New calibration methods for extreme precipitation probabilities in subseasonal-to-seasonal forecast models

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Summary

- Provide a model based guidance for week-2 precipitation extremes in the US (Probabilistic Extremes Forecast Tool)
  - 3-day accumulated precipitation (8-10, 10-12, 12-14) above 85th

Current calibration approach:
- Ensemble regression method
- Does not vary from one forecast to another
- One method to calibrate the whole pdf of the process (i.e. precip is heavy tailed)

Proposed calibration approach:
- Focused on extremes (i.e. week-2 probability of 3-day accumulated precip above 85th)
- Includes informations about the state of the forecast/process (i.e. precip, env. variables)
Data

Probability 3-day accumulated precipitation (L= 8-10, 10-12, 12-14) above 85th

Forecast model:

- SubX GEFS v.11 hindcast (1999-2016) [real time forecast for 2017-2019]
- Hindcast are daily data (00z-00z) - 10 ens. mem. - 1 start once a week

Reanalysis data (match in time and spatial grid):

- NARR - 3 hourly data- aggregated to 00z - 00z
- CPC Unified - daily data- 12z-12z and do not match forecast 00z-00z
- PERSIANN - daily data- 00z-00z
Roadmap

- Extract climatologies ($I_{3d, 85^{th}}$) for forecast and reanalysis data

- Extract occurrence of exceedance ($I_{3d > 85^{th}}$) for forecast and reanalysis for a range of lead times: $L=8-10$ day and NARR

- Evaluate baseline skill of uncalibrated forecasts

- Present and Assess preliminary new calibration methods.
For each grid point and calendar day we extract climatologies for 85th

**Forecast model**

- Functional form: annual harmonics, 3 harmonics correspond to 7 params
  \[
  I = \exp[a_0 + \sum_{k=1}^{3} (a_k \cdot \sin(k \cdot nu \cdot x) + b_k \cdot \sin(k \cdot nu \cdot x))]
  \]
  \[\text{nu} = \frac{2\pi}{365.25}, \text{x} = \text{day}\]

- For each calendar day we pool rolling window L=4-33 days

**Reanalysis**

- No Harmonics - Pooling a rolling window of data (-15 to +15 days)
Climatologies for extremes $I_{3d, 85^{th}}$

Annual mean of frequency of exceedence of climatology (15%)

In sample (hindcast)

Out of sample (real time)

Comparing climatologies: GEFS vs. Reanalysis
Comparing climatologies: GEFS vs. Reanalysis

Correlations between reanalysis and GEFS climatologies

- Reanalysis and GEFS climatologies correlate well except for 3 areas where correlations < 0.
- The Colorado and Eastern blue areas could be due to some orographic effect. Not so for Texas blue area.
- Differences do not depend on time.
- Tend to resolve at 50th percentiles for Colorado, not for Texas.
Extract occurrence of exceedance ($I_{3d} > 85^{th}$)

Uncalibrated GEFS $I_{3d, 85th}$ 8-10 days skill vs. NARR

Reliability

Brier skill score (ref: Climatology)

Annual Brier skill score

May—August Brier skill score

May—August
Explored calibration methods

Model set up

- Extract occurrence of exceedance, $I_{3d} > 85^{th}$, $L=8-10$ days
- Regressors: ensemble probabilities, $I_{3d}$, $I_{3d}$ anomalies, and large scale environments ($CAPE, T, Td, w$): up to 3 params ~ 220 combinations
- Spatially varying multivariate Logistic Regression: $\ln \frac{p}{(1 - p)} = \beta_0 + \beta_1 x_1 \ldots$
- Each grid point fit pooling data from a 7x7 spatial uniform kernel
- Train on 2/3 of hindcast forecast data - Test on remaining 1/3

Assessment

- Look at Reliability, BSS, time varying BSS (random walk).
- Overall Reliability: WLS fit; BSS random walk: last value
Results

- All combinations (1 to 3 params) result in significantly better model than the raw forecast wrt BSS (all negative total counts in BSS random walk below black line).
- Not all models improve reliability.
- Looking at different metrics (Reliability vs. BSS) identify a small pool of best performing models.
**Results**

- Best of 3 parameter: ensemble probabilities, anomalies, log-precip
- Best of 1 parameter: ensemble probabilities

**May—August Brier skill score**

- Forecast Prob vs. Empirical Prob for May, June, July, August
- Brier skill score (ref: Climatology)

**Maps**

- 3 params: 3 parameter ensemble probabilities
- 1 param: 1 parameter ensemble probabilities
Conclusions

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- Future work:
  - Extend to all year, all SubX Models
  - Detailed comparison of differences among various models (including ER)
  - Extend to GEFS v.12