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# Evaluation of a satellite-based rain estimation algorithm using a network of meteorological stations. Preliminary results in a region with complex terrain

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# Scope of the study

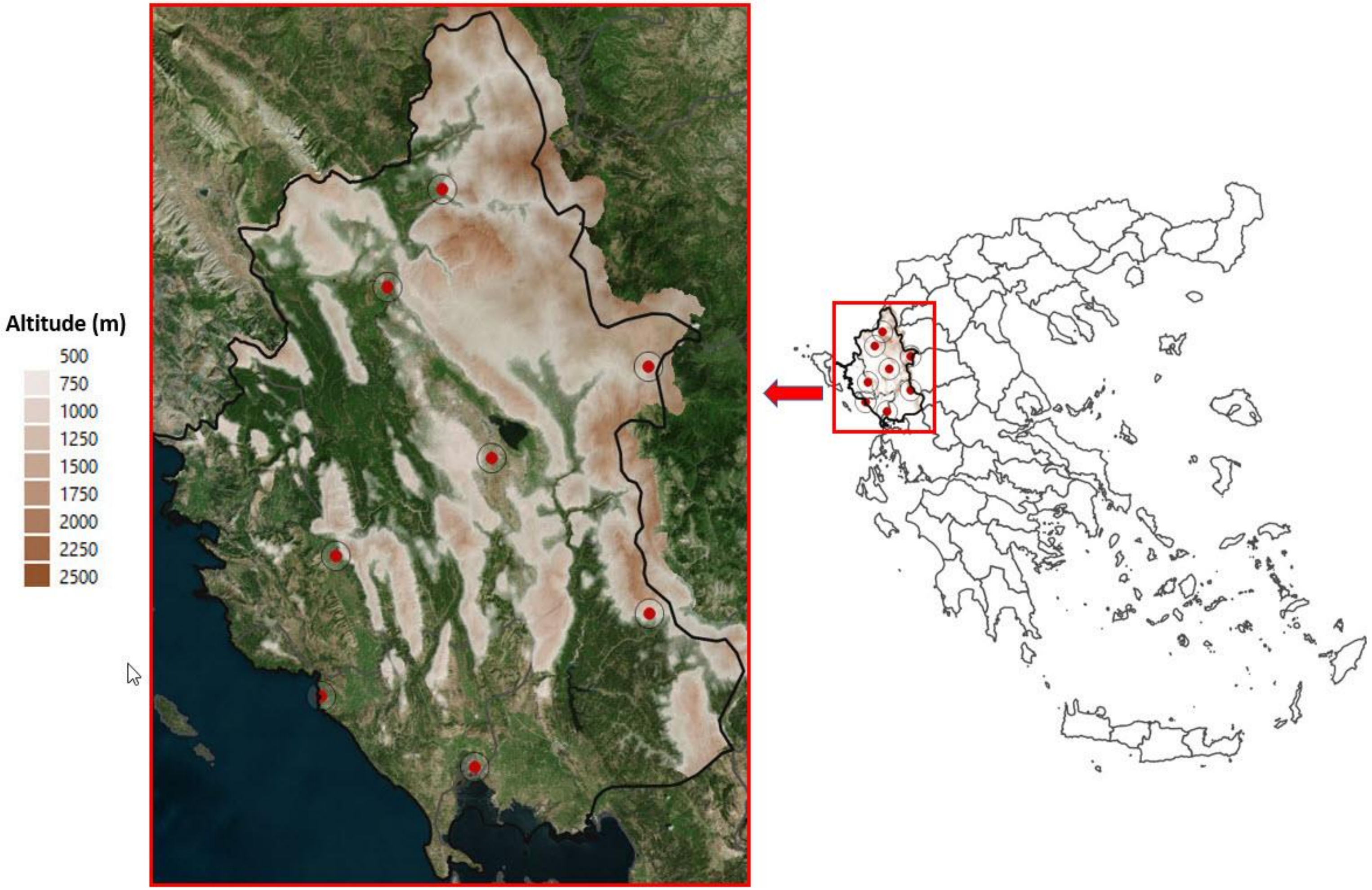
This study provides the preliminary results of the first attempt to quantitatively evaluate an existing satellite-based rain estimation algorithm using a network of ground-based meteorological stations in an area with complex terrain and high rainfall amounts of convective nature

## More specifically…

The present study is an attempt to quantitatively evaluate an existing satellite-based rain estimation algorithm using measurements from a network of ground-based meteorological stations. The study domain is the Epirus Region (the rainiest region in Greece) where the laboratory of Meteorology and Climatology of Ioannina University operates eight meteorological stations distributed across the study domain.

# Study domain and data used

The study domain (Epirus Region, Greece). The circles with red dots, refer to the locations of the **meteorological stations** whose **rainfall measurements** were used in the present study.



# Data

Spectral characteristics of the four channels of **SEVIRI instrument** onboard the **Meteosat satellite** that are used in the satellite rain algorithm.

| Channel (Band) | Spectral interval (μm) | Spectral center (μm) |
|---|---|---|
| 5 | 5.35 - 7.15 | 6.2 |
| 6 | 6.85 - 7.85 | 7.3 |
| 9 | 9.8 - 11.8 | 10.8 |
| 10 | 11-13 | 12.0 |

An existing satellite-based **automated rain algorithm** converts the digital values of these channels in Brightness Temperatures (BTs) and Brightness Temperature Differences (DBTs).

# Rain Rate estimation

**Regarding the procedure of the rain estimation by the algorithm**

- Firstly, a cloud mask is applied on the SEVIRI multispectral data in order to characterize a specific pixel as rainy/no rainy.

*More specially, if for a pixel:*

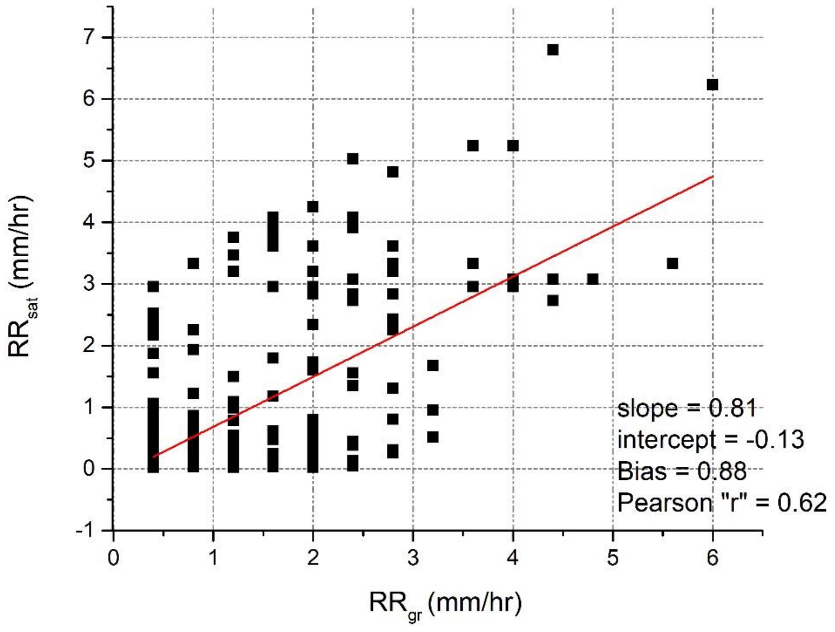
***(i) $BT_{10.8\mu m} < 250$ K***
***(ii) The $BTD_{6.2\mu m-7.3\mu m} > -20$ K***
***(iii) $BTD_{10.8\mu m-12.0\mu m} < 3$ K***

*then a rain rate (mm/hr) estimate is assigned to this pixel. Otherwise, the pixel is considered to be no rainy.*

- For the pixels characterized as rainy, the rain estimate is performed by a non-linear (exponential) model having as independent variable the $BT_{10.8\mu m}$ while the dependent variable is the rain rate.

# Evaluation procedure

Every 30-min, the total satellite-based rainfall estimations, on a pixel level basis, a correlated with the half-hourly rainfall measurements. This procedure has been developed and applied for 20 selected rainy days of the year 2019, during which significant amounts of rainfall were recorded in the network of the eight ground-based meteorological stations. As a result of this procedure, a final dataset of 1323 pairs of values in total, (satellite-based rain estimates and rainfall measurements from the network of the meteorological stations) was created and used in the correlation analysis.




Analytical equations of statistical metrics used for the evaluation of the rain satellite algorithm

| Statistical Parameter | Equation | Value |
|---|---|---|
| MAE | $MAE = \sum_{i=1}^{n} (\lvert RR_{gr_i} - RR_{sat_i} \rvert) / n$ | 1.57 |
| ME | $ME = \left( \sum_{i=1}^{n} (RR_{gr_i} - RR_{sat_i}) \right) / n$ | 0.22 |
| RMSE | $RMSE = \sqrt{\left( \sum_{i=1}^{n} (RR_{gr_i} - RR_{sat_i})^2 \right) / n}$ | 2.36 |
| $r_P$ | $r_P = \frac{\sum_{i=1}^{n} (RR_{gr_i} - \overline{RR_{gr}}) (RR_{sat_i} - \overline{RR_{sat}})}{\sqrt{\left(\sum_{i=1}^{n} (RR_{gr_i} - \overline{RR_{gr}})^2\right)} \sqrt{\left(\sum_{i=1}^{n} (RR_{sat_i} - \overline{RR_{sat}})^2\right)}}$ | 0.62 |

# Evaluation procedure

The computed Probability of False Detection (POFD), Probability of Detection (POD) and the bias (BS) score are equal to **0.22, 0.69** and **0.88**, respectively, indicating a relatively good performance of the rain satellite algorithm

Contingency table with calculated statistical scores used to evaluate the ability of the satellite-based algorithm to estimate the rain intensity over the study domain.

| Threshold value | | Ground-based measurements | |
|---|---|---|---|
| | | *Yes* | *No* |
| Rain estimations | *Yes* | Hit (H) | False Alarm (FA) |
| | *No* | Miss (M) | Correct Negative (CN) |

**POD** stands for the probability of detection, FAR stands for the false alarm ratio, **POFD** stands for probability of false detection, and **BS** stands for the overall (systematic) bias

$$POD = \frac{H}{(H + M)}$$

$$POFD = \frac{FA}{(FA + CN)}$$

$$BS = \frac{(H + FA)}{(H + M)}$$

# Conclusions

- ✓ This study presents the results of a preliminary quantitative evaluation of a satellite-based rain estimation algorithm using measurements from a network of ground-based meteorological stations. The study domain is the Epirus Region (Greece), which is one of the rainiest areas of Greece, with a complex relief, and where a network of eight meteorological stations distributed across the study area, is available.

- ✓ The undertaken statistical analysis led to satisfactory results, which highlight a promising performance of the satellite-based rain estimation using Meteosat data.

- ✓ The automatic and reliable rain rate estimation with an algorithm using exclusively images from the Meteosat satellites, can be very useful and support both operational and research activities aiming at the real-time monitoring and nowcasting (very short-range forecasting) of rain, providing modern and useful services to final users and the wide public.