Sinuosity as a Metric for Quantifying Tropospheric Polar Vortex Modification Associated with Arctic Cyclones

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1) Motivation

- Arctic cyclones (ACs) are synoptic-scale features that are often responsible for incursions of warm, moist air from middle latitudes into the Arctic
- AC-related warm-air incursions can result in longitudinally varying horizontal temperature gradients, which are associated with the amplification of the tropospheric polar vortex
- Amplification of the tropospheric polar vortex is associated with flow patterns that cause ACs originating in middle latitudes to track into the Arctic
- Considerable variability occurs in the evolution of the tropospheric polar vortex for these aforementioned flow patterns

2) Overview

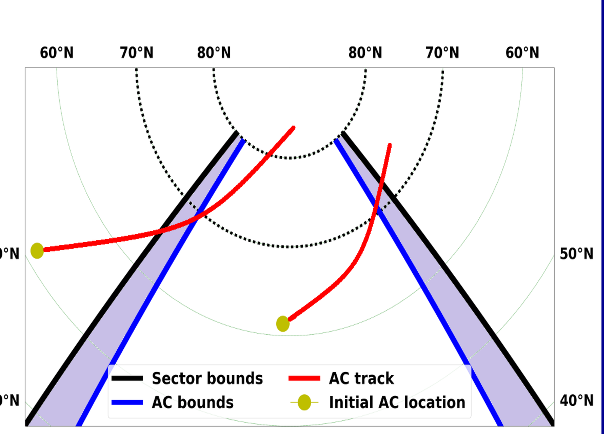
- Identify pathways where the frequency of ACs originating in middle latitudes and tracking into the Arctic is high
- Identify synoptic patterns that are conducive for ACs to track into the Arctic from middle latitudes
- Diagnose the modification of the tropospheric polar vortex associated with ACs that track into the Arctic from middle latitudes by quantifying the waviness of the equatorward vortex edge

3) Data and Methods

- Create a 1979–2018 AC climatology
- Obtain cyclone tracks from 1° ERA-Interim cyclone climatology prepared by Sprenger et al. (2017)
- ACs are deemed cyclones that last ≥ 2 days and spend at least some portion of their lifetimes in the Arctic (>70°N)

4) Sector Identification

- AC tracks are identified, and 90° longitudinal sectors are centered at locations of high AC track frequency
- An AC that originates or terminates outside of a given sector is associated with that sector if the longitude of the cyclone at 70°N falls 5° of longitude inward from the bounds of that sector



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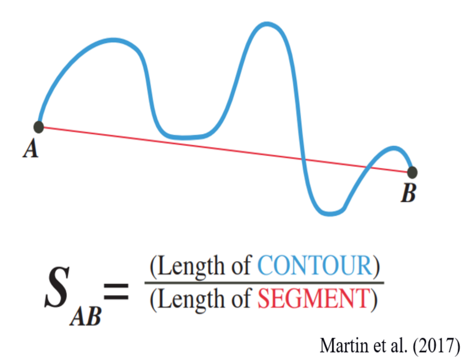
5) Polar Vortex Edge

- Following Frauenfeld et al. (2003), the 300 hPa geopotential height threshold for the polar vortex edge varies by month from a minimum of 8880 m in the cold season to a maximum of 9240 m in the warm season

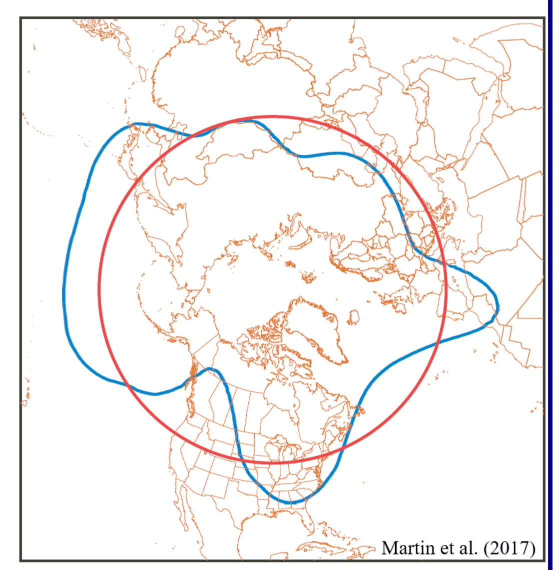
6) Sinuosity

- A metric describing flow amplitude
- Martin et al. (2016) calculated sinuosity for 500 hPa geopotential height contours



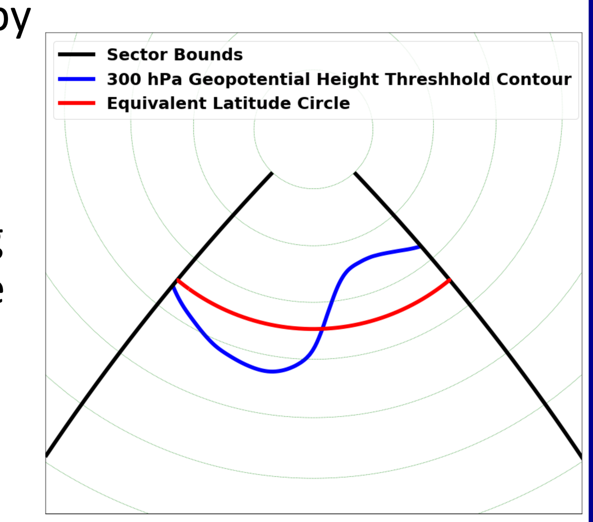
7) Circumpolar Sinuosity

- Calculate area enclosed by the 300 hPa geopotential height threshold contour (blue) determined by Frauenfeld et al. (2003)
- Determine the equivalent latitude (red) corresponding to the calculated area
- Calculate the ratio of the length of the 300 hPa geopotential height threshold contour (blue) to the length of the equivalent latitude circle (red)

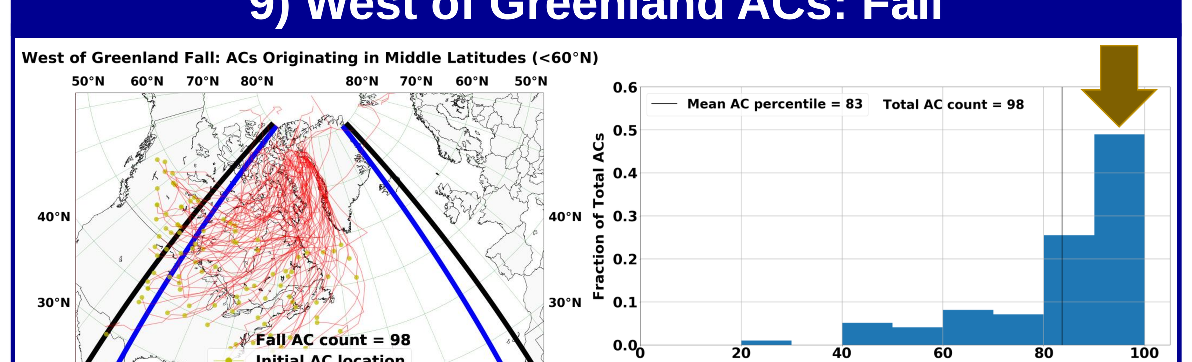


8) Sectorial Sinuosity

- Calculate area of the sector enclosed by the 300 hPa geopotential height threshold contour (blue) determined by Frauenfeld et al. (2003)
- Determine the equivalent latitude (red) corresponding to the calculated area of the sector
- Calculate the ratio of the length of the 300 hPa geopotential height threshold contour (blue) to the length of the equivalent latitude sector (red)



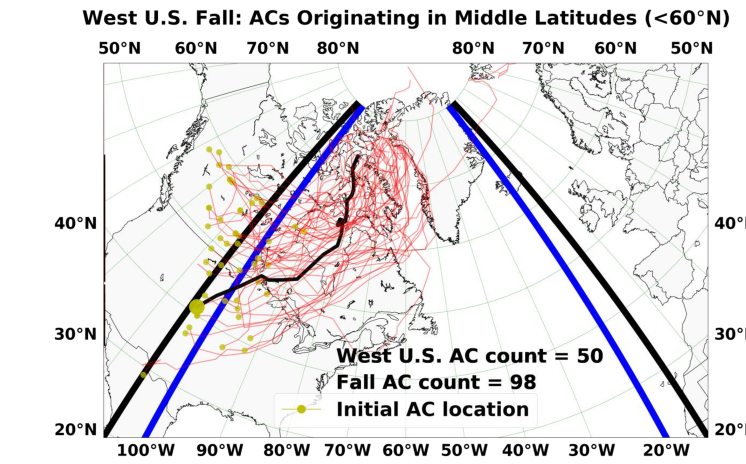
9) West of Greenland ACs: Fall



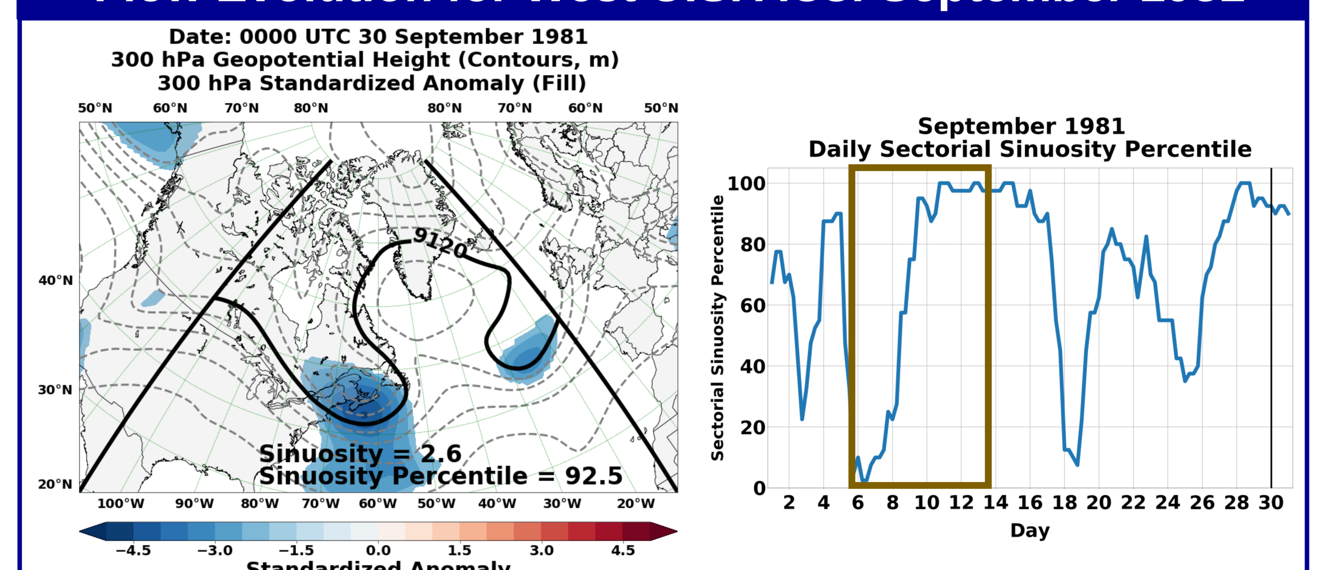
Arrow denotes the bin from which the two cases discussed in section 10 are taken

10) West U.S. ACs: Fall

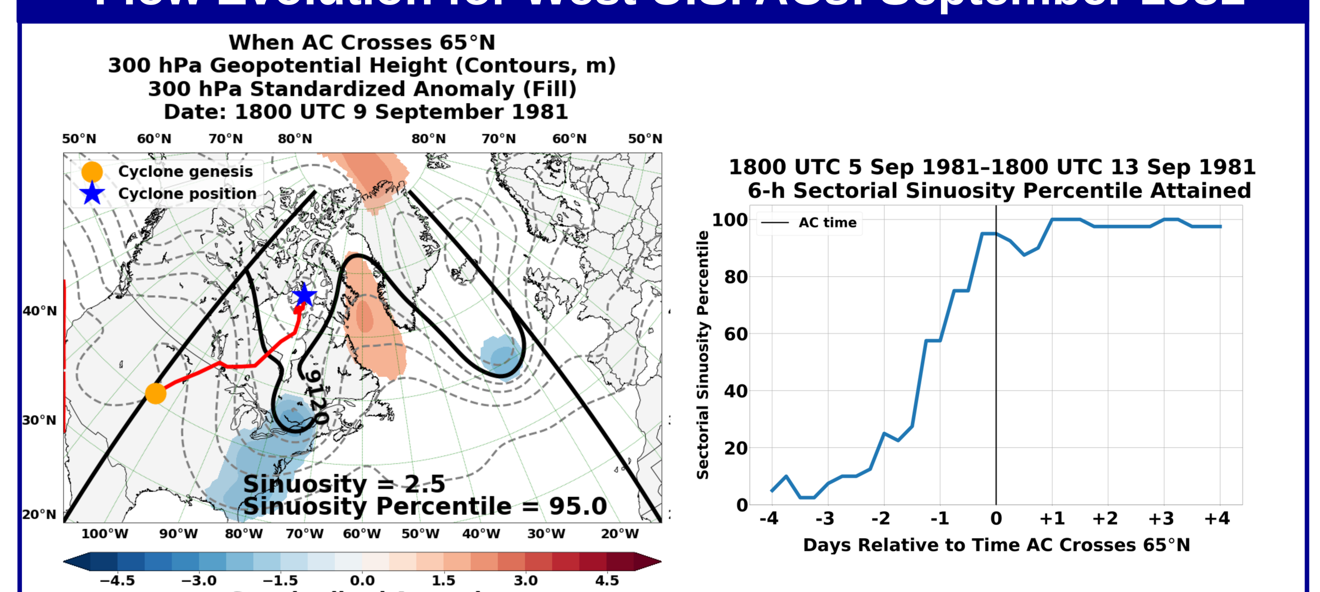
- ACs originating west of Great Lakes: Bolded track corresponds to AC track with maximum sectorial sinuosity >90th percentile as denoted in section 9



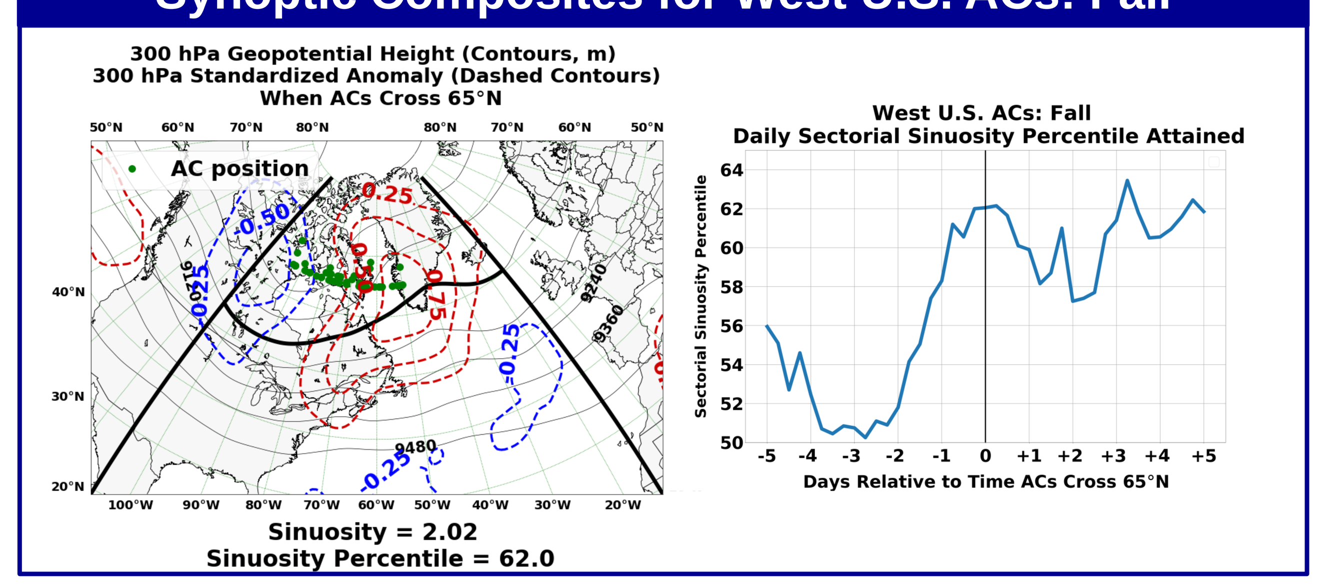
Flow Evolution for West U.S. ACs: September 1981



Flow Evolution for West U.S. ACs: September 1981

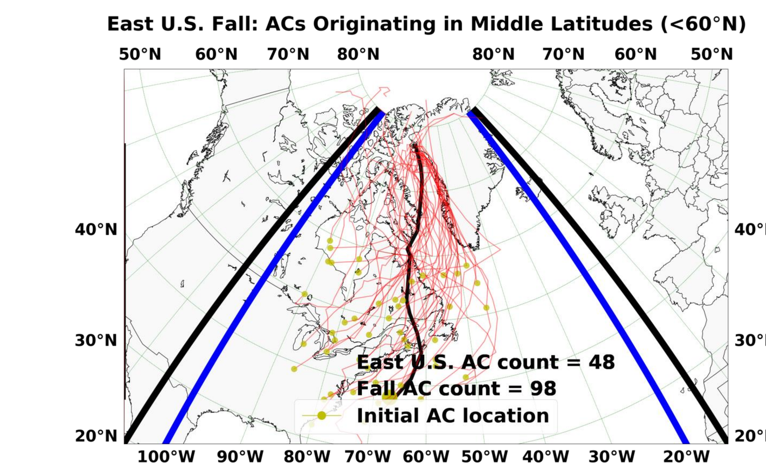


Synoptic Composites for West U.S. ACs: Fall

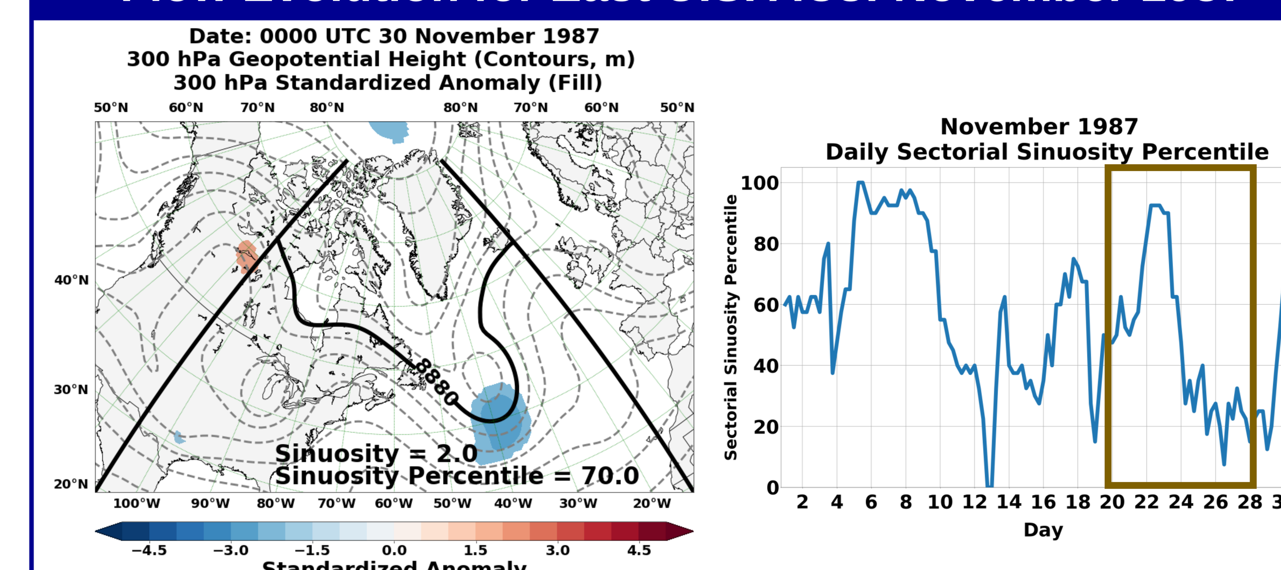


East U.S. ACs: Fall

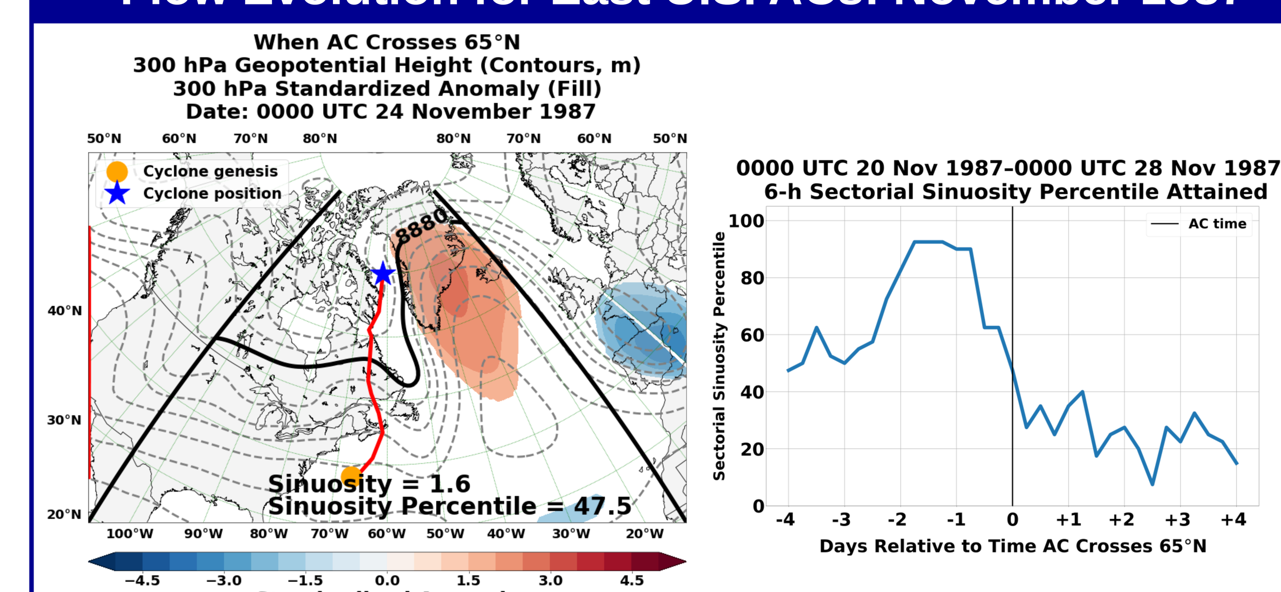
- ACs originating east of Great Lakes: Bolded track corresponds to AC track with maximum sectorial sinuosity >90th percentile as denoted in section 9



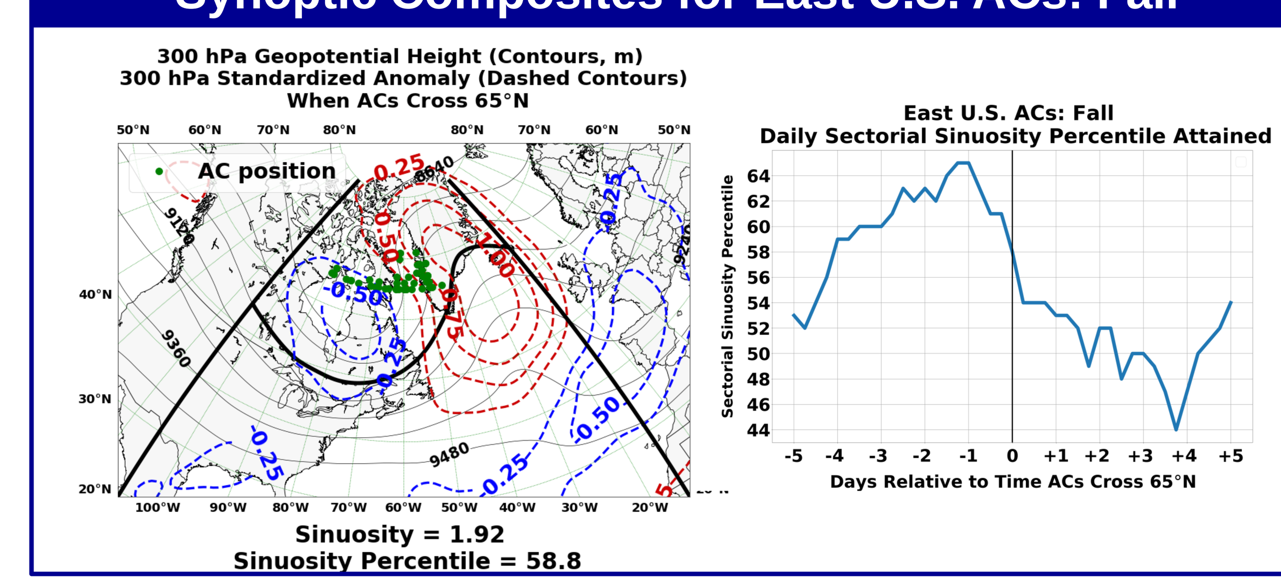
Flow Evolution for East U.S. ACs: November 1987



Flow Evolution for East U.S. ACs: November 1987



Synoptic Composites for East U.S. ACs: Fall



11) Summary

- Modification of the tropospheric polar vortex edge associated with ACs was quantified using sinuosity
- East U.S. ACs, on average, tend to be associated with flow that transitions from high to low sinuosity
- West U.S. ACs, on average, tend to be associated with flow that transitions from low to high sinuosity
- Flow patterns conducive to ACs tracking into the Arctic from middle latitudes are characterized by a downstream blocking ridge and an upstream trough
- ACs have been categorized in this study according to genesis location
- ACs may be categorized in future research according to oceanic vs. continental AC life cycles and sinuosity trends during AC life cycles