

## **EOPEN**

opEn interOperable Platform for unified access and analysis of Earth  
observationN data  
H2020-776019

# **Evaluation of the final system and field demonstrations**

<b>Dissemination level:</b>	Public
<b>Contractual date of delivery:</b>	Month 36, 31/10/2020
<b>Actual date of delivery:</b>	Month 36, 30/10/2020
<b>Work package:</b>	WP7 Evaluation and pilot implementation
<b>Task:</b>	T7.2 Field demonstrations
<b>Type:</b>	Demonstrator
<b>Approval Status:</b>	Final
<b>Version:</b>	1.0
<b>Number of pages:</b>	86

<b>Filename:</b>	D7.4- Evaluation of the final system and field demonstrations v1.0.docx
<b>Abstract</b> This deliverable reports on the evaluation of the final system and on the field demonstrations. It illustrates how was deployed and validated the technologies for each pilot, together with a set of recommendations emerging from the pilot demonstration. This deliverable includes also the final demonstrations that showcase the EOPEN functionalities	
The information in this document reflects only the author's views and the European Community is not liable for any use that may be made of the information contained therein. The information in this document is provided as is and no guarantee or warranty is given that the information is fit for any particular purpose. The user thereof uses the information at its sole risk and liability.	



This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement 776019

## History

Version	Date	Reason	Revised by	Approved by
1.0	26/10/2020	First revision of preliminary draft.	Gabriella Scarpino Serco	
1.0	28/10/2020	Revised	Silvia Scifoni (Serco)	
1.0	30/10/2020	Final revision	Gabriela Scarpino	

## Author list

Organisation	Name	Contact Information
AAWA	Francesco Zaffanella	francesco.zaffanella@distrettoalpiorientali.it
NOA	Vassilis Sitokonstantinou	vsito@noa.gr
FMI	Jani Tyynelä	jani.tyynela@fmi.fi
Serco	Gabriella Scarpino	Gabriella.Scarpino@serco.com
SpaceApps	Bernard Valentin	bernard.valentin@spaceapplications.com
CERTH	Stelios Andreadis	andreadisst@iti.gr
USTUSS	Li Zhong	li.zhong@hlrs.de

## Executive Summary

This deliverable is the last one of the WP7 and it reports on the final evaluation of the EOPEN platform carried out by each PUC, with a focus on the PUC1 field exercise. As reported in deliverables 7.1, 7.2 and 7.3, PUCs developed their own demonstration and evaluation plan and provided training materials to their stakeholders; in the annex, KRs evaluation update, based on the same metrics as defined in D7.2 are reported in addition to some additional implementation on PUC1. Also, this deliverable reports about the feedback received on each use case and about any innovation asked by stakeholders, not included in the previous deliverables since this concludes the work package.

Structure of the document:

- PUC evaluation
- Field exercise
- PUC1 Questionnaires results
- Conclusions

Annex including KRs evaluation update, based on the same metrics as defined in D7.2.

## Abbreviations and Acronyms

<b>AOI</b>	Area Of Interest
<b>API</b>	Application Programming Interface
<b>ARI</b>	Adjusted Rand Index
<b>CFD</b>	Centro Funzionale Decentrato (one of the regional civil protection centres in Italy)
<b>COM</b>	Current Operating Model
<b>DCNN</b>	Deep Convolutional Neural Network
<b>DEM</b>	Digital Elevation Model
<b>DSM</b>	Digital Surface Model
<b>DSM</b>	Digital Surface Model
<b>GA</b>	Grant Agreement
<b>HPC</b>	High Performance Computing
<b>HPDA</b>	High Performance Data Analytics
<b>IoU</b>	Intersection over Union
<b>KPI</b>	Key Performance Indicator
<b>LDA</b>	Latent Dirichlet Allocation
<b>MNDWI</b>	Modified Normalized Difference Water Index
<b>NDVI</b>	Normalized Difference Vegetation Index
<b>NDWI</b>	Normalized Difference Water Index
<b>NER</b>	Name Entity Recognition
<b>NMI</b>	Normalized Mutual Information
<b>OA</b>	Overall Accuracy
<b>OWL-DL</b>	Ontology Web Language Description Language
<b>PA</b>	Producer's Accuracy
<b>PSRI</b>	Plant Senescence Reflectance Index
<b>RDF</b>	Resource Description Framework
<b>RF</b>	Random Forests
<b>RNN</b>	Recurrent Neural Networks
<b>SAR</b>	Synthetic Aperture Radar
<b>SWIR</b>	Short-Wave InfraRed
<b>TOM</b>	Target Operating Model
<b>UA</b>	User's Accuracy
<b>WFS</b>	Web Feature Service
<b>WMS</b>	Web Map Service
<b>WMTS</b>	Web Map Tile Service

## Table of Contents

<b>1</b>	<b>INTRODUCTION .....</b>	<b>8</b>
<b>2</b>	<b>PUCS IMPLEMENTATION AND EVALUATION .....</b>	<b>9</b>
<b>2.1</b>	<b>PUC1 – Flood risk assessment and prevention.....</b>	<b>9</b>
2.1.1	Timeline for PUC 1 implementation .....	9
2.1.2	Monitoring of PUC 1 implementation against the User Requirements.....	12
2.1.3	Test Scenarios vs KPIs .....	18
2.1.4	Overall Assessment, Lessons Learnt .....	24
<b>2.2</b>	<b>PUC2 – EO datasets to monitor Food Security in South Korea .....</b>	<b>26</b>
2.2.1	Timeline for PUC 2 implementation .....	26
2.2.2	Monitoring of PUC 2 implementation against the User Requirements.....	28
2.2.3	Test Scenarios vs KPIs .....	30
2.2.4	Overall Assessment, Lessons Learnt .....	35
<b>2.3</b>	<b>PUC3 – Monitoring Climate Change through Earth Observation.....</b>	<b>44</b>
2.3.1	Timeline for PUC 3 implementation .....	44
2.3.2	Monitoring of PUC 3 implementation against the User Requirements.....	44
2.3.3	Test Scenarios vs KPIs .....	47
2.3.4	Overall Assessment, Lessons Learnt .....	52
<b>3</b>	<b>PUC1 FIELD EXERCISE.....</b>	<b>55</b>
<b>3.1</b>	<b>PUC1 Questionnaires results.....</b>	<b>63</b>
<b>4</b>	<b>CONCLUSIONS.....</b>	<b>65</b>
<b>5</b>	<b>REFERENCES.....</b>	<b>66</b>
<b>ANNEX - SYSTEM EVALUATION UPDATES WITH REFERENCE TO D7.2 EVALUATION REPORT</b>		
<b>.....</b>		<b>67</b>
<b>1.1</b>	<b>Event detection in social media (KR02).....</b>	<b>67</b>
1.1.1	Purpose of Scientific Activity .....	67
1.1.2	Description of the scientific framework .....	67
1.1.3	Results and metrics.....	67
1.1.4	Discussion.....	69
<b>1.2</b>	<b>Similarity fusion (KR04).....</b>	<b>69</b>
1.2.1	Purpose of Scientific Activity .....	69
1.2.2	Description of the scientific framework .....	69
1.2.3	Results and metrics.....	70
1.2.4	Discussion.....	71

1.3.1	Purpose of Scientific Activity .....	71
1.3.2	Description of the scientific framework .....	71
1.3.3	Results and metric .....	72
1.3.4	Discussion.....	72
<b>1.4</b>	<b>Text clustering of non-EO data (KR06) .....</b>	<b>73</b>
1.4.1	Purpose of Scientific Activity .....	73
1.4.2	Results and metrics.....	73
1.4.3	Discussion.....	74
<b>1.5</b>	<b>Community detection (KR07) .....</b>	<b>74</b>
1.5.1	Purpose of Scientific Activity .....	74
1.5.2	Description of the scientific framework .....	75
1.5.3	Results and metrics.....	75
1.5.4	Discussion.....	76
<b>1.6</b>	<b>Evaluation of the performances for querying Linked Data (KR08) .....</b>	<b>77</b>
<b>1.7</b>	<b>Linking Open EO Data (KR09) .....</b>	<b>78</b>
<b>1.8</b>	<b>EO data acquisition (KR10) .....</b>	<b>79</b>
1.8.1	Purpose of the technological activity .....	79
1.8.2	Description of technological framework .....	79
1.8.3	Functionalities and performance.....	80
1.8.4	How does the technology enable PUC implementation.....	81
<b>1.9</b>	<b>Social media crawlers (KR12) .....</b>	<b>81</b>
1.9.1	Purpose of the technological activity .....	81
1.9.2	Description of technological framework .....	82
1.9.3	Functionalities and performance.....	82
1.9.4	How does the technology enable PUC implementation.....	83
<b>1.10</b>	<b>High Performance Computing (KR15) .....</b>	<b>83</b>
1.10.1	Purpose of the technological activity .....	83
1.10.2	Functionalities and performance .....	83
1.10.3	How does the technology enable PUC implementation .....	85
<b>1.11</b>	<b>PUC1 latest Implementations (by SpaceApps and Serco) .....</b>	<b>86</b>

## **1 Introduction**

This deliverable focuses mainly on the description of PUC1 Field Exercise; KPIs related to PUCs will be further elucidated as well as measurement criteria.

The final evaluation includes updates of the PUC evaluation carried out on the 2nd prototype, reported in D7.2, in addition to stakeholders' assessment and feedback following webinars organized in the latest months.

In the current document, each PUC leader reports on the work to align, as much as possible, the EOPEN final system to the expectations arisen during the meetings with stakeholders and reported on previous deliverables.

Regarding PUC1, the storyline of the demonstration, the field exercise and all other reports about the activity including the final questionnaires of the system are reported.

The final questionnaire is compared to the one sent to stakeholders after the Info day (September 2019) to track any improvement of the platform.



## 2 PUCs implementation and evaluation

### 2.1 PUC1 – Flood risk assessment and prevention

The test scenario of PUC1 was expected to be based on the flood event of 2010 in Vicenza; as during the project the VAIA storm (2018) caused many damages in the North East of Italy, AAWA evaluated to adapt the scenario to include this recent event.

In particular the storyboard provided in deliverable D2.1 was modified to account for a larger area (the whole Eastern Alps River Basin District), following the same structure reported for the emergency management and the “Command Chain”. This change allows to provide to the stakeholders a demonstration of a recent event that can be assessed based on more datasets as well as satellite images from Copernicus.

During all emergencies (included the VAIA storm) all forces work together with a common target that is the emergency support and safety for citizens; the main problem is the fragmentation of information due to the number of actors involved. During emergencies it is very difficult to share information in traditional ways (papers, emails, fax and so on) and it requires a lot of time, so the decision maker can’t have a precise and timely view of the emergency. Another issue is that at the end of an emergency the lack of a unique database results in losing acquired information from the event.

The scope of this “play” is to highlight on the command chain, the important role of the Civil Protection structure (planning included) that is the framework during the emergency.

In fact, AAWA is an administration that supports decision makers during emergencies and during ordinary time providing knowledge about flood risk management (as mentioned in about the 2007/60 EU Directive).

The test scenario underlines also how EOPEN can be useful for EO and non-EO experts.

#### 2.1.1 Timeline for PUC 1 implementation

This paragraph updates the tables of the deliverable 7.2 to report the status of the platform and services before the field exercise.

Table 1 PUC 1 implementation timeline

Milestone	Completion Month	Status	Comments
EOPEN User Requirement Meeting	M6	Done	Meeting with PUC 1 stakeholders in Vicenza about EOPEN User Requirements
Questionnaires	M8	Done	
Requirements gathering	M8	Done	Both user and data requirements are defined. These may be refined during the project based on the feedback of the end users.
Development of baseline flood detection method	M16	Done	Developed by CERTH
Integration of the baseline flood detection (ref. Change Detection module) with the platform	M19	Done	Developed by CERTH
Hydraulic model (1st prototype) (Basement)	M21	Done	Transferred to the platform by SpaceApps
Questionnaires	M24	Done	2nd iteration during infoday in September 2019

Flood detection product (baseline) (Water Presence Map Ref. 1.4)	M23	Done	Collaboration with CERTH
Hydrologic-Hydraulic model	M26	Done	Provided 2 models, one for Piave river (reach: Nervesa-Zenson) and one for Brenta river (reach: Bassano-Carturo)
Development of refined/sophisticated flood detection method (Water Presence Map ref. D1.4)	M26	Done	Defined the workflow to run it
Query on AAWA products – workflow integration	M28	Done	EOPEN provides a tool to harvest and publish datasets from AAWA
Integration of refined/sophisticated flood detection module with the platform (Water Presence Map (Ref. D1.4)	M28	Done	Done by CERTH
Water Presence Change Monitoring (WPCM) (final)	M28	Done	Collaboration with CERTH, the 2019 quota will be useful to test the algorithm

### 2.1.2 Monitoring of PUC 1 implementation against the User Requirements

Table 2: PUC 1 Implementation against the User Requirements; the list of products appearing in the following table has been updated and specified in the D1.4 Table 4 – second names are the updated ones.

Use case G-id	Users of the EOPEN platform	Status
PUC1_GA1	Must be provided with capabilities for data dissemination and integration of EO data, weather information and relevant social media text and images.	Done
PUC1_GA2	Must be allowed geo-localisation of social data and real time control.	Done
PUC1_GA3	Should be provided with an intuitive online platform with the possibility to visualise EO data (e.g. from webcam or mobile phone) and possibility to send text messages (e.g. SMS or tweet) and analyse its semantics for meaningful automatic decision-making.	Done (email or Mattermost notifications)
PUC1_GA4	Must be enabled to merge different administrative databases and formats in a unique platform with all data shared.	Done
PUC1_GA5	Should be enabled to implement EWS and add maps in the platform.	Done
PUC1_GA6	Should be provided with an intuitive and robust interface.	Done

PUC1_GA7	Must be provided with an interactive archive of each event; all data from social network communities and from satellites should be stored in a specific database to provide a history of each event.	Done by dates.
<b>Use case D-id</b>	<b>List of Datasets requested by stakeholders</b>	
PUC1_DA1	DEM/DSM 1m (e.g. Airbus Pleiades) from Copernicus	Delivered
PUC1_DA2	Snow maps with a resolution < 20m	Delivered
PUC1_DA3	Soil moisture maps with resolution < 10m	Delivered
PUC1_DA4	Flood maps (EOPEN AAWA AMICO Early Warning System Flood Forecast/AA EWS FF)	Done
PUC1_DA5	Damage maps (EC EMS Damage Map (or others)/EC EMS DM (tbc))	Delivered (risk maps)
PUC1_DA6	Water presence maps WPM (B- Water Presence Change Monitoring WPCM)	Delivered*
PUC1_DA7	Bathymetry of coast, lakes, rivers	not prov.
PUC1_DA8	Orthophoto with resolution of 50 cm (e.g. WorldView4)	Delivered
PUC1_DA9	Vegetation presence	Delivered

PUC1_DA10	Land cover	Delivered
PUC1_DA11	LAI and other vegetation indexes	Delivered
PUC1_DA12	Other maps (thermal or multispectral data ready to be processed) with high resolution	Delivered
PUC1_DA13	Weather forecast	Delivered

(\*): This work is performed by CERTH with the help of AAWA as a co-designer.

PUC1\_GA1: There are different interfaces for the visualization: the dashboards, the GIS viewer and an interface for the processing.

PUC1\_GA5: The hydrological-hydraulic model, developed and used inside (use “on demand”) the platform using GPU’s, can increase the performance of the whole EWS with a reduction of the computational time (as shown in the tables below for the Circular Dam Breach benchmark).

As reported in Deliverable 7.2 the most important aspect of the EOPEN platform for PUC 1 is the possibility to run an algorithm to detect floods. The WPM (Water presence maps) derived from this algorithm are useful for decision makers to see the situation on the territory. Since AAWA is also the most important stakeholder, those maps allowed a more precise calibration of hydraulic models.

From the Deliverable D7.2 a collaboration between FMI, Spaceapps and SERCO developed the algorithm that provides the cumulative precipitation expected for each municipality of the Eastern Alps district and calculates the exceeding of some thresholds. This layer also provides the level of danger of the precipitation amount for the following 24h, 36h and 48h and the maximum hour value expected (useful to prevent flash floods). If there is any threshold exceeded, an alarm is sent via email to users.

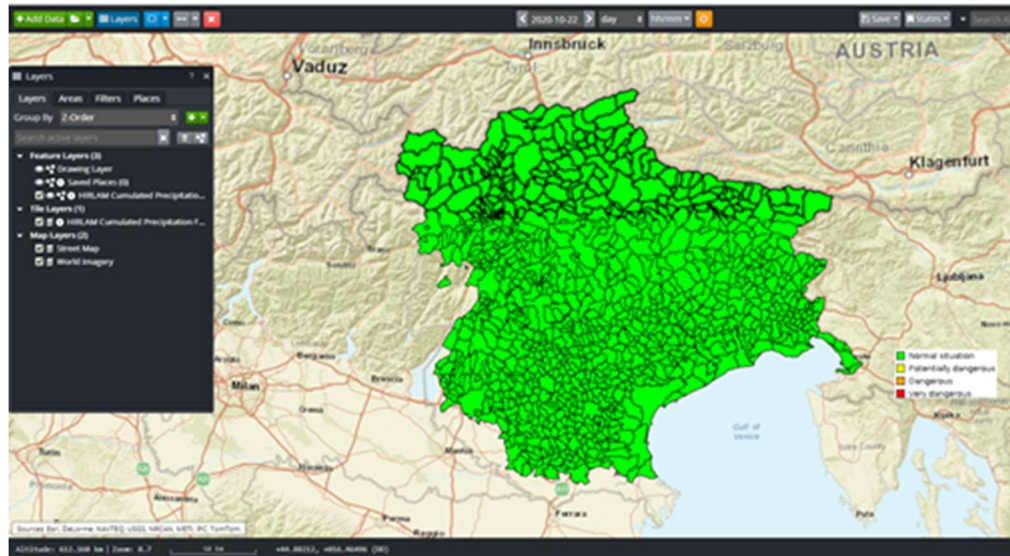


Figure 1: HIRLAM precipitation forecast for each municipality

Thresholds as specified by AAWA were shown to stakeholders during training sessions.

[EOPEN] (PUC1) New precipitation statistics and alerts available

Notification Type: Default  
 Dag ID: 2025\_10\_14\_09\_35\_464012\_admin\_hires\_historical\_precipitation\_statistics  
 Dag Run Order: 1st/last  
 Execution date and time: 2025-10-14 09:35:464012-00:00  
 Start date and time: 2025-10-14 09:35:464012-00:00  
 Notification data: 2025-10-14 09:35:464012-00:00

Municipality	Cadaster Code	Forecast Time	Forecast Value	Alert Level
Agordo	020001	24h	58.8254	Potentially dangerous in 24h
Agordo	020001	30h	78.8613	Potentially dangerous in 30h
Agordo	020001	40h	162.0056	Potentially dangerous in 40h
Ala	020001	24h	61.5305	Potentially dangerous in 24h
Ala	020001	40h	108.964	Potentially dangerous in 40h
Alagna/2504/20Piave	020002	24h	99.12723	Dangerous in 24h
Alagna/2504/20Piave	020002	30h	129.9688	Dangerous in 30h
Alagna/2504/20Piave	020002	40h	276.8689	Dangerous in 40h
Algha	020003	40h	129.1715	Potentially dangerous in 40h
Alpago	020072	24h	83.7507	Dangerous in 24h
Alpago	020072	30h	107.6564	Dangerous in 30h
Alpago	020072	40h	183.9137	Potentially dangerous in 40h
Albaudese	024005	24h	88.49832	Dangerous in 24h
Albaudese	024005	30h	116.6176	Dangerous in 30h
Albaudese	024005	40h	188.8434	Potentially dangerous in 40h
Albino	020001	24h	78.4748	Dangerous in 24h
Albino	020001	30h	102.6261	Dangerous in 30h
Albino	020001	40h	162.0534	Potentially dangerous in 40h
Amara	030002	24h	138.2767	Very dangerous in 24h
Amara	030002	30h	186.9841	Dangerous in 30h
Amara	030002	40h	271.3812	Dangerous in 40h
Ampezzo	030003	24h	67.24832	Dangerous in 24h
Ampezzo	030003	30h	111.4472	Dangerous in 30h
Ampezzo	030003	40h	196.7122	Potentially dangerous in 40h
Andalo	022006	24h	66.17801	Potentially dangerous in 24h
Andalo	022006	30h	90.56333	Potentially dangerous in 30h
Andalo	022006	40h	163.2965	Potentially dangerous in 40h
Andria	090001	24h	183.8725	Very dangerous in 24h
Andria	090001	30h	133.7402	Dangerous in 30h
Andria	090001	40h	229.4215	Dangerous in 40h
Antenore	021003	40h	168.1672	Potentially dangerous in 40h
Arfa	090002	24h	131.8726	Very dangerous in 24h
Arfa	090002	30h	167.1564	Dangerous in 30h
Arfa	090002	40h	241.2184	Dangerous in 40h
Arco	020002	24h	68.66238	Potentially dangerous in 24h
Arco	020002	30h	88.6713	Potentially dangerous in 30h
Arco	020002	40h	113.8844	Potentially dangerous in 40h
Arco	020007	24h	67.50091	Potentially dangerous in 24h
Arco	020007	30h	91.88481	Potentially dangerous in 30h

Figure 2 : Example of notification due to the exceeding of some threshold

The hydraulic model results are also inside the platform for two rivers (Brenta and Piave rivers).



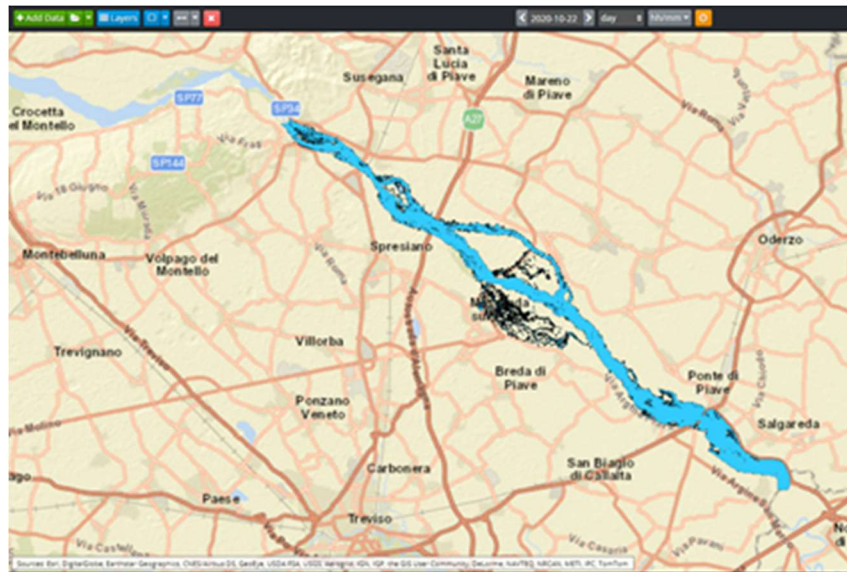


Figure 3: Hydraulic model results (Piave River)

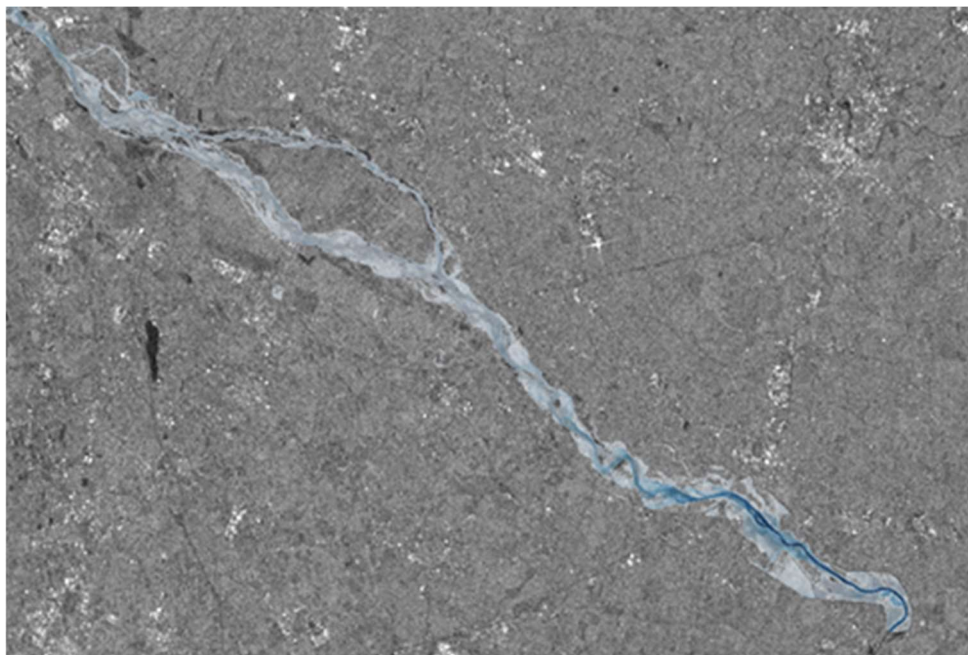


Figure 4: Comparison between Sentinel 1B\_ 29-10-2018 16:57 and results of the hydraulic model Piave (29-10-2018 17:00)

AAWA has also uploaded risk maps from Flood Risk Management Plan on the platform.



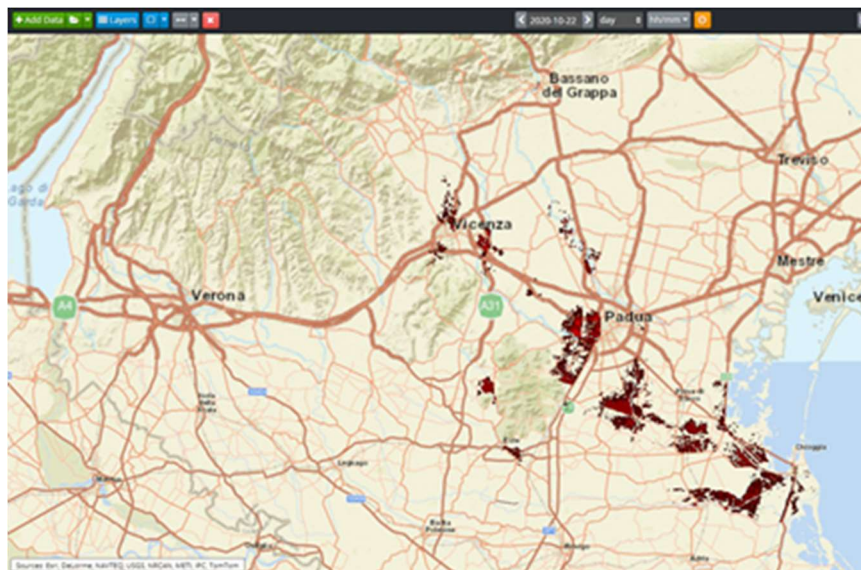


Figure 5: Risk maps from AAWA, uploaded in EOPEN

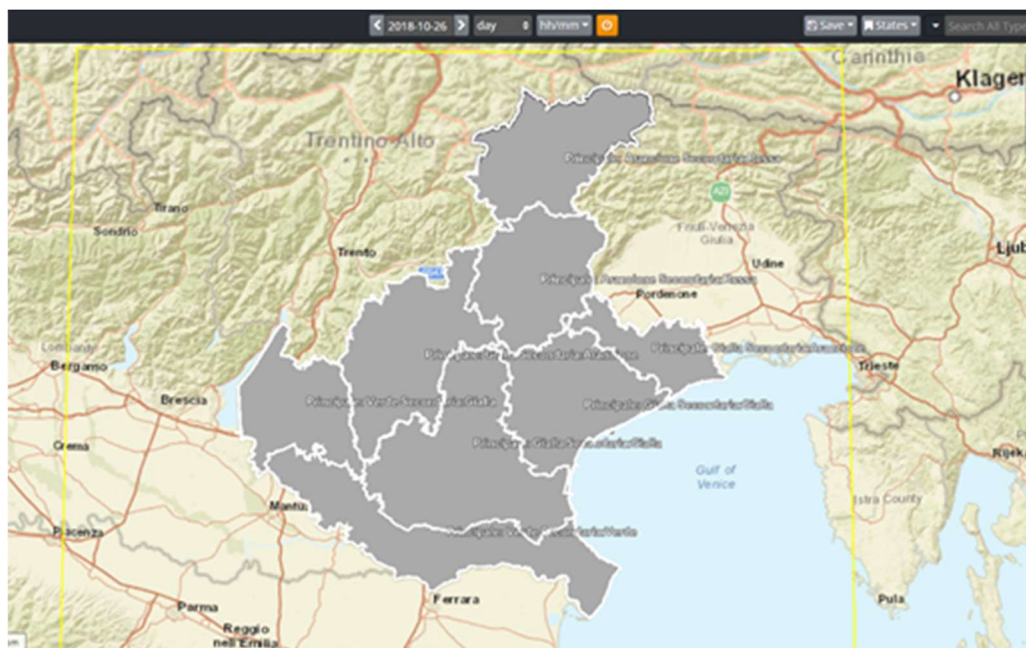


Figure 6: CFD layer (civil protection bulletins)

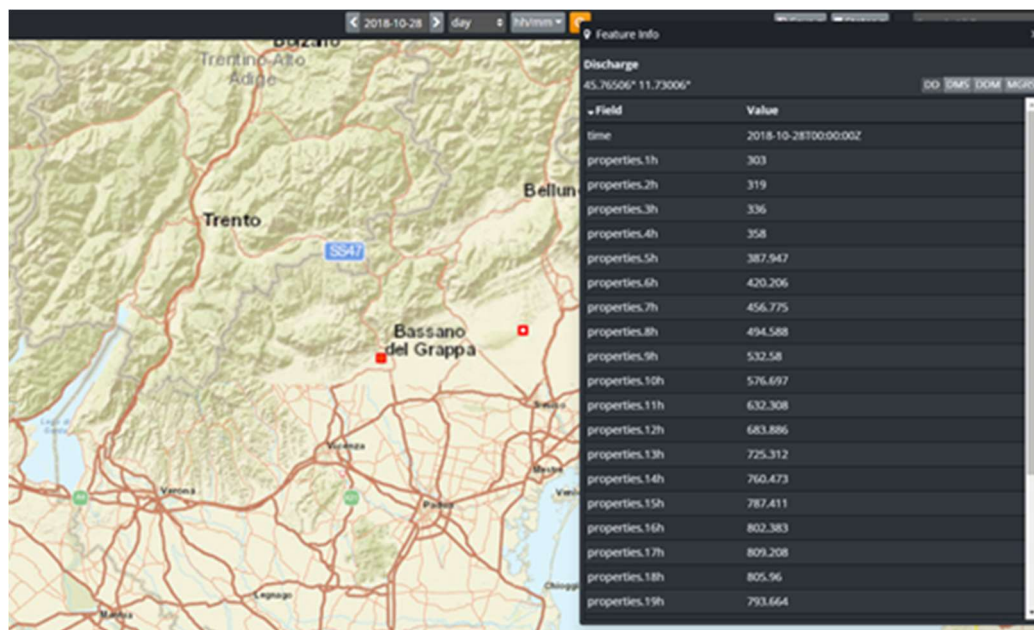


Figure 7: Discharge, uploaded in EOPEN in mc/s

In the last version of the platform, the interaction between AAWA EWS and EOPEN platform has been reviewed as in the following flowchart.

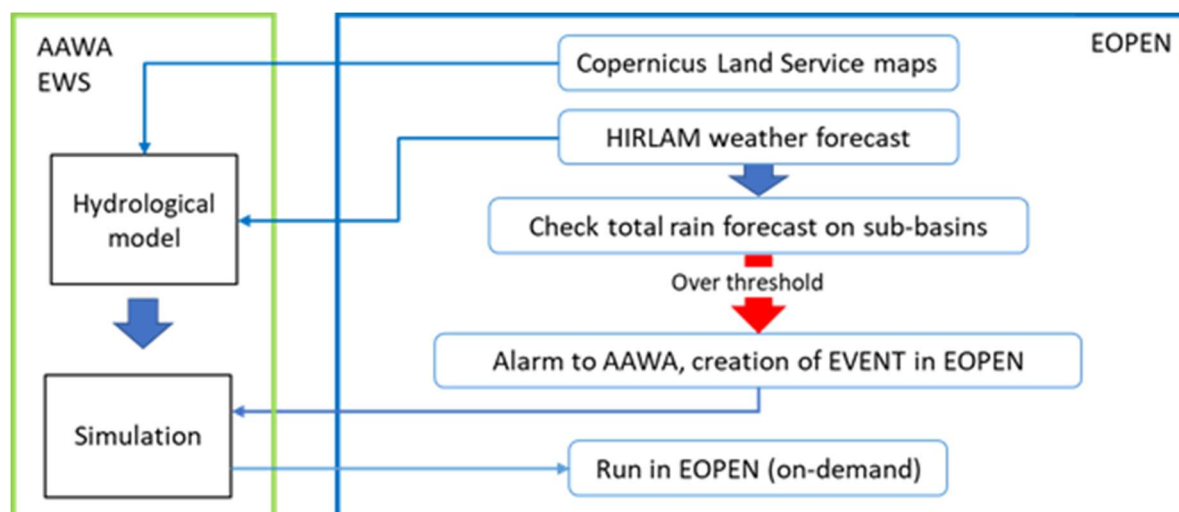


Figure 8: Flowchart of interaction between EOPEN and AAWA EWS

### 2.1.3 Test Scenarios vs KPIs

In this paragraph there are the results of the evaluation of the final system and the scenarios from D 7.2 that mainly drove the field exercise storyline as reported in the field exercise chapter. Some of those scenarios were evaluated offline by AAWA technicians.

## Scenario 1 A, B

The first scenario deals with the automatic and near real-time identification of flooded areas through the flood detection product (Water Presence Map).

We will evaluate the accuracy of the detection algorithm, specifically, if these results can be merged or layered to the administrative database and formats integrated in the EOPEN platform; if the information is presented in a clear and understandable way that could potentially lead to a time reduction to take a decision and subsequent actions during a flood.

The scenario, part A, consists in the delineation of an AOI with the tool available in the platform, find the product, select the product and visualize it. After this passage, the user should be able to upload on the viewer its own layers to visualize for example the municipalities affected by flood or the fluvial areas provided by AAWA.

For expert users will be developed a scenario B, where each user will be able to build the workflow in the platform and generate a product of scenario part A. After this point the user will develop the scenario as described in part A.

Table 3: Evaluation parameters, metrics and results regarding Scenario 1A and B

Parameter	Metrics	Results
accuracy of the detection algorithm	% of area detected	AAWA technicians manage to run the algorithm and extract those areas, over 90% of area detected

## Scenario 2

The second scenario is about the flood prediction and the early warning products, involving the flood detection product and the hydraulic model; in particular, EOPEN platform identifies areas at risk of imminent flooding based weather forecast and in-situ data and provides warnings of the likelihood of a flood event based on HIRLAM weather forecasts.

In this scenario, it will be evaluated i) the accuracy of the detection of the imminent flooded areas from the satellite images, ii) if these results can be merged or layered to the administrative database and formats integrated in the EOPEN platform, iii) if the data can be integrated with information from social media.

In regard with the early warning product, we will evaluate the time required for the platform to provide new or updated forecasts, as compared to the system currently used,

focusing also on the speed up factor of the hydraulic model due to the parallel GPU's and CPU's computation, in comparison to the current serial computation.

Moreover, it will be evaluated if the prediction and early warning products are easily understandable and if they provide a clear outline of the situation, as these aspects could be translated, during a flood, in time reduction to make a decision and subsequent actions.

This scenario is mainly oriented to AAWA users; since AAWA is also an important stakeholder, this scenario will demonstrate the importance of EOPEN in AAWA working environment. Once an event occurs, the operator should access the EOPEN User Portal and inquiry the last Water Presence Map. Water presence maps can show the real situation of the territory and if any flood occurred. To support this task and predict possible floods AAWA will use 2 functionalities of the platform: the meteorological criteria that define an "Event" and send a notification and the hydraulic EWS. Once identified an area that could be affected by floods, AAWA will run on the platform the hydraulic model with as input, the variables (discharge) derived from AAWA EWS. The hydraulic model will provide an estimation of the flooded area useful for the comparison with satellite data in case an event occurs.

Flooded areas derived both from satellite images and hydraulic models will be compared to some ground truth acquired by the social media analysis, if any, to confirm the situation on the territory and to provide the decision makers with important datasets.

Table 4: Evaluation parameters and metrics regarding Scenario 2

Parameter	Metrics	Results
the accuracy of the detection of the imminent flooded areas from the satellite images	% of area detected	100% detected (no flooded area detected but AAWA manage to identify some dangerous areas)
the merged or layered of the administrative database and formats integrated in the EOPEN platform	Yes/no criteria	Yes

the integration of information from social media	Yes/no criteria and number of tweets detected	Yes
the speed up factor of the hydraulic model	speed up factor (AAWA computational time/ HPC computational time)	1/56 1/60 (1 hour on the platform = 60 hours on normal workstation)

### Scenario 3

This scenario will exploit the EOPEN features of providing flood damage based upon the scale of flooded land and user input data. We will evaluate the precision of the estimated damage, and if the data can be merged or layered to the administrative database and formats integrated in the EOPEN platform. Finally, we will also assess the time and workload reduction to prepare damage reports.

For this scenario the results are linked with some metrics already expressed, for damage maps the precision is the precision of flooded area detection (Table 4), for the ability of merging different datasets the results are also reported in table 4. For the workload reduction since it depends on the Administration and specific internal protocols, using EOPEN there is a reduction of computational time to derive maps from satellite images and flood models. The possibility to merge different datasets provide a reduction of time also in the report generation process.

### Scenario 4

This scenario deals with the real time monitoring of environmental variables (LAI, Snow cover, Land Use) and meteorological forecasts (i.e. rainfall), in addition to having access to a database of historical measurements.

We will evaluate the User Experience, in particular regarding the ease access to the historical data; the time required for the System to provide the real-time datasets (e.g. weather forecasts) and to update it once new data arrives; if the interface is clear and robust; if the data can be merged or layered to satellite data and the administrative database and formats integrated in the EOPEN platform; if the data can be integrated with social media derived information.

The users should be able to access, visualize and download several products also from the past, archived in EOPEN.

Table 5: Evaluation parameters and metrics regarding Scenario 4

Parameter	Metrics	Results
User Experience, in particular regarding the easiness to access to the historical data	time spent on EOPEN/ time spent on the web research; number of EOPEN account/number of account needed	1/2 ( 1hour on EOPEN = 2 hours on web) with a unique account vs 2 or more accounts (1/2)
the time required for the System to provide the 'real time' measurement and to update it once new data arrives	seconds	600-1000s (for example HIRLAM datasets)
the interface is clear and robust	Yes/no criteria	Yes
the integration of information from social media	Yes/no criteria	Yes
if the data can be integrated social media derived information	number of tweets detected	Yes

## Scenario 5

This scenario deals with the platform capability that provides the users warnings and notifications of potential extreme weather events.

We will evaluate the User Experience, in particular: the easiness to access data; if the information is clear, easily understandable and if it provides a clear outline of the situation of the emergency.

We will also evaluate the availability of the notification and the time reduction to make a decision and take subsequent actions consequently.



This scenario will start with the development in the platform of a specific workflow to allow users to set rain rate thresholds on sub-basins. The user should, after that, receive an alert message when a threshold is exceeded. After that, the user should run the hydraulic model on the platform and monitor the situation with tweets.

Table 6: Evaluation parameters and metrics regarding Scenario 5

Parameter	Metrics	Results
User Experience, in particular regarding the easiness to access the historical data	time spent on EOPEN/ time spent on the web research; number of EOPEN account/number of account needed	1/3 ( 1hour on EOPEN = 3 hours on web) with a unique account vs 2 or more accounts (1/2)
Provide warning and notification	number of warning sent/ number of correct warnings;  number of warning sent/ number of warning unsent	number of warning sent/ number of correct warnings =1  number of warning sent/ number of warning unsent= not applicable because we have no warning unsent
the integration of information from social media	Yes/no criteria and	Yes
if the data can be integrated social media derived information	number of tweets detected	Over 10.000/year
in time reduction to make a decision and take subsequent actions	time before (COM)/time with EOPEN (TOM)	1/3 ( 1hour with EOPEN = 3 hours without)  (Evaluated by AAWA)

	this parameter will take into account also learning factors	
--	-------------------------------------------------------------	--

### 2.1.4 Overall Assessment, Lessons Learnt

PUC 1 is focused on flood management, during a flood emergency; the most important problem is the lack of information because of the different formats, data sources and timing. EOPEN platform was implemented to satisfy specific requirements collected from stakeholders that are directly involved in the flood management during an emergency and reported in D2.2. PUC 1 stakeholders include experts that are both familiar and unfamiliar with EO, so there was a heterogeneous audience to test the EOPEN developments.

The EOPEN platform can make accessible a plethora of data from different data sources (PUC1\_GA1, PUC1\_GA4), and several Copernicus services, through a scalable system. For EOPEN expert users and non-expert users there are many different tools to make services accessible to everyone; in particular non expert users can use pre-developed algorithms by scientific partners (CERTH, NOA etc.), and can also develop specific workflows within the platform.

EOPEN can make available meteorological forecasts and elaborations with specific time series tools, useful for users and also useful for AAWA EWS.

EOPEN can also provide information and data from the change detection module; water presence maps are already available on the platform. The algorithm runs on the platform analysing data from Sentinel 1 and Sentinel 2 missions. The Water Presence Maps are produced and stored automatically within the EOPEN platform, so non-expert users can visualize them on the web GIS interface (Opensphere).

The “field exercise” was developed with stakeholders involved in the user requirements meeting held in Vicenza in 2018 and during the Info day in 2019; they are the decision makers that act during a flood emergency.



Table 7: PUC 1 field demonstration timeline

Milestone	Completion Month	Status	Comments
Training session setup	M31	Done	
Training sessions	M33	Done	Training sessions with stakeholders
EOPEN Field demonstration	M34	Done 14-10-2020	Field demonstration with stakeholders

## 2.2 PUC2 – EO datasets to monitor Food Security in South Korea

This paragraph updates the tables of the deliverable 7.2 to report the status of the platform and services with reference to PUC2.

### 2.2.1 Timeline for PUC 2 implementation

Table 8: Timeline of PUC2 implementation

Milestone	Completion month	Status	Comments
Questionnaires	M8	Done	
Requirements gathering	M8	Done	Both user and data requirements are defined. These may be refined during the project based on the feedback of the end users.
Recurrent Neural Networks based rice classification product	M16	Done	National scale application, over multiple years of inspection (2016, 2017, 2018).
Random Forest based rice classification product	M17	Done	For the South Korean provinces of Dangjin and Seosan
Change detection – land cover map update methodology (baseline)	M17	Done	Update of the 2015 land cover map
Integration of RNN based rice classification in the EOPEN platform	M18	Done	

End to end integration of the RNN based rice classification product – from data acquisition using the EOPEN Umbrella API to producing rice maps in the front end	M21	Done	
Integration of change detection algorithm	M23	Done	
Integration of the RF based rice classification algorithm in USTUTT's HPDA	M23	Done	Large-scale application using distributed processing
Development of Rice Status Indicator and Rice Yield Estimation (RYE)	M23	Done	Time-series of vegetation indices and crop growth indicators, but also biomass and yield indicators
Prototype demonstration	M24	Done	During ACRS 2019 conference and EOPEN special session, held in South Korea, PUC2 presented the current status of PUC2 to the audience. The audience included an official of the PUC2 stakeholder KREI. A dedicated webinar has been held, attended by multiple stakeholders such as KREI, RDA, CJ and others. The PUC2 developments have been demonstrated and feedback has been received by the audience.

## 2.2.2 Monitoring of PUC 2 implementation against the User Requirements

Tables 9 and 10: Monitoring of PUC 2 implementation against user requirements

Use case G-id	User of the EOPEN platform:	Current Status
PUC2_GB1	Must be provided with an agriculture monitoring system (based on earth observation data) that will provide more accurate cultivation area mapping and production estimates coupled with statistical data.	Done
PUC2_GB2	Must be provided with a crop monitoring solution/platform that will integrate spatial and statistical data.	Done
PUC2_GB3	Should be enabled to overlay the GIS data of “soil atlas” with remote sensing data.  <b><u>Hint:</u></b> <i>National Institute of Agricultural Sciences provide a system called “Soil Atlas” but this system shows the agricultural land area according to land usage which does not show the actual crop production area and location.</i>	Done  NOTE: All PUC 2 products have been provided in standard formats so as to be potentially reusable. The products can additionally be downloaded
PUC2_GB4	Should be provided with services that account for big data handling, meteorological data coupling with statistical yield estimations and satellite data.	Done  Products:  Paddy Rice Mapping, Rice Status Indicator

PUC2_GB5	Must be enabled to integrate different platforms to the governmental statistics system.	N/A
PUC2_GB6	Must be provided with data at farm level (e.g. crop type classification, etc.)	Done
PUC2_GB7	Must be enabled to download agriculture related information over the web.	Done
PUC2_GB8	Should be enabled to receive agriculture related information through reports.	N/A  NOTE: Information will be provided in the form of raster and vector layers, which is deemed to be far more efficient, intuitive and useful than a report.
PUC2_GB9	Should be enabled to integrate the produced agriculture related information into the national statistics system.	Done  See PUC2_GB3 response

Use case D-id	List of Datasets requested by stakeholders	Status	Description
PUC2_DB1	High resolution remote sensing imagery (a. Timeseries of vegetation indices and crop growth indicators, b. Timeseries of rice maps at 10 m spatial resolution – ref. D1.4	Done	Timeseries of vegetation indices, crop growth indicators and rice maps at 10 m spatial resolution

PUC2_DB2	Detailed meteorological observation data	Done	Air temperature, Wind speed and direction, Precipitation, and Solar Radiation
PUC2_DB3	In field inspection data	Done	Land cover maps available with 10 yr interval. These maps are updated through change detection for the year of inspection
PUC2_DB4	Farmers' claims data	Not available	
PUC2_DB5	Accurate yield statistics	Done	Rice Status Indicator
PUC2_DB6	EO based production status		
PUC2_DB7	Statistical data on national fertilizer usage	Not available	
PUC2_DB7	Statistical data on crop yields	Not available	Rice Status Indicator (Biomass and Yield Indicators)
PUC2_DB8	Social media	Done	Event detection module

### 2.2.3 Test Scenarios vs KPIs

Four scenarios were implemented during the evaluation stage. The first one is related to the recurrent neural networks approach while the next two to the random forest method. The results of both rice classification methods and of the rice status indicator will be presented in the form of four test scenarios. All of the rice classification scenarios are validated against a dataset of approximately two million pixels that has been annotated through elaborate photo-interpretation, using three different evaluators (double blind).

#### Scenario 1

The first scenario involves the RNN rice paddy detection algorithm that trains based on the land cover map of 2015. The trained model is applied to a time-series of Sentinel 1 images, at national scale, for the years 2017-2019. This way the generalization of the model is evaluated, identifying the significance of the accuracy decrease in the succeeding years of 2015.

Scenario 1 has been completed and fully reported on D7.2.

## Scenario 2

The second test scenario involves the Random Forest rice classification approach that utilizes the dynamic land cover map update for training. We trained the model using the generated training data of Seosan and Dangjin and applied it on other regions. Additionally, the Seosan-Dangjin trained model is tested in other provinces against locally trained models. This way we can identify an operational framework for rice mapping, evaluating the generalization and transferability of the scheme.

Scenario 2 has been completed and fully reported on D7.2.

## Scenario 3

Following the example of Scenario 2, this scenario will fill the gap of unavailable updated land cover maps of other South Korean provinces by using generated data from K-Means algorithm. This test scenario also involves the Random Forest rice classification approach that utilizes the K-Means Clustering methodologies to create a training dataset for the year of inspection. Train the model using the generated training data of Seosan and Dangjin and apply it on the rest of the country. At the same time, the Seosan-Dangjin trained model will be tested in other provinces against locally trained models. The generalization of the model will be thereby evaluated.

This scenario has been reported in D7.2. However, further implementation was performed since then. In our attempt to showcase the generalization of the model, a third area of interest has been tested. Strengthening the argument of the system's geographic transferability towards a national scale application. The third area in South Korea, Cheorwon, which is located in the north of the country and has a slightly different climate than Seosan and Dangjin. In Figure 1 we can see the differences among the three different areas. The figure displays the average NDVI signatures for the rice cultivations in the three areas, and Haenam shows a significant presence of dual cultivations throughout the year. This is indicated by the NDVI jump prior to the mid of May. Therefore training a model in only one of the areas of interest, i.e. Seosan and Dangjin, and applying it successfully to other areas of different characteristics is a rather innovative achievement.

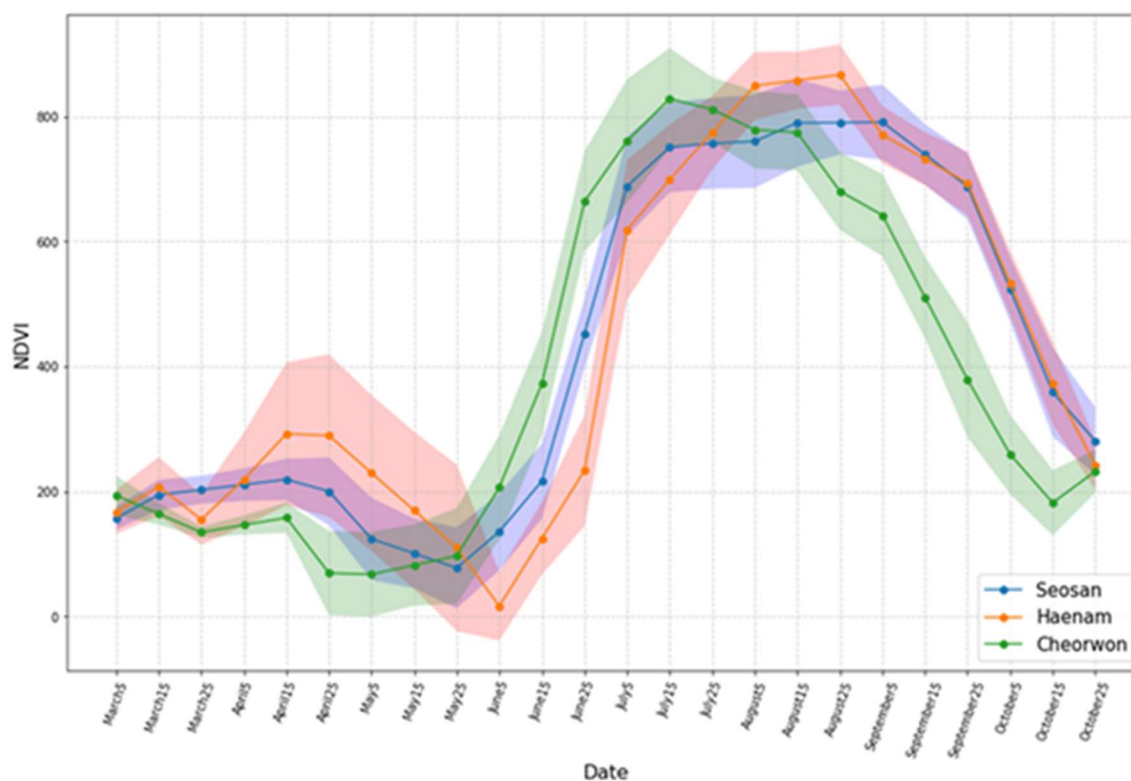


Figure 9: Average NDVI time-series, along with their respective standard deviations for the three AOIs

Figure 3 highlights the performance of the multiple Random Forest models (with different depth and number of trees) trained in Seosan/Dangjin and applied on Cheorwon, while Figure 2 presents the performance of the models with fixed number of trees at 50 and various depth values, applied on both Cheorwon and Haenam in order to capture the overall geographic generalization of the model (Seosan/Dangjin). The models are trained in mid-summer in order to provide timely information for pertinent decision making, therefore the feature spaces used for the classification include acquisitions until the end of July (27<sup>th</sup> of July).



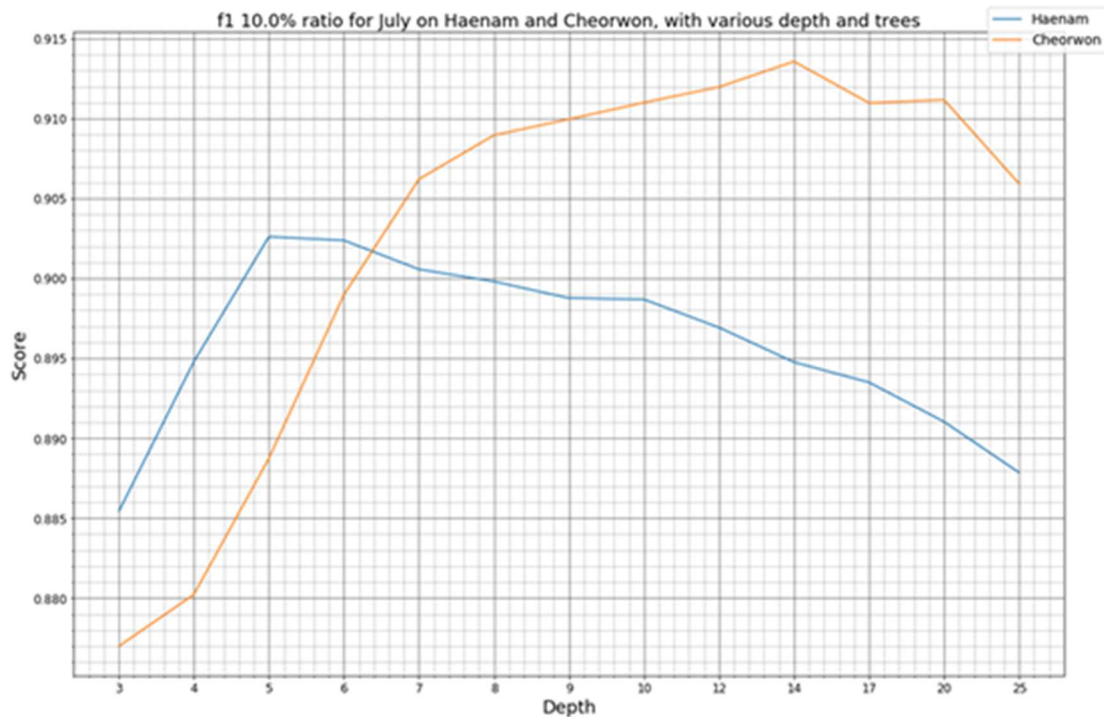


Figure 10: F1 score for the Haenam and Cheorwon AOIs, with fixed number of trees at 50 and varying depth

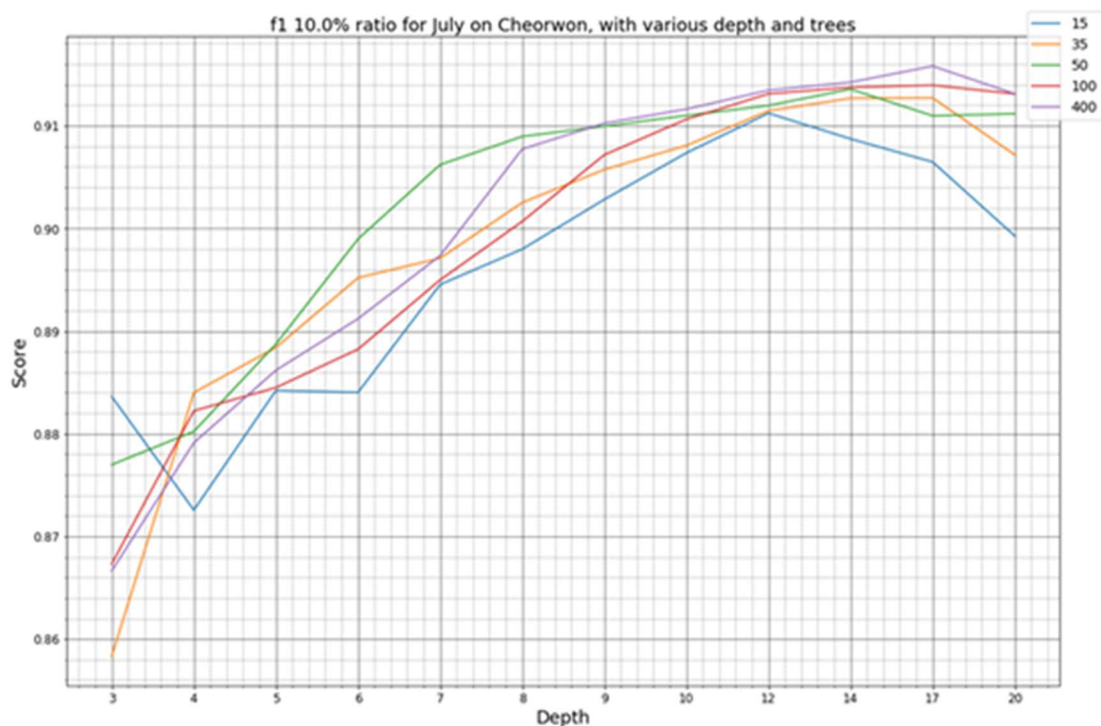


Figure 11: F1 score for Cheorwon with various depth and trees

In Figure 4 below, it can be observed how the locally trained models perform against the transferred model that has been trained in Seosan/Dangjin. The figures show that the

difference is minimal between the locally trained models and the one coming from the reference area; illustrating this way that near optimal performance of the transferred model.

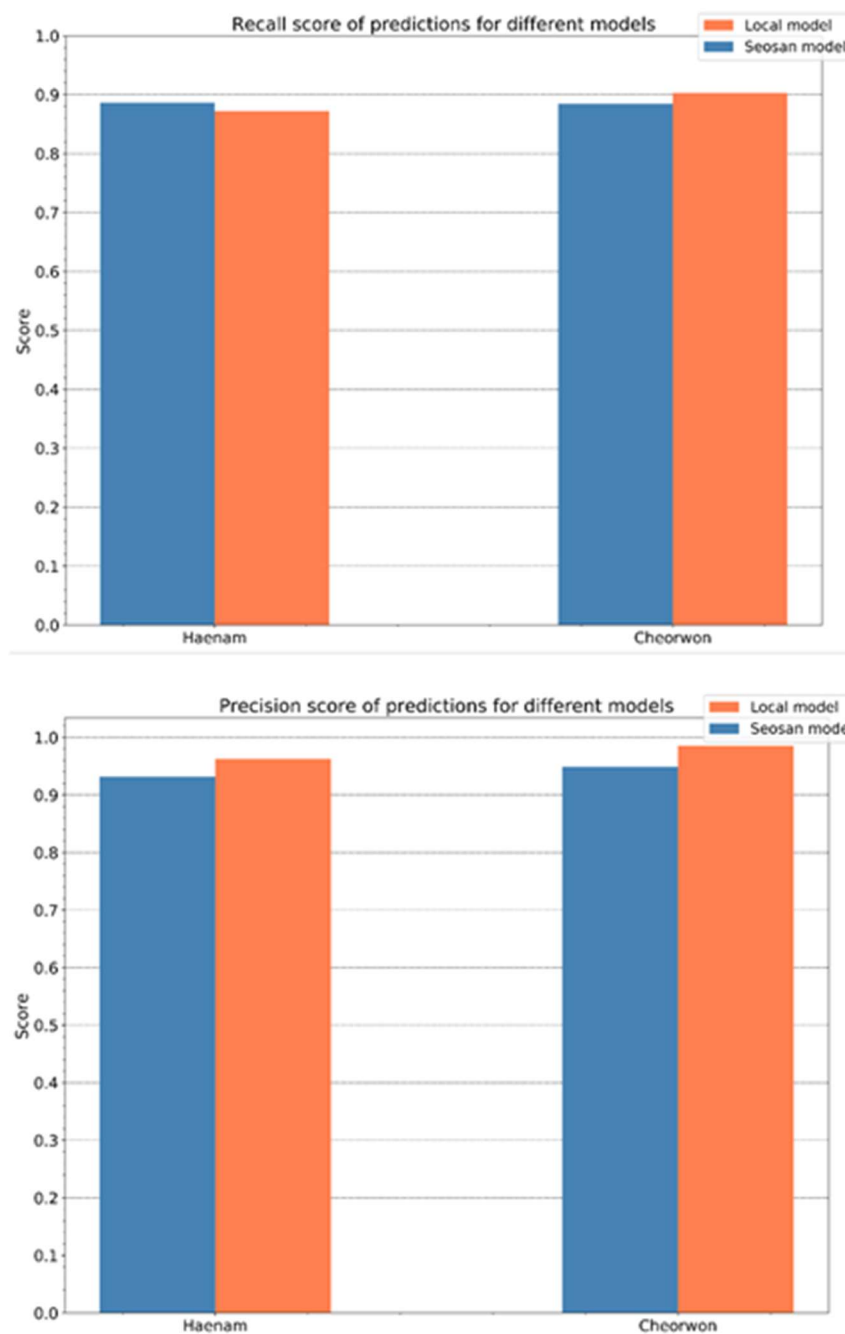


Figure12: Recall and precision scores of the locally trained and the reference (Seosan/Dangjin) model

From the results, we can strongly claim that the Seosan-Dangin model can be successfully applied on the whole country, resulting to very high accuracies, since Haenam and Cheorwon

are located in completely different geographical areas and with very different climatic conditions and agricultural practices, and yet it applied successfully in both of them.

## Scenario 4

Following the rice classification of Scenario 2 and 3, in this scenario will investigate how the rice status indicator, which was thoroughly described in the methodology section, can extract valuable information regarding the biomass and the yield of the rice crop. The primary identification of start, peak and end day of year at the NDVI time-series, apart from indicating crucial crop cultivation phases, reveal the behaviour of the crop over time, which can be quantified from the calculation of integrals, in order to provide biophysical meanings to the NDVI curve [1](Boschetti et al., 2009).

Scenario 4 has been fully reported in D7.2

### 2.2.4 Overall Assessment, Lessons Learnt

#### PUC2 Webinar and Evaluation survey

To evaluate the PUC2 outputs, but also the platform as a whole, two actions took place; a PUC2 webinar and a follow-up survey that was offered to the participants. The description of stakeholders that participated and the evaluation report based on their feedback are presented below.

#### Stakeholders

##### Description of stakeholders

(1) Suk Kyu Kim from CJ Cheil Jedang

Mr. Suk Kyu Kim is a general manager of Strategy & Business Planning Team at CJ Cheil Jedang, the largest general food manufacturer in South Korea. He is in charge of BIO & Grain Trading Business management, carrying out bio business and manufacture of food, medicine, and feedstuffs and other ingredients. Keeping up with market trends, CJ further analyses social and environmental impacts.

(2) Dr Jong In Kim from KREI (Korea Rural Economic Institute)

Dr Jong In Kim works at a national agricultural policy research institute focused on the development of agriculture, rural areas and through the food industry. The institute is responsible for agricultural monitoring, Free Trade Agreements, world agriculture information, agricultural policies.

(3) Prof. Chang Gil Kim from the Dept of Agri Economics and Rural Development at Seoul National University

Prof. Chang-Gil Kim was an ex-president of KREI now works for Invited Professor. He focuses on research and teaching in the areas of agriculture, rural communities, natural resources and environment, as well as regional development in the department of Agricultural Economics and Rural Development.

(4) Yoon Ji Kim from KU Lab of Environmental Ecological Planning and Policy Studies (EEPPS Lab, Korea University)

Ms. Yoon Ji Kim works at the laboratory of environmental ecological planning and policy studies under the supervision of Prof. Seong Woo Jeon. The laboratory is focused on environmental ecological planning, adaptation for climate change and environmental policies.

(5) Dr Sang Il Na from NASS (National Institute of Agricultural Science) Dr Sang Il Na works at the research institute under the Rural Development Administration, which is in charge of testing and research to develop agriculture into sustainable and competitive biological industry. The role of NASS is generating new income by exploration of the values of agricultural resources and maintaining a healthy agricultural ecosystem, crop protection and etc.

## Evaluation:

### Webinar

The webinar aimed to generate full awareness of the developed services, to help the assessment of delivered products' success and to further engage stakeholders to potentially uptake the PUC2 system and/or its constituent components. In this direction, the participants of this webinar are strongly connected to food security decision making and the agri-food industry. Hence, the webinar aimed at analysing all the innovative methodologies that PUC2 brings, the big data technologies behind them and the importance of the results for the purposes of food security monitoring in South Korea.

Table 9: Name and Institute/Organisation of each participant

Name	Institute / Organisation
Dr. Jong In Kim	KREI
Suk Kyu Kim	CJ Corporation (South Korea company in food industry)

Chang-gil Kim	KREI, Seoul National University
Sang-il Na	National Institute of Agricultural Sciences (NIAS)
Nguyen Lam-Dao	VNSC, VN Rice Project
Simon Han	Trading company HAN
Hunju Yoon	Sundosoft company
Woo-Kyun Lee	Korean University
Hyun-Woo Jo	Korean University
Sujong Lee	Korean University
Halim Lee	Korean University

## PUC2 Webinar - Questions and Answers

During the webinar a series of questions came up regarding several subjects. Initially, participants were interested in the biomass indicator, the purpose for calculating such an index and the methodology behind the calculation of it using Sentinel data. Moreover, participants asked about the optical cloud pixel recovery process that took place via interpolation. Another question was related to the calculation of rice paddy mapping accuracy and the significance of the reported numbers. The interest in the algorithm's accuracy was raised in another question, this time related to the specifications of the stakeholder; namely to have at least 90% accurate results until August. Satisfactory answers were given to all the questions judging from the participants' feedback. All live responses, on the questions above, can be found in the Annex, in the form of a consolidated verbatim transcript.

### b. Survey

After the completion of the webinar, an online questionnaire has been released to allow users to give their feedback based on the information they received. The survey remained open for several days, with access via google forms. Finally, four of the stakeholders completed the survey.

Three of the four participants of the survey have replied positively on investing in an interoperable platform like EOPEN, while the fourth one replied with “maybe”. Among the different Key Results of the EOPEN platform, the most popular were the Big Data infrastructure and the seamless access to big satellite data.

The representative of CJ, Cheil Jedang, was interested in the Rice Status Indicator service, while the representative from KREI was interested in Rice Paddy Mapping service. The most popular of the three services were the Rice Paddy Mapping and the Rice Status Indicator with 75% of the votes. The participants from KREI and CJ prefer the transferability of the service at national scale, with slightly less accuracy, instead of a local, more accurate, model. On the other hand, the representatives from SNU, which are researchers, have chosen the local scale of slightly higher accuracy.

Another interesting finding from the questionnaire is that the CJ representative finds sufficient the early July classification with accuracy more than 85%, as they are more interested in timely information, early in the year. On the other hand, the participant from KREI prefers a rice paddy mapping accuracy of 98% in September; because they are more interested in correcting the annual statistics and timeliness is not essential. Moving to the Rice Status Indicator service, KREI’s representative finds that a minimum mapping unit of 20x20 meters is sufficient. He also believes that the Yield indicator can be provided at the end of the season and can be useful for correcting statistical data. The products and services were rated, against the original user requirements, as follows.

Products and services offered (1=not achieved and 5=fully achieved) [Must provide accurate cultivation area mapping]: 4

Products and services offered (1=not achieved and 5=fully achieved) [Must be at farm level]: 3.5

Products and services offered (1=not achieved and 5=fully achieved) [Should be able to integrate to other systems]: 4

Figures 13,14,15,16,17,18 and 19 below show the aggregated statistics of the responses on each question of the survey.

Would you invest in an interoperable platform like EOPEN?

4 responses

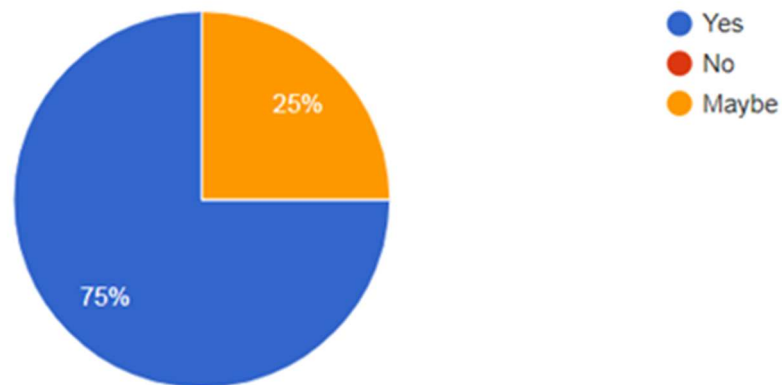


Figure 13: Answers to question 1 regarding interoperability of the EOPEN Platform

Which of the following Key Results of EOPEN interest you?

4 responses

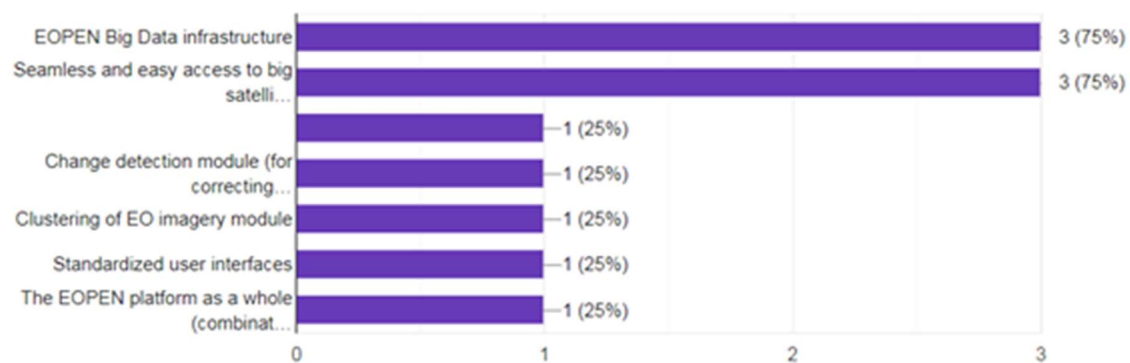


Figure 14: Answers to question 2 regarding interesting on key results of EOPEN

Which of the presented services could be useful in your business and you would be willing to invest on?

4 responses



Figure 15: Answers to question 3 regarding interest on offered services of EOPEN

Do you prefer services of high local accuracy or transferable to the entire country?

4 responses

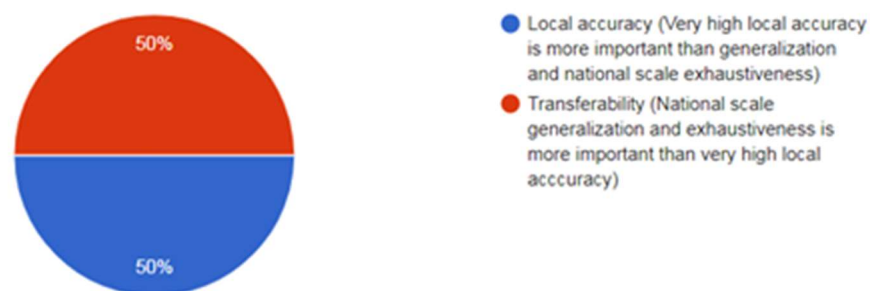


Figure 16: Answers to question 4 related to accuracy and transferability of the model

Rice Paddy Mapping service

4 responses

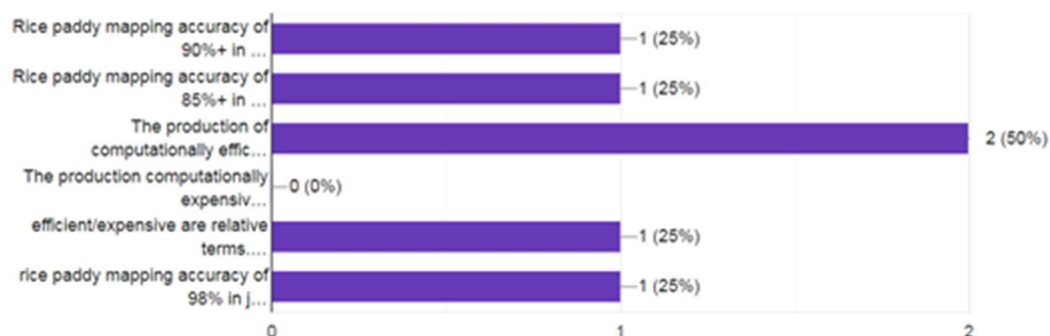


Figure 9: Answers related to Rice Paddy Mapping Service



### Rice Status Indicator (i.e. Vegetation indices, phenological metrics, Start of Season, Peak of Season, End of Season)

4 responses

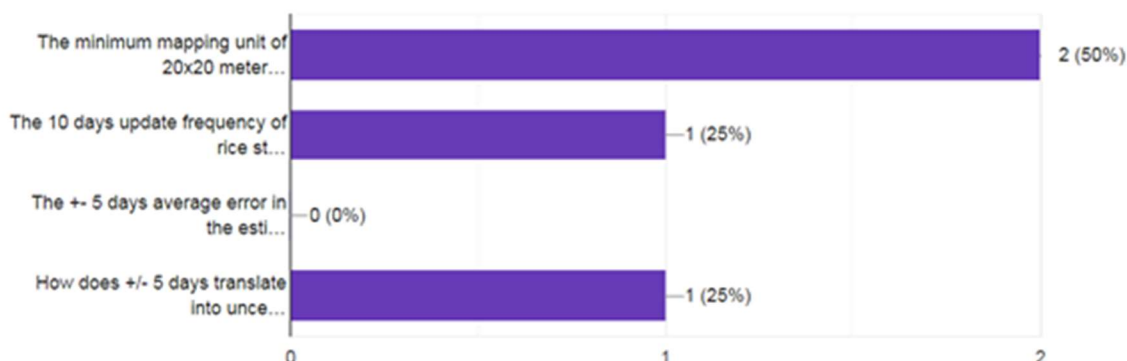


Figure 17: Answers related to Rice Status Indicator Service

### Biomass and Yield Indicator

4 responses

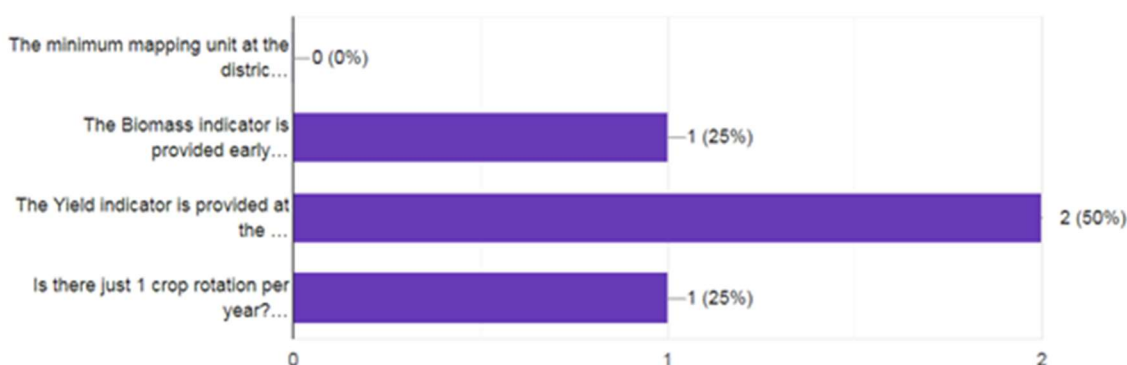


Figure 18: Answers related to Biomass and Yield Indicator

### Other comments

2 responses

Have not seen how integration with other systems is done. What are the other systems?

It is believed that convergence research with experts dealing with economic aspects in food security research will increase the effectiveness of the research results.

Figure 19: Other comments

### Lessons learnt

In conclusion, PUC2 can be thought as a successful use case, addressing the majority of the call requirements, using a plethora of the generic EOPEN scientific and technological KRs and addressing effectively the majority of the collected user requirements.

More specifically, PUC2 addresses [Call Requirements I\[1\]](#), by developing value adding services (i.e. land cover map update, clustering for pseudo-labelling, distributed rice classification, rice growth monitoring). The majority of the aforementioned pipelines have been deployed on the interoperable EOPEN platform, in the form of modular processors that can be reused and parameterized by users. [Call Requirements X\[2\]](#) is also addressed, by effectively exploiting Copernicus data to tackle food security issues, targeting non-traditional users, such as food companies (CJ), economic institutes (KREI), ecological planning and policy researchers.

PUC2 has effectively used a number of scientific and technological KRs to address its user requirements, showcasing the value of the EOPEN platform, in its interoperability, modularity and generality. Specifically, PUC2 has used KR01 to update past land cover maps and KR05 to perform unsupervised rice classification to create training datasets. Additionally, KR02 is utilized to identify events related to food and agriculture in South Korea. KR10 is used to automatically search and download the Sentinel data time-series in an efficient and coherent manner. KR13 is also used to access the Korean databases of meteorological data. Maps of precipitation, temperature and solar radiations will be available in gridded images on the EOPEN User Portal. KR12 continuously harvests relevant food security tweets in both Korean and English, which are annotated as relevant or not by KU. KR14 is exploited to allow the user to visualize the PUC2 outputs (i.e. timeseries of rice status indicators, evolution of rice classification product, meteo datasets etc.). KR15 is extensively used, with PUC2 having effectively utilized the HPDA module to perform distributed clustering and supervised classification for the large-scale application of the outputs. Finally, KR17 - the EOPEN platform, has fostered the integration of the various PUC2 pipelines in an interoperable platform that will allow the user to reuse the processors and alleviate any infrastructure and deployment challenges.

PUC2 has developed solutions targeting South Korean stakeholders. The distance, different time zones and language barriers have brought up certain challenges with respect to the active engagement of those stakeholders, in providing timely feedback and evaluation for the PUC2 outputs. Nevertheless, the PUC2 webinar has proven to be very successful, offering a lively and fruitful discussion with the stakeholders that seemed to appreciate greatly the contributions of this use case. Additionally, the survey has provided us with further insights on the users' evaluation of the PUC2 outputs, which were predominantly positive. Most importantly the majority of the stakeholders that participated in the survey have expressed a real interest in investing in a platform such as EOPEN and in utilizing at least one of the PUC2 products and services.

As a take home message, based on the webinar interactions, we could say that the South Korean stakeholders, especially the people from KREI, SNU and RDA are rather familiar with Earth Observation and its significance in their business. Most of them understood very well, even the technical specifics of the implementation, making clear the innovations of PUC2 in big data management, distributed machine learning, model generalization and reduction of

computational complexity, but also the innovation of pseudo-labelling to overcome the scarcity of ground truth information. It was apparent that the PUC2 outputs had a clear value for them. Most of them could identify on the spot how each of the services addressed their needs and gaps and how the EOPEN solution related to the current operating model.

Finally, it is important to stress the significance of having a successful use case in a non-EU country, such as South Korea. The use case was predominantly based on the exploitation of Copernicus data, tangibly showcasing their value to a non-EU user community.

[1] Enable value adding services on generic data and information storage and processing facilities which can allow public and commercial users an effective production environment to interact with and serve their user base without deploying their own storage and processing facilities.

[2] Optimize the use of Copernicus data by non-traditional user communities to meet societal challenges.

## 2.3 PUC3 – Monitoring Climate Change through Earth Observation

This paragraph updates the tables of the deliverable D7.2 to report the status of the platform and services

### 2.3.1 Timeline for PUC 3 implementation

Table 10. Timeline and status of the PUC3 implementations.

Milestone	Completion month	Status	Comments
Questionnaires	M8, M30	Done	
Requirements gathering	M8	Done	
Phone interviews with stakeholder representatives	M10, M18	Done	
Road passability product	M33	Done	Part of KR01
Integration of change detection algorithm	M33	Done	Part of KR01
Data gathering	M21	Done	
Data integration with platform	M36	Done	
Prototype demonstration	M24	Done	Held in South-Korea
User workshop	M30	Done	Webinar

### 2.3.2 Monitoring of PUC 3 implementation against the User Requirements

Table 11: Stakeholder requirements and their status in PUC3.

Requirement ID	Description	Status
PUC3_GC1	Should be provided with a user friendly interface.	Done
PUC3_GC2	Should be provided with easy access and management of datasets.	Done
PUC3_GC3	Must be provided with data integration capabilities.	Done
PUC3_GC4	Must be enabled to overlay satellite and ground observation data over a map background.	Done
PUC3_GC5	Should be provided with the capability to select a user-	Done

	defined area of interest.	
PUC3_GC6	Should be enabled to visualize the situation in “real time” (most recent data).	Done
PUC3_GC7	Must be enabled to browse historical observations.	Done
PUC3_GC8	Should be provided with tools for statistical analyses of selected area, time period and dataset(s).	Done
PUC3_GC9	Should be provided with tools for visualizing time series of datasets and statistical analyses.	Done
PUC3_GC10	Should be provided with time series trend analysis and future projections capabilities.	Done
PUC3_GC11	Must be enabled to compare multi-platform data (e.g. satellite vs satellite, satellite vs. ground observation).	Done
PUC3_GC12	Should be provided with access to relevant tweets with specific keywords through the platform.	Done

Table 12: PUC3 data sets and their integration status in the EOPEN platform.

Dataset ID	Dataset name	Status	Description
PUC3_DC1	GlobSnow SWE	Done	Gridded daily, weekly or monthly data for snow cover with 25 km resolution starting from 1995. Based on satellite and ground weather station data.
PUC3_DC2	SMOS Level 3 Freeze/Thaw	Done	Gridded daily soil state (Thaw/Frozen/Partially frozen) with 25 km resolution starting from 2010. Based on satellite and ground weather station data.
PUC3_DC2	Sentinel LST	Done	Land Surface Temperature data from Sentinel satellites.
PUC3_DC3	Air Temperature FMI ClimGrid	Done	Grid-interpolated daily averages of air temperature with 10 km resolution starting at 1961 until 2018. Based on ground station data. Pre-computed maps (no API).

PUC3_DC4	Snow depth FMI ClimGrid	Done	Grid-interpolated daily averages of snow cover maps with 10 km resolution starting from 1961 until 2018. Based on ground station data. Pre-computed maps (no API).
PUC3_DC5	FMI Open Data, Climatological values (Climatological data for meteo observations (ref. D1.4))	Done	Long-term (30-year) statistics of meteorological variables
PUC3_DC6	Social media data (twitter)	Done	Annotated set of tweets of snow. FMI provides annotations, CERTH handles the rest.
PUC3_DC7	FMI Open Data, Climate model output	Done	Estimated changes in climatological values over decades, based on multiple climate models and future climate scenarios.
PUC3_DC8	FMI Open Data, Weather observations	Done	Instantaneous weather observations and daily, monthly, seasonal, and yearly values.
PUC3_DC9	FMI Open Data, Weather model output (HIRLAM weather forecast ref. D1.4)	Done	Numerical weather prediction forecasts and model reanalysis, e.g. ERA5 from Copernicus Climate Change Service
PUC3_DC10	Regions of Finland	Done	Region and municipality area borders in Finland. Pre-computed maps.
PUC3_DC11	Reindeer herding areas	Done	Herding area borders in Lapland. Pre-computed map.
PUC3_DC12	FTIA Road maintenance classes	Done	Road maintenance classification in Finland for snow removal and sanding.

All the user requirements were fulfilled in the Use Case. All the data sets were integrated into the EOPEN platform. In addition to the data sets, tools to produce statistics for a selected area

or a time series for a time-stamped data was implemented into the OpenSphere viewer as an extension.

### 2.3.3 Test Scenarios vs KPIs

**Test scenario 1:** The winter 1972-1973 was exceptionally bad for reindeer herders due to 'deep icy snow' and 'deep snow' as reported by them (Vuojala-Magga et al. 2011). Due to this, more herding and additional feeding was required. How can EOPEN visualize the trends for snow depth over past winters for the herders?

**KPI:** Quantitative difference in snow depth: **Achieved**

Length of time to get the results: **5 min**

**Data:** ClimGrid snow depth (PUC3\_DC4)

**Tools:** Statistical measures, Data filters

**Minimum criteria:** User is able to compare maps in particular regions in Lapland of the snow depth for the bad and good winters.

[2]

For this scenario, the user wants to visualize the trend for the snow depth in Lapland, Northern part of Finland, for the past winters around 1972-1973. To do this, the OpenSphere GIS viewer is used for the visualization. The FMI ClimGrid Snow depth (PUC3\_DC4) product is chosen from the GeoServer and the Lapland area is selected in the map viewer. The time series tool is used to produce the output, which is stored in the EOPEN database. The output can be viewed and saved to disk in the user Dashboard window.



Figure 20: The snow depth statistics in the Lapland area during the winter of 1971-1972. The standard deviation (blue line), the maximum value (green line), the average value (yellow line) and the minimum value (red line) of snow depth are shown over the period 01.12.1971-30.04.1972

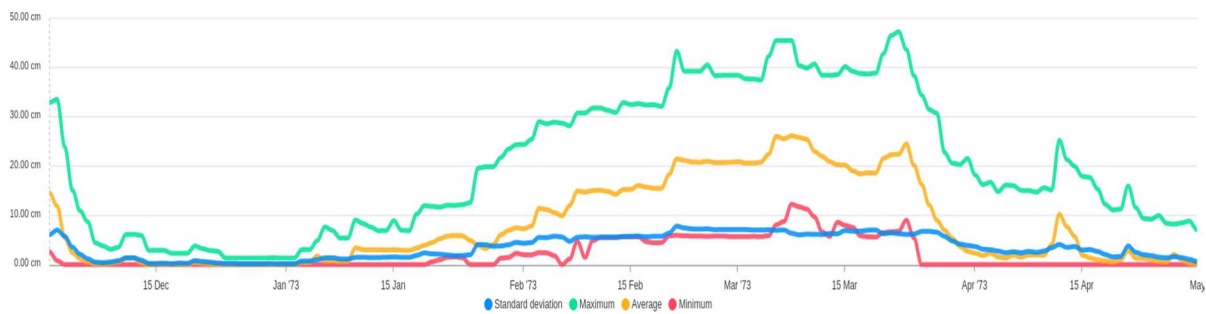


Figure 21: The snow depth statistics in the Lapland area during the winter of 1972-1973. The standard deviation (blue line), the maximum value (green line), the average value (yellow line) and the minimum value (red line) of snow depth are shown over the period 01.12.1972-30.04.1973

In Figure 20, the snow depth statistics over the winter of 1971-1972 is shown. During the February and March, the snow depth is up to 80 cm at maximum down to 40 cm at minimum. The snow accumulated early in the winter and lasted late in the spring. When compared to the statistics over the winter of 1972-1973 as shown in Figure 21, the snow started accumulating a month later and melted earlier in the spring. The snow depth was only up to 25 cm at maximum down to 8 cm at minimum.

The minimum criteria in this test scenario was achieved as the user is able to compare the time series statistics of snow depth over past winters and over selected areas in great detail. Due to this, the KPI for the quantitative difference of snow depth is evaluated as Achieved. The KPI for the length of time was about 5 minutes.

**Test scenario 2:** In a recent paper by Anttila et al. [3] it was shown that in the European Arctic zone the long-term trends for the onset of melting is getting earlier and the melt season is getting longer. Can a researcher visualize the same trends using EOPEN? Is there a difference in the trends between satellite and on-ground data?

**KPI:** Qualitative agreement with the main results: **Achieved**

Number of data sources/tools used in the visualization: **4**

Length of time to get the results: **1.5 h**

**Data:** Globsnow (PUC3\_DC1), ClimGrid snow depth (PUC3\_DC4), Reindeer herding areas (PUC3\_DC11)

**Tools:** Statistical and time series analysis tools, Data filters

**Minimum criteria:** User is able to show the long-term trend over time for the onset of snow melting in Northern Finland.



For this scenario, a user wants to check if there is an observable trend in the onset of snow melting using both, ground-based and satellite-based measurements. To do this, the user has to login to the EOPEN Development portal and run the Use Case process. For the input, the user has to put the starting and ending year for the time series, the fraction of snow-free pixels in the area that need to have zero depth, and select the reindeer herding district. The output is stored in the EOPEN database and can be viewed and saved to disk in the user Dashboard window.

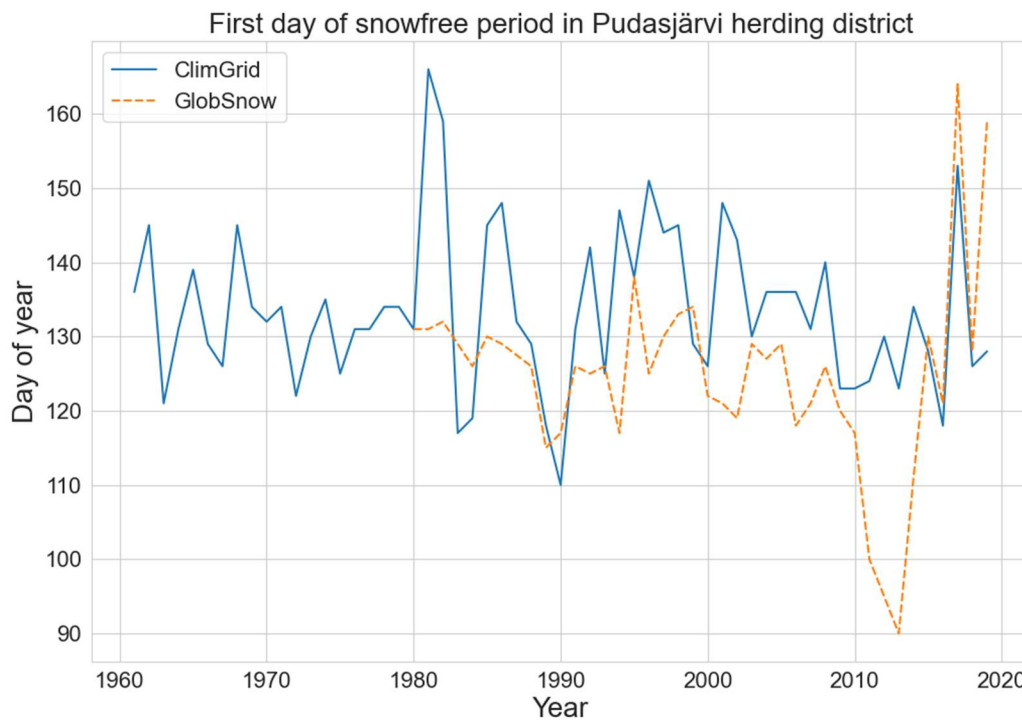


Figure 22: The onset of snow melting in the Pudasjärvi reindeer herding district between 1960-2020

In Figure 22, the onset of snow melting as indicated by the day of year is shown for the period 1960-2020. The ground-based ClimGrid measurements are plotted (blue line) as well as the satellite-based GlobSnow measurements (orange dashed line). As can be seen, there is a qualitative lowering trend within the last 25 years, which can be seen in both data sets. The GlobSnow product shows earlier snow-free days than ClimGrid, which is mainly due to the larger pixel size and therefore fewer number of pixels for GlobSnow, which is more sensitive to changes. It should be noted here that the results in the Anttila et al. (2018) study were derived from satellite-based albedo data (MODIS) over significantly larger areas, so these results should be seen as complementary to the study.

The minimum criteria in this scenario was achieved and the KPI for the qualitative agreement with the results in the study was also achieved although the applications were different. The KPI for the number of data products and tools was 4 as the scenario included the ClimGrid and

GlobSnow products, Reindeer herding areas and the process. The KPI for the length of time was about 1.5 hours.

**Test scenario 3:** Climate change will increase flooding and cause permafrost to thaw in localized areas. FTIA wants to minimize gaps in road maintenance at low-priority regions and improve their road maintenance planning. How can EOPEN help in this?

**KPI:** Quantitative difference in soil-freeze levels: **Achieved**

Number of data sources/tools used in the visualization: **4**

Length of time to get the results: **30 min**

**Data:** SMOS Freeze-Thaw (PUC3\_DC2), Road maintenance classes (PUC3\_DC12), Regions of Finland (PUC3\_DC10)

**Tools:** Statistical and time series analysis tools, Data filters, Map filters

**Minimum criteria:** User is able to show how the soil freezing levels have changed over the winters in remote road areas in Northern Finland.

For this scenario, a user wants to check how the freezing levels of ground have changed for the low-priority roads over the past winters. To do this, the user has to login to the EOPEN Development portal and run the Use Case process. For the input, the user has to put the starting and ending year for the time series, select the administrative region in Finland, and select the road maintenance class according to the Finnish Transport Infrastructure Agency (FTIA). The output is stored in the EOPEN database and can be viewed and saved to disk in the user Dashboard window.

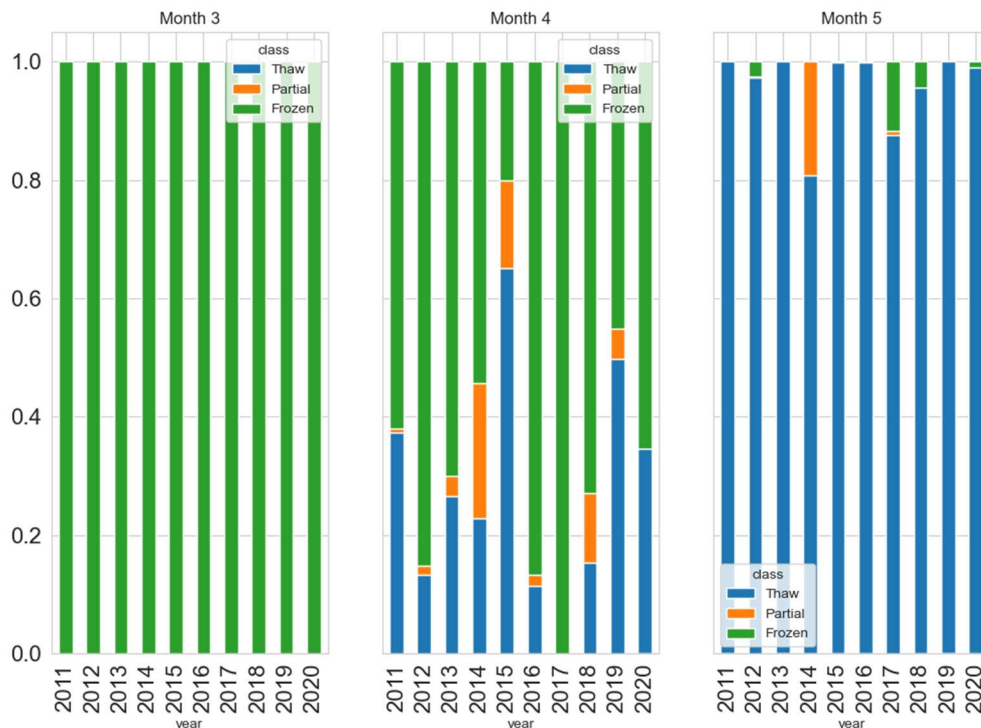


Figure 23: Averaged fractions of ground freezing levels (SMOS Freeze-Thaw) for the low-priority roads (Class III) in the Inari district at the Northern part of Finland. The blue bars indicate thawed or melted roads, orange bars partially melted roads, and green bars frozen roads

In Figure 23, the averaged fractions of the ground freezing levels are shown for the low-priority roads (Class III) in the Inari district, which is at the Northern Lapland in Finland. Even though, there does not seem to be any clear trends over the past nine winters, the combination of the SMOS Freeze-Thaw product with the FTIA road maintenance classes does offer statistical estimates of the freezing levels for the different classes of roads, which is important for FTIA as they need to adjust their road maintenance thresholds every year, which in turn affects their budget. The results show how April is the most crucial month for road maintenance in the Inari district as the average road condition can vary from year-to-year.

The minimum criteria in this scenario was achieved and the KPI for the quantitative difference in the ground freezing levels was also achieved. The KPI for the number of data products and tools was 4 as the scenario included the SMOS Freeze-Thaw product, the road maintenance classes, the Finnish administrative regions and the process. The KPI for the length of time was about 30 minutes.

### 2.3.4 Overall Assessment, Lessons Learnt

**Webinar:** The webinar was organized by Jani Tyynelä and Petteri Karsisto from the Finnish Meteorological Institute in order to showcase the EOPEN platform to the stakeholders and assess their opinions of how the development up to that point had aligned with their requirements and needs. One aim for the meeting was to gather feedback for future user requirements for the platform.

In addition to the presenters, there were a total of five members present during the webinar, which included persons from the University of Lapland and the Reindeer Herders' Association, who represented the reindeer herders' and reindeer researchers' perspective (2 out of 3 stakeholders), and also persons from the Finnish Meteorological Institute. The meeting was held remotely using the Microsoft Teams program and the link to the meeting had been sent a week earlier for all interested parties.

The meeting started at about 14:00 EEST with a short presentation of the EOPEN project in general, the platform implementation and its current status by Jani Tyynelä. After that, Petteri Karsisto demonstrated the platform live showing the user Dashboard and its functionalities, the developer platform and controlling and running workflows, and finally the OpenSphere visualization and data that can be displayed there from the GeoServer. After the presentations there was discussion about the platform implementations and ideas to improve it.

During the discussion, it was mentioned that the CLIMINI project (<https://www.arcticcentre.org/FI/climini/climini-EN>), which is funded by the European Regional Development Fund (ERDF), just started this year and it is also aligned with the objectives of the Use Case. The goals of the project are to gather information about the impacts of climate change on the reindeer husbandry, how the herders are adapting to it, and based on those recommend better strategies and management plans for them. One of the project coordinators present in the webinar mentioned that the EOPEN platform, especially the services provided by the Use Case 3, could be very beneficial for their project and their stakeholders, which are the reindeer herders.

A topic that was discussed at length was the product selection on the platform. The stakeholders were generally satisfied by the selection of products and tools in the platform such as the snow depth and temperature information, which are important for both the herders and researchers. The HIRLAM weather prediction product was also mentioned. They noted that in addition to the snow depth, the quality of the snowpack would also be important knowledge. Periods of freezing and thawing produce layers in the snowpack, which can prevent the reindeer for digging through it. The SMOS 3 Freeze/Thaw product, which provides the ground freezing condition is also helpful in this regard, but there does not seem to be any available data for the quality of the snowpack. We mentioned that the Sodankylä Research Station operated by FMI does monitor the quality of the snowpack, but only locally and this data is not available in the FMI Open Data interface.

Another potentially interesting products for the herders were cloudiness, air visibility, and wind (strength and direction) information, which all could be important for small aircrafts operating in the reindeer herding areas.

At the end of the meeting, there was also discussion about possible collaboration between EOPEN and CLIMINI projects such as a joint workshop, or joint article in the Poromies-magazine, which is a yearly magazine dedicated to reindeer herders and anybody associated with reindeer herding.

**Questionnaire:** After the webinar, a link to a Webropol questionnaire was sent to the stakeholders. The purpose of the questionnaire was to gather feedback from the stakeholders about the platform and its usefulness to them. In the questionnaire, there were six questions, with some evaluated by a number and some by a selection and a free format. The answers to this questionnaire were gathered during the following months after the webinar. Due to the summer holiday season in Finland, a significant delay until August was expected. In the end, there were only two returned questionnaires.

Both users were satisfied (4) with the data sets and the tools on the platform. They also thought that the user interface in EOPEN was slightly difficult (3). Neither users were interested in running their own programs on the platform. They considered that Sentinel data was adequately (2) and quite (3) useful for them. For the other products that should be on the platform, only the numerical weather prediction was mentioned. In the other comments, it was mentioned that there are a couple of other research groups in the Arctic Center and The University of Eastern Finland that could be interested in EOPEN.

Due to the limited amount of feedback, it is difficult to make general conclusions about the question categories, but they do leave a positive view of the implementation and development status in Use Case 3.

**Hands-on testing:** After the webinar and questionnaire, two of the stakeholders wanted to try to platform by herself/himself. For this, we sent them user accounts and passwords for the developer platform through email and links to the project website, which has the training videos and exercises for new users. One of them sent feedback from the testing through email.

The main points were:

- The functionality and role of the Dashboard was unclear, especially the way a user could add their own collection of data
- The OpenSphere visualization software was easy to use and allowed the user to select specific areas
- The hints provided by the platform were useful, but not as intuitive as the user wanted
- The weather predictions and historical snow data were informative (user also used the animation tool)
- User wanted, but had no time to test the time-series tool for certain reindeer herding area

**Overall assessment:** Overall, PUC3 has been successful in addressing the user requirements by providing access to multiple data sources for weather and environmental monitoring, and tools for their better utilization and visualization. These also address High Level Call Requirement I by alleviating the need of computing resources, and the High Level Call Requirement IV by allowing the users to quickly estimate the importance of detected events in local and global scale. PUC3 also utilizes KR02 and KR12 by providing a snow-related tweet event detection that is available in the used Dashboard. KR13 is utilized in the test scenarios that are relevant to the stakeholders' monitoring needs.

The webinar succeeded in informing the stakeholders of the EOPEN platform implementations and confirmed their relevance. It also succeeded in gathering feedback about additional data sets that could be useful for them. Even though the feedback gathered after the webinar was not adequate for a statistical analysis, it did reveal some of the strengths and weaknesses in the platform that could be improved in the future.

For the stakeholders, key strengths are the broad selection of data for environmental monitoring and the visualization tools for the data. As these played an important role also in the user requirements that were gathered in the early part of the project, the implementation strategy for the Use Case was successful.

Stakeholders also mentioned some of the weaknesses in the platform, such as the unclear role for the Dashboard and its usefulness to them. As the Dashboard is a central hub for accessing the data, processes and the visualizations, and can be modified by the user, it should be an important part of the EOPEN experience for the user. It is therefore suggested that its role should be emphasized in future presentations of the platform.

This paragraph updates the tables of the deliverable D7.2 to report the status of the platform and services.

### 3 PUC1 Field Exercise

The Field exercise was an important step in the project lifetime since it was the first real demonstration of the usage of the platform. In the proposal this event had been foreseen as a co-location meeting nevertheless, due to the COVID-19 emergency and the restriction imposed by the Italian government, AAWA organized the event as an online webinar where each participant, following a storyline could experience the EOPEN platform guided by an AAWA technician. The setup of the field exercise was supported by the EOPEN developer team, especially the partner responsible for the platform's integration and supervised by the Project Coordinator.

To carry out this exercise AAWA provided to the stakeholders an account (in total 15 anonymous accounts were generated by the platform responsible) during the training session before the exercise. Each stakeholder in this way was able to explore the platform before the exercise. The event, involving 15 participants, was scheduled on 29 September 2020 nevertheless it was interrupted shortly after as the system was blocked, in particular the GIS viewer, due to overload as several concurrent processes related to PUC final implementations were running on the platform at the same time, which was confirmed by a subsequent analysis; the developer proposed to move the most resource demanding back-end service to a new machine for improving the performance of the final system. The field demonstration was rescheduled on 14 October 2020 with the same participants who managed to complete the storyline.

Table 13: PUC 1 field demonstration stakeholders

Stakeholder	Description
ARPAV	This administration is the environmental agency of Veneto Region; inside this office there is also the Copernicus contact person for Veneto Region
Regione Veneto Difesa Suolo	This Administration is the office of Veneto Region Administration responsible for land use, water, environmental planning, and waste management. This office is also responsible for cartography.
Regione Veneto Protezione Civile	This Administration is the office of Veneto Region Administration responsible of Civil Protection Volunteer (at regional scale, so about formation, guidelines etc.), for Bulletins (Alert bulletins)

Genio Civile di Vicenza	This Administration is the operative office of Veneto Region Administration in water management (river maintenance, river project, dikes etc.)
Corpo Nazionale dei Vigili del Fuoco di Vicenza	The firefighters of Vicenza.
Provincia di Vicenza protezione Civile	This is the provincial office of Civil Protection, similar to Veneto Region Civil Protection office but at province level.
Comune di Vicenza	Municipality of Vicenza.
Consorzio APV	This Administration is a Land reclamation authority responsible for “Alta Pianura Veneta” basin.
Consorzio Brenta	This Administration is a Land reclamation authority responsible for “Brenta” basin.
AAWA (Autorità di Bacino dei fiumi Isonzo Livenza Piave Brenta-Bacchiglione)	This Administration is the higher water authority in Veneto, Trentino-Alto-Adige and Friuli region; it is also responsible for some international basins like Timavo Basin (Slovenia). It is an office directly dependent from the Italian Environmental Ministry.

In the following there are the different layers used by each stakeholders during the field exercise.

Table 14: PUC 1 field demonstration timeline

Field exercise 13-10-2020 layers used
Alluvione_2010_Saletto_rilevata



Aree_Fluviali_Brenta_Bacchiglione
Aree_Fluviali_Piave
Brenta_Bacch_Haz_Tr30
Brenta_Vaia_modello
CFD
CSK_Allagamenti_2010
CSK_Piave_20181112044056_20181112044103
CSK_ireact_01_11_18
Corine Land Cover 2012
Corine Land Cover 2018
Discharge
FieldExerciseTweets
HIRLAM Precipitation Forecast

Piave_Haz_TR30
Piave_S1_20181026T052625_20181026T052650
Piave_S1_20181027T051858_20181027T051923
Piave_S1_20181029T165756_20181029T165821
Piave_S1_20181101T052707_20181101T052732
Piave_S1_20181102T051816_20181102T051841
Piave_Vaia_modello
Segnalazioni
flood_map_3_5_vaia_storm_1_2018-10-27
flood_map_3_5_vaia_storm_2_2018-10-27
flood_map_3_5_vaia_storm_3_2018-10-27
flood_map_3_vaia_storm_1_2018-10-27
flood_map_5_vaia_storm_1_2018-10-27

flood\_map\_5\_vaia\_storm\_3\_2018-10-27

Below is the Storyline with reference to evaluation scenarios 1,2 and 5, in cursive is reported the narrative:

Login and interface configuration (dashboards)

*The exercise provides the simulation of the VAIA event in October-November 2018, each participant can freely consult the layers including the WMS services In the period 26-30 October 2018 the weather forecast shows the passage of an intense perturbation over Italy, numerous regions issue weather warnings.*

The algorithm that generates a precipitation layer (\*) is launched on the platform (AAWA) – input file: HIRLAM forecast of 26-10-2018 h6.00 pm

Loading of the alert map layer of the Veneto Region (.json alert areas with info) (AAWA or Veneto region)

Visualization and evaluation of the layers by the participants and discussion on the actions to be taken (ALL)

AAWA decides to prepare a hydrological run to verify the expected flood based on available forecasts and upload a json file with maximum expected discharge (AAWA)

Subsequently it is considered the day 27-10 at 12.00

The algorithm that generates a precipitation layer (\*) will be launched on the platform – input file: HIRLAM forecast of 27-10-2018 12.00

Civil Protection updates bulletin with new .json (AAWA or Veneto region)

AAWA decides to prepare a hydrological run to verify the expected flood on the basis of available forecasts

AAWA produces a .json of the maximum flow rates at the top with relative time and loads it on the platform

*Subsequently it is considered the day 28-10 at 00.00*

the algorithm that generates a precipitation layer (\*) is launched on the platform – input file: HIRLAM forecast of 28-10-2018 h00.00

Civil Protection updates bulletin with new .json

AAWA decides to prepare a hydrological run to verify the expected flood flows on the basis of available forecasts

AAWA produces a .json of the maximum flow rates at the top with relative time and loads it on the platform

AAWA provides the most likely flood scenario of the PGRA

AAWA launches hydraulic modelling run (Basement simulation tool from ETH Zurich)

*Subsequently we consider the day 29-10 at 00.00*

The algorithm that generates a precipitation layer (\*) is launched on the platform – input file: HIRLAM forecast of 29-10-2018 at 00.00; the event generated widespread critical issues throughout the region.

Civil Protection updates bulletin with new .json
AAWA verifies satellite images of the previous days in order to estimate the extent of the floods and decides whether to activate the request for “rush” satellite acquisitions
The administrations (consortium, Municipality of Vicenza and soil preservation) insert .json with areas that have suffered damage or any hydraulic criticalities of the territory
Participants browse social networks in search of useful information
Everyone compares visible information to ground truths and data (JDIG verification)
<i>Subsequently we consider the day 30-10 at 00.00</i>
The algorithm that generates a precipitation layer (*) is launched on the platform – input file: HIRLAM forecast 30-10-2018 h00.00 the event seems to be over.
Civil Protection updates bulletin with new .json
AAWA checks the presence of satellite images of the previous days in order to estimate the extent of the floods and inserts the required rush processing
The administrations (consortium, Municipality of Vicenza and soil preservation) update the .json files with areas that have suffered damage or any hydraulic criticalities of the territory
Participants browse social networks in search of useful information
Everyone compares visible information to ground truths and data (JDIG verification)

the algorithm that generates a precipitation layer (\*) is launched on the platform – input file: HIRLAM forecast 31-10-2018 h00.00 the event seems to be actually at the end.

*Final tour of the platform, debriefing and questionnaires.*

(\*) The precipitation layer is generated by associating the municipalities' centroids to the highest rainfall values, as from the HIRLAM grid values (nearest grid center-value).

At the end of the exercise were sent some questionnaires to evaluate the final system with the following requests:

Evaluate the following aspects of the platform giving a grade from 1 (minimum) to 5 (maximum) based on what was tested during the project exercise

- Ability to view social media data (text) \*
- Semantic analysis of data from social networks (extraction of key concepts, words, etc. e.g. : flood) \*
- Speed up and quality in the survey of flooded areas from images already available \*
- Ability to superimpose flooded areas with other data (Social media, GIS etc.) \*
- Possibility to use a webgis directly online \*
- Ability to define areas of interest on the web map \*
- Ability to filter data \*
- Possibility of overlapping different information levels to define new scenarios (e.g. viable roads in case of flood) \*
- Ability to view weather forecast \*
- Secure storage and download capability \*
- Pre-configured processors (e.g. flood detection) \*
- Ability to search and download data \*
- How do you rate the EOPEN platform overall? \*
- Is the EOPEN platform simple and intuitive? \*

- Will the EOPEN platform increase the speed with which you can do the elaborations? \*
- Are you satisfied with the datasets available on the platform? \*
- Other datasets that you would like to integrate (e.g. data from weather satellite or other?)
- Do you think the platform could be useful in your activities?
- If you want to use the platform, would you prefer a “fee” service at a fixed cost or “pay per use”?

### 3.1 PUC1 Questionnaires results

In this section are reported the results of questionnaires of PUC1 from Italian stakeholders after the field exercise compared with the ones sent during the Infoday.

The first result that clearly appears from questionnaires is the higher grade of satisfaction after the use of EOPEN during the field exercise.

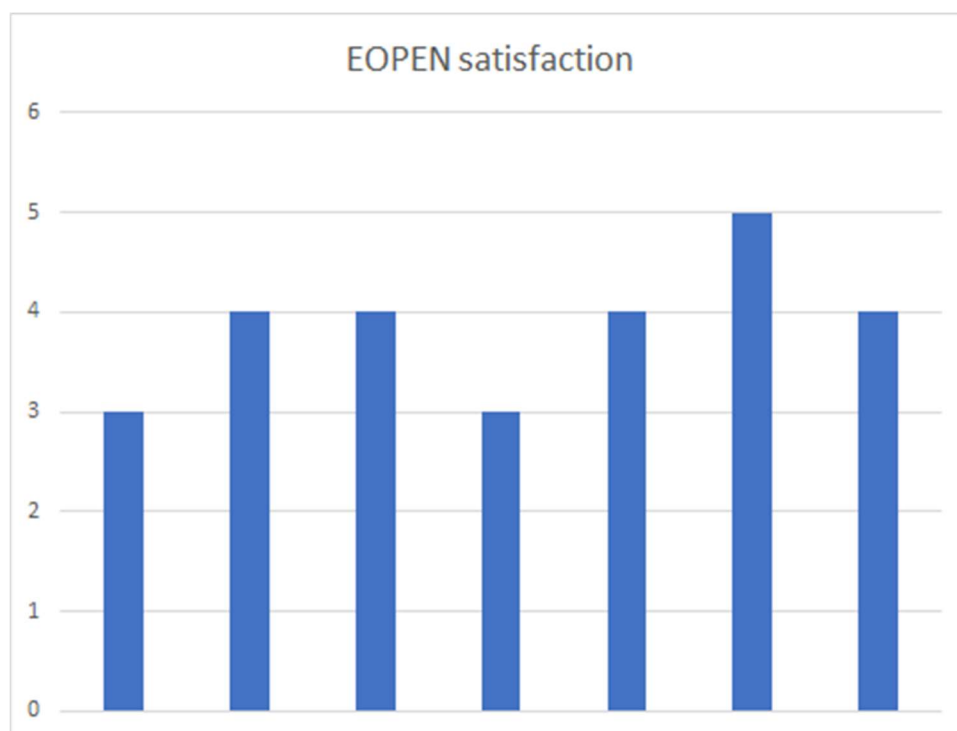


Figure 24: Answers related to the satisfaction of users, in vertical is reported the mark (1 to 5) received for each questionnaire (represented by each bar)

The second important result emerges from the comparison between the same answers from the questionnaire after the Infoday and after the Field Exercise; the number of answers are statistically equals (6 after the Infoday and 7 now) so the results can be directly compared.

The important result reported in the graph below is that from the presentation of the platform (where many stakeholders provide the higher level of expectations) during the Infoday and after the Filed exercise (after the use of EOPEN) are more or less equals.

This demonstrate that the platform meets the expectation of stakeholders for PUC1.

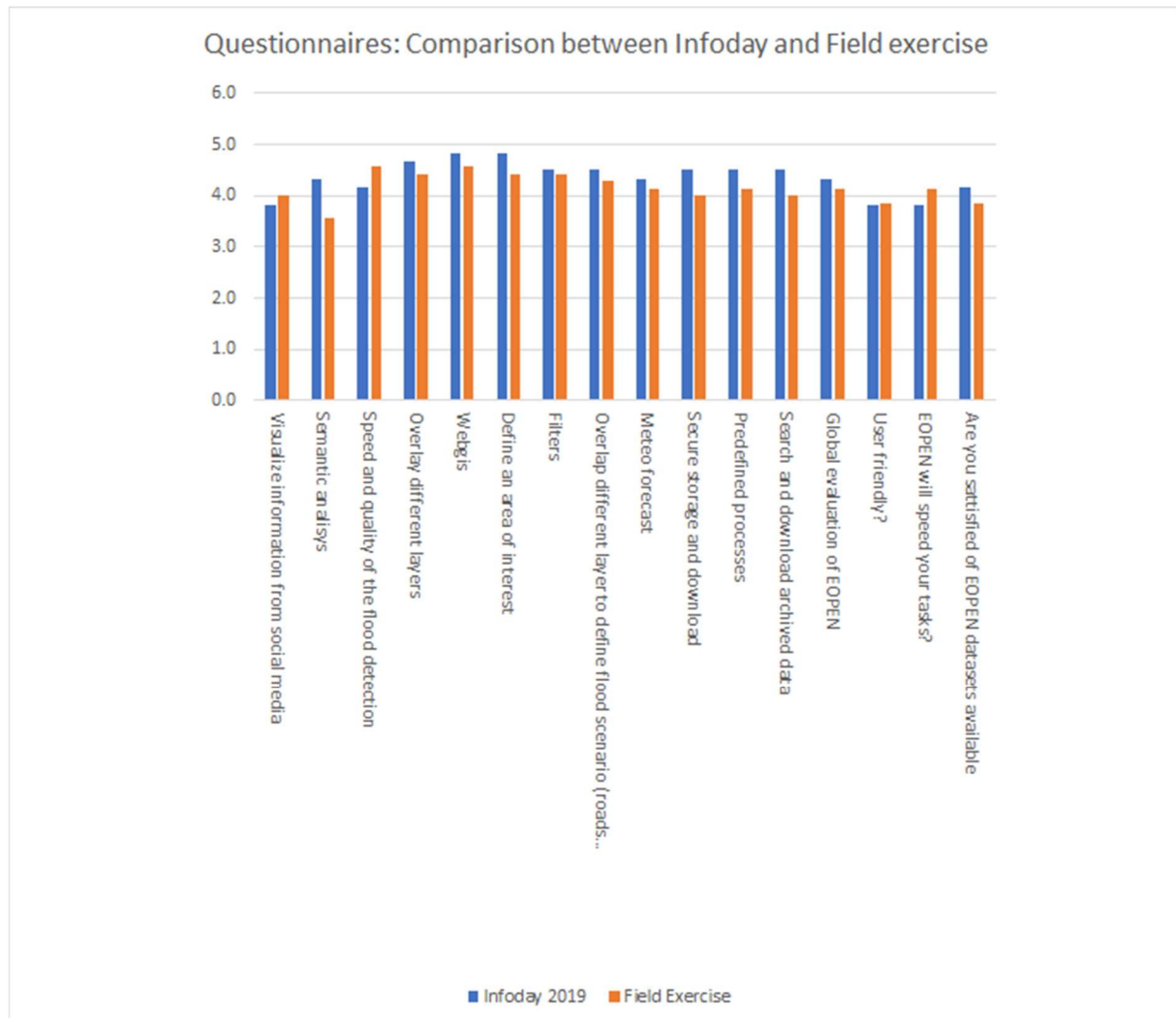


Figure 25: Comparison between answers after the Infoday and after the EOPEN Field exercise



## 4 Conclusions

The overall assessment of EOPEN in its final stage demonstrated to be aligned with the expectations of stakeholders. One of the most important things is that almost all datasets and products stemming from the user requirements are inside the platform and this was mostly appreciated by stakeholders. Another important aspect is that who tested directly the platform (stakeholders of PUC1) provided important positive feedback to the final version of EOPEN. All of them reported that they would use this instrument if available in the future and this aspect is perfectly aligned with the concept expressed in the JDIG approach (overcome COM to reach a TOM).

Another important aspect is the capacity of overcoming problems like in the case of the field exercise, which was successfully carried out after prompt reaction of the development & coordination partners, thus showing the robustness of the system that permits important changes in a small time.

## 5 References

- [1] Boschetti, Mirco & Stroppiana, Daniela & Brivio, Pietro & Bocchi, Stefano. (2009). Multi-year monitoring of rice crop phenology through time series analysis of MODIS images. *International Journal of Remote Sensing*. 30. 4643-4662. 10.1080/01431160802632249.
- [2] Vuojala-Magga T., Turunen M., Ryyppö T., and Tennberg M. (2011). “Resonance strategies of Sami Reindeer Herders in Northernmost Finland during Climatically Extreme Years”, *Arctic* 64 (2), 227-241.
- [3] Anttila K., T. Manninen, E, Jääskeläinen, A. Riihelä, and O. Lahtinen (2018). The Role of Climate and Land Use in the Changes in Surface Albedo Prior to Snow Melt and the Timing of Melt Season of Seasonal Snow in Northern Land Areas of 40° N–80° N during 1982–2015, *Remote Sens.* 10, 1619

## **Annex - System evaluation updates with reference to D7.2 evaluation report**

### **1.1 Event detection in social media (KR02)**

#### **1.1.1 Purpose of Scientific Activity**

The Event Detection module aims to identify possible events based on non-EO data. The current implementation focuses on the crawled tweets, derived from the social media monitoring task, and uses the fluctuation of the number of relevant tweets per day to discover events. When an event is detected, the most mentioned location (based on the results of the localisation technique) and the most mentioned keywords in the tweets text are identified, so as to provide more insights on the event. Finally, a respective notification and/or an email are produced to inform the interested users. An implementation of the module runs daily as a process in the EOPEN platform (High level Call Requirement I) and generates JSON files with information for any detected events. The complete description of Event Detection is given in D4.4.

#### **1.1.2 Description of the scientific framework**

In order to determine whether an event occurs in a given date, we calculate the z-score of that date's number of relevant tweets. The z-score indicates how many standard deviations this day is from the sample's mean, assuming a Gaussian distribution, where sample is the previous thirty days (previous month). If a date z-score is above a constant threshold, then we can assume there is an event on that day.

#### **1.1.3 Results and metrics**

For the evaluation of the Event Detection module, we have designed an experiment that concerns PUC1 and is able to provide a quantitative evaluation of the approach. We have collected all the flooding incidents that occurred in Italy in the years 2017 and 2018 to use as ground truth and applied the Event Detection method on the Italian tweets that were collected in this time period and include keywords related to floods.

We have experimented with two parameters: (i) the sample to compare each point (whole year / the total month / the previous thirty days) and (ii) the threshold of z-score above which the point is considered an event (2.5 / 3 / 3.5). The metrics we use for the results are precision, recall, and F-score. The key performance indicators that are calculated can be seen in the following table.

Table 15: Performance indicators and scientific metrics for event detection in social media

Indicator/Scientific metric	Value	Relevance to User Requirements	Comments
Precision	%	US_V_02a4 US_V_02a5	
Recall	%	US_V_08a	
F-score	%		

The results can be seen in the next table. The best precision (1.00) is achieved for the year sample and the 3.5 threshold, followed by thresholds 3 (0.67) and 2.5 (0.67). This means that all or most outliers in the annual fluctuation of tweets are linked to real events. On the other hand, the best recall (0.86) is achieved for the sample of the last thirty days for all three thresholds, which means that more real events were able to be discovered, but the lower precision indicates that many false alerts were detected. More detailed results can be found in D4.4.

Table 16: Evaluation of the event detection methodology

Sample to compare	Threshold	TP	FP	FN	Precision	Recall	F-score
Year	3.5	4	0	3	1.00	0.57	0.73
Month	3.5	3	12	4	0.20	0.43	0.27
Last 30	3.5	6	17	1	0.26	0.86	0.40
Year	3	4	2	3	0.67	0.57	0.62
Month	3	5	14	2	0.26	0.71	0.38
Last 30	3	6	14	1	0.30	0.86	0.44

Year	2.5	4	2	3	0.67	0.57	0.62
Month	2.5	5	17	2	0.23	0.71	0.34
Last 30	2.5	6	18	1	0.25	0.86	0.39

#### 1.1.4 Discussion

This module discovers possible events exploiting the social media data that has been crawled by the corresponding task. Each dataset is use case-specific by defining different search criteria during the crawling procedure, so events are detected per each use case separately and independently. Every end user that is interested in a certain use case will be only notified about events relevant to that use case. Notifications for PUCs 1 and 3 can serve as early warning for incidents linked to extreme weather conditions, such as floods or heavy snow, while notifications for PUC2 highlight changes in the food industry and encourage interested users to investigate what is commented on social media (Cross-partner assessment).

## 1.2 Similarity fusion (KR04)

### 1.2.1 Purpose of Scientific Activity

The Similarity Fusion module aims to retrieve similar content found inside the EOPEN collection. Given that the module considers different modalities for retrieving similar EO and non-EO content, there is the need to fuse these multimodal objects in a scalable way, taking into account memory and computational complexity, in order to retrieve similar content in response to a query. We provide single modality retrieval modules that consider text, visual features, visual concepts, geolocation and time and also propose a late fusion algorithm that combines the above information. Details can be found in D4.3.

### 1.2.2 Description of the scientific framework

The following single modalities retrieval modules have been developed:

- **Spatiotemporal retrieval:** This module involves the retrieval of the closest tweets in terms of time and location and it considers the metadata either pre-existing in the tweet or produced by other EOPEN modules (i.e. localization module).
- **Visual concept-based retrieval:** This module produces apart from the top 10 concepts a 345 vector with the probabilities of the 345 SIN TRECVID concepts. Then, similarly to the visual features, an index is created that considers these vectors and creates and updates on a regular basis an Asymmetric Distance Computation index to achieve fast retrieval.
- **Visual features-based retrieval:** This module considers the same DNN network.

Text-based retrieval: This module uses an Apache Lucene for text retrieval and indexing.

Furthermore, an algorithm for fusing the above modalities is thoroughly described in D4.3.

### 1.2.3 Results and metrics

The evaluation of the Similarity Fusion module in the EOPEN dataset involves the separate performance of the single modalities retrieval and the comparison of the proposed fusion approach to other state-of-the-art methods. The key performance indicators for both are:

Table 17: Performance indicators and scientific metrics for similarity fusion

Indicator/Scientific metric	Value	Relevance to User Requirements	Comments
Average Precision	%	US_V_02a2	
mean Average Precision	%	US_V_02b3	

The results, shown in the following table, indicate that retrieval based on visual features achieves the best performance, followed by temporal search, while the text modality has the lowest score. From the fusion techniques the ones that perform the best are the proposed EOPEN algorithm and the Borda fusion algorithm. However, the irrelevant retrieved results are ranked higher in the Borda fusion algorithm. More details can be found in D4.3.

Table 18: Average precision and mean Average Precision

		Average Precision@10			mean Average Precision
		PUC1	PUC2	PUC3	
Single modalities retrieval	Text	1.0	1.0	0.586	0.862
	Time	0.839	0.867	1.0	0.902
	Visual Features	0.878	1.0	1.0	0.959

	Visual Concepts	0.638	1.0	1.0	0.879
Multiple modalities retrieval	EOPEN	0.906	1.0	1.0	0.969
	Borda	0.906	1.0	1.0	0.969
	Reciprocal	1.0	0.649	1.0	0.883
	Condorcet	1.0	0.947	0.947	0.965

#### 1.2.4 Discussion

This module allows the user to retrieve similar EO and non-EO content given a query tweet or EO product. Given that the tweet content, which involves both the text and image included (if it exists) and the EO products are rather different per UC, the similar content that will be retrieved will thus differ per UC.

### 1.3 Clustering of EO data (KR05)

#### 1.3.1 Purpose of Scientific Activity

The purpose of this module is to cluster EO data into groups so that end users can find the interested patterns.

#### 1.3.2 Description of the scientific framework

Regarding the EO data, DBSCAN-Martingale has been proposed for clustering satellite imagery patches in a supervised way and experiments demonstrated that multiple iterations in a parallel manner can estimate the most probable number of clusters.

In addition, an algorithm for clustering of Sentinel-2 images time-series to automatically identify rice fields and create labelled data for supervised classification (PUC2) has been developed by NOA, with the support of HLRS. The technology of k-means and w-net have been adopted. W-net is a deep neural network which is composed of a two-stage U-net and organized in an AutoEncoder-Decoder architecture. Through this model, the EO images can be automatically segmented based on the clustering of pixels and further the rice fields could be identified.

Within the context of PUC2, clustering was used for the generation of a training dataset. The idea is to exploit vegetation indices (NDVI, NDWI, PSRI) calculated from Sentinel-2 times-series imagery as input to a distributed K-Means algorithm ([High level Call Requirement I](#)). Temporal interpolation was required to allow generalization and transferability of the model so that it does not depend on the time/date of acquisition; since Sentinel-2 satellites visit each area on

different timestamps. Thus, each pixel was assigned to the weighted average value within a fixed time step of a 10-day window. Linear interpolation was also used to derive interpolated values for the pixels classified as cloud, according to the Scene Classification product. The first iteration of K-Means results in two clusters which were used as a water mask. Having extracted pixels considered to be water, a second-level group of K-Means executions takes place for creating a variant number (5-15) of clusters. Each of these clusters is assigned to different observations. Thus, the identification of the rice cluster on each K-Means execution along with the final number of clusters are based on certain metrics, such as Mean Squared Error, Recall and Precision compared to a validation dataset.

### 1.3.3 Results and metric

The following metrics were used to evaluate the performance (Self-assessment). The results for rice clustering to create training labels is evaluated on its own. Nonetheless, in the PUC2 section we report on the performance of the supervised classification using the k-means based labels.

Table 19: Performance indicators and scientific metrics for Rice Clustering to create labelled data

Indicator/Scientific metric	Value	Relevance to User Requirements	Comments
Precision	97.90%	US_SK_03b	
Recall	89.98%	US_SK_03c	
F-score	93.78%	US_SK_04	
Reduce manual effort for labelling data	3 Person Days	US_SK_10	Manual annotation took 3 PDs, while clustering runs in only several minutes

### 1.3.4 Discussion

Clustering algorithms are initially developed for defining groups of similar images. However, in image segmentation it is also widely used, especially when clustering the pixels of an image. Towards this direction and using unsupervised machine learning techniques, a set of labelled rice pixels at Seosan and Dangjin districts of South Korea are produced.



## 1.4 Text clustering of non-EO data (KR06)

### 1.4.1 Purpose of Scientific Activity

The purpose of this module is to cluster textual information from crawled tweets into groups, which can be perceived as topics that are trending on social media. Currently the module has been implemented, deployed as a service on the EOPEN platform and is available to be called at any time ([High level Call Requirement I](#)). The service receives as an input the use case of interest (e.g., Italian tweets about flood events) and responds with the clusters detected in the most recent relevant tweets, so as to capture the trending topics. Each topic has the tweets it comprises and some keywords that reflect the most common terms mentioned in these tweets. A complete description of the Text Clustering module can be found in the resubmitted D4.2.

### 1.4.2 Results and metrics

The key performance indicators used for the evaluation of the proposed text clustering methodology are ([Self-assessment](#)):

Table 20: Performance indicators and scientific metrics for text clustering of non-EO data

Indicator/Scientific metric	Value	Relevance to User Requirements	Comments
Processing Time	millisecond (ms) or hours (h)	US_V_02a3 US_V_02a5	Experiments from CERTH showed that the execution time of distributed DBSCAN is 3.75 hours on 32 cores.  Experiment from HLRS showed that the execution time distributed LDA on 100000 twitter records (1.5GB) is 251 seconds on 3 nodes (36 cores and 400GB Memory per node)

As reported in D4.2, the processing time of a parallelized (multi-core) version of the algorithm has been calculated for different numbers of cores. The results can be summarized in the following table and demonstrate that processing time significantly decreases while the number of cores increases, proving that text clustering is a problem that can benefit from parallelization.

Table 21: Processing Time related to number of cores

Number of cores	Processing Time (h)
1	85.00
2	46.96
4	24.85
8	13.19
16	7.08
32	3.75

### 1.4.3 Discussion

When calling the service for text clustering, the use case has to be defined as input. Then, the module uses tweets that have been crawled specifically for this use case and returns the detected topics. End users have the ability to call the service for the use case they are interested in and get informed about the relevant trending topics on social media. Thus, it can be used for all three PUCs (Cross-partner assessment).

An example for PUC1 follows. The end user is notified by the Event Detection module (KR02) that a potential event is happening with regards to floods, along with some first details, e.g. possible area of the event. In order to gain more insight, the user runs the Topic Detection module and is presented with trending topics, in the visually appealing form of word clouds. Each word cloud contains keywords that explain the topic, e.g. affected places, type and severity of the incident. If the user desires to get more in depth, clicking on the word cloud shows the complete list of the tweets of the cluster, providing access to the original, raw information. In such a way, the end user is able to view what is happening on social media from high-level to low-level information. A very similar scenario can be described for PUC3, where the main subject is the snow coverage instead of flooding incidents.

## 1.5 Community detection (KR07)

### 1.5.1 Purpose of Scientific Activity

The objective of this module is to detect end-user communities through their relationship. The current version of the module focuses on social media accounts and their “following” interaction, while it can be easily adapted to focus on users of the EOPEN platform and the similarity of their behaviour. The module has been deployed on the EOPEN platform (High

level Call Requirement I) as a service and is currently online. The inputs to the service are the use case of interest and a date range. The response includes the pairs of connected users, the detected communities, and a list of the most influential users. The Community Detection module has been described in D4.4.

### 1.5.2 Description of the scientific framework

The methodology of this module serves two functionalities: the detection of key-communities and the identification of key-players. After mapping users and their relationships to nodes and edges, the Louvain algorithm is adopted to discover communities (Blondel et al., 2008). On the detected community of nodes, the degree measure is computed per node, defined as the number of its neighbours. The nodes with the largest degree are the key-players.

### 1.5.3 Results and metrics

The metrics to evaluate (Self-assessment) the Community Detection method can be seen in the following table and include the modularity of networks, i.e. the strength of division of a network into communities, and the time the process needs to run.

Table 22: Performance indicators and scientific metrics for community detection

Indicator/Scientific metric	Value	Relevance to User Requirements	Comments
Modularity	[-1,1]	US_V_02a US_F_01b	This KPI is examined in relation to alternative community detection algorithms and increase of days.
Execution Time	millisecond (ms)		This KPI is examined in relation to alternative community detection algorithms and increase of days.

Among the experiments presented in D4.4, a comparison of alternative community detection algorithms (i.e., Edge Betweenness, Fast Greedy, Label Propagation, Louvain, Walktrap, and Infomap) has been performed and the outcomes can be seen in the next two figures. The dataset selected for this experiment has been Italian tweets about floods, collected between 01/09/2017 and 15/09/2017 (including a flooding incident). The results show that Louvain achieves the highest modularity, has the best average execution time and is also proven to be the most scalable.

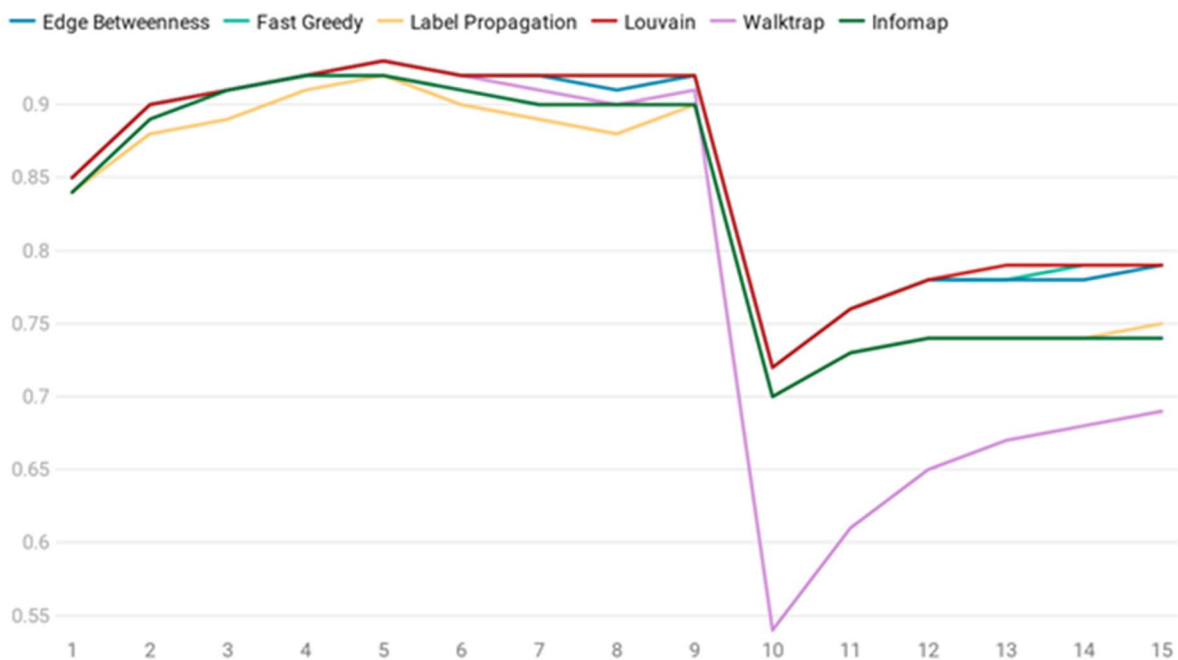


Figure 26: Modularity of communities detected by each algorithm as days increase

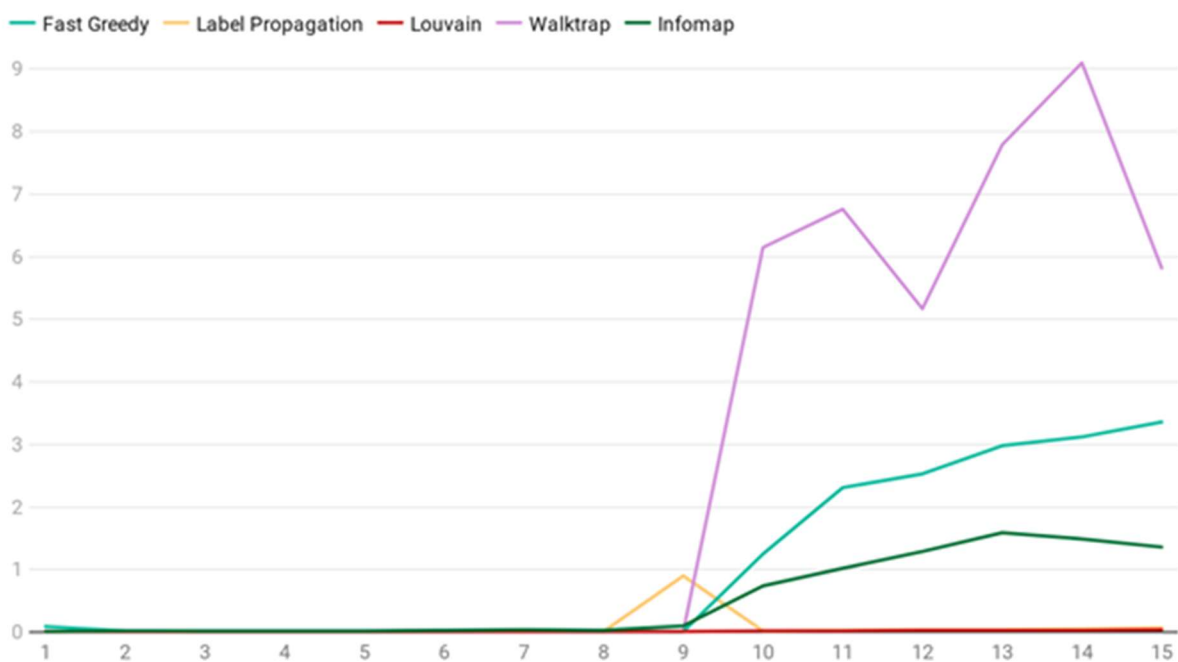


Figure 27: Execution time of each algorithm as days increase (Edge Betweenness is excluded because it is significantly slower and this would affect the readability of the figure)

### 1.5.4 Discussion

The implemented service searches for formed communities inside a network of user-to-user interactions, where users are social media accounts whose posts have been collected for

EOPEN. Since the collections of crawled tweets are use case-based, the results of the service refer to specific use cases (Cross-partner assessment). For PUC1 and PUC3 that concern critical situations due to floods and snow respectively, the identification of communities and key players that are in the centre of these communities leads to the detection of accounts that function as “authorities”, i.e they inform/influence other citizens through social media during a crisis of extreme weather conditions. On the other hand, for PUC2 these “authorities” accounts can be further investigated by the end users with regards to their influential role in matters of food security.

## 1.6 Evaluation of the performances for querying Linked Data (KR08)

As part of the work performed in KR08, the EOPEN Platform has been used to produce, store and retrieve geo-localised and time-enabled non-EO data (tweets, events and flooded areas) as Linked Data.

Hereafter we are providing response times collected while retrieving non-EO Linked Data. The service under test is the “*Retrieve Linked Data Service*” implemented by CERTH. This receives an AOI and TOI as inputs, for corresponding entities in GraphDB (triplestore) using SPARQL/GeoSPARQL queries and returns the result as an OGC “FeatureCollection”, in GeoJSON format.

In order to evaluate the performance of the service without the overhead of the workflow executions, this has been queried using the “curl” command as follows:

```
time      curl      -v      -X      POST      -d      @request.json      \
-H      "Accept:      application/json"
-H      "Content-Type:      application/json"
"https://<domain>/<path>/RetrieveInsidePolygon"
> request-response.json
```

Example payload (request.json):

```
{
  "geometry": "POLYGON((-24.6 35.7, 32.1 35.7, 32.1 71.1, -24.6 71.1, -24.6 35.7))",
  "start_date": "2020-01-01T00:00:00.000Z",
  "end_date": "2020-12-31T23:59:59.999Z"
}
```

Four AOIs and TOIs have been used to evaluate the performance of the service. All TOIs are chosen in 2020 as only recent data is available in the triplestore. Each query has been executed 10 times. The results are provided in the following table:

Table 23: Retrieve Linked Data Service Response Time

AOI (bbox)	TOI	Response Time	Response Content
------------	-----	---------------	------------------

Europe (-24.6, 35.7, 32.1, 71.1)	2020-05-01 - 2020-09-30	Min: 2.33 s Max: 3.18 s Average: 2.74 s	Tweets: 6189 Events: 8 Flooded areas: 0
North Italy (6.5, 43.7, 13.8, 47.2)	2019-01-01 - 2020-06-30	Min: 1.00 s Max: 1.91 s Average: 1.38 s	Tweets: 1 Events: 1 Flooded areas: 1
South Korea (125.8, 33.1, 129.7, 38.7)	2020-09-01 - 2020-09-30	Min: 1.13 s Max: 1.58 s Average: 1.37 s	Tweets: 587 Events: 0 Flooded areas: 0
Finland (20.2, 59.7, 31.9, 70.3)	2020-09-01 - 2020-10-15	Min: 1.05 s Max: 1.74 s Average: 1.33 s	Tweets: 82 Events: 0 Flooded areas: 0

## 1.7 Linking Open EO Data (KR09)

The test data has been specified as a query to the Umbrella Application for Sentinel products. This query allows identifying a constant set of products and obtaining their metadata.

The criteria are as follows:

- Area of interest (bounding box): 20.8,38.41,23.82,40
- Time of interest (date range): 2020-01-01/2020-06-30
- Product type (mission): sentinel1

The metadata of 100 products has been retrieved, converted (from JSON to RDF) and stored in a triplestore (Strabon) using a processing workflow in the EOPEN Platform. This workflow is detailed in section 4.4.1 "EO Products Metadata Conversion to Linked Data and Storage in Strabon" of D5.3 "Linked Open EO Data".

A second workflow has been created for querying the triplestores used in the EOPEN Platform: Strabon (for EO data), and MongoDB (for non-EO data such as tweets, and events) and returning a merged version of the resulting graph. This second workflow is detailed in section 4.4.2 "2 Interoperable semantic query to retrieve EO and non-EO data" of D5.3.

The execution of the "Query Linked Data" workflow takes in average 600-900 seconds to complete. This includes the overhead brought by the process scheduling, the deployment and management of containerized processes, etc. Only querying Strabon or MongoDB takes in average 50-80 seconds.

Table 24: Performance indicators and scientific metrics for Linking Open EO data

Indicator/Scientific metric	Value	Value achieved	Relevance to User Requirements	Comments
Conversion speed	Number	300-500 seconds	US_SK_03 US_SK_05	
Number of EO products (metadata) successfully converted	Percentage of test conversions	100%	US_SK_06a	Products metadata obtained dynamically from the Umbrella Application.
EO products metadata successfully stored in the KB	Percentage of test storage	100%		EO products metadata in RDF stored in Strabon.
EO products metadata searchable in the KB	Percentage of test searches	100%		EO products metadata searched using SPARQL queries.
Successful cross-concept queries	Percentage of test queries	100%		SPARQL queries used to search for EO and non-EO data (incl. tweets) simultaneously.

## 1.8 EO data acquisition (KR10)

### 1.8.1 Purpose of the technological activity

The developed Umbrella Sentinel Hub, under the EO data acquisition Key Result, provides a transparent and seamless access to Sentinel data to the user, enabling the Earth Observation (EO) based implementations of the PUCs. This EOPEN platform service (High level Call Requirement I) offers a single point of access to multiple Sentinel hubs, allowing access to all Sentinel missions, with no geographic restrictions, high performance, and minimal delays. In the final version, ten hubs have been connected to the Umbrella hub, while a dedicated API accepts requests for metadata harvested from these sources.

### 1.8.2 Description of technological framework

The developed application connects to the APIs of multiple Sentinel hubs, searches and stores new metadata and chooses the most appropriate source from which a requested product will

be downloaded from (High level Call Requirement II). The Umbrella application PostgreSQL database frequently collects metadata of newly ingested Sentinel products, keeps up to date by deleting no longer available products and scores the different connected hubs according to their download speed.

### 1.8.3 Functionalities and performance

The API application creates a REST API via Django views module and allows users to make GET requests to it. In this request, the users are able to define their parameters (mission, product, model, date etc.) based on their needs. The Umbrella hub gives back a result set that contains metadata from the most efficient source to download from. Furthermore, an evaluation methodology has been established and introduced in the following table (Self-assessment):

Table 25: Performance indicators and scientific metrics for EO data acquisition

Indicator/Scientific metric	Value	Value achieved	Relevance to User Requirements	Comments
Number of connected hubs	Number	10	US_V_01c US_V_05a3 US_SK_03	ONDA DIAS and PEPS among the connected hubs
Mean download speed compared to Open Access Hub	Percentage of increase		US_SK_06c US_SK_07a	Ensured timeliness for time sensitive applications
Mean latency compared to Open Access Hub	Percentage of decrease		US_SK_12a US_F_01a2 US_F_03	Ensured timeliness for time sensitive applications
Access to all Sentinel missions	Boolean	Yes	US_F_04a US_F_04a3	Access to S-1, S-2, S-3 and S-5p allowing the generation of diverse datasets from soil moisture to bathymetry
Search data for a user defined area of interest	Boolean	Yes		



Search data on a specific time range	Boolean	Yes		
Number of broken links per 1000 requests	Number	43 broken links		1000 requests on a randomly selected product to the Umbrella database. Most of the broken links came from PEPS. This is because they update their online/offline DB very frequently.

#### 1.8.4 How does the technology enable PUC implementation

This Umbrella Sentinel API functions as the basic building block in all EO based PUC workflows, enabling EO data acquisition in a comprehensive manner. On top of this API, customized PUC-specific processors are built. PUCs used this API successfully (Cross-partner assessment): For the case of PUC2 where time-series of Sentinel imagery is required to capture the phenological stages of the crops, the time-series processor has been implemented by the PUC developers. This is another general process utilizing the Umbrella application to search and download Sentinel-1 and Sentinel-2 time-series, which can be parameterized by the user (start month, end month, max number of images per month etc). PUC1 uses satellite data for mapping flood extent as part of the change detection process. During the same process PUC3 identifies also via satellite images whether a road is passable or not due to flood or snow. Both modules use successfully Umbrella API for searching Sentinel-1 and Sentinel-2 products of the previous day for the desired Areas of Interest (AoI) via processes which are executed on a daily basis.

### 1.9 Social media crawlers (KR12)

#### 1.9.1 Purpose of the technological activity

The Social Media Crawling module is responsible to gather information from Twitter that serves as a non-EO data source for EOPEN. Based on suggestions by end users, proper search filters are used to crawl valuable social media posts. In the current version, after being collected, we detect whether tweets are fake, we try to detect their location if mentioned, and we analyse their images to extract visual concepts and check for nudity. In addition, we use textual information of tweets to automatically estimate whether they are relevant or not to the examined use cases. The crawling procedure and the complementary components run on CERTH's side, but all the information is stored in a database that the platform has access to. A full description of this module is given in deliverable D3.3.

### 1.9.2 Description of technological framework

In order to gain access to the global stream of Twitter data, we use Twitter API, a free option to stream real-time tweets. The retrieval options can be keywords that must be included in the posts, open user accounts and locations in form of bounding boxes. Using these search criteria, the API constantly retrieves new tweets in a JSON format and stores them in a MongoDB database. Any information derived from the analysis of the crawled tweets (e.g., extracted locations and concepts, relevancy estimation, nudity detection, etc.) is appended to the JSON before storing.

### 1.9.3 Functionalities and performance

The evaluation of this module focuses on the textual classification techniques regarding the relevance of collected tweets. The developed models are language- and use case-specific, so they have been evaluated separately. The metrics to be calculated can be seen in the following table. The automatic estimation of relevance focuses on PUC1 and PUC3, in order to filter out tweets that do not contain information about critical events of extreme weather. The implementation of such models strongly requires training datasets, i.e. ground truth that can be obtained by human annotation; a task that has been completed for both PUCs.

Table 26: Performance indicators and scientific metrics for social media crawlers

Indicator/Scientific metric	Value	Relevance to User Requirements	Comments
Precision	%	US_V_02a1	
Recall	%	US_V_02a2	
F-score	%	US_F_01b	

The best representation and classification methods for each dataset as well as the achieved metrics are presented in the following table. The detailed evaluation can be found in D3.3.

Table 27: Evaluation of different representation and classification methods for the Italian Floods and Finnish Snow dataset

Dataset	Parameter	Text input	Classifier	Precision	Recall	F-score
Italian floods (PUC1)	Pre-trained model = bert-base-multilingual-cased	Without stop words & with stemming	Linear Regression	0,66646	0,65961	0,66302
Finnish snow (PUC3)	n-gram = 2	Without stop words	Random Forest	0,7528	0,7756	0,7640

#### 1.9.4 How does the technology enable PUC implementation

As mentioned above, the social media crawling procedure uses predefined search criteria, which are tailored to the needs of each PUC. For example, for PUC 1 we search for Italian keywords regarding flooding events inside the bounding box of north-east Italy. For PUC 2 we follow accounts relevant to food security and search for Korean words that refer to agriculture. Finally, for PUC 3 we search for Finnish terms about snow coverage. As a result, every collection of tweets is directly connected to a use case. However, the automatic estimation of relevant tweets will be limited to PUCs 1 and 3, for which we have gathered the human annotation that is needed (Cross-partner assessment).

### 1.10 High Performance Computing (KR15)

#### 1.10.1 Purpose of the technological activity

The goal of this module is to integrate HPC and HPDA infrastructures into the EOPEN platform for deployment of embarrassingly-parallel tasks and data analytics applications. Specifically, Cloudify orchestrator will be implemented to enable access to both High Performance Computing (HPC) and High Performance Data Analytics (HPDA) infrastructures in a seamless and user-friendly manner.

#### 1.10.2 Functionalities and performance

The performance has been measured via different experiments and the monitoring framework ATOM, which has been deployed on the HLRS's infrastructure.

Table 28: Performance indicators and scientific metrics for concept extraction in social media

Indicator/Scientific metric	Value	Value Achieved	Relevance to User Requirements	Comments
Access to HPC	Boolean	True	US_V_01 US_V_02	Access to HPC enabled via ssh and Cloudify
Access to HPDA	Boolean	True	US_V_08d US_F_08c1 US_F_10a1 US_F_10b1 US_F_11a1	Access to HPDA via ssh is done.  And access to HPDA via Cloudify is enabled by the development and implementation of Cloudify HPDA plugin.
At least three application kernels parallelized	Number	6		A distributed random forest and a distributed k-means has been implemented by NOA on HPDA. Besides, a distributed text analysis (LDA), clustering of twitter images and a deep neural network to segment the EO image are also implemented on HPDA.  And a distributed DBSCAN for topic detection has been implemented by CERTH on HPDA
Improved application performance by at least 15%	Percentage	N/A		The deployment of ATOM has been done.  Experiments from CERTH showed that the execution time of distributed DBSCAN has decreased 95.59% on 32 cores.  Experiments showed that distributed LDA to extract

				the main topics from 100000 twitter records (1.5GB) is reduced from 1400 seconds on one core to 251 seconds on 3 nodes (36 cores and 400GB Memory per node).
At least 5 workflows ported to HPC/HPDA	Number	5		A Random Forest workflow for rice classification A Twitter Image clustering workflow A Twitter topic extraction workflow An EO image segmentation workflow A distributed DBSCAN for twitter topic detection workflow
Workload manager as a component	Boolean	True		Employed Cloudify as orchestrator for HPC/HPDA; Integrated within the EOPEN platform
Adopted state of the art data analytics frameworks	Boolean	True		State-of-the-art frameworks for data analytics (e.g. Apache Spark) and deep learning (e.g. Tensorflow) are made accessible on HLRS infrastructure via the EOPEN platform

### 1.10.3 How does the technology enable PUC implementation

For PUC1, it is required to provide faster and more effective emergency responses to extreme weather by increasing the speed of risk analysis and by improving in-field coordination of emergency response. This requirement can only be satisfied by exploiting large-scale distributed computing power provided by HPC and HPDA. EOPEN builds on state-of-the-art methods in HPC and HPDA, and as the basic building block in all EO based PUC workflows, the

extreme performance of the computing systems will be exploited by the EOPEN analytics platform. The High Performance Computing and High Performance Data Analytics (HPDA) can provide two different strands for PUC: batch job processing for static workloads as well as stream processing for live data analytics. One great example is PUC2 that deals with a long time-series of Sentinel imagery that extends over multiple years. Such applications, at the national scale, constitute big data problems and can be solely tackled by high performance computing systems - see more information in the PUC2 section.

### 1.11 PUC1 latest Implementations (by SpaceApps and Serco)

- HIRLAM precipitation forecast for municipality: this algorithm harvest the HIRLAM forecast every day and provides the expected value of cumulative precipitation in 24-36 and 48 hours (maximum value for each municipality). In the second version, developed at the end of the project, the algorithm checked also the maximum hour cumulative value of rainfall. All of those values are compared with thresholds and if any is exceeded, the system sends out an alarm via email with the name of municipality, the level of danger and the expected value.

- SpaceApps implemented in the EOPEN Platform the possibility to use GPUs from within application workflows and has used this capability to provide a generic, re-usable process that embeds the Basement simulation tool from ETH Zurich. This has permitted to drastically reduce the execution time of the hydraulic models.

- The hydraulic model was set up in two different areas, in the Piave river area, from the section of Nervesa to Zenson and in the Brenta river area, from the section of Bassano to Carturo. In those areas each river manifests a branching flow.

- The AOI of the field exercise was extended to the whole river basin district.

- Technical partners developed processes to harvest and publish .json datasets (discharge and CFD layer( that are civil protection bulletins)) and geotiff datasets.