SMOSREX: A Long Term Field Campaign Experiment for Soil Moisture and Land Surface Processes Remote Sensing

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- Introduction: SMOSREX several-year experiment
- Observing results at various temporal scales
- Investigations in passive microwave radiometry

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1. Introduction: SMOSREX experiment

Context:

SMOS: Satellite project (2007) for Global Soil Moisture and Ocean Salinity

SMOSREX: Surface Monitoring Of Soil Reservoir EXperiment

Part of PIRRENE programme (http://wwwe.onecert.fr/pirrene/)

Objectives:

- Development of L-Band direct and inverse algorithms.
- Use of soil moisture remote sensing in soil plant atmosphere interactions studies.

Use of different tools:

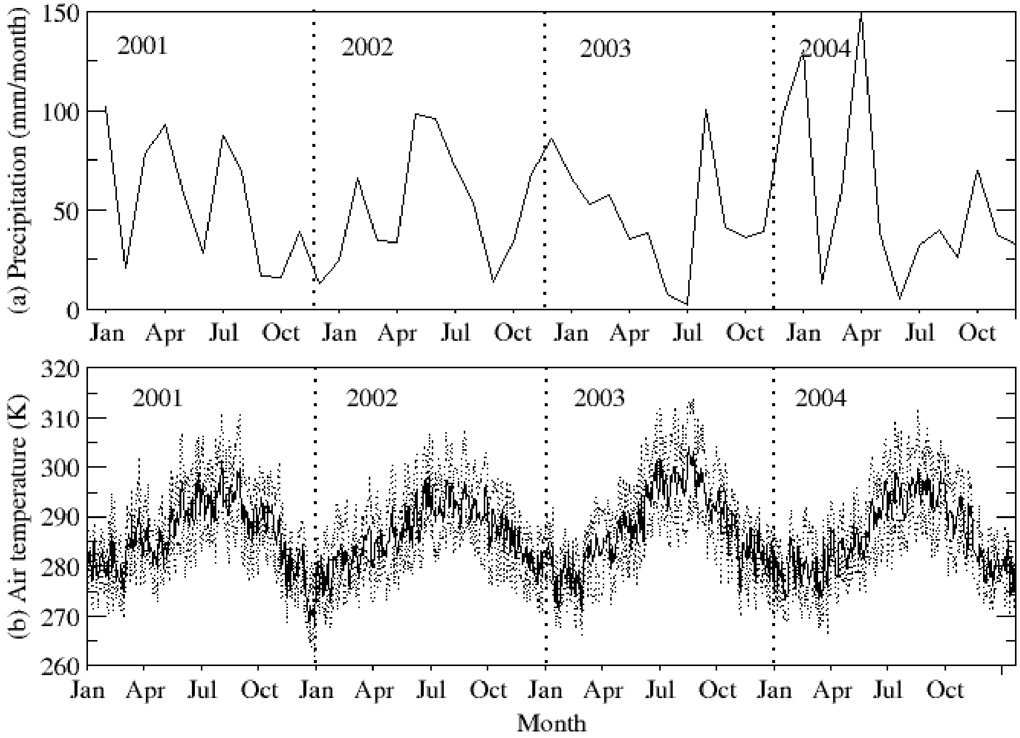
- Multi frequency remote sensing (L-Band, TIR, IR, VIS)
- Field measurements (ground, meteo, vegetation)
- Radiative transfer models and land surface models

Long term field experiment 3 years with remote sensing (2003-2005).

Experimental site

ONERA (Fauga-Mauzac, $43^o23'N$, $1^o17'E$, at 188m height), located in **South-West of France**

Meteorological measurements 2001-2004:
Cumulative precipitation respectively: 621, 677, 574, 634 mm



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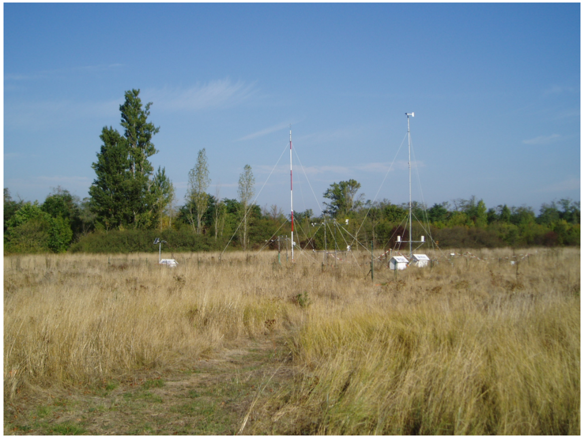
Ground measurements

Meteorological station:

automatic and continuous acquisition (with a 30 min time step) of precipitation, air temperature at 2m, surface fluxes (H/LE), radiative fluxes (solar and infrared), wind speed and direction, dew, air pressure



Soil moisture profiles:

Delta T device probe at 0-5cm (x4), 10cm (x3), 20cm (x3), 30cm (x2), 40cm (x2), 50cm (x2), 60cm (x2), 70cm, 80cm, 90cm.

Soil temperature profiles:

PT100 at 1cm, 5cm, 20cm 50cm and 90 cm

Manual measurements: soil density, soil roughness, soil texture, gravimetric soil moisture, biomass, LAI

CESBIO

INRA
Institut National de la Recherche Agronomique

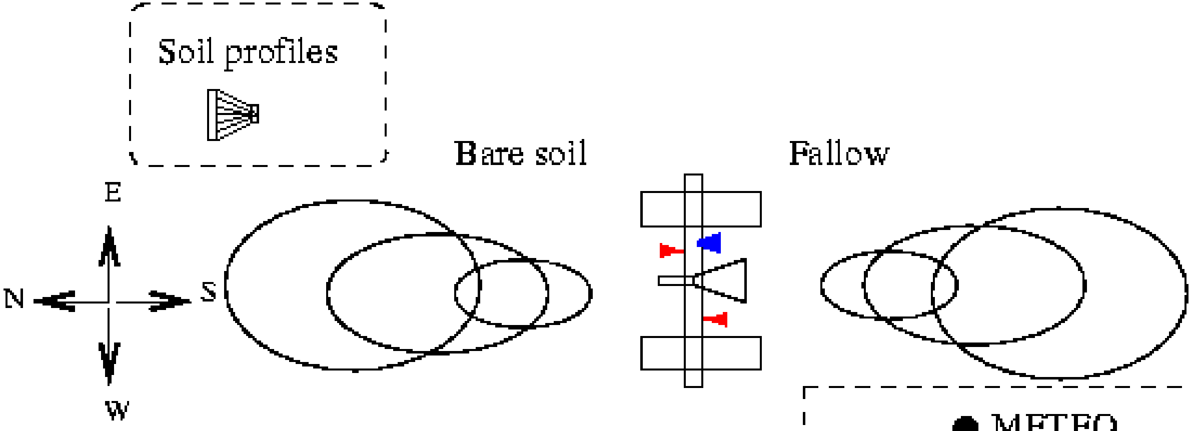
ONERA

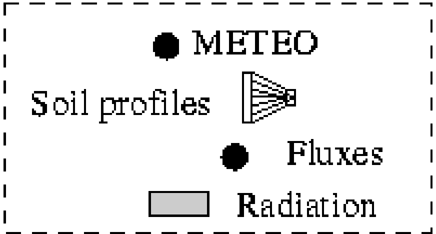
METEO FRANCE

SMOSREX:

Multi frequency acquisition

- TIR Pyrometers (KT15): at 40° incidence
- VIS to IR Luminancemeter (Cimel) 5–band: 837(91), 648(53), 549(85), 450(40), 1640(165) nm
- LEWIS: L–band (1.4GHz) L–band radiometer for Estimating Water In Soils





Scanning mode 8 time per day allows LEWIS to monitore Tb on both fallow and bare soil. at 6 incidence angles from 20 to 60°

2. Observing results 2003-2005

LEWIS radiometer measures the surface brightness temperature, T_b at both v and h polarizations:

$$T_{bv} = e_v T_{eff}$$

and

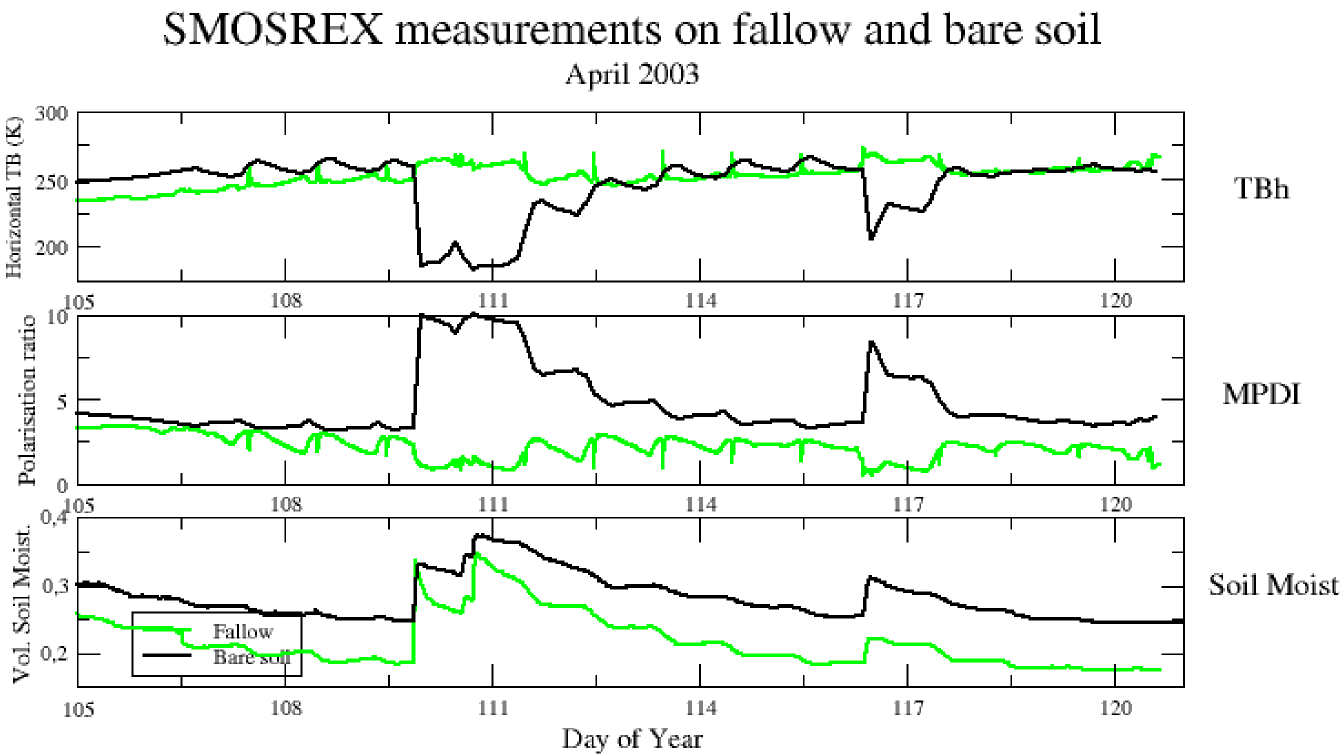
$$T_{bh} = e_h T_{eff}$$

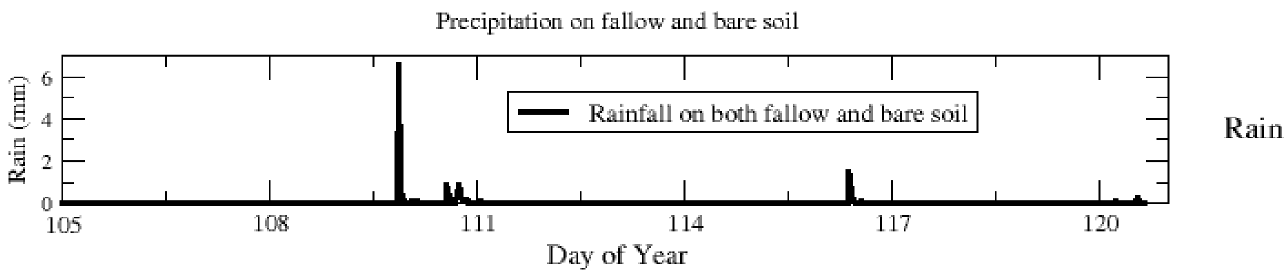
where T_b and e are the brightness temperature and emissivity.

In order to remove the dependency on surface temperature we use the Microwave Polarization Difference Index, $MPDI$ (or Polarization Ratio):

$$MPDI = \frac{T_{bv} - T_{bh}}{T_{bv} + T_{bh}} \quad (1)$$

Rain effect - April 2003





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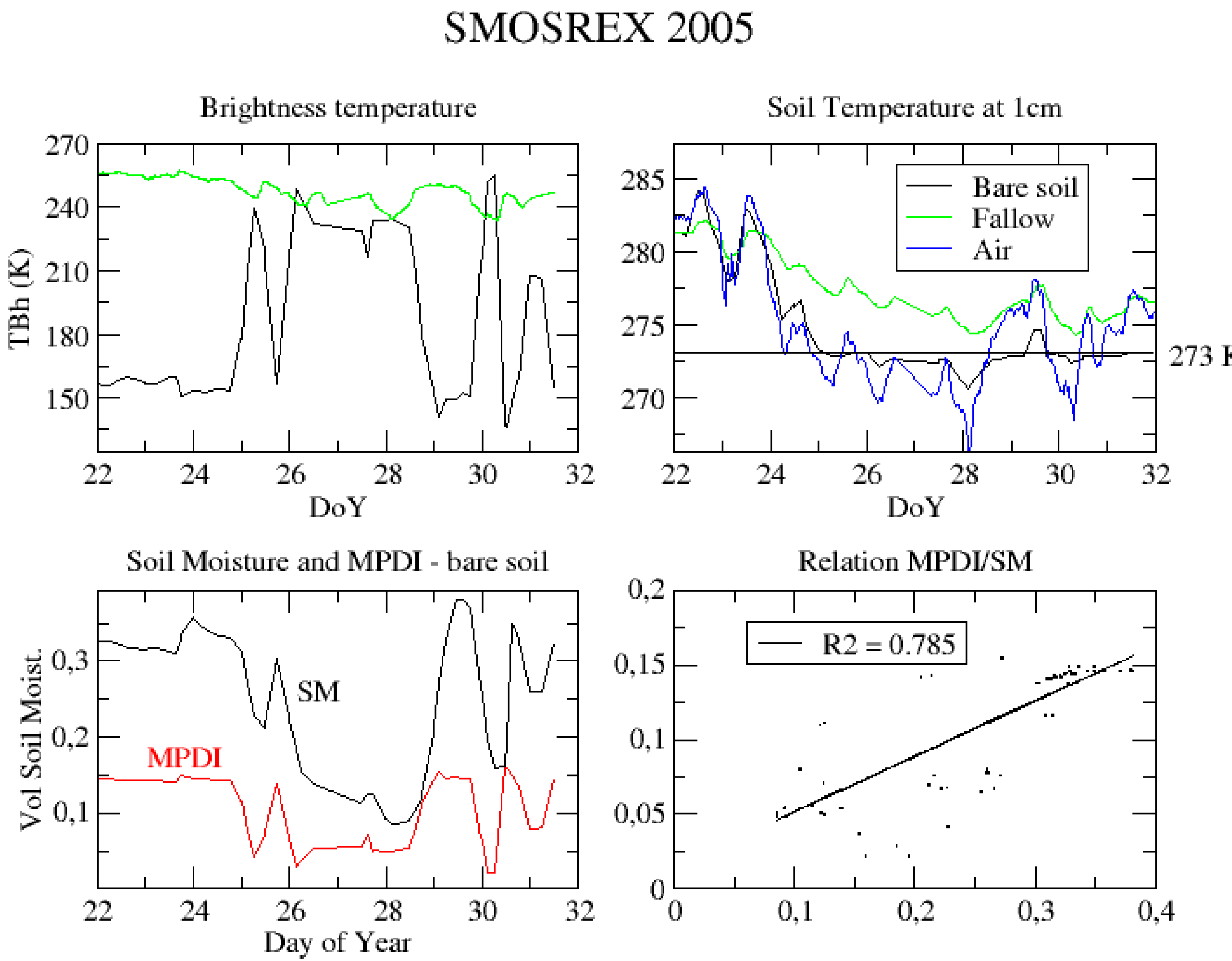
Soil freezing January 2005



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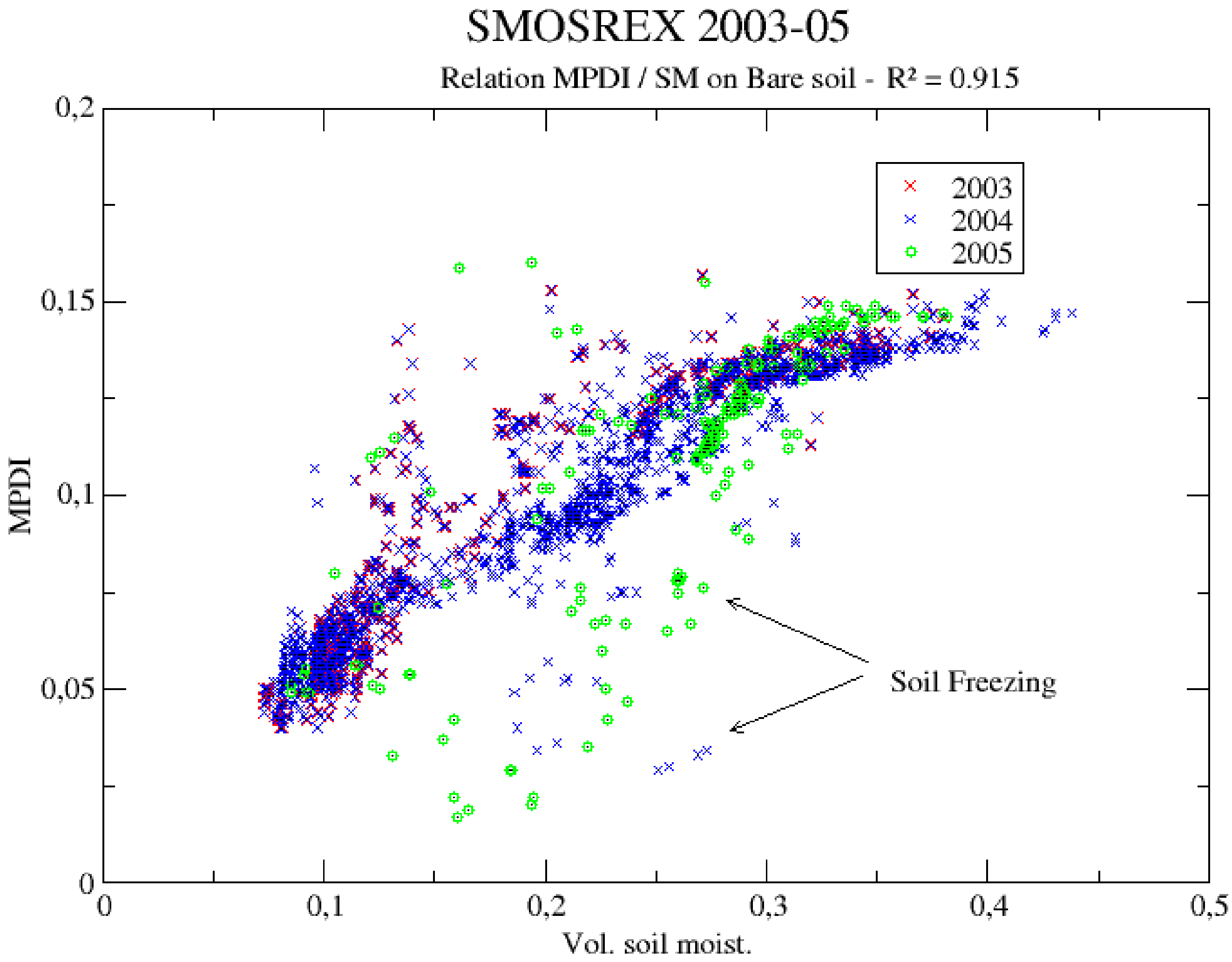
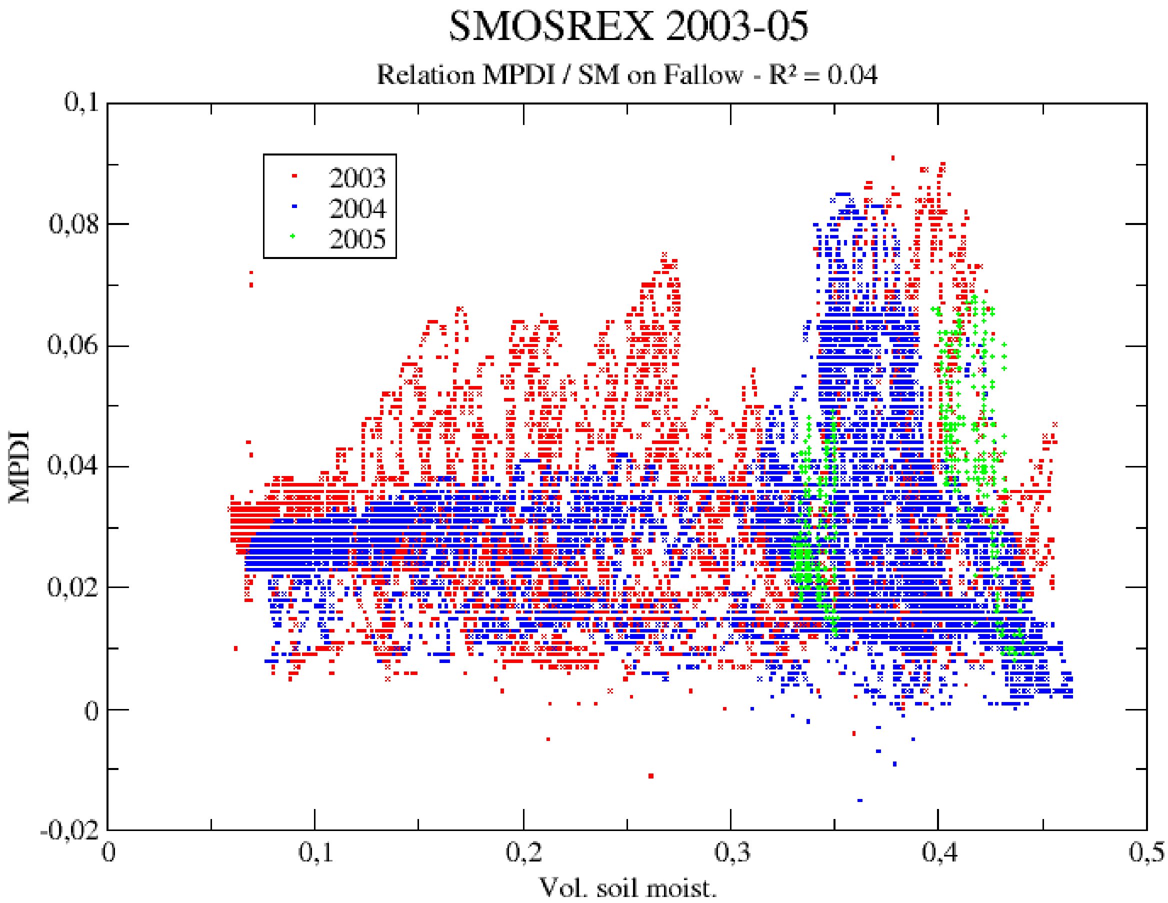
Relation MPDI at 40^o / soil moisture on bare soil



Stable relation over long time scales including several soil density and roughness modifications.

Relation MPDI 40 ^{o} / soil moisture on fallow



Standing vegetation and litter intercept and absorb large amount of precipitation. Soil emission significantly attenuated and vegetation emission increases ⇒ Need to detect periods of possible retrieval.

3. Large range of investigations in microwave radiometry

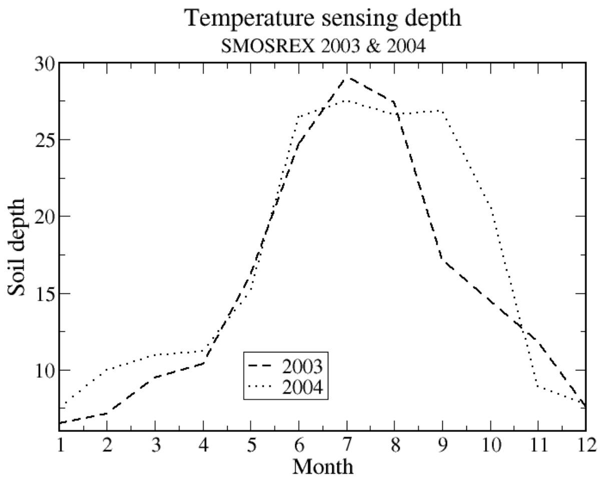
- Long term feature and parameterization of effective temperature
- Bare soil roughness
- Effect of intercepted water by vegetation and litter on the signal
- Multi-spectral assimilation in land surface models

All of these investigation are critical to address the soil moisture retrieval from passive microwave radiometry

3.1. Effective temperature and soil roughness

The T_{eff} relates T_b to the emissivity (e): $e = T_b/T_{eff}$

Temperature sensing depth: the top thickness of the profile below which the radiated energy is divided by a factor $exp(1)$.
Temperature sensing depth is larger when soil is getting dry.



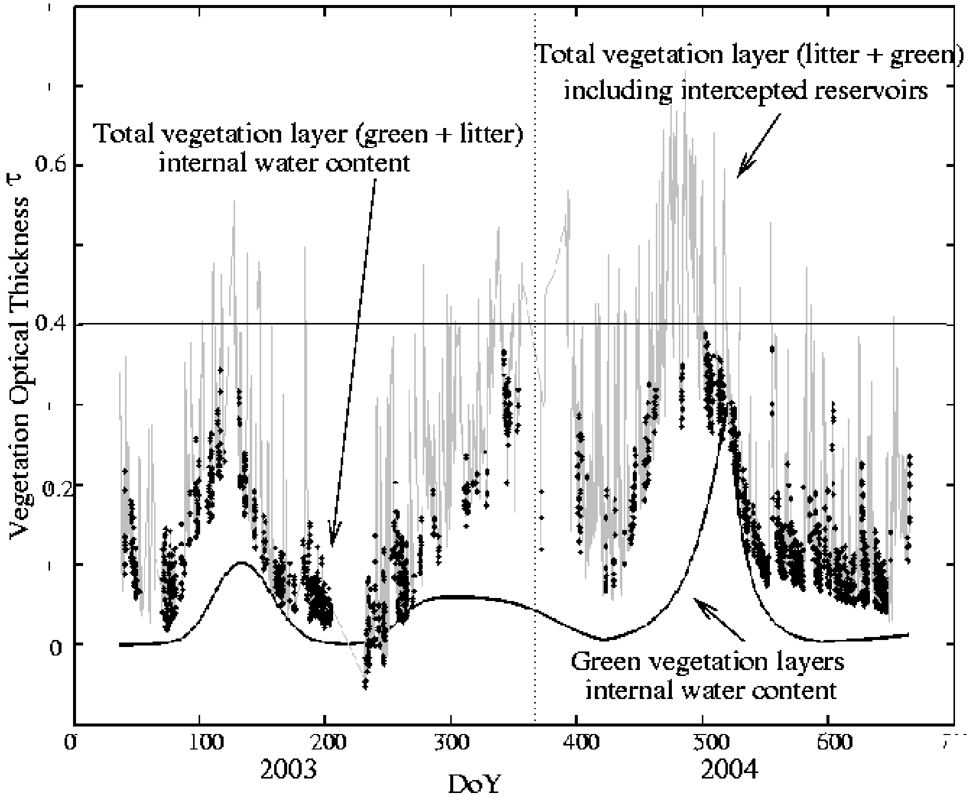
For bare soil, strong annual cycle of the penetration depth, down to 30cm.

Long term data set ⇒:

New parameterization of effective temperature: Holmes et al., 2005
Soil dielectric roughness increases with the penetration depth: Escorihuela et al., 2005

3.2. Effect of intercepted water on the signal

Modeling approach (LMEB) and long term data set allow to separate the different contributions of the vegetation reservoirs to the vegetation optical thickness.



⇒ Important part of the signal due to litter water content and intercepted water

Saleh et al. 2005

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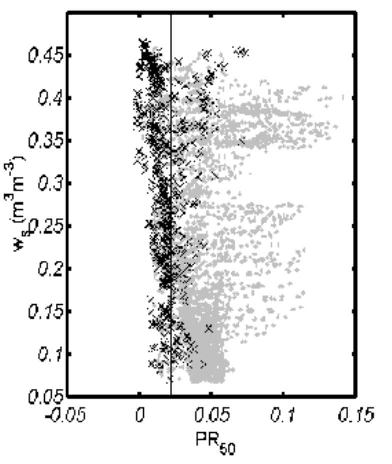
Effect of intercepted water on the signal

On fallow plot: rain ⇒ TBv-TBh decreases ⇒ MPDI decreases.



Interception flag MPDI< 0.02

	Rain - 12h	No Rain -12h	Total
MPDI< 0.02	14.6	2.5	17.1
MPDI> 0.02	12.9	70.0	82.9
Total	27.5	72.5	100.0

- Direct approach: effect of rain on the signal
  Rain in the last 12h ⇒ MPDI< 0.02 in 53%
  No rain ⇒ MPDI> 0.02 in 97%
- Inverse approach: detection of periods with intercepted water
  MPDI< 0.02, ⇒ rain in the last 12h in 85% of the cases
  MPDI> 0.02, ⇒ no rain in the last 12h in 84% of the cases

Saleh et al. 2005

4. Conclusions

- SMOSREX: for the preparation of SMOS mission, long term data set of L-band temperature as well as ground measurements and multi-spectral remote sensing on both natural fallow and bare soil.
- Long term features of the microwave emission in various conditions allows to address the following issues, critical for soil moisture retrieval:
  - penetration depth and related modification of soil dielectric roughness
  - Very strong effect of intercepted water on vegetation and litter on the microwave emission and consequence for soil moisture retrieval
  - definition of interception flags from multi-angular and bi-polarized signal, suitable to define periods of possible soil moisture retrieval.
- Open news investigations in land surface processes modeling and multi-frequency assimilation in land surface schemes
  - necessity to improve the modeling of the litter microwave emission.
  - interception flags for other vegetation types and up-scaling to satellite pixel size.

L band radiometry

LEWIS L-band radiometer for Estimating Water In Soils

- Cornet Antenna
- 1.4 GHz,
- H and V Polarizations
- Beamwidth 13.5 ^{o}
- 3m long, 200kg
- Thermal regulation: 47.20 ^{o}C
- No rear lobe
- Automatic scanning mode

Informations:

PIRRENE: http://wwwe.onecert.fr/pirrene/

SMOS & SMOSREX: http://www.cesbio.ups-tlse.fr/us/indexsmos.html