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Indian Ocean Dipole and Ocean Mean Temperature: Forecasting the Monsoon

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Indian Ocean Dipole and Ocean Mean Temperature: Forecasting the Monsoon

The Indian Ocean has its own temperature see-saw. It can rescue India’s monsoon in an El Niño year. It can also dry out Australia in the same season. This lesson shows how the see-saw is measured, how it builds, and what it did in key years. It then explains Ocean Mean Temperature, a deeper ocean reading that researchers use for an early monsoon signal.

Must know: the 2017 question and the IOD basics

1 What did UPSC ask about the IOD in 2017?

UPSC tested the Indian Ocean Dipole with two statements. One was true. The other swapped one ocean for another.

What was the question?

This was UPSC Civil Services Prelims 2017, General Studies Paper I, Series A, Question 66. The official wording reads:

The code options were:

- (a) 1 only
- (b) 2 only
- (c) Both 1 and 2
- (d) Neither 1 nor 2

What is the answer?

The official answer key gives **(b) 2 only**. UPSC's Series A key lists no dropped items for this paper. Statement 1 is false. Statement 2 is true.

Why is statement 1 false?

- The IOD compares the western and the eastern tropical **Indian** Ocean.
- The eastern Pacific belongs to El Niño, not to the IOD.
- The question changes only one ocean. That one change is the trap.

Why is statement 2 true in 2017?

A 2001 study found that the IOD can counter or support the circulation that El Niño sets up over India. Section 4 explains this in full.

> **Quick check 1.** The IOD is a temperature difference between the western Indian Ocean and the eastern Pacific. *(True or False?)*
>
> See answer ↓

Sources: web.archive.org

2 What is the IOD, and how is it measured?

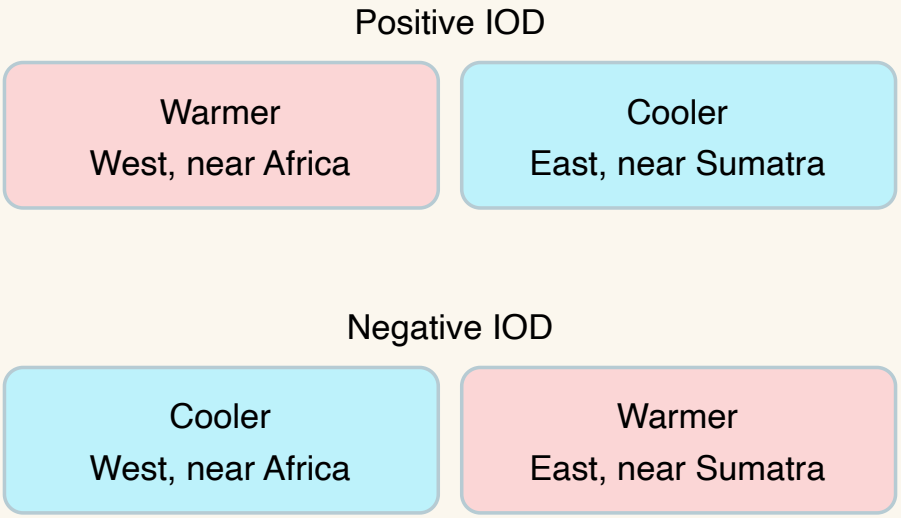
The **Indian Ocean Dipole**, or IOD, is a temperature see-saw inside one ocean. The Bureau of Meteorology (BoM) of Australia defines it as the difference between sea surface temperatures in the tropical western and eastern Indian Ocean. The western side is near Africa. The eastern side is near Indonesia.



The Indian Ocean, whose western and eastern temperature difference drives the IOD. Map: NordNordWest, public domain, via Wikimedia Commons.

What are the three phases?

- **Positive IOD:** the west is warmer than normal and the east is cooler than normal.
- **Negative IOD:** the west is cooler than normal and the east is warmer than normal.
- **Neutral IOD:** temperatures stay close to normal across the basin.



Positive: west warmer, east cooler. Negative: the reverse. Original explanatory diagram.

How is the IOD measured?

Scientists use the **Dipole Mode Index**, or DMI. It subtracts the eastern temperature anomaly from the western one. An anomaly is the gap between today's temperature and the normal for that place and season.

BoM names two fixed boxes for the index:

- **West box:** 50°E to 70°E and 10°S to 10°N.
- **East box:** 90°E to 110°E and 10°S to the equator.

The east box lies off Sumatra.

What are the thresholds?

BoM treats sustained values above +0.4°C as typical of a positive IOD. It treats values below –0.4°C as typical of a negative IOD. The word “sustained” matters. A single week above the line does not make an event.

These cut-offs come from Australian climatologists. IMD’s bulletin uses the same ±0.4 band for its own forecasts.

Who identified the IOD, and when?

N. H. Saji, B. N. Goswami, P. N. Vinayachandran and T. Yamagata reported it in the journal *Nature* in 1999. Their paper showed low sea surface temperatures off Sumatra and high ones in the western Indian Ocean. They found that this pattern is independent of the El Niño Southern Oscillation. They said it accounts for about 12% of sea surface temperature variability in the Indian Ocean.

> **Quick check 2.** In a positive IOD, the western Indian Ocean is warmer than normal and the eastern Indian Ocean is cooler than normal. *(True or False?)* See answer ↓

Sources: bom.gov.au; repository.ias.ac.in; mausam.imd.gov.in

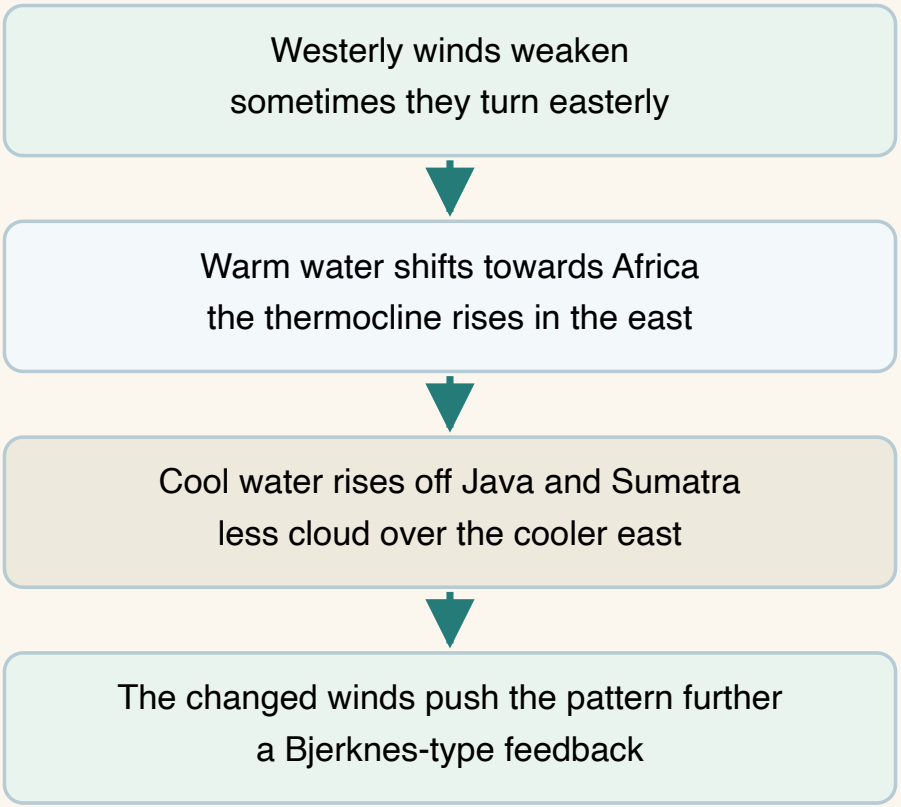
Good to know: how events form and what they change

3 How does an IOD event form, and when?

An IOD event feeds itself. A small change in the winds starts it. The ocean then strengthens the change.

How does a positive event build up?

It works in six steps.



Each step strengthens the next, so the event feeds itself. Original explanatory diagram.

- Westerly winds along the equator weaken. Sometimes they turn easterly.
- Warm surface water shifts towards Africa.
- The **thermocline** rises in the east and sinks in the west. The thermocline is the layer where temperature drops quickly with depth.
- Cool water rises from the depths off Java and Sumatra.
- Cooler water and sinking air in the east mean less cloud there.

- The changed winds push the pattern further. Scientists call this a **Bjerknes-type feedback**.

Yamagata and colleagues describe this chain in a 2004 paper. They note that seasonal winds along the Java coast also strengthen in a positive event. That adds more upwelling and more cooling.

When do events happen?

BoM gives a clear calendar for IOD events:

- They usually start around May or June.
- They peak between August and October.
- They decay quickly when the northern Australian monsoon arrives, around the end of spring.

Each phase occurs about every three to five years on average. A 2001 study adds that the IOD is locked to the summer monsoon season. That timing is why it matters for India.

Can an IOD happen without El Niño?

Yes. Yamagata and colleagues list positive IOD events in 1961, 1967 and 1994 that grew without an El Niño. They built composites from 9 independent IOD events, both positive and negative.

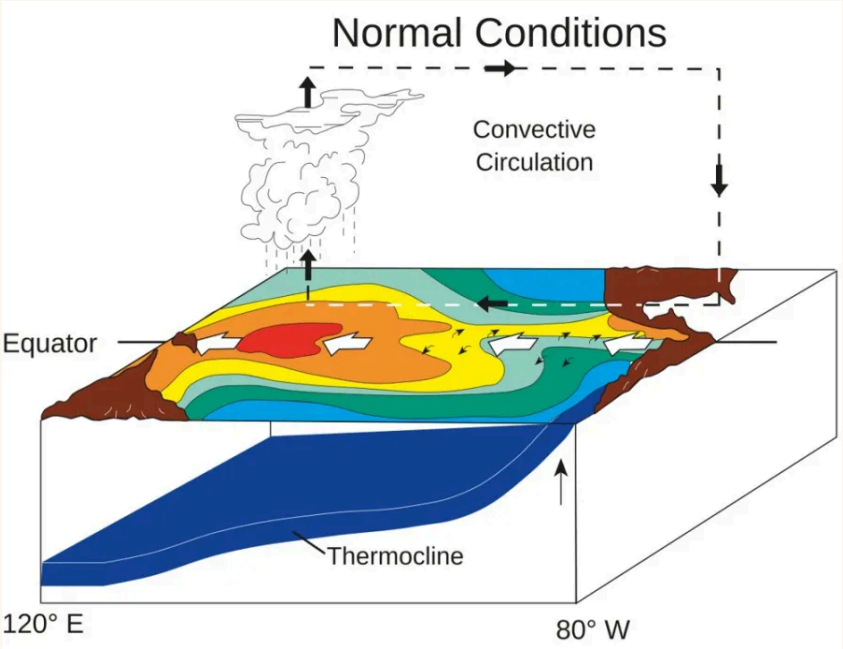
The two patterns can also occur together. BoM says an El Niño with a positive IOD can reinforce dry effects in Australia.

> **Quick check 3.** IOD events usually peak between August and October. *(True or False?)* See answer ↓

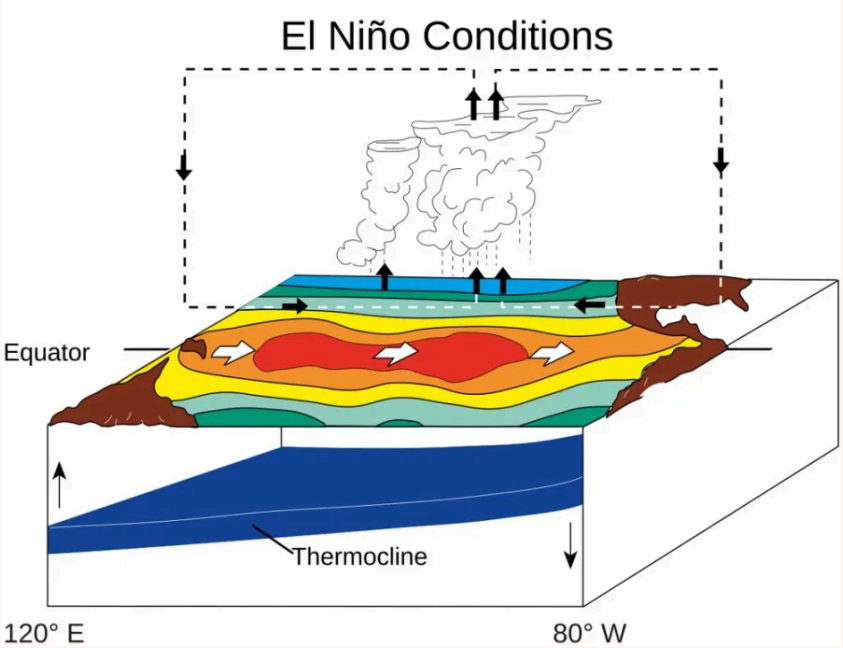
Sources: bom.gov.au; ftp.cpc.ncep.noaa.gov

4 How does the IOD change India's monsoon?

El Niño years often bring a weaker Indian monsoon. The IOD can push the other way. Its effect depends on its phase and on its strength against El Niño.



Normal Pacific conditions, the Pacific partner of the IOD. Diagram by Fred the Oyster, public domain, on Wikimedia Commons.



El Nino conditions in the Pacific, the event the IOD can offset over India. Credit: Fred the Oyster, based on NOAA/PMEL/TAO data, public domain, from Wikimedia Commons.

Why was the link once unclear?

Saji and colleagues found a correlation of only 0.32 between the IOD and monsoon rainfall. They called the link unclear. Later work asked a better question. It looked at the IOD and ENSO together, year by year.

What did the 2001 study find?

Ashok, Guan and Yamagata studied the years 1958 to 1997. They published in *Geophysical Research Letters* in 2001. Their findings were:

- The IOD and ENSO affected the monsoon in complementary ways.
- When the ENSO link to the monsoon was weak, the IOD link was strong.

- ENSO's effect over India is either **countered or supported** by an IOD circulation cell.
- Of 11 intense positive IOD events, 8 matched above-normal rainfall in the same season. That is 73%.
- Of 3 intense negative IOD events, 2 matched below-normal rainfall.

These are tendencies, not guarantees.

Which years show the offset?

The paper names 1983, 1994 and 1997. In these summers a positive IOD helped bring normal or excess rain. The Southern Oscillation was in its negative phase at the same time.

- **1997:** all-India monsoon rainfall was about 102% of normal, per the Economic Survey 2000-01 chart.
- **1994:** Ashok lists it among the offset years, but the IOD event ran without an intense El Niño. It shows the IOD acting alone.
- **1982 against 1983:** in 1982 El Niño was stronger than the positive IOD, with normalised values of 1.7 against 1.4. The paper says this may explain the monsoon deficit. In 1983 the positive IOD was stronger. The paper says this may explain the surplus.

The lesson is simple. The **relative strength** of the two events decides the outcome.

What changes in the air?

In the study's model, a positive IOD reduces rising air over the cooler eastern Indian Ocean. Air converges over the Bay of Bengal instead. That strengthens the north-south monsoon circulation. This is how the IOD can replace the sinking air that El Niño brings over India.

> **Quick check 4.** A positive IOD helped India receive normal or better monsoon rain in 1997, despite El Niño-type conditions. *(True or False?)* See answer ↓

Sources: jamstec.go.jp; indiabudget.gov.in

5 What does the IOD do in Africa, Indonesia and Australia?

The IOD shifts rain across the whole basin. Places on opposite sides of the ocean often get opposite results.

What happens in East Africa and Indonesia?

Saji and colleagues found that active IOD years cause severe rainfall in eastern Africa. They also cause droughts in Indonesia. Ashok and colleagues repeat this for a positive IOD: heavy rain and floods over East Africa, and drought over Indonesia.

What happens in Australia?

This is a common exam trap, so read it slowly.

- A **positive** IOD often brings less rain and higher temperatures to parts of Australia in winter and spring.
- A **negative** IOD typically brings above-average winter and spring rain to parts of southern Australia.
- A positive IOD is the dry one for Australia. It is not the negative one.

BoM gives two historic examples:

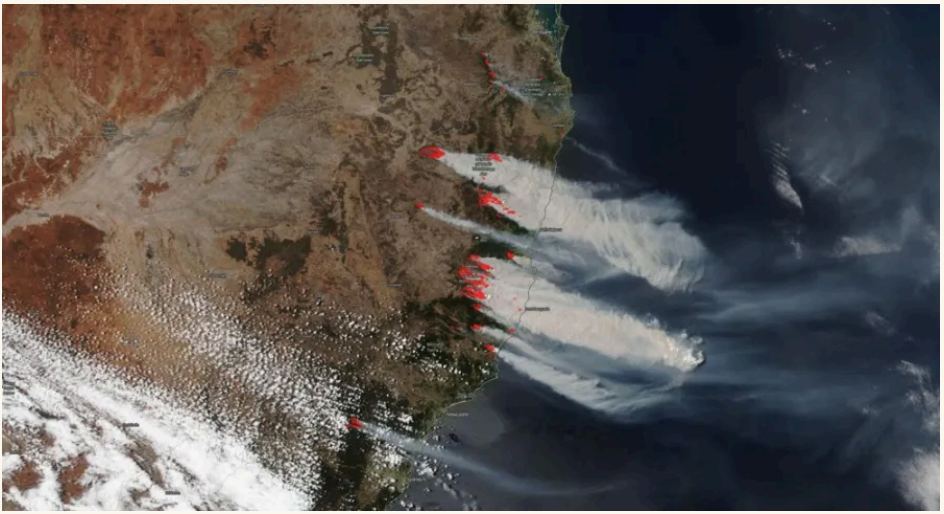
- **1982:** a positive IOD and El Niño together. It was the driest year on record for southeast Australia. The Ash Wednesday bushfires followed.

- **1974 and 2010:** a negative IOD and La Niña pushed rain towards Australia. These are two of the three wettest years on record.

What happened in 2019?

BoM calls the 2019 positive IOD the strongest on record. WHOI reports that it was a big player in Australia's severe drought. It was also linked to floods in East Africa.

The WHOI release adds a note on history. Large positive IOD events were historically rare. They became more frequent and intense during the 20th century.



Smoke from eastern Australia's bushfires in late 2019, seen from space. This is a NOAA satellite image, not a map of the IOD. Image: NOAASatellites, public domain, via Wikimedia Commons.

Sources: bom.gov.au; whoi.edu

Great to know: Ocean Mean Temperature and the 2026 monsoon

6 What is Ocean Mean Temperature?

The IOD compares two places on the surface. **Ocean Mean Temperature**, or OMT, goes down instead.

What does OMT measure?

OMT is the average temperature of the water from the sea surface down to the 26°C isotherm. An **isotherm** is a line joining points of equal temperature. The depth of the 26°C isotherm is called **D26**.

Think of it as a single reading for a whole column of water. It tells you how much heat the upper ocean holds.

Where and when is it measured?

- **Place:** a south-western Indian Ocean box, 50°E to 70°E and 10°S to the equator.
- **Time:** the January to March average.

- **Why that window:** it is a transition period between winter and the south-west monsoon.

Notice the longitudes. They match the western box of the IOD index.

What depth does the study report?

The 2018 study gives a January to March mean D26 of 59 m in that box. The study's ocean heat content for that region is 50 kJ per square centimetre.

Why not use surface temperature alone?

The study makes three points:

- Sea surface temperature describes a very thin layer.
- Winds, evaporation and thick clouds disturb that layer.
- OMT varies more steadily and with less spread.

For scale, one BoM sea surface product is taken at about 0.2 metres depth. It is similar to temperatures down to about 10 metres in well-mixed water. OMT covers the water down to about 59 m in this region.

> **Quick check 5.** Ocean Mean Temperature is the average temperature from the sea surface down to the 26°C isotherm. *(True or False?)* See answer ↓

Sources: ebi.ac.uk; bom.gov.au

7 How well does OMT predict the monsoon?

A joint team tested OMT against other ocean signals. It asked one question. Could each signal predict whether the monsoon would be above or below average?

Who ran the study?

The authors were Venugopal, Ali, Bourassa, Zheng, Goni, Foltz and Rajeevan. Their institutions included Florida State University, IITM Pune, NOAA's Atlantic Oceanographic and Meteorological Laboratory, and the Ministry of Earth Sciences. It appeared in *Scientific Reports* in 2018.

How was it tested?

- The record ran for 25 years, from 1993 to 2017.
- Rainfall data came from IMD, using 6,955 rain gauges.
- Each signal was a January to March average.
- The test counted how often each signal got the sign of the rainfall anomaly right.

What were the results?

Signal	Years correct	Success rate
—	—	—
Ocean Mean Temperature	20 of 25	80%
Sea surface temperature	15 of 25	60%
El Niño Modoki Index	14 of 25	56%
Niño3.4 index	13 of 25	52%
Dipole Mode Index (IOD)	12 of 25	48%

What are the limits?

- The authors call it a statistical examination, not a process study.
- It aims to predict the sign of the anomaly, not its size.

- The record is only 25 years long.

The IOD usually starts around May or June. A January to March reading therefore comes before an event begins. That may help explain its low score here. The study says OMT gives a signal by the end of March.

Does IMD use OMT?

The highlights of IMD's April 2026 forecast name ENSO, the IOD and northern snow cover. They do not name OMT. So OMT is best described as a research signal.

Sources: ebi.ac.uk; mausam.imd.gov.in

8 What did UPSC ask about OMT in 2020?

UPSC turned the OMT study into a two-statement question. One statement hid a number.

What was the 2020 question?

This was UPSC Civil Services Prelims 2020, General Studies Paper I, Set A, Question 93. The official wording of this item reads:

The options used the same four codes as in 2017.

What is the 2020 answer?

The official Set A key gives **(b) 2 only**. This item was not among the two dropped items. Other sets number the questions differently, so check your own set.

What about the depth figure?

UPSC's paper prints 129 meters. The 2018 study gives a mean D26 of 59 m for that box and season. We did not find 129 m in that paper.

The key marks statement 1 as wrong. So the exam lesson is plain. A wrong number can make a statement false even when the idea is right.

Why is statement 2 correct in 2020?

The study shows that a January to March OMT can indicate whether the monsoon will be above or below its long-term mean. Section 7 shows the 80% result.

Sources: web.archive.org; ebi.ac.uk

9 Where do the IOD and OMT stand in 2026?

The year 2026 is an El Niño year with a weak monsoon. These are dated snapshots. Check the linked pages for later updates.

What did IMD forecast, and what happened?

- **13 April 2026:** IMD forecast 92% of the Long Period Average, with a model error of ±5%. It called the monsoon likely to be below normal.
- **Same release:** IMD said the IOD was neutral. It said models showed a positive IOD developing towards the end of the season.
- **30 September 2026:** UNI, quoting IMD, reported a 12.6% rainfall deficit for 1 June to 30 September. It called this the fourth weakest monsoon since 2001.

What does the ocean record show?

IMD's September 2026 bulletin gives the IOD record for the past year:

- A negative IOD persisted from September to December 2025.
- The DMI turned positive from February to April 2026.
- It turned negative in May and June 2026.
- Neutral conditions held in July and August 2026.

- The Niño3.4 index crossed the El Niño threshold in May 2026. It reached about +2.08°C by August.

What is the latest reading?

- **BoM, 29 September 2026:** the IOD is still called neutral. The index was +0.76°C for the week ending 27 September.
- That is the third week in a row above +0.4°C. BoM says sustained values are needed before an event counts as established.
- BoM expects a positive IOD to develop in spring. It notes some uncertainty about strength and length.
- **Niño3.4:** +2.72°C for the same week. BoM calls it the second-highest weekly value in its weekly SST data, which start in 2008.
- **NOAA, 8 October 2026:** an El Niño advisory is in force. A strong to very strong event is likely through January to March 2027, at above 83% chance.

Did the IOD rescue the 2026 monsoon?

No. This is our reading of the dates. The monsoon season ran from June to September. The index only rose above +0.4°C in September, for three weeks, and BoM still called the IOD neutral. That was too late and too short to offset El Niño.

What came before?

- **2019:** BoM calls it the strongest positive IOD on record.
- **2023:** in October 2023, BoM said the positive IOD might come close to the 2019 event in strength.
- **2025:** a negative IOD was weakening in December. BoM gave an index of –0.63°C for the week ending 7 December 2025.

Sources: bom.gov.au; mausam.imd.gov.in

Sources: uniindia.com; mausam.imd.gov.in; bom.gov.au; cpc.ncep.noaa.gov

10 How do exams test this?

This page covers two UPSC Prelims questions, from 2017 and 2020. Each one built a trap from a single wrong detail.

Which facts should you hold?

- The IOD compares the western and eastern tropical **Indian** Ocean.
- Positive IOD: west warmer, east cooler. Negative IOD: the reverse.
- The DMI uses two boxes, and BoM uses ±0.4°C thresholds.
- The IOD was reported in *Nature* in 1999 by Saji, Goswami, Vinayachandran and Yamagata.
- Events start around May or June and peak between August and October.
- The IOD can modulate El Niño's effect on the monsoon. A positive IOD helped in 1983, 1994 and 1997.
- A positive IOD tends to bring floods to East Africa, drought to Indonesia, and dry weather to parts of Australia.
- OMT is the average temperature down to the 26°C isotherm, read for January to March.
- OMT helps judge whether the monsoon will be above or below its long-term mean.

What are the common traps?

- Swapping the eastern Indian Ocean for the eastern Pacific, as in 2017.
- Printing a wrong depth for the 26°C isotherm, as in 2020.

- Reversing the Australian effect. Positive is the dry phase there.
- Treating the IOD and ENSO as one system. They can run independently.
- Treating any reading as an event. Values between –0.4°C and +0.4°C count as neutral.

Sources: web.archive.org; bom.gov.au; mausam.imd.gov.in

Review the feedback after each answer. The understanding-check score lasts for this page session.

Reset the checks when you want another attempt. This score is separate from the Native Practice score below.

Questions to think through

Why can a positive IOD help India but dry out Australia?

A positive IOD cools the eastern Indian Ocean, near Indonesia and Australia's west. That cuts cloud and moisture there. The study's model shows air converging over the Bay of Bengal instead, which supports the monsoon.

Why does BoM still call the IOD neutral at +0.76°C?

BoM wants sustained values above +0.4°C. At the time of its 29 September 2026 update, the index had been above that line for three weeks. BoM held the label until the signal lasted.

Why would a deeper reading be steadier than surface temperature?

The surface layer is thin. Winds, evaporation and thick clouds disturb it quickly. The paper says a column average down to the 26°C isotherm is more stable and less spread than surface temperature.

Why did the 1982 monsoon fail while the 1983 monsoon held up?

In 1982 El Niño was stronger than the positive IOD. In 1983 the positive IOD was the stronger of the two. Relative strength decided the result.

How should you handle a number you cannot match to a source?

UPSC printed 129 meters for the OMT depth. The study gives 59 m. Follow the official key for the exam. Check the original study before you repeat any figure.

Practice MCQs

1. With reference to 'Indian Ocean Dipole (IOD)', sometimes mentioned in the news while forecasting Indian monsoon, which of the following statements is/are correct?
1. IOD phenomenon is characterised by a difference in sea surface temperature between tropical Western Indian Ocean and tropical Eastern Pacific Ocean.
2. An IOD phenomenon can influence an El Nino's impact on the monsoon.

A. 1 only

B. 2 only

C. Both 1 and 2

D. Neither 1 nor 2

See answer ↓

2. A positive Indian Ocean Dipole phase is defined by which sea-surface temperature pattern?

A. Both the eastern and western Indian Ocean warm simultaneously

B. The western Indian Ocean is warmer than normal, the eastern Indian Ocean cooler

C. The eastern Indian Ocean is warmer than normal, the western Indian Ocean cooler

D. Neither side of the Indian Ocean shows any temperature change

See answer ↓

3. In which year was the Indian Ocean Dipole first identified and named, and where was the finding published?

A. 1971, in the journal Weather

B. 1999, in the journal Nature

C. 2004, in the journal Geophysical Research Letters

D. 1985, in the journal Science

See answer ↓

4. With reference to Ocean Mean Temperature (OMT), which of the following statements is/are correct ?
1. OMT is measured up to a depth of 26°C isotherm which is 129 meters in the south-western Indian Ocean during January – March.
2. OMT collected during January – March can be used in assessing whether the amount of rainfall in monsoon will be less or more than a certain long-term mean.
Select the correct answer using the code given below :

A. 1 only

B. 2 only

C. Both 1 and 2

D. Neither 1 nor 2

See answer ↓

5. Why did a 2018 joint study find Ocean Mean Temperature (OMT) a better monsoon-rainfall predictor than plain SST?

A. OMT can be measured from land-based weather stations only

B. OMT is cheaper to measure than SST

C. SST cannot be measured in the Indian Ocean at all

D. SST is restricted to a thin surface layer and is noisier; OMT reflects a deeper, more stable heat reservoir

See answer ↓

Answer Key

1. **B.** The answer is 2 only. The IOD compares the western and eastern tropical Indian Ocean, not the eastern Pacific. So statement 1 is false. A 2001 study found that the IOD can counter or support El Niño's effect on the monsoon. So statement 2 is true. ↑ Q1
2. **B.** The answer is a warmer western Indian Ocean and a cooler eastern Indian Ocean. BoM describes cooler water near Indonesia and warmer water near Africa. The reverse pattern is a negative IOD. ↑ Q2
3. **B.** The answer is 1999, in the journal Nature. Saji, Goswami, Vinayachandran and Yamagata reported the Indian Ocean dipole mode there. The paper was in Nature, volume 401. ↑ Q3
4. **B.** The answer is 2 only. Statement 1 gives 129 meters. The 2018 study gives a mean depth of 59 m for this box and season, so the key marks statement 1 wrong. Statement 2 is correct. January to March OMT helps judge whether the monsoon will be above or below its long-term mean. ↑ Q4
5. **D.** The answer is that SST covers only a thin layer and is noisier, while OMT reflects a deeper and steadier heat store. The 2018 study says winds, evaporation and thick clouds disturb the thin surface layer. It reports an 80% success rate for OMT against 60% for SST over 25 years. One BoM sea surface product is taken at about 0.2 metres depth. It is similar to temperatures down to about 10 metres in well-mixed water. ↑ Q5

Quick-check answers

1. **False.** The IOD compares the western and eastern tropical Indian Ocean. The eastern Pacific was the trap. ↑ 1
2. **True.** BoM describes warmer water near Africa and cooler water near Indonesia. ↑ 2
3. **True.** BoM says events start around May or June, peak between August and October, then decay. ↑ 3
4. **True.** Ashok and colleagues list 1997 with 1983 and 1994. The Economic Survey shows about 102% of normal rain in 1997. ↑ 4
5. **True.** The study averages the water column from the surface down to the depth of the 26°C isotherm. ↑ 5

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