Modelling approach for remote sensing validation of ALMIP soil moisture products:

The AMMA Land surface Models Inter-comparison Project - Microwave Emission Model

(ALMIP-MEM)

P. de Rosnay, A. Boone, M. Drusch, T. Pellarin, T. Holmes, J.-P. Wigneron, G. Balsamo

I – Introduction: ALMIP, ALMIP-MEM and soil moisture remote sensing

II – CMEM forward operator of surface microwave emission

III – Preliminary results: C-band ALMIP brightness temperature for SOP

Goal:

Obtain a better understanding of the West African Monsoon (WAM) on daily to inter-annual timescales. AMMA relies on:

i) the use of extensive observations, notably multi-sensor remote sensing products,

ii) a multi-year field campaign over west Africa, and

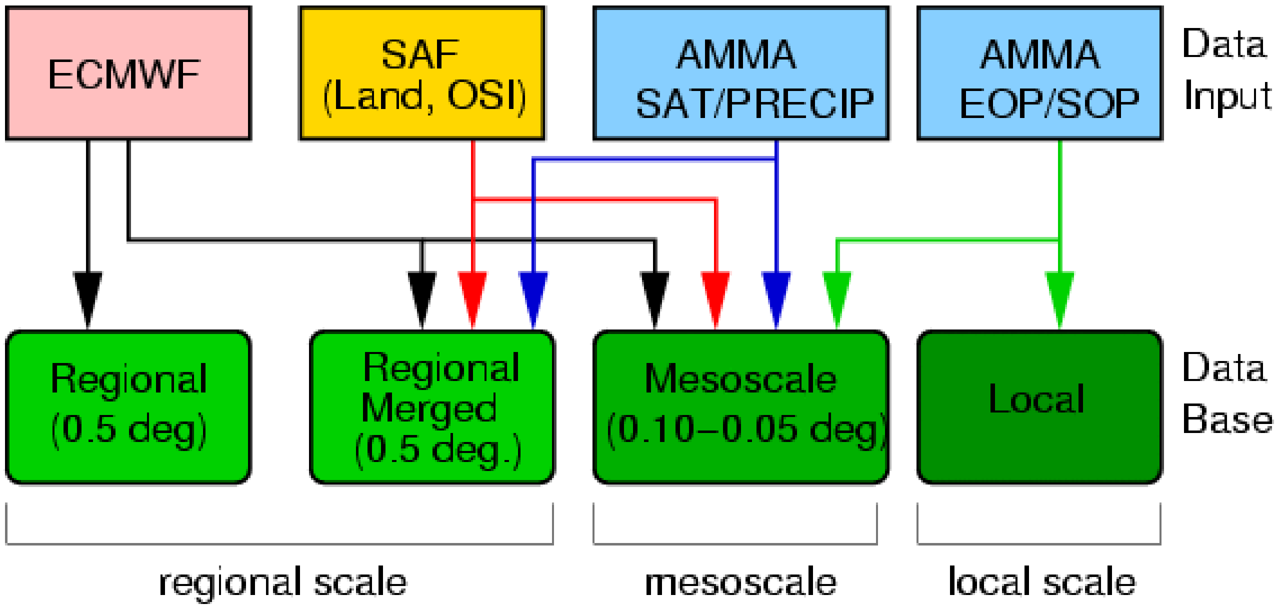
iii) a coordinated modeling strategy at different spatial and temporal scales.

ECMWF Forecast Product (EXP1):

- Lowest model level atmospheric variables ➔ Tair, Qair, Wind, PSurf
- Vertically integrated fluxes ➔ SWdown, LWdown, Rainf, CRainf

Merged Forcing (EXP2):

- ECMWF + Satellite based



ALMIP LSMs

ORCHIDEE	LMD, Paris, France	J. Polcher, T. Orgeval
ISBA	CNRM / Météo France Toulouse	A. Boone
TESSEL	ECMWF, Reading, UK	A. Beljaars, G. Balsamo
JULES	CEH, Wallingford, UK	C. Taylor, P. Harris
SETHYS	CETP, France	C. Ottlé, B. Decharme
CaB	UPMC, France	A. Ducharne, S. Gascoin
IBIS	ISE, Monpellier, France	C. Delire
SSib	U. Nantes, France, UCLA, USA	I. Poccard-Leclercq, Y. Xue
MIKE-SHE	U. Copenhagen, Denmark	A. Norgaard, I. Sandholt
CLM	NCAR, Boulder, CO, USA	B. Lamptey
SWAP	Inst. Of Water Problems, Moscow, Russia	Y. Gusev, O. Nasonova
NOAH	(NCEP, USA) CETP, France	C. Ottlé, B. Decharme

Validation of ALMIP simulation at regional scale ?
-> Use of soil moisture remote sensing

AMSR-E (**Advanced Microwave Scanning Radiometer on EOS**)

- 2002-present; 25km of spatial resolution, ~1 day
- Brightness Temperature at 6 frequencies, including
- C and X Bands (6.9 & 10.7GHz) for soil moisture remote sensing

SMOS (**Soil Moisture and Ocean Salinity**)

- Launch in Oct 2008 ; 40km of spatial resolution, ~3 day
- Brightness Temperature at L-Band (1.4GHz)
- Specifically designed for soil moisture remote sensing (over land)
- AMMA is an ESA validation site of SMOS for 2009

ALMIP-MEM

Concept:

Coupling ALMIP simulations to a Microwave Emission Model (CMEM)

CMEM: simulates C-Band Brightness Temperature as seen by AMSR (at C-band or X-band) or as seen by the future SMOS at L-Band

Validation with AMSR-E TB

Aim:

-> Range of TB simulated by ALMIP LSMs with diff forcings (Exp1-2)

-> Scatter C-band TB simulated by set of LSMs at regional scale

-> Validation of surface soil moisture simulated by LSMs

-> Test and validation of different microwave modelling approaches, with the modular Community Microwave Emission Model, to be used for the future SMOS

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CMEM: Community Microwave Emission Model

- Land surface emission model developed at ECMWF for Numerical Weather Prediction (NWP) applications
- To be used as the forward operator for computing TOA Brightness Temperature in the operational data assimilation scheme

  -> NWP model interface

- Conceptually based on:
  - LMEB (L-Band Emission of the Biosphere), Wigneron et al., 2007,
  - LSMEM (Land Surface Microwave Emission Model), Drusch et al., 2001
- Modular: combines different parameterizations for computing surface and atmospheric emissions
- Specifically designed for L-band microwave emission for SMOS
- Also applicable for a large range of Frequency: 1 GHz to 20 GHz (suitable for RTTOV)

(CMEM references: Holmes et al 2007, Drusch et al 2007)

CMEM: Modular Model

Allows accounting for different parameterizations for each component:

- **Soil dielectric mixing model**

  (Wang & Schmugge / Dobson / Mironov)

- **Effective temperature model**

  (Choudhurry / Wigneron / Holmes)

- **Soil roughness model**

  (None = Smooth / Choudhurry / Wegmuller / Wigneron a or b or c)

- **Smooth surface emissivity model**

  (Fresnel / Wilheit)

SOIL

- **Vegetation opacity model**

  (None / Kirdyashev / Wegmuller / Wigneron)

VEGETATION

- **Atmospheric radiative transfer model**

  (None / Pellarin / Liebe / Ulaby)

ATMOSPHERE

In red: options to be tested/validated in ALMIP-MEM

CMEM: flexible portable software

CMEM is coded in Fortran90, according to NWP Centres requirements.

CMEM is flexible for:

- **Input / Output file format:**

  Grib, Ascii, Netcdf

- **Input / output file size and variable dimensions**

  Automatic detection of input size and variable allocations.

- **Portable code, for any Linux and Unix systems**

  Requirements: Grib and Netcdf both compiled with fortran 90

  NWP model routines and libraries are externalized (on going)

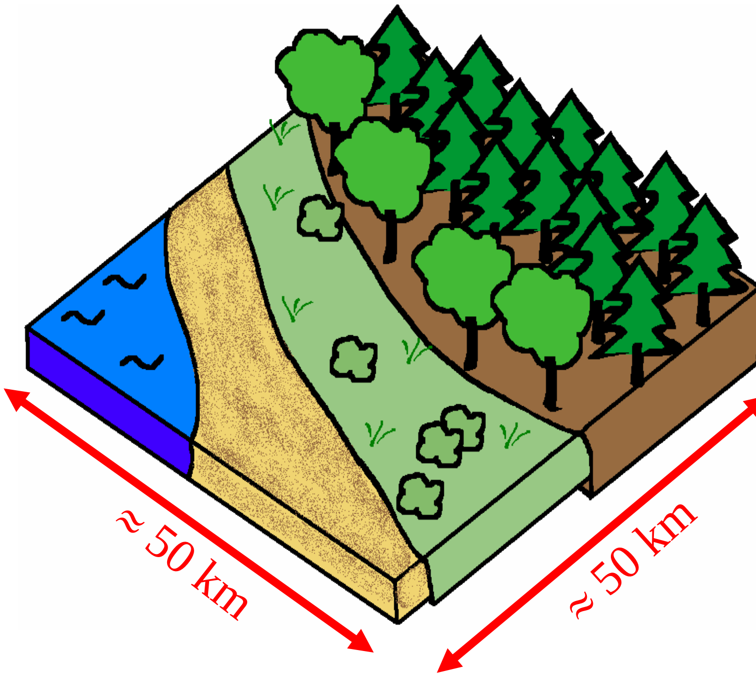
CMEM code: 6910 lines of fortran

First tagged version of CMEM (version 1.0) distributed in December 2007

CMEM: Subgrid scale parameterization

Tiles approach in CMEM:

- Bare soil (with / without snow)
- Low vegetation (with / without snow)
- High Vegetation (with / without snow)
- Water



(from Pellarin et al)

Low vegetation: C3/C4 Crops/Grass

High vegetation: Deciduous/Coniferous/Rain Forests

Vegetation microwave parameters (b',b'',tth,ttv ...) provided for each tile according to the dominant canopy type

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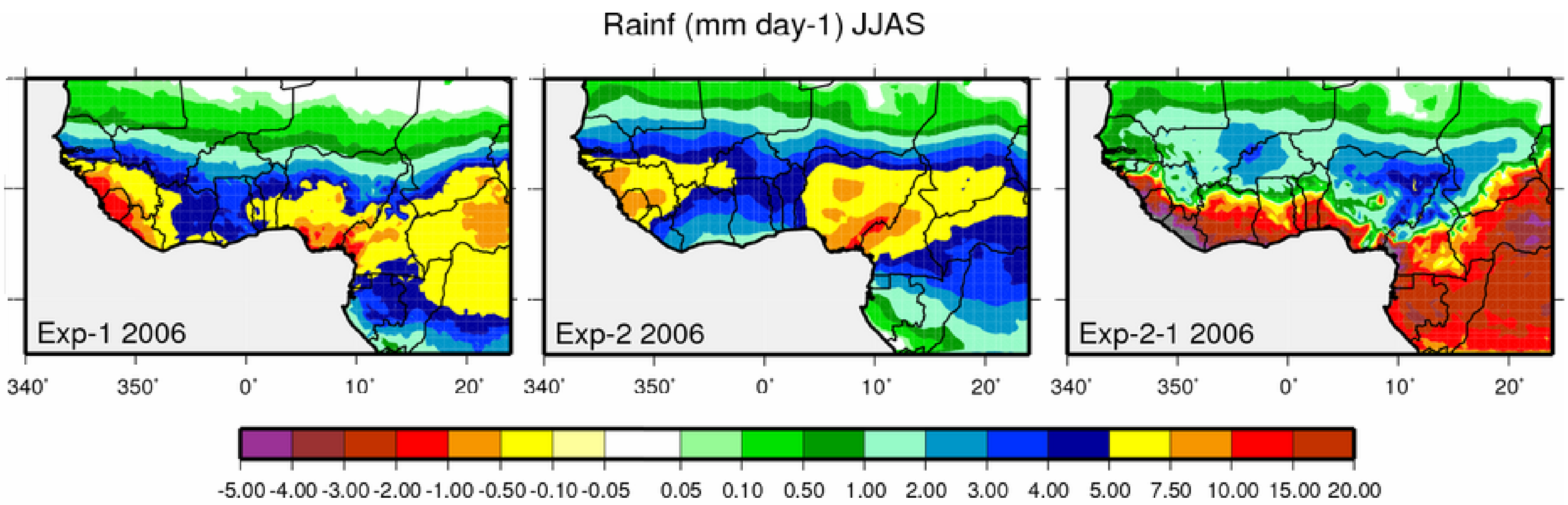
ALMIP-MEM: simulation of C-band TB (H and V) as seen by AMSR-E for :

- ALMIP Exp1 and Exp2 with different forcing
- CMEM in different configurations of the modular emission model
- Ascending and descending AMSR-E orbits

-> CMEM allows to evaluate radiative transfer modeling for future SMOS validation over AMMA

Here simulated TB are shown as obtained from ORCHIDEE simulations and compared to AMSR-E measurements

To be extended to the other ALMIP LSMs...



Rainfall differences between EPSAT-SG(Exp2) less ECMWF (Exp1)

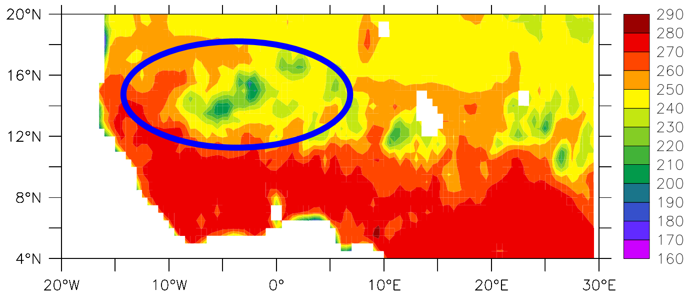
Shift of the active monsoon rain-band to the north

AMSR-E brightness temperature at horizontal Pol (TBH)

Wet Patches Shown by lower TB

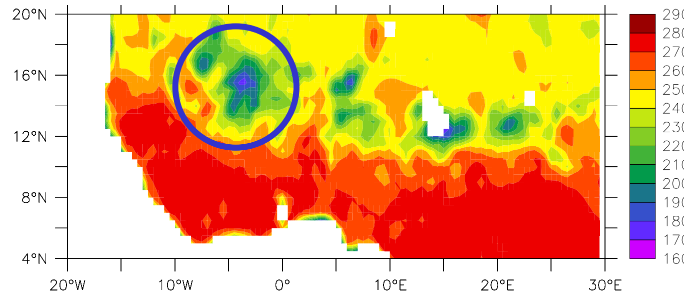
AMSR-E Descending orbit (1am), 2days average

Doy 190-191



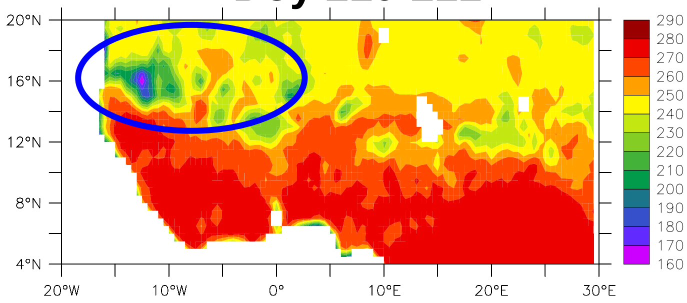
AMSR TBH (Desc.) 6.9 GHz 190 2006

Doy 200-201



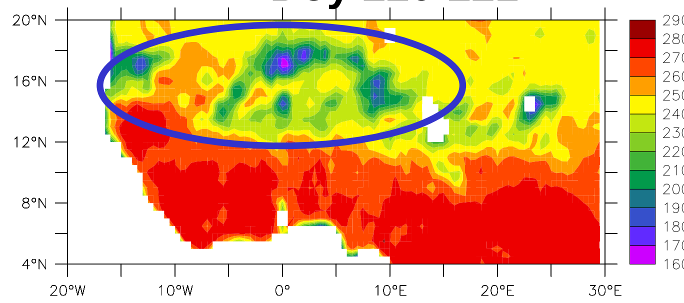
AMSR TBH (Desc.) 6.9 GHz 200 2006

Doy 210-211



AMSR TBH (desc.) 6.9 GHz 210 2006

Doy 220-221



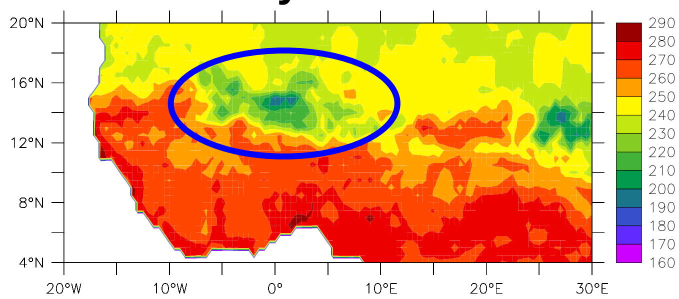
AMSR TBH (Desc.) 6.9 GHz 220 2006

ALMIP-Exp2 brightness temperature at horizontal Pol (TBH)
Four case study in 2006

Soil Moisture: EXP2 (PRECIPAMMA forcing), ORCHIDEE-CWRR LSM (at 00.00 UTC, 2d ave)

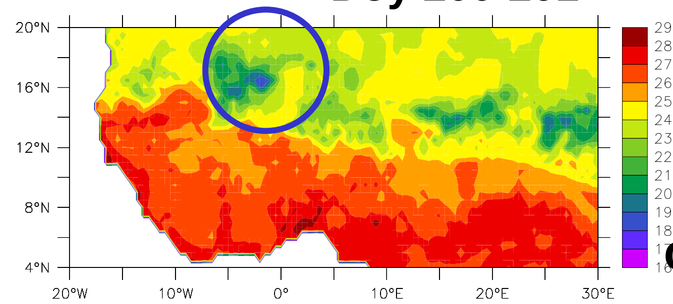
Microwave module: Mironov dielectric and Kirdyashev opacity

Doy 190-191



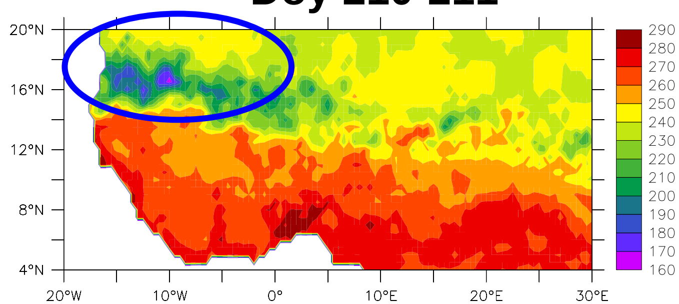
CMEM MiKi (ORCH CWRR EXP2) TBH6.9GHz 190.0 2006

Doy 200-201



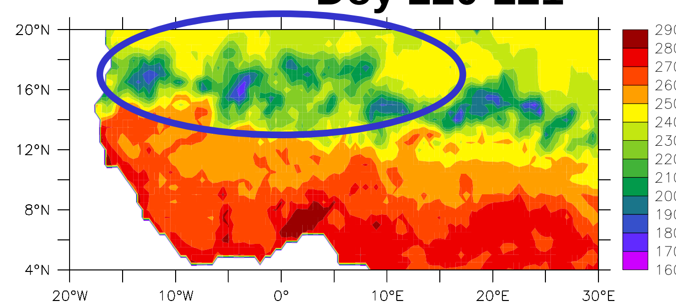
CMEM MiKi (ORCH CWRR EXP2) TBH6.9GHz 200.0 2006

Doy 210-211



CMEM MiKi (ORCH CWRR EXP2) TBH6.9GHz 210.0 2006

Doy 220-221



CMEM MiKi (ORCH CWRR EXP2) TBH6.9GHz 220.0 2006

Corr AMSR-E

Doy	R2
190	0.69
200	0.68
210	0.64
220	0.72

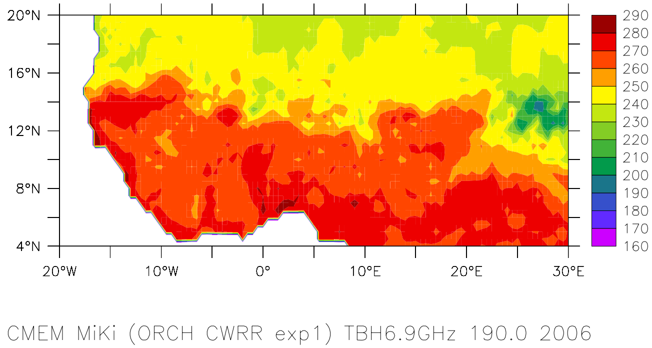
Good agreement in ALMIP-MEM and AMSR-E TBH spatial features

ALMIP-Exp2 brightness temperature at horizontal Pol (TBH)
Four case study in 2006

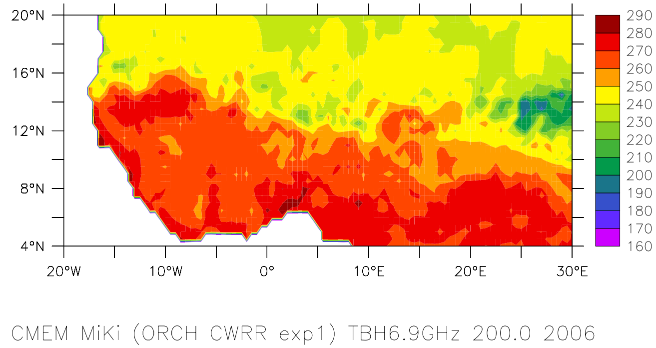
Soil Moisture: EXP2 (ECMWF prcp forcing), ORCHIDEE-CWRR LSM (at 00.00 UTC, 2d ave)

Microwave module: Mironov dielectric and Kirdyashev opacity

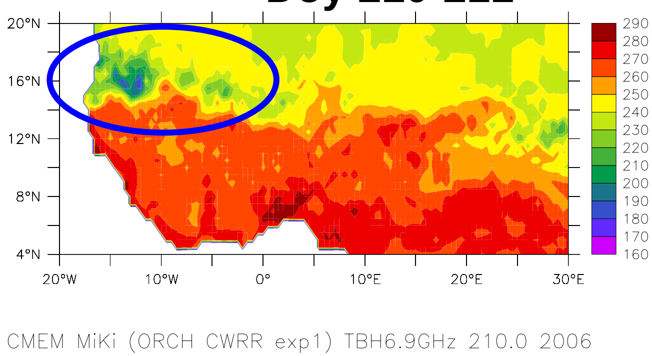
Doy 190-191



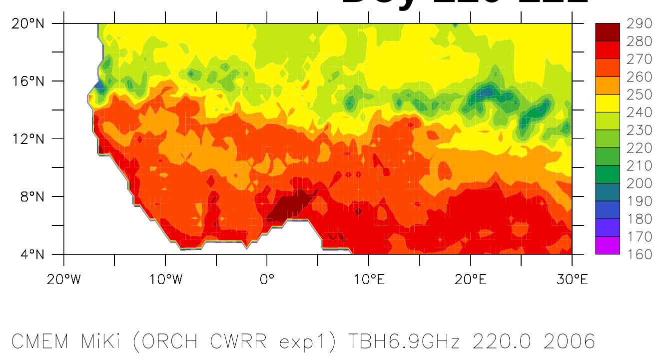
Doy 200-201



Doy 210-211



Doy 220-221



Corr AMSR-E

Doy	R2
190	0.56
200	0.49
210	0.59
220	0.61

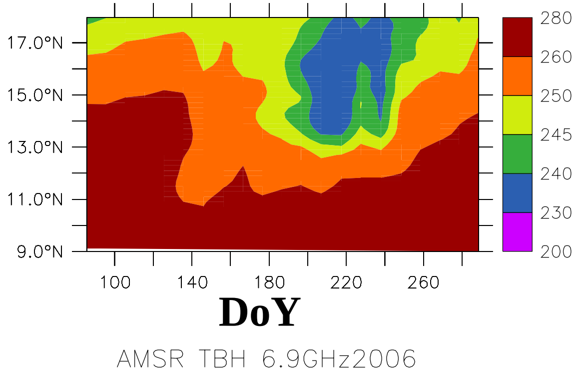
Much poorer agreement when simulated SM is obtained from Exp1

ECMWF

Latitude-Time diagram of TBH for 2006

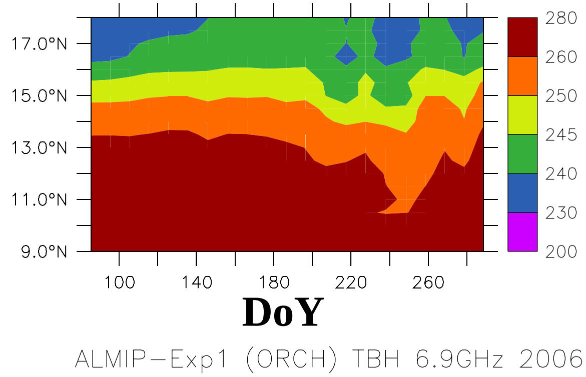
(10W-10E ave)

AMSR-E

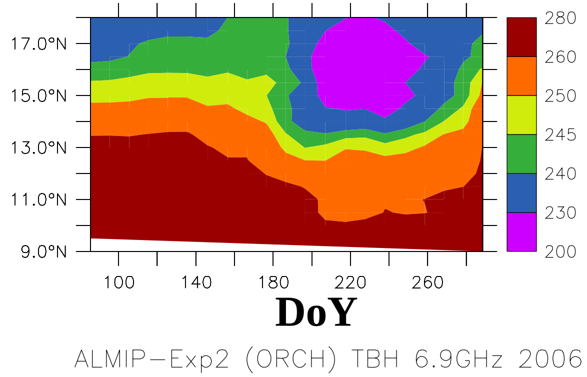


ALMIP (ORCH-CWRR)

Exp1



Exp2



- **AMSR-E observation of TBH shows a wet patch in Lat-Time, over Sahel in Jul-Aug**
- **EXP1 (ALMIP simulation with ECMWF forcing) underestimates latitude-time dynamics**
- **EXP2 (ALMIP with PRECIPAMMA) capture the seasonal latitudinal dynamics of TB, showing that lat-time of soil moisture is captured by this model**
- **Wet patch over Sahel is slightly over estimated**

Summary

- ALMIP-MEM: Simulate C-Band and X-band TB as seen by AMSR-E
- Provide a validation of both simulated soil moisture and radiative transfer model
- Context of the preparation of SMOS (launch in 2008)
- Compare different LSM and different radiative transfer modelling approaches
- Based on CMEM microwave emission model, portable fortran90 software to compute SMOS microwave emission of land surfaces in NWP models.
- Preliminary results of TB simulated by ORCHIDEE-CMEM. Capture convective system occurrence in Sahel, as well as latitude-time feature of TB
- Better precip foring in EXP2 of ALMIP provides TB in better agreement with AMSR-E measurements
- ALMIP-MEM is on-going
- To be extended to ISBA, TESSEL, NOAH,JULES, SSib, SETHYS, Mike-She, CaB, IBIS, CLM, SWAP