[Thoughts about] Plans for Multi-Year NMME

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CIMAS/RSMAS

For the US CliVar Societally-Relevant Multi-year Climate Predictions workshop

30 March 2022

Protocol Workshop February 2020

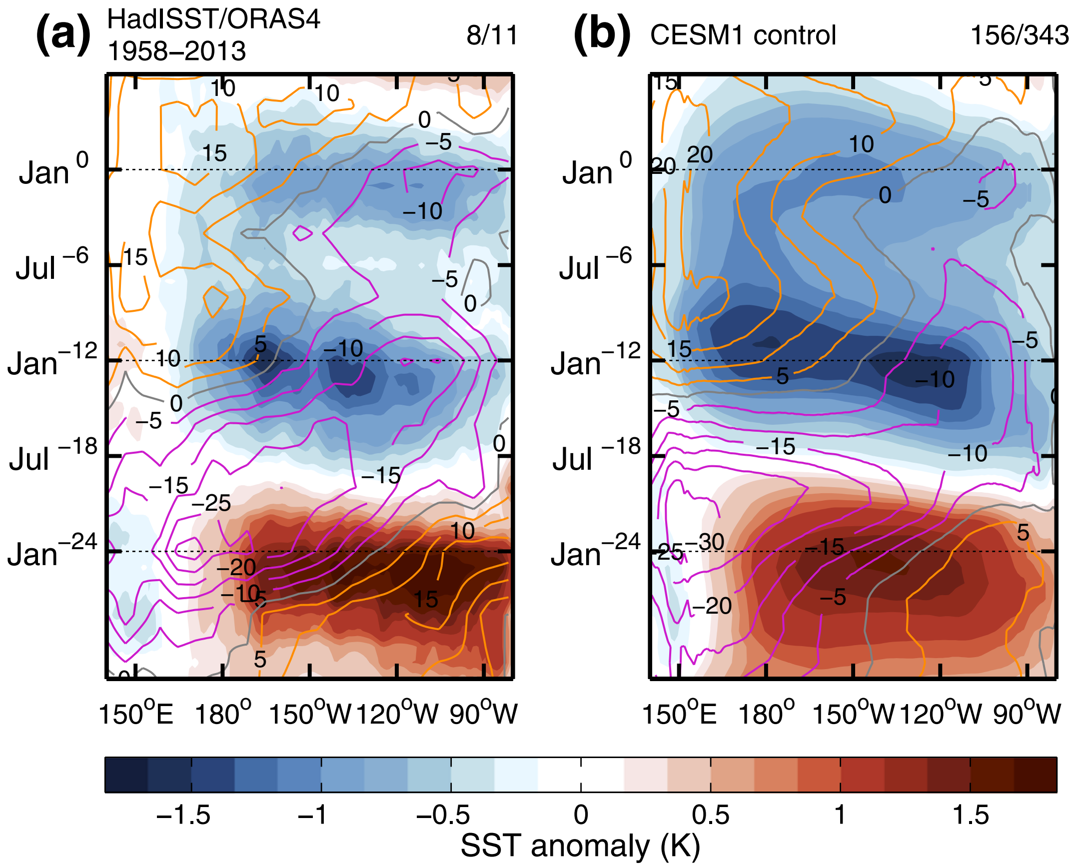
Draft Protocol Leveraging NMME and CMIP/DCPP

- Four Modeling groups (GFDL, NCAR, NASA, ECCC)

Participants

- Gerry Meehl, Steve Yeager, Haiyan Teng
- Tom Delworth, Charlie Stock
- Matt Newman, Mike Jacox, Mike Alexander
- Billy Sweet
- Ben Kirtman, Emily Becker
- Jim Kinter, Kathy Pegion
- Bill Merryfield
- Andrea Molod
- Andy Wood
- CPO
- OWAQ (now WPO)

1-Day in Person Meeting

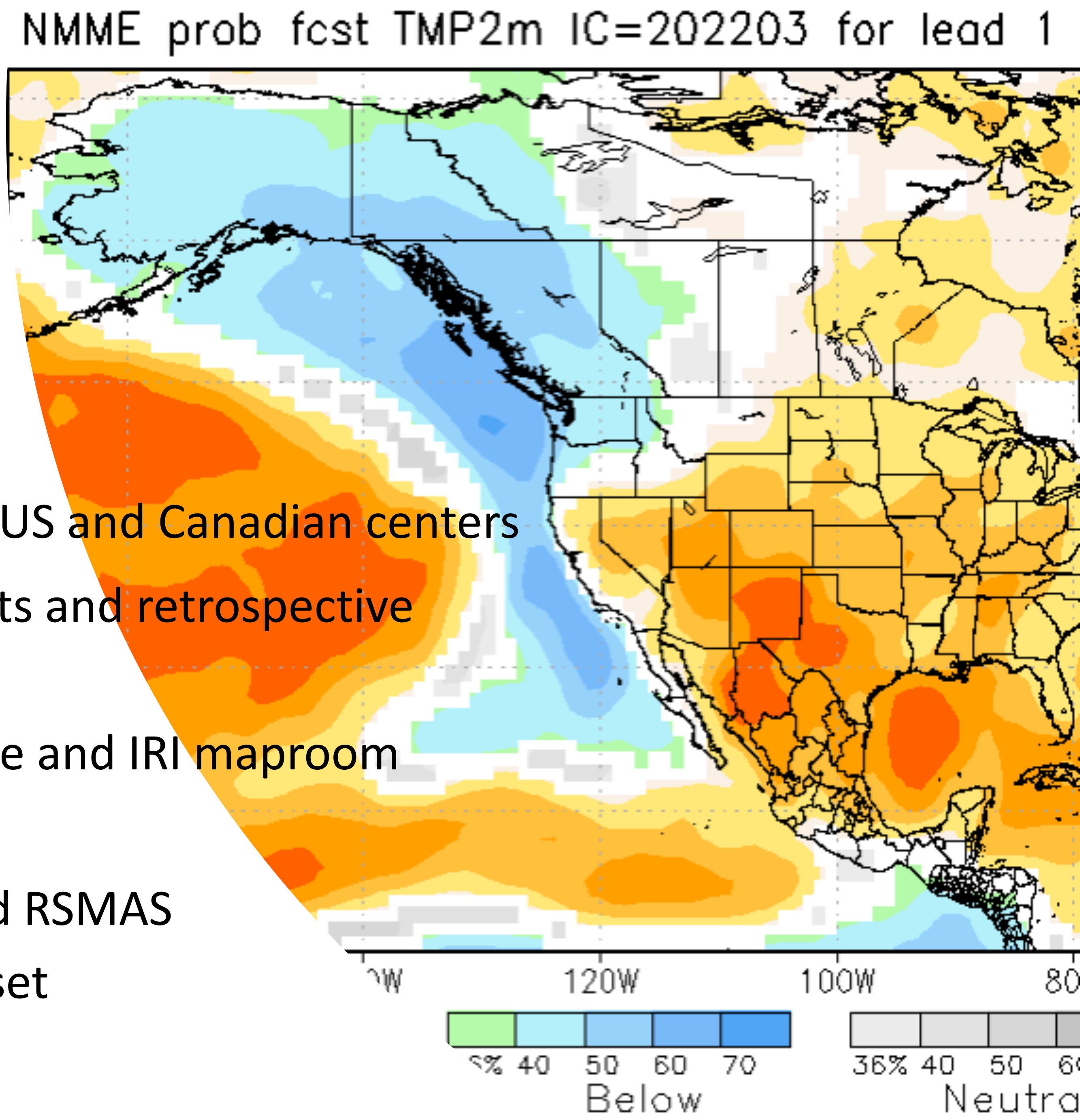


Goal of the potential project

- Bridge the gap between the seasonal and decadal multi-model efforts
- Monthly and seasonal means out to 36 months and near-term annual means (i.e., averages of months 18-30, 19-31, … 25-36)
- Predictability and potential forecast skill on these timescales stems from interannual ENSO variability, re-emergence processes of extratropical oceanic anomalies, land surface memory, and sea-ice processes, among others
- A large array of potential user communities exists for such interannual forecasts, as many entities have planning horizons one or more years into the future

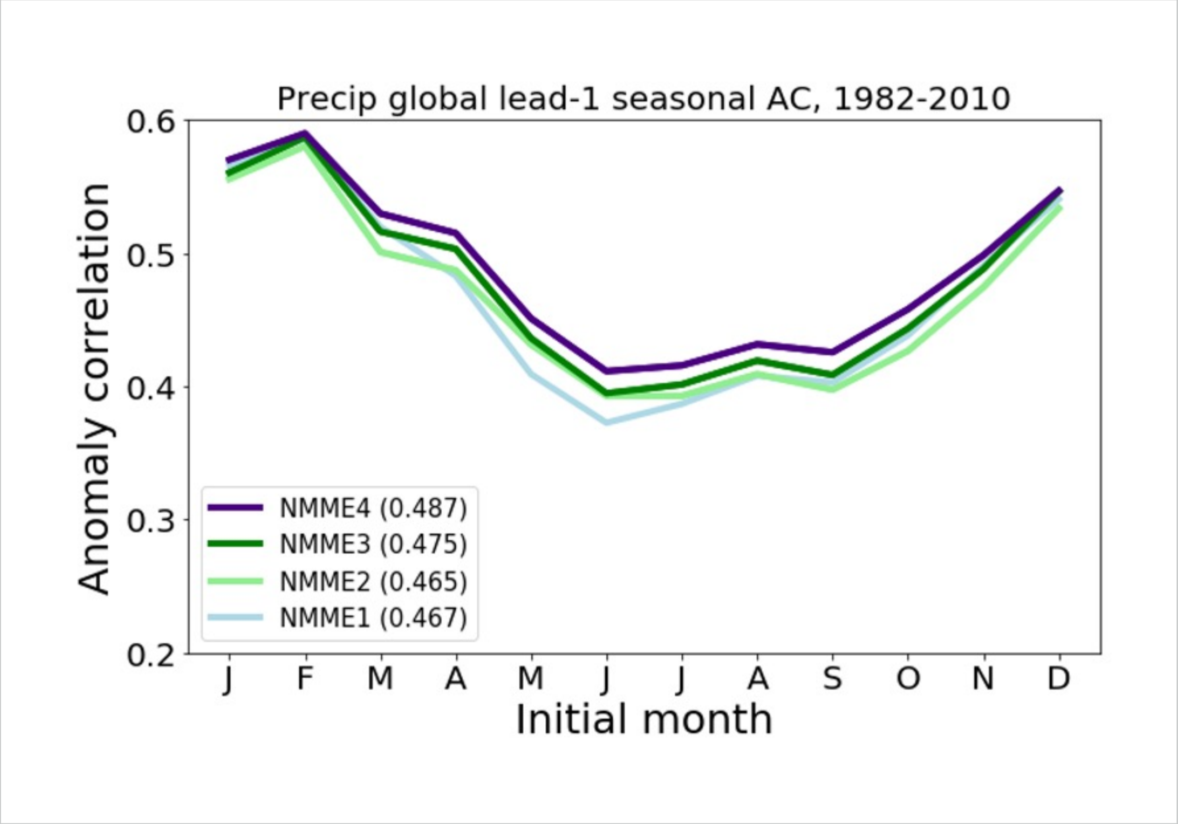
NMME overview

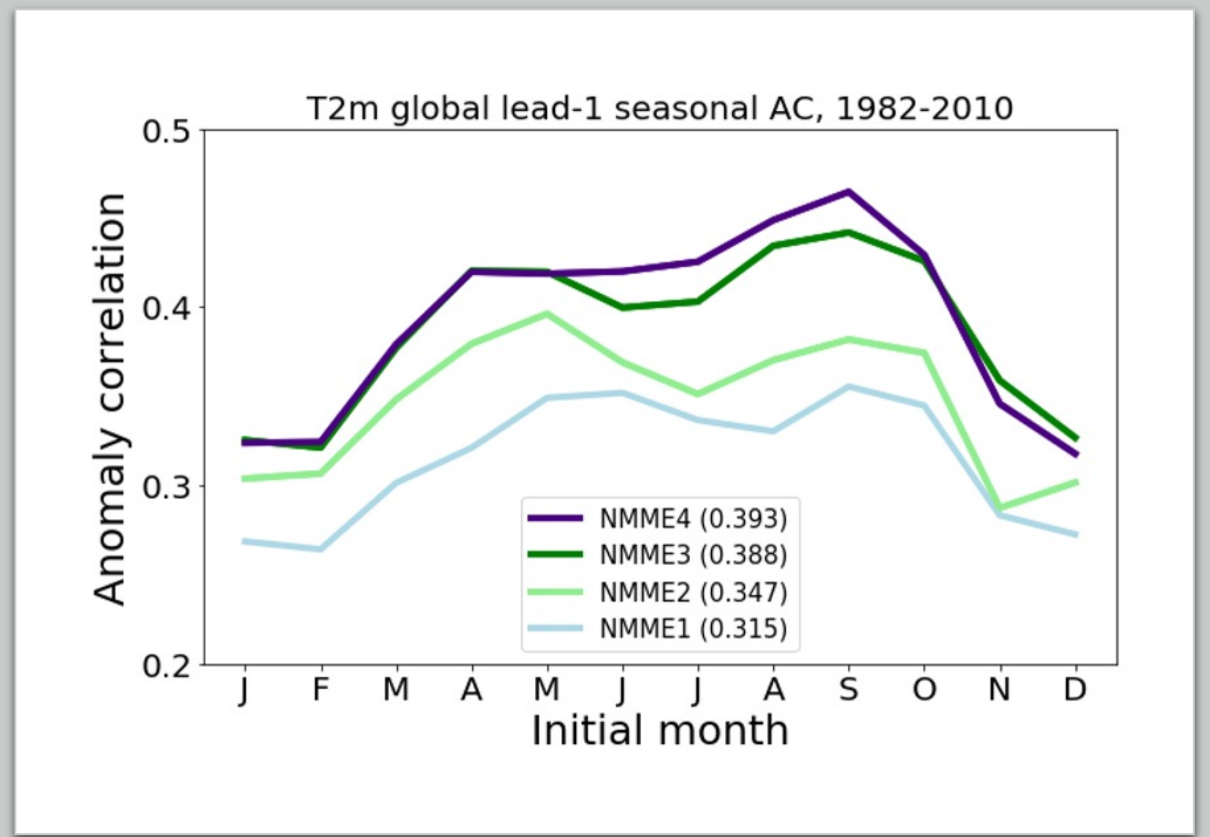
- Initiated in August 2011
- Research and operational models from US and Canadian centers
- Free, real-time availability of all forecasts and retrospective forecasts
- Real-time images posted on CPC website and IRI maproom
- 17 models/versions so far
    - upgrades 2022/23 for GEOS-S2S and RSMAS
    - only CFSv2 continues from original set



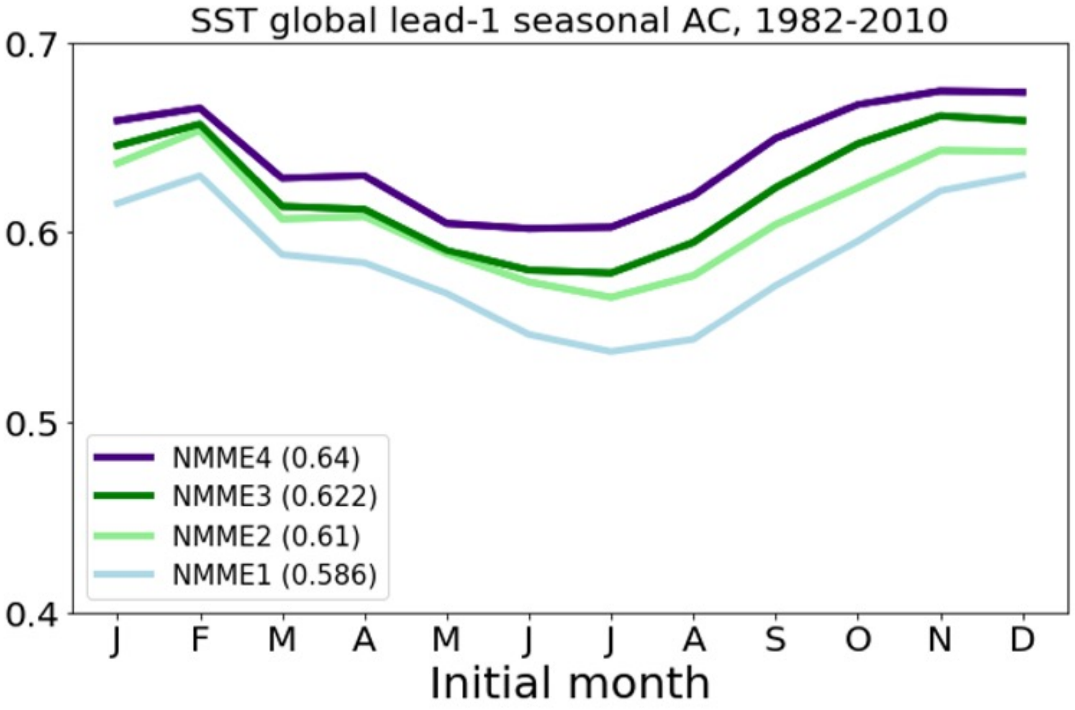
Change in 1982–2010 anomaly correlation from NMME 2011 suite of models to 2020 suite

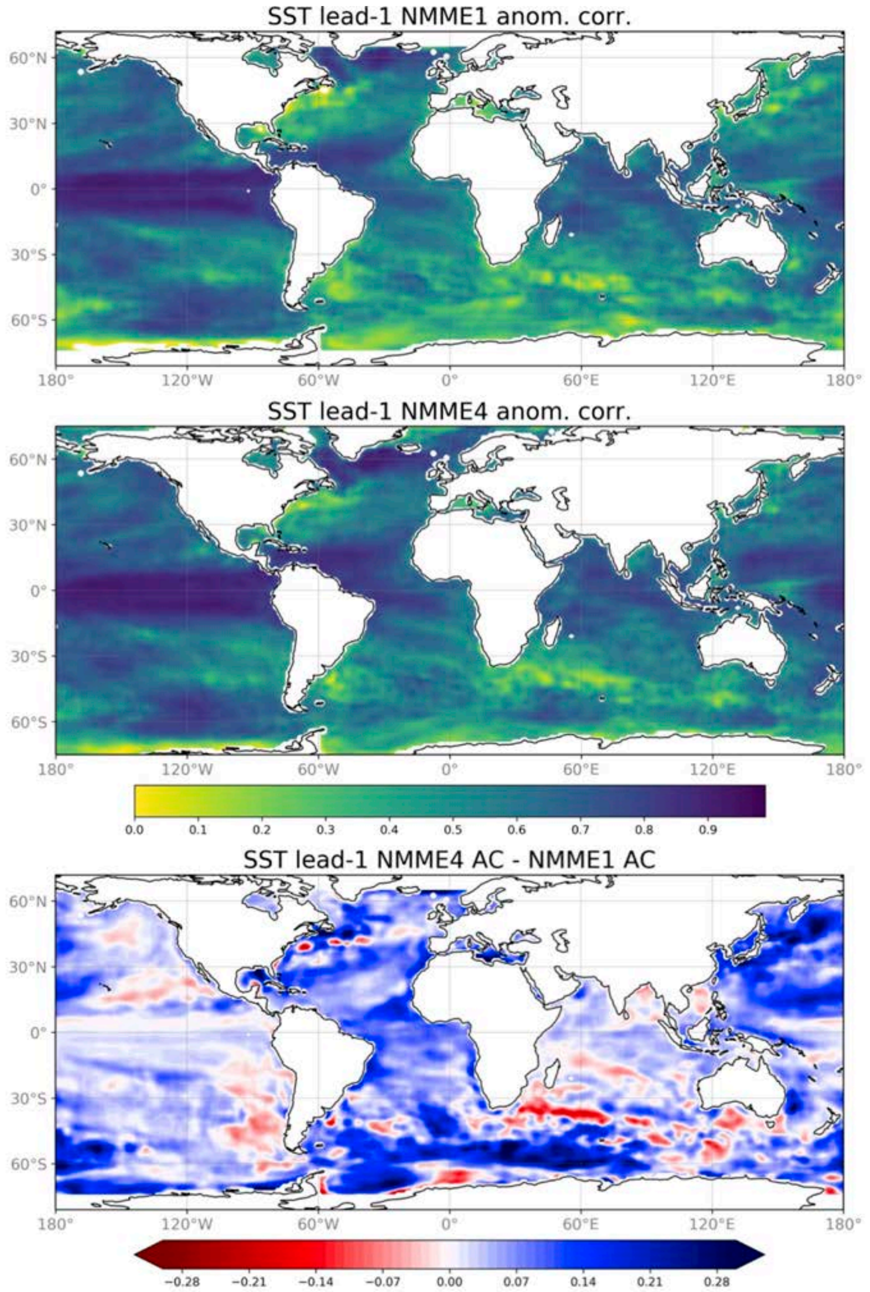
- Area-aggregate anomaly correlation (AC) for NMME hindcast (1982–2010) lead-1 seasonal prediction from all 12 initial months of 2 m temperature over all land gridpoints 60°S–75°N (left) and precipitation over all gridpoints land and ocean 75°S–75°N (right). Four combinations of NMME models are shown, representing four real-time suites. Annual average anomaly correlation for each combination is shown in parentheses in the legends. Land-only T2m average does not include Antarctica.



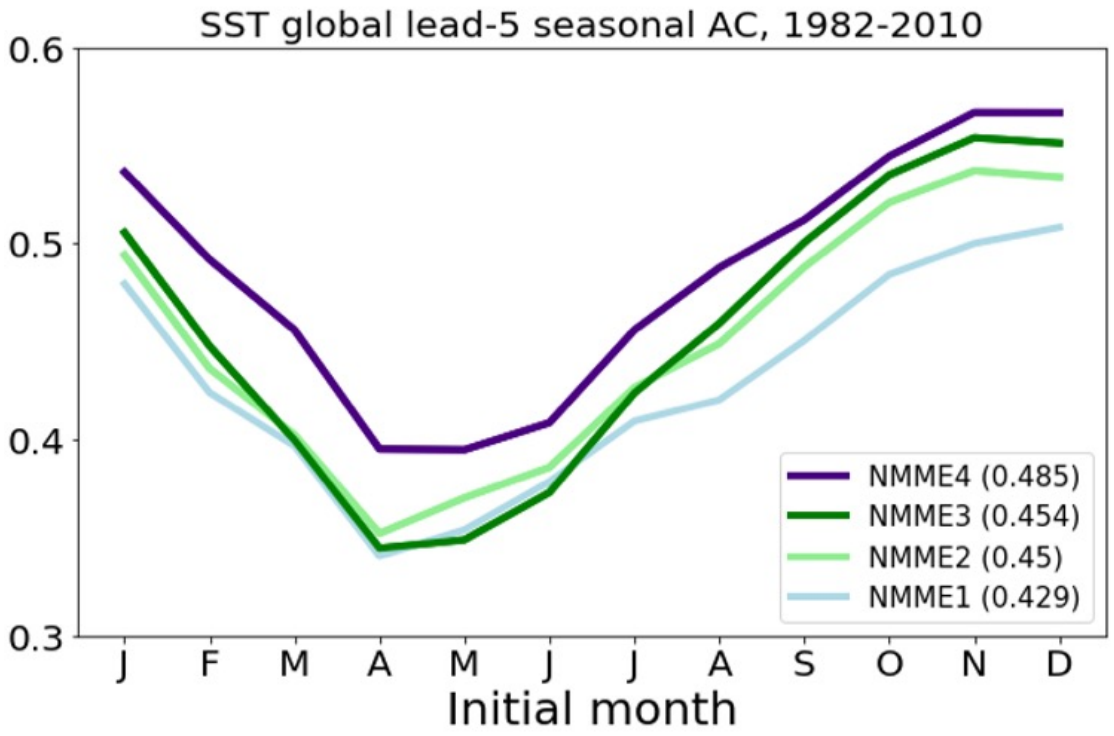


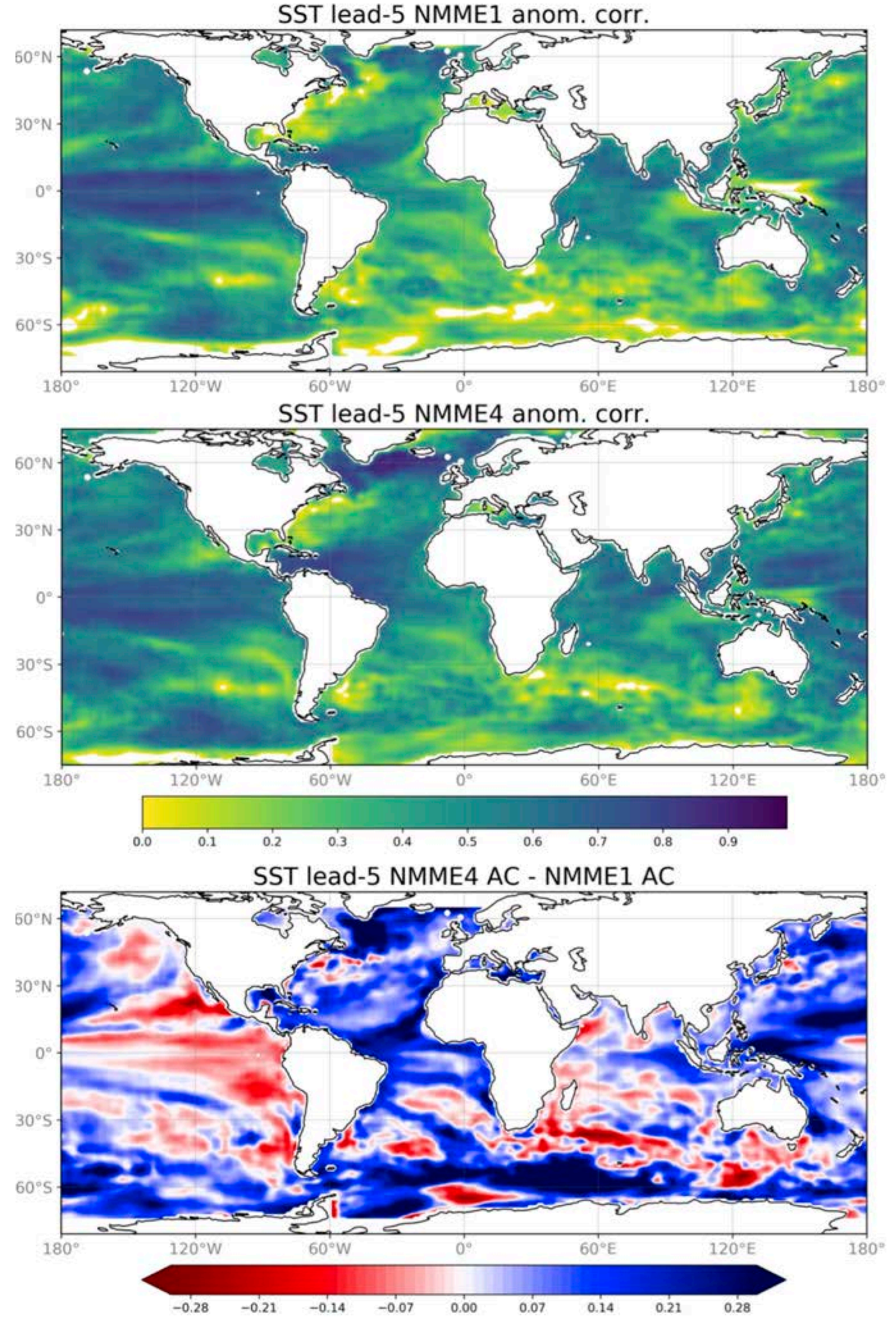
Lead-1 seasonal prediction of global sea surface temperature 75°S–75°N





Lead-**5** seasonal prediction of global sea surface temperature 75°S–75°N

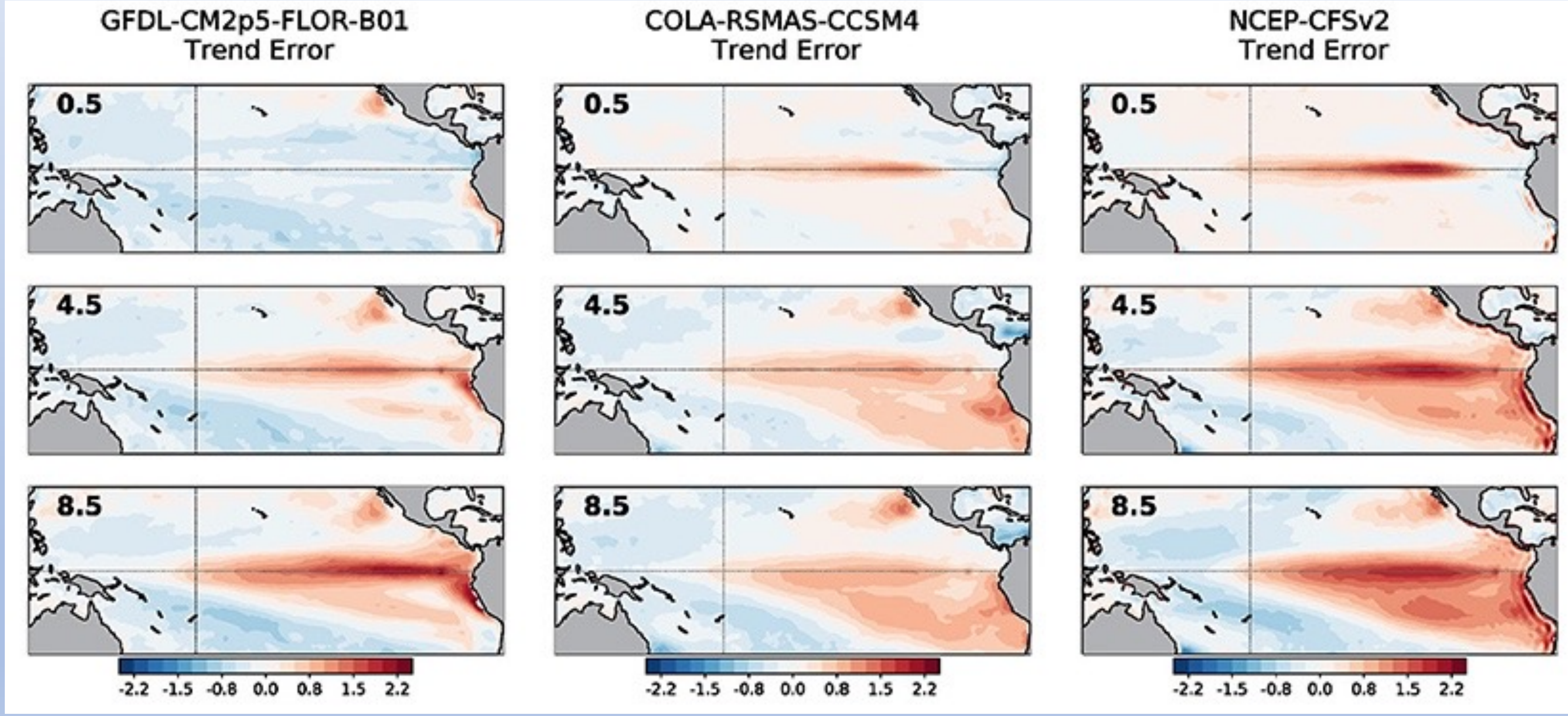




Difference between model SST trend and observed trend (1982-2020): Trend error grows with lead

0.5-month lead

8.5-month lead



L'Heureux et al. 2022

NMME lessons learned

- Well-vetted protocol
- Ease of data availability and visibility is key
- Resources are necessary for maintenance
- Training/documentation/basic scripts
- Regular research and operational discussions

Multi-Year Prediction Protocol Development

What's Distinct From Existing Decadal Prediction Efforts

Critical Issues

Draft Protocol Considerations

- Research Agenda
- Leveraging CMIP/DCPP and NMME
- Initialization Frequency, Retrospective Forecast Period
- What Fields to Save
- Data Hosting/Management
- Experimental Real-Time (Share with UKMO Effort?)

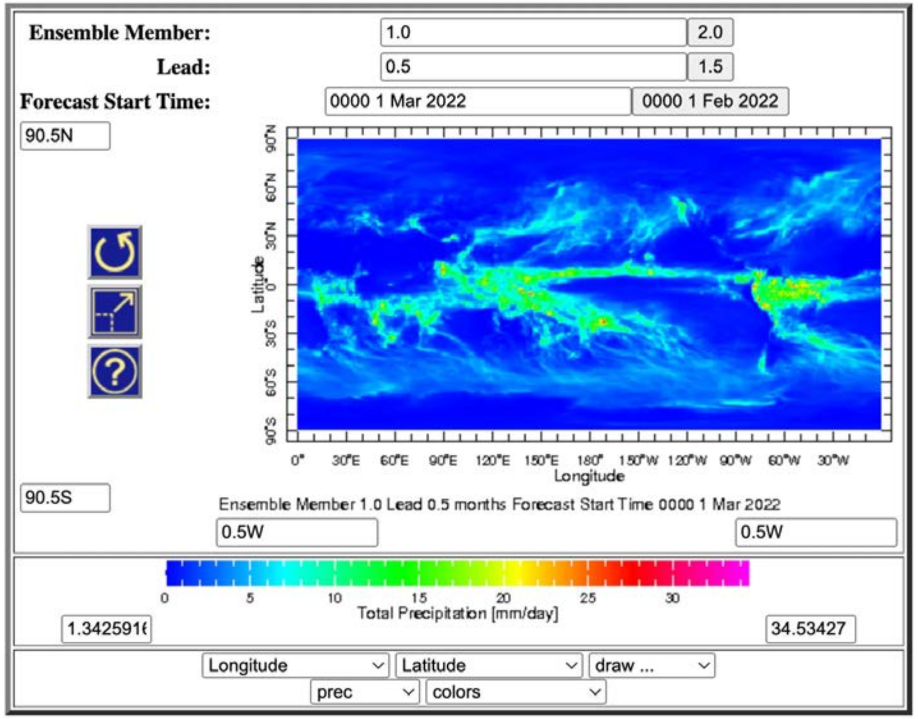
CMIP6/DCPP vs. Multi-Year Prediction

- Multi-Model
- Emphasis on Annual Mean or Multi-Year Mean
- Initialized Once Per Year
  - 5-Year Hindcasts, Initialized Every-Year from 1960 onward (end-of-year)
- Robust Data, not “real-time”
- UKMET “Real-Time”
  - Limited Annual Mean Data
- DPLE (NCAR)

- Multi-Model
- Emphasis on Monthly or Seasonal Means
- <u>Initialized Multiple Time per Year</u>
  - Protocol TDB
- Robust Data
  - Emphasizing: Coastal Prediction (NOS), Marine Heat Waves and Other Marine Ecosystem Use (NMFS), e.g.
- Real-Time

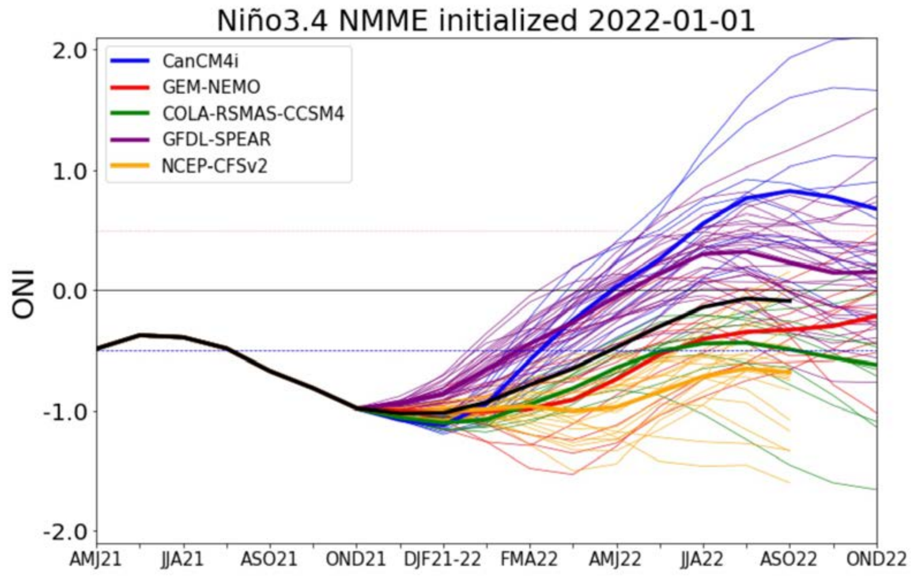
Data storage and management

- The database host must have adequate space and an accessible interface and management system to ensure users can obtain data in a straightforward manner.
- Effective virtual map room or other display capability for hindcast quality assessments and real-time forecasts
- Raw data will be made available at daily and monthly resolutions; the team will explore the viability of providing derived quantities such as climate indices or seasonal or longer-term means.



Initialization frequency/timing

- Initialized frequently enough to provide predictions for varying periods, such as regional water years (e.g. May-April), agricultural seasons at long leads, fisheries planning, etc.
- It is estimated that four initializations per year would provide the temporal resolution necessary to meet prediction requirements for these stakeholders
- Optimal initialization months will be defined through discussion with the proposed user communities.



Research priorities; project assessment

- The team will develop a set of predictability and prediction research questions to focus initial research activities
- It is anticipated that the research community will design independent studies, and the team will maintain open communication with the research community to compile a record of studies using the proposed database.
- Initial research foci will include assessments of interannual (heterogeneous and homogeneous) predictability and mechanisms of predictability.

The proposed program would include ongoing performance assessments, both of traditional skill metrics (correlations, skill scores, etc.) of hindcasts and forecasts, and use/application assessments to optimize the utility of the forecast system for the applications communities.

Draft protocol from 2020 workshop

- Retrospective forecast period of 1982-present is preferable. Some models may not have consistent hindcasts starting in 1982; these should provide the maximum number of retrospective forecast years possible.
- Forecast length 36 months minimum.
- Minimum ensemble size of 10.
- Initialization frequency at least four times per year.
- New/replacement models must be quality controlled by model provider.
- Hindcast and realtime model must be identical.
- Output data requirements
  - Data output on 1°-longitude by 1°-latitude grid
  - Total fields will be contributed
  - All ensemble members will be contributed (i.e., not ensemble mean)
  - Land-sea mask must be provided
  - Missing values must be specified consistently
  - Variables must be named consistently

NMME Seasonal prediction

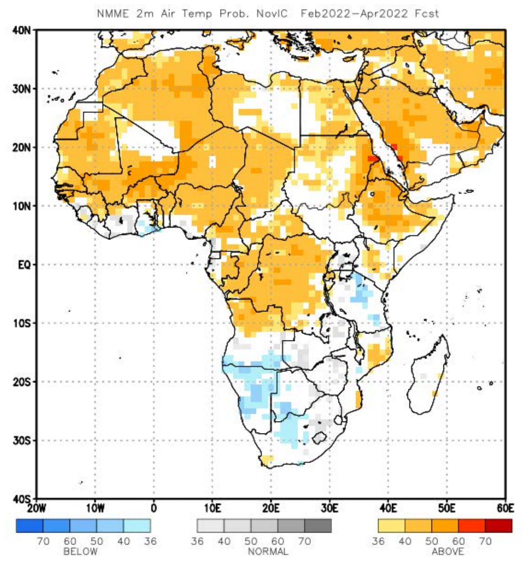
Precip & T2m

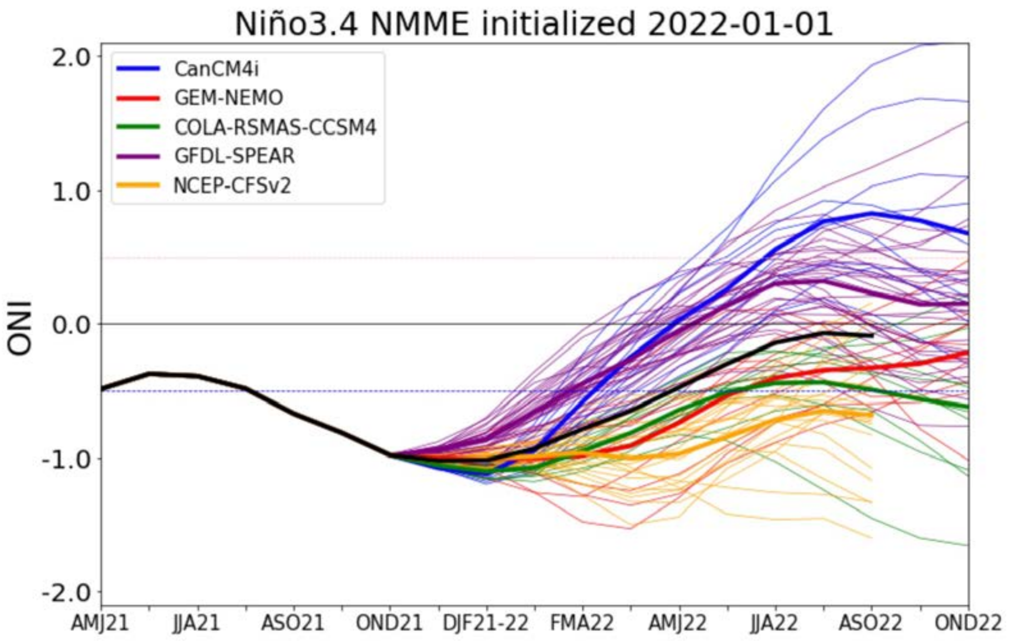
- Regional predictions include precipitation and/or temperature in northeast Brazil, Iran, Israel, the Sahel, and the Indian summer monsoon
- Statistically downscaled NMME predictions, and predictions aggregated to watershed or basin-scales, have been explored for regions of the U.S. by several groups
- NOAA's International Desks

ENSO prediction

- Niño-3.4 plumes first available in January 2012
- Still has a real problem with the spring predictability barrier! (Barnston et al. 2019; Tippett et al. 2019)
- Potential for a skillful forecast for 7 categories (Tippett et al. 2019, L'Heureux et al. 2019)

Marine heatwaves (Jacox et al. 2022)





NMME Applications

Global monthly fields from NMME used to force specialized models

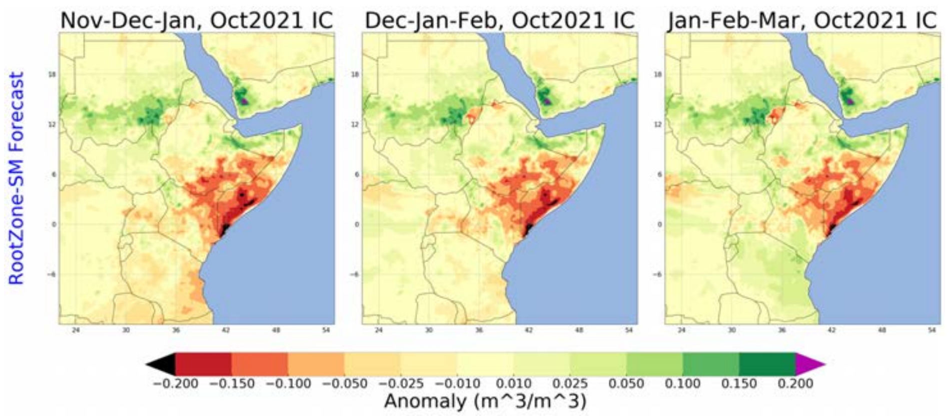
- Climatic suitability for invasive insects, malaria, mosquitos
- Coffee yield in Central America
- Hydropower planning
- Model-analogue ENSO prediction
- Global seasonal fire activity

Hybrid dynamical-statistical prediction systems

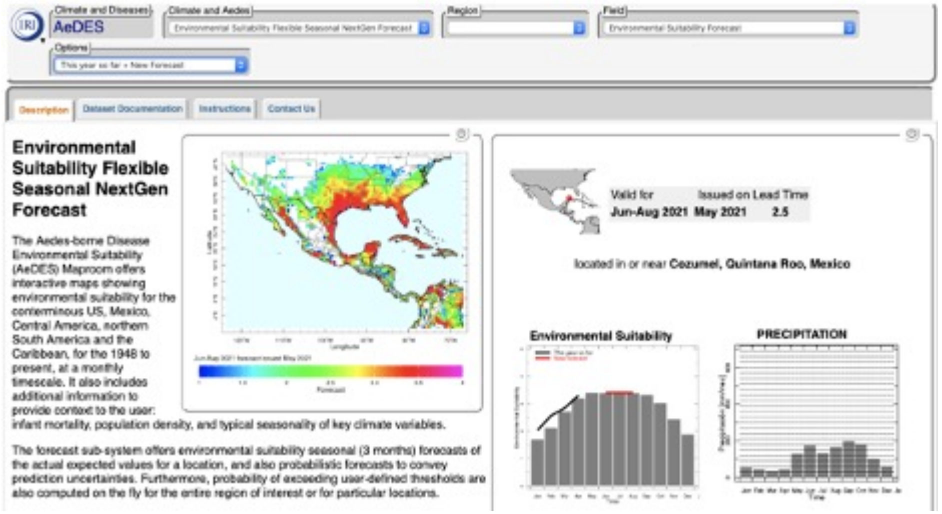
- Tropical cyclone activity
- Hydrological applications: regional drought prediction, streamflow, NASA's NHyFAS system [right upper]
- Seasonal tornado prediction
- Coastal flooding

IRI's NextGen approach [right lower]

- A systematic general approach for co-designing, implementing, producing, and verifying objective forecasts at multiple timescales



Example map from NASA's NHyFAS website (https://ldas.gsfc.nasa.gov/fldas/models/forecast) showing the root zone soil moisture prediction for Africa based on October initial conditions.



Example of the NextGen forecast system from the IRI's website.

NMME Research

Statistical methods

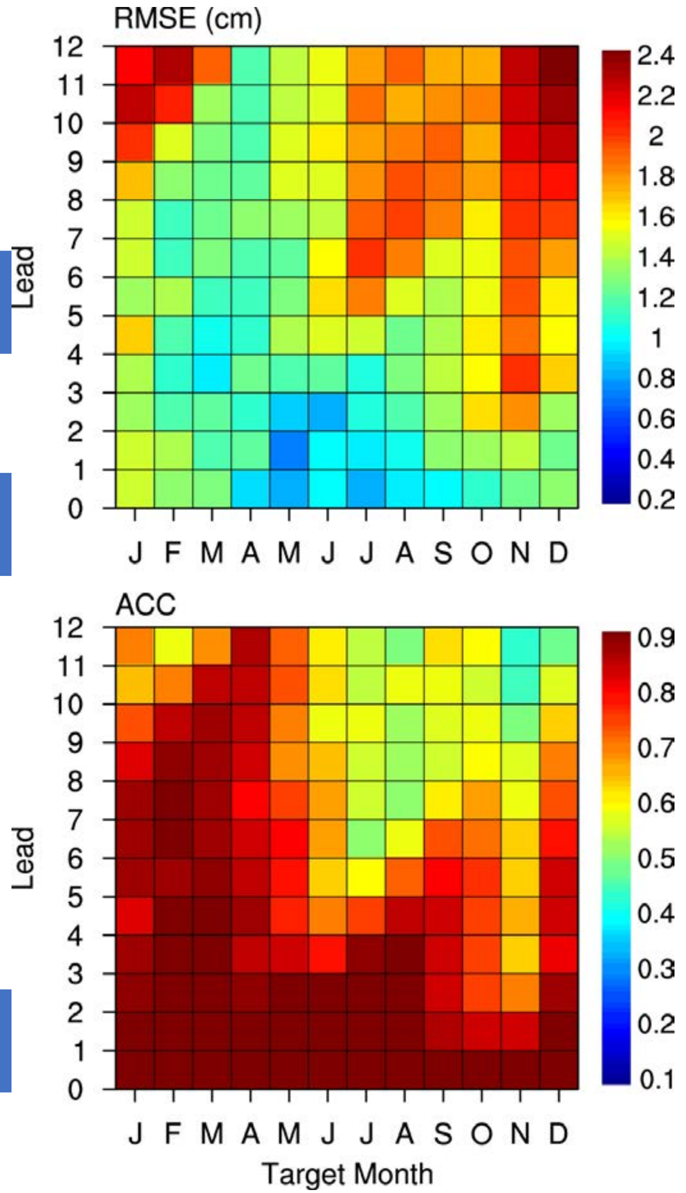
- Established and novel bias correction and calibration
- Multi-model ensemble techniques

Predictability

- Predictability of regional t2m & precip
- ENSO, asymmetries in ENSO prediction,
- Predictable component of Z200
- NAO/ENSO
- Hydrological extremes
- Characteristics of precipitation
- etc. etc.

Trends

- model trend representation
- trend correction potential



NMME ensemble mean forecast skill for the recharge-discharge (SSH_w) for all lead-times and target months as computed via the RMSE (top panel) and anomaly correlation coefficient (bottom panel). From Larson & Pegion (2020)