Operational monitoring of soil moisture: an overview of the TU Wien product suite

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INTRODUCTION

Soil moisture represents a key variable in the global water cycle and belongs to the Essential Climate Variables as defined by the Global Climate Observing System (GCOS). Remote sensing was found to be a powerful instrument to observe soil characteristics and especially microwave remote sensing is recognized to be the most efficient tool for extracting meaningful soil moisture information.

Since the late 1970's a variety of active and passive microwave missions provide information on soil moisture on a global scale resulting in various soil moisture products. Among them are the products developed at the Vienna University of Technology (TU Wien) of which an overview will be given in this presentation.

SOIL MOISTURE PRODUCT BASED ON THE ADVANCED SCATTEROMETER (ASCAT)

Advanced Scatterometer (ASCAT)

- onboard the METOP (Meteorological Operational) satellite series
- a real-aperature radar operating at C-band (5.25 GHz)
- VV Polarization
- incidence angle range: 25-64°
- inclination: 98,7°
- temporal resolution: 8-15 acquisitions/day
- spatial coverage: ~80% global coverage/day
- spatial resolution:
  - 50 km (operational mode)
  - 25 km (research mode)
- measured quantity: Sigma-0 [dB]
- operating since October 2006

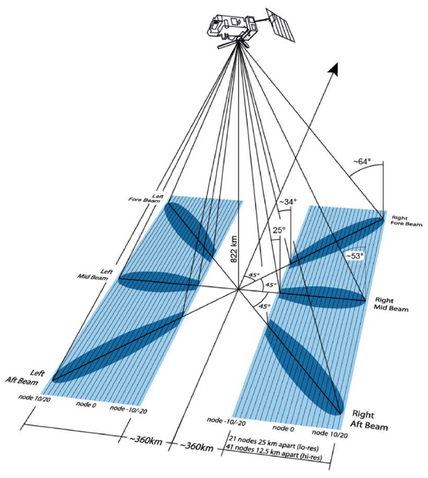

Fig. 1: METOP ASCAT specifications

Overview of ASCAT Soil Moisture Product Family:

1) Surface Soil Moisture (SSM)

- moisture in the upper few centimetres of soil
- soil moisture given in degree of saturation (%)
- spatial resolution of 25 km (globally)
- irregularly updated time series at a discrete global grid

2) Profile soil moisture = soil water index (SWI)

- soil moisture in a depth between 2 – 100 cm
- spatial resolution of 25 km (globally)

3) Downscaled ASCAT-ASAR soil moisture

- moisture in the upper few centimetres of soil
- spatial resolution of 1 km
- available in near real-time on a fixed grid for Europe

1) Surface Soil Moisture (SSM)

Starting from the observed backscatter signal the data is resampled to a global discrete grid. A change detection approach is applied, which references the lowest and highest values to the driest and wettest conditions of soil surface and accounts indirectly for surface roughness and land cover heterogeneity. The yearly effect of vegetation is eliminated by the model parameters derived from the backscatter time series.

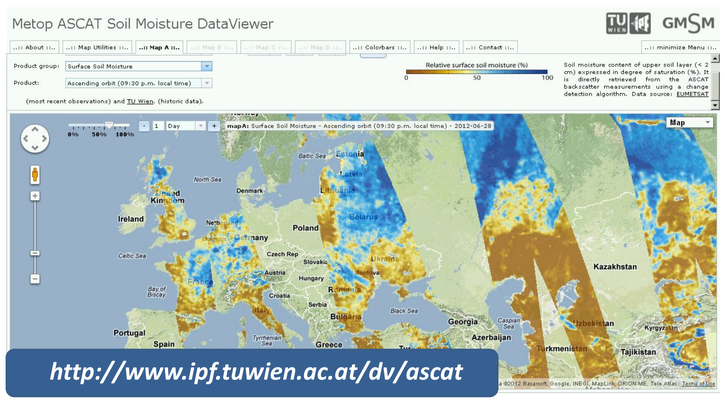

Fig. 2: Screenshot of the METOP ASCAT soil moisture data viewer.

2) Soil water index (SWI)

Filtering the surface soil moisture time series with an exponential function leads to the soil water index, a measure of the profile soil moisture content.

Depending on the number of latest ssm values used for the calculation, different SWI values are obtained. The product is defined for 8 different T-values, where T represents the characteristic time length in days. The higher the T values the smoother the SWI time series.

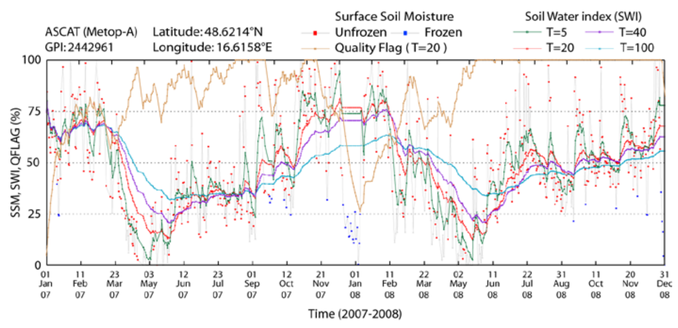

Fig. 3: Example of a surface soil moisture and SWI time series for different T values.

3) Downscaled ASCAT-ASAR soil moisture

The downscaled 1km product is the result of combining METOP/ASCAT and ENVISAT/ASAR backscatter information for each European grid point. By applying the linear relationship between the mean surface soil moisture characteristics of a small scale local area and its regional scale mean on the resampled regional-scale measurements relative soil moisture values at 1 km scale are created.

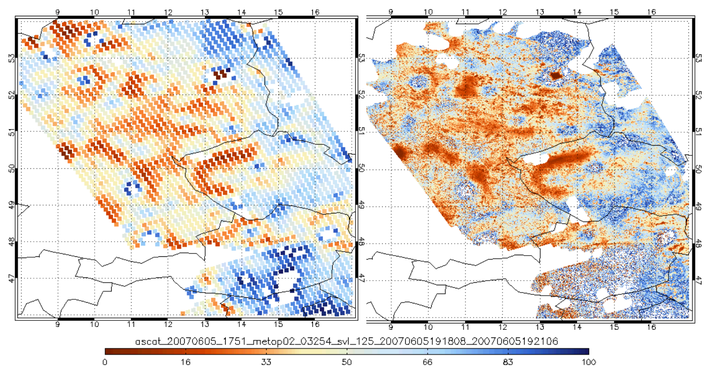

Fig. 4: Left; 25 km ASCAT, right: 1 km downscaled surface soil moisture.

THE ASAR Global Mode soil moisture product

Advanced SAR (ASAR)

- onboard the European Environmental Satellite ENVISAT
- operating at C-band (5.331 GHz)
- altitude: 800 km
- repeat rate: 35 days
- using the global mode (GM) data
- HH Polarization
- incidence angle range: 20-40°
- swath width: 405 km
- spatial/temporal resolution: 1000m/3-10 days
- operating phase 2002-2012

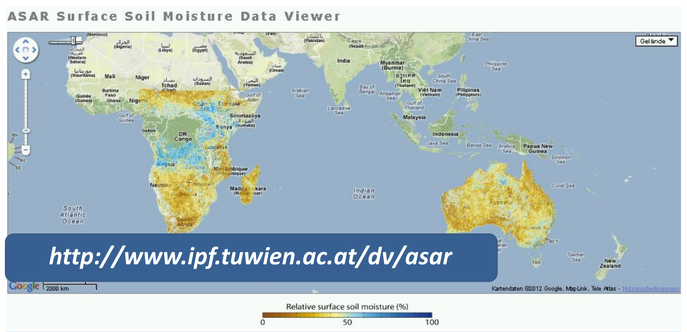

Fig. 5: Screenshot of the ASAR surface soil moisture data viewer.

ASAR GM soil moisture

Soil moisture is retrieved by applying a change detection algorithm which relies on the idea that the backscatter cross section of natural surface changes over short timescales mainly due to variations in soil moisture, while vegetation or surface roughness are assumed to be constant or only slowly varying. A soil moisture product providing medium resolution (1km) is obtained. As ENVISAT has reached its end a successive satellite mission, Sentinel, is foreseen to be operated over the period 2012 to 2030.

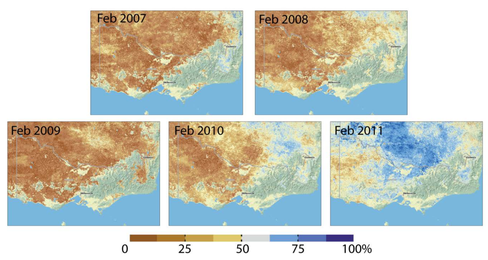

Fig. 6: Mean monthly ASAR GM relative soil moisture over Victoria in February 2007-2011

CONCLUSION

Remotely sensed soil moisture products provide highly valuable information. Depending on the temporal and spatial resolution different applications are possible, like flood monitoring and forecasting, wetland monitoring, irrigation planning or observation of climatological phenomena and conditions.

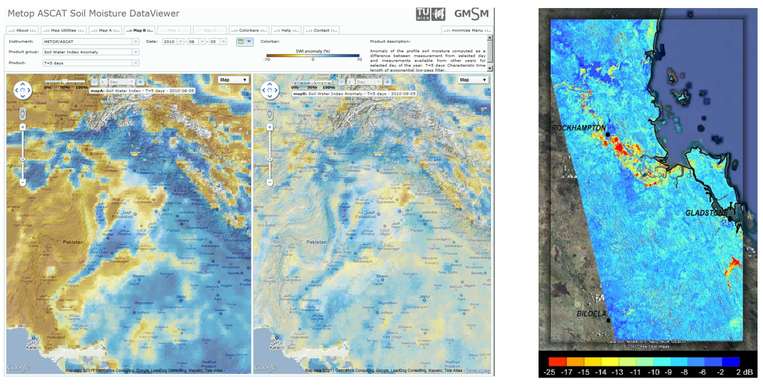

Fig. 7: Left: SWI (T=5) and SWI anomaly for August 2010 during the monsoon season across Pakistan; right: ASAR backscatter showing the flood event in Queensland, Australia, January 2011

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