Counting the Ocean's Greenhouse Gas Emissions

A new database seeks to improve estimates of oceanic emissions of methane and nitrous oxide.

Ocean surface photographed directly from above. Credit: Shutterstock/anmo

By Annette Kock and Hermann W. Bange 10 February 2015

To understand how Earth’s climate will change in the future, scientists need to know how much heat-trapping gas is going into the atmosphere today. However, oceans’ emissions of two major greenhouse gases, methane (CH$_4$) and nitrous oxide (N$_2$O), vary dramatically in time and space. With a centralized digital resource, the Marine Methane and Nitrous Oxide (MEMENTO) database, information on CH$_4$ and N$_2$O concentration measurements from around the globe are collected to help researchers more precisely quantify these oceanic emissions.

Oceanic CH$_4$ can arise from shallow sediments, and both CH$_4$ and N$_2$O are produced by ocean-
dwelling microbes. Although only a relatively small fraction of global CH$_4$ emissions—around 2%—come from the ocean (including coastal areas), oceans are a major source for atmospheric N$_2$O, providing around 25% of the total. When it reaches the stratosphere, N$_2$O attacks ozone, destroying it on a global scale.

Estimates of oceanic emissions are based on extrapolations of concentrations measured at the ocean’s surface or results from model studies. For example, using the data set of Weiss et al. [1992], Nevison et al. [1995] calculated the first global field of surface ocean N$_2$O concentrations to estimate the marine N$_2$O source to the atmosphere.

However, the fluxes of N$_2$O and CH$_4$ can vary substantially from day to day and from place to place, meaning that even with recent improvements in measurement techniques and increased measurements, global emission estimates are still highly uncertain [see Ciais et al., 2013]. Millions of measurements taken at different times and covering the globe are needed for researchers to more precisely estimate how much gas is being emitted.

**MEMENTO Ups the Game**

MEMENTO, an initiative that began in 2009, is the first attempt to systematically compile all global data on oceanic CH$_4$ and N$_2$O measurements. MEMENTO, an initiative that began in 2009, is the first attempt to systematically compile all global data on oceanic CH$_4$ and N$_2$O measurements. It archives data taken not only at the ocean surface but also from the deep ocean. As curators of the data set, our goals are to see how oceanic concentrations of the gases vary in time and space and to provide more precise global emission estimates of oceanic CH$_4$ and N$_2$O to the climate research community.

MEMENTO already includes original data from more than 180 measurement campaigns, which have provided more than 20,000 CH$_4$ and more than 100,000 N$_2$O measurements over the past 50 years (see Figure 1 for sampling locations). These data sets include dissolved gas concentrations along with information on sampling position, sampling depth and time, and, if available, data on ocean temperature and salinity as well as oxygen and nutrient concentrations.
Fig. 1. (a) Locations of surface and (b) depth profile (stations with sample depths greater than 10 meters) of N$_2$O (green), CH$_4$ (blue), and collocated N$_2$O and CH$_4$ (red) measurements included in MEMENTO as of January 2015.

If available, we also include atmospheric measurements from the same campaign, such as air temperature and air pressure, usually sampled a few meters above sea level height. We also add to all submissions the contact information of the researchers who provided the data, their related publications, and if available, a link to the host center of the original data sets.

**An Emphasis on Quality**

If measurements lack information on sampling position, sampling time, and sampling depth (for oceanographic data), we do not import them into the database. We put all data submissions imported to MEMENTO through a systematic quality control procedure to guarantee that essential metadata are available and to minimize erroneous entries. If measurements lack information on sampling position, sampling time, and sampling depth (for oceanographic data), we do not import them into the database. In addition, we apply a first-order range check to all imported variables to exclude obviously incorrect data entries, such as negative concentrations, erroneous date formats, or data positioned over land.
CH₄, N₂O, and oxygen data are imported in their original units. In a second data-processing step, we will calculate global surface fields and depth profiles in common units. Missing temperature and salinity data will be supplied from external data sources.

**A Work in Progress**

We regularly update the database with newly available data sets and continuously improve it by including additional meta-information, allowing additional data formats, and implementing new data quality control criteria.

In addition, we are working closely with the recently initiated Scientific Committee on Oceanic Research (SCOR) Working Group 143 (http://www.scor-int.org/SCOR_WGs_WG143.htm), entitled “Dissolved N₂O and CH₄ measurements: Working towards a global network of ocean time series measurements of N₂O and CH₄.” As an additional quality flag for our data, we will implement standard procedures that are developed within the working group for measuring N₂O and CH₄.

As we expand MEMENTO, we will also build on the experiences researchers have gained from existing databases such as the Surface Ocean CO₂ Atlas (SOCAT (http://www.socat.info)), the Global Surface Seawater Dimethylsulfide Database (GSSDD (http://saga.pmel.noaa.gov/dms/)), and the Halocarbons in the Ocean and Atmosphere Database Project (HalOcAt (https://halocat.geomar.de)). Specifically, we are looking to create best practices on how to structure data archives, methods for checking data quality, and ways to make data archives more user friendly.

**A Resource for the Research Community**

We intend for MEMENTO to serve as a living resource from which researchers can pull quality-controlled oceanic CH₄ and N₂O data for a variety of purposes. Researchers have already begun using the database to produce important results. For example, Zamora et al. [2012] and Suntharalingam et al. [2012] used MEMENTO data to model N₂O production and consumption processes on global and regional scales. Freing et al. [2012] used the database to compute global N₂O production rates from the in situ measurements. A list of associated publications (https://memento.geomar.de/publications) is available on the MEMENTO website.

MEMENTO data are freely available to interested users, who can access the database via the MEMENTO website (https://memento.geomar.de). We would like to expand our database, so please consider adding your CH₄ and N₂O data. Contact us (mailto:akock@geomar.de) to obtain the log-in information to the database and information on how to submit your data to MEMENTO.

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