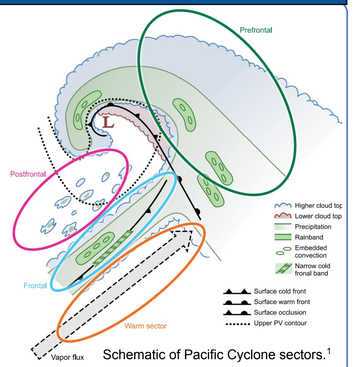
Orographic Enhancement of Postfrontal Precipitation During OLYMPEX

Alex Hewett, Lynn McMurdie and Andrew DeLaFrance

Department of Atmospheric Sciences, University of Washington, Seattle, WA

Motivation and Introduction

- Motivation: Improved understanding of precipitating systems will provide improvements in weather, flooding, and snowpack forecasting.
- **This study focuses on postfrontal sectors** (circled in pink) that are characterized by cold westerly to north westerly winds, instability, and low melting levels.



Schematic of Pacific Cyclone sectors.[1]

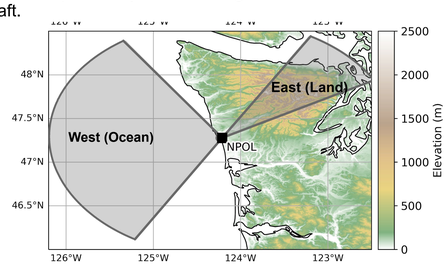
- The Olympic Mountains Experiment (OLYMPEX) measured precipitation in winter storms with radar, ground instruments, and aircraft in the 2015-2016 winter season.[1]
- Previous work that focused on postfrontal convection during OLYMPEX noted likely orographic enhancement of postfrontal showers based on aircraft data of three events. The sample was too small to conclude statistical significance.[2]

Science Question

- What is the nature, if it occurs, of orographic enhancement of postfrontal precipitation when postfrontal convection cells approach the Olympic Mountain slopes?

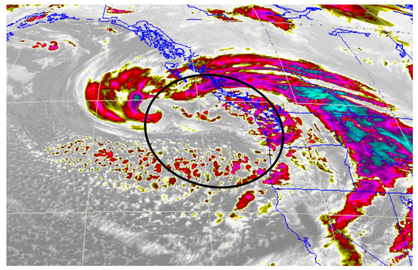
Methods

- Postfrontal events were identified using North American Regional Reanalysis (NARR) data for OLYMPEX and criteria from McMurdie et al. 2018[3]
  - melting level <= 1200m
  - IVT <= 250 kg $m^{-1}s^{-1}$
  - moist static stability <= -0.25x10^{-4} s^{-2}
  - wind direction between 270-090 degrees
- 7 events were identified. November 15, 18, 24; December 14, 18, January 13, 14. Three additional events on Dec 4, 10, and 13 were identified and examined by Zagrodnik et al. 2019[2], however, these events were previously studied using APR-3 data taken from NASA DC-8 aircraft.



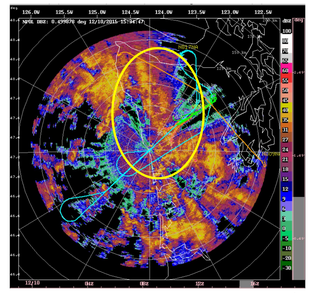
- NASA Dual-Polarization (NPOL) Radar reflectivity data was examined for the entire OLYMPEX period (Nov. 12, 2015 - Jan. 15, 2016).
- The NPOL radar data were gridded with 0.5km horizontal and 0.25km vertical resolutions.
- Maximum height of 15 dBZ echo is used as a proxy for the tops of precipitating clouds.
- Grid-point maximum heights of 15 dBZ echoes were computed across each ~20-minute NPOL scan.
- The means of ocean and land sector maximum heights of 15 dBZ echoes were computed per NPOL scan.

10 December 2015 Postfrontal Example



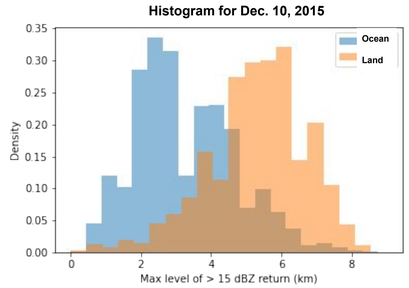
GOES-West IR satellite at 1800 UTC Dec 10 2015.[4]

- GOES-West IR satellite imagery shows transition from cellular convection to stratiform over terrain.



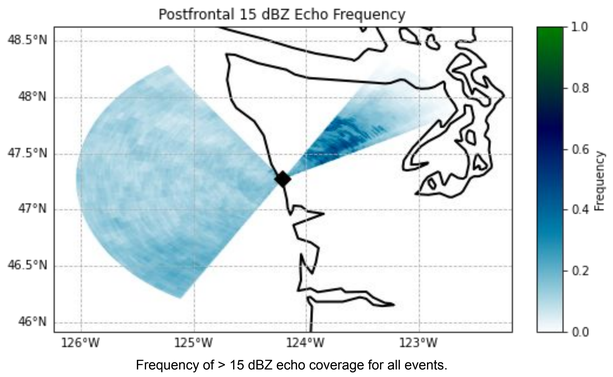
NPOL Radar imagery at 1530 UTC Dec 10, 2015.[4]

- NPOL reflectivity shows more continuous coverage over land (circled) vs. ocean.



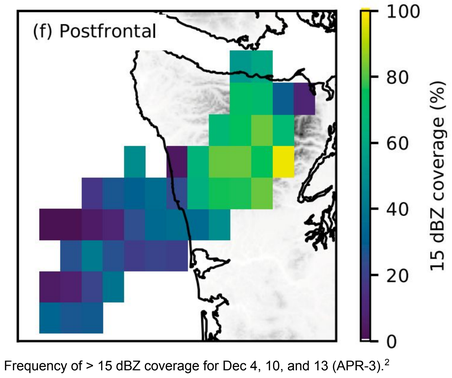
- Histogram of NPOL maximum >15 dBZ echo heights shows that the clouds are taller over land.

Results



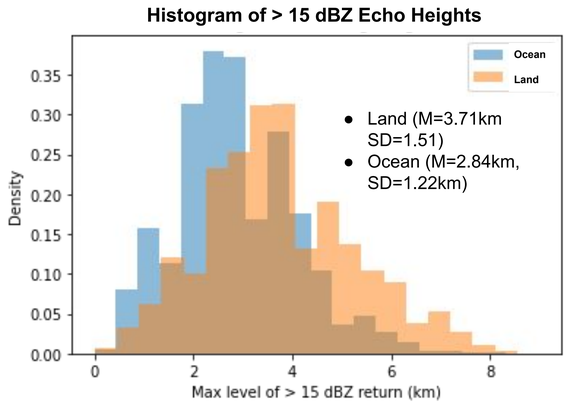
Frequency of > 15 dBZ echo coverage for all events.

- Radar echo exceeding 15 dBZ occurs more frequently over land than the upstream ocean.

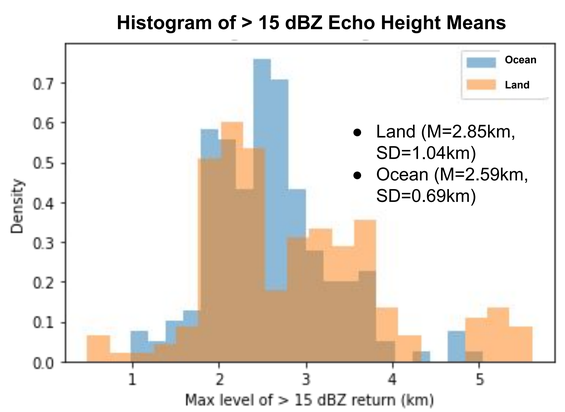


Frequency of > 15 dBZ coverage for Dec 4, 10, and 13 (APR-3).[2]

- Our results are similar to those of Zagrodnik et al. 2019[2].



- The histogram of the **15 dBZ echo height for all grid points and radar scan cycles** indicates that the convection over terrain is deeper than over the ocean at the 95% confidence level.



- The histogram of the **sector-mean 15 dBZ echo height for each radar scan cycle** also indicates that the convection over terrain is deeper than over the ocean at the 95% confidence level.

Conclusions

- The results show that there is a statistically significant difference in the mean postfrontal shower convection height, suggesting taller clouds over land and shallower clouds over ocean.
- Precipitating clouds are more frequently present over land implying that scattered convective cells over the ocean transition to hybrid stratiform/convective systems over land.
- These results confirm those of Zagrodnik et al. 2019[2], but do so using more events based on an objective postfrontal classification criteria and using a ground-based radar.

Acknowledgements

The authors thank the Quinault Indian Nation for permission to install the NPOL radar on their land and the scientists and NASA engineers who operated NPOL during all hours and under all conditions during OLYMPEX. All OLYMPEX data used in this study are found at https://doi.org/10.5067/GPMGV/OLYMPEX/DATA101. The NARR data were obtained from https://www.earl.noaa.gov/psd/data/gridded/data.narr.html.

References

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