



# COMBINE – Comprehensive Modelling of the Earth System for Better Climate Prediction and Projection

> Decadal Prediction: Can it be skillful?

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**Partners:** 22  
**Duration:** 48 months (plan: 01.05.2009 – 30.04.2013)  
**EC sci. officer:** Philippe Tulkens



## Partner institutes of COMBINE



1 Coord.	Max Planck Society / MPI-M	12	PBL
2	Met Office	13	SMHI
3	CNRS	14	Univ. Wageningen
4	CMCC	15	Univ. Helsinki
5	MF - CNRM	16	CERFACS
6	KNMI	17	UCL
7	Univ. Bergen	18	Univ. Bristol
8	Danish Met. Institute	19	Univ. Kassel
9	ECMWF	20	Tech. Univ. Crete
10	ETH Zürich	21	Cyprus R&E Foundation
11	Finnish Met. Institute	22	INPE

8 of 22 partners involved in decadal climate prediction



# The building blocks of the COMBINE project



## Structure

CMIP5/RCPs

<b>Topics (WP1-5)</b>
(C1) Carbon and nitrogen cycle
(C2) Aerosols, clouds and chemistry
(C3) Stratosphere
(C4) Cryosphere
<b>(C5) Initialisation</b>
<b>Centennial Simulation (WP6)</b>
(CS1) Pre-industrial control
(CS2) 20 <sup>th</sup> century
(CS3) 21 <sup>st</sup> century scenario (RPCs)
(CS4) +1% CO <sub>2</sub> / year to 4xCO <sub>2</sub>
<b>Decadal Simulation (WP7)</b>
<b>(DS1) Prediction (2005-2035)</b>
<b>(DS2) Hindcasts</b>
<b>Impacts, and scenarios (WP8)</b>
Impacts in sectors and regions
Scenarios

## Tools/Methods

### Obs. and re-analyses

<b>ESMs</b>	
(M1) COSMOS	MPG
(M2) HadCM, HadGEM	METO
(M3) IPSL-ESM	CNRS
(M4) CMCC	CMCC
(M5) CNRM-CM	MF-CNRM
(M6) EC-EARTH	EC-Earth cons.
(M7) NORCLIM	UiB

<b>ESMs</b>	<b>Differences</b>
(E1) ESM	$D_A(C(i)) = (E2) - (E1)$
(E2) ESM + C(i)	$D_\Omega(C(i)) = (E4) - (E3)$
(E3) newESM - C(i)	$D_\Sigma(\Sigma_j C(j)) = (E4) - (E1)$
(E4) newESM	

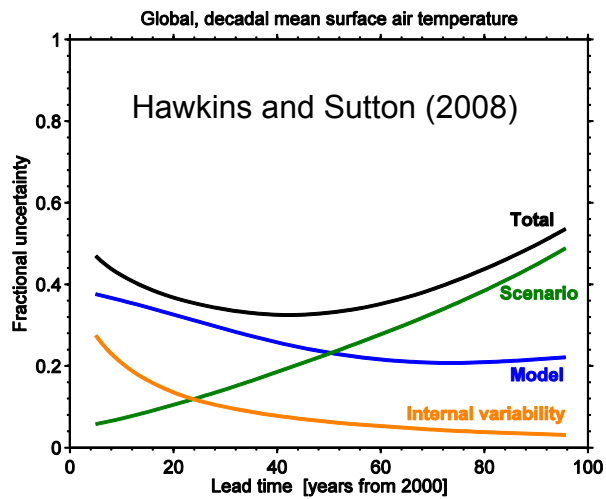
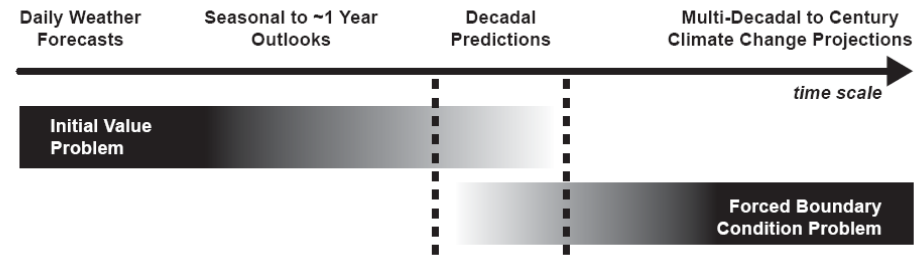


# Motivation for decadal climate prediction



## From Meehl et al. (2009, in print at BAMS)

Time scales and initial and boundary conditions



Lead times and contributions to uncertainty



## Major questions w.r.t. decadal climate prediction



- **Which *internal modes of variability* exist in the climate system that allow skillful climate prediction on decadal time scales?**
  - What *data* are needed? (ARGO)
  - Initialization *methods*?
  - In which *regions* does predictability exist?
  - For which time scales is a prediction *skillful*? (5, 10, 20 years?)
  
- What is the role of different *climate processes* and related *feedbacks* for climate decadal climate prediction
  - Cryosphere
  - Stratospheric dynamics and strat. trop. coupling
  - Clouds, aerosols, and chemistry



- To improve climate forecasts out to 2030 by predicting natural internal variability in addition to anthropogenic changes. This will be a significant advance over IPCC AR4 projections, which did not attempt to predict internal variability.
- To investigate the possibility of providing a climate prediction methodology that avoids the need for expensive spin-up and transient simulations, thereby enabling higher resolution decadal forecasts to be made.
- To assess the impact of new components (cryosphere, aerosols and chemistry, stratospheric dynamics) and new initialization procedures on decadal predictions.



- **Pilot studies of COMBINE partners:**
  - Smith D, S Cusack, A Colman, A. Folland, G Harris, J Murphy, Improved surface temperature prediction for the coming decade from a global circulation model. *Science*, **317**, 796-799, 2007.
  - Pohlmann, H., J. H. Jungclaus, A. Köhl, D. Stammer, and J. Marotzke, Initializing Decadal Climate Predictions with the GECCO Oceanic Synthesis: Effects on the North Atlantic. *J. Climate*, 2009.
  - Keenlyside, N. S., M. Latif, J. Jungclaus, L. Kornblueh, and E. Roeckner, Advancing decadal-scale climate prediction in the North Atlantic sector, *Nature*, 453, 84-88, 2008.
  
- **International overview paper:**
  - Meehl et al., Decadal Prediction: Can it be skillful?, *BAMS*, 2009, in print.
  
- EU FP6 project ENSEMBLES
  - Seasonal to decadal work package
  
- ❖ **CMIP5 protocol**
  - ❖ provides framework for climate predictability experiments



## Extension of Smith et al. (2007)

- 10 year forecast from 1 March and 1 June 2005
  - DePreSys: 20 initial states with assimilated observations
  - NoAssim: 8 initial states from transient simulations
- 10 year hindcasts 1 March and 1 June 1985 and 1995
  - DePreSys: 8 initial states with assimilated observations
  - NoAssim: 8 initial states from transient simulations

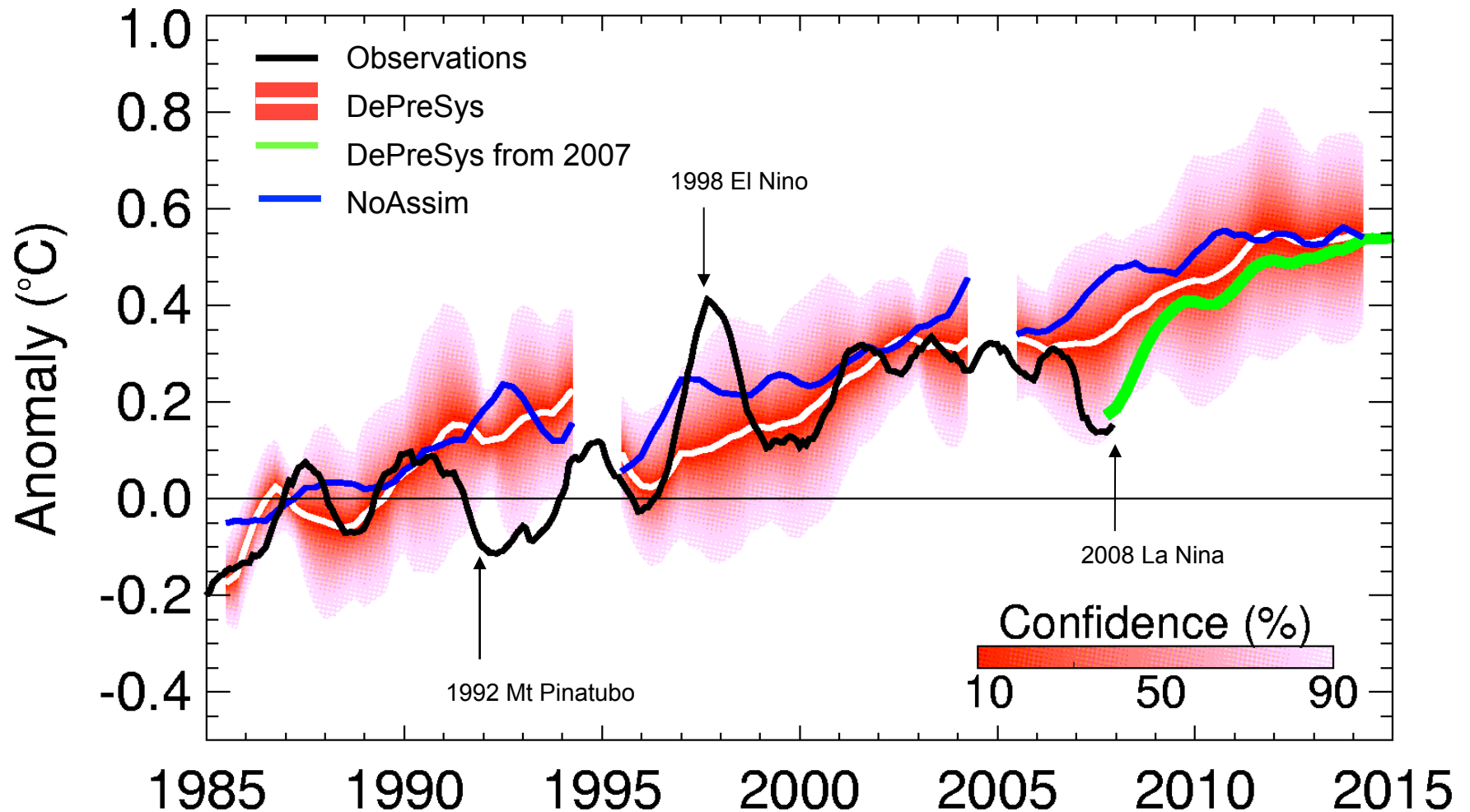




# Global annual mean surface T



2014 predicted to be 0.3°C warmer than 2004  
Half of years after 2009 predicted to be hotter than 1998



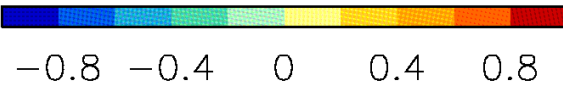
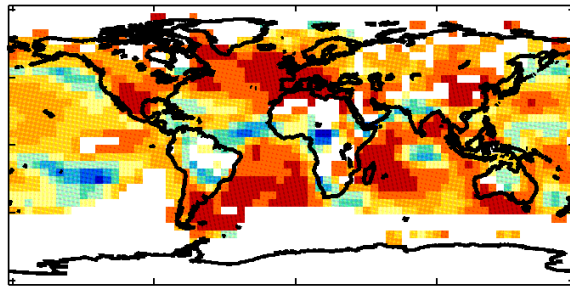


# Time series correlation maps and RMS error of temperature

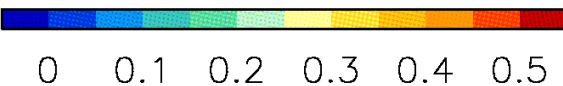
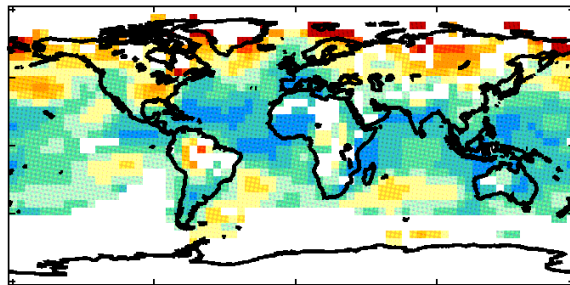


- 9 year mean surface temp: 15x15 degrees
- 9 member hindcasts starting each year from 1960 to 2005)

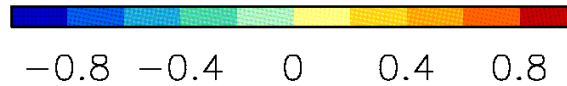
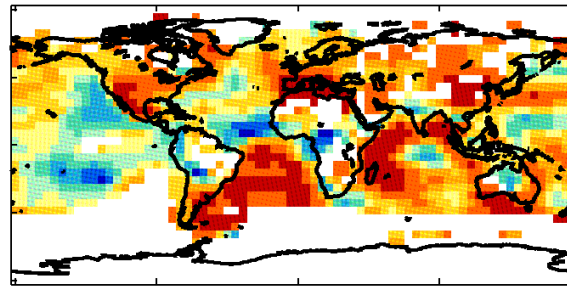
t1.5 : HadCRUT3 : 9yr  
corr : DePreSys



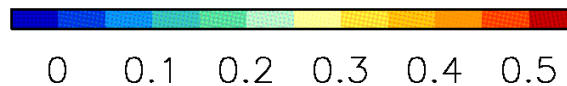
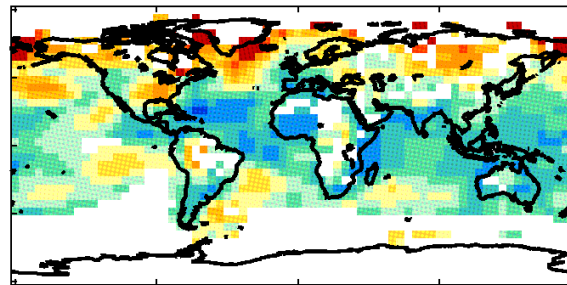
rmse : DePreSys



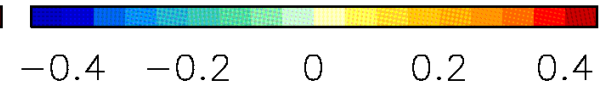
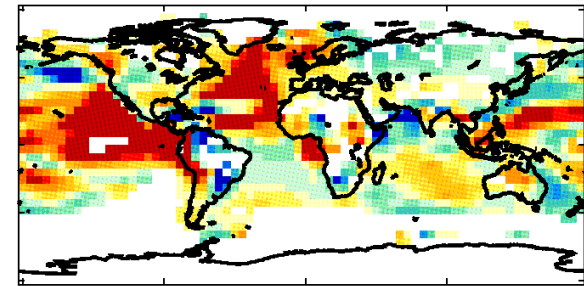
corr : NoAssim



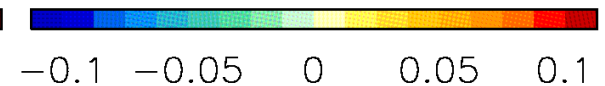
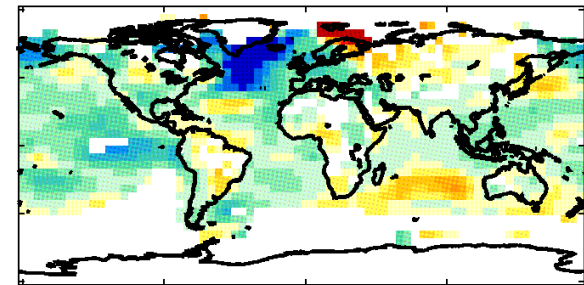
rmse : NoAssim



corr : Diff



rmse : Diff





- Decadal climate prediction is a fairly new research field
  - Prospect for *skillful* global or regional predictions still unclear
  - Potential for reducing global/regional uncertainty for predictions over about a decade → IPCC AR5 → users
  - Major challenges
    - ◆ Observing system
    - ◆ Scarcity of past observations
    - ◆ Understanding of climate system (feedbacks)
    - ◆ Model biases
    - ◆ Methodology
- COMBINE will contribute to the research in this field in the coming four years.



- COMBINE is strongly linked to the CMIP5 activities and hence will contribute to the 5th assessment report of IPCC
- The CMIP5 protocols for experiments and data archival provide the framework for international exchange and collaborative research.



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Thank you