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

META-DATA TO BE APPENDED TO REPROCESSED DATA

This paper responds to Action 29.23 which requests "CGMS Members to propose lists of parameters and data which should be contained in "meta-data" to accompany reprocessed data".
The document discusses the ancillary information needed to process geostationary satellite data in support to climate studies in the light of experience gathered during the ongoing reprocessing of Meteosat data from the archive.

META-DATA TO BE APPENDED TO REPROCESSED DATA

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 studies on climate variability and, possibly, on the detection of trends.

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 to discuss 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 THE POTENTIAL 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 generally lower for polar orbiting satellites. They are actually designed for the monitoring of synoptic scale weather and rapidly changing weather phenomena. These features, in conjunction with their programme duration, do offer a perspective toward *understanding* regional climate processes better and their variability.

3 REQUIREMENTS FOR META-DATA

The Meteosat 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 observed before launch. Its temporal degradation is difficult to assess, however means to estimate the degradation should be established.
- **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. On board calibration systems should be fully characterised.

Ground segment of the latest generation of Earth observation satellites (e.g., Envisat, Terra) recognises two different levels of satellite data according to the type of processing. Data received from the spacecraft are referred to as level 1.0 of 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, 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.

This well-controlled documentation of parameters and version number fundamental to precision and accuracy of satellite measurements needs to be established as correlative data (meta-data) for climate products. As opposed to climate products, meteorological products do not generally require a precision compatible with climate monitoring. However, it is expected that more precise and consistent longer-term climate products will be derived through a reprocessing of level 1 or level 1.5 data with improved or new algorithm and/or the refined use meta-data

4 STATUS OF THE METEOSAT ARCHIVE

When Meteosat archive started, almost 20 years ago, the concept of level 1.0 and level 1.5 data did not exist. The data were actually 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.

5 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. It is however not foreseen to archive information on algorithm version number that has been used to produce these data.

6 ESSENTIAL META-DATA

A list of essential meta-data should include:

- characterisation of instruments (e.g. spectral response function of overall system and of components)
- calibration information (i.e. functional relationship and corresponding coefficients)
- documentation of actual calibration algorithm
- information on the geo-referencing of level 1.5 data
- all information necessary to reproduce the actual geo-referencing from level 1 data and necessary for improved future geo-referencing
- for each product a controlled documentation of the algorithm version used for the product derivation