Geophysical Research Abstracts
Vol. 21, EGU2019-11413, 2019
EGU General Assembly 2019

Marine DOC Modeling Suggests the Importance of Hydrothermal Vents and Initial DOC Production

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Marine DOC represents the largest ocean reservoir of reduced carbon, holding > 200 times the carbon inventory of marine biomass, or an amount of carbon roughly equal to that in the atmosphere. Therefore, the DOC reservoir is significant in terms of long-term climate change. The largest fraction of DOC is characterized as refractory (DOCR) and radiocarbon ages indicate that this fraction survives multiple deep ocean mixing cycles. While DOCR production is understood to be tied mainly to primary production in the surface ocean, the mechanisms for DOCR removal are less well-understood, which has caused difficulty in quantifying the dynamics of this reservoir. However, photoalteration and hydrothermal alteration have been identified as likely mechanisms. In this study, DOC dynamics were incorporated into a well-calibrated dynamic ocean model, which explicitly represents important DOC processes: DOC production through primary production and degradation via photoalteration, hydrothermal vent interaction, and slow background decay. A model simulation using literature values for key model parameters resulted in large discrepancies from observation in both DOC concentration and the gradient in DOC concentration along the path of deepwater circulation. These discrepancies suggests that the current state of knowledge of the underlying processes related to these observations is incorrect. After tuning model parameters, most notably DOCR production and the hydrothermal vent flux, a Best Case Run was achieved. From this run, sensitivity tests were performed to examine how dependent model results were to changes in key model parameters. Between the Literature Value Run, the Best Case Run, and the sensitivity tests, two conclusions were made: (1) it is likely that the current literature value for the fraction of NPP that becomes DOCR is too large, by about five times, and (2) the literature value for hydrothermal vent flux is likely too small and should be nearly ten times the current value. Ideally, these conclusions will help guide the collection of observations to either confirm or disprove the model results found here.