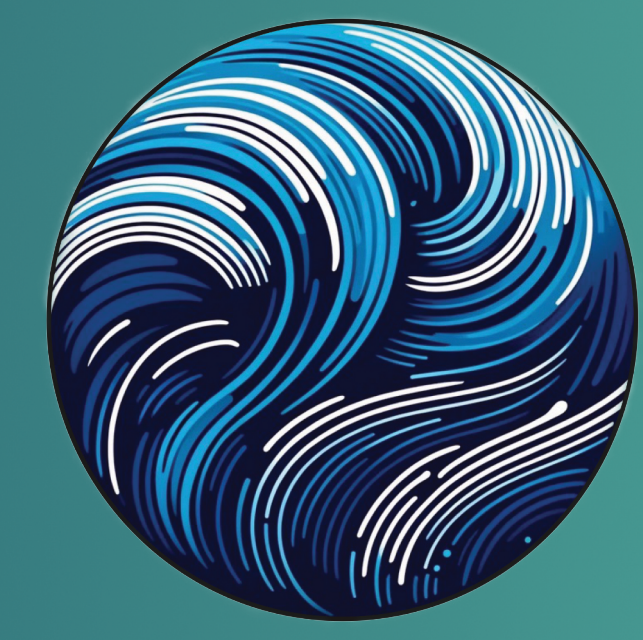


Variability in the Subpolar Gyre circulation and throughput towards the Nordic Seas



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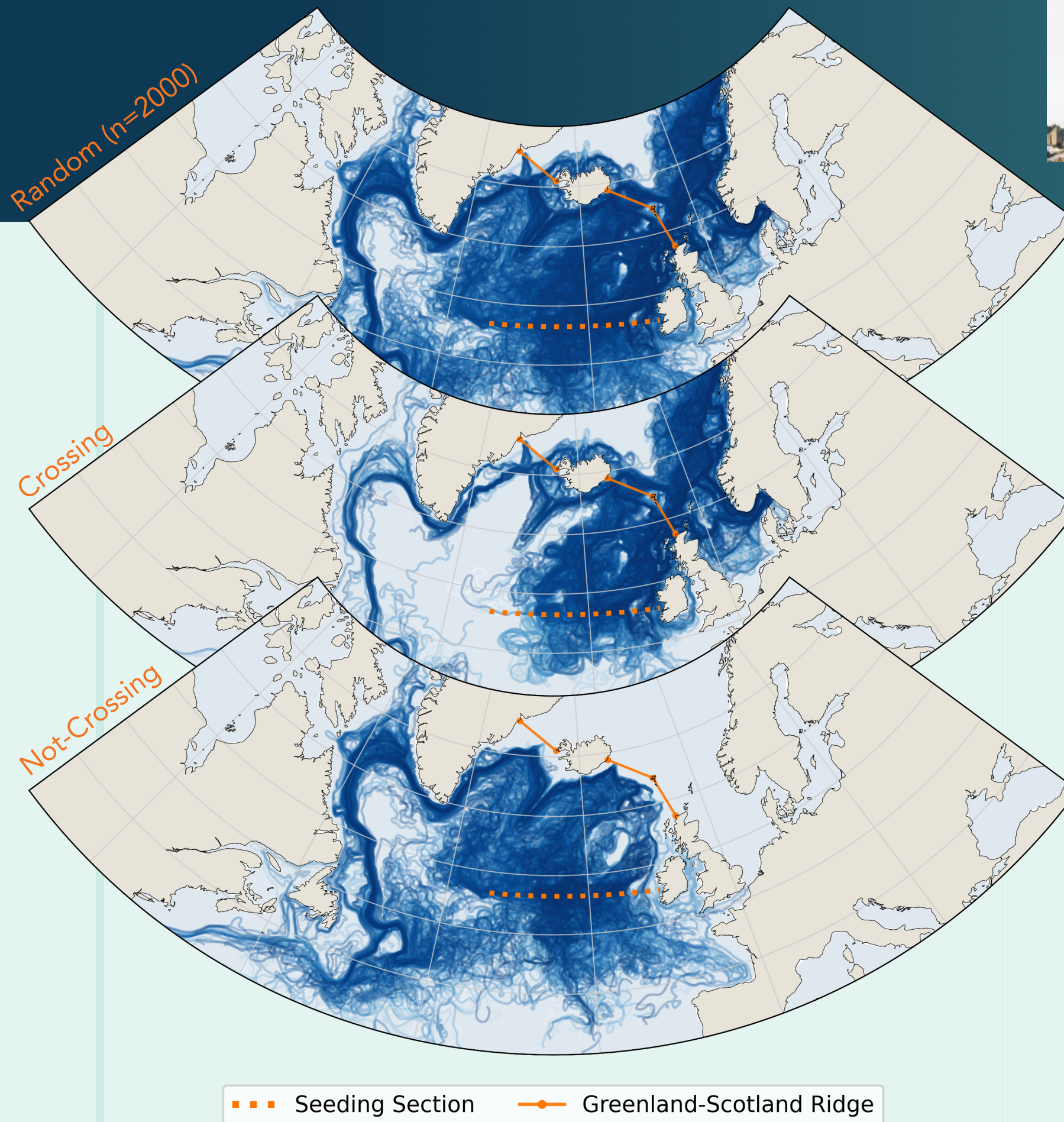


1. Context and Motivation

Although the **Atlantic Meridional Overturning Circulation (AMOC)** is often described as a conveyor belt, implying a coherent and closed system, evidence increasingly suggests a more intricate and dynamically variable structure. A lack of interannual to decadal coherence in the Atlantic basin leaves critical gaps in our ability to detect and attribute changes in the overturning circulation. Understanding how regional processes, such as gyre dynamics and wind forcing, obscure **basin-wide coherence** remains a key challenge.

2. Objectives

- Quantify **mechanisms** driving variability in the **Nordic Seas inflow** across the **Greenland-Scotland Ridge (GSR)** versus **Subpolar Gyre (SPG) recirculation**
- Assess how these **processes modulate northward transport** of warm, saline **Atlantic waters** and associated heat flux across the **GSR**



3. Data and Methods

We use **Eulerian** and **Lagrangian** techniques to determine the **Nordic Seas inflow variability** from 1979 to 2017.

NEMO GOv8.7 JRA55 eORCA12:

- ocean hindcast
- forced with JRA55
- 1/12° horizontal grid; 75 levels
- monthly resolution; 1979–2021

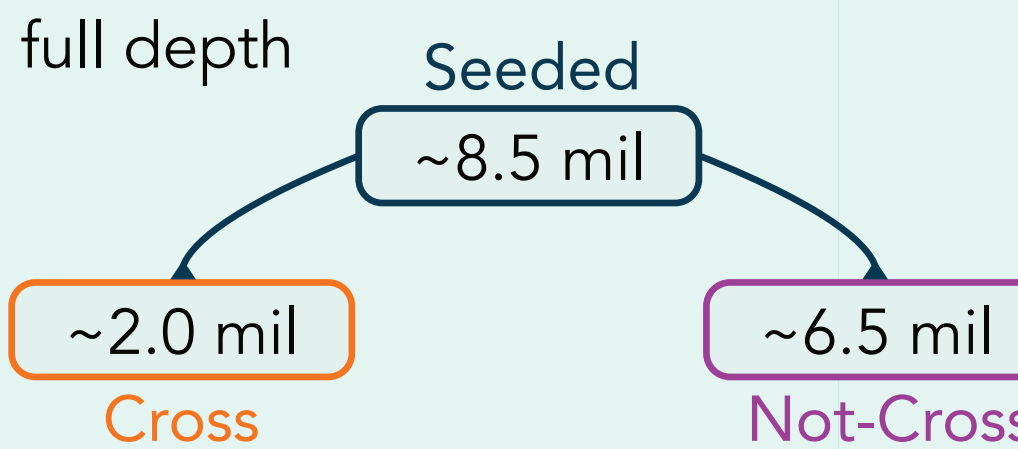
TRACMASS:

- Lagrangian tracking tool
- analytical trajectory solution
- mass/volume conserving
- Eulerian velocity input fields

We employ **multivariate linear regression** with **physically motivated indices** to reconstruct and quantify variability in the Nordic Seas inflow.

3.1 Lagrangian Seeding

- seeding in **North Atlantic Current (NAC)** at ~53°N
- monthly seeding 1979–2017
- positive v-cells and full depth
- tracking of 4 years



$$I(t) = \beta_0 + \sum_{j=0}^P \sum_{l \in L_j} \beta_{j,l} X_j(t-l) + \epsilon(t)$$

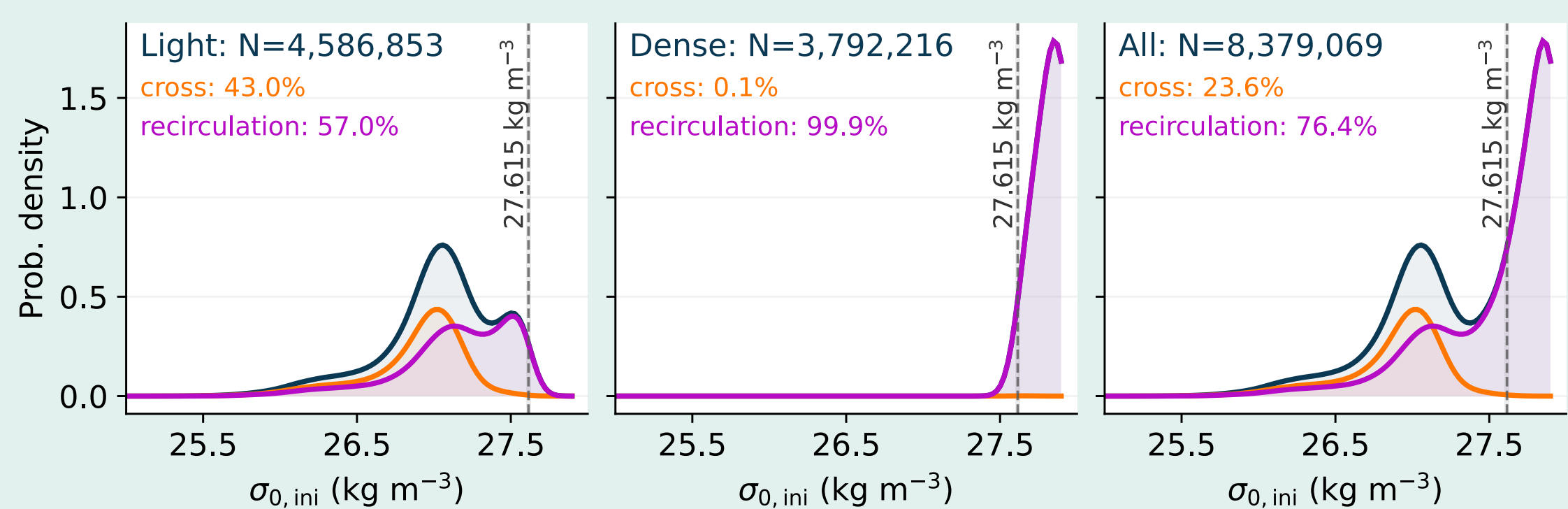
- $I(t)$... GSR inflow index
- β_0 ... intercept
- $\beta_{j,l}$... regression coefficient j at lag l
- P ... number of predictors
- L_j ... set of lags considered for predictor j
- $X_j(t-l)$... predictor j at lag l
- $\epsilon(t)$... residual

4. Results

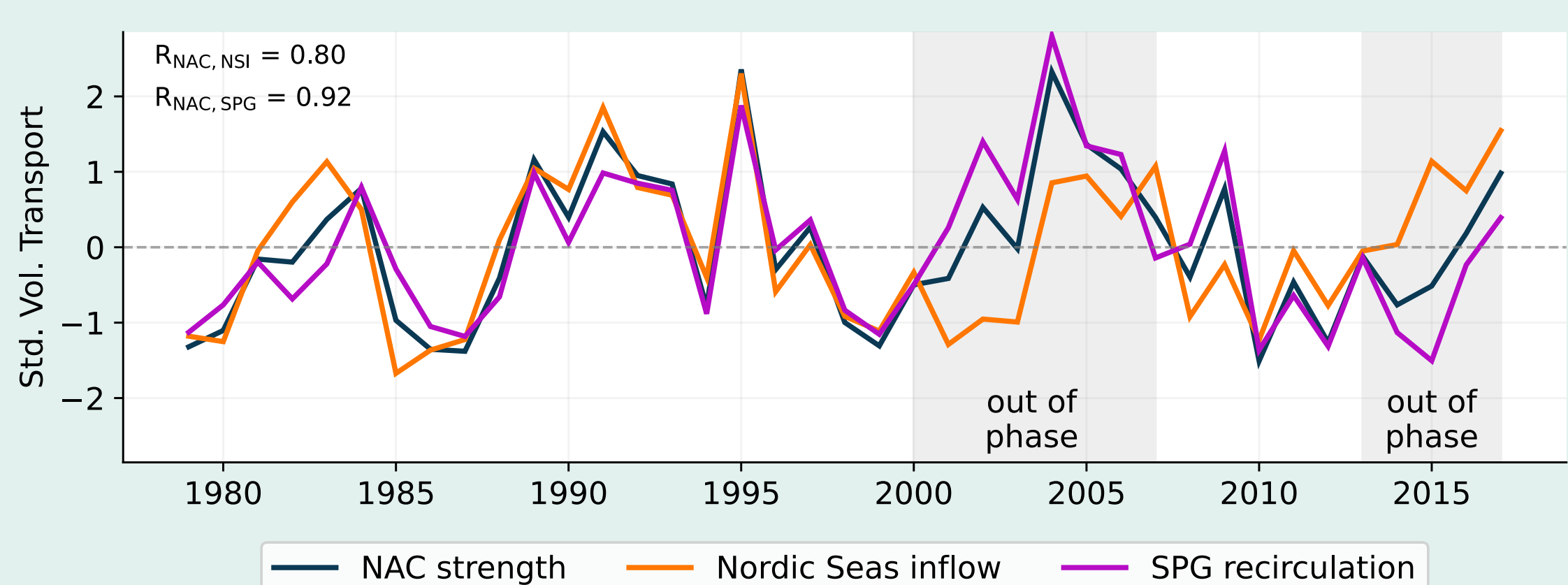
4.1 North Atlantic Current

Question: Is **NAC** strength determining Nordic Seas Inflow?

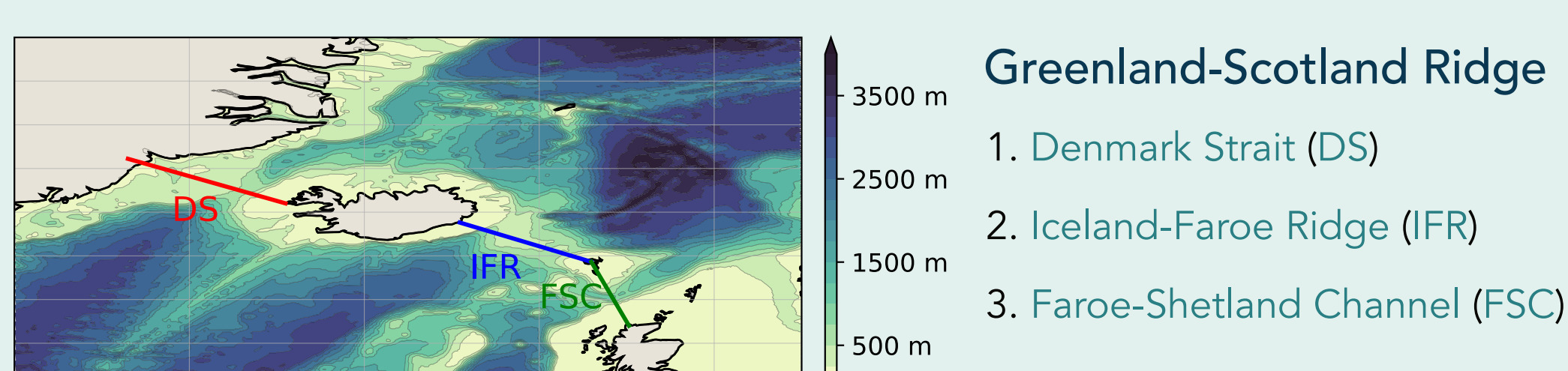
We define the **NAC** as the transport of all water masses lighter than $\sigma_{0,NAC} = 27.615 \text{ kg m}^{-3}$ (maximum Eulerian overturning isopycnal) at the seeding section. This enables a clear separation between light and dense waters.



The probability density distribution of particle density at seeding time t_0 shows that virtually **no particles denser** than $\sigma_{0,NAC}$ will **cross the GSR**. This indicates that **density** at the **seeding section** is a **prerequisite** for crossing the **GSR** and contributing to Nordic Seas inflow. Therefore, only particles **lighter** than $\sigma_{0,NAC}$ (i.e. **NAC** particles) are considered in the following analysis.

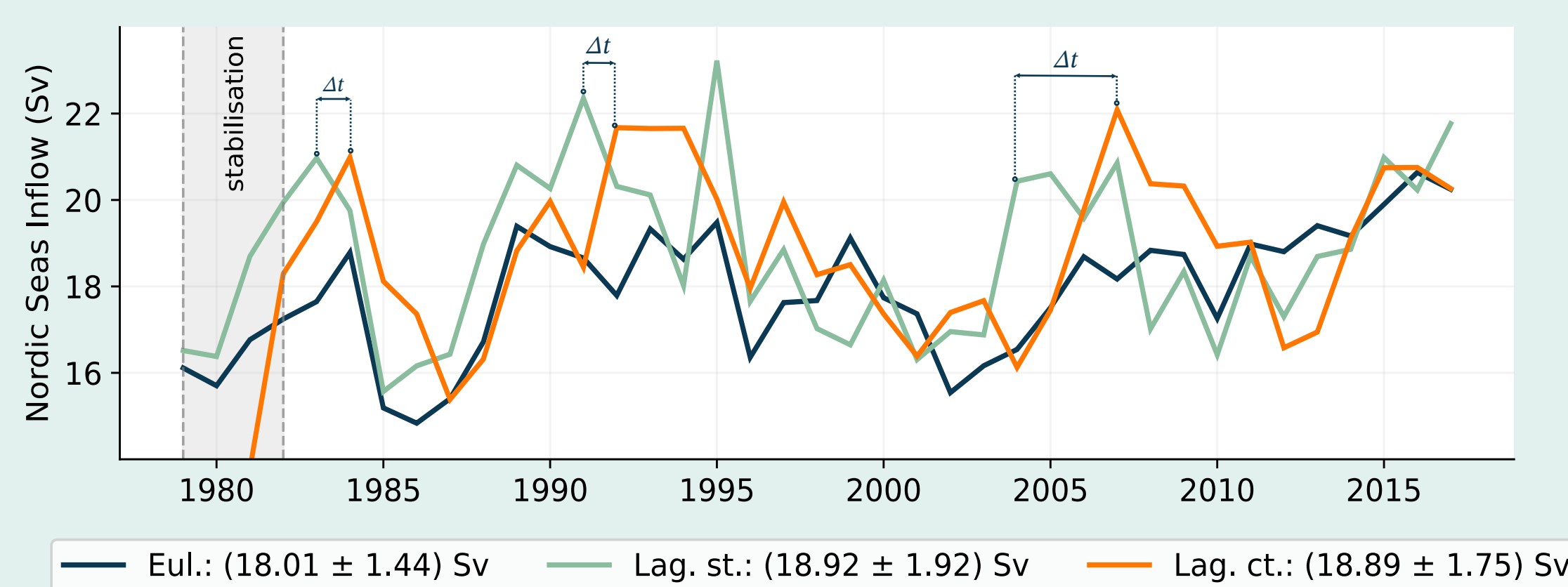


The **NAC** appears to drive both Nordic Seas inflow and **SPG** recirculation. However, periods of **out-of-phase variability** between **NAC** transport and Nordic Seas inflow suggest the presence of **additional mechanisms** controlling the **inflow** at the **GSR**.

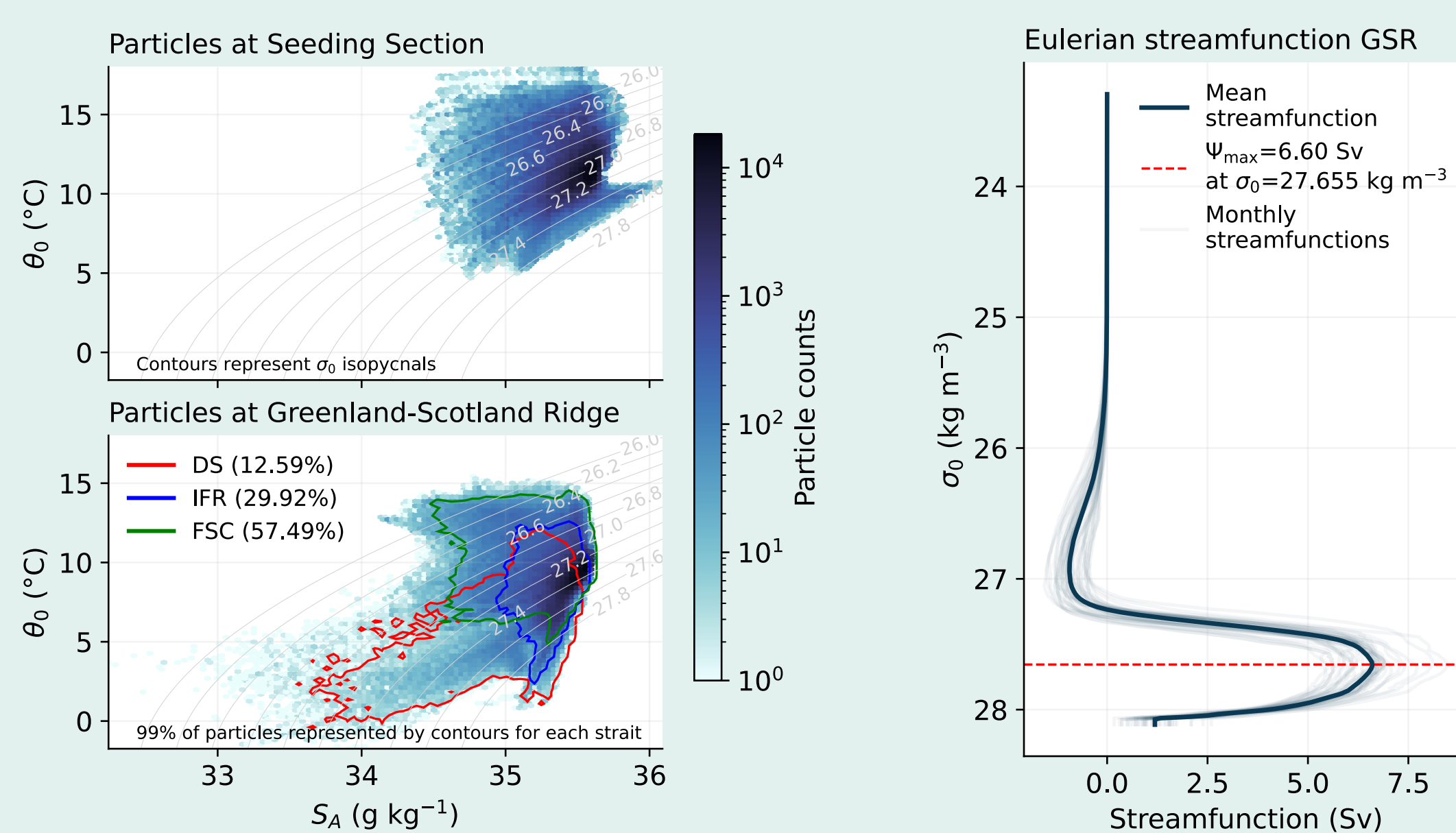


4.2 At the Greenland-Scotland Ridge

The **GSR** is the **principal gateway** from the Atlantic to the Arctic via the Nordic Seas, comprising three main passages (**DS**, **IFR**, and **FSC**). To validate the Lagrangian transport estimates, we compute the **Eulerian inflow** using **normal vector projection** across the defined **GSR**.

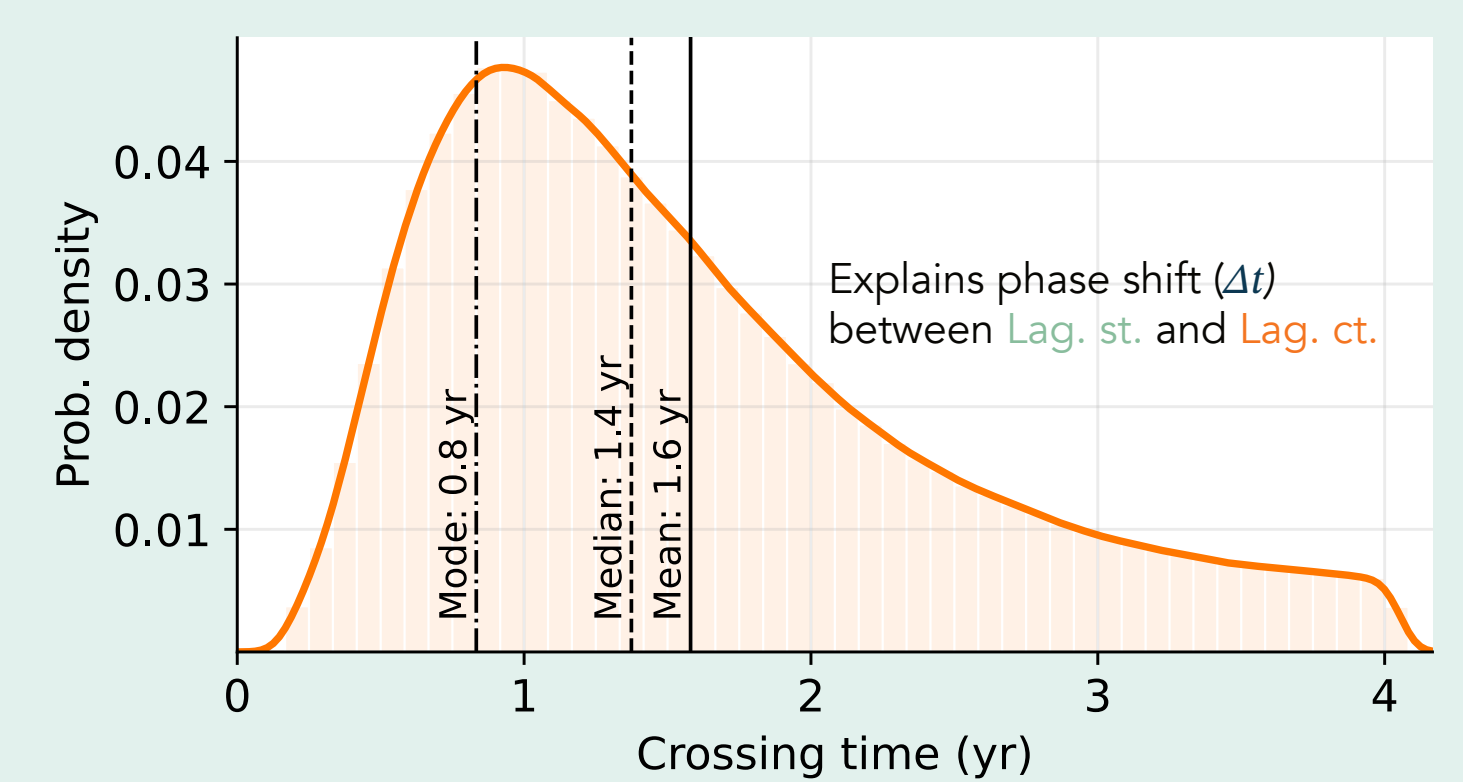


During their pathway, particles undergo **water mass transformation**. This is reflected in a shift towards higher densities between the seeding section and the GSR, with most **particles densifying** and **preferentially** reaching the ridge via the **FSC**.



Crossing Time

Particles crossing the **GSR** follow different pathways and do **not share a unique transit time**. Instead, their travel times are described by a **probability distribution** called **Transit Time Distribution (TTD)**.



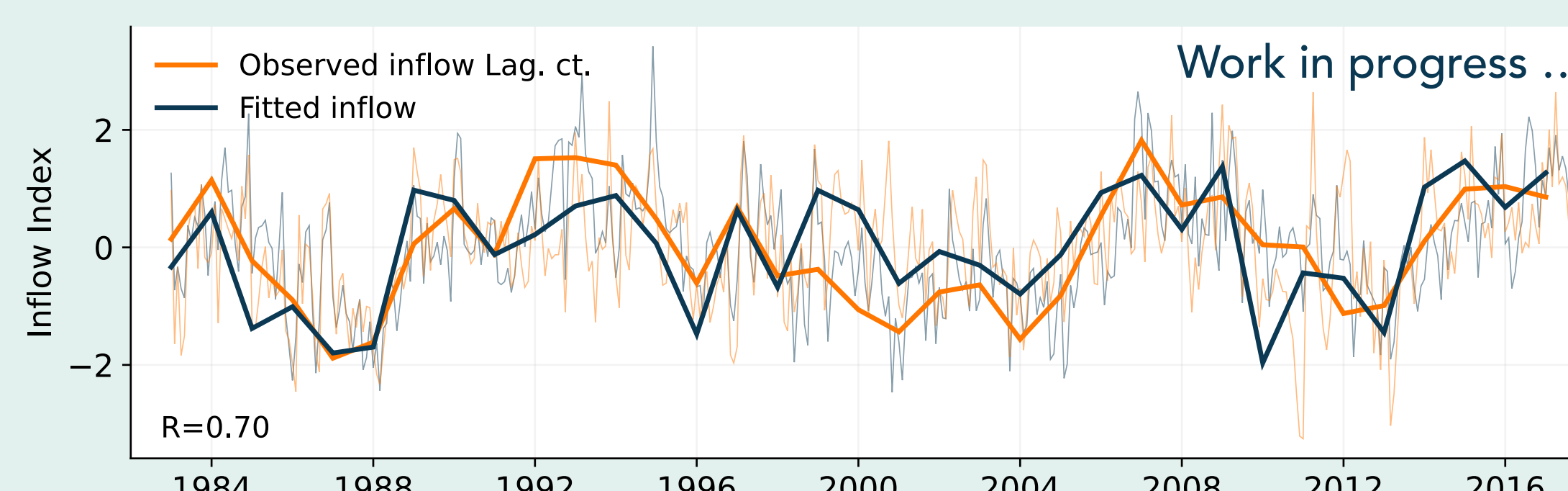
Two **Lagrangian** approaches to estimate Nordic Seas inflow:

- Seeding time (st):** group crossing particles by release period
- Crossing time (ct):** group crossing particles by actual crossing time

4.3 Mechanisms Nordic Seas Inflow

Question: Which mechanisms reconstruct inflow?

To address this, we use a **multivariate linear regression model** that represents **Nordic Seas Inflow** as a **function** of multiple physically motivated **predictors**.



5. Future Work

- Additional inflow mechanisms**
- Unique vs. shared variance** of predictors?
- Dependence of results on **time scales**?
- "Large-scale"** regression (*NAO, EAP, ...*)
- "Small-scale"** regression ($\omega_E, \Delta SSH, ...$)
- Information transfer** between predictors
- Passage transports (DS, IFR, FSC)**
- Heat flux** across **GSR**

Predictors

	Scandinavian Pattern	North Atlantic Oscillation	Dense Overflow	Cross-Ridge SSH Gradient	Vertical Ekman Velocity
L_j	1–2	1–12	0	0	0
ΔR^2	22.0%	19.7%	17.1%	10.9%	6.6%

L_j ... set of lags ΔR^2 ... unique explained variance