Satellite-based river discharge estimation: the STREAMRIDE project

Stefania Camici[1], Angelica Tarpanelli[1], Luca Brocca[1], Christian Massari[1], Paolo Filippucci[1], Karina Nielsen[2], Nico Sneeuw[3], Mohammad J. Tourian[3], Shuang Yi[3], Marco Restano[4], and Jérôme Benveniste[5]

[1] CNR-IRPI, Via Madonna Alta 126 – 06128 Perugia (PG), Italy
[2] DTU-Space, 2800 Kongens Lyngby, Denmark
[3] GIS - Stuttgart, Geschwister-Scholl-Str. 24D, 70174 Stuttgart, Germany
[4] SERCO/ESRIN, Largo Galileo Galilei, I-00044 Frascati, Italy
[5] ESA-ESRIN, Largo Galileo Galilei, 00044 Frascati, Italy

Venice - Italy
https://ostst-altimetry-2022.com/

PURPOSE

The ultimate goal of the STREAMRIDE project was to merge two methods, STREAM model and RIDESAT algorithm for obtaining accurate river discharge estimation by using satellite observations.
Both STREAM and RIDESAT approaches were tested over a large number of case studies and they demonstrated a good capability to reproduce river discharge observations except over specific case studies (i.e., in basin where the flow is regulated by the presence of dams, reservoirs or floodplains along the river; or in highly irrigated areas).
The objectives of the STREAMRIDE project were to:

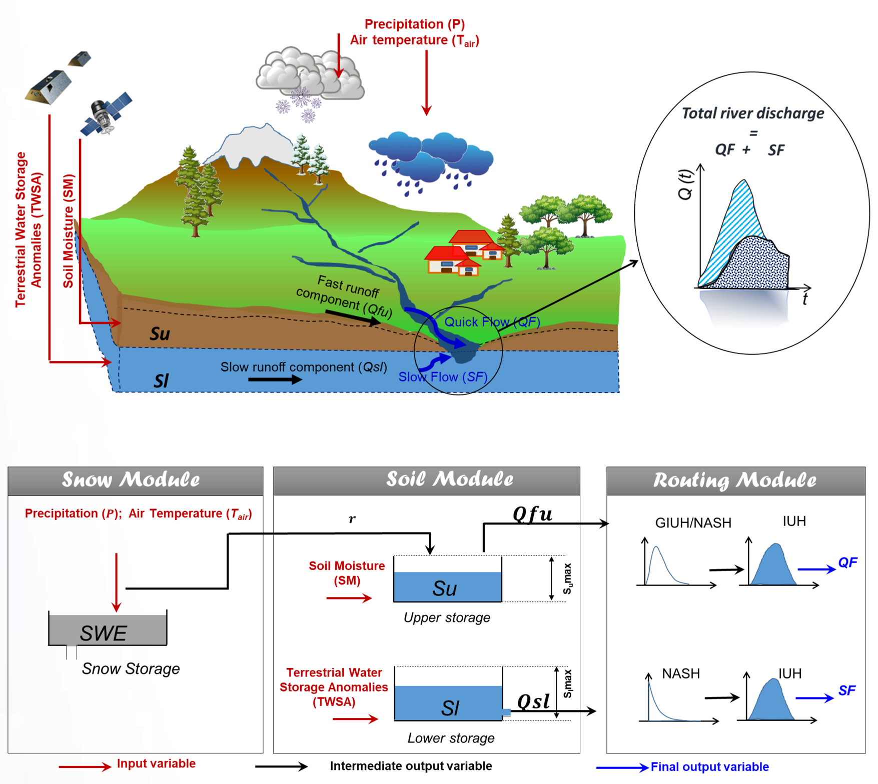
1) improve the STREAM model and the RIDESAT algorithm in river discharge estimation with respect to specific case studies, such as in presence of densely vegetated and mountainous areas or in non-natural basins with high anthropogenic pressure, selected over the Mississippi and Amazon river basins;
2) to investigate the complementarity of the two satellite-based approaches for river discharge estimation over the period 2003-2020.

STREAM MODEL

STREAM is a conceptual hydrological model able to provide daily river discharge and runoff estimates at basin scale.

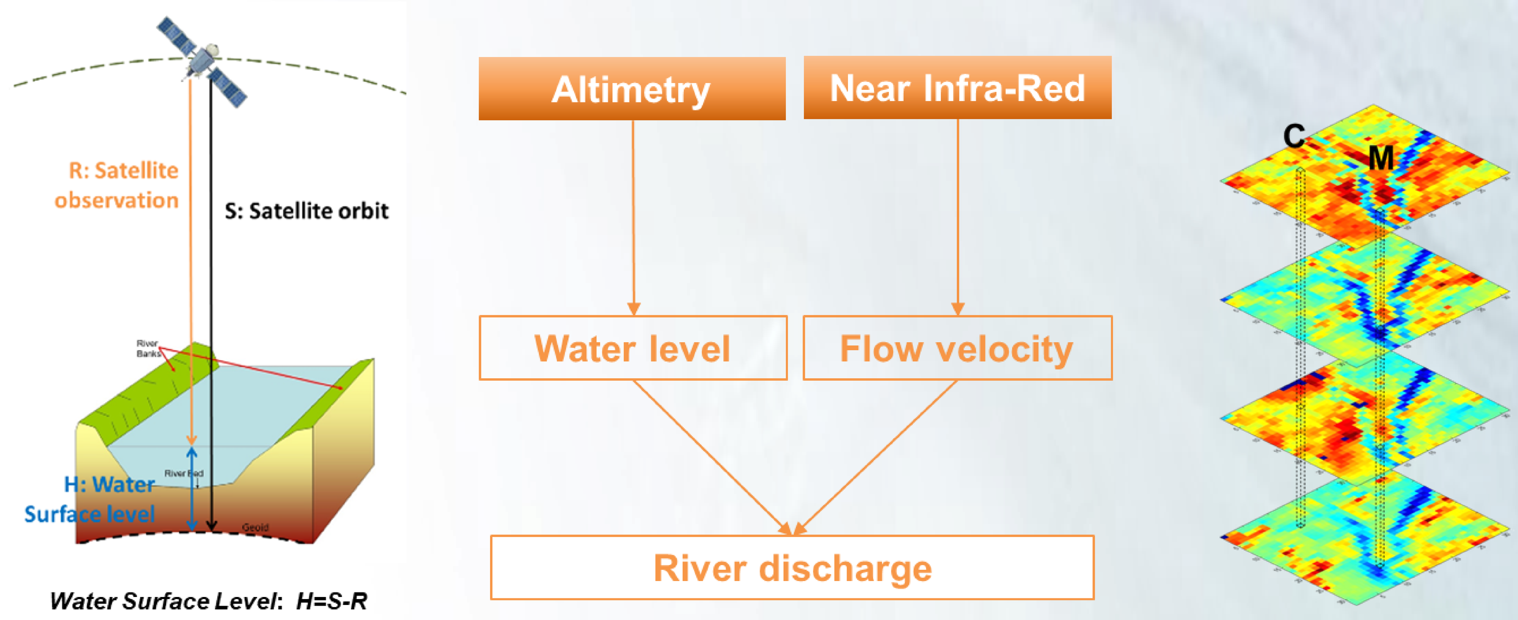
The model uses as input:
- Precipitation (Global Precipitation Measurement Mission, GPM, NASA);
- soil moisture (ESA CCI soil moisture);
- terrestrial water storage anomalies (GRACE, GRACE-FO).

The model in its original formulation was not able to provide accurate river discharge estimates over mountainous or anthropized basins.



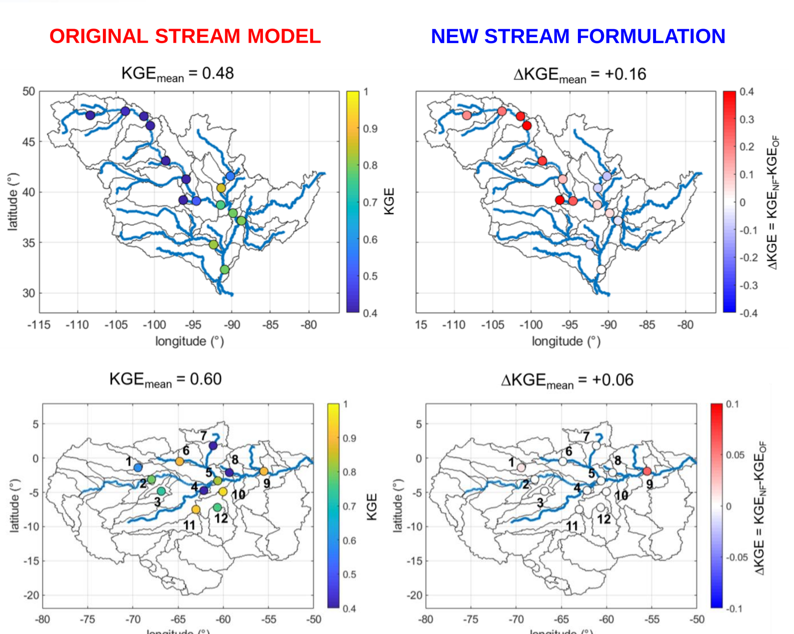
RIDESAT APPROACH

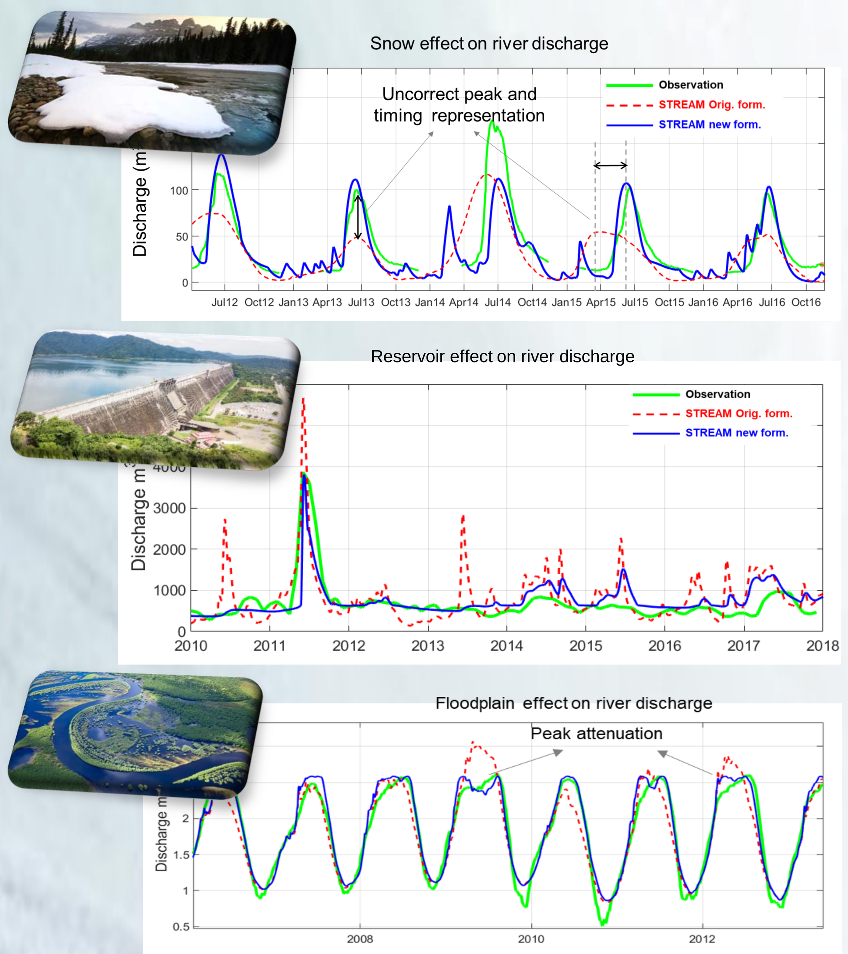
RIDESAT is an approach based on the joint use of altimetry, for the measurement of water level, and on the reflectance index C/M derived by NIR band as a proxy of river flow velocity. The river discharge is calculated as the product of both by considering three parameters to be calibrated with the in situ measurements of river discharge. In its original formulation the approach was able to provide discharge estimates every 3 days.



MODEL IMPROVEMENT

Specific modules/formulations were added to the original STREAM model to better reproduce the presence of snow, reservoirs or floodplains (see figures below). The new model formulation allowed to better reproduce observations.

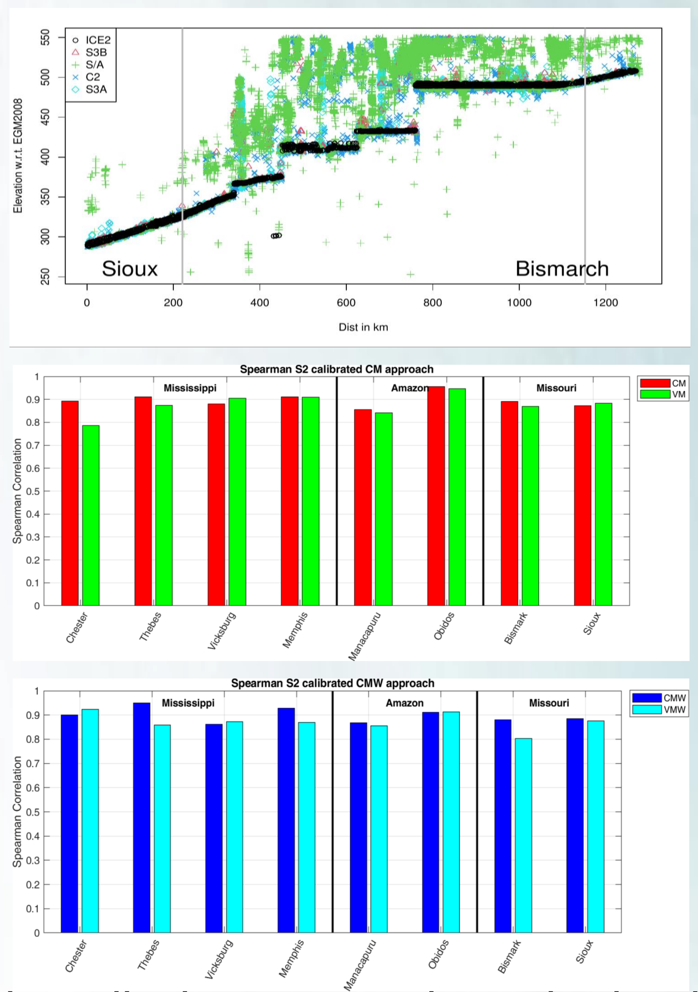


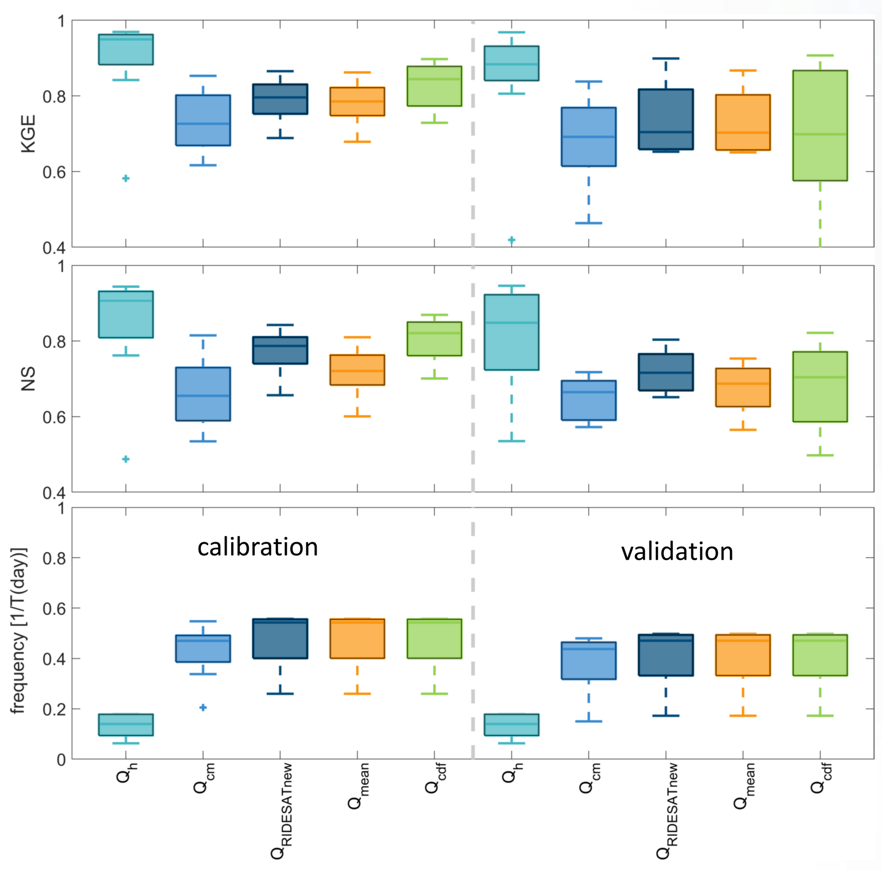


The figure shows the performances in terms of Kling-Gupta efficiency index (KGE) of the new STREAM formulation (left images) obtained for the Mississippi and Amazon river basins. The improvements with respect to the original model formulation are shown on the images on the right. Red points (model improvement) are mostly located downstream reservoirs/dams and floodplain (Amazon basin).

ALGORITHM IMPROVEMENT

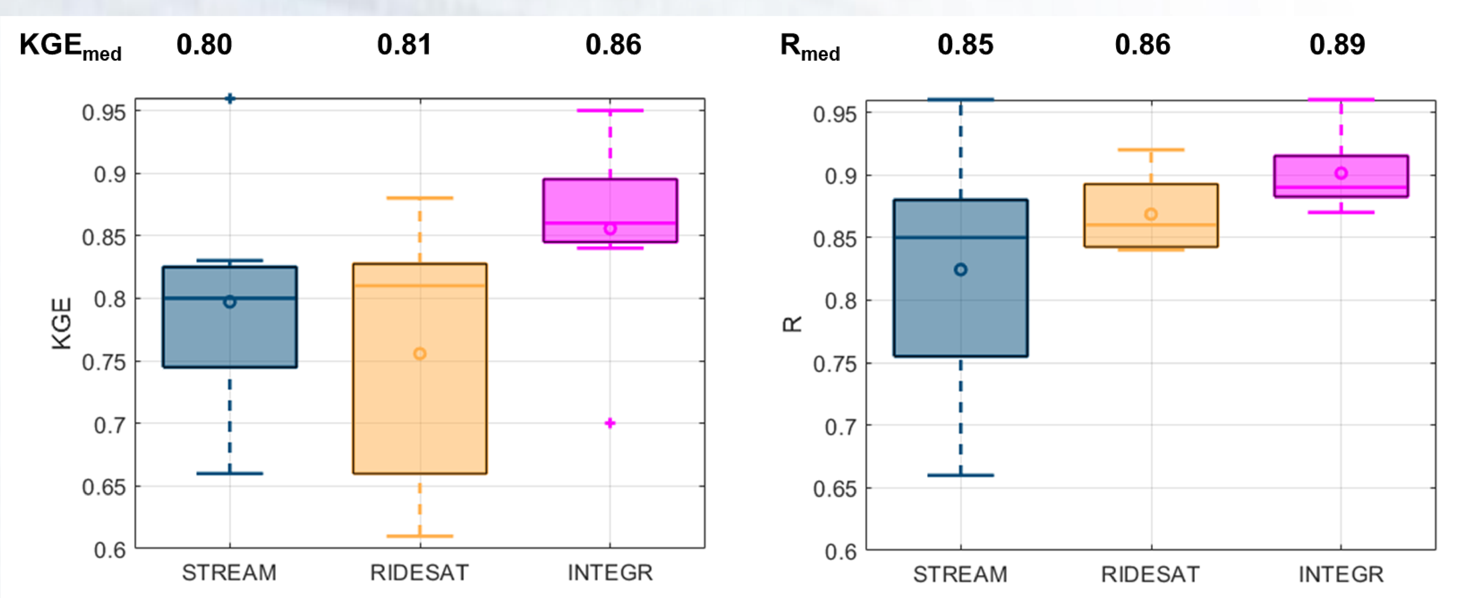
Multi-mission altimetry model was improved removing outliers and considering the presence of dams and reservoir.
The reflectance index CM was modified by ingesting the contribution of sediments (W) and vegetation (V) for a total of 4 indices derived (CM, VM, CMW, VMW). A multi-mission approach was applied to merge the information coming from Sentinel-2 and MODIS.





River discharge was then obtained using different model formulations from literature and the RIDESAT approach was found the best compromise between performances and frequency (1 day).

RIVER DISCHARGE INTEGRATION: STREAMRIDE RESULTS



The integration between STREAM and RIDESAT river discharge estimates was performed through a Bayesian analysis. The results of the integration, carried out over several sections along the Mississippi and Amazon river basin, are illustrated in the boxplot on the left in terms of KGE and correlation coefficient (R).
From the figure two conclusions can be drawn:

1. Accurate STREAM and RIDESAT river discharge estimates at basin/local scale were obtained also over critical areas (e.g., topographic complex or highly anthropized basins) in the analysed period (2003 – 2020);

2. The integration approach to obtain continuous river discharge estimates is evidently beneficial, overcoming the intrinsic limits of each satellite-based approach.

Acknowledgment

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http://hydrology.irpi.cnr.it/projects/streamride/

Contact information
stefania.camici@irpi.cnr.it
angelica.tarpanelli@irpi.cnr.it