Regional Performance of Precipitation Forecasts from a Convection-Permitting Ensemble Relative to Operational Guidance over the Western United States

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MOTIVATION

- Convection-permitting ensemble modeling systems are required to ***capture the large spatial variability*** and ***quantify the inherent uncertainty*** of precipitation forecasts in areas of complex terrain
  - Ensemble modeling systems remain largely untested at convection-permitting grid spacings (4-km or less) over the western U.S
  - Experimental NCAR Ensemble (10 members at 3-km) serves as ideal platform for QPF validation study of next generation NWP

OBJECTIVES

- *Determine the advantages of QPF from a cloud-permitting ensemble forecast system over complex terrain in the western US*
  - Deterministic: How well does a single member of the NCAR Ensemble predict characteristics of precipitation?
  - Probabilistic: What is the *reliability* and *resolution* of probabilistic QPF from all 10 members of the NCAR Ensemble?

MODEL DATA

Model	Resolution	Convection Permitting?	Forecasts Used
NCAR Ensemble Member 1	3-km	Yes	Hours 12-36 from 00Z
HRRRv1	3-km	Yes	Hours 3-15 from 09Z and 21Z
NAM-4km	4-km	Yes	Hours 12-36 from 00Z
NAM-12km	12-km	No	Hours 12-36 from 00Z
GFS	0.5° (~28-km)	No	Hours 12-36 from 00Z
NCAR Ensemble (10 Members)	3-km	Yes	Hours 12-36 from 00Z
GEFS (20 Members)	1.0° (~55-km)	No	Hours 12-36 from 00Z
ECMWF Ensemble (50 members)	0.5° (~28-km)	No	Hours 12-36 from 00Z

Table 1: Models used in study. Red shading indicates single member, deterministic models. Blue shading indicates multi-member, ensemble models. All data from 2015/2016 cool season.

REGIONAL VALIDATION RESULTS

Why Validate QPF by Region?

163 days in 2015/2016 Cool Season:

~ 130 precip events in the Cascades
~ 20 precip events in mountains of AZ/NM

Significant differences in climatology affect model skill (Hammill and Juras 2006)

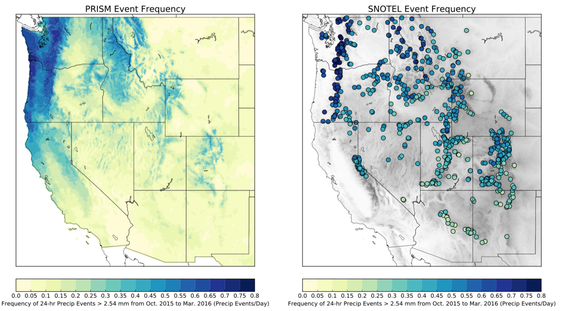

Figure 2: Frequency of precip events from PRISM (left) and SNOTEL (right)

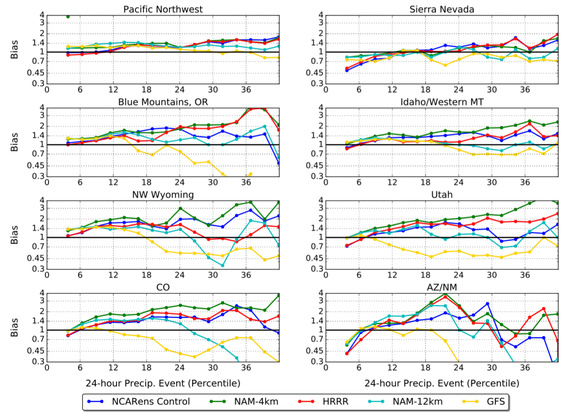

Figure 4: 24-hour precip event bias frequencies

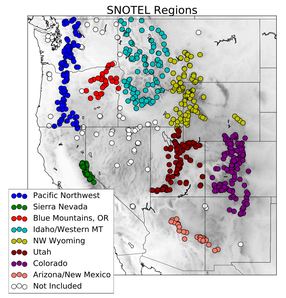

Figure 3: Regions used in study. Based on characteristics of climate for each SNOTEL site. Same as used in Serreze et al. 1999

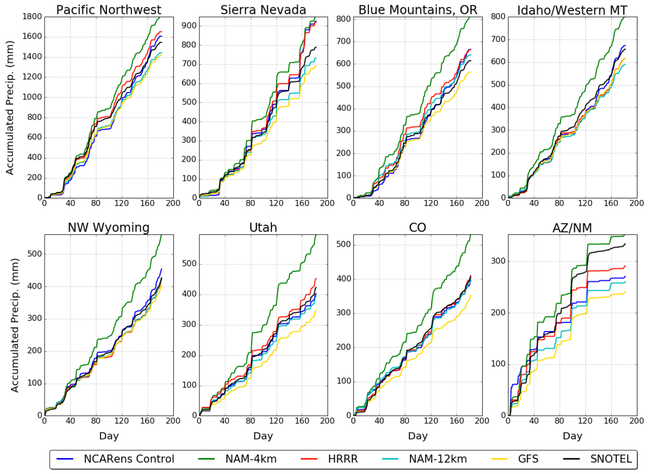

Figure 5: Mean accumulated precip in each region throughout the 2015/2016 cool season

Probabilistic Validation

- NCAR Ensemble performs well overall, but struggles to capture all events in the Sierra Nevada
- Around half of observed events fall above the ECMWF Ensemble and GEFS spread – likely due to coarse resolution of each model

NCAR Ensemble 10 members | ECMWF Ensemble 50 members | GEFS 20 members

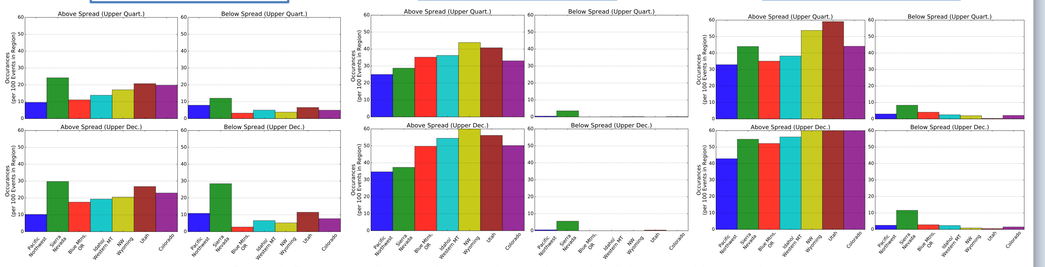

Figure 6: Frequency of events that are observed outside of the ensemble spread

OBSERVATIONAL DATA

SNOTEL

- Located in upper elevations
- Long-term storage gauges that report hourly precip to one-tenth of an inch (2.54 mm)
- Daily (12Z to 12Z) precip used

PRISM

- PRISM Group at Oregon State University
- Used to reveal model climatology
- 4-km gridded daily (12Z to 12Z) precip data
- Uses point data, spatial data, and a digital elevation model

** All data from 2015/2016 cool season*

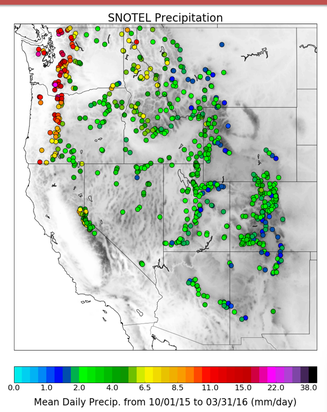

Figure 1: Location and mean daily precip of SNOTEL sites

SUMMARY

- ***Majority of precip events occur in Cascades***
  - SNOTEL sites in wet climates have larger impact on precip validation metrics for the entire Western US
- ***Stronger event frequency and total seasonal precip biases (~1) found in coastal regions compared to inland regions***
- ***More upper quartile and decile precip events fall above the NCAR Ensemble's spread than below***
- ***ECMWF Ensemble and GEFS struggle to catch large events***
  - Likely to due low resolution

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**See more results on poster 1177*

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