GPC-Washington Overview

Arun Kumar

Climate Prediction Center

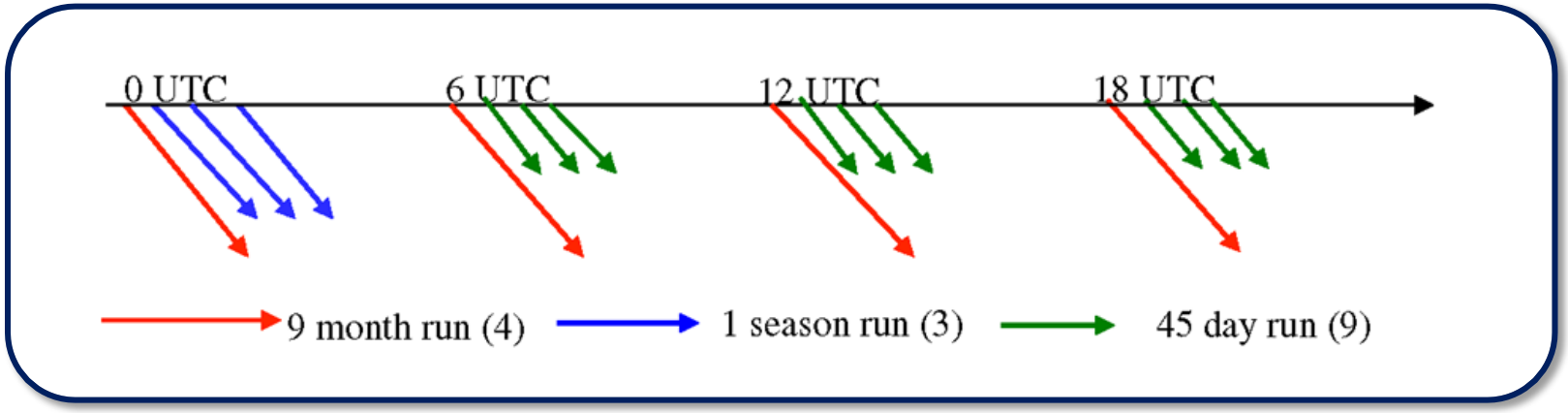
arun.kumar@noaa.gov

Long-Range Forecast System

- Coupled Model
  - Made operational March 2011
  - Atmospheric model: T126/L64 (~1 Deg lat/lon)
  - Ocean model: MOM4 (0.5 Deg lat/lon)
- Initialization
  - Climate Forecast system reanalysis (CFSR)
    - Atmosphere
    - Land
    - Ocean
- No immediate plans for a system update

Real-time Forecast Configuration

- Forecasts done in a continuous mode
- A suite of extended-range forecasts each day
  - Four 9-month lead forecasts/day
  - Four 120 day lead forecasts/day
  - Sixteen 45 day lead forecasts/day



Hindcast Configuration

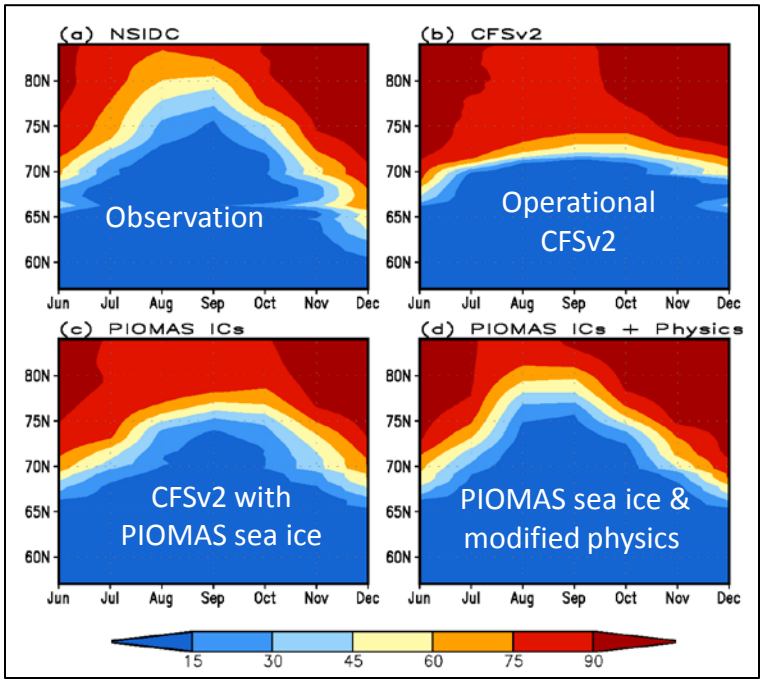
- Seasonal
  - Four 9-month lead forecasts every 5th day of calendar month
  - 1981-2010
- Monthly/Sub-seasonal
  - Four 45-day lead forecasts everyday of calendar month
  - 1999-2010
- Effective hindcast (for research and analysis)
  - Seasonal: 1981-present
  - Monthly/Sub-seasonal: 1999-present

Data Availability

- 7-day rotating archive for real-time forecasts
- Hindcasts available via various sources
  - NCEP
  - NCDC/NCEI
  - IRI
  - S2S database at ECMWF
- Real-time forecast data sent to
  - Seasonal: Lead Center for Long-Range Forecasts
  - Monthly: ECMWF S2S

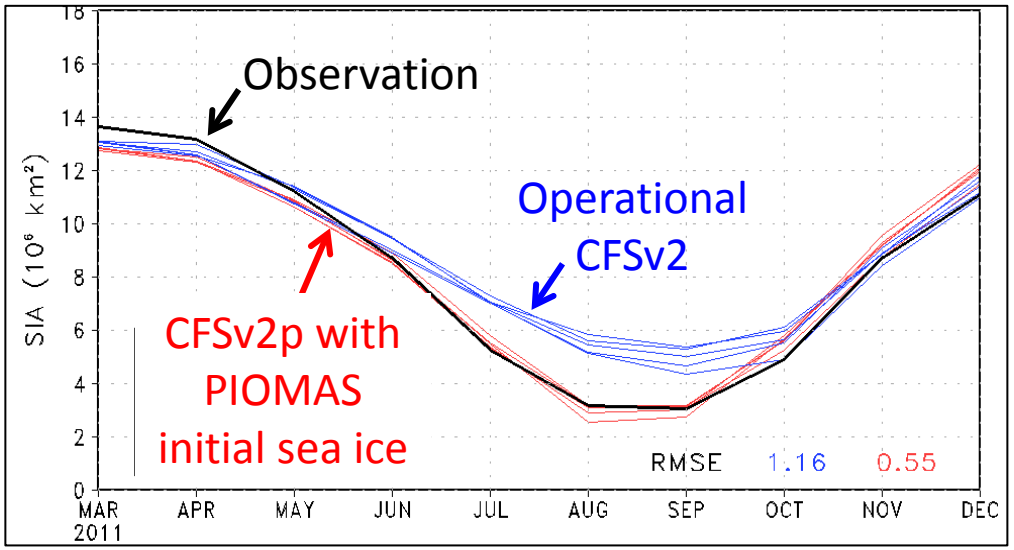
Some Research Highlights

- Improving sea-ice predictions



Zonal mean sea ice concentration (%) around Bering and Chukchi Sea (170-200E)

2011 sea ice extent from March ICs

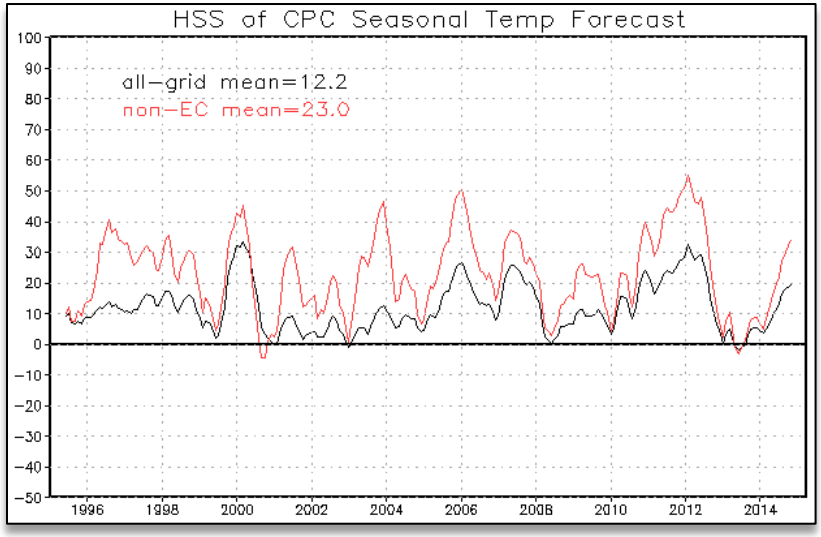


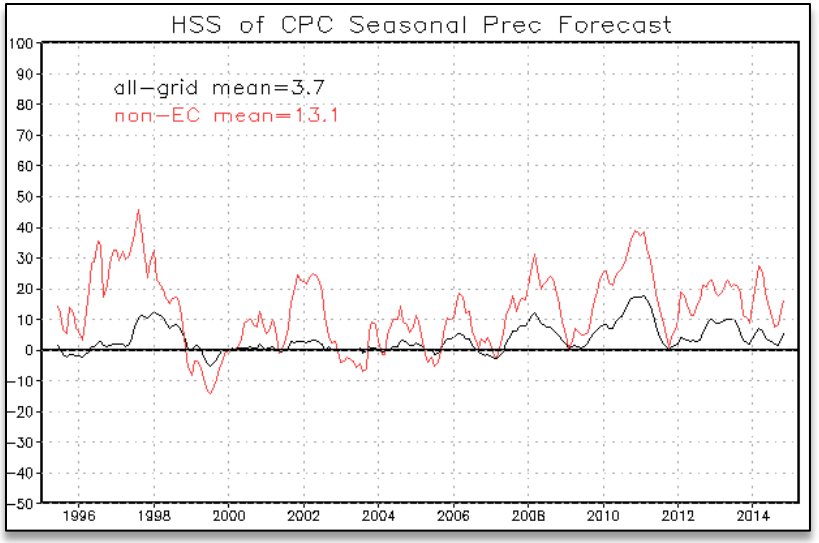
Some Research Highlights

- Tropical Pacific observing system and influence on ENSO prediction
- Low-frequency variability in ENSO
- Understanding recent increase in AO/NAO prediction skill
- Developing an experimental predictions for Week3 and Week 4 surface temperature and precipitation over the U.S.
- Causes and understanding of California drought

Research Issues

- Understanding limits of predictability and managing expectations





Some Research Issues

- Causes for low-frequency variability in skill (ENSO, AO/NAO,...)
- Predictability of (or anticipating) low-frequency variations
- Predictability of sub-seasonal extremes
- Given limited resources, guidance on which developmental pathways (hindcast length, ensemble size, more resolution, forecast configuration strategies,...) are most beneficial for improvements in skill?

North American Multi-Model Ensemble (NMME)

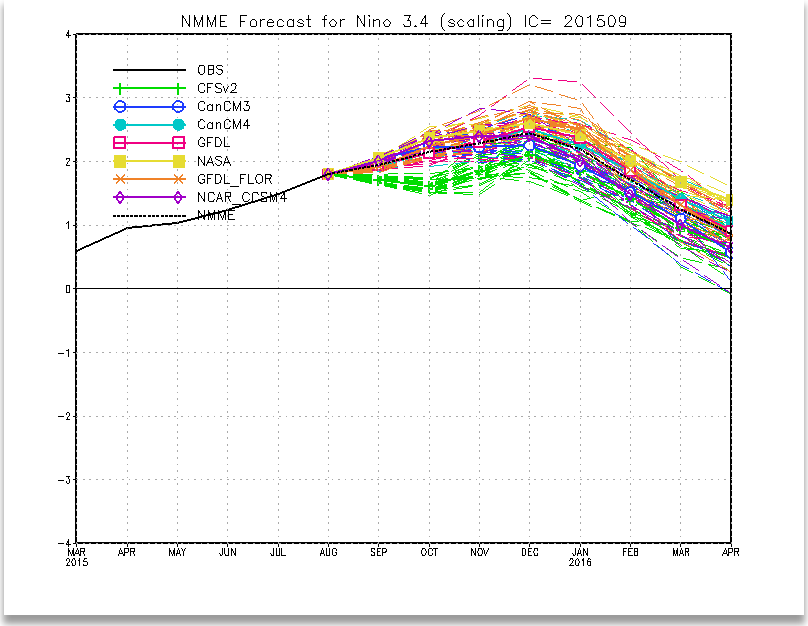
http://www.cpc.ncep.noaa.gov/products/NMME/

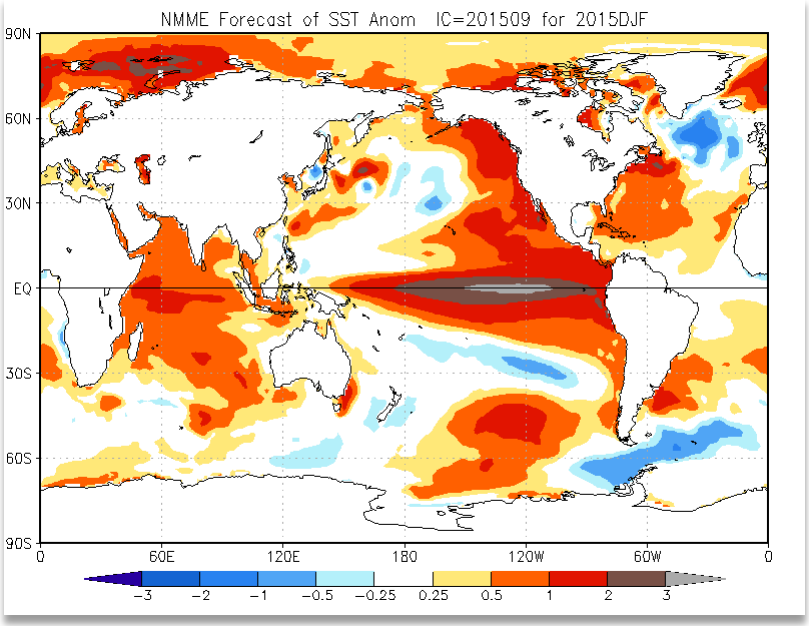
Thanks to Dr. Jin Huang

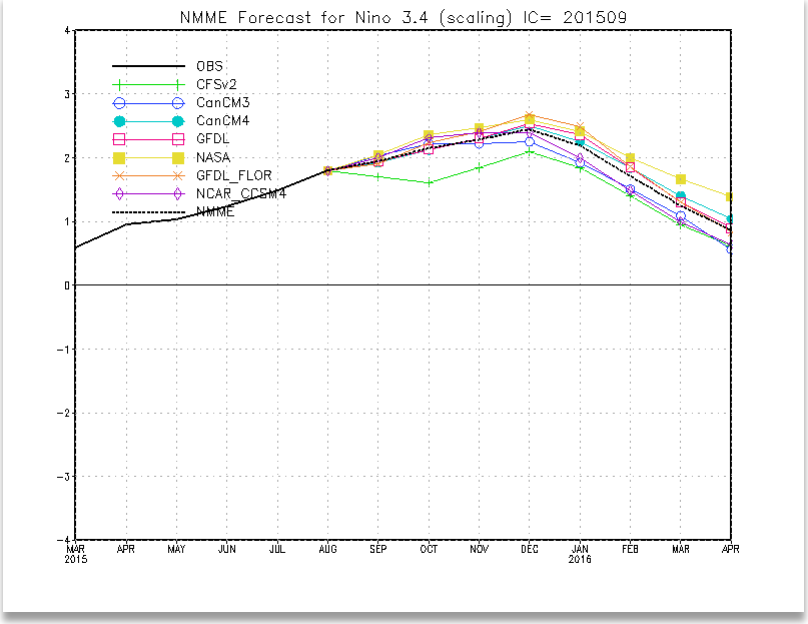
Contributing Models

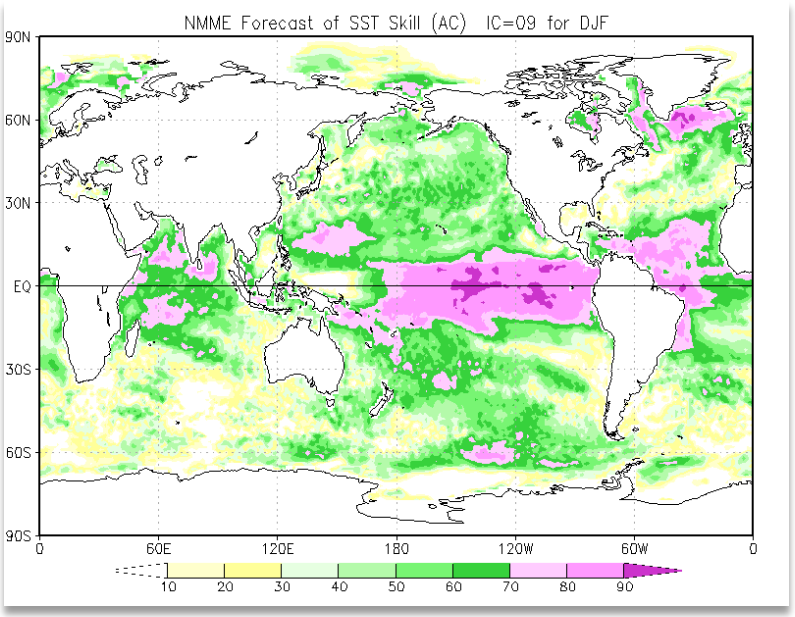
Model	Hindcast Period	No. of Members	Arrangement of Members	Lead (month)	Model resolution (atmos)	Model resolution (ocean)	Reference
Active							
NCEP/CFSv2	1982-2010	24 (28)	4 members (0, 6, 12, 18z) every 5th day	0-9	T126L64	MOM4L40 .25deg Eq	Saha et al (2010)
GFDL/CM2.1	1982-2010	10	All 1st of the month 0Z	0-11	2x2.5degL24	MOM4L50 .3deg Eq	Delworth (2006)
GFDL/CM2.5 (FLOR)	1982-present	24	All 1st of the month 0Z	0-11	C18L32 (50km)	MOM5 L50 0.30 deg Eq 1degPolar1.5	Vecchi et al (2014)
CMC1-CanCM3	1981-2010	10	All 1st of the month 0Z	0-11	CanAM3 T63L31	CanOM4L40 .94deg Eq	Merryfield et al (2013)
CMC1-CanCM4	1981-2010	10	All 1st of the month 0Z	0-11	CanAM4 T63L35	CanOM4L40 .94deg Eq	Merryfield et al (2013)
NCAR/CCSM4	1982-2010	10	All 1st of the month 0Z	0-11	0.9x1.25degL26	POPL60 .25deg Eq	Kirtman et al. (in prep)
NASA/GEOS5	1981-2010	11	4 mems every 5 days; 7 mems on last day of last month	0-9	1x1.25 deg L72	MOM4L40 .25deg Eq	Vernieres et al (2012)
Retired							
NCEP/CFSv1	1982-2009	15	1st 0Z +/-2 days, 21st 0z +/-2d, 11th 0z +/-2d	0-8	T62L64	MOM3L40 0.30 deq Eq	Saha et al (2006)
NCAR/CCSM3	1982-2010	6	All 1st of the month 0Z	0-11	T85L26	POPL42 0.3deg Eq	Kirtman and Min2009)
IRI-ECHAM4f	1982-2010	12	All 1st of the month 0Z	0-7	T42L19	MOM3L25(1.5x0.5)	DeWitt (2005)
IRI-ECHAM4a	1982-2010	12	All 1st of the month 0Z	0-7	T42L19	MOM3L25 (1.5x0.5)	DeWitt (2005)
Planned							
NCAR/CESM1	1982-2010	10	All 1st of the month 0Z	0-11	0.9x1.25degL30	POPL60 .25deg Eq	Tribbia et al.

NMME graphical products









NMME Data Available to Public

1. Realtime forecasts from CPC website
   - http://www.cpc.ncep.noaa.gov/products/NMME/

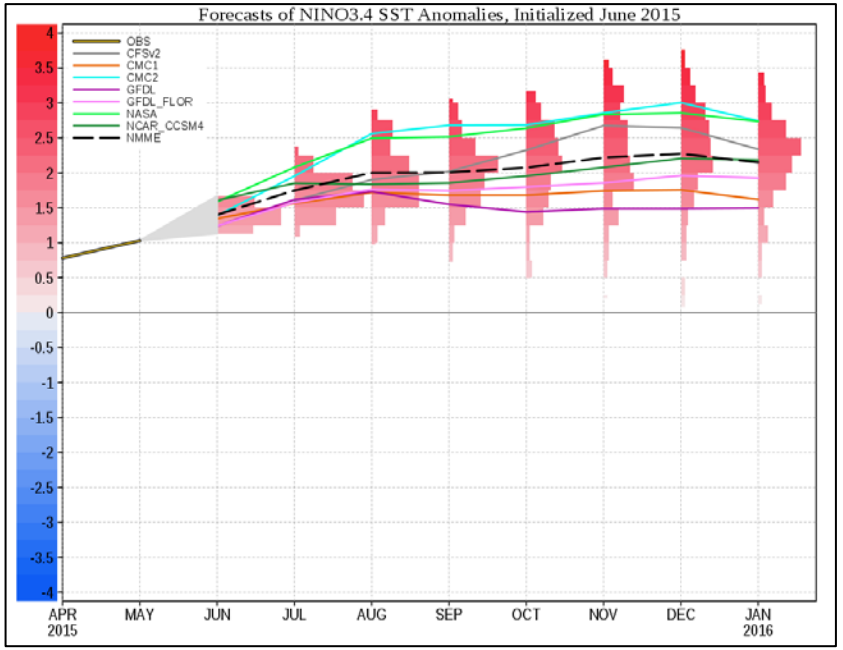
2. Phase-I Reforecast data in IRI website available now
   - Monthly Mean of 30 year reforecast
   - 8 variables (P, T, SST, Z200, Tmax, Tmin Soil Moisture, Runoff)
   - http://iridl.ldeo.columbia.edu/SOURCES/.Models/.NMME/

3. Phase-II Reforecast data in NCAR
   - Data available starting July 2014, October 2014 for complete set
   - Selected (22) daily atmospheric and land variables
   - Daily atmospheric pressure level fields (5)
   - Monthly seas ice and ocean fields (9)
   - https://www.earthsystemgrid.org/search.html?Project=NMME

Currently over 250 subscribers of the NMME mailing list: 20% from the private sector, 27% academic, 14% NOAA, 16% from international, meteorological services , 23% others.

NMME – Key Achievements

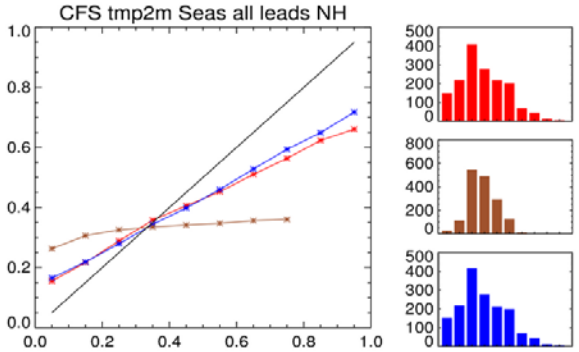
- Contributing experimentally to NOAA operational seasonal outlooks since 2011
- Most comprehensive seasonal prediction data set accessible to the public
- Enabling prediction and predictability research and informing and benefiting from model improvement (~50 publications)
- The diversity of models in NMME enhances seasonal prediction skill, beyond individual model forecasts



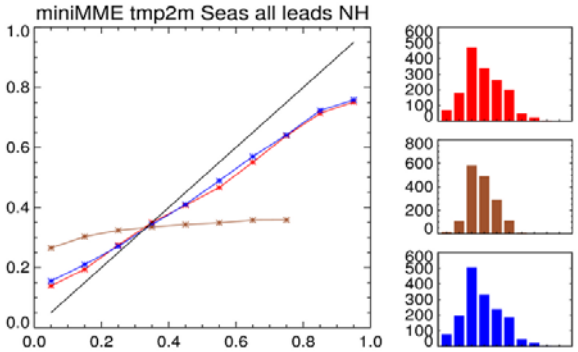
NMME-based ENSO Plume: Forecasts of Nino 3.4 SST Anomalies, initiated in June 2015 (Courtesy of COLA)

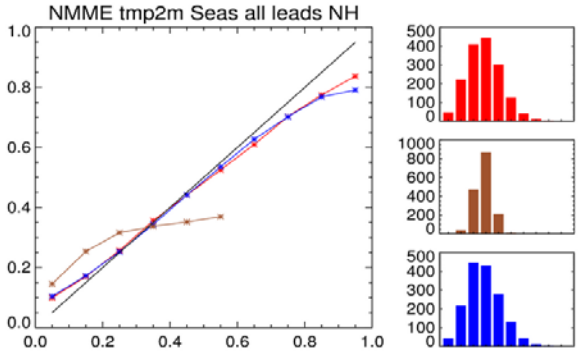
NMME Improves Forecast Reliability

CFS (1 model, 24 members)



Mini-NMME (6 models, 24 members)





Full-NMME (6 models, ~ 100 members)

NMME increases forecast reliability due to both ensemble size and model diversity.

NMME Sub-seasonal Forecast System Exploratory Workshop

NCWCP, College Park, MD
March 30–31, 2015

Workshop Purpose:

- To explore scientific opportunities and feasibility to evolve the current NMME seasonal forecast system to enable sub-seasonal forecasts
- To design a coordinated reforecast protocol for a potential NMME sub-seasonal forecast system
- To assess operational and stakeholder needs for future testing and implementation

Workshop Participants

- US Agencies:
  NOAA, NASA, Navy, Air Force
- International:
  Environment Canada, ECMWF, UK Met Office, Korea/APCC
- Universities
- US/NRC S2S Study members

NMME Sub-seasonal Forecast System Exploratory Workshop – Presentations/Discussions

Key scientific questions and opportunities:

- WCRP/WWRP S2S project:
  - Useful dataset, but 3-weeks embargoing won't meet real-time multi-model needs
  - S2S models don't follow the same protocol.
- Sub-seasonal predictability and prediction opportunities
  - Land-atmospheric interaction
  - Stratosphere-troposphere interaction
  - MJO-NAO coupling
  - Air-sea interaction (not presented)
  - Spatial resolution of atmospheric models is critical

Assessments of community needs (what's critical vs negotiable, what's the feasibility, ….)

- Overview of needs
  - Operational
  - Research community
  - Other Applications
- Technical Needs
  - Data frequency
  - Data variables
  - Resolution
  - Data transfer
  - Case studies
  - Bench marks

Workshop Outcome: Experimental Sub-seasonal Forecast Protocol

General Requirements:

- Reforecasts: minimum 1999-2015
- Ensemble members: minimum 4
- Models and procedures including initial conditions for real-time forecasts and reforecasts should be the same
- Forecast Length: minimum of 32 days.
- One-year of real-time forecasts is required

Requirements Specific for Real-time:

- All forecasts (& hindcasts) must be sent to CPC 5pm ET each Wednesday
- Output data for real-time forecast include: T2m, Precip, Z500, Z200, SST, SM

Initialization Requirements:

- Initialization Frequency: once a week
- Forecast providers are encouraged to use the most recent observations to initialize real-time forecasts.
- Initialization of the atmosphere and land surface is required; Initialization of the ocean is required for coupled O-A models; Other models should use the time evolving predicted (and/or persisted) ocean state.

Output Data Requirements:

- Data will be output on a 1x1 grid
- Total fields, not anomalies, must be provided.
- All ensemble members, not the ensemble mean, must be provided.
- Daily means of the variables should be output (and reforecasts will include more variables than real-time)