

Response document to reviews on egusphere-2026-1852 RC1

Reviewer comments are presented first in *blue italics*, then followed by the author's response in normal font. Line numbers are referring to the original manuscript and are denoted as L145 for Line 145. For changes to text, we include the original in **red** and the changed version or new additions in italic *green*.

General comments

The manuscript, "A high-resolution, submesoscale-resolving ocean model of South East Queensland (ROMS v4.2)," presents a new high-resolution ocean model covering southeast Queensland and northern New South Wales, developed to realistically represent submesoscale processes in a region where the East Australian Current interacts with the continental shelf. The authors provide a comprehensive model evaluation using a wide range of both surface and subsurface observations. They also demonstrate that the high-resolution SEQId ROMS simulation captures substantially more kinetic energy within the mesoscale and submesoscale bands than coarser-resolution model and observation.

Although the evaluation identifies some model deficiencies, including a cold bias over the shelf and discrepancies in volume transport magnitude and phase relative to observations, these limitations are expected. As the model does not employ data assimilation, it is not intended to reproduce ocean features at their exact time and location. Rather, its purpose is to provide a dynamically consistent and realistic representation of the regional circulation and associated submesoscale processes.

Overall, this is a well-written and easy to follow manuscript describing a valuable modelling framework that will benefit future studies in the region. I recommend publication after the authors address the comments and suggestions provided below.

We thank the reviewer for their thorough consideration of our manuscript.

Specific comments

Introduction

L66 and L73: Regarding "intensification region" and "intensification zone", I find this terminology confusing. First, because your model domain covers much more than just the so-called intensification zone. The intensification zone is a specific area in the northern part of your domain. Second, it has been shown that the EAC jet intensifies poleward from 27.5°S to 32°S, reaching its maximum at 32°S (Kerry, 2020). Since your simulation only covers the year 2012, you do not have sufficient seasonal, interannual, and decadal variability to conclude that this is consistently the region where the jet intensifies. I recommend specifying the latitude where the intensification occurs, e.g. "jet intensification at 25°S" or "northern jet intensification", and using this terminology consistently throughout the manuscript.

We take the point that the model has a broader focus than the intensification zone, which has significant latitudinal variation. We have chosen to instead use the phrase 'jet-dominated' instead of 'intensification', changing the following lines to:

L11:

For the EAC jet-dominated region

L50:

This jet-dominated region is a critical dynamic zone:

L53:

the jet-dominated region has received

L66:

most energetic, jet-dominated region,

L73:

EAC jet-dominated zone, designed to answer

L281:

upstream adjustment region of the EAC jet-dominated zone.

L287:

focus on the EAC jet-dominated zone with a

L295:

East Australian Current system in the jet-dominated zone

L318:

resolve the mesoscale circulation of the EAC jet-dominated zone and the submesoscale

L341:

submesoscale-permitting ocean simulation of the jet-dominated zone of the East Australian Current

L73: "... numerical ocean model of the EAC jet intensification zone." Again, your model covers almost the entire EAC jet, not only the region where it intensifies around 25°S. Please revise this throughout the manuscript wherever it appears.

See above.

Model description

L88: For a more logical structure, begin with the model simulation period (move the first sentence of the paragraph starting at L124, leaving the "Model spin-up..." sentence to be included with the forcing description). Then describe the model domain (L95–97: "The model

domain..."). Move the descriptive paragraph beginning at L105 (key model features) to before the description of the vertical stretching. Then present the horizontal resolution, vertical stretching, lateral and surface forcing, initial conditions, and finally the model spin-up.

We have re-arranged mostly following the suggestions from the reviewer:

- We use the Regional Ocean Modelling System...
- The model domain extends...
- Key features in the model domain are...
- For SEQId ROMS we configure the vertical stretching parameters...
- We use the Generic Length Scale vertical mixing scheme...
- The model surface and lateral boundaries...
- Simulation period and spin-up

We opted to follow the model description with the design of the experiment (simulation time period and spin-up).

- *You need a section describing the datasets used for model evaluation. Please include the spatial and temporal resolution, the number and spatial distribution of Argo floats, details of the mooring array, and whether the model output was extracted at the same latitude/location as the observations. This information should be clearly described in the manuscript.*

As both reviewers pointed out, more information needs to be given about the observational datasets. We have added a new subsection in the methods, "Observational datasets":

2.1 Observational datasets

The surface, subsurface and submesoscale characteristics of the SEQId ROMS simulation are compared against observational datasets of sea surface temperature and height, circulation, temperature and salinity properties, transport and kinetic energy. These datasets allow for an assessment of the model's large scale hydrography and circulation, as well as the mesoscale and submesoscale variability.

Daily sea surface temperature fields from the Operational Sea Surface Temperature and Ice Analysis (OSTIA; Good et al., 2020) are used to evaluate the modelled surface thermal structure. OSTIA provides a gridded, satellite and in situ observation-based estimate of global SST.

Gridded satellite-derived sea surface height observations are used to assess the spatial variability of surface height anomalies and geostrophic ocean circulation. The IMOS OceanCurrent DM03 gridded, multi-mission altimetry compilation (IMOS, 2025a) provides an estimate of geostrophic surface currents and surface elevation at ~20km spatial resolution. The dataset for 2012 is used for comparison with modelled circulation and kinetic energy spectra. In addition, high-resolution (250 m) Surface Water and Ocean Topography (SWOT) Level-3, unsmoothed, filtered, surface ocean topography observations (AVISO/DUACS, 2024) along swath paths parallel to the SE Qld coast are used to examine spatial variability at finer scales. The high-spatial resolution of the unsmoothed SWOT product is used for spectral comparisons of geostrophic kinetic energy. As the SWOT observations do not coincide temporally with the 2012 model simulations, these comparisons (with cycle 44,

passes 198 and 476, from 10- and 20-January-2026) are interpreted as statistical assessments of spatial variability rather than direct contemporaneous validation.

Argo temperature and salinity profiles (Wong et al., 2020) provide in situ observations of the hydrographic structure throughout the domain (IMOS, 2025b). The dataset used here comprises over 2.3 million measurements from 107 drifting profiling floats, taken from 4075 profiles. Profiles are taken from 2012 to 2026, in order to provide as much data for comparison as possible (as 2012 only had 330 profiles). Argo profiles were scattered evenly over the whole domain, though with limited measurements on the continental shelf. Observations of velocity from the EAC mooring array are provided as gridded fields constructed using self-organising maps (Sloyan et al., 2024).

Model evaluation and results

L147, L153 and L180: *In all three cases, the manuscript overlooks the fact that the model exhibits considerably cooler temperatures on the shelf between 27°S and 31°S, while attributing significant errors mainly to the coarse-resolution products. Although you used RAMSSA SST, OSTIA would likely be a better observational product for this region. Since you state in L159 that the model "may in fact be closer to reality than implied by the calculated RMSE...", I suggest repeating the SST comparison using OSTIA to determine whether the observed shelf cooling is also present in that product.*

All analysis now uses OSTIA, and references to RAMSSA have been replaced with OSTIA. With OSTIA, we now see a hint of cooler coastal waters - though not to the degree as seen in the model.

We've added more context to the line:

"though the eastern half of the domain displays a warm bias. Waters in Moreton Bay and immediately adjacent to the coast southwards from 29S have a cool bias, though this signal is present to a lesser degree in OSTIA."

We have modified this:

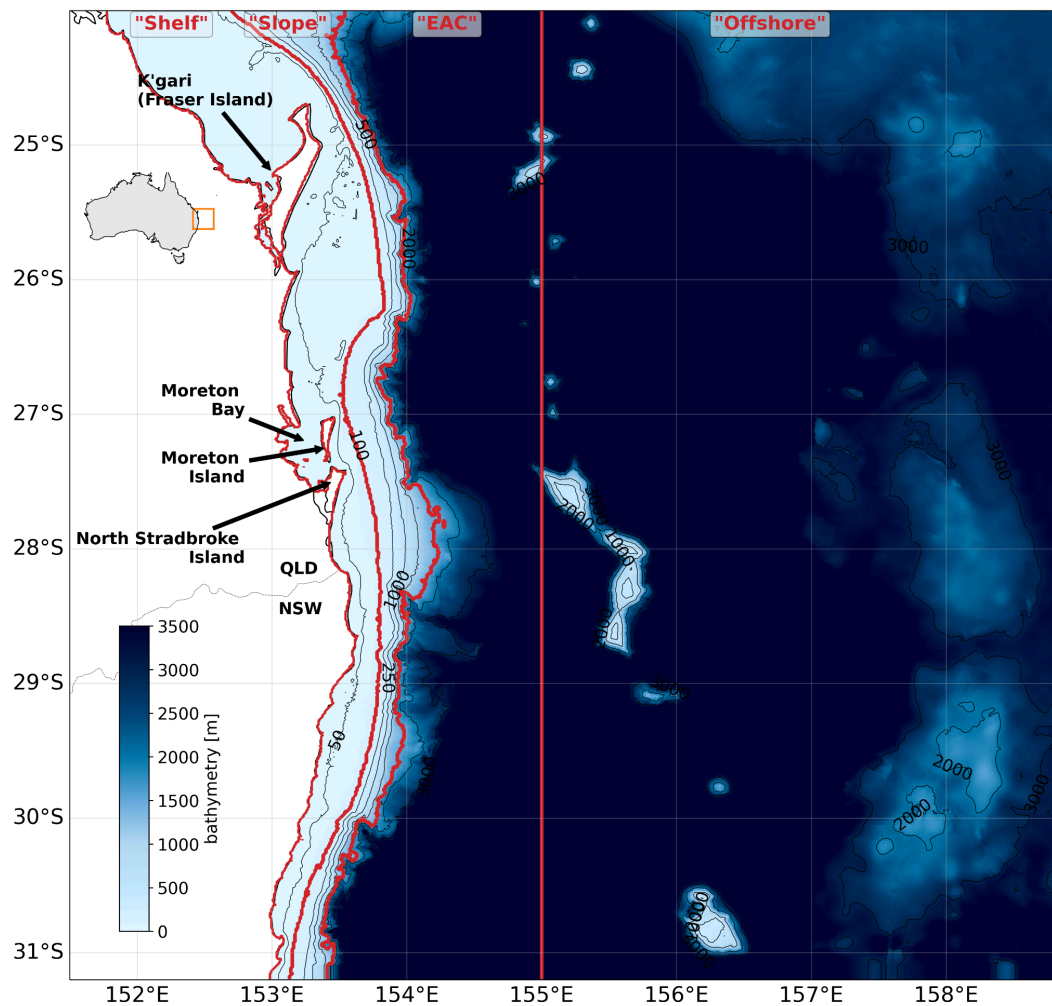
"Shelf observations may also contain significant error - arising from coarse resolution and complex coastal geography - such that the model representation may in fact be closer to reality than implied by the calculated RMSE (e.g. Figure 3a)."

To:

"Differences between the model and observations on the continental shelf (e.g. Figure 3a) may also reflect limitations in the gridded observation product in the vicinity of coastlines and coastal geography."

- *I would like to see a map showing the mean circulation, SST and isobars with the four defined regions (shelf, slope, EAC, and offshore) overlaid. Unless there is a specific reason to use <100 m, I would also recommend adopting the more common definition of the shelf as ≤200 m.*

The mean circulation and contoured mean SST is already shown in Figure 2, panels a and c. However, I have updated Figure 1 (and its caption) to include the regions as specified in caption of Figure 3:



With regards to the shelf definition being $<100\text{m}$, we take the reviewers point. However, we're not using these definitions for dynamic classification of water masses, instead, they're used to partition the domain for the RMS calculations. We have modified the text to more clearly say this:

The regions are not intended to exactly represent distinct dynamical regimes, but rather provide a partition of the model domain for evaluating spatial variations in RMS error. In particular, the slope and EAC regions should not be interpreted as separating slope-only and EAC-dominated waters, as the EAC extends across the continental slope.

- *For the TS diagram, you do not specify the number of Argo floats used, the time period (I assume they are from 2012), or whether they were colocated with the model output. It would also be useful to include a supplementary figure showing the spatial distribution of the Argo profiles used, so the reader can assess their coverage and potential sampling biases.*

We have added information on the Argo floats in the new methods section (See above). We decided not to add a map of the spatial distribution, as they are scattered over the whole domain (except generally on the continental shelf). This has been described in the new observational dataset section.

Submesoscale dynamics

- *To improve the logical flow, I suggest beginning this section with the SEQId ROMS vs BRAN comparison (Figures 6 and 7), followed by the whole-domain diagnostics (Figure 5), and finally the K'gari analysis (Figure 8). This sequence completes the model evaluation before moving into the diagnosis of submesoscale dynamics.*

We have adjusted the submesoscale dynamics results section as suggested, by rearranging to be:

- Assess SEQId ROMS vs. BRAN, surface observations,
- Whole domain snapshot analysis,
- Case study of K'gari.

In addition, the lead in sentence to the KE analysis:

To calculate the kinetic energy spectra (Figure 6a), two-dimensional Fourier transforms are applied to the horizontal velocity components u and v . Spectral kinetic energy density is then computed using Parseval's theorem as $E(k_x, k_y) = 1/2(|\{u\}|^2 + |\{v\}|^2)$ where $\{u\}$ and $\{v\}$ are the Fourier components.

Is changed to:

To examine the representation of variability across spatial scales, including the emergence of submesoscale variability in the high-resolution simulation, kinetic energy spectra are calculated for the SEQId ROMS and BRAN2023 simulations, compared with two observational products (Figure 6a). The spectra are calculated by applying two-dimensional Fourier transforms to the horizontal velocity components u and v .

Technical comments

Abstract

L1–5: This section is rather long for an abstract. It could be shortened by providing a more concise explanation of what submesoscale processes are and why they are important. Some of this material could instead be moved to the Introduction.

The ocean exhibits a continuum of motions spanning basin-scale circulation to micro-scale turbulence where between mesoscale eddies and small-scale turbulence lies the submesoscale (~0.1-10 km, hours-days). The submesoscale is characterised by fronts, filaments and small coherent vortices that arise from instabilities of mesoscale currents, interactions with topography, and buoyancy forcing.

Changed to:

The ocean exhibits a continuum of motions spanning basin-scale circulation, mesoscale eddies, the submesoscale, and micro-scale turbulence. The submesoscale encompasses motions with spatial scales of O(0.1-10) km and timescales of hours-days, and is characterised by fronts, filaments and small coherent vortices.

L6: "... the jet accelerates and interacts with the ..." Please provide more context. Where does it accelerate? Does it only interact with the shelf when it accelerates?

the western boundary current of the South Pacific Gyre, the jet accelerates and interacts with the continental shelf off South East Queensland

Changed to:

the western boundary current of the South Pacific Gyre, the jet accelerates along the South East Queensland continental margin, while interacting with the adjacent continental shelf

L8: "...in existing regional simulations" — do you mean simulations for southeast Queensland specifically, or for the broader region?

Changed to:

Yet these processes remain unresolved and unexplored in existing simulations of this region

L11: "...for the EAC jet intensification region" Again, the model is not limited to the jet intensification region; it covers the entire jet extension. Consider rephrasing to something like "for the EAC jet-dominated region (latitude range)."

We have adjusted as suggested, though we haven't added the latitude range, as it might suggest that the latitude range is the range of the jet-dominated region (which is poorly defined, as the reviewer suggests), rather than the range of the model. However, following above comment, we have changed to:

Here, we present a submesoscale-permitting implementation of the Regional Ocean Modelling System (ROMS v4.2) covering the EAC jet-dominated region of South East Queensland and northern New South Wales, Australia (South East Queensland Ocean Model; "SEQId ROMS").

L14: "... increased hotspots of divergence ..." Divergence of what? Please clarify.

Changed to:

Relative to mesoscale-resolving simulations, SEQId ROMS exhibits hotspots of substantially increased horizontal velocity divergence, vorticity

L15: "... flatter kinetic energy spectrum" Flatter where? Please provide more context.

Changed to:

and a kinetic energy spectrum that is flatter over the mesoscale and submesoscale wavenumber ranges, indicating greater kinetic energy at smaller scales.

L16: "... vicinity of K'gari" Please include the latitude.

From:

A demonstration of the continental shelf break in the vicinity of K'gari shows the accelerating jet interacting with coastal promontories and the shelf break, producing localised and persistent submesoscale activity.

Changed to:

Near K'gari (~25S), the accelerating EAC jet interacts with coastal promontories and the shelf break, producing localised and persistent submesoscale activity.

L17: "This configuration" Which configuration? Please be specific.

Changed to:

The SEQId ROMS configuration enables investigation of submesoscale emergence

L18: "...jet-shelf modification..." This expression is unclear. Please clarify what is meant.

Changed to "jet-shelf interaction" which is a well investigated concept:

investigation of submesoscale emergence and interaction with the mesoscale circulation, including jet-shelf interaction,

L19: "This approach" Which approach? Please state it explicitly.

Changed to:

The SEQId ROMS configuration enables investigation of submesoscale emergence and interaction with the mesoscale circulation, including jet-shelf interaction, cross-shelf exchange and energy transfer across scales, with insights relevant beyond the East Australian Current to other western boundary current systems.

L19: "pathway" is repeated twice in close succession.

See above.

Introduction

L25: "... sustained observations of submesoscale processes remain challenging." Please briefly explain why they remain challenging.

From:

While large-scale and mesoscale features can be observed from satellite and inferred from long-term monitoring, sustained observations of submesoscale processes remain challenging, leading to large unknowns.

Changed to:

While large-scale and mesoscale features can be observed from satellite and inferred from long-term monitoring, sustained observations of submesoscale processes remain challenging due to their short spatial and temporal scales, leading to large unknowns.

L32: "... horizontal strain and extension" Please clarify what is meant by "extension".

Changed to:

Common submesoscale features include eddies (rotating bodies of water), filaments (elongated regions of coherent water properties formed by enhanced horizontal strain and stretching) and fronts (sharp horizontal gradients in water properties).

L42–43: "... strongly influences ocean conditions ..." Please provide more context on how the EAC influences ocean conditions.

Changed to:

The East Australian Current (EAC), the western boundary current of the South Pacific Gyre, strongly influences water mass properties and circulation, weather and climate along Australia's populous east coast (Oke et al., 2019),

L44–50: Consider adding the circulation schematic to Figure 1 and referring to it here.

See above comment. We have kept the circulation and SST in Figure 2, but updated Figure 1 to include the diagnostic regions.

L54: The citation displayed as Sloyan et al. (2024) should be Chapman et al. (2024).

This citation has been updated to Chapman et al., (2024).

L65: "Yet" is repeated. Please reword.

Changed to:

However, no studies have yet examined the prevalence

Model description

L125: The hyperlink for Sloyan et al. (2024) points to Chapman et al. (2024). Please check this throughout the manuscript.

The citation hyperlink seems to correctly point to the Sloyan et al references in the bibliography, and the DOI link resolves to the correct website for the Sloyan publication. Possibly it was fixed through re-compiling.

- After introducing the model name **SEQId ROMS**, use this consistently throughout the manuscript instead of simply "ROMS" to avoid ambiguity.

Changed to "**SEQId ROMS**" at L220, L226, L228, Fig 7 caption, L246, L247, L250, L256, L258, L314, L317

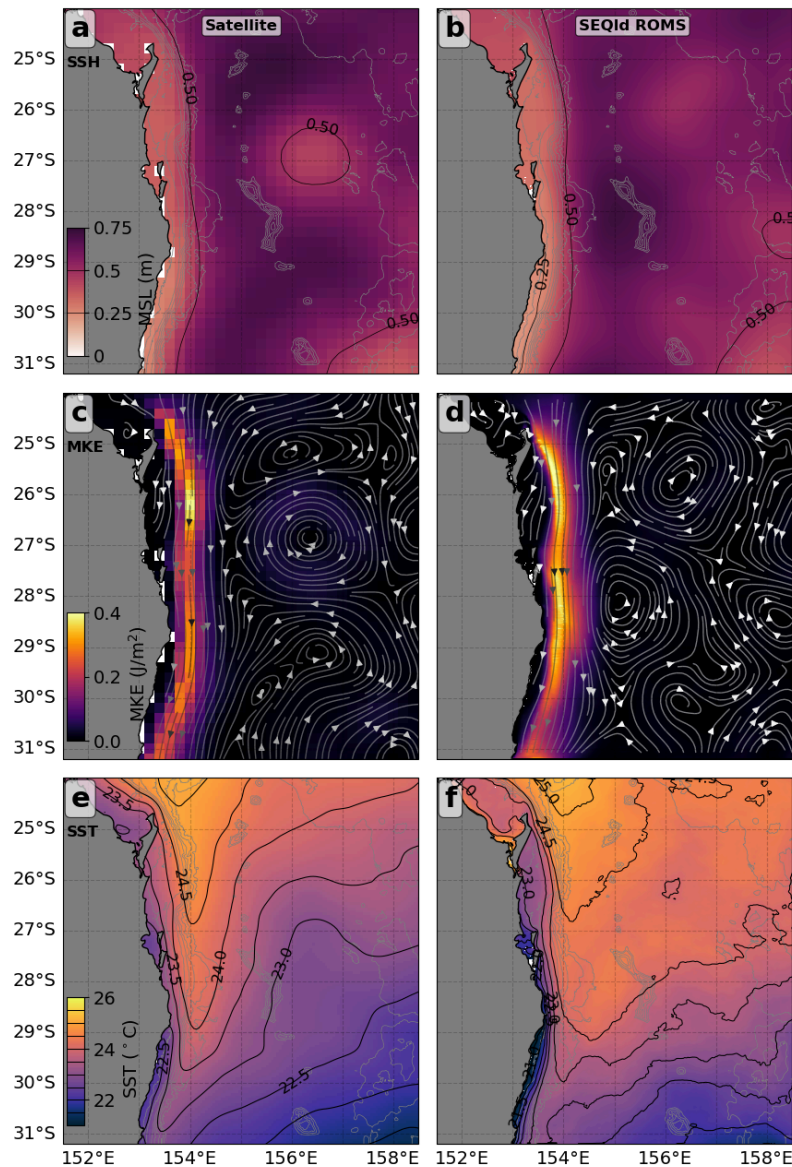
Model evaluation and results

Figure 2

- Label the columns as **Satellite** and **SEQId ROMS**, rather than simply Obs and Model. Corrected.
- Add panel titles indicating the variable (SSH, MKE, SST). Corrected.
- For SSH, include contour labels. Corrected.
- For SST, adjust the contour labels to improve visibility. Corrected.

- *Add bathymetric contours to the SSH and SST panels.* Corrected.

Corrected as suggested:



L128: *Since there is only one subsection, I recommend removing subsection 3.1.*

Section 4 Submesoscale dynamics has been renamed as subsection 3.2. Section 3 is Results, Section 3.1 is Mean state evaluation, Section 3.2 is Submesoscale dynamics.

L129: *Remove "this" from "We evaluate the ability of this SEQId ROMS..."*

Changed to:

We evaluate the ability of SEQId ROMS to represent

L150: *Include the region definitions in the text rather than only in the Figure 3 caption, and briefly justify the chosen boundaries.*

Changed to:

This analysis is further broken up, with spatial averages over four regions: shelf (<100 m deep, where shelf processes dominate), slope (between 100 m to 1500 m deep, and west of 154.3E), EAC (deeper than 1500 m and west of 155S) and offshore (east of 155E). The regions are not intended to exactly represent distinct dynamical regimes, but rather provide a partition of the model domain for evaluating spatial variations in RMS error. In particular, the slope and EAC regions should not be interpreted as separating slope-only and EAC-dominated waters, as the EAC extends across the continental slope.

L160: Add (Figure 1) at the end of the sentence.

Changed to:

Overall, these results demonstrate that SEQId ROMS captures both the observed temporal evolution (Figure 3) and the large-scale spatial structure (Figure 2).

Figure 3 caption

- *Remove the RMSE equation, as it already appears in the main text.* We would prefer to leave it both in the text and the caption for quick reference.
- *Adjust the RMSE annotation, as some text overlaps the plotted lines.* To address this comment, we have moved the 'RMSE = ...' wherever it would overlap the plotted lines:

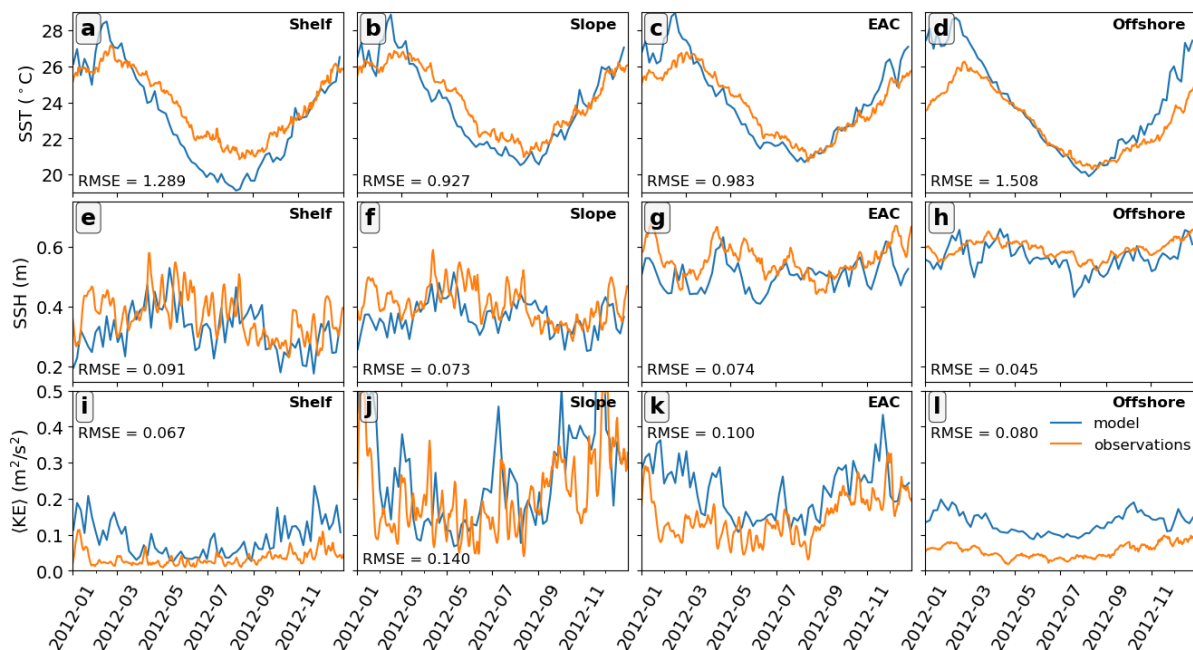
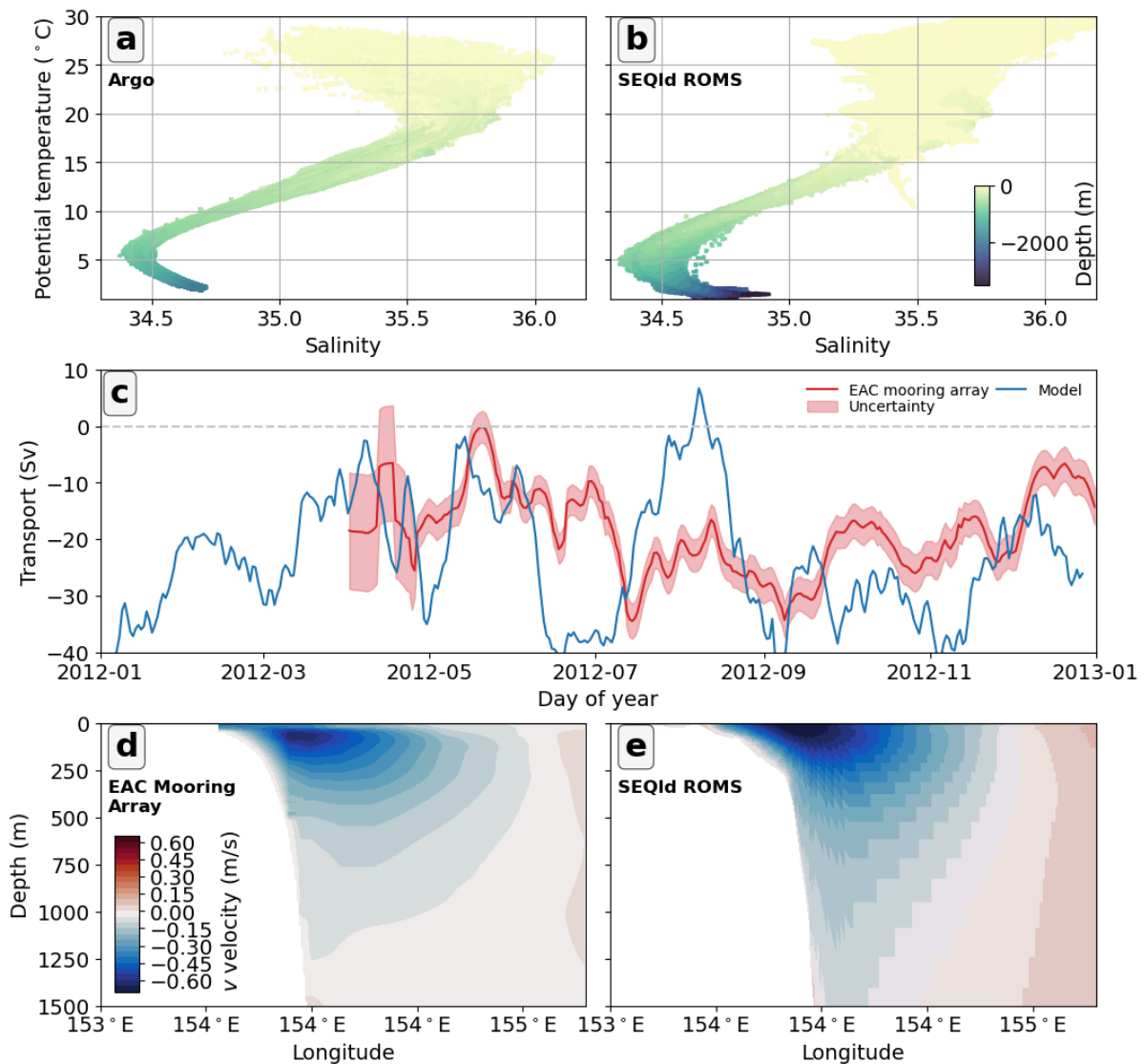


Figure 4

- *Add titles to panels (a) and (b): **Argo** and **SEQId ROMS**, respectively.*
- *Salinity units are missing.* Model output is on the practical salinity scale and so it is inappropriate to show units. We have added to caption: *Salinity is reported as Practical Salinity (PSS-78) and is therefore dimensionless.*
- *Add titles to panels (d) and (e): **Mooring array** and **SEQId ROMS**, respectively.*

Figure 4 has been updated as suggested above. Further, we have corrected an analysis issue which was sampling the transect along the whole model latitude, rather than just along the line of the mooring array. Correcting this issue brings the model volume transport, for the most part, closer to the observations. We have also updated the volume transport to daily model output (rather than 5 day averages).



L179: Replace the parentheses around "The biases..." with commas, as this is relevant information and does not require parentheses.

Changed to:

The biases, warm SST over the east of the domain and cool SST immediately adjacent to the coastline, are not considered to be fundamental issues.

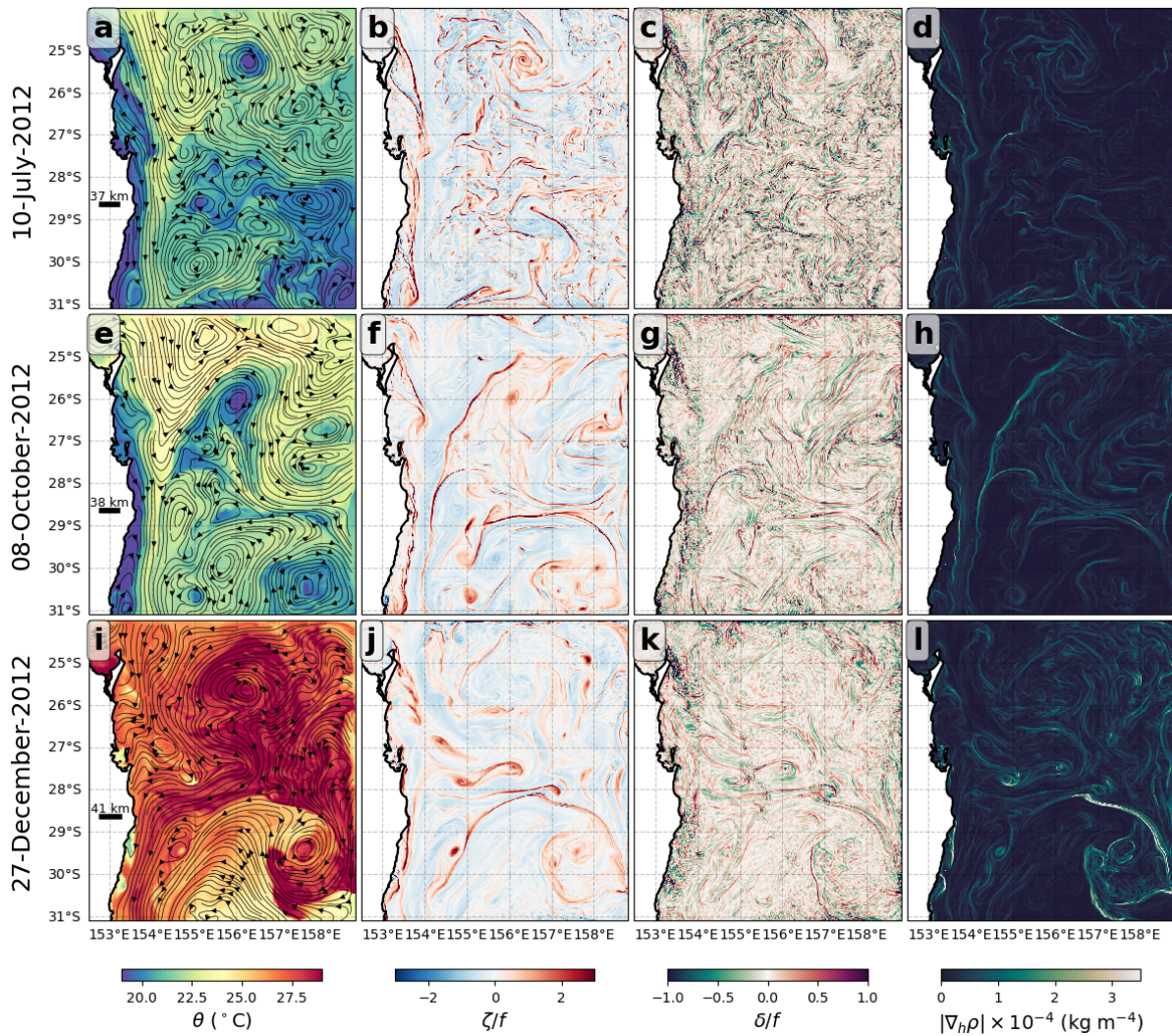
Submesoscale dynamics

Figure 5

- Add the year to the figure titles.

- Increase the font size of the colour bar labels.
- Add a top-row panel showing surface circulation and SST to help interpret the diagnostics.

Figure 5 has been updated and transposed (for a better layout), and label references updated accordingly:



The figure description has been updated:

The SST and circulation fields show the characteristic signature of the EAC jet, with the warm EAC waters and strong along-shelf flow evident (Figure 7a,e). Embedded within and along the edges of the jet are numerous filaments and smaller-scale features that evolve between snapshots.

And a description of the submesoscale marker has been updated in the caption:

In (a,e,i), a length scale marker indicates the approximate boundary between mesoscale and submesoscale motions at this latitude and time, calculated from the Coriolis parameter and stratification in the EAC (the first baroclinic Rossby radius).

Caption

- *Begin with "SEQId ROMS diagnostics..."* Changed to: *SEQId ROMS diagnostics of submesoscale activity are presented*
- *Specify **horizontal flow convergence**.* Changed as suggested.
- *Include austral winter and austral summer, together with the corresponding dates (10 July 2012; 8 October 2012; 27 December 2012).* Changed to: *These fields are calculated for several snapshot periods: (a-d) 10-July-2012, (e-h) 08-October-2012 and (i-l) 27-December-2012.* Later in the caption, we added: *"Snapshots were chosen to highlight times with strong submesoscale activity occurring from austral winter to austral summer."*
- *Add the year to all dates.* Added.

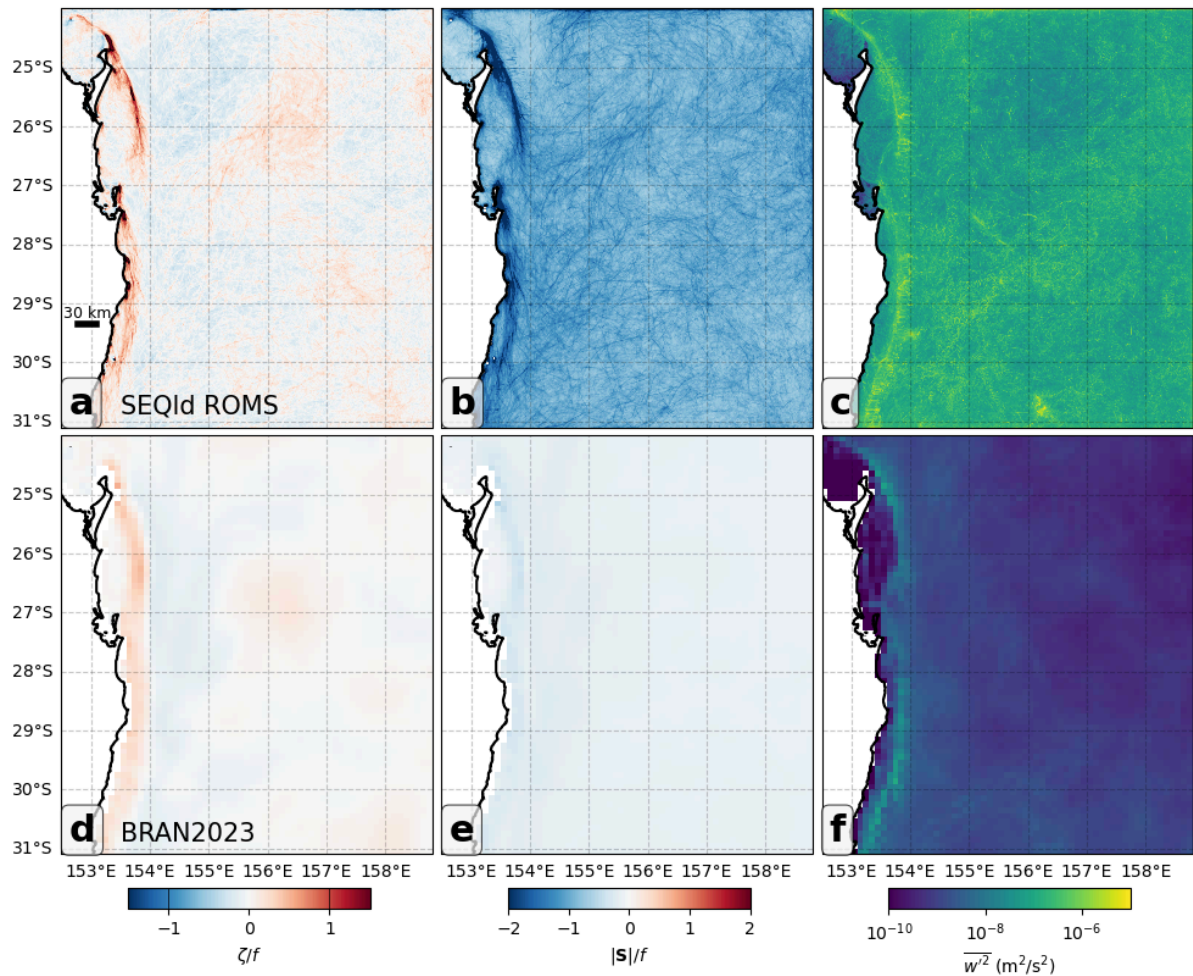
Paragraph beginning at L202

- *When describing Figure 5 (L203), because all features appear in all panels, I suggest removing the individual panel references and instead referring collectively at the end of the sentence, e.g. "...small submesoscale eddies (Figure 5a–c)."* Changed as suggested.
- **L203:** *Delete "in" from "... (e.g. Figure 5b) and in small submesoscale eddies..."* Changed as suggested.
- **L204:** *When stating that "...fields have patches of $O(1)$ which shift through time", provide an example region (as you do later for K'gari) to help the reader understand where these shifting features occur.* Added: *"(for example, a filament of strong divergence occurs on 08-October-2012 at 154.5E, 28S; Figure 7g)"*
- **L207:** *Add flow before divergence.* Changed as suggested.

Figure 6

- *Add **SEQId ROMS** and **BRAN** labels to the right of the corresponding rows.*
- *For the Ro panels (a) and (d), reducing the colour bar limits may improve the visibility of offshore features without compromising the shelf features.*

Both issues have been fixed:



L208: Replace our model with **SEQId ROMS**. Occurrences of “our model” replaced with SEQId ROMS at Figure 6 caption, L208 and abstract L12.

L211: Delete “the” from “to expect time slices from the **SEQId ROMS**”. Sentences have been deleted.

L212: End the sentence after metrics. Begin the following sentence with “We compare annual-mean fields...” Sentences have been deleted. Instead, at the end, we say: *Furthermore, annual averaging is used because these diagnostics exhibit substantial short-term variability, making instantaneous comparisons between independent simulations less informative.*

L213: Move the magnitude strain equation from L218 to its first mention in L213. Changed as suggested. We also moved the Rossby number definition to this same location.

L213: Explain why the analysis is averaged over the upper 100 m. Changed to: *averaged over the top 100 m. Analysis considers this depth as it captures the majority of the mixed layer where submesoscale dynamics are most active.*

L215: Add respectively in (Figure 6a,d, respectively). Changed.

- Replace all occurrences of **ROMS** with **SEQId ROMS**. See above changes.

L262: Add respectively to (Figure 8a,b, respectively).Changed.

Discussion and conclusions

- *Please refer to the earlier comment regarding the use of intensification zone and ensure consistent use of the model name **SEQId ROMS** throughout the manuscript.*
Changed as per suggestions above.