RESULTS OF THE DOMEX-2 EXPERIMENT: COMPARISON BETWEEN SMOS AND RADOMEX DATA COLLECTED AT CONCORDIA BASE ANTARCTICA

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Outline

- Objectives and background
- The Domex experiment
- Satellite (SMOS- AMSR-E) and ground data
- Model results
- Conclusions and Perspectives
Objectives

- **Verify the applicability of the East Antarctic plateau as an extended target** for calibrating and monitoring low frequency microwave radiometers using ground based (the Domex-2 experiment) and satellite data (SMOS)

- **Understanding the multi-frequency microwave emission** of the Antarctic plateau by using satellite and ground data in combination to e.m. model
Dome C and the Antarctic Plateau

- The site is viewed on a **sub-daily frequency** by polar-orbiting satellites, at a variety of incidence and azimuth angles.

- **Homogeneity** of snow surface at the **100 km scale**.

- **Small surface roughness** relative to other ice sheets.

- Low snow accumulation rate (around 3.7 cm/yr).

- **Clear sky**, and extremely dry and stable atmosphere.

- Well known topography and environmental condition

Concordia Station (Dome C): 75.125 S, 123.25 E
3270 a.s.l
The Domex-2 experiment

- With a view to the launching of the ESA’s SMOS satellite, an experimental activity called DOMEX, supported by ESA and PNRA, was started at Dome-C, Antarctica in 2005 with a first pilot project (Domex-I, duration one month) and continue with Domex-2.

- The main scientific objective is to demonstrate the stability of the site in order to provide L-band microwave data for SMOS calibration.

- DOMEX-2 experiment consisted in an L-band and an infrared (8-14 µm) radiometers (RADOMEX) installed at Concordia base on an observation tower at a height of 15 m respect to the ice sheet. Data were collected continuously (24/24 h) over two entire Austral annual cycle, starting from December 2008. Snow measurements (including snow stratigraphy, density, grains size and shape, temperature) and meteorological data, were also collected during the experiment.
The Instrument

- **RaDomeX - Radiometer**
- **Frequency**: 1413 MHz
- **Bandwidth**: 27 MHz
- **Sensitivity**: = 0.2 K (Ti =2 sec)
- **Polarization**: H and V
- **Antenna**: Potter Antenna
- **HPBW**: 20°
- **Active (PID) thermal control**

![Diagram of the instrument with labeled parts: IR radiometer, Actuator, L- Band – Potter Antenna.]
The DOMEX Campaign

TOWER VIEW

Concordia base

Air temperature
Mean: - 53 degs
Max: - 23 degs
Min: - 78 degs
Tower Installation

- L-band Antenna
- IR - Radiometer

15 m
Complementary Snow measurements

**Summer**

**Snow deposition:**
Grains shape and size
Classification (precipitation, hoar, wind, etc.)

**Winter**

**Snow layers:**
Temperature
Hardness
Density
Grains shape and size
Dielectric constant
Domex-2 - Campaign Summary

• 2008-2009 Campaign:
  - Radiometer Installation: November 2008 (summer campaign)
  - Power Supply Problem: June 2009
  - Ended: November 2009

• 2009-2010 Campaign:
  - Power Supply Problem PC-Crash: April-June 2010
  - Ended: December 2010
  - Summer campaign and tests – November/December 2010

• 2011 Post Calibration activity:
  - Instrument verification
  - Receiver calibration
  - Radiometer calibration including antenna (extended target)
Domex -2 – 2009 campaign

No temperature control →
Low temperature /High fluctuation

Theta = 42° SMOS angle

Power Failure > 10 days
Radomex Temperature < -60°C !!!
Domex-2 – November 2008 – May 2009

- Sky Brightness Temperature [K]
- Snow Brightness Temperature [K]

Stable Period 1
Stable Period 2

ΔT

01/12/08 01/01/09 01/02/09 04/03/09 04/04/09 05/05/09

Tv

ΔT

ΔT
Explanation: anomaly in the Th reference load

![Graph showing temperature anomalies over time]

- **2009**
  - Th Temperature: ranging from 342 to 360 K
  - Dates: 29/10/08 to 25/08/09

- **2010**
  - Th Temperature: ranging from 342 to 360 K
  - Dates: 03/12/09 to 18/11/10
Data after Correction

\[ T_{bv} = 208.44 \text{ K} \quad \text{sdev} = 0.55 \text{ K} \]

\[ T_{bh} = 187.50 \text{ K} \quad \text{sdev} = 1.18 \text{ K} \]
Domex-2 : 2010 campaign

Tbv = 206 K – sdev = 0.55 K

Tbh = 188 K – sdev = 1.5 K

Power Failure
PC crash April 10

Problem
Solved – July 2010

11 months data
SMOS comparison - Temporal Trends

Jumps are also observed on SMOS!

SMOS data:
- alias free FOV
- sun, moon, galactic glint, or RFI flags set were discarded
- Earth incidence angles of 42±0.5 degrees were used
- polarization was rotated from x-y coordinates to H-V using SMOS tools

Domex Tb could be used as a benchmark for improve SMOS data?
Possible Explanation of jumps: wind effect

An agreement was observed between Tb jumps and high wind events.

The hypothesis is that wind causes an effect in snow metamorphism, then is able to modify the ice sheet layering.

Lines = High Wind Speed (> 7 m/s)
Layering effect: Tb variation – surface/subsurface effect

Because of layering the sun effect is observed as «fringes» in the signal. Since we observe at $\theta = 42^\circ$ ($\approx$ Brewster angle) the effect is evident at H polarization.
Domex -2 Angular Trends : 2009 Data

Because of the acquisition cycle data were regularly acquired (several scan per day)
Angular trends: 2009-2010 comparison

Data comparison:
Fourth months 2009 vs End of 2010
SMOS – comparison: Angular Trend

SMOS data provided by CESBIO

SMOS data:
- alias free FOV
- sun, moon, galactic glint, or RFI flags set were discarded
- Earth incidence angles of ± 2 degrees were used
- polarization was rotated from x-y coordinates to H-V using SMOS tools
Multi-frequency Tb data: temporal trends

almost a Black Body

Obs. angle 55 deg

V pol fluctuates less because of the Brewster angle!
Tb – StdDev vs Frequency (AMSR-E & DOMEX)

Tb sdev decreases when frequency decreases

The site is stable at L band
Model Results (DMRT – multilayers)

- Comparison of multi-frequency temporal trends

The model is able to estimate the e.m. data with a good accuracy. Some discrepancy are present at Ku- and Ka-band.
Model Results

- Penetration depths

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<tr>
<th>Frequency (GHz)</th>
<th>Penetration depth (m)</th>
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<td>37</td>
<td>1.5</td>
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Conclusions

- The Domex-2 was a very challenging project was carried out in an extreme environment and which required a lot of effort in terms of: technical implementation, campaign organization (logistic and programmatic) data processing and analysis.

- The high temporal stability of Tb at V polarization is confirmed in both 2009 and 2010. Tb at H polarization exhibits a high fluctuation due to the surface and sub-surface effect (as expected).

- The angular and temporal trends exhibit a very good agreement with SMOS data.

- Multi-frequency data and model analysis emphasize the mechanisms that dominate the emission of the ice sheet.
Suggestions for future activities

• Establish a permanent long-time period tower based experiment for current and future L band missions (SMOS, SMAP, SMOSnext, etc.).

• Spatial airborne survey of the area near to Dome-c in the FOV of satellite. Including ground measurements

• More in depth spatial analysis of SMOS data over the entire plateau

• Continuous observation of snow parameters for a better understanding of H polarization signal

• Development of a dedicated theoretical model for data analysis (on going at LGGE)
RADOMEX looking in the Antarctic night

Thanks for the attention!