A new field of climate:

Decadal Prediction

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Introduction to decadal prediction

Regional study (Smith et al 2007)

Regional study (Keenlyside et al 2008)

Conclusion and Ongoing study
Introduction to decadal prediction

Time scale & uncertainties

10 – 30 year

- Internal variability
  *(e.g. ENSO, PNA, PDO)*

- Model uncertainty

- Scenario uncertainty
  *(e.g. GHG emission, solar cycle)*

Meehl et al 2009
Introduction to decadal prediction

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Conclusion and Ongoing study
### Experiment Design

<table>
<thead>
<tr>
<th></th>
<th>NoAssim</th>
<th>DePreSys</th>
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</thead>
<tbody>
<tr>
<td><strong>Initial condition</strong></td>
<td>None assimilation</td>
<td>Assimilating $H$</td>
</tr>
<tr>
<td><strong>Boundary condition</strong></td>
<td>Same external forcing</td>
<td></td>
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</tbody>
</table>

$H$: upper 113m ocean heat content --- $H = H(SST)$

**Data assimilation**: combination of climate state and observations together to get best initial condition

**Aim**: to evaluate the importance of initialization (data assimilation).
9-yr hindcast, Rolling run from 1982 to 2001, initialization every year

<table>
<thead>
<tr>
<th>Initialization time</th>
<th>hindcast/forecast period</th>
<th>X-axis of First year</th>
<th>X-axis of 9-yr mean</th>
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<tr>
<td>2001</td>
<td>2002-2010</td>
<td>2002</td>
<td>Without verification observation</td>
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Global surface temperature anomalies

First year hindcast

Both NoAssim and DePreSys capture the warming trend, but DePreSys predicts better interannual variability.

RMSE = 0.094 in NoAssim
RSME = 0.066 in DePreSys

9 year mean hindcast

Both NoAssim and DePreSys show bias due to the assumption of no volcanic eruption in 1992. but the bias is smaller in DePreSys.

Bias in NoAssim = 0.075
Bias in DePreSys = 0.016
RMSE of 9-year average anomaly relative to observation

RMSE: Root Mean Square Error
The smaller the RMSE, the more skillful

Regional improvement of $T_s$ is coincident with the improvement of $H$.

R=0.75

The increase of the ocean observations will further improvement the regional and global forecast.

Smith et al. 2007
Summary of Smith’s study

The smaller bias and RMSE in DePreSys than NoAssim indicates the importance of assimilating the ocean observations.

Smith et al 2007
outline

- Introduction to decadal prediction
- Regional study (Smith et al 2007)
- Regional study (Keenlyside et al 2008)
- Conclusion and Ongoing study
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<td>initializing <em>SST anomaly</em></td>
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<td>Observational external forcing</td>
<td>Artificially specified forcing</td>
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**20C-RF:** 20 century radiative forcing observation.

**Hindcast:** assimilating the ocean observation but use specified forcing

**Aim:** to evaluate the relative importance of initialization and external forcing.
Decadal mean of 10-year hindcast/forecast

Verification Observations
20C-RF: 20 century radiative forcing observation but without initialization

Hindcast: assimilating the SST but without observational forcing

The Hindcast get improvements in various region.
Summary of Keenlyside’s study

The improvement of predict skill in Hindcast indicates the relative importance of initialization than external forcing.
Decadal prediction focuses on the climate evolution and variability over next 10-30 years.

Studies by Smith et al and Keenlyside et al show that initialization plays a significant role in improving the regional and global decadal prediction.

Initialization with ocean observations can improve the decadal prediction.
Ongoing study---CMIP5

Coupled Model Intercomparison Plan phase 5

Core 1: a set of 10-yr experiments
Evaluate the decadal predictability by a series experiment considering different aerosol, GHG emission, initialization schemes, ensemble size……

Core 2: a set of 30-yr experiment
Evaluate the decadal predictability when external forcing become more important with time.

Schematic of experiments of CMIP5 (Taylor et al 2009)

