Work Package 3: Atmospheric research services

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ATHENA Research & Innovation Information Technologies

NEANIAS

Novel EOSC Services for Emerging Atmosphere, Underwater & Space Challenges

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Atmospheric Work package Goal

- Develop and integrate at EOSC three innovative cross-cutting atmospheric services.
- To allow tackling operationally atmospheric-related studies and engineering tasks
- Towards engaging several user communities linked to the atmosphere, including:
  - meteorologists, industrial air pollutant emitters, ecologists, rural urban planners and air quality authorities, geohazards, civil protection, insurance, health agencies.

Services

- **A1: ATMO-FLUD** – Greenhouse gases flux density monitoring
- **A2:**
  - **ATMO-STRESS** – Monitoring components in active tectonic regions
  - **ATMO-SEISM** – Monitoring atmospheric perturbations and corelating them with seismic activity
- **A3: ATMO-4CAST** – Air quality estimation, monitoring and forecasting

Results produced by the NEANIAS project

- Requirements collected, updated, and published
- Software for all 3 services deployed, operational, and published at EOSC for public consumption
- Three validation rounds already done for all services
- All above results are reported at the corresponding project deliverables

Service A1 (ATMO-FLUD) Overview

- Calculating Flux Densities of momentum, energy and scalars (e.g., CO_2), using two methods:
  - Eddy covariance
  - Gradient method
- Started with existing proven algorithms, published in the peer-reviewed literature, implemented in Matlab, at TRL6
- Arrived at a TRL8 web service with user-friendly U/I, REST API, CI/CD, automated testing, integration with NEANIAS core services.

Service operation

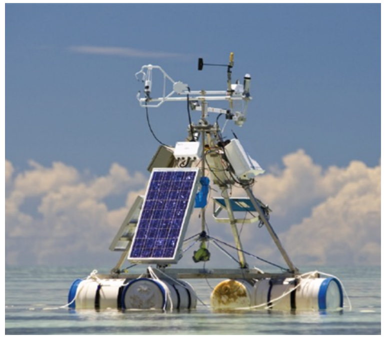
- Input from sensors from a flux tower.
  - Either “fast” data (10Hz), used as input to the Eddy Covariance algorithm
  - Or “slow” data (1Hz) from 4 different heights, used as input to the Gradient Method
- Data analyzed and cleaned as part of the algorithm

- Output
  - Graphs with data analysis and fluxes of the measured energy, momentum, or scalar(s)
  - Text file with results
  - Pdf report ready to be published

Applications

- Scientific applications (e.g. climate change research, oceanography)
- Regulatory applications (e.g. landfill monitoring, municipal emissions)
- Commercial applications (e.g. leak detection, agricultural carbon sequestration, irrigation and efficient water use)

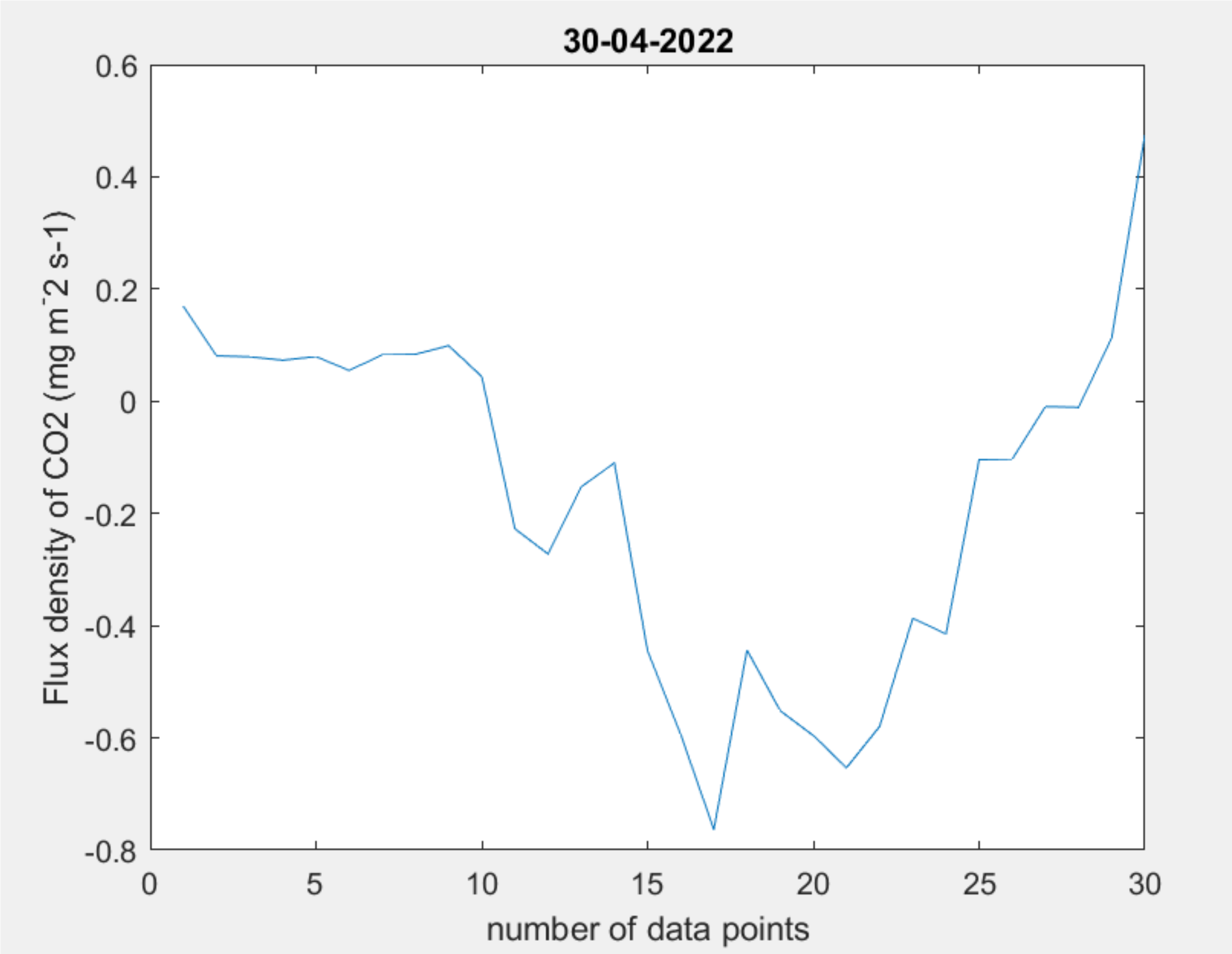


Example use-case

- AGRO4+ project, carbon footprint estimation for vineyard farmers
- Flux towers collect micro-meteorological data and CO_2 concentration
- Data from the tower is fed to the ATMO-FLUD service
- Service produces average CO_2 flux density for the complete field, helping estimate the carbon absorbtion by the plants
- Further processing produces an estimation of the carbon footprint per bottle of produced wine.

Example result for CO2 flux densities

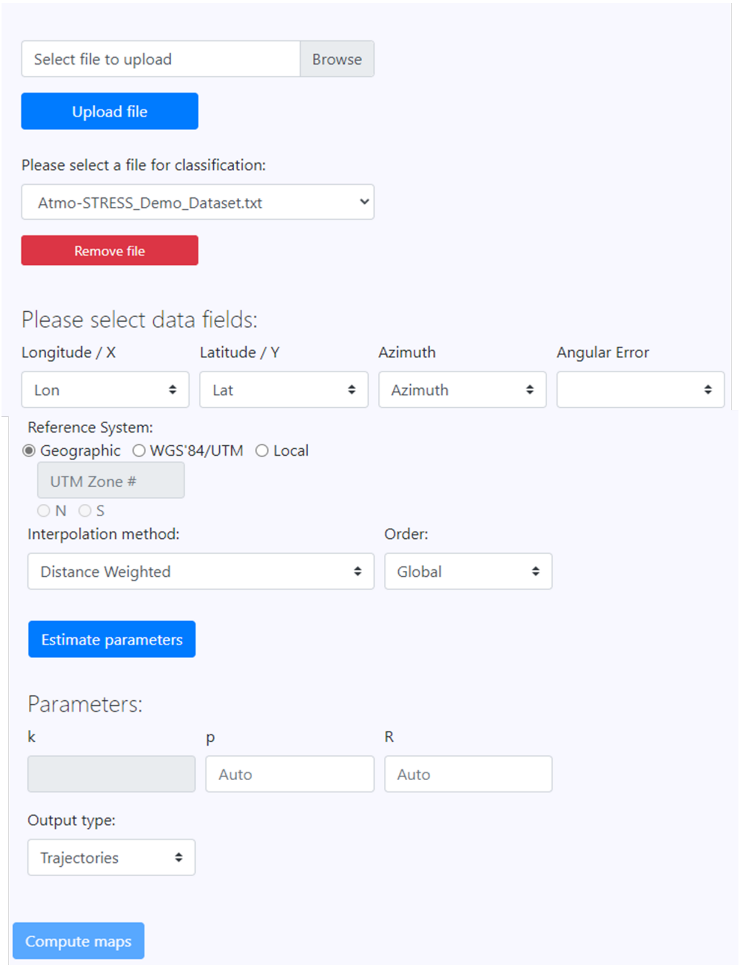


A2 Services: Overview

- The purpose is to monitor atmospheric perturbations and components in active tectonic regions by
  1. Computing regional stress field of a study area using **ATMO-STRESS** service
     - Based on Lee, J. C., & Angelier, J. (1994). Paleostress trajectory maps based on the results of local determinations: the “Lissage” program.
  2. Correlating gas emissions with earthquakes and atmospheric conditions with **ATMO-SEISM** service
     - Based on Neri, M., Ferrera, E., Giammanco, S., Currenti, G., Cirrincione, R., Patanè, G., & Zanon, V. (2016). Soil radon measurements as a potential tracer of tectonic and volcanic activity.
- Integration with essential core services (AAI, logging, accounting, data sharing, and monitoring)

Service operation

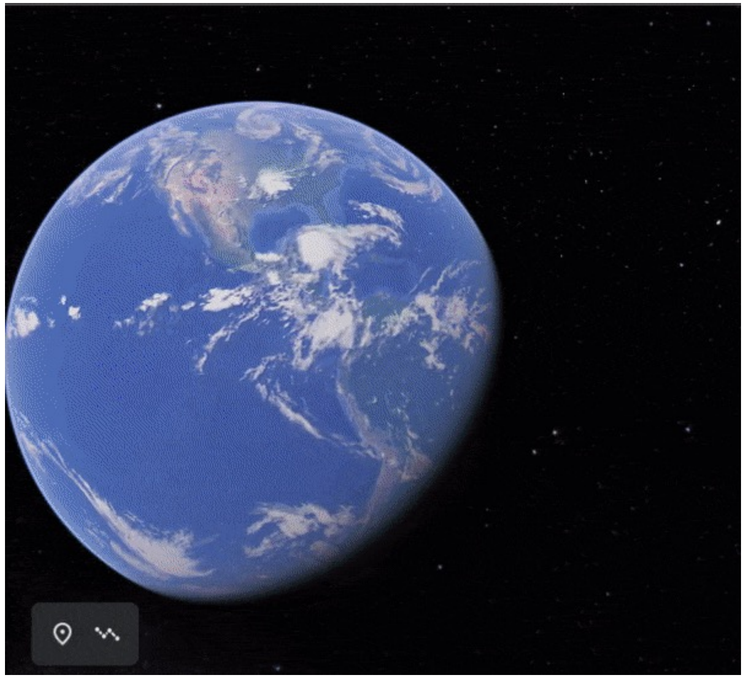
- Input files provided by the user
  - Coordinates (lat/lon): define the geographic position of the data
  - Azimuth or direction of the stress (0-360°)
  - Error evaluated on stress calculation
  - Reference coordinate system
- Analysis of input data and automatic evaluation of parameters
- Outputs:
  - Trajectories map
  - Grid Map
  - Both results are generated in different formats (.json, .kml, .shp and .png)



ATMO-STRESS service: Example use-case

- It is possible to use the service in both tectonic and volcanic area:
  - to calculate and reconstruct the stress field trajectories
  - to identify the possible uprise pathway of the magma and/or gases components

- Knowing the stress field of a specific area can be very useful:
  - In the **oil and gas/petroleum** industries to determine whether hydrocarbon displacement can generate seismic activity
  - In the **geothermal** industries to define presence and position of ground discontinuities that allow geothermal fluids to rise to the surface



Service A3 (ATMO-4CAST) Overview

- **Purpose:** Weather and Air quality estimation, monitoring and forecasting
- Composed by **3 different modules** (weather, emissions and air quality simulations)
- Last module (air quality) build as an **Air Quality system**
- Started **at TRL6** being based on different core models (AUSTAL2000; QTraffic and WRF):
  - Janicke, U. (2014). AUSTAL2000, Program Documentation of Version 2.6. 2014-02-24. Janicke Consulting, Dunum (Germany).
  - Dias D., Antunes A. P., Tchepel O., 2019. Modelling of emissions and energy use from biofuel fuelled vehicles at urban scale. Sustainability, 11(10), 2902.
  - UCAR (2019). Weather Research & Forecasting Model, Version 4 Modeling System User's Guide. https://www2.mmm.ucar.edu/wrf/users/docs/user_guide_v4/
- Arrived **at a TRL8** web service with user-friendly U/I, REST API, integration with NEANIAS core services.

Service operation

- Input files provided by the user for each module:
  - Weather (global meteorological data and configuration files)
  - Emissions (traffic fleet and activity data)
  - Air Quality (both local (traffic) and background contributions; local weather)
- Data analyzed and adapted for each core model
- Outputs:
  - 2D maps generated in different formats (csv; png; geojson; tiff; shapefile;netcdf)
  - 2D maps visualized on the web page

Example use-case: Stavanger city (Air Quality module)

Domain area: 11 km^2
Spatial resolution: 50 m
Duration: 4 min

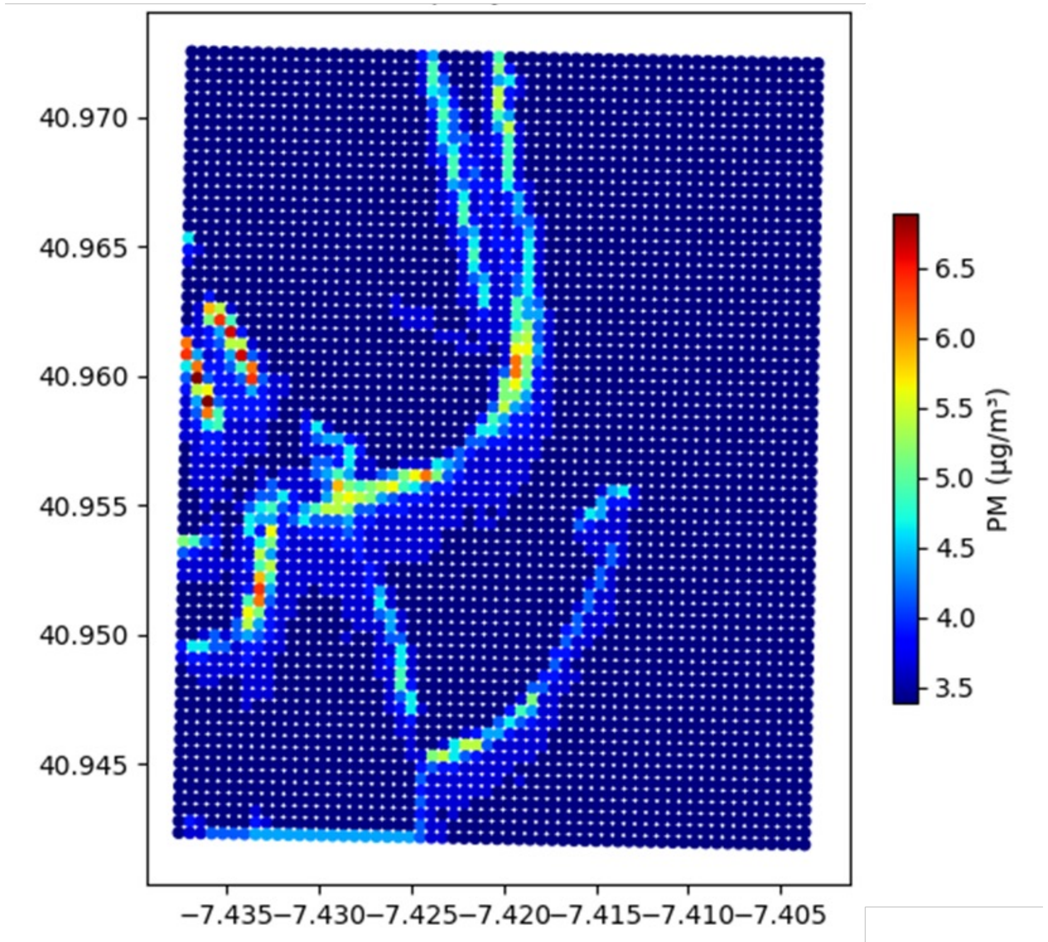
Input:

- Local traffic emissions (based on real traffic counting)
- Local weather obtained from local forecasts
- Vicinity contributions (named background concentrations) from CAMS (obtained by ADAM API)

Outputs:

2D Heat maps generated for every single hour in different formats (csv; png; tiff; geojson) and visualized on the webpage

PM2.5 daily concentrations



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Thank you!
Questions?

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