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MOXXI Measurements & Observations in the 21st Century

Working Group - International Association of Hydrological Sciences

Università di Cagliari

Evaluation of GPM satellite precipitation against observations in Sardinia and Sicily (two major Mediterranean islands)

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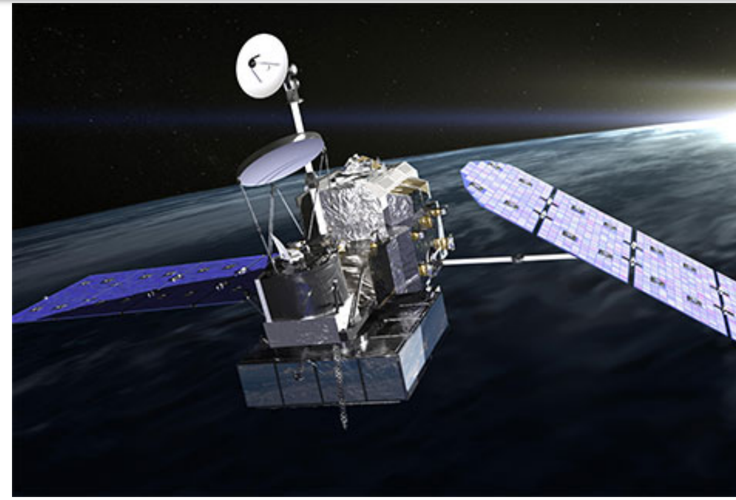
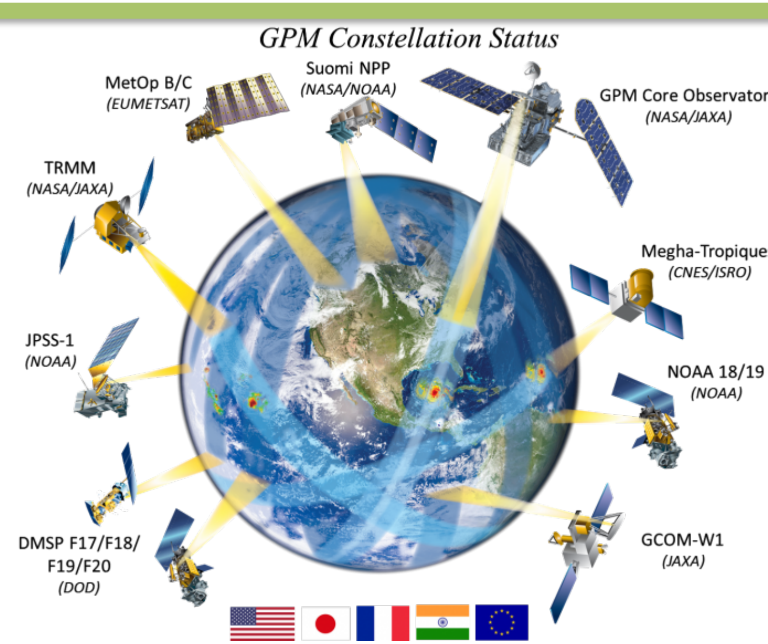
Global Precipitation Measurement (GPM) mission

Global Precipitation Measurement (GPM) **Core Observatory** was deployed on February 27, 2014 by a joint effort of the American and Japan aerospace agencies (**NASA** and **JAXA**), as a successor of TRMM.



The GPM spacecraft collect data from an **international constellation** of about ten **partner satellites** to provide new-generation global observations of rain and snow.

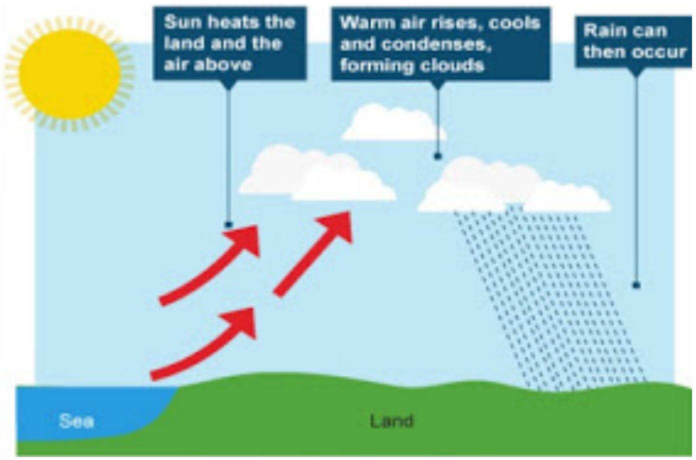


We analyse post real-time "Final" IMERG run:

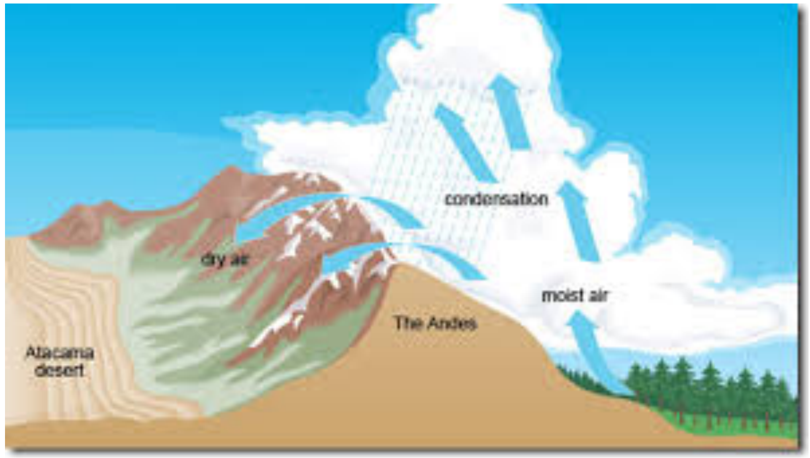
- **0.1° spatial resolution (≈10 km)**
- **half-hour temporal resolution**

Satellite-based estimations can **deteriorate** when spotting precipitation in **costal areas** (land-sea transition) and in areas with **steep orography**.

Thermal-induced lift in land-sea boundary



Topographic-induced lift in steep orography

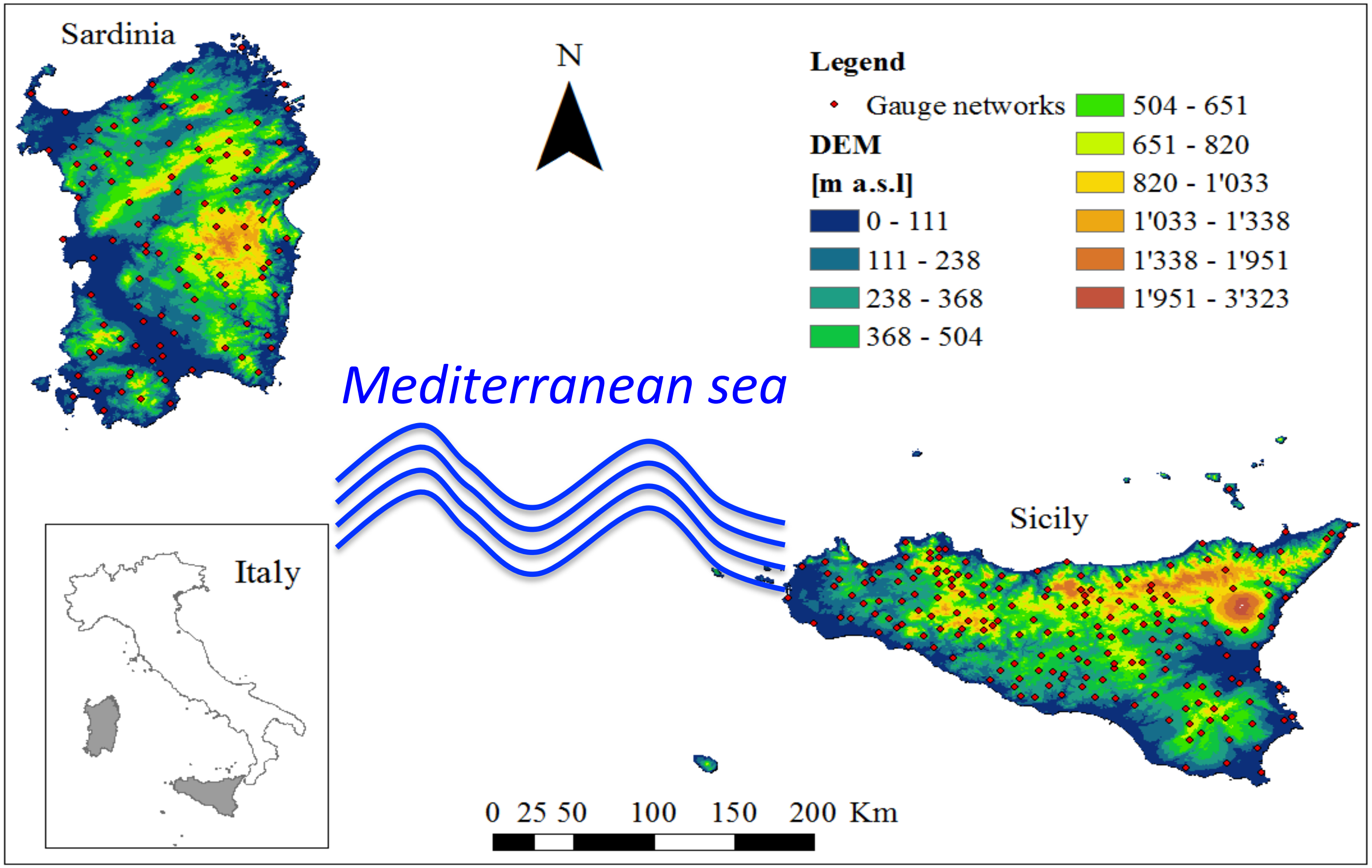


To investigate GPM performances under these problematic conditions, we selected **the two major islands of Mediterranean Sea**, i.e. Sicily and Sardinia.

Indeed, the combination of geographic position, **climate, shape and morphology** of both islands represent an interesting opportunity for the validation of satellite-precipitation data in the European mid-latitude area and in **complex domains.**

Study areas – Elevation maps of Sardinia & Sicily

Sardinia and **Sicily** (about 2,5 x 10^4 km^2) are characterized by **long see-land transition borders** and **complex morphology**.

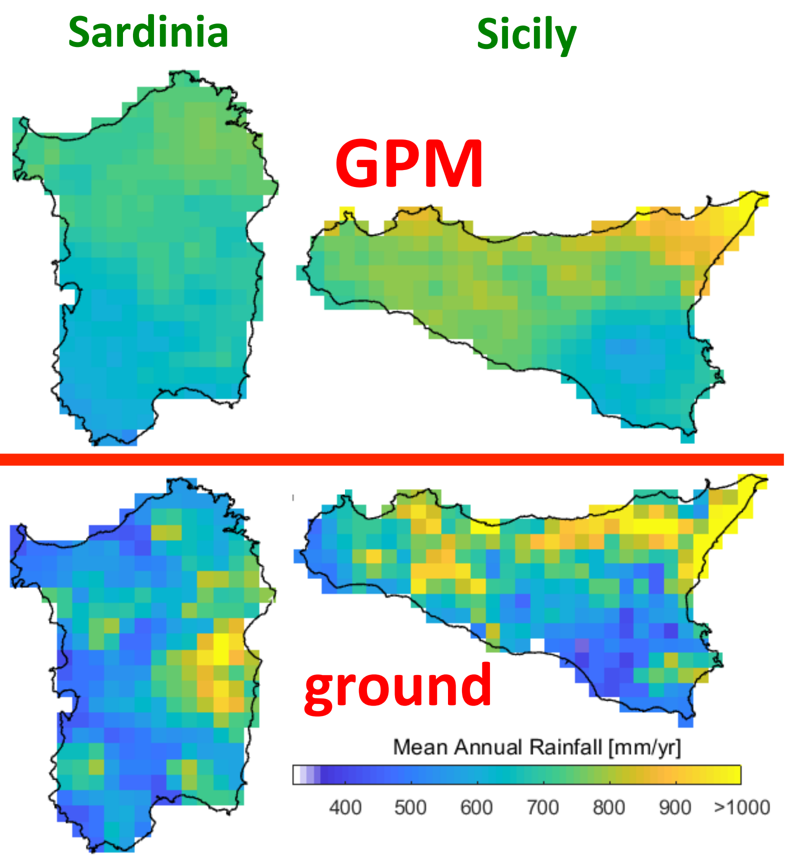


We test **2-year** (2015-2016) *GPM-IMERG v04 "Final" products* against Thiessen interpolation of *dense raingauges networks*: **0.1° spatial resolution - hourly and daily aggregations**

Preliminary analysis on cumulated precipitation

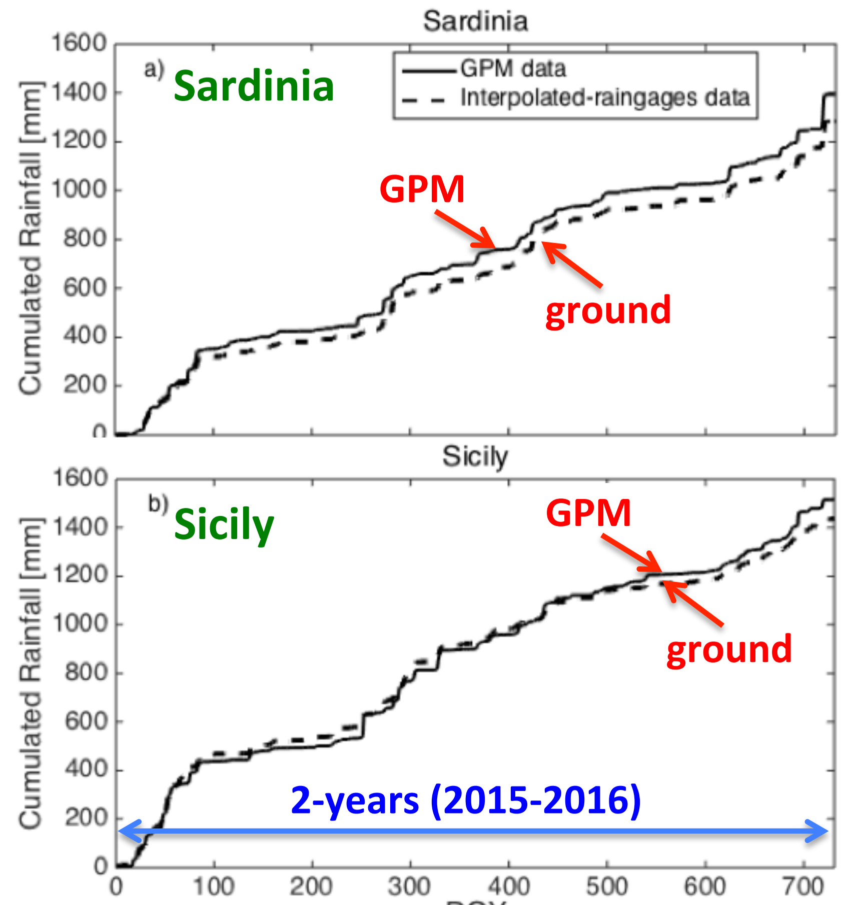
Spatial maps

Cumulated precipitation **in time**
(2-years, 2015-2016),
same 0,1° spatial resolution



Temporal evolution of MAP

Cumulated precipitation depths of
daily **MAP** (Mean Areal Precipitation)
over the whole islands



Indices of performances (on hourly and daily data)

continuous — precipitation values
categorical — precipitation occurrences
volumetric — volumetric occurrences

Continuous
- CC
- S-RMSE
- S-MBE

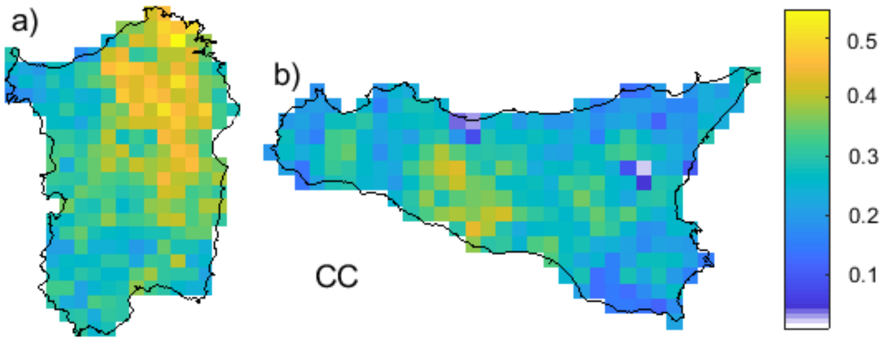
Computed on hourly and daily time series

categorical
- POD
- FAR
- MISS
- CSI

volumetric
- VHI
- VFAR
- VMI
- VCSI

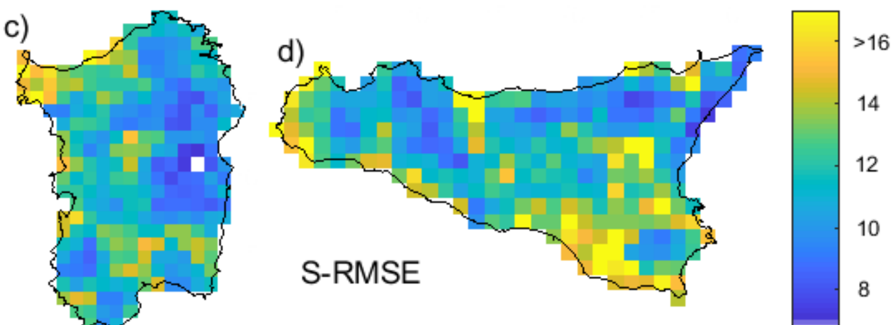
Hourly precipitation, continuous indices

Metrics calculated on the the **hourly time series in each 0,1° grid-cell**:
GPM IMERG precipitation <-> interpolated-raingauges data



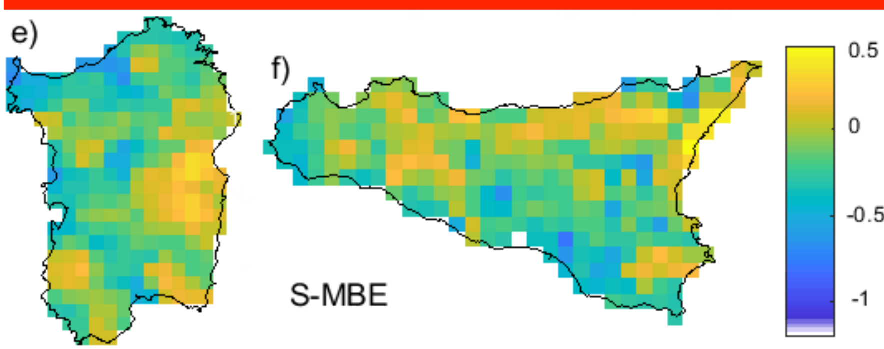
CC, correlation coefficient

$$CC = \frac{\mathrm{cov}(P_{est}, P_{obs})}{\sigma(P_{est}) \cdot \sigma(P_{obs})}$$



S-RMSE, standardized root mean square error

$$S-RMSE = \sqrt{\frac{\sum_{i=1}^{n}(P_{obs}^{(i)} - P_{est}^{(i)})^2}{n}} \Big/ \left(\frac{\sum_{i=1}^{n} P_{obs}^{(i)}}{n} \right)$$



S-MBE, standardized mean bias error

$$S-MBE = \frac{\sum_{i=1}^{n}(P_{obs}^{(i)} - P_{est}^{(i)})}{\sum_{i=1}^{n} P_{obs}^{(i)}}$$

Indices of performances (on hourly and daily data)

continuous — precipitation values

categorical — precipitation occurrences

volumetric — volumetric occurrences

Continuous

CC

S-RMSE

S-MBE

categorical

POD

FAR

MISS

CSI

Computed on True-False **contingency tables** classifying occurrence above **thresholds** set to the 5^{th} and 50^{th} percentiles of non-zero precipitation at each pixel

volumetric

VHI

VFAR

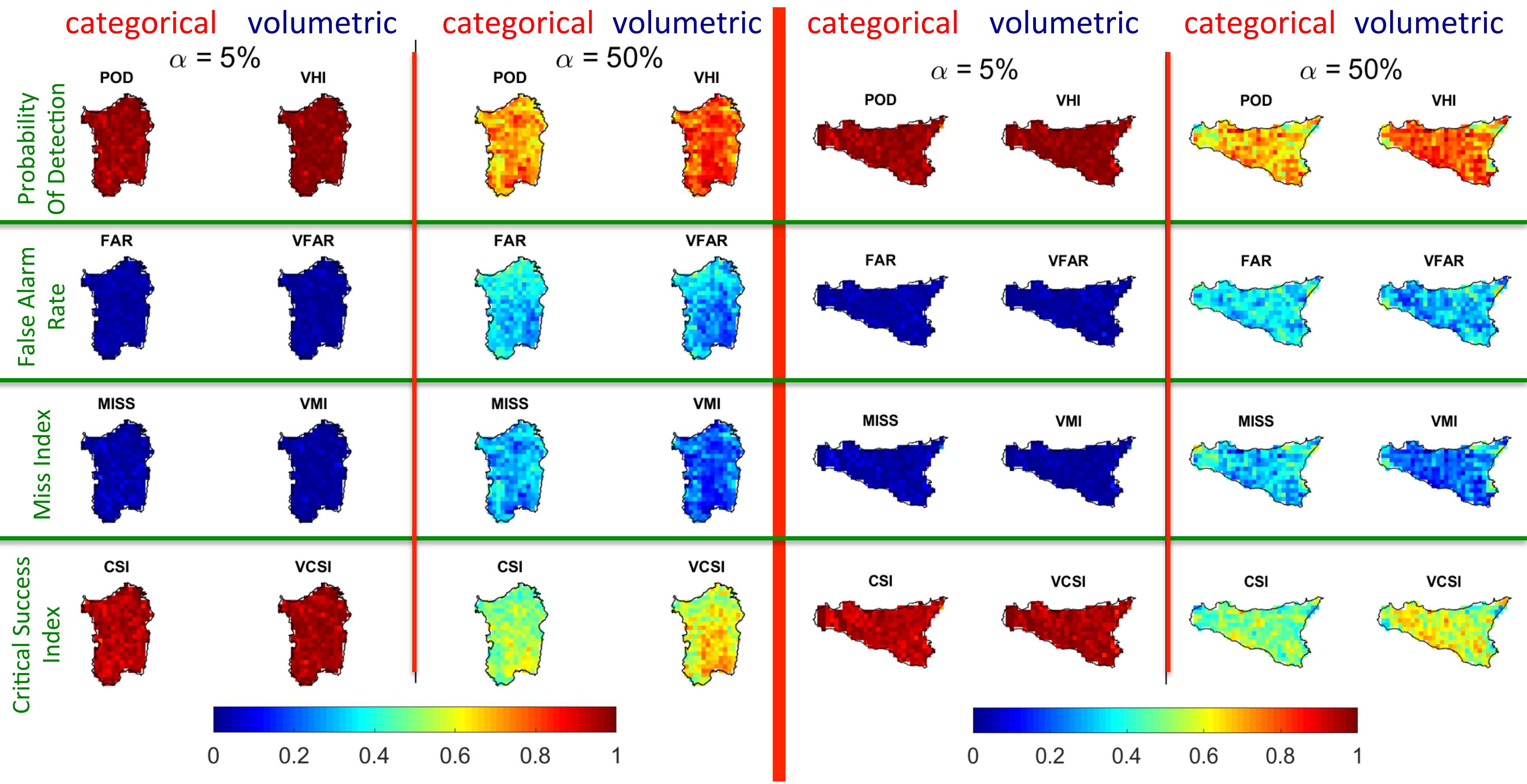
VMI

VCSI

Computed on cumulated precipitation values categorized by contingency tables with 5^{th} and 50^{th} % thresholds

		event occurred ?	
		yes	no
event forecast ?	yes	hit *h*	false alarm *f*
	no	miss *m*	quiescent or null event *q*

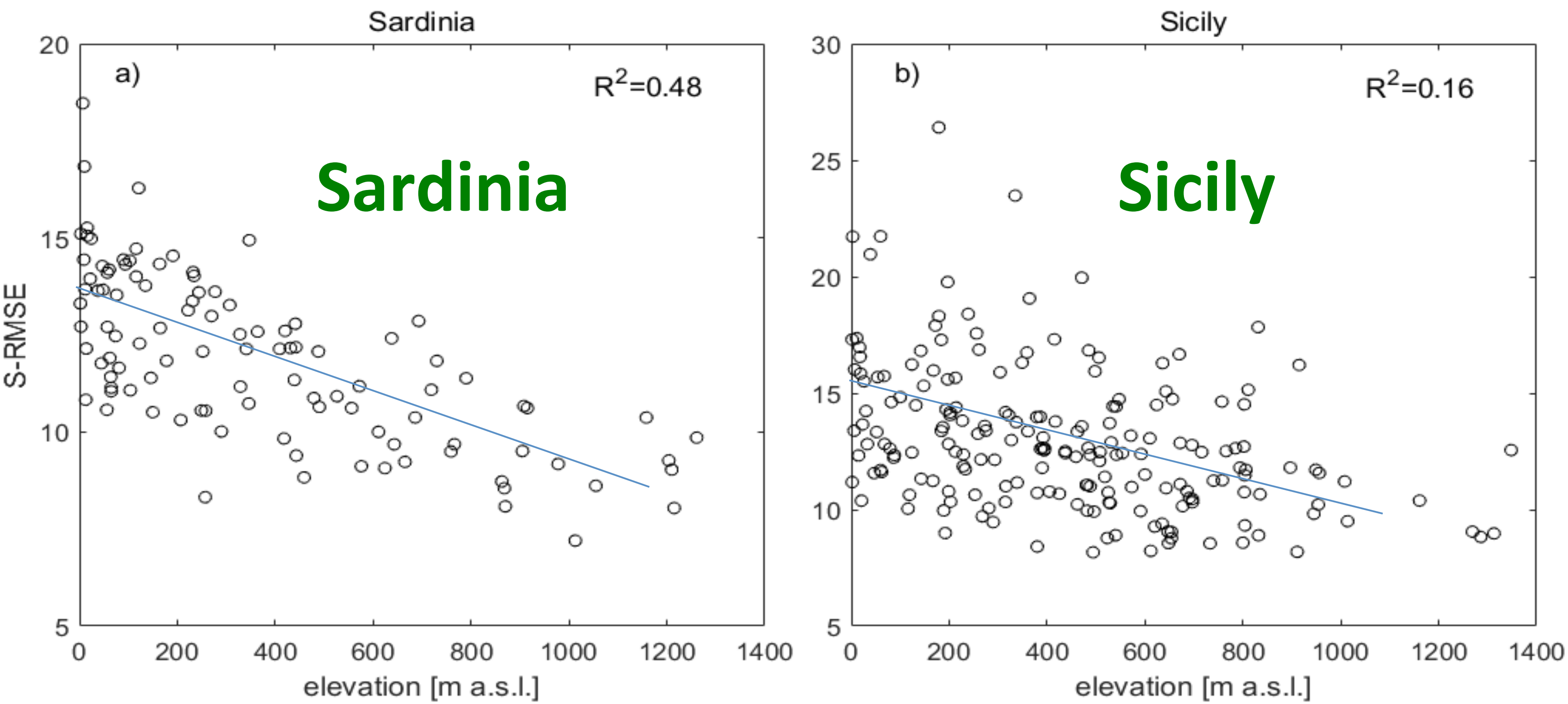
Hourly precipitation, categorical and volumetric indices



Comparison of hourly *GPM* satellite precipitation and interpolated-raingauges data by categorical and volumetric indices

Dependance of performances on elevation

Scatterplots of *S-RMSE* at hourly time scale vs elevation
for each raingauge.



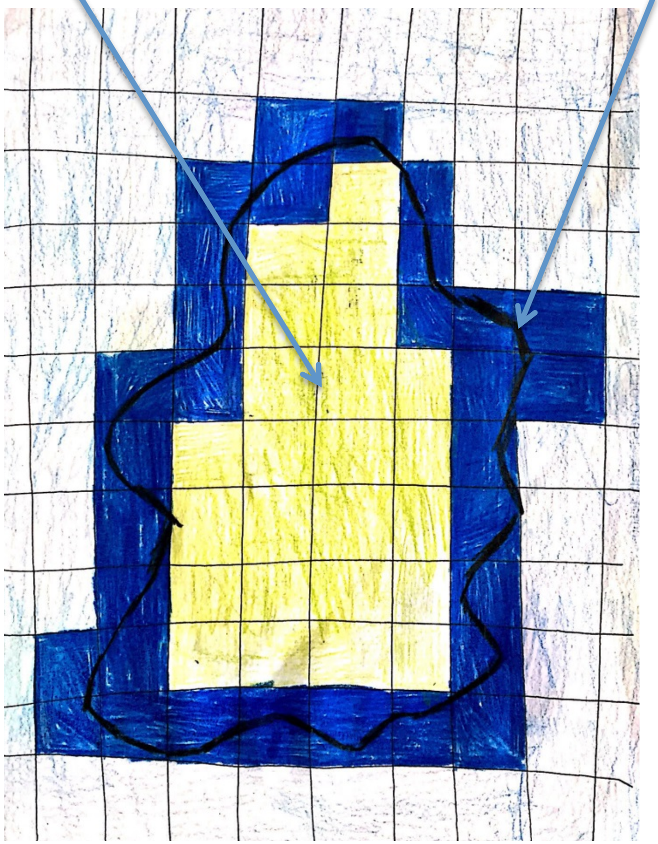
The higher the elevation, the higher the accuracy

Performances and sea-land transition

Grid-cells were grouped into two samples:

only internal pixels

only coastal pixels



Results from continuous indices for each (internal/costal) sample:

Indices	Sardinia		Sicily	
	Coastal	Internal	Coastal	Internal
CC	0.29	0.35	0.22	0.27
S-RMSE	12.60	10.83	13.46	11.77
S-MBE	0.20	0.13	0.17	0.11

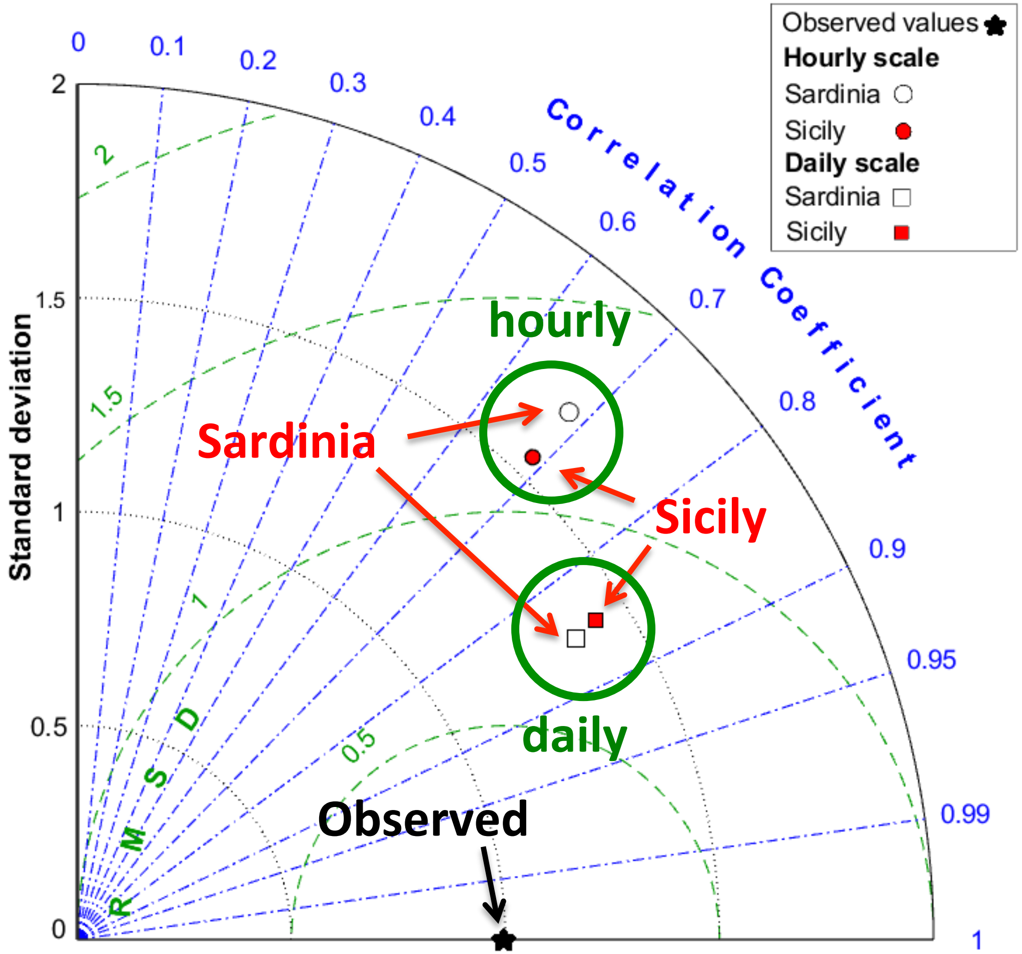
Errors are larger in coastal pixels

Statistical tests on the mean discriminate the two samples:

Internal ≠ coastal pixels

Taylor diagram on Spatial averaged precipitation

Normalized Taylor diagram from ***MAP* time series** at **hourly** and **daily** scales in Sicily and Sardinia.



GPM performs similarly in Sardinia and Sicily

GPM performances increase with aggregation time (hourly ---> daily)

Performances at different time scales

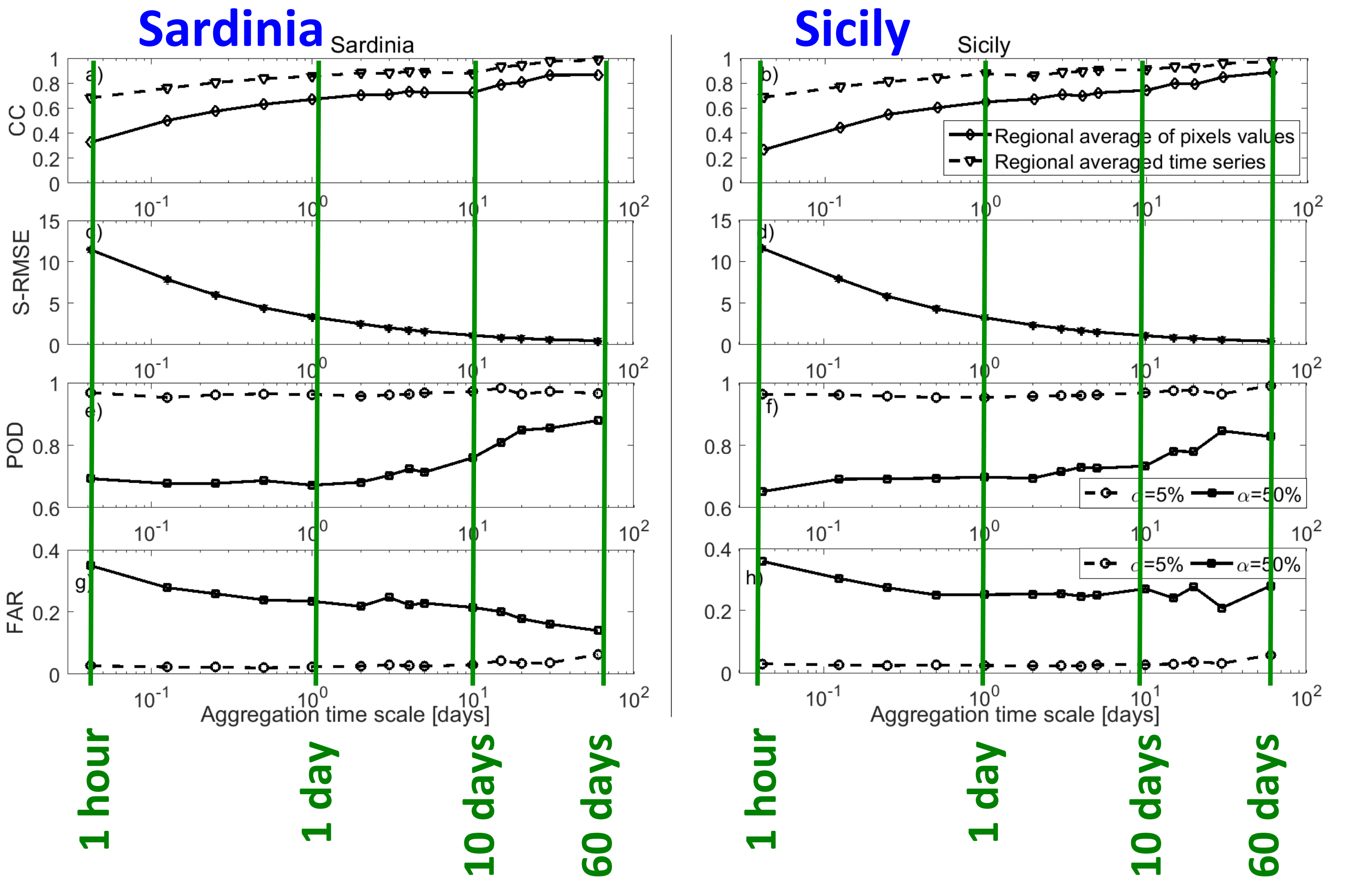
Spatial averages of performance indices computed on 0,1° grid-cells at different aggregation time scales (from 1 hour to 60 days)

Correlation coefficient

Stand. root mean square error

Probability of detection

False alarm ratio



Some conclusions

Performances of GPM-IMERG v04 precipitation products were evaluated against dense raingauge networks in Sardina and Sicily, characterized by **long see-land borders** and **complex morphology**

- *GPM* satellite data slightly overestimates rainfall over the study areas (confirming results in other areas), but they are in agreement with the interpolated raingauges data.
- Metrics based on total volume above a given threshold indicate better performances than those simply computed on occurrences above the same threshold .
- *GPM* products have some drawbacks near the coastal regions, showing worst performances than internal land areas.
- Accuracy of *GPM* products increase with elevation.
- Performances improve as the temporal aggregation increases.

Thank you for your attention