ALMIP-MEM (AMMA Land surface Models Intercomparison Project – Microwave Emission Model)

ECMWF
ALMIP AMMA Land Surface Model Intercomparison Project

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ALMIP-MEM is presented here. It concerns soil moisture estimation over West Africa by the means of passive microwave remote sensing and land surface modelling. Soil moisture is a key variable modulating land-surface-atmosphere feedbacks. It controls the water and energy exchanges between the surface and the atmosphere.

P. de Rosnay[1], A. Boone[2], M. Drusch[1], G. Balsamo[1], T. Pellarin[3], J.-P. Wigneron[4]

1 European Centre for Medium Range Weather Forecasts (ECMWF), Reading, UK, **2** CNRM/Météo-France, France, **3** LTHE, France, **4** INRA/EPHYSE

Contact Patricia.Rosnay@ecmwf.int

ALMIP – AMMA Land Surface Model Intercomparison Project

- Ensemble of state-of-the-art regional scale Land Surface Models (LSMs) simulations (2002–2006). Twelve LSMs are participating to ALMIP (*Boone and de Rosnay, 2007*).
- Simulates soil moisture and surface fluxes for this period (3h time step).
- Two ALMIP experiments (EXP1 and EXP2) with different forcing data sets (Figures 1 and 2)

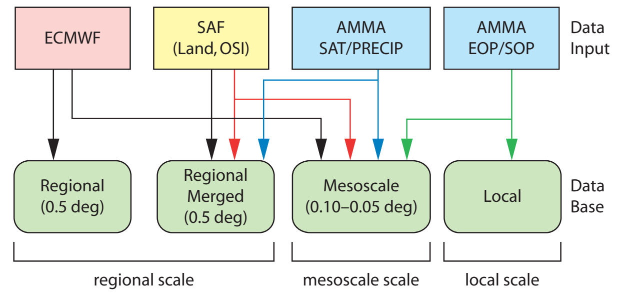


Figure 1 ALMIP forcing data sets. EXP1 is based on ECMWF forecasts. EXP2 forcing data set results from the ECMWF forecasts merged with PRECIPAMMA and OSI-SAF.

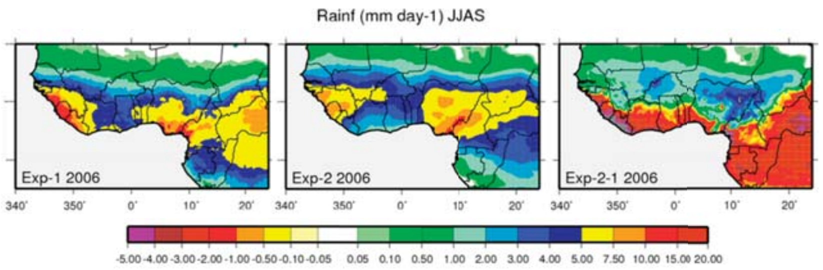


Figure 2 Precipitation rate (mm/d) for JJAS for EXP1 (left), EXP2 (middle) and the difference EXP2–EXP1 (right).

AMSR-E – Advanced Microwave Scanning Radiometer on EOS

- Satellite launched in 2002 on EOS Aqua (*Njoku, 2004*).
- Measures Earth brightness temperatures (TB) at 6 frequencies, including C-band reliable for soil moisture (*Gruhier et al, 2008*).
- AMSR-E AE_Land3 TB product used at 25 km spatial resolution, ~ 1 day.

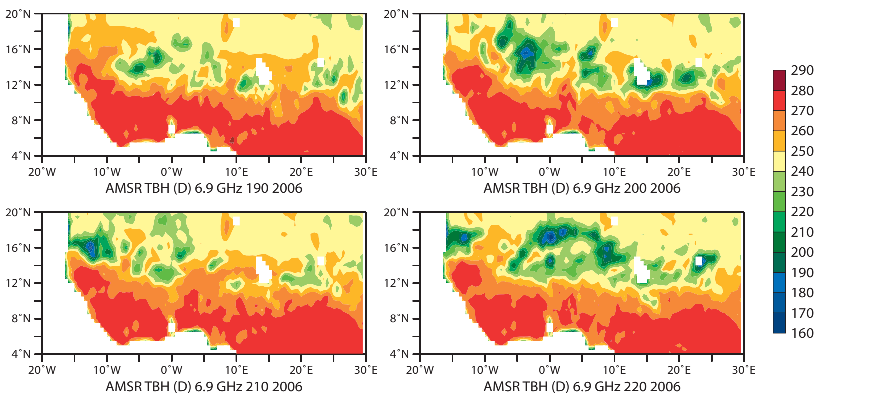


Figure 3 AMSR-E brightness temperature at horizontal polarization (TBH), in K, over West Africa. For four case studies during the monsoon season in summer 2006: Day of Year 190–191, 200–201, 210–211, 220–221. Wet patches over Sahel, associated with the occurrence of convective rainfall, correspond to lower values of TB. Higher vegetation cover is associated to higher values of TB (south).

CMEM – Community Microwave Emission Model

- ECMWF passive microwave low frequency forward operator (*Drusch et al, 2008*).
- Based on the state-of-the-art in microwave emission modelling.
- Modular code: combines different parameterizations for computing surface and atmospheric emissions (figure 3).
- Flexible and modular Input/Output (grib,ascii, netcdf) and portable for any linux/unix systems.
- Specifically designed for L-band microwave emission for the future SMOS (Soil Moisture and Ocean Salinity, to be launched in 2009).
- Also applicable for a large range of Frequency: 1 GHz to 20 GHz (suitable RTTOV).

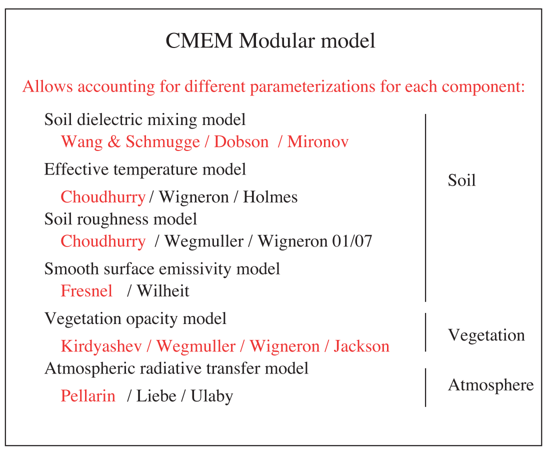


Figure 4 CMEM modular structure. Options in red are evaluated in ALMIP-MEM.

ALMIP-MEM – ALMIP Microwave Emission Model

- Coupling between ALMIP LSMs outputs (year 2006) and CMEM.
- Produce a set of C-band brightness temperatures for the different ALMIP LSMs, as seen by the AMSR-E 6.9 sensor.
- Quantitative assessment of background errors on simulated C-band brightness temperatures for a set of 6 models: TESSEL, HTESSEL, CTESSEL, ORCHIDEE, JULES, ISBA.
- Set of simulated brightness temperatures by the different models is evaluated against AMSR-E C-band data set, which will provide an evaluation tool for the simulated soil moisture. The approach and preliminary results are presented here.
- ALMIP-MEM simulations:
  - 2 ALMIP Experiments with different precipitation forcing (exp1, exp2)
  - 6 LSMs (HTESSEL, CTESSEL, TESSEL, JULES, ISBA, ORCHIDEE)
  - 2 observing configurations: C-band and X-band
  - 2 orbits per day: desc. Orbit (night) and asc. Orbit (day)
  - 12 configurations of the forward model:
    - 3 dielectric models (*Dobson, Mironov, Wang*)
    - 4 Vegetation models (*Kirdyashev, Wigneron, Wegmueller, Jackson*).
- –> 96 1-year simulations per LSMs.
- –> Total of 576 simulations, each on 101 × 51 × 365 grid-cells (lon × lat × day) (1.9 × 10^6).

For the comparison and to compute background errors: AMSR-E TB interpolated on the ALMIP grid (0.5 degree).

Results

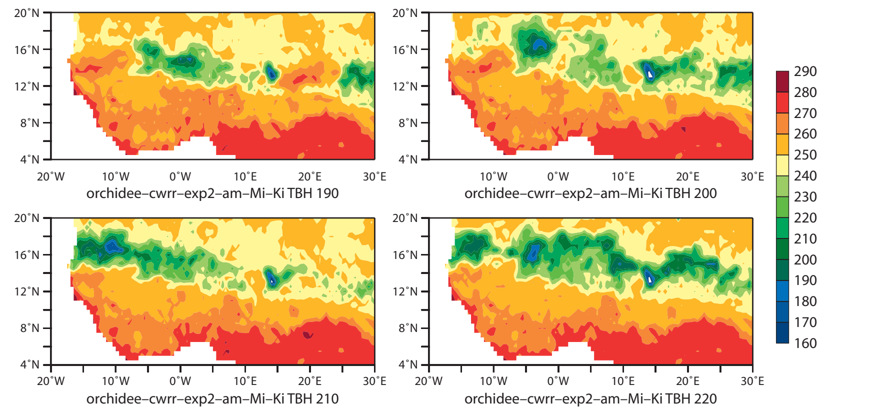


Figure 5 Simulated TBH (K) by ORCHIDEE-CMEM, in the configuration using Mironov dielectric model and Kirdyashev vegetation opacity model. When the complete annual cycle is considered, over a region between –10W : 10E and 9N : 20N, the correlation between AMSR-E data and this simulation is R = 0.74, RMSE = 10.4K, Bias = –1.4K.

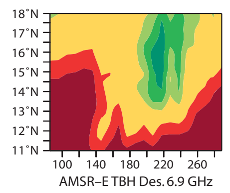
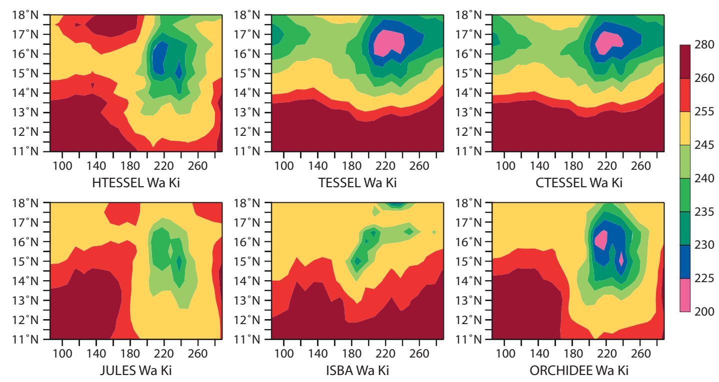


Figure 6 Latitude-Time diagrams of TBH in K (longitude averaged between 10W and 10E), for AMSR-E data and the 6 ALMIP-MEM LSMs coupled to CMEM. For each LSMs-CMEM simulation a bias correction was applied according to Table 1. The best microwave emission modelling configuration, which minimizes the errors when compared to AMSR-E data, is for any land surface model the Kirdyashev vegetation opacity model, and either the Wang or the Mironov dielectric model depending on LSMs.



Model	Correlation	RMSE	Bias
HTESSEL	0.54	13.4	1.6
TESSEL	0.69	19.2	-13.4
CTESSEL	0.67	19.1	-12.9
JULES	0.63	14.8	10.1
ISBA	0.69	14.2	10.1
ORCHIDEE	0.70	10.1	2

Table 1 Quantitative comparison between the ALMIP-MEM simulations of TBH and the AMSR-E observation, when the microwave emission modelling configuration uses the Wang and the Kirdiashev models (Figure 4).

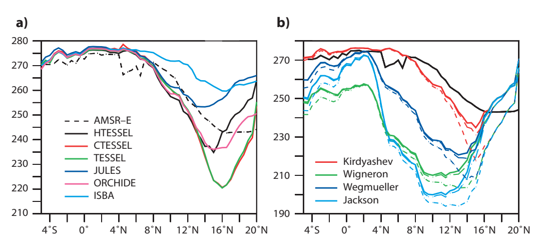


Figure 7 Zonal distribution of TBH, a) for all LSM coupled to CMEM in the Wang and Kirdyashev configuration (different LSMs, same forward approach), b) HTESSEL LSM coupled to CMEM in 12 different microwave modelling configurations (same LSM, different forward approach). Figure 7b, full line depicts the Wang dielectric model, dashed line depicts the Mironov model and dotted line depicts the Dobson model.

Conclusions

Good agreement with AMSR-E TB provides:

- Validation of ALMIP LSMs simulated surface soil moisture for 2006.
- Validation of precipitation forcing for ALMIP exp2 (PRECIPAMMA), in terms of precipitation occurrence.
- Identify forward modelling approach that minimizes the background errors with actual satellite measurements of AMSR-E at C-band.
  - Kirdyashev opacity model performs best, with lower background errors compared to AMSR-E measurements.
  - Dielectric models of Wang and Mironov gives the best agreement with AMSR-E data.
  - Larger sensitivity of the background errors to the forward approach than to the LSM. –> High importance of suitable MW modelling approach for SM retrieval and SM assimilation.
- Preparation of the future SMOS mission, and future SMOS validation over West Africa.

Websites

ALMIP: *www.cnrm.meteo.fr/amma-moana/amma_surf/almip/index.html*
CMEM: *www.ecmwf.int/research/ESA_projects/SMOS/cmem/cmem_index.html*

References

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