### **Evaluating Cloud Microphysical Schemes in Simulating Orographic Precipitation Events Using OLYMPEX Field Experiment Observations**



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This work is supported by NASA PMM #NNX16AD81G

## Motivation and Goals

- Previous studies over the Pacific Northwest (e.g., IMPROVE-2; Garvert et al. 2005; Colle et al. 2005, Lin et al. 2009, ...) showed many bulk micro schemes over-predict windward precipitation and snow aloft (too much cloud water lower windward slope and too little near crest).
- There are large bulk microphysical parameter (BMP) uncertainties to riming and other ice characteristics (habit, size distribution, density, etc...).
- Orographic precipitation is also highly sensitive to the upstream cross barrier flow, moisture, and stability.
- There has been limited verification of orographic flooding events (high freezing levels) over the PNW.



## **OLYMPEX** Field Experiment

- Coastal soundings: Upstream flow, moisture, and stability
- WSR-88D/NPOL: Precipitation evolution around barrier
- DOW/ MRR: Detailed precipitation structures over windward slope/valley
- Gauges/Citation Aircraft: Spatial precipitation amounts and microphysics verification



## Motivational Questions

- How do the orographic precipitation structures evolve for these flooding cases (focus on 12-13 Nov 2015 event)?
- How well do the various bulk microphysical schemes (BMPs) in WRF predict these precipitation structures and amounts?
- Are there any microphysical differences aloft between the BMPs?

# WRF Model Setup

- Three heavy precipitation cases simulated (12-13 Nov 2015, 17-18 Nov 2015, and 8-9 Dec)
- WRF V3.7.1 at 9, 3, and 1 km grid spacing (50 vertical levels).
- IC/BCs: (GFS analyses and NARR so far)
- MYJ PBL, Grell-Freitas (9 km), RRTMG
- 36-h runs starting (11/12/12z, 11/16/12z, and 12/08/00z). First 9-h spin-up.



#### Bulk Microphysical Schemes (BMPs)

- <u>Thompson</u> (2008) ~2D ice, ice size distribution from Field et al. (2005), variable riming efficiency.
- Morrison (MORR, 2-moment -2009) predicts number concentration (Nx) to get snow/ice size distribution (I) and intercept (Nos). Spherical ice/snow.
- <u>Stony Brook</u> (SBU, 2011) Uses Nos(T), ~2-D ice/snow, combines snow and graupel into one category, and a degree of riming is estimated and variations in snow density (T). Snow/rime properties not advected horizontally.
- <u>P3</u> (2015) <u>(Control Run)</u> Four prognostic mixing ratio variables (total ice mass, rime ice mass, rime volume, and total number) predict the bulk particle properties of a single ice-phase. Advects ice/rime properties.

# 12-13 November 2015 Event

Significant atmospheric river (~30 mm PWTR: obs and in WRF)



# Stability/Flow Evolution (Obs-CSU vs WRF)



- Before 0300 UTC 13 November – Stable layer between 950 and 800 hPa
- Closer to moist neutral after 0600 UTC 13 November
- Freezing level slowly rising from 2.3 to 2.7 km AMSL.





## NPOL SW-NE Cross Section Comparison



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#### 13 Nov 2015 Precipitation Total (in mm) and 1-km WRF % of Obs



12-13 Nov Precipitation Time Series (Prairie Creek)



### WRF Micro Along NPOL Section (08 UTC 13 Nov)



### WRF Micro Along NPOL Section (08 UTC 13 Nov)







#### Citation Aircraft Micro Comparisons with WRF BMPs



# Conclusions

- For the 12-13 November 2015 event, relatively large lowlevel stability early in the event resulted in flow splitting and maximum precipitation immediately west of the lower windward slope.
- As the stability decreased the maximum precipitation shifted over the Olympics higher terrain.
- WRF BMPs underpredicted precipitation over the lower windward slope by 10-30%. Some of this was the result of the precipitation ending too soon.
- WRF P3 scheme more realistically predicted the amounts and precipitation rate which is partially (mostly?) attributed to more riming and precipitation fallout.
- Morrison (2009) scheme showed largest underprediction in precipitation likely due to minimal graupel "riming" production and reduced precipitation fallout.

#### Citation Aircraft Micro Comparisons with WRF (P3 and MORR)



### WRF Micro Along NPOL Section (08 UTC 13 Nov)

