Simulation of Cloudburst Event Over Kerala During 2019 Monsoon Season

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Introduction

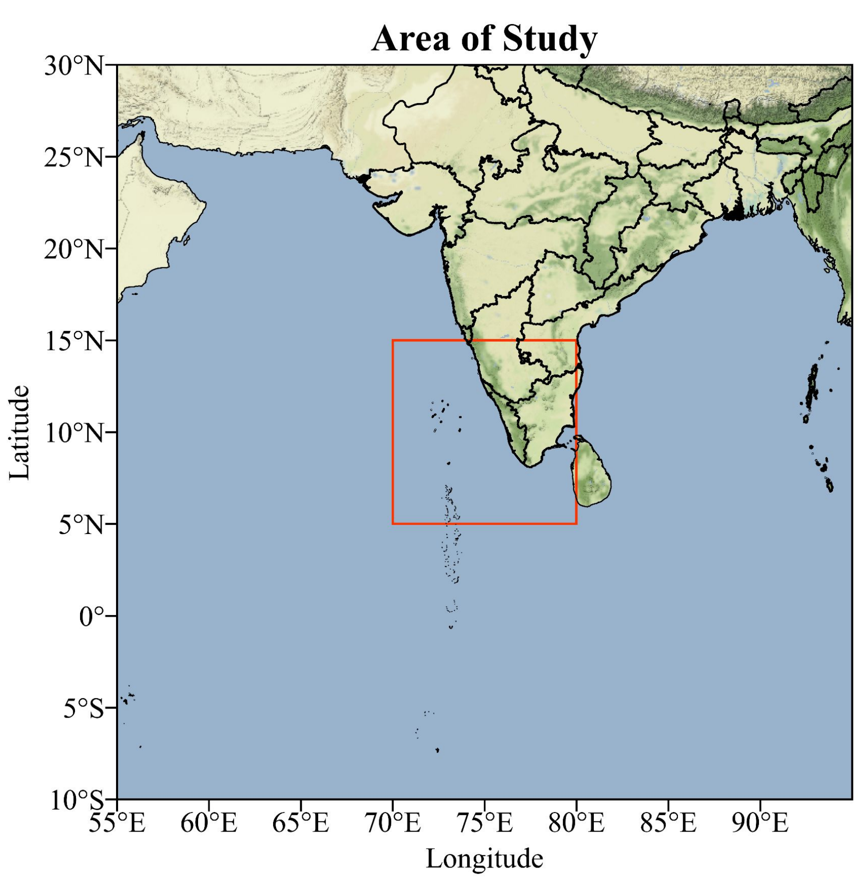
The Cloudburst is an extreme weather event capable of producing torrential rainfall in a small area in a short time. A heavy rainfall event where the rainfall rate exceeds 100 mm/h is termed a classical Cloudburst. Cloudburst generally occurs during the monsoon season due to strong convection associated with orographic forcing over the western Ghats and Himalayan region which causes widespread damage to property and loss of lives. So it is crucial to predict such events to help authorities to take preventive measures. We use the numerical mesoscale model Weather Research Forecast model (WRF) to simulate the cloudburst of Kerala on 8 th August 2019, to capture and understand the underlying dynamical and thermodynamical characteristics of this event.

Objectives

To simulate the cloudburst with WRF model to verify microphysical and convective parameterization which will lead to a reasonably good forecast of extreme rainfall. It is important to investigate the role of dynamics, microphysics convection etc in the cloudburst events that occurred in Kerala 2019 in order to forecast such events with adequate lead time. The use of multi-satellite sensors makes it possible to investigate the model performance and its evaluation through a process based approach.

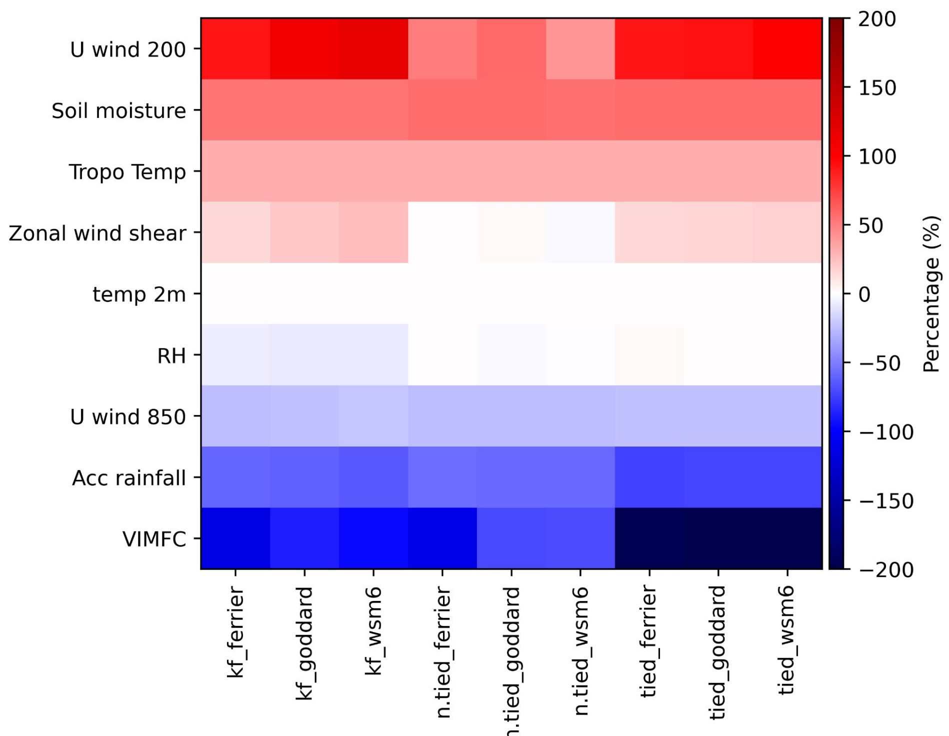
Data & Methodology

The WRF model was initialized on 00 UTC of 7th August 2019 with NCEP GDAS with two domains, the outer domain spans from 10°S to 30°N latitude, 55°E to 95°E longitude. The inner domain spans from 5°N to 15°N latitude, 70°E to 80°E longitude. We ran simulation with two sets of resolutions 15km, 5km and 9 km, 3km. .The simulations were based on Mercator projection, interacting with each other through two way nesting strategy. Each domain has 34 hybrid vertical levels and the model top is defined at 50 hPa. Three cloud microphysics parameterizations namely Ferrier, WSM6 and Goddard, and three cumulus parameterizations namely Kain-Fritsch, Tiedtke and New Tiedtke have been used for sensitivity study and examine the performance of the schemes.

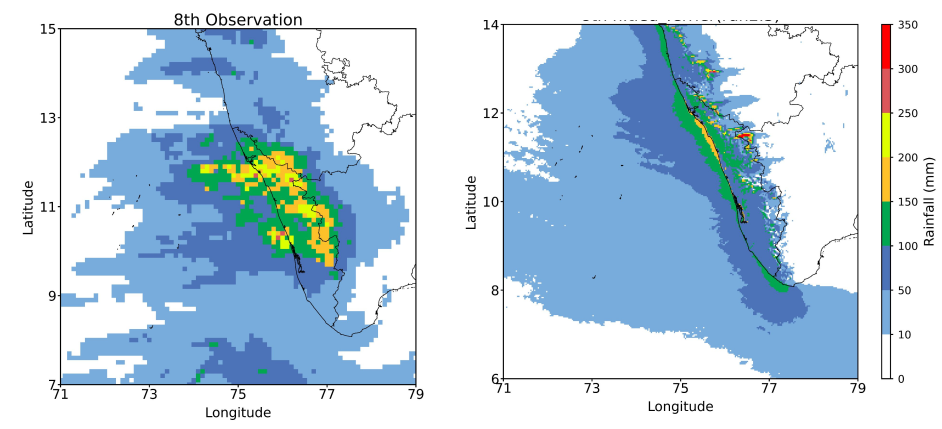


Results & Discussion

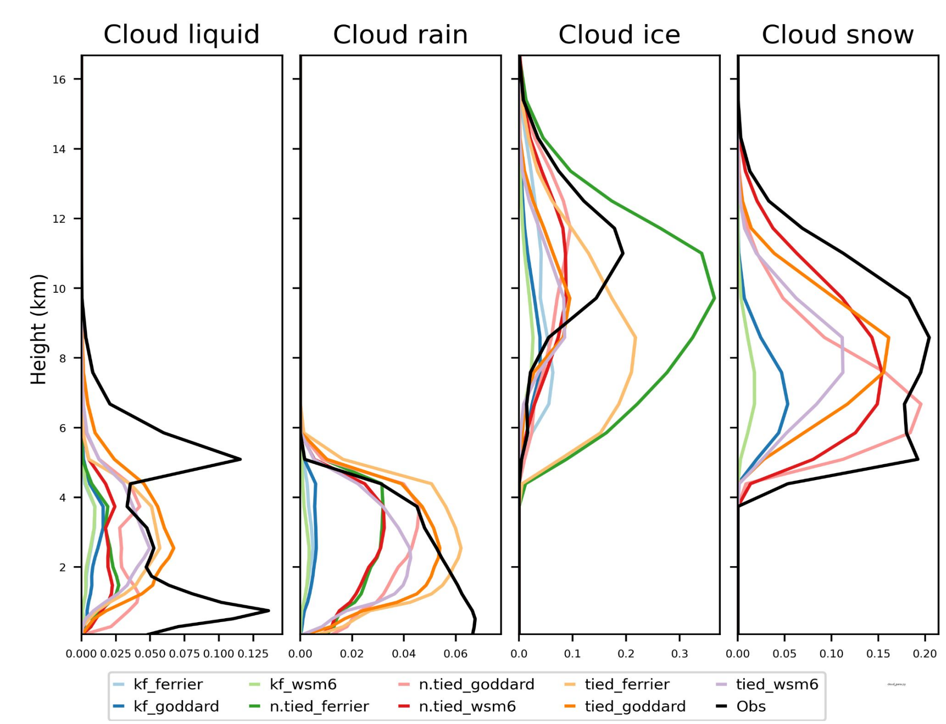
To analyze the outputs of the simulations, we look at the percentage of deviation of different variables predicted by the WRF model on 8th August 2019. The figure shows variables like area averaged of daily accumulated rainfall, Zonal wind at 850 hPa and 200 hPa, vertically integrated moisture convergence from 800 hPa to 300 hPa, temperature at 2m, relative humidity surface to 500 hPa, integrated temperature from 700 hPa to 200 hPa and zonal wind shear between 850 and 200 hPa over the Kerala region.

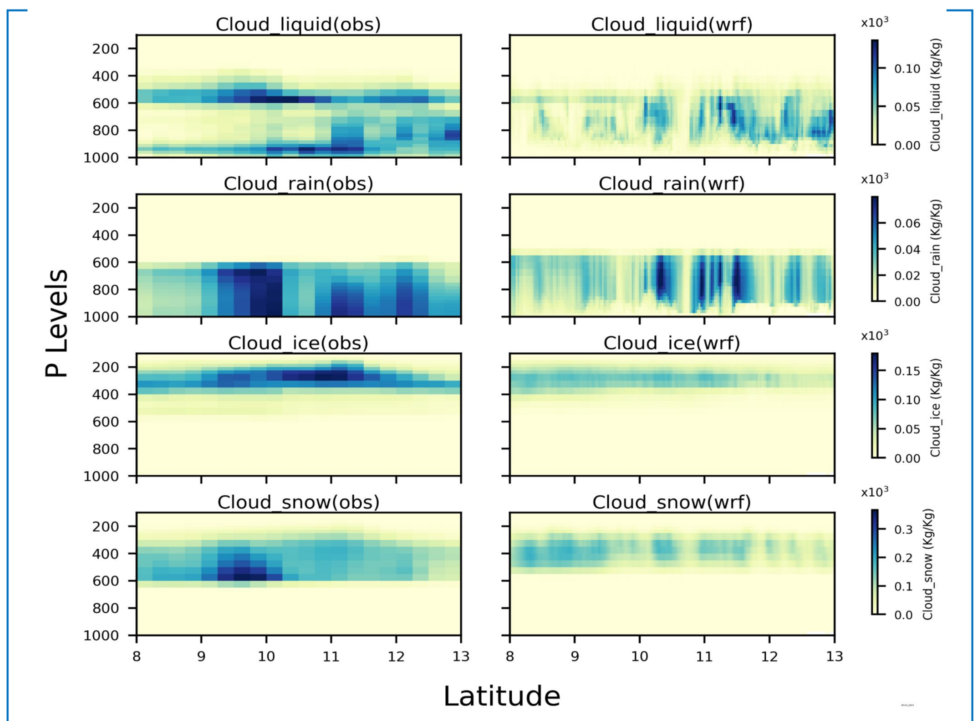


From the results we can conclude that all the simulations are overestimating the zonal wind at 200 hPa, Soil moisture, Tropospheric temperature, Zonal wind shear. The simulations are also underestimating the variables like relative humidity, zonal wind at 850 hPa, daily accumulated rainfall, vertically integrated moisture flux. The simulation using New Tiedtke cumulus scheme performed better than other simulations.



Above figure shows the spatial distribution of rainfall simulated by New Tiedtke Ferrier simulation with observation (GPM).Now we analyze the cloud hydrometeos predicted by the wrf model.The Figure shows the area-averaged vertical profile of the different cloud parameters like Cloud liquid, Cloud rain, Cloud ice, Cloud snow in Kg/kg with ERA-5 data.We have to note that Ferrier microphysics scheme does not compute cloud snow concentrations. All the simulations failed to capture the vertical profile characteristics of Cloud liquid and cloud rain.





But in the case of Cloud ice and cloud snow the simulations performed better. The simulations using Kain-fritsch performed least in the prediction of the cloud hydrometeors.The simulations using Tiedtke cumulus schemes performed best to capture the cloud hydrometeors vertical profile among the simulations. The latitudinal variation of cloud hydrometeors of Tiedtke Goddard simulation is shown above figure.

Summary/Conclusion

From our study, we found the parameterization schemes mentioned were not able to accurately predict the cloudburst event of 8th August 2019. Although some parameterization schemes came close in prediction of different parameters but all of them failed to perfectly simulate the cloudburst event. The schemes like WSM6 and Ferrier with Kain-Fritsch and New Tiedtke where the best to simulate the rainfall but they failed to produce the same accuracy in the cloud hydrometeors.The Tiedtke scheme performed well in the prediction of cloud hydrometeors but could not predict the rainfall with same accuracy.

From the spatial distribution of rainfall, cloud hydrometeros plots we can see that New Tiedtke and Ferrier scheme was the best to simulate rainfall event over Kerala. Nevertheless, rainfall simulation in WRF over complex topography is still a challenging issue, and its ability to accurately simulate rainfall, particularly mountainous and foothills areas, is far from ideal. Further investigation should focus on simulating more rainfall events for which observed data could be available, as well as testing additional microphysical and cumulus schemes.

Acknowledgements & References

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