WCRP C37
Abstract #: TH65A

AMOC: Compensation at the western boundary between the Gulf Stream and Interior Transport

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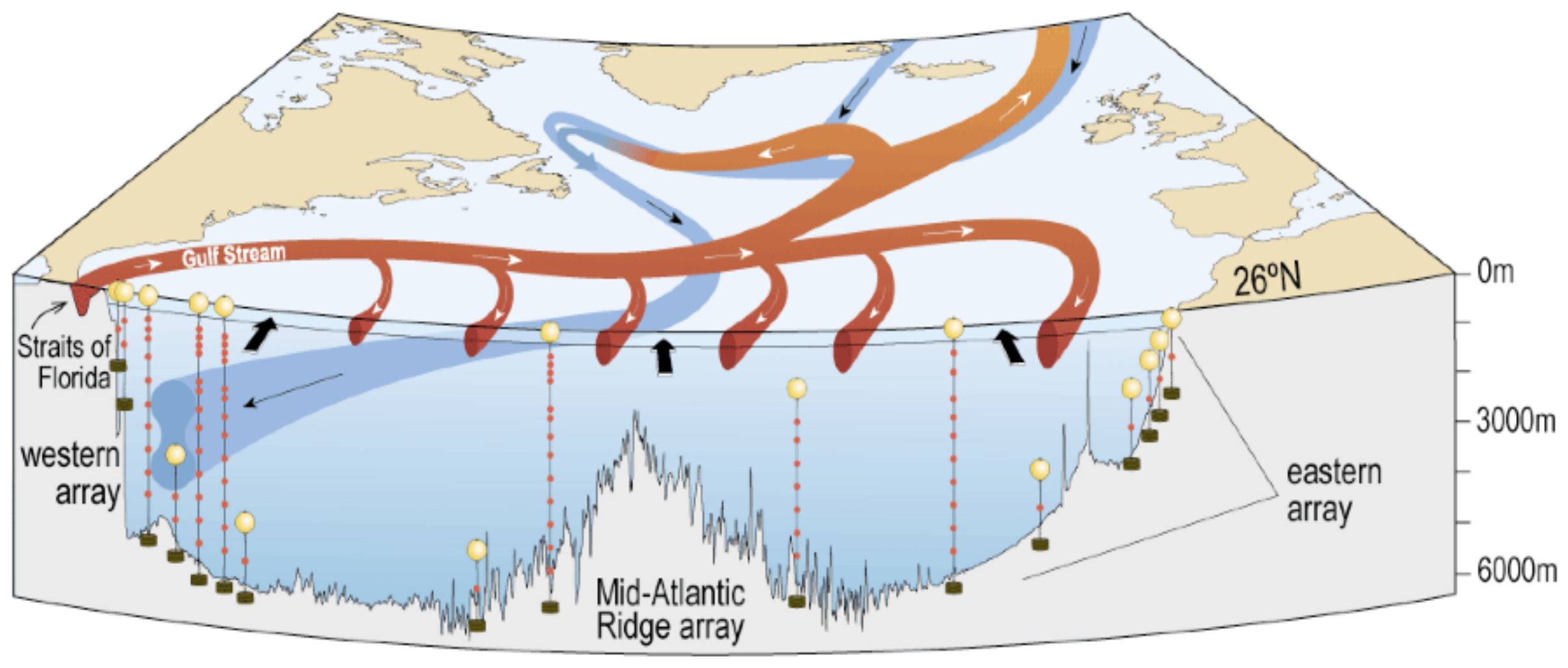
1. MOTIVATION

The Meridional Overturning Circulation (MOC) transports heat northward in the North Atlantic, contributing to northwestern Europe's mild climate. How are the components related? **We focus on the co-variability between transport in the Florida Straits (between Florida and the Bahamas) with transport east of the Bahamas.**



2. DATA

The main 3 components of the MOC transport at 26°N are (1) internal mid-ocean ocean variability, (2) Gulf Stream from cable measurements in Florida Straits, (3) Ekman from surface winds.

Internal mid-ocean variability is measured by current meter moorings at the west and the geostrophic transport between density at the west and east.

$$Tmoc = Tgs+Tek+Tumo$$

where Tmoc is the vertical integral of mid-ocean transport down to the deepest northward velocity (~1km) on each day.

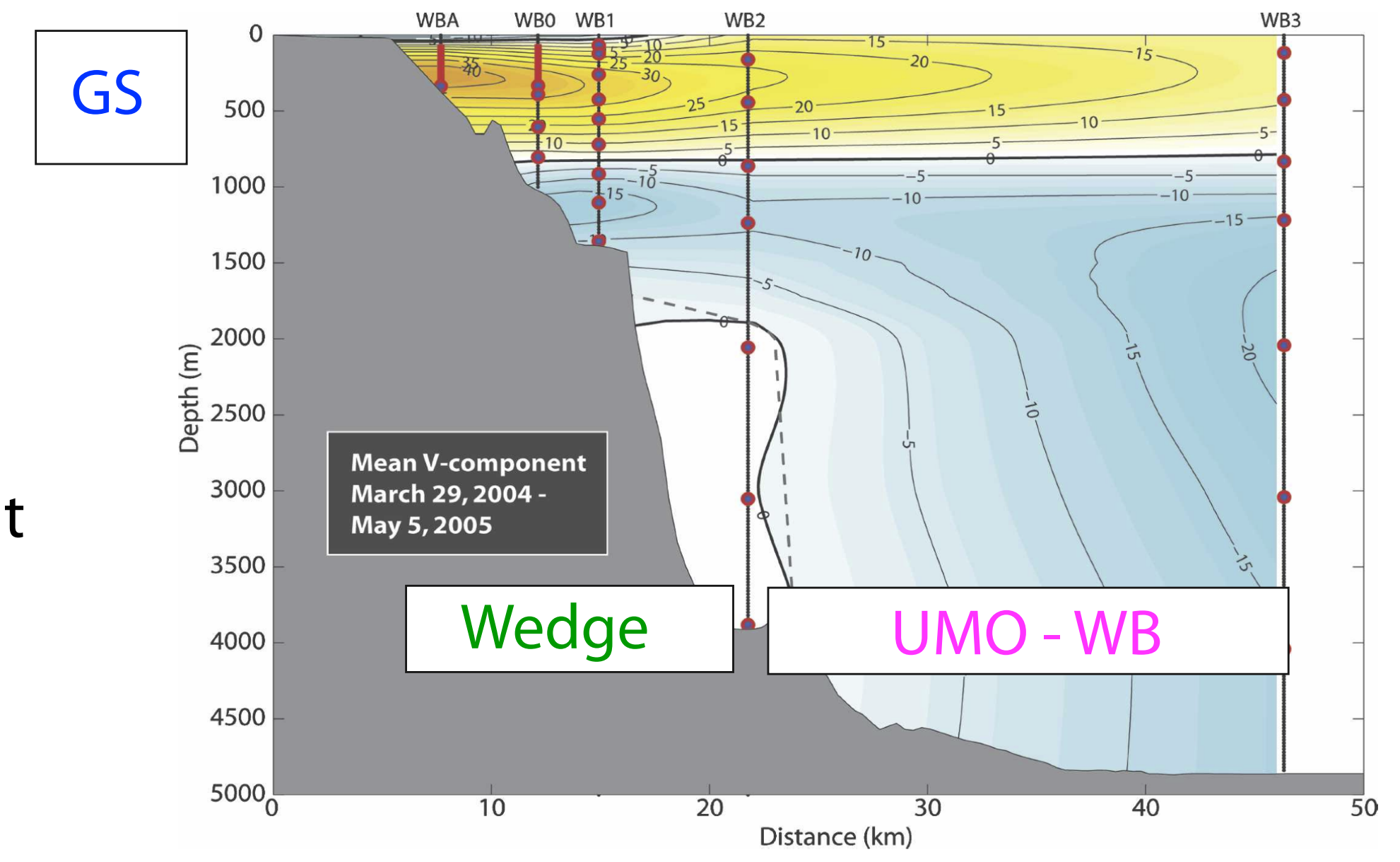
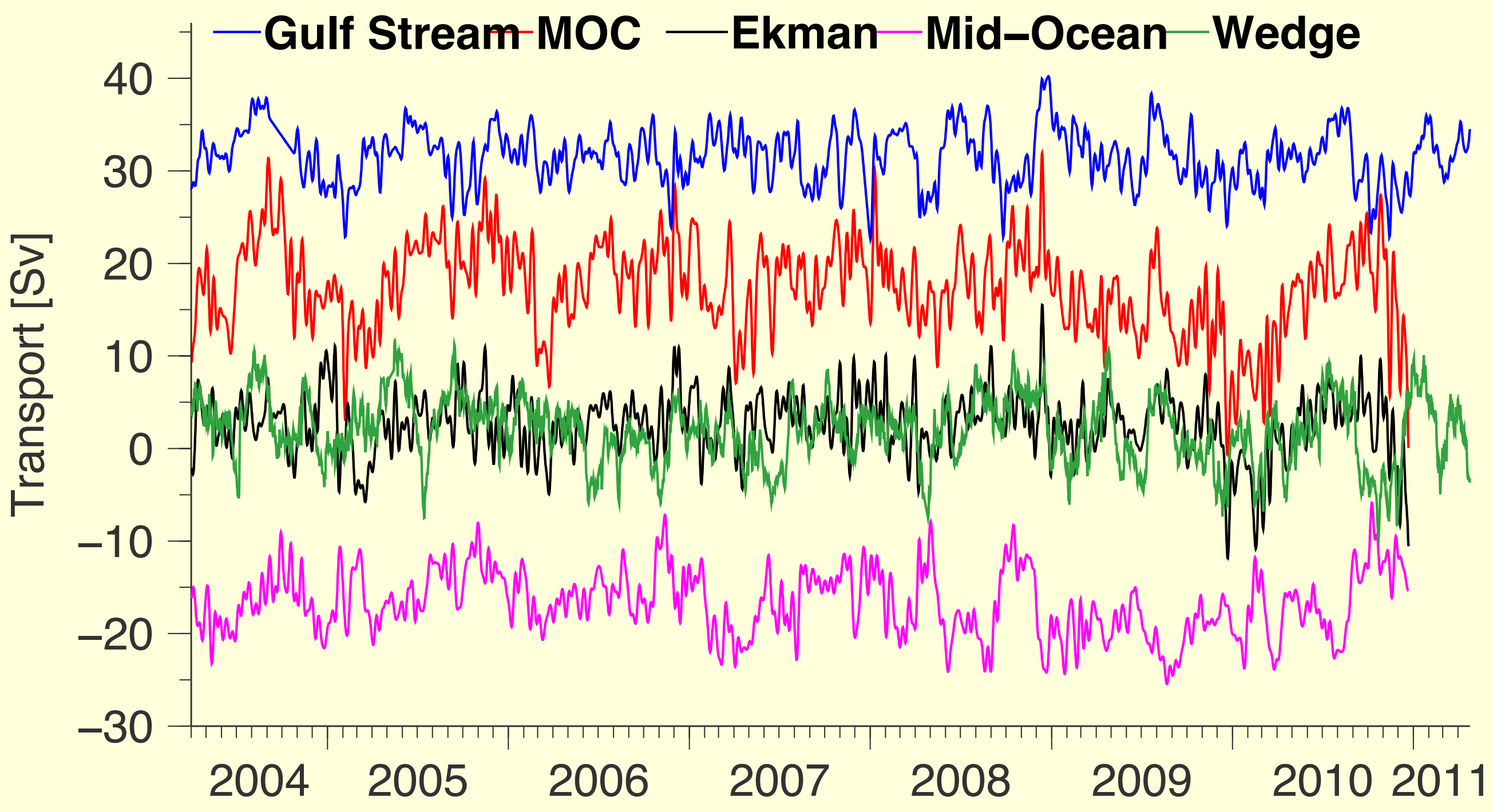


Figure (Johns et al, 2008): showing meridional velocities at the western edge of the RAPID/MOCHA array.

3. METHOD

Figure (right): 10-day low pass filtered transport timeseries. The MOC is in red. Gulf Stream is blue, Mid-Ocean is magenta and Wedge is green. While Wedge transport has a mean near zero, the fluctuations are large.



In order to analyse the changes seen in the time series, we separate the various sources of variability into components.

$$Tumo = T\,geo + T\,wedge + T\,comp$$

$$\text{where } Tgeo=\int vz\, dz \text{ and } vz = -g/\rho L\, [\rho e - \rho w]$$

here Tgeo is the geostrophic transport calculated between density moorings at the east and west of the Atlantic, Twedge is the transport measured by direct current meter measurements, and Tcomp is a compensating term included to enforce mass balance across 26°N. vz is meridional velocity shear, g gravitational acceleration, L the width of the basin, ρe and ρw water density at the east and west.

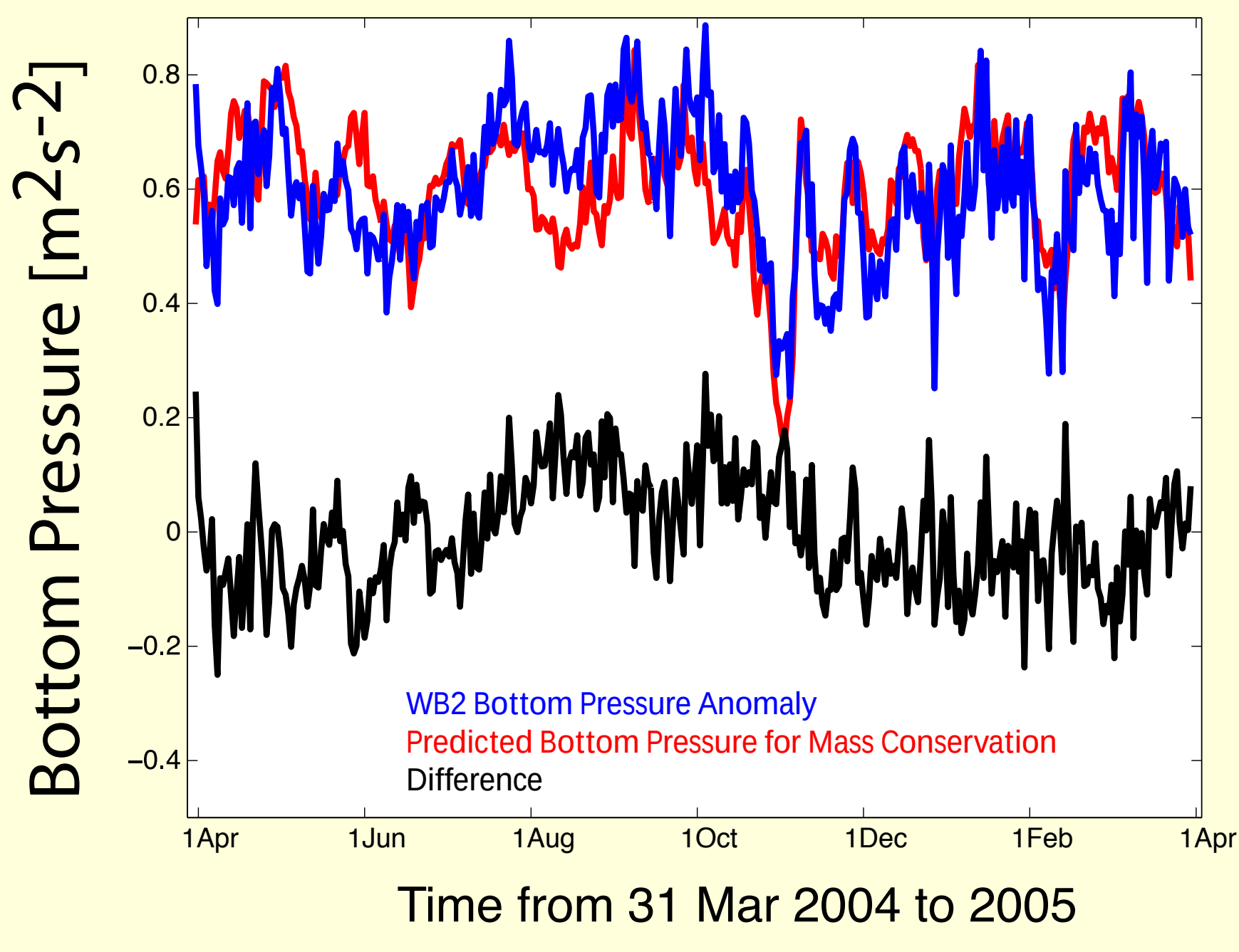
In comparing the Gulf Stream transport with these various components, it was found that only considering Tgeo due to variations at the west (ρw), with ρe constant, improved correlations, indicating that there is a physical relationship between density on the east side of the Bahamas and transport through the Florida Straits. Further, this relationship was strongest at lower frequencies (30 day low pass filter).

4. PREVIOUS RESULTS

Based on the first 3 years of data from RAPID, Kanzow et al, (2010) concluded that the major components of the MOC (UMO, GS, and Ekman) are uncorrelated and each project variance independently to the MOC.

As a slight modification to that result, Bryden et al (2009) found that bottom pressure measurements east of the Bahamas in the first year of data bore some relation to the Gulf Stream transport west of the Bahamas.

Figure (right). The blue curve shows the bottom pressure anomaly 77°W from a zonal average of bottom pressures. The red curve shows the baroclinic contribution to bottom pressure. Agreement indicates that baroclinic variability is locally compensated. The residual (black) balances the Gulf Stream.



5. NEW RESULTS

Since 2006, the situation has changed. The Gulf Stream was *anti-correlated* with the western boundary contribution to the UMO in 2006-2008. In 2010, the wedge transport (east of the Bahamas, inshore of the 4000m isobath) was significantly *correlated* with Gulf Stream transport.

Figure (right, upper two panels). Windowed correlation between the GS and UMO (black) and GS and Wedge (green) using a sliding 360-day window. Significant correlations are bolded. In the lower panel, the gain is shown. Negative values indicate anticorrelations.

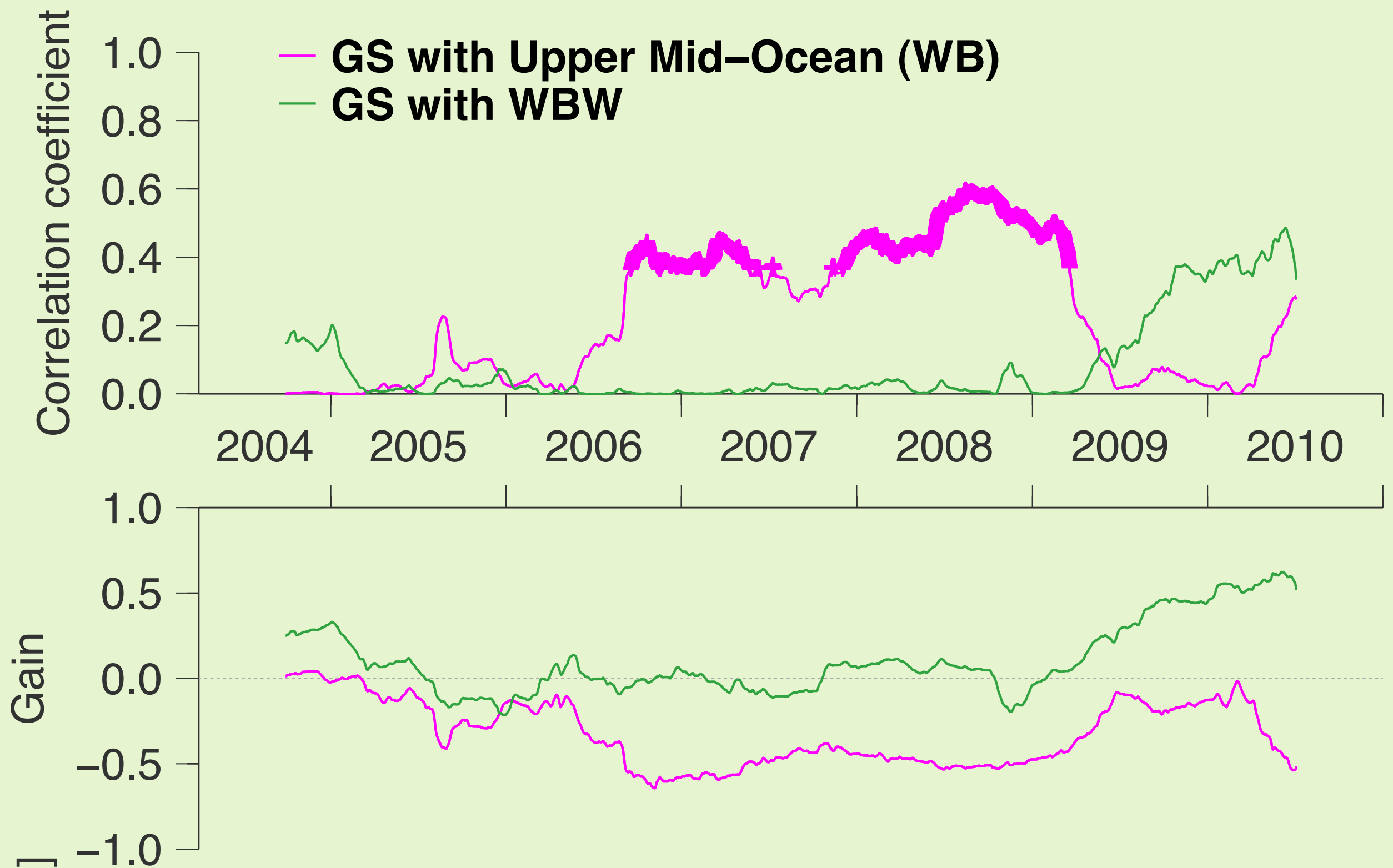
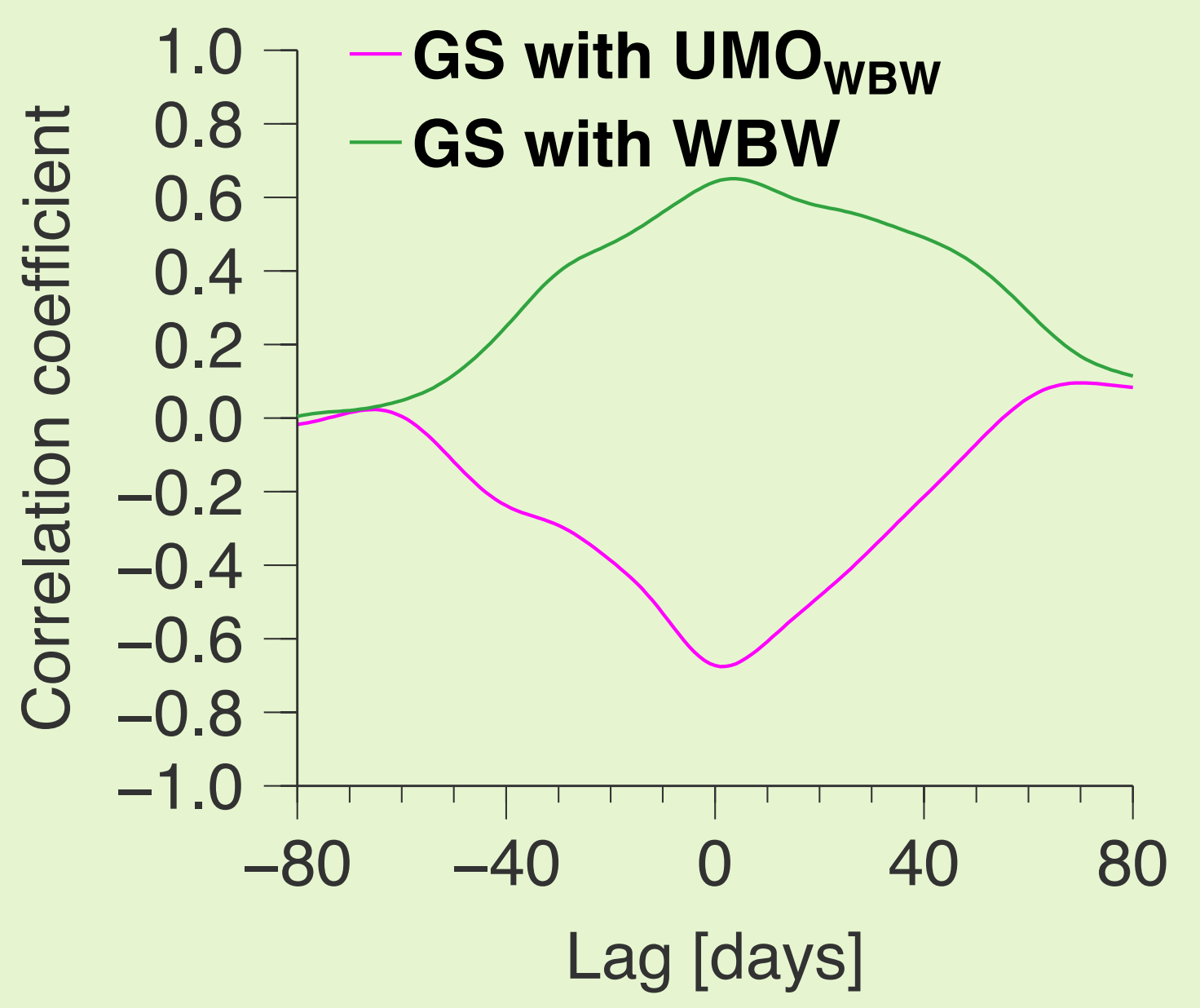


Figure (below). Lag correlations between the GS and two time series east of the Bahamas indicate that GS fluctuations lag the western boundary fluctuations by ~1-2 days.



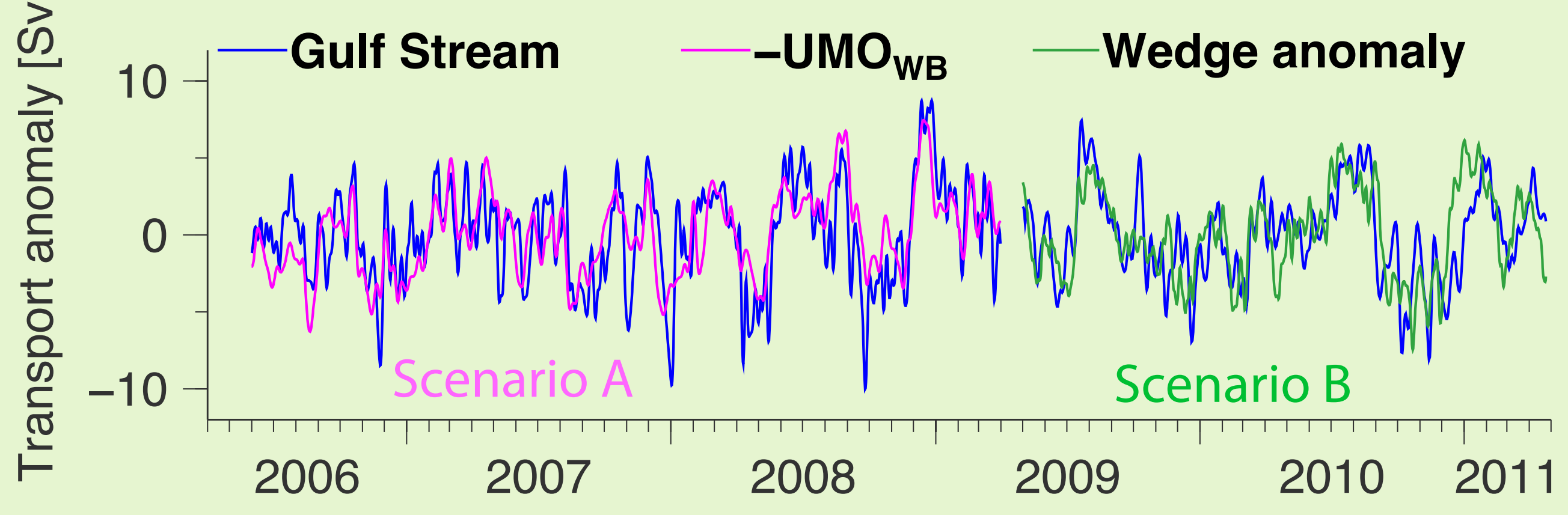


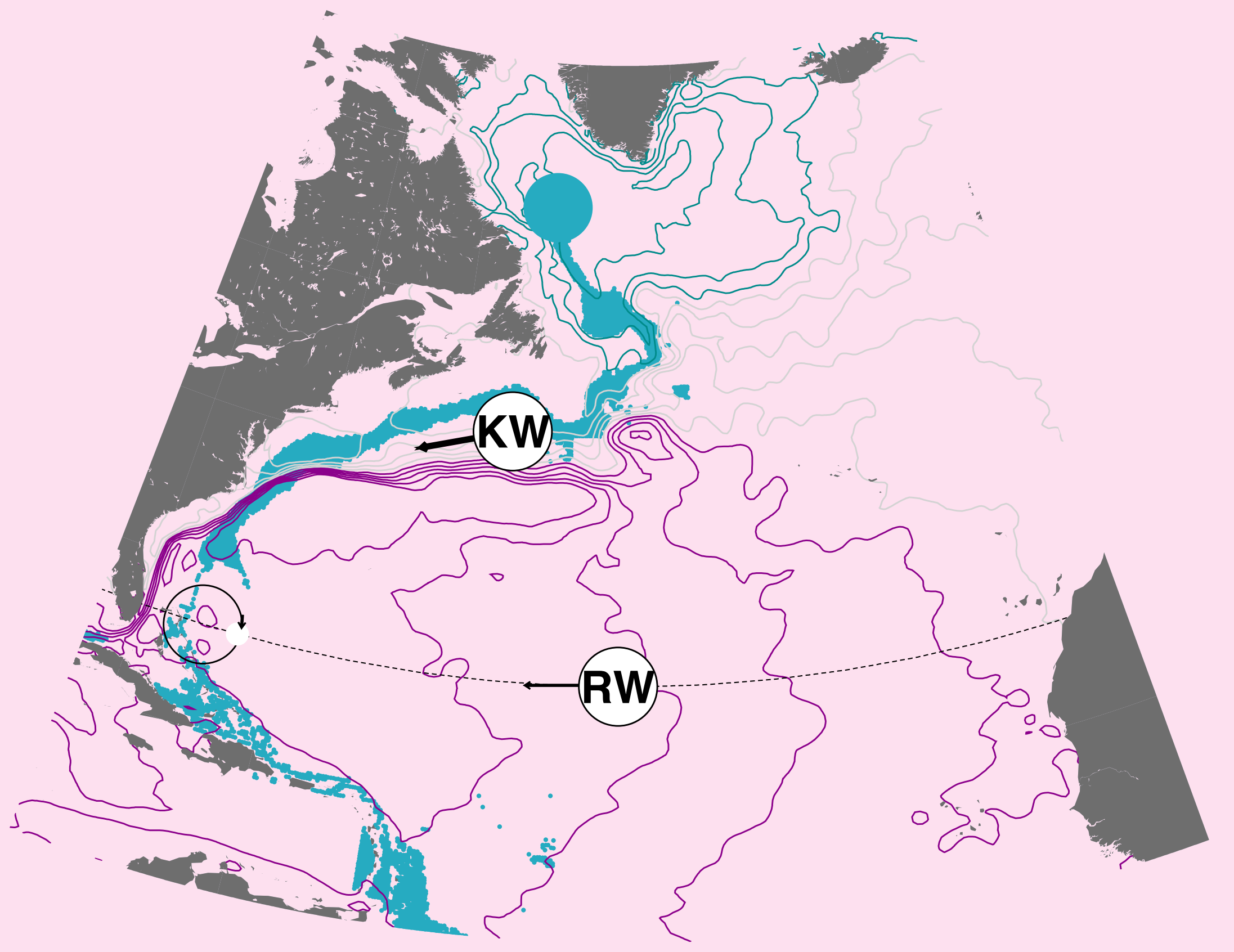
Figure (above). Considering only Jun 2006-Apr 2009 (for GS, UMO) and May 2009-April-2011 (for GS, Wedge), low-passed transport anomalies are shown.

Two different scenarios:
Scenario A, the Gulf Stream is anticorrelated with the western boundary transport. Northward GS recirculates around the Bahamas. Scenario B, the Gulf Stream transport is split onto either side of the Bahamas. Variability is of the same order of magnitude.

6. SOURCES OF VARIABILITY

Sources of variability at the western boundary may include: Transport fluctuations at higher latitudes transmit along the boundary (Elipot, et al, in prep); Rossby waves in the interior propagating westward to the boundary (Clement, et al, in prep); Local topographic effects around the Bahamas (Lin et al, 2009).

Here we have shown that these variability east of the Bahamas may communicate to the Gulf Stream, possibly through local topographic effects.



7. IMPLICATIONS

1. The Gulf Stream transport at Florida Straits is widely used as a climate index. We have shown here that **transport variability on the east side of the Bahamas may communicate directly and on short time scales with the Gulf Stream (gains greater than 0.5 and lags < 2 days).**
2. New efforts are being made to create an MOC index using Sverdrup transport as a proxy for the gyre transport (e.g., poster **TH64B**). However, results here show that **a significant part of the northward transport variability at the western boundary may be east of the Bahamas** (Scenario B). Indices which assume the Florida Straits contains most of the northward wind-driven transport may be biased.

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