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Geoscientific Model Development Discussions

Interactive comment on "Coupling between the JULES land-surface scheme and the CCATT-BRAMS atmospheric chemistry model (JULES-CCATT-BRAMS1.0): applications to numerical weather forecasting and the CO_2 budget in South America" *by* D. S. Moreira et al.

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We thank the referee #3 for his(er) insightful and helpful comments, which contributed to improve the paper. The answers to his(er) questions/comments are below:

1 Specific comments:

1. **Abstract: It is vague to just mention that the new model provides a significant gain in its performance. Please also make the abstract in more concise and organized.**

   The abstract was replaced to:

   "This article presents the coupling of the JULES surface model to the CCATT-BRAMS atmospheric chemistry model. This new numerical system is denominated JULES-CCATT-BRAMS. We demonstrate the performance of this new model system in relation to several meteorological variables and the CO_2 mixing ratio on a large part of South America, focusing on the Amazon basin. The evaluation was conducted for two time periods, the wet (March) and dry (September) seasons of 2010. The model errors were calculated in relation to meteorological observations at conventional stations in airports and automatic stations. In addition, CO_2 mixing ratio in the first model level were compared with meteorological tower measurements and vertical CO_2 profiles were compared with observations obtained with airborne instruments. The results of this study show that the JULES-CCATT-BRAMS modeling system provided a significant gain in performance in the considered atmospheric fields relative to those simulated by the LEAF (version 3) surface model originally employed by CCATT-BRAMS. Besides, the new system significantly increase your ability to simulate processes involving air-surface interactions, due to the ability of JULES to simulate photosynthesis, respiration, dynamic vegetation, among other processes. Also we discuss a wide range of numerical studies involving coupled atmospheric, land surface and chemistry processes that could be done with the system introduced here. Therefore, this work presents to the scientific community a free modeling tool, with good performance in comparison with observed and reanalysis model data, at least for the region and time period

discussed here. This model is able to produce atmospheric hindcast/forecast simulations at different spatial resolutions, for any period of time and in any region of the globe."

2. **Page 455 line 5: What does "pressure reduced to mean sea level" mean?**

   "The sea level pressure is the atmospheric pressure at sea level at a given location. When observed at a reporting station that is not at sea level (nearly all stations), it is a correction of the station pressure to the sea level. This correction takes into account the standard variation of pressure with height and the influence of temperature variations with height on the pressure. The temperature used in the sea level correction is a twelve hour mean, eliminating diurnal effects. Once calculated, horizontal variations of sea level pressure may be compared for location of high and low pressure areas and fronts."
   Fonte: http://w1.weather.gov/glossary/index.php?word=sea+level+pressure

3. **Page 455 lines 9-11: It is not necessary to mention this specifically in the abstract.**

   It was removed.

4. **Page 456 Lines 22-26: repeat of lines 11-15**

   In lines 11-15 was replaced:

   "...either directly or indirectly (through the formation of secondary gases, for example, ozone), as well as particulate matter (Andreae, 1991; Artaxo et al., 2002; Andreae et al., 2004). The latter has an important influence on radiation balance,..."

   by:

   "...either directly or indirectly through the formation of secondary gases, for example, ozone. Previous studies suggested that the assimilation of ozone is likely to significantly affect forest net productivity (Sitch et al., 2007). In addition to gases, vegetation fires also produce particulate material (Andreae, 1991; Artaxo et al., 2002; Andreae et al., 2004), which have an significant impact on radiation budget ,..."

   In lines 22-26 was removed the paragraph:

   "Another process relevant to the rainforest is the formation of ozone from precursors emitted by fires. Previous studies suggested that the assimilation of ozone is likely to significantly affect forest net productivity (Sitch et al., 2007)."

5. **Page 457 Lines 1-15: This is a general discussion fitting in for all modeling work and not necessary to be presented in this paper.**

   We think this paragraph should be important to show to the reader the importance of having a model with new parametrizations or schemes, justifying the best model performance with JULES compared to LEAF, due to the JULES updated formulations. Also it discuss that currently is it possible to have more complex models because we have improved computers.

6. **Page 458 lines 6-14: Add a description for the measurements that are used in model evaluation somewhere probably in section 2 after the description**

of the models.

In section 3 (Evaluation and sensitivity tests) was created the subsection:

3.1 Data to evaluation

To evaluate JULES-CCATT-BRAMS were used the data:

- **METAR and PCDs**: Observations from surface meteorological stations installed at airports (METAR) and automatic stations (PCDs) installed and maintained by the National Institute of Meteorology (INMET). These data have a temporal frequency of an hour and an irregular spatial distribution. They are available daily on the respective websites: http://www.redemet.aer.mil.br and http://www.inmet.gov.br/sonabra/maps/automaticas.php.
- **Km-67 tower**: Observed data measured by an eddy correlation system installed at a meteorological tower at an altitude of 57.9 m. This tower is located to the south of Santarém–PA, Brazil, close to kilometer 67 of the Cuiabá-Santarém highway (Tapajós forest: 55.04 W; 2.85 S). These data were collected in an automatic and continuous way from August 2008 with a temporal resolution of 1 h
- **Airplane**: Observed data collected aboard an airplane. 80 profiles were performed during the year 2010 in a descending spiral profile from 4300 m to 300 m in four Amazon locations: Santarém-PA (SAN), Rio Branco-AC (RBA), Alta Floresta-MT (ALF) and Tabatinga-AM (TAB). All profiles were usually taken between 12–14 h local time. At the RBA, TAB and ALF sites, 12 flasks were sampled with a portable sampling system consisting of separate compressor and flask units. These units were loaded onto a light aircraft. A GPS and temperature and relative humidity sensors were also attached to the compressor unit. The pilot initiated sample collection at a pre-determined altitude using a wired remote control. At SAN the flask unit contained 17 flasks and for all units each flask had a volume of 700 mL

and was pressurized to about 270 kPa, described in Gatti et al. (2010).

- **ECMWF**: ECMWF ERA-Interim reanalysis (Dee et al., 2011). This reanalysis has a horizontal resolution of 1.5 and utilizes a 4-D-Var system (Bouttier and Kelly, 2001) to assimilate observed data (available online at: http://data-portal.ecmwf.int/data/d/interim_daily/levtype=sfc/).
- **TM5**: CarbonTracker/TM5 carbon data assimilation system (Krol et al., 2005; Peters et al., 2007) with a horizontal resolution of 3×2 and 34 vertical levels (http://www.esrl.noaa.gov/gmd/ccgg/carbontracker/documentation_4pdf.html).

Therefore, the text looked like this:

- Page 466 lines 1-7: "The data obtained from numerical simulations were compared with METAR and PCDs data. The simulated values of..."
- Page 472 lines 10-21: "To evaluate the ability of the JULES-CCATT-BRAMS modeling system to reproduce observed CO_2 profiles, was used the profiles from airplane data described in subsection 3.1. Figure 9 presents eight..."
- Page 473 lines 19-23: "Figure 10 shows the daily evaluation of the mean CO_2 concentration in the month of March 2010. An increase is observed during..."
- Page 464 line 29 and page 465 lines 1-2: "Initial and boundary conditions for CO_2 were taken from outputs of the TM5 model."
- Page 467 lines 20-21 and page 468 lines 1-3: "Also was calculated the error of the ECMWF reanalysis, following the same methodology described above."

7. **Page 460 lines 7-12: Rephrase this sentence.**

Was rephrased to:

"JULES-CCATT-BRAMS has available two advection schemes, one with non-monotonic (Tremback et al., 1987) and another which has a monotonic (Freitas et al., 2012) formulation. The non-monotonic scheme uses a second order forward-upstream approximation, this formulation is simpler and faster to calculate the transport of scalars, however it can generate non-physical negative mass concentrations and also new extrema. The monotonic scheme is more complex, but does not produce any new extrema (over- or undershoots) of the mass mixing ratio of the tracer being transported as well as not causing strong numerical diffusion."

8. **Page 460 line 19: Elaborate on size distribution and complex refractive index used in this work.**

   In order to calculate smoke aerosol radiative effects we parameterized the following spectral optical properties in the model: single scattering albedo, extinction factor efficiency and asymmetry parameter. These optical properties were previously obtained from a Mie code using as input to the code climatological size distribution and complex refractive index from Amazonian smoke areas based on retrieval from Aerosol Robotic NETwork sunphotometers (AERONET; Dubovik and King, [2000], Dubovik et al. [2000],). In the model, smoke aerosol size distribution was assumed as unimodal lognormal function described by climatological median radius (r_m) and standard deviation (σ_m) from AERONET. Beside size distribution, AERONET also provides real and imaginary parts of complex refractive index (m+nik). A manuscript discussing specifically smoke optical properties variability among the sites analyzed and describing in detail the associated microphysical parameters (size distribution and complex refractive index) is being prepared for submission by a member of my group (Rosário et al., 2013).

9. **Page 464 lines 6-10: Please explain "the land use map" and "the soil type" used in this work.**

   Reference to the land use map and Soil type are cited in Table 1.

   => In page 483 (Table 1) was changed "Vegetation:" by "Land use map:" and "Soil texture:" by "Soil type:"

10. **Page 466 lines 2-8: Move the description of the observation data to section 2.**

    It was moved to the new section (3.1), as described in answer #6.

11. **Page 468 lines 7-14: It may be misleading to give the scores on a daily basis since the bias during day and night may have an opposite sign. For example, the performance of ECMWF in comparing temperature at 2m is worst among the four approaches if the evaluation is separated over day and night. However, if the overall bias of ECMWF would be better than that of LEAF if the evaluation was conducted on a daily mean basis.**

    Figure 4b shows the RMSE and not bias. ECMWF has the best skill in night (near of zero) e the worst in daytime. Therefore, in daily mean it was a little better than LEAF.

12. **Pages 468-470: for the discussion of Figure 4 and Figure 6, please add tables to list the bias/RMSR during day/night for the discussed parameters.**

    Was included in text the tables below:

Table 1. Error values to night period (06 UTC), daylight period (18 UTC) and Daily Mean (DM) on wet season (March/2010).

		LEAF_ad0_ae0			JULES_ad0_ae0			JULES_ad1_ae0			ECMWF		
		06	18	DM	06	18	DM	06	18	DM	06	18	DM
RMSE	Temp.	1.62	2.63	1.97	1.64	2.38	1.86	1.61	2.22	1.80	1.40	2.92	1.96
	Td	2.67	3.78	3.01	2.20	2.81	2.44	2.23	2.84	2.49	2.05	2.77	2.31
	LSP	1.89	2.65	2.21	1.92	2.64	2.23	1.90	2.59	2.20	1.65	2.64	2.00
	Prec.	2.76	3.39	2.89	2.72	3.12	2.82	2.78	3.03	2.79	2.16	3.41	2.90
	Wind	1.25	1.53	1.35	1.65	1.90	1.76	1.68	1.90	1.78	1.46	1.67	1.55
BIAS	Temp.	0.60	-0.70	0.05	-0.14	-1.01	-0.45	0.02	-0.63	-0.20	-0.05	-1.77	-0.64
	Td	1.90	2.82	2.00	1.21	1.72	1.44	1.36	1.78	1.57	1.11	1.29	1.08
	LSP	-1.63	-2.35	-1.64	-1.67	-2.34	-1.65	-1.66	-2.30	-1.62	-0.93	-2.37	-1.36
	Prec.	1.47	2.39	1.83	1.42	2.10	1.72	1.44	2.01	1.67	1.38	2.80	2.23
	Wind	0.61	-0.53	0.14	1.20	0.92	1.10	1.23	0.96	1.14	0.76	0.01	0.52

Table 2. Error values to night period (06 UTC), daylight period (18 UTC) and Daily Mean (DM) on dry season (September/2010).

		LEAF_ad0_ae0			JULES_ad0_ae0			JULES_ad0_ae1			ECMWF		
		06	18	DM	06	18	DM	06	18	DM	06	18	DM
RMSE	Temp.	2.26	2.99	2.55	2.26	2.21	2.33	2.28	2.14	2.32	2.14	2.41	2.23
	Td	2.55	3.27	2.80	2.17	3.12	2.54	2.14	3.12	2.54	1.76	2.72	2.16
	LSP	3.05	3.29	2.13	3.06	3.30	3.15	3.06	3.30	3.15	2.83	3.04	2.88
	Prec.	3.90	2.12	2.65	3.78	2.21	2.63	3.78	2.10	2.66	1.62	2.03	2.02
	Wind	1.73	1.61	1.63	2.45	2.33	2.31	2.44	2.33	2.29	2.18	1.72	1.96
BIAS	Temp.	1.16	1.52	1.18	-0.05	0.28	-0.04	-0.19	0.06	-0.25	1.05	-0.76	0.23
	Td	0.43	1.59	0.75	0.80	1.58	1.04	0.77	1.63	1.06	0.14	0.68	0.24
	LSP	-0.33	0.49	-0.27	-0.26	0.40	-0.26	-0.23	0.44	-0.23	-0.18	-0.15	-0.32
	Prec.	-0.56	1.26	0.54	-0.77	1.36	0.57	-0.83	1.25	0.51	0.76	1.74	1.37
	Wind	1.04	-0.39	0.41	1.99	1.45	1.75	1.98	1.44	1.73	1.64	0.18	1.05

13. **Page 471 lines 4-21: How sensitive is the JULES-CCATT-BRAMS simulation to NCEP bias? Does the simulation of JULES-CCATT-BRAMS enlarge or shrink the input initial and boundary errors?**

    Was included in page 471 line 18 the paragraph below:
    "Zhang et. al (2006) using MM5 Mesoscale Model showed that small-amplitude

    initial errors can grow rapidly and, subsequently, contaminate the short-term deterministic mesoscale forecast within 36 h. Xu and Zhong (2009) also found similar results using Weather Research and Forecasting (WRF) model."
    JULES-CCATT-BRAMS normally decreases the error over the first hours of simulation. One can observe this behavior in figure 3c. This was why we decided to disregard in evaluating the first two days of integration.

14. **Page 474 lines 13-17: How do you know the interpolation delivers a lower value? Could you justify this conclusion with any theory or example?**

    Because the flux of carbon from soil to atmospheric is directly proportional to amount carbon in soil. So, if the carbon in atmospheric is lower than observed data, a reason to this maybe is because there is little flux to atmospheric, due the model to assume a lower amount of carbon soil.

15. **Page 474 lines 14-15: Briefly describe "to be quite complicated".**

    "to be quite complicated" in this context means that there are a lot of land use transformations in this region that yet not were included in land use map. But really this phase may sound bad to reader, so it was removed of the text.

16. **Page 475 lines 12-14: Discuss why the surface CO2 simulated by the model agrees with observation at tower km-67, but not at the four sites of Amazon basin.**

    The tower localization is near of Santarém (SAN), so, is possible observe in fig. 9a that the profile also agree with airplane data observation. But, to other sites the possible causes are those described on page 473 lines 3-16.

17. **Page 475 lines 16-17: Is it possible to obtain any optimal setting constrained by local observations over Amazon basin?**

    The Amazon basin is very large and has a huge variability. Because of the high cost to perform measurements in this region do not yet have enough data to fit a model perfectly. But even with the few existing data it is possible to make adjustments to improve the simulation, p. ex. adjusting the value of the roughness can obtain a better estimate of the wind near surface.

2 Technique correction:

1. **page 455 line 24: Add "to be" before "able to produce ...".**

   The phase was changed to: "... re-analysis, at least for the region and time period analyzed here. This model is able to produce atmospheric simulations/forecasts at different resolutions, for any period of time and in any region of the globe."

2. **Page 458 line 3: Change the sentence to "... was able to simulate most of the ...".**

   Was Changed.

3. **Page 458 line 6-14: You sometimes use "section 2", sometimes "sect. 4". Please be consistent.**

   Was Changed to: "section 4".

4. **Page 458 line 17: BRAMS has been spelled out on page 457 line 15-16 already.**

   Was deleted the word: "(BRAMS)".

5. **Page 459 line 20: Is "tracers em form of" a typo?**

   The phase was changed to: "The general mass continuity for tracers solved in the model, in tendency form, is:"

6. **Page 460 line 28: Change "PREP-CHEMSRC" to "PREP-CHEM-SRC".**

   Was Changed.

7. **Page 461 line 17: Change "schematic form the processes" to "schematic form of the processes".**

   Was Changed.

8. **Page 465 line 3-4: Change the sentence to "The time in processing JULE-CCATT-BRAMS in relation to CCATT-BRAMS was increased around 17%."**

   Was Changed.

9. **Page 469 line 16: Delete "as well".**

   Was deleted

10. **Page 470 line 18-19: Change the sentence to "The monthly mean column amount of particulate matter less than 2.5 um (PM2.5) in the area showing in Fig.7a..."**

    Was Changed.

11. **Page 472 line 5: Change the first "observed" to "observation".**

    Was Changed.

12. **Page 472 line 20: Change "(Gatti et al., 2010)" to "Gatti et al., (2010)".**

    Was Changed.

13. **Page 474 line 8: Change "Fig. 10" to "Fig. 9".**

    Was Changed.

14. **Table 1: Please check whether "No-hydrostatic" should be "Non-hydrostatic".**

    You are right, the correct is Non-hydrostatic. Was replaced.

15. **Table 2: Why does rootd_ft have 6 instead of 7 values.**

    Have 5 values to rootd_ft, one for each plant functional types (PFTs): BT=5.00, NT=1.00, C3G=0.50, C4G=0.50 and shrub=0.50.