

SUPPLEMENTARY INFORMATION

Model-data comparison Extensive model validation is performed using concurrent ship-based observations since this is the first time that a high-resolution ocean state estimate is applied to the simulation of biogeochemical cycles and anthropogenic carbon dioxide. Direct comparison of simulated tracer fields with in-site measurements from CLIVAR repeat hydrography line A16S and P16S shows that the model can reproduce observed pattern of water mass distribution and tracer properties. The representations of hydrographic (T,S) structure and water mass distribution are well reproduced in the model (Figure S1). Model-data comparison of biogeochemical tracers such as DIC and alkalinity also demonstrates remarkable similarity to the observed in-situ distributions (Figure S2), however these tracers show greater model-data misfit than that of temperature and salinity.

Spatial pattern of anthropogenic carbon uptake Correlation between aCO_2 uptake and physical parameters are evaluated. There is a qualitative resemblance between the spatial patterns of aCO_2 uptake, the standard deviation of vertical velocity, and the eddy kinetic energy (Figure S3). Correlation coefficients of anthropogenic carbon uptake with (i) logarithm of standard deviation of vertical velocity and (ii) eddy kinetic energy are 0.51 and 0.34 respectively (both are statistically significant at 95% confidence interval). These moderate correlations between the anthropogenic carbon uptake and physical parameters are expected due to the relatively slow response of air-sea gas transfer (with typical timescales of a year) in the presence of strong horizontal advection. Enhanced anthropogenic carbon uptake near frontal regions appears to be the result of enhanced vertical exchange there.

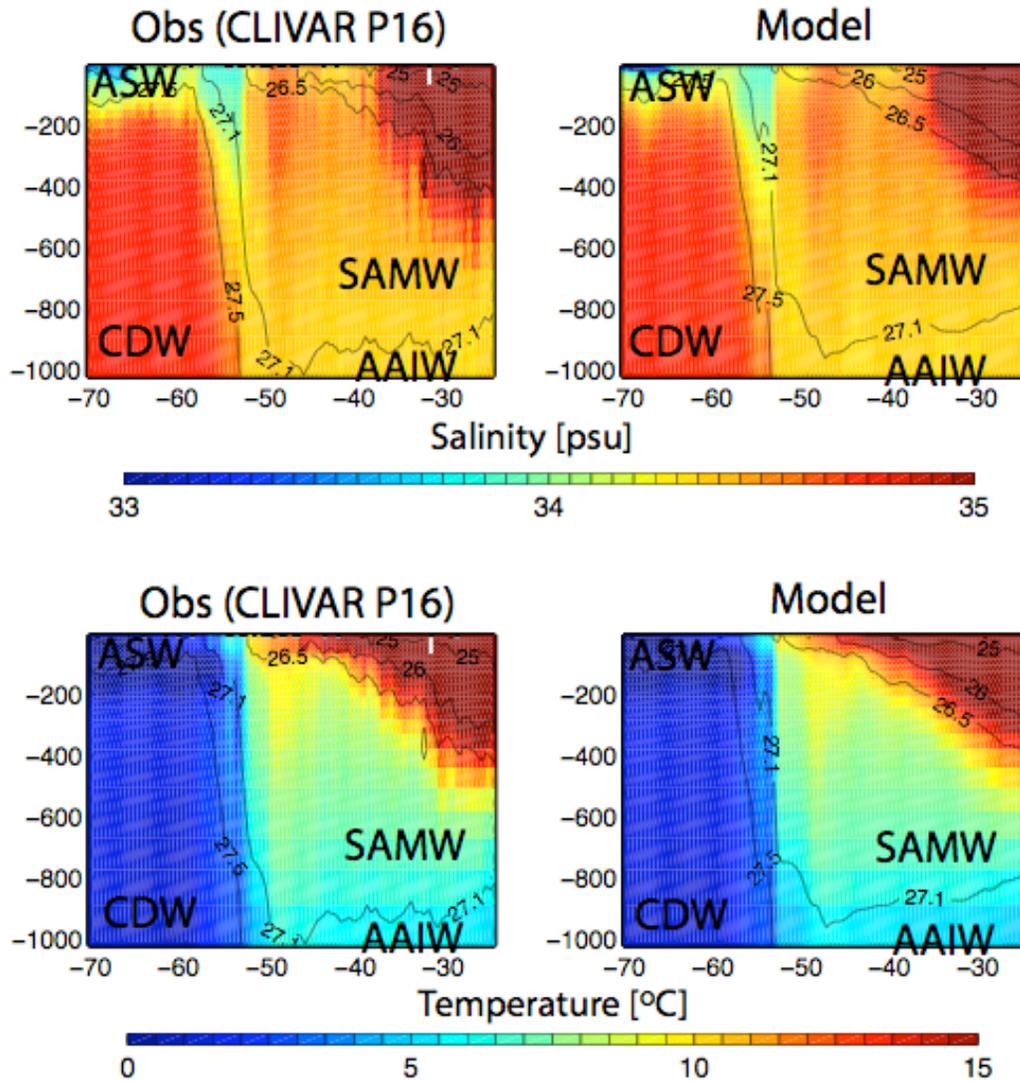


Figure S1. A hydrographic section from Clivar repeat section P16 in the top 1000m. Left column is the observational data and the right column is the concurrent section from the model. The top panels show the comparison of salinity (color shading) and potential density (solid contour). The bottom panels also compare thermal structure (color shading). Major water masses are marked such as Antarctic Surface Water (ASW), Circumpolar Deep Water (CDW), Subantarctic Mode Water (SAMW) and Antarctic Intermediate Water (AAIW).

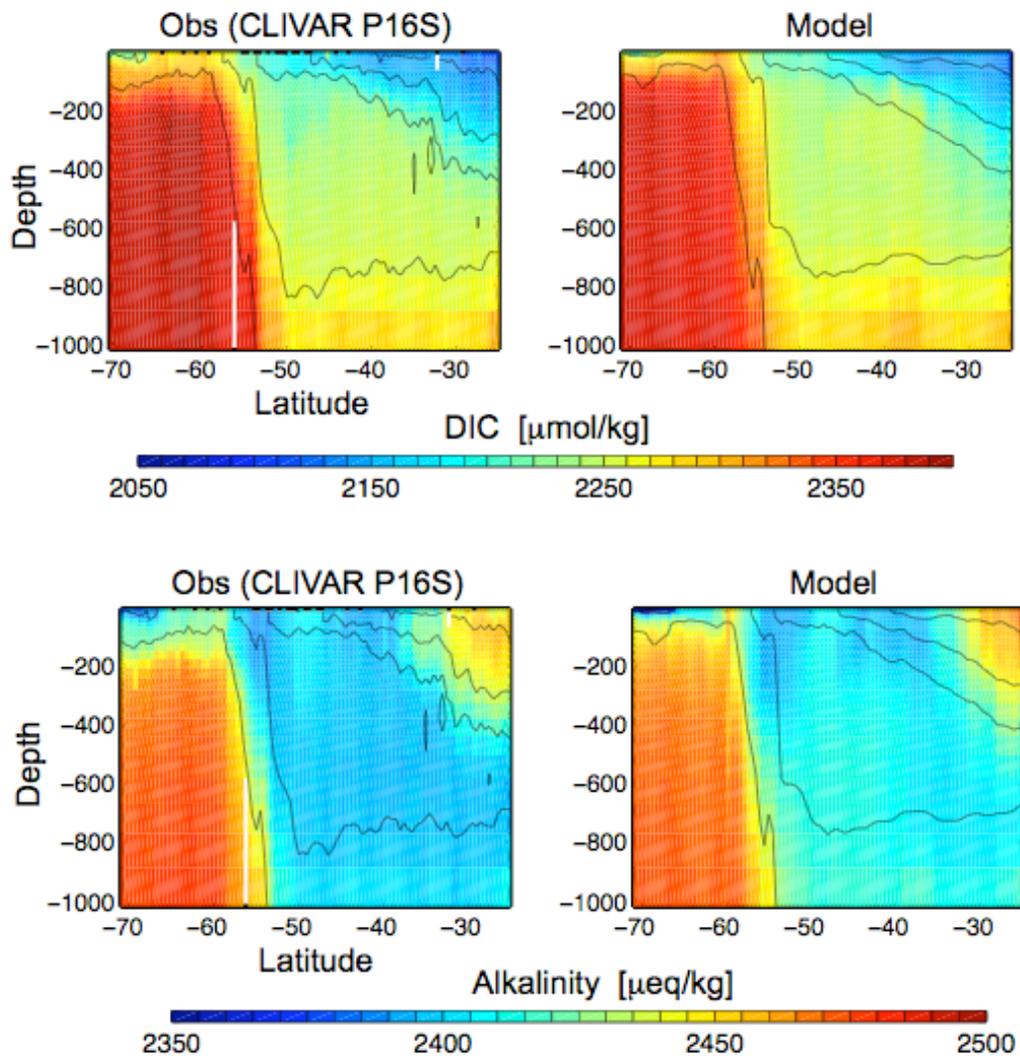


Figure S2. Comparison between observed (left column) and simulated (right column) distribution of (top) *DIC* and (bottom) alkalinity, in the top 1000m from the CLIVAR repeat hydrography P16S line. Bottle data is interpolated onto regular vertical grid consistent with the model, and model data is horizontally interpolated onto the location of hydrographic stations evaluated at the time when the cruise took place during early 2005. Solid black contours are potential density surfaces.

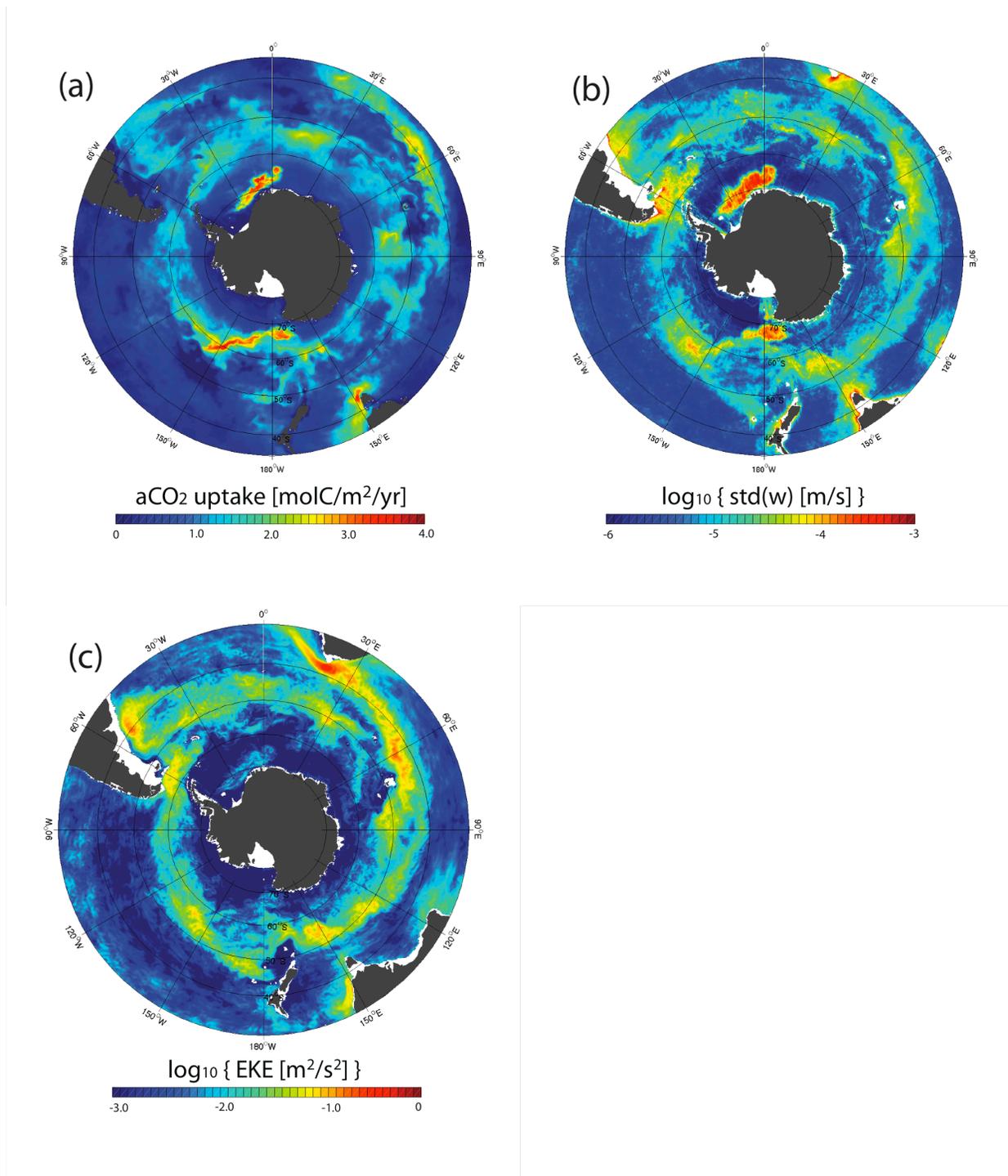


Figure S3. Spatial pattern of (a) aCO_2 uptake, (b) logarithm of standard deviation of vertical velocity, and (c) logarithm of eddy kinetic energy, calculated from 5 day-average fields from January 2005 to December 2006. (b) and (c) are evaluated at the 225m depth level.