Parcel Trajectories Linked to Shore-Parallel and Wind-Parallel Bands Over Lake Erie

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Introduction

Lake-effect snow is common within the Great Lakes region. As cold air crosses over a lake, the warmer lake temperature causes convergence, lifting moist air resulting in snow-producing clouds (Rauber et al., 2017).

Niziol et al. 1995 established a classification system with five categories for lake-effect cloud bands.

> Type I snow bands are shore-parallel bands (SPBs), and form when either strong or weak winds blow parallel to a Great Lake's strong axis.
>
> Type II snow bands are wind-parallel bands (WPBs) and form when strong winds blow across the short axis of a lake (Niziol et al., 1995).

There is little established research on North American air mass origination, particularly in coordination with lake-effect cloud bands. However, Shadbolt et al. did perform a climatological study regarding the major air mass pathways into Michigan's lower peninsula on a daily basis. Shadbolt et al. divided North America into several regions to aid in the classification of different air masses' source region.

Using a similar approach, **this study explored the origins and trajectories of air parcels arriving at Lake Erie for different lake-effect convection types (i.e., SPB and WPB).**

Data and Methods

The initial dataset used daytime GOES Satellite imagery to analyze lake-effect cloud bands on the Great Lakes, categorizing them as WPB, SPB, or UNCL (unclear).

This project focuses on SPB or WPB convection on Lake Erie for the winter months starting in December 2009 to February 2019, excluding days with both SPBs and WPBs due to the complex environment.

> This includes a total of 45 cases for SPBs and 105 cases for WPBs.

NOAA's HYSPLIT software was employed to calculate air parcel back trajectories five days prior to each lake-effect day.

> To minimize uncertainty, ensemble trajectories were calculated for all — each ensemble included 27 trajectories extending from a singular terminus point.
>
> The North American Regional Reanalysis (NARR) model was chosen, and parcels were released at 1500 meters at 1700 UTC.

The collected trajectories were divided into 12-hour intervals and examined by convection type and month.

Figure 1 presents an adapted version of Shadbolt's regions, focused on the Great Lakes region, featuring back trajectories from January 27th (a SPB day) and February 17th, 2013 (a WPB day).

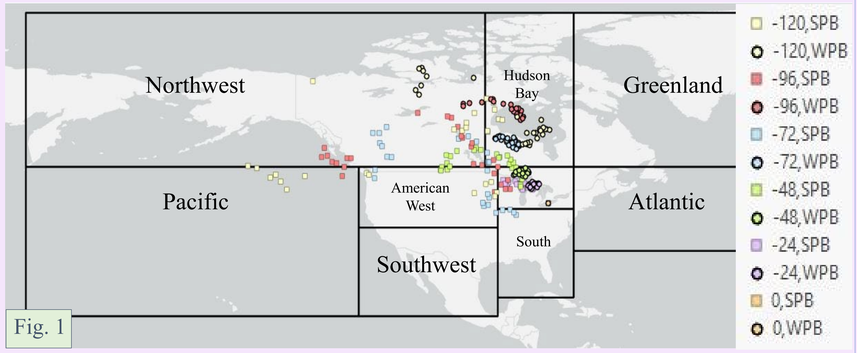


Fig. 1

Results

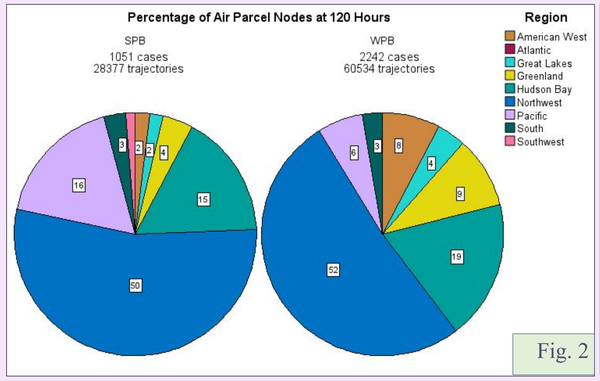


Fig. 2

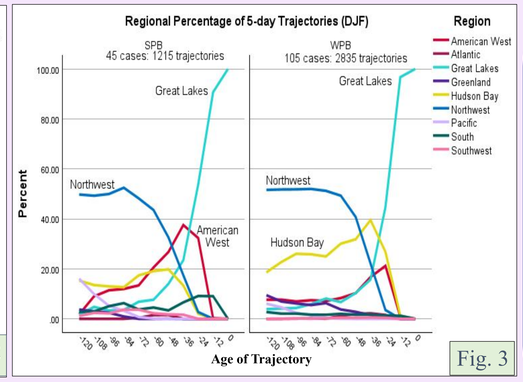


Fig. 3

- The percentage of parcels in different regions observed 5 days before Lake-effect days is shown in Figure 2.
  - Both the Northwest and Hudson Bay regions have the highest percentages for both convection types.
  - However, SPB days see a significant number of parcels in the Pacific region as well.
- Figure 3 tracks these parcels over time, with regions color-coded and values recorded as percentages.
  - The Northwest remains dominant for both convection types
  - Although, SPBs display more westward trajectories while WPBs follow more northward trajectories, aligning with expected cloud band behavior.

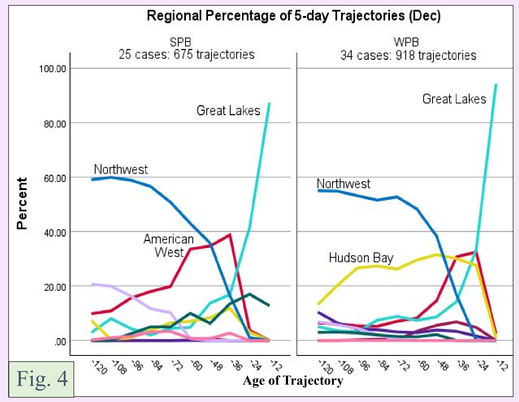


Fig. 4

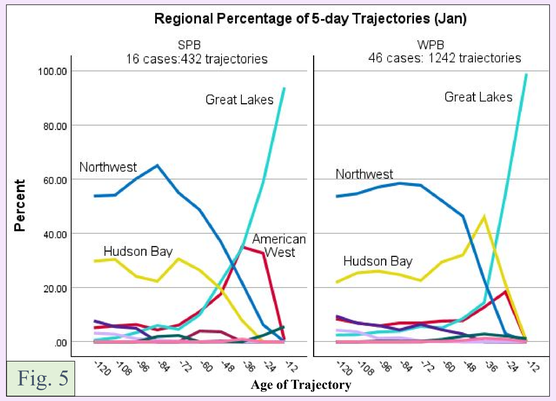


Fig. 5

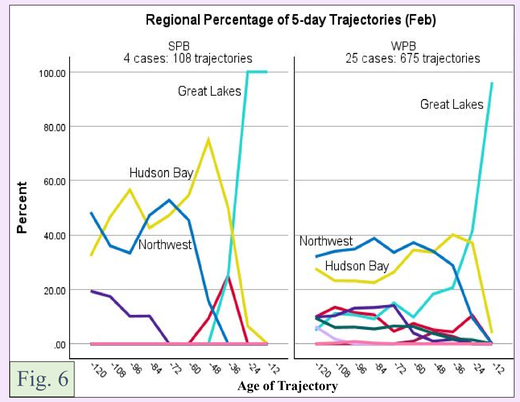


Fig. 6

- Figures 4, 5, and 6 are structured similarly to Figure 3, but they differentiate the trajectories for each winter month separately.
- All graphs indicate that the Northwest region is most prominent, but distinctions emerge when examining the data by individual months.
  - Figure 4 depicts December, highlighting the prevalence of westward trajectories for both convection types, indicated by the red line representing the American West region.
  - Figure 5 focuses on January, which shows a predominance of northern trajectories, marked by the yellow line for Hudson Bay.
  - Figure 6 illustrates February, also characterized by more northern trajectories, with some originating from the Greenland region, as shown by the purple line.
- Despite considerable variation in both convection types, general pathways can still be observed.

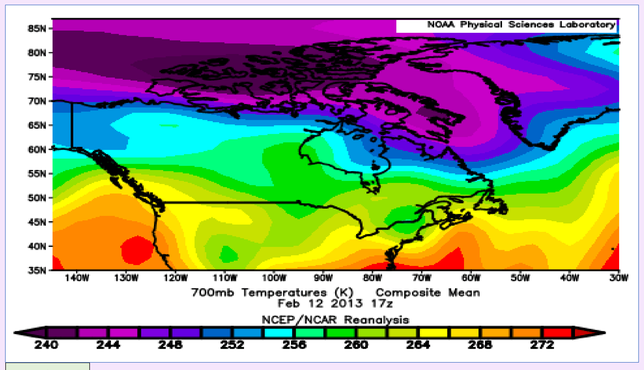


Fig. 8

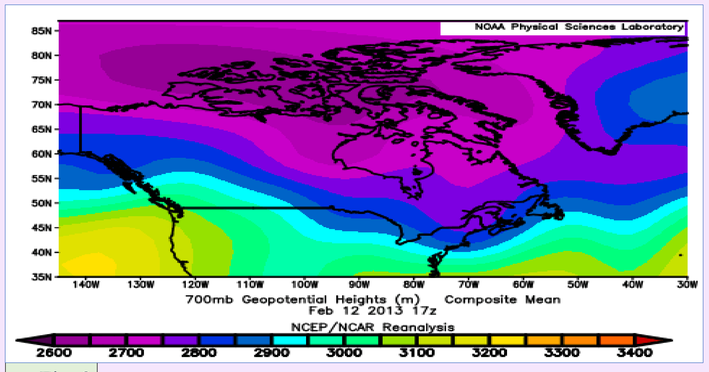


Fig. 9

- To corroborate the trajectory data, NCEP-NCAR reanalysis maps were generated to track geopotential height and temperature over a 5-day duration.
- A case study was conducted using February 17th, 2013, a WPB day, for this analysis. Figure 1 displays each trajectory at 24-hour intervals, color-coded for clarity.
  - Figure 8 shows the average temperature at 1700z, 5 days prior to the event. Comparing Figure 8 with Figure 7 reveals that the 120-hour trajectories align with the coldest regions depicted in Figure 8.
  - Figure 9 exemplifies the geopotential height at 1700z, 5 days prior to the event. The lowest heights correspond with the 120-hour trajectories indicating parcels likely follow the wind gradient.
- Further research is needed to draw definitive conclusions

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