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

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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**.

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**.
Sardinia and Sicily (about $2.5 \times 10^4 \text{ km}^2$) 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

- Sardinia
- Sicily

**Temporal evolution of MAP**

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

- **Sardinia**
- **Sicily**

**GPM**

**Ground**

2-years (2015-2016)
Indices of performances (on hourly and daily data)

<table>
<thead>
<tr>
<th>Continuous</th>
<th>Precipitation values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Categorical</td>
<td>Precipitation occurrences</td>
</tr>
<tr>
<td>Volumetric</td>
<td>Volumetric occurrences</td>
</tr>
</tbody>
</table>

**Continuous**
- CC
- S-RMSE
- S-MBE

**Categorical**
- POD
- FAR
- MISS
- CSI

**Volumetric**
- VHI
- VFAR
- VMI
- VCSI

Computed on hourly and daily time series
Hourly precipitation, continuous indices

Metrics calculated on the hourly time series in each 0.1° grid-cell:
GPM IMERG precipitation <-> interpolated-raingauges data

CC, correlation coefficient

\[
CC = \frac{\text{cov}(P_{\text{est}}, P_{\text{obs}})}{\sigma(P_{\text{est}}) \cdot \sigma(P_{\text{obs}})}
\]

S-RMSE, standardized root mean square error

\[
S - \text{RMSE} = \sqrt{\frac{\sum_{i=1}^{n} (P_{\text{obs}}^{(i)} - P_{\text{est}}^{(i)})^2}{n}} \sqrt{\frac{n}{\sum_{i=1}^{n} P_{\text{obs}}^{(i)}}}
\]

S-MBE, standardized mean bias error

\[
S - \text{MBE} = \frac{\sum_{i=1}^{n} (P_{\text{obs}}^{(i)} - P_{\text{est}}^{(i)})}{\sum_{i=1}^{n} P_{\text{obs}}^{(i)}}
\]
Indices of performances (on hourly and daily data)

Continuous precipitation values
Categorical precipitation occurrences
Volumetric volumetric occurrences

CC
S-RMSE
S-MBE

POD
FAR
MISS
CSI

VHI
VFAR
VMI
VCSI

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

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

<table>
<thead>
<tr>
<th>event forecast?</th>
<th>event occurred?</th>
</tr>
</thead>
<tbody>
<tr>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>hit</td>
</tr>
<tr>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td>false alarm</td>
</tr>
<tr>
<td>no</td>
<td>miss</td>
</tr>
<tr>
<td></td>
<td>quiescent or null event</td>
</tr>
</tbody>
</table>

h
f
m
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/coastal) sample:

<table>
<thead>
<tr>
<th>Indices</th>
<th>Sardinia</th>
<th>Sicily</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coastal</td>
<td>Internal</td>
</tr>
<tr>
<td>CC</td>
<td>0.29</td>
<td>0.35</td>
</tr>
<tr>
<td>S-RMSE</td>
<td>12.60</td>
<td>10.83</td>
</tr>
<tr>
<td>S-MBE</td>
<td>0.20</td>
<td>0.13</td>
</tr>
</tbody>
</table>

Errors are larger in coastal pixels

Statistical tests on the mean discriminate the two samples:
- Internal ≠ coastal pixels
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