Cloud Parameters from Infrared and Microwave Satellite Measurements

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Main Objective

Investigation of Horizontal and Vertical clouds distribution using infrared and microwave data (AIRS and spatial and temporal collocated AMSU)
AIRS Cloud Detection Scheme

- AMSU/AIRS regression tests
- AIRS Spectral Signature of Clouds
 AMSU channel 4,5,6 and 9 are used to predict AIRS channels at 
909.9, 1080.2, 2419.6 and 2563.9.

AIRS FOV is labeled cloudy if the:
predicted AIRS - measured AIRS > 3 K
AIRS Spectral Signature of Clouds

- Windows Channel Tests
- AIRS Inter-channel Regression Tests
- Test for Polar Regions
- Horizontal Coherency Test (Windows channel and water absorption band)
## AIRS Cloud Mask Validation using MODIS and SEVIRI data

<table>
<thead>
<tr>
<th>MODIS CLEAR FOVS PERCENTAGE</th>
<th>FOVS DETECTED EXACTLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>70 %</td>
<td>84.1 %</td>
</tr>
<tr>
<td>90 %</td>
<td>96.3 %</td>
</tr>
<tr>
<td>100 %</td>
<td>90.7 %</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SEVIRI CLEAR FOVS PERCENTAGE</th>
<th>FOVS DETECTED EXACTLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>70 %</td>
<td>86.3 %</td>
</tr>
<tr>
<td>90 %</td>
<td>96.7 %</td>
</tr>
<tr>
<td>100 %</td>
<td>93.7 %</td>
</tr>
</tbody>
</table>
MODIS and SEVIRI

<table>
<thead>
<tr>
<th>FOVS DETECTED IN THE SAME WAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>95.4 %</td>
</tr>
</tbody>
</table>
**DATA SET**

<table>
<thead>
<tr>
<th>SEVIRI</th>
<th>DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>28 OCT 2004</td>
<td>DAY/NIGHT</td>
</tr>
<tr>
<td>20 NOV 2004</td>
<td>DAY</td>
</tr>
<tr>
<td>10 DEC 2004</td>
<td>DAY/NIGHT</td>
</tr>
<tr>
<td>15 JAN 2005</td>
<td>NIGHT</td>
</tr>
<tr>
<td>15 FEB 2005</td>
<td>DAY</td>
</tr>
<tr>
<td>20 MAR 2005</td>
<td>DAY/NIGHT</td>
</tr>
<tr>
<td>15 APR 2005</td>
<td>NIGHT</td>
</tr>
<tr>
<td>01 MAY 2005</td>
<td>DAY/NIGHT</td>
</tr>
</tbody>
</table>

1500 AIRS and MODIS granules

ITSC XIV  Beijing, China  25-31 May 2005
In this study we investigate the errors in CO2-slicing cloud top pressure retrievals due to the presence of multilayered clouds. When multi cloud layers are present, the CO2 slicing retrievals result in cloud top pressures located somewhere between the upper and lower cloud layers.

We use two different techniques to identify multilayered clouds.
To detect multilayered clouds, we use a technique which identifies MODIS pixels that contain thin cirrus overlying lower-level water clouds. Our approach uses the 2.13 μm band reflectance (for daytime), the 8.5 and 11 μm band brightness temperatures and the MODIS retrieved CO2 silicing as a function of observed 11-μm BT.

Multilayered clouds are identified as those cloudy FOVs that have significant differences between the IR and MW cloud height.
Infrared Cloud Top Height

T(IR) => CO2 slicing method
Clear Radiances => Kriging cloud clearing
Temperature and Humidity Profiles => ECMWF
Microwave Cloud Top Height

A lookup table for clear and cloudy AMSU/B brightness temperature was produced. To estimate LWP, Cloud water content (CWC, liquid or ice), and T(MW), T(IR) is used to selected a value of T(MW) and LWP from the lookup table to start AMSU simulation.

If the difference between the observed and the estimated reaches a minimum, the retrieval process finishes, otherwise the cloud top is moved down and the steps are repeated.
Spectral properties of atmosphere gases and clear radiances are computed using RTTOV*, while cloud radiances for different cloud types are computed using RT3**.


Modified RT3 code searches for the best solution: simulated brightness temperature are compared to the observed selected 300 AIRS channels. Cloud top estimated using CO2 slicing method is used to start simulation. If the difference between the observed and the estimated reaches a minimum, the retrieval process finishes, otherwise the cloud top is moved up.
Multilayer

Single-layer (CO2 slicing)
h_{CT} = 6.5 \text{ km}

h_{CT} = 7 \text{ km} \quad \text{Cloud Thickness} = 3.1 \text{ km}

h_{CT} = 2.7 \text{ km} \quad \text{Cloud Thickness} = 1 \text{ km}
\[ h_{CT} = 6.3 \text{ km} \]

\[ h_{CT} = 7.4 \text{ Cloud Thickness } = 2.3 \text{ km} \]

\[ h_{CT} = 3.05 \text{ km Cloud Thickness } = 3 \text{ km} \]
\( h_{CT} = 9.1 \text{ km} \) 

\( h_{CT} = 9.0 \text{ km} \) Cloud Thickness = 1.8 km

\( h_{CT} = 1.0 \text{ km} \) Cloud Thickness = 0.8 km
h_{CT} = 6.2 \text{ km}

h_{CT} = 6.7 \text{ km} \quad \text{Cloud Thickness} = 1.4 \text{ km}

h_{CT} = 4.1 \text{ km} \quad \text{Cloud Thickness} = 1.2 \text{ km}
h_{CT} = 9.5 km Cloud Thickness = 4.3 km

h_{CT} = 1.0 km Cloud Thickness = 0.8 km

LWP (Kg/m²)
MW AMSU ECMWF
0.09 0.12 0.11

IWV (Kg/m²)
MW AMSU ECMWF
31.9 30.5 29.7

ICW g/m³
AMSU RADAR
0.026 0.019-0.03

r_e1 (micron)
Sat Radar
12 8-14

r_e2 micron
Sat Radar
40 50
CONCLUSION AND FUTURE WORK

• A proper combination of infrared and microwave measurements could be useful to determine the cloud coverage, the vertical cloud structure and composition in all weather conditions.

• Validation of cloud parameters, based on ground based measurements, will be extend to a large data set.
International TOVS Study Conference, 14\textsuperscript{th}, ITSC-14, Beijing, China, 25-31 May 2005.