Sensitivity of simulated global ocean carbon flux estimates to forcing by reanalysis products

Gregg, W.W. et. al, *Ocean Modelling* 80: (2014) 24-35.
doi:10.1016/j.ocemod.2014.05.002

Objectives:

- The objective of this study is to provide quantitative information on the spatial distributions of air–sea carbon fluxes (FCO_2) and ocean partial pressure of carbon dioxide (pCO_2) globally, regionally, and sub-regionally using a model forced by four state-of-the-art, widely used reanalysis products.
- The reanalysis products include the MERRA (Modern-Era Retrospective analysis for Research and Applications) product, two from the National Center for Environmental Prediction (NCEP2 and NCEP1), and one from the European Centre for Medium-range Weather Forecasts (ECMWF).
- The biogeochemical model used in this study was the NASA Ocean Biogeochemical Model (NOBM), which is a three-dimensional representation of coupled circulation/biogeochemical/ radiative processes in the global oceans.
- NOBM was spun-up for 200 years under climatological forcing from each reanalysis, and then the results from the last year (year 200) were compared with in situ data and with one another.
- Comparisons were statistical and include differences between model global and regional means and correlation analysis, with an emphasis on large temporal and spatial scale results, using annual area-weighted means and correlation analysis across the 12 major oceanographic basins.
- Additionally, model pCO_2 and FCO_2 from one of the reanalyses, MERRA, is compared against in situ data sub-regionally to estimate the influences of inherent model biases.

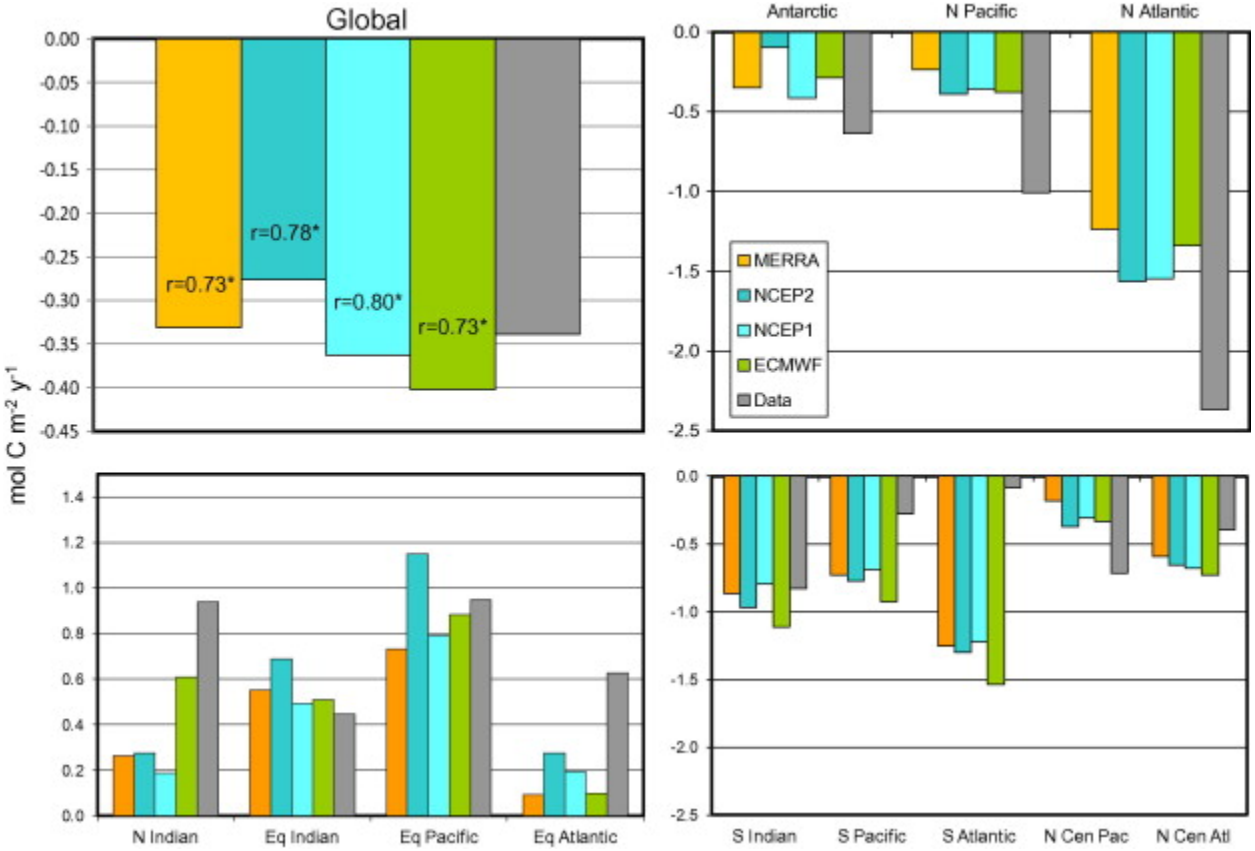
New Science:

- Global air–sea FCO_2 and pCO_2 were relatively insensitive to the choice of forcing reanalysis.
- All global air-sea carbon flux estimates from the model forced by the four different reanalysis products were within 20% of in situ estimates.
- Correlations for pCO_2 are similarly positive and significant, with global pCO_2 estimates within 1% of in situ estimates.
- Although the global FCO_2 and pCO_2 distributions are similar among reanalyses, there are considerable differences on oceanographic basin scales.
- There were substantial departures among basin estimates from the different reanalysis forcings, with the high latitudes and tropics having the largest ranges in estimated fluxes among the reanalyses.
- On regional scales, more model-data deviations are apparent and they can be large at times.
- None of the reanalysis products are uniformly superior in all basins, nor are any uniformly inferior, as compared to in situ estimates.

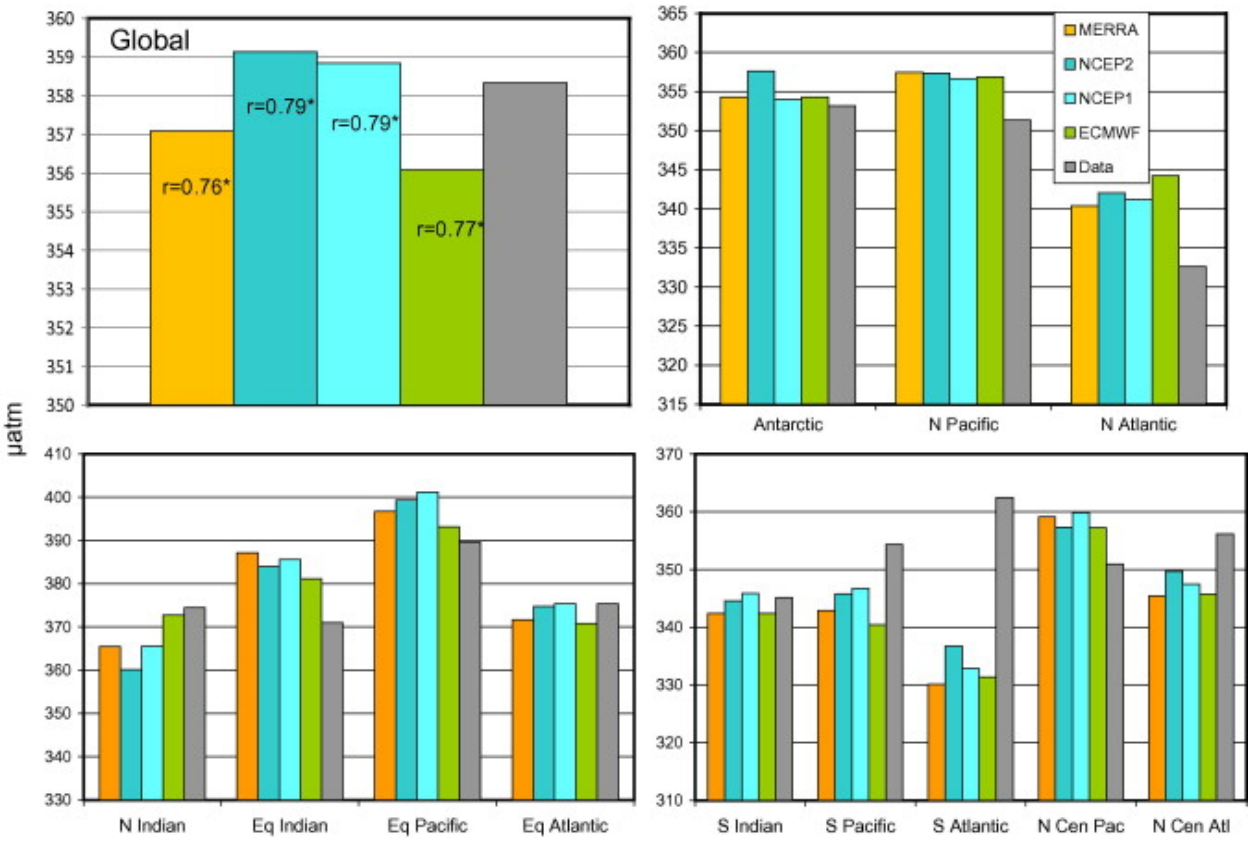
Significance:

- The oceans play a critical role in the global carbon cycle, with more than 90% of the active non-geological carbon pool residing in the oceans.
- Estimates of global primary production suggest that the oceans contribute about half; in addition, one-quarter of the carbon emitted by anthropogenic sources is thought to be sequestered in the oceans, annually.
- Understanding the role of the ocean in the global carbon cycle is a driving question in modern Earth science.
- The results of this study provide useful information on the characterization of uncertainty in current ocean carbon models due to choice of reanalysis forcing.
- That global air–sea carbon fluxes and pCO_2 are generally similar regardless of reanalysis forcing suggests that important variables used for ocean carbon model forcing are similar on global scales, and that whatever important differences there are among the four reanalysis products, global ocean carbon mean fluxes and pCO_2 are insensitive to them.
- The finding that global means are insensitive to the choice of reanalysis product suggests that at least for the variables most important for ocean carbon exchange (wind speeds, SST, and ice) the reanalysis products are either in general agreement, or that the differences among them are relatively unimportant at the largest spatial scales.
- In regional analyses, large differences in FCO_2 are observed depending upon the reanalysis product used for forcing, suggesting that the choice of regional and local model selections can have an important influence on carbon cycling and exchange estimates.
- The finding that different estimates of air–sea fluxes are produced by different reanalyses at regional scales reinforces other, earlier studies.
- This effort provides a milepost for evaluating the use of different reanalysis forcing products for ocean carbon models, and the results should provide help in the selection and use of reanalysis products for global and regional ocean carbon models.
- The findings are potentially important not only to ocean carbon modelers, but also for reanalysis developers and analysts, satellite mission conceptual designers, and atmospheric scientists who can use the findings in their selection, uses, and understanding potential pitfalls of different reanalysis products in the context of ocean carbon models.

(Figures recommended are Figure 5 page 28 and Figure 7, page 29)



Global and basin annual mean air–sea carbon fluxes (FCO_2). The basins are arranged by high latitudes (top right), tropical (bottom left), and sub-polar (bottom right). Correlation coefficients compared with in situ estimates are shown in the global plot, where an asterisk indicates $P < 0.05$.



Global and basin annual mean pCO_2. The basins are arranged by high latitudes (top right), tropical (bottom left), and sub-polar (bottom right). Correlation coefficients compared with in situ estimates are shown in the global plot, where an asterisk indicates $P < 0.05$.