UTILIZATION MONITORING OF SATELLITE TRACKED WIND PRODUCTS TRANSMITTED THROUGH THE MDD SYSTEM IN DEVELOPING COUNTRIES

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ABSTRACT

Data such as satellite tracked winds are becoming increasingly important in all aspects of weather forecasting given the relentless demise of surface observing networks in the developing countries.

This paper describes the overview of the high utilization of satellite derived wind products transmitted through the Meteorological Data Distribution (MDD) system in the developing countries. It also gives an outline of the main development-oriented applications which are currently known to take advantage of METEOSAT within the African continent and describes the additional benefit which can be expected from this point of view with the Second Generation of METEOSAT (MSG) and the future EUMETSAT Polar System (EPS). It furthermore suggests possible orientations in order to maximize the benefit of EUMETSAT programmes for supporting environment-related development efforts in Africa.

A previous case study shows that Cloud Motion Winds are found to be comparable with radiosonde winds. Operationally in the meteorological services Direction and speed of CMW can be validated using satellite images to show the development a synoptic system.

1. BACKGROUND

The United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in June 1992 stressed the need of international efforts to combat desertification which is though to affect about 1/6 of the world population. Sustainable land-use and water-management policies, which are considered as crucial components of this effort, extensively require weather satellite data.

Several priority orientations were identified by WMO in its strategy to support this challenge: monitoring/assessment of drought and desertification, application of meteorology and hydrology to development programme especially for land use and water-management projects, research on weather and climate affecting critical areas, training and education, as well as supporting regional centres of excellence.

All those recommendations were relevant for EUMETSAT, which is took them into account as far as possible in the design and implementation of its programmes, in accordance with its charter, and in consistency with the numerous cooperation links already established

bilaterally between the meteorological services of EUMETSAT Member-States and African partners.

2. RELEVANCE OF METEOROLOGICAL SATELLITES FOR DEVELOPMENT PROGRAMMES IN AFRICA

2.1 "Meteorological" versus "remote-sensing" satellites

Earth-observation data are an essential tool for the management of sustainable development. Satellite data, used alone or in combination with some ground based data, are especially helpful in developing countries due to the limited ground based observation infrastructure usually available locally in comparison with the huge area to cover. It is recognized that the "meteorological" satellites, such as the NOAA and METEOSAT series, and the "remote-sensing" satellites like SPOT, LANDSAT or ERS, are playing here complementary roles, the first ones having the advantage of high image recurrence, while the latter offer a better spatial resolution. In what follows, we will focus on the applications of "meteorological" satellites.

In addition to their classical use for operational meteorology, meteorological satellite data are required to address specific key issues for the development which are directly related to environmental/climate parameter. These applications can be roughly sorted into three categories:

- assessment of climate trends and of desertification,
- resources management,
- defence strategy against disasters.

In the context of developing countries, meteorological satellites such as METEOSAT are also essential to support ground based networks and facilities through their additional telecommunication capabilities known as:

- the Data Collection System
- the Meteorological Data Distribution mission

2.2 Assessment of Climate Trends and Desertification

Direct monitoring of desertification and deforestation, although best achieved using high-resolution images from remote-sensing satellites such as SPOT and LANDSAT, may be usefully complemented by weather satellites such as NOAA which offer a lower resolution but a greater amount of images. On the other hand, the monitoring and study of climate in the African area, namely the monthly estimation of rainfall and the intertropical cloud cover climatology.

2.3 Resources Management

Satellite provides an efficient support to the management of critical resources such as land, food, water, fishery. Typical applications are:

- decision making for establishing pasture corridors for nomadic cattle (thus saving sensitive vegetation areas),

- advanced crop estimates enabling famine warning,

- soil temperature and moisture monitoring, for irrigation management,

- short-term rainfall estimation, integrated over a catchment basin for irrigation management purposes,

- identification of favourable fishing zones through sea-surface-temperature gradient derivation

The first three classes of applications are based on the calculation of the so-called "vegetation index" derived from channels 1 and 2 of the NOAA AVHRR, in combination with some ground-based or remote-sensing data, while the fourth class is a typical Meteosat application.

2.4 Disaster Warning

Meteorological satellite data can be made available at a proper time-scale to be relied upon as a basis in real time warning strategies against natural plagues or disasters such as: bush fires, floods, sand storm, or desert locust invasion. The latter case is again a critical issue, bearing in mind that a desert-locust invasion of the African continent might result in a dramatic famine (and furthermore cost several hundred millions of US$ of emergency measures to the world community). Satellite data are here an essential tool to identify at a proper scale and in operational time constraints all favourable zones with respect to temperature, moisture and vegetation, which are likely to attract the locust swarm, and where operational control activities should be concentrated.

2.5 Operational Meteorology

Although operational meteorology is not really an activity specific to developing countries, it provides an essential support to hydrological and agricultural development projects. The operational meteorological mission, including the forecasting of cloud cover, squall lines and wind, is also vital for air traffic safety above the continent. The weather observation and forecasting activity is highly dependent on the quality of satellite information received, due to the limited coverage achievable from ground-based observation networks and the limited transmission facilities, which are a general feature in the severe natural and economical conditions of developing countries.

3. USE OF EUMETSAT DATA AND SERVICES IN SUPPORT TO DEVELOPMENT

3.1 MDD and DCP

Besides the imaging mission which will be discussed below in more details the Meteorological Data Distribution (MDD) mission and the Data Collecting System (DCS) of the Meteosat Operational Programme are certainly two major contributions to support developing countries, as they are especially designed to provide an efficient transmission of environmental data in remote or poorly equipped areas.

The Data Collection System enables the real time collection, and retransmission, of environmental data acquired by beacons located away from any ground-based transmission network. It is thus especially suitable for severe environments and areas of low-accessibility. Among the 480 or so Data Collection Platforms which are regularly active in the Meteosat area of coverage, more than 120 are located in Africa.

The Meteorological Data Distribution mission consists of using a part of the dissemination capacity of the satellite to broadcast general meteorological information in addition to the satellite image dissemination. This general meteorological information includes a selection of observation data, numerical forecasts, or other more specialised products. The MDD mission appears thus as a useful complement of, or an alternative to, the Global Transmission System (GTS) of the WMO, especially well fitted to the needs of those meteorological services or other specialised centres where no adequate and reliable connection to the GTS is available. Among the 40, or so, currently registered MDD users, one half are located in Africa.

The interest of DCS and MDD has been acknowledged and enthusiastically supported by WMO on behalf of the meteorological services of the African region in particular. The adequacy of the DCS and the MDD in this context has been evaluated through the OWSE-Africa project which stated the high operational benefit offered by these facilities while highlighting the related training and maintenance requirements.

It should be pointed out that the MDD mission not only provides a means to broadcast “European” products, but enables the distribution over the continent of dedicated products provided by regional centres of excellence. This has been initiated with the AGRHYMET and ACMAD centres in Niamey, and the Drought Monitoring Centre in Nairobi. EUMETSAT is currently operating two MDD uplink stations (Bracknell and Rome); the current plan of establishing a significant flexibility in the dissemination schedule thus enabling the requirements of the African users and development projects to be more effectively accommodated.

3.2 Current Use of Meteosat Image Data

3.2.1 Users

Meteosat image data are currently used in multiple ways in Africa and surrounding countries, where a number of receiving systems are implemented and operated. These systems are either low-cost "Secondary User Stations" (SDUS) which receive low-resolution images in standard analogue WEFAX format, or "Primary Data User Stations" (PDUS) able to receive the full resolution calibrated data disseminated in digital form. Although there is currently no direct registration procedure for the users, the extension of the user community and the range of applications can be estimated from the participation to scientific users meetings, and from the indications provided by the equipment manufacturers and by sponsoring entities. On this basis, 26 PDUS (+14 in project) have been already identified and can be sorted into following categories of applications:

a) Multiple Applications Derived from Meteorology:

PDUS systems are operated by national meteorological services and used as an input for general meteorology and derived applications. Indirectly they are serving local development needs such as water resources management and agriculture.

MOP images are the daily basis of routine cloud analysis, cloud-top-height determination and squall lines forecasting which are crucial for the support to aircraft safety in the Inter-Tropical Convergence Zone. As far as the eastern part of the Indian Ocean is concerned, they also support the cyclone monitoring and warning system.

b) Dedicated Use for Development Projects:

Some PDUS systems are dedicated to applications such as water resources management, desert locust control, pest control, crop management, or livestock management. They are operated by national meteorological services or by other entities (Institutes, Universities, National Parks). Most of them have been implemented and funded in the framework of a well identified development project.

c) Dedicated Use for Air Traffic Safety:

3 PDUS are operated by ASECNA, in Dakar, Niamey and Antananarivo.

3.2.2 Rainfall Estimation and Support to Development Projects

The general approach of rainfall estimation from cold-top-cloud duration has been discussed by many authors and is currently used in various projects with minor adjustments according to the area concerned and the specific needs of the users. Improvements are expected with the future generation of Meteosat as the multispectral data should enable a better identification of the rainy clouds.

A special mention has to be made of the Africa Real Time Environmental Information System (ARTEMIS) set up by the FAO. The ARTEMIS processes Meteosat image data, received through a PDUS located in Harare (Zimbabwe), as well as NOAA data. The ARTEMIS provides information to a large number of users, both in Africa through a satellite Direct Access Network for Africa (DIANA) as well as at the FAO headquarters for the "Desert Locust Plague Prevention" project and the "Global Information and Early Warning System".

3.2.3 Support to Research and Climate Studies

The monthly rainfall estimates, the identification of squall lines and the migration of the Inter-Tropical Convergence Zone are key inputs for climate studies relevant to Africa. The continuous coverage of the African continent by MOP is also providing a unique data set for the global International Satellite Cloud Climatology Project (ISCCP) and for radiation budget studies. Furthermore, MOP image data are used by several climate-research teams to derive surface parameters such as Soil Moisture and Sea-Surface Temperature anomalies.

3.2.4 Discussion

The potential offered by MOP is currently used to a large extent by operational users or researchers working in the African area, and generally speaking the interest of MOP data and services for developing countries is clearly acknowledged. However there is a clear interest in improving the performance of the rainfall estimation, which is a key-application currently limited by the capability of the MOP system.

3.3 Improvements of the MSG

3.3.1 New Features of MSG

The MSG system is expected to dramatically improve the usefulness of geostationary satellite data to African users: it will include the existing capacities of the current MOP (Namely the MDD and DCS mission, and the basic broad-band visible imaging mission) and furthermore display significant additional functionality, mainly in terms of additional wavelength channels, double image recurrence and improved spatial resolution (2 to 3 times the MOP pixel density).

While the MOP imager has only 3 channels (Visible, Thermal-Infra-Red, Water-Vapour Infra-Red), the MSG imager "SEVIRI" will present 12 channels; the spectral characteristics of 7 of those channels are similar to those of the NOAA imager embarked on the polar satellites, thus enabling an efficient use of the knowledge already developed on AVHRR applications. As regards the spatial resolution, SEVIRI will provide a sub-satellite point sampling distance of 3 km for all the infra-red channels, and 1 km for the High-Resolution broad-band visible channel.

MSG will thus provide a broader support to many applications in the areas of Nowcasting, Numerical Weather Prediction, Climate and Environment Monitoring. This latter point is of special relevance for supporting the developing countries.

3.3.2 Weather Prediction and Climate Studies

The new features of the MSG imager will benefit African users, as European ones, in improving the overall quality of operational products (wind vectors, cloud covers) as well as climate parameters.

The so-called air-mass analysis channels together with the finer resolution should be of special interest for very short range forecasting in the areas affected by tropical convection. The improved capacity of cloud identification should enable to refine the relationships between cloud detection and rain-rate, thus allowing to improve the monthly rainfall estimates.

3.3.3 Resources Management

A major progress is expected in that field by the fact that, for the first time, a geostationary satellite will provide, on a 15 minutes basis, multispectral images of the African continent in 12 wavelength channels, enabling the derivation of more accurate geophysical products such as sea and land temperatures. Seven of the SEVIRI channels will be similar to those of the NOAA polar AVHRR imager. Although the spatial resolution will not be that of a polar low-orbit satellite, the number of available images is a considerable advantage enabling to select the most appropriate solar angle, to select cloud-free images, and provide homogeneous image series which are easy to superimpose and compare.

This will allow advantage to be taken of the know-how already developed in using vegetation indexes and bring to an operational stage those applications who are conceptually developed but limited in their practical use by the availability of images.

3.3.4 Ground Systems Concept

As regards the ground system concept, two elements can be pointed out as favourable for users in African developing countries. The one is the integration of MDD and DCS in the image dissemination channels, and namely in the Low Resolution Information Transmission, enabling a Secondary user to get those 3 different flow of data through the same integrated system.

The other element is the agreed policy for the EUMETSAT ground segment where the concept of Satellite Applications Facilities (SERF) provides a proper framework for the possible operational elaboration of specialised development-oriented products to the extent that the users' requirements, the relevant centre of excellence, and the necessary funding can be identified. The SERF concept is then expected to provide the best conditions of an efficient interaction in partnership between the users' community, the centres of excellence, and the EUMETSAT member-states as a whole.

3.4 Impact of EPS

The Eumetsat Polar System (EPS) programme will provide a follow-on for one of the 2 components of the NOAA polar programme, enabling to provide imaging data from AVHRR or its successor (VIRSR) and improved sounding data from the morning orbit after the year 2000.

As mentioned above, the high resolution imager data are already proven to be essential for a wide range of environmental applications, especially in developing countries, for the derivation of vegetation indexes and subsequent products. In comparison to MSG, the specific interest of the polar system imager relies on the higher resolution allowed by the lower orbit, the global coverage, thus not restricting the applications to the METEOSAT field of view, and the well established users community involved in environmental applications of AVHRR.

The improved temperature and humidity sounding data, which are primarily designed to respond to a requirement of global numerical weather forecasting, should also be of direct relevance to improve the regional forecasting of instability and rainfall in the intertropical areas.

4. MAXIMISING THE BENEFIT OF EUMETSAT PROGRAMMES TO USERS IN DEVELOPING COUNTRIES

Every effort should be made in order to ensure a long-term continuity of the operational satellite coverage beyond the current Meteosat and NOAA programmes. Beyond this essential objective, and in order to maximise the benefit of EUMETSAT programmes to users in developing countries, care should be taken of the accessibility of the data to users involved in development programmes, and to their applicability in this context.

4.1 Practical Availability of the Data

An important element for the practical availability of the data is to ensure that adequate user-stations are available and affordable for those users involved in “development projects”. To this respect the integration, already mentioned, of DCS and MDD data flow into the image dissemination channels is a favourable element which should enable these users to have cost-saving integrated receiving systems.

Furthermore, proper links should be maintained and developed with this users community in order to take their requirements into account as far as possible, namely as regards:

- the image dissemination schedule
- the MDD schedule
- the dissemination of dedicated products

4.2 Legal Accessibility of the Data

It can be recalled that EUMETSAT has defined an overall data policy, taking as a basic constraint that it should seek to increase the world meteorological data base. Three basic features of this data policy should be highlighted:

- The context of growing commercial value-added activities, of growing costs of observation systems and data handling facilities, leads to the conclusion that the access to the data has to be controlled and submitted to certain conditions with possible charging of a fee, especially for those commercial users who make profit with the data without contributing to the system. Otherwise the National Meteorological Services of the EUMETSAT Member-States would be faced with a biased competition which would weaken their ability and willingness to make further long-term commitments to fund the satellite observation system.

- Notwithstanding with the above, and in line with a long-standing tradition of cooperation within the meteorological community, EUMETSAT has committed itself to provide a basic set of data free of charge to all national weather services, identified as the representatives of WMO members, for their internal use in the frame of WMO activities.

- Furthermore the EUMETSAT Council reserved the possibility to consider special licenses or cooperation agreements including provisions for the free access to some sets of data, in order to support the activities of certain categories of users of non-member-states, identified on a case-by-case basis. Several cooperation agreements have been concluded already, and the EUMETSAT Council has always been very supportive to the use of Meteosat Data in development programmes.

From a practical point of view, it should be recalled that the controlled access to Meteosat High Resolution Image Data will be operational in 1994, and that all users, even expecting to be granted a free access to the data for cooperation and development purpose, are urged to make the necessary technical provisions and legal arrangements with EUMETSAT in order to be in a position to continue to receive and use the data. All major equipment manufacturers have been made aware of the technical provisions related to the controlled access, and the way to interface the decryption unit which will be provided by EUMETSAT to registered users.

4.3 Applicability of the Data

Although many applications are already operated with METEOSAT data, some progress might still be made, either in improving the accuracy of the current applications, or in promoting new ones. This is both a matter of promoting the expertise and the scientific development effort in that field, and possibly elaborating new routine products meeting specific needs.

Users from developing countries are welcome and will be further encouraged to participate to the METEOSAT users' meetings and DCP users' conferences. It should be noted that already about 20% of the applications addressed in the EUMETSAT users' conferences are related to developing countries.

It has also been noted that the WMO recently defined a training strategy for satellite applications, aiming at the creation of centres of excellence which the main satellite operators are invited to sponsor. EUMETSAT has given full support to African countries with special attention when elaborating its plans to a contribution to education and training.

As regards the feasibility of further elaborating and disseminating specific products for use in African development programmes, several ways may be considered:

- The MDD mission offers an easy and reliable way to disseminate specific products which can be elaborated either by EUMETSAT or by African entities. That is presently the case for some AGRHYMET and Nairobi-Drought-Monitoring-Centre products, and can be extended and improved in a near future when starting the operation of the third uplink, with an adequate coordination and data link between the relevant centres and the uplink. The MDD is adequate to transmit information to an identified number of users having each the necessary infrastructure to receive, and use themselves or dispatch to end-users.

- Specific products may be elaborated by EUMETSAT and disseminated by the Low Resolution Image Transmission channel, which will take over the current WEFAX dissemination, in order to reach a wide community of end-users.

The new orientation of EUMETSAT in terms of ground segment policy is worth to be noted with respect to such projects. It has been decided that the future EUMETSAT ground segment would be designed as a network configuration with a central coordinating node and several "Satellite Applications Facility" located in entities having an expertise in a given application field. This is expected to provide in the future a proper framework with some flexibility for undertaking ground segment activities beyond the elaboration of the core products, to the extent that a scientific and financial partnership can be set up with one or several operational centres.

4.4 User Interaction

A proper level of interaction should be defined with the users from developing countries.

A first step is to be able to identify these users. This will become easier once the access to the high resolution data will be submitted to a registration procedure. This will enable EUMETSAT to directly contact the users and to forward to them any relevant information.

As regards the main policy and overall programme definition, while it is not realistic to directly involve a wide end-user community in the decision making process, the specific needs of developing countries can be expressed in the most efficient way by the observer of

WMO who regularly participates in the meetings of the EUMETSAT Council and technical advisory group.

However, for some well defined issues which require direct contact between the end-users' community and the EUMETSAT Secretariat, direct representatives of the users from developing countries should be invited to participate in the dialogue.

4.5 Coordination with other Organisations

Noting that the EUMETSAT Member-states are already involved in cooperation actions, either bilaterally or within WMO cooperation programmes, and in order to provide a proper framework for an efficient support to development programmes, EUMETSAT is willing to harmonize its efforts with WMO and ESA as well as to establish contact with the major partners having a specific mandate as regards the support to developing countries.

EUMETSAT is willing to consider enhancing the cooperation with the local Centres of excellence, involved in the application of meteorological satellite data to African development programmes.

5. VERIFICATION OF CLOUD MOTION WINDS -CASE STUDY

Previous study aimed at comparing and later verifying CMW forecast products against radiosonde winds indicate that CMW will continue to represent a valuable data source.

6. VALIDATION OF CMW USING SATELLITE IMAGE

With regard to validating CMW over Africa to locate synoptic features, Meteosat image, upper air wind and temperature, ECMWF Forecast and significant weather forecast are compared. Results indicate that the low pressure cell situated over the eastern part of south Africa is accurately analysed from the CMW as seen from the MDD's wind products.

7. RECOMMENDATIONS

- encourage participation of African counties in the African Satellite Meteorological Education and Training (ASMET) project

- initiate the acquisition of reliable internet system

- Improve the network of ground satellite receiving equipment in most countries

8. CONCLUSION

CMW data is currently offering a wide potential to support weather forecasting on the African continent, and numerous users are actually taking advantage of this potential. The future MSG and EPS systems will dramatically increase the potential benefit of

EUMETSAT programmes to African development programmes.

In order to maximise the actual benefit of its programmes to this respect, emphasis should be given to the accessibility and applicability of the data for development programmes, as well as to support the users from developing countries through involvement in users' conferences, through a contribution to education and training in cooperation with one or several regional centres, and through enhancing the user interaction, with special emphasis on development-oriented applications. EUMETSAT is willing to coordinate its actions with those major partners acting in this domain.

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