Contributions of Global cloud-resolving model simulations to YOTC

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Contents

• NICAM overview and some recent results
• TC Fengshen simulations: June 2008
• 3.5km mesh simulations and satellite comparisons
• Contributions of NICAM to YOTC
  – Experiments, plan and suggestions
NICAM outlines

• Outline of NICAM
  Nonhydrostatic ICosahedral Atmospheric Model
  for Global Cloud-Resolving Simulations (Satoh et al., 2008, JCP)
  First global dx=3.5km run in 2004 (Tomita et al. 2005, GRL)

• MJO and Tropical Cyclones

• High resolution simulations comparable to satellite observations
Realistic MJO simulation

Miura et al. (2007, Science), Nasuno et al. (2009, JMSJ),

NCEP/CPC IR

NICAM 7km, OLR

Liu et al. (2009, MWR)
MJO and Tropical cyclone

NICAM reasonably produced not only the large-scale circulation, such as the MJO, but also the embedded mesoscale features, such as TC rainbands.

Surface rain rate (mm hour$^{-1}$) by TRMM-TMI

Surface rain rate (mm hour$^{-1}$) by NICAM

Fudeyasu et al. 2008 GRL
Precipitation distribution over south Asia average, June-Aug., 2004

Precipitation rate - JJA 2004 - [TRMM3B42]

Precipitation rate - JJA 2004 - [GL10]

Oouchi et al. (2009, Geophys. Res. Lett.)
Diurnal cycle and ISV (northward propagation of convective system) in the Indian Ocean are realistically captured. JJA 2004
Myanmar cyclone Nargis (2008) ensemble simulations
TC genesis captured with ISV and MJO
26 Apr. – 26 May 2008
TC cyclogenesis in Indian Ocean is generally captured with ISV using stretch-NICAM Yanase et al. (2009, JMSJ, submitted)
Simulation of Fengshen (2008):

- Initialization 3 days before genesis
- Typhoon development and track similar to the observation
- Plan of more simulations with a higher resolution (dx=dy=3.5 km)
EXAMPLE: Synoptic Event of Interest June/July 2008
MJO/Kelvin Waves -> E.Pac ITCZ -> TCs -> Gulf Surge -> NA Monsoon -> Flash Floods AZ, NM
Contributed by J. Gottschalck/NCEP & M. Wheeler/ABOM
Hovmöller diagrams (5S-5N)

Eastward propagating (Kelvin) signals with westerly anomalies in mid June
• Four westward-propagating off-equatorial disturbances.
• One grew into TY Fengshen while others didn’t grow.
• Slowly eastward propagation of the whole packet, like the behavior of MRG/TD-type waves (Dickinson and Molinari 2002; Straub and Kiladis 2003)
Evolution of Cloud Bands (relative to pre-TC center)

Convective Burst
Meso-scale convection and vorticity at the cyclogenesis stage

Mesoscale convective vortices in the mid troposphere
(mainly within the fore-side cloud system)
Meso-scale convection and vorticity at the cyclogenesis stage

Top of spiral cloud band

Vorticity signal
NICAM TC Fengshen simulation

Stretched-7km-grid; Init 12UTC 16th Jun (Genesis: 12UTC 18th)

NICAM: 12UTC 18th

NICAM: 12UTC 20th

NICAM: 12UTC 22nd

JCDAS: 12UTC 18th

JCDAS: 12UTC 20th

JCDAS: 12UTC 22nd
Simulation using NICAM (dx=7km)

OBS. (MW rain, sea-level wind)

NICAM (rain, UV at z=10m)
Erroneous poleward bias in ALL forecast models

 JTWC’s 2008 Annual Tropical Cyclone Report (ATCR), Page 38:

“It is highly unusual to have all forecast guidance be incorrect, so JTWC forecasters were reluctant to go against all the models, resulting in highly inaccurate official forecasts. Immediate evaluation by the modeling community is necessary to determine the root causes of the unreliability of the dynamic models in this case.”

<table>
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<th>Forecast Track Errors</th>
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<th>CONW</th>
<th>AVNI</th>
<th>EGRI</th>
<th>GFNI</th>
<th>NGPI</th>
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</tbody>
</table>

Table 1-5: Average FTE (Homogeneous Comparison) Through Tau 120

JTWC: JTWC official forecasts
CONW: JTWC model consensus
AVNI: GFS model
EGRI: UK Met Office model
GFNI: GFDN model
NGPI: NRL NOGAPS model
Track forecast (init. 00UTC, 20 June)

JMA weekly ensemble (51 members)
JMA typhoon ensemble (11 members)
JMA GSM (20km resolution)
Track forecast (init. 00UTC, 20 June)

JMA weekly ensemble (51 members)
JMA typhoon ensemble (11 members)
JMA GSM (20km resolution)
ECMWF ensemble (51 members)
SATELLITE COMPARISONS
3.5KM MESH SIMULATIONS AND CLOUD PROPERTIES
NICAM 3.5 km mesh global simulation comparable to satellite observation

Ice cloud evaluation by split windows

Inoue et al. (2009, JGR, submitted)
Calipso/CloudSat simulated reflectivities by COSP

532 nm (1/km/sr) 00 UTC 26 Dec, 2006

NICAM ICE PROFILE 26 Dec

Cloud ice

NICAM SNOW PROFILE 26 Dec

Snow

CLOUDSAT dBZ 26 Dec

Calipso

CloudSat
NICAM IWP is larger than the observed range of IWP.

Waliser et al. (2009)

Iga et al. (2009, in preparation)
NICAM IWC is larger in the tropics.
Cloud Microphysics Schemes of NICAM

• Grabowski (1998)
• NSW6 (Tomita 2008, JMSJ)
  – Single-moment 6-categories of water
• NDW6 (Seiki-Mitsui)
  – Double-moment 6-categories of water
Stretch-NICAM exp.

- Use of NICAM as a regional model: local-CRM: (Tomita, 2008, JMSJ)
- \( dx = 2.5 \text{km} - 250 \text{km} \)
  - Stretch factor = 100, Glevel8
- Integration: 2007.1.1.12-1.5.12
- Sensitivity to cloud microphysics scheme NSW6
Stretch-NICAM exp.
5UTC 2 Jan. 2007

Cloud band

TBB : 2007.1.2.5Z: global–IR

OLR : 2007.1.2.5Z : nicam dx=3.5km

Tropical Cyclone ISOBEL
NICAM Cloud Properties
Sensitivity to cloud microphysics schemes: CFADS of CloudSat/CALIPSO signals using COSP

CloudSat/CALIPSO

Grabowski(1998), NICAM-GCRM 3.5km (90-130E, 20S-20N)

NSW6 (Tomita 2008), stretched-NICAM dx=2.5~5km
Pilot simulations of 2-moment cloud model with Global 7km resolution.
Comparisons with satellites and further challenges.
(Validation of 2-moment cloud model)

Nakajima lab. Seiki Tatsuya.

[Images of earth with MODIS/Aqua Level 2 COT(all clouds) and NICAM_gl10(SB06+CCNMAP) COT(cloud,rain,ice,snow,graupel) data for 2006/11/19]
Summary

• NICAM simulations
  – MJO and ISV (Miura et al., 2007; Nasuno et al., 2009 JMSJ; Liu et al, 2009 MWR; Oouchi et al. 2009 GRL)
  – TC (Fudeyasu et al. 2009, GRL)
  – Ensembles for ISV & TC genesis (Taniguchi & Yanase 2009 JMSJ)

• Evaluation using satellite data
  – GMS
  – CloudSat/CALIPSO & TRMM PR
Contribution to YOTC

• May 2008: TC Nargis & after
  – ISV/Northward Propagation and TC genesis

• June 2008: TC Fengshen
  – Obs. Palau2008/2010

• Experiments, plan and suggestions
  – Global 3.5 km run for a week
    • 15-25 June 2008
  – MJO Ensemble simulations 7km
    • 1 or 2 months x several runs
  – Multiscale structure and meso-scale convective systems
  – Comparison with satellite observations
  – Output data, time interval?