite of 500-hPa height anomalies (m) 3 days prior to onset with ridge and trough axes analyzed from the mean height
- Right: Composite of mean 500-hPa height (m) at onset

- The trough associated with the lake-effect snow originates over southwestern Canada

-AO at Onset Composite



n=16

- Left: Composite of 500-hPa height anomaly (m) 3 days prior to onset with ridge and trough axes analyzed for the mean height
- Right: Composite of mean 500-hPa height (m) at onset.

- The trough associated with the lake-effect snow originates over western United States

References

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Conclusions and Future Work:

- For cases >42 h there seems to be an MJO influence 7-10 days prior to onset
- The upper-tropospheric trough associated with the lake-effect snow originated in different locations for the +AO (southwest Canada) and –AO (western United States) cases
- Future work: closely examine the other categories, increase the case list, and perform statistical significance testing