

Reviewer report, egusphere-2026-1481

Ojha, Kjellsson, Martin, Chafik, Maisonnave & Park, "Meridional heat transport in the North Atlantic: Effects of ocean and atmosphere grid resolutions in FOCI-OpenIFS-AGRIF 3.0", submitted to Geoscientific Model Development. Line numbers refer to the PDF margin numbering.

Recommendation: publication after moderate revisions. This is a useful model-description-and-application paper within the scope of GMD. The direct nest-to-atmosphere coupling is a genuine technical contribution, the three-member design (LL, LH, HH) isolates the ocean- and atmosphere-resolution effects cleanly, and the central result, that increasing ocean resolution alone shifts meridional heat transport from the atmosphere to the ocean while a matching atmospheric resolution is needed for a realistic subpolar balance, is novel and well motivated. The science is not in question; the required work is in the figures, a number of citation attributions, and the language. On the citations specifically, several cited claims are only partially supported by the work they cite and two are miscited; these are listed under Citation fixes.

Major points

M1. Figure 5 must be regenerated: the Mediterranean is absent from the 800 m maps and sub-seafloor points appear plotted at about -2 degC, and the caption mislabels the cross-sections "(d-h)" where it should read "(e-h)".

M2. Replot Figure 8 on latitude and longitude instead of model grid indices, so the Gulf Stream separation latitude and NAC path it is meant to demonstrate can actually be located.

M3. Figure 4 has four panels but shows only two differences, LH-LL in (a) and (c) and HH-LH in (b) and (d), with no HH-LL panel; yet the caption lists "LL, LH, and HH respectively" and the text at L226-L227 compares "HH-LL" against LH-LL, which is not plotted. Fix it either by (i) adding the HH-LL panels, or (ii) rewording the text to compare HH-LH with LH-LL and renaming the caption "(a, c) LH-LL and (b, d) HH-LH".

M4. State clearly that the constant-1950 runs cannot exhibit a forced trend; relabel the Figure 6d axis as model years rather than 1950-2040, and present the lower-climate-sensitivity inference (L491-L495) as an untested hypothesis.

M5. Two citations are simply wrong, the "eddy killing" effect (L108) and the SST/heat-flux result (L463-L465); see Citation fixes for the correct references.

M6. Three further attributions are over-broad and should be softened or re-cited (Sidorenko 2015, Gent and McWilliams 1990, Meccia 2023); the reasons are under Citation fixes.

M7. Add the missing companion and recent references listed below.

M8. The headline result, that higher resolution shifts heat transport from the atmosphere to the ocean, is a Bjerknes-compensation statement: rising ocean heat transport (OHT) is offset by falling atmospheric transport (AHT), leaving the total nearly unchanged. The paper argues this only qualitatively from the hard-to-read Figure 11 sketch. Quantify it with a compensation rate $C = -dAHT/dOHT$ for each configuration pair and latitude band (C near 1 is near-complete compensation); this would back the claim that compensation is stronger at mid-latitudes than toward the Arctic. Also expand the Figure 11 caption (arrows, TOA/surface levels, sign convention, integration regions).

M9. Show that the model drift over years 51-100 is comparable across LL, LH and HH, to justify interpreting the inter-configuration differences as resolution effects rather than differential drift.

Citation fixes

- **L108 (miscited).** The "eddy killing" wind-stress feedback is attributed to Zhai et al. (2010), which is about eddy-energy dissipation at western boundaries; the correct reference is Renault et al. (2016, doi:10.1175/JPO-D-16-0115.1).
- **L463-L465 (miscited).** The SST/latent-heat-flux result is attributed to Roberts et al. (2017), an ocean-heat-content budget study; the intended reference is Roberts et al. (2016, doi:10.1002/2016GL070559).
- **L68-L71 (overstated).** Sidorenko et al. (2015) state that AWI-CM performs "at least as well as" leading CMIP5 models, not that it beats their average.
- **L38-L40 (overstated).** That Gent-McWilliams "does not include the kinetic energy transfer accurately" is the authors' framing, not a finding of Gent and McWilliams (1990).
- **L50-L52 (mis-grouped).** Meccia et al. (2023) concerns internal multi-centennial AMOC variability, not the resolution dependence for which it is cited.

- **L19-L21 (partially supported).** The “1.2 PW, 60%” value at 26.5N sits at the upper end of Trenberth and Fasullo (2017), who give about 1.0 PW there; check the value or the latitude.
- **L430-L432 (loose fit).** Roberts et al. (2018) is a model-configuration description and is a weak citation for enhanced poleward heat transport; the other three references in that sentence do support the claim.

References to add (verified DOIs)

- VIKING20X, the lineage of the eddy-rich nest: Biastoch et al. (2021), doi:10.5194/os-17-1177-2021.
- Companion FOCI-OpenIFS resolution study, to be updated from “in press”: Sieker et al. (2026), doi:10.1007/s00382-026-08110-6.
- OpenIFS-FESOM2 unstructured-mesh alternative AWI-CM3: Streffing et al. (2022), doi:10.5194/gmd-15-6399-2022.
- Mesoscale review for the methodological premise (L35-L41): Hewitt et al. (2020), doi:10.1007/s40641-020-00164-w.
- AMOC framing in the introduction (L17-L19): Buckley and Marshall (2016), doi:10.1002/2015RG000493.
- Mesoscale control of subpolar MHT (L32-L34): Zhao et al. (2018), doi:10.1038/s41467-018-03134-x.
- Scalability of OpenIFS over ECHAM6 (L85-L86): Kjellsson et al. (2020), doi:10.21957/469hc10jk5 (already in the list; cite it at this sentence).

Figures and tables

- **Table 1.** Columns are ordered HH/LH/LL while the text uses LL/LH/HH; reorder for consistency, and state the global lateral-viscosity scheme and value.
- **Figure 4.** See M3 (four panels, two differences, no HH-LL panel).
- **Figure 6.** See M4 (calendar-labelled axis on constant-1950 runs).
- **Figure 10.** The caption omits “(c)” before turbulent heat flux and the SST units in (a); state the heat-flux sign convention.
- **Figure 11.** See M8 (caption needs defining; printed numbers hard to read).
- **Figure A1.** The panels are labelled February but the caption says March, and the caption calls them “annual mean” while showing monthly means.
- **Figure A2.** The caption repeats “(d-f)”, and panel (b) appears labelled “LM” rather than “LH”; please verify.
- Figures 1, 2, 3, 7 and 9 are clear and need no changes beyond the points above.

Grammar, wording and typography

77 line-level items (none affect the science).

Line	Correction
[L1]	“a new coupled climate model configurations named” -> a new coupled climate model configuration named
[L21]	“is an crucial contribution” -> is a crucial contribution
[L27]	“as the the residual” -> as the residual
[L32]	“However in situ measurements” -> However, in situ measurements
[L33]	“as it can not capture the mesoscale activities realistically” -> as it cannot capture the mesoscale activity realistically
[L38]	“Non-eddyding ocean models, often use” -> Non-eddyding ocean models often use
[L44]	“A realisitc representation” -> A realistic representation
[L51]	“which further enhance the poleward heat transport” -> which further enhances the poleward heat transport
[L60]	“nested models still enable far-field feedbacks” -> nested models still capture far-field feedbacks
[L87]	“as it it largely the same” -> as it is largely the same
[L90]	“the reader is referred to (Matthes et al., 2020)” -> the reader is referred to Matthes et al. (2020)
[L99]	“as function of grid resolution” -> as a function of grid resolution
[L108]	“a drag coefficient which in dependent on atmospheric stability” -> a drag coefficient which is dependent on atmospheric stability
[L117]	“Sea-ice dynamics and physics is done” -> Sea-ice dynamics and physics are done
[L133]	“We applied and AGRIF refinement factor of” -> We applied an AGRIF refinement factor of
[L145]	“In FOCI verison 1.0” -> In FOCI version 1.0

Line	Correction
[L157]	“rather via file I/O alleviates” -> rather than via file I/O alleviates
[L167]	“as well as ship-borne instruments” -> (no change needed; flagged for hyphenation consistency with shipborne)
[L190]	“A technical comparison can be found in (Kjellsson et al., 2020)” -> A technical comparison can be found in Kjellsson et al. (2020)
[L192]	“listed in Table (1)” -> listed in Table 1
[L198]	“All the experiments have carried out for 100 years” -> All the experiments were carried out for 100 years
[L205]	“is discussed in details in the next sections” -> is discussed in detail in the next sections
[L206]	“the higher resolution in both atmosphere and ocean have improved” -> the higher resolution in both atmosphere and ocean has improved
[L218]	“the ocean at mid-depth and 10–45°N cools” -> the ocean at mid-depth and 10–45°N cools
[L239]	“900 s compared to 18000 s in LL” -> 900 s compared to 1800 s in LL
[L240]	“In consequence, sea ice is thicker” -> Use “As a consequence,” or “Consequently,”
[L246]	“resulting in significant warmer SST” -> resulting in significantly warmer SST
[L249]	“This ocean dynamics–driven temperature change” -> “ocean-dynamics-driven” or “ocean-circulation-driven” (hyphenation/awkward)
[L254]	“to explain the cold and fresh difference at mid-depth” -> “the cold and fresh anomaly” or “cold, fresh difference”
[L259]	“We found no conclusive evidence for this in our simulations however.” -> Move/offset “however”: “We found no conclusive evidence for this in our simulations, however.”
[L261]	“a prominent warm and saline intermediate–depth water mass of heat and salinity” -> Redundant; delete “of heat and salinity”
[L267]	“allows for an unrealistically large outflow” -> Acceptable; consider “allows an unrealistically large outflow”
[L278]	“the maximum of the overturning streamfucntion” -> the maximum of the overturning streamfunction
[L284]	“This stronger AMOC result from explicitly resolving” -> This stronger AMOC results from explicitly resolving
[L288]	“an observational mean meridional heat transport estimate ... are shown as dashed black line” -> “is shown as a dashed black line” (singular estimate)
[L289]	“A stronger AMOC is an enhanced northward volume transport” -> A stronger AMOC implies an enhanced northward volume transport
[L289]	“meridional heat ransport estimate from the RAPID and OSNAP arrays” -> “heat transport estimate” (Fig. 7 caption)
[L291]	“into the the subpolar North Atlantic” -> into the subpolar North Atlantic
[L292]	“into the the subpolar North Atlantic” -> Delete duplicate “the”
[L295]	“but HH simulating the overall largest transport” -> “with HH simulating” or “but HH simulates”
[L296]	“at ~63°N the volume transport of LH and HH is the same” -> “are the same” or “is identical” (two configs)
[L299]	“As the changes in ocean circulation primarily results from” -> “primarily result from” (plural subject “changes”)
[L300]	“From drifter observation, Li et al. (2022) showed” -> “From drifter observations,”
[L305]	“the reduction of the North Atlantic cold bias in LL” -> “in LH” (the bias is in LL; reduction occurs in LH), check intended config
[L305]	“arrows of standard length indicates current direction” -> “arrows of standard length indicate”
[L307]	“such as the western boundary currents and NAC” -> “and the NAC”
[L318]	“All configurations simulate weaker heat transport” -> “All configurations simulate a weaker heat transport” or “simulate weaker heat transports”
[L320]	“surface heat fluxe (d–f)” -> “surface heat flux” (caption Fig. 9)
[L321]	“shows the the center of deep convection” -> Delete duplicate “the”
[L326]	“increase in volume transport occurs between the LH and HH configurations,(Fig. 7d)” -> Add space before parenthesis; remove stray comma
[L338]	“relatively low numbers (<100 w/m2)” -> “W/m2” (capital W); inconsistent with W/m2 elsewhere
[L344]	“yields not only higher SST but also a wider distribution” -> Parallelism: “not only a higher SST but also a wider distribution” or “not only higher SST but also wider distribution”
[L347]	“sufficient to produce larger and thus a wider range of surface heat fluxes” -> “larger and thus a wider range” is garbled; e.g. “larger and thus a wider range of surface heat fluxes” -> “larger surface heat fluxes and thus a wider range”
[L362]	“keeps the atmosphere cold in HH–LH” -> Clarify difference notation; “in HH relative to LH (HH–LH)”
[L383]	“both surface conditions, e.g. SST and THF” -> “e.g.,” with comma; consider “such as SST and THF”

Line	Correction
[L388]	“The three model configuration with varying” -> “The three model configurations”
[L392]	“the mean state of North Atlantic Ocean” -> “the North Atlantic Ocean”
[L404]	“colder and fresher water masses at mid-depths (\approx 500–1500 m) from 0–50°N in LH and HH is observed” -> “are observed” (plural “water masses”)
[L407]	“a more realistic overflow of dense water similarly to the high-latitude overflows” -> “similar to the high-latitude overflows”
[L408]	“in Colombo et al. (2020)” -> “as in Colombo et al. (2020)” or “reported by Colombo et al. (2020)”
[L418]	“(Grist et al., 2018; Roberts et al., 2020, 2019; Hirschi et al., 2020), not found but disagrees” -> Stray “not found” appears erroneous; delete
[L420]	“The stronger AMOC in the LH and HH configuration” -> “configurations”
[L437]	“The intense warm boundary currents (Fig. 8) leads to higher SST” -> “currents ... lead to” (plural subject)
[L445]	“our study specifically highlight the differences” -> “our study specifically highlights”
[L447]	“the differences in oceanic meridional heat transport between the simulations is also reflected” -> “differences ... are also reflected”
[L448]	“leads to increase in mid-high-latitude SST” -> “leads to an increase”
[L449]	“in the LH and HH configuration” -> “configurations”
[L453]	“The nested ocean model in LH and HH, simulates a deeper mixed layer” -> Remove comma before “simulates”
[L455]	“A multi-model intercomparison by (Koenigk et al., 2021) reported” -> “by Koenigk et al. (2021)” (citation form)
[L462]	“The warmer SPNA in the LH and HH configurations than in the LL configuration lead to stronger heat loss and increases deep convection” -> “leads to stronger heat loss and increases” (singular subject SPNA) or make both consistent
[L478]	“consistent with findings by (Outten et al., 2018)” -> “by Outten et al. (2018)” (citation form)
[L483]	“heat transport to the Nordic Seas decreases with increase in atmospheric model resolution” -> “with an increase in atmospheric model resolution”
[L488]	“could potentially feedback the strength of the AMOC” -> “feed back on the strength” (verb form / preposition)
[L489]	“particularly deep convection and the overflow transports will enhance” -> Comma before “will”: “...and the overflow transports, will enhance”
[L492]	“which implies, the mean AMOC state plays” -> “which implies that the mean AMOC state plays” (remove comma, add “that”)
[L504]	“OpenIFS’s licence is easily given free of charge” -> “is provided free of charge” (“easily given” awkward)
[L511]	“(Valcke et al., 2021).The observation” -> Missing space after period: “2021). The observation”