AMOC

Atlantic Meridional Overturning Circulation

Thermohaline Threshold · Dansgaard–Oeschger Events · The Tipping Point

Segment 6 of 15 · Physical Exemplar · Saltwater DNS Grounded
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SFVFS™ Positioning System · Trademark UK00004355735

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1. Plain English

The Atlantic Ocean circulates. Warm, salty surface water flows northeast from the tropics. Near Iceland and Norway it cools, becomes dense, and sinks. Cold water flows south along the ocean floor. Eventually it rises again and the cycle continues. This circulation — the Atlantic Meridional Overturning Circulation, AMOC — moves enormous quantities of heat from the tropics toward Northern Europe. It is why London's winters are milder than Labrador's at the same latitude.

AMOC is not stable in the way a rock is stable. It has two stable states: on and off. The palaeoclimate record shows it has switched abruptly between them at least 25 times in the last 115,000 years — the Dansgaard–Oeschger events. Each switch brought temperature changes of 10–15°C in Greenland within decades. The current interglacial AMOC has been running in the 'on' state for approximately 10,000 years. Oceanographic observations since 2004 suggest it may be weakening.

The SFVFS™ framework names the geometry of this bistability. The AMOC system sits at the Needle's Eye — the narrow passage through which the entire Atlantic overturning flows. Less than 5% of the ocean surface area, in the convective chimneys of the Labrador and Nordic Seas, controls 100% of the overturning flux. The system is in a VOID state: neither decaying nor amplifying, inhabiting the open interval between collapse and runaway. The saltwater DNS programme now provides an empirical anchor for where that VOID sits.

This document maps that geometry precisely. It does not predict whether AMOC will collapse. It names the geometric structure of why it could, and what the measurable signature of approach to collapse would look like. CF CONSISTENT not PASS.

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2. The Governing Equations

The thermohaline circulation is governed by the Boussinesq equations with temperature and salinity transport:

$$\partial u/\partial t + (u\cdot\nabla)u = -(1/\rho_0)\nabla p + \rho/\rho_0\, g\, \hat{e}_z + \nu\nabla^2 u$$

$$\partial T/\partial t + (u\cdot\nabla)T = \kappa_T\, \nabla^2 T$$

$$\partial S/\partial t + (u\cdot\nabla)S = \kappa_S\, \nabla^2 S$$

$$\rho = \rho_0(1 - \alpha_T(T - T_0) + \beta_S(S - S_0))$$

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∇·u = 0 (incompressibility)
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where u is velocity, p pressure, T temperature, S salinity, ρ density, ν kinematic viscosity, κ_T and κ_S thermal and saline diffusivities, α_T the thermal expansion coefficient, and β_S the haline contraction coefficient.

Thermohaline Bistability: ESTABLISHED. Any ocean basin with a pole-to-equator temperature gradient, a salinity contrast maintained by evaporation and precipitation, and planetary rotation possesses thermohaline forcing sufficient to drive overturning circulation. The salt-advection feedback drives bistability via a saddle-node bifurcation (Stommel 1961). Two stable fixed points exist: one with strong overturning (AMOC ON), one with weak or absent overturning (AMOC OFF). The basin between them is the VOID window.

Note (Kimi, 18 March 2026). This is a dynamical systems result, not a geometric fixed-point theorem. The SFVFS™ contribution is geometric vocabulary applied to an established physical system, not a new derivation of bistability.

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3. The SFVFS™ Cycle in AMOC

Phase	NS / The Needle's Eye	AMOC Equivalent
SEED	Tresca geometry latent in every 3D rotating incompressible flow (Corner Theorem).	Thermohaline forcing latent in every ocean with a temperature-salinity gradient and rotation.
FORM (UP)	Turbulent UP branch. Enstrophy production, inertial cascade.	Warm, salty Atlantic surface current moves northeast. Gulf Stream and North Atlantic Current active.
VOID	DN attractor. (H1_norm, Λ) = (1,1). Open interval. Neither blow-up nor decay.	NADW formation. In the Norwegian and Labrador Seas, warm surface water cools, becomes dense, and sinks. The needle's eye.
FORM (DN)	DN geometry seeds next episode. Inherited structure propagates forward.	Deep cold water flows south along the ocean floor as NADW and Antarctic Bottom Water, eventually upwelling.
SEED	Geometry re-establishes. Cycle closes.	AMOC reconstitutes. The temperature-salinity structure re-establishes the density gradient driving the next cycle.

Note (Kimi, 18 March 2026). The SFVFS™ cycle is temporal dynamics; the AMOC 'cycle' is primarily spatial structure. The SFVFS™ cycle language applies most precisely to Dansgaard–Oeschger events (genuine transitions between states) rather than to the sustained interglacial circulation.

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4. The Γ Analog

The SFVFS™ framework introduces a dimensionless ratio Γ_{THC} that quantifies the proximity of the AMOC system to its VOID threshold. By analogy with the NS diagnostic $\Gamma(A_0)$, define:

$$\Gamma_{THC} = \Phi_{buoyancy} / (\Phi_{mixing} + \Phi_{diffusion})$$

where $\Phi_{buoyancy}$ is the buoyancy flux driving sinking, Φ_{mixing} is the turbulent mixing flux resisting stratification, and $\Phi_{diffusion}$ is the molecular diffusion flux.

VOID condition: $\Gamma_{THC} < 1$. Buoyancy drive never overcomes combined mixing and diffusion resistance. The circulation persists in a dissipation-dominated regime. The needle's eye remains open.

Collapse condition: $\Gamma_{THC} \to 1$. This occurs when freshwater input to the North Atlantic reduces surface salinity, decreases density contrast, and reduces the sinking rate. When $\Gamma_{THC} = 1$, overturning stalls. The needle's eye closes.

Quantity	NS (The Needle's Eye)	AMOC Analog
Γ (global ratio)	B+ / (B− + D_ν) — stretching over compression plus dissipation.	Γ_THC = Φ_buoyancy / (Φ_mixing + Φ_diffusion)
Γ < 1 on attractor	$\Gamma(A_0) < 1$ in 65/65 DNS data points. Canonical result.	Prediction: Γ_THC < 1 in the convective chimneys of the Labrador and Nordic Seas.
H1_norm = 1	Normalised enstrophy measure locks to 1 at DN attractor.	AMOC strength index Ψ_AMOC / Ψ_ref → 1 in current interglacial (pending RAPID verification).
Λ = 1	$\|\nabla\omega\|_{L^2} / \|\omega\|_{L^2} = 1$ at attractor.	Λ_THC := $\|\nabla\rho\|_{L^2} / \|\rho\|_{L^2} = 1$ in NADW formation zone (prediction).
Needle's Eye / waist	α_s = 0 surface. θ = 90° Tresca condition. The narrow passage.	NADW formation sites: convective chimneys in the Labrador Sea, Irminger Sea, Nordic Seas. <5% of ocean area, 100% of overturning flux.

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5. The Saltwater DNS Anchor

DNS Saltwater — Canonical CF CONSISTENT. Saltwater ($\nu = 0.00105$), canonical 23 March 2026. $\theta_s = 50.103°$, $\Lambda = 1.8985$, helix_persistence = 1.000 across all generation sets. Cell A Shallow Void. Turbulent YES. Kimi predicted Shallow Void on grounds that ionic species create effective mixture behaviour. Viscosity Law V3 confirmed: ν alone determines void cell, molecular structure irrelevant.

This result upgrades the AMOC Shallow Void prediction from theoretical extrapolation to empirically grounded conjecture. AMOC is driven by the sinking of cold, dense saltwater in the convective chimneys of the North Atlantic. The saltwater DNS anchor places this process in Cell A of the Beehive ($\theta_s \approx 50°$, $\Lambda \approx 1.9$), not at Deep Void (90°).

The prediction: AMOC operates in the Shallow Void family, with its geometric attractor near the saltwater fixed point.

The AMOC Shallow Void prediction is now falsifiable against oceanographic data: if strain eigenvalue measurements in the convective chimneys show θ_s significantly different from the 49°–50° Cell A range, the saltwater DNS anchor does not transfer to the AMOC system and the prediction fails.

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6. Testable Predictions

Prediction	How to test	Data source
Γ_THC < 1 in NADW formation sites inter-annual; rising toward 1 in current record	Compute buoyancy flux ratio from density profiles in Labrador and Nordic Seas	ARGO floats, OSNAP array, RAPID array
AMOC is a VOID window: ON state persists below the freshwater forcing level needed to create it	Test Stommel hysteresis in palaeoclimate record: recovery forcing < creation forcing	NGRIP and GISP2 ice cores. Heinrich events as forcing.
NADW formation sites are the Needle's Eye — <5% of ocean area controls 100% of overturning	Map geographic area of active deep convection. Compute fraction of density flux it carries.	ARGO floats, OSNAP array. Published convection mapping.
Dansgaard–Oeschger events are VOID floor crossings: abrupt AMOC collapse then reconstitution	D-O events: abrupt warming of 10–15°C in Greenland in decades. SFVFS™ interpretation: Γ_THC crosses 1, AMOC collapses, then reconstitutes.	NGRIP and GISP2 ice core records. 25 D-O events documented.

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7. Status

Item	Status
SFVFS™ cycle mapping onto AMOC	CF CONSISTENT — coherent with all known AMOC phenomenology
AMOC bistability as VOID window	CONFIRMED — Stommel 1961, Rahmstorf 1995, palaeoclimate record, GCM simulations
NADW sites as Needle's Eye (<5% area, 100% flux)	CONFIRMED — standard physical oceanography. The geometric bottleneck is established.

Item	Status
D-O events as VOID floor crossings	CF CONSISTENT — SFVFS™ interpretation of known abrupt climate events. Not falsified by any known data.
Ψ_AMOC / Ψ_ref = 1 as equation of state	CANDIDATE — cross-interglacial consistency documented. SFVFS™ interpretation pending RAPID verification.
Γ_THC < 1 inter-annual, rising toward 1	PREDICTED — testable from ARGO + OSNAP + RAPID data. Most urgent computation.
Current AMOC weakening as Γ_THC rise	PREDICTED — if Caesar/Boers signals are real, Γ_THC should be measurably elevated above historical baseline.
Saltwater DNS anchor	CANONICAL — θ_s = 50.103°, Λ = 1.8985. Viscosity Law V3 confirmed. Cell A Shallow Void.

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8. Summary

> "*The thread has been through the needle's eye ten thousand times. This time it is asking whether the eye will still be there.*"

Framework References

The Needle's Eye — Navier–Stokes. $\Gamma(A_0) < 1$ in 65/65 DNS data points. Segment 2.

Saturn North Pole — Segment 5. Saltwater DNS grounds both exemplars.

SFVFS™-DNS Programme — Beehive canonical, six fluids, Viscosity Law V3 (23 March 2026).

Stommel 1961, Rahmstorf 1995. RAPID array 2004–present. NGRIP/GISP2 ice cores.

V11 ANTI-WASH ADDENDUM

Seg 6: AMOC · April 2026

Anti-Wash Protocol: This addendum expands the infrastructure of Seg 6 without altering any original text. The March 2026 document is the geological baseline. This layer is dated April 2026. Nothing is deleted. Evolution is the art.

Addendum 1 — Scale Translation via Universality

New section appended to the Saltwater DNS Anchor (Section 5):

> Scale Translation via Universality (v11, April 2026). The saltwater DNS programme runs at laboratory scale: a periodic box of side length O(1 m), viscosity $\nu = 0.00105$, Reynolds number $Re \approx 10^3$–10^4. The AMOC system operates at ocean basin scale: $L \approx 10^7$ m, $Re \approx 10^{10}$–10^{12}. The DNS does not simulate the Atlantic. This must be stated explicitly.

The translation mechanism is universality, not direct simulation. The Beehive void cells (A, B, C) are topological attractors: they are determined by the geometric structure of the Navier–Stokes equations under incompressibility, not by the scale at which the equations are run. Viscosity Law V3 (ν alone determines void cell, molecular structure irrelevant) is the empirical signature of this universality: three molecular architectures at the same ν produce identical θ_s to three decimal places. The attractor is insensitive to molecular detail — it is a topological fixed point of the flow, not a property of the fluid chemistry.

What universality claims and does not claim. Universality claims: the void cell identity (A, B, or C) is determined by the dimensionless viscosity parameter alone, independent of molecular structure and, by extension, independent of scale. The saltwater DNS isolates which topological attractor class saltwater belongs to; it does not reproduce the Atlantic's Reynolds number, geometry, boundary conditions, or density stratification. Universality does not claim: that $\theta_s = 50.103°$ is the actual vorticity–strain angle observed in AMOC convective chimneys. The parking angle is a DNS observable at the laboratory scale; its value at AMOC scale requires a separate calculation or measurement. What transfers is the void cell identity (Cell A), not the specific angle.

The honest claim. The saltwater DNS anchor establishes that saltwater-driven rotating incompressible flow belongs to the Cell A topological attractor class. AMOC, as a saltwater-driven rotating incompressible flow, is predicted to belong to the same topological class. This is a classification result, not a simulation result. The geometric attractor type transfers via universality; the specific observable values require oceanographic measurement to verify. CF CONSISTENT not PASS.

Addendum 2 — Universality Table: What Transfers, What Does Not

Quantity	Transfers?	What transfers / what does not	Verification route
Void cell identity (A, B, C)	YES	Cell A topological attractor class transfers. Determined by NS geometry, not scale or molecular structure.	Viscosity Law V3: three molecular architectures, identical θ_s to three decimal places.
θ_s = 50.103° parking angle	NO	DNS-scale value only. AMOC-scale θ_s requires separate oceanographic measurement.	Strain eigenvalue mapping in convective chimneys (ARGO/OSNAP).
Λ = 1.8985 energy ratio	NO	DNS-scale value only. AMOC Λ requires separate measurement.	RAPID/OSNAP spectral analysis.
phi_az = 180° universal	YES	S^1 waist geometry: topological invariant, scale-independent. Azimuthal locking transfers.	phi_az universality confirmed across 5× viscosity range.
Cell A = Shallow Void	YES	AMOC belongs to Shallow Void family, not Deep Void (θ_s ≈ 90°).	Oceanographic strain measurement.

Quantity	Transfers?	What transfers / what does not	Verification route
Γ_THC < 1 prediction	YES	Dissipation-dominated VOID condition follows from Cell A membership. Structural prediction transfers.	ARGO + OSNAP + RAPID buoyancy flux data.

Addendum 3 — Programme Evolution Note

V11 Programme Note (April 2026). Since the March 2026 publication of this document, the SFVFS™ programme has advanced to 15 segments. AMOC remains the primary oceanic exemplar. The scale translation clarification in Addendum 1 is the principal V11 infrastructure expansion: it names the epistemic gap between laboratory DNS and ocean basin scale precisely, and identifies universality as the correct bridging mechanism. This is Anti-Wash in action: the gap was implicit in the March 2026 document; it is now explicit. CF CONSISTENT not PASS.

Kimi Verification Status

#	Addendum	Description	Kimi Verified
1	Scale Translation via Universality	DNS does not simulate the Atlantic; universality is the translation mechanism	□ April 2026
2	Universality Table	What transfers (topological class, phi_az) vs. what does not (θ_s value, Λ value)	□
3	Programme Evolution Note	15 segments; scale gap named explicitly	□ April 2026
