20 Year Climatology of Upslope Snow on Mount Washington (2005-2025)

Peter Edwards

Summit Intern

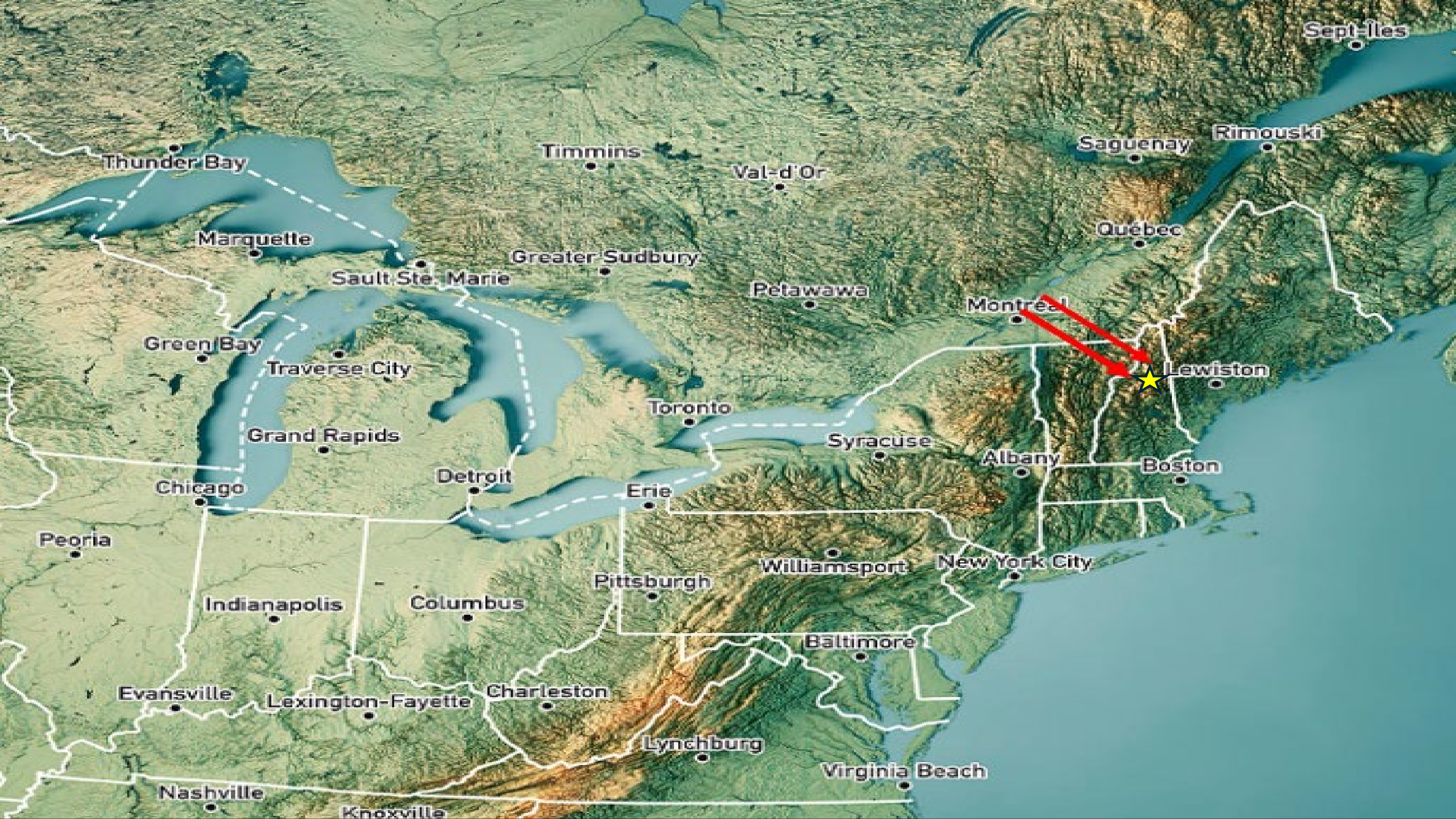
Recipe for Upslope Snow

Four essential ingredients:

- Cold air
- Northwest or west winds
- Moisture or high levels of humidity in lower elevations
- A stationary or slow-moving weather pattern

What is Upslope Snow and How Does it Occur?

- **Precipitation event specific to higher terrain**
- A storm passes by and brings in **colder air**.
- **Winds** turn from the **northwest** and hit the mountain head-on
- The mountain range acts **a physical barrier** to the winds.
- The winds pick up **moisture** from nearby valleys and drive it up the slopes
- If these ingredients stick around, the mountain keeps getting snow
- The best setup? A **storm stalled to the northeast around the Canadian Martimes** and **high pressure to the west.** This combo gives us **strong northwest winds** and the potential for lots of upslope snow.


Sept-Îles
Thunder Bay
Timmins
Saguenay
Rimouski
Val-d'Or
Marquette
Québec
Greater Sudbury
Sault Ste. Marie
Petawawa
Montreal
Green Bay
Traverse City
Lewiston
Toronto
Grand Rapids
Syracuse
Albany
Boston
Detroit
Chicago
Erie
Peoria
Williamsport
New York City
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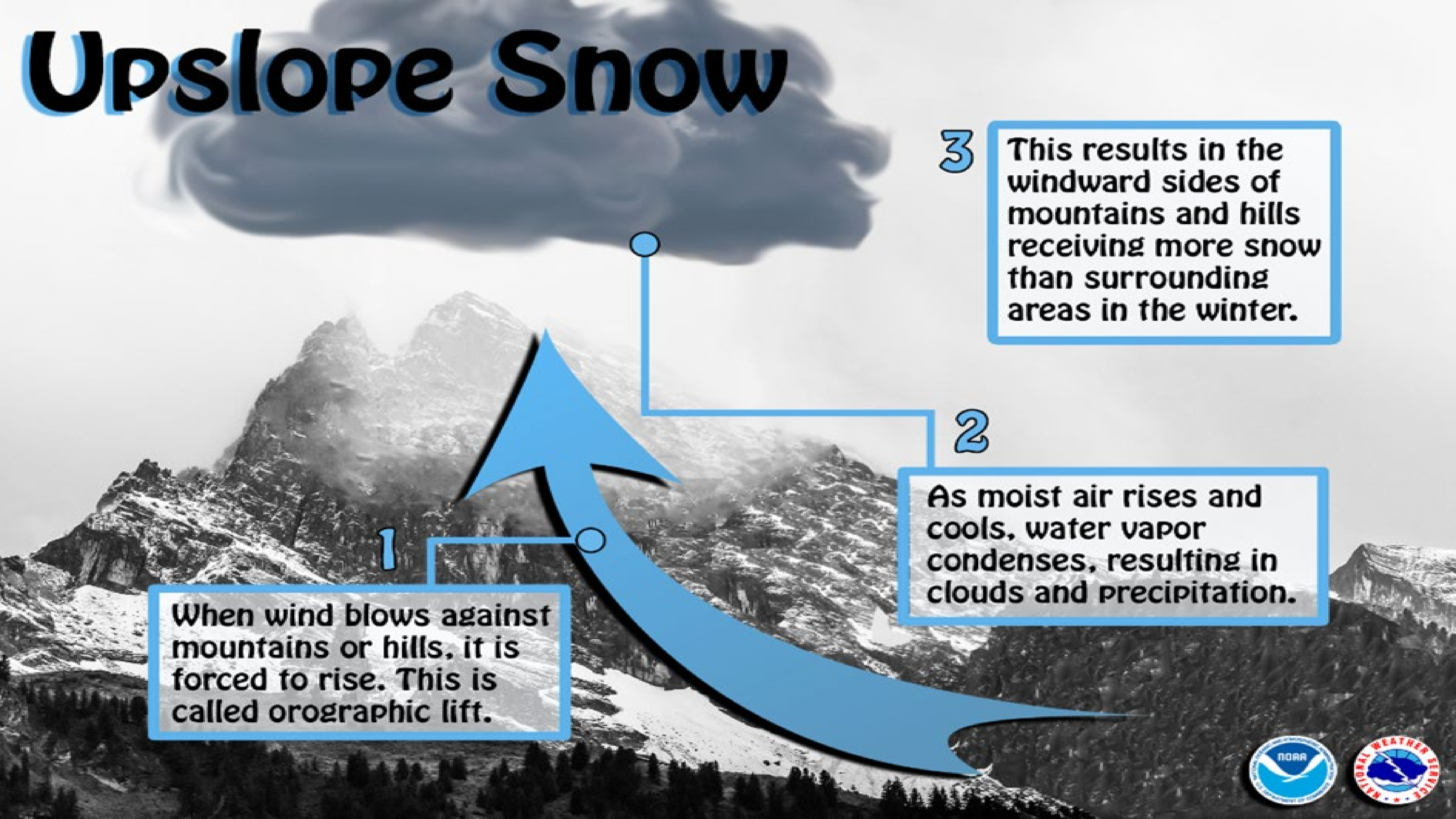
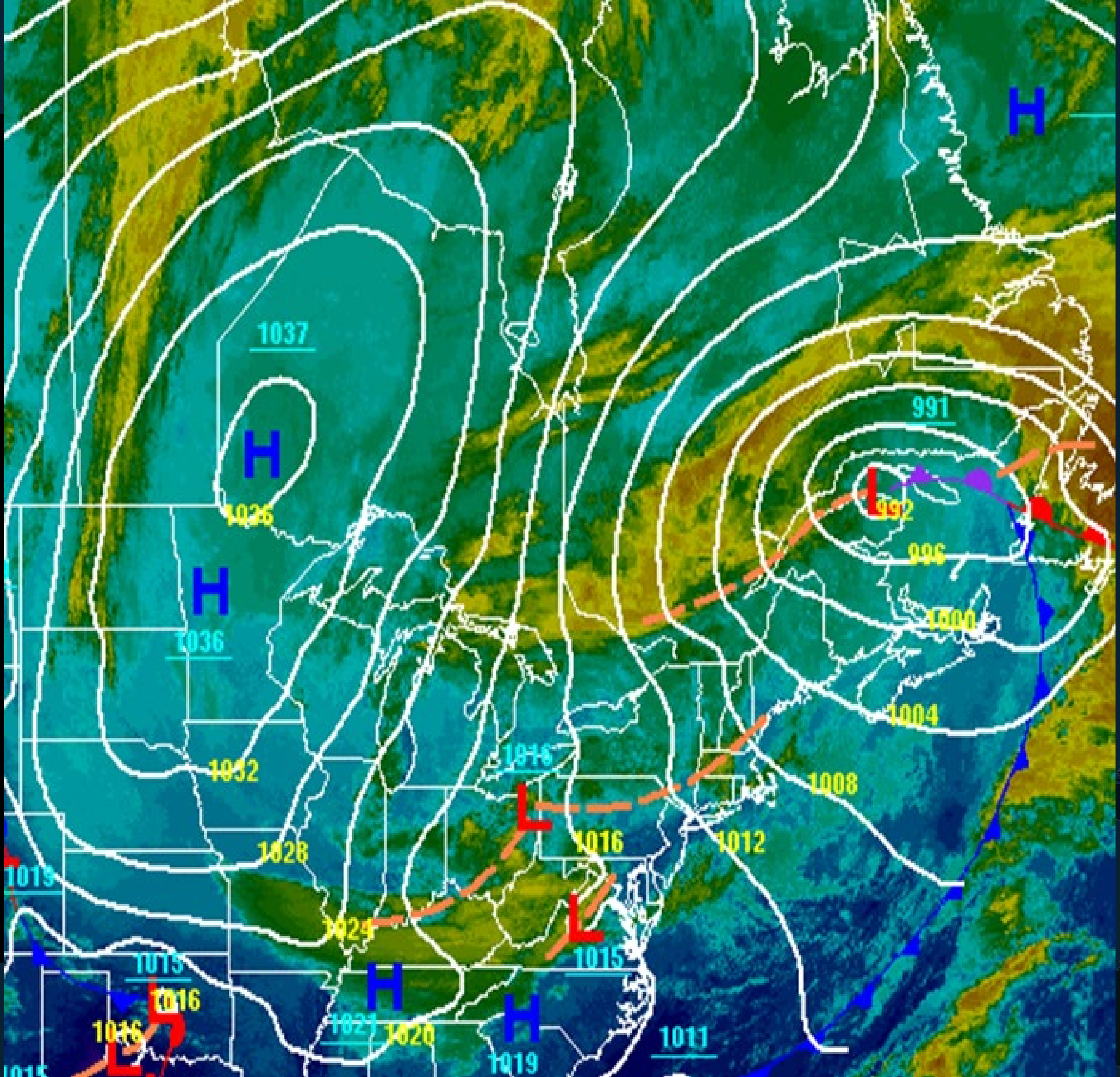
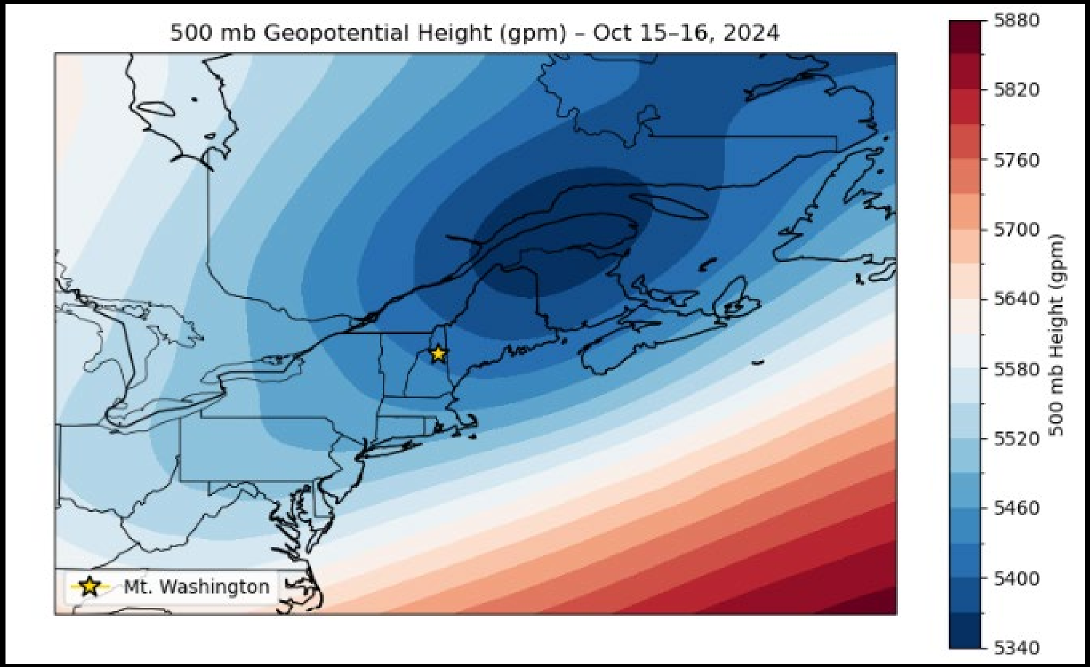

Upslope Snow
3
This results in the windward sides of mountains and hills receiving more snow than surrounding areas in the winter.
2
As moist air rises and cools, water vapor condenses, resulting in clouds and precipitation.
1
When wind blows against mountains or hills, it is forced to rise. This is called orographic lift.
NOAA
NATIONAL WEATHER SERVICE

October 15–16, 2024 Upslope Snow Event

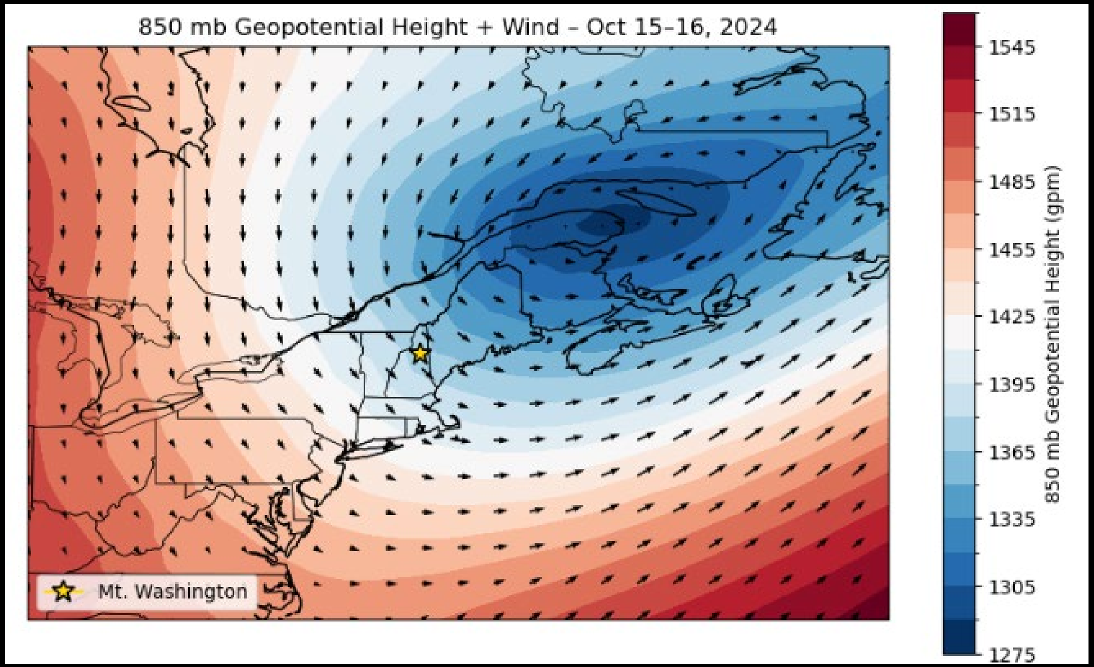
- Surface map of an upslope event from October 15–16, 2024
- Winds from the northwest were strong and steady.
- Air was full of moisture and cold enough for snow.
- Upper-level weather patterns were *perfectly lined up* to keep snow falling on the slopes over the course of 2 days, where 7.6 inches of snow fell on Mt Washington



Important features for the event: Pressure Patterns and Wind direction

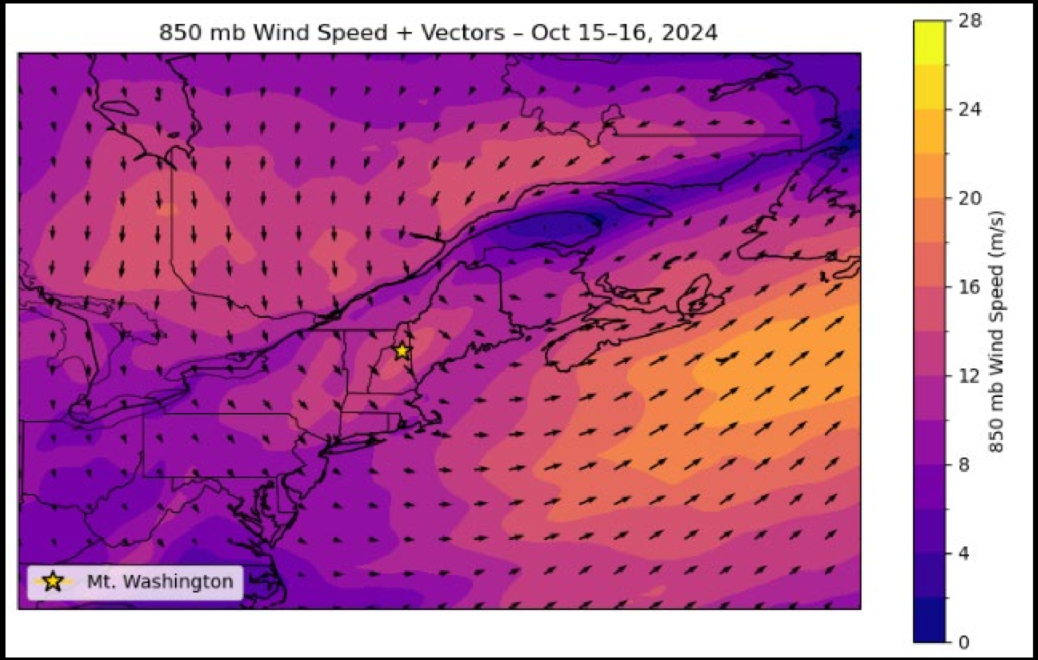


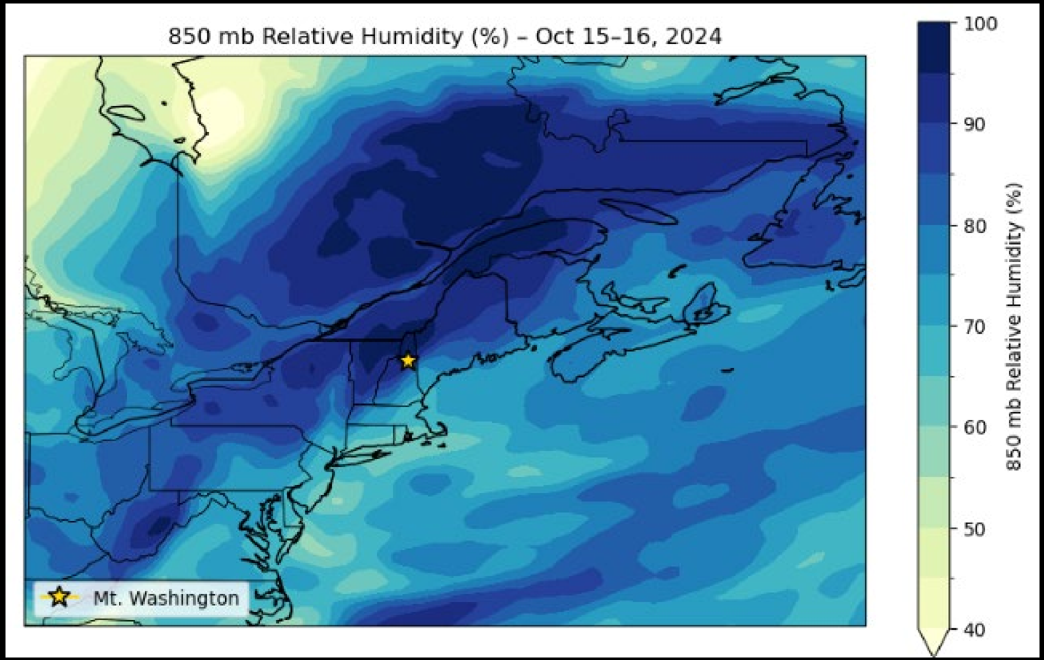
Pressure pattern in upper levels of the atmosphere (~20,000 ft)



Low level wind direction and pressure pattern (~5000ft)

Wind Speed + Direction and Moisture





Wind speeds over Mt Washington were blowing at ~ 40 knots on average from the NW

Humidity at low elevations was nearly saturated (~100%) along the windward slopes

Event Recap

- Overall pattern was consistent with most upslope snow events on Mt Washington
- Cold air moved in after the passage of the storm
- Strong and sustained winds out the NW due to the stalled storm to the northeast of Mt Washington while high pressure moved in from the west
- High levels of moisture present at surrounding low elevations to fuel the snowfall
- 7.6 inches of snowfall fell during over the course of 2 days

Research Project Summary

- Looked at the last 20 years of upslope snow events on Mount Washington
- Determined how often they happened yearly and seasonally
- Determined how much snow they added to the mountain overall.
- Used weather data to see what patterns cause these events.

Methods

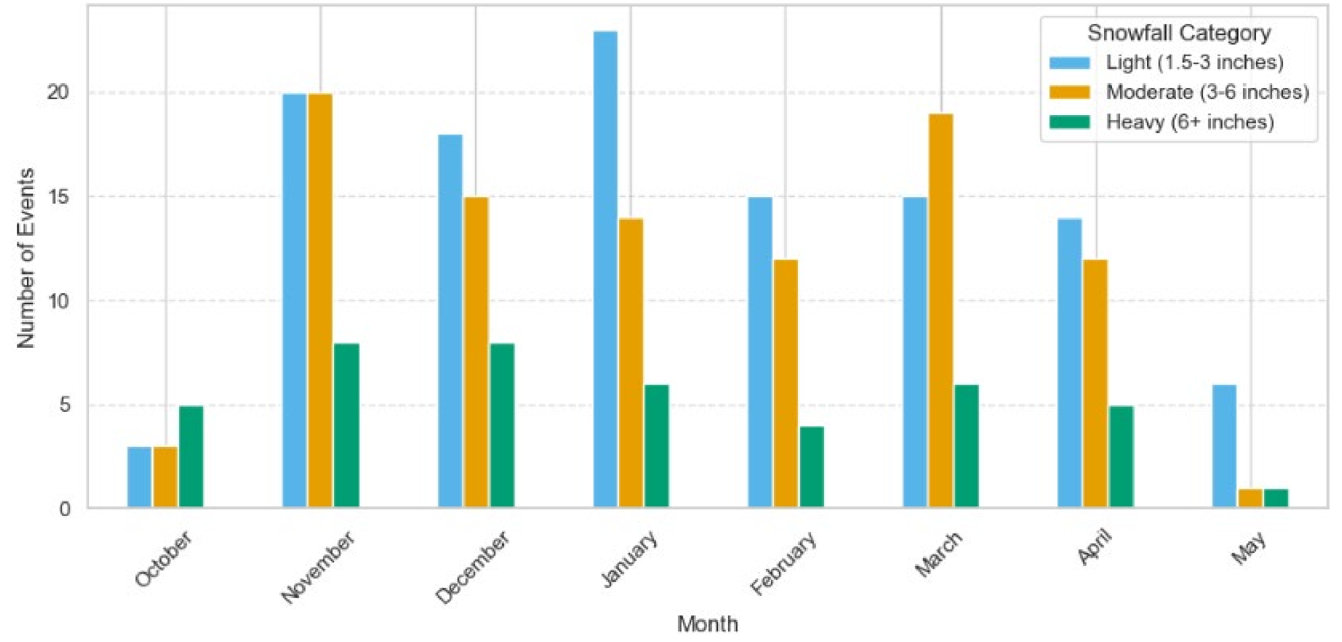
- Created criteria for upslope events MWOBS snow data and station data from Fryeburg, Whitefield and Berlin (2005-2025)
- Snowed at least 1.5 inches on Mt Washington (1 inch for multi day events), .05 inches or less of liquid precipitation at lower elevation stations
- Prevailing winds out of the NW or W
- Once events were chosen with a python script further analysis with radar composites and surface charts were used to verify all the events

- Some events had to be removed due to presence of mesoscale banding
- Weak, dry clipper systems were the most common cause of false flags in the data
- Station data would occasionally report snowfall totals a day late resulting in additional false flags
- Some synoptic events that transitioned to upslope events had to be removed as well due to the inability to calculate total snowfall
- Events were then binned into light (1-3 inch), moderate (3-6 inch) and 6+ inch categories

Results

- Over the 20-year study period, a total of 254 upslope snowfall events were identified, of which 206 were single day events and 48 multi-day upslope snow events.
- These events displayed a strong seasonal signal, with the highest frequency occurring between November and March. Light to moderate events were most common during the winter months of December, January, and February.
- SLR distribution of events

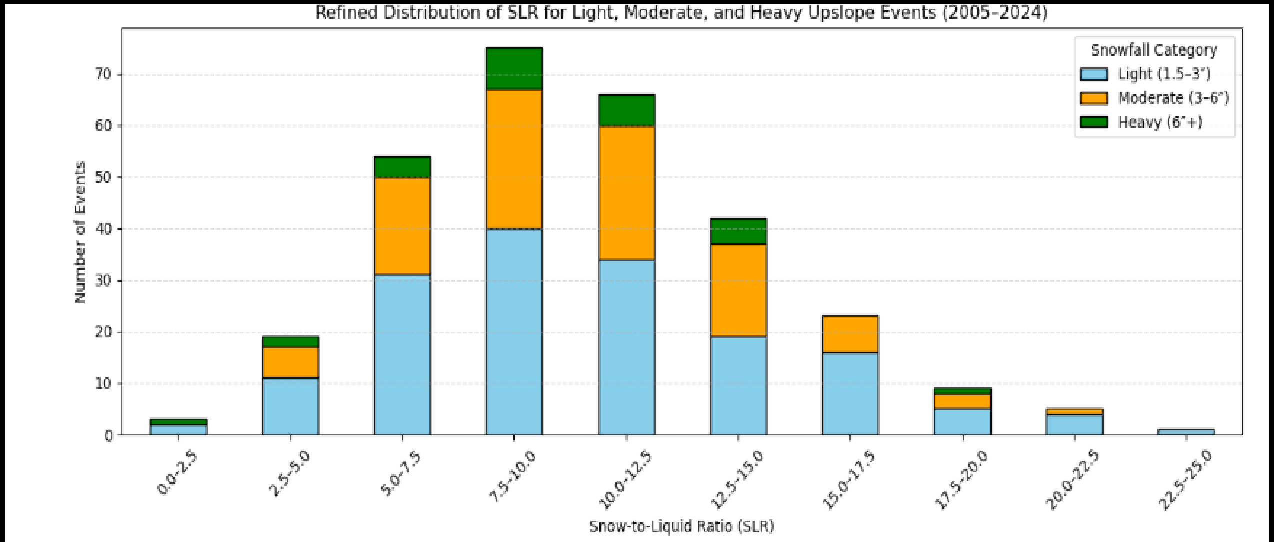
Categorized Events by Month and Total Snowfall



Figure(1.2): Monthly Frequency of light, moderate and heavy upslope snow events using local Winter Storm Warning Criteria

- Events were categorized based on the local winter weather warning criteria
- Higher number of events occur in the winter months
- Heavier events occur more often in shoulder seasons

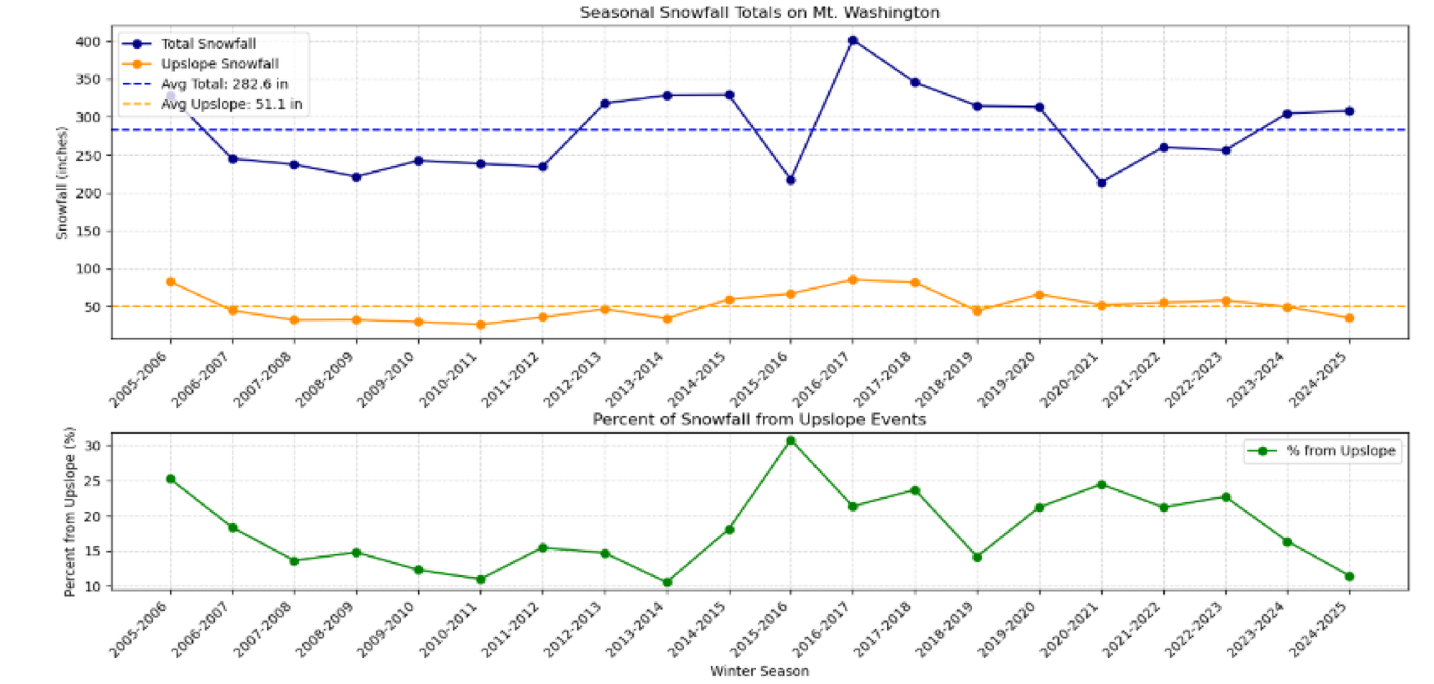
SLR Distribution of Upslope Events



(Fig 1.3a): Stacked frequency distribution of snow-to-liquid ratio (SLR) for upslope snowfall events on Mount Washington from 2005–2024. Events are categorized by snowfall amount: Light (1.5–3″), Moderate (3–6″), and Heavy (6″+). Bins are evenly spaced in 2.5-unit intervals, with a cap at 25:1 SLR to avoid distortion from rare outliers. Most upslope events cluster between 5:1 and 15:1, with the peak around 7.5–10.0. Heavy events are rare but more evenly spread across SLR bins, while light events dominate the lower SLR ranges. This refined binning better resolves structure around the 10:1 threshold and highlights differences across snowfall categories.

- Events categorized by snowfall amount light (1-3in), moderate(3-6in), heavy(6in+)
- Bins spaced every 2.5 SLR units,
- Peak SLR clusters around 7.5-10:1
- Heavy events are more evenly distributed across bins and are slightly more prominent at higher SLR values
- More distinct clustering of events around 10:1

Seasonal Snowfall and Upslope Contribution



Fig(1.1): Seasonal snowfall totals on Mount Washington, separated into total snowfall (blue) and snowfall from upslope events (orange) for each winter season. Dashed lines indicate the long-term seasonal average for each. The bottom panel shows the percentage of each season's total snowfall that was attributable to upslope events, highlighting their variable but often substantial contribution to annual snowpack.

- Blue line represents total annual snowfall on Mt Washington (283 inches per season)
- Red line represents annual upslope snow amounts on Mt Washington (51 inches per season)
- Green line represents upslope snows annual contribution to total snowfall on Mt Washington
- Upslope contribution varies between <10% to over 30% depending on the year. True estimate is higher due to events that were removed

Main Takeaways

- Long term climate trends can't be determined from this data but an increase of 1.03 inches per year since 2005 is notable
- Heavier events are slightly skewed toward the shoulder seasons
- Upslope snow contribution has high variability season-to-season
- This work could enable longer term climate studies to be performed in future
- Could enable future interns, students or researchers to look further into the meteorological dynamics and impacts of upslope snow events on Mt. Washington

End of Presentation
Thank you!

EMAIL: peter_edwards1@student.uml.edu