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Evaluation of the physics suite in NOAA's GFSv16 using field-campaign observations and diagnosis of physics tendencies

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Shallow cumulus clouds play an important role in the weather in the Atlantic Tropical Convergence Zone. Their interaction with the atmospheric environment and oceanic mixing processes has a significant impact on the convective organization and tropical dynamics. It is still a scientific challenge for numerical weather prediction models to accurately simulate them due to deficiencies in the model's representation of physical processes.

In this study, we investigate how the physics parameterization schemes in NOAA's most recent operational global forecast system (GFSv16) perform in the simulation of shallow cumulus clouds in the western Atlantic in terms of their interaction with the large-scale atmospheric dynamics. Previous studies have indicated that the impact of physics parameterization schemes on model's tendencies during the first few hours can provide critical information on their suitability for short- and medium-range forecasts. Therefore, we first evaluate the GFSv16 forecasts against the observations obtained from the European field campaign called the ATOMIC/EUREC4A that occurred between 12 January and 23 February 2020. We then diagnose the sensitivity of the GFSv16 physics tendencies to changes to the physics parameterization schemes over the first 6 hours of the forecast, which is the timescale before dynamical feedback becomes significant. Using the information from the observational evaluation and physics tendency diagnosis, we further explore possible improvement in the physical process representation that can positively affect the physics tendencies and lead to overall forecast improvement beyond 6 hours.