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THE IMPACT OF CLIMATE VARIABILITY ON LARGE MARINE ECOSYSTEMS OF THE WESTERN SOUTH ATLANTIC

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Outline

1. Definition of Large Marine ecosystems (LMEs).
2. How climate change can affect LMEs?
3. The Brazilian LMEs and their susceptibility to climate changes.
4. Conclusions.

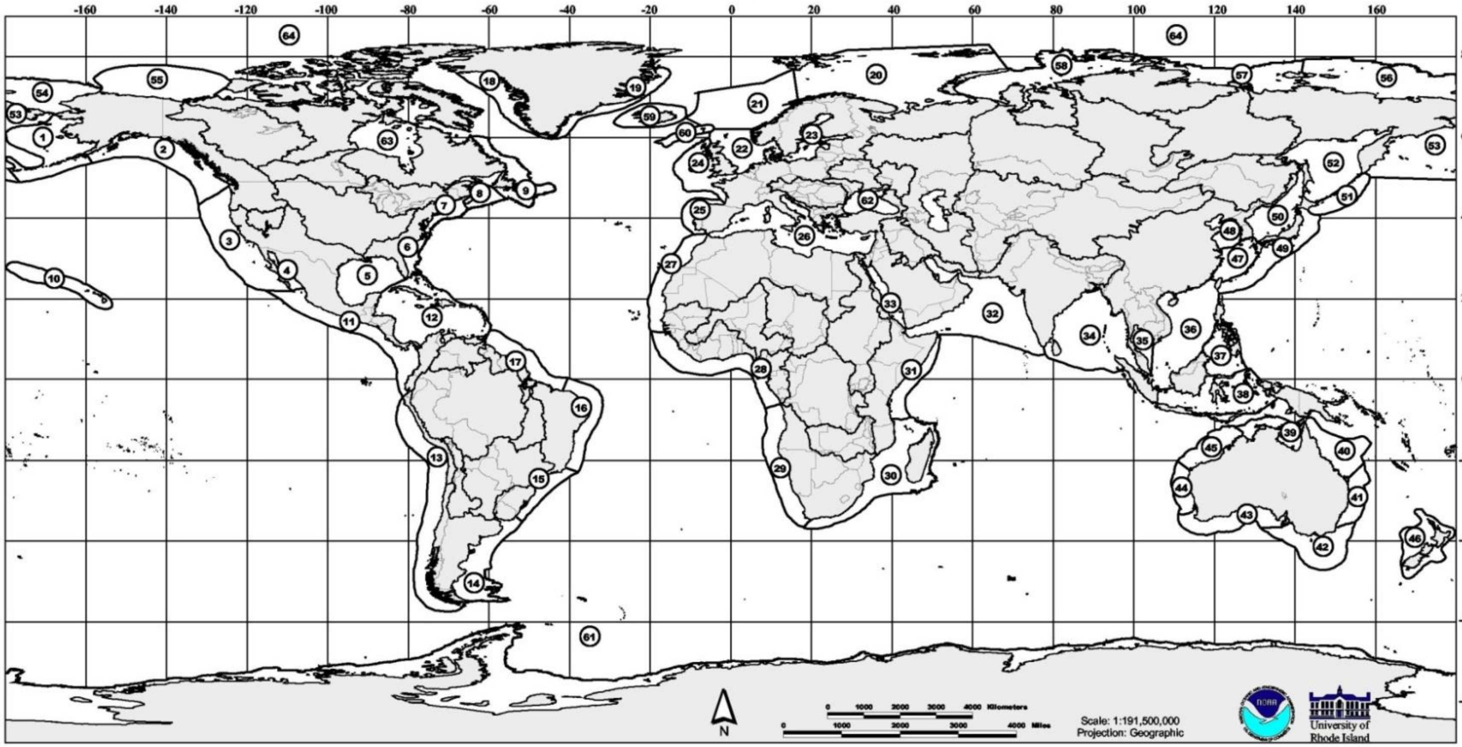
- Large Marine ecosystems are functional units used for environmental assessment and management. They are defined according to four ecological criteria: bathymetry, hydrography, productivity, and trophycally-related populations (Sherman, 1991).

- My view: despite their importance, the response of LMEs to climate changes is unlikely to be controlled by the ecological criteria used to define them.

LMEs: why bother?

- Responsible for 90% of the global fish biomass yield and other living marine resources.
- Critical processes controlling the structure and functioning of biological communities have a strong regional component, such as:
  - ✓Sea surface temperature shifts,
  - ✓Ecosystem connectivity, metapopulation.

Large Marine Ecosystems of the World
with Linked Watersheds



1. East Bering Sea
2. Gulf of Alaska
3. California Current
4. Gulf of California
5. Gulf of Mexico
6. Southeast U.S. Continental Shelf
7. Northeast U.S. Continental Shelf
8. Scotian Shelf
9. Newfoundland-Labrador Shelf
10. Insular Pacific-Hawaiian
11. Pacific Central-American
12. Caribbean Sea
13. Humboldt Current
14. Patagonian Shelf
15. South Brazil Shelf
16. East Brazil Shelf
17. North Brazil Shelf
18. West Greenland Shelf
19. East Greenland Shelf
20. Barents Sea
21. Norwegian Sea
22. North Sea
23. Baltic Sea
24. Celtic-Biscay Shelf
25. Iberian Coastal
26. Mediterranean
27. Canary Current
28. Guinea Current
29. Benguela Current
30. Agulhas Current
31. Somali Coastal Current
32. Arabian Sea
33. Red Sea
34. Bay of Bengal
35. Gulf of Thailand
36. South China Sea
37. Sulu-Celebes Sea
38. Indonesian Sea
39. North Australia
40. Northeast Australia
41. East-Central Australia
42. Southeast Australia
43. Southwest Australia
44. West-Central Australia
45. Northwest Australia
46. New Zealand Shelf
47. East China Sea
48. Yellow Sea
49. Kuroshio Current
50. Sea of Japan
51. Oyashio Current
52. Sea of Okhotsk
53. West Bering Sea
54. Chukchi Sea
55. Beaufort Sea
56. East Siberian Sea
57. Laptev Sea
58. Kara Sea
59. Iceland Shelf
60. Faroe Plateau
61. Antarctic
62. Black Sea
63. Hudson Bay
64. Arctic Ocean

How climate change can affect Large Marine Ecosystems?

Chavez et al., Science (2003). From anchovies to sardine and back: multidecadal change in the Pacific Ocean.

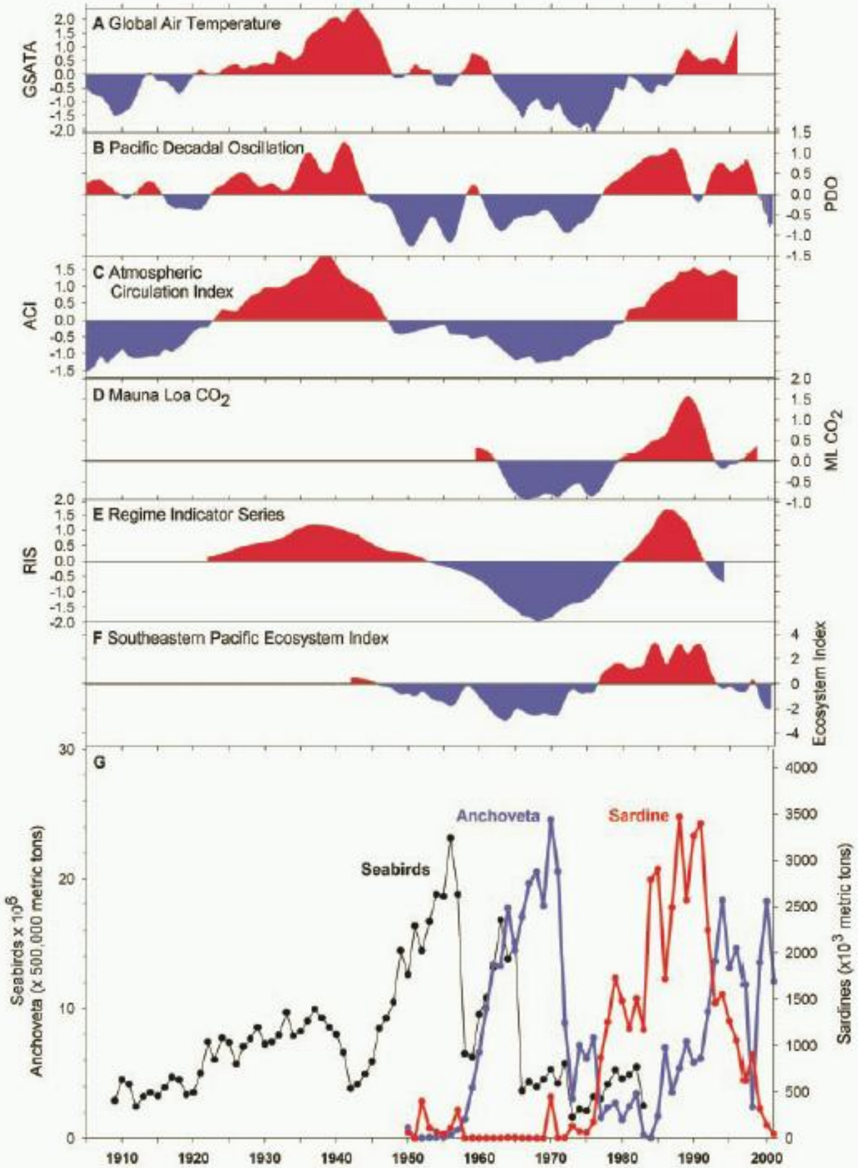


Fig. 1. Anomalies of (**A**) global air temperature, with the long-term increase removed (*8*); (**B**) the Pacific decadal oscillation (PDO) index (°C), derived from principal component analysis of North Pacific SST (*10*); (**C**) the atmospheric circulation index (ACI), which describes the relative dominance of zonal or meridional atmospheric transport in the Atlantic-Eurasian region (*9*); (**D**) atmospheric CO_2 measured at Mauna Loa (parts per million) with the long-term anthropogenic increase removed (*7*); (**E**) the regime indicator series (RIS) that integrates global sardine and anchovy fluctuations (*5*); and (**F**) a southeastern tropical Pacific ecosystem index based (*19*) on (**G**) seabird abundance and anchoveta and sardine landings from Peru. All series have been smoothed with a 3-year running mean.

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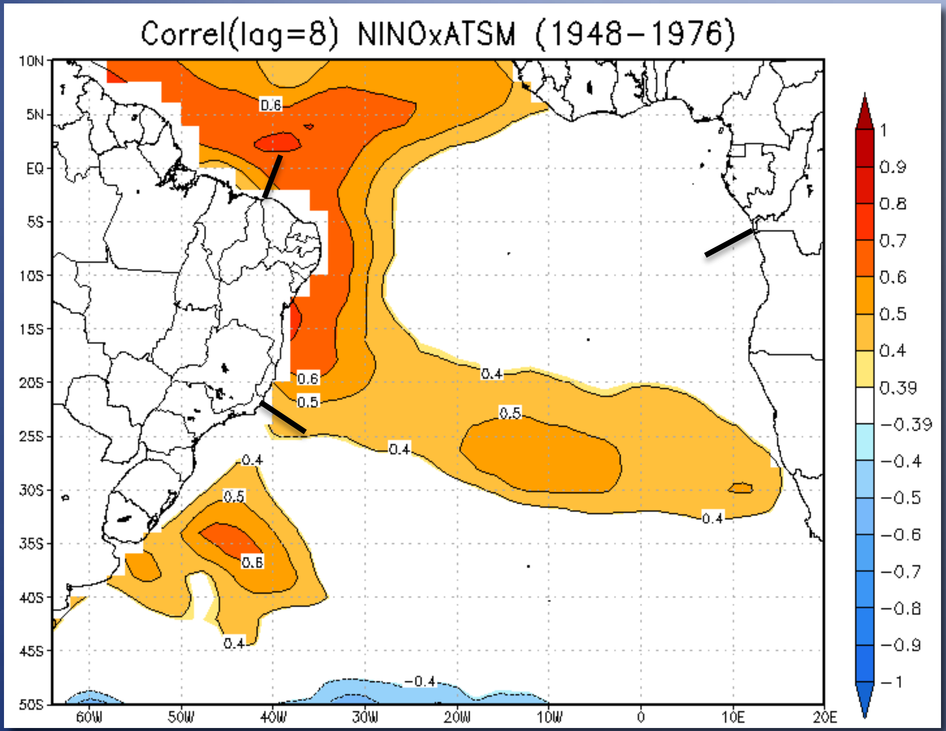
The Brazilian LMEs:

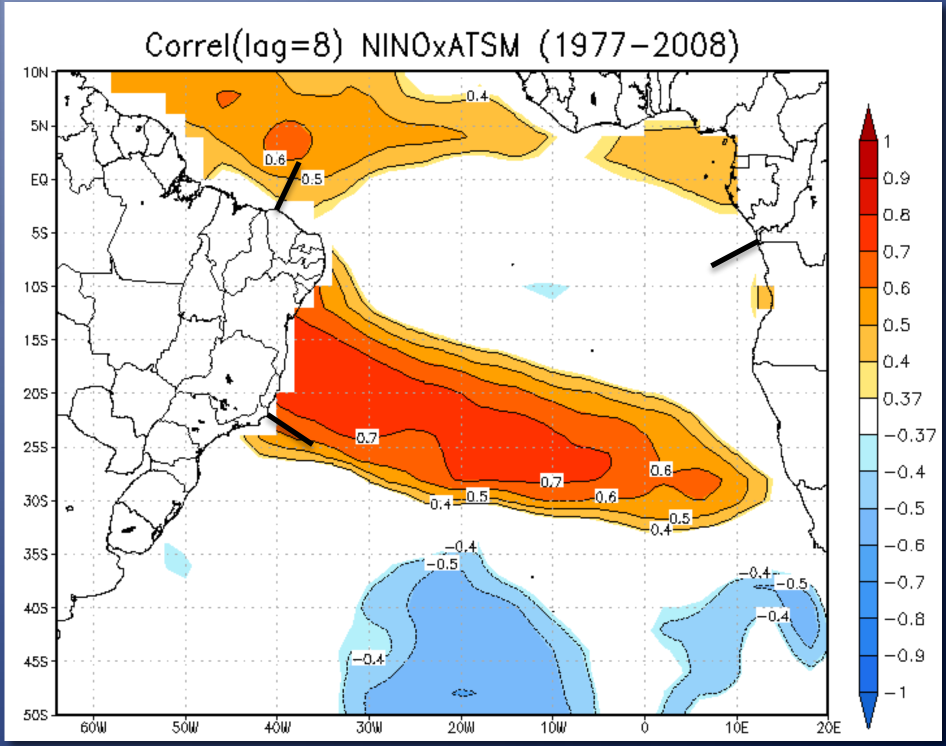
remote forcing *vs.* Atlantic variability

Data and methods

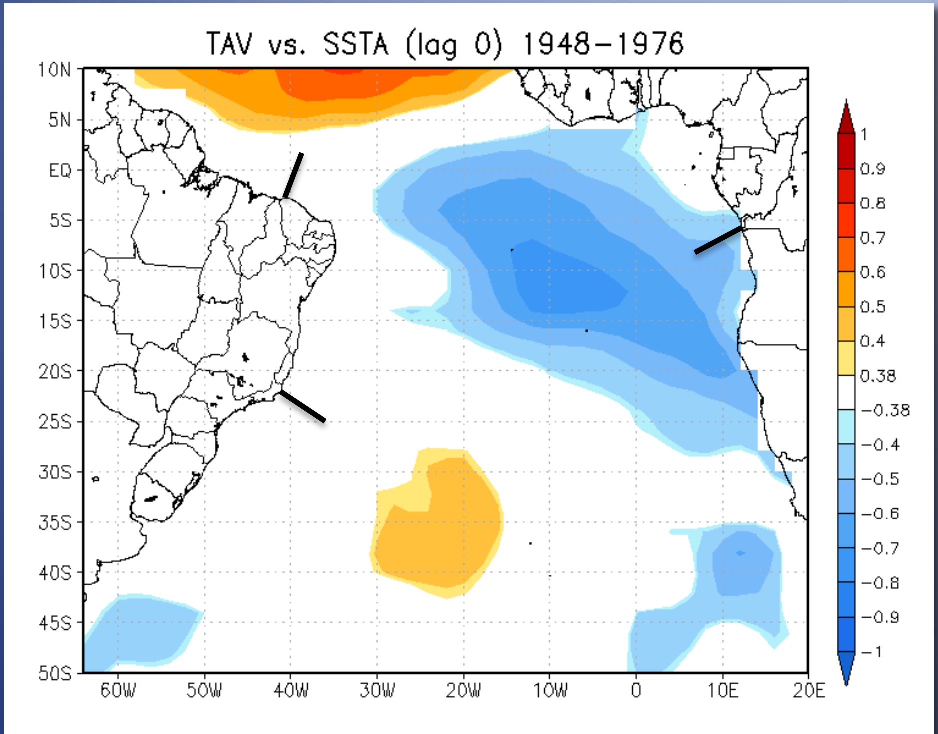
- Climate indices: Niño 3, TNA, TSA - http://www.cdc.noaa.gov/data/climateindices/list/
- SST data: version 3 (reconstructed) SST gridded series, 2° x 2°, from 1948 to 2008 - http://www.cdc.noaa.gov/data/gridded/data.noaa.ersst.html
- Wind stress data, 0.5° x0.5°, from *Simple Ocean Data Assimilation* (SODA) - http://dsrs.atmos.umd.edu/DATA/
- Monthly AAO dataset: from 1979 to 2007 - http://www.cpc.noaa.gov/products/precip/CWlink/daily_ao_index/aao/aao.shtml.
- Detrended, standardized data were Morlet wavelet filtered: 2 to 7 years.
- Correlations are t-tested at 95% confidence.

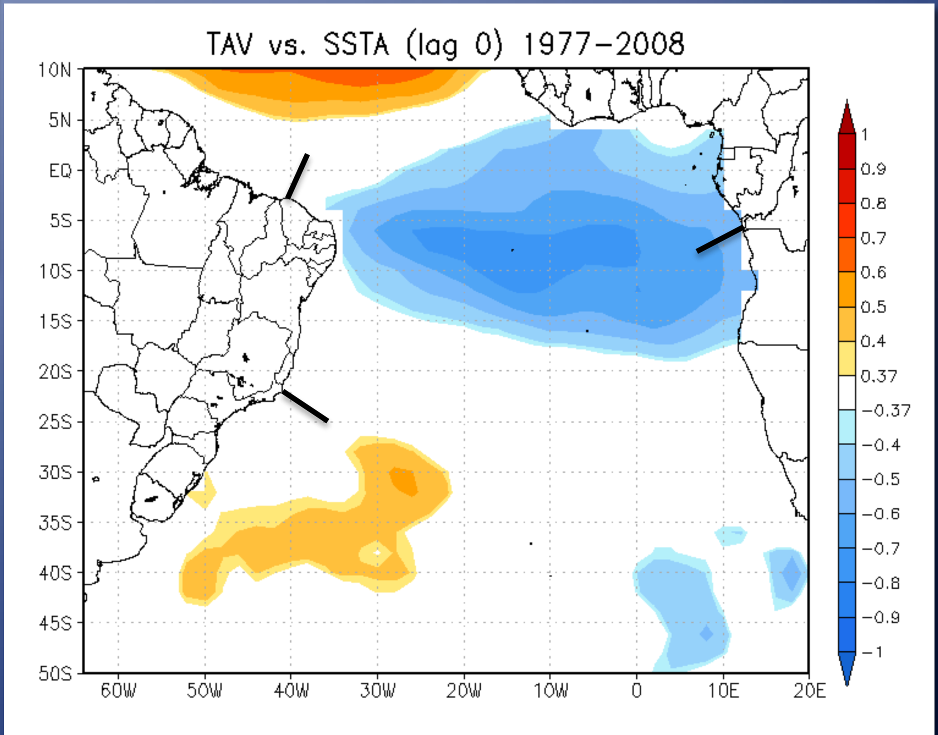
Niño 3 *vs*. SSTA



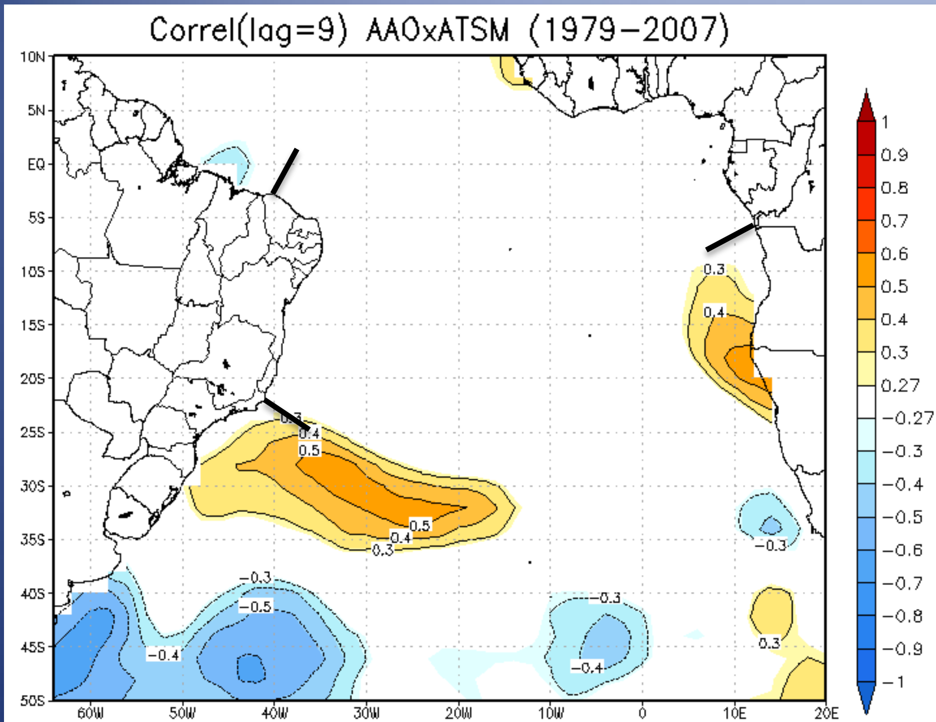


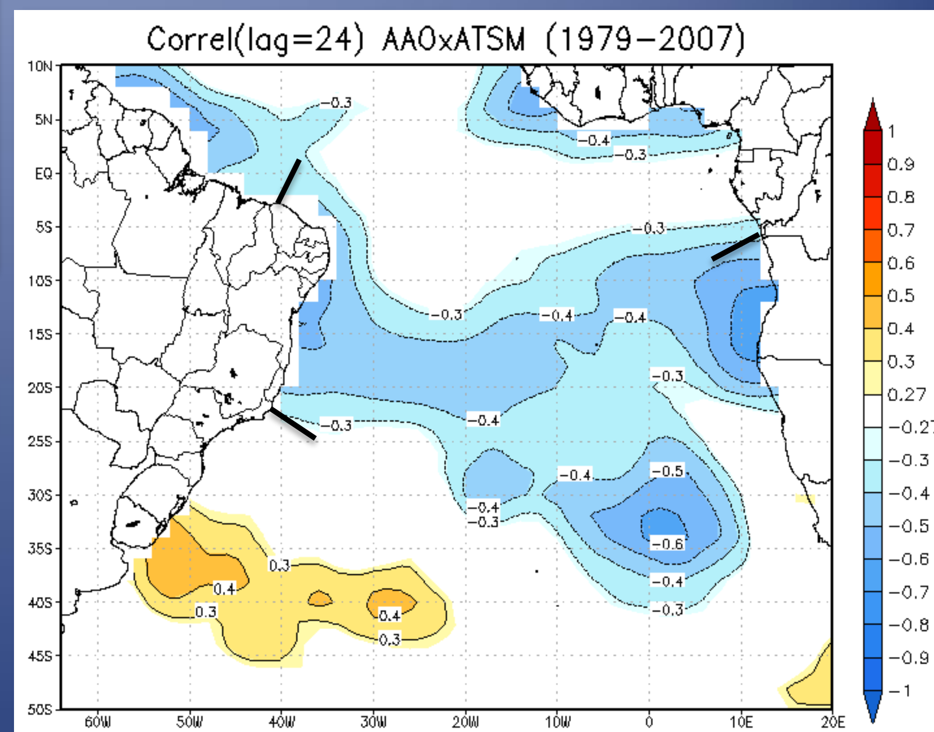
TAV *vs*. SSTA


TAV vs. SSTA (lag 0) 1948–1976
10N
5N
EQ
5S
10S
15S
20S
25S
30S
35S
40S
45S
50S
60W
50W
40W
30W
20W
10W
0
10E
20E
1
0.9
0.8
0.7
0.6
0.5
0.4
0.38
−0.38
−0.4
−0.5
−0.6
−0.7
−0.8
−0.9
−1

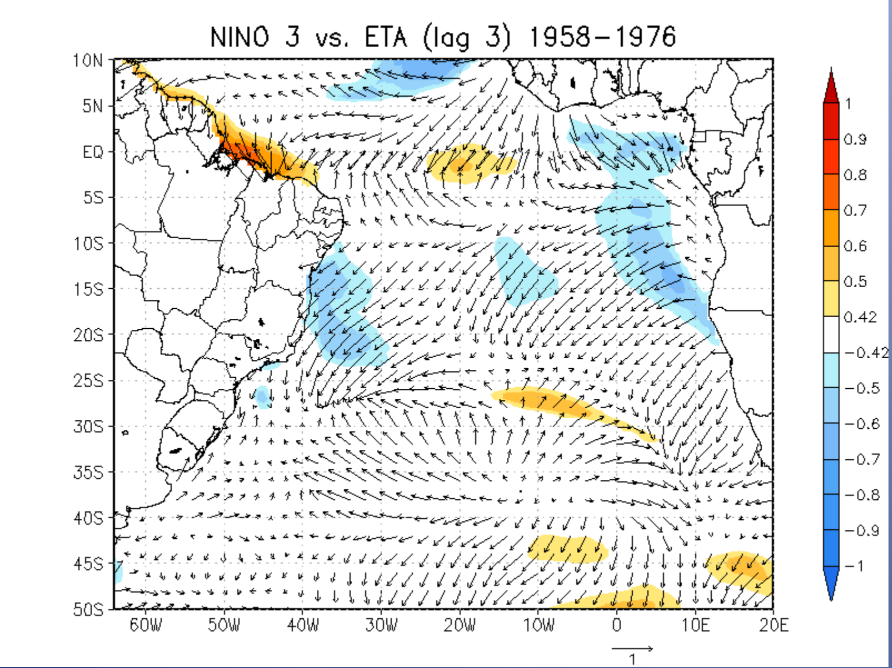

TAV vs. SSTA (lag 0) 1977–2008
10N
5N
EQ
5S
10S
15S
20S
25S
30S
35S
40S
45S
50S
60W
50W
40W
30W
20W
10W
0
10E
20E
1
0.9
0.8
0.7
0.6
0.5
0.4
0.37
−0.37
−0.4
−0.5
−0.6
−0.7
−0.8
−0.9
−1

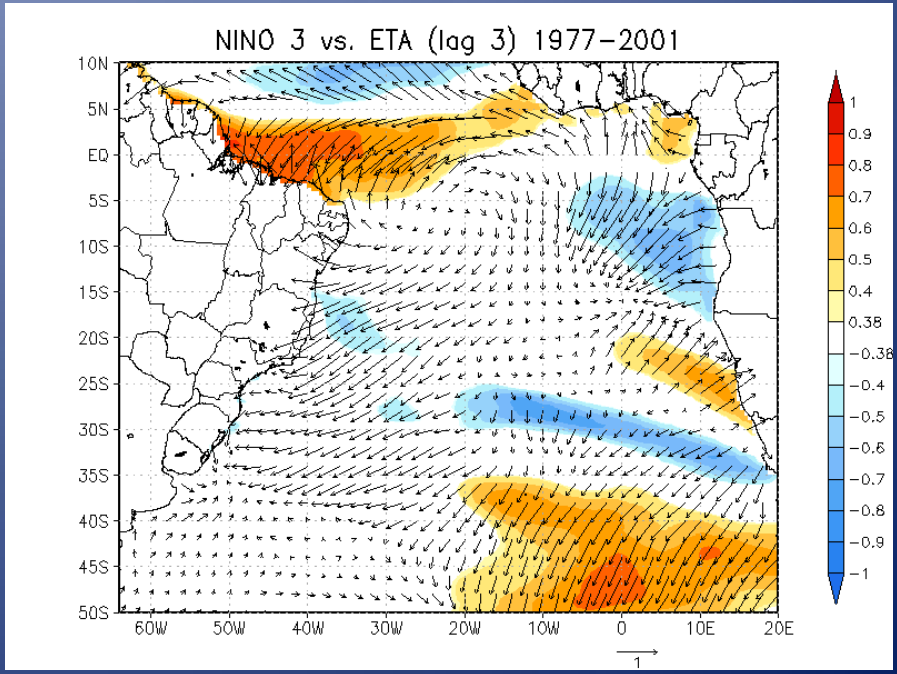
AAO *vs*. SSTA


Correl(lag=9) AAOxATSM (1979–2007)
10N
5N
EQ
5S
10S
15S
20S
25S
30S
35S
40S
45S
50S
60W
50W
40W
30W
20W
10W
0
10E
20E
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.27
−0.27
−0.3
−0.4
−0.5
−0.6
−0.7
−0.8
−0.9
−1

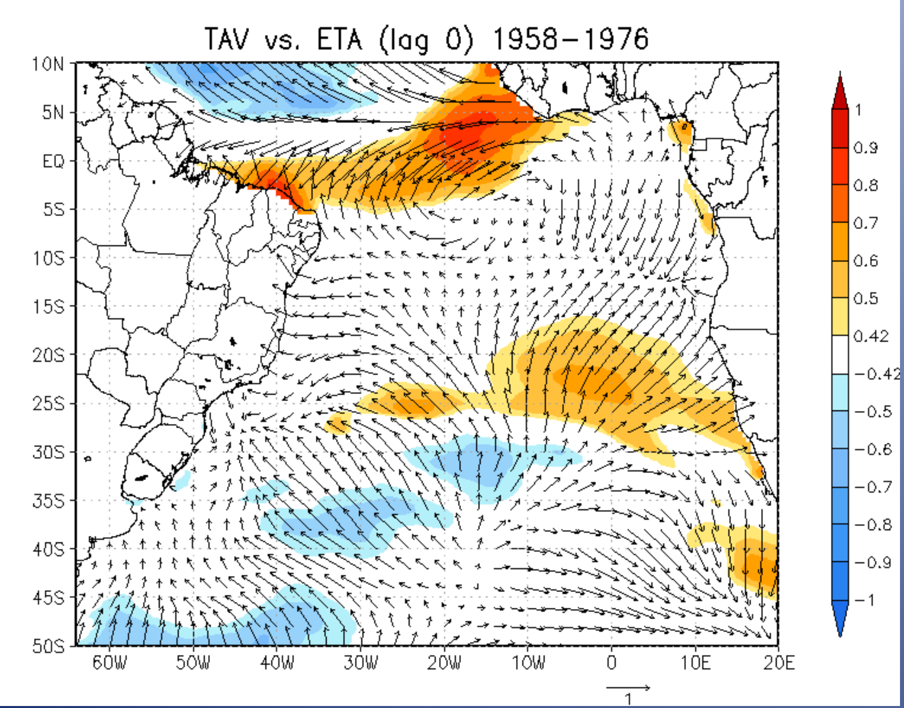

Correl(lag=24) AAOxATSM (1979–2007)
10N
5N
EQ
5S
10S
15S
20S
25S
30S
35S
40S
45S
50S
60W
50W
40W
30W
20W
10W
0
10E
20E
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.27
−0.27
−0.3
−0.4
−0.5
−0.6
−0.7
−0.8
−0.9
−1

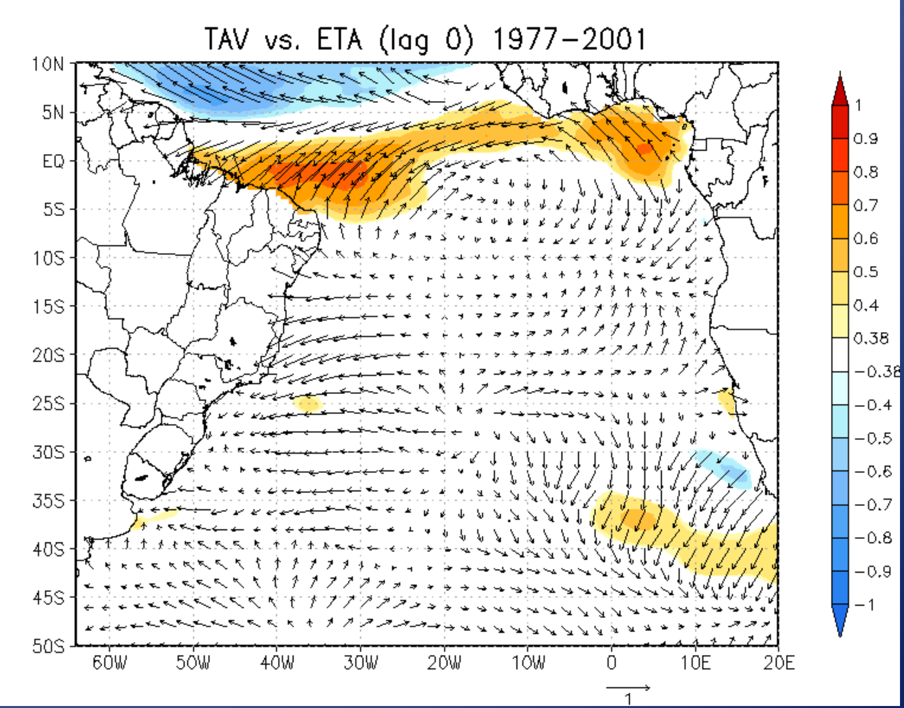
Niño 3 *vs*. Ekman transp anomaly





TAV *vs*. Ekman transp. anomaly





Conclusions

- **Spatial and temporal (decadal) shifts in the susceptibility of the Brazilian LMEs to climate change are significant.**
- **There is a mismatch between NB and EB LME areas and the actual influence of remote and regional forcings.**
- **The time lags observed for the AAO *vs*. SSTA correlations show evidences of relevant temporal evolution of its influence on the Brazilian LMEs.**

Conclusions

- **TAV influence on ETA is more restricted to the NB LME, compared to Niño3.**
- **As far as climate change is concerned, the use of LMEs in Brazil for ecosystem-based management has to be conducted with caution.**
- **The world distribution of LMEs may need to be revisited.**

Thank you!