ECOPOTENTIAL online data services legacy and possible relevant applications within SCERIN

ioannis Manakos, Dr.
Associate Researcher in Remote Sensing

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

Online data services as main ECOPOTENTIAL results

- ✓ A key aim of the EU Horizon 2020 ECOPOTENTIAL project is to realize online monitoring data services for ecosystem indicators for the users' community.

- ✓ Selected process-based, conceptual/correlative models and other model supportive workflows are transformed into online data services and then integrated into the Virtual Laboratory (Vlab) platform; a service-based platform aiming to study ecosystems and contribute to GEO/GEOSS.

- ✓ Focus is placed on the degree of assimilation of Earth Observation (EO) data into a model's processing chain.

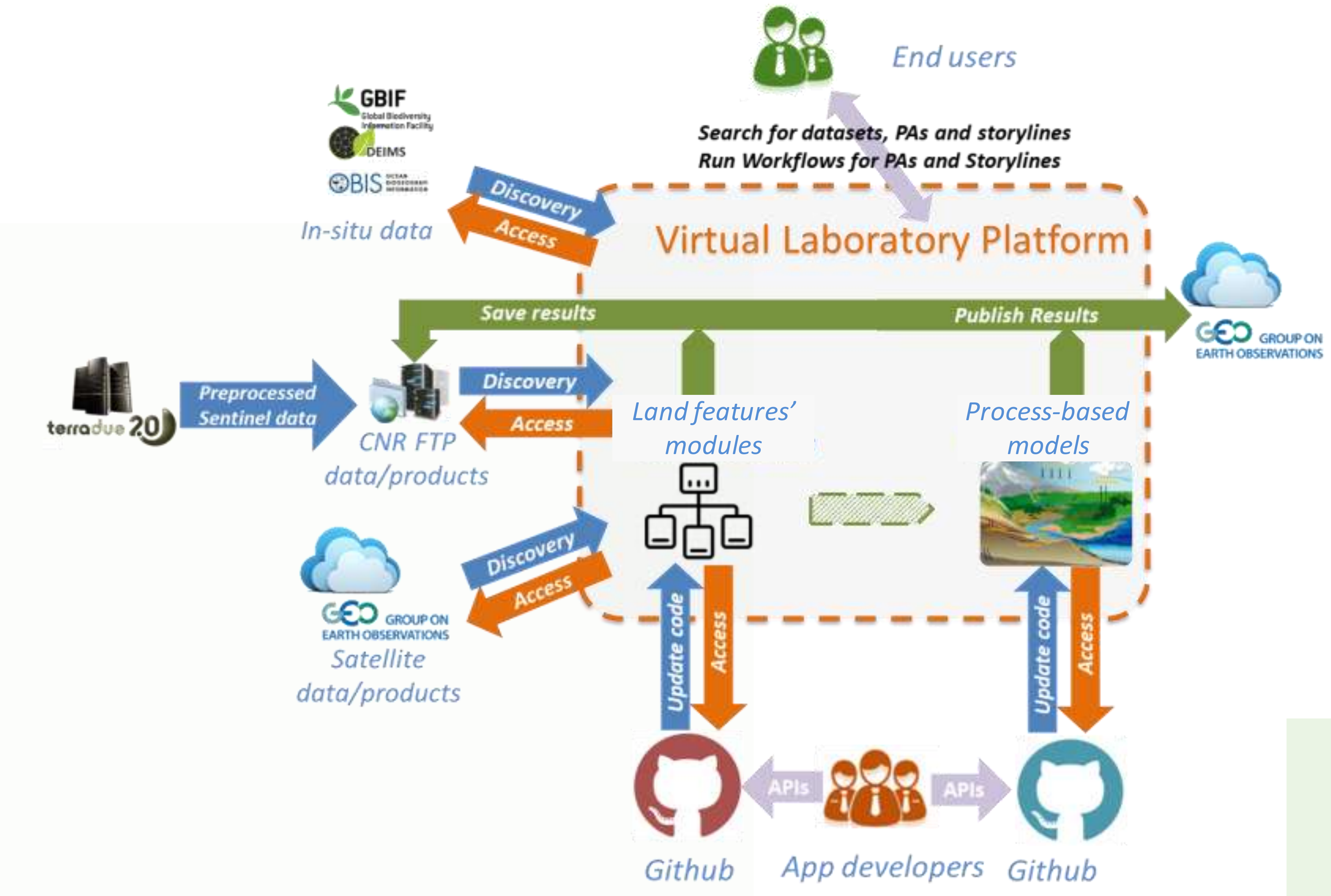
Online data services as main ECOPOTENTIAL results

- ✓ Of importance is the capacity of the models to integrate data and/or information existing into the ECOPOTENTIAL knowledge base, as these data were generated, following the consultation of users and according to the user requests.

- ✓ Issues considered include the functionality of the model, the Protected Area of implementation, main inputs and outputs, as well as copyright requirements.

- ✓ Modules (initially in the form of manual workflows) for the derivation of map and land cover feature products from EO data are also transformed to easy-to-initiate-and-use operational online data services; (i) either as stand-alone services or (ii) as workflow components to generate input for models.

An overview of the online data services



https://vlab.geodab.eu

- ✓ NetLogo, R, Python
- ✓ Open access
- ✓ Easy to use
- ✓ Demos execution & Custom ones

Species distribution models

INSTAR

(Developed by UGR team: M. Suárez-Muñoz, F. Bonet-García, J. A. Hódar, L. Torres-Muros, R. Pérez-Pérez)

Objective is to provide a deeper understanding of the population dynamics of *Thaumetopoea pityocampa* forest pest and forecast the probability of occurrence and intensity of the pest outbreaks at landscape scale, under different climate and land use scenarios.

- Related Storyline: Temporal evolution of ecosystem services in Sierra Nevada
- Protected Areas of application: Sierra Nevada (Spain)
- Technical details: NetLogo (v. 5.2.1) language

Thaumetopoea pityocampa

Picture Credit: María Suárez-Muñoz, Francisco J. Bonet García and José A. Hódar, INSTAR: simulating the biological cycle of a forest pest in Mediterranean pine stands University of Granada, Spain, EGU 2017.

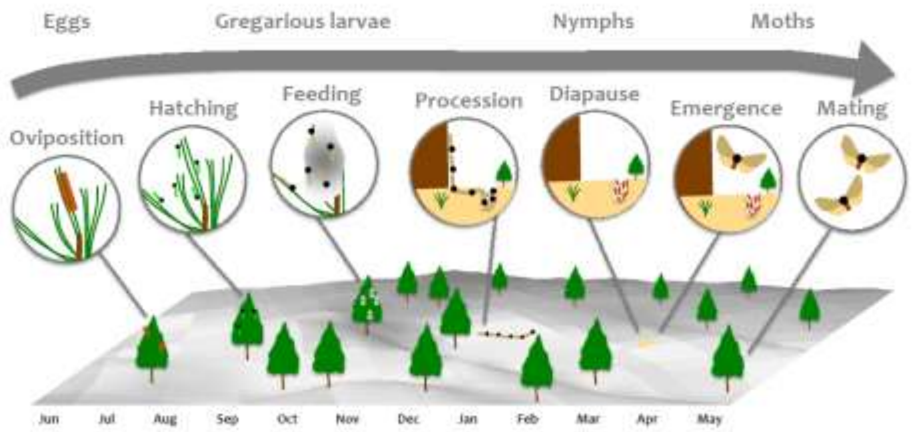
INSTAR

Approach:

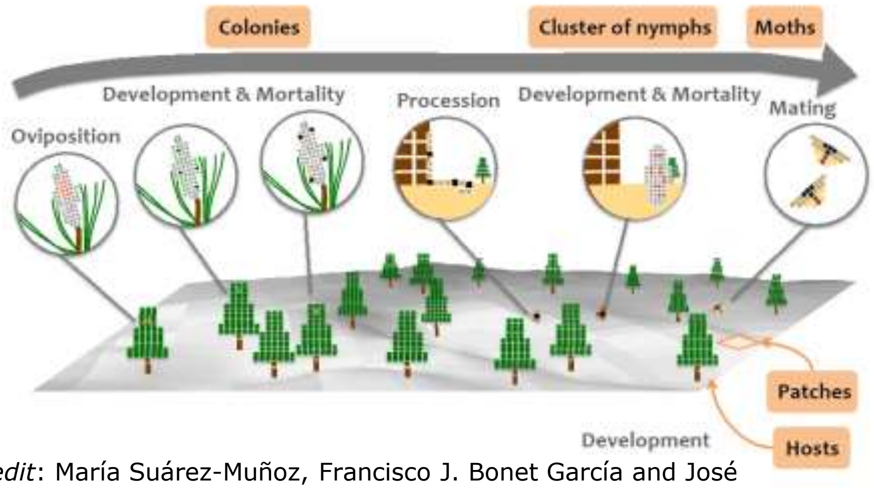
- INSTAR is an agent-based model that simulates the pest development in a given area, for which elevation and pine trees are considered.
- It also integrates environmental information into a population dynamic model, namely meteorological variables obtained from the hydrological model WiMMed (Herrero et al. 2009) executed for the area of interest.
- All these variables are inputs of the model and feed a set of functions simulating pine growth, processionary development, mortality and movement.

María Suárez-Muñoz, Francisco Javier Bonet-García, José A. Hódar Correa, Javier Herrero Lantarón, Mihai Tanase, Lucía Torres-Muros. INSTAR: an Agent-Based model linking climate and the biological cycle of forest pests in Mediterranean ecosystems. Ecological Modelling (under review)

Ecological background



Modelled system



Picture Credit: María Suárez-Muñoz, Francisco J. Bonet García and José A. Hódar, INSTAR: simulating the biological cycle of a forest pest in Mediterranean pine stands University of Granada, Spain, EGU 2017.

INSTAR

Input data:

- Digital Elevation Model, as raster (asc);
- Pines location (shp) (calculated from LiDAR data);
- Land cover map, as raster (asc);
- WiMMed-produced maps of daily minimum and maximum temperature, as raster (asc).

Output data:

INSTAR generates a table where state variables are described for the whole simulated area. These cover the number of pine processionary moths, at each stage for each day of the simulation, as well as the percentage of infected pines and average biomass of the pines.

COINS

(Developed by CNR-IAC team: A. Martiradonna, F. Diele, C. Marangi)

Objective is to calculate the optimal spatiotemporal COntrol of INvasive Species (COINS) in natural protected areas of high conservation value.

Applied to Murgia Alta PA for *Ailanthus Altissima* plant species, where an on-going eradication program runs (in-field data provided by the EU LIFE - LIFE12 BIO/IT/000213 Alta Murgia Project).

- Related Storyline: Interaction between agro-ecosystems and natural grasslands: stone graining and loss of natural ecosystems
- Protected Areas of application: Murgia Alta (Italy)
- Technical details: R (version 3.5.0) language

Ailanthus altissima

Picture Credit: https://en.wikipedia.org/wiki/Ailanthus_altissima

COINS

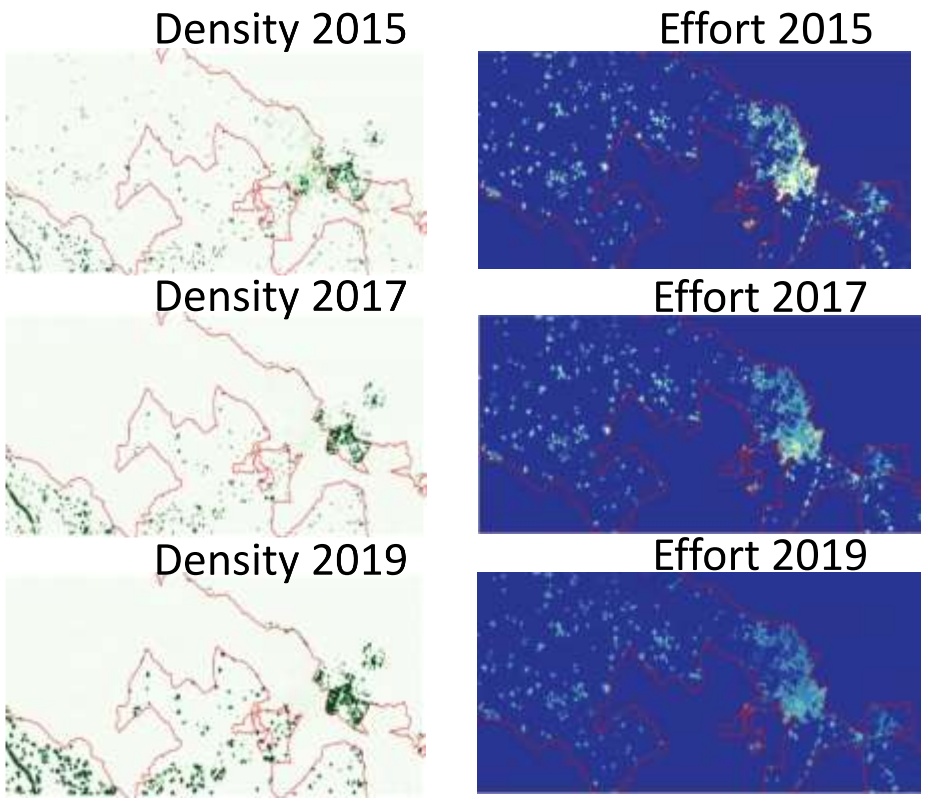
Approach: The model is based on diffusion equations and includes a functional response, which models the control rate as a function of the state variable, i.e. the invasive species density.

-> The species growth is modulated by a habitat suitability function internally computed by using the land cover map of the study area and the map of the initial density of the invasive species.

-> Control variable: the effort needed to eradicate the invasive species (budget constraint is imposed to the amount of effort as well).

-> The routine solves a constrained optimal control problem, by searching for optimal effort allocation, which minimizes invasive species density in time & space.

Baker, C.M., Diele, F., Marangi, C., Martiradonna, A., Ragni, S. (2018). Optimal control governed by a diffusion PDE with Holling type II reaction term and budget constraint, Natural Resource Modelling.



5 years eradication plane (2014-2019). Raster time series of the population density under control, along the simulation period & Raster time series of the effort allocation strategy for the control of the species, along the simulation period.

COINS

Input data:

- All model parameters (species parameters e.g. growth & diffusion, budget constraint etc.) (csv);
- Map of initial density of the species (tif);
- Boundary of the area (shp);
- Land cover map (shp).

Output data:

- Habitat suitability map (tif);
- Raster time series of the effort allocation strategy for the control of the species along the simulation period (rts);
- Raster time series of the population density under control along the simulation period (rts).

EO-SDM

(Developed by UFZ team: A. Cord, M. Ewald, E. Kasch, A. Dittrich)

EO-SDM stands for 'Ensemble modelling of species distributions using Earth observation data'.

Objective is to test the applicability of established species distribution modelling algorithms (applied for rove beetles) in combination with remote sensing (RS) data.

- Related Storyline: Mountain biodiversity as a sentinel of environmental change
- Protected Areas of application: Gran Paradiso National Park (Italy)
- Technical details: R language

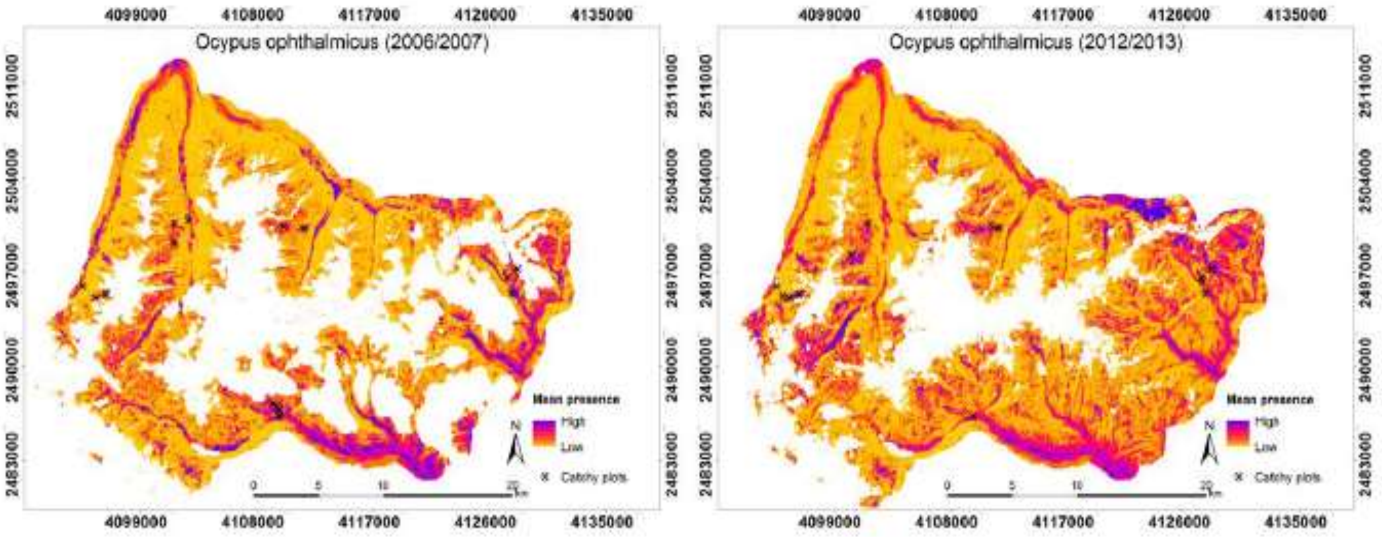
Ocypus ophthalmicus

Picture Credit: https://en.wikipedia.org/wiki/Ocypus_ophthalmicus

EO-SDM

Approach: The modeling framework is not based on a new algorithm, but makes use of established species distributions modeling algorithms (Maxent, Random Forest – RF and Generalised Linear Models - GLM, as implemented in the biomod2 package version 3.1) and tests their applicability in combination with RS data.

The code includes the calculation of a model uncertainty map and provides algorithm-specific estimates of the importance of various RS input variables.



Mean species distribution likelihood for *Ocypus ophthalmicus* in 2006/2007 and 2012/2013 based on aggregated true presence data for model training. Locations of catchy plots area also shown to emphasize variability of input data for model training.

Dittrich, A., Cerrato, C., Ewald, M., Sonnenschein, R., Viterbi, R., Cord, A. Modelling distributions of rove beetles in mountainous areas using remote sensing data. Remote Sensing (under review)

EO-SDM

Input data:

- Remote Sensing data (GeoTiff): Digital Elevation Model, Eastness, Greenness, Land Surface Temperature, Northness, Slope, Terrain Ruggedness Index, Wetness variables maps;

- Input species data incl. geographic coordinates of species locations (csv);

- Model parameters (i.e. Random Forest & Maxent-related parameters) (txt).

Output data:

Maps of species-specific habitat suitability and model uncertainty (raster data, GeoTIFF).

IRIS-SDM

(Developed by ICETA/InBIO team: J. Goncalves, S. Arenas-Castro)

IRIS-SDM stands for "Infrastructure for Running, Inspecting and Summarizing Species Distribution Models".

Objective is to predict spatial distribution of suitable habitat conditions (tested with *Iris boissieri*) derived from Species Distribution Models for narrowly distributed species based on satellite-derived Ecosystem Functional Attributes (EFA).

- Related Storyline: Vegetation Dynamics as a Proxy of Socio-ecological Transitions and Future Societal Benefits in Mountain PAs
- Protected Areas of application: Peneda-Gerês National Park (Portugal)
- Technical details: R language

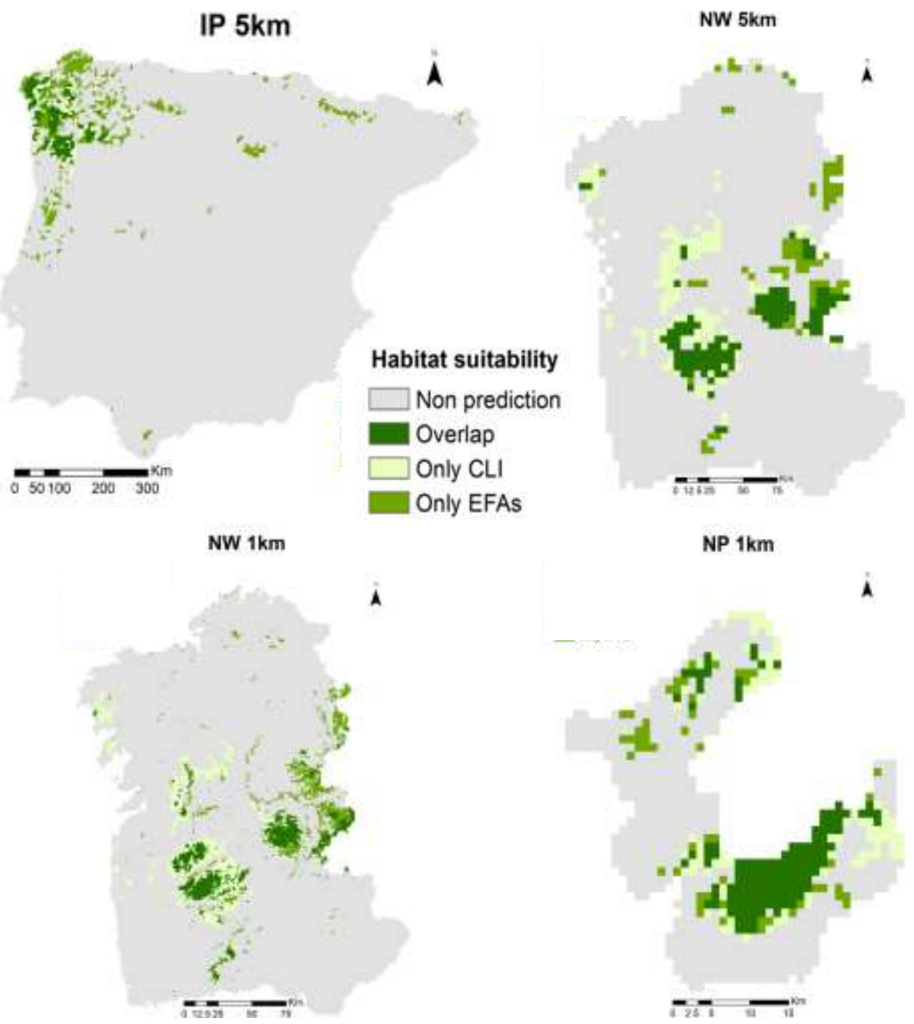
Iris boissieri

Picture Credit: https://en.wikipedia.org/wiki/Iris_boissieri

IRIS-SDM

Approach: IRIS-SDM models the species distribution relying on the biomod2 package for multi-algorithm ensemble forecasting and a set of predictors from satellite-derived EFA. -- Three components are considered, related to carbon gains (Enhanced Vegetation Index-EVI), sensible heat (Land Surface Temperature-LST) and radiative balance (albedo).

Figure: Spatial projections of habitat suitability for *Iris boissieri* derived from SDMs based on traditional predictors (bioclimatic variables - CLI) and on satellite-derived EFA. Overlay maps of current potential presence-absence distributions predicted using an ensemble modelling approach per combination of spatial extent (IP, NW & NP) and resolution (1km & 5km). IP: Iberian Peninsula; NW: Northwest IP; NP: Peneda-Gerês National Park.



Arenas-Castro, S., Gonçalves, J., Alves, P., Alcaraz-Segura, D., & Honrado, J. P. (2018). Assessing the multi-scale predictive ability of ecosystem functional attributes for species distribution modelling. PloS one, 13(6), e0199292.

IRIS-SDM

Input data:

- Set of predictor variables with known linkage to the target species' distribution and habitat suitability (GeoTiff raster files);

- Input species records containing presence-only records for the target species (csv);

- Set of parameter values for running R biomod2 package ensemble modelling approach (csv).

Output data:

- Model-based spatially-explicit predictions for the current distribution of the target species in raster format and GeoTIFF format.
- Tables (csv) containing a summary of model performances for partial and ensemble models as well as an importance ranking for each predictor variable.

Hydrology model and modules

WiMMed

(Developed by the Fluvial Dynamics and Hydrology Research Group/ UCO)

Objective is to generate maps for two ecosystem services related to hydrology (aquifer recharge & surface runoff) with the hydrological model WiMMed.

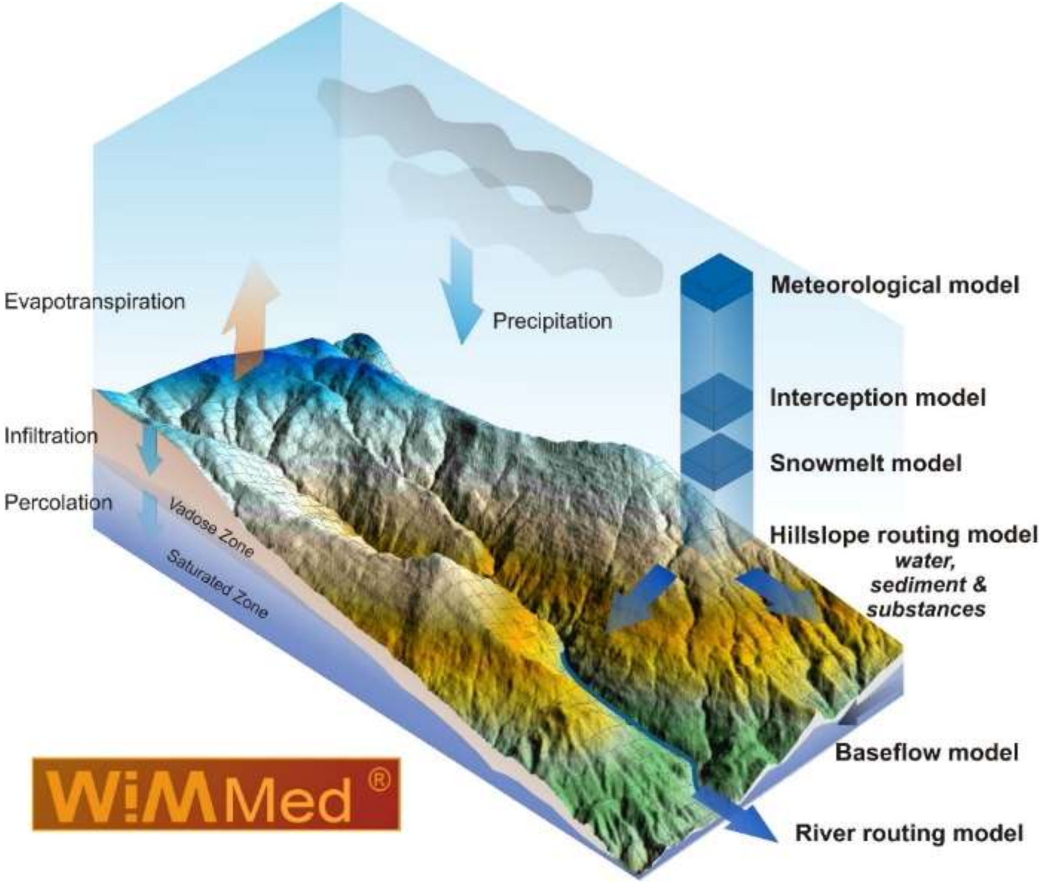
Applied to Sierra Nevada PA at 90x90m for 2007-2008.

- Related Storyline: Temporal evolution of ecosystem services in Sierra Nevada
- Protected Areas of application: Sierra Nevada (Spain)
- Technical details: Python language

WiMMed

Approach: In general, WiMMed simulates the whole water cycle. It starts with the interpolation of the meteorological variables in space (meters) & time (hourly). Then, it simulates interception, snow accumulation/snowmelt, infiltration, surface runoff, soil water movement, evapotranspiration, aquifer recharge/discharge, river flow, sediment production/transport.

Two services are studied in the Vlab case: i) *Surface runoff,* which is an ES of water regulation, as it represents the excess of water that directly flows into rivers, making it susceptible to generate floods. ii) Accumulated *aquifer recharge,* which is an ES of water provisioning related with available water for drinking & cropping in low-elevation places during summer.



Herrero, J., Millares, A., Aguilar, C., Dıaz, A., Polo, M. J., & Losada, M. A. (2011). WiMMed. Base teórica.(WiMMed. Theoretical basis). Grupo de Dinámica de Flujos Ambientales,(University of Granada) and Grupo de Dinámica Fluvial e Hidrologıa,(University of Córdoba), Granada.

WiMMed

Input data:

- Topography (DEM, from which the rest of topographical properties are automatically calculated);

- meteorology (precipitation, temperature, solar radiation, wind speed, relative humidity) measured in meteorological stations;

- soil properties (physical & hydrological properties as saturated hydraulic conductivity, depth, soil moisture saturation..., in two different layers);

- vegetation cover (veg. fraction cover, veg. maximum storage capacity, transpiration capacity).

For more details, the WiMMed user manual can be found here.

Output data:

- Accumulated surface runoff generated in each cell and Accumulated aquifer recharge
- Rest of hydrometeorological variables generated by WiMMed: Accumulated precipitation as rainfall + snowfall, acc. snowfall, mean temperature, acc. potential evapotranspiration, acc. solar radiation, acc. vegetation interception, acc. soil surface infiltration, acc. evaporation/sublimation from the snow cover & acc. evapotranspiration from the soil.

WaterMasks

(Developed by CERTH team: G. Kordelas, I. Manakos, M. Bakratsas, K. Marini, G. Chantziaras)

Objective is to estimate the free open surface water extent of an area.

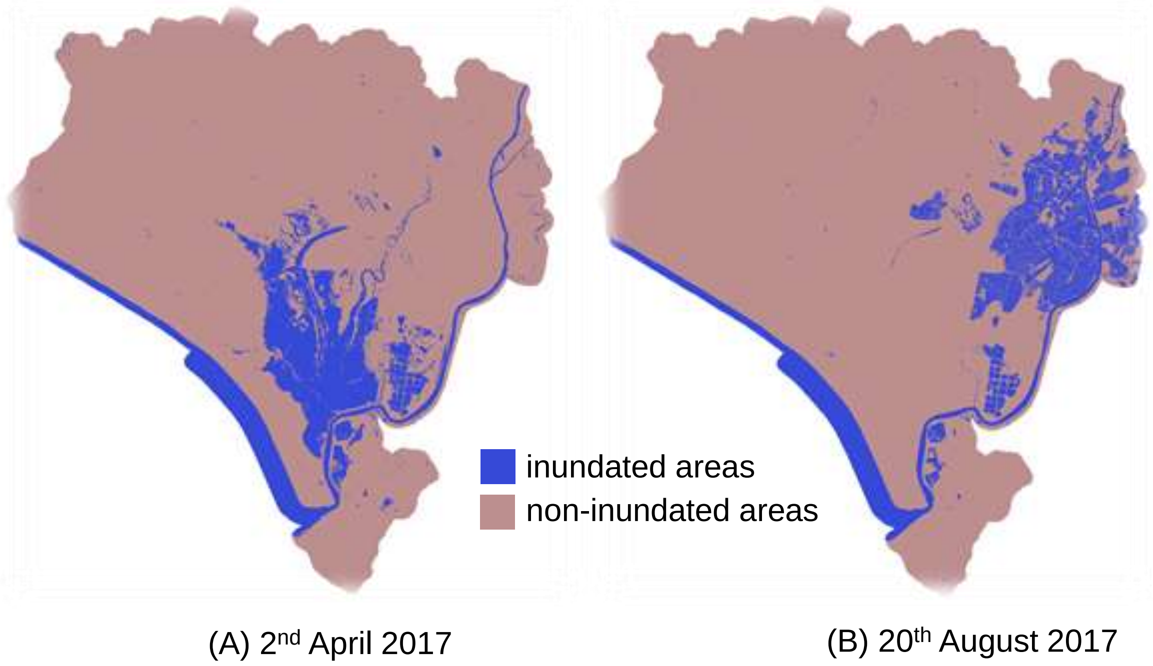
- Related Storyline: Conserving dynamic wetlands under combined global, regional and local stressors
- Protected Areas of application: Doñana (Spain), Camargue (France)
- Technical details: Python language

The module applies a novel automatic thresholding methodology for separating water class areas from non-water class areas from a single Sentinel-2 radiometrically corrected image **in an effort to minimize the need for the user's intervention**.

WaterMasks

-> The module detects automatically thresholds on the Short-Wave Infrared (SWIR) band and on a Modified-Normalized Difference Vegetation Index (MNDVI) derived from the Sentinel-2 data.

-> After combining them in a meaningful way, based on a knowledge base coming out of an iterative trial and error process, it finally present values for two classes of interest, namely flooded (water class) and dry (non-water class) areas.



Water masks of Doñana National Park on (A) 2nd April 2017 and (B) 20th August 2017, depicting the marshlands (A) that are dried during summer months, and the artificially flooded rice paddies (B).

Kordelas, G.A.; Manakos, I.; Aragonés, D.; Díaz-Delgado, R.; Bustamante, J. Fast and Automatic Data-Driven Thresholding for Inundation Mapping with Sentinel-2 Data. Remote Sens. 2018, 10, 910.

WaterMasks

Input data:

Rasters (GeoTIFF files of the required bands) of the area; Following six bands required: Band 2 - Blue, Band 3 - Green, Band 4 - Red, Band 5 - Red Edge Vegetation, Band 7 - Infrared Edge Vegetation, Band 11 – SWIR.

Output data:

WaterMasks (in GeoTIFF format) with distinct values for flooded and dry areas.

HydroMap

(Developed by CERTH team: G. Kordelas, I. Manakos, M. Bakratsas, K. Marini, G. Chantziaras)

Objective is to calculate the hydroperiod of a given area for a desired time-period from a series of Sentinel-2 satellite-based water masks, falling within the time-period between the starting and the ending date of the hydroperiod*.

- Related Storyline: Conserving dynamic wetlands under combined global, regional and local stressors
- Protected Areas of application: Doñana (Spain), Camargue (France)
- Technical details: Python language

* *meaning the length of time the area remains flooded throughout a defined period*

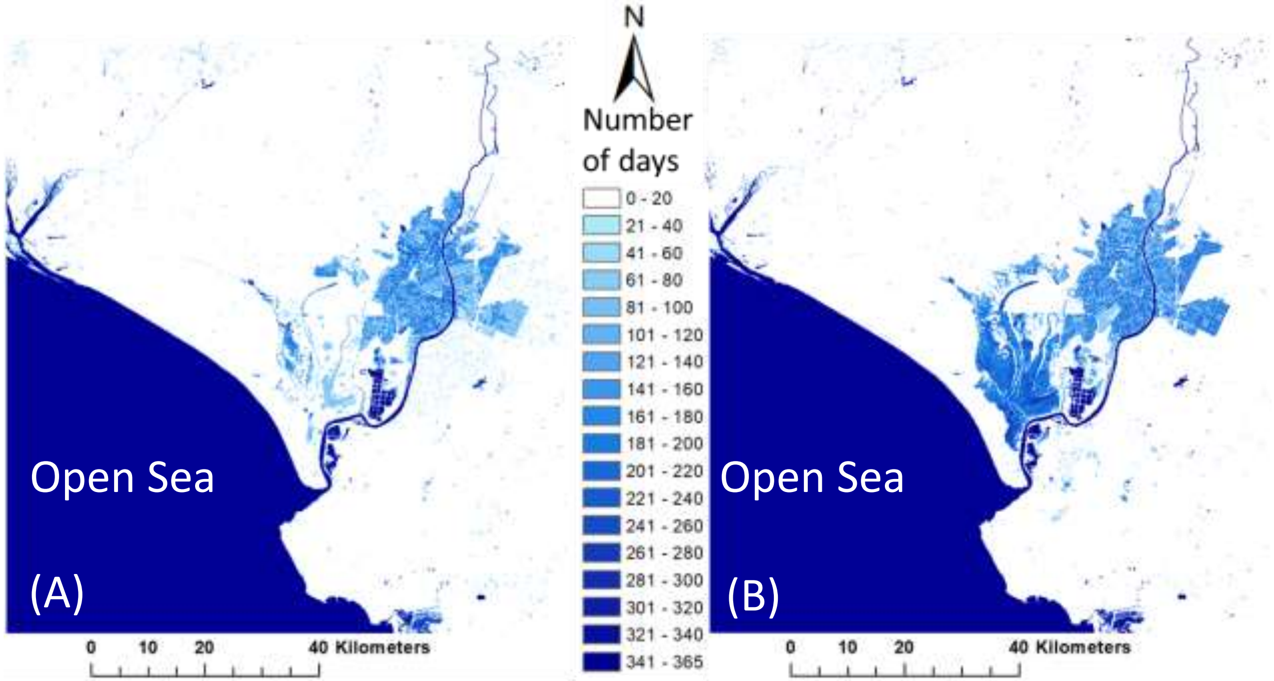
HydroMap

Interpolation approach:

-> For two dates separated by n days, the occurrence of water is compared.

-> If a pixel is inundated on both dates, then it is assumed inundated for n-days. If a pixel is not inundated on both dates, then it is assumed inundated for n/2 days.

-> The total number of days of inundation per pixel is determined by accumulating the water masks throughout the desired time period.



Hydroperiod maps generated for the periods: (A) 01.09.2015 to 31.08.2016, and (B) 01.09.2016 to 31.08.2017, for Doñana National Park, using Sentinel-2 data.

Díaz-Delgado, R.; Aragonés, D.; Afán, I.; Bustamante, J. Long-Term Monitoring of the Flooding Regime and Hydroperiod of Doñana Marshes with Landsat Time Series (1974–2014). Remote Sens. 2016, 8, 775.

HydroMap

Input data:

- Watermasks (in GeoTIFF format) of the area (at least 2 rasters required);
- Additional textual information containing core configuration settings.

Output data:

HydroMap (in GeoTiff format).

LAST-EBD (Flood Mask, Water Turbidity & NDVI)

(Developed by CSIC team: D. Díaz, R. Díaz-Delgado, I. Afán, D. Aragonés, J. Masó, L. Pesquer, J. Bustamante)

Objective is to generate a series of thematic raster files from a Landsat scene and more specifically the Normalized Difference Vegetation Index (NDVI), water turbidity, and flood (water) mask.

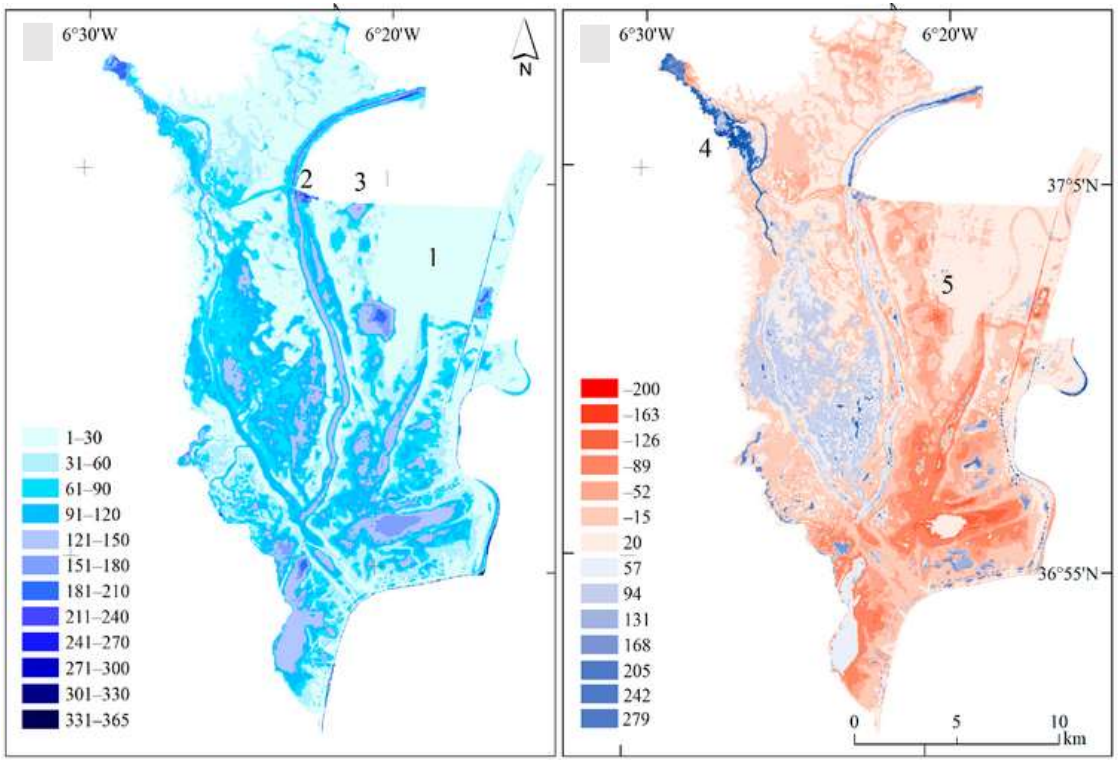
- Related Storyline: Conserving dynamic wetlands under combined global, regional and local stressors
- Protected Areas of application: Doñana (Spain)
- Technical details: Python language (GDAL and FMASK are also used)

LAST-EBD (Flood Mask, Water Turbidity & NDVI)

-> The process first generates a normalized image, based on pseudo-invariant areas, upon which it afterwards calculates the three aforementioned products.

-> Generated flood masks are finally used for the hydroperiod estimation of the respective area.

-> Calculated hydroperiod is an important ecological parameter driving the growth and composition of vegetation communities, and the abundance and distribution of animals in wetlands.



(A) Mean hydroperiod for Doñana marshes (1974–2014); (B) Hydroperiod anomaly calculated for the flooding cycle 2007–2008. Both are expressed in days per year.

Díaz-Delgado, R.; Aragonés, D.; Afán, I.; Bustamante, J. Long-Term Monitoring of the Flooding Regime and Hydroperiod of Doñana Marshes with Landsat Time Series (1974–2014). Remote Sens. 2016, 8, 775.

LAST-EBD (Flood Mask, Water Turbidity & NDVI)

Input data:

- Landsat scene;
- Additional information about Pseudo Invariant Areas (PIAs) for normalization.

Output data:

- NDVI;
- Flood mask;
- Water Turbidity mask.

Phenology modules

PhenologyMetrics

(Developed by CERTH team: G. Kordelas, I. Manakos, M. Bakratsas, K. Marini)

Objective is to generate phenology related layers relying on NDVI time series covering a vegetation growth period.

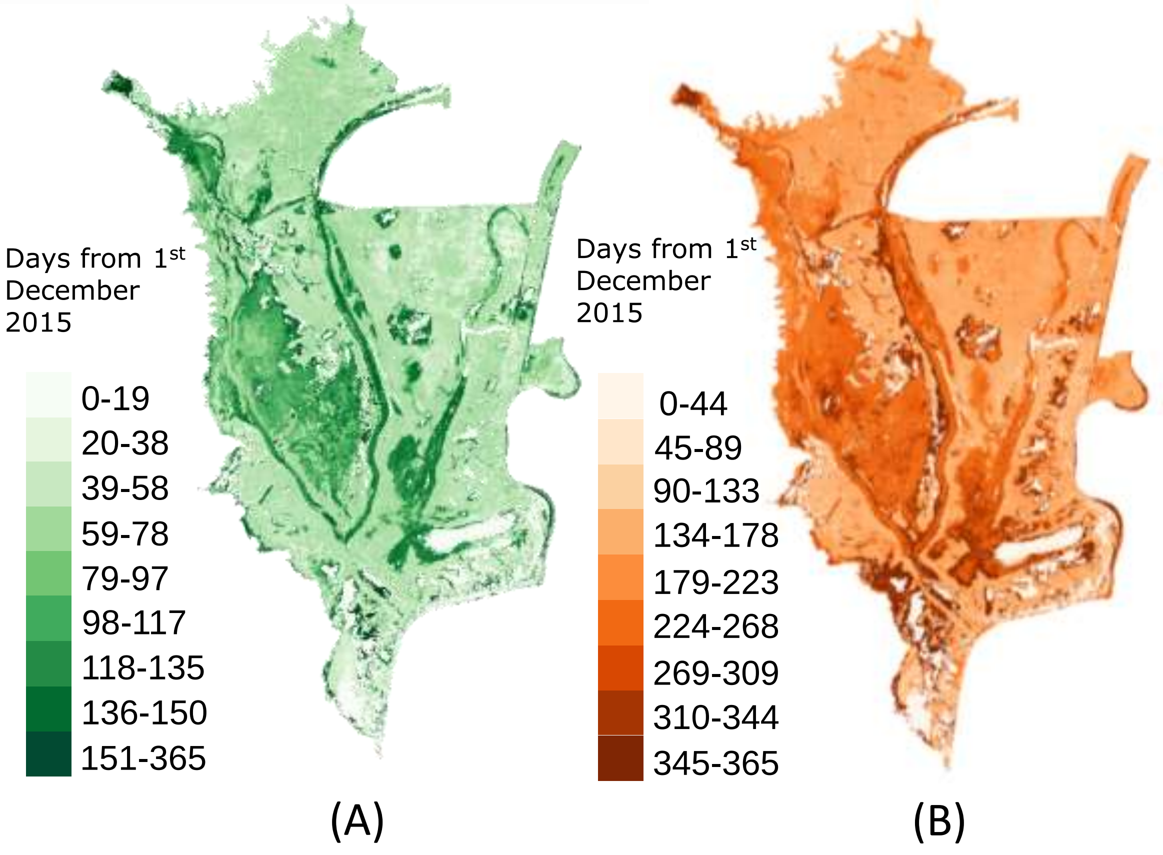
- Related Storyline: Conserving dynamic wetlands under combined global, regional and local stressors
- Protected Areas of application: Doñana (Spain)
- Technical details: R language

PhenologyMetrics

-> Phenology Metrics is relying on the application of the "phenoPhase" function (phenex R package) to NDVI time series layers to estimate per area, NDVI peak, greenup date and senescence date, within the detected values' fluctuation (possible phenological cycles).

-> If values are assigned to objects representing vegetation communities (patches/ objects), then the number of peaks per area is provided, as a proxy for the object's encapsulated biodiversity.

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 (last accessed on 15 June 2019).



Day of year for which (A) greenup and (B) senescence are detected for Doñana marshlands between December 2015 and November 2016.

PhenologyMetrics

Input data:

- NDVI (in GeoTIFF format);
- Additional information (e.g. time period definitions).

Output data:

Raster file with multiple layers of information, namely:

- Day at which greenup takes place;
- Day at which senescence takes place;
- Day with highest NDVI value (peak).
- There is an additional layer, which denotes per pixel the total number of the phenological cycles detected within the set time period.

PhenologyChanges

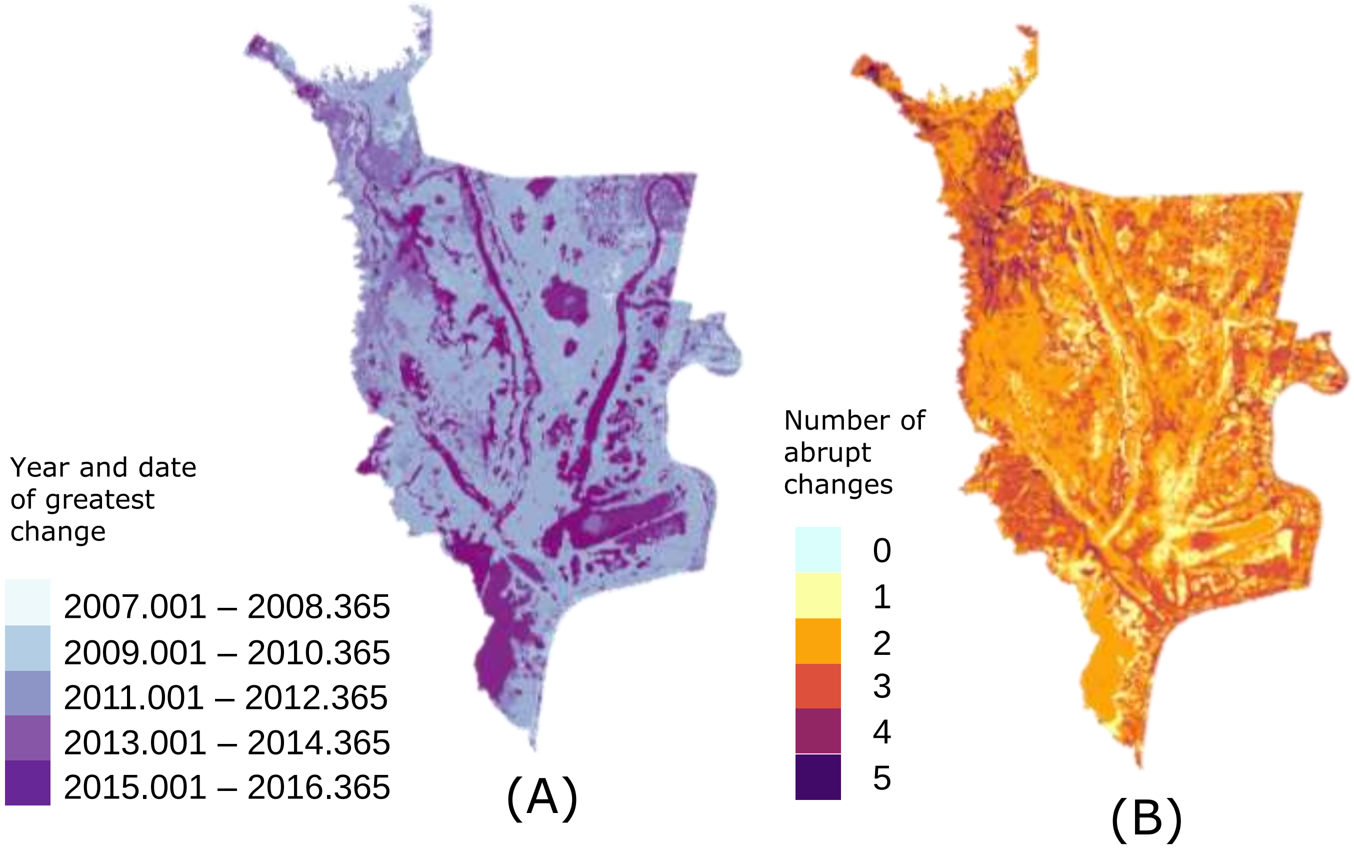
(Developed by CERTH team: G. Kordelas, I. Manakos, M. Bakratsas, K. Marini)

Objective is to calculate the abrupt trend changes in the vegetation phenology cycles throughout numerous annual NDVI series.

- Related Storyline: Conserving dynamic wetlands under combined global, regional and local stressors
- Protected Areas of application: Doñana (Spain)
- Technical details: R language

PhenologyChanges

The module is based on the iterative decomposition of the NDVI time series into trend, seasonal and remainder components via using the Breaks For Additive Seasonal and Trend (**BFAST**) and the consequent detection of the abrupt trend changes within the trend component.



(A) Time period for which the greatest abrupt change occurred {year.day-of-year} in Doñana marshlands, and (B) total number of abrupt changes that occurred between 2007 and 2016.

Verbesselt, J.; Zeileis A.; Hyndman, R.: Breaks For Additive Season and Trend (BFAST), R Package Version 1.5.7. Available online: https://cran.r-project.org/web/packages/bfast (accessed on 15 June 2019).

PhenologyChanges

Input data:

- NDVI (in GeoTIFF format). Several raster files shall be provided covering a wide range of years. They will be used to create an interpolation for all calendar days within the years range based on the earliest and latest chronological dates of the provided raster files.
- Additional textual information.

Output data:

- Total number & occurrence dates of abrupt changes;
- Date of the maximum abrupt change.

Landscape model and modules

MountainMetapop

(Developed by EPFL team: J. Giezendanner, D. Pasetto)

Objective is to study the impact of landscape topography on species distribution under climate warming. Applied to Gran Paradiso National Park PA as a case study on how elevation influences metapopulation dynamics in time and space.

- Related Storyline: Mountain biodiversity as a sentinel of environmental change
- Protected Areas of application: Gran Paradiso National Park (Italy)
- Technical details: Python language

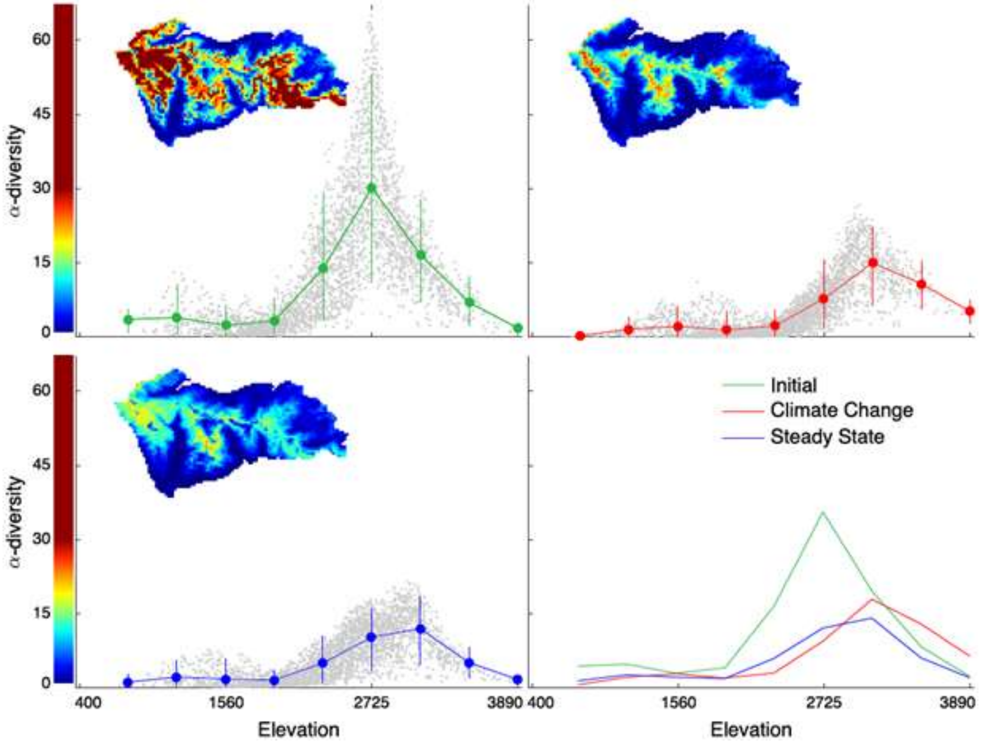
MountainMetapop

-> Simulates the average presence of a species with certain traits in a landscape, based on spatial patch occupancy model (SPOM).

-> The model consists of local colonization and extinction events that randomly occur in space and time.

-> The probability of occurrence of these events on a particular grid cell depends on the global species occupancy and on the fitness of the species to the local landscape features.

Giezendanner, J., Bertuzzo, E., Pasetto, D., Guisan, A., & Rinaldo, A.. A minimalist model of extinction and range dynamics of virtual mountain species driven by warming temperatures. PloS one, 2019, 14(3), e0213775.



α-diversity per grid cell at different elevations; results at different temporal phases of the climate warming simulation: the "initial phase" (green) represents the current conditions, "climate change" (red) is the α-diversity after 100 years of warming and "steady-state" (blue) shows the final results under the new climate.

MountainMetapop

Input data:

- Digital elevation model (DEM);
- Specific parameter values of a focus species (i.e. optimal elevation, dispersal rate, niche width, colonization- and extinction rate).

Output data:

- Average presence of a single species (tif).

LandMetrics

(Developed by CERTH team: Z. Petrou, I. Manakos, M. Bakratsas, G. Kordelas, K. Marini, G. Chantziaras)

Objective is to calculate numerous landscape measures used as indicators of fragmentation and/or connectivity of land cover or habitat classes in a selected study area.

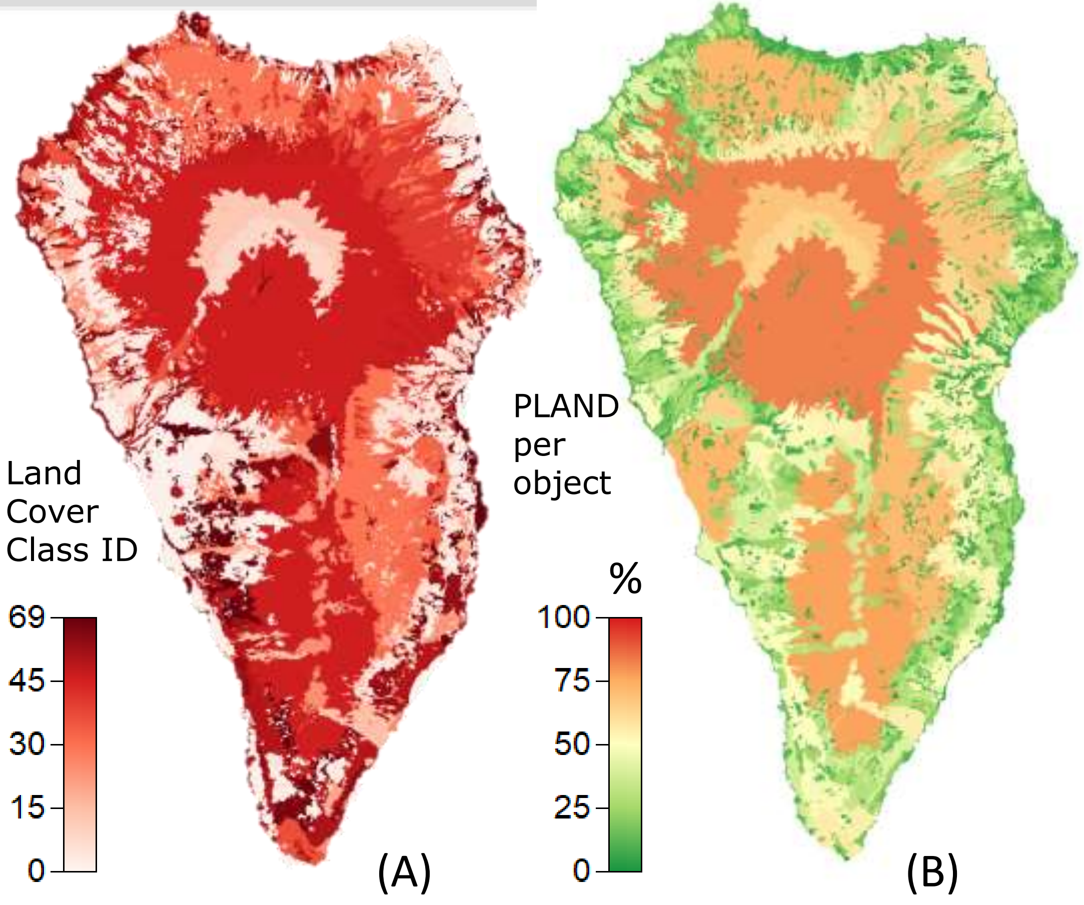
- Related Storyline: Invasive species impacting the functioning and services of island protected areas through losses of endemic species
- Protected Areas of application: Sierra Nevada (Spain), Samaria (Greece), Montado (Portugal), Lake Prespa (FYROM), La Palma (Spain), Curonian Lagoon (Lithuania)
- Technical details: Python language

LandMetrics

Calculated measures (outputs) correspond to selected FRAGSTATS metrics and include:

- Percentage of landscape (PLAND)
- Total class area (CA);
- Patch density (PD)
- Mean patch size (MPS)
- Shape index (SHAPE) distribution
- Effective mesh size (MESH)
- Area-weighted mean patch fractal dimension (AWMPFD)

Petrou, Z.I.; Manakos, I.; Kosmidou, V.; Lucas, R.; Adamo, P.; Tarantino, C.; Blonda, P. Indicator extraction software. FP7 project BIO_SOS, Deliverable 6.12, 2013.



Land Cover of (A) La Palma island in 2007, and (B) its corresponding Percentage of landscape (PLAND) map.

LandMetrics

Input data:

- GeoTiff image file that represents a land cover or habitat class.

Output data:

- File with calculated landscape measures;
- File with values of the indicators for each object;
- Segmentation class as a GeoTiff raster, in case not provided by user as input.

SpeckleRemoval

(Developed by CERTH team: G. Kordelas, I. Manakos)

Objective is to suppress speckle in the SAR Sentinel-1 product, while keeping the texture structure, by using guided image filtering.

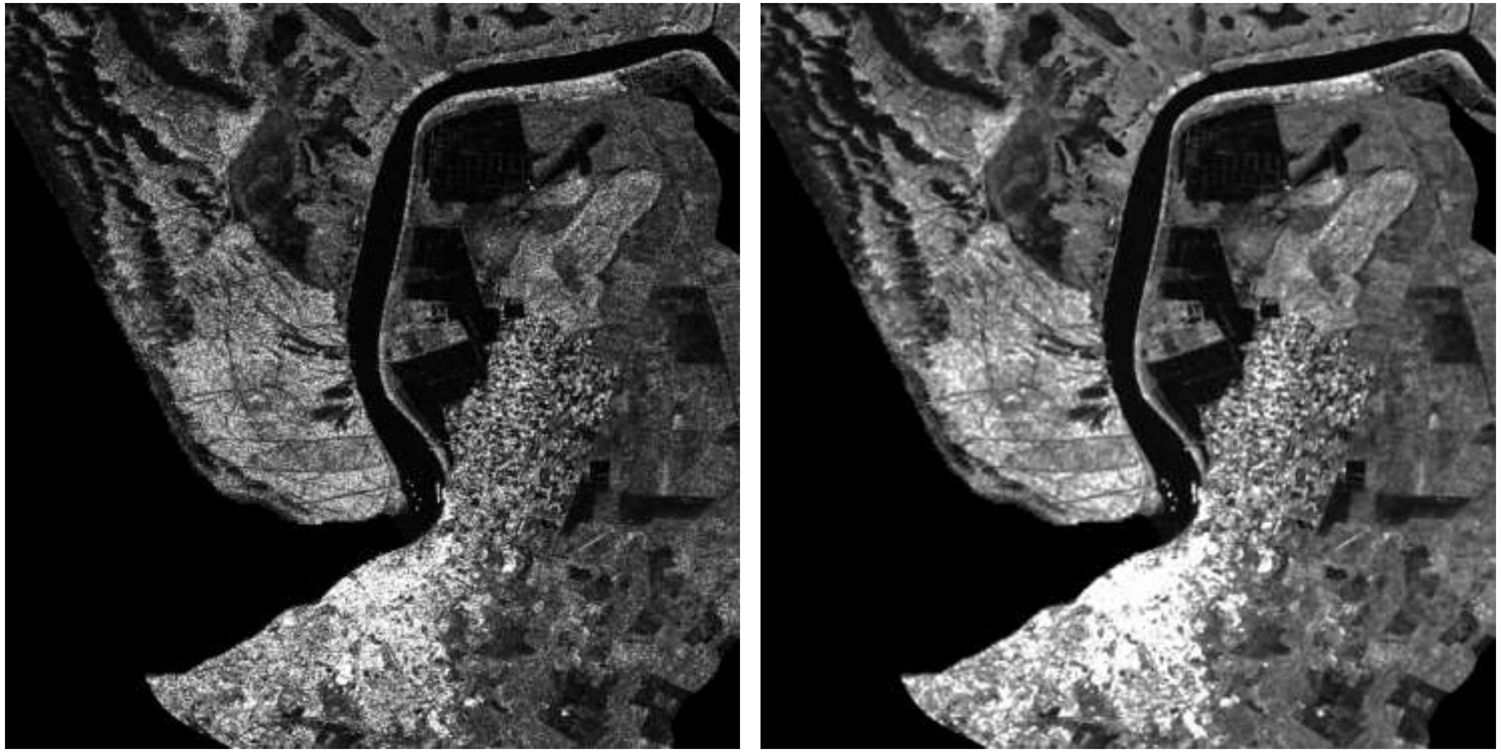
- Related Storyline: Conserving dynamic wetlands under combined global, regional and local stressors
- Protected Areas of application: Doñana (Spain)
- Technical details: Python language

SpeckleRemoval

-> The guided filter computes the filtered output by using the content of a second image, called a guidance image (Sentinel-2 RGB image).

-> It takes into account the statistics of a region in the corresponding spatial neighborhood in the guidance image when calculating the value of the output pixel.

-> Guided filter has a good edge-preserving property, while it suppresses speckle noise.



SAR data (A) before despeckling and (B) after despeckling.

Verdoliva, L.; Amitrano, D.; Gaetano, R.; Ruello, G.; Poggi, G. SAR despeckling guided by an optical image. IEEE International Geoscience and Remote Sensing Symposium, 2014, pp. 3698-3701.

SpeckleRemoval

Input data:

- A geotiff image file that represents the guided image;
- A geotiff image file that represents the guidance image (Sentinel-2 RGB);
- Additional text files including definitions of the images' filenames to be used and the core configuration settings.

Output data:

- A raster file with the despeckled SAR image.

Relevant applications within SCERIN

Idea → **Vision**

-> Identify application areas of interest

-> Identify Protected Areas within SCERIN

Please get engaged with ideas

-> Joint scientific efforts

-> Joint papers

Please attend our tomorrow session about *"Progress on three studies/papers, next steps and alternatives"*

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

CENTRE FOR RESEARCH & TECHNOLOGY - HELLAS
Information Technologies Institute