

# Does SMOS Accomplish GODAE Requirements? Issues Concerning Satellite Salinity Retrieval

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## Overview

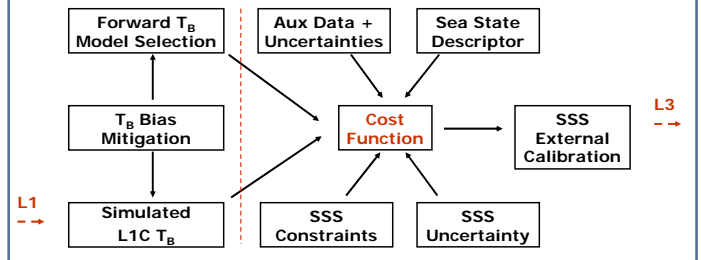
ESA's Soil Moisture and Ocean Salinity (SMOS) mission will be launched in early 2009 to provide sea surface salinity (SSS) maps on a global basis with frequent temporal coverage. The SMOS ocean community is currently defining a reliable inversion scheme to obtain SSS estimations from the multi-angular brightness temperatures ( $T_B$ ) provided by the MIRAS (Microwave Interferometric Radiometer by Aperture Synthesis) sensor.

$$\chi^2 = \frac{1}{N_{obs}} \sum_{n=1}^{N_{obs}} \left\| \frac{F_n^{meas} - F_n^{model}}{\sigma_{F_n}} \right\|^2 + \frac{(SSS - SSS_{aux})^2}{\sigma_{SSS}^2} + \frac{(SST - SST_{aux})^2}{\sigma_{SST}^2} + \frac{(U_{10} - U_{10aux})^2}{\sigma_{U_{10}}^2}$$

## Salinity Retrieval Issues

- Scene-dependent **bias** in the simulated  $T_B$  measurements
- **Radiometric Sensitivity** (rms error associated to thermal noise) and **Radiometric Accuracy** (rms error associated to imperfect instrument and calibration)
- L-band forward modeling definition (**Geophysical Model Function**)
- **Auxiliary data**, namely sea surface temperature (**SST**) and wind speed ( **$U_{10}$** ), sources and **uncertainties**
- Adequate **sea-state descriptor**
- **SSS Constraint** and **SSS Uncertainty**
- **Sun contamination** analysis
- Adequate spatio-temporal averaging (**L3**)

## Salinity Retrieval Scheme Flowchart

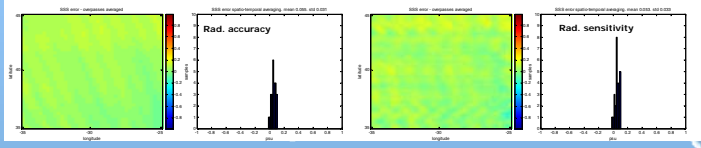


## Scientific Requirements for Salinity Retrieval

- Global Ocean Data Assimilation Experiment (GODAE, 1997) 0.1 psu, 200 km, 10 days
- Salinity and Sea Ice Working Group (SSIWG, 2000) 0.1 psu, 100 km, 30 days
- SMOS (Mission Requirements Document v5, 2002) 0.1 psu, 200 km, 30 days

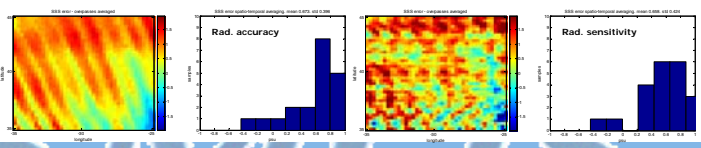
## Ocean Salinity Error Budget (Constrained configuration)

| Items  | Bias           |                | Accuracy 2°x2° |               |
|--|----------------|----------------|----------------|---------------|
|  | Tx/Ty (psu)    | I (psu)        | Tx/Ty (psu)    | I (psu)       |
| <b>Instrument and Image Reconstruction Algorithm</b> |                |                |                |               |
| 1. Radiometric accuracy                              | 0.055          | 0.060          | 0.031          | 0.042         |
| 2. Radiometric sensitivity                           | -0.002         | 0.000          | 0.011          | 0.021         |
| <b>External Sources</b>                              |                |                |                |               |
| 3. Faraday   | 0.001          | N/A            | 0.014          | N/A           |
| <b>Geophysical Sources</b>                           |                |                |                |               |
| 4. Dielectric constant                               | -0.046         | -0.066         | 0.008*         | 0.021         |
| 5. Foam  | -0.018         | -0.016         | 0.026*         | 0.018*        |
| 6. Auxiliary SST                                     | 0.004          | 0.009          | 0.026          | 0.028         |
| 7a. Auxiliary wind                                   | -0.137         | -0.205         | 0.217          | 0.287         |
| 7b. mss  | -0.258         | -0.292         | 0.117 / 0.362  | 0.167 / 0.557 |
| 8. Total error budget flat surface                   | 0.054          | 0.060          | 0.036 / 0.044  | 0.047 / 0.055 |
| 9a. Total error budget aux parameters                | 0.054 / -0.079 | 0.060 / -0.136 | 0.036 / 0.220  | 0.047 / 0.291 |
| 9b. Total error budget mss                           | 0.054 / -0.204 | 0.060 / -0.232 | 0.122 / 0.364  | 0.173 / 0.559 |



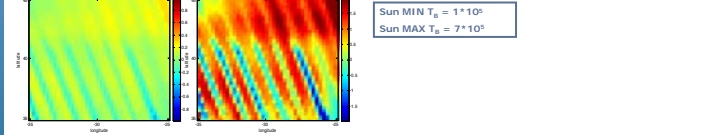
## Ocean Salinity Error Budget (Non-Constrained configuration)

| Items  | Bias          |               | Accuracy 2°x2° |               |
|--|---------------|---------------|----------------|---------------|
|  | Tx/Ty (psu)   | I (psu)       | Tx/Ty (psu)    | I (psu)       |
| <b>Instrument and Image Reconstruction Algorithm</b> |               |               |                |               |
| 1. Radiometric accuracy                              | 0.673         | 0.543         | 0.396          | 0.370         |
| 2. Radiometric sensitivity                           | -0.015        | 0.001         | 0.152          | 0.195         |
| <b>External Sources</b>                              |               |               |                |               |
| 3. Faraday   | 0.009         | N/A           | 0.157          | N/A           |
| <b>Geophysical Sources</b>                           |               |               |                |               |
| 4. Dielectric constant                               | -0.614        | -0.591        | 0.223*         | 0.212*        |
| 5. Foam  | -0.147        | -0.135        | 0.301*         | 0.131*        |
| 6. Auxiliary SST                                     | 0.004         | 0.009         | 0.026          | 0.028         |
| 7a. Auxiliary wind                                   | -0.137        | -0.205        | 0.217          | 0.287         |
| 7b. mss  | -0.258        | -0.292        | 0.117 / 0.362  | 0.167 / 0.557 |
| 8. Total error budget flat surface                   | 0.667         | 0.542         | 0.452 / 0.453  | 0.418 / 0.419 |
| 9a. Total error budget aux parameters                | 0.667 / 0.534 | 0.542 / 0.346 | 0.452 / 0.501  | 0.418 / 0.507 |
| 9b. Total error budget mss                           | 0.667 / 0.409 | 0.542 / 0.250 | 0.467 / 0.579  | 0.450 / 0.696 |



## Sun Contamination Analysis

| Sun contamination               | Bias        |         | Accuracy 2°x2° |         |
|---------------------------------|-------------|---------|----------------|---------|
|                                 | Tx/Ty (psu) | I (psu) | Tx/Ty (psu)    | I (psu) |
| <b>Restricted, weighted</b>     |             |         |                |         |
| Master                          | 0.055       | 0.060   | 0.031          | 0.042   |
| Sun MIN, cancelled              | -0.002      | 0.006   | 0.014          | 0.021   |
| Sun MAX, cancelled              | 0.004       | 0.017   | 0.018          | 0.021   |
| Sun MIN, NOT cancelled          | 0.004       | 0.013   | 0.034          | 0.047   |
| Sun MAX, NOT cancelled          | 0.012       | 0.030   | 0.077          | 0.118   |
| <b>Non restricted, weighted</b> |             |         |                |         |
| Master                          | 0.673       | 0.543   | 0.396          | 0.370   |
| Sun MIN, cancelled              | 0.067       | 0.052   | 0.251          | 0.184   |
| Sun MAX, cancelled              | 0.107       | 0.136   | 0.253          | 0.190   |
| Sun MIN, NOT cancelled          | 0.198       | 0.173   | 0.382          | 0.327   |
| Sun MAX, NOT cancelled          | 0.767       | 0.816   | 0.453          | 0.427   |



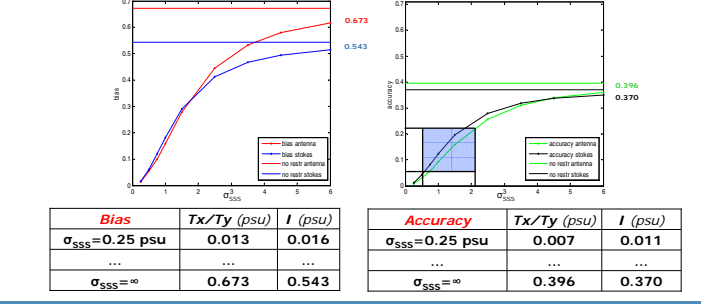
## Future Lines (Cost Function Balancing)

$$\chi^2 = \frac{N_{eff}}{N_{obs}} \sum_{n=1}^{N_{obs}} \left\| \frac{F_n^{meas} - F_n^{model}}{\sigma_{F_n}} \right\|^2 + A \frac{(SSS - SSS_{aux})^2}{\sigma_{SSS}^2} + B \frac{(SST - SST_{aux})^2}{\sigma_{SST}^2} + C \frac{(U_{10aux} - U_{10})^2}{\sigma_{U_{10}}^2}$$

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## $\sigma_{SSS}$ Sensitivity



## Conclusions

- SSS Error Budget quantified at L3
- Despite **bias** mitigation, residual offset still present: post-processing **SSS calibration**
- **Auxiliary data** introduce large uncertainties
- **SSS constraint** trade-off
  - Too restrictive vs too large error (saturation)
  - Tx/Ty vs I performances (**crossover**)
- **Sun** impact analysis
  - Need for a proper contamination correction
  - Estimation of Sun  $T_B$  not critical (except in the non-constrained case)
- **Ideal case**: accomplishment of the GODAE/SMOS requirements
- **Worst** (quasi-realistic ?) case. (Far) Beyond the GODAE/SMOS requirements:
  - Constrained: 0.036/0.364 psu (Tx/Ty) or 0.047/0.559 psu (I) & no Sun
  - Non-Constrained: 0.452/0.579 psu (Tx/Ty) or 0.418/0.696 psu (I) & no Sun