Conducting Data Analysis on the Northern Hemisphere Polar Jet Stream as an Undergraduate in the Change(HI) Project

With global warming increasing the wave patterns of the jet stream, could Hawai'i see an increase in cut-off low activity and Kona low occurrences?

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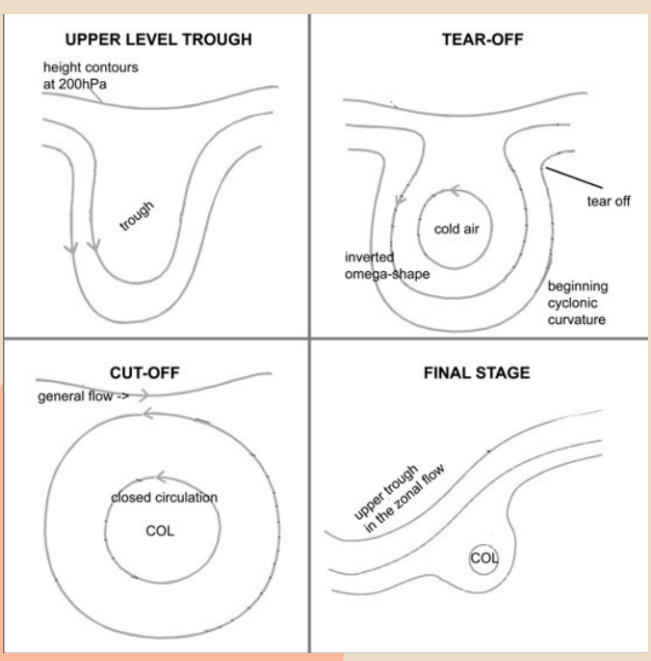
Image 1



Cut-off Lows in Hawai'i

- Cold air from higher latitudes reach Hawai'i due to southward dips in the jet, forming a trough that can close itself off from the jet's movement. This forms a cut-off low that traps cool air within its cyclonic movement (**Image 1**).
- Cut-off lows move erratically and unpredictably, making their paths hard to forecast.
- For Hawai'i, cut-off lows can evolve into a class of subtropical storms known as Kona lows that can bring strong cold fronts, gusty winds, heavy rain, and thunderstorms.

The N.H. Polar Jet Stream

- Regions of maximized wind speeds that reside at the top of the troposphere, around 250 hpa (~10 km above sea level).
- Indicated by steep changes in geopotential heights across latitudes due to strong meridional temperature gradients near the surface.
- Faster jets flow more zonally (parallel to latitudes); Slower jets exhibit a more wavy pattern.
- The poles are warming at a faster rate than the tropics, decreasing the meridional temperature gradient, thus slowing the jet stream and increasing its waviness.

Data Analysis

- NCAR reanalysis datasets of 250 hpa geopotential heights are useful as this is where the jet cores (maximized wind velocities) are usually found.
- netCDF files are the most common type of file to store meteorological data. I had to learn how to work with multidimensional arrays in order to analyze geopotential height variables.
- So far, I have learned how to calculate average 250 hpa geopotential heights across the globe over 24 hours.

Further Analysis

- I will determine the most recent Equivalent Latitude, the average line that the jet follows using 250 hpa geopotential heights (**Image 2**).
- Next, I will calculate the Average Latitudinal Displacement (ALD) by measuring the troughs and ridges created by the jet using the Equivalent Latitude as a reference point, in order to determine the jet's waviness (**Image 3**).

Image 2

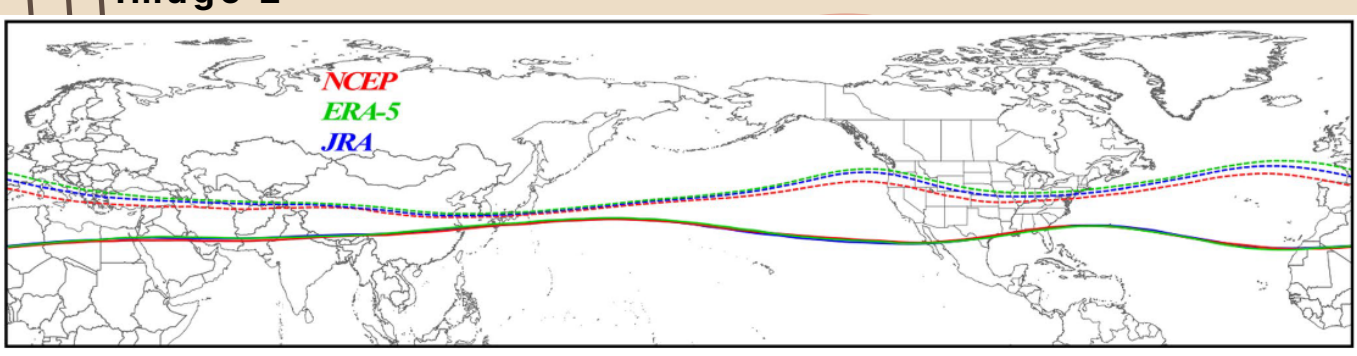
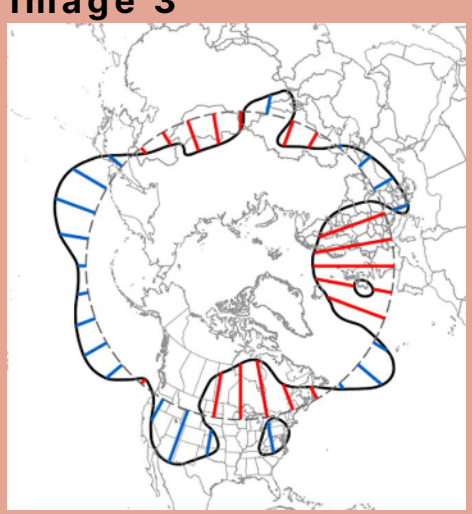


Figure 4. DJF average latitude of the core isertels of both the polar jet (dashed lines) and the subtropical jet (solid lines) from the NCEP, JRA, and ERA-5 reanalysis data sets. NCEP, National Centers for Environmental Prediction.

Image 3



Ultimately, these values will help me to analyze jet waviness over long time scales to suggest the effect of a warming planet on the jet's probability to form cut-off lows and Kona lows around Hawai'i. I hope to apply my analysis to assist operational forecasting of these synoptic weather events.

Resources:
Martin, J. E. (2021). Recent trends in the waviness of the Northern Hemisphere wintertime polar and subtropical jets. Journal of Geophysical Research: Atmospheres, 126, e2020JD033668. https://doi.org/10.1029/2020JD033668