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ONE CASE OF SIMULATION OF UPPER TROPOSPHERIC CYCLONIC VORTEX IN THE BRAZIL NORTHEAST – IMPACT IN THE CONVECTION PARAMETERIZATION

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Abstract

In this study, we made three numerical experiments using the MM5 regional model to investigate the atmospheric circulation associated with a case of Upper Tropospheric Cyclonic Vortex (UTCV) which favored significant precipitation in the Brazil Northeast (NEB), impacted when we used differents parameterization schemes of convection (PC). For this, the following schemes were used: Betts-Miller (BM), Kain-Fritsch (KF) and Grell (GR) and the outputs of the simulations were generated mean fields of wind and relative humidity in the levels of 200, 500 and 700 hPa and accumulated precipitation for the day December 19, 2006 (the second day of action VCAN). The simulations were evaluated through comparisons with the data analyzes from the National Centers for Environmental Prediction (NCEP) and daily precipitation from the Global Precipitation Climatology Project (GPCP). We can say that for the reported day, anything of the PC schemes simulated the significant accumulated precipitation observed in NEB. However, it was observed in terms of smaller scales, these schemes induced erratic movement in average levels (500 hPa) and lower (700 hPa) over the regions where precipitation was overestimated. We verified for the simulation study, the most appropriate PC is the KF because it was the one that best simulated the observed precipitation over NEB on rated as well, not overestimated as much as the BM scheme the precipitation in the center region of the VCAN which provided a better representation of the intensity of this system.

Key-words: Regional Model, numerical experiments, precipitation, VCAN.

Introduction

The Upper Tropospheric Cyclonic Vortex (UTCV) are systems of low pressure, originated in the Upper Tropospheric, in which the circulation presents the colder center than your periphery and occur more frequently in January (Kousky and Gan, 1981; Coutinho et al., 2010). The vertical movement associated with (UTCV) has been illustrated in the Figure 1 by Kousky and Gan (1981). This system has circulation features thermally direct according to Kousky and Gan (1981) with potential energy available disorder being converted in kinetic energy. In theory, the cold air in the center system down to be denser, which in mass conservation, a warmer air rises on the periphery, where there is formation of cloudiness.

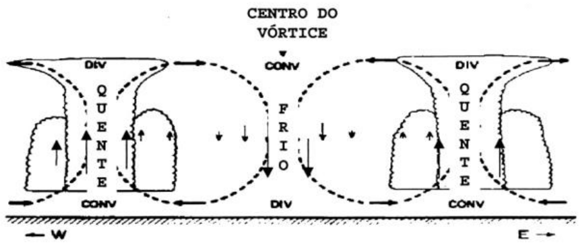


Figure 1 – Illustration of the vertical movement observed in the UTCV. Source: Kousky and Gan (1981).

Frank (1966) has observed that the associated cloudiness with UTCV studied varied considerably and depends of the intensity and of the depth it, with a tendency to be concentrated in the periphery and present asymmetrical features. Kousky and Gan (1981) showed that the cloudiness associated with UTCV was generally higher in the direction that it moves.

Gan and Kousky (1986) through of satellite images in the infrared channel has been observed UTCV cases in the periphery was accompanied by a lot of cloudiness, while the center presented features with clear skies. In other cases, there were cumulonimbus cloud formation in the center, that according to Gan and Kousky (1986), the UTCV course hot waters or reached into the continent, showing strong diurnal variation. These authors concluded that the UTCV reached in the Brazil Northeast affect the distribution and intensity of the precipitation. Although, these systems suffer from an erratic shifting (Kousky and Gan, 1981) that makes complex weather forecast.

There is a difficulty to represent the latent heat release associated with cumulus convection, due to the limited knowledge of how this process really occurs in the nature. Besides, the interaction between convection and large scale circulation is not a process linear. Many efforts have been used to improve understanding of the interaction between the large-scale circulation and the cumulus convection, especially schemes that parameterized (Kuo *et al*., 1997). Various schemes have been developed and incorporated into numerical models as Kuo (1974), Arakawa and Schubert (1974), Betts and Miller (1986), Kain and Fritsch (1990) and Grell (1993), but so far, none of the existing schemes is considered better than another under any atmospheric condition (Kuo *et al* ., 1997).

In this context, is very important to analysis the numeral simulations as purpose to find a best numeral scheme that represent satisfactory the convection and associated atmospherics to the meteorological systems that act in tropical regions, as UTCV. To verify the convection parameterization scheme (PC) which best represents the produced precipitation and air flow associated with this weather phenomenon synoptic scale simulations using smaller grid spacing is indicated, since this is a convection process scale sub-grid. Thus, the use of regional models is indicated because the computational workload to a global model with reduced grid is not feasible, from an operational point of view.

The UTCV analyzed here occurred between 18 and 20 December 2006 and presented favorable positioning the occurrence of accumulated volumes of rain in some northeastern cities, highlighting Recife/PE, where there was occurrence of flooding and landslides barriers (Climanálise, 2006). According to the National Institute of Meteorology were recorded 92 mm of rain in this city between 19 and 20 December 2006.

The purpose of this study is to investigate whether the associated circulation with this UTCV suffer impacted when using different convective parameterization schemes. For this analysis, we will use the regional atmospheric model MM5 and the PC will be used: Betts -Miller (Betts and Miller , 1986), Kain-Fritsch (Neto, 2008) and Grell (rell, 1993).

Methodology and Data

In this research was studied one case of UTCV that presented three days of life cycle (from 18 to 20 December of 2006) and has been formed in the Atlantic Ocean near the southeast coast of Bahia. The simulations that of this UTCV were made using the regional atmospheric model MM5.

To evaluate these simulations were used of analysis data from the "National Centers for Environmental Prediction" (NCEP) every 12 hours with spatial resolution of 1° of latitude by 1° of longitude and daily precipitation of the "Global Precipitation Climatology Project" (GPCP)[1] with the same spatial resolution, however temporal frequency of 24 hours (considered as observational data).

The MM5 model used in this study was implemented in 2007 in the Atmospheric Sciences Division of Aeronautics and Space Institute (Oyama, 2007), is a model of non-hydrostatic primitive equations using sigma coordinate vertical (Grell *et al*., 1995) and B grid Arakawa-Lamb horizontally. The resolution of the model is 50 km horizontal and 34 vertical levels with the top pressure of 100 hPa. The upper boundary condition is "upper radiative boundary condition". While the PC's are different for each experiment (See Table 1), parameterization does not differ between experiments, being used "simple ice" (Dudhia, 1989) for microphysics (explicit convection); RRTM (Mlawer *et al.*, 1997) to radiation; MRF- PBL (Hong and Pan, 1996) to the planetary boundary layer; and Noah-LSM (Chen and Dudhia, 2001) for surface processes.

The initial and boundary conditions used come from NCEP analyzes provided by

[1] http://precip.gsfc.nasa.gov/index.html

Weather Prediction and Climate Studies Center (CPTEC) in horizontal resolution of 1° of latitude by 1° of longitude. Temperature data of sea surface (TSM) comes from the National Oceanic and Atmospheric Administration (NOAA) ("Optimum Interpolation Analysis SST", Reynolds et al., 2002) and are persisted during integration. Temperature, soil humidity and snow cover are initialized with the monthly climatology of the NCEP/NCAR (National Center for Atmospheric Research) with the period between 1971 and 2000. However, while the temperature and soil humidity are prognostic variables model, the snow cover is kept equal to the weather throughout the integration.

The integrations in the model starting with the most recent analysis file and extend for 36 hours and can also be extended for a longer period. The first 12 hours are discarded as "spin-up" model, therefore, only the final 24 hours of integration are considered. The time step is 30 seconds and the radiative processes are updated every 10 min.

In this research, the area of the simulations comprises the latitude ranges from 29ºS to 0° to and longitude from 57ºW to 13ºW (Fig. 2). These simulations started at 13:00 Z on December 18, 2006, and the integration of the model was made for the period of 48 hours. Here, an evaluation of the simulations was obtained on December 19, 2006 (second day of UTCV performance under study). For this, three experiments have been made in accordance with the selected PC layout option, as illustrated in Table 1. Each one of the PC scheme is described in section 2.2.

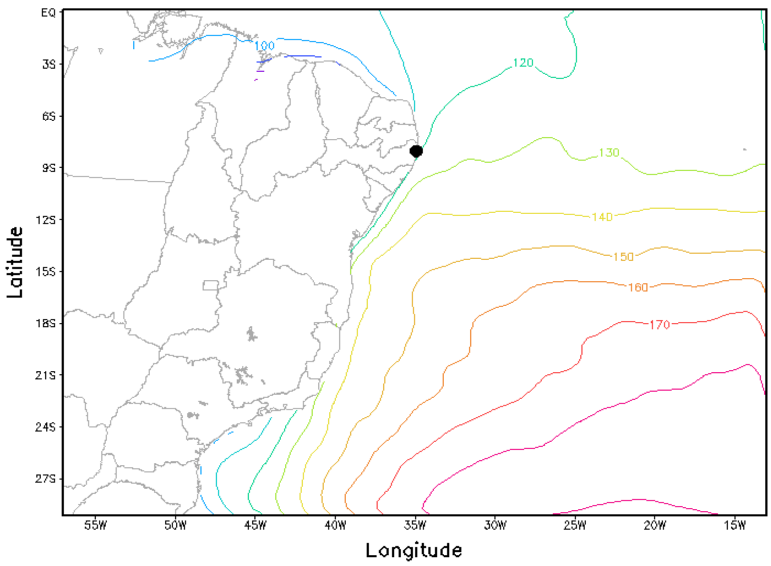


Figure 2 – Used grid for simulations with MM5 model. The black color point represents the geographic position of the Recife/PE (8.07°S e 34.92°W).

Table 1 – Experiments according schemes options of PC used in the MM5 model.

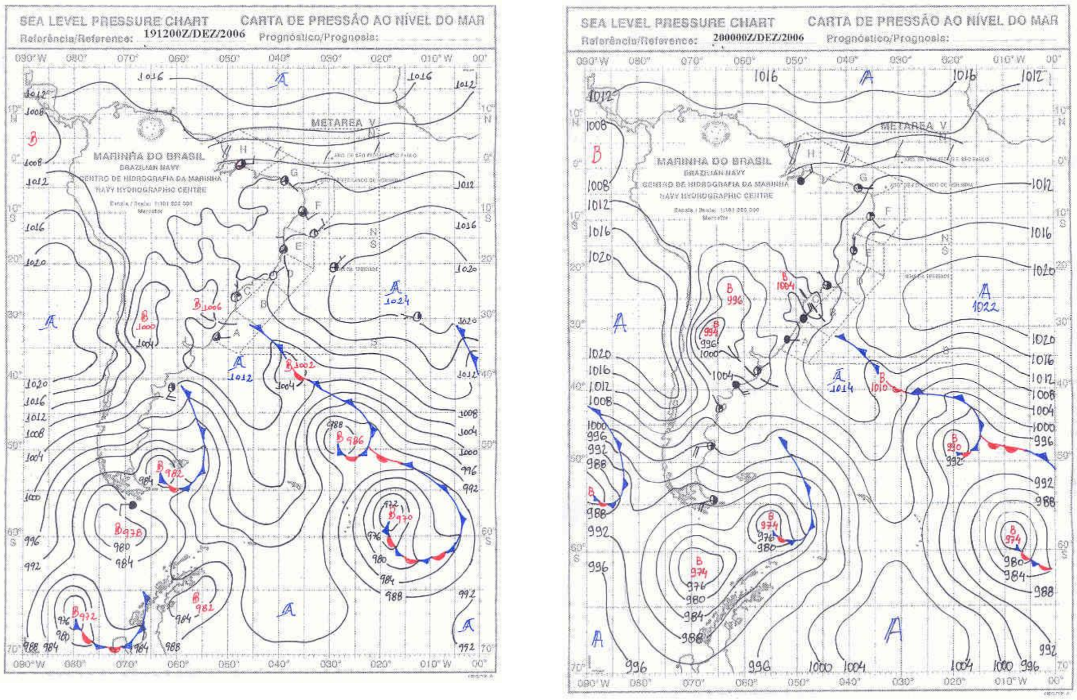
Experiment	Schemes PC
EKF	Kain-Fritsch
EGR	Grell
EBM	Betts-Miller

Synoptic Analysis

In the analysis of synoptic maps of Surface December 19, 2006 (Figs. 3a and 3b), observe the presence of a frontal system that operates of stationary form in the region 35ºS and 40ºW . This system follows cold by Atlantic until the cyclone with pressure of 990 hPa and position around 50ºS and 20ºW which has its hot branch coupled to another front around 60ºS and 10ºW. The northeast of this frontal system, the South Atlantic Subtropical High is centered on 25ºS and 15ºW with pressure of 1024 hPa. The intertropical convergence zone in this day oscillated between 0ºN and 5ºN over the Atlantic. The map of 9HL (Local Time) (Fig. 3a) shows that on the coast of Pernambuco, the sky was practically overcast (6/8) and southeast winds (10 knots), while the map of 21HL shows that on this region, the sky was mostly sunny (1/8) and remained the southeast winds (10 knots) of the map of 9HL.

In the period from 18 to 20 December 2006, configured a UTCV on eastern Brazil, accompanied by a frontal system in a surface that had formed on the 16th day and moved from Argentina to the east of Santa Catarina (not shown) until 24th day. Associated with the frontal system, considerable cloudiness over the Parana states, Santa Catarina, north of Rio Grande do Sul and Sao Paulo downtown, which can be seen in Fig. 4. An intense cloudiness over the Tocantins and a less intense cloudiness over Pernambuco and surrounding states can be seen in this same figure, being associated with UTCV.

The positioning of this UTCV was favorable to the instability areas organization on the NEB region. Between the days 19 and 20, has been registered a significant cumulative volumes of rain in Recife - PE (92 mm Source: INMET), already close to the Holy Spirit coasts, in the north of Rio de Janeiro and ocean regions are not noticed cloudiness, just by the fact that in the central of UTCV has subsidence vertical movements, which suppresses the formation of cloudiness.



(a) (b)

Figure 3 – Synoptic maps of the December 19, 2006 (a) at 9HL, (b) at 21HL.

Source: Brazil Marinha.

PC Schemes

The PC is a used method in the models to quantify the convective effects through redistribution of heat and humidity in a column of the grid, which reduces the atmospheric instability.

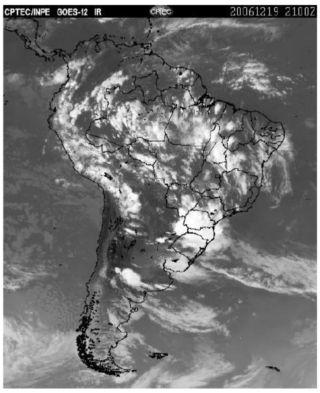


Figure 4 – Imagem in the infra-red spectral channel of the Geostationary satellite GOES-12 for the December 19, 2006 at 21 Z.

PC schemes account the effects of the subgrid scales for the descending mass flow ("downdraft") and ascendant ("updraft") in the cloud, through of instability atmospheric reduction, immediate fall of rainfall and changes in vertical profiles of humidity and heat. Each PC scheme defines parameters and settings using averages information from grid and investigate: to trigger convection in the grid column, as the current convection changes the column as well as the convection and the dynamics of grid scale relate (Comet Metid)[2]. In the following subsections will find a brief description of the three options of PC schemes that were used in the experiments to simulate the case of UTCV study.

Kain Fritsch (KF)

The PC scheme Kain - Fritsch (Kain and Fritsch, 1990) is a mass flow scheme that has divided in three parts: function that triggers the convection, mass flow of the formulation and the closing hypothesis. Some modifications were proposed to the original scheme (Kain, 2004; Neto, 2008). The main changes are: specification of a minimum rate of entrainment and disemboweling, radius variation of undercurrent ascending in a vertical speed magnitude function in the level of condensation rise (NCA) minimal vertical extension of the ascending undercurrent in temperature function of NCA and the inclusion of shallow convection (non- precipitating).

[2] http://www.meted.ucar.edu/

Function that triggers the convection

The function that triggers the convection is a sequence of tasks that determines the temporal space of activity convective of the parameterization (Kain and Fritsch, 1990). The following conditions must be met to trigger convection scheme: probing provide a source mass flow ascending in the layer (each layer has a depth of 50 hPa, being tested different layers in the first 200hPA), sufficient speed (a few meters per second) for the portion penetrate this layer and the depth of the convective cloud exceeds a threshold (4 km).

Mass flow Formulation

Sensitivity tests indicate that the convective heat and humidity profile are more sensitive when entrainment and disemboweling are variable. The inclusion of the descending mass flow in the convective scheme balances the mass flow in the lower troposphere and aid to produce convective heating and drying in the lower part of the cloud. Although the original scheme use the level as the level of sinking origin of the descending mass flow, the free sinking level of pressure can vary significantly from approximately 300 hPa to 850 hPa below. This leads to several problems with the predicted warming and drying of the convective scheme. The latest version of the scheme assumes that the downward mass flow originates between 150 and 200 hPa above the USL ("Updraft

Source Layer") (Kain, 2004). The downward mass flow is saturated above the cloud base, whereas below this, the relative humidity of the descending mass flow decreases at a rate of 20% per km.

Closing hypothesis

Each convective parameterization scheme adopts a different closing event to define the relationship between implicit clouds and the variables in the grid scale. The closing hypothesis of the Kain - Fritsch scheme controls the intensity of convection and related parameterization with the large - scale. Since the relationship between ascending and descending mass flow were established, the mass rearranging scheme in ascending column using mass flows downward and the environment until at least 90% of the convective available potential energy (CAPE) is removed Initial by deep convection process. In the scheme, the calculation of the initial CAPE is based on the rise of an undiluted portion, having the features of USL.

Grell (GR)

This PC scheme is a simplified version of Arakawa and Schubert (1974). The rain is determined by the assumption of nearly balanced, wherein the column is stabilized by convection to the same rate that is destabilized by the large scale flow. The properties of the clouds are calculated using a simple mass flow upward without entraining it unravels at the top of the cloud and the descending mass flow which starts at the lowest level of moist static energy and unravels at a specific depth above the surface.

Betts Miller (BM)

This PC scheme requires three conditions are required to trigger convection: a minimum of CAPE, the depth of the convective cloud exceeds a threshold value and the investigation of moisture profiles are active. Changes in convection is initiated from a reference profile (climatology of a convective state fixed on the top, base and cloud ice level) that is adjusted to the probe origin. This last profile differs from the reference profile in the amount of precipitable water and some sources of heating or cooling. The BM scheme modifies the reference profile matching the latent heat to the heat source of origin investigation. The rain is produced by reducing the precipitable water passing from the source probe to the reference probe.

Results and discussion

The average horizontal flow field at the level of 700 hPa (Fig. 5a-d) shows similar circulation between observation (Fig. 5a) and the simulations (Fig. 5b-d), presenting a defined anticyclone over the South Atlantic Ocean centered at about 19° S and 29° W. As observed in simulations (Figs. 5b-d), the wind north in center of anticyclone circulation is zonal, nevertheless the observation (Fig. 5a) indicates a southeast wind. Another difference is observed on the Minas Gerais state, where the simulations indicate Wind Northwest, while the observation (Fig. 5a) indicates a wind undefined standard.

It may be noted that the average horizontal flow field at 500 hPa analysis (Fig. 6a) shows a closed vortex on the frontier between the Minas Gerais states, Espírito Santo and Rio de Janeiro, while the simulations (Figs. 6b-d) not show this vortex in this position. In the EKF, this vortex was not simulated, since the EGR, it is observed a vortex located at 24° S and 39° W and in EBM, two small vortices are seen: one located in the northern region of Minas Gerais and another over the ocean centered at 24° S and 39° W (center of UTCV region). In all simulations (Fig. 6b-d), the anticyclones circulation is find over the South Atlantic Ocean was well represented by the model.

The simulations (Fig. 7b-d) the average horizontal flow at the level of 200 hPa follow a quite similar observed behavior (Fig. 7a), being noted the presence of UTCV well defined, with center located in the northern region of the Holy Spirit.

A small difference between the simulation obtained by the EBM (Fig. 7c) and the observation (Fig. 7a) is seen on the NEB and the Minas Gerais state. The simulation (Fig. 7c) in these regions shows South Wind and the observation (Fig. 7a) shows southeast wind.

An important point to be remembered is that upward vertical movement induces a cyclonic horizontal circulation, in which the PC schemes trigger convection. That is, regions where occur upward vertical movements induced horizontal cyclonic vorticity. Thus, regions where convection was triggered abnormally originated anomalous cyclonic circulation. Another fact, is that near the domain frontiers the simulations in a regional model tend to accumulate rainfall or no rainfall generate due to the transition between analysis grids for the model grid, thus, are not discussed the precipitations and circulations that are 3° of distance of the meridional and zonal frontier.

The KF scheme to include several physical process in its structure (entrainment and disemboweling, consumption of available potential energy, interaction with the external environment cloud, conservation of mass, thermal energy and momentum, etc.), tends to indicate consistent accumulated precipitation observed. In this study, the EKF (Fig. 8b) simulated rainfall manner consistent with the observation (Fig. 8a). However, in both regions, there is over estimation of precipitation: North Paraná and the central UTCV. The first over estimation induced anomalous cyclonic circulation at the level of 700 hPa, nevertheless not alter the flow at 500 hPa, indicating that the cloud was not deep enough to reach this level, which can be confirmed by field relative humidity (Fig . 9b) at 500 hPa in the region (lower values).

The second overestimation is associated with the center of UTCV, as in the EKF, the EBM experiments (Fig. 8c) and EGR (Fig. 8d) overestimated precipitation observed (Fig. 8a) in this region.

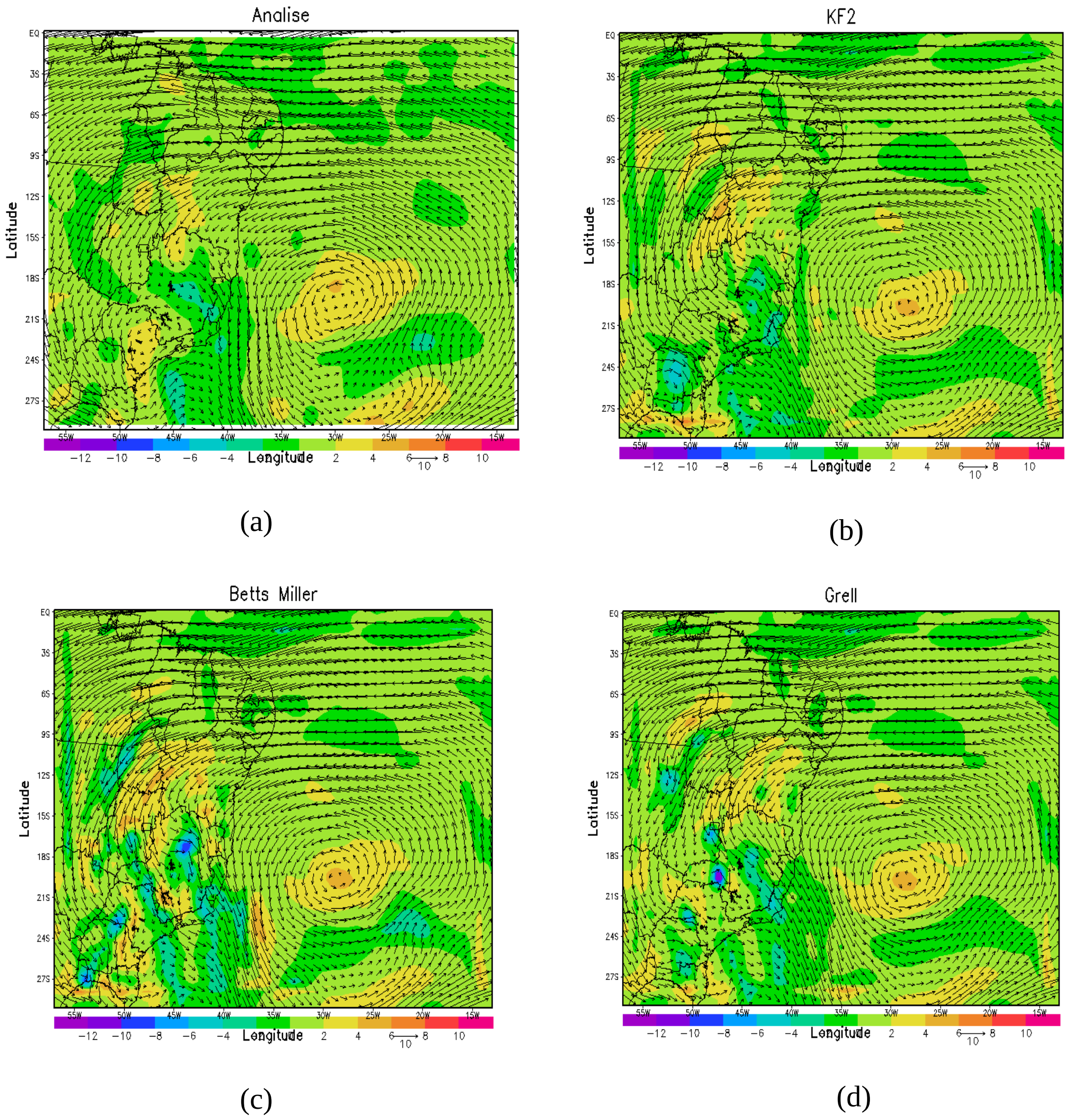


Figure 5 - Average horizontal flow (vector) and average relative vorticity (hatched) in the level of 700 hPa for the day December 19, 2006.

This overestimation obtained by simulations induced a more intense cyclonic circulation (Figs. 7b-d) of the observation (FIG. 7a) in this region, leading to an enhancement of UTCV. However, the EKF has shown a slight enhancement of UTCV, which was not able to change the movement in the level of 200 hPa. This overestimation may have occurred as a result of mass confluence in medium and low levels, which may have been able to generate enough energy to trigger convection. BM is a convective adjustment parameterization scheme, in other words, adjusts temperature profiles and blending ratio for the reference profiles. Where the reference profile is based on climatology. Once precipitation is triggered, it can induce much

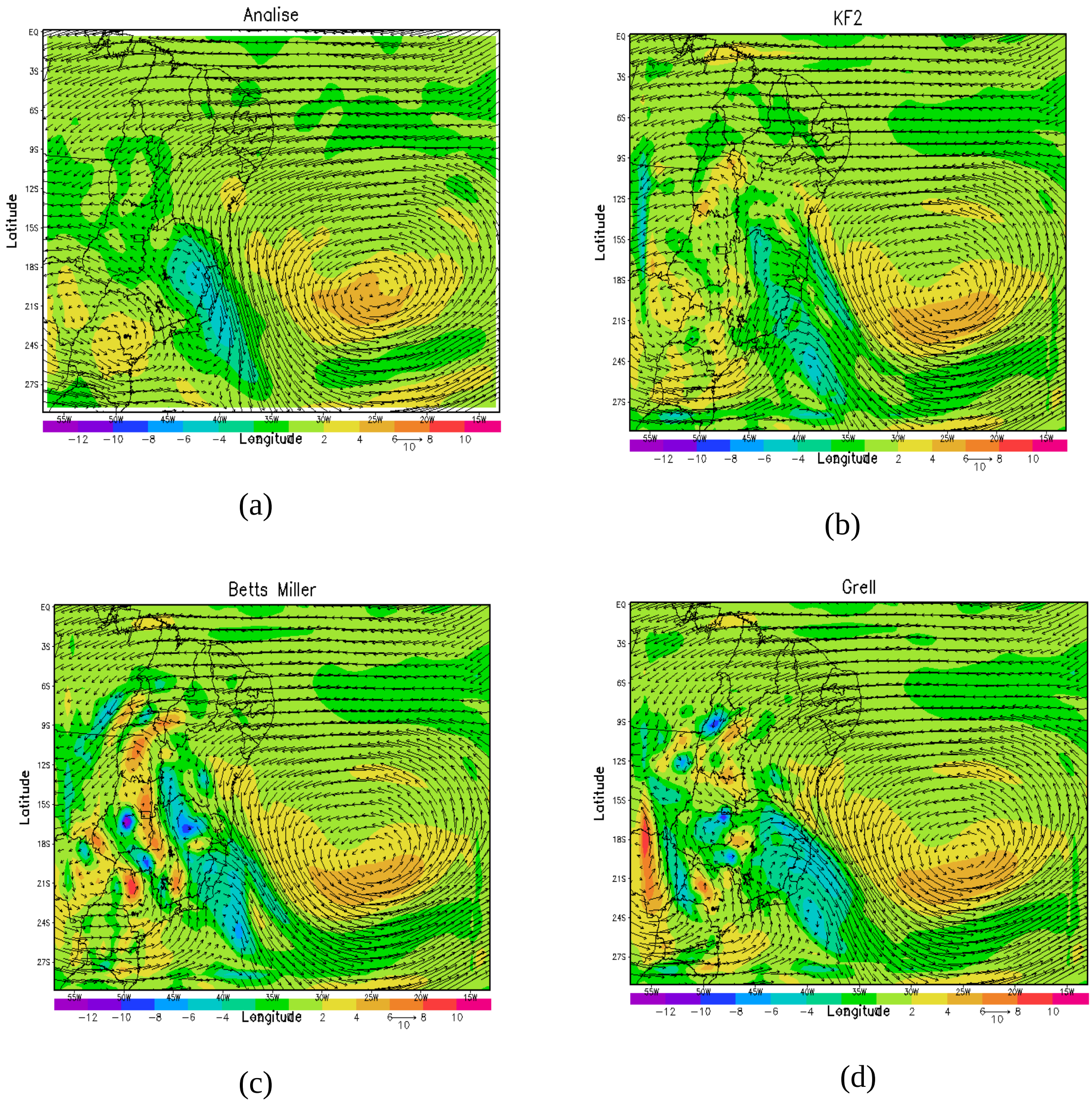


Figure 6 – Average horizontal flow (vector) and average relative vorticity (hatched) in the level of 500 hPa for the day December 19, 2006.

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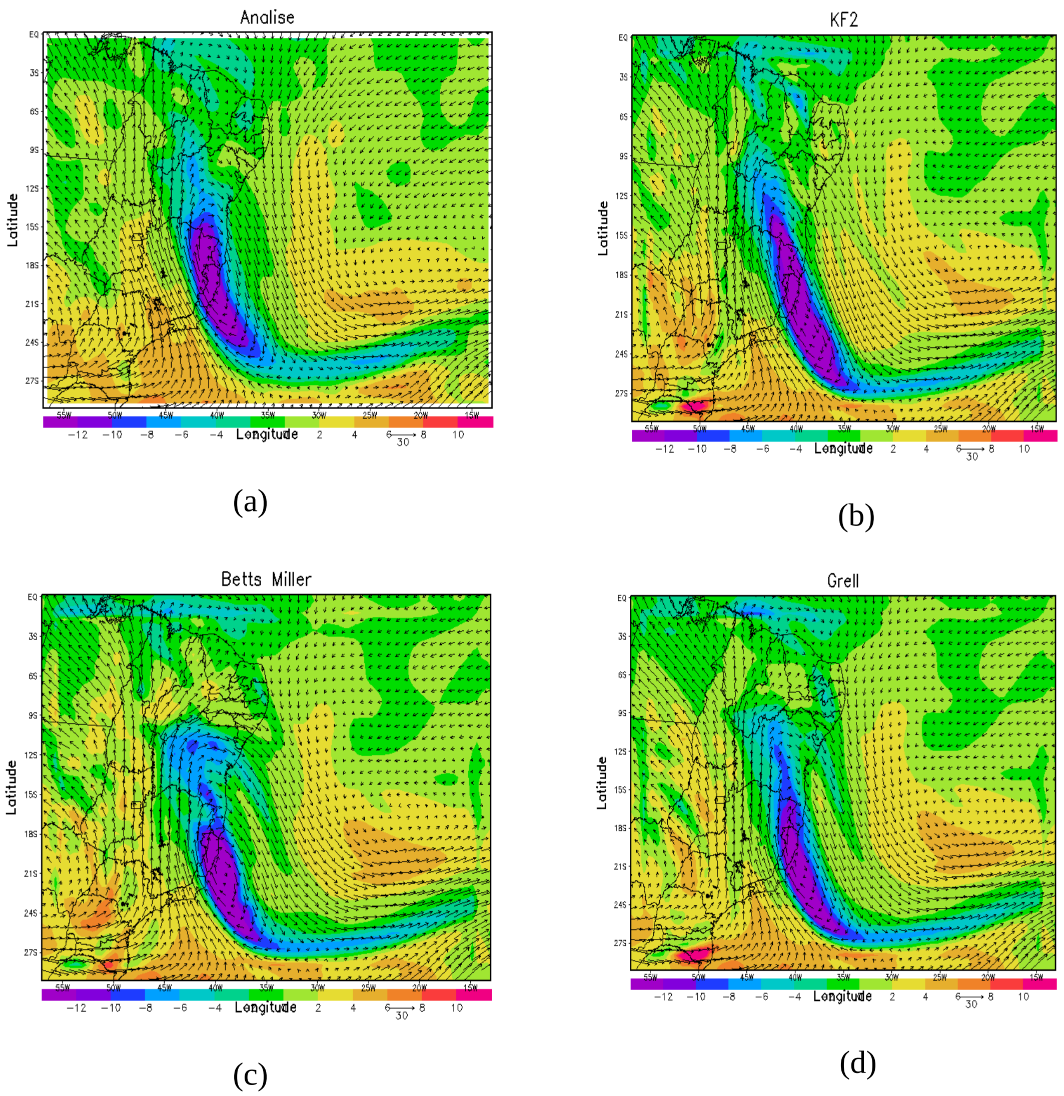

Figure 7 – Average horizontal flow (vector) and average relative vorticity (hatched) in the level of 200 hPa for the day December 19, 2006.

In the EBM (Fig. 8c) , the observed precipitation (Fig. 8a) was overestimated in several regions : western São Paulo state; North of Minas Gerais; Goiás center; a region that includes eastern Mato Grosso, Pará southeast, Tocantins and South of Maranhão and central UTCV. These overestimation induced abnormal intense cyclonic circulation for the first three regions, while for the penultimate region, the abnormality was less intense in the circulation, as well for the 700 hPa as for the 500 hPa level, which indicates that the clouds had great vertical development (above the level of 500 hPa), confirmed by the high relative humidity at this level (Fig. 9c).

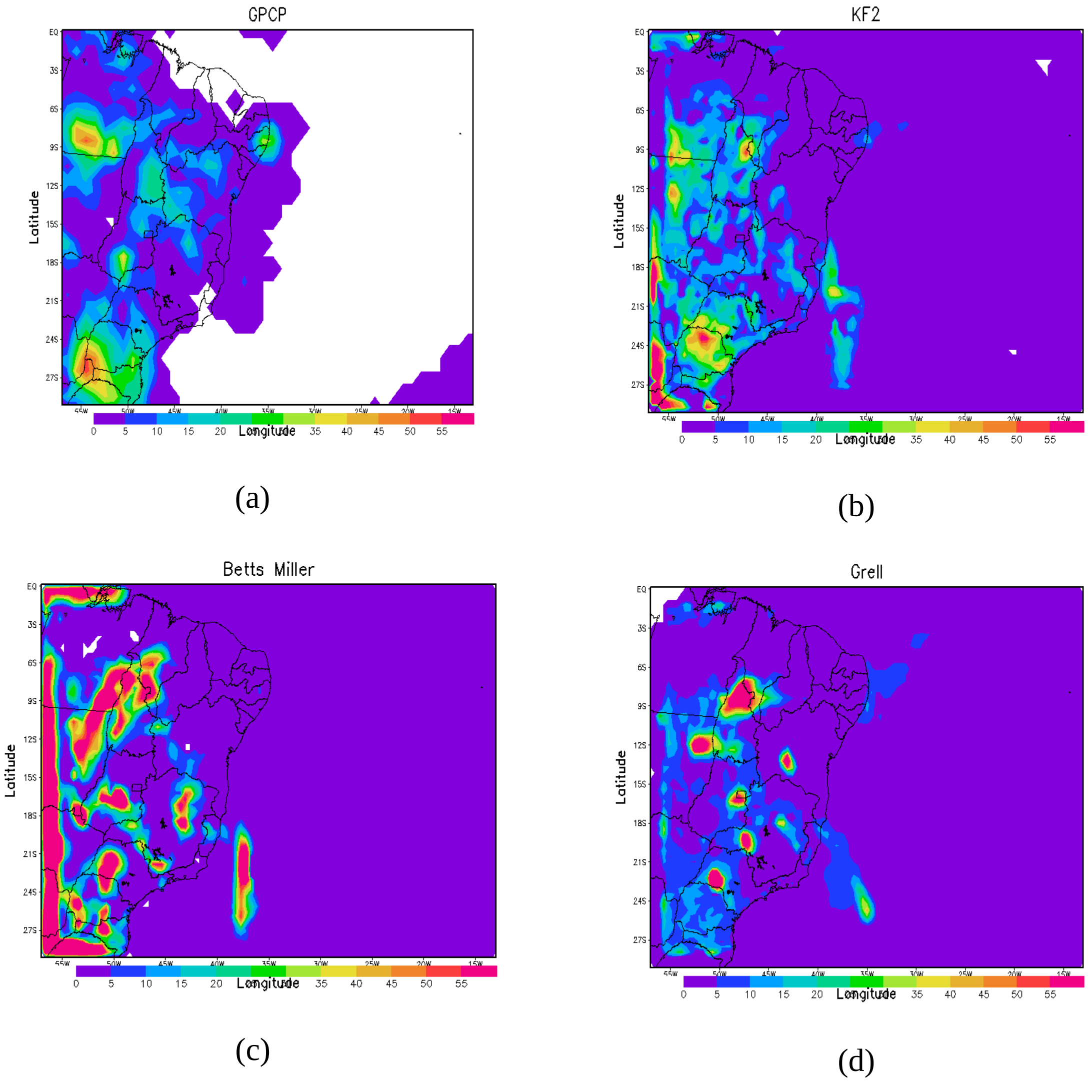

Figure 8 – Accumulated precipitation (mm/day) for 19 December 2006. (a) GPCP; (b) EKF; (c) EBM; (d) EGR.

For the central UTCV, the overestimation of precipitation (Fig. 8c) intensified cyclonic circulation (Fig. 7c) of UTCV at the level of 200 hPa, this intensification deformed circulation even on the north region of Minas Gerais state and NEB. These overstate the other regions may be associated with very dry reference profiles, just in regions with high relative humidity levels the scheme showed a lot of rain. For the region of the center of UTCV, the overestimation may be associated with a very dry reference profile and a wind confluence, which may be generated instability in the atmosphere and contributed to convection be stimulate.

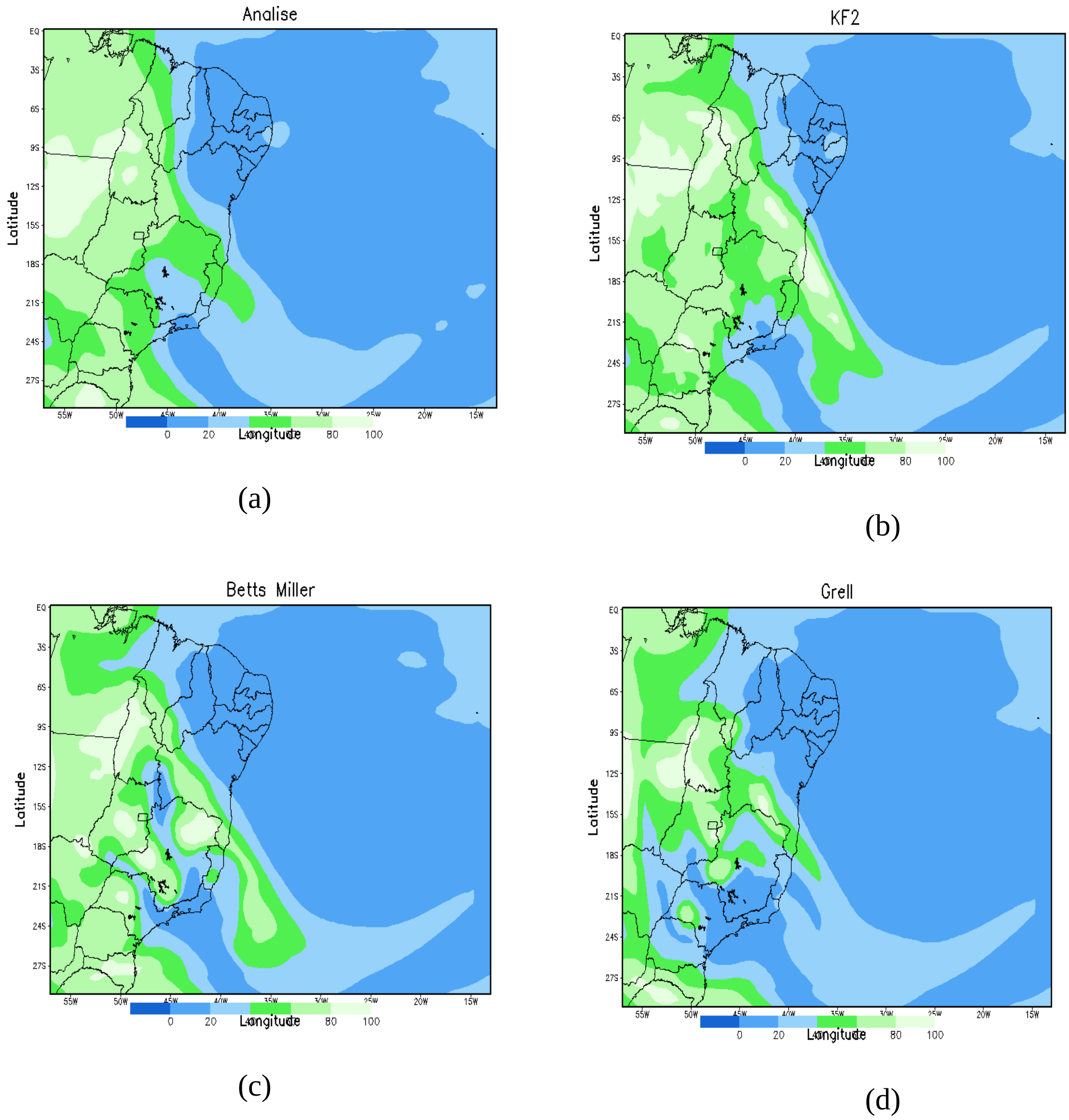

Figure 9- Horizontal moisture average relative humidity (%) at 500 hPa for 19 December 2006. (a) analysis; (b) EKF; (c) EBM; (d) EGR.

In Grell scheme, energy is in a state of statistical equilibrium with the flow of large scale. This statistical equilibrium is called close-to-balance state, which allows diagnosing the cloud mass flow through a function called "cloud-work". The precipitation efficiency is a vertical wind shear function in the lower troposphere thus where there is no wind shear, precipitation efficiency is zero.

In the EGR (Fig. 8d), the observed precipitation (Fig. 8a) was overestimated in the following regions: western of São Paulo state; Triangulo Mineiro; northeast Mato Grosso; Brasilia; north of Tocantins and southwest of Bahia; and in central UTCV. On the northern of Tocantins and southwest of Bahia, the circulation at the level of 700 hPa was little affected by overestimation of precipitation, but at 500 hPa, the circulation had a more obvious anomalous cyclonic behavior. On the other regions (except the central UTCV) the overestimation of precipitation induced anomalous cyclonic flow levels of 700 hPa and 500 hPa, indicating the presence of clouds with great vertical development of these regions, which can be confirmed by high relative humidity at 500 hPa (Fig. 9d). For the downtown area of UTCV, the overestimation of precipitation (Fig. 8d) was small, favoring a slight intensification of the vortex, nevertheless not changing the average horizontal flow (Fig. 7d) at the level of 200 hPa.

None of the experiments was able to reproduce the total rainfall occurred (Fig. 8a) in the north of Bahia and Pernambuco coast. In these regions, the precipitation was underestimated, and the EKF (Fig. 8b) indicated a local maximum in Pernambuco coastland (10-15 mm/day, while precipitation was observed approximately 30 mm/day), and not showed in the local maximum in northern Bahia, which also occurred in other experiments (Figs. 8c-d). The EBM (Fig. 8c), the same way for the northern region of Bahia, not showed a local maximum precipitation on the coast of Pernambuco. While the EGR (Fig. 8d) showed a local maximum at low intensity (5-10 mm/day) and located only on the ocean. This underestimation of these regions may have been caused by the fact that the clouds have not had great vertical development in these regions (see Fig. 4), thus not reaching minimum to trigger convection. Although there was this underestimation of rainfall, was not noticed significant difference in flow fields on those regions, only the EBM (Fig. 7c) showed anomalous flow to the level of at 200 hPa, nevertheless this circulation was induced by strong intensification of UTCV.

It may be also noted that for the Atlantic Ocean region, all PC schemes overestimated rainfall, and only the region associated with the center UTCV induced anomalous circulation, as for the other ocean regions, this was not observed.

Conclusion

Nevertheless it can be said that, the circulation of the day December 19, 2006, associated with the UTCV, which persisted between 18 and 20 days was well simulated by the model for EKF and EGR experiments, while the EBM experiment presented less satisfactory results.

The experiments showed different results from each other for all analyzed fields, being that the EKF showed more consistent with observations. EBM scheme that was most diverged compared with the observed fields. The EGR showed coherent with the observations in the averaged field flow in high levels (200 hPa) and differed more than EKF in the flow fields at average levels (500 hPa) and low (700 hPa), in a consequence of a larger number of regions with anomalous accumulated rainfall.

None of these schemes PC was able to simulate the significant cumulative rainfall occurred in the NEB. For this study, these PC schemes used appeared has not a good performed in representing the generated rainfall by not very deep clouds. Thus, it is suggested that the minimum depth threshold clouds PC these schemes is reduced. More detailed studies should be done to see if this occurs in a systematic way or only occurred in this case, despite this underestimation of rainfall have not caused significant errors in circulation.

The representation of different precipitation was not able to significantly affect the flow at large scale in the EKF and EGR experiments, while that in the EBM, the circulation about the NEB showed inconsistent. When the analysis is made in mesoscale terms, it was noted that the PC schemes has induced erratic circulation at average levels (500 hPa) and low (700 hPa) on the regions where rainfall was overestimated.

From what has been obtained from simulations, precipitation overestimated in the UTCV center region has favored the representation of this system more intensely than that observed and this overestimation was higher, the greater the intensification of UTCV.

Nevertheless it can be said that, for this UTCV case, the choice of the PC scheme has presented differences in flow fields, being this differences became more visible when evaluated smaller scale and lower levels, while high levels were less sensitive the choice of PC schemes.

For the simulation of this study, the most appropriate PC is the Kain-Fritsch, according to the studies of Wang and Seaman (1997) and Cohen (2002), in which this scheme showed precipitation with better results than others. Thus, if the simulated rainfall is well represented by the model, there will be tendency in not induce the anomalous circulation.

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References

Arakawa, A.; Schubert, W. H. 1974. Interaction of a cumulus cloud ensemble with the largescale environment. Part I. Journal of the Atmospheric Sciences, v. 31, n.3, p. 674- 701.

Betts, A. K.; Miller, M. J. 1986. A new convective adjustment scheme. Part II: Single column tests using GATE wave, BOMEX, ATEX and artic air-mass data sets. Quarterly Journal of the Royal

Meteorological Society, v. 112, n. 473, p. 693-709.

Betts, A.K.; Miller, M.J. 1993. The Betts–Miller scheme. In: Emanuel, K.A.; Raymond, D.J. (Ed.) The Representation of Cumulus Convection in Numerical Models. Boston, Massachusetts: Amer. Meteor. Soc., cap.9, p.107–122.

Chen, F.; Dudhia, J. 2001. Coupling an Advanced Land Surface-Hydrology Model with the Penn State-NCAR MM5 Modeling System. Part I: Model Implementation and Sensitivity, Monthly Weather Review, v. 129, p. 569-585.

Cohen, C. 2002. A Comparison of Cumulus Parameterizations in Idealized Sea-Breeze Simulations. Monthly Weather Review, v. 130, p. 2554 – 2571.

Coutinho, M. D. C ; Gan, M. A. ; Rao, V. B. 2010. Método objetivo de identificação dos Vórtices Ciclônicos de Altos Níveis na região Tropical Sul: validação. Revista Brasileira de Meteorologia (Impresso), v. 25, p. 311-323.

CLIMANALISE. 2006. Boletim de Monitoramento e Análise Climática. Cachoeira Paulista, SP: INPE, Mensal.

Dudhia, J. 1989. Numerical study of convection observed during winter monsoon experiment using a mesoscale two-dimensional model. Journal of the Atmospheric Sciences, v.46, p.3077-3107.

Frank, N. L. 1966. The weather distribution with upper tropospheric cold lows in the tropics. Technical memorandum, Oct.

Gan, M. A; Kousky, V. E. 1986. Vórtices ciclônicos da alta troposfera no Oceano Atlântico Sul. Revista Brasileira de Meteorologia, v. 1, n. 92.651, p. 19-28, Junho.

Grell, G. A. 1993. Prognostic evaluation of assumptions used by cumulus parameterization. Monthly Weather Review, v. 121, n. 3, p. 764-787.

Grell, G.A.; Dudhia, J.; Stauffer, D.R. 1995. A Description of the Fifth-Generation Penn State/NCAR Mesoscale Model (MM5). Boulder, Colorado: NCAR, 122p.

Hong, S. Y.; Pan, H. L. 1996. Nonlocal boundary layer vertical diffusion in a medium-range forecast model, Monthly Weather Review, v. 124, p. 2322-2339.

Kousky, V. E.; Gan, M. L. 1981. Upper tropospheric cyclonic vortices in the subtropical South Atlantic. Tellus, v. 33, p. 538-551, Nov.

Kuo, H. L. 1974. Further studies of the parameterization of the influence of cumulus convection on large-scale flow. Journal of the Atmospheric Sciences, v. 31, n. 5, p. 1232-1240.

Kuo, Y.-H.; Bresch, J.F.; Cheng, M.-D.; Kain, J.; Parsons, D.B.; Tao, W.-K.; Zhang, D. L. 1997. Summary of a mini workshop on cumulus parameterization for mesoscale model. Bulletin of the American Meteorological Society, v. 78, n. 3, p. 475-491.

Mlawer, E.J. et al. 1997. Radiative transfer for inhomogeneous atmosphere: RRTM, a validated correlated-k model for the longwave. Journal of Geophysical Research: Atmospheres, v.102, n.D14, p.16663-16682.

Oyama, M.D. Sistema de Previsão de Tempo para o Centro de Lançamento de Alcântara Utilizando o Modelo Regional MM5: Versão 1.0. São José dos Campos: Divisão de Ciências atmosféricas, Instituto de Aeronáutica e Espaço, 2007. 11p. Publicação interna, PI-008.

Ramirez, M. C. V. 1996. Padrões climáticos dos vórtices ciclônicos em altos níveis no Nordeste do Brasil. 132p. (INPE-6408-TDI/618). Dissertação (Mestrado em Meteorologia) - Instituto Nacional de Pesquisas Espaciais (INPE), São José dos Campos, 1997.

Reynolds, R.W. et al. 2002. An Improved In Situ and Satellite SST Analysis for Climate. Journal of Climate, v.15, p.1609-1625.

Wang, W., Seaman, N. 1997. A Comparison Study of Convective Parameterization Schemes in a Mesoscale Model. Monthly Weather Review, v. 125, p. 252- 278, FEB.