Climate Prediction Center Products and Decision Support

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Climate Prediction Center / NCEP

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Acknowledgements:
Wayne Higgins, Jon Gottschalck, *Huug ven den Dool, Mike Halpert, Jae Schemm, Kingtse Mo, Peitao Peng*

Outline

- CPC overview and product suites
- Forecast format, tools, post-processing, and verifications
- Examples of decision support products
- CPC future plans

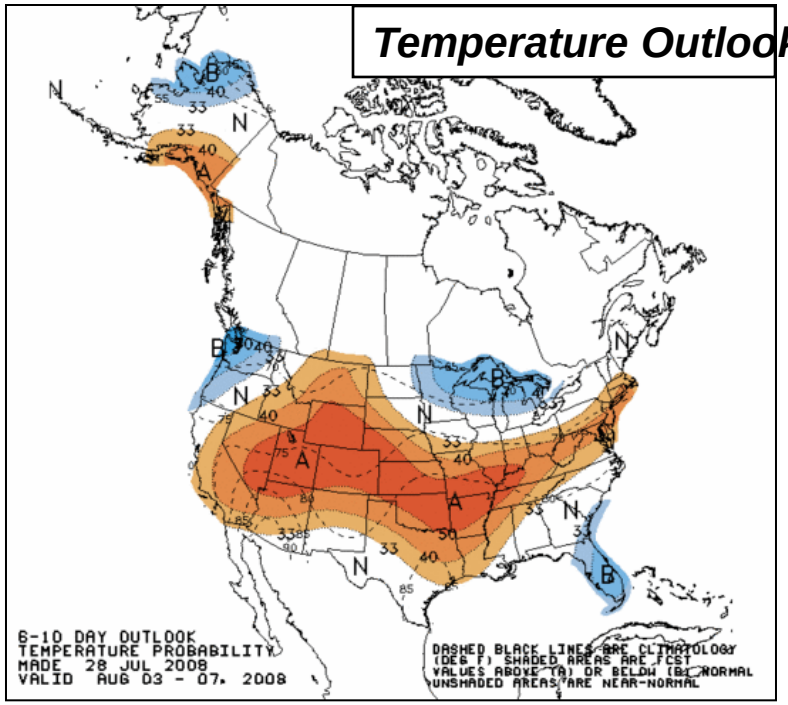
CPC Mission

CPC delivers real-time products and information that predict and describe climate variations on timescales from weeks to years thereby promoting effective management of climate risk and a climate-resilient society

Operational Requirements:

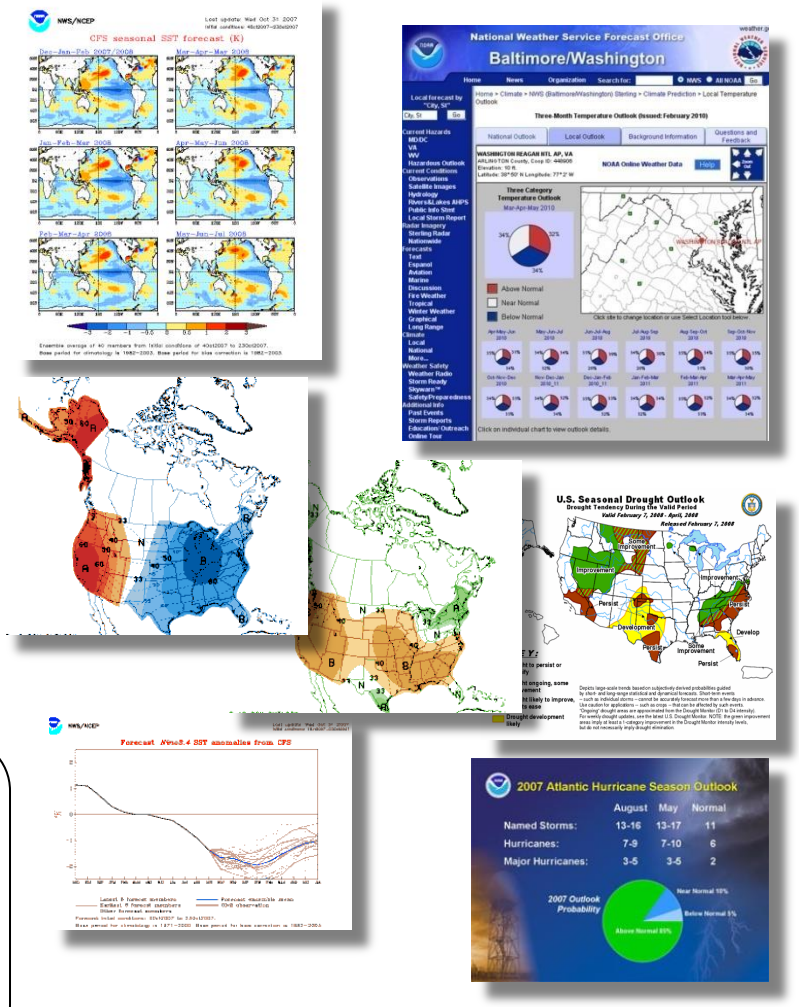
- **Deliver national outlook products: temperature, precipitation, drought, hurricanes, ...**
- **Span weeks, months, seasons, years**
- **Embrace collaborative forecasting with other NCEP Service Centers, NOAA line offices, other agencies and labs**
- **Ensure real-time, on-time, all the time (since ‘79)**
- **Enable NGSP Societal Challenges: “Water” and “Extremes”**

Temperature Outlook



CPC Climate Prediction Products

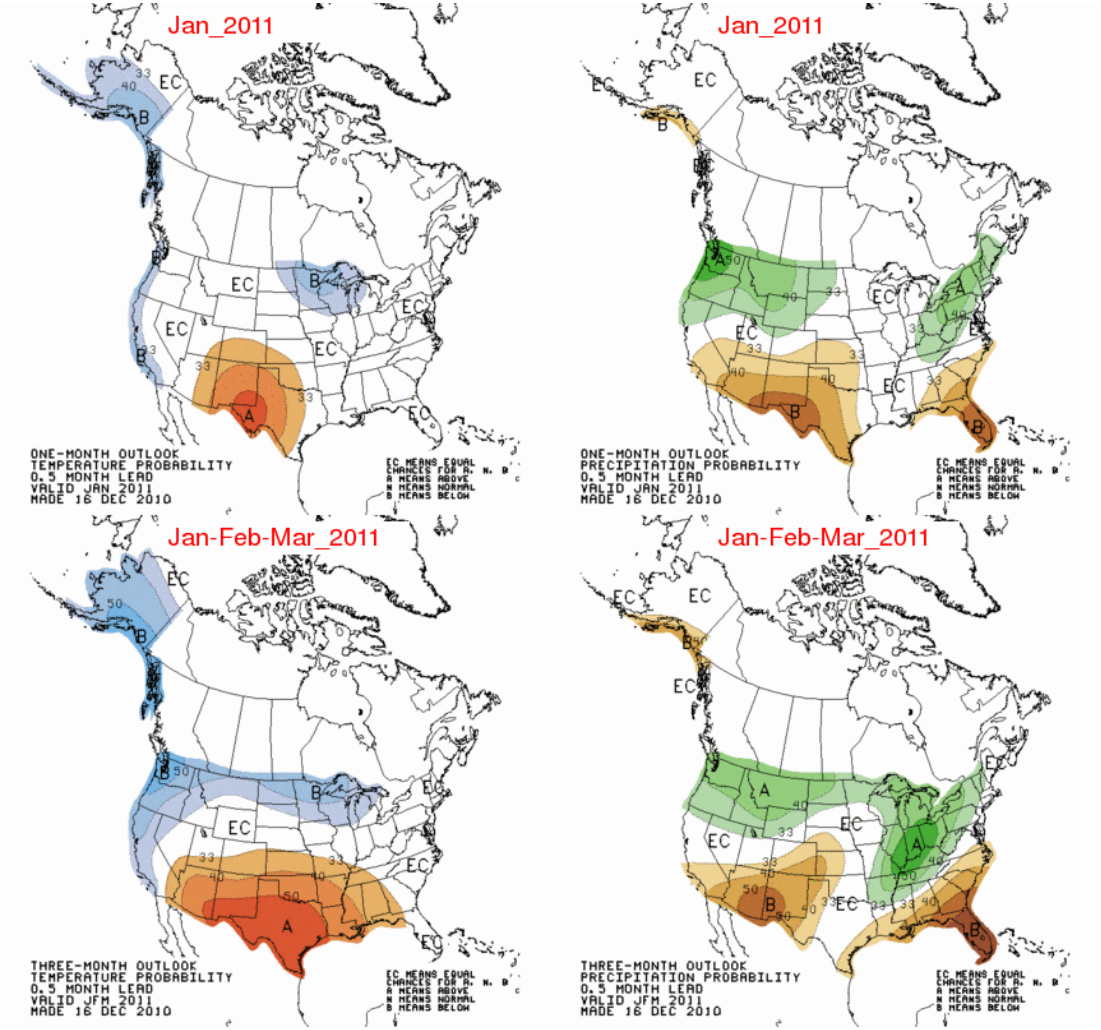
- **Official Outlooks focused on week-2, monthly, seasonal**
  - **6-10 Day & 8-14 Day Precipitation & Temperature Outlooks**
  - **Day 3-14 Hazards Outlooks (US, Global Tropics)**
  - **Monthly & Seasonal Precipitation & Temperature Outlooks**
  - **Seasonal Drought Outlook**
  - **Seasonal Hurricane Outlooks (Atlantic and Eastern Pacific)**
  - **Monthly ENSO Prediction**



Tools used to develop prediction products
- **Dynamical Models**
- **Statistical Models**
- **Historical Analogs**
- **Historical Composites**

Monthly/Seasonal Forecast

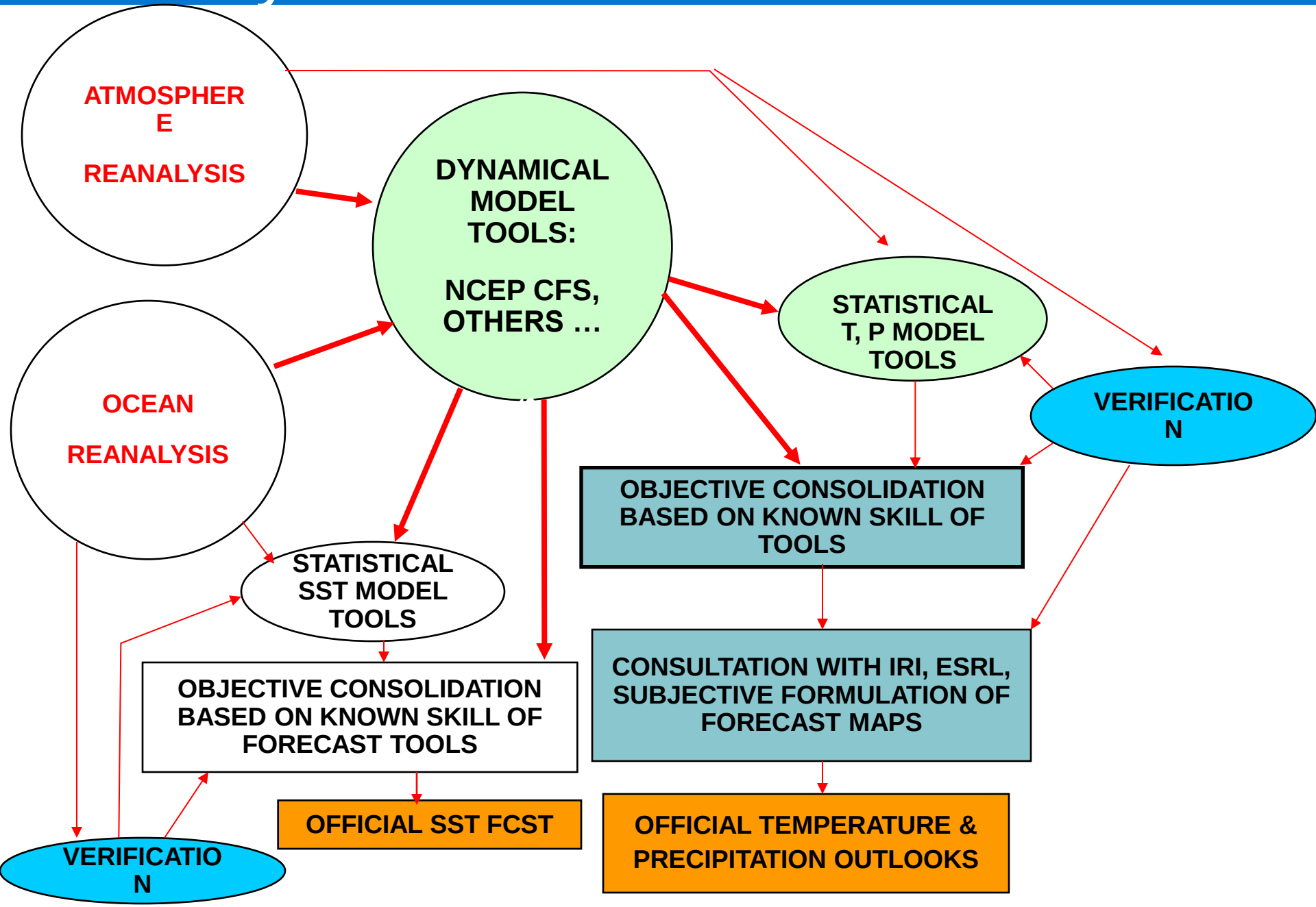
- Mean Temp and Total Precip
- Three tercile categories
  - Above
  - Below
  - Normal
- Probabilistic



Monthly/Seasonal Forecast Schedule

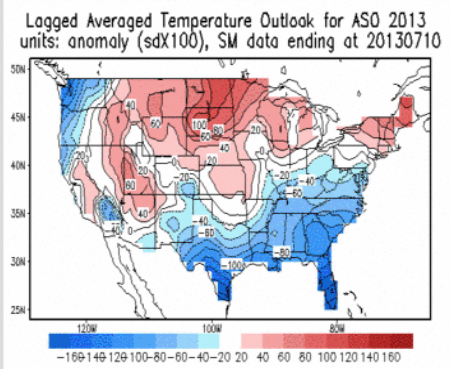
- Monthly, released 3rd Thursday of each month
- Two conference calls for coordination
- **Monthly Forecast**: two leads
  - ½ month lead
  - zero month lead
- **Seasonal forecast**:
  - ½ month lead to 12 ½ month lead

Monthly / Seasonal Process Flowchart

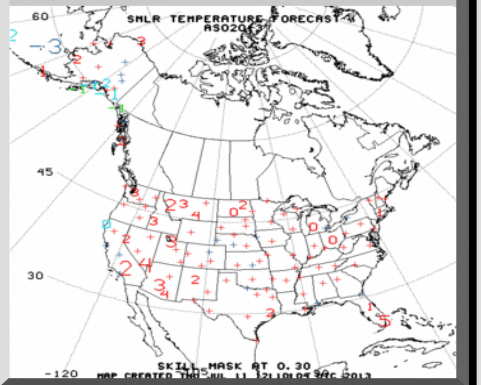


ASO Season [Temperature]

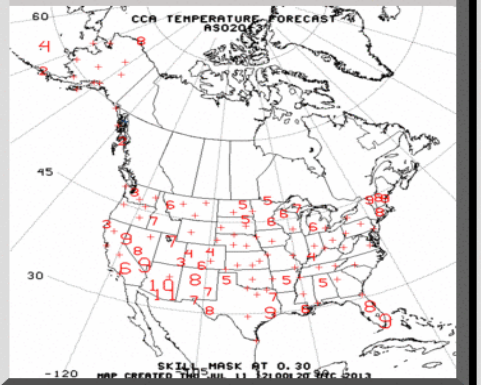
CAS



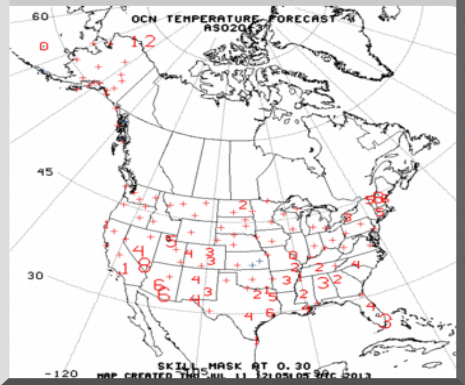
SMLR



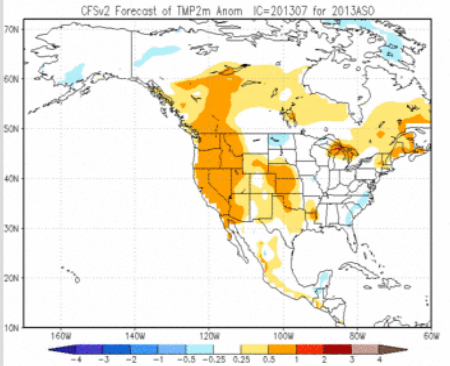
CCA



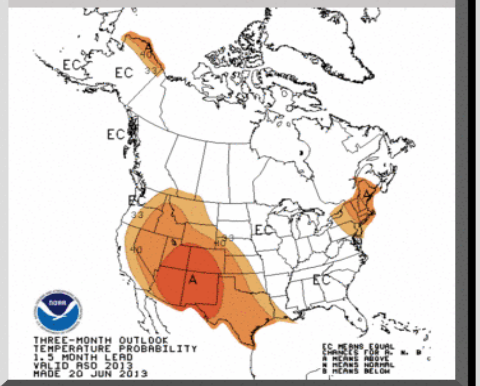
OCN



CFSv2



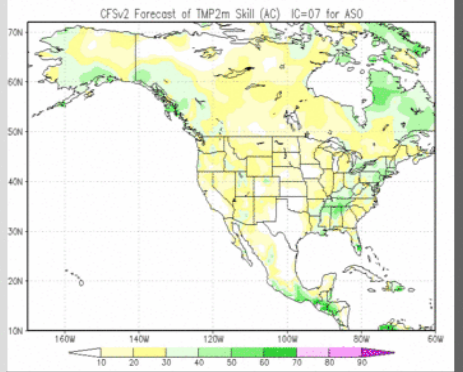
OLD OUTLOOK



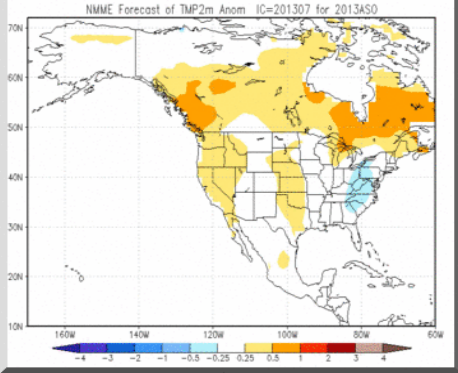
** NEW OUTLOOK **

IMAGE
NOT
AVAILABLE

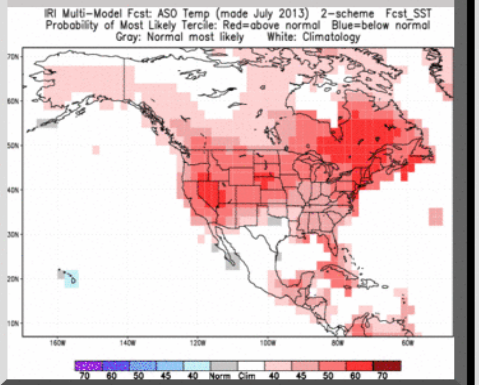
CFSv2 (skill)



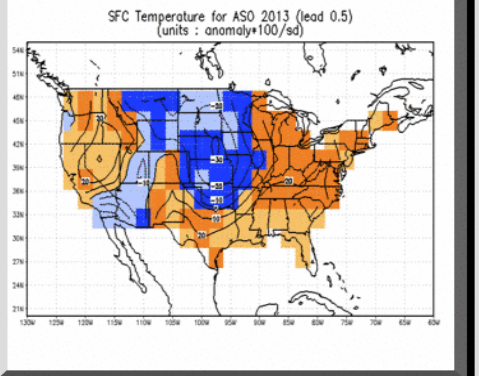
NMME



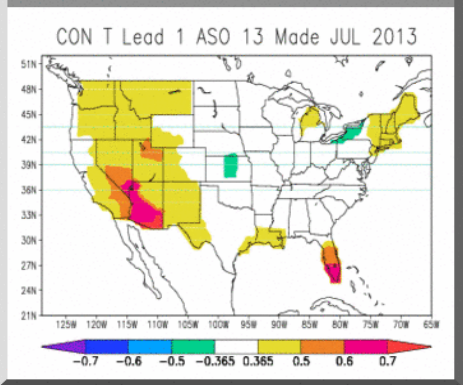
IRI



ENSEMBLE CCA (ECCA)



CONSOLIDATION



Forecast Tools for Monthly/Seasonal Outlooks

Statistical Tools:

- CCA (Canonical Correlation Analysis)
  - Relationship of tropical Pacific Ocean SSTs, 700 hPa heights, (the predictors) and U.S. T and P (the predictands).
- OCN (Optimal Climate Normal)
  - Takes accounts for climate trends
- CA (Constructed Analog)
  - CA for soil moisture (CAS) is used for warm seasons only
- SMLR (Screening Multiple Linear Regression
  - Extract info from two or more variables (Global SST, 700 hPa heights, T, P, SM) and apply to US climate divisions

Dynamical Tools:

- Dynamical Model Output – CFSv2
- National Multi-Model Ensemble (NMME)

Other Factors considered in final process:

- ENSO composites
- snow cover, soil moisture, SSTs, PDO, ….

CPC Objective Consolidation

- CON is to generate a single probabilistic forecast tool with weighted combination of multiple tools based on available hindcasts skills

Tools used in consolidation include both statistical and dynamical forecasts:

- CCA
- SMLR
- OCN
- ECCA
- CFSv2

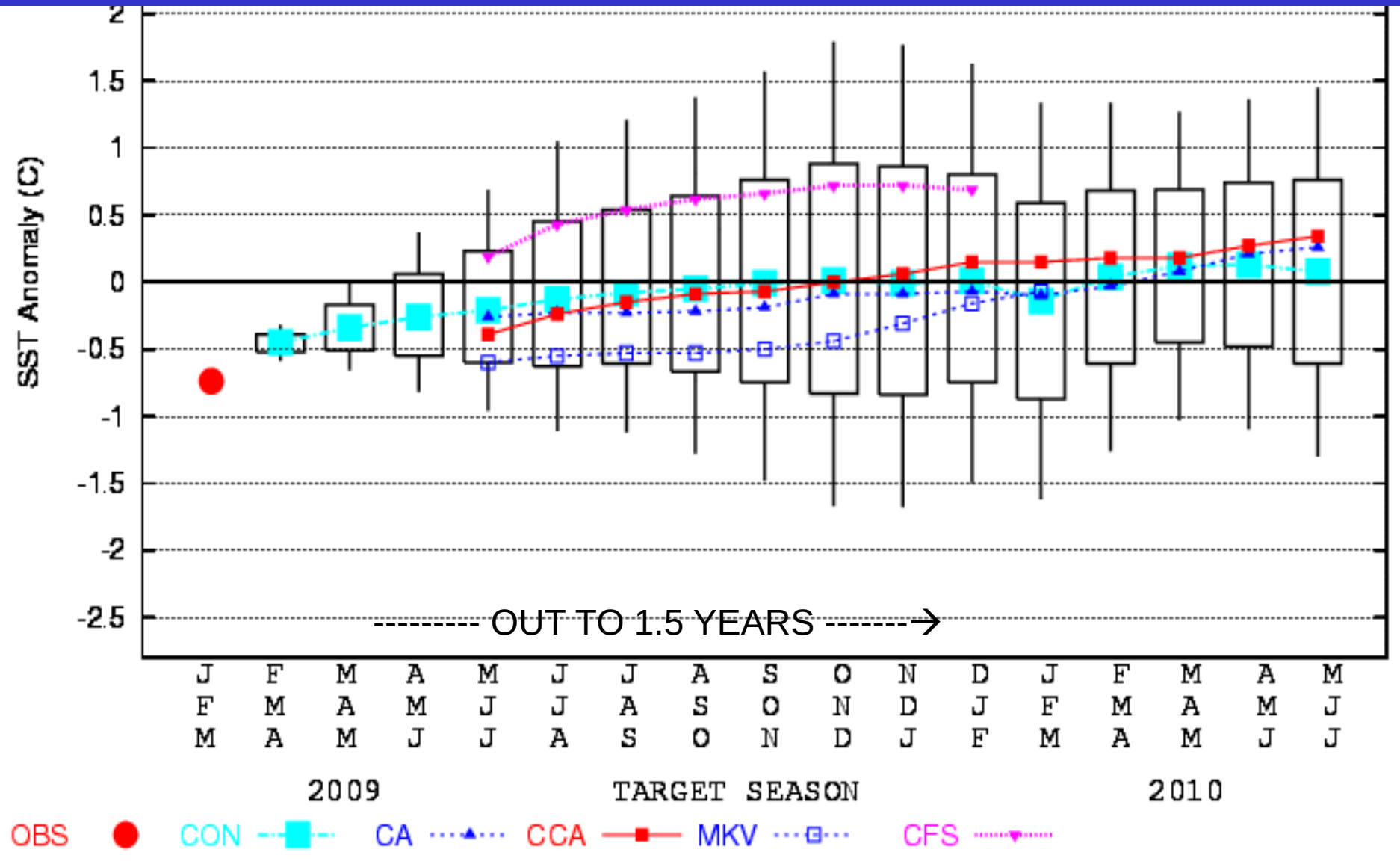
Example of CON for SST forecast:

$$CON = \sum_{k=1}^{K} \alpha_k SST_k$$

i.e. a weighted mean over K model estimates

One finds the K alphas typically by minimizing the distance between CON and observed SST.

Consolidation Increases ENSO Forecast Skills

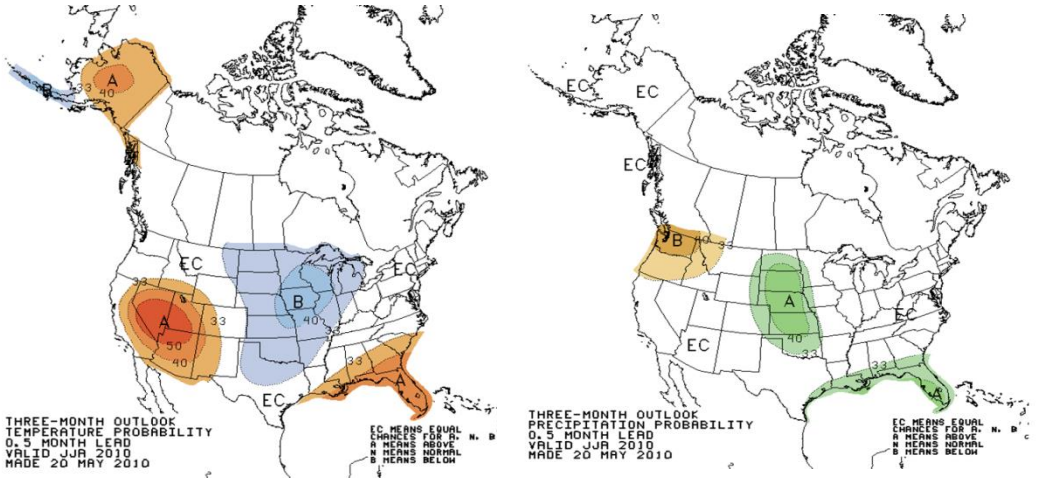


Verification For Seasonal Forecasts

- Rely on a combination of empirical and dynamical prediction tools, such as CCA, ECCA, OCN, EOCN, regression tool, partly coupled model (1995-2004), CFSv1(2004-2011), CFSv2(from 2011);
- Have been routinely made since December of 1994;
- Issued for 13 running seasons and released in the middle of each calendar month

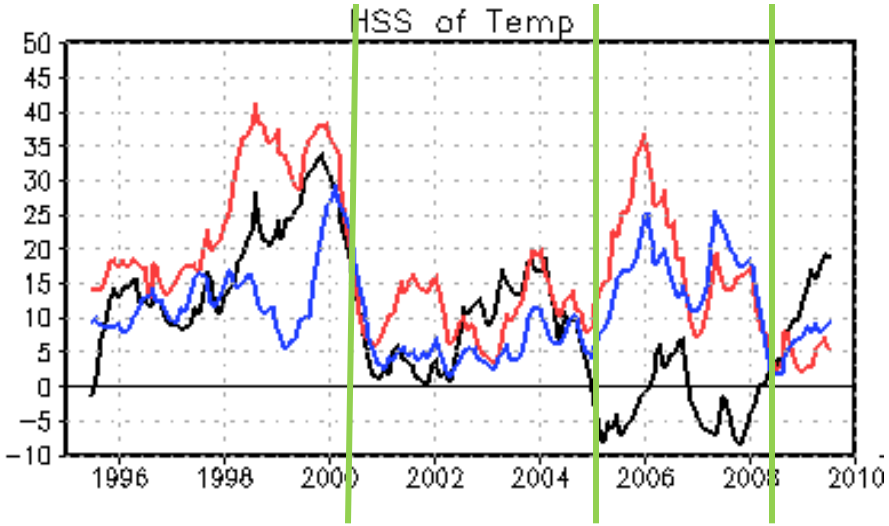
Categorical measures:
- Heidke Skill Score (HSS)

Probabilistic measures:
- Ranked probability Skill Score (RPSS)
- Relative Operating Characteristics (ROC)
- Reliability Diagrams



(after Peitao Peng et al, 2013)

Temporal Variation and Seasonal Cycle of Spatially Averaged HSS for Temp Forecast

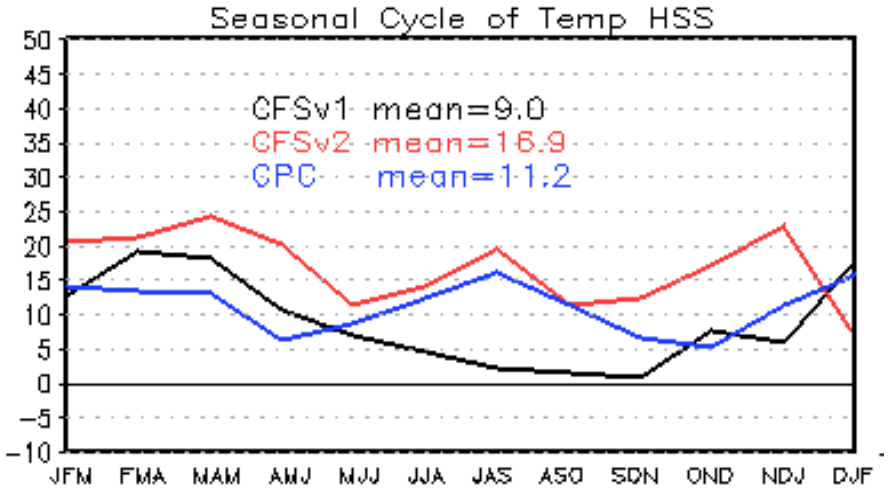


1.CFSv2 outperformed CFSv1 and CPC throughout most of the period;

2.CFSv1 significantly underperformed CFSv2 and CPC for 2005-2008, but turned the best afterwards;

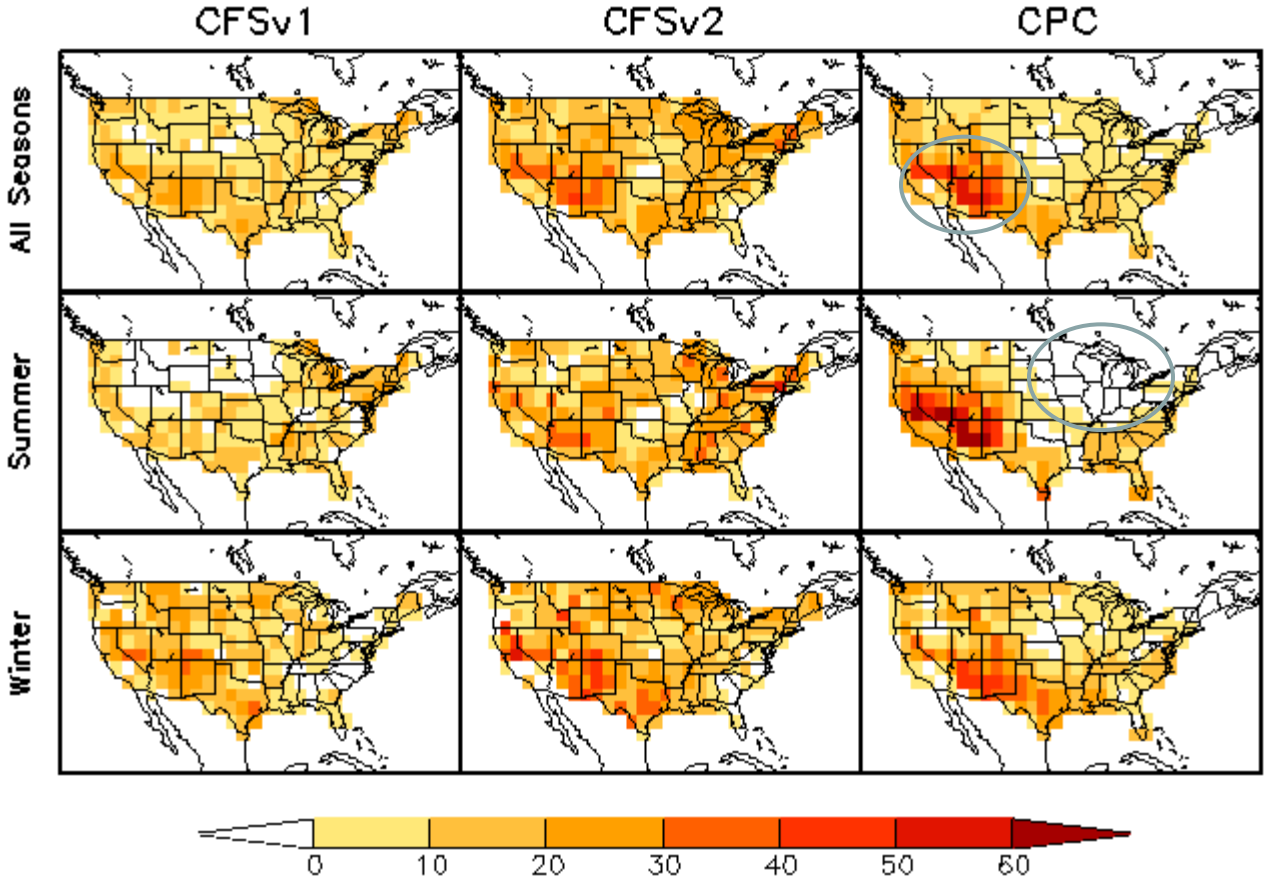
3.CFSv1 and v2 appears well correlated during 1995-2000, but this correlation decreases thereafter;

4.Prior to 2007, CFSv2 is rarely outperformed by CPC.



1. CFSv2 and CPC have peaks in northern winter and summer and minima in late spring and late fall;
2. CFSv2 has lowest skill in DJF;
3. CFSv1 is lack of a summer skill peak, probably due to a problem in initializing soil moisture (Wang et al 2009)

Geographical Distribution of Temporally Averaged HSS for Temp



1.CFSv2 outperforms CFSv1 over much of the US;

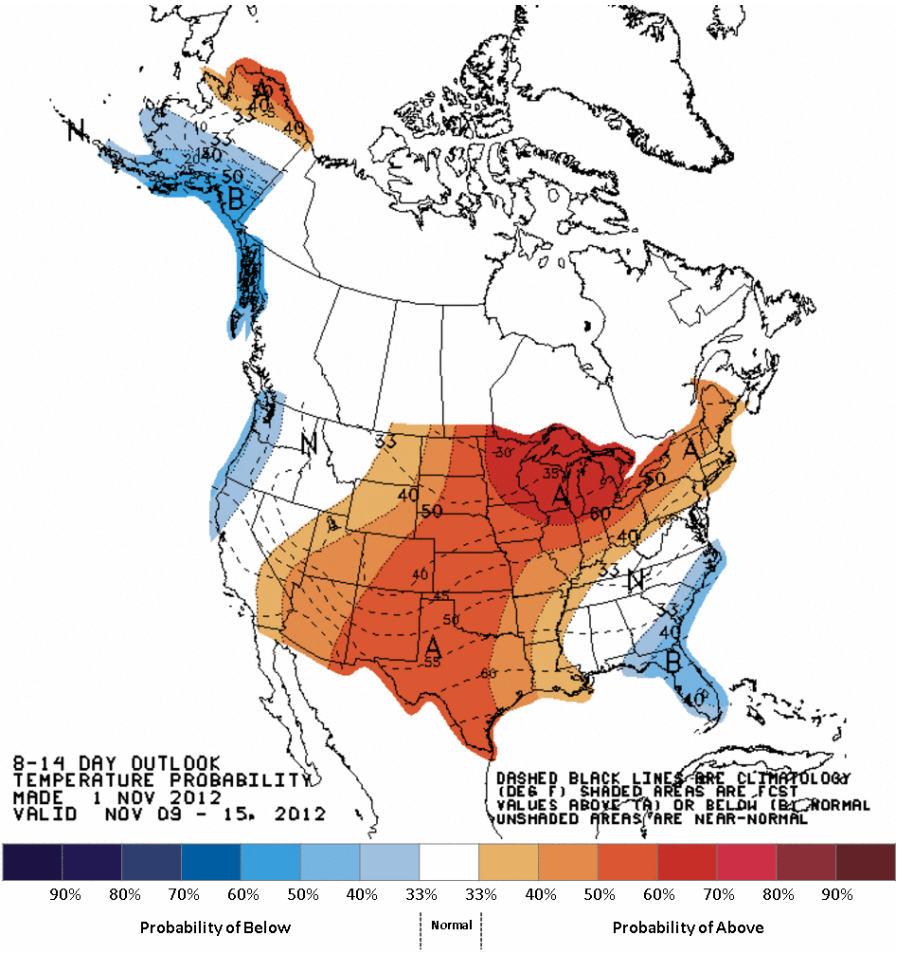
2.A skill maximum in southwest region, where strong warming trend has been observed;

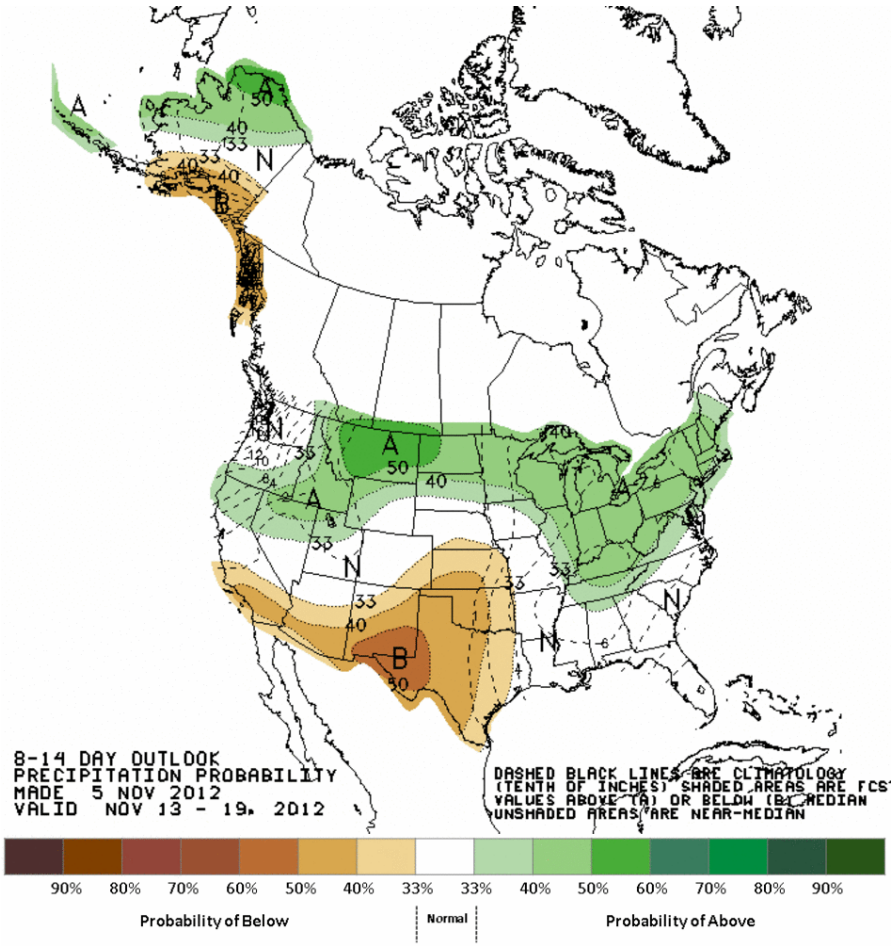
3.CPC's high skill over the southwest region relies on OCN tool;

4.CFSv2 forecasts the warming trend better than CFSv1, due in part to evolving CO_2 in it;

5.Both CFS versions performed better than CPC in far northeastern US.

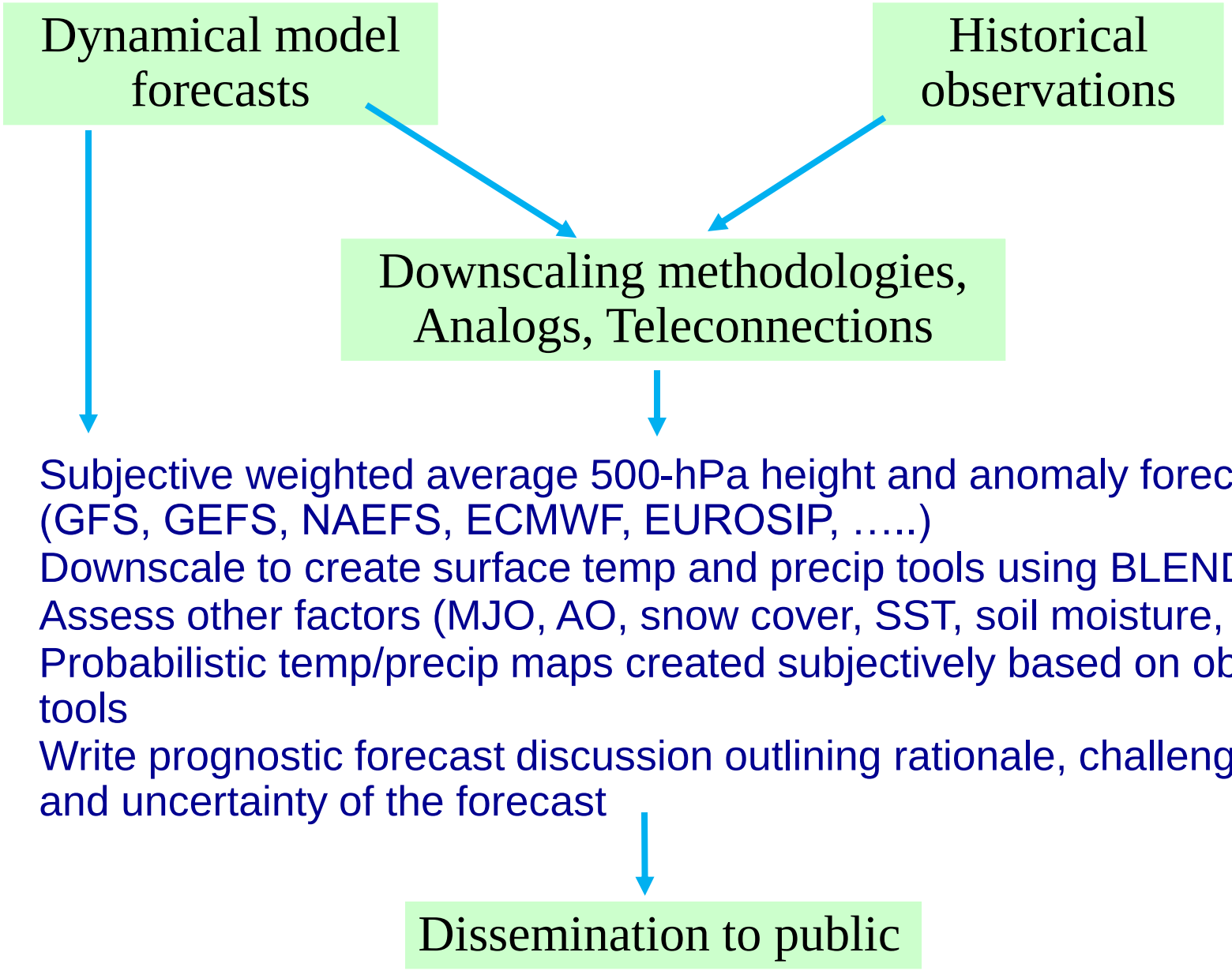
Extended Range Forecast





- Daily,
- Probabilistic
- Two periods: 6-10 Day and 8-14 Day

Extend Range Forecast Process Flowchart



Verification Metrics

Metric: Heidke Skill Score (HSS)
Forecast Type: Deterministic (Favored Category)
Range: -50 to 100 (3 Class System)

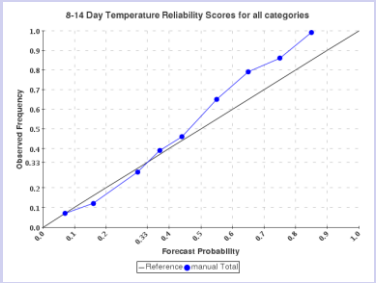
HSS (%) = 100 * (H - E) / (T - E)
where H = Number of correct forecasts, E = Expected number of correct forecasts (1/3 of total), and T = Total number of valid forecast-observation pairs

Metric: Rank Probability Skill Score (RPSS)
Forecast Type: Probabilistic
Range: up to 1.0

RPSS = 1 - RPSforecast/RPSreference

Where:
RPS = 1/n * SUM[(probB(k)-obsB(k))^2 + (probN(k)-obsN(k))^2 + (probA(k)-obsA(k))^2]

Metric: Reliability Diagram
Forecast Type: Probabilistic (Frequency of Occurrence)



Public Resources (Current)

Forecast Archives

CPC 6-10 & 8-14 Day Data & Graphics Archive

Available from December 2001

Enter Year of Forecast Issuance (yyyy format):	
Enter Month of Forecast Issuance (mm format):	
Enter Day of Forecast Issuance (dd format):	

Submit Query

Forecast Data

PARM=TBLW;TNRM;TABV;TCAT;PBLW;PNRM;PABV;PCAT

STN	YYMMDD/HHMM	TBLW	TNRM	TABV	TCAT
69002	120519/0000	28.81	42.38	28.81	2.00
69007	120519/0000	28.77	42.47	28.77	2.00
69008	120519/0000	28.90	42.19	28.90	2.00
69012	120519/0000	31.40	37.21	31.40	2.00
69013	120519/0000	28.88	33.33	37.79	3.00
69014	120519/0000	30.53	38.94	30.53	2.00
69016	120519/0000	30.49	39.02	30.49	2.00
69017	120519/0000	30.73	38.53	30.73	2.00
69019	120519/0000	31.24	37.53	31.24	2.00
70026	120519/0000	25.73	33.33	40.94	3.00
70063	120519/0000	20.25	33.33	46.42	3.00
70086	120519/0000	19.82	33.33	46.85	3.00
70133	120519/0000	28.24	33.33	38.43	3.00

Prognostic Map Discussion

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PROGNOSTIC DISCUSSION FOR 6 TO 10 AND 8 TO 14 DAY OUTLOOKS
NWS CLIMATE PREDICTION CENTER CAMP SPRINGS, MD
300 PM EDT FRI MAY 11 2012

6-10 DAY OUTLOOK FOR MAY 17 - 21 2012

TODAYS ENSEMBLE MEAN SOLUTIONS ARE IN GOOD AGREEMENT FEATURING A
THE SOUTHEAST COAST, A POSITIVELY-TILTED TROUGH ACROSS THE WESTER
TROUGH OVER THE BERING SEA WITH A DOWNSTREAM RIDGE OVER CENTRAL A
OPERATIONAL 6Z GFS DEPICTS A DEEP, CLOSED 500-HPA LOW OVER THE MI
WHICH IS CONSIDERED AN OUTLIER SOLUTION. THE OPERATIONAL 0Z ECMWF
THE RIDGE OVER THE NORTHEAST PACIFIC AND ALASKA, WHICH IS NOT SUP
ENSEMBLE MEAN AND OTHER OPERATIONAL MODEL RUNS. ALL ENSEMBLE MEAN
DEPICT A LARGE POSITIVE 500-HPA HEIGHT ANOMALY CENTER OVER SOUTHE
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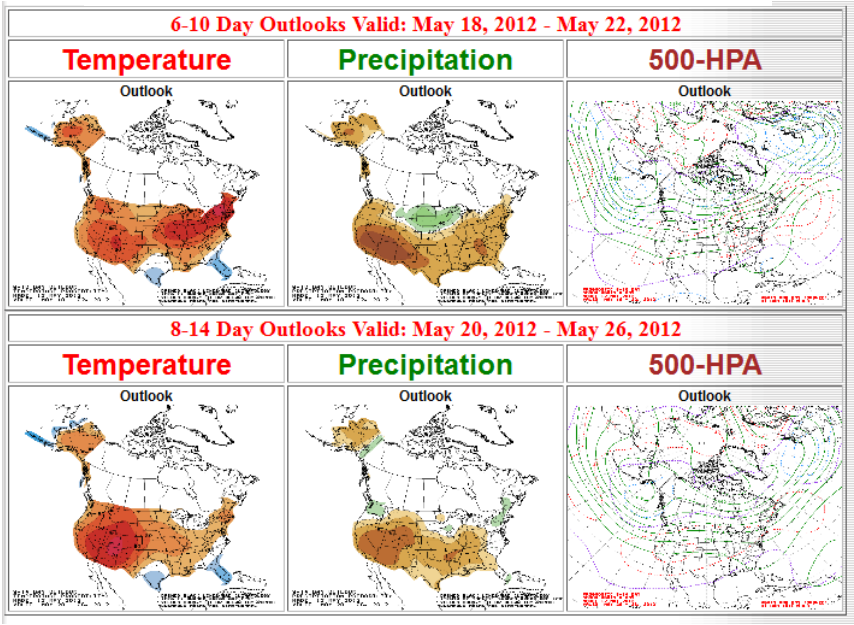
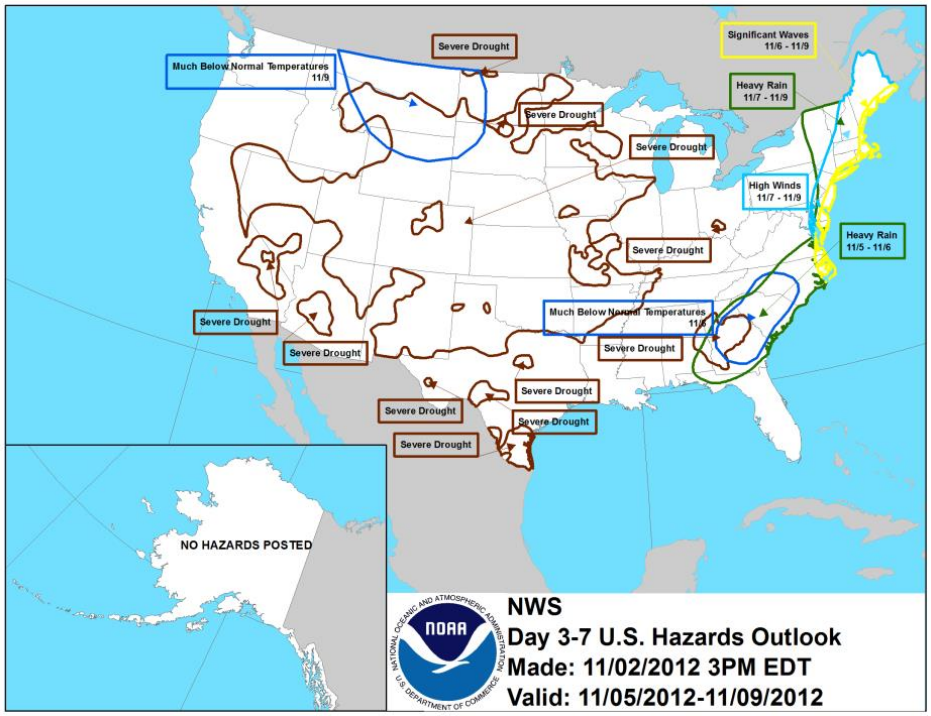
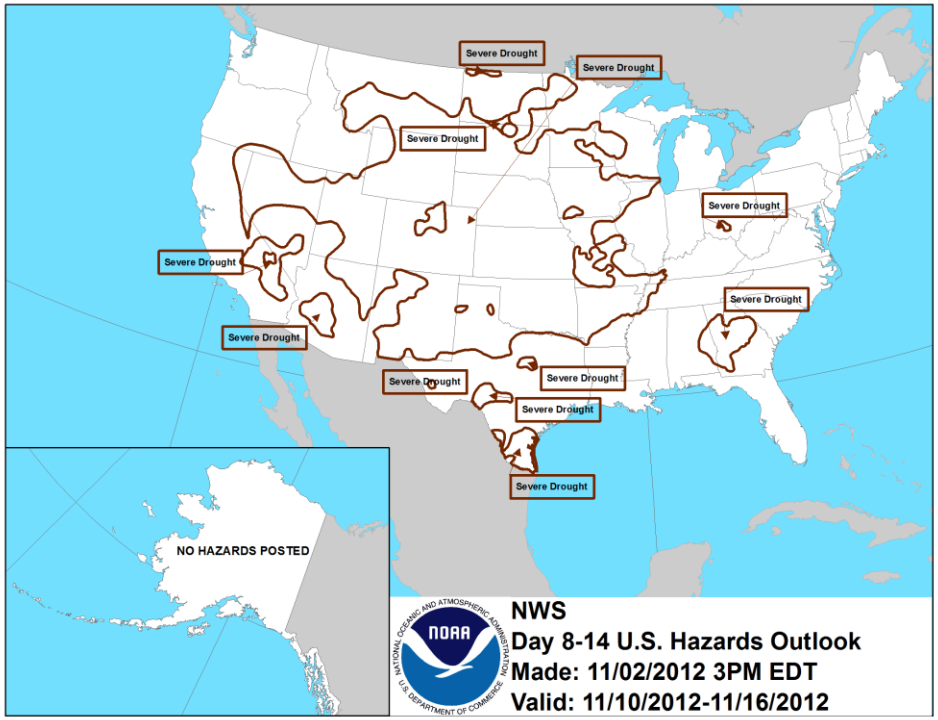
Forecast Maps

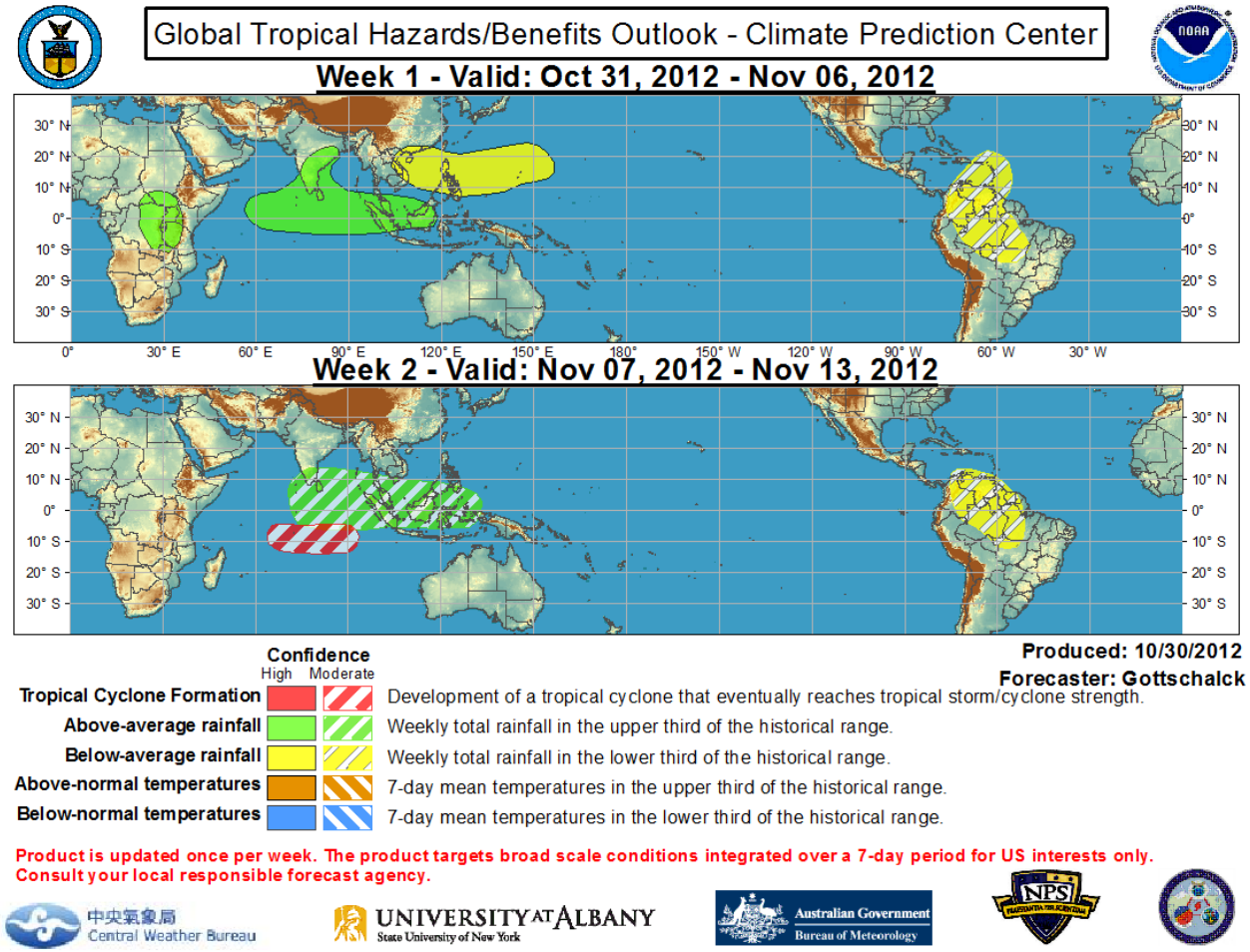


U.S. Hazards Outlook





- Several types of threats, CONUS, Alaska
- Daily, categorical and subjectively drawn based on objective criteria
- Days 3-14
- Primarily based on medium/extended range deterministic / ensemble guidance
- High degree of coordination with other NCEP centers and NWS regions

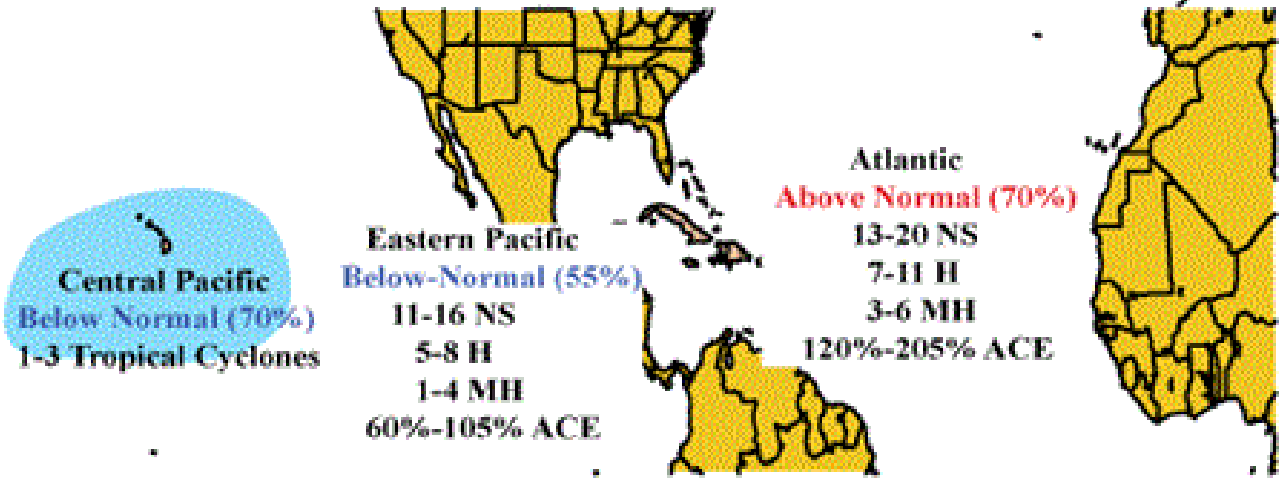


- Weekly, Weeks 1-2
- Categorical and subjectively drawn based on objective forecast tools
- Factors include ENSO, MJO, ER and Kelvin waves, statistical forecast tools (C-LIM, etc.), dynamical model output
- Weekly coordination with SUNY, CICS, JTWC, NHC, NPS and NWS regions

NOAA Hurricane Season Outlook
for the Atlantic and Eastern North Pacific basins

- Issued since 1998
- Probabilistic types - above, near and below normal season
- Ranges in the number of named storms, hurricanes and major hurricanes, the ACE (*Accumulated Cyclone Energy)* index
- Dynamic hurricane season prediction has become part of the NOAA Hurricane Season Outlook processes since 2009.
- April and July initial conditions
- Consensus prediction prepared by 7 HSO forecasters based on all forecasts generated with statistical and dynamical tools; 2 from CPC, 4 NHC and 1 AOML

NOAA's 2013 Hurricane Season Outlooks Issued in May



NOAA's 2013 Atlantic and Eastern Pacific hurricane season outlooks indicate the likely ranges (each with a70% chance) of Named Storms (NS), Hurricanes (H), Major Hurricanes (MH), and percentage of the median Acccumulated Cyclone Energy (ACE).

NOAA's 2013 Central Pacific hurricane season outlook indicates the likely number of tropical cyclones, which include tropical depressions, tropical storms and hurricanes.

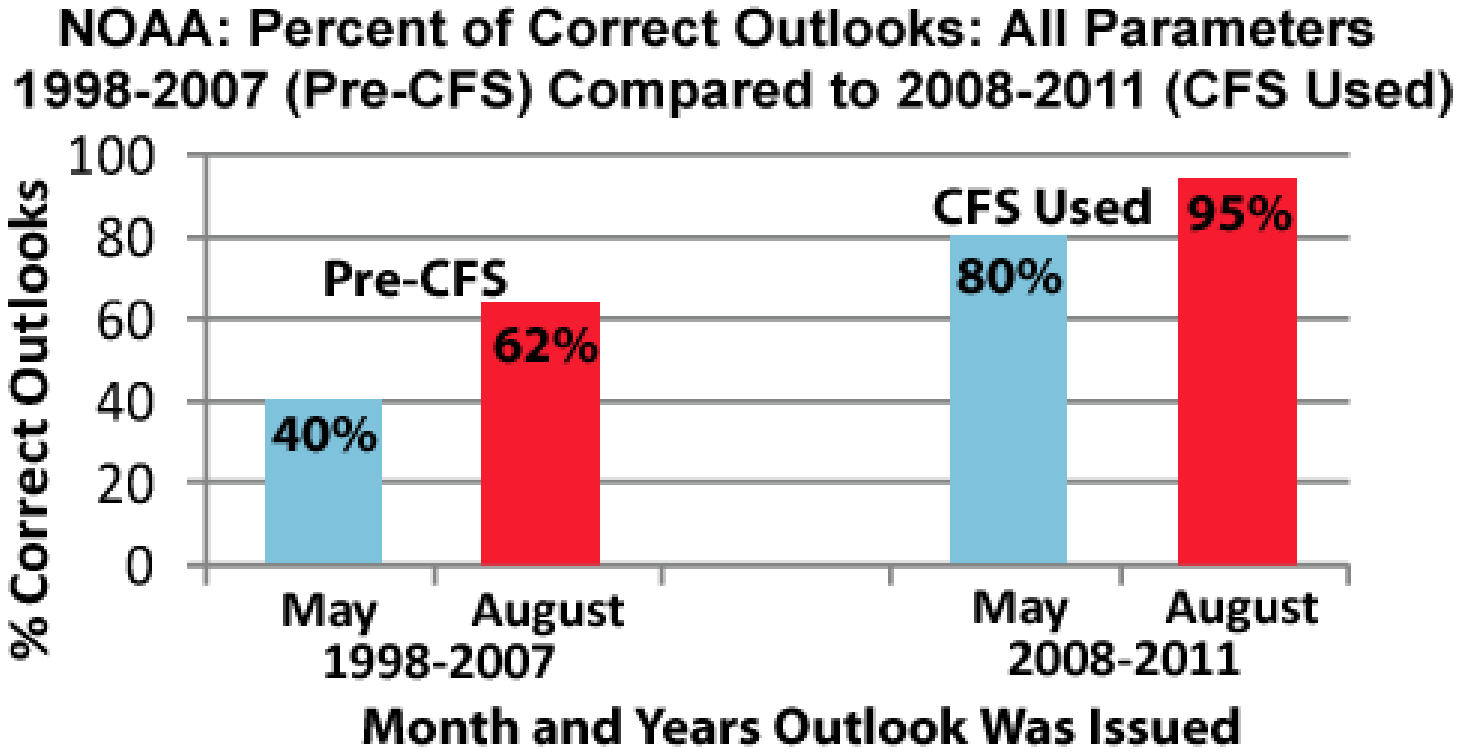
For 2013 the probabilities of each season type are:

	Atlantic	Eastern Pacific	Central Pacific
Above Normal	70%	10%	5%
Near Normal	25%	35%	25%
Below Normal	5%	55%	70%

Hurricane Forecasts and Verification

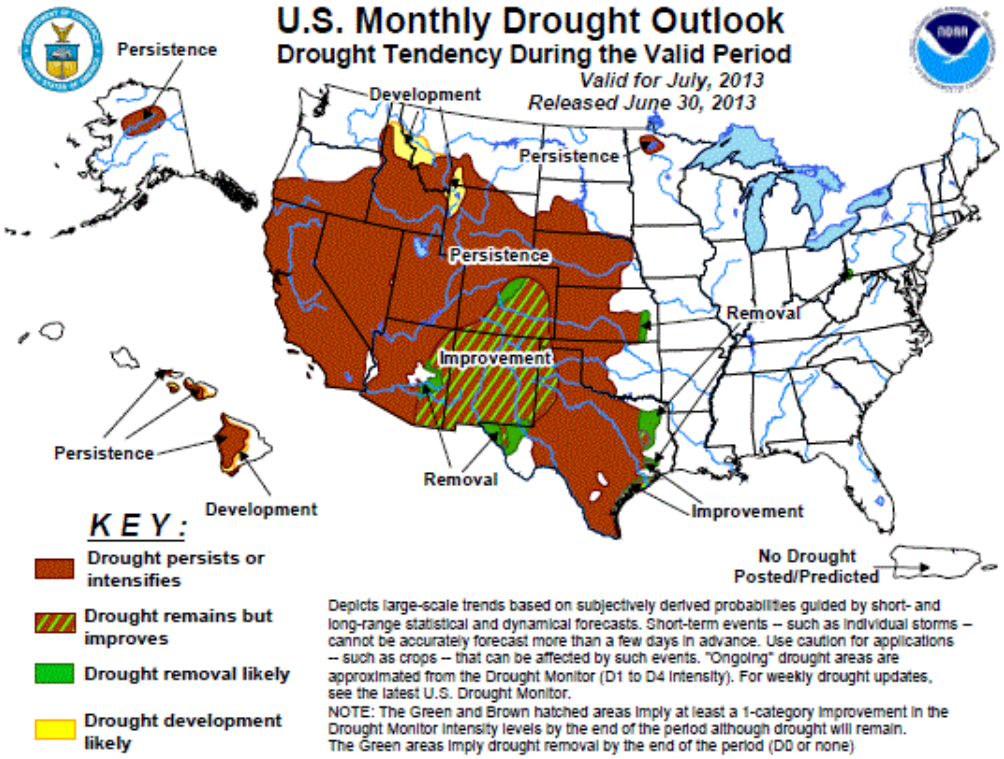
	Atlantic Basin	Tropical Storms	Hurricanes	ACE Index (% of Median)
2009	Ensemble	7.4	2.6	82.8
	Range	5-10	1-4	61-104
	Verification	9	3	57
2010	Ensemble	21.5	10.5	262.3
	Range	18-25	7-14	212-312
	Verification	19	12	185
2011	Ensemble	13.9	5.0	144.6
	Range	10-17	3-7	104-185
	Verification	19	7	134
2012	Ensemble	12.4	3.7	124.4
	Range	10-15	0-7	89-160
	Verification	19	10	133

Atlantic Outlook Verification: All Parameters



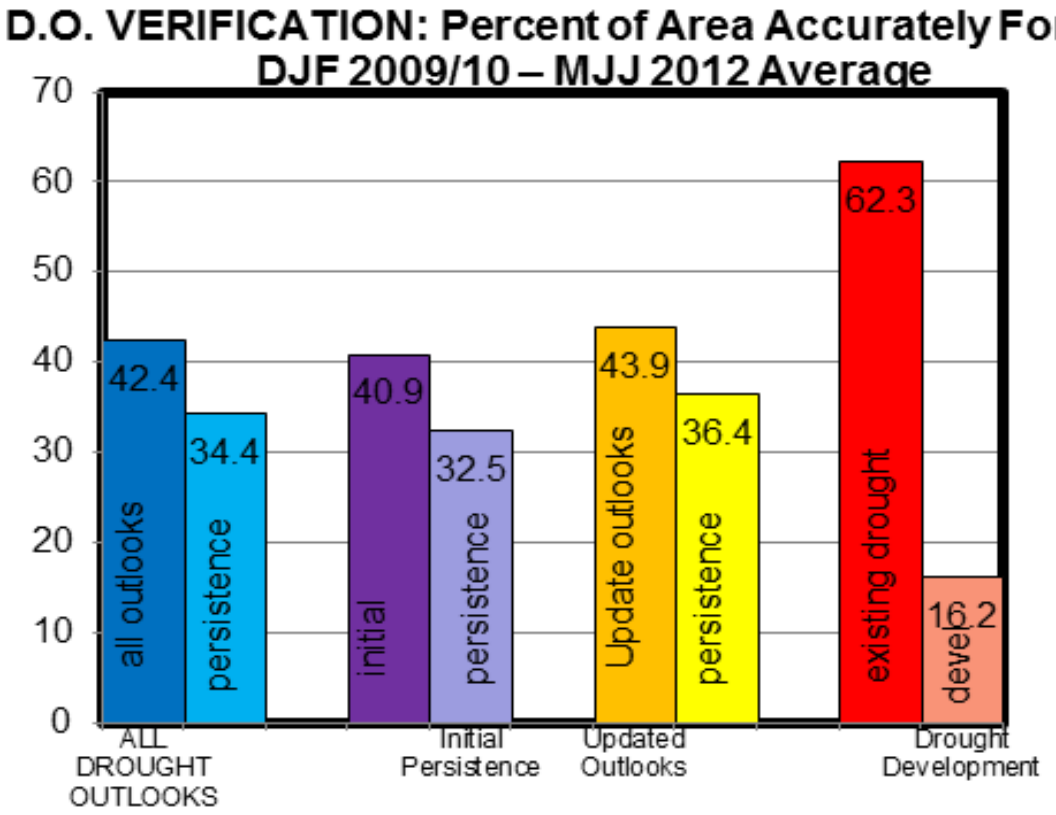
The use of dynamical models since 2008, especially the CFS, has contributed to a large improvement in outlook accuracy.

Drought Monthly and Seasonal Outlooks



- CPC, NDMC, USDA, NCDC jointly produce a weekly **Drought Monitor**
- **CPC produces Drought Outlook** twice each month (seasonal on 3rd week of the month and monthly on the last day of the month).
- **Multiple inputs**: short-term, extended range and seasonal Outlook, climatology, NLDAS, ENSO forecast, CFS, NMME, ESP and many more
- Combination of meteorological, hydrological and agriculture droughts

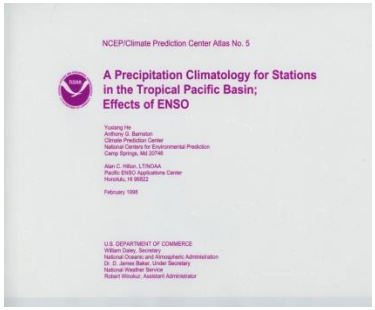
Drought Outlook Verification



- **Verification** consists of comparing the accuracy of the official Drought Outlook with a forecast of persistence of current observations forward
- A MAPP Drought Task Force **Drought Assessment Protocol** is under development

Regional Outlooks Example: Hawaii

Pacific Rainfall Atlas



NCEP/Climate Prediction Center Atlas No. 5

A Precipitation Climatology for Stations in the Tropical Pacific Basin; Effects of ENSO

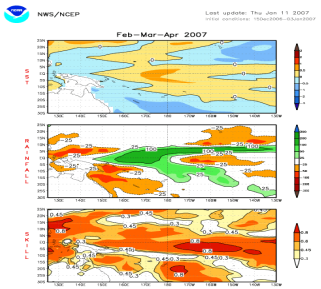
Yuxiang He
Anthony G. Barnston
Climate Prediction Center
National Centers for Environmental Prediction
Camp Springs, Md 20746

Alan C. Hilton, LT/NOAA
Pacific ENSO Applications Center
Honolulu, Hi 96822

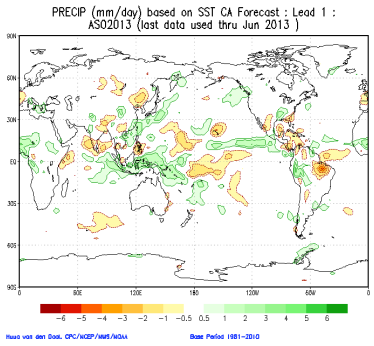
February 1998

U.S. DEPARTMENT OF COMMERCE
William Daley, Secretary
National Oceanic and Atmospheric Administration
Dr. D. James Baker, Under Secretary
National Weather Service
Robert Winokur, Assistant Administrator

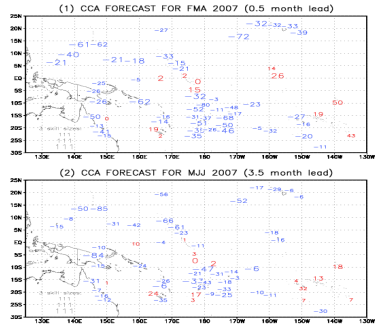
CFS



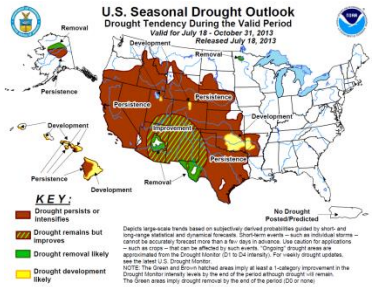
CPC CA



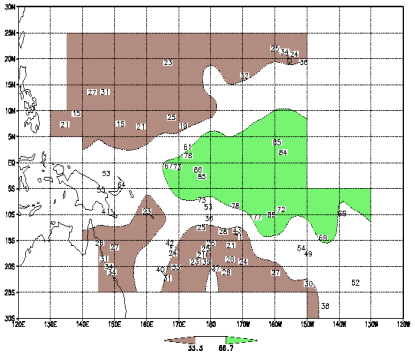
CPC CCA



Hawaii drought



ENSO Composite



pacific **ENSO** update

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A Quarterly Bulletin of the Pacific El Niño/Southern Oscillation Applications Climate (PEAC) Center Providing Information on Climate Variability for the U.S.-Affiliated Pacific Islands

http://www.prh.noaa.gov/peac

CURRENT CONDITIONS

The tropical Pacific climate system fell just short of El Niño status during July, August and September of 2012. During these three months the SST in the Niño 3.4 region of the tropical central Pacific warmed to the threshold of El Niño (an SST anomaly at or above +0.5°C). During October 2012, however, the SST in the crucial Niño 3.4 region fell below this threshold. By December 2012, the SST there was below normal, and has remained slightly below normal ever since. By definition, the climate state of the Pacific thus entered ENSO-neutral, but weather conditions more in-line with La Niña (e.g., a weakening of the monsoon, reduced tropical cyclone activity and elevated sea level) became established across Micronesia. In the South Pacific there was an early start to tropical cyclone activity with a major cyclone affecting Samoa and Fiji during December 2012. Enhanced tropical cyclone activity in the South Pacific near Samoa sometimes occurs during ENSO-neutral, but is most pronounced during a weak or moderate El Niño. A strong El Niño can move the cyclone activity so far to the east that American Samoa is spared, while La Niña tends to move the cyclone activity so far to the west that Samoa is spared in that condition as well. This same east-west shift of tropical cyclone activity is seen in the western North Pacific as well in response to the neutral status of ENSO.

During the first part of the calendar year, most islands of Micronesia enter their typical dry season. At islands north of 10°N (e.g., Guam and the islands of the CNMI) the dry season is prolonged (~6 months), while at islands further to the south, the dry season is shorter. For example, at Pohnpei Island there are typically only two or three relatively dry months (January, February or March). In island groups that span across a wide range of latitudes, the rainfall can vary substantially, with islands further to the north more prone to very dry conditions. The first three months of 2013 provided a good example of this large north-south rainfall disparity as the northern-most islands of Chuuk State, the Republic of the Marshall Islands (RMI) and some islands of Yap state became very dry, with islands further to the south relatively unaffected. In the RMI, dry conditions in the northernmost islands (e.g., Kwajalein, Wotje and Utirik) became severe with impacts to water quality and quantity. The WFO Guam in conjunction with the RMI regional weather service office began to issue drought statements in February 2013. These statements continue to be issued at the time of this writing. By April 2013, the situation became so dire that the RMI Cabinet and the Chief Secretary declared a state of emergency for the northern RMI. Although normally very dry during the first part of the calendar year, Guam and some of the islands of the CNMI have recently become abnormally dry, with enhanced frequency and extent of brush fires being the most notable effects so far.

While dryness has been the dominant condition seen recently across most of the USAPI, it has not been dry everywhere. Notable surpluses of rainfall have been seen in American Samoa and continue still at Kapingamarangi and Nukuoro in Pohnpei State.

After a record setting dry fall and early winter seasons for the Hawaiian Islands, the January-February-March (JFM) season saw above average precipitation totals over large portions of the islands providing a much needed relief from drought conditions. January provided rainfall over all the islands improving drought conditions over the whole state while February and March rainfall was mostly concentrated over the western Islands of the state making for drought conditions still pervasive in some areas of The big Island and Maui. The JFM season also saw a few record braking events for precipitation maximums and low temperatures associated with frontal passages.

See the Local Variability Summaries for more details on the climate and weather of each island group.

The following comments from the **EL NIÑO/SOUTHERN OSCILLATION (ENSO) DIAGNOSTIC DISCUSSION** were posted on the U.S. Climate Prediction Center/NCEP and the International Research Institute for Climate and Society web site on April 4, 2013:

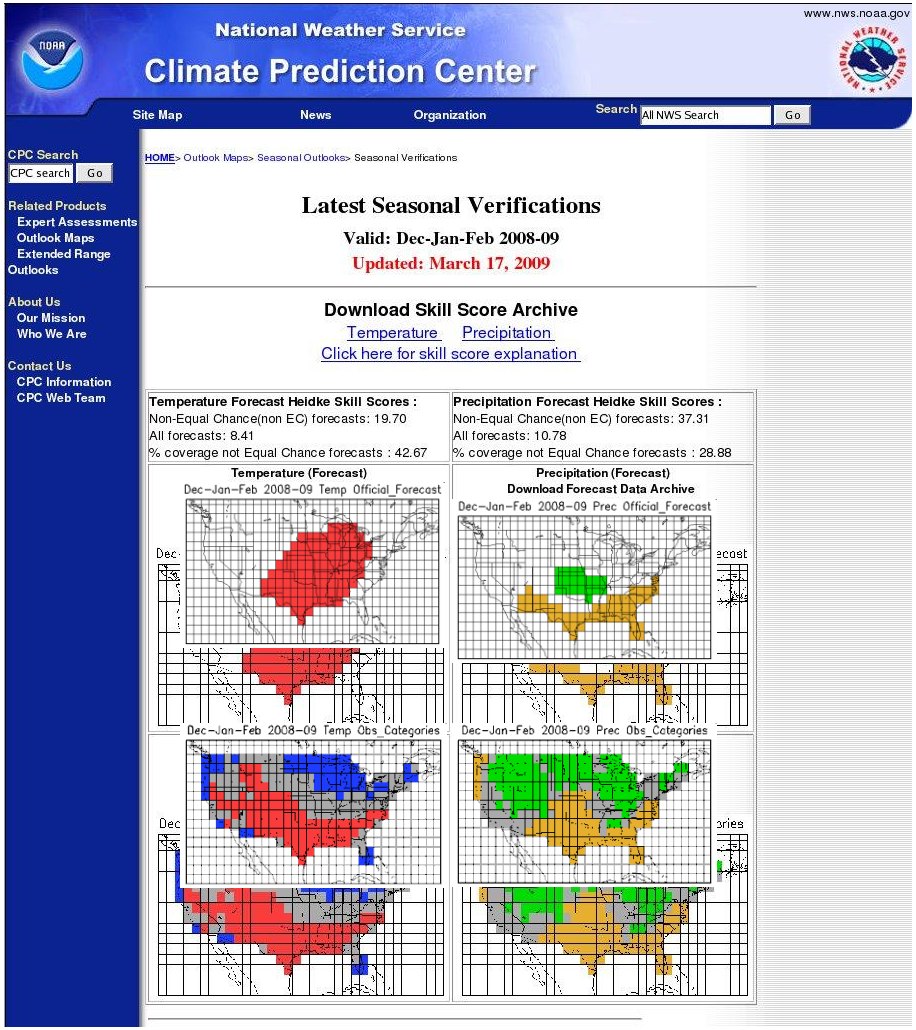
"ENSO Alert System Status: Not Active

Synopsis: ENSO-neutral is favored into the Northern Hemisphere summer 2013.

During March 2013, ENSO-neutral continued, with slightly above average SSTs in the eastern portion of the basin. Weekly values of all the Nino indices were between -0.5°C and +0.5°C during the month. The oceanic heat content (average temperature in the upper 300m of the ocean) increased to near-average during the month as an area of above-average temperatures at depth moved eastward into portions of the eastern basin."

CPC Real-time Foreast Verification

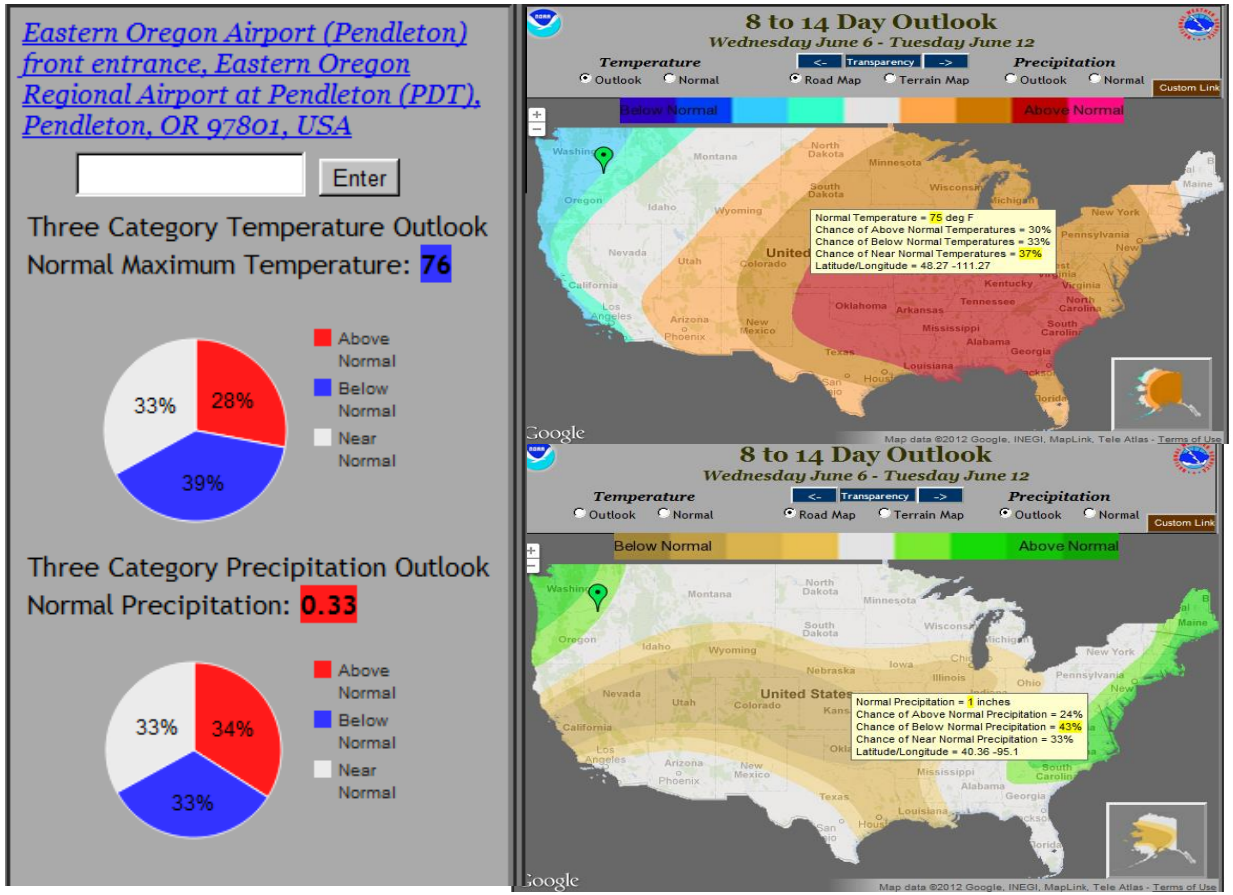
http://www.cpc.ncep.noaa.gov/products/predictions/long_range/tools/briefing/seas_veri.grid.php



CPC provides real-time gridded verification of its official outlooks

- **downloadable archive**
- **observations**
- **performance metrics**

Pendleton WFO Web Interface for CPC Outlooks



Transferring a Web Interface developed at WFO Pendleton that gives users a number of options to display information from CPC's official outlooks at specific locations (includes mouse over capability, pie charts, climate normals; etc.)

CPC Plans for Future Products (in CPC Strategic Plan)

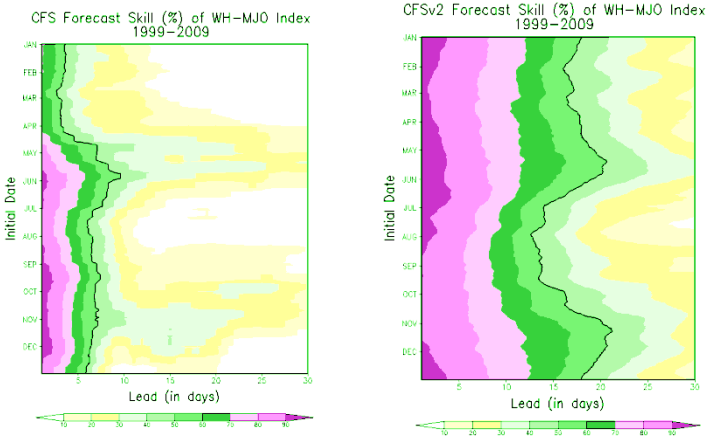
- **Expand CPC products into weeks 3 and 4**
- Expand the monthly outlook to include outlooks for months 2 and 3
- Advance towards a **probabilistic forecast for hurricane landfalls** after research and development.
- Experiment with 1-2 year outlooks for key climate variables and phenomena (e.g., drought).
- Incorporate new satellite observations to enhance climate monitoring and prediction products.
- Implement monthly to seasonal **outlooks for severe weather**.
- Collaborate with partners to develop Arctic-specific forecasts including sea ice forecasts in line with societal needs.
- Expand the regional and local product suites.

- CPC plans to stop redundant and underutilized products
- CPC plans to create and utilize an Advisory Board to inform changes, priorities, and evaluations of CPC products and services.

Plans on Intra-Seasonal Forecast

- Making forecasts for weeks 3 and 4 is in the newly developed CPC Strategic Plan
- Increased model capability in simulating MJO makes the intra-seasonal forecasts hopeful.

CFSv1 and CFSv2 Forecast Skill of MJO index



- CPC and CTB are working with the NMME team to develop plans for intra-seasonal forecasts
  - A mini-workshop to develop forecast protocol for intraseasonal
  - Work with other agencies and ESPC partners to develop stakeholder and user requirements

Summary

- CPC develops, verifies and disseminates official climate forecast products for ISI time scales.

- CPC post-processing includes
  - Objective consolidation of dynamical and empirical tools
  - Subjective decision for the official products

- Forecast format, tools, procedures and verification metrics vary with time scales and products

- CPC plans to introduce new products (and stop underutilized products) in collaboration with the research community, the weather community and other agencies.
  - Climate Test Bed is a mechanism for R2O and O2R