OCEANIC ADVECTIVE TRANSPORT AND DIVERGENCE OF CO_2 IN THE ATLANTIC

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ABSTRACT

The Atlantic's central role in the global thermohaline circulation suggests that this basin should be an important laboratory for understanding the ocean carbon cycle and possible temporal variations in that cycle. Here we present the set up and results from an oceanic box model inversion which focuses on the transport and divergence of total inorganic carbon (TIC) and anthropogenic carbon within the Atlantic.

A large number of basin-wide, high quality Atlantic hydrographic data sets were obtained during the period of the World Ocean Circulation Experiment (WOCE) and Joint Global Ocean Flux Study (JGOFS) programs of the 1990's. Many of these transects included measurements of carbon parameters. Combining data from 24 hydrographic sections occupied during this period to form approximately 40 closed boxes, an inverse model formalism is employed to diagnose the general circulation, and to investigate the uptake, transport and storage of total inorganic carbon (TIC), anthropogenic carbon and pre-industrial (*i.e.* prior to human intervention) carbon. We are currently working on the development of two different models: a simple two-box version of the North Atlantic and a full Atlantic model (Fig. 1).

NORTH ATLANTIC MODEL

The model is defined by:

- the 1998 A05 repeat across 24^{o}N , the 1997 A02 47^{o}N transect, a portion of the 1997 A24 survey between Scotland and Greenland, and repeat AR07W section between Newfoundland and Greenland.
- Conservation of surface to seafloor mass, salt & silica, as well as, conservation of salinity & heat anomaly and volume within individual layers.
- Initial velocity reference surfaces defined by *Macdonald et al.* [2003] at 24^{o}N & by averaged float velocities at 47^{o}N & 57^{o}N

The model finds:

- Across 24^{o}N, a TIC transport similar to the previous estimate found using the 1998 24^{o}N data alone, but with significantly reduced uncertainty.
- Across 57^{o}N, a net TIC transport and uncertainty similar to previous findings
- Across 47^{o}N, a very strong southward transport of TIC (2.1±0.7 $PgCyr^{-1}$) associated with a stronger then expected horizontal component to the circulation.

These results imply:

- Either a strong uptake of carbon occurring further north than originally expected, and outgassing within the subtropics
- Or combining these results with *Takahashi's* [2003] CO_2 air/sea exchange estimates strong, balancing source/sink regions and a weaker uptake of carbon today spread over a greater region within the North Atlantic than pre-industrially.
- Anthropogenic carbon uptake in the south, northward advection and outgassing in the north

FULL ATLANTIC MODEL

Some 3000 hydrographic stations have been quality controlled and reformatted for use within the full Atlantic model. Measured properties for these stations including oxygen, nitrate, silicate, phosphate, cfcs, and total inorganic carbon, as well as, derived estimates of anthropogenic carbon from the Global Ocean Data Analysis Project (GLODAP) have been interpolated onto the same 2 db pressure intervals which describe the temperature and salinity record. Cross-over data have been used to minimize property differences among the data sets. The stations pairs at the box corners have been carefully chosen to minimize differences in dynamic height. Using these station data to determine an initial estimate of the velocity field relative to a set of chosen references surfaces, a Gauss-Markov-type least squares inversion is used to solve for the unknown elements in the system (velocity at the reference surfaces, dianeutral velocities and diffusion coefficients, corrections to initial estimates of Ekman transport and source/sink terms).

Initially, this model is made up of about 40 boxes. It is based on most, but not all the data shown. In particular, in some cases, we chose to remove some of the smaller boxes in which aliasing of spatial and temporal variations cause the model to produce unrealistic flow patterns. Note, not all the datasets include measurements of TIC or estimates of anthropogenic carbon. The boxes which do not include estimates of carbon parameters are used solely to constrain the overall basin circulation.

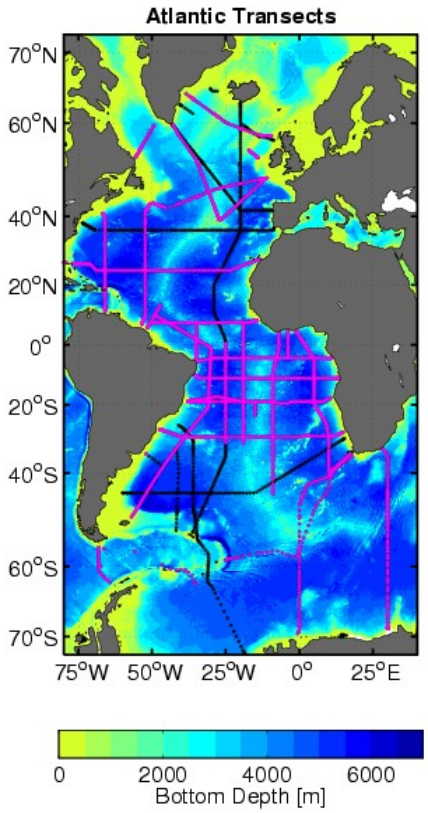

Fig 1. Locations of the hydrographic stations used in inverse model. Pink/Grey – includes some carbon parameters. Black – does not.

The Atlantic model should provide insight into a number of questions:

- What is the character (strength and structure) of the Atlantic circulation as observed through the WOCE dataset?
- Based on this circulation, what are the spatial patterns and magnitude of the horizontal and vertical transports of TIC and anthropogenic carbon within the Atlantic?
- Which water masses are responsible for these transports?
- How do these present-day values compare to estimates of pre-industrial transports?
- Where within the basin does storage occur?
- What is the character and magnitude of the air-sea exchange of CO_2?

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