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VIRTUAL ON
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Satellite soil moisture improves rainfall just where needed

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THE UPDATED ABSTRACT!

See notes for additional details of the slides

Soil moisture is a fundamental variable in the water and energy cycle and its knowledge in many applications is crucial. In the last decade, some authors have proposed the use of satellite soil moisture for estimating and improving rainfall, doing hydrology backward. From this research idea, several studies have been published and currently preoperational satellite rainfall products exploiting satellite soil moisture products have been made available.

The assessment of such products on a global scale has revealed an important result, i.e., **the soil moisture based products perform better than state of the art products exactly over regions in which the data are needed: Africa and South America**. However, over these areas the assessment against rain gauge observations is problematic and independent approaches are needed to assess the quality of such products and their potential benefit in hydrological applications. On this basis, the **use of the satellite rainfall products as input into rainfall-runoff models**, and their indirect assessment through river discharge observations is an alternative and valuable approach for evaluating their quality.

For this study, a **newly developed large scale dataset of river discharge observations over 400+ basins throughout Africa** has been exploited. Based on such unique dataset, a **large scale hydrological assessment of multiple near real time satellite rainfall products** has been performed: (1) the Early Run version of the Integrated Multi-Satellite Retrievals for GPM (Global Precipitation Measurement), IMERG Early Run, (2) SM2RAIN-ASCAT, and (3) GPM+SM2RAIN. Additionally, gauge-based and reanalysis rainfall products have been considered, i.e., (4) the Global Precipitation Climatology Centre (GPCC), and (5) the latest European Centre for Medium-Range Weather Forecasts reanalysis, ERA5. As rainfall-runoff model, the semi-distributed MISDc (Modello Idrologico Semi-Distribuito in continuo) model has been employed in the period 2007-2018 at daily temporal scale.

Results reveal the great value of satellite soil moisture products in improving satellite rainfall estimates for river flow prediction in Africa, and particularly in West Africa. Such results highlight the ***need to exploit satellite rainfall products for operational applications in Africa addressed to the mitigation of flood risk, to water resources management, and to agriculture****.*

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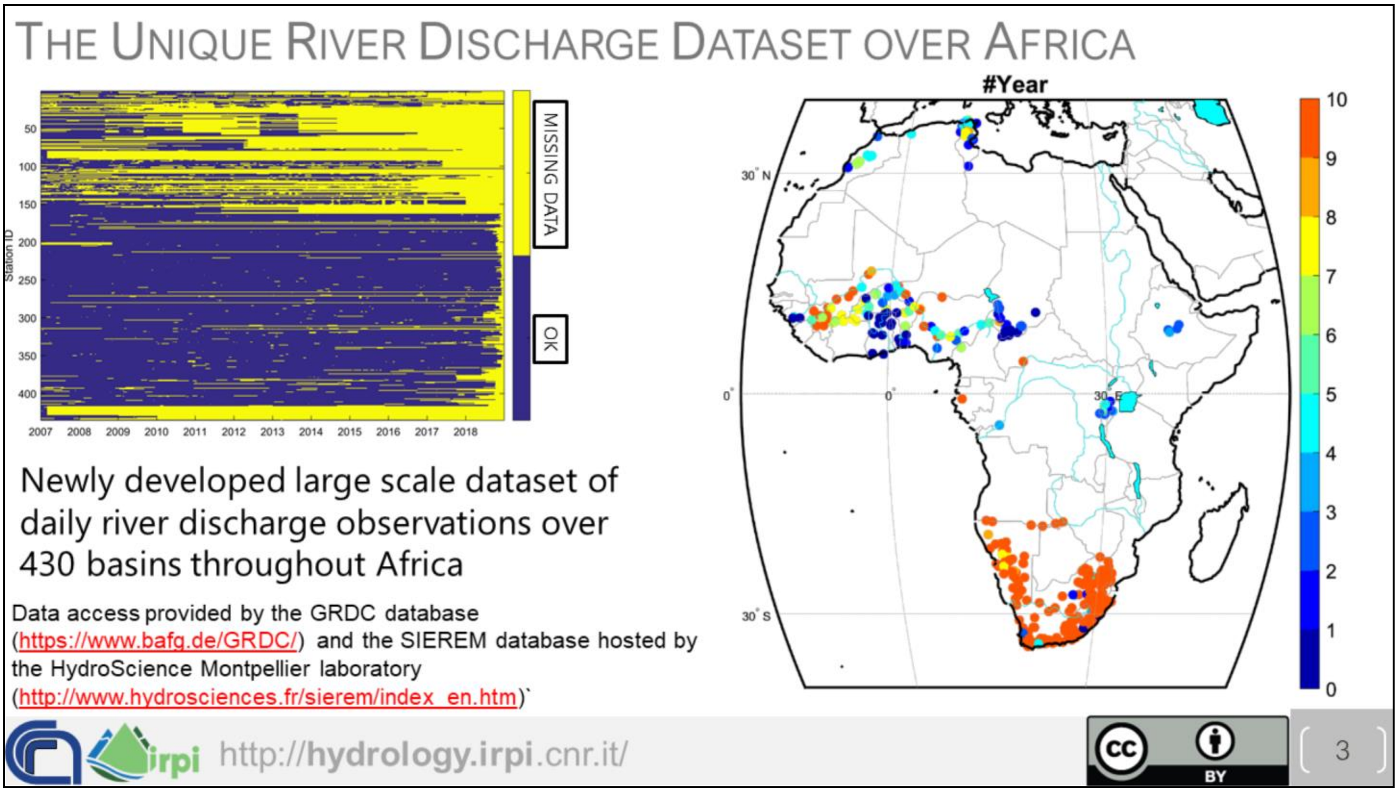

A large database of river discharge observations at 1000+ basins over the Africa continent has been collected (thanks to HydroScience Montpellier laboratory). For this study a subset of the database has been used starting in 2007 by considering the availability of satellite rainfall products.

For details please refer to the mentioned references.

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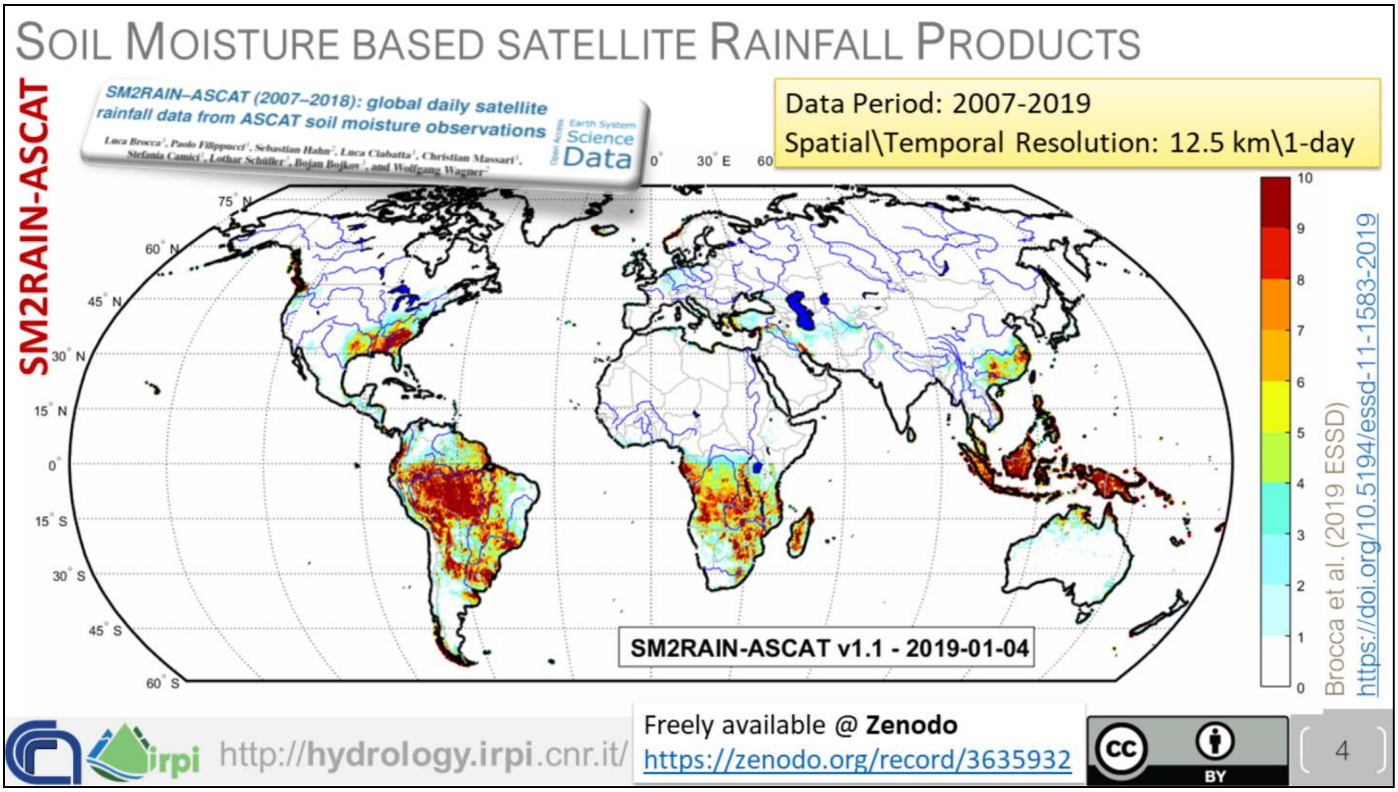

SM2RAIN-ASCAT is a global satellite rainfall dataset developed from the application of SM2RAIN algorithm (Brocca et al., 2014, http://dx.doi.org/10.1002/2014JD021489) to ASCAT soil moisture product (Wagner et al., 2013, http://dx.doi.org/10.1127/0941-2948/2013/0399). The product is freely available in Zenodo (see the link on the slide) and in a recent study (Brocca et al., 2019, ESSD) it has been found performing good in Africa and South America. Therefore, this product is considered suitable for flood modelling in Africa as carried out in this study.

The animation shows the global daily rainfall for 2019 as an example.

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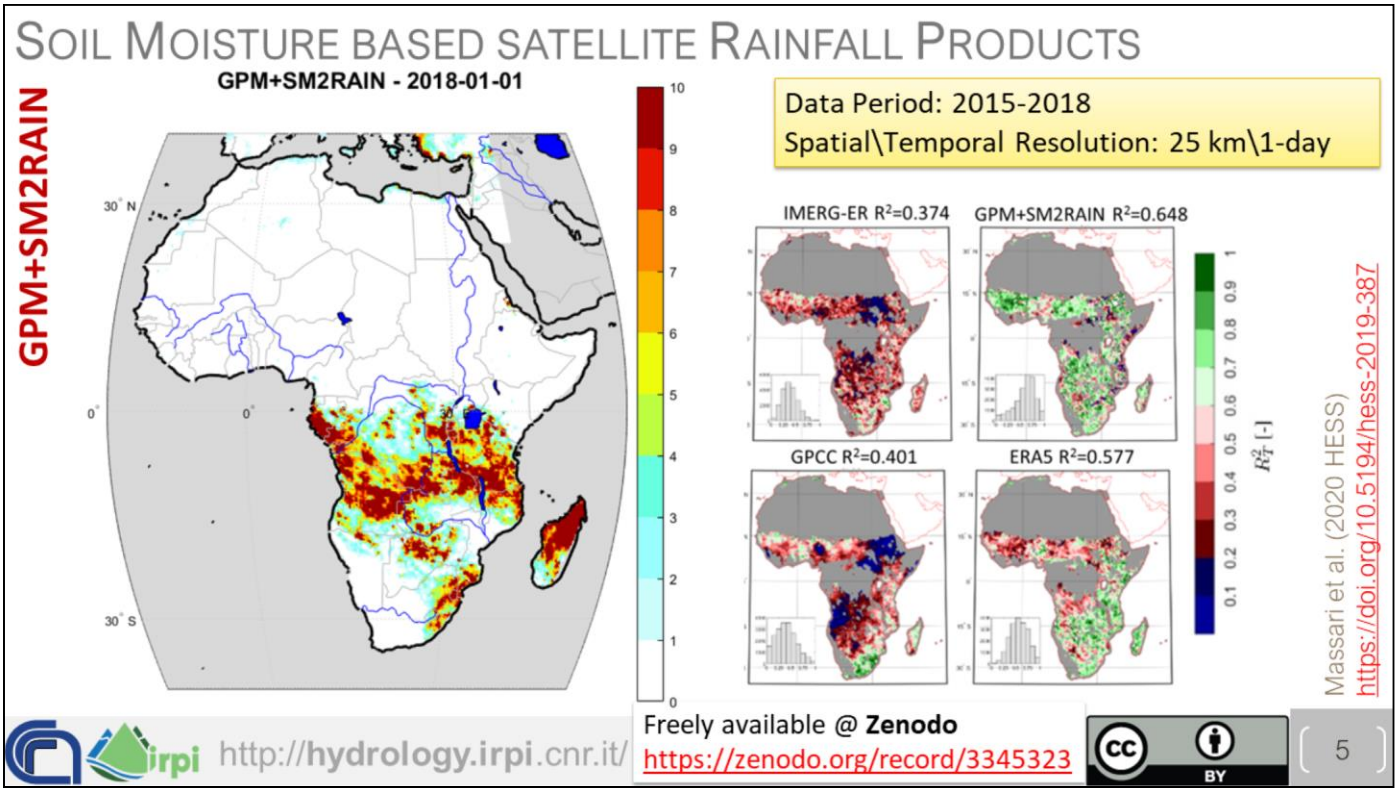

GPM+SM2RAIN is based on the integration of IMERG-Early Run of the Global Precipitation Measurement Mission (GPM) with SM2RAIN-based rainfall estimates derived from ASCAT, SMOS and SMAP L3 soil moisture products. The dataset is currently available for Africa and South America (2015-2018), Europe, India, Contiguos United States and Australia (2015-2017). Massari et al. (2020, HESS) have shown that GPM+SM2RAIN outperforms all other products in Africa (greener colors in the 4 panels on the right). Also this dataset is freely available in Zenodo (see the link on the slide).

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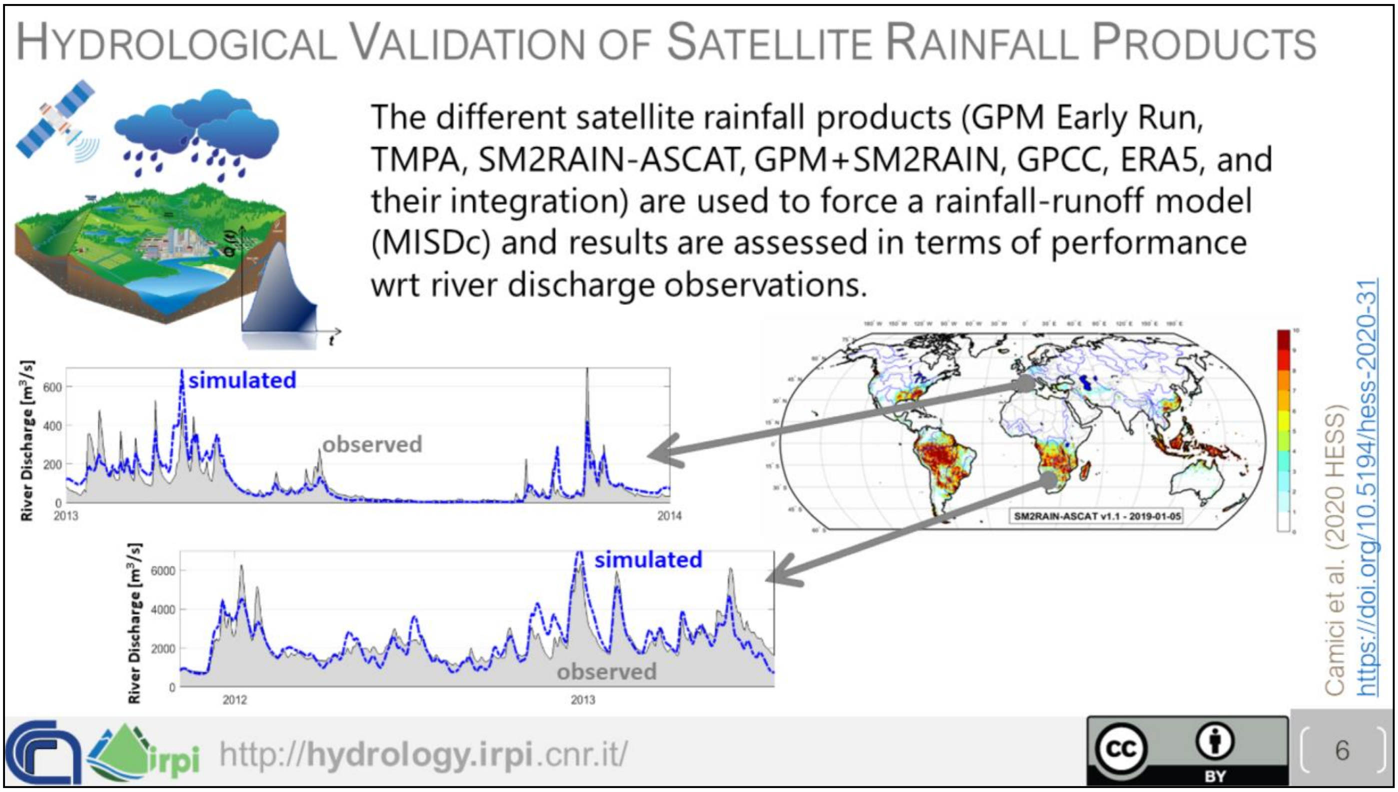

For this study, we have used different satellite rainfall products (GPM Early Run, TMPA, SM2RAIN-ASCAT, GPM+SM2RAIN), one gauge-based rainfall product (GPCC) and the latest reanalysis rainfall product from ECMWF (ERA5). The integration of different products has been also considered. Each rainfall product has been used to force a rainfall-runoff model (MISDc, Brocca et al., 2011, http://dx.doi.org/10.1002/hyp.8042) and produce river discharge simulations for each basin. For each basin and for each rainfall product, the model parameter values have been calibrated (by using a feasible range of values). The simulated river discharge has been compared with ground discharge observations from the Africa database (slide 3). The main score used for assessing the performance is Kling-Gupta Efficiency (KGE) with optimal value equal to 1.

See Camici et al. (2020, HESS) for more details on the procedure as we have carried out the same approach here.

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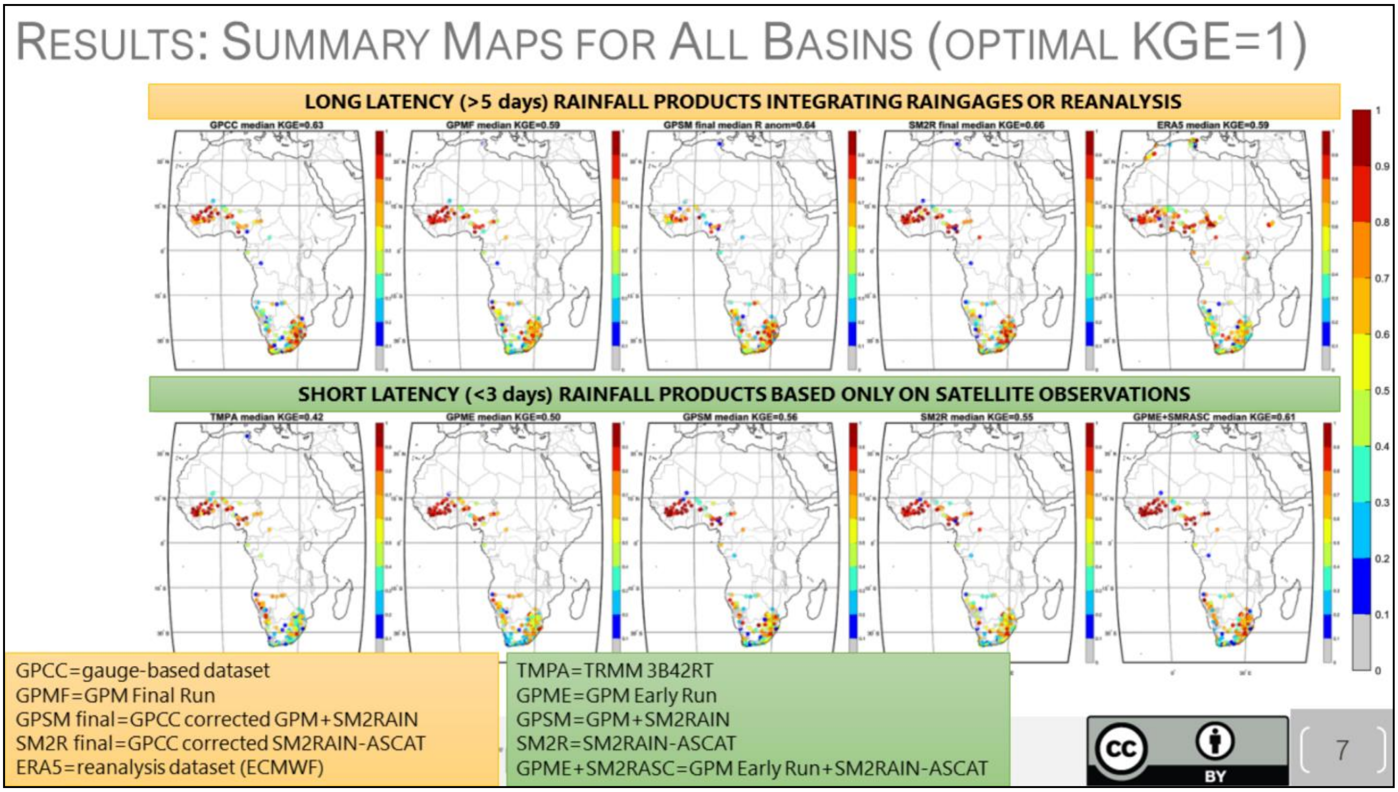

Each map shows the KGE values obtained for all basins (435) and all products (same range for all panels, visible colorbar on the right). On the top the long latency products are shown, i.e., with latency greater than 5 days (but usually in the order of 1 month). On the bottom the short latency (<3 days) products are shown, based only on satellite observations (not gauge corrected and without including reanalysis).

Among the long latency products, the performance of GPCC (median KGE=0.63) can be considered as a reference. GPM Final Run and ERA5 perform slightly worse (0.59) and the integration of GPCC with GPM+SM2RAIN and SM2RAIN-ASCAT gives some improvements (up to 0.66), particularly in West Africa.

Among the short latency products, TMPA gives the lower performance (0.42) while SM2RAIN-ASCAT and GPM+SM2RAIN provide significantly better results (~0.56) and an ad hoc integration of GPM Early Run with SM2RAIN-ASCAT gives performance very close to long latency products (0.61).

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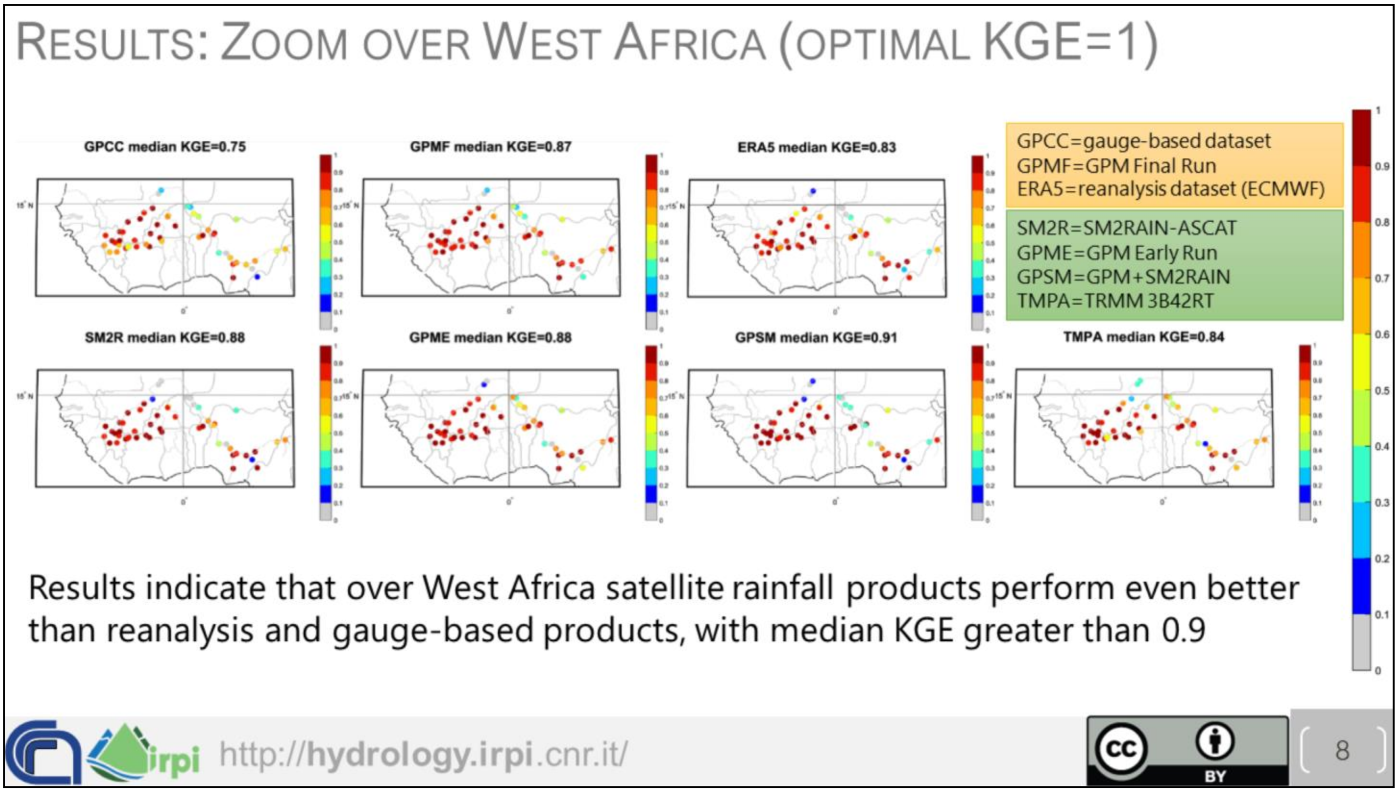

As mentioned in the previous slide, results indicate that over West Africa satellite rainfall products perform even better than reanalysis and gauge-based products, with median KGE greater than 0.9. In this area it is expected to obtain the higher benefit in using such product for hydrological applications.

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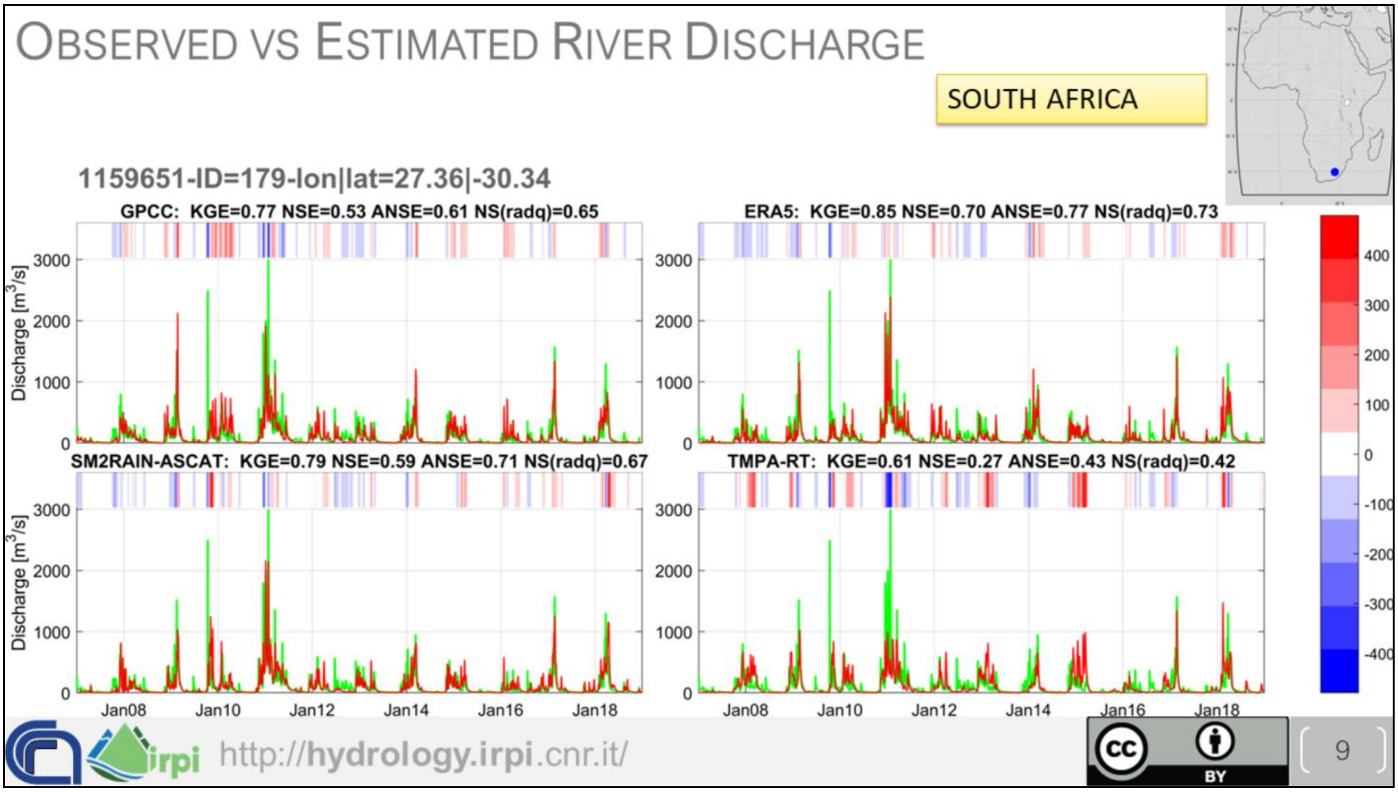

For the period 2007-2018, each panel shows the comparison between observed and simulated river discharge by using 4 rainfall products (GPCC, top left; ERA5, top right; SM2RAIN-ASCAT, bottom left; and TMPA-RT, bottom right).

A basin in South Africa is shown. If requested, the same figure can be easily done for all basins, and all investigated products.

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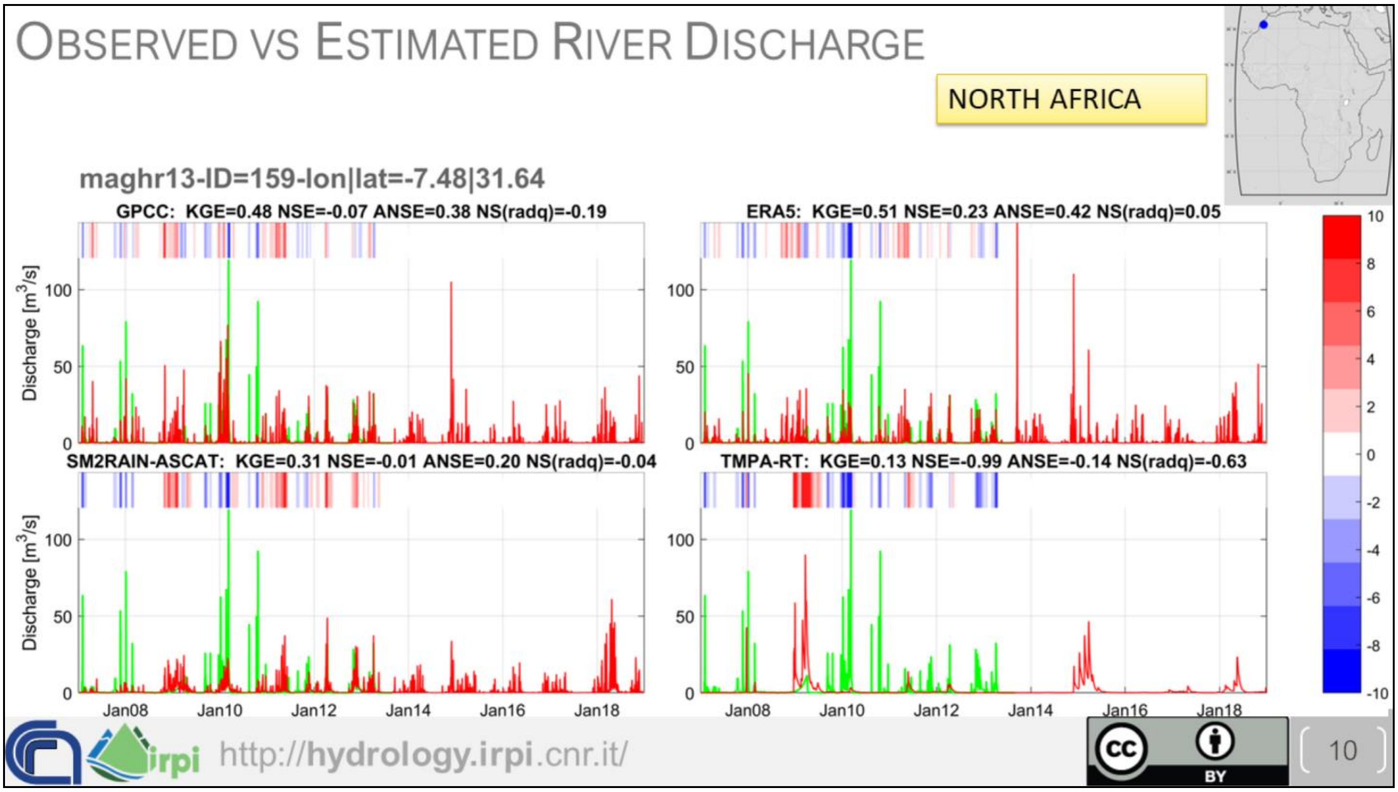

For the period 2007-2018, each panel shows the comparison between observed and simulated river discharge by using 4 rainfall products (GPCC, top left; ERA5, top right; SM2RAIN-ASCAT, bottom left; and TMPA-RT, bottom right).

A basin in North Africa is shown. If requested, the same figure can be easily done for all basins, and all investigated products.

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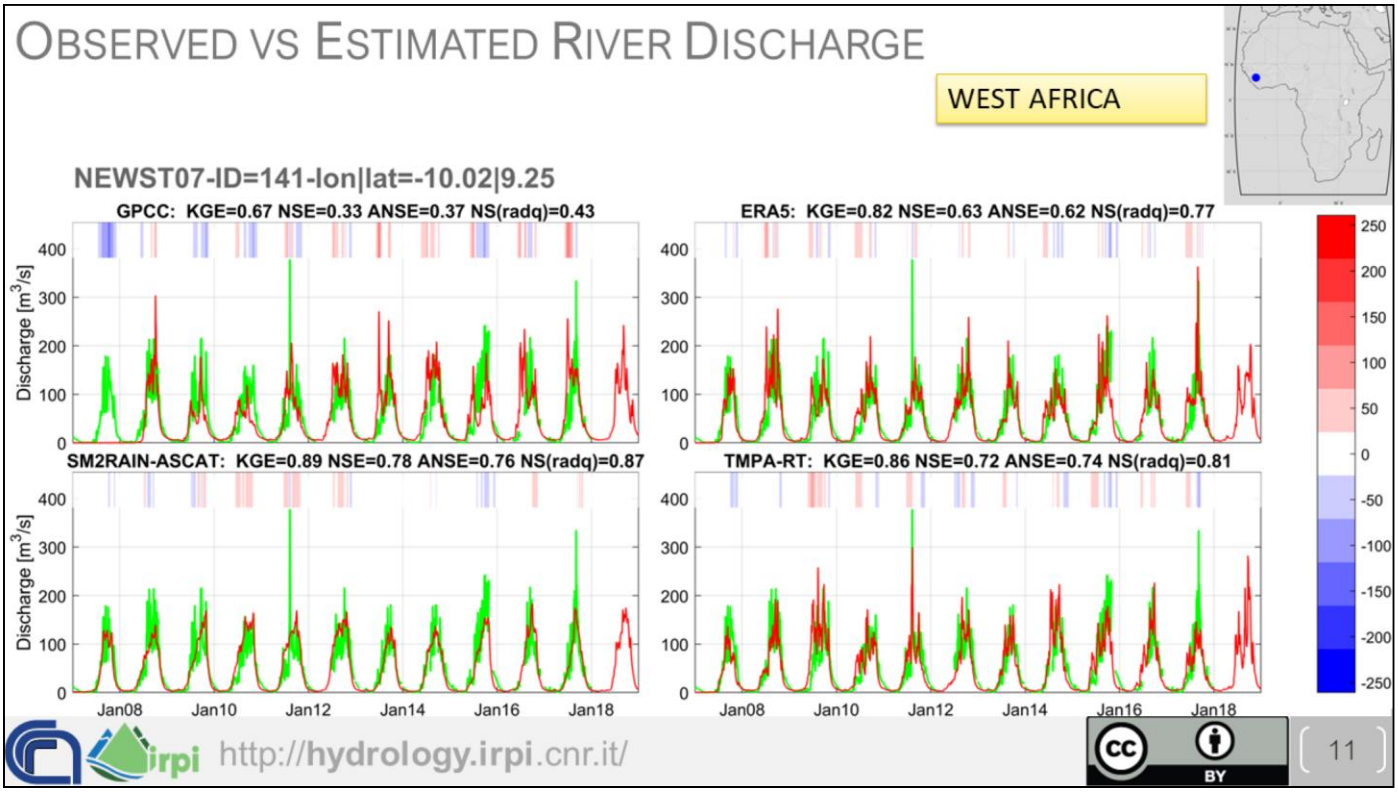

For the period 2007-2018, each panel shows the comparison between observed and simulated river discharge by using 4 rainfall products (GPCC, top left; ERA5, top right; SM2RAIN-ASCAT, bottom left; and TMPA-RT, bottom right).

A basin in West Africa is shown. If requested, the same figure can be easily done for all basins, and all investigated products.

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TAKE HOME MESSAGE

Satellite rainfall products integrating satellite soil moisture observations through SM2RAIN show good performance in Africa in reproducing river discharge

Need to exploit satellite rainfall products for operational applications in Africa addressed to the mitigation of flood risk, to water resources management and to agriculture

Further info and details:

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The take home message of our study is that satellite rainfall products integrating satellite soil moisture products have reached a good level of maturity and accuracy. Therefore, we foster their use in operational applications in hydrology (e.g., flood and landslide prediction), in water resources management (e.g., reservoir management), and in agriculture.

For details please refer to the mentioned references.

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