

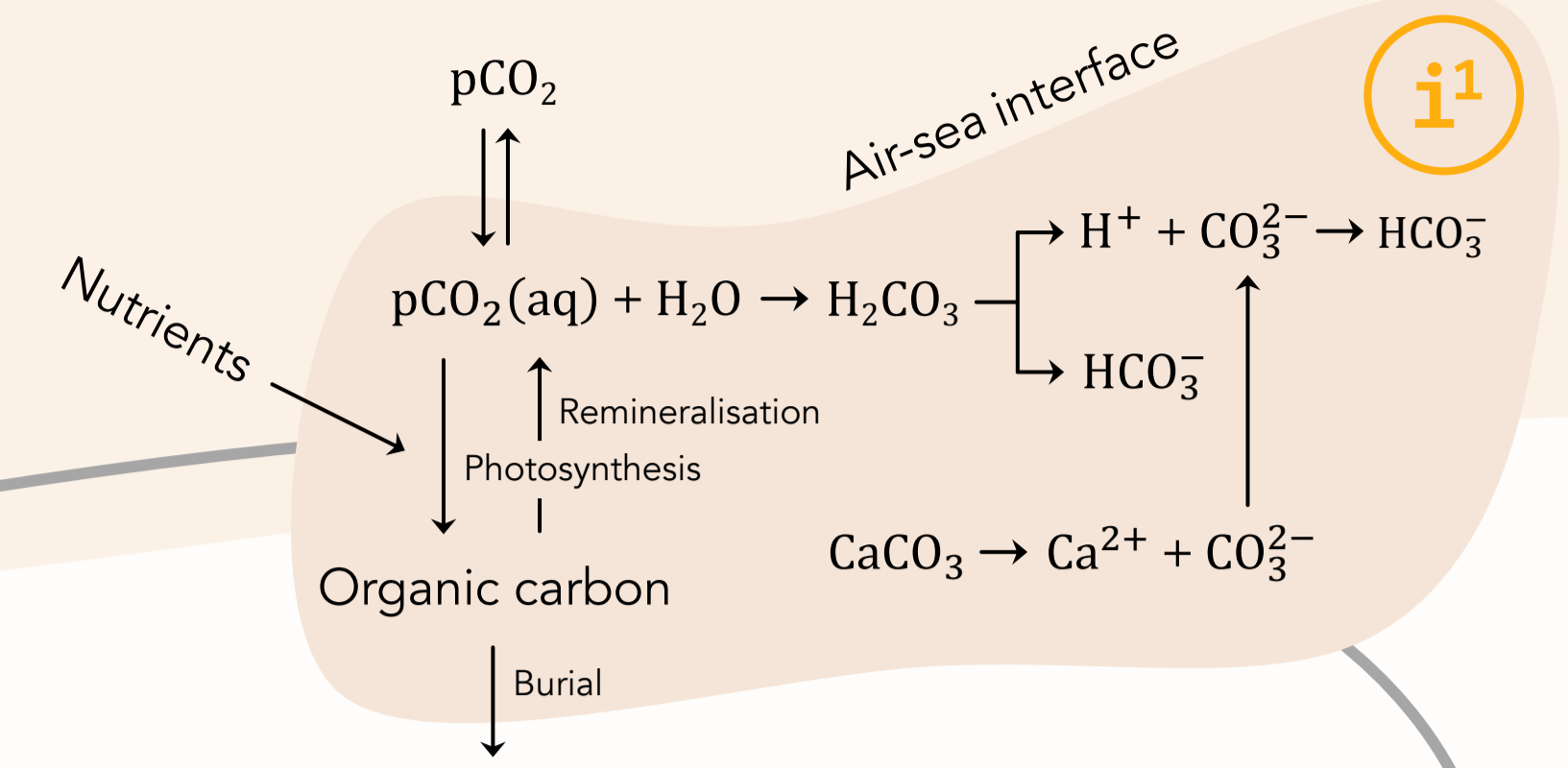
Quantifying how nutrient and carbon inputs from land affect Arctic Ocean acidification

Helene A. L. Hollitzer¹, Ronny Lauerwald², Laurent Bopp³, Jens Terhaar¹

¹Oeschger Centre for Climate Change Research, University of Bern, Switzerland

²Université Paris-Saclay, INRAE, AgroParisTech, UMR ECOSYS, Palaiseau, France

³LMD-IPSL, ENS, Université PSL, Ecole Polytechnique, Sorbonne Université, CNRS, Paris, France



1 Ocean acidification in the Arctic

- Globally, ocean acidification is mainly driven by rising CO₂ emissions. About 25% of the emitted CO₂ is being absorbed by the oceans, triggering chemical reactions that ultimately drive acidification (Box i¹).
- In the Arctic, ocean acidification is additionally influenced by large amounts of carbon and nutrients entering from land (i.e. terrigenous inputs) via:
 - Riverine transport (Box i²) and
 - Coastal erosion.
- Despite their known importance for Arctic ocean acidification, these inputs are often poorly represented in models – or omitted altogether – leaving a knowledge gap in understanding their pan-Arctic impacts. This is concerning as terrigenous inputs are changing due to climate change (Box i³). Thus, we sought to find out:

How do terrigenous inputs affect Arctic Ocean acidification? What can this tell us about future acidification changes?

2 Ocean model

NEMO(version 3.2)-PISCES, ~14 km resolution in the Arctic (ORCA025)

Model simulations 1990–2010^{a,b}

- Baseline scenario:** Includes terrigenous inputs from rivers and coastal erosion.
- No-inputs scenario:** Excludes all terrigenous inputs.
- No-erosion scenario:** Includes only riverine inputs (excludes coastal erosion).

^aAll simulations were run by Terhaar et al.^[5] and use a gridded, observation-based forcing dataset for Arctic land-ocean carbon and nutrient fluxes from rivers and coastal erosion^[5].

^bStudy period: 2005–2010

3 Results

Terrigenous carbon and nutrient inputs influence Arctic Ocean acidification through a number of pathways (overview in Fig. 1):

Carbon inputs

- Coastal erosion** releases org. carbon, leading to acidification (Fig. 2c, Box i⁴).
- Rivers** add. supply inorg. carbon, increasing alkal. and mitigating acidification (Fig. 2b).

Nutrient inputs

- At the surface ocean**, nutrients derived from both rivers and coastal erosion boost primary productivity and mitigate acidification by removing CO₂.
- Below the surface** (~20–100 m depth), remineralisation of the newly produced organic matter releases CO₂ and increases acidification.

The resulting **vertical pattern** is strongest during the biologically-active summer (Fig. 1). This seasonality has a non-negligible effect: terrigenous inputs account for ~50% of the seasonal variation in Ω^c on a pan-Arctic scale.

At depth, these biological dynamics create low-Ω hotspots (Box i⁴).

^cAragonite saturation state; one proxy for ocean acidification.

In the Laptev and East Siberian Seas, 5% of the water volume between 20–100 m has Ω values up to 20% lower due to terrigenous inputs (annual mean).

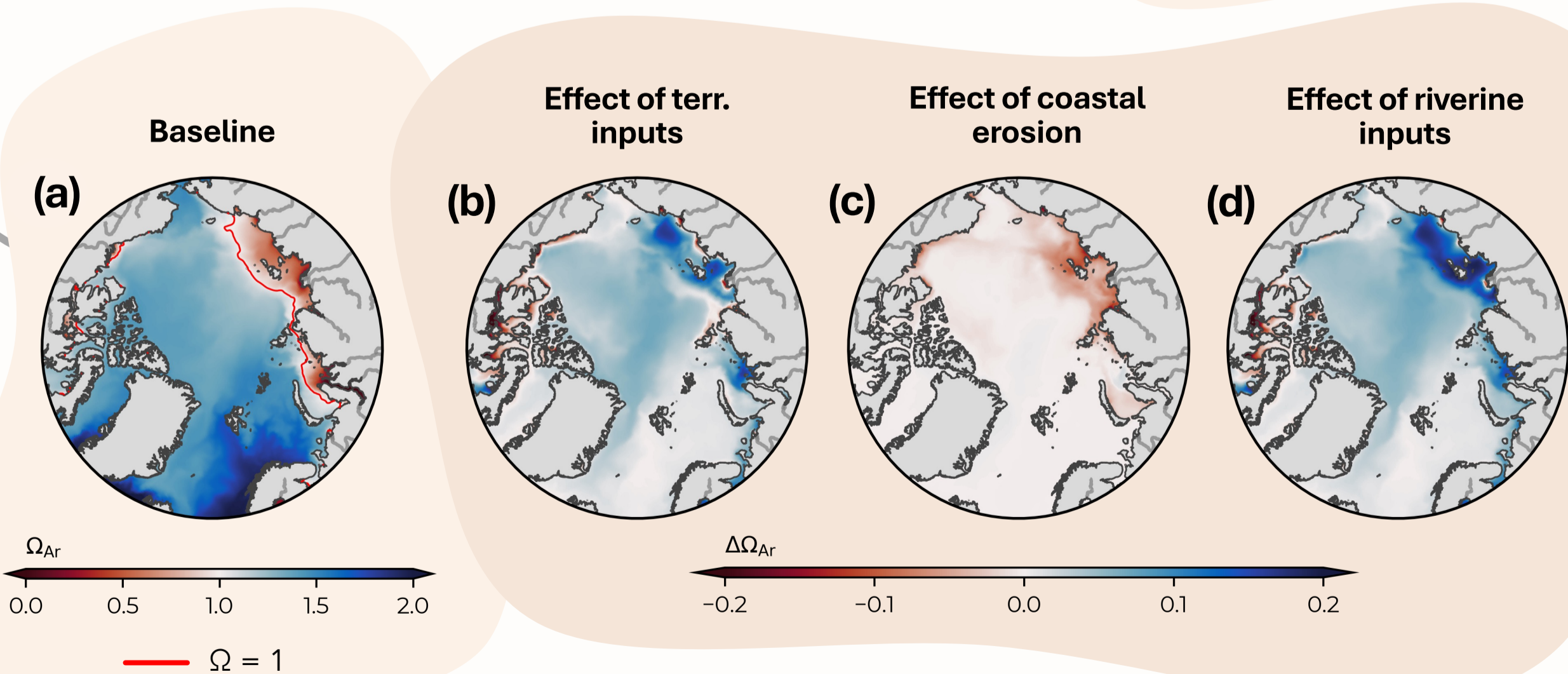


Figure 2: Maps showing the effect of terrigenous nutrient and carbon inputs on Arctic Ocean Ω. (a) Simulated surface ocean Ω (2005–2010) considering terrigenous inputs (baseline scenario). Panels (b–d) show anomalies relative to the baseline scenario: (b) total anomaly from all terrigenous sources, (c) anomaly due to coastal erosion inputs, and (d) anomaly due to riverine inputs.

References

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Author

Helene A. L. Hollitzer
PhD Student
Department of Physics
University of Bern
helene.hollitzer@unibe.ch



4 Conclusions

- Terrigenous inputs are a key driver of Arctic Ocean acidification patterns, influencing both annual mean Ω and seasonal Ω variability. These results highlight the importance of – currently often omitted – terrigenous inputs in model-based projections of Arctic Ocean acidification and broader biogeochemical changes.
- The projected increase in Arctic coastal erosion may increase subsurface acidification during the 21st century.

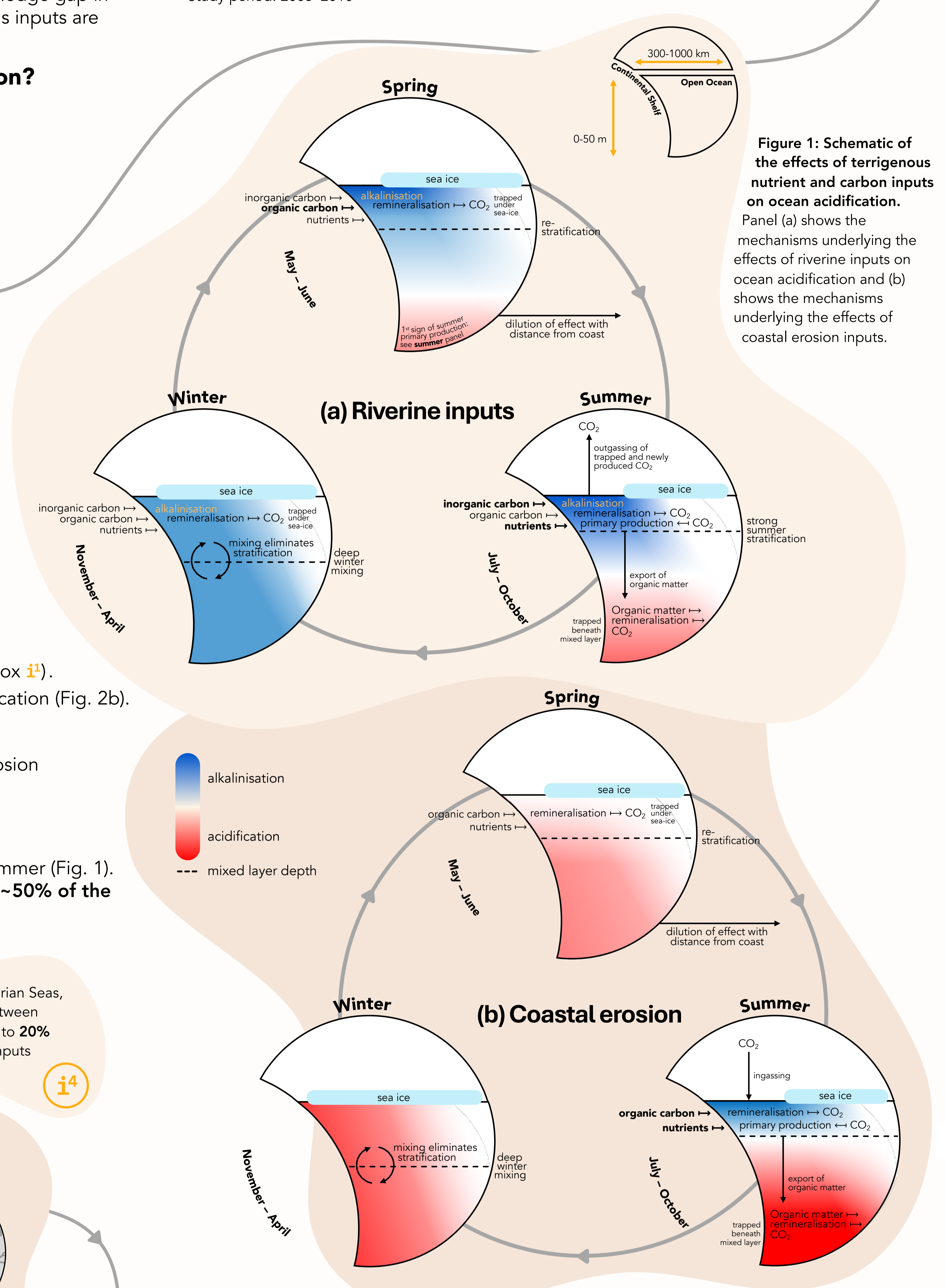


Figure 1: Schematic of the effects of terrigenous nutrient and carbon inputs on ocean acidification.

Panel (a) shows the mechanisms underlying the effects of riverine inputs on ocean acidification and (b) shows the mechanisms underlying the effects of coastal erosion inputs.