Decadal Variability Of The Gulf Stream North Wall Position And Its Connection To Ocean Heat Content

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Abstract

To trace the Gulf Stream (GS) path across five decades from 1965 to 2017, we mapped the annually averaged positions of the Gulf Stream North Wall (GSNW) defined by the 15°C isotherm at 200 m depth computed using in situ seawater temperature records from the World Ocean Database 2018 (WOD18). Inter-annual GSNW variability is noticeably different west and east of ˜50°W. There are two distinct variability zones west and east of that longitude—a zone with a rather narrow envelope (˜3° of latitude-wide) west and a zone with a twice as wide envelope (˜ 6° of latitude-wide) east of that longitude. The more disperse annual pathways are near the Mid-Latitude Transition Zone. Moreover, within the ˜50-year timeline, the quasi-decadal period of 2005–2017 is marked by far larger spread in the annual GSNW positions than the previous decades, especially between 50°W and 40°W. The principal conclusion of our analysis, is that the GS between Cape Hatteras and the Grand Banks (west of 50°W) is not only stiff but maintains its position with astounding resiliency. The GSNW average position along that stretch of longitudes migrates slowly northward as a whole, but it is unlikely that such a slow and spatially insignificant migration could cause substantial changes in the Atlantic Meridional Overturning Circulation (AMOC). In contrast, near the Grand Banks (east of 50°W), the GSNW northward shift is quite noticeable—over 2.6° in latitude over ˜50 years—and thus could have some impacts on the AMOC long-term dynamics. There are significant correlations between the GSNW and Ocean Heat Content (OHC) variability east of 50°W that may be critical for the GS path resilience and its future changes over decadal and longer time scales. Furthermore, the significant correlations between OHC and GSNW in the extension zone rose from r=0.5 for annual to r=0.8 for pentadal to r=0.9 decadal time scales. We assert that the OHC may become the best indicator of the GS path's variability on decadal and longer time scales.

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CISESS Cooperative Institute for Satellite Earth System Studies

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The Gulf Stream (GS) path across five decades from 1965 to 2017 is traced by mapping the annually averaged positions of the Gulf Stream North Wall (GSNW)[1]. The GSNW is defined by the 15°C isotherm at 200m depth using in situ seawater temperature records from the World Ocean Database 2018 (WOD18)[2]. Inter-annual GSNW behavior is noticeably different west and east of ~50°W. There are two distinct modes of variability of the GS path in those two parts of the GSNW—a zone with a rather narrow envelope (~3° of latitude-width) west and a zone with a twice as wide envelope (~6° of latitude-width) east of that longitude (Figure 1).

Within the ~50-year time frame, the quasi-decadal period of 2005–2017 is manifested by far more spread in the annual GSNW positions than the previous decades, especially between 50°W and 40°W.

We conclude that the GS in the area between Cape Hatteras and the Grand Banks *is not only stiff but maintains its position with astounding resiliency* (Figure 1 insert).

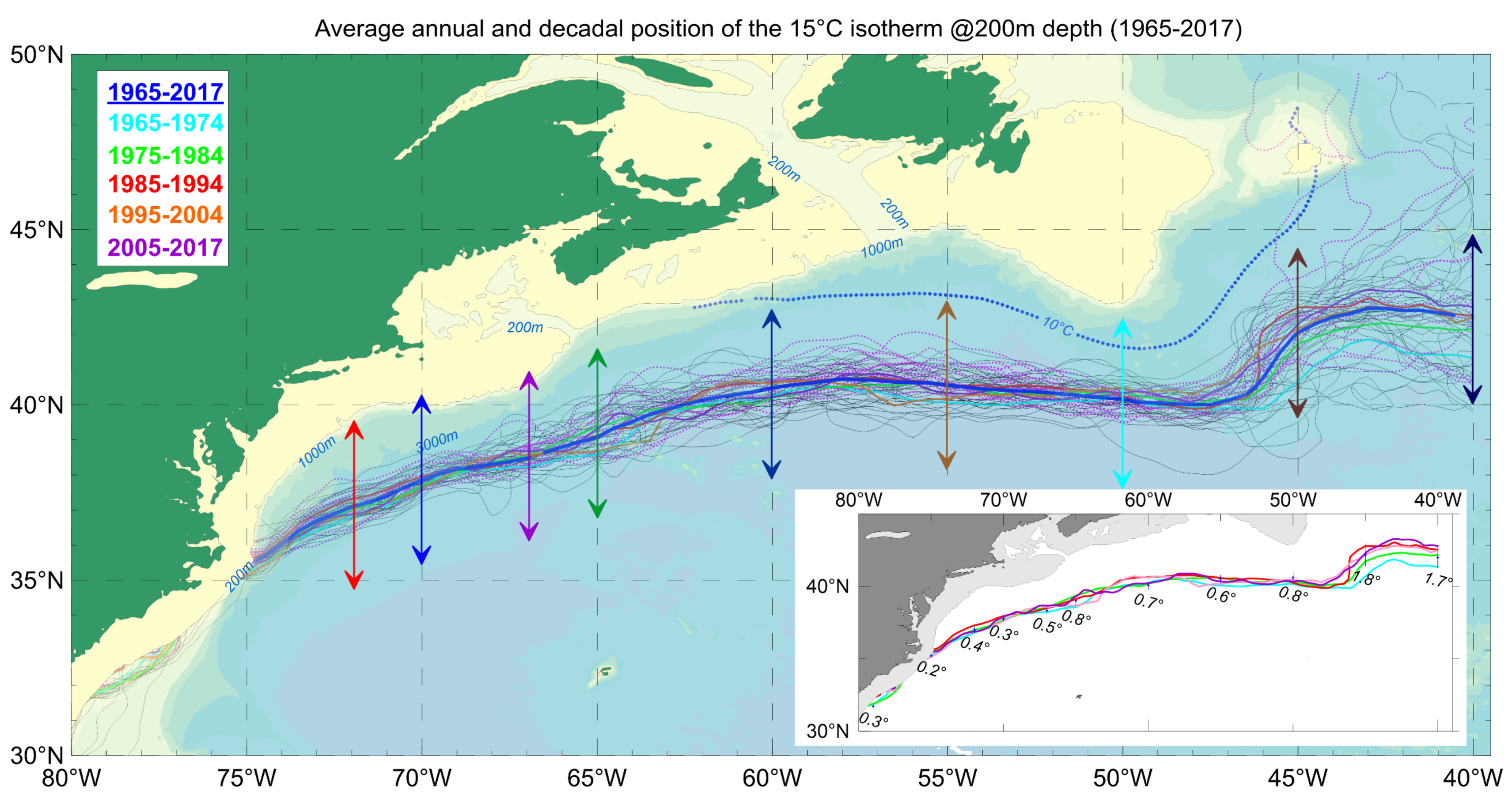

Figure 1. Annual (1965–2004: grey; 2005–2017: magenta), decadal, and 52 years average GSNW positions. The 10°C isotherm @200m depth illustrates the North Atlantic Current veering northward. Insert: STD (in degrees of Latitude). Arrowed lines – locations of the meridional sections noted on Fig. 2

As Figure 2 implies, the GSNW average position between 75°W and 50°W slowly migrates northward as a whole (curves for 72°W-50°W on Figure 2), but *it is unlikely that such a slow and spatially insignificant migration could cause substantial changes in the AMOC.*

In contrast, near the Grand Banks, the GSNW northward shift is quite noticeable—over 2.6° in latitude over ~50 years (curves for 45°W and 40°W on Figure 2) — and thus *could have some impacts on the AMOC long-term dynamics*.

The change in the upper 700m OHC is illustrated by 30-year annual temperature differences in North Atlantic over 60 years (Figure 3)[3]. That relationship may be critical for the GS path resilience and its future changes over the forthcoming decades.

We found significant correlations between the GSNW variability east of 50°W and North Atlantic Ocean Heat Content (OHC) in the upper 700m. The significance of the correlations between OHC and GSNW in the extension zone depends on the time period in consideration and rose from r=0.5 for annual to r=0.8 for pentadal to r=0.9 on decadal time scales.

We, therefore, assert that *the OHC may become the best indicator of the GS path's variability* on decadal and longer time scales (Figure 4, curves are smoothed by 5yr moving average).

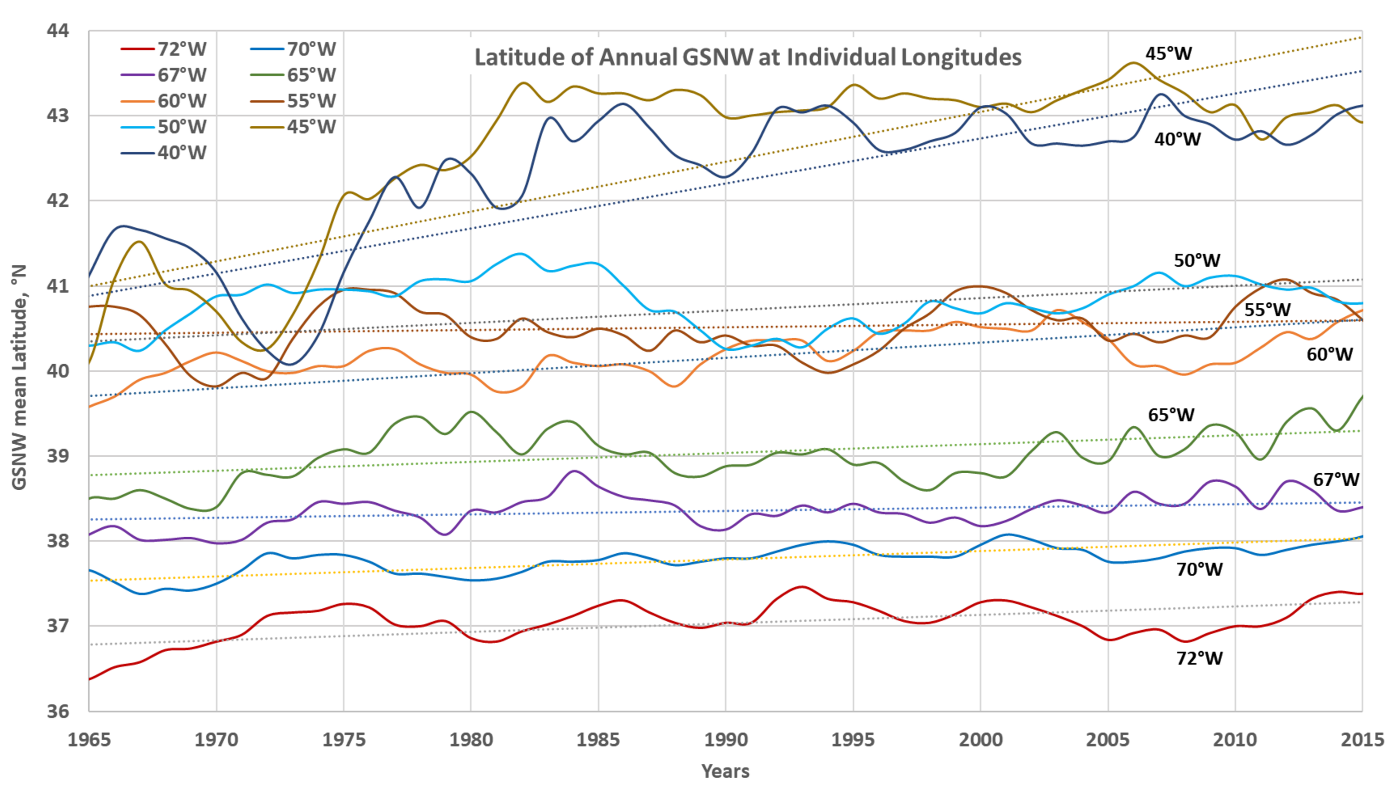

Figure 2. Mean annual latitudes of GSNW (smoothed with 5yr moving average) at nine different longitudes (locations denoted on Fig. 1 by colored arrowed lines); the dotted lines show the linear trends.

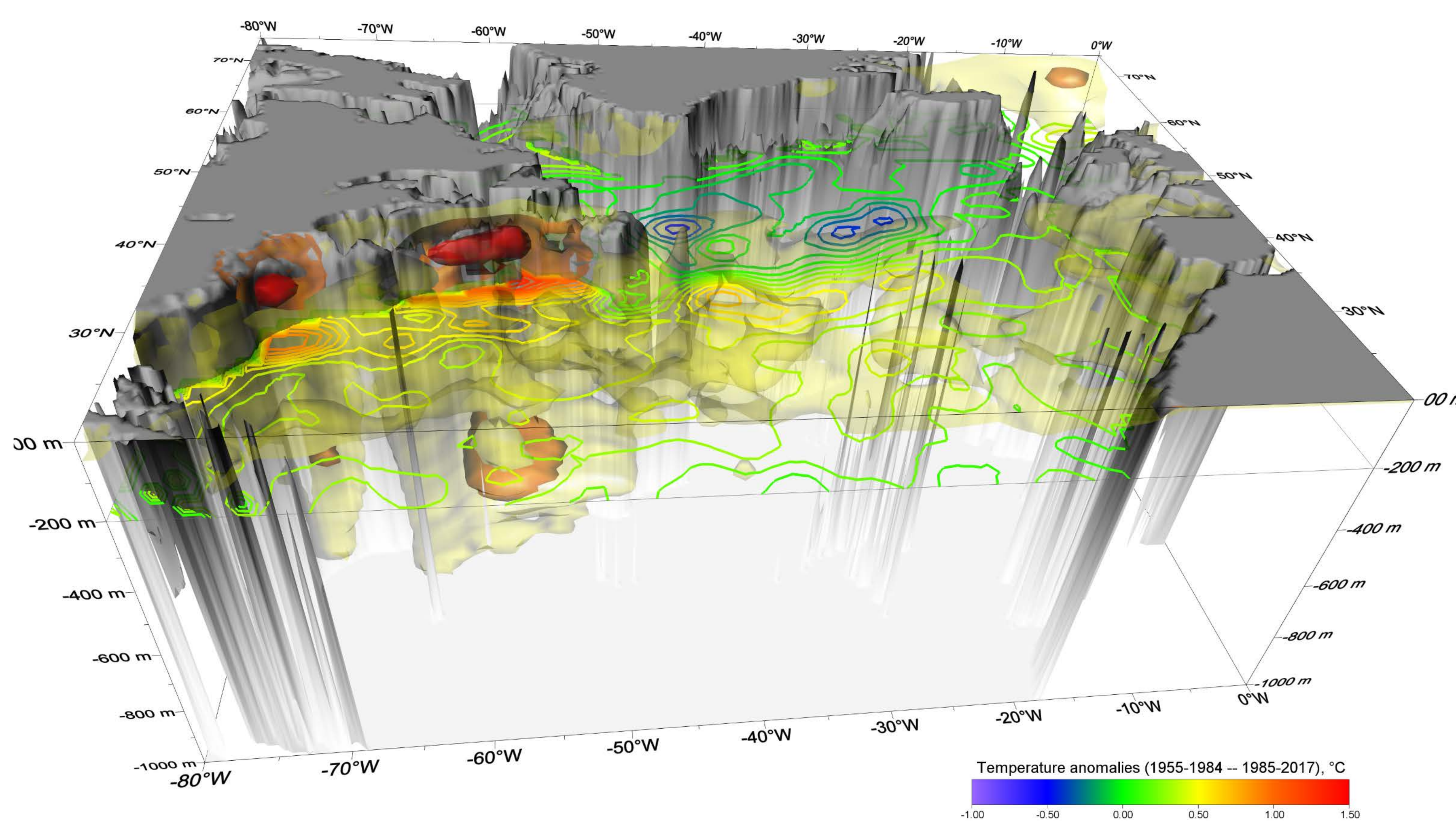

Figure 3. North Atlantic 30-years annual temperature differences over 60 years period (1955-1984 minus 1985-2017 climate normals): contours @ 200m depth (0.1°C interval) and isothermal surfaces of 0.5°C, 1°C, and 1.5°C temperature anomalies.

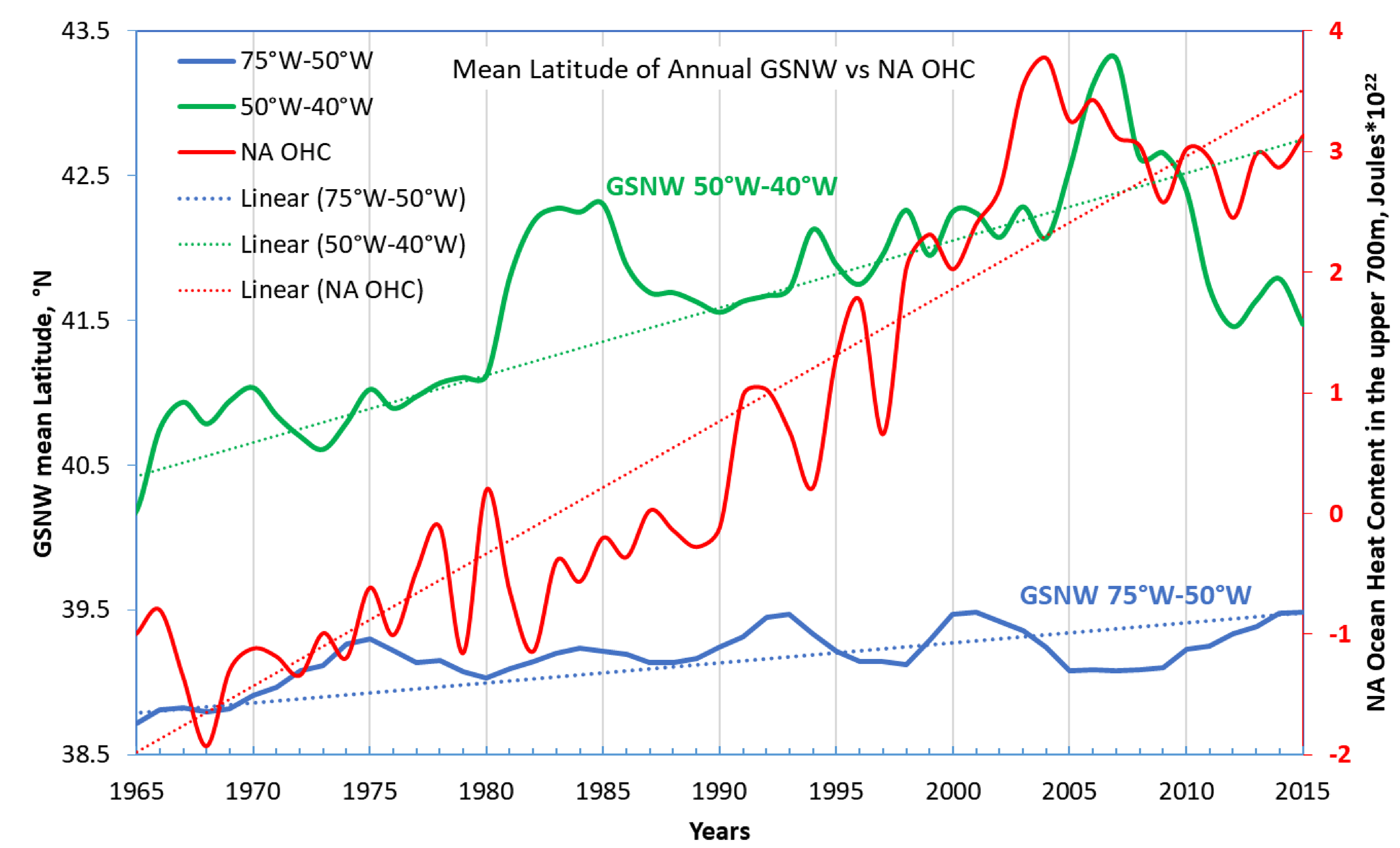

Figure 4. Mean latitudes of GSNW lines for two zones (east and west of 50°W) vs North Atlantic ocean heat content in the upper 700 m (red line, units = Joules*10^{22}); the dotted lines show the linear trends.

References

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