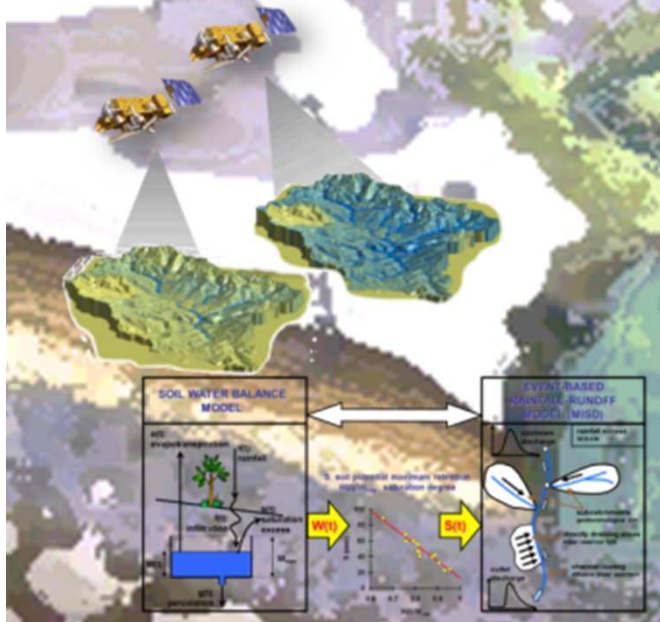
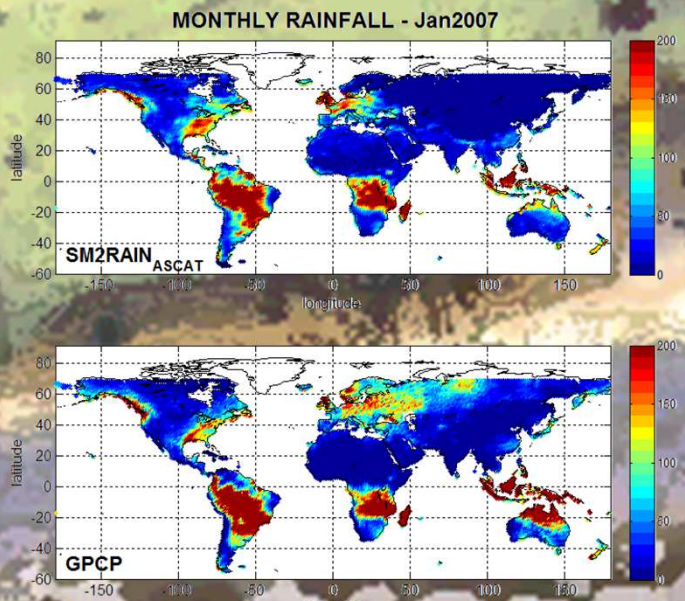
USE OF SMAP SOIL MOISTURE PRODUCTS FOR OPERATIONAL FLOOD FORECASTING:

DATA ASSIMILATION AND RAINFALL CORRECTION (SM2RAIN)





Use of SMAP soil moisture products for operational flood forecasting: data assimilation and rainfall correction

Luca Brocca

Objectives

The project aims at understanding the capability of SMAP soil moisture (SM) products at different spatial resolution (3, 9, and 36 km) for operational hydrological applications in Europe. Specifically, the purpose of the project is to use simulated data 1) for assimilation into continuous rainfall-runoff modelling to demonstrate the impact on runoff prediction with emphasis on extremes, and 2) to address the estimation of rainfall from SM data

The work on data assimilation will be implemented for improving the early warning system for flood and landslide forecasting of the Umbria Region Civil Protection centre. The use of soil moisture data to correct and/or replace precipitation estimates will be applied to the whole Italian territory for the hydro-meteorological and hydraulic risk assessment at the Italian Department of Civil Protection.

Team Membership

Luca Brocca, Research Institute for Geo-Hydrological Protection, National Research Council; SMAP contact: Dara Entekhabi

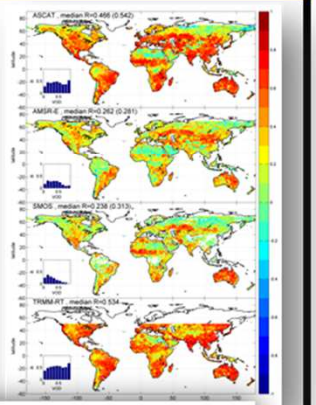
Status

- **Selected 3rd quarter 2014**

With existing satellite SM data

1) Improving flood forecasting through the assimilation of ASCAT and AMSR-E soil moisture products
2) Rainfall estimation from ASCAT, AMSR-E, and SMOS SM data (see correlation maps in Fig.1 against GPCC: Brocca et al. 2014)

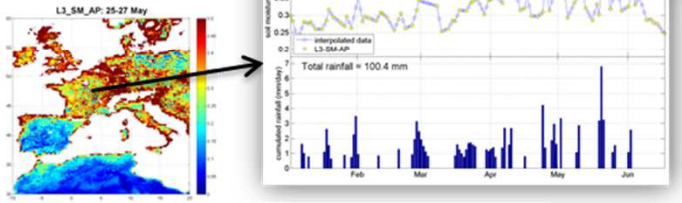
Fig.1



With SMAP simulated SM data

- Reading, processing and extracting the data
- Estimation of rainfall through SM2RAIN algorithm over Europe (see Fig.2)

Fig.2



Methodology/Approach

1) ***SMAP data assimilation into rainfall-runoff modelling***
This activity was already carried out by considering different satellite-derived SM products (e.g. Brocca et al. 2012, doi:10.1109/TGRS.2011.2177468) and it will be applied as soon as actual SMAP data will be available.

2) ***SM2RAIN: Estimation of rainfall from SMAP SM data***
The SM2RAIN algorithm (Brocca et al. 2014, doi:10.1002/2014JD021489) will be applied to SMAP SM products to obtain a new daily rainfall products that can be also merged with other state-of-the-art satellite products as the ones delivered from the Global Precipitation Measurement (GPM) mission.

Schedule and Issues

- Implementation of the extraction of SMAP simulated data, at different spatial resolution, for several catchments across Italy on which to perform the data assimilation studies

- Global scale estimation of rainfall through SM2RAIN algorithm from SMAP simulated data at 9 km resolution (L3_SM_AP product)

Issues:

a) The temporal resolution of SMAP data might be not sufficient for daily rainfall estimation through SM2RAIN (to be tested with actual data).
b) Anomaly or missing values of SMAP simulated data for coastlines, mountains, and highly urbanized areas
c) Lack on information on the generation of simulated data

Rainfall estimation from soil moisture data

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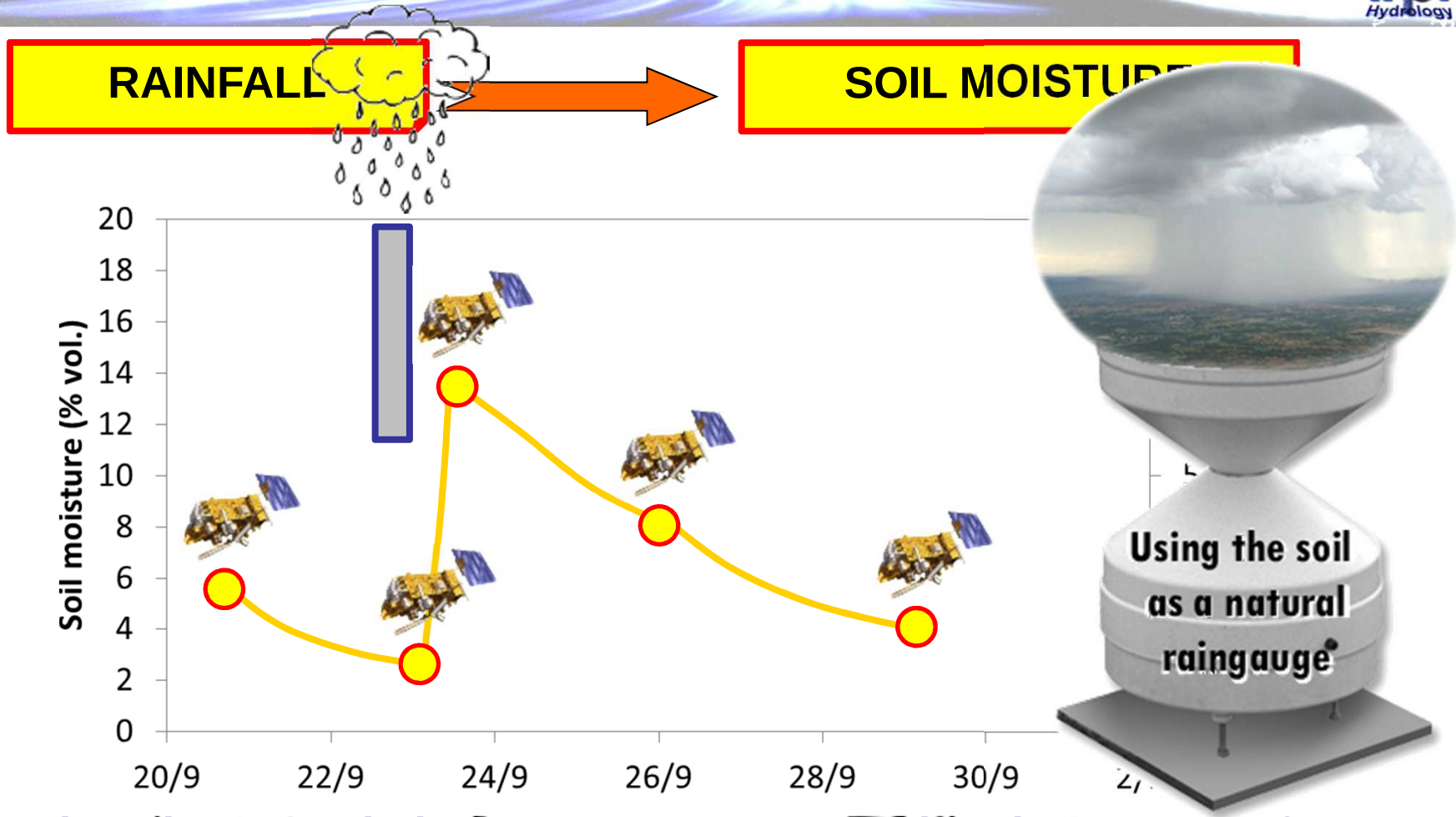
Luca



The soil moisture variations are strongly related to the amount of rainfall falling into the soil. Therefore, we can use soil moisture observations for estimating rainfall by considering the "soil as a natural raingauge".

SM2RAIN

"Top down" vs "Bottom up" perspective

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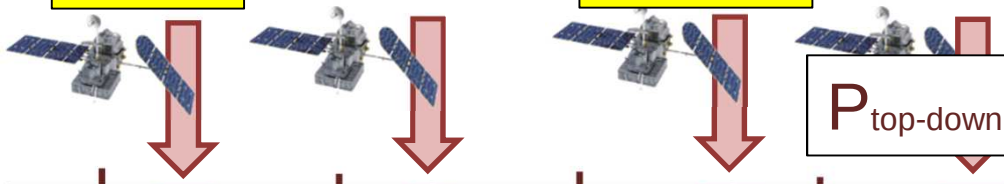
Luca

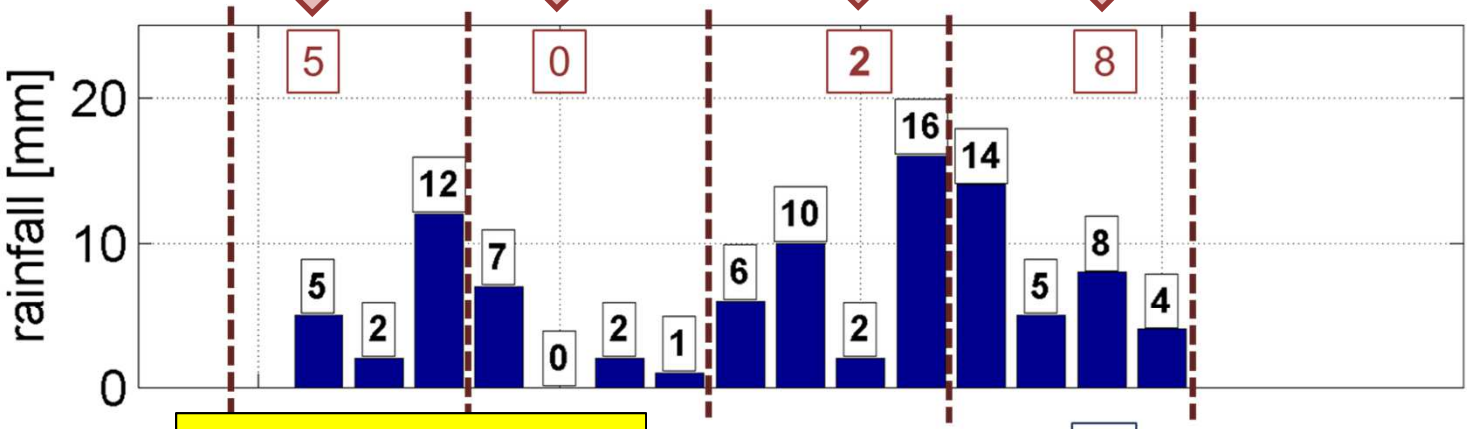
GPM

SMAP



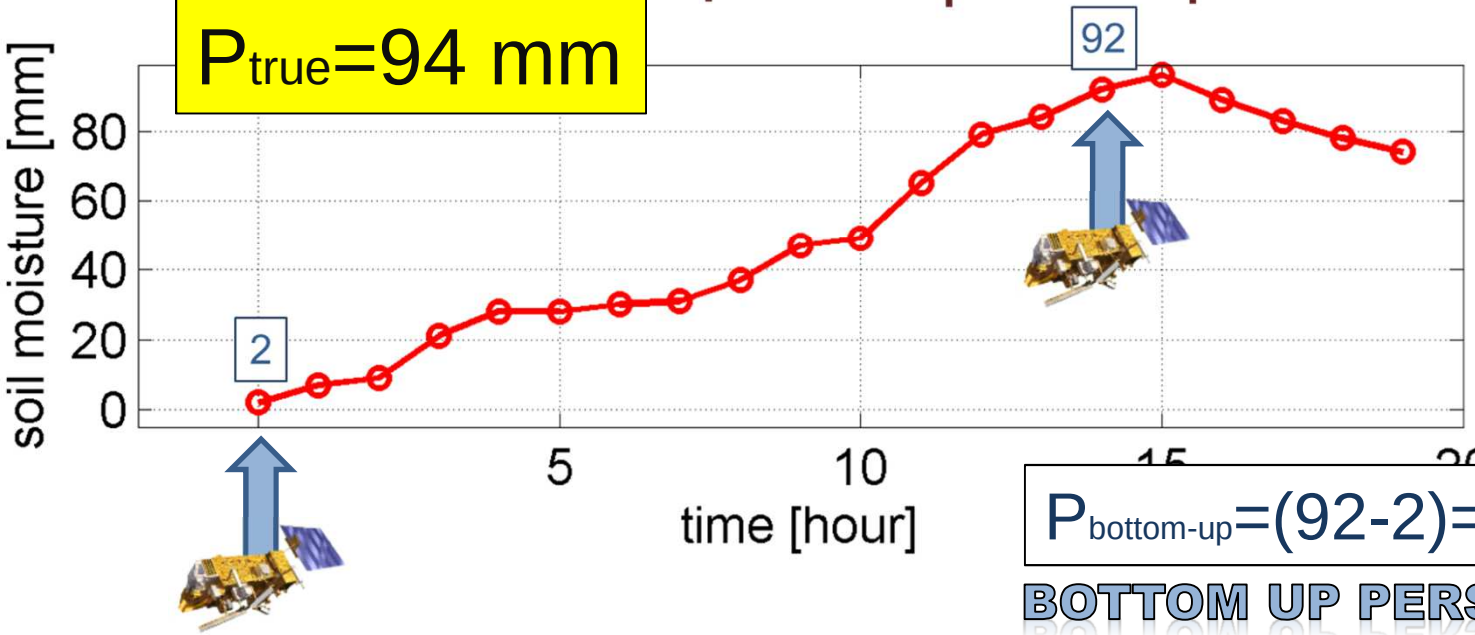
TOP DOWN PERSPECTIVE

$P_{top\text{-}down}=(5+0+2+8)*4= 60$ mm



The underestimation is due to the satellite overpasses in period with low rainfall

$P_{true}=94$ mm



With only two overpasses the bottom up approach provides a better estimate of the accumulated rainfall

$P_{bottom\text{-}up}=(92-2)= 90$ mm

BOTTOM UP PERSPECTIVE

Global scale: correlation

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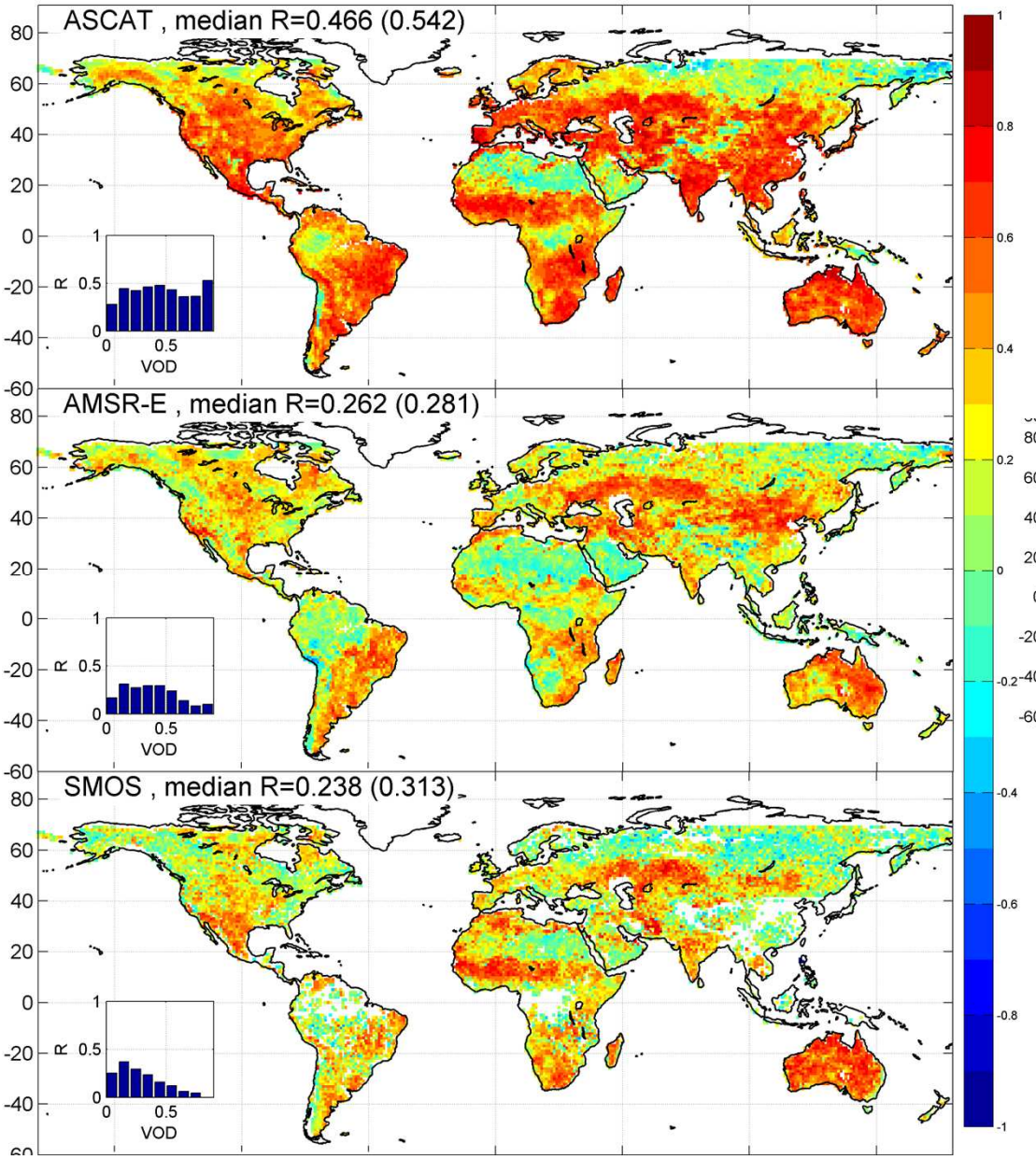
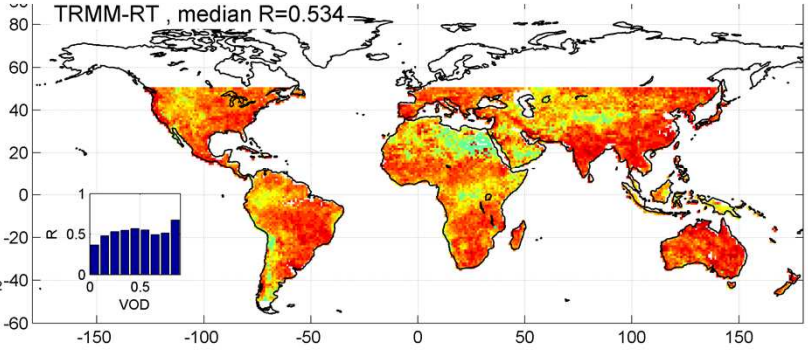


Correlation map between 5-day rainfall from GPCC and the rainfall product obtained from the application of SM2RAIN algorithm to ASCAT, AMSR-E and SMOS data plus TMPA 3B42RT (*VALIDATION period 2010-2011*)



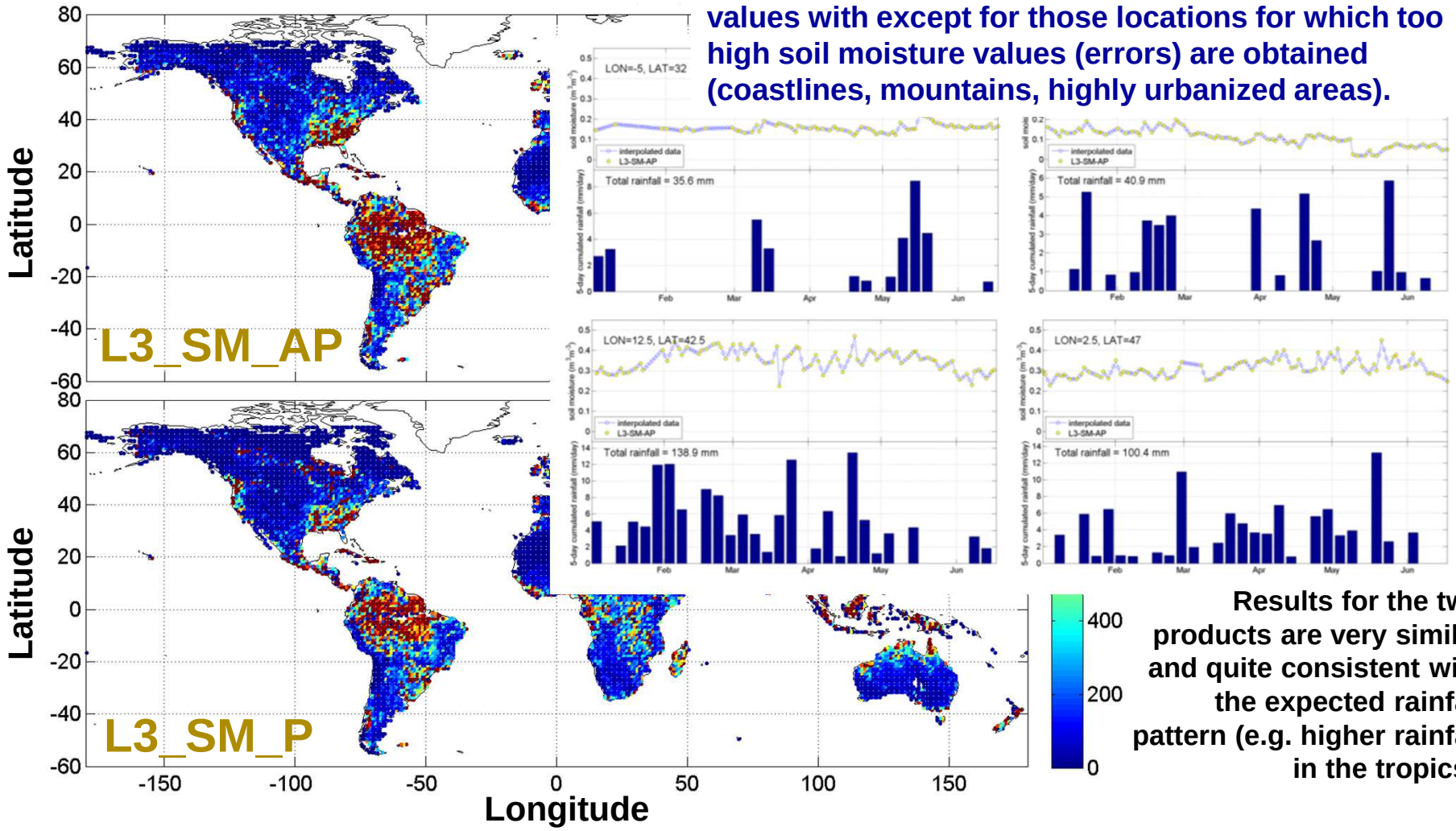
Brocca, L., Ciabatta, L., Massari, C., Moramarco, T., Hahn, S., Hasenauer, S., Kidd, R., Dorigo, W., Wagner, W., Levizzani, V. (2014). Soil as a natural rain gauge: estimating global rainfall from satellite soil moisture data. *Journal of Geophysical Research*, 119(9), 5128-5141.

SM2RAIN → SMAP simulated data

Brocca
Luca

- Global scale (1° spatial resolution), Whole simulated period (6 months)
- Active + Passive (L3_SM_AP) and only Passive (L3_SM_P) soil moisture products

The estimated rainfall data shows reasonable values with except for those locations for which too high soil moisture values (errors) are obtained (coastlines, mountains, highly urbanized areas).



Results for the two products are very similar and quite consistent with the expected rainfall pattern (e.g. higher rainfall in the tropics).

References to SM2RAIN

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Luca

FOR FURTHER INFORMATION
URL: http://hydrology.irpi.cnr.it/people/l.brocca
URL IRPI: http://hydrology.irpi.cnr.it

2013

GEOPHYSICAL RESEARCH LETTERS, VOL. 40, 853–858, doi:10.1002/GRL.50173, 2013

A new method for rainfall estimation through soil moisture observations

L. Brocca,[1] T. Moramarco,[1] F. Melone,[1] and W. Wagner[2]

Received 16 October 2012; revised 9 January 2013; accepted 15 January 2013; published 6 March 2013.

[1] Rainfall and soil moisture, SM, are two important quantities for modeling the interaction between the land surface and the atmosphere. Usually, rainfall observations are used as input data for modeling the time evolution of SM within hydrological and land surface models. In this the last two decades through the development of in situ net… works [*Dorigo et al., 2011*], remote sensing sensors and advanced retrieval algorithms [*Wagner et al., 2007*; *Kerr et al., 2012*]. Usually, SM data sets are employed within hydrological and meteorological models to improve …

RESEARCH HIGHLIGHTS

ATMOSPHERIC SCIENCE

Detecting rainfall from the bottom up

A method that allows researchers to estimate global rainfall levels using soil-moisture data could help to improve hazard planning for floods and landslides.

To estimate rainfall in places that lack ground-based rain gauges, researchers rely on satellite data of atmospheric moisture, but this is notoriously inaccurate. Luca Brocca at the National Research Council in Perugia, Italy, and his colleagues developed an algorithm that calculates rainfall amounts on the basis of satellite data on soil moisture. They compared their estimates with rain-gauge data and found that their method accurately estimates rainfall in several regions around the world.

Moreover, their algorithm is better than a state-of-the-art method at detecting light rainfall events and precipitation at high latitudes.

J. Geophys. Res. Atmos. http://doi.org/sp7 (2014)

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Potential of soil moisture observations in flood modelling: Estimating initial conditions and correcting rainfall

Christian Massari, Luca Brocca, Tommaso Moramarco, Yves Tramblay, Jean-Francois Didon Lescot

ARTICLE INFO

ABSTRACT

Rainfall runoff (RR) models are fundamental tools for reducing flood hazards. Although several studies have highlighted the potential of soil moisture (SM) observations to improve flood modelling, much research has still to be done for fully exploiting the evident connection between SM and runoff. As … way of example, improving the quality of forcing data, i.e. rainfall observations, may have a great bene… in flood simulation. Such data are the main hydrological forcing of classical RR models but m…

AGU PUBLICATIONS

Journal of Geophysical Research: Atmospheres

RESEARCH ARTICLE

10.1002/2014JD021489

Soil as a natural rain gauge: Estimating global rainfall from satellite soil moisture data

Luca Brocca[1], Luca Ciabatta[1], Christian Massari[1], Tommaso Moramarco[1], Sebastian Hahn[2], Stefan Hasenauer[2], Richard Kidd[2], Wouter Dorigo[2], Wolfgang Wagner[2], and Vincenzo Levizzani[3]

[1]Research Institute for Geo-Hydrological Protection, National Research Council, Perugia, Italy, [2]Department of Geodesy and Geoinformation, Vienna University of Technology, Vienna, Austria, [3]Institute of Atmospheric Sciences and Climate, National Research Council, Bologna, Italy

Key Points:
- New method to measure terrestrial rainfall from satellite soil moisture data
- Global-scale application by using three satellite soil moisture products
- The new satellite products estimate accurately the accumulated rainfall

Supporting Information:
- Readme
- Figures S1-S8

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Abstract Measuring precipitation intensity is not straightforward; and over many areas, ground observations are lacking and satellite observations are used to fill this gap. The most common way of retrieving rainfall is by addressing the problem "top-down" by inverting the atmospheric signals reflected or radiated by atmospheric hydrometeors. However, most applications are interested in how much water reaches the ground, a problem that is notoriously difficult to solve from a top-down perspective. In this study, a novel "bottom-up" approach is proposed that, by doing "hydrology backward," uses variations in soil moisture (SM) sensed by microwave …

2015

Hydrol. Hydrotech., 63, 2015, X: XXX–XXX
DOI: 10.1515/johh-2015-0016

Rainfall estimation from in situ soil moisture observations at several sites in Europe: an evaluation of the SM2RAIN algorithm

Luca Brocca[1*], Christian Massari[1], Luca Ciabatta[1], Tommaso Moramarco[1], Daniele Penna[2], Giulia Zuecco[3], Luisa Pianezzola[3], Marco Borga[3], Patrick Matgen[4], José Martínez-Fernández[5]

INTEGRATION OF SATELLITE SOIL MOISTURE AND RAINFALL OBSERVATIONS OVER THE ITALIAN TERRITORY

Journal of Hydrometeorology, in press

Luca Ciabatta[1*], Luca Brocca[1], Christian Massari[1], Tommaso Moramarco[1], Silvia Puca[2], Angelo Rinollo[2], Simone Gabellani[3], Wolfgang Wagner[4]

SM2RAIN dataset from ASCAT, 0.25°, 2007-2013, freely available