An automatic workflow based system to download, process and analyze remote sensing information: Creating knowledge to foster environmental decision making

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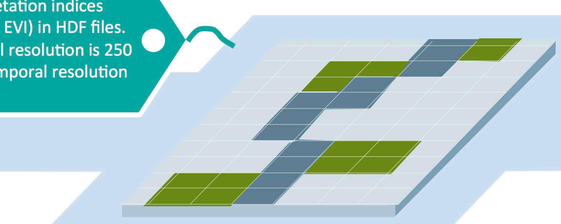
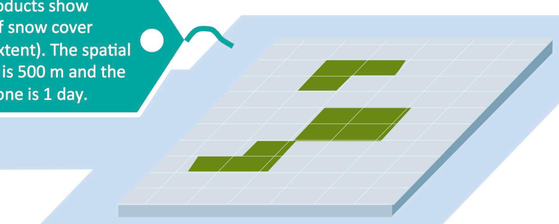
MOD13Q1 MODIS products show vegetation indices (NDVI and EVI) in HDF files. The spatial resolution is 250 m. The temporal resolution is 16 days.



MOD10A1 and MOD10A2 MODIS products show features of snow cover (albedo, extent). The spatial resolution is 500 m and the temporal one is 1 day.

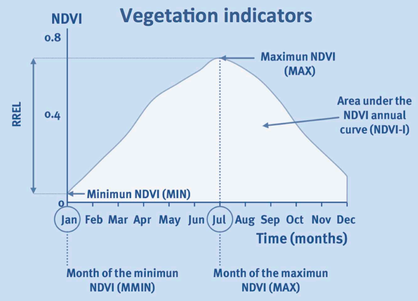


The first step in our processing chain is to extract useful information from HDF files and store it in a PosgreSQL database which allows to create complex queries.

We have created an indicator system whose main aim is to assess significant changes in the habitats existing in the Sierra Nevada Natura 2000 site. This system automatically downloads, process and analyse raw data from two MODIS products (snow cover and vegetation indexes). Besides, the system calculates automatically several indicators to assess different ecological functions of Sierra Nevada habitats: phenology, seasonality of biomass production, duration of snow cover, etc. We also calculate trends in those indicators. These indicators are aggregated into composite indexes that allow to identify habitats suffering significant changes in both their ecological functions and physical context. Finally we created an ontology that adds semantic meaning to the whole dataset. This allows the formulation of complex questions regarding the changes observed in habitats.

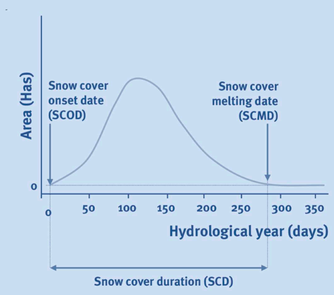
Sierra Nevada is an isolated high mountain (reaching 3482 m. a. s. l.) located in Southern Spain. It's considered the most important biodiversity hotspot in the Western Mediterranean region. It is a Biosphere Reserve, a National Park and belongs to LTER and GLORIA networks

Vegetation indicators



NDVI and EVI seasonal measurements allow to quantify productivity and biomass seasonality as well as phenological information:
annual mean (NDVI-I) can be used to estimate faPAR and thus net primary production.
annual relative range (RREL); difference between maximum and minimum NDVI divided by annual mean. It provides an indicator of the seasonality of the photosynthetic activity.
maximum and minimum NDVI values (MAX and MIN)
months of the maximum and minimum values of NDVI (MMAX and MMIN), which provide an additional description of vegetation phenology, indicating the intra-annual distribution of the periods with maximum and minimum photosynthetic activity.

Snow cover indicators

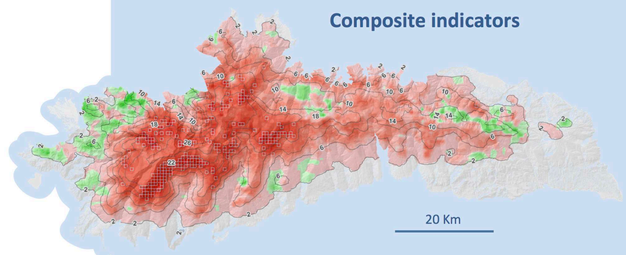


We have used MOD10A2 for this work. This raw information is processed to obtain the following indicators:
snow cover duration (SCD): It summarizes the total effect of snow cover.
snow cover onset dates (SCOD): It refers to the starting date of a snow covered period.
snow cover melting dates (SCMD): This indicator refers to the ending date of a snow cover period.
snow cover melting cycles (SCMC): This index shows the number of melting cycles that suffers each pixel per hydrological year.

Then we calculate a set of indicators regarding snow cover and vegetation indexes. They are obtained via SQL statements for any pixel.

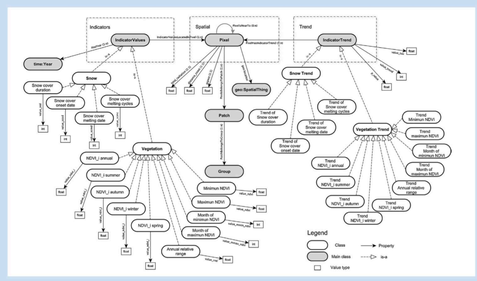
Once the indicators are calculated we can proceed to obtain composite indexes. The so created database is aggregated with semantic processing techniques.

Composite indicators



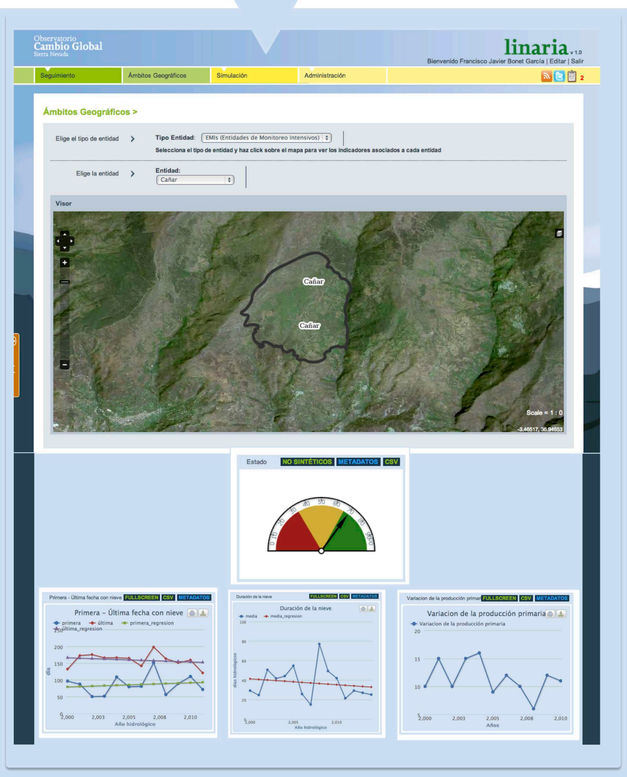
Thanks to the previously described indicators, we can create composite indices to identify significant changes in the habitat functioning. We calculate one composite indicator for vegetation indices and another one for snow cover. The first one has to be with the general functioning of the habitat (production, phenology, etc.) and shows changes in this functioning. The snow cover composite indicator shows deviations in snow patterns. The map shows the Mann-Kendall trend in the snow cover duration per hydrological year from 2000 to 2011. Red pixels show a negative trend. Only grey outlined pixels show a significant trend.

Semantic processing

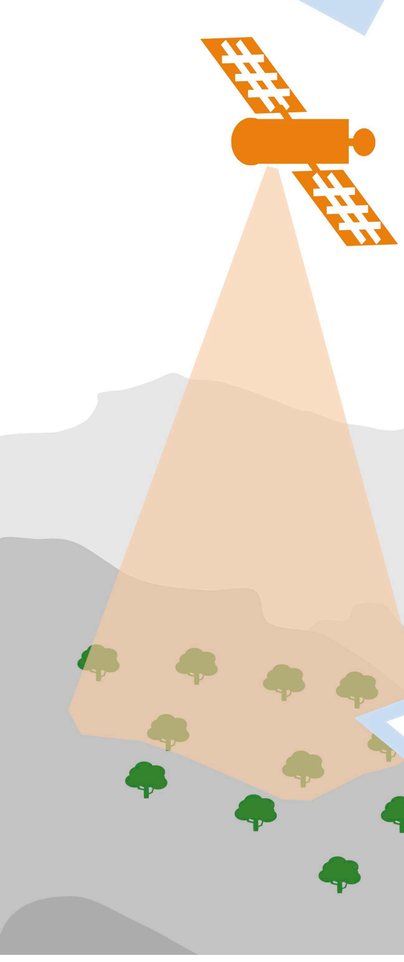


Semantic processing allows spatio-temporal aggregation of huge amount of data. We can dynamically answer different complex questions: Where are the habitats with a significant change in snow and/or vegetation trends? Is there any habitat with a positive trend in vegetation indexes in spring? The resulting ontology (see figure) includes complex domains as time and spatial dimensions. Once we calculated all the indicators, we structured them according to the ontology. By using an ontology reasoning engine, we will discover new relationships between the modelled variables.
The semantic tool can be queried following this link:
http://obsnev.es/ontologia

Finally , we show all the created knowledge in a flexible data portal that also shows information from other biophysical variables in Sierra Nevada: **Linaria**



Linaria is a web portal (**http://linaria.obsnev.es**. Free registration required) that shows both the raw data about vegetation and snow cover and also the composite indicators previously described. It creates dynamic graphs whose metadata show the analytical procedures that have been carried out to create them. Users can also obtain information about the conservation status of selected habitat types. This information will hopefully be used in the last step of the whole process:



Environmental managers will "translate" the above described information into "decisional" energy to improve the conservation status of habitats in a context of global change

More information:
Pérez-Luque, A.J.; Pérez-Pérez, R.; Bonet-García, F.J. & Magaña, P.J. (2015). An ontological system based on MODIS images to assess ecosystem functioning of Natura 2000 habitats: A case study for Quercus pyrenaica forests. *International Journal of Applied Earth Observation and Geoinformation*, 37: 142–151.

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