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CSIR Climate Modeling Highlights

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Introduction

- Initiatives aimed at reducing the uncertainty of climate predictions have undergone tremendous efforts over recent years;
- Despite tremendous progress, predicting many aspects of the climate system in midst of climate change pose immense challenges to climate models;
- Efforts to use ESMs (CHFP, NMME) in climate predictions (seasonal to inter decadal timescales) may advance the state climate predictions and their predictive potency that presumably arise form interactions among the ocean, cryosphere, atmosphere, biosphere, etc.
- Representing the relevant feedbacks and teleconnections in climate models may offer a source of predictability particularly for extratropics (mid-latitude) and polar regions which mostly found to be elusive as opposed to tropical climate predictability.
- This presentation is aimed at exploring some resent developments made at the CSIR in the space of climate modelling by placing emphasis on seasonal predictions.

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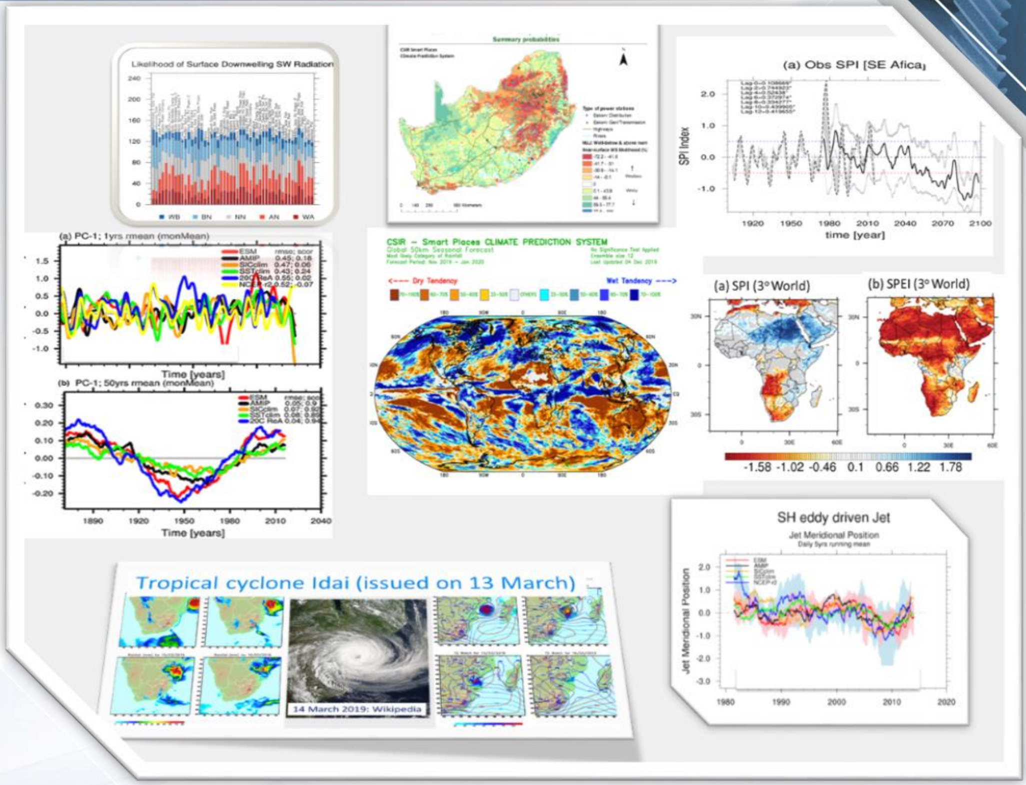
CSIR Seamless Forecasting System (SFS)

- CSIRO ESM couples ocean (Thatcher et al. 2015), atmosphere (McGregor and Dix 2008), biosphere (Kowalczyk et al., 2013) and dynamic sea-ice (O'Farrell 2004) models (also described in Beraki et al., 2020)
- All model components cast on a cube-based grid and can be applied either at quasi-uniform horizontal resolution to function as a global climate model, or in stretched-grid mode to function as a high-resolution regional climate model.
- C-grid uniformity is computationally economical as it negates the need for grid type or resolution reconciliation in message exchange
- A prognostic aerosol scheme with anthropic and O_3 forcings
- A dynamic river routing scheme adapted from the CSIRO Mk3.5 climate model.
- CSIR SFS uses the CHPC computational facility



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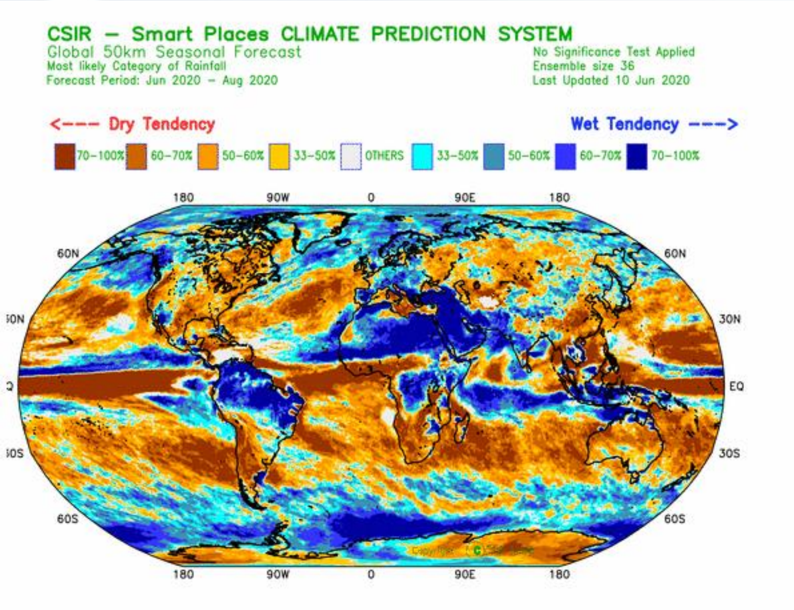
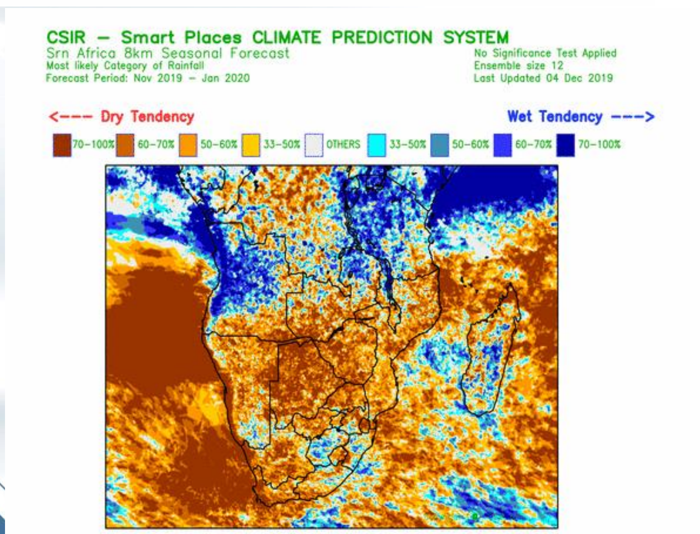
CSIR Seasonal Prediction System (prototype)

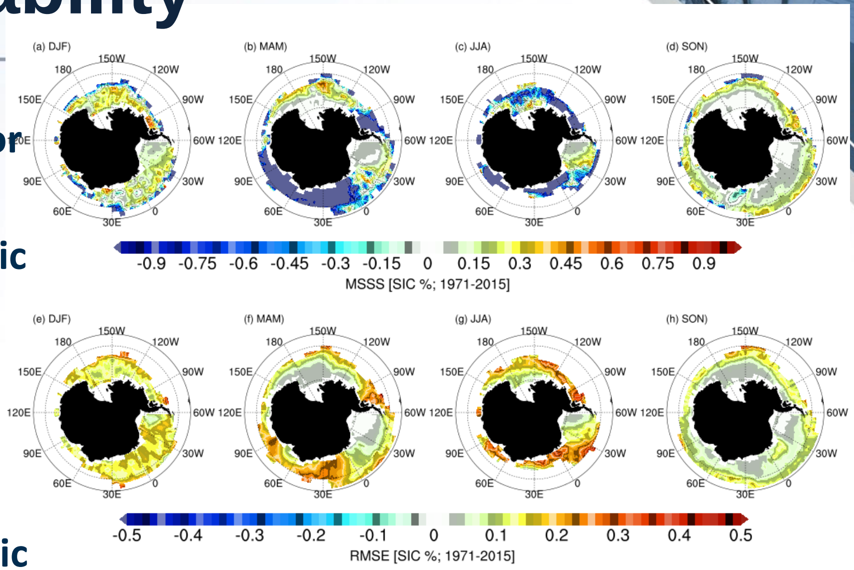


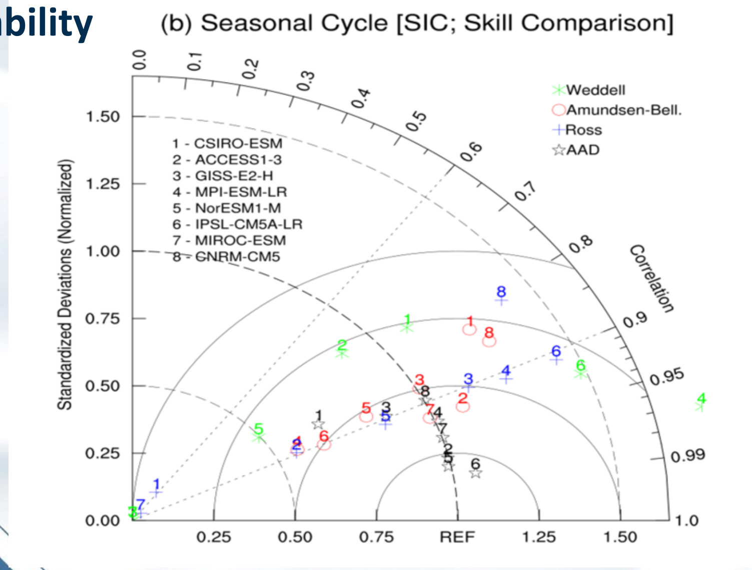


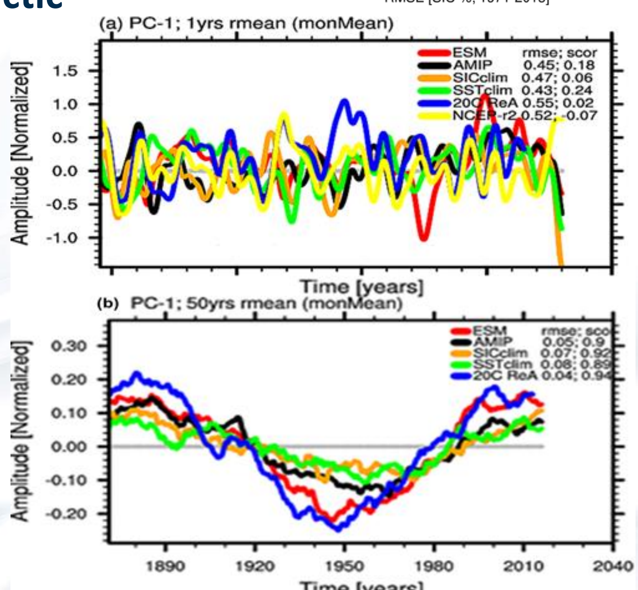
- The seasonal Prediction System uses C192G (~50km) global resolution with 18 and 36 ensemble size for hindcast (15yrs) and real-time respectively;
- C192G hindcast and real-time runs are initialized with NCEP R2 and GFS atmospheric states respectively;
- C192G Nudged with the NMME SSTs and observed SIC climatology;
- Forced with CMIP5 GHG and $O_{3;}$
- The RCM (C192R), a variable resolution (~8k over Africa), dynamically downscales the C192G.

SH Simulated Seasonal to interdecadal Climate Variability

- ESM SH SIC skill concentration is found where the error level is marginal, suggests model error is major contributor to weaken model fidelity.
- Southern Annual Model (SAM) is found to be chaotic at seasonal to interannual timescales but its longer slowly evolving signal might be predictable with a better outcome when the ocean + sea-ice models activated;
- Most models reasonably capture SH SIC seasonal cycle of various Southern Ocean basins and Antarctic sea-ice dipole (AAD) but with wider intermodel variability







(excerpts from Beraki et al., 2020)

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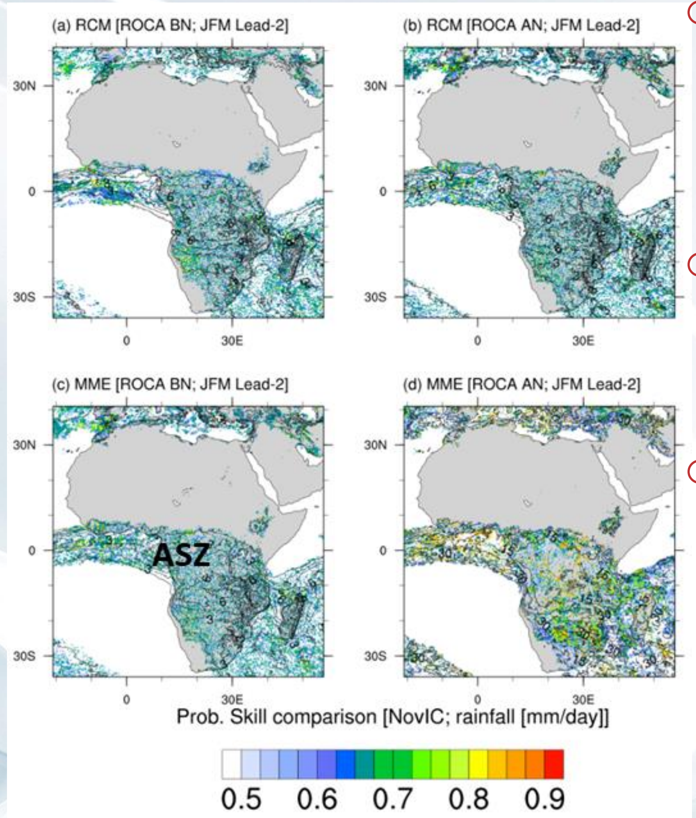
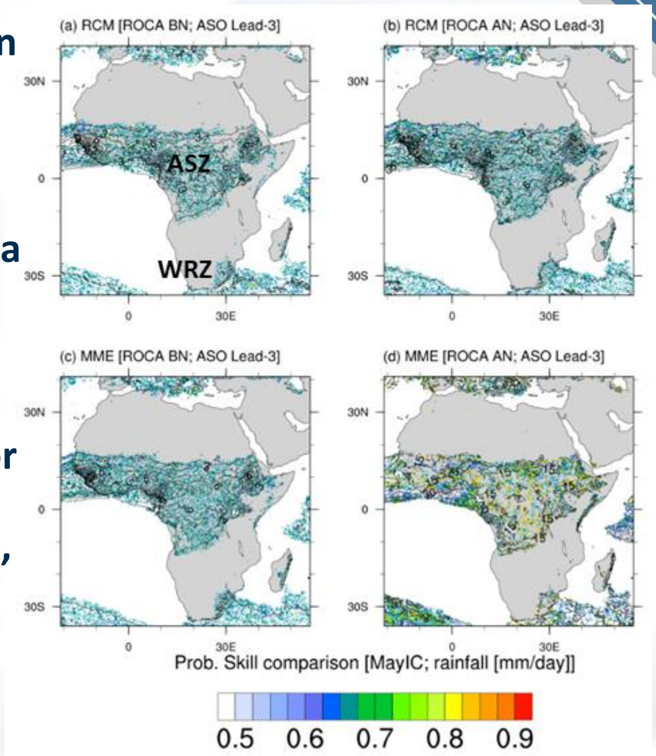
Probabilistic models' skills (African Monsoon)



- Model Rainfall probabilistic skill is diagnosed using ROC area (model's ability to discriminate events from non events);
- Suite of ESMs from the NMME and CHFP (both denoted as "MME") used as a benchmark (baseline skill)
- The models demonstrate statistically significant (95%; shades) probabilistic skills for the three rainfall regimes (ASZ – Austral Summer Zone, BSZ – Boreal Summer Zone, WRZ – Winter Rainfall Zone) although ROC area is not sensitive to model errors.
- The significance test is conducted using a variant of the Mann–Whitney nonparametric technique (Mason and Graham, 2002)



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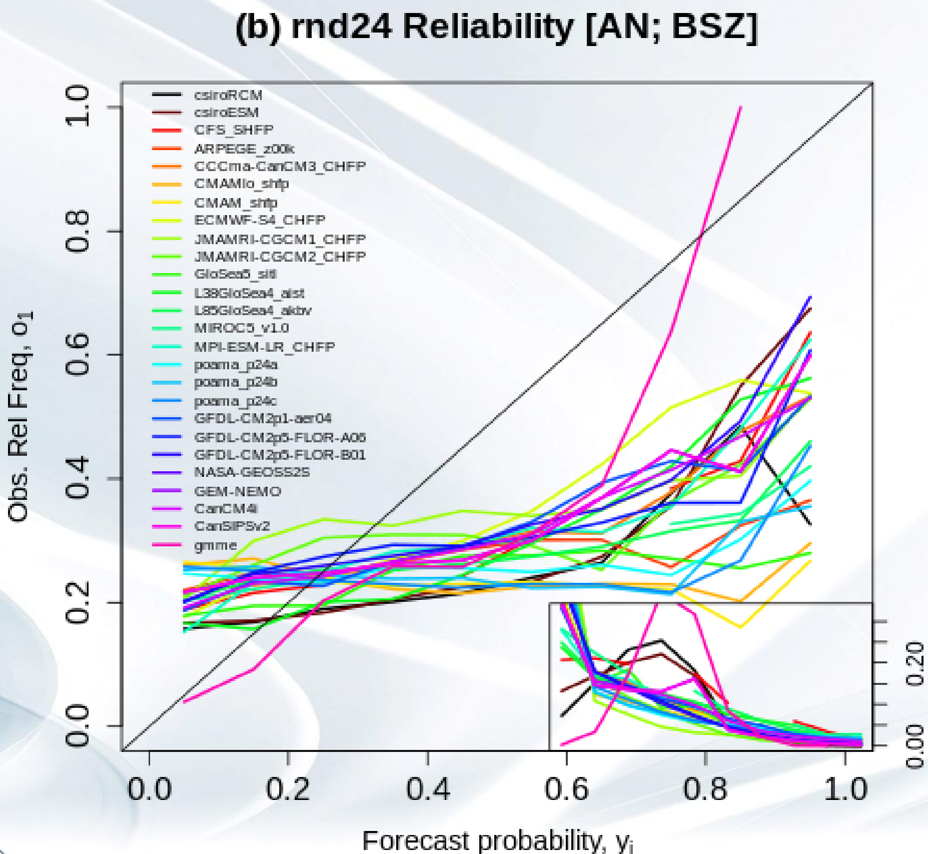
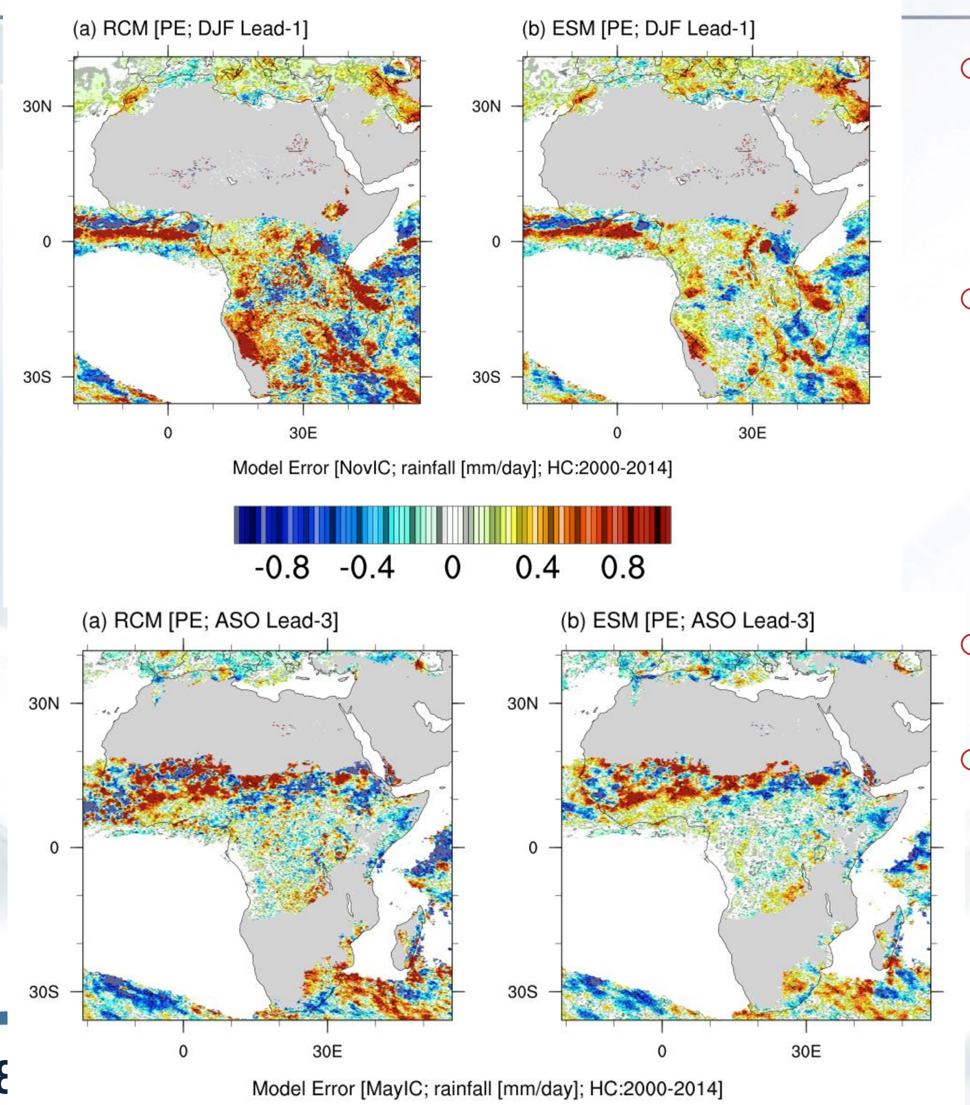
Probabilistic Model skills (African Monsoon)



- Suite of ESMs from NMME and CHFP reliability shown along with the CSIRO ERM and RCM analysis suggests predicting Boreal Summer Zone (BSZ; also a case for other zones considered in the analysis) exceeding 75 percentile (above-normal) rainfall mostly characterized by overconfidence syndrome.
- GMME (a combination of NMME and CHFP models) tends to improve the reliability substantially although its conservative frequency of use of near-climatological probability bins.
- Marginal gains in predicting rainfall from dynamical downscaling effort although the benefit may be manifested in other variables, constraining application models such as renewable energy and bias correction (on going process)

Possible sources of model errors



- Type of Model Errors are assessed with the decomposed components of the MSSS (Murphy, 1988).
- Phase error (PE; conditional error) is dominant type of error, suggesting model errors are intrinsic origin (presumably emerge from the underline climate processes).
- PE tends to propagate and amplify with dynamical Downscaling
- Sensible bias correction methods may help out to remove model biases and maximize the utility of climate predictions no matte how computetionally expensive or sophisticate models are used.

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Concluding Remarks and Way-forward

- Rainfall has tremendous societal relevance and multifaceted applications but its reliability remains low even with the use of most expensive and sophisticated models.
- Intrinsic model errors are found to play a major role in curving state-of-the-art climate models abilities particularly in reliably predicting rainfall.
- Dynamical downscales seemingly suffers heavily from the inherited errors with a tendency of dynamical growth and amplification and confronting model errors with robust bias-correction methods should be viewed an essential components of climate predictions to maximize the potential benefits (not a new recommendation but just to reiterate based the outcome 26 climate models).
- We are testing a range of bias correction methods such as inflation variance method (CSTools newly arrived R-Package) and Quintile Mapping (QM also available in R) as alternative to the widely used Model Output statistics (MOS) approach.

Acknowledgments

- CHPC for generously hosting computationally expensive the CSIR’s SFS
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- NCEP for making NCEP-R2 Reanalysis and GFS atmospheric states accessible
- Most of the analyses and graphics use NCL and R.

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Thank You!

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