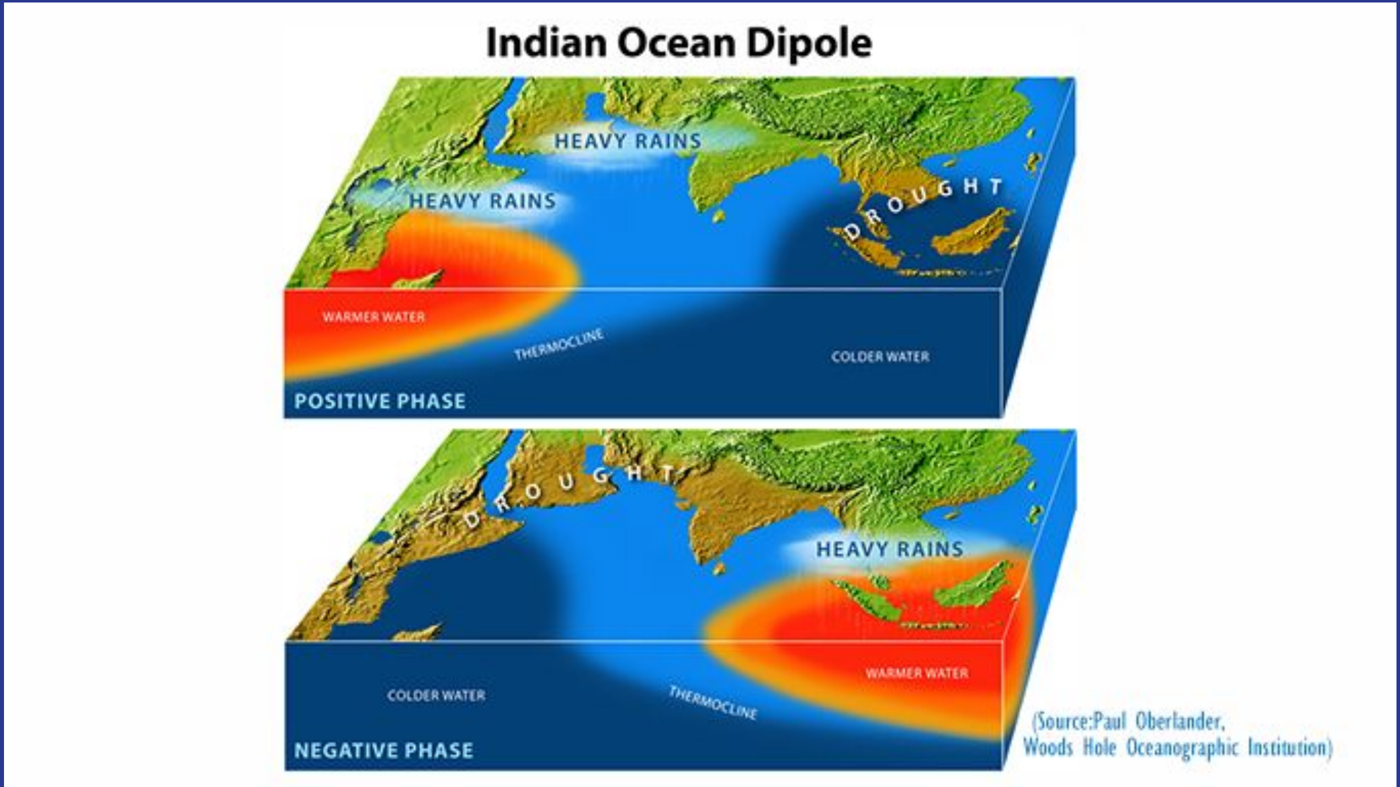
Paper Discussion:



Ashok et. al 2003

<u>Goals:</u>

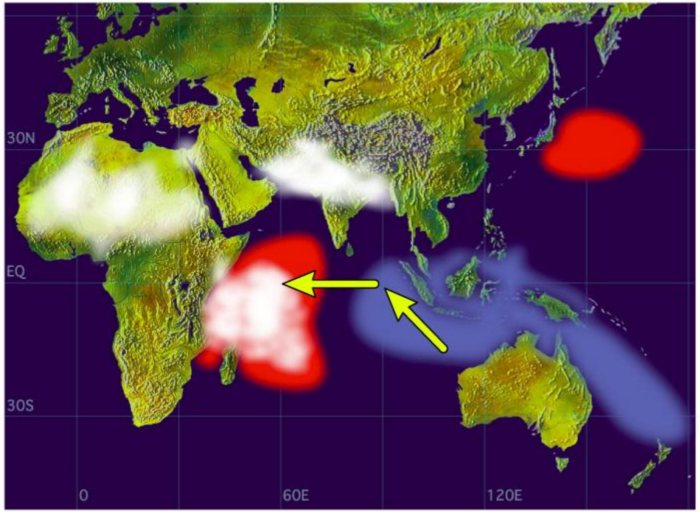
- Increase forecasting ability for Indian Monsoon region.
- Demonstrate using an Atmospheric General Circulation Model (AGCM) that IOD impacts ENSO-induced influence of the Indian region.

Ashok et. al 2003 - The Basics

1. What is a positive Indian Ocean Dipole (IOD) event and how does it affect Indian Summer Monsoon Rainfall (ISMR)?

- Increases

Positive Dipole Mode

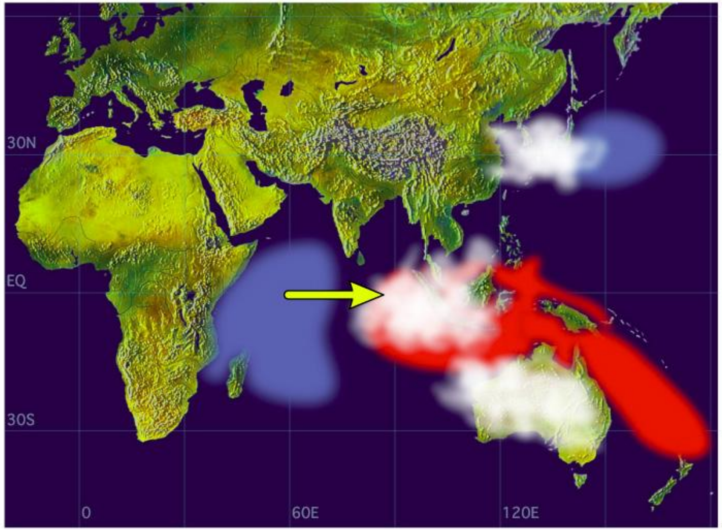


http://www.jamstec.go.jp/frsgc/research/d1/iod/e/iod/about_iod.html

Ashok et. al 2003 - The Basics

2. What is a negative IOD event and how does it affect ISMR?

- Reduces



http://www.jamstec.go.jp/frsgc/research/d1/iod/e/iod/about_iod.html

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3. What are the AGCM experiments and do you think they provide an adequate tool for analysis? How realistic are these ensembles when compared to the observational analyses?

- Four experiments consisting of 5 member ensembles with different initial conditions. (Same initial conditions for each experiment)
    - 1. Control: Seasonal variations
    - 2. ENSO type SST anomalies on top of seasonal
    - 3. Positive IOD type SST anomalies on top of seasonal
    - 4. Combination IOD and ENSO type SSTA on top of climatological SSTs
- Observational analysis “successfully simulated observed influence”
    - WHAT DOES THIS MEAN
    - “For further details, refer to the relevant publications on the model performance (Guan et al. 2000, 2003)” <Could not find??

2.

3.

4.

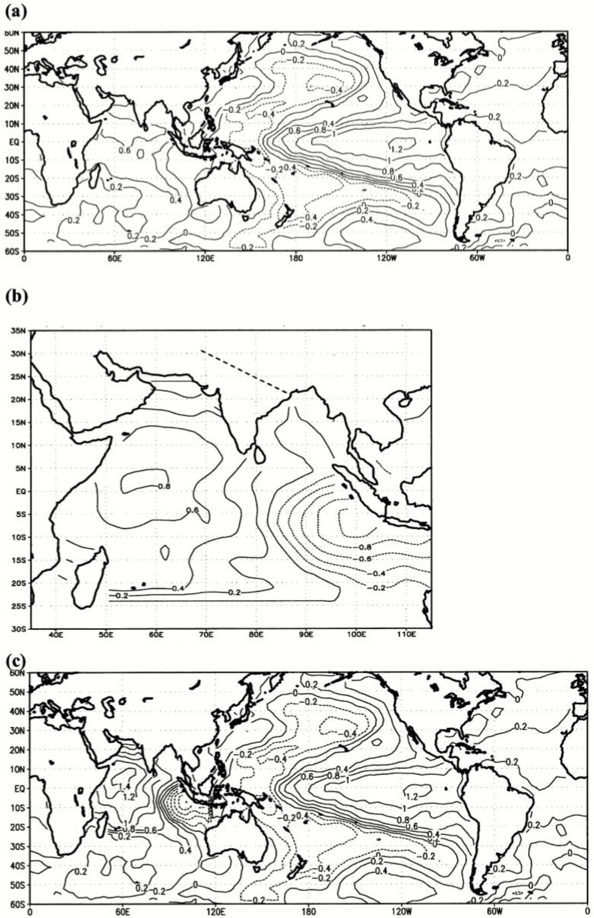

FIG. 1. Sep SSTA (°C) imposed in (a) the ENSO experiment, (b) the IOD experiment, and (c) the combined experiment. The dashed line over the Indian region shown in (b) indicates the mean climatological position of the monsoon sea level pressure trough during July (from Rao 1976, Fig. 2.2, p. 4).

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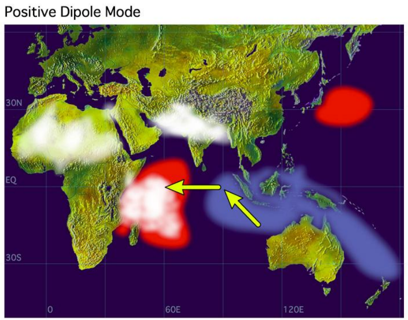
4. What is the reason for the decline in El Nino’s impact on Indian Summer Monsoon Rainfall (ISMR) since the 1980s?

- Coincided with positive IOD events
    - *ENSO equatorial western Pacific Ocean divergence center weakens, anomalous divergence center forms in the eastern tropical Indian Ocean forming an anomalous Walker cell over IOD region strengthening cross-equatorial Hadley circulation.*
    - *Both poles of IOD contribute to surplus rainfall over India, reducing ENSO induced drought.*



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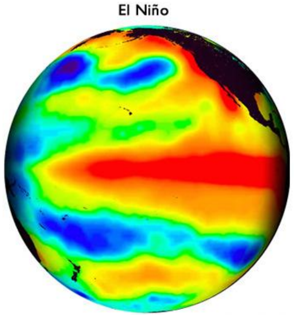

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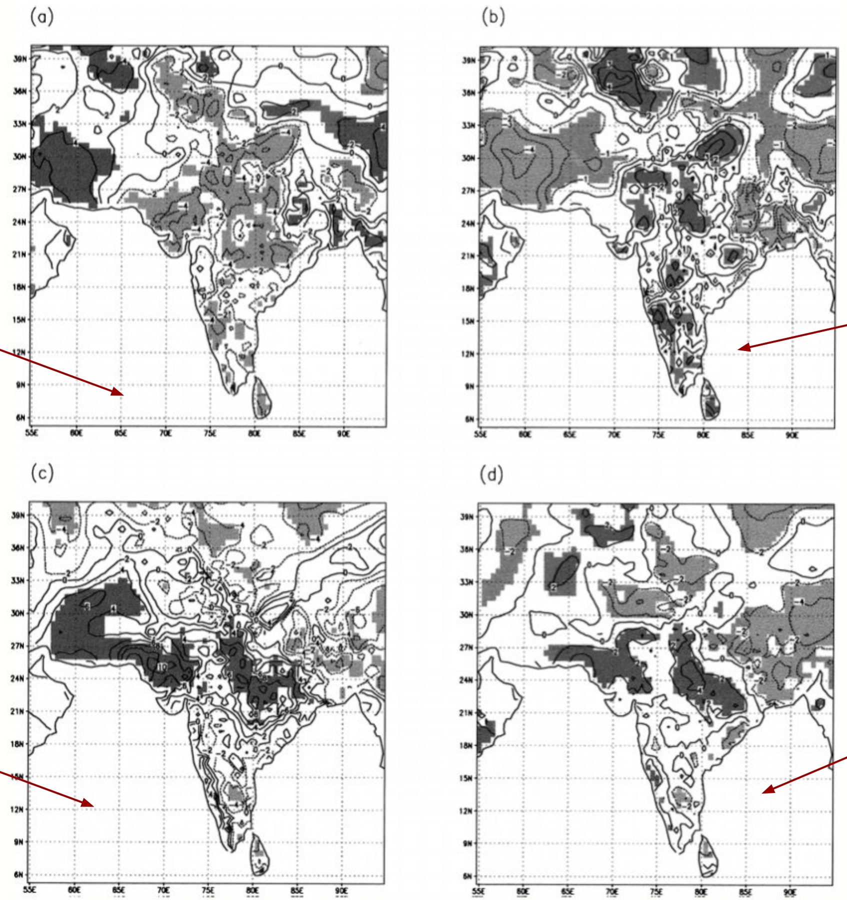

Just El Nino

Pos IOD + El NIno - Pure El Nino

Just Pos IOD

Pos IOD + El NIno

FIG. 2. Composite of the normalized ISMR anomaly distribution over (a) all El Niños between 1958 and 1997; (b) all El Niño years including those with positive IOD events minus that over pure El Niño years; and (c) pure positive IOD years. (d) As in (c) but for all positive IOD years including those that co-occurred with El Niños. Values significant at the 90% confidence level (from a two-tailed Student's *t* test) are shaded; positive (negative) significant values are shaded dark (light).

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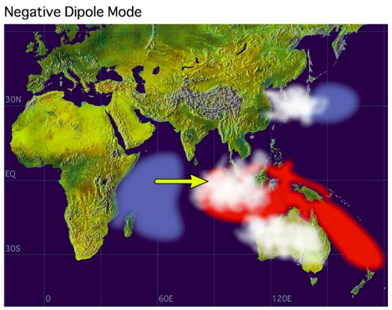
5. How does La Nina impact the effects of negative IOD events on ISMR?

- Negative IOD’s produce drought in the monsoon trough regions
- La Ninas bring surplus rainfall to this region
- Averaged rainfall deficits are reduced



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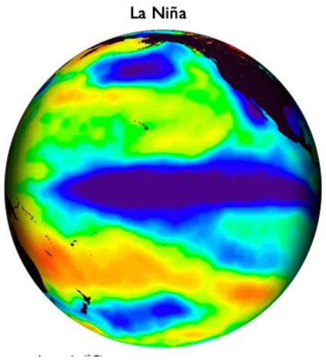

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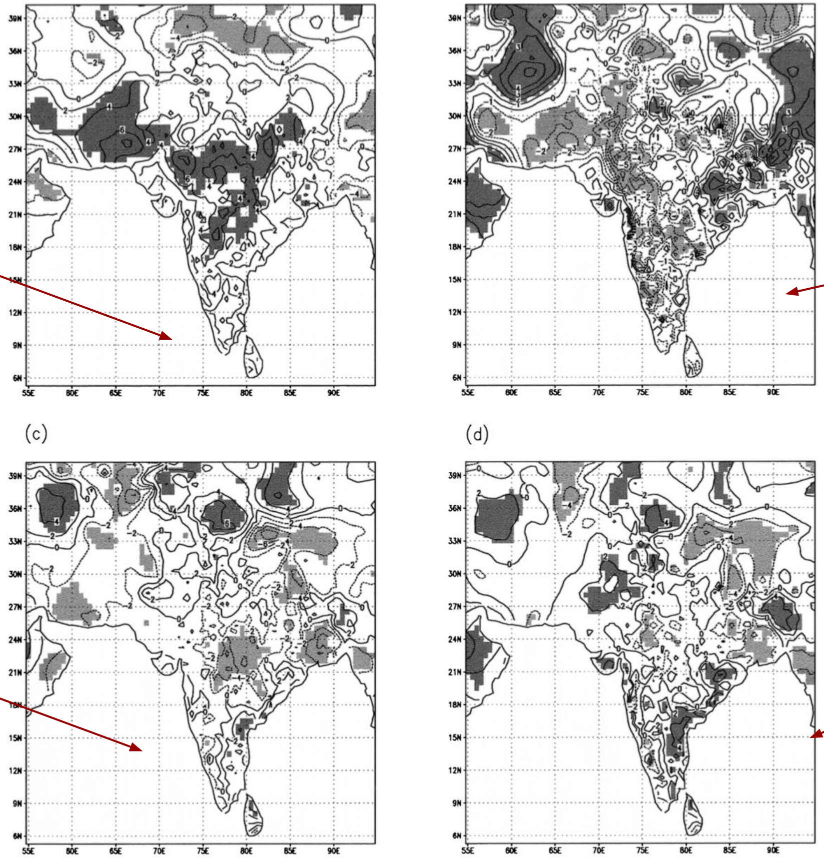
Just La Nina

Neg IOD + La Nina
- Pure La Nina



Just Neg IOD

Neg IOD + La Nina

FIG. 3. Composite of the normalized ISMR anomaly distribution (a) over all La Niñas between 1958 and 1997; (b) over all the La Niña ears including those with negative IOD events minus that over pure La Niñas; and (c) over pure negative IOD years. (d) As in (c) but for ll negative IOD years including those that co-occurred with La Niñas. Values significant at the 90% confidence level (from a two-tailed tudent's *t* test) are shaded; positive (negative) significant values are shaded dark (light).

Ashok et.

6. In summary hc ts of the IOD on ISMR relate to oı edictor of ISMR?

- During the ; MR are opposite to c
- Either way, ı onsoon rainfall than expecte
- “The fact tha ıonsoon relationship r the Indian summer moı
  - QUEORY *along with ENSO variability?*

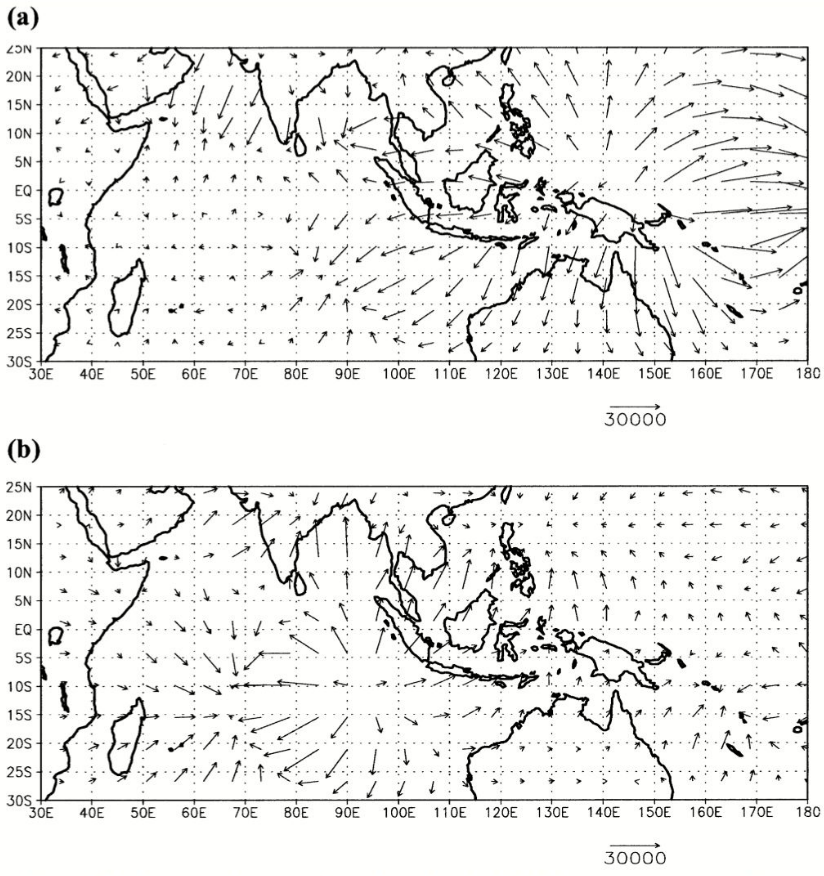


FIG. 8. Vertically integrated moisture flux (to be divided by 10 000; in kg m^{-1} s^{-1}) (a) anomalies as simulated in the ENSO experiment and (b) differences (combined − ENSO).

Nitty Gritty Mechanics from part 2 - Any thoughts?

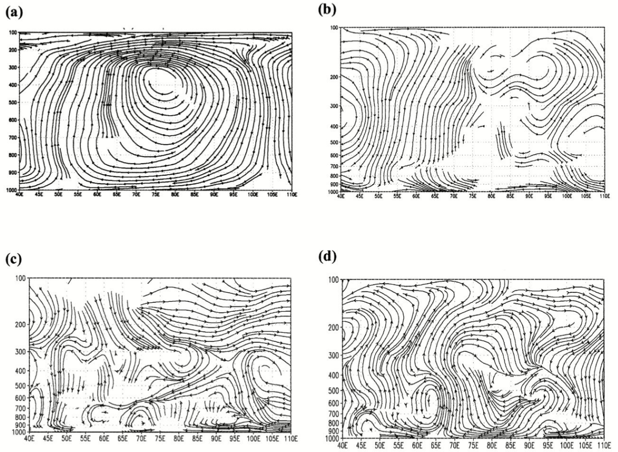


FIG. 9. The anomalous equatorial Walker circulation streamlines during JJAS (averaged over 10°S–5°N), derived from the NCEP nonrotating zonal component of the velocity and the vertical velocity: (a) composited over the pure positive IOD years 1961, 1967, and 1994 and (b) composited over the pure El Niño years 1969, 1987, and 1991. Simulated anomalous equatorial JJAS Walker circulation streamlines (averaged over 10°S–5°N): (c) in the ENSO experiment and (d) differences (combined − ENSO).

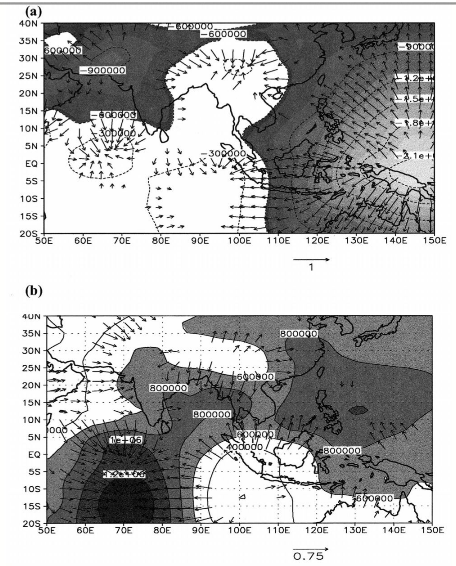


FIG. 7. (a) The 850-hPa JJAS velocity potential anomalies (contours; in $m^2\ s^{-1}$) and divergent winds (vectors; in $m\ s^{-1}$) as simulated in the ENSO experiment; (b) as in (a) but for the differences (combined − ENSO). Only the *significant* divergent wind anomalies (significant at the 90% confidence level from the two-tailed Student's *t* test) are shown at this level. Values less than −60 000 $m^2\ s^{-1}$ in (a) and those less than 60 000 $m^2\ s^{-1}$ in (b) are shaded.

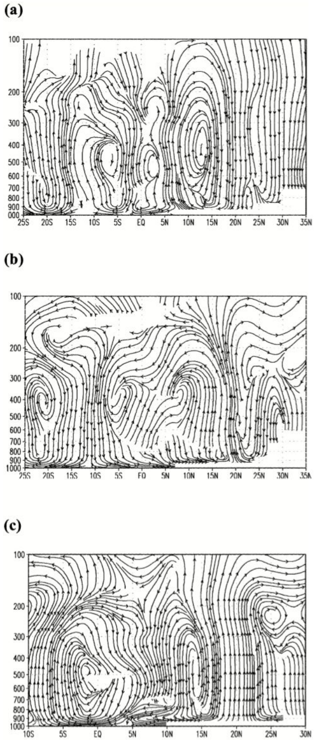


FIG. 10. Anomalous JJAS Hadley circulation streamlines (a) simulated in the ENSO experiment (zonally averaged over 70°–85°E) and (b) differences (combined − ENSO) zonally averaged over 80°–95°E. (c) As in (b) but zonally averaged over 65°–75°E. Orography mask has been applied in all figures.

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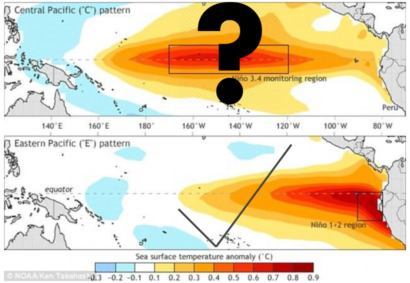
7. Knowing what we do about ENSO variability now – what is something this study may have overlooked? Using what we've learned so far how might we expect changing climate patterns to affect this IOD/ENSO relationship with ISMR?

- All ENSO experiments were carried out using Nino3 variations - how might these effects change considering the dynamics of the Central Pacific El Nino? What about with….. ~ CLIMATE CHANGE? ~



Takahashi et al., 2011

Saji and Yamagata 2003

I am so sorry it was so long just think of how many times I had to read it was really self punishment

Saji and Yamagata 2003

1. What are the two anomalous SST patterns this pattern mentions and which will the paper be discussing? Why do you think this is?

- In one, the SST anomaly over the entire basin is uniformly modulated lagging the El Niño Southern Oscillation (ENSO) (Pan & Oort 1983, Wallace et al. 1998)
- second pattern exhibits anomalous and strong zonal SST gradients in the equatorial regions, phase-locked to the boreal summer and fall

Saji and Yamagata 2003

2. What mechanisms does the paper cite as causes of IOD and how do they differ from East to West?

- Surface winds reverse direction from westerlies to easterlies during the peak phase
- SST is cool in the East and warm in the West
- Zonal SST gradient reversed from normal years
- Sea level anomalously lowered in the East and raised in central and Western Indian ocean during positive IOD events

Saji and Yamagata 2003

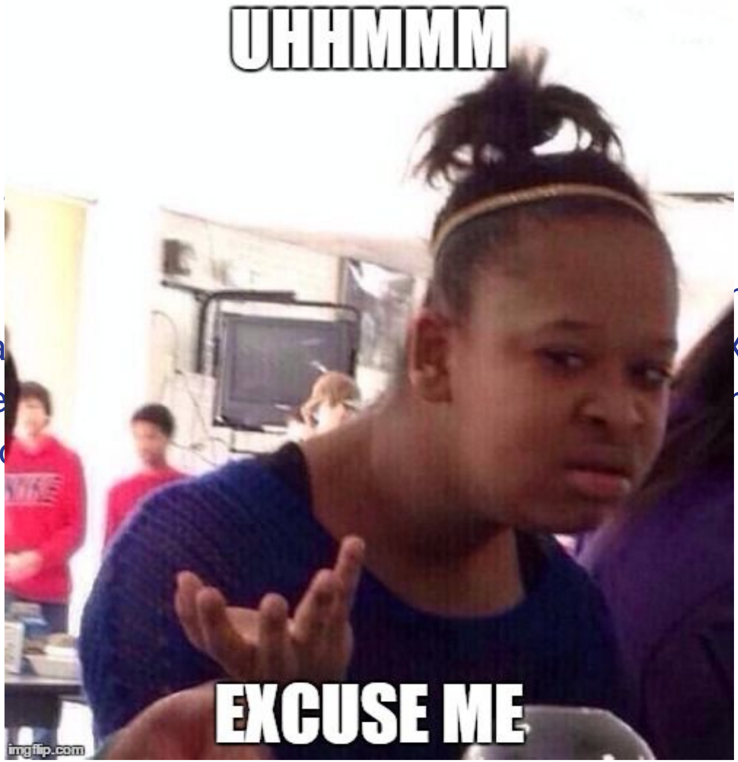
3. What time period does the paper use to compare ENSO events to IOD events? What do the authors conclude?

- 1958 to 1997 (40 years)
  - IOD had peak power in the 1960's and 90's. ENSO had peak in 70's and 80's. (How does this compare to our past papers?)
  - ENSO had broadband spectrum w/ lengthening into 70's & 80's. IOD had 2 "well-separated, elongated and narrow bands."
  - **Inverse relation between ENSO and IOD activity based on decadal time scales**

Saji and Yamagata 2003

4. What is the author’s

- an alternate hypothesis th nteractions inherent to the Indian Ocean.
  - “In this scenario the nted for as mutual interaction, wherein it is specula Kie et al. 2002), that IOD may trigger ENSO at othe re are times when the phenomena are unc



Saji and Yamagata 2003

5. There are a ... ne them

- first assumption ... account in searching for IOI...
  - Second, co ... strong as that in the Pacific.
- IOD and ENSO ... s. In particular we assume that IOD ...

Saji and Yamagata 2003

6. What was the field significance test and what did it yield?

- A Monte Carlo procedure

- Shuffle DMI and Nino 3 time series
- Correlate with rain or temperature field over prescribed region
- Percentage of space time points over 95% local sig is calculated
- Repeat time 10,000, 5% is calculated

Table 2 and 3

Table 2. Association of land temperature over selected regions with DMI and Nino3. p_d (p_n) is the correlation of temperature on DMI (Nino3), partialling the effects of Nino3(DMI); values in parenthesis are correlations using unfiltered data. Season: the season of largest association with DMI. Eq: equator

Region	Season	p_d	p_n
South Africa (15–25° E, 35–20° S)	SON	+0.49 (+0.43)	−0.04 (−0.09)
E Africa (25–45° E, 10° S–Eq.)	JJA	+0.49 (+0.39)	−0.28 (−0.14)
SE Europe (0–15° E, 30–40° N)	JJA	+0.45 (+0.36)	−0.22 (−0.14)
S Iran (55–65° E, 25–35° N)	SON	+0.45 (+0.30)	−0.21 (−0.05)
NE Asia (115–150° E, 39–45° N)	JJA	+0.55 (+0.51)	−0.40 (−0.31)
Papua New Guinea (135–150° E, 10–Eq.)	SON	−0.53 (−0.38)	−0.13 (−0.07)
N Australia (122–136° E, 21–15° S)	JJA	−0.51 (−0.39)	+0.00 (+0.03)
SW Australia (115–150° E, 40–25° S)	SON	+0.58 (+0.51)	−0.19 (−0.08)
North America (72–54° W, 42–53° N)	JAS	+0.57 (+0.34)	−0.71 (−0.54)
South America (70–40° W, 30–10° S)	ASO	+0.73 (+0.67)	−0.26 (−0.22)

Region	Season	p_d	p_n
South Africa (20–30° E, 35–32° S)	SON	−0.50 (−0.30)	+0.30 (+0.20)
Angola (10–20° E, 20° S–10° N)	OND	+0.49 (+0.33)	−0.32 (−0.27)
Gabon (9–12° E, 6° S–2° N)	OND	+0.50 (−0.36)	−0.45 (+0.39)
Djibouti (41–44° E, 11–13° N)	SON	+0.52 (+0.44)	−0.10 (−0.06)
Ethiopia (32–46° E, 3–7° N)	SON	+0.60 (+0.51)	−0.17 (−0.10)
Somalia (41–46° E, 0–5° N)	SON	+0.60 (+0.56)	+0.11 (+0.11)
Uganda (29–35° E, 1° S–4° N)	SON	+0.53 (+0.50)	−0.32 (−0.30)
Democratic Republic of Congo (24–30° E, 10–2° S)	SON	+0.57 (+0.50)	−0.20 (−0.16)
Tanzania (30–40° E, 10–2° S)	SON	+0.67 (+0.64)	−0.02 (+0.03)
N Mozambique (35–40° E, 14–10° S)	SON	+0.42 (+0.31)	−0.02 (+0.04)
S Germany (8–15° E, 46–51° N)	ASO	−0.52 (−0.46)	+0.05 (+0.09)
Hungary (17–23° E, 44–48° N)	SON	−0.44 (−0.38)	+0.13 (+0.16)
Ukraine (24–34° E, 46–52° N)	SON	−0.53 (0.51)	+0.26 (+0.26)
Egypt (29–34° E, 26–31° N)	SON	+0.51 (+0.50)	+0.15 (+0.13)
S Pakistan (65–69° E, 24–27° N)	JAS	+0.46 (+0.40)	−0.46 (−0.43)
NW India (75–80° E, 20–26° N)	OND	+0.53 (+0.33)	−0.12 (+0.02)
Bhutan (89–92° E, 27–28° N)	JJA	−0.53 (−0.32)	+0.09 (−0.09)
Lhasa (89–94° E, 28–30° N)	JJA	−0.47 (−0.33)	+0.05 (+0.03)
S China (105–112° E, 25–29° N)	SON	+0.58 (+0.51)	+0.22 (+0.18)
Sri Lanka (80–82° E, 6–8° N)	SON	+0.49 (+0.48)	+0.14 (+0.16)
S Sumatra (100–106° E, 6° S–Eq.)	JAS	−0.80 (−0.75)	−0.19 (−0.12)
Java (106–115° E, 8.5–6° S)	SON	−0.65 (−0.56)	−0.33 (−0.27)
Kalimantan (110–118° E, 4° S–5° N)	SON	−0.55 (−0.48)	−0.50 (−0.43)
Sulawesi (119–123° E, 6–1° S)	ASO	−0.52 (−0.40)	−0.62 (−0.51)
New Guinea (134–14&1° E, 10–2° S)	JAS	+0.10 (+0.15)	−0.71 (−0.71)
SW Australia (115–130° E, 34–20° S)	JJA	−0.58 (−0.58)	+0.24 (+0.25)
Central America (97–87° W, 14–19° N)	OND	−0.39 (−0.35)	+0.12 (+0.10)
W USA (112–106° W, 35–39° N)	ASO	+0.46 (+0.39)	−0.16 (−0.13)
Quebec (80–74° W, 49–53° N)	JJA	−0.54 (−0.40)	+0.33 (+0.07)
Venezuela (66–63° W, 5–10° N)	ASO	+0.65 (+0.61)	−0.72 (−0.68)
S Brazil (70–50° W, 25–15° S)	ASO	−0.57 (−0.61)	+0.52 (0.55)
Uruguay (57–52° W, 34–31° S)	JJA	+0.55 (0.42)	−0.23 (−0.16)
S Chile (72–70° W, 36–33° S)	ASO	+0.52 (+0.41)	+0.37 (+0.33)
S Argentina (70–66° W, 45–41° S)	JJA	+0.46 (+0.42)	+0.08 (+0.11)

Saji and Yamagata 2003

7. What do the results of table 2 mean in context of past papers? (hint: think ENSO + monsoons)

- The paper suggests that IOD is consistently associated with warm anomalies far from the Indian Ocean during positive events and cool during negative events
- All correlations of IOD with extratropical regions are positive
- If we are warming these regions, can't this influence ENSO events?

Saji and Yamagata 2003

8. How does IOD affect the extratropics, and what could this mean for the region as climate changes?

- IOD is associated with warm temperature anomalies, reduced rainfall and positive height anomalies.

- Positive height anomalies indicate anticyclonic circulation anomalies, which further imply clear skies and enhanced radiation and **thus warmer land surface temperatures**.
    - Tropical divergence anomalies in the southern Indian Ocean can lead to upper level teleconnections (nice) by Rossby Wave propagation, but its not clear how this enhanced radiation will affect the Northern hemisphere.

Saji and Yamagata

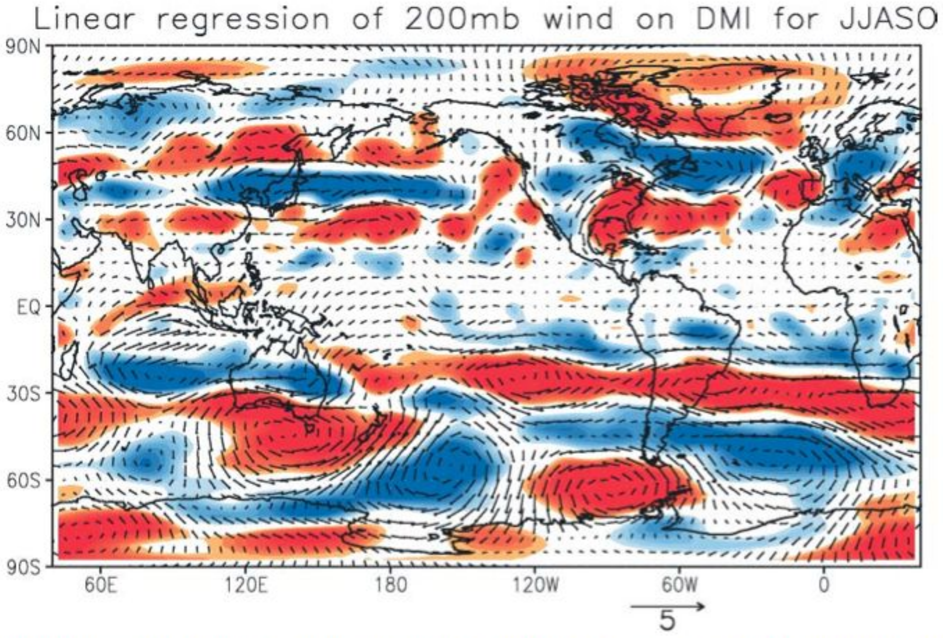


Fig. 20. Partial regression of 200 mb wind anomaly on DMI independent of Nino3 (vectors). Blue (red) shading: negative (positive) curl associated with this wind field

@global climate