Investigations of the vertical transport of atmospheric CO_2 associated with cumulus convection on Amazonia.

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Abstract

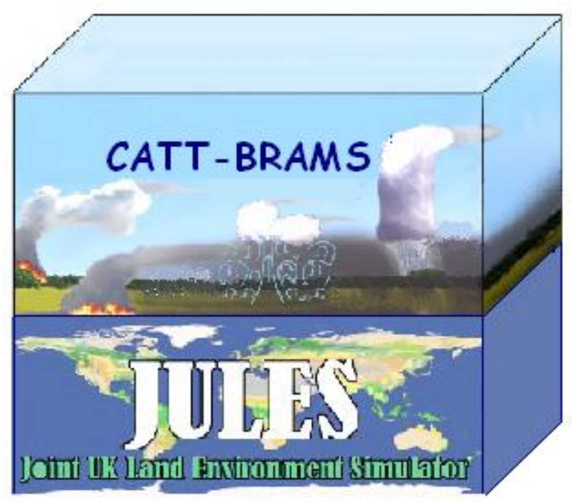
We describe preliminary results of the role of vertical transport of CO_2 by convective systems by using the newest version of a regional atmospheric model fully coupled with a state-of-the-science land surface model. The new modeling system was developed by integrating JULES (Joint UK Land Environment Simulator) land surface model within the CCATT-BRAMS (Coupled Chemistry, Aerosol and Tracer Transport model to the Brazilian developments on the Regional Atmospheric Modeling System) to allows numerical simulations of CO_2 atmospheric concentration including interactive, on-line biogenic surface fluxes, in addition to the anthropogenic fluxes (biomass burning, urban-industrial-transportation and charcoal production, etc.).

Model simulations with horizontal grid spacing of 15 kilometers over the Amazon basin using the new model, which have a tracer convective transport module coupled with the cumulus parameterization, were performed.

The role of shallow-non precipitating and deep convection on transporting CO_2 from the planetary boundary layer (PBL) to the free troposphere (FT) is presented. In particular, we focus on the discussion of the rectifier effect through simulation of the transport to the FT of PBL air masses with low CO_2 concentrations due to assimilation by vegetation during the afternoon, when both CO_2 fixation and convection are at their maximum activity. The importance of a correct numerical representation of the diurnal cycle of convection over the land is then reinforced.

Methodology

- The surface **JULES** model (Blyth et al., 2006) was coupling in **CCATT-BRAMS** atmospheric model (Freitas et al., 2005, 2007):



It is a two-way coupling:

CCATT-BRAMS ➡ JULES: Wind, Temperature, Precipitation and Radiation.

JULES ➡ CCATT-BRAMS: VOC, CH_4, CO_2, CO, Aerosol, H e LE

Fig.1: Scheme of the coupling.

- Atmospheric initial and boundary condition from NCEP analysis with resolution 63 km.
- Initial and boundary condition for CO_2 mixing ratio was provided by TM5 (Global Chemistry Transport Model, Krol et al., 2005).
- The model resolution was 15 km and the simulation covered 1 month of 2004, starting on 1 May, with 3 hours of the output frequency and the domain of integration covering the Amazon basin.

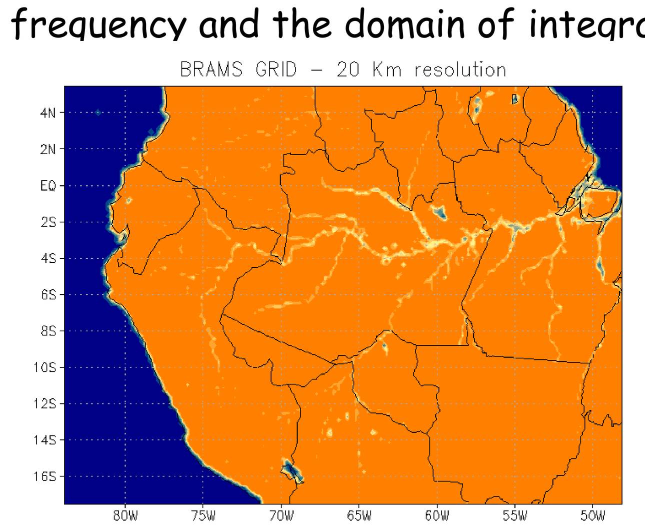


Fig.2: Domain of integration.

- Parameterizations used are: CARMA for short and long wave radiation, Grell and Dévény (2002) cumulus ensemble scheme using closure type Grell, shallow cumulus from Souza and Mellor-Yamada diffusion for PBL.
- The Coupling model JULES-CATT-BRAMS products was compared with observations data (METAR and SYNOP) and the native surface parameterization of BRAMS model (LEAF - Walko et al., 2000).

Near surface model evaluation with/out the coupling with JULES

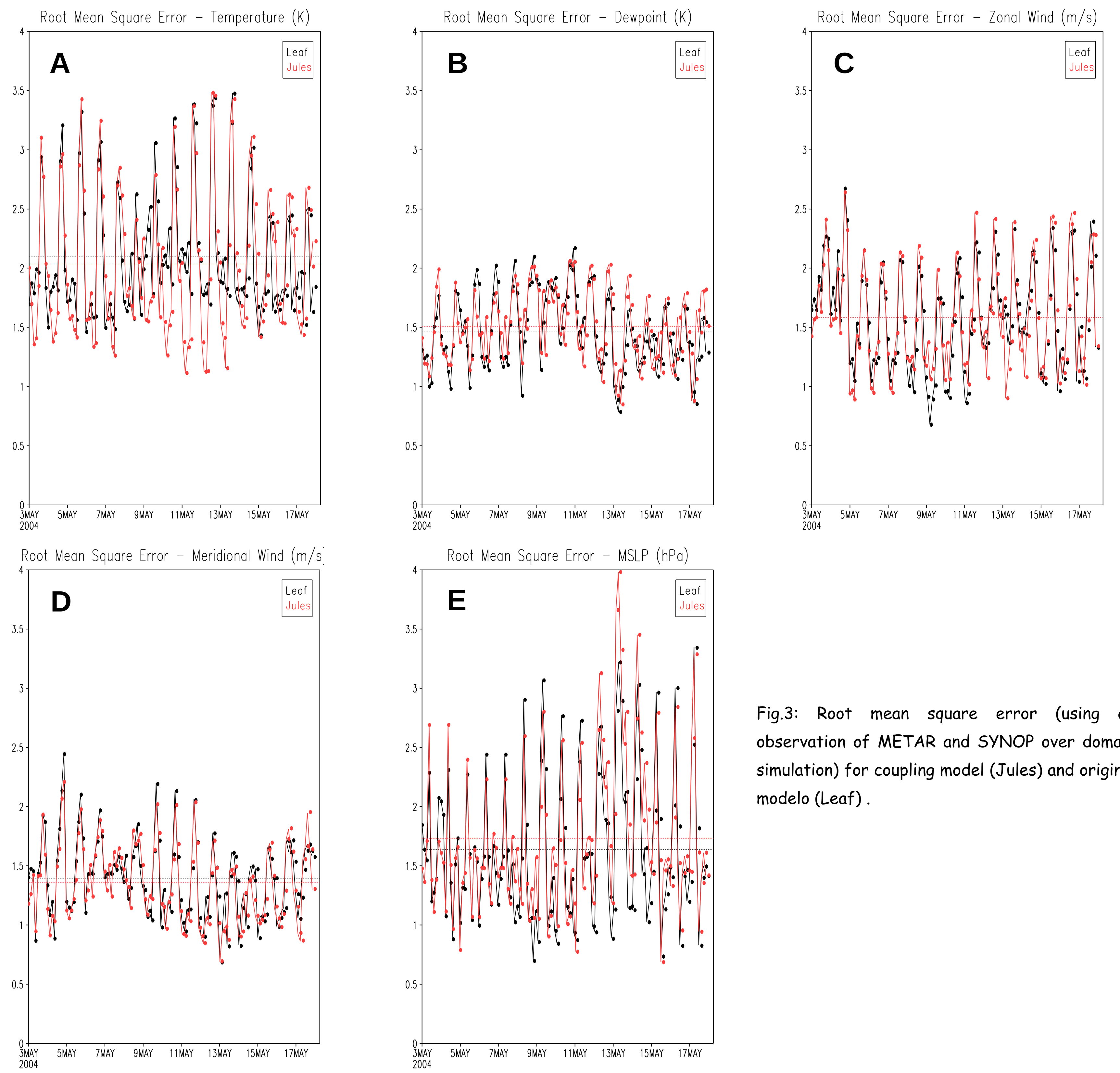


Fig.3: Root mean square error (using all observation of METAR and SYNOP over domain simulation) for coupling model (Jules) and original modelo (Leaf) .

CO_2 on surface : begin of the morning (left) and late afternoon (right)

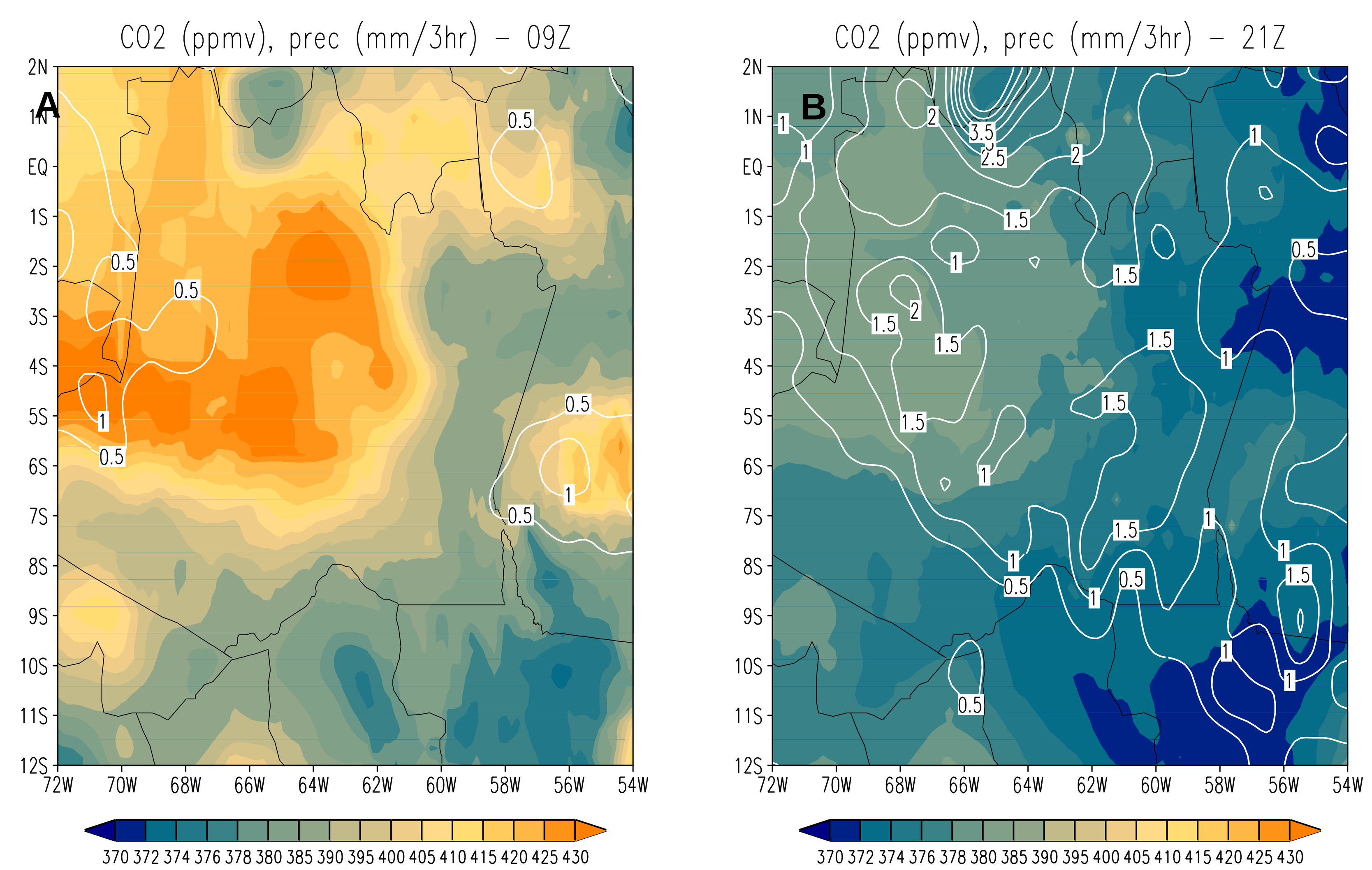


Fig.4: CO_2 mixing ration in 49 meters (shaded) and precipitation (contour). Mean for all 09 (A) and 21 (B) GMT of the period 10 to 31 (May/2004).

Vertical CO2 distribution over convective (A) and non-convective (B) areas

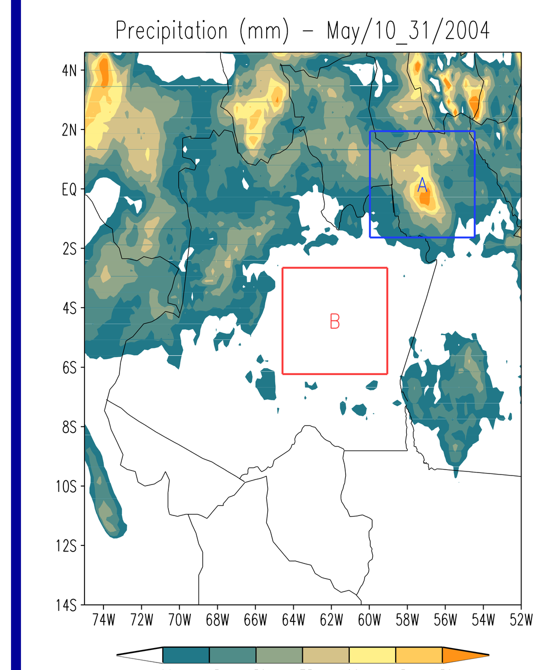


Fig.5: Accumulated precipitation during the period of 10 to 31 (May/2004). Square blue is a convective region and red is a non-convective region.

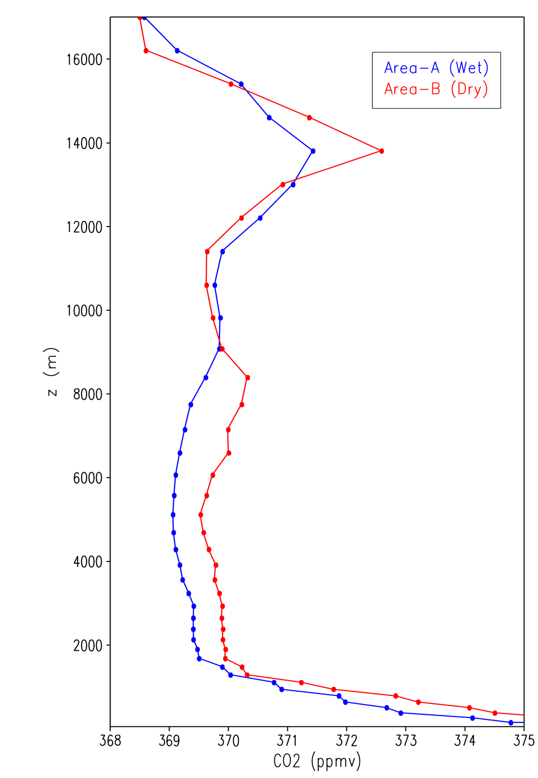


Fig.6: Temporal mean (10/May to 31/May) of Vertical profile of CO_2 concentration. Blue is average over convective region and red over non-convective region (see fig. 5).

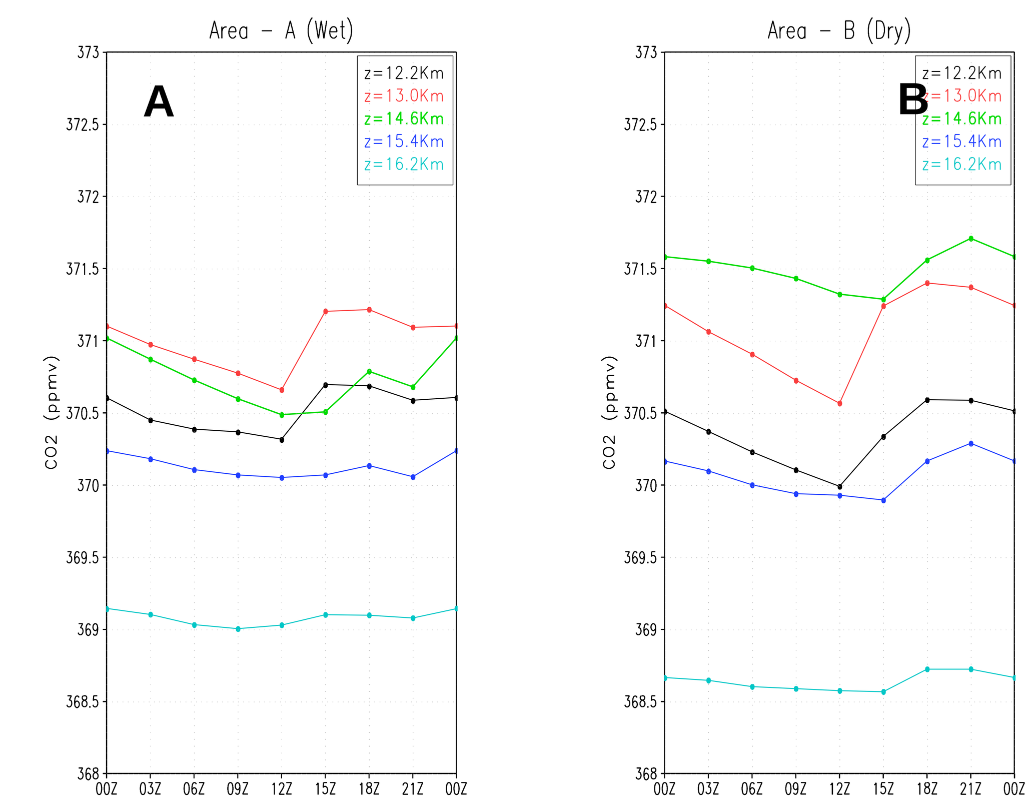


Fig.7: Mean diurnal cycle of CO_2 concentration. A) average over convective region, B) average over non-convective region (see fig. 5).

Conclusions:

- These preliminary results from JULES-CCATT-BRAMS showed that the atmospheric model results are consistent with the simulation done using the native LEAF surface scheme, indicating that the coupling is on right way.
- In the lower levels, the photosynthetic and respiration processes were well represented.
- Further work on JULES-CCATT-BRAMS system will be done to get better vertical transport of CO2 in the atmospheric, consequently to have a better simulation of the rectifier effect.

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