The ESA CoSMOS study for the validation of the SMOS L2 prototype

OUTLINE

1. Presentation of the CoSMOS study
2. Data processing for validation of the SMOS L2 SSM
3. Science studies in progress: SM retrievals
4. Calibration issues
5. Conclusion & following activities
1/ Objectives of the CoSMOS study (2007-2008)

- First evaluation of the SMOS SM Level 2 (L2) algorithm using real data
- Performance of the SMOS L2 ‘default model’?
- Fine tune modelling of microwave model L-MEB
- Sensitivity of retrievals to input surface data? (e.g. surface T, roughness …)
- ‘Special issues’ (e.g. sun-glint over land, polarimetric data …)
CoSMOS-NAFE Campaing
6-week campaign (end 2005)
2 L-band sensors onboard two aircrafts (EMIRAD, PLMR)

Good complementarity:
PLMR: Multi-resolution (pushbroom)
EMIRAD: Bi-angular (along-track), frequent flights
## CoSMOS study schedule (2007-2008)

<table>
<thead>
<tr>
<th>WP number and title</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
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<td>WP2000 Literature review</td>
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<td>WP3100 Data acquisition</td>
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<td>WP3200 Data processing</td>
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<td>WP5000 Analysis of NAFE-05 PLMR flights</td>
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<td>WP6200 Conclusions and recommendations (2)</td>
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<td>Meetings</td>
<td>K-O</td>
<td>P M</td>
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### MAIN CONCLUSIONS

- **SMOS launch**

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1 RADIOMETRIC DATA / EMIRAD

- What are we measuring? Polarisation mixing? Calibration errors?
- TRAP package (June 2007), Extra test wing-wag flights processed by TUD
- Antenna pattern correction included + Polarisation correction (surface to antenna correction)

2 GROUND DATA GRIDS

- Preparation of ground data set (Land use classification, soil moisture, estimates of biomass, etc.) // Gridded data for model simulations at resolutions of 50-250 m.

3 MODELLING ACTIVITIES

- Surface modelling and Soil Moisture retrievals using SMOS BB (CESBIO) // Design of retrievals and definition of study cases
2/ Data processing for validation of the SMOS L2 SSM

1. Antenna projected onto the surface
   \( f(\text{aircraft attitude, antenna orientation, gain pattern, topography}) \)

2. Land-use distribution
   (e.g. crop, grass, forest)  
   + Local incidence angles  
   + Ancillary surface data

3. Simulated \( T_{bi,j} \)

4. Transportation of simulated Stokes vector to antenna level

5. Antenna WEF

6. Comparison to measured Stokes
Data processing for validation of the SMOS L2 SSM

1. Antenna projected on the surface (local angles shown)

2. Comparison to measured Stokes

3. Simulated $T_{bi,j}$

4. Transportation of simulated Stokes vector to antenna level

5. Antenna WEF

6. $T_{bsim}$ ↔ $T_{bmeas}$
2/ Data processing for validation of the SMOS L2 SSM

Wide angle antennas

‘All energy from boresight’

‘Off-nadir emission accounted for’

Errors?
Heterog. 5% trees inside 3dB area or
Heterog. 15% trees scattered outside 3dB area nadir ~3 K ~ SSM up to 1% vol.vol

‘Boresight approach’ valid for modelling work over areas with little heterogeneity/
Integration over antenna pattern advised for areas with significant mixing or when
we want to model the emission of mixed pixels
Data processing for validation of the SMOS L2 SSM

Generation of ‘static’ maps

- LU classification 25 m
- ‘L2 model parameters’
- Soil type / texture
2/ Data processing for validation of the SMOS L2 SSM

Generation of ‘dynamic maps’: soil moisture, MODIS-NDVI-LAI
EMIRAD NADIR DUAL POLARISATION
NADIR IR TEMPERATURE
250-M LAI MAPS

DEFAULT L2 MODEL PARAMETERS +
1) DEFAULT ROUGHNESS (HR 0.05 TO 0.1)
2) ROUGHNESS MODIFICATION (HR=F(SM))/
   [HR_MIN=0.05, HR_MAX=1]

5 FARMS COMPOSITION:
Native grass, Crops, Mixed grass/crops

L-MEB parameters
CLASS 1- GRASS, CROPS, BARE SOIL
CLASS 2- OPEN WOODLAND

3/ Science studies in progress: SM retrievals
3) Science studies in progress: SM retrievals

17/11 Stanley Grass/clayey

RMSE(SSM)=2.9%
RMSE(TB)=0.6 K [0.94]

HR_MAX=1.0
HR_MIN=0.05
Science studies in progress: SM retrievals

RMSE(SSM) = 2.9%
RMSE(TB) = 0.6 K
HR_MAX = 1.0
HR_MIN = 0.05
3/ Science studies in progress: SM retrievals

23/11 Merriwa
Wheat/Grass/clay-loam

RMSE(SSM)=2.8%
RMSE(TB)=0.7 K
[0.82]
HR_MAX=1.0
HR_MIN=0.05
Science studies in progress: SM retrievals

23/11 Midlothian
Grass/clayey

**RMSE(SSM)** = 4.6%
**RMSE(TB)** = 3 K
[0.46]
**HR_MAX** = 1.0
**HR_MIN** = 0.05
Science studies in progress: SM retrievals

15/11 Pembroke
Grass/crop/clayey

RMSE(SSM)=8.0%
RMSE(TB)=0.6 K
HR_MAX=1.0
HR_MIN=0.05
Science studies in progress: SM retrievals

17/11 Illogan Grass/Barley/Oats /silt-loam
RMSE(SSM)=10%
RMSE(TB)=0.4 K
[0.99]
HR_MAX=1.0
HR_MIN=0.05
3/ Science studies in progress: SM retrievals

(Saleh et al, RSE, 2007)

Generalisation $HR = f(sm)$?
**4/ Calibration issues- EMIRAD data/ nadir**

Glenbaw Lake (no wing-wags)

*near nadir only*

Q = -1.2 ± 1.1

Alexandrina Lake (wing-wags)

Q = -2.7 ± 0.1

Ocean coast near Alexandrina (wing-wags)

Q = -2.8 ± 0.1

* near nadir only
**4/ Calibration issues- EMIRAD data/ nadir**

<table>
<thead>
<tr>
<th>ERRORS IDENTIFIED BY THE OCEAN STUDY</th>
<th>NADIR</th>
<th>EXPECTED IMPACT OVER SM RETRIEVALS</th>
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</thead>
<tbody>
<tr>
<td>1) ROTATION POL. BASIS</td>
<td>negligible</td>
<td>LOW FOR LAND</td>
</tr>
<tr>
<td>2) ANTENNA PITCH/ROLL OFFSETS</td>
<td>negligible</td>
<td>LOW FOR LAND</td>
</tr>
<tr>
<td>3) Q OFFSET AT NADIR</td>
<td>1-3 K</td>
<td>~ 1 % vol/vol</td>
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</table>

- Compared to simulations over water (Glenbawn Lake, using ground data):
  - RMSE ~ 1K (V pol), RMSE ~ 2 K (H pol)
- Possibilities to correct for this?
- Evaluate sensitivity of retrievals to Q offset
4/ Calibration issues- EMIRAD data/ nadir

RMSE(SSM)=3.3%
RMSE(TBH)=0.8 K
-2 K offset H pol,
-1 K offset V pol

RMSE(SSM)=2.9%
RMSE(TB)=0.6 K
Half of 2.8 K offset to each channel

RMSE(SSM)=2.9%
RMSE(TBH)=1.4 K

Half of 2.8 K offset to each channel

17/11 Stanley Grass/sparse
5/ Conclusion & planned activities

i) The CoSMOS study has now initiated the algorithm validation tasks

ii) Mid-term review with main conclusions due March 2008

iii) First tests of ‘default’ L2 model performance indicate,

   I) roughness is likely to be higher than assumed by L2 default parameters. After roughness correction rather good retrievals over grass, and mixed areas with grass and crops

   II) retrievals for wet soils to be tested with roughness fit

iv) Calibration issues: Q offset detected and should be included in sensitivity analysis
5/ Conclusion & planned activities

This is ongoing work, other assumptions (input temperature, vegetation emission, etc.) yet to be evaluated

Multi-angular retrievals yet to be performed

Related posters at the SMOS cal/val Workshop

- Escorihuela et al. (Sun-glint)
- Panciera et al. (SM retrievals from PLMR data)

Publications related to the CoSMOS study / CoSMOS campaign

- Saleh et. al, in Proceedings IGARSS-2007
4/ Calibration issues- EMIRAD data /nadir

Alexandrina (lake)
True nadir pitch
~ 2 deg
True nadir roll & heading
~ 0 deg
Q offset at nadir
2.7 K

Near Alexandrina (ocean)
True nadir/pitch
~ 2 deg
True nadir/roll & heading
~ 0 deg
Q offset at nadir
2.8 K
4/ Science studies in progress: SM retrievals
### 3/ Science studies in progress: SM retrievals

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<tr>
<td>Grass</td>
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<tr>
<td>17/11 Stan</td>
<td>1.0</td>
<td>2.9%</td>
<td>0.6 K</td>
<td>dry</td>
<td>0.1</td>
<td>5.0%</td>
<td>0.6 K</td>
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<tr>
<td>23/11 Midlot.</td>
<td>1.0</td>
<td>2.9%</td>
<td>0.6 K</td>
<td>dry</td>
<td>0.1</td>
<td>3.4%</td>
<td>0.7 K</td>
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<td>Grass/crops</td>
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<tr>
<td>23/11 Merr</td>
<td>1.0</td>
<td>2.8%</td>
<td>0.6 K</td>
<td>dry</td>
<td>0.1</td>
<td>3%</td>
<td>1.5 K</td>
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<td>15/11 Pem</td>
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<td>8%</td>
<td>0.6 K</td>
<td>Dry/wet</td>
<td>0.1</td>
<td>10%</td>
<td>0.6 K</td>
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<tr>
<td>17/11 Illog</td>
<td>1.0</td>
<td>10%</td>
<td>0.5 K</td>
<td>Dry/wet</td>
<td>0.1</td>
<td>14%</td>
<td>0.5 K</td>
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<thead>
<tr>
<th></th>
<th>MODIFIED L2 PARAM</th>
<th>DEFAULT L2 PARAM</th>
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**DEFAULT L2 PARAM**

**MODIFIED L2 PARAM**
**Sub-studies for WP4000**

**GROUP OF STUDIES 1**

- **L2 VALIDATION FOR HOMOGENEOUS SURFACES**
  - USES L-BAND DATA UNDER 1 KM
  - OUTPUT:
    - performance of ‘default L2 model’
    - recommendations

- **VALIDATION SOIL MICROWAVE MODEL**

- **VALIDATION GRASS/CROPS MICROWAVE MODEL**

- **LITTER AND INTERCEPTION**

- **FOREST MICROWAVE MODEL**
Sub-studies for WP4000

GROUP OF STUDIES 2

VALIDATION L2 HETEROGENEOUS SURFACES

USES L-BAND DATA UNDER 1 KM

OUTPUT:
- performance of ‘default L2 model’
- recommendations

SM RETRIEVALS IN MIXED PIXELS ‘NOMINAL’ + ‘NOMINAL’

SM RETRIEVALS IN MIXED PIXELS ‘NOMINAL’ + ‘FOREST’ (SM retrieved in the nominal part only)
Sub-studies for WP4000

GROUP OF STUDIES 3

VALIDATION OF LOW-RES SM

USES LOW-RES L-BAND DATA

OUTPUT:
- performance of ‘default L2 model’
- recommendations

SM RETRIEVALS AT 1 KM FROM L2 AGGREGATED TBs

SM VALIDATION FROM L2 RETRIEVALS AT THE SMOS SCALE

1 km   40 km

SM?   SM?
Sub-studies for WP4000

GROUP OF STUDIES 4

'�PECIAL ISSUES'

QUANTIFICATION OF SUN-GLINT OVER LAND (see poster by M.J. Escorihuela)

USE OF FULLY POLARIMETRIC L-BAND DATA

COMPARISON PLMR-EMIRAD

TOPOGRAPHY EFFECTS