Figure 1 – Number of months in each 4° x 5° box area where at least one surface water pCO_2 measurement has been made since the early 1970's. Of a total of 1,760 boxes, 50% of them have observations in 3 months or less, and 32% of them have observations in 6 months or more. White areas have no measurements. The total number of surface water pCO_2 measurements is 2.8 million.

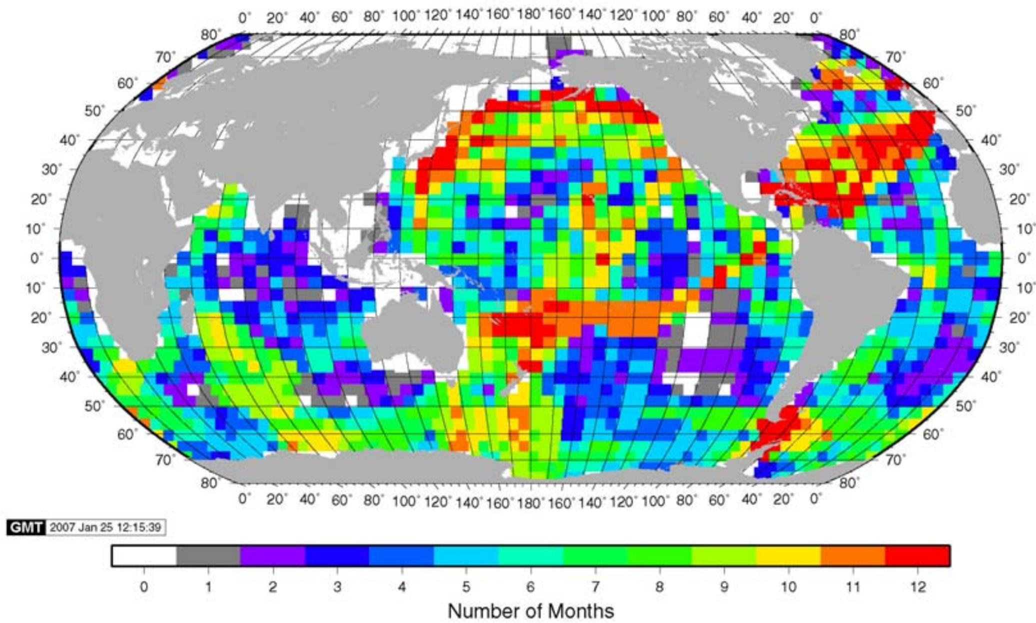

Figure 2 – Surface water pCO_2 and SST data obtained in the Vanuata area, 20°S-25°S and 165°E-175°E in the South Pacific in 1993-1996. The mean seasonal variability for the three year period is established assuming that the seasonal variations remained unchanged over this period. The open circles are monthly mean values and the error bars represent one standard deviation of observations. The values for months with no measurements are linearly interpolated using adjacent monthly mean values, and are shown with open squares. The horizontal line indicates the annual mean. The differences between the monthly mean and the annual mean indicate the seasonal corrections used for deseasonalization.

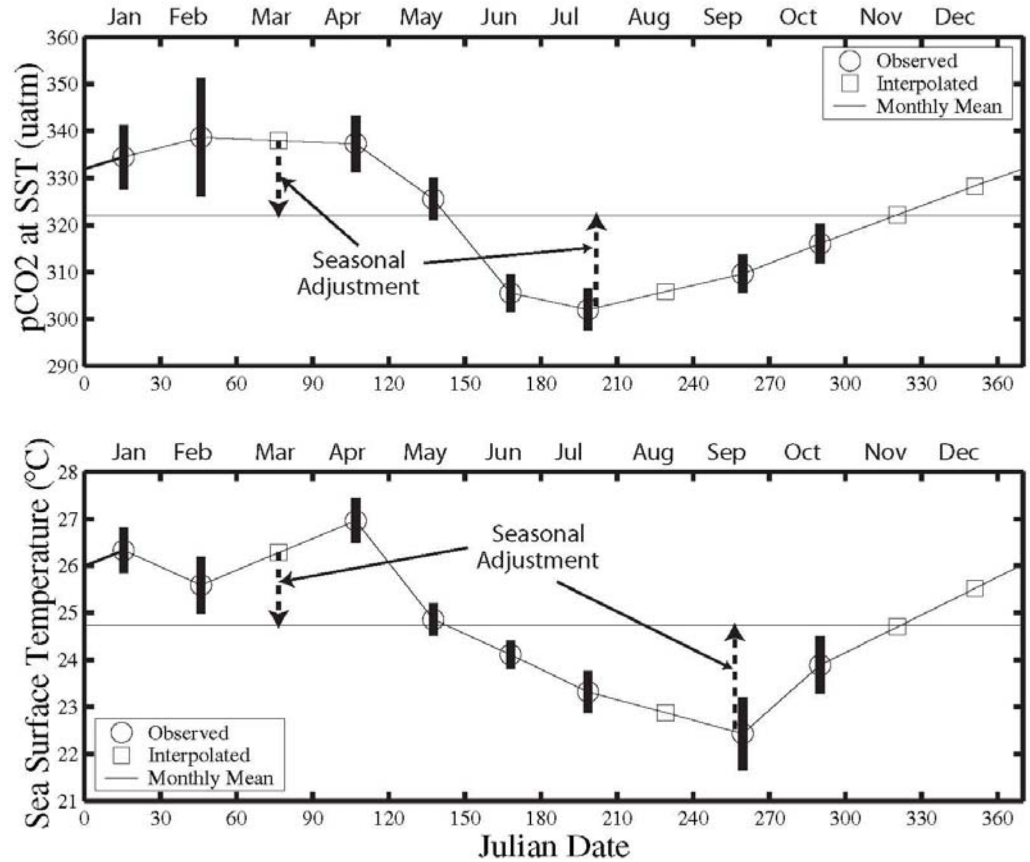

Figure 3 – Temporal change in the surface water pCO_2 observed in the Irminger Sea (60°N-65°N; 30°W-20°W) (top panel), north of the Azores (45°N-50°N; 20°W-10°W) (middle panel) and east of Barbados (15°N-20°N; 60°W-50°W) (bottom panel). Black (non-El Nino periods) and green (El Nino periods) dots indicate the observed values, and the open red circles indicate the deseasonalized mean monthly values. The solid red line shows a linear regression, and the mean rate of change is shown at the bottom of each panel. N is the number of monthly mean values used.

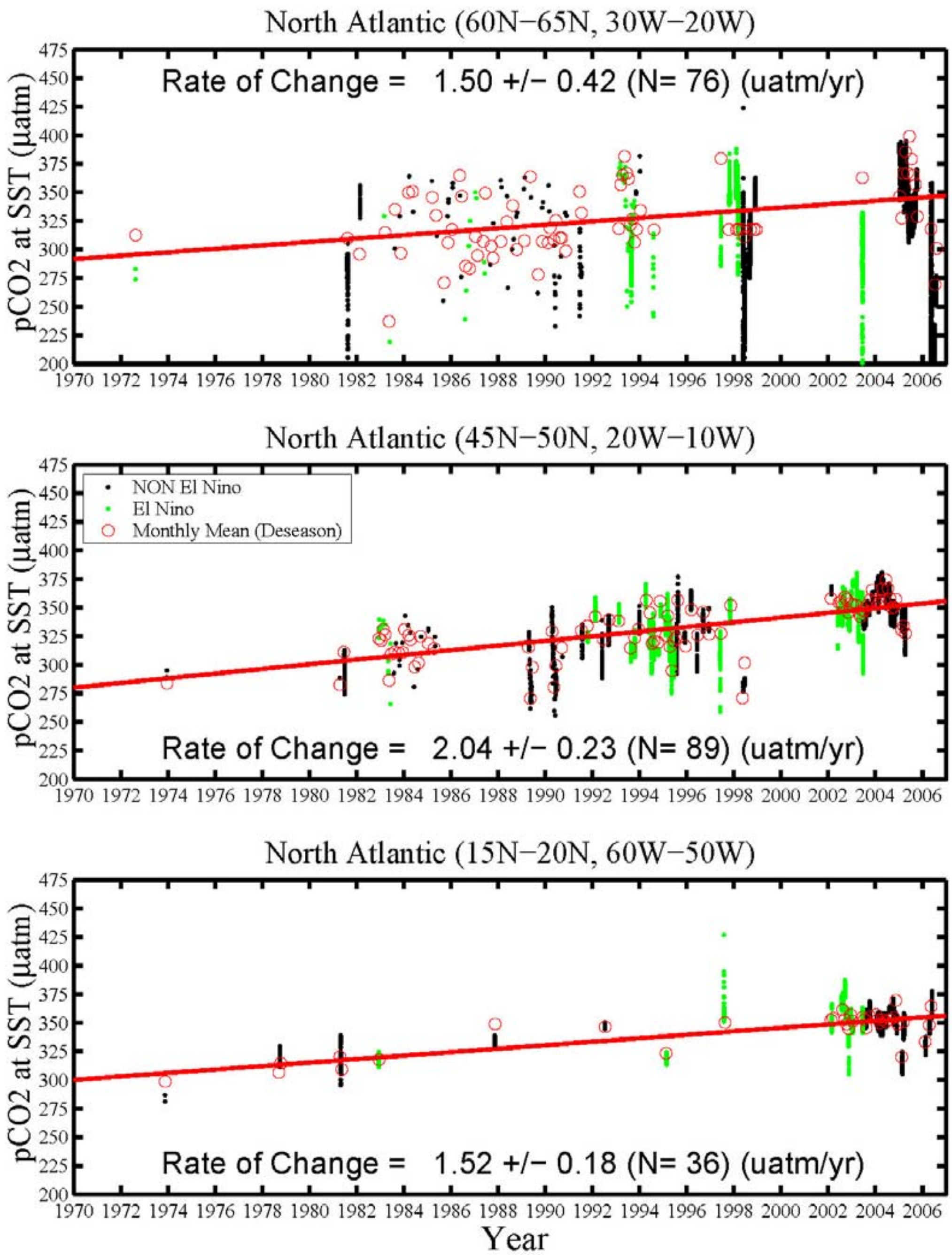

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Figure 4 –Mean rates of increase during 1970-2006 in surface water pCO_2 in 5° x 10° box areas in the North Atlantic. The red numbers indicate the rates in μatm yr^{-1}. Uncertainties for the rates range between ±0.1 and ±0.6 μatm yr^{-1} depending upon the seasonal amplitude and the length of record in each box area. The mean of the 37 box areas that is computed by weighting with reciprocal of the uncertainty is 1.77 ± 0. 37 μatm yr^{-1}.

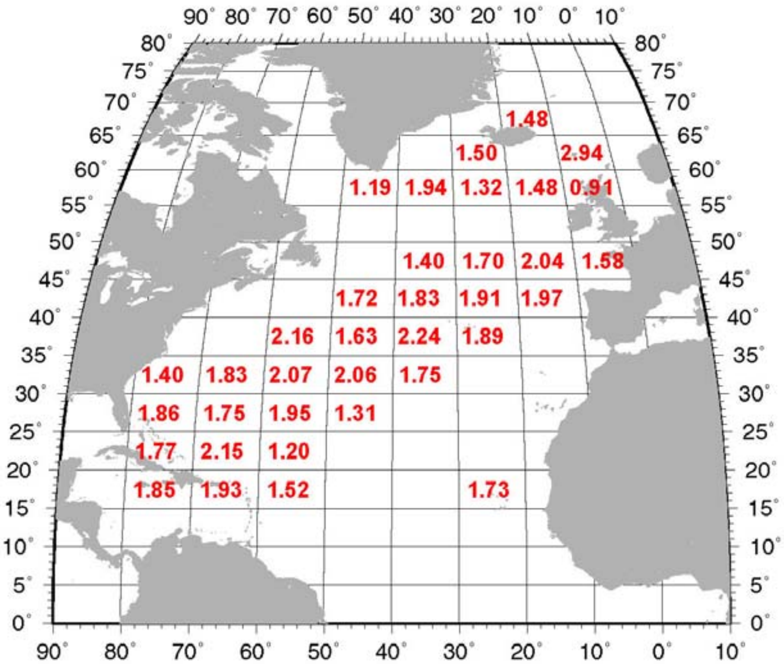

Figure 5 – Temporal change in the surface water pCO_2 in the Station "P" area (top panel), HOT area (middle panel) and Southern Bering Sea (bottom panel). Black dots indicate the observed values during non-El Nino periods, and green dots those during El Nino periods. Red open circles indicate the de-seasonalized mean monthly values, and the solid line shows a linear regression computed using the mean monthly values. The mean rate of change is shown at the bottom of each panel. N is the number of monthly mean values used.

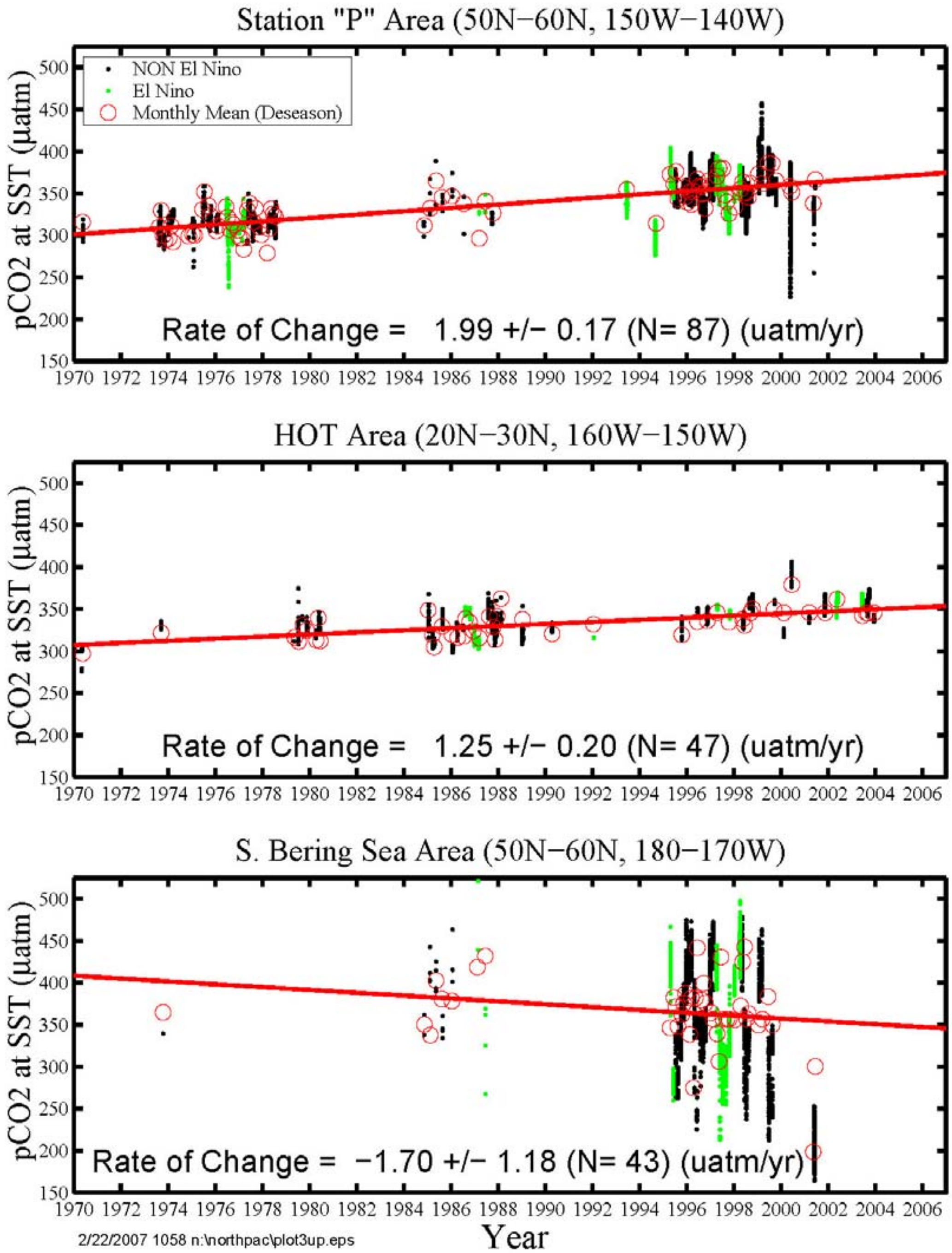

Figure 6 - Rates of increase in surface water pCO_2 in three areas in the temperate South Pacific. Small solid dots (black for non-El Nino periods and green for El Nino periods) indicate individual measurements, and red open circles are the deseasonalized monthly mean for values. The mean annual rate of change is computed using a linear regression for the deseasonalized mean monthly values.

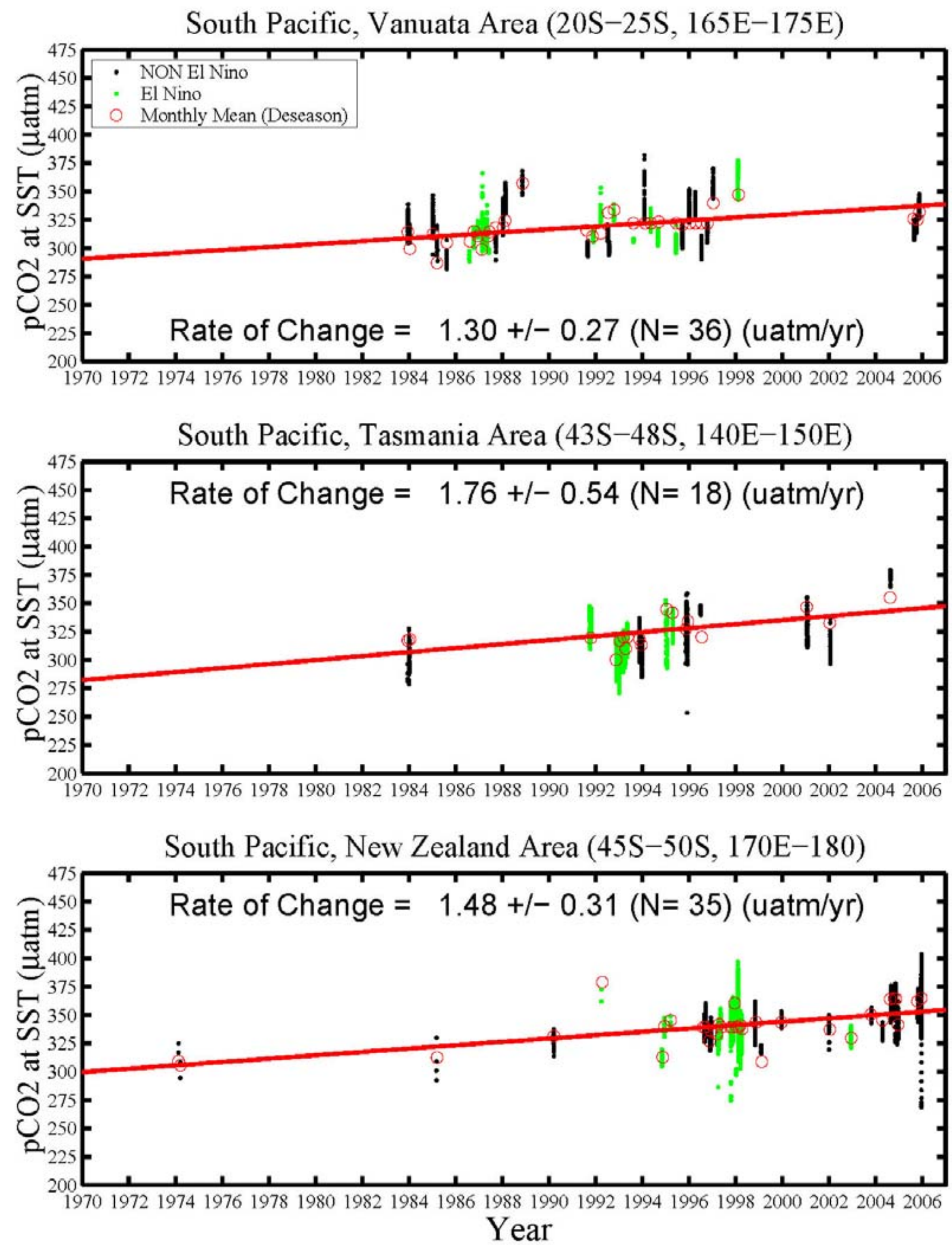

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Figure 7 – Rates of increase in surface water pCO_2 in the subpolar region (south of 50°S) of the Southern Ocean in the winter months (Julian dates from 172 to 326) during the period from 1986 to 2006. The top panel is for SST between 0.8 to 1.5°C; the middle panel for SST between 1.5 and 2.5°C; and the bottom panel for SST between 4.5 and 5.5°C. Black dots indicate measurements made in non-El Nino periods; and green dots indicate those made in El Nino periods. There is no discernible difference between these periods. The mean rates are estimated by linearly regressing all individual data; and N is the data count.

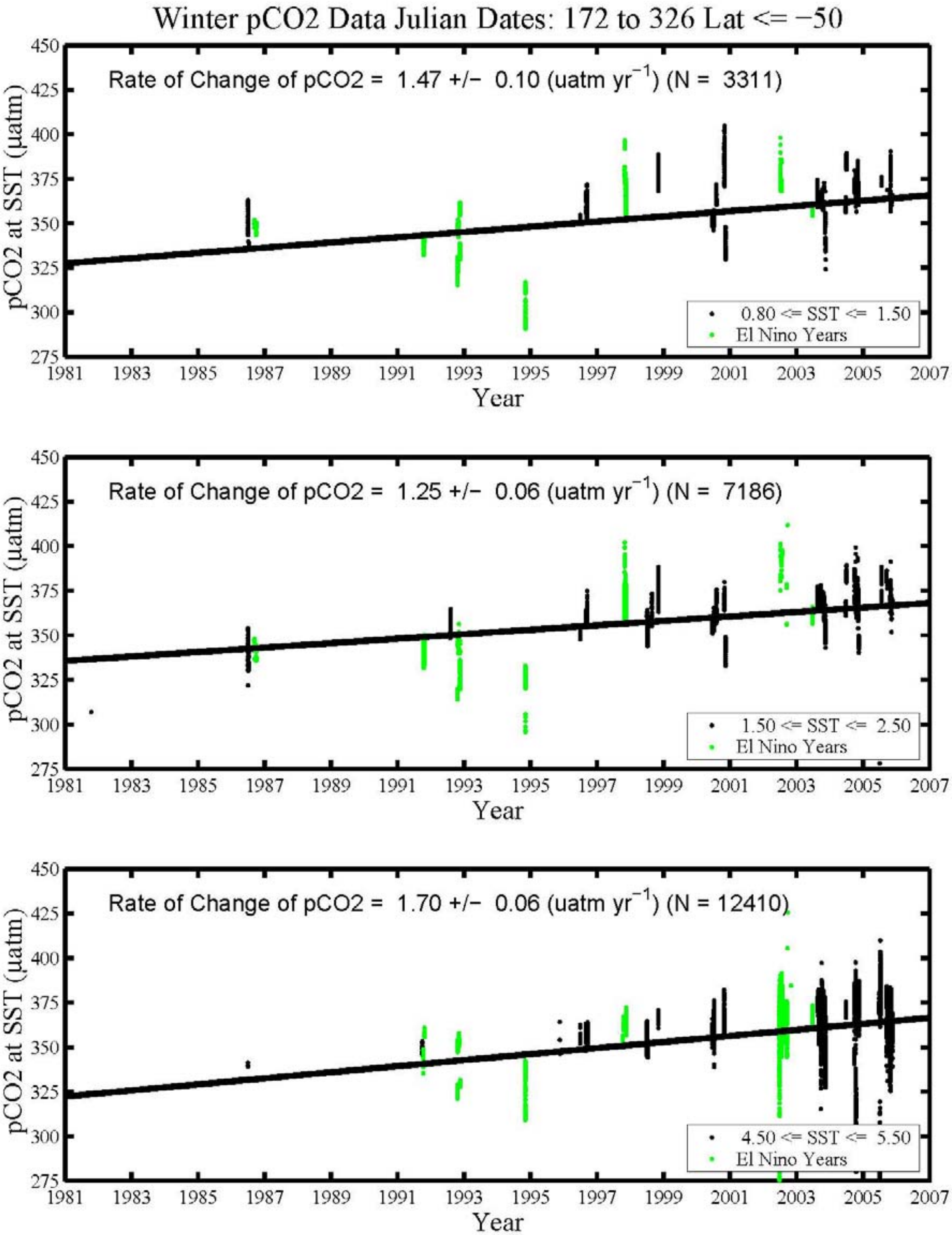

Figure 8 – Multi-year pCO_2 data observed in ice-field waters (temperatures less than -1.75°C) in the Southern Ocean south of 60°S during the austral winter months, June through September. The pCO_2 increases with progressing seasons. When these waters are exposed to the air, they are a source for CO_2 since they have pCO_2 values greater than those in the overlying atmosphere.

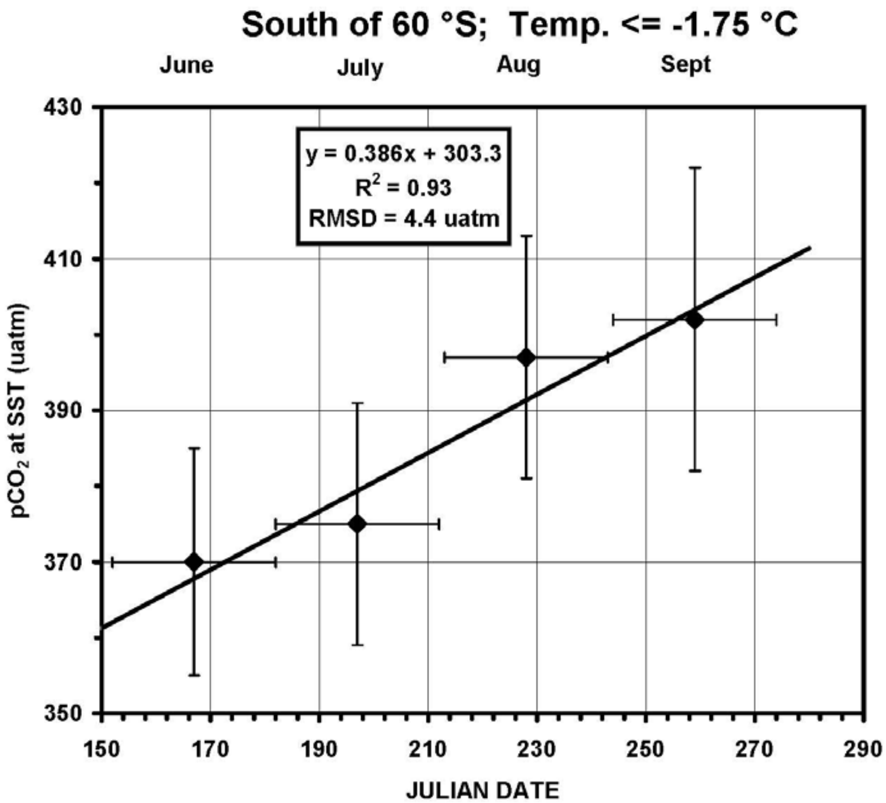

Figure 9 –The monthly mean values for sea-air pCO_2 differences in the four major ocean basins. The values represent climatological mean adjusted to the reference year 2000. Orange-yellow colors indicate positive ΔpCO_2 (sea is a source for atmospheric CO_2), green indicates near zero ΔpCO_2, and cyan-blue colors indicate negative ΔpCO_2 (sea is a CO_2 sink). Heavy pink curves indicate the positions of ice-field fronts.

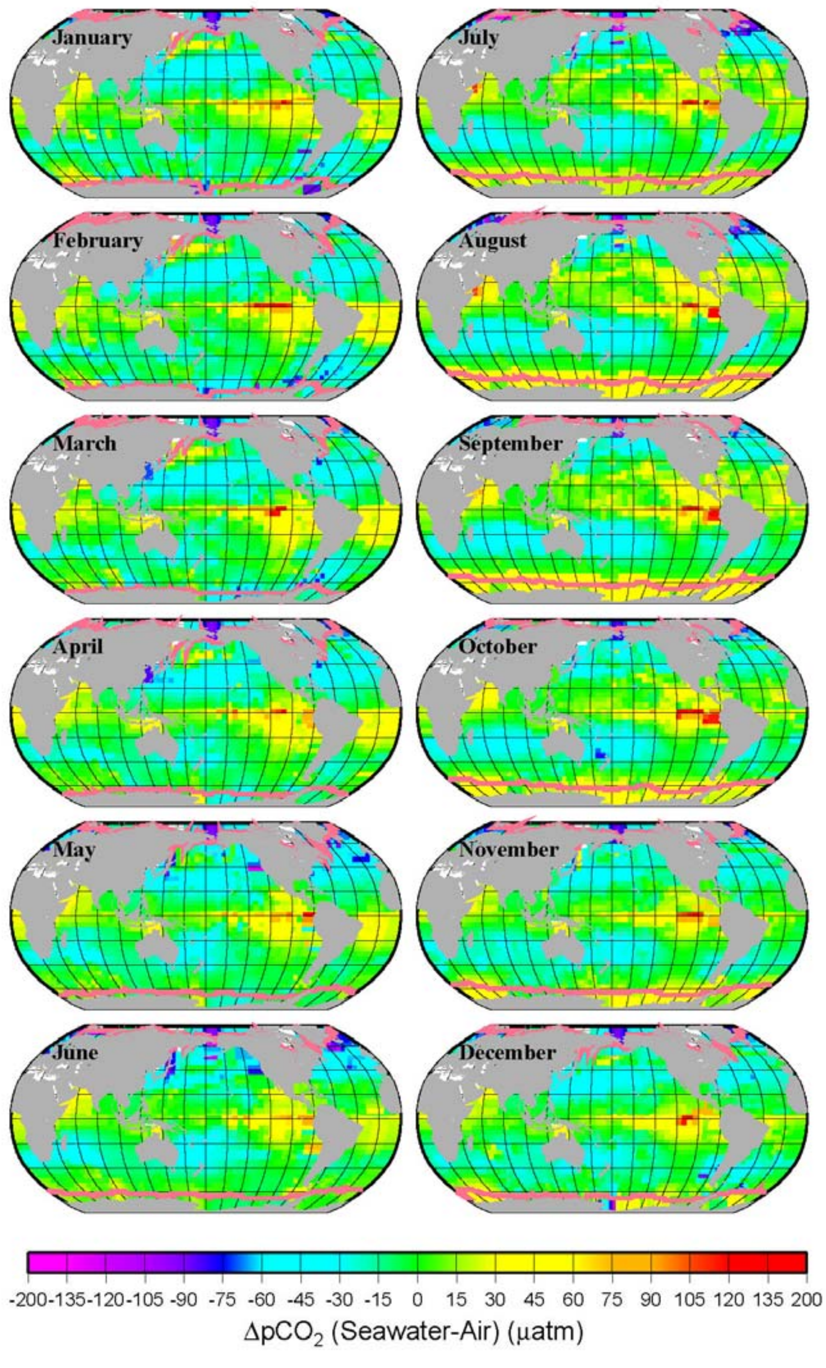

Figure 10 – The monthly mean values for sea-air pCO_2 differences in the four major ocean basins. Average values in each climatic zone are plotted against month (1 = January, 2 = February, ..., 12 = December and 13 = January). The zones "50S-62S" and "S of 62S" in the Southern ocean represent respectively the open water zone and the seasonal ice zone.

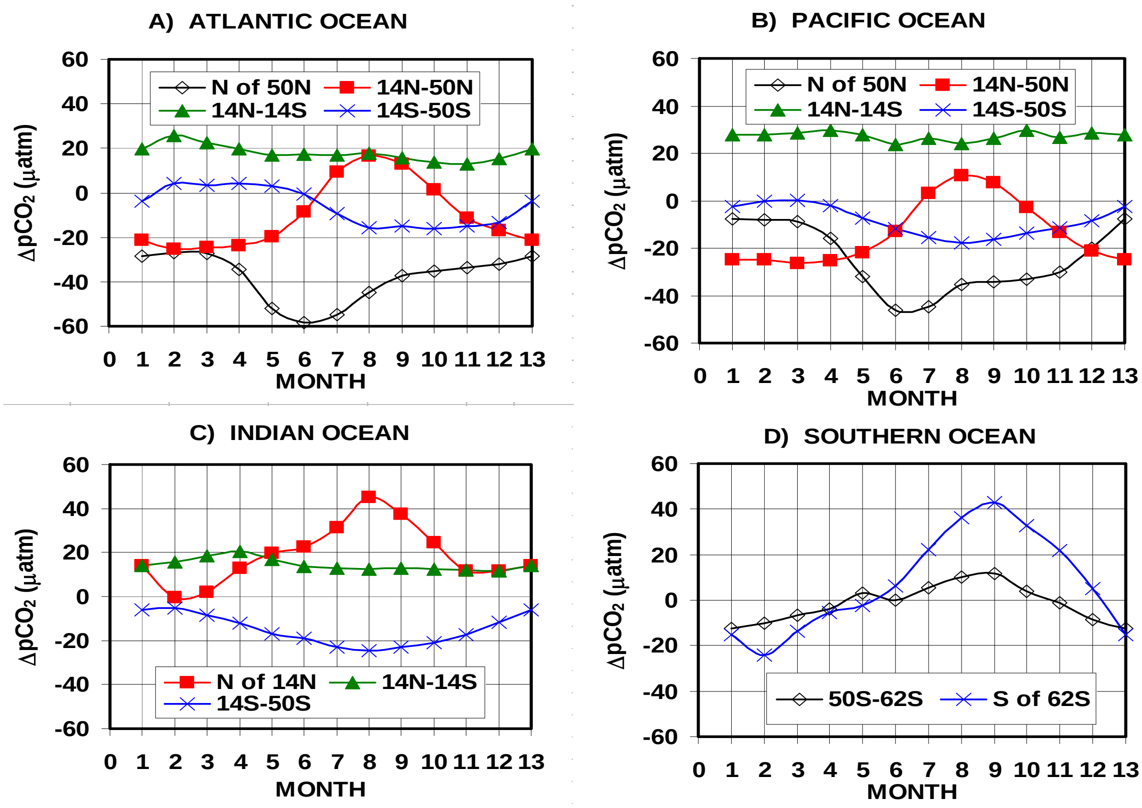

Figure 11 – Monthly mean values for the CO_2 gas transfer rate coefficient, Tr, in (millimol m^{-2} $month^{-1}$ μatm^{-1}) computed using Eq. (8). The monthly mean values for U_{10} in each 4° x 5° box were computed using the 1979-2005 NCEP-DOE AMIP-II Reanalysis data (updated version of Kanamitsu et al., 2002). The monthly mean values for each zone shown in the plots are area-weighted mean values of the box areas within each zone. Months are expressed as 1 = January, 2 = February,...., 12 = December, and 13 = January.

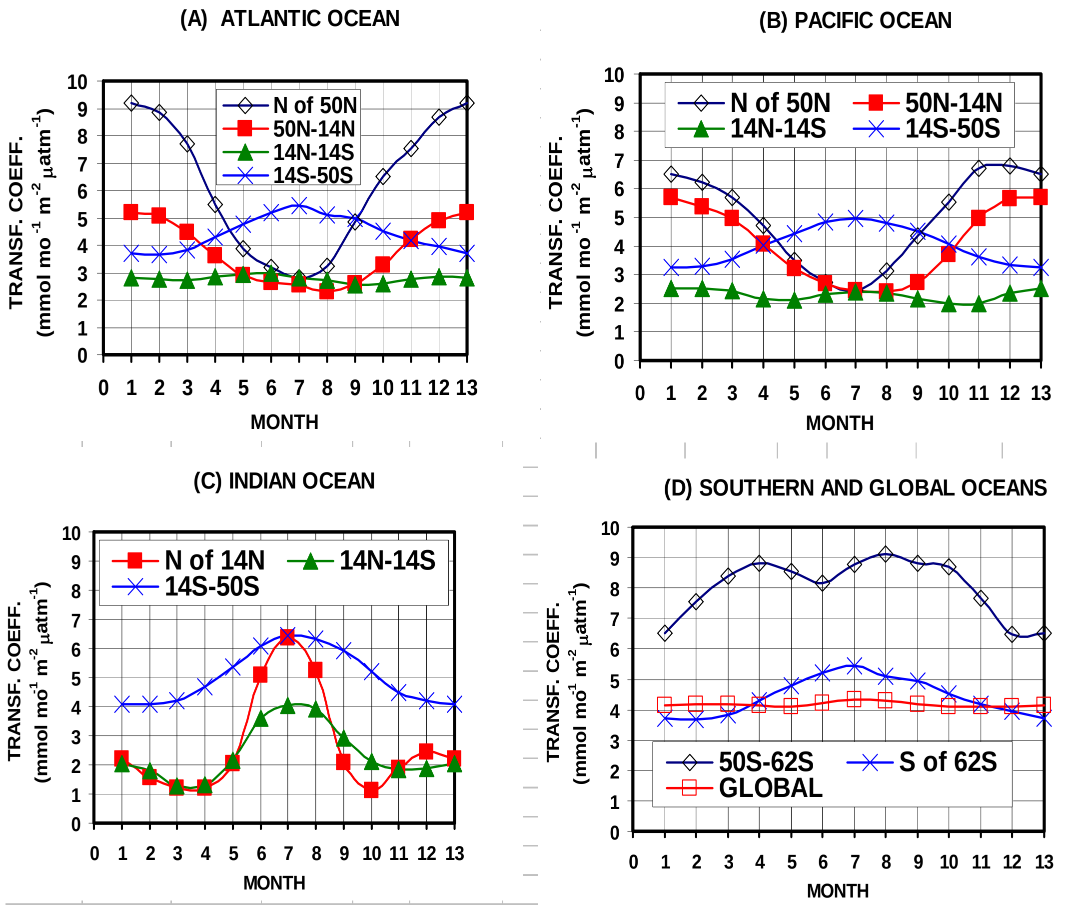

Figure 12 - Climatological mean annual sea-air CO_2 flux (moles CO_2 m^{-2} yr^{-1}) for the reference year 2000 (non-El Nino conditions). The map is based on 2.791 million surface water pCO_2 measurements obtained since 1970. Wind speed data from the 1979-2005 NCEP-DOE AMIP-II Reanalysis (R-2) and the gas transfer coefficient with a scaling factor of 0.24 (Eq. 8) are used. This yields a net global air-to-sea flux of 1.22 Pg-C yr^{-1}.

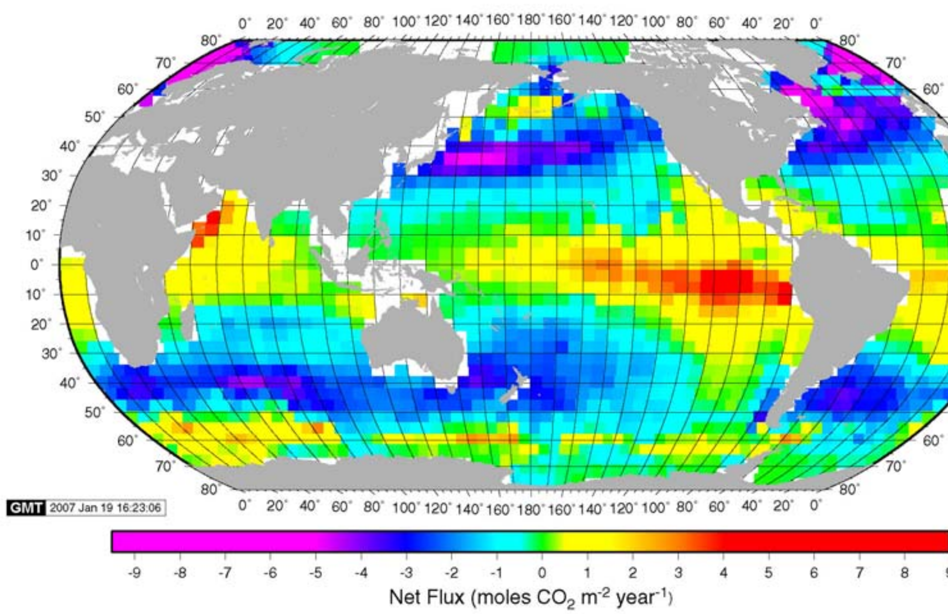

Figure 13 – Zonal mean sea-air CO_2 flux in the four major ocean basins. The flux values are expressed in Tg (10^{12} grams)-C yr^{-1} for each 4°-wide zonal band across each ocean basin. This plot gives a total global air-to-sea flux is 1.22 Pg-C yr^{-1}. The wind speed data are from the 1979-2005 NCEP-DOE AMIP-II Reanalysis, and the gas transfer coefficient is computed using Eq. (8).

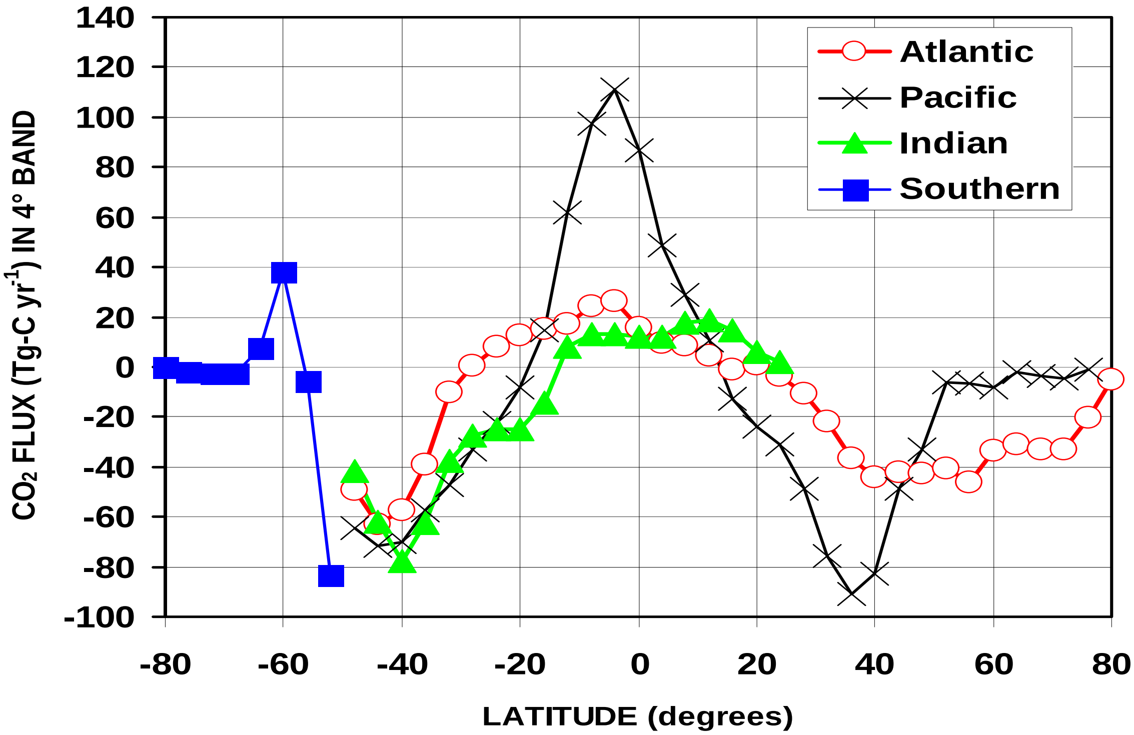

Figure 14 – Climatological mean sea-air CO_2 flux (mol CO_2 m^{-2} $month^{-1}$) in February (A) and August (B) in the reference year 2000. The wind speed data are from the 1979-2005 NCEP-DOE AMIP-II Reanalysis, and the gas transfer coefficient is computed using Eq. (8).

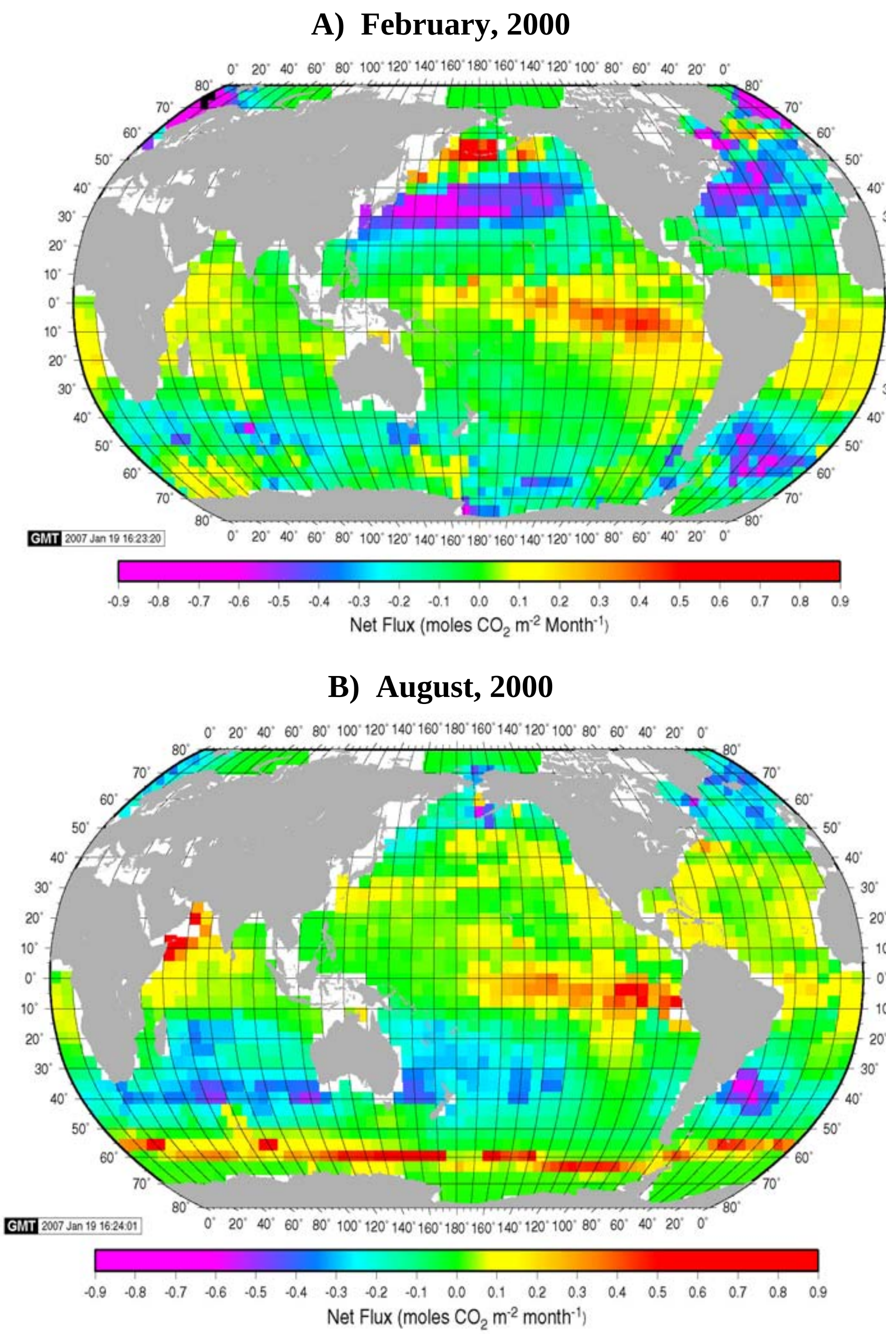

Figure 15 – Monthly changes in the area mean sea-air CO_2 flux for the four major ocean basins and the global oceans. A) Atlantic, B) Pacific, C) Indian and D) Southern and Global Oceans. Month numbers 1 and 13 are January, and Month number 12 is December. For the region “South of 62°S” in panel D, the blue solid curve with “x” indicates the flux per km^2 of geographic area including ice cover; and the blue dashed curve with solid circles indicate the flux per km^2 of water exposed to the air in leads and polynyas in the ice fields. Positive values indicate sea-to-air fluxes, and negative values air-to-sea fluxes.