Calibration of SMOS Observations and Validation of SMOS and SAR-Based Soil Moisture Products in China

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An important land surface state controlling interactions between the land surface and atmosphere is soil moisture (Koster et al. 2004, Shukla and Mintz 1982). Being highly variable in both space and time, it is not feasible to base large-scale soil moisture monitoring on in-situ measurements. Various remote sensing techniques have, therefore, been explored for their potential of monitoring soil moisture (e.g. Dubois et al. 1995, Jackson et al. 1999, Wagner and Scipal 2000, Su et al. 2003). Low frequency (1.4 GHz) microwave instruments have been found superior for retrieving soil moisture. As a result, missions carrying L-band microwave sensors have been proposed to space agencies for this purpose.

In 2009, the European Space Agency (ESA) launched the first soil moisture satellite called the Soil Moisture and Ocean Salinity (SMOS, Kerr et al. 2001) mission. SMOS' main payload consists of an innovative 2D-inferometric radiometer, which enables global soil moisture monitoring at a 40 km spatial resolution every 1-2 days. The backbone for processing the SMOS's brightness temperature observations to its global soil moisture products is the L-band Microwave Emission model of the Biosphere (Wigneron et al. 2007).

Parallel to the coarse resolution mapping with SMOS L-band radiometer, the Synthetic Aperture Radar (SAR) technique has also been widely investigated for its potential of monitoring soil moisture. Most recent SAR missions, of interest to the soil moisture community, are the Advanced SAR (ASAR) onboard ESA Environmental Satellite (EnviSat) and the Phased Array type L-band SAR (PALSAR) by the Japan Aerospace Exploration Agency (JAXA). Some capability of ASAR data (C-band) in retrieving soil moisture, in spite of the negative effects of surface roughness and vegetation, has been reported by Paloscia et al. (2008, 2010 and 2011) and Van der Velde et al. (Accepted for publication). The use of an inversion algorithm based on a Neural Network method revealed to be a suitable approach for the retrieval of soil moisture maps at different spatial scales.

Continuation of both ESA's and JAXA's SAR programmes are secured via the Sentinel-1 SAR as ESA's contribution to the Global Monitoring for Environment and Security (GMES) programme, and PALSAR-2 as a part JAXA's Advanced Land Observation Satellite (ALOS)-2. Both missions were expected to be launched in 2013 and, with their improved temporal resolution, will open new opportunities for an operational SAR-based soil moisture product. Candidate algorithms are the ones mentioned above.

However, inherent to any algorithm are uncertainties. For the quantification and remediation of these uncertainties in SMOS and SAR-based soil moisture products regional soil moisture measuring networks have been established around the world (e.g. Jackson et al. 2010). Two of these initiatives have focused on the Tibetan Plateau and Taklamakhan. Su et al. (2011) describe a Plateau-scale soil moisture/temperature observatory consisting of three regional soil moisture calibration/validation sites. Each site holds a network of at least 20 stations and data records starting from 2006, 2008 and 2010 for the three sites, respectively. Similarly, a comprehensive soil moisture/temperature network has been installed in the Taklamakhan desert. The latter network is also equipped with ground instrumentation for measuring the L-band brightness temperatures

For this project, we will use these data sets to validate the SMOS and our experimental SAR soil moisture products from ASAR, Sentinel-1 and PALSAR-2. Via this analysis we specifically target to reduce soil moisture retrieval uncertainties related to surface roughness and vegetation effects. The discrete scatter modelling suite developed at the Tor Vergata University in Rome (Bracaglia et al. 1995) will be utilize as a theoretical reference and for the advanced interpretation of the observations.

中国区域SMOS观测校正和基于SMOS和ASAR土壤湿度产品的验证

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土壤湿度是控制陆-气相互作用一个重要变量（Koster等 2004，Shukla and Mintz 1982）。由于其时空分布差异较大，利用地面观测网进行实时土壤湿度监测是不可行的。因此，各种卫星遥感土壤湿度技术被用于探索监测土壤湿度的潜力（如Dubois等 1995，Jackson 等 1999，Wagner and Scipal 2000，Su等 2003）。低频（1.4GHz）微波仪器被认为有反演土壤湿度的潜力。因此，L波段微波辐射计被做为备选载荷推荐给航天局以实现这个目的。欧空局于2009年发射了土壤湿度和海洋盐度的卫星（SMOS, Kerr等 2001），这是第一颗可用于遥感反演土壤湿度的卫星。SMOS主要荷载为一个二维的干涉辐射计，能够以40公里空间分辨率和1-2天的时间分辨率进行全球土壤湿度监测。将SMOS亮度温度观测值处理为全球土壤湿度产品的关键是发展准确的适合生物圈研究的L波段微波辐射模型(Wigneron等 2007)。

对应于SMOS的L波段辐射计的粗分辨率，合成孔径雷达（SAR）技术被广泛地应用于土壤湿度监测潜力研究。近年来，对土壤湿度工作者最感兴趣的是搭载于欧空局环境卫星上的高级合成孔径雷达（ASAR）和日本宇宙开发署研发的相控阵L波段合成孔径雷达(PALSAR)。尽管Paloscia 等（2008, 2010 and 2011）和Van der Velde等（2012）报道了植被和粗糙度在微波遥感土壤湿度中的负效应，但ASAR数据仍然有反演土壤湿度的能力。一个基于神经网络的反演算法适合反演不同空间分辨率土壤湿度空间分布。

Sentinel-1 SAR是欧空局和日本宇宙开发署SAR计划的后继者，并且作为欧空局全球环境和安全监测计划（GMES）重要贡献，PALSAR-2作为日本宇宙开发署高级地面观测卫星（ALOS）的。这两颗卫星预计2013年发射。借助其改进的时间分辨率，将为生成基于SAR土壤湿度数据业务产品提供新的机会。备选算法为以上提到的土壤湿度反演模型。

然而，任何算法都含有不确定性。为了定量化和纠正基于SMOS和ASAR土壤湿度产品中的不确定性，在全球范围内建立了多个土壤湿度监测网络（Jackson等. 2010）。其中有两个建在青藏高原和塔克拉玛干沙漠。Su等（2011）给出了一个高原尺度土壤湿度/温度观测站网的介绍，该站网由三个区域土壤湿度校正/验证观测场组成。每个观测场至少包含20个观测站点。龙计划3期（编号：10611）数据记录在三个观测场分别起始于2006年、2008年和2010年。同样，一个土壤湿度/温度综合观测网络建在塔克拉玛干沙漠，该网络同样配备了土壤湿度/温度仪器设备观测L波段亮度温度。

通过本项目，我们将利用这些地面观测数据验证SMOS土壤湿度产品和由ASAR、Sentinel-1和PALSAR-2估算的土壤湿度试验产品。我们以减小地表粗糙度和植被对反演土壤湿度的影响为目标，分析这些数据产品。以罗马Tor Vergata大学发展的The discrete scatter modelling suite（Bracaglia等 1995）作为理论参考和对观测数据的解释。