OLYMPEX Data Workshop: GPM View

W. Petersen, NASA Marshall Space Flight Center

OLYMPEX Primary Objectives: Datasets to enable……

- Direct validation over complex terrain at multiple scales, liquid and frozen precip types,
  - Do we capture terrain and synoptic regime transitions, orographic enhancements/structure, full range of precipitation intensity (e.g., very light to heavy) and types, spatial variability?
  - How well can we estimate space/time-accumulated precipitation over terrain (*liquid + frozen*)?
- Physical validation of algorithms in mid-latitude cold season frontal systems over ocean and complex terrain,
  - What are the column properties of frozen, melting, liquid hydrometeors- their relative contributions to estimated surface precipitation, transition under the influence of terrain gradients, and systematic variability as a function of synoptic regime?
- Integrated hydrologic validation in complex terrain
  - Can satellite estimates be combined with modeling over complex topography to drive improved products (assimilation, downscaling) [Level IV products]
  - What are capabilities and limitations for use of satellite-based precipitation estimates in stream/river flow forecasting?

Requests From GPM Algorithm Developers

- Ensure well calibrated instruments producing near collocated data (Ocean & Land)
- Coordinate remote sensing and in situ microphysical profiles along ground-based radar & disdrometer radials over both ocean and land (ice and liquid PSDs, type, $q_{i,l}$-contents)
- Collect surface reference emissivity and σ_0 data over land/ocean in rain-free conditions
- Provide estimates of seasonal/basin-integrated snow water equivalent
- Collect T/P/RH sounding profiles
- Coordinate aircraft/ground instruments with GPM overpasses ……

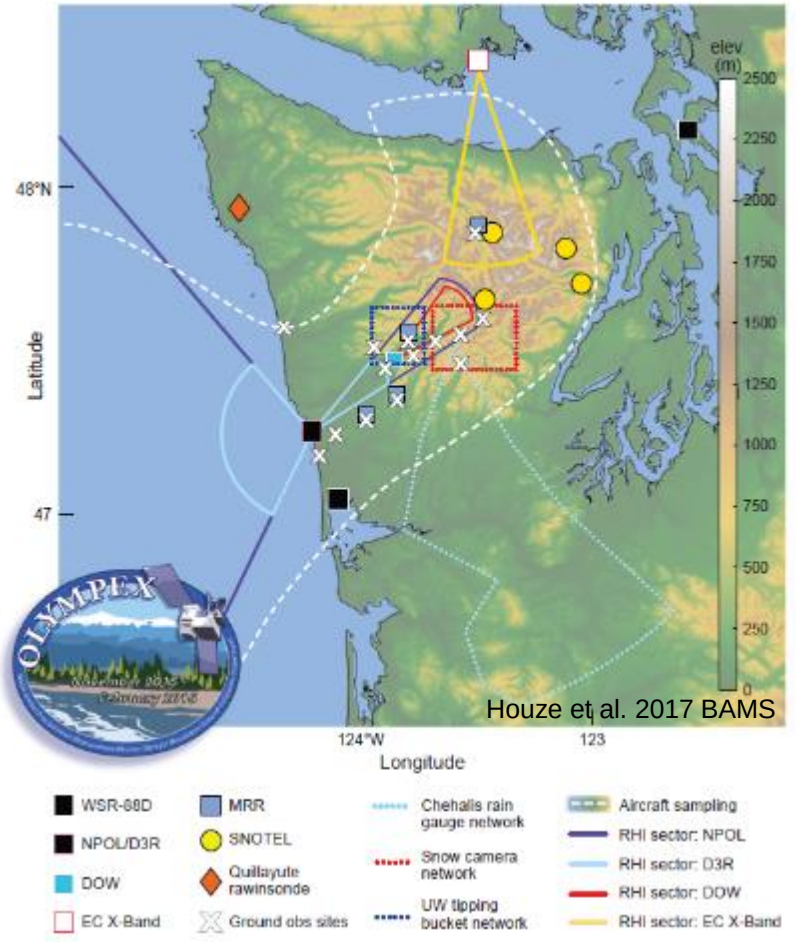
……Translated to OLYMPEX Observations

Airborne

- Well-stacked airborne microphysics (ice-liquid) and “simulator” (radar, radiometer) observations over land/ocean, *coincident GPM core* (Ka-swath)
- Quality over quantity; preference for stratiform over convective
- Over ocean radiometer/radar instrument calibration
- Rain/no-rain reference backscatter cross-sections and emission (land/sea)

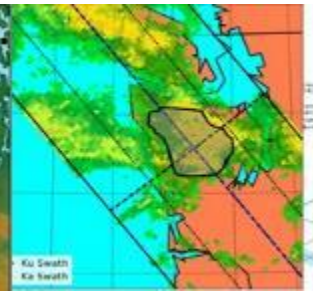
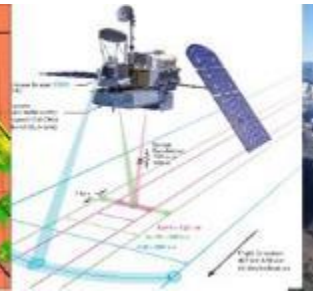
Ground Based

- Operational network radar for continuous/regular background sampling
- Research-grade scanning multi-frequency/polarimetric and vertically-pointing radars (rain mapping, hydrometeor profiling, "build the column")
- Reference gauge/disdrometer/sounding network(s) supporting ground-radar retrievals, environment and process characterization, hydrologic studies.
- Regional falling snow estimates/measurements in terrain
- Basin hydrologic measurement networks (stream flow, soil state etc.)



Houze et al. 2017 BAMS

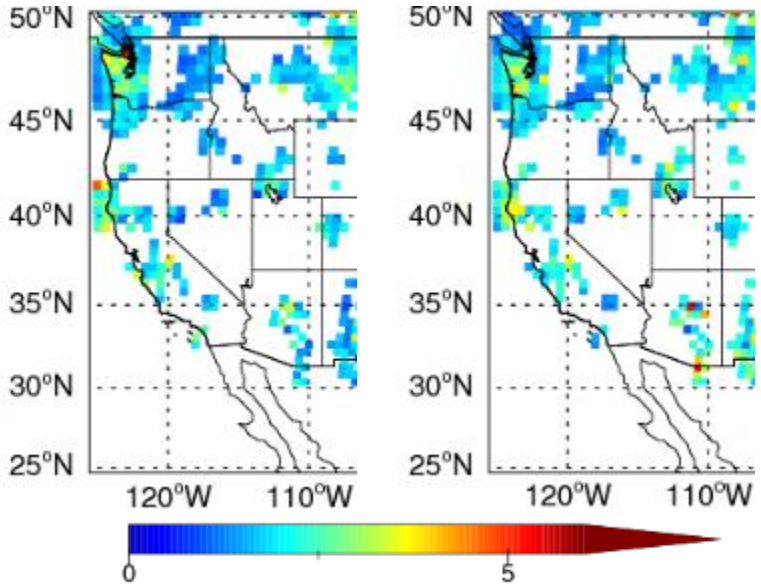


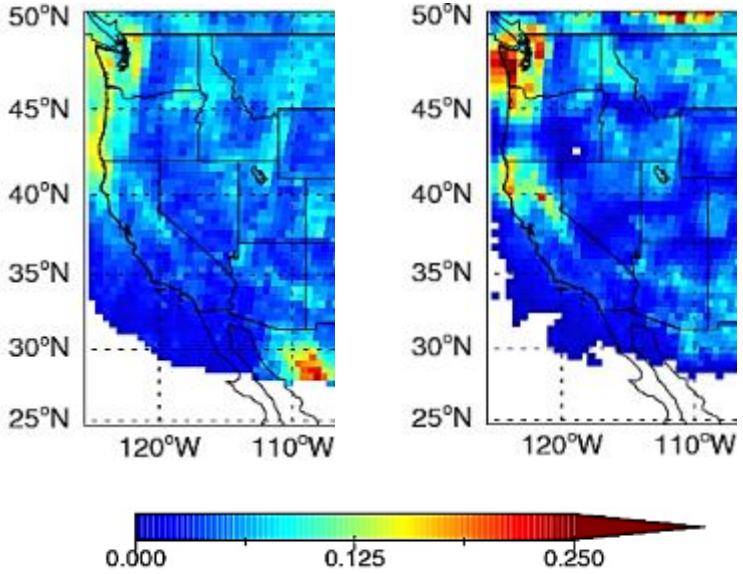


Mission to OLYMPEX: The Bottom Line (Precipitation Rate)

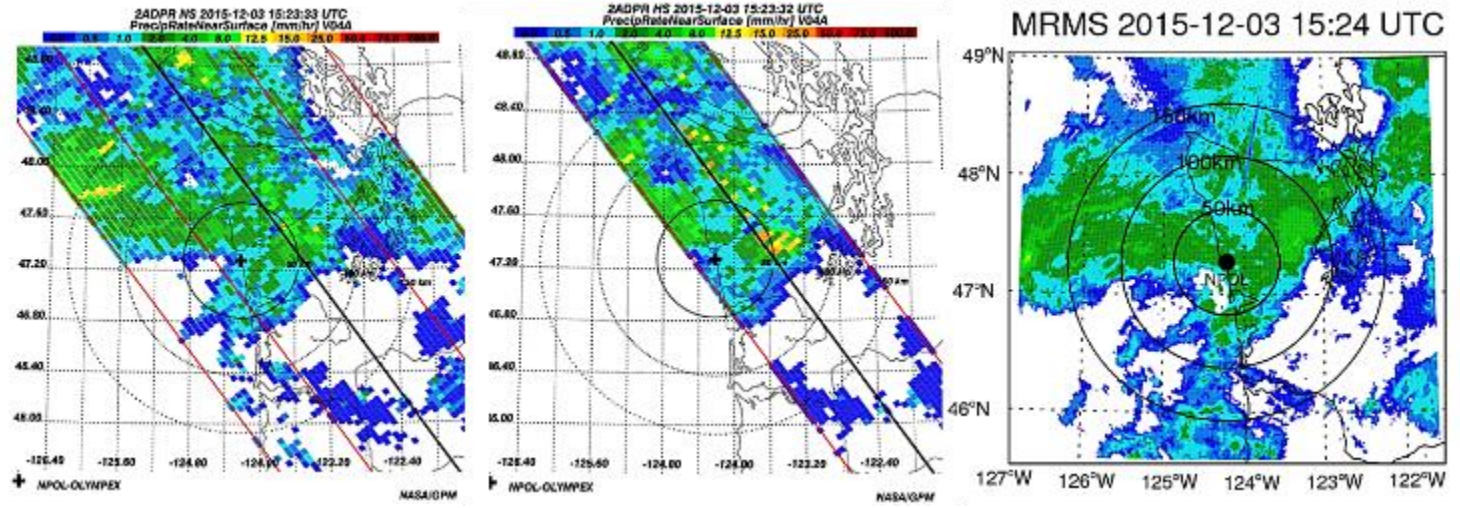
DPR V4 2014-2016

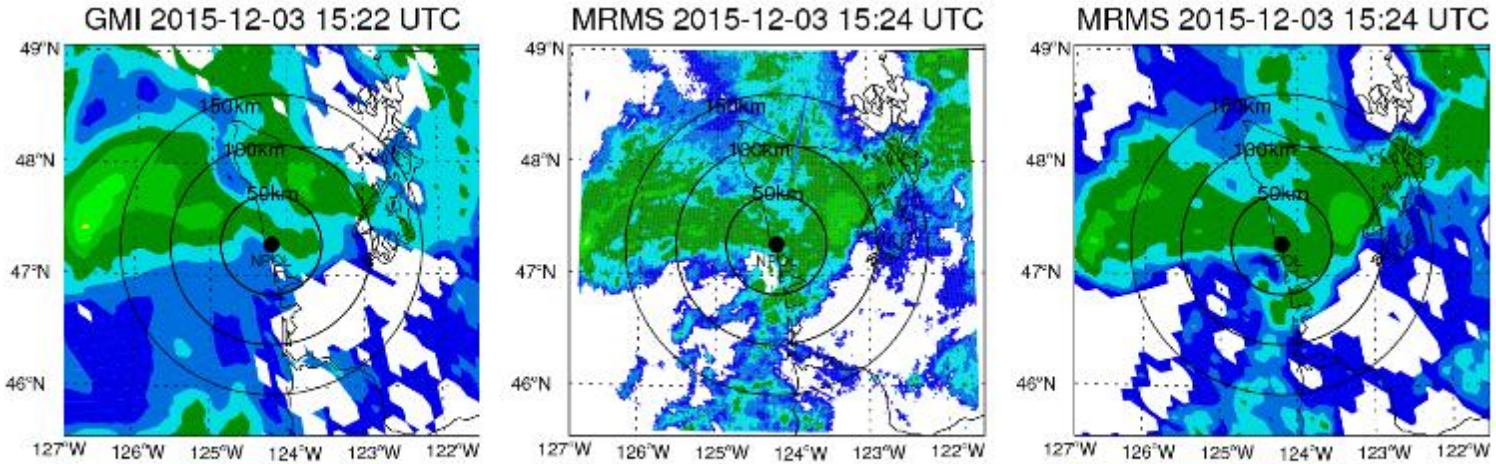


GMI V4 2014-2016



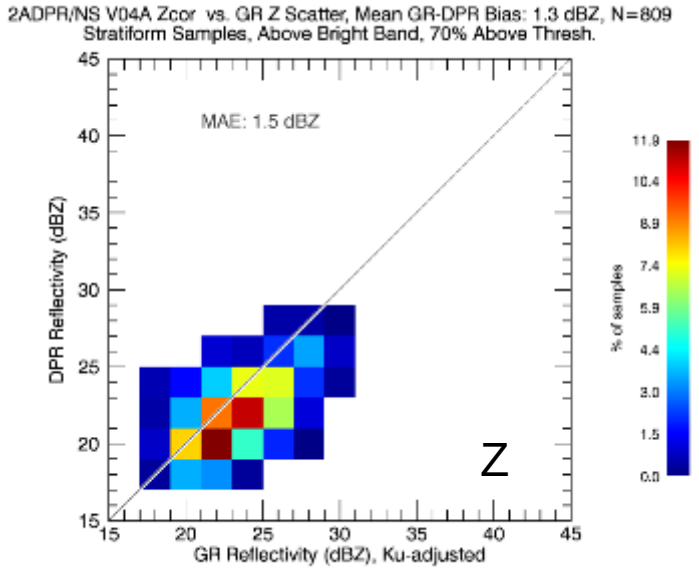
12/3 Case

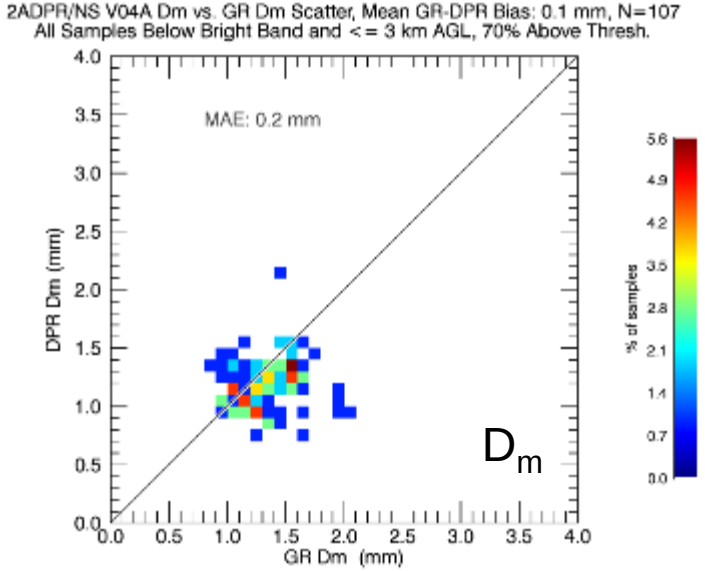


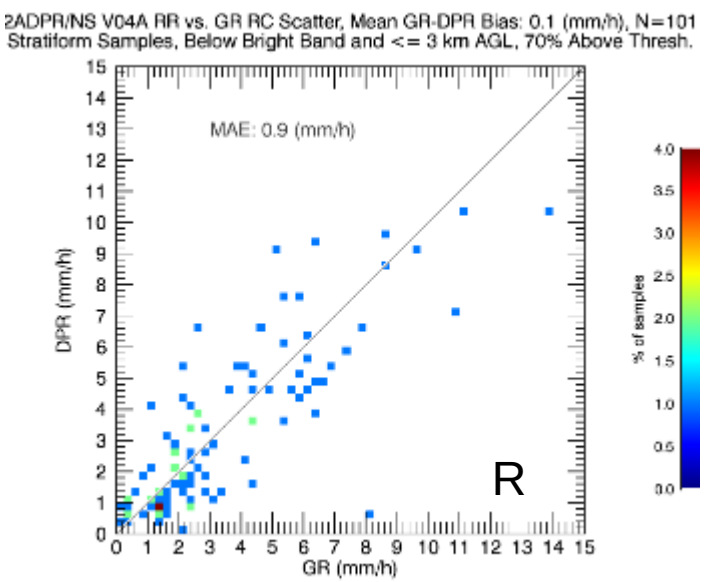


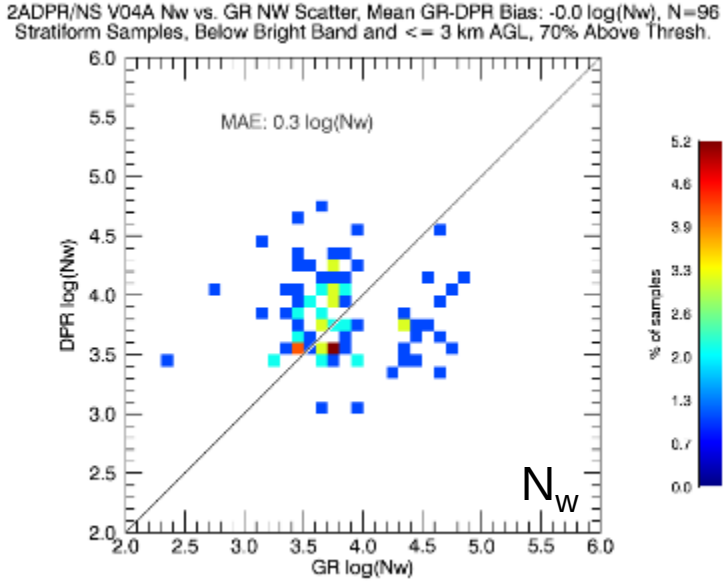
Performance in *broader stratiform* (light/moderate) Ok…..

Mission to OLYMPEX: Key Observables to Key Retrievals



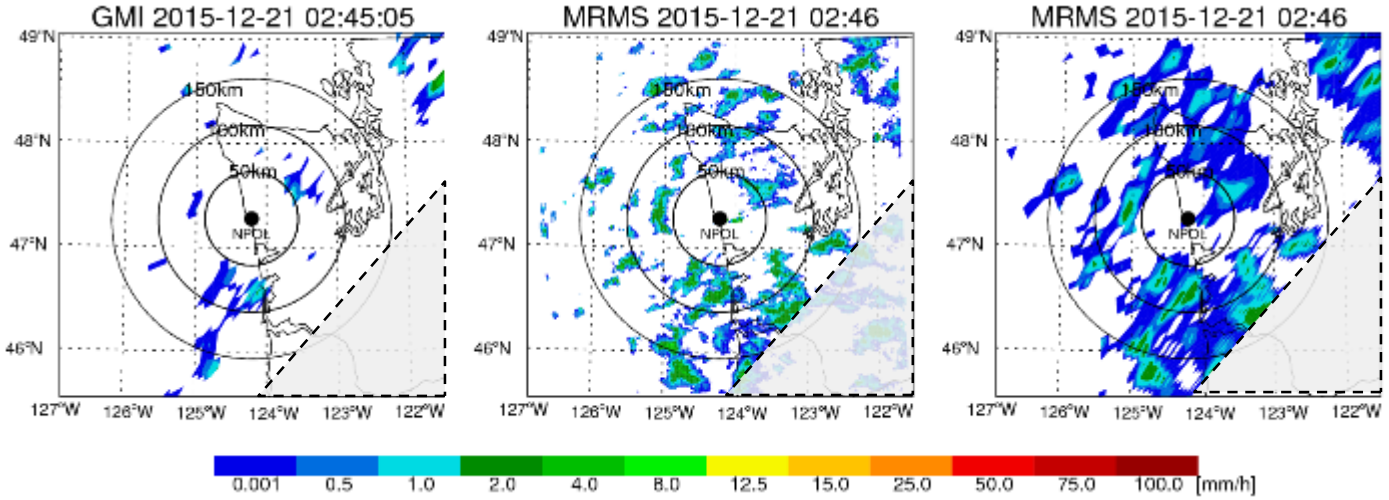




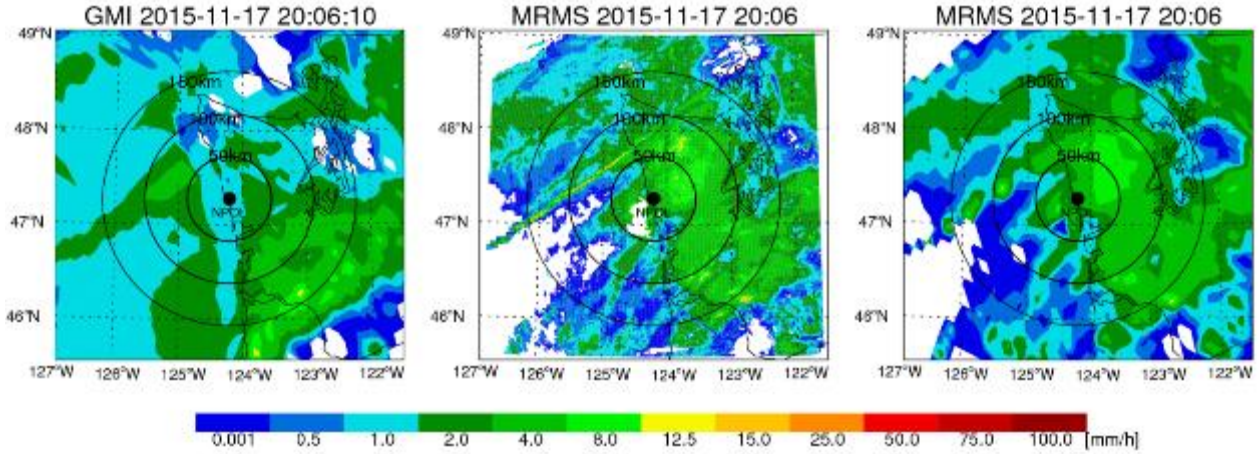


Potential Challenges GMI: Regime, Land Surface

Post frontal

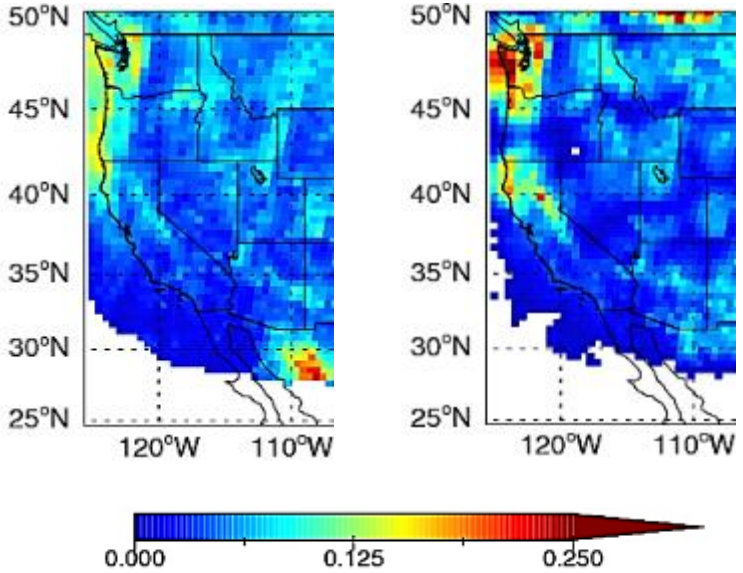


Coastal, Pre-Frontal/Frontal NCFR



89 GHz had little or no ice scattering offshore; DPR NS consistent with GV

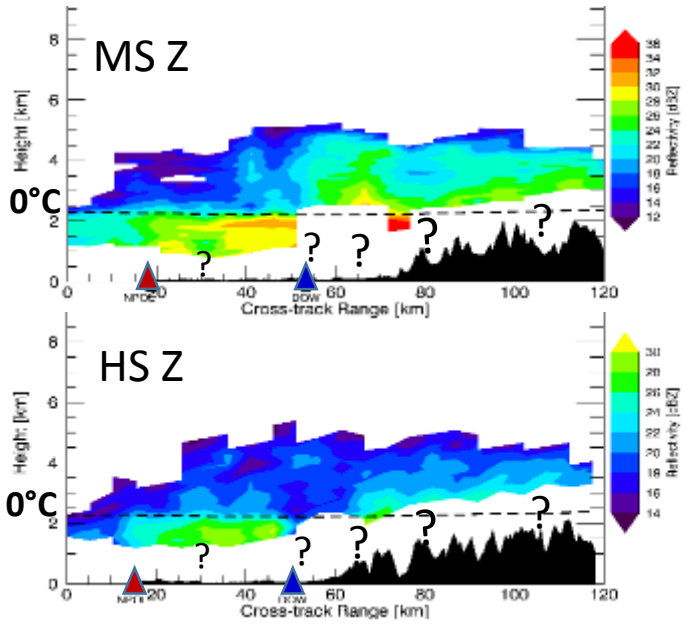
GMI V4 2014-2016



Potential Challenges DPR: Clutter and Orographic Processes

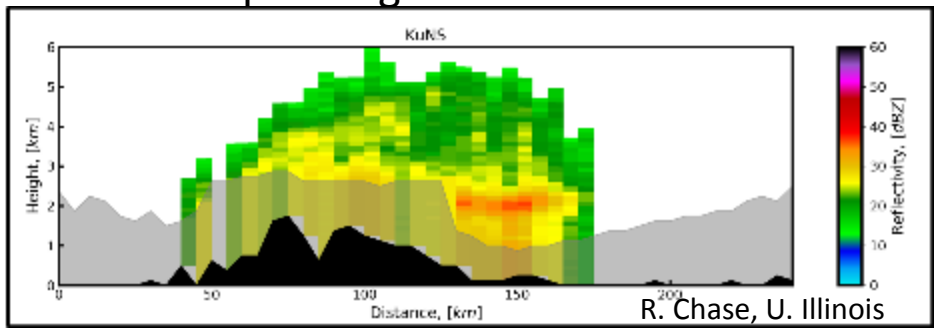
How well can we detect the orographic enhancement and precipitation process?

3 Dec 2015 GPM OP 1523-25 UTC



NPOL/D3R

Extrapolating to the surface……..?



R. Chase, U. Illinois

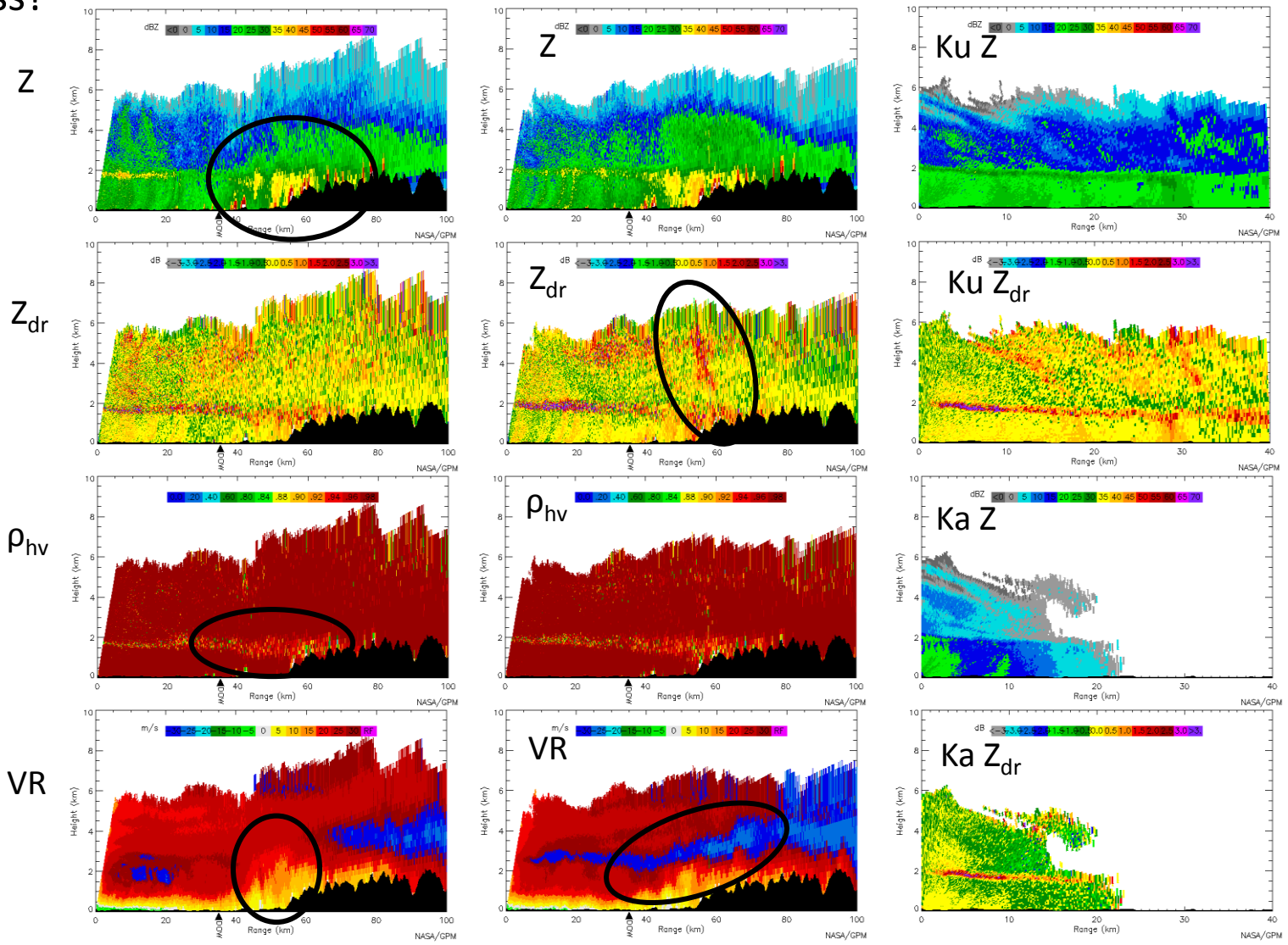
NPOL RHIs up River Valley, across DPR

1512 UTC (OP-10 min)

1532 UTC (OP+10 min)

Coincident D3R

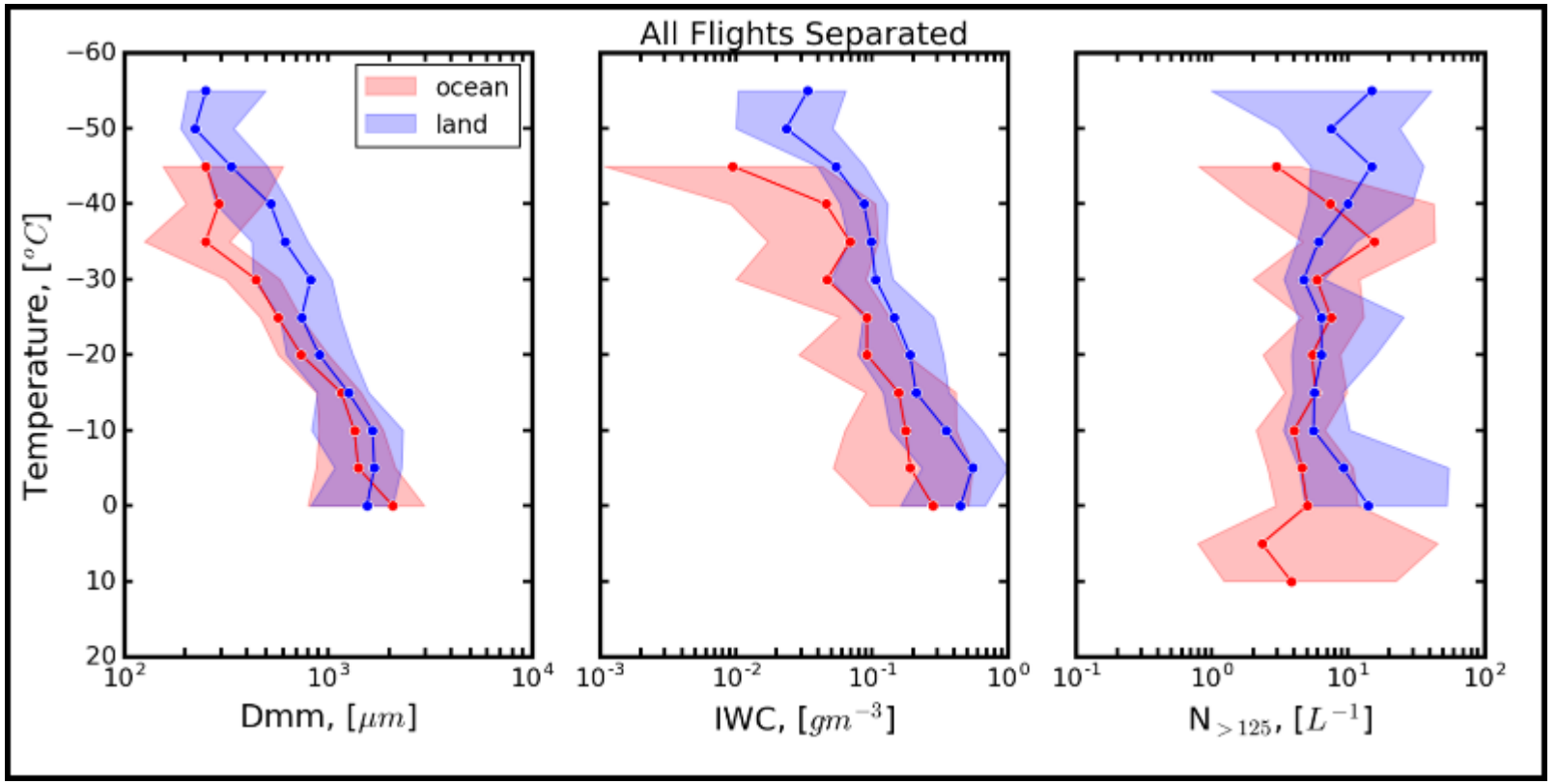
1528 UTC (OP+6 min)



Stephanie Wingo, NASA MSFC/NPP

Column Properties and Variability

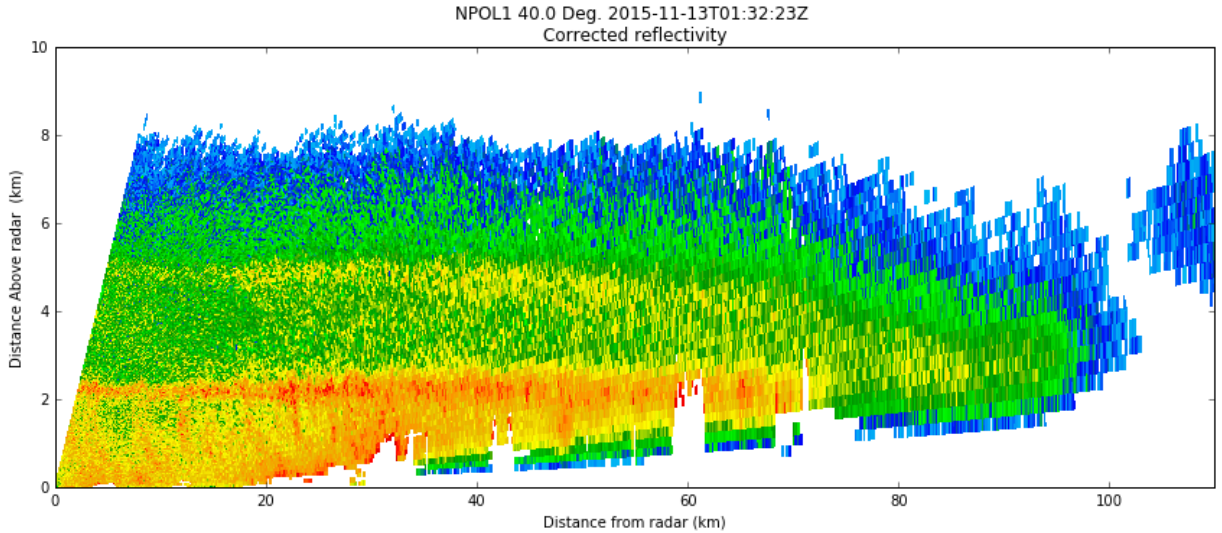
Ocean to Summit

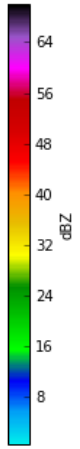


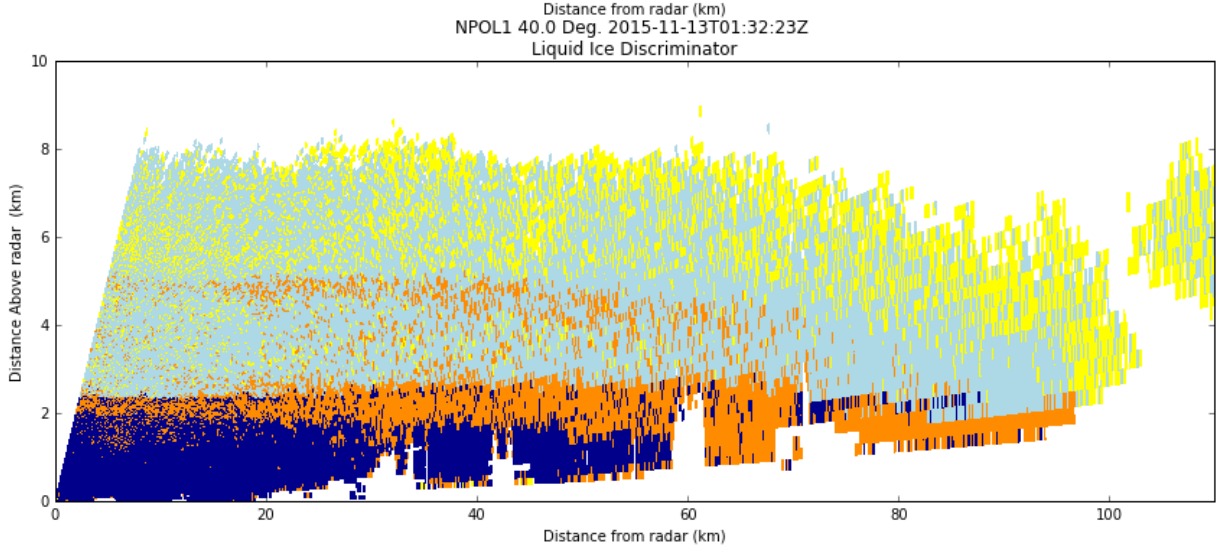
Can we capture the microphysical parameter and process variability from ocean to summit?

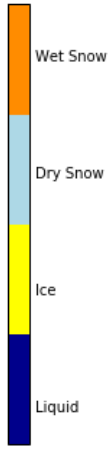
Ice Process Contribution to Rain Water as f(regime, terrain)

Examining Ice and liquid water path (IWP, LWP) under the influence of orography







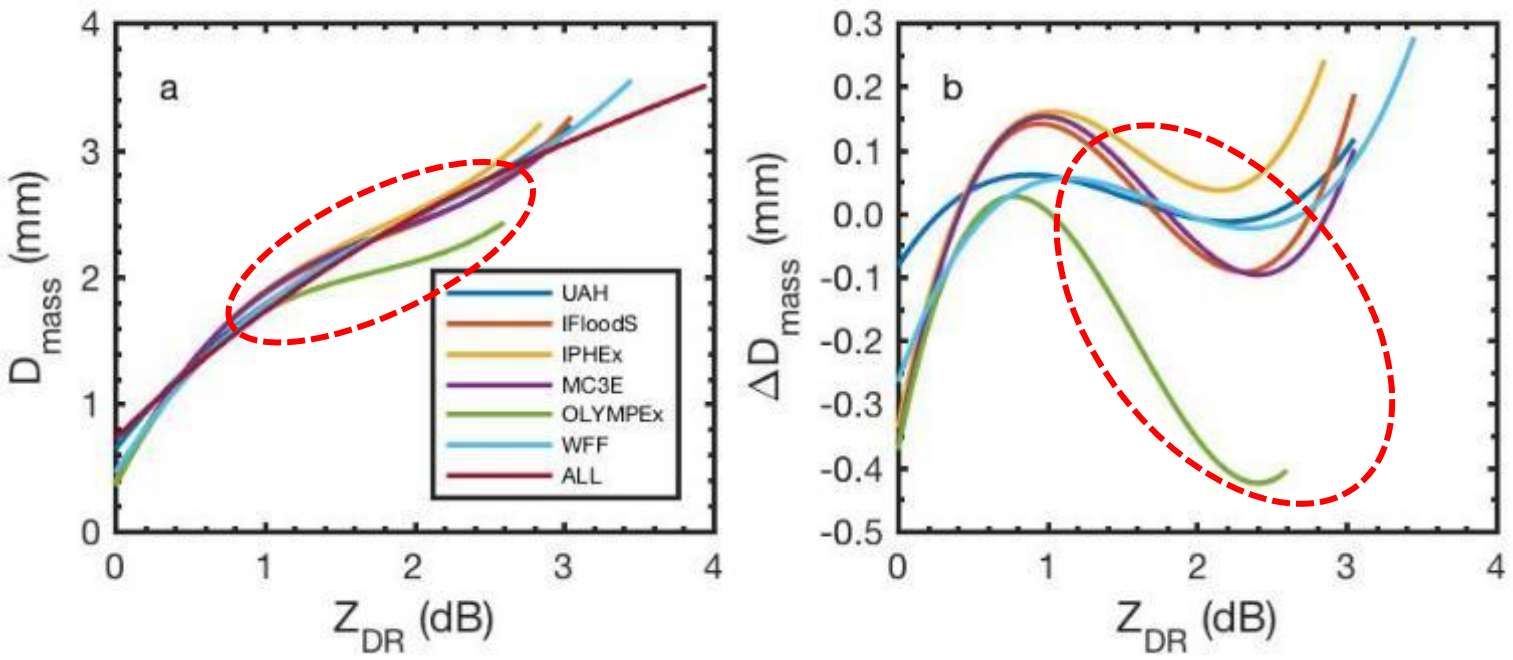


- NPOL/D3R (DOW) RHIs over ocean and terrain
- Hydrometeor ID (refine density estimates)
- Calculate mass contents and structure using Z-M relationships for ice and liquid (multiple existing, OLYMPEX aircraft, disdrometers)
- Sum mass contents in vertical columns for IWP/LWP
- Compare to GMI IWP (TB) measurements
- Systematic behavior/bias in IWP (TB) vs. estimated rain water due as f(terrain type/slope, synoptic regime)

Alexis Hunzinger, UAH

Capturing the Uniqueness of OLYMPEX Regime: DSD

DSD "REGIME" IMPACT
GV D_{mass}-Z_{DR} relationship



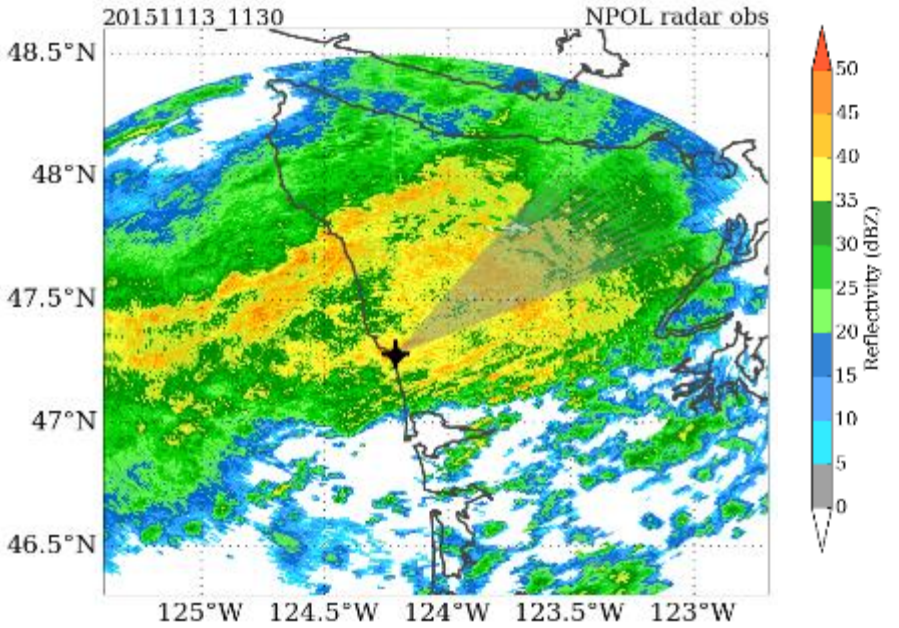
Empirical nature of the ZDR-D_m fits combined with the prodigious numbers of smaller drops and attendant ZDR in the OLYMPEX precip regime illustrate:

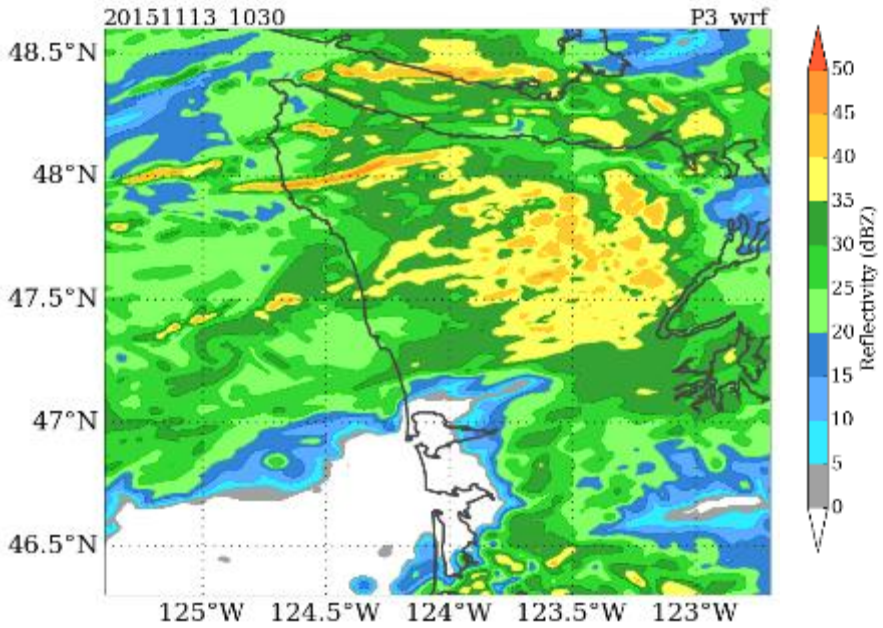
a) uniqueness of OLYMPEX regime; and
b) the impact of "regime" when considering/parameterizing global behavior.

- **OLYMPEx relationship underestimates D_{mass} at Z_{DR} > 1.5 dB significantly if its relationship were used for ALL locations**

Cloud Resolving Models to Bridge Observational Gaps

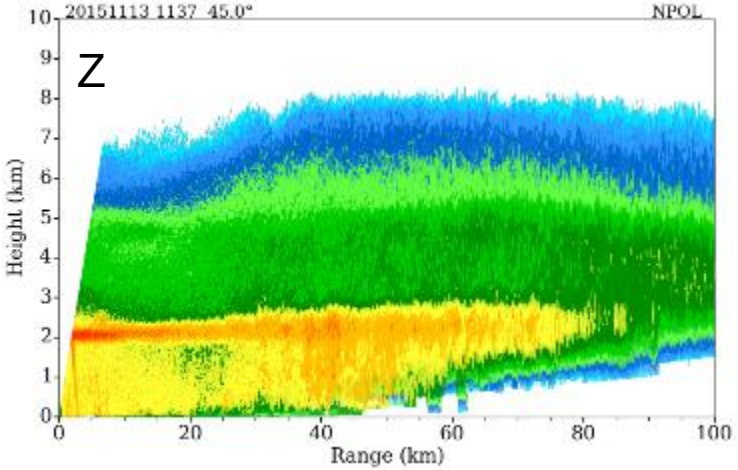
Observed (NPOL)



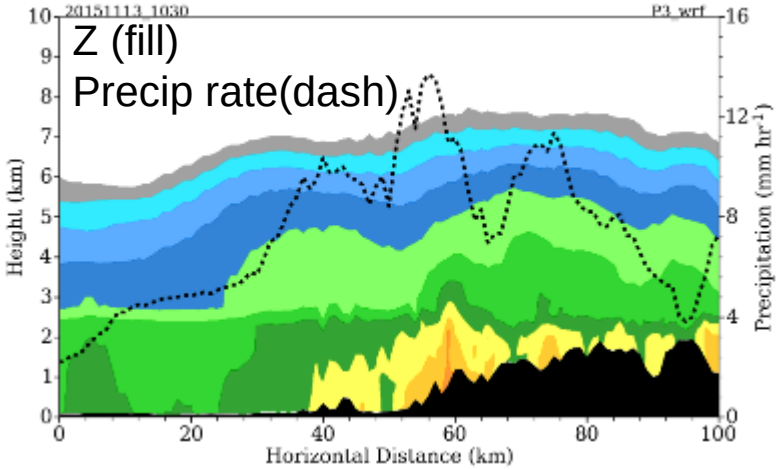


Simulated (WRF)

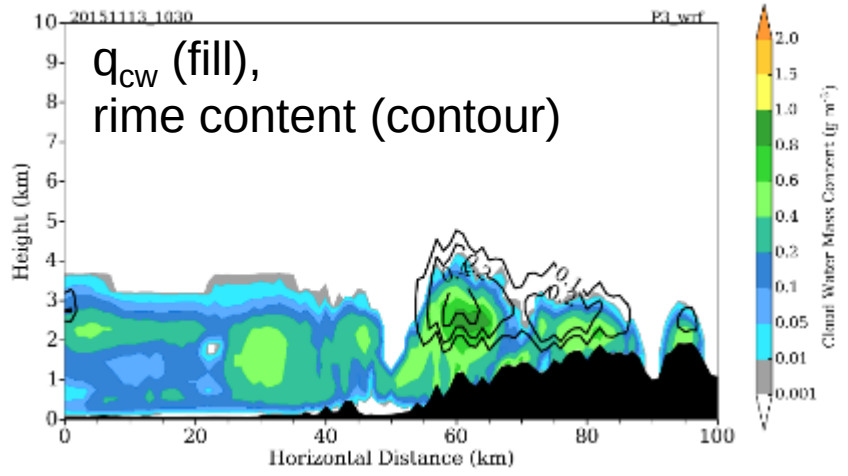
Observed NPOL



Simulated WRF



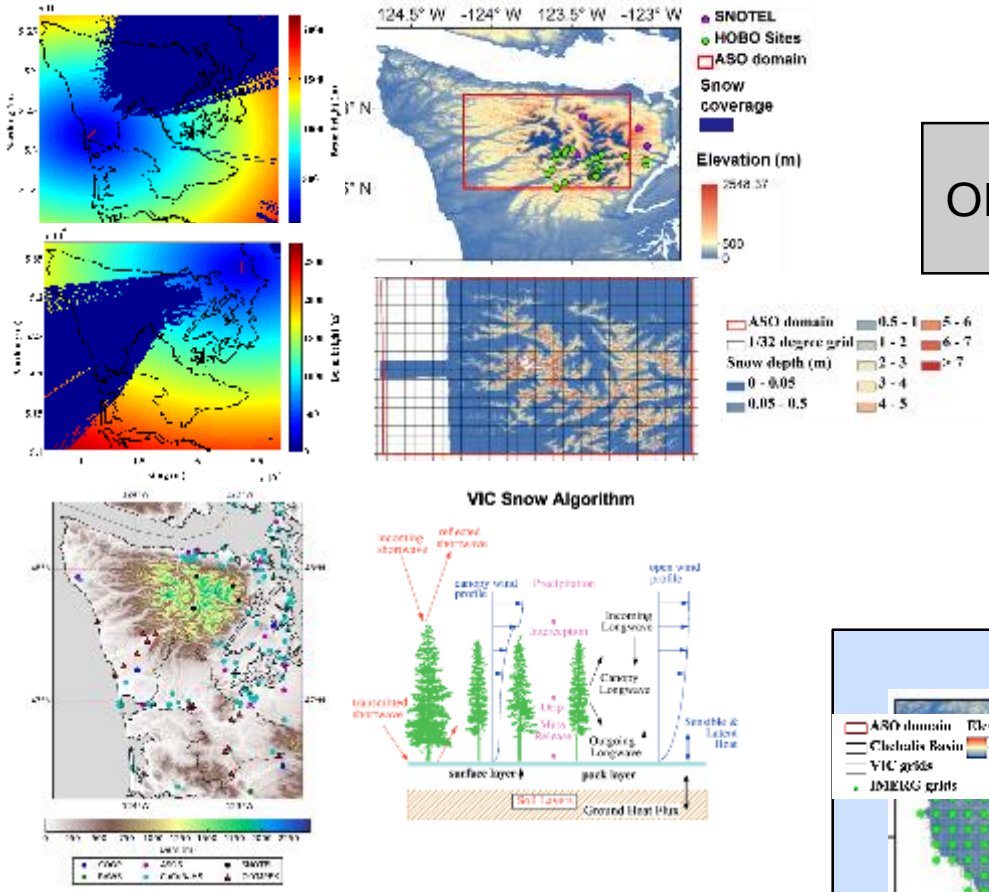
Simulated WRF



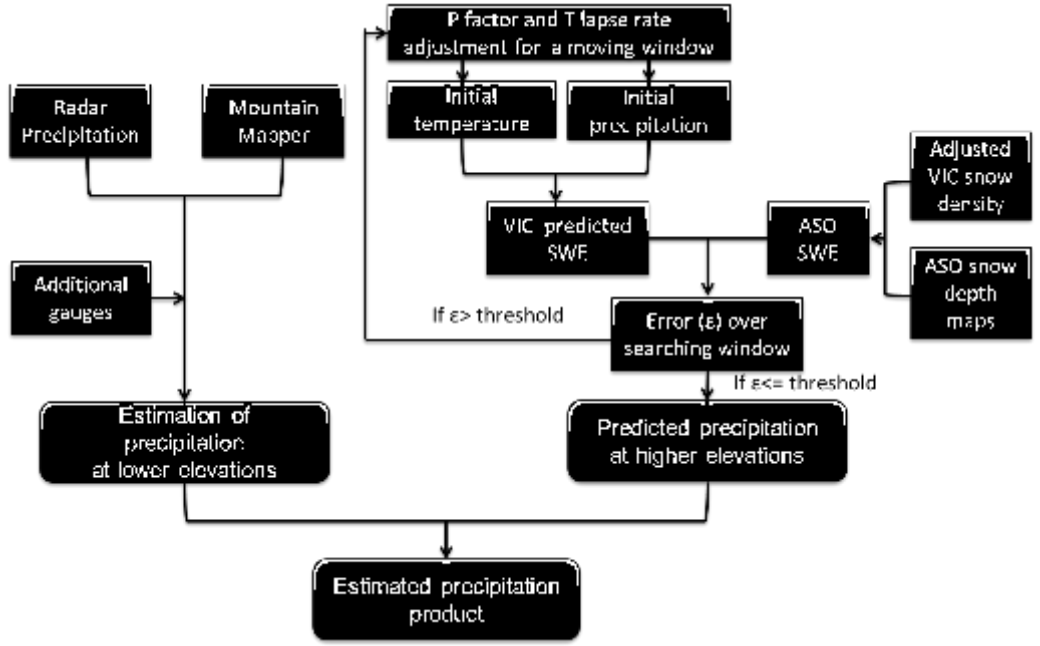
Courtesy, Aaron Naeger, UAH

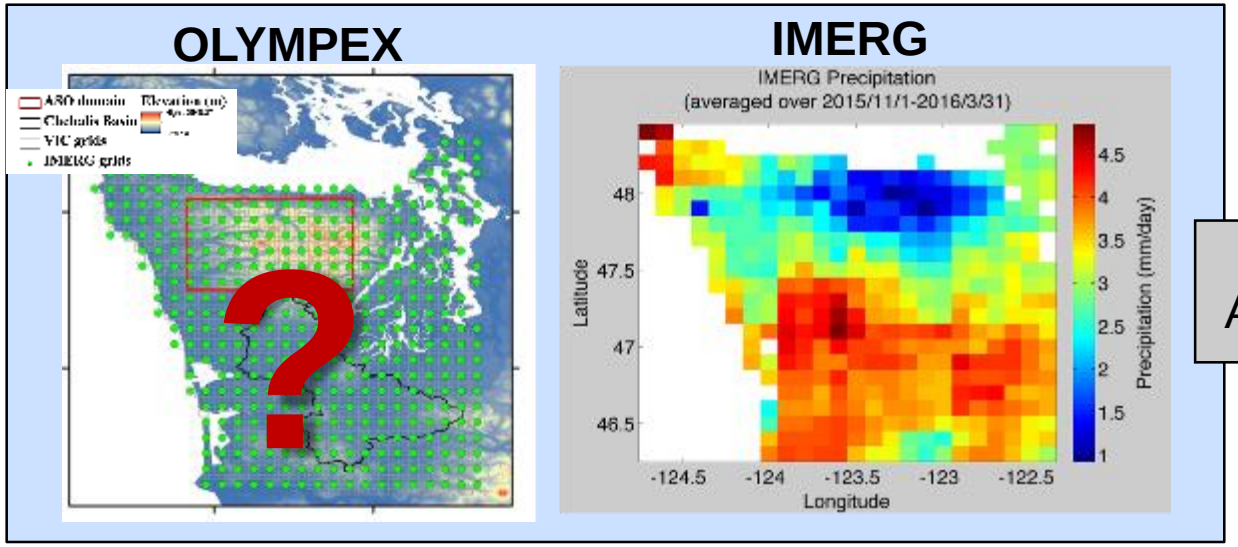
Seasonal Precipitation: Verifying Integrated Multi-Satellite Estimate

First, we need to create a "best" estimate!



OBS + VIC Model





Hydrologic Application?

OLYMPEX gauge, radar, snow observations integrated with VIC to create "best" estimate
How will Satellite estimates do?

Multi-Platform Data Fusion: E.g., SIMBA Applied to OLYMPEX

SIMBA Framework

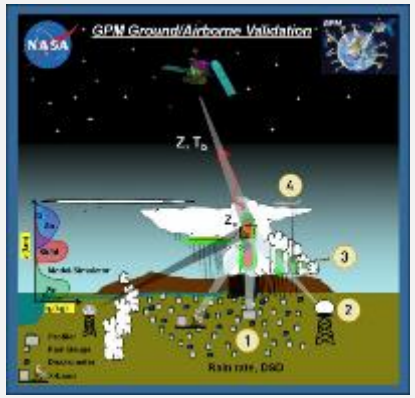
System for Integrating Multi-platform data to Build the Atmospheric column

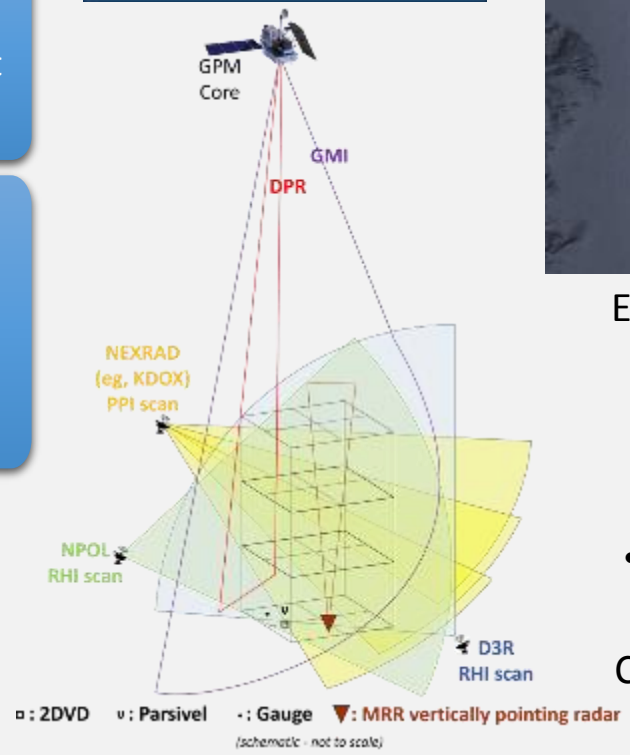
Define Column: grid center location, horizontal and vertical extent, spacing

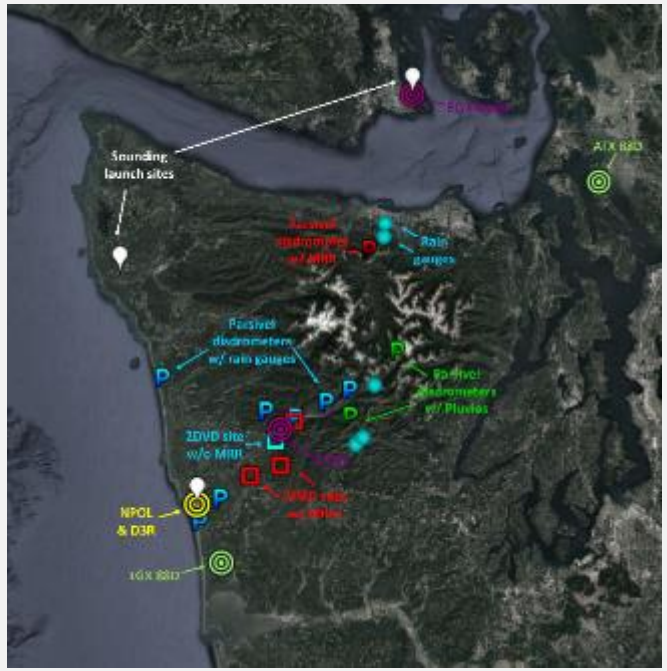
Platform-specific Modules: read in native data formats, process gridding and/or interpolation as needed to set coincident observations into single, 3D column grid

SIMBA Column Data File: Write all available observations to a **common 3D grid in NetCDF** format. Attributes maintain key properties of original data (exact locations, operation modes, algorithm versions, etc.)

- Developed initially for NASA WFF Precipitation Research Facility
- Versatile SIMBA system can be applied to multi-sensor observations in any geographic domain







Existing SIMBA modules support several OLYMPEX sensors:

- NPOL
- D3R
- DOW
- NEXRAD/88D
- APUs
- 2DVDs
- Pluvios
- Gauges
- GMI/GPROF
- DPR/2ADPR

Continuing work to incorporate:

- Soundings
- Aircraft-based platforms

SIMBA's data-fusion column product can accelerate precipitation process & satellite algorithm assessment studies

Contact: Stephanie.M.Wingo@nasa.gov -- NPP/USRA at NASA MSFC

Summary

Datasets collected for determining…….

- Direct validation: Product uncertainties and their association with orographic enhancements, synoptic regime, terrain gradients, precipitation intensity and type, area/time-accumulated precipitation over terrain (*liquid + frozen*)…..Link to physical validation where possible.

- Physical validation: Column properties/processes of liquid, melting, frozen precipitation in terrain gradient and frontal regimes; systematic variability that can be observed, modeled, and represented in algorithms.

- Integrated hydrologic validation in complex terrain
  - Can satellite estimates be combined with modeling over complex topography to drive improved products (assimilation, downscaling) [Level IV products]
  - How can satellite-based precipitation estimates be best used in stream/river flow forecasting over orographic watersheds?