Cloud Screening Algorithms

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Cloud Problematic

- Thick bright clouds
- Optically thin clouds
- Clouds over bright surfaces
  - snow, ice, bright sand, turbid waters
- Cloud borders
- Cloud shaddow

- Undetected clouds/partly cloudy pixel mess up high level products retrieval
Cloud characteristics

- bright
- white
- cold
- higher than surface
- water vapour absorption
- spatial radiation variability

- none of these criteria is always true
  - there are clouds that are not very bright
  - there are clouds that are at the surface (e.g. mountains)
  - there are warm clouds etc
The need for a cloud detection

1. Clouds are the subject of interest
   - climate studies
   - weather forecast

2. Clouds are masking the signal of interest
   - e.g. ocean colour, SST, land surface properties, mosaicking ...

→ the requirements/quality of a cloud detection depends on the purpose

<table>
<thead>
<tr>
<th></th>
<th>if pixel type is in doubt, the pixel classification should be:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L2</td>
</tr>
<tr>
<td>cloud studies</td>
<td>processing algorithm and application dependent</td>
</tr>
<tr>
<td>land/ocean studies</td>
<td>cloud</td>
</tr>
</tbody>
</table>
A little bit of history

- **NOAA AVHRR (1980 +)**
  - statistical histogram analysis (Phulpin, 1983)
  - threshold on thermal and visible bands (Saunders & Kriebel 1988)
  - pattern recognition based on large scale textures (Garand and Weimann, 1986)
    → working well over the ocean
    → problems in polar and tropical

- **ATSR-1 (1990 +)**
  - threshold tests
    - b12 threshold
    - B11/B12, B3.7/B12 differences
    - histogram test
    - nadir/forward view
    - ...
  - spatial coherence
AATSR Cloud Screening

classification prior to IPF 6

<table>
<thead>
<tr>
<th>Test</th>
<th>Land/Sea</th>
<th>Day/Night</th>
</tr>
</thead>
<tbody>
<tr>
<td>gross cloud test</td>
<td>Sea only</td>
<td>Day/Night</td>
</tr>
<tr>
<td>thin cirrus test</td>
<td>Land/Sea</td>
<td>Day/Night</td>
</tr>
<tr>
<td>medium/high level cloud test</td>
<td>Land/Sea</td>
<td>Night</td>
</tr>
<tr>
<td>fog/low stratus test</td>
<td>Land/Sea</td>
<td>Night</td>
</tr>
<tr>
<td>11 micron spatial coherence test</td>
<td>Land/Sea</td>
<td>Day/Night</td>
</tr>
<tr>
<td>1.6 micron histogram test</td>
<td>Sea only</td>
<td>Day</td>
</tr>
<tr>
<td>11/12 micron nadir/forward test</td>
<td>Sea only</td>
<td>Day/Night</td>
</tr>
<tr>
<td>11/3.7 micron nadir/forward test</td>
<td>Sea only</td>
<td>Night</td>
</tr>
<tr>
<td>infra-red histogram test</td>
<td>Sea only</td>
<td>Day/Night</td>
</tr>
</tbody>
</table>

recent changes:
- enable gross test over land
- disabled spatial coherence test over land
- new test using NDVI
- new snow test using NDSI
Logical combination of 8 (max) tests:

<table>
<thead>
<tr>
<th>Test</th>
<th>Land</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bright pixel</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Low pressure estimate 1 (NN)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low pressure estimate 2 (polynomial)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product confidence 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product confidence 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressure consistency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whiteness (reflectance ratio)</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Bright land surface (reflectance ratio)</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

Potential of the O2 absorption feature is yet unexploited → currently addressed in „O2 Exploitation“ and „MERIS AATSR Synergy“ projects

Current MERIS L2 cloud screening is trying to please everyone → consequently it is not satisfactory for any user
Classification of methods

- **Threshold methods**
  - exploiting spectral characteristics
  - brightness, whiteness (slope)
  - O2 absorption – pressure/height
  - temperature

- **Feature extraction and classification**
  - spectral features
  - spatial features
  - dynamic thresholds
  - classification

- **Learning algorithms**
  - Bayesian approach / data mining
  - cloud probability
  - cloudiness index

- **Multitemporal analysis**
  - globcover/albedomap

(Probabilistic Cloud Screening)

(from Merchant, QJR Meteor. Soc, 2005)
Example for a learning algorithm: Cloudiness Index

• Motivation

1) a better cloud screening for ocean pixel was required
   → Case2Regional project
2) the idea of a „graduated scale“ should be tried

• Realisation

– Labelling of cloud and clear pixel by hand
– assigning a cloudiness index
– training of a set if neural nets (bottle neck technique)

→ see presentation of H. Krasemann
Cloud Sampling Tool
Classification Result

Profile Plot for cloud_index

cloud_index [-]

0.0 0.51 1.0
MERIS AATSR Synergy

AATSR B12 nadir

MERIS B13
## MERIS & AATSR Synergy

### Instrument Combinations vs. Method

<table>
<thead>
<tr>
<th>Instrument Combinations</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>spectral bands</td>
<td></td>
</tr>
<tr>
<td>bM, bA</td>
<td>TREE</td>
</tr>
<tr>
<td>bM</td>
<td>MLP</td>
</tr>
<tr>
<td>bA</td>
<td>SVM</td>
</tr>
<tr>
<td>bM, bA</td>
<td>LDA</td>
</tr>
</tbody>
</table>

Results obtained by L. Gomez-Chova, Univ. Valencia, MERIS-AATSR Synergy Project

**Preliminary!** Model dataset needs revision.
Validation

- Comparison with manual expert classification
- Satellite products intercomparison
  - limited use because of „purpose“ problematic
- Continuous cloud observations from ground
- Meteorological observations
- Indirect validation through higher level algorithms
Example: Sky Camera

**ASTIC320 installation at Chilbolton Radar Facility**

(J.-P. Muller, University College London)

Fish-eye lens, all sky thermal IR camera (ASTIC), developed by a UCL spin-off company, Blue Sky Imaging, which acquires 30 second imagery, 24 hours a day, 365 days a year.
Example: Nebulosity Data
GlobCover project, Noveltis France

Nebulosity data (gratefully provided by Météo-France) corresponding to human observations of the cloud cover fraction
Tools

• BEAM cloud detection processors
  
  - Available
    • Cloud probability processor
      - Albedomap project, FUB
    • BEAM band arithmetic
    • BEAM training course example
  
  - Future
    • Chris cloud detection
    • AlbedoMap / Globcover
    • Case2R cloudiness index → Case2R project
    • O2 exploitation project → Cirrus clouds
    • Synergy project(s) → Guanter methods
    • Snowradiance project
    • BEAM cloud processor, integrating the above
Outlook

- **MERIS**
  - requires improvement of current cloud identification
  - improved pressure product → improvement of current threshold technique
  - implementation of AlbedoMap/GlobCover Cloud screening seems possible for next reprocessing

- **AATSR**
  - I am not an expert, but I would like to become more familiar with it

- **Sentinel 3**
  - graduated scale / cloudiness index approach should be the way ahead
  - candidates are available
    - Case2R cloudines (over water only, available in BEAM 2008)
    - Synergy project (available in BEAM 2009)

- **ESA cloud working group**
  - re-activate in 2009
Thank you