WGSIP and Sub-Seasonal Prediction Project

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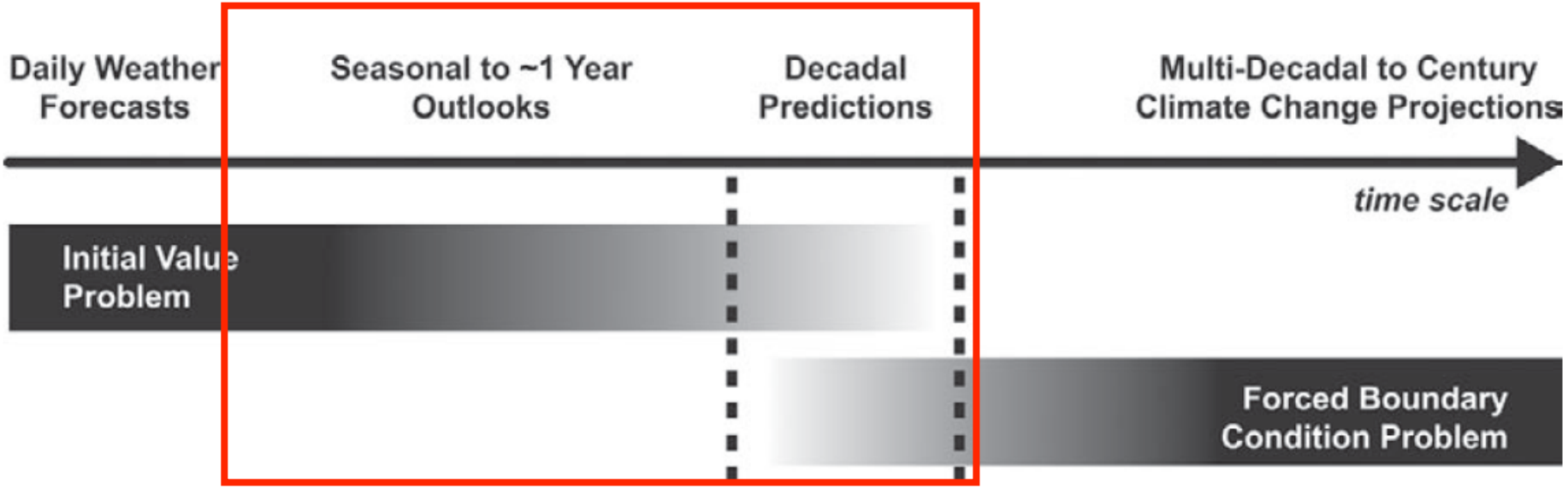
Prediction on climate time scales

Progression from initial-value problems with weather forecasting at one end and multi-decadal to century projections as a forced boundary condition problem at the other, with climate prediction (sub-seasonal, seasonal and decadal) in the middle. Prediction involves initialization and systematic comparison with a simultaneous reference.

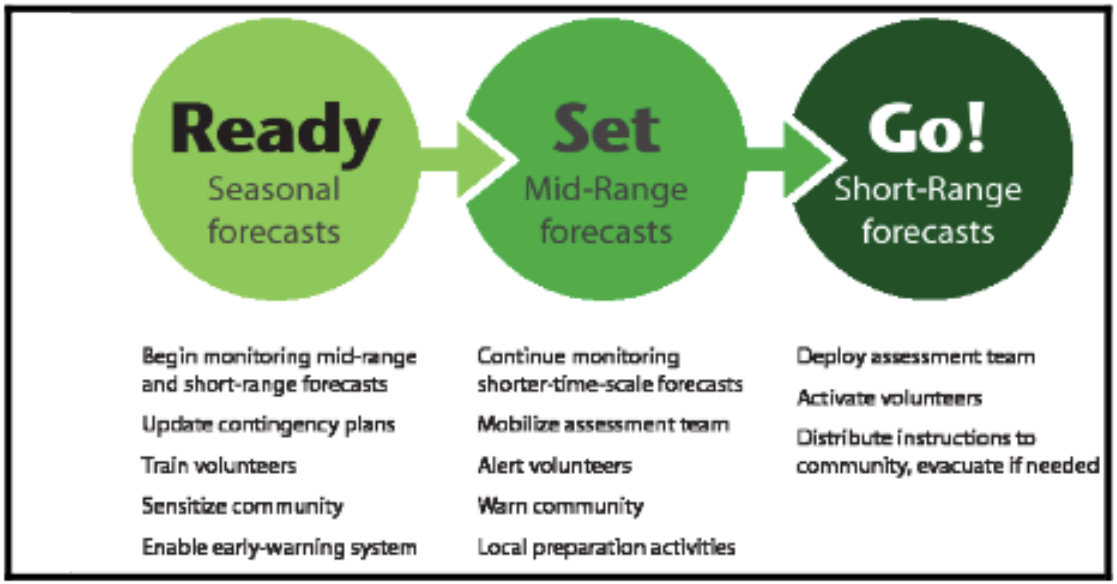


Meehl et al. (2009)

Seamless prediction

Application of seamless climate and weather information. Example from the IRI-Red Cross collaboration:

- Likelihood of severe, high-impact weather (drought, flooding, wind storms, etc.), humanitarian planning and response to disasters, agriculture (e.g. wheat and rice production), disease control (e.g. malaria, dengue and meningitis), river-flow (e.g. flood prediction, hydroelectric power generation and reservoir management).



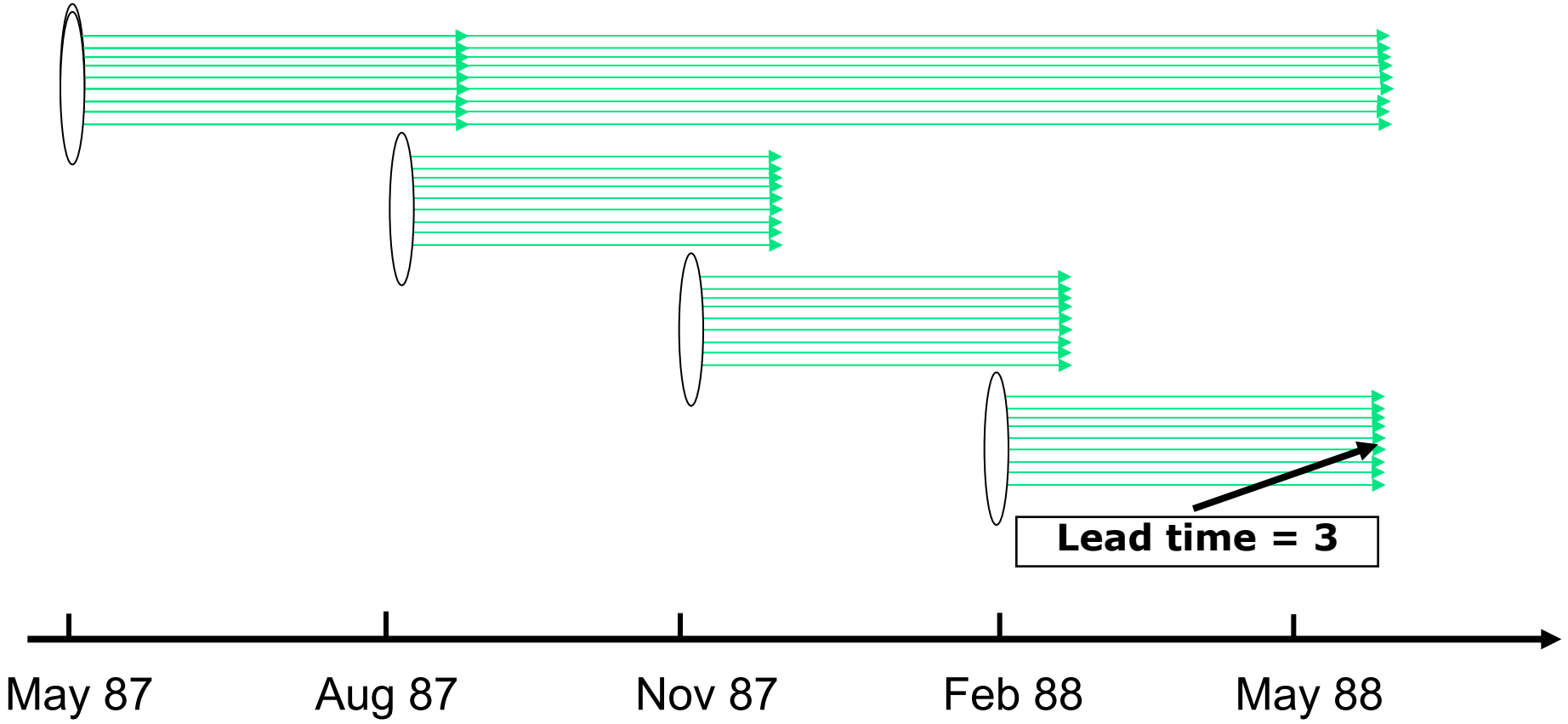
Courtesy IRI

Methods for climate prediction

- Empirical/statistical forecasting
  - Use past observational record and statistical methods
  - Works with reality instead of error-prone numerical models
  - Limited number of past cases
  - A non-stationary climate is problematic
  - Can be used as a benchmark
- GCM forecasts
  - Include comprehensive range of sources of predictability
  - Predict joint evolution of ocean and atmosphere flow
  - Includes a large range of physical processes
  - Includes uncertainty sources, important for prob. Forecasts
  - Systematic model error is an issue!
- <u>Predictions are expected to be probabilistic.</u>

Ensemble climate forecast systems

Assume an ensemble forecast system with coupled initialized GCMs



Sub-seasonal to seasonal prediction

- Fill the gap between medium-range and seasonal (10-30 days) forecasting, linking WCRP and WWRP.
- Requested by WMO Commission of Atmospheric Sciences (CAS) at its 15th session (Nov. 2009).
- WCRP/WWRP/THORPEX workshop (Exeter, 1-3 Dec. 2010).
- Kick-off meeting (Geneva, 2-3 Dec. 2011).
- Implementation plan written with priority given to
  - establishment of collaboration between operational centres undertaking sub-seasonal prediction for consistency and to enable the production of databases of sub-seasonal predictions for standard verification procedures and research
  - facilitating the wide-spread research use of the data collected for CHFP, TIGGE and YOTC for research
  - sponsorship of a few international research activities
  - establishment of a series of regular workshops

Sub-seasonal to seasonal prediction

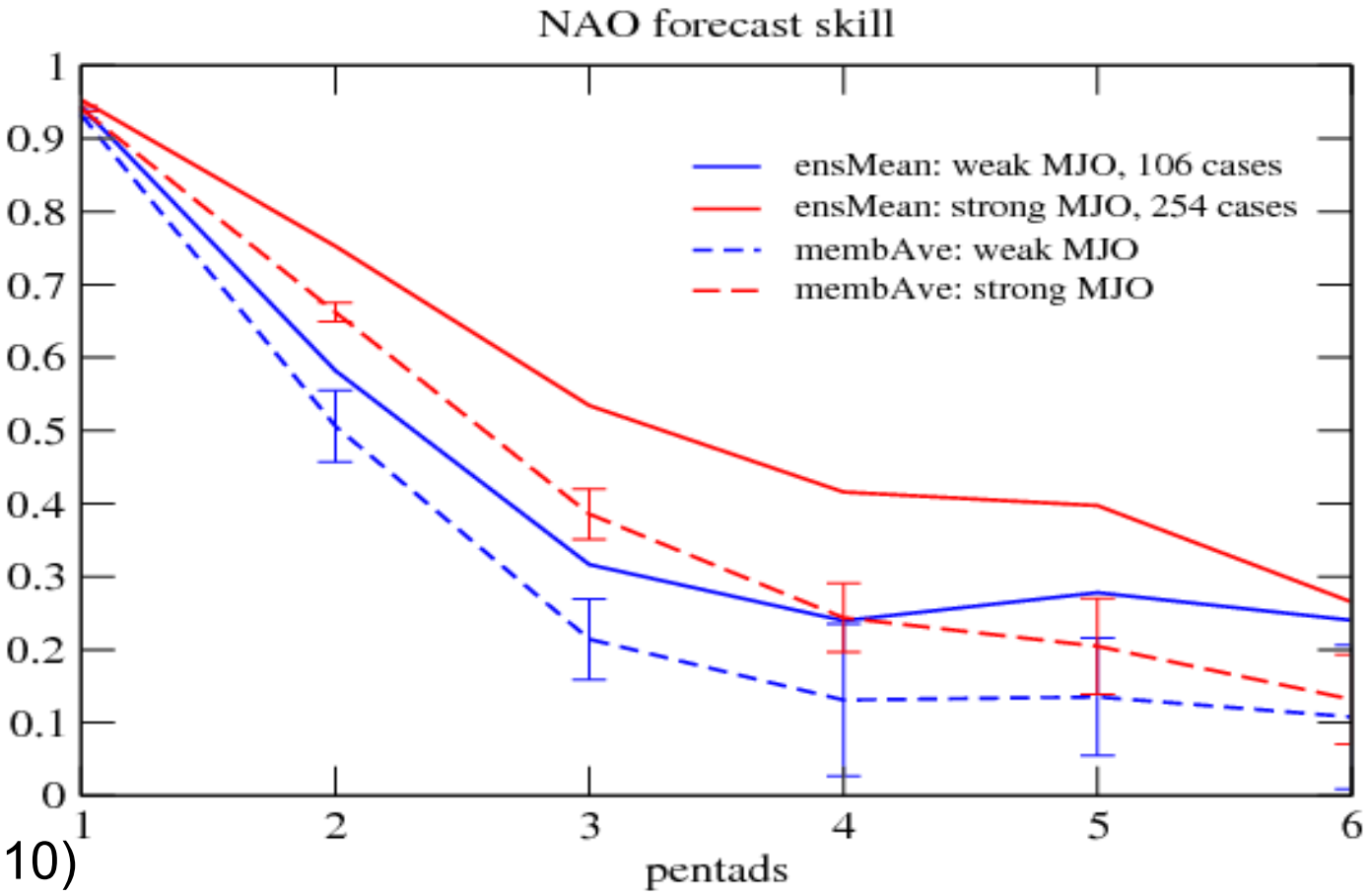
- Five years, plus a possible five-year extension
- Co-Chairs: Frédéric Vitart (ECMWF), Andrew Robertson (IRI)
- Members: Arun Kumar (NCEP), Harry Hendon (CAWCR), Yuhei Takaya (JMA), Hai Lin (EC), Alberto Arribas (UKMO), June-Yi Lee (U. Hawaii), Duane Waliser (JPL NASA), Ben Kirtman (UM RSMAS), Hyun-Kyung Kim (KMA)
- Liaison group: Carolina Vera (WCRP JSC Liaison), Richard Graham (UKMO, CBS), Jean-Pierre Céron (Météo-France, CCL), Barbara Brown (JWVGR), Steve Woolnough (GEWEX/ GASS)
- David Anderson (WMO consultant)

Sub-seasonal to seasonal prediction

- Sub-seasonal prediction is especially important where initial conditions and intraseasonal oscillation is strong, while seasonal predictability is weak, such as the Indian summer monsoon.
- Sources of predictability: MJO, SSTs, sea ice, snow cover, soil moisture, coupling stratosphere-troposphere.
- User-relevant data and modelling needs:
  - Availability of long hindcast histories needed to develop post-processing and tailoring models, and for skill estimation.
  - High-frequency data, especially for a few key variables including precipitation and near-surface temperature and wind speed.
  - Regional high-resolution predictions.
  - Open data access to enable uptake.

Predicting the NAO and the MJO

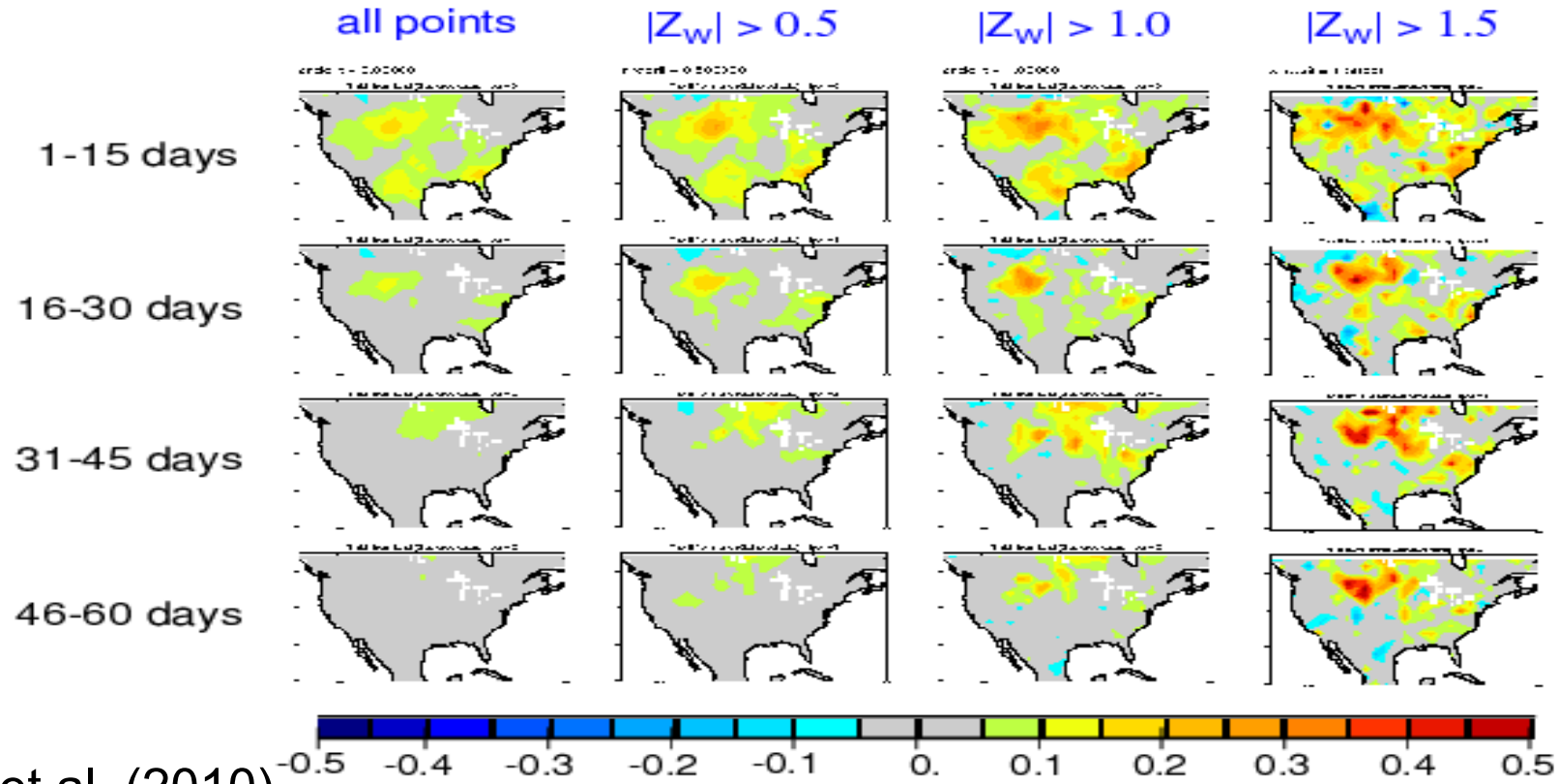
NAO ensemble-mean correlation from monthly forecasts with the Canadian forecast system (using observed SSTs).



Lin et al. (2010)

Impact of soil moisture

Difference in squared correlation for temperature forecasts between initialized and randomly initialized GLACE2 predictions, where the sample of forecasts are conditioned on the initial soil moisture anomaly.



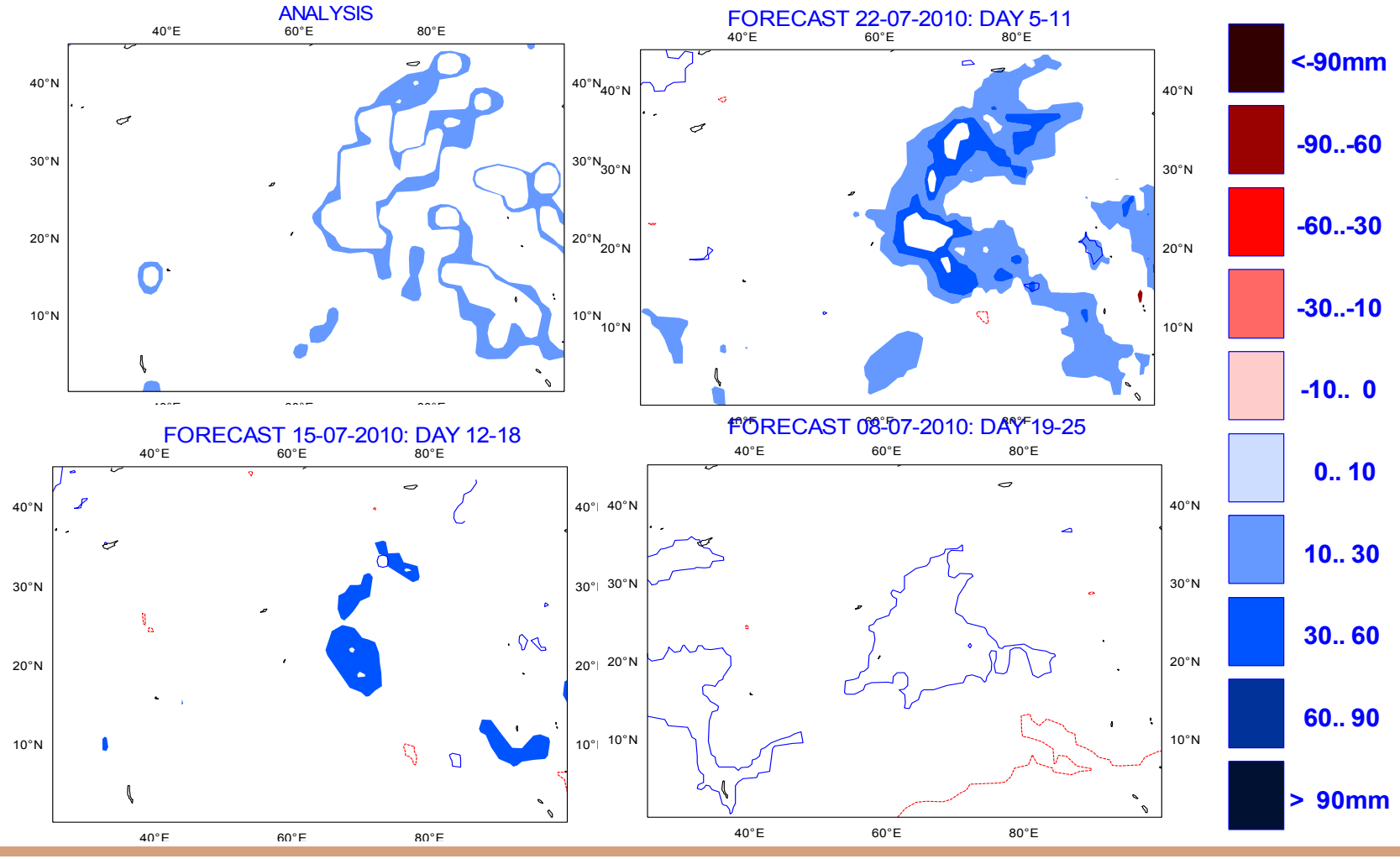
Koster et al. (2010)

Sub-seasonal to seasonal prediction

- Scientific and modelling issues:
  - Identify sources of predictability
  - Prediction of the MJO and its impacts in numerical models
  - Teleconnections as forecasts of opportunity
  - Monsoon prediction
  - Rainfall predictability and extreme events
  - Polar prediction and sea-ice
  - Stratospheric processes
  - Understanding systematic errors and biases in the sub-seasonal to seasonal forecast range
  - Comparing, verifying and testing multi-model combinations
  - Focussing on some specific extreme event case studies, such as the Russian heat wave of 2010, the Pakistan floods in 2010, Australian floods of 2011, European cold spell in 2012, as demonstration projects; at least one of the demonstration projects should be on real time

Demonstration projects

ECMWF monthly precipitation forecasts for the Pakistan 26 Jul-01 Aug torrential rainfall. Reference ERA Interim.



Sub-seasonal to seasonal prediction

	Range	Resol.	Ens. Size	Freq.	Hcsts	Hcst length	Hcst Freq	Hcst Size
ECMWF	D 0-32	T639/319L62	51	2/week	On the fly	Past 18y	weekly	5
UKMO	D 0-60	N96L85	4	daily	On the fly	1989-2003	4/month	3
NCEP	D 0-60	N126L64	16	daily	Fix	1999-2010	daily	4
EC	D 0-35	0.6x0.6L40	21	weekly	On the fly	Past 15y	weekly	4
CAWCR	D 0-120	T47L17	33	weekly	Fix	1989-2010	3/month	33
JMA	D 0-34	T159L60	50	weekly	Fix	1979-2009	3/month	5
KMA	D 0-30	T106L21	20	3/month	Fix	1979-2010	3/month	10
CMA	D 0-45	T63L16	40	6/month	Fix	1982-now	monthly	48
CPTEC	D 0-30	T126L28	1	daily	No	-	-	-
Met.Fr	D 0-60	T63L91	41	monthly	Fix	1981-2005	monthly	11
SAWS	D 0-60	T42L19	6	monthly	Fix	1981-2001	monthly	6
HMCR	D 0-60	1.1x1.4 L28	10	monthly	Fix	1979-2003	monthly	10

WGSIP: Seasonal-Interannual Prediction

- WGSIP uses current ocean observations and climate models to produce regional climate predictions from intra-seasonal, seasonal, and decadal time scales.
- Response to WCRP grand challenges:
  - Challenge 1 (Provision of skillful future climate information on regional scales): The CHFP (Climate Historical Forecast Project) gives a state of the art measure of the forecast quality of regional climate predictions out to months ahead
  - Challenge 3 (Cryosphere response to climate change): Several global producing centres (e.g. UKMO, CCCMA, NCEP) now make real time seasonal-to-decadal (s2d) forecasts with initialized sea ice
  - Challenge 5 (Past and future changes in water availability): S2d predictions naturally output the full range of climatic variables and form the basis for future climate services in water availability out to years ahead
  - Challenge 6 (Science underpinning the prediction and attribution of extreme events): Prediction of extreme events is at the core of the s2d prediction effort

WGSIP

- Foci: sub-seasonal, seasonal, decadal.
- Active meeting schedule:
  - OceanObs09 (Venice, Sept 09)
  - 8th Workshop on Decadal Climate Variability (Maryland, Oct 09)
  - Earth-System Initialization for Decadal Prediction (deBilt, Nov 09)
  - Predicting Climate of the Coming Decades (Miami, Jan 10)
  - WGSIP-13 (Buenos Aires, July 10)
  - Conference on Decadal Predictability (Trieste, Aug, 10)
  - Workshop on Decadal Variability, Predictability and Predictions: Understanding the role of the oceans (NCAR, Sept 10)
  - WGCM-14 (Exeter, Oct 10)
  - Seasonal to Multi-decadal Predictability of Polar Climate (Bergen, Oct 10)
  - IPCC 1st LA Meeting (Kunming, Nov 10)
  - Making sense of the multi-model prediction experiments from CMIP5 (Aspen, June 11)
  - IPCC 2nd LA Meeting (Brest, July 11)
  - WGSIP-14 (Trieste, Sept 11)
  - IPCC 3rd LA Meeting (Marrakech, Apr 12)
  - WGSIP-15, joint with WCRP/WGCM (Hamburg, 24-26 September 12)

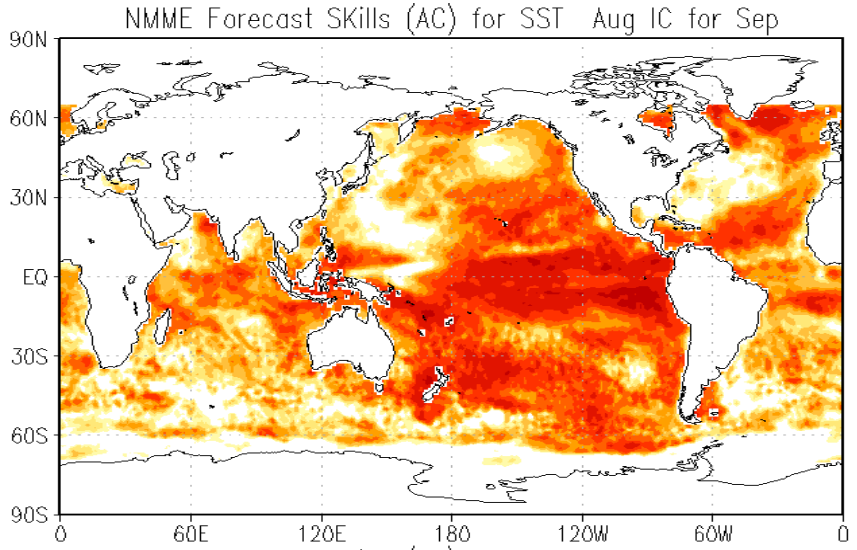
WGSIP seasonal

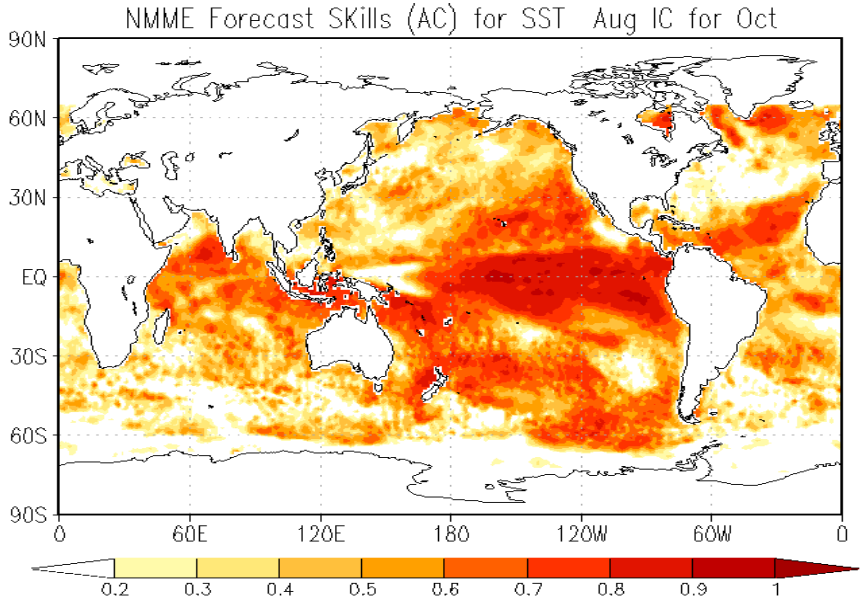
- CHFP: EU ENSEMBLES, UKMET, APCC, NOAA-NCEP, NOAA-GFDL, NASA-GMAO, COLA-UMiami-NCAR, BMRC, JMA, CCCma, CPTEC, IRI. http://chfps.cima.fcen.uba.ar/
- National Multi-Model Ensemble (NMME), http://iridl.ldeo.columbia.edu/SOURCES/.Models/.NMME
- EUROSIP

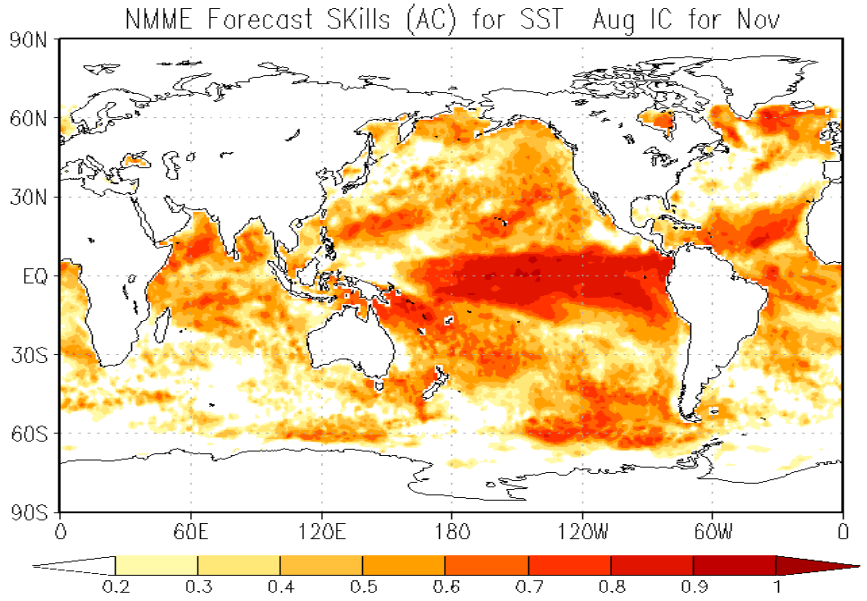
Model	Hindcast Period	Ensemble Size	Lead Times	Arrangement of Ensemble Members	Contact and reference
CFSv1	1981-2009	15	0-8 Months	1st 0Z +/-2 days, 21st 0Z +/-2d, 11th 0Z+/- 2d	Saha (Saha et al. 2006)
CFSv2	1982-2009	24(28)	0-9 Months	4 members (0,6,12,18Z) every 5th day	Saha (Saha et al. 2010)
GFDL-CM2.2	1982-2010	10	0-11 Months	All 1st of the month 0Z	Rosati (Zhang et al. 2007)
IRI-ECHAM4-f	1982-2010	12	0-7 Months	All 1st of the month 0Z	DeWitt (DeWitt 2005)
IRI-ECHAM4-a	1982-2010	12	0-7 Months	All 1st of the Month 0Z	DeWitt (Dewitt 2005)
CCSM3.0	1982-2010	6	0-11 Months	All 1st of the Month 0Z	Kirtman (Kirtman and Min 2009)
GEOS5	1981-2010	6	0-9 Months	1 Member every 5th day	Schubert (Vernieres et al. 2011)

WGSIP seasonal

SST verification (ensemble-mean correlation) of NMME against NCEP OISST, 1982-2009.





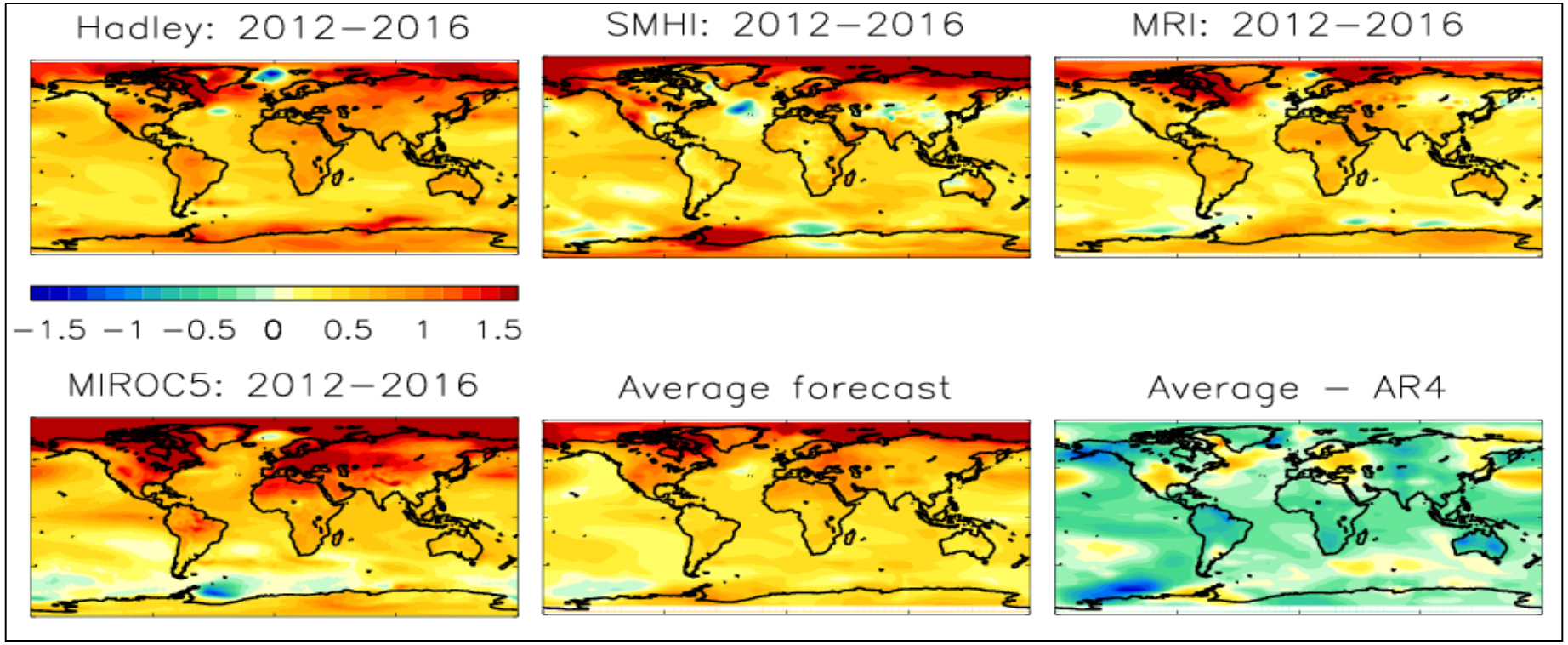


WGSIP seasonal

- Three additional experiments:
  - Land Surface, the GLACE2 experiment (R. Koster): Soil moisture experiments in seasonal mode. Transposed to assess impact of snow initial conditions.
  - Stratosphere, Stratospheric Historical Forecast Project (A. Scaife): High top - Low top hindcasts.
  - Sea Ice, Ice Historical Forecast Project (D. Peterson): Case studies with/ without initial sea-ice data (2007/1996).

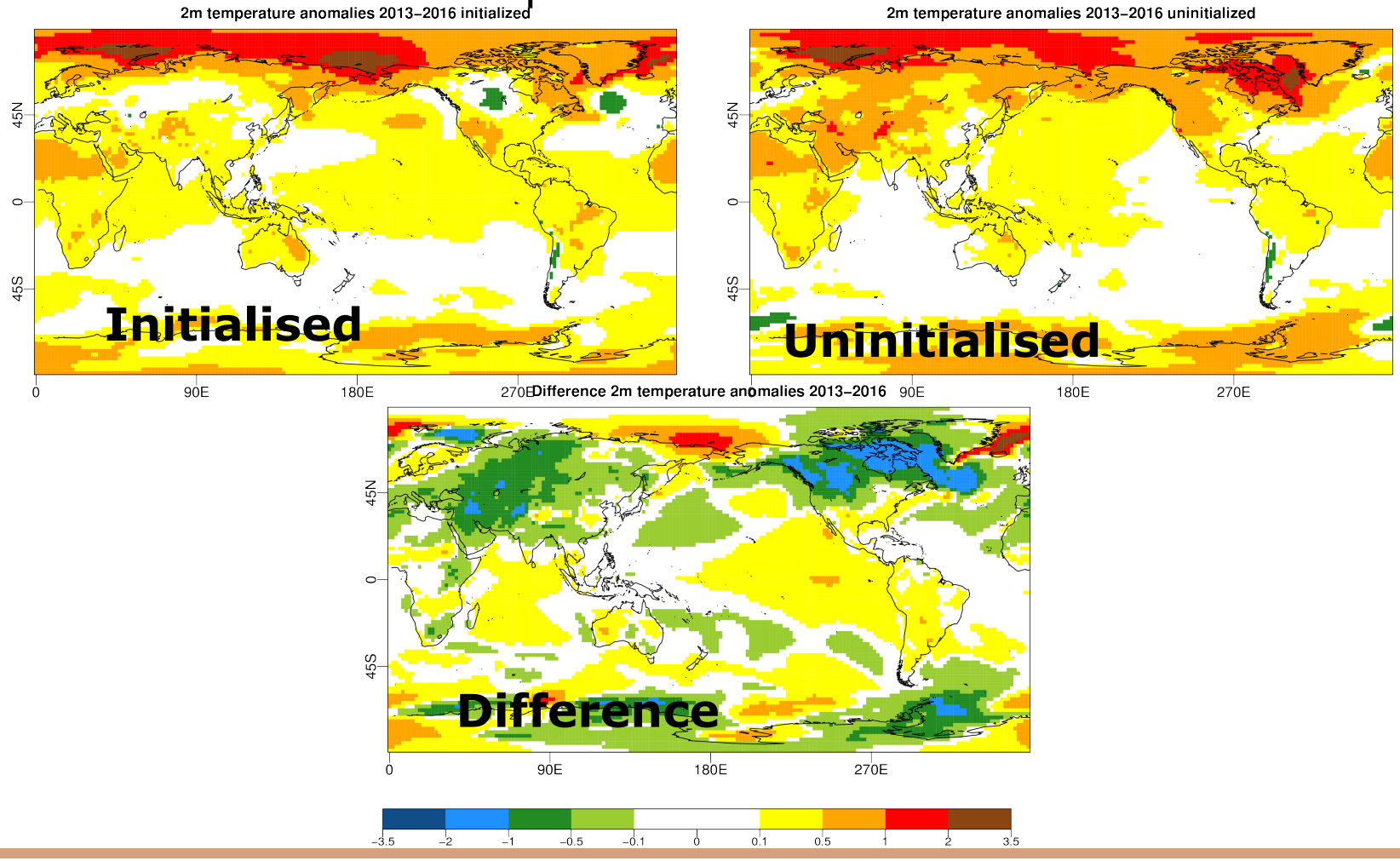
WGSIP decadal

- Large (more than 14 forecast systems) amount of contributions to the CMIP5 decadal prediction exercise.
- Experimental near real time decadal prediction exchange lead by the Met Office.



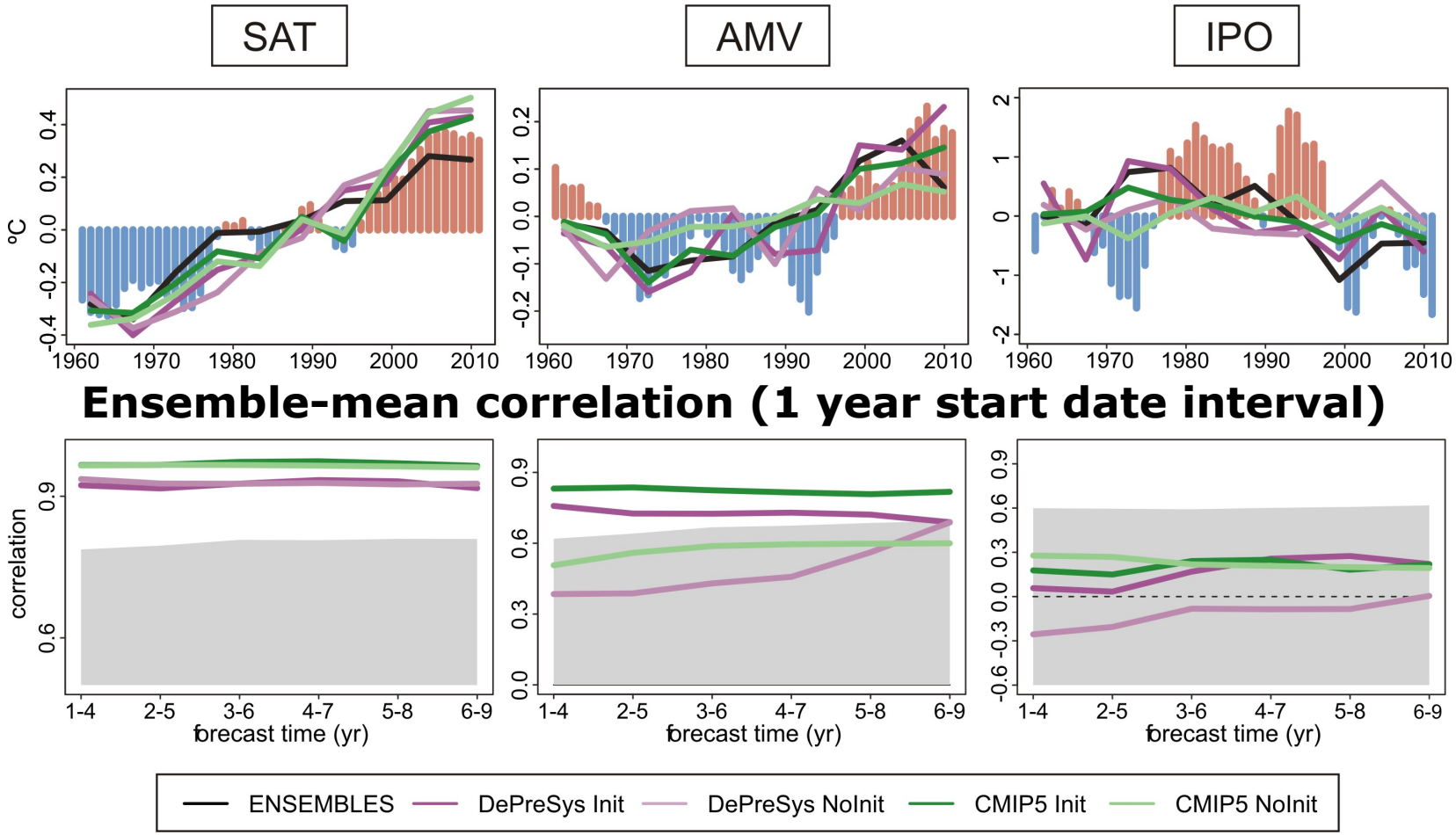
WGSIP decadal

EC-Earth 2-5 year near-surface air temperature ensemble-mean predictions started in November 2011. Anomalies are computed with respect to 1971-2000.



CMIP5 decadal predictions

Decadal predictions from DePreSys_PP, ENSEMBLES and CMIP5 multi-models over 1960-2005. GISS and ERSST data used as reference. Grey area for the 95% confidence level.



WWRP Polar Prediction Project

Promote cooperative international research enabling development of improved prediction services for the polar regions, on time scales from hourly to seasonal. This is the hourly to seasonal research component of the WMO Global Integrated Polar Prediction System (GIPPS).

- Understand the needs for enhanced prediction/services in polar regions
- Establish and apply verification methods appropriate for polar regions
- Determine predictability and sources of forecast errors in polar regions
- Improve knowledge of two-way linkages between polar and lower latitudes, and their implications for global prediction
- Improve representation of key polar processes in (coupled) models of the atmosphere, land, ocean and cryosphere
- Develop and exploit ensemble prediction systems with appropriate representation of initial conditions and model uncertainty for polar regions
- Develop data assimilation systems for the characteristics of polar regions
- Provide guidance on optimizing polar observing systems, and coordinate additional observations to support modelling and verification

Climate prediction

- Some questions linked to modelling activities for the next 5-10 years:
  - Q1: Can ocean-atmosphere, land-atmosphere or sea ice-atmosphere coupling drive predictable year to year changes in extratropical atmospheric circulation and, hence, extreme events?
  - Q2: Given that we nominally remove the model bias in both seasonal and decadal predictions, how do current ocean model errors affect the skill of predictions months to years ahead?
  - Q3: What are the key climate model changes needed to best represent the processes in Q1 and to minimize the errors in Q2 in our seasonal to decadal forecast systems?

Links

- WGNE, CLIVAR and GEWEX including regional panels
- GFCS
- CBS
- WMO lead center for long-range forecasts multi-model ensemble (LC-LRFMME) /http://wmolc.org/
- Verification working groups (SVS-LRF and JWGFVR)
- FP7 SPECS, NOAA MAPP
- C20C
- HPC initiatives: PRACE, INCITE, ENES