Skill in simulating cloud properties in a perturbed physics ensemble and the relation to model errors on short time scales

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Outline

- Motivation
- Perturbed physics ensemble
- Skill scores for clouds
- Data assimilation to assess fast evolving errors
- Is there a link?
Motivation

GCM grid size 10s-100s Km

A. Tompkins
## Perturbed parameter

<table>
<thead>
<tr>
<th>CODE</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENTRSCV</td>
<td>Entrainment rate for shallow convection [Tiedtke, 1989]</td>
</tr>
<tr>
<td>ENTRPEN</td>
<td>Entrainment rate for penetrative convection [Tiedtke, 1989]</td>
</tr>
<tr>
<td>CMFCTOP</td>
<td>Cloud mass flux above non-buoyancy level [Tiedtke, 1989]</td>
</tr>
<tr>
<td>ZASIC</td>
<td>Correction to asymmetry parameter of ice clouds [Stephens et al. 1990]</td>
</tr>
<tr>
<td>ZINHOML</td>
<td>Inhomogeneity of liquid clouds [Cahalan et al. 1994]</td>
</tr>
<tr>
<td>ZINHOMI</td>
<td>Inhomogeneity of ice clouds [Cahalan et al. 1994]</td>
</tr>
<tr>
<td>CPRCON</td>
<td>Conversion efficiency of cloud water to precipitation [Tiedtke, 1989]</td>
</tr>
<tr>
<td>Gpicmea</td>
<td>Gravity wave drag activation threshold (peak-mean)</td>
</tr>
<tr>
<td>Gstd</td>
<td>Gravity wave drag activation threshold (Standard deviation)</td>
</tr>
<tr>
<td>Dampth</td>
<td>Coefficient for horizontal diffusion</td>
</tr>
<tr>
<td>Calbmni</td>
<td>Albedo minimum (glacier, snow on ice)</td>
</tr>
<tr>
<td>Calbmns</td>
<td>Albedo maximum (glacier, snow on ice)</td>
</tr>
<tr>
<td>Calbmxs</td>
<td>Albedo minimum (bare sea ice)</td>
</tr>
<tr>
<td>Calbmxs</td>
<td>Albedo maximum (bare sea ice)</td>
</tr>
</tbody>
</table>
Skill measures

Following Pincus et al. 2008
Bias
Ratio of standard deviation ( > 1 if model too variable)
Root mean square
Correlation

\[
\text{SW cloud radiative effect} (SW_{\text{CRE}} = SW_{\text{tot,ToA}} - SW_{\text{clr,ToA}})
\]

\[
\text{LW cloud radiative effect} (LW_{\text{CRE}} = LW_{\text{tot,ToA}} - LW_{\text{clr,ToA}})
\]

Cloud cover
Precipitation

2.5° x 2.5° climatological monthly means

<table>
<thead>
<tr>
<th>Variable</th>
<th>Observation #1</th>
<th>Observation #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short wave cloud radiative effect</td>
<td>CERES</td>
<td>ERBE</td>
</tr>
<tr>
<td>Long wave cloud radiative effect</td>
<td>CERES</td>
<td>ERBE</td>
</tr>
<tr>
<td>Cloud cover</td>
<td>ISCCP-2D</td>
<td>MODIS</td>
</tr>
<tr>
<td>Precipitation</td>
<td>GPCP</td>
<td>CMAP</td>
</tr>
</tbody>
</table>
What range of skills do we sample?

**Single parameter varied**

- STDV = 0.0099
- Mean = 0.5300

**All parameters varied (latin hypercube)**

- STDV = 0.0269
- Mean = 0.4803
Combined skill

STDV = 0.0274
Mean = 0.4806

Obs #1 0.6014
Obs #2 0.6316

PDF [%]
Cloud cover

STDV = 0.0180
Mean = 0.7685

Precipitation

STDV = 0.0602
Mean = 0.2799
Short wave cloud radiative effect

STDV = 0.0559  Mean = 0.3810

- Obs #1 0.4879
- Obs #2 0.4794

Long wave cloud radiative effect

STDV = 0.0246  Mean = 0.5688

- Obs #1 0.6592
- Obs #2 0.6671
Robust in time?
And with resolution?
Data assimilation

Nudge model states to make them more consistent with observations

Work flow:
Forecasts – expected observations – compare to observation – increments – analysis - repeat

Dart website: www.image.ucar.edu/DAReS/DART/
Links to skill and sensitivity?

'Bad'

'so lala'

'Good'

Model-space

Obs-space

Time
Summary

We are investigating a set of perturbed physics experiments focusing on cloud properties.

We are looking for a link of the models skill in simulating cloud properties to assimilation increments, as a measure for fast evolving errors.

For the future: If above successful, we are curious, if there is any connection between fast evolving errors, skill in cloud properties and cloud feedback strength (climate sensitivity).