Influence of surface heterogeneity on L-band (1.4 GHz) measurements at various spatial resolutions; some preliminary results of the CoSMOS/NAFE'05 field campaign

Grant, J.P.[1,2], Van de Griend, A.A.[1], Wigneron, J.-P.[2], Walker, J.P.[3], Kalma, J.[4], Saleh, K.[2], Panciera, R.[3]

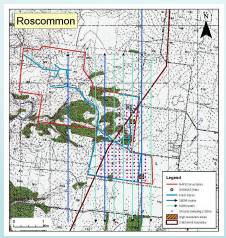
[1]Vrije Universiteit Amsterdam, Dept. of Hydrology & Geo-Environmental Sciences, De Boelelaan 1085, 1081 HV, Amsterdam, The Netherlands. Tel: +31 (0) 20 5987276; Fax: +31 (0) 20 6462457; Email: jennifer.grant@falw.vu.nl
[2]INRA Ephyse, Bordeaux, France; [3]Dept. of Civil and Environmental Engineering, University of Melbourne, VIC, Australia;
[4]School of Engineering, University of Newcastle, NSW, Australia

BACKGROUND:

In order to understand the influence of forested areas on the soil moisture retrieval of inhomogeneous pixels, further research is necessary, especially based on experimental data. Almost all existing knowledge of this subject at the moment is based on modelling studies and represents rather optimistic cases in terms of retrieval and error. In these studies (e.g. Van de Griend *et al.*, 2004) it was concluded that ignoring the *a priori* knowledge of the forest cover fraction (α) gives large errors in soil moisture retrieval if α ≥ 10%, but if α is known and ≤ 50%, soil moisture in the non-forested area can be determined with a precision better than 4%. Results of the CoSMOS/NAFE'05 field campaign will be used to validate these findings, and to try to improve data analysis for mixed vegetation pixels.
This work is part of the project 'Disaggregation of SMOS data at the catchment scale and assimilation into distributed hydrological model' – CNES, France.

OBJECTIVE:

To compare modeled values of emissivity with airborne measurements over heterogeneous tree-covered areas, in order to give an idea of the influence of vegetation heterogeneity by showing errors in emissivity for different % cover situations.



Flight lines above Roscommon farm

SITE: 'Roscommon' farm:

Vegetation:
Mix of native grassland and forest
Open-forest formation: Box, Ironbark & Black Cypress-pine.
Open-heath understory: Sifton bush

Sandy soils, high % rock cover

Litter:
average layer height 0.5 cm
average dry bulk density 0.15 ± 0.05 g/cm^3

MATERIALS:

L-band dual-polarized radiometers:
- EMIRAD: simultaneous measurements at 0° & 40° (~800m resolution)
- PLMR: measurements at high (~62.5m) & medium (~250m) resolution

Models:
- Wang-Schmugge dielectric model
- L-MEB (L-band Microwave Emission of the Biosphere, Wigneron *et al.*, 2006), based on 'tau-omega' model:

$$TB_P = e_s T_s \gamma_P + (1-\omega_P)(1-\gamma_P)Tv + (1-\omega_P)(1-e_s)Tv(1-\gamma_P)\gamma_P$$

Ground measurements:
- Soil moisture & temperature (top 5 cm) - Hydraprobe
- Litter moisture - grab samples
- LAI - fish-eye photographs
- Temperatures of a tree (canopy, trunk) and soil (0, -2, -4 and -50 cm)

METHODOLOGY:

Wet & dry day chosen for preliminary analysis (8th and 22nd Nov.)

From grid over topographical map, cells with 100%, 75%, 50%, 25% and 0% forest cover were selected (N=15)

For each grid cell emissivity was calculated with
error = (measured – expected)

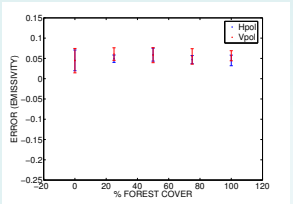
For each % forest cover, results are presented as mean error ± st.dev.

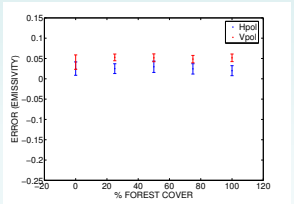
omega=0.1 (default value ATBD (ESA, 2006))
Tsoil at -2 cm
Tcan from tree temp measurements
tau = either 0.24 or 0.5 (default values ATBD for grass & forest)

Assumptions:
- no *a priori* knowledge of surface cover
- uniform soil moisture

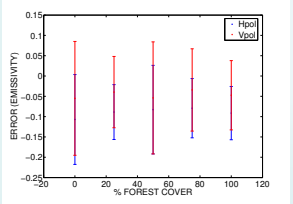
RESULTS:

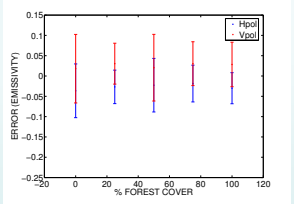
dry conditions:





wet conditions:





tau = 0.5 tau = 0.24

DISCUSSION:

Expected from the literature (Van de Griend *et al.*, 2003):
(1) larger mean error for mixed pixels
(2) larger standard deviation for wet soils (smaller soil contribution -> sensitivity to ground characteristics weaker)
(3) errors have general order of magnitude 0-0.06

- (1) only found (slightly) for dry conditions
- (2) clearly seen in results
- (3) similar order of magnitude

Further analysis:
- also with *a priori* knowledge of cover fraction
- effect of litter layer
- optimize more realistic values of tau from EMIRAD dual-angle data

References:
- Van de Griend *et al.* (2003), 'Consequences of Surface Heterogeneity for Parameter Retrieval from 1.4 GHz Multiangle SMOS Observations; *IEEE Transactions on Geoscience and Remote Sensing*, vol. 41 (4)
- Van de Griend *et al.* (2004), 'Soil Moisture Retrieval from Heterogeneous Surfaces by 1.4 GHz Multi-Angle SMOS Observations using 'A Priori Knowledge' of Surface Cover Fractions, *IGARSS 2004*
- J-P Wigneron *et al.* (2006), 'L-band Microwave Emission of the Biosphere (L-MEB) Model: Results from calibration against experimental data sets over crop fields'; *to be submitted*
- ESA (2006), Algorithm Theoretical Based Document (ATBD), SMOS level 2 processor for soil moisture

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