CPTEC/INPE OPERATIONAL GOES-10 ATMOSPHERIC MOTION VECTORS

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Abstract

The Center for Weather Forecast and Climatic Studies (CPTEC/INPE) developed a set of Cloud Drift Winds (CDW) models using GOES satellites images. These models use the visible (0,5µm), near infrared (3,9µm), water vapor (WV - 6,7µm) and infrared (IR-10,2µm) channels. Visible and near infrared CDW models are used to estimate winds in lower atmospheric levels while the IR and WV models are used to estimate wind in the middle and high levels. From 1st March 2007 GOES-10, located in 60W, began to be the INPE/CPTEC operational geo satellite. Using GOES-10 INPE/CPTEC began to produce operationally cloud drift wind, each 15 minutes, for the four channels described above. This higher time resolution makes possible to identify displacement of clouds more precisely raising the results quality. Beyond the aspect of the temporal resolution, GOES-10 is exclusively dedicated to South America allowed to get regularly wind fields. GOES-10 CDWs models have a new automatic quality control based on the methodology used by the EUMETSAT. Each vector is evaluated, in different aspects, for a series of equations and its results are combined in a quality indicator (QI). This index makes possible that the final user choose a threshold in accordance with its needs. This study presents the quality evaluation using GOES-10 and the new quality indicator function. Using WV Atmospheric Motion Vectors (AMV) we have computed the upper levels wind divergence. The AMV's estimated by using water vapor images are interpolated in a regular grid. From this filed is calculated wind divergence above of 400hPa using finite differences methodology. This study uses a 0.5 degrees spatial resolution grid each 15 minutes. The preliminary results evidence the great potential of these fields for operational applications. This paper describes the current operationally CDW operationally running in INPE/CPTEC, the wind vectors quality and some examples of the wind divergence applications.

1. INTRODUCTION

INPE/CPTEC AMV's models used images from visible (VIS-0.5µm), near-infrared (NIR-3.9µm), water vapor (WV-6.7µm) e infrared (IR-10.2µm) GOES-10 satellite channels. The VIS (diurnal) and NIR (nocturnal) channels are used only for low levels wind estimation. Water vapor channel is used to estimate the high level winds and the IR is used to obtain the winds in all levels.

A detailed description of the cloud drift winds algorithms utilized in INPE/CPTEC can be obtained in the following studies: Laurent et. al. (2002) and Machado et. al. (2006). This set of algorithms allows INPE/CPTEC to retrieval winds in nearly all levels, during the day and night each 15 minutes, Figure 1 shows an example of the winds retrievals at different levels (channels) using GOES-10.

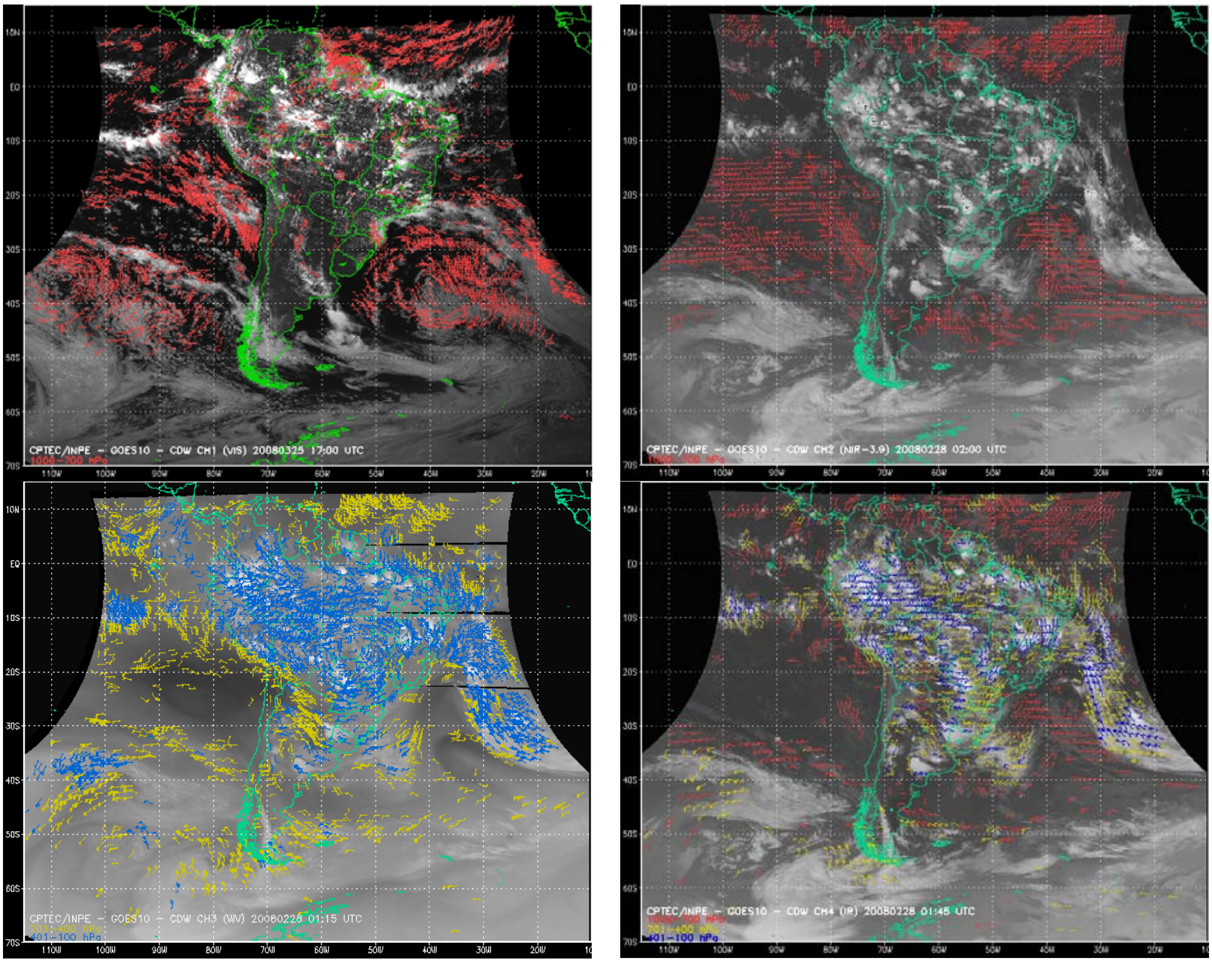


Figure 1: **Operational INPE/CPTEC AMV's for VIS,NIR, WV and IR channels**

2. AMV'S FROM GOES-12 TO GOES-10

The CPTEC/INPE have AMV`s models operationally since 2003. Up to February, 2007, AMV's were estimated using GOES-12 images. These images had temporal resolution of 30 minutes, covering the region of 110°W a 20°W e 30°N a 60°S, and were composed of two images, the extended North Hemisphere and the South America Sector.

During the occurrence of extreme events in North Hemisphere, the image scanning over South Hemisphere was compromised. Due to these GOES-12 discontinuities service for South America, NOAA moved the GOES-10, in the early of 2007, to 60W, to cover South America. This dedicated satellite to South America is able to scanning the sector each 15 minutes. This new NOAA service provides the capability to INPE/CPTEC to have wind fields in high temporal resolution without images lack as was often observed for GOES-12.

Figure 2 shows the impact of the satellite change in the IR CPTEC/INPE wind models. This Figure presents the statistics for GOES-12 for 2006 and GOES-10 for 2007. This result corresponds to the South America and adjacent Oceans in the tropical region (20N-20S). Besides the satellite change between the years of 2006 and 2007 the quality control was also changed from the traditional tests do the new QI (see section 3). Results show that the RMSVD did not significantly change from 2006 and 2007. The statistics was computed based in all AMV's/radiosonde pair samples except those pairs having differences in velocity and direction great than 30m/s and or 60 degrees, respectively. This filter was applied to be in agreement with the others statistics used by the space agency.

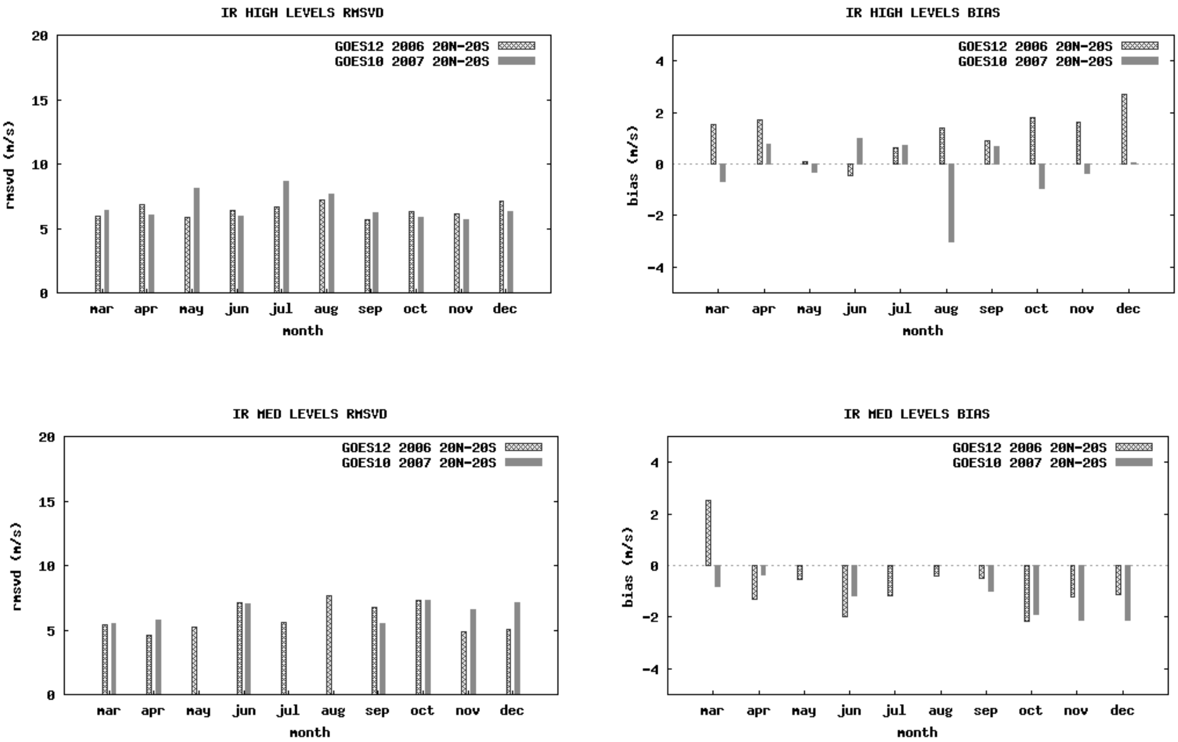


Figure 2: **Comparison between the AMV's statistics computed for IR CPTEC-INPE models in 2006, by GOES-12 and in 2007 by GOES-10, for middle and high level in March to December.**

The possible reason for this small difference between the statistics for GOES-12 and GOES-10, are probably related to two opposite factors. From one side, the GOES-10 statistics should be improved due to the shorter time interval that changes from 30 minutes to 15 minutes. However, from the other side, the GOES-10 orbit drift decrease the navigation accuracy and the results are probably worst, therefore it seems that what we gained with higher time resolution as compensated by the problems related to the orbit drift.

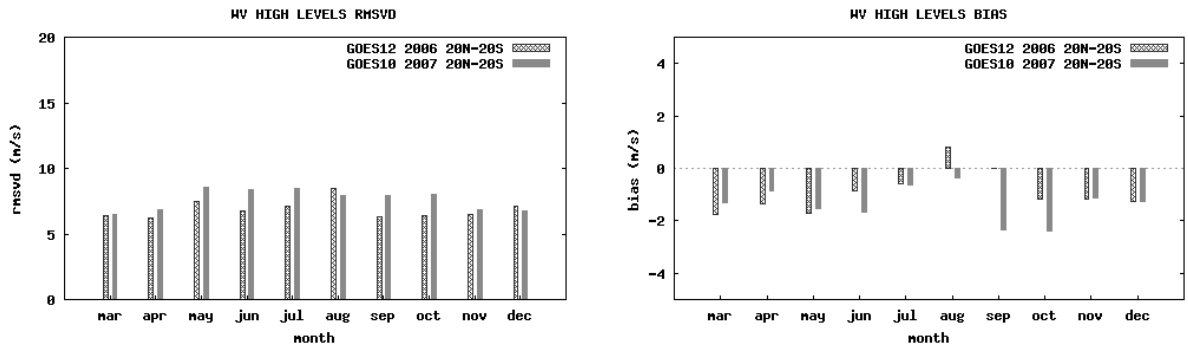


Figure 3: **Comparison between the AMV's statistics computed for WV CPTEC-INPE models in 2006, by GOES-12 and in 2007 by GOES-10 in March to December.**

Figure 3 also does not show significant changes between the values of RMSVD and BIAS for the WV winds, the performance of the model was remained well similar. This result is positive since with the use of the images of satellite GOES-10 we have winds with the same quality of the GOES-12 but without the time discontinuities, due the alterations of satellite operation schedule during occurrence of extreme events in the North Hemisphere. If the statistics did not change, the number of vector, as showed in Figure 4, had a considerable increase after the satellite changed. This increase is evident in both cases. The amount IR vectors increased remaining itself constant in about 1000 vectors per field. For the fields obtained from images of WV channel, a great increase is observed after the satellite alteration, decaying until the June and raising themselves until the December. The decrease between March and June can be explained by the end of austral autumn and beginning of austral winter when the incursion of cold and dry air masses in the region resulting in a smaller capacity of identification and tracking of structures.

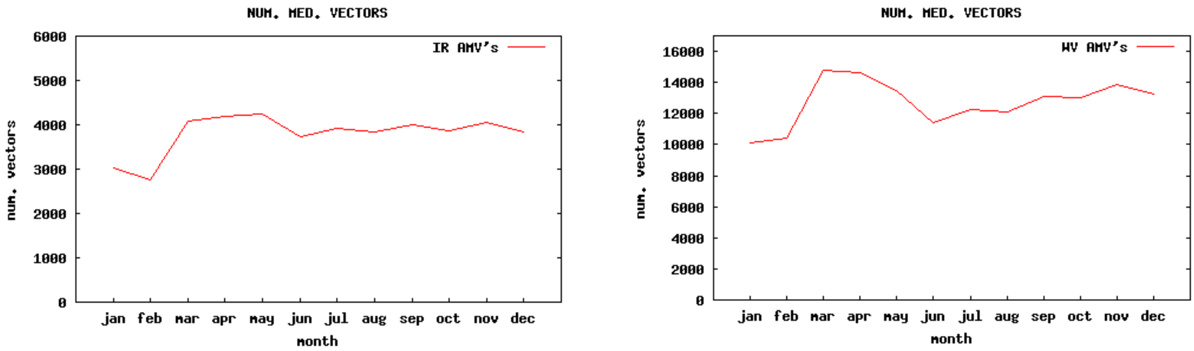
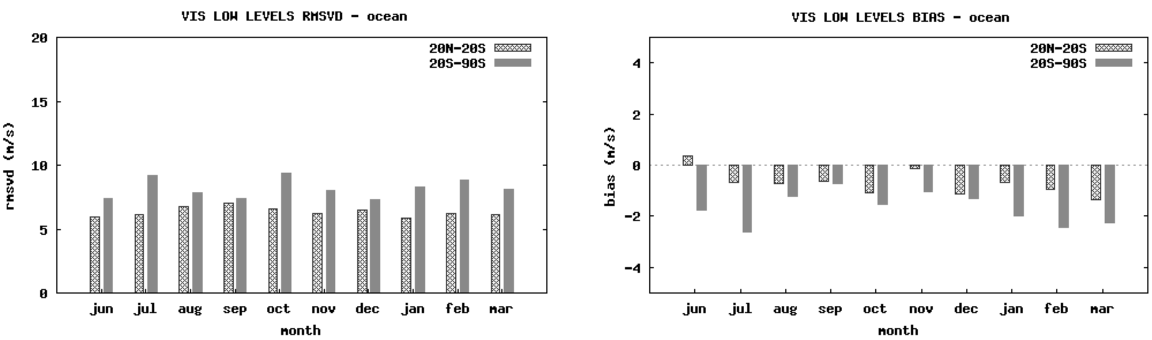


Figure 4**: Mean amount vector per field. In January and February are used GOES-12 images. After march, GOES-10 satellite are used. IR AMV's (left), WV AMV's (right).**

The statistics showed in Figures 2 and 3 demonstrated that the satellite changed from GOES-12 to GOES-10 was satisfactory. The values of the RMSVD and BIAS had not modified significantly in the majority of evaluated cases and the amount of AMV's increased due to great temporal resolution, which provides the identification of the displacements of clouds more easily. We cannot forget the exclusive dedication of GOES-10 to South America providing continue coverage of the South America.

In relation to AMV's estimated with Vis and NIR channels, it was not possible to carry through this comparison because in the period of satellites change, such models was still under development. Also, these models mainly estimate the wind over oceanic regions and on such regions we do not possess available radiosonde profiles for comparison. Therefore, the wind vectors had been compared with NCEP reanalysis data.

Figure 5 presents the statistics for Vis and NIR AMV's over oceanic areas. These fields are compared against NCEP reanalysis winds. The statistics seem to be high in comparison with the low level wind speed. A more deep analysis will be performed to understand these features.



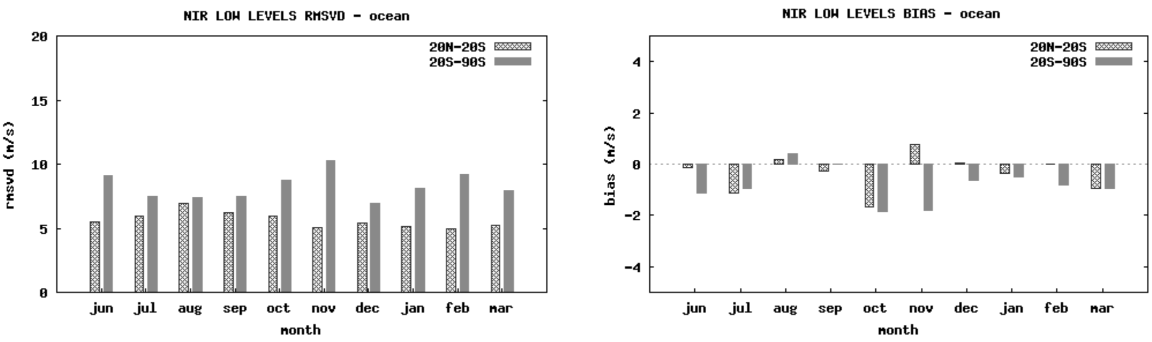


***Figure 5*: Statistics of Vis (top) and NIR (botton) AMV`s for june, 2007 to march 2008**

3 NEW QUALITY CONTROL

All operational INPEC/PTEC AMV's are evaluated for an automated schematic quality control (CQ). In begin of 2007 the quality control was modified. The new QC implemented is based in that one proposed by Holmlund et. al. (2002). The old schematic shows obsolete when compared with others used in various meteorological centers. For this reason we decided change it. Such CQ is composition by equations below:

a. Direction Consistency

This function evaluates the direction of each vector in relation to the direction of its corresponding vector of images (t0-Δt, t0).

$$IQ1 = 1 - \tanh\left[\frac{Dif}{Ae^{\left(\frac{-Vlc}{B}\right)} + C}\right]^{D} \quad (1)$$

where: Dif = Direction difference (degrees) between the two vectors components.
Vlc = Velocity of the vector evaluated (same for the equations below)

b. Velocity Consistency

This function verifies the velocity of each vector with your correspondent vector extracted from images in instants t0-Δt and t0.

$$IQ2 = 1 - \tanh\left[\frac{\left||V_1| - |V_2|\right|}{MAX\,(AVlc, B) + C}\right]^{D} \quad (2)$$

where: V1, V2: vectors from first and second pair of images (same for equation 3).

c. Vectorial Consistency

In this function, the vector differences of the pair of vectors are evaluated.

$$IQ3 = 1 - \tanh\left[\frac{|V_1 - V_2|}{MAX\,(AVlc, B) + C}\right]^{D} \quad (3)$$

d. Spatial Consistency

This function evaluates each vector in relation to their neighbors (vectors with distance lower than 1,5 degrees).

$$IQ4 = 1 - \tanh\left[\frac{|V_1 - V_x|}{MAX(AVlc, B) + C}\right]^D \quad (4)$$

where: Vx is the neighborn vector with the lower vector difference

The final QI is determined by the weighed mean of the four partial quality indicators cited above. In this average, the test of space consistency receives weight 2 and the others 3 receive weight 1. The constants, B, C and D are used to adjust each function and its values are presented in table 1.

	parameter	value
direction	A	20
	B	10
	C	10
	D	4
speed	A	0,1
	B	0,01
	C	1
	D	2,5
vectorial	A	0,2
	B	0,01
	C	1
	D	3
spatial	A	0,2
	B	0,01
	C	1
	D	3

Table1: **Parameters for QI schematic equations**

4. OPERATIONAL HIGH LEVEL WIND DIVERGENCE

Using the CDW's gotten from WV, the wind divergence in the high levels is calculated, following the procedures described for Laurent and Sakamoto (1998) and Sakamoto and Laurent (2003). In this procedure, the wind fields are initially interpolated in a regular grid with 0.5 degrees of spatial resolution. The fields present the temporal resolution of 15 minutes. This interpolation is made simultaneously in time and space having aimed at the field continuity (Doswell, 1977). Only vectors located above of 300hPa are used in this estimate.

Knowing the wind divergence we can use this parameter to monitor vertical fluxes of humidity, assisting in the forecast, and the convective systems, what already it is carried through in the INPE/CPTEC.

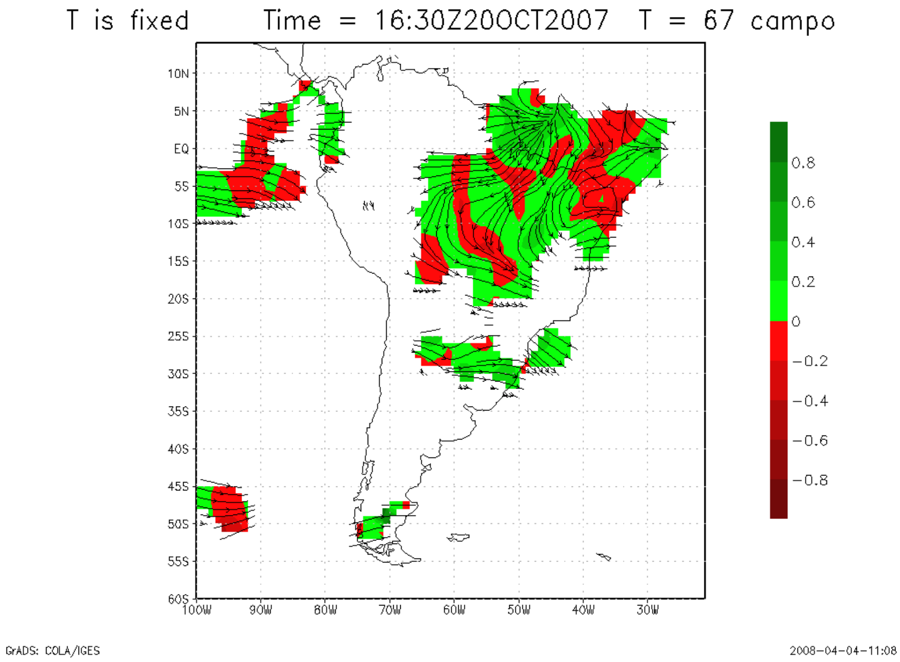


Figure 6: **High level wind divergence**

6. CONCLUSIONS

The results show that the GOES-10 image is able to have cloud drift winds with similar quality that these one were obtained using GOES-12. The main advantage is that GOES-10 has an operational routine scan that cover South America each 15 minutes. The high temporal resolution of AMV's fields, from GOES-10, increases the amount of vector per image. These wind fields become more detailed and the time discontinuities for temporal series are eliminated.

The change of automatic quality control schematic is recent and the parameters of equations need a fine tune yet. With the high level wind divergence fields, others CPTEC/INPE satellite products can be enhanced, for example, the FORTRACC, and it can be used in the initialization of INPE/CPTEC numerical forecast model and help precipitation estimation.

REFERENCES

Doswell, C. A., (1997) Obtaining Meteoro1ogy Significant Surface Divergence Fields Throught the Filtering Property of Objective Analysis. Monthly Weather Review, v.105, 885-892.

Holmlund, K., Velden, C. S. And Rohn, M., (2001) Enhanced Automated Quality Control Applied to High-Density Satellite-Derived Winds. Monthly Weather Review, v.129, 517-529

Laurent, H., Arai, N., Fomin, B., Machado, L. A. T., e Gondin, M. A., (2002) Extração do Vento Utilizando Imagens de Satélite no CPTEC: Nova Versão e Avaliação com Dados do WETAMC/LBA e dados Operacionais da DSA/CPTEC. Revista Brasileira de Meteorologia, v.17, n.1, 113-123.

Machado, L. A. T.; Negri, R. G.; Lima, W. F. A.; Macedo, S. R.; Ferreira, S. H. S., (2006) CPTEC atmospheric motion vectors: validation, assimilation and characteristics. 8th International Winds Workshop Beijing, China. Proceedings. ISBN 92-9110-075-7. ISSN 1023-0416. (INPE-14229-PRE/9317). Available in: <http://urlib.net/sid.inpe.br/mtc-m15@80/2006/08.08.12.53>. Access in: 02 may 2008.

Sakamoto, M.; Laurent, H. (2003) Wind Estimation - The Studies Made at Funceme. The 2003 EUMETSAT Meteorological Satellite Conference, Weimar, Germany, 29 September - 3 October 2003. Publ. EUMETSAT, In Press, 3-15.