Working Group on Seasonal-to-Interannual Prediction (WGSIP)

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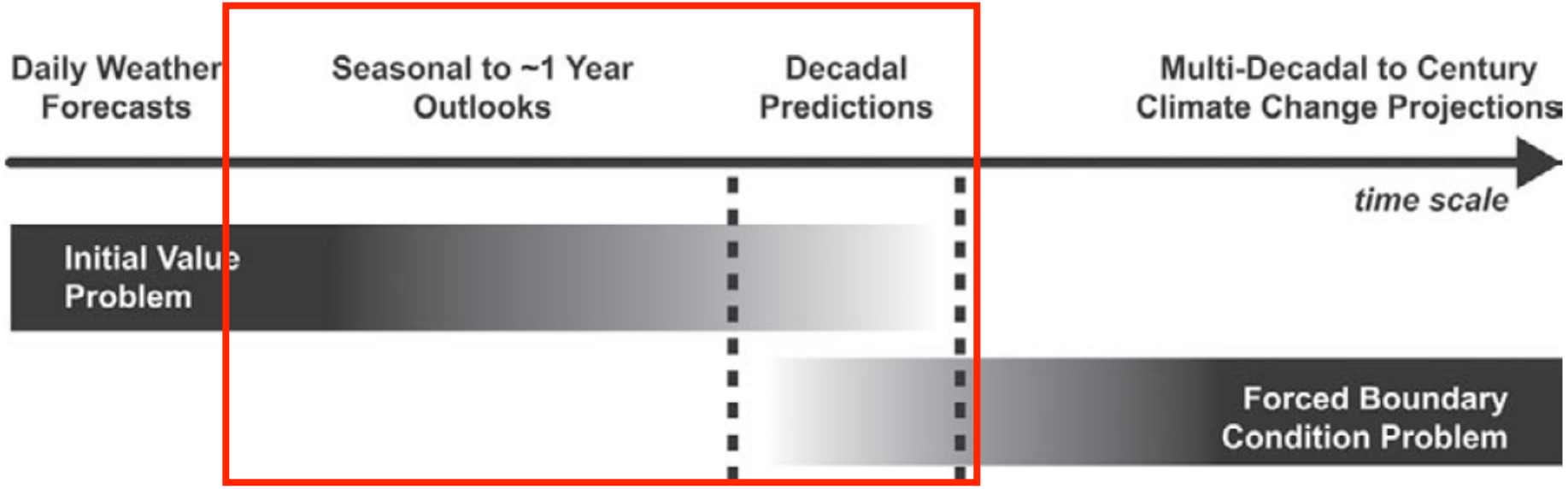
with information from Adam Scaife and Ben Kirtman

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.

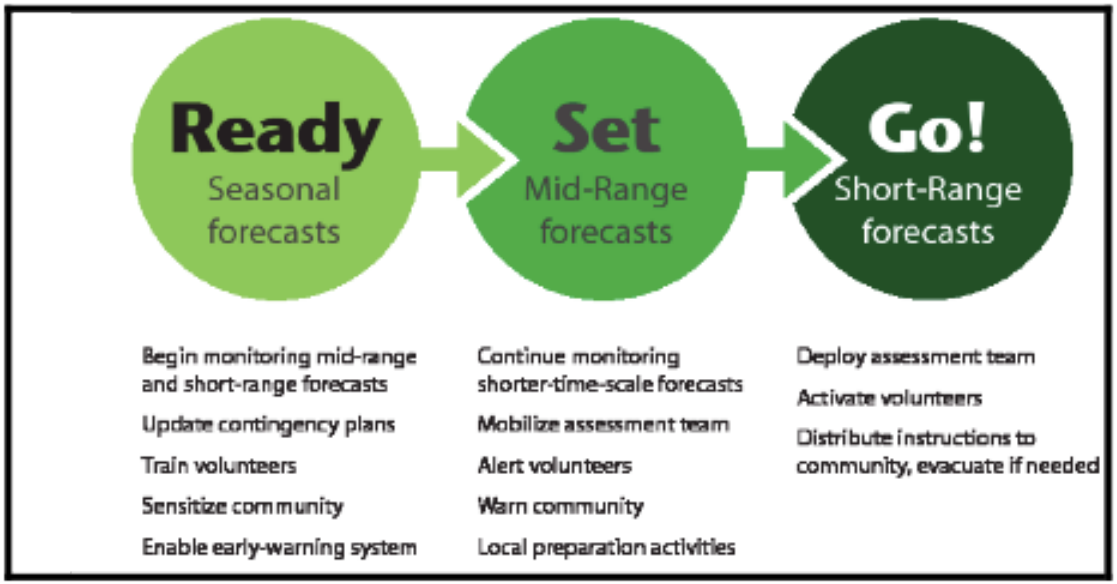


Meehl et al. (2009)

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

WGSIP ToR

Terms of reference

- Develop a programme of numerical experimentation for seasonal-to-interannual variability and predictability, paying special attention to assessing and improving predictions
- Develop appropriate data assimilation, model initialization and forecasting procedures for seasonal-to-interannual predictions, considering such factors as observing system evaluation, use of ensemble and probabilistic methods and statistical and empirical enhancements, and measures of forecast skill
- Foster synergies with the joint WCRP-WWRP project on Subseasonal to Seasonal Predictions to capitalize on both weather and climate scientific knowledge
- Advise the WCRP core projects and the JSC on the status of seasonal-to-interannual forecasting
- Liaise with WGCM, WGRM, WGNE and other relevant groups through WMAC and other channels as appropriate
- Liaise with the WDAC on the adequacy of the observing systems for model assessment and validation

WGSIP JSC actions

Actions from JSC32:

- ACTION: Greater participation by the sea ice community is needed on the third group of WGSIP experiments.
- *WGSIP has been engaged in the WWRP Polar Prediction Project, participated in the WCRP Polar Predictability Initiative while the IceHFP experiment is making progress. However, WGSIP doesn't have regular participation from CliC at the meetings (C. Deser attended WGSIP-14).*
- ACTION: WGCM and WGSIP to engage core projects in analyzing the non-stationarity of modes of climate variability based on CMIP5 results and report back to JSC.
- *This point will be discussed at the joint WGCM/WGSIP meeting in September.*

WGSIP at meetings

- Active meeting schedule (since late 2010):
  - 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)
- Future meetings
  - WGSIP-15, joint with WCRP/WGCM (Hamburg, 24-26 September 12)
  - Joint WGCM/WGSIP s2d workshop (spring 2013) with objectives
    - illuminate the state of climate prediction in general including, especially, the results of the CHFP and the Decadal Prediction component of CMIP5
    - bring the seasonal forecasting and climate modelling communities together to discuss model formulation, initialization, forecast assessment, forecast post-processing etc.

CHFP

Data server at CIMA http://chfps.cima.fcen.uba.ar/

Institute	Location	Status
COLA-UMIAMI-NCAR		**Done Transfer Pending**
UKMO Hadley Centre	CIMA	**DONE IN SERVER**
BMRC	CIMA	**DONE IN SERVER**
NASA GMAO		**Done Transfer Pending**
Météo France	CIMA	**DONE IN SERVER**
JMA	CIMA	**DONE IN SERVER**
CCCMA	CIMA	**DONE IN SERVER**
NOAA-GFDL		**Done Transfer Pending**
NOAA-NCEP	CIMA	**DONE IN SERVER**
IRI		**Done Transfer Pending**
EU ENSEMBLES	Linked Server	**DONE IN SERVER**
APCC	Linked Server	**DONE IN SERVER**

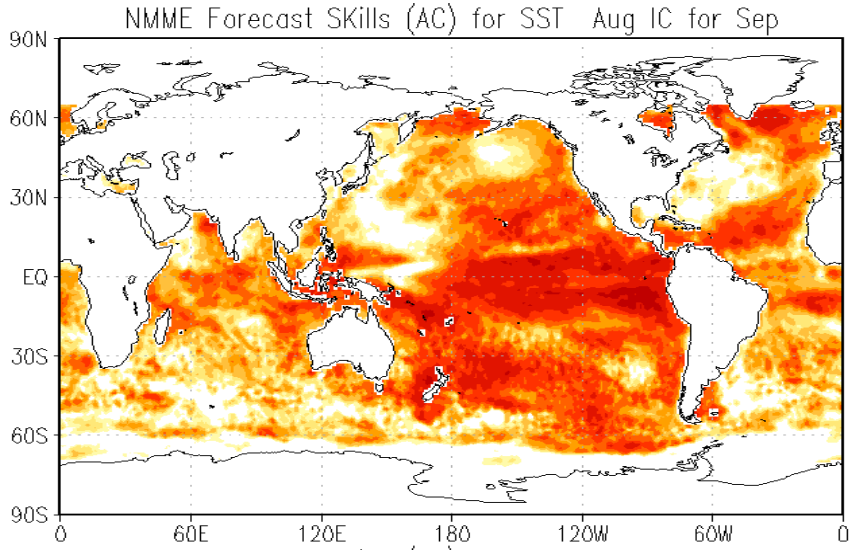
Other sources of seasonal hindcasts

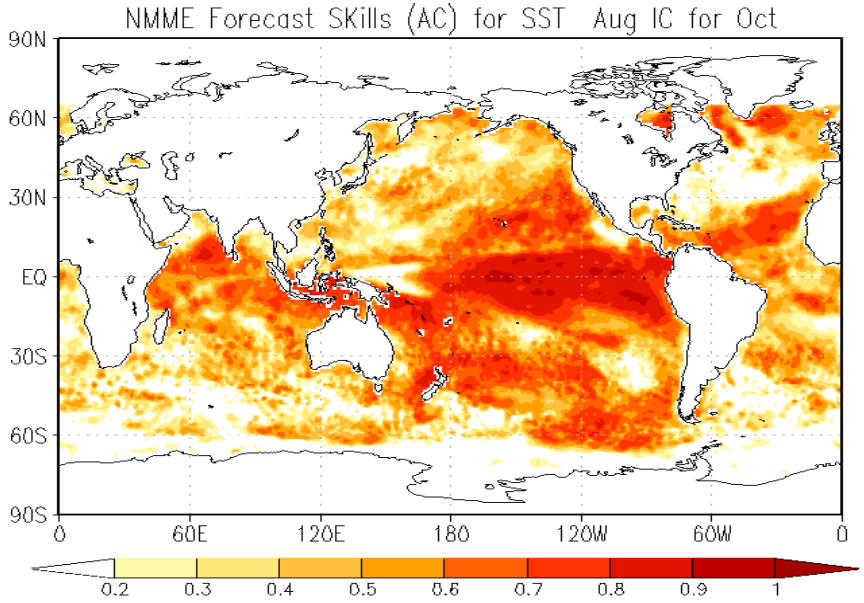
- National Multi-Model Ensemble (NMME), http://iridl.ldeo.columbia.edu/SOURCES/.Models/.NMME
- EUROSIP

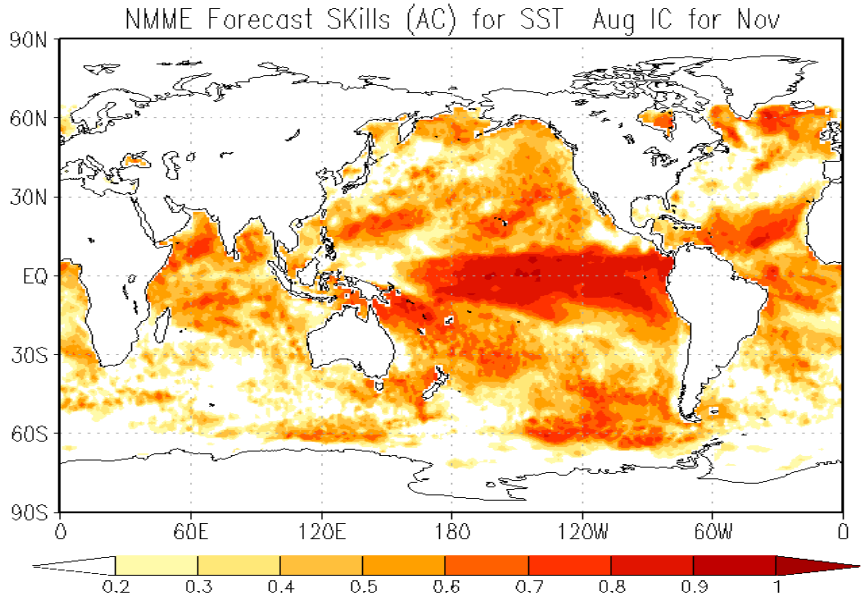
Model	Hindcast Period	Ensemble Size	Lead Times	Arrangement of Ensemble Members	Contact and reference
CFSv1	1981-2009	15	0-8 Months	1st 0Z +/-2 days, 21st0Z +/-2d, 11th 0Z+/- 2d	Saha (Saha et al. 2006)
CFSv2	1982-2009	24(28)	0-9 Months	4 members (0,6,12,18Z) every 5th day	Saha (Saha et al. 2010)
GFDL-CM2.2	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. Note that apart from systematic error there is drift.





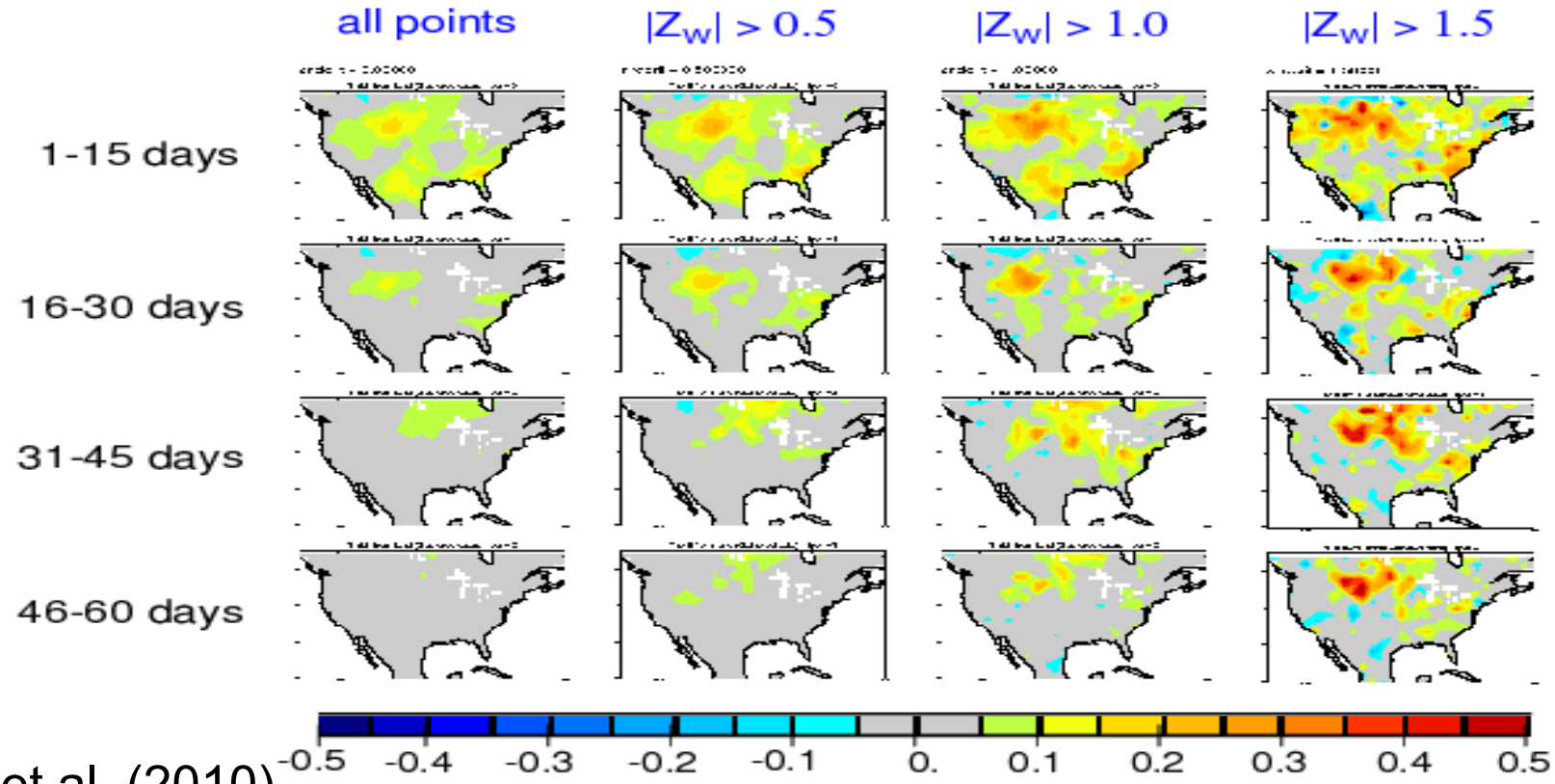


WGSIP seasonal

- Areas of untapped skill were identified at the WCRP 2007 workshop on seasonal prediction.
- Lead to three additional experiments:
  - Land Surface, the GLACE2 experiment (R. Koster): Soil moisture experiments in seasonal mode. Data for ten different systems available from R. Koster upon request. Transposed to assess impact of snow initial conditions (snowGLACE).
  - Stratosphere, Stratospheric Historical Forecast Project (A. Scaife): High top-Low top four-month hindcasts from 1989 starting in May and November. Météo-France, Met Office, NCEP and CCCma experiments available on server (others committed). Analyses (ENSO teleconnections, strong/weak vortex events) coming shortly.
  - Sea Ice, Ice Historical Forecast Project (D. Peterson): Six-month predictions starting in May, August and November for case studies with observed and climatological initial sea-ice data (2007/1996). Météo-France, Met Office and MPI experiments done. Data not to be in server.
- To be revised and updated in FP7 SPECS.

GLACE2

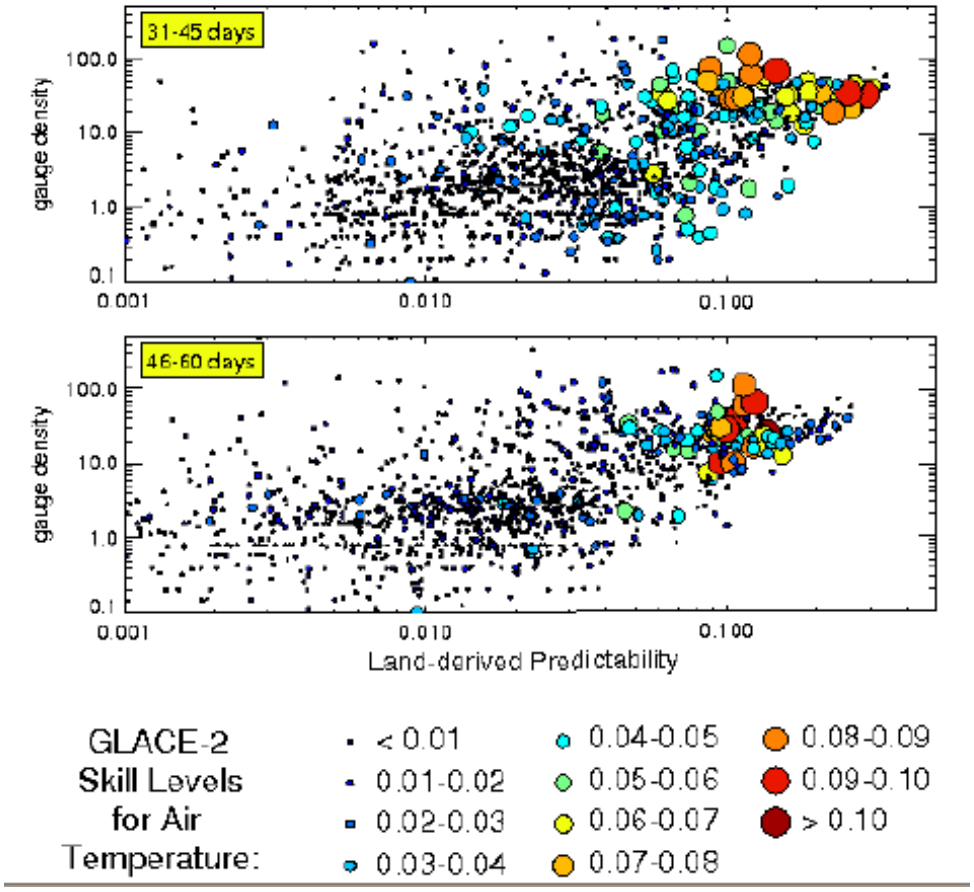
Difference in squared correlation for temperature forecasts between initialized and randomly initialized GLACE2 predictions, where the sample of forecasts are conditioned on the initial soil moisture anomaly.



Koster et al. (2010)

GLACE2

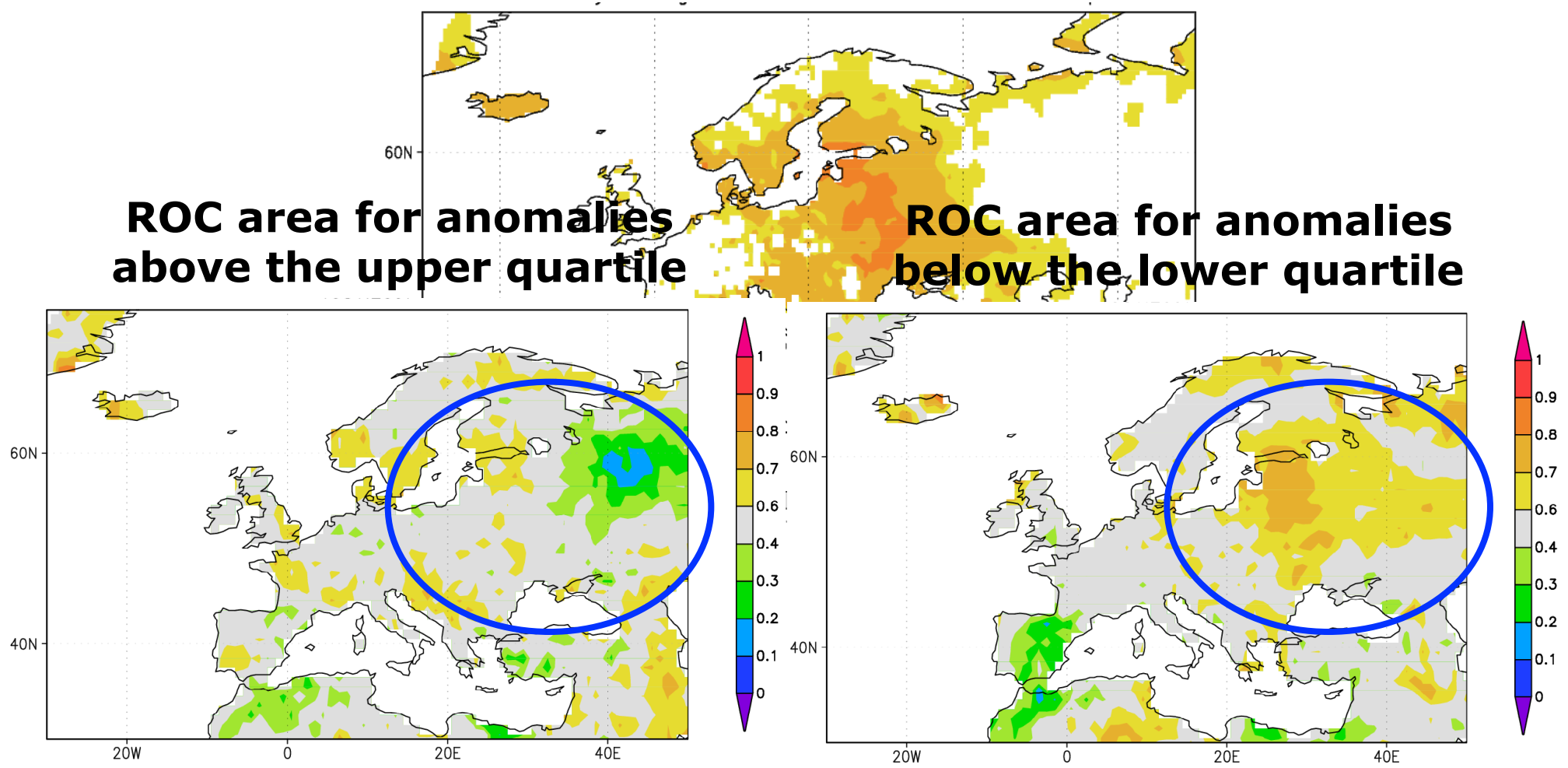
GLACE2 multi-model Series 1 skill as a function of the R2 difference between Series 1 and Series 2 (horizontal axis) and the gauge density (vertical axis). The size of the dots corresponds to the local Series 1 skill.



Koster et al. (2011)

Sources of predictability: snow cover

Correlation of System 3 MAM temperature in 1981-2005 wrt to GHCN temperature (adapted from Shongwe et al., 2007).

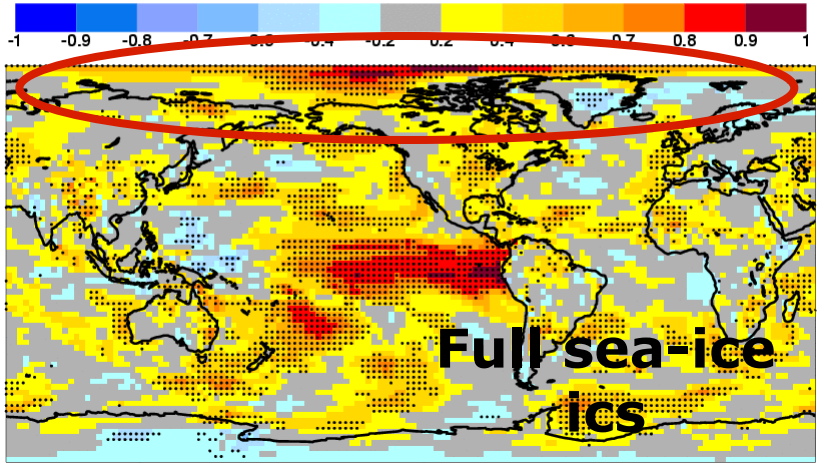


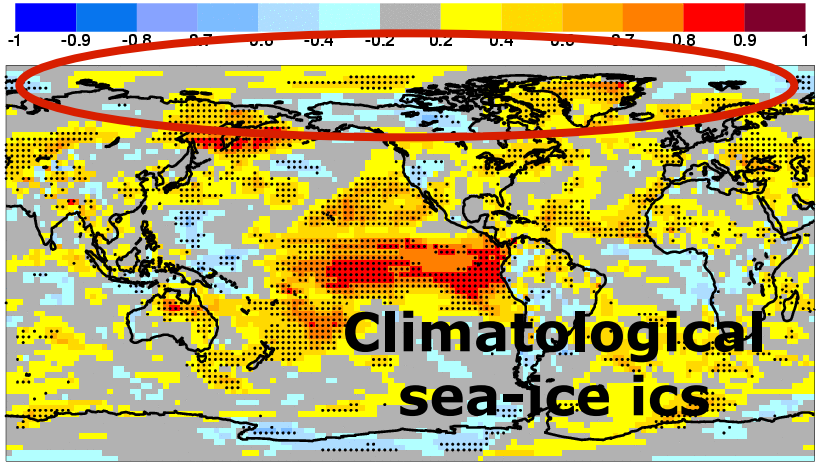
ROC area for anomalies above the upper quartile

ROC area for anomalies below the lower quartile

Sea-ice initialization impact

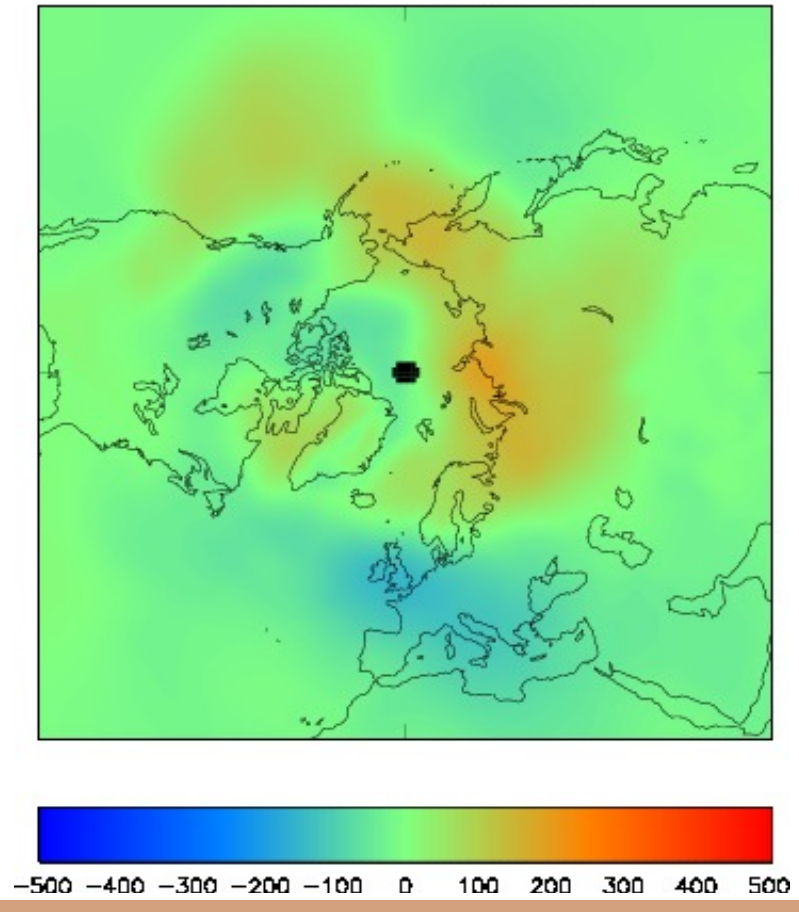
Ensemble-mean correlation of EC-Earth near-surface air temperature 5-7 month (SON) re-forecasts wrt ERA40/Int over 1991-2005. Dots for values statistically significant with 95% conf.





IceHFP

Multimodel SLP difference (Pa) for DJF 2007/8 when initialized with observed sea ice versus climatological initial conditions with start date Nov 2007.



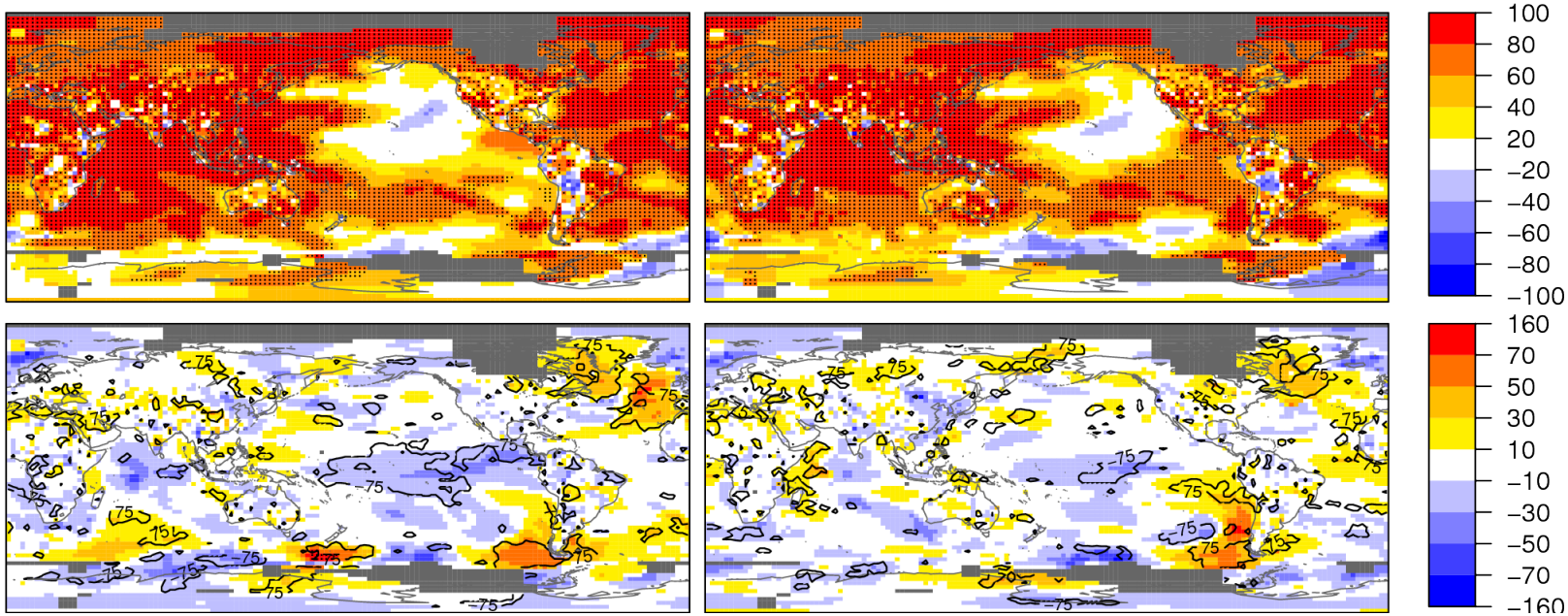
Courtesy D. Peterson

WGSIP and CMIP5 decadal prediction

(Top) Near-surface temperature multi-model ensemble-mean correlation from CMIP5 decadal initialised predictions (1960-2005); (bottom) correlation difference with the uninitialised predictions of 2-5 year (left) and 6-9 year (right) wrt ERSST and GHCN.

Init ensemble-mean correlation

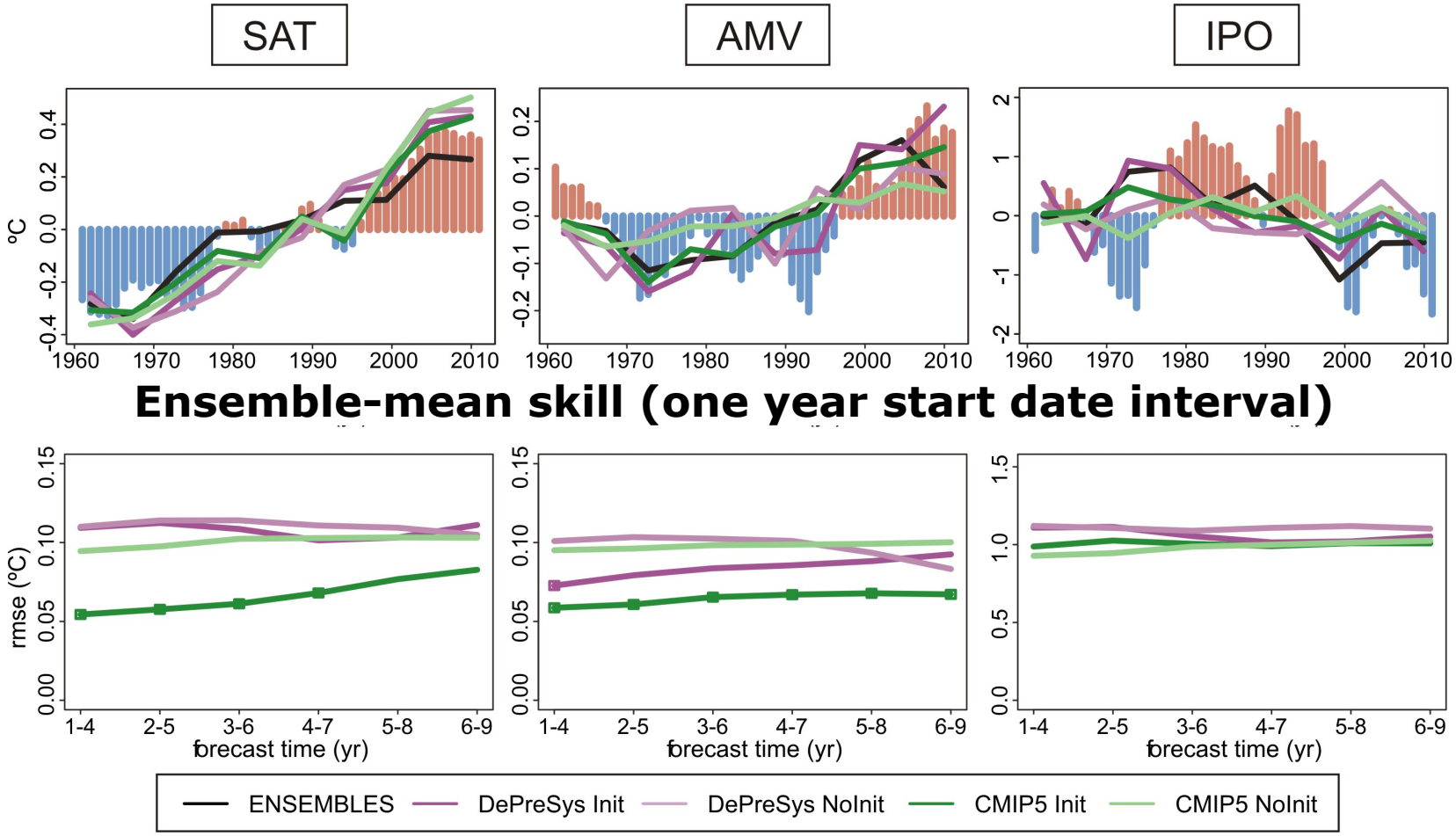
Init minus NoInit ensemble-mean correlation difference



Doblas-Reyes et al. (2012)

WGSIP and CMIP5 decadal prediction

Decadal predictions from DePreSys_PP, ENSEMBLES and CMIP5 multi-models over 1960-2005. GISS and ERSST data used as reference.



Doblas-Reyes et al. (2012)

WGSIP decadal post-CMIP5

- Many groups are now developing decadal prediction systems, many based on the CMIP5 experience.
- Decadal predictions exchange recommended at 15th WMO Commission for Climatology session.
- A proposal went out to various groups earlier last year to exchange decadal prediction information
  - research exercise – we can learn a lot from this
  - prevent over-confidence from a single model
  - equal access, ownership and recognition
- Very simple exchange:
  - Global annual mean temperature
  - One file for each year, all members, once per year around November
  - Methodology suggested by DCPP (Decadal Climate Prediction Panel)

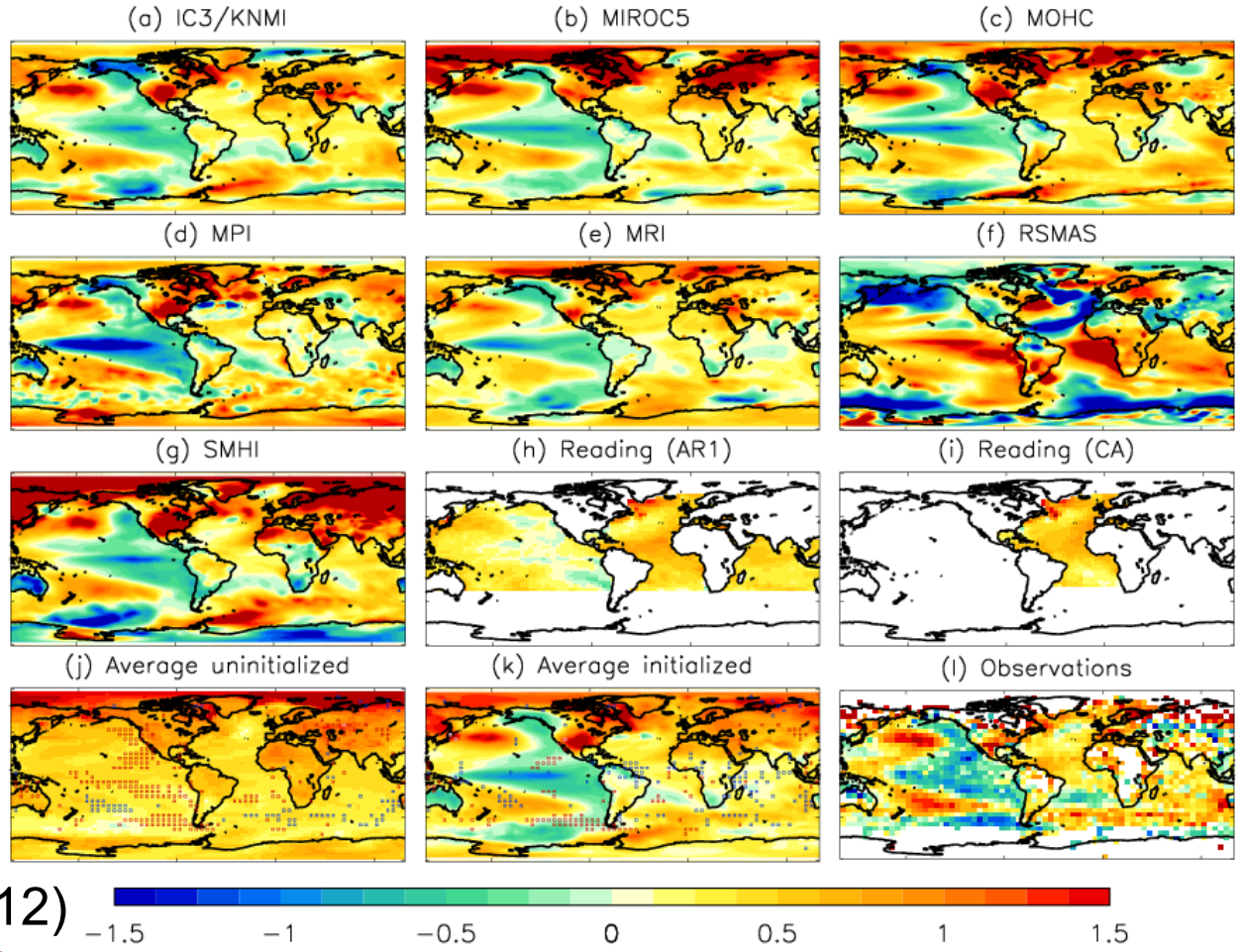
http://www.wcrp-climate.org/decadal/references/DCPP_Bias_Correction.pdf

Decadal exchange

		2011	2012	Uninitialised
Hadley	UK Met Office	✓	✓	✓
EC-Earth anomaly	SMHI (Sweden)	✓	✓	✓
EC-Earth full field	IC3 (Spain) KNMI (Holland)	✓	✓	✓
MRI	JMA (Japan)	✓	✓	✓
MIROC	University of Tokyo	✓	✓	✓
RSMAS	University of Miami	✓	✓	
MPI	Max Planck Institute (Germany)	✓	✓	✓
CCCMA	Canada		✓	✓
GFDL	USA		✓	✓
NRL	USA (statistical)		✓	
Reading	University of Reading (statistical)	✓	✓	

Decadal exchange

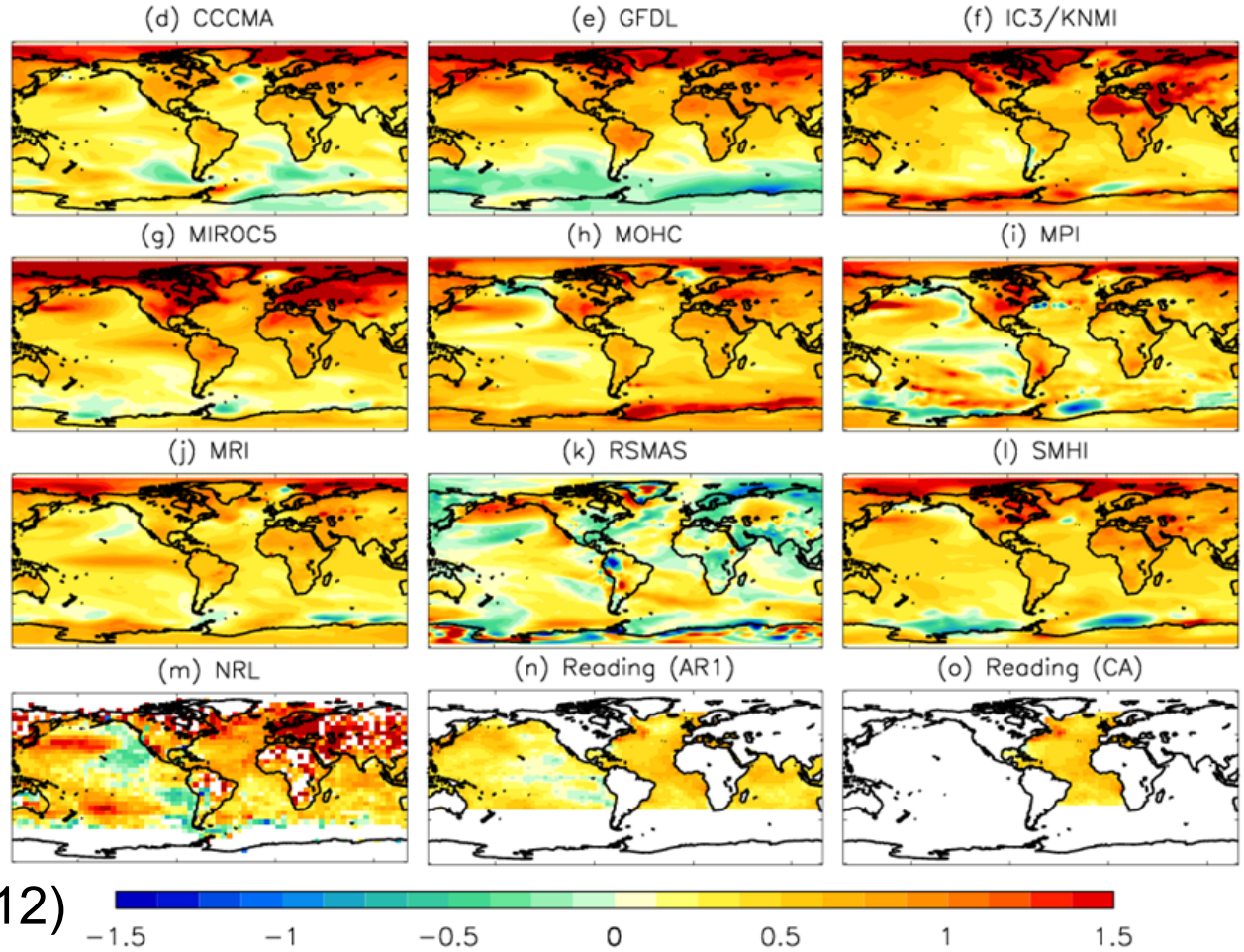
First-year forecasts (2011, wrt 1971-2000) of near-surface temperature anomalies (started before the end of 2010).



Smith et al. (2012)

Decadal exchange

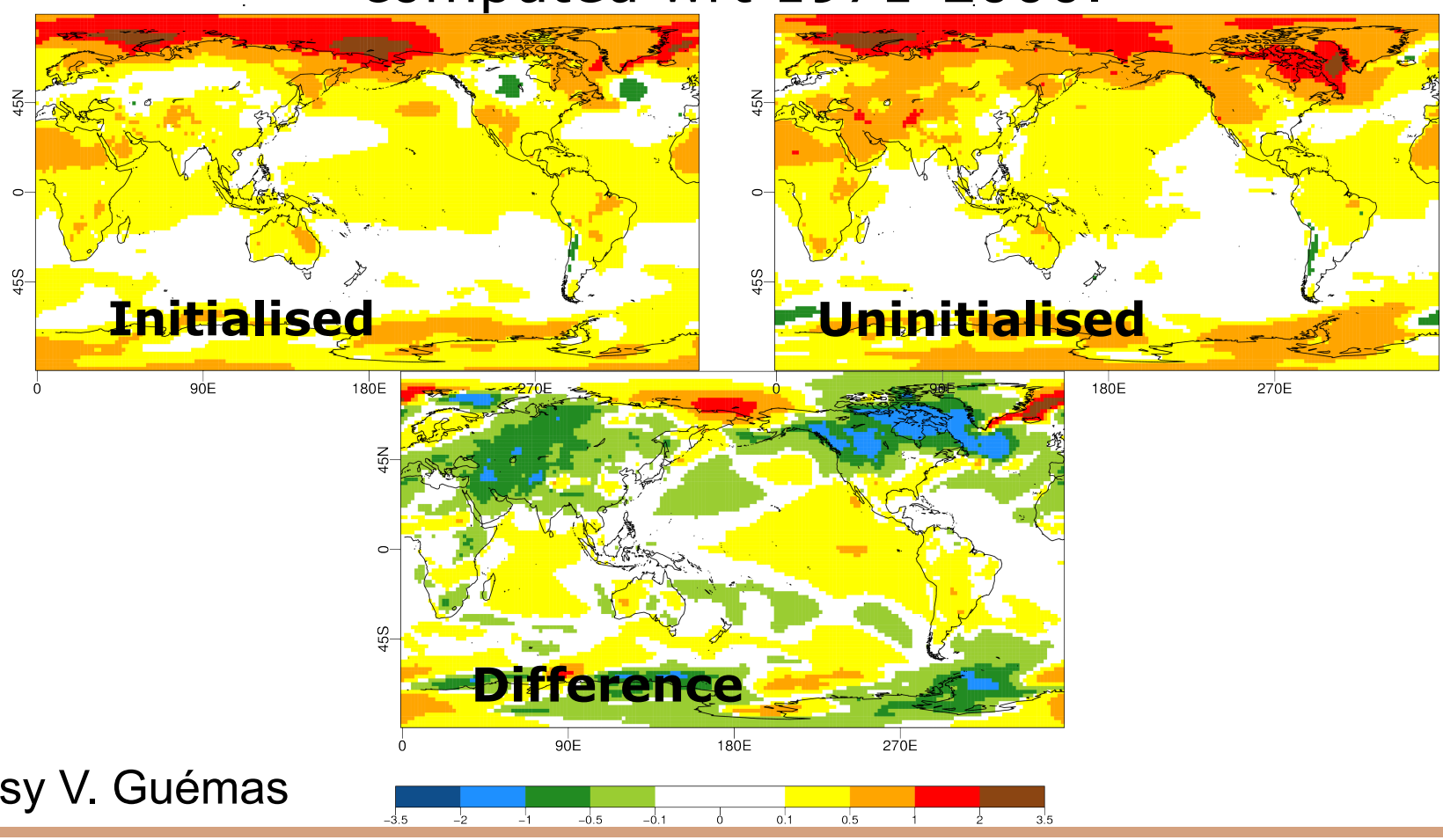
1-5 year forecasts (2012-2016, wrt 1971-2000) near-surface temperature anomalies (started before end of 2011).



Smith et al. (2012)

WGSIP decadal

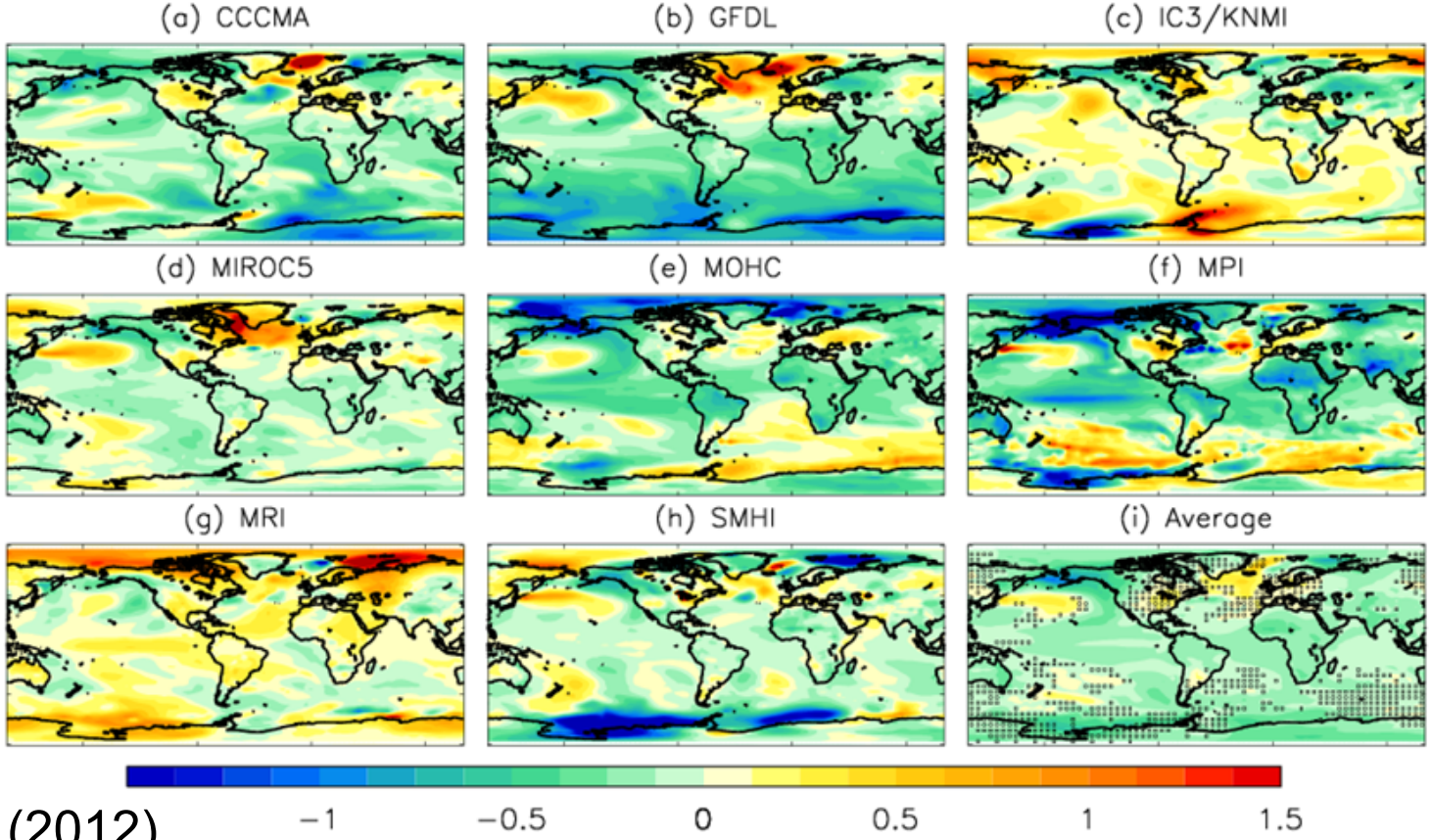
EC-Earth 2-5 year near-surface air temperature ensemble-mean predictions started in November 2011. Anomalies are computed wrt 1971-2000.



Courtesy V. Guémas

WGSIP decadal

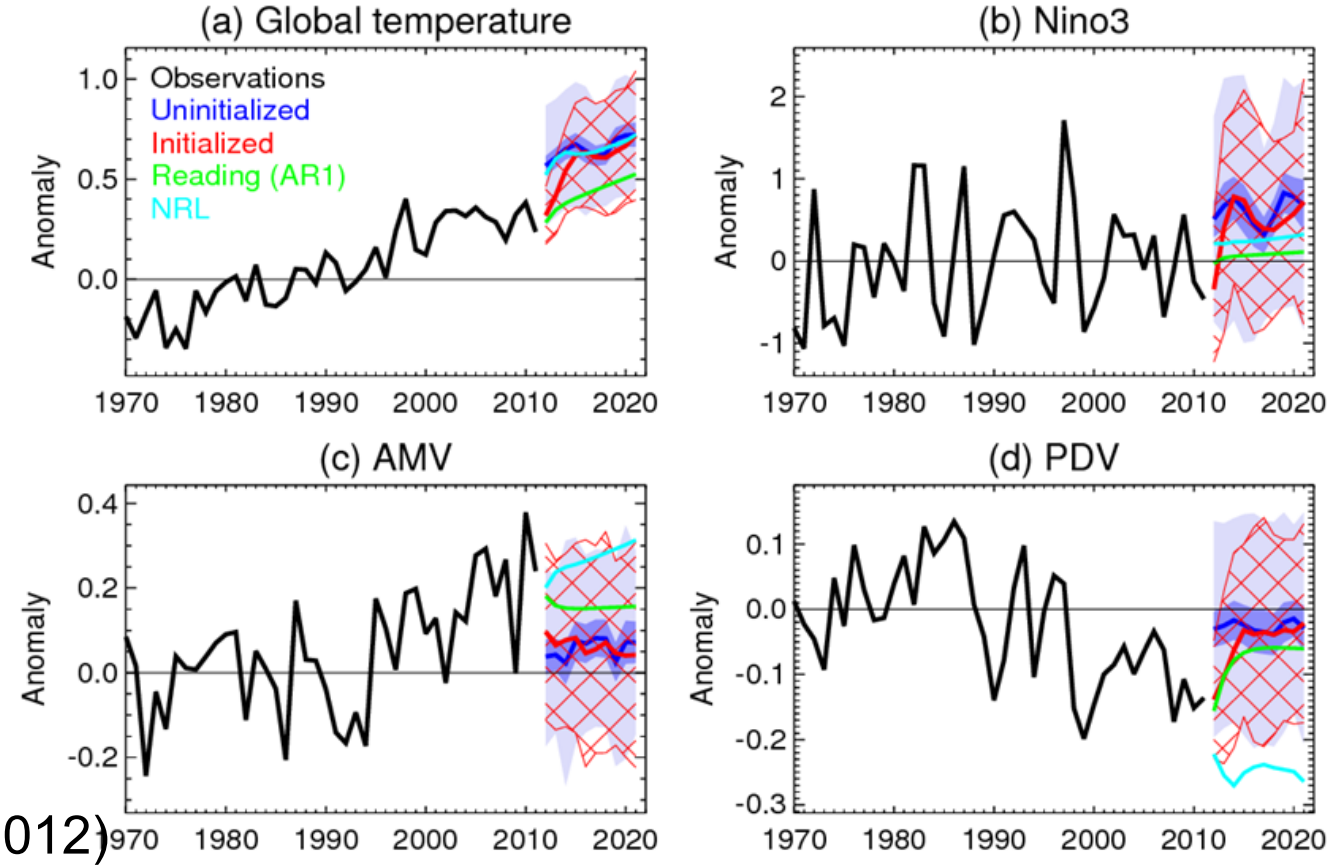
1-5 year (2012-2016) differences (stippled not significant) of near-surface temperature: initialized (started before end of 2011) minus uninitialized simulations.



Smith et al. (2012)

WGSIP decadal

Decadal predictions from initialized (red, started before the end of 2011), uninitialized (blue) dynamical simulations, an AR1 model (green) and an ML regression model (cyan).



Smith et al. (2012)

Sub-seasonal to seasonal prediction

- Fill the gap between medium-range and seasonal (10-60 days) forecasting, linking WCRP and WWRP activities.
- 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.
- Coordinated database of sub-seasonal predictions based, mainly, on operational systems for, at least, the past 15 years. Public dissemination using GRIB2.

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

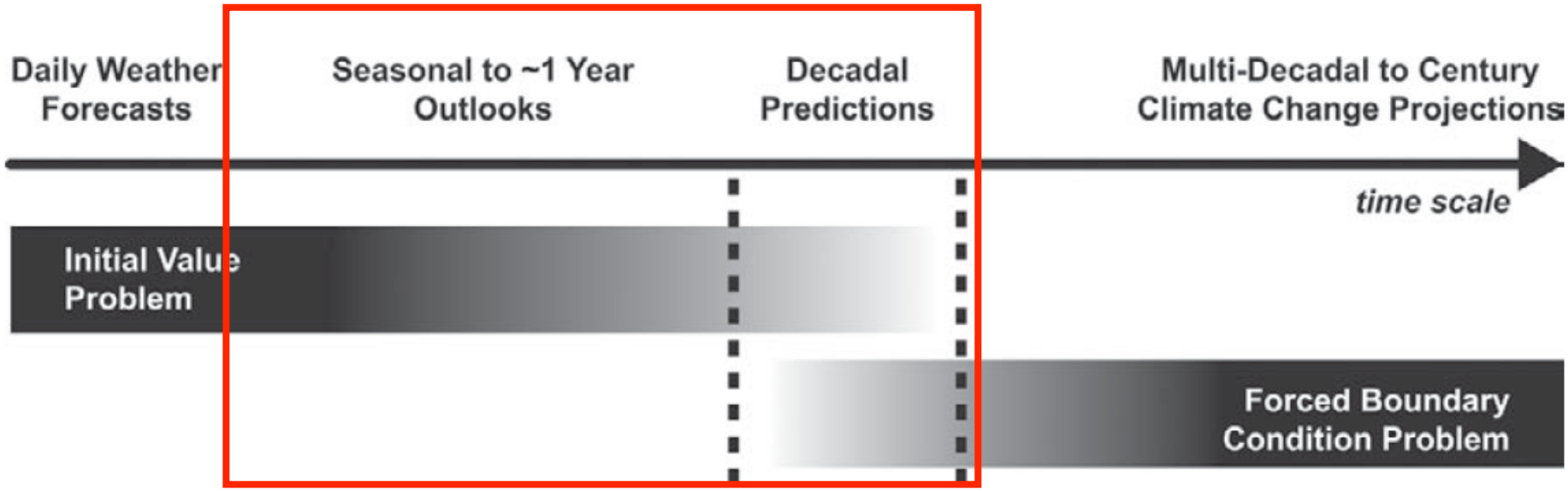
WGSIP and Grand Challenges

- 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. Work on attribution is becoming more popular

Prediction on climate time scales

What WGSIP can get from work at different time scales:

- Leverage resources from the more appealing climate-change problem
- Share understanding and reduction of systematic errors, using information from the model drift.
- Progress in data assimilation for ensemble initialization of the coupled system to reduce drift



Meehl et al. (2009)

Climate prediction questions

- 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 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 seasonal to decadal forecast systems?

Shorter-term plans

- Status of current seasonal prediction systems (paper in progress).
- Encourage documentation of current forecast system reliability and identification of sources of and solutions to lack of reliability.
- Identify low-hanging fruits: skill from changing atmospheric composition.
- Facilitate dissemination and analysis of existing datasets.
- Continue supporting informal exchange of real-time decadal predictions.
- Discussion on what is a prediction, a forecast and a projection.
- Enhance links with climate services and WGRM.

Links

- Operational activities
- GFCS
- WMO lead center for long-range forecasts multi-model ensemble (LC-LRFMME) /http://wmolc.org/
- Verification working groups (SVS-LRF and JWGFVR)
- FP7 SPECS, NACLIM and EUPORIAS, NOAA MAPP
- C20C
- HPC initiatives: PRACE, INCITE, ENES