Low level wind patterns over the Indian Ocean

Langlade Sébastien, tropical cyclone forecaster

based on

La Réunion, 2019/11/04
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: *seasonal shift of the inter-hemispheric pressure gradient*.

- Equatorial westerlies: *enhanced with strong east-west gradient pressure with weak near equatorial southern trade winds*
Tropical Indian Ocean surface winds patterns: Background

- Annual cycle dominated by the shift between the southern and northern summer monsoon: seasonal shift of the inter-hemispheric pressure gradient.

- Equatorial westerlies: enhanced with strong east-west gradient pressure with weak near equatorial southern trade winds.
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)
Austral summer (January to March)
Austral summer (January to March)
Austral summer (January to March)

**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)

18th February 2009

Winds at 925 hPa

Monsoon Trough (MT)
Austral winter (June to August)
Austral winter (June to August)

Figure 2.8. Mean surface level streamline analyses over the Indian Ocean for July (Sadler, 1975).
Austral winter (June to August)

Figure 2.8. Mean surface level streamline analyses over the Indian Ocean for July (Sadler, 1975).
Austral winter (June to August)

\[
\frac{\partial u}{\partial y} = f v - \frac{\partial p}{\partial x}
\]

\text{Coriolis}

\text{Zonal pressure gradient}

\[\text{H} \quad \text{L} \]

\[\begin{array}{l}
\geq 28 \text{ kt} \\
\geq 16 \text{ kt} \\
\leq 4 \text{ kt} \\
\geq 16 \text{ kt} \\
\end{array}\]

\text{LP}

\text{Indonésia}

\text{July (Sadler, 1975)}
Austral winter (June to August)

India and south-eastern Asia monsoons

July rain climo

Southern Indian Ocean rain max

Figure 2.8. Mean surface level streamline analyses over the Indian Ocean for July (Sadler, 1975).
Austral winter (June to August)

India and south-eastern Asia monsoons

Buffer area

Southern Indian Ocean rain max

July rain climo

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

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

Figure 2.9. Mean surface level streamline analyses over the Indian Ocean for October (Sadler, 1975).
Tropical Indian Ocean surface winds patterns: Background

\[ \frac{dV}{dt} = -fk \times V - \alpha \nabla p + F. \]  \hspace{1cm} (1)

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

\[ v \frac{\partial u}{\partial y} = +fv - \alpha \frac{\partial p}{\partial x}. \]  \hspace{1cm} (2)

- 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

![Diagram of wind patterns over the Indian Ocean during Austral spring/autumn, highlighting regions with wind speeds of ≥8 kt and ≥16 kt. The diagram also indicates the Near Equatorial Trough (NET)].

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

Near Equatorial Trough
définition:
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

Near Equatorial Troughs (NET) → Double Near Equatorial Troughs (DNET)

Winds at 925 hPa

12th December 2008
PRACTICAL EXERCISE:
Which BP (Basin Pattern) is it?
PRACTICAL EXERCISE:
Which BP (Basin Pattern) is it?

Monsoon Trough

05/01/2009
PRACTICAL EXERCISE:
Which BP (Basin Pattern) is it?
PRACTICAL EXERCISE:
Which BP (Basin Pattern) is it?

Near Equatorial Trough

10/05/2016
PRACTICAL EXERCISE:
Which BP (Basin Pattern) is it?
Access to RSMC daily analysis

Tradewind Meteorological Equator

Monsoon Trough

Near Equatorial Trough
OUTLINE

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

- Other wind patterns

- Conclusion
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 basin 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 (i.e., 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.