REPROCESSING METEOSAT IMAGES FOR ECMWF REANALYSIS

Bertrand Theodore1,2, Leo van de Berg1, Sakari Uppala2, Mark Jenner1

1 EUMETSAT, Am Kavalleriesand 31, 64295 Darmstadt, Germany
2 ECMWF, Shinfield Park, RG2 9AX Reading, United Kingdom
3 MOLTEK-SAS BP 77206, 31672 Labege, France

Abstract

This paper presents the METEOSAT first generation reprocessing project at EUMETSAT. This project has been initiated in support of the ECMWF ERA-40 project. A special facility dedicated to this project has been set up and is now operational. An overview of some of the results of the first part of the project, consisting in reprocessing image data obtained between 1989 and 1990 are presented. Some insights on the future activities are given.

INTRODUCTION

An extensive 45 year reanalysis of meteorological observations from September 1957 to August 2002 was completed by the ERA-40 project at ECMWF in 2003. Within the frame of this project ECMWF enquired EUMETSAT the feasibility to reprocess Meteosat-2 image data in order to provide atmospheric motion vector (AMV) products using state of the art algorithms. As a result EUMETSAT reprocessed new products for the period 1982 - 1988 with a positive impact on the quality of ERA-40 products over the period. These reprocessed data have also been supplied to the Japanese 25 year Reanalysis Project.

Presently ECMWF is preparing a follow up reanalysis project, ERA-Interim, to provide updated reanalysis for the period 1989 onwards. ECMWF has thus enquired EUMETSAT to reprocess Meteosat image data from this period, with the emphasis not only on the AMV product but also on the clear sky radiance (CSR) product.

THE RMPEF

The Reprocessing Meteorological Products Extraction Facility (RMPEF) at EUMETSAT was set up in 1999 using the operational MPEF system as a basis. However the system has been reengineered so that the processing is completely data (and not time) driven (see figure 1). As in the operational MPEF, additional support data is required for determination of the atmospheric absorption, but instead of forecasts, the RMPEF uses ECMWF analyses from the ERA-15 project. It is currently possible to reprocess 30 days of image data within 24 hours.
Care has to be taken especially when using early images of the pre-operational satellites (METEOSAT-2 and 3). For instance the WV imagery from these satellites is very noisy, with respect to those from the operational satellites. In addition to the noise, there is a systematic difference in the occurrence of even and uneven counts, causing a problem for the histogram analysis scheme. To avoid the latter problem, within the reprocessing system the six-bit WV images have been reduced to five-bit data, while for technical reasons the VIS images have been converted to eight bits by adding two random bits in the least significant end. Also problems with image rectification have been found in some cases with an impact on the products generation.

The requested period spans the operations of MET3 to MET7 and includes the MET3 extended mission over the Atlantic Ocean (ADC) as well as the MET5-Indian Ocean coverage (INDOEX). This amounts to more than 340,000 images stored in the EUMETSAT archiving system UMARF (figure 2).
RECALIBRATION

Since no black-body information is available from Meteosat-2 and -3, RMPEF uses the old vicarious calibration method, i.e. comparisons with sea surface temperatures for the IR calibration and radiosonde humidity observations for the WV channel. All support data is retrieved from the ECMWF archive (MARS). The first EUMETSAT reprocessing project has shown that a more stable calibration, especially the water vapour (WV) channel, is a pre-requisite for the CSR product to be used in any meteorological analysis.

A recalibration of the IR and WV channels has thus been performed over the selected period. A "calibration run" is first performed to compute a new set of calibration coefficients six times a day. These are then smoothed in time in order to remove small scale variability.

These newly determined calibration coefficients are shown on figure 3 and 4 for METEOSAT4 on some restricted period of time. For the IR band, improvement in the stability of the calibration coefficient can be observed as well as a general reduction of the coefficient value up to 2 %. The difference in the WV band appears to be large, of the order of 5 %. The high time variability intrinsic to the vicarious calibration method has been removed by the smoothing process.

In both channels, jumps can still be observed when a gain change occurs, between two different satellites or possibly between processing periods. This problem will be addressed in the next phase of the project.

![Figure 3: Time series of the infrared calibration coefficients for two months in fall 1990 and for MET4. Note the two jumps corresponding to a spacecraft decontamination beginning of November and to a gain change on November 26.](image)
Figure 4: Time series of the water vapour calibration coefficients for six months in fall 1990 and for MET4. Several decontaminations and gain changes have taken place during that period as is apparent in the calibration time series. That made difficult the determination of a “clean” calibration coefficient and yielded the spurious oscillations that can be observed.

ATLANTIC DATA COVERAGE

A special challenge has been the processing of Meteosat-3 image data from the Atlantic Data Coverage (ADC) and the Extended Atlantic Data Coverage (XADC) missions, with satellite locations at, respectively, 50° W and 75° W. Those missions comprised a European support to the USA, after the failure of a GOES spacecraft. These unique meteorological products have been delivered to ECMWF, as part of the ERA-Interim project. On figure 5 is an example of these products: it shows the wind product when hurricane Emily approached the North-Carolina coast on Aug. 31st, 1993.
Figure 5: Wind product generated for August 31, 1993, 18TU when MET3 longitude was 60W.

WIND PRODUCT

A marked increase - by a factor of 4 for MET3 - in the number of generated winds has been observed. Not only this product has been generated every 1.5 hours instead of two or four times daily, but winds has also been generated from the VIS band as illustrated on Figure 6 that shows the time series of the number of generated winds per channel (IR, VIS, WV) over the MET3-ADC mission. The large dispersion in the VIS channel is expected; on the other hand, the outliers in the IR could be indicators of a problem in the input image that should be further investigated.

Figure 6: Number of winds generated per slot for each channel during the MET3 Atlantic Coverage mission.
Figure 7 shows both the internal consistency of the generated winds as well as the consistency with ECMWF forecasts for the MET3 Atlantic Coverage mission. The values obtained are comparable with the ones obtained on MET7 in 2004 for instance, although the dispersion is a higher. This probably owes its origin to the lower quality of the input images. Again here it will be interesting to assess the origin of the observed outliers.

The quality of the generated winds can be estimated by comparison with collocated radio-soundings. Figure 8 shows the time evolution of the monthly RMS difference between R/S and METEOSAT winds. The positive impact of the reprocessing appears here with a RMS decreased by about 10%.

Figure 7: Internal consistency of the generated wind vectors (dark blue) and consistency with ECMWF forecasts (light blue) during the MET3 Atlantic coverage mission.

Figure 8: Time series of the monthly RMS difference between Meteosat winds and Radiosondes measurements.
FUTURE ACTIVITIES

The RMPEF is currently being entirely redesigned to make it simpler and more flexible in order to increase performances and maintainability. The first runs, focusing on the Meteosat Surface Albedo (MSA) product, are expected to take place at the end of 2006.

A recalibration of the entire period is planned; the current calibration has been impeded by some images unavailability yielding possible jumps between processing periods that may have impacted the quality of the products.

On the long term, the reprocessing of the complete archive is foreseen.