Low level wind patterns over the Indian Ocean

Langlade Sébastien, tropical cyclone forecaster

based on
Hastenrath and Polzin, 2004, Dynamics of the windfield over the equatorial Indian Ocean, Q. J. R. Meteorol. Soc. (2004), 130, pp. 503–517

La Réunion, 2019/11/04

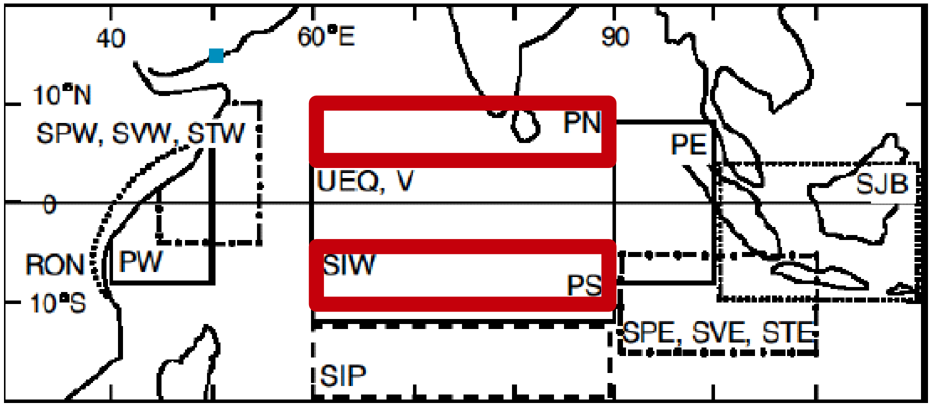
OUTLINE

- Indian Ocean annual cycle and associated low level wind patterns
  - Background
  - Austral summer
  - Austral winter
  - Austral spring / autumn

- Other wind patterns

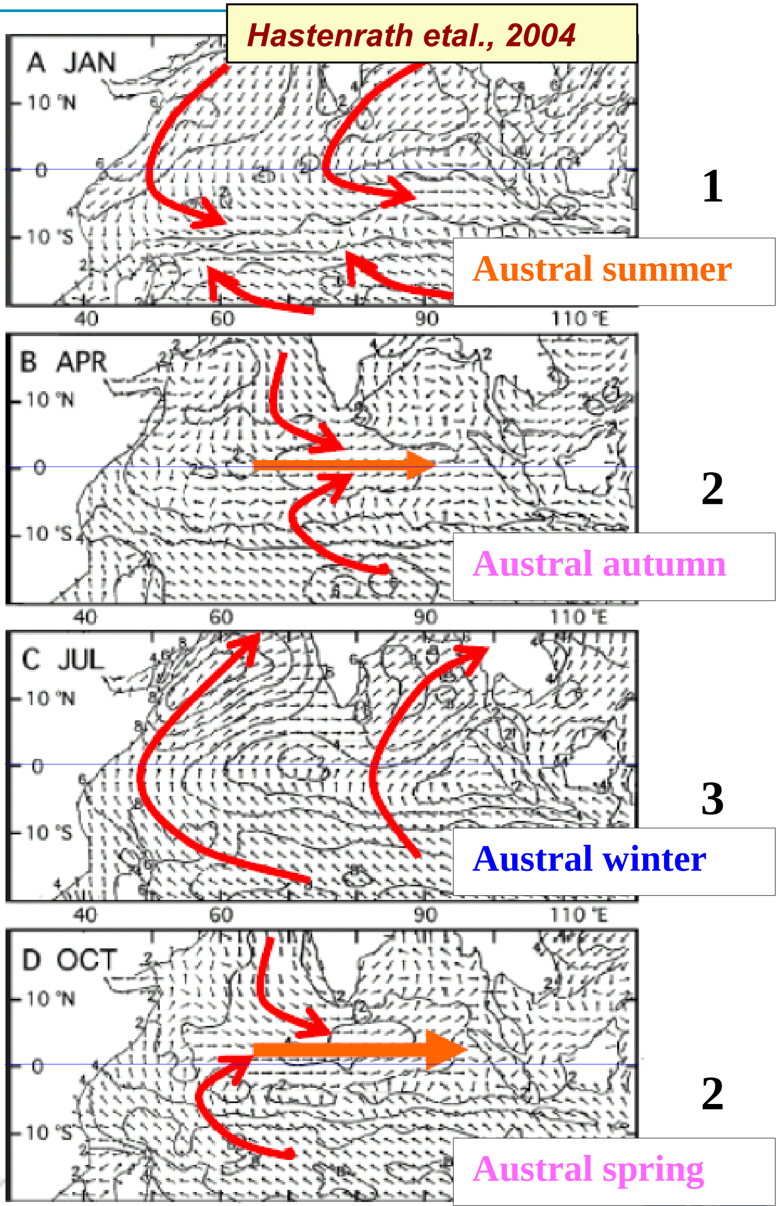
- Conclusion

Tropical Indian Ocean surface winds patterns: Background



• Annual cycle dominated by the shift between the southern and norther summer monsoon : seasonnal shift of the inter-hemispheric pressure gradient .

•Equatorial westerlies: enhanced with strong east-west gradient pressure with weak near equatorial southern trade winds



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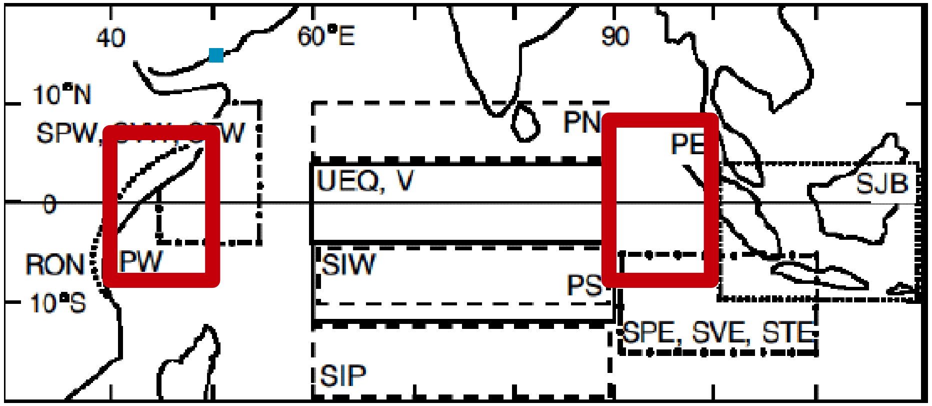

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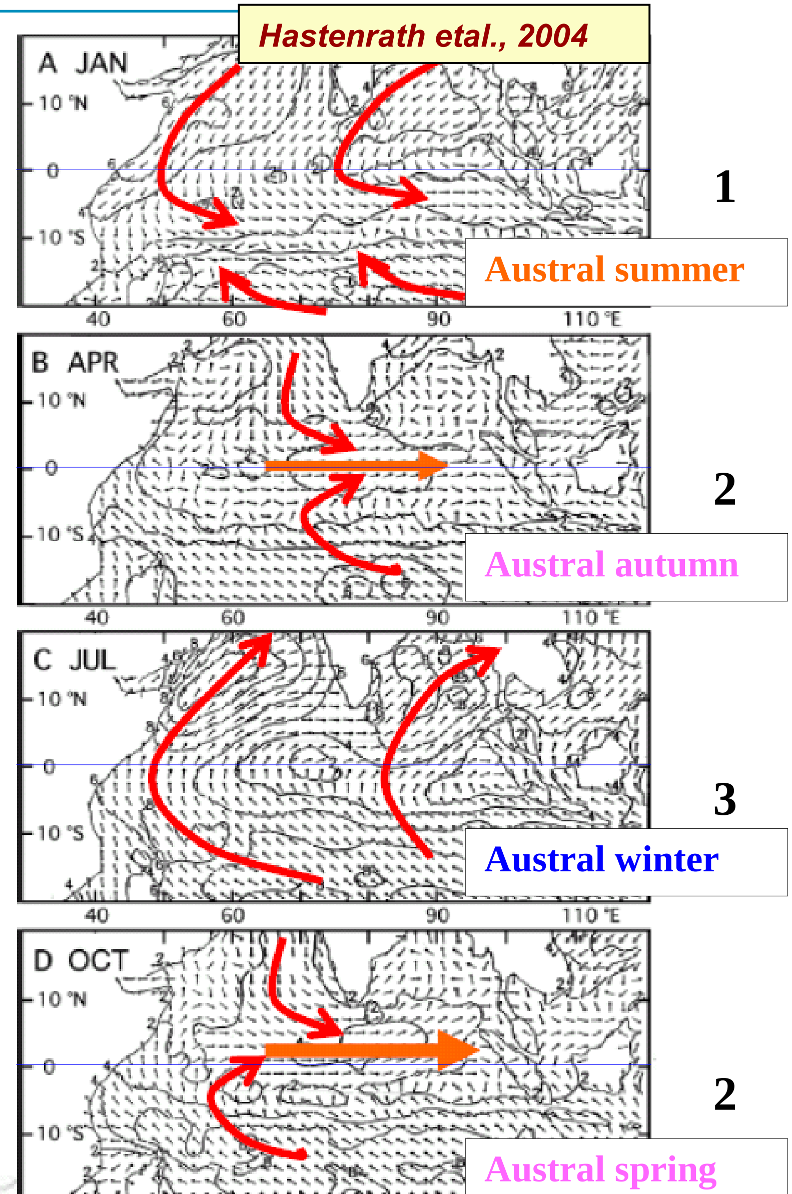


METEO FRANCE

Austral summer (January to March)

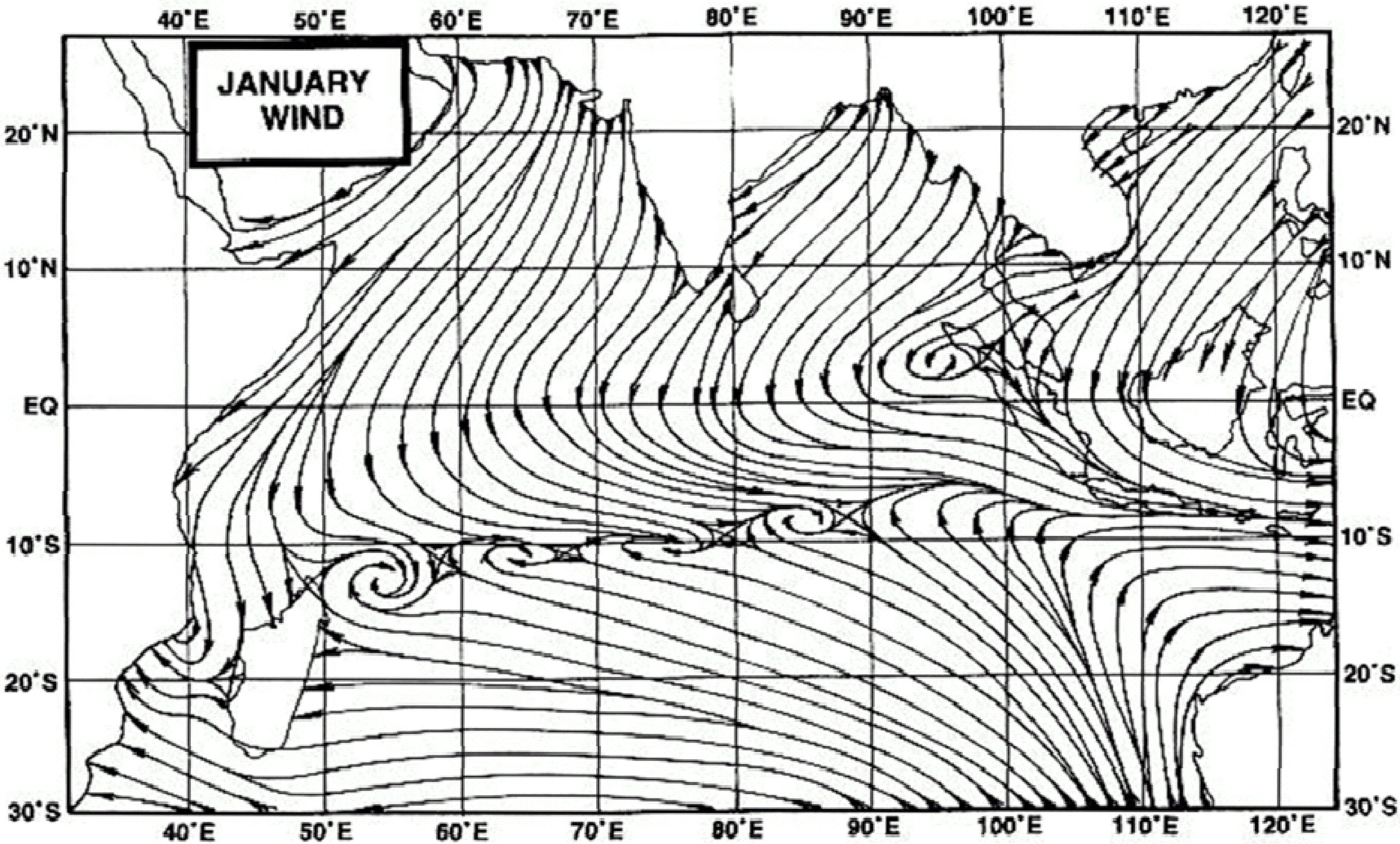
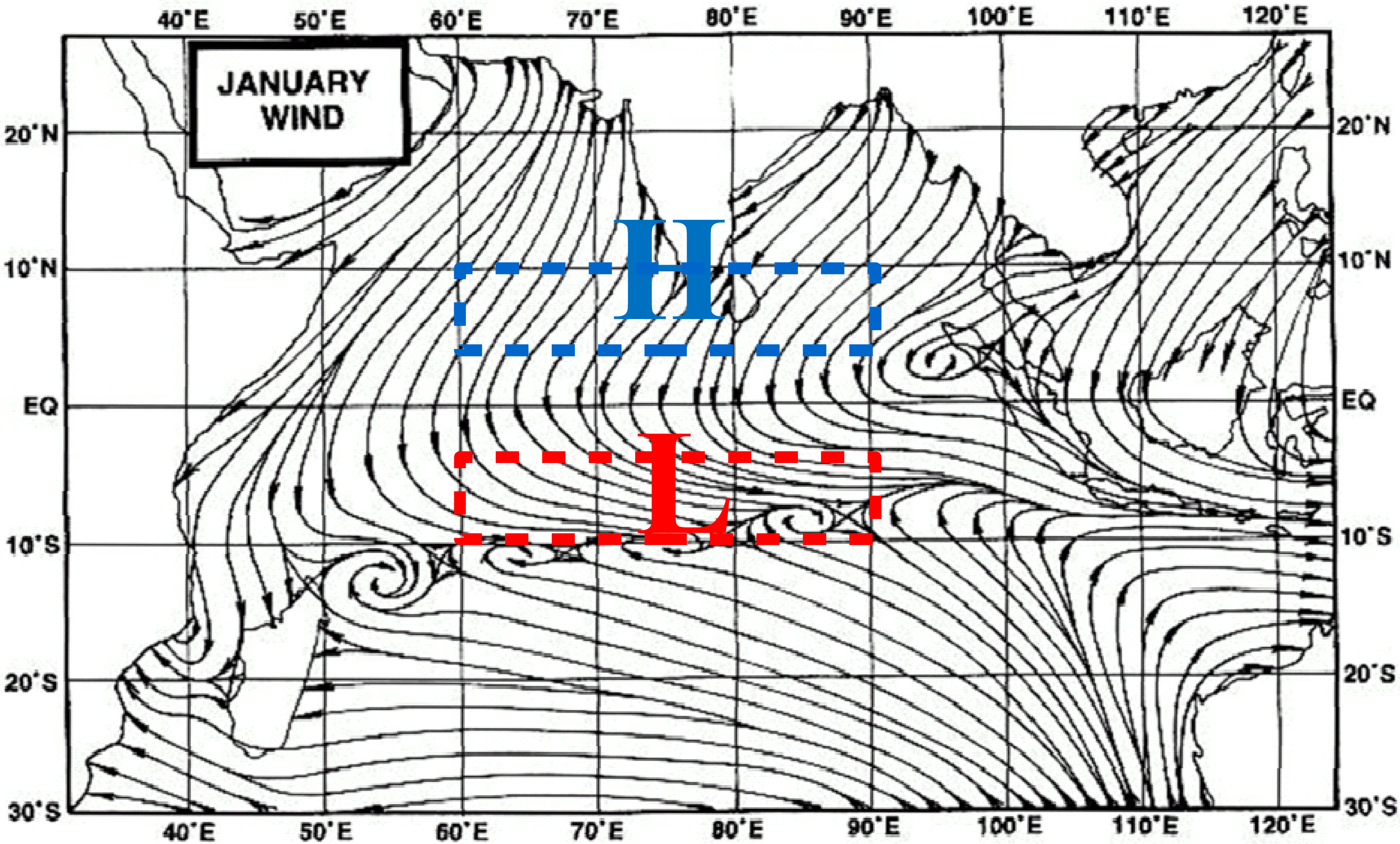


Figure 2.6. Mean surface level streamline analyses over the Indian Ocean for January (Sadler, 1975).

Austral summer (January to March)



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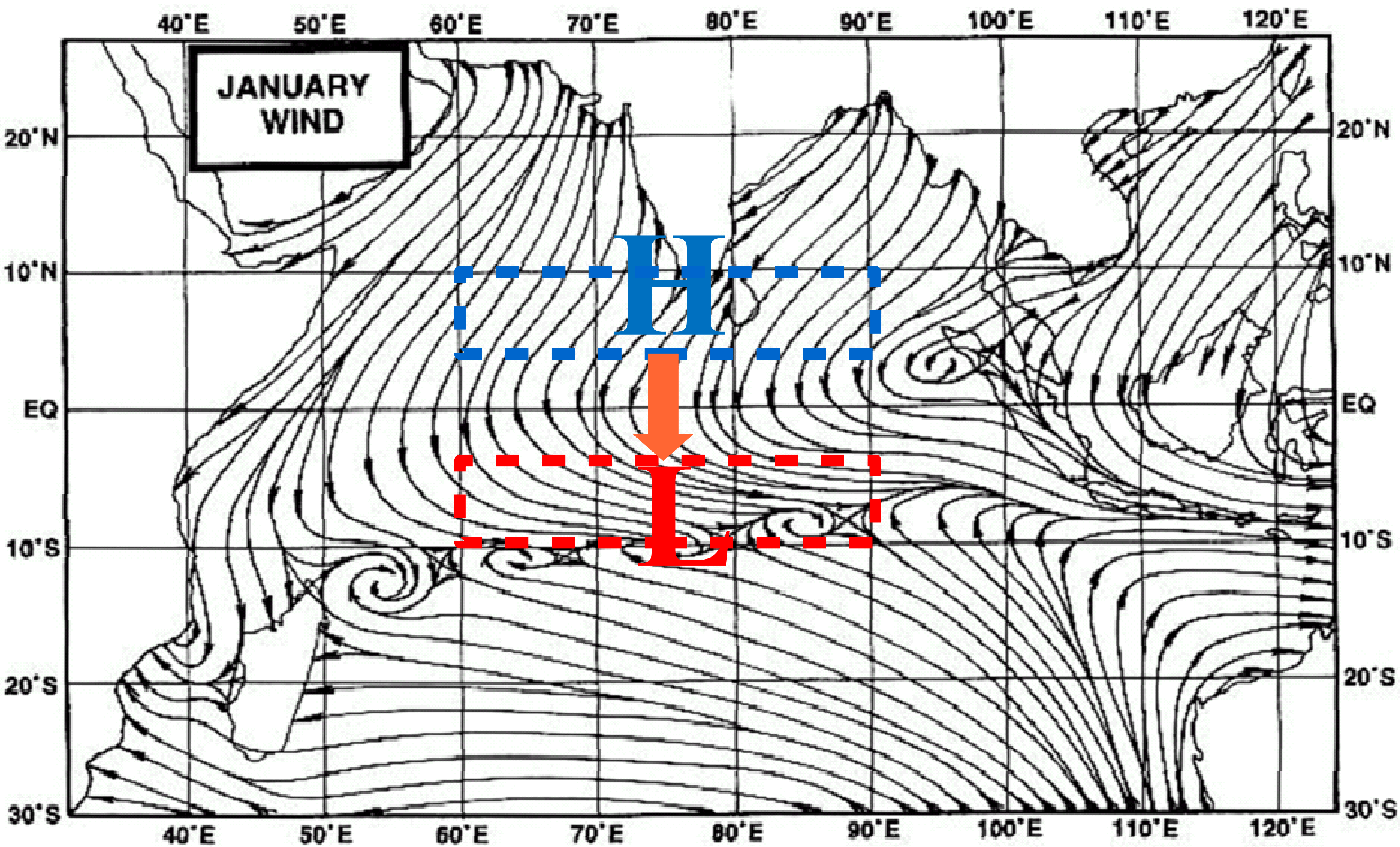

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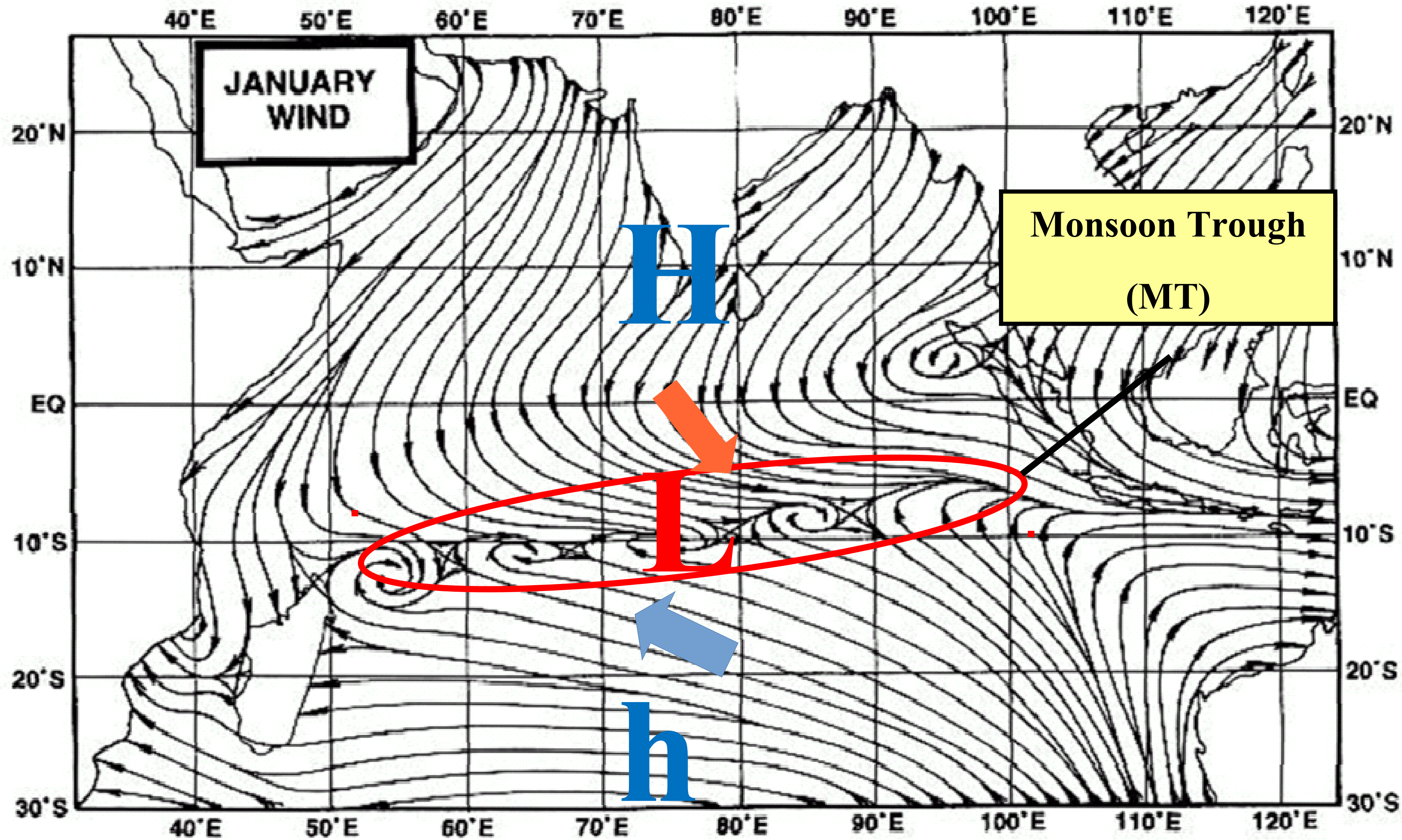

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METEO FRANCE

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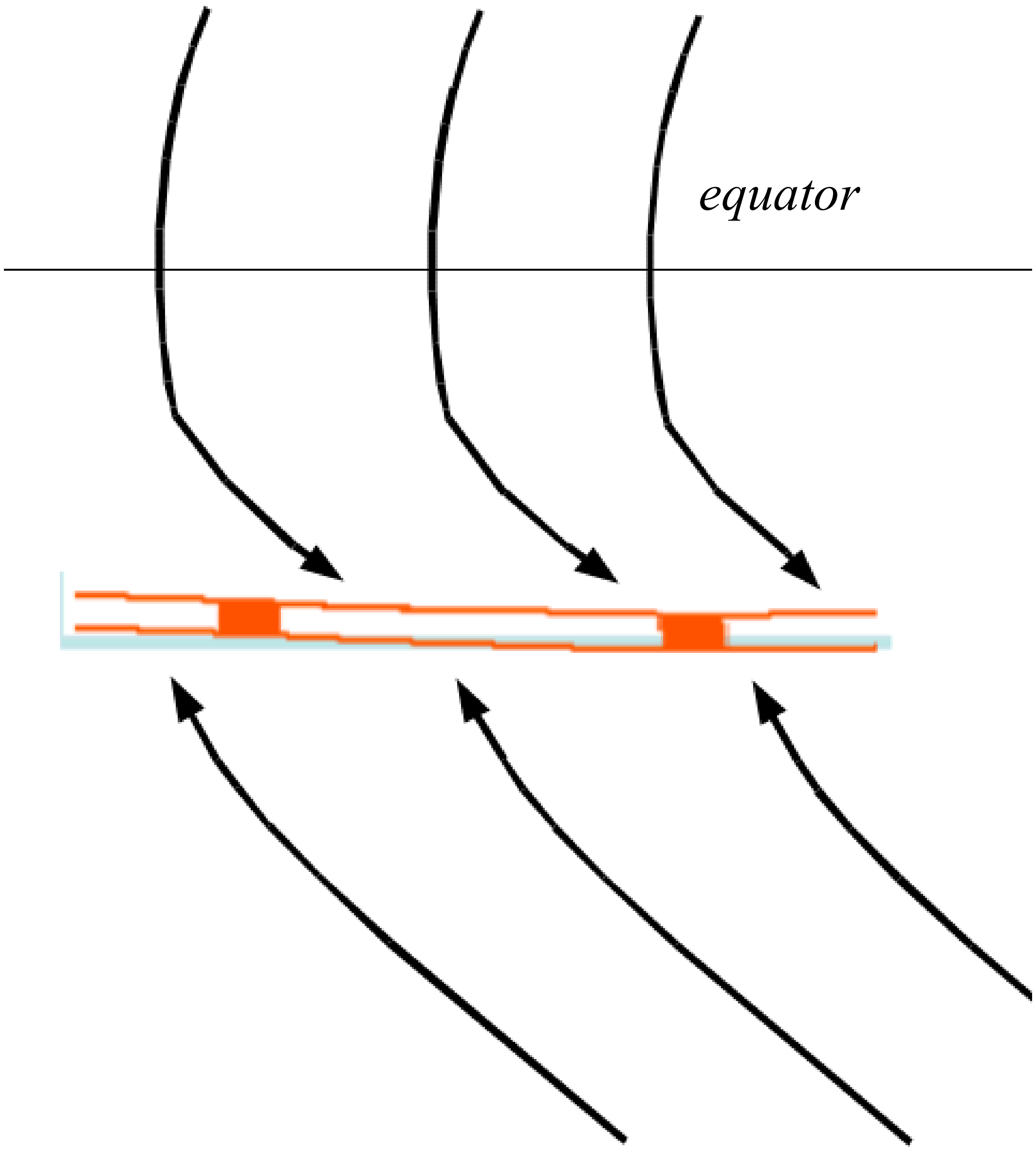
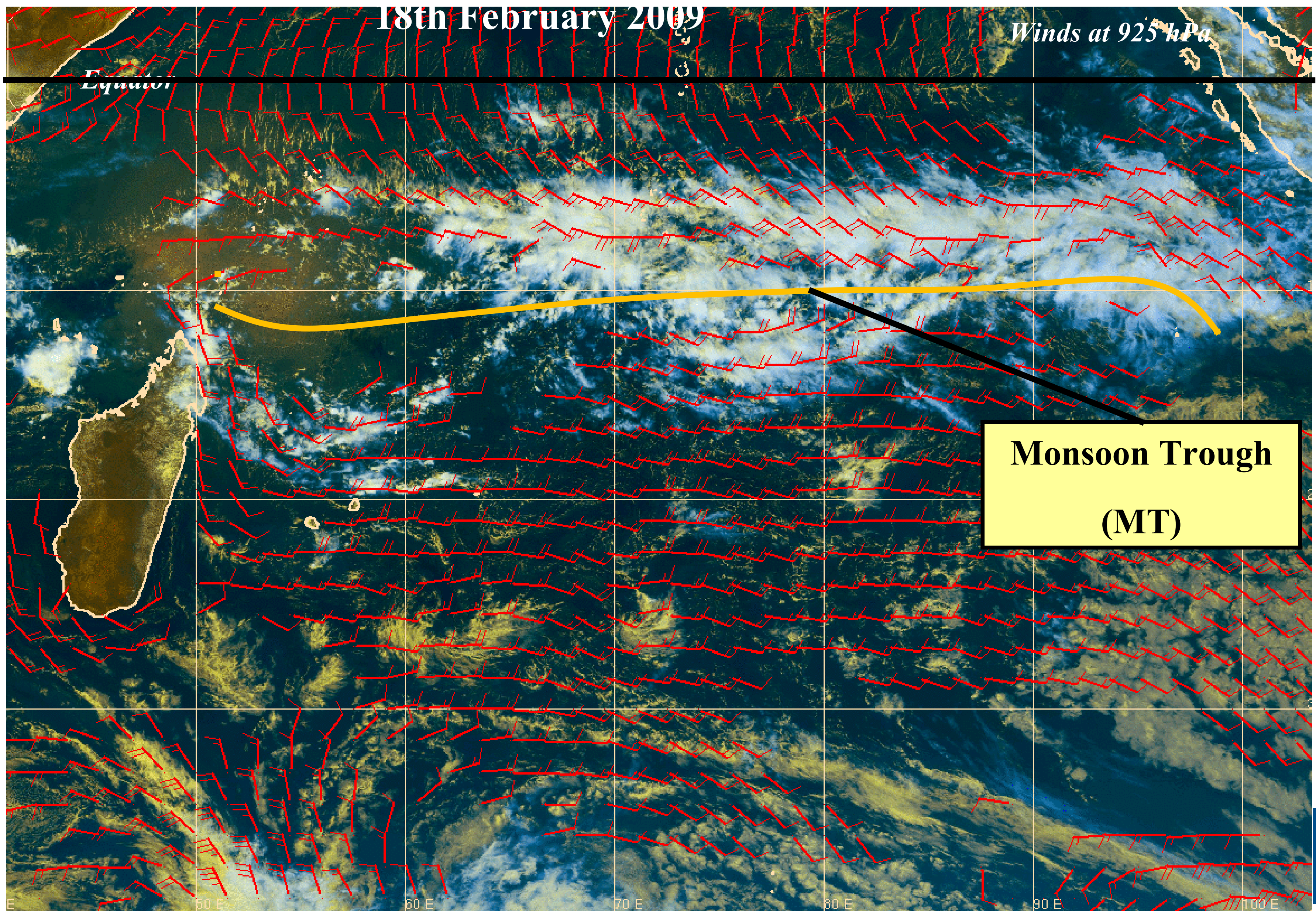


Monsoon Trough définition:

Low level trough (surface to 850 hPa) located within the mixing area between the monsoon and tradewinds flow. Associated equatorial winds have a strong meridional component.

→ **Low level large scale vorticity associated**.

Austral summer (January to March)



Austral winter (June to August)

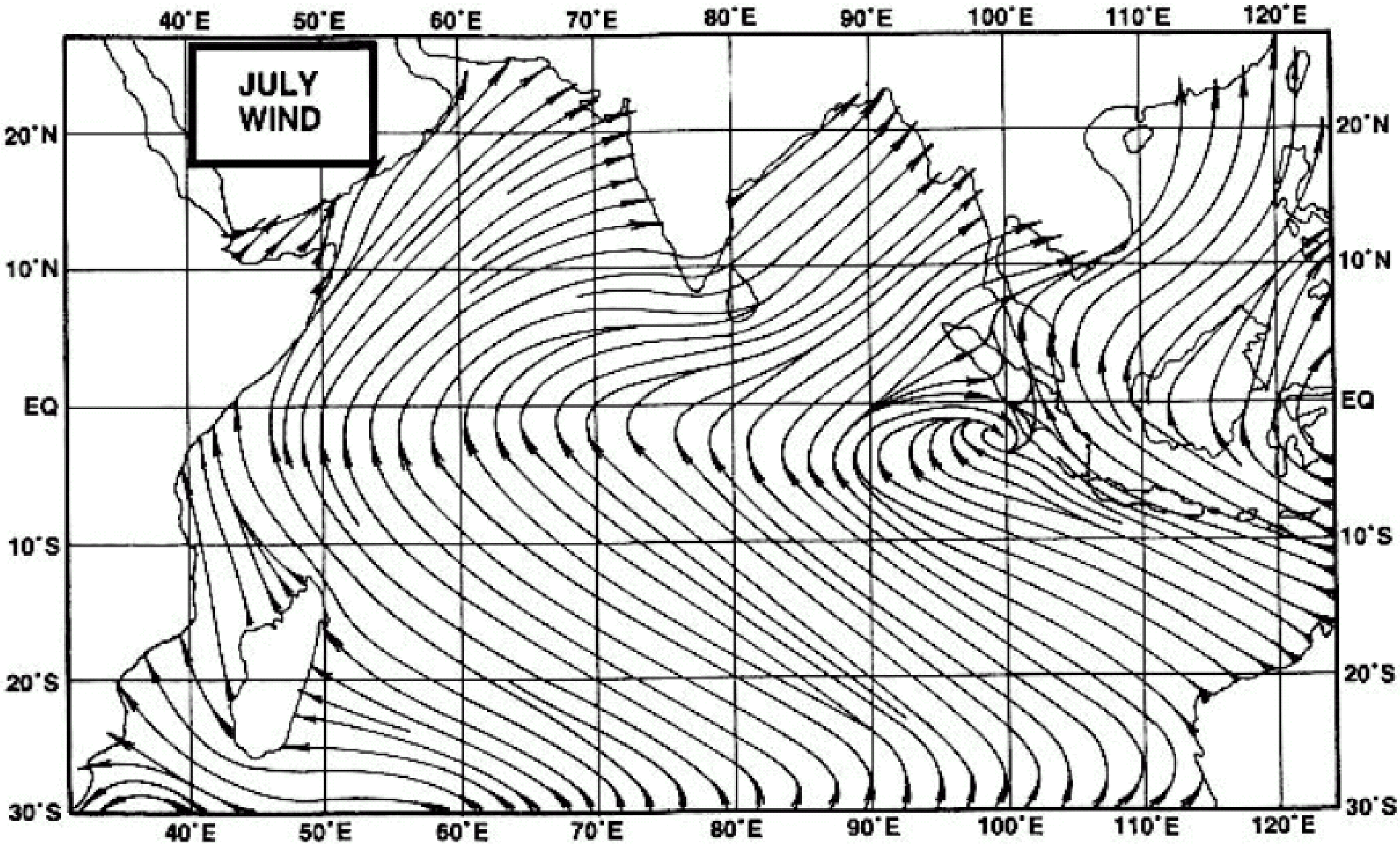


Figure 2.8. Mean surface level streamline analyses over the Indian Ocean for July (Sadler, 1975).

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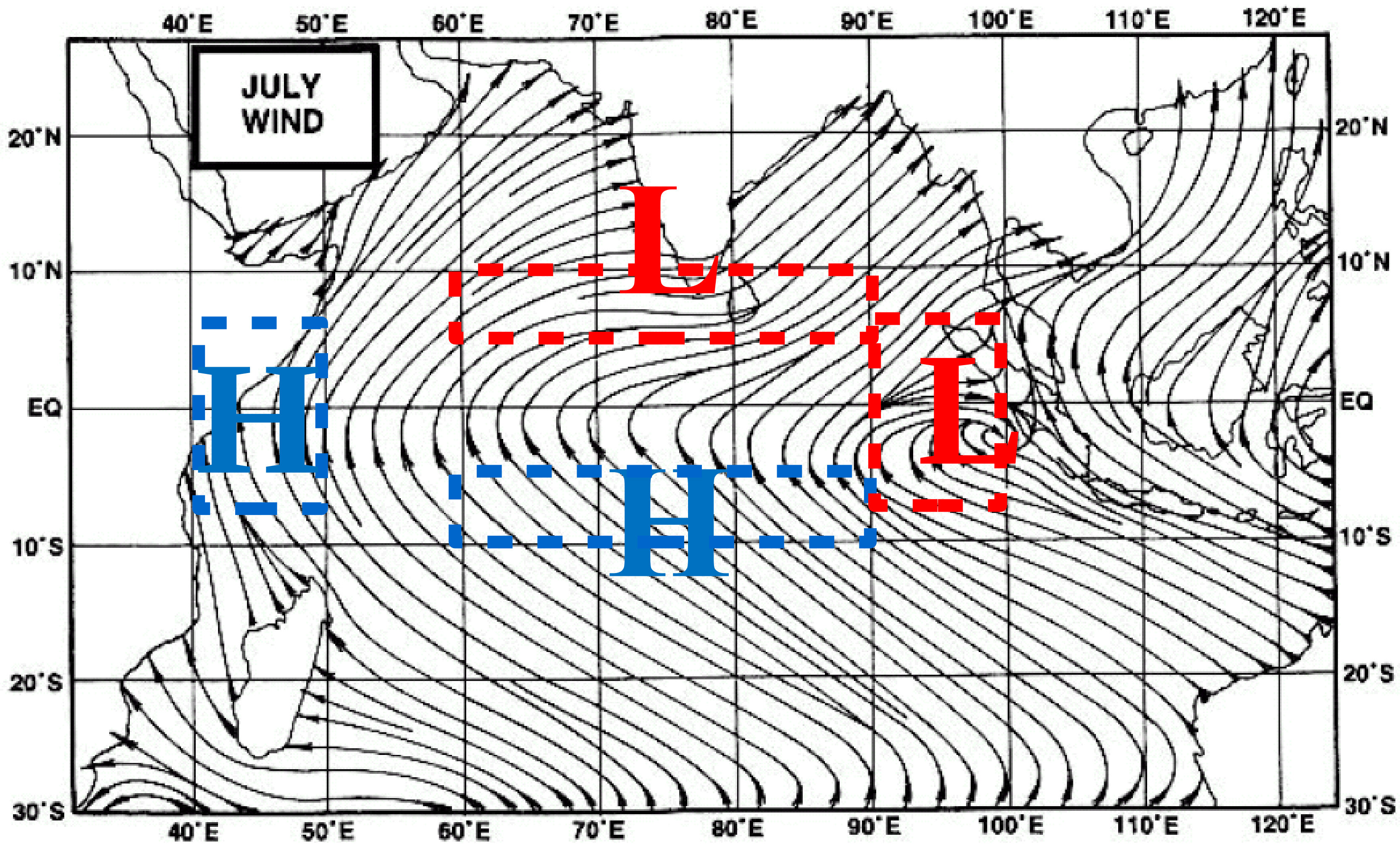

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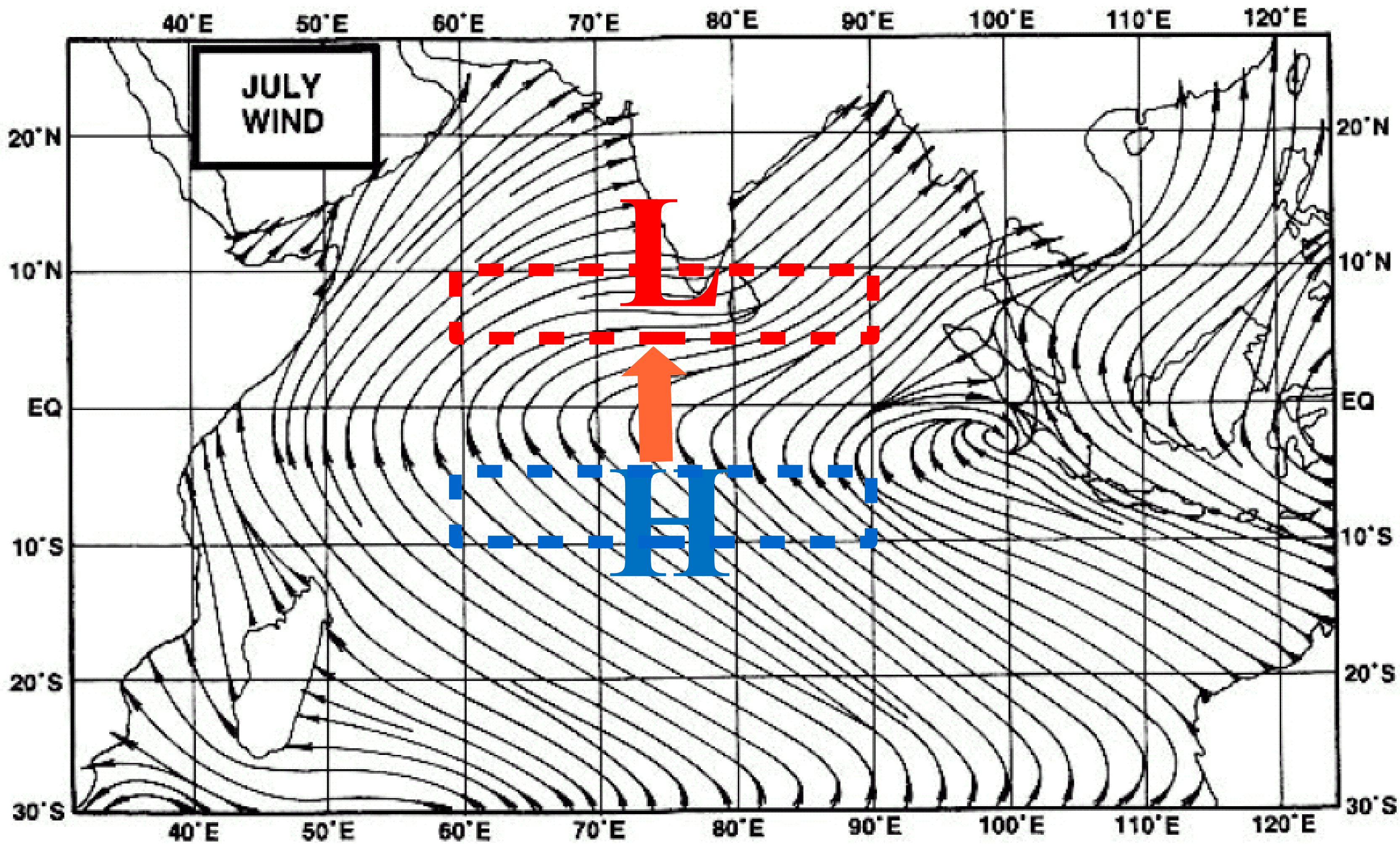

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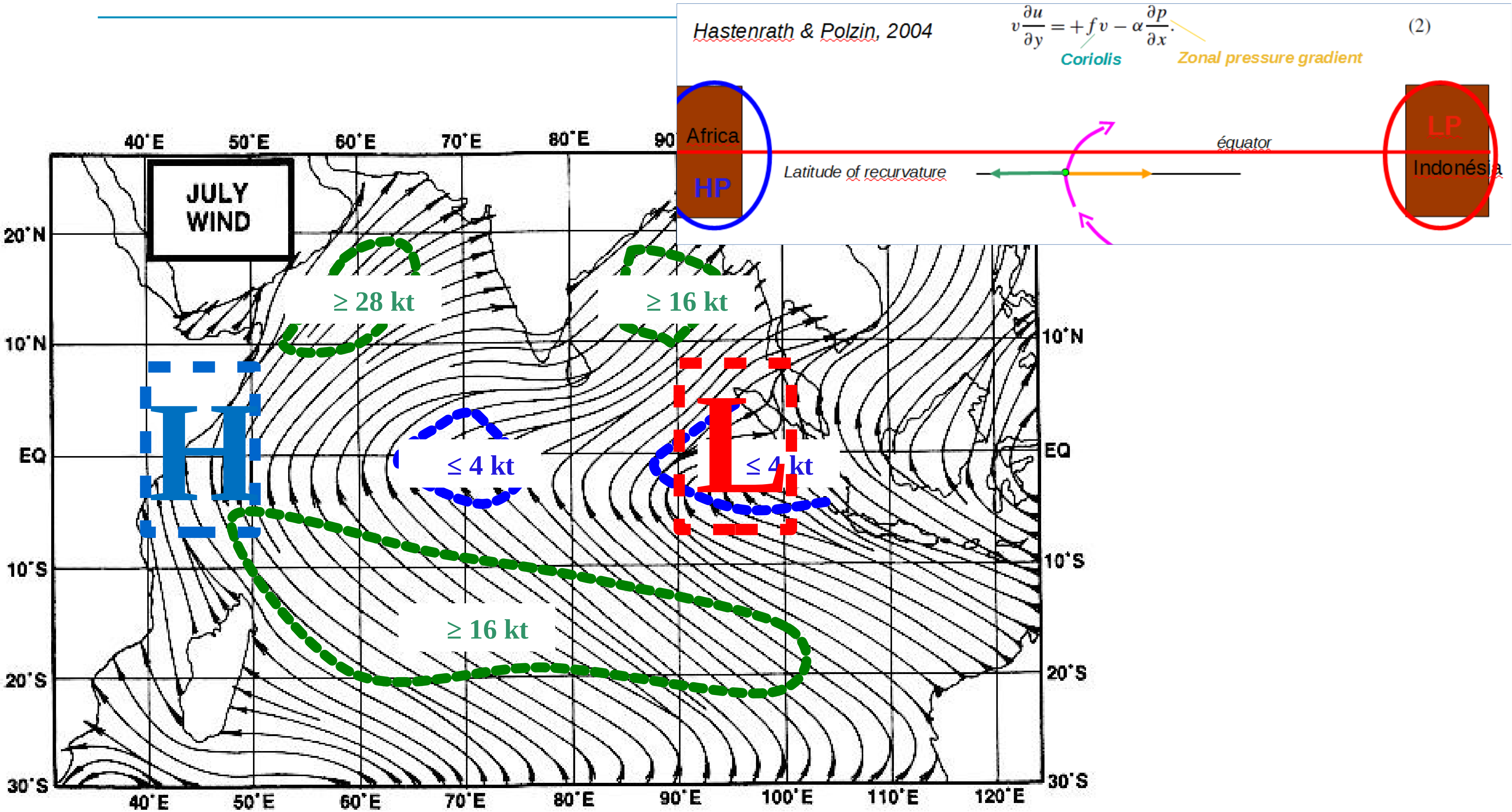

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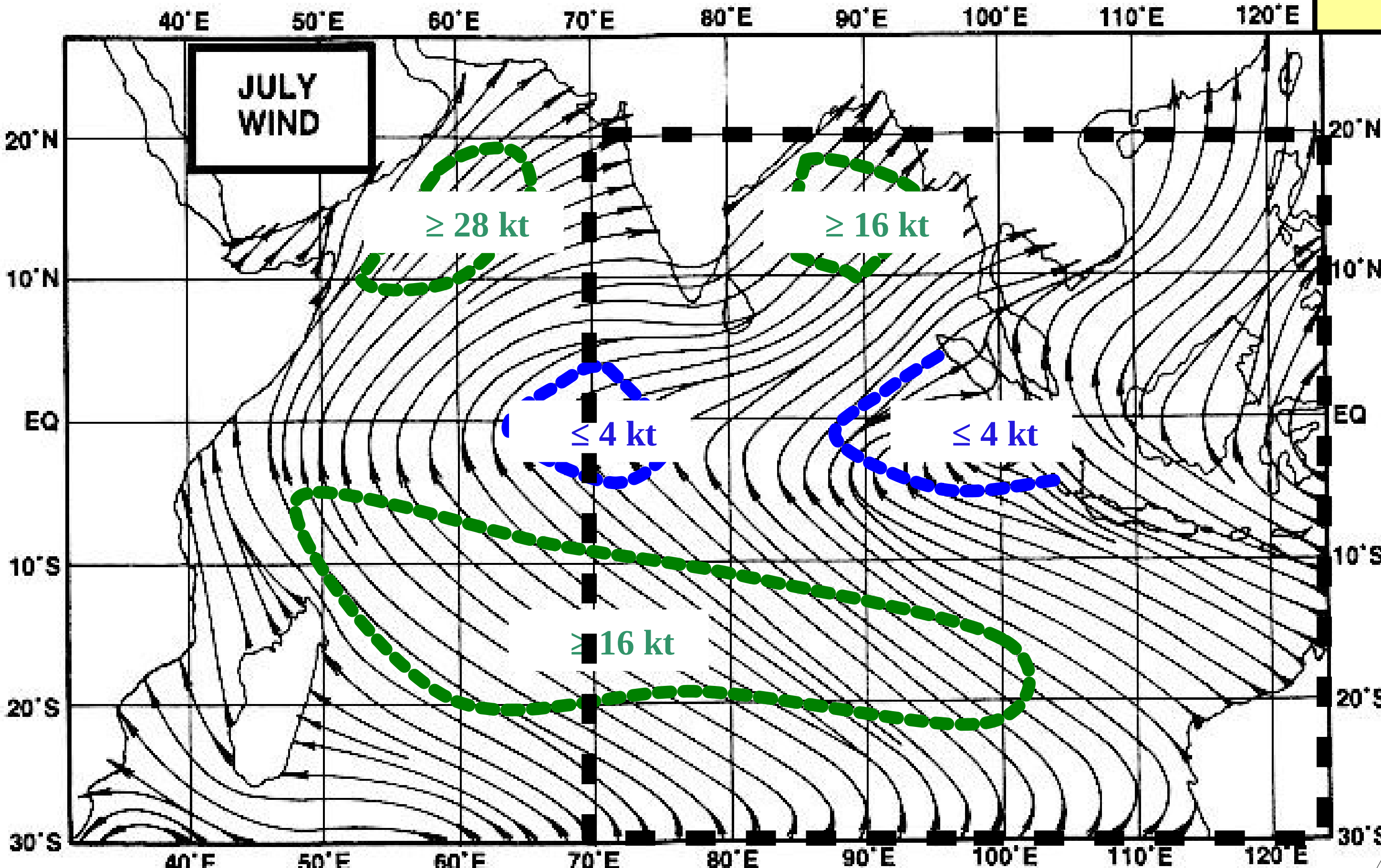
Austral winter (June to August)

India and south-eastern Asia monsoons



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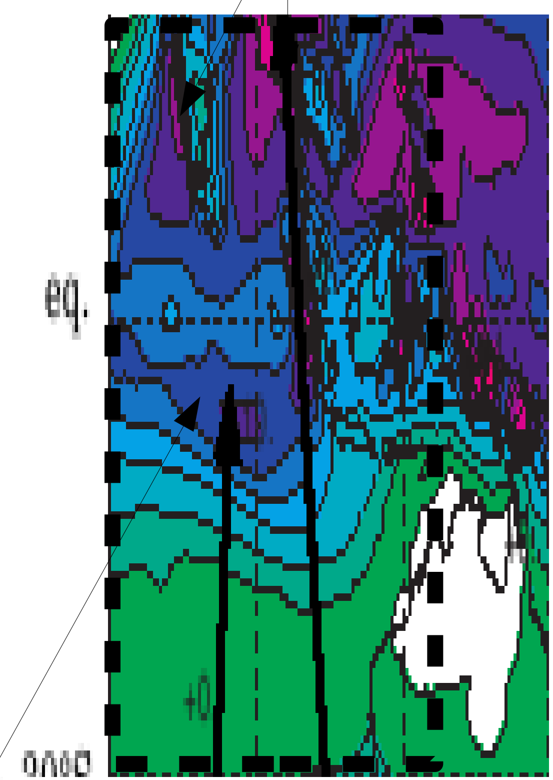
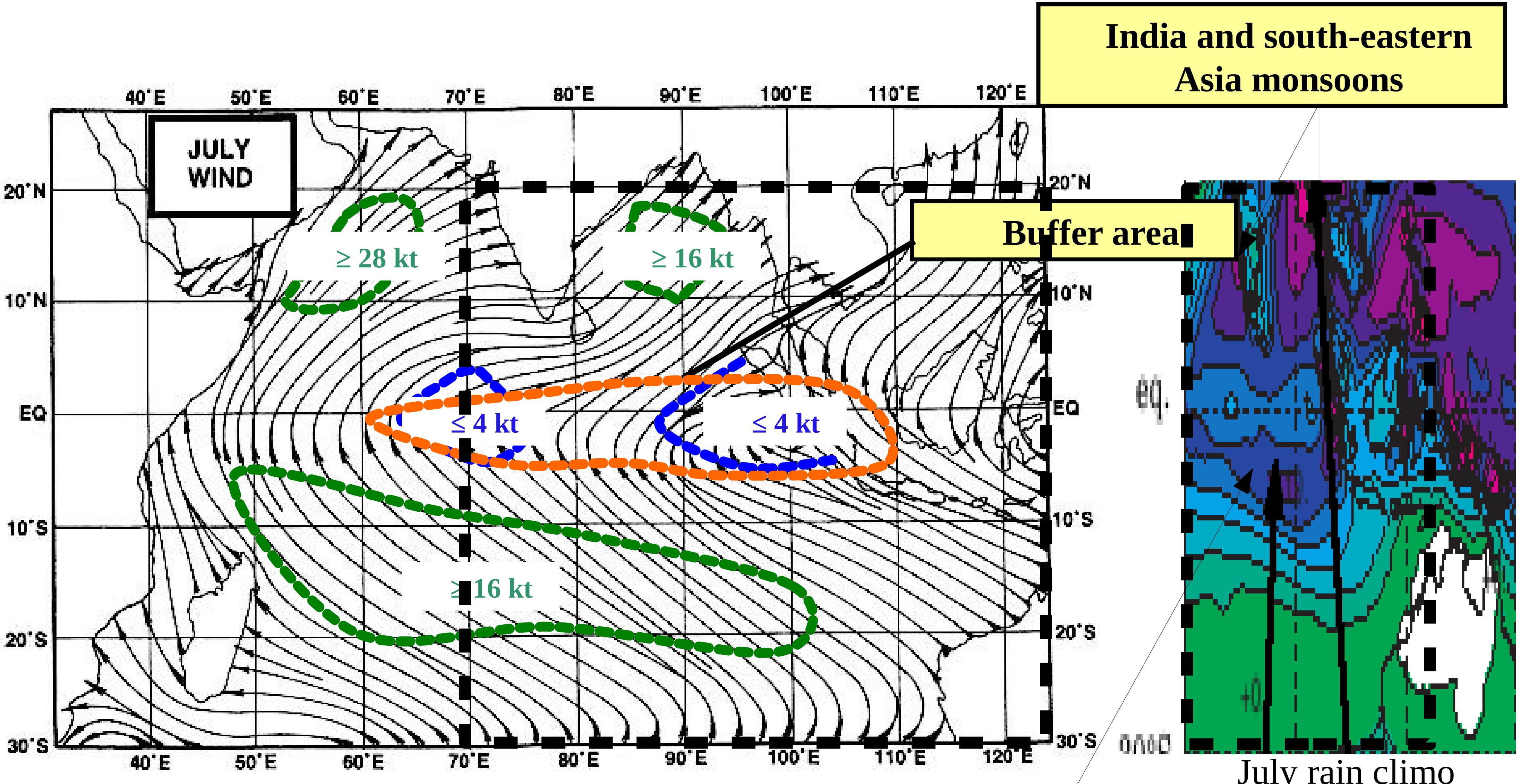


July rain climo

Southern Indian Ocean rain max

METEO FRANCE

Austral winter (June to August)



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Southern Indian Ocean rain max

Austral spring / autumn

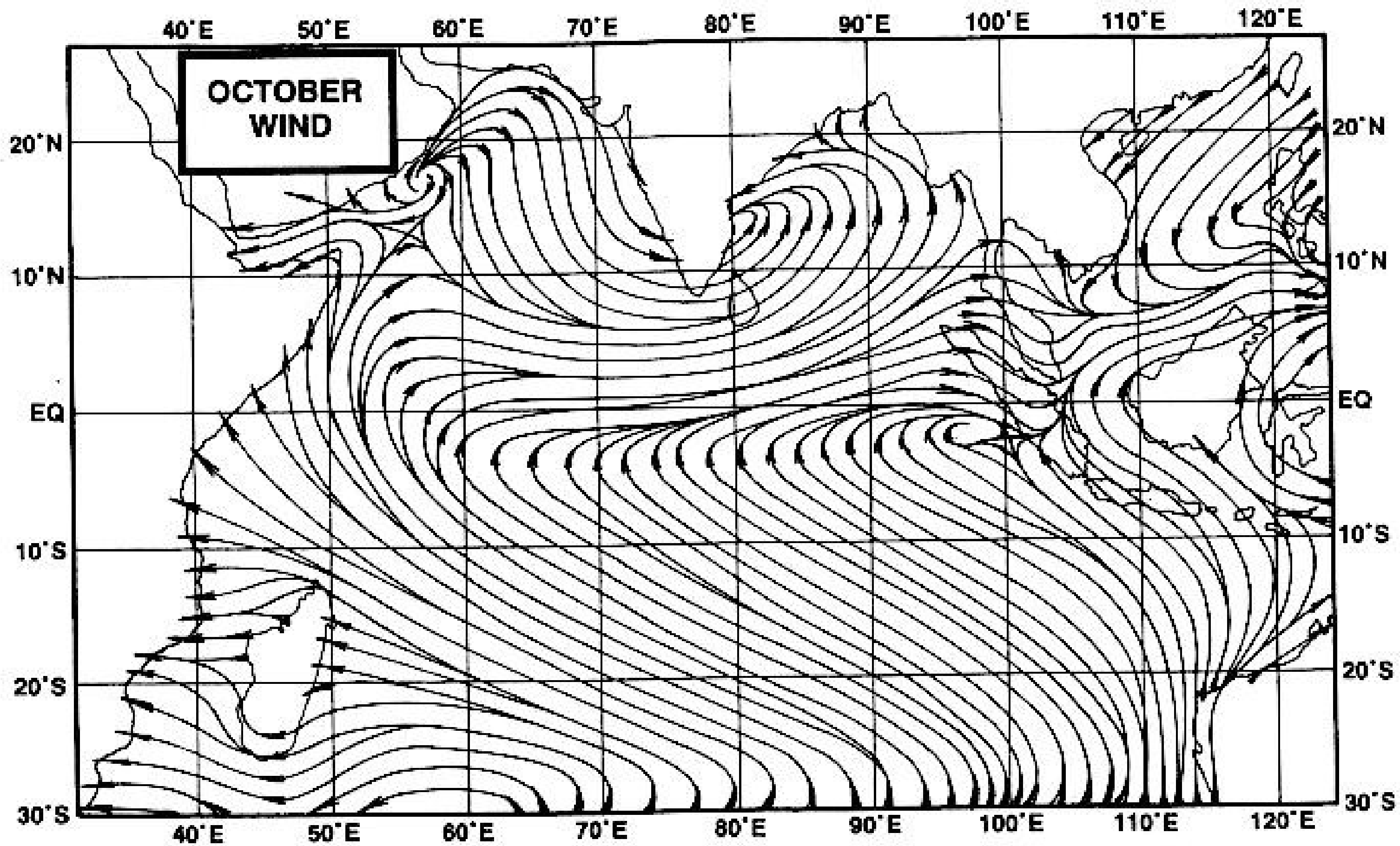
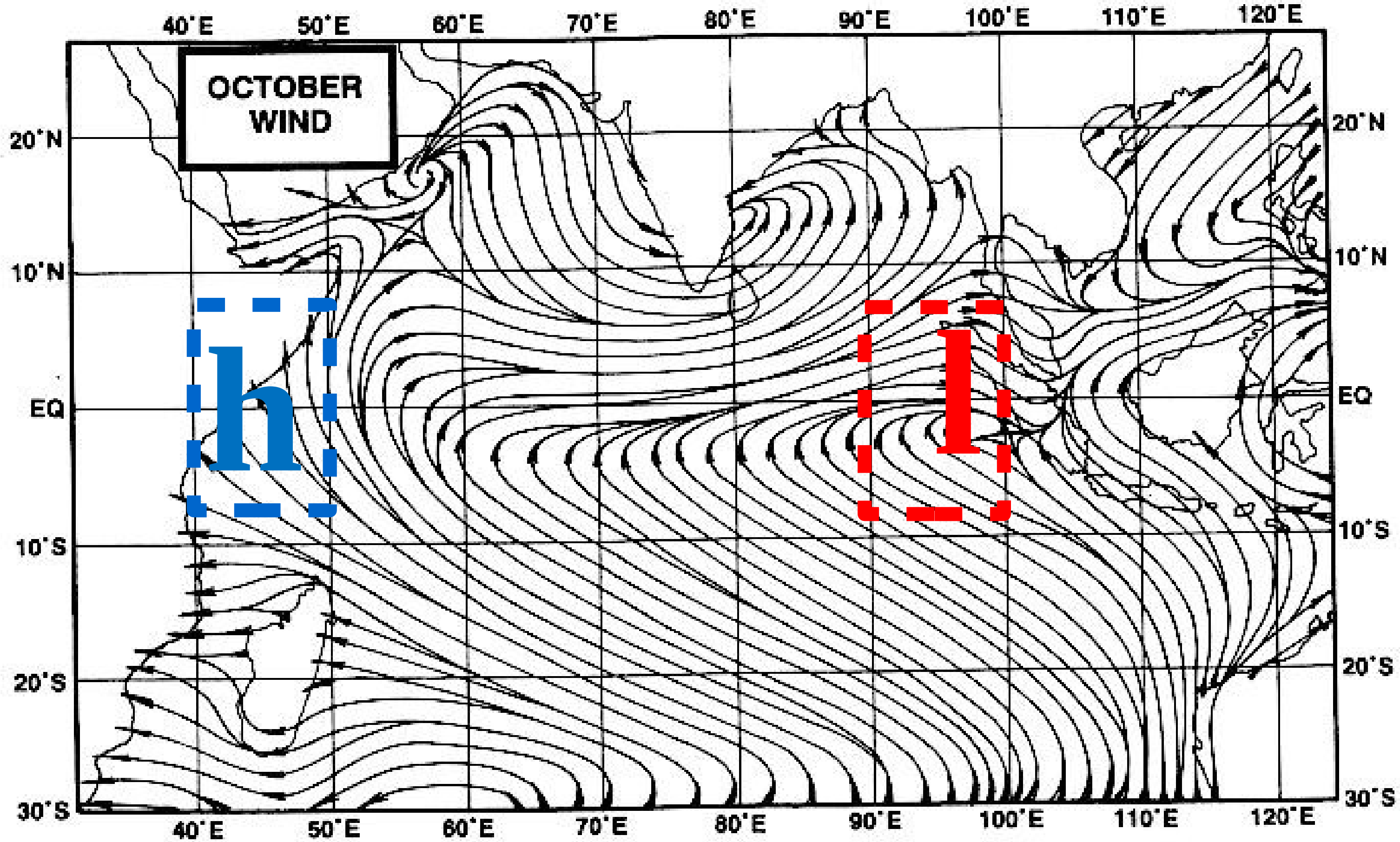


Figure 2.9. Mean surface level streamline analyses over the Indian Ocean for October (Sadler, 1975).

Austral spring / autumn



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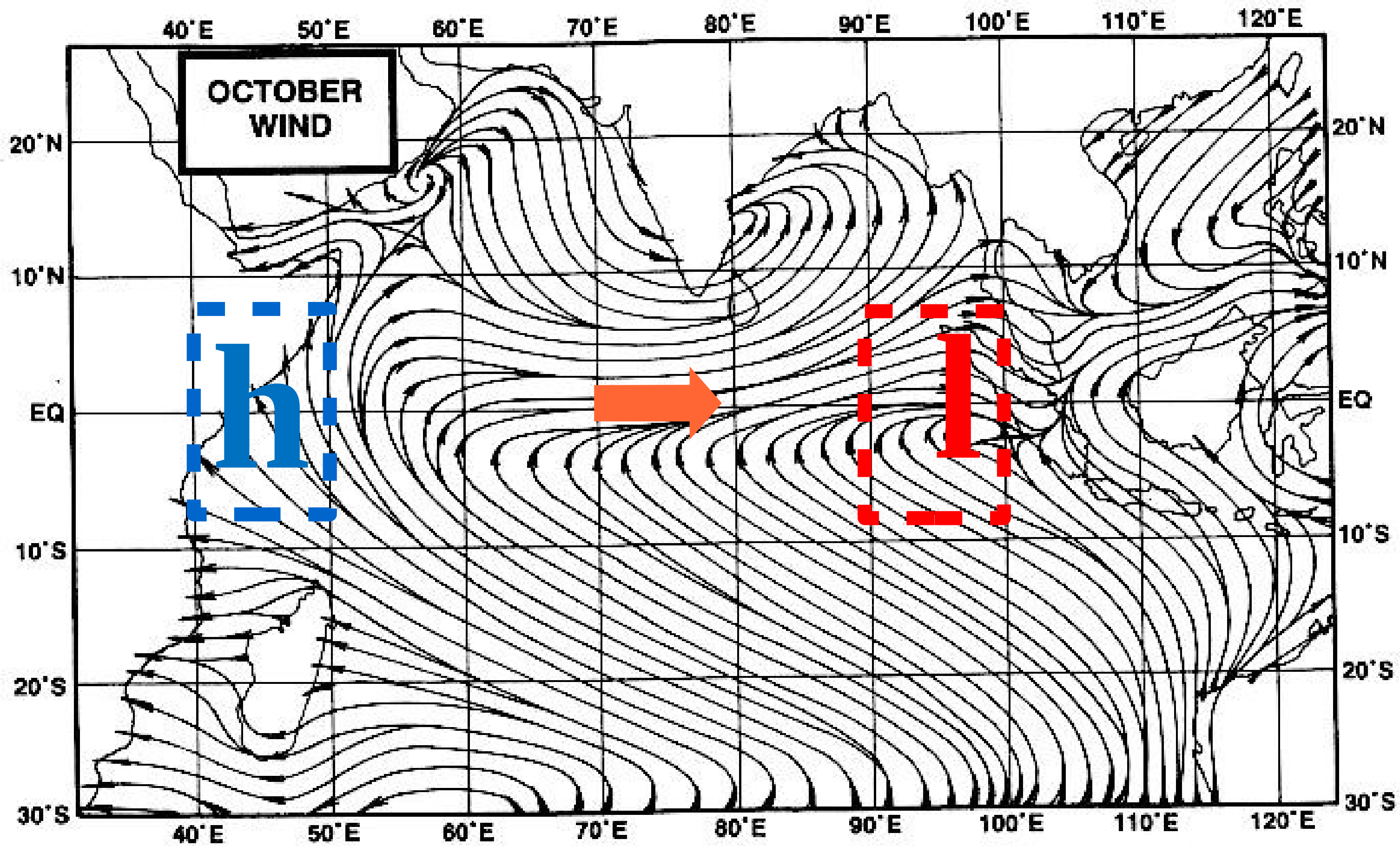

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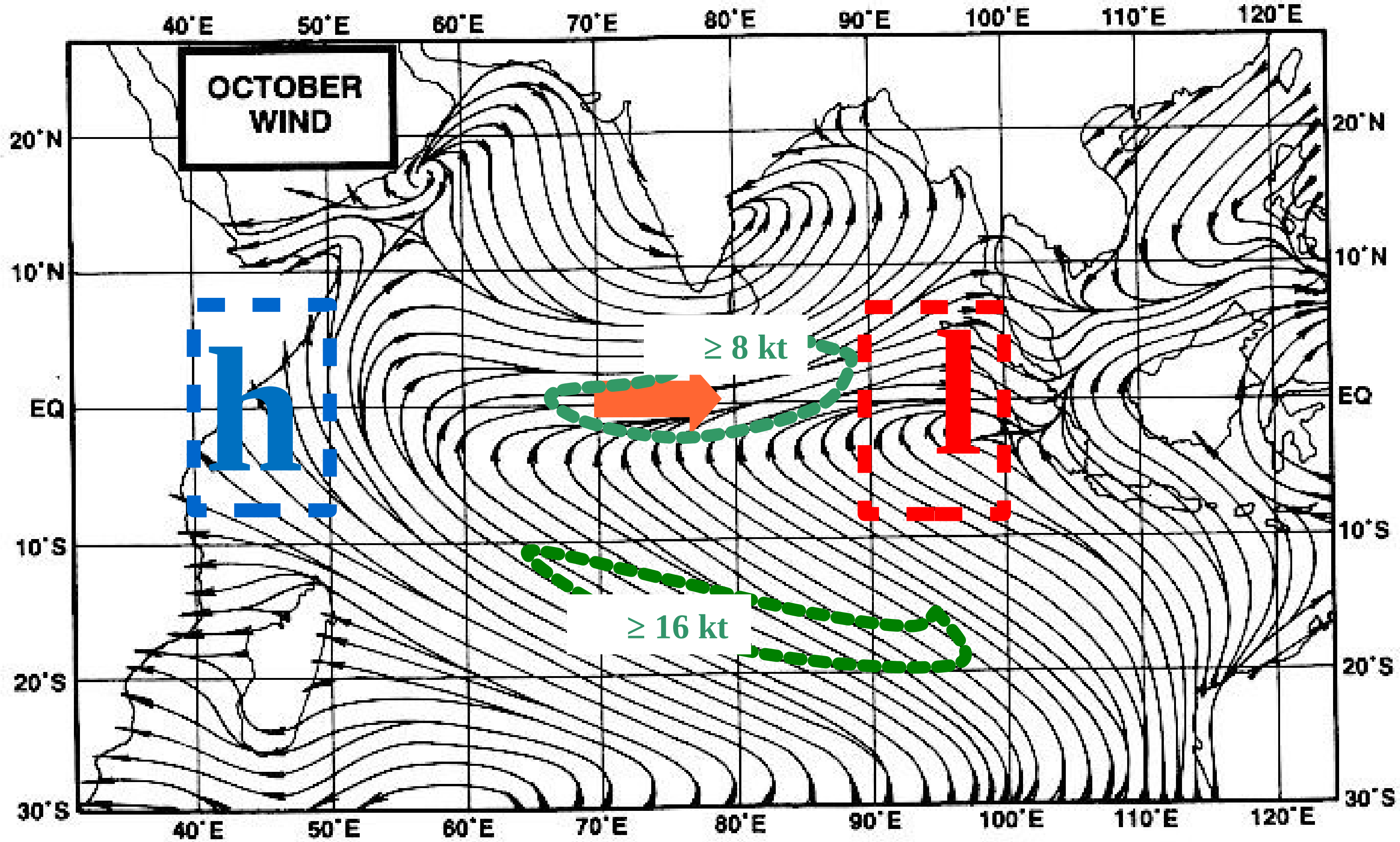

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METEO FRANCE

Tropical Indian Ocean surface winds patterns: Background

$$\frac{\mathrm{d}\mathbf{V}}{\mathrm{d}t} = -f\mathbf{k}\times\mathbf{V} - \alpha\nabla p + \mathbf{F}. \qquad (1)$$

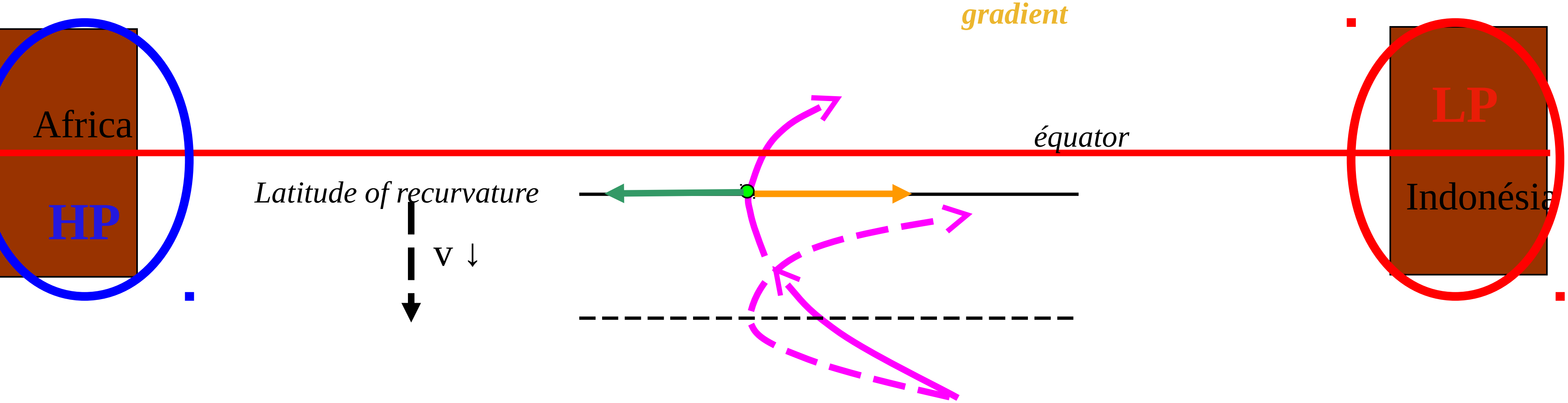
The first component equation of motion simplifies at the latitude of recurvature $(u = 0)$ to

Hastenrath & Polzin, 2004

$$v\frac{\partial u}{\partial y} = +fv - \alpha\frac{\partial p}{\partial x}. \qquad (2)$$

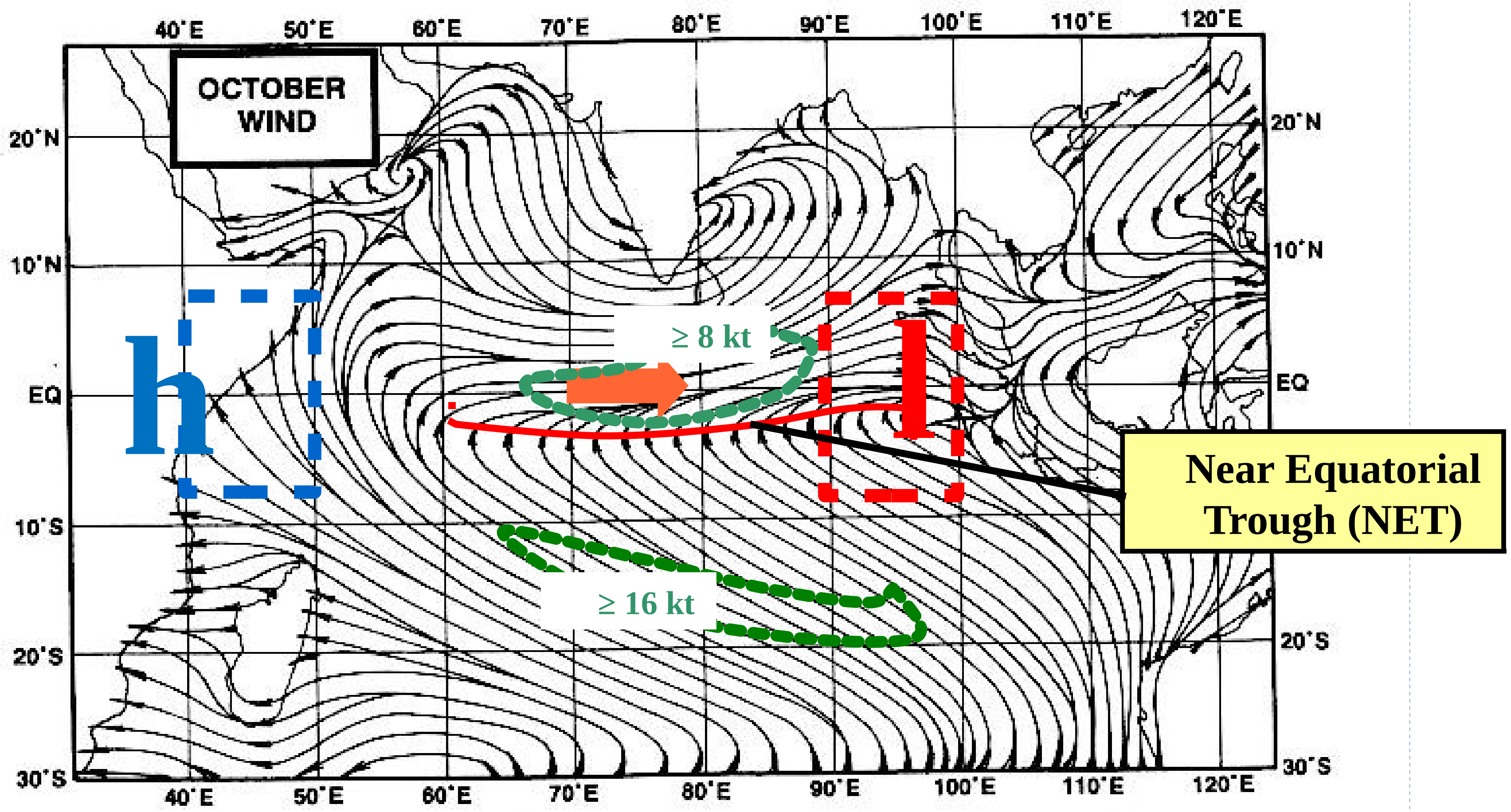
Coriolis

Zonal pressure gradient



- The latitude of recurvature depends on the imbalance between two accelerations (zonal pressure gradient and Coriolis force)
- With steep eastward pressure gradient and slow trade winds the flow can recurve relatively far south ; with slack pressure gradient and fast trades, the recurvature occurs only nearer to the equator.
- The farther south the recurvature takes place, the broader the equatorial band in which westerlies can develop.

Austral spring / autumn



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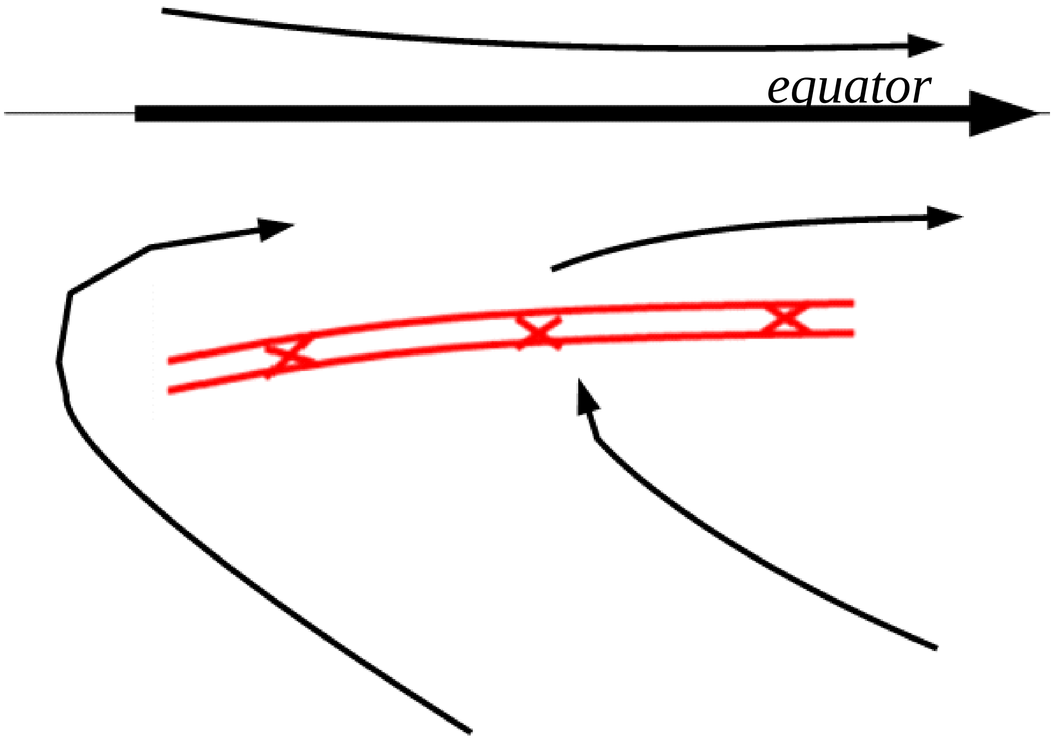
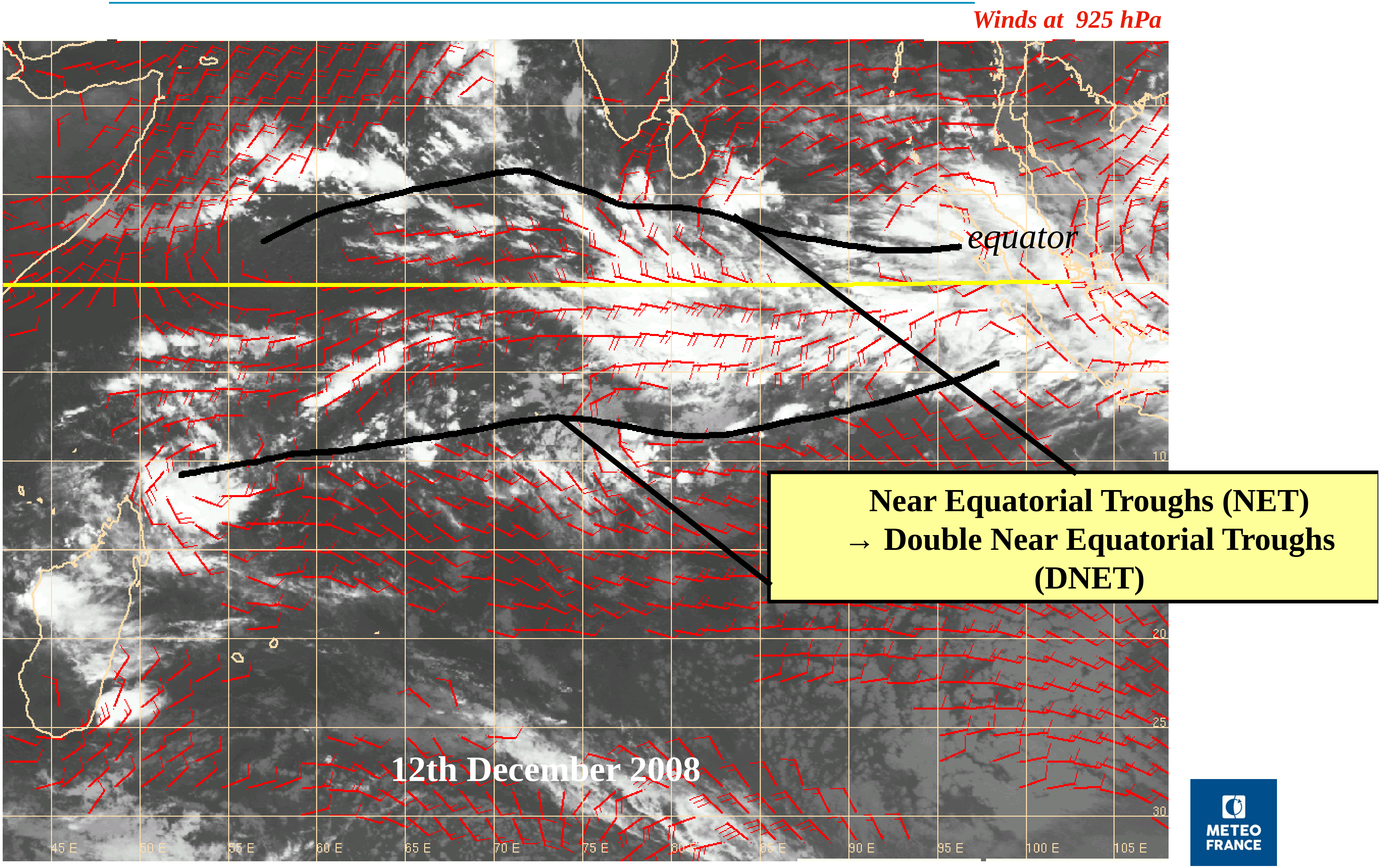


<u>Near Equatorial Trough définition:</u>

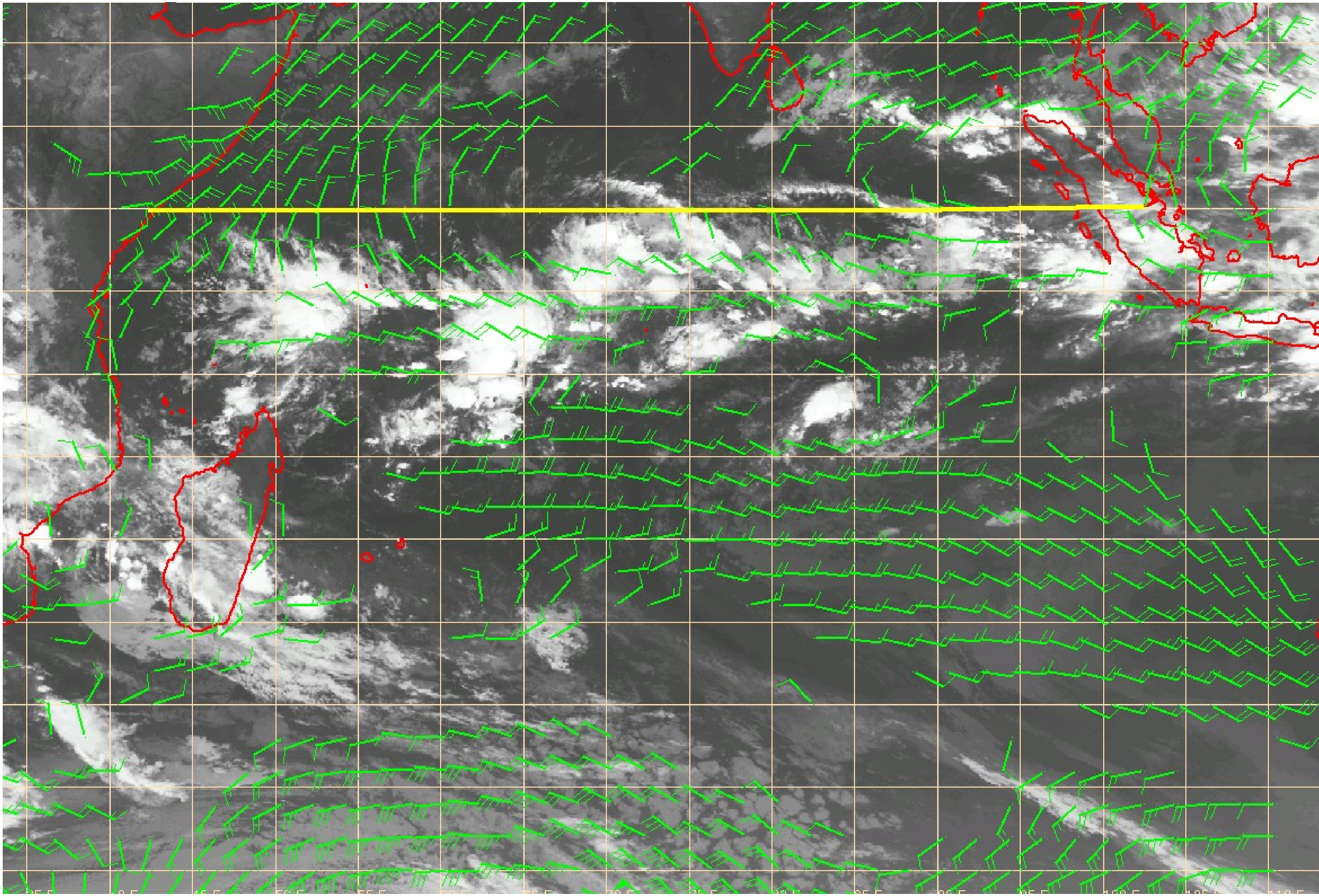
Low level trough (surface to 850 hPa) associated with equatorial winds with a strong zonal (westerly) component.

→ **Low level large scale vorticity associated**.

Austral spring / autumn



PRACTICAL EXERCISE :
Which BP (Basin Pattern) is it ?



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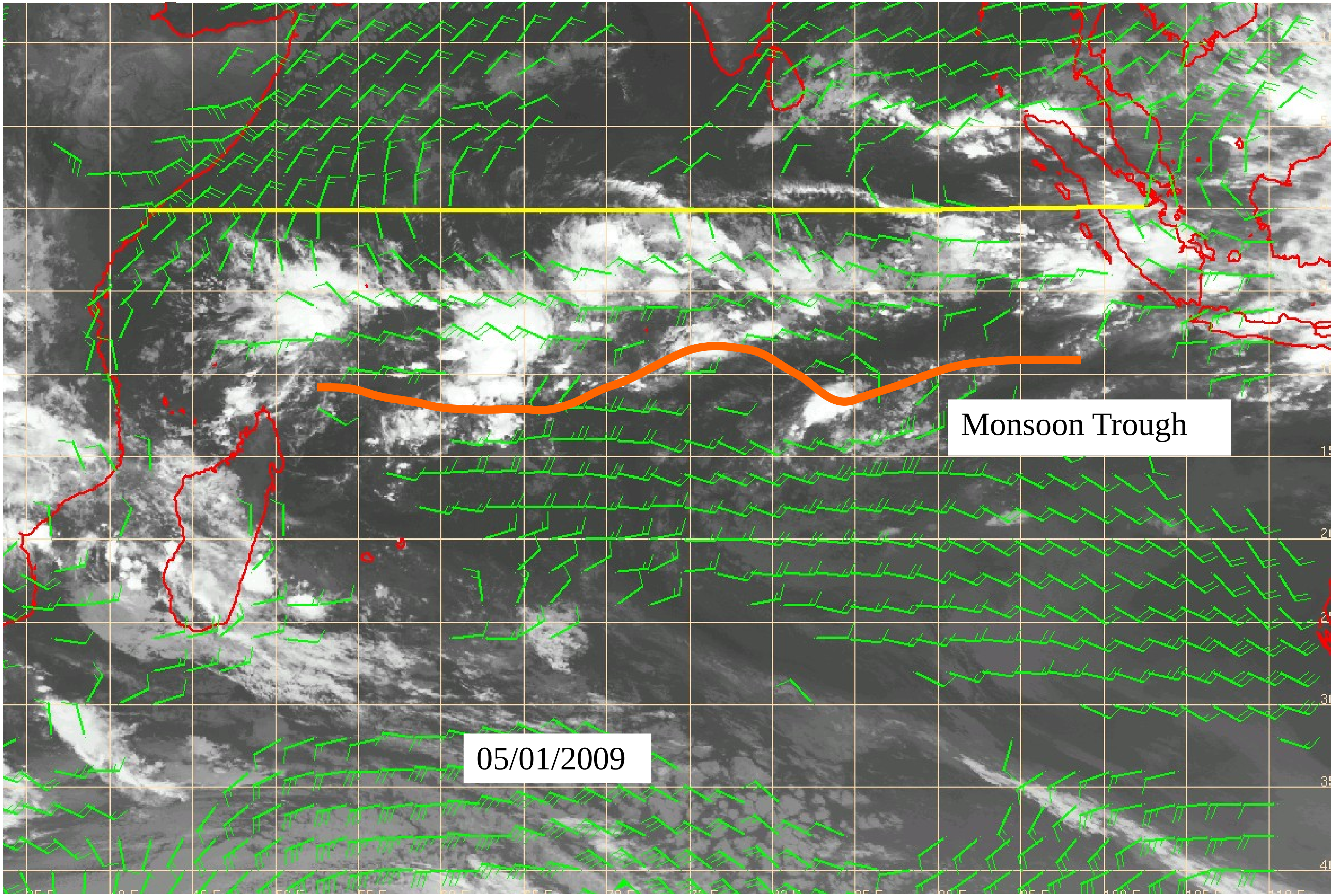

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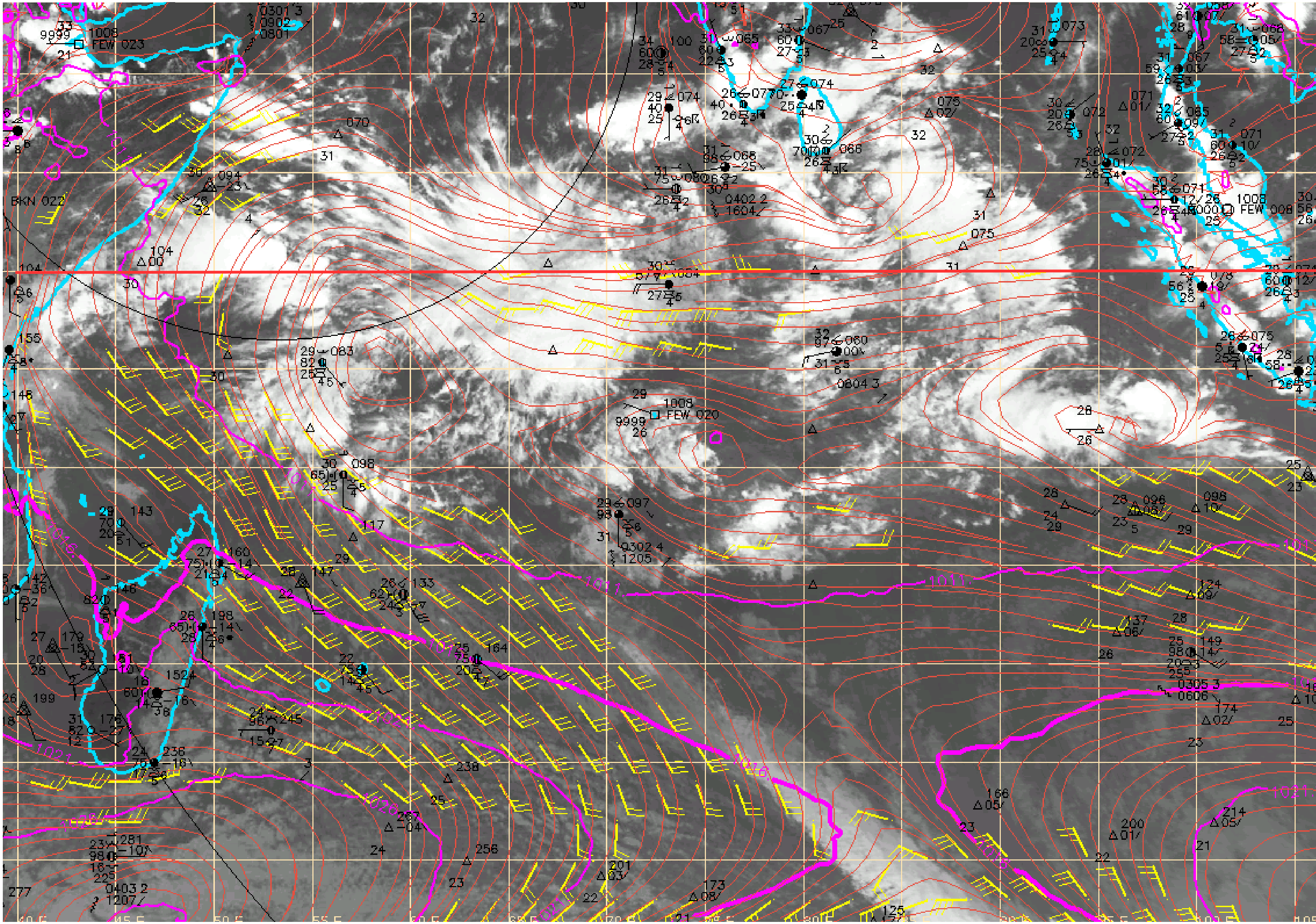

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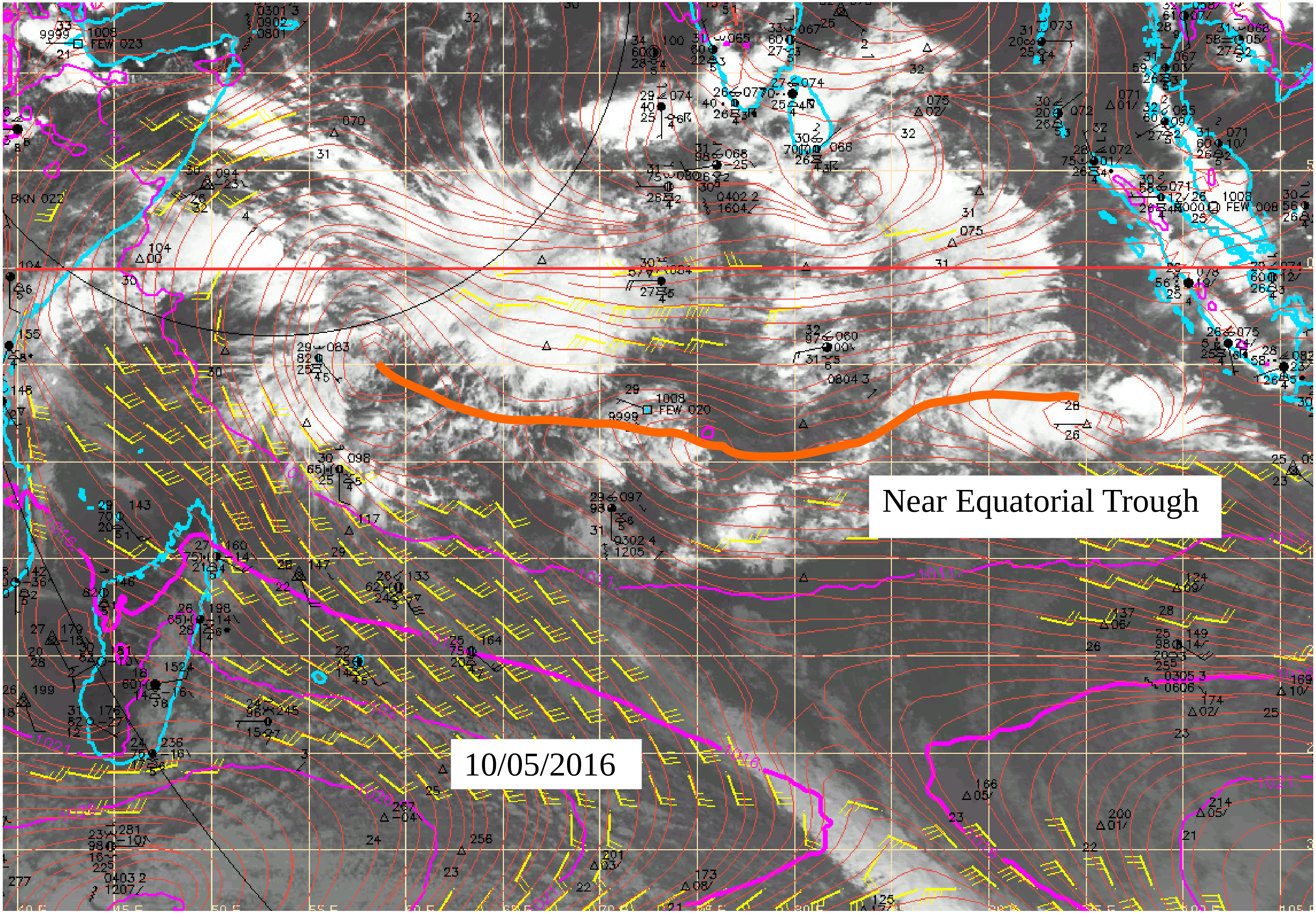

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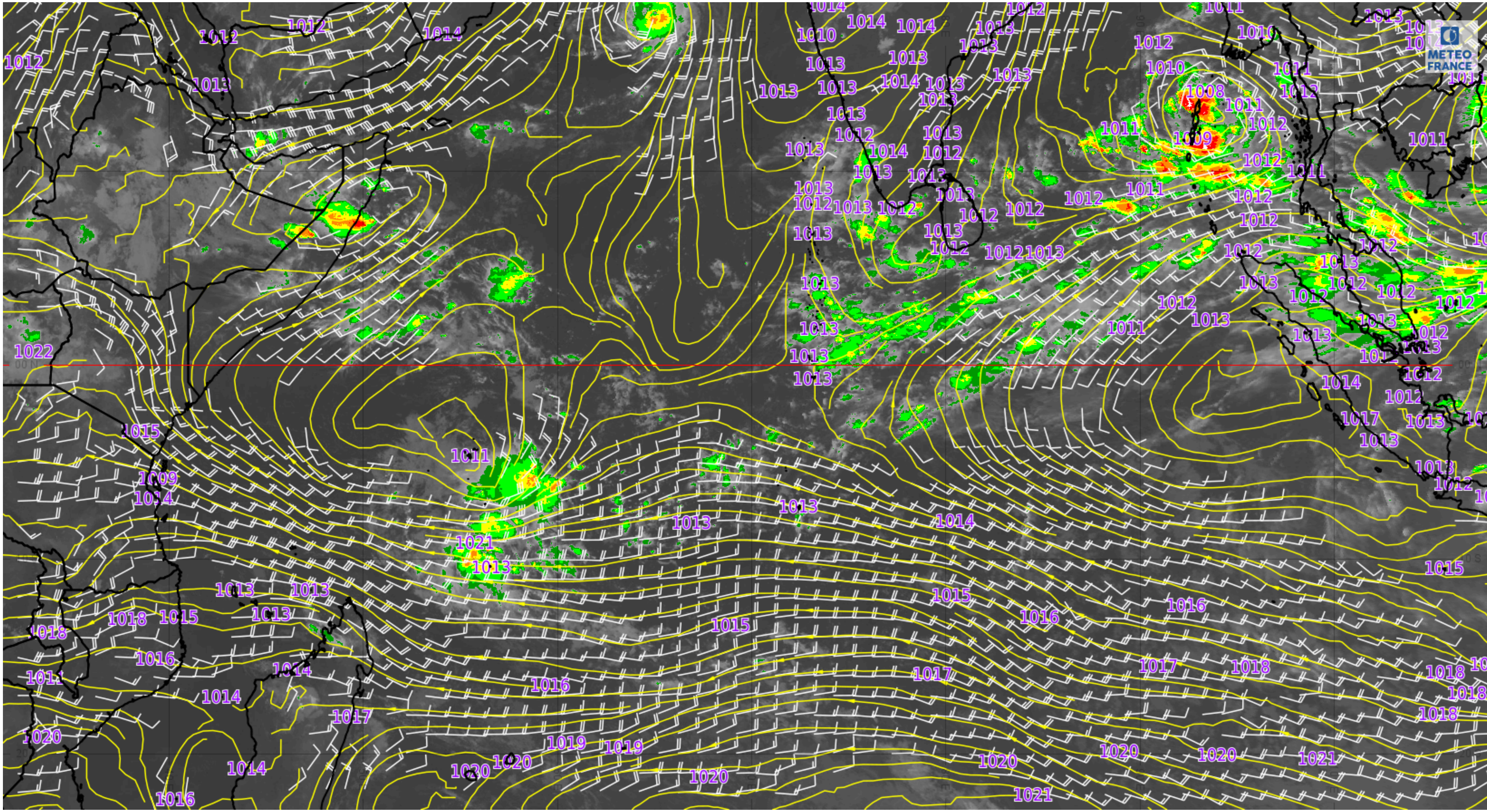
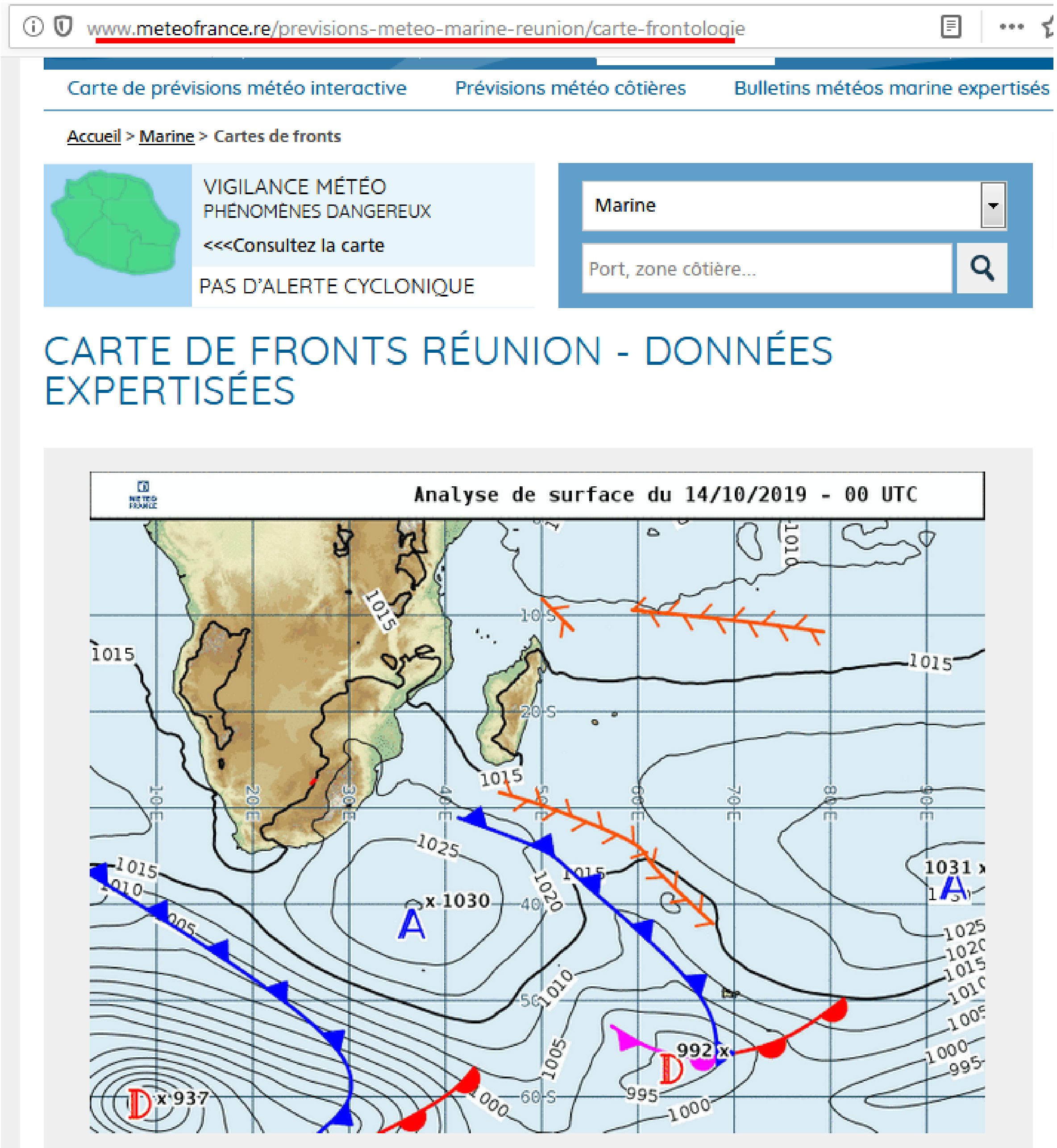
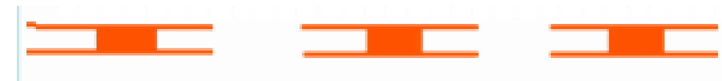


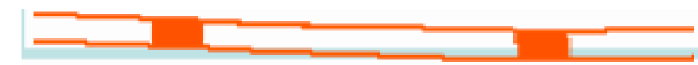
Access to RSMC daily analysis



Tradewind Meteorological Equator



Monsoon Trough



Near Equatorial Trough

OUTLINE

- Indian Ocean annual cycle and associated wind patterns
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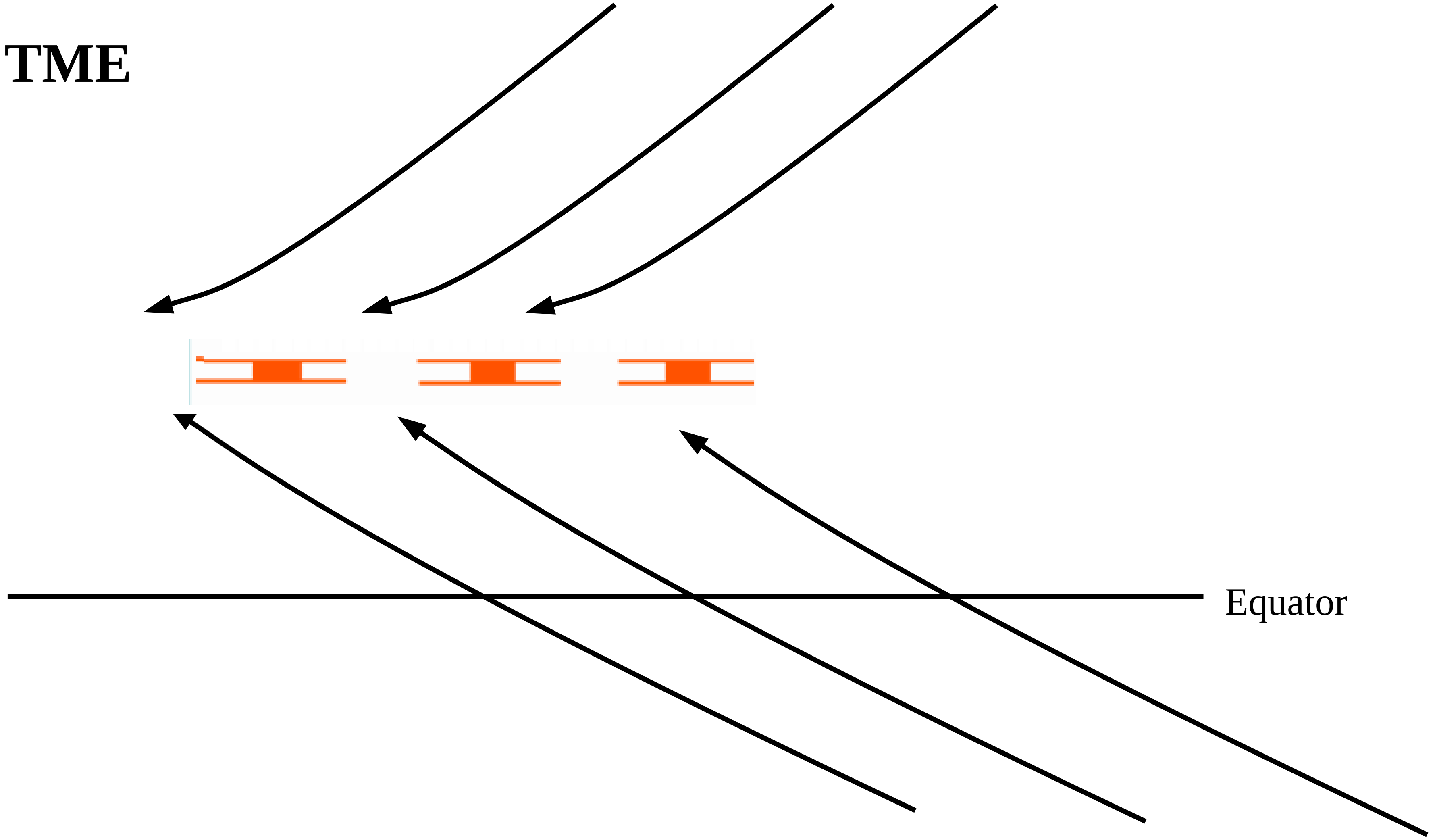
- **Other wind patterns**

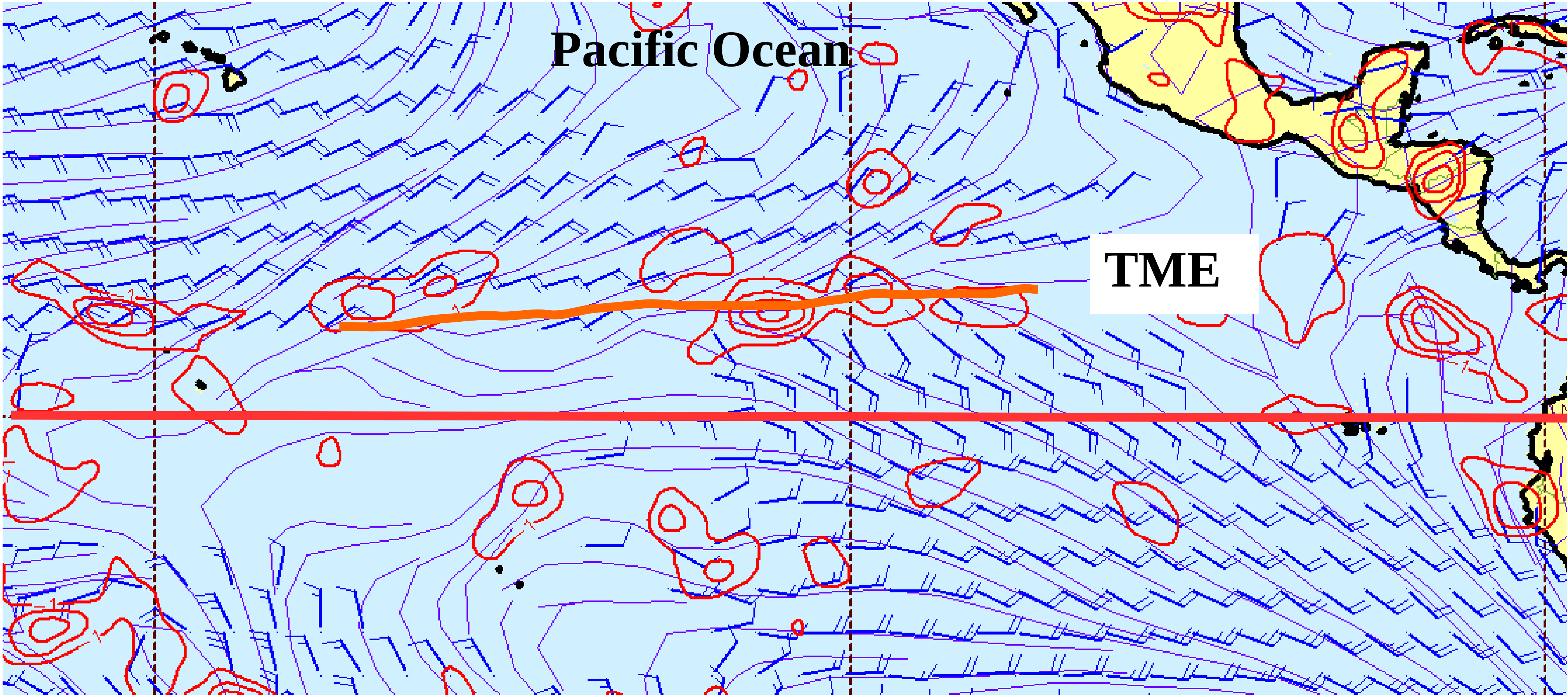
- Conclusion

Tradewind Meteorological Equator



Definition: Axis of confluence between northeasterly trades from Northern hemisphere and southeasterly trades from Southern hemisphere. Little or no low level vorticity associated.

Tradewind Meteorological Equator



CONCLUSION

- The Indian Ocean is a specific bassin where the low level wind pattern in the near equatorial area depends on large scale zonal and meridional pressure gradient

- The annual cycle of this large scale pressure gradient defines specific low level wind pattern (ie the Bassin Pattern)

- The Monsoon Trough is the pattern of the austral summer. The Near Equatorial Trough is the pattern of the intermediate season (spring / autumn)

- Associated with low level vorticity, these patterns are preliminary conditions towards cyclogenesis over the Indian Ocean.

METEO FRANCE