# Alpine forest biodiversity estimated from space: testing the Spectral Variation Hypothesis comparing Landsat 8 and Sentinel 2 using a multi-temporal Rao Q index

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eurac research

C3A CENTRO AGRICOLTURA ALIMENTI AMBIENTE

UNIVERSITÀ DI TRENTO
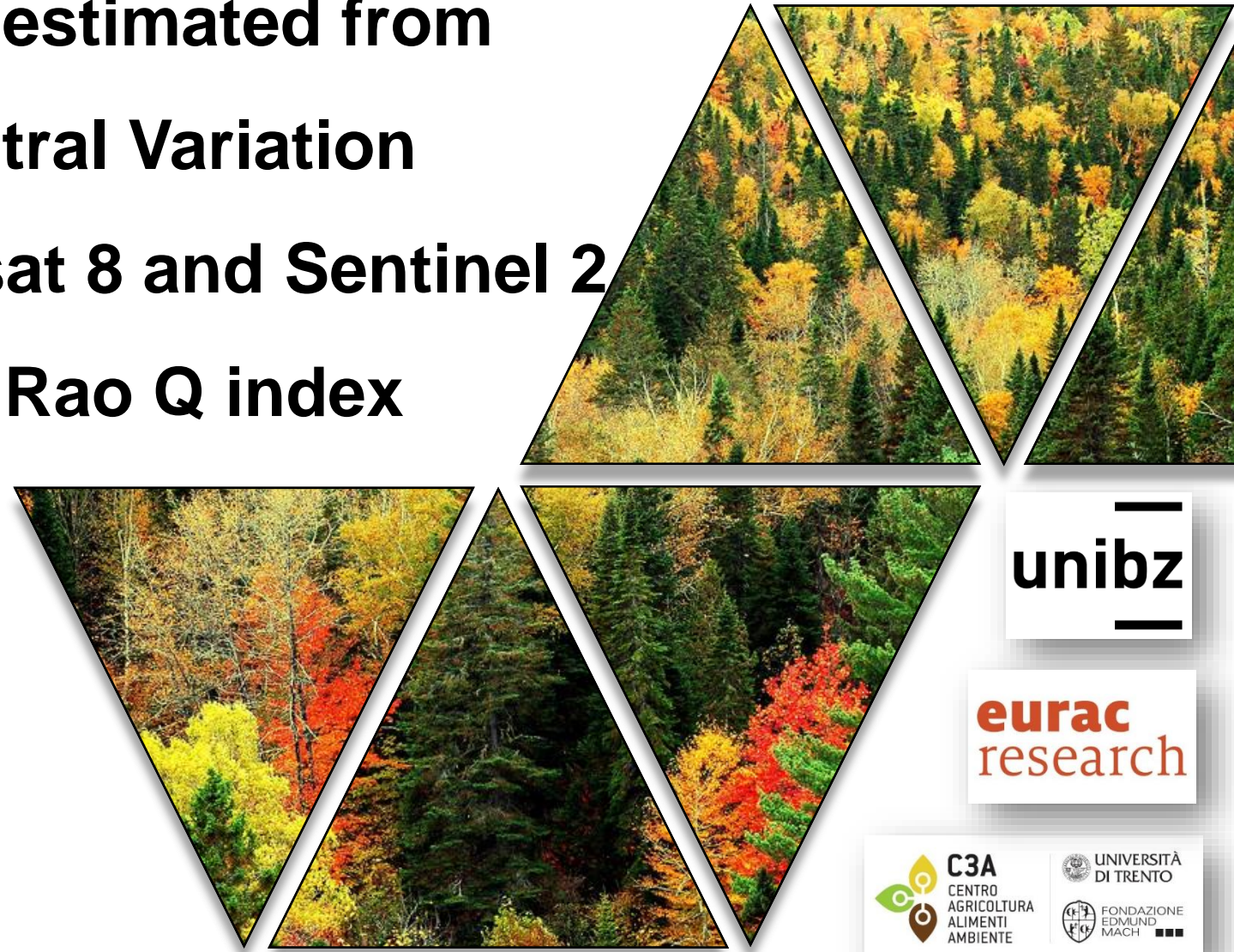
FONDAZIONE EDMUND MACH

- Forests cover 30 % of the Earth surface

- The most biodiverse ecosystem

- **Essential benefits** and **ecological services** that we

  derive from the forests depend on its **biodiversity**

vs

Loss of Forest Biodiversity

In the last 8000 years about **45% of the Earth's original forest** cover has disappeared, most of which was cleared during the **past century** (FAO, 2013).

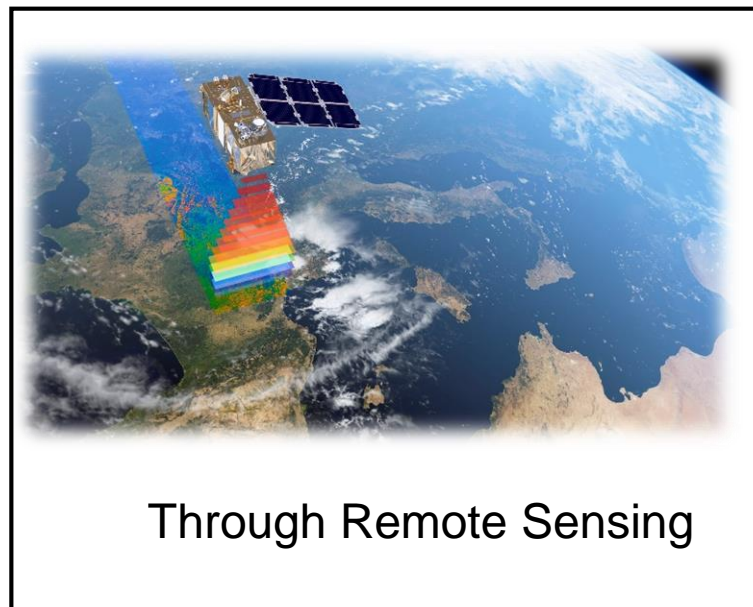Not only a theoretical concept…

Basvada Lavazèna ZPaggenjoch

"…to preserve the biological diversity of a forest, accurate information are required"

- How to estimate Forest Biodiversity?
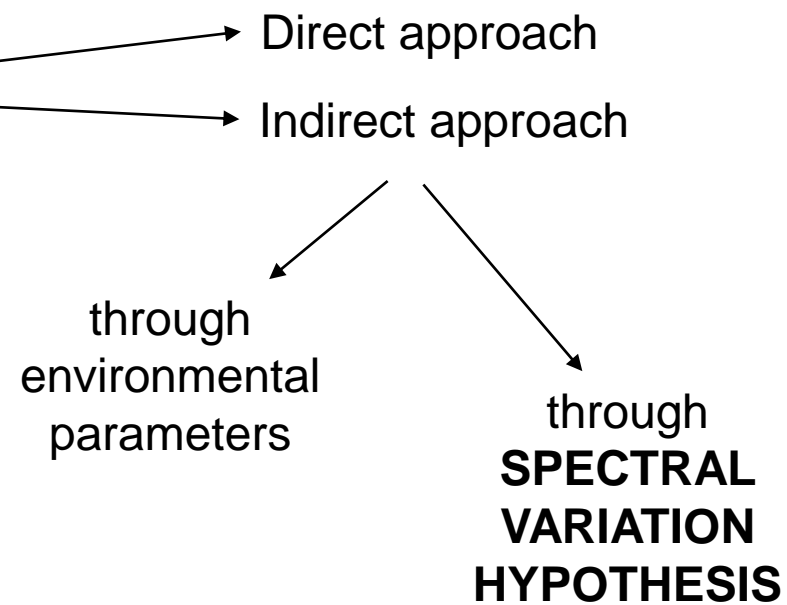

Directly in the field

vs

Through Remote Sensing

Direct approach

Indirect approach

through environmental parameters

through **SPECTRAL VARIATION HYPOTHESIS**

Concept of **Spectral Variation Hypothesis (SVH)** and **Environmental Heterogeneity (EH)**

(Palmer et al. 2002, Rocchini 2004)

Spectral Variation (SV) of an image ❯ Environmental Heterogeneity (E.H.) ❯ Species diversity

E.H. 👍

E.H. 👎

Spectral Variation Hypothesis (SVH)		
Ecosystem	Savana, Wetland, Riparian vegetation, Grassland, landscape cases, across landscapes	Never on alpine forests
Data	Hyperspectral Multispectral: MODIS, Landsat, QuickBird…	Never with Sentinel 2
Data level	Single bands, multiple bands, PCA components	V.I. : NDVI (no time series analysis)
Spectra variation index	Coefficient of variation, Standard deviation, Shannon's H, Mean distance from centroid…	Lead to discrete results

Research question:

- Testing the SVH in an **alpine forest ecosystem** using the **new spectral variation index : Rao's Q.**

- Data used: **NDVI derived from Sentinel 2 and Landsat 8** images (different sensors and spatial resolution)

- Approach used: **time-series analysis** (2016 and 2017)

- **Rao's Q index**

$$Q = \sum_{i=1}^{F-1} \sum_{j+i=1}^{F} d_{ij} * pi * pj$$

p = relative abundance of a pixel value in a selected image (F)
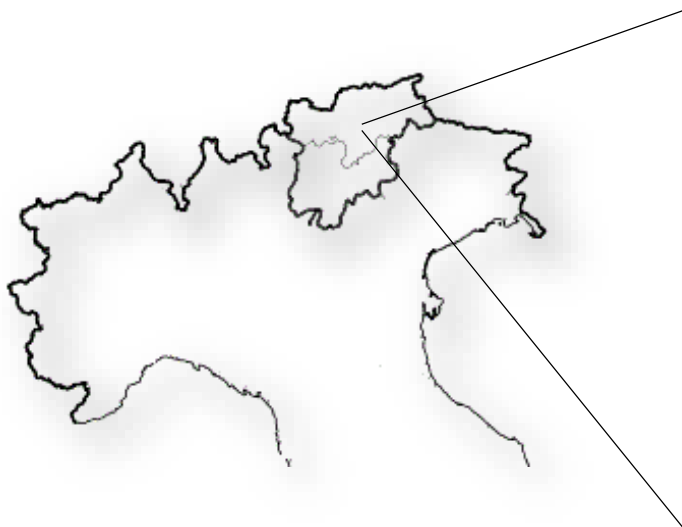d_{ij} = spectral distance between the i-th and j-th pixel value ($d_{ij} = d_{ji}$ and $d_{ii} = 0$)
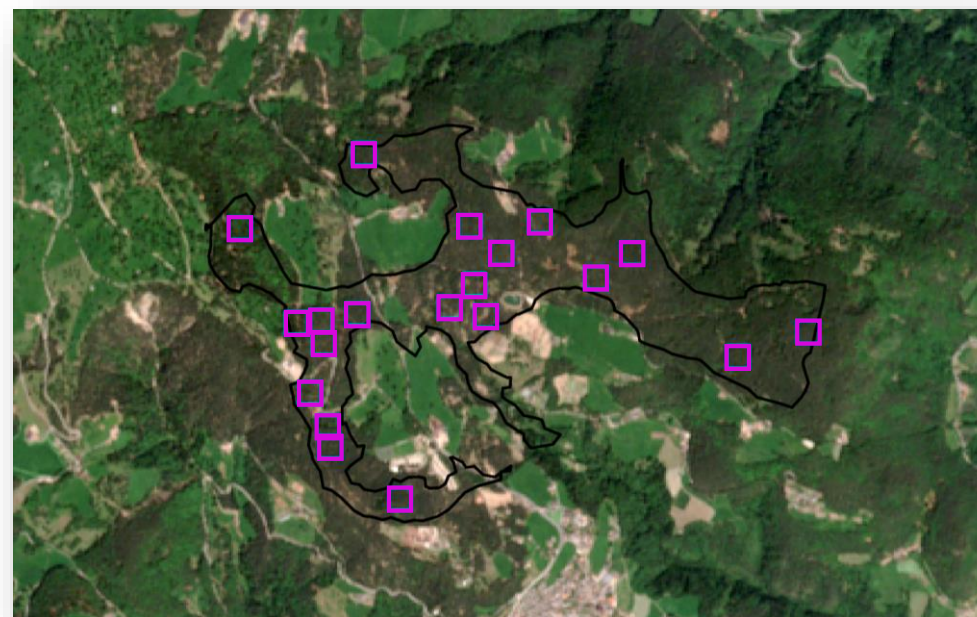i = pixel i
j = pixel j

5	13	22
4	1	67
2	66	91

(|5-13|)*(1/9)*(1/9) + (|5-22|)*(1/9)*(1/9)   + (|5-4|)*(1/9)*(1/9)…. + (|66-91|)*(1/9)*(1/9)

Field data

San Genesio atesino / Jenesien

$\frac{100}{m}$ m

100 m

trees with Ø > 5cm

AREA	*Pinus sylvestris*	*Picea abies*	*Larix decidua*	*Fagus sylvatica*	*Betula alba*	*Corylus avellana*	*Salix caprea*	*Populus tremula*	*Sorbus aucuparia*	Shannon' H
Area 1	93.49 %	5.85 %	0.31 %	0.16 %	0.03 %				0.013 %	0.27
Area 2	71.37 %	13.89 %	6.11 %	0.84 %	5.47 %	2.11 %				0.97
Area 3	55.81 %	21.94 %	4.52 %	3.39 %	5.32 %	6.94 %	0.16 %	0.97 %	0.16 %	1.36
….										…
Area 20	68.51 %	29.82 %	0.5 %		1.17 %					0.69

8

Remote sensing data

NDVI

Sentinel 2 time-series 2016 and 2017 (10m)

Landsat 8 time-series 2016 and 2017 (30m)

Heterogeneity indices

- Rao's Q index

- Coefficient of Variation CV

- Shannon's H

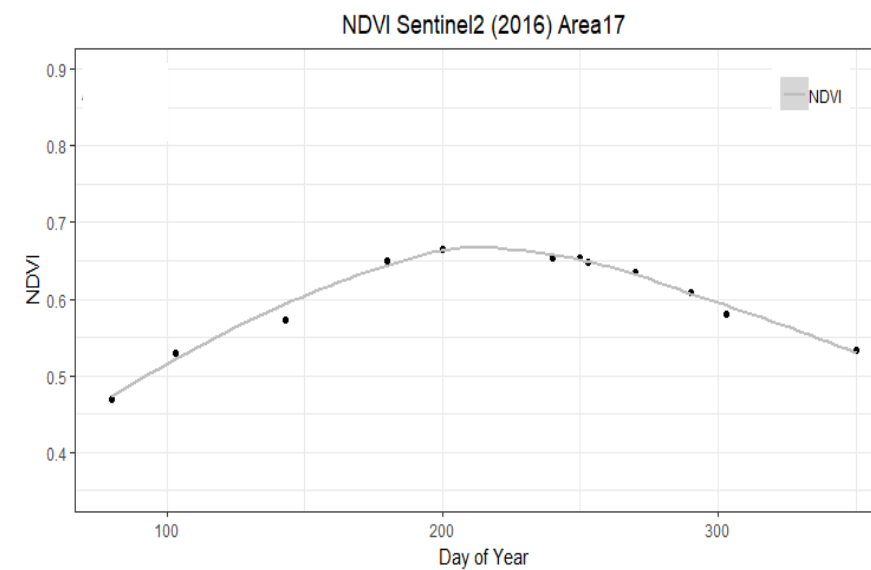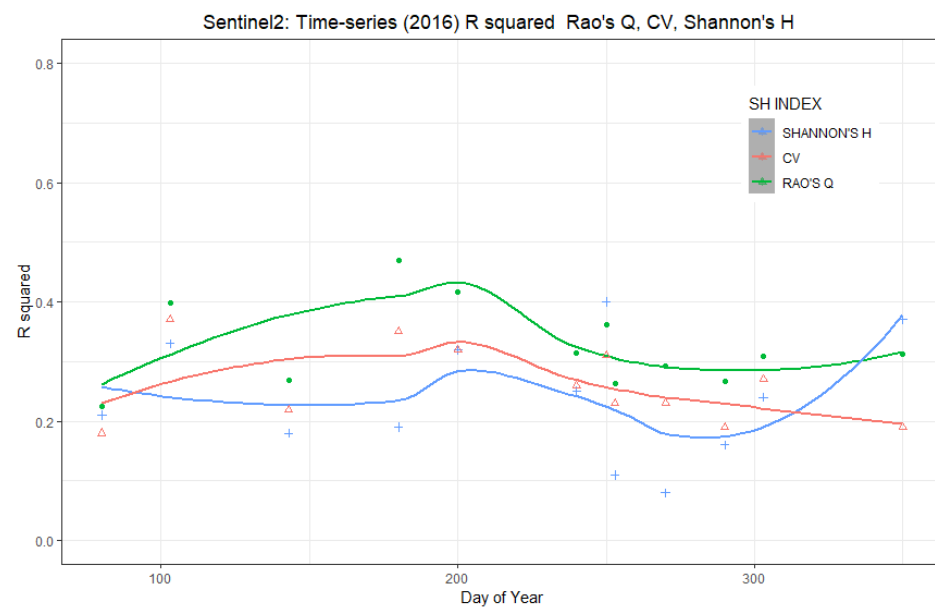FIELD DATA (shannon) vs NDVI_270117: RAOQ (no moving window)
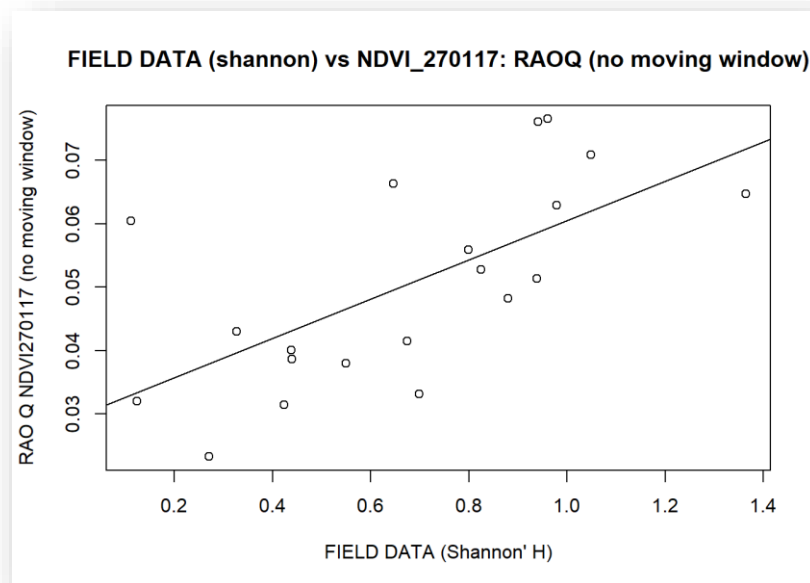
Field data: Shannon's H
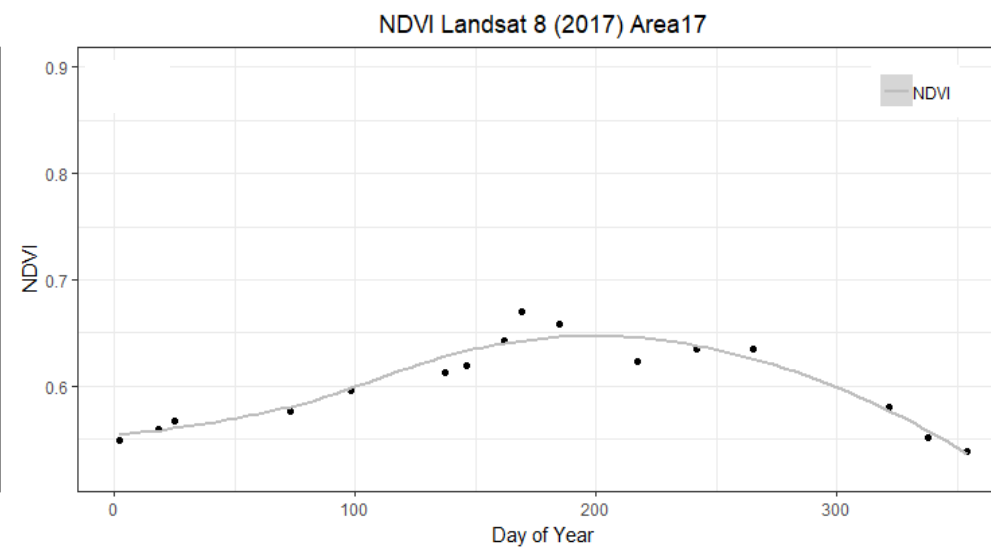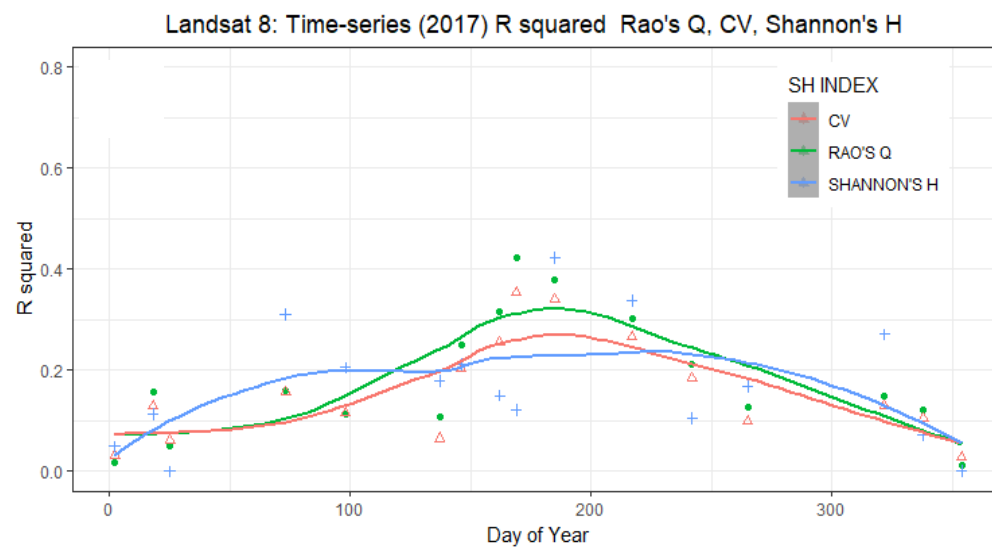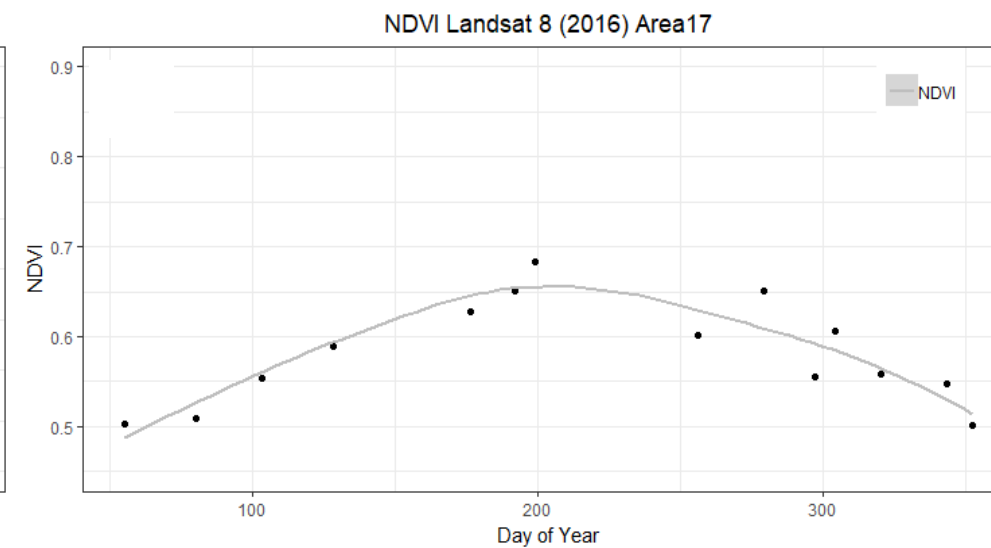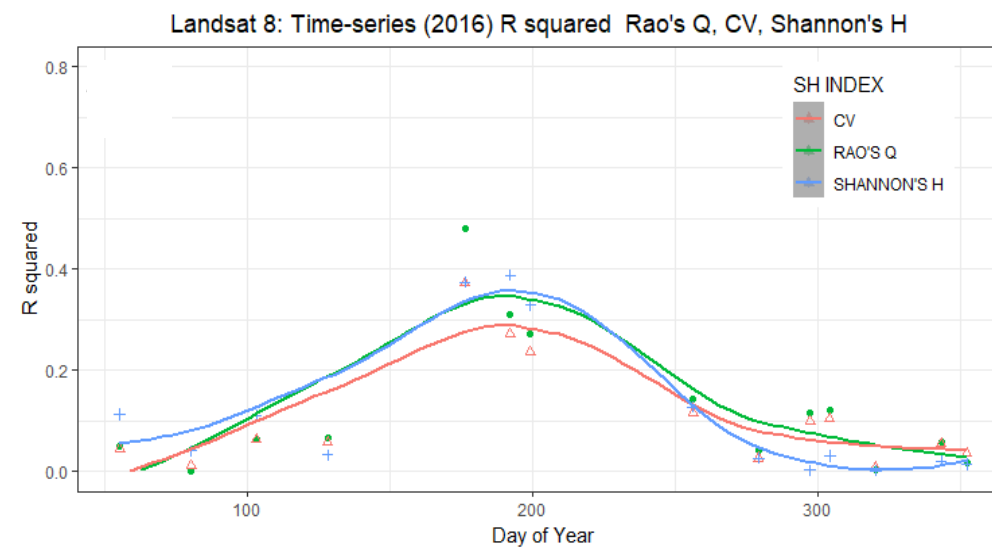
Sentinel 2 (10m)

2017 →
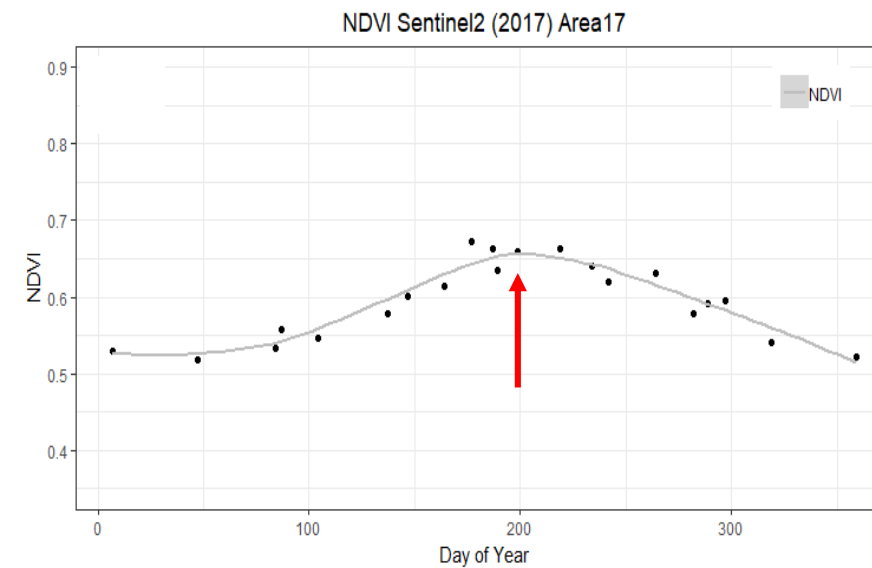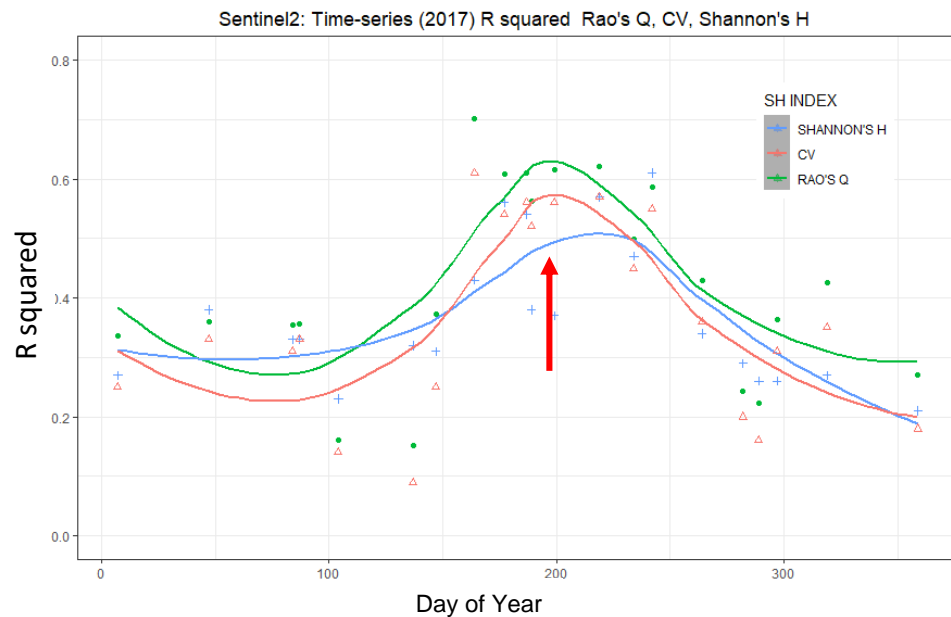
N available images: 21
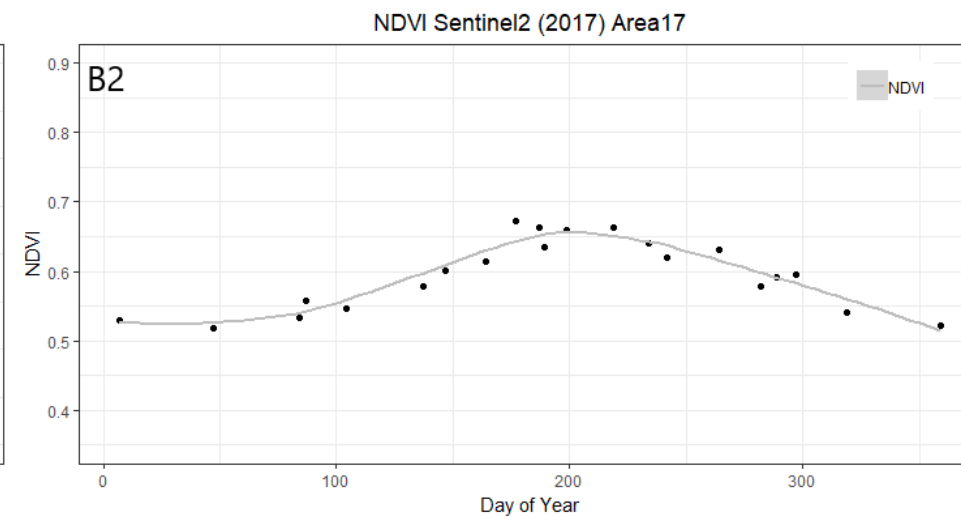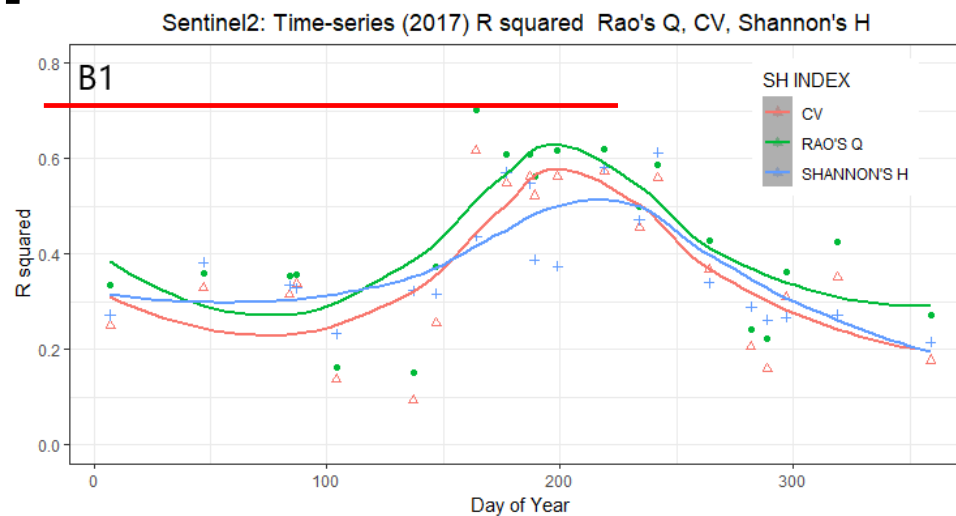
2016 →

N available images: 13

Landsat 8 (30m)

2017 →

Landsat 8: Time-series (2017) R squared Rao's Q, CV, Shannon's H

NDVI Landsat 8 (2017) Area17

2016 →

Landsat 8: Time-series (2016) R squared Rao's Q, CV, Shannon's H
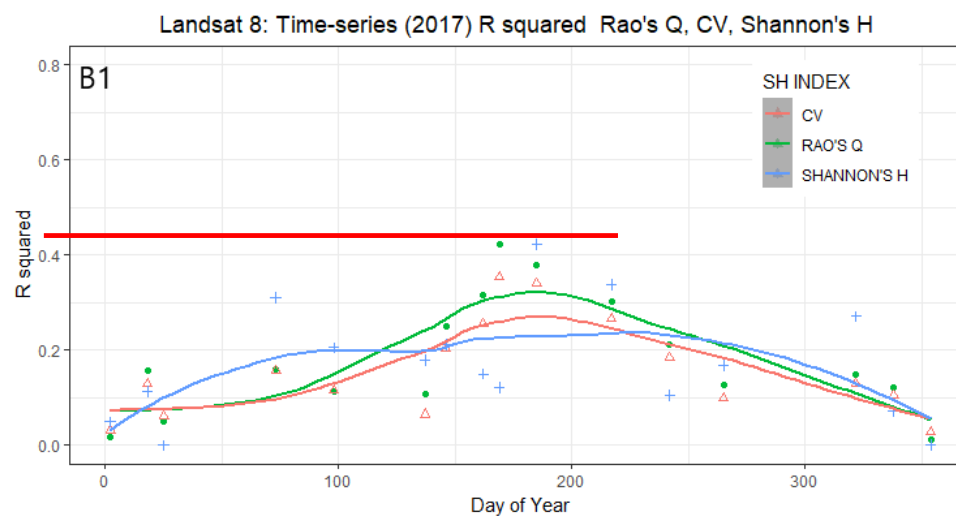

NDVI Landsat 8 (2016) Area17

2017

Sentinel 2 →

Landsat 8 →
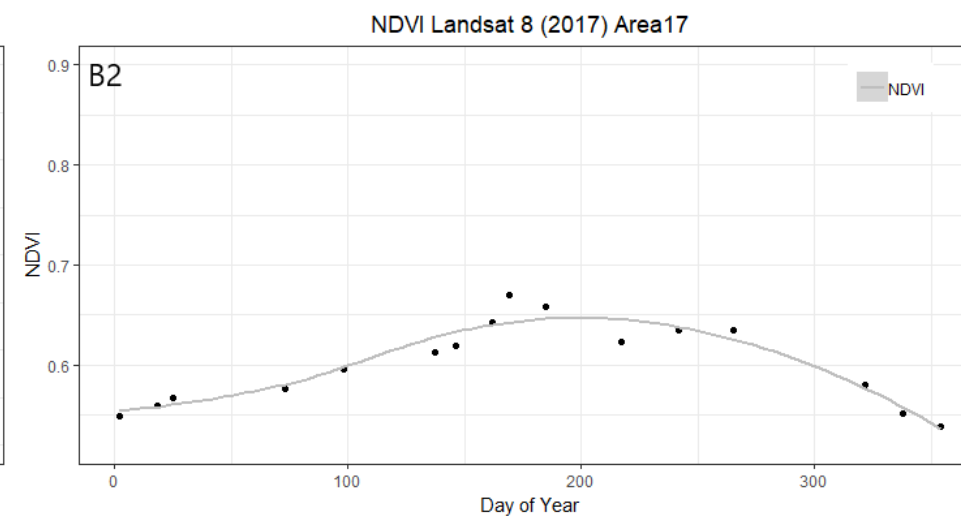
- SVH is sensor/scale dependent

Conclusions

- The Rao's Q index showed good results, performing better than the other 2 considered indices

- Testing the SVH with NDVI data showed good outcomes ⟶ Best time of the year to apply the SVH to NDVI when NDVI is at its peak

- SVH is scale/sensor dependent ⟶ S2 showed positive outcomes compared with L8

- The trend was affected by the number of available images (Sentinel 2 A & B)

Thank you for your attention!

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