Developments in cloud and aerosol detection for infrared radiance data

Reima Eresmaa¹

Hyoung-Wook Chun¹,², Julie Letertre-Danczak¹, Tony McNally¹

(¹) European Centre for Medium-range Weather Forecasts
(²) Korea Institute of Atmospheric Prediction Systems
Departure-based cloud detection: the operational implementation at ECMWF

The primary focus in the operational use of advanced infrared sounder radiances is in the assimilation of clear channels (often above clouds)

Cloud-contaminated radiances are detected and rejected using a refined version of the scheme of McNally & Watts (2003)

The scheme ranks channels in vertical according to their sensitivity to cloud and looks for a monotonic increase (or decrease) in background departure – if found, it will be interpreted as a signature of cloud

There is a comprehensive and up-to-date description of the implementation in the documentation of the associated NWP SAF deliverable at

https://nwpsaf.eu/deliverables/IR_aerosol_cloud_detect/index.html
Identifying clear and cloudy channels in the ECMWF scheme

Scenario 1: All channels are clear
Accounts for ~10% of all cases over sea, but only up to 4% over land

Scenario 2: Warm cloud over cold surface
Accounts for polar clouds but is chosen commonly over land everywhere

Scenario 3: Cold cloud over warm surface
The typical case: accounts for 80-85% of all cases over sea and 60-70% over land
Simulated error statistics from missed cloud

Errors due to undetected cloud are large over land!

Errors are strongly correlated because of missed cloud!
Departure-based cloud detection over land: interaction with skin temperature error

Cloud is often missed because of skin temperature error cancelling the cloud effect

→ “Clear” population contains a large amount of cloudy scenes associated with a background error

Correlation between observation and background errors!

→ A major complication on the use of infrared radiances over land!
OB/BG error correlation and how to reduce it

Two approaches are being taken with the aim at reducing the OB/BG error correlation in the active population:

1. Using collocated imager statistics as additional input to the cloud detection
2. Exploiting inter-channel differences in observed brightness temperature spectra
Imager-assisted cloud detection as we currently do it

Easy access to clustered statistics of AVHRR radiances within each IASI FOV

→ Useful information on scene homogeneity and inter-cluster consistency to assist distinguishing between background errors and cloud

Imager-assisted cloud detection as we currently do it

<table>
<thead>
<tr>
<th></th>
<th>Clear</th>
<th>Cloudy</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear</td>
<td>5.2%</td>
<td>3.4%</td>
<td>8.6%</td>
</tr>
<tr>
<td>Cloudy</td>
<td>5.5%</td>
<td>85.9%</td>
<td>91.4%</td>
</tr>
<tr>
<td>Total</td>
<td>10.7%</td>
<td>89.3%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

An independent imager-based cloud flag is determined from the collocated cluster statistics and used as additional input in the imager-assisted scheme.

Instead of using the departure-based scheme and having ~11% of FOVs completely clear, we use the imager-assisted scheme and reduce the fraction of completely clear FOVs to ~5%.
Impact of the imager-assisted cloud detection

Impact on mean 700-1000 hPa thickness

→ Lower-tropospheric warming over sea ice and a beneficial forecast impact
Inter-channel differences in observed $T_B$ spectra as we are just about to start exploiting them

See poster 8p.04 by Letertre-Danczak & McNally: Dust detection with IASI measurements in the weather forecast.
Summary

Applying a departure-based cloud detection over land introduces correlation between observation and background errors – these cannot be handled properly by any data assimilation scheme.

Recent and near-future developments to the cloud detection aim at reducing the dependency on background information:
- Using collocated imager information
- Exploiting inter-channel differences in observed spectra

The future use of infrared radiances over land will rely on fundamentally different cloud detection and observation error covariance as compared with the use of radiances over sea.