



Impact of convection schemes on forecasts of TC-Kirrily

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1. Introduction

Representation of convection in numerical models significantly influences the accuracy of tropical cyclone (TC) forecasts. We examine forecasts of TC Kirrily using the Unified Model GA8GL9 and GAL9 configurations, comparing the current convection scheme (Gregory and Rowntree 1990) and the CoMorph-A configuration (Whitall and Matsubayashi 2022), a package of changes which includes the CoMorph convection scheme.

2. Model descriptions

- GA8: default global model configuration (uses 6A mass-flux convection scheme)
- GA8-CoM: GA8 but with CoMorph-A convection package
- GA9: default global model configuration (uses 6A mass-flux convection scheme)
- Model horizontal resolution: 12km
- Vertical levels: 70

3. Large scale environment

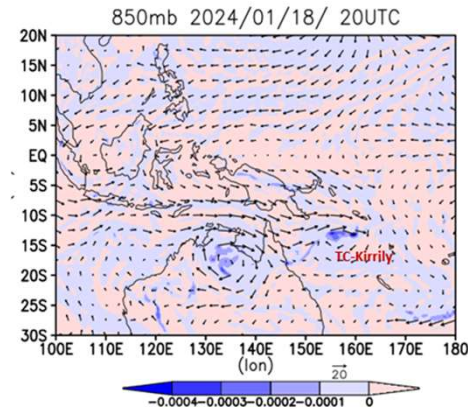


Fig. 1: 850 hPa wind vectors (m/s) and vorticity (1/sec) (shaded) from the ERA5 reanalyses at 20 UTC on 18 January 2024

The large-scale flow was typical of the Australasian monsoon. On 18 January 2024, in the early stages of the developing cyclone, strong easterlies between 8°N and 15°N turned to northerlies in the western part of the domain, crossing the Equator and feeding into strong westerlies south of the equator. These westerlies turned clockwise, forming cyclonic flows in the Southern Hemisphere, and one of the lows that developed was TC Kirrily.

4. TC-Kirrily: Intensity and track forecasts

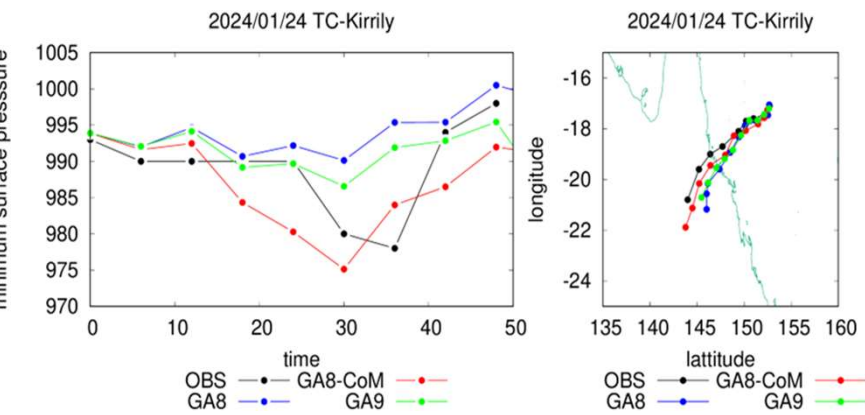


Fig. 2 The intensity evolution with time (hours) in terms of minimum surface pressure (left); and the track in terms of the position of the central surface pressure (right) for TC Kirrily from observations (black; the best track databases) and forecasts from GA8 (blue), GA8-CoM (red) and GA9 (green). The forecasts were initialised at 00UTC on 24th January 2024.

TC Kirrily experienced slow intensification starting on 24th Jan. This was followed by rapid intensification, reaching a minimum surface pressure of 978 hPa after 36 hours, just before landfall. The cyclone then rapidly decayed.

The GA8 (blue) and GA9 (green) forecasts did not capture the rapid intensification. GA8-CoM (red) agreed well with OBS (black), albeit intensifying earlier. The track forecasts were more similar between the models.

7. Conclusion

GA8 did not capture the cyclone's rapid intensification, whereas GA8-CoM did significantly better. A key difference is in how they handle convective and large-scale rainfall. GA8 captured the dominant role of parameterized convection during the developing stage of the cyclone. However, when the moist static stage was reached, the large-scale rainfall failed to dominate. Consequently, the TC core region dried out, causing the storm to weaken. In contrast, GA8-CoM captured the shift in deep convection within the core, transitioning from parameterized convection to large-scale moisture processes. This transition drives the rapid intensification and maintains the cyclone's strength.

5. Large-scale vs convective rainfall: azimuthal averaged rainfall rate

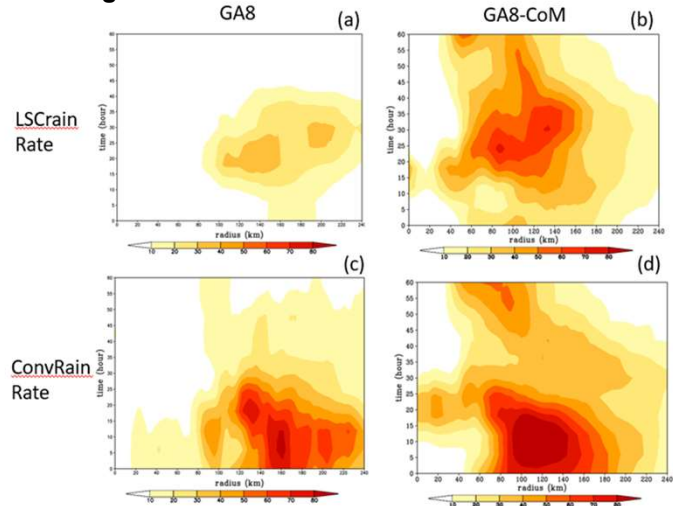


Fig.3: Time-radius plots of the azimuthal average of the large-scale (a and b) and convective (c and d) rainfall rates for the GA8 experiment (left) and GA8-CoM experiment (right).

A key difference between GA8 and GA8-CoM is the role of large-scale rainfall during the mature stage of the TC. In GA8-CoM, large-scale rainfall peaks leading up to the mature stage of the TC and is sustained, which is responsible for the TC's rapid intensification and reaching its mature stage.

Conversely, in GA8, the large-scale rainfall remains weaker than parameterised convective rainfall, and is not sustained, preventing the storm from rapidly intensifying and maturing.

6. Relative humidity: azimuthal average

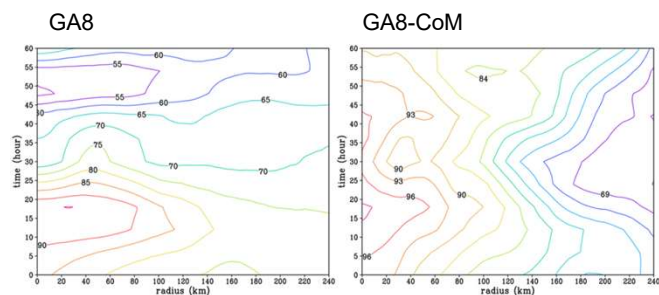


Fig4: Time-radius plots of the azimuthal averaged relative humidity at 500hPa for GA8 (left) and GA8-CoM (right).

In GA8-CoM, the coupling between parameterised convection and large-scale convection led to a quasi-saturated TC core region that was sustained during the intensification and mature phases of the TC. In contrast, the saturated core is not sustained in GA8 due to the decoupling of the convective and large-scale rainfall.