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SATELLITE DATA ASSIMILATION: IMPACT ON TROPICAL CYCLONE FORECAST.

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1. INTRODUCTION

Quality of tropical cyclone (TC) forecast by numerical weather prediction (NWP) model is linked with their representation in analysis. Oceans are often poor with in-situ data. Assimilation of satellite data is crucial on these areas.

In this study we will show the impact of ERS scatterometer data in the 3D-var and 4D-var assimilation of the French model ARPEGE. We also have introduced a synthetic observation (bogus) from Dvorak TC analysis (Dvorak, 1984). The quality control of the simulations is done against best track.

2. DESCRIPTION OF THE EXPERIMENTS

The aim of these experiments has been to investigate the impact of ERS scatterometer data in ARPEGE assimilation. The TCs season 1999-2000 of the Southern hemisphere has been investigate carefully, and we have chosen two TCs, where we had many ERS data: Babiola (3-12 January 2000) and Hudah (24 March - 2 April 2000). We have conducted 6 experiments.

- 3D-var
- 3D-var with ERS data
- 4D-var
- 4D-var with ERS data
- 4D-var with Bogus
- 4D-var with Bogus and ERS

The bogus observation as described in Soulan and al. (2000) is only an observation of sea surface pressure at the center of the TC calculated through Dvorak analysis introduced every 6 hours in the observation data file.

The model ARPEGE is a spectral model with full physics (Courtier et al 1988), in its tropical version over Indian ocean with a truncation T127, 31 levels and a stretch coefficient C3.5. The computation grid has a resolution a bit less than 30 km in the area of TC Babiola and Hudah.

The 3D-var analysis is a T95L31C1, and the 4D-var is multi incremental T42T63L31C1.

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3. RESULTS

In a first part we will focus on the impact of 4D-var versus 3D-var assimilation. Then we will show how scatterometer data are taken into account in 3D and 4D assimilation, without or with bogus observation.

3.1 Impact of 4D-var versus 3D-var

There is a main difference between 3D-var and 4D-var assimilation scheme. For 3D-var assimilation, as in the optimal interpolation scheme, all the observations are translated in time on the nearest synoptic time. In case of 4D-var, time dimension of observations is taken into account. All the observations are introduce in the analysis at the time of observation. That could be very important for satellite data, as ERS-scatterometer winds.

On Babiola case, even with a coarser resolution the 4D analysis is closer to the best-track than 3D one (figure 1). We can see that both analysis have the same shape at the very beginning of the Babiola history, as it was only a tropical storm (wind less than 87 km/h), but a bit far from the best-track analysis. As Babiola reaches the severe tropical storm status, both analysis are nearer of the best-track than in the previous days. But in 4D-var the trajectory has also a better shape between 9 and 10 January.

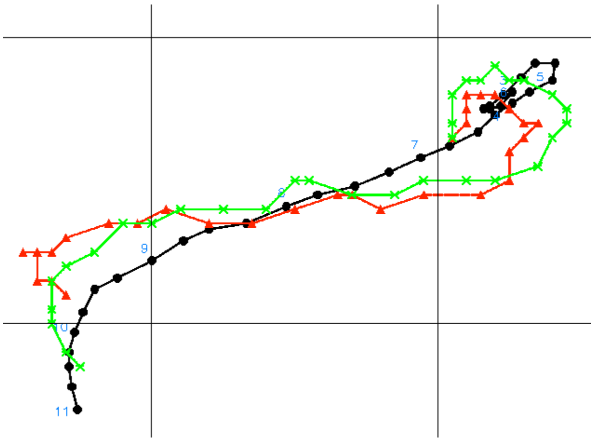

Figure 1: Analysed position with 3D-var scheme (triangles symbols), 4D-var (crosses) in regard with best-track (dots),

Even with a coarser resolution the impact on forecast is more important, in 4D-var analysis. Table 1 shows the improvement in localisation of the center of the TC due to 4D-var versus 3D-var. In this table we have shown the results for both TCs (Babiola and Hudah). The mean improvement is about 60 km.

Forecast	0 h	12 h	24 h	36 h	48 h	60 h	72 h
km	67	56	52	59	79	44	62

Table 1: Improvement of 4D-var analysis scheme versus 3D-var (17 forecast).

3.2 ERS or no-ERS, in 3D-var and 4D-var

ERS scatterometer winds have an important limitation due to the narrow swaths (500 km) of the instrument. As yet pointed out by Isaksen et al. (2000) the full circulation could hardly be taken into account by these winds. In case of a cyclone on the edge of the swath, such data can introduce artificial asymmetries in the analysed TC structure, which can result in a wrong initial movement, and a poor forecast.

It is also important to remind that in our quality control check scatterometer winds are rejected as well as wind are more intense than 25 m/s in the first guess of the NWP, or in the measurement from ERS. This point is very important in case of tropical cyclone. To be consistent with the analysis resolution we have taken only one wind each four (100 km resolution).

A main result of this study is that the impact of ERS-scatterometer wind in the analysis and in the forecast is not very important. The impact is lightly positive with the 3D-var scheme for Babiola, and slightly negative for Hudah. The impact is in the reverse sense for 4D-var scheme. As pointed out previously the impact is sometimes negative due to the artificial asymmetries introduced.

3.3 Impact of a bogus observation in 4D-var

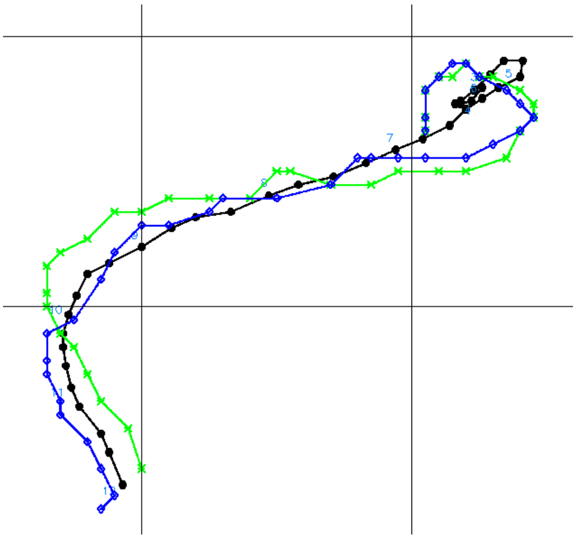

Figure 2: Analysed position with 4D-var scheme with (rhombus), without bogus (crosses) in regard with best-track (dots),

In this part we focus our study on 4D-var analysis (the last four experiments) and in the Babiola case. As shown in figure 2, the bogus observation introduced improve the analysis. The forecast scores are also far better. For example, the 72 h forecast error falls from more than 560 km in 4D- simulations to less than 300 km in the 4D-bogus. The impact on the intensity is also very important, as the mean central pressure error in the TC falls from 20 hPa to about 4 hPa.

We have also tested the impact of ERS-scatterometer wind in the bogus analysis. But the impact is not significant. As the vortex in the guess is better represented in this analysis, we thought that there were less wind rejected by the quality control check. We suggest that as the intensity is better seen in the analysis, there are more wind with a speed above 25 m/s and them more wind rejected by the creaming. This is seen on the number of wind rejected in the vicinity of the TC that increase with the bogus analysis.

4. CONCLUSIONS

On this preliminary study on two cases of TC over Indian ocean, we show that the impact of ERS-scatterometer wind is not significant. The improvement of the quality of the trajectories is well correlated with the quality of the analysed intensity of the TCs. As seen by other authors, the narrow swaths of the instrument can be pointed out as introducing asymmetries and by the way false intensity analysis. We hope Quikscat data will help to solve this problem. But increasing the analysis resolution is an other way to improve the intensity analysis with satellite observations.

5. REFERENCES

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