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Variability of Air-Sea CO_2 Fluxes and Dissolved Inorganic Carbon Distribution in the Atlantic Basin: A Coupled Model Analysis

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ABSTRACT

The biogeochemical dynamics of carbon in the ocean is a subject of fundamental interest to environmental studies. In this context, we have implemented a ten year run of the Brazilian Earth System Coupled Ocean-Atmosphere Model (BESM-OA2.3) integrated with TOPAZ biogeochemical model for the Atlantic basin. The modeled ΔpCO_2 for the tropical Atlantic shows very clearly a high dominance of positive fluxes, that is, the CO_2 fluxes are sea-to-air throughout the tropical region and for both winter and summer periods. In the mid-latitudes regions negatives fluxes (air-to-sea) were observed for both seasons. An exception to this pattern is an extensive negative tongue on the latitude 10°N. The occurrence of this negative ΔpCO_2 tongue region in the Tropical Atlantic is highly correlated to negative Evaporation-Precipitation values during this season. In the northern hemisphere (NH) summer the negative values of ΔpCO_2 in the tropical Atlantic region are concentrated in the adjacent zone of the Amazon river mouth due to the North Equatorial Counter Current intensification. This process favors the formation of a carbon sink in the adjacent region of the Amazon river mouth. Model results show lowest values of dissolved inorganic carbon (*DIC*) in a surface layer (100 - 150 m). Highest *DIC* values are observed in deeper layers and concentrated in an equatorial band. The chlorophyll bloom in equatorial zones was well represented by the model. These blooms are the result of equatorial upwelling that brings the high concentration tongues of *DIC* present in the equatorial band towards the euphotic zone. This is the first published paper about the BESM-OA2.3 integrated with TOPAZ. The presented results suggest that this modeling system is able to reproduce the main regional carbon dynamics features of the mid-latitude/tropical Atlantic.

KEYWORDS

Carbon Cycle; Atlantic Basin; Coupled Model; Climatological Analysis

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References

[1] J. L. Sarmiento and N. Gruber, "Ocean Biogeochemical Dynamics," Princeton University Press, 2006.

[2] C. D. Winn, Y. H. Li, F. T. Mackenzie and D. M. Karl, "Rising Surface Ocean Dissolved Inorganic Carbon at the Hawaii Ocean Time-Series Site," Marine Chemistry, Vol. 60, No. 1-2, 1998, pp. 33-47. doi:10.1016/S0304-4203(97)00085-6

[3] T. M. Hall, T. W. N. Haine and D. W. Waugh, "Inferring the Concentration of Anthropogenic Carbon in the Ocean from Tracers," Global Biogeochemical Cycles, Vol. 16, No. 4, 2002, pp. 1-15. doi:10.1029/2001GB001835

[4] D. C. E. Bakker, H. J. W. Baar and E. Jong, "The De pendence on Temperature and Salinity of Dissolved In organic Carbon in East Atlantic Surface Waters," Marine Chemistry, Vol. 65, No. 3-4, 1999, pp. 263-280. doi:10.1016/S0304-4203(99)00017-1

[5] S. C. Doney, I. Lima, A. R. Feely, D. M. Glover, K. Lindsay, N. Mahowald, J. K. Moore and R.

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Wanninkhof, "Mechanisms Governing Interannual Variability in Upper-Ocean Inorganic Carbon System and Air-Sea CO2 Fluxes: Physical Climate and Atmosphere Dust," Deep Sea Research Part II, Vol. 56, No. 8-10, 2009, pp. 640 655.

[6] Z. Liu, W. Dreybrodt and H. Wang, "A New Direction in Effective Accounting for the Atmospheric CO2 Budget: Considering the Combined Action of Carbonate Dissolution, the Global Water Cycle and Photosynthetic Uptake of DIC by Aquatic Organisms," Earth-Science Reviews, Vol. 99, No. 3-4, 2010, pp. 162-172. doi:10.1016/j.earscirev.2010.03.001

[7] R. G. Williams and M. J. Follows, "Ocean Dynamics and the Carbon Cycle," Cambridge University Press, Cambridge, 2011.

[8] G. L. Hunt and P. J. Stabeno, "Climate Change and the Control of Energy Flow in the Southeastern Bering Sea," Progress in Oceanography, Vol. 55, No. 1-2, 2002, pp. 5-22. doi:10.1016/S0079-6611 (02)00067-8

[9] N. R. Bates, M. H. P. Best and D. A. Hansell. "Spatio Temporal Distribution of Dissolved Inorganic Carbon and Net Community Production in the Chukchi and Beaufort Seas," Deep-Sea Research Part II, Vol. 52, No. 24-26, 2005, pp. 3324-3343. doi:10.1016/j.dsr2.2005.10.003

[10] J. T. Mathis, N. R. Bates, D. A. Hansell and T. Babila, "Net Community Production in the Northeastern Chukchi Sea," Deep-Sea Research Part II, Vol. 56, No. 17, 2009, pp. 1213-1222, 2009. doi:10.1016/j.dsr2.2008.10.017

[11] A. Samuelsen, L. Bertino and C. Hansen, "Impact of Data Assimilation of Physical Variables on the Spring Bloom from TOPAZ Operational Runs in the North Atlantic". Ocean Science, Vol. 5, No. 4, 2009, pp. 635-647. doi:10.5194/os-5-635-2009

[12] N. Wen, Z. Liu, Q. Liu and C. Frankignoul, "Observations of SST, Heat Flux and North Atlantic Ocean-Atmosphere Interaction," Geophysical Research Letters, Vol. 32, No. 17, 2005, pp. 1-4.

[13] C. Lé Quére, O. Aumont, P. Monfray and J. Orr, "Propagation of Climate Events on Surface Stratification, Marine Biology and CO2: Case Studies over the 1979-1999 Period," Journal of Geophysical Research: Oceans, Vol. 108, No. C12, 2003, pp. 1-14.

[14] J. W. Hurrel and C. Deser, "North Atlantic Climate Vari ability: The Role of the North Atlantic Oscillation," Journal of Marine Systems, Vol. 78, No. 1, 2009, pp. 28-41. doi:10.1016/j.jmarsys.2008.11.026

[15] J. While, I. Totterdell and M. Martin, "Assimilation of pCO2 Data into a Global Coupled Physical-Biogeochemical Ocean Model," Journal of Geophysical Research, Vol. 117, No. C3, 2012.

[16] A. Griesel and A. M. Maqueda, "The Relatzion of Meridional Pressure Gradients to North Atlantic Deep Water Volume Transport in an Ocean General Circulation Mo del," Climate Dynamics, Vol. 26, No. 7-8, 2006, pp. 781 799. doi:10.1007/s00382-006-0122-z

[17] M. Manizza, M. J. Follows, S. Dutkiewicz, D. Menemenlis, J. W. McClelland, C. N. Hill, B. J. Peterson and R. M. Key, "A Model of the Artic Ocean Carbon Cycle," Journal of Geophysical Research, Vol. 116, No. C12, 2011,

[18] P. Nobre, R. A. De Almeida, M. Malagutti and E. Giarol la, "Coupled Ocean-Atmosphere Variations over the Sou th Atlantic ocean," Journal of Climate, Vol. 25, No. 18, 2012, pp. 6349-6358. doi:10.1175/JCLI-D-11-00444.1

[19] P. Nobre, et al., "Climate Simulation and Change in the Brazilian Climate Model," Jornal of Climate, 2012, Submitted.

[20] S. M. Griffies, "Elements of MOM4p1. NOAA/Geophysical Fluid Dynamics Laboratory," Princeton, 2009, pp. 444.

[21] J. P. Dunne, A. Gnadesikan, J. L. Sarmiento and R. D. Slater, "Technical Description of the Prototype Version (v0) of Tracers of Phytoplankton with Allometric Zooplankton (TOPAZ) Ocean Biogeochemical Model as Used in the Princeton IFMIP Model," Biogeosciences Supplement, Vol. 7, 2010, pp. 3593-3624.

[22] M. Wakita, S. Watanabe, A. Murata, N. Tsurushima and M. Honda, "Decadal Change of Dissolved Inorganic Carbon in the Subartic Western North Pacific Ocean," Tellus B, Vol. 62, No. 5, 2010, pp. 608-620.

[23] F. J. Millero, "The Marine Inorganic Carbon Cycle," Chemical Review, Vol. 107, No. 2, 2007, pp. 308-

341. doi:10.1021/cr0503557

[24] Z. Liu, W. Dreybrodt and H. Wang, "A New Direction in Effective Accounting for the Atmospheric CO2 Budget: Considering the Combined Action of Carbonate Dissolution, the Global Water Cycle and Photosynthetic Uptake of DIC by Aquatic Organisms," Earth-Science Reviews, Vol. 99, No. 3-4, 2010, pp. 162-172. doi:10.1016/j.earscirev.2010.03.001

[25] R. F. Weiss, "CO2 in Water and Seawater: The solubility of Non-Ideal Gas," Marine Chemistry, Vol. 7, No. 3, 1974, pp. 203-215. doi:10.1016/0304-4203(74)90015-2

[26] C. Mehrbach and C. H. Culberson, J. E. Hawley and P. Pytkowicz, "Measurement of the Apparent Dissociation Constants of Carbonic Acid in Seawater at Atmosphere Pressure," Limnology and Oceanography, Vol. 18, No. 6, 1973, pp. 898-907. doi:10.4319/lo.1973.18.6.0897

[27] World Data Centre for Greenhouse Gases (WDCGG), "Mauna Loa CO2 Data," 2012. http://ds.data.jma.go.jp/gmd/wdcgg/

[28] D. J. Cooper, A. J. Watson and R. D. Ling, "Variation of pCO2 along a North Atlantic Shipping Route (UK to the Caribbean): A Year of Automated Observations," Marine Chemistry, Vol. 60, No. 1-2, 1998, pp. 147-164. doi:10.1016/S0304-4203(97)00082-0

[29] T. Takahashi, S. C. Sutherland, R. Wanninkhof, C. Sweeney, R. A. Feely, D. W. Chipman, B. Hales, G. Friederich, F. Chavez, A. Watson, D. C. E. Bakker, U. Schuster, N. Metzl, H. Yoshikawa-Inoue, M. Ishii, T. Midorikawa, Y. Nojiri, C. Sabine, J. Olafsson, Th. S. Arnarson, B. Tilbrook, T. Johannessen, A. Olsen, Richard Bellerby, A. K?rtzinger, T. Steinhoff, M. Hoppema, H. J. W. de Baar, C. S. Wong, Bruno Delille and N. R. Bates, "Climatological Mean and Decadal Changes in Surface Ocean pCO2, and Net Sea-Air CO2 Flux over the Global Oceans," Deep-Sea Research II, Vol. 56, No. 8-10, 2009, pp. 554-577. doi:10.1016/j.dsr2.2008.12.009

[30] ECMWF, "ERA-40 Atlas," 2006. http://www.ecmwf.int/research/era/ERA-40_Atlas/docs/section_B/

[31] S. Emerson and J. Hedges, "Chemical Oceanography and the Marine Carbon Cycle," Cambridge University Press, Cambridge, 2008. doi:10.1017/CBO9780511793202

[32] T. Takahashi, J. Olafsson, J. G. Goddard, D. W. Chipman, and S. C. Sutherland, "Seasonal Variation of CO2 and Nutrients in the High-Latitude Surface Oceans: A Comparative Study," Global Biogeochemical Cycles, Vol. 7, No. 4, 1993, pp. 843-878. doi:10.1029/93GB02263

[33] S. J. Lentz, "Seasonal Variations in the Horizontal Structure of the Amazon Plume Inferred from Historical Hydrographic Data," Journal of Geophysical Research Oceans, Vol. 100, No. C2, 1995, pp. 2391-2400. doi:10.1029/94JC01847

[34] W. R. Geyer, R. C. Beardsley, S. J. Lentz, J. Candela, R. Limeburner, W. E. Johns, B. M. Castro and I. D. Soares, "Physical Oceanography of the Amazon shelf," Continental Shelf Research, Vol. 16, No. pp. 1996, 575-616.

[35] C. A. Nittrouer and D. J. DeMaster, "The Amazon Shelf Setting: Tropical, Energetic, and Influenced by a Large River," Continental Shelf Research, Vol. 16, No. 5-6, 1996, pp. 553-573. doi:10.1016/0278-4343(95)00069-0

[36] R. L. Bourles, B. Molinari, E. Johns, W. D. Wilson and K. D. Leaman, "Upper Layer Currents in the Western Tropical North Atlant (1989-1991)," Journal of Geophysical Research-Oceans, Vol. 104, No. C1, 1999, pp. 1361 1375. doi:10.1029/1998JC900025

[37] D. M. Fratantoni and D. A. Glickson, "North Brazil Current Ring Generation and Evolution Observed