Numerical simulation of a giant-hail-bearing Mediterranean supercell in the Adriatic Sea

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Introduction

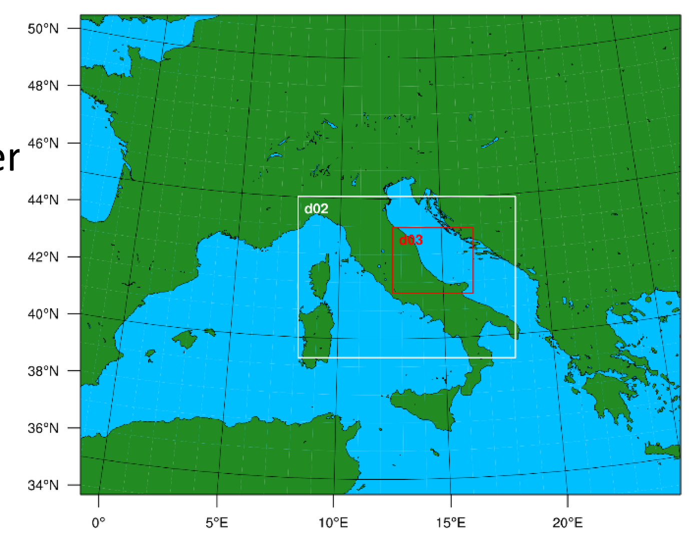
- Hail forecasting is very difficult due to the complexity of the formation and growth processes of hailstones (e.g., Rasmussen and Heymsfield, 1987; Dennis and Kumjian, 2017; Martius et al. 2018).
- The Mediterranean regions represent a hotspot for climate change, as an increase in the intensity of heavy rainfall and intense cyclone is predicted, as reported in the IPCC-AR6 (International Panel for Climate Change-Sixth Assessment Report, 2021)
- On 10 July 2019, a hail-bearing supercell hit the central part of western (Italian) coastline of the Adriatic Sea. This supercell was catalogued in the European Severe Weather Database (ESWD) as a severe convective event, with hailstone sizes up to 14 cm observed at the surface (Montopoli et al., 2021).

Goals

The aim of the present study is to evaluate the dynamic and thermodynamic characteristics of the environment where the supercell developed, using numerical simulations with the Weather Research and Forecasting (WRF) model. For the simulation of the hailstones, in particular of the hail size, the HAILCAST module is employed.

Model setup and data

- Numerical simulations are implemented over three nested domains, with grid spacings of 16, 4 and 1 km, respectively .



- Global Forecasting System (GFS) and European Centre for Medium-range Weather Forecast–Integrated Forecasting System (ECMWF-IFS) are both used to force the model as initial and boundary conditions every 3 hours.

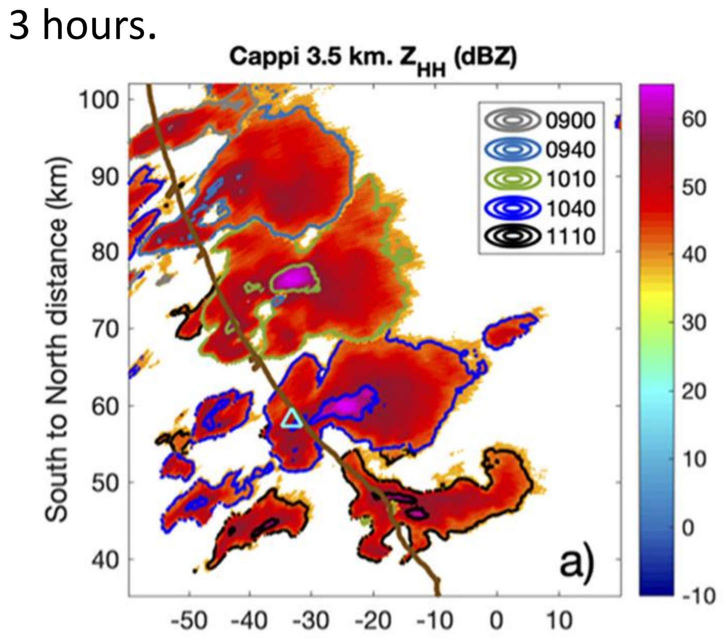


Fig.1 Z_{HH}: Reflectivity Factor. The supercell moving from 09 to 11 UTC along the Adriatic coast and passing near Pescara between 10 and 11 UTC (Montopoli et al., 2021)

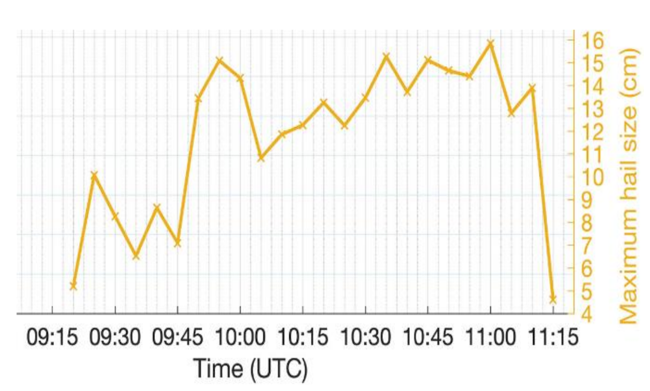


Fig.2 Maximum hailstones size observation on the city of Pescara (Montopoli et al., 2021)

Results

Supercell development

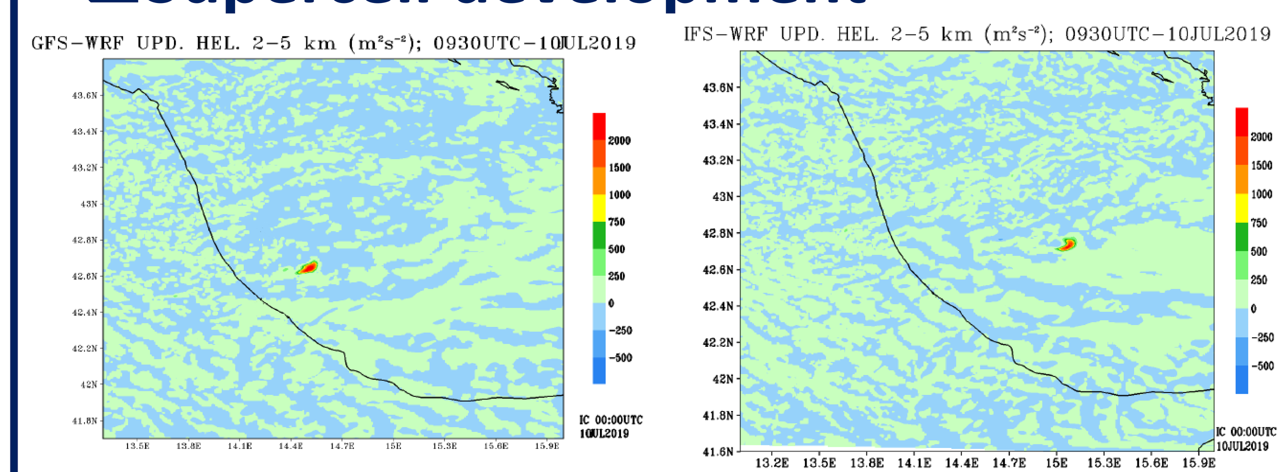


Fig.3 Updraft helicity between 2 km and 5 km at 0930UTC obtained from IFS and GFS data

- To identify the presence of the supercell, updraft helicity between 2 km and 5 km is considered.
- A comparison between the two simulations shows that the model run forced with the GFS data seems to reproduce the case study better

Mesoscale environment

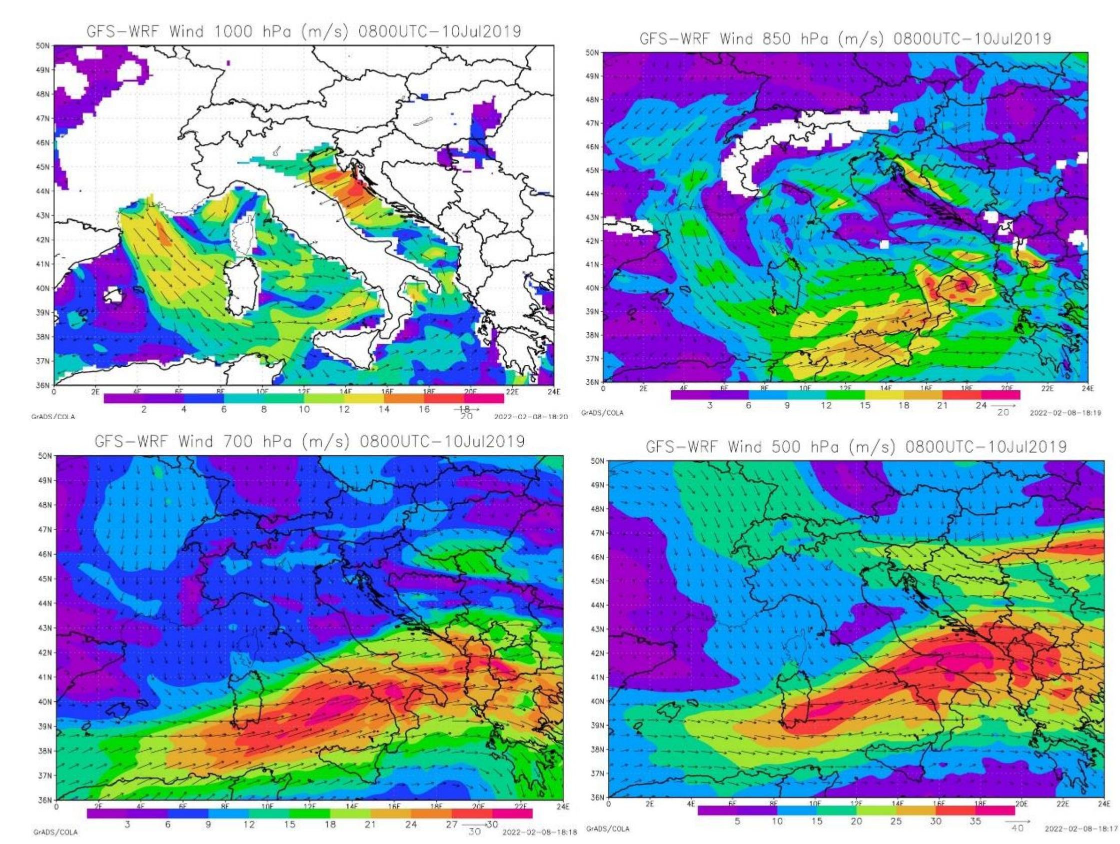


Fig.4 Wind maps at 1000 hPa, 850 hPa, 700 hPa and 500 hPa at 0800UTC from GFS data

- Strong vertical wind shear over the Adriatic Italian regions

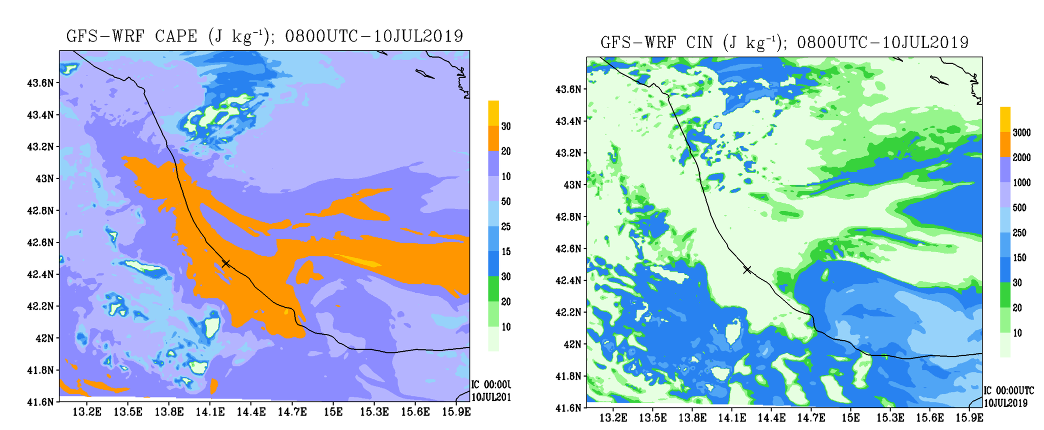


Fig 5 CAPE and CIN maps at 0800UTC from GFS data

- A supercell develops in the area due to the combination of large wind shear, high CAPE (above 2000 J/kg), low CIN (less than 10 J/kg),

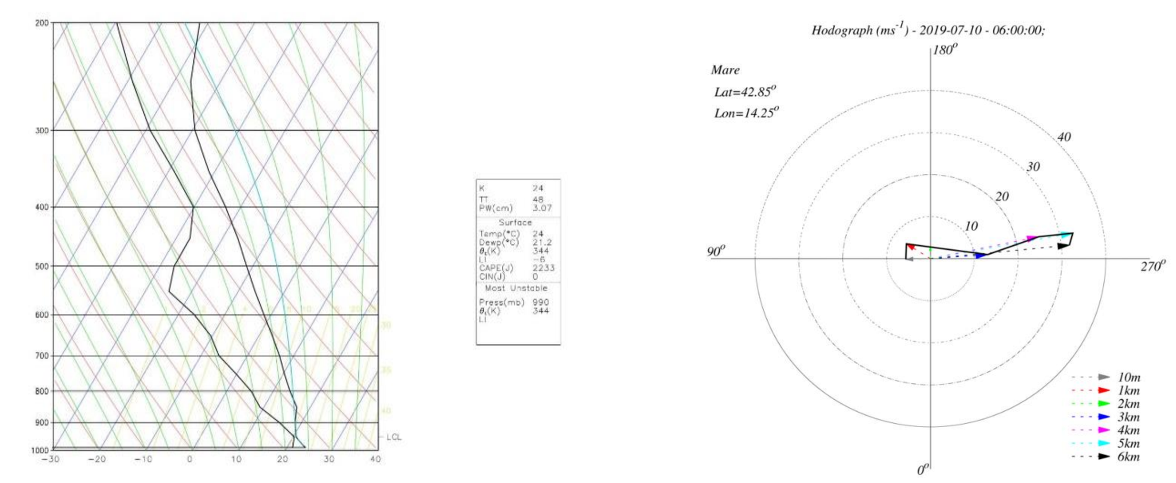


Fig.6 Sounding and hodograph at 0900UTC over the town of Pescara from GFS data

- Unstable profile
- Rotation and intensification of the wind with altitude

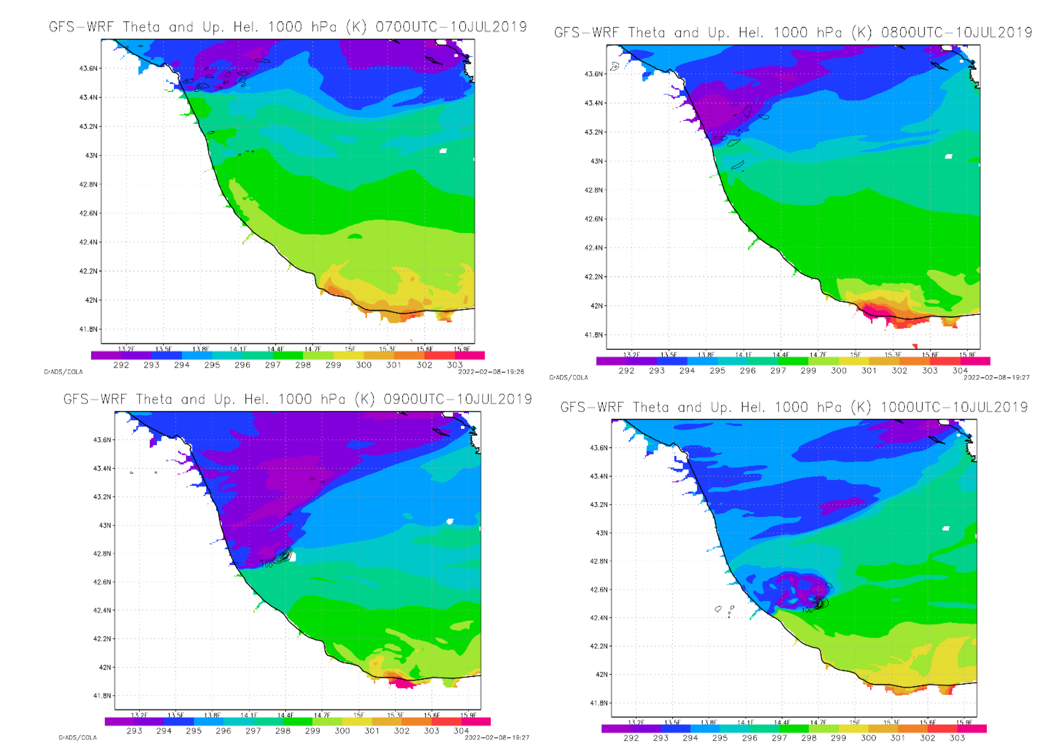
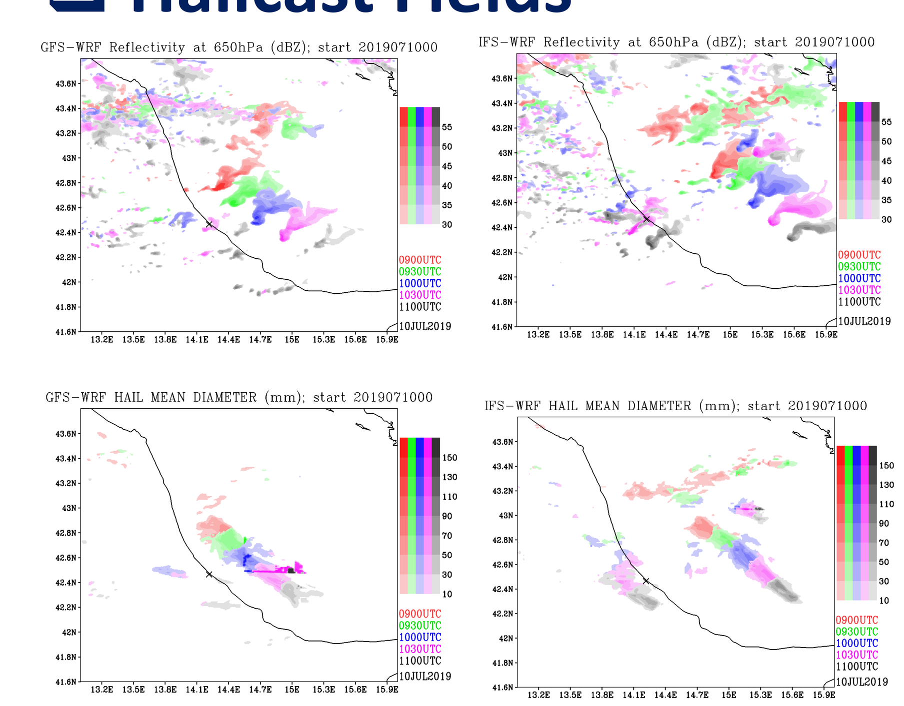


Fig.7 Potential temperature at 1000 hPa and UH between 2 km and 5 km, from 0700UTC to 1000UTC, using GFS data.

- The cold front had plausibly the role of triggering the convective system

Hailcast Fields



WRF model runs using the HAILCAST module match very well with the observations (hailstones diameter and transit time of the supercell on Pescara)

Fig.8 Reflectivity and hail mean diameter according to the GFS-WRF run and to the IFS-WRF run

Conclusions

- The Environment was favorable for the development of the supercell.
- The supercell is well reproduced by the model.
- The hail diameter was also simulated using WRF HAILCAST module. These simulations are in agreement with the satellite and radar observations
- The results of this case study are therefore encouraging in terms of the ability of the WRF HAILCAST module to simulate hail events

References

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