Advances in Real-time Probabilistic Seasonal forecasting at The International Research Institute for Climate and Society (IRI)

International Research Institute for Climate and Society
EARTH INSTITUTE | COLUMBIA UNIVERSITY

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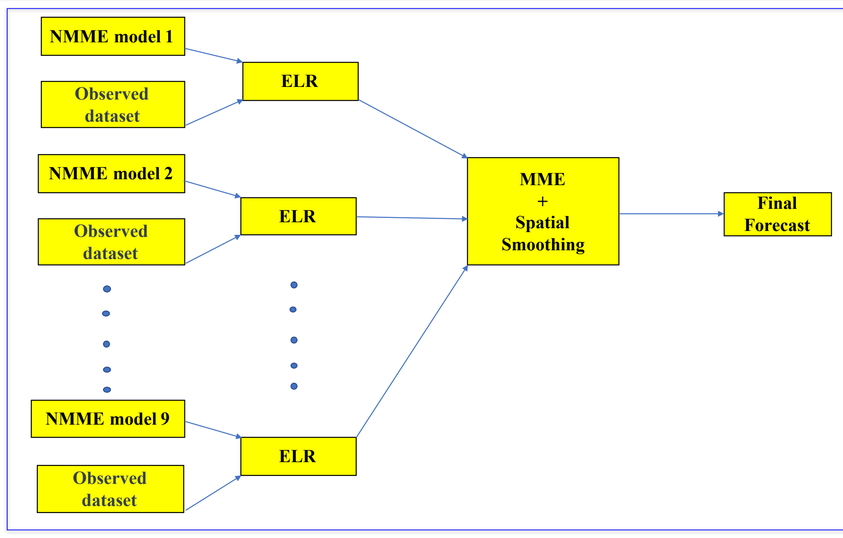
1. About IRI's forecast system

- The International Research Institute for Climate and Society (IRI), Columbia University, began routinely providing calibrated user-oriented seasonal climate forecasts forecasts for temperature and precipitation since the late 1990s based on a two-tiered multi-model ensemble dynamical prediction system. In fact, IRI is the pioneer of using statistical calibration method to the raw GCM's output to make multi model ensemble (MME) based seasonal forecast.
- The forecasts are probabilistic with respect to the occurrence of tercile categories of seasonal total precipitation and mean temperature—below, near, and above normal as defined by the 30-year base period in use at the time.
- Forecasts were initially issued quarterly, but in 2001 began being issued each month and for all four overlapping 3-month periods between the first and second seasons. In 2012, IRI developed a more flexible forecast format that enabled users to extract more detailed climate forecast information than earlier (Barnston and Tippet,2014).
- Since April 2017, IRI update the seasonal temperature and precipitation forecasts based coupled ocean-atmosphere models from the NOAA's North American Multi-Model Ensemble project (NMME) project.

2. What's new in IRI's forecast system

	Old IRI forecast system	New IRI forecast system
GCM used (Predicators)	2-tier (uncoupled) models: ECHAM 4.5, CCM3.6, COLA, GFDL,CFSv2.	1-tier (coupled) NMME models: CMC1-CanCM3,CMC2-CanCM4,NCEP-CFSv2,NCAR-CESM1,COLA-RSMAS-CCSM4,NASA-GMAO-062012,GFDL-CM2p1-aer04,GFDL-CM2p5-FLOR-A06,GFDL-CM2p5-FLOR-B01.
Observed data used (Predictand)	Precip: CMAP Temp: CAMS	Precip: CPC-CMAP Temp: GCHN updated
Calibration/MME method	Several statistical methods used in past • Pattern-based correction of ensemble means of individual GCM • Bayesian • Canonical variate method • Gaussian frame work.	• Extended Logistic Regression (ELR) has been applied to ensemble mean of each NMME model separately at grid point level • These forecast probabilities are then averaged together with equal weighting to obtain the final multi-model ensemble forecast. • Final forecast probabilities are to be smoothed spatially using local kernel-function smoothing.
Dry mask	Forecast are only produced when the climatology being more than 30 mm precipitation in any given season.	Forecast are only produced when the at least 10% of the training sample are non-zero.
Making Flexible forecast	Used mean and SD of the forecast, then use parametric approach.	Integrated part of the ELR method.

3. Flow chart of new forecast methodology



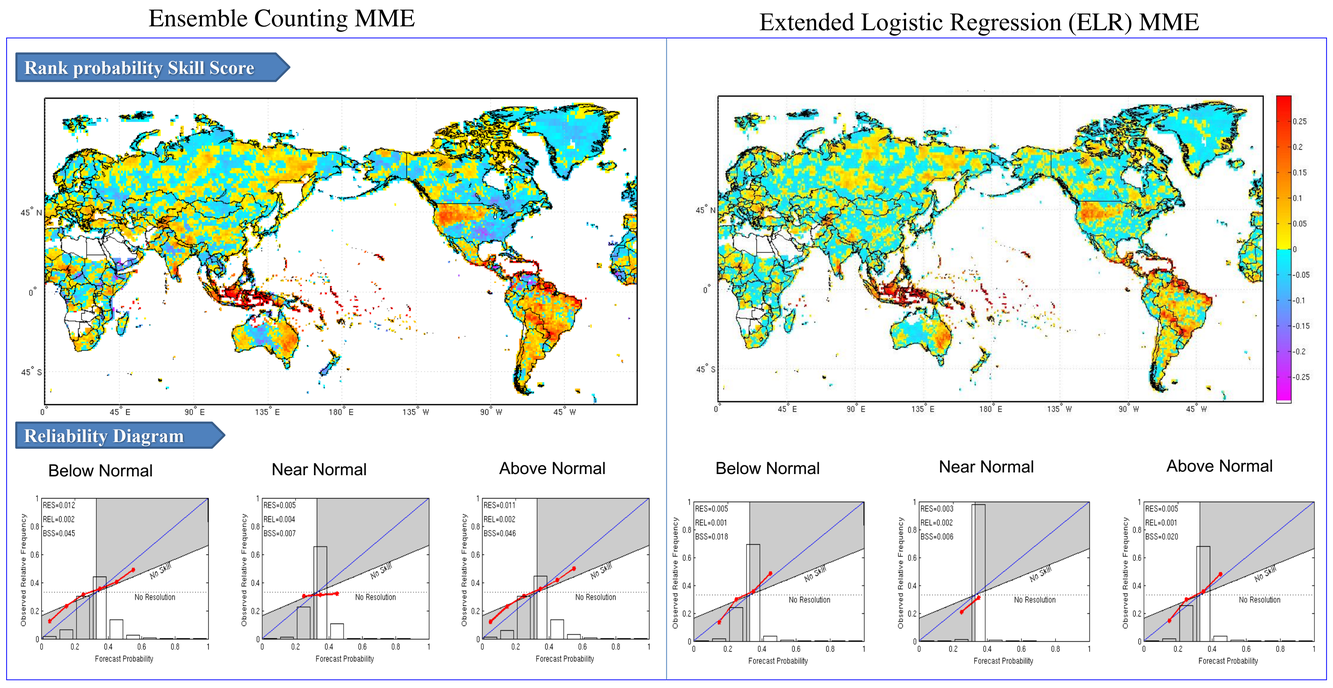
3. About new calibration method

- IRI's new calibration method is based on an extension of logistic regression (ELR) which allows to derive of full probability distributions by including the predictand threshold in the regression equations (Wilks,2009).
- We fit ELR between each NMME model's ensemble mean and historical observed data as $\ln\left(\frac{p}{1-p}\right) = f(\overline{x}_{\text{ens}}) + g(q)$ where $p = Pr\{V \le q\}$ is the (cumulative) probability of the quantile q.
- As the definition of ELR methodology leads to mutually consistent individual threshold probabilities, it allows flexible choice of threshold probabilities according to user's needs.
- ELR has been applied to obtain calibrated tercile probabilities from each NMME model separately at each grid point; these forecast probabilities are then averaged together with equal weighting to obtain the final multi-model ensemble forecast. Final forecast probabilities are to be smoothed spatially using local kernel-function smoothing.

5. Skill assessment of New forecast system

- The skill of ELR-based MME forecasts is evaluated over 1982-2010 following a leave-one-year-out cross-validation.
- Comparison of ELR-based MME method with ensemble-counting-based MME (as benchmark) also done.

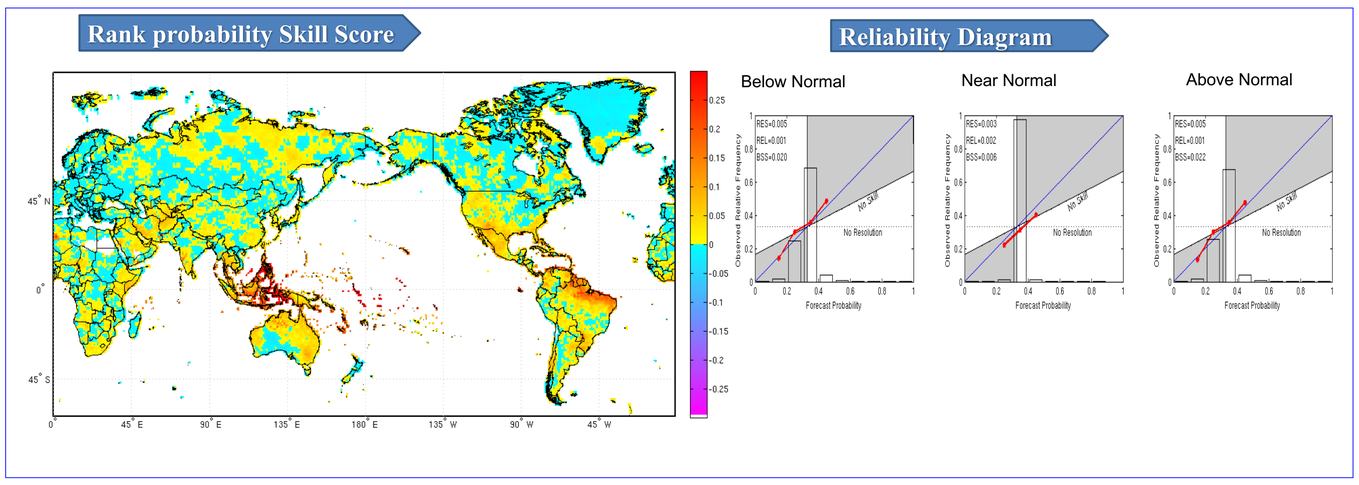
5.1. Ensemble Counting vs ELR: Comparison for of JJA precipitation forecast at May start



- RPSS: ELR remove strong negative skills of Ensemble counting and makes them more mild. The areas of positive skill tend to be slightly weakened.
- Reliability diagram: ELR-based forecast follow the diagonal line more closely than Ensemble counting though ELR having low sharpness which is appropriate when the original reliability shows slight overconfidence.

5.2. ELR based forecast for all seasons in lead-1

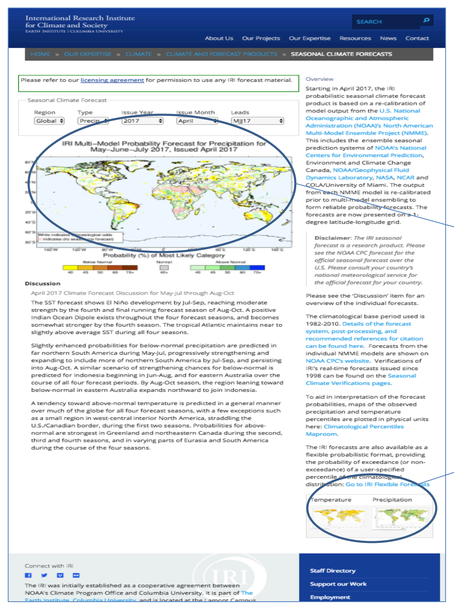
- lead-1 (next three month average) ELR MME forecast of precipitation, calculated for all monthly starts over the NMME hindcast period (1982 to 2010).



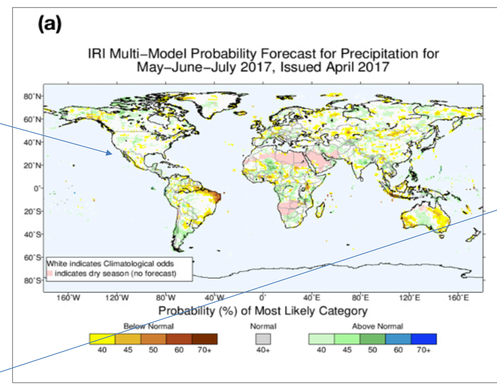
- The skill of the ELR based forecast is quite satisfactory with extensive areas of positive RPSS (forecast system performs better than climatology), especially in the tropics. Large negative values of RPSS indicative of poorly calibrated forecasts are notably absent
- The resulting MME forecasts are characterized by good reliability but low sharpness.

5.3. Real time tercile and flexible format forecast

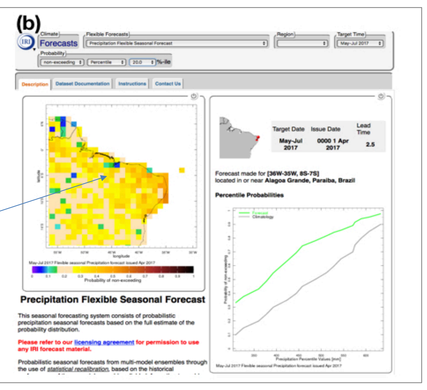
- IRI real-time forecast updated at every third Thursday of the month for next six month.
- Forecasts were issued at 0.5-, 1.5-, 2.5-, and 3.5-month lead times.



Tercile format



Flex format



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- **Barnston AG, Tippet M.,, 2014: Climate information, outlooks, and understanding–where does the IRI stand? Earth Perspectives., 1:20**
- **Wilks, D., 2009: Extending logistic regression to provide full-probability-distribution MOS forecasts. Meteor. Appl., 16, 361–368.**

Acknowledgments:

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NOAA-NMME project