Sensitivity of an unusual cyclone in southeast South America to convective parameterization schemes in the new ICTP RCM (RegCM5)

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ABSTRACT

Raoni storm (2021) was a winter extratropical cyclone that underwent rapid intensification and transitioned to a subtropical cyclone over the Atlantic coast of southern South America, inducing gale-forced winds. This study evaluates the performance of three parameterization schemes (Tiedtke, Emanuel and Grell) in simulating the cyclone evolution. The Tiedtke scheme demonstrated the best performance in representing the position, intensity and duration of the cyclone, though it underestimated maximum intensities.

METHODOLOGY

The RegCM5 model [1] is used to assess the following mixed schemes: Tiedtke over continent and Kain-Fritsch over ocean (Tiedtke), Emanuel over continent and Grell over ocean (Emanuel); and Grell over continent and Emanuel over ocean (Grell). Simulations are performed with a 25-km horizontal grid resolution (305 × 235 points) and 23 vertical levels for the period from 00 UTC June 15th to 18 UTC July 5th, 2021. Initial and lateral boundary conditions are derived from the ERA5 reanalysis. A tracking algorithm [2] based on 6-hourly relative vorticity at 850 hPa is used to identify and track the cyclone.

RESULTS

- Tiedtke scheme: Best performance in reproducing cyclone evolution and precipitation pattern.
- Emanuel scheme: Represents cyclone growth well but dissipates too early.
- Grell scheme: Poor performance, indicates cyclone moving southeastward into the ocean.

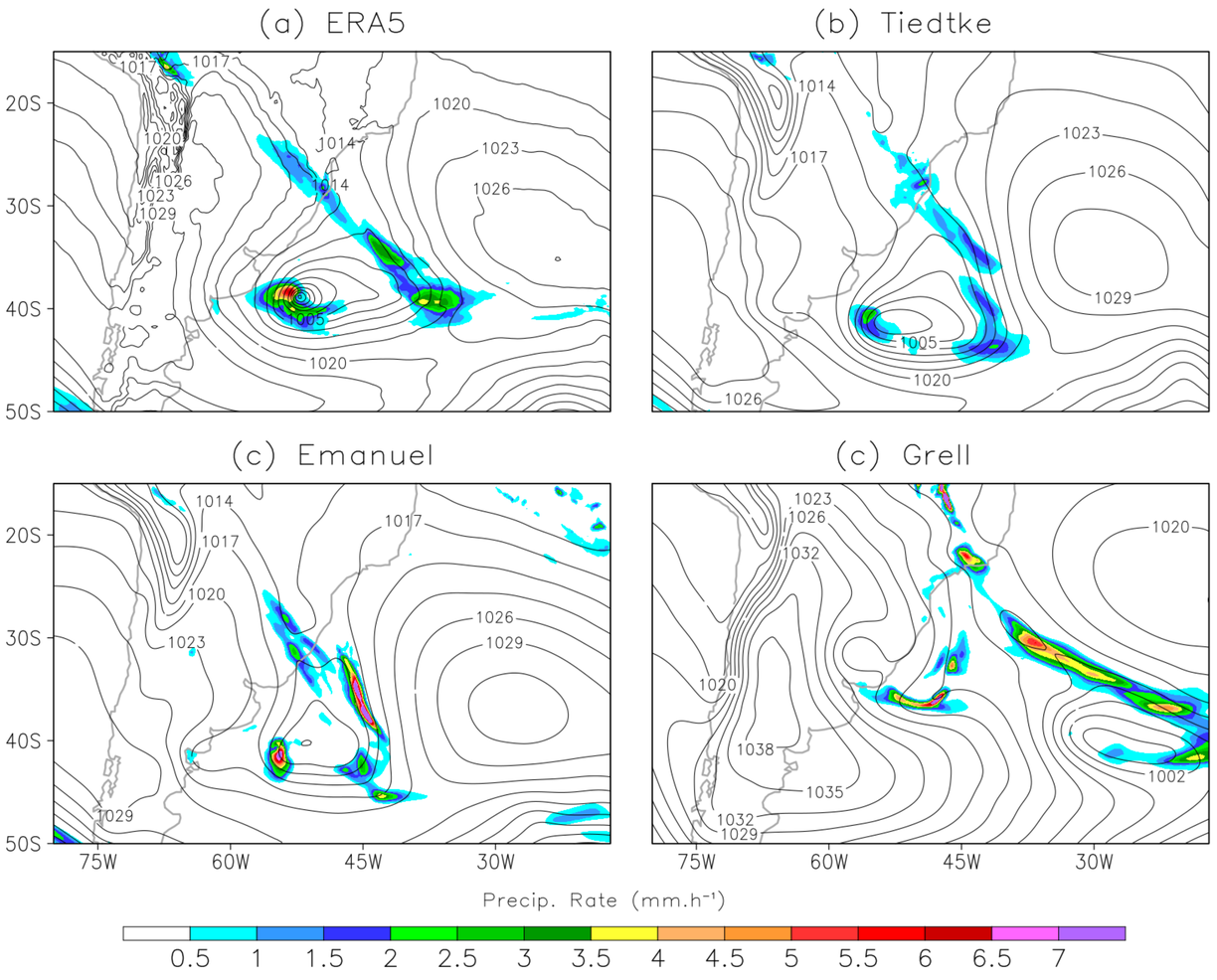

Figure 1 – MSLP (black contour) and 6-hourly total precip. rate (colour) for ERA5 and RegCM5 model with different parameterization schemes.

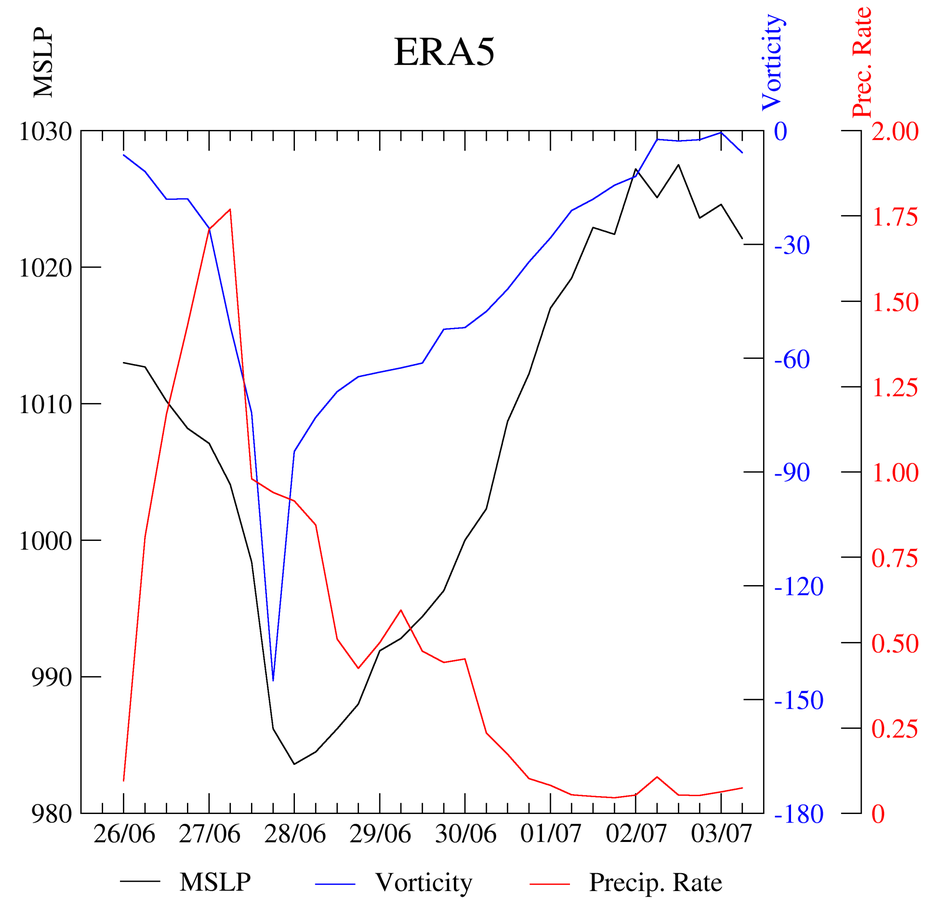

Figure 2 – Temporal Evolution of cyclone Raoni in terms of area-averaged precipitation (red), and minima of MSLP (black) and 850-hPa vorticity (blue) for ERA5 .

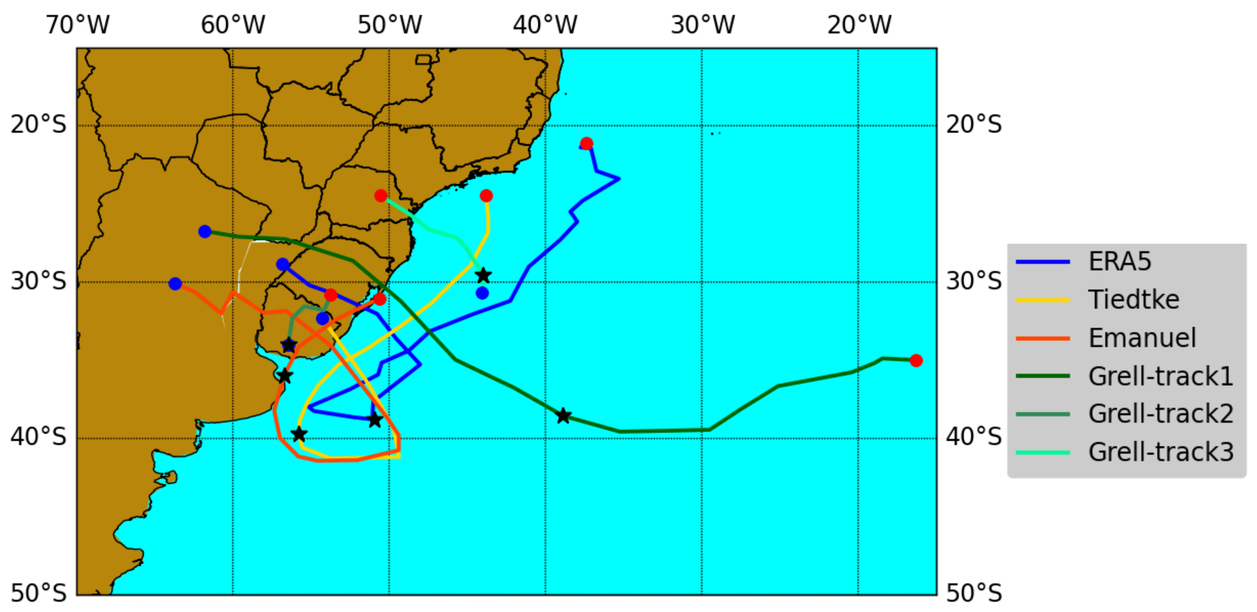

Figure 3 – Cyclone trajectory in RegCM5 compared to ERA5. Blue (red) points are the first (last) track points; star is the peak intensity in the 850-hPa vorticity..

CONCLUSIONS

Model simulations show shorter cyclone lifecycles compared to reanalysis, likely due to intensity underestimation. The Tiedtke scheme performs best in representing cyclone evolution (position, intensity, duration). The Emanuel scheme captures growth and initial propagation well but the cyclone dissipates prematurely. The Grell scheme poorly simulates cyclone evolution. Overall, the model correctly simulates the precipitation cycle with the peak rate just before cyclone intensity, followed by a rapid decline.

REFERENCES

[1] GIORGI, F. et al. The Fifth Generation Regional Climate Modeling System, RegCM5: Description and Illustrative Examples at Parameterized Convection and Convection-Permitting Resolutions. Journal of Geophysical Research: Atmospheres, v. 128, n. 6, p. e2022JD038199, 2023.

[2] HODGES, K. I. Feature tracking on the unit sphere. Monthly Weather Review, v. 123, n. 12, p. 3458-3465, 1995.

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