


From: Ludivine Conte ludivine.conte@lsce.ipsl.fr 
Subject: Re: GEIA 2017 - Conference Final Program and Presentation/Poster Postings
Date: October 2, 2017 at 5:24 AM
To: paulette paulette@panoramapathways.net



Hi Paulette,

I had a poster during the GEIA conference. I send you here my final pdf version. You can post it.

Best,
Ludivine Conte

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Envoyé: Vendredi 29 Septembre 2017 23:31:22
Objet: GEIA 2017 - Conference Final Program and Presentation/Poster Postings



Hi Everyone

Thanks for your participation in GEIA 2017.

Please find attached the final program. Let us know if you see any errors.


We will be posting oral presentations and posters from the conference soon. Please confirm whether or not you want your presentation and/or poster posted by October 13. Either provide us with an updated version of your talk or poster, or let us know that it is OK to use the one we already have on file from you from the conference. If you have already sent me your poster or talk, thanks; we will use these. Please send your updated presentations and/or posters in pdf format. If we do not hear from you, we will assume that you do NOT want your materials posted.

Many thanks and all the best
Paulette

Global Modeling of Oceanic Carbon Monoxide Emissions

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Introduction

Carbon monoxide (CO) is important for trophospheric chemistry being the dominant sink for OH radicals and a key player in ozone chemistry. Hence, CO indirectly affects lifetime of greenhouse gases like methane and has impacts on air quality. The ocean has been shown to be a source of atmospheric CO² and, even if a minor CO source at the global scale, could play a key role far from continental anthropogenic zones. The CO marine production is linked to both photooxidation of dissolved organic matter and phytoplanktonic activity^{1,2}, and can thus have large spatial and temporal variabilities. Several campaigns have been carried out to characterize oceanic concentrations and were used to assess the global oceanic source but due to their scarcity and to large heterogeneities in phytoplankton and organic matter distribution, their extrapolation is rather imprecise.

Using a global marine biogeochemical model which explicitly represents CO sources and sinks, our study aims to better quantify the global CO oceanic source and to assess its spatial, seasonal and inter-annual variability. Simulated oceanic CO concentrations have been compared to surface data collected around the world during the last 40 years and reported in the literature. Finally, the use of such a model allows us to explore how oceanic emissions could respond to climate change.

Sensitivity Analyses and Evaluation of surface CO concentration

*** We performed tests on the Rate of bacterial Consumption and Photo-production**

Photo-production (38 TgC/yr) is the main source and falls into the range of other published estimations :
 - 30 to 84 TgC/yr^{1,2} (extrapolations from in situ measurements)
 - 29 TgC/yr (Model estimate using satellite's data)
 This source controls the surface CO concentration patterns (Figure 1) : its strength follows areas with relatively high CDOM and irradiance. Several parametrizations have been tested on the function relating chl a and CDOM absorption and lead to an estimated photo-production range of 29 - 84 TgC/yr

- Biological Production (8 TgC/yr) represents 14% of the total source
- Despite Bacterial Sink (43 TgC/yr) being the main sink, it is very poorly constrained

Rate of bacterial consumption	Photo-prod. (TgC/yr)	CO flux (TgC/yr)	RMSE
constant = 0.02	40.76	3.06	1.38
linear = 0.01 of [CDOM] + 0.02	40.76	3.70	1.38
linear = 0.01 of [chl a] + 0.02	41.24	4.35	1.36
linear = 0.01 of [chl a] + 0.02	41.71	5.00	1.34

Small changes in bacterial sink can induce strong changes on the global ocean-atmosphere CO flux (Table 1)

Using a varying consumption rate with chlorophyll and temperature is biologically more pertinent than using a constant rate, but doesn't change much the bacterial sink
 => This is due to the fact that temperature and chlorophyll effects compensate each other

Comparisons with in situ data helped to constrain this term (e.g. RMSE calculation)

*** We varied in situ bioactive elements of surface CO concentration to evaluate simulated concentrations**

Only few in situ CO measurements have been performed (Figure 2)
 - In the range of 0 to 4 nmol/L, the model is able to reproduce most concentrations by less than a factor of 2
 - High in situ data (up to 9 nmol/L) in polar regions (red circles), are not accurately represented by the model
 These polar data present a large spatial and temporal variability and suggest specific CO production processes involved in ice-covered regions

Spatio-Temporal evolution of oceanic CO emissions

*** Spatio-temporal variability**

Spatial patterns of oceanic emissions follow the CO² climatology (Figure 3)
 - Emissions present a strong seasonal variability : reached in late spring / summer in both hemispheres > 40°, corresponding to regions experiencing high seasonal high CDOM concentration and irradiance, reached in the southern hemisphere is stronger than in the northern hemisphere => During one year, the SH emits 1.7 TgC more than the NH
 - Inter-annual variability of emissions is relatively low => for a 1 year, the standard deviation is less than 0.5% of the global mean

*** Comparison of computed emissions with the ones of Erickson (1988)!!**

- For 20 years, tripartite models have been using the oceanic CO emissions provided by Erickson 1988 (Figure 4) : CO concentrations in surface waters were calculated considering a linear relationship with irradiance based on radiologic data from Conrad et al. (1982).
 - Our dynamical model provides quantitatively and qualitatively very different CO emission patterns => Erickson's patterns are driven by light and wind speed whereas MEMO-PISCES patterns are mainly driven by the photooxidation of colored dissolved organic matter as recommended in the recent literature
 - Our global emission budget is 1.7 TgC/yr against 70.7 TgC/yr for Erickson => which is much closer from more recent estimates based on extrapolations from in situ measurements (5 to 11 TgC/yr^{1,2,3,4,5})

Methods

MEMO-PISCES model :

- A global circulation model (MEMO) and a Biogeochemical model (PISCES)¹¹
- 2 phytoplankton groups / 3 non-living organic matter pools / 5 nutrients
- Run for 3990 years to reach equilibrium using a mean climatology
- Resolution : 2° x 2° (coarse) with 31 vertical levels

Processes Affecting oceanic CO concentration :

$$\frac{\partial CO}{\partial t} = [E_{CO_2} \times A_{CDOM} \times AQY] + [\tau_{Diat} [Diat] + \tau_{Nano} [Nano]] - [k_{Bact} [CO]] - [k_{Flux} (CO_{atm} - H \cdot pCO_2)]$$

Photo-dissociation of Colored Dissolved Organic Matter Biological production by Diatoms and Nanophytoplankton Bacterial Sink Ocean-Atmosphere flux

↓ Efficiency of CDOM to produce CO²
↓ with Constant Rate¹² CO might be a by-product of phytoplanktonic activity
↓ Carotant Rate = 0.8 d⁻¹ OR depending on temperature and chl a¹³
↓ Transfer velocity (depends on temperature and wind speed)¹⁴ ↓ Partial pressure in Atmosphere (mixing ratio + Water)¹⁵ ↓ Solubility ↓ Temperature salinity¹⁶

How Emissions respond to Climate Change ?

- We performed two long runs (from 1850 to 2100) :
 => one with a constant pre-industrial atmospheric CO₂ concentration (315 ppm) => one with an increasing CO₂ concentration corresponding to RCP 8.5 (ppm)

- The global CO flux increases by 15.8% under an increasing atmospheric CO₂ concentration
 - The global budget of biological source and sink show little change

Attribution of the rise of the global CO flux to a combination of physical processes :

↑ Solubility of CO (pH) decreases due to a global rise of sea surface temperature
↑ Transfer velocity (k_{tr}), depending on temperature and wind speed, increases
↑ CO concentration in surface seawater tends to increase slightly ↑ Temperature ↑ stratification ↑ mixing ↑

⇒ Among those processes, the change of the gas transfer velocity k_{tr} due to the surface temperature dominates to increase the CO flux towards the atmosphere (Figure 5)

GEIA Conference
Emissions Science for a Healthy Environment;
The interplay of human versus natural influences on climate and air quality emissions
13 - 15 September 2017, University of Hamburg, Germany
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Conclusion

- We provide the first model-based estimation of oceanic CO emissions which will be available soon for atmospheric models
 - The mechanistically-based model helped to better understand processes influencing CO concentrations and of importance for the determination of global CO flux to the atmosphere, as the importance of consumption term
 - Such a dynamical model allowed us to forecast that CO fluxes could slightly increase under a considering high increase of atmospheric CO₂ concentration
 - The same approach will be used to study other short lived gases such as volatile organic compounds