

## Inconsistent model uptake of anthropogenic tracers in the Southern Ocean

KATSUMI MATSUMOTO<sup>1</sup>, A. GNANADESIKAN<sup>2</sup>,  
N. GRUBER<sup>3</sup>, R.M. KEY<sup>4</sup> AND J. L. SARMIENTO<sup>4</sup>

<sup>1</sup>Geological Survey of Japan, AIST, 1-1-1 Higashi, Tsukuba, 305-8567, Japan (katsumi@ni.aist.go.jp)

<sup>2</sup>Geophysical Fluid Dynamics Laboratory, NOAA, Princeton, NJ, 08544, USA (a1g@gfdl.noaa.gov)

<sup>3</sup>Institute of Geophysics and Planetary Sciences, UCLA, Los Angeles, CA, 90095, USA (gruber@igpp.ucla.edu)

<sup>4</sup>Program in Atmospheric and Oceanic Sciences, Princeton University, Princeton, NJ, 08544, USA (key@princeton.edu; jls@princeton.edu)

Here we examine a suite of ocean biogeochemistry model experiments in their ability to ventilate the Southern Ocean. The experiments differ in their vertical and horizontal mixing schemes and hence in their large-scale overturning circulation. We gauge the performance of the experiments by comparing their simulations of natural  $\Delta^{14}\text{C}$ , anthropogenic  $\text{CO}_2$ , bomb  $\Delta^{14}\text{C}$ , and CFC-11 with appropriate "observations". We find that no model is able to simultaneously ventilate the Southern Ocean on centennial time scale as indicated by natural  $\Delta^{14}\text{C}$  and on decadal time scale as suggested by the other anthropogenic tracers. While some model experiments are able to simulate natural  $\Delta^{14}\text{C}$  and CFC reasonably well, their uptake of anthropogenic  $\text{CO}_2$  and particularly bomb  $^{14}\text{C}$  is insufficient. In contrast, those simulations that take up about the right amount of anthropogenic  $\text{CO}_2$  and bomb  $^{14}\text{C}$  in the Southern Ocean have too old deep waters. This discrepancy is also evident in other coarse-resolution models that participated in the Ocean Carbon-Cycle Model Intercomparison Project. A partial resolution of this discrepant finding may have its source in the uncertainty of the "observed" anthropogenic  $\text{CO}_2$  and bomb  $^{14}\text{C}$ . The concentrations of these two tracers, unlike natural  $\Delta^{14}\text{C}$  and CFCs, are not measured directly but estimated from the measured concentrations of nutrients and dissolved gases using rather complicated methods. It is also possible that our finding may be partially caused by too slow an air-sea gas exchange speed in our model. A faster gas exchange would likely enhance the transfer of anthropogenic  $\text{CO}_2$  and bomb  $^{14}\text{C}$  from the atmosphere to the ocean proportionally more than CFC-11, because the former two tracers have longer equilibration time scales than CFCs. There would be relatively little impact on CFC-11, which is already much nearer to equilibrium anyway. A faster gas exchange should therefore bring simulated anthropogenic  $\text{CO}_2$  and bomb  $^{14}\text{C}$  into closer agreement with CFC-11, whose uptake in the Southern Ocean was better simulated.

## Chemical characterization of marine aerosol over the western North Pacific Ocean

K. MATSUMOTO

Japan Science and Technology Cooperation, Kawaguchi / Ocean Rearch Institute, The University of Tokyo, Tokyo, Japan (kiyoshi@ori.u-tokyo.ac.jp)

### Introduction

Long-range transport of anthropogenic and mineral aerosols from the Asian continent to the North Pacific may have significant impacts on global radiation balance, atmospheric chemistry, and oceanic biogeochemistry. The author has conducted the observations of marine aerosol chemistry over the western North Pacific in the last decade<sup>1,2,3,4</sup>, in order to understand seasonal and geographical distributions of chemical species in marine aerosols over the oceanic region as well as their chemical and physical properties. Here the author focus on the recent observations of aerosol chemistry in Japanese remote islands, and discuss chemical properties and long-range transport of ionic and carbonaceous species over the western North Pacific Ocean.

### Long-range transport and chemical properties

Simultaneous observations of aerosols chemistry have been carried out at four remote islands (Rishiri, Sado, Hachijo, and Chichi-jima) since March 2001. Geographical distributions and temporal variations of land-derived chemical species in aerosols over the oceanic regions have been obtained in this study<sup>3</sup>. The outflows of continental air masses to the western North Pacific are accelerated by certain synoptic-scale weather systems. Post frontal outflows of continental air masses have been frequently found, especially during spring periods, which cause high loading of anthropogenic aerosols over the oceanic regions<sup>2,3</sup>.

Particulate nss-sulfate mainly exists in fine particles as ammonium salt in marine atmosphere, whereas nitrate is associated with dust particles in East Asian Pacific rim region or with sea-salt particles in the remote ocean<sup>4</sup>. Nitrate and nss-calcium, especially nss-calcium, are effectively removed from the atmosphere during their long-range transport. Particulate organic carbon shows relatively higher concentrations over the remote ocean<sup>1</sup> probably due to oceanic sources, although elemental carbon is derived only from combustion sources.

### References

- 1; Matsumoto, K., H. Tanaka, I. Nagao, and Y. Ishizaka, *Geophys. Res. Lett.*, 24, 655-658, 1997.
- 2; Matsumoto, K., I. Nagao, H. Tanaka, H. Miyaji, T. Iida, and Y. Ikebe, *Atmos. Environ.*, 32, 1931-1944, 1998.
- 3; Matsumoto, K., M. Uematsu, T. Hayano, K. Yoshioka, H. Tanimoto, and T. Iida, *J. Geophys. Res.*, in press, 2003.
- 4; Matsumoto, K., Y. Uyama, T. Hayano, H. Tanimoto, I. Uno, and M. Uematsu, *J. Geophys. Res.*, in press, 2003.