Analysis

Ideas for analysis

- **Diabatic vs adiabatic heating/cooling**
- **Moisture uptake**

This method comes from Sodemann, Schwierz, and Wernli (2008); they cite James et al. (2004). One simply calculates the change in specific humidity between equally spaced periods along the trajectory.

- **Moisture Source Attribution**

This method comes from Sodemann, Schwierz, and Wernli (2008).

I think it might be interesting to plot symbols on the trajectory map that show moisture uptake (blue = evaporation) and moisture loss (blue = precipitation; color represent gain and loss to the atmosphere). *Think about color choices here…*

- **Associate trajectory with cloud base height**

Determine the cloud-base height at each trajectory time. (This can be done using the CL61 summary files at 15 minute resolution.) Then select the vertical level that is closest to the cloud-base height. Plot all of these trajectories together to determine if they might be categorized. Determine the SOMs that are associated with the resulting categories; see below.

- **Associate trajectory with Self Organizing Map**

Determine the SOMs that are associated with each near-surface trajectory. I suspect that some SOMs will the associated with precipitation along the trajectory and some won't.

- **Regional trajectory analysis**

Use the methods of Hermann, Papritz, and Wernli (2020) to analyze multiple trajectories across the SW region of Greenland for the summer of 2024 to investigate how representative the SLEIGH measurements are. A lot of cool research questions here:

- How large of an area in SW Greenland if affected by similar conditions to Raven?
- How representative are the SLEIGH measurments under different atmospheric conditions (SOMs)?

Ideas for plots

- Plot an individual trajectory in the context of ALL the trajectories at a given vertical level for the Raven 2024 field season. All the trajectories would use a very think line, while the desired trajectory would me bold and thick. Similar to Figure 2 in Hermann, Papritz, and Wernli (2020).
- Plot time series of an individual trajectory in the context of ALL the trajectories at a given vertical level for the Raven 2024 field season. Use shading to show the upper and lower quartiles and upper and lower deciles. Similar to Figures 2, 3, 5, 6, 7, 8 in Bieli, Pfahl, and Wernli (2015).
- Create potential temperature (theta) vs air temperature (T) plots. Add lines of constant pressure. Similar to Figure 10 of Bieli, Pfahl, and Wernli (2015) and Figure 10 of Hermann, Papritz, and Wernli (2020). (Note that Hermann plotted T vs theta instead of theta vs T).

Useful equations

Diabatic versus Adiabatic changes

$$\frac{dT}{dt} = \frac{\kappa T \omega}{p} + H \left(\frac{p_o}{p} \right)^{-\kappa}$$

- the first term on the right represents the adiabatic heating/cooling from compression/expansion. $\omega > 0$ for *descending* motion (compression and heating, + term).
- the second term on the right represents diabatic temperature changes from latent heating in clouds (rare at the surface), radiation, and surface fluxes. Therefore, the term H can be written as $H = H_{cld} + H_{rad} + H_{sfl}$.

Changes in Moisture Content

$$\frac{dq}{dt} \approx \frac{\Delta q}{\Delta t} = E - P = Evaporation - Precipitation[units : gkg^{-1}(1h)^{-1}]$$

- Thus, changes in the air parcel's moisture content can be approximated by simply determing the change in q (specific humidity) between each time step (because each time step is equal; 1 hour).

Air Parcel Velocity

$$\frac{d\mathbf{x}}{dt} = \mathbf{u}(\mathbf{x})$$

Plot ideas

- Θ vs. T
  - T changes while Θ remains constant = adiabatic contribution
  - T and Θ change in parallel = diabatic contribution
- Trajectory time series showing median value and interquartile and interdecile ranges of:
  - q
  - Θ'
  - lat - lat_0
  - p
  - T - To
  - $\Theta - \Theta_o$

Bieli, Melanie, Stephan Pfahl, and Heini Wernli. 2015. "A Lagrangian Investigation of Hot and Cold Temperature Extremes in Europe." *Quarterly Journal of the Royal Meteorological Society* 141 (686): 98–108. https://doi.org/10.1002/qj.2339.

Hermann, Mauro, Lukas Papritz, and Heini Wernli. 2020. "A Lagrangian Analysis of the Dynamical and Thermodynamic Drivers of Large-Scale Greenland Melt Events During 1979–2017." *Weather and Climate Dynamics* 1 (2): 497–518. https://doi.org/10.5194/wcd-1-497-2020.

James, P., A. Stohl, N. Spichtinger, S. Eckhardt, and C. Forster. 2004. "Climatological Aspects of the Extreme European Rainfall of August 2002 and a Trajectory Method for Estimating the Associated Evaporative Source Regions." *Natural Hazards and Earth System Sciences* 4 (5/6): 733–46. https://doi.org/10.5194/nhess-4-733-2004.

Sodemann, H., C. Schwierz, and H. Wernli. 2008. "Interannual Variability of Greenland Winter Precipitation Sources: Lagrangian Moisture Diagnostic and North Atlantic Oscillation Influence." *Journal of Geophysical Research: Atmospheres* 113 (D3). https://doi.org/10.1029/2007JD008503.