# Application of CMEM model to SMOS data over wetlands in Poland

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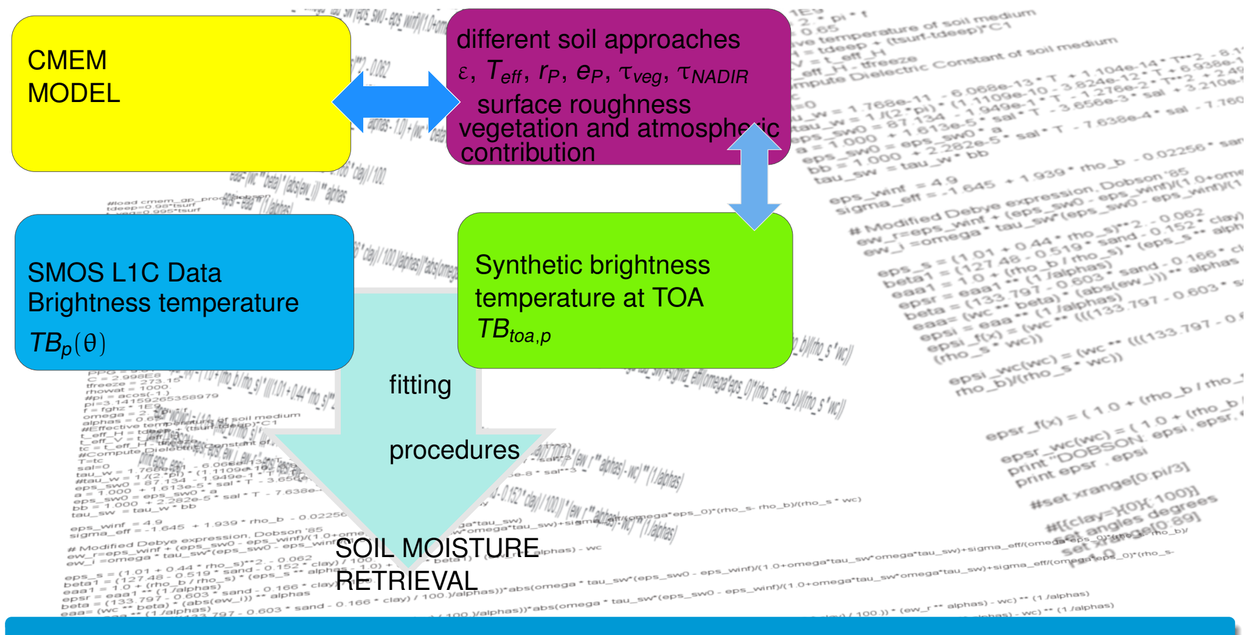
## Introduction

Since the launch of SMOS satellite in November 2009, space-borne passive microwave observations at L-band (1.4 GHz) has become available. SMOS provides global mapping of brightness temperature at wide range of incidence angles, provides data for angular signatures, and is dedicated to provide estimations retrieved from measurements in near-real-time global soil moisture products. Presented work is focused on validating SMOS data to support critical evaluation of the trust to it.

## Objectives and Work Scenario

- In the present studies and approaches to validations, we have undertaken a use of Common Microwave Emission Model (CMEM), elaborated at ECMWF.
- Testing contributions from common vegetation indexes, physical properties and the land coverage, to SMOS data in terms of brightness temperature $T_B$ leads us to the domain of electromagnetic polarization modes, and focus the work on different aspects of data processing, from enormous range of the require data fusion, through large scale requirements, and up to advanced statistical aspects of the work.
- Here, general scenario of conducted work with sample of obtained results is presented.




## Theoretical assumptions

- The modeling approach description is based on Radiative Transfer Equation (RTE) in layered media, with special interest on simplified solution of RTE for vegetation layer - single-scattering layer above rough surface ($\tau - \omega$ approach)
- In general, the observed brightness temperature at the top of the atmosphere $TB_{toa}$ is a function of soil, vegetation, and atmospheric parameters.
- Brightness temperature at the Top Of Atmosphere (toa) $T_{B,toa}$ for polarization $P$:

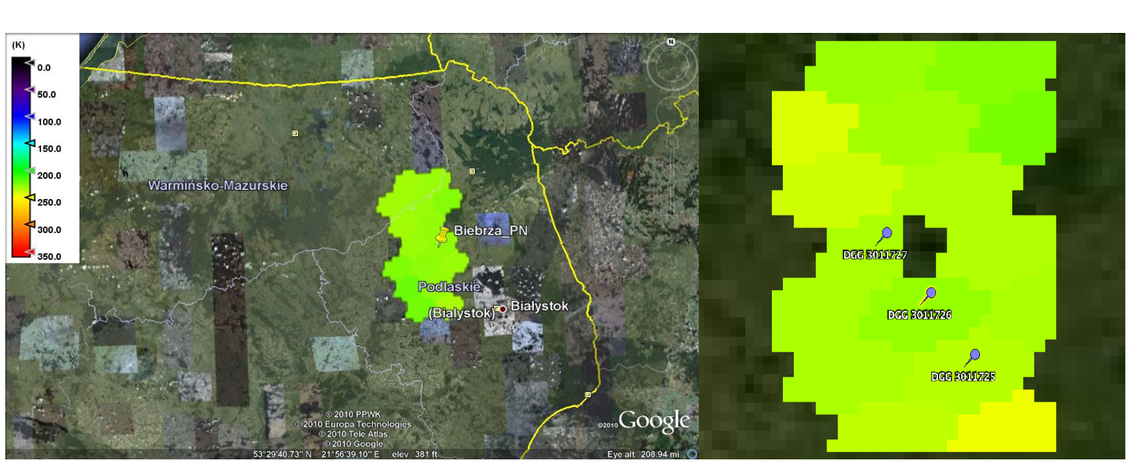
$$T^P_{B,toa} = T^P_{B,au} + \exp(-\tau^P_{atm}) T^P_{B,tov},$$

$$T^P_{B,tov} = T^P_{B,soil} \exp(-\tau^P_{veg}) + T^P_{B,veg}(1 + r^P_r \exp(-\tau^P_{veg})) + T_{B,ad} r^P_r \exp(-2\tau^P_{veg})$$

where $T_{B,au}$ and $T_{B,ad}$ are the up- and down-welling atmospheric brightness temperature; $\tau_{atm}$ means the atmospheric opacity; $\tau_{veg}$ means the vegetation optical depth; $T_{B,soil}$, $T_{B,veg}$ are the soil and vegetation layer contributions; $r^P_r$ is the surface reflectivity.

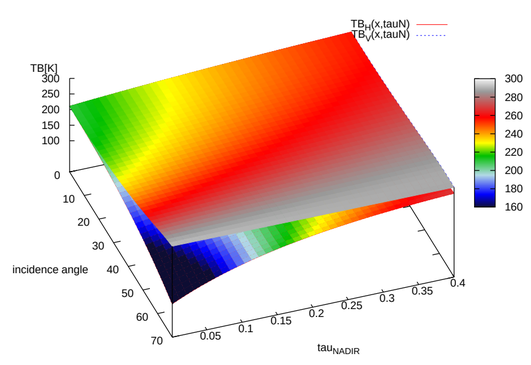
- CMEM provides modular representation of each layer component. CMEM modularity allows considering different parametrization of the soil dielectric constant as well as different soil approaches (either coherent of incoherent) and different effective temperature, roughness, vegetation and atmospheric contribution opacity models.
- results obtained in this work are based on following modular settings: soil dielectric mixing model - *Dobson model*, effective temperature model - *Wigneron*, soil roughness model - *Wigneron*, smooth surface emissivity model - *Fresnel*

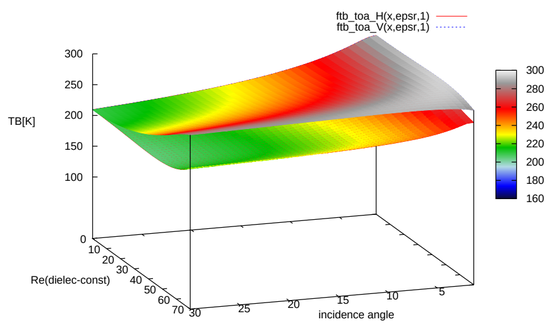
## Test site area

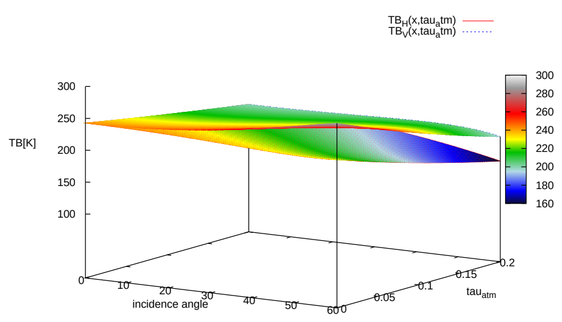


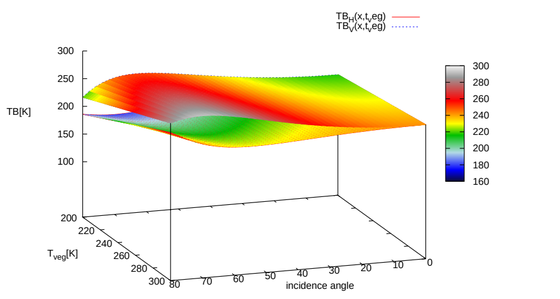

- Biebrza wetland is one of the examples of areas selected for SMOS Cal/Val campaigns over territory of Poland and belongs to the group of the largest wetland ecosystems in Europe.
- In the following studies, data from three DGG points along one profile are considered (ID 3011725,ID 3011726,ID 3011727), for SMOS L1C data: **SM_OPER_MIR_SCLF1C_20100516T025353_20100516T034755_330_003, SM_OPER_MIR_SCLF1C_20100608T025819_20100608T035218_330_003**

## Simulations of brightness temperature $T_{B,p}$ - sensitivity to different parametrization and incidence angle



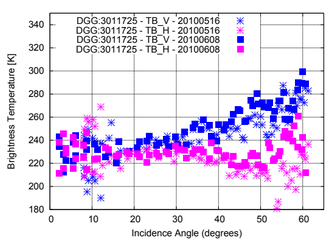



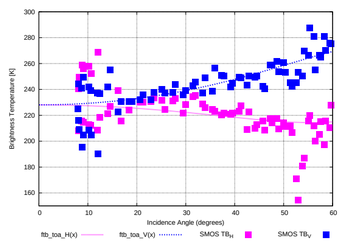



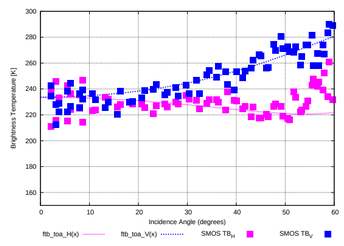



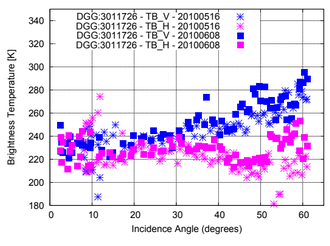

## Results - SMOS $T_{B_{H,V}}$ and Synthetic $T_{B_{H,V}}$ - Retrieved parameters

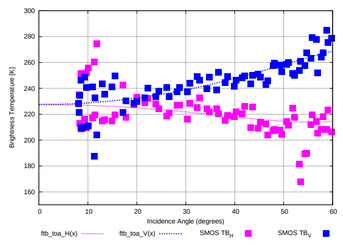
Temporal evolution | $16^{th}$ of May 2010 | $8^{th}$ of June 2010

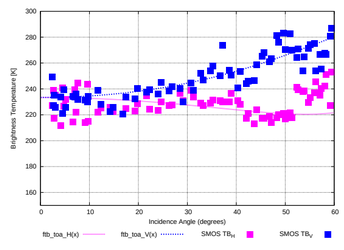


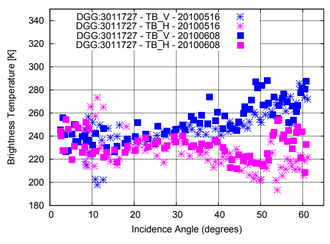



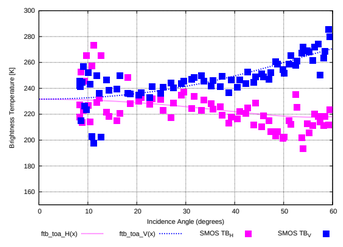



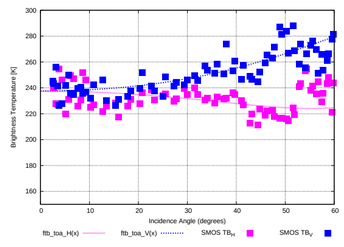



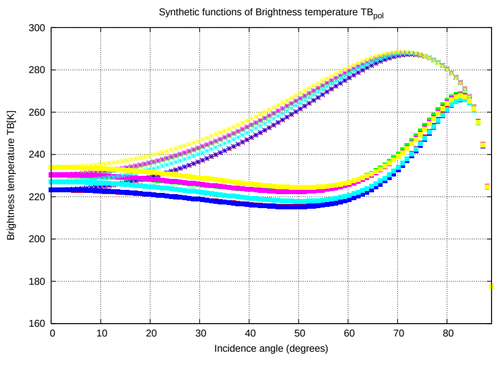




**Retrieved parameters**

| DGG | SM $[m^3m^{-3}]$ | $\sigma(SM)$ | $\tau_N$ | $\sigma(\tau_N)$ |
|---|---|---|---|---|
| 11725 | 0.200415 | 0.006 | 0.225598 | 0.008 |
| 11725 | 0.207465 | 0.005 | 0.217699 | 0.006 |
| 11726 | 0.200979 | 0.004 | 0.226037 | 0.006 |
| 11726 | 0.207264 | 0.005 | 0.218311 | 0.006 |
| 11727 | 0.196196 | 0.004 | 0.227139 | 0.005 |
| 11727 | 0.199295 | 0.004 | 0.222601 | 0.005 |

## Summary

- Errors of presented retrived parameters are not greater than 4 %.
- Results of fitted synthetic functions $TB_p$ to measurements obtained by SMOS satellite are satisfactory, however obtained values are greater than assumed.

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