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MESOSCALE CLOUD ANALYSIS USING METEOSAT DATA: APPLICATION TO THE JET2000 EXPERIMENT

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1. INTRODUCTION

It is generally well accepted that mesoscale model forecasts of precipitation benefit from the addition of mesoscale details in the initial state of humidity. This is particularly true for tropical and equatorial areas which are characterized by a lack of reliable conventional atmospheric humidity measurements provided by radiosoundings. Hence the large scale analysis (such as the French operationnal analysis ARPEGE or the ECMWF one) used to initialize the mesoscale model is strongly influenced by the guess-field, through the complexity of the assimilation procedure. Satellite cloud data is a piece of information that can provide indirect information on the humidity field, which is not taken into account by the current large scale analysis. Geostationnary satellites such as METEOSAT over Africa provide information on the cloud distribution each 30' with a resolution of 5km (Visible (VIS) and Infra-Red (IR) channels). This time resolution will be increased to 15' in the near future with METEOSAT Second Generation (MSG).

2. DATA AND METHOD

In this study, we take advantage of the JET2000 field campaign which took place in August 2000, using the British C-130 aircraft to make observations of the African Easterly Jet and the west African monsoon. During the flights of the campaign (4 flights) dropsondes were released at high resolution. This data together with the conventional radiosoundings and surface observations provide a good database to evaluate numerical simulations over Africa.

The approach is based on the use of a cloud classification performed by EUMETSAT from the METEOSAT IR/VIS imagery at the pixel resolution (5km). A methodology that adapts the satellite-based cloud classification scheme to the purpose of providing mesoscale relative humidity information through the production of vertical profiles of humidity is proposed. Koch (1997) proposed the following relationship between the cloud fraction f(T) and the relative humidity (RH):

$$RH(T) = (RH_{max}(T) - RH_{min}(T)) \times f(T)^{\frac{1}{2}} + RH_{max}(T) \qquad (1)$$

- T corresponds to the layer that the cloud belongs (High (H), Medium (M) or, Low (L) level-cloud types).
- $RH_{max}(T)$ and $RH_{min}(T)$ are thresholds values, which depend on the layer T.

The pseudo-profiles are produced on the model grid, hence in this case study at a 30km resolution. Only those corresponding to clear conditions (f(T)=0) or cloudy conditions (F(T)=1) are assimilated with a monovariate Optimal Interpolation (OI) scheme in order to modify the initial humidity field only. Simulations have been performed with the MESONH model (Lafore et al., 1998) initialized either by the conventionnal large scale analysis (SIM_CTRL run), or with the modified analysis (SIM_REF run). Meso-β (30km) and meso-γ (5km, explicit convection, inner model nested with the 30km-resolution model) have been performed. 24h simulations have been performed starting either on 28th August 12UTC or 18UTC.

3. RESULTS

Figure 1 shows the METEOSAT IR satellite image taken on 29th August 2000 at 00UTC (only the pixels with a IR brightness temperature below 277K have been plotted). From figure the 3 main convective areas can be identified: A wide area along 20°E, from the Equator to 12°N, in which 3 Main Convective Systems (MCSs) are visible , labelled A1, A2 and A3 on fig. 1. A second area close to 10°E, west of lake Tchad is concerned by MCS B. Another MCS (labelled C) is found close to 5°W.

Numerical simulations at 30km resolution have been performed with the MESONH model starting on 28th August 2000 18UTC, initialized either with the ECMWF fields (SIM_CTRL run) or with the same fields except for the humidity field modified by the insertion of cloud information (SIM_REF run). The synthetic IR METEOSAT images for 29th August 2000 00UTC (6h range) computed from the MESONH simulated fields are shown on figure 2 (SIM_CTRL run) and figure 3 (SIM_REF run).

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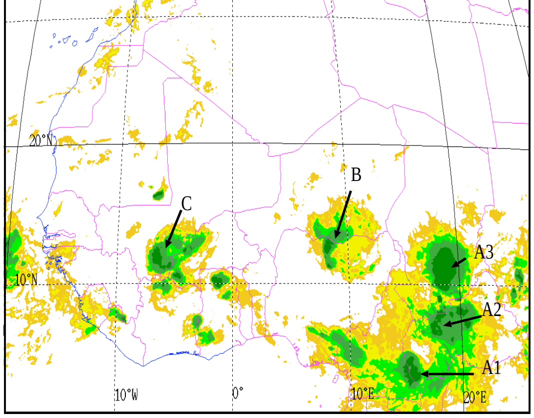

Figure 1: IR METEOSAT image taken on the 29th August 2000 at 00UTC. ($T \leq 277^\circ K$ plotted)

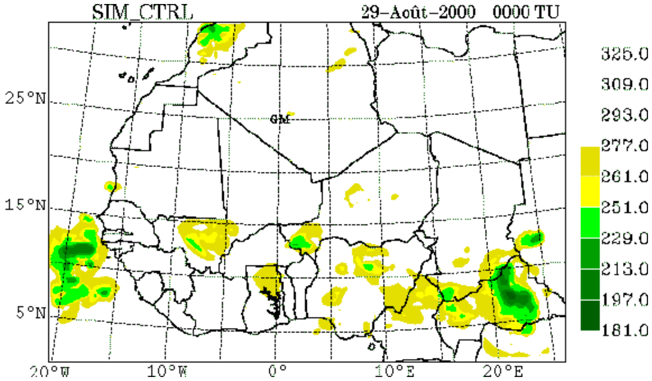

Figure 2: Synthetic IR METEOSAT image for 29th August 2000 at 00UTC for the SIM_CTRL run.

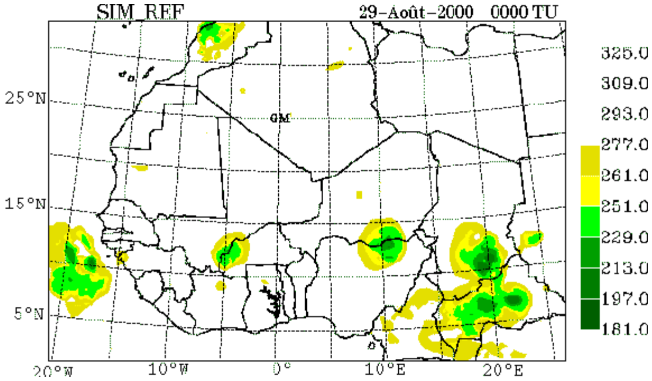

Figure 3: Same as fig.2 but for the SIM_REF run

From those figures it can be seen that system A3 is much more active in the SIM_REF run than in the SIM_CTRL run. A2 is simulated by both the SIM_CTRL and SIM_REF runs. Neither simulation predict correctly system A1. System B which was weakly triggered in the SIM_CTRL run, but not at the precise location is now present in the simulation at the correct position, when cloud information is inserted in the initial conditions. System C is better localized in the SIM_CTRL run. Moreover the convective system observed in the SIM_CTRL run by 2E,13N, not observed by the satellite does not exist anymore in the SIM_REF run. It is clear from above that the insertion of cloud information in the initial state leads to a dramatic improvement in the simulation. A sensitivity study showed that the improvements are larger when the insertion time is 18UTC instead of 12UTC, due to the fact that convective activity over western Africa peaks in the afternoon (between 16 and 20 local time). Nevertheless it should be noted that the simulated MCS's propagate too slowly and dissipate during the night contrary to the METEOSAT images. We guess that it is due to the convection parameterization scheme used at this resolution (30km).

To test this hypothesis Meso-γ scale simulations have been performed on system A3 at a 5km resolution, with explicit representation of convection on a 540kmx540km domain, nested in the previous domain. Initial conditions were taken from the modified analysis since no convection was triggered when using standard ECMWF analysis. At meso-γ scale, the model shows a much more realistic simulation, in term of propagation speed and life cycle than in the meso-β simulation.

4. FUTURE

It is foreseen (under development) to use the Wator Vapor (WV) channel of METEOSAT to improve the estimation of humidity in clear sky conditions or above low level clouds. This will be done by using the Upper Troposheric Humidity (UTH) information derived from the WV channel (Roca, 2002).

5. REFERENCES

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