Highlander

High performance computing
to support smart land services

D5.1 ROADMAP OF ACTIONS AND MATERIAL TO BE USED IN INTERACTIONS WITH USERS (QUESTIONNAIRES, MAILING LIST, SOCIAL PLATFORM, ETC.)

Deliverable Lead	DIBAF
Deliverable due date	2021/03/31
Status	FINAL
Version	V3.0

Co-financed by the Connecting Europe
Facility of the European Union

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DOCUMENT CONTROL PAGE

Title	D5.1
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Publisher	Highlander Consortium
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Type	Report
Language	EN
Rights	Copyright “Highlander Consortium”
Audience	Public X
	Restricted
Requested deadline	M18

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1 Introduction

Activity 5 is based on user-tailored Downstream Application and (pre-)Operational Services (DApOS). The purpose of this activity is to demonstrate the potential of intensive HPC exploitation, done in Activity 4, in generating and preliminarily post-processing huge datasets. Datasets will be combined to create several applications and services for multi-level and multi-sectoral users. Applications and services will be based on users' active participation to define their needs and priorities and, then, to deliver customized products. Activity 5 is divided into two main tasks and here we are presenting the third report of the first one. It consists in an update about exchanges among project partners and interested users to maximize the usefulness, exploitability and sustainability of implemented applications and generated services that will be developed in task 5.2.

Highlander is promoting a user participatory approach for different purposes, such as review and understanding of each user's needs and priorities, co-design and improve of the DApOS directly with users, support the implementation and test of user-tailored DApOS, in order to make it tailored for multiple users at the same time.

All the data, from surveys, working groups, meetings, etc., will be collected in a user platform. It will be a science-society interface, able to facilitate co-design and user-tailored production of applications and services. The dialogue with users will be essential to achieve the purpose and improve the services. Different categories of users will be identified and potentially involved by project partners, such as associations, farmers' organizations, researchers, practitioners, entrepreneurs, etc.

The pandemic situation has slowed down these activities, making it necessary to develop new ways of carrying out the actions envisaged in the presence.

Two blocks of services have been identified: i) continuous short-term forecasts to medium-term projections of climate variability and ii) Integration of climate data, satellite observations and IoT data.

A roadmap of actions has been set up on how to use previous experiences and projects knowledge and tools and how to implement them for the users. Some partners are collaborating to the same DApOS in different Italian regions. This screening on how expected applications and services are currently going on was made through web-call with partners concerning updates related to different DApOS. The roadmap of actions will be implemented and updated every six months.

2 DApOS description and development

2.1 Soil erosion

The DApOS "Soil erosion" is being developed by CMCC.

Actions already taken

The literature has been reviewed about the approaches available to compute the different factors of the Revised Universal Soil Loss Equation (RUSLE), already applied in the C3S Demo Case Soil Erosion (https://climate.copernicus.eu/soil-erosion). However, in HIGHLANDER, they

can benefit from finer resolution climate data and also from tuning of topographic parameters, thanks to better consideration of territorial features potentially stopping the surface flows.

In terms of data, the huge recent efforts to collect sub-hourly rainfall measurements from regional agencies (e.g. environmental, agro-meteorological, hydrological) will be exploited and the harmonization of these time series was completed. Sub-hourly measurements will be used to validate, at point station level, the approach to calculate rainfall erosivity applied to downscaled era5. This work is in progress right now.

Stakeholders' preferences have been largely investigated thanks to the C3S Demo Case Soil Erosion project, allowing to select, as period of interest, the medium term 2021-2050 or, if runs will allow, 2036-2065.

Data from climate simulations (ERA5 downscaling) to use were examined, including needs of pre-processing (units conversion, derivation of secondary variables from primary ones, etc..). The algorithms to be implemented to calculate the rainfall erosivity factor have been defined step by step. Twelve algorithms have been selected to provide a sort of uncertainty due to the use of different empirical models.

Next actions

The mode of return to the user will be via web-GIS maps starting from ready-made layers in which the user can choose the parameters and/or the area of interest and can visualize spatial statistics, changes across time periods and similar.

Pilot area: Italy

2.2 Human wellbeing

The DApOS “Human wellbeing” is being developed by CMCC.

Actions already taken

The literature has been reviewed about the indicators, and their threshold/classification, available to quantify the (dis)comfort for humans due to climate conditions, in particular temperature “real” vs. “perceived” due to relative humidity (e.g. Humidex, Heat index), or also indicator considering wind (Wind Chill index). The advantage of using very high resolution simulations with a special configuration of urban areas will be also evaluated, comparing the same indices obtained under model ensembles without similar configuration.

This DApOS will be in synergy with the one - conducted by DIBAF - evaluating (dis)comfort conditions for animals by using the same or additional climate variables combined into indicators tailored for the livestock sector.

Stakeholders’ preferences have been largely investigated thanks to previous projects, allowing to select, as period of interest, the medium term 2021-2050 or, if runs will allow, 2036-2065.

Data from climate simulations (ERA5 downscaling) to use were examined, including needs of pre-processing (units conversion, derivation of secondary variables from primary ones etc.). The algorithms used for this DApOS were simpler because there are only six indicators. Instead, the processing is heavier since the indicators must be analyzed on hourly and not on a daily scale.

Pilot area: Italy

2.3 Land suitability for vegetation (forests)

The DApOS “Land suitability for vegetation” related to forests is being developed by CMCC.

Actions already taken

The literature has been reviewed to calibrate the approach to be used in the project, evaluating *pros* and *cons* of ensemble of simple to complex algorithms (e.g. BIOMOD) vs. simplified (clustering/grouping or maximum entropy procedures already working with GIS compatible formats and languages). Considering the purposes of HIGHLANDER and the need to exploit HPC for embedding workflows of operations and related services to access results, the latter approach was finally selected.

In terms of data, base maps on forest species at national to regional level have been analyzed and elaborated, to evaluate their representativeness of valuable species for multiple sectors and purposes (e.g. ecosystem services) and to overcome/reduce their heterogeneity and thus required effort for harmonization in terms of classes and map units.

Stakeholders’ preferences have been investigated, thanks to some previous projects (Interreg Central Europe TEACHER-CE, Climate KIC MADAMES and MADAMES-AX). The information obtained allowed to select, as period of interest, the medium term 2021-2050 or, if runs will allow, 2036-2065.

The algorithms to be implemented to derive bioclimatic indicators, predictors of forest suitability, have been defined step by step, from raw data to output variables; moreover, forest presence probability will be extracted through the species distribution modelling tool as final information for end users.

Next actions

The DApOS will be offline because ready routines from old jobs will be used. "Offline" means that the tool implemented to assess forest suitability will not run on HPC due to difficulties in integrating codes that are already running on other machines (and do not need HPC). HPC will be instead used to prepare climate data feeding these tools. The mode of return to the user will be via web-GIS maps starting from ready-made layers in which the user can choose the bioclimatic indicator and the species of interest and the area to be selected in order to explore e.g. spatial statistics about environmental conditions or forest presence (proxy of habitat suitability).

This DApOS will be complementary with another component related to land suitability for crops and developed by CIA-PIEMONTE and ARPAP.

Pilot area: Italy

2.3.1 Changes in the land suitability for vegetation (forests, crops)

The DApOS "Changes in the land suitability for vegetation (forests, crops)" are being developed by CIA in collaboration with ARPAP.

Climate change introduces new biological risks for the typical crops of the territory. By combining the analysis of data collected in the field, the historical data from high-resolution reanalysis and the predictions of climate scenarios, it is possible to prevent these risks and define adaptation policies for particularly prone crops, such as vineyards, autumn-winter and spring-summer cereals, particularly relevant for regional economy.

Actions already taken

Previously, web meetings have been organized between CIA and ARPAP to better define the DApOS; development and test of procedures to manage climate data, that will be carried out by ECMWF and CMCC, have been made.

2.3.1.1 Mycotoxins on cereal

Currently, a study on mycotoxins (DON on wheat – AFLATOXINS in corn) in 3 territories (Alessandria, Carmagnola, Canavese) is ongoing. The first data on the impact of mycotoxins on the agri-food chain date back to 2010. CIA has achieved organized data from 2012 onwards from two territories (Alessandria and Carmagnola) and is waiting for data belonging to Canavese.

2.3.1.2 Evaluation of the grapevine vocationality at regional level

Regarding viticulture, ARPAP is waiting for high-resolution data for the models but ready for testing.

2.3.1.3 Changes in forest habitat suitability

Regarding forests, a collaboration with Prof. Garbarino (UNITO) is ongoing. Starting from own climatic data with those of ensemble, a comparable downscaling to that made by CMCC was prepared.

Pilot area: province of Torino

2.4 Water cycle and sustainability of competing uses

The DApOS "Water cycle and sustainability of competing uses" is being developed by CMCC.

Actions already taken

The literature has been reviewed to calibrate the approach to be used in the project, evaluating *pros* and *cons* of sophisticated and spatial distributed hydrological models (e.g. ArcSWAT, TOPKAPI) - better representing hydraulic connectivity over hill slopes but with a lot of parameterization required - vs. simplified lumped models - less accurate spatially but with the advantage of reducing the number of initializing information/parameters often impossible to find.

Considering the purposes of HIGHLANDER and the need to exploit HPC for embedding/running workflows of operations and related services to access results, the latter approach was finally selected.

In terms of data, previously collected information from *Hydrological Yearbooks* (Bari Compartment) on rainfall and discharge, has been checked for possible errors in data registering (spikes, gaps) and in the digitizing operations. Besides the outlet station San Samuele di Cafiero, other hydrological stations were added to investigate upstream and downstream hydrological behaviour in the watershed.

Stakeholders' preferences have been investigated, thanks to some previous projects (South East Europe Transnational Cooperation Programme ORIENTGATE, Interreg Central Europe TEACHER-CE). The information obtained allowed to select, as a period of interest, the medium term 2021-2050 or, if runs will allow, 2036-2065.

A study on which combination of climatic variables affects the dynamics of the Ofanto river discharge is ongoing. Some indicators - especially related to droughts - have been tested but they did not return interesting correlations at this time.

Next actions

The data on the flow of the river are being analyzed for the first time and by the end of the summer, once the simulations are over, they will be ready and the DApOS will proceed quickly.

This DApOS will be strictly connected with the one on "Crop water requirements forecasts in Apulia pilot", conducted by ARPAE in the area of Capitanata irrigation consortium (see 2.5.3).

Pilot area: Ofanto river basin, Puglia.

2.5 Crop water requirements forecasts

The DApOS “Crop water requirements forecasts” is being developed by ARPAE.

It is a climate service addressed to irrigation water management in agriculture. The accomplishment of the Tasks is ongoing, in synergy with Highlander partners and stakeholders. The stakeholders’ involvement will allow collecting input data and validating the results.

This DApOS is a climate service that will provide **sub-seasonal forecasts of irrigation needs** for crops and **impact studies of crop irrigation under climate change projections**. Therefore, this DApOS includes two different rationales according to the forecast/projections used as input. In general terms, this DApOS combines information on agricultural land use from satellite data, observed weather data, climate weather series, HIGHLANDER sub-seasonal forecast/future projections and a soil water balance model.

During the period covered by the current milestone, a networking activity was carried out in order to set up and organize the work devoted to the development of the DApOS and apply it to the Highlander pilot regions (Emilia-Romagna, Trento province, Piedmont, Apulia). Therefore, several virtual meetings were held between ARPAE and the project partners in order to define needs, aims and specific features of applications of the DApOS in the pilot areas.

In the following, these progresses are described.

2.5.1 ARPAE preparatory activities

Actions already taken

Technical documentations on data requirement specifications and output format have been provided to the HIGHLANDER partners involved in the DApOS pilot development. The 2 reports on soil water balance (SWB) output are made available at the following links:

Highlander SWB output description

Highlander SWB data requirements

The definition of input data format for sub-seasonal forecasts was provided to ECMWF.

In previous months a document has been compiled to clarify the specifications of the DApOS: data flow, input and output data, etc. This information is needed by the CINECA and CMCC partners who are designing the Highlander platform architecture. The specifications of the DApOS "Crop irrigation" have been collected in a document that is proposed as a template to all DApOS managers to provide the specifications of their DApOS.

Subsequently, a test match has been made and a requirement has been added: the data rotated pole grid format has been re-interpolated on a regular lat-lon grid only in the areas of interest of the DApOS.

Then, identification of meteorological variables and format needed for the DApOS has been made and also a pipeline modification to move from deterministic prediction data to probabilistic prediction data (ECMWF format).

2.5.2 DApOS Crop water requirements forecasts in Emilia-Romagna pilot

Actions already taken

Activity plan of ARPAE: The crop water requirement forecasts outputs will be delivered to the users through a webGIS platform, starting from the prototype developed within CLARA project (https://servizigis.arpae.it/moses/home/index.html). CLARA project conceived so far to produce 7-day deterministic forecasts and seasonal probabilistic forecasts. The webGIS has been activated on Burana Irrigation Consortium (representative of Emilia sub-region) and Romagna Irrigation Consortia (representative of Romagna sub-region).

Next actions

Using ECMWF sub-seasonal forecast the platform will be extended to produce probabilistic monthly forecasts of irrigation needs. ECMWF will produce the bias-corrected (based on ecpoint post-processing) variables between April (minimum and maximum temperature) and June 2021 (daily total precipitation). In the meantime, ARPAE will test applications with the non-calibrated ones.

Pilot area: 4 Land reclamation and Irrigation Boards (consorzi di bonifica) from Emilia-Romagna

2.5.3 DApOS Crop water requirements projections in Apulia pilot

Actions already taken

Activity of ARPAE and CMCC: The coordination activities via web call allowed to frame the opportunity to set up the DApOS of climate projections of irrigation in the Apulia region, with a focus on Land reclamation and irrigation consortium of Capitanata. In this area, an interest

about impact study of climate projections of irrigation has been identified, due to the strategic value of information on water resource planning in agriculture, conceived in the broader context of water resource management, by means of a synergy with the DApOS 'Water cycle and sustainability of competing uses'.

The case studies have been decided, preparing the arrival of the first data is in progress.

Pilot area: sub-area of irrigation consortium of Capitanata, to be defined

2.5.4 DApOS Crop water requirements projections in Trento pilot

Actions already taken

Activity of ARPAE and Fondazione Mach (and Dedagroup): web meetings have been organized in order to define the DApOS with Fondazione Mach and Dedagroup. An impact study on climate change projection of irrigation can provide data and information that could be useful in order to add further contents and details within the Climate change Adaptation Plan of Trento Province.

The case studies have been decided, preparing the arrival of the first data is in progress.

Pilot area: Pianura Rotaliana, where orchards and vineyards are widespread. The area was selected due to the strategic importance of these crops, in terms of economic value.

2.5.5 DApOS Crop water requirements projections in Piedmont pilot

Actions already taken

Activity of ARPAE and ARPAP: web meetings have been organized in order to define the DApOS, involving also the Agriculture department of Piedmont Region. ARPAE and ARPAP, in collaboration with Piedmont Region, will set up the pilot by collecting input data. Furthermore, exchange of knowledge between ARPAE and ARPAP, in terms of tools aimed at assessing water balance in agro-ecosystems, will be done. An impact study on climate change projection of irrigation in Piedmont can be useful to assess the water needs of arable lands and orchards.

ARPAP has downloaded and installed the software Criteria and is conducting some tests on weather data. Three territories with different crops were identified. The model ran on its weather data and grid data waiting for data processing from CMCC.

Pilot area: possibility to select the plain areas of Cuneese, Alessandrino and Torino/Carmagnola, where arable land and orchards are widespread.

2.6 Animal welfare and land suitability for farming

The DApOS “Animal welfare and land suitability for farming” are being developed by CIA in collaboration with ARPAP .

Climatic variations can have an impact on the availability of forage in the mountain pastures. Through the intersection of observed historical data, coming from high-resolution models and forecasts on scenarios, it is possible to suggest adaptation policies aimed at setting a more relevant pasture calendar for effective management rather than applying ordinary exceptions.

Actions already taken

To carry on the activity several web meetings have been organized to better define the needs. From the end of October 2020 CIA has started to provide the historical data of ascent and descent from the pastures in order to investigate the possible link with climate.

Currently, a study on how pastures can be compromised by climatic variations is ongoing.

Next actions

Prof. Lombardi (UNITO) will provide CIA with data on pasture forage species.

Pilot area: province of Torino

2.7 IoT for animal wellbeing

The DApOS “IoT for animal wellbeing” is being developed by DIBAF.

Actions already taken

At the beginning of the project, DIBAF has started a dialogue with different breeders associations, in particular Associazione Italiana Allevatori (National breeder association) - AIA; Associazione Nazionale della Pastorizia (Sheep and goat association) - ASSONAPA; Associazione Nazionale Allevatori Suini (Pig breeder association) - ANAS.

Collaborations have been established with ANAS, University of Bologna and “Università Cattolica del Sacro Cuore” of Piacenza. Visits have been organized to the ANAS Genetic Centre in Vittoria Di Gualtieri (Reggio Emilia), Bologna and Piacenza; this region is considered an important centre of swine husbandry.

Other dialogues were organized by phone, emails and web-calls. From this collaboration with the stakeholders, in the first roadmap in March, it has been assessed that:

1) one of the major concerns regards the economic impact of climate changes on livestock production efficiency reduction due to heat stress. Therefore, DIBAF was actively involved in the evaluation of sensors for temperature detection in two different conditions: stable (cattle and swine) or pasture (cattle and sheep) breeding;

2) IoT capable of detecting livestock position and movements for pasture livestock would be very useful to identify the state of health and other conditions.

Therefore, DIBAF has been involved in the evaluation of sensors for temperature detection. Animal talkers are sensors that detect changes in animal’s physical features and relate them to their conditions like, for example, disease or stress. The sensors measure the animal skin temperature, in bovine and ovine. The data detected will be correlated, through appropriate relations, to the environment temperature and humidity, determining animal conditions. Different models of animal talkers were being evaluated (i.e. collar, subcutaneous, heartbeat detector). The expectation was to conduct the first field trial in early 2021. The dialogue with AIA has been continuing. Technical documentation has been provided to the HIGHLANDER partners and has been published in the wiki at the following link:

Animal talker HIGHLANDER data

DIBAF had also developed techniques for -omics analysis, in particular metabolomics. This is relevant, in this particular in this DapOS, because -omics data could be used to evaluate the animal welfare state and the animal productions (quality/quantity). As an example, results from metabolomics have been disseminated through this article Anti-Inflammatory Potential

of Cow, Donkey and Goat Milk Extracellular Vesicles as Revealed by Metabolomic Profile, in which CEF HIGHLANDER Project is cited in the acknowledgments.

Updates on this DApOS concerns three connected elements:

AnimalTalker

A suitable BLE chip was found (Nrf52840) and tested using evaluation boards. Both hardware and software tests were made. An accelerometer and a temperature sensor were connected to the BLE chip. A new possible technology (NB-IOT) to allow internet connection and a suitable GPS module was found. Two possible providers of RFID subcutaneous temperature sensors were contacted and an RFID reader was bought to perform some compatibility test. The first Animal buttons are currently under development using EDA software (EasyEDA).

AIA production data

AIA collects livestock production, reproduction, sanitary and managerial data from entire Italy. Through LEO project – Livestock Environment Opendata (https://www.leo-italy.eu/) and DIBAF collaboration, these data will be used in the Highlander project. An ad hoc database to store the data inside the Data Lake has been created. All the collected data will be analyzed together with climatic data using Machine learning approaches.
The objectives are to create indicators of animal wellbeing, due to climate conditions (in this case historical data -climate and productions- will be used) and to evaluate animal wellbeing, due to physiological (in this case, IoT data will be used) and environmental conditions.
At this moment, AIA has shared the first batch of dairy data production from Italian Simmental (Pezzata Rossa Italiana dairy cow). The data shared are milk yield, fat, protein, lactose, SSC, urea, casein, fatty acid profile (partial and on few animals), coagulation parameters (R, A30, LDG), cryoscopy, BHB, pH, etc. Moreover, animal information such as coordinates, number of lactation, days in milk, etc. was shared. These data are from Friuli-Venezia Giulia and Sicilia regions (to evaluate different environments), from 2015 and 2020. The dataset comprises more than 580000 entries, from more than 814 farms and more than 37000 cows. The objective is to start the test to identify the best model to predict the environmental effect in milk production.
Then, the entire historical AIA dataset for Holstein and Simmental (almost 1.2M of animals and 10k of farms per year evaluated) will be used for the real algorithm training.

Climatic data

The DApOS needs, from CMCC, downscaled ERA5 reanalysis data (1989-2018), at this moment computed until 2013, and downscaled projections data (2021-2050), starting when GALILEO

100 will be available. From ECMWF, ERA5 historical data and sub-seasonal forecast data (15-30 days), available from March/April 2021, will be used.
We identified the most suitable meteorological set of variables to use in the ML algorithm to evaluate animal wellbeing with the help of ECMWF and CMCC teams.
ECMWF extracts data from ERA5 hourly dataset, from 2015 to 2020 for entire Italy. The data will be used in a test, together with AIA data.

Pilot area: Italia

2.8 Natural park environmental management

The DApOS "Natural parks environmental management" is being developed by FEM, in collaboration with DIBAF.

In-situ sensors' network, combined with remote sensing images, will be used to monitor mountain forests' health and climate variability in a natural Park, based on tree ecophysiological variables measured at individual level. The data continuously collected by the *in situ* monitoring network will be exploited for a fast assessment of forests health and trends (i.e. vulnerability, threats, response to disturbance). The average state of the forest will be made at different time scale through basic statistics. Advanced data analytics tools, including machine learning (ML), will be used. Moreover, ML algorithms will be tested as early warning system. In the same area, Sentinel 2 data was used to test their suitable to predict meadow cuts and to improve pasture management. Satellite data was calibrated with a field spectral data collected with a drone in three different pastures. The algorithms developed in test area will be implemented and applied, thanks to HPC, throughout the Park area.

Actions already taken

At the beginning of the project the importance of planning on the integration of short- and long-term climate data, satellite observations and in-situ IoT data was highlighted. Using this integrated system we will apply animal welfare models to cow farms in the Trentino mountains. FEM has a database of satellite images, collected from the end of 2013, and ground data in high resolution, from Trento Province. The sites for the installation of the sensors were identified and installation permits were obtained. Fifty sensors will be used in two areas: beech and spruce forests. Moreover, FEM, in cooperation with Udine and Padova University, was developing collars equipped with GPS for monitoring animal wellbeing.

As a dissemination task, involving also ART-ER, FEM was in contact with "Nature Park Paneveggio - Pale di San Martino" to organize an event to present Highlander project, and with "Institution Trentino Sviluppo" to plan a seminar to display potentiality of this DApOS.

Data collection related to treetalker has begun on July.

Treetalker is a device that allows to measure:

- tree radial growth, as an indicator of photosynthetic carbon allocation in biomass. It is measured using an infra-red pulsed distance sensor positioned at few centimeters away from the tree trunk's surface and kept in place by a carbon fiber stick anchored in the xylem;
- air temperature and relative humidity, to compare the data measured with the external conditions;

tree stability parameters, to allow real time forecast of potential tree fallings by mean of an accelerometer;

stem humidity, to evaluate the xylem moisture content as indicator of hydraulic functionality;

light penetration in the canopy, in terms of fractional absorbed radiation and light spectral components related to foliage dieback and physiology. This measurements are performed using two spectrometers which are sensitive to bandwidth ranging from 450 nm to 860 nm;

sap flow, as an indicator of tree transpiration and functionality of xylem transport. It is calculated according to the thermal dissipation method of Granier: a probe pairs is inserted in the main trunk with a vertical separation of 10 cm, the upper probe is heated while the other is used to measure the reference temperature and includes a capacitive sensor of wood humidity (stem humidity). The sap flow can be obtained starting from the difference between the two temperatures.

Technical documentations on data have been provided to the HIGHLANDER partners and have been published in the wiki at the following link: Tree talker data

The updates of this DApOS consist of three parts: IoT data from tree talker, satellite data for meadows and pastures, and forests.

Regarding sensors, two sites in Parco di Paneveggio has been chosen and there 25 sensors in each site were installed in July. Four other sites in Trentino (two in Parco Adamello- Brenta and two in forests located in the East part of the Province) were added to extend the area of interest. In total 170 working devices are in place collecting data.

Regarding meadows and pastures, Sentinel 2 satellite images have been downloaded from ESA, the algorithm has been tested and the output consists of maps to estimate forage availability in pastures during the summer. The maps will be updated every fifteen days. In this use case, no climatic data are needed.

Regarding forests, hyperspectral and Lidar data have been used to classify species and predict forest biomass. The algorithm has been partially tested in CINECA and implemented. The output consists of static maps of these two variables.

Pilot area: Trentino

2.9 Forest fire prediction and controls

A DApOS similar to that defined by FEM in the Trentino area, is being developed by DIBAF and CMCC in the Puglia region. Data coming from sensors will be used for monitoring variables potentially linked to fires. This DApOS is linked to the "OFIDIA – Operational FIre Danger preventIon plAtform" project, funded by: European Territorial Cooperation Operational Programme "Greece-Italy" (2007 – 2013). For these reasons, Letter of Agreement for the exchange of data between Highlander and Ofidia has been produced.

Conservation of forest resources and prevention of forest fires are fundamental activities to mitigate and reduce climate change impacts. There are already services and projects to monitor, through remote and proximal sensing data, the progression of forest fires and the condition that can trigger and foster them. The goal in "Forest fires prediction" is to set up and apply a model based on remote data, such as satellite images, proximal data, such as ground sensors (IoT), and medium term meteorological predictions, to provide a forest fire risk analysis service. This service will support the green areas and natural parks' management to preserve the forest resources of the area, and, at the same time, to guarantee the safety of human settlements nearby.

Actions already taken

Technical documentations on data have been provided to the HIGHLANDER partners and have been published in the wiki at the following link: Tree talker fire data

Fire risk in the Mediterranean regions can be modeled exploiting different data layers available in Highlander. All the following data will be included in Highlander DataLake for Machine Learning analysis:

- Climate data (CMCC, ECMWF) offering a perspective on drought which is the main driver of fire occurrence;
- tree talker fire;
- remote sensing data (from satellite or airborne) can produce information on
    - Vegetation senescence: by specific indices, linked to the amount of dry matter that favors fire occurrence and spread. E.g. satellite Sentinel 2 data (10-20 m spatial resolution)
    - E.g. airborne hyperspectral senescence indices
    - E.g. airborne lidar data to estimate vegetation (fuel) biomass
    - E.g. satellite radar data linked to vegetation biomass and water content;

- ancillary information:
  - E.g. Historical fire maps: very important inputs in models to establish fire risk classes;
  - E.g. Local vegetation maps (including silviculture data) can help in the fine-scale classification of vegetation

The joint use of these layers as input in machine learning classification models allows predicting classes of fire risk in different environments. The accuracy of the fire risk prediction model is dependent on the amount and quality of input information.

Pilot area: Puglia

2.9.1 Forest fire potential

The DApOS "Forest fire potential" are being developed by ARPAP in collaboration with UNITO.

The Mediterranean basin is considered a biodiversity hotspot and, more than other regions of the globe, is subject to global change (climate and land use). With the help of historical data, high resolution models using the past and future climatic data, will predict the future dynamic trends of Mediterranean forests (mainly the alpine one). The results will be analyzed at the level of specific composition and alteration of the regimes of natural disturbances.

Actions already taken

Several web meetings have been carried out to better define the needs of such a DApOS. A preliminary activity to test the procedure for the evaluation of the forest fire potential using available climate data was carried on in order to build a tool to be used with CMCC climate scenarios. Currently, ARPAP is waiting for data processing by CMCC to continue.

Personnel involved: in order to be able to carry out the activities described above, three internal employees from ARPAP have been assigned to the project, one temporary employer has been hired and an agreement has been signed with UNITO (University of Turin) to support a PhD fellow.

Pilot area: Piemonte