WS2 Progress on three studies/papers, next steps and alternatives

FG3 activities

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Information Technologies Institute
Centre for Research and Technology Hellas (CERTH)

Ideas proposed by CERTH/ ITI to advance FG3 activities

✓ Paper 1 idea

Working Title: Inland surface water mask derivation via a fast and automatic thresholding approach: transferability and validation of an existing approach to areas within SCERIN

Related reference: G. Kordelas, I. Manakos, D. Aragones, R. Diaz-Delgado, J. Bustamante, "*Fast and automatic data-driven thresholding for inundation mapping with Sentinel-2 data*", 2018, Remote Sensing, 10, 910.

✓ Paper 2 idea

Working Title: Complementary ability of S-2 and Landsat for the derivation of phenology metrics: derivation from the real situation and validation in SCERIN area

Related reference: Lange, M.; Doktor, D. *Phenex: Auxiliary Functions for Phenological Data Analysis, R Package Version 1.4-5*. Available online: https://CRAN.R-project.org/package=phenex

✓ Paper 3 idea

Working Title: Canopy height derivation using S-2 bands' texture features

Related reference: Z. Petrou, I. Manakos, T. Stathaki, C. A. Mücher, M. Adamo, "*Discrimination of vegetation height categories with passive satellite sensor imagery using texture analysis*", 2015, IEEE Journal of Selected Topics in Applied Earth Observation and Remote Sensing, 8(4), 1442–1455

3 Google Docs were created and three skype meetings organized (August 2018) by CERTH to search for interested members in relation with the three paper ideas

Paper 1 discussions (1/2)

Interested members	Affiliation	Pilot Area	Data availability/ experience	Comments
P. Kenderessy, A. Halabuk	Slovak Academy of Sciences	Podunajska niizina (Danubian) lowland	Expertise focused on mapping the ephemeral water bodies in agricultural landscape. So far developed S2 composite mosaic of arable land of Podunajska niizina lowland in Slovakia. Could also offer in-situ measurements taken by UAV system or field spectrometry.	
L. Filchev	Bulgarian Academy of Sciences	area of Burgas or close to Sofia area	Application of interest flash floods. Limited ground data.	will work together with the Romanian team
P. Campbell, J. Albrechtova, L. Kupkova, P. Stych	Charles Univ.	Czech site (to be selected)	***Petya*****:** "I am working on a project for evaluating tundra in Alaska, using AVIRIS data. We could apply the approach to AVIRIS data. There is a lot of standing water in the tundra, so it is not hard to mask with AVIRIS and test the approach and the idea for validating it (using spectral data). To bring it close to SCERIN Petya may ask for spectral data for a Czech site, which Frantisec and Olga would have."	will further search for sites
M.	Univ. of Zagreb			interested to

Paper 1 discussions (2/2)

Interested members	Affiliation	Pilot Area	Data availability/ experience	Comments
A. Irimescu, D. Mihailescu	Meteo Romania	There is not regularly flooded area in Romania. One possible area on Danube Delta (where the vegetation does not allow to see the water surface), or any other open lakes in the plain or mountain areas	***Anisoara***: "In 2018, floods occurred in the central part of Romania. All products based on S1, since the S2 data were covered by clouds. There are 6 flooded areas, including the Danube Delta. Many products are based on MODIS data since it was an historical flood event. We are not allowed to use any more (will ask for permission) the data taken by International Disaster Charter. There are ground data (taken in 2005 or 2006) but can not guarantee to find them. Since S2 launch two flood events occurred in Romania: in 2016 and 2018, but S2 could not be used to monitor the floods because of the clouds. There are old events as mentioned above, but I have to look for the raw data."	will work together for the Romanian case
N. M. Daniel	Brasov University			
Volodymyr Starodubtsev	Ukraine			

Paper 1 wrap-up

- **Possible pilot areas.** Danube Lowland (Slovakia), area of Burgas or a close to Sofia area, a Czech site, a Danube area (Romania, close to borders with Bulgaria)

- **Ground data.** Limited access to available ground data. Need to intensify efforts.

- **Satellite data.** If we go for floods, Sentinel-2 data are probably inappropriate because of clouds. Need to discuss further on the topic/ area of interest before and choose the appropriate satellite data and method (e.g. fusion of multi-source data is also a possibility).

Steps forward (technical)

- How many pilot sites are we going to select finally? Describe their main characteristics (e.g. flat areas, free-fluctuating-through-time boundary).
- Find out ground data (preferably taken in dates within operational time of S-2 or even, in case of cloudy areas, Landsat data).
- Check the environmental or socioeconomic interest of sites to maximize impact.
- Work allocation and assignments.
- Timeline

Workload	Assignments	Timeline
Pilot site(s) selection & description		
Ground data		
Literature review/ State-of-the-art analysis		
Satellite data retrieval and processing		
Statistics		
Discussion		

Steps forward (authorship)

Chapter	Assignments	Timeline
Introduction		
Materials and Methods		
Results		
Discussion		
Conclusions		

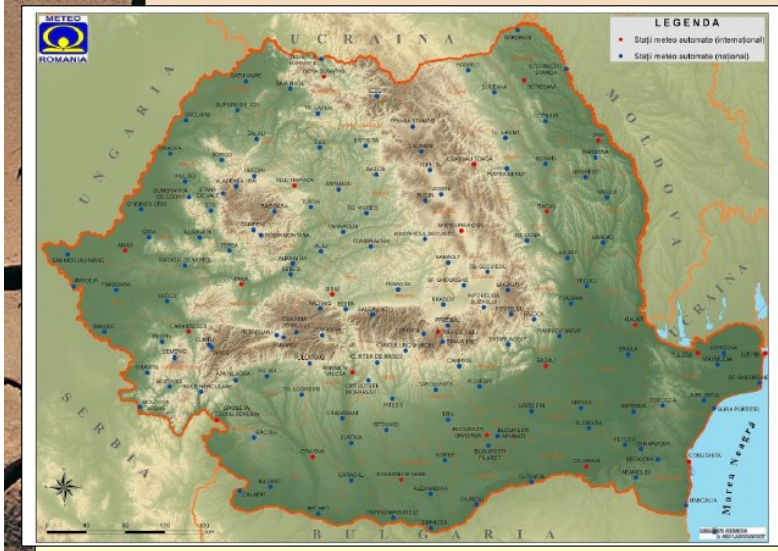
Paper 2 discussions (1/2)

Interested members	Affiliation	Data availability/ Experience/ Comments
A. Halabuk & team	Slovak Academy of Sciences	Experience in calculating phenology metrics & simple thresholding for the detection of cutting in grasslands using MODIS time series (http://www.mdpi.com/2072-4292/7/5/6107). Increasing spatial resolution would be of added value. Discuss possible specific research objectives (e.g. detection of grasslands (for creation of grassland mask) and identification of grassland management practices and some crucial driving processes (e.g. spring flooding, overgrowing or intensive pasturing).
I. Manakos	Centre for Research and Technology Hellas	CERTH modules for the calculation of phenology metrics may serve all processes as a common basis. Also following the finalization of the ideas and concept, CERTH will seek inland what may be provided in terms of ground data.
A. Irimescu	Meteo Romania	***Anisoara-Mihai***: Network across country for data takes about phenology metrics (around 55 meteo stations). ***Agriculture phenology:*** phenology parameters for main crops (corn/maize & winter wheat) available in the plain areas at country level; no field polygons available; more than 5 years data available (but there is no S-2 data available); a protocol available; no digital format for data; only one measurement point for each crop type [there are 55 points/crop type for the entire country; the crops are: corn/maize and winter wheat; we know the number of points (one point for each station); we know the date the measurements are done (the date is recorded); the database is at least 5 years old]. ***Forest phenology:*** some phenology parameters exist for the forest in the Brasov County; 1 or 2 years archive available; one student can be involved for future measurements
N. M. Daniel	Brasov University	

www. meteoromania.ro
NMA – Surface Observation Network

Synoptic and climatological network – 160 automatic stations

Agrometeorological network – 55 automatic stations



- 7 Regional Meteorological Centres
- 160 weather meteorological stations
- 55 weather stations integrating a special program of agrometeorological measurements – soil moisture and phenological data (winter wheat, maize, sunflower, rape, fruit trees and vineyards.

Paper 2 discussions (2/2)

Interested members	Affiliation	Data availability/ Experience/ Comments
P. Campbell, L. Kupkova, P. Stych, J. Albrechtova	Charles University	According to **Jana and Lucie**, there exist individual efforts and possibilities for which we will be informed with an e-mail of theirs, following an international search they will perform. ***Lucie**:* "Right now we deal with phenology in tundra area in the Krkonoše Mts., Czechia. We will have also field data and some field spectra of selected species/ communities." ***Jana**:* "Phenological data (green up and senescence for sure) gathered by children in the framework of the program GLOBE, may be used. Data are archived centrally and available for scientific purposes (https://www.globe.gov/de/web/european-phenology-campaign). The data are not so often used and any use for scientific research is very welcome. I have been collaborating with GLOBE program for many years, contributed to creation of other protocols on carbon cycle (contact person Jana). Extra comment: GLOBE Europe is lead by Czech GLOBE Office in TEREZA - Jana will retrieve the info and update."
L. Filchev	Bulgarian Academy of Sciences	Existing network (similar to Romania) but data are for sale only. **Lachezar** is aware of a team that gathers data for smaller areas. Also he has some acquaintances in Montenegro and Turkey, where ground data may exist and be utilized for the purpose of our common work. Lachezar will inform us about what may be achieved in these cases. Lachezar pointed out that GLOBE is not performing equally well in the SEE countries but at least for Czech republic it is a good source. In some other SEE countries is also nice resource but it strongly depends on schools involvement and the coordination.

Paper 2 wrap-up

- **Possible pilot areas.** Maybe go for the Danube site considered for Paper 1 as well.

- **Possible application areas.** Monitoring of agricultural cultivations or detection of grasslands and identification of grassland management practices/ driving processes or monitoring of a forest area.

- **Ground data.** Extensive data available for the main crops from the monitoring network in Romania.

- **Other data.** Maybe use data gathered in the framework of the program GLOBE (contact person P. Campbell).

Steps forward (technical)

- Decide whether we go for agricultural cultivations or else (e.g. grasslands).
- How many pilot sites within SCERIN we will finally select? Describe their main characteristics.
- Reference data (preferably taken in dates within operational time of S-2 or even, in case of cloudy areas, Landsat data).
- Check the environmental or socioeconomic interest of sites to maximize impact.
- Work allocation and assignments.
- Timeline

Workload	Assignments	Timeline
Pilot site(s) selection & description		
Ground data		
Literature review/ State-of-the-art analysis		
Satellite data retrieval and processing		
Statistics		
Discussion		

Steps forward (authorship)

Chapter	Assignments	Timeline
Introduction		
Materials and Methods		
Results		
Discussion		
Conclusions		

Paper 3 discussions

Interested members	Affiliation	Data availability/ Experience/ Comments
O. Brovkina	Czech Globe	***Olga***: Test the approach to forest site in the Czech Republic (Krkonoše area). The site has about 50 forest plots (circle, area of the plot is 500 m2) with prevalence of spuce and beech. Field measurements of forest stand height are available for validation and testing the suggested approach. In addition, Olga reported about having time-series airborne lidar and HS data 2010, 2013, 2015 on the Tesinske Beskydy site, and a person who could work with them, provided that the method is made understood. **Lucie & Premek** reported having Lidar data for habitats in Krkonoše area (5 points per m2) for 2012. Similar situation is assumed for Šumava forest. At the same time, they can make available APEX HS airborne data, out of which we could simulate S2 ones or also work with them directly. Issue is the person to find to work with, with some programming skills. In a longer term this person could be found or they could cooperate with a third party person from another Entity of this team to work upon these data.
P. Campbell, J. Albrechtova, L. Kupkova, P. Stych	Charles University	
L. Filchev	Bulgarian Academy of Sciences	Will send a summary of forest stands data takes in Bulgaria and then may find out whether a case may be set up there. Issue is to find a person to work on the data.
M. Gašparović	University of Zagreb	interested to contribute
A. Irimescu	Meteo Romania	**Mihai** reported about 1ha plots in Romania with height information and 5cm spatial resolution data takes from a drone. Mihai shall send more info

Paper 3 wrap-up

- **Possible pilot areas.** Forest site in the Czech Republic (Krkonoše or the Sumava forest?) and/or another Romanian site.

- **Reference data.** Available airborne datasets and field measurements.

- **Human resources:** Issue to find a person with some programming skills as well to work with data.

Steps forward (technical)

- How many pilot sites are we going to select finally? Describe their main characteristics.
- Reference data (dates/ resolution)
- Check the environmental or socioeconomic interest of sites to maximize impact.
- Work allocation and assignments
- Timeline

Workload	Assignments	Timeline
Pilot site(s) selection & description		
Ground/ airborne data		
Literature review/ State-of-the-art analysis		
Satellite data retrieval and processing		
Statistics		
Discussion		

Steps forward (authorship)

Chapter	Assignments	Timeline
Introduction		
Materials and Methods		
Results		
Discussion		
Conclusions		

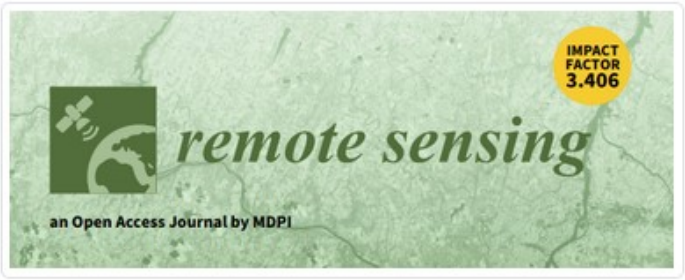
Alternative ideas

- EODESM application in sites of SCERIN **(Annex I)**
- Analysis Ready Data development on the basis of Open Data Cube format **(Annex II)**
- Aesthetic vision as a quality status Indicator for Protected Areas within SCERIN **(Annex III)**
- Continuation of the validation of continental land cover layers

Open special issues for submissions (1/2)

Special Issue "Remote Sensing in Ecosystem Modelling"

https://www.mdpi.com/journal/remotesensing/special_issues/ecosystem_modelling_RS



Deadline: 30 September 2020

Topics of interest

- direct comparisons of EO with in-situ data
- assessment of the added value of EO to ecosystem models
- interoperability topics, for example spatial and temporal scale issues, derived from the incorporation of EO in ecosystem models
- uncertainty propagation of EO-derived inputs in ecosystem models
- benefits by the EO assimilation and side-effects in the designed processing chains
- adjustments in ecosystem models to better integrate EO inputs
- the new capacity being developed and explored by the installation and operation of the Data and Information Access Services (DIASs)

Open special issues for submissions (2/2)

Special Issue "Monitoring Land Cover Change: Towards Sustainability"

https://www.mdpi.com/journal/land/special_issues/EARSeL

Deadline: 31 December 2019

Topics of interest

- New instruments and data processing methods
- Geological, hydrological, land and ice applications
- Climate and climate change
- Agriculture and Forestry
- Urban and Thermal remote sensing
- Use of LIDAR and RADAR data for various applications
- Applications employing UAVs and UASs
- Synergy of remote sensing technologies for land-use change monitoring-
- The role of earth observations within the Water–Energy–Food nexus
- Social and behavioral aspects of land use supported by remote sensing observations
- Advances and outlook in the processing and analysis of remotely sensed data

With a smile and a vision

Thank you
for your attention

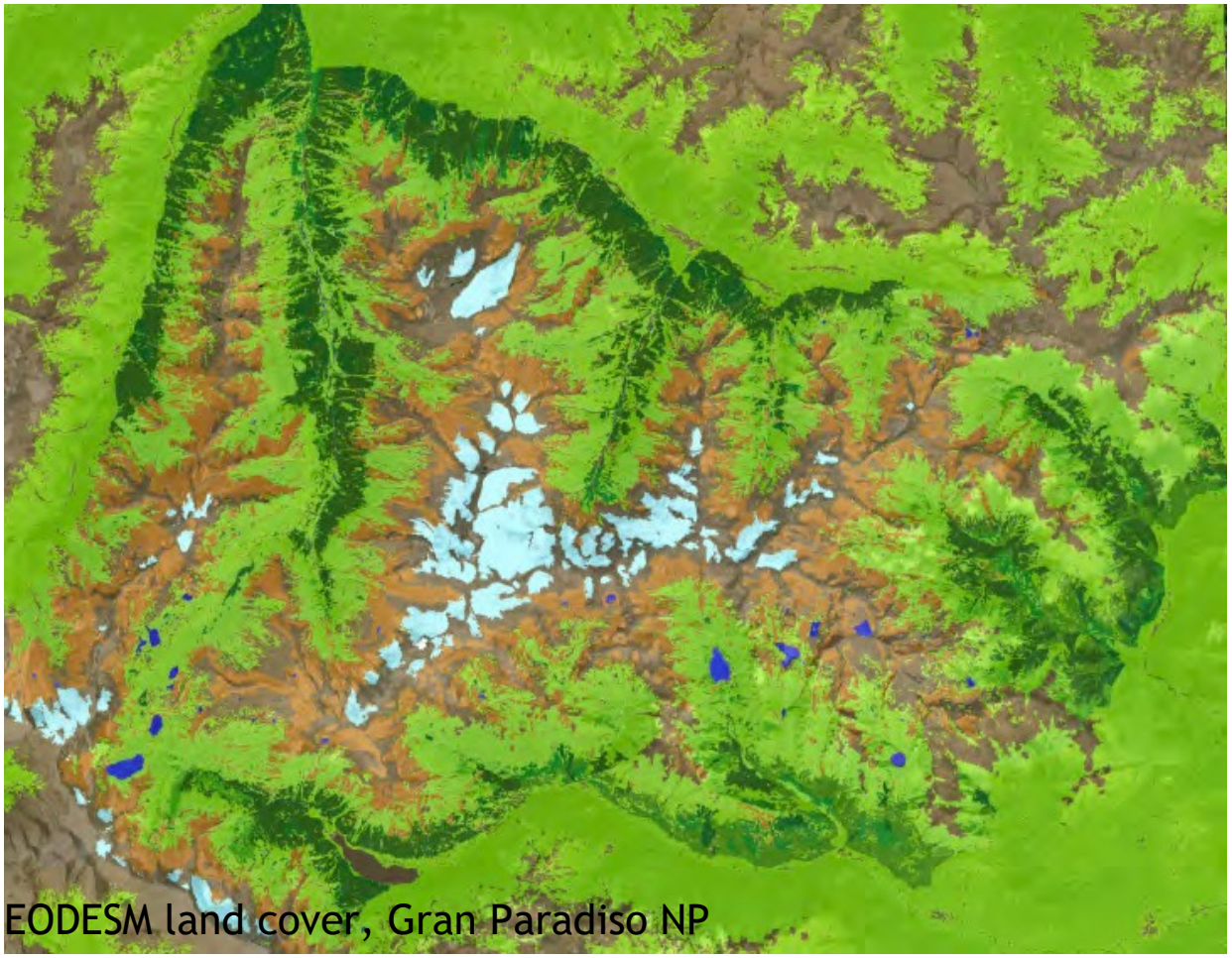
At your disposal
for questions/ clarifications

http://www.eoservices.iti.gr/

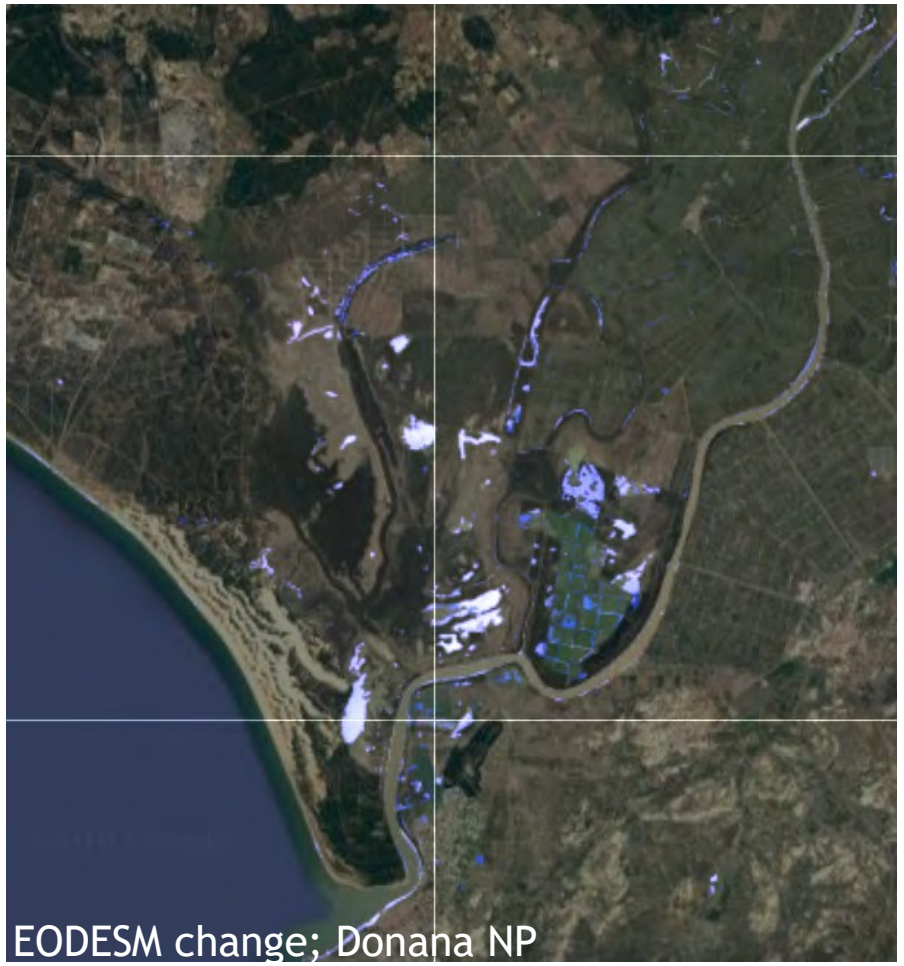
imanakos@iti.gr

Annex I

The Earth Observation Data for Ecosystem Monitoring (EODESM)



EODESM land cover, Gran Paradiso NP



EODESM change; Donana NP

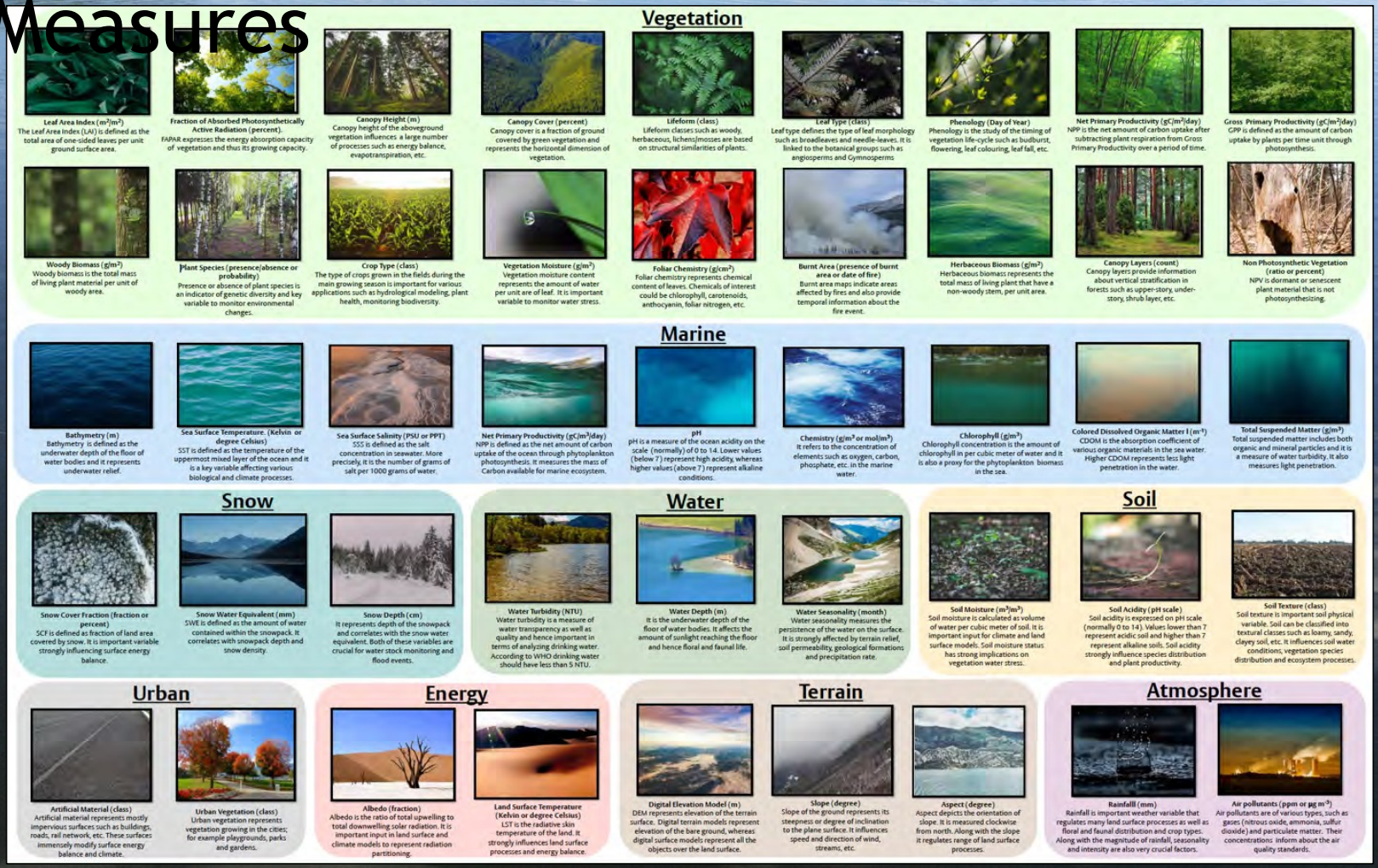
This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No

ECOPOTENTIAL: improving future ecosystem benefits through earth observations

Challenge: Standardized Classification and Land Cover Change

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 641762

Environmental Variables with Unit Measures



This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 641762

Environmental Variables with Unit Measures

WOODY BIOMASS

Woody biomass is defined as the total mass of living plant material per woody area. Aboveground biomass plays a key role in the carbon cycle and climate processes. It can be measured through direct or indirect in situ sampling (see here) or estimated through satellite/airborne sensors. Typically, biomass in woody areas ranges between 0 (poorly...

READ MORE

HERBACEOUS BIOMASS

Herbaceous biomass is defined as the total mass of living plants, that have a non-woody stem, per area. Aboveground biomass plays a key role in the carbon cycle and climate processes and is of major importance in various field such as agronomy, biodiversity, climate, energy production, etc. Herbaceous biomass can be measured through destructive or...

READ MORE

LEAF AREA INDEX

The Leaf Area Index (LAI) is defined as the total area of on-sided leaves per ground surface area. It is a fundamental property of the plant canopy as it plays a key role in the absorption of solar radiation, through photosynthesis, and thus on the vegetation growth. LAI can be estimated by ground measurements...

READ MORE

ALBEDO

Albedo is defined as the ratio of total upwelling to total downwelling solar radiation at the surface. It represents the energy balance at the soil-vegetation-atmosphere interface. The albedo allows to quantify the part of the energy that is absorbed by Earth surface and then transformed to heat. The albedo is a unitless variable ranging from...

READ MORE

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Accessing Environmental Variables

CANOPY COVER

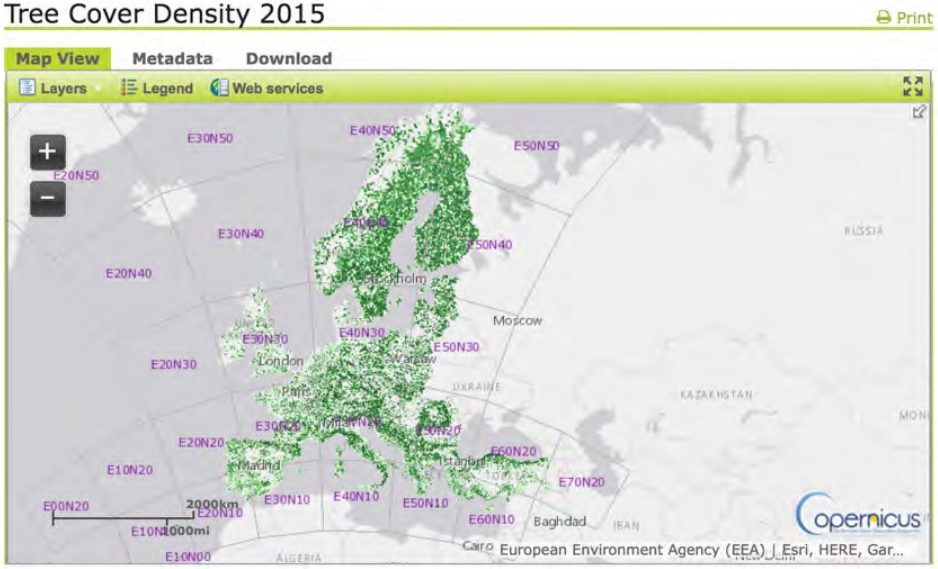
The canopy cover is defined as the fraction of ground covered by green vegetation. This variable represents the horizontal dimension of the vegetation and allows to quantify its spatial extent. Canopy cover is an essential variable as vegetation extent strongly influences the water, energy and matter fluxes of land surface. Canopy cover is notably very...

READ MORE

- COPERNICUS BioPAR GEOv1
- COPERNICUS BioPAR GEOv2
- COPERNICUS PROBA-V GEOV3
- USGS Landsat 7 ETM+ Global Tree Canopy Cover (circa 2010)
- NASA Landsat 5 TM / ETM+ Global Tree Canopy Cover
- NASA MODIS MOD44B VCF
- CYCLOPES FCOVER
- COPERNICUS HRL Tree Cover Density

PROTECTED AREAS from SPACE
ECOPotential view

Tree Cover Density 2015



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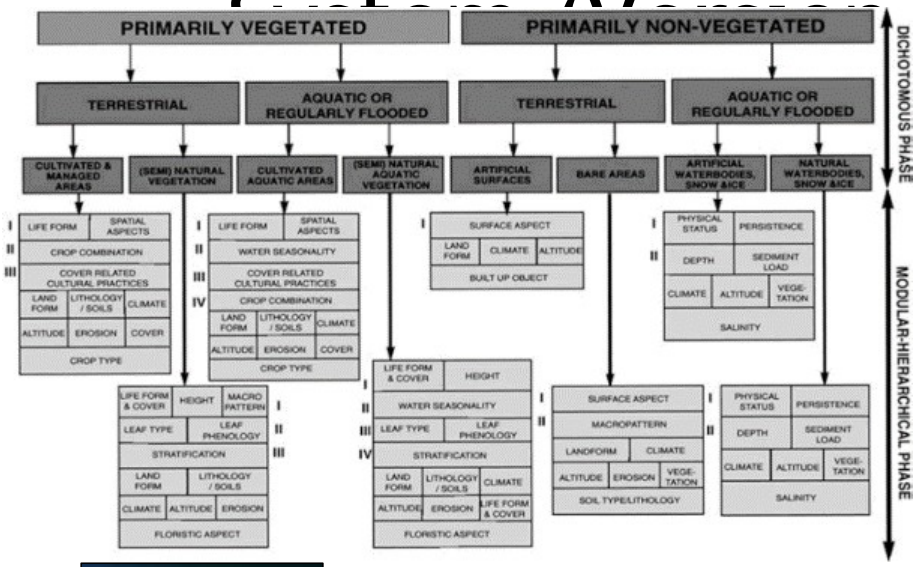
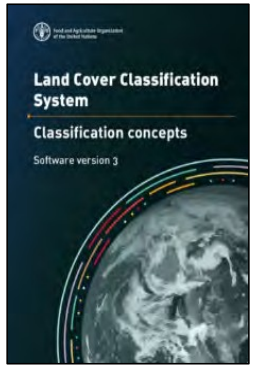
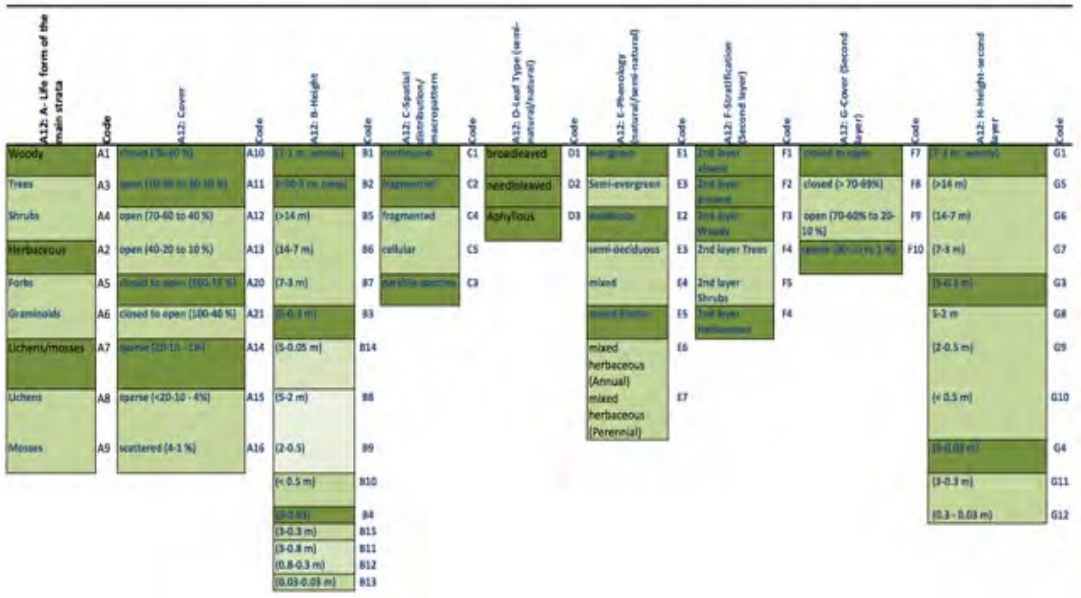
The Food and Agriculture Organisation (FAO) Land Cover Classification System (Version 2







A3.A10.B2.C1.D1.E1.F1.F9.G7

Trees closed canopy (>70-60 %) tall (14-30 m) continuous broadleaved evergreen with 2nd layer supporting open canopy 7-3 m in height.

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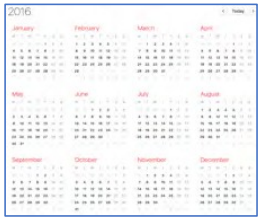
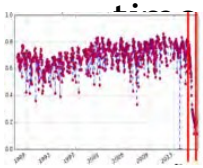
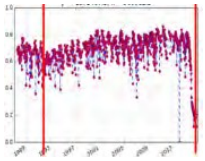
EODES

Independence of scale



Adaptable in





Built from

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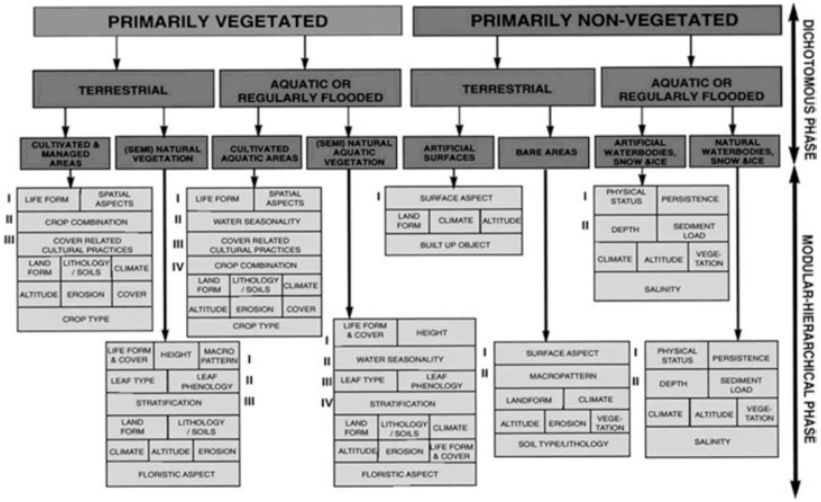
Integrating Environmental Variables into Land Cover Change Classifications

Land Cover Classifications Generated from Environmental Variables according to the Food and Agriculture Organization (FAO) Land Cover Classification System (LCCS) and derived from **Environmental Variables** with unit quantities (e.g., m, %, days)



Trees closed canopy (>70-60 %) tall (14-30 m) continuous needle-leaved evergreen with 2nd layer supporting open canopy 7-3 m in height; Above Ground Biomass of 210 Mg ha^{-1}; dominated by *Pinus sylvestris*)

Trees closed canopy (< 20 %) tall (14-30 m) continuous needle-leaved evergreen (Above Ground Biomass of 157 Mg ha^{-1}; dominated by *Pinus sylvestris (e.g. following wildfires)*

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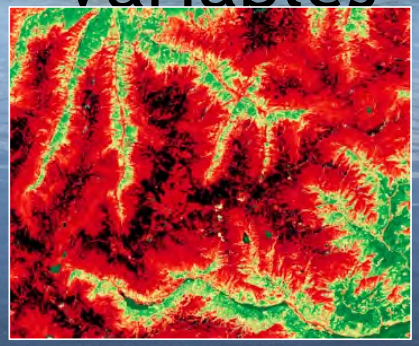
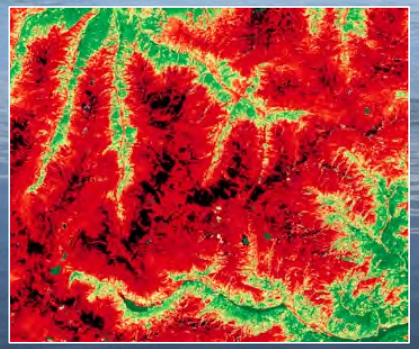
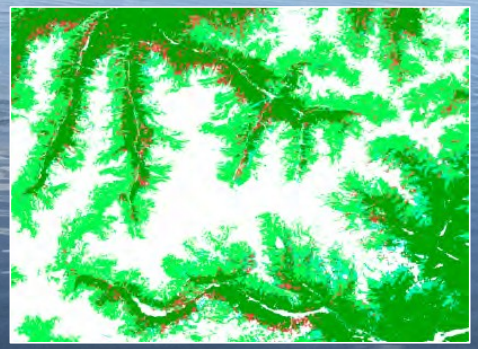
Detection of Change Through Integration of Environmental Variables



Tree cover density (2000)



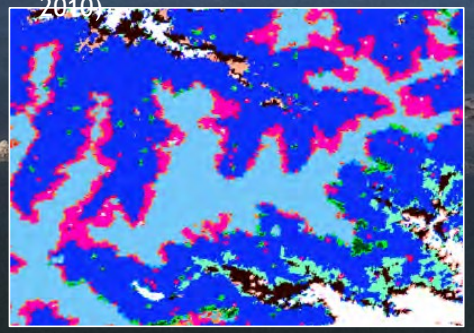
Tree cover density (2010)



Tree cover density changes (2000-2010)

Snow hydroperiod (2015/16)

Snow hydroperiod (2016/17)



Snow hydroperiod change (2016/17)

2015/16

Change based on Evidence (Flooding)
2016/17

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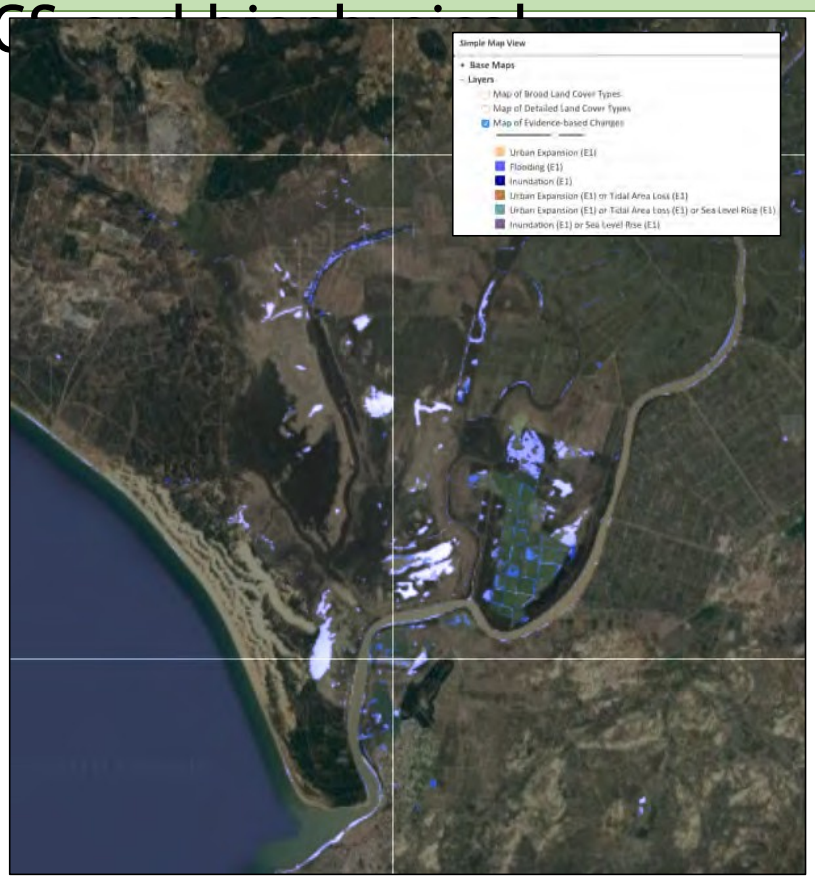
Automated Detection of Change with Alerts

(Based on Weighted Evidence of LCC change)

Natural Vegetation	Agriculture	Urban	Water	Background
Deforestation	Herbicide Spraying	Road Abandonment	Flooding	Lava Flows
Degradation	Burning	Greening	Inundation	Sedimentation
SelectLogging	Cutting	Browning	DryingEvent	Erosion
Defoliation	Grazing	Planning	Long Term Drying	Dune Change
Thinning	Growth	Urban Densification	Net Snow Accumulation	
Dieback	Stubble Formation	Urban Renewal	Net Snow Loss	
Growth	Agri. Expansion	Waste Dumps/Extraction	SnowFall	
Thickening	Agri. WaterSupp	Comm. Installation	SnowMelt	
Encroachment	Agri. TimeFactor	Comm. Abandonment	Waterlogging	
Abandonment	Tillage	Rail Conversion	Water OutBurst	
Hedgerow removal	Pasture Degradation	Rail Construction	Dam Creation	
	Pasture Replanting	Urban Expansion	Land Drainage	
	Crop Change	Road Conversion	Freezing	
	Crop Growth	Road Construction	Thawing	
	Crop Sequence change	Road Improvement	Glacial Flow	
	Agri. Homogenisation	Industrialisation	Sea Level Rise	
	Agri. Division	Infilling/levelling	Water Pollution	
	Plantations		Tida lLoss	
	Plantation Growth			
	Grass Fertilization			
	Orchard planting			
	Slurry or sediment spreading			
	Liming			



Layers used for evidence-based detection of change (deforestation)
Level 3 Change: Chg_L3
Level 4 Change: Chg_L4_Lifeform, Chg_L4_MCanopyco,
Changes in Environmental Variables: P1AvPlantspD, P1AvAGB, P1AvCanopyco, P1AvCanopyht, P2AvPlantspD, P2AvAGB, P2AvCanopyco, P2AvCanopyht

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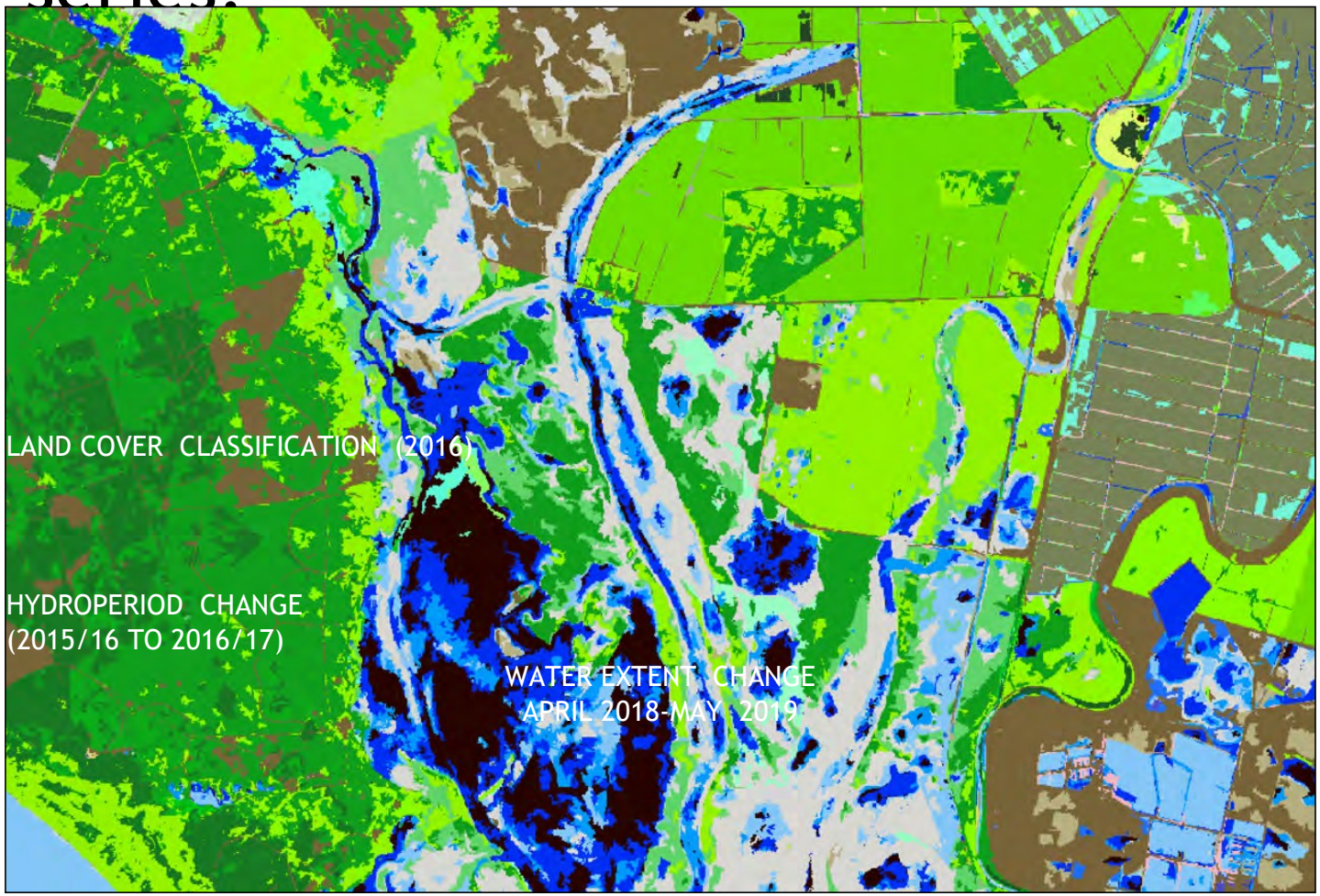
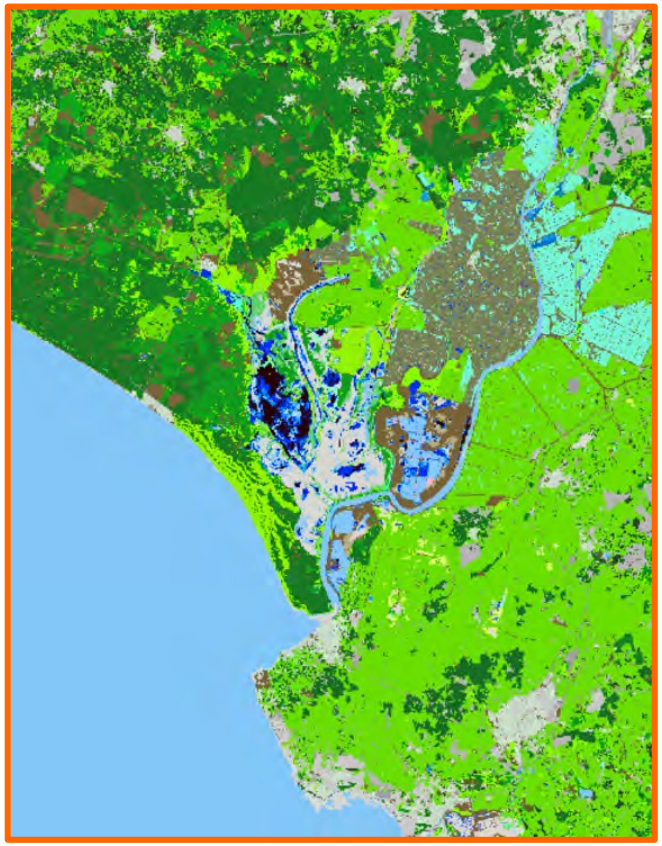
Comprehensive Detection of Change Over Multiple Time-series.



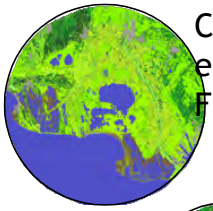


EXAMPLE FROM DONANA NATIONAL PARK, SPAIN, USING SENTINEL-2

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 641762

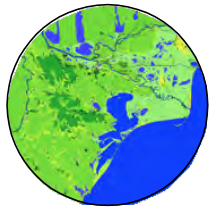
Earth Observation Data for Ecosystem Monitoring (EODESM)

- Consistent classification of land covers for any site globally using the FAO LCCS-2 taxonomy.
- Inclusion of biophysical layers (thematic and continuous), including time-series (e.g., hydroperiod, snow cover, phenology), both internal and external to the classification.
- Detection of change in LCCS codes and environmental variables
- Evidence-based approach to change detection.
- Attribution of change to a potential cause and consequence.
- Capacity to translate LCCS to Habitat and other taxonomies.

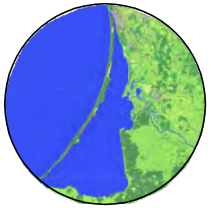


Camargue France

Donana Spain

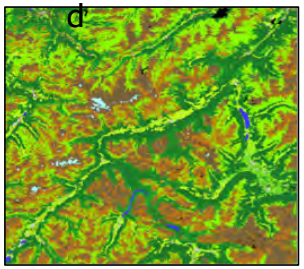


Danube Romania / Ukraine

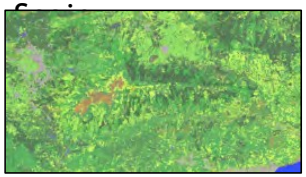


Curonian Lagoon Lithuania

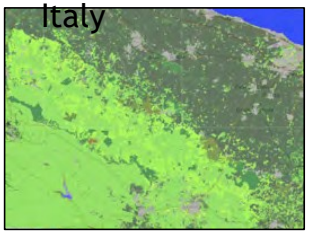
Swiss NP, Switzerland

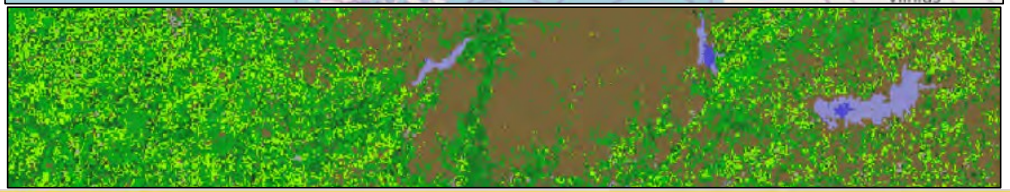


Sierra Nevada,



Murgia Alta, Italy





Peneda Geres, Portugal

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 641762

Earth Observation Data for Ecosystem Monitoring (EODESM)

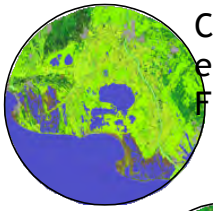
- Selection of any data layers into the classification, no matter how derived and including knowledge.
- Inclusion of local to global layers

- Applicable at any spatial scale
- Facilitates comparison between any two time-separated periods and considers dense time series.

- Can be replicated with in situ data and has dedicated Mobile App
- Able to ingest all forms of earth observation and other geographical (spatial) data.

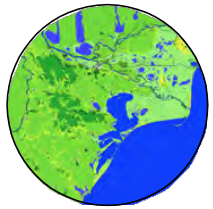
- Simple to use, understand and implement

- Is informative, utilizes ecological knowledge, and allows for targeted applications.
- Open source software (Python, RSGISLib, KEA, EODESM, ARCSI)

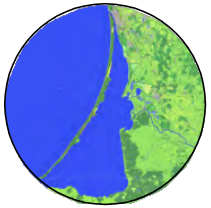


Camargue France

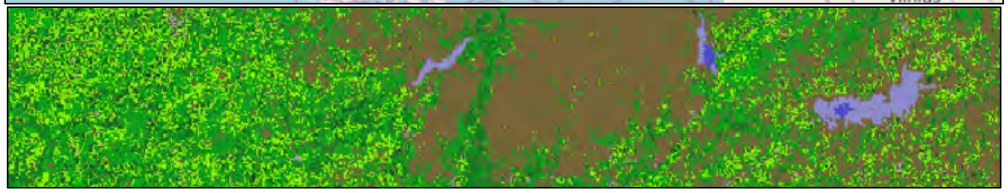
Donana Spain



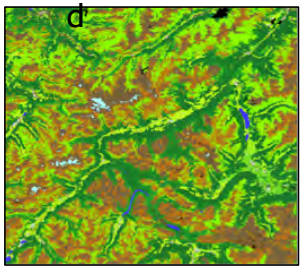
Danube Romania / Ukraine



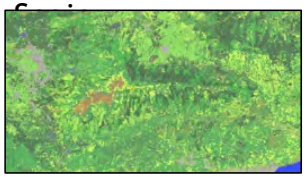
Curonian Lagoon Lithuania



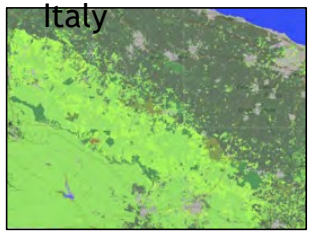
Swiss NP, Switzerland



Sierra Nevada, Spain



Murgia Alta, Italy



Peneda Geres, Portugal

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EODESM within Ecopotential's Virtual Laboratory

https://vlab.geodab.eu

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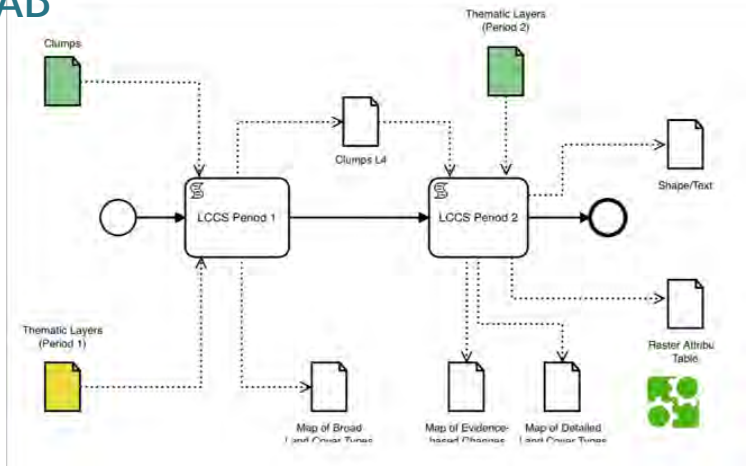
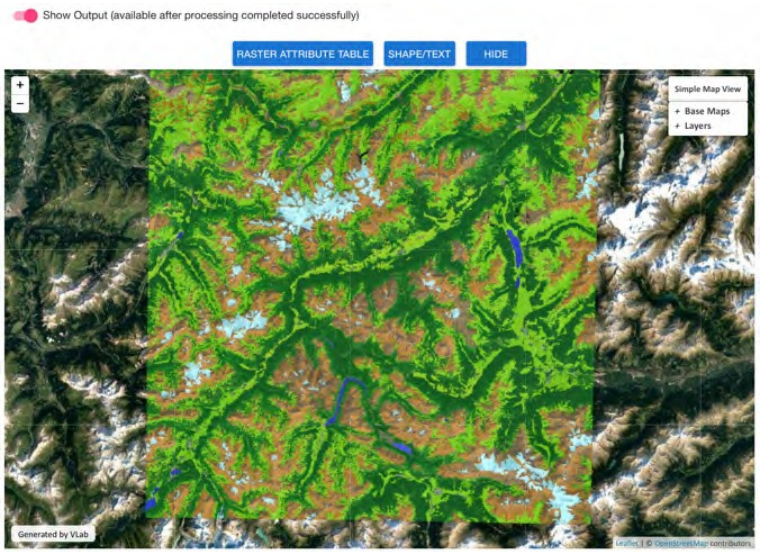
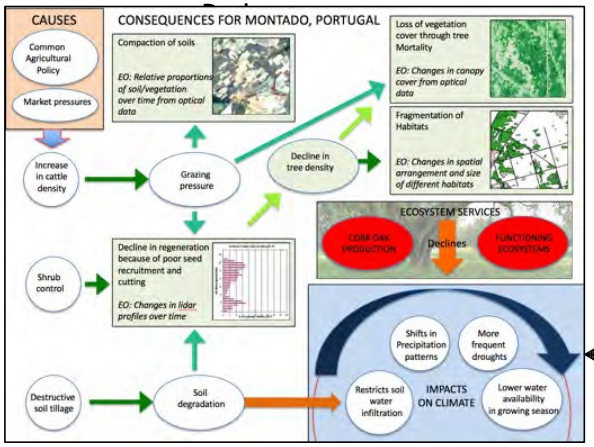
THE ECOPOTENTIAL VIRTUAL LAB





LCCS Level 4 Classification (P1) Swiss National



Input S

	P1Lifeform	P1PLlifeform_0	P1PLlifeform_3	P1PLlifeform_4	P1LeafType	P1PLeafType_0	P1PLeafType_1
0	-1	0.00	0.00	0.00	-1	0.00	0.00
1	3	0.00	0.92	0.08	1	0.25	0.75
2	4	0.02	0.48	0.50	1	0.28	0.72

Environmental Variables

		P1AvAGB	P1AvChla	P1AvNitrogen	P1AvLignin	P1AvVegmos
32.39	4.62	0.00	0.00	0.00	0.00	0.00
41.08	5.54	0.00	0.00	0.00	0.00	0.00
26.81	5.57	0.00	0.00	0.00	0.00	0.00

LCCS Classification (P1)

P1_LCCS	P1_LCCSdescription
A24.A3.A20_A21.B2_B6.D1.E1	Broadleaved PhenEvergreen Closed to Open (40-100%) Medium Trees on Flooded land
A24.A3.A20_A21.B2_B6.D1.E1	Broadleaved PhenEvergreen Closed to Open (40-100%) Medium Trees on Flooded land
A24.A3.A20_A21.B2_B6.D1.E1	Broadleaved PhenEvergreen Closed to Open (40-100%) Medium Trees on Flooded land
A24.A3.A20_A21.B2_B6.D1.E1	Broadleaved PhenEvergreen Closed to Open (40-100%) Medium Trees on Flooded land

LCCS Classification (P2)

P2_LCCS	P2_LCCSdescription
A24.A3.A20_A21.B2_B7.D1	Broadleaved Closed to Open (40-100%) Low Trees on Flooded land
A12.A3.A20_A21.B10.D1	Broadleaved Closed to Open (40-100%) Trees
B28.A1.B2	Natural Non-Perennial waterbodies
B28.A1.B2	Natural Non-Perennial waterbodies

Changes in LCCS classes (P1 and P2)

Chg_L3	Chg_L4_Lifeform	Chg_L4_MCanopy	Chg_L4_MCanopyht
NAV-NAV	Remained as...	NA	Trees (14-7 m)(B6)to Shrubs (< 0.5 m)(B10)
NAV-NAV	Remained as...	NA	Shrubs (5-3 m)(B8) to Forbs and/or graminoids (3-0.8 ...
NS-NTV	NA	NA	NA
NTV-NTV	Remained as...	NA	Trees (7-3 m)(B7) to Shrubs (< 0.5 m)(B10)

Evidence-based change alerts

TidalLoss	SeaLevelRise	Sedimentation	Erosion
Tidal Area Loss (E1)	Sea Level Rise (E1)	NA	NA
Tidal Area Loss (E1)	Sea Level Rise (E1)	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA

0 Selected

- Causes and consequences
- Movement of materials and gases
- Implications for policy, society & economy

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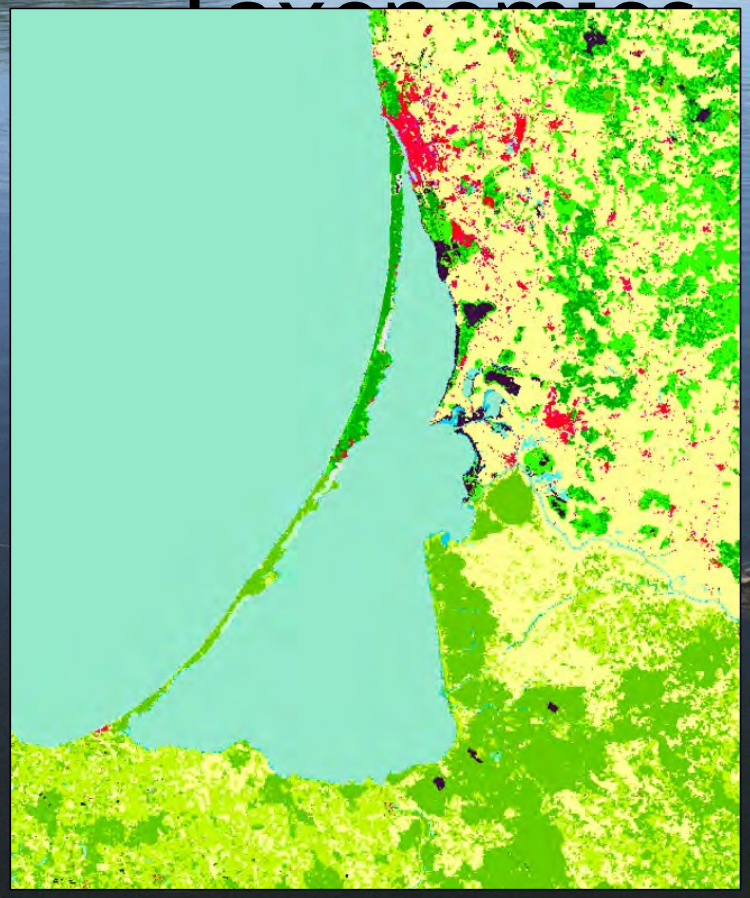
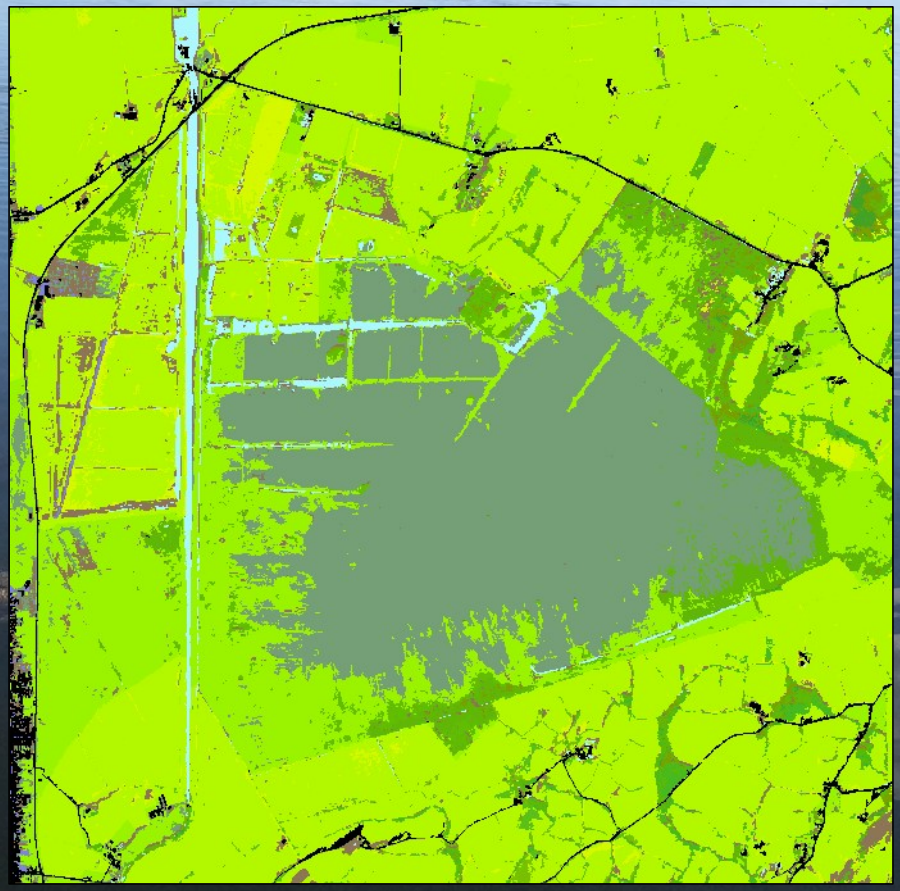
Translation to Other Taxonomies



To Corine Land Cover



To General Habitat Categories

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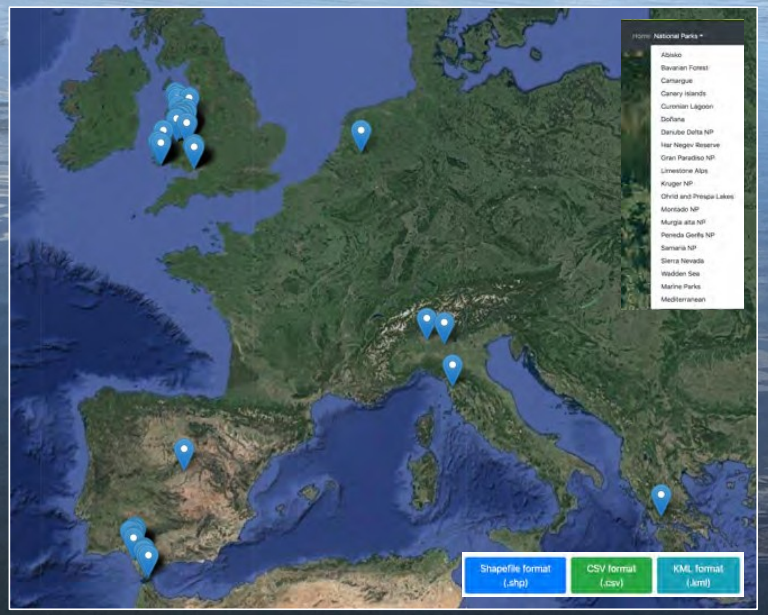
Near Real Time Collection and Delivery of Ground Data

Demonstration of near real time data collection



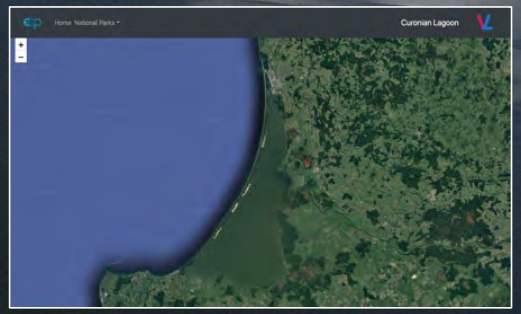
Implementation with easy data access (including for protected areas)

Donana NP

Gran Paradiso National Park

Kruger National Park

Ohrid and Prespa lakes



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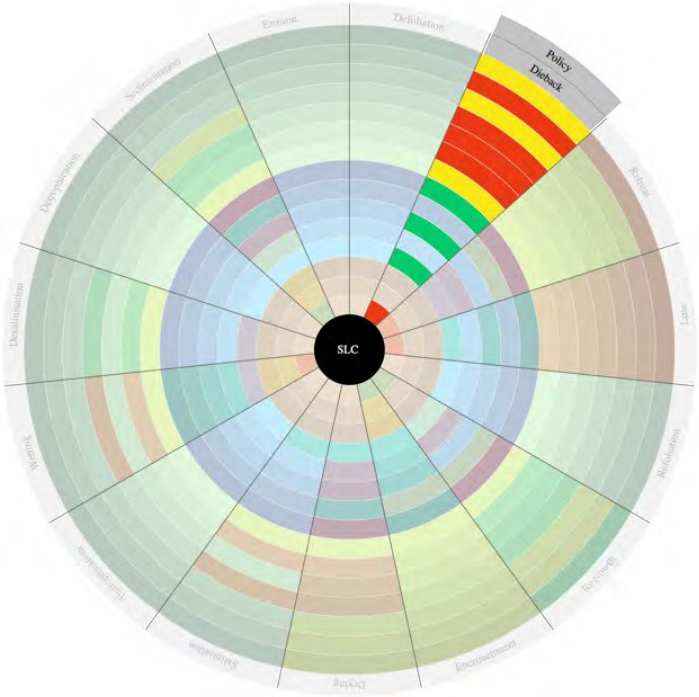
Policy, Planning and Future Change

UN Sustainable Development Goals

Change in LCCS Level 3 Categories

PERIOD 1

PERIOD 2	CTV	NTV	CAV	NAV	AS	BS	AW	NW
CTV	Stable	Agricultural expansion	Agriculture drainage	Wetland drainage	Withdrawal of settlements	Agriculture expansion	Wetland drainage	Wetland drainage
NTV	Afforestation	Stable	Afforestation/ Abandoment	Wetland loss	Withdrawal of settlements	Vegetation establishment	Wetland drainage	Vegetation encroachment
CAV	Change in agriculture	Agricultural expansion	Stable	Wetland establishment	Withdrawal of settlements	Vegetation establishment	Vegetation establishment	Wetland drainage
NAV	Afforestation	Inundation	Vegetation establishment	Stable	Withdrawal of settlements	Vegetation establishment	Vegetation establishment	Vegetation encroachment
AS	Urban expansion	Urban expansion	Urban expansion	Urban expansion	Stable	Urban expansion	Urban expansion	Urban expansion
BS	Vegetation loss	Vegetation loss	Vegetation loss	Vegetation loss	Withdrawal of settlements	Stable	Wetland drainage	Wetland drainage
AW	Inundation	Inundation	Inundation	Inundation	Inundation	Inundation	Stable	Urban expansion
NW	Inundation	Inundation	Inundation	Inundation	Inundation	Inundation	Wetland establishment	Stable

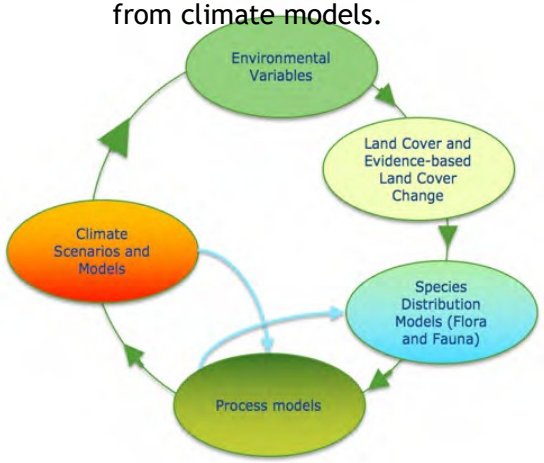


Future Predictions

•Environmental variables can be used as direct input to species distribution models.

•Ability to predict future land cover using environmental variables predicted from process models (e.g., plant growth, hydrological).

•Changes in environmental variables (e.g., plant growth, sea level rise, glacial processes) can be predicted from climate models.



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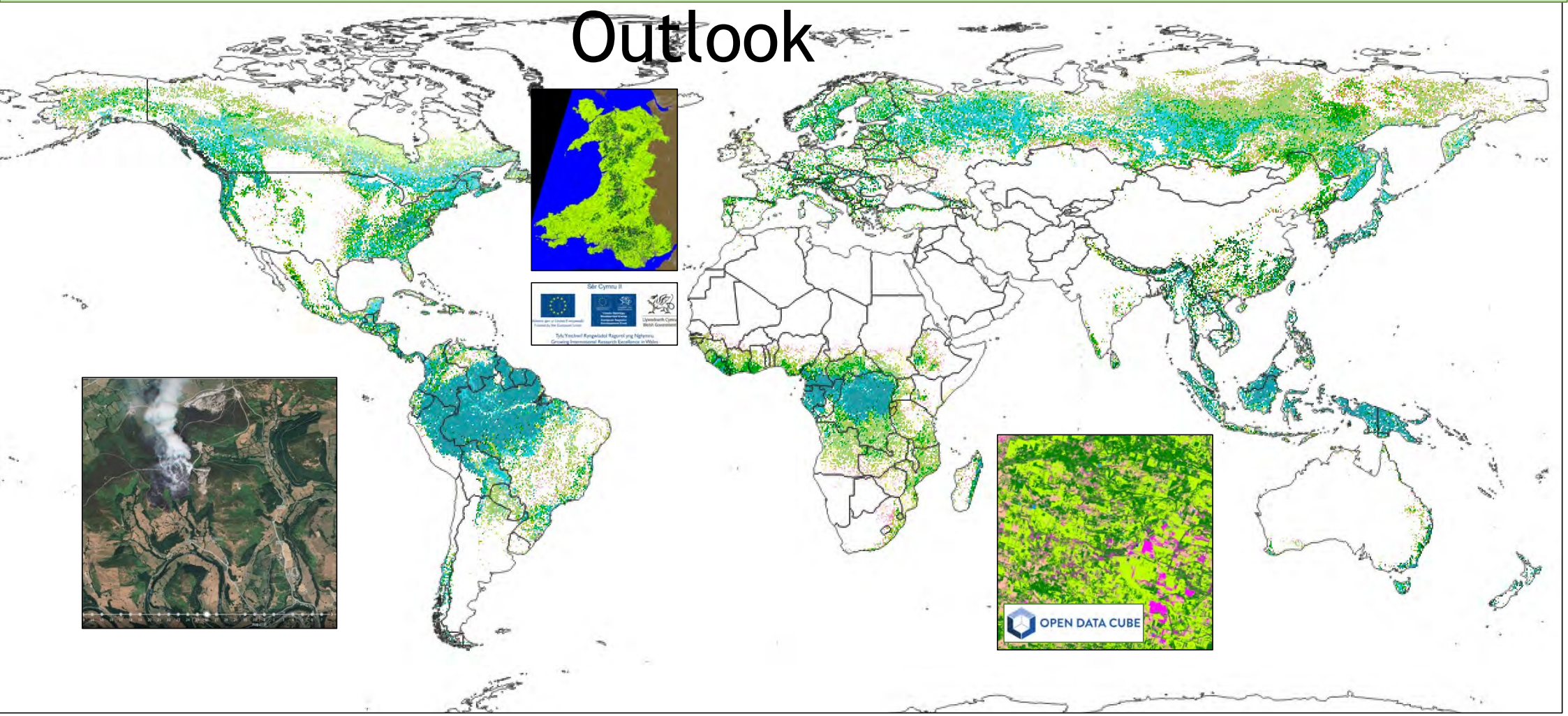
Future Outlook



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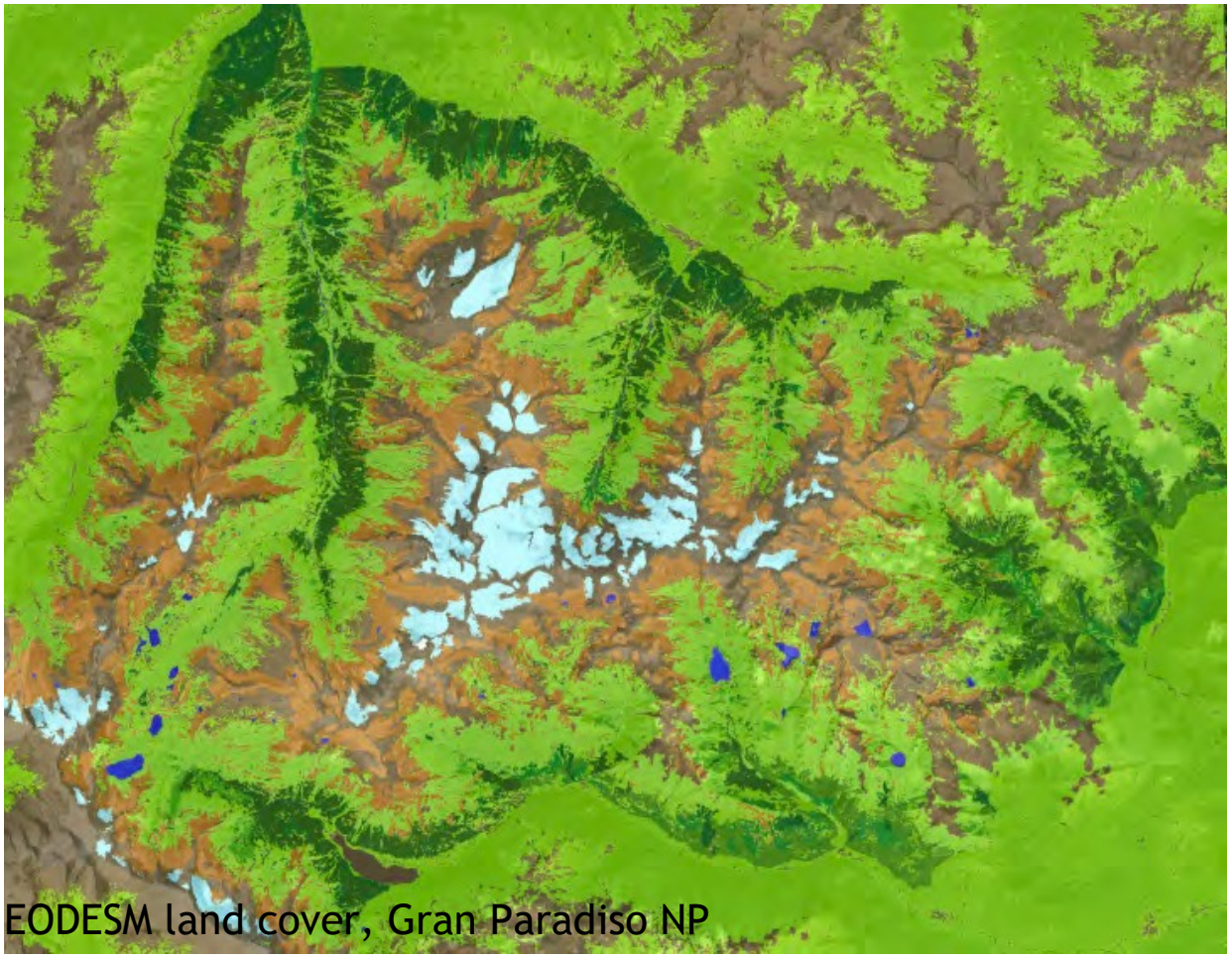
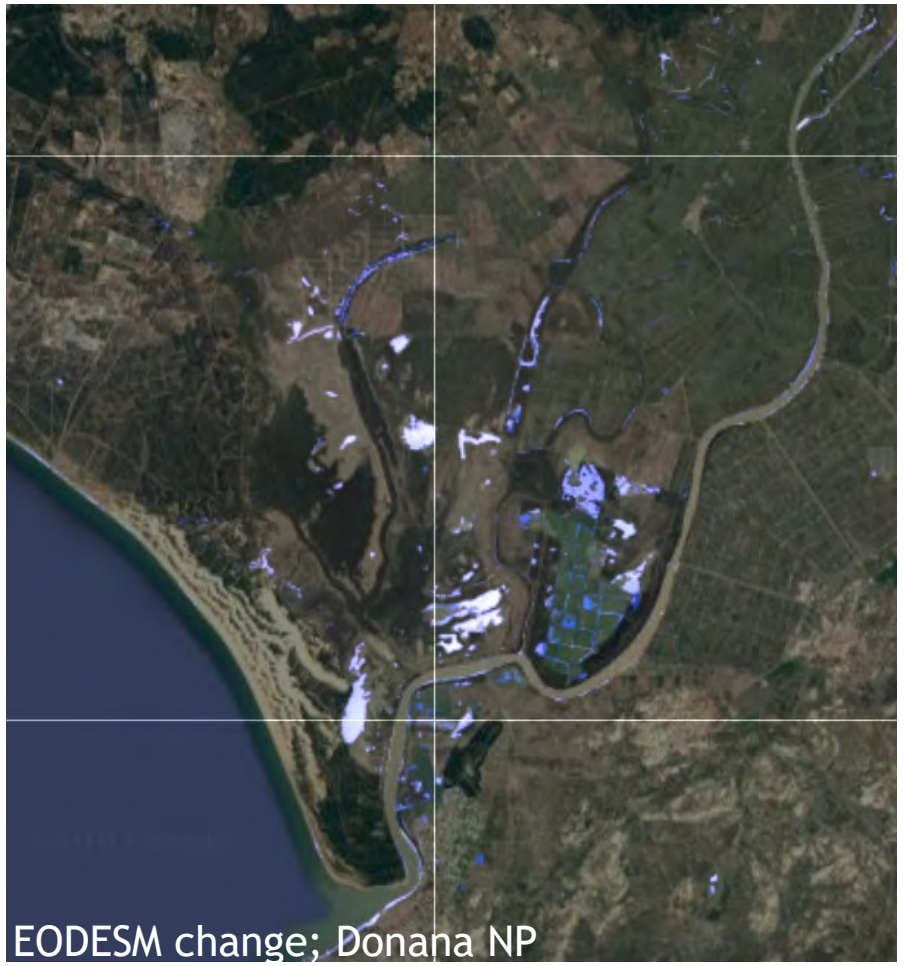
The Earth Observation Data for Ecosystem Monitoring (EODESM)



EODESM land cover, Gran Paradiso NP



EODESM change; Donana NP

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No

Annex II

Exploring the potential of Earth Observations Data Cube for monitoring a protected area

***Ioannis Manakos[1], Danai Aristeridou[1], Georgios Kordelas[1], Kalliroi Marini[1], Gregory Giuliani[2], Yaniss Guigoz[2], Bruno Chatenoux[2], Nektarios Chrysoulakis[3], Dimitris Poursanidis[3]**

[1]Centre for Research and Technology Hellas/Information Technologies Institute, Greece
[2]United Nations Environment Programme/GRID – Geneva & University of Geneva, Switzerland
[3]Foundation for Research and Technology Hellas, Greece

Satellite data (1)

In 1946, rocket-borne cameras **gave us our first look** at Earth from beyond the atmosphere.

NOW

✓By the end of 2018, a total of 13,049,181 Copernicus Sentinel products had been published on the Open Hub since the start of operations, with a total data volume of **9.69 PiB**.

✓ More than **1,000 scenes** from Landsat 7 and Landsat 8 are added to the USGS archive each day.

https://earth.esa.int
2018 Sentinel Data Access Annual Report

Satellite data (2)

The volume of the available satellite data has **increased significantly**. This information could help us to create products with great impact to important environmental, economic and social challenges, including at the local, regional and global scales.

Issue 1: in order to process them scientific knowledge is needed

Issue 2: lack of resources - infrastructure

About the Open Data Cube (1)

What is the Open Data Cube?

The Open Data Cube (ODC) is an **Open Source Geospatial Data Management and Analysis Software project** that helps you harness the power of satellite data in an efficient and easy way.

Purpose

The ODC's objective is to increase the **value and impact of global Earth observation satellite data**. It is based on a an open and freely accessible exploitation architecture.

"The ODC seeks to foster a community to develop, sustain, and grow the technology and the breadth and depth of its applications for societal benefit."

https://www.opendatacube.org/

About the Open Data Cube (2)

Where does it come from?

The **Committee on Earth Observation Satellites** (CEOS) is a founding partner in the Open Data Cube (ODC).

This project was born out of the work done under the "Unlocking the Landsat Archive" and the **Australian Geoscience Data Cube** (AGDC) projects.

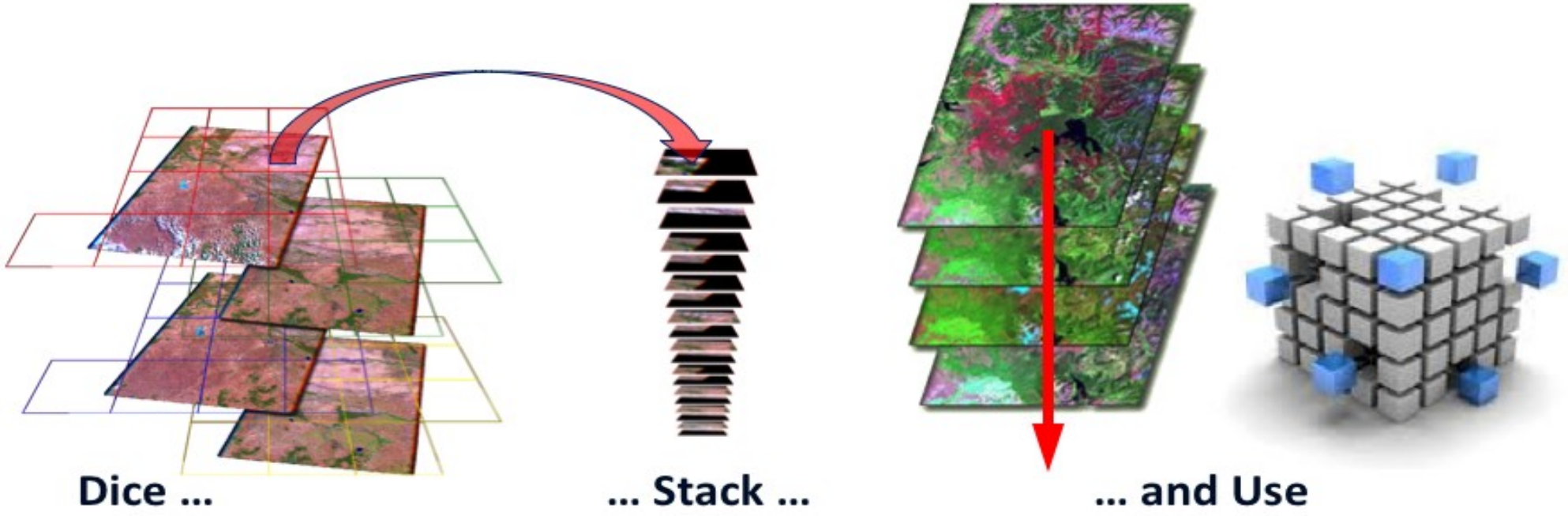
What does it provide?

ODC allows **analysis-ready satellite data** to be packaged in "cubes" in order to minimize data preparation complexity. It also yields rapid results, and utilizes an international global community of contributors.

http://ceos-cube.org/

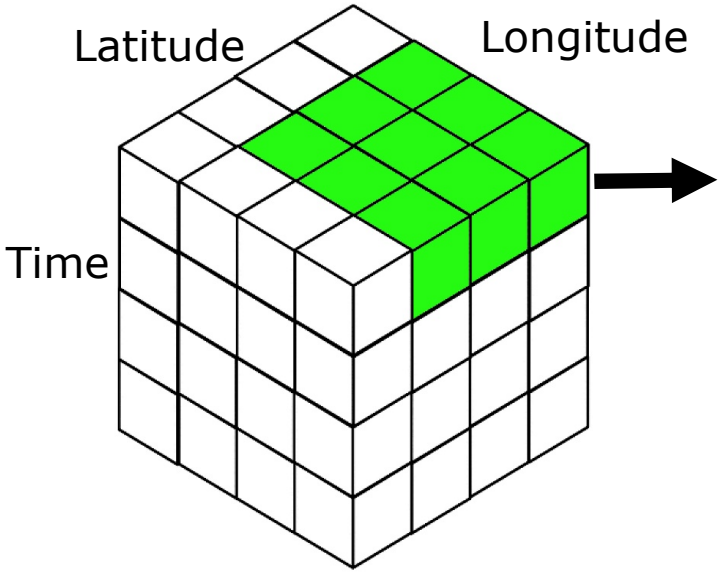
How Data Cubes work (1)

Data cubes are time-series multi-dimensional (space, time, data type) stack of spatially aligned pixels. Data cubes include modules which can be used to perform analysis in matters such as Urbanization, Water Detection, etc.

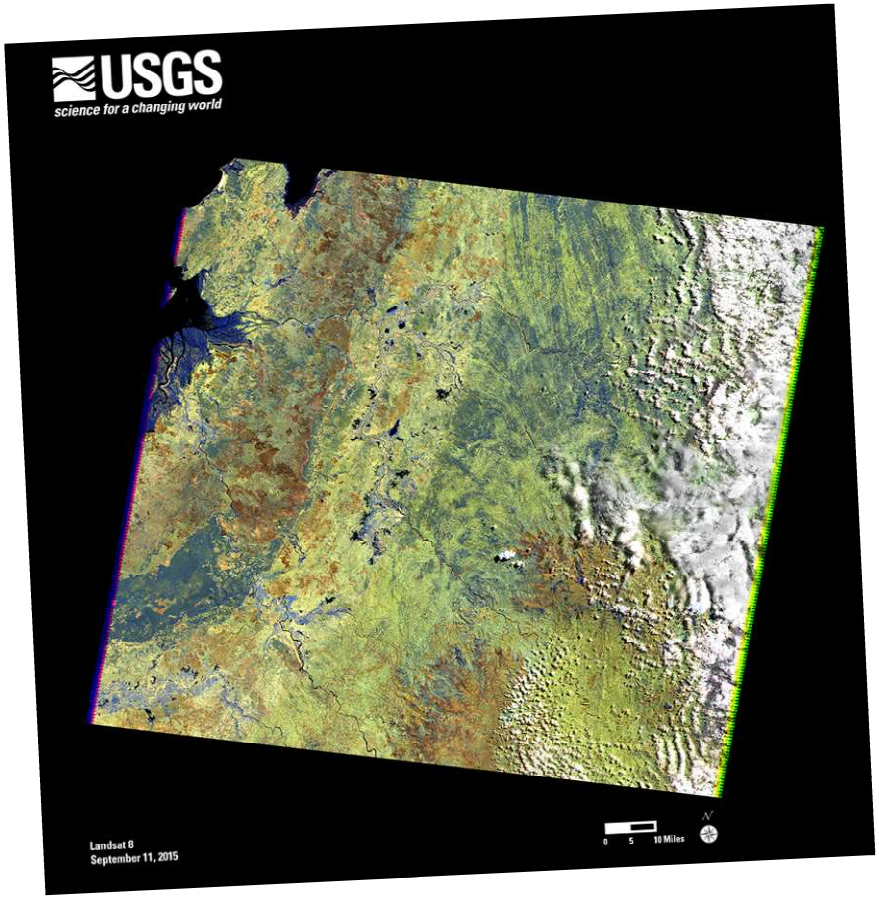


Australian Geoscience Data Cube https://www.opendatacube.org/

Sampling a Data Cube (1)



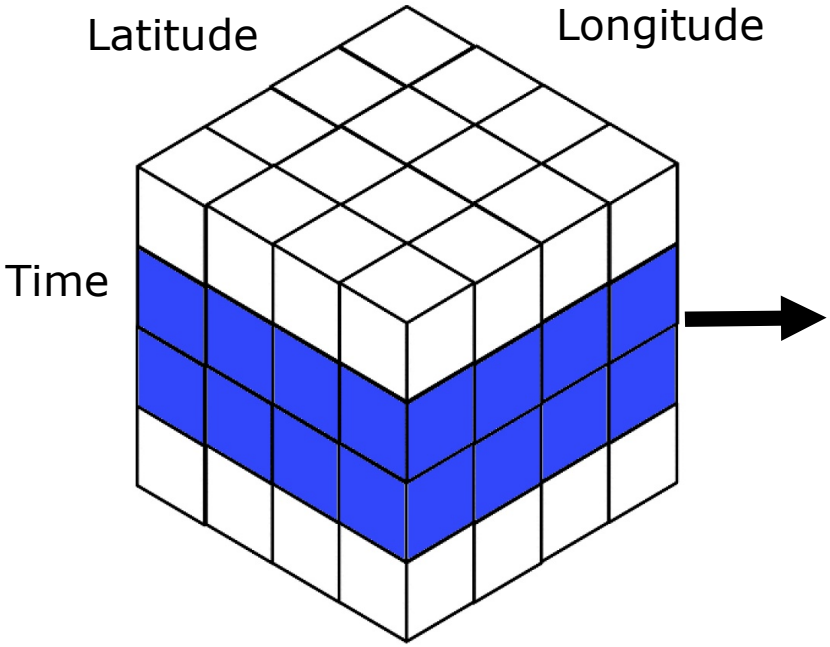
A single time slice, similar to a standard **"scene"** can be used to assess a single point in time



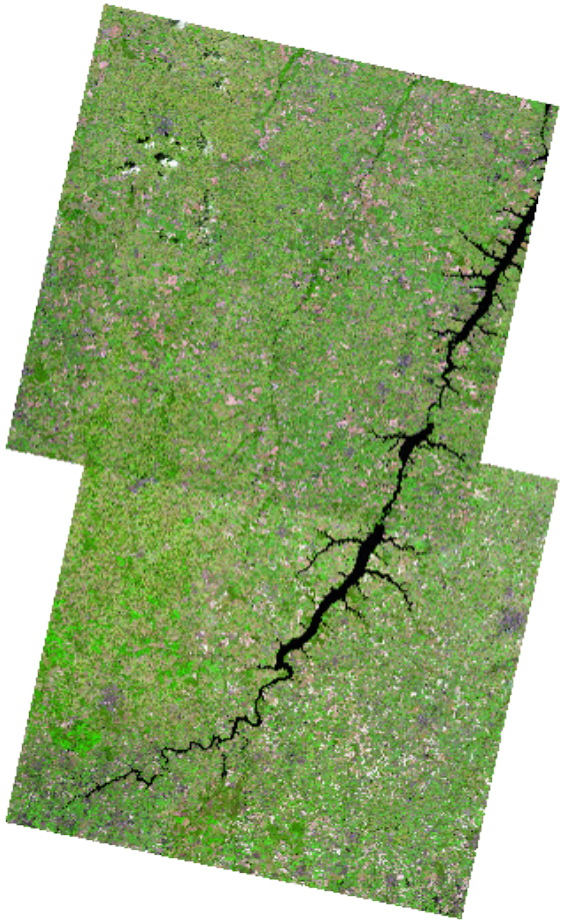
Pixels in the Data Cube are processed, aligned, and compressed and ready for data analysis

Adapted from CEOS

Sampling a Data Cube (2)



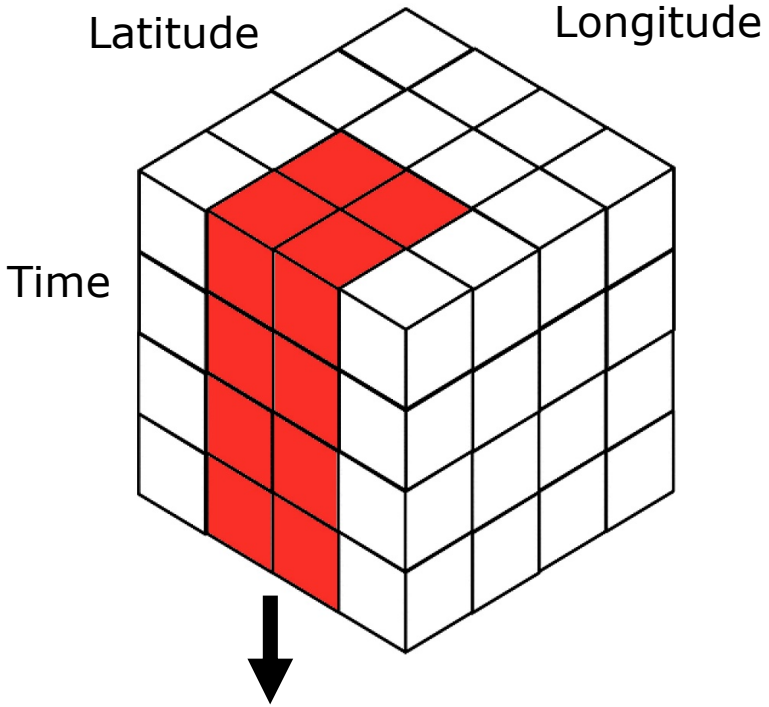
Several time slices can be combined into one to form a "**Mosaic**". This is often used to reduce clouds or create seasonal or annual images.



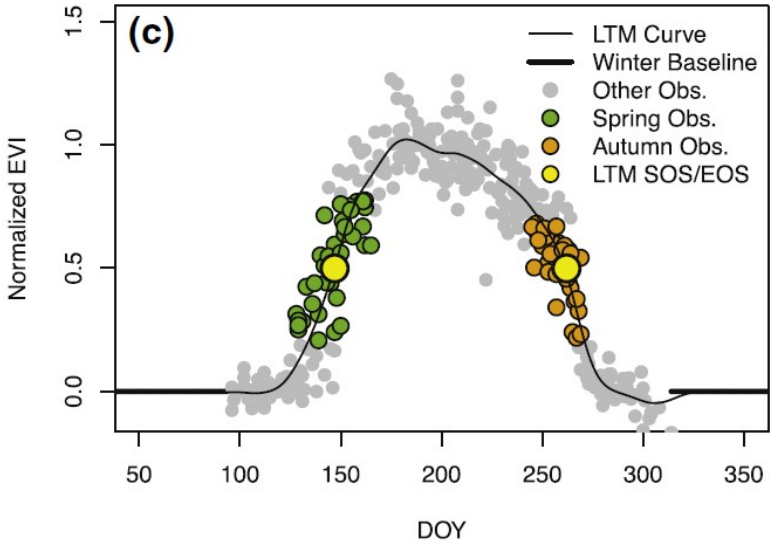
Typical Mosaics … Most/Least Recent Pixel, Mean/Median, Geomedian, Min/Max NDVI

Adapted from CEOS

Sampling a Data Cube (3)



Examples of **Time Series** analyses include: Land Change (PyCCD), Water Change (WOFS), Parameter variation along a transect (Hovmoller plot)



Time Series analyses consider the variation of data over time to assess change

Adapted from CEOS

Data Cube capabilities (1)

Data cube allows the user to easily calculate **metrics**, including:

Data cube modules for Analysis Ready Data

Land

- Urbanization
- Spectral Indices
- Slip
- NDVI anomaly
- Fractional Cover

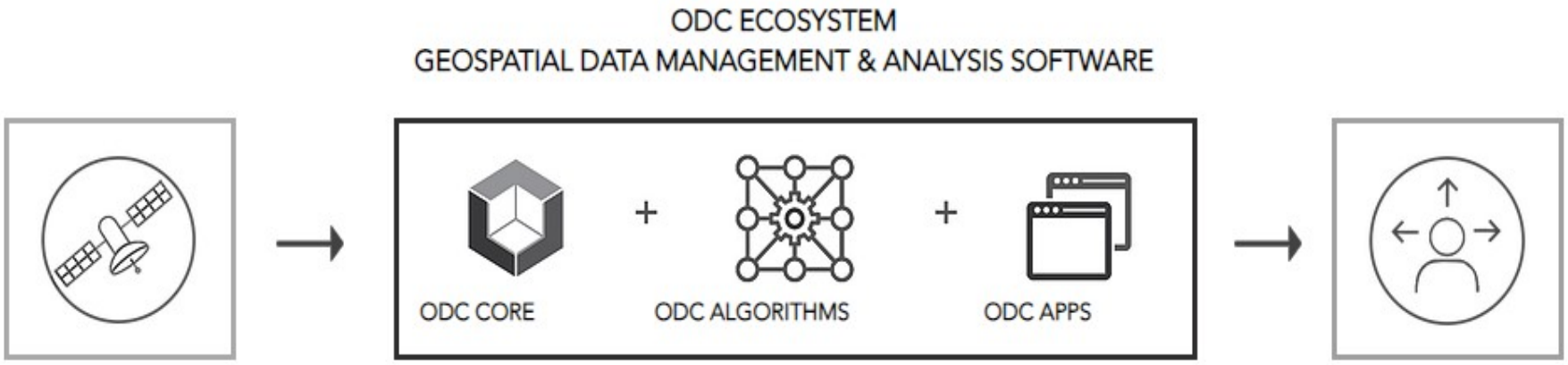
Water

- Coastal Change
- Water Detection
- Water Quality TSM

General

- Cloud Coverage
- Custom Mosaic

Data Cube capabilities (2)



SATELLITE DATA

Examples:

- *Landsat*
- *Sentinel*
- *MODIS*

FLEXIBLE DEPLOYMENT

Depending on your application, the Open Data Cube can be deployed on HPC, Cloud, and local installations. Typical installations run on LInux, MacOS, and Windows.

INFORMED DECISIONS

Examples:

- *Deforestation*
- *Water Quality*
- *Illegal Mining*

https://www.opendatacube.org/

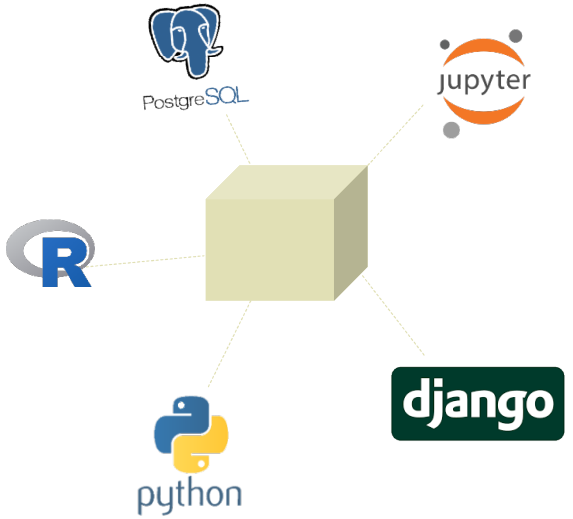
Data Cube Technologies

Technologies

The Data cube is an open source software (Apache 2.0 license). At its core, the Open Data Cube (ODC) is a set of Python libraries and PostgreSQL database that helps you work with geospatial raster data.

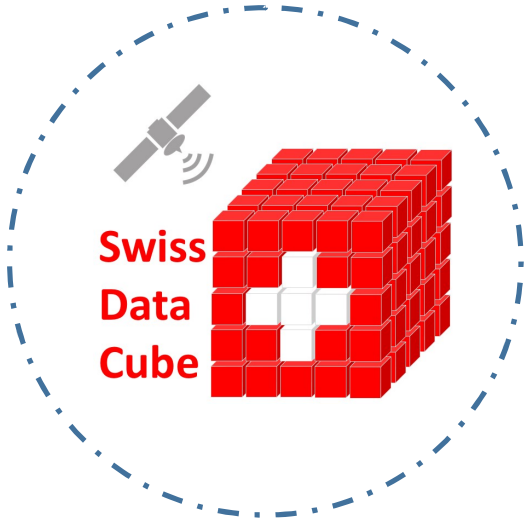
In summary:

✓Django administration panel
✓Jupyter notebooks
✓PostgreSQL database
✓Custom scripts – modules written in R and Python



Operating Data Cubes

- Digital Earth Australia
- Digital Earth Africa
- Swiss Data Cube



… and many others Data Cubes in development

Swiss Data Cube (1)

- Swiss Data Cube is powered by University of Geneva and UN Environment/GRID-Geneva. It contains Landsat 5,7,8 and Sentinel 1, 2 collection in Analysis Ready Data for the whole Switzerland.

- Based on the results from the analysis performed within the Swiss Data Cube, a new product was created, the **Swiss Data Cube Viewer**.

This new product contains:

- **Cloud-free mosaic of Switzerland** for the year 2016 (Sensor Landsat 8 Algorithm: Custom Mosaic Method: Median)
- **Snow Cover of Switzerland for winter month Years: 1995 - 2005** (Sensor: Landsat 5, 7 Algorithm: Snow Observations from Space)
- **Snow Cover of Switzerland for winter month Years: 2005 - 2017** (Sensor: Landsat 5, 7 Algorithm: Snow Observations from Space)
- **Snow Cover Change**: This layer is the difference between the two periods (1995-2005; 2005-2017) showing gain and losses of snow over the last two decades for winter month.

http://www.swissdatacube.ch

SWISS DATA CUBE *in Numbers*

A unique Analysis Ready Data Archive

Updated every week!

35 years
FROM 1984 to 2019

7 sensors
LANDSAT 5/7/8;
SENTINEL-1/2 A-B

10-30-90m
PIXEL RESOLUTION

> 450 millions
PIXELS

> 200 billions
OBSERVATIONS

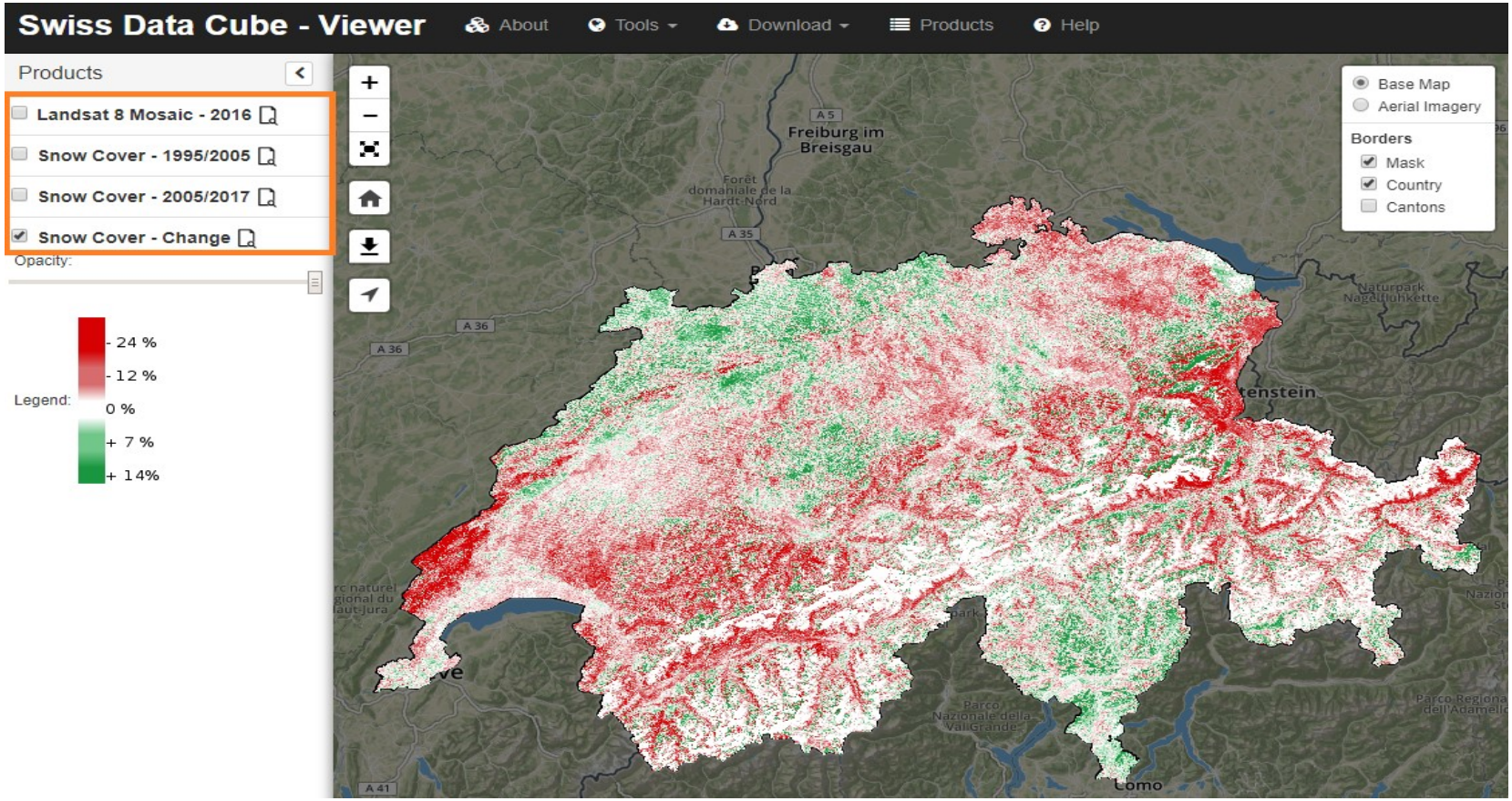
~ 10000 images
INGESTED

~6 TB
ANALYSIS READY DATA

~10 millions CHF
COST OF DATA WITHOUT OPEN DATA ACCESS POLICY

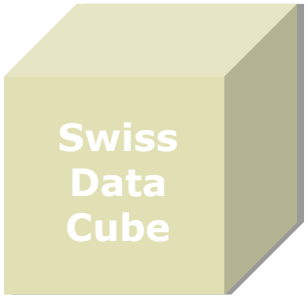
Giuliani G., Chatenoux B., De Bono A., Rodila D., Richard J.-P., Allenbach K., Dao H., Peduzzi P. (2017) Building an Earth Observations Data Cube: lessons learned from the Swiss Data Cube (SDC) on generating Analysis Ready Data (ARD). *Big Earth Data 1(1):1-18*

Swiss Data Cube (2)



➡ Example: **Snow Cover Change** layer between the two periods (1995-2005; 2005-2017)
https://www.swissdatacube.org/viewer/

Data Cubes Benefits (1)

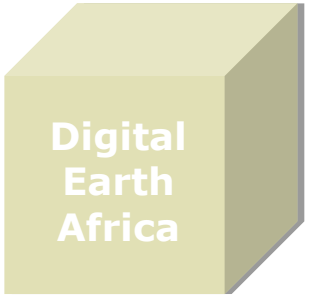


The **Swiss Data Cube (SDC)** will deliver a unique capability to process, interrogate, and present Earth observation satellite data in response to environmental issues of Switzerland.

It will allow tracking changes across Switzerland in unprecedented detail, and will be able to provide new information for every 10 square meters of Switzerland, every five days.

This near real-time information can be readily used as an evidence base for the design, implementation, and evaluation of policies, programs and regulation, and for developing policy advice.

Data Cubes Benefits (2)



Digital Earth Africa will improve understanding of Africa's changing landscape and provide with much-needed insights.

Such insights will enable African governments, NGOs, businesses, and individuals to make more informed decisions about soil and coastal erosion, agriculture, deforestation, desertification, water quality and changes in human settlements.

Digital Earth Africa includes micro-cubes of areas in Kenya, Senegal, Sierra Leone, Ghana, and Tanzania.

The analysis that is performed within Data cube will be even more valuable for protected areas or areas who lack resources/infrastructure.

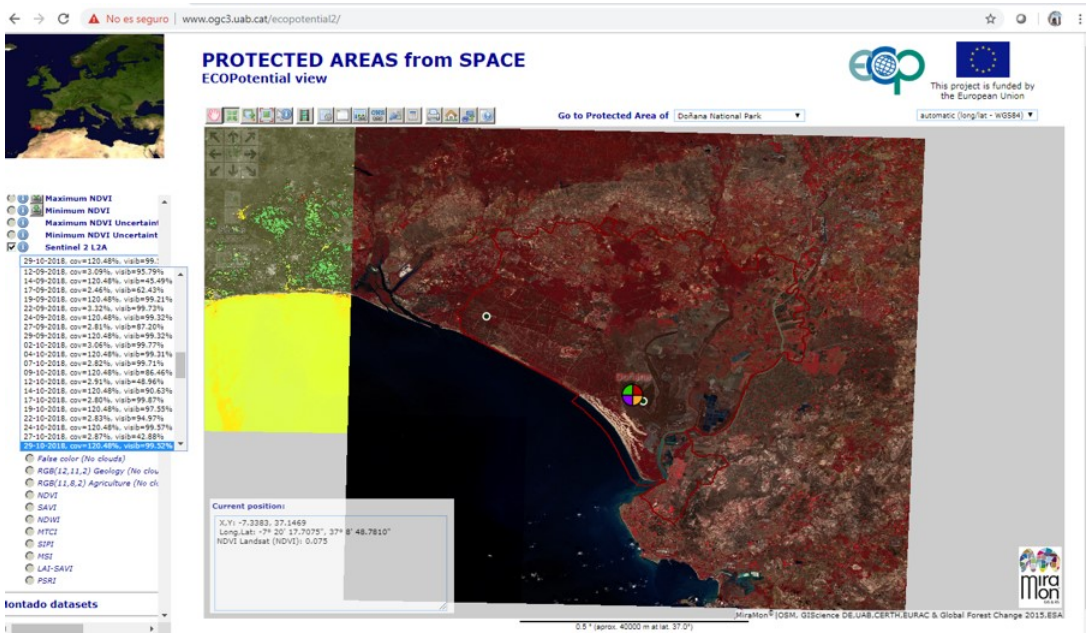
http://www.ga.gov.au/digitalearthafrica

Web map browser Sentinel-2 L2A

by CREAF – credit: Joan Maso

- We have developed an automatic procedure to download relevant granules over a protected area
- We have built a data cube based on the Open Data Cube for each PA ready to analyse

From March 2018 to March 2019
•15 protected areas
•2553 granules (199360 jp2 files
•1693 dates (adding all PA)
•4.16Tbytes of JP2 files



Currently limited to:

•Abisko
•Bayerischer Wald
•Camargue
•Donana
•Gran Paradiso
•Har Ha Negev
•High Tatra
•La Palma

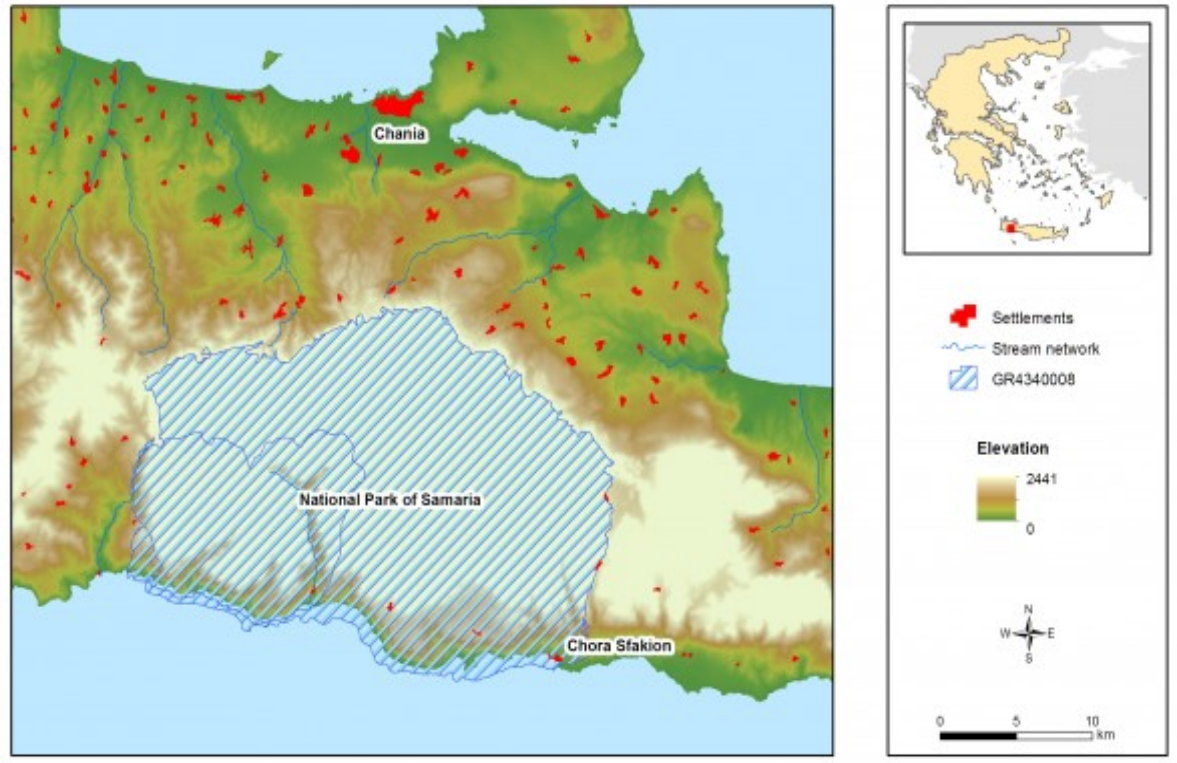
- Murgia Alta
- Northern Limestone
- Ohrid Prespa
- Peneda Geres
- Samaria
- Sierra Nevada
- Swiss National Park

http://maps.ecopotential-project.eu/

Samaria National Park (1)

- **The Samaria National Park is one of the most recognized and awarded protected areas of Greece**. It contains one of the largest gorges in the Balkans, Samaria Gorge, with a total length of 13 km while nine main gorges are located within the area of the White Mountains.

- It is a multi-designated area and specifically a National Park, Landscape of Outstanding Beauty, Natura 2000 site coded GR 4340008 and GR4340014 and Biosphere Reserve in the framework of the "Man and Biosphere" Program of UNESCO.



https://www.samaria.gr, https://deims.org

Samaria National Park (2)

- The National Park is characterized by a rich biodiversity, a high degree of endemism in fauna and flora, distinctive geological configurations and specific landscape features.

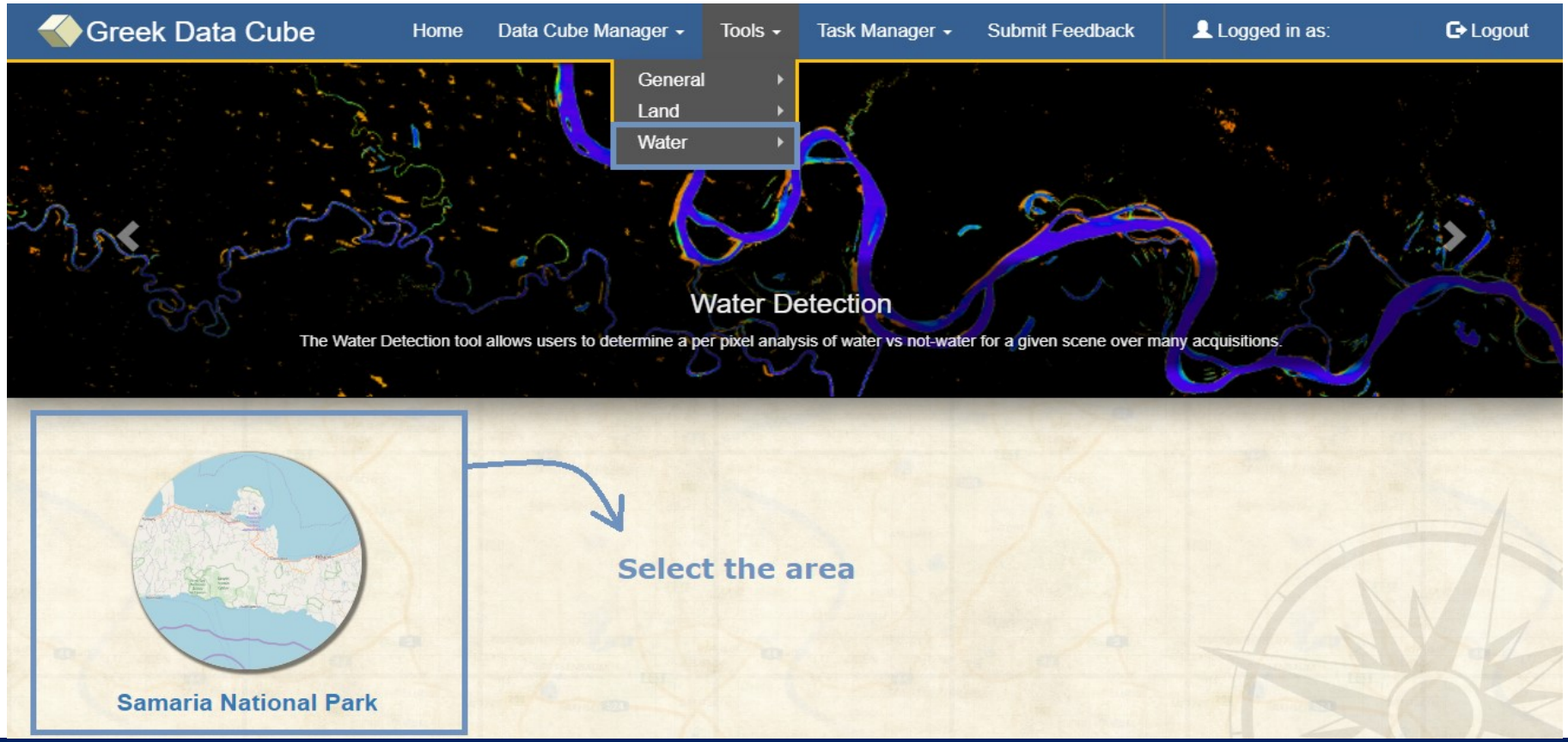
- Nowadays, the system is focused on the monitoring and surveillance of 15 terrestrial habitats and 34 species of flora, the recording of meteorological and hydrological conditions, etc.

- The **basic threats and pressures** characterizing the site can be cumulated in:
  - landscape fragmentation
  - desertification induced by overgrazing and uncontrolled fires
  - modifications in water and groundwater regime induced by large scale infrastructures
  - poaching and uncontrolled abstraction of endemic species of flora
  - massive touristic flow and
  - relative medium and large-scale touristic infrastructures

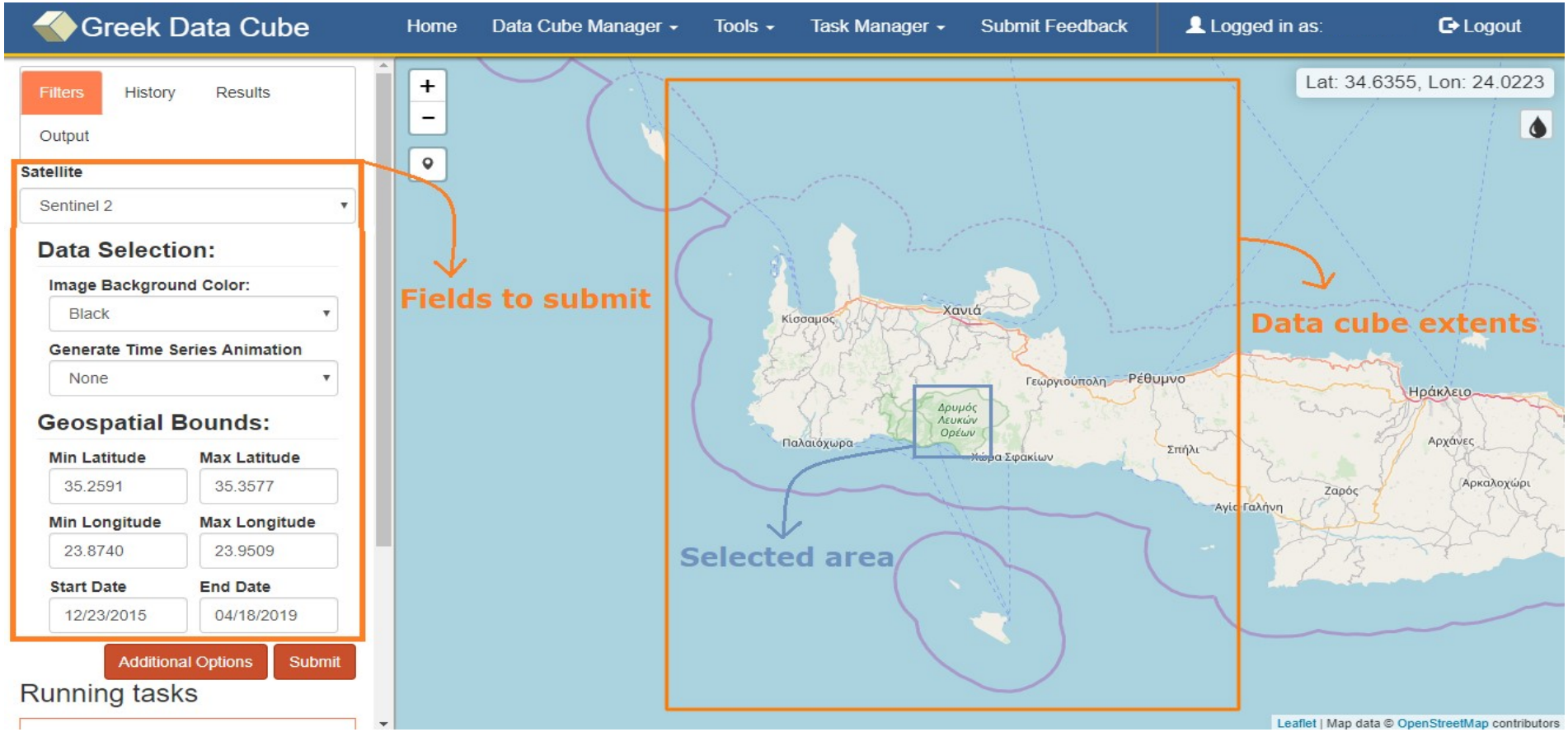
- The creation of Samaria's micro-cube will be highly important and make more efficient the monitoring of the area.

How to use Data Cubes - example (1)

From the menu select *Tools*, choose the main category (e.g. Water), the module (e.g. Water Detection) and finally select the area.

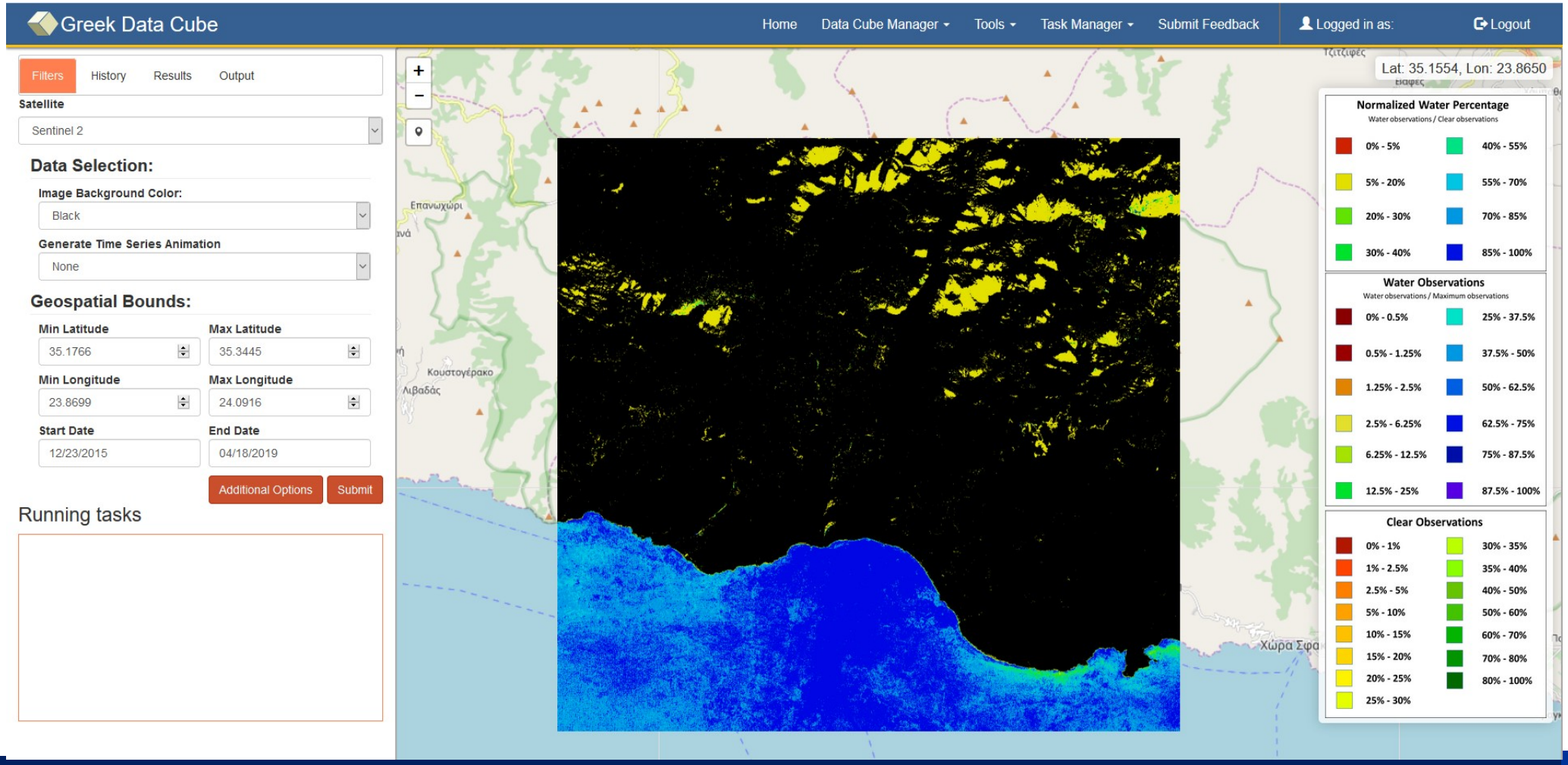


How to use Data Cubes - example (2)

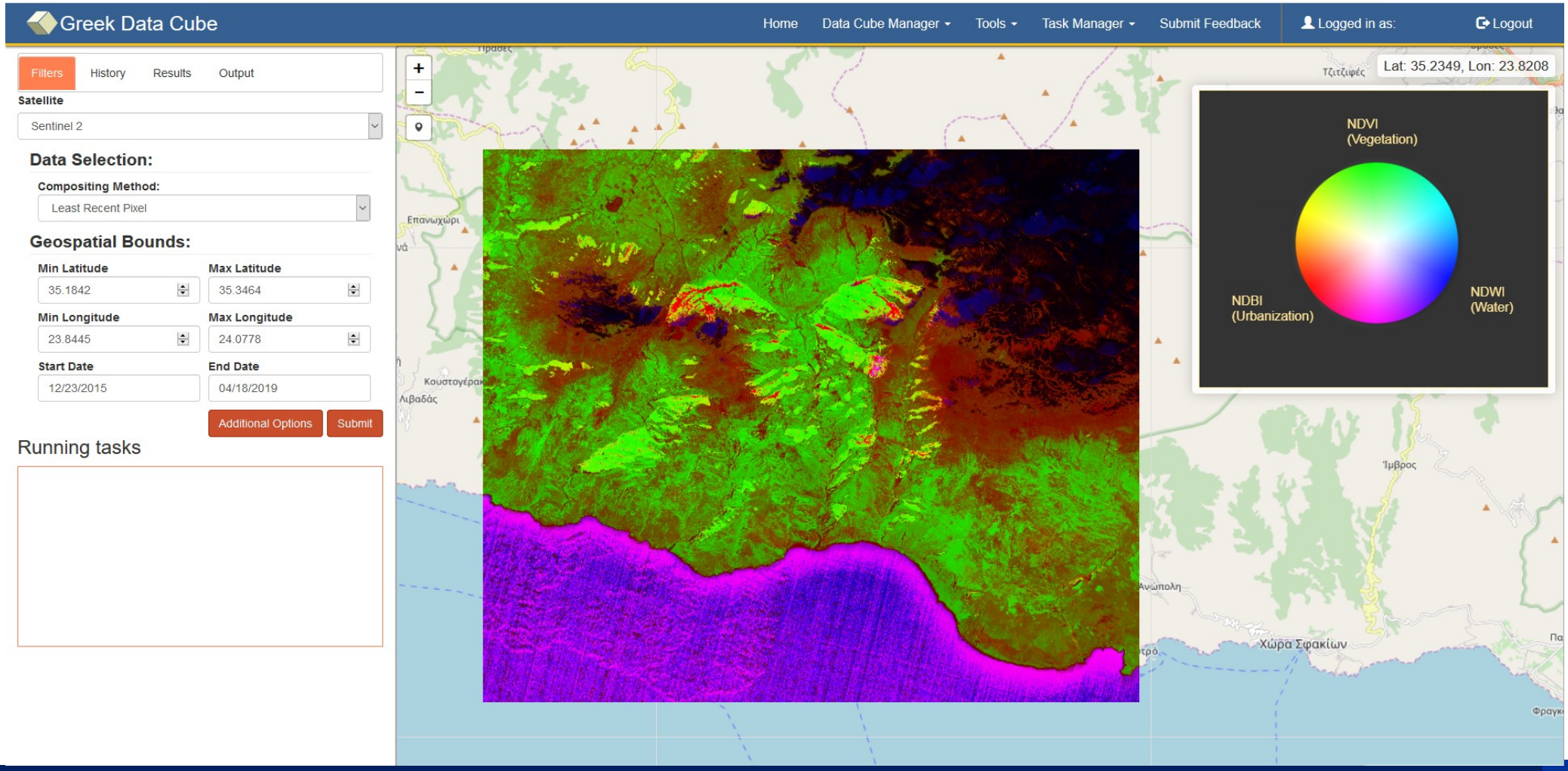


Complete the fields on the left side, click *Submit* and get the results.

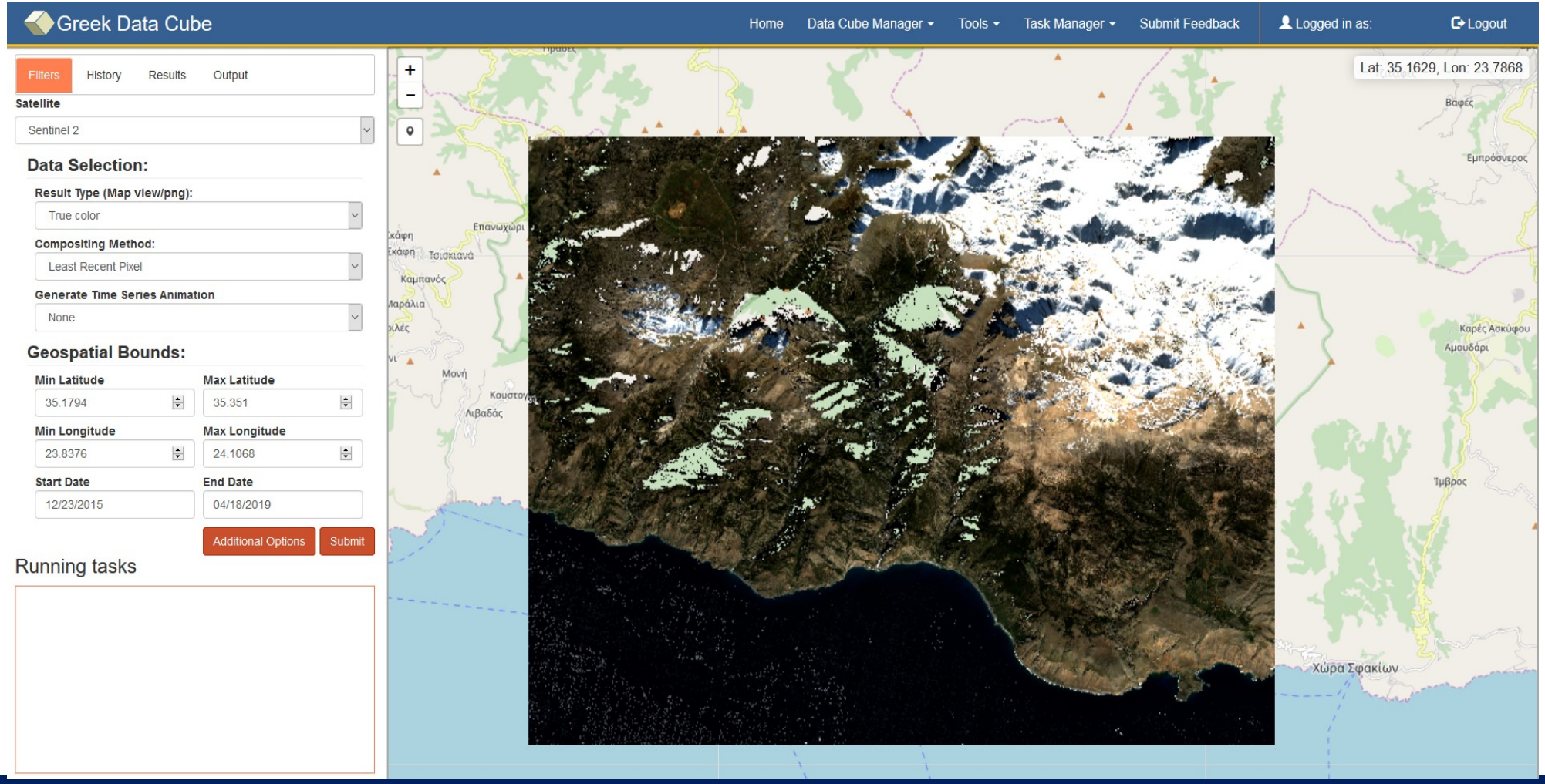
Water Detection



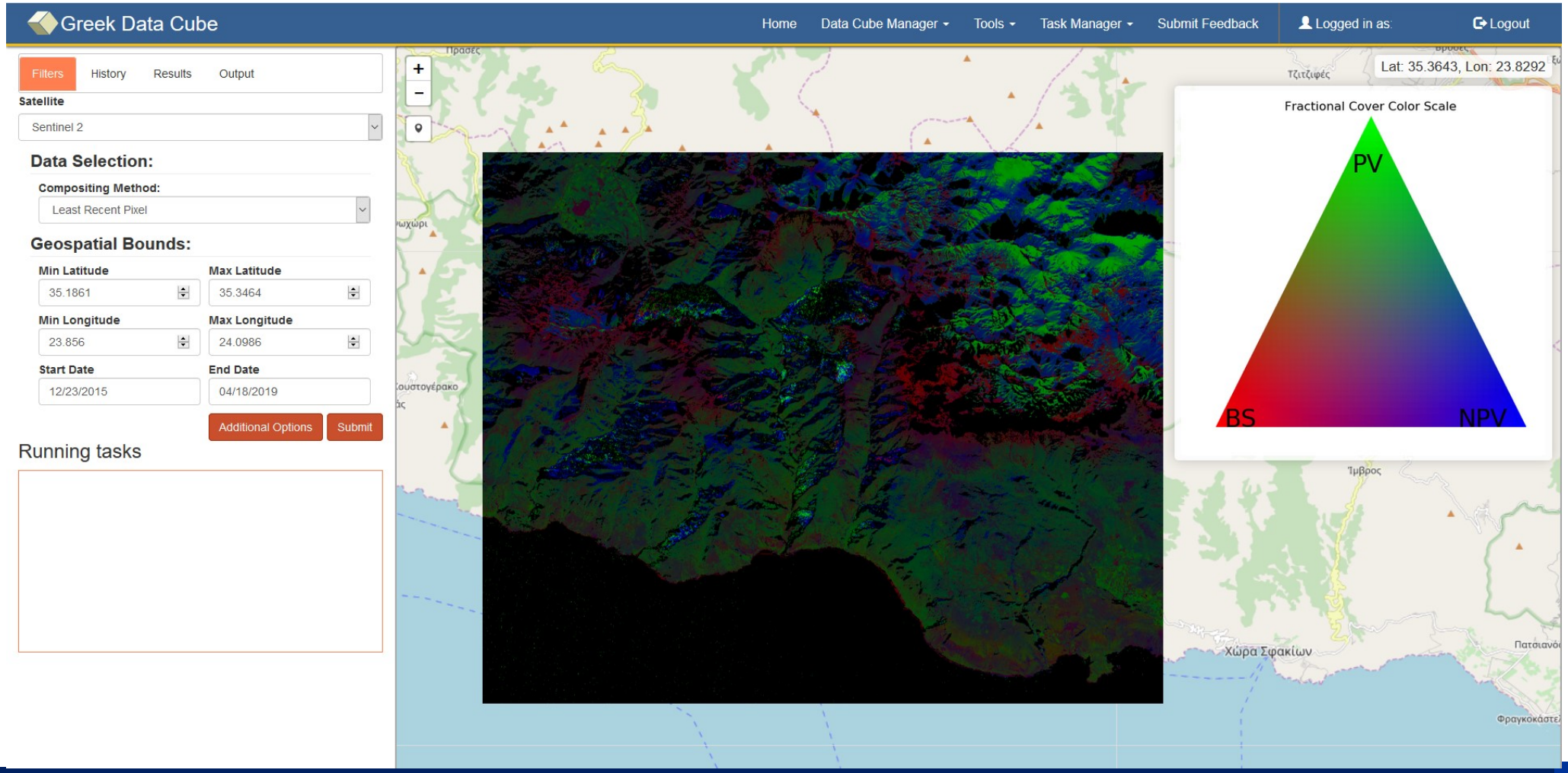
Urbanization



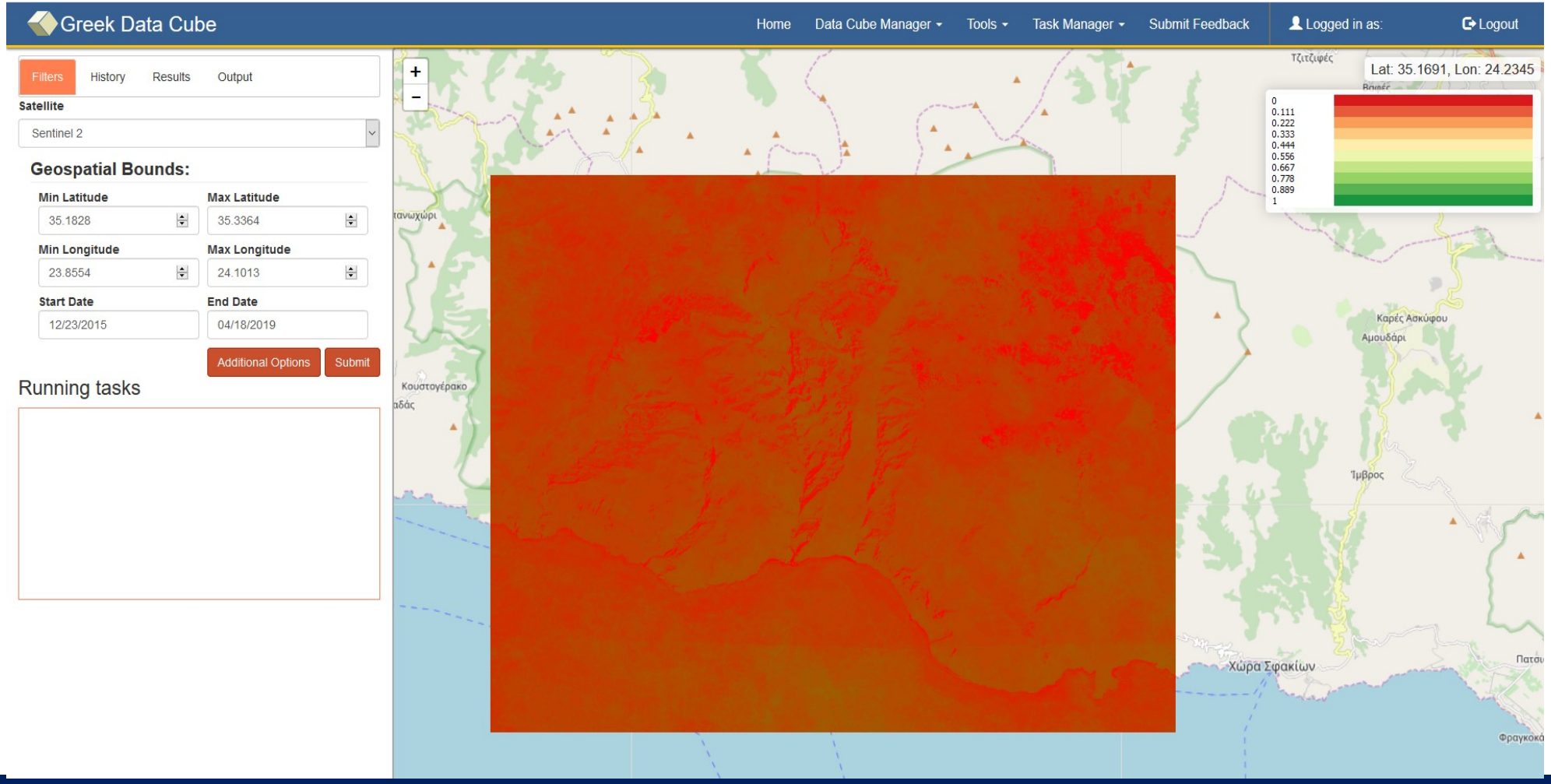
Custom Mosaic



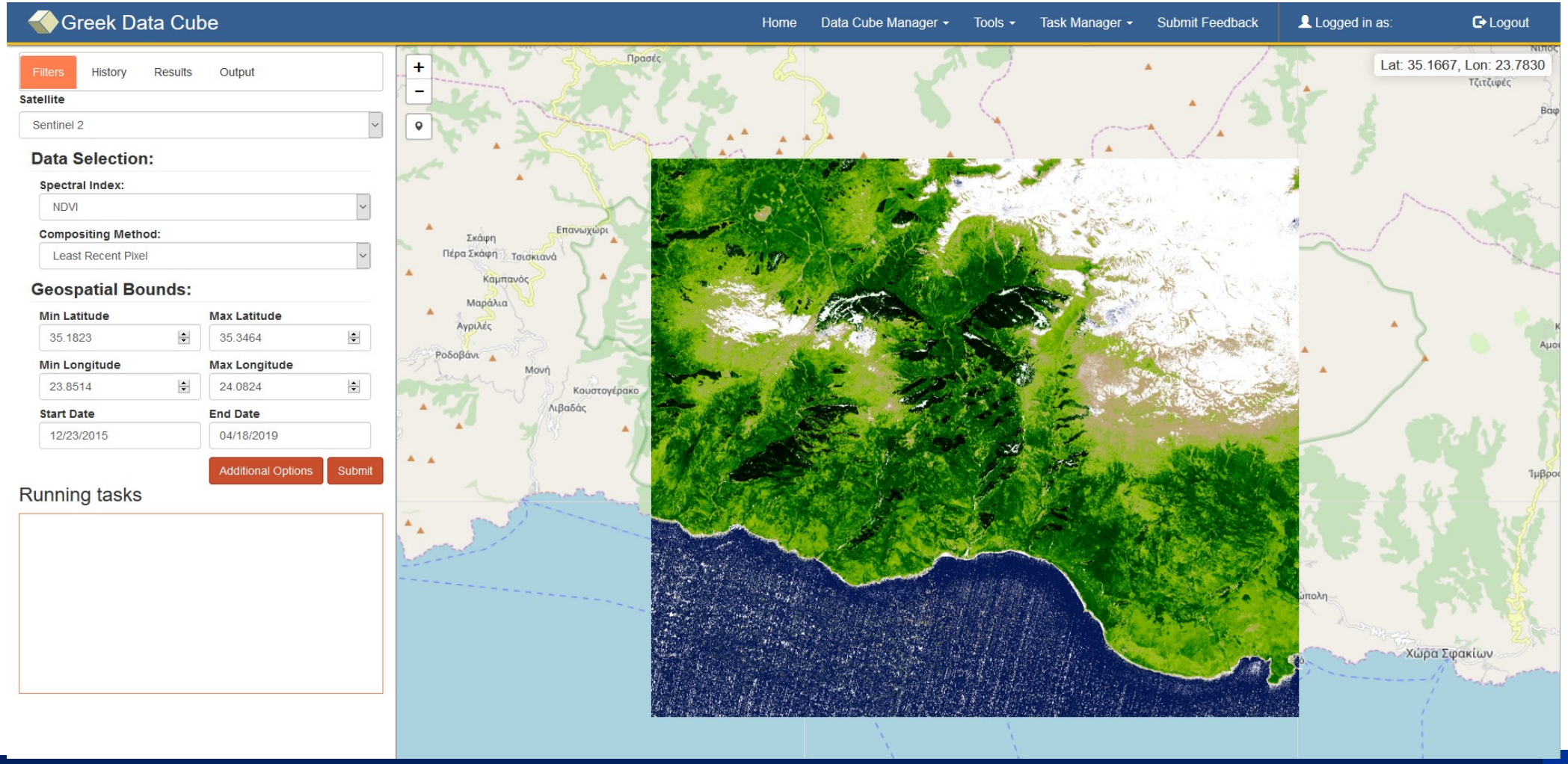
Fractional Cover



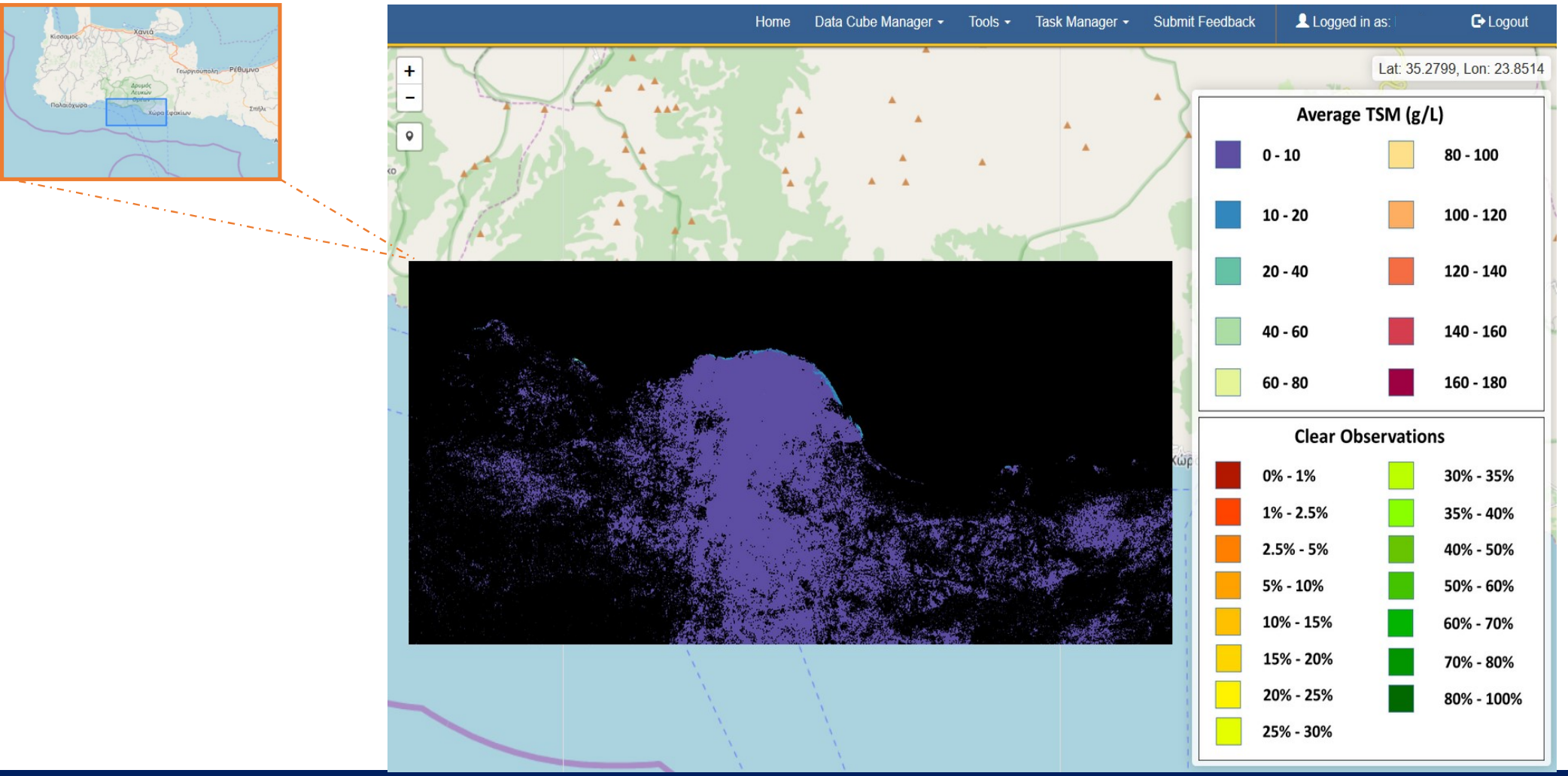
Cloud Coverage



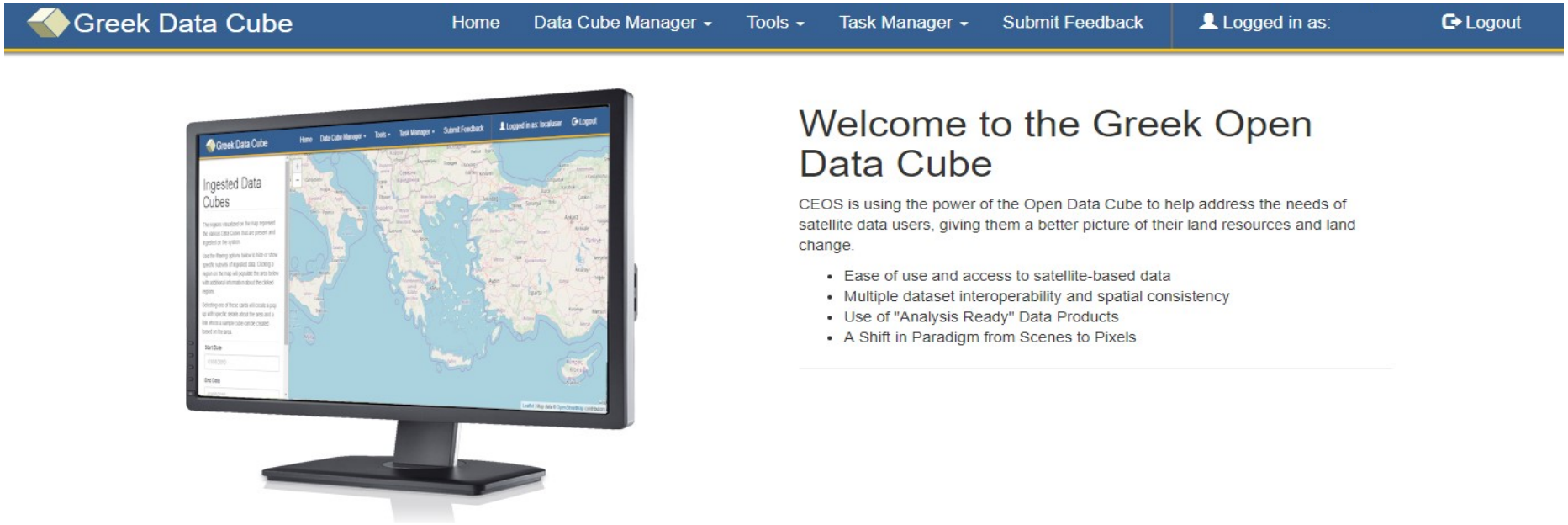
Spectral indices: NDVI



Water Quality TSM



Greek Data Cube



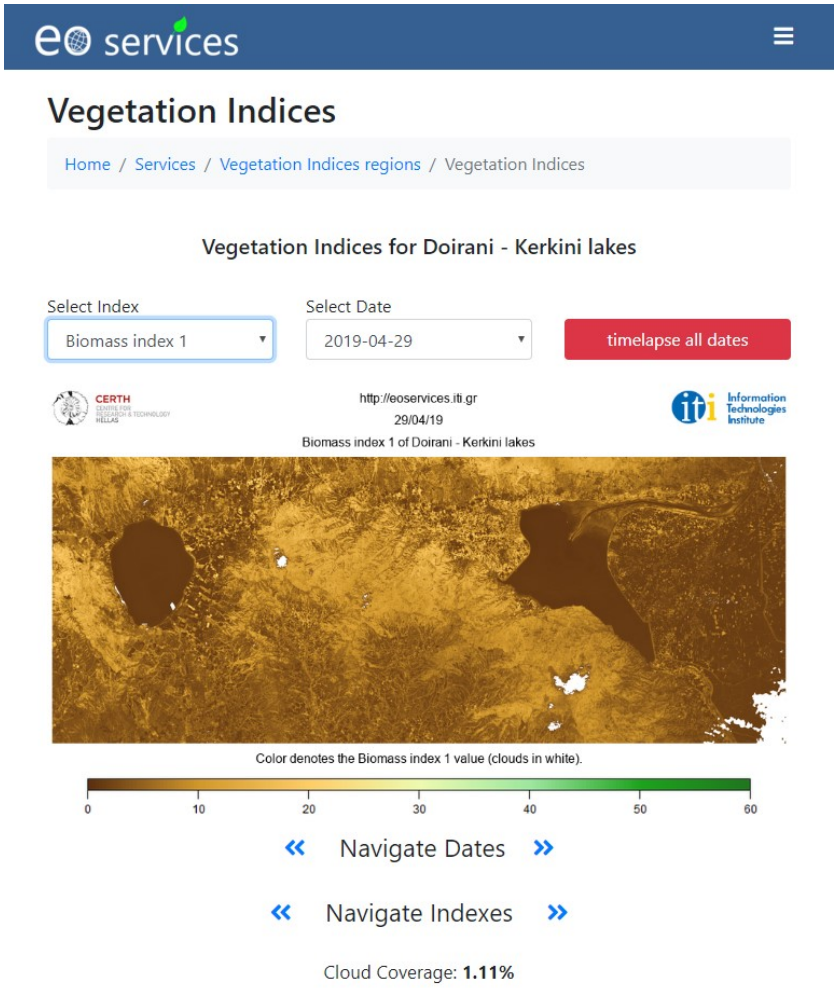
- Greek Data cube is operating in its first version. It is based on CEOS and the Swiss Data cube. It is currently in the stage of ingesting more satellite data – scenes, in order to export results with scientific value.

- Greek Data cube is currently using Sentinel-2 imagery. Landsat 5, 7 and 8 imagery is going to be added soon. At the moment, Greek Data cube contains only the micro-cube of Samaria National Park.

Future plans

- After the completion of Samaria's data ingestion, the creation of another micro-cube may follow. For example, the Data cube of another protected area.

- At a next stage, more modules - algorithms are going to be added to the Data cube, through Jupyter notebooks. For example, the modules that have already been created in the website of the eoservices team, **eoservices.iti.gr**.



http://eoservices.iti.gr

Exploring the potential of Earth Observations Data Cube for monitoring a protected area

Thank you for your attention

At your disposal for questions/clarifications

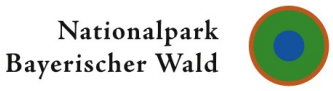
On behalf of the working group
Manakos Ioannis, Dr.
imanakos@iti.gr

Annex III

WP9: Aesthetic vision as a quality status Indicator for Protected Areas

Ioannis Manakos[1], Georgios Kordelas[1], Marco Heurich[2]

[1]CERTH, Thessaloniki, Greece
[2]Bavarian Forest Administration, Germany



Aesthetic vision as a quality status Indicator for Protected Areas

Objective:

•Estimate visual pollution and disturbance per pixel within the boundaries of a Protected Area

Demonstration site:

•Bavarian Forest in Germany

Inputs:

•Digital Elevation Model

•Digital Surface Model

•Land Cover Map

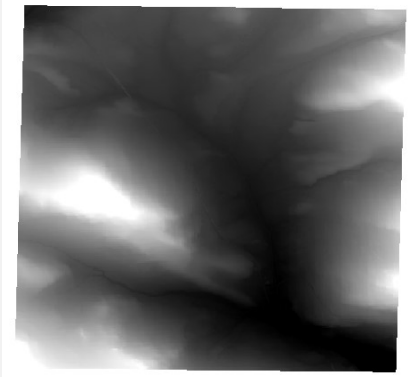
Output:

•Viewshed visual disturbance by human artefacts map

Aesthetic vision as a quality status Indicator for Protected Areas

Viewshed analysis

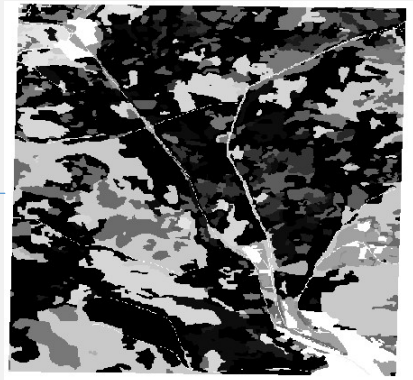
Digital Elevation Model (DEM)



Digital Surface Model (DSM)

Modified DSM (for areas of LC man made objects the DSM is set to the minimum DSM value of that area)

Land Cover map (LC map)



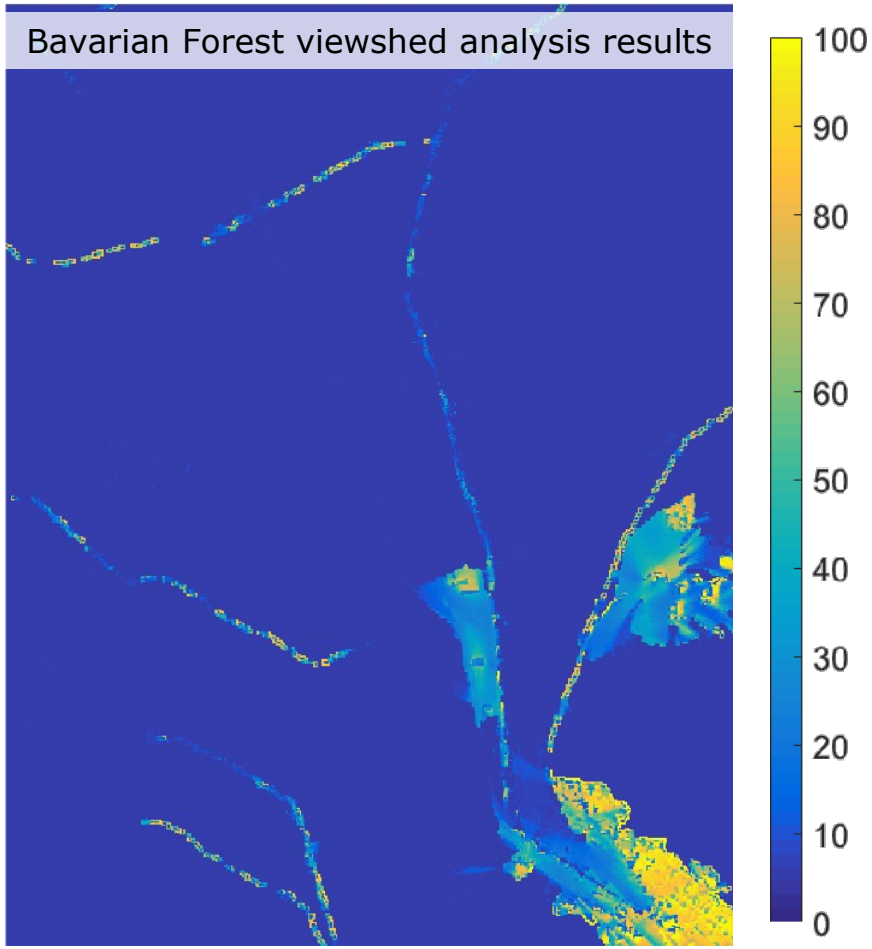
Disturbance map: containing per pixel the total number of observed pixels

Observer position:
1. Set from DEM for trees' covered areas
2. Set from DSM for other areas

Reference map: containing per pixel the total number of observed pixels

Viewshed visual disturbance by human artefacts map : containing per pixel the percentage of the observed pixels disturbed by human made objects vs. the reference map

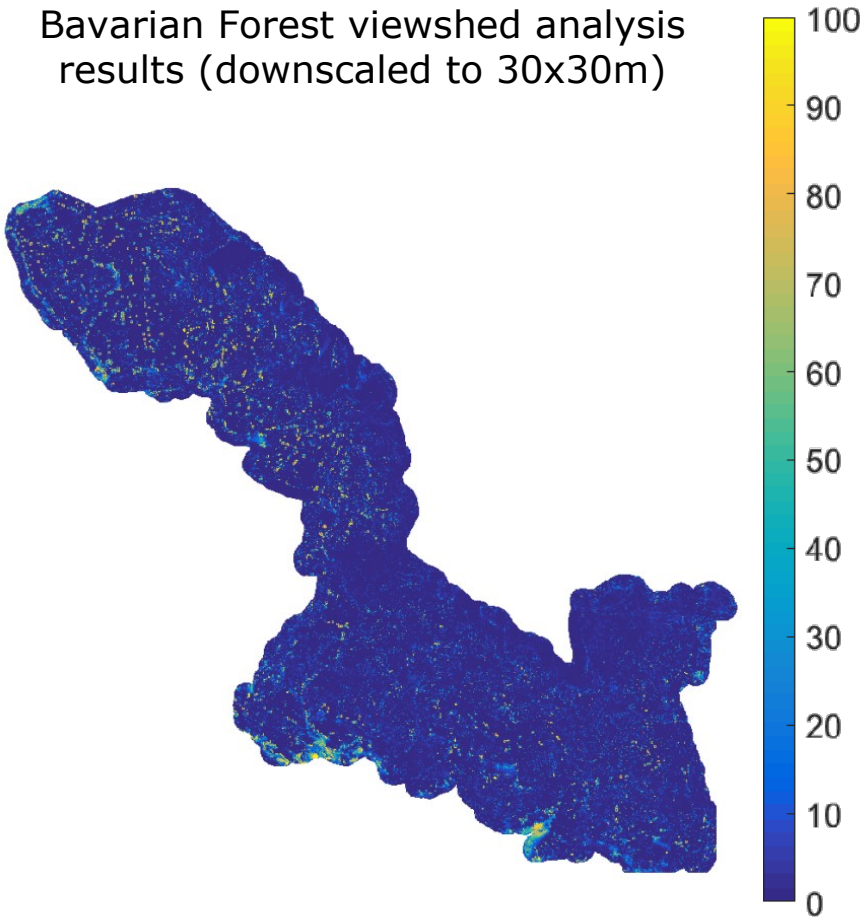
Aesthetic vision as a quality status Indicator for Protected Areas



Aesthetic vision as a quality status Indicator for Protected Areas

Bavarian Forest true color airborne image (downscaled to 30x30m)

Bavarian Forest viewshed analysis results (downscaled to 30x30m)



2,5 days of continuous computation on a high end PC

Aesthetic vision as a quality status Indicator for Protected Areas

Open issues:

•Estimation of the modified DSM:
- Option 1: to set the DSM value of patches where man-made objects exist to the minimum DSM value.
- Option 2: to set patches' DSM value equal to the minimum of the DSM values of the neighbouring patches.
- Option 3: other?

•Position of the observer in relation to human artefacts: On top or inside a building?

•Should a maximum radius of visibility be set for an observer? In such a case which should be the radius value?

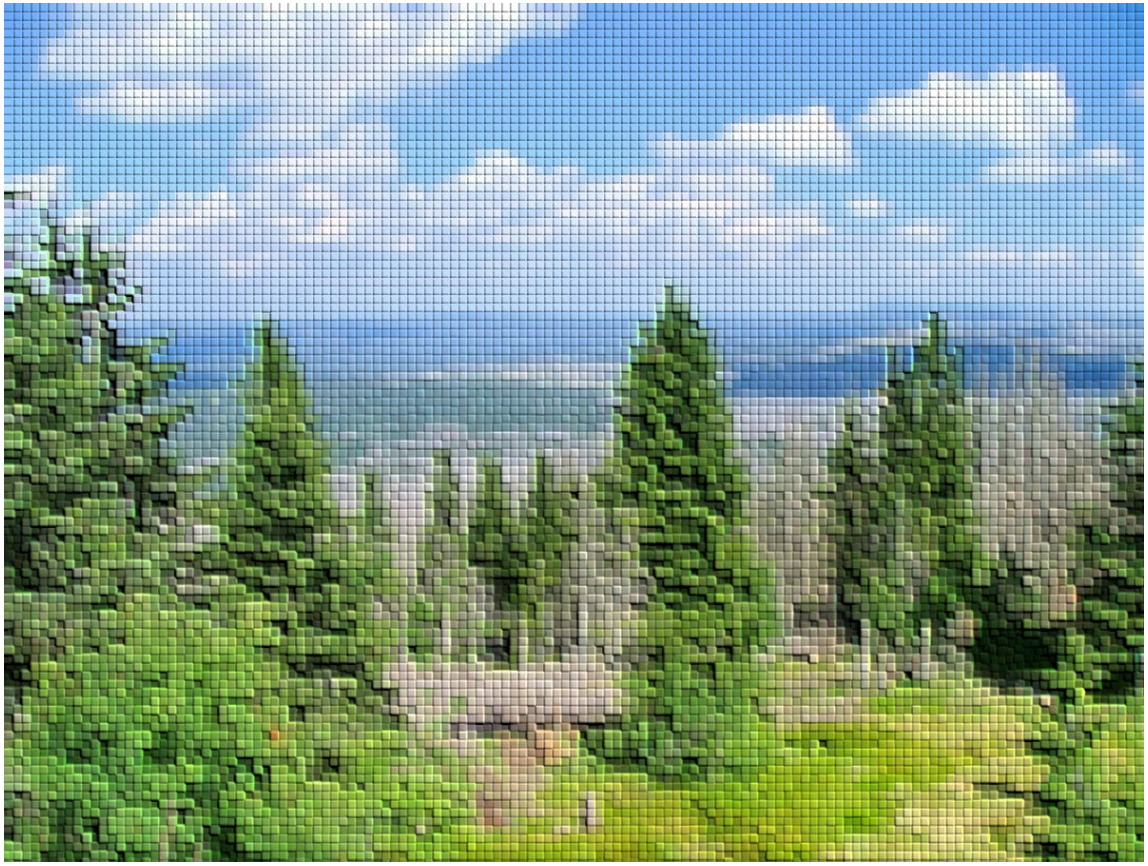
•Estimation of visual disturbance in pristine natural areas can be skipped for saving computation cost. Would this be acceptable by PA managers?

Cooperation issues:

•Is it desirable and beneficial to couple viewshed analysis with the assessment of recreational visitor groups using Flickr, developed by the team of the University of Leeds?

•Sharing of computational power with CERTH to run time expensive viewshed analysis.

Aesthetic vision as a quality status Indicator for Protected Areas



At your disposal!

Ioannis Manakos (imanakos@iti.gr), Georgios Kordelas (kordelas@iti.gr),
Marco Heurich (Marco.Heurich@npv-bw.bayern.de)