Tropical cyclone track forecasts using a limited-area model: sensitivity to the lateral boundary conditions

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Abstract: The link between tropical cyclone track forecasts by Aladin-Réunion limited-area model and by its coupling model Arpege is investigated in the South-West Indian Ocean. A significant impact of the coupling model on the LAM track forecasts is shown after the 2-days term, although the sensitivity to initial conditions remains predominant in some cases.

1. Introduction

Limited-area models (LAM) at high resolution are commonly used for tropical cyclone (TC) forecasting. In the South-West Indian Ocean, Météo-France operates the LAM Aladin-Réunion (Montroty et al, 2008) at 8 km horizontal resolution over the domain [31.5E,88.5E] $\times$ [0,32S]. Aladin has its own 3D-Var assimilation cycle and it assimilates wind bogus pseudo-observations to initialize TCs. Its lateral boundary conditions come from the Arpege coupling global model (CGM), at a 3-hour coupling frequency. Both models have the same dynamics and physics.

On average, the cyclone track forecasts by Aladin are better than the ones by Arpege until the final term (84 h). Little is known about the sensitivity of track error to the CGM, and what skill change may be expected from using a different CGM. To address this question, two diagnostics are presented here: a correlation analysis between errors by different models and some case studies.

2. Statistical link between track error in a LAM and in its coupling global model

The TCs of all intensities during the 2009-2010 season (from october 2009 to april 2010) are considered here. Correlations are computed between the forecast errors by different models (Fig. 1): Aladin, Arpege and the European Centre for Medium-Range Weather Forecasts operational deterministic model (IFS).

The correlation between the independent models (Arpege vs IFS, Aladin vs IFS) is around 0.5 at the initial forecast time, but then it vanishes steadily until it reaches a zero value at 84 h. The correlation between Aladin and its CGM Arpege conversely starts at a low correlation value (around 0.2), increases rapidly until 24 h and then increases steadily until it reaches the 0.6 value at 84 h. The low correlation at 0 h lead time may be due to the assimilation of wind pseudo-observations in the Aladin 3D-Var, which has a strong impact on the TC position in the analysis. The correlation between the LAM and its CGM reaches high values compared to the independent models after 48 h. But track errors of the LAM and of its CGM are not perfectly correlated, even at 84 h: the LAM forecast tracks are partially independent of the CGM forecast tracks.

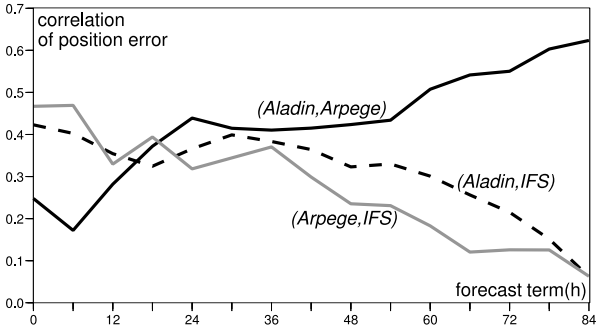

FIG. 1. Evolution with the forecast lead time of the correlation between the position errors of the TC forecasts by Aladin, its CGM Arpege and IFS, during the 2009-2010 cyclone season.

3. Sensitivity of track error in the LAM to its coupling model

The sensitivity of TC track forecasts by the LAM to its CGM is investigated on two TCs, Gael (February 2009) and Edzani (January

2010), which have both reached an intense stage (maximum winds over 90 kts). Two configurations of the stretched CGM Arpege have been run, one at the truncation T538C2.4 (roughly 55 km equivalent grid spacing), called ArpT538, and the other one at T798C2.4 (roughly 35 km equivalent grid spacing), called ArpT798. The Aladin assimilation cycles and forecasts coupled with both configurations of Arpege have also been run, leading to the associated forecasts called AlaT538 and AlaT798. In both experiments, the LAM configurations are the same. The initial instants of the forecasts are at 00 UTC and at 12 UTC. The mean evolution of the position error along the forecast terms for these 4 models on several forecasts (Fig. 2) reflects the sensitivity of the LAM to its CGM.

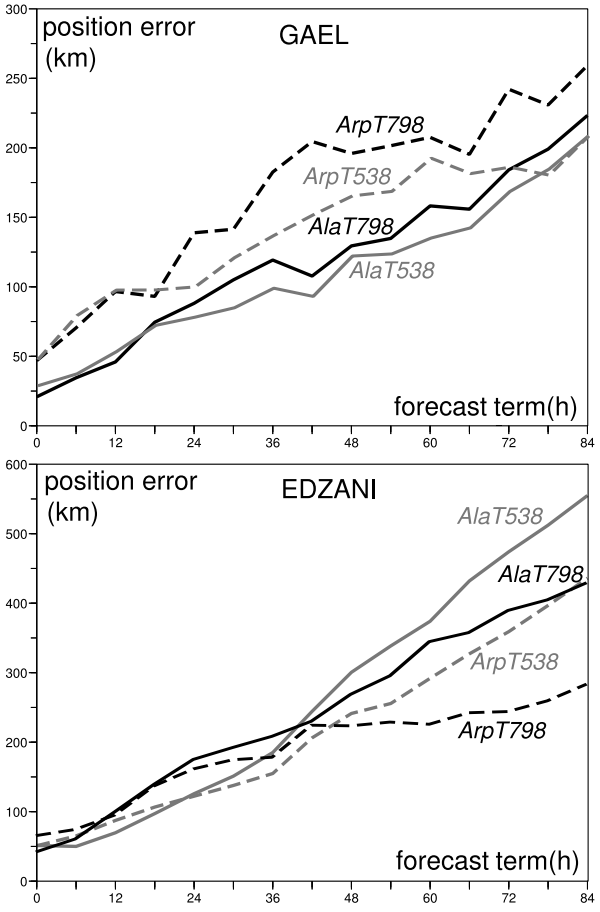

FIG. 2. Evolution for the TCs Gael (top) and Edzani (bottom) of the error of the forecast positions by the CGM Arpege at truncation T538C2.4 (ArpT538, dashed grey), at truncation T798C2.4 (ArpT798, dashed black) and by the associated LAM Aladin (AlaT538, solid grey) and (AlaT798, solid black). The curves are an average of 7 forecasts for Gael and 9 forecasts for Edzani.

Gael and Edzani illustrate two different configurations of position errors. In the case of Gael, the LAM performs better than its CGM, which happens the most frequently. For Edzani, the CGM performs globally better than the LAM. In both cases, the error reduction at long terms (after 48 h) between ArpT538 and ArpT798 apply partially to the LAM forecasts. Moreover, in the case of Edzani, ArpT798 is the only model that is able to represent an abrupt change of track: even AlaT798 does not show it. In such a case, the initial conditions in the LAM may play a critical role.

4. Conclusion

This short study documents how changing the CGM used for the lateral boundary conditions of the LAM Aladin may change its performance for TC track forecasts. At short range (below 48 h terms), the forecast position error of the LAM is not much linked to the CGM error. After 48 h, the CGM performance has an impact on the LAM, and it explains about an half of the LAM forecast error. Still, in some cases, the LAM track forecast is only slightly linked to the CGM one, which suggests that sensitivity to the initial conditions is predominant.

These results, which may depend on the size of the domain, are consistent with some previous studies using a different model in Taiwan (Hsiao et al, 2009). Better data assimilation in LAM for tropical cyclones is critical for improving track forecasts, but the performance of coupling global model also deserves attention.

References

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