



Supplement of

Temperature-based diagnosis of the Gulf Stream path overestimates its northward shift in a warming ocean

Lina Garcia-Suarez et al.

Correspondence to: Lina Garcia-Suarez (lina.garcia@dal.ca)

The copyright of individual parts of the supplement might differ from the article licence.

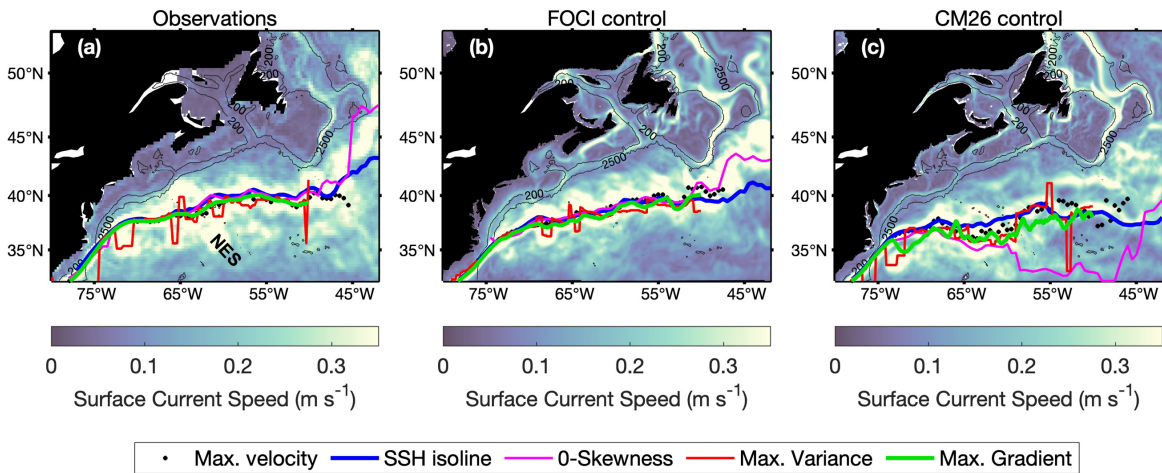
5 *Supplement*

Contents of this file

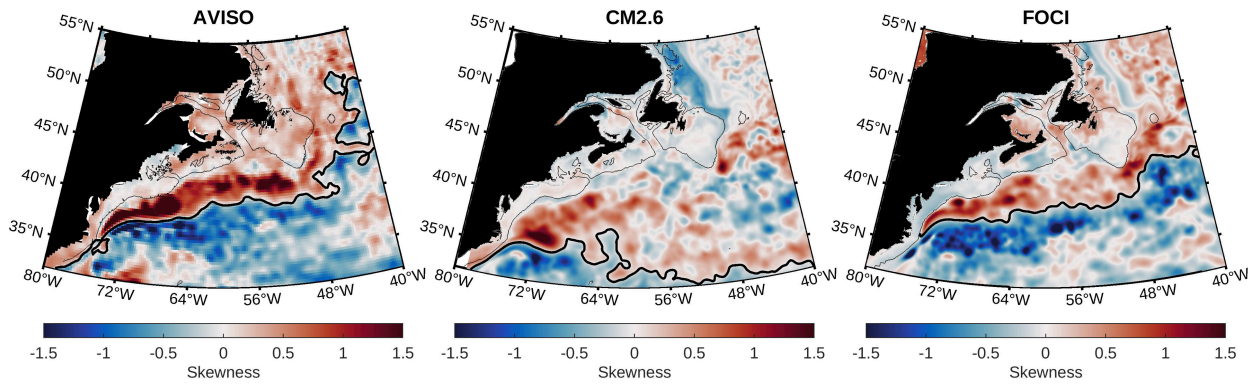
Figures S1 to S4

10 Tables S1 to S2

Supplementary figures

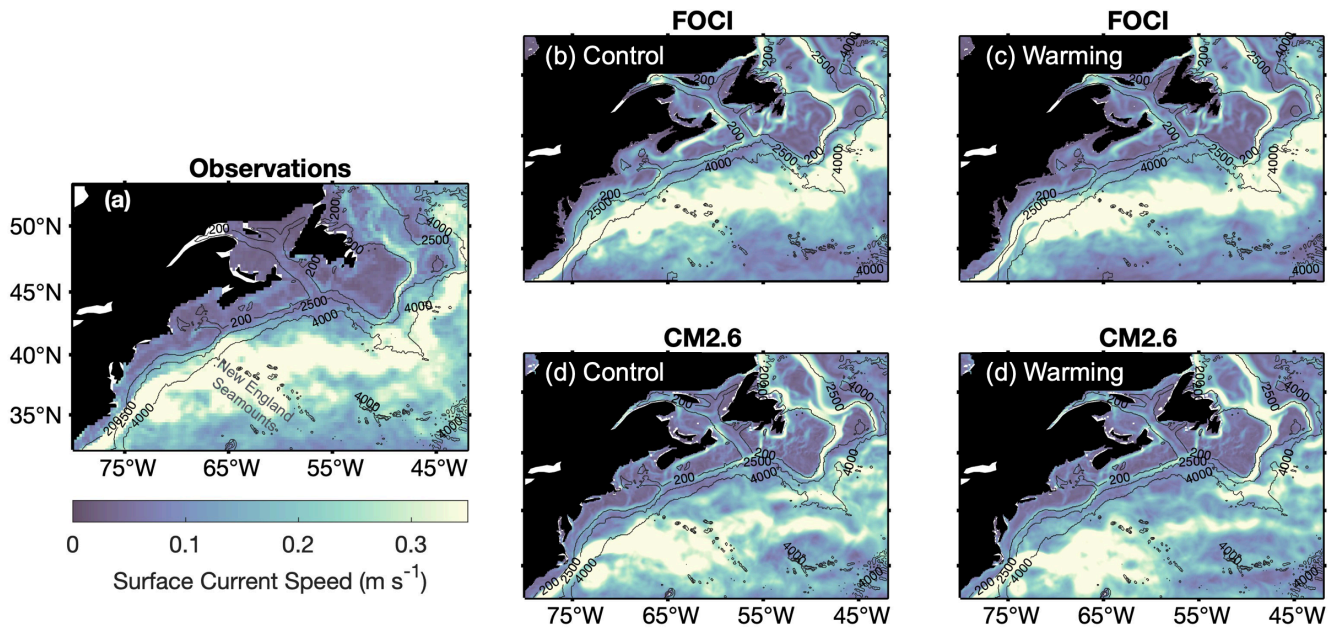


15 **Figure S1.** Annual mean surface velocity and Gulf Stream position based on SSH-based criteria from observations (a), FOCI (b), and CM2.6 (c) in the North Atlantic region in 2015. The background shading represents the average surface current speed (m s^{-1}). Blue contours indicate SSH values of -0.23 m (CM2.6), 0.1 m (FOCI), and 0.25 m (observations). Magenta contours mark the zero-skewness lines of SSH from monthly means (2015 – 2023). Red contours indicate the maximum SSH variance. Green contours show the maximum SSH gradient. Black points represent the locations of maximum surface velocity. NES: New England Seamounts.

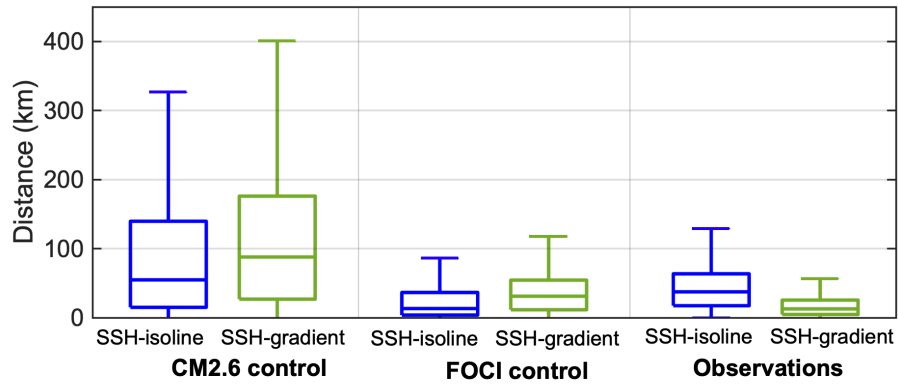


20 **Figure S2.** Skewness of sea surface height (SSH) calculated from monthly means between 2015 and 2023 northwest North Atlantic Ocean. The thin black contour represents the 200 m isobath, marking the edge of the continental shelf. The thick black contour corresponds to the zero-skewness line (skewness = 0), which is commonly used to approximate the path of the Gulf Stream. Data sources include AVISO observations and two climate models (CM2.6 and FOCI).

25



30 **Figure S3.** Mean annual surface velocity (m s^{-1}) for the North Atlantic in 2015 based on monthly means. Panel (a) provides observational data. Panels (b) and (c) display results from FOCI under control and warming scenarios, respectively. Panels (d) and (e) show results from CM2.6. The color shading represents the surface current speed. The Gulf Stream is clearly visible as a region of high velocity, especially in the observational data and the FOCI simulations.



35 **Figure S4.** Distance (km) between the Gulf Stream maximum velocity axis and two SSH-based criteria (SSH-contour in blue and SSH-max. gradient in green) for the CM2.6 and FOCI control simulations, as well as observations. In each boxplot, the central line represents the median, the box spans the interquartile range, and the whiskers extend to 1.5 times the interquartile range. Outliers beyond this range are not shown.

40 **Supplementary Tables**

Table S1. Linear trends for the northward shift of the Gulf Stream position from 2015 to 2100, based on temperature-based, SSH-based, and maximum velocity criteria. Trends (degrees of latitude per decade) are shown for regions A1 (75°W to 70°W) and A2 (70°W to 50°W), for both the FOCI and CM2.6 models. Confidence intervals and p-values were estimated using Newey–West heteroskedasticity and autocorrelation-consistent (HAC) standard errors.

Model	Criterion	Region							
		A1 (75°W to 70°W)				A2 (70°W to 50°W)			
		Trend (°lat dec ⁻¹)	95% CI (°lat dec ⁻¹)	R ²	p-value	Trend (°lat dec ⁻¹)	95% CI (°lat dec ⁻¹)	R ²	p-value
FOCI	T12	0.05	[0.02, 0.09]	0.32	0.00	0.02	[-0.01, 0.05]	0.05	0.03
	T15	0.10	[0.06, 0.15]	0.51	0.00	0.13	[0.08, 0.18]	0.44	0.00
	SSH-based	0.04	[0.01, 0.07]	0.21	0.00	-0.06	[-0.09, -0.04]	0.41	0.00
	Max. velocity	0.03	[0.01, 0.06]	0.16	0.00	-0.02	[-0.04, 0.00]	0.08	0.01
CM2.6	T12	0.12	[0.07, 0.18]	0.60	0.00	0.13	[0.07, 0.19]	0.37	0.00
	T15	0.24	[0.19, 0.30]	0.72	0.00	0.20	[0.14, 0.25]	0.84	0.00
	SSH-based	0.13	[0.07, 0.18]	0.38	0.00	0.11	[0.05, 0.17]	0.38	0.00
	Max. velocity	0.09	[0.03, 0.16]	0.20	0.00	0.08	[0.01, 0.16]	0.20	0.00

45

50 **Table S2.** Linear trends for the of the mean surface and 200-m depth temperature from 2015 to 2100. Trends are shown for the slope and subtropical regions, for both the FOCI and CM2.6 models. The trends are measured in °C per decade.

Model	Depth	Region					
		Slope			Subtropical		
		Trend (°C decade ⁻¹)	R ²	p-value	Trend (°C decade ⁻¹)	R ²	p-value
FOCI	Surface	0.12	0.47	0.00	0.06	0.43	0.00
	200 m	0.22	0.55	0.00	0.09	0.61	0.00
	450 m	0.17	0.50	0.00	0.01	0.77	0.00
CM2.6	Surface	0.25	0.76	0.00	0.11	0.86	0.00
	200 m	0.29	0.80	0.00	0.09	0.80	0.00
	450 m	0.18	0.75	0.00	0.11	0.76	0.00