climate change initiative

RIVER DISCHARGE

Multispectral images-based river discharge

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User Workshop

Météo-France, Toulouse

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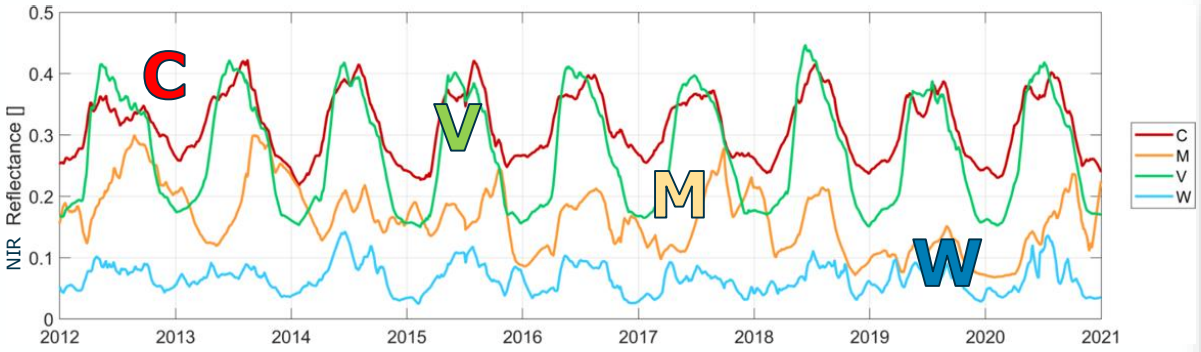
river discharge cci

Methodology: Algorithms

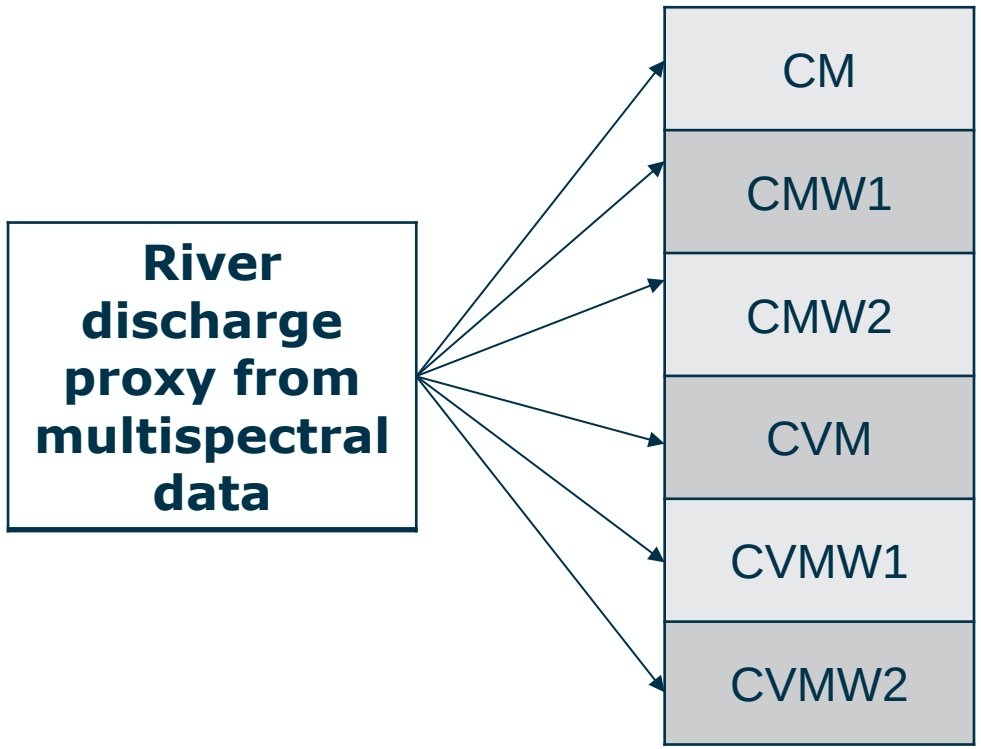


Several combination of the signals have been developed according to the selected site characteristics

CM	CMW1	CMW2
CVM	CVMW1	CVMW2

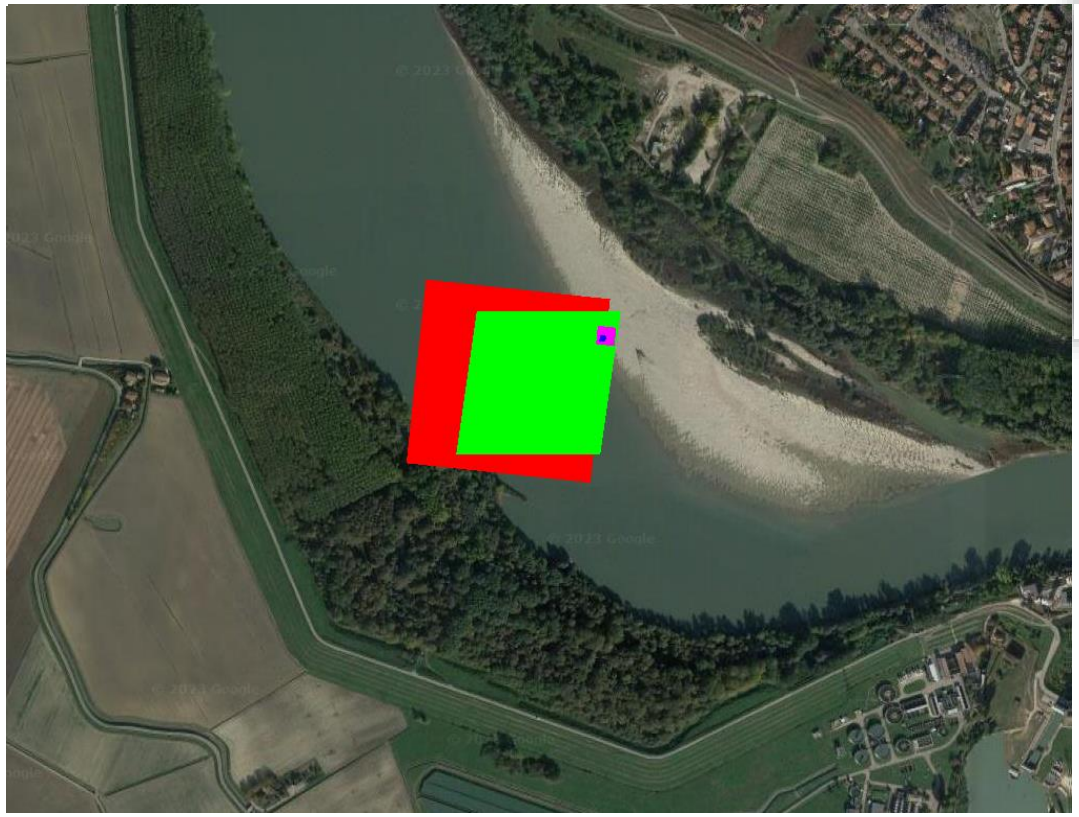
Methodology

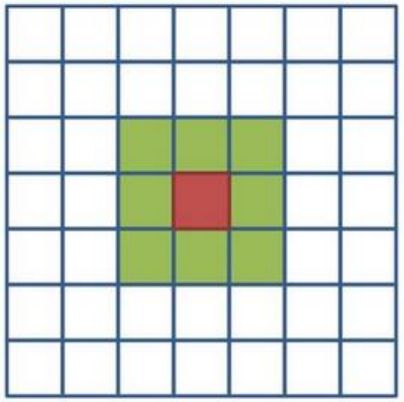
Algorithms



6

Methodology: Spatial resolution





Kernel application (x 2)

45 Sites		
Estimated river width variation	10	400
Sentinel 2 kernel	0	20
Landsat kernel	0	6
MODIS kernel	0	1

Sentinel-3 Spatial Resolution = 300 m

MODIS Spatial Resolution = 230 m

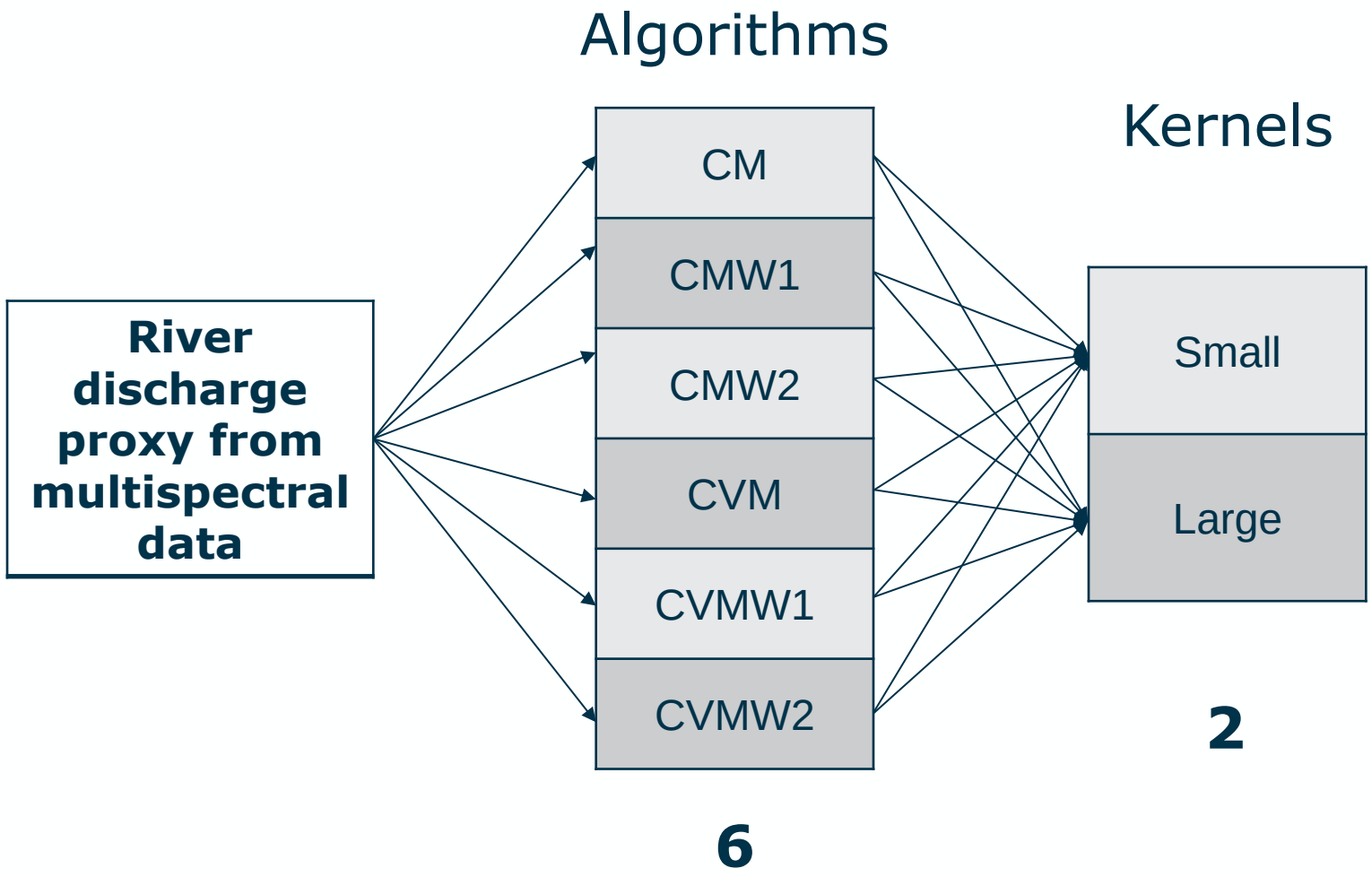
LANDSAT Spatial Resolution = 30 m

Sentinel-2 Spatial Resolution = 10 m

Two kernels are selected for each site:

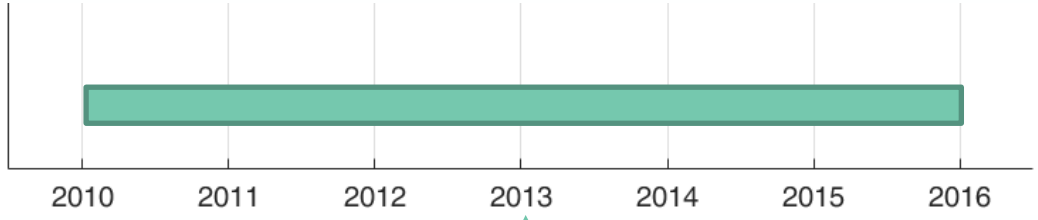
one **large** and one **small**

Methodology

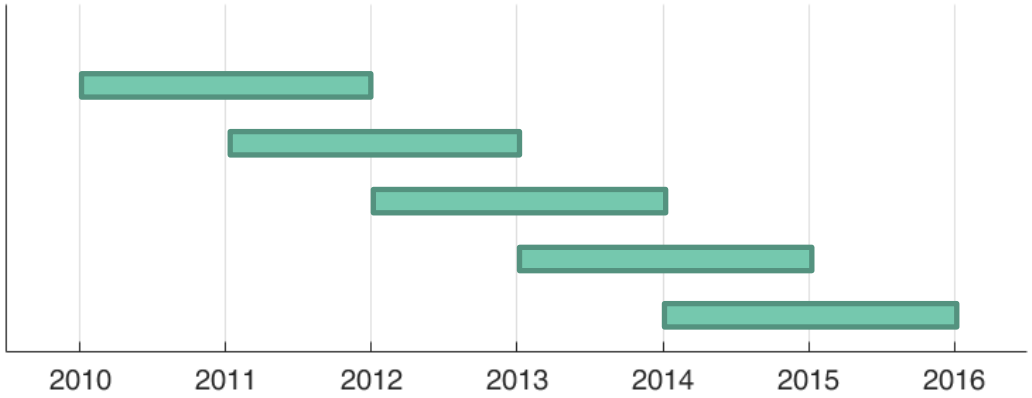


Methodology: Temporal variability

Full calibration



Two calibrations methods:

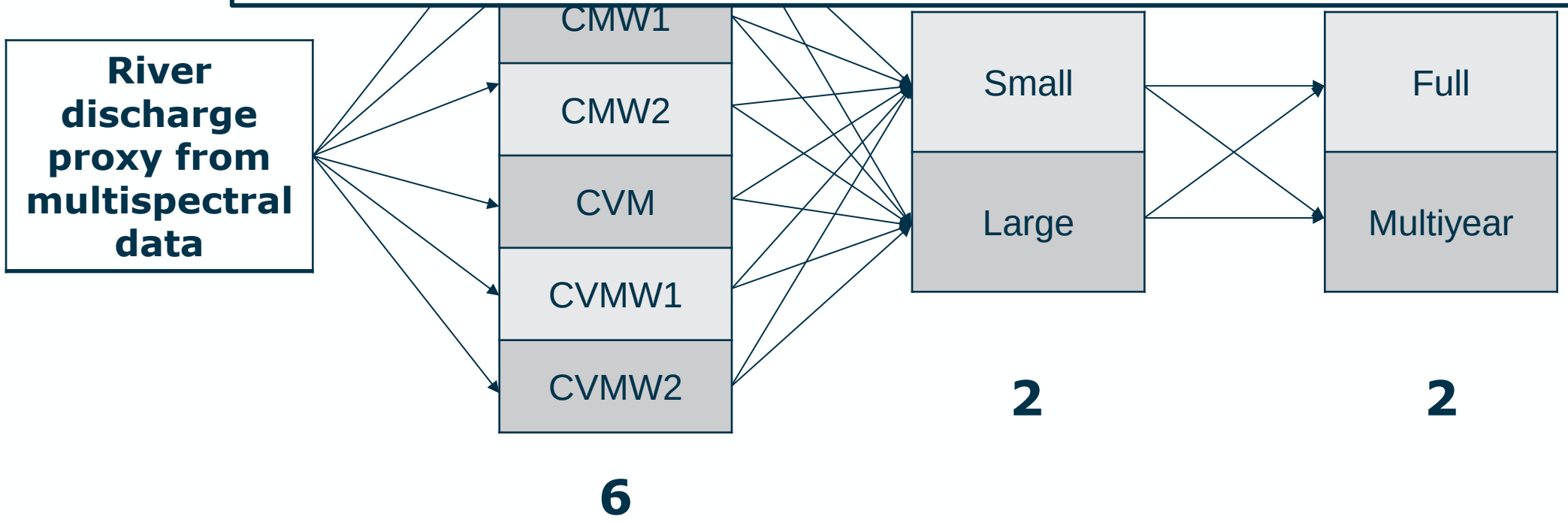


Multiple calibration

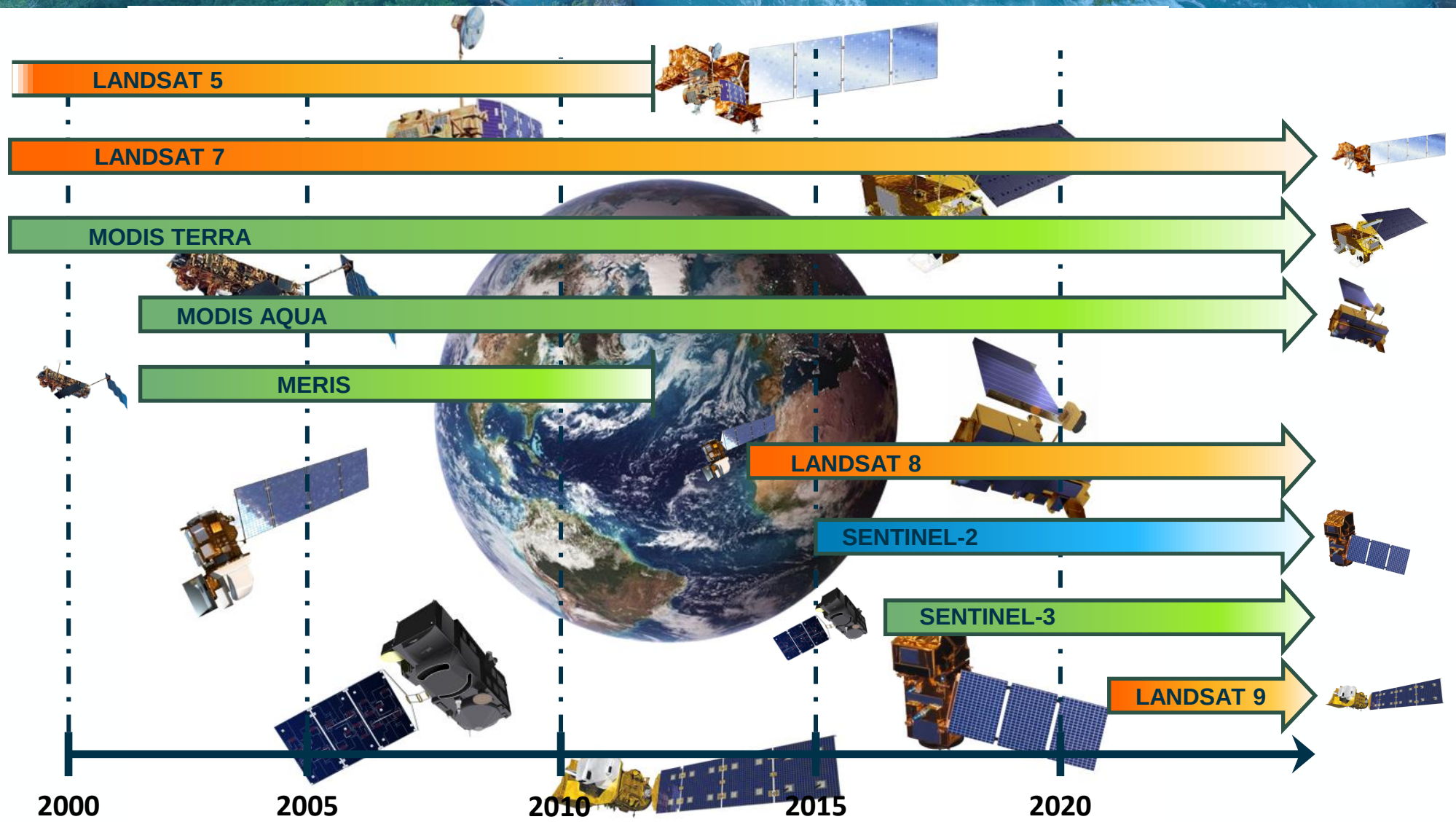
Methodology

Algorithms

24 potential approaches adapting to different environments

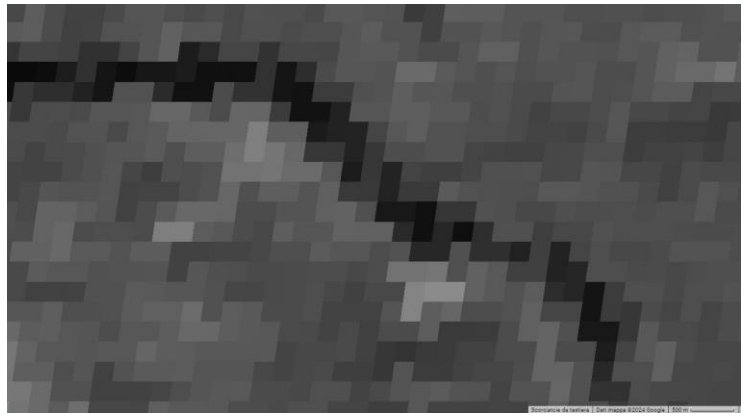


Products


LANDSAT 5
LANDSAT 7
MODIS TERRA
MODIS AQUA
MERIS
LANDSAT 8
SENTINEL-2
SENTINEL-3
LANDSAT 9
2000
2005
2010
2015
2020

Products: Spatial resolution

COARSE RESOLUTION
MODIS (500-250 m)
MERIS, Sentinel-3



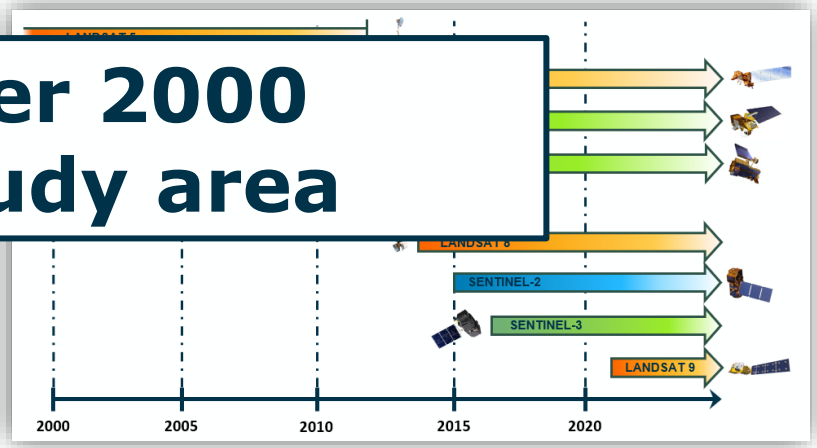
HIGH RESOLUTION
LANDSAT (30 m)

Sentinel 2 (10 m)

Products: Temporal resolution

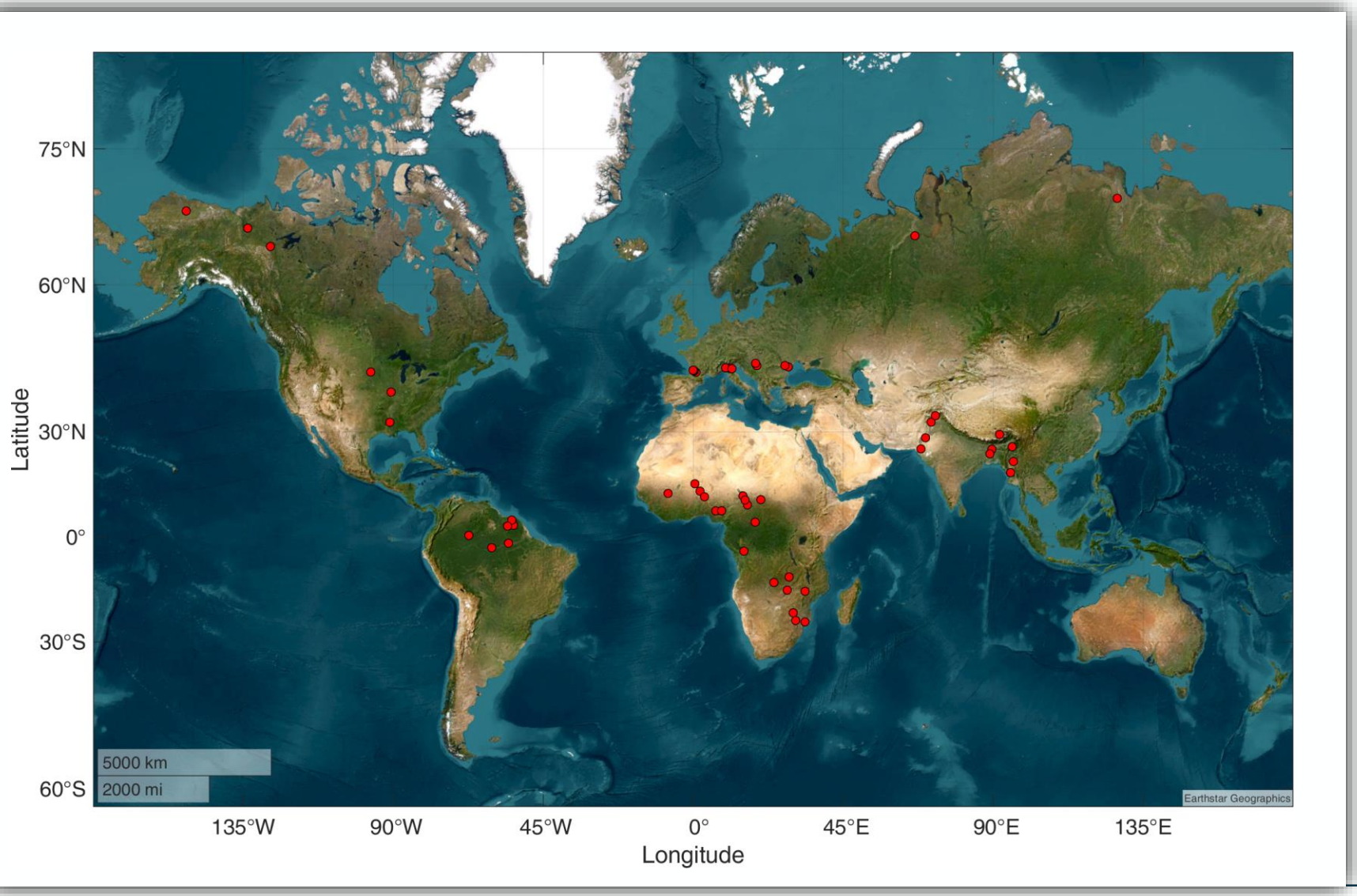
About 25000 images after 2000 to be analyze for each study area

PRODUCTS	IMAGES x MONTH	TOTAL IMAGES
HR LANDSAT 5		
HR LANDSAT 7		
HR LANDSAT 8		
HR LANDSAT 9	~ 2	~ 50
HR SENTINEL-2 GEE	~ 6	~ 600
HR SENTINEL-2 SH	~ 6	~ 600
HR LANDSAT 8-9+SENTINEL-2	~ 8	~ 800
CR SENTINEL-3	~ 30	~ 2000
CR MERIS	~ 30	~ 4000
CR MODIS AQUA	~ 30	~ 8000
CR MODIS TERRA	~ 30	~ 8000

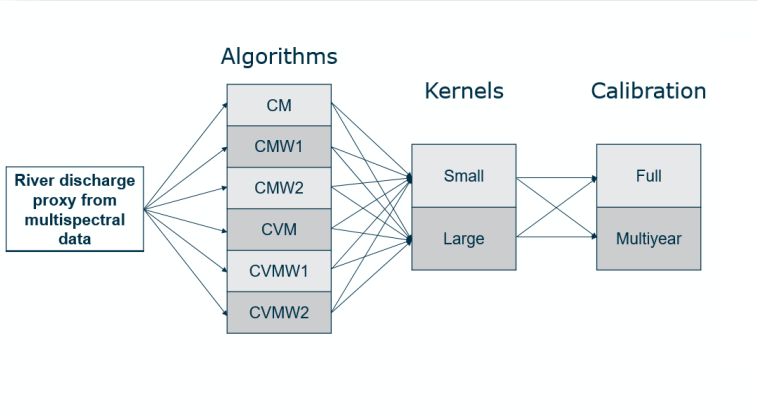


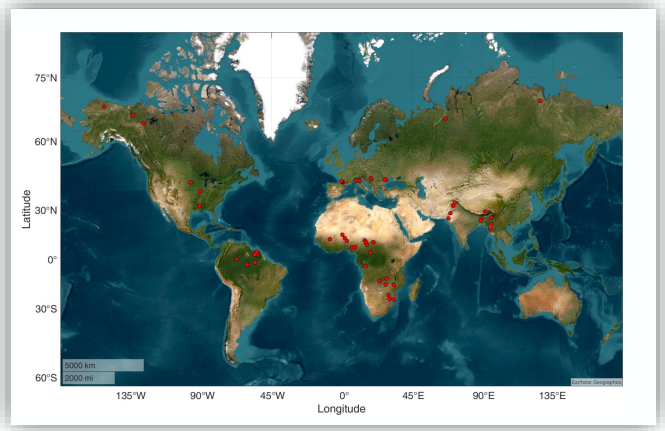
Study area

54 sites spread over different climates and environments

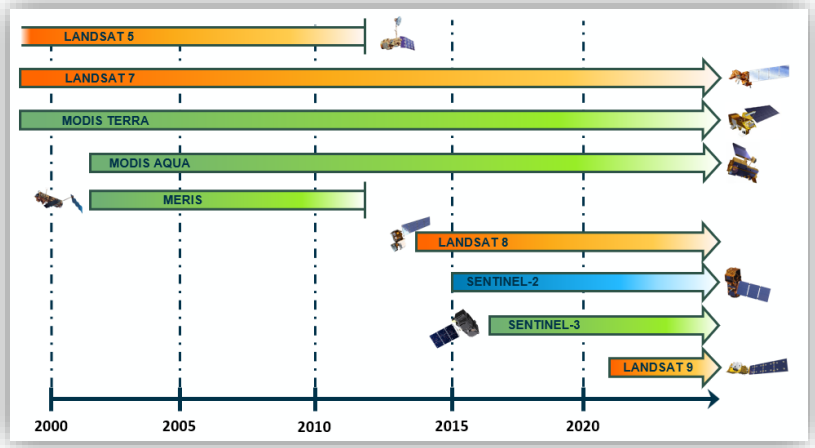


A few numbers…





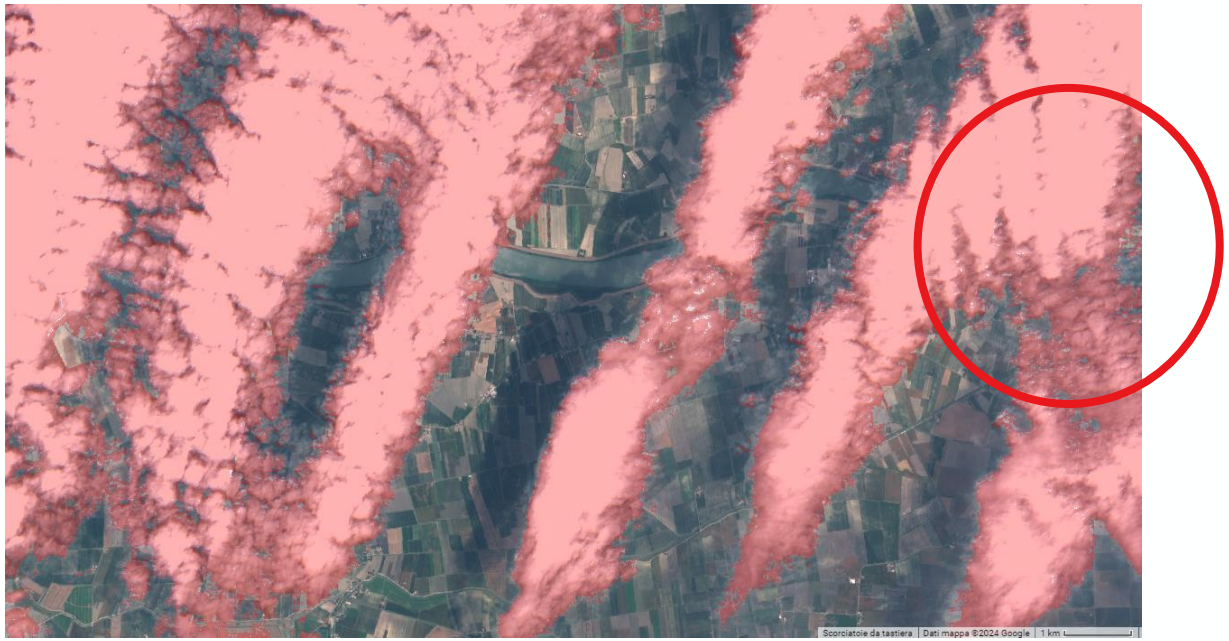
$$24\ methods * 25000\ images * 54\ stations = \sim 32,400,000\ images$$



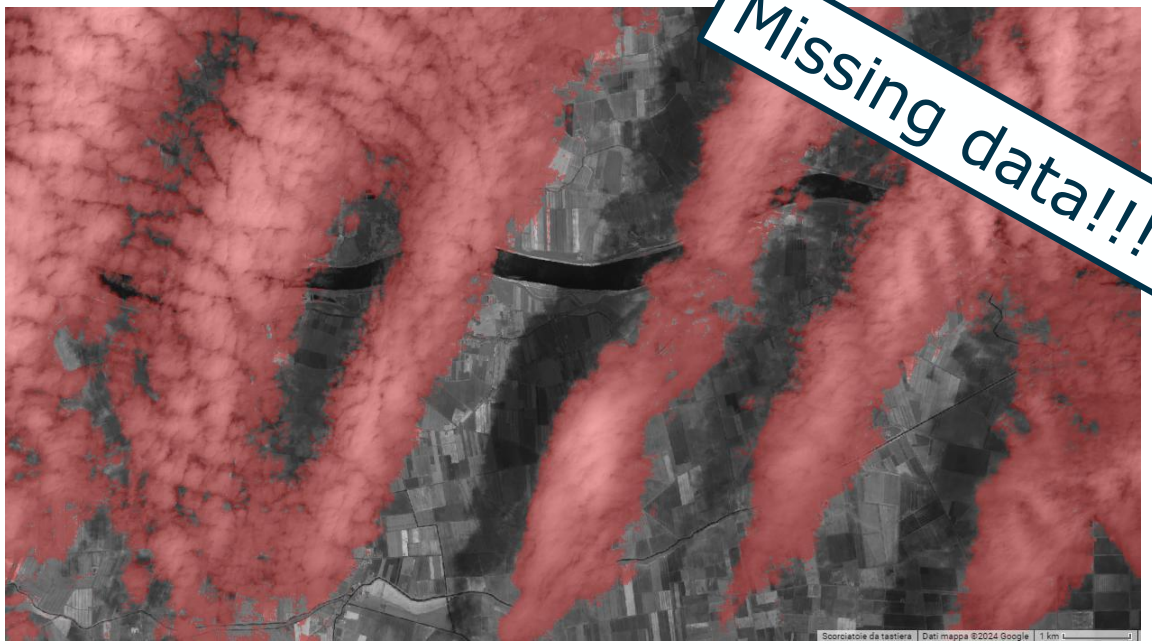
Limitations

Clouds

RGB



NIR



$$Q \propto \frac{C}{M}$$

Clouds on C => Overestimation of Q

Clouds on M => Underestimation of Q

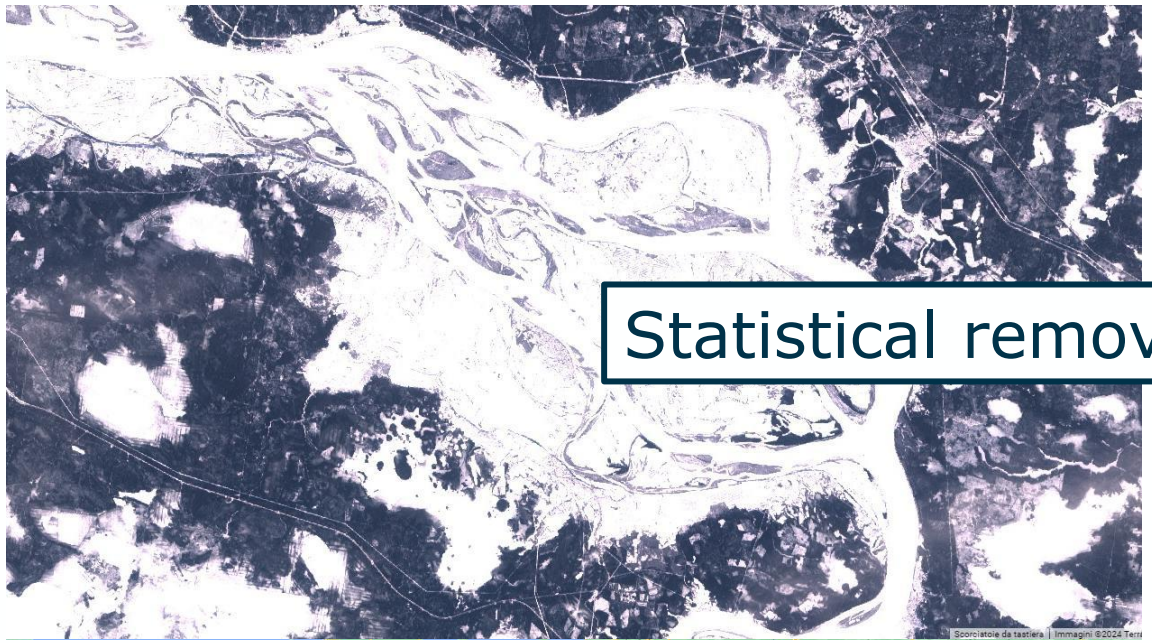
Cloud shadows on C => Underestimation of Q

Cloud shadows on M => Overestimation of Q

Limitations

Snow/Ice

RGB



NIR

Statistical removal of frozen periods

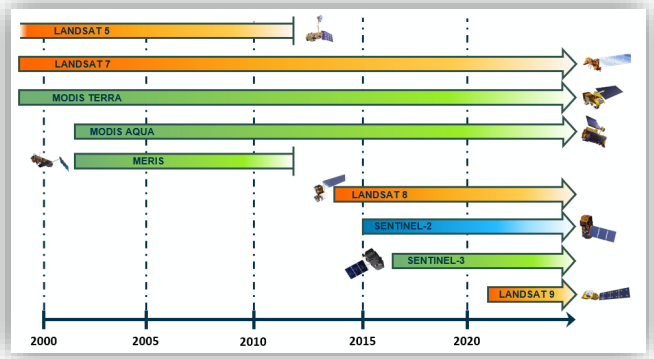
$$Q \propto \frac{C}{M}$$

Snow/Ice on C => Overestimation of Q

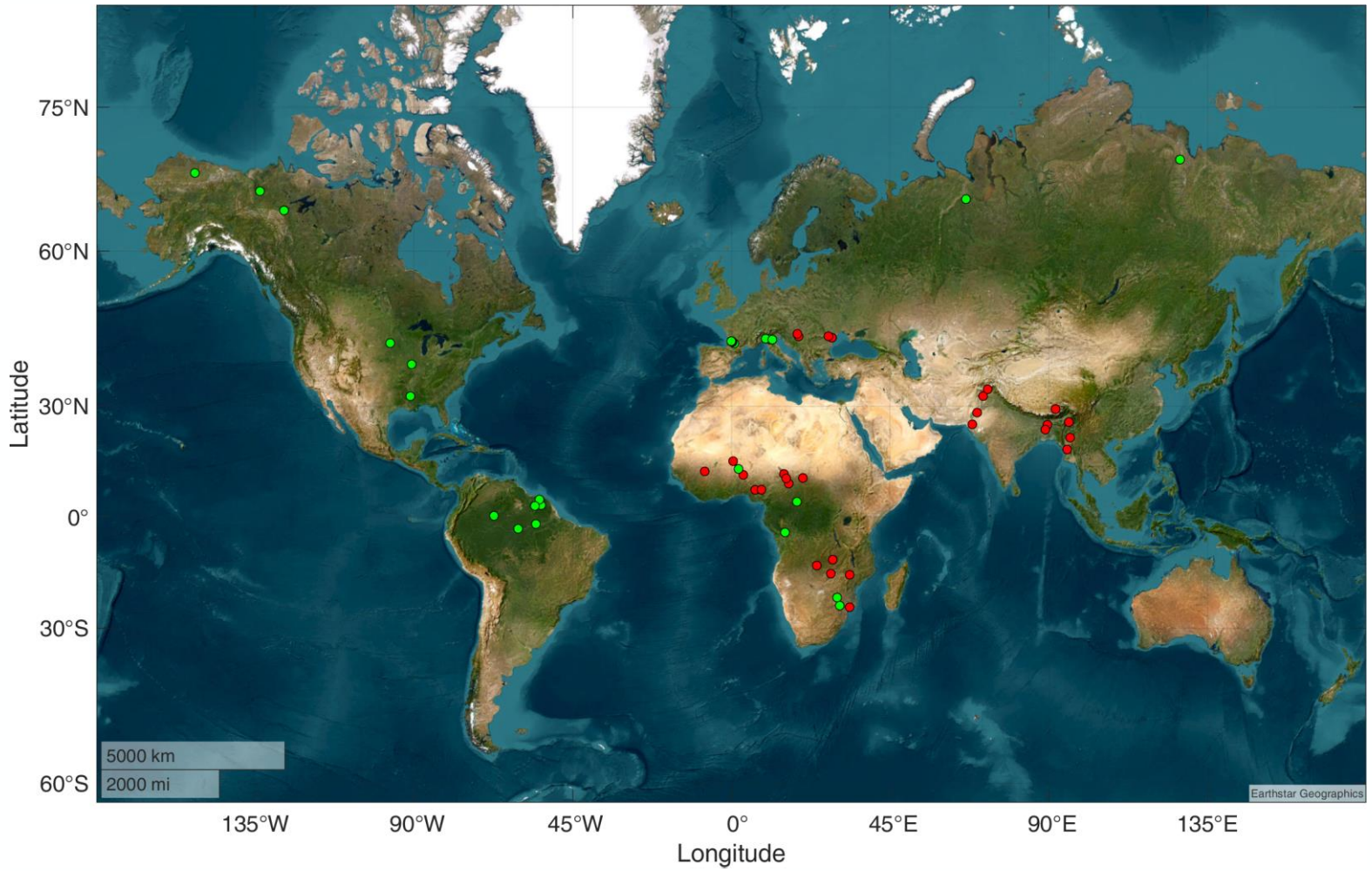
Snow/Ice on M => Underestimation of Q

Calibrated Results

Calibration

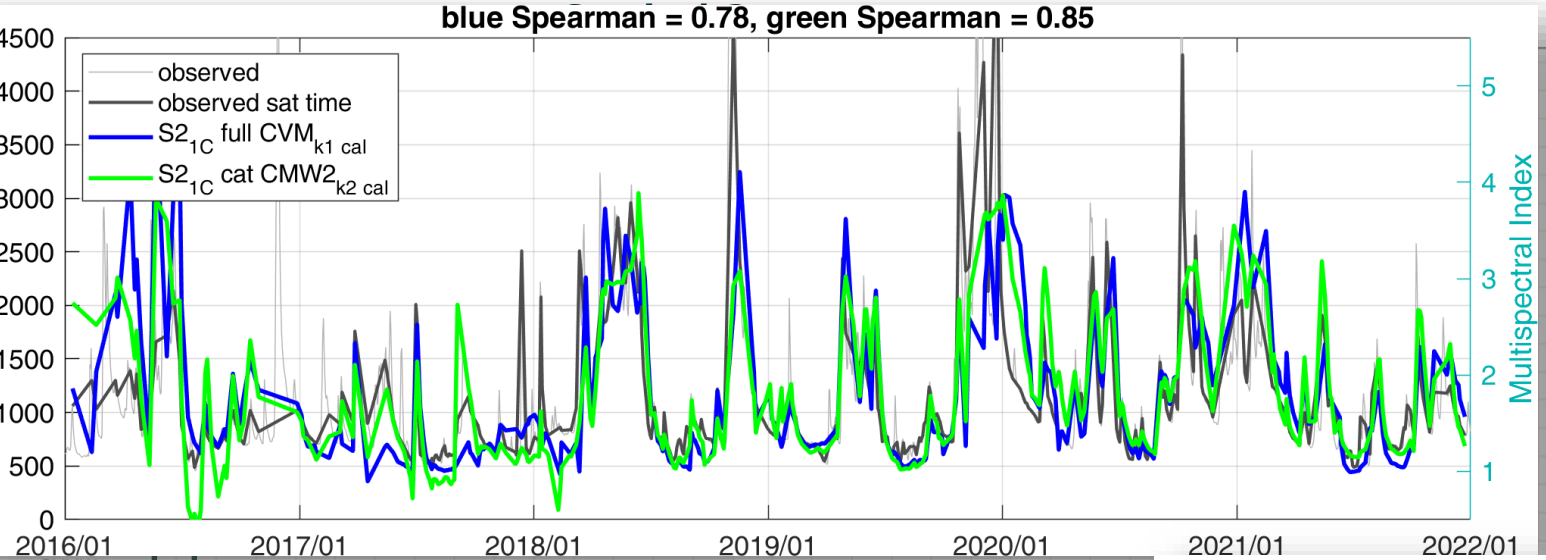


Calibration on 23 stations where observed data are available in the recent period

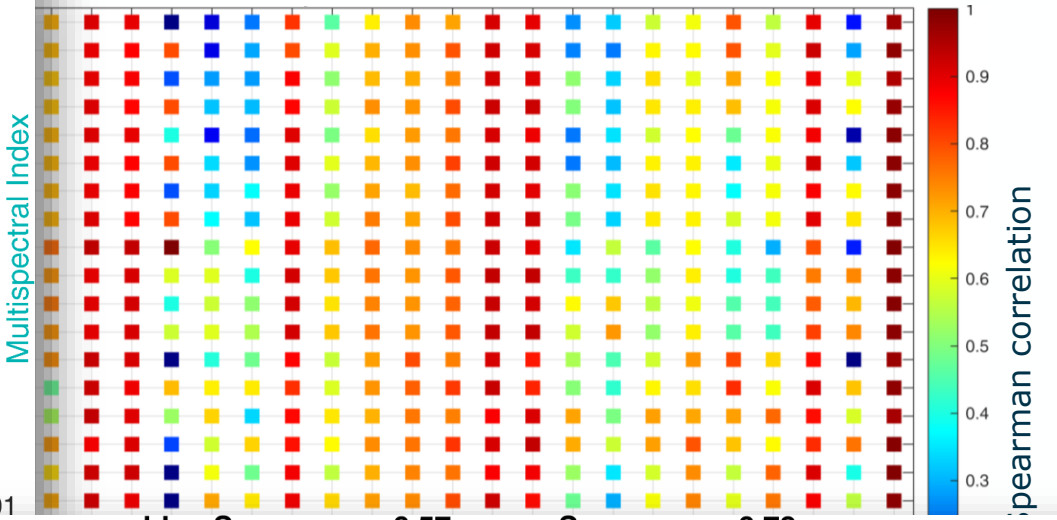


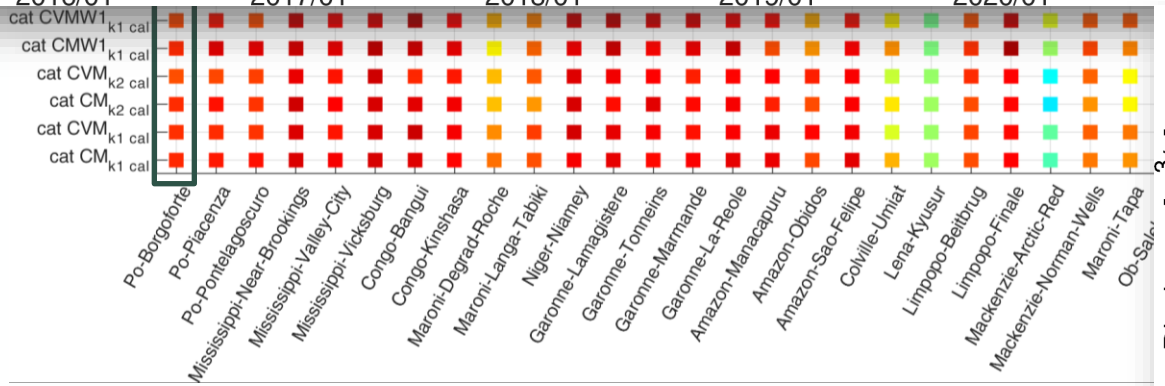
Calibration

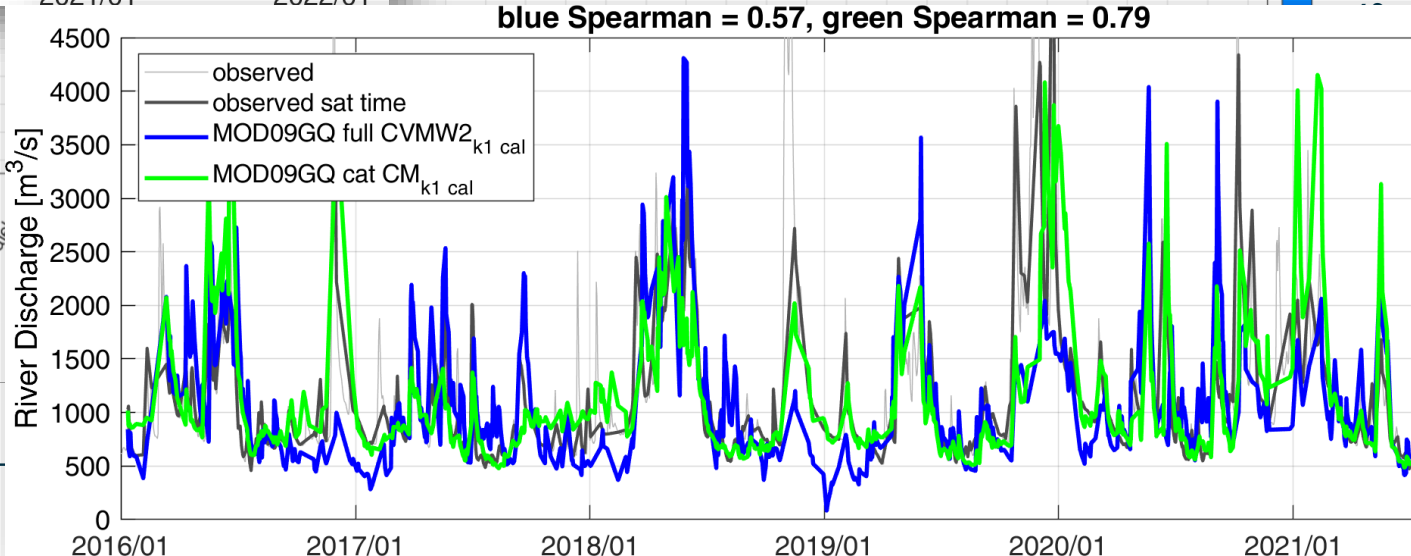
Exemplary results:



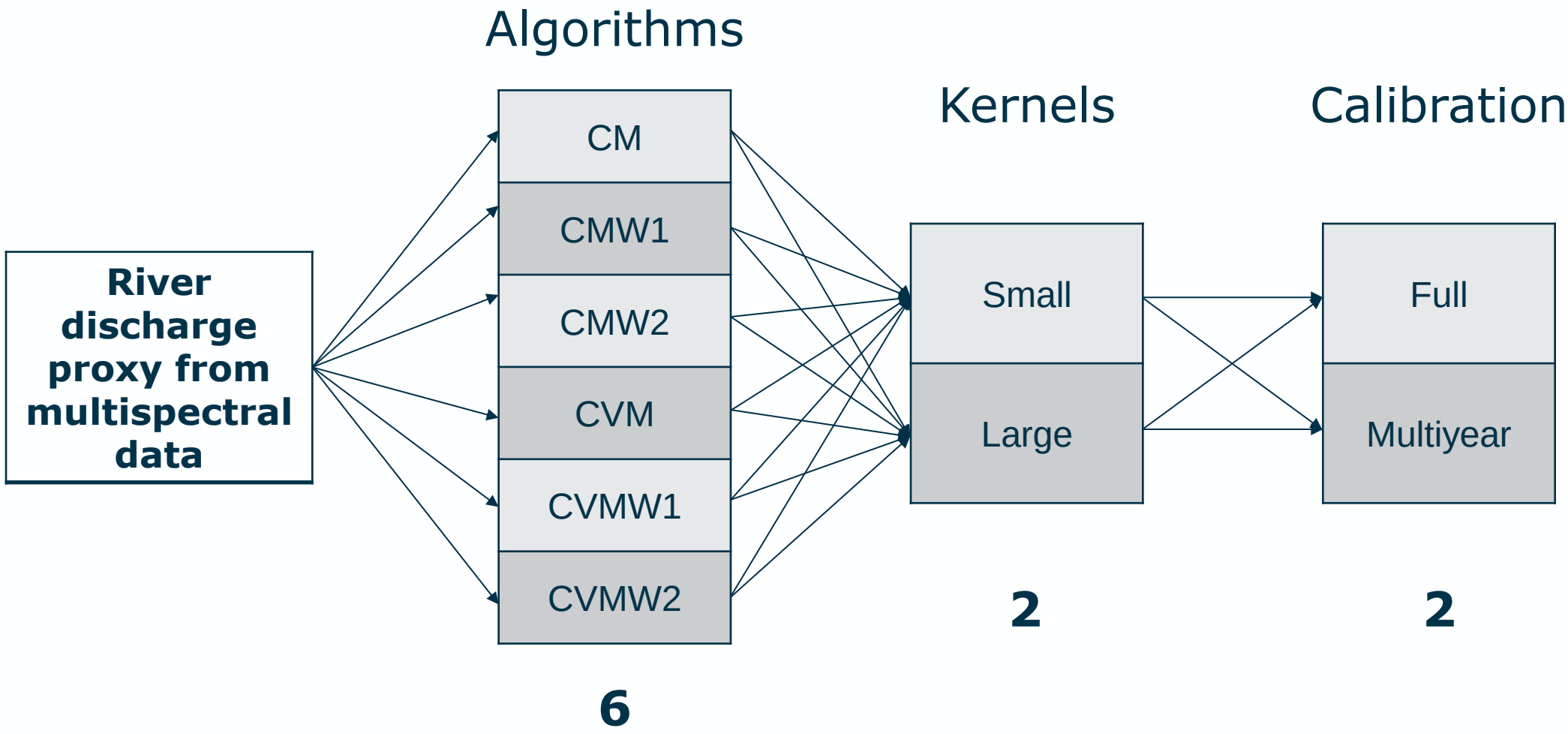
Exemplary results:
MODIS TERRA

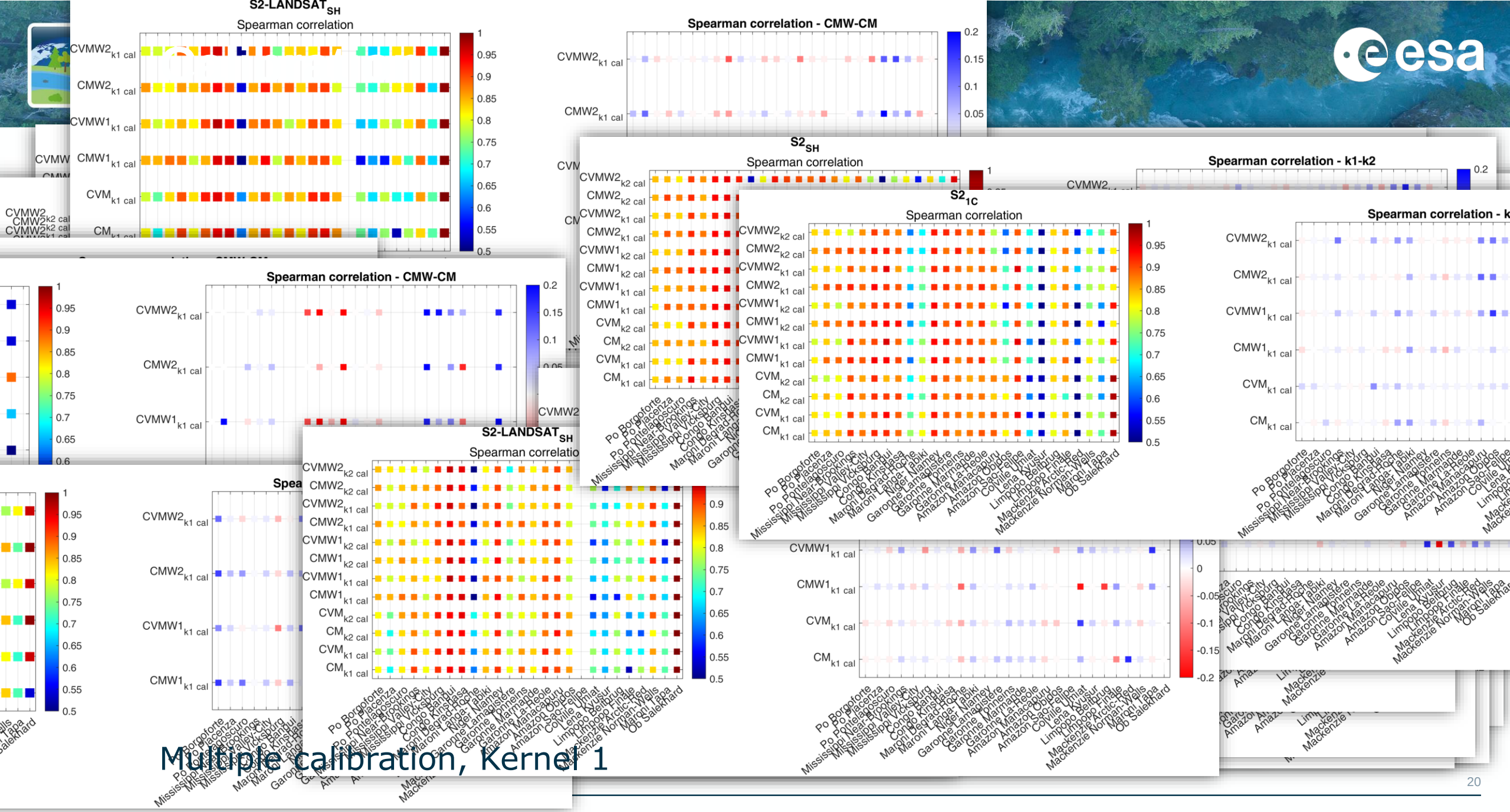




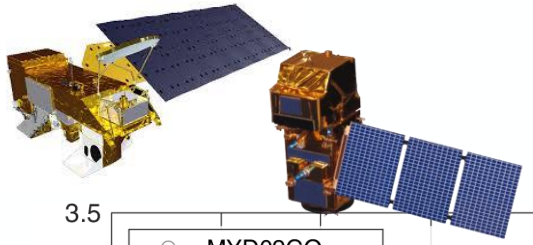


Methodology

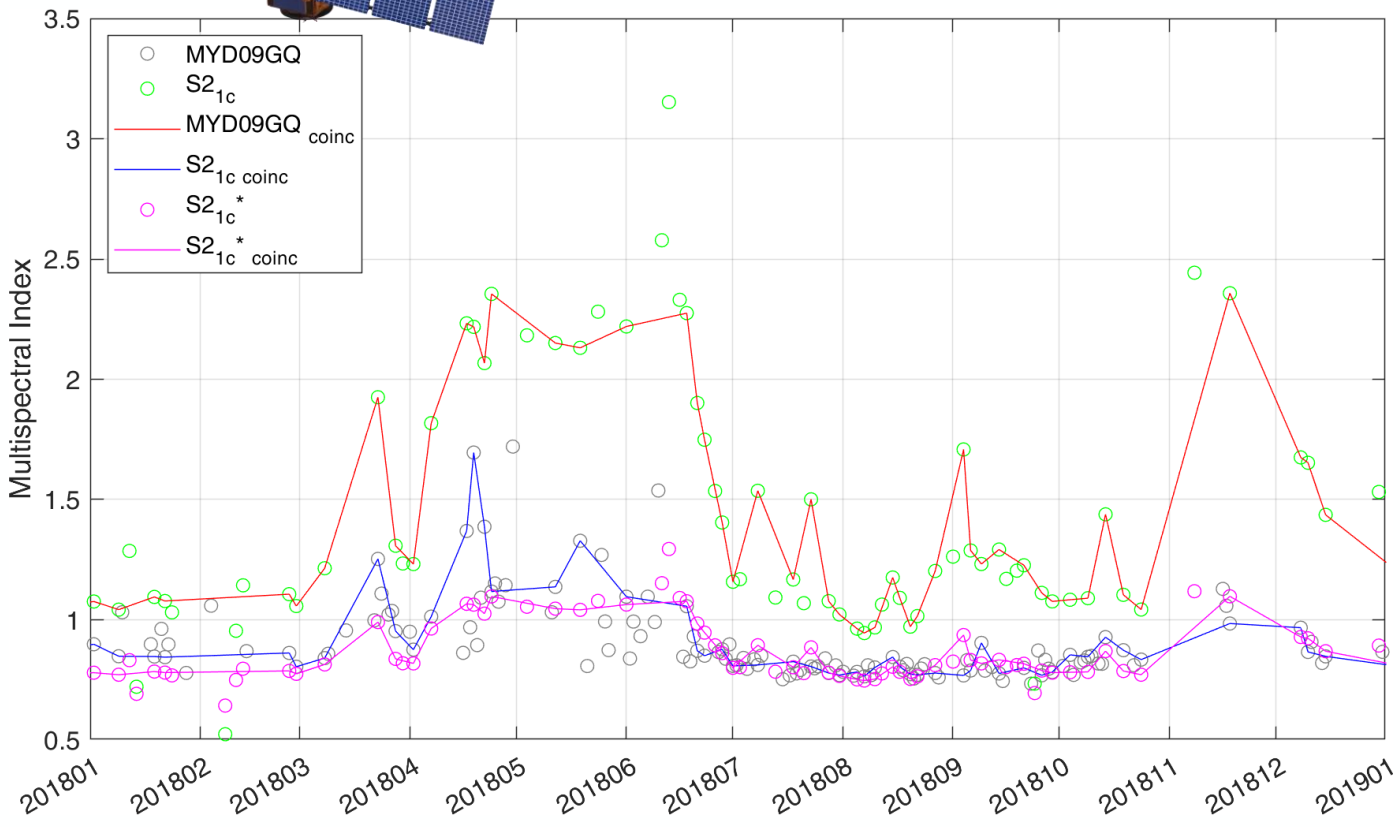


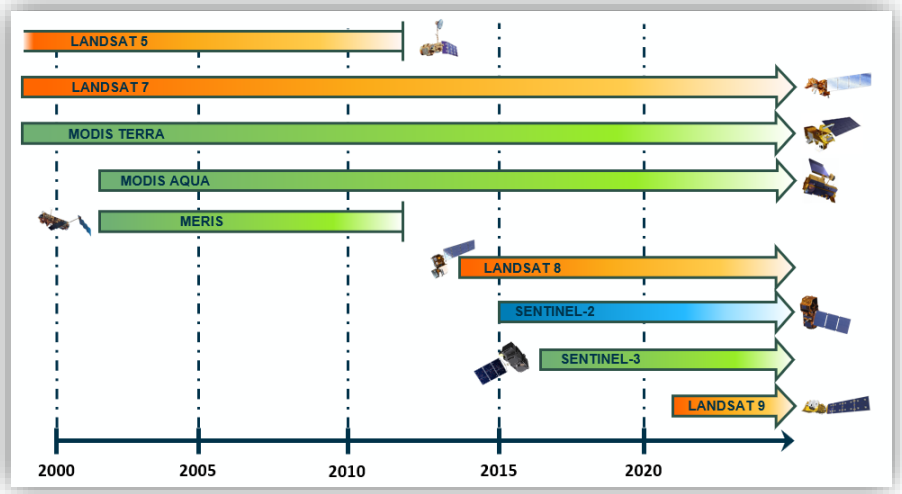


Multiple calibration, Kernel 1



Merging procedure

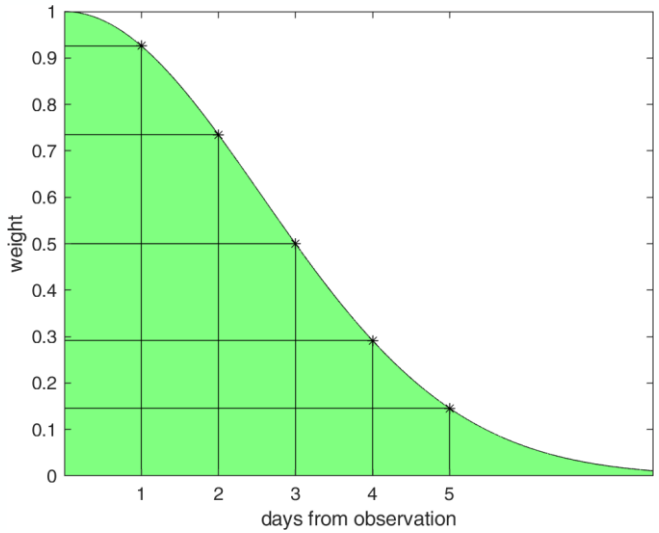


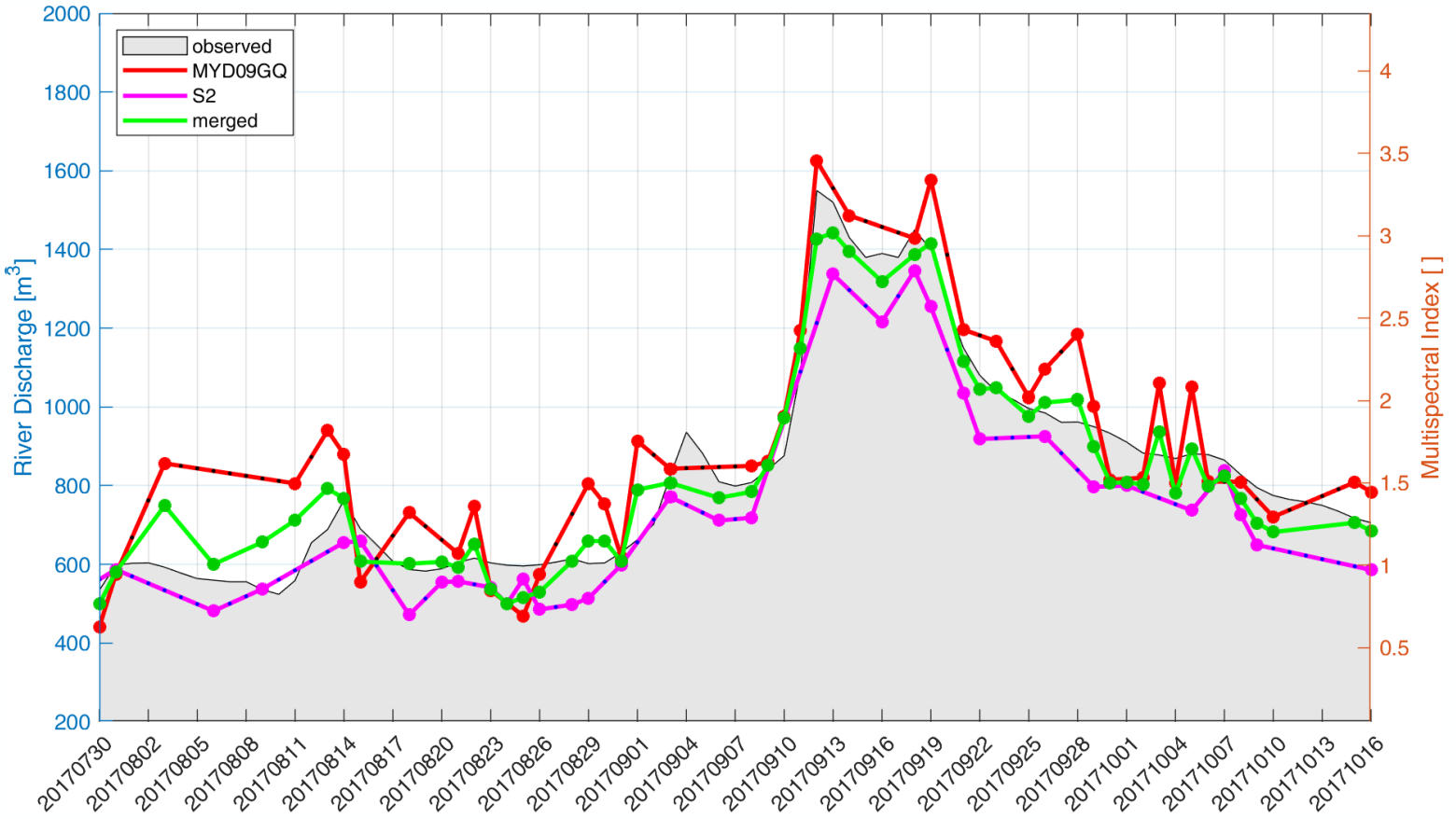


- Step 1: Scaling CM data of different sensors (with respect to the one with more data) according to min and 75th percentile of concurrent days

Calibration: Merging

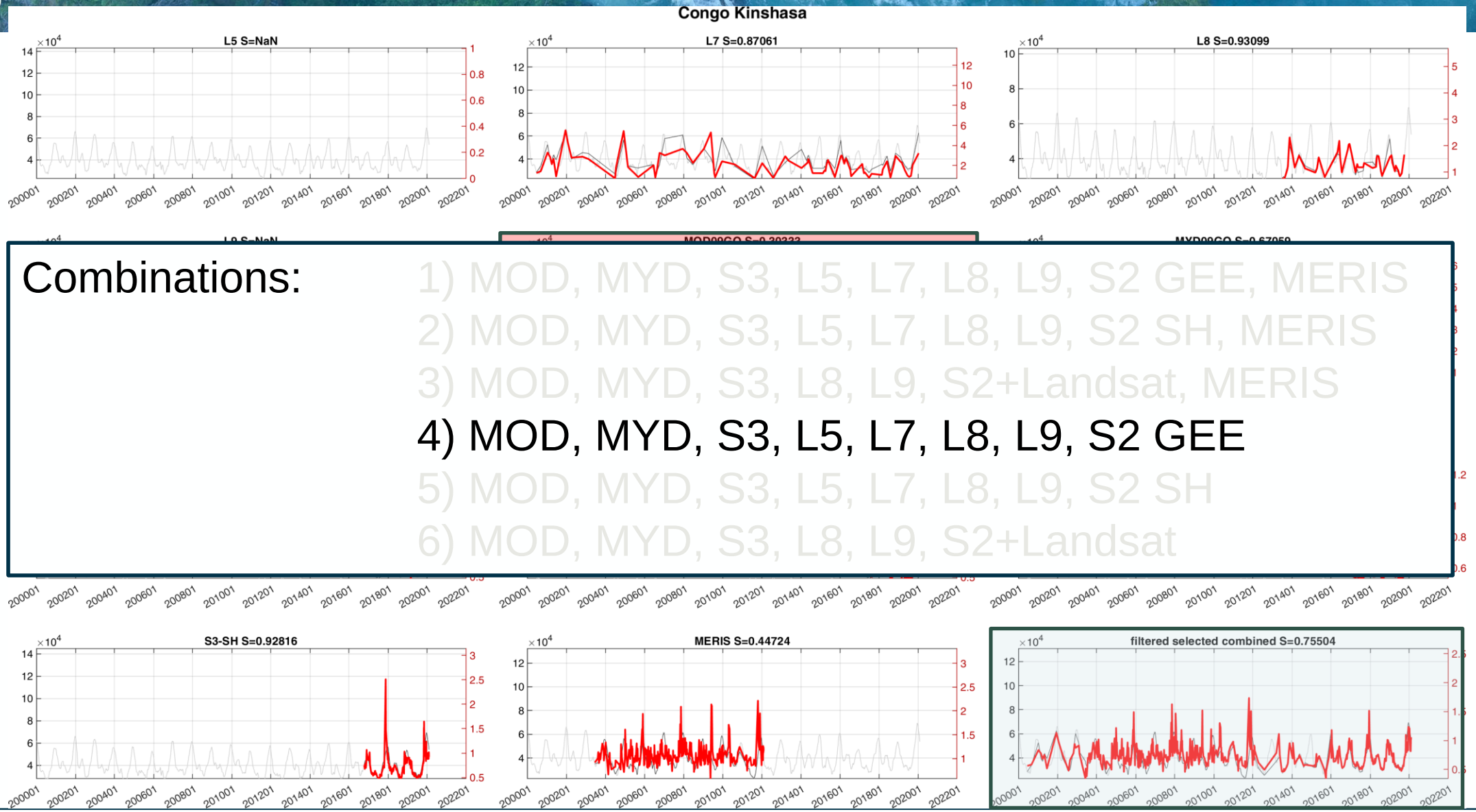
- Step 2: Merge the products (daily interpolated) with weights decreasing according to the temporal distance from the observation day





- Step 3: statistical noise removal and temporal filtering are applied to the merged data

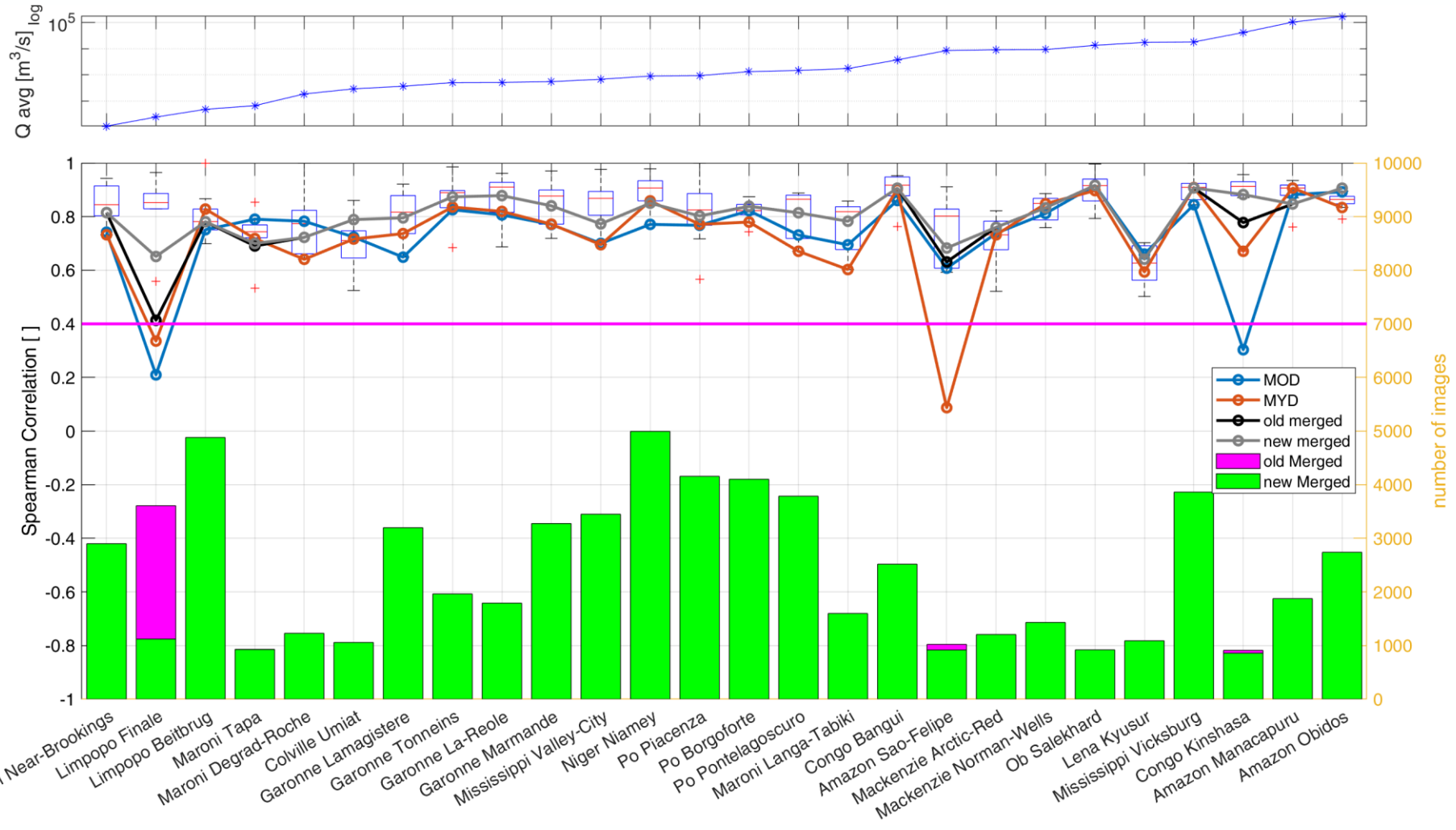
Calibration: Merging



Combinations:

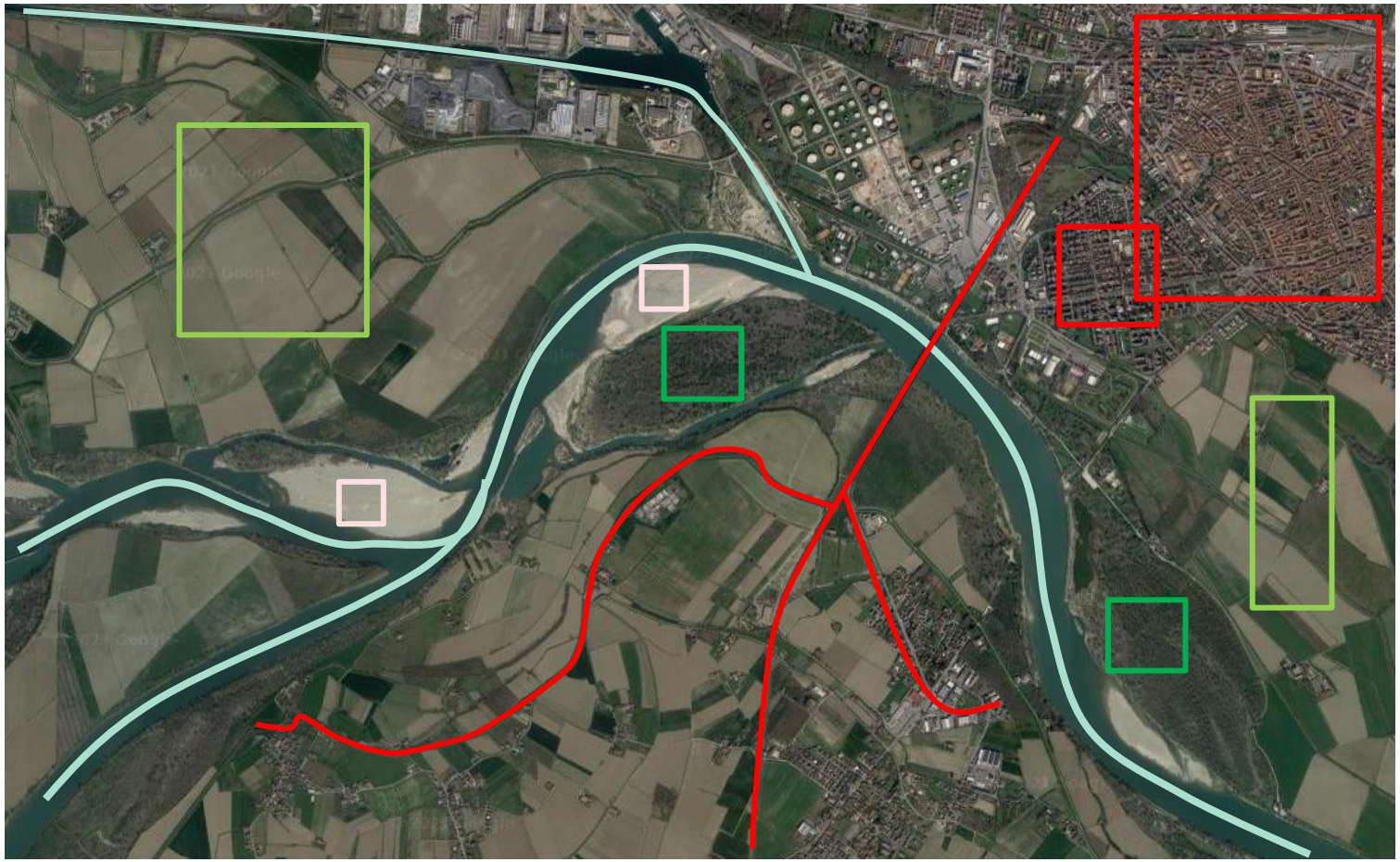
1) MOD, MYD, S3, L5, L7, L8, L9, S2 GEE, MERIS
2) MOD, MYD, S3, L5, L7, L8, L9, S2 SH, MERIS
3) MOD, MYD, S3, L8, L9, S2+Landsat, MERIS
4) MOD, MYD, S3, L5, L7, L8, L9, S2 GEE
5) MOD, MYD, S3, L5, L7, L8, L9, S2 SH
6) MOD, MYD, S3, L8, L9, S2+Landsat

Calibration: Results



Uncalibrated Results

Methodology



- *Cities*
- *Roads*

$\Rightarrow C$

- *Forest* $\Rightarrow V_s$
- *Fields* $\Rightarrow V_a$
- *Water* $\Rightarrow W$
- *Water/Soil* $\Rightarrow M$

Uncalibrated procedure

How to find M?

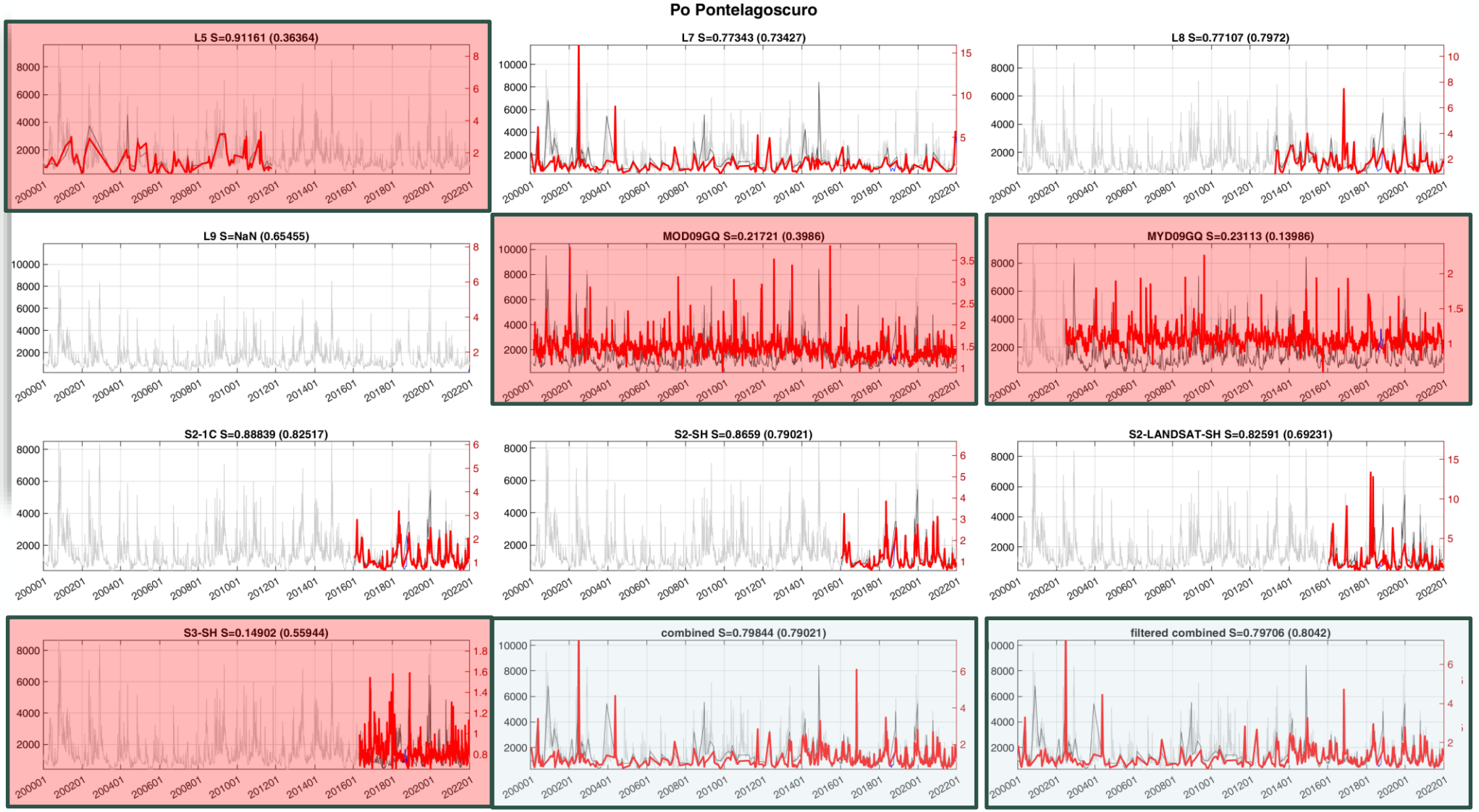
- Find correlation with Land features: C, V_f, V_a over the river area
- Extract Land correlation, T, for each pixels as the max between the correlation with C, V_f, V_a
- Extract correlation with Water, W
- Select those pixels that are lowly correlated with W and with T:

The selected pixel are all used as M

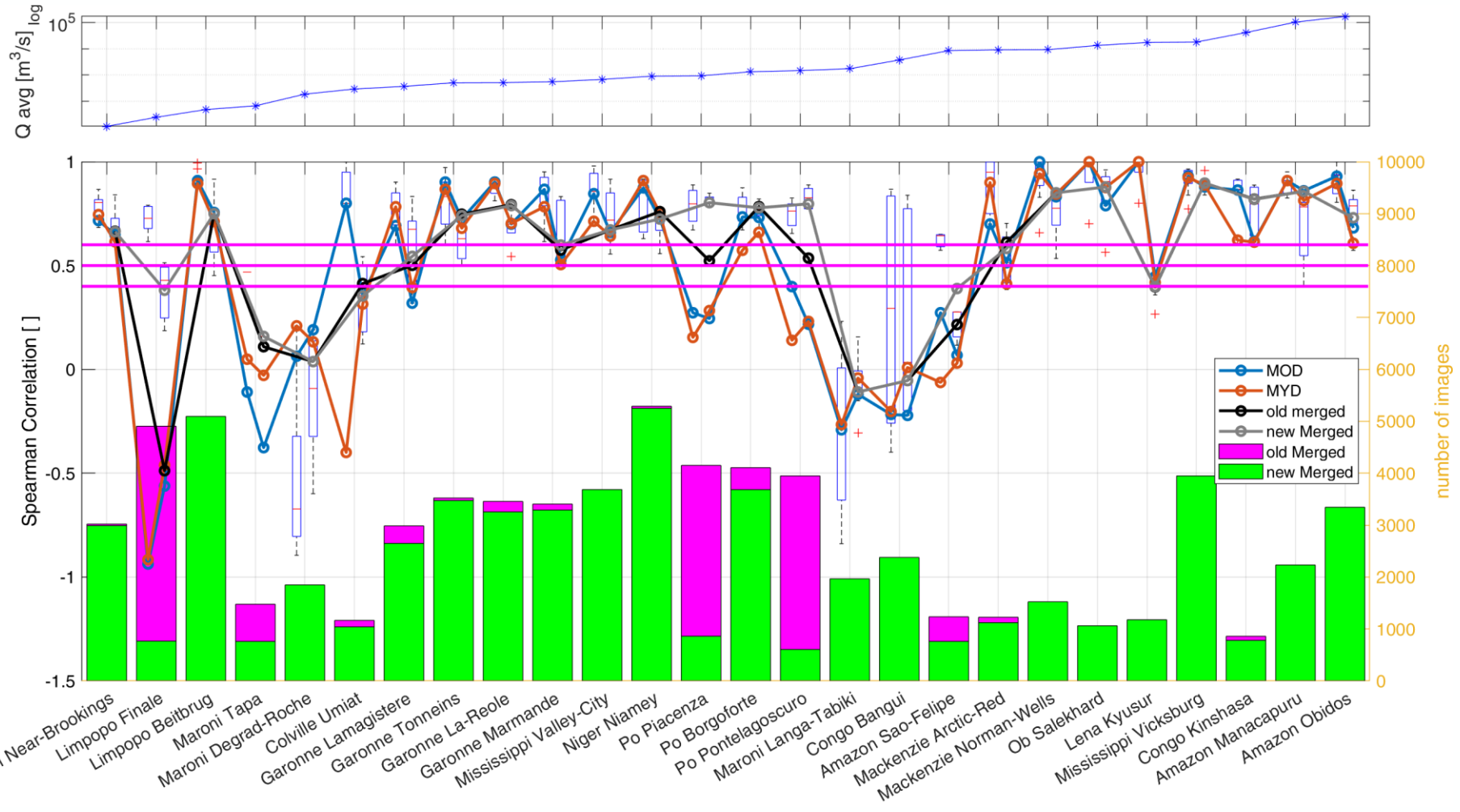
Uncalibrated procedure

Calibration:	Multiyear: if braided river Full: elsewhere
Kernel:	Not needed: already multipixel
Method:	CM: small river or small variation or Amazon CMW: elsewhere
W1, W2, C, CV:	It depends upon M. First approximation W1 and C. Limited effect for uncalibrated areas

Uncalibrated procedure



Uncalibrated procedure



Conclusions and suggestions for the Roadmap

- ✓ The multispectral images are used to extract **long time series of reflectance indices** that are useful to identify **variations of river discharge** over several environments.
- ✓ The **uncalibrated procedure** is consistent with the those calibrated and **represents a valid tool for ungauged sites.**
- ✓ The **uncalibrated procedure** needs to be **improved** with the ingestion of a more **detailed water mask**: Sentinel-1 or Global Surface Water (Pekel et al., 2016 Nature) can support the identify the signal of water
- ✓ The **multiyear calibration** should be **improved** when the data in the common period are scarce in number or when the cloud coverage is significant. Alternative methods are necessary.
- ✓ **Clouds effect should be improved**: cold periods can be identified with albedo; at seasonal level the noise can be removed.

Thank you for your attention