

Does SMOS Accomplish GODAE Requirements? Issues Concerning Satellite Salinity Retrieval

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Overview

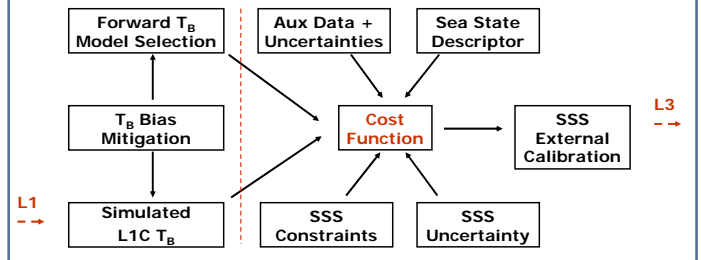
ESA's Soil Moisture and Ocean Salinity (SMOS) mission will be launched in early 2009 to provide sea surface salinity (SSS) maps on a global basis with frequent temporal coverage. The SMOS ocean community is currently defining a reliable inversion scheme to obtain SSS estimations from the multi-angular 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

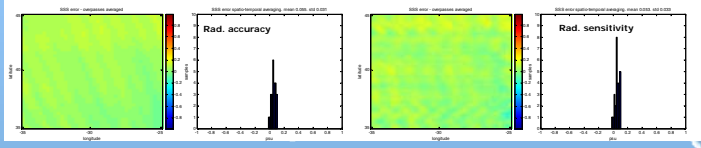


Scientific Requirements for Salinity Retrieval

- 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

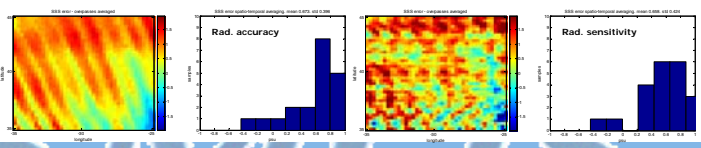
Ocean Salinity Error Budget (Constrained configuration)

Items	Bias		Accuracy 2°x2°	
	Tx/Ty (psu)	I (psu)	Tx/Ty (psu)	I (psu)
Instrument and Image Reconstruction Algorithm				
1. Radiometric accuracy	0.055	0.060	0.031	0.042
2. Radiometric sensitivity	-0.002	0.000	0.011	0.021
External Sources				
3. Faraday	0.001	N/A	0.014	N/A
Geophysical Sources				
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



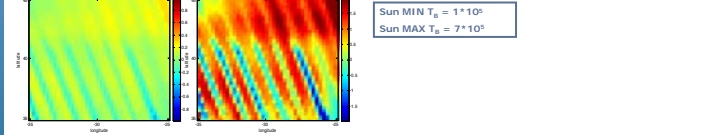
Ocean Salinity Error Budget (Non-Constrained configuration)

Items	Bias		Accuracy 2°x2°	
	Tx/Ty (psu)	I (psu)	Tx/Ty (psu)	I (psu)
Instrument and Image Reconstruction Algorithm				
1. Radiometric accuracy	0.673	0.543	0.396	0.370
2. Radiometric sensitivity	-0.015	0.001	0.152	0.195
External Sources				
3. Faraday	0.009	N/A	0.157	N/A
Geophysical Sources				
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)
Restricted, weighted				
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
Non restricted, weighted				
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



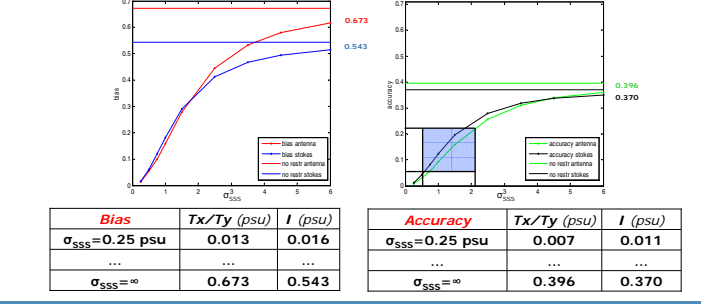
Future Lines (Cost Function Balancing)

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

Acknowledgements

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σ_{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