ECOFAHRE (ECOsystem Functional Attributes High Resolution Estimator) service

Saverio Vicario[1], Maria Adamo[1], Cristina Tarantino[1],
Adrián Regos[2], Domingo Alcaraz-Segura[3], Palma Blonda[1]

[1] CNR-IIA,
[2] Universidade de Santiago de Compostela - Research Centre in Biodiversity and Genetic Resources,
[3] University of Granada, UGR · Department of Botany

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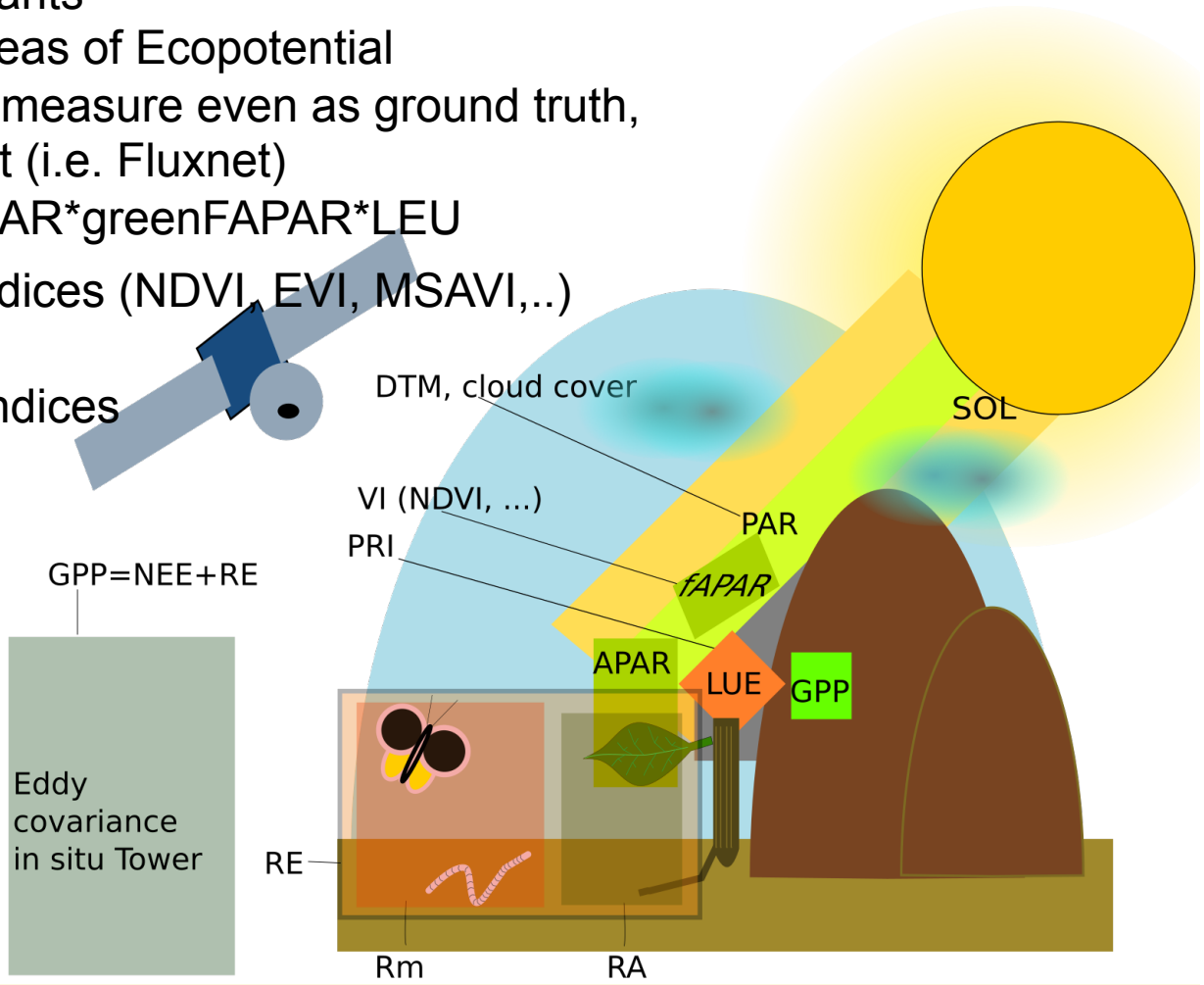
Measuring Primary Productivity

Gross PP= carbon fixed by plants
Requested in all Protected Areas of Ecopotential
Quite difficult to have precise measure even as ground truth,
But good times series do exist (i.e. Fluxnet)
SRS estimator is product of PAR*greenFAPAR*LEU

greenFAPAR ⟶ Structural indices (NDVI, EVI, MSAVI,..)
LUE → PRI
FAPAR*LUE =? Chlorophyll indices

Rossini et al. 2012.
Biogeosciences.;9:2565–2584.
Nestola et al. 2018
Sci. Total Environ. 2018;612:1030–1041.



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Estimators of FAPAR:

Building interpolation and expectation

- Higher spatial resolution is needed where landscape is not so uniform to fit in 300m squares (Mountains area, Mediterranean areas, Karst, …)
- High spatial resolution entails low temporal frequency. (see MODIS vs Landsat5-8 and Sentinel2 frequencies)
- Lower frequency makes estimation more prone to clouds cover and generate sparse times series.
- Raw data statistics are undependable given that missing data are clustered and not random respect to seasonality
- Seasonality estimation method that require equally spaced date become not applicable (i.e. R pkgs as **greenbrown**, **Bfast**).
- Two options:
  - If missing data not excessive -> interpolators
  - If missing data are high -> explicit seasonal models over multi-year data

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Time series for GPP proxy

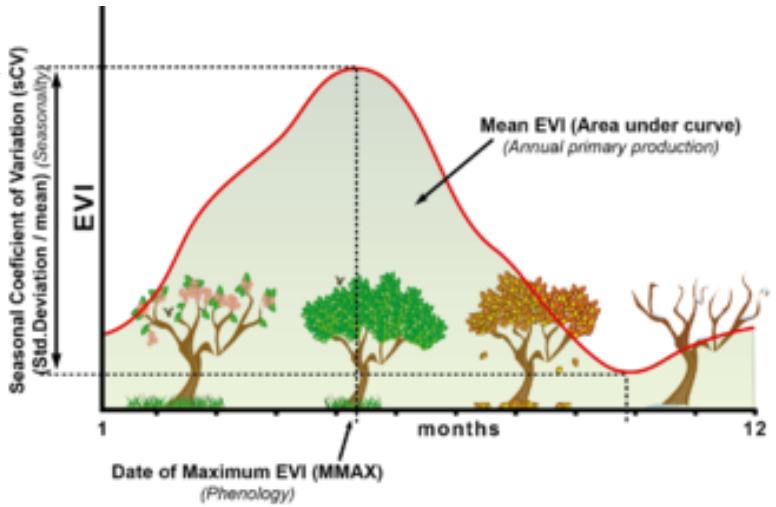
Question by the Ecologist (Domingo Alcaraz Segura):
Can Ecosystem Functional Types (EFT) predict bird biodiversity distribution in Peneda Geres?

- Bird observations in situ (2010) were provided by Adrián Regos Sanz.
- **Peneda Geres (PG):** 66 Landsat (5,7) images (2005-2010)

The areas is highly cloudy: in 2006 only 3 images have less 70% cloud cover, in period 2005-2010 about 11 images per years pass the threshold

EFT is a ecological space defined by 3 seasonality features of GPP:

- Mean value
- Yearly Coefficient of variation (stand. Dev. divided mean)
- Day of the Year of maximum values



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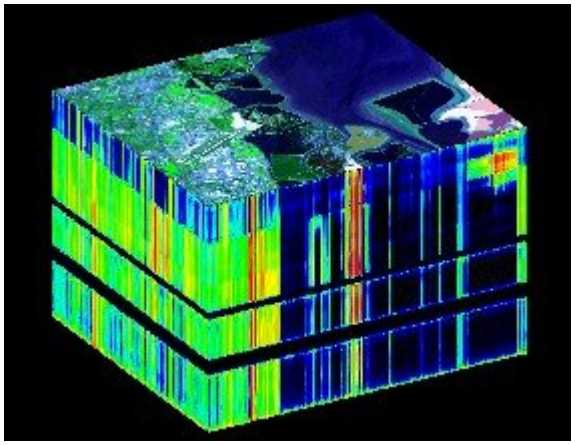
Data analysis

Goal to Build a simple but flexible model to extract Time series dynamics

- Typically observation pixel was covered by a small path with no vegetation while surrounding pixel could have different cover in the same surrounding.
- Seasonality with annual, semester, quadrimester components plus change component: or linear trend or yearly anomalies.
- The mode of fit: linear, robust and weighted (proportional to error expectation given signal intensity)

$$VI_t = \alpha + \alpha_y + \sum_{s \in 1,2,3} \gamma_s \sin\left(\frac{2\pi st}{f_{year}} + \delta_t\right)$$



s= seasonality component

t= time

f_{year}=a year in unit of time

With trigonometric transformation model becomes linear respect to t

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Remote Sens. 2013, 5, 2113-2144; doi:10.3390/rs5052113

Output

A multi-layer ENVI or GeoTiff files

Mod_mean
Mod_CV
Mod_pos
raw_mean
raw_CV
raw_pos
anomal SD

Time series summary:EFT
+ stability indicator

year1
...
year n

Single Year
Anomalies/deviation

liu test p-value
liu test value
harmonic model p-value
harmonic model rsq

Quality Evaluation

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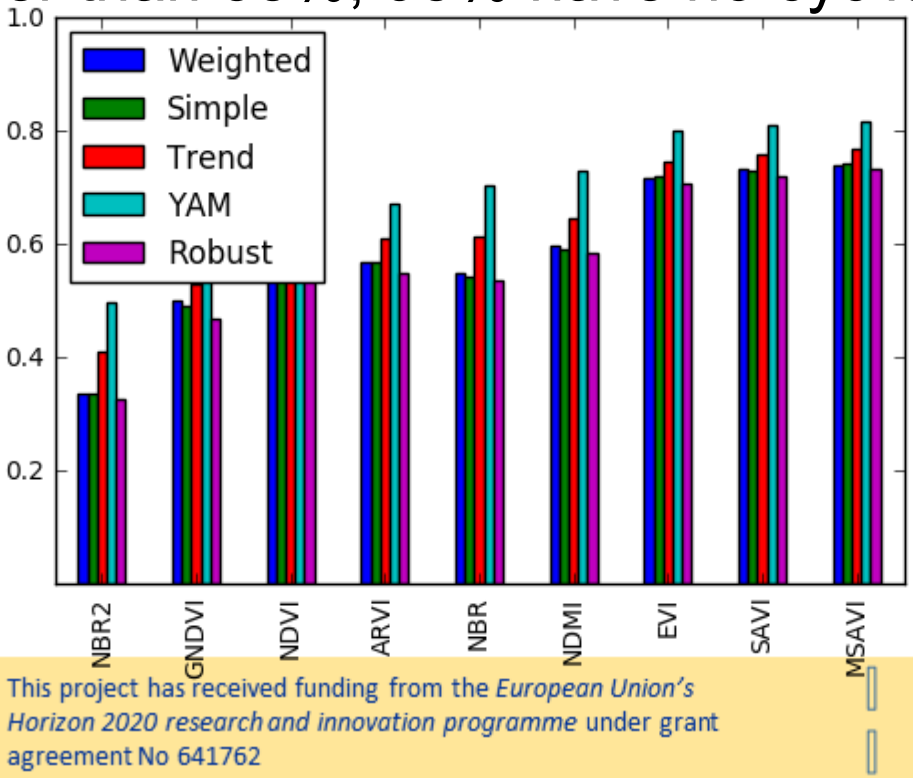
Good fit for 3 harmonics model

- The model with seasonality by year, semester and quadrimester fit quite well data in the pixels around observations.
- MSAVI was found the best indicator. Coupled with best model (YAM) 3% pixels over 0.01 p-value, 90% have Rsq larger than 58%, 98% have no cyclical residuals (p>0.01)



- Weighting by expected error due to signal intensity was useful for NDVI and few others
- Error estimated by partial derivative of indicator over 2 signal channels
- Adding Trend line or different annual mean increase fit

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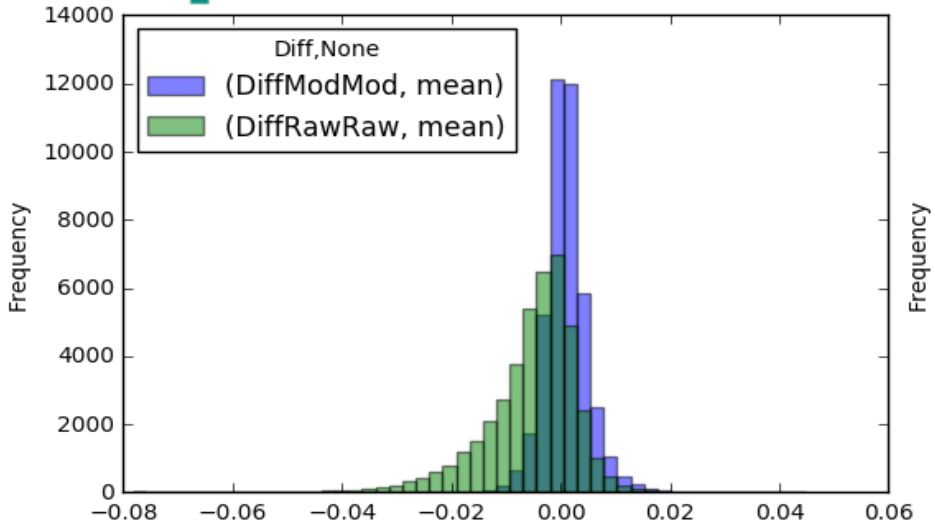
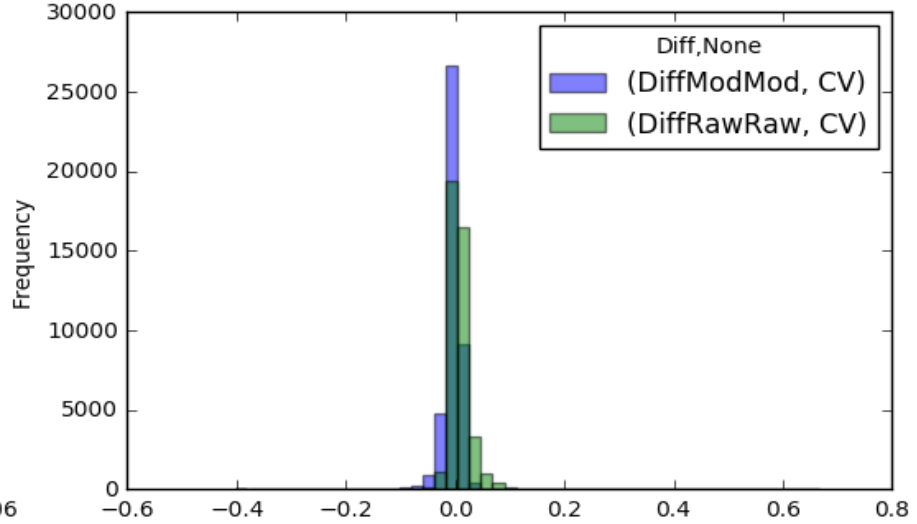
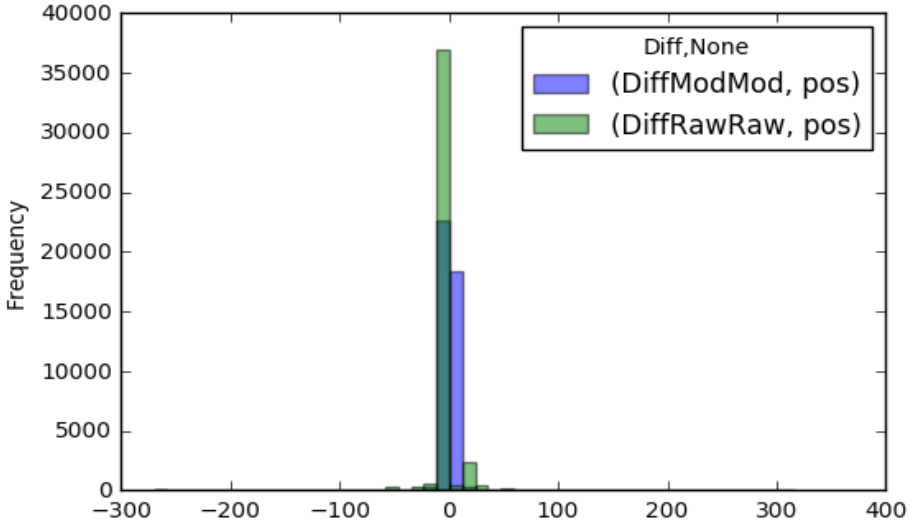
EFT from model or raw data







For the 423 pixels cloud free,
we applied on each 100 random cloud patterns from the rest of the data and calculate 3 EFT dimensions from raw data or from model.
We plot difference within each approach between perturbed and full series.
Model gives Mean and CV less perturbed by clouds, while Model max positition have more small perturbation, while raw data have low frequency larger jump.

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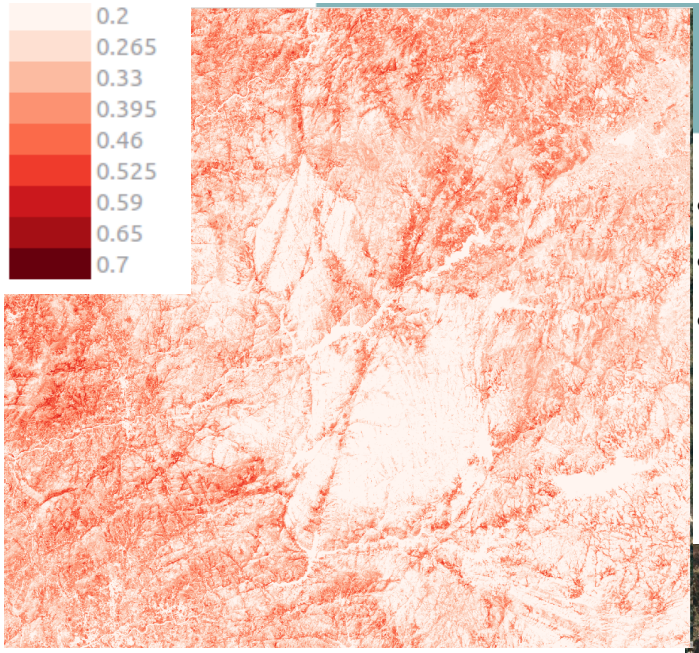
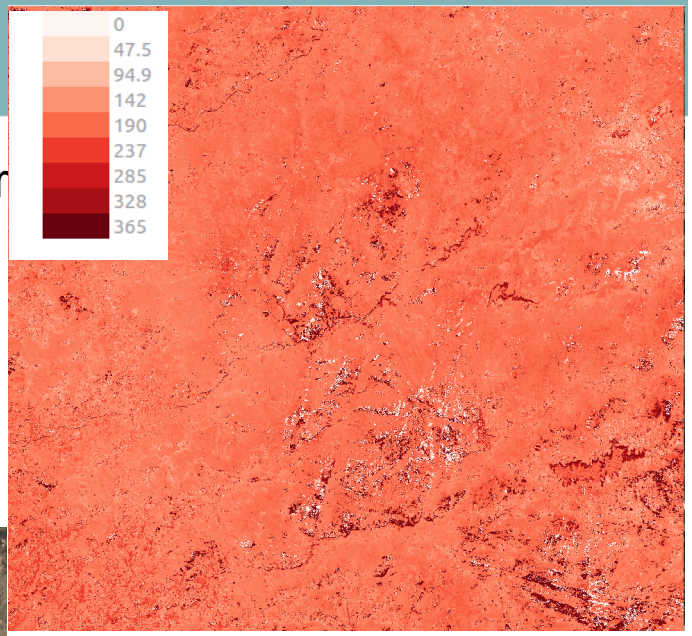
Relatively fast calculation

- Stationary model 1 hour
- YAM Model 2 hours
- for 8CPUs and 32 RAM for 6 millions pixel over 66 views



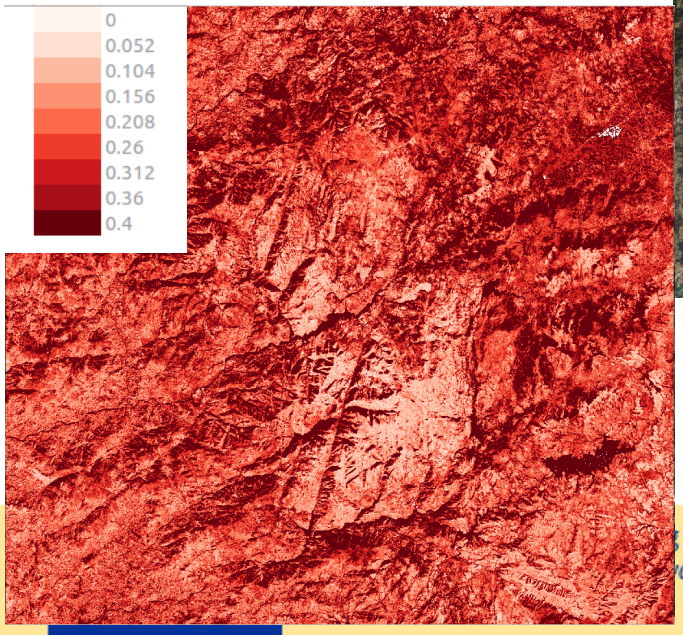
Yearly Mean



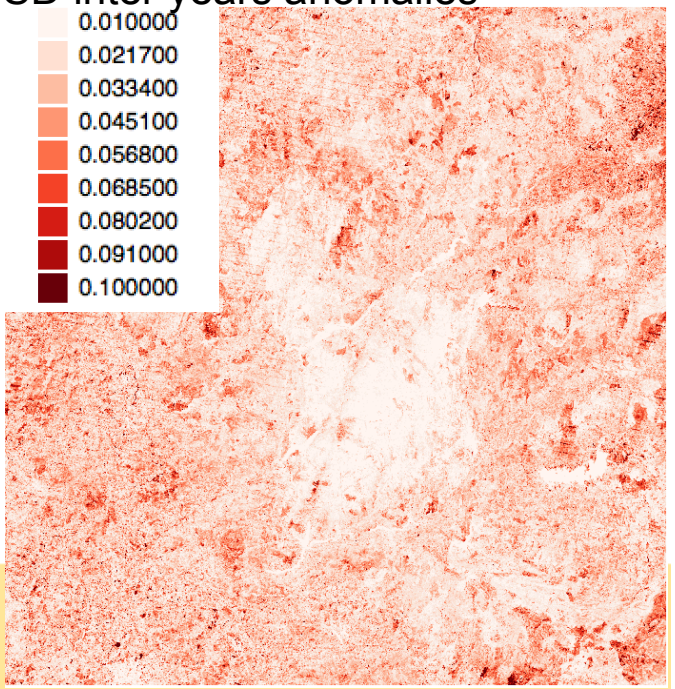
Seasonal Pick

Google 2018
TrueEarth 15m
From Landsat7

Yearly Coeff. of Variation



SD inter years anomalies



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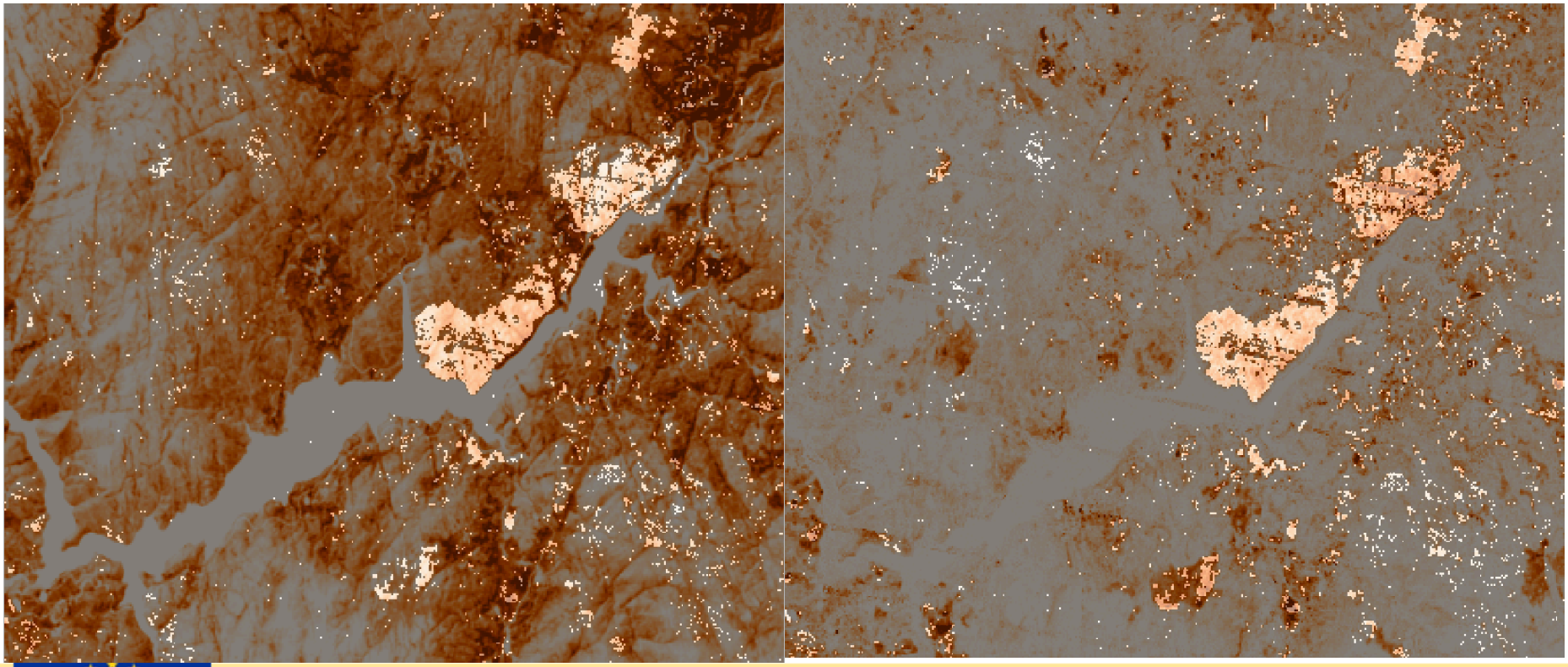
ation programme under grant

Overlay with residual Power Spectrum

P-value < 0.01 for Liu test on Power Spectrum

Significant PS_{res} vs Mean VI

Significant PS_{res} vs SD inter years anomalies



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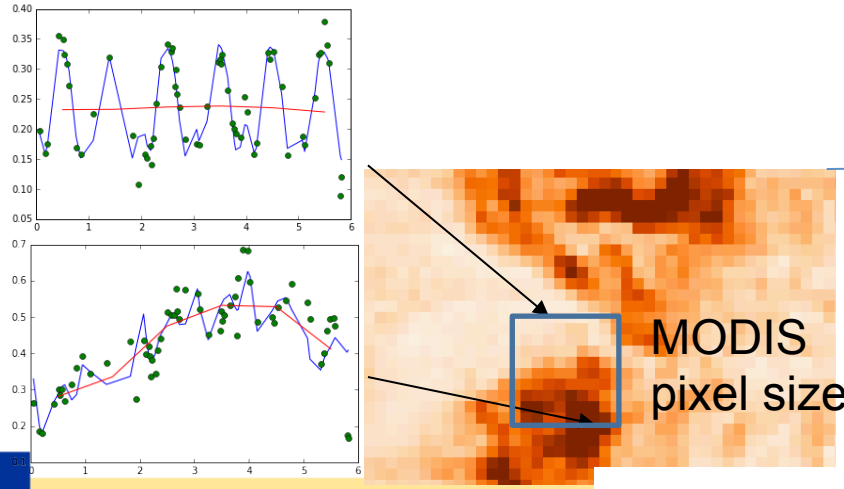
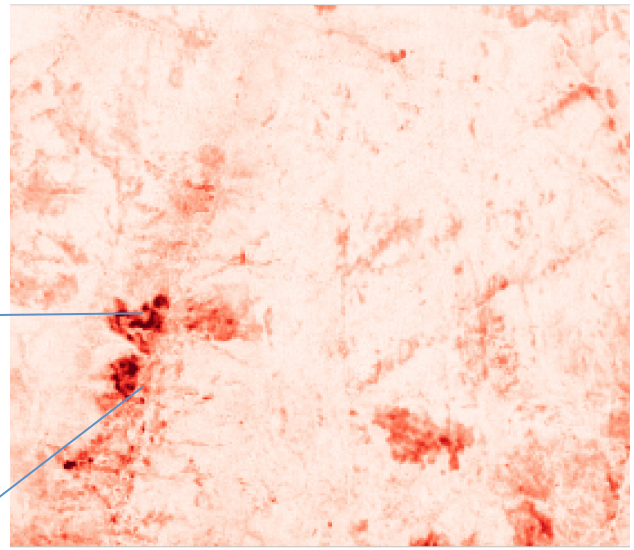
Landsat/Sentinel versus Modis

Often MODIS 16 days mosaic is preferred to avoid to deal with clouds but lower of resolution can be very limiting





inter-years Stand. Dev.

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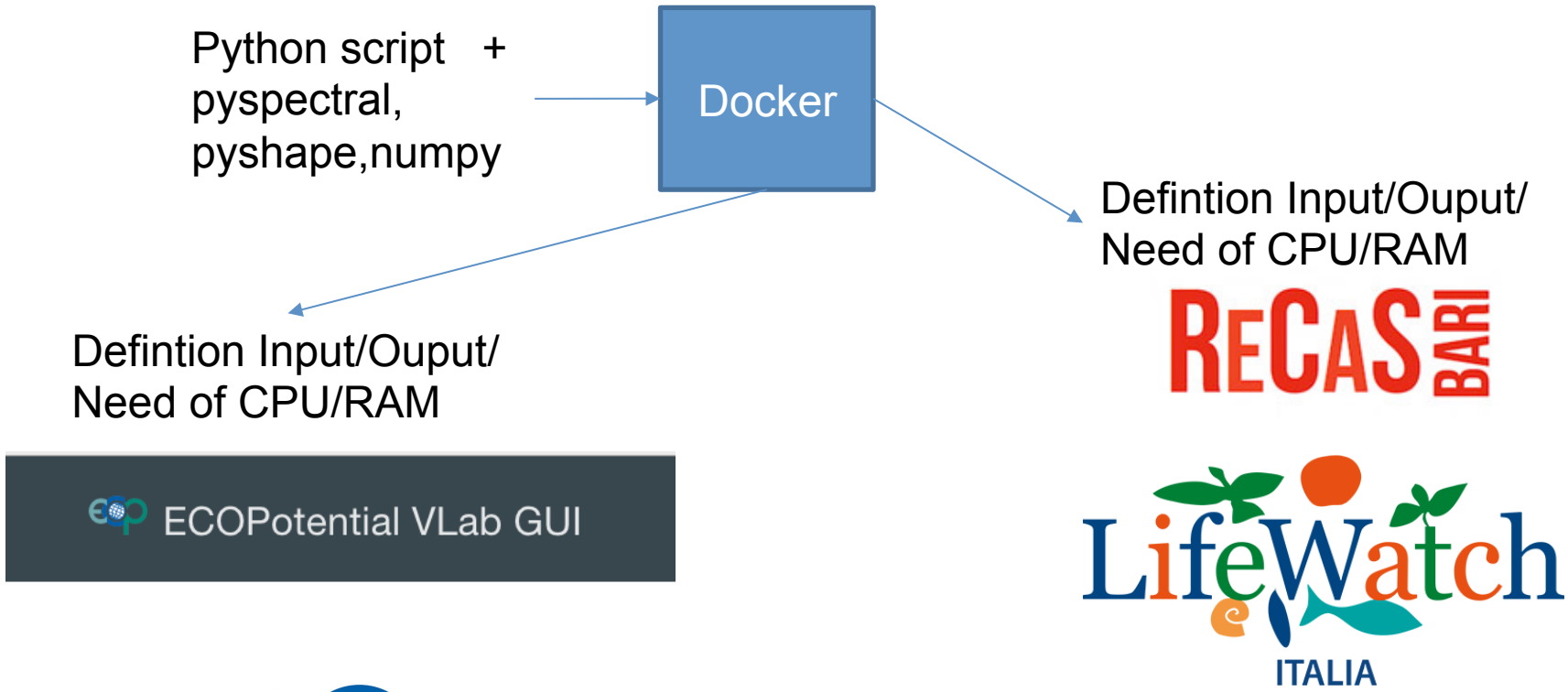
Future service porting



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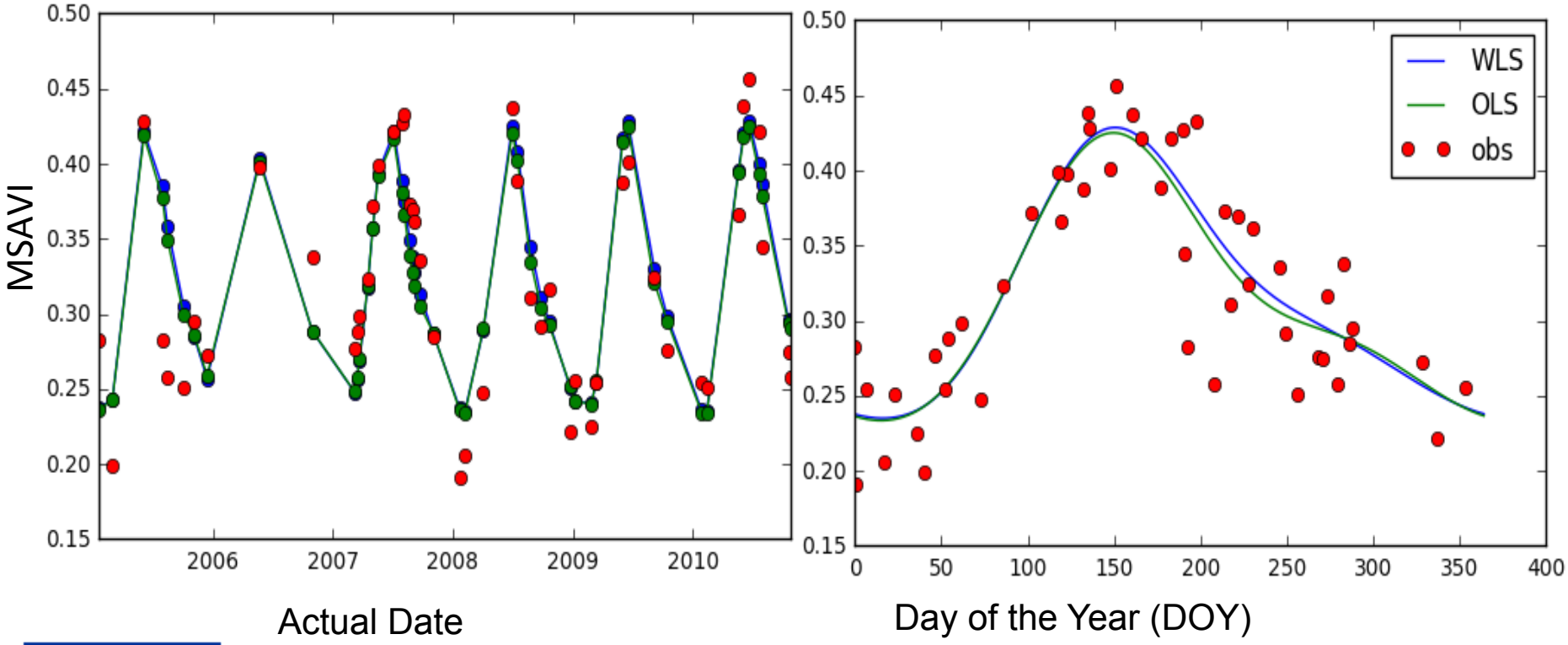
Fit of the model

Full set of 6 years MSAVI times series values of an exemplar pixel



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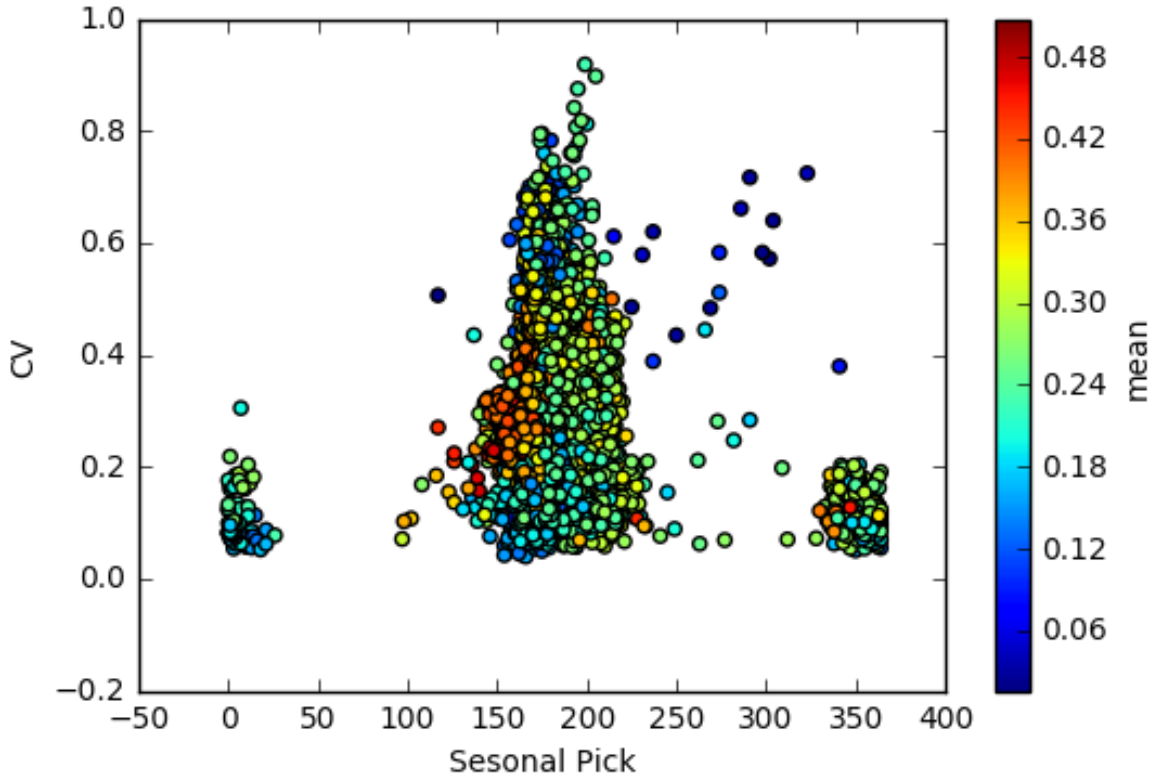
EFT space



Pixel 4984 around the 385 observation points

Few points peaks in winter, even with good mean values.
Several points with peak in spring have secondary peak in winter (november-december even january)
Could be grassland under shurbs and tree between rocks
Unclustered dark blue points are bare rocks with scant vegetation

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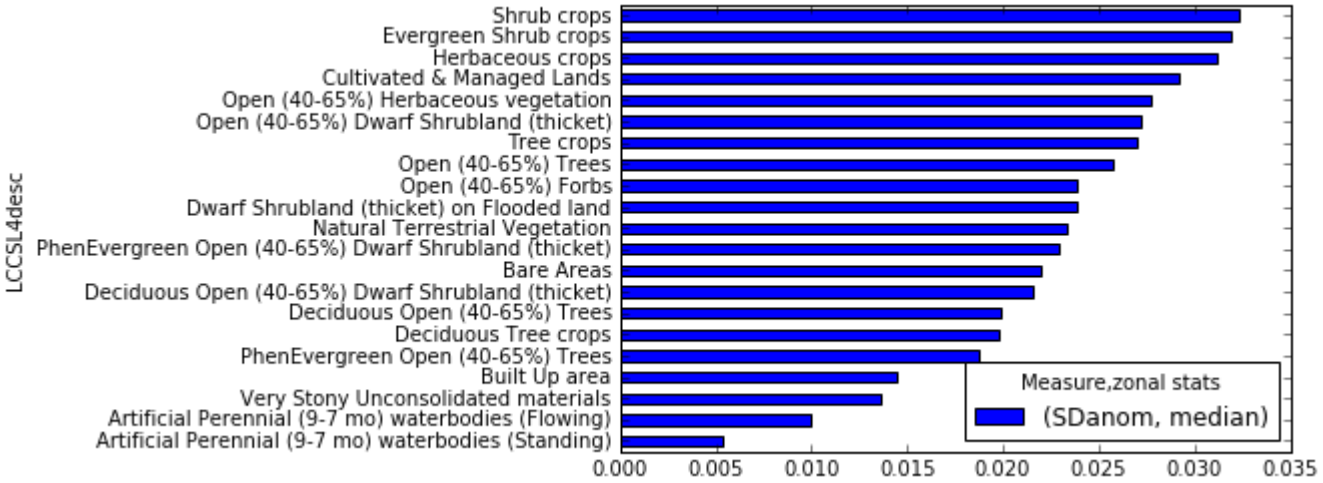
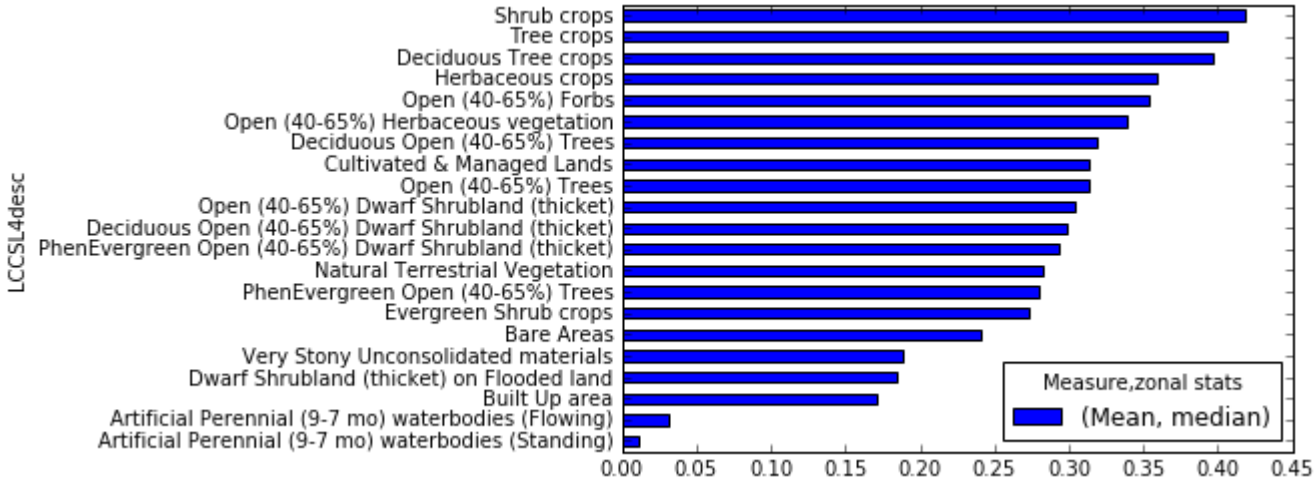
Ecological Validation:
by LandCover (EODESM)



Crops have higher Standard Deviation of yearly anomalies Consisent with change of practices across year

Crops have higher Mean, followed by deciduous, thicket and then evergreen.



intra-year Coeff. Variation

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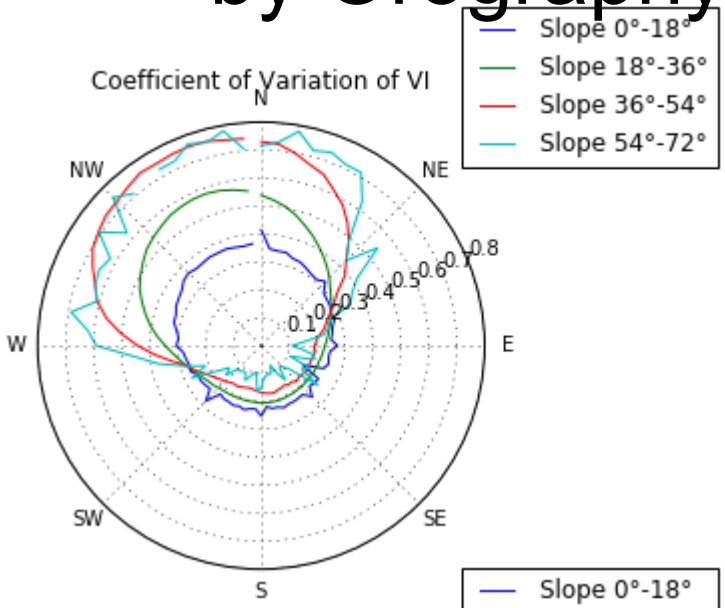
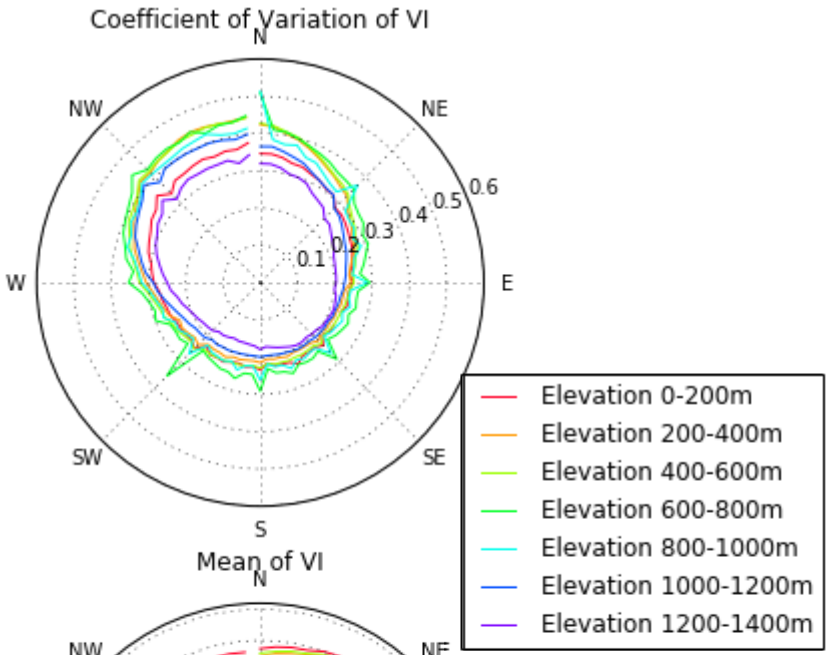
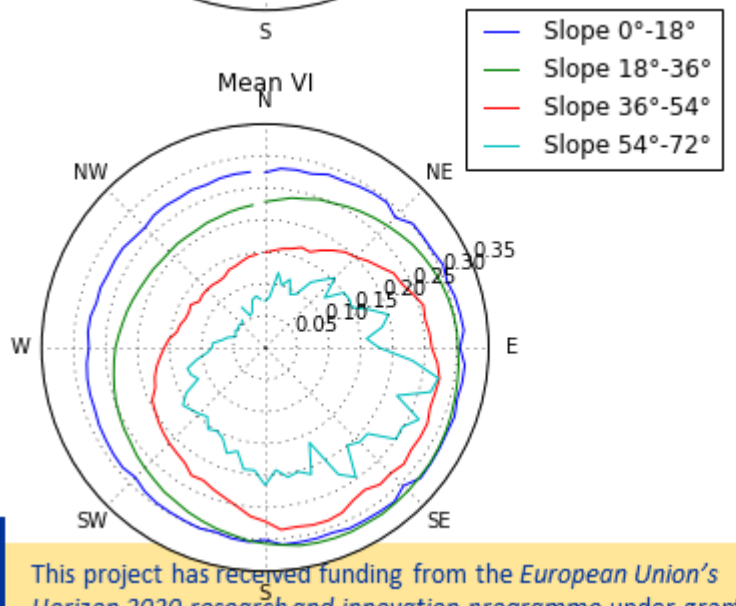
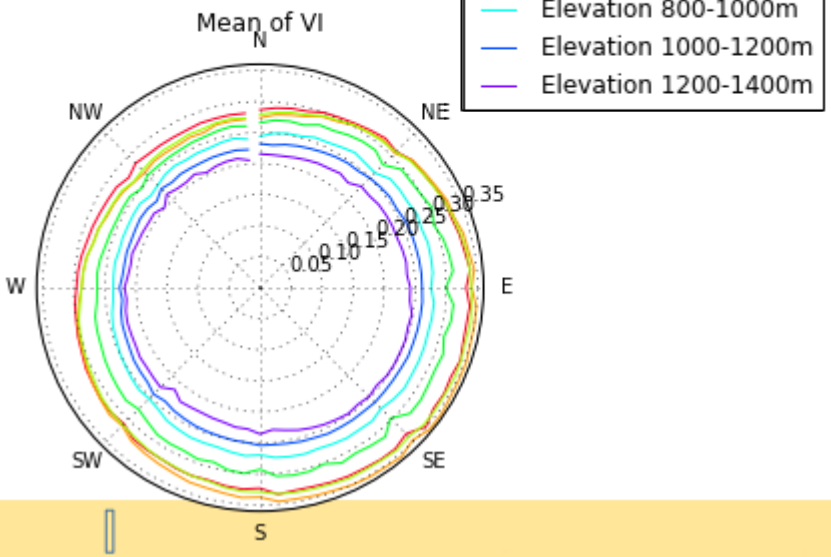
Ecological Validation:
by Orography (30m DEM)









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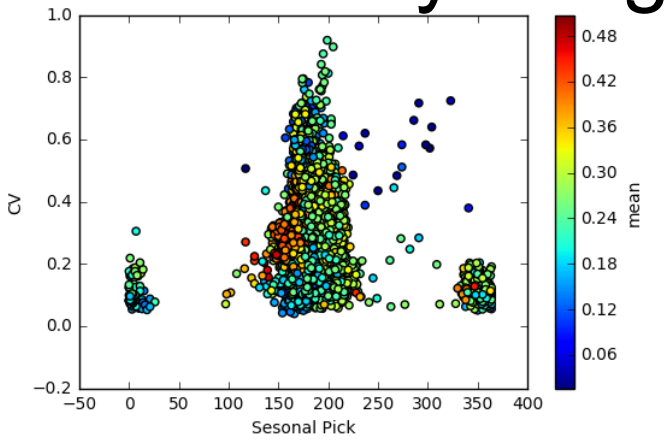

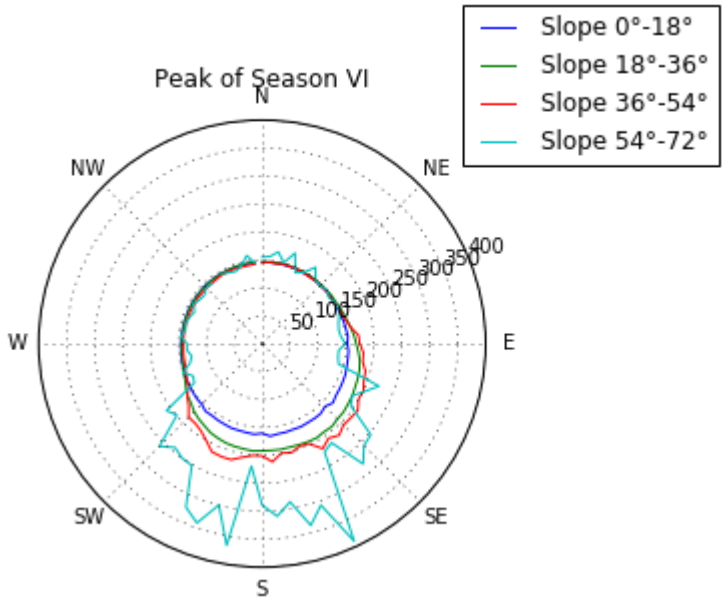

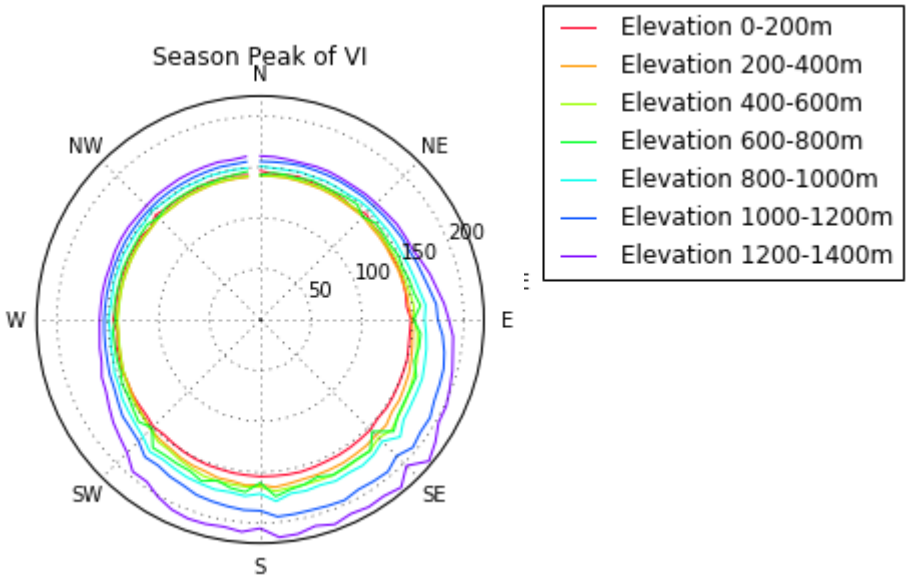

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Thanks for your attention

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