The International Soil Moisture Network: a global soil moisture monitoring platform

Angelika Xaver[1], Alexander Gruber[1], Wouter A. Dorigo[1], Alena Hegyiova[1] and Antonio D. Sanchis-Dufau[1]

[1] Vienna University of Technology, Institute of Photogrammetry and Remote Sensing, Vienna, Austria

EUROSOIL 2012, Soil Science for the Benefit of Mankind and Environment, Bari, Italy, 2-6 July 2012

1) MOTIVATION

In situ soil moisture measurements are indispensable for calibrating and validating satellite- and land surface model based soil moisture estimates. Although a couple of meteorological networks measuring soil moisture exist, on a global and long-term scale, ground-based observations are few. In addition, measurements from different networks are performed in different ways, resulting in significant disparities:

- different soil moisture definitions and units
- various measurement depths
- Individual sampling rates
- several sensors (types and position)
- data formats
- distribution methods

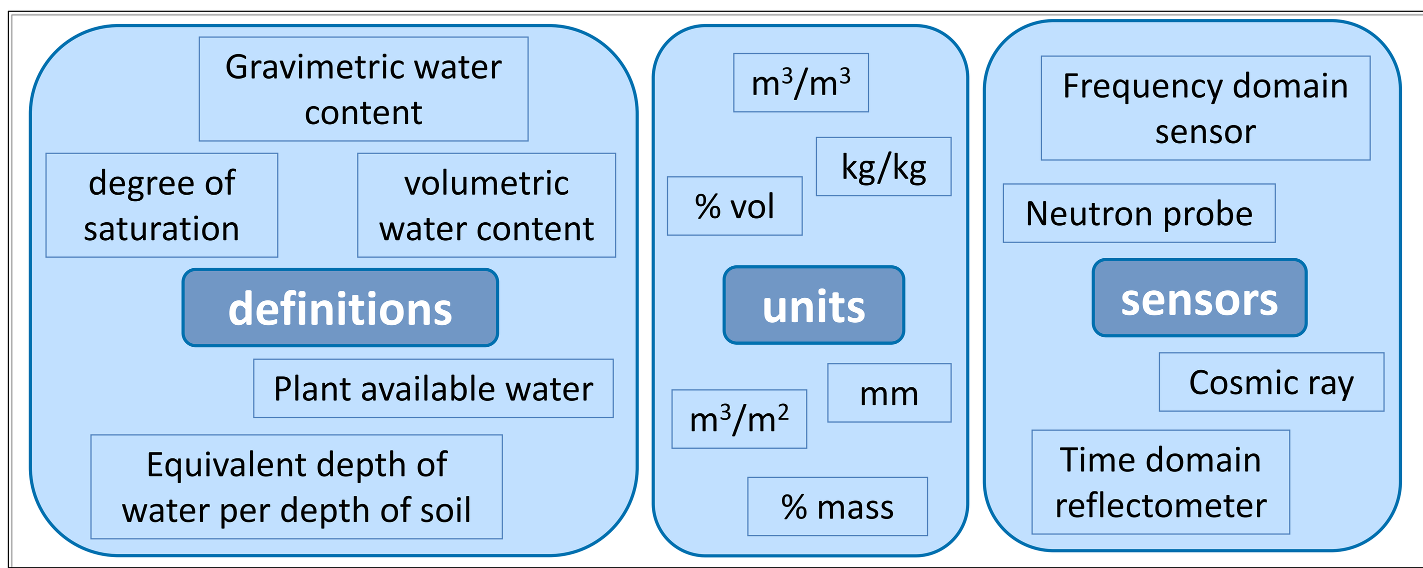


Fig. 1: Examples of various definitions, units and sensor used in different soil moisture measurement facilities.

2) INTRODUCTION

These difficulties have been the motivation for initiating the **International Soil Moisture Network** (ISMN; http://www.ipf.tuwien.ac.at/insitu), a centralized data hosting facility for in situ soil moisture observations.

Available in situ soil moisture measurements from various networks over the whole globe are collected, automatically converted into volumetric soil moisture units, and harmonized in terms of temporal scale. After a quality check they are stored in a database. Through a web interface users can easily access and download the data in homogeneous units, temporal resolution and file formats (Fig. 2).

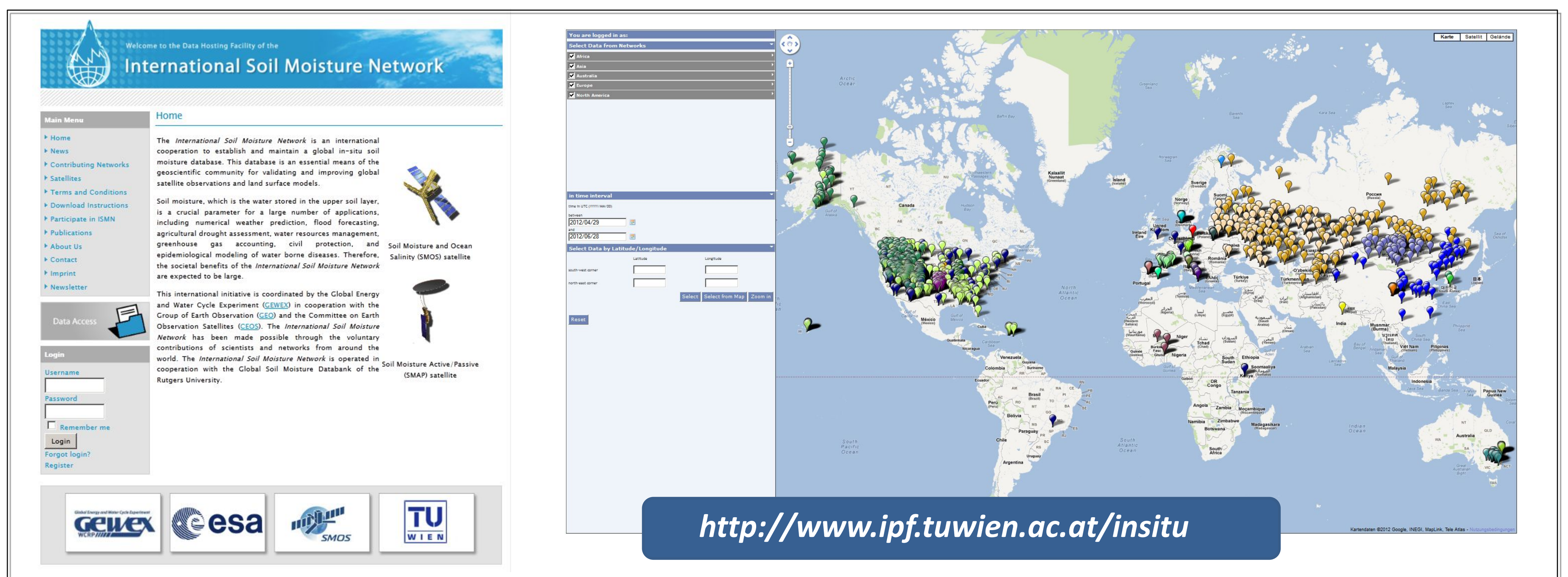


***Fig. 2:** Impressions of the ISMN web portal.*

3) DATA

Currently, data from 33 networks in total covering more than 1200 stations in Europe, North America, Australia, Asia and Africa is hosted by the ISMN, including historical datasets from 1952 on up to operational datasets with near-real time availability (Fig. 4). In addition, meteorological variables such as soil temperature, air temperature and precipitation are inserted into the ISMN as well as wilting point and field capacity.

***Fig. 3:** Example of an ISMN soil moisture time series.*

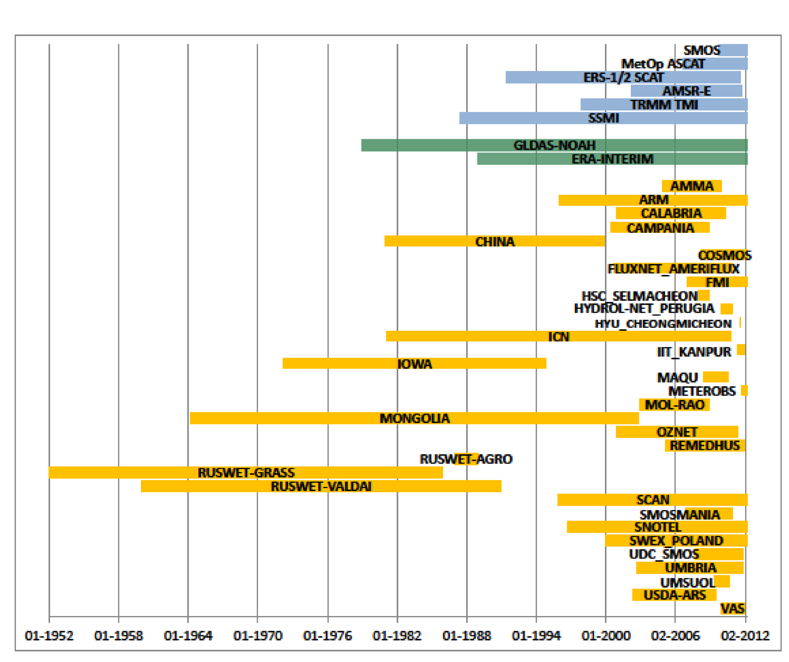


***Fig. 4:** Overview of the temporal availability of in situ soil moisture datasets included in the ISMN with respect to important satellite missions and land surface model estimates.*

4) BASIC QUALITY CONTROL

The quality of in situ soil moisture measurements is crucial for the validation of satellite- and model-based retrievals. Therefore quality flags are added to each measurement after a check for plausibility and geophysical limits, so that users are able to mask these measurements in their applications.

A basic error detection mechanism in the form of threshold-based tests has already been implemented in the ISMN. Observations exceeding the range of plausible geophysical values are flagged in accordance to the CEOP standards (Fig. 5). The geophysical validity of measurements is also checked in relationship to other variables measured at the same location, such as air temperature, soil temperature or precipitation.

Variable name	Variable range
Soil moisture	0 – 60 %
Soil temperature	-60 – 60 °C
Air temperature	-60 – 60 °C
Precipitation	0 – 100 mm h^{-1}
Soil suction	0 – 2500 kPa
Saturation point	variable

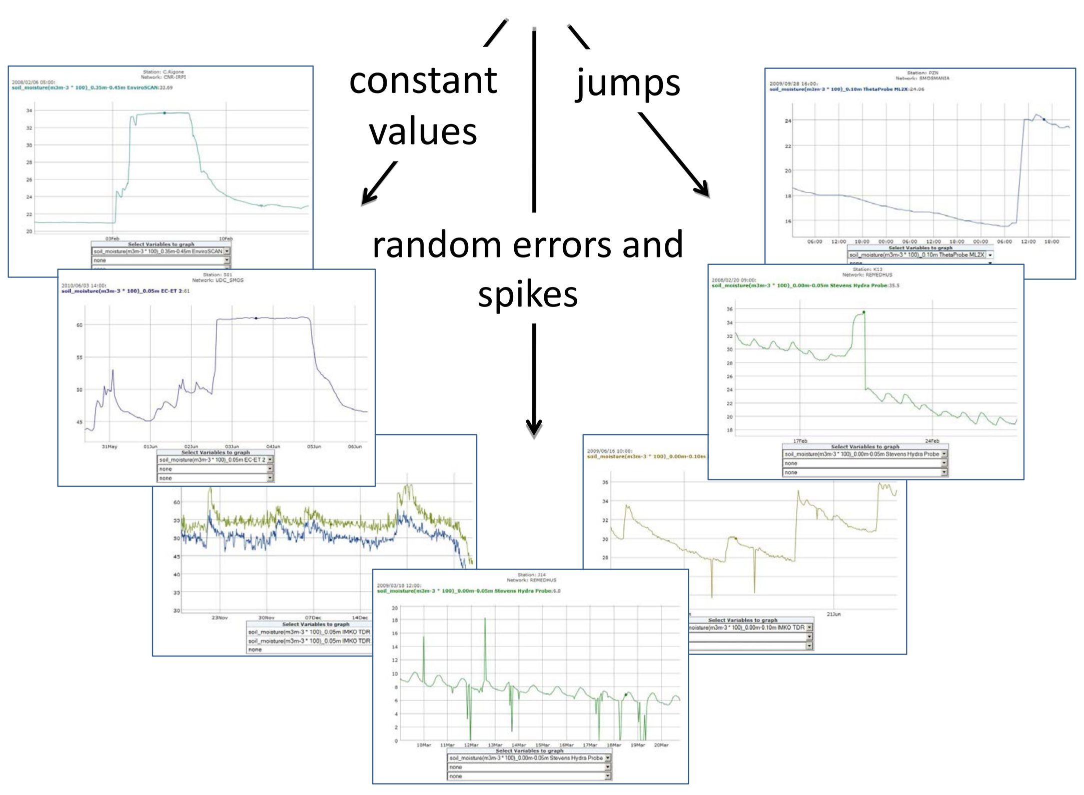
Flag value	Definition
C	Reported value exceeds output format field size OR was negative precipitation.
M	Parameter value missing OR derived parameter can not be computed.
D	Questionable/dubious
U	Unchecked

***Fig. 5:** Plausible variable ranges for most important meteorological data and CEOP flags.*

5) NEW QUALITY CONTROL METHOD

A variety of erroneous measurements exist, which occur within plausible ranges, therefore an advanced quality detection approach is needed.

Sources of errors:
-(temporary) sensor drop out
- unresponsiveness of sensor
- reduced current supply
- …



The widely known Savitzky-Golay filter was applied to derive the first two derivatives of the underlying function of observations. When a spike, negative jump or saturated plateau appears in the in situ time series the derivatives show a specific behaviour (Fig. 6). For instance, a positive spike induces a negative spike in the second derivative, surrounded by two almost equally sized smaller peaks.

Through empirical investigations new terms for quality checks, based on the characteristics of the derivatives, could be defined.

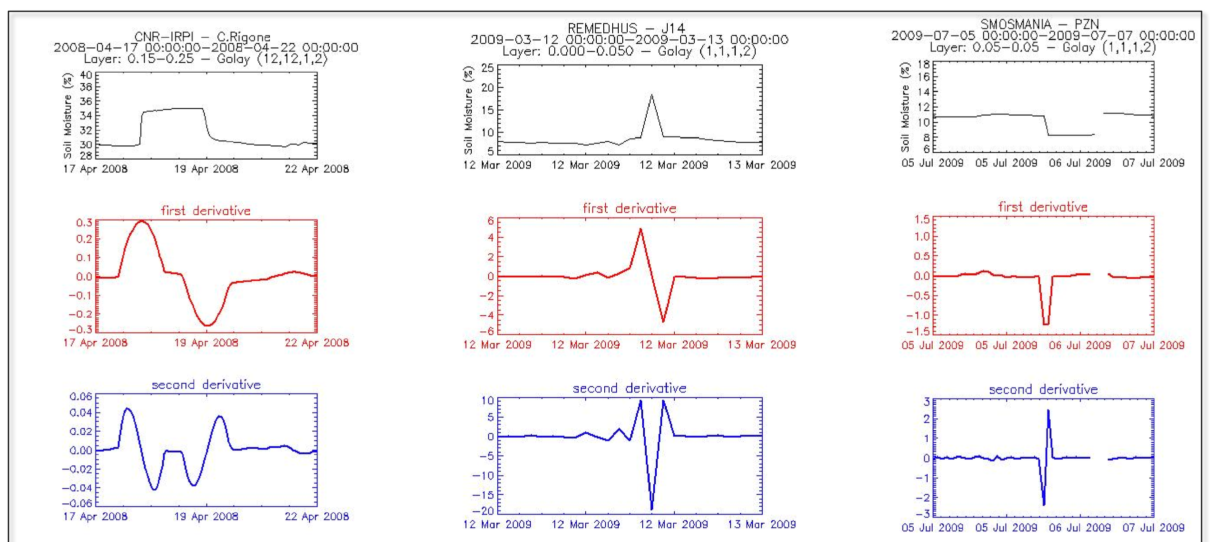


***Fig. 6:** Examples of behaviour of 1st and 2nd derivative when a saturated plateau, spike or negative jump occurs in the original data.*

6) RESULTS AND OUTLOOK

An **evaluation of the new quality checks** was done for a sample of 42 datasets, from 23 different networks including a variety of soil moisture sensors and various measurement depths. Erroneous data was classified manually in a first step, afterwards the outcome of the quality control algorithms was tested for their correctness.

Overall **87% of erroneous data was flagged correctly**, and less than 1% of the correct data was identified as erroneous.

The ISMN is growing continuously and the number of users downloading data is increasing. In the upcoming future the focus is on providing a better global coverage as well as implementing and improving the new quality control system.

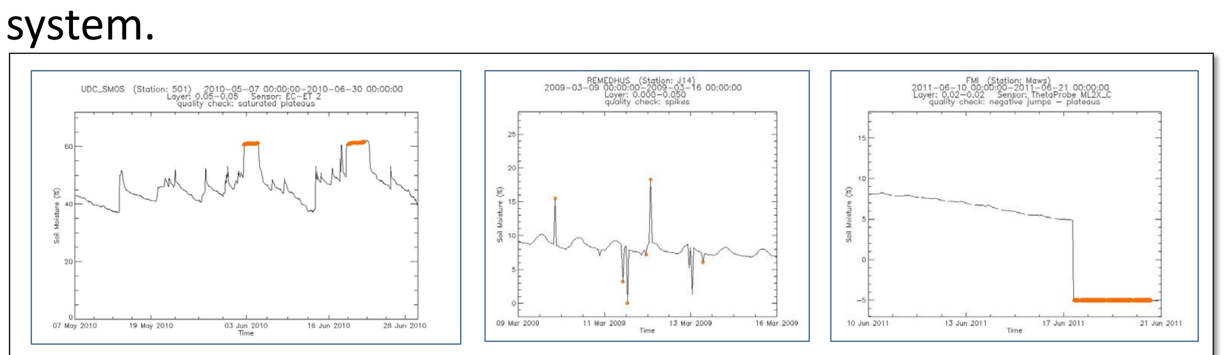


***Fig. 7:** Examples for flagging results of the different quality detection algorithms for spikes, negative jumps and saturated plateaus.*

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ACKNOWLEDGEMENTS

The ISMN has been funded through ESA's SMOSNet soil moisture network study (Contracts no. 22954/09/NL/CT and 4000102722/10/NL/FF/fk).
We greatly thank all data providers who kindly shared their data with the ISMN.

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CONTACT

Angelika Xaver
Vienna University of Technology
Institute of Photogrammetry and Remote Sensing
Gußhausstraße 27-29, 1040 Wien, Austria
Tel. +43-01-58801-12256
E-mail: ax@ipf.tuwien.ac.at