Validation of the BRAMS high resolution simulations by satellite radiance comparison

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Objetives

Assess the BRAMS high resolution simulations skill to produce convection by the comparison with real satellite imagery and build a data base of simulated radiances of IR and MW satellite sensors.

The comparison is done by simulating the respective satellite imagery using a radiative transfer model (here, RTTOV version 9.3)
The microphysical species of the NWP is used in the radiances simulations.

Uses the cloud scattering scheme (assumes clouds are not black body) – **IR only**

Need to determine the kind of clouds in each NWP level as well its concentration [kg/kg] and coverage (fraction)

Cloud types used:

- Cumulus (continental/maritime);
- Stratus (continental/maritime);
  - Cirrus.

Need to chose between 2 ice crystal shapes:

- Hexagonal;
- Aggregates.

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<table>
<thead>
<tr>
<th>2D vars</th>
<th>3D Vars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp. 2m [K]</td>
<td>Cloud [kg/kg]</td>
</tr>
<tr>
<td>land/sea mask [0 or 1] no height</td>
<td>Ice [kg/kg]</td>
</tr>
<tr>
<td>Sea Level Pressure [hPa]</td>
<td>Hail [kg/kg] *</td>
</tr>
<tr>
<td>Tveg2 [K]</td>
<td>Pristine [kg/kg] *</td>
</tr>
<tr>
<td></td>
<td>Snow [kg/kg] *</td>
</tr>
<tr>
<td></td>
<td>Graupel [kg/kg] *</td>
</tr>
<tr>
<td></td>
<td>Aggregates [kg/kg] *</td>
</tr>
<tr>
<td></td>
<td>Rain [kg/kg] ***</td>
</tr>
<tr>
<td></td>
<td>Total Condensated [kg/kg]</td>
</tr>
<tr>
<td></td>
<td>Pressure [hPa]</td>
</tr>
<tr>
<td></td>
<td>Relative Humidity [%]</td>
</tr>
<tr>
<td></td>
<td>Specific Humidity [ppmv]</td>
</tr>
<tr>
<td></td>
<td>Temperature [K]</td>
</tr>
<tr>
<td></td>
<td>Cloud Fraction [%] **</td>
</tr>
</tbody>
</table>

* Only used to choose ice shape and or cloud type;
** Calculated by the cloud scheme, not by Ramspost
*** Only for MW simulations
Working progress
(simulated radiances database)

• IR radiances – **DONE** *(only Fortaleza and Vale)*
  – GOES/Imager (3.9, 6.7, 10.2)
  – MSG/SEVIRI (3.9, 6.2, 7.2, 8.7, 10.8, 12)
  – AVHRR (maybe is worth to simulate too?)

• MW radiances – **BEING DONE**
  – SSMIS/S
  – AMSU/A
  – AMSU/B
  – TRMM
Cloud scheme (CS) comparison
“all or nothing” vs Xu and Randall (1996)

• “All or nothing”:
  Cloud fraction (cloud cover) = 100% if total condensate > 0.1 [g/kg]
  0% otherwise

• Xu and Randall (1996):

  \[ C = RH^p \left[ 1 - e^{\frac{-\alpha_0 q_l}{(q_s-q_v)\gamma}} \right] \]

Where:
  \( p, \alpha \) and \( \gamma \): method adjust constants;
  \( RH \): relative humidity;
  \( q \): mixing ratio of saturation (s), vapor (v) and liquid water/ice (l).

The Xu and Randall CS has been used for the BRAMS/RTTOV simulations.
CS “Xu and Randall (1996)” minus “all or nothing”

Brightness temperature from 9 up to 15 K colder
CS Xu and Randall (1996)
Cloud top are colder than the ones simulated using the cloud fraction calculated by the Xu and Randall (1996) CS.
First analysis

• Verify some general aspects of the convection produced by the BRAMS, the GOES-12 6.7 and 10.2 μm radiances, for all golden days:
  – Convection start, is it in phase with the reality?
  – Cloud position (not expecting the exactly position);
  – Cloud amount, (number of cells, its sizes);
  – High level humidity distribution (Water vapor absorption channel 6 μm).

• The analysis was done by:
  – Visual inspection of the simulation/satellite plots;
  – Brightness temperature histograms analysis.

• An table in next slide shows a brief description of each golden day of Vale do Paraíba experiment.

• For the Fortaleza experiment, the representation of the observed convection is poor, for almost all golden days, if compared with the Vale do Paraíba ones.

• Until now, the runs for Belém and Alcântara experiments are not available, but will be soon.
# First analysis

## Experiment: Vale do Paraíba

<table>
<thead>
<tr>
<th>Golden Days</th>
<th>Rating</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/11/11</td>
<td>good</td>
<td>med level clouds are overestimated</td>
</tr>
<tr>
<td>12/11/11</td>
<td>good</td>
<td>very homogeneous cloud field after 2nd third</td>
</tr>
<tr>
<td>13/11/11</td>
<td>good</td>
<td>same as previous golden day</td>
</tr>
<tr>
<td>14/11/11</td>
<td>bad</td>
<td>very different than reality</td>
</tr>
<tr>
<td>15/11/11</td>
<td>bad</td>
<td>very different than reality</td>
</tr>
<tr>
<td>22/11/11</td>
<td>good</td>
<td>reproduce nebulosity (right half) after 21UTC</td>
</tr>
<tr>
<td>23/11/11</td>
<td>bad</td>
<td>mostly clear sky</td>
</tr>
<tr>
<td>28/11/11</td>
<td>very good</td>
<td>convection underestimated (area), convection start/pos. match</td>
</tr>
<tr>
<td>29/11/11</td>
<td>bad</td>
<td>convection underestimated (heavily) and mismatch</td>
</tr>
<tr>
<td>30/11/11</td>
<td>good</td>
<td>convection underestimated</td>
</tr>
<tr>
<td>01/12/11</td>
<td>very good</td>
<td>one of the best cases</td>
</tr>
<tr>
<td>02/12/11</td>
<td>bad</td>
<td>mostly clear sky</td>
</tr>
<tr>
<td>14/12/11</td>
<td>very good</td>
<td>capture the main features, overestimate nebulosity</td>
</tr>
<tr>
<td>15/12/11</td>
<td>very good</td>
<td>like previous, last 3 hours are useful</td>
</tr>
<tr>
<td>18/12/11</td>
<td>very good</td>
<td>match well, overestimate long life clouds</td>
</tr>
<tr>
<td>19/12/11</td>
<td>good</td>
<td>match well the last hours, mostly clear sky</td>
</tr>
<tr>
<td>20/12/11</td>
<td>very good</td>
<td>but have only 7 hours, last 3 are useful</td>
</tr>
</tbody>
</table>
28 Nov 2011 – Vale do Paraiba
BRAMS’s convection started allmost at same time
Almost no longer life clouds
Few middle level clouds

GOES 10.2 μm

BRAMS/RTTOV
18 Dec 2011 – Vale do Paraiba - very good case

GOES 6.7 μm

BRAMS/RTTOV 6.7 μm

High level humidity overestimation (too cold BTs)

GOES 10.2 μm

BRAMS/RTTOV 10.8 μm
18 Apr 2011 – Fortaleza
Shift to the colder region – too much humidity at higher levels

28 Nov 2011 GOES-12 6.7 μm

Satellite (black lines)  RTTOV/BRAMS (blue)
28 Nov 2011 GOES-12 10.2 μm

Satellite (black lines)  RTTOV/BRAMS (blue)

Few low/mid level cloud
Conclusions

• For the golden days of Vale do Paraiba experiment:
  – The BRAMS high resolution simulations have few middle level clouds.
  – An delay of 1 to 3h was observed for the convection start in the BRAMS.
  – The high level humidity (400 hPa) gradients show a tendency to became weaker since the begin of the simulations.
  – The convective cells and the nebulosity are, in many golden days, located near to the observed convection, however, the horizontal area are generally small.

• The Xu and Randall (1996) cloud scheme work well (the high level cloud tops are not too cold as when using the “all or nothing” CS).
Next Steps

• Finish the MW simulations for Vale do Paraíba experiment and analyze the whole dataset.

• Verify with the CPTEC/BRAMS modeling group why the Fortaleza simulations are poor.

• Apply a different Cloud Scheme for a more concise comparison.