RESILIENCE AND RECOVERY IN AQUATIC SYSTEMS
ASLO AQUATIC SCIENCES MEETING 2023
4–9 JUNE 2023 · PALMA DE MALLORCA, SPAIN

HIGH RESOLUTION OCEAN COLOUR IMAGES TO DETECT FINE-SCALE FRONTS:

A case study from Aotearoa – New Zealand

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Background

"What is the spatio-temporal variability of fine-scale fronts?"

- Fronts are ubiquitous, yet out understanding is biased toward physical parameters at large scales.

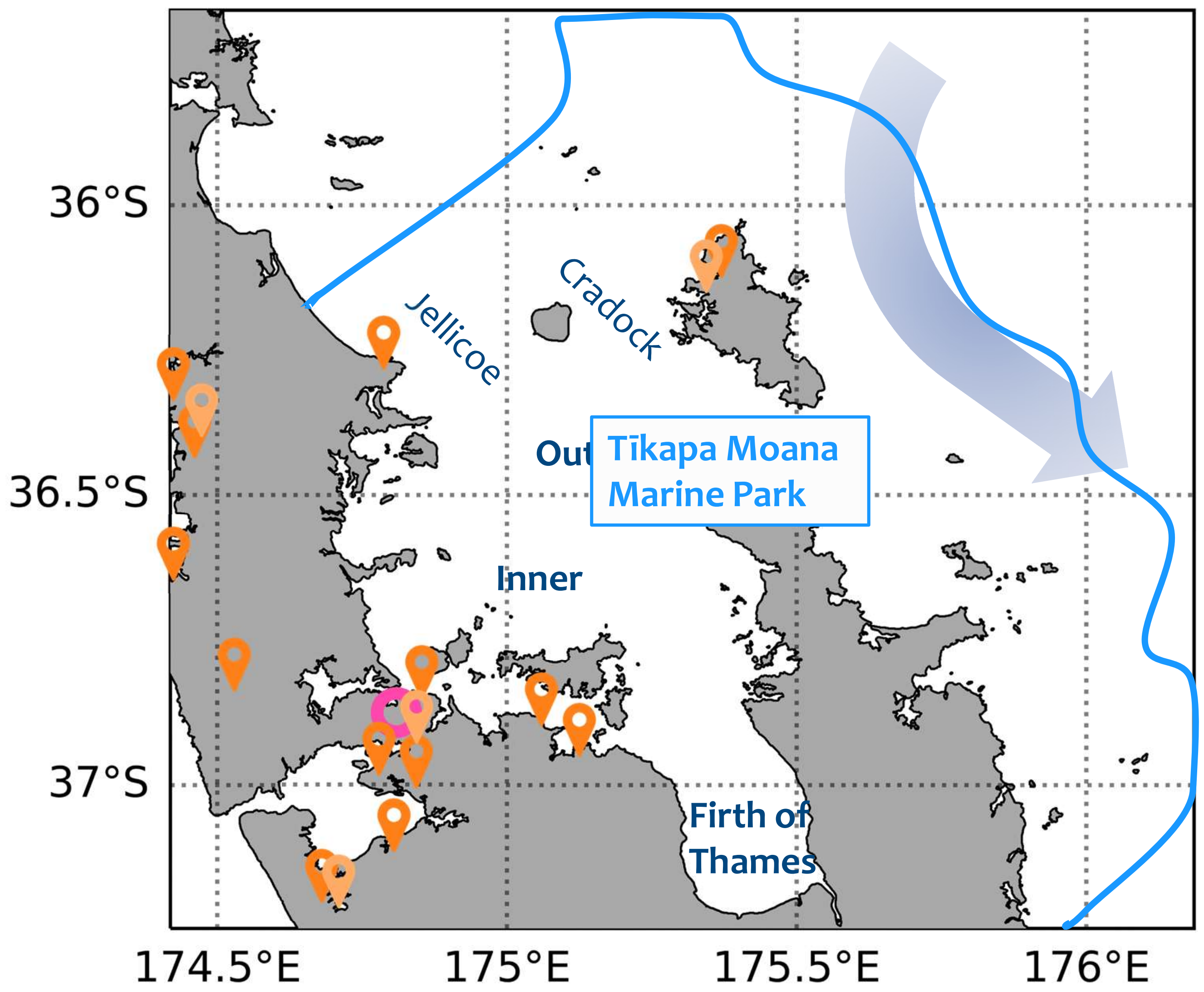
"front+[…]":

temperature	chlorophyll	mesoscale	submesoscale
5'740'000	212'000	255'000	10'600

- Physical-Biological link less documented, less so in costal areas

Study area

- 1.67 million people (2023)
- 19 iwi authority
- Marine park home to 24 seabirds sp, cetaceans & mantas

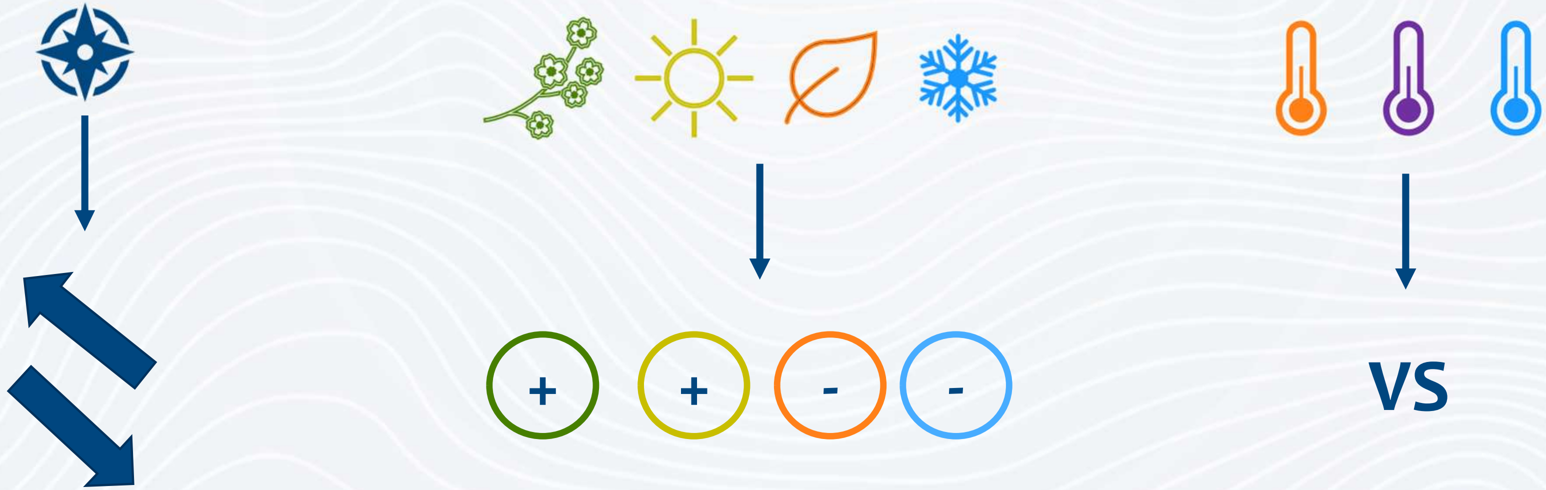


Objectives

“What is the spatio-temporal variability of fine-scale fronts?”

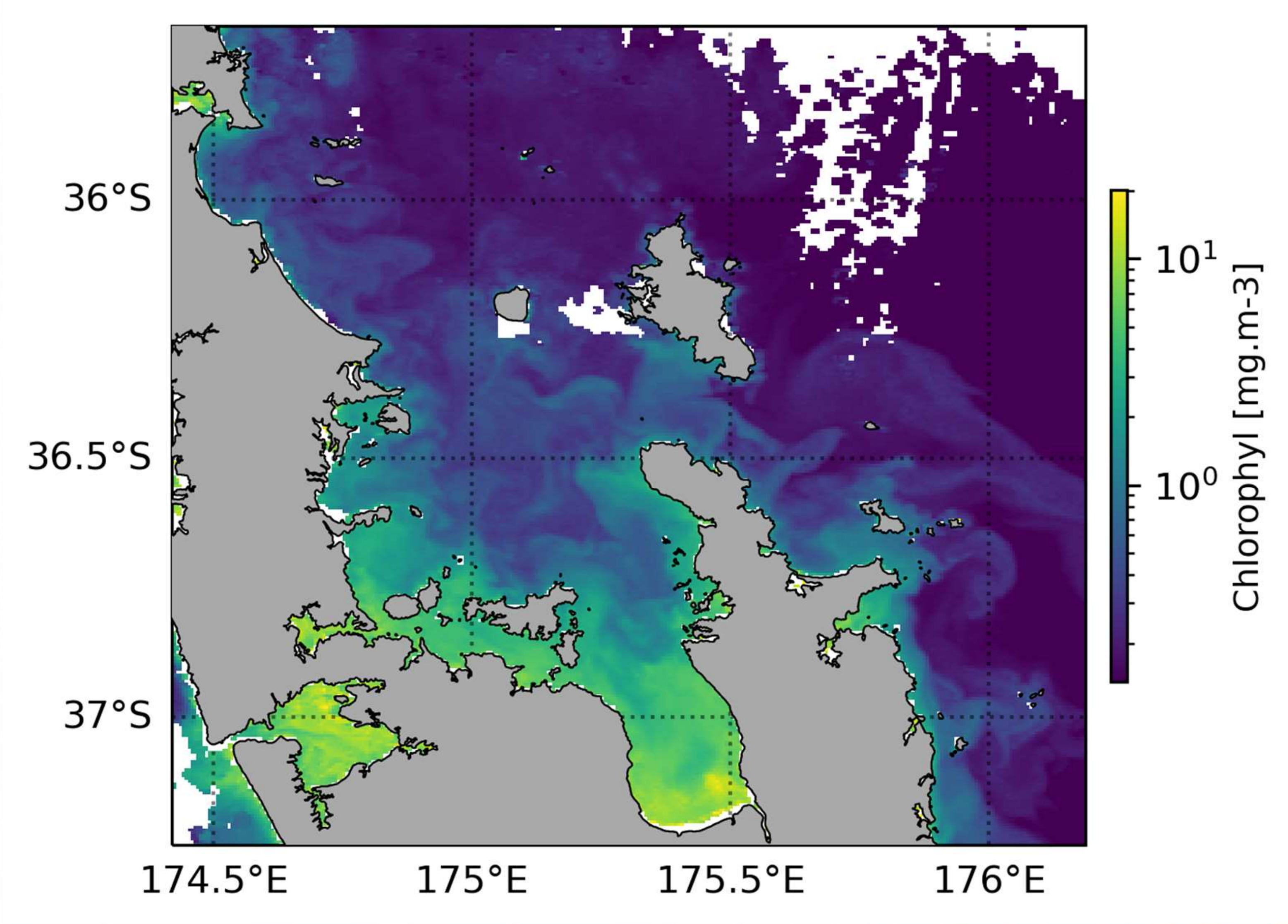
3 factors considered:

winds (8 groups) **season** (4 groups) **ENSO** (2-3 groups)



pyBOA

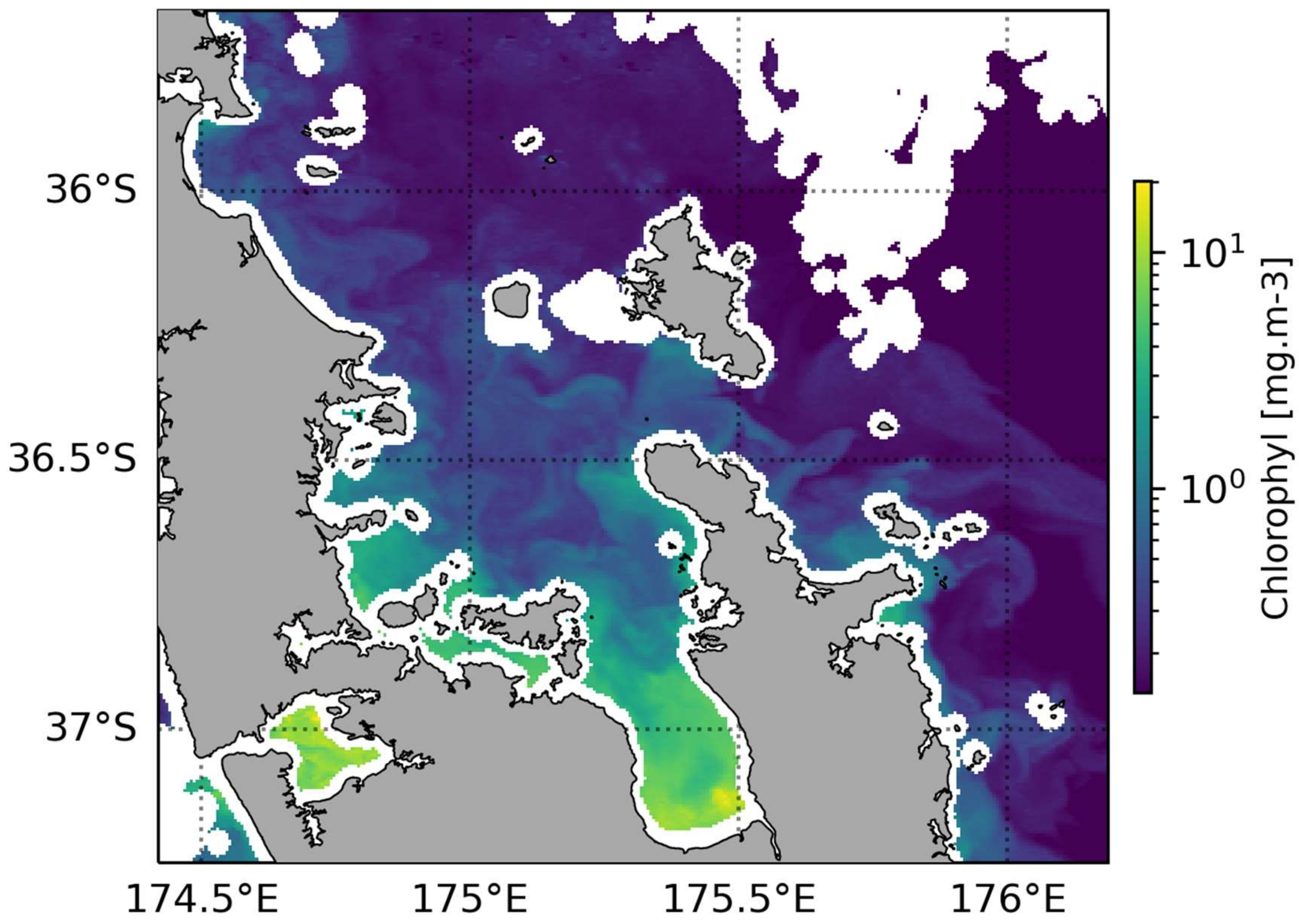
♒CHL <= 30mg.L



Methods

pyBOA

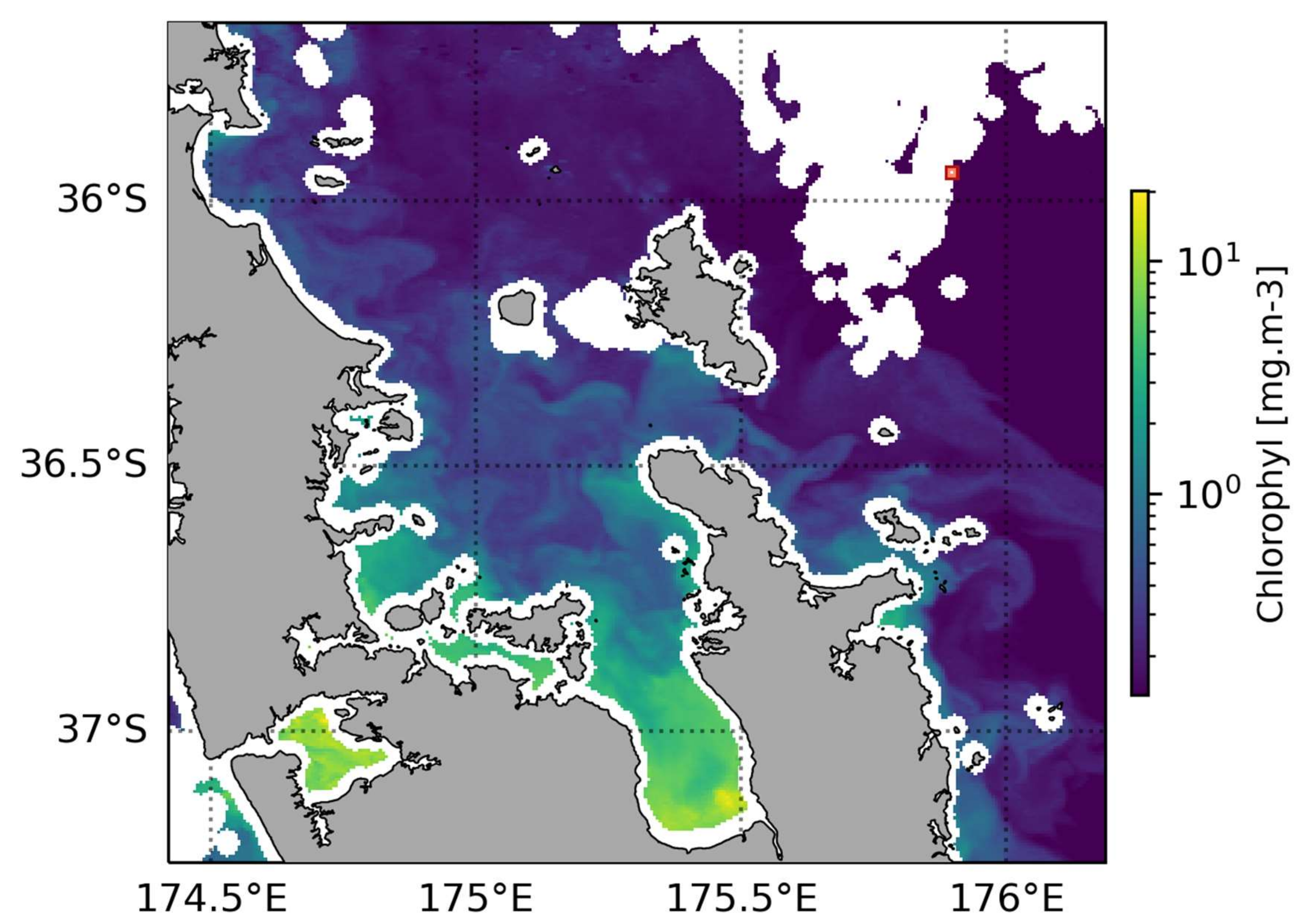
- CHL <= 30mg.L
- NaN proximity



Methods

pyBOA

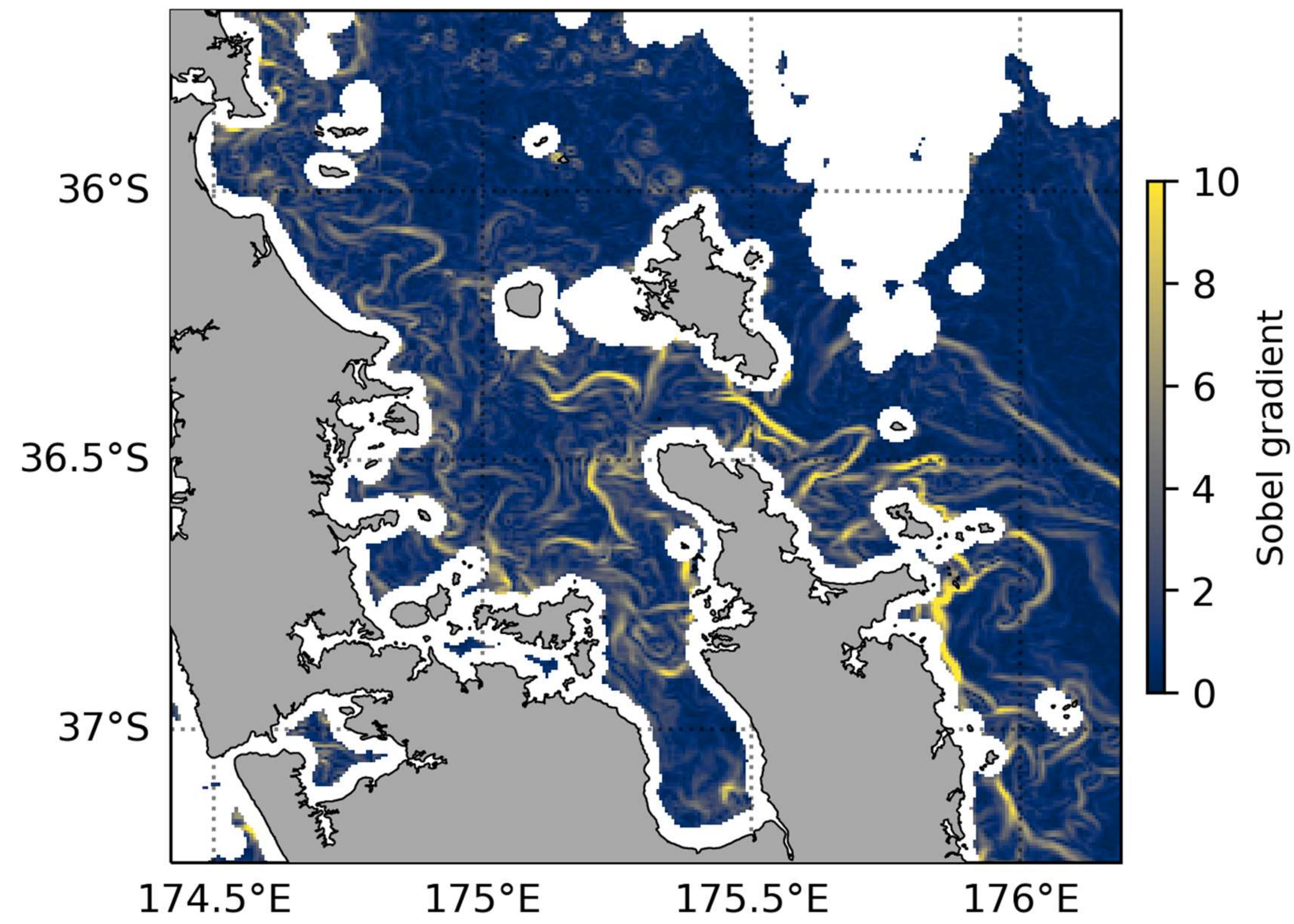
- CHL <= 30mg.L
- NaN proximity
- RMSE



Methods

pyBOA

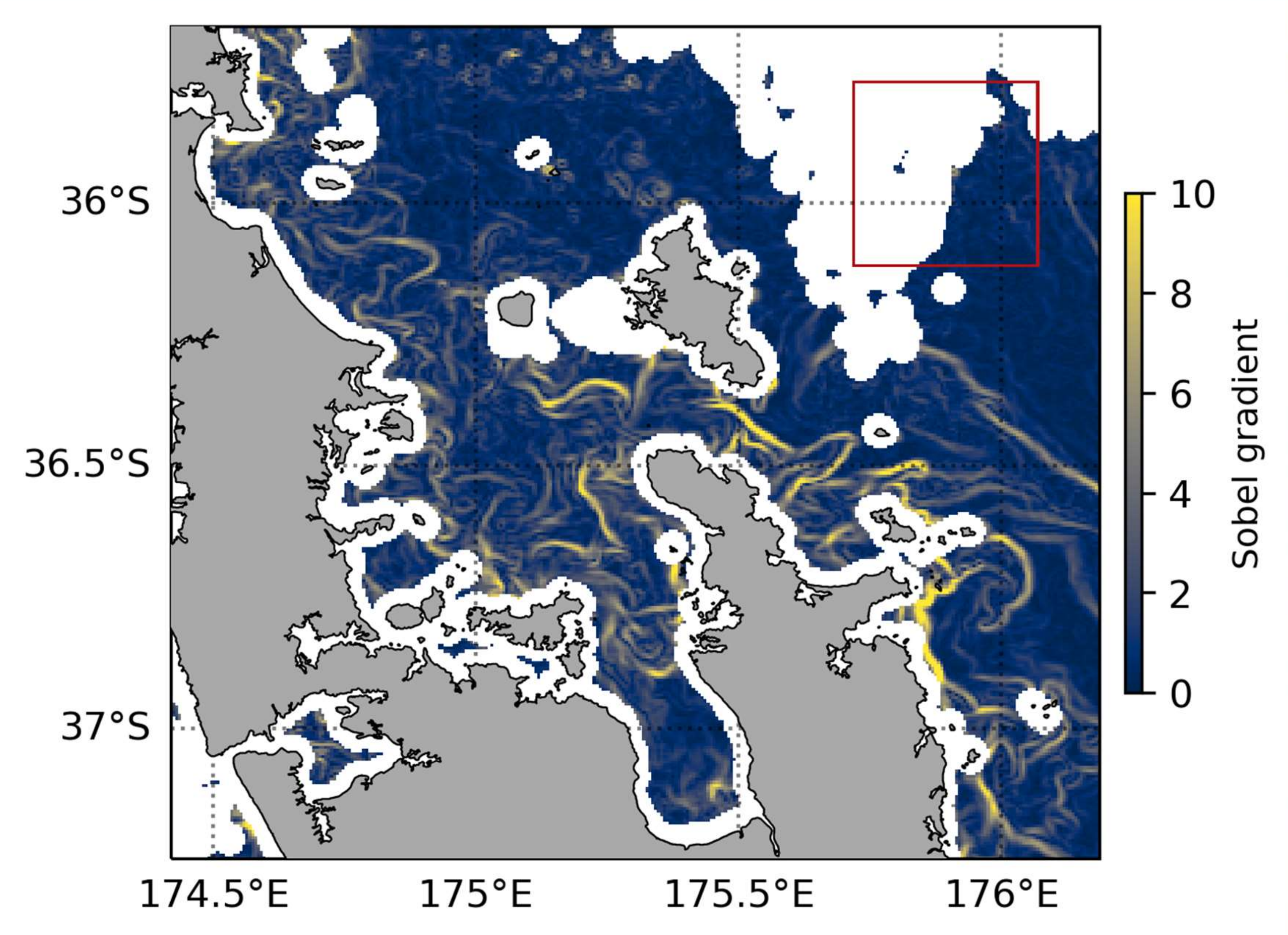
- CHL <= 30mg.L
- NaN proximity
- RMSE
- Gradient



Methods

pyBOA

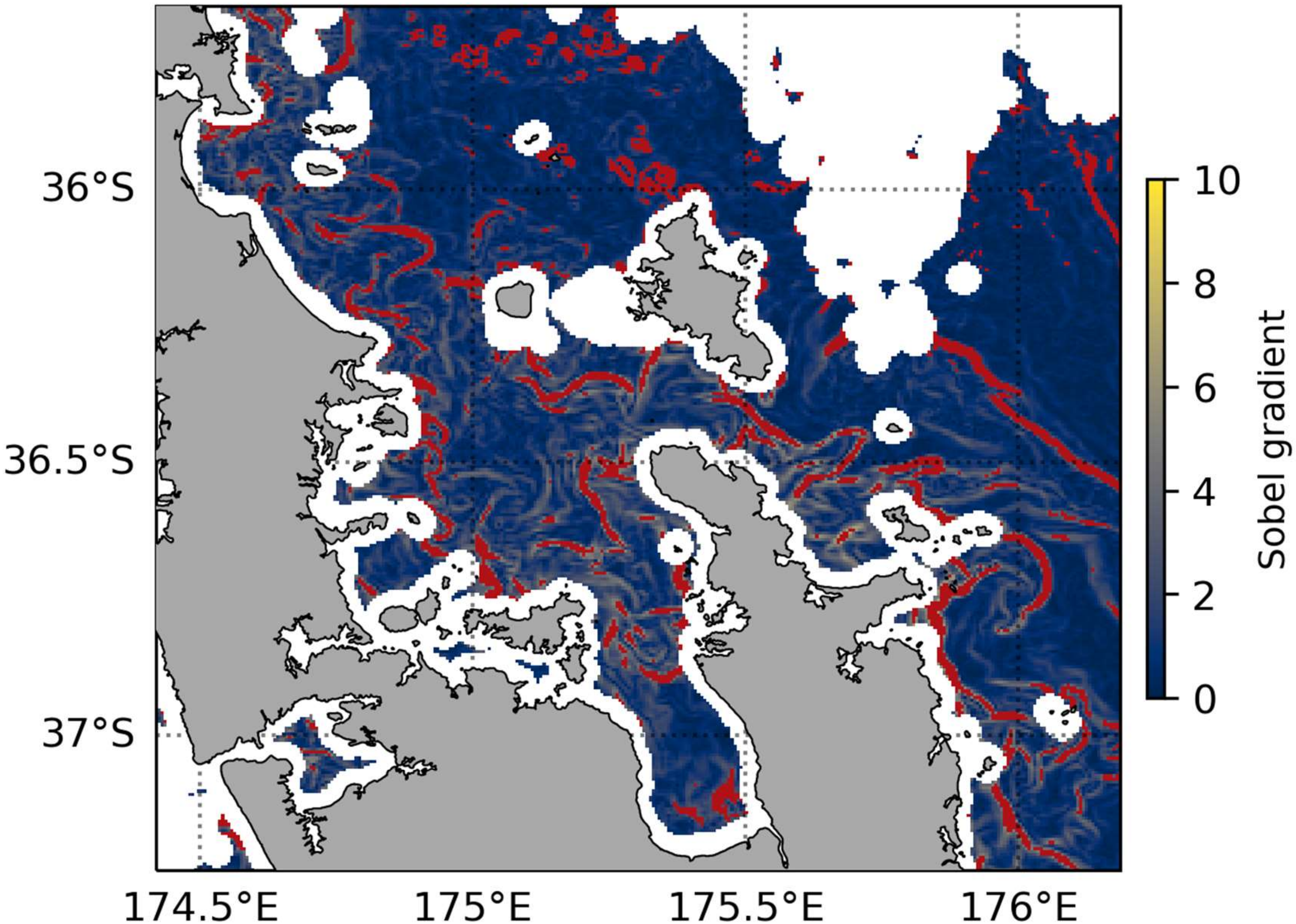
- CHL <= 30mg.L
- NaN proximity
- RMSE
- Gradient
- 90th percentile



Methods

pyBOA

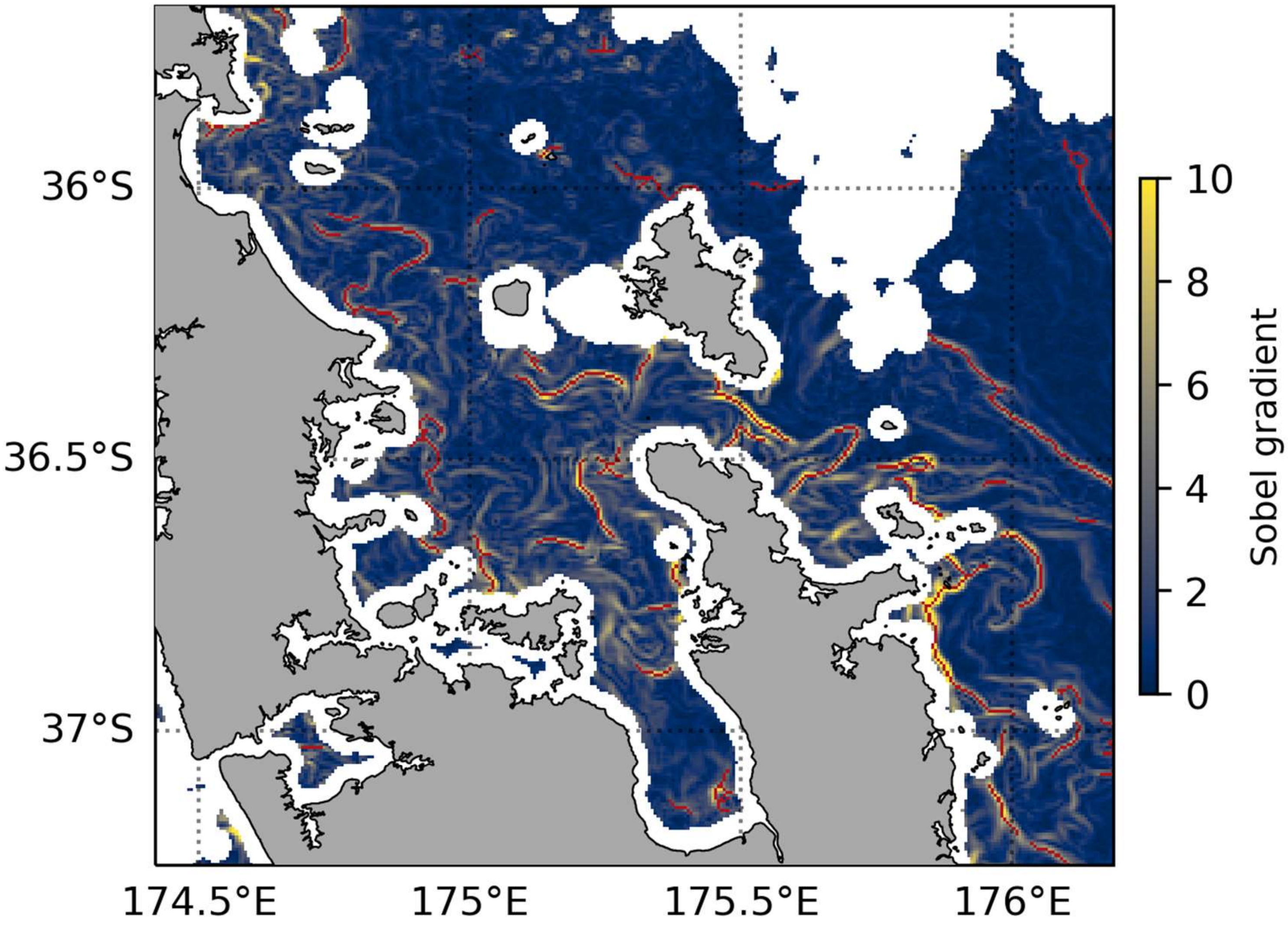
- CHL <= 30mg.L
- NaN proximity
- RMSE
- Gradient
- 90th percentile



Methods

pyBOA

- CHL <= 30mg.L
- NaN proximity
- RMSE
- Gradient
- 90th percentile
- Line thinning



Methods

pyBOA

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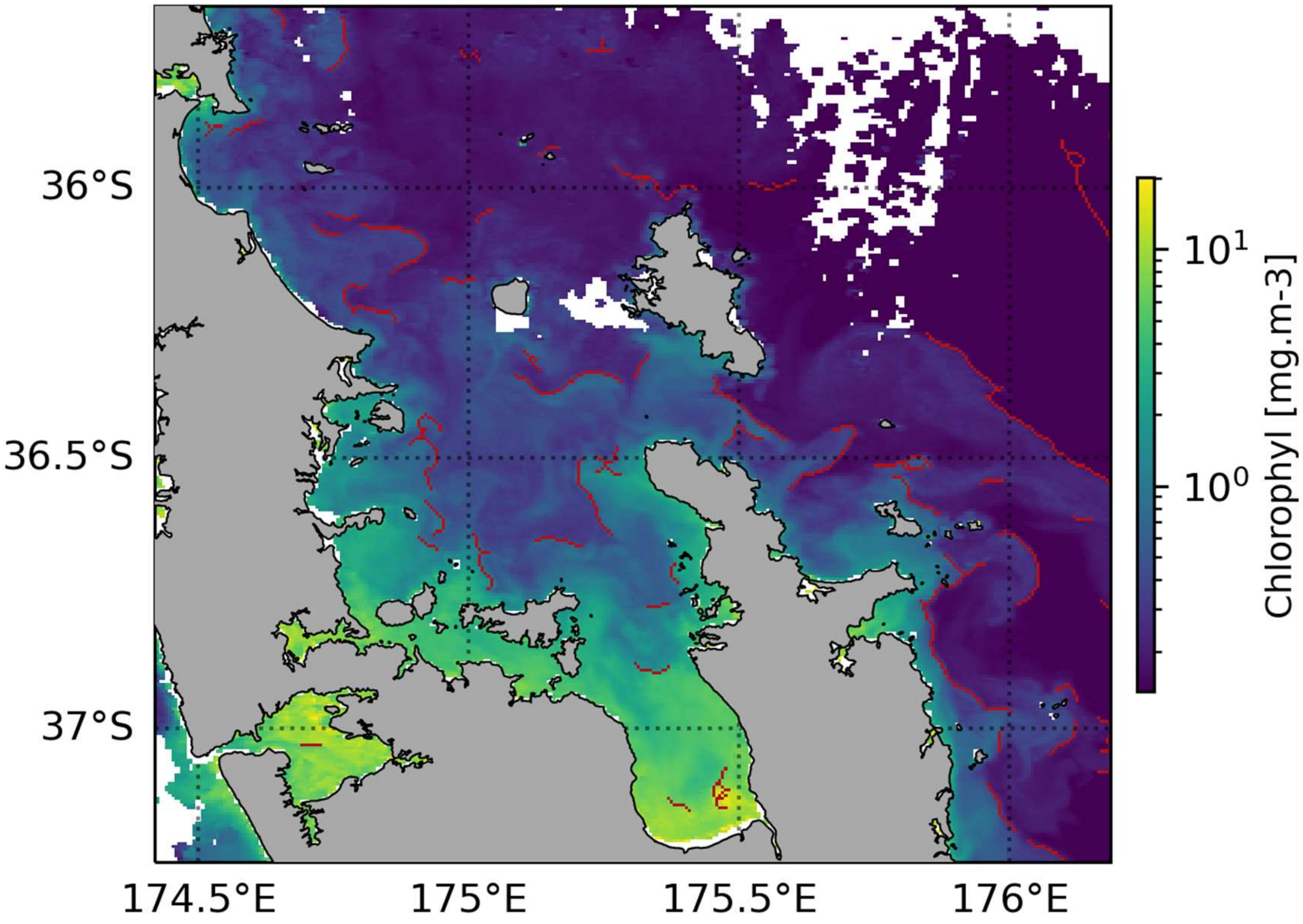
- Gradient
- 90th percentile
- Line thinning



Methods

pyBOA

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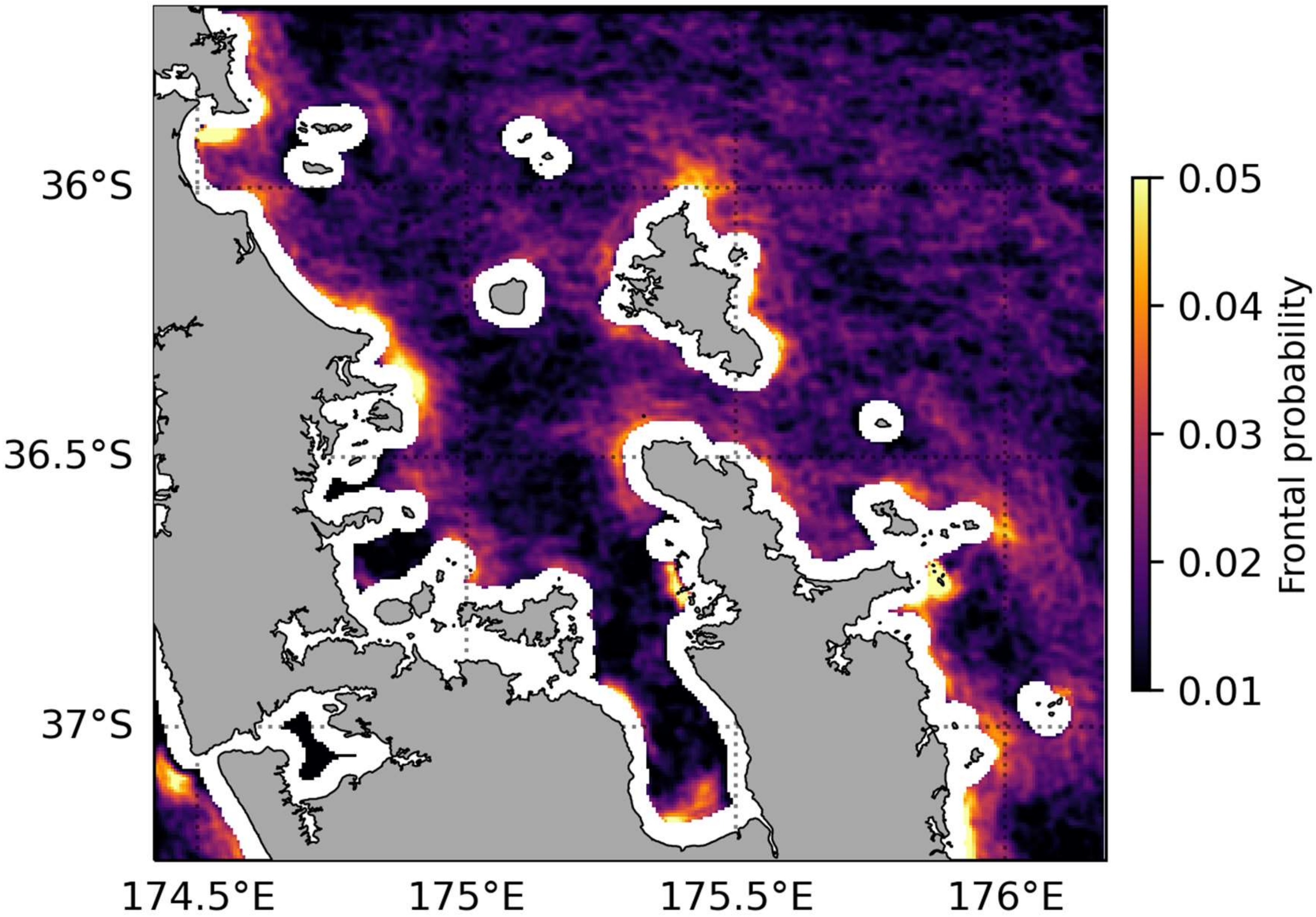
- RMSE
- Gradient
- 90th percentile
- Line thinning



Methods

Statistics

- 3 factors considered:

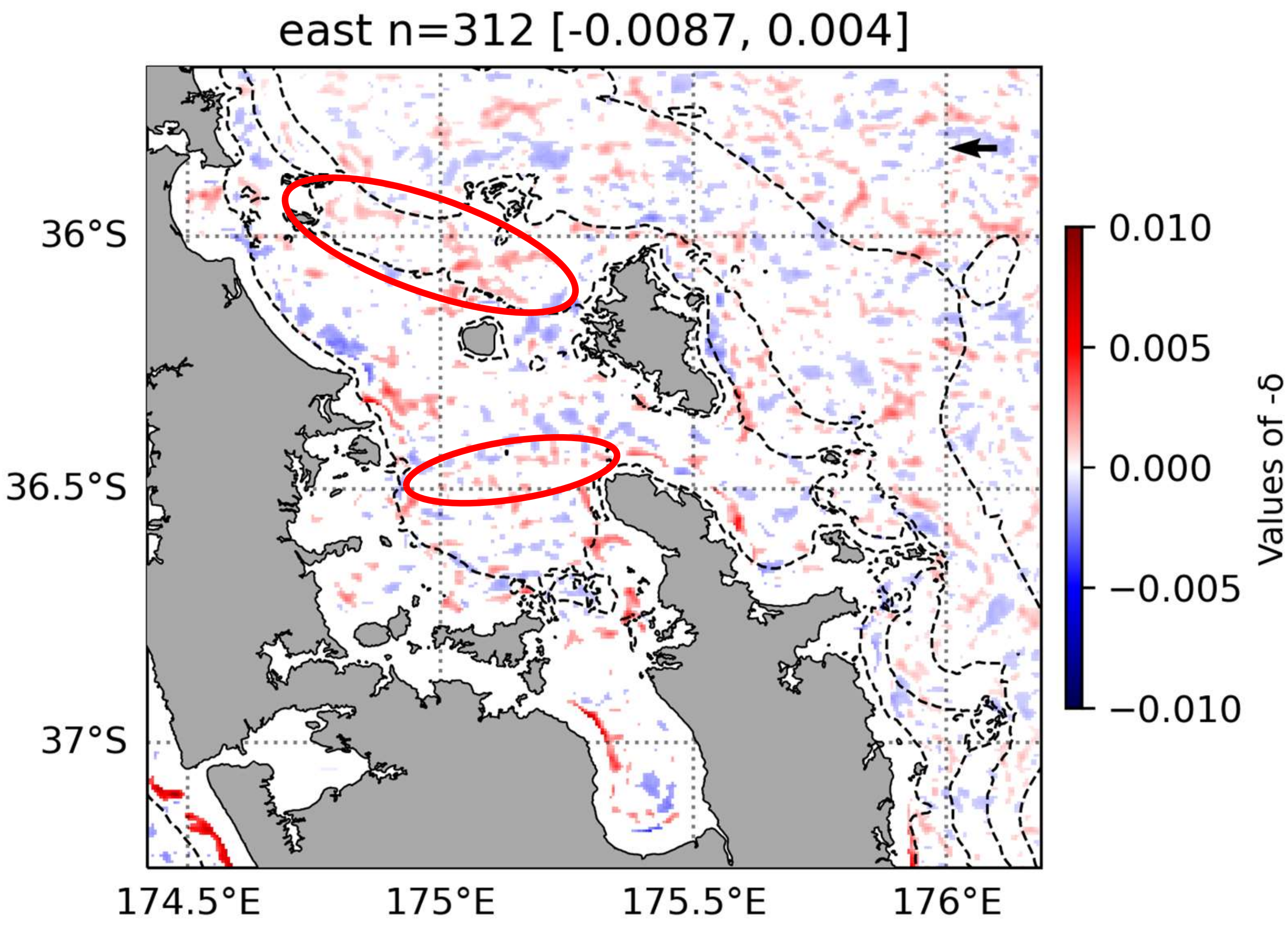
winds (8 groups) **season** (4 groups) **ENSO** (2-3 groups)

- **Jackknife** & **δ:**
  - $Jackknife_{group\ i} = \dfrac{Fronts_{total} - Front_{group\ i}}{Valid_{total} - Vali_{group\ i}}$
  - $\delta_{group\ i} = Jackknife_{group\ i} - P_{total}$ **or** $\boxed{\delta_{group\ i} = P_{group\ i} - P_{neutral}}$

- Student t-test $\boldsymbol{Jackknife_{group\ i}}$ **VS** $\boldsymbol{P_{total}}$ with **α=0.01**

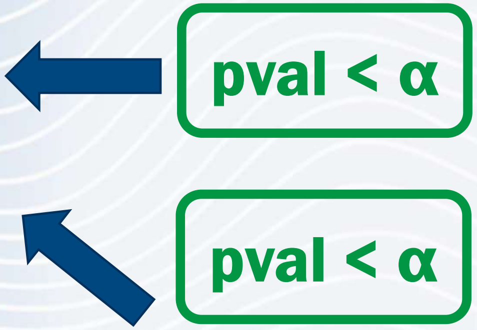
Winds

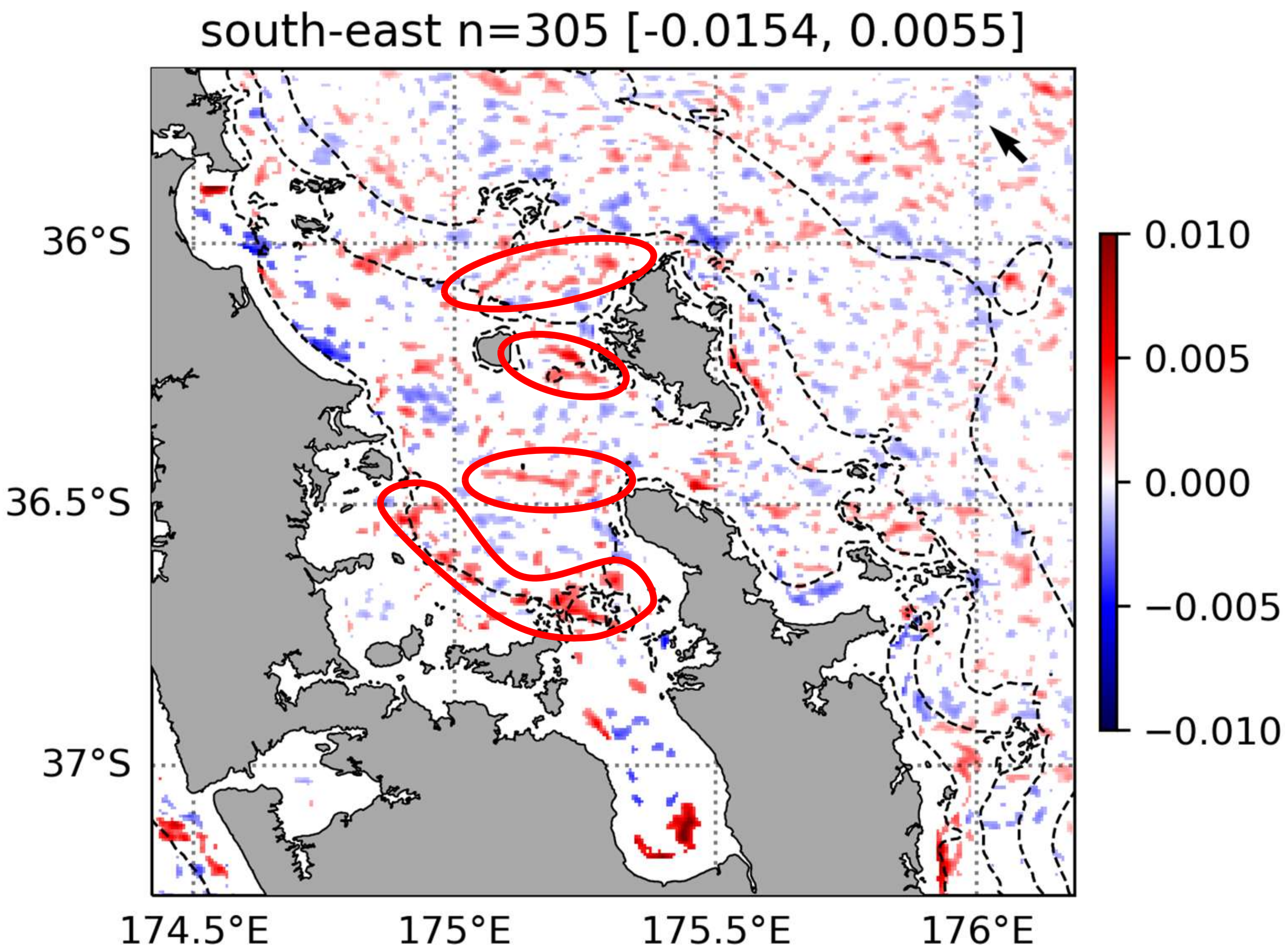
pval < α



Results

Winds


pval < α
pval < α

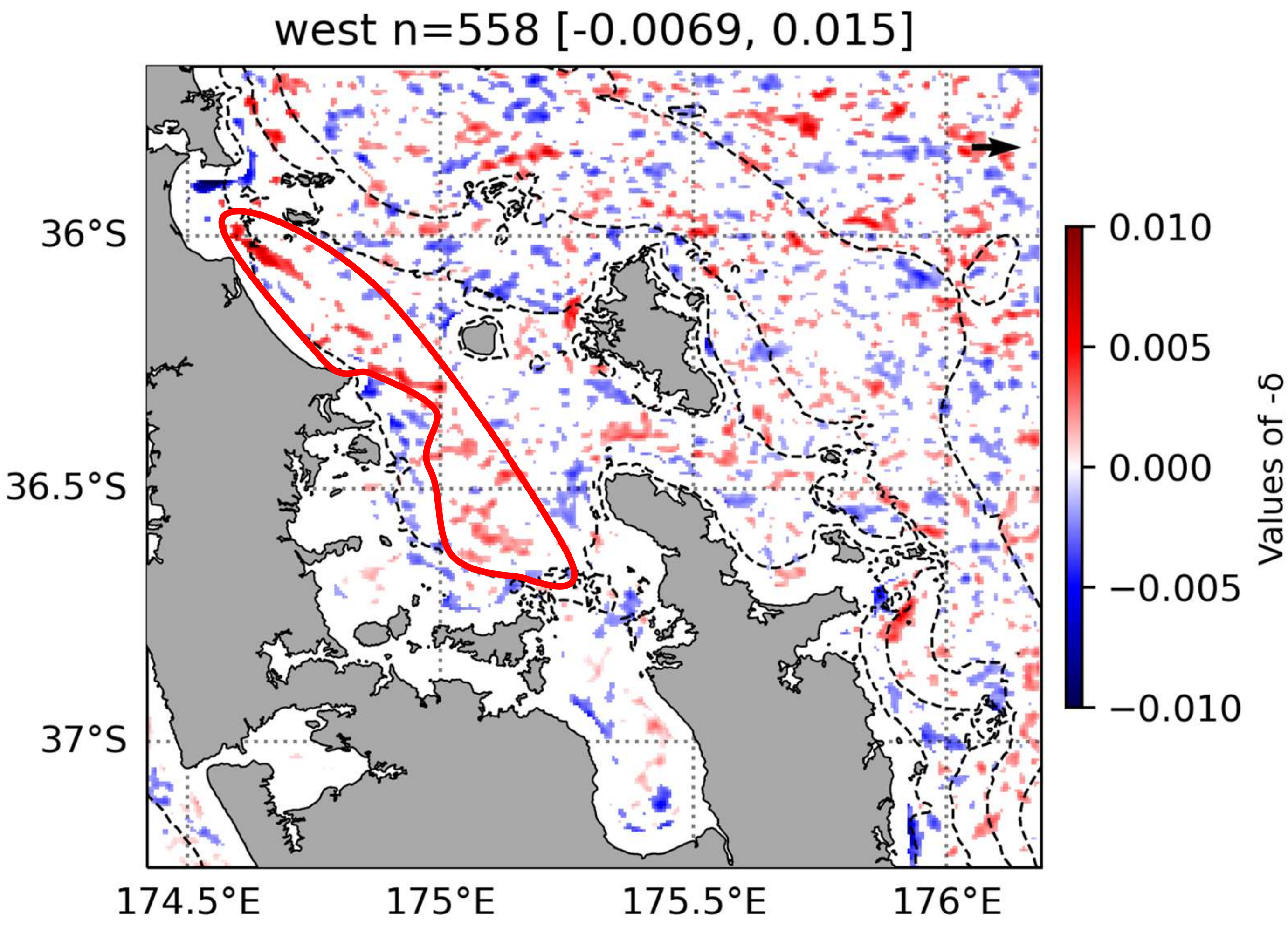

south-east n=305 [-0.0154, 0.0055]
36°S
36.5°S
37°S
174.5°E
175°E
175.5°E
176°E
0.010
0.005
0.000
−0.005
−0.010
Values of -δ

Winds

pval < α

pval < α

pval < α



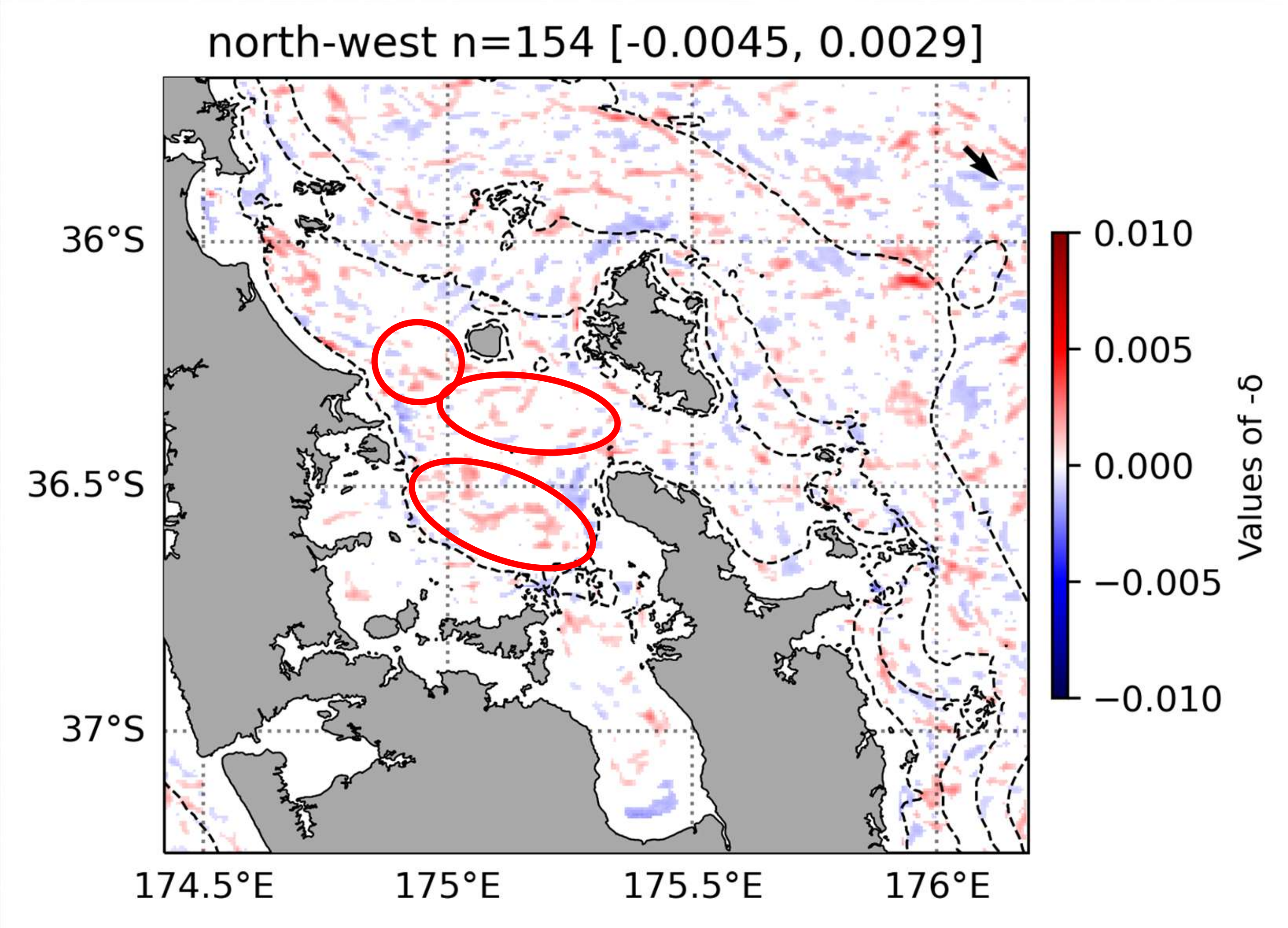
Winds

pval < α

pval < α

pval < α

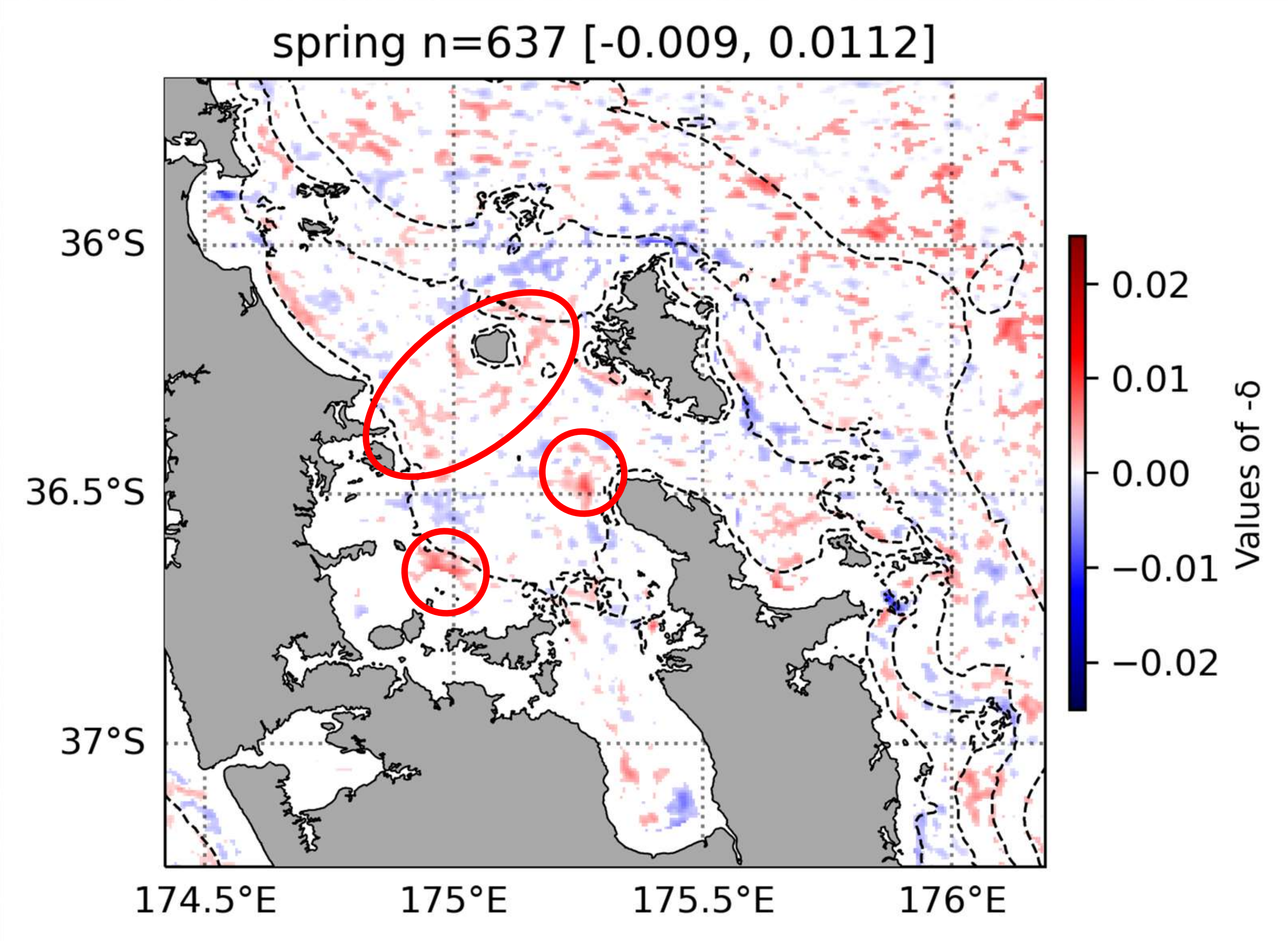
pval > α



Results

Season

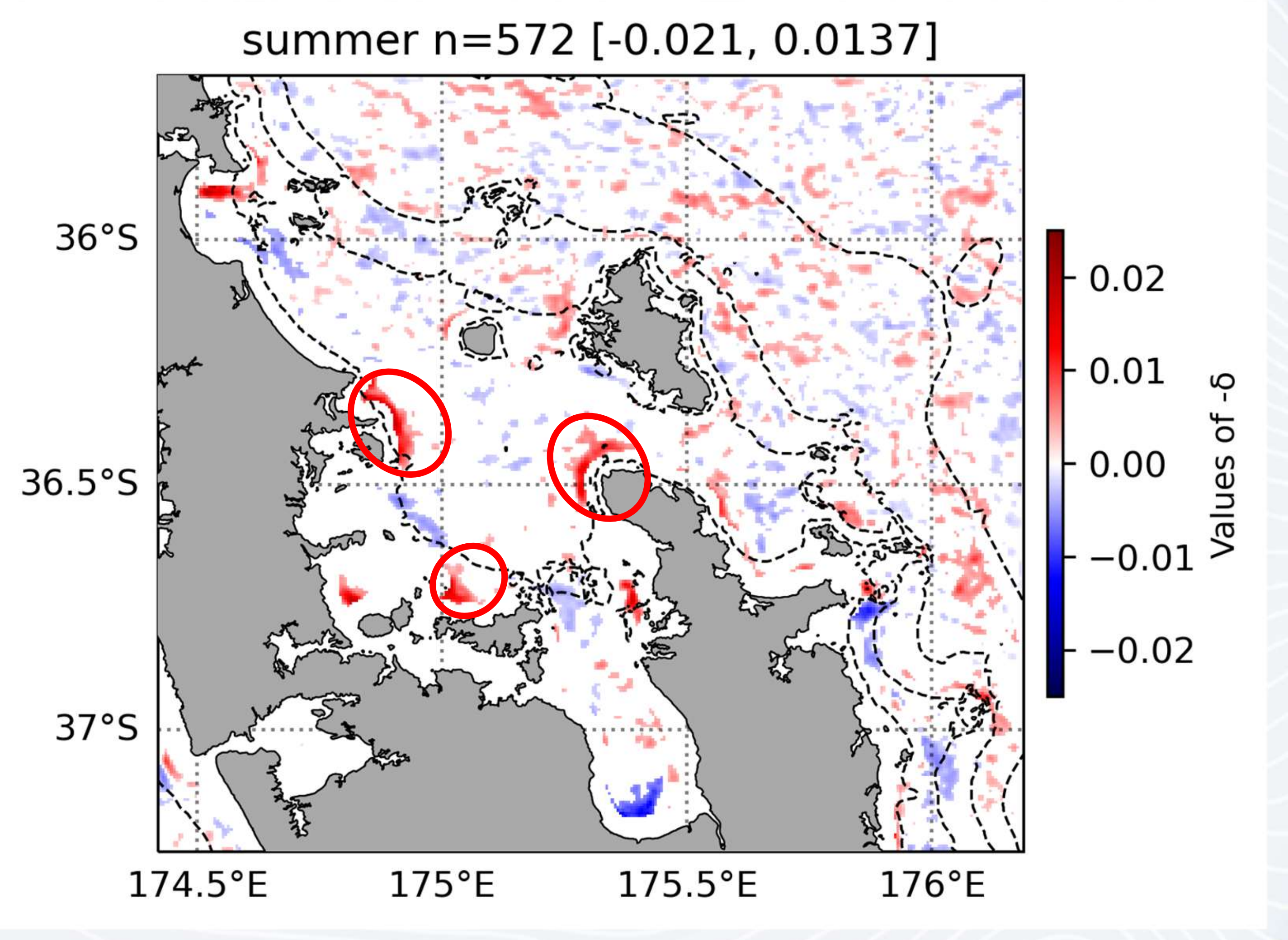
pval < α



Season

pval < α

pval < α

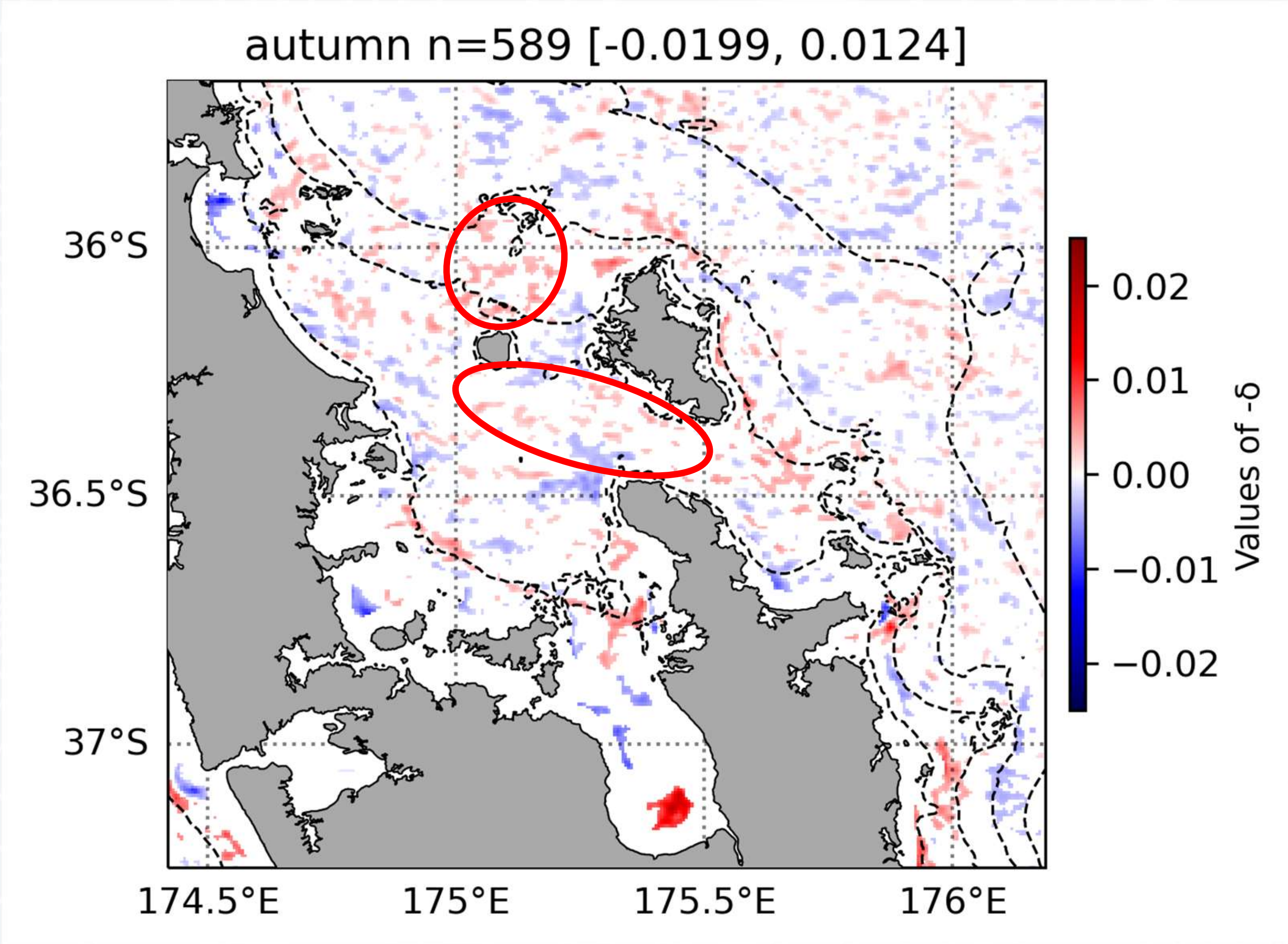


Season

pval < α

pval < α

pval > α



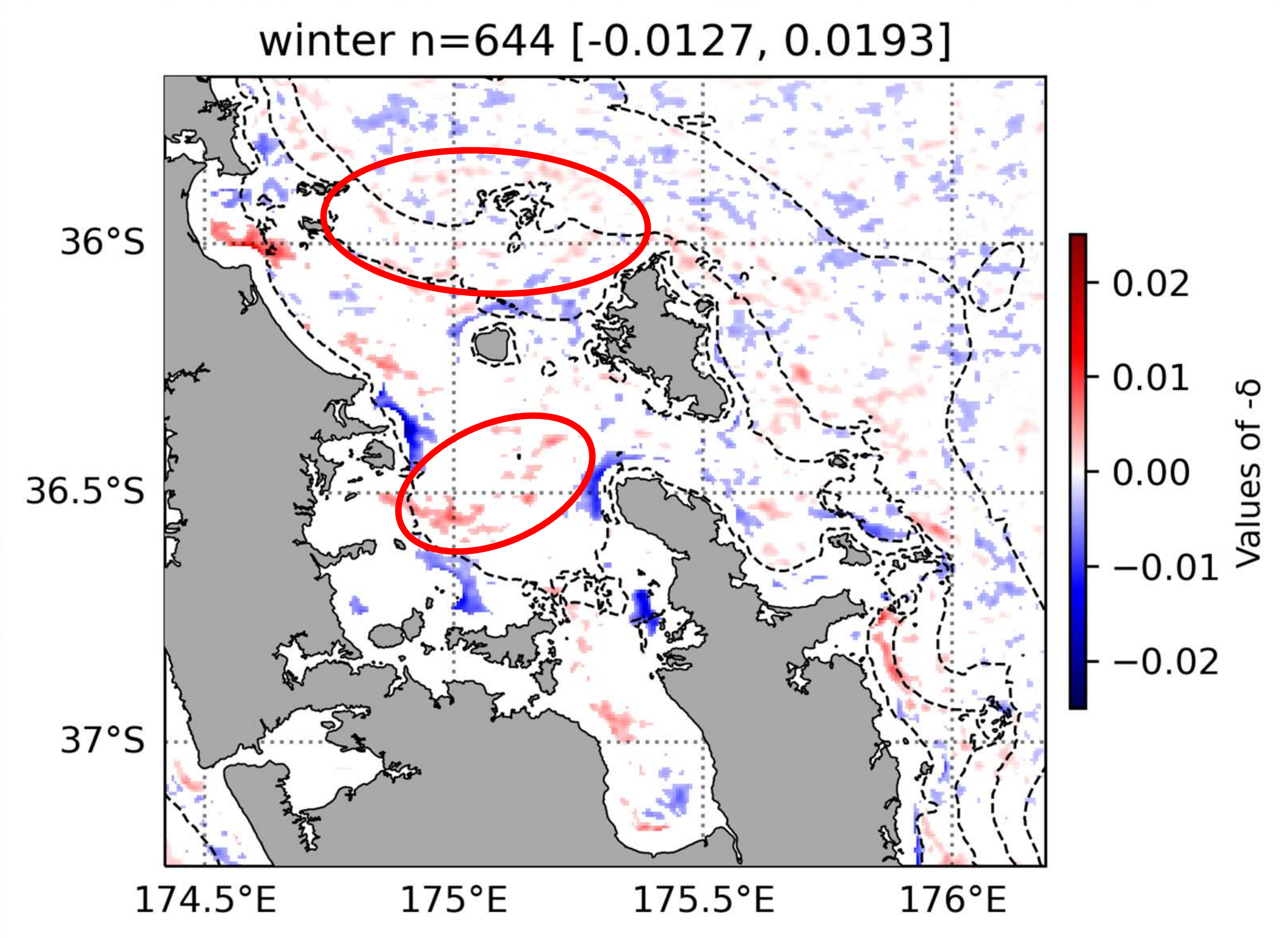
Season

pval < α

pval < α

pval > α

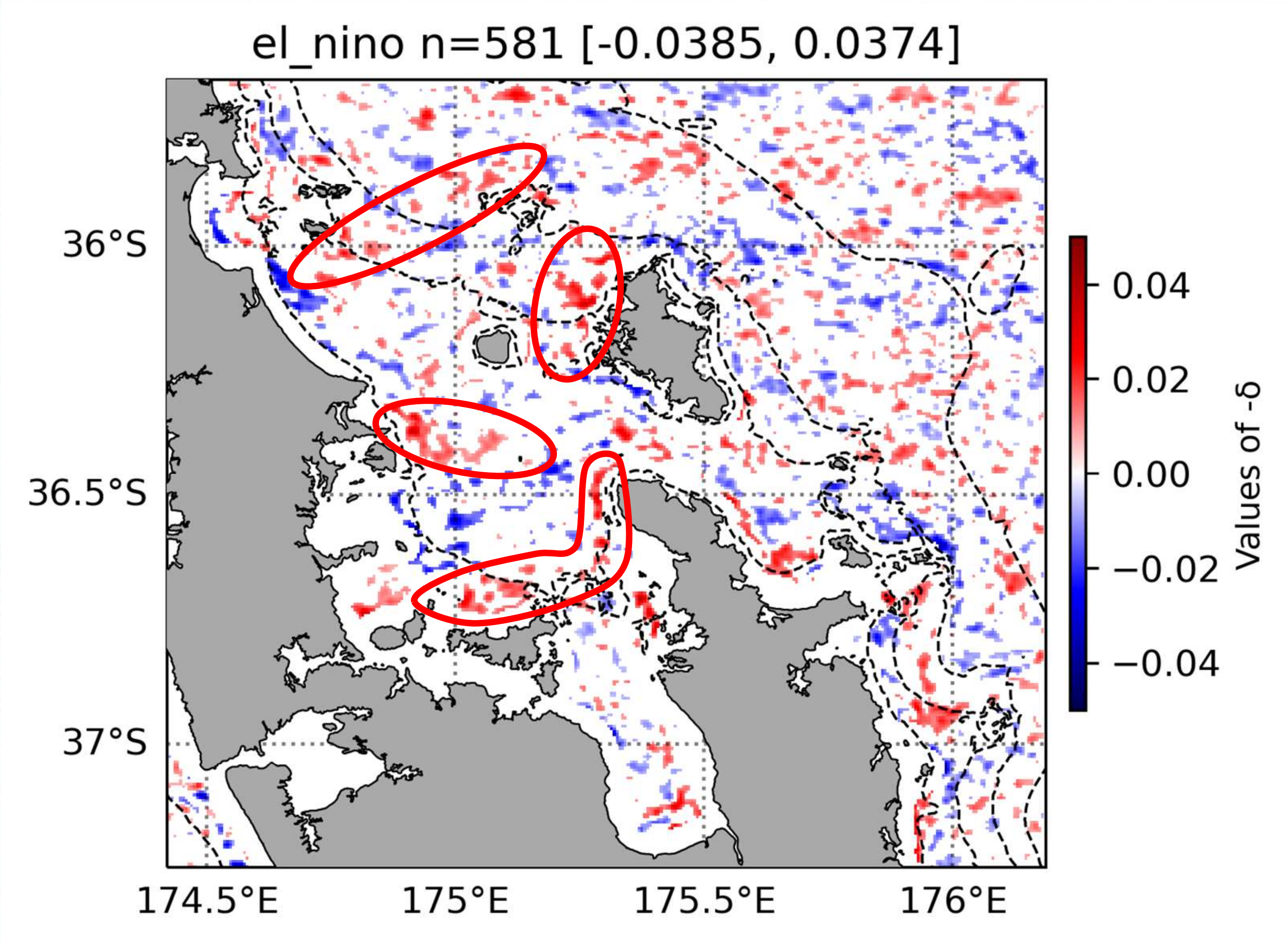
pval < α



Results

ENSO

pval < α

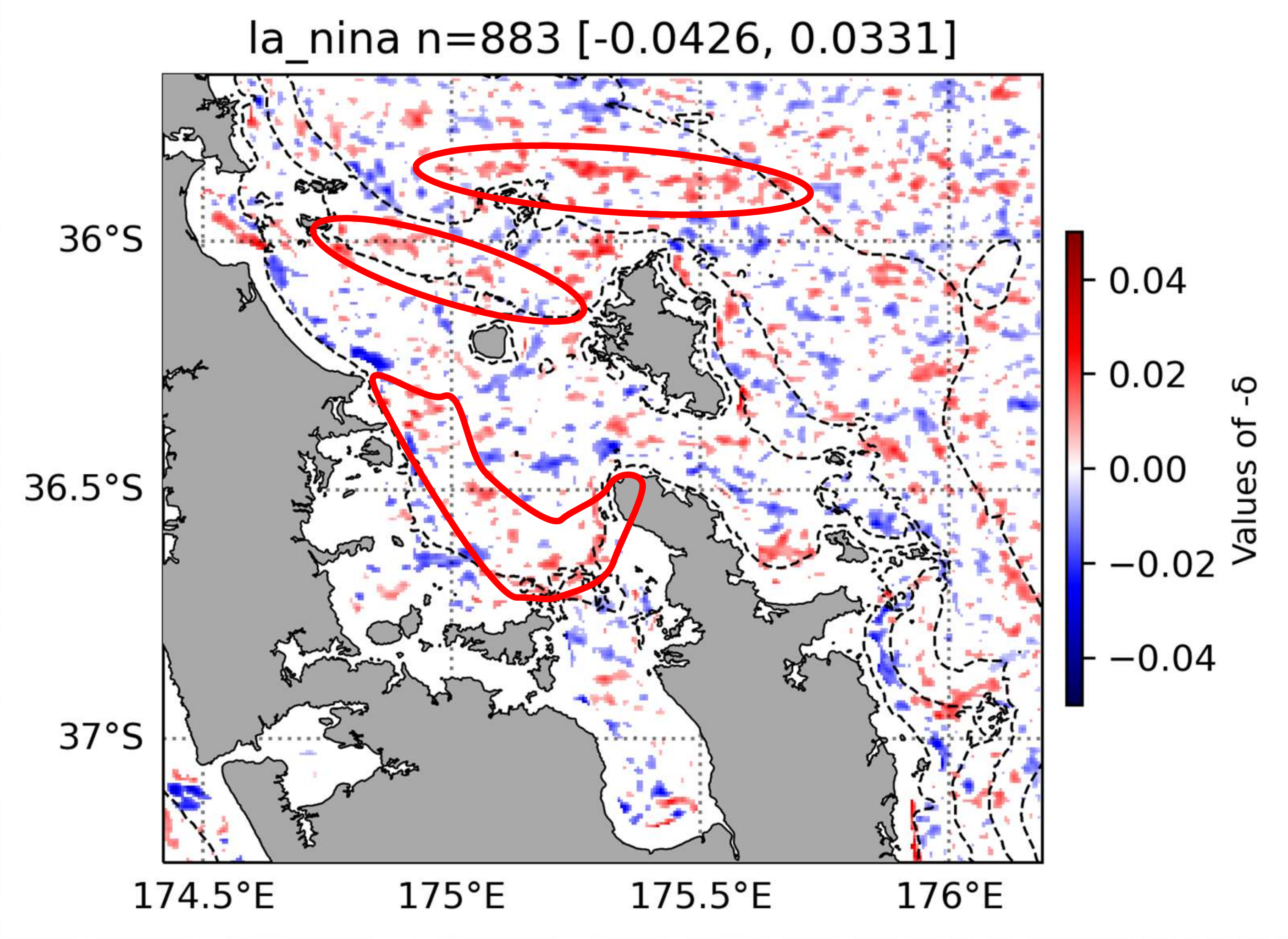


Results

ENSO


pval < α


pval < α

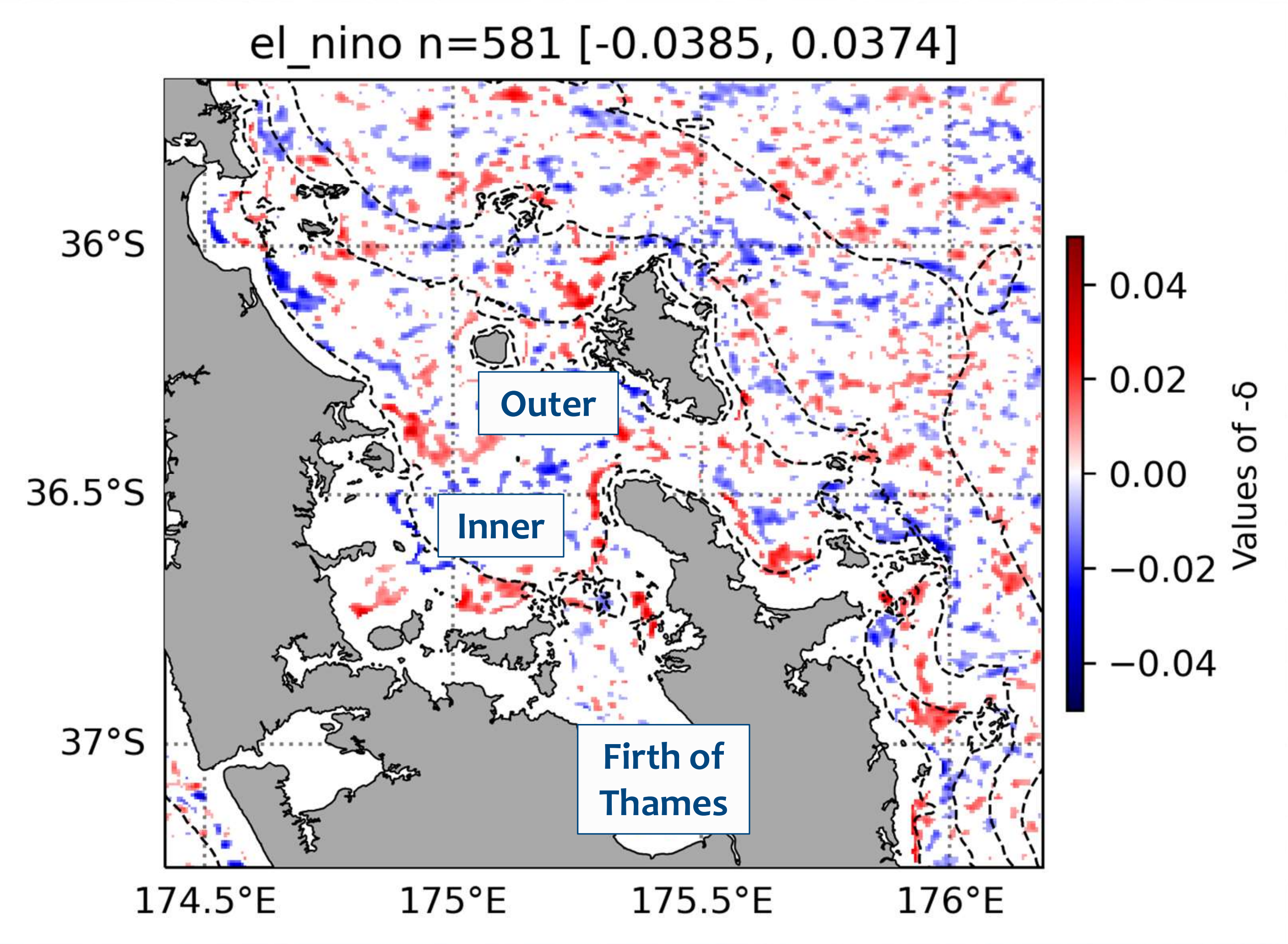


Results

ENSO

pval < α

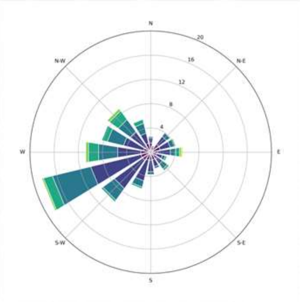
pval < α

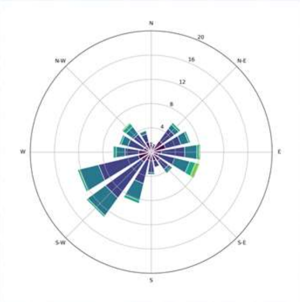


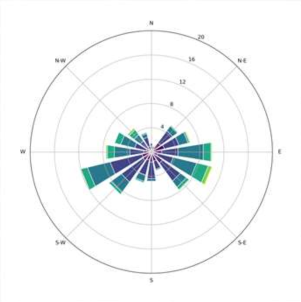
Results

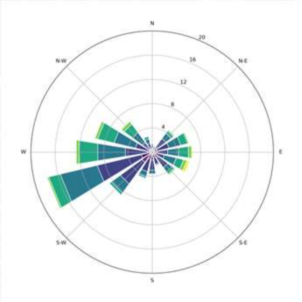
Conclusions and Discussion

- The Hauraki Gulf – Tīkapa Moana is subject to **important variations of physical structures**
- Seasonal movement of fine scale features linked to **wind shift**









- ENSO phase promote **opening/closing** of the Hauraki Gulf sub-elements
- Most fronts can be related back to the Gulf's **bathymetry and wind origin interaction**

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Thanks for your attention

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pyBOA: https://github.com/AlxLhrNc/pyBOA

References

- [1] Auckland Council (2021). The hapū and iwi of Tāmaki Makaurau
- [2] Gaskin, C. (2021). State of our Seabirds 2021 - Seabird ecology, research and conservation for the wider Hauraki Gulf / Tīkapa Moana / Te Moananui-ā-Toi region. *Technical report, Northern New Zealand Seabirds Charitable Trust*, Auckland, New Zealand.
- [3] Belkin, I. M. and O'Reilly, J. E. (2009). An algorithm for oceanic front detection in chlorophyll and SST satellite imagery. *Journal of Marine Systems*, 78(3):319–326
- [4] Levine, R. S., Yorita, K. L., Walsh, M. C., and Reynolds, M. G. (2009). A method for statistically comparing spatial distribution maps. *International Journal of Health Geographics*, 8(1):7

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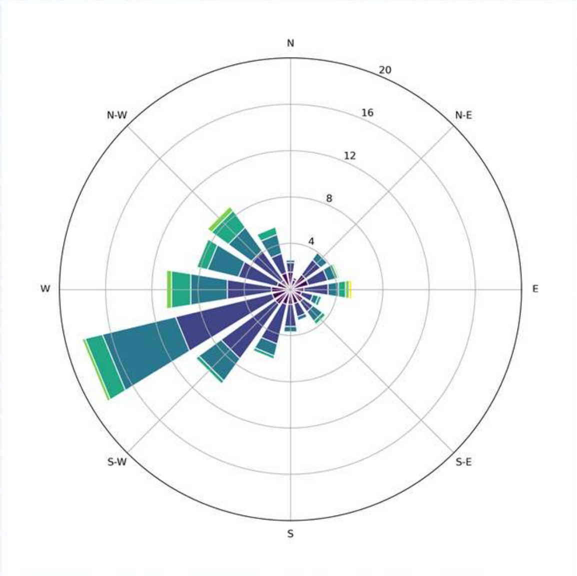
$$♒ Jackknife_{group\ i} = \frac{Fronts_{total} - Front_{\ group\ i}}{Valid_{\ total} - Valid_{\ group\ i}}$$

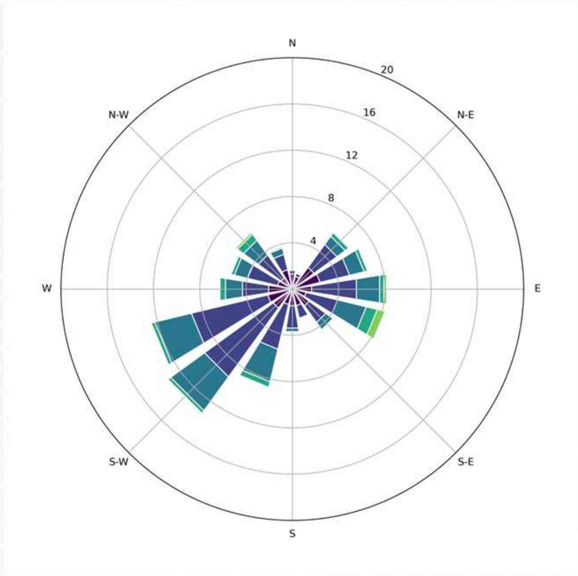
$$♒\ \delta_{group\ i} = Jackknife_{group\ i} - P_{total}$$

$$\delta_{group\ i} = P_{\ group\ i} - P_{neutral}$$

Winds (season)

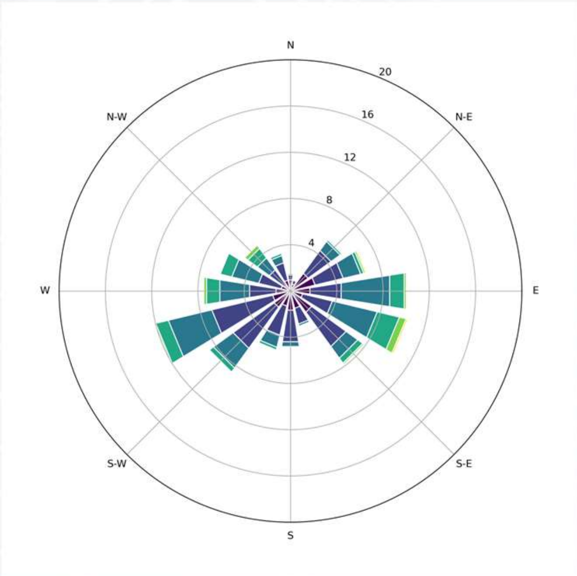


Spring

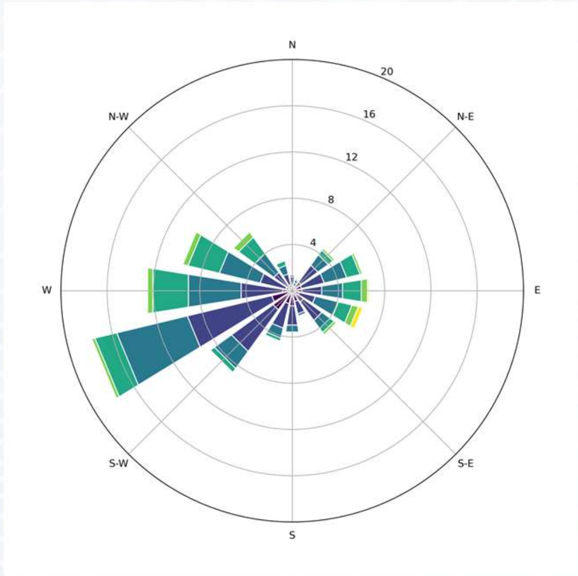


Summer

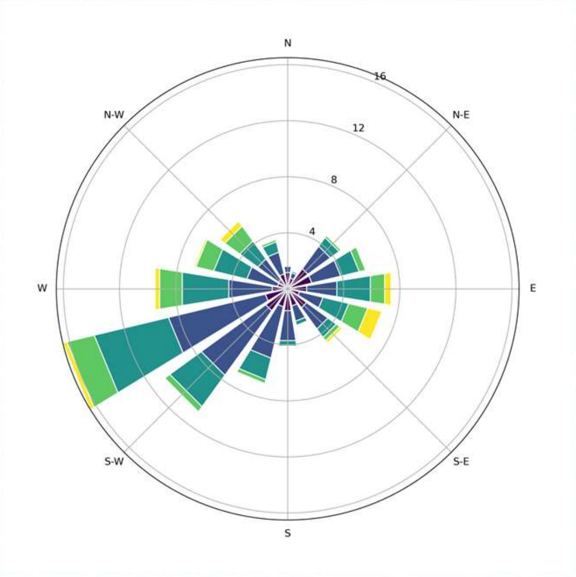
Autumn



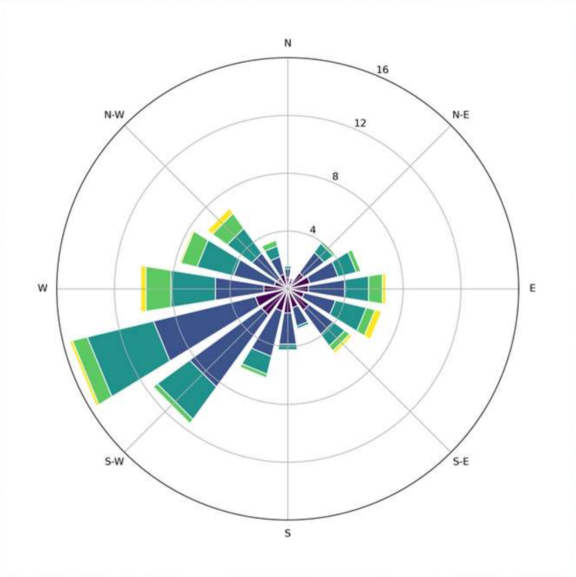
Winter



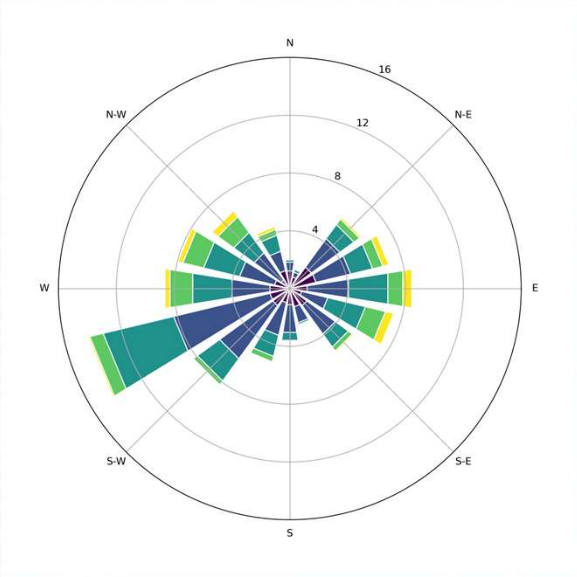
Winds (ENSO)



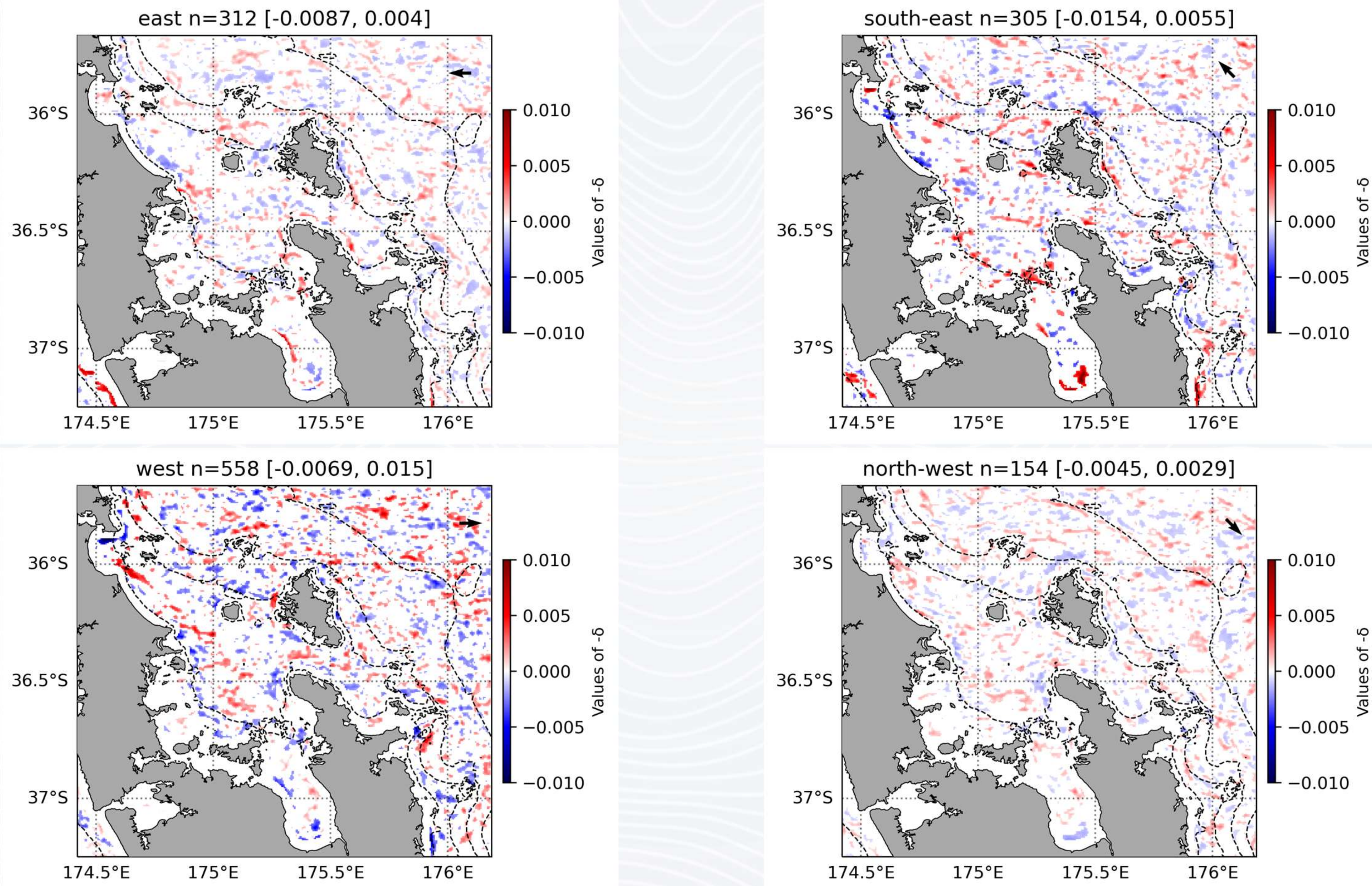
El Niño



Neutral

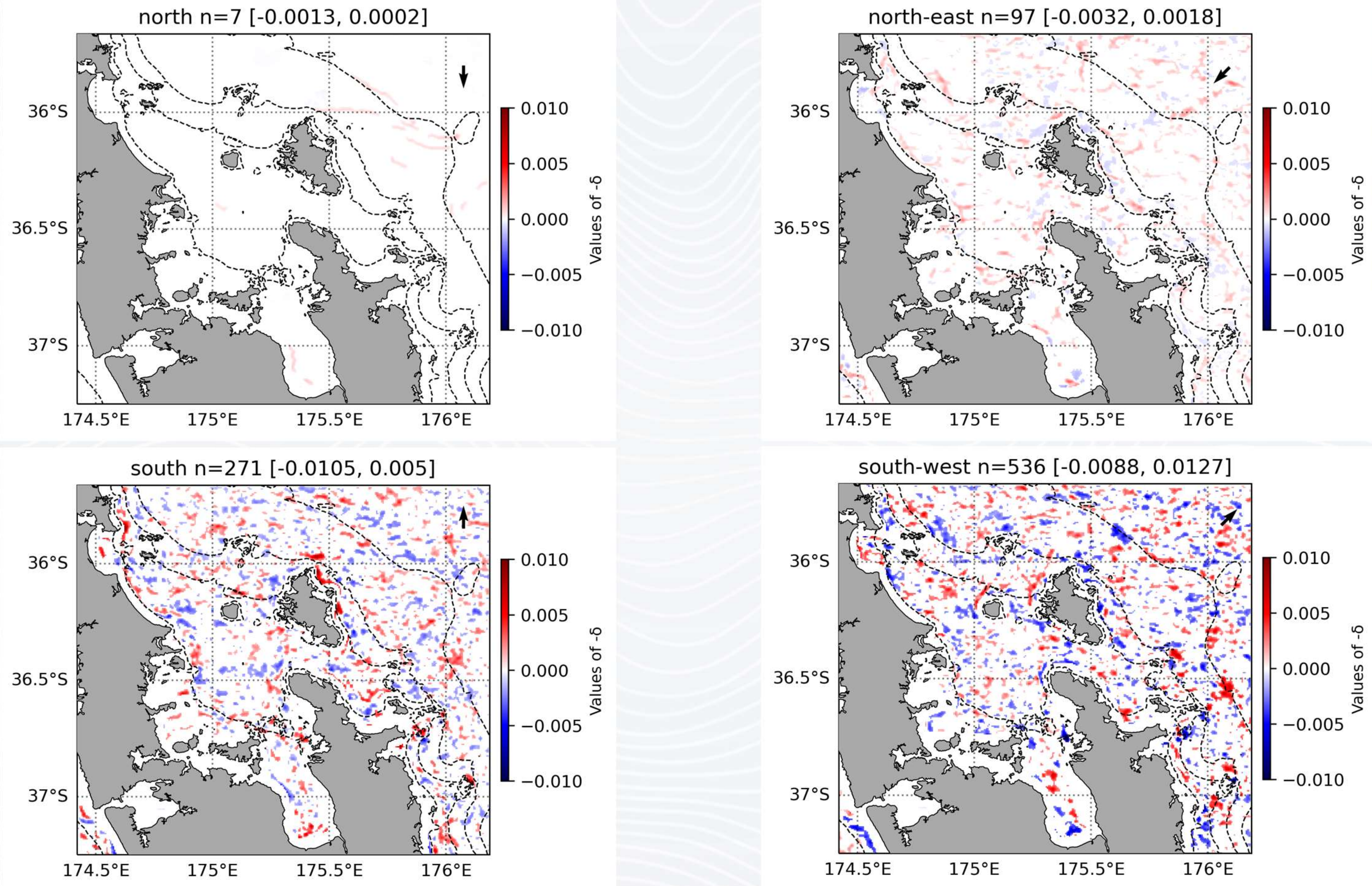


La Niña

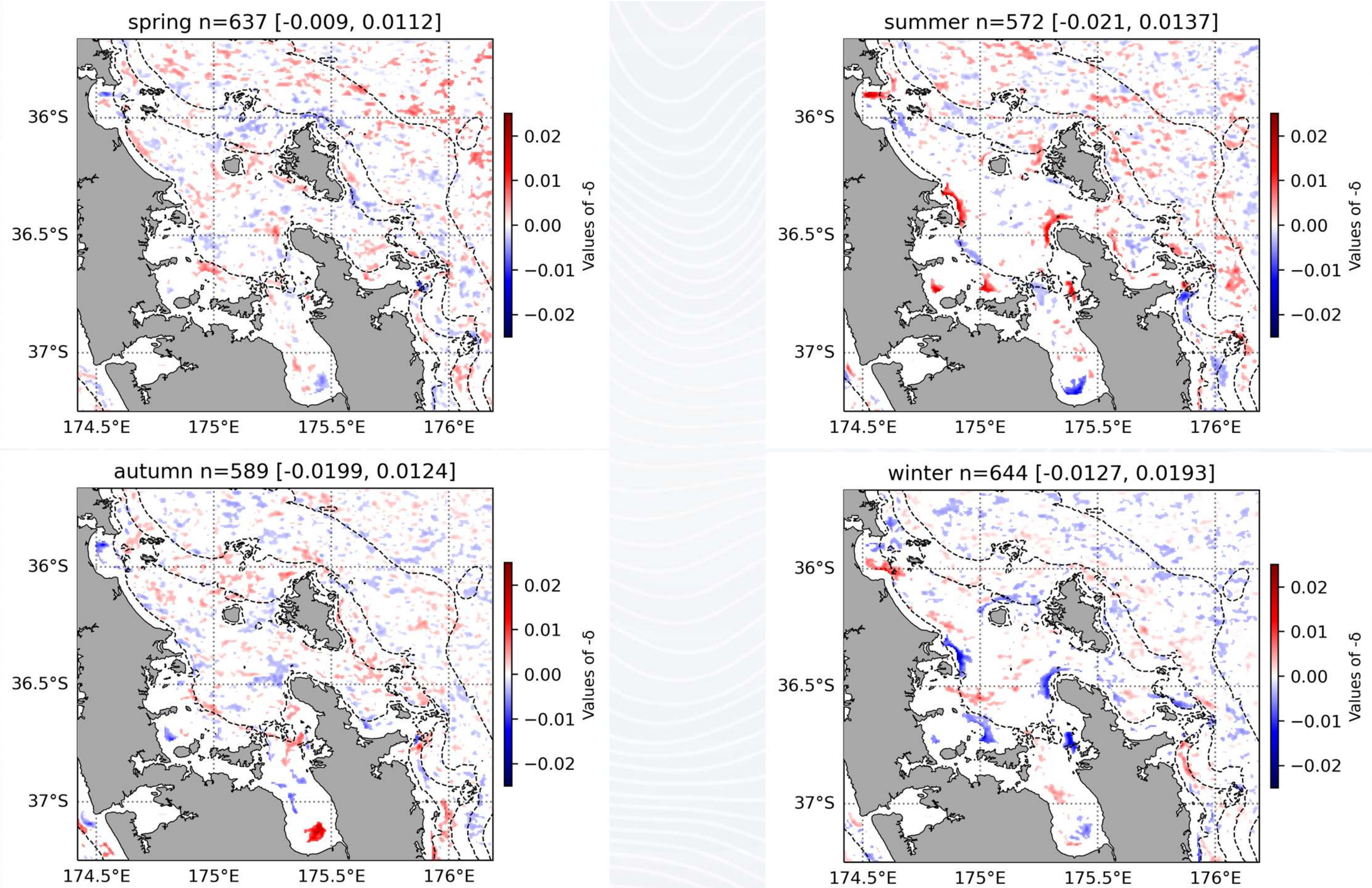


east n=312 [-0.0087, 0.004]
south-east n=305 [-0.0154, 0.0055]
west n=558 [-0.0069, 0.015]
north-west n=154 [-0.0045, 0.0029]
36°S
36.5°S
37°S
174.5°E
175°E
175.5°E
176°E
0.010
0.005
0.000
−0.005
−0.010
Values of -δ

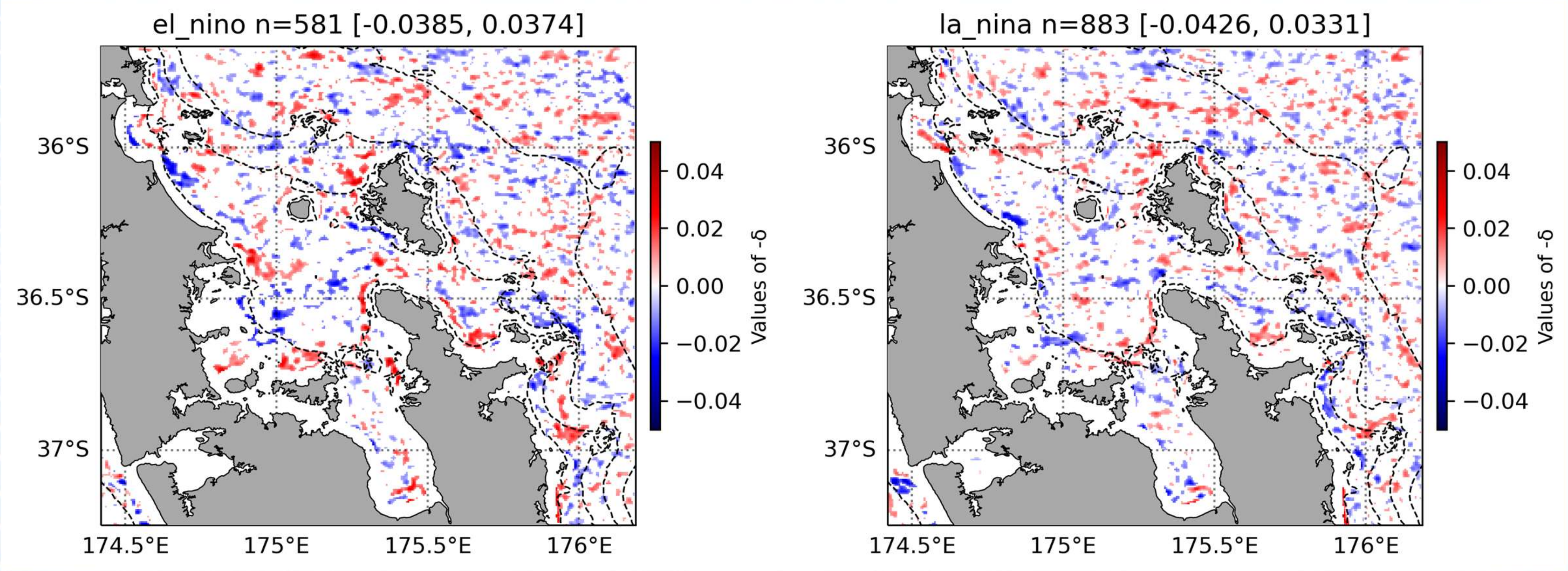
δ (winds 1)


north n=7 [-0.0013, 0.0002]
north-east n=97 [-0.0032, 0.0018]
south n=271 [-0.0105, 0.005]
south-west n=536 [-0.0088, 0.0127]
36°S
36.5°S
37°S
174.5°E
175°E
175.5°E
176°E
0.010
0.005
0.000
−0.005
−0.010
Values of -δ

δ (winds 2)


spring n=637 [-0.009, 0.0112]
summer n=572 [-0.021, 0.0137]
autumn n=589 [-0.0199, 0.0124]
winter n=644 [-0.0127, 0.0193]
36°S
36.5°S
37°S
174.5°E
175°E
175.5°E
176°E
0.02
0.01
0.00
−0.01
−0.02
Values of -δ

δ (season)



el_nino n=581 [-0.0385, 0.0374]
la_nina n=883 [-0.0426, 0.0331]
36°S
36.5°S
37°S
174.5°E
175°E
175.5°E
176°E
0.04
0.02
0.00
−0.02
−0.04
Values of -δ

δ (ENSO)