V1.3 A DEDICATED CONVECTION-PERMITTING ENSEMBLE IN THE OPERATIONAL NWP SYSTEMS AT METEO-FRANCE FOR THE TROPICS

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1 Introduction

Tropical cyclone (TC) intensity change forecast is quite crucial, especially when such phenomena are approaching coastal-island regions. Complex interactions between both environmental (large-scale) external factor and internal (fine-scale) mechanisms strongly control TC predictability, and therefore our ability to properly predict intensity changes. The French Overseas territories, present in most of TC basins (North Atlantic, South West Indian Ocean and South Pacific), are largely concerned by TC hazards. In order to provide ever more effective guidance to RSMC - La Réunion TC center, weather numerical prediction systems at the French Weather Service, Météo-France, have been improved, notably the Arome Overseas operational deterministic chain, and very recently, for operations in 2023, its ensemble prediction system called AROME-OM EPS. The AROME-OM model, described by [1], has a horizontal resolution of 2.5km and is operated twice daily across five tropical domains.

The objective of the present study is to assess the performance of the AROME-OM EPS for TC prediction focussing on reforecasts of TC events that occurred in the southwest Indian Ocean (SWIO) during the 2022-2033 TC seasons. Special attention is paid to predictability of TC Batsirai (2022). An analysis of a few synoptic-scale environmental and TC-scale variable calculation has been performed in a probabilistic framework in order to assess the ability of AROME-OM EPS in providing guidance of possible scenarios of Batsirai while approaching Mauritius and La Réunion islands.

2 The AROME-OM Ensemble Prediction System

The AROME-OM EPS ensemble set-up is the following :

(i) The ensemble runs comprise 15 'perturbed' + one control 'unperturbed' member (16 members) up to 72 h forecast range.

ii) Lateral Boundary Conditions (LBC) are provided by a subset of about fifteen members of the ARPEGE EPS called PEARP ([2]), selected according to a clustering approach.

iii) Initial perturbations from PEARP are downscaled on the 2.5 km AROME-OM grid and added to AROME-OM analysis (zonal and meridional wind, temperature and surface pressure).

iv) Atmospheric model errors are represented by the stochastic perturbation of physics tendencies (SPPT) scheme from ECMWF and adapted for the AROME model ([3])

v) Surface (continental) and sea surface temperature (SST) and ocean (temperature) conditions of the AROME model are also perturbed using the same 2D horizontal random pattern.

3 Overall performance of AROME-OM EPS

In order to assess the overall performance of AROME-OM EPS for TC prediction, a statistical analysis of intensity, track, and structure errors was performed for 7 storms that occurred in the simulation domain during 2022-2023 TC seasons. AROME-OM EPS and its driving model (PEARP) are verified RSMC La Réunion Best-Track (BT) database. In order to fairly compare both ensembles, model fields are interpolated onto the same grid with a horizontal resolution of 0.025°.

Although AROME-OM EPS overestimates intensity at longer range, intensity biases are significantly reduced compared with PEARP, which tends to underestimate TC intensity at all lead times (Fig1a). Contrary to what one would expect, absolute track errors are improved for AROME-OM EPS against PEARP (Fig.1b). It could be due to much better initial conditions in AROME-OM analysis that could imply better interaction between the TC's vortex and its environmental steering flow. Regarding surface wind structures (tropical storm wind radii), AROME-OM EPS biases are quite reduced, although being slightly positive between 36h and 60h (not shown). Broadly speaking, AROME-OM EPS has a much better handle on TC intensification (not shown).

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Figure 1: a) Maximum wind bias, b) Absolute Track errors from AROME-OM EPS (red) against its coupler PEARP (blue) as a function of forecast time (h). The error bars show the 95% confidence interval.

4 Predictability of TC Batsirai (2022)

Special attention is paid to TC Batsirai (2022). After having impacted by vertical wind shear and dry air (Fig 3a), Batsirai found very favorable conditions over the SWIO basin and became a powerful TC (Fig 3b). It moved very close to both Mauritius and La Réunion islands, before hitting Madagascar very hard.



Figure 2: 72-h tracks of TC Batsirai started on 30/01/22, at 1800 UTC. Squares show the Best Track. Thick line highlights the ensemble mean. Number labels mark TC position at 24h, 48h and 72h, respectively

Based on this specific run (30/01/22 at 18UTC), AROME-OM EPS already showed two possible track scenarios : either moving southwest very close to Mauritius and La Réunion, or more west-southwest a bit away from the islands (Fig.2). One of the key parts of TC intensity



Figure 3: Time-series of Batsirai's predicted intensity change. Forecast starts on 31/01/22, at 1800 UTC. The lines indicate different percentile thresholds. Red squares show the BT. The green line highlights the rapid intensification (RI) threshold.

change prediction is also to correctly predict its (rapid) intensification. AROME-OM EPS enables to capture fairly well the Batsirai's RI almost 30h-36h ahead (Fig.3).

Furthermore, the decrease of spread on inner-core structure metrics, including vortex tilt ([4]) and on the related convective structure suggested a very favorable configuration (upshear convection triggering along the radius of maximum wind (RMW) and less uncertainty for a scenario of a powerful intensifying TC approaching the islands (not shown).

5 Conclusions and future works

AROME-OM EPS has demonstrated its ability to capture and anticipate the Batsirai's rapid intensification. Work is in progress at Météo-France in order to improve this first version of AROME-OM EPS, better taking into account for modeling errors. Results will be reported during the next AMS Hurricane and tropical cyclone conference.

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