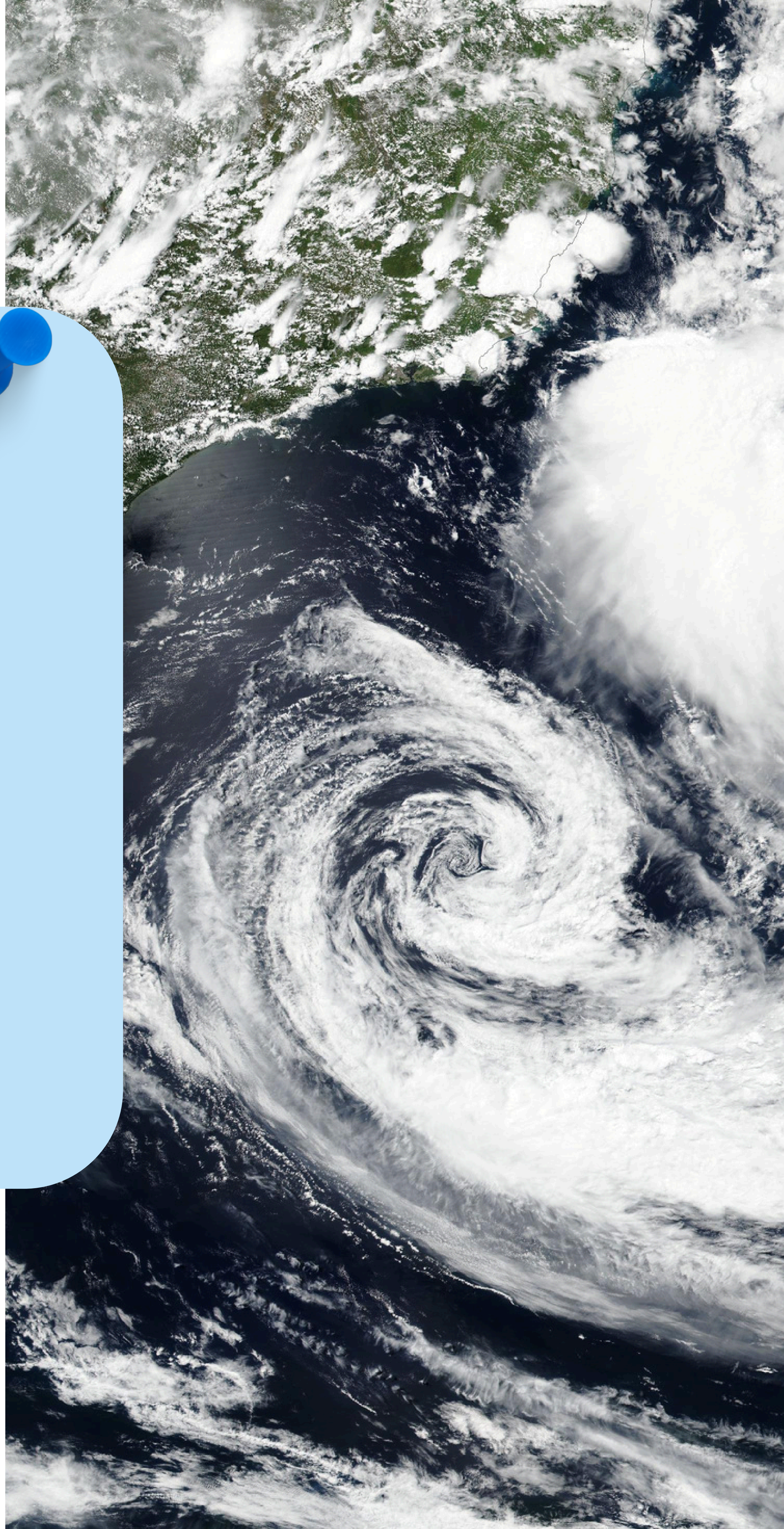
Unraveling the Rare Tropical Transition of Cyclone Akará in the South Atlantic

Danilo Couto de Souza

4th Workshop on Waves, Storm Surges and Coastal Hazards



Research team

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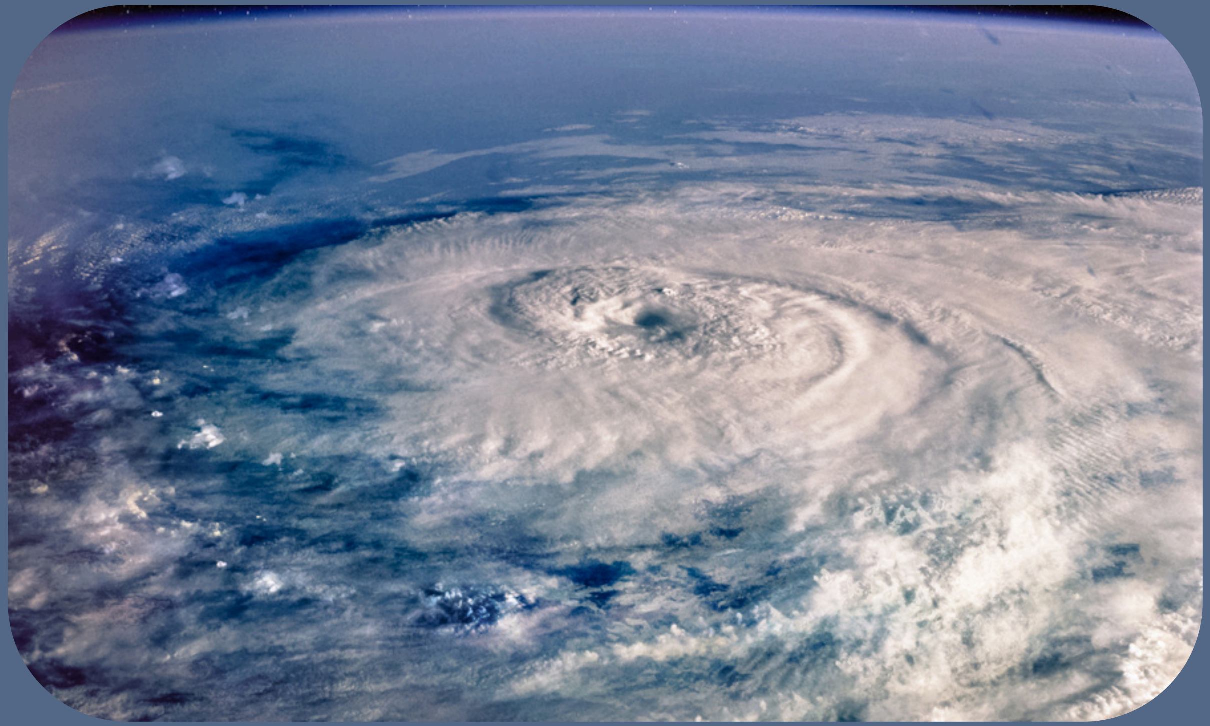
USP

MASTER
METEOROLOGIA APLICADA A SISTEMAS DE TEMPO REGIONAIS

BR PETROBRAS CENPES

INPE

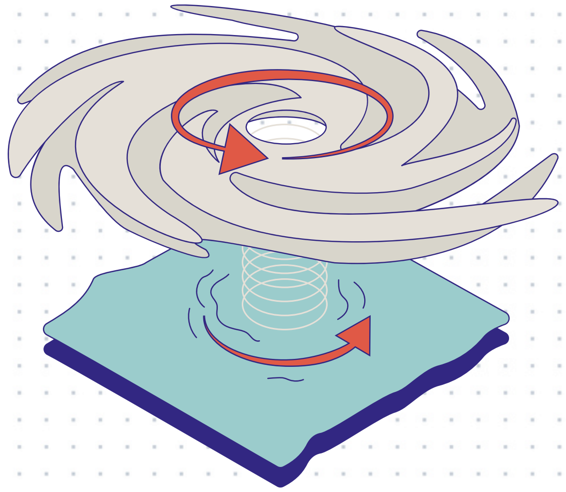
IRB(P&D)



Overview

04

Objectives



Objective 1

Understand why tropical cyclones are rare in the South Atlantic and the causes of the few exceptions.

Objective 2

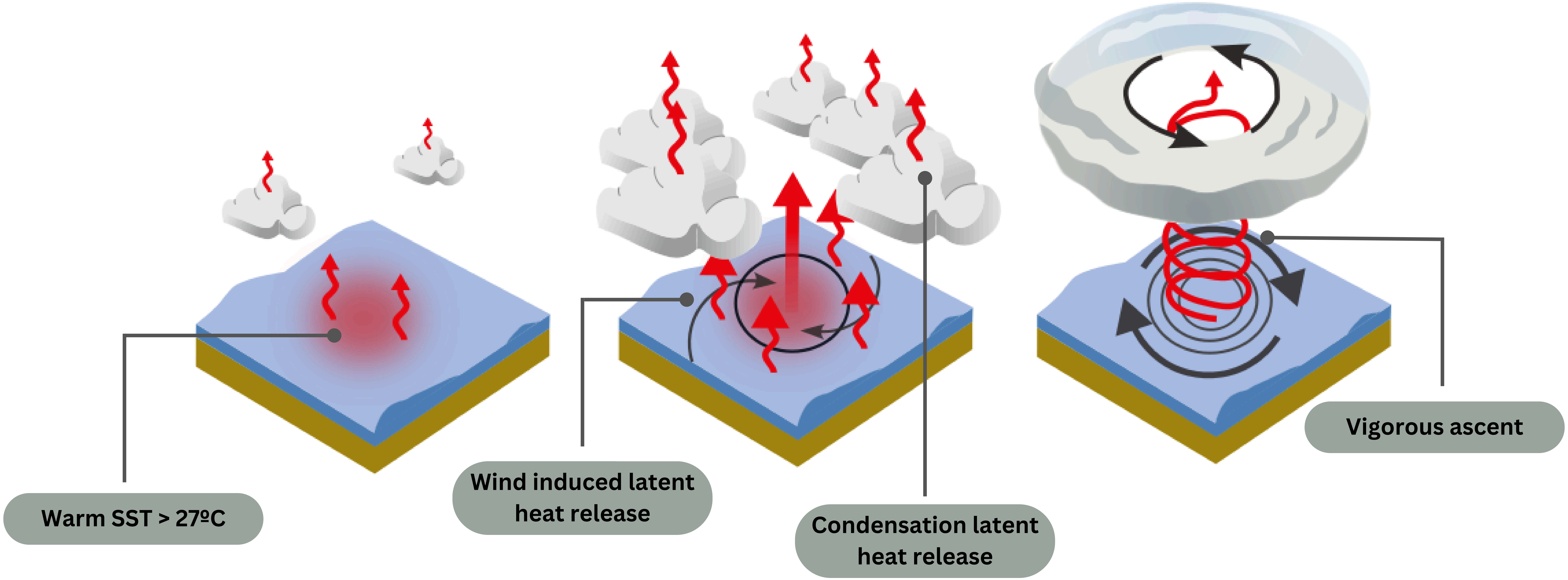
Analyze and investigate the mechanisms related to the tropical transition of Cyclone Akará in February 2024.

Objective 3

Investigate the impacts of such a system on the SST and wave fields

How do tropical cyclones form?

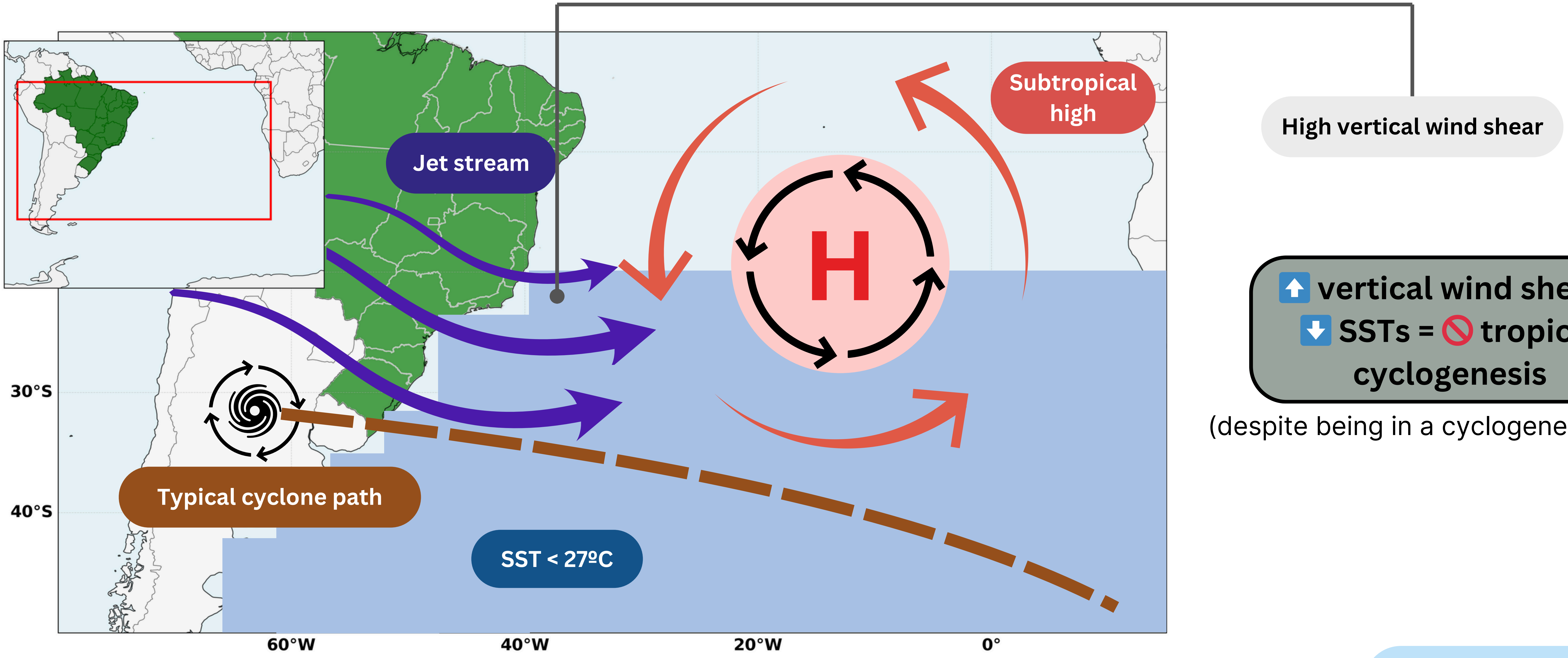
(the ultimate oversimplification)



(adpted to the southern hemisphere)

Tropical cyclones in the South Atlantic

(not quite a love story)



⬆ vertical wind shear + ⬇ SSTs = 🚫 tropical cyclogenesis

(despite being in a cyclogenesis region)

Our analysis

Heat budget

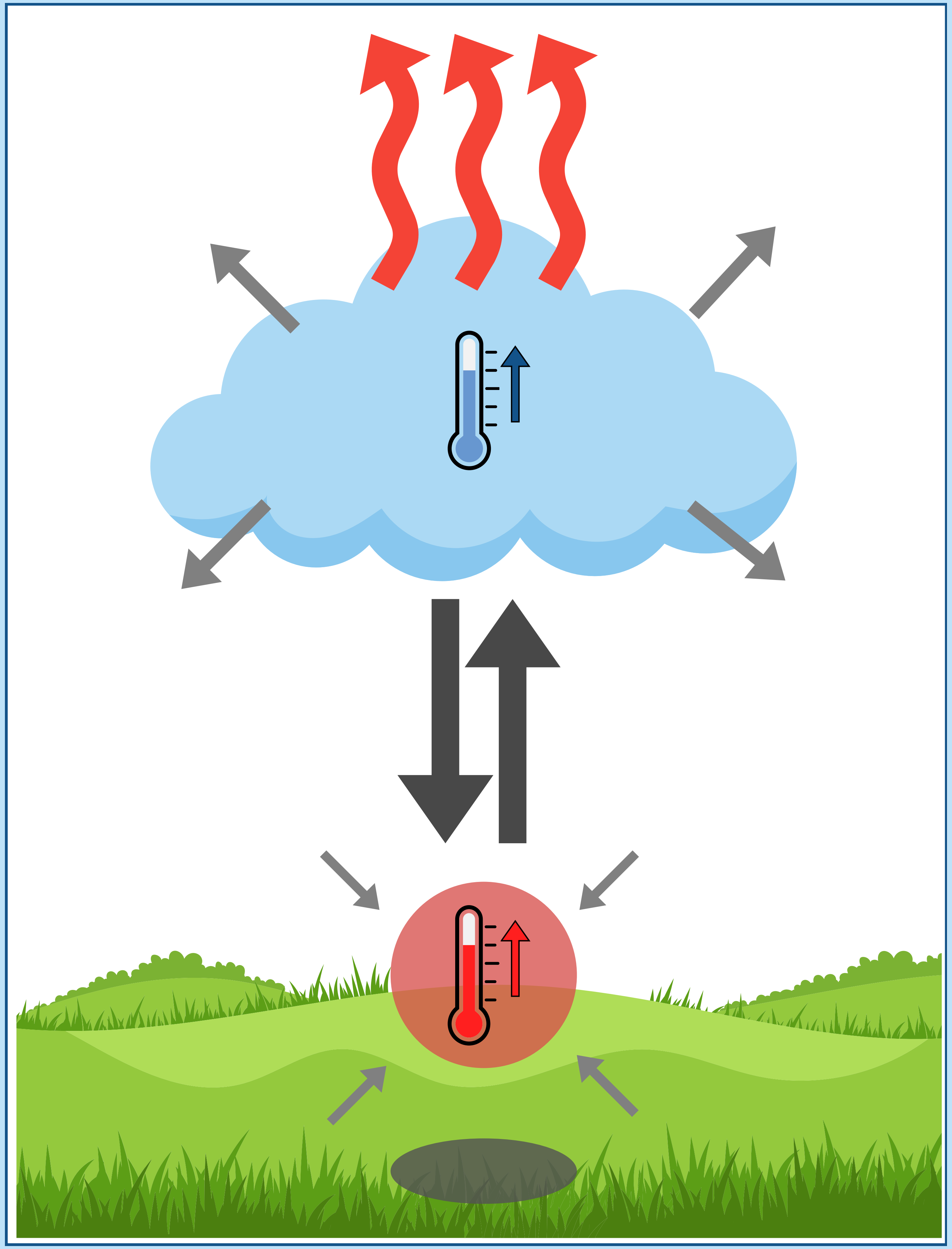
$$\underbrace{\frac{\partial T}{\partial t}}_{(A)} = \underbrace{-\mathbf{V}_h \cdot \nabla_h T}_{(B)} - \underbrace{S_p \omega}_{(C)} + \underbrace{Q}_{(D)},$$

Temperature h. advection

Latent heat release

Temperature tendency

Adiabatic compression/ expansion



Our analysis

Vorticity budget

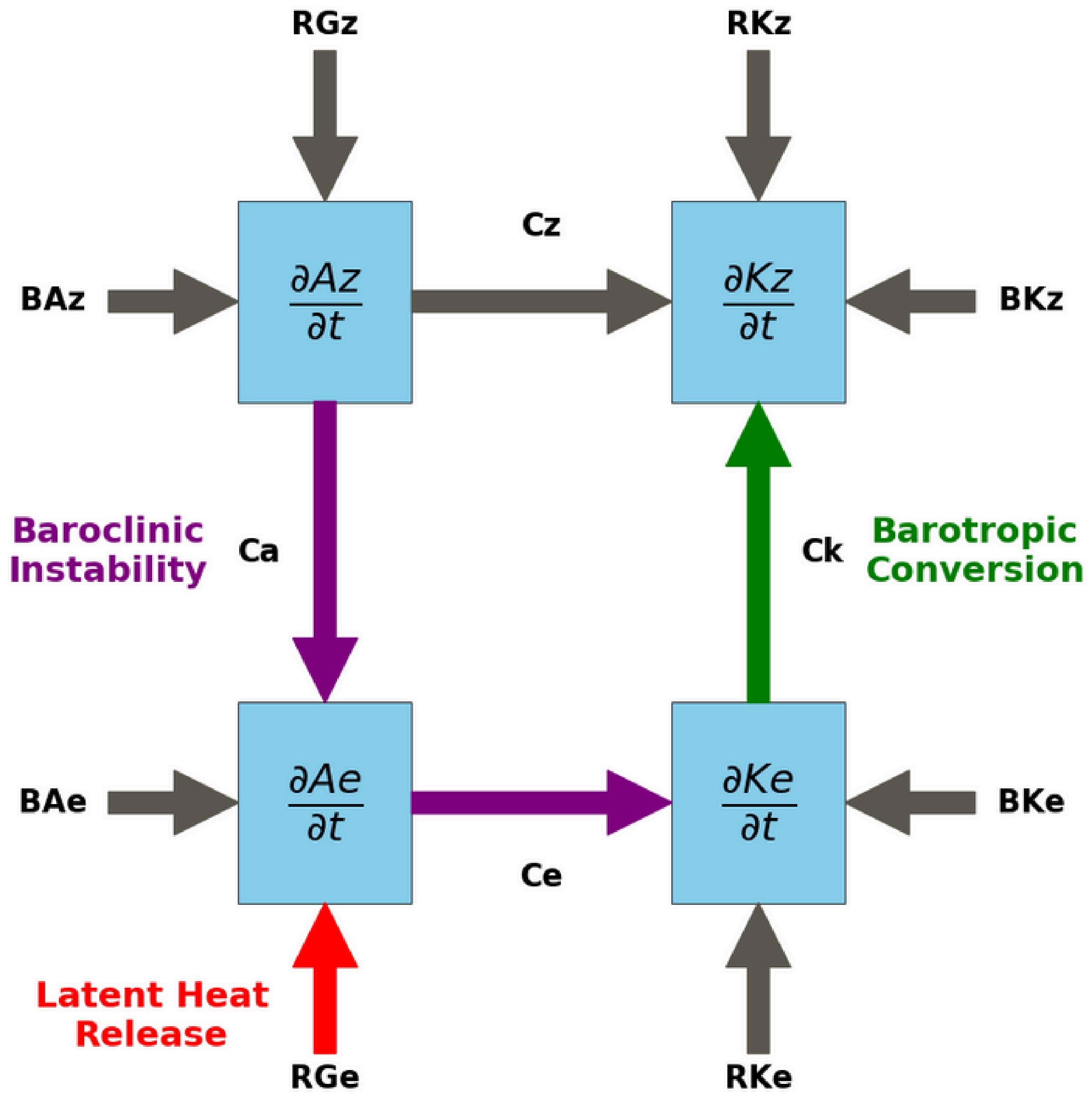
$$\underbrace{\frac{\partial \zeta}{\partial t}}_{(A)} = \underbrace{-\mathbf{V}_h \cdot \nabla_h \zeta}_{(B)} + \underbrace{-\omega \frac{\partial \zeta}{\partial p}}_{(C)} + \underbrace{-\beta v}_{(D)} + \underbrace{-\zeta \nabla \cdot \mathbf{V}_h}_{(E)} + \underbrace{-f \nabla \cdot \mathbf{V}_h}_{(F)} + \underbrace{\left(\frac{\partial \zeta}{\partial y} \frac{\partial u}{\partial p} - \frac{\partial \zeta}{\partial x} \frac{\partial v}{\partial p} \right)}_{(G)} + \underbrace{F_\zeta}_{(H)}$$

- (A) ζ tendency
- (B) ζ h. advection
- (C) ζ v. advection
- (D) Advection of f
- (E) stretching term (ζ contr.)
- (F) stretching term (f contr.)
- (G) tilting term
- (H) friction

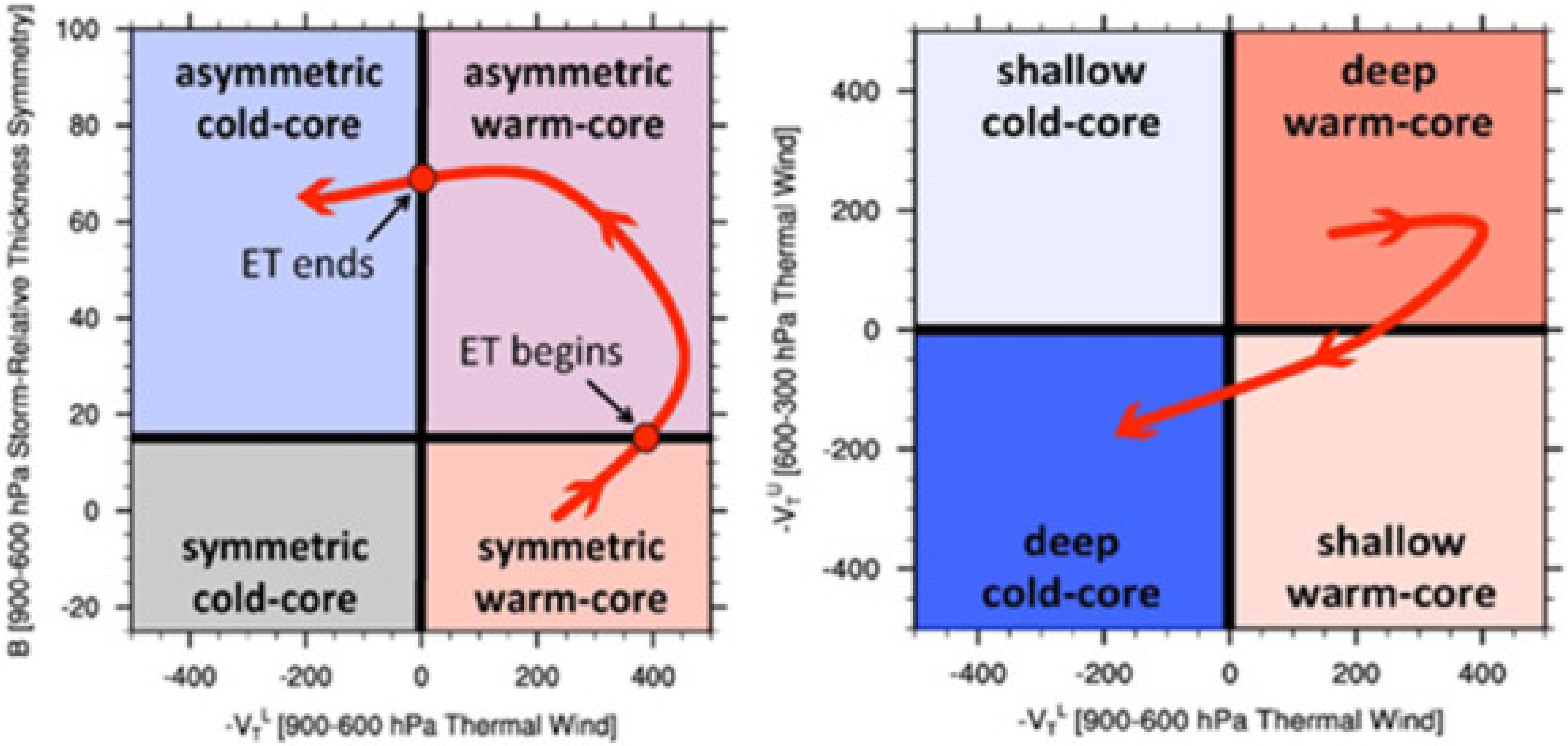
ζ = relative vorticity
f = planetary vorticity (Coriolis)

Our analysis

Lorenz Energy Cycle



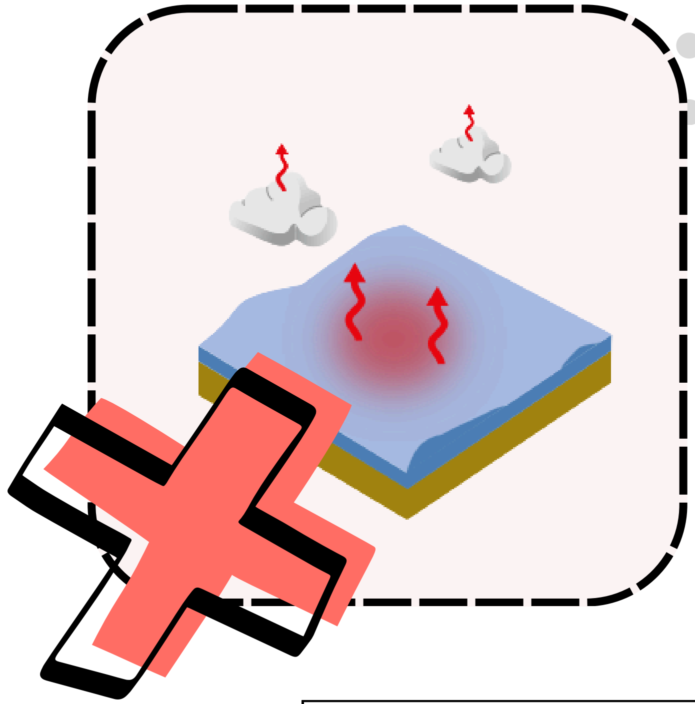
Cyclone Phase Space

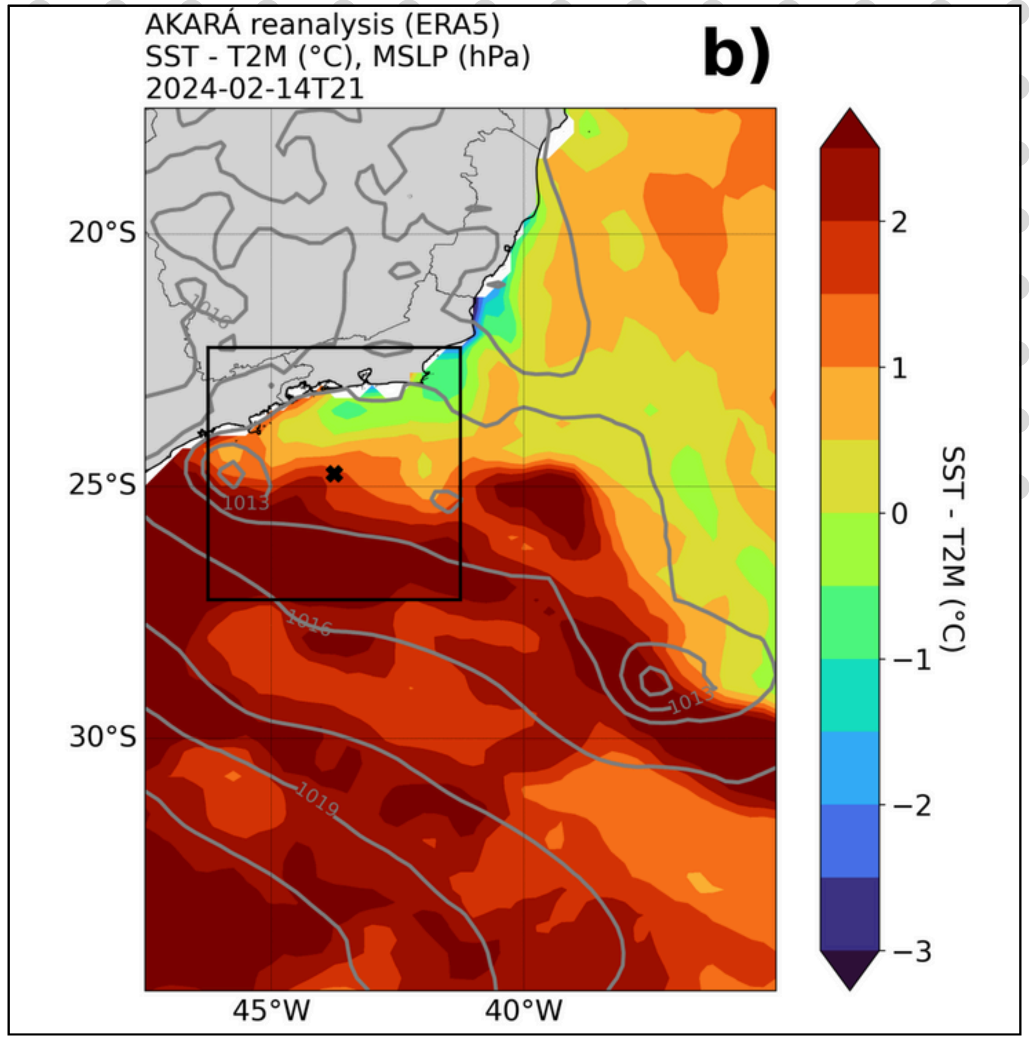


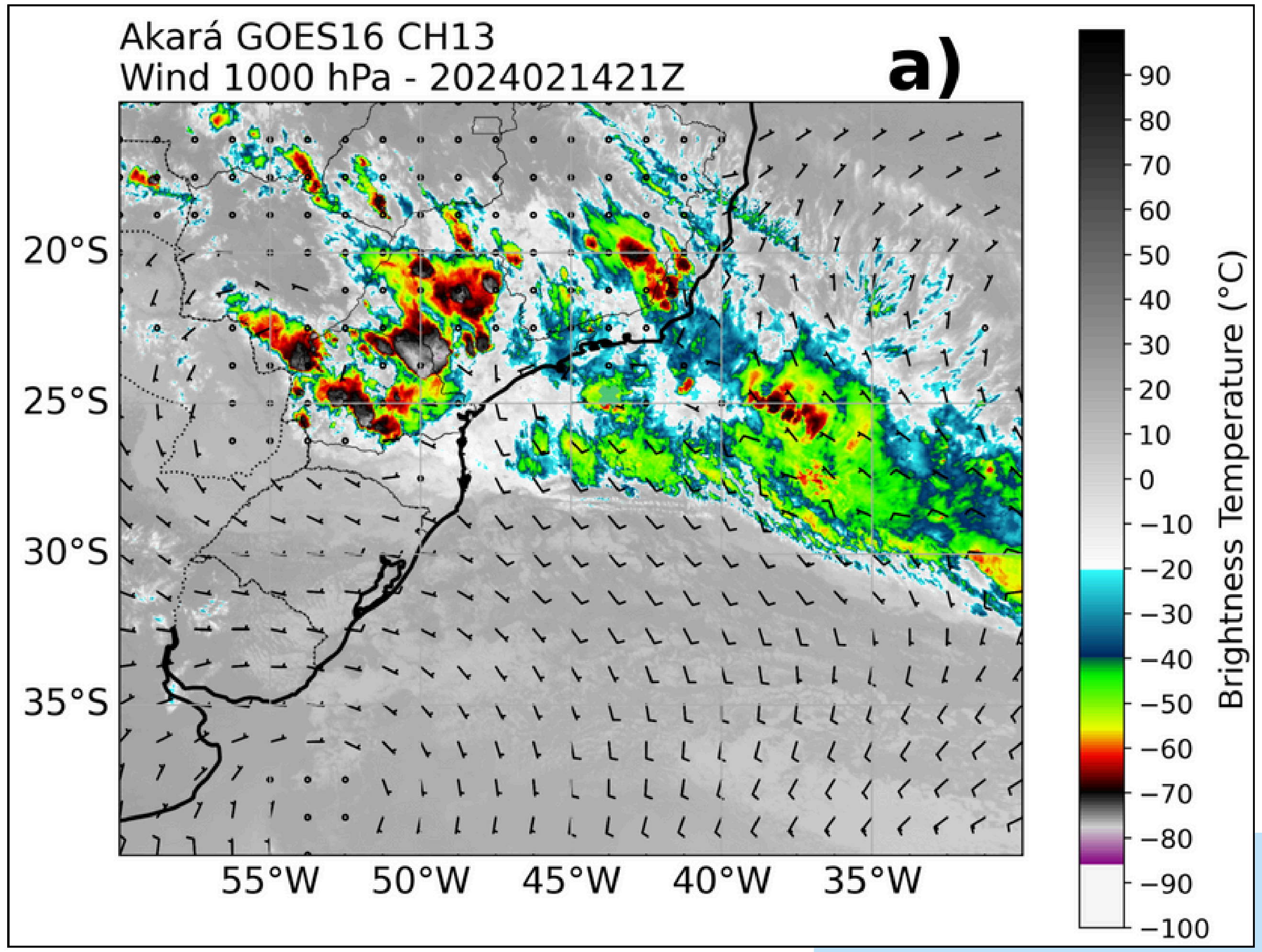
Akará development

Cyclogenesis

- Frontal region: baroclinic environment with deep convection
- High ocean-atmosphere thermal contrast → convection → latent heat release
- Later: coupling with cutoff-low (high altitude, cold core) → enhcanced convection
- **Subtropical cyclone**



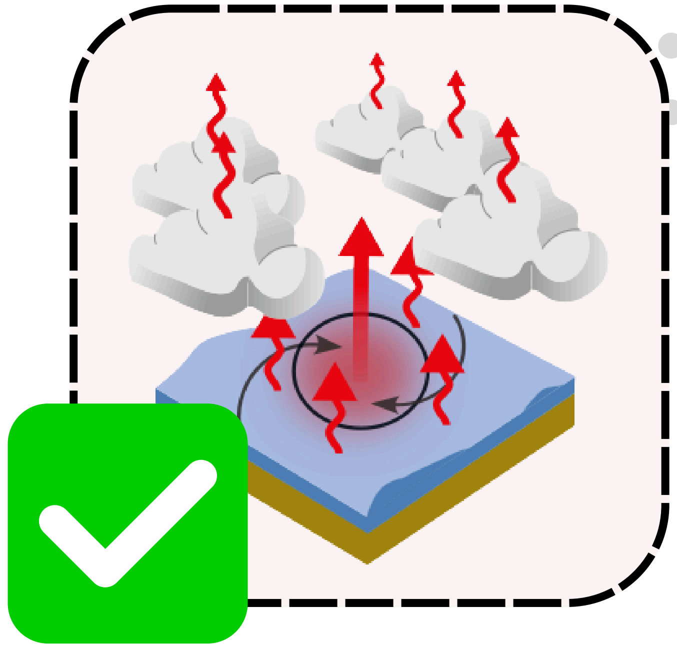


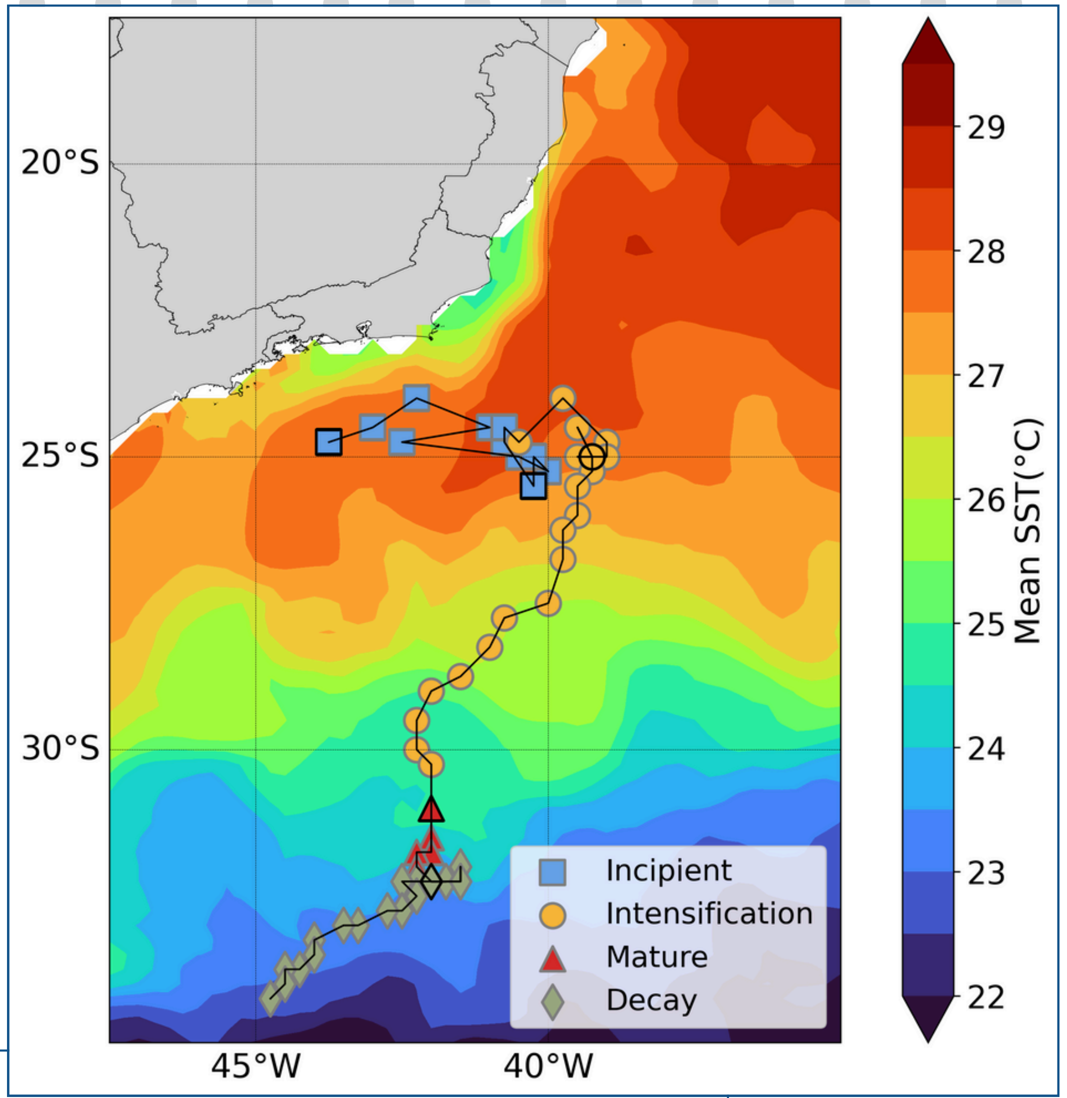


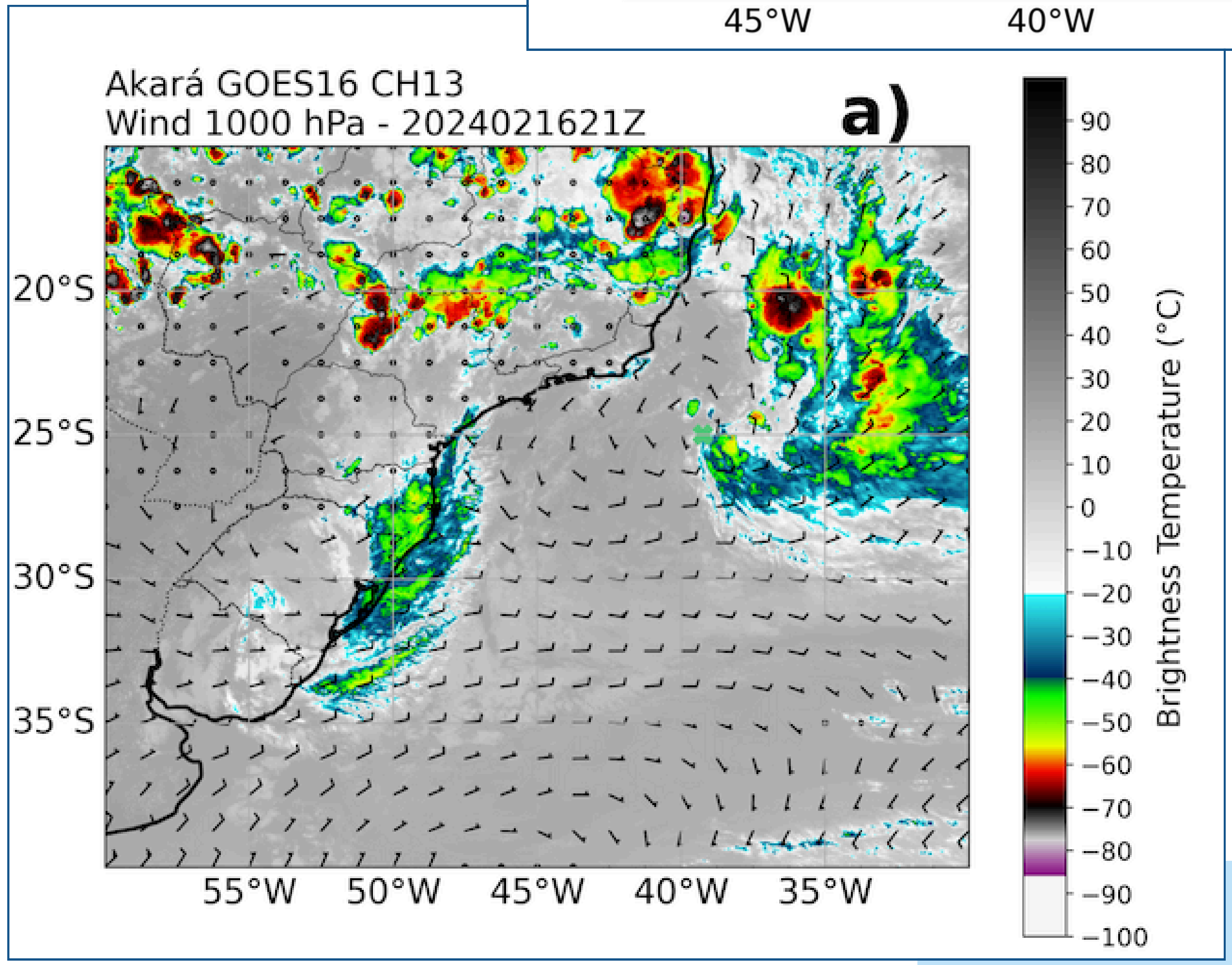
Akará development

Intensification

- Low-level convergence and upper-level divergence
- High SSTs (> 28°C)
- Barotropic conversions on mid to low atmosphere
- **Tropical transition with deep warm core**



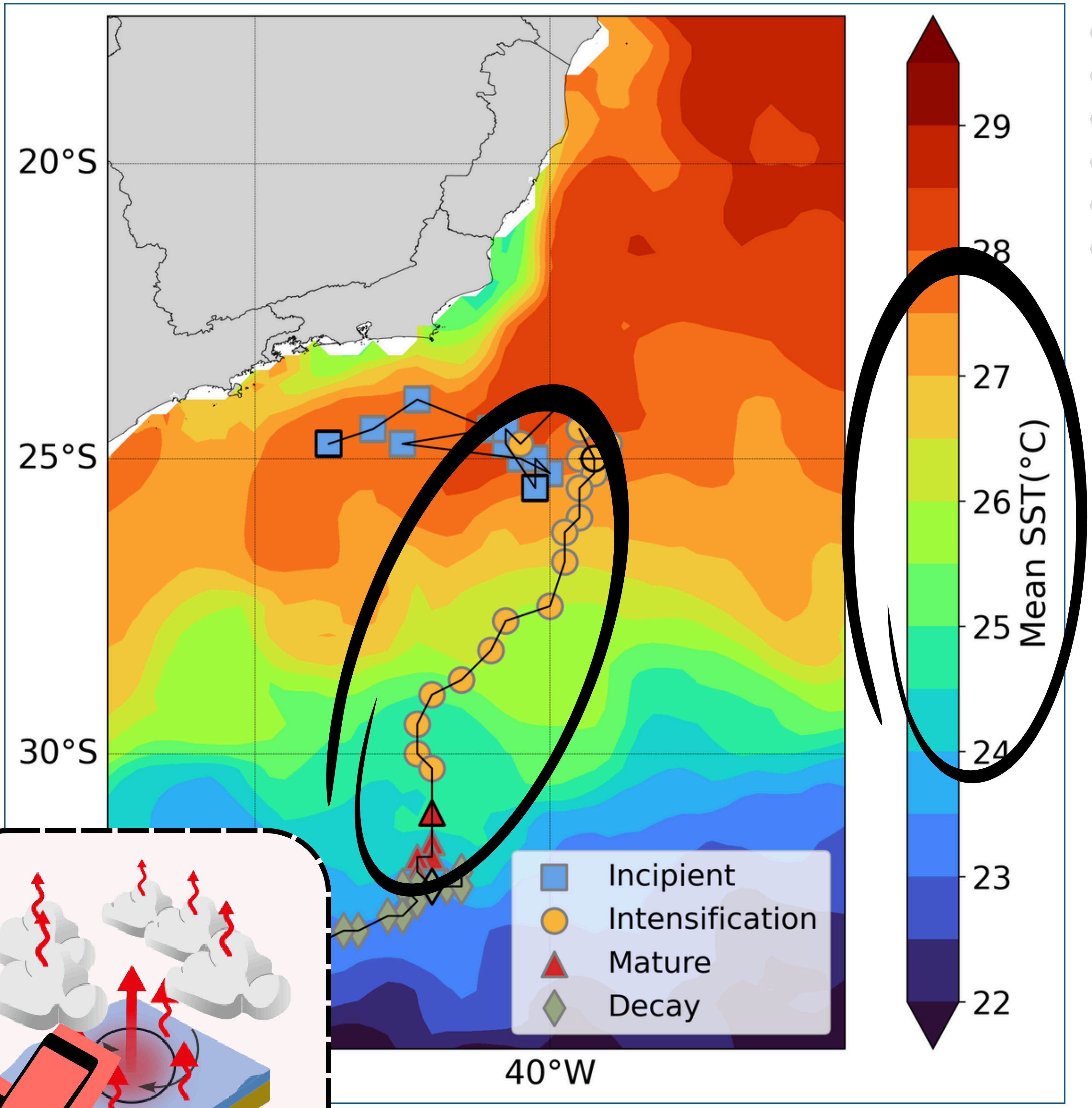




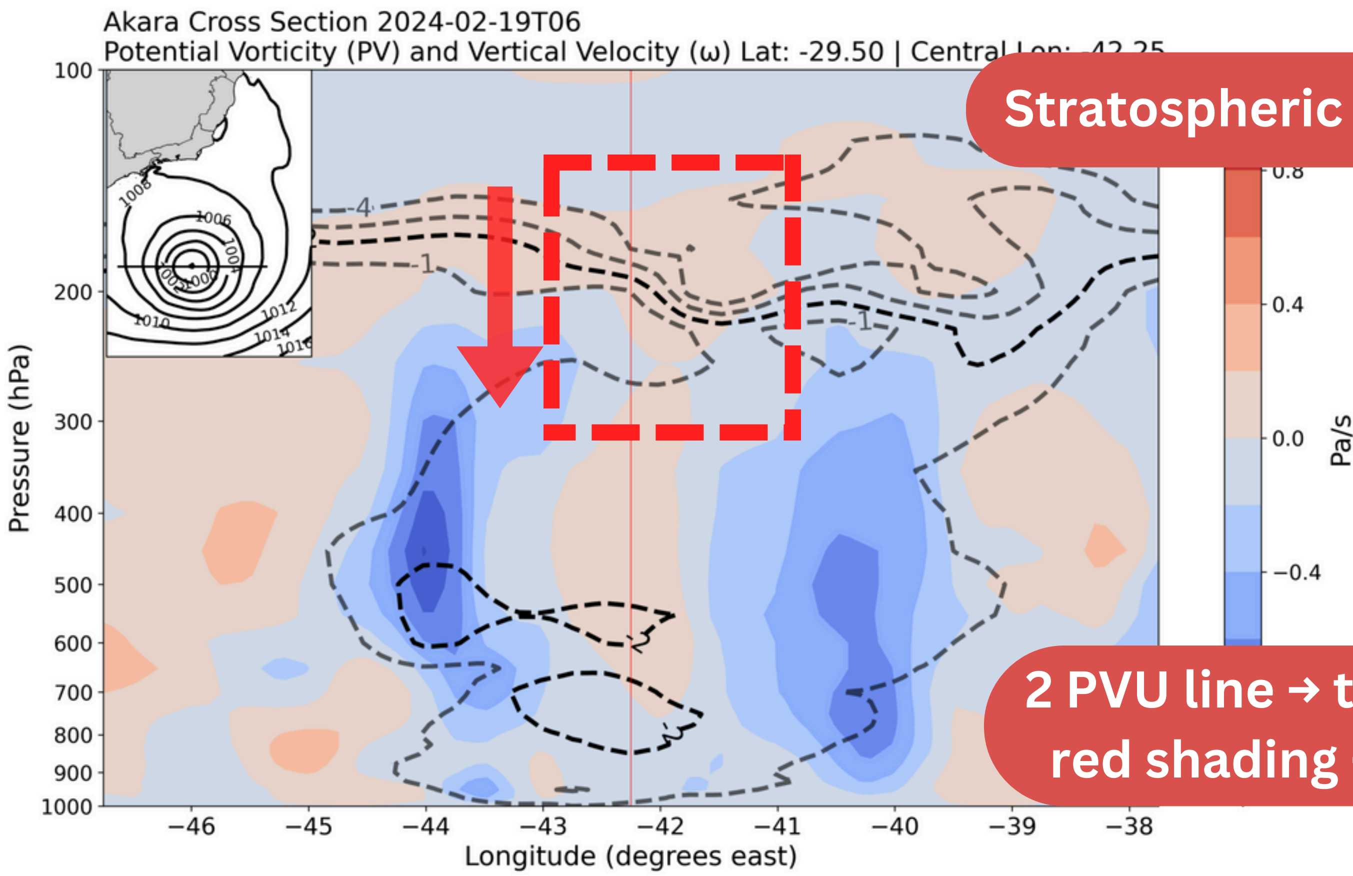
Akará development

But during intensification....

- Displacement towards low SSTs
- This would make **convective activity decrease** and development to **stop**

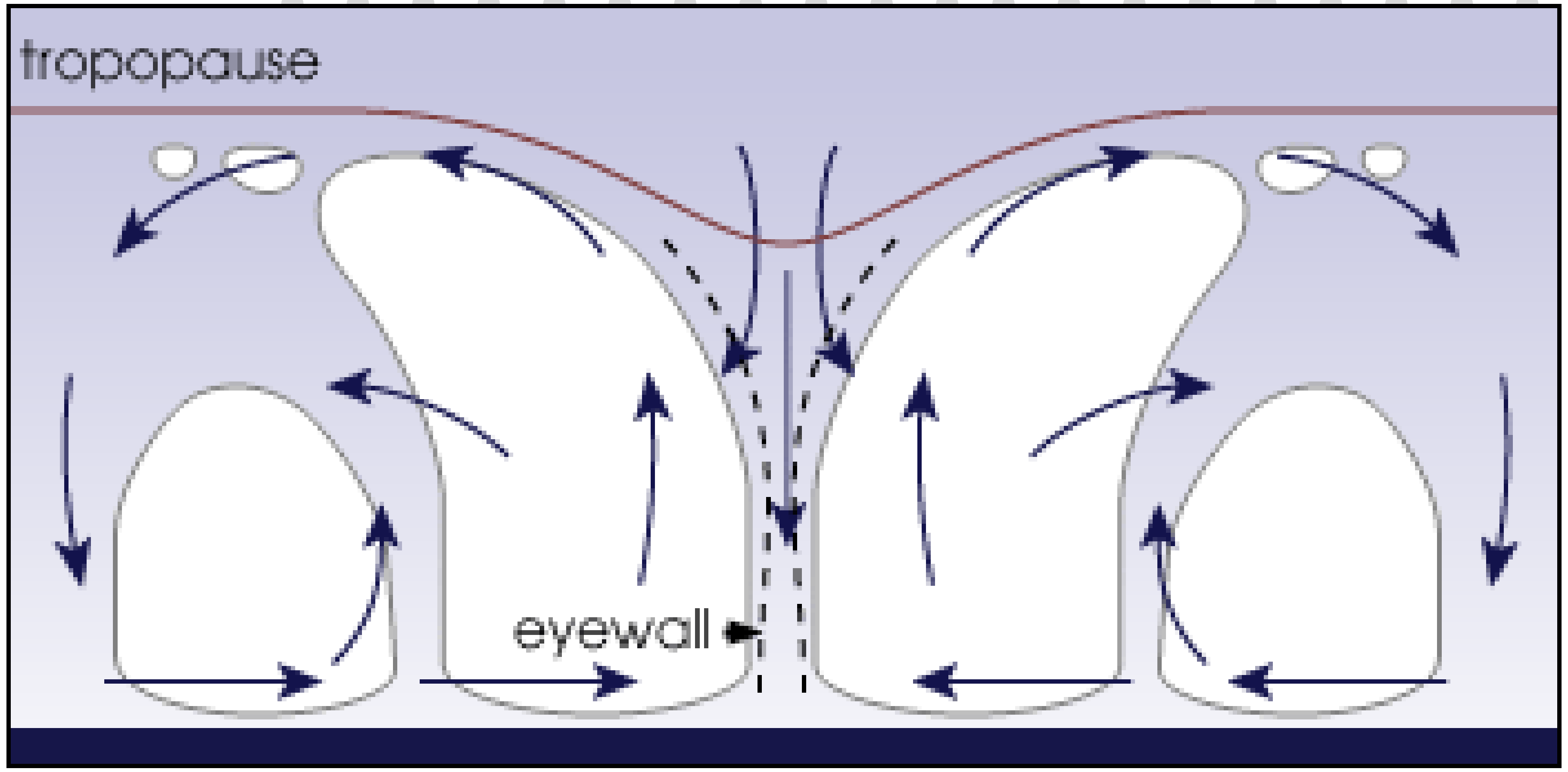


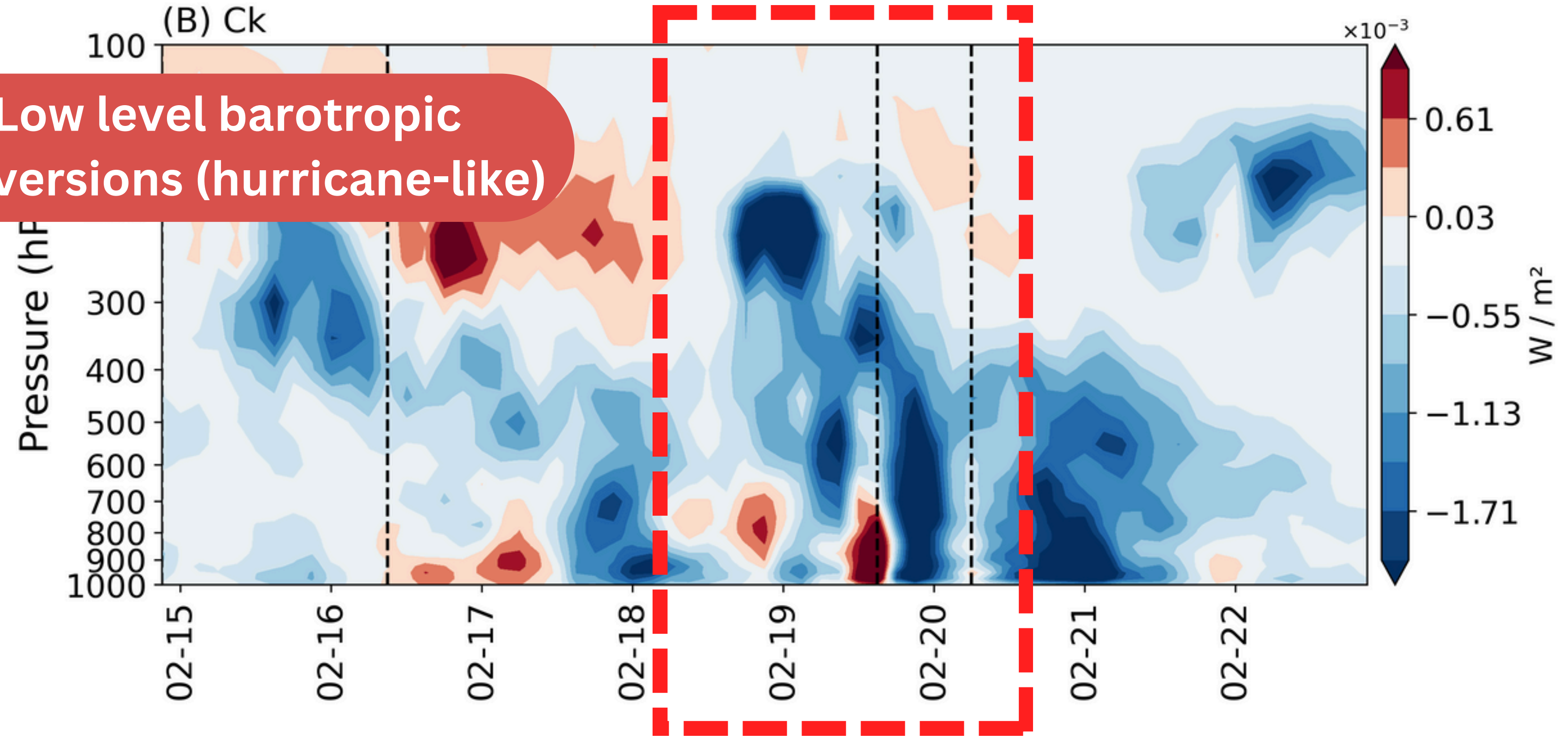
Stratospheric incursions



Stratospheric intrusions

2 PVU line → tropopause
red shading → descent



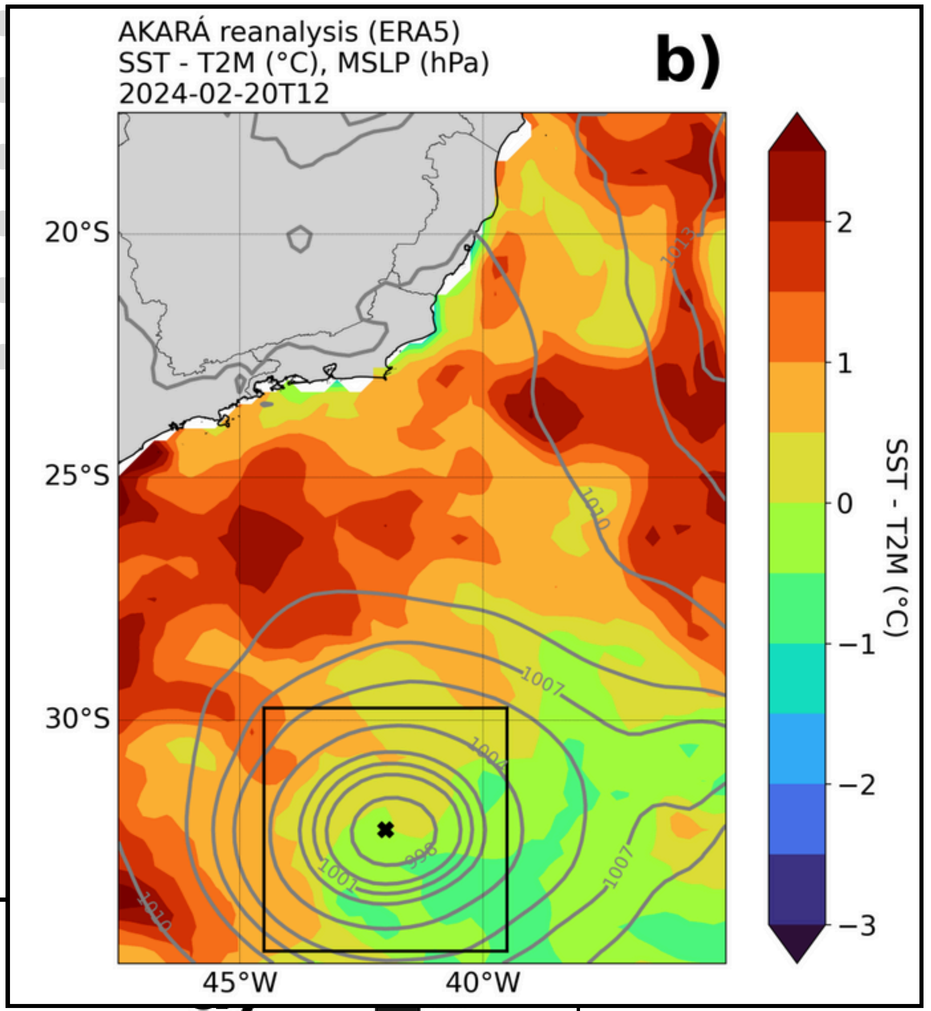


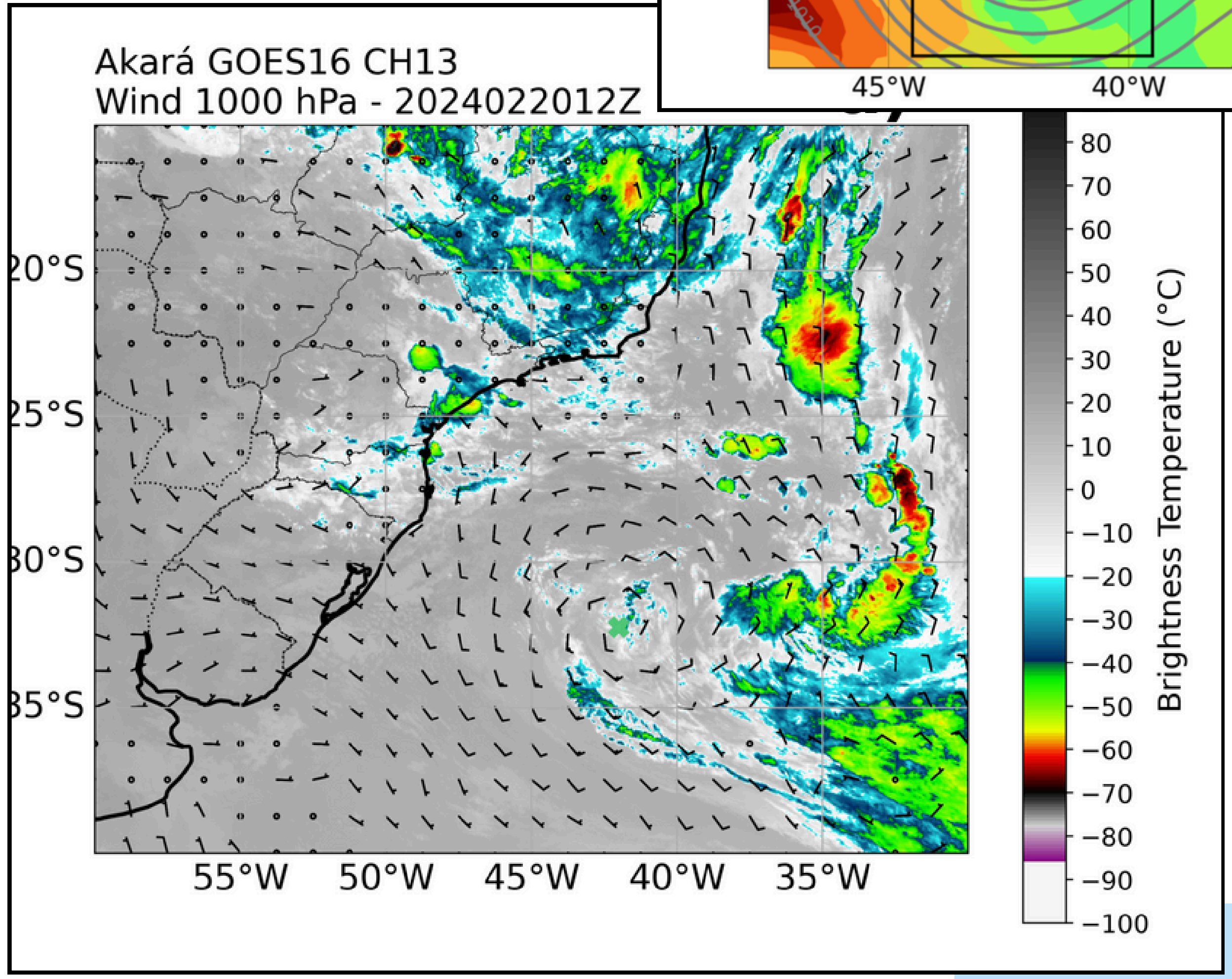
Low level barotropic
conversions (hurricane-like)

Akará development

Decay

- Increase in vertical wind shear → **decrease in convective activity**
- Cyclone approaches a baroclinic zone
  - Barotropic conversions change from surface levels to upper levels.
- Subtropical transition marked by:
  - **Cooling** in the mid-to-upper troposphere
  - Movement over **colder waters** (< 23°C)
- Displacement into a **colder atmospheric region**





Research Article

Revisiting The Rare Transition of a South Atlantic Cyclone to Tropical Storm Akará: Energy Cycle and Stratosphere-Troposphere Interaction

Danilo Couto de Souza, Victor Antunes Ranieri, Pedro Leite da Silva Dias, and 2 more

This is a preprint; it has not been peer reviewed by a journal.

https://doi.org/10.21203/rs.3.rs-6536558/v1

Abstract

Cyclone Akará was the third documented tropical cyclone in the South Atlantic, undergoing a rare subtropical-to-tropical transition in February 2024. This study investigates the dynamical, thermodynamical, and energetic evolution of Akará using a diagnostic framework combining the Lorenz Energy Cycle (LEC) and heat and vorticity budgets. Akará originated in a post-frontal, weakly baroclinic environment characterized by warm sea surface temperatures (>28$\circ C$), strong ocean-atmosphere thermal contrast, and low vertical wind shear. These conditions favored convective activity and led to the development of a symmetric warm core, initially supported by latent heat release and interaction with an upper-level cutoff low. As the system intensified, it transitioned into a tropical cyclone, exhibiting a deep warm core and organized convection. Stratospheric air intrusions were identified during and after the tropical transition, contributing to upper-tropospheric warming and enhancing cyclone intensification. Heat

Status: Under Revision

Springer
Climate Dynamics

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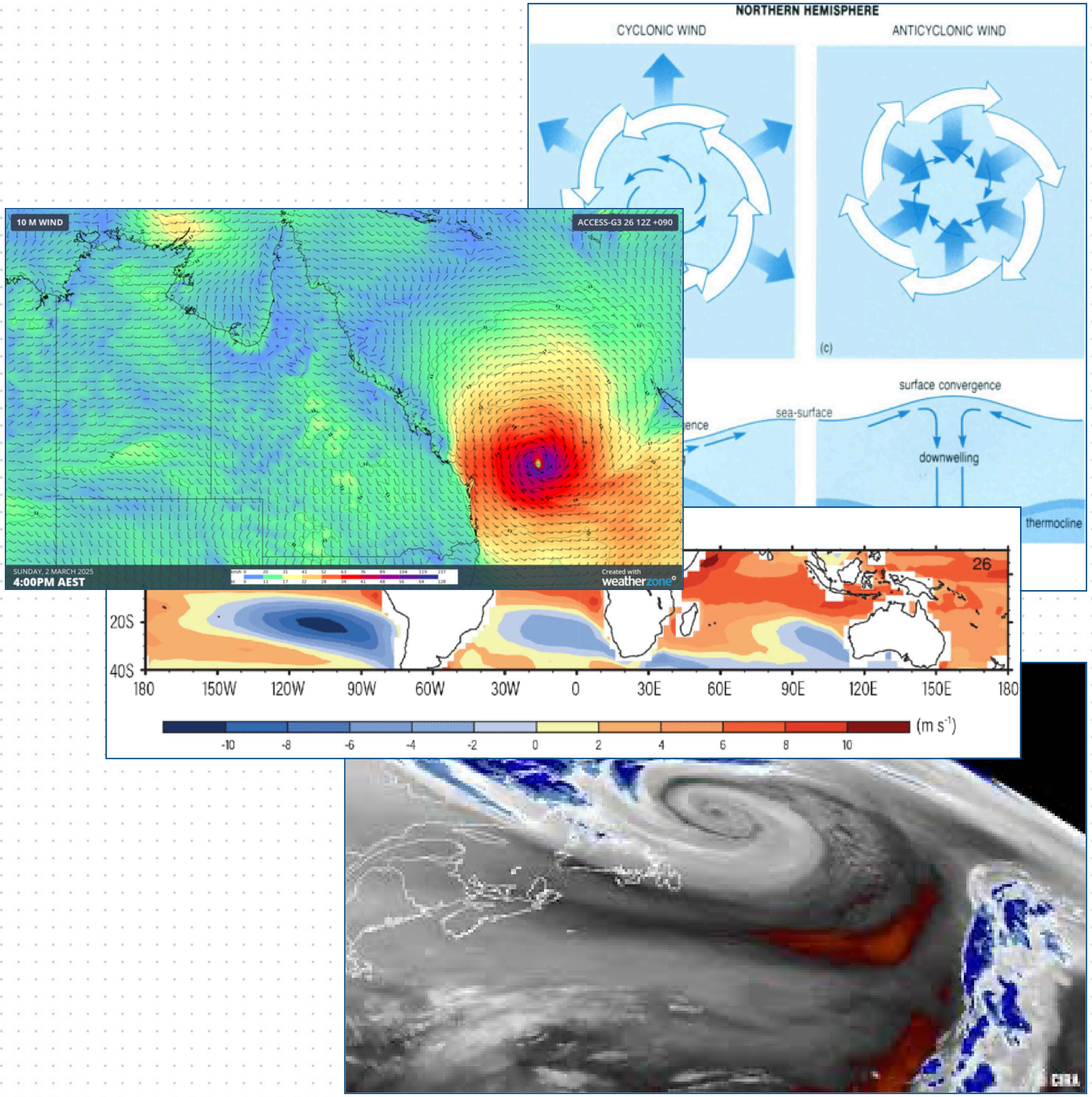
Reviewers invited by journal	04 Jun, 2025
Editor assigned by journal	23 May, 2025
First submitted to journal	13 May, 2025

You are reading this latest preprint version

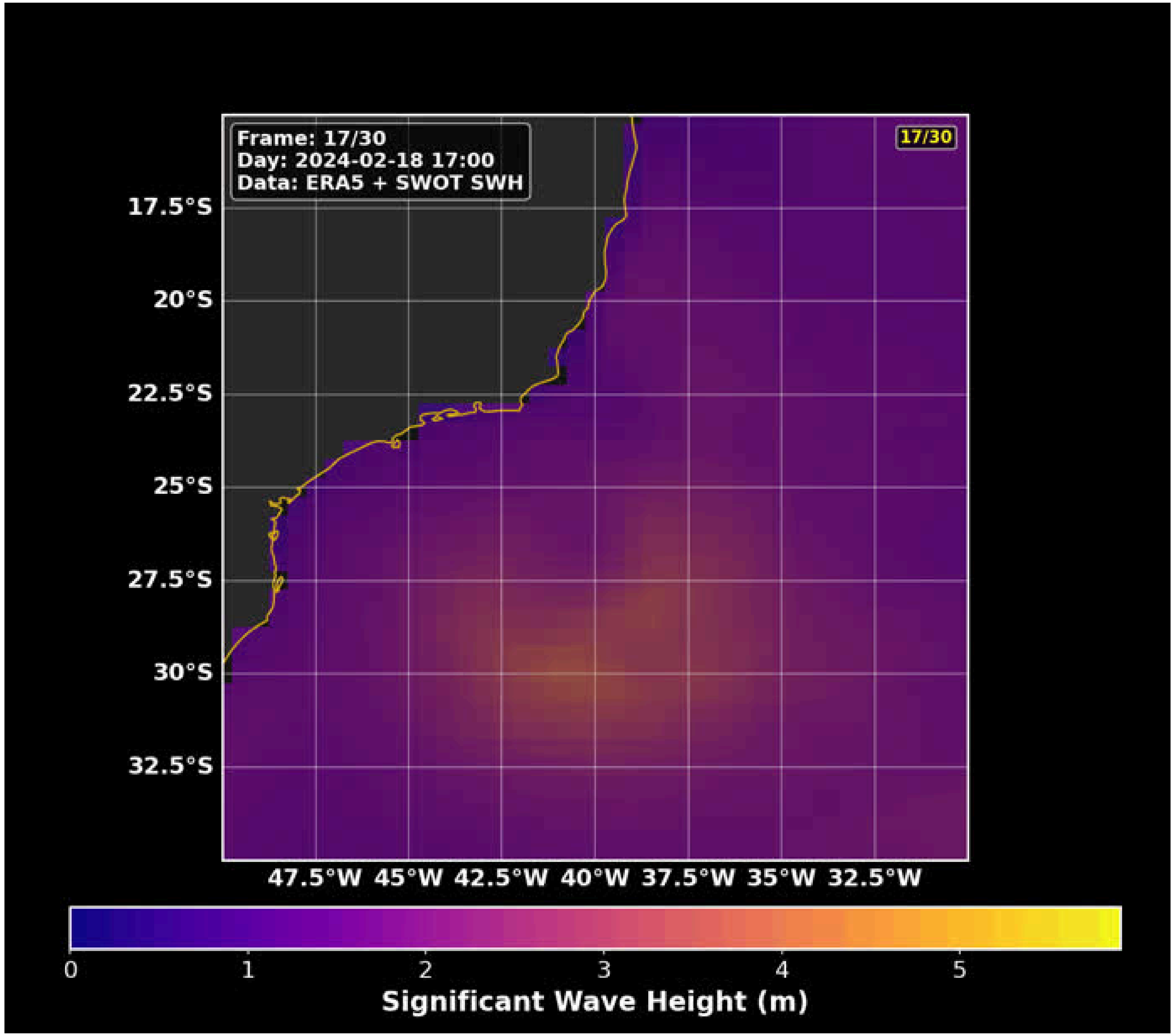
Next steps

Oceanic analysis

1. Analysis of upwelling and the Ekman pump (was there a cold wake associated?)
2. Compute ocean heat content and intensification potential (was it anomalous?)
3. Swell propagation generated by the cyclone to the coast (would it have been threatening to coastal communities if its track was less southward?)



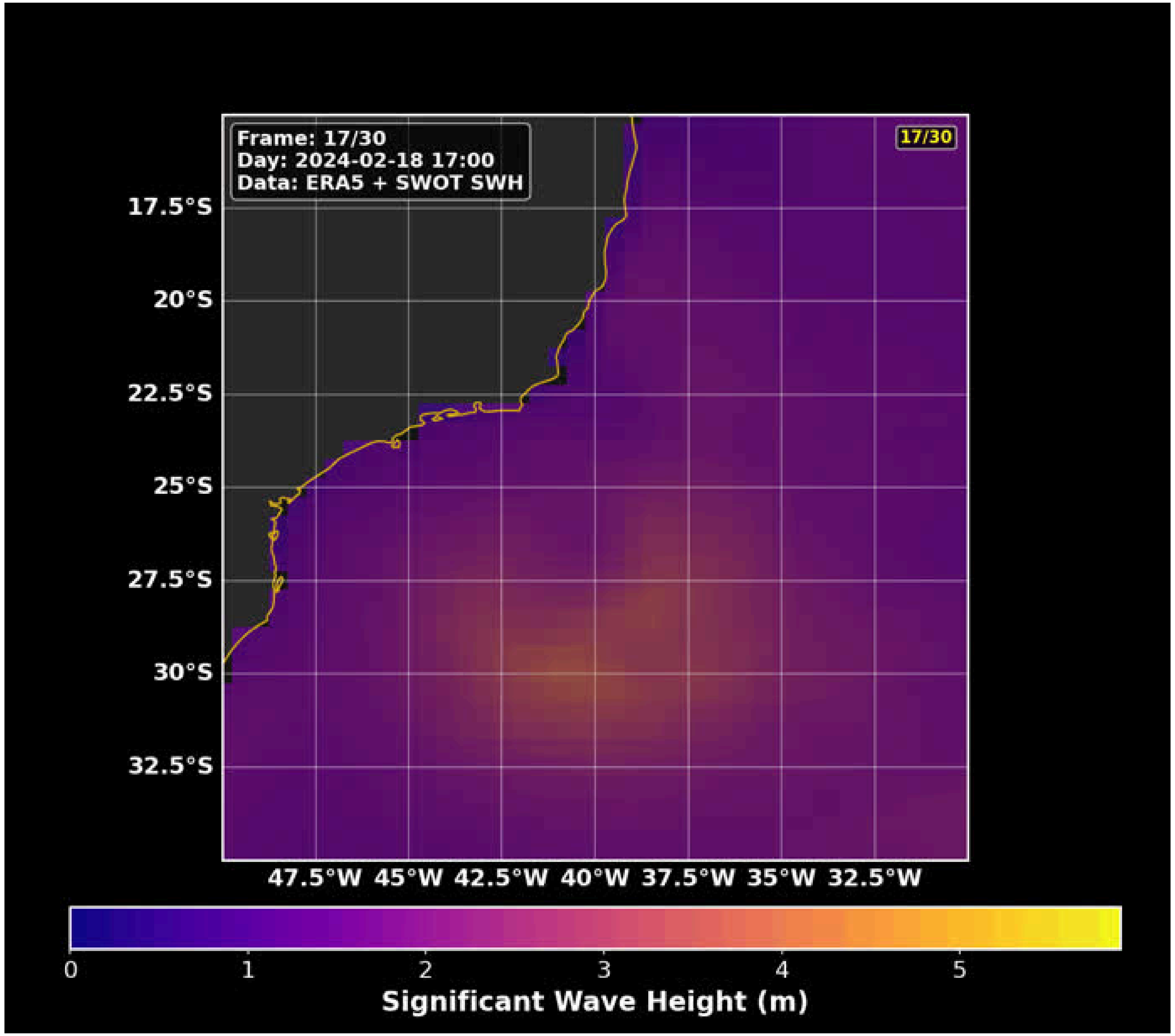
SWOT + ERA5 Hs



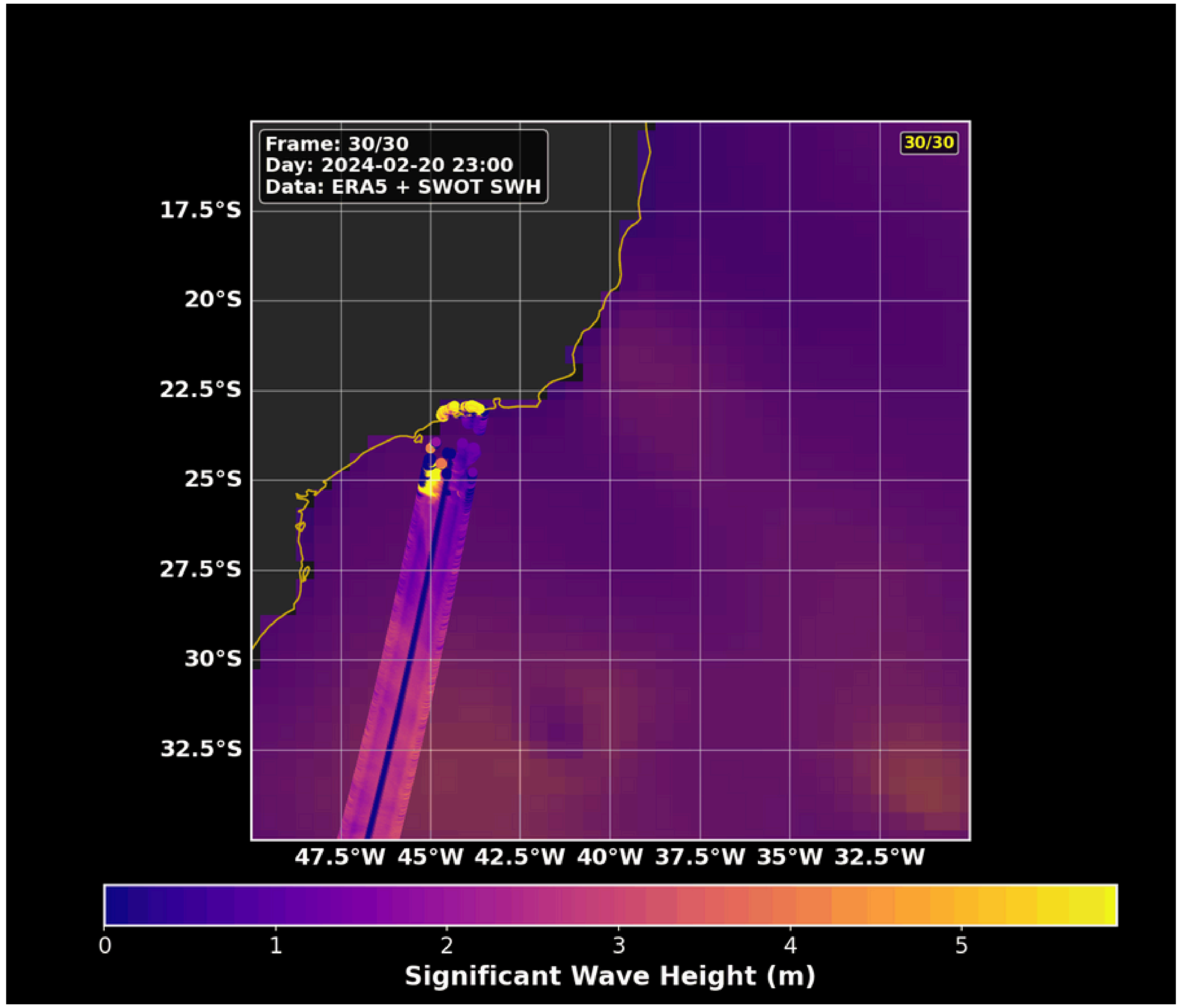
Dataissues

- **Just few observations when we filter out rain and low quality flag points**

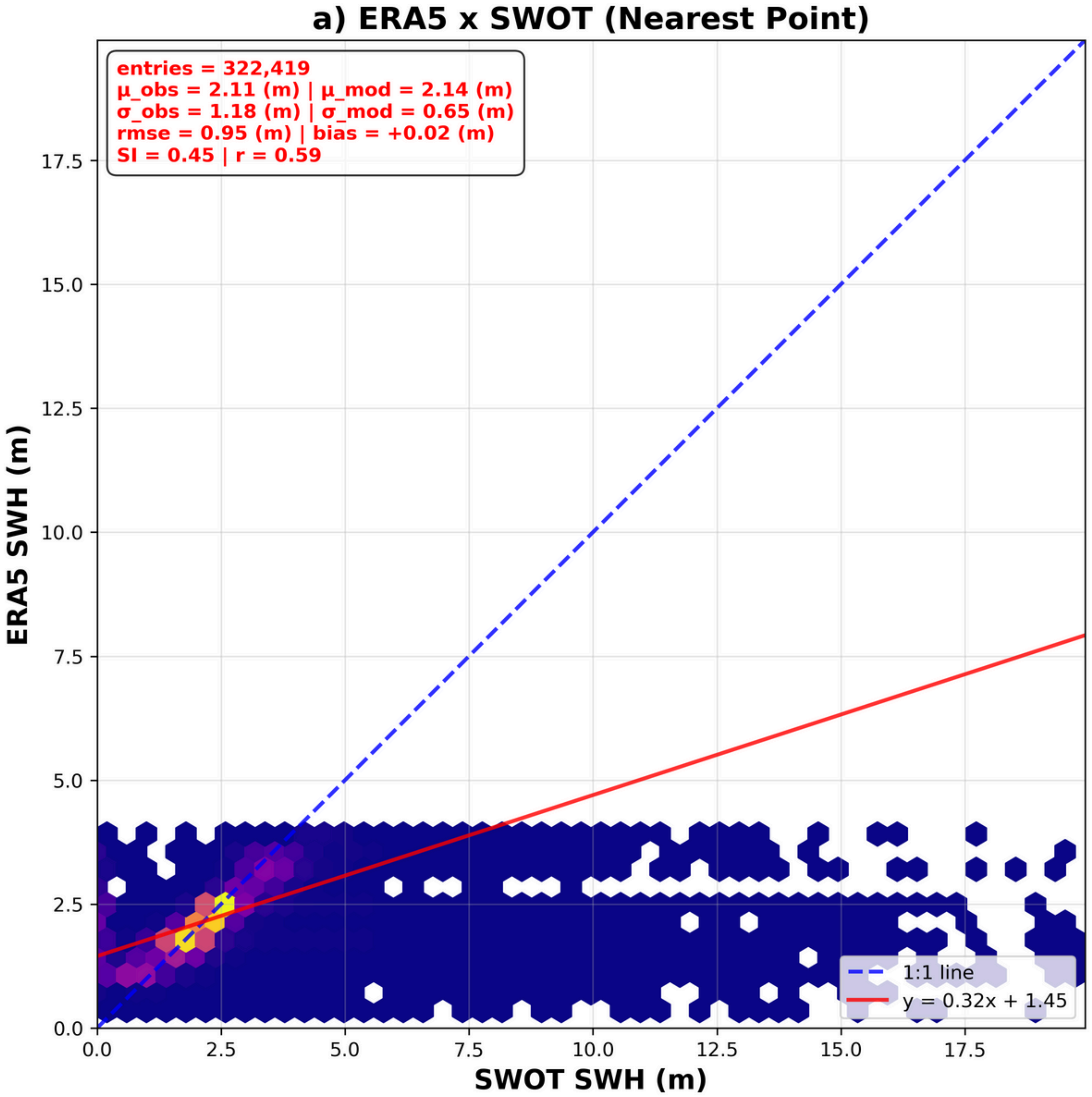
SWOT + ERA5 Hs

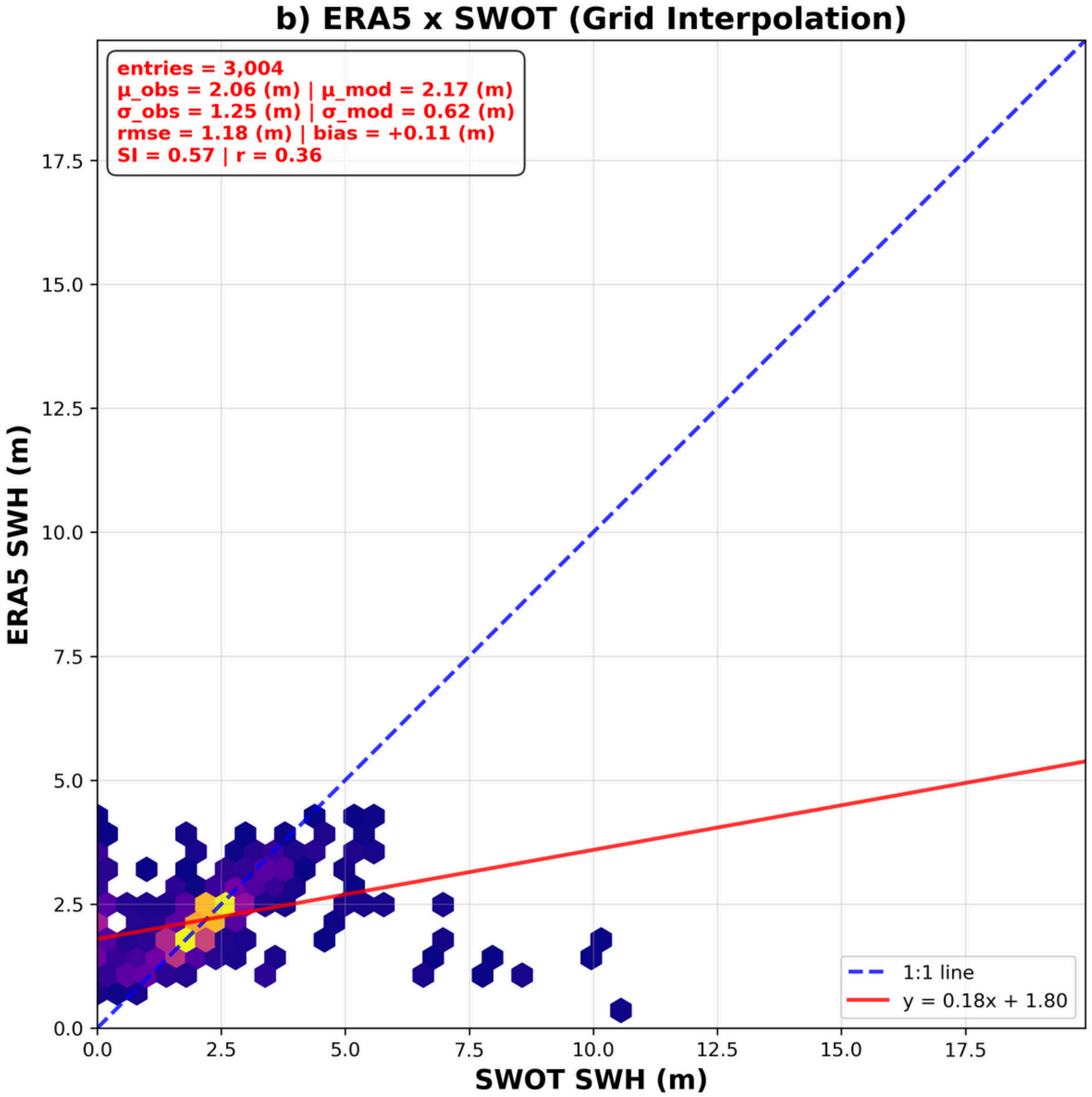


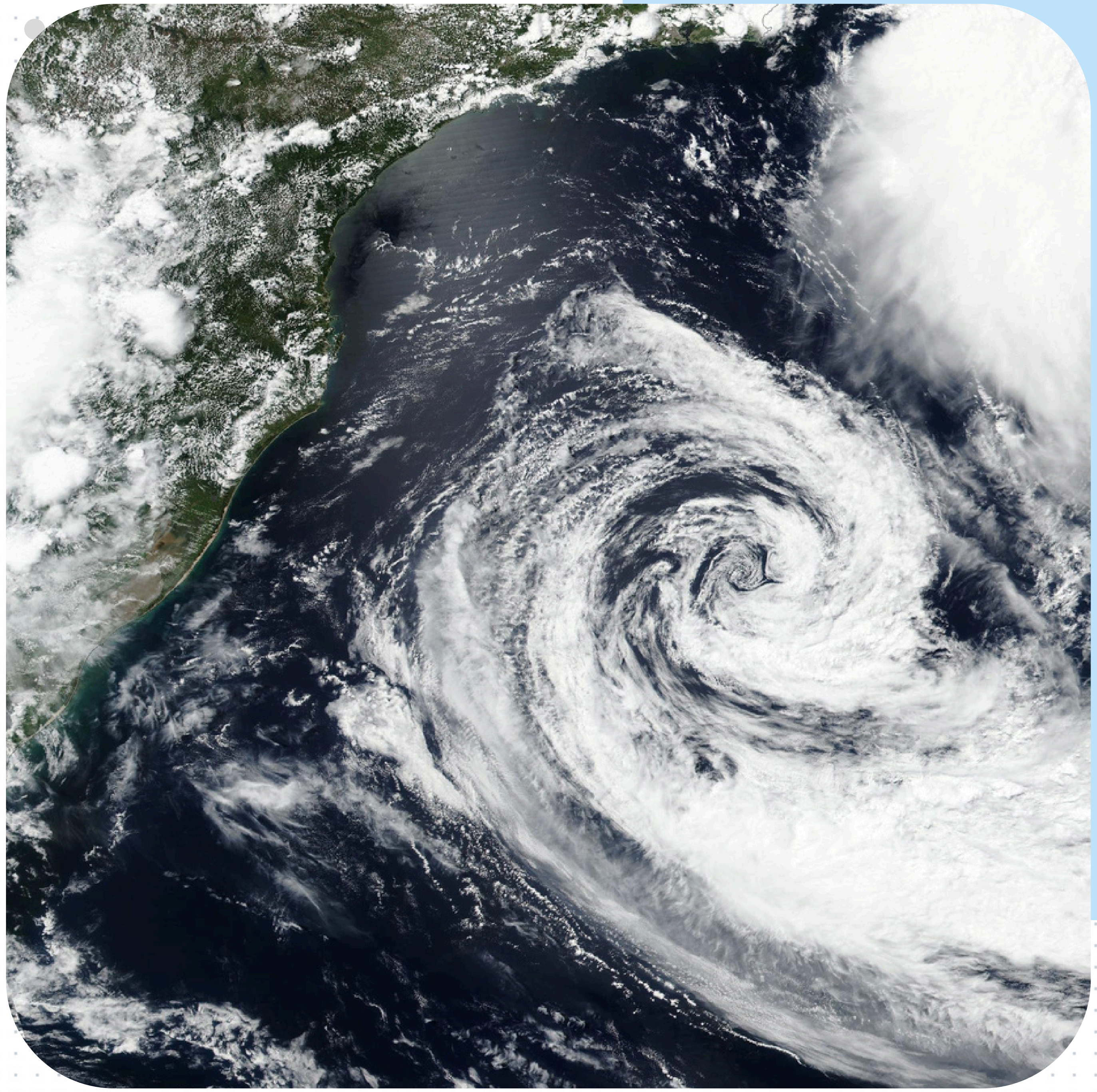
Bias in ERA5 or in SWOT?



SWOT x ERA5 Hs







Thank You

Presentation by **Danilo C. de Souza**

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