



# **Soil moisture evaluation using in situ data : SM-DAS-2, ASCAT and SMOS**

**C. Albergel, P. de Rosnay, C. Gruhier, J.-C. Calvet, S. Hasenauer,  
J. Muñoz-Sabater, L. Isaksen, Y. Kerr, W. Wagner**

**EGU - General Assembly 2012  
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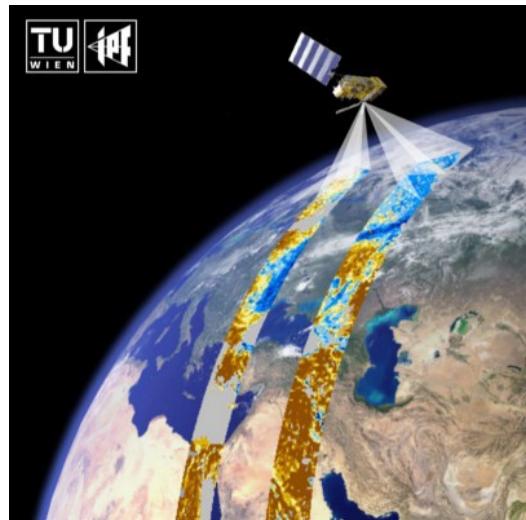
**[HS6.2: Remote sensing of soil moisture]**

**Context of the study: H-SAF Visiting Scientist program (June-December 2011)  
→Collaboration ECMWF, CESBIO, IPF Vienna**

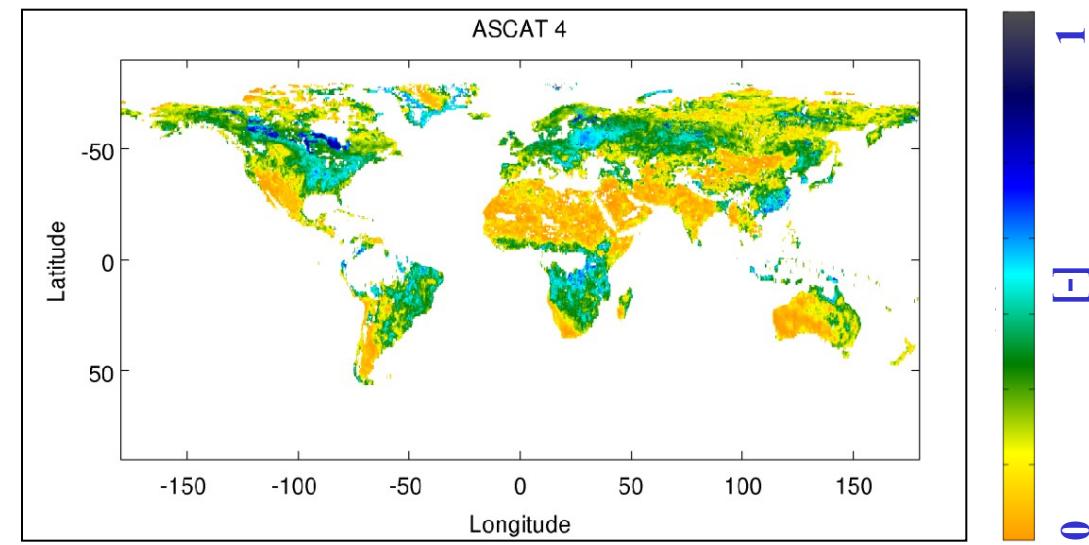
# Soil moisture from remote sensing: ASCAT

- Advanced Scatterometer on MetOP (launched in 2006)
- Active microwave instruments operating at C-band (5.6GHz)
- Surface soil moisture index based on TUWien retrieval scheme (Wagner et al., 1999)
- **ASCAT operational SM product** : NRT data and disseminated to NWP community via EUMETSAT

~50 km resampled 25km



ASCAT monthly mean soil moisture (April 2010)

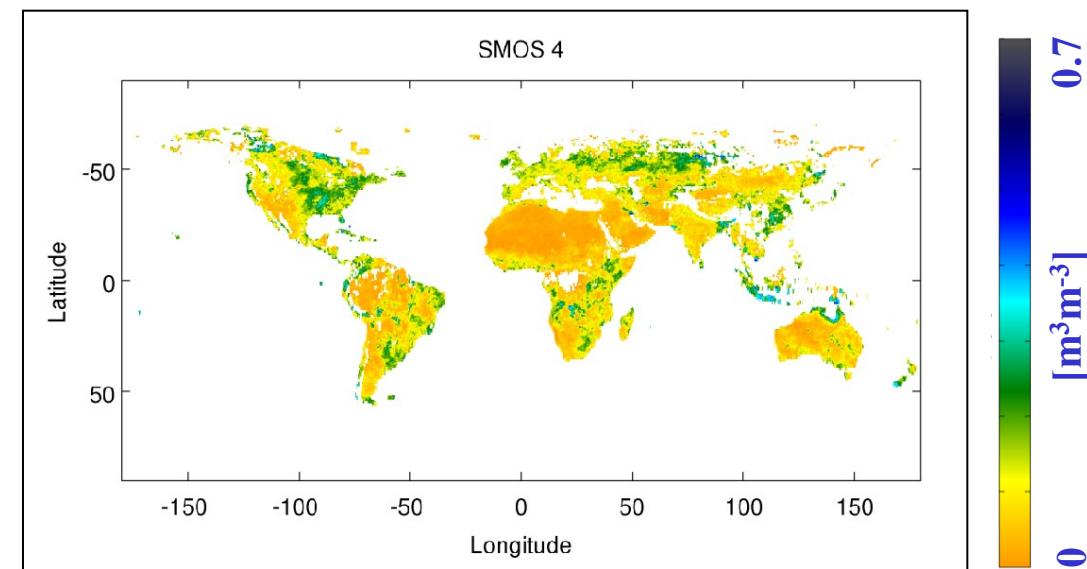


# Soil moisture from remote sensing: SMOS

- Soil Moisture and Ocean Salinity (launched in 2009)
- Passive microwave interferometric radiometer operating at L-band (1.4 GHz)
- Multi-angular measurements of Brightness Temperature (TB) (Kerr et al., 2010)
- Data (TB) access in NRT



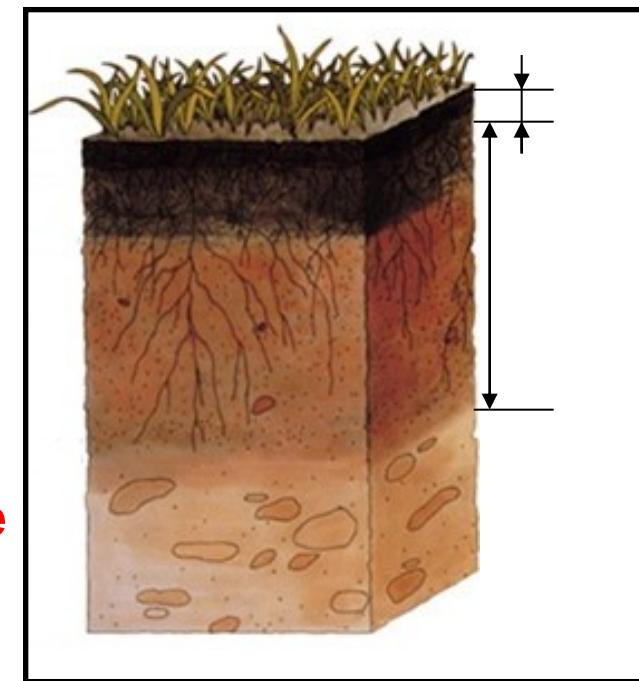
monthly mean soil moisture (April 2010)



In this study : SMOS L2 i.e. surface soil moisture (CESBIO)

# Soil moisture from remote sensing

- **Remote Sensing** : Provides quantitative information about the water content of a **shallow near surface layer**
- Main variable of interest for applications such as meteorological modelling and hydrological studies : **root-zone soil moisture**



→ Accurate retrieval requires to account for physical processes:  
Complementarities between satellite data and models

**SM-DAS-2 : Root-zone SM retrieval based on Data Assimilation**

# H-SAF : SM-DAS-2 Production chain

NRT in 2012



ECMWF Atmospheric conditions

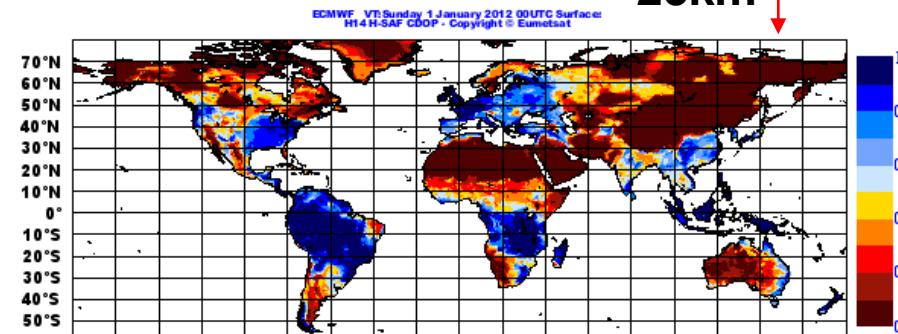
SYNOP  
T2m RH2m

ASCAT  
Surface SM

EKF  
Soil Moisture  
Analysis

SM-DAS-2:  
Soil Moisture  
Profile

~25km



EKF corrects the trajectory of the Land Surface Model

4 layers :  
0-7cm, 7-28 cm, 28-100 cm & 100-289cm

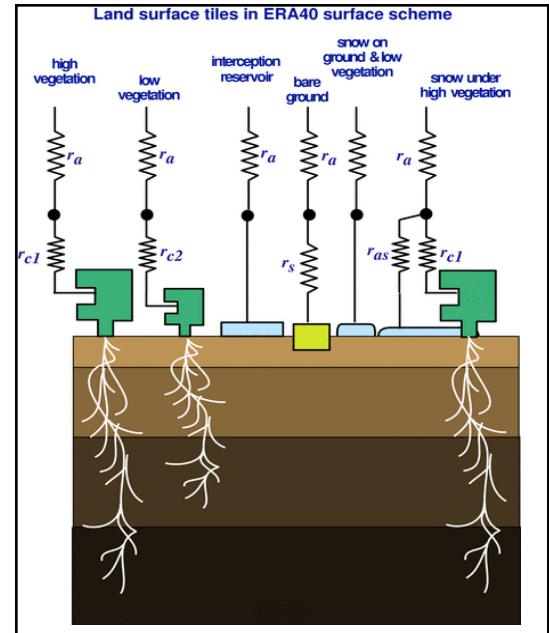
# Simplified EKF soil moisture analysis



For each grid point, analysed state vector  $\mathbf{x}_a$ :

$$\mathbf{x}_a = \mathbf{x}_b + \mathbf{K} (\mathbf{y} - \mathcal{H}[\mathbf{x}_b])$$

$\mathbf{x}_b$  background state vector,  
 $\mathcal{H}$  non linear observation operator  
 $\mathbf{y}$  observation vector  
 $\mathbf{K}$  Kalman gain matrix, fn of  
     $\mathbf{H}$  (linearisation of  $\mathcal{H}$ ),  $\mathbf{B}$  and  $\mathbf{R}$  (covariance matrices  
of background and observation errors).



Simplified EKF :  
de Rosnay et al., 2011, 2012  
LSM H-TESSEL :  
Balsamo et al., 2011

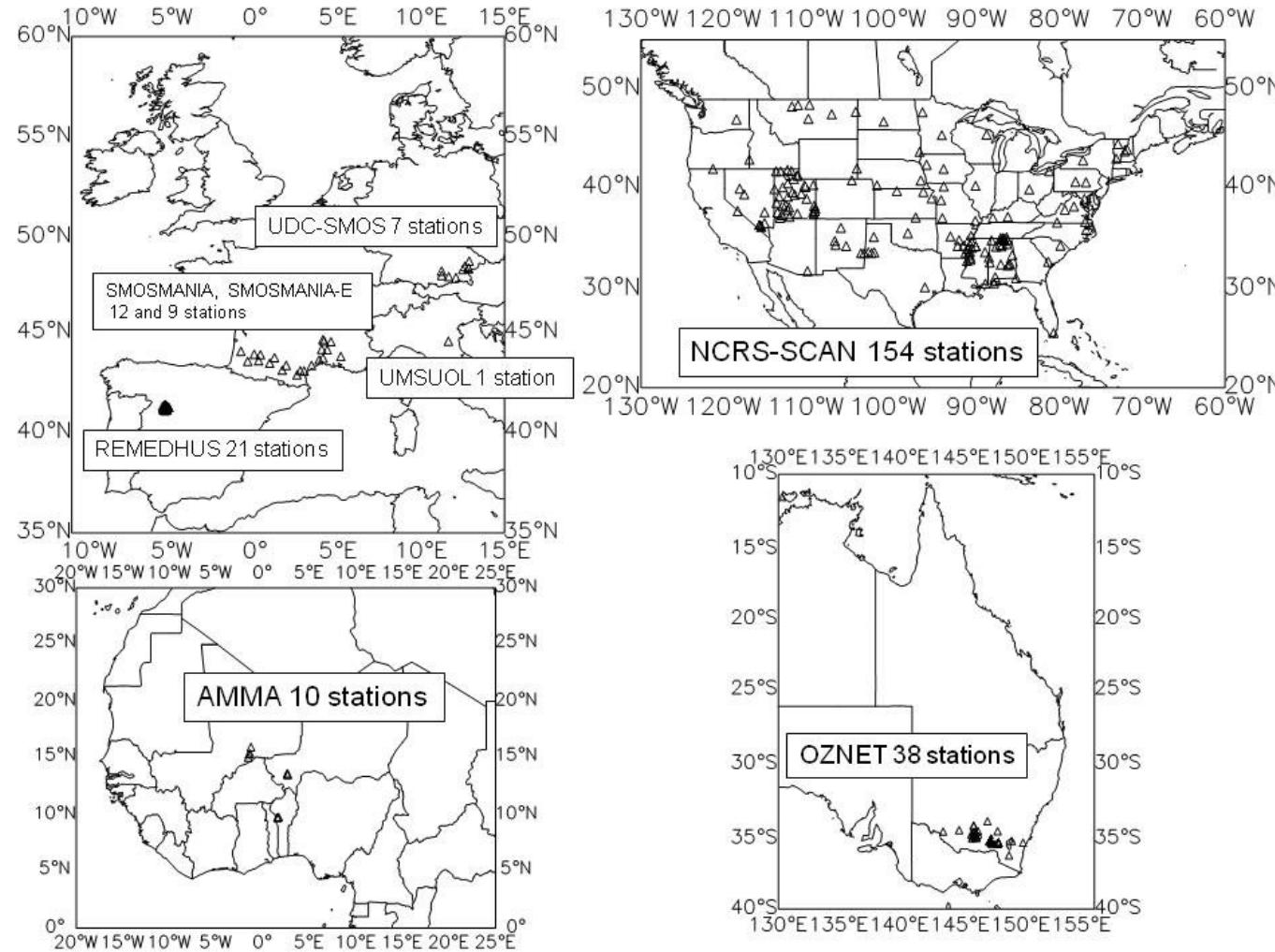
EGU2012-5488

26 Apr 2012 - 09:00 - Room: 36

ASCAT data assimilation at ECMWF

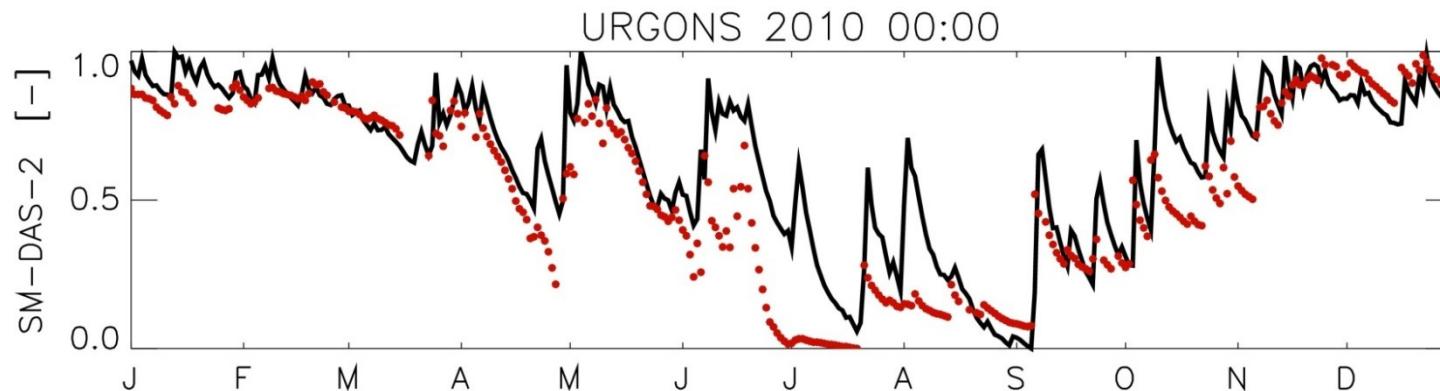
P. de Rosnay, C. Albergel, G. Balsamo, and J. Muñoz Sabater

# In situ SSM : 252 stations available in 2010

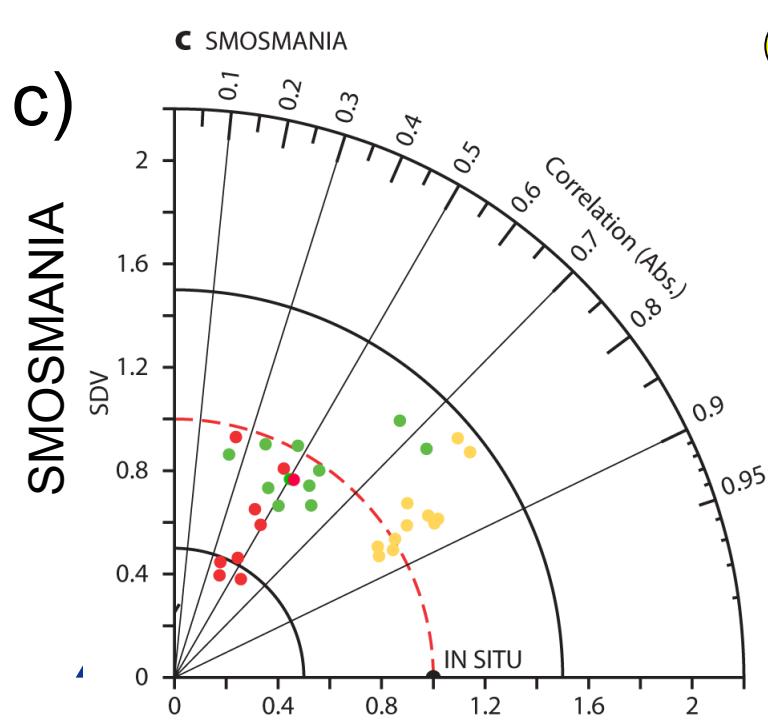
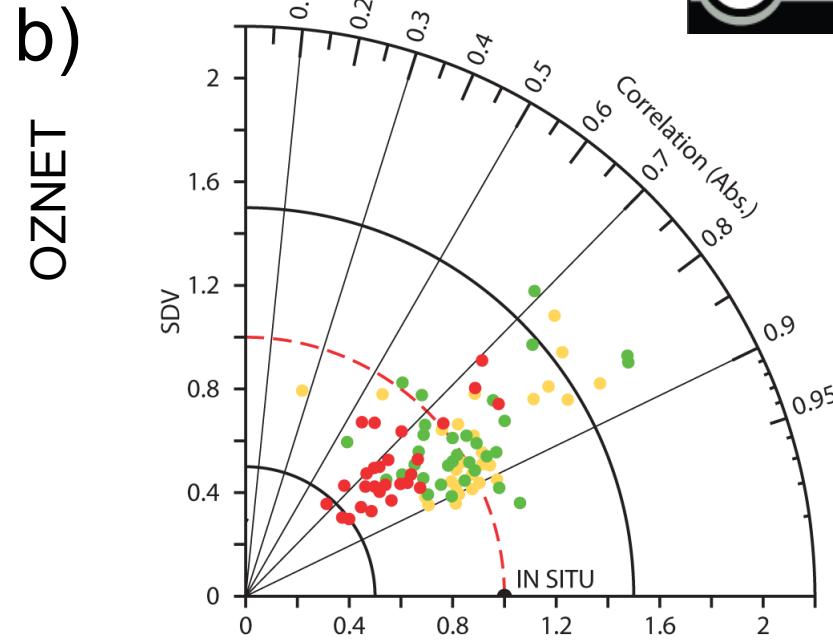
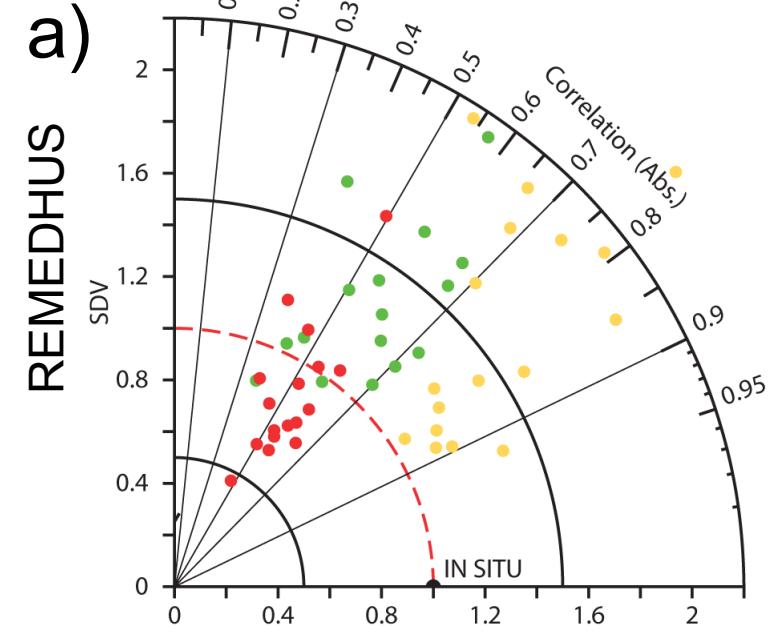


# Data Preparation and metrics

- 2010 times series
  - Index ([-]): SM-DAS-2, ASCAT
  - Volumetric SM ( $\text{m}^3\text{m}^{-3}$ ): SMOS, in situ
- ➔ Each product is normalized using its own min and max



- Metrics used : RMSD, R, Bias (significant level of R, p-value<0.05)



**SM-DAS-2**

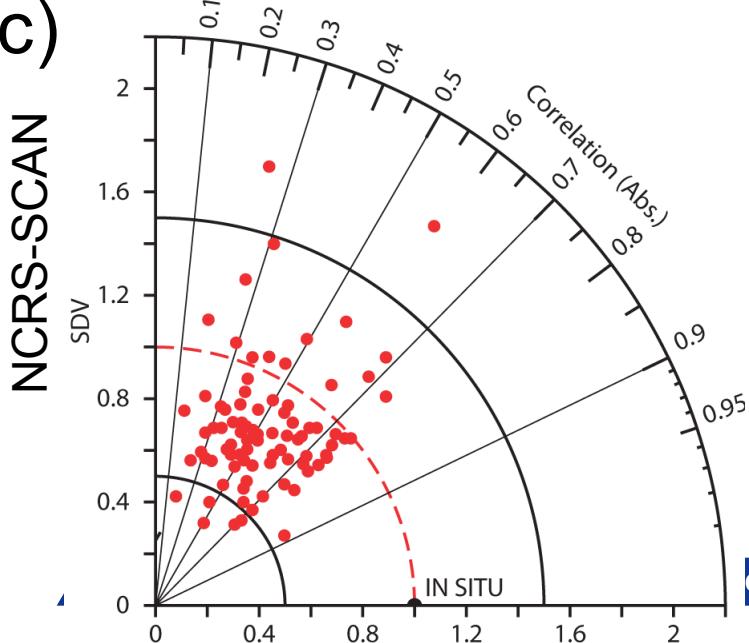
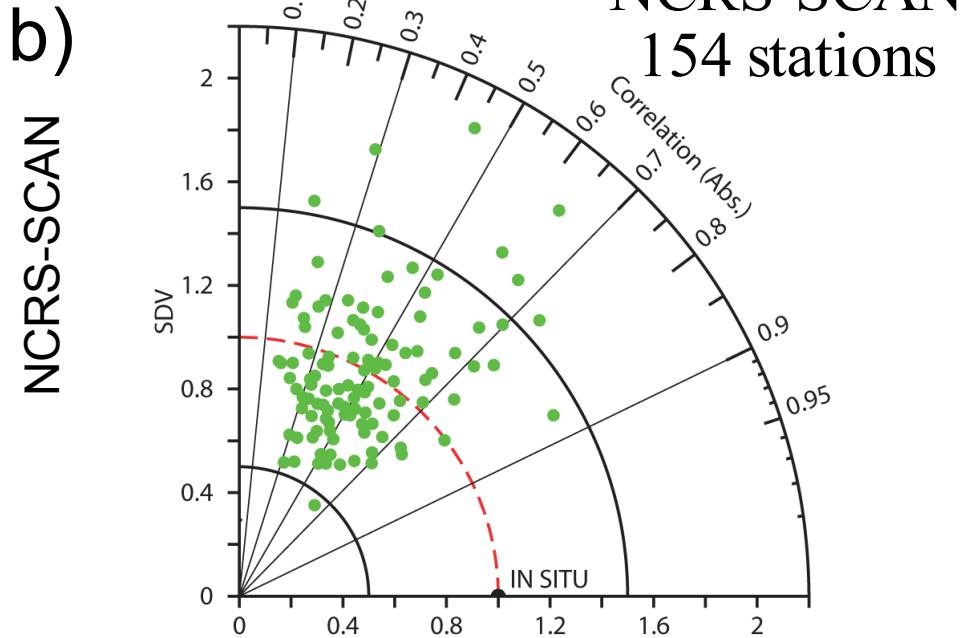
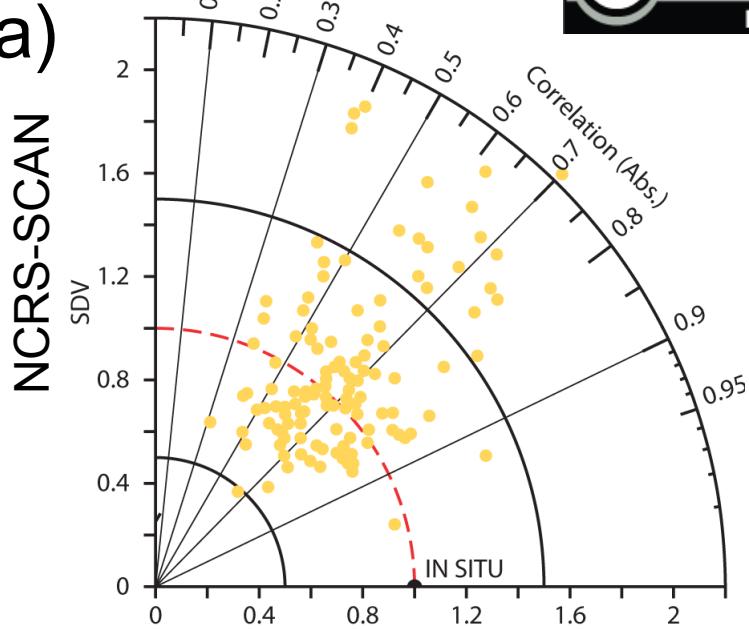


**ASCAT**



**SMOS**

Network	Mean Correlation [-] (for stations with significant values)		
	<b>SM-DAS-2</b>	<b>ASCAT</b>	<b>SMOS</b>
<b>REMEDHUS</b> (nb stations)	<b>0.79</b> <b>(17)</b>	<b>0.57</b> <b>(17)</b>	<b>0.52</b> <b>(17)</b>
<b>OZNET</b> (nb stations)	<b>0.82</b> <b>(36)</b>	<b>0.80</b> <b>(34)</b>	<b>0.74</b> <b>(30)</b>
<b>SMOSMANIA</b> (nb stations)	<b>0.83</b> <b>(11)</b>	<b>0.52</b> <b>(11)</b>	<b>0.44</b> <b>(10)</b>



SM-DAS-2



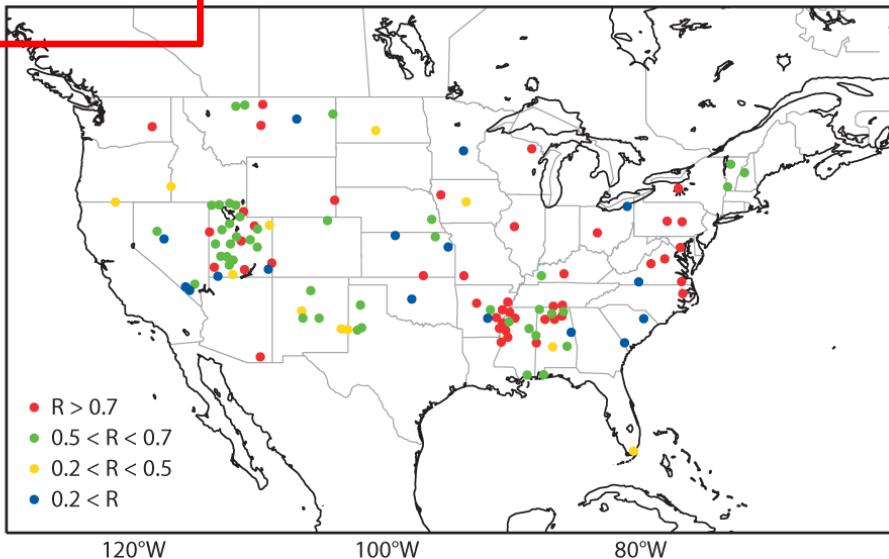
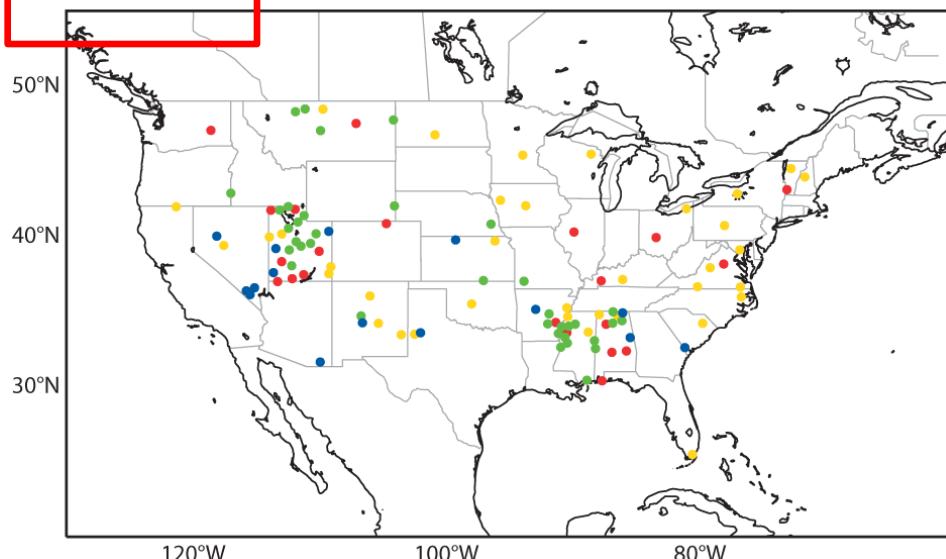
ASCAT



SMOS

**Correlation [-]**  
**(for stations with significant values)**

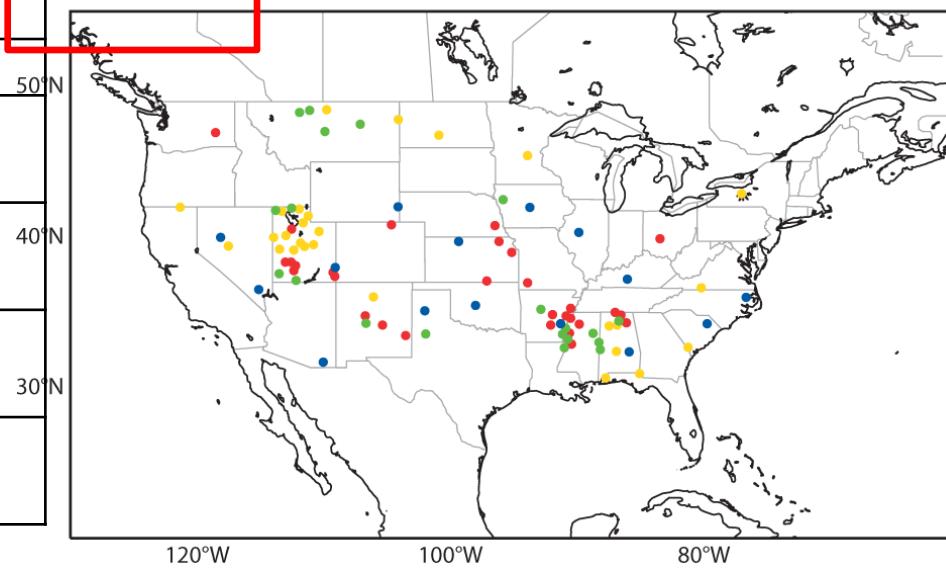
**SM-DAS-2****ASCAT****SMOS****0.65**  
(131 stations)**0.48**  
(125 stations)**0.51**  
(106 stations)

**a** SM-DAS-2**b** ASCAT

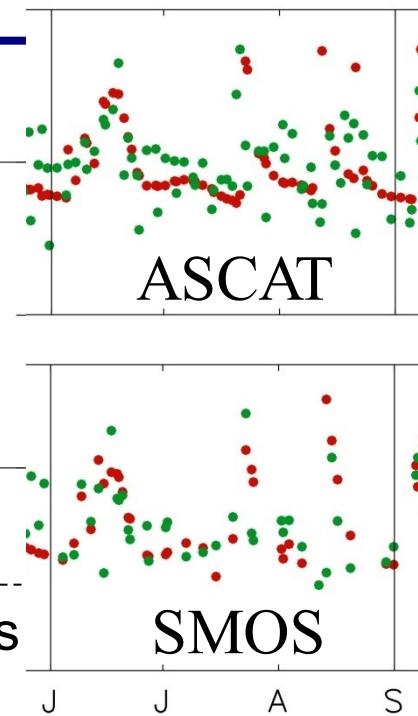
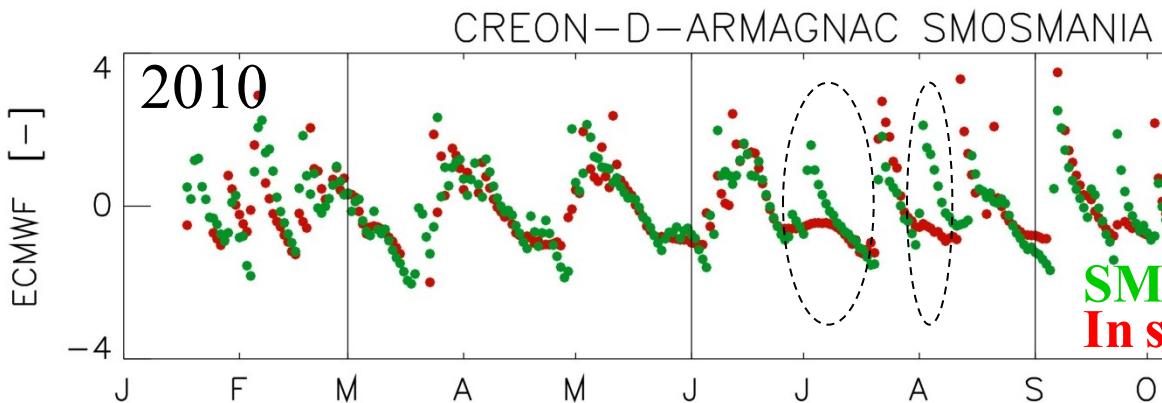
## Distribution (%) of correlation values

**NCRS-SCAN**

Correlation	<i>SM-DAS-2</i>	<i>ASCAT</i>	<i>SMOS</i>
Inadequate $R < 0.2$	2	7	3
Poor $0.2 < R < 0.5$	14	47	48
Fair $0.5 < R < 0.7$	50	39	32
Good $R > 0.7$	34	7	17

**c** SMOS

# Comparison of the Anomaly time-series



Soil Moisture data set	Correlation [-]		
	<i>SM-DAS-2</i>	<i>ASCAT</i>	<i>SMOS</i>
Winter	0.70	0.71	0.55
Spring	0.65	0.56	0.51
Summer	0.53	0.46	0.46
Autumn	0.62	0.50	0.45

- Representativeness of local rainfall could induce discrepancies when compared to coarse resolution products
- Assimilation of rain-gauge rainfall accumulation is an ongoing activity

# Conclusion (1)

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- Good performances of the three products to capture surface soil moisture annual cycle as well as short term variability
- Results particularly encouraging over the Oznet network
  - does not seem to be affected by RFI
  - dense vegetation canopies → reduced sensitivity to soil moisture
  - land use is predominantly agricultural → significant fraction of bare soil and/or of dry vegetation

Normalized Product (nb stations with significant R)	SM-DAS-2 (219)	ASCAT (208)	SMOS (180)
Correlation	0.70	0.53	0.54
Bias (index) (In Situ - Product)	- 0.05	- 0.07	0.12
RMSD (index)	0.235	0.255	0.243

# Conclusion (2)

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- ASCAT and SMOS present similar performances, algorithm improvements are expected for both
  - New reprocessed ASCAT data sets were shown to have better correlations (e.g., over Europe, Brocca et al., 2011, Parrens et al., 2012)
  - SMOS L2, recent physically-based algorithm which let margin for shortcoming improvements
- Albergel et al., 2012, RSE doi:10.1016/j.rse.2011.11.017
- Gruhier et al. 2011:  
[http://www.ecmwf.int/research/EUMETSAT\\_projects/SAF/HSAF/ecmwf-hsaf/files/SM\\_VS11\\_02\\_FINAL\\_REPORT.pdf](http://www.ecmwf.int/research/EUMETSAT_projects/SAF/HSAF/ecmwf-hsaf/files/SM_VS11_02_FINAL_REPORT.pdf)
- More information on HSAF project/products: <http://hsaf.meteoam.it>  
Contact: [hsafcdop@meteoam.it](mailto:hsafcdop@meteoam.it)



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