CGMS-XXIX EUM-WP-22
Prepared by EUMETSAT
Agenda Item: II/6
Discussed in WG II

META-DATA REQUIRED FOR SATELLITE DATA REPROCESSING FOR CLIMATE APPLICATIONS

This document discusses the ancillary information needed to process geostationary satellite data in support to climate studies in the light of the actual archive state and plan for the archiving of data from future missions.

In view of the importance of meta-data for the reprocessing of satellite data from an archive and the general lack of this type of information, the CGMS Working Group on Satellite Products is invited:

- to discuss the need of such meta-data
- to establish a first list of parameters and data that such a "meta-data set" should contain.

META-DATA REQUIRED FOR SATELLITE DATA REPROCESSING FOR CLIMATE APPLICATIONS

1 INTRODUCTION

The first generation of meteorological geostationary satellites has been designed nearly 30 years ago, essentially for real-time operational imagery purposes. The primary objective of these Programmes is the acquisition of Earth atmosphere images and their dissemination to the user's community. The potential value of these data for climate monitoring should however not be underestimated. During the late seventies and early eighties, space-borne observations of the Earth were very scarce, essentially limited to geostationary meteorological observations and a few polar platforms. The extent of these observations, acquired at a high temporal frequency in almost identical conditions during almost 20 years, represents therefore a potentially valuable input to climate monitoring.

The utilisation of these archived geostationary observations for climate studies raises several technical and scientific issues about radiometric quality, geometric rectification and finally data calibration. For instance, the various Meteosat sensors exhibit small technical differences between themselves, and radiometric anomalies occurred on several instruments. Additionally, calibration techniques have been improved, in particular during the late eighties. As a result, the archived calibration coefficients, if any, cannot be used in a straightforward way for long time series analysis. The exact data acquisition conditions should be documented as accurately as possible.

The purpose of this paper is therefore to analyse the ancillary information needed to process these data in support to climate studies in the light of the actual archive state and plan for the archiving of data from future missions. The potential support of geostationary observations to climate applications is first discussed.

2 POTENTIAL SUPPORT OF GEOSTATIONARY OBSERVATIONS TO CLIMATE APPLICATIONS

Space-borne observations support an increasing number of climate investigations and thereby contribute directly to our knowledge and understanding of the Earth as a global and integrated system. Over the last two decades, most of these space-based data have been acquired by operational meteorological satellites, which have, in general, not been designed for this objective. These observations, however, represent a unique data set whose exploitation for climate monitoring is worthwhile, as already demonstrated by the Pathfinder Programme, initiated jointly by NASA and NOAA.

Climate observation can be categorised into two fundamental approaches. The first one aims at *understanding* climate processes and their variability. The second one addresses the *detection* of climate change. The International Satellite Cloud Climatology Project (ISCCP) represents a typical example of the first approach. It was the first project of the World Climate Research Programme (WCRP) tasked to produced a global data set on cloud parameters that

should ultimately promote research to improve the understanding of the Earth's radiation budget and the hydrological cycle. The possibility of detecting trends from these data is essentially constrained by the magnitude of the expected change, which defines the required calibration accuracy.

Geostationary satellites do not provide a global view of the Earth and their performance in terms of spatial resolution and radiometric noise is hampered by the large distance from the Earth. They are actually designed for the monitoring of synoptic events and in support of nowcasting and their orbital position is precisely maintained. Geostationary satellites form a key part of the global observing system with a ring of satellites around the Equator covering the equatorial regions, sub-tropics and mid-latitudes. They have a clear advantage in *understanding* regional climate processes better and their variability (e.g. they are the key element for ISCCP).

3 REQUIREMENTS FOR META-DATA

Geostationary satellites have been originally designed to acquire “images” of the Earth disc at frequent interval. Instrument on board these satellites measure actually radiances in different spectral bands that are later on converted into count values. The quantitative analysis of these data requires the full characterisation of the observation conditions of each observed pixel, i.e., the time of acquisition, the location of the pixel on Earth, the geometry of observation and finally the spectral band or sensor spectral response. The conversion of count value to the corresponding radiance is also of primary importance. Hence, in addition to the digital values themselves, following ancillary information and its associated error should be delivered.

- **Time**: The definition of the acquisition time of each pixel is quite straightforward for geostationary satellites because of the data acquisition mechanism.
- **Position**: The definition of the location of each pixel requires the accurate characterisation of the spacecraft position and attitude at the time of the data acquisition. The accuracy of the rectification can be assessed by means of ground control points.
- **Observation angles**: The definition of the observation angles requires in addition the characterisation of the instrument optics.
- **Sensor spectral response**: This quantity should be measured before launch with an estimate of its accuracy. Its temporal degradation is difficult to assess.
- **Calibration coefficient and offset**: The evaluation of calibration coefficient, associated error and temporal drift are the most critical information. In the absence of on-board calibration device, vicarious calibration is required. A prerequisite for obtaining accurate calibration is a complete understanding of the radiometer characteristic (e.g. temperature effects, emissivity, dependence of scan mirror on angle of incidence etc.).

Ground segments of the latest generation of Earth observation satellites (e.g., Envisat, Terra) recognise two different levels of satellite data according to the type of processing. Data received from the spacecraft are referred to as level 1.0 or A and level 1.5 or B when the information listed above has been computed and made available to the users. Hence, when archiving level 1.0 data, it is important to also archive all the relevant information that would allow the re-generation of level 1.5 data. This information concerns essentially the position of the spacecraft at the data acquisition time, the optical characteristics of the instrument like

registration parameters, and any other relevant information concerning the state of the radiometer (temperature, operation mode, gain, offset, re-scaling, etc.). When level 1.5 data are archived, all the information about the algorithm that have been used for the generation of these data like software version number, set up parameters, *etc.* need to archived as part of the level 1.5 data.

3.1 Status of the Meteosat archive

When Meteosat archive started, almost 20 years ago, the concept of archiving were not thought through in order to serve requirements for climate studies. The data were archived in a hybrid format in the sense that raw count values were archived together with deformation matrices that allow the determination of the position of each pixel. The exact position and attitude of the spacecraft that have been used for the derivation of these deformation matrices were not systematically archived. Consequently, the re-generation of level 1.5 data using state-of-the-art rectification algorithm is almost impossible. Calibration and sensor drift monitoring is also a critical issue. Operational calibration of the thermal bands has been subject to constant improvement and should clearly be re-estimated using state-of-the-art techniques. In particular the status and performance during the early years of operations are not well documented.

3.2 Status of MSG/SEVIRI archive

For MSG/SEVIRI, data will be archived in both level 1.0 and 1.5 format, together with all the information needed to regenerate the level 1.5 in case major improvements in the pre-processing algorithm occur. However, further improvements are required, which enable a tracking of the algorithm version that has been used to generate the data.

4 CONCLUSION

In view of the importance of meta-data for the reprocessing of satellite data from an archive and the general lack of this type of information, the CGMS Working Group on Satellite Products is invited:

- to discuss the need of such meta-data
- to establish a first list of parameters and data that such a “meta-data set” should contain.