Performance of WRF in Simulating the Hail Event over Istanbul on 27 July 2017

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Summary : This study investigates a hail event that occurred over İstanbul on 27 July 2017 using the state-of-the-art Weather Research and Forecasting (WRF) model. The performance of the model in simulating the hail event was assessed by comparing the model outputs with the observations. Default physics options of the model were changed and sensitivity simulations were performed with using different schemens. This study is still in progress, and further sensitivity simulations will be performed to understand whether the surface conditions have any effect on the formation, intensification and location of the hail event.

1. Introduction

HAIL

The water droplets in the deep convective clouds are transported to the higher levels by means of ascending and descending air movements. Water droplets cool down at these higher levels and become ice particles. As a result of the repetition of the vertical transport in the cloud, the ice particules become larger. They fall when they defeat the gravity force.

AIM

- Understand the structure of the extreme hail event
- Perform simulations for the hail event using the atmospheric model and determine the parametrizations that gives the best prediction of the event

2. Model and Data

DOMAİNS AND PARAMETERS

Horizontal Resolution	27, 9, 3, 1 km
Center Point	41.96°N 20.06°E
Temporal Resolution	180, 180, 180, 15 minutes
Beginning of Simulation	26 July 2017 1800 UTC
Simulation Duration	30 hours
Microphysics	Lin, Milbrant 2-mom, NSSL 2-mom, Kain Fritsch, New SAS, Multi Scale KF
Cumulus	KF-Cup, New Tiedtke
Planetary Boundary Layer	YSU, MYNN2
Short-wave Radiation	Dudhia, RRTMG
Long-wave Radiaton	RRTM, RRTMG

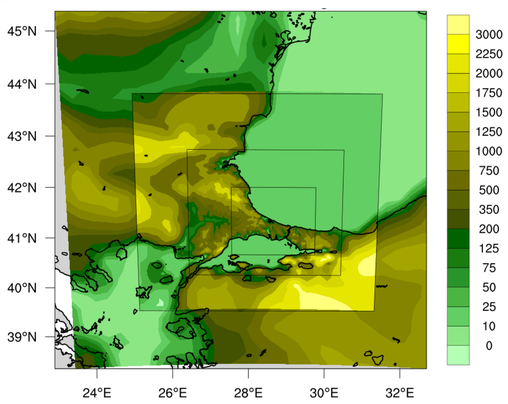

Figure1) *Domains and terrain (km)*

ERA-INTERIM REANALYSIS DATA

Spetial Resolution	0,75° x 0,75°
Temporal Resolution	6 hours
Time Steps	0000, 0600, 1200, 1800 UTC

OBSERVATION DATA

Data were obtained from Turkish State Meteorological Service for the day of the hail event.

- Start time and end time of the event for different meterological stations
- Rawinsonde (12 Hours) and hourly inversion thickness
- AWOS data (1 minute) from 32 stations
- Hourly radar and 15 minutes satellite images

3. Hail Event

SYNOPTIC ANAYLSIS

The low-pressure center located on the European side, and the jet in the upper-levels, caused the rising air movements over the Thrace region. As a result of these rising air movements, vertically developed clouds have occured. These weather conditions influenced the region for 12 hours.

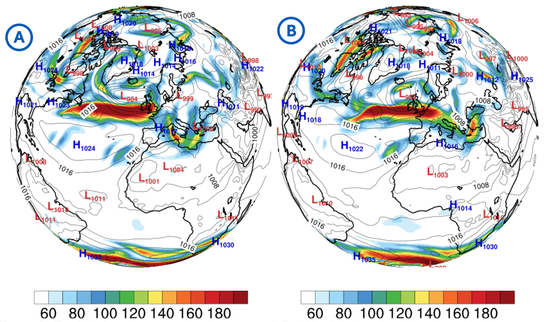

Figure 2) *Era-Interim, mean sea level pressure (hPa) (4 mb interval contours) and jet stream (km/hour) in 300 hPa pressure level*
a) *26.07.2017 18:00 UTC,* ***b)*** *27.07.2017 18:00 UTC*

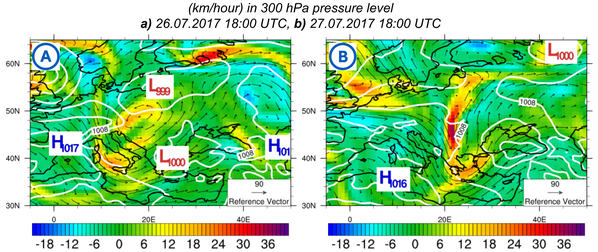

Figure 3) *Mean sea level pressure (hPa) (4 mb interval contours) and relative vorticity (10E-5/s) in 300 hPa*
a) *26.07.2017 18:00 UTC,* ***b)*** *27.07.2017 18:00 UTC*

REGİONAL SITUATION

The hail event monitored on Thrace region around 12:00 UTC and became effective bewteen 14:00 UTC and 15: 00 UTC [Figure 4] over the different regions in Istanbul.

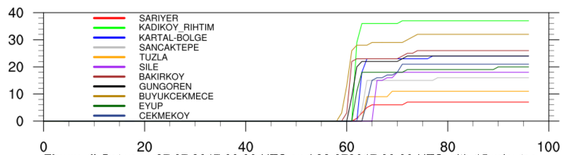

Figure 4) *Between 27.07.2017 00:00 UTC and 28.072017 00:00 UTC with 15 minutes interval, accumulated rain(mm) on 11 stations*

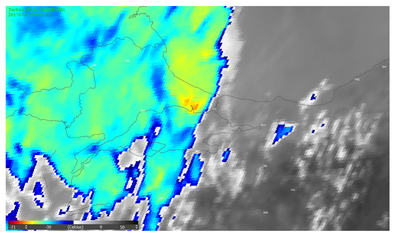

Figure 5) *Satellite image on 27.07.2017 14:15 UTC, cloud top temperature*

4. Results

The WRF model contains predefined variables. In this study, 41 and 28 values are used for the vertical resolution. It was observed that the outputs were more successful when using 41 value. Some parameterizations such as PBL, Cumulus were also determined by doing sensivity simulations. Sensitivity simulations conducted for YSU and MYNN2 PBL schemes and for New SAS, Multi Scale KF, KF-Cup and New Tiedtke culumus schemes. Milbrant and NSSL microphysics schemes were performed to evaluate the mıcrophysıcs parameterization effect for the case study. [Table 1] shows the setup for sensıtıvıty test of the microphysc shecemes. Milbrant and NSSL microphysical options were compared with running model [Figure 5].

Physics Options			Variables	
MP	Milbrant 2-mom	NSSL 2-mom	**num_metgrid_lvl**	38
CU	Kain-Fritsch	Kain-Fritsch	**e_vert**	41
PBL	MYNN2	MYNN2	**sf_sfclay_physics**	5
RA_sw	Dudhia	Dudhia	**cudt**	5
RA_lw	RRTM	RRTM	**radt**	30

Table 1) *Values of variables and physics options included in the simulations compared Milbrant and NSSL microphysics options*

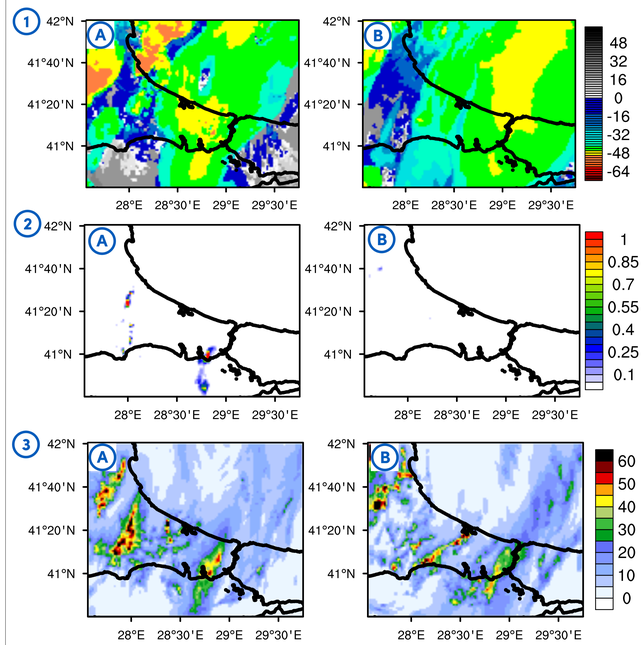

Figure 6) *Two different models outputs launched for 27.07.2017 14:15 UTC*
1) *Cloud top temperature(℃),* ***2)*** *Hail (mm),* ***3)*** *Daily acuumulated rain(mm)*
a) *Milbrant 2-mom,* ***b)*** *NSSL 2-mom*

RRTMG scheme [Figure 7,8,9] were used for both the shortwave radiation and the longwave radiation, instead of the model default options. Sensitivity simlations with RRTMG gives better performance than the default one.

Microphysic	Milbrant 2-mom
Cumulus	Kain Fritcsh
Plabetary Boundary Layer	MYNN2
Short-wave Radiation	RRTMG
Long-wave Radiaton	RRTMG

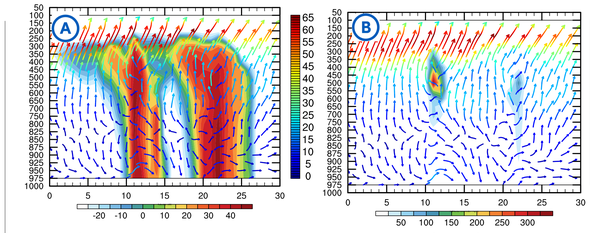

Figure 7) *In the coordinates of the Bakırköy station, the simulation performed for 30 steps of 15 minutes interval between 27.07.2017 09:00 - 16:30 UTC at 1000 mb to 50 mb pressure levels. Vertical bar shows wind (m / s).*
a) *Reflectivity (dbz),* ***b)*** *Hail Concentration(1/kg)*

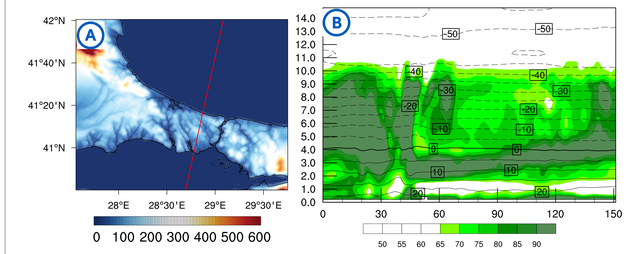

Figure 8) *The map is created for cross-section on 27.07.2017 14:15 UTC.*
Y-axis shows height (km), X-axis shows relative humidity, and contours show temperature.
a) *Terrain Height(m) and Cross-section Line,* ***b)*** *Relative Humidity(%), Temperature (℃)*

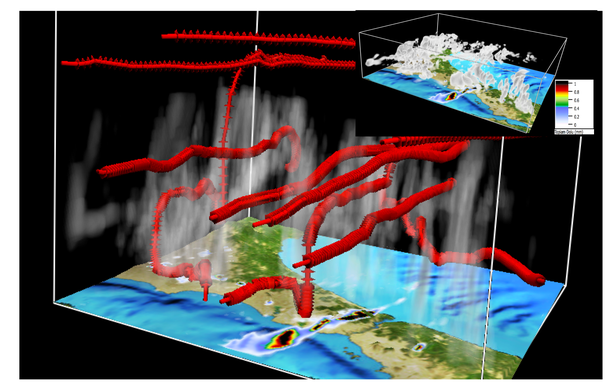

Figure 9) *3D cloudiness(0-1), accumulated hail(mm) and directions of air movement in the cloud*

5. Conclusion

- Due to the low-pressure system in Europe, and the winds, the air has risen in the Thrace region.
- The cloud top temperature on Istanbul has decreased to -50 ° C.
- Vertically developed clouds, reaching about 10 km height, affected the growth of hail, and occurrence of hail precipitation.
- Sensitivity tests showed that the microphysics scheme is more important than the other schmes for hail events.
- Maximum hail concentration occurred at about 500 mb pressure level.
- The combination of Milbrant, Kain Fritsch, MYNN2, RRTMG schemes has the best performance in all the sensitivity tests.

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