Low clouds in NICAM

A preliminary result of the Intra-seasonal (Jun–Aug 2004) Global Experiment by 14km–mesh NICAM

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Objective

• High-resolution Global Simulation on the Earth Simulator (14km-, 7.5km-, 3.5km-mesh models)
  – Explicit cloud microphysics (i.e., No cumulus parameterization)
• Variation of Climatology
  – Boundary-layer cloud
  – Tropical cyclone
  – Monsoon circulation
• Improvement of Model Physics and Climatology
  – Turbulence with subgrid-scale cloud
  – Parameterization for subgrid-scale convective systems (for 7km, 14km-mesh model)
  – Cloud microphysics
### Experimental Design

<table>
<thead>
<tr>
<th>Initialization</th>
<th>NCEP Global analysis on 00Z Jun 01, 2004</th>
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<tbody>
<tr>
<td>Nudging</td>
<td>None</td>
</tr>
<tr>
<td>Bottom boundary</td>
<td>Bucket model and Weekly Reynolds SST</td>
</tr>
<tr>
<td>Horizontal resolution</td>
<td>14km</td>
</tr>
<tr>
<td>Vertical resolution</td>
<td>Stretched grid (80m～2.9km)</td>
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<tr>
<td>Cloud</td>
<td>Cloud microphysics by Grabowski (1998)</td>
</tr>
<tr>
<td>Turbulence</td>
<td>Improved version of Mellor-Yamada Level 2 (e.g., Nakanishi &amp; Niino 2004; Mellor and Yamada 1982) ※Not producing a partial cloud yet</td>
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<tr>
<td>Surface flux</td>
<td>Bulk parameterization by Louis (1979)</td>
</tr>
<tr>
<td>Radiation</td>
<td>MSTRNX (Nakajima et al. 2001; Sekiguchi 2004)</td>
</tr>
<tr>
<td>Integration period</td>
<td>2004/6/1～6/9 (9days at present) (trying for several months to examine climatology)</td>
</tr>
</tbody>
</table>

※12hrs for 9-day experiment on Earth Simulator
Boundary layer scheme in NICAM
Mellor and Yamada schemes

- MY2D
  - Without moist process
- MY2Smith
  - Moist process according to Smith (1997)
- MY2moist
  - Yamada and Mellor (1979)
  - Nakanishi and Niino (2004)
    - Re-evaluation of coefficients using LES results
- MY2.5
- MY3
Obs. vs. M-Y3, M-Y2.5

Frog on 3 Aug. 1977 over Cabauw, Holland

Figure 1. Time-height cross section of the observed visibility at Cabauw on 3 August 1977 (reproduced from Figure 3a in Masson-Genon, 1987). The unit of the visibility is m. Sunrise is at about 0500 UTC.

Figure 3. Same as Figure 1 except for the simulated visibility.

Density fluctuations may be possible, which adds a new research topic. (Nakanishi 2004)
Low-level cloud in Globe

Climatology on June by ISCCP Obs.

ISCCP simulator in NICAM (6～9 June 2004)
GPCI cross-section

Spatial development of PBL cloud in subtropics

※averaged over 6~9 June 2004
Mean GPCI liquid water crosssection - JJA98

NCAR

MeteoFrance

UKMO

Too shallow -> fog

Is this too much liquid water?

How deep should the PBL be..?

We need observations of cloud and boundary layer (PBL) parameters: PBL height, liquid water,...
ERBE vs. NICAM

OSR

High OSR may come from high cloud amount accompanying baroclinic instability waves.
Surface precipitation

**GPCP vs. NICAM**

Spatial distribution looks nice
But, somewhat strong especially in tropics

**GPCC (June 2004)**

**NICAM (6~9 June 2004)**
Effect of partial clouds
ISCCP low clouds

• partial clouds are diagnosed by the MY2M scheme
  • i.e. qc may not be zero if grid average RH is less than 100%.
• Radiation calculation takes account of cloud water of partial clouds
• Results: overestimation of low clouds

Without partial clouds

With partial clouds
Summery and Future

Summery

• Intersa-asonal experiment by 14km-mesh global model is now being conducted
• BL cloud in NICAM looks nice so far
  – off the coast of California, Peru, Guinea, South-East of the Atlantic Ocean, South of Indian Ocean,…
  – Spatial development in the subtropics along the GPCI cross section
  – maybe too much along the mid-latitude, though

Future

• Improvement of the boundary-layer process
  – Treatment of the subgrid-scale condensation for small-scale clouds
  – Time-dependent turbulent closure for the high-resolution model
• Validation of Climatology and cloud development
  – Diurnal variation
  – Detailed comparison with GPCI
  – Role of large-scale circulations
• Sensitivity experiments
  – What is a key to reproduce the BL cloud?
  – Influence of the vertical resolution
MISC.
1) What is the current behavior of the MMF in the low cloud regime? How is the analysis proceeding? How can it stimulate or interact with other activities in the group? What are the next steps?
   - Improvement of low clouds over west coasts of continents (Peru, California, Guinea)
   - Evaluation of overall improvement of radiation budget is not yet.
   - Task is to clarify the difference between results from low resolution and high resolution exp.
   - Next step: dependency on vertical resolution, impact of level 3/2.5 schemes, and compare with observations.

2) What are the characteristics of the forcing/response across aqua planets? This is something you should speak to and at the meeting a concrete plan of how to get further on this road, particularly with regard to interactions with the SCMs (Cara-Lyn) and CRMs (Anning?) should be a discussed. In other words, how can these tools help us? What will we plan on doing in the coming months both with traditional models and the MMF?
   - We have done APE using a former boundary layer scheme MY2D.
   - We have not analyzed low clouds of APE. A.Noda feels difficulty in finding information from APE, since the counterpart of APE low clouds in reality is unclear.
   - In the first, we need to understand behaviors in realistic cases, and then go to APE.
   - If standard products are known, we will analysis our APE results in terms of low clouds to compare with other MMF results.

3) How do CRMs (particularly when formulated as in the prototype MMF) represent the GCSS cases? This was listed as a cross cutting issue. It is a discussion that should follow Anning's presentation. Here the discussion should focus on the question of what he should do next. How can his results be used to improve what we are doing, or how should it change the direction we are going?
   - A. Noda participated in WG1 cases using a regional model JMA-NHM.
   - We are thinking of GPCI for NICAM. NICAM is not yet tested for WG1 cases, but they are important.
   - We may propose a case or analysis from results of 1).

4) How can we use the MMF as a means to embed LES in the GCM? Here there were too issues: (i) was delocalized physics, (ii) big-brother experiments with SAM. I will send a slide on delocalized physics tomorrow or Monday, and Matt perhaps can talk about the UW contribution here. The other thread to follow in this discussion is ongoing experiences/interests with the so-called mini-LES that Marat had been working with.
   - A.Noda said he is not willing to use Mini-LES from his experience; his regional model study with nesting a dx=100m model did not improve vertical distribution of low clouds.
   - We will investigate performance of the MY series.
CRMモード vs. パラメタリゼーションモード

@GL9

9日目

コントロール(CRMモード)

微物理の代わりに予報AS＋LSCを使用

雲水量は大幅に変化するものの、
境界層の分布はそれなりに再現されている
→境界層雲の再現に積雲バラ、大規模凝結は本質的に阻害しているわけではない

パラメタリゼーションモード