Evaluation of satellite soil moisture retrieval algorithms using AMSR-E data

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Introduction

Soil moisture is a key variable in the interaction of land surface and atmosphere. Therefore, it needs to be monitored over extensive areas and periods of time. Several passive microwave sensors and algorithms to retrieve soil moisture from them have been proposed. In this work three retrieval algorithms using data of the Advanced Microwave Scanning Radiometer (AMSR) were evaluated and tested on two different datasets.

Microwave remote sensing & soil moisture

Soil moisture retrieval is based on the Radiative Transfer Equation:

\[ T_B = \Gamma \cdot e_r \cdot T_S + (1 - \omega) T_C (1 - \Gamma) + (1 - e_r) (1 - \omega) T_C (1 - \Gamma) \]  

(1)

where \( T_B \) is brightness temperature, \( T_S \) and \( T_C \) are assumed equal and the single scattering albedo \( \omega \) can be neglected at microwave wavelengths. The canopy transmissivity \( \Gamma \) depends on the vegetation optical depth \( \tau \) and the viewing angle \( \nu \). Soil moisture content can be derived from surface emissivity \( e_r \) by means of a correction factor for surface roughness, the Fresnel equation and a dielectric mixing model. In this work three retrieval algorithms were evaluated, see Figure 1.

To evaluate the algorithms two datasets were used. The first one contained data from central Mongolia over a three month period (July-September 2002). The second dataset originated from the Soil Moisture Experiments (SMEX) campaign in 2002 around Ames, Iowa, in June and July 2002.

Results

In the Mongolia dataset, observations reacted slower to rainfall events than retrieved values (Figure 2), this was because observations took place at a depth of 3 cm while the viewing depth at the used frequency is only about 1 cm.

Table 1: Statistics for all algorithms and both datasets

<table>
<thead>
<tr>
<th></th>
<th>Mongolia</th>
<th></th>
<th>SMEX02</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Daytime</td>
<td>SEE</td>
<td>Nighttime</td>
<td>SEE</td>
</tr>
<tr>
<td>Jackson</td>
<td>-9.9144</td>
<td>3.2330</td>
<td>0.3895</td>
<td>3.1799</td>
</tr>
<tr>
<td>De Jeu</td>
<td>1.6498</td>
<td>4.1958</td>
<td>0.8072</td>
<td>4.1643</td>
</tr>
<tr>
<td>Wen</td>
<td>0.3803</td>
<td>2.9482</td>
<td>0.8995</td>
<td>2.8369</td>
</tr>
</tbody>
</table>

For the SMEX02 dataset, especially the Jeu and Wen algorithms performed better at nighttime (Table 1), although the observations took place during the day. This was due to the dense vegetation layer.

Conclusions

After proper validation all algorithms can yield reasonable results, but additional vegetation information appeared to be an essential input. Compared to the Jackson and Wen algorithms, the de Jeu algorithm required hardly any validation at all. This makes the de Jeu algorithm the most applicable for large-scale (global) applications. The used validation datasets were not ideal, but they were different in terms of vegetation and representative for practical situations, which made them suitable test cases.

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