WRF - *High Performance Simulation*
Computational Mathematics and Data Analytics 2021-2022

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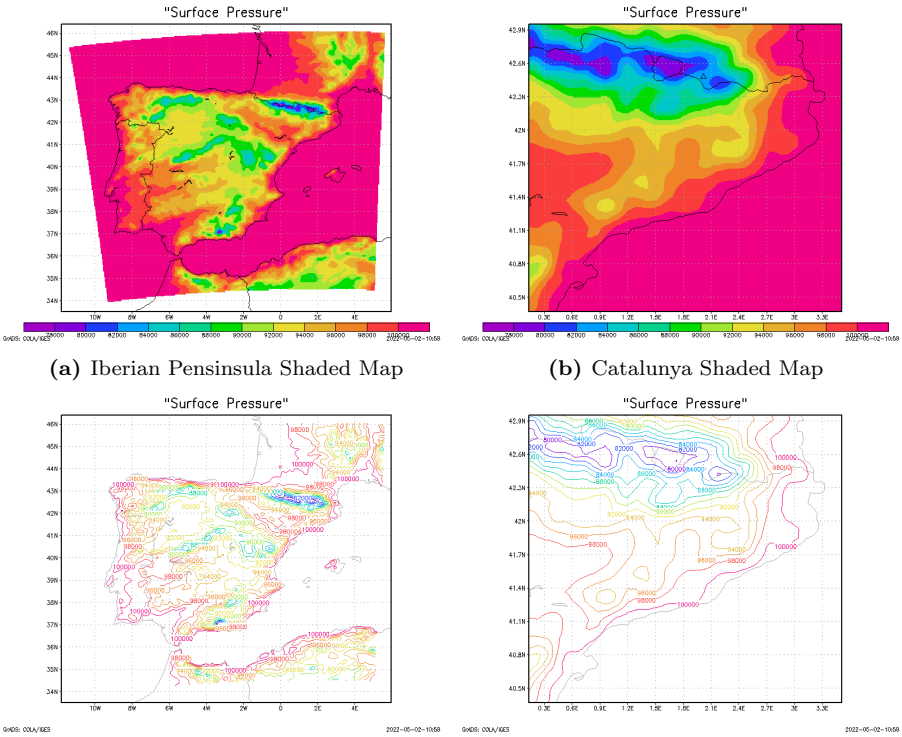
1 Basic Post-processing Case

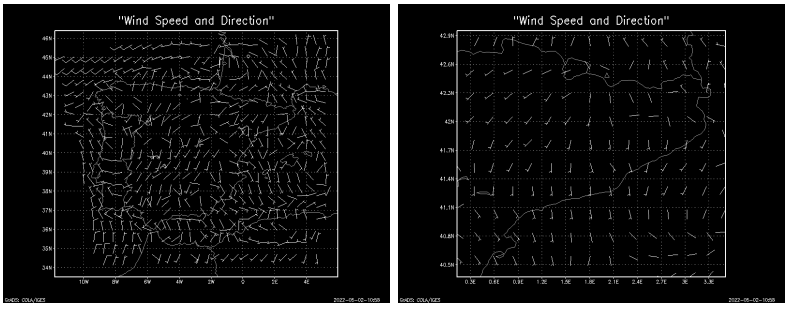
After generating the images of the day 20/07/2015 at 12:00UTC, we plot them here. We use `ARWpost.exe` to crop the domain in order to create a zoom-in over Catalonia in the second column.



(a) Iberian Pensinsula Shaded Map **(b)** Catalunya Shaded Map

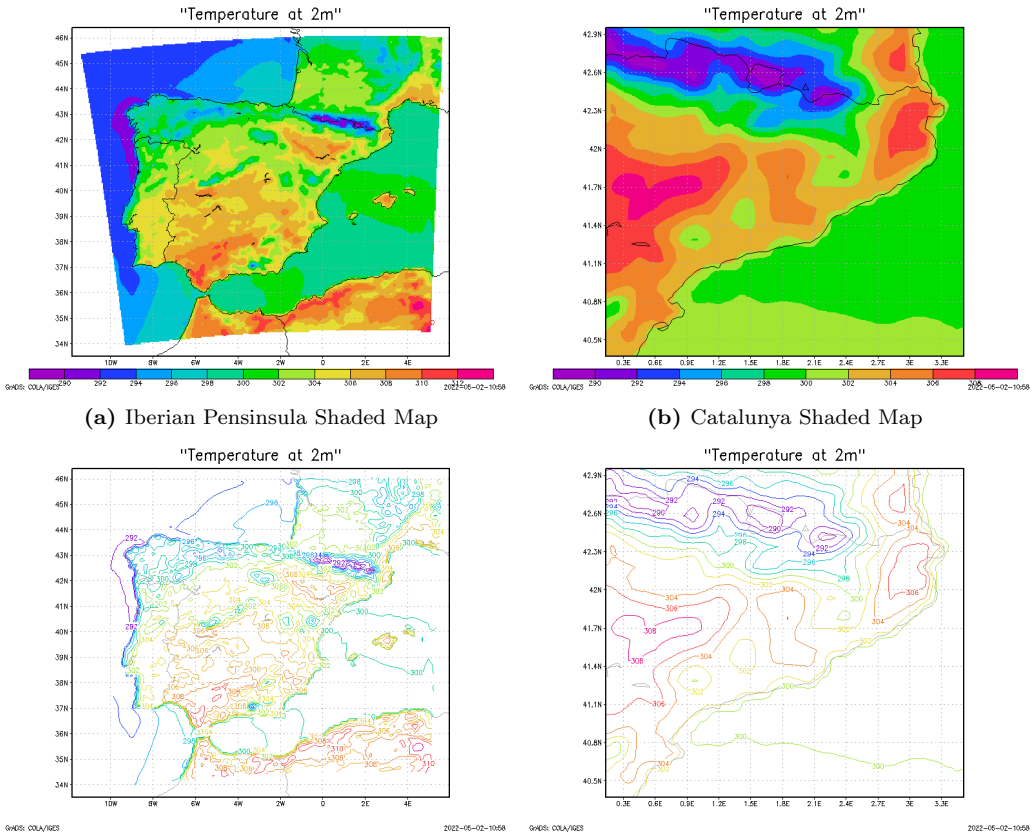
(c) Iberian Peninsula Contour Map **(d)** Catalunya Contour Map

Figure 1: Plot of the predicted surface pressure of day 20/07/2015 at 12:00UTC.



(a) Iberian Pensinsula **(b)** Catalunya

Figure 2: Plot of the predicted wind speed and direction in a barb plot for day 20/07/2015 at 12:00UTC.



(a) Iberian Pensinsula Shaded Map

(b) Catalunya Shaded Map

(c) Iberian Peninsula Contour Map

(d) Catalunya Contour Map

Figure 3: Plot of the predicted temperature at 2 meters height of day 20/07/2015 at 12:00UTC.

2 Full Basic Case

We now generate a nested domain inside a parent domain, with a relation 1/3, in order to get a higher resolution prediction of the meteoreological variables over Catalunya. In the Figures 4, 6 and 5, the resulting maps can be seen. We represent a zoom-in over Catalunya for the parent domain along with the fine domain, to see that effectively the resolution of the prediction is higher.

Question 1

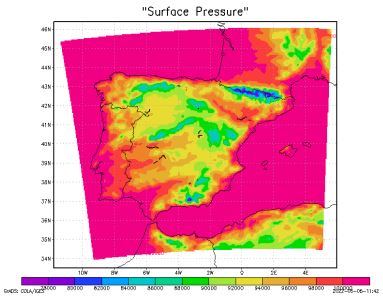
Describe what the preprocessing phase of a meteorological model consists of. For WRF in particular, specify which are the different modules that constitute the preprocessor and explain briefly but clearly their function. You also explain the purpose of the GEOGRID.TBL and Vtable files

We typically start with a geographical static database file with information about the whole planet and a coarse global numerical meteorological prediction model. Then, since we want to get a finer prediction for a more local region of the planet, with a custom nested grid, a pre-processing of the global data is required in order to prepare an ad-hoc grid, boundary conditions and static properties of each grid point.

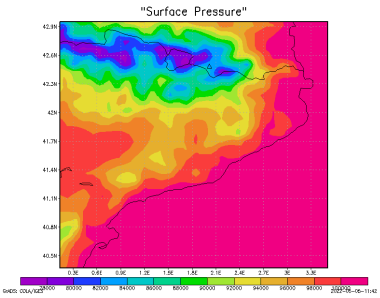
For this, WRF in particular employs a three step procedure. First, modules GEOGRID and UNGIRB must be run, for which the desired settings must be specified in `namelist.wps`. GEOGRID takes care to prepare the static geographical data of the selected region and nested grid, creating the whole setting for the 3D grid. UNGRIB takes the `grib` formatted file with the global metoeorological model and extracts the required data for the selected region. The module METGRID, taking the outputs

of the two previous modules interpolates the meteorological data of the global simulation for this region to the grid points fixed by GEOGRID, to be used as initial conditions for the dynamical WRF simulation.

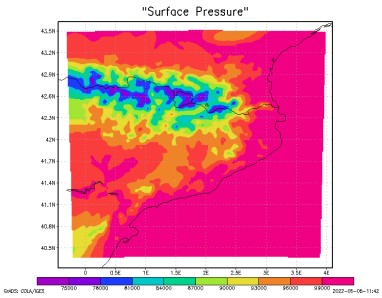
The GEOGRID.TBL file is a text file that defines parameters of each of the data sets to be interpolated by geogrid. On the other hand, GRIB files typically contain more fields than are needed to initialize WRF. The GRIB format uses various codes to identify the variables and levels in the GRIB file. UNGRIB uses tables of these codes – called Vtables, for "variable tables" – to define which fields to extract from the GRIB file and write to the intermediate format.



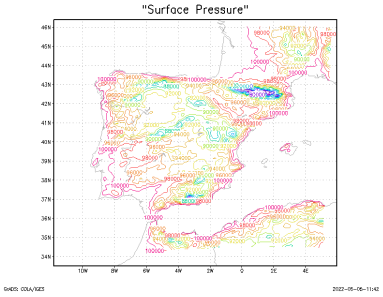
(a) Iberian Pensinsula Shaded Map Dom. 1



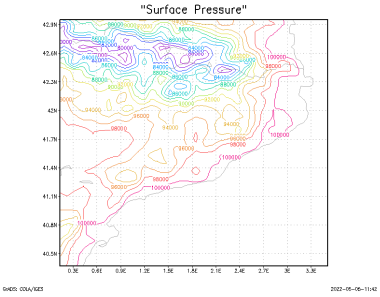
(b) Catalunya Shaded Map Dom. 1



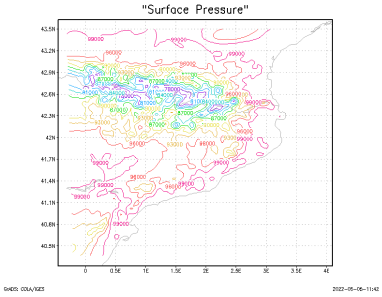
(c) Catalunya Shaded Map Dom. 2



(d) Iberian Pensinsula Shaded Map

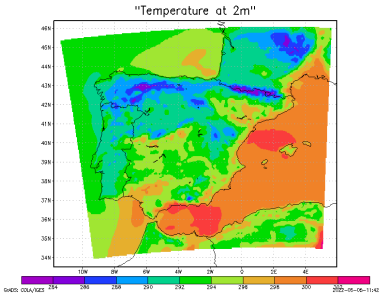


(e) Catalunya Shaded Map Dom. 1

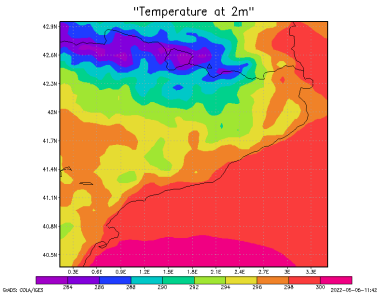


(f) Catalunya Shaded Map Dom. 2

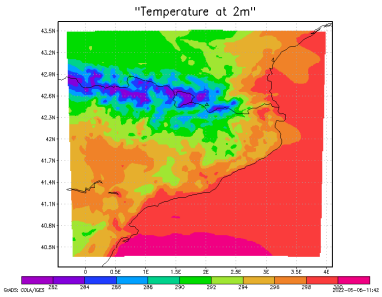
Figure 4: Plot of the predicted surface pressure of day 20/07/2015 at 5:00UTC, employing a nested domain.



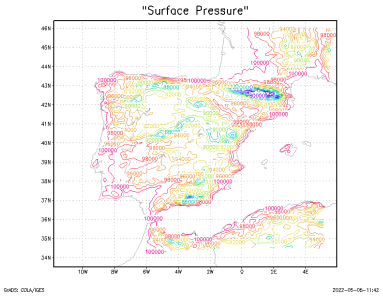
(a) Iberian Pensinsula Shaded Map Dom. 1



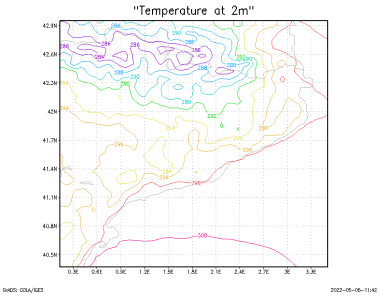
(b) Catalunya Shaded Map Dom. 1



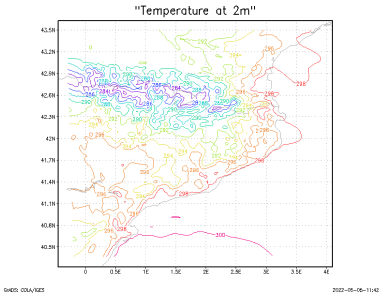
(c) Catalunya Shaded Map Dom. 2



(d) Iberian Pensinsula Shaded Map

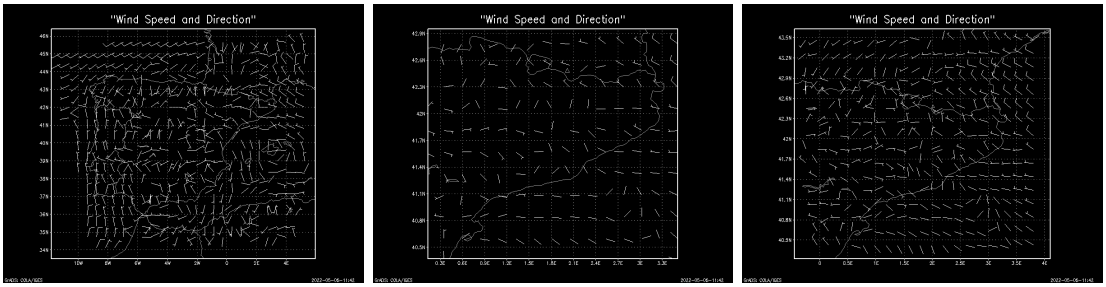


(e) Catalunya Shaded Map Dom. 1



(f) Catalunya Shaded Map Dom. 2

Figure 5: Plot of the predicted temperature at 2m height of day 20/07/2015 at 5:00UTC, employing a nested domain.



(a) Iberian Pensinsula Dom. 1 **(b)** Catalunya Dom. 1 **(c)** Catalunya Dom. 2

Figure 6: Predicted wind speed and direction in a barb plot for day 20/07/2015 at 5:00UTC, using a nested domain.

Question 2

Explain qualitatively why it is necessary to avoid very large jumps in the grid resolution (dx) when nesting. Suppose someone has provided us with data from a global climate model with a 2.5º grid resolution. If with a mesoscale model we would like to zoom or regionalize the model output (this is called dynamical downscaling), how many nestings would be recommended to reach a grid resolution of 8km?

It is necessary to avoid very large jumps in the grid resolution as the start values at each point of the grid resolution are defined by the metgrid.exe which horizontally interpolates the meteorological data extracted by ungrib to the model grids defined by geogrid. Therefore if the jump in resolution is very large we will be starting the WRF simulation using interpolated data instead of simulated data which we would get by nesting multiple domains and using smaller resolution jumps between them. Nesting making the transition of the grid spacing smoother aids both in terms of stability of the solution and interpolating from a very sparse grid employed as initial condition.

For example if we have a global climate model with a 2.5º grid resolution which is equivalent to 277.5 km and considering that the recommended optimal grid ratio between domains is 1/3 then 3 nesting levels gets us to 10.8km and 4 gets us to 3km. Therefore we can use 3 nesting levels where the last level will have a slightly larger than 1/3 reduction.

Question 3

We want to obtain 10 snapshots per hour of the weather state in a 36-hour simulation with a grid resolution of 12 km. What parameters should be modified in the namelist.input file to specify this configuration?

The first parameters that we should modify are related to the start and end date, as in this case we are using a simulation of 36 hours. The following should be the amount of time that we want between each output, that corresponds to 1 hour. Moreover, as we are using a grid resolution of 12 km, we should change the *time_step* variable to 72 (6*12). Consequently, we should also modify the *dx* and *dy* variables to 12000.

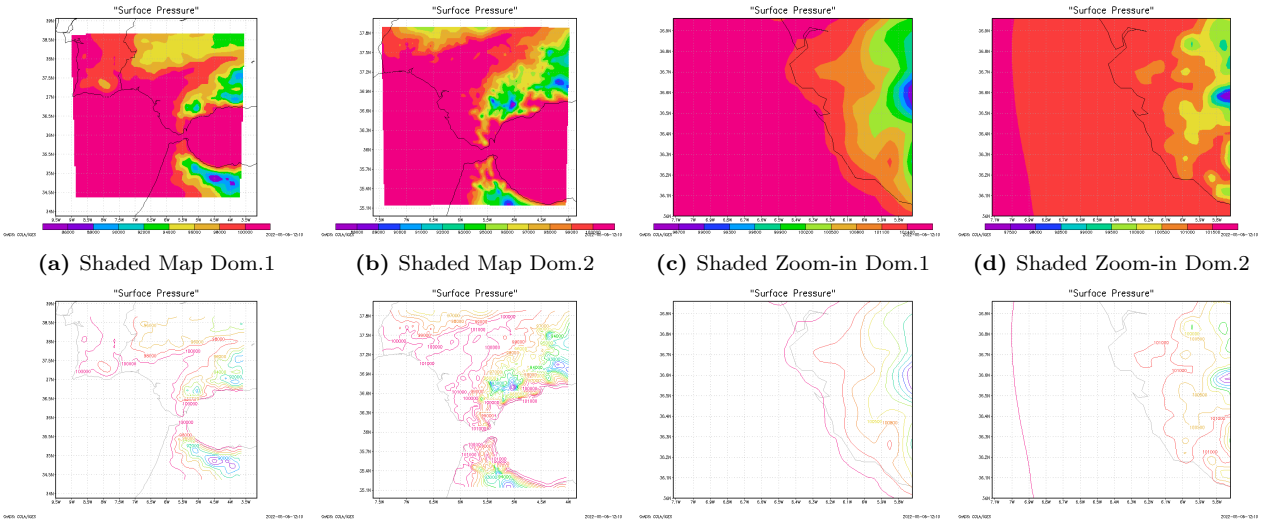
3 Study Case

The main aim of the study case is to preprocess, run and postprocess WRF for the day 20/07/2015 centering the parent domain in the city of Cádiz (Spain) with a 10 km grid resolution and with a nested domain centered in the same point.

We decide to employ a domain grid step ratio 1/3, since this is the optimally recommended one for the goodness of interpolation. In particular, since the parent domain has a 10 km grid step, we choose the nested domain to have a 3.33333 km grid step, following the chosen ratio. Then, the extent of the nested domain is chosen such that it takes within the city of Cadiz.

The results can be seen in Figures 7, 9 and 8. We decide to plot the whole parent and nested domains, which we call domain 1 and domain 2 respectively, together with a zoom-in around the city of Cadiz for both domains.

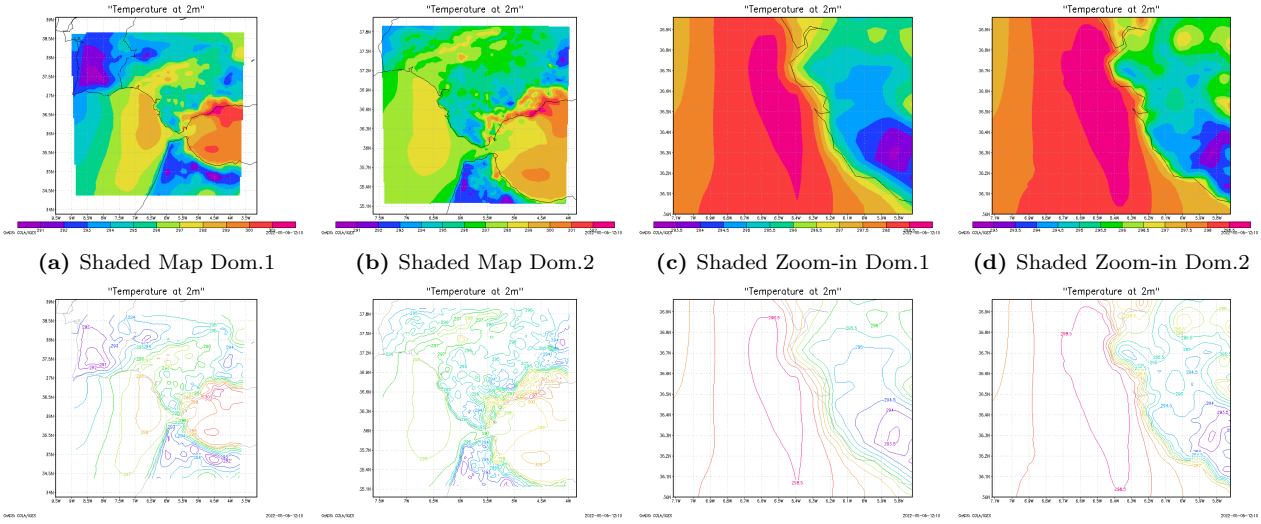
We can see, as could be expected, that the predicted variables for the local window around Cadiz have significantly greater resolution for the nested domain than for the parent domain.



(a) Shaded Map Dom.1 **(b)** Shaded Map Dom.2 **(c)** Shaded Zoom-in Dom.1 **(d)** Shaded Zoom-in Dom.2

(e) Contour Map Dom.1 **(f)** Contour Map Dom.2 **(g)** Contour Zoom-in Dom.1 **(h)** Contour Zoom-in Dom.2

Figure 7: Plot of the predicted surface pressure of day 20/07/2015 at 5:00UTC.



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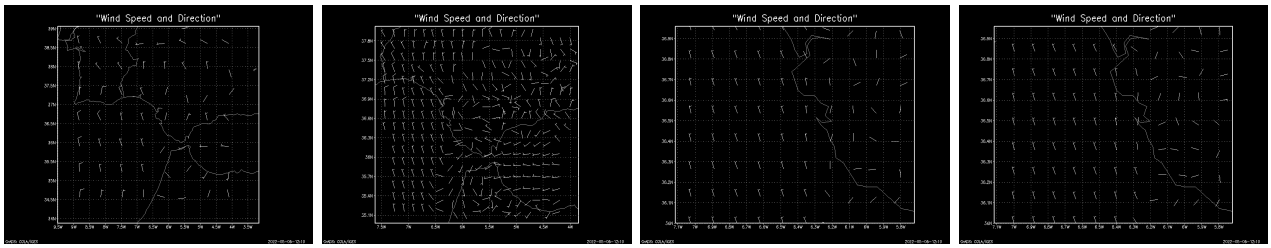
(e) Contour Map Dom.1 **(f)** Contour Map Dom.2 **(g)** Contour Zoom-in Dom.1 **(h)** Contour Zoom-in Dom.2

Figure 8: Plot of the predicted temperature at 2 meters height of day 20/07/2015 at 5:00UTC.



(a) Dom.1 **(b)** Dom.2 **(c)** Zoom-in Dom.1 **(d)** Zoom-in Dom.2

Figure 9: Plot of the predicted wind speed and direction in a barb plot for day 20/07/2015 at 5:00UTC.