**INTRODUCTION**

Cloud detection is essential to estimate accurate atmospheric and geophysical parameters. A statistical and physical approach has been developed for MSG in order to improve cloud identification for very thin and very low cloud. The statistical algorithm is a pattern recognition technique that uses textural and spectral features. It was trained on the basis of MSG images collected for different seasons and different regions. The physical algorithm is based on dynamic threshold tests and it doesn’t require any ancillary data. If the algorithms do not agree a decision has to be taken to decide the final FOV flag.

**MODIS**

The Moderate resolution Imaging Spectroradiometer on board AQUA and TERESA polar EOS satellites, provides global observations in VIS and IR region of the spectrum.

It measures radiances at 36 wavelength (from 0.4 to 14.5 µm) at 250 nm spatial resolution in two visible bands, 500 nm resolution in five visible bands and 1000 nm resolution in the infrared bands.

**SEVIRI**

The Spinning Enhanced Visible and Infrared Imager on board the First Meteosat Second Generation have been available since February 2003. Its spatial resolution is 3 km at sub-satellite for all channels except 1 km for the high resolution visible channel. The major improvement is its enhanced spectral characteristic that, combined with its higher temporal resolution (15 minutes) allows an accurate cloud cover analysis.

**Physical and statistical approach for MSG cloud identification**

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**Physical approach**

The algorithm is based on a multi spectral threshold technique applied to each pixel of the image. The test depends on the solar illumination (day time, night time, sun glint) and on the viewing angles. The thresholds have been determined on the basis of training database which gather pixels manually selected and labeled as cloud free.

For the i-th test the probability is the pixel is clear \( P_{\text{clear}} \) or cloudy. \( P_{\text{cloudy}} \) will be determinate.

If the i-th test is successful (the pixel is cloudy) then \( P_{\text{cloudy}} \) is determined on the basis of the distance between the real value and the thresholds:

\[
P_{\text{cloudy}} = \frac{\mu_m - \text{DiffThreshold}}{\text{Threshold} - \mu_m}
\]

Otherwise, the pixel is clear if

\[
P_{\text{clear}} = \frac{\text{DiffThreshold}}{\text{Threshold} - \mu_m}
\]

**Statistical approach**

The classification algorithm is based on a K-nn pattern recognition technique and it uses textural and spectral features estimated in boxes 3x3. Spectral and textural features characterizing each pixel are extracted for IR SEVIRI radiance data at 3.9 µm (particularly useful in the detection of low level water clouds) 8.7 µm, 10.8 µm, 12 µm. The features are shown in the table: The large number of spectral and textural features can be reduced since not all of them are useful. The Fisher distance is the feature selection criterion:

\[
D_{\text{Fisher}} = \frac{\mu_{\text{positive}} - \mu_{\text{negative}}}{\sigma_{\text{positive}} + \sigma_{\text{negative}}}
\]

where \( \mu \) is the number of samples in class \( c_i \) and \( k \) are the samples closest to the features vector \( \mathbf{r} \), \( V \) is the volume in which those \( k \) reside. In order to define the distance between two points in the feature space and calculate the volume \( V \), we have assumed that the feature space is a metric space and the function which expresses the distance between \( \mathbf{x}_1 \) and \( \mathbf{x}_2 \) is the Euclidean distance:

\[
d_{\text{Euclidean}} = \sqrt{\sum (x_i - y_i)^2}
\]

When the Euclidean distance measure is used, some features (the ones with the largest variance across the design set) tend to dominate this measure so it has been necessary to normalize the features.

Finally, we are able to classify the pixel as cloudy if

\[
P_{\text{cloudy}} > \sum_{i=1}^{k} d_{\text{Fisher}}(\mathbf{r}_i, \mathbf{r})
\]

and

\[
P_{\text{clear}} < \sum_{i=1}^{k} d_{\text{Fisher}}(\mathbf{r}_i, \mathbf{r})
\]

Otherwise, the pixel is clear if

\[
P_{\text{clear}} > \sum_{i=1}^{k} d_{\text{Fisher}}(\mathbf{r}_i, \mathbf{r})
\]

**Ensemble of Statistical and Physical methods (CMESP)**

The physical and statistical approach run independently then the individual decisions are matched; if the two methods do not agree, the final FOV flag will be clear if \( P_{\text{cloudy}} > P_{\text{cloudy}} \) or \( P_{\text{clear}} < P_{\text{clear}} \).

If the difference between the probabilities is lower than 5%, a further test on the Robert Gradient \( |\nabla I|_1 \rangle \) has to be done:

\[
|\nabla I|_1 > \text{Threshold}
\]

the pixel is cloudy.

\[
|\nabla I|_1 < \text{Threshold}
\]

is a dynamic threshold.

**Results**

MSG cloud mask has been validated against MODIS cloud mask (Ackerman et al., 1998) and compared with SAFNWC cloud mask (Schoevent et al., 2002). MODIS cloud mask is collocated with SEVIRI footprint. SEVIRI FOV has been determined to be clear. In result interpretation it should be observed that MODIS cloud mask not always detects cloudy pixels correctly. Moreover it sometimes classifies as uncertain pixels that CMESP detects correctly. The blue ring surrounds some pixels that SAF cloud mask detects wrongly.

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**References**