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Ecosystem Functional Types as an Essential Biodiversity Variable to monitor functional diversity

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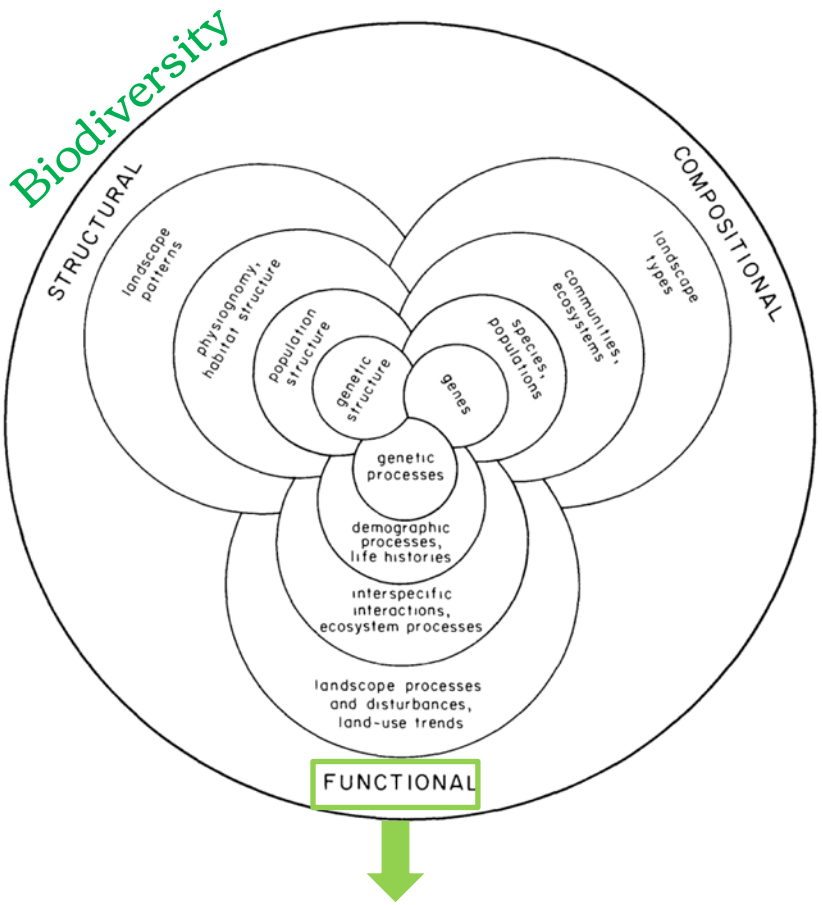
LifeWatch ERIC

LifeWatch ERIC Scientific Community Meeting
Rome – Italy – May 27-29 2019

Need to incorporate all biodiversity dimensions across all hierarchical levels

Noss (1990): "The three components of biodiversity (composition, structure, and function) at all levels of organization determine, and in fact constitute, the biodiversity of an area, and should be considered in conservation".



Composition: identity and variety of entities in a collection (e.g. species list & diversity index)

Structure: physical organization or pattern of a system (e.g. habitat complexity & physiognomy of vegetation)

Function: *ecological and evolutionary processes (e.g. gene flow, information, matter & energy exchanges)*

Ecosystem functioning: Matter and energy exchanges

Ecosystem Functional Types to characterize ecosystem functioning heterogeneity

Functional units aim:

- To reduce the diversity of entities based on processes.
- To categorize continuous gradients into discrete units.
- To obtain homogeneous groups with a specific and coordinated response to environmental factors.

Plant Functional Types (PFTs)

Groups of plants that share similar functional traits (nitrogen fixation, photosynthetic pathway, etc.).

Díaz & Cabido, 2001, *TREE*

Ecosystem Functional Types (EFTs)

Groups of ecosystems or patches of the land surface that share similar dynamics of matter and energy exchanges between the biota and the physical environment.

Paruelo *et al.* 2001, *Ecosystems*
Alcaraz-Segura *et al.* 2006, *Global Ecol. Biogeo.*

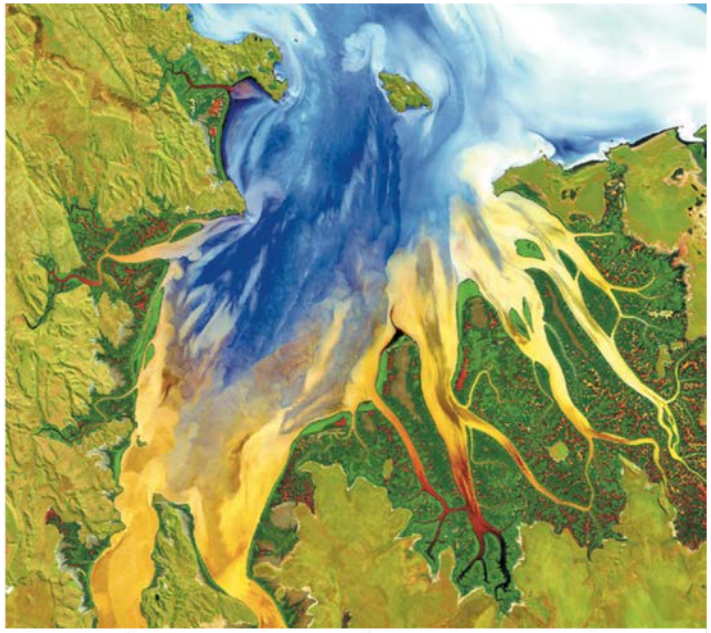
What are the *Essential Biodiversity Variables?*

www.sciencemag.org **SCIENCE** VOL 339
Published by AAAS
POLICYFORUM

Essential Biodiversity Variables

H. M. Pereira,[1*†] S. Ferrier,[2] M. Walters,[3] G. N. Geller,[4] R. H. G. Jongman,[5] R. J. Scholes,[3]

- Minimum set of essential measures that capture main biodiversity dimensions: composition, structure and function.
- Inform on biodiversity status
- Sensitive to biodiversity change
- Feasible, ecosystem agnostic, global



2015 | VOL 523 | NATURE | 403

Agree on biodiversity metrics to track from space

Ecologists and space agencies must forge a global monitoring strategy, say **Andrew K. Skidmore**, **Nathalie Pettorelli** and colleagues.

GEO BON
Group on Earth Observations
Biodiversity Observation Network

CBD

What Essential Biodiversity Variables relate to Ecosystem Function so far?

EBV Class	EBV candidates (Pereira et al., 2013)	RS-EBV candidates (Skidmore et al., 2015)
Genetic composition	Allelic diversity, co-ancestry, …	
Species populations	Species distribution, abundance…	Species occurrence
Species traits	Phenology, body mass, …	Plant traits (leaf area & nitrogen content)
Community composition	Taxonomic diversity Species interactions	
Ecosystem function	**Primary productivity** Secondary productivity Nutrient retention Disturbance regime	**Primary productivity** Vegetation phenology Inundation Fire occurrence
Ecosystem structure	Habitat structure Ecosystem extent and fragmentation Ecosystem composition by functional type	Ecosystem distribution Fragmentation and heterogeneity Land cover and vegetation height

Main:

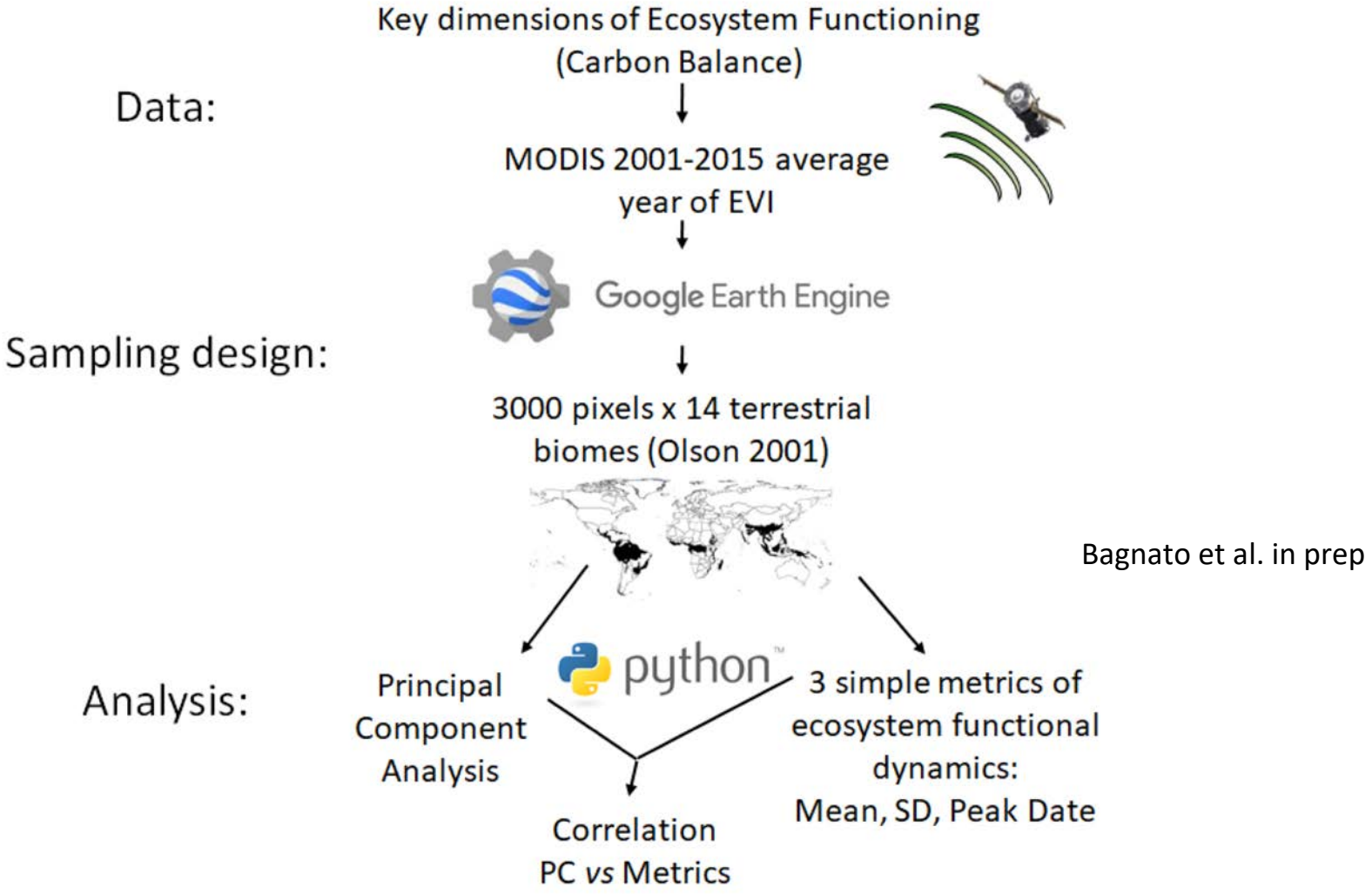
To provide a proof of concept on how Ecosystem Functional Types can be used as a multi-purpose tool for protected area management and decision taking

Specific:

1. To search for satellite-derived **simple metrics** that could be used as a set of **highly informative essential** variables that characterize ecosystem functioning across all terrestrial biomes.
2. **To provide empirical evidence** on how satellite-derived **EFTs** significantly **differed in their energy and matter exchanges** measured on ground
3. **To use** satellite-derived EFAs and EFTs in Ecology and Conservation

Objective 1.

Searching for satellite-derived **simple metrics** that could be used as a set of **highly informative essential** variables that characterize **different dimensions** of ecosystem functioning across all terrestrial biomes.



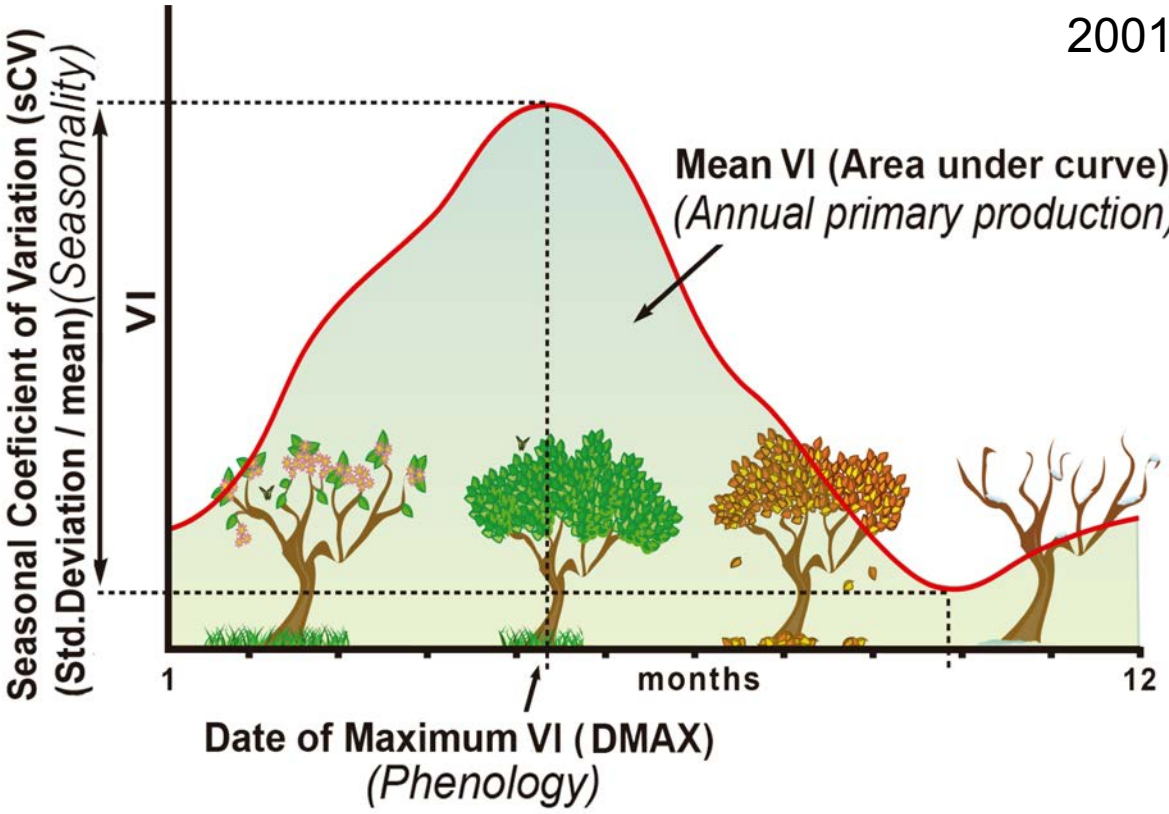
Bagnato et al. in prep

Objective 2.

Derive satellite-based Ecosystem Functional Attributes (EFAs) and **Ecosystem Functional Types (EFTs)** that characterize regional heterogeneity in ecosystem functioning

We identify EFTs from 3 **functional attributes of the seasonal curve of spectral vegetation indices**:

MODIS EVI 230 m
2001-2016



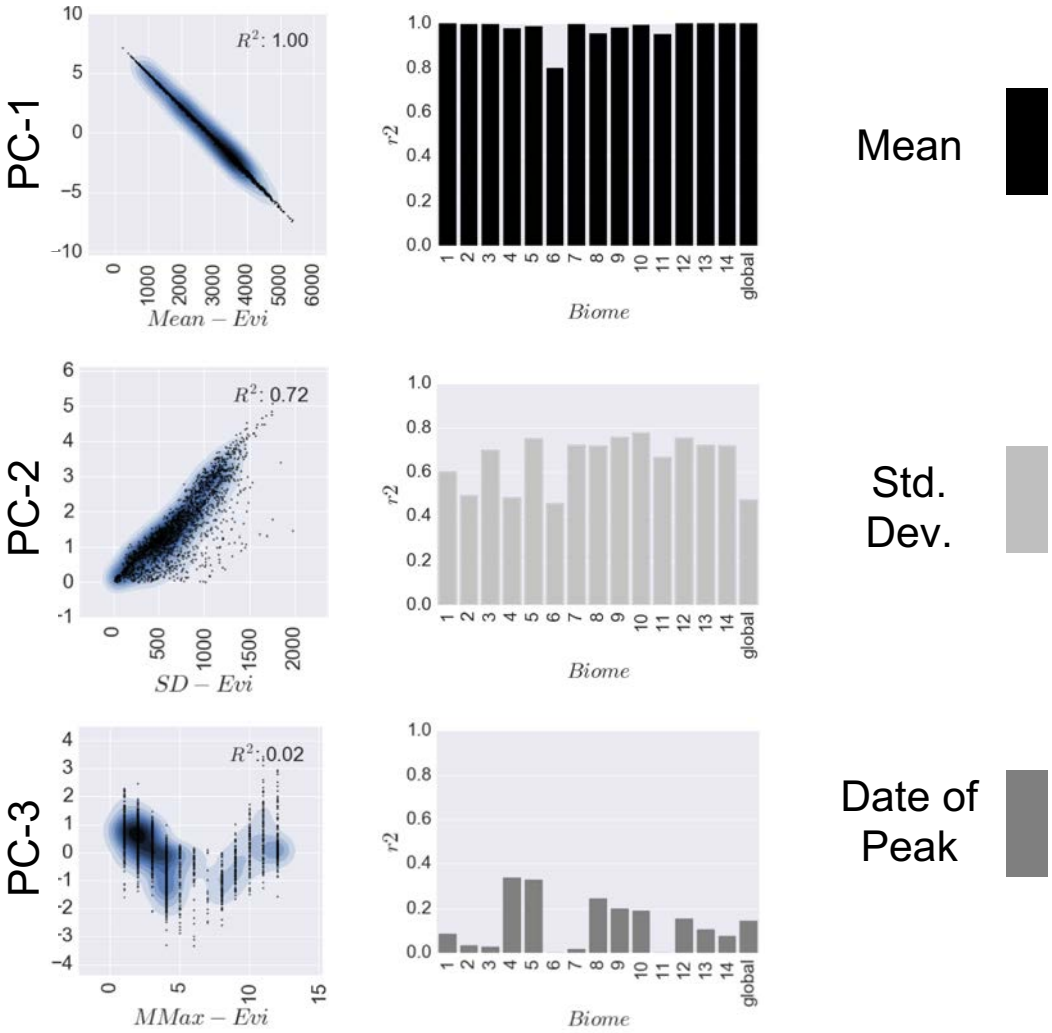
https://en.wikipedia.org/wiki/Ecosystem_Functional_Type

Result 1

Do principal components (which capture >90% of variance) correlate with 3 simple metrics?

Amount: Mean
Seasonality: SD or CV
Phenology: DatePeak

EVI Enhanced Vegetation Index



Mean

Std. Dev.

Date of Peak

The three principal components are correlated with mean of EVI, std and date of peak

Bagnato et al. *Ecosystems* (in revision)

Identifying Ecosystem Functional Types

Paruelo et al. 2001 *Ecosystems*, Alcaraz-Segura et al. 2006 *GEB*

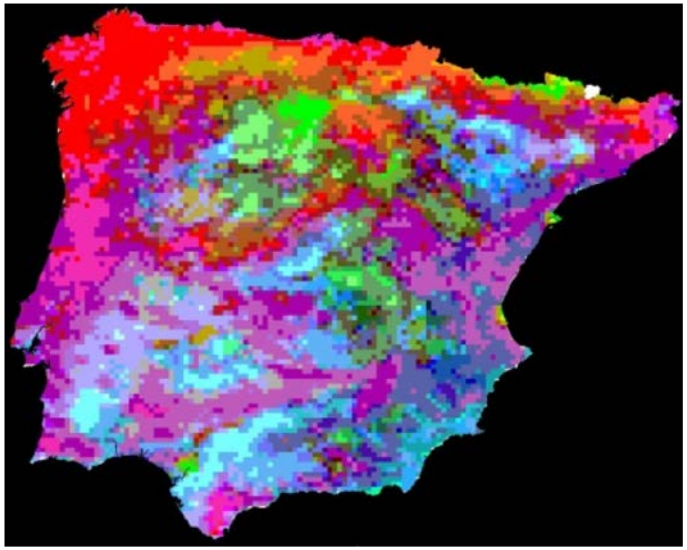
Continuous EFAs:

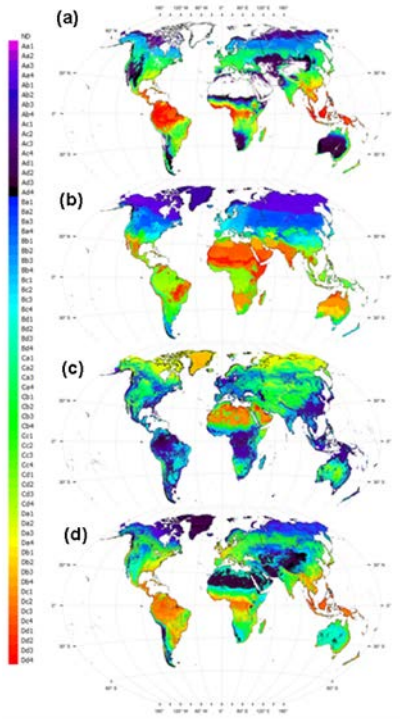
EVI_mean (productivity)

EVI_sCV (seasonality

Peak EVI Date (phenology)

Classes of EFTs:





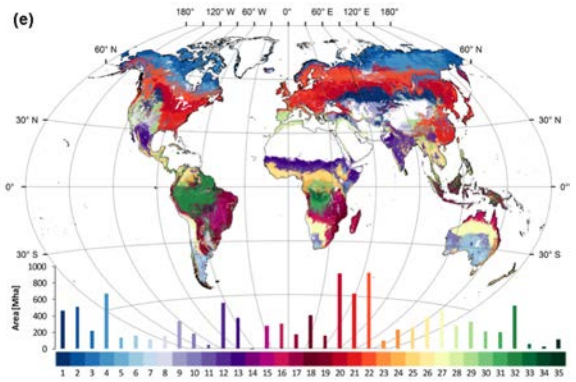
EVI-based EFTs

Albedo-based EFTs

LST-based EFTs

ET-based EFTs

Combined EFTs



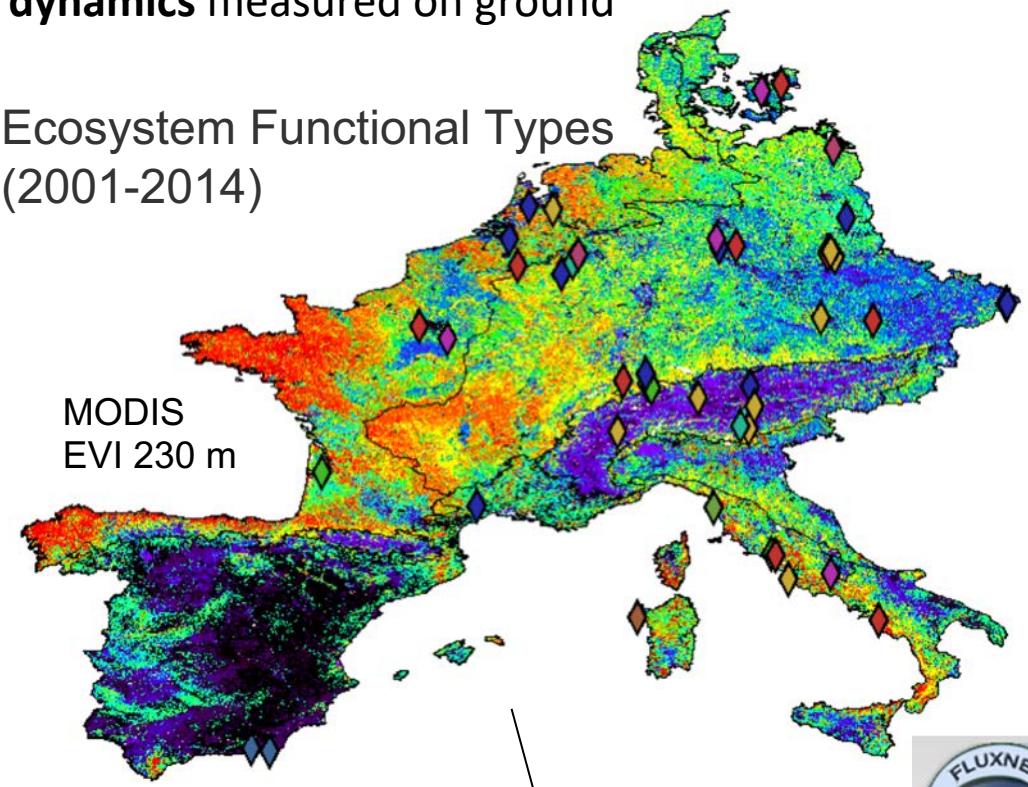
https://en.wikipedia.org/wiki/Ecosystem_Functional_Type

Objective 3.

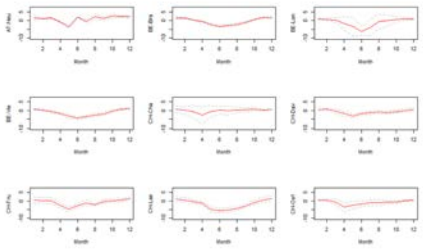
Empirical evidence on how satellite-derived **EFTs** significantly **differed in their carbon dynamics** measured on ground

Ecosystem Functional Types (2001-2014)

MODIS EVI 230 m



50 eddy-covariance towers FLUXNET 2001-2014 CO_2 NEE



01) Aa1	17) Ba1	33) Ca1	49) Da1
02) Aa2	18) Ba2	34) Ca2	50) Da2
03) Aa3	19) Ba3	35) Ca3	51) Da3
04) Aa4	20) Ba4	36) Ca4	52) Da4
05) Ab1	21) Bb1	37) Cb1	53) Db1
06) Ab2	22) Bb2	38) Cb2	54) Db2
07) Ab3	23) Bb3	39) Cb3	55) Db3
08) Ab4	24) Bb4	40) Cb4	56) Db4
09) Ac1	25) Bc1	41) Cc1	57) Dc1
10) Ac2	26) Bc2	42) Cc2	58) Dc2
11) Ac3	27) Bc3	43) Cc3	59) Dc3
12) Ac4	28) Bc4	44) Cc4	60) Dc4
13) Ad1	29) Bd1	45) Cd1	61) Dd1
14) Ad2	30) Bd2	46) Cd2	62) Dd2
15) Ad3	31) Bd3	47) Cd3	63) Dd3
16) Ad4	32) Bd4	48) Cd4	64) Dd4

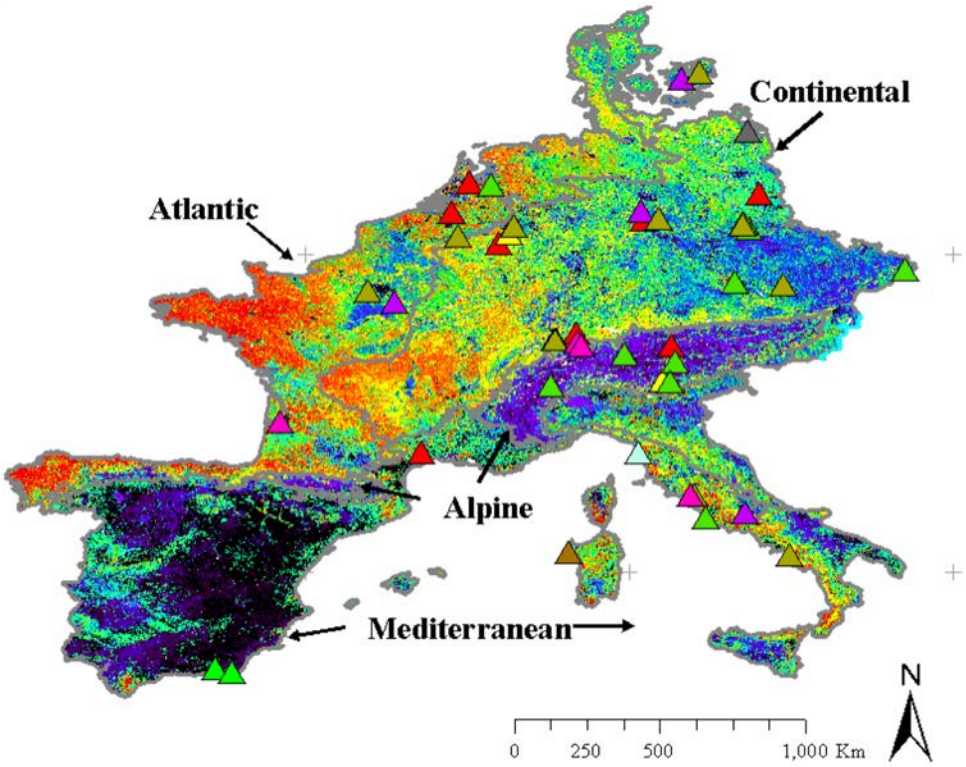
A–D: Productivity (increasing)
a–d: Seasonality (decreasing)
1–4: Phenology (SP–SU–AU–WI)

Discriminant Analysis

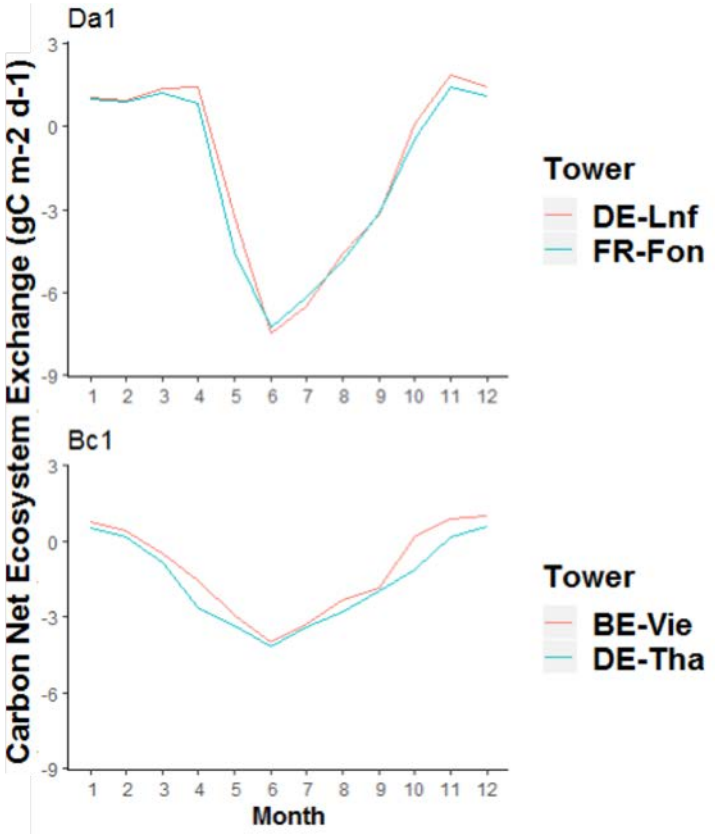
Result 3

Cazorla et al. *Ecosystems* (in prep.)

Do EFTs actually differ in their energy and matter exchanges measured on ground with the eddy covariance technique?



50 eddy-covariance towers



- EFTs map ecosystem functioning

Results (for CO_2 NEE):

		EFTs
Kappa	0.95	0.92
Accuracy	0.97	0.95

Objective 4.

Applications in Ecology and Conservation of satellite-derived EFAs and EFTs

Ecosystem Functional diversity

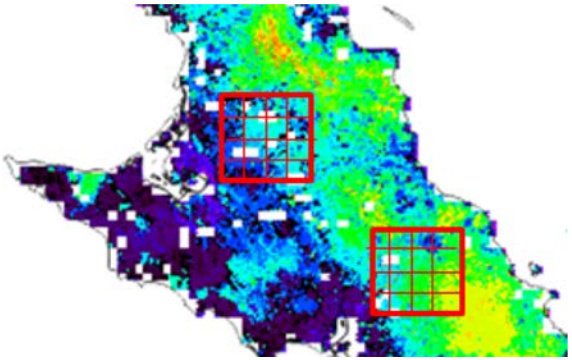
Richness: nº of EFTs in 4x4 pixels sliding window

Rarity: *EFTi rarity = (EFTmax area − EFT_i area) / EFTmax area*

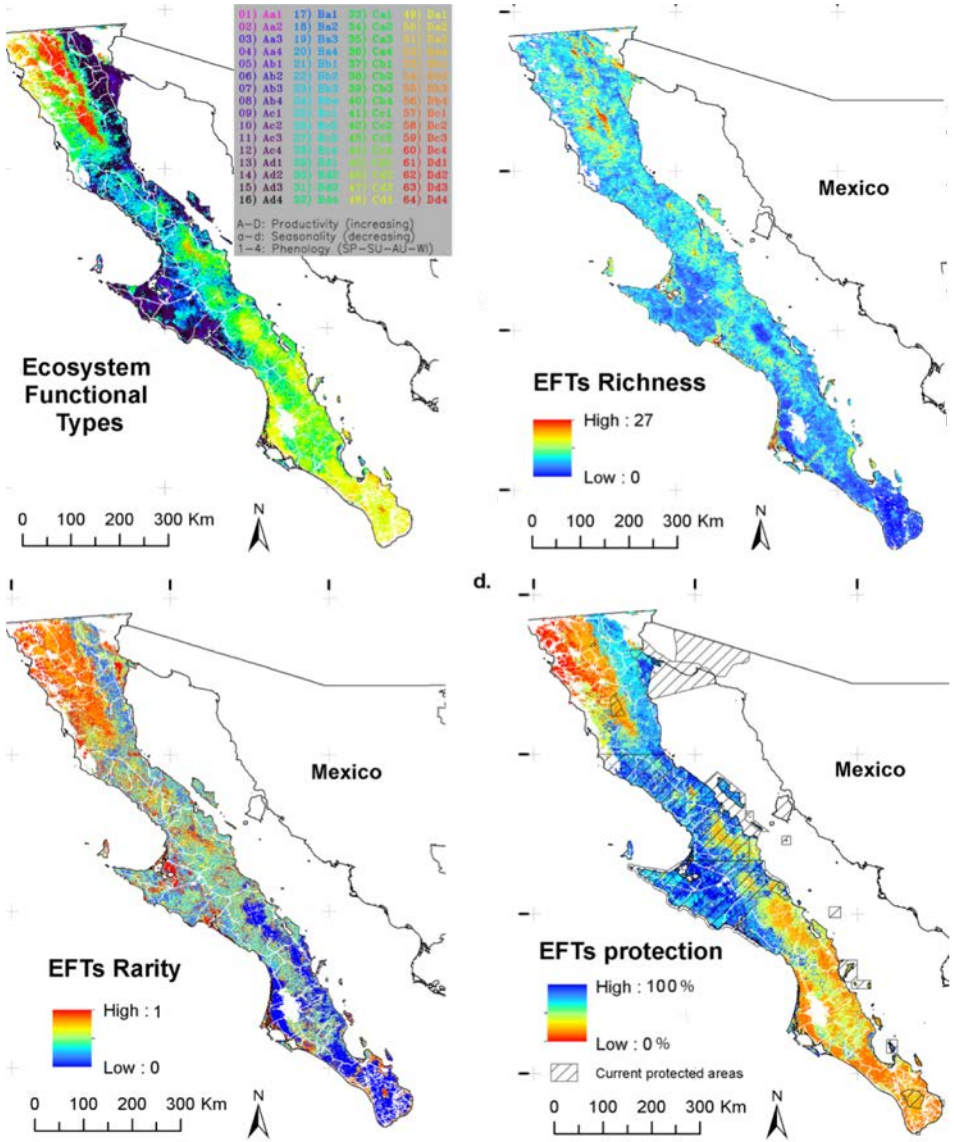
Ecosystem Functional stability

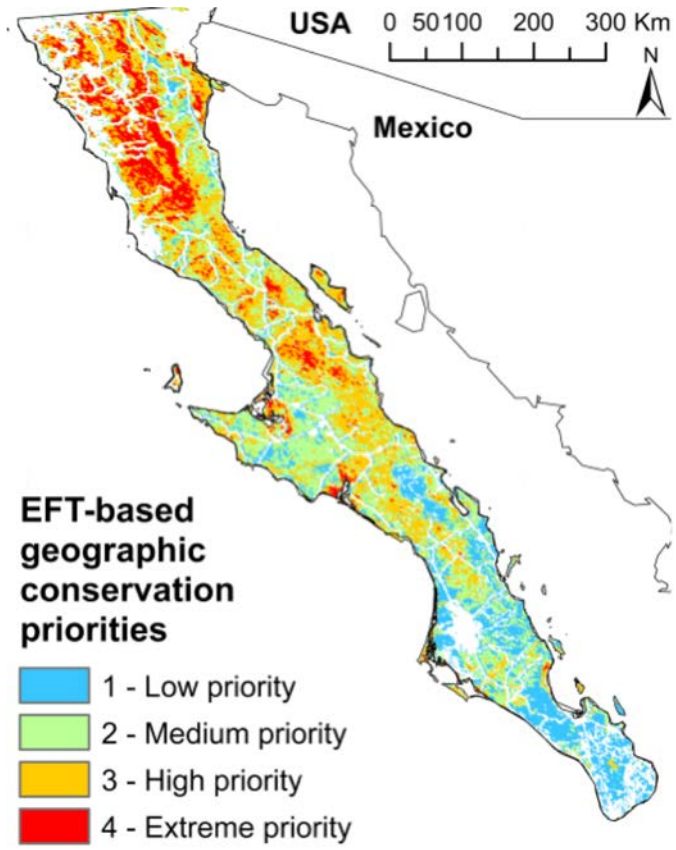
Interannual variability: nº of different EFTs in a same pixel along the period.

Interannual dissimilarity: Inverse of Jaccard index in 4x4 pixel window (924 x 924 m; ∼1 km^2).



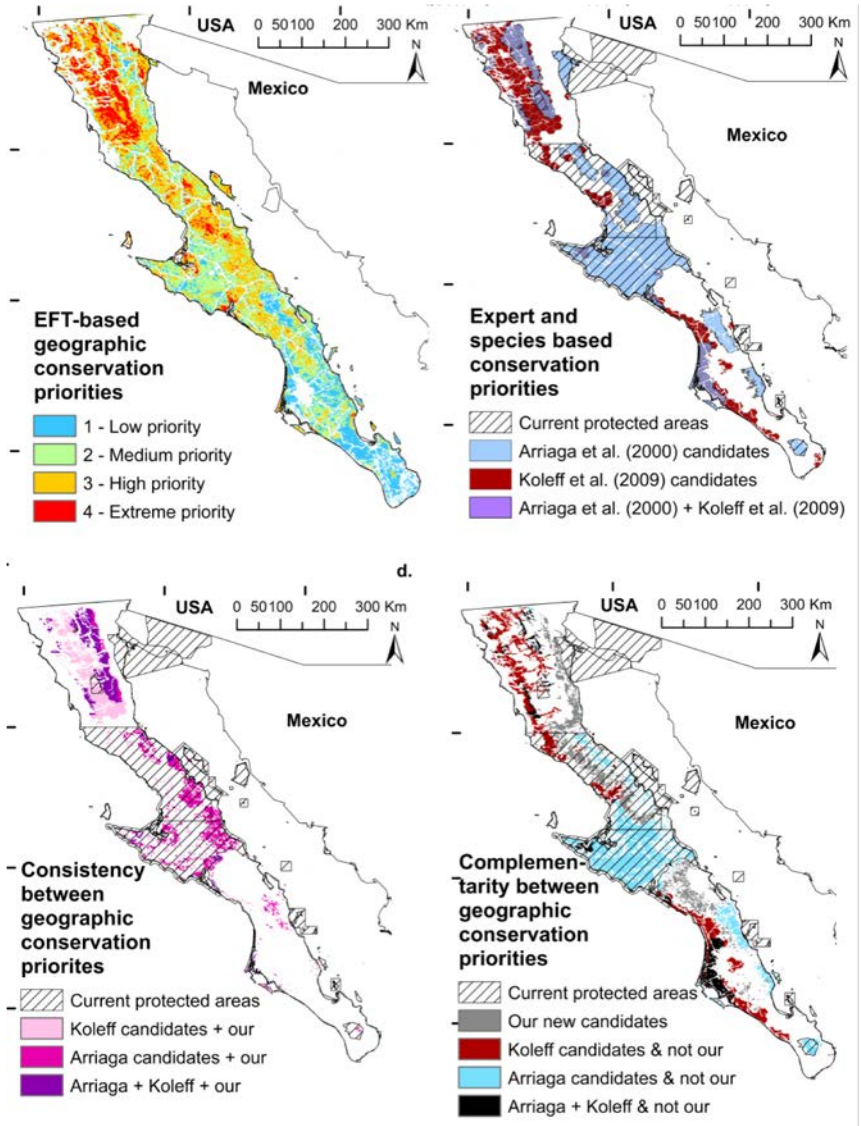
Conservation priorities in Baja California for Ecosystem Functional Diversity



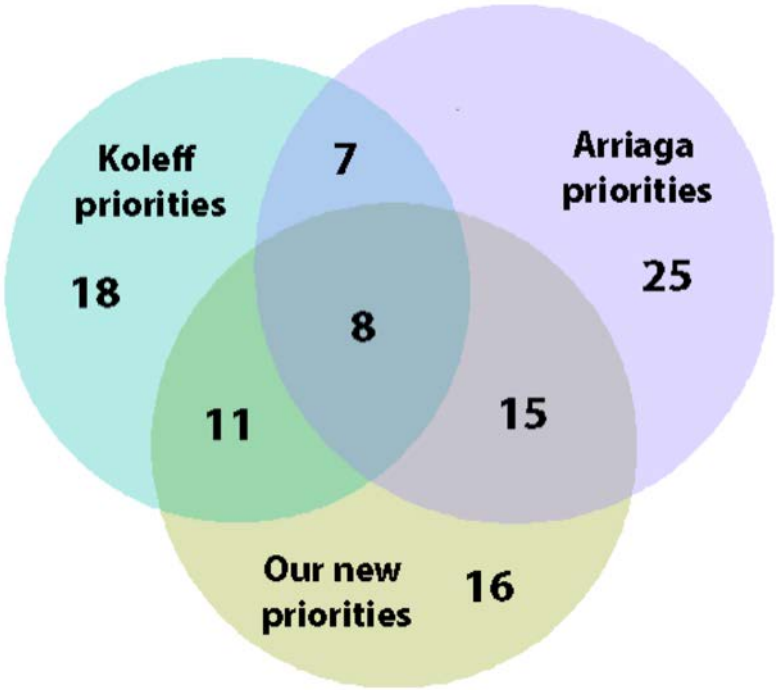


Cazorla et al. *Ecosystems* (in revision)

Conservation priorities in Baja California for Ecosystem Functional Diversity



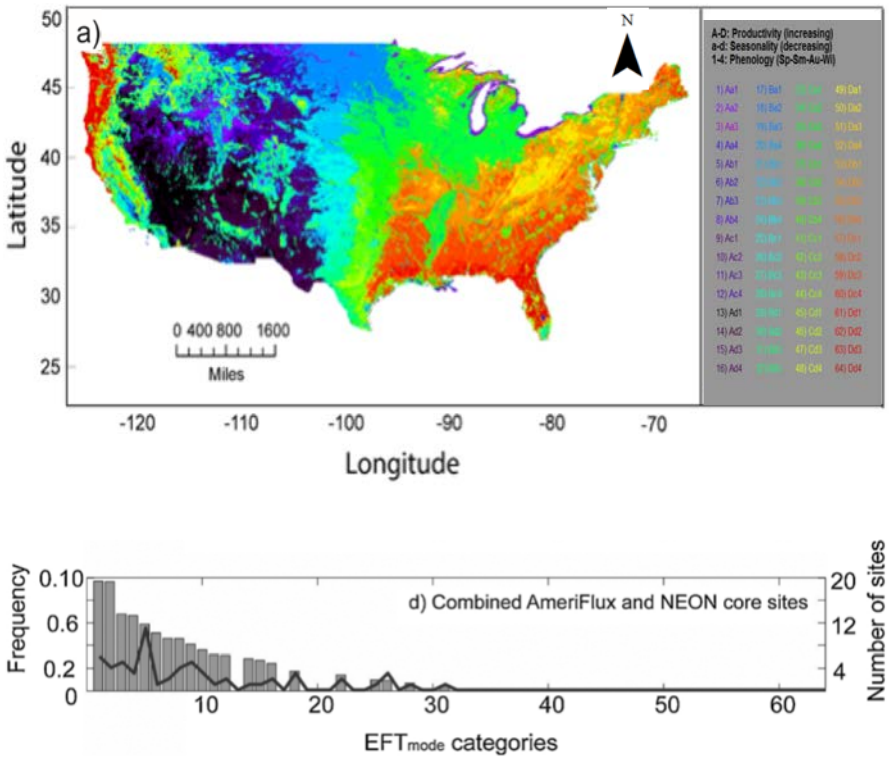
Our approach agrees more with the species-based approach and with the expert-based approach than they agree between each other

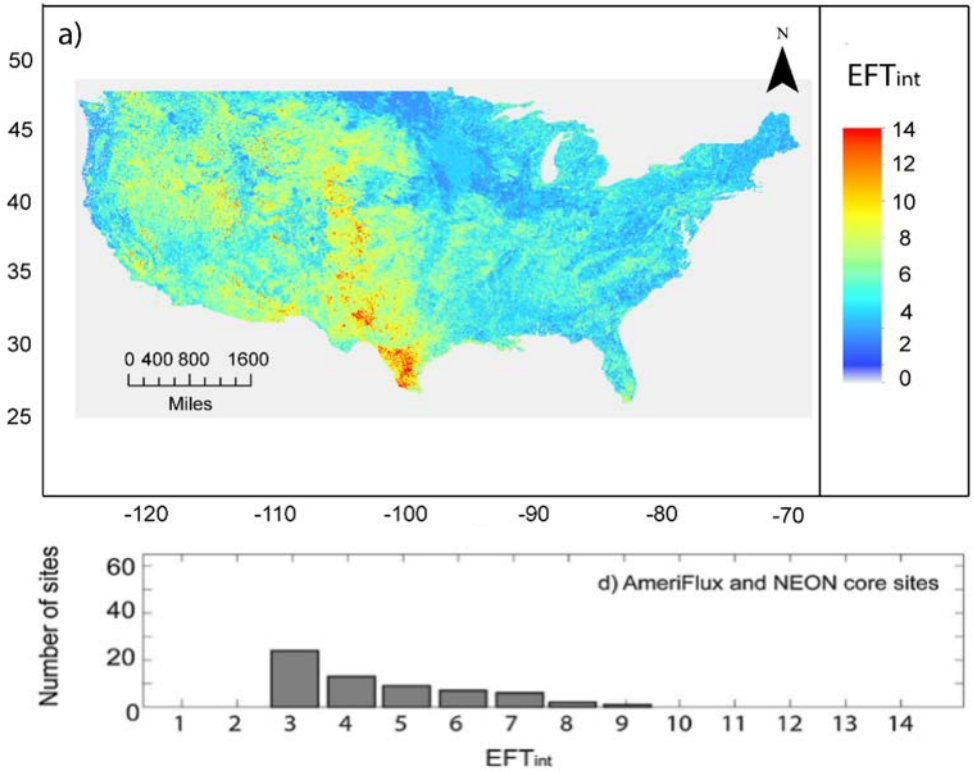


Cazorla et al. *Ecosystems* (in revision)

Representativeness of Functional Diversity in observatory networks:

- **NEON and Ameriflux Networks** (Villareal et al. 2019 Agr. & For. Met.)





Villareal et al. (2018) *Agricultural and Forest Meteorology*

Result 4

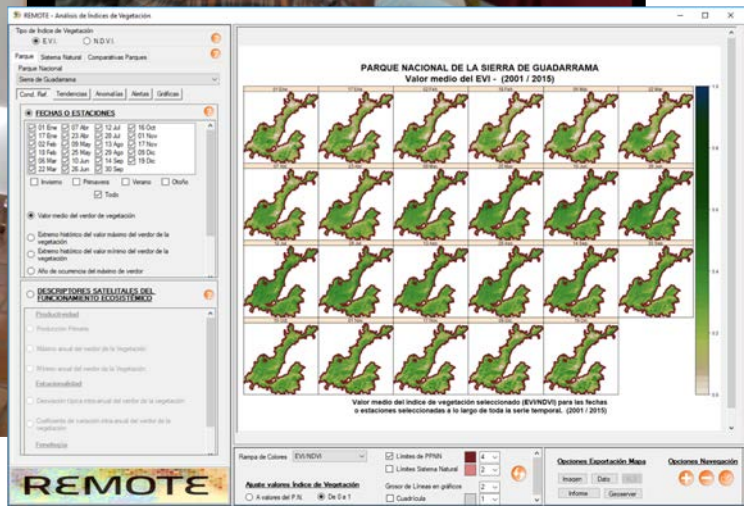
MONITORING SPAIN NATIONAL PARKS NETWORK WITH REMOTE SENSING

https://www.miteco.gob.es/gl/red-parques-nacionales/plan-seguimiento-evaluacion/seguimiento-ecologico/productividad.aspx

Cabello et al. 2016. *Revista de Teledetección; Alcaraz-Segura et al. 2009. Env. Management*

REMOTE. Integrating RS and natural areas management: a real challenge!!!!

CO-WORKING SINCE EARLY STAGES

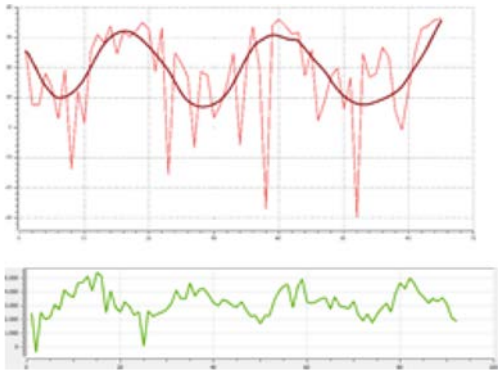


Result 4

- It offers a PA monitoring system based on EFAs
- It works at 3 levels: Network, Park and ecosystem
- It offers: reference conditions, change detection, trends, anomalies, complete time series, maps and graphs.

Requirements

- Management and managers oriented.
- Free Software
- Free access imagery with time continuity.



Cabello et al. 2016. *Revista de Teledetección*

Concluding remarks

1. The **annual amount** (Mean), **seasonality** (SD), and **phenology** (Date of peak) are **three simple but informative descriptors** for Primary Production (EVI) dynamics in all biomes (Ecosystem Functional Attributes, EFAs).

1. The combination of EFAs in a synthetic classification of **Ecosystem Functional Types** integrates the spatial and temporal heterogeneity in ecosystem functioning.

1. Satellite-derived **EFTs capture the regional patterns of CO_2 net ecosystem exchange** between the biota and the atmosphere at continental scales (even better than PFTs).

1. EFAs and EFTs allowed to **identify hotspots of ecosystem functional diversity** and of interannual variability.

1. The Spanish National Park Organism now counts with a monitoring system based on EFAs and EFTs to **inform managers on the dynamics, changes and anomalies** of essential ecosystem functional attributes for PAs.

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Thank you!

Ecosystem Functional Types as an EBV to characterize functional diversity

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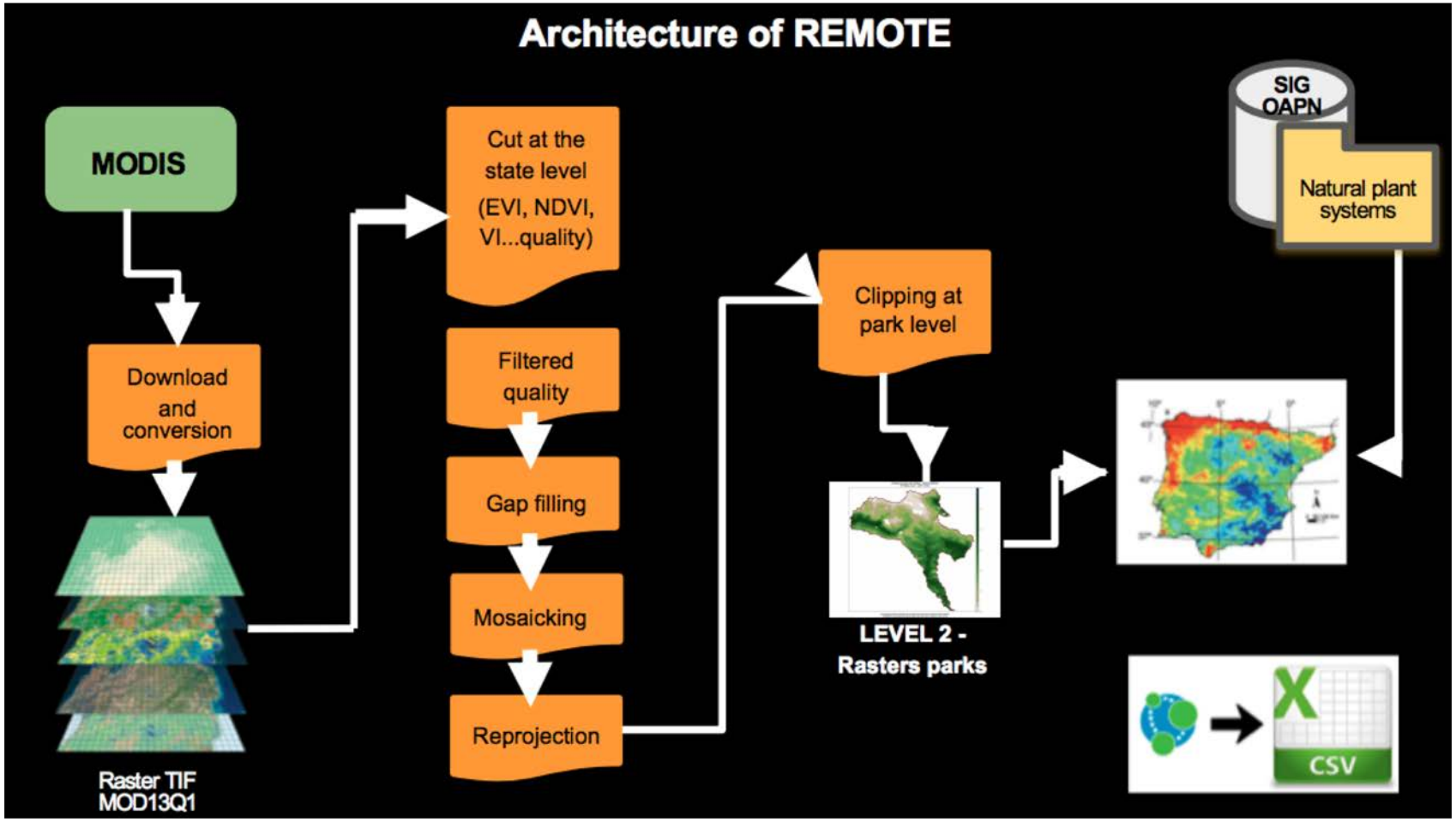
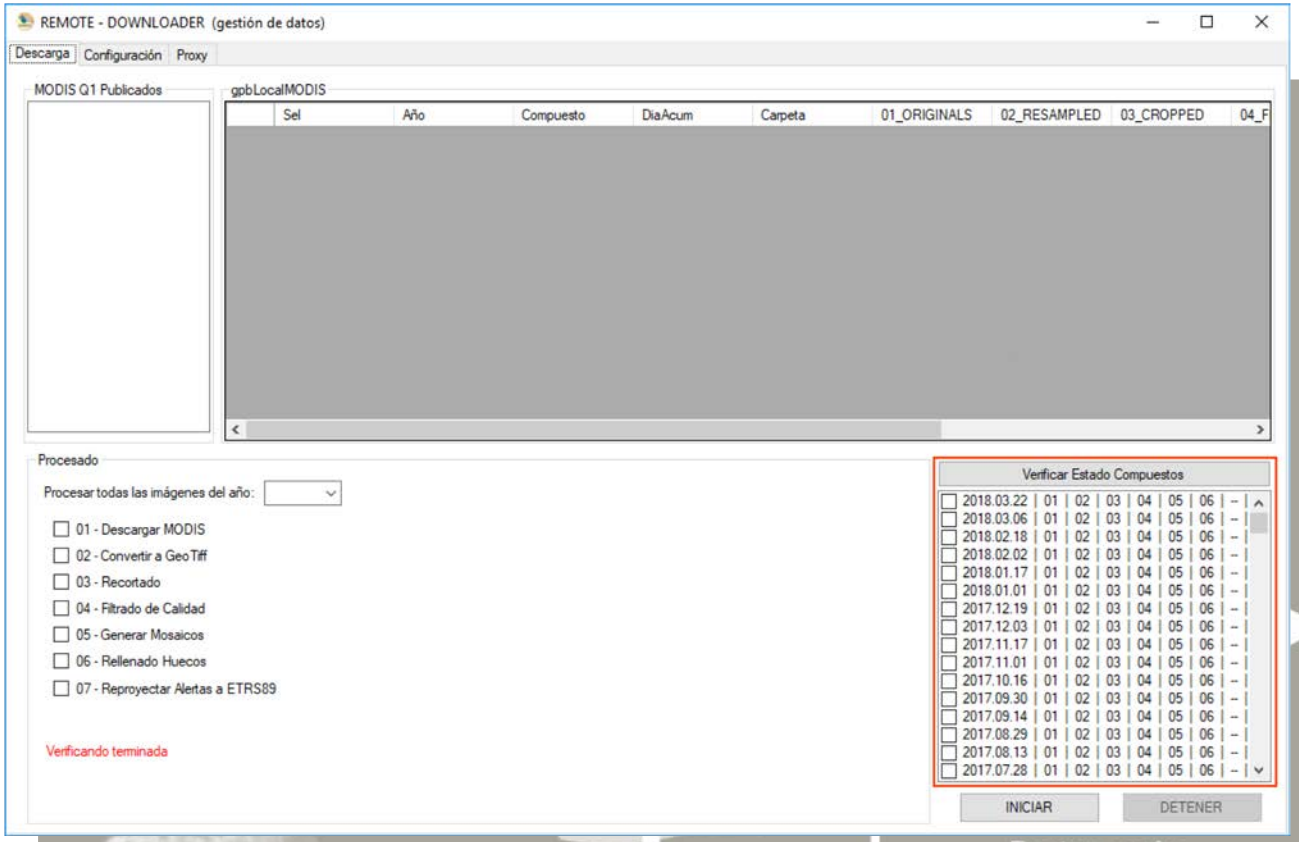
This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 641762

REMOTE


Architecture of REMOTE
MODIS
Download and conversion
Raster TIF MOD13Q1
Cut at the state level (EVI, NDVI, VI...quality)
Filtered quality
Gap filling
Mosaicking
Reprojection
SIG OAPN
Natural plant systems
Clipping at park level
LEVEL 2 - Rasters parks
CSV

REMOTE



AUTOMATIC AND CUSTOMIZABLE IMAGE DOWNLOADER

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	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23
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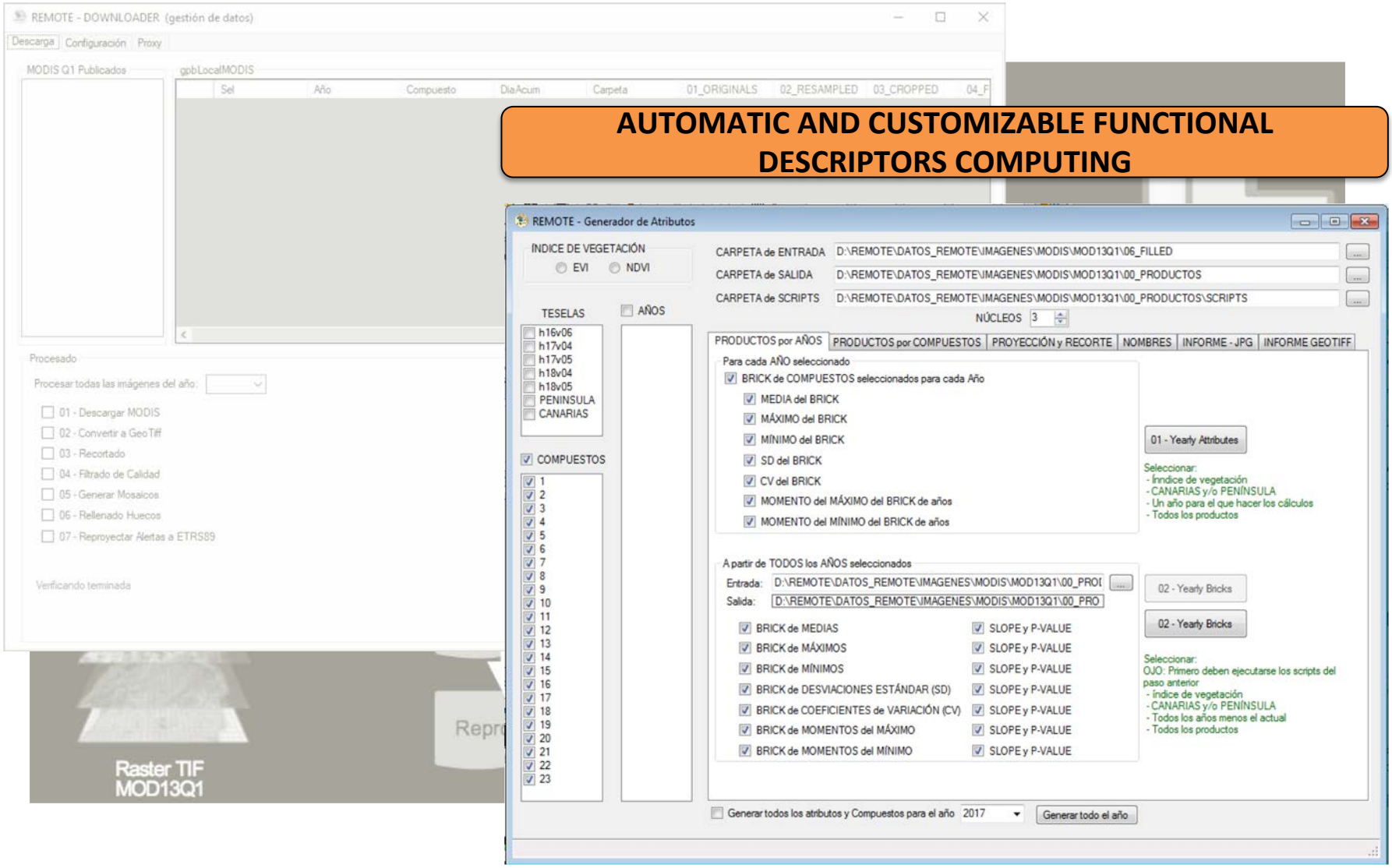
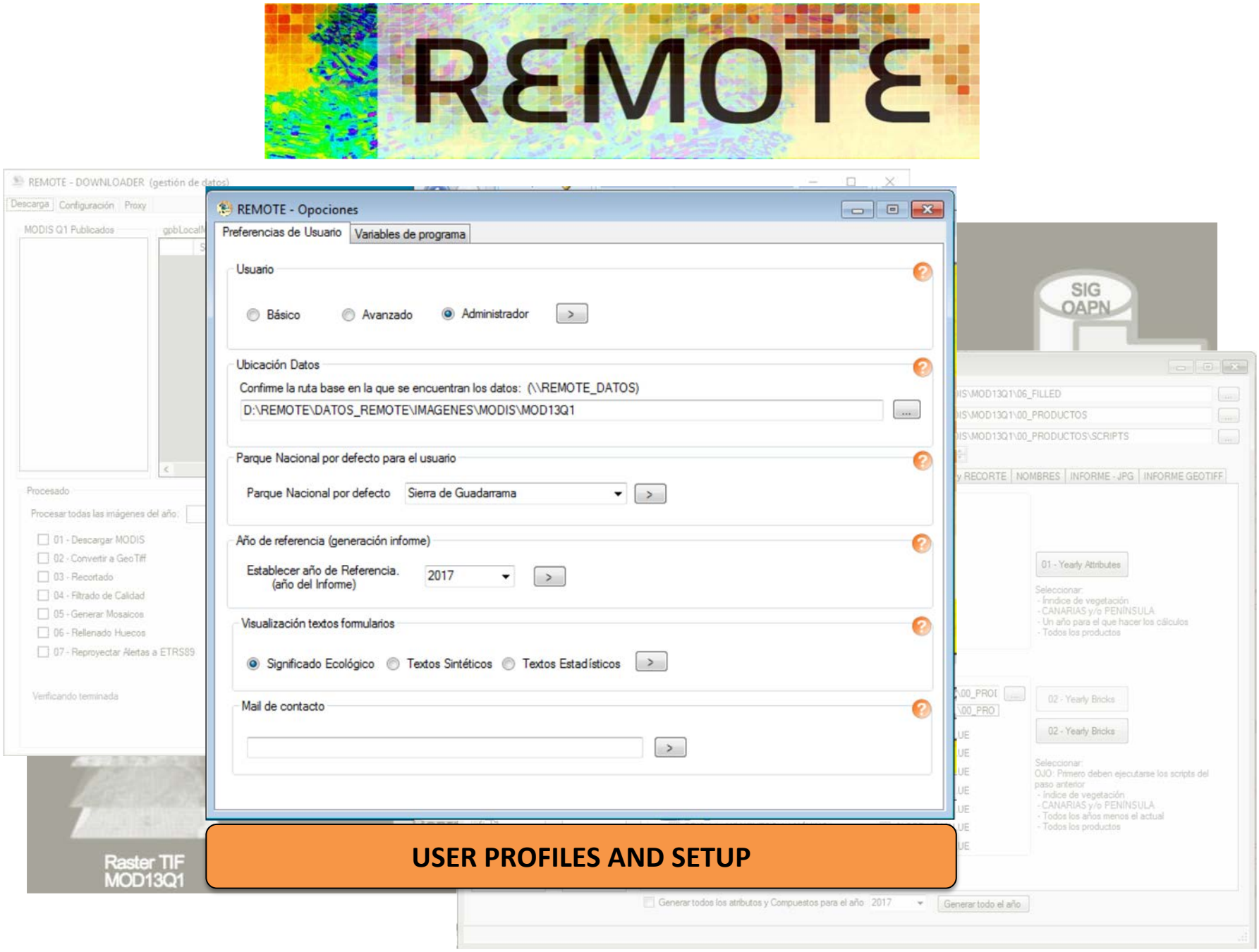
REMOTE

AUTOMATIC AND CUSTOMIZABLE FUNCTIONAL DESCRIPTORS COMPUTING




REMOTE
REMOTE - Opciones
Preferencias de Usuario
Variables de programa
Usuario
Básico
Avanzado
Administrador
Ubicación Datos
Confirme la ruta base en la que se encuentran los datos: (\\REMOTE_DATOS)
D:\REMOTE\DATOS_REMOTE\IMAGENES\MODIS\MOD13Q1
Parque Nacional por defecto para el usuario
Parque Nacional por defecto
Sierra de Guadarrama
Año de referencia (generación informe)
Establecer año de Referencia. (año del Informe)
2017
Visualización textos formularios
Significado Ecológico
Textos Sintéticos
Textos Estadísticos
Mail de contacto
SIG OAPN
Raster TIF MOD13Q1
USER PROFILES AND SETUP

REMOTE - Análisis de Índices de Vegetación

Tipo de Índice de Vegetación
E.V.I. N.D.V.I.

Parque | Sistema Natural | Comparativas Parques

Parque Nacional
Sierra de Guadarrama

Cond. Ref. | Tendencias | Anomalías | Alertas | Gráficas

FECHAS O ESTACIONES

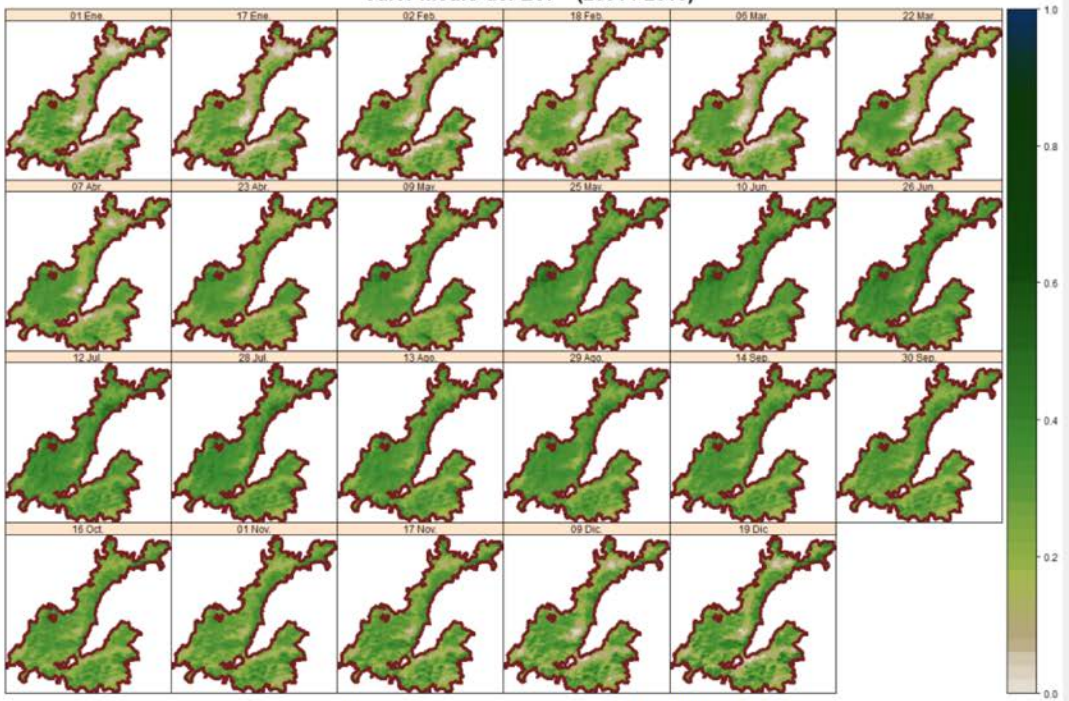
01 Ene	07 Abr	12 Jul	16 Oct
17 Ene	23 Abr	28 Jul	01 Nov
02 Feb	09 May	13 Ago	17 Nov
18 Feb	25 May	29 Ago	09 Dic
06 Mar	10 Jun	14 Sep	19 Dic
22 Mar	26 Jun	30 Sep	

Invierno Primavera Verano Otoño
Todo

Valor medio del verdor de vegetación
Extremo histórico del valor máximo del verdor de la vegetación
Extremo histórico del valor mínimo del verdor de la vegetación
Año de ocurrencia del máximo de verdor

DESCRIPTORES SATELITALES DEL FUNCIONAMIENTO ECOSISTÉMICO

Productividad
Producción Primaria
Máximo anual del verdor de la Vegetación
Mínimo anual del verdor de la Vegetación
Estacionalidad
Desviación típica intra-anual del verdor de la vegetación
Coeficiente de variación intra-anual del verdor de la vegetación
Fenología



Rampa de Colores EVI/NDVI

Límites de PPNN 4
Límites Sistema Natural 2

Ajuste valores Índice de Vegetación
A valores del P.N. De 0 a 1

Grosor de Líneas en gráficos 2
Cuadrícula 1

Opciones Exportación Mapa
Imagen | Dato | XLS
Informe | Geoserver

Opciones Navegación

REMOTE