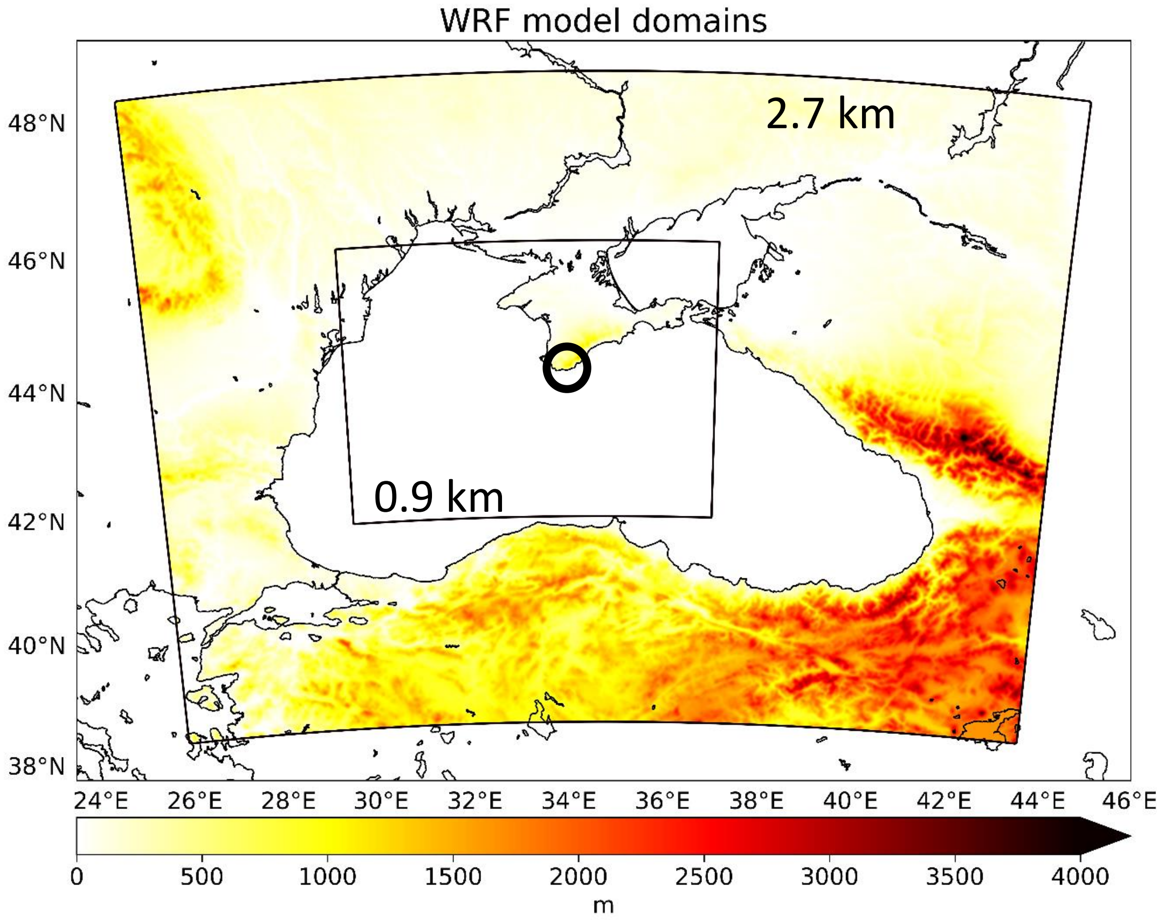
Extreme rainfall event in Crimea: Cloud-resolving modeling and radar observations

Anatolii Anisimov (1), Vladimir Efimov (1), Margarita Lvova (2), Viktor Popov (2), Suleiman Mostamandi (3)

(1) Marine Hydrophysical Institute, Russian Academy of Sciences, Sevastopol, Russian Federation
(2) Voeikov Main Geophysical Observatory, Saint Petersburg, Russian Federation
(3) King Abdullah University of Science and Technology (KAUST), Physical Sciences and Engineering Division, Thuwal, Makkah, Saudi Arabia



Motivation

- **An extreme rainfall event hit the coastal city of Yalta on September 6, 2018, followed by the flashflood.**
- Over 100 mm of rainfall was produced in Yalta. In the mountains, about 140 mm of rainfall was reported.
- Large-scale models were seen to hardly capture the mesoscale event.
- Therefore, there was a demand to evaluate the **WRF** performance.

Data & Model setup

Meteorology & BCs

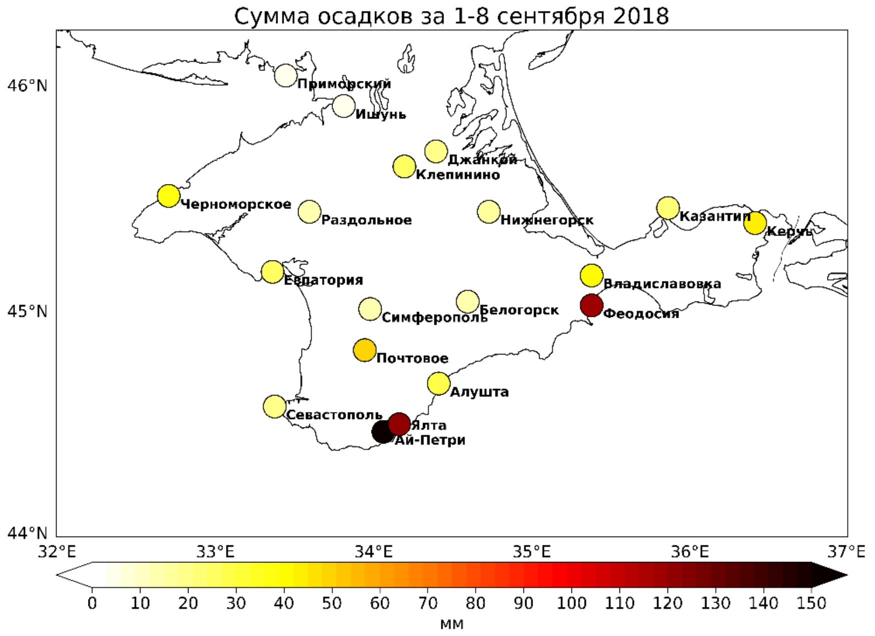
- **7 days simulation: 1 – 7 April, 2018**
- 2 nested cloud-resolving domains (2.7 + 0.9 km), 40 vertical layers
- **ECMWF IFS 10 km operational analysis for meteorological BC**

Process	WRF option
Microphysics	**5 double-moment schemes (Thompson, Milbrandt, Morrison, WDM6, NSSL)**
Shortwave radiation	RRTMG
Longwave radiation	RRTMG
Cumulus parameterization	**Off**
Surface layer	Eta
Land-surface model	Noah
PBL	MYJ

Data

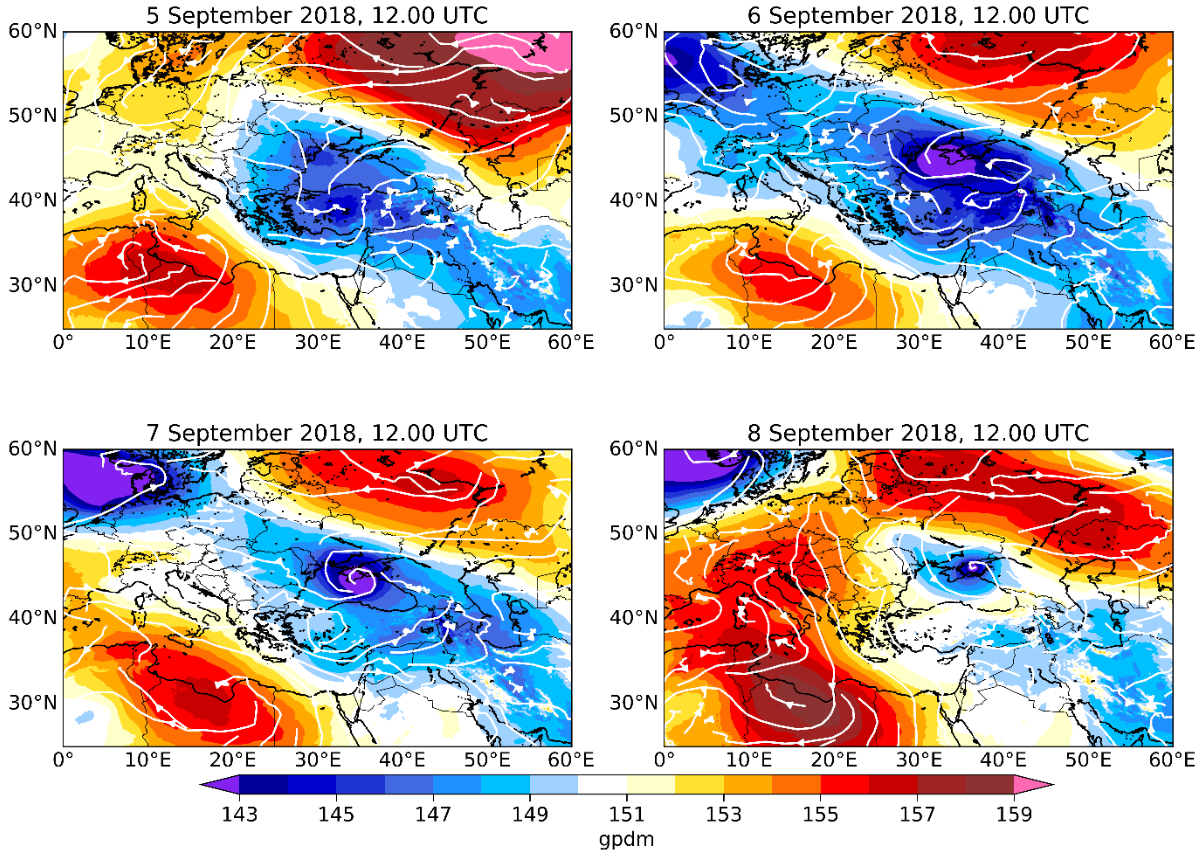
- NASA **MERRA-2** 50-km reanalysis: bias-corrected rainfall product.
- Weather radar measurements in Simferopol airport.
- GPM IMERG precipitation satellite product.
- Weather station data (note that only 4 stations are used for GPM calibration).

Rainfall amount during September 1-8:

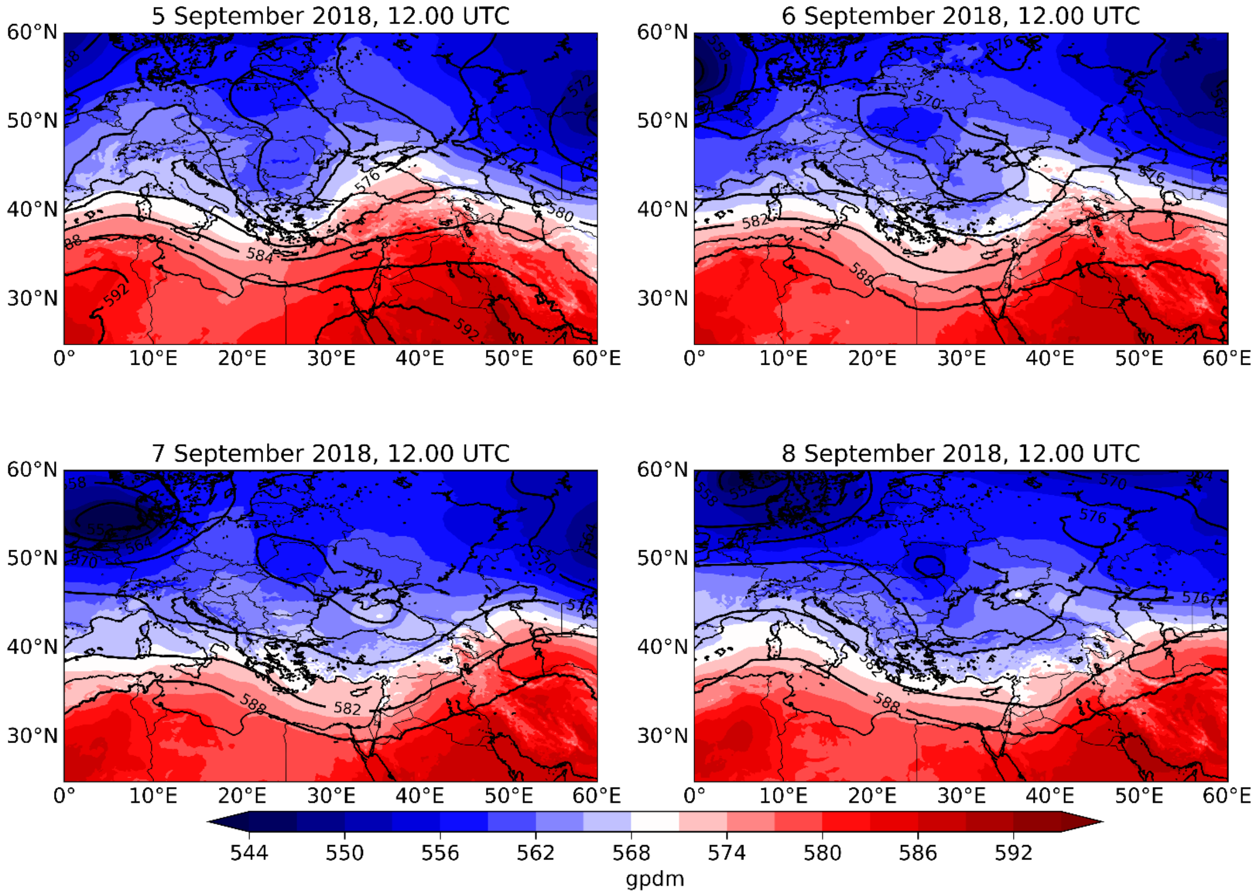


Synoptic situation during the rainfall event
ECMWF operational analysis

GP @850hPa (color) + wind velocity @850hPa (vectors)



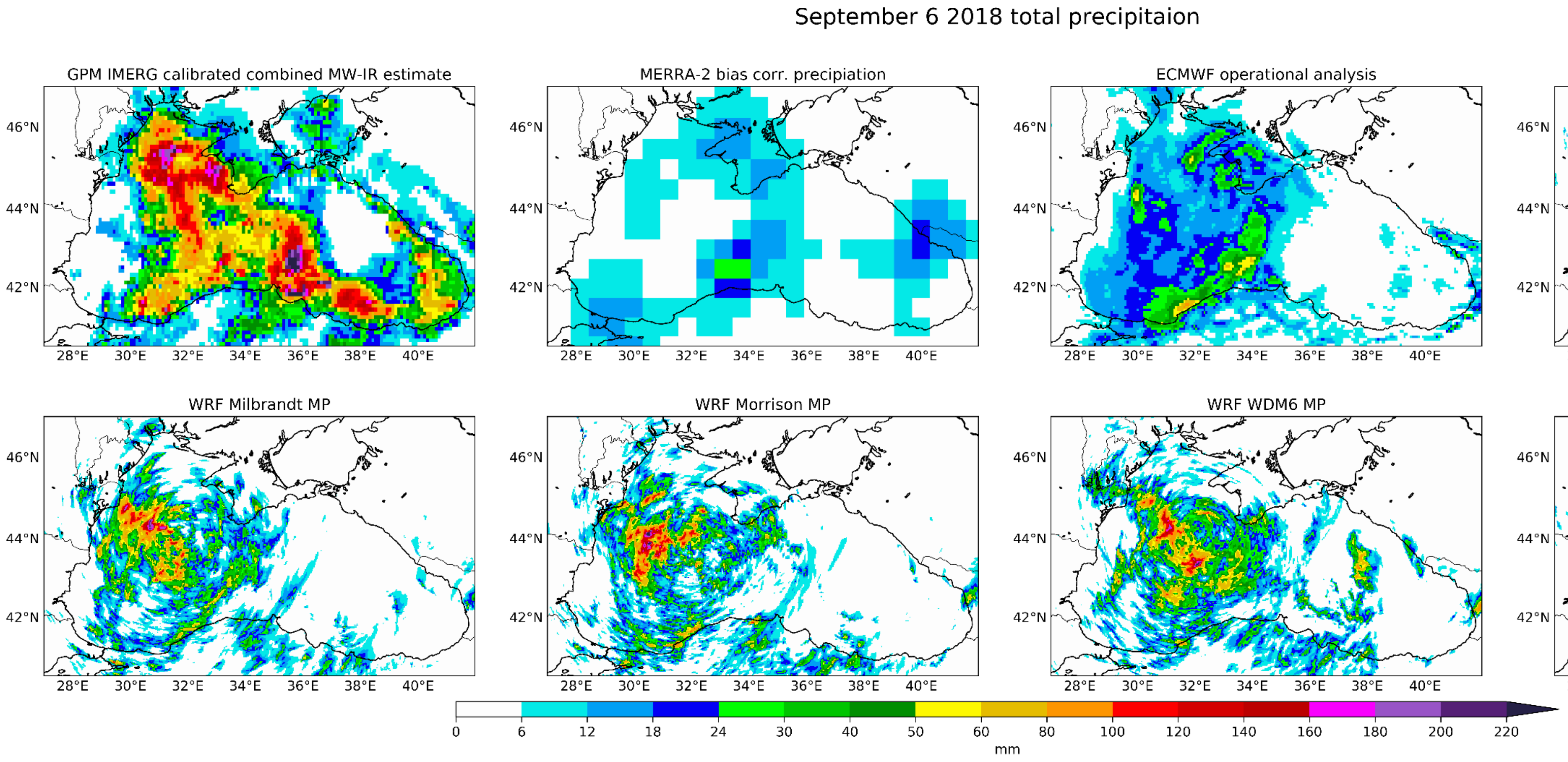
GP @500hPa - GP @1000hPa (color) + GP @500hPa (contour lines)



September 6, 2018 observed and simulated precipitation

(the day of event)

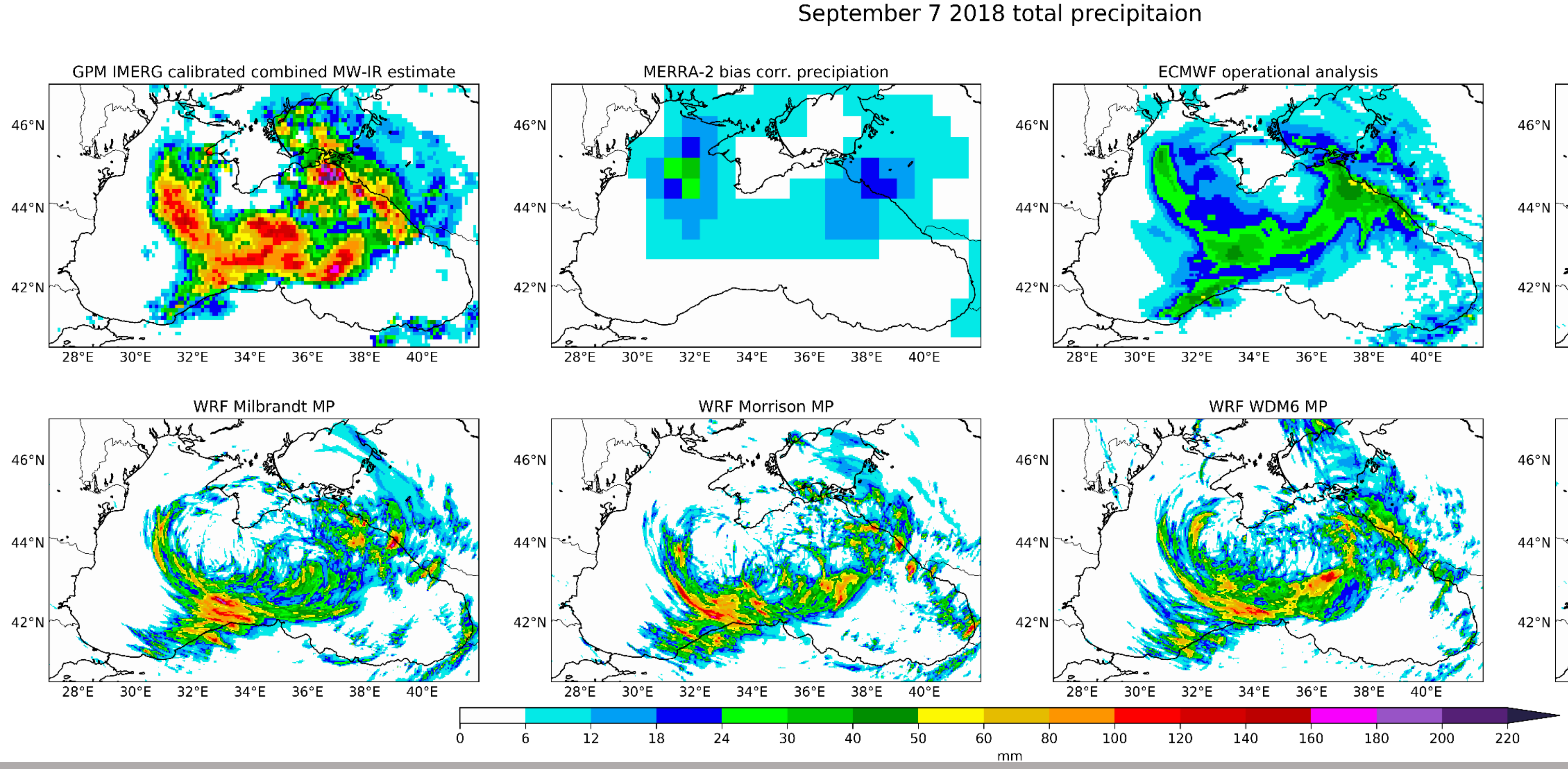
- It could be seen that both ECMWF operational analysis and MERRA-2 reanalysis missed this extreme event.
- The GPM measurements might be unreliable both over the Black Sea and Crimean Peninsula (due to the low number of stations used for calibration).



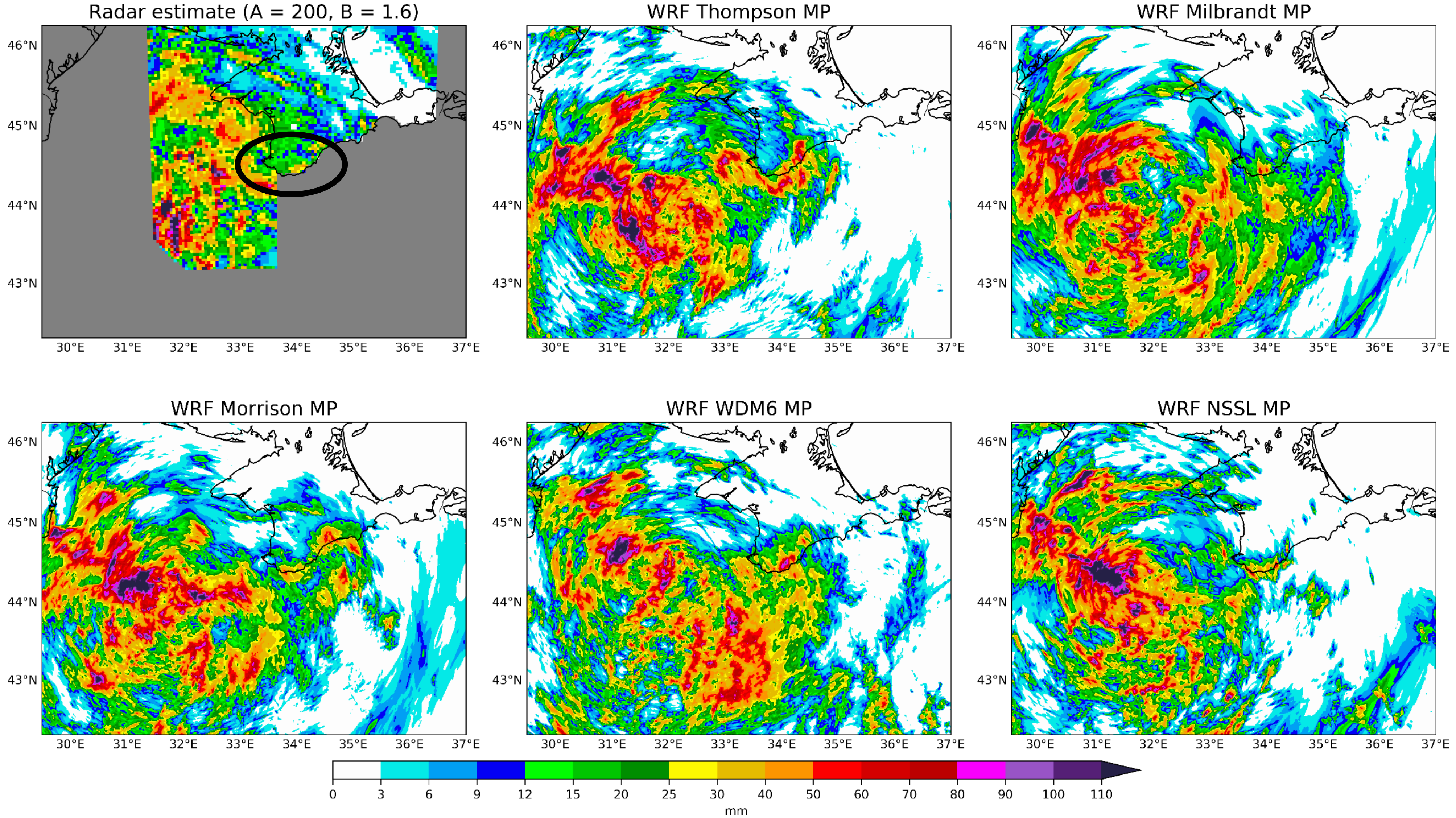
September 7, 2018 observed and simulated precipitation

(the passage of the cyclone)

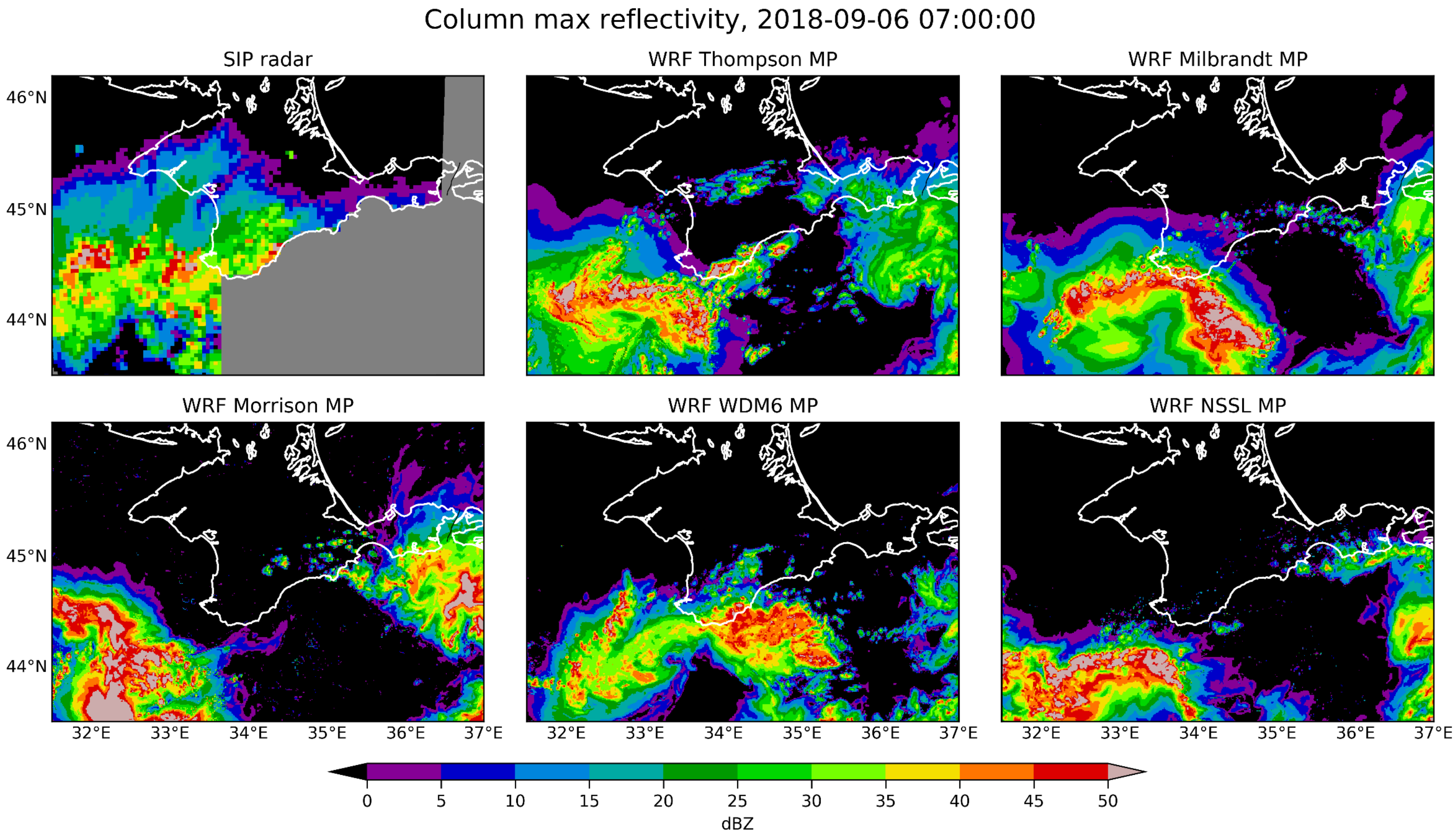
- Again, global NWP products do not seem to do a fair job.
- WRF downscaling is able to add value and significantly increases the amount of rainfall produced.



September 6, 2018 observed and simulated precipitation
(small domain)

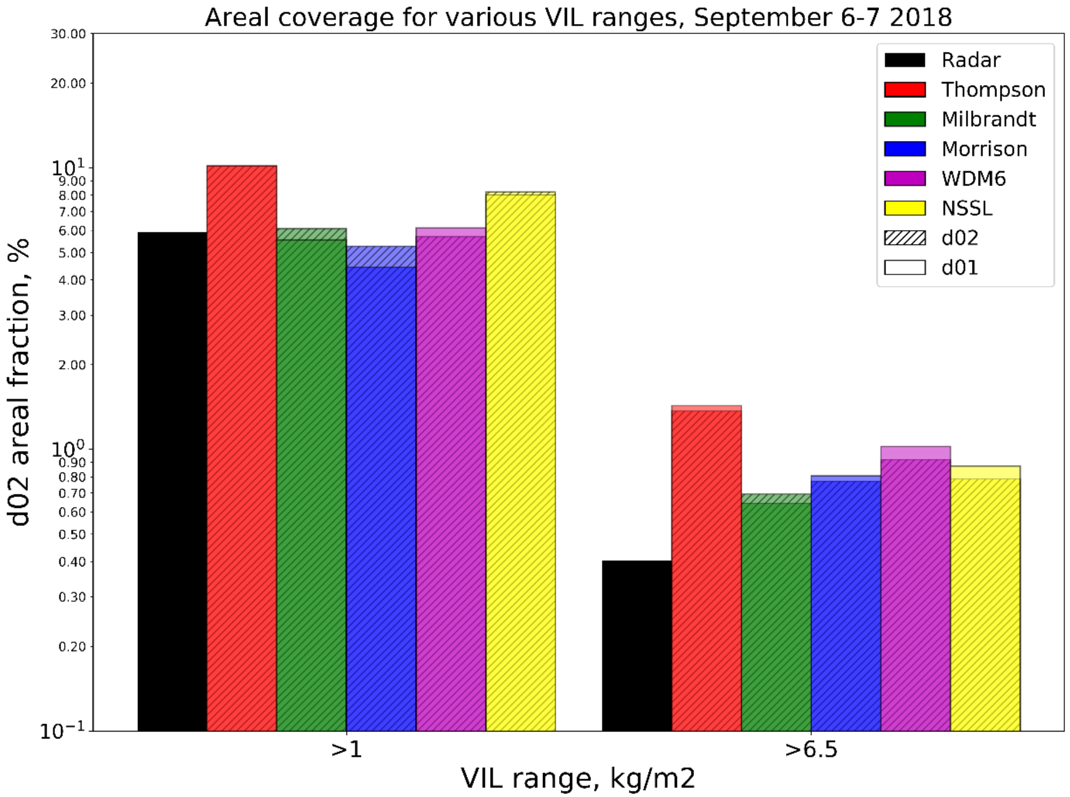


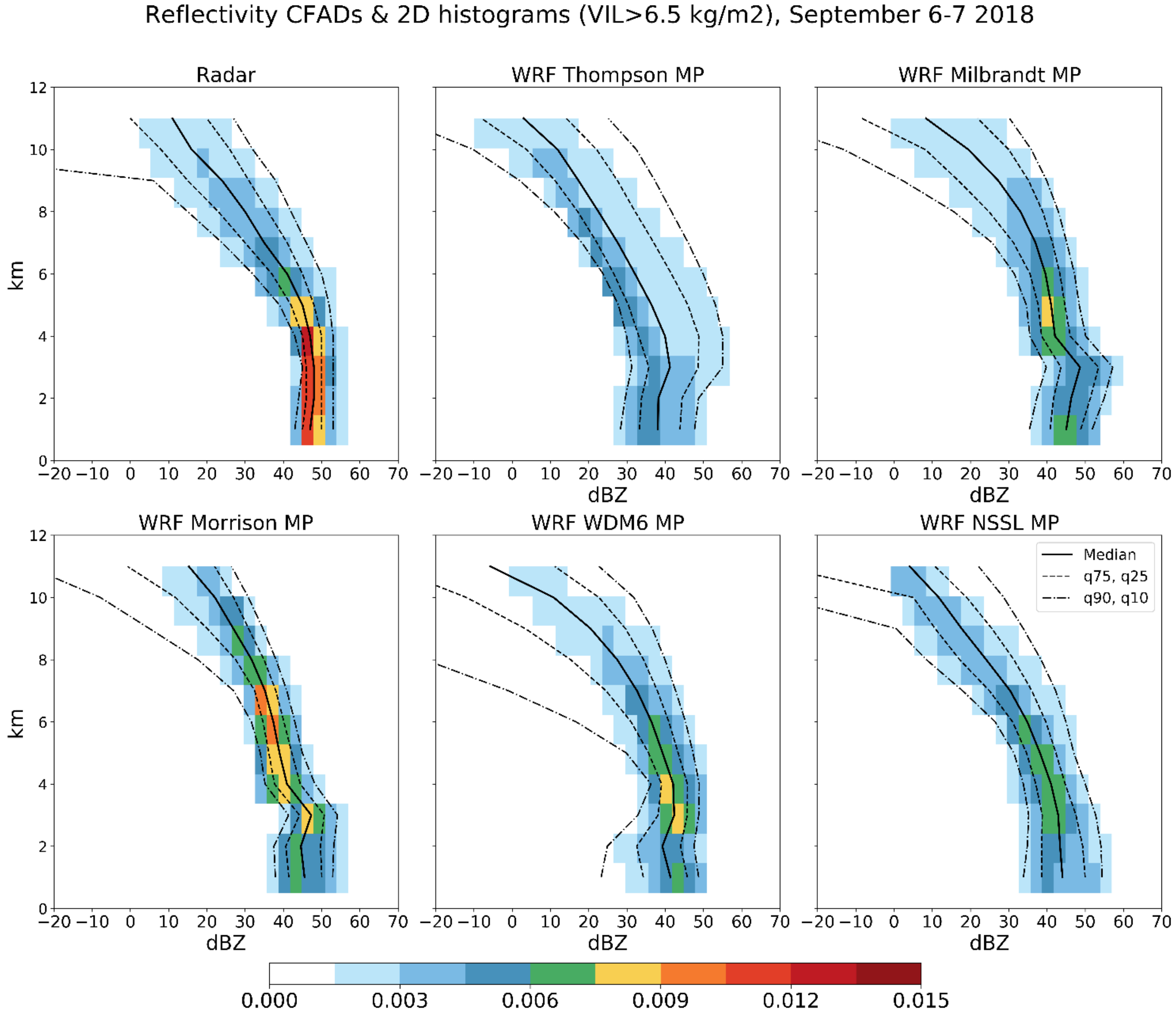
Observed and simulated reflectivity patterns



Spatial and vertical structure of simulated convection

averaged over the area covered by the weather radar





Conclusions

- All of the schemes are able to add value, capture the event and significantly increase the amount of rainfall compared to the driving model.
- WDM6, Milbrandt and Morrison schemes perform best to reproduce the rainfall orographic enhancement in the mountains and the vertical structure of convection.
- The amount of rainfall in the child domain was also slightly larger compared to the parent one.
- Despite the rainfall underestimation, the simulated reflectivity patterns are in good agreement with observations, although the convective cores are wider and less intense compared to those observed by the radar.