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STATUS OF PRECIPITATION ESTIMATION AND VALIDATION ACTIVITIES

In response to CGMS action/recommendation A35.22

This paper presents EUMETSAT's activities in producing and validating satellite derived precipitation estimates:

The at EUMETSAT centrally derived multi-sensor precipitation product is described, the activities of the EUMETSAT Satellite Application Facility network in the area of precipitation are outlined, and finally the joint project between EUMETSAT and the South African Weather Service regarding a NOAA based algorithm is discussed.

It should be noted that this paper is a follow-up paper of EUM-WP-20 of CGMS-35.

CGMS is invited to take note of EUMETSAT's activities in the area of quantitative precipitation estimates and validation activities.

Status of Precipitation Estimation and Validation Activities

1 INTRODUCTION

EUM-WP-20 of CGMS-35 has outlined the underlying algorithms and application areas of two precipitation estimates that are derived using the data of the geostationary Meteosat satellites of both first and second generation. The precipitation products are the so-called Multi-Sensor Precipitation Estimate (MPE) which is extracted centrally at EUMETSAT, covering the entire field of view of both Meteosats (Meteosat-9 over 0° longitude, Meteosat-7 over 57° E), and a local stand-alone version of the so-called Hydroestimator, which is running at the South African Weather Service (SAWS), covering the southern half of the African continent.

In addition, this document also describes the activities in the framework of EUMETSAT's Satellite Application Facilities (SAFs). SAFs are specialized development and processing centres, which utilize the specific expertise available in EUMETSAT's Member and Cooperating States. The SAF network complements the production of standard meteorological products derived at EUMETSAT's central facilities.

Seven SAFs are currently in the Continuous Development and Operations Phase (CDOP), and one is in its Development Phase. A total of eight "themes" are covered, where three SAFs provide service related to precipitation: The Nowcating SAF, the Hydrology SAF, and the Climate Monitoring SAF.

2 PRECIPITATION ESTIMATES

2.1 EUMETSAT's Multi-Sensor Precipitation Estimate (MPE)

The MPE product is produced operationally in near real-time for both operational Meteosat satellites, covering the geostationary positions over 0° longitude and over 57° E. The major focus of the product is to provide near real-time rain rate information to users in regions without precipitation radar coverage. Reactions from users in Africa and Europe show that the MPE can be a valuable contribution to various meteorological and also non-meteorological applications.

The MPE is a pixel-based instantaneous rain rate. It is derived with a classical blending algorithm, using rain rates derived from passive microwave instruments onboard polar orbiting satellites as "calibration" reference for the collocated infrared window brightness temperatures, measured by the geostationary satellite. The continuous re-calibration requires the availability of operational microwave data sets with a timeliness of better than 6 hours. These data are provided by the SSM/I instruments on the DMSP satellites.

The applied methodology is adequate to derive near real-time precipitation data on a global basis, but it also limits the reliability of the product to convective weather situations. In the focus regions of this product – subtropical and tropical Africa and Asia, and during summer in the mid-latitudes, convective precipitation is responsible for more than 90% of the surface rain rates.

In order to provide information on the instantaneous applicability of the product, two quality indicators were developed. They are based on the accuracy of the dynamic process of the "calibration" of the geostationary data against the rain rates from the microwave sensors.

The first quality indicator – QI-1 – shows the correlation between the MPE and the microwave rain rates for the "calibration" cases. The second indicator – QI-2 – describes the absolute difference between the MPE and the microwave rain rates. While QI-1 is very useful to identify regions where the MPE method is generally applicable, QI-2 provides more detailed information about the accuracy of location and time. Figure 1 shows the MPE product together with its two quality indicators, demonstrating that the quality is considerably higher in the strong tropical convection cells, while frontal precipitation in mid-latitudes is associated with lower quality.

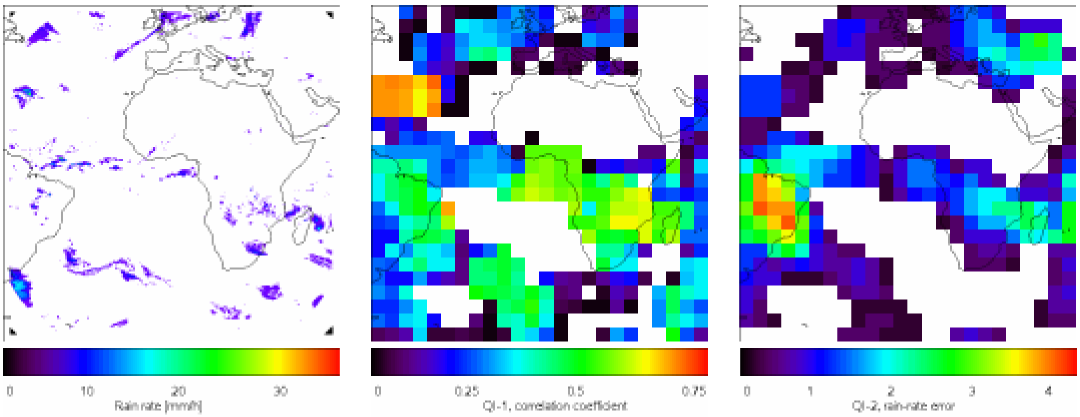

Figure 1: MPE instantaneous rain rates in mm/h (left), QI-1 correlation coefficient based quality indicator (middle), QI-2 rain-rate error based quality indicator.

The MPE product from Meteosat-9 and Meteosat-7 are available via internet in the GRIB-2 format. The product consists of the instantaneous rain rates in the respective Meteosat pixel resolution, and the two quality indicators in a 5° latitude/longitude resolution. The data of Meteosat-9 are also distributed via EUMETCast. In addition, the Meteosat-9 MPE product is also available as a visual product on the EUMETSAT web site. The Reduced Scanning Service (RSS) of Meteosat-8 – which is currently located over 10° E – also provides an MPE product for Europe and North Africa, with a temporal resolution of 5 minutes. This is already available via trial dissemination on EUMETCast as an RSS demonstration product, and the start of the fully operational data dissemination is envisaged for October 2008.

In the framework of the PEHRPP study (Program to Evaluate High Resolution Precipitation Products), the instantaneous MPE rain rates are sampled on 0.25° latitude/longitude boxes and provided to the European PEHRPP centre in Oxford, UK. First results of the validation study were presented during the EUMETSAT User Conference in September 2008.

2.2 SAF Products and Activities Related to Precipitation

2.2.1 The Nowcasting SAF

The SAF on “Support to Nowcasting and Very Short Range Forecasting” (NWC-SAF) was established to utilize the data of the Meteosat Second Generation (MSG) satellites and the EUMETSAT Polar System (EPS) for enhanced nowcasting applications. Software packages are being developed for the operational extraction of products relevant for nowcasting, and these packages are distributed for local installation.

The large product suite includes the “Convective rain rate” product, which provides information associated to convective rain rates coming from the MSG channels in the visible, infrared window and water vapour absorption bands.

The “Precipitation Clouds” product exists for both the geostationary and polar platforms: It provides a measure of likelihood for precipitation. For the geostationary part, this is based on the spectral characteristics of a number of MSG imager channels, while for the polar platform it relies on AVHRR and AMSU measurements. The product gives the forecaster a quick overview over the probability of precipitation in a few coarse intensity classes, and is especially intended for areas without radar coverage. Figure 2 shows an example.

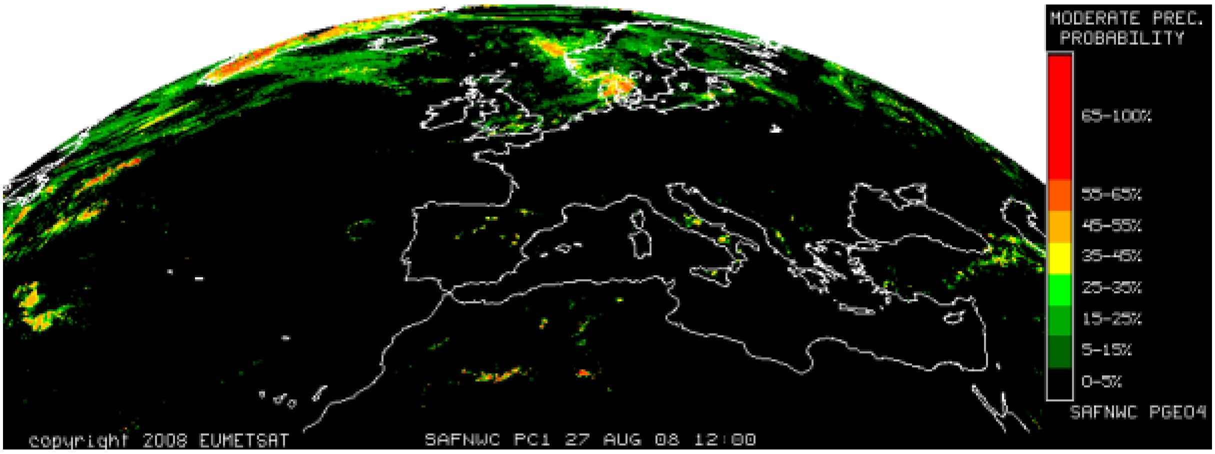

Figure 2: Map of precipitation probability as calculated from MSG SEVIRI information with the NWC-SAF software package “Precipitating clouds PC”

Information on algorithm details, validation results and current developments can be retrieved via the NWC-SAF web page http://nwcsaf.inm.es.

2.2.2 The Hydrology SAF

The SAF on “Support to Operational Hydrology and Water Management” (H-SAF) started into its Development Phase in September 2005. The main objective of this SAF is to operationally provide new satellite-derived products in three areas: precipitation (mainly using microwave and infrared sensors), soil moisture (at the surface in the roots region), and snow (cover, melting conditions, water equivalent). In addition, the H-SAF will perform independent validation of the usefulness of the new products for hydrological applications.

The initial precipitation products are currently under evaluation in the framework of the H-SAF hydrological validation programme. The assessment of the results will follow in autumn 2008 with the expected release and start of the initial open distribution of data in 2009 after successful reviews.

2.2.3 The Climate Monitoring SAF

The SAF on "Climate Monitoring" (CM-SAF), with the start of its CDOP in March 2007, began the integration of the processing system for precipitation estimates over ocean from passive microwave data (SSM/I) into their operational processing unit. The algorithms and initial processing system (as part of the Hamburg Ocean Atmosphere Fluxes and Parameters from Satellite data, HOAPS) was developed at the University of Hamburg and the Max-Planck-Institut für Meteorologie in Hamburg, Germany. The included precipitation provides the CM-SAF with a third part of the water cycle, after having already produced cloud and water vapour products (Figure 3). The users of those products will clearly benefit from the more complete set of provided variables for the energy and water cycle. The final product will be a data set of monthly mean precipitation over ocean covering the years 1987 – 2011 with a target accuracy of 0.25 mm/h (BIAS) and 0.5 mm/h (RMS error) at a spatial resolution of 0.5° latitude/longitude.

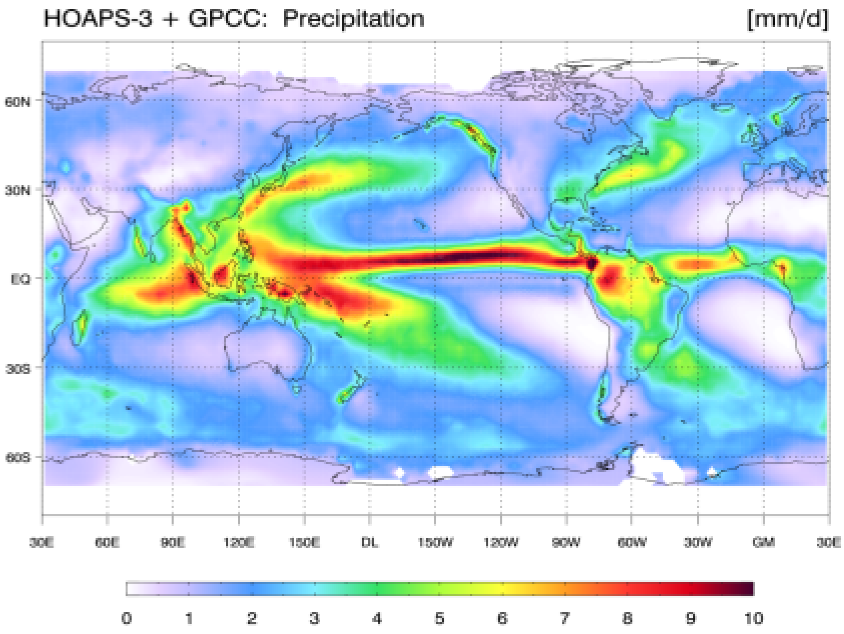

Figure 3: Ten year average precipitation rate 1994-2004 in mm/d, over ocean: based on the passive microwave data over ocean (SSM/I) derived with the CM-SAF/HOAPS algorithms, over land: data from the Global Precipitation Climatology Centre GPCC at Deutscher Wetterdienst DWD. Figure provided by Stefan Bakan, MPI Hamburg.

Further information on the product and on the expected availability of the data can be retrieved from the CM-SAF web page http://www.cmsaf.eu.

2.3 The EUMETSAT-SAWS Installation of the Hydroestimator

As already outlined in CGMS-35 EUM-WP-20, EUMETSAT – in cooperation with the South African Weather Service (SAWS) – has supported a trial installation of a satellite-based precipitation product, using the so-called Hydroestimator method (Scofied, R.A. and R.J Kuligowski, 2003: Status and outlook of operational satellite precipitation algorithms for extreme precipitation events. *Wea. and Forecasting*, **18**, 1037-1051).

The Hydroestimator uses a statistically established relation between local rain rate and the satellite measure IR window brightness temperature. This baseline relation, however, is locally changed depending on local fields of total precipitable water, layer relative humidity, and the 750 hPa wind field to account for orographic effects. This ancillary information is contributed by a forecast model, in the case of SAWS this is the mesoscale Unified Model, which provides hourly forecasts of all necessary fields on a ~0.11 deg latitude/longitude horizontal spacing. The Hydroestimator method implies that it is geared toward convective rain and is much less suited for stratiform rain.

For the SAWS installation, the original Hydroestimator was additionally changed to account for high and seasonally variable tropopause height (and thus temperature), which is used as a minimum possible cloud top temperature within the Hydroestimator algorithm.

The SAWS installation of the Hydroestimator uses 15-minute Meteosat-9 of the 10.8 m channel as input and derives a rain rate in mm/hour for every 15 minute repeat cycle.

Further processing is done at SAWS to compute e.g. 3-hour and 24-hour rain rates, and visualisation software is available for all these products.

Initial validation work has been started at SAWS, dealing with eyeball comparison of the two MSG based rain products, the MPE and the Hydroestimator (Figure 4).

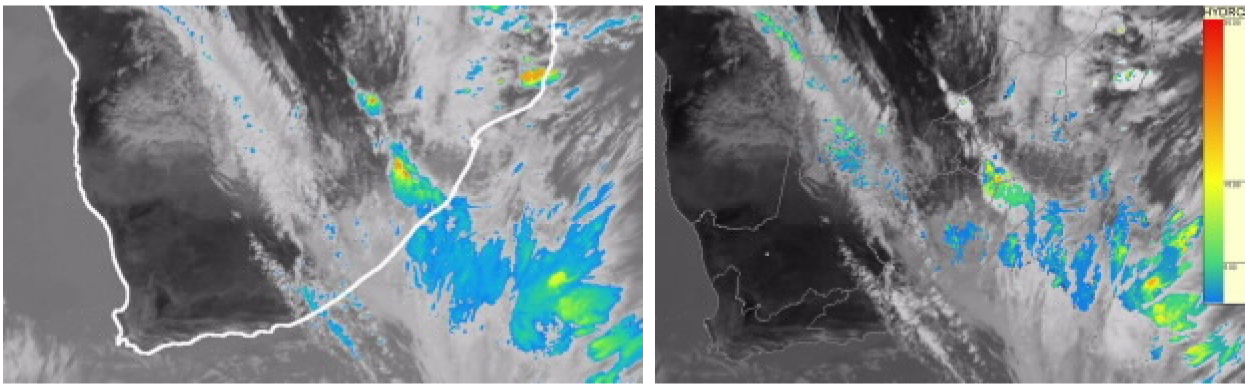

Figure 4: MPE results (left) and Hydroestimator results (right) of the instantaneous rain rate (mm/hour) based on the 100 UTC MSG image of 6 November 2007. The colour coded product is shown on top of the 10.8 m MSG image – differences in grey scales are only due to different enhancements that are applied to the background image.

A number of case studies are available, where the 24-hour totals of the Hydroestimator were compared to point measurements of the SAWS rain gauge system. Figure 5 shows an example.

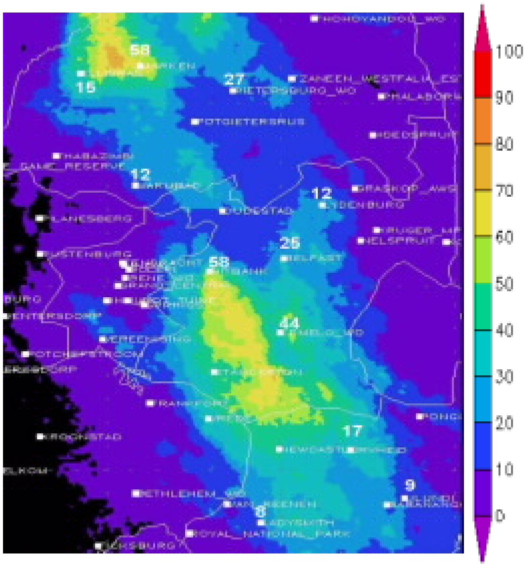

Figure 5: Example of a point comparison of the Hydroestimator product (colour coded) to individual rain gauge measurements (white numbers) for a 24-hour period on 11 November 2007. The area is the eastern part of South Africa.

Work towards a more quantitative comparison is given in Figure 6, which shows the 14-hour accumulated rainfall, as estimated from the Hydroestimator, and as provided by the ground network of rain gauges. Statistical measures are provided, e.g. average and maximum rain, probability of detection, and correlation coefficient (0.63 for this case) – which is in range with what can be expected from the Hydroestimator method. Although this case shows a pronounced overestimation of rain by the Hydroestimator, the opposite is often also found for other days.

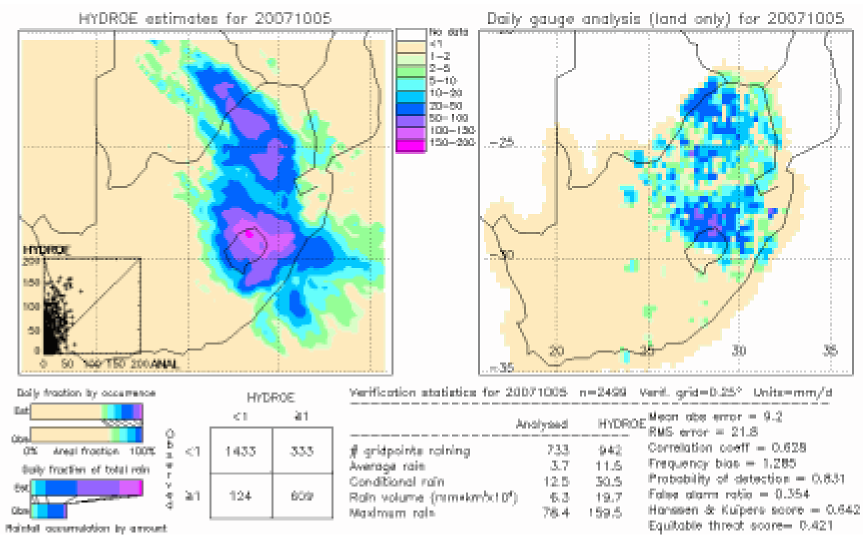

Figure 6: Example of the initiated quantitative comparison to the land-based rain gauge network. Compared are 24-hour rainfalls for 05 October 2007.

It should be noted that the Hydroestimator method offers a lot of “tuning” mechanisms, as much of the corrections done to the initial rain rate, depending on the model fields, are simply performed by means of empirical parameters. The ongoing validation work thus also helps to infer an improved adaptation to the model fields.

A successful validation of the Hydroestimator – which would demonstrate the areas of applicability and the limitations – could then lead to a EUMETSAT central or SAF product, based on this algorithm, on the entire Meteosat field of view.

3 CONCLUSIONS

CGMS is invited to take note of EUMETSAT’s activities in the area of quantitative precipitation estimates and validation activities.