NEANIAS ATMO-4CAST Service

Air pollution is currently the most important environmental risk to human health (as reported by the European Environment Agency[1]), especially in urban areas, where most of the population lives, according to the UN[2]. The dream is to abate air pollution; however, it is unrealistic to speak about no air pollution given the impossibility of eliminating all anthropogenic sources and the difficulty of controlling natural source emissions. Thus, the air quality programs, plans and strategies aim to reduce atmospheric pollutants to a point that well-being is assured. The reduction of air pollution in largely populated areas remains a challenge because it requires a substantial economic investment and changes in human behaviours and energy use. But how do we aim to reduce air pollution in cities if we lack the knowledge of the spatial distribution of air pollutants through an urban area? The local air quality monitoring stations may give information on pollutants concentration in the specific monitored area. However, they are not sufficient to give the overall information on urban air quality. Therefore, it is crucial to develop and implement air quality modelling systems that may report urban air quality information.

Therefore, the ATMO-4CAST service aims to help in answering this one crucial question by proposing a modelling system able to forecast and estimate urban air quality. This service will deliver a novel cloud-based solution providing crucial information and products to a variety of stakeholders in agriculture, urban/ city authorities, health, insurance agencies and relative governmental authorities. The air quality modelling system, currently under development, must consider the transport of pollutants from long distances and local scale effects, which are intrinsically dependent on the local weather.

In this sense, the ATMO-4CAST provides the possibility to make weather predictions by means of the Advanced Research Weather Research and Forecasting (WRF-ARW) modelling system. The WRF-ARW is suitable for use in a broad range of applications from urban to regional scale studies. This model has two classes of simulations: ideal or real initialisation. Given the purpose of ATMO-4CAST, the service developed only simulates the last class. In a way of simplifying the compilation of data, the service developed requires only the WRF Pre-processing System (WPS) input data and the definition of both namelist inputs (configuration files), as explained below. In the ATMO-4CAST service there are two ways of compiling the input data.

1. Input data

The service requires input data to generate a forecast, which consists of recent meteorological data of the intended area of the forecast. There are mainly two input methods available:

- GRIB1/GRIB2 formatted data along with configuration files.
- JSON formatted data and configurations (JSON structure detailed in the documentation).

Moreover, the input data may be stored and managed using NEANIAS Data storage/sharing core service (Nextcloud).

1.1. GRIB method

To run the first stage of the WRF model (i.e. WPS) one needs meteorological data that may be provided by global weather models such as GFS (Global Forecasting Service)[3]. This data is provided in GRIB

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[1] EEA (European Environment Agency), 2019. Air quality in Europe — 2019 report. EEA Report No 10/2019. https://doi.org/10.2800/822355

[2] UN Sustainable Development Goal 11: Make cities inclusive, safe, resilient and sustainable https://www.un.org/sustainabledevelopment/cities/

[3] Global Forecasting Service (available https://www.ncei.noaa.gov/products/weather-climate-models/global-forecast)

format, which will be internally processed by the service through the ungrib executable (generate intermediate format data) and then by the metgrid program (see Figure 1). Both programs are set in the namelist.wps.
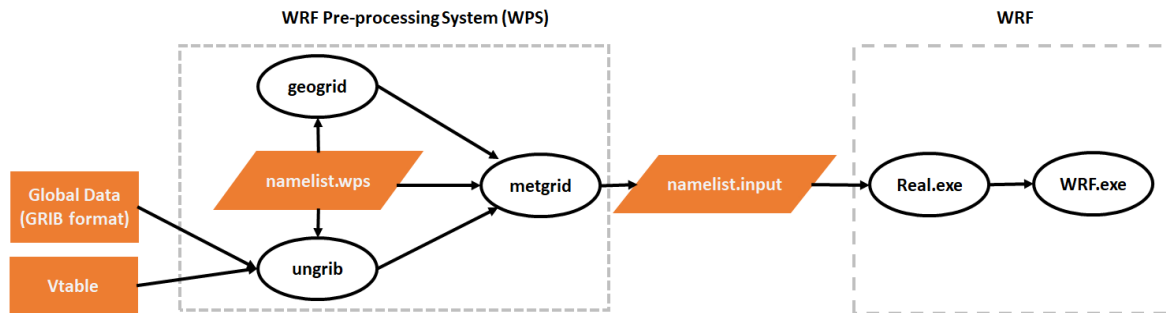

Figure 1: ATMO-4CAST structure for GRIB method (input files in orange).

Also, a Vtable file is requested for the provided GRIB data. The Vtables are used by the ungrib program that reads GRIB files, "degribs" the data, and writes the data in a simple format called the intermediate format. The GRIB files contain time-varying meteorological fields and are typically from another regional or global model, such as NCEP's NAM or GFS models. However, these files usually contain more fields than needed to initialise WRF. The ungrib uses these tables to define which fields to extract from the GRIB file and write to the intermediate format. Vtables may be also provided by GFS and other datasets (e.g. ECMWF, NCEP/NCAR Reanalysis archived at NCAR).

Finally, the service requests the definition of the configuration files: (i) namelist.wps, (ii) namelist.input. While the namelist.wps enables to define each WPS program (geogrid, ungrib and metgrid programs), the namelist.input is used to run the real.exe and then the wrf.exe programs by using as input the data provided by the metgrid program.

1.2. *JSON method*

For the second method, the service requires input data on meteorology and WRF configurations, both in JSON format. This method follows a similar logic to the input method previously mentioned. In fact, it is only a simplification/conversion of the same inputs into JSON format. To achieve this, the historical data required for the WPS stage is provided in a JSON file, and the configurations (both namelist.wps and namelist.input) are provided in a second JSON file. This separation allows easier manipulation and inspections of the configurations since the first file usually becomes very large in size. A detailed description on how these files should be constructed in order to be successfully read by the service is provided in the documentation of the service[4].

2. How to use it

1. First access the web service using this link (https://atmo-4cast.neanias.eu/)

2. To initiate a new study choose that option as presented in Figure 2 and make the login with a google account. Also, the user may consult a list of past simulations.

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[4] JSON Structure Details (available here: https://docs.neanias.eu/projects/a3-service/en/latest/json_structure.html#json-matrices-file)
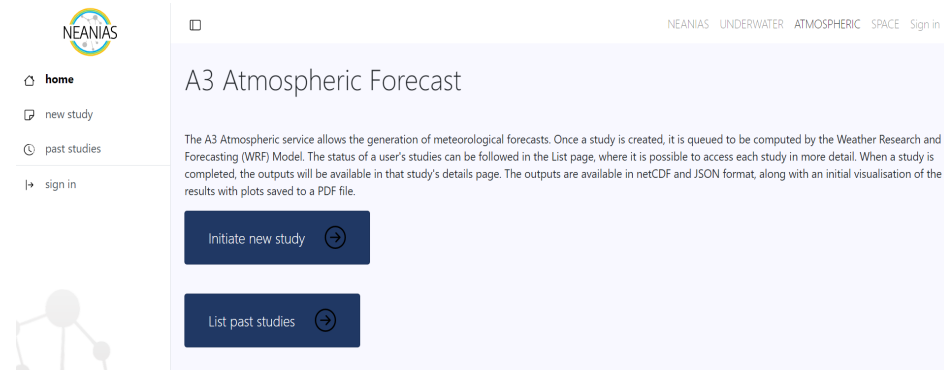
Figure 2: Initiate a new study in ATMO-4CAST service.

3. The input method must be selected (Figure 3): (i) demo files - to run the test files that are directly uploaded in the service; (ii) or (iv) the user must upload directly the requested input data for JSON or GRIB method, respectively; (iii) or (v) the input data shared in the Could may be uploaded directly for JSON or GRIB method, respectively. Then the forecast name must be defined, and select/upload the input data and submit the test.
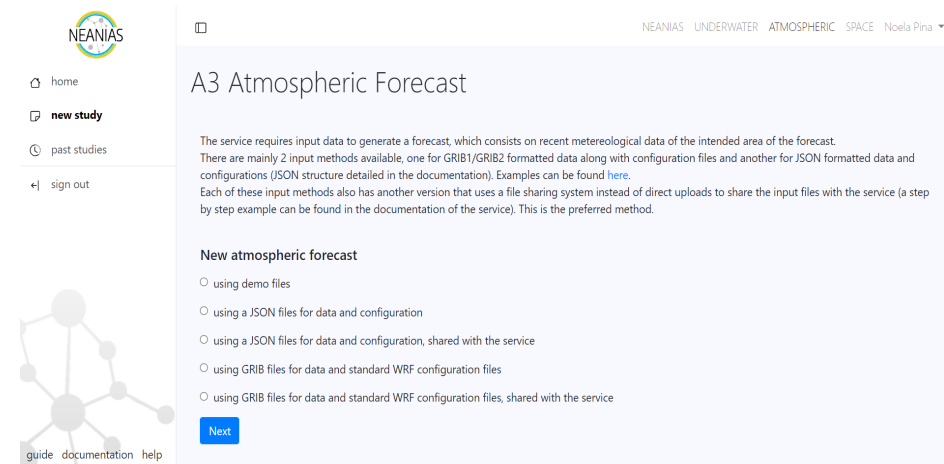

Figure 3: Select the input method.

4. While running, a processing stage table will appear, which may help the user understand at which stage the model is running. When the simulation is finished, the user may download the outputs in netCDF and JSON formats. Moreover, a visualisation of outputs are presented in the service and the maps are provided as PNG images.
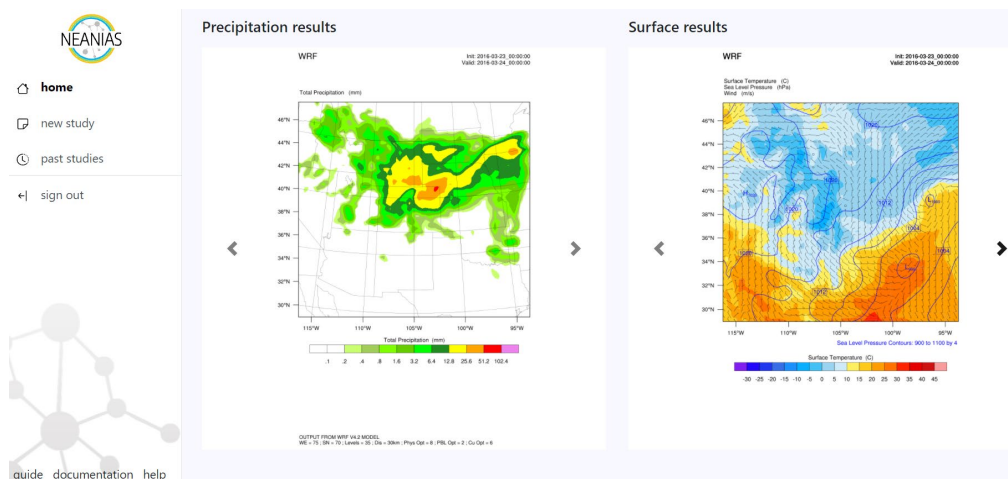

Figure 4: Visualization of output maps in the ATMO-4CAST service.