An Evaluation of IMERG Orographic Precipitation during the 2017-18 Cool Season

Caleb Wood[1], Dr. Christian Kummerow[2], Kyle Hilburn[2], & Ryan Gonzalez[2]

[1]Dept. of Geological & Atmospheric Sciences, Iowa State University

[2]Dept. of Atmospheric Science, Colorado State University

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Motivation

- Winter precipitation = important water source for semi-arid Interior Western United States (Jing 2017)
  - Mountain snowpack leads to most of water resources later in the year
  - Vital for water management/protection agencies

- Global Precipitation Measurement (GPM) Mission
  - IMERG --- Integrated MultisatellitE Retrievals for GPM
    - Interpolates all microwave radiameter data from GPM satellites to estimate precipitation (NASA 2018)
    - Key component for high-resolution precipitation monitoring from space

Research Objectives

- How does IMERG precipitation *compare* to numerical weather prediction (NWP) and surface-based observations?

1. What *specific precipitation regions* in the western United States are well-represented by IMERG?
2. What *precipitation magnitude events* are caught by IMERG?
3. What *seasonal patterns* exist with IMERG precipitation data?
4. In what ways can IMERG orographic precipitation *be improved*?

Methods

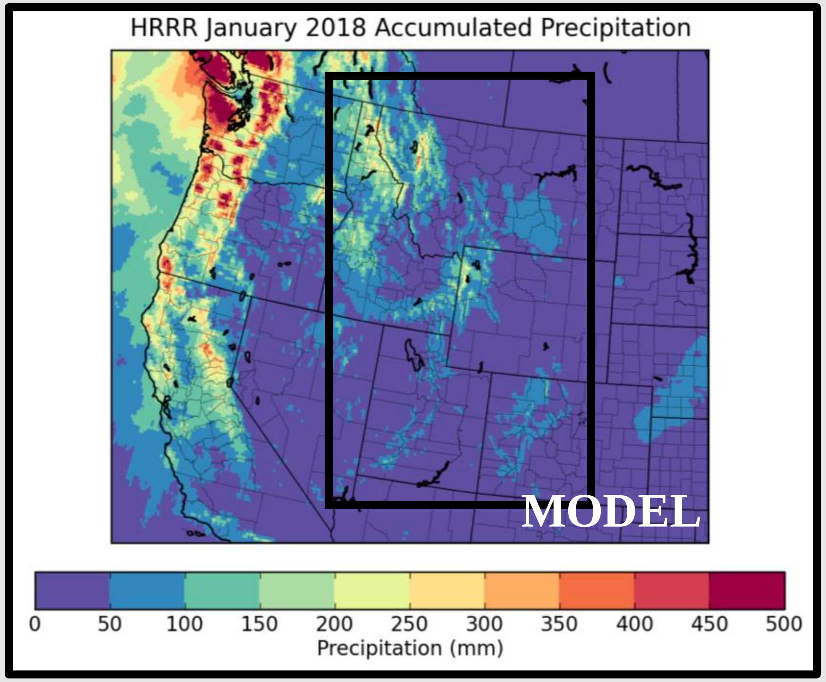
- Time period: October 2017 - April 2018 (Cool Season)
- Region of interest: western third of United States
  - Split region into 2 subdomains for geographic analysis --- Coast vs. Interior
- Precipitation data = rain + melted snow
- IMERG: Integrated Multi-SatellitE Retrievals for GPM
- HRRR: High Resolution Rapid Refresh Model
- PRISM: Parameter-elevation Relationships on Independent Slopes Model
- GMI: GPM Mircrowave Imager (used for case study)

Project Datasets

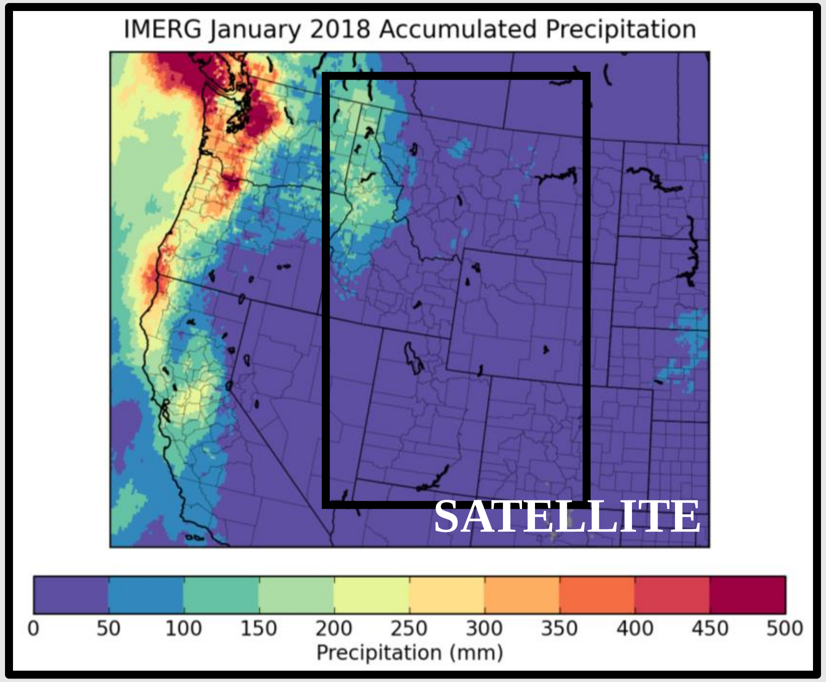
Dataset	Type	Temporal Resolution	Spatial Resolution
IMERG	Satellite	Half-hourly (30 min)	10 km
HRRR	Numerical Weather Model	Hourly	3 km
PRISM	Sfc Observations/ Spatial Interpolation	Daily	4 km

- HRRR and PRISM datasets resampled to IMERG 10 km spatial grid
- Provides "common ground" for comparison and statistical analysis

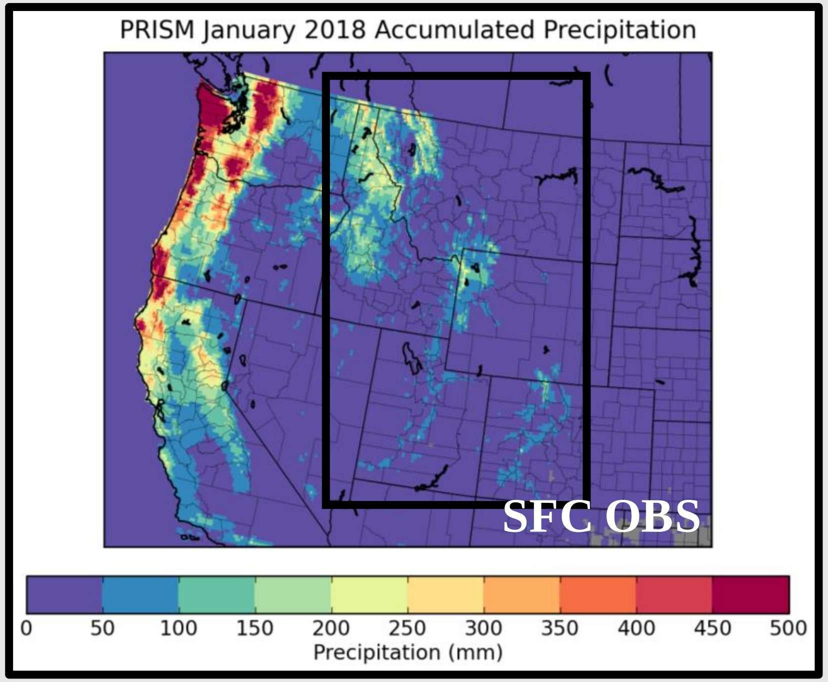
Geographic & Magnitude Patterns



Map 1: Total Accumulated Precipitation forecasted by HRRR during January 2018

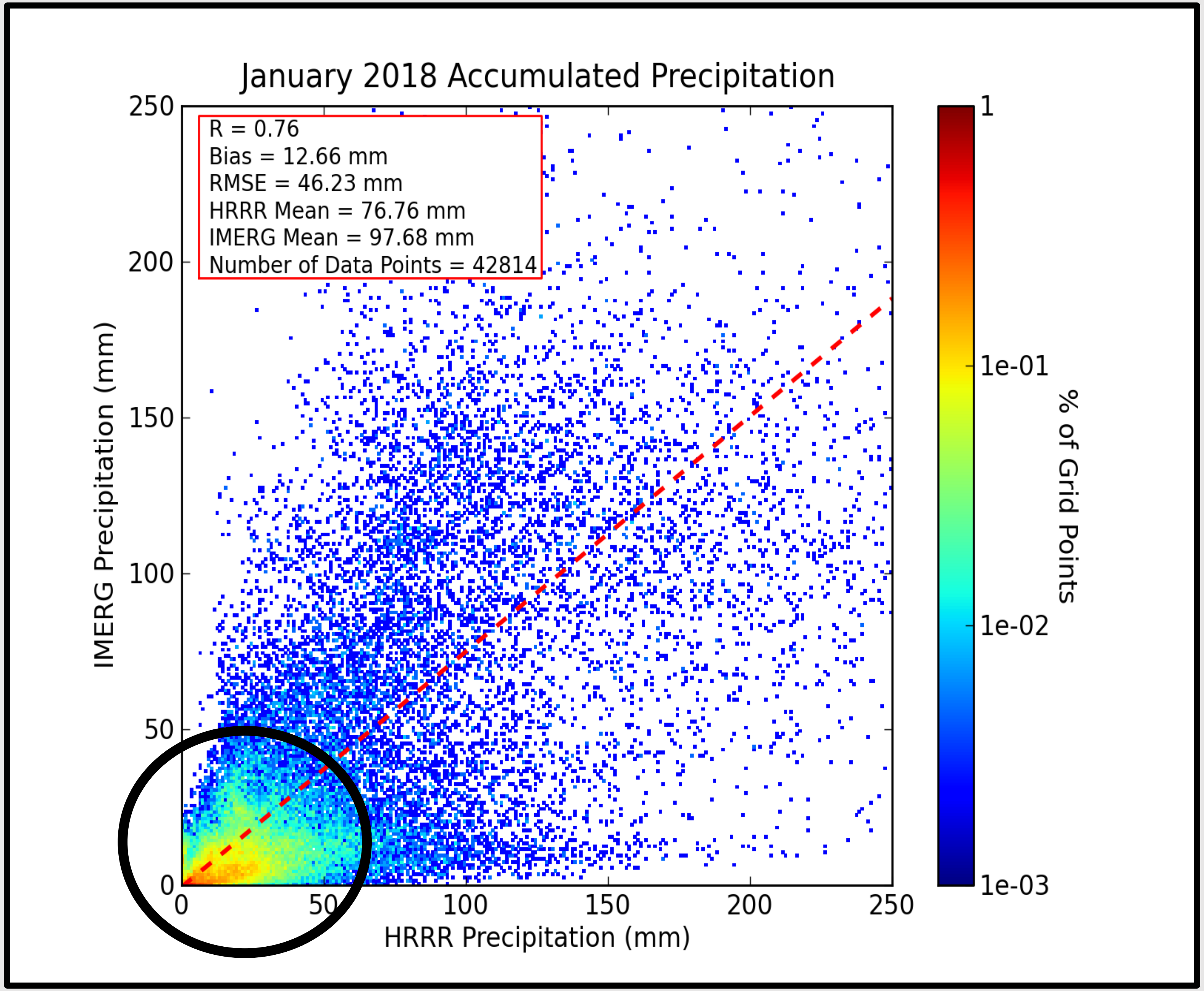


Map 2: Total Accumulated Precipitation detected by IMERG during January 2018

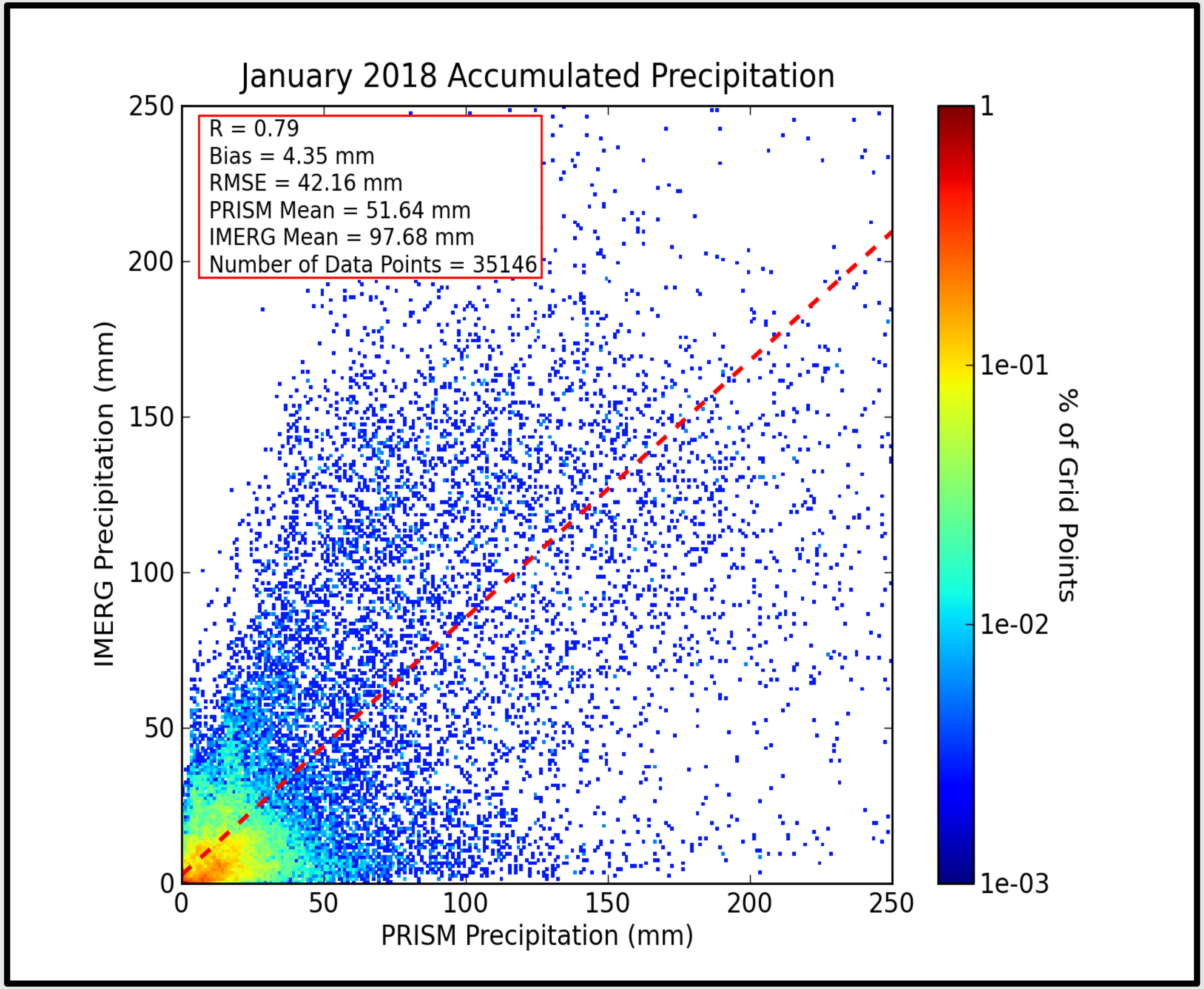


Map 3: Total Accumulated Precipitation measured by PRISM during January 2018

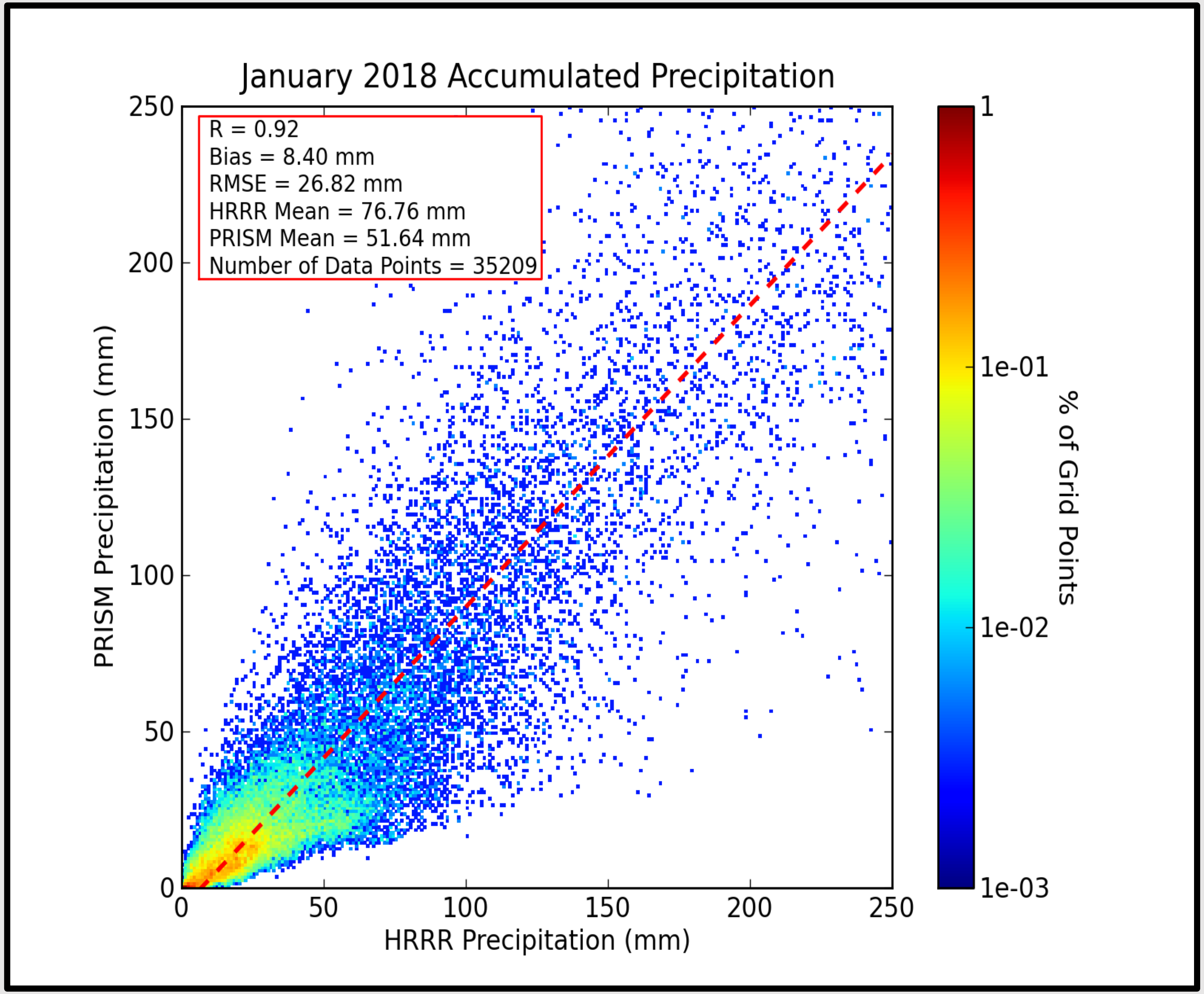
- West coast/Cascade Mts. - heavy precip
- Northern Rockies into Colorado Front Range - lighter/more scattered precip
- <u>Where did the Rocky Mts. precip go for IMERG?</u>



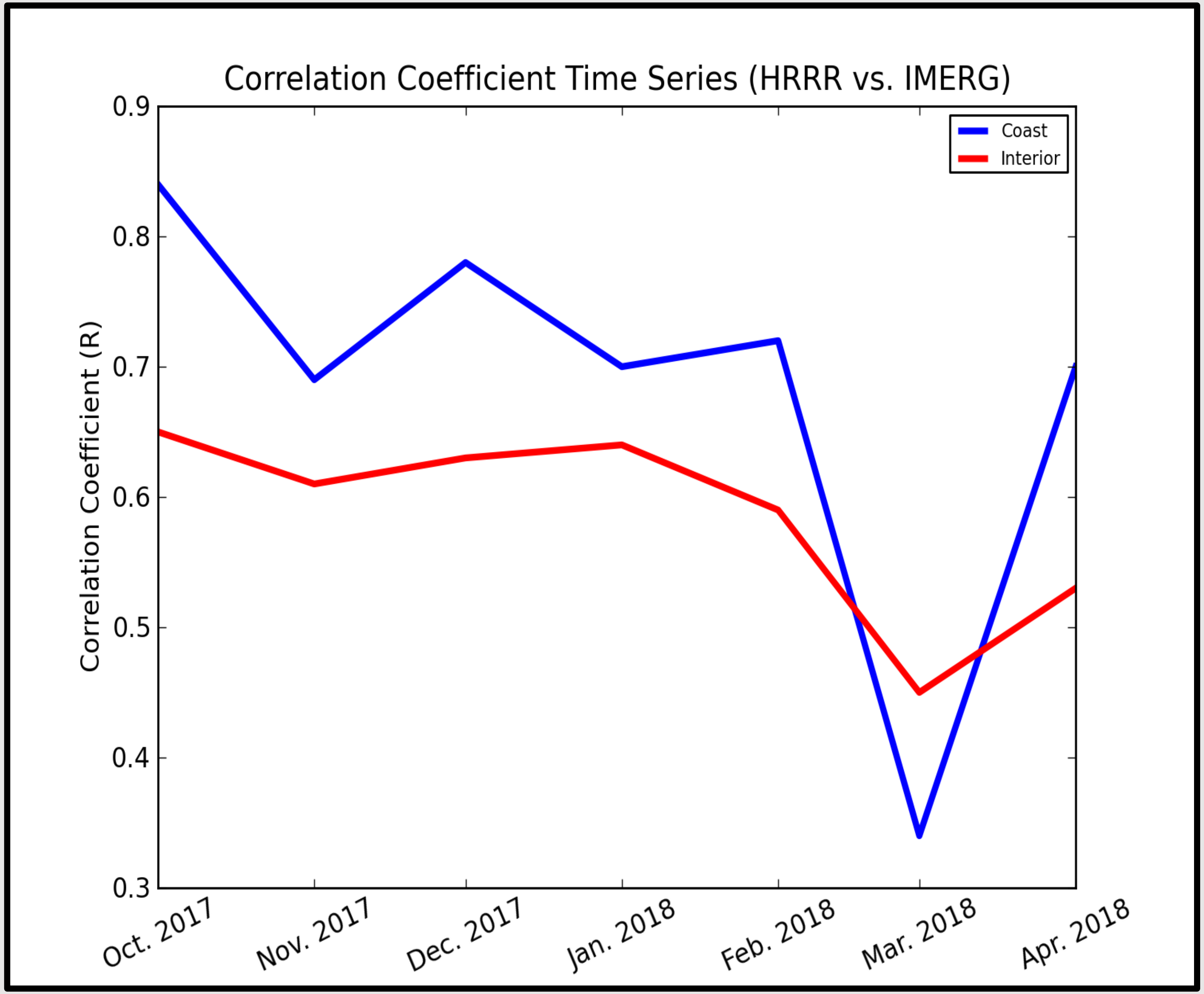
- For most grid points:
  - HRRR = heavier
  - IMERG = lighter
- Light precip - skewed towards HRRR
  - HRRR produces many light precip events
  - IMERG doesn't "catch" them
- Heavier precip - more of an IMERG focus



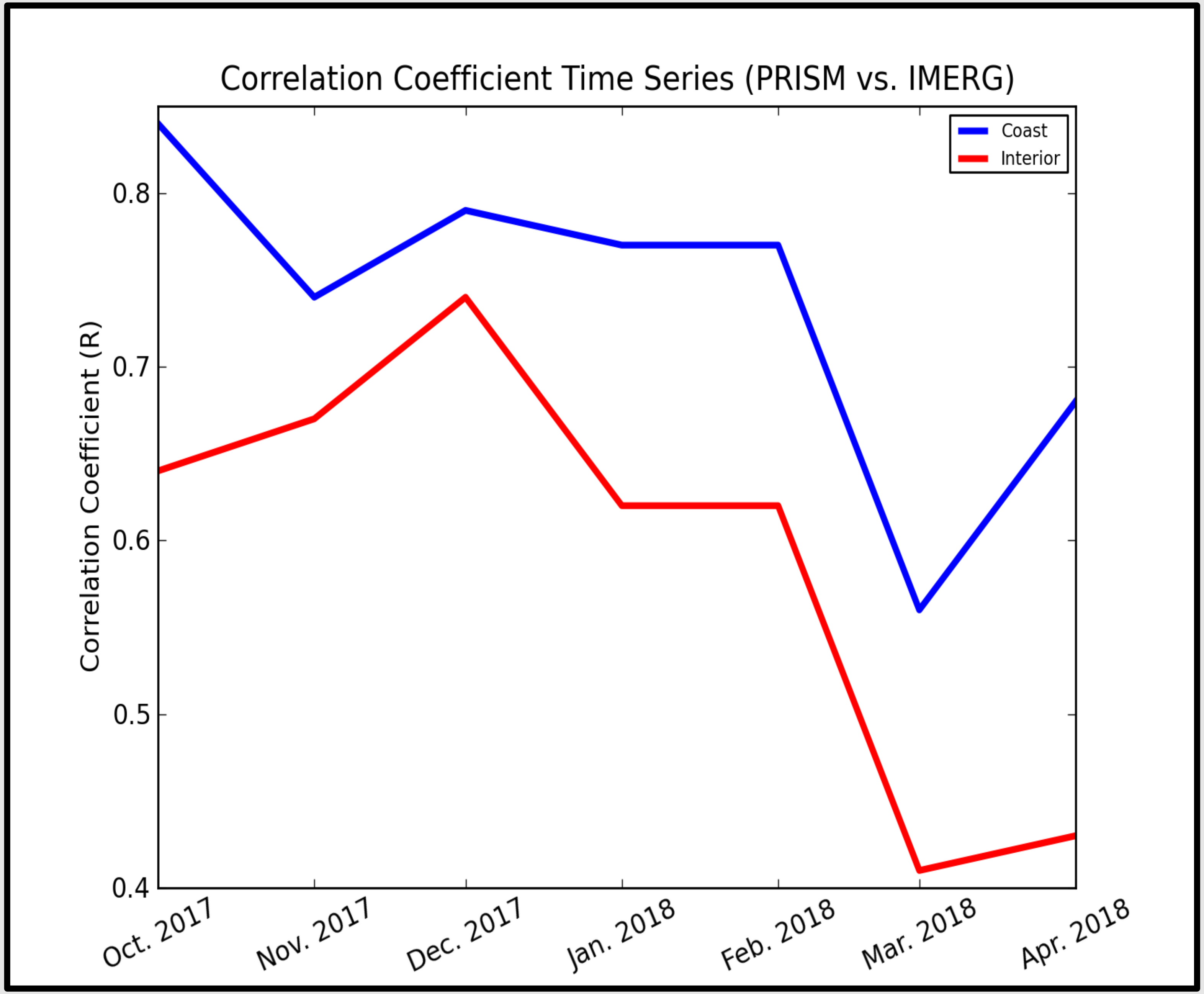
- Much the same story as with HRRR vs. IMERG
- Slight skew towards PRISM at the lower precip spectrum



- For most part, HRRR and PRISM line up well
- High R-value
- Sfc obs validate HRRR model forecasts



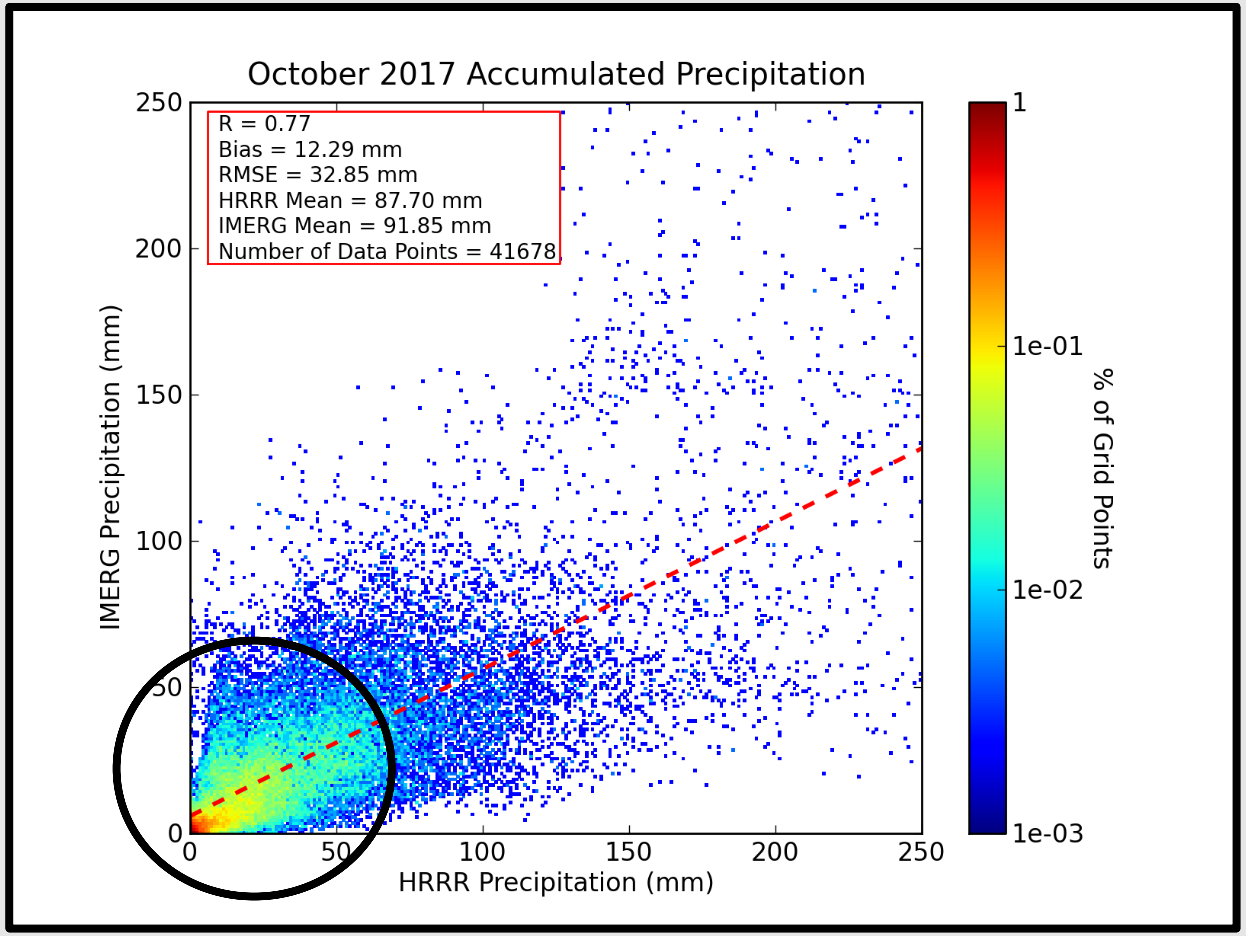
- For most part, precip more correlated along the **Coast** as opposed to the **Interior**
- Higher mean elevation in **Interior** region
- Slow decrease in correlation as winter progresses

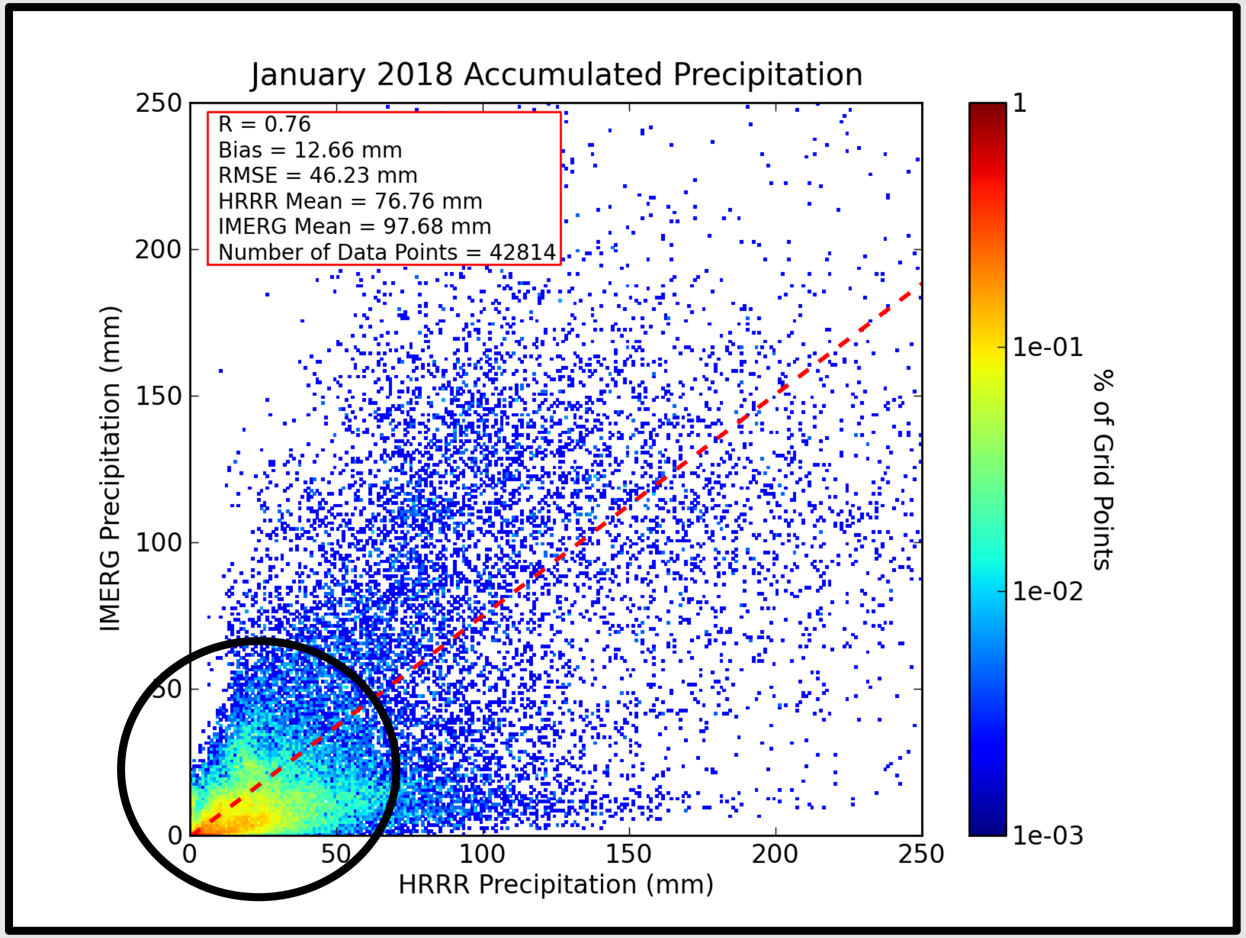


- **Coast** precip more correlated than **Interior** throughout duration of cool season

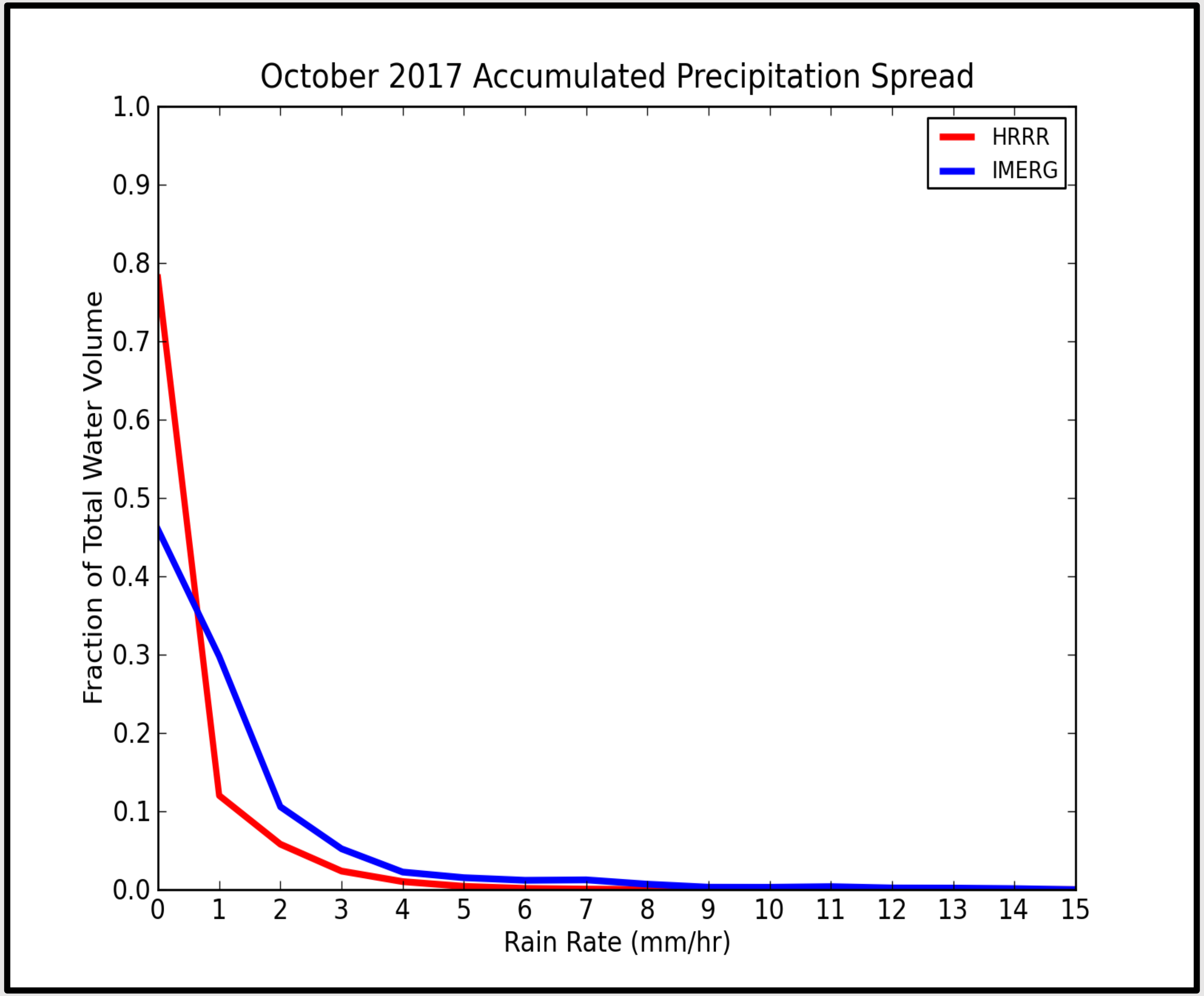
- Again, slow decrease in R-values over time
  - Potential seasonal effect

Seasonal Variability during the Cool Season

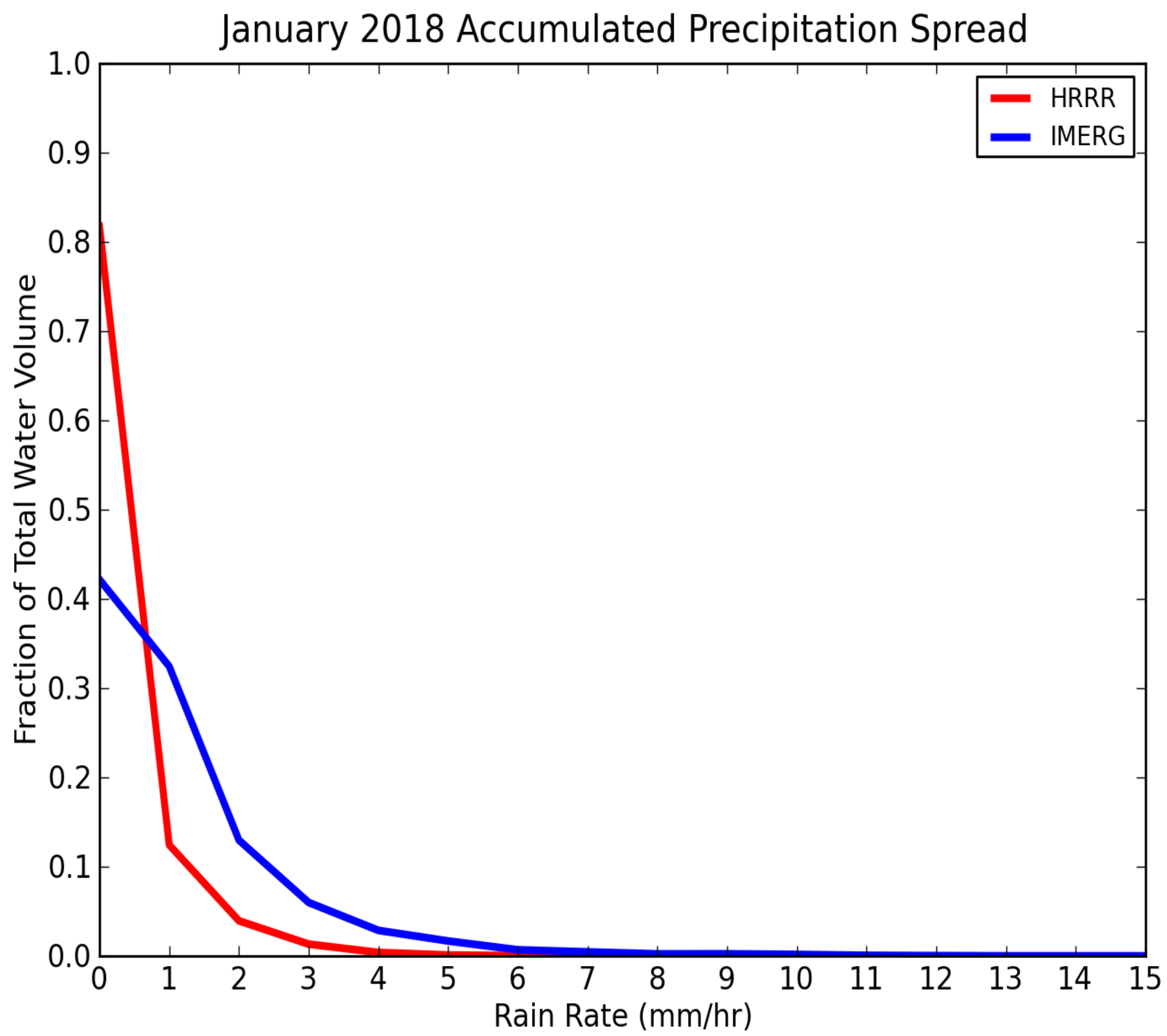




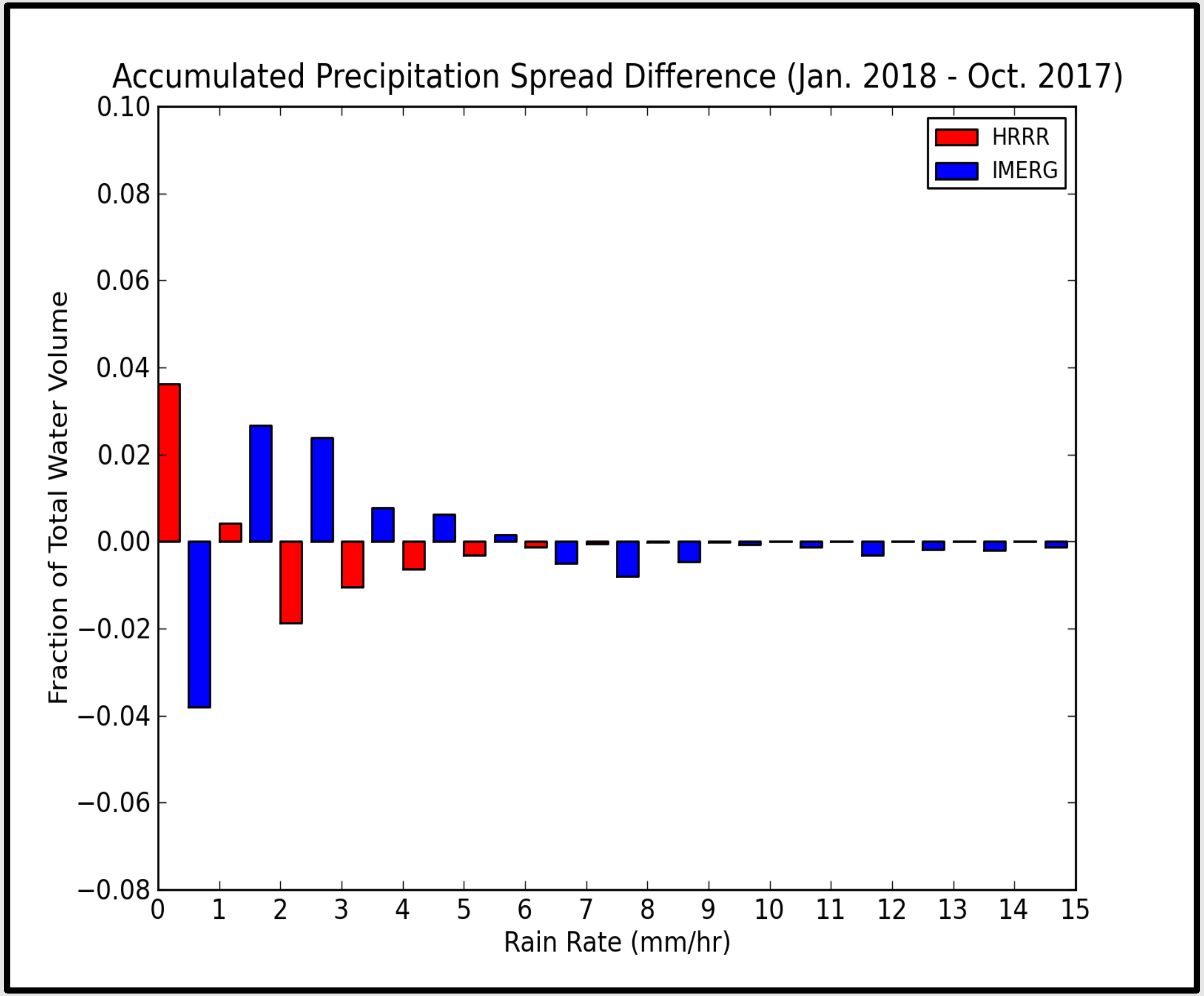
- October 2017 - light precip balance with HRRR and IMERG
- January 2018 - light precip leans towards HRRR
- As cool season progresses, more snowpack on surface



- **HRRR** - large portion of total water volume falls at low rain rates
- **IMERG** - more of its precipitation accums occur at heavier rain rates
- Less emphasis on very light precip for **IMERG**

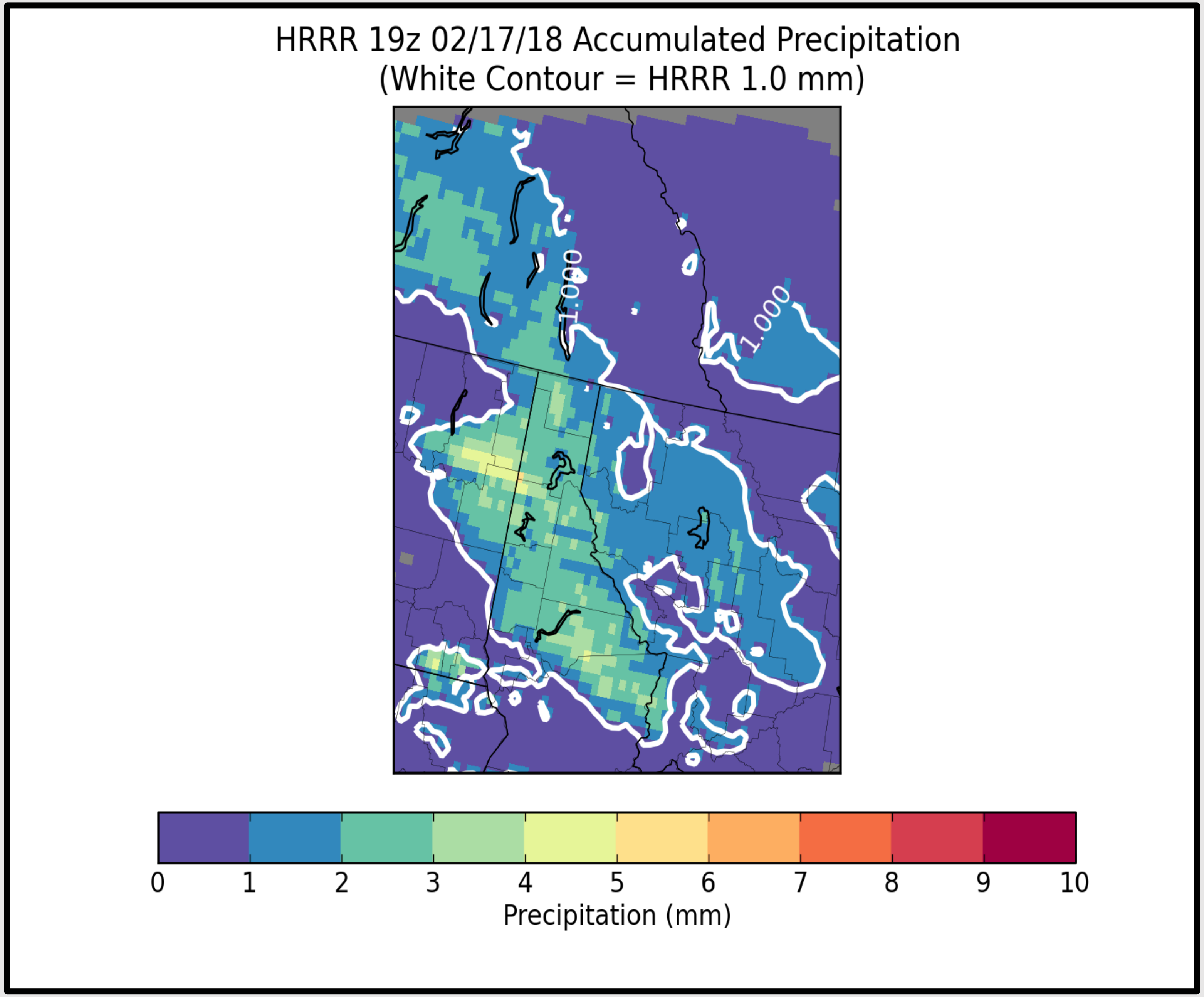


- Appears to have the same story as October 2017
  - **HRRR** - light precip focus
  - **IMERG** - heavier precip focus

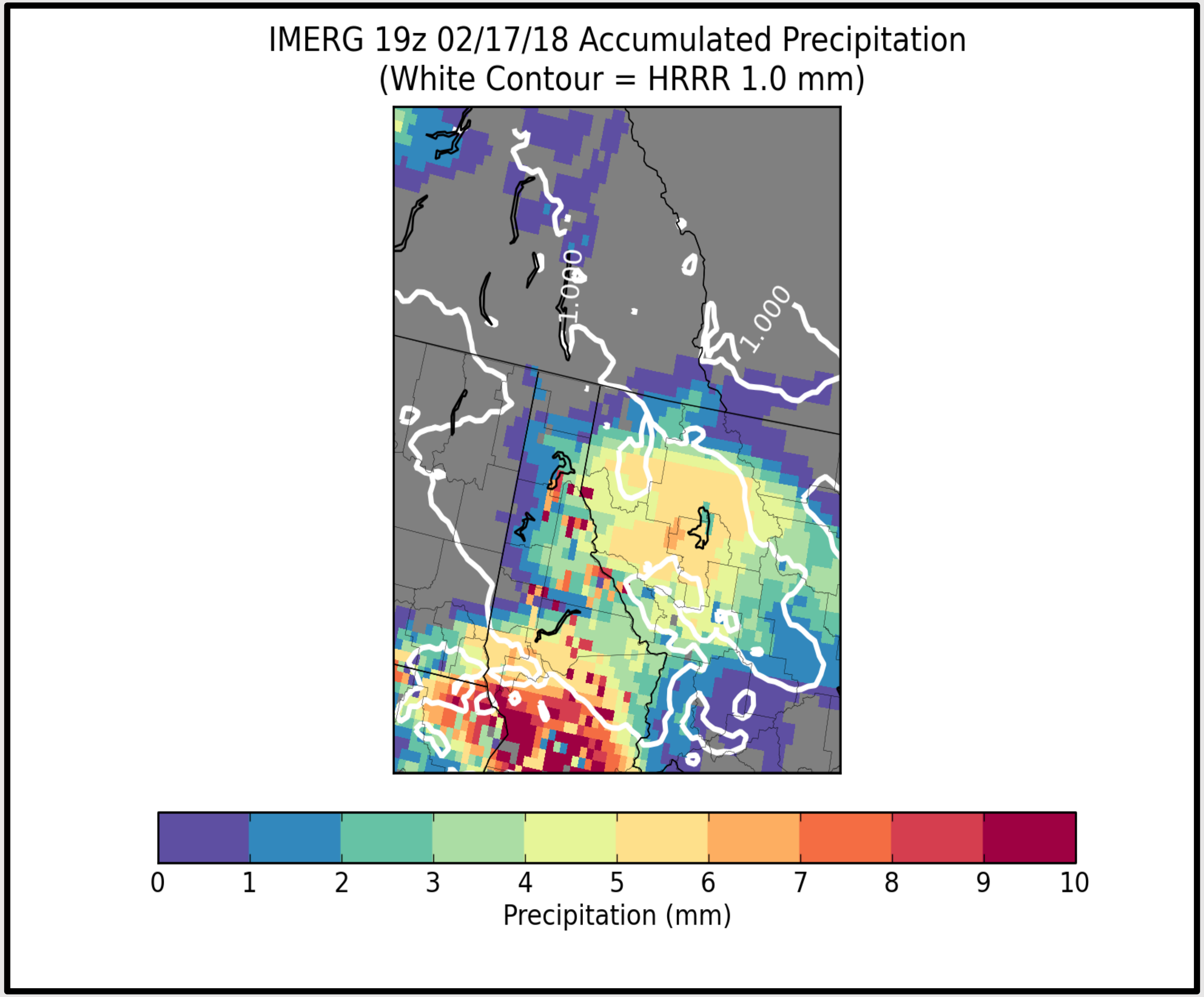


- Is there a seasonal difference in the precip distribution by rain rate?
  - From the 0-1 mm rain rates, **IMERG** has less precip in Jan. as compared to Oct.
  - More heavy precip (rain rates > 2 mm) in Jan.
  - As cool season progresses, light precip is not detected as well

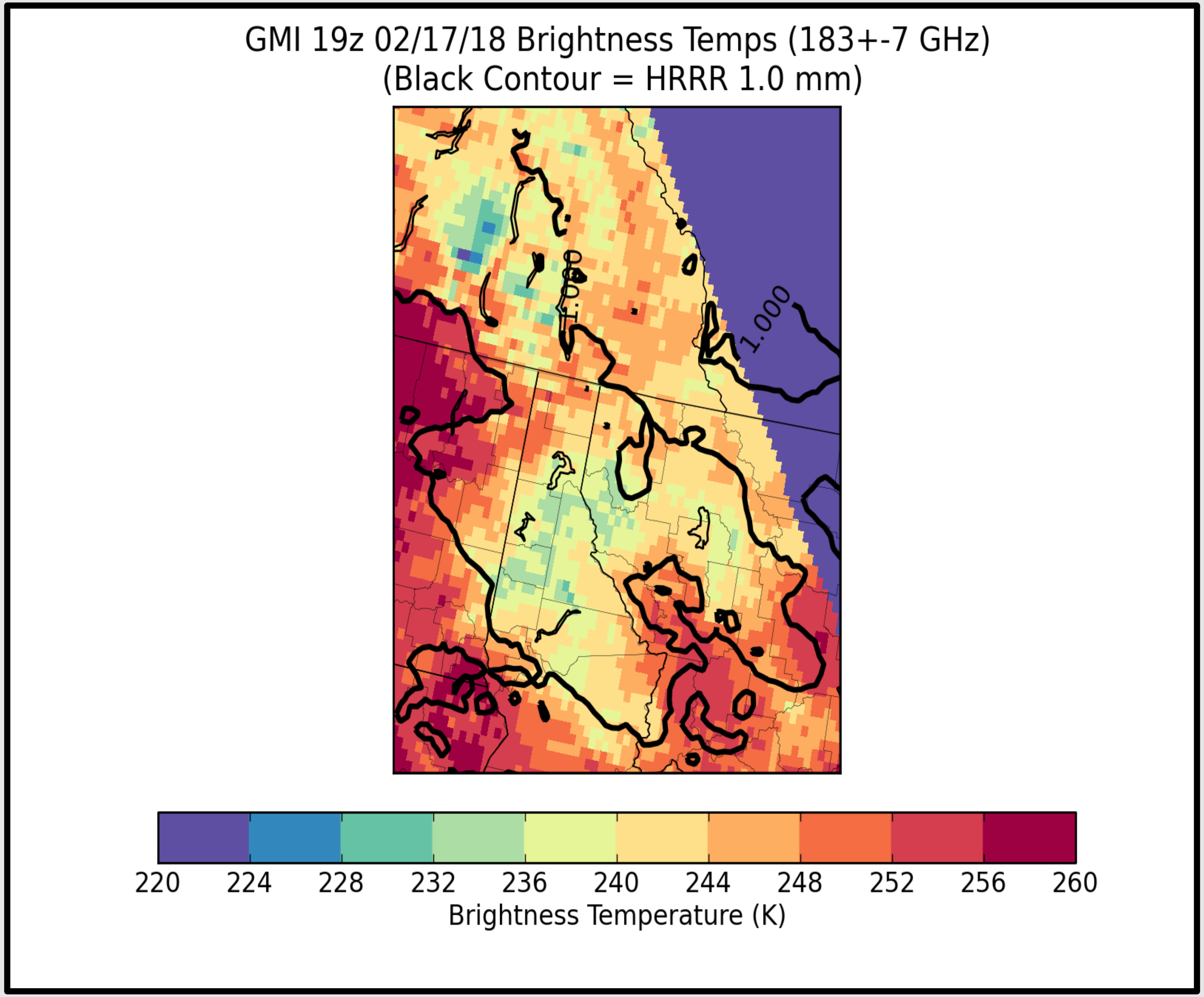
Case Study



- Region of heavier precip/snow in northern Idaho during Feb. 2018
- HRRR 1.0 mm contour outlines heavy/light precip boundary



- IMERG precip maxima are shifted south compared to HRRR
- Extreme northern region outlined by HRRR contour is empty



- Temperature at which GMI sees surface/clouds
- Cooler brightness temps (Tb's) often indicate precip
  - Due to scattering of microwave radiation by cloud ice particles
- HRRR contour outlines cooler Tb's well for this case
- Greater emphasis on Tb patterns at ice scattering frequencies could help improve IMERG cool season precip

What Did We Learn?

- IMERG struggles with the following during cool season precip:
  1. Up - higher elevation at which sfc snowpack can exist for extended time
  2. Low - light precip events with minimal ice scattering signal
  3. Late - deep winter months (JFM) when snowpack is present

- Improvement with IMERG precip algorithms?
  1. GMI high-frequency brightness temperatures can be used in greater detail to highlight potential precip area

References

1. Cao, Q., T. H. Painter, W. R. Currier, J. D. Lundquist, and D.P. Lettenmaier, 2018: Estimation of Precipitation over the OLYMPEX Domain during Winter 2015/16. *J. Hydrometeor*, **19**, 143—160, DOI: 10.1175/JHM-D-17-0076.1.
2. Jing, X., B. Geerts, Y. Wang, and C. Liu, 2017: Evaluating Seasonal Orographic Precipitation in the Interior Western United States Using Gauge Data, Gridded Precipitation Estimates, and a Regional Climate Simulation. *J. Hydrometeor*, **18**, 2541—2558, DOI: 10.1175/JHM-D-17-0056.1.