Data Descriptor

Simulations of the Derecho Event in Poland of 11th August 2017 Using WRF Model

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Abstract

This series contains datasets related to the forecasting of a severe weather event, a derecho, in Poland on 11 August 2017. The simulations were conducted using the Weather Research and Forecasting (WRF) model version 4.2.1 with different initial and boundary conditions of the pressure and model levels derived from 5 global models: Global Forecast System (GFS), Global Data Assimilation System (GDAS), European Centre for Medium-Range Weather Forecasts (ECMWF), and ERA5. Each simulation, shared as a separate dataset, was performed for two starting hours: at 00:00 and 12:00 UTC. The datasets contain about 280 meteorological parameters stored as 2D or 3D fields with high-spatial (2.5 km and 0.5 km domains) and temporal (10 minutes) resolutions. The three-dimensional fields are calculated at 50 levels up to 50 hPa. All data are stored in easily accessible NetCDF files.

Keywords: WRF; derecho; bow echo; severe weather forecast; GFS; GDAS; ECMWF, ERA5

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Specification table (data records)

Subject area	Meteorology
More specific subject area	Severe weather event forecast
Type of data	Meteorological parameters from WRF model

How the data was acquired	Using WRF 4.2.1 model and five different global models as initial and boundary conditions (GFS, GDAS, ECMWF, ERA5 on pressure levels, ERA5 on model levels)
Data format	NetCDF files
Experimental factors	All factors and parametrisations were the same for all simulations and described in the paper in detail
Data source location	MOST Wiedzy Open Research Catalog, Gdańsk University of Technology, Gdańsk, Poland
Data accessibility	The dataset is accessible and is publicly and freely available for any research or educational purposes

Background

Severe weather events are occurring increasingly often, which is connected with climate change. They pose a direct threat to human health and life and cause numerous and costly material losses. Therefore, it is extremely important to forecast them accurately, both in terms of location and time of occurrence. Numerical weather prediction models (NWP) have been used for this purpose for several decades. With the development of algorithms and the increase in the processing power of computers, it is possible to obtain fast and reliable forecasts for up to tens of hours. Additionally, it is possible to obtain forecasts with time steps of even several minutes and a spatial resolution of less than 1 kilometre. It concerns especially mesoscale models designed for the forecasting of local phenomena. The accuracy of NWP forecasts depends on many factors: the parameterisation of the physical phenomena and model dynamics used, the accuracy of the geographical data, and the initial and boundary conditions, etc. These initial and boundary conditions are usually derived from global models and can vary significantly especially during local severe weather events. Thus, their utilisation may lead to different NWP results using the same model parameterisations.

These series of datasets are concerned with forecasting a severe weather event which is the derecho which occurred in Poland on 11th August 2017, and caused very significant tree stand and material damage. The datasets include simulations using a mesoscale model and various boundary and initial conditions.

Methods

The simulations were conducted using the Weather Research and Forecast (WRF) model which is designed for atmospheric research and weather forecasting (Skamarock et al., 2005). This implementation of the model has been adapted to work on the Tryton high performance computer located at Academic Computer Centre in Gdańsk. The simulations were performed independently for five different sets of boundary and initial conditions, which were the following global models: Global Forecast System (GFS), Global Data Assimilation System (GDAS), European Centre for Medium-Range Weather Forecasts (ECMWF), and two versions of the ERA5 model – on pressure and model levels (here and after called ERA5P and ERA5M respectively). Three, one-way nested domains were used. This first domain covers most of Europe and has a spatial resolution equalling 12.5 km for the GFS, GDAS, and ERA5 models, and 7.5 km for forecasts using the ECMWF model. This difference is due to the resolution of the global models: 0.25° for GFS, GDAS, ERA5, and 0.125° for ECMWF. The spatial resolution of the second and third domains are equal for all simulations and are 2.5 km and 0.5 km, respectively. The first of this domain covers the area of Poland while the second one, the area where most of the damage occurred. Details of the locations of domains 2 and 3 are shown in Fig. 28.1. Also, the maximum reflectivity derived from WRF+GDAS at 20:00 UTC is presented for illustrative purposes. In the vertical, the WRF model was configured with an upper limit of 50 hPa and 50 levels using a vertical coordinate dependent on terrain height and hydrostatic pressure. All simulations were started at two epochs: 00:00 and 12:00 UTC, 11th August 2017. The length of the forecast was 24- and 12-hours, respectively. The results were saved with two different intervals: 1-hour for domain 1, and 10-minutes for domains 2 and 3. All of the basic parameters of the simulations are presented in Tab.28.1.

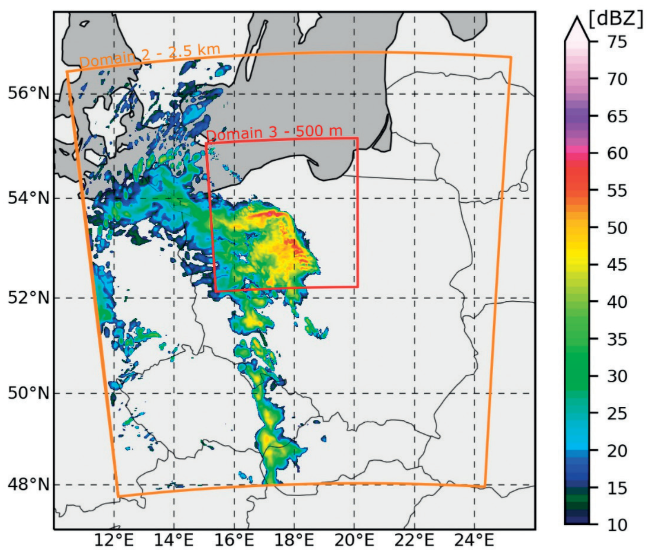

Fig. 28.1. Geographical localisation of two of the three WRF domains on the background on maximum reflectivity derived from the WRF+GDAS simulation at 20:00 UTC, 11th August 2017

Tab. 28.1

Details of the simulations performed using the WRF model.

Parameter	Name/Value				
Model name	WRF model version 4.2.1				
Global model (initial and boundary conditions)	GFS	GDAS	ERA5P	ERA5M	ECMWF
Global model resolution	0.25°	0.25°	0.25°	0.25°	0.125°
Number of global model levels	32	32	38	137	26
Global model vertical level types	pressure	pressure	pressure	model level	pressure
Number of domains	3				
Domain size (in nodes)	#1: 268 × 229 #2: 366 × 391 #3: 646 × 656				#1: 178 × 183 #2: 352 × 367 #3: 646 × 656
Domain resolutions	#1: 12.5 × 12.5 km #2: 2.5 × 2.5 km #3: 0.5 × 0.5 km				#1: 7.5 × 7.5 km #2: 2.5 × 2.5 km #3: 0.5 × 0.5km
Time resolution	#1: 1 hour #2 & #3: 10 min				
Number of levels	50 levels up to 50 hPa				
Time of forecast start	Two forecasts: at 00 and 12 UTC, 11th August 2017				
Time range of forecast	24 hours for forecast started at 00:00 UTC 12 hours for forecast started at 12:00 UTC				

It is worth noting that the parametrisation of all of the physical processes and model dynamics was the same for all simulations. A single-moment microphysics scheme with 6 hydrometeor classes (WSM6) (Zaidi and Gisen, 2018) was used, which is most suitable for high-resolution simulations (Hong and Lim, 2006). In the first domain, the convective processes were modelled using Grell-Freitas parameterisation (Grell and Freitas, 2014), while for second and third domains, explicit wet process physics were used. Moreover, we applied parameterisations of shortwave and longwave radiation according to the RRTMG radiation propagation scheme, which is a new version of RRTM (Iacono et al., 2008). To model the boundary layer processes, the Mellor Yamada Nakanishi Niino (MYNN) turbulence scheme with closure 2.5 was used (Nakanishi and Niino, 2009). The near-surface layer was parameterised according to the MYNN scheme (Nakanishi and Niino, 2006). Land topography, land use and soil type datasets were applied to the model at the WRF preprocessing stage. For the first and second domains, the standard data contained in the WRF model geographic database (LULC) of IGBP MODIS and USGS GMTED2010 (30 arc seconds resolution) were used. These data are insufficient for high-resolution simulations (De Meij and Vinuesa, 2014, Jiménez-Esteve et al., 2017). Therefore, in our datasets, for the third domain (0.5 km), we prepared new geographic data with a higher resolution. Land use data with a 100-metre spatial resolution were prepared based on the CORINE Land Cover (CLC) project 2018. The terrain topography, with a 30-metre resolution, was prepared on the basis of the Shuttle Radar Topography Mission (SRTM).

Data quality and availability

All simulations are stored in separate, hourly NetCDF files. They can be easily accessed by any GIS software or script language. A NetCDF file contains data and metadata in the same file. This metadata contains information about the parameter name, dimensions and units. The datasets were verified in terms of the correctness of the data contained. No gross errors were found.

Datasets DOI:
10.34808/ceh3-7z70
10.34808/3s00-kn10
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10.34808/fkmj-dh09
10.34808/kxnc-rc32

Datasets License:
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