Rationale

- Presentation of what exists
  - Necessity to compare instruments
  - Need for a “reference”
  - Long term data sets
- Some results
- What’s next?

SMOS
Principle and key points

- 2D L band Interferometric fully polarimetric radiometer
  - ❖69 antennas/receivers
  - ❖ 8 m equivalent aperture
- ➢ launched November 2nd 2009
- ➢ http://www.cesbio.ups-tlse.fr/SMOS_blog/
- ➢ http://www.cesbio.ups-tlse.fr/fr/indexsmos.html
- ➢ http://www.esa.int/smos

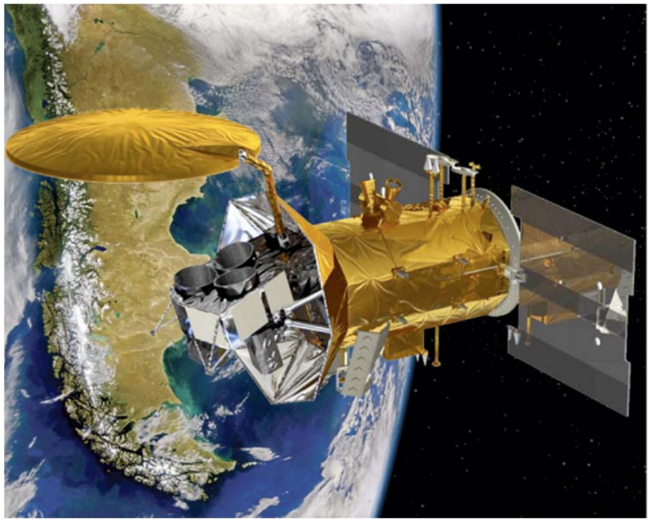
Complete coverage of the globe
 in less than 3 days at
both 6 am and 6 pm and
multiangular acquisitions

- 43 km average (real) resolution

AQUARIUS

Partnership between NASA and CONAE for monitoring Sea Surface Salinity from space.

- 3 radiometers (+ 1 scatterometer)
  - L-band 1.413 GHz
  - parabolic reflector, 3 feed horns
  - filled aperture (2.5 m)
  - ^patial resolution 100 km
  - Every 8 day at 6pm 6am
- launched June 10th 2011
- http://www.nasa.gov/aquarius



The contenders

- Only active missions providing L-Band global measurements of brightness temperatures
- Primary objectives are soil moisture and ocean salinity retrieval.

SMOS **since November, 2nd 2009**

4 Stokes, incidences [0°,65°]

Radiometric interferometer

Calibration based on internal noise diodes and deep sky

1st reprocessing data set

V550 –>V 600

Aquarius **since June, 10th 2011**

3 Stokes, incidences 29.3°, 38.4°, 46.2°

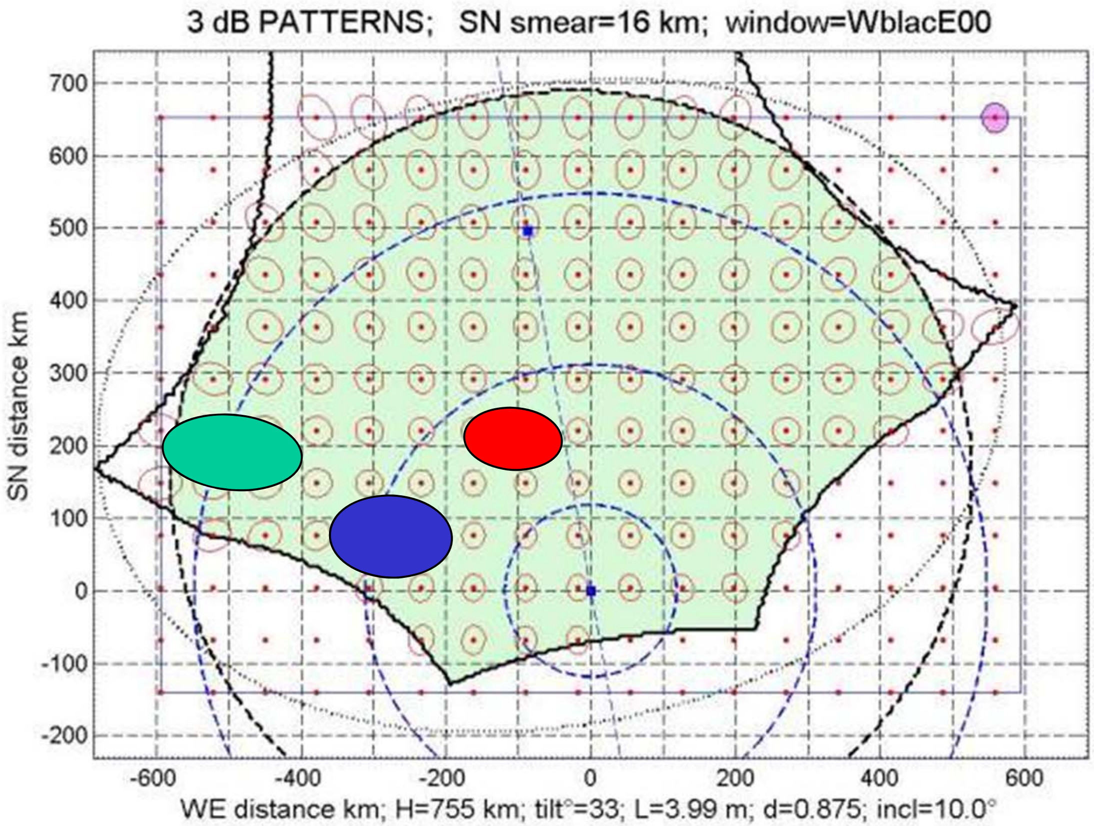
2.5 m reflector and feed horns

Calibration based on internal noise diode and vicarious

Processing V2.0

Lagerloef et al.

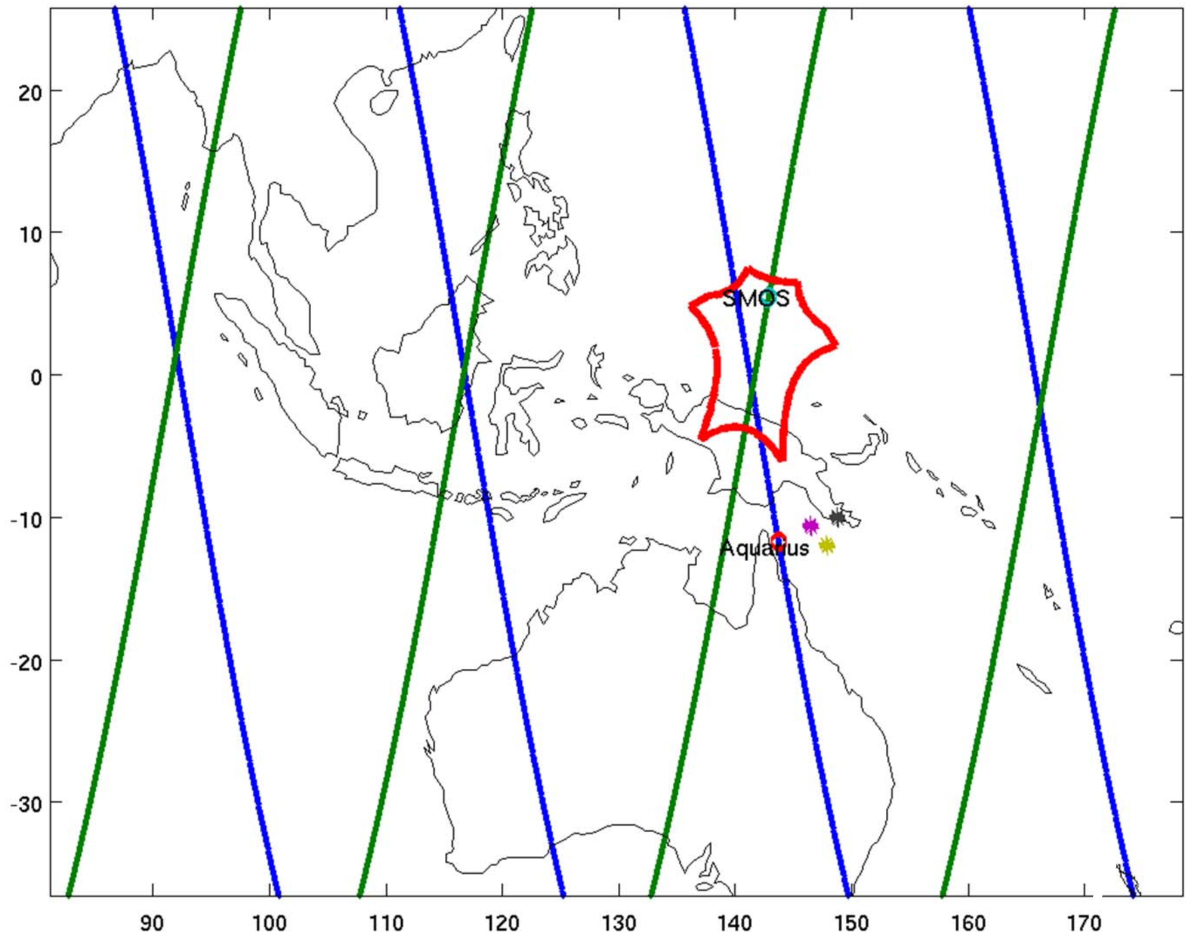
AQUARIUS and SMOS



SMO Aquarius co-locations

Every 3 days, SMOS over flies Aquarius in 2 to 4 occasions
Over 500 days in 2011-2012, over 750 co locations where selected

Over fly:
Seen from ground apparent distance less than 2.5°



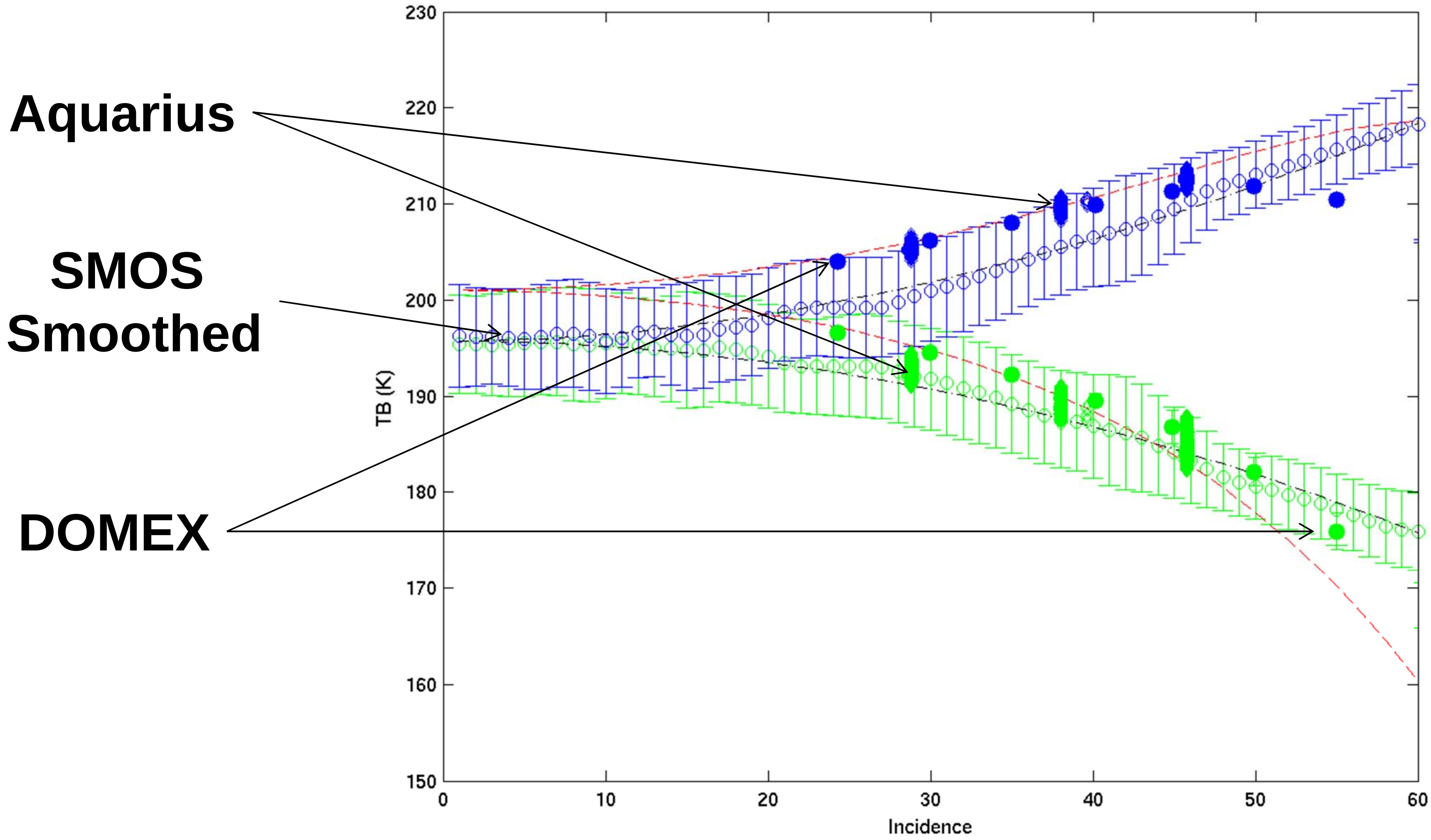
F. Cabot

Inter-comparison

- Need to find similar TB!
- Need to have similar geophysical products
- Need find ways to efficiently go from one to the other

- Inter calibration
  - Deep space
  - Ocean
  - Warm target (Antarctica?)
- SS product inter-comaprison
  - More challenging over land (different spatio temporal samplings)

DOME C



Cabot et al.

Long term stability over Antarctica

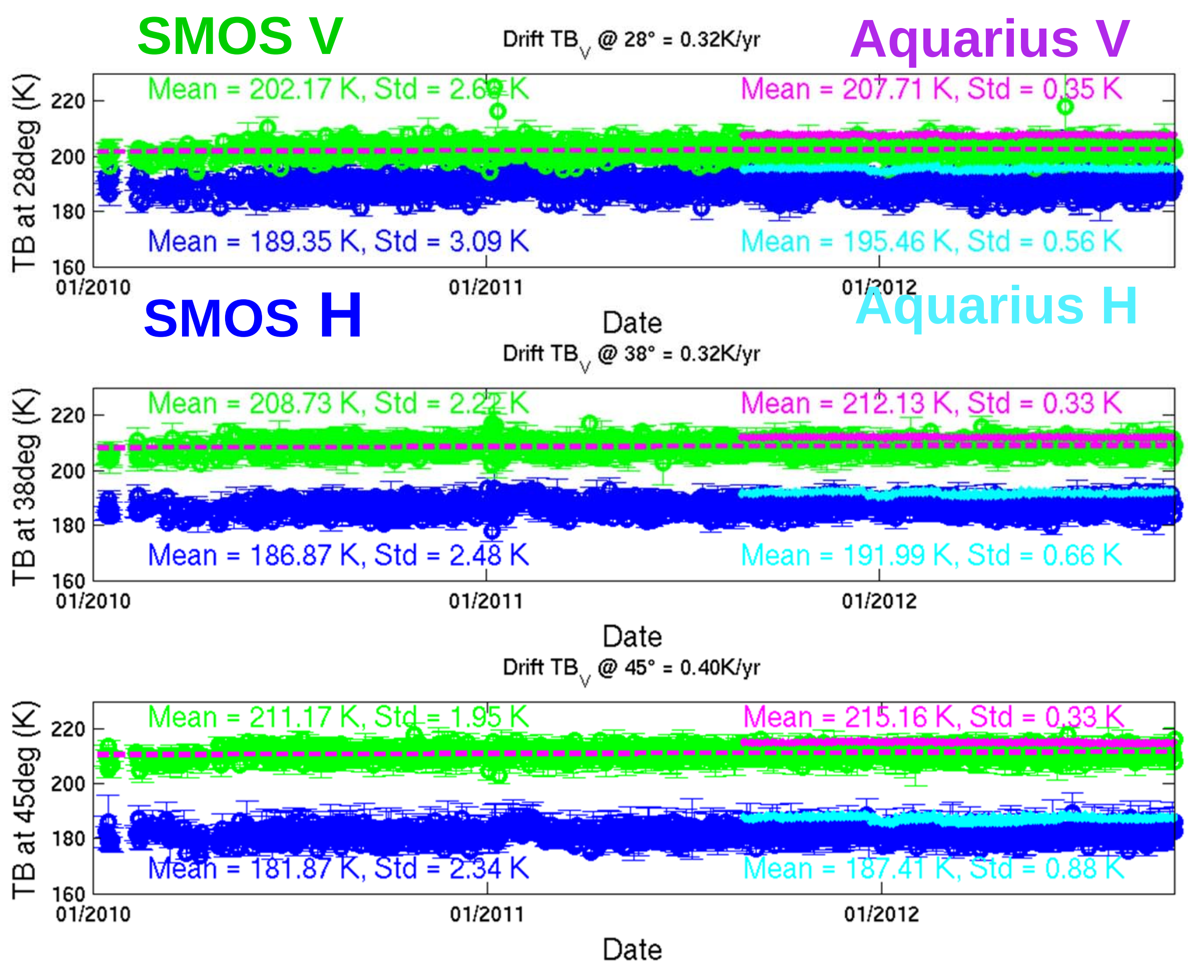
Both instruments show good long term stability

Difference in sensitivity clearly evidenced

Summer surface changes induce noisier behavior at V polarization

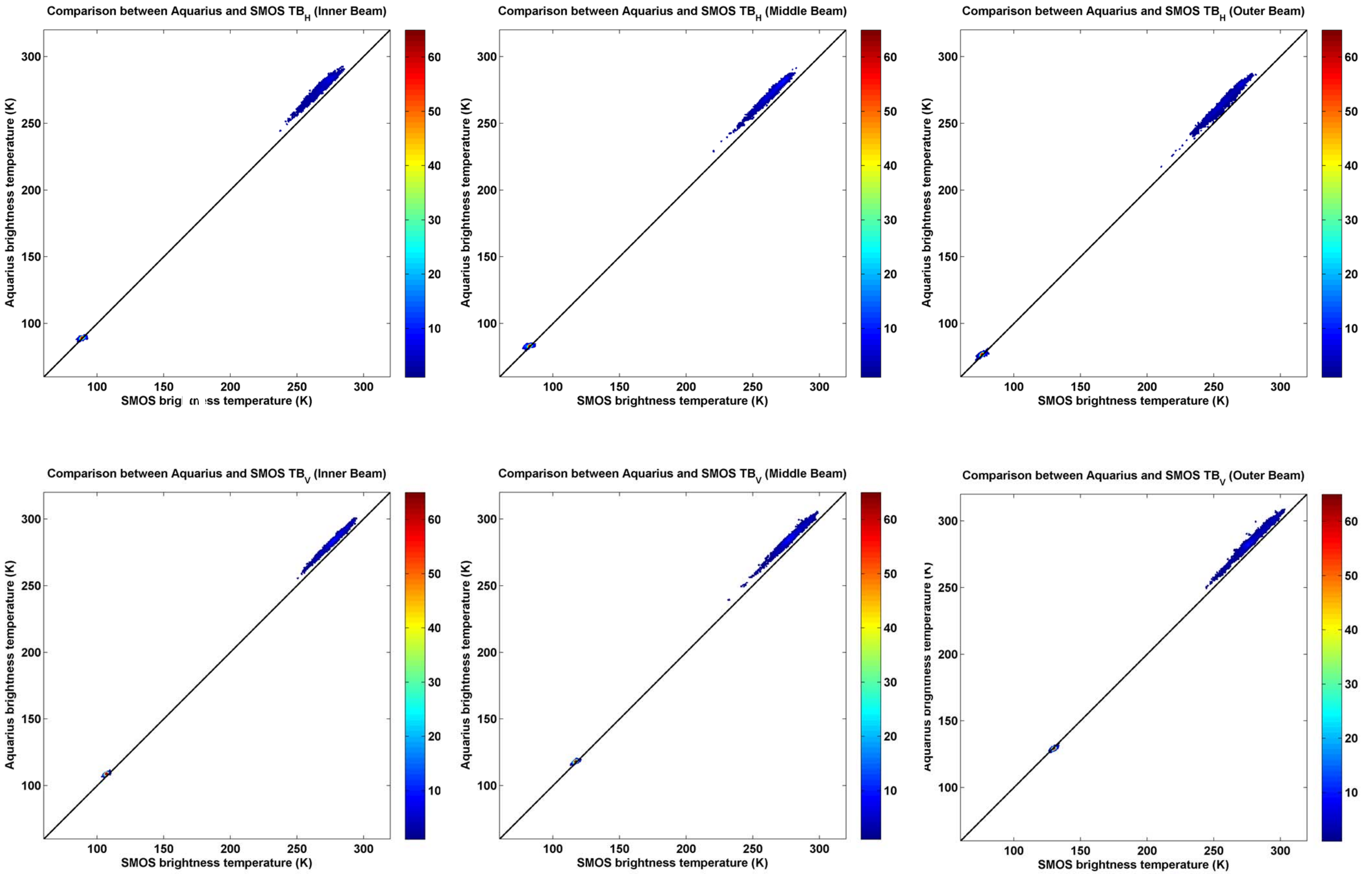
Mean biases

	H	V
inner	6.11	5.54
middle	5.12	3.40
outer	5.54	3.99



Cabot et al.

Comparison between Aquarius and SMOS



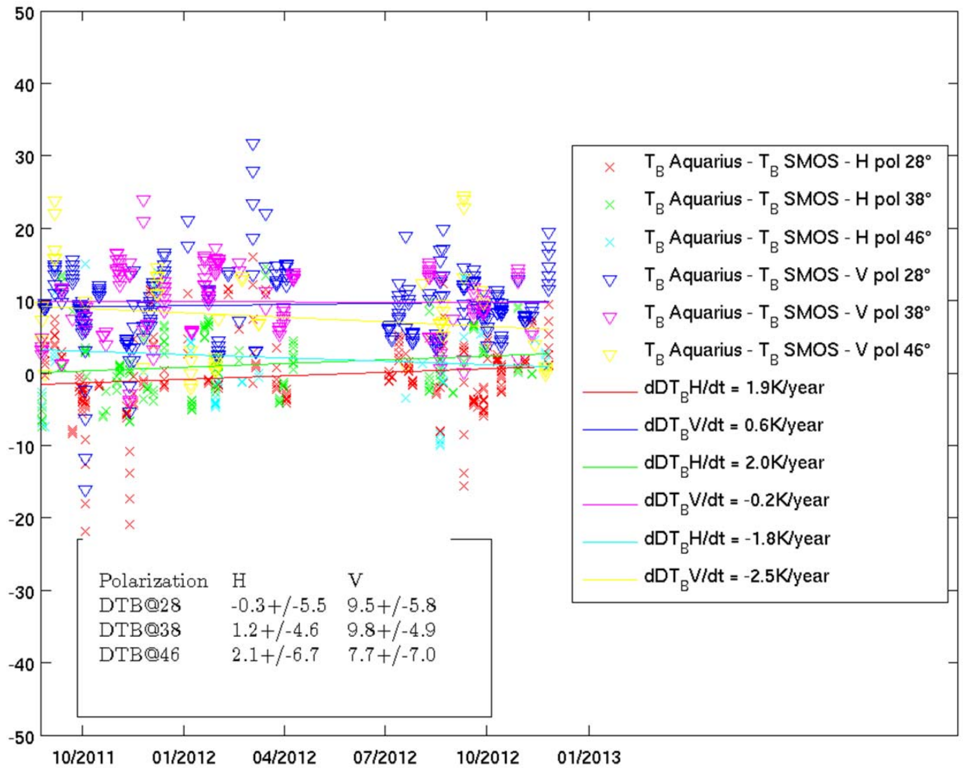
Rajat Bindlish and Tom Jackson, USDA

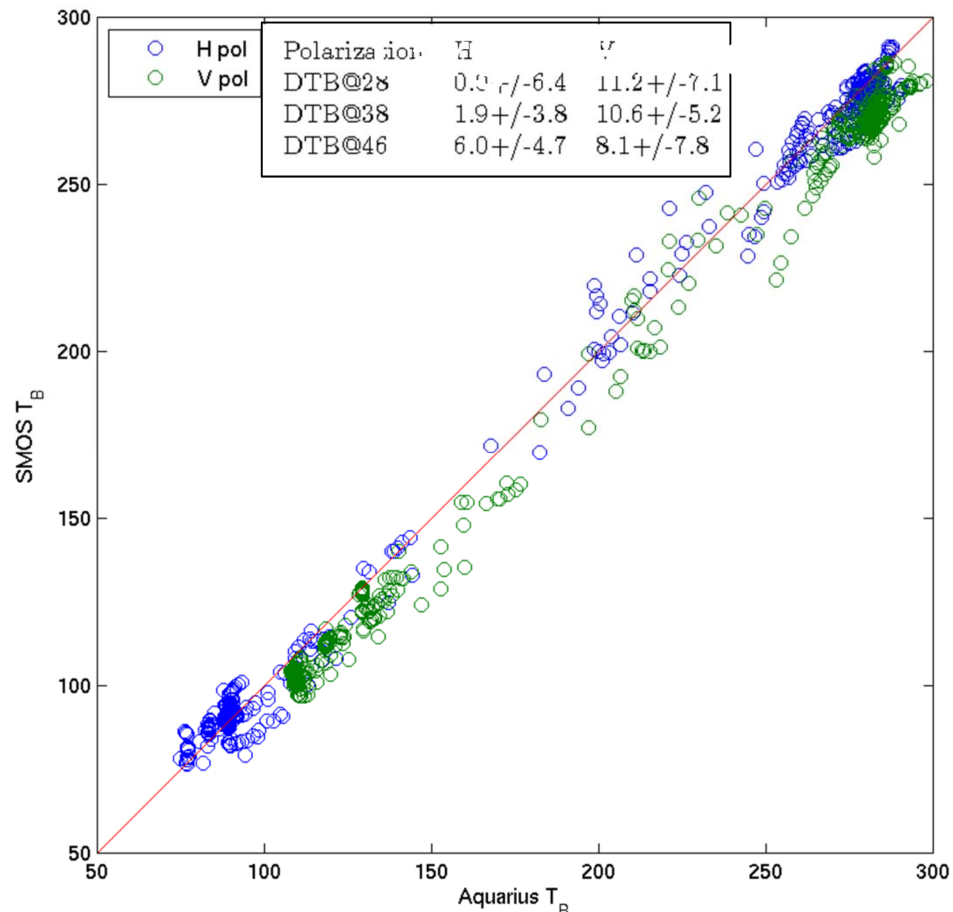
SMOS-Aquarius comparison over all surfaces

Collocations show slightly different trend from DomeC

Main issue is dependency wrt Tb evidenced by selecting land only

Accuracy is much lower because of surface heterogeneity





F. Cabot

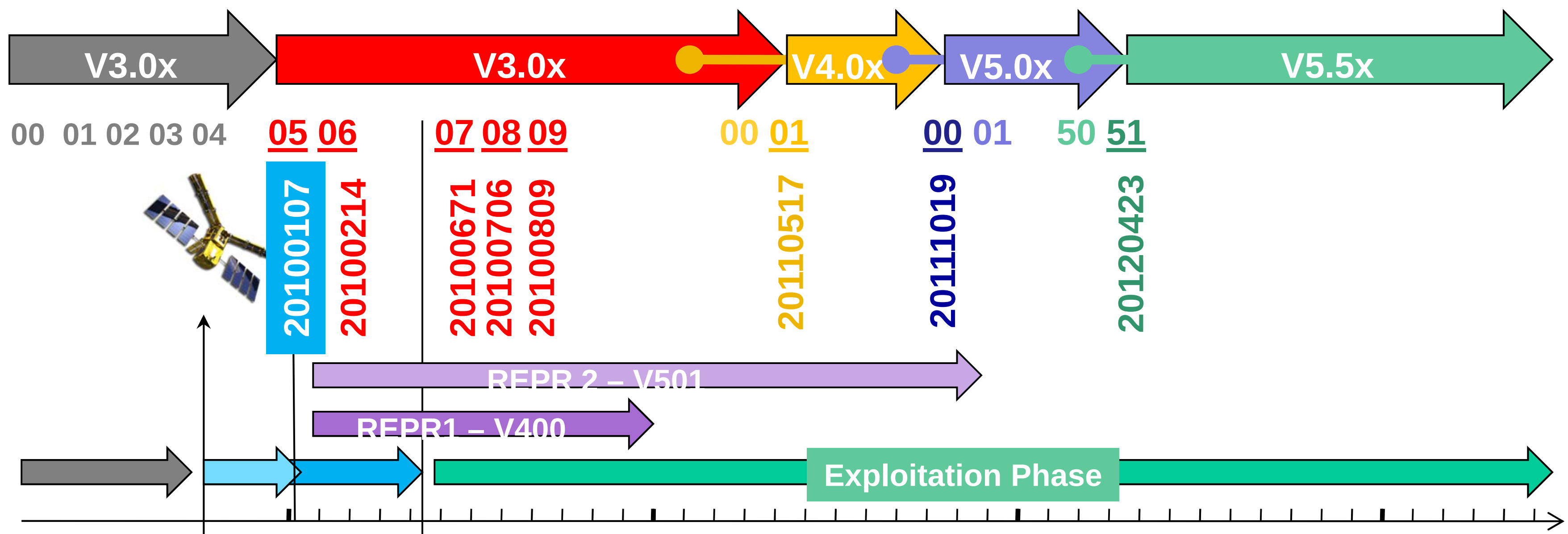
The SMOS view

- Approach
- Issues
  - Versioning
  - Quick evolution but larger and larger data sets Cal Val and results

Calibration

- Need either
  - A large area fully and perfectly known and modelled
    - Does not exist
      - Spatial Heterogeneity
      - Temporal evolution
  - Or an area homogeneous and very stable
    - Ocean
      - Wind speed, SST
    - Antarctica (dome Concordia)
    - Galactic pole
      - Need manoeuvres
  - Avoid using unless fully mastered
    - Deserts → source of issues → science topic by itself
    - Forest not stable →see later
    - Greenland → strange behaviour → science topic by itself
    - Etc!

SML2PP Evolutions For The Past 3 Years



3.06 Introduction to the switch ESL mode / OPER mode

3.09 Only the retrieval parameters are given the other set to -999
DFFLAI is based on ECOCLIMAP only – no more MODIS mixed

4.00 Dual Pol in Full Pol mode
New Formulation for Forest Tau function of LAImax and LAI(t)
☞new versions of DFFLAI & DFFLMX from ECOCLIMAP
Scaled SWVL1 added to AUX_ECMWF & AUX_ECMCDF created

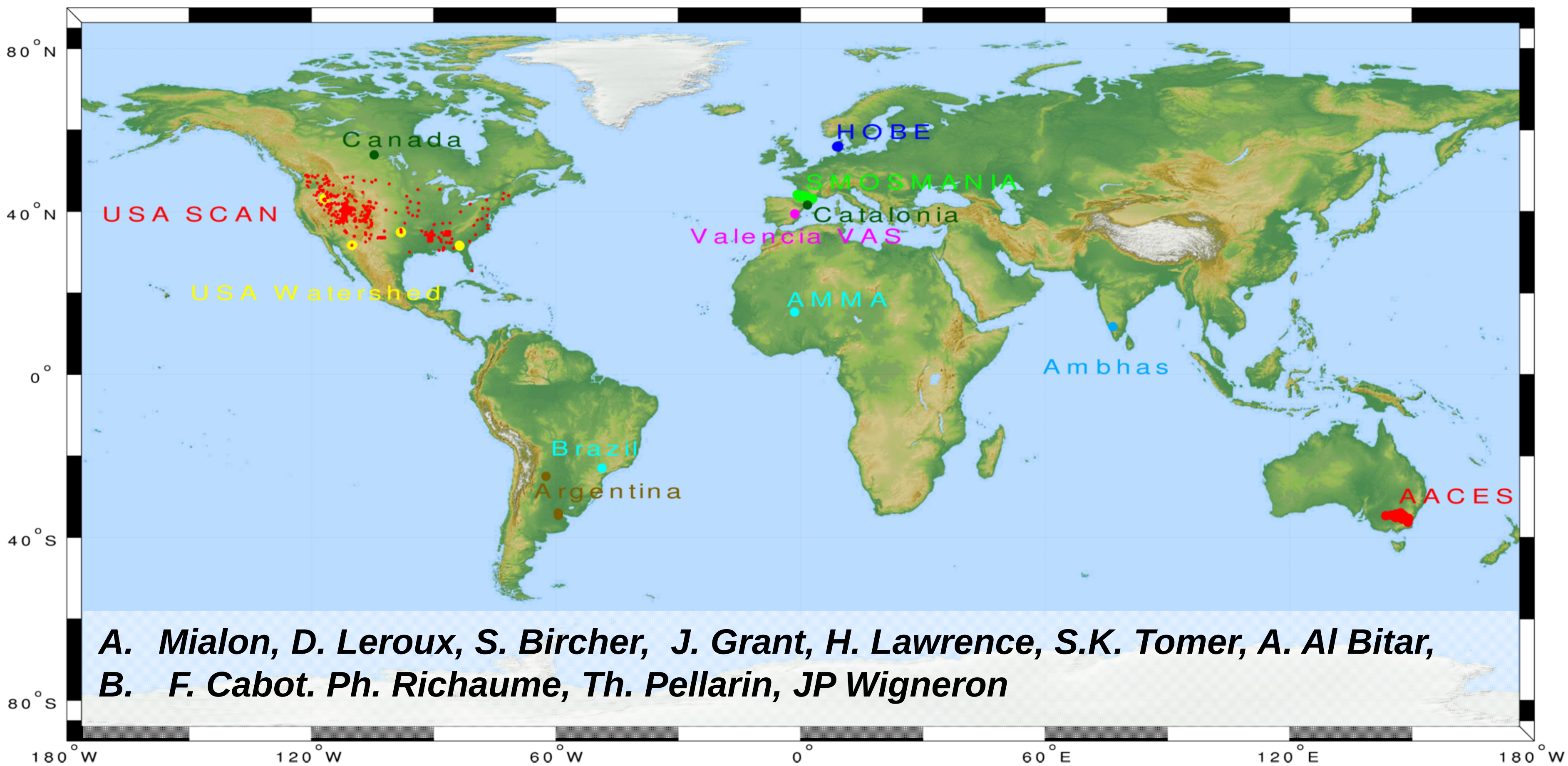
5.01 RFI screening now uses dynamic thresholds ⇒ stricter
RFI probability from AUX_DGGRFI added to the UDP
SML2PP becomes multithreaded the largest orbit = 1h30 max

5.51 Mironov dielectric constant model is added and activated

Validation: the SMOS approach

- Rely on good quality validated networks (US watersheds)
  - Worked very well
- Rely on some ground sites
  - Well known, and monitored
  - With a radiometer
  - Representative or with tools to expand to 50 km resolution
    - Uniform (Dome C)
    - Spatialised (Valencia Anchor Site or Danube Upper Basin)
  - This did not work so well
- Rely on A/C campaigns
  - Australia
    - Worked poorly during the commissioning phase (SMOS data access from ESA) but provided some data
  - Europe
    - Not much yield

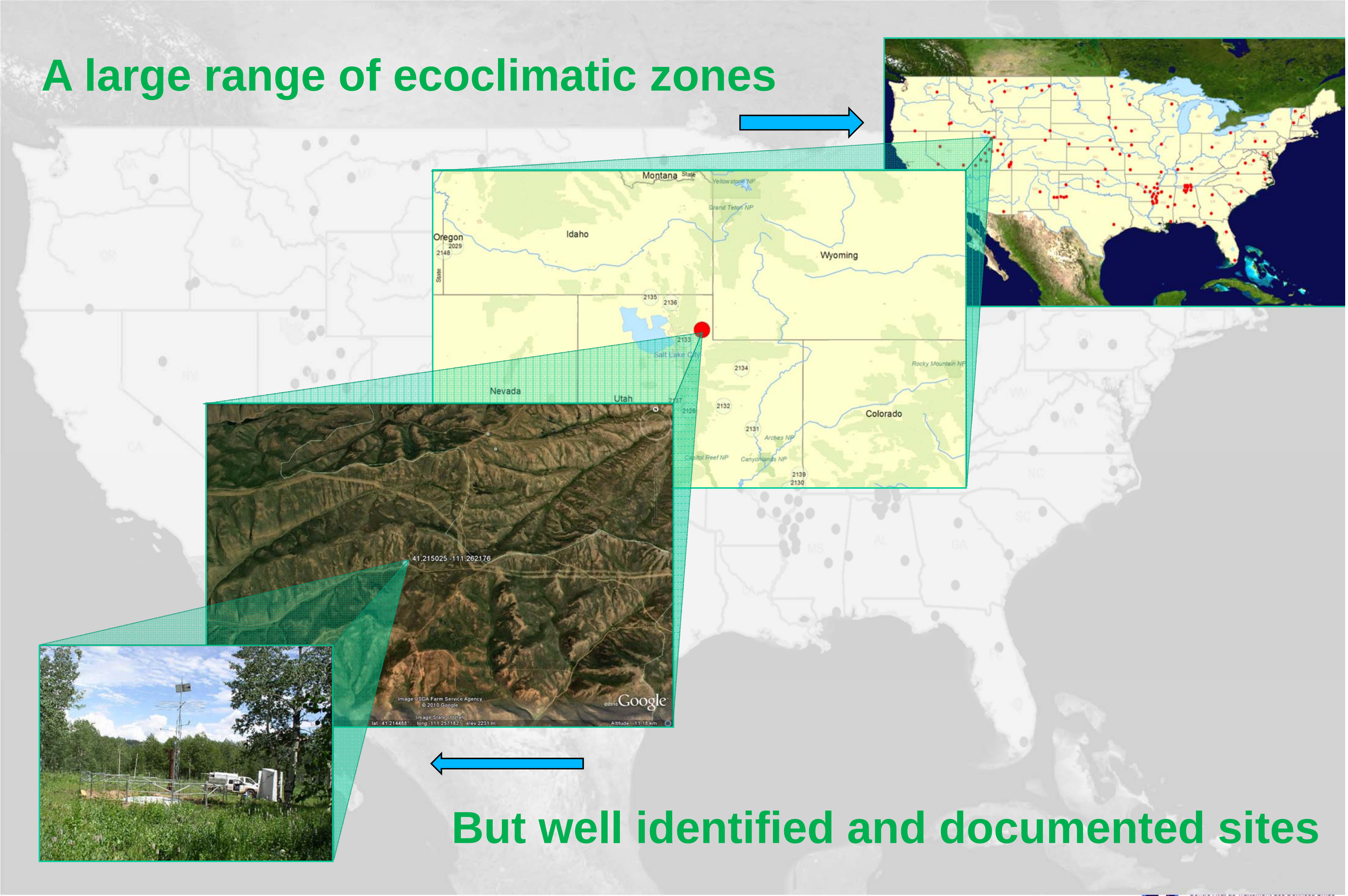
Many in situ datasets



Collaborations : T. Jackson, E. Lopez, M. Sekhar, J. Walker, E. Wood

SCAN network

A large range of ecoclimatic zones

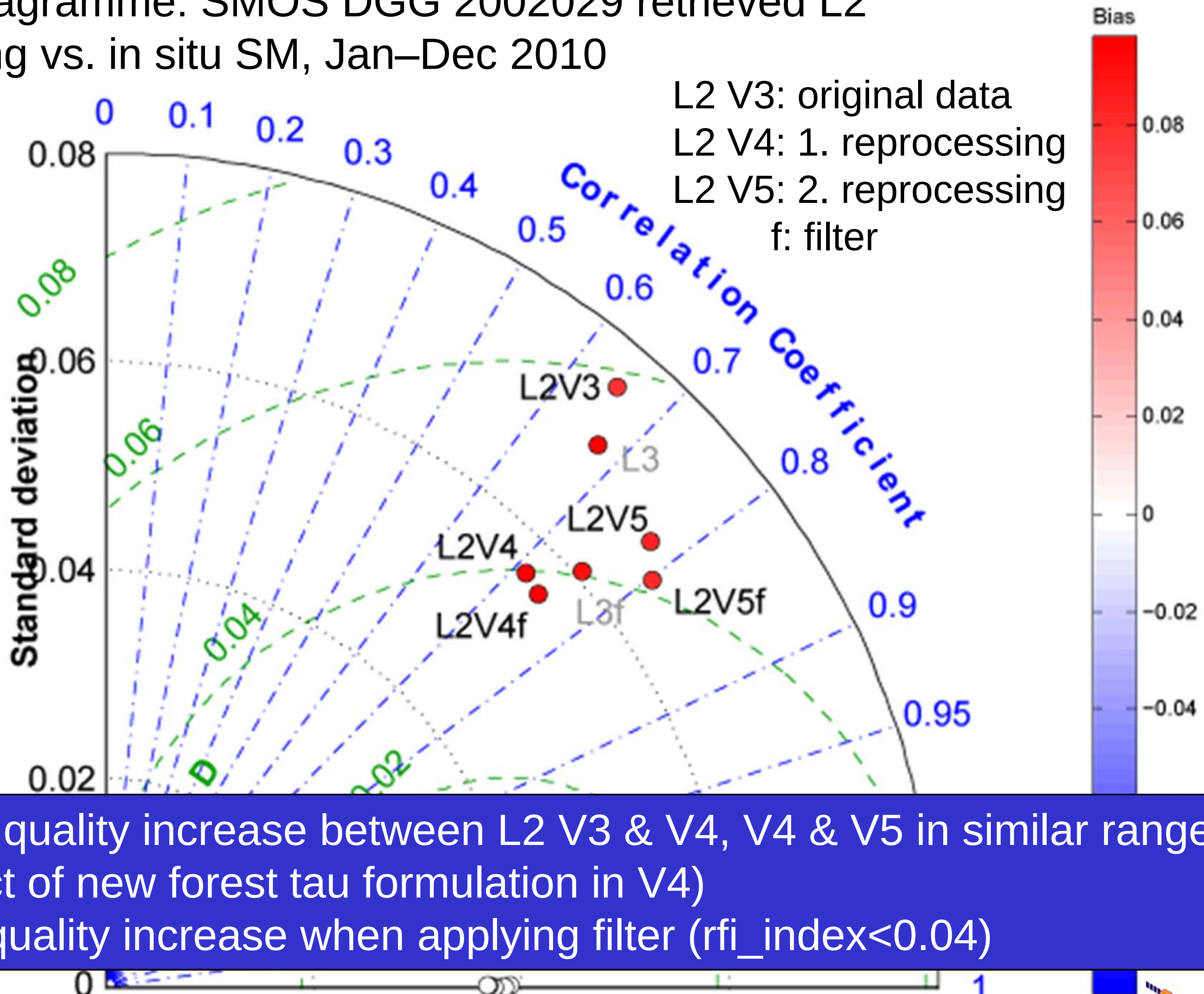


But well identified and documented sites

S Bircher - HOBE

Taylor diagramme: SMOS DGG 2002029 retrieved L2 ascending vs. in situ SM, Jan–Dec 2010

L2 V3: original data
L2 V4: 1. reprocessing
L2 V5: 2. reprocessing
f: filter



→Clear quality increase between L2 V3 & V4, V4 & V5 in similar range (high impact of new forest tau formulation in V4)

→Also quality increase when applying filter (rfi_index<0.04)

[Figure adapted from A. Mialon]

Soil moisture retrieval validation

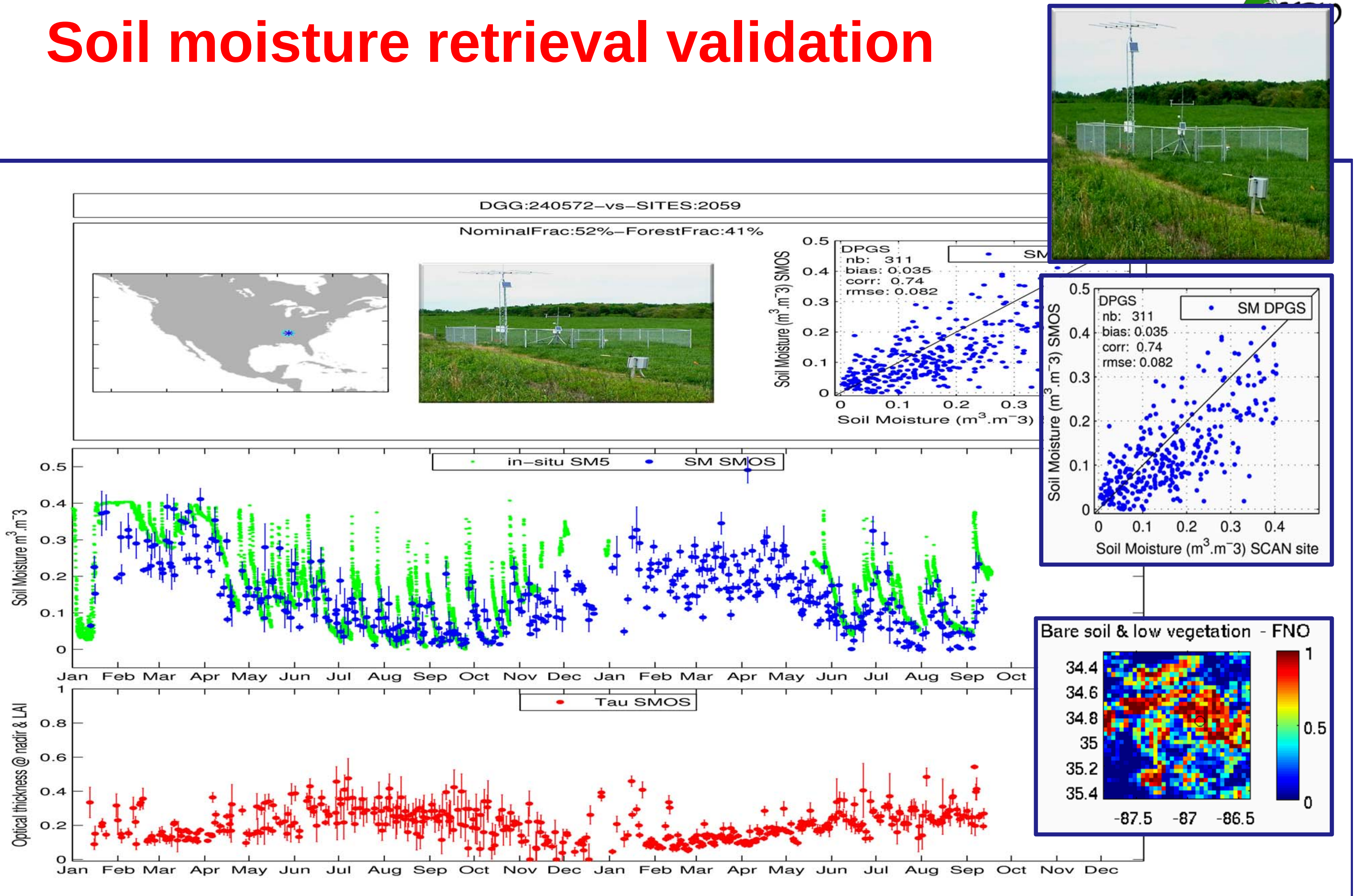
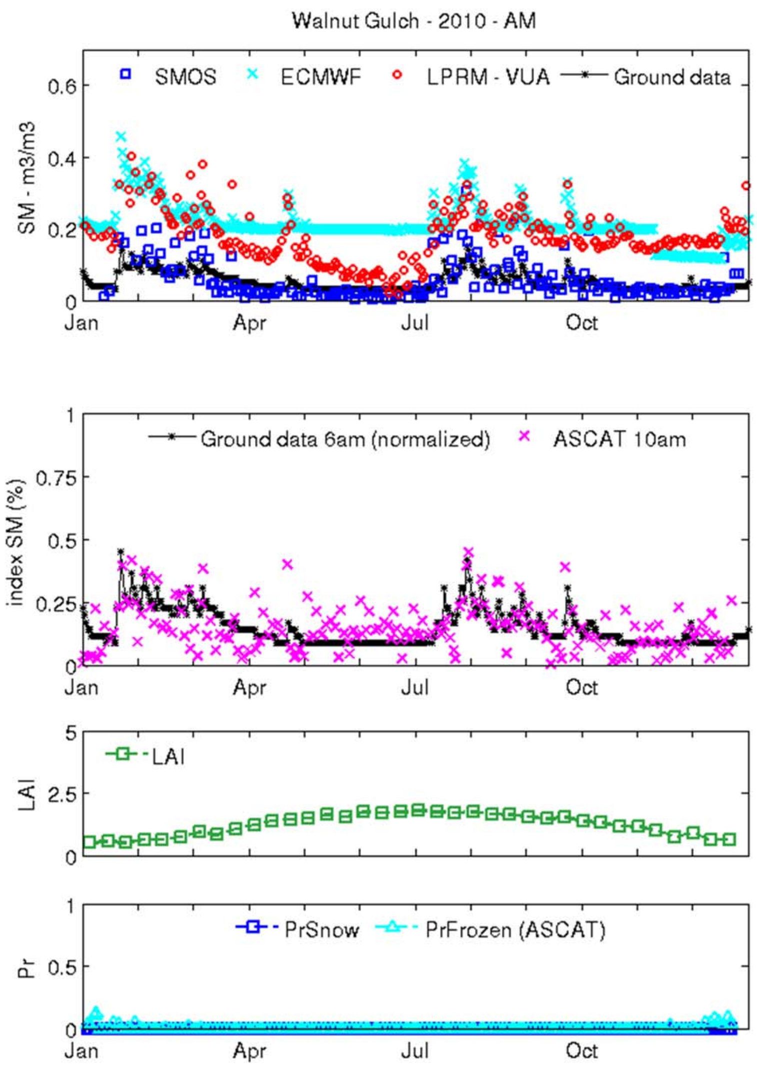
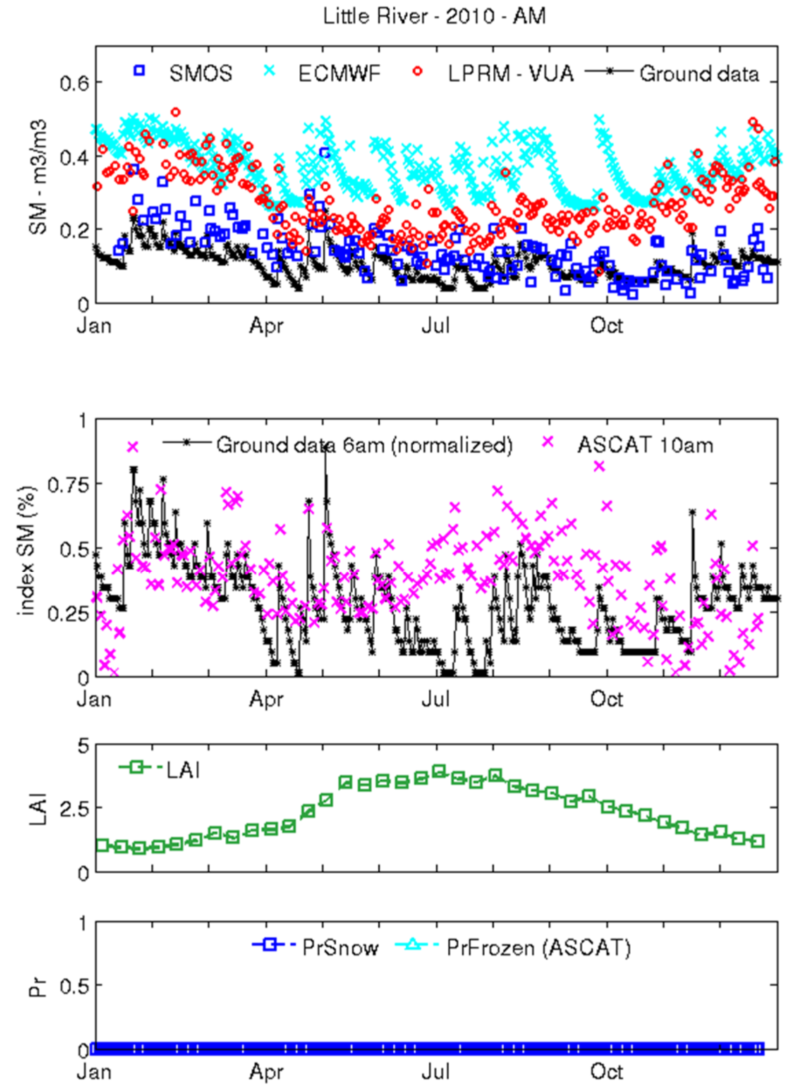


Fig 2. Time series over site 2059 with filtering for Percentage of RFI < 30%, SM_DQX < 0.07 and Tau_DQX<0.15.

(Al Bitar et al., 2011), (Al Bitar et al. 2012)

US Watershed





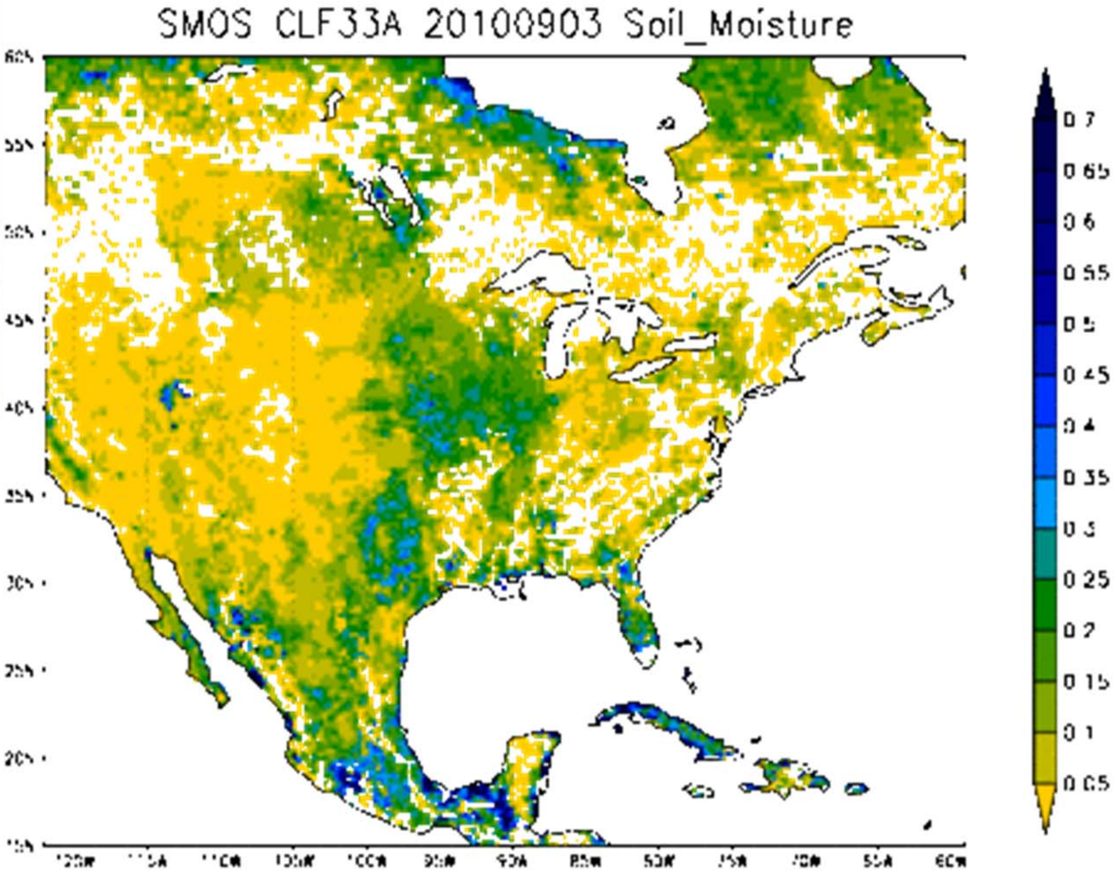
D. Leroux, T Jackson

Representative of SMAP/ SMOS pixels

Examples of results

- Hurricane impact Floods
- Forest modelling
- Root zone soil moisture
- Droughts
- Dis- aggregation
- Frozen soils

Monitoring Hurricanes over land



Towards risk mapping

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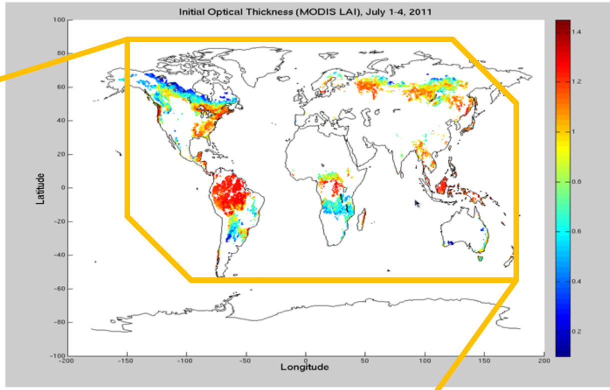
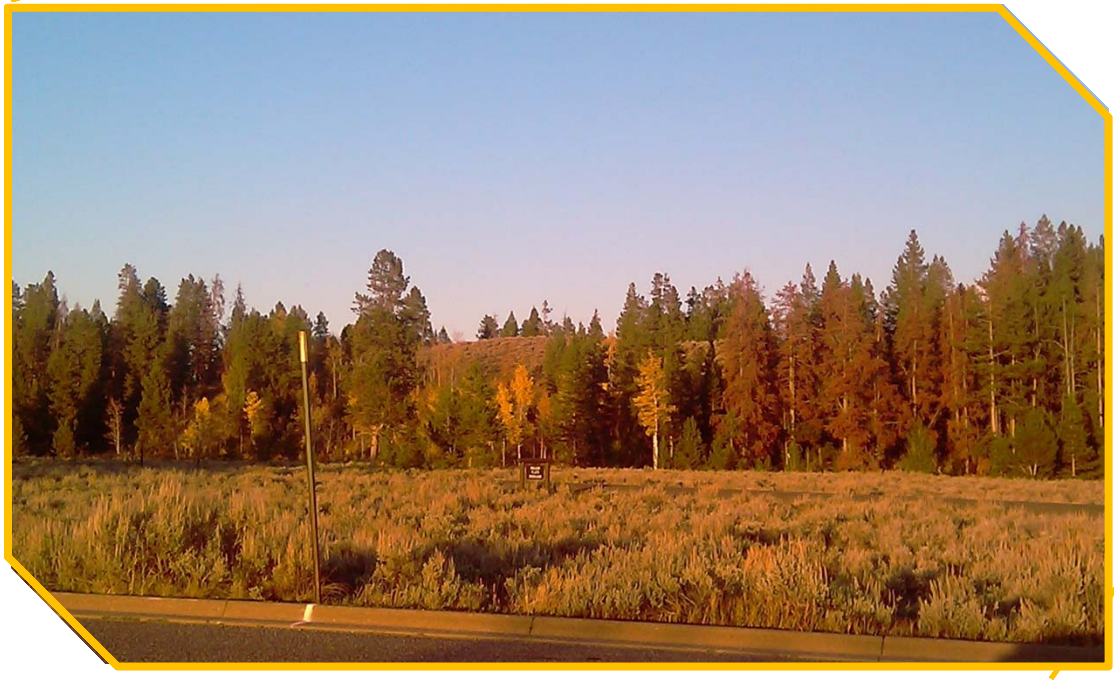
Forested areas





Forest Biomass

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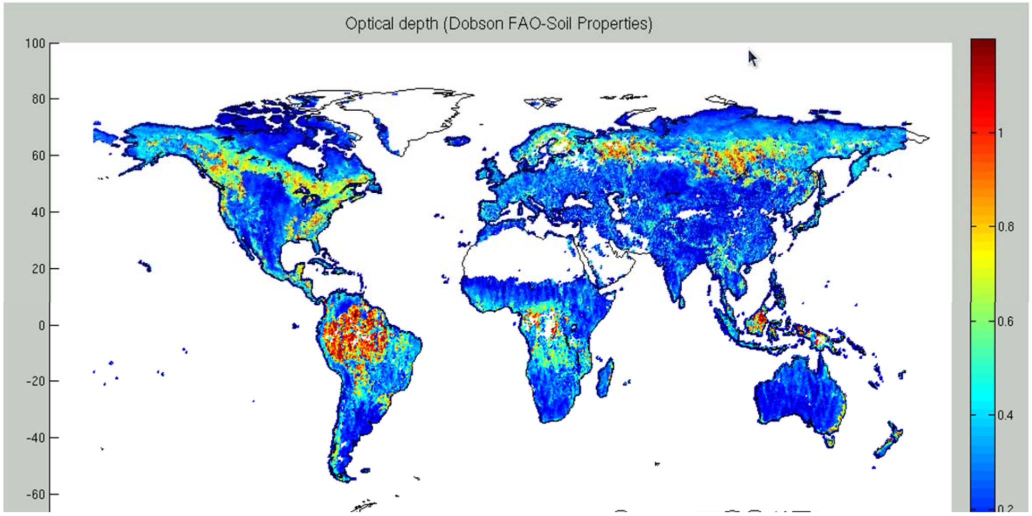
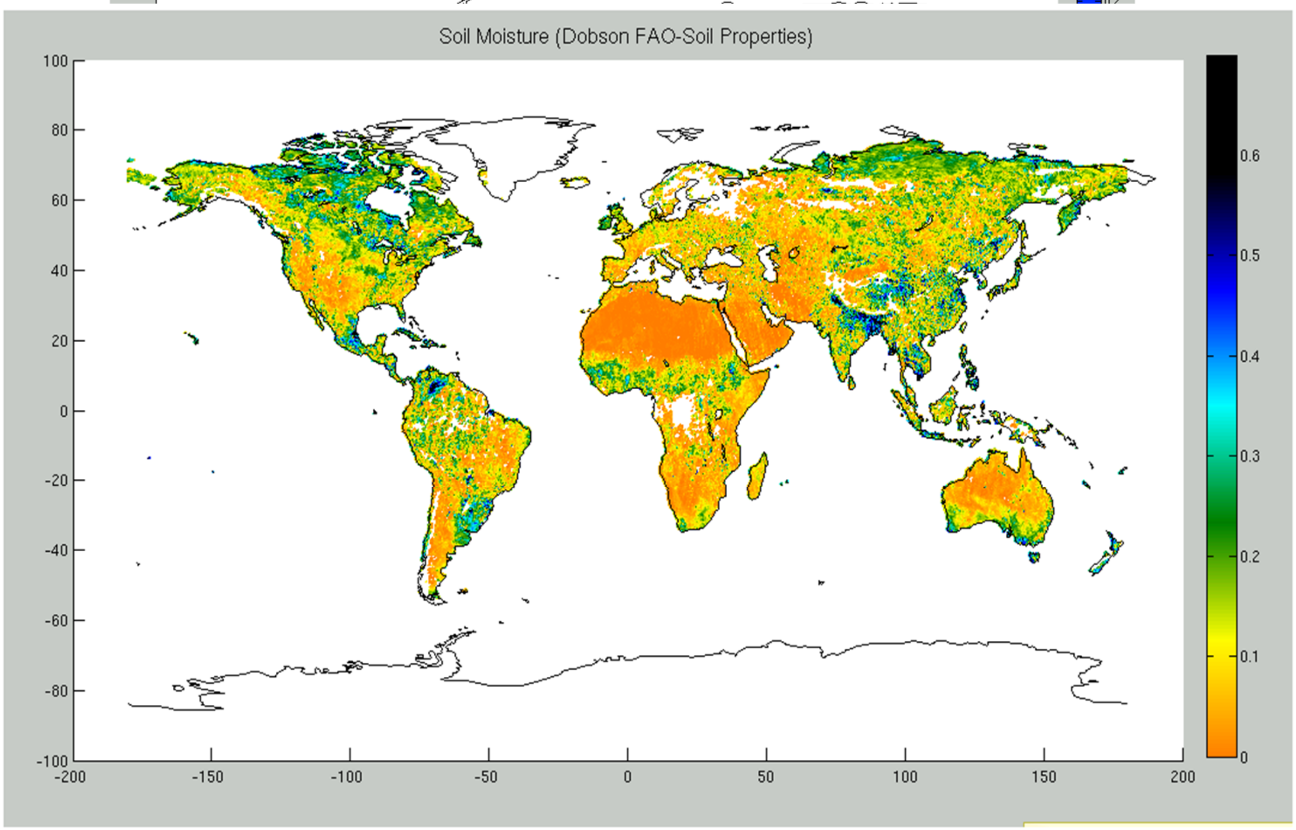
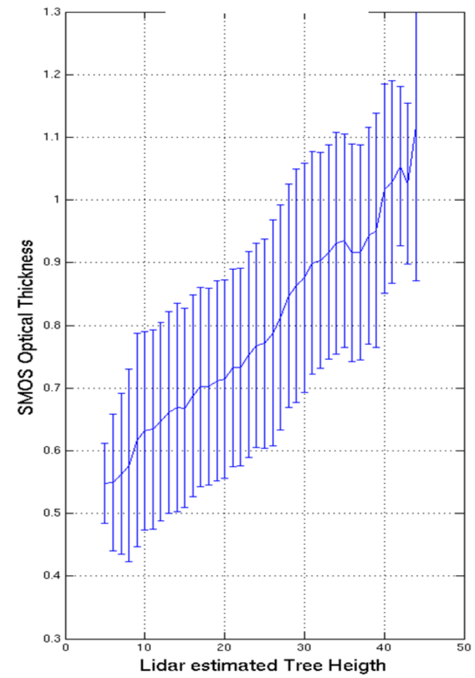
Global Map of retrieved optical thickness

Ferrazzoli
Rahmoune



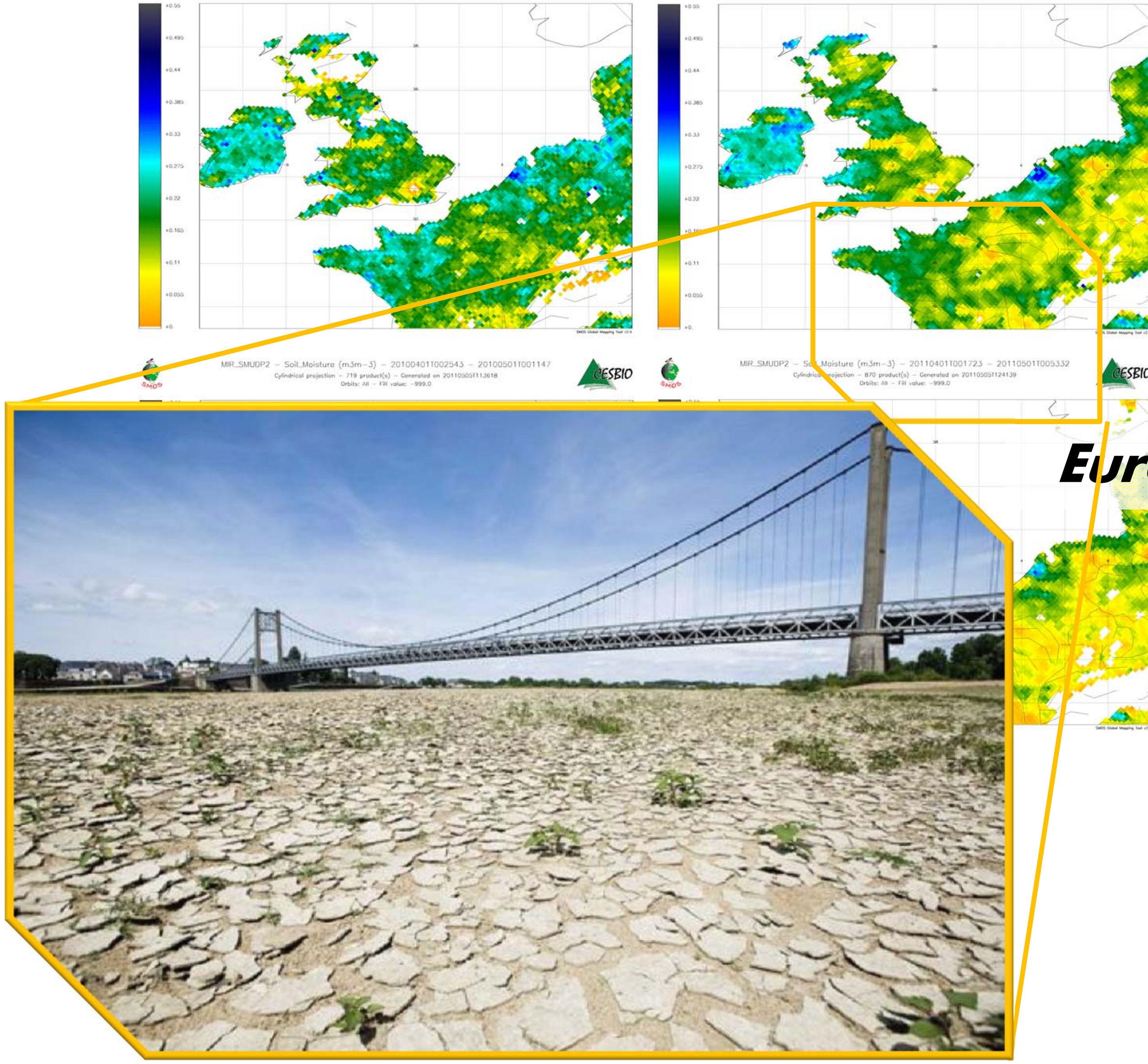




For reference:
Forest height estimated by GLAS-ICESat Lidar (Simard et al., 2011)

And Global map of Soil moisture

Drought – post analysis



European Drought

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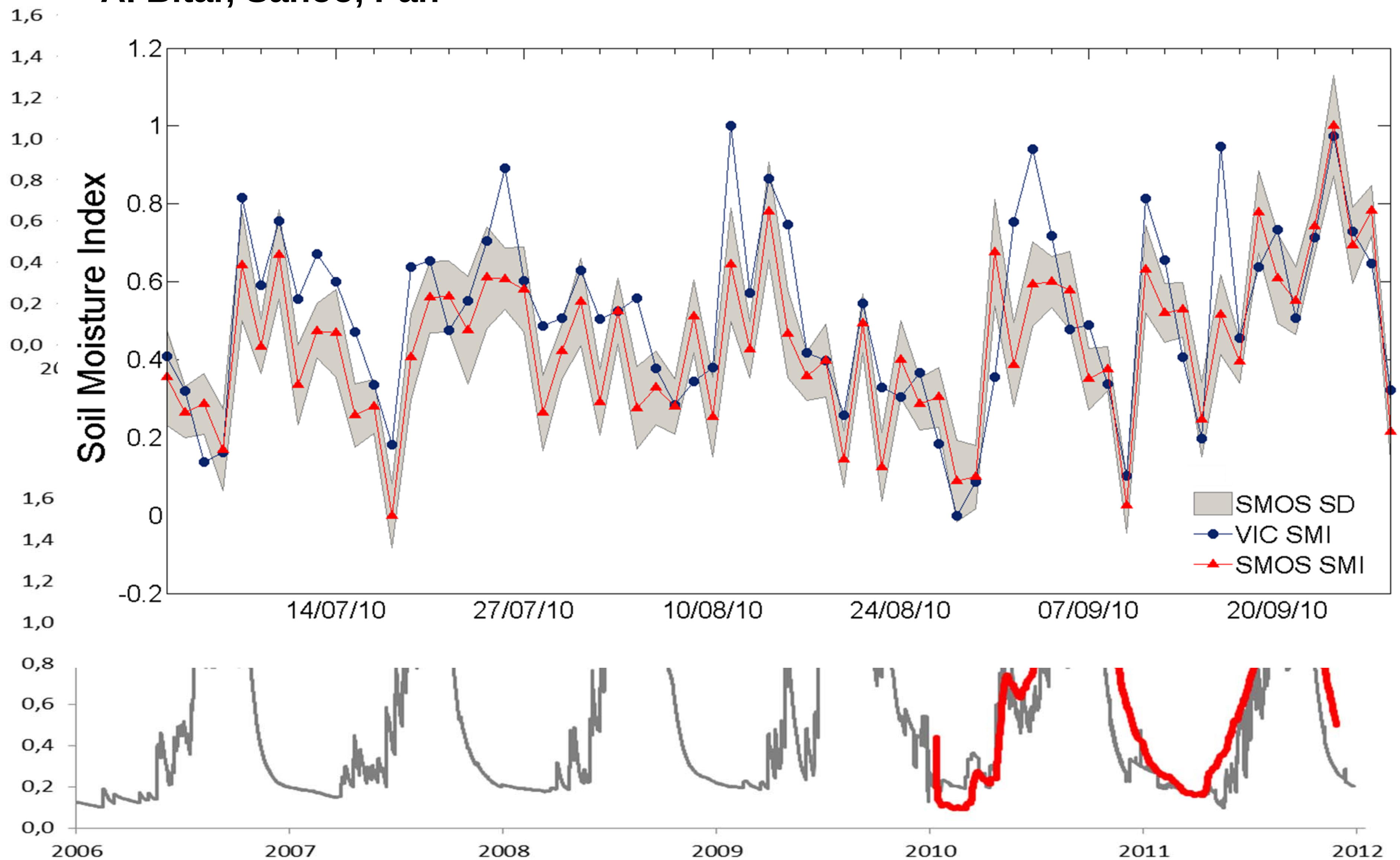
SMOS Root-zone soil moisture

V500

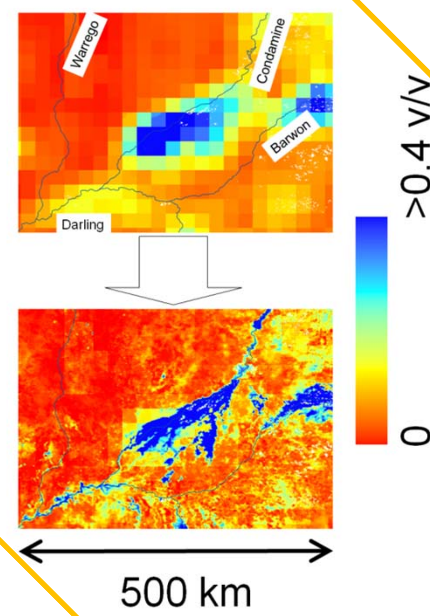
T. Pellarin

Al Bitar, Sahoo, Pan



Irrigation Water management

Root zone soil moisture and Dis-aggregation



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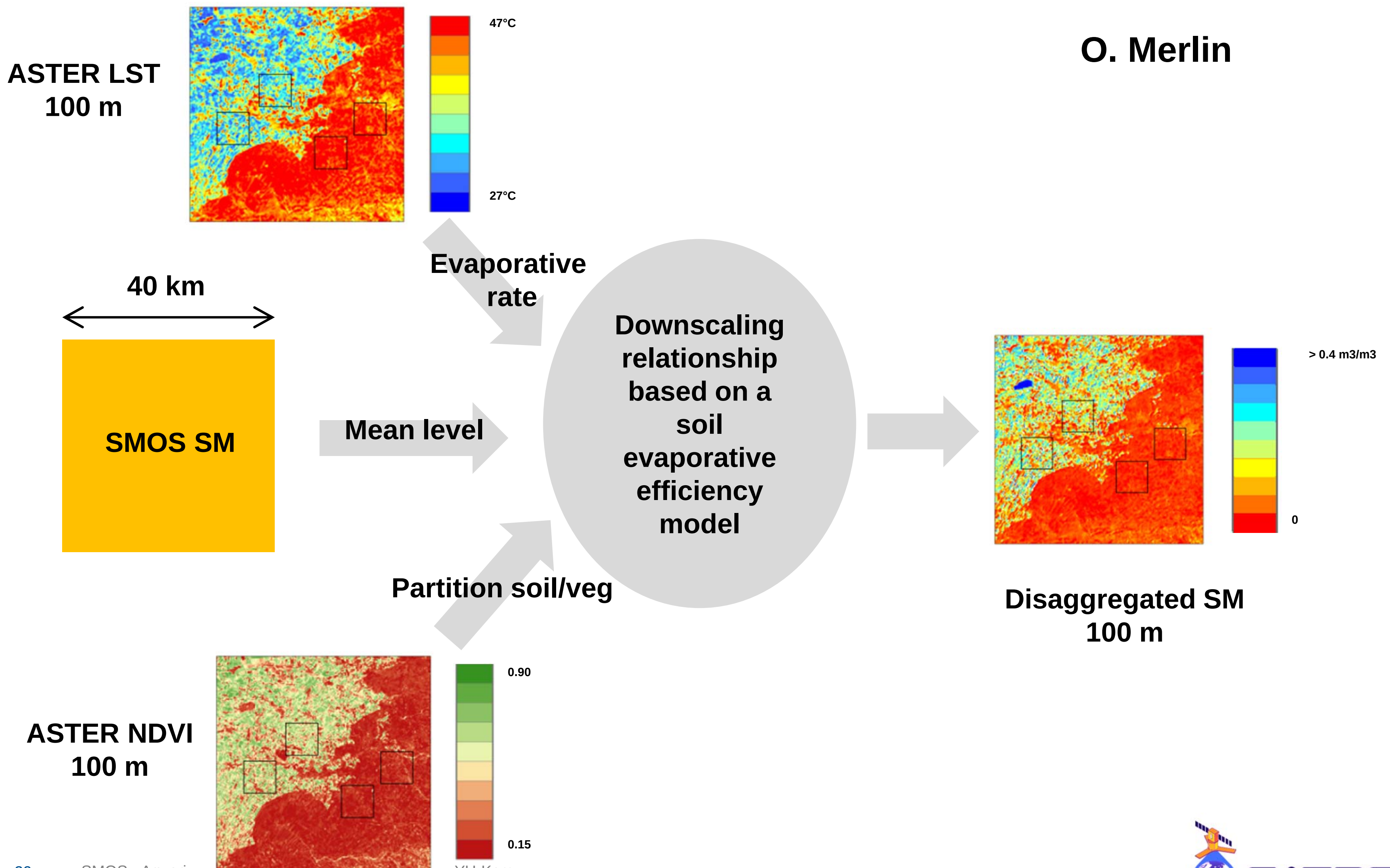
Dis-aggregation (DISPATCH) basic principle

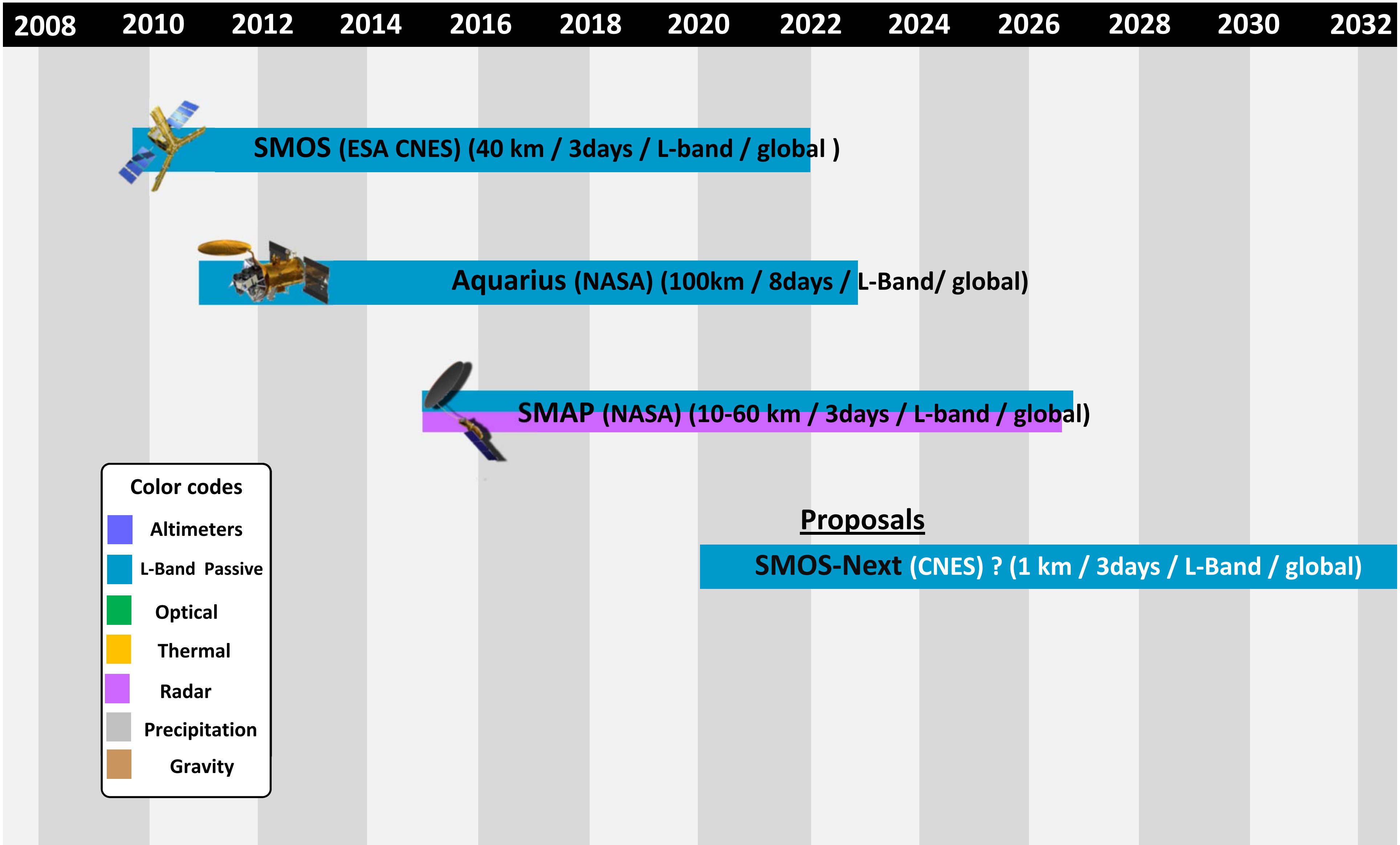


Soil Moisture Active Passive Mission (SMAP)

- NASA
- One of the first missions resulting from the NRC Decadal Survey
  - L-band: microwave radar (1-3 km), microwave radiometer (40 km)
    - 40 degrees incidence angle
    - Polarimetric
  - Three day global coverage
  - Launch 2015

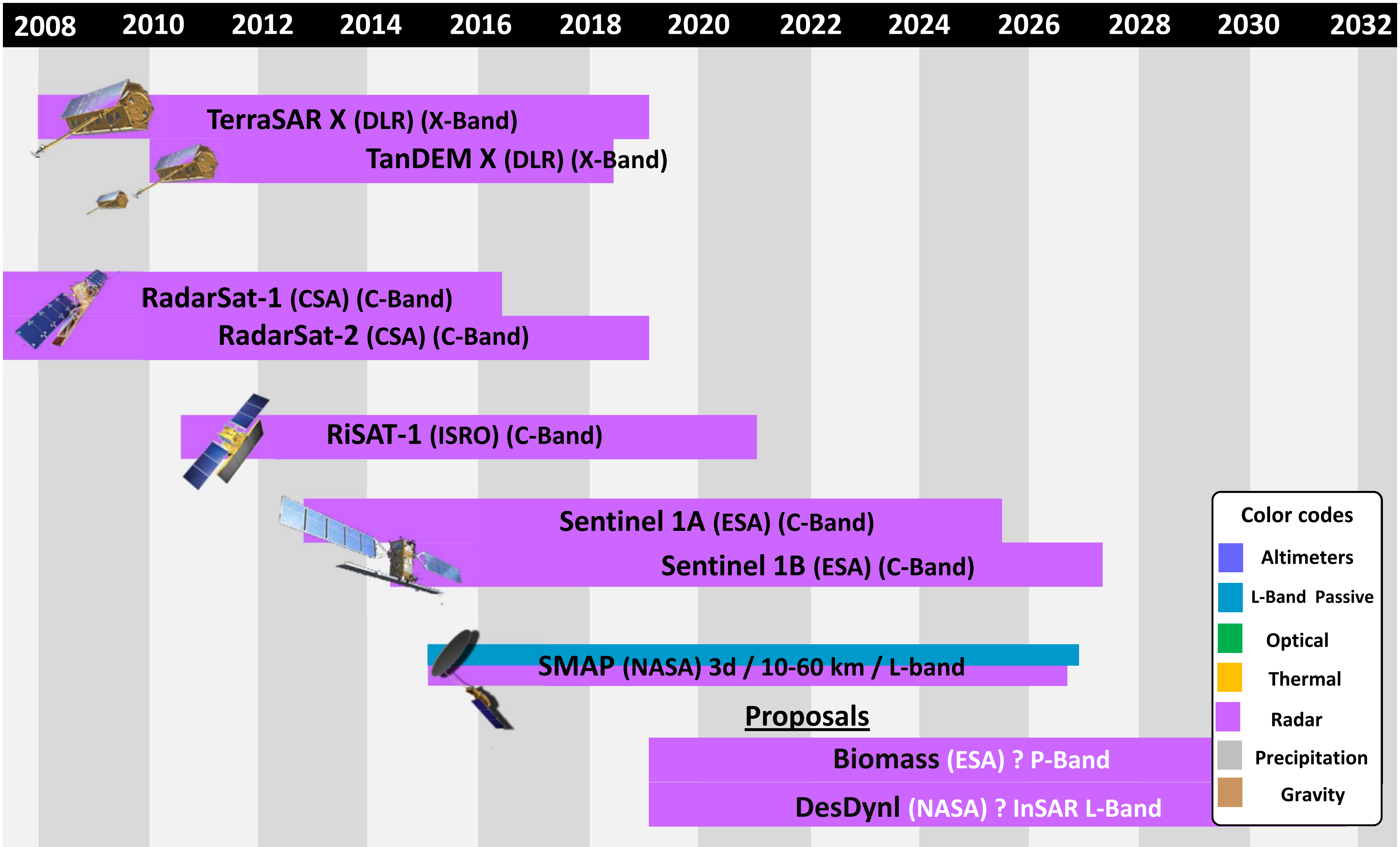
L-Band radiometer missions

A. AlBitar



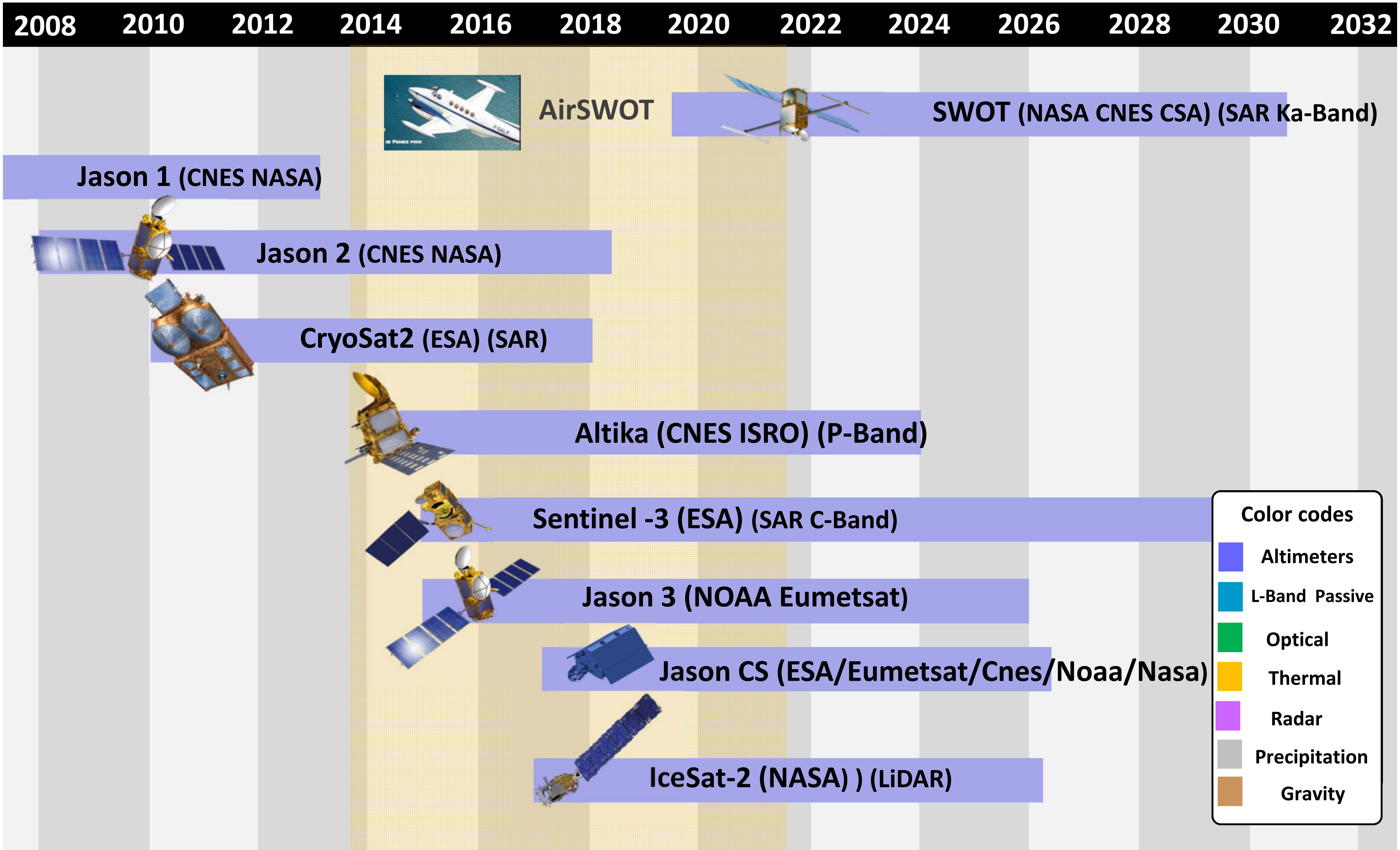
Radar missions

A. AlBitar



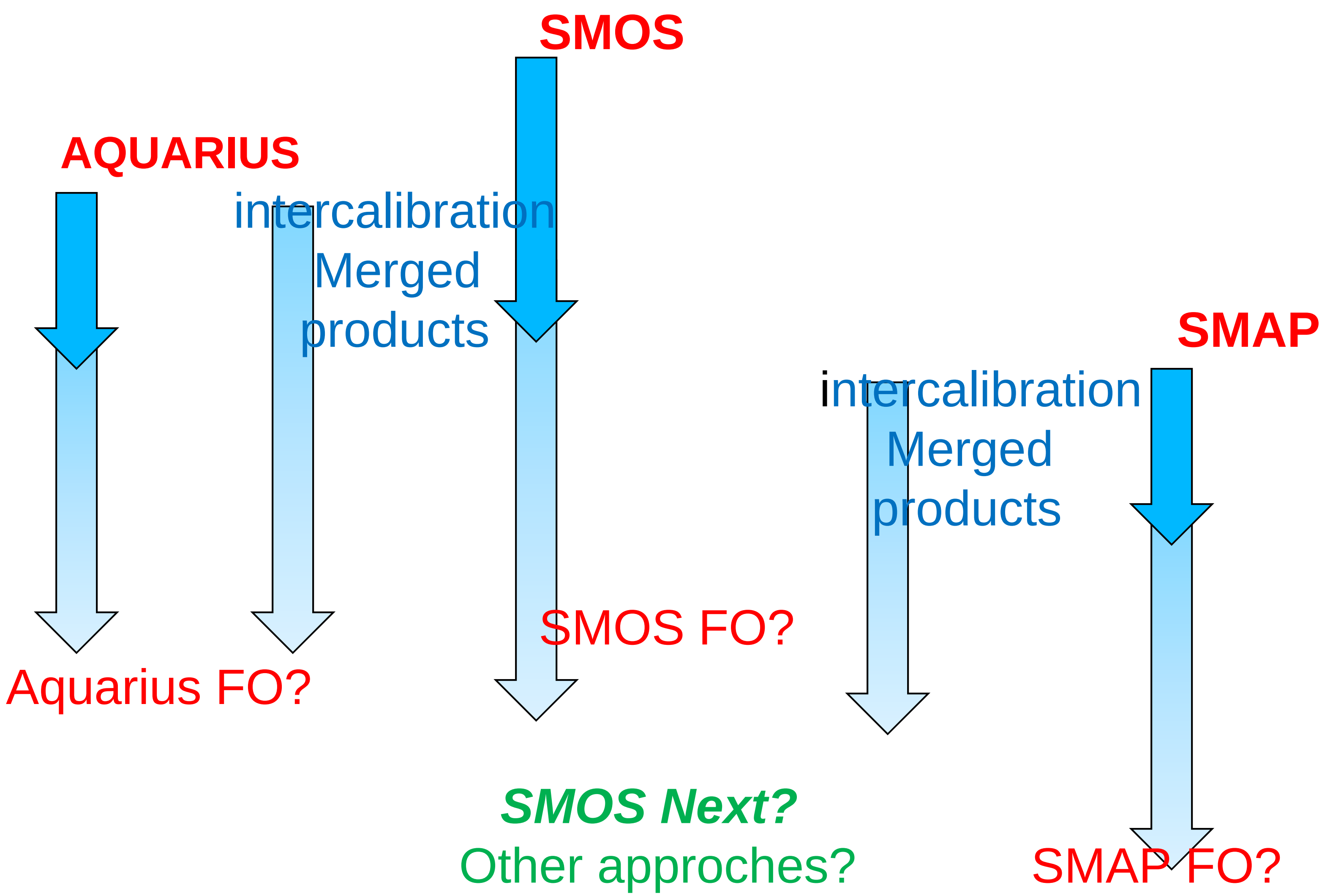
Altimetry missions

A. AlBitar



So....where are we?

- 2009
- 2010
- 2011
- 2012
- 2013
- 2014
- 2015
- 2016
- 2017
- 2018
- 2019
- 2020
- 2021
- 2022
- 2023
- 2024



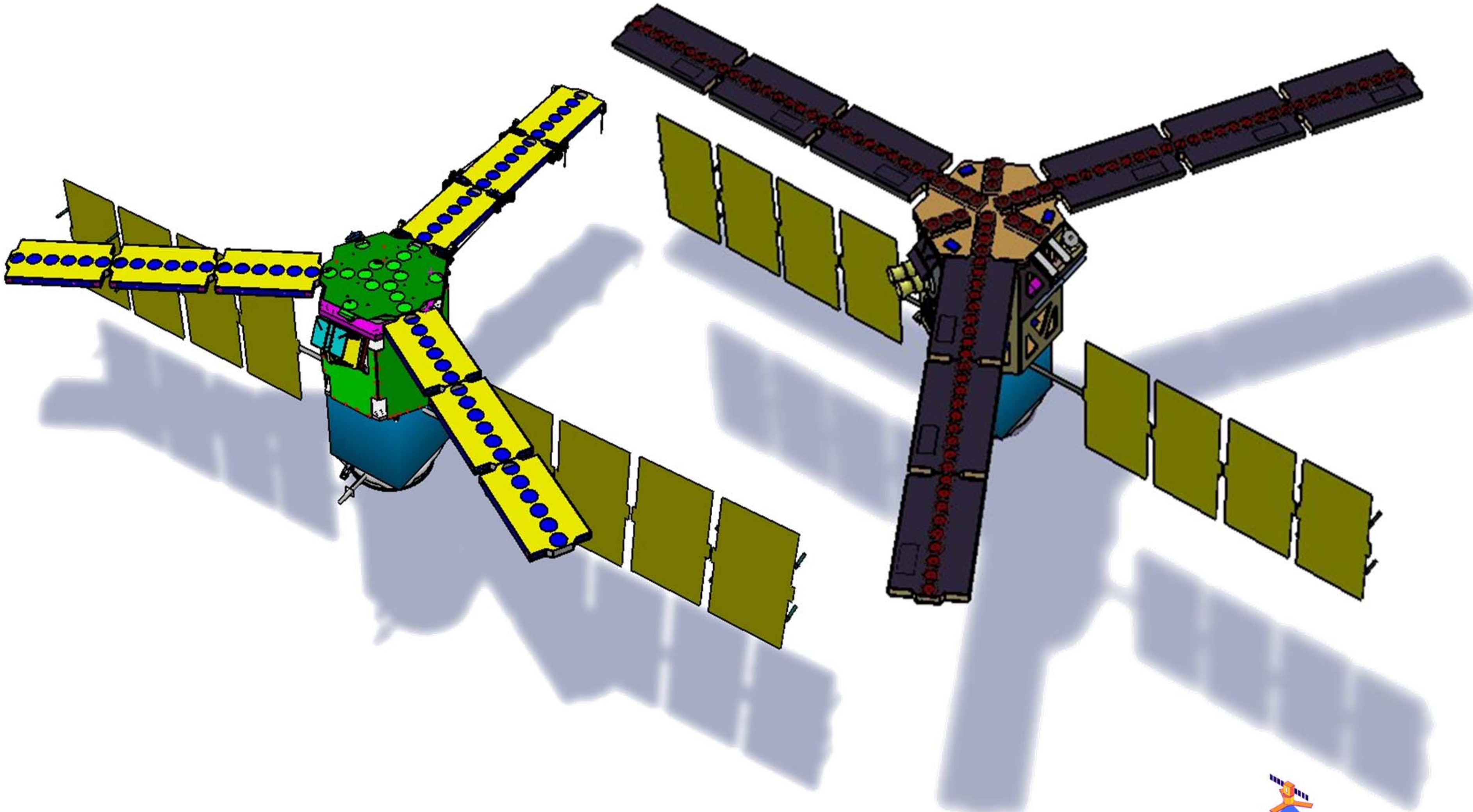
Step 1 → SMOS Ops

- Need for an operationnal suite
  - Same design (risk reduction)
  - Several copies (cost reduction)
  - Correct mistakes (RFI!)

- Likelihood??!!!!

- Need to investigate best trade off
  - Real vers synthetic antenna
  - Active passive,
  - One angle vs several angle etc

SMOS vs SMOSops



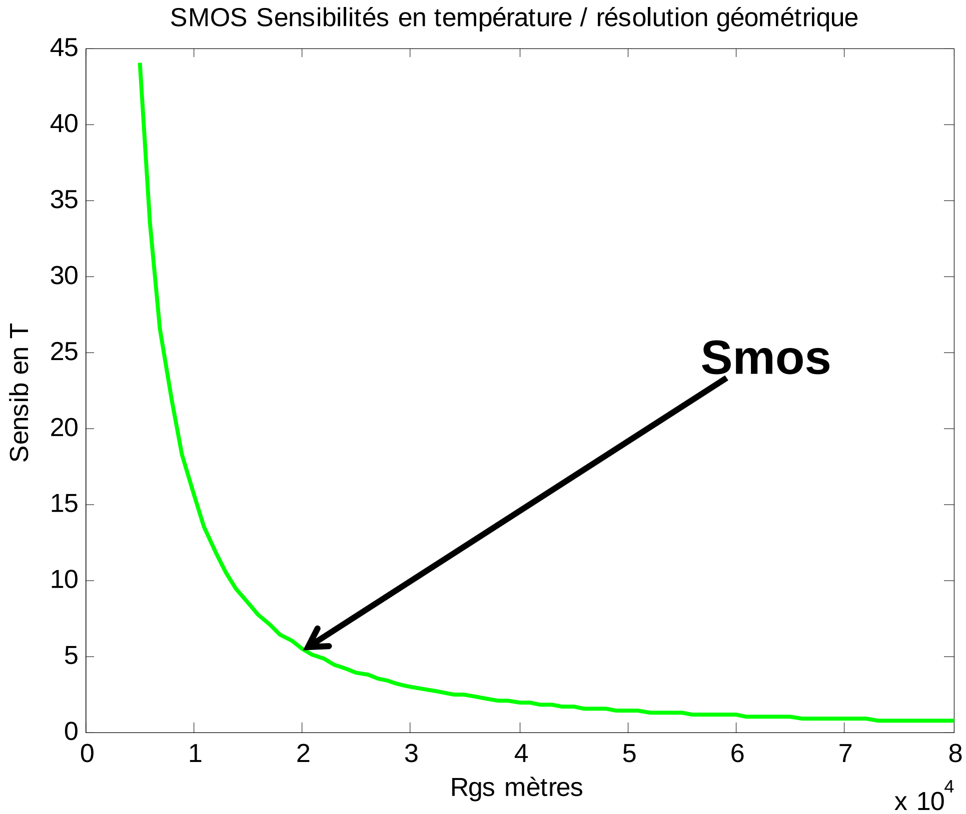
STEP 2 where to go?
The Options

- SSS
  - Improve sensitivity
  - Improve spatial resolution
  - Real antenna is the best option a priori
  - Is it sufficient?
- SM
  - Improve spatial resolution
  - Improve temporal sampling?

- SMOS type is the limit

SMOS
Rg *vs* sensitivity

Tempertaure sensitivity



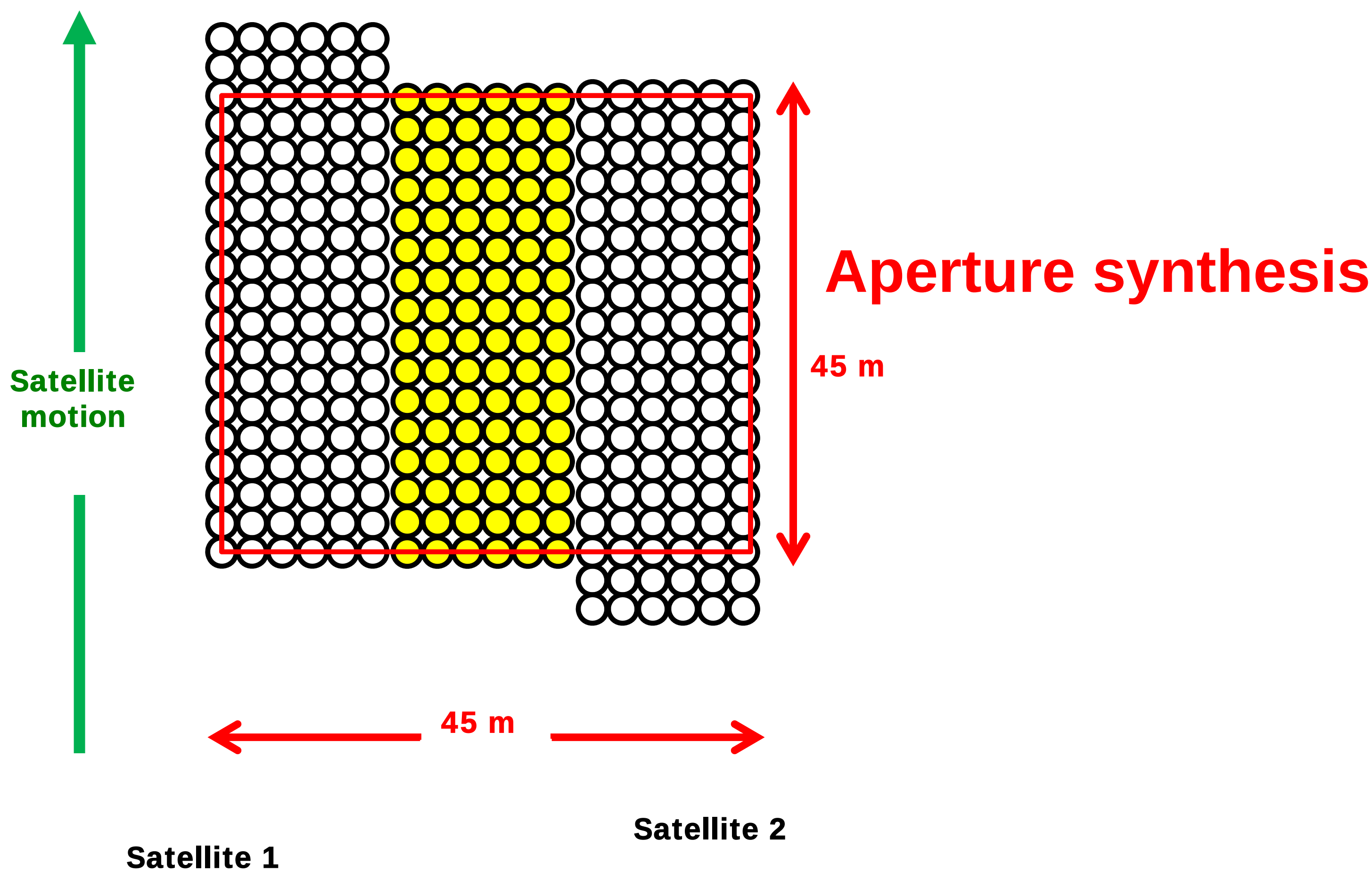
Rg

Step «3 → One option: SMOS NEXT

- Goal
  - Same specs as SMOS
  - With a resolution of 2-5 km
  - And an improved sensitivity (X3?)
- Same principle but different design ?
- Uses long and short baselines in a different way
- Use space and time for image synthesis

- R&T Studies at CNES
- Phase 0 study at CNES

Synthetic antenna

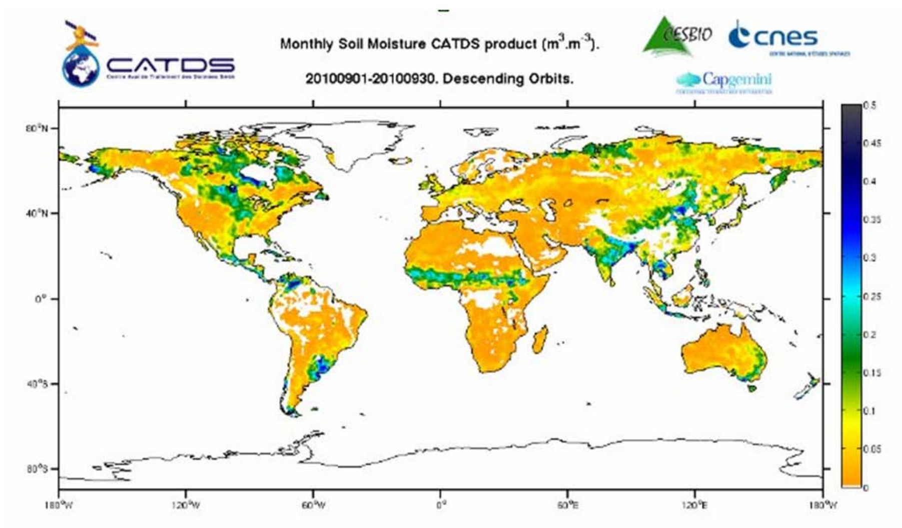


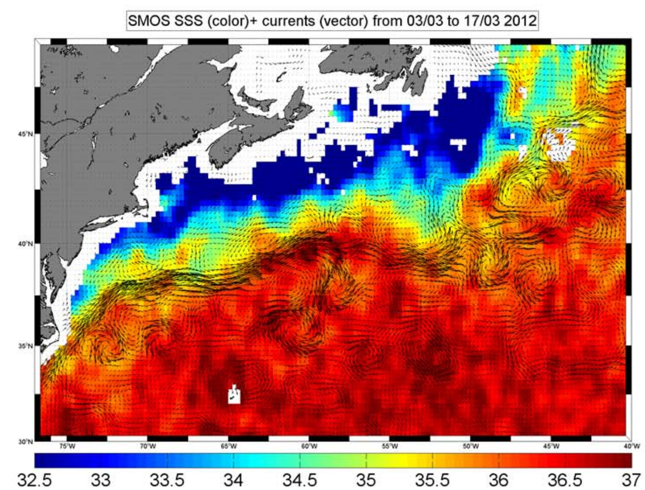
A full new set of challenges!!!

Summary

- ❑ New and innovative instrument and observations
  - ➢ First L band measurements
  - ➢ Still on the learning curve
  - ➢ Need for long term data sets
    - ❖ Inter calibration, harmonise products
- ❑ Retrievals
  - ➢ RFI
  - ➢ New scope for products (L4 SMOS + Aquarius)
- ❑ So it is only the beginning!

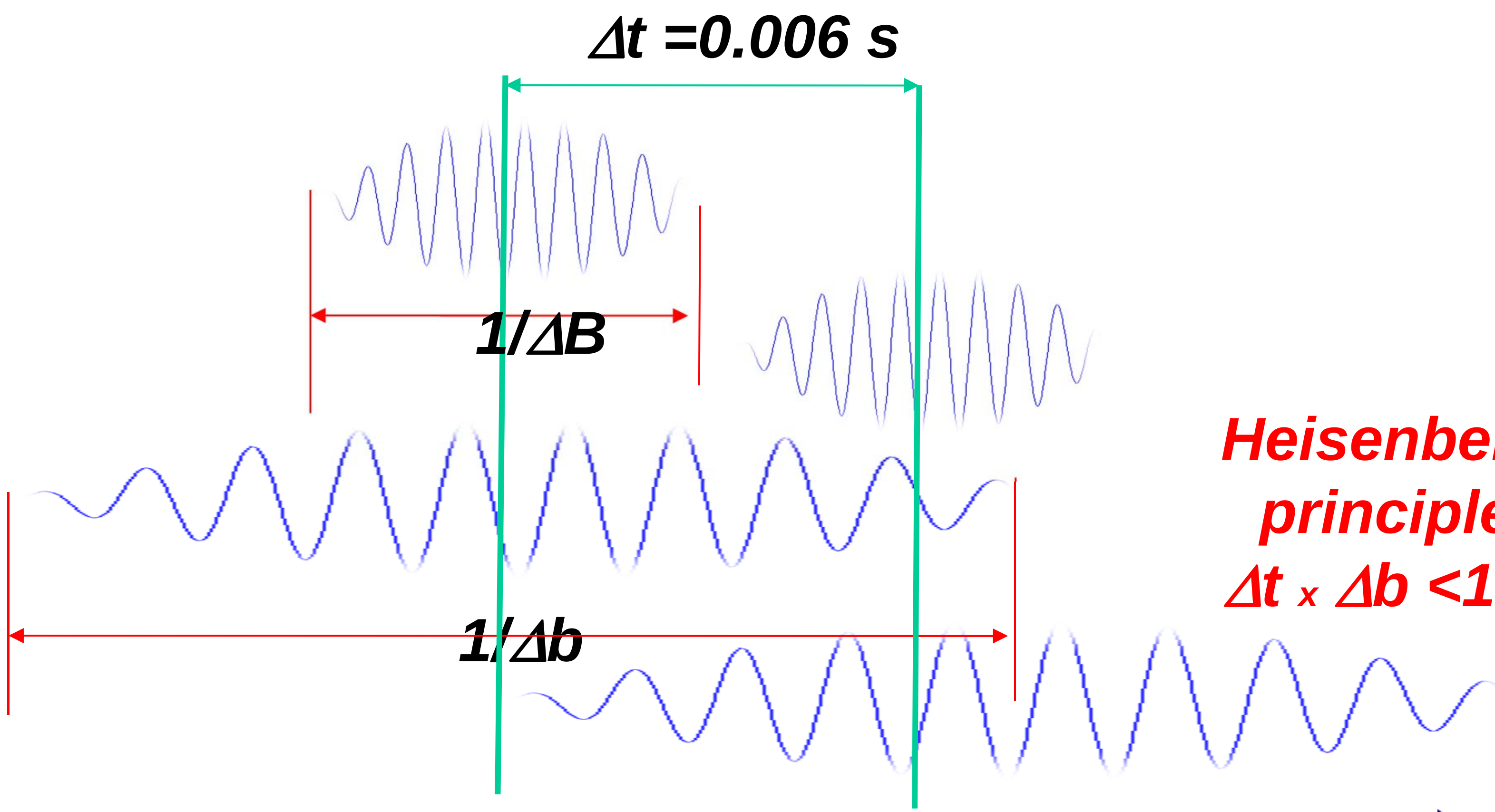
- ❑ Stay tuned → **http://www.cesbio.ups-tlse.fr/SMOS_blog/**





Aperture synthesis with incoherent light, where is the limit ?

- Wave packets long enough in a narrow band ?
- How to determine the coherence length for a given band

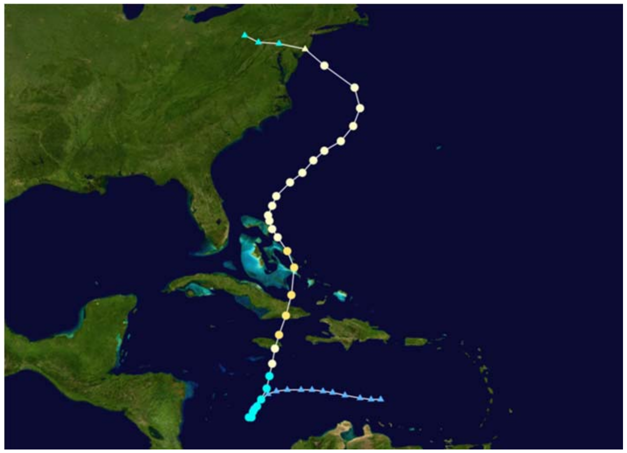


Heisenberg principle
$\Delta t \times \Delta b < 1$?

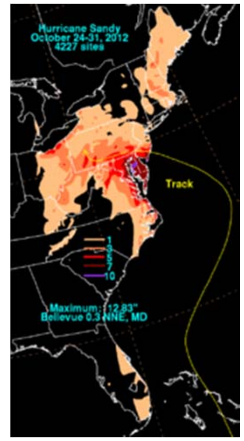
Hurricane Sandy 2012

Storm image

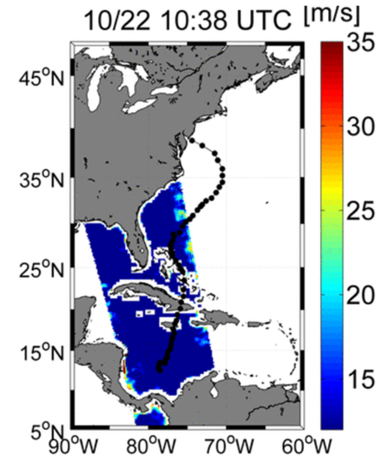
Storm path



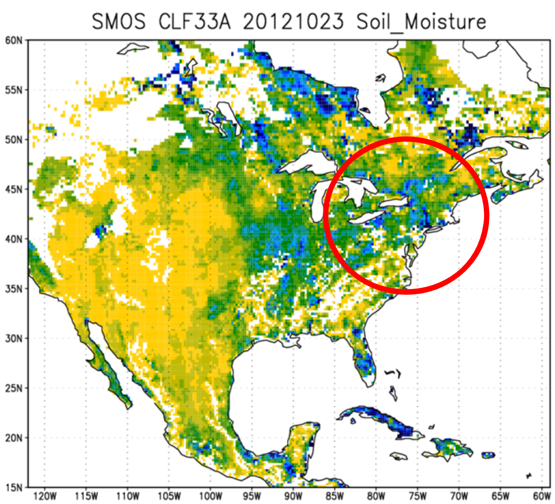
Cumulative rainfall

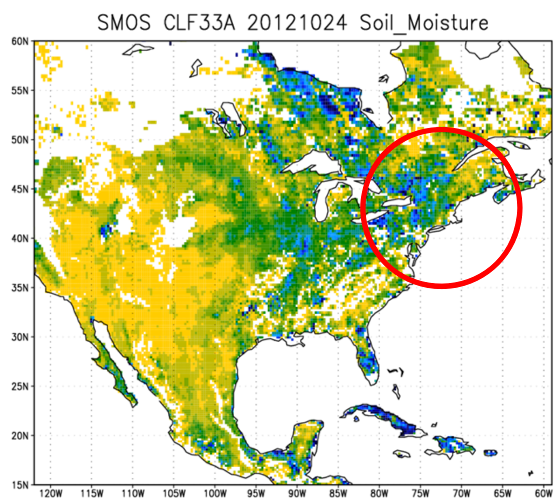


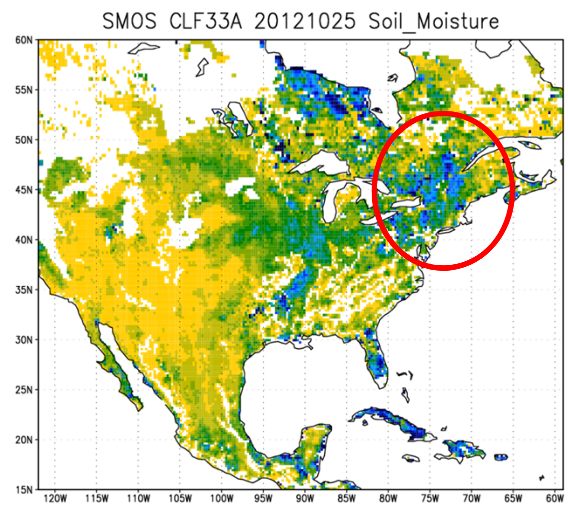
Wind speed (N Reul)

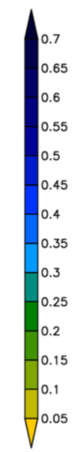


SMOS Soil moisture









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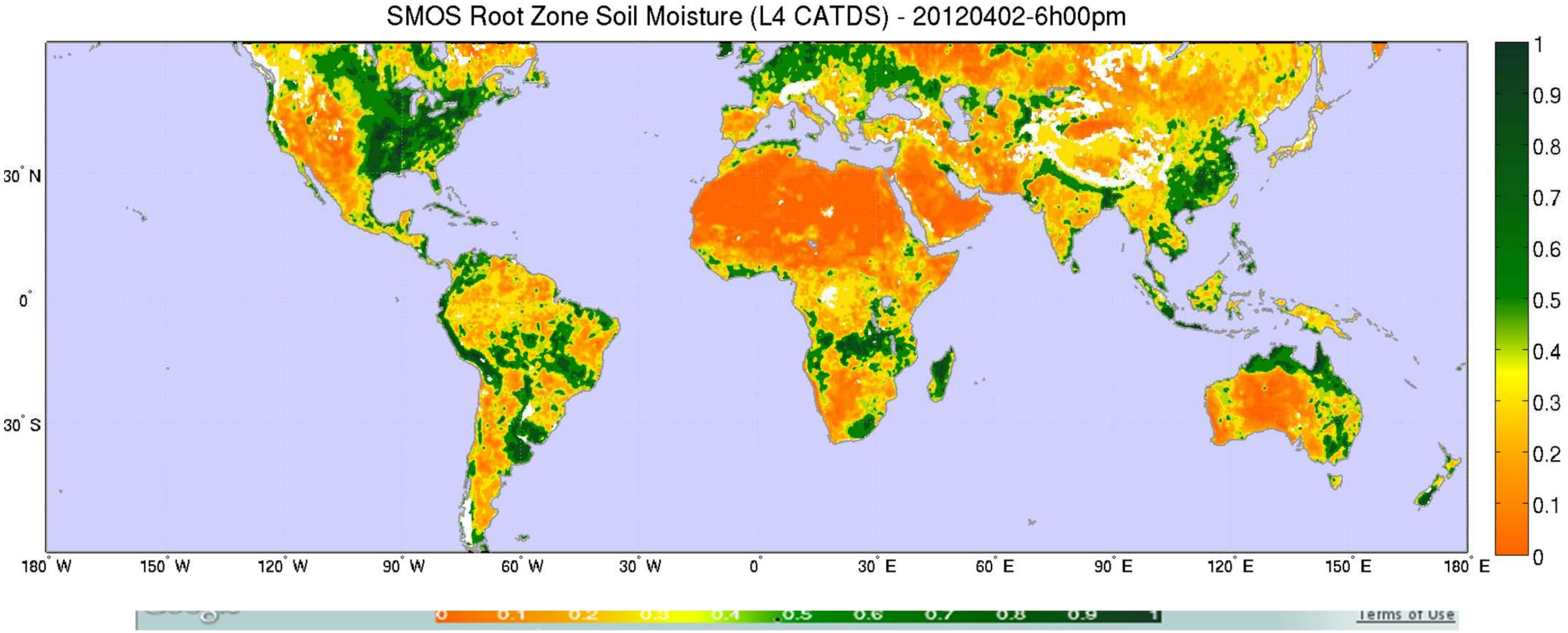
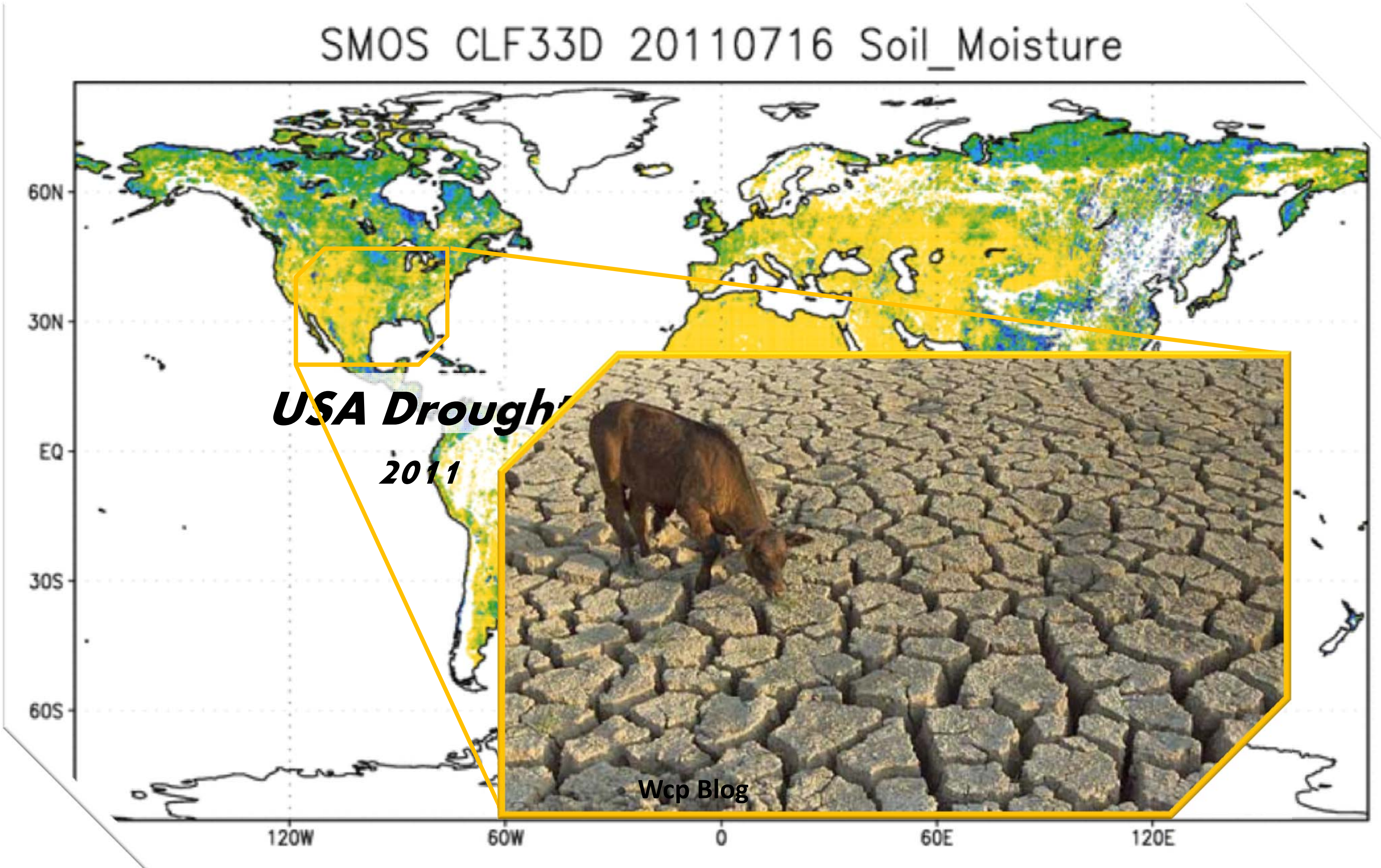
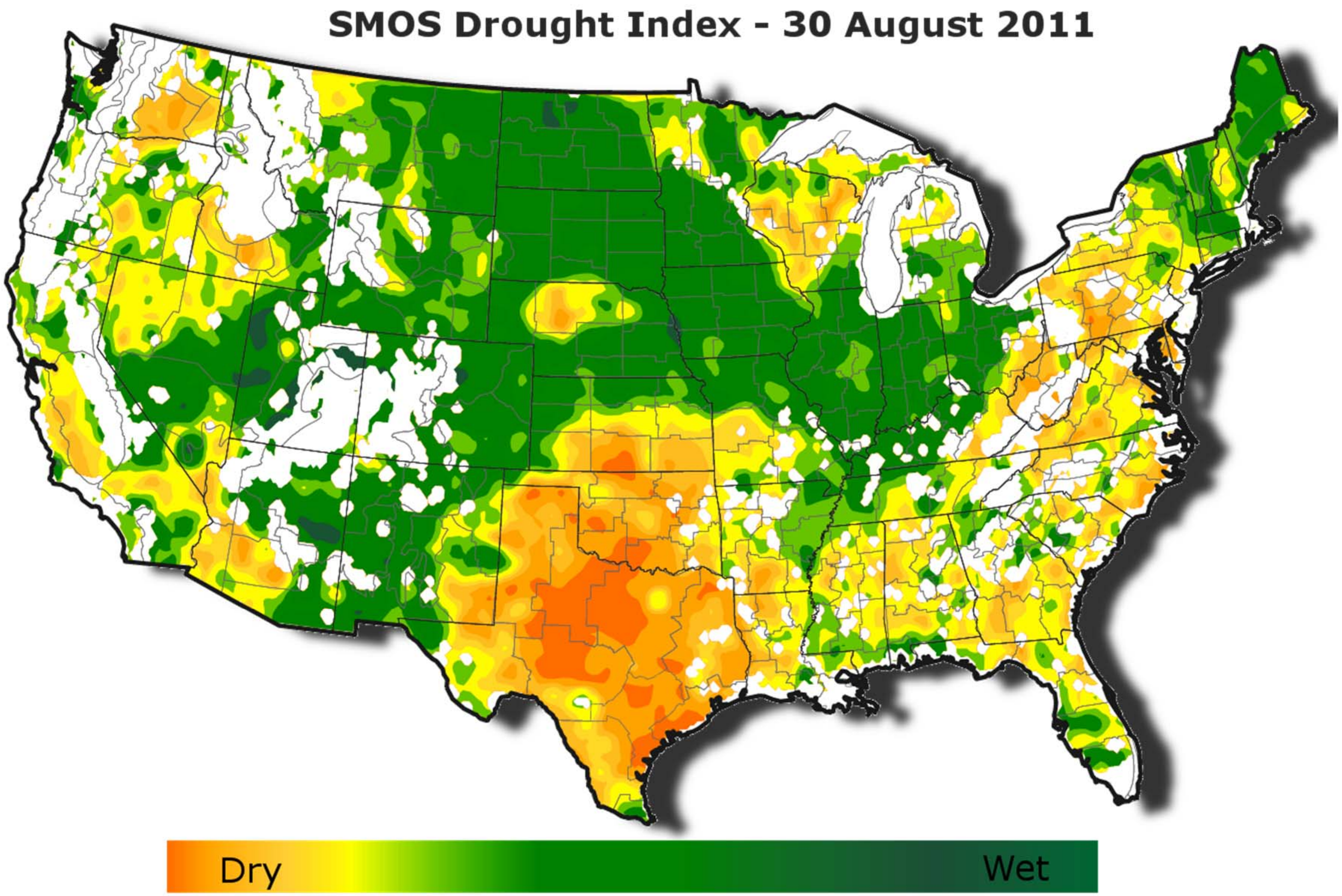
Root zone soil moisture



SMOS Drought index –Monitoring



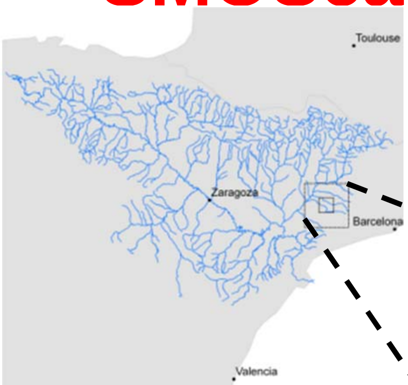
From Root Zone moisture to Drought Index

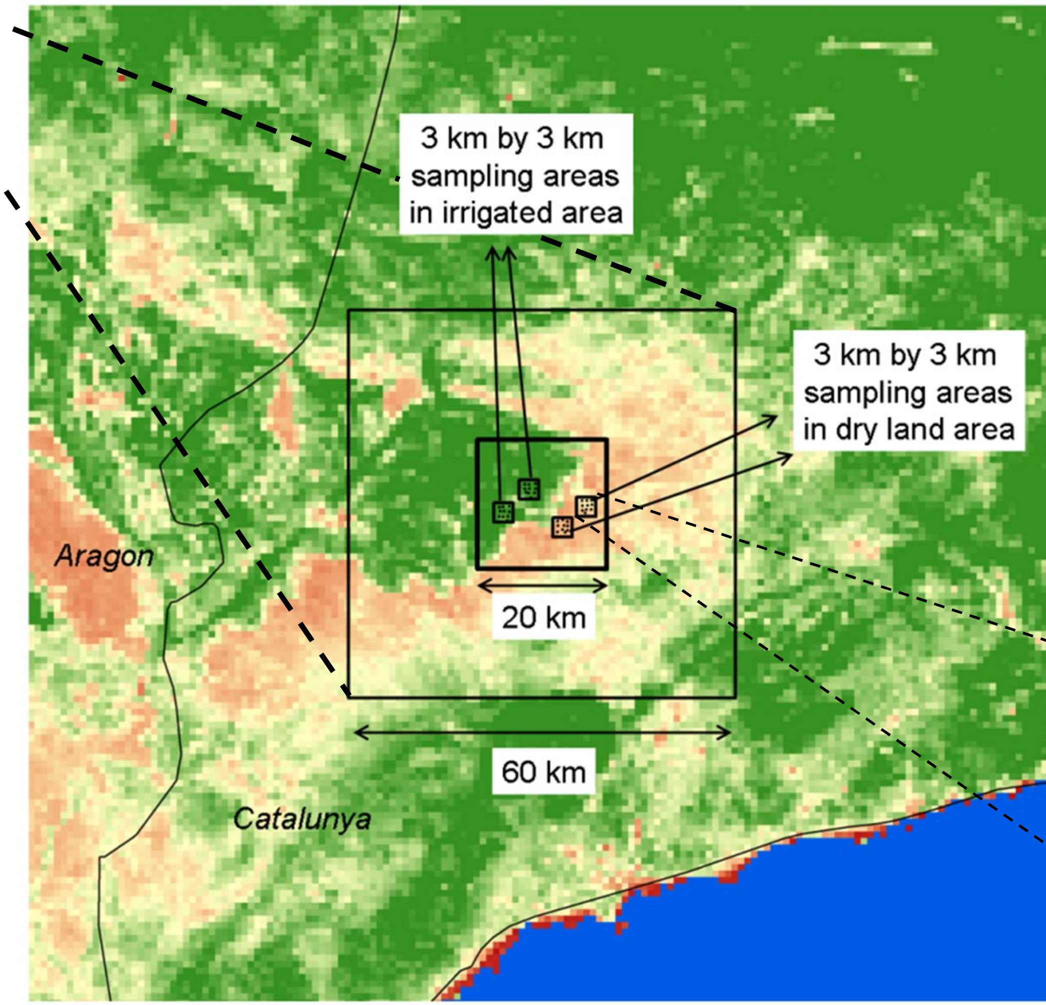


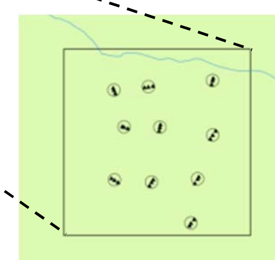
Al Bitar A., Kerr Y., Le Roux D., Merlin O., Wigneron J-P. – CESBIO – INRA Bordeaux

SMOScat: 11 field experiments in 2011-2012

O. Merlin







SMOS-next
Data rate vs sensitivity for Rg=2.5 km