Long-term precipitation biases and evaluation of simulated rain characteristics in the Pacific Northwest

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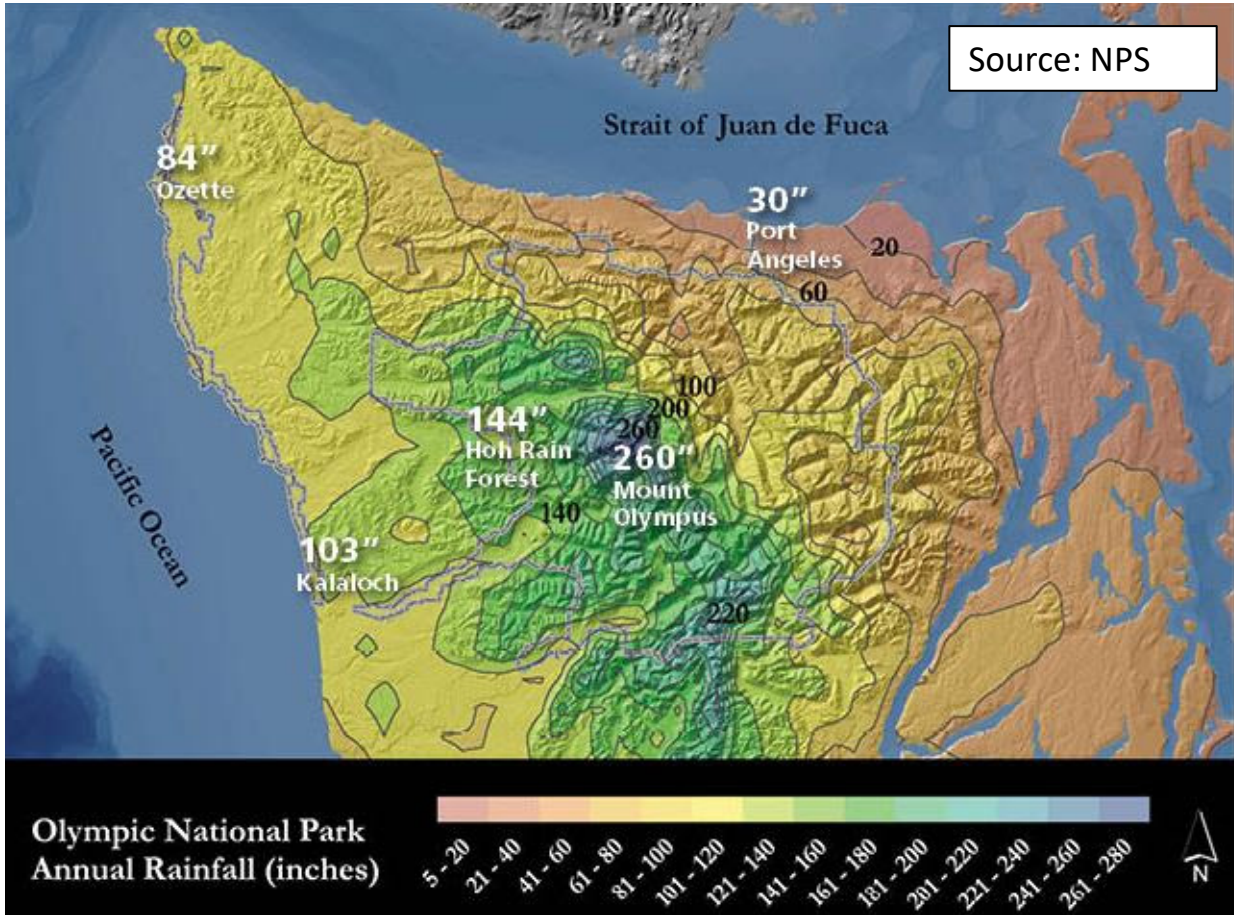
Complex terrain for NWP microphysics evaluation

- Clouds and precipitation are often locked to areas of terrain.
- Assets can be pre-positioned prior to weather events.
- Long history of field campaigns in terrain, especially in the Pacific NW (e.g. IMPROVE 2001).
- But none observations sufficient for comprehensive microphysical evaluations in mesoscale models.



Past Precipitation Evaluations in the PNW

- Because of the IMPROVE campaign (Stoelinga et al., 2003), overprediction of precipitation was noted along windward slopes of the Oregon Cascades.
(Colle and Zeng, 2004; Garvert et al., 2005a,b; Lin and Colle, 2009)

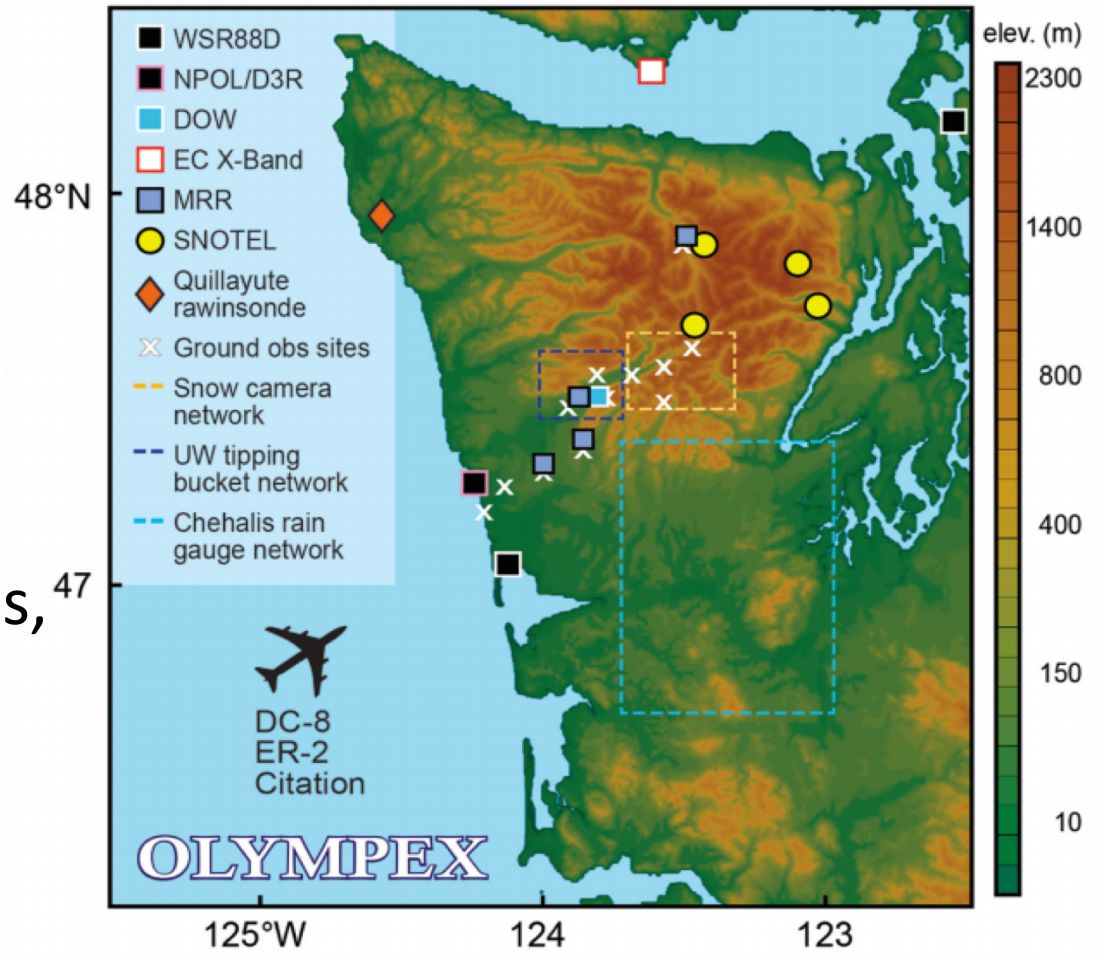
- Underprediction of extreme precipitation events in Western Washington. (Minder et al., 2008)

Along came OLYMPEX…

- Winter 2015-2016

- Assets included 3 aircraft, several radars, satellite (GPM), additional radiosondes, dropsondes, rain gauges, and parsivels.

- Observations on windward and leeward slopes, including radar coverage.



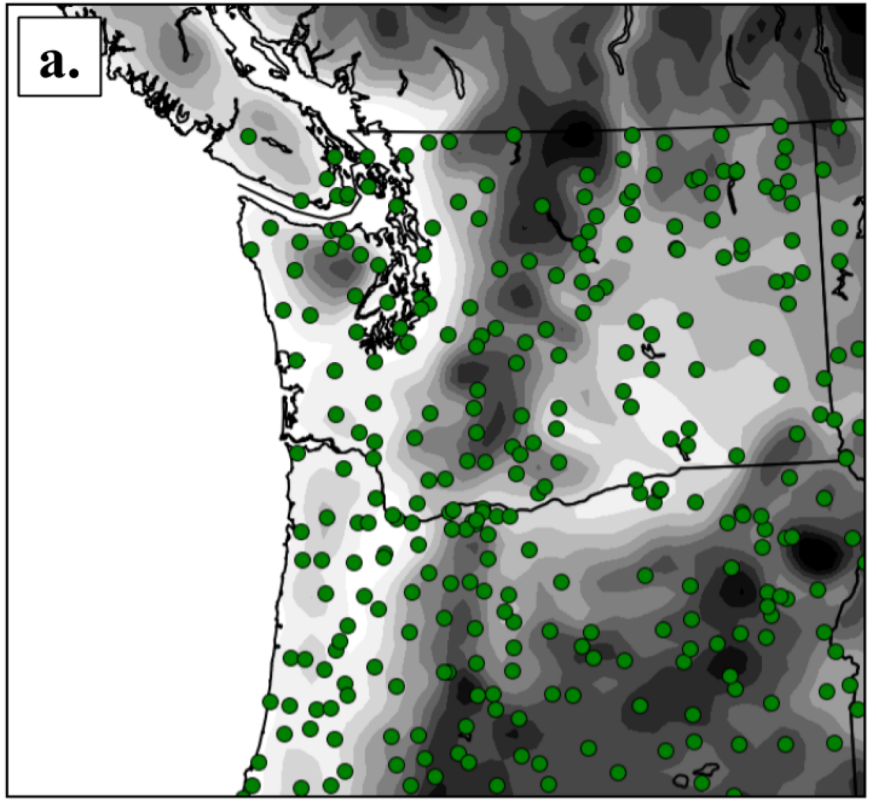
Goals

1. Describe precipitation and rain DSD accuracy in the operational University of Washington WRF during OLYMPEX.

2. Explore precipitation and DSD accuracy during heavy precipitation events

UW WRF Configuration & Data

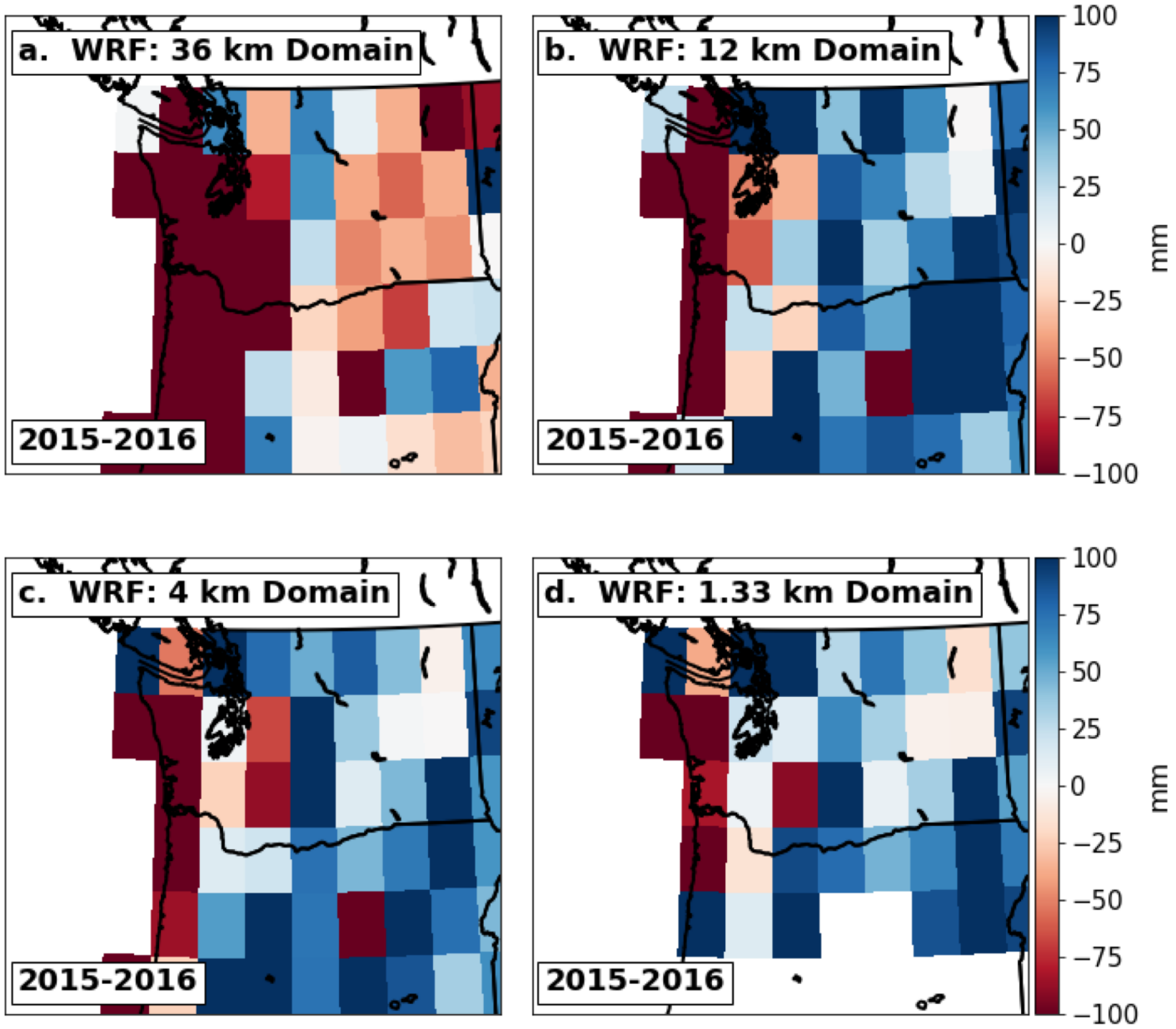
- During OLYMPEX, the UW WRF used v.3.7.1
  - 36-12-4-1.33 km domain configuration.
  - 38 vertical levels
  - Thompson MP; YSU PBL; NOAH-MP; RRTMG
  - GFS IC/BC, 36-km grid nudging.



- Precipitation data from ASOS/AWOS and MesoWest stations.

UW WRF Precipitation Evaluation:

Nov. 2015-Feb. 2016

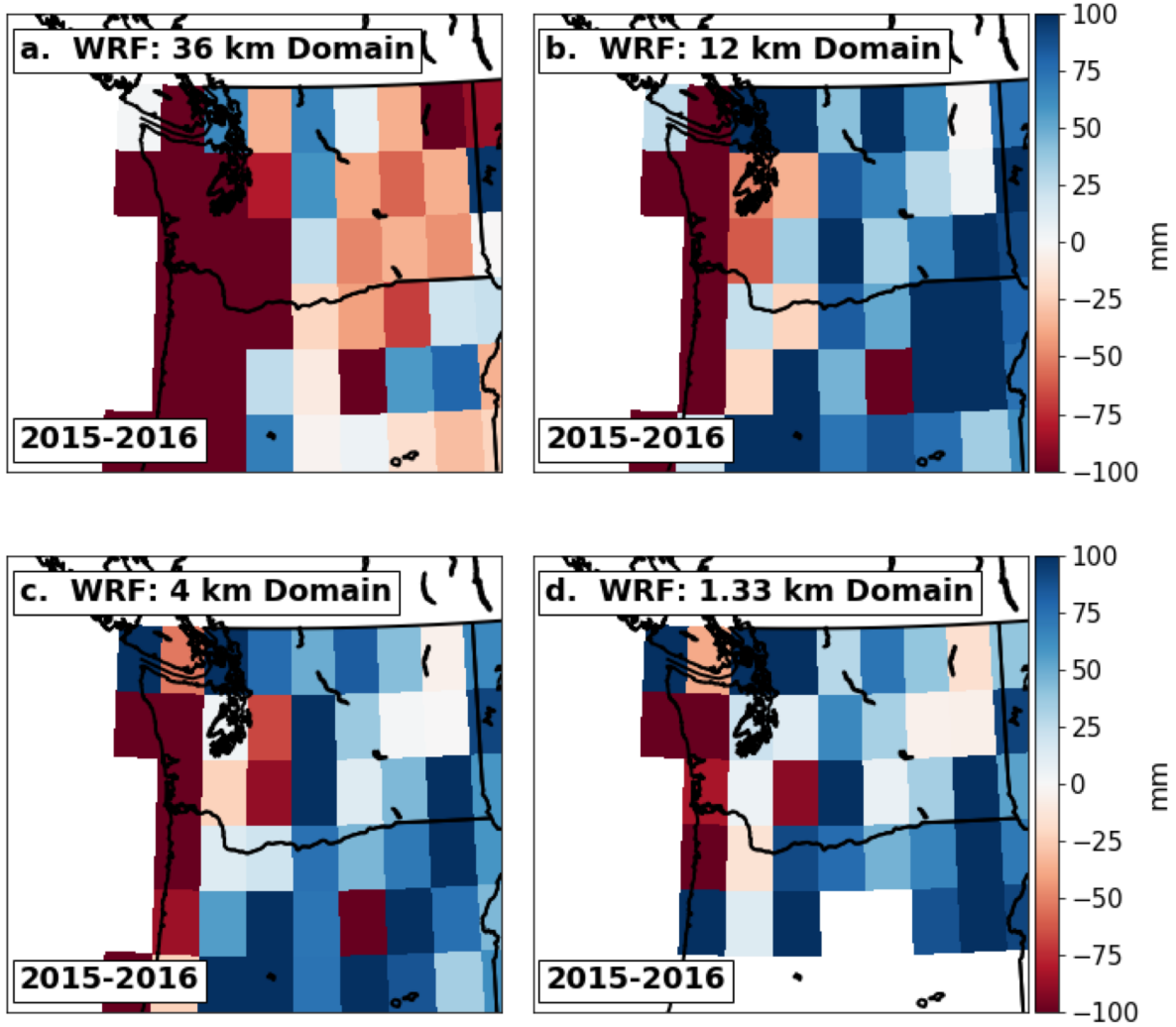


- **UW WRF (Thompson MP)**
  Forecast – Observations

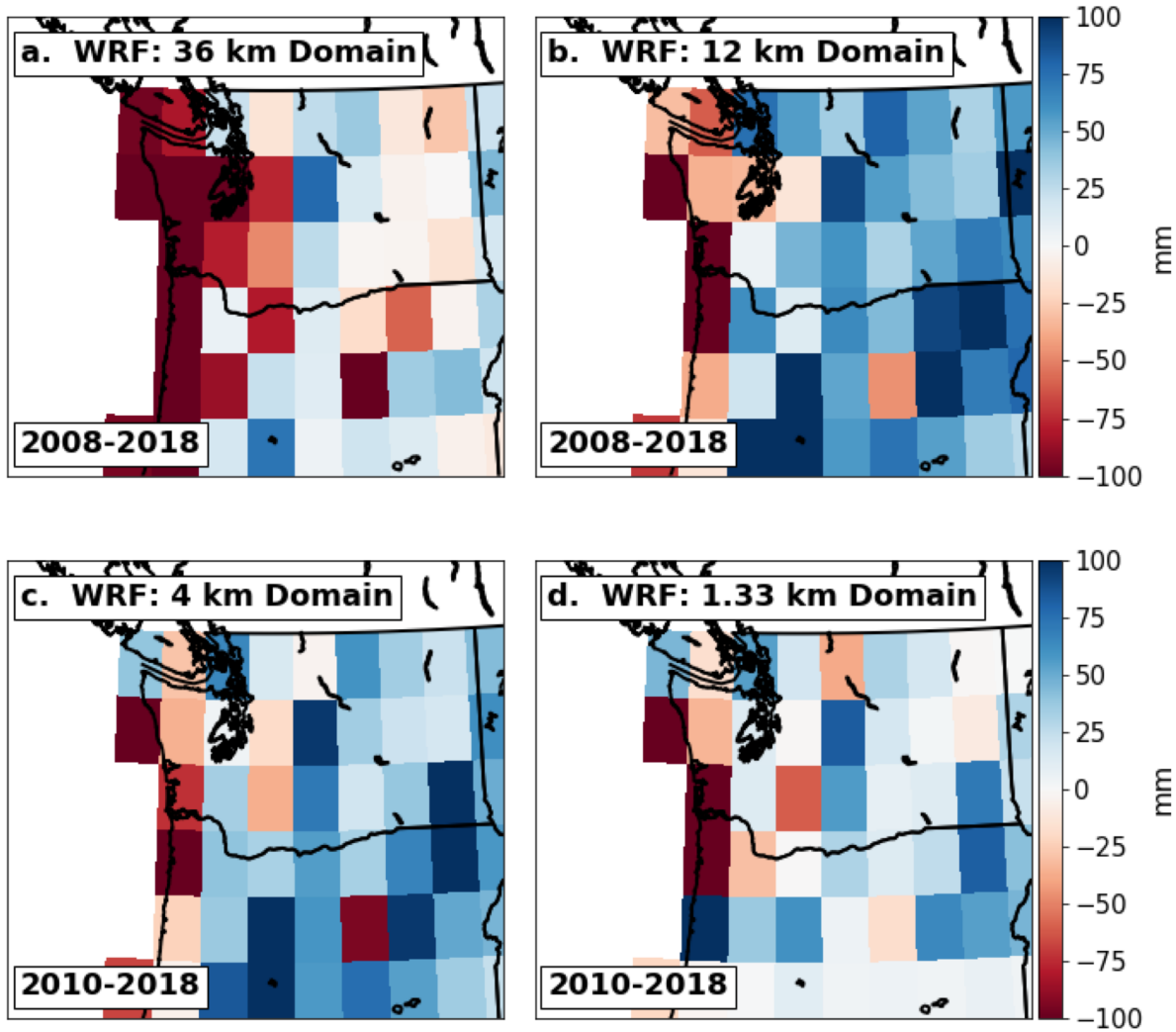
- Coastal underprediction.
- General overprediction elsewhere, including the OR Cascades.

WRF precipitation biases are persistent…

Winter 2015-2016

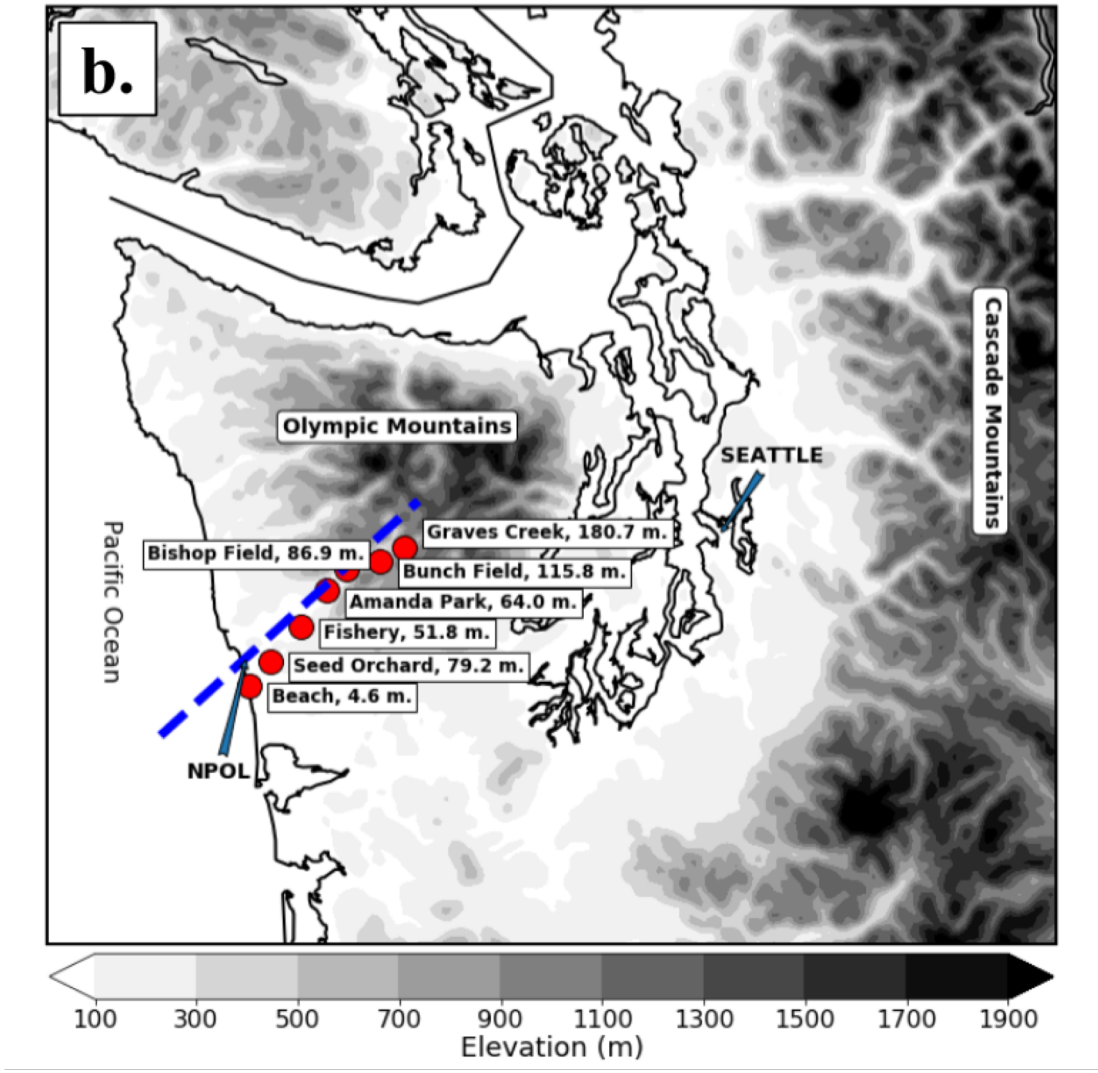


Winter 2008-2018



OLYMPEX Parsivel Observations

- Surface microphysics data from OLYMPEX Parsivel disdrometers in a windward valley.
- D_0 and N_w computed from WRF using Thompson MP scheme.
- WRF adjusted to match Parsivel.

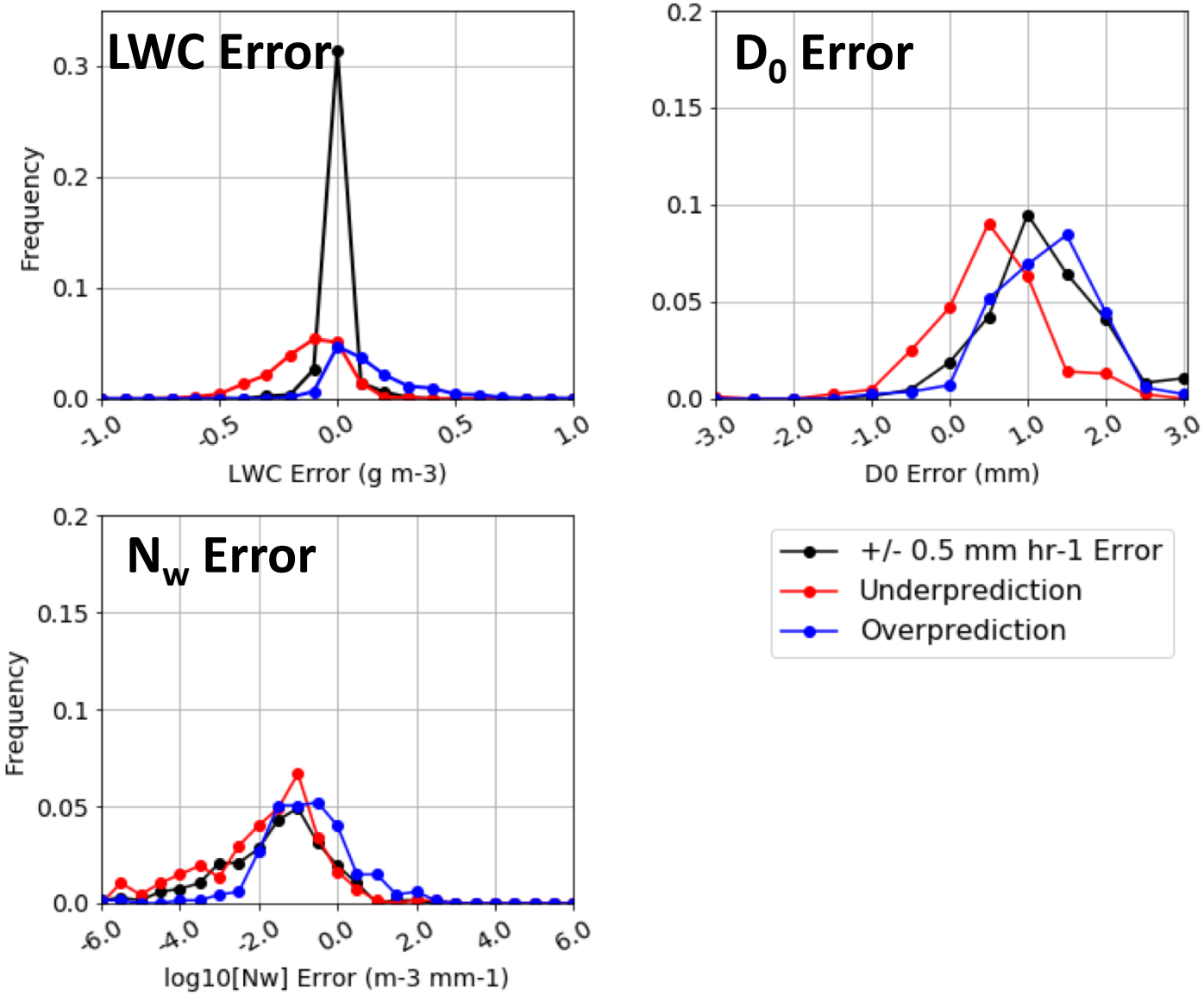


Windward Microphysics: November-February

- UW 1.33 km WRF (Thompson MP)
- **D_0 is too big; N_w too small.**
  - **Compensating errors.**
- Underprediction:

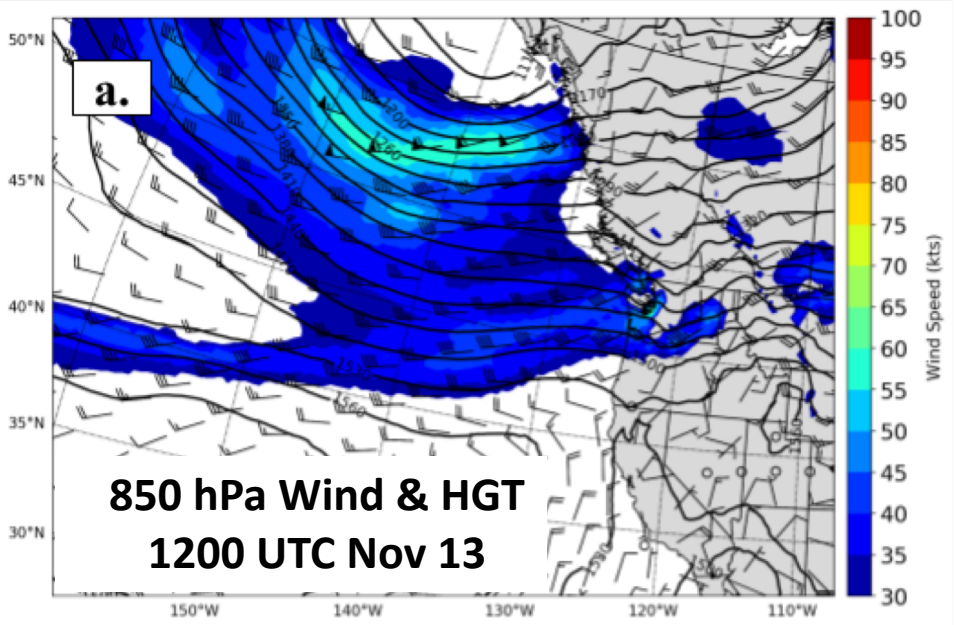
  More realistic (smaller) D_0
- Overprediction:

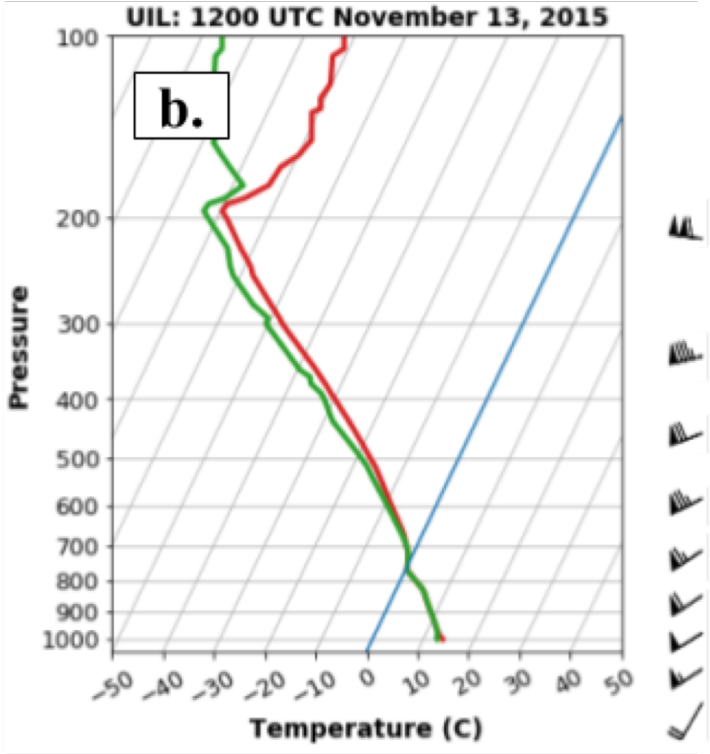
  Larger N_w



Heavy Precipitation Simulations

- We simulated two OLYMPEX atmospheric river events.
  - November 13 & 17, 2015
  - Similar WRF configuration as UW WRF except:
    - WRF v.3.8.1
      51 vertical levels
      Various bulk MP schemes:
      - Thompson (control)
      - WSM6
      - WDM6
      - SBUYLIN
      - P3
      - Morrison 2-moment
      - Milbrandt-Yau 2-moment

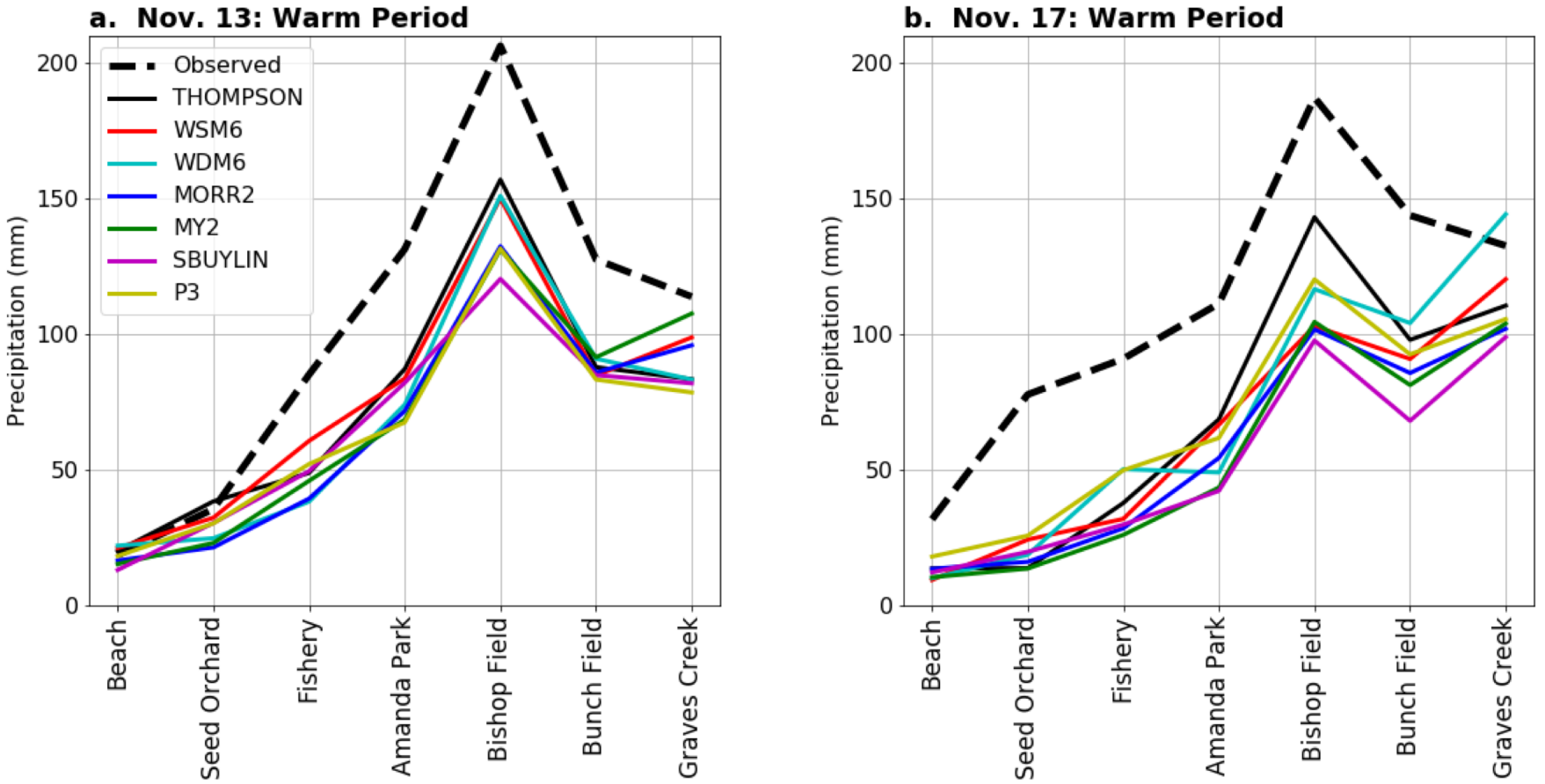




Windward Precipitation

- Like the whole OLYMPEX winter, sites on the windward slopes of the Olympic Mountains saw <u>underpredicted precipitation</u>, regardless of MP scheme.

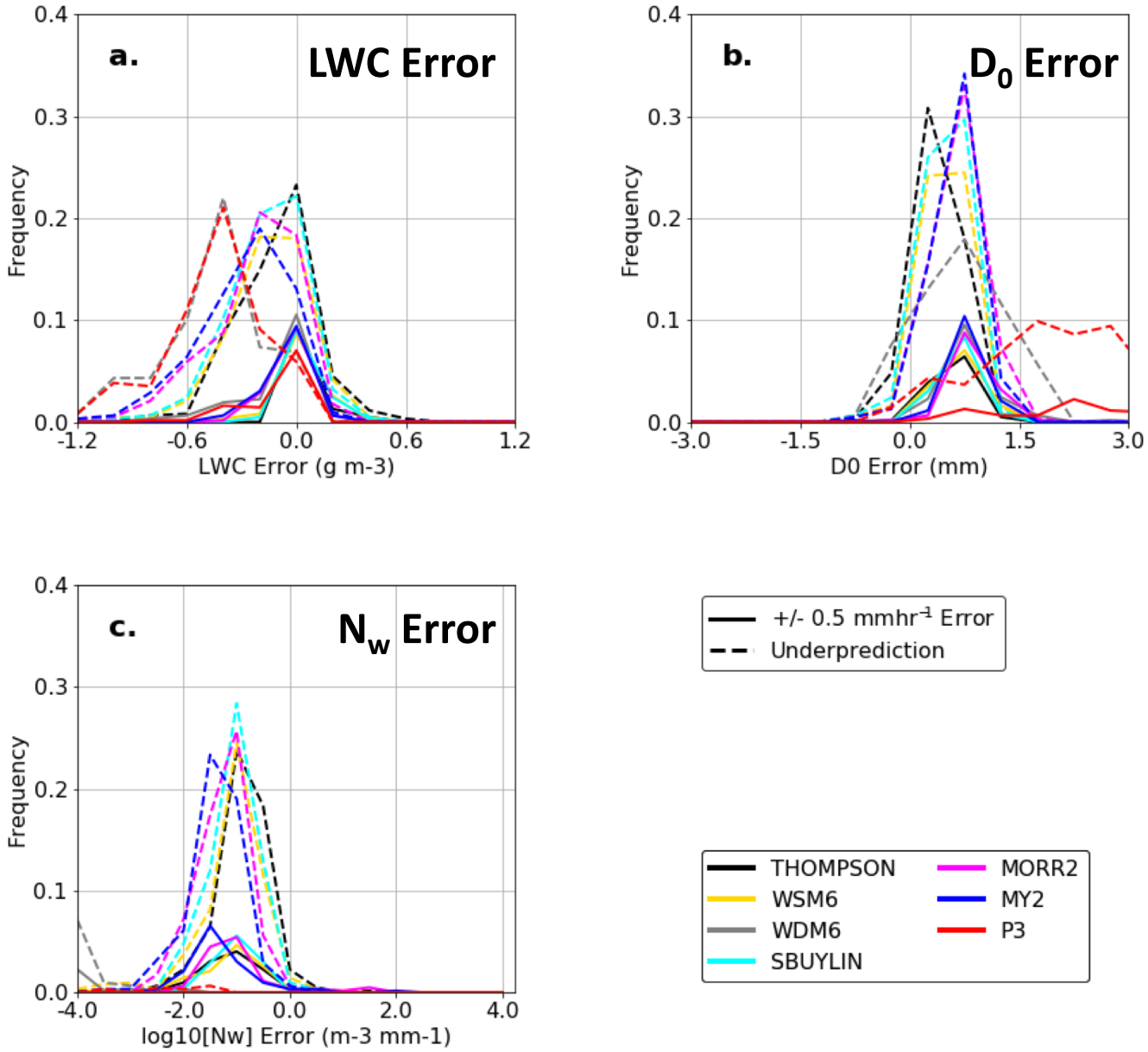
1.33-km Domain



Windward Microphysics

1.33-km Domain

- Similar errors as in Nov-Feb period.
- Thompson performs best in terms of D_0 and LWC.
- P3 has very large LWC and D_0 errors. WDM6 has large LWC and N_w errors.



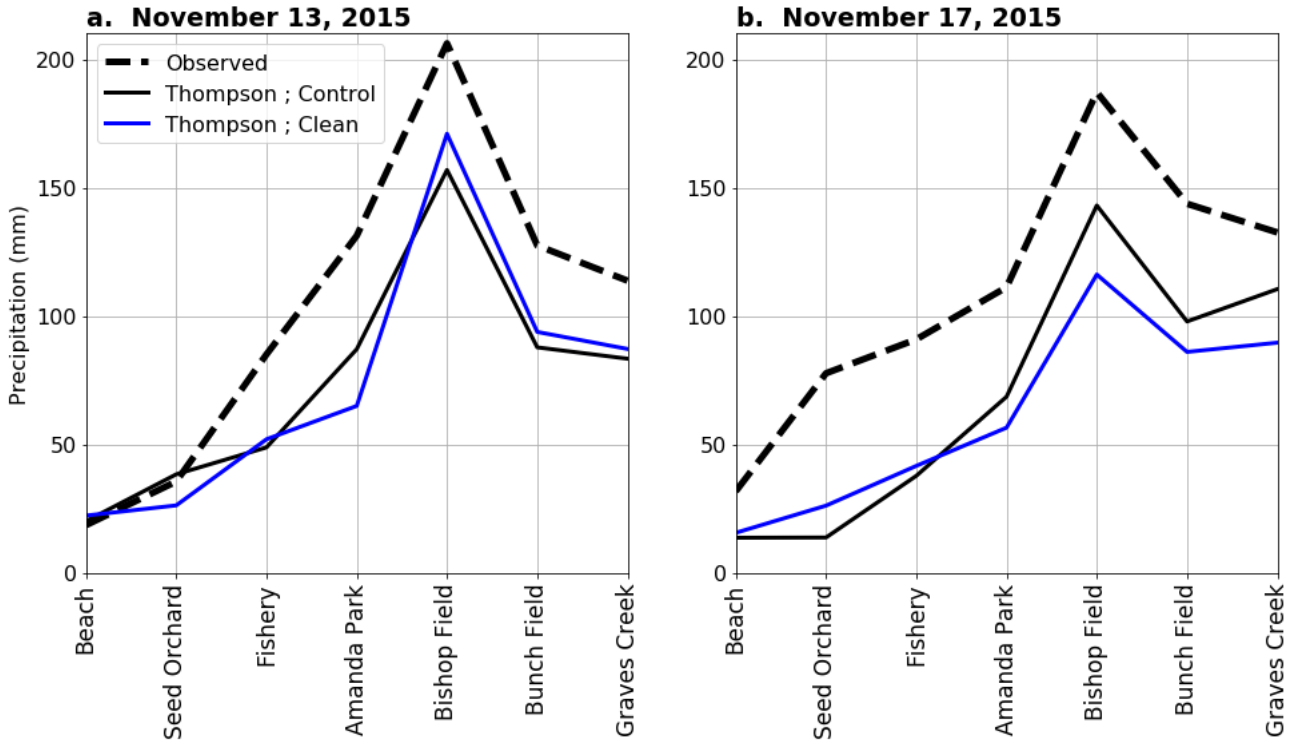
Are model aerosols to blame?

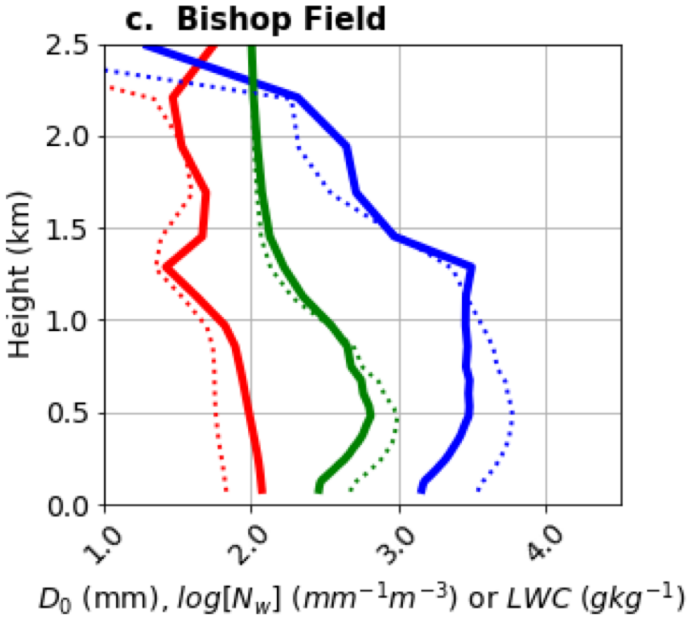
- Thompson and Eidhammer (2014) showed that a decrease in cloud number concentration caused a decrease in rain diameter and increase in rain number were decreased in Thompson scheme.
    - Invigoration of warm-rain processes.

- Experiment: decrease the prescribed cloud droplets in Thompson (option=8) to 25 cc^{-1} instead of default 100 cc^{-1}.
    - 25 cc^{-1} consistent with observations off WA coast (Hegg et al., 1991).

Results: 25 cc^{-1} vs 100 cc^{-1}

Minimal change in precipitation on windward slopes. →





D_0
$log[N_w]$
$LWC + 2$

Thompson; Control
Thompson; Clean

←

Decrease in D_0; Increase in N_w; Increase in LWC

Conclusions

- Winter precipitation is persistently underpredicted on Pacific Northwest coastal areas. General overprediction on OR Cascades and inland.
- Compensating rain errors: D_0 too large; N_w too small.
  D_0 controls underprediction; N_w overprediction.
- Choice of MP scheme does little to improve these biases.
- Reducing prescribed N_c does help to improve D_0 and N_w errors, but does not substantially impact precipitation.

Future Work: (1) Investigate other aerosol configurations, including Thompson Aerosol-Aware. (2) Determine which processes may be to blame.

IVT Accuracy