Y. Kerr, and the SMOS Team

The 4 phases of a project

- The concept
  - Expression of needs
  - Theoretical solution
  - Practical solution
- The selling
  - Proposal writing
  - Concept fine tuning
  - Get the approval and funding (i.e., … support, help appreciated)
  - Keep it alive…
- The making (help also appreciated)
- The use, demonstration of usefulness etc… (help will be appreciated)
- The next generation

Background

- Initiated more than 20 years ago
  - Water and energy budget/ water resources management in Western Africa
- After testing many approaches
  - Vis NIR
  - Thermal infra red
  - Thermal inertia
  - Scatterometer and radar
- To no avail

The solution?

- Passive microwaves at Low frequency
  - L Band
- Collaborations with E Njoku and T Schmugge, D.Le Vine and C. Ruf
  - interferometry
- And with radioastronomers and antenna specialists
  - 2D Interferometry

Walk through

Rationale

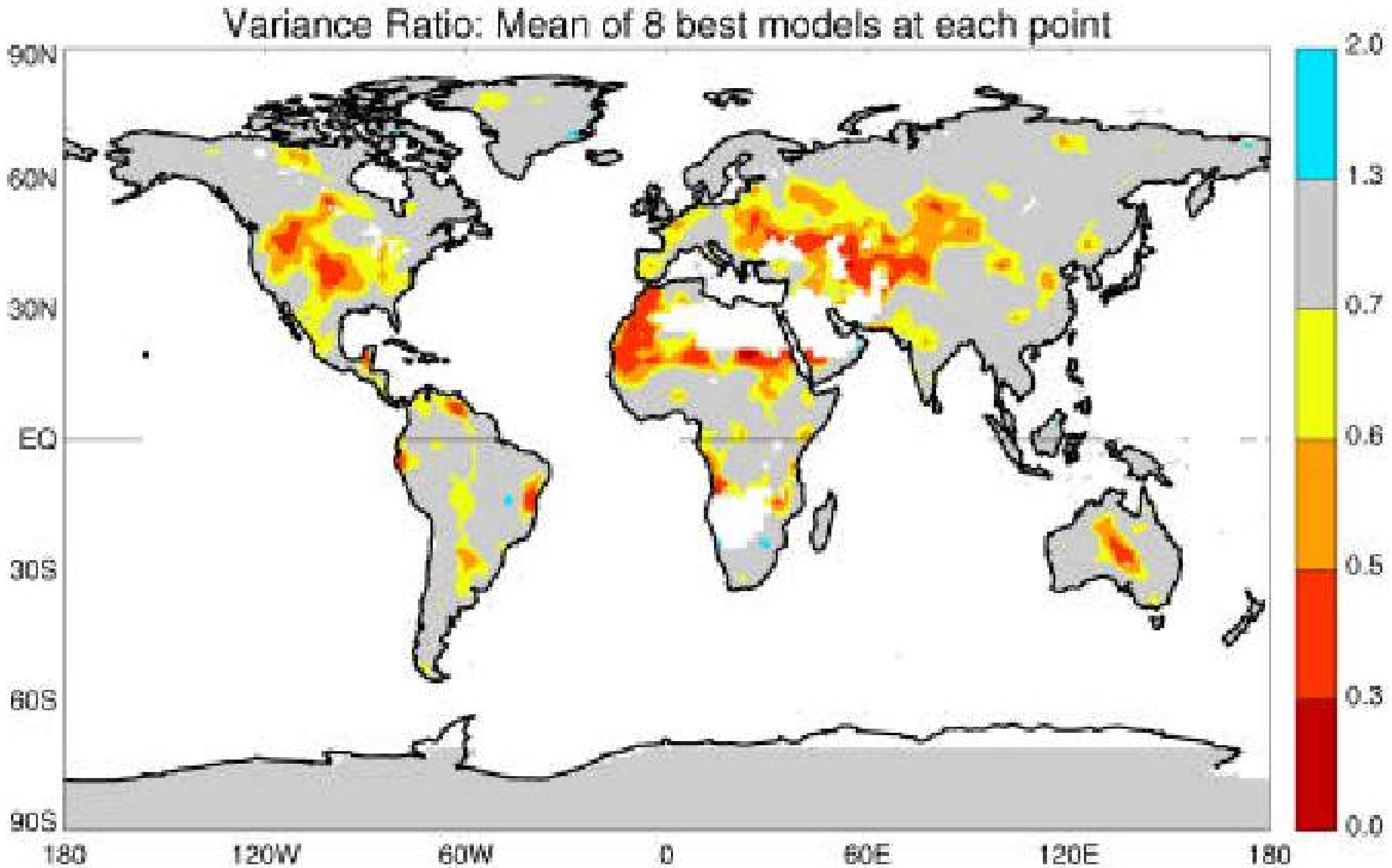
- Changing climate
- Extreme events (floods, droughts, storms…)
- Increase skills of weather forecasts
- Water management
- Adequacy of crops and cultural practices to forcings

- ➔ requires better forecasting and decision making tools
- need for SSS and SM frequent and global fields

Why measuring Soil moisture?

***Scientific Objectives*:** Improve our understanding of the land component of the global hydrologic cycle, of the spatial and temporal evolution of the water storage, and of the soil atmosphere interactions so as to improve **global water ressources management - globally**.

Multi-Model Consensus of Regions Where Soil Moisture Impacts Seasonal Precipitation



Koster et al. (2004), *Science*, 305, 1138-1140.

Why do we want to measure sea surface salinity with the SMOS mission?

From J Font et al 2008

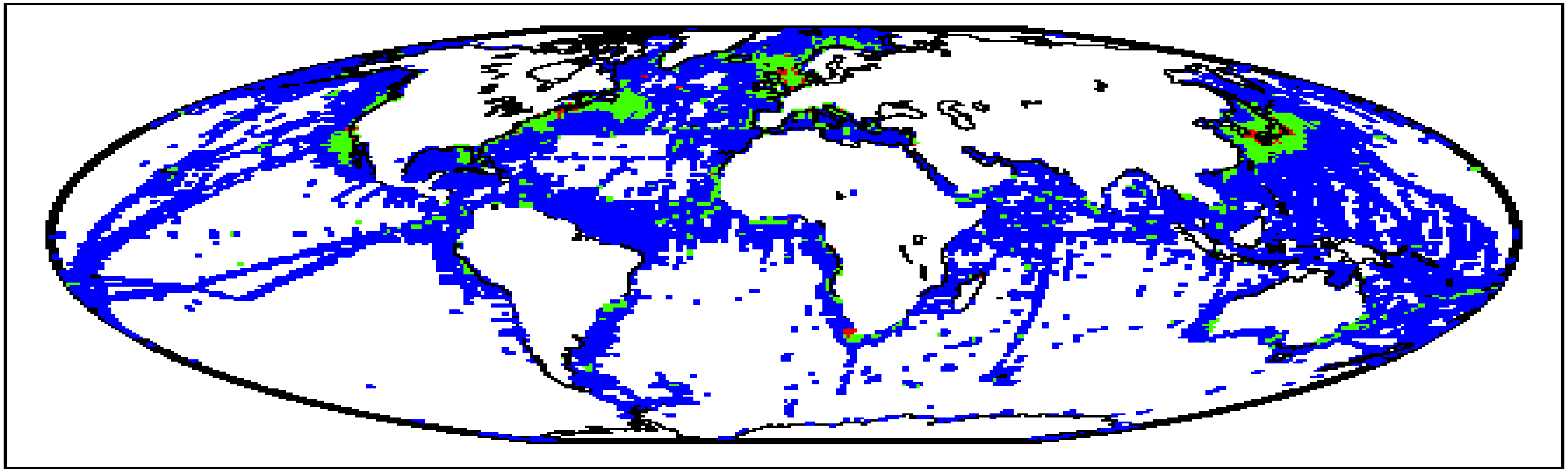
Scientific objectives: **to increase the knowledge on the ocean component of the global water cycle, large scale circulation, and ocean's role on the climate system**

Ocean salinity rationale

- **Thermohaline overturning circulation.**
  How can climate variations induce changes in the global ocean circulation?
- **Air-sea freshwater budget.**
  How are global precipitation, evaporation, and the cycling of water changing?
- **Tropical ocean and climate feedback**

Lagerloef et al., 2001

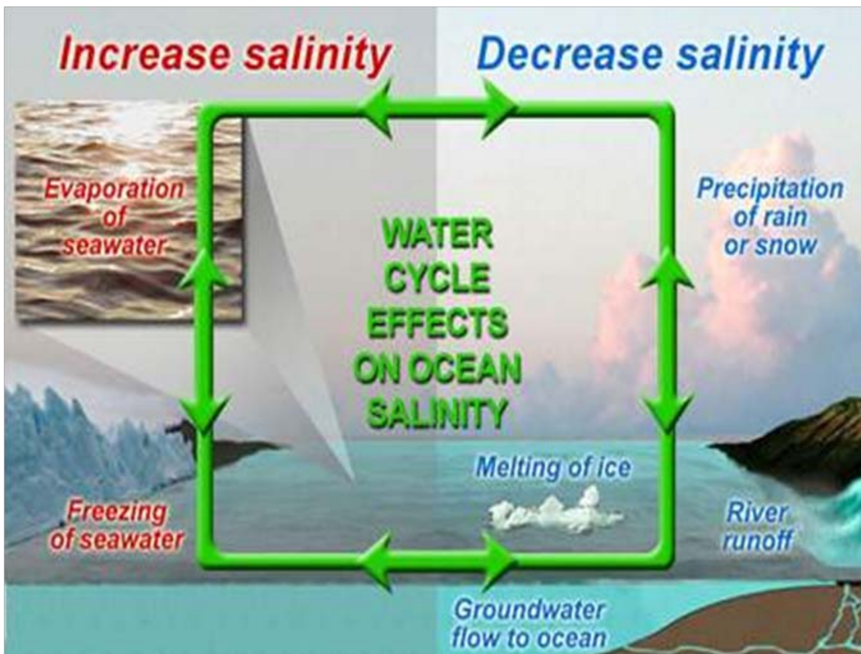
Number of Observations by 1° Square



Ocean Salinity and Climate

Salinity links the climatic variations of the global water cycle and ocean circulation

- Salinity is required to determine seawater density, which in turn governs ocean circulation.
- Salinity variations are governed by freshwater fluxes due to precipitation, evaporation, runoff and the freezing and melting of ice.



Air-Sea Water Flux accounts for

- ***86% of global evaporation***
- ***78% of global precipitation***

Importance

- ***Climate prediction***
- ***El Niño forecasts***
- ***Global Water budget***

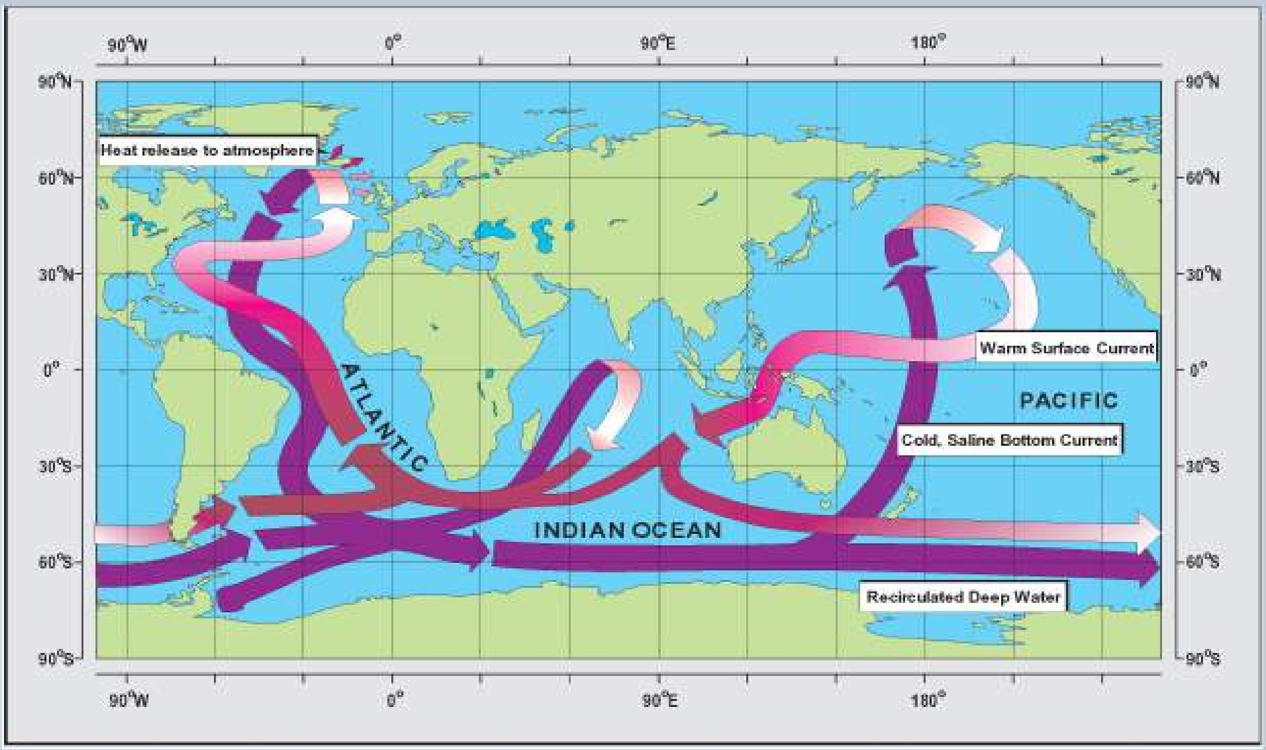
From J Font et al 2007

Salinity and Ocean Circulation

The ocean conveyor is sustained by elevated salinity in the Atlantic

The Atlantic Thermohaline Circulation

- A key Element of the Global Oceanic Circulation -



Schematic diagram of the global ocean circulation pathways, the 'conveyer' belt (after W. Broecker, modified by E. Maier-Reimer).

AV/D3/99-2

From J Font et al 2007

Science Objectives for *SMOS*: The *SMOS* Mission

SMOS is the second Earth Explorer opportunity mission (1st round)

An ESA/CNES/CDTI project

Selected in 1999, initiated in 2000

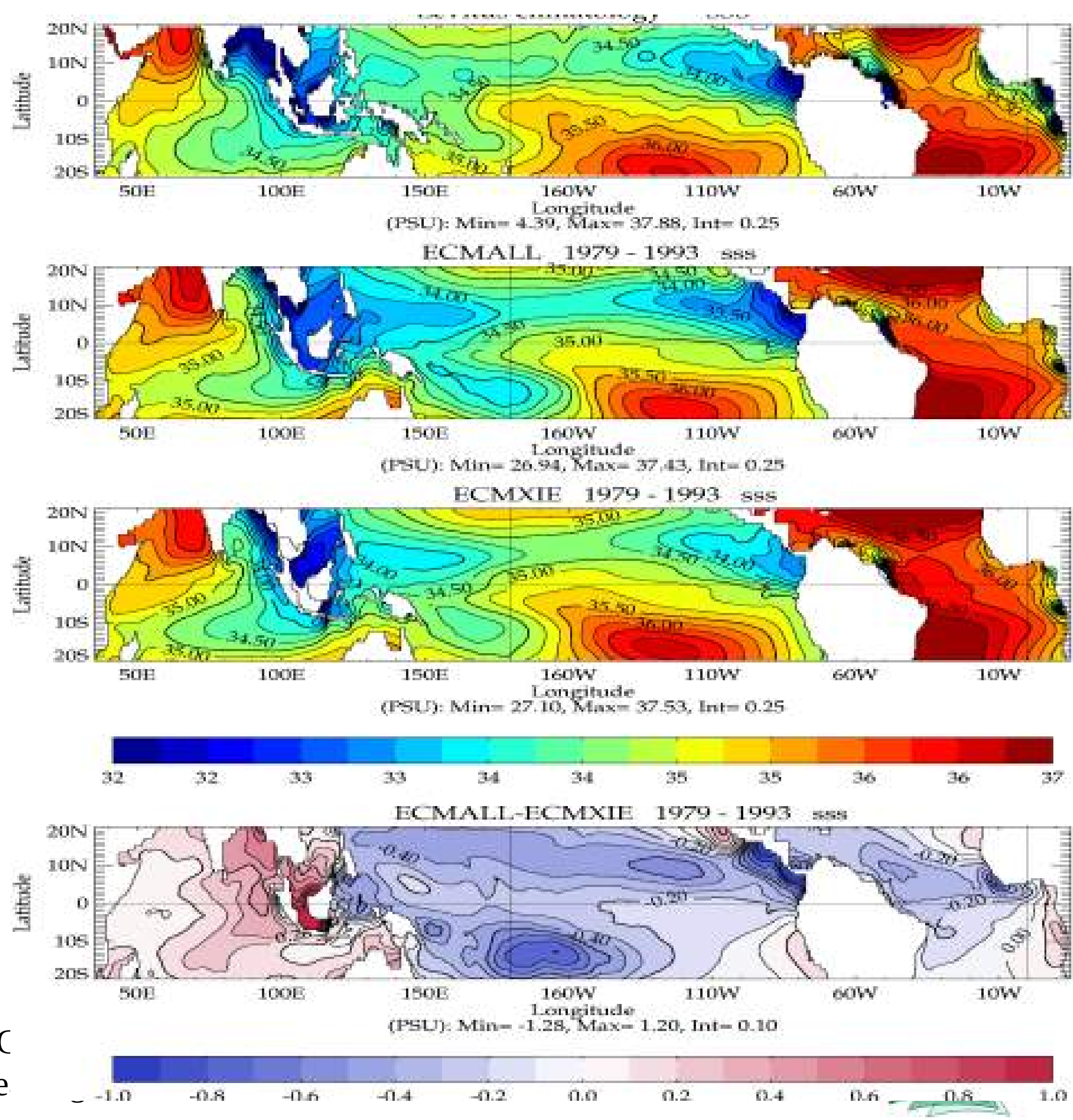
Phase B finished, C/D Started in January 2004 for a launch in 2009

A **new technique** (2D interferometry) to provide **global measurements** from space of **key variables** (SSS and SM) for the **first time**.

Pellarin et al

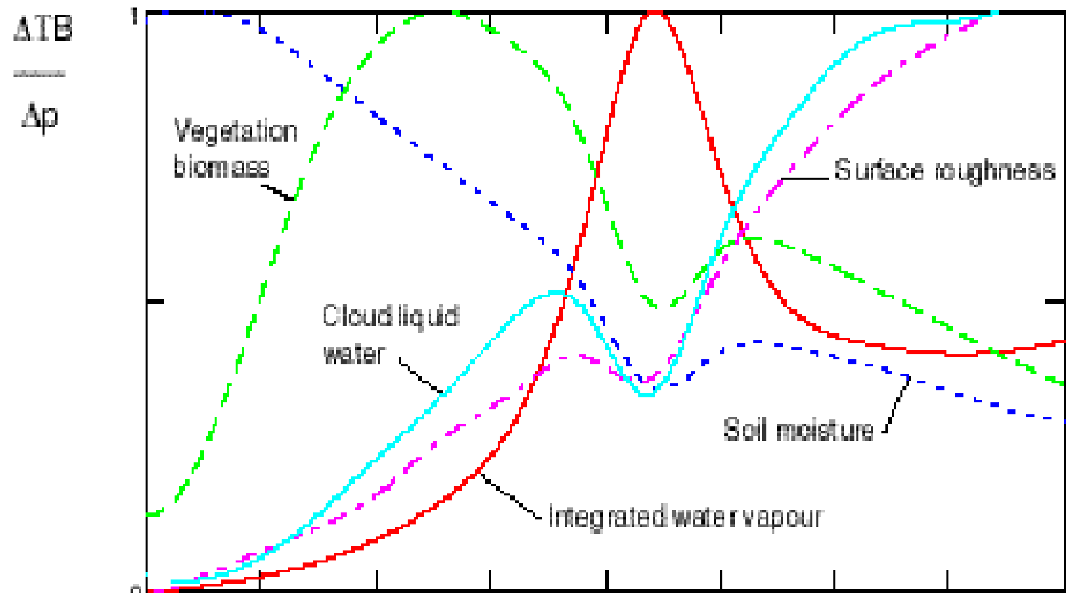
Le Traon et al

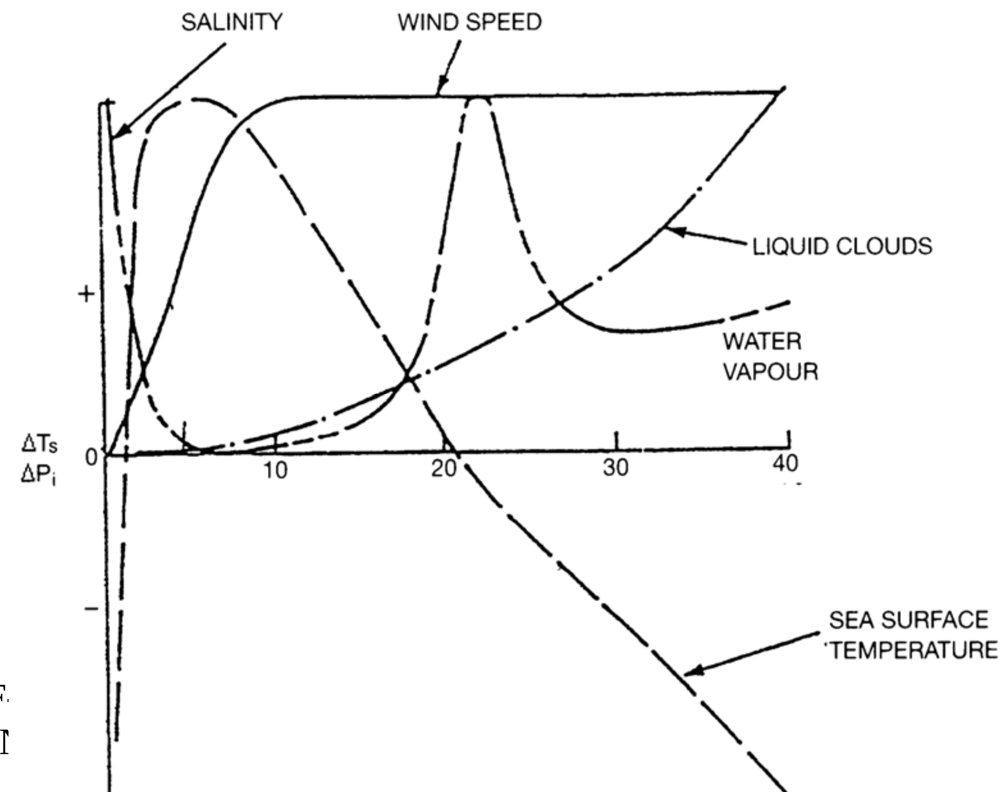
EC
Re



HOW?

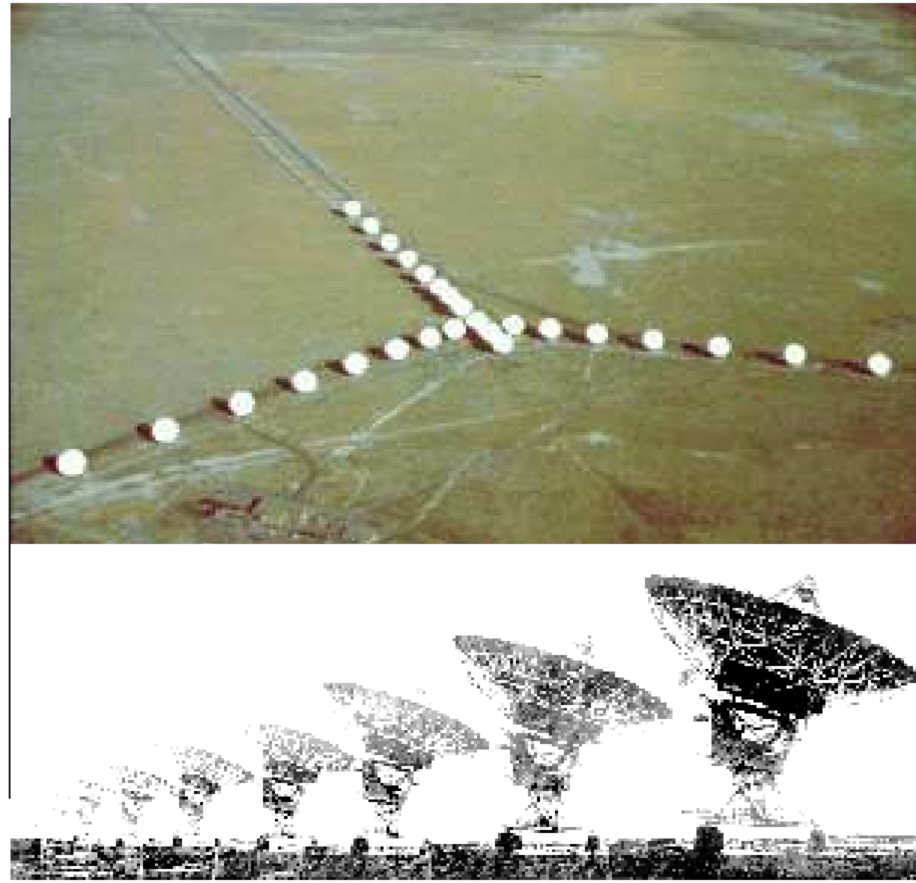
- Passive microwaves
- L Band
- Antenna size → Two concepts
  - Aquarius/ SMAP
  - SMOS





Interferometry

- angular resolution provided by **distant** antennas
- correlation products $s(1)^*s(2) \rightarrow$ visibility functions $V(D/\lambda)$
- Inverse F.T. on $V \rightarrow T_B(\theta)$

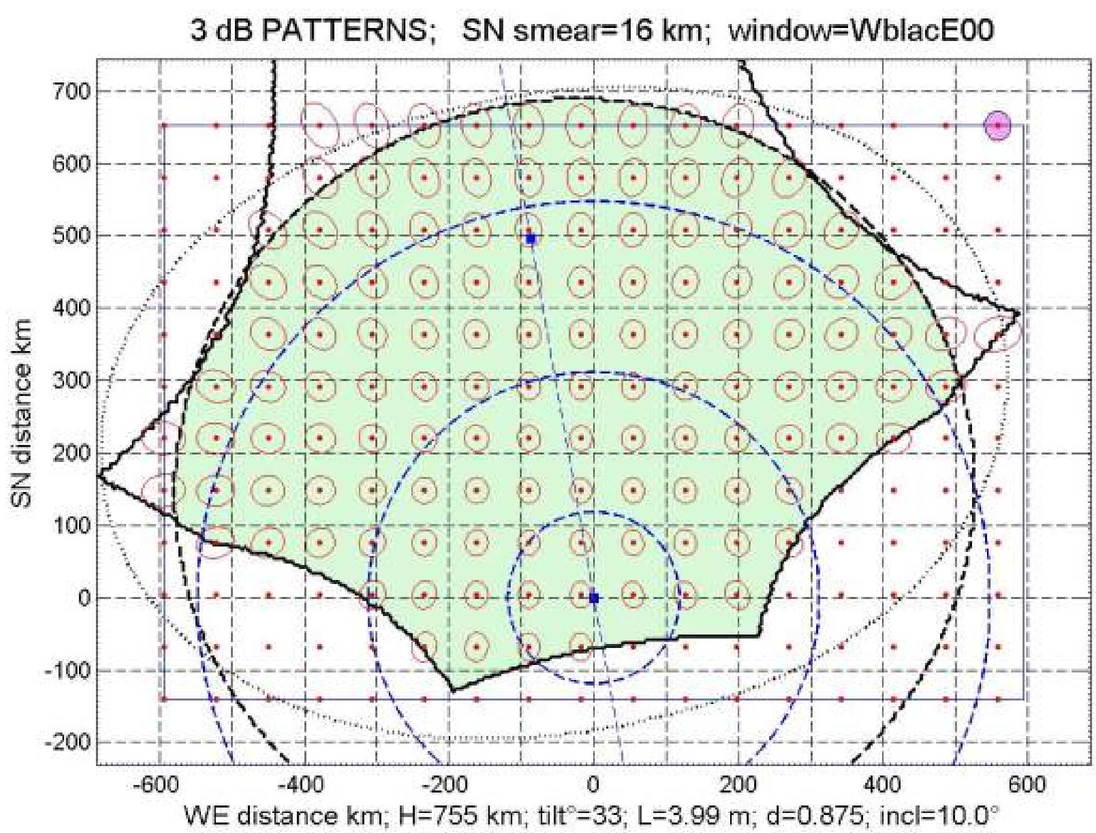


Space sampling requirement : every $\lambda/2$ value **at least one time** ; hence "**thinning**" possibilities.

Principle of operations

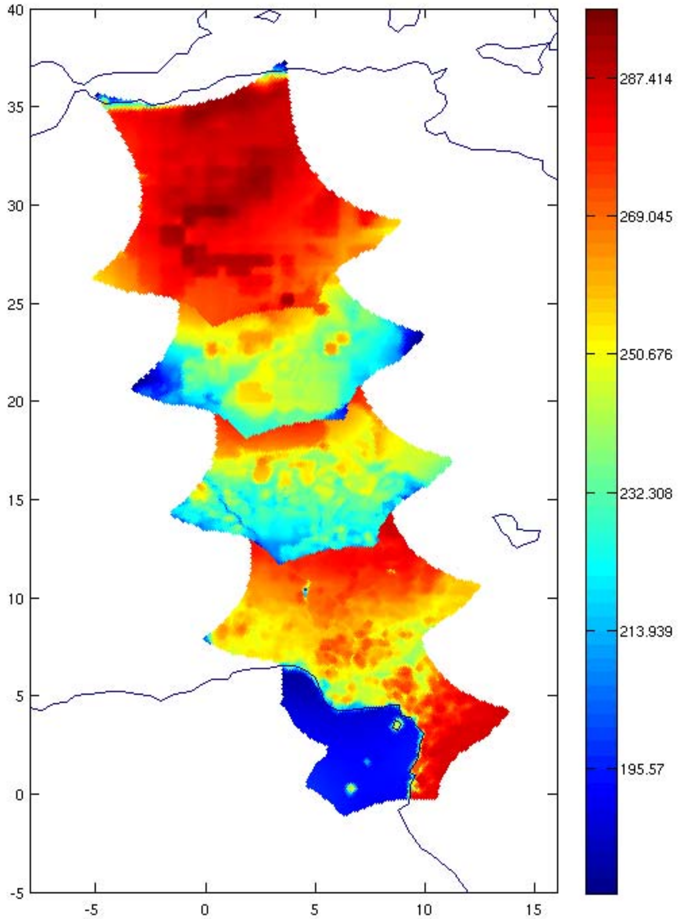
SMOS FOV; 755 km, 3x6, 33°, 0.875λ,

- Each integration time, (2.4 s) a full scene is acquired (dual or full pol)
- Average resolution 43 km, global coverage
- A given point of the surface is thus seen with several angles
- Maximum time (equator) between two acquisitions 3 days



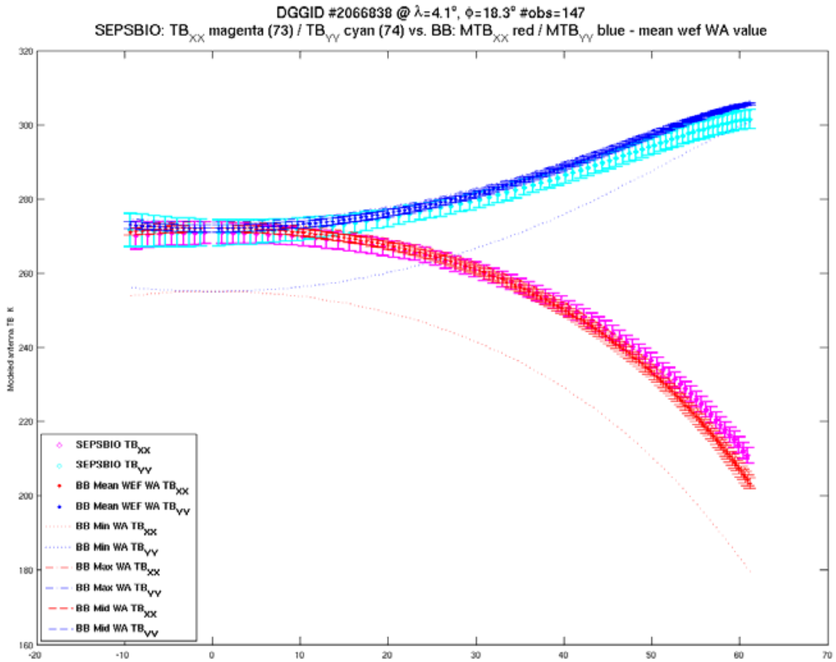
P. Waldteufel, 2003

L1c DATA



Making full use of angular measurements

High temporal sampling



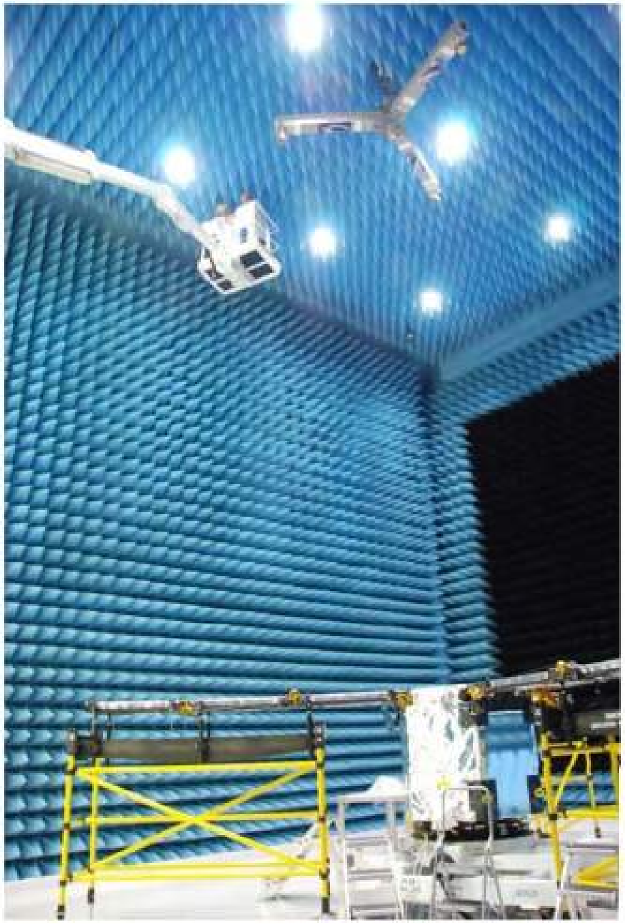
F-

N

The satellite

SMOS PLM PHASE C/D

IVT / EMC



SPECS

	System Parameter	Specified Value	SAT-PDR (actual value)	SAT-QR (IVT and RACT)
	Systematic Error	1.5 K RMS (0°) 2.5 K RMS (32°)	Not Available	0.9 K RMS in alias-free FoV
	Level-1 SM Radiometric Sensitivity (220 K)	3.5 K RMS (0°) 5.8 K RMS (32°)	2.43 K RMS 3.98 K RMS	2.23 K RMS 3.95 K RMS
	Level-1 OS Radiometric Sensitivity (150 K)	2.5 K RMS (0°) 4.1 K RMS (32°)	1.99 K RMS 3.26 K RMS	1.88 K RMS 3.32 K RMS
	Stability (1.2 s integration)	4.1 K RMS (< 32°) during 10 days inside EMC chamber	Not Available	4.03 K RMS
	Stability (long integration)	0.03 K	Not Available	< 0.02 K

A few dates

- March 17 → GOCE launch
- November 2nd SMOS launch
- November 18 SODAP
- Start of data flow a few days after (piecewise) → calibration tests
- First image December 6th
- Around mid December starting full data acquistion (1 week DP-1 week FP etc)
- Cal val Activities
- Early May 2010 end of commissioning phase, routine operations

Launch Campaign

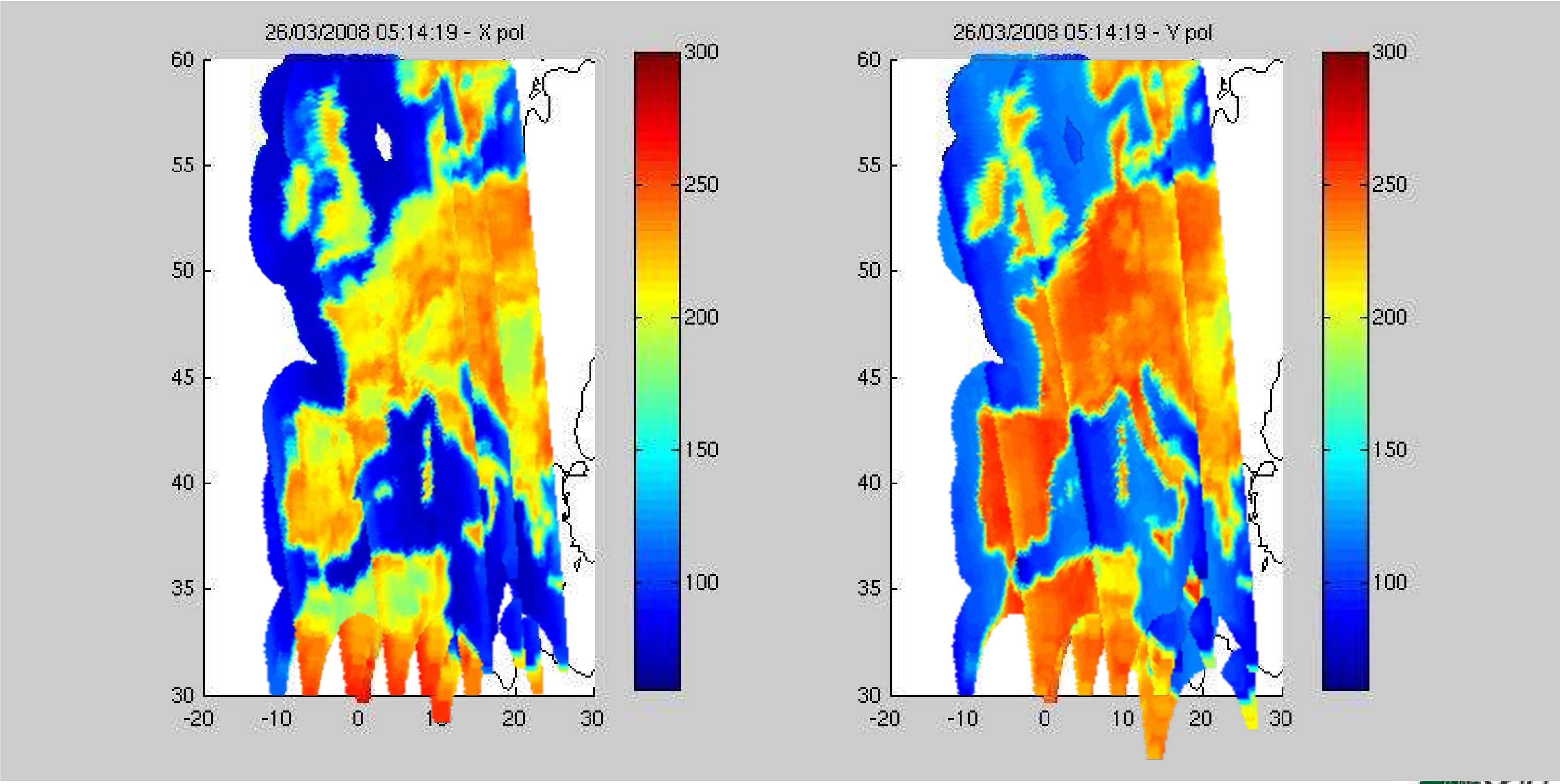
Products

ESA products

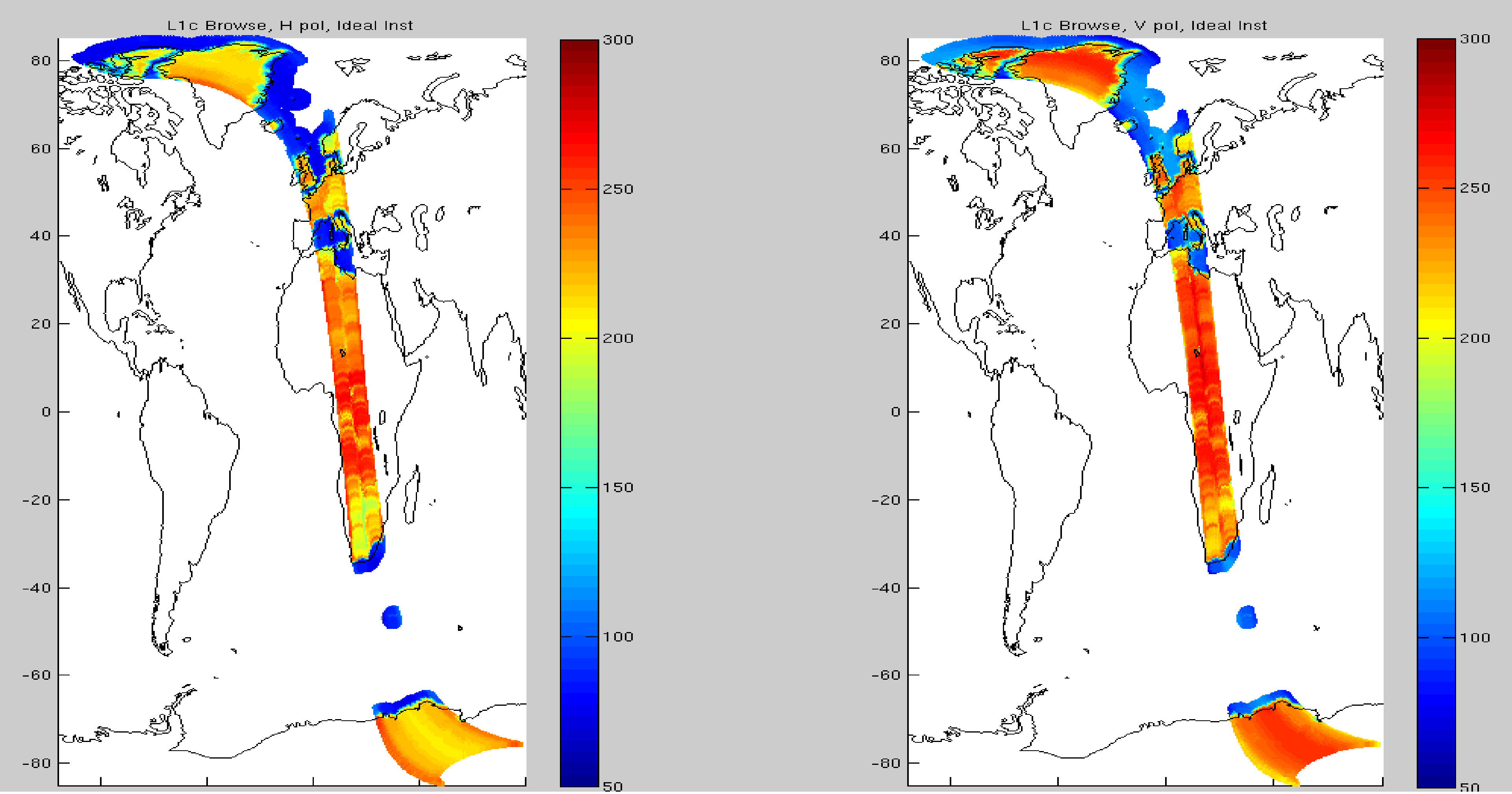
- Level 1
  - 1b snapshots --> possible to make pixels
  - 1c angular signature
  - Browse (42.5 deg, SMAP?)
- Level 2
  - 2 SM, Tau
  - 2 SSS
  - 2 Tb

F Cabot et al

Or simulated data Products – L1C



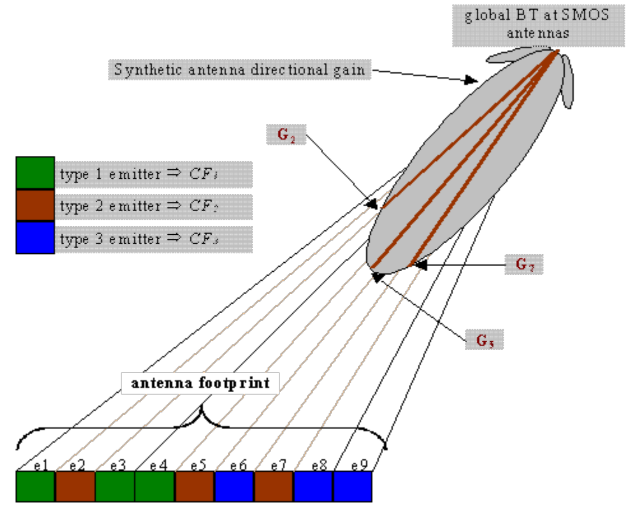
End to End


L1c Browse, H pol, Ideal Inst
L1c Browse, V pol, Ideal Inst
80
60
40
20
0
-20
-40
-60
-80
300
250
200
150
100
50

Models and mixed pixels

: Aggregated fractions FM_0 and FM

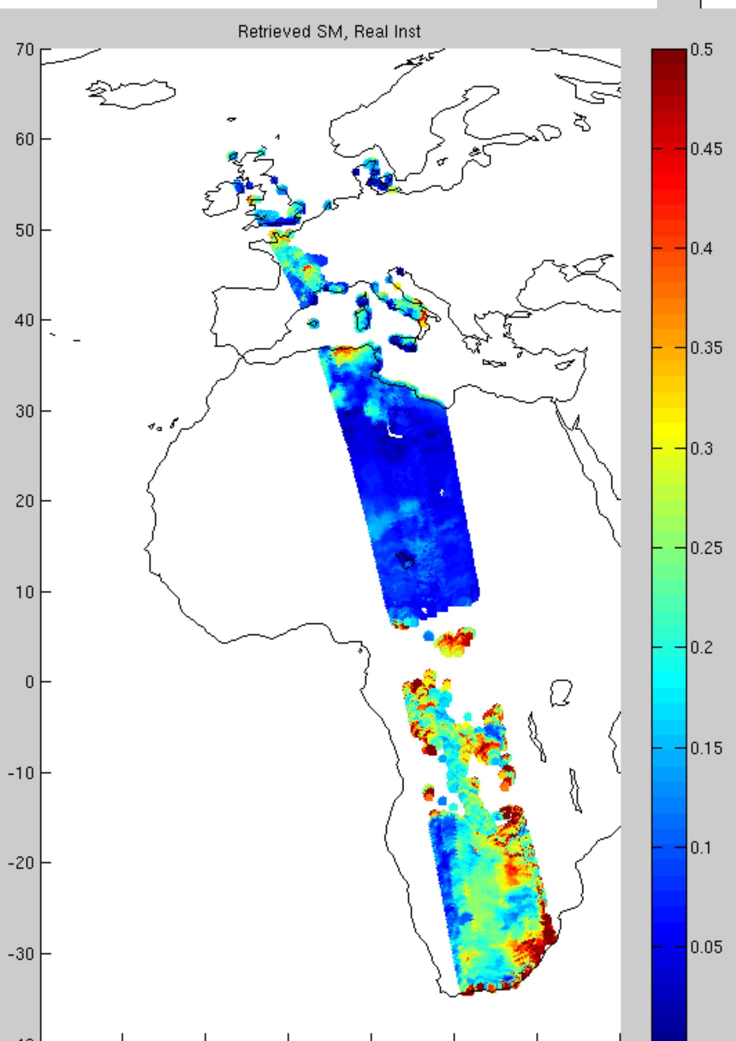
FM0 class	Aggregated land cover	FM class	Complementarity	
A	B	C	D	E
FNO	Vegetated soil + sand	FNO	Comple-mentary	Sum of comple-mentary fractions equals unity
FFO	Forest	FFO		
FWL	Wetlands	FWL		
	Open fresh water	FWP		
	Open saline water	FWS		
FWO	Open water			
FEB	Barren	FEB		
FTI	Total Ice fraction			
	Ice & permanent snow	FEI		
	Sea Ice	FSI		
FUL	Low urban coverage			
FUM	Moderate urban coverage			
FTS	Strong topography		Supple-mentary	Supple-mentary fractions are super-imposed
FTM	Moderate topography			
FRZ	Frost	FRZ		
FSN	Non permanent dry snow	FSN		
	Non permanent wet snow			
	Non permanent mixed snow			

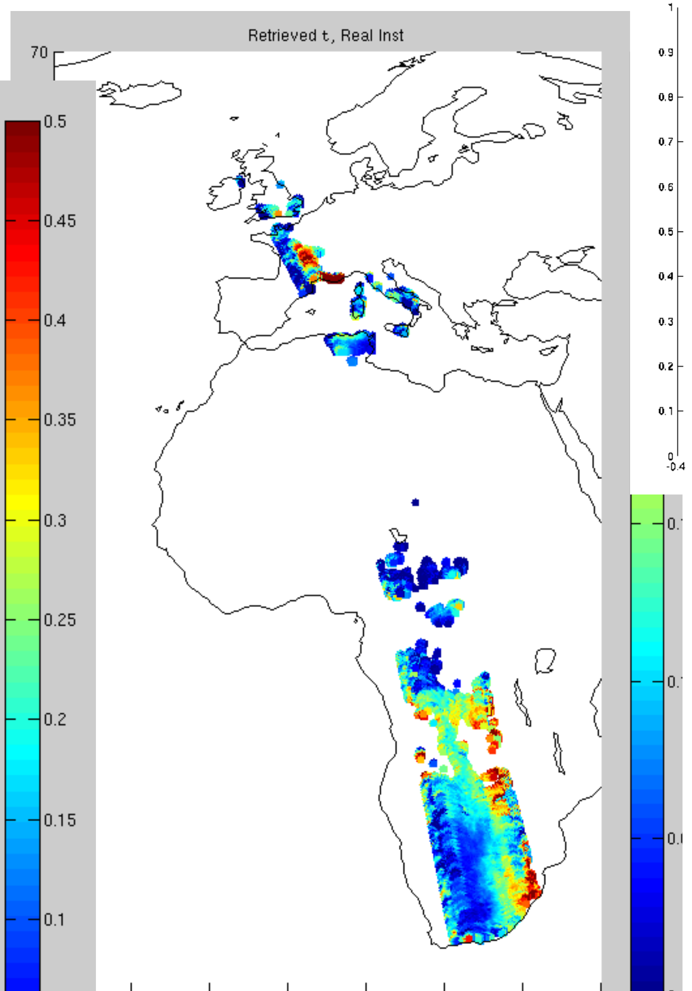


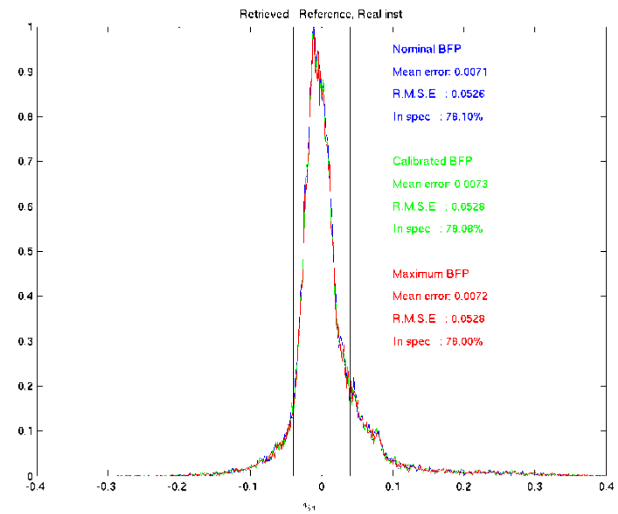
Set of models for each surface type

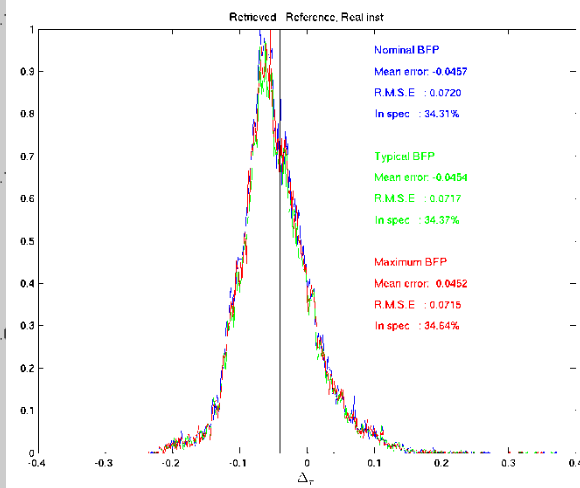
End to End

- Performances for Soil Moisture level2









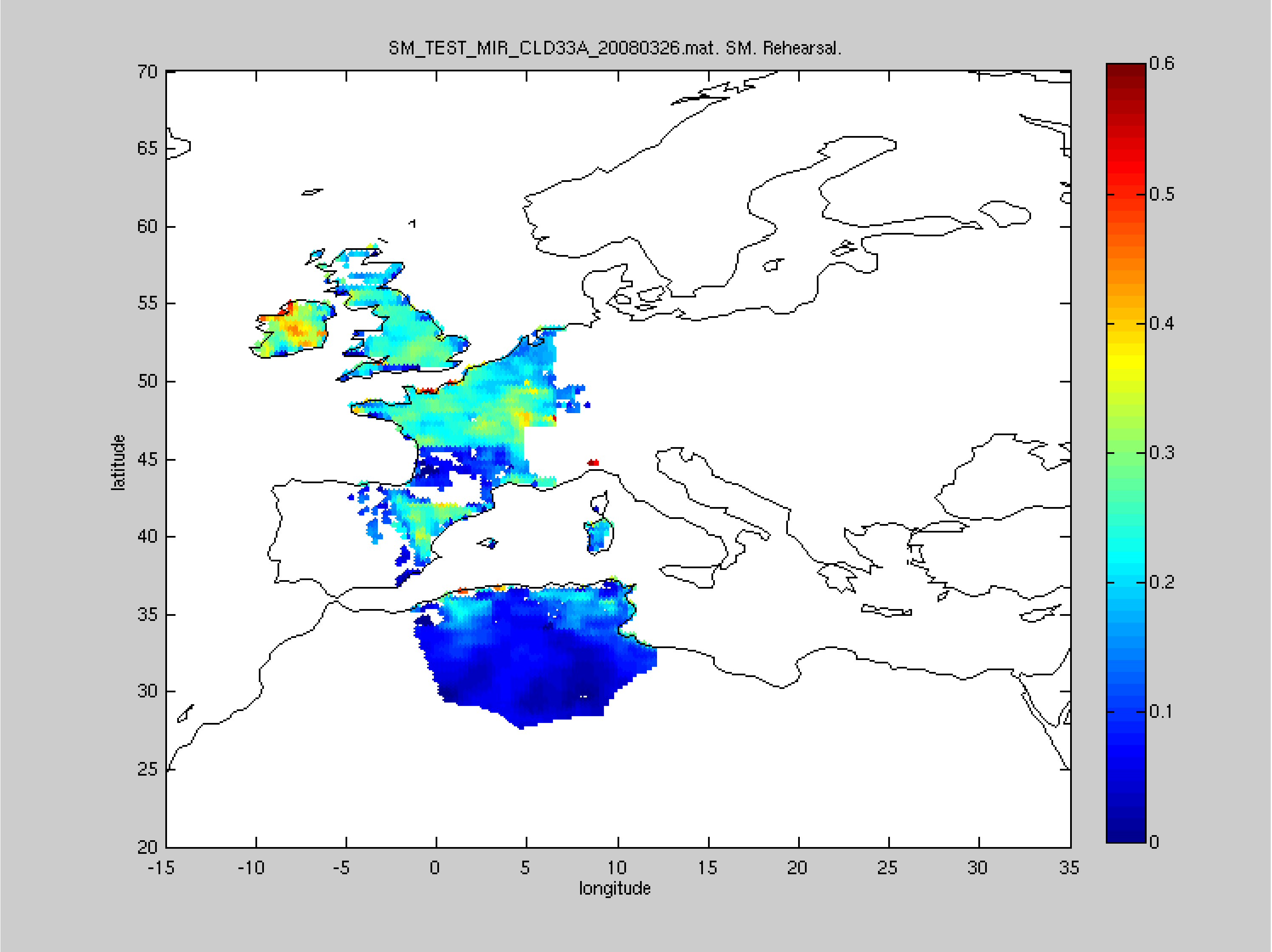
Retrieval characteristics

- Over part of the pixel
- Pixel content taken into account
- Antenna gain taken into account
- « pseudo » dielectric constant
- Temporal aspects (vegetation contribution)

- Extensive Algorithm validation
- Comparison with existing satellite data
- **Needs now actual data**

Higher levels

- CNES products
- L3 SM and OS
  - Spatially aggregated SSS
  - Buoys assimilated SSS
  - Multiorbit invesrion (both)
  - Event detection
- L4 SM
  - Disaggregation
  - Root zone soil moisture
  - Risks detection
  - Multi sensor approach
  - Coastal areas
- Facilities to test your own: snow, texture, sea ice..

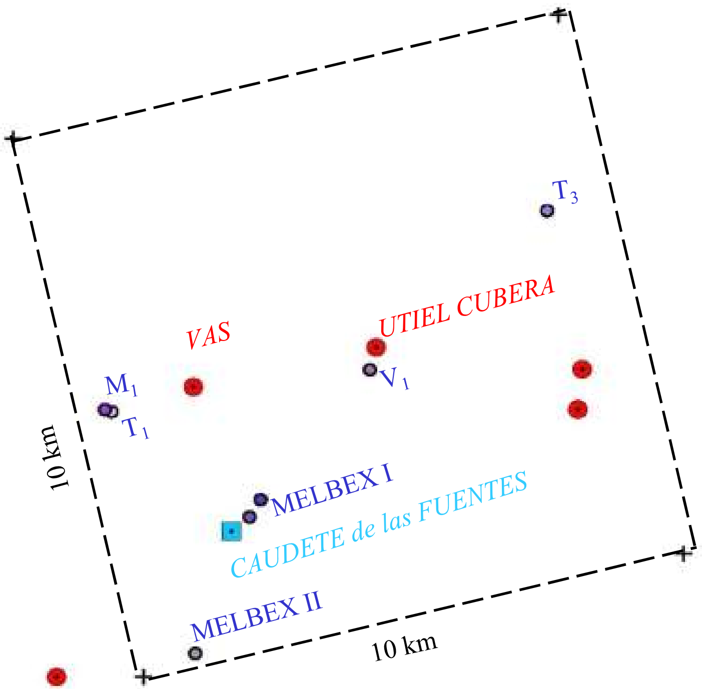

SM_TEST_MIR_CLD33A_20080326.mat. SM. Rehearsal.
latitude
longitude
70
65
60
55
50
45
40
35
30
25
20
-15
-10
-5
0
5
10
15
20
25
30
35
0.6
0.5
0.4
0.3
0.2
0.1
0

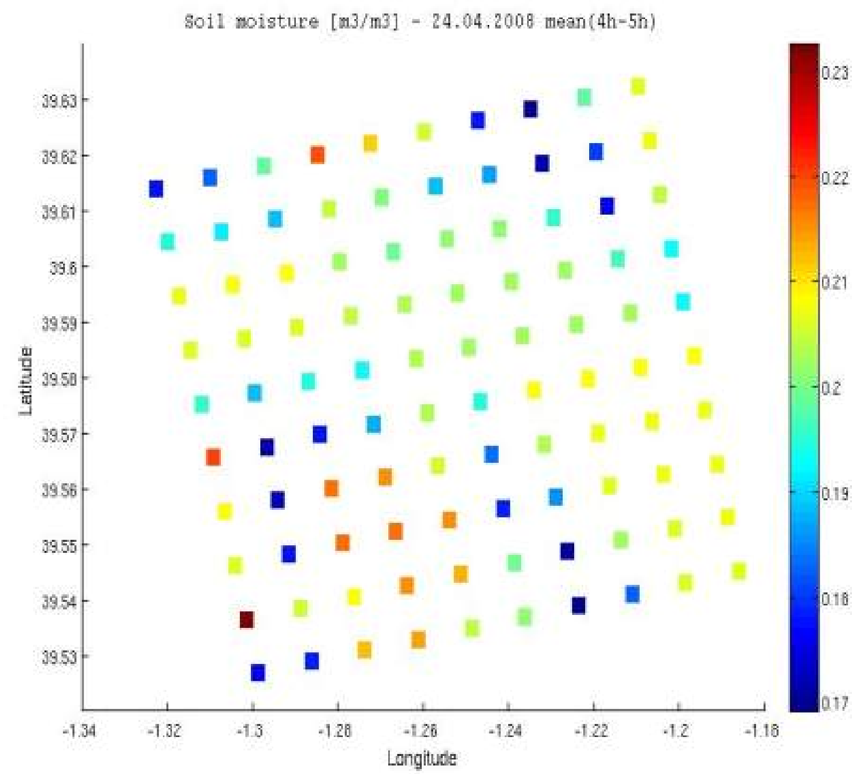
Sites strategy

- Taklamakhan, Dome C, Ocean
- Danube and VAS
- Moisture Map –Australia
- Northern Europe Siberia
- Southern Europe (SW France , Salamanca), USA, Canada
- Western Africa (Mali Benin) South Africa…
- Orther SM sites from ISMWG initiative?

spatialising soil moisture

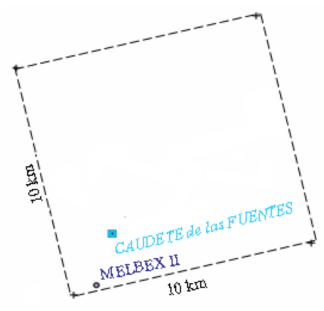
✓ *Interpolating atmospheric forcing with "actual" varying surface characteristics*





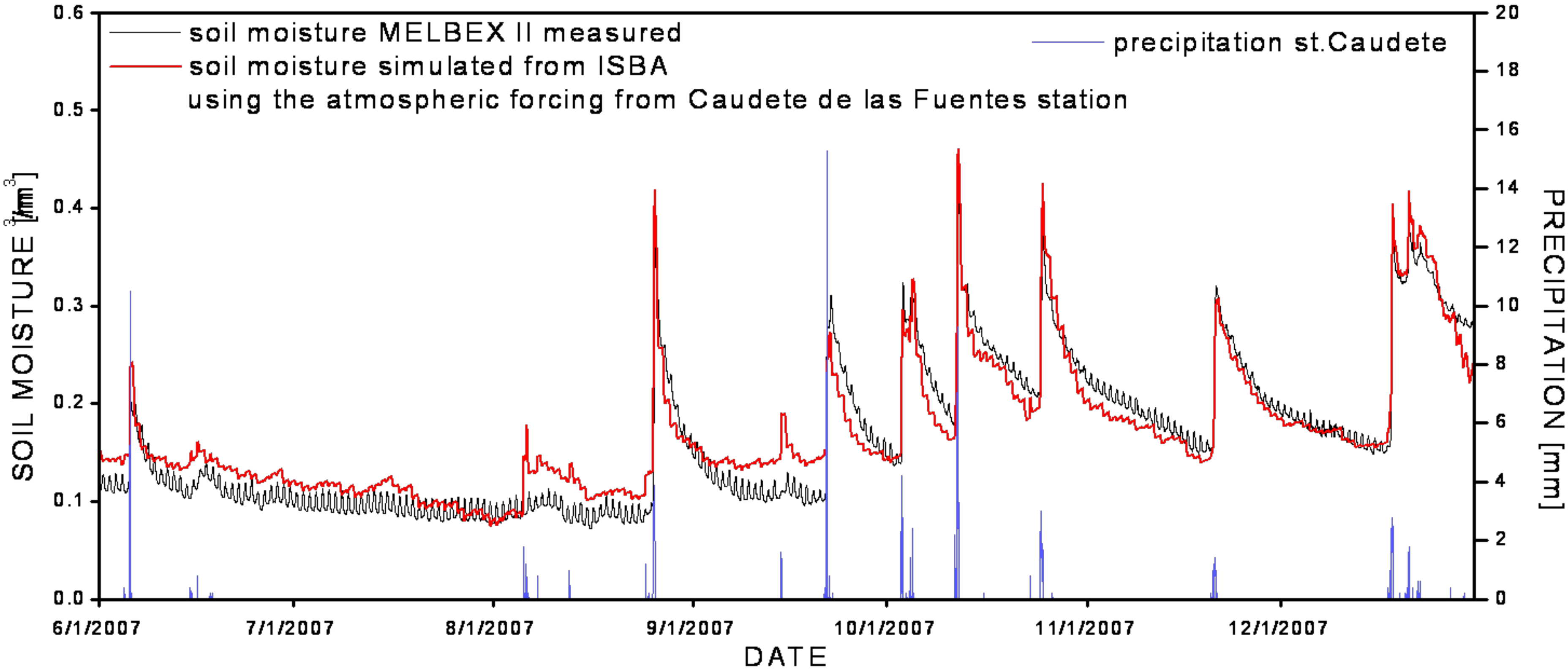
S Juglea et al

Soil moisture simulated with ISBA and LMEB: Comparison with in situ measurements

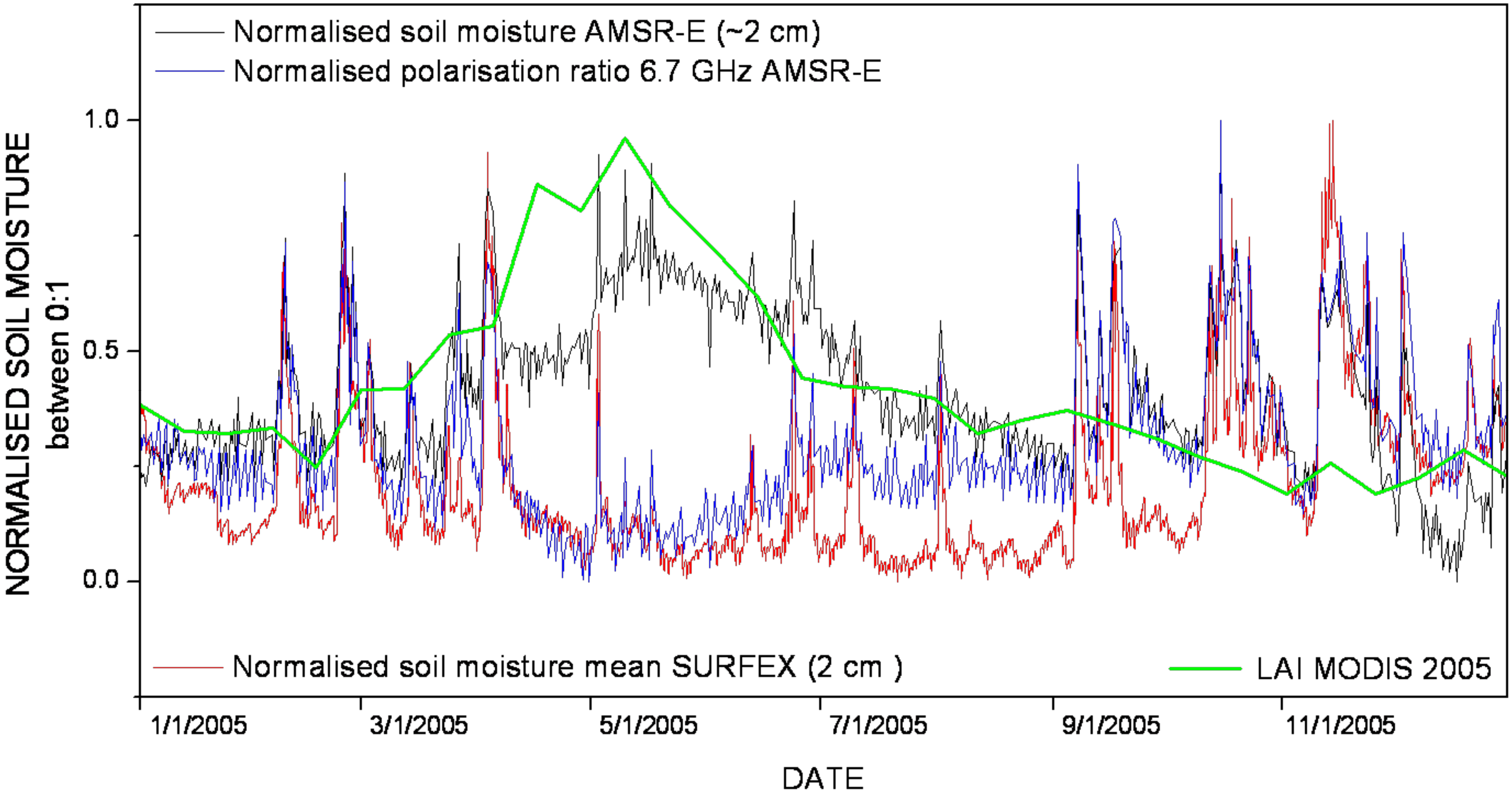


RMSE = 0.0240

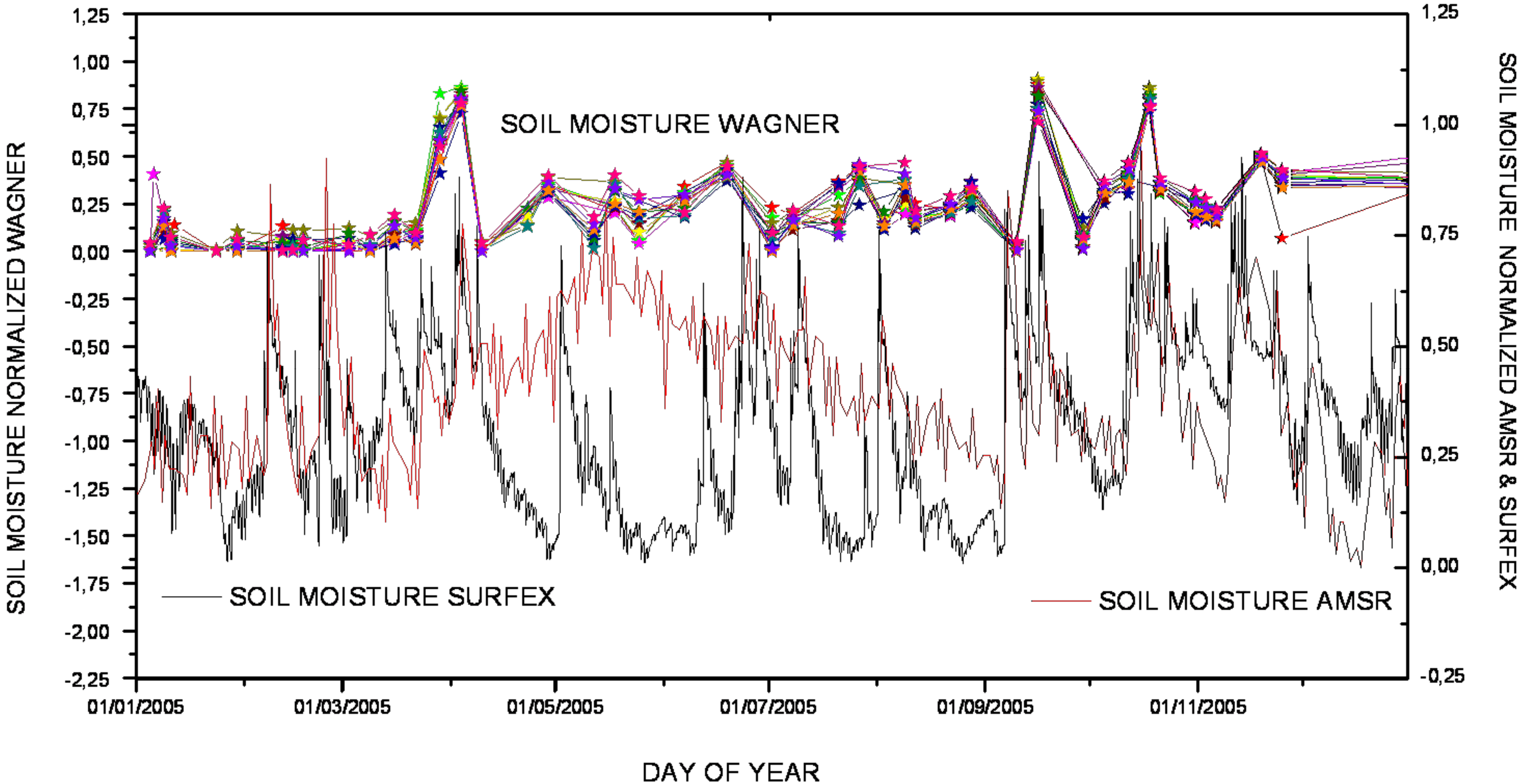
R^2 = 0.9096



And comparison with satellite data



And comparison with satellite data



Next steps SM Algo

- Keep simulators and prototype up to date.
- Analyse commissionning rehearsal data : make use of ground campaign in Germany, Spain, Australia and France.
- Fully validate/ correct during commissioning phase
- Feed back to level 1
- Inter-comparison exercises
- Start working on statistical approaches.
- Synergies ==> AMSR-SCAT, etc…

Issues

- RFI
- Variable water bodies
- Snow ice (partial)
- Water routing
- Algo improvements
- …

Next steps

- SMOS FO?
  - same as SMOS almost
  - But for 15 years (3 off)
- SMOS NEXT
  - Water resources management
  - All specs kept but for spatial resolution (10 times better
  - Or sensitivity (100 times better)
  - Or any combination of the two

Conclusion

- **First two phases are over**
- **Now we must validate**
- **Disseminated**
- **And do research with the data**
- **NOTE**
  - **SM and Vegetation opacity**
  - **Spatial resolution!**

- **In other words still loads to do!**


http//www.cesbio.ups-tlse.fr/us/indexsmos.html
Thank you for your attention
Any questions?