Anomalous eddy kinetic energy in the Charlie-Gibbs Fracture Zone: Sources, downstream impacts and model discrepancy

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Previously titled: Southward Export of Iceland-Scotland Overflow Water constrained by deep potential vorticity structure near the Charlie-Gibbs Fracture Zone revealed by RAFOS observations

INTRODUCTION

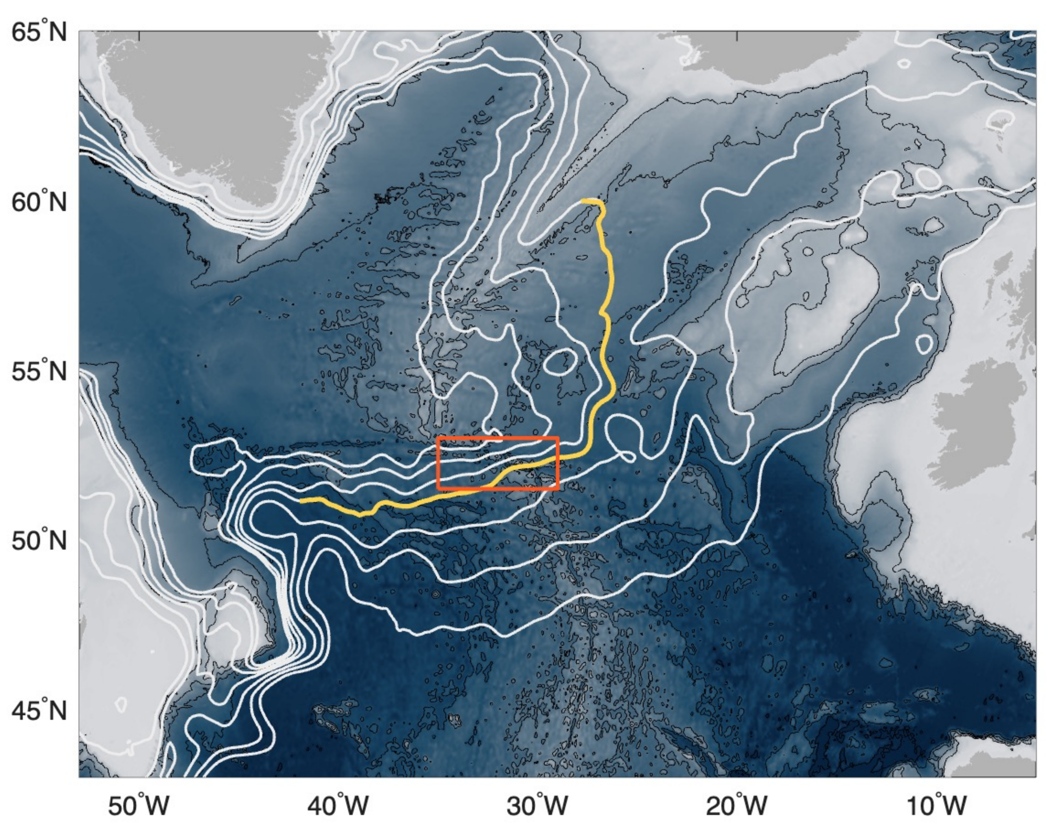

Fig 1: Mean sea surface height contours of the North Atlantic Current on bathymetry contoured every 1000 meters. Orange box denotes the Charlie-Gibbs Fracture Zone and the region where EKE values are averaged over. Yellow contour identifies the SSH streamline used in figure 5.

The AMOC transports warm, salty subtropical waters to the subpolar North Atlantic via the North Atlantic Current (NAC), which separates from the western boundary at the Northwest Corner and flows eastward across the basin. Previous studies attribute the northward propagation of thermohaline anomalies in the subpolar North Atlantic to variability in midlatitude ocean heat transport at the subtropical-subpolar boundary, highlighting fluctuations in volume transport associated with changes in the strength and position of the NAC (e.g. Desbruyéres et al. 2013). At the intergyre boundary, the NAC encounters the Mid-Atlantic ridge, a major topographic obstacle that steers the current along preferred pathways quasi-locked to fracture zones, most prominently the Charlie-Gibbs Fracture Zone (CGFZ) (Bower and von Appen, 2008). However, the variability of the NAC over the CGFZ, its drivers, and the implications of its configuration for downstream heat fluxes into the subpolar gyre remain poorly quantified.

EKE in the CGFZ

- EKE in the CGFZ significantly elevated in 2013 and between 2016 – 2018 with dominant frequencies near 150 days
- Anomalous EKE represented in the data assimilating Global Ocean Physics Reanalysis (GLORYS12V1) but not in the free running Hybrid Coordinate Ocean Model (HYCOM)
- Monthly composites reveal a meandering NAC and strong SSH gradients during years of elevated EKE in the CGFZ compared to a stable, zonal jet
- Monthly composites from the same months in HYCOM show a far less meandering NAC but a relatively strong SSH gradient in the CGFZ

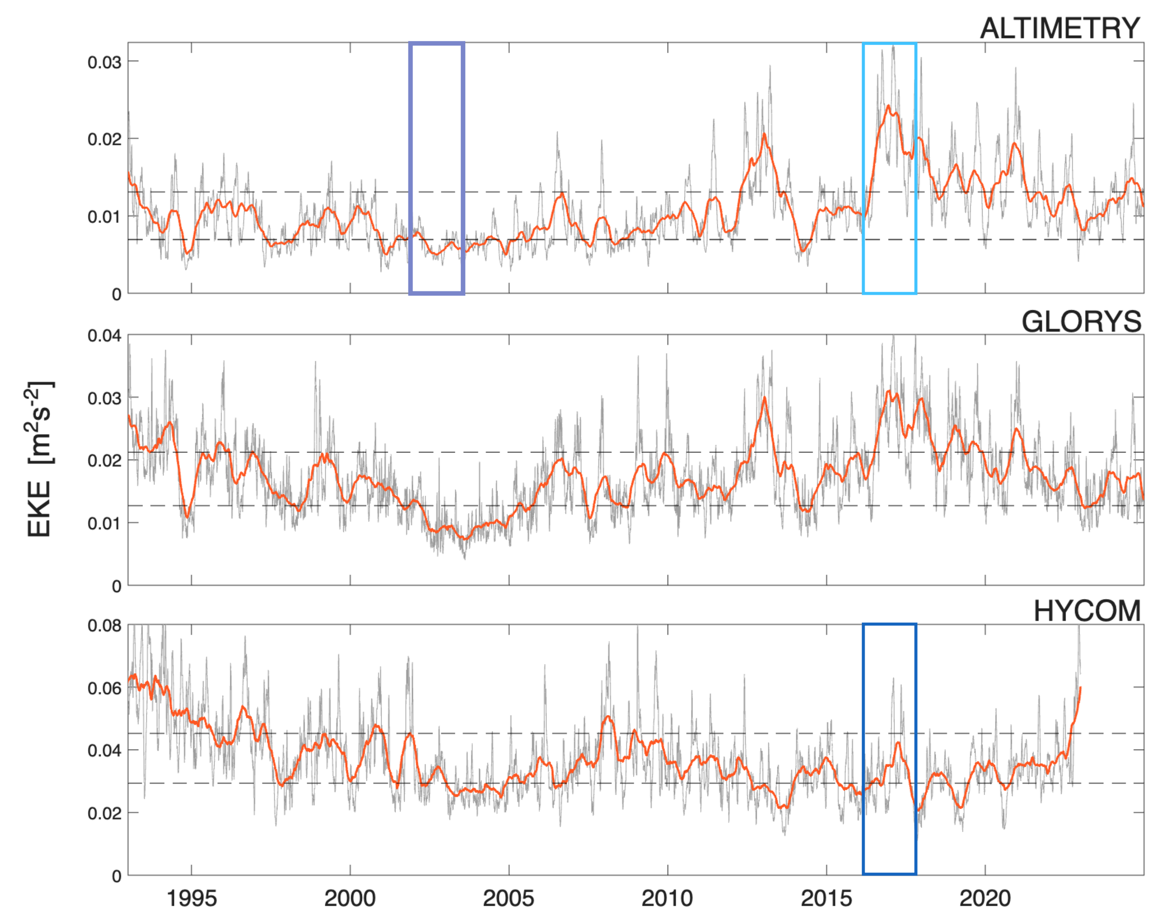

Fig 2: Spatially averaged surface EKE within the CGFZ from A) altimetry B) GLORYS and C) HYCOM. Gray is the daily timeseries while orange lines represent the 180-day moving mean. Dashed lines denote the top and bottom 25% of daily EKE values. Blue boxes identify the time periods of monthly averages illustrated in figure 3.

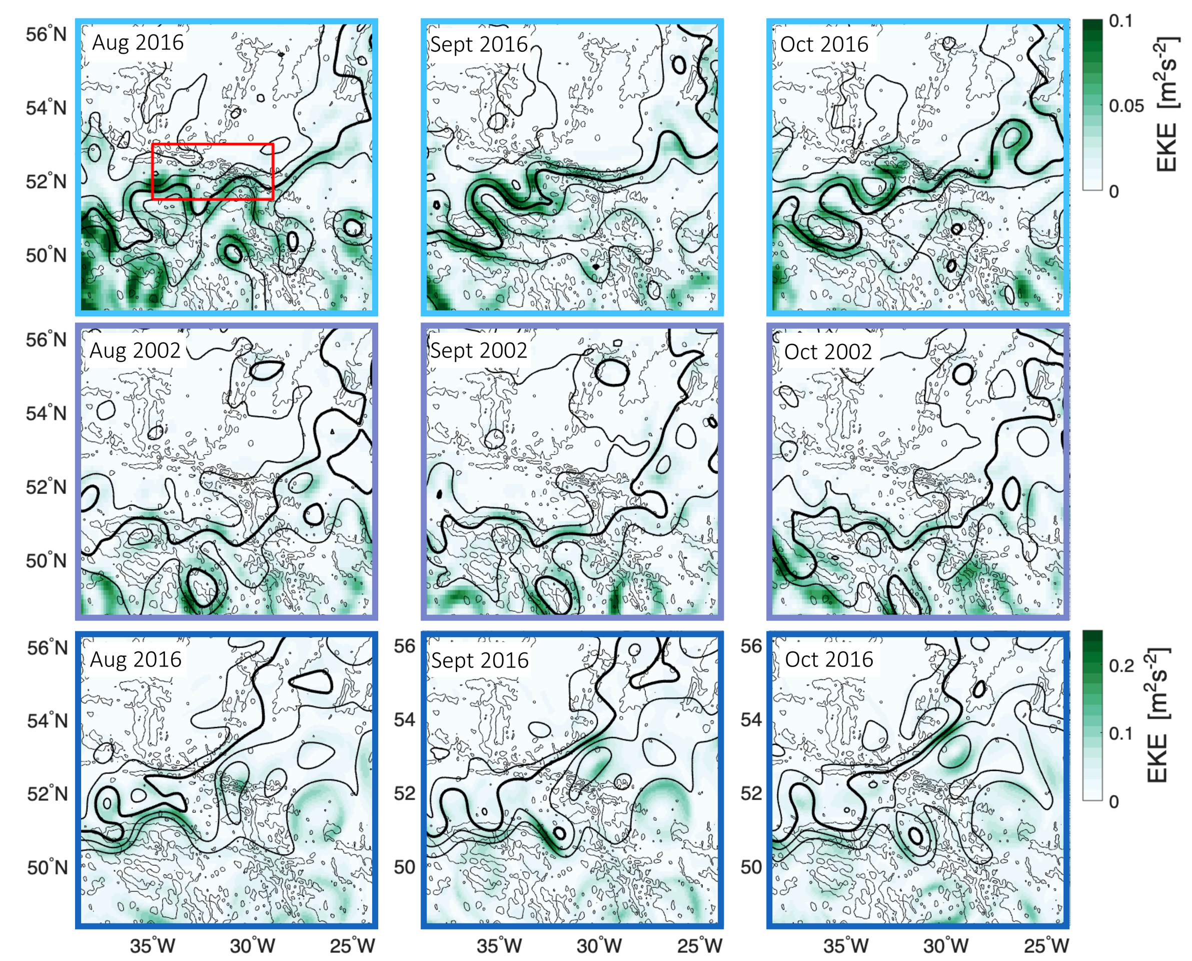

Fig 3: Top and Middle: monthly composites of EKE and sea surface height contours derived from altimetry during time periods of elevated EKE in the CGFZ (top) and reduced EKE in the CGFZ (middle). Bottom: monthly composites of EKE and sea surface height contours derived from HYCOM during periods of elevated EKE identify from altimetry.

PROPAGATION OF ANOMALIES

Years with elevated EKE in the CGFZ are associated with:

- Elevated EKE in the Iceland Basin
- Elevated SSH within the CGFZ and downstream in the Iceland Basin
- Elevated MKE suggesting larger meridional volume and heat transport

Hovmöller reveals signals that originate in the CGFZ and can propagate both northward into the subpolar gyre and westward back towards Northwest Corner

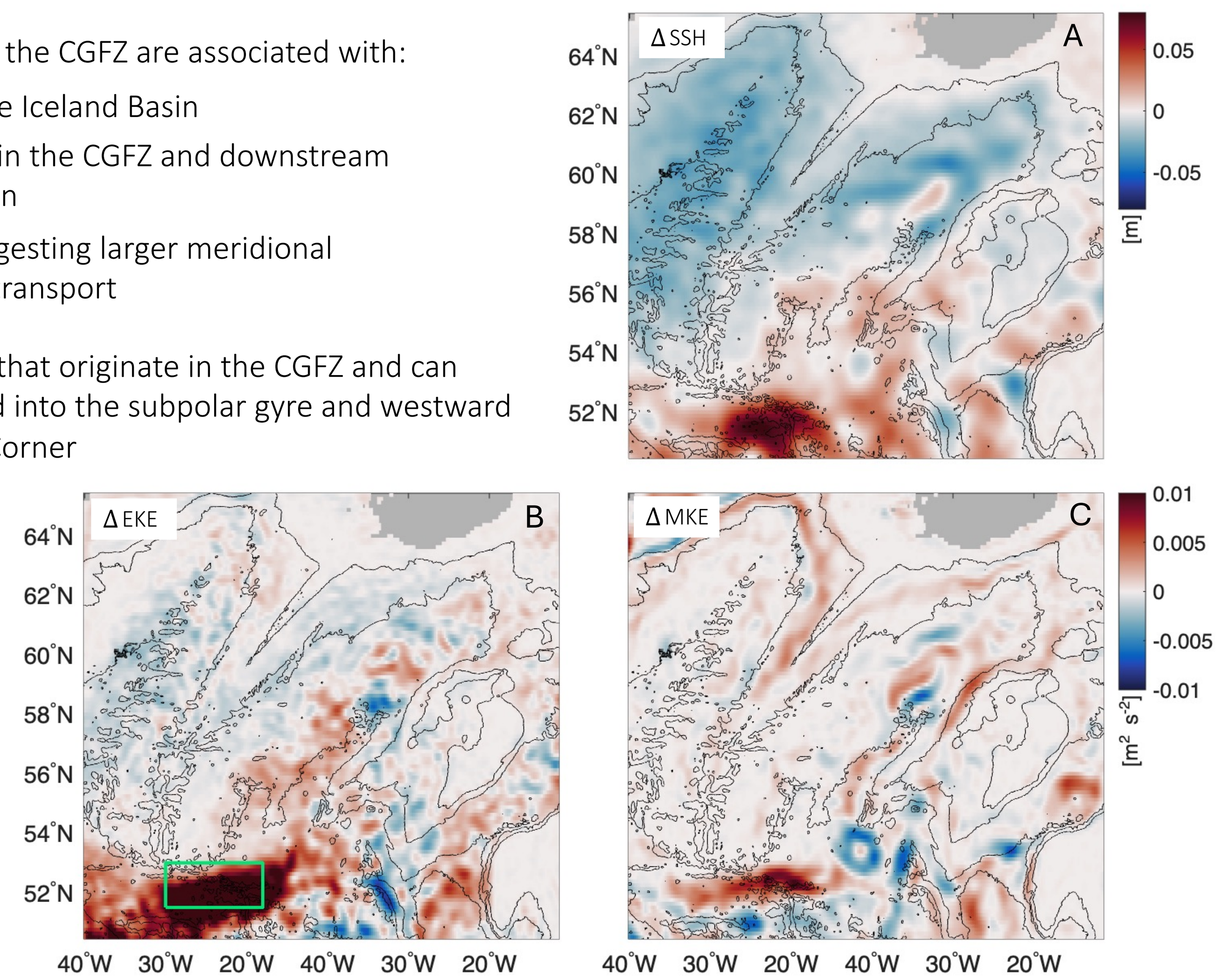

Fig 4: Composite difference in A) SSH, B) EKE and C) MKE associated with high and low EKE conditions in the CGFZ. Years in which CGFZ EKE falls within the upper (lower) 25% of the full time series are classified as high (low) EKE years. The composite is constructed by averaging EKE over high years and subtracting the corresponding average over low years

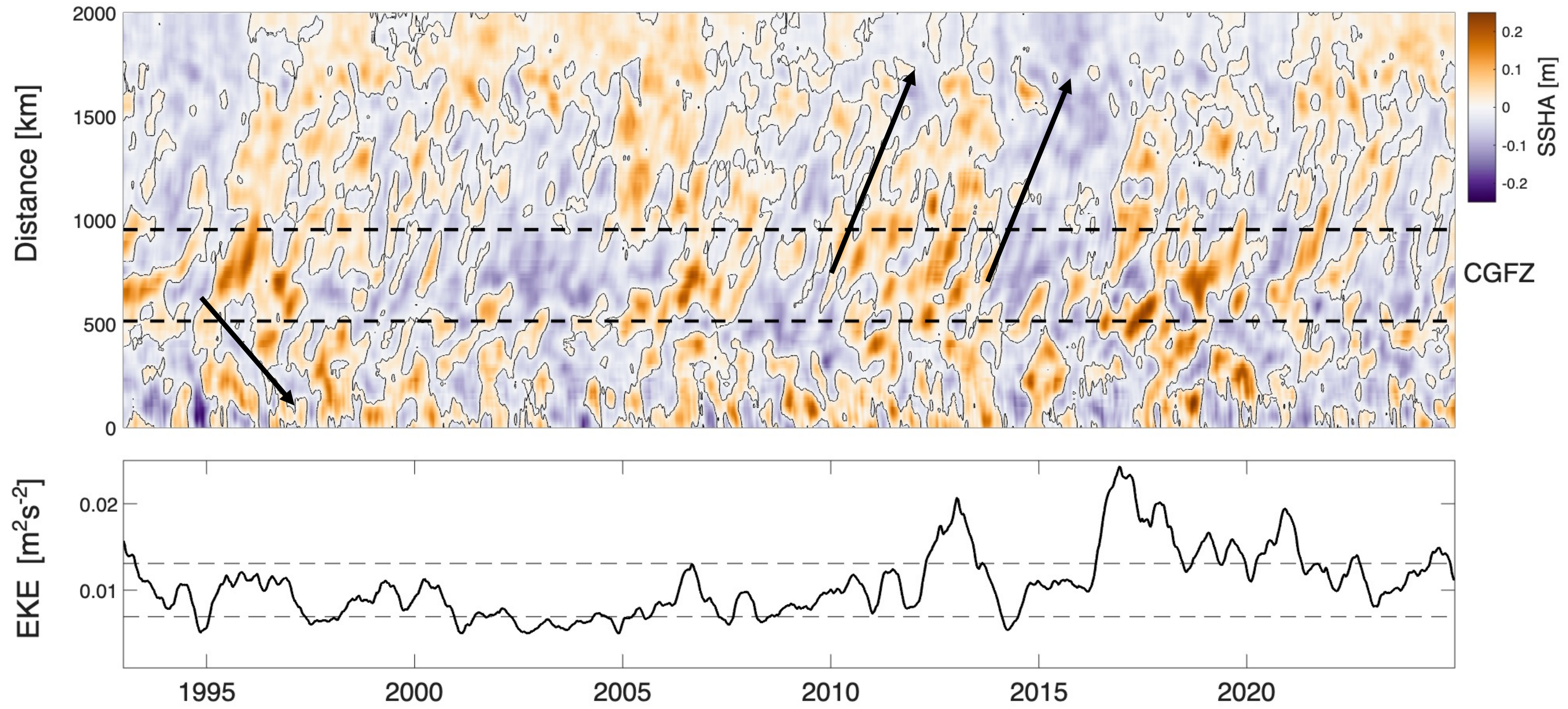

Fig 5: Top) Hovmöller of sea surface height anomalies along the mean sea surface height contour colored in yellow on figure 1. Dashed lines represent the location of the CGFZ. Sollid black lines indicate the zero line. Y-axis measures along contour distance from the Northwest Corner. Bottom) time series of EKE averaged within the CGFZ derived from altimetry. Dashed lines represent the top and bottom 25% of daily EKE values.

FUTURE WORK

What environmental driver or set of conditions might push the NAC into a prolonged unstable regime?

- Xu et al. (2018) suggested a strong correlation between modeled (HYCOM) ISOW and NAC transport through the CGFZ and zonal wind stress in the Western European Basin
- Wintertime NAO has low correlation with time series of EKE in the CGFZ. Possible relationship to East Atlantic Pattern?
- Upstream conditions: Holliday et al. (2020) showed pronounced freshening event between 2012 – 2016 originated in the Northwest Corner and associated with a strengthening of the southern NAC branch

What are the downstream impacts of heat and freshwater fluxes into the subpolar gyre?

- Dotto et al. (2025) showed that periods of enhanced NAC volume transport are associated with reduced regional EKE

What is the impact of westward propagation of anomalies from the CGFZ?

- Rossby wave propagation?

Why doesn't anomalous EKE show up in HYCOM?

Suggestions?

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