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COOPERATION ON THE DEVELOPMENT OF PRODUCTS FROM FUTURE GEOSTATIONARY IMAGERS: NOWCASTING APPLICATIONS

In response to CGMS action/recommendation A37.02 and R37.25

The paper responds to CGMS Action 37.02: "EUMETSAT and NOAA to inform CGMS about the cooperative scientific studies being carried out as part of the preparations for MTG and GOES-R" and to CGMS Recommendation 37.25: "On the basis of existing software for product retrievals, NOAA and EUMETSAT offer to other satellite operators existing prototype algorithm software for testing and further development".

Interest and need for satellite products for nowcasting are high, so that this area is a field of very active research and development. In many application areas, the multi-spectral capabilities of Meteosat Second Generation (MSG) have significantly improved nowcasting products, thus paving the way to future geostationary missions with similar or even better spectral resolution. Nowcasting products can be either simple qualitative products like spectral composites (RGBs), dedicated to a certain phenomenon, or more advanced quantitative products like airmass analysis or the retrieval of cloud microphysical properties.

Convection nowcasting is one of the most important nowcasting areas. International coordination and collaboration exists through the Convection Working Group, where again many new concepts for future geostationary missions are tested with MSG data.

This paper provides a short overview over all these activities. Taking a specific nowcasting application (convection) as an example, this paper suggests further scientific cooperation on "Nowcasting Applications from Geostationary Satellites" among CGMS operators. The existing Convection Working Group is a good forum for that. Such cooperation is also useful with a view to develop consistent nowcasting products from future geostationary imagers (e.g. Himawari-8/-9, GOES-R ABI and MTG-FCI).

Action/Recommendation proposed:
CGMS is invited to comment.

Cooperation on the Development of Products from Future Geostationary Imagers: Nowcasting Applications

1 INTRODUCTION

Geostationary satellite images, taken in the solar and thermal spectral range, with their rapid updates, provide important support to nowcasting activities: application areas include detection of fog formation/dissipation, of local cloud conditions and changes thereof, of dust storms and volcanic ash plumes, of rapid cyclogenesis, and of convective processes. The focus of this paper is on convection, as this can lead to severe weather (strong wind gusts, lightning, hail, tornado outbreaks) with potentially high local impact.

Although operational forecasters have to rely on the geostationary satellite data that is available for their specific area, much of the scientific development for convection nowcasting draws on the benefits of the specific spectral resolution of the Meteosat Second Generation (MSG) satellite. Specific expertise is usefully gained from MSG imagery. An important perspective for the future is that the benefits from MSG will be equally applicable to future missions like GOES-R (NOAA), Himawari-8/-9 (JMA), or MTG-FCI (EUMETSAT).

Taking convection as an example, this paper suggests further scientific cooperation on "Nowcasting Applications from Geostationary Satellites" among CGMS operators. The existing Convection Working Group is a good forum. Such cooperation is also useful with a view to develop consistent nowcasting products for the above mentioned future geostationary imagers.

2 NOWCASTING PRODUCTS AND COLLABORATION AREAS

2.1 Image Products

Many of the nowcasting "products" are image products, highlighting the special spectral signature of the phenomenon in question: These image products can be special colour enhancements (e.g. to highlight overshooting cloud tops) of a single channel image, a channel difference (e.g. for fog detection) or colour composites of three channels or channel differences (e.g. dust RGB, volcanic ash RGB, airmass RGB, convection RGB, etc.). The advent of the12-channel instrument onboard MSG has shown a wealth of RGB and channel difference applications. A comprehensive summary of all these applications can be found in the MSG Interpretation Guide, available from http://www.eumetsat.int. In order to foster a standardisation of RGB "colours" and easier internationally agreed interpretation of such images, the CBS OPAG-IOS Expert Team on Satellite Utilization and Products (ET-SUP) recommended that a dedicated workshop should be held on this topic. This proposal was endorsed by CGMS in November 2005. The final report is available on the WMO web pages: (http://www.wmo.int/pages/prog/sat/documents/RGB_workshop_final_report_rev1.pdf).

A corresponding training module is available in the COMET Training Library (http://www.meted.ucar.edu/resource_modlist.php, under the name "Multispectral Satellite Applications: RGB Products Explained".

2.2 Special Quantitative Products for Convection Nowcasting

As even the newest generation of operational high-resolution numerical weather prediction models cannot well forecast the exact location and intensity of convective storms, satellite and weather radar data are absolutely necessary to issue short-term warnings. Satellite data are proven to be useful to

1. assess the pre-convective environment (air stability)
2. detect clouds that have convectively initiated
3. depict cloud top features of the mature phase, as overshooting tops and cloud top microphysics indicative of strong updraft regions

The recently established Convection Working Group (http://convection.satreponline.org) is a group of scientists and forecasters who work on convection nowcasting with a strong focus on satellite based methods. The group states as one of its main goals the "Coordination of development and enhancement of techniques for early detection and prediction of convective storms", and thus provides an excellent international framework for identifying best practices in the use of satellite data in all of the above mentioned three areas. The EUMETSAT Satellite Application Facility on Support to Nowcasting and Very Short Term Forecasting (NWC-SAF) specifically deals with the current operational nowcasting needs of MSG users and is of course also a member of the Convection Working Group, so that new research can find its way into an operational service through this route.

Single image and RGB products are only of limited use for convection nowcasting (with the exception of the mature phase where the "convection RGB" well depicts the regions of strongest updrafts, at least during daylight hours, and where any infrared window channel can show overshooting tops and V- or ring shaped cloud top signatures). Convection nowcasting thus has a high demand for Level 2 products, which relieve forecasters from (subjective) image interpretations; the products have to be available in a timely manner.

2.2.1 Pre-Convective Environment

MSG's multispectral information allows the derivation of air mass stability in clear sky regions (for details, see EUM-WP-27 of CGMS-35), providing the so-called Global Instability Indices (GII) product. This product is centrally derived at EUMETSAT and disseminated to users, is available over the full MSG disk, but only in a relatively coarse spatial resolution. A number of EUMETSAT Member States and other countries within MSG's field of view have shown interest in a local installation of the GII software, where the spatial resolution and the processing area can be locally controlled. This has led to a "stand-alone GII software package", which can be run with only minor modifications regarding the data interface. Local installations are currently operationally available in Poland (IMGW), Slovakia (SHMU), in the UK (Met Office), and in South Africa (SAWS), and these local installations have instigated more research and validation efforts. The stand-alone GII software package was in the past made available to KMA (through B.J. Sohn, Seoul National University), and JMA has recently also expressed interest.

2.3 Convective Initiation

An automatic scheme to detect clouds that have convectively initiated (hereafter referred to as CI product) has been developed at NOAA-CIMMS/UW Madison for the GOES satellite. Recently, collaboration efforts between NOAA-CIMSS, EUMETSAT and UAH (University of Alabama - Huntsville) have extended the existing scheme to make full use of MSG's multi-

spectral capabilities. In addition, the CI algorithm, originally designed to work with Level 1 image data, was tested with retrieved cloud microphysical parameters. Much of this work, including validation, is currently still ongoing. First results are published in

> Siewert, C., M. König, J. Mecikalski, 2010: Application of Meteosat Second Generation data towards improving the nowcasting of convective initiation. ***Meteorol. Appl.***, DOI 10.1002/met.176

> Mecikalski, J., W. MacKenzie, M. König, S. Muller, 2010: Cloud-top properties of growing cumulus prior to convective initiation as measured by Meteosat Second Generation. Part I: infrared fields. ***J. Climate Appl. Meteor.***, **49**, 521-534
> (Note: Part II of this series – visible fields - is accepted for publication in the same journal).

Much of this work was achieved through the EUMETSAT Visiting Scientist Programme and through EUMETSAT funded science studies.

A CI scheme, based on very similar principles, was developed by JMA. In order to further stimulate collaboration, a version of the EUMETSAT CI algorithm, as developed under the above mentioned Visiting Scientist Programme, was made available to JMA.

2.3.1 Mature Convective Clouds

Detection of overshooting tops and areas of strong updrafts are often done through visual inspection of related imagery products like enhanced IR window images to detect coldest tops, high resolution visible images to evaluate cloud top structure. For MSG a specific "Convection RGB" composite exists which highlights cold cloud tops with smallest ice crystals, this being a proxy for the presence of strong updrafts.

A first attempt at a more quantitative approach was made by Rosenfeld et al., as published in

> Lensky, I. and D. Rosenfeld, 2008: Clouds-aerosols-precipitation analysis tool (CAPSAT). Atmos. Chem. Phys., 8, 6739-6753, http://www.atmos-chem-phys.net/8/6739/2008

where a larger area of surrounding clouds are analysed according to their microphysical properties which ultimately leads to a "storm severeness" indicator. This work was funded through a EUMETSAT scientific study. The corresponding tool is a stand-alone software package (for MS-Windows), which works for MSG data only: The tool is meant as a research tool, i.e. some settings and selections need to be done manually, and also the final evaluation of the data is somewhat subjective and depends on the user's skill. The software tool is still seen as a good test environment to understand and follow cloud processes. EUMETSAT makes this tool freely available upon request: JMA, NOAA-CIMSS and UAH were already provided with a copy.

On the detection of overshooting tops, a quantitative approach was recently developed by K. Bedka, capitalising on work performed at NOAA-CIMSS in preparation for GOES-R:

Bedka, K., 2010: Overshooting cloud top detections using MSG SEVIRI infrared brightness temperatures and their relationship to severe weather over Europe. Accepted for publication in Atmospheric Research

3 CONCLUSIONS

Interest and need for satellite products for nowcasting are high, so that this area is a field of very active research and development. Especially the multi-spectral capabilities of the current MSG series and the even higher potential of future geostationary missions foster a number of new products and applications. The Convection Working Group with its biannual workshops and regular exchanges through its web site has proven to be an excellent forum to present latest developments and outreach to operational services and their capabilities in supporting operational use and long-term validation. MSG is commonly regarded as the best current test bed for future advanced imagers, i.e. the meteorological community can expect best use of these imagers as of their first day of operations.

CGMS is invited to comment.