Systematic errors in Climate Models

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Global SAT

Temperature anomaly (°C)

Year

1900 1920 1940 1960 1980 2000

Santa Maria  Agung  El Chichon

IPCC 2007
Systematic errors in SAT

IPCC 2007
Seamless prediction, Palmer 2008
### History of climate models

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<td>Interactive Vegetation</td>
<td>Biogeochemical Cycles</td>
<td>Ice Sheet</td>
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Are we making progress or just increasing the uncertainty?

to be continued
Uncertainties in global change projections

Hawkins and Sutton 2009
Uncertainty in climate sensitivity

Best estimate: 3 degrees

Equilibrium Climate Sensitivity (°C)
Physics in climate models

Typical grid size is $O(100\text{km})$, many processes (e.g., clouds) cannot be simulated explicitly.
High resolution (50km) matters

Fronts and other fine structures in sea surface temperature are not well resolved in coarse-resolution models.
Tropical wind speed sensitivity to horizontal resolution

Zurich, July 8th 2010
ENSO-like variability in the tropical Atlantic: a case study
Correlation SST/SSH

Cor.: Reynolds SSTa and T/P SSHa (10/1992–02/2002)
Anomalous equatorial Atlantic and Pacific heat content and SST

NCEP forced OGCM; HadISST 1.1 with 3-120 month filter
ENSO-like variability in the equatorial Atlantic

(a) imaginary part of SSH
(b) real part of SSH

(c) imaginary part of SST and wind stress
(d) real part of SST and wind stress

(e) Time series of combined POP analysis and cold tongue SST

Zurich, July 8th 2010
Local explained variances

(a) SSH

(b) SST

(c) Zonal wind stress

(d) Meridional wind stress

Zurich, July 8th 2010
Seasonal prediction skill

Correlation between predicted and observed SST anomalies at six months lead

The map shows the correlation between predicted and observed SST anomalies. The color scale ranges from -1 (dark blue) to 1 (dark yellow), with intermediate shades indicating varying degrees of correlation.
The Tropical Atlantic SST bias in the Kiel Climate Model (KCM)

The zonal SST gradient along the equator is reversed in many models
Model Bias in May and August

SST 10m wind cloud cover rainfall
An attempt to reduce the bias by tuning cloud parameters
Possible reasons for the bias

- Convection over land too weak, too weak wind stress along the equator
- Too low ocean resolution, coastal and equatorial upwelling not well resolved
- Coupled feedbacks amplify errors in the individual components
An experiment to demonstrate the importance of equatorial Atlantic variability

- Perform a set of seasonal hindcast experiments
- Repeat the hindcasts and prescribe observed tropical Atlantic SST
- Analyze skill improvement to assess the impact of realistically forecasted Atlantic SST
Increase in ENSO forecast skill

Zurich, July 8th 2010
Skill improvement
Model improvement is awfully slow, but is pays off

Normalised RMS error in simulation of climatological patterns of monthly precipitation, mean sea level pressure and surface air temperature

IPCC 2007
Thank you for your attention