Validation of satellite soil moisture products over southwestern France using model simulations and in-situ data

J.-C. Calvet, C. Albergel, J.-F. Mahfouf (CNRM)

C. Rüdiger, J. Walker (U. Melbourne)

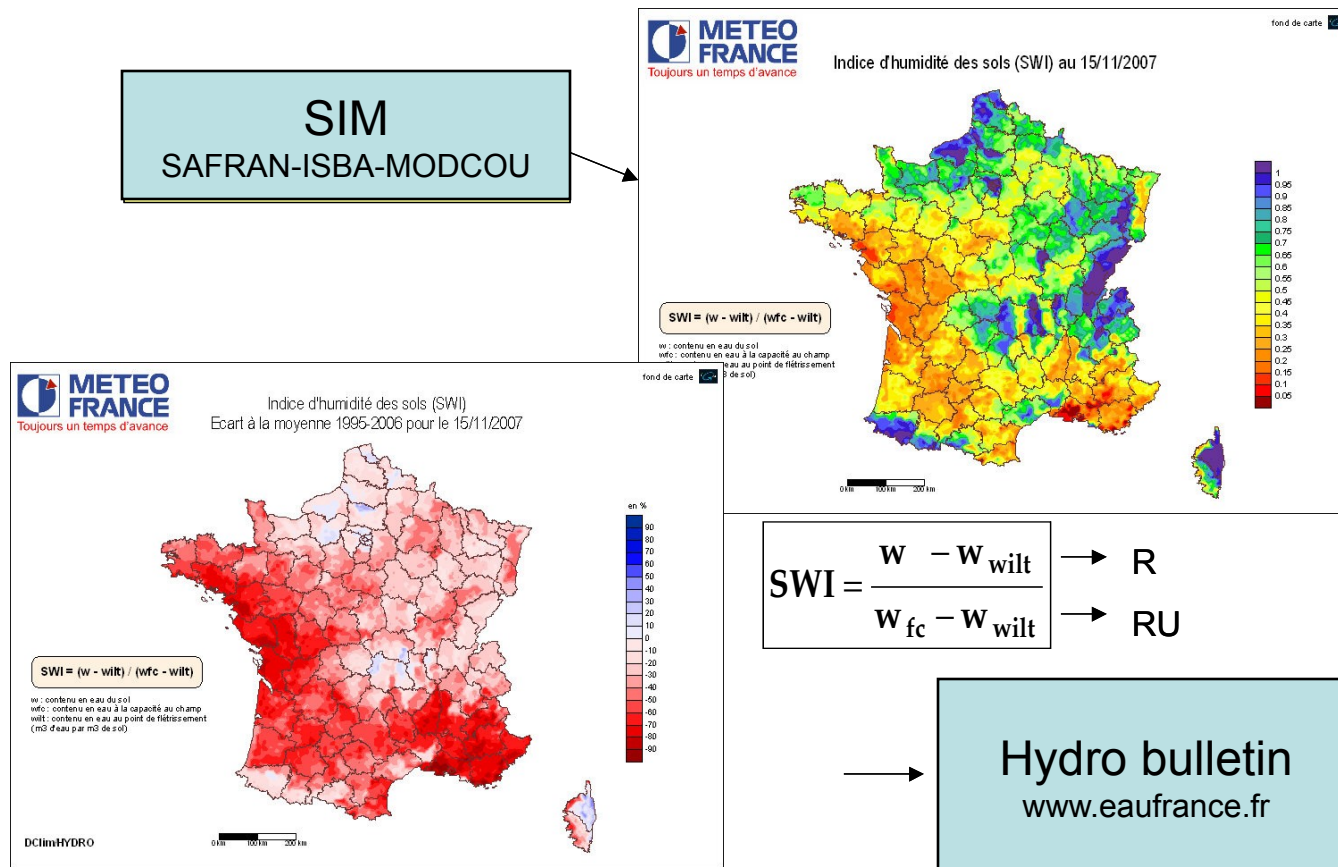J.-P. Wigneron, A. Chanzy (INRA)

Y. Kerr (CESBIO)

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Soil moisture products over SW France

Objective: monitoring land

- NWP, hydrological, environmental applications
- Assess the vulnerability to climate change
- Monitor the weather, seasonal, interannual variability of
  - Surface fluxes (water, carbon)
  - Soil moisture, vegetation biomass
  - Droughts
  - Drainage, surface runoff, snow, wetlands, …
- Build
  - A Land Data Assimilation System able to integrate EO data, in situ data, land surface models, land cover maps, carbon & water cycles
  - A climatology of LAI, soil moisture, water and carbon fluxes
 - NRT capacity

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Soil moisture products over SW France

Operational soil moisture monitoring over France

SIM
SAFRAN-ISBA-MODCOU

$$SWI = \frac{w - w_{wilt}}{w_{fc} - w_{wilt}} \begin{array}{l} \longrightarrow R \\ \longrightarrow RU \end{array}$$

Hydro bulletin
www.eaufrance.fr

Soil moisture products over SW France

NRT EO data: example of EUMETSAT SSM (ASCAT)

ASCAT Surface Soil Moisture Anomalies

Surface Soil
Moisture Anomaly (%)
>35
0
< −35

Date: 15-21 March 2007
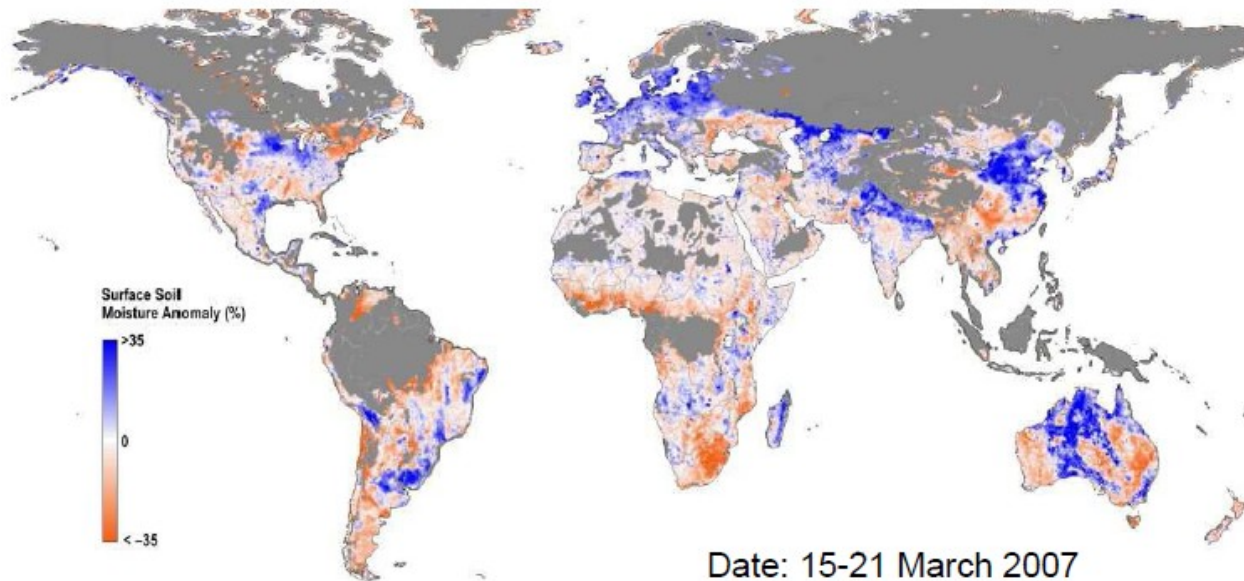
Bartalis et al. (2007) Geophysical Research Letters

Vienna University of Technology
Institute of Photogrammetry and Remote Sensing

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Reprocessed microwave EO data

– WACMOS ESA Strategic Action, Soil moisture component (VUA, TU Wien)
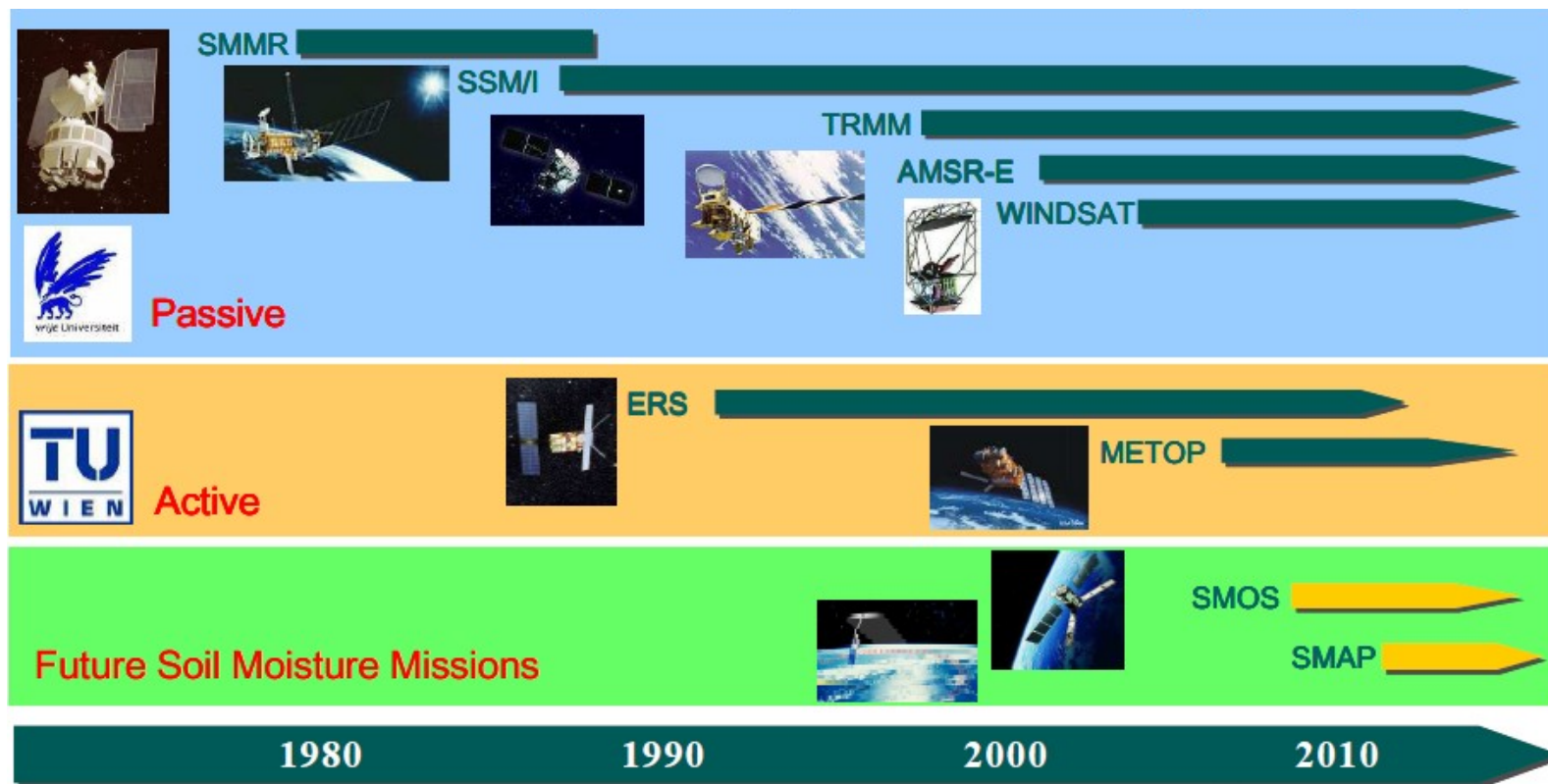
Soil moisture products over SW France

Tools

- SURFEX modelling platform
- ISBA-A-gs land surface model
  - CO_2-responsive
  - Simulates soil moisture and LAI
- Assimilation of EO data: LDAS
  - EKF
  - Soil moisture
  - LAI
- In situ soil moisture observations
  - SMOSMANIA network

Soil moisture products over SW France
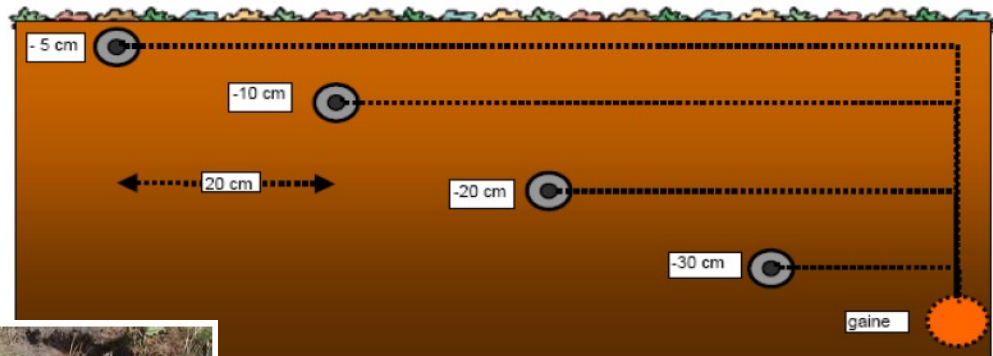
Land data assimilation system
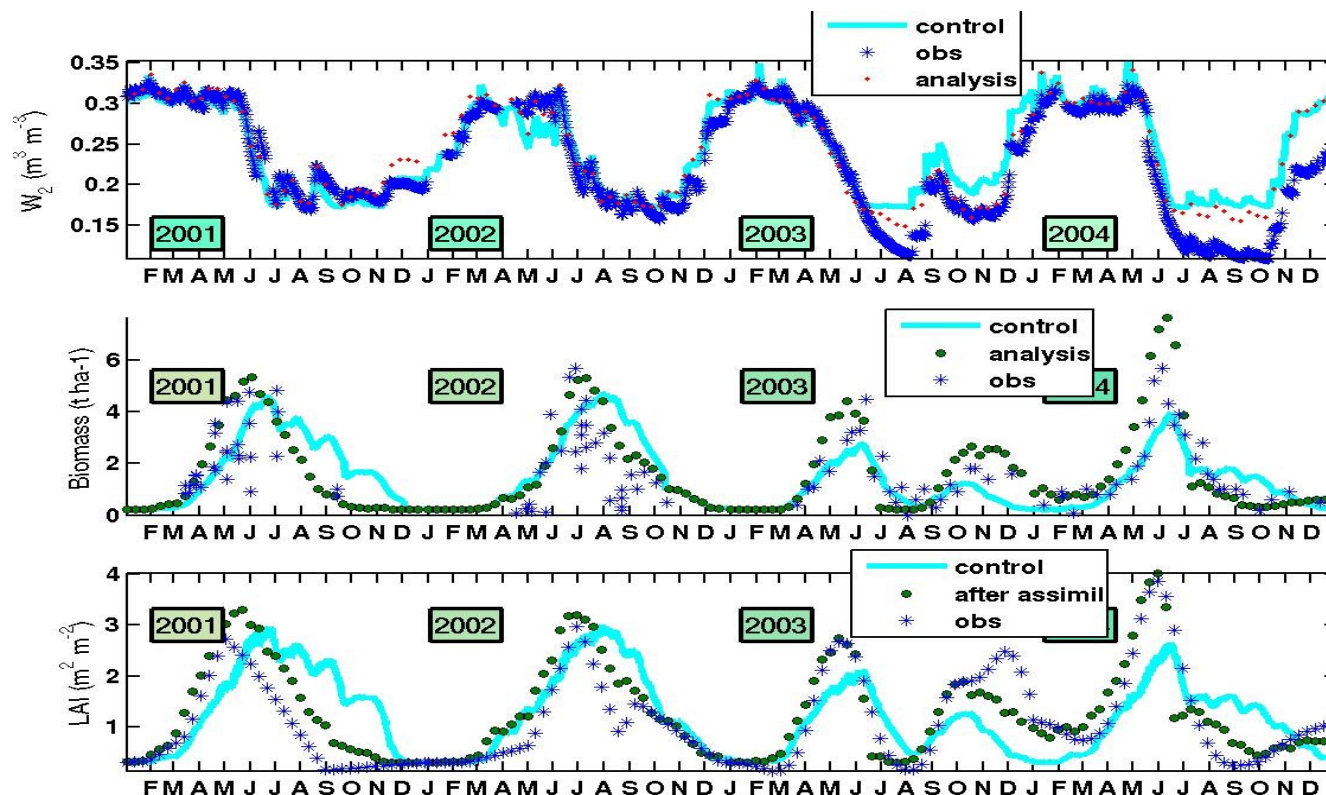
Assimilation of LAI and surface soil moisture observations over the SMOSREX site
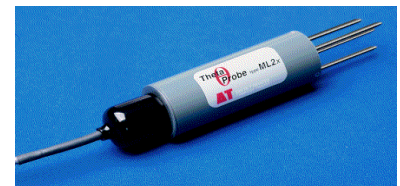
Sabater et al. 2007, 2008

Soil moisture products over SW France

Soil moisture networks: SMOSMANIA

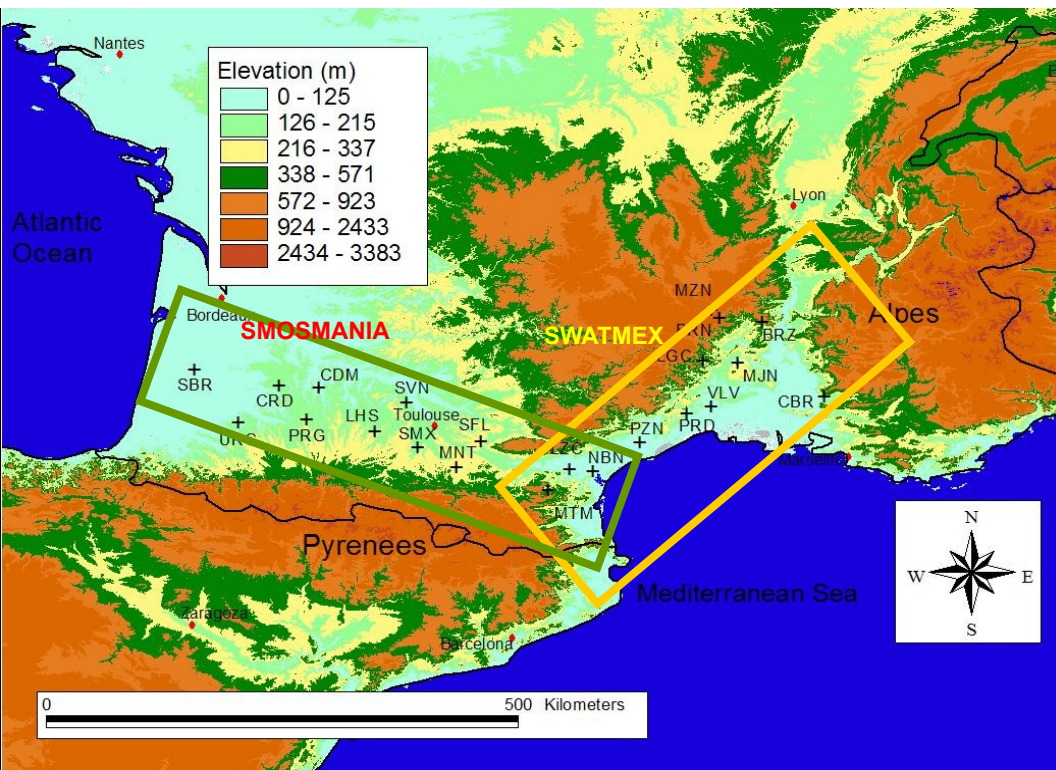– ThetaProbe profile (5, 10, 20, 30 cm)

ThetaProbe ML2X

Soil moisture products over SW France

Soil moisture networks: SMOSMANIA

- SMOSREX long-term observations (CNRM, CESBIO, INRA, ONERA)
- SMOSMANIA extended to Mediterranean areas

SMOSMANIA	SWATMEX
NARBONNE	NARBONNE
LEZIGNAN CORBIERES	LEZIGNAN CORBIERES
MOUTHOUMET	MOUTHOUMET
SAINT FELIX DE LAURAGAIS	PEZENAS
MONTAUT	PRADES LE LEZ
SAVENES	LA GRAND COMBE
LAHAS	MAZAN L'ABBAYE
CONDOM	VILLEVIEILLE
PEYRUSSE GRANDE	BARNAS
CREON D'ARMAGNAC	MEJANNES LE CLAP
URGONS	BERZEME
SABRES	CABRIERES D'AVIGNON

Soil moisture products over SW France

Soil moisture networks: SMOSMANIA

– Soil moisture at 5cm, 12 stations, 2007-2008
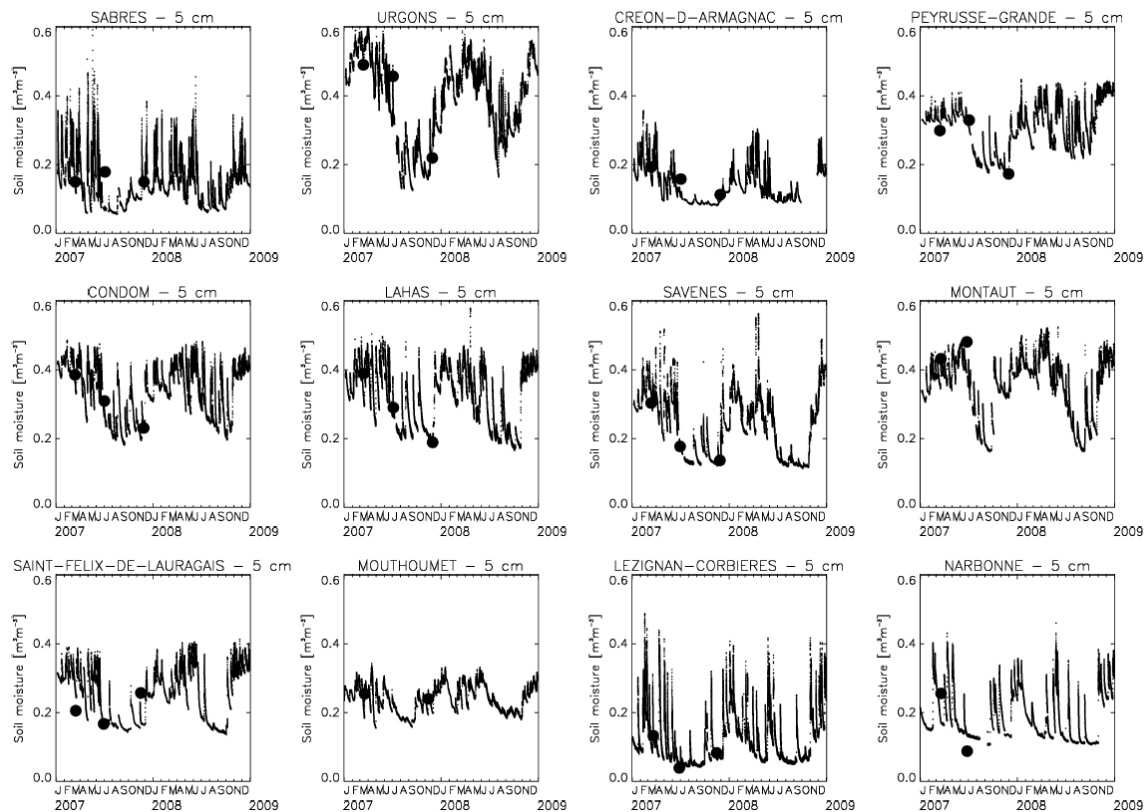
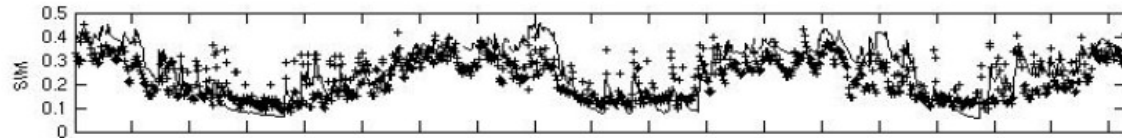# Soil moisture products over SW France

Questions

- Active vs. passive microwave soil moisture products ?
  - Satellite / in situ / model 'cross-verification'
- Low vs. high frequencies ?
  - PORTOS-93 multi-frequency experiment
- Soil moisture retrieval in regions of intensive agriculture ?
  - Crop rotation generates bare soil surfaces
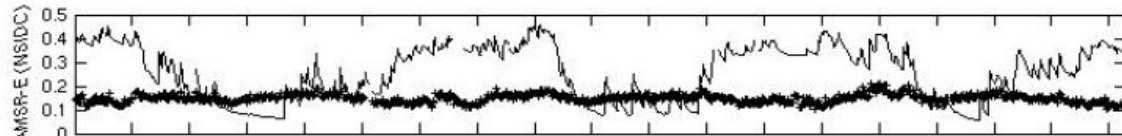 - Explanation for X-band sensitivity to soil moisture ?

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Soil moisture products over SW France
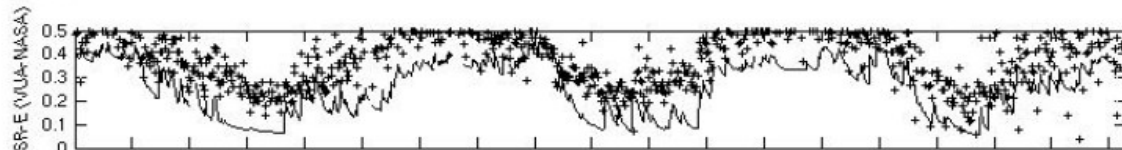
Satellite / in situ / model cross-validation
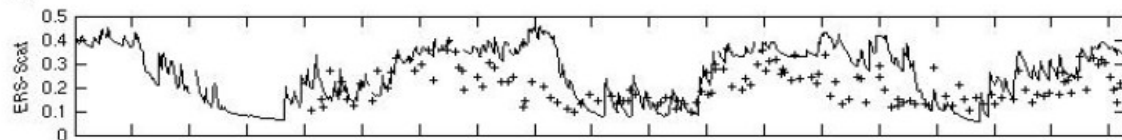
SIM vs SMOSREX

AMSR-E vs SMOSREX

AMSR-E vs SMOSREX

ERS-Scat vs SMOSREX

Windsat vs SMOSREX
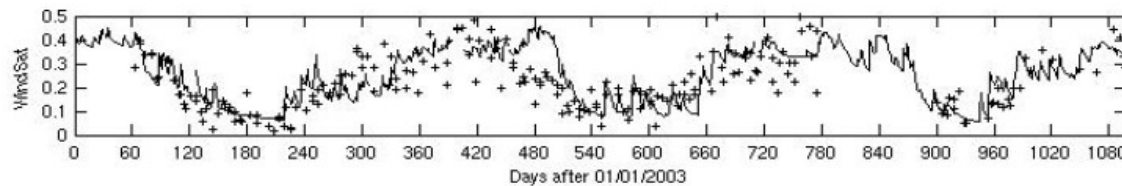
Rüdiger et al. 2009

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Soil moisture products over SW France

Satellite / in situ / model cross-validation

ASCAT anomaly
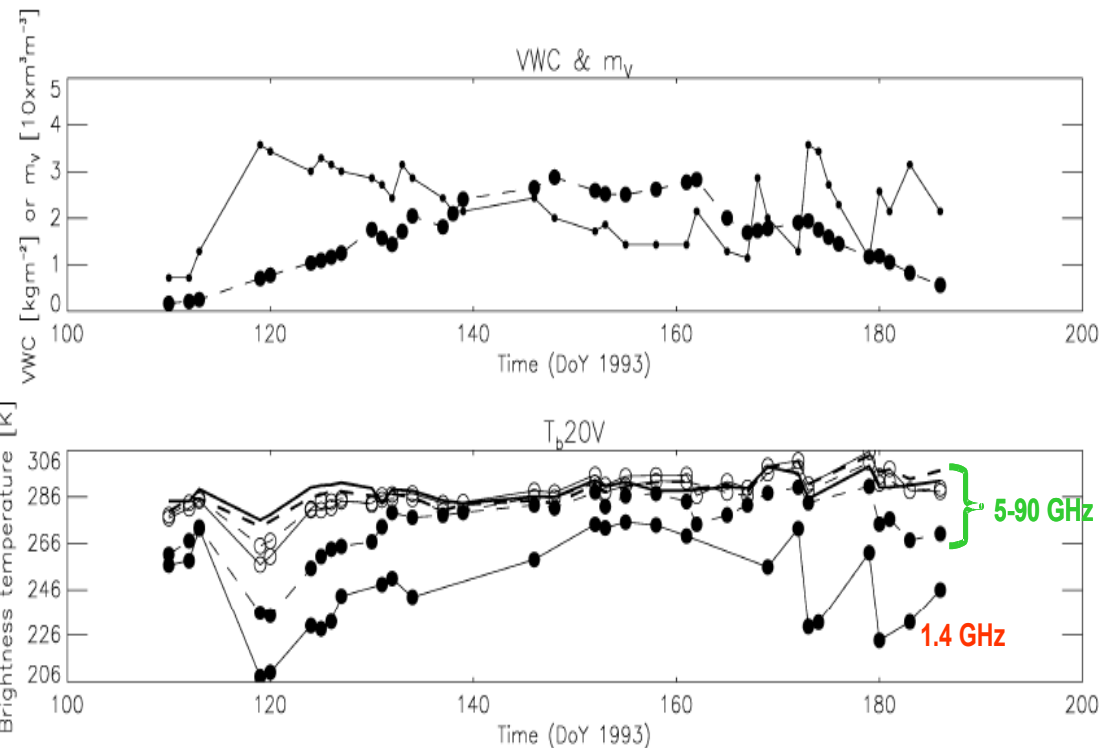In situ anomaly
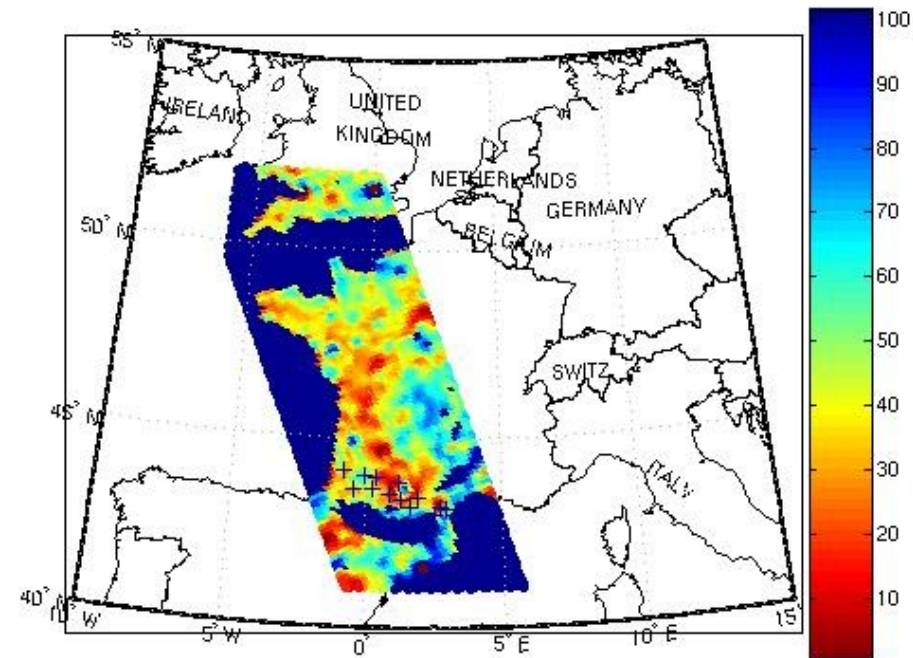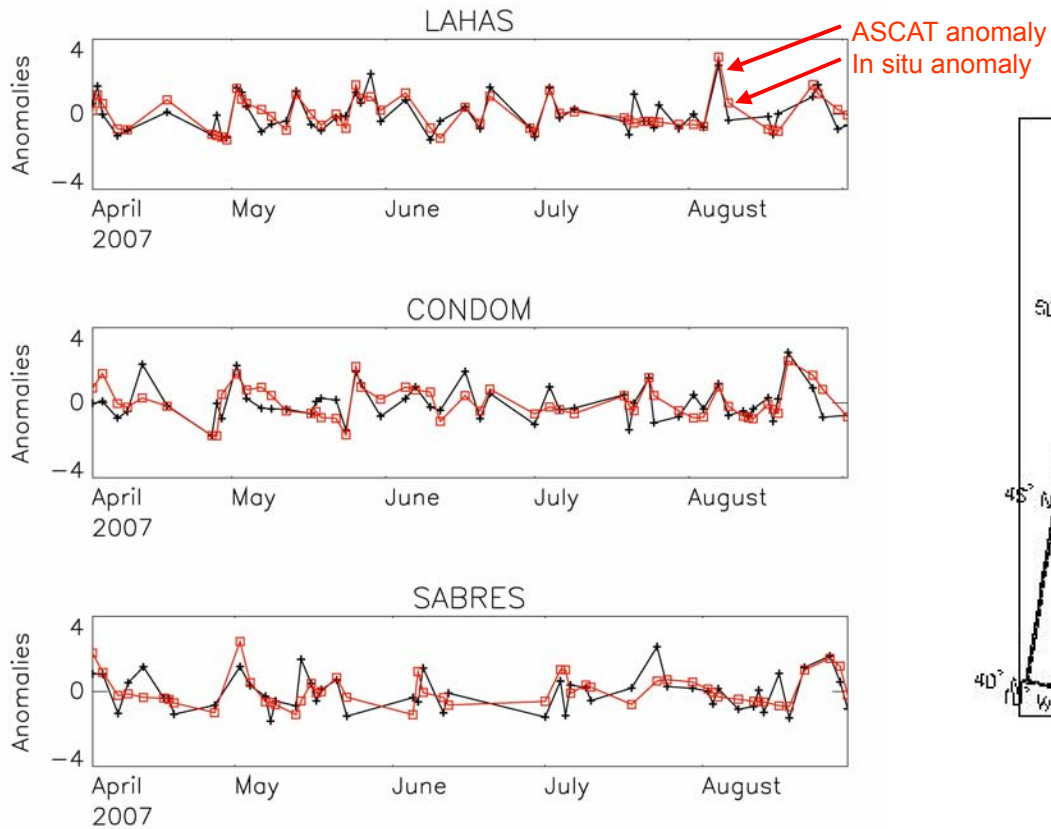
Albergel et al. 2009

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Soil moisture products over SW France

PORTOS-93 *(Wigneron et al. 1995)*

– L-band to W-band: 1.41, 5.05, 10.65, 23.8, 36.5, 90 GHz

Wheat field

Soil moisture products over SW France

PORTOS-93

- L-band: Log relationship

between *mv* or *VWC* and reflectivit

(Wigneron et al. 2004, Saleh et al. 2006)

- Higher frequencies ?

Biangular (20-50°) or bipolar approaches. Regression p-value ~

$$VWC = \exp\left(A_{VWC} \ln\left(1 - \frac{T_b(\theta_1, p)}{T_{IR}} \right) + B_{VWC} \ln\left(1 - \frac{T_b(\theta_2, q)}{T_{IR}} \right) + C_{VWC} \right)$$

$$m_v = \exp\left(A_{mv} \ln\left(1 - \frac{T_b(\theta_1, p)}{T_{IR}} \right) + B_{mv} \ln\left(1 - \frac{T_b(\theta_2, q)}{T_{IR}} \right) + C_{mv} \right)$$

mv	1.41 GHz	5.05 GHz	10.65 GHz	23.8 GHz	36.5 GHz	90 GHz
50H20H	***				NS	NS
50V20V	***		NS	NS	NS	NS
20VH	***				NS	NS
VWC	1.41 GHz	5.05 GHz	10.65 GHz	23.8 GHz	36.5 GHz	90 GHz
50H20H		***	***	***		
50V20V	***	***	***	***		
20VH		***	***	***		***
50VH		***	***	***	NS	

Soil moisture products over SW France

Conclusions

- C-band scatterometer signal is sensitive to soil moisture
  - Similar to C- or X-band passive microwave products
  - ASCAT SSM product operational (EUMETSAT)
- Merged, reprocessed active/passive microwave soil moisture products are needed (WACMOS)
- Most operational satellite microwave emissivities are produced at high incidence angles (~50°)
  - No sensitivity to soil moisture from C- to W-band over dense vegetation
  - High sensitivity to VWC
  - Observed sensitivity to soil moisture due to bare soil surfaces (?)

cnrs

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Soil moisture products over SW France

Prospects

- SMOS
  - CAL/VAL
  - Assimilation
- CAROLS
  - 2008-2010 : airborne L-band radiometer over SMOSMANIA with the ATR-42 aircraft (**www.safire.fr**)
- HYMEX (2011-2020)
  - International campaign, water cycle of the Mediterranean basin
  - Hydrometeorology, oceanography
  - Use of historical and NRT soil moisture products

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THANK YOU FOR YOUR ATTENTION