Charting a Path Forward at the Climate Prediction Center

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Outline

- Core values
- Examples of strategic product development in collaboration with partners
- Examples of gaps that need to be addressed
  - Improved Forecast Tools (Seasonal as example)
  - More user-friendly products
- Foundational activities to support CPCs mission
- My top priorities for next one to two years
- Climate Testbed
- CDPW Report

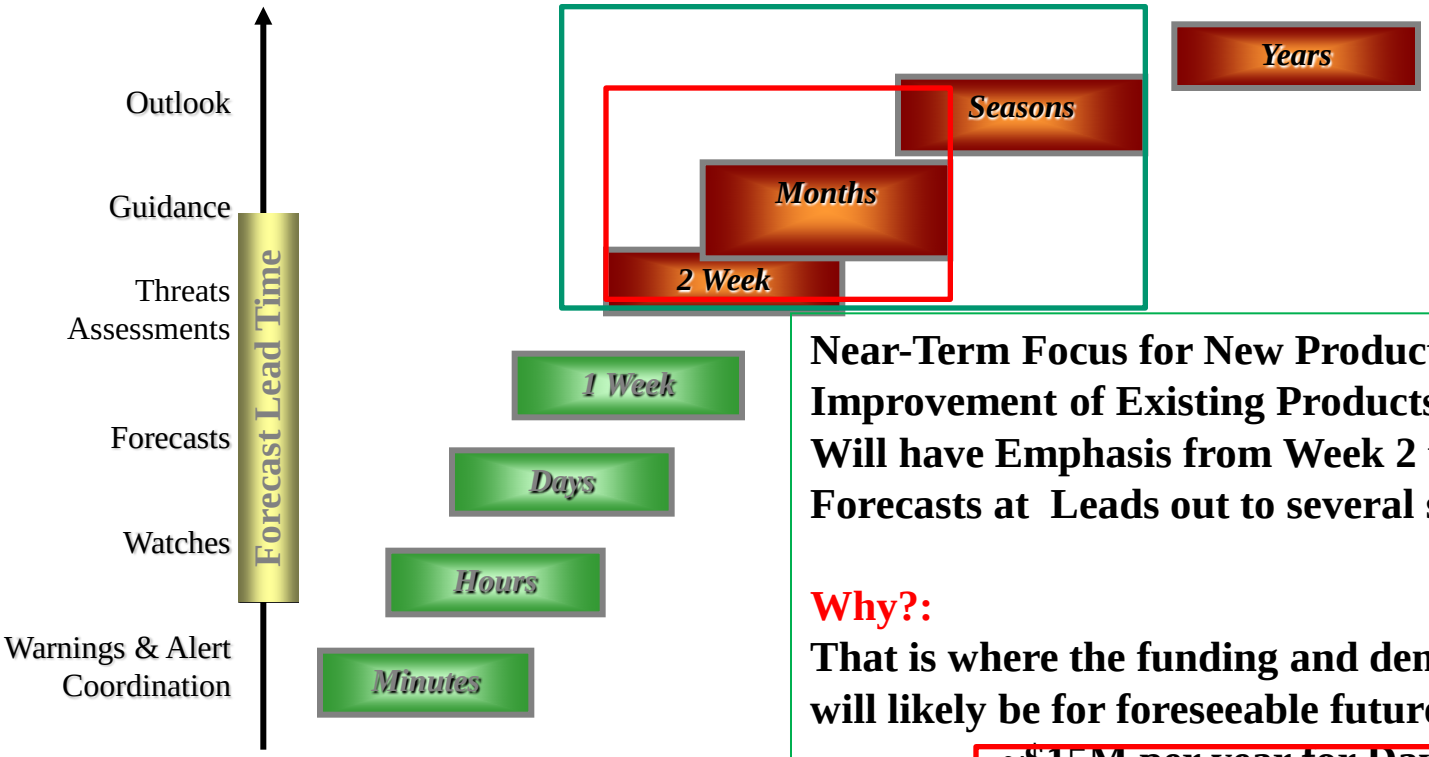
Core Values

- Need to have focused product development and supporting research. (Working on everything diminishes our ability to work on highest priorities).
  - Timescale of products
  - Need to balance requests for new products with current state of the science. Educate customers about skill profile of products and potential products.
    - Need to maintain our status as authoritative source of credible short-term climate information.
- Vigorous collaboration with partners:
  - Short-term climate forecasting and monitoring is a difficult problem and we need to engage the whole community to be successful.
  - Co-development (ideally from the beginning) but we can't be dogmatic (examples shown later).

Core Values

- Transparency in research and development
  - Educate people about what we are working on and why.
  - This will enable more effective collaboration
- Acknowledgement of strengths and weaknesses of products and tools (example shown later)

CPC Near-Term Focus within NOAA Seamless Suite of Forecast Products



Near-Term Focus for New Products and Improvement of Existing Products Will have Emphasis from Week 2 to Seasonal Forecasts at Leads out to several seasons.

Why?:

That is where the funding and demand are and will likely be for foreseeable future.

~$15M per year for Days 1 to 30
~$5M per year for Weeks 3-4

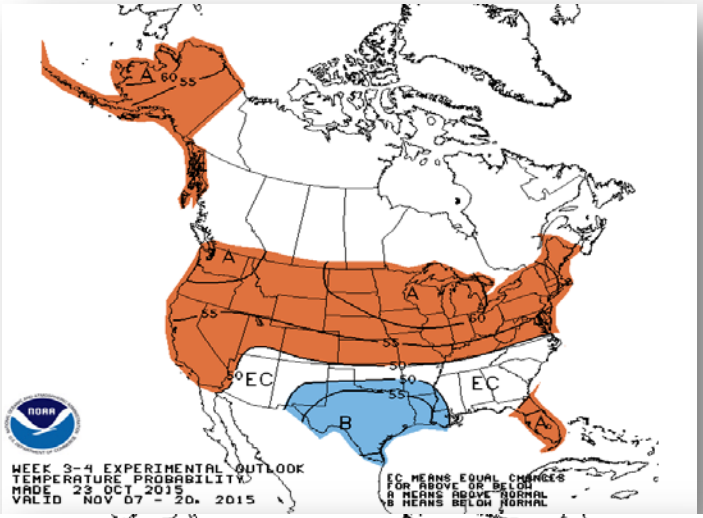
Longer timescale is important but is handled by other parts of NOAA.

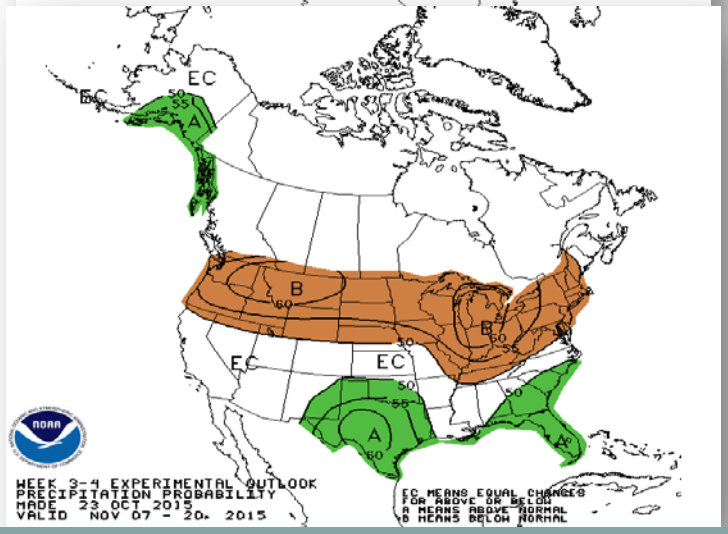
Strategic Product Development Leveraging Partnerships: Experimental Week3-4 Temperature and Precipitation Outlooks

CPC started issuing Experimental combined Weeks 3-4 Temperature and Precipitation Outlooks on September 18, 2015.

- Cross-branch activity within CPC with contributions from **Scripps/GFDL, ESSIC, and ESRL PSD.**
- Utilizes dynamical model output from CFS, ECMWF, and JMA.
- Utilizes **statistical tools** including:
  - MJO-ENSO Phase Model (**CTB project.)**
  - Coupled Linear-Inverse Model (C-LIM).
  - Constructed Analog
- Issued once per week on Friday afternoon
- Forecasts are 2-class (above/below) as opposed to traditional 3-class tercile probabilities.
- Users can provide feedback on product via web
- Forecasts of opportunity depending on presence of large-scale climate drivers

Forecasts Valid for Nov. 7-20, 2015

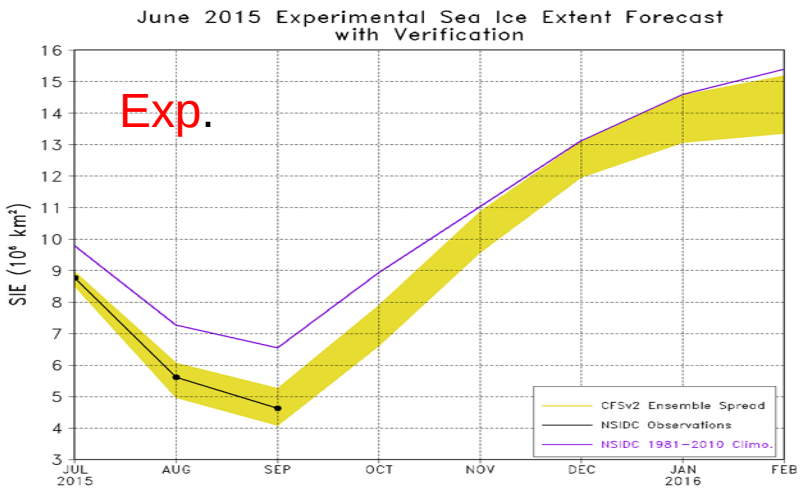


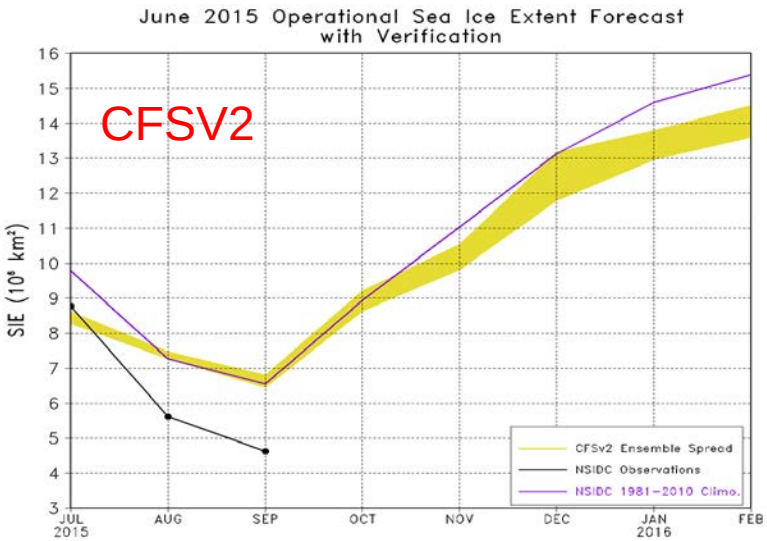


Strategic Product Development Leveraging Partnerships: Experimental Seasonal Arctic Sea Ice Outlooks

<u>CPC started providing Experimental</u> Arctic Sea Ice Outlooks to the NWS Alaskan Region in March 2015.

- Outlooks are issued once per month for March to October ICs and extend for 9 months.
- 3 Improvements over baseline CFSV2 system::
  - Improved sea-ice initial conditions (PIOMAS from U. Washington).
  - Modified atmospheric physics (stratus clouds)
  - Modified ocean physics (heat flux constraint)





Generation of Seasonal Forecasts at CPC

Human Forecasters Use Various Tools To Develop Seasonal Predictions:

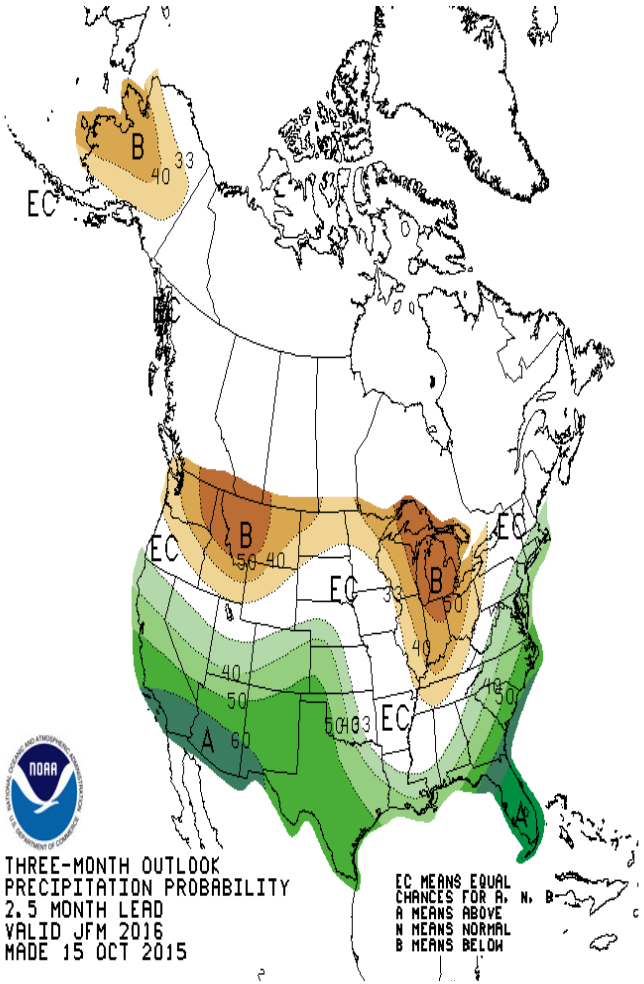
- Dynamical Models
- Statistical Models
- Historical Analogs
- Historical Composites

Goal is to leverage complementary skill between the tools.

Ultimately, skill of seasonal forecast depends on skill of tools made available to the forecaster.

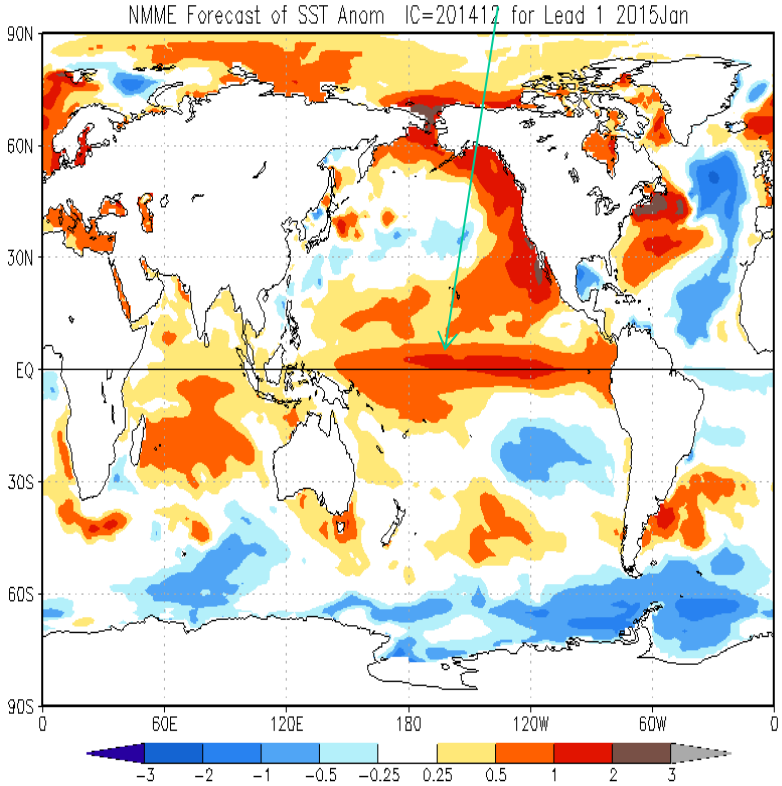
Need to improve skill of forecast tools.

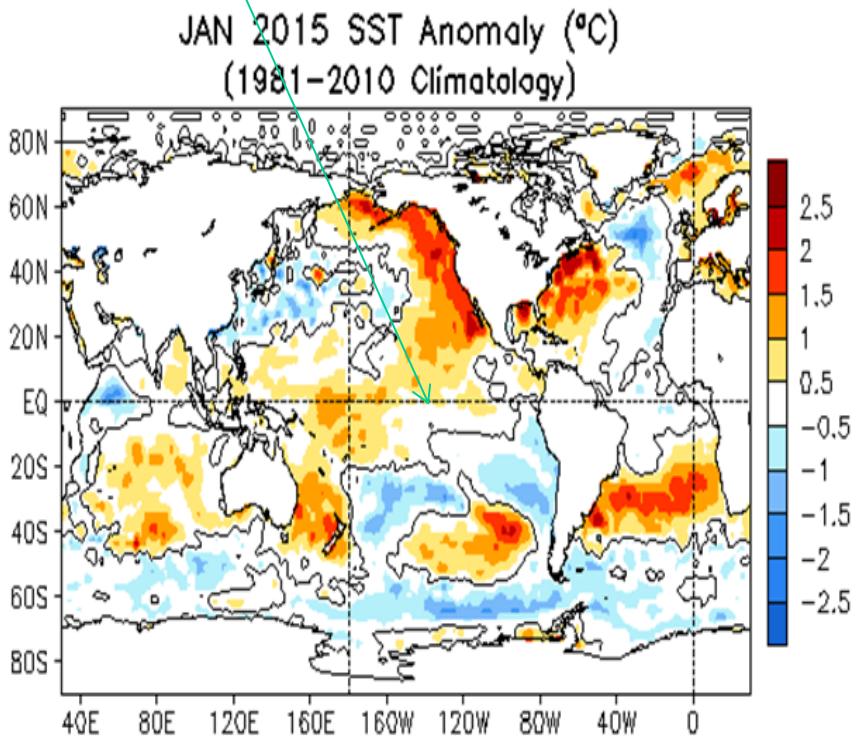
Need to invest in development of statistical tools.



Need to acknowledge strengths and weaknesses of tools
Lead 1 NMME SST Forecast Bust for January 2015

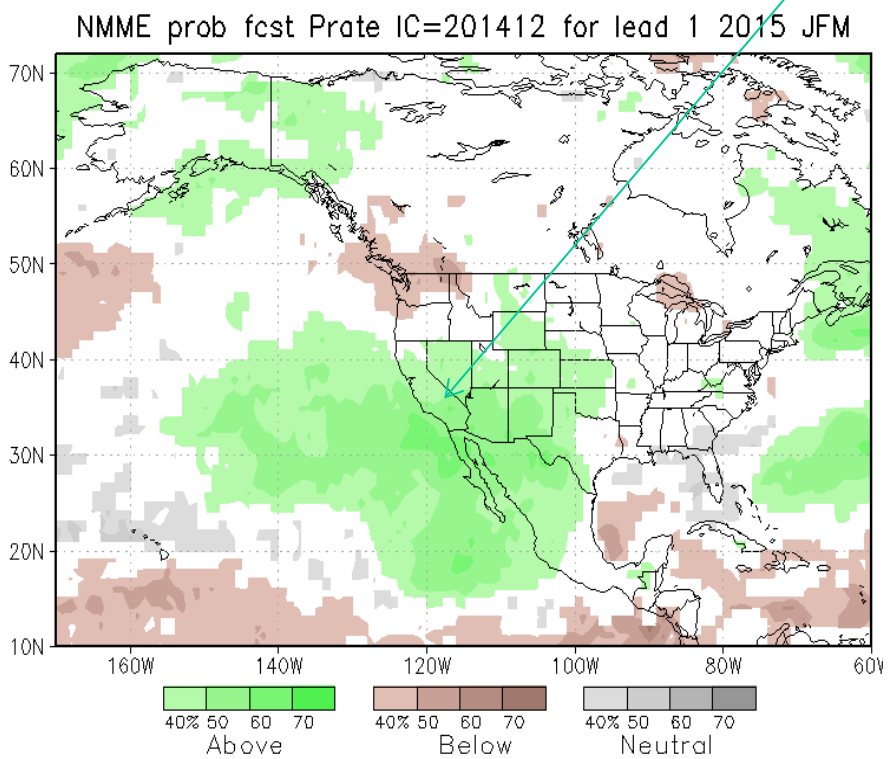
1 month lead NMME forecast calls for moderate cannonical El-Nino while observed anomalies were confined to western Pacific. Indicates gap in understanding of air-sea coupling processes.

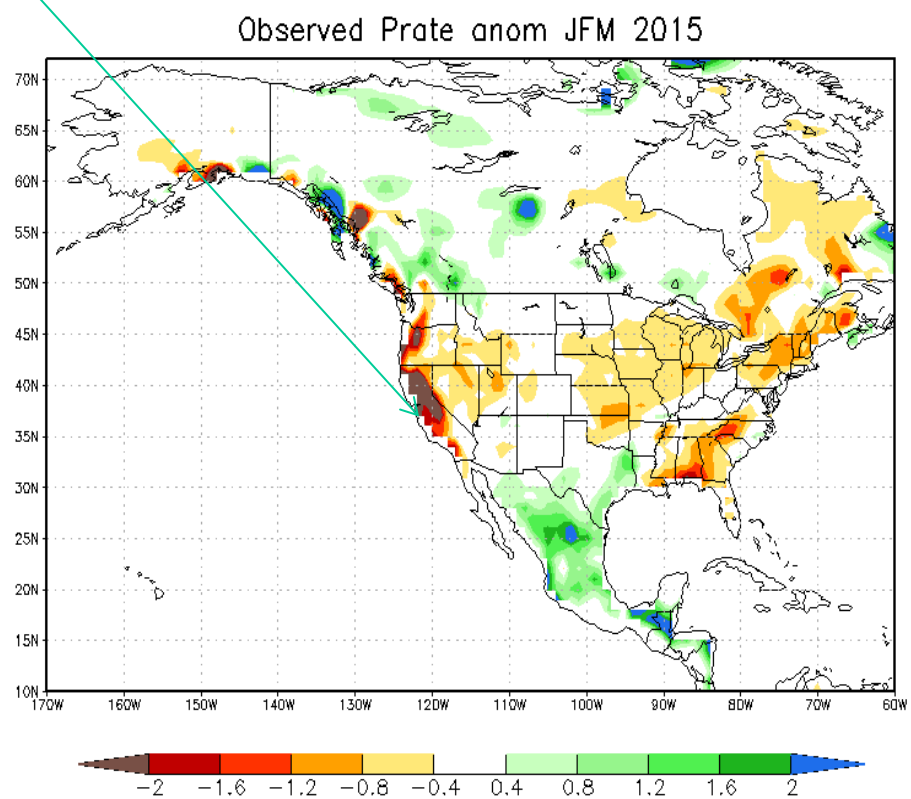




Need to acknowledge strengths and weaknesses of tools
Lead 1 NMME Precipitation Forecast Bust for JFM 2015

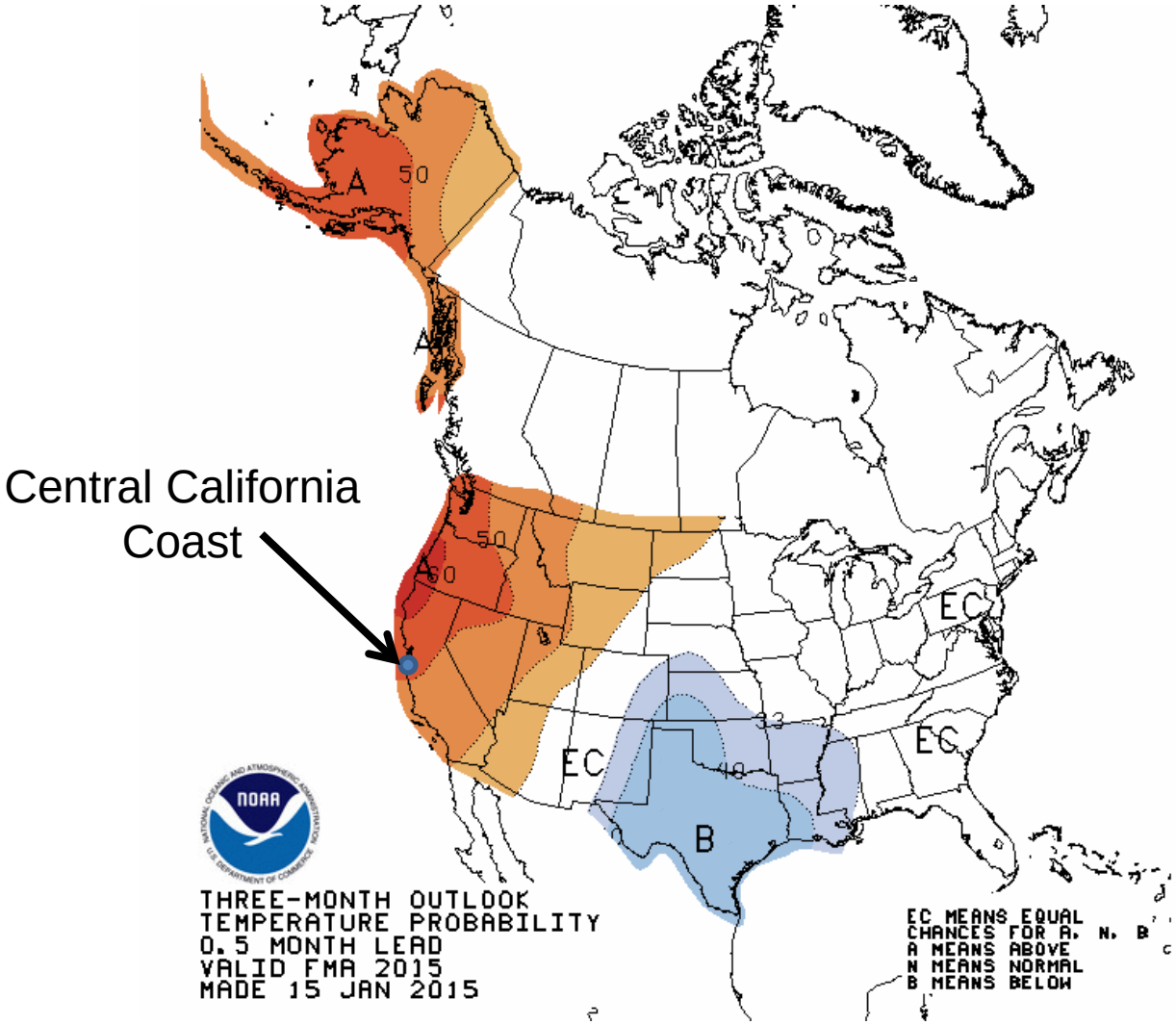
Associated precipitation forecast calls for modest probability of above normal precipitation, while record breaking drought was observed.





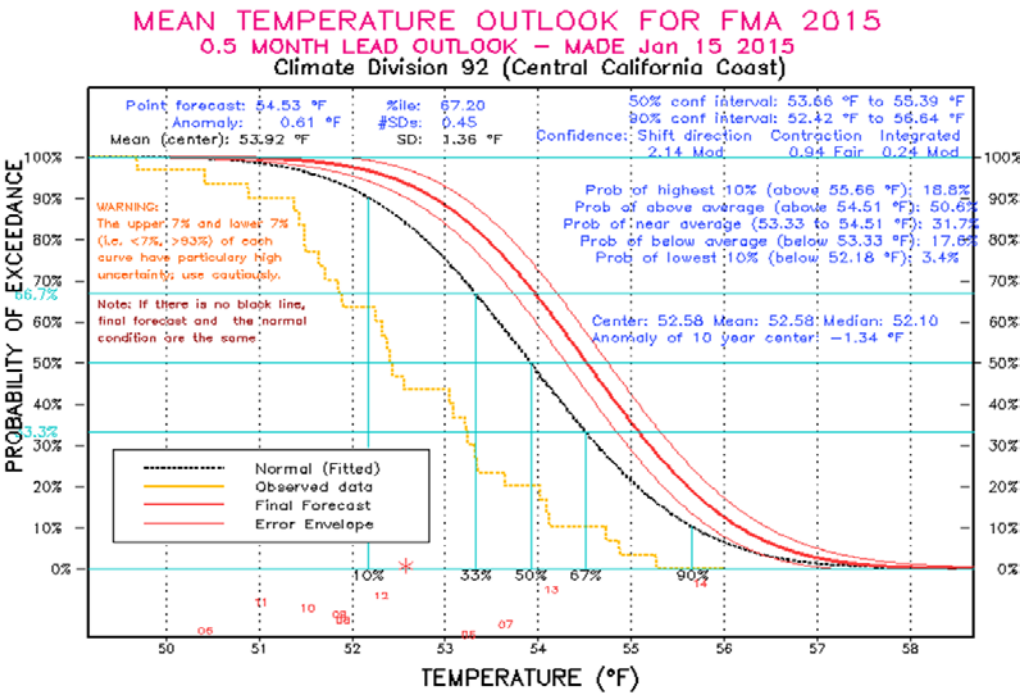
Need for User-Friendly Tools

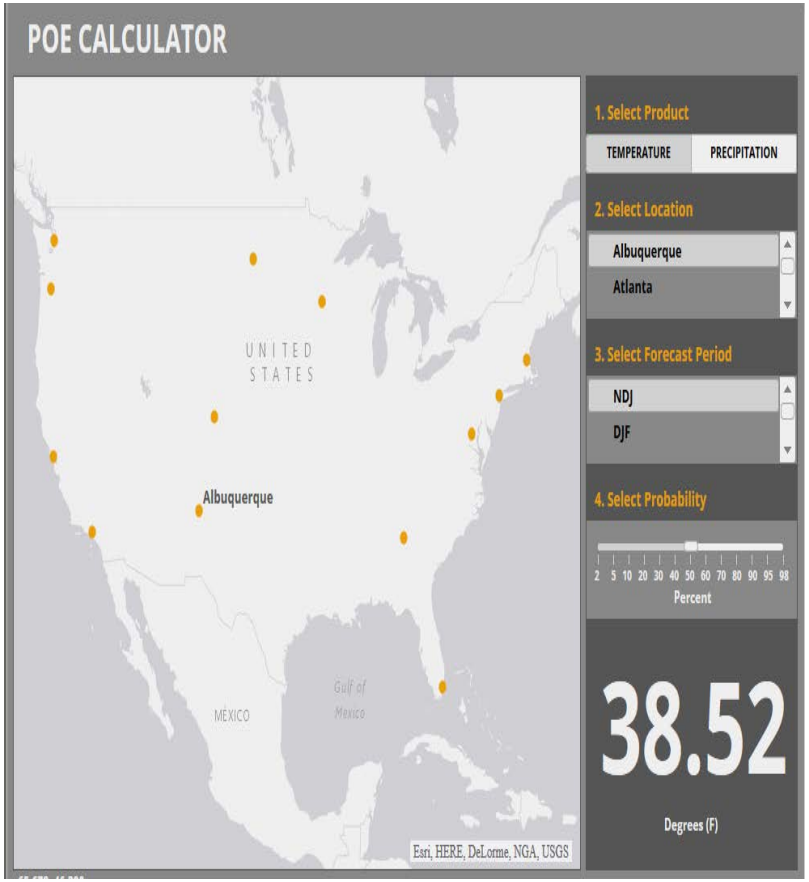
Temperature Outlook FMA 2015



Need to Transition To More User-Friendly Interfaces
Example: Probability of Exceedance (POE) Tool for Seasonal Outlook

User-Friendly POE Tool will allow users to tailor forecast to their own needs/risk profile.





Current POE Tool

Mock-Up of Interactive POE Tool

Foundational Activities Needed to Support CPC Mission

Collaboration Required to Address Broad Portfolio

- **Forecast tool development / improvement**
- **Climate monitoring tool development / improvement**
- **Climate model diagnostics and evaluation**
- **Understanding atmospheric and oceanic predictability**
- **Understanding climate trends**
- **Weather / climate links**
- **Attribution of climate anomalies**
- **Predicting drought / floods and other extreme events**

My Short-Term Priorities to Ensure CPC is Successful

- Generation of Reanalysis/Reforecasts for Extended and Long-Range Forecast Systems
- Implementation of an updated climate reanalysis for monitoring
- Improved forecast tools (statistical and dynamical)
- Collaboration with social scientists to better understand our users and evolve our products to meet their needs
- Establishment of a robust requirements process based on transparent co-development and frequent two-way dialog
- Facilitate collabration with the wider community
- Stable (non-competitive) funding for operational monitoring and prediction products

Advancing Climate Prediction: The Climate Test Bed

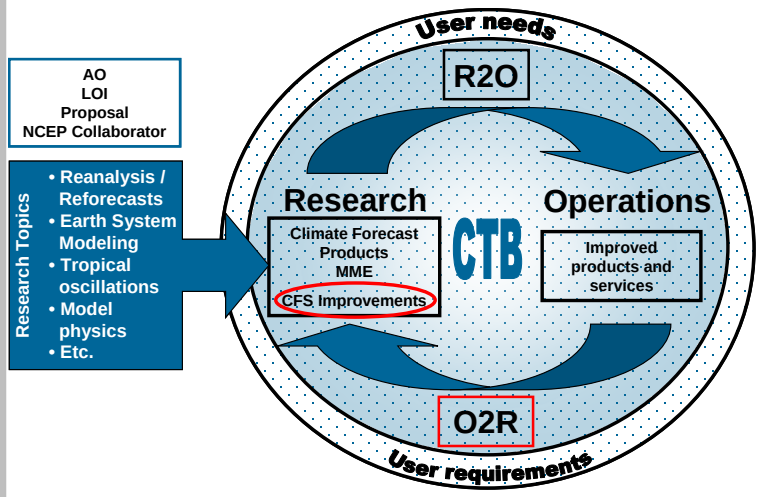
- **Jointly established in 2004 by NCEP and NOAA Climate Program Office**
- **Serves as conduit between the operational, academic and research communities**

Mission

- ***To accelerate the transition of scientific advances from the climate research community to improved NOAA climate forecast products and services***

Research to Operations (R2O)
Operations to Research (O2R)

- **Focus Areas**
  - *CFS Improvements*
  - *Multi Model Ensemble (MME) Prediction Systems*
  - *Climate Forecast Products*
- **Competitive Grants Program**
- **CTB Seminar Series**
- **CPC/CTB - RISA Program**
- **Distinguished Visiting Scientist Program**



Extra Slides

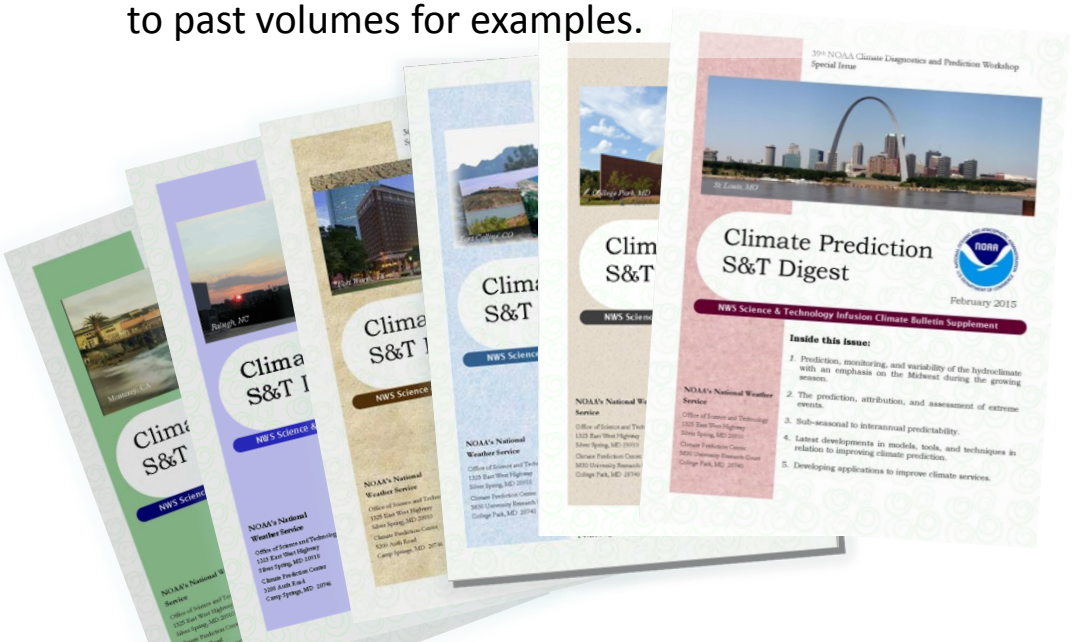
The 40th NOAA Annual Climate Diagnostics and Prediction Workshop Digest

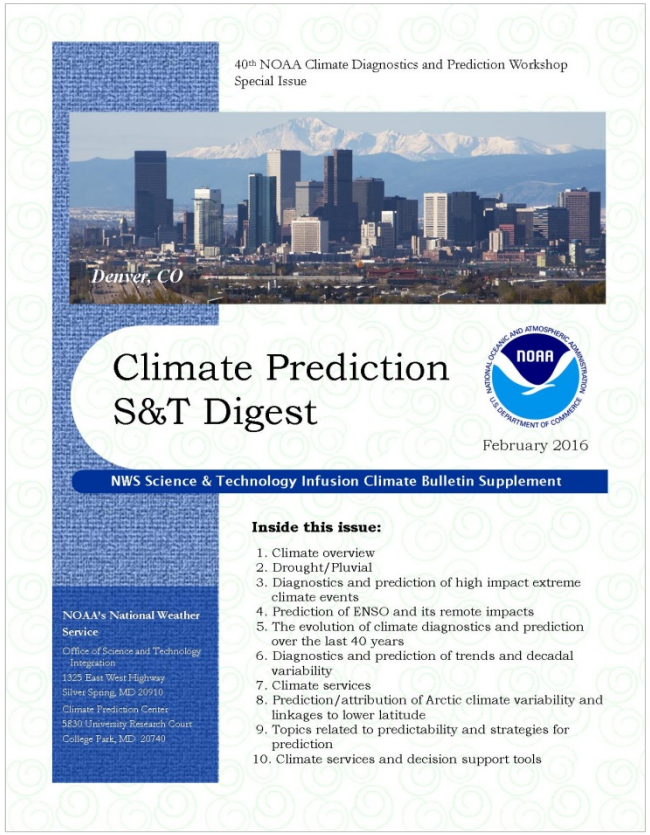
Solicitation of Extended Summaries

Objective: Promote full scope S&T exchanges between research and operation to benefit the entire climate community

Invitees: All 40th CDPW presenters (oral and poster)

Format: MS Word document, high quality figures, flexible length (preferably 1-4 pages). Reference to past volumes for examples.





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The CDPW Digest (2009-) and previous Proceedings (1976-2000) are available via NOAA Library online catalogue, or at NWS S&TI Climate Bulletin *http://nws.noaa.gov/ost/climate/STIP/Collections.htm*

Office of Science and Technology Integration & Climate Prediction Center

NOAA's National Weather Service

Subject: Acceptance of CDPW Extended Summaries as References in Papers Submitted to AMS

We contacted AMS publication authority for the acceptance of CDPW Digest extended summaries as references in papers submitted to AMS journals for publication. Here are the questions and replies.

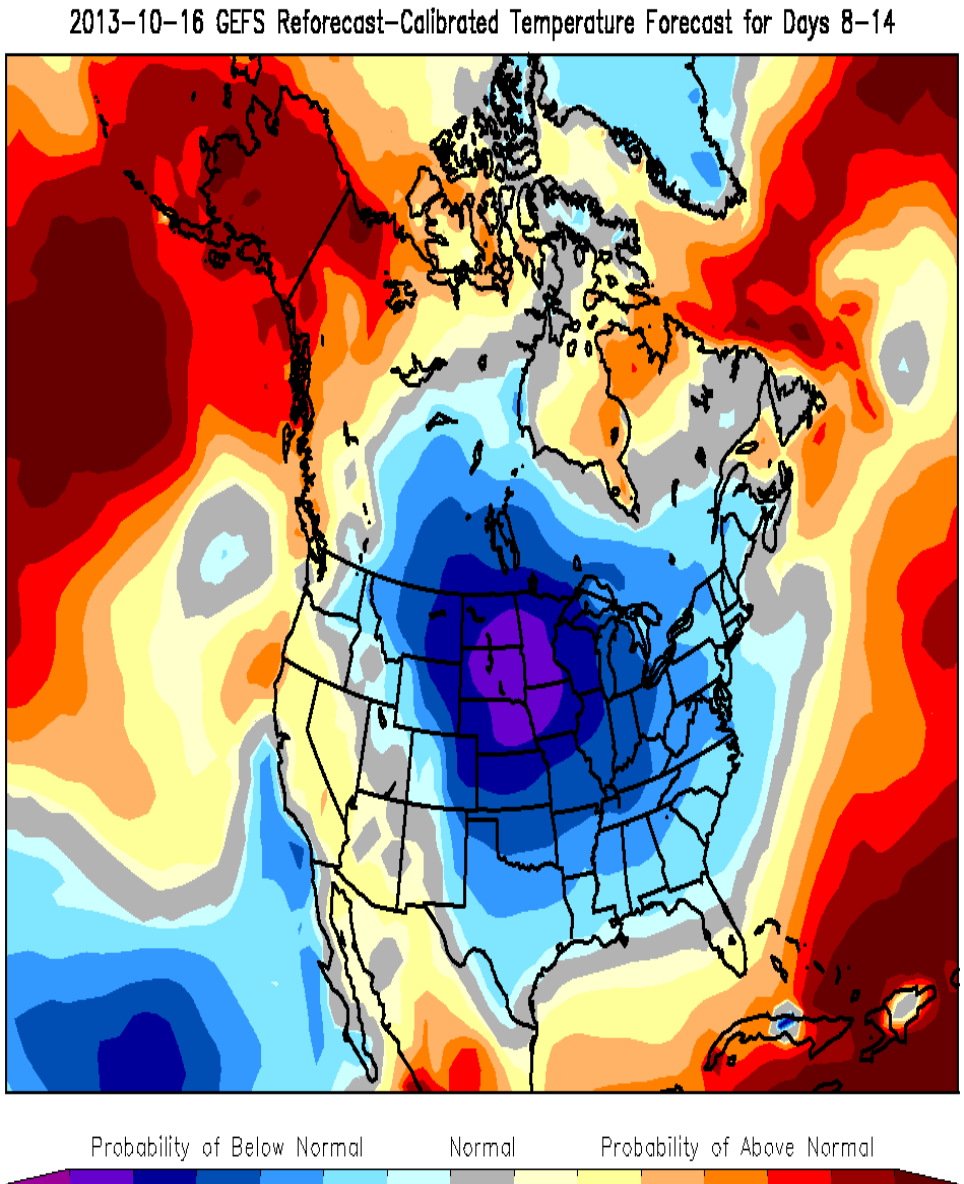
Q: We have an e-version of the workshop proceedings (having been archived by NOAA Central Library since 2010) named Climate Prediction S&T Digest, which replaced previous paper-version that was discontinued after 2000. People in the community would like to confirm with AMS publication authority that the extended summaries included in the CDPW Proceedings (now the Climate Prediction S&T Digest) are eligible for using as references in their papers submitted to AMS journals for publication so long as following the Authors Guide on referencing conference preprint or proceedings (copied).

R: AMS encourages references to peer-reviewed publications, but does not have a policy of completely restriction of references to peer reviewed documents. We do require that any document referred to by an author be accessible either through electronic or paper means, and the extended summaries in the Climate Prediction S&T Digest satisfies that criteria. (by Robert M. Rauber, Commissioner, AMS Publications Commission and Ken Heideman, Director of Publications, AMS Administration)

Strategic Product Development Leveraging Partnerships: Recalibrated GEFS Forecasts Using Reforecasts

CPC uses the GEFS reforecasts to produce an extended range calibrated forecast tool.

- Calibrated forecasts are more skillful than raw GEFS model output.
- Reforecasts produced by **ESRL PSD.**
- Reforecasts enable us to assess historical skill of model
- Next set of GEFS reforecasts will require new reanalysis as well as model has diverged considerably from atmospheric component of CFSR. This will also allow opportunity to address discontinuity issues in CFSR that resulted from older bias correction technique and changes in observing system.



Implementation of Interactive User-Friendly Web Tools

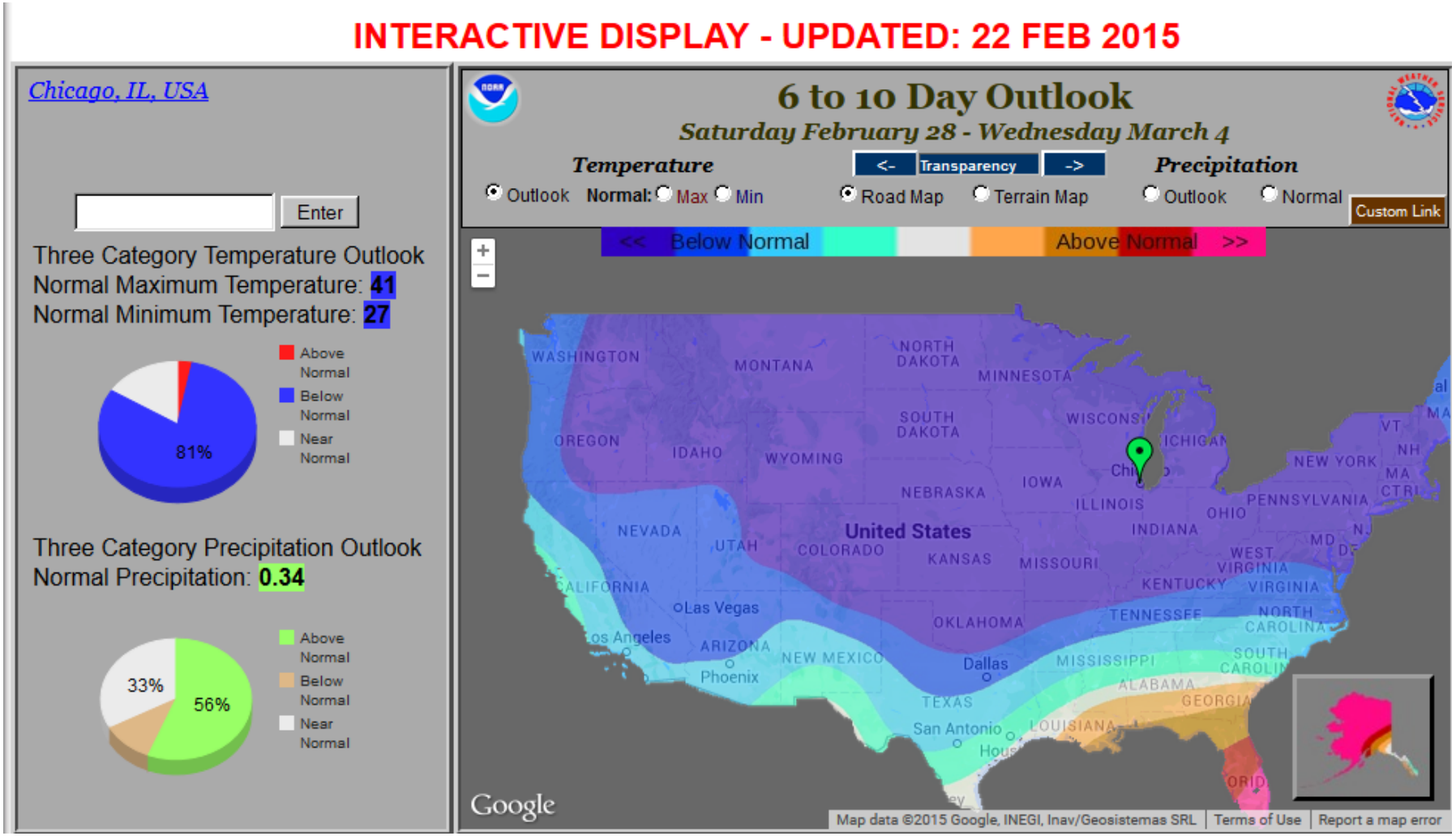
Two Examples:

Pendleton Tool for Extended Range Outlooks (operational):

- Originally Developed by Pendleton, Oregon WFO Example of Transitioning Research to Operations

GUI-driven Probability of Exceedance Interface for Seasonal Outlooks (desired)

Pendleton Tool for Extended Range Outlooks (6 to 10 and 8 to 14 day)
Originally Developed by Pendleton, Oregon WFO
Example of Transitioning Research to Operations



Multi-Model Ensembles and the North-American Multi-Model Ensemble (NMME) Project

Why do use multi-model ensembles (MME) for forecasts?:

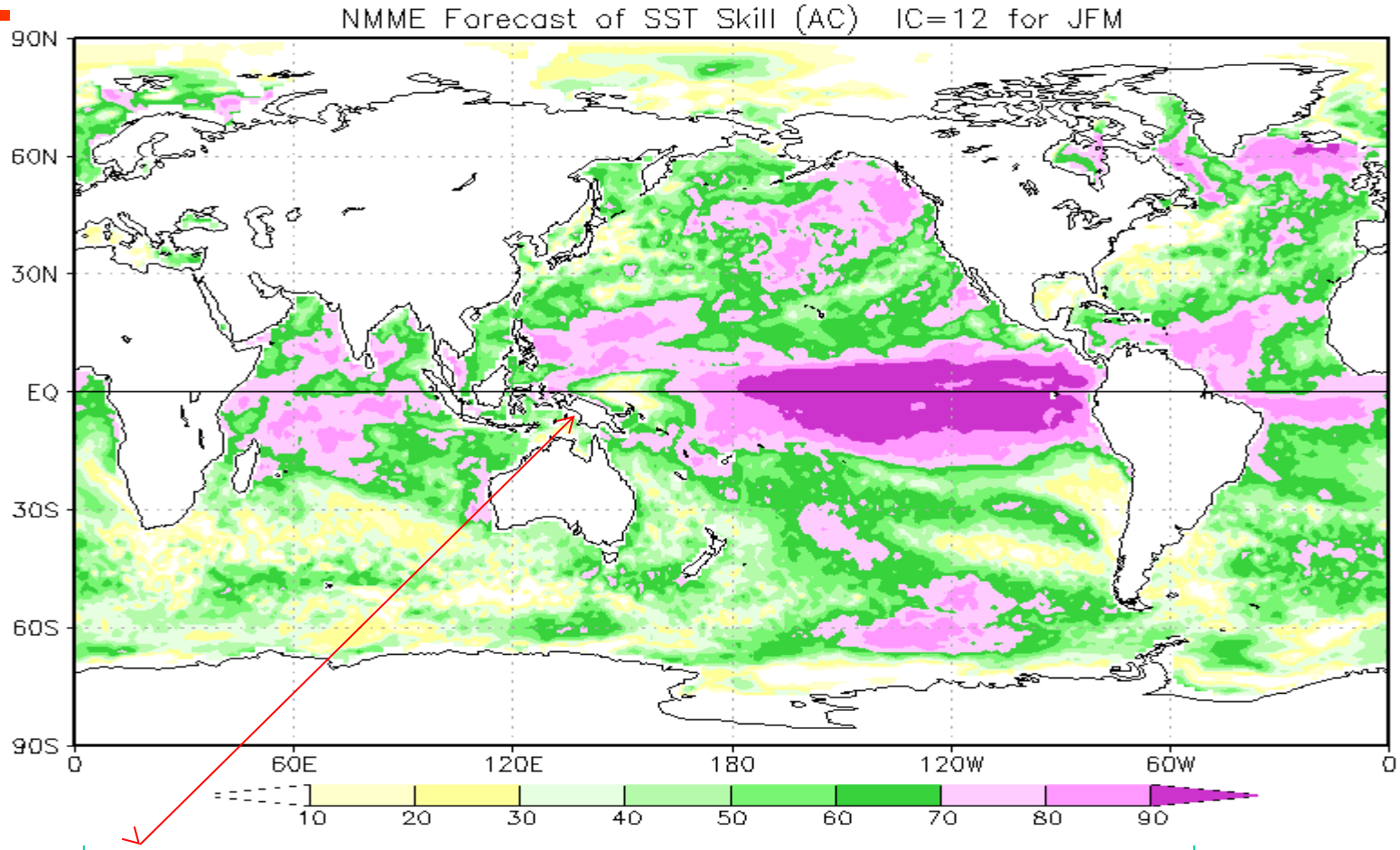
- **Allows representation of model uncertainty.**
- **Possibility of complementary skill between models.**
- **Skill of MME is frequently higher than that from the most skillful member in the ensemble (though if one model is dominantly better this is not always true).**

NMME is frequently our most skillful tool but there is still room for improvement.

Models/Groups Participating in NMME

Organizations	Models
NOAA/NCEP	CFSv2
NOAA/GFDL	CM2.1 FLOR (March 2014)
NASA/GMAO	GEOS5
Environment Canada	CMC1-CanCM3 CMC2-CanCM4
NCAR	CCSM3.0 CCSM4.0 (July 2014)
NCAR	CESM1.0 (Mar. 2015)

Retrospective Forecast Skill of Lead 1 NMME SST Forecast for JFM from NMME



State of the Art MME Dynamical Forecast System has Low Skill in Predicting Near-Equatorial Western Pacific SST. If SST in this region drove the large-scale pattern past two years there is an issue.