CGMS-37 EUM-WP-30
v1, 23 September 2009
Prepared by EUMETSAT
Agenda Item: II/7
Discussed in WGII

# MSG DATA AND PRODUCTS AS PROTOTYPE FOR THE MTG IMAGER

The MTG Imager (MTG-FCI – Meteosat Third Generation Flexible Combined Imager) will provide approximately 3 times more information than the current Meteosat Second Generation (MSG) SEVIRI instrument. Any efficient usage of this data will require a comprehensive and objective image analysis to derive meteorological products, where, in the light of the mere data volume of the image data, the importance of the derived products is expected to grow in the MTG era.

This paper describes how the currently already available MSG-SEVIRI data can be used to prepare for a growing demand on products and on product quality.

Although the current MSG product retrieval algorithms are a good first baseline for the MTG-FCI, the advent of MTG should be used to prepare for a more comprehensive image interpretation and corresponding product extraction scheme, which is presented in this paper. First feasibility studies in this respect suggest that MSG data can be well used to test these novel ideas.

# MSG Data and Products as Prototype for the MTG Imager

## 1 INTRODUCTION

The Flexible Combined Imager instrument onboard the planned third series of Meteosat satellites – hereafter referred to as MTG-FCI, will provide unprecedented spectral, spatial and temporal coverage from a geostationary orbit. In view of the planned 16 channels covering the solar and infrared spectrum with a spatial resolution of 1-2 km and a full disk coverage every 10 minutes, MTG-FCI will provide approximately 3 times more information than the current Meteosat Second Generation (MSG) SEVIRI instrument. Any efficient usage of this data will require a comprehensive and objective image analysis to derive meteorological products, where, in the light of the mere data volume of the image data, the importance of the derived products is expected to grow in the MTG era.

This paper describes how the currently already available MSG-SEVIRI data can be used to prepare for this growing demand on products and on product quality. MSG has a number of channels in common with MTG-FCI, has an only slightly worse spatial resolution, scans the full disk in 15 minutes, but also offers reduced scans in 5 minute intervals. In addition, MSG imagery has the big advantage over any synthetic data (e.g. simulations derived from model outputs), that it comprises a range of realistic atmospheric conditions and, even more important, realistic surface, cloud and aerosol conditions, so that new product processing techniques can be better tested.

Although the paper will focus on the specific product knowledge transfer from MSG to MTG, the same concept can apply for any other advanced satellite system: Today's available data is of sufficient quality to serve as a proxy for the future. Certain new aspects (as new channels, better temporal sampling) need special attention. The commonality with current progress of NOAA toward the GOES-R ABI is noted.

## 2 ADVANCED PRODUCT GENERATION TECHNIQUES

In this section, we first discuss current operational products which are based on methods that have matured through continuous development over the years. Conceptually it is clear that these methods and products are already a good prototype for analogous future products. In addition, the innovative elements of the MTG-FCI, e.g. new spectral channels, need to be addressed in a specific way to create viable proxy data.

As MTG-FCI, however, will offer such a wealth of information, current productalgorithms can potentially be revisited and changed to a more comprehensive product retrieval technique, which is presented in the second part of this section.

## 2.1 Current Core MSG Products

The core suite of MSG meteorological products are products which are either already operationally available or have reached a mature prototype range and are expected to soon become operational. These products are a Scenes Analysis as a first underlying image interpretation step (identifying presence of clouds, dust, volcanic ash or active fires), followed by a more detailed Cloud Product (cloud top height, cloud microphysical information), an Aerosol Product describing the aerosol optical depth over a given field-of-view, an Airmass Analysis to detect atmospheric instability, and the Atmospheric Motion Vector product, which uses a number of consecutive images to derive wind information. Further products are derived from the MSG imagery within the Satellite Application Facilities.

It can be assumed that a number of current MSG products need to be continued in the MTG era because a sustained requirement from the user community exists.

## 2.2 Comprehensive Image Analysis

Currently used underlying algorithms are a mixture of traditional thresholding techniques (e.g. used for the initial cloud detection) and more advanced optimal estimation type of techniques (e.g. used for the cloud microphysical product and the instability analysis). In addition, the processing is in many instances such that the products don't "know" of each other, e.g. humidity fields are retrieved for the instability products, but the cloud detection step does not use this updated humidity information and rather relies on forecast fields.

An integrated approach to geophysical product derivation from geostationary platform imagery is possible and can already be tested with the currently available MSG data. The basic premise here is that the best use of geostationary data demands that the extraction of products is not regarded as a collection of individual and separately executed algorithms, each operating on a single image repeat cycle (in the worst case even on a single pixel or field-of-view), but as a consistent and continuously analysis of a sequence of images, also taking into account each pixel's environment and history. This approach ensures that the strong advantage of geostationary observations – their fast temporal repeat rates, is actually exploited.

The underlying reason for this demand is that, as with any remotely sensed data available to date, MSG measurements alone do not completely determine the geophysical parameters within an observed pixel – a limitation that will stay with MTG-FCI. There is the need to import boundary information (e.g. NWP fields, as mentioned above). In addition, regarding the fast image repeat cycles for MSG (and slightly faster cycles for MTG-FCI), the information available at an image cycle can be propagated forward and made available at the next cycle. The proposed comprehensive image analysis will thus "complete" the image products in time and space.

Any algorithm that processes just a single pixel has to deal with some uncertain parameters as e.g. humidity, surface temperature, ozone, which are usually supplied with values from external data like climatology or NWP – or the channel that is severely affected by that parameter is simply omitted within the processing. Neighbouring pixels of different scene type, however, may allow the derivation of the parameter. An example is surface temperature, which is supplied to the cloud detection algorithm by the respective forecast field – for cloud-free pixels, however, this temperature can be directly derived from the measurements. In a single pixel approach, the algorithm would not "know" about adjacent cloud free pixels and their surface temperature measurements, which is clearly a limitation. A simple example is given in Figure 1, showing the sea surface temperature in the Southern Atlantic, as provided by NWP, and as inferred from a sequence of MSG images: The much more appropriate depiction of small-scale structure like ocean eddies or cold coastal upwelling is obvious, and this boundary information is in turn beneficial for cloud detection and cloud processing.

The 15 minute repeat cycle of MSG measurements is a relatively high rate with respect to most geophysical parameters. Consequently, the value of most parameters at a pixel in a particular cycle will be more or less strongly auto-correlated with the value at the previous cycle. The degree of correlation will depend on the situation and the parameter. Using the surface temperature example again, this will show high correlation over remote ocean locations but lower correlations over sun-illuminated land surfaces.

Going further, parameters that are only weakly observable within a single pixel may be estimable with observations from a larger number of cycles. The Meteosat First Generation land surface albedo product and the Land Daily Aerosol algorithm essentially use the equivalent of a two-pass time dimension filter to extract surface albedo and aerosol optical depth from an entire daytime record at a pixel and it has been developed because decoupling aerosol and albedo effects at a single pixel/cycle over reflecting land surfaces is not possible, the information content is too low. Another example is the extraction of surface emissivity, using the assumption that this only varies very slowly in time. This has already been suggested within a feasibility study.

Completing (filtering, analysing) retrieved fields of geophysical variables of direct relevance to radiative transfer in the MSG channels supplies more accurate boundary conditions for product generation than is available from the analogous completion of NWP fields (and other auxiliary data) alone.

Concerning MTG-FCI, its new aspects like increased spectral, temporal and spatial resolution, can be easily accommodated in such a comprehensive scheme.

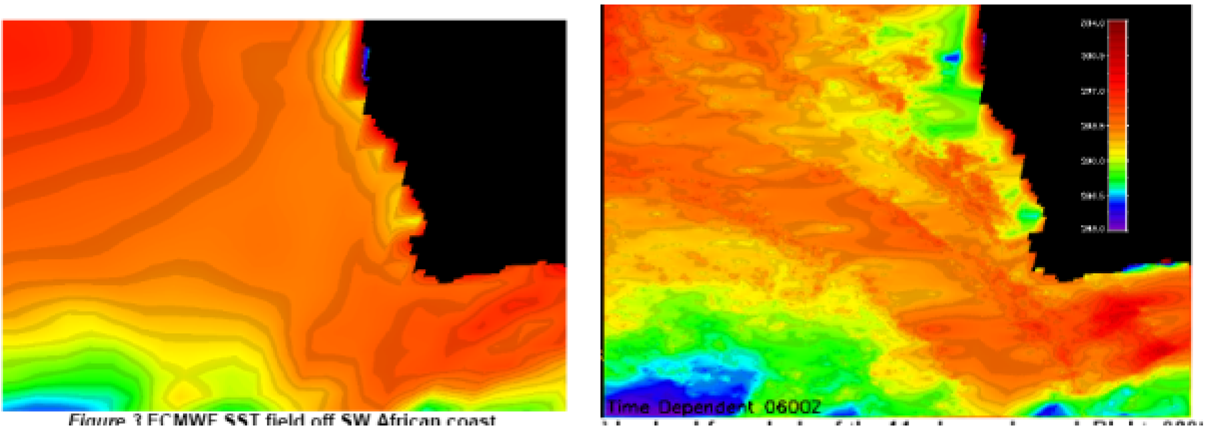


Figure 1: Sea Surface Temperature over the Southern Atlantic as [prescribed by NWP (left) and as directly inferred from MSG image data, filtered and accumulated over 12 hours (right): especially the cold upwelling off the coast of Africa is better detected by the filtering methods, and this updated background SST will be less detrimental to e.g. the cloud mask.

## 3 CONCLUSIONS

The growing demand on satellite derived meteorological products and product quality information will in the future ask for more advanced product retrieval concepts. These concepts will make a better and, more important, more consistent use of the available satellite information.

An implementation of such a comprehensive system will require significant research effort and a substantial shift in the current notion of independent product algorithms and is therefore suited to preparatory activity for MTG-FCI and other advanced imagers rather than development activity for MSG. The current MSG data provide probably the best available test data and results to date. An international coordination of the already ongoing research activities in this direction would be highly beneficial to ensure best usage of satellite data.