Does Non-Gaussian Calibration Improve Multi-Model Seasonal Forecasts?

Nachiketa Acharya[1], Michael K Tippett[2], Andrew W Robertson[1] and Lisa Goddard[1]

[1]International Research Institute for Climate and Society, Earth Institute at Columbia University, Palisades, NY, USA

[2]Department of Applied Physics and Applied Mathematics, Columbia University, New York, New York, USA

1. Motivation & Goals

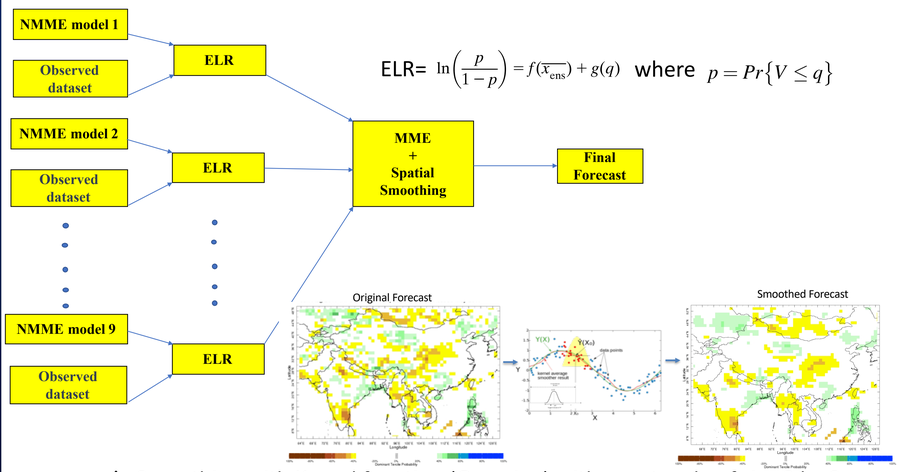
- Since April 2017, The International Research Institute for Climate and Society (IRI), update the seasonal temperature and precipitation forecasts based on coupled ocean-atmosphere models from the NOAA's North American Multi-Model Ensemble Project (NMME) project.
- IRI's new calibration method is based on an extension of logistic regression (ELR), a nonlinear regression method where probability itself can be considered as the predictand rather than a measurable physical quantity, is an alternative model for the Gaussian approach, which allows deriving of full probability distributions by including the predictand threshold in the regression equation
- Does this method works improves forecast??

2. Non-Gaussian Calibration: Extended Logistic Regression

- Logistic Regression is a Machine Learning algorithm which is used for the classification problems, it is a predictive analysis algorithm and based on the concept of probability. Unlike linear regression, no need to fulfill assumptions of linearity, normality and homoscedasticity.
- Limitation of Logistic regression: Probabilities of different categories estimated by fitting separate equations for selected predictand quantile thresholds (q), are not constrained to be mutually consistent.
- Extending Logistic regression: Extending LR by including the predictand threshold as an additional predictor (link function g itself function of the quantile q), allows the cumulative probability for a smaller predictand threshold cannot be larger than the probability for a larger threshold (Wilks,2009).

Implementation

- We fit ELR between each NMME model's ensemble mean and historical observed data.
- 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.

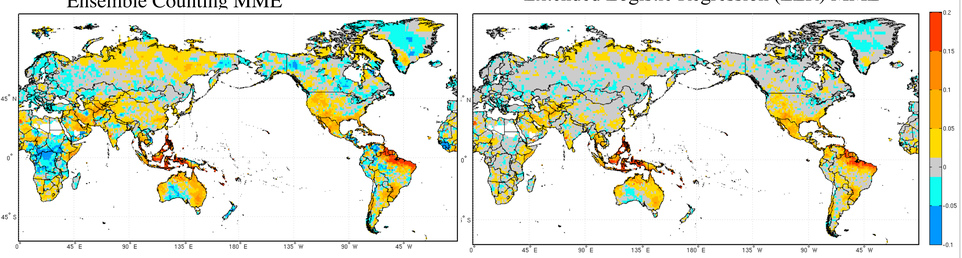


$$\text{ELR= } \ln\left(\frac{p}{1-p}\right) = f(\overline{x}_{\text{ens}}) + g(q) \quad \text{where} \quad p = Pr\{V \le q\}$$

- Smoothing with Kernel function (Gaussian) with a rectangle of size 9 by 9.

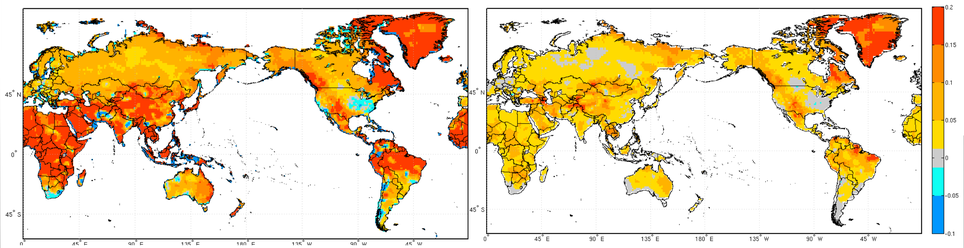
3.RPSS of ELR vs Ensemble Counting

Lead-1 hindcast skill scores for Precipitation



- ELR removes strong negative skills of Ensemble counting and makes them milder (~climatology). The areas of positive skill from counting retain in ELR but tend to be slightly weakened.

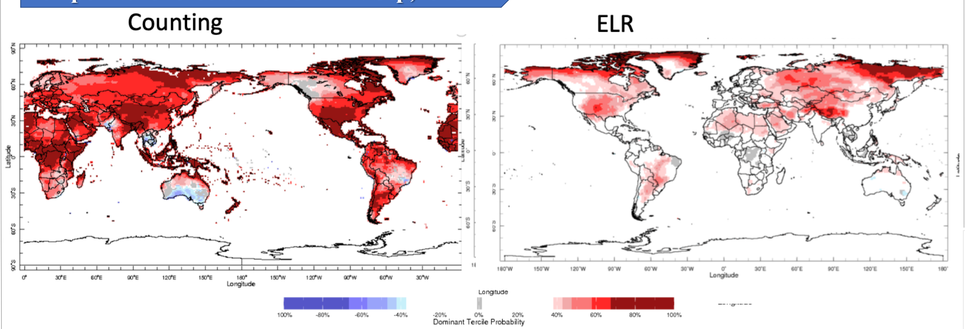
Lead-1 hindcast skill scores for Temperature



- The areas of positive skill from Ensemble counting retain in ELR but tend to be weakened, especially in tropics.

4. Temperature forecast: ELR vs Ensemble Counting

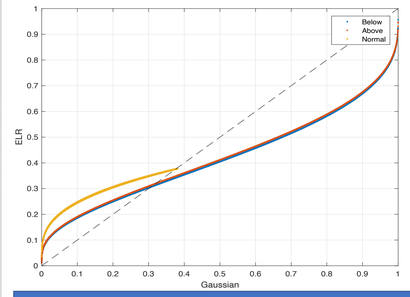
Temperature forecast for OND at Sep,2020



- In ELR, the AN probabilities tend to be very mild in tropics compared to counting.

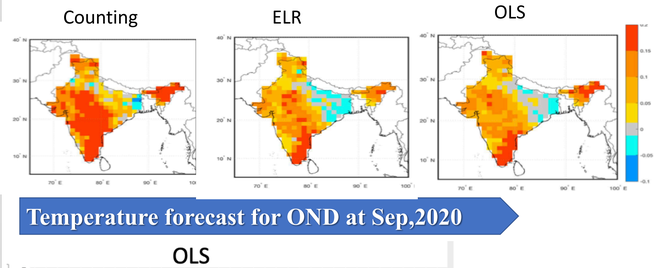
5. Scopes in temperature forecast

- If temperature truly followed Gaussian distribution then is ELR is right choice?

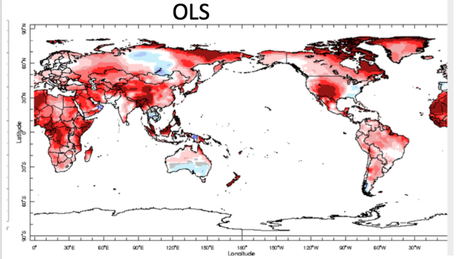


- Other option; OLS= "Ordinary Least Square Method"
  First calibrated model with OLS and then convert to probability forecast based on Gaussian assumption.

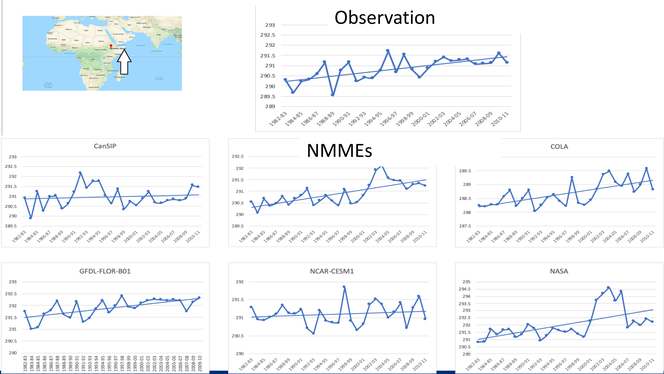
RPSS of lead-1 DJF Temperature



Temperature forecast for OND at Sep,2020



- In OLS, the AN probabilities are retained in tropics.
- Did GCM captured the Long term trend compared to observation?



6. Conclusions

- ELR is a more robust method compared to other calibration method based on the Gaussian assumption for precipitation.
- This method might not the best for Temperature forecast, however, temperature forecast has other challenges (trend?).