Proceedings for the 13th International Winds Workshop
27 June - 1 July 2016, Monterey, California, USA

STATUS OF THE OPERATIONAL SATELLITE WINDS PRODUCTION AT CPTEC/INPE AND IT USAGE IN REGIONAL DATA ASSIMILATION OVER SOUTH AMERICA

Renato G. Negri, Luiz F. Sapucci, Lucas Avanço, Nelson Ferreira, Luiz G. G. Gonçalves

National Institute for Space Research, Center for Weather Forecasting and Climate Research, Rod. Pres. Dutra, km 40, Cachoeira Paulista, SP, 12.630-000, Brazil

Abstract

Tropospheric winds are estimated using satellite imagery since late 60's and today they are a very important source of information for numerical weather forecasts. The CPTEC/INPE has being producing Atmospheric Motion Vectors (AMV), operationally, since early 2000's, using GOES satellites. The typical spatial coverage is the South America and surrounding oceans covered by the GOES satellites. The wind extraction at CPTEC/INPE is done using the visible, near infrared (3.9 μm) water vapor absorption (6.7 μm) and window infrared (10.2 μm) channels. The visible and 3.9 μm are used only to estimate the low level winds for day and night only respectively, 6.7 μm allows to estimate winds at middle and high troposphere and 10.2 μm is used to estimate the wind at all tropospheric layers. This algorithm makes use of triplets of successive GOES images with at least 30 minutes between each pair, which allow having a new wind field at least half hour. The quality control applied to the wind fields is based on developed at EUMETSAT where each AMV receive a quality indicator and the final users can choose what level is more suitable to their application. The wind estimates produced are disseminated by the World Meteorological Organization's Global Telecommunications System (GTS) in the BUFR format. Recently, CPTEC/INPE has started its rapid data assimilation cycle with convective scale regional models over South America and some selected locations over Brazil. During the experimental stage, high resolution model using nested domains were implemented. In order to minimize the latency of the availability information, important issue in this activity, the AMV produced by CPTEC have been used and the first results have been obtained. This work shows the actual status of the production of AMV data at CPTEC/INPE as well the applications for regional data assimilation and the plans for use GOES-R images.

1. INTRODUCTION

CPTEC/INPE operational Atmospheric Motion Vectors (AMV) algorithm is based on the advanced algorithm version developed by the European Space Operations Centre (Schmetz et al. 1993, Laurent 1993). The algorithm was improved at CPTEC/INPE (Machado and Ceballos 2000, Laurent et al. 2002, Negri and Machado, 2008) using cloud or water vapor structures tracked from successive image sequences as tracers to estimate the wind speed and direction. Wind information is very important to monitor in real time short waves, normally associated with intense convection. The AMVs produced by CPTEC/INPE has been assimilated into global numerical weather forecast models and also disseminated through the Global Telecommunications System (GTS). This product locally inferred reduces the latency for data assimilation. Negri et al. (2014) presents a new methodology for retrieving very high resolution AMV employing SEVIRI/MSG multi-channel combinations. It is expected to apply this methodology with GOES-R Imager to obtain inner cloud top structures over South America. CPTEC/INPE is a operational numerical weather prediction center. Its major activitie is to provide numerical weather forecasts to various governamental entities. All recent activities done at CPTEC/INPE related to AMV production, use and research are briefly presented here.

2. CURRENT STATUS OF AMV PRODUCTION AND USE AT CPTEC/INPE

The main objective to produce AMVs at CPTEC/INPE is to reduce the data latency in the data assimilation scheme for the operational regional models. For other areas where no real time satellite image can be received, the AMVs transmited over the GTS (Global Telecommunication System) network are used. This AMVs produced locally is also used in the operational forecasting done at CPTEC and a recently created group for weather monitoring and nowcasting uses AMV based products. Tropospheric winds are produced operationally at CPTEC/INPE since early 2000's, using images from the GOES East satellites. Now, visible, near infrared (3.9 μm), water vapor (6.2 μm) and window infrared (10.2 μm) GOES-13 channels are used to produce AMVs while the CO2 channel (13.0 μm) is used only for the height assignment. The winds algorithm used operationaly uses an image triplet, where the time interval between each pair must be less than 30 minutes. The tracking method is the Maximum Cross Correlation (MCC). For height assignment, three methods are used: Effective Black Body Temperature (EBBT), IR/WV intercept and CO2 rationing. For the quality control, a Quality Indicator scheme, similar to that used at EUMETSAT, is applied to the AMVs. The CPTEC/INPE operational AMV algorithm has been adapted to use Meteosat Second Generation (MSG) images, planned to start the production of AMVs, only over Atlantic and east portion of South America, by the end of 2016. Only the visible, 3.9, 6.2, 7.2 and 10.8 μm SEVIRI channels will be used. Using the Meteosat images will extend the spatial coverage what will benefit the CPTEC/INPE regional models as well when GOES-13 images are unavailable due changes in its scanning routine.

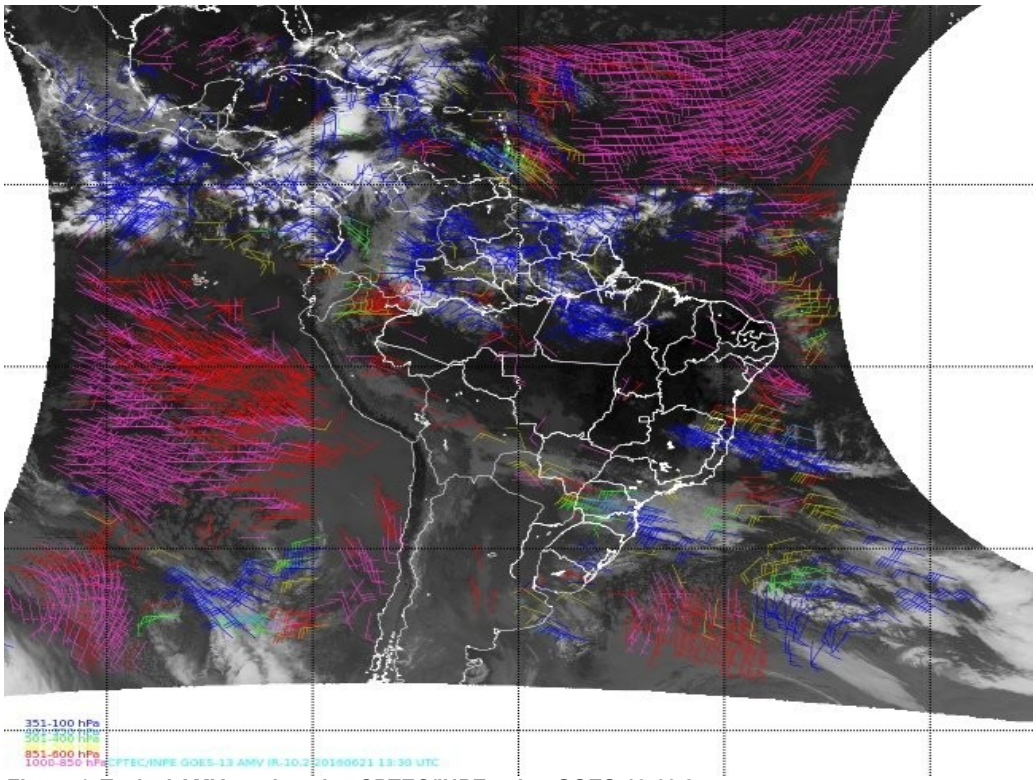

Figure 1: **Typical AMV produced at CPTEC/INPE using GOES-13 10.2 μm.**

Figure 2 shows the RMSVD and BIAS calculated between the WV and IR AMVs and the South American radiossonding network based on standard CGMS AMV statistics. The operational algorithm was revised and the new version replaced in August 2014. After this change, an slightly imporvement in the RMSVD was achieved for WV and IR channels for the extra tropics zone. but the error levels for 2015 and 2016 is similar than before the code revision. Overall, there is no considerably changes in the quality of the AMVs generated at CPTEC/INPE.

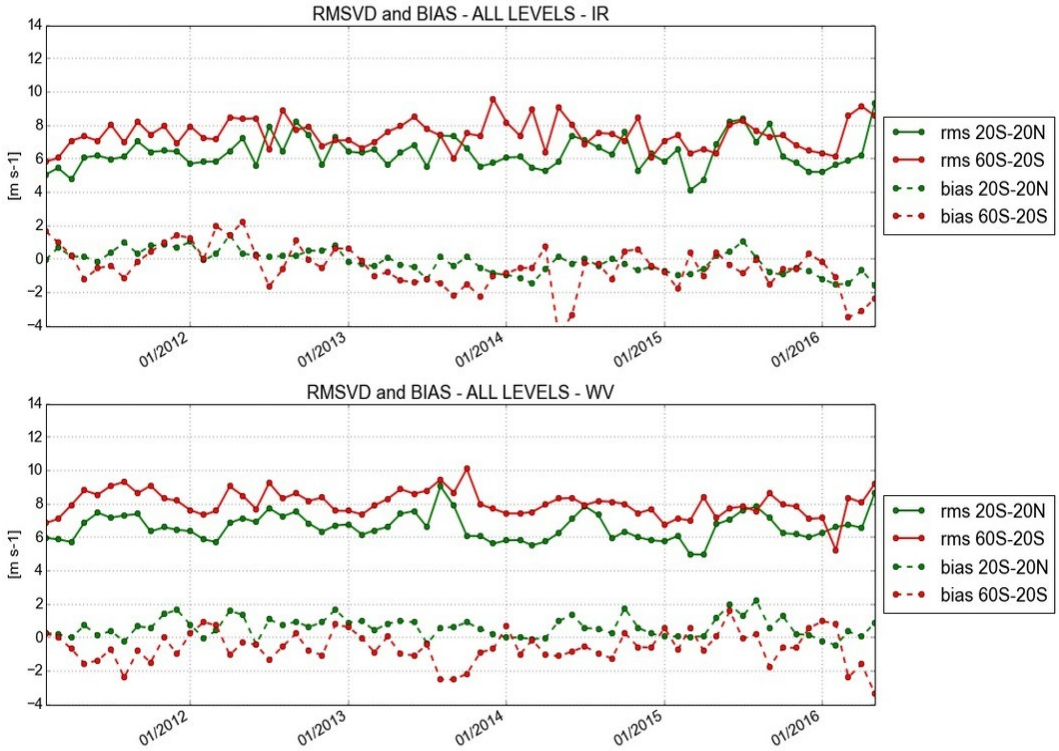

Figure 2: **Time-series of the RMSVD and BIAS for AMV (QI > 0.7) produced at CPTEC/INPE using GOES-13 WV 6.2 and IR 10.2 µm channels for all levels over South America and surrounding oceans. Values for AMVs in the tropics (20S-20N) are shown in green and extra tropics (60S-20S) in red.**

Currently, all locally produced AMVs are assimilated in the Global Modelling System (GMS), which refers to the new CPTEC global model denominated BAM (Brazilian global Atmospheric Model) with data assimilation using Gridpoint Statistical Interpolation (GSI) Data Assimilation System. This global system has horizontal resolution of 20 km and data assimilation cycle each 6 hours. Another initiative is assimilate the AMVs regional data base in the Regional Modelling System (RMS) over South America using the GSI coupled to Brazilian Regional Atmospheric Modelling System (BRAMS). This system is been developed with horizontal resolution of 5 km and cycle of 3 hours in support to nowcasting activities with Rapid Update Cycle (RUC) over South America done at CPTEC. An effort has been done to assimilate wind at mesoescale resolution and high resolution from radar using Local Modelling System (LMS) which is composed by WRF/DA and WRF model. The horizontal resolution of this System will be 2km and temporal resolution will be 1 hour, but this Activity still in an early phase. Figure 3 shows the assimilation scheme used at CPTEC/INPE in the different temporal and spatial resolutions.

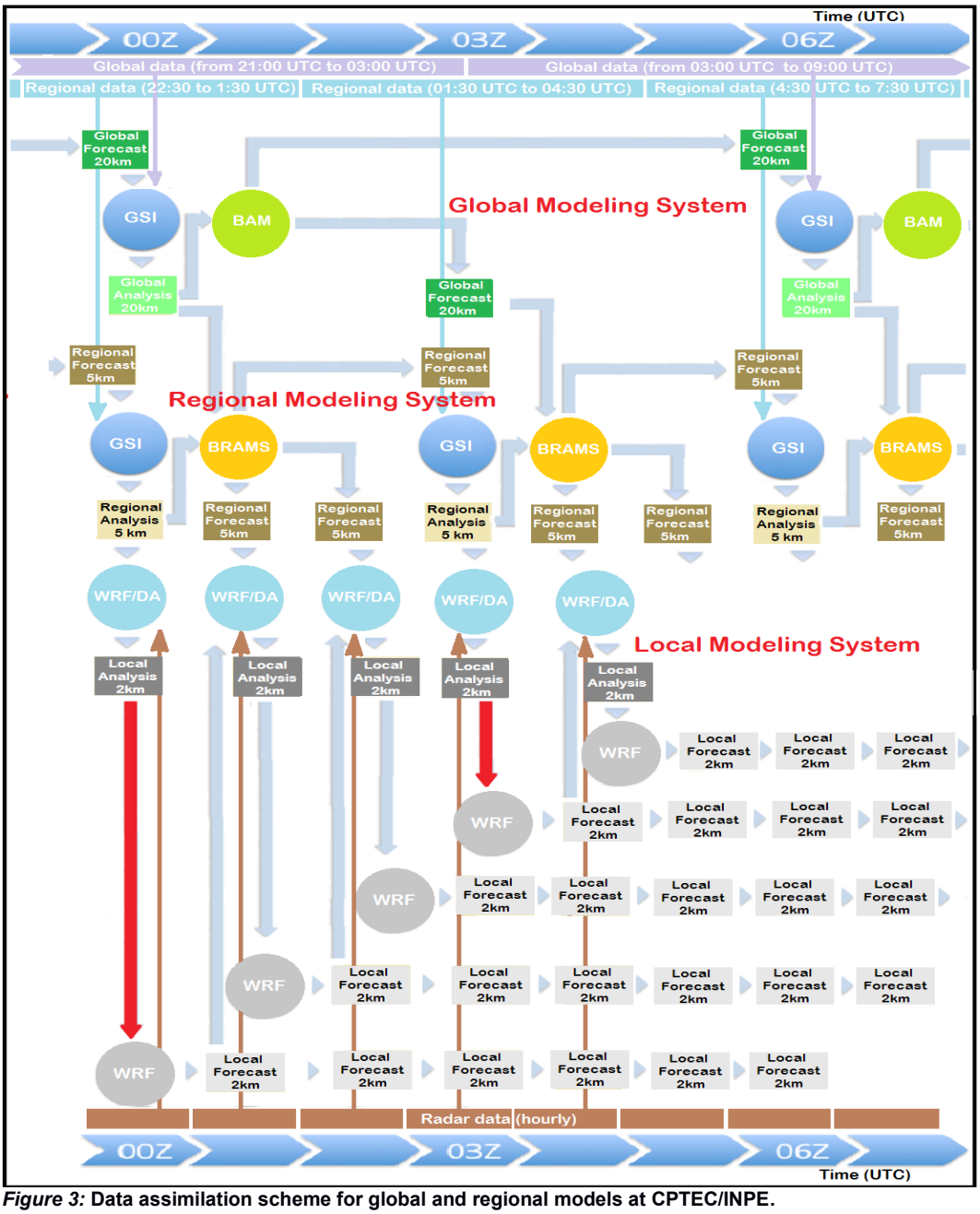

Figure 3: **Data assimilation scheme for global and regional models at CPTEC/INPE.**

3. CGMS-39 INTER-COMPARISON

During the last AMV algorithms inter comparison study proposed by the Coordination Group for Meteorological Satellites (CGMS), an error up to 5 m/s for u and v wind components was found in the CPTEC/INPE dataset. This error was due to a problem in an old routine which was used to compensate AMVs speed and direction overestimatives when 1 hour timesteps were used. Its purpose was to modify slightly the AMV speed and direction for targets displacing several pixels. However, a rounding floating number issue was changing randomly the wind for high satellite viewing angles. Figure 4 shows the Northwest corner of the full disk MSG image used in the CGMS experiment. The

original AMV field at left and the one after the problematic routine been removed at right, with CPTEC amvs in read and the EUMETSAT in yellow as a reference. After removing the fine adjustment routine the CPTEC AMVs agrees very well with the EUMETSAT ones, despite the difference in the target windows positions. This error has never been detected because it is more evident for viewing angles greater than 60 degrees, which is not typical for South America and surrounding oceans. The operational version of the wind derivation algorithm was updated correcting this problem.

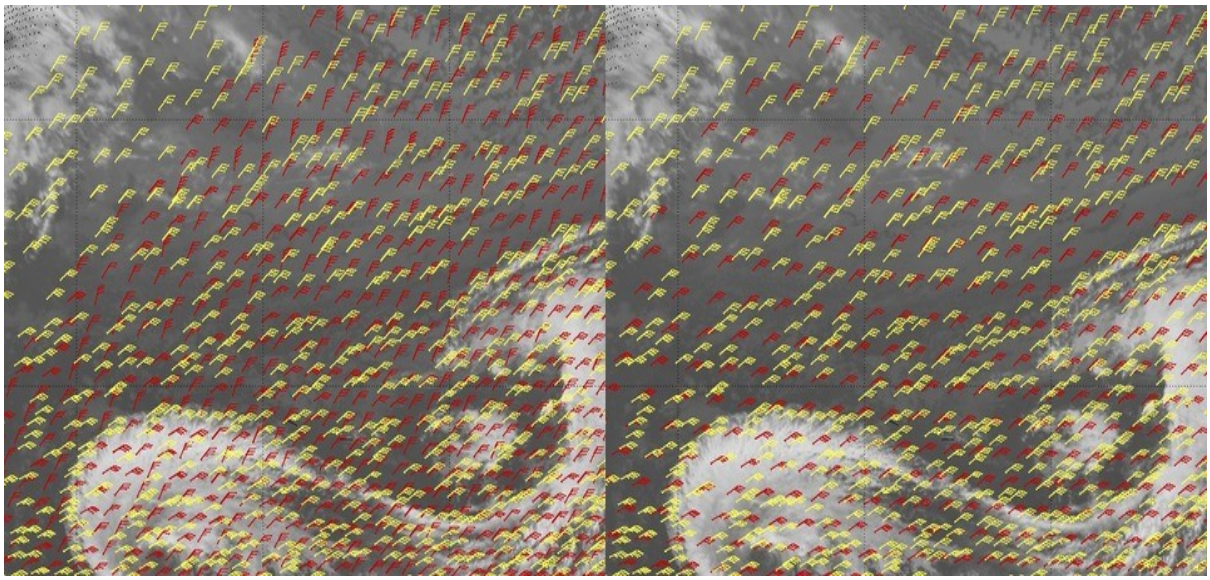

Figure 4: **Error in AMVs estimative founded during the inter-comparison proposed by the CGMS-39. AMVs sent to the inter-comparison (left) and after the correction being applied (right), with CPTEC (red) and EUMETSAT (yellow).**

4. PLANS FOR THE NEXT YEARS

GOES-R will be launch by the end of this year. CPTEC/INPE is working on the preaparation to produce AMVs based on the GOES-R Advanced Baseline Imager (ABI) operationally. Also, the higher temporal and spatial resolution, with the added spectral channels, will allow to increase also the spatial resolution of the AMVs data, as has being done with the Himawari-8 data. Research on new tracking methodologies has been carried on to explorer the higher time and spatial resolution. These high resolution wind fields will help the newer nowcasting activities at CPTEC/INPE as well the assimilation on cloud scale model that has been doing operationally by the regional models. Efforts has been done to increase the spatial resolution up to 25 km using the actual GOES and MSG satellite generations (Negri et al, 2014). This iniciative to derive wind using channel combination to increase the spatial variance on cloud tops, highligting areas base on the microphysics compositions (water droplets, small ice cristals, mixed pashed, etc). The best result was obtained when using MSG images due its higher spatial resolution. This allows use a smaller target window while geting less ambiguit level in the cross correlation, as well due to the more spectral channels, allowing classify the cloud tops more precisaly. When using GOES images, the results were satisfactory, despite the slightly lower spatial resolution and fewer spectral channels.

5. SUMMARY

CPTEC/INPE is generating AMVs from GOES-13 meteorological satellite using the visible, NIR, WV and IR channels every 30 minutes and the AMV produced are disseminated via GTS network. The wind algorithm was revised after the CGMS-39 intercomparison experiment and a improvement in the

data quality was achieved. For next year the use of MSG is planned to increase spatial coverage of the AMVs produced localy. GOES-R will be received at CPTEC/INPE and the wind estimative and weather monitoring will be one of the main use of its data.

REFERENCES

Laurent, H., 1993: Wind Extraction from Meteosat Water vapor channel image data. J. Appl. Meteor. **32**, pp 1124–1133.

Laurent, H., N. Arai, L.A.T. Machado and M. Gondim, 2002: Wind extraction using satellite images in CPTEC: New version and evaluation with WETAMC/LBA and operational DSA/CPTEC data. **6th International Winds Workshop**, Madison.

Machado, L. A. T., J. Ceballos, 2000: Satellite based products for monitoring weather in South America: winds and trajectories. **5th International Winds Workshop**. Saannenmoser .

Machado, L. A. T., and H. Laurent, 2004: The convective system area expansion over Amazonia and its relationships with convective system life duration and high-level wind divergence. Mon. Wea. Rev., **132**, pp 714–725;

Negri, R. G., L. A. T. Machado, 2008: Estimativa do vento para os baixos níveis utilizando imagens dos canais visível e infravermelho próximo 3.9 μm. Rev. Bras. Meteor., **23**, pp 206-218.

Negri, R. G., L. A. T. Machado, 2008, R. Borde, 2014: Inner convective system cloud-top wind estimation using multichannel infrared satellite images. International Journal of Remote Sensing, **35**, pp 651-670.

Schmetz, J., K. Holmlund, J. Hoffman, B. Strauss, B. Mason, V. Gaertner, A. Koch, and L. V. D. Berg, 1993: Operational cloud-motion winds from Meteosat infrared images. J. Appl. Meteor., **32**, pp 1206–1225.