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INTER-PROGRAMME EXPERT TEAM ON SATELLITE UTILIZATION AND PRODUCTS

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SCOPE NOWCASTING PILOT PROJECT 3: GLOBAL QUANTITATIVE PRECIPITATION ESTIMATES

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Summary and Purpose of Document

To summarize the status of activities under this SCOPE-Nowcasting Pilot Project.

ACTION PROPOSED

The second session is invited to:

(a) Take note on the conclusion of this project;
(b) Encourage WMO to seek community feedback on the demonstrator developed in this Pilot Project (current IPET-SUP Action 1.14);
(c) Discuss the mechanisms to make the SCOPE project award by the global users;

Appendices: A. **Product Description**

DISCUSSION

1. Introduction

This pilot project is based on the WMO Space Programme effort to foster Sustained, Co-Ordinated Processing of Environmental Satellite Data for Nowcasting (SCOPE-Nowcasting), to demonstrate continuous and sustained provision of consistent, well-characterized satellite products for nowcasting and severe weather risk reduction. This document provides the characteristics of a rainfall nowcasting pilot project for global application in real time through an open access web based system. This system provides accumulated rainfall for up to 3 days, and near-real time one-hour rainfall accumulation and the extrapolation for the next three hours. The system is based on a Geographical Information System that allow the users to zoom in and out for a specified region, add different layers, and follow the rainfall structures.

2. General Characteristics

Theme:	Blended satellite global precipitation product (GEO+LEO)
Lead:	Daniel Vila – Luiz Machado (INPE CPTEC)
Region of Coverage:	Quasi-Global Coverage (60° N - 60° S)
Providers:	NOAA/NASA HydroEstimator, NASA TRMM (3B42), NOAA (real-time MW)
Host:	INPE CPTEC
Users/Clients:	WMO Severe Weather Forecasting Demonstration Project, NMHSs, Civil Authorities, general users
Expected benefits:	• Improved confidence in products generated through SCOPE-NOWCASTING; • Reduced operating costs associated with technological change and software upgrades; • Fast delivery of severe rainfall information to decision-makers and disaster response authorities (2h extrapolation forecast and ex-post 24h/48h/72h QPEs)
Current needs & gaps	Rapid, facilitated access to quantitative precipitation estimates
Technical details of planned product/service	• Product content & format: Precipitation intensity (real-time and nowcasting), Cumulated precipitation • Access and dissemination: WebGIS • Quality control: Adherence to code standards • Provisions for integration and sustainability: TBD • Facility for user feedback: TBD
Facility for user feedback	TBD
Current status – Feb 2015	Draft Concept Paper available

3. Technical details

Basic Products and Software:

- **The TRMM multi-satellite precipitation analysis (TMPA) -real time version- product**: Cumulated Precipitation in the last 24, 48 and 72 hours.
- **Global Hydro-Estimator (GHE) Product** : Real Time Precipitation Intensity (2 hours latency)
- **Forecasting and Tracking Active Cloud Clusters (ForTrACC)**: Nowcasting of precipitation Intensity (3 hours in Advance)

The TRMM multi-satellite precipitation analysis (TMPA) -real time version- dataset: This dataset is provided by NASA GEO DIS. The TMPA-RT 3-hourly binary data files can be uploaded at the

following webpage: ftp://disc2.nascom.nasa.gov/data/TRMM/Gridded/3B42RT/. This data has horizontal/time resolution of 0.25° x 0.25° each 3 hours. The TRMM multi-satellite precipitation analysis (TMPA) provides a calibration-based sequential scheme for combining precipitation estimates from multiple satellites. This product merges radiometer imager and sounder retrievals. It fills in gaps with 4km 1 hour IR products statistically calibrated by the microwave imager data. In 2011, TRMM completed a reprocessing of all its data products (version 7) using new and improved algorithms. One of the exciting changes is in the GPROF (Goddard Profiling) retrievals which replaced a cloud resolving model based a-priori profile database with an a-priori database built from two years of PR data (pre-boost). Specific information about this dataset can be accessed thought the following URL: http://disc.sci.gsfc.nasa.gov/precipitation/documentation/TRMM_README/TRMM_3B42_readme.shtml

This SCOPE-Nowcasting product is based on a Geographical Information System and integrates 3-hourly rainfall data into 24, 48 and 72 hours accumulated rainfall, considering the last received file as the end of the integration time. This product is updated every 3 hours and the latency is linked with the TMPA-RT product (~8 hours after the observation time). The aim of this product is for monitoring global rainfall accumulation for the most recent 3 days. This information is useful for Civil Defense Operations (Warnings and Alerts dissemination) and Disaster Management. Each place on the world has its specific vulnerability and total rainfall accumulation is key information for local decision makers to define a local warning.

The Global Hydro-Estimator (GHE) Product: The GHE extends the current operational GOES rainfall estimate capability from only over the continental U.S. to the entire globe equator-ward of 60 degrees to meet the NWS users' need in supporting the global flash flood guidance. The GHE also upgrades the current operational system to meet code standards with enhanced error handling, quality monitoring and validation capability. The Hydro-Estimator (H-E) is a single-channel (11-μm) rain rate algorithm whose origins go back to the Auto-Estimator (A-E; Vicente et al. 1998) algorithm. The primary feature of the A-E is a fixed relationship between rainfall rate and that was derived from 6800 pairs of collocated IR brightness temperatures and radar rainfall rates from convective cores of mesoscale convective systems (MCSs) for 16 events from March-June 1995. The improved algorithm differentiates between "convective core" and "non-core" precipitation (based on empirical rather than physical definitions) and assigns a rain rate that is a combination of the two depending on the spatial characteristics of the nearby cloud mass. Both the presence/absence of precipitation and its intensity are a function of the extent to which a particular pixel is "core" or "non- core". The H-E assigns rainfall only to pixels that are colder than the average of the surrounding cloudy pixels in order to eliminate cirrus clouds, and also uses separate PW (Precipitated water) and RH (relative humidity) corrections to reduce cold-season overcorrection. For more information about Hydroestimator algorithm see Appendix A. The operational GHE products includes: Instantaneous rain rate, 1 hour, 3 hour, 6 hour, 24 hour and also multi-day precipitation accumulation over the globe. In this SCOPE-Nowcasting Project implementation, 1 hour accumulation from 60 degrees north to 60 degrees south is provided in order to identify the current severe weather (high rain rates) and for monitoring the evolution of those storms (Figure 1). In this case, the latency is dramatically reduced from the previous product (less than 2 hours) due to this algorithm relies only in GEO-IR data.

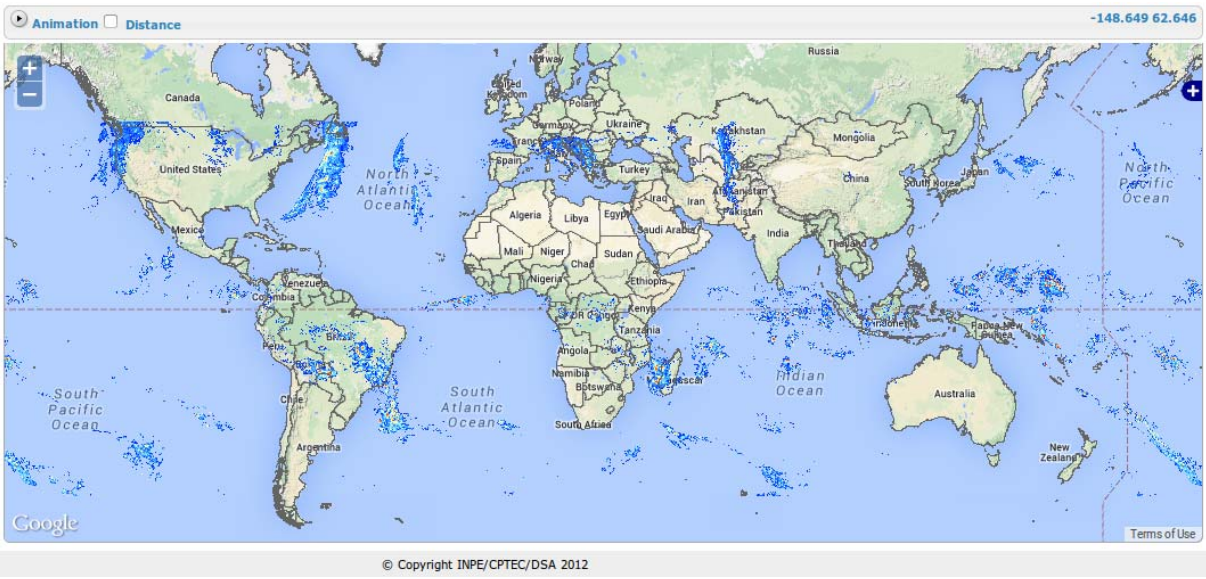

Fig.1: Example for SCOPE GHE output for 1-hour rainfall accumulation

Forecasting and Tracking of Active Cloud Clusters (ForTrACC) product: This short-term forecast algorithm is implemented at CPTEC/INPE since 2004 for tracking Mesoscale Convective Systems and it is fully described in Vila et al 1998. For this SCOPE-Nowcasting Project, the original algorithm was adapted to ingest GHE data instead of GEO-IR brightness temperature while the output produces 60, 120 and 180 minutes 1-hour accumulation rainfall forecast considering the GHE estimated rainfall features as the initial condition. To avoid confusions between tracking clouds or rainfall features, this new implementation will be called HydroTrack

The methodology used by HydroTrack is based, similar to ForTrACC technique, in three steps. i) Detection of rainfall features: To capture a spectrum of storm types, we used a single rainfall threshold of 0.1 mm and a size threshold of 100 pixels. The size threshold reduces the number of tracked storms by filtering out small-scale events and reducing the number of splits and merges. ii) Tracking using area overlap: HydroTrack uses an area overlap technique to track the storms, both forward and backward in time. If two rainfall cells identified in different time steps have shared pixels, they were considered the same system. If more than one match have overlaps, the largest overlap system is tracked. iii) Forecast: the near-term forecast (1 hour) is based on the extrapolation of the current observed system along its life cycle and a statistical approach of rainfall features life cycle (initiation, mature stage and dissipation) to predict that stage for the next hour. This process is repeated three times to produce up to 3-hours forecast of current rainfall features. This process has two main goals, reduce the latency of 2 hours of the global rainfall field and provide information to the users about the propagation direction of the rainfall cell.

4. Access to the information: The SIGMA

The system is a web-based Geographic Information System (SIGMA geographic visualization tool based on GoogleEarth). This system is a useful tool to interpret, summarize and integrate the environmental information and display or sends warning for emergency management groups. This is an open access system to also serve the population giving real time information to reduce citizen vulnerability, the information are presented using the GoogleEarth tool. Figure 2 show the current layout of the web page: http://pindara.cptec.inpe.br/scope

On the right side, the clickable menu allows to display the different product with its own colour scale. A pop-up menu also allows displaying a given product for previous times. Several tools are included in this prototype: i) zoom; ii) country and states layer; iii) distance tool; iv) automatic zoom and pane for SWFDP regions (see below)

Users/Clients:
This is an open web-based system, therefore anyone can access. All regions without a well-developed rainfall network or without an integrated system to make that information available in real time can use this system as a first approach of rainfall systems reaching the region or the accumulated rainfall in the last days. The latter is key information for Civil Defense, because it is associated with the potential of landslides and flooding.
One of the potential users of this information is the WMO Severe Weather Forecasting Demonstration Project (SWFDP). The Severe Weather Forecasting Demonstration Project (SWFDP) is successfully strengthening capacity in National Meteorological and Hydrological Services (NMHSs) in developing and least developed countries including Small Island Developing States (SIDSs) to deliver improved forecasts and warnings of severe weather to save lives, livelihoods and property. The project has improved the lead-time and reliability for alerts about high-impact events such as heavy precipitation

Pilot Products and Expected Benefits:
The products available are all based on precipitation estimation from satellite and the accumulation and extrapolation out to 3 hours to make the information close to the real time (global satellite product has a delay of 3 hours). The main product is the integration of rainfall in the last 3 days and in the last hours of any particular day. The product is near global but can be accessed local due to the tools available by the GIS. The basic resolution is 0.25x0.25 degrees.

5. References

Huffman, George J., et al. "The TRMM multisatellite precipitation analysis (TMPA): Quasi-global, multiyear, combined-sensor precipitation estimates at fine scales." *Journal of Hydrometeorology* 8.1 (2007): 38-55.
Vicente, Gilberto A., Roderick A. Scofield, and W. Paul Menzel. "The operational GOES infrared rainfall estimation technique." *Bulletin of the American Meteorological Society* 79.9 (1998): 1883-1898.

Vila, Daniel A., et al. "Forecast and Tracking the Evolution of Cloud Clusters (ForTraCC) using satellite infrared imagery: Methodology and validation." *Weather and Forecasting* 23.2 (2008): 233-245.

Appendix A – Product Description

Products

Current rain rates: The Hydro-estimator (GHE) technique, provided by NOAA OSPO (Office of Satellite and Products Operations), is used to retrieve 1-hour accumulation (mm/h) rainfall on real time basis. This algorithm uses an empirically-derived relationship between rain rate on the surface and cloud-top brightness temperature measured by geoestationary satellites around the world between 60º S and 60º N. The temporal and spatial resolution of this product is 1 hour and approximately 5 km respectively, while the latency is around 2 hours. More information about this algorithm will be discussed in the algorithms's description section
Date/Hour: 1-hour accumulation (mm/h) rainfall *ending* at the given date/hour. Last 6 hours are available though the pop-up menu.
Opacity: Transparency of rain rates layer
Animation: Animation tool (separate window) for the last 6 hours.
Label: rain rate color scale (mm/h)

Nowcasting

The short-term forecast algorithm, called ForTrACC (Forecasting and Tracking or Active Cloud Clusters), was adapted from its original version to ingest GHE data to produce rainfall nowcasting for 60, 120 and 180 minutes lead time. Current rain rates from GHE are considered as the initial condition (not necessarily the ground truth) to produce the final output. The temporal and spatial resolution of this product are the same of GHE.
These options will appear once one of the products is selected:
Date/Hour: 24, 48 and 72 hours accumulated (mm) rainfall *ending* at the given date/hour. Last 6 hours are available though the pop-up menu.
Opacity: Transparency of forecasted rain rates layer
Label: rain rate color scale (mm/h)
Animation tool is not implemented yet.

Accumulated Precipitation

The TRMM multi-satellite precipitation analysis (TMPA) -real time version- dataset provided by NASA GEO DIS is used to estimate precipitation on an horizontal/time resolution of 0.25° x 0.25° each 3 hours. The TMPA provides a calibration-based sequential scheme for combining precipitation estimates from multiple sensors including active and passive microwave. In this implementation, we provide 24, 48 and 72 hours accumulation with a time latency of about 8 hours. More information about this algorithm will be discussed in the algorithms's description section
These options will appear once one of the products is selected:
Date/Hour: 24, 48 and 72 hours accumulated (mm) rainfall *ending* at the given date/hour. Last 6 hours are available though the pop-up menu.
Opacity: Transparency of rain accumulation layer
Label: rain rate color scale (mm/h)
Animation tool is not implemented yet.

Additional layers

Several tools are included in this prototype by clicking on the proper box: country and states layer and distance tool. The last tool could be used by clicking on check box first, then one click on the map at the initial point and one double-click at the end point.

SWFPD Regions

Automatic zoom for Severe Weather Forecast Demonstration Project (SWFDP) regions are displayed once the proper box is clicked. The Severe Weather Forecasting Demonstration Project (SWFDP) is one of the main users of this application. This project is successfully strengthening capacity in National Meteorological and Hydrological Services (NMHSs) in developing and least developed countries including Small Island Developoing States (SIDSs) to deliver improved forecasts and

warnings of severe weather to save lives, livelihoods and property. More information about this at http://www.wmo.int/pages/prog/www/swfdp/