Assimilation of earth observation data in the ISBA land surface model of Météo-France

Jean-Christophe Calvet, Clément Albergel, Marc Crapeau, Clara Draper, Yann H. Kerr, Arnaud Mialon, Christoph Rüdiger, Jeffrey P. Walker, Jean-Pierre Wigneron, Mehrez Zribi

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Assimilation of EO data in ISBA

METEO FRANCE
Toujours un temps d'avance

Assimilation of EO data in ISBA

- Modelling tools using ISBA (Meteo-France)
  - SURFEX modelling platform (http://www.cnrm.meteo.fr/surfex/)
  - SAFRAN-ISBA-MODCOU (http://www.eaufrance.fr/)
  - ALADIN (http://www.cnrm.meteo.fr/aladin/)
- Passive monitoring (EO / in situ / model cross-verification)
  - Soil moisture in situ data: SMOSMANIA / SMOSREX
  - EO SSM vs. in situ SSM
  - EO SSM vs. model SSM
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  - SSM / LAI synergy
  - Test of joint SSM / LAI assimilation at SMOSREX
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- Further steps for SMOS
  - Airborne campaign: CAROLS

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Modelling tools

- SURFEX modelling platform (http://www.cnrm.meteo.fr/surfex/)
  - Surface Externalisée
  - Autonomous, modular code with various parameterisations
  - Stand-alone or coupled simulations
  - Various applications (NWP, hydrology, drought monitoring, etc.)
- SIM (SAFRAN-ISBA-MODCOU) (http://www.eaufrance.fr/)
  - Daily soil moisture products over France
  - 8km resolution
- ALADIN (http://www.cnrm.meteo.fr/aladin/)
  - NWP limited area model
  - International consortium (Algeria, Austria, Belgium, Bulgaria, Croatia, Czech Rep., France, Hungary, Morocco, Poland, Portugal, Romania, Slovakia, Slovenia, Tunisia, Turkey)

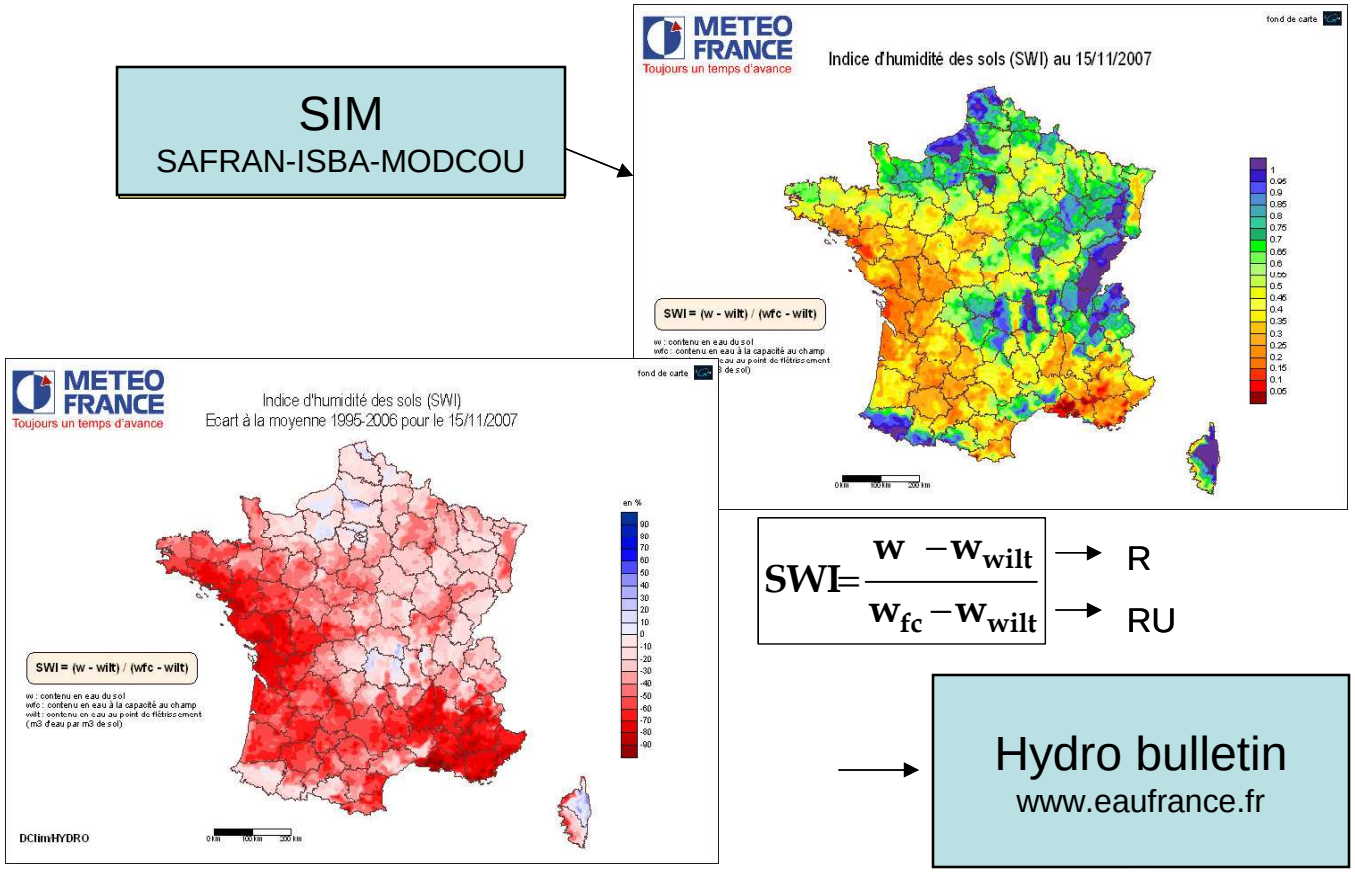
Modelling tools

FIG. 1 – ISBA in SURFEX

ISBA (options)	Soil	- Force restore, 2 or 3 layers, heat, water, ice - Diffusion, multi-layer, heat, water, ice
	Vegetation	- Noilhan et Planton 89 (~Jarvis) - A-gs photosynthesis and CO_2 flux (Calvet et al. 1998-2008) - A-gs and LAI / biomass (Calvet et al. 1998, Gibelin et al. 2006)
	Hydrology	- No subgrid processes - Subgrid surface runoff - Subgrid deep runoff - Floods and couplig with TRIP
	Snow	- 1 layer, variable albedo and density (Douville 95) - Multi-layer, variable albedo, density and liquid water (Boone and Etchevers 2000)

Modelling tools

FIG. 2 – SIM (SAFRAN-ISBA-MODCOU)



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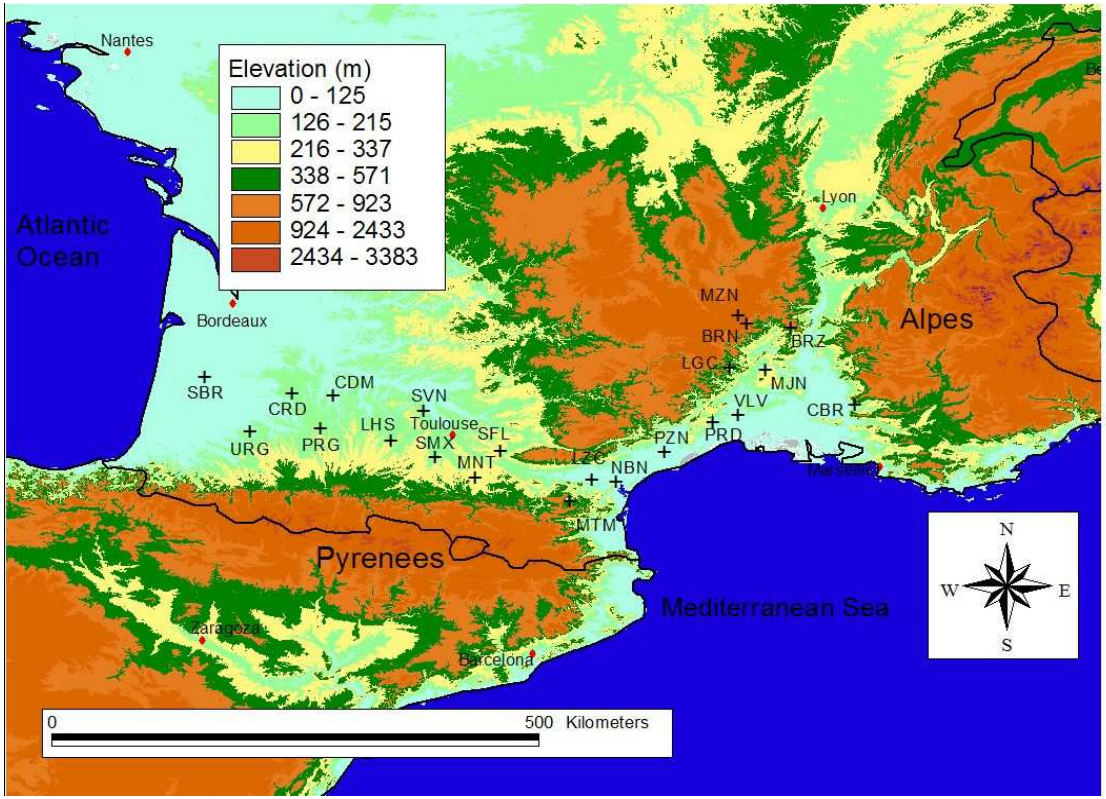
EO / in situ / model cross-verification

- In situ observations
  - SMOSMANIA network (RADOME) extended to Mediterranean region:
    - 21 stations now
    - 12 since January 2007
    - 9 since January 2009
    - Data provided to GEWEX ISMWG
  - SMOSREX site (January 2001 to present): will continue in 2010 for the SMOS CAL/VAL
  - Additional local intensive observations in support of airborne campaigns

EO / in situ / model cross-verification

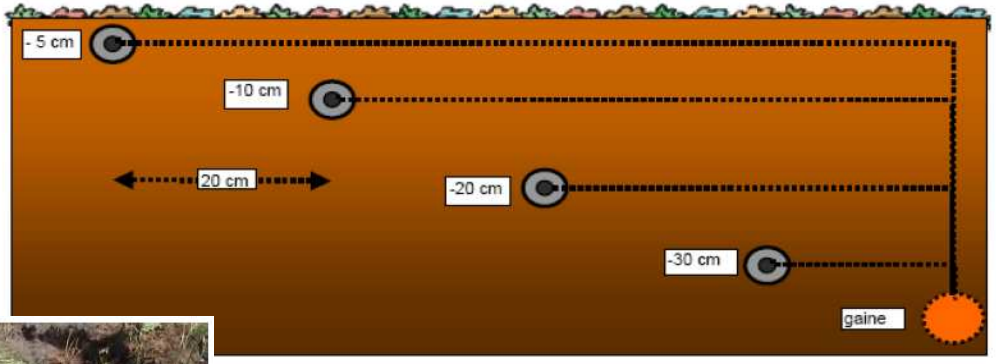
FIG. 3a – SMOSMANIA: 21 stations



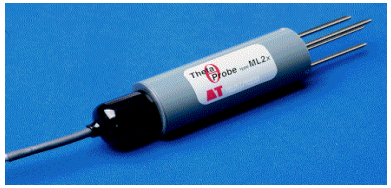
Aquitaine	Languedoc-Roussillon
CREON D'ARMAGNAC	NARBONNE
URGONS	LEZIGNAN CORBIERES
SABRES	MOUTHOUMET
Midi-Pyrénées	PEZENAS
SAINT FELIX DE LAURAGAIS	PRADES LE LEZ
MONTAUT	LA GRAND COMBE
SAVENES	MEJANNES LE CLAP
LAHAS	VILLEVIEILLE
CONDOM	**Rhône-Alpes**
PEYRUSSE GRANDE	MAZAN L'ABBAYE
PACA	BARNAS
CABRIERES D'AVIGNON	BERZEME

EO / in situ / model cross-verification

FIG. 3b – SMOSMANIA: soil moisture/temperature at 5,10,20,30cm

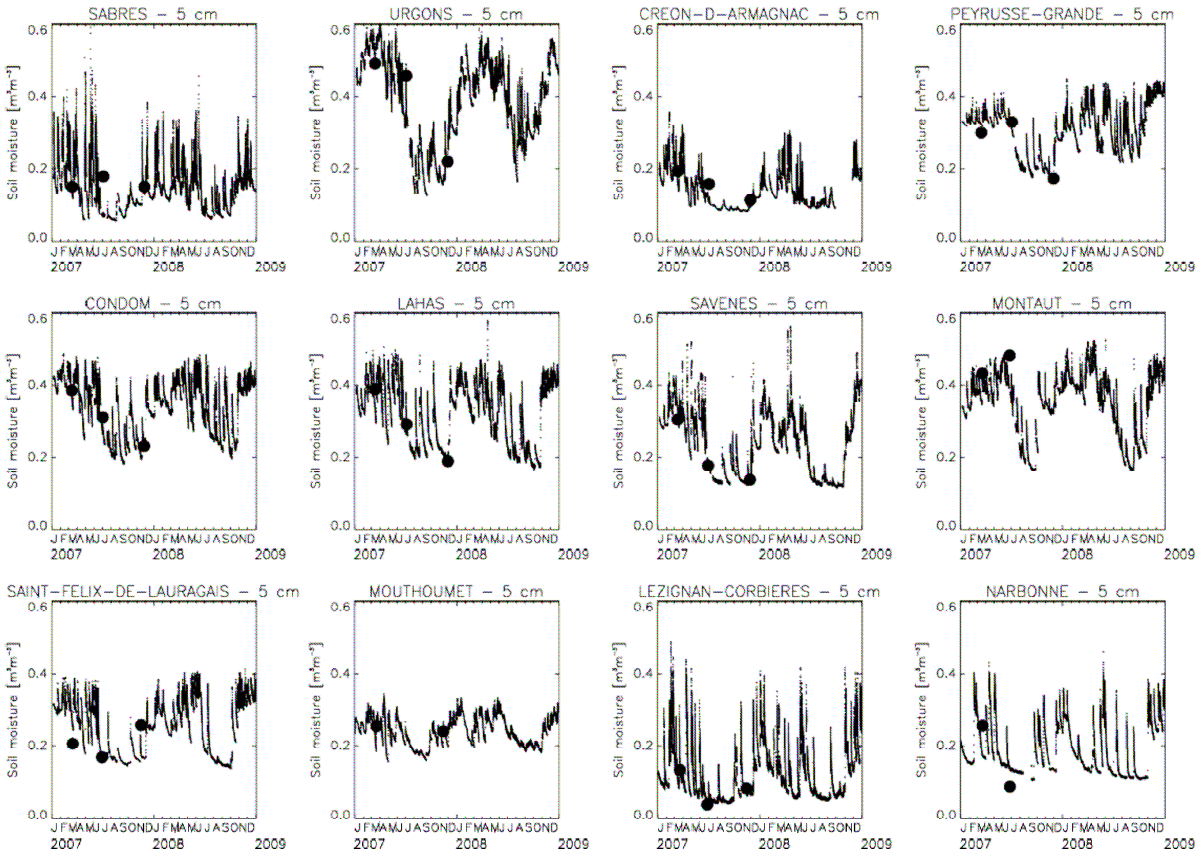


ThetaProbe ML2



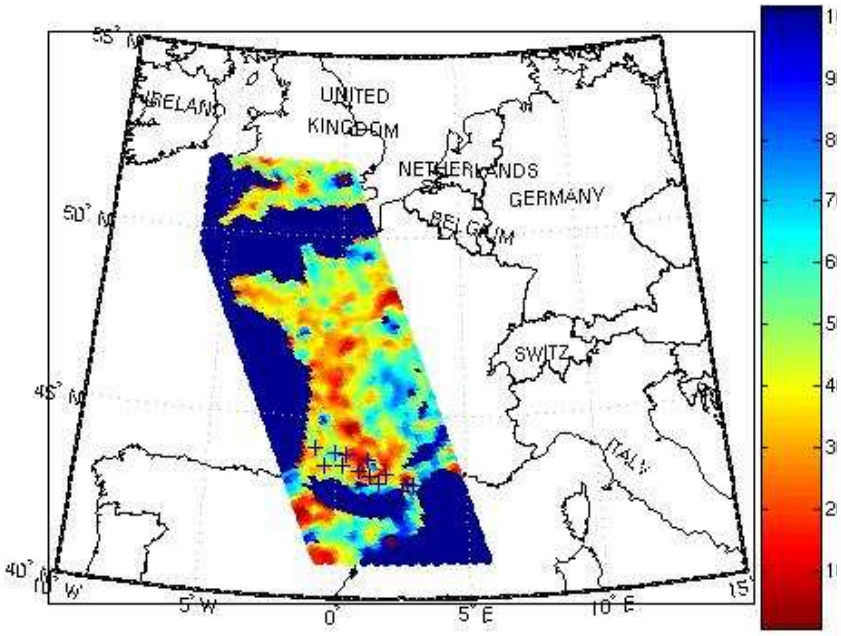
EO / in situ / model cross-verification

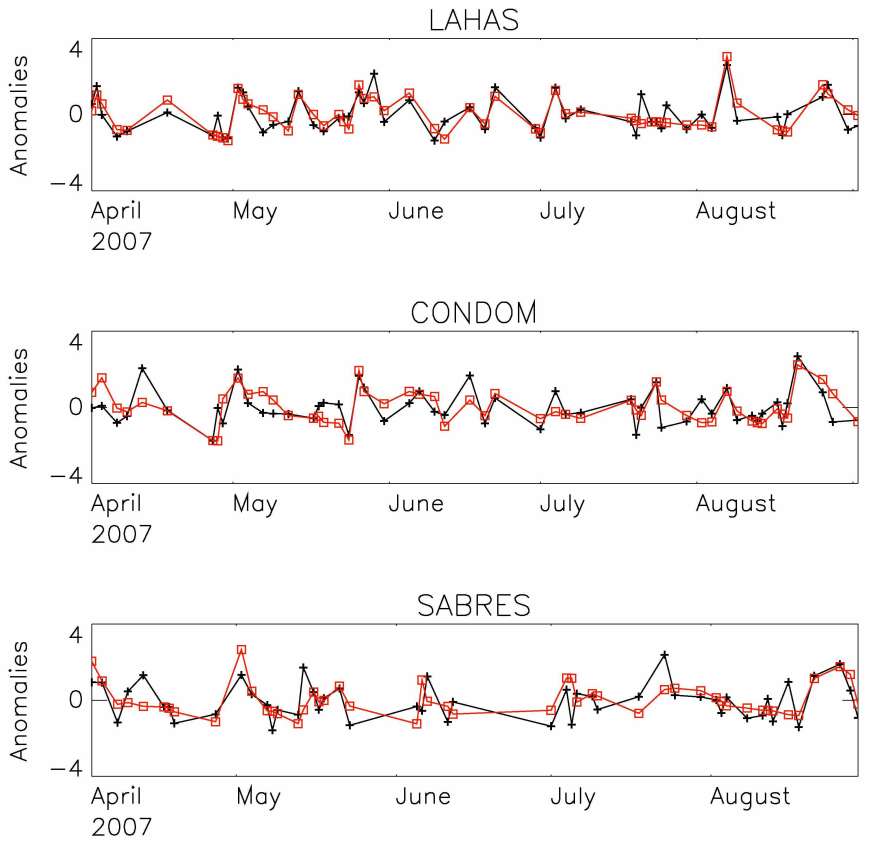
FIG. 3c – SMOSMANIA: first results



EO / in situ / model cross-verification

FIG. 4a – ASCAT SSM vs. SMOSMANIA



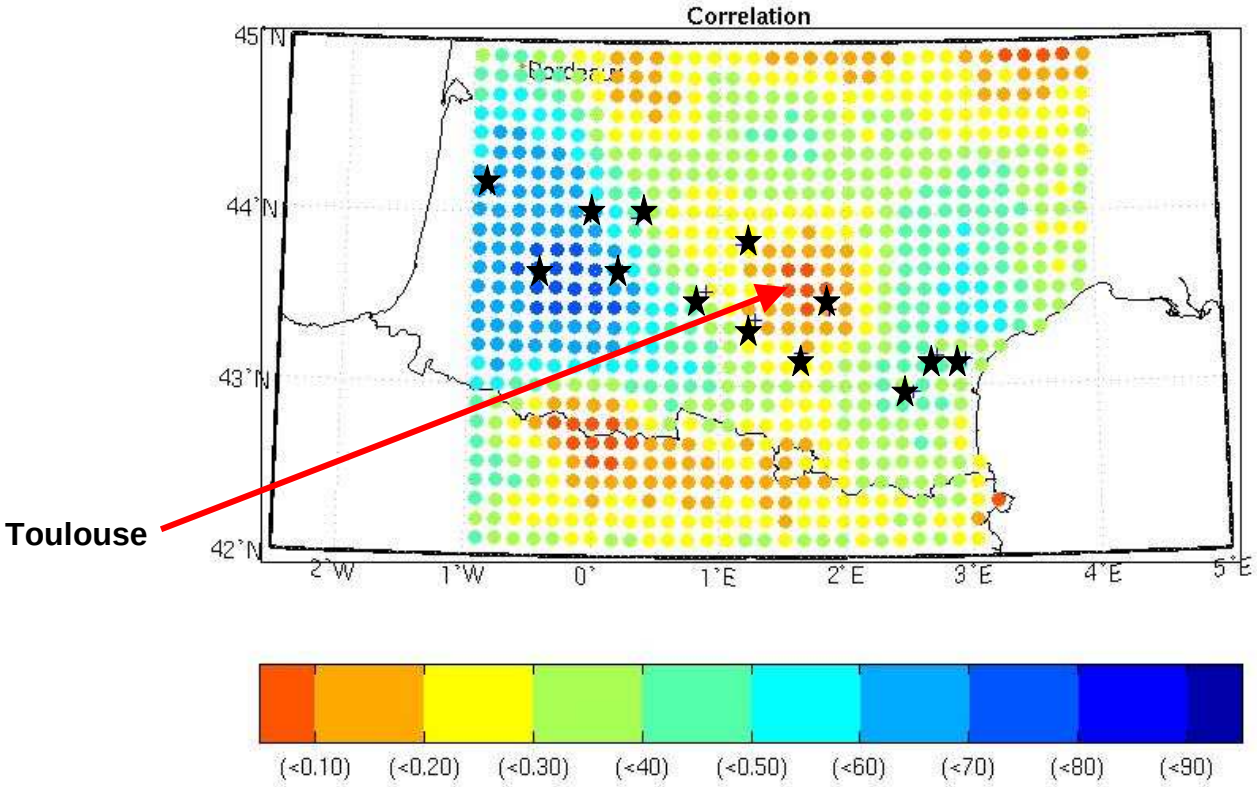


RMSE ~ 0.06 m^3m^{-3}

Albergel et al. 2009

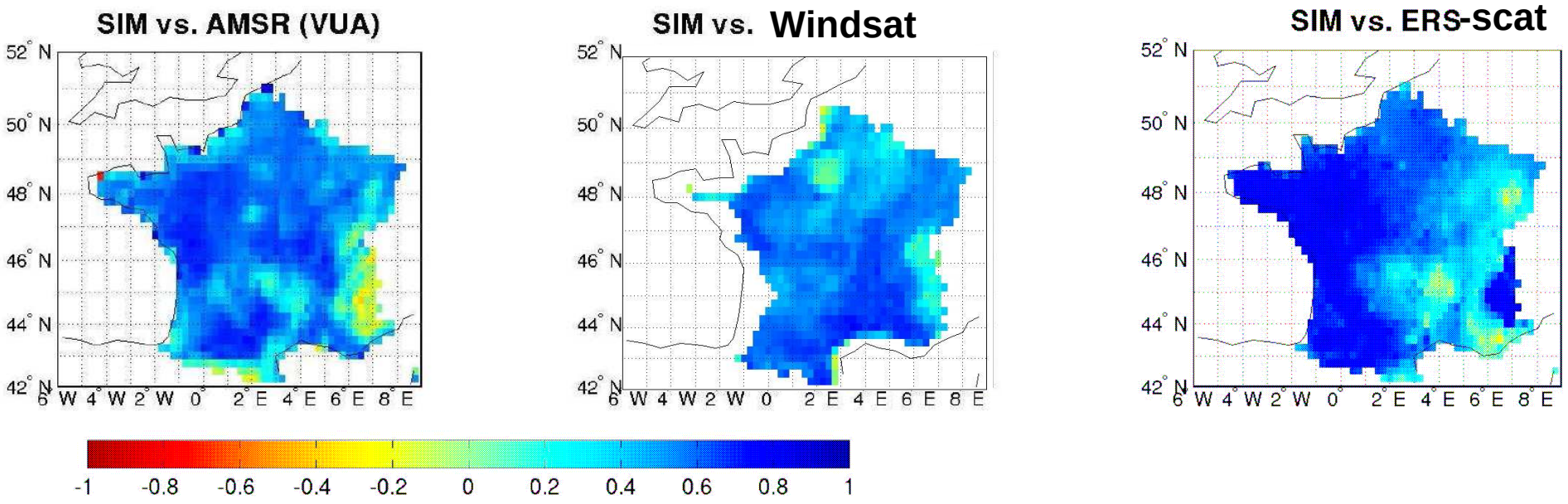
EO / in situ / model cross-verification

FIG. 4b – ASCAT SSM vs. SMOSMANIA (correlation)



EO / in situ / model cross-verification

FIG. 5 – AMSR-E, WINDSAT, ERS vs. SIM (correlation)



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Data assimilation

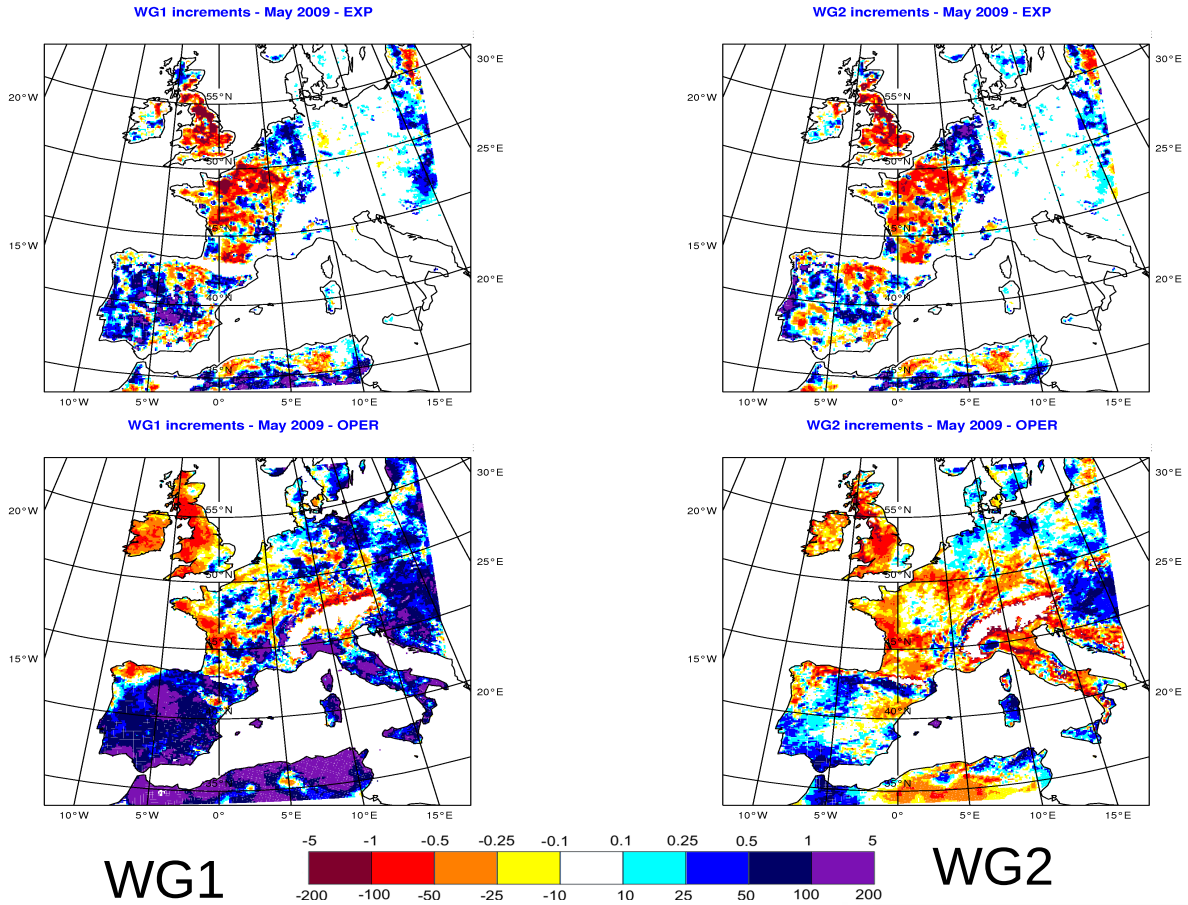
- Demo assimilation in ALADIN
  - 3D-Var ALADIN/France + SURFEX
  - Period : May 2009
  - Use of a simplified SURFEX EKF : Analytical formulation of the Jacobians of the ISBA scheme
  - ASCAT superficial soil moisture at 12.5 km resolution provided by EUMETSAT – data screening using quality flags – bias correction scheme using CDF matching technique – error specifications from statistics of innovations
  - Experiments :
    - **CTRL** (no soil analysis),
    - **EXP** (soil analysis from ASCAT),
    - **OPER** (soil analysis from T2m/RH2m observations)

Data assimilation

FIG. 6 – Monthly soil moisture increments (mm)

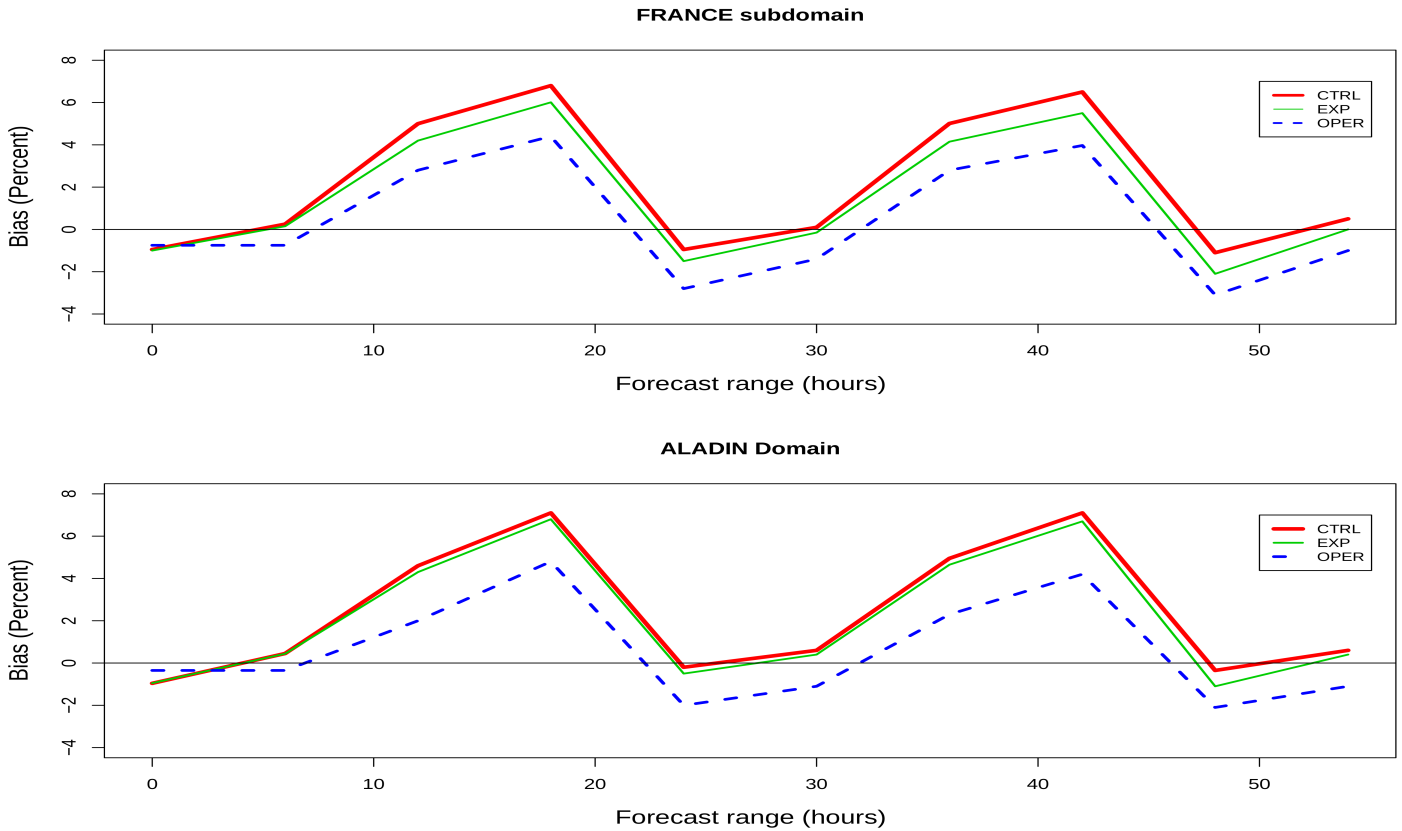
EXP

OPER



Data assimilation

FIG. 7 – Forecast error (bias) on RH2m

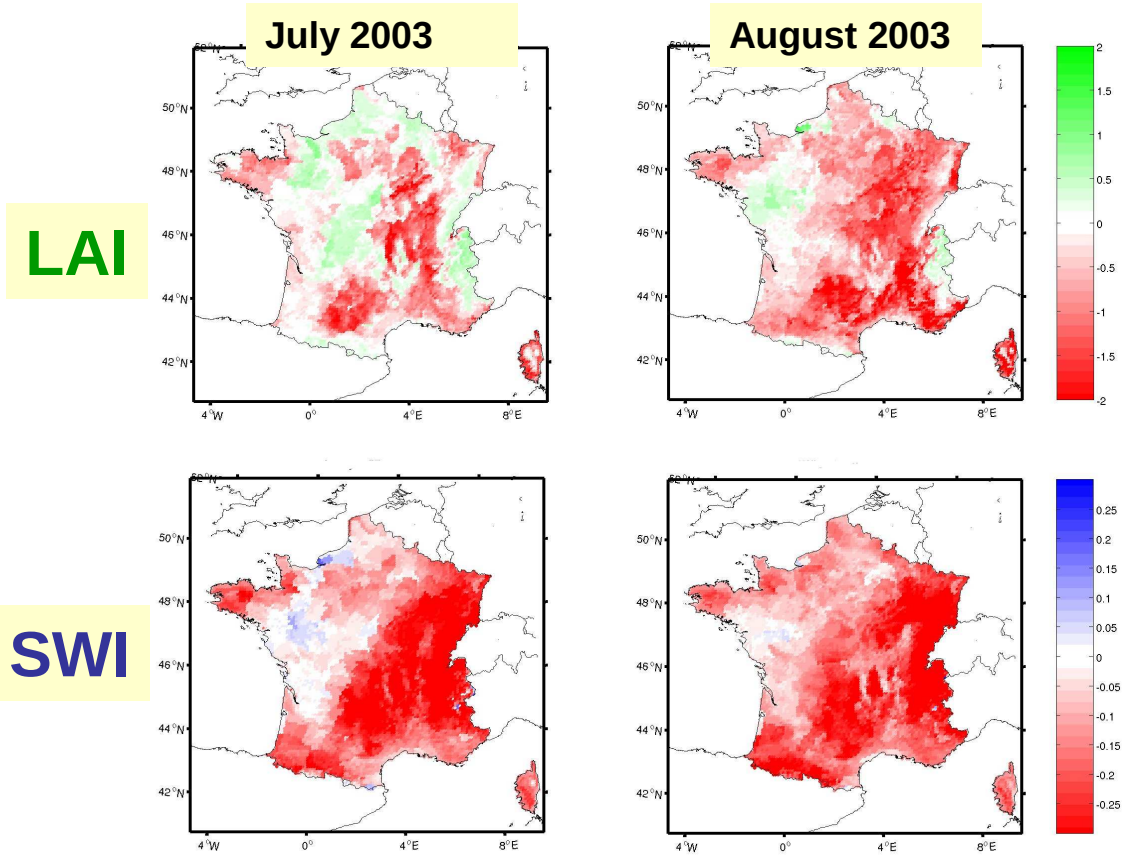


Data assimilation

- Demo assimilation in ALADIN: conclusions
  - Is ASCAT SSM PDF realistic ? Can be corrected (to some extent) by CDF matching
  - ASCAT-derived and T2m/RH2m-derived soil moisture increments are consistent
  - The assimilation of ASCAT SSM improves the forecasts
  - Not as much, however as the assimilation of T2m/RH2m (less data are available)

Data assimilation

FIG. 8 – SSM/LAI synergy: simulated 2003 heat wave anomaly on LAI and SWI, over France



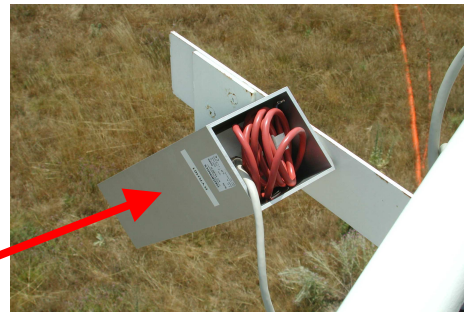
Data assimilation

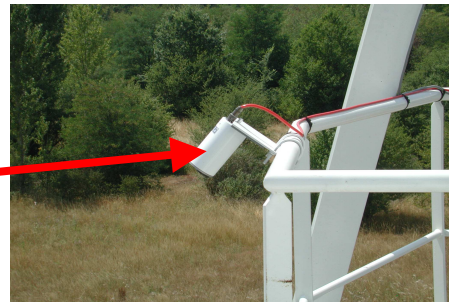
FIG. 9a – SMOSREX joint SSM / LAI assimilation

Partners:
Météo-France/CNRM
CESBIO
INRA Bordeaux
ONERA

Radiometers:

- **L band (ONERA)**
- **Infrared (Heitronics)**
- **VIS, NIR, SWIR (CIMEL)**

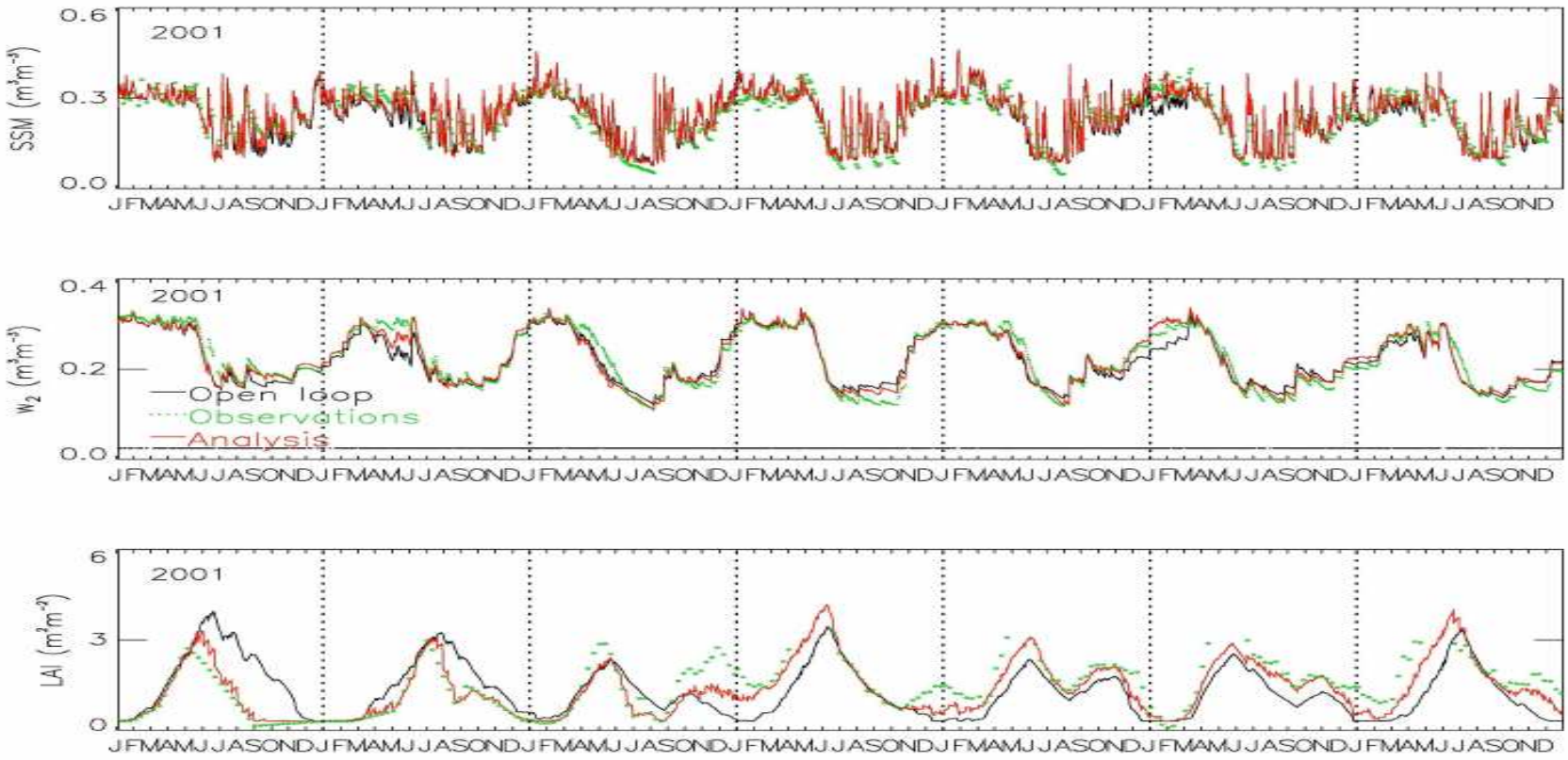




De Rosnay et al. 2006

Data assimilation

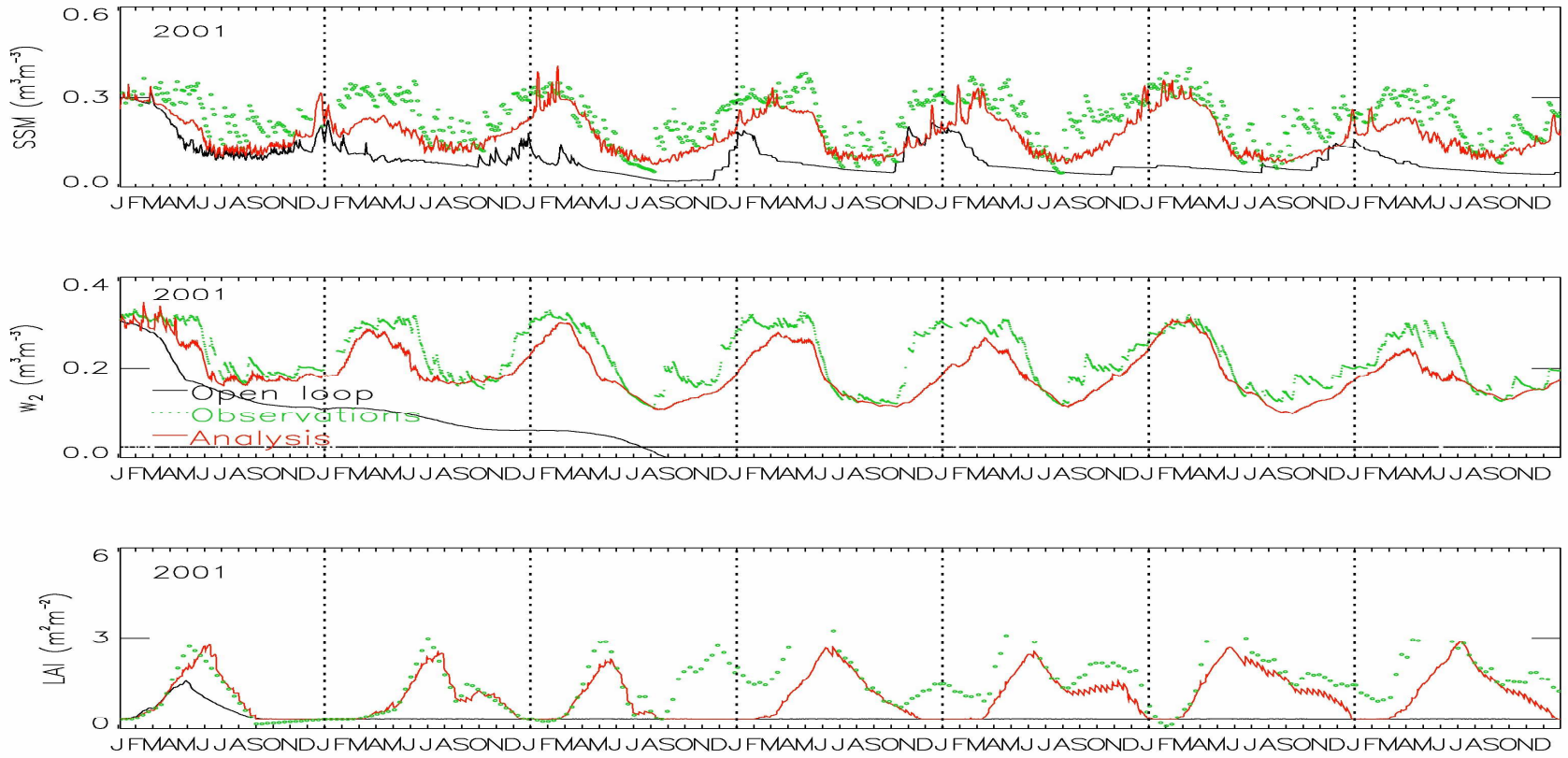
FIG. 9b – SMOSREX joint SSM / LAI assimilation



Albergel et al. 2009

Data assimilation

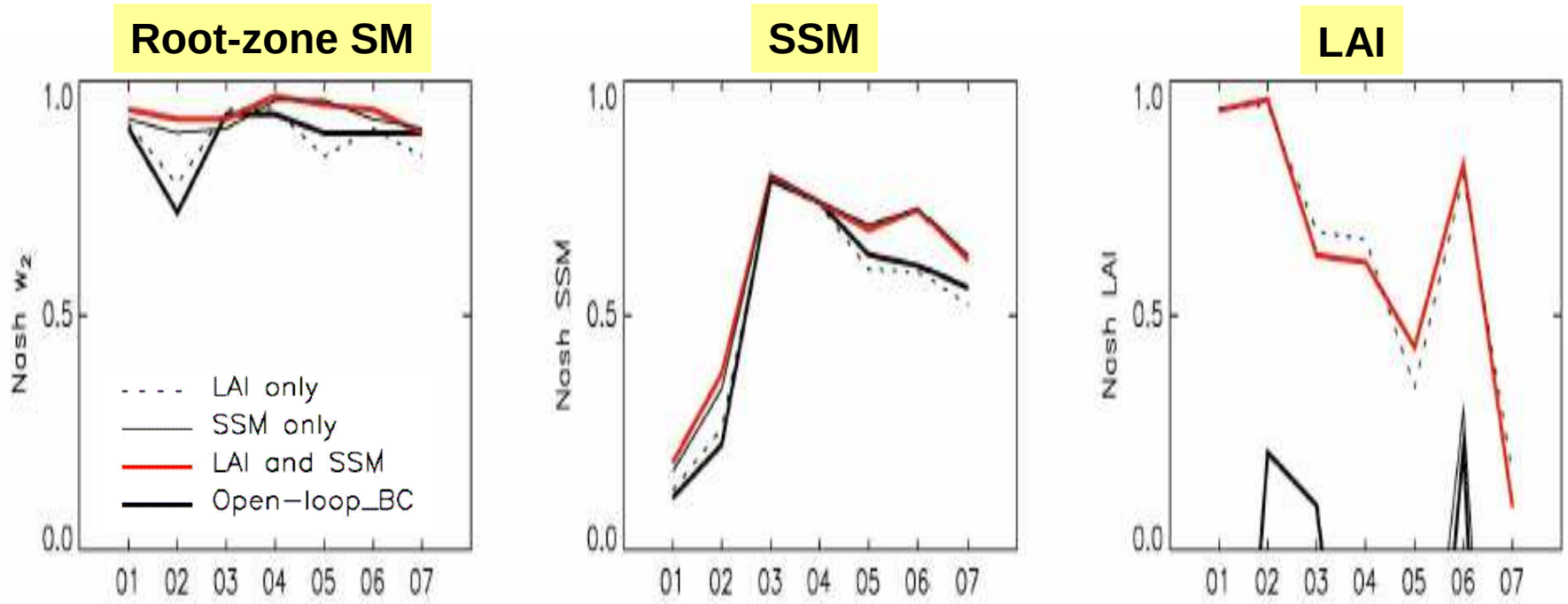
FIG. 9c – SMOSREX joint SSM / LAI assimilation: zero precipitation test



Albergel et al. 2009

Data assimilation

FIG. 9c – SMOSREX joint SSM / LAI assimilation: scores



Albergel et al. 2009

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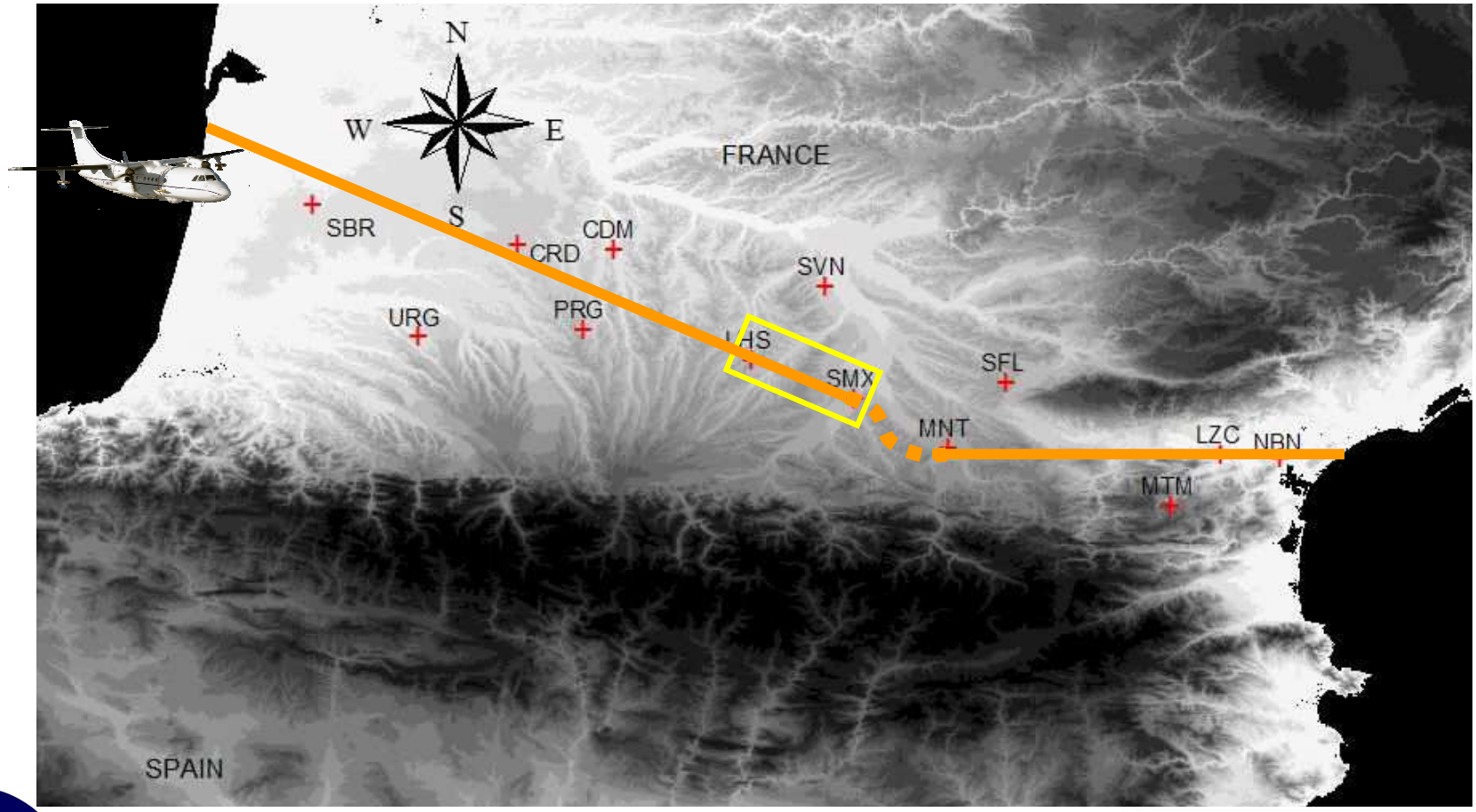
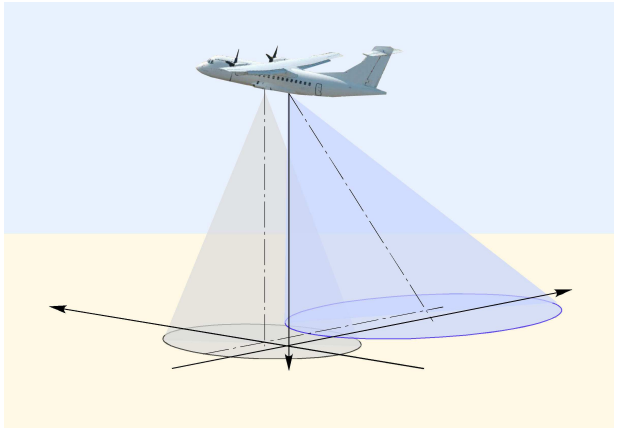
Further steps for SMOS

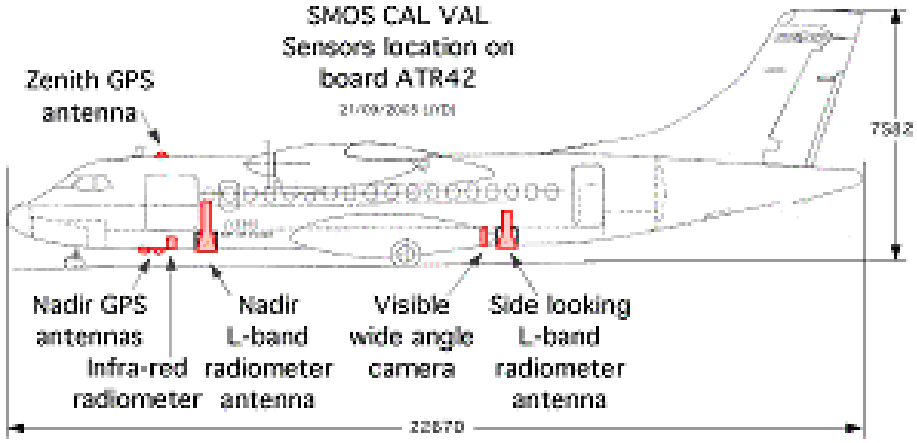
FIG. 10a – CAROLS



Further steps for SMOS

FIG. 10b – CAROLS

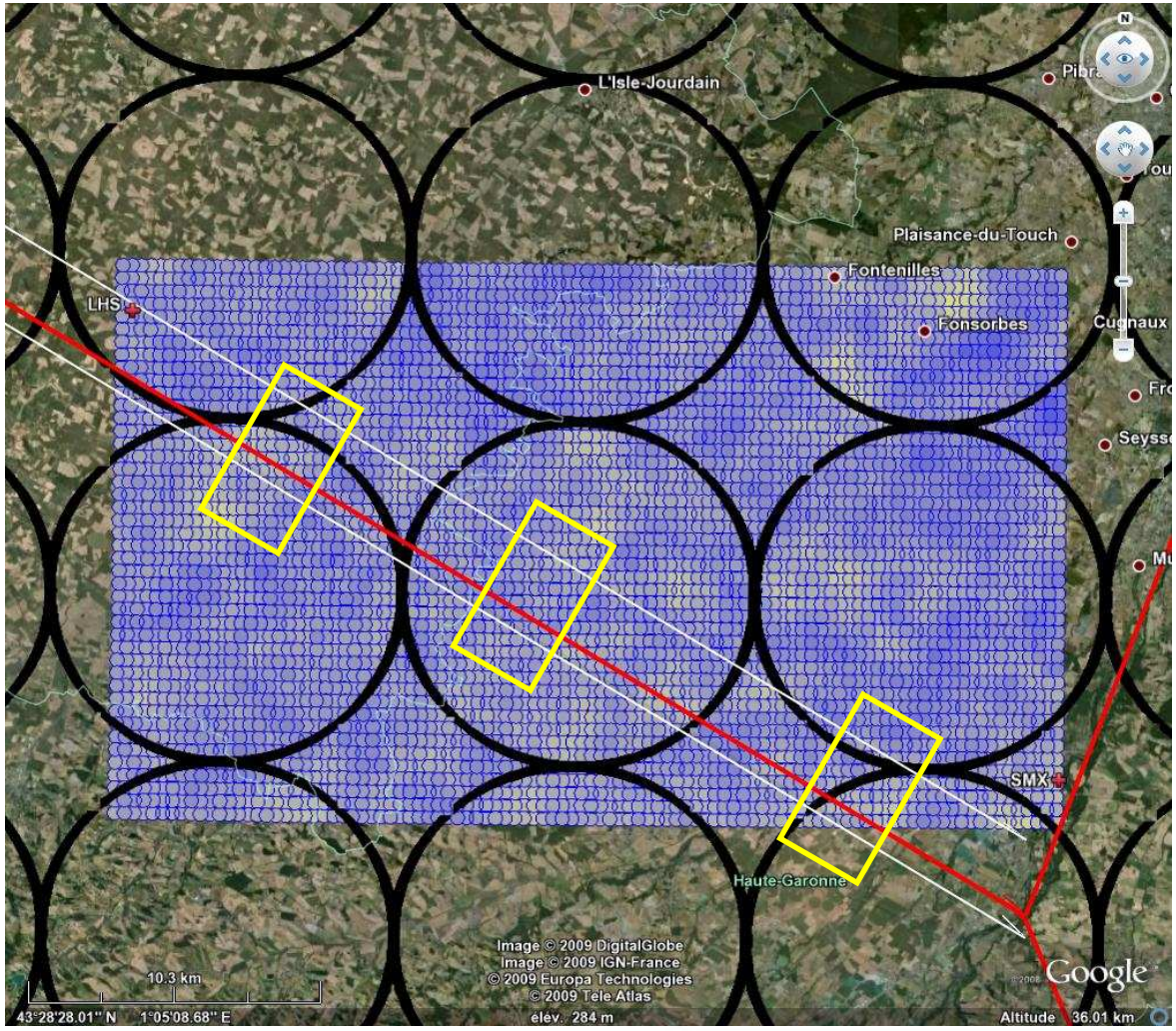




Further steps for SMOS

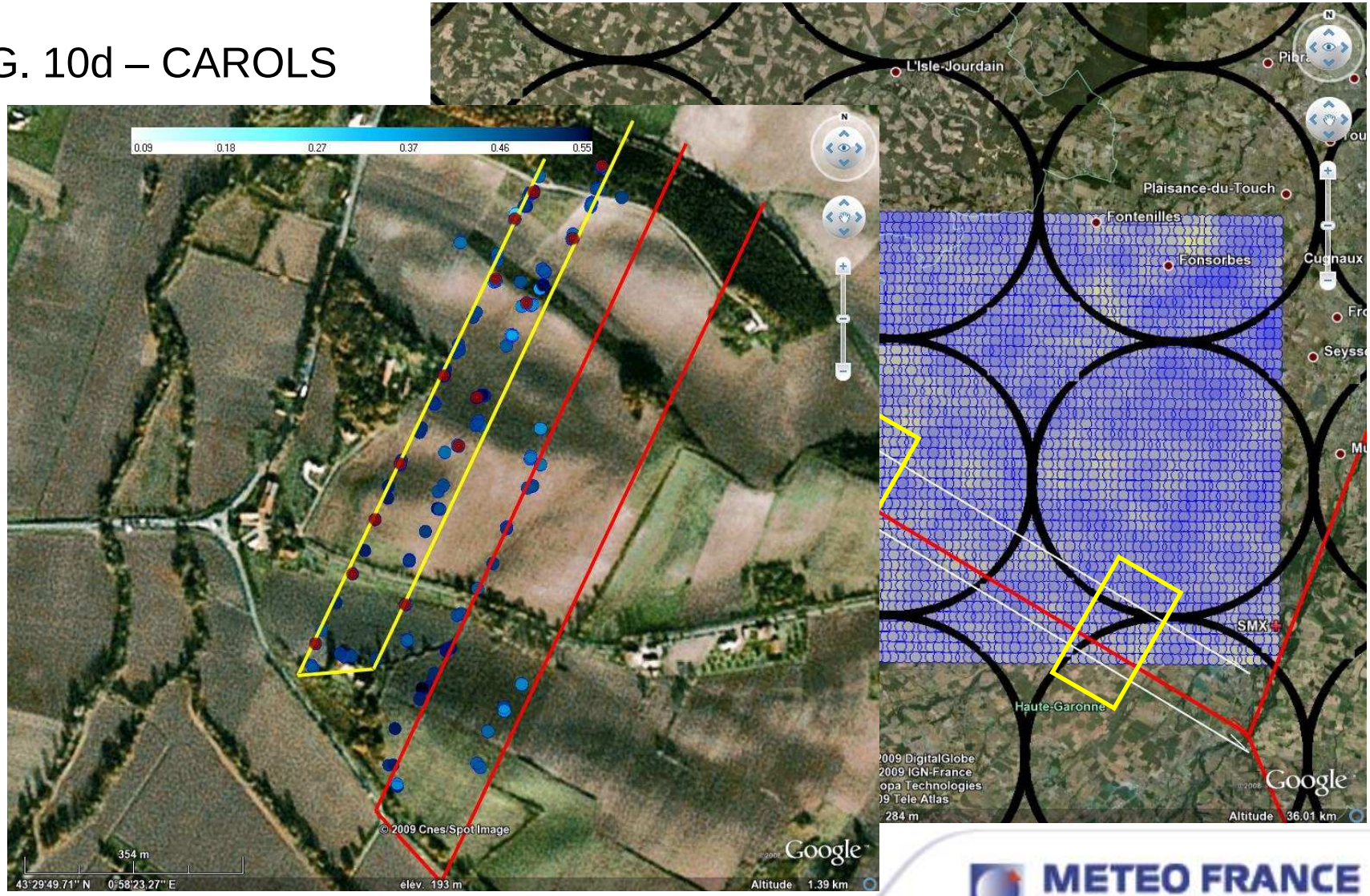
FIG. 10c – CAROLS

In situ observations at
the SW of Toulouse during
SAFIRE ATR-42 flights
with
STORM scatterometer
CAROLS L-band radiometer



Further steps for SMOS

FIG. 10d – CAROLS



Assimilation of EO data in ISBA

- Conclusions
  - EKF in SURFEX able to assimilate
    - T2m/RH2m observations
    - SSM products
    - LAI products
  - LAI response to drought differs from the soil moisture response
    - Joint assimilation of SSM and LAI
  - France is optimal for cross-verification
    - Existing HR soil moisture products
    - In situ soil moisture network
  - SMOS CAL/VAL
    - Will prepare the assimilation of the SMOS data

THANK YOU FOR YOUR ATTENTION

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