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Editorial article

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Anomalies Of Isobaric Fields In The Southwestern Indian Ocean During El Nino Climatic Events

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Abstract
The el Nino climate event has produced upheavals in the global climate. Among many others is the prolonged drought in the Sahel. In fact, these upheavals are the direct consequences of changes in the centers of action. Therefore, we are interested in knowing their configuration in the South-West Indian Ocean basin, SWOI, both on the ground and at altitude during the two seasons, summer and winter in the southern hemisphere. It has been observed that there are negative pressure anomalies in the western part of the SWOI and positive ones in its eastern part; moreover the geopotential levels 700hPa and 500hPa include positive anomalies in the north and negative anomalies in the south. These mid-altitude results continue at high altitude, with the tropopause experiencing low anomalies on the equator side and high anomalies on the south pole side. As a result on the other hand, the southern winter experiences more moisture than normal. The significance of the images showing isobaric field anomalies was tested by the Student t-test.

Keywords: Anomalies; El Nino; Isobaric Situations; Southwest Indian Ocean; Weather

Introduction
The changing weather in the southern winter is witnessed by the Malagasy saying, "tsy mena mivadika toy ny andro ririnina", literally "someone who is not ashamed to change to a promise is like winter weather". This shifting situation is determined by the mobility of the action centers. Indeed, the sequences of weather types, statistically frequent on a monthly, seasonal and annual scale, determine the climate of a given place. If el Nino climatic events are held among those responsible for the current climate upheaval, we will ask ourselves about the synoptic situations they generate on the ground and at altitude during the two seasons: austral summer, from October to April, and austral winter, from April to October in the Southwest Indian Ocean or SWOI. The repetition of the situations of these two periods of the year represents the summer and winter conditions. Thus, we want to know to what extent el Nino climatic events affect the seasonal trends of the isobaric situations based on the anomalies with respect to the climatological mean, from 1981-2010. The SWOI is considered a zone located between latitudes 20°N-50°S and longitudes 20°E-100°E. The objective of this paper is to know the anomalies of the pressure fields both on the ground and in altitude of the two seasons summer and winter during the el Nino events. Moreover, the SWOI is exposed to the trade winds and is the cradle of tropical cyclone tracks during the austral summer. This article also seeks to explain, on a smaller scale, the El Nino events in Madagascar.

Method
If the major El Nino events have been recorded since 1790, those considered in this research began in 1968 because of the limitation to 20 years of the number of possible years to compose in the logiciel. These are the periods 1968-1970, 1972-1973, 1982-1983, 1997-1998, 2002-2007, 2009-2010, 2014-2016.

By choosing the composite anomaly method to know the anomalies undergone by the pressures both on the ground and at different levels of the atmosphere, we expect to know the synoptic situations corresponding to the frequent and dominant types of weather for the two seasons. The levels at which the pressure is observed are the surface taken at sea level or SLP, the geopotential level 700 hPa because of the stability of the pressure at this level and its interest in estimating or predicting the atmospheric circulations of the lower layers. Then the geopotential level 500 hPa chosen for its stability too: the change that could affect this level is due to advection and moreover at this level, the atmosphere is barotropic. And finally, the observation of the 200 hPa pressure, considered the mean level of the tropopause.

In order to process the selected information on the parameters taken into account, we used the software from the www.cdc.noaa.gov/ncep.ncar Reanalysis website. According to this site, the data are processed by Perl script which reads the inserted data. The software tests the data and then does the processing in fortran code to have composite files, in netCDF. Then these files are processed by scriptGrADS version 2.0.2. It has been written in this site that "The GrADS script is executed as a batch job. The plotting options are entered into the GrADS script. The plot in the frame buffer is converted to a gif and this gif is displayed as part of an html document. The netCDF file and the gif file are kept in a directory where the files are periodically deleted". To test the significance of the composite images, the Student's t-test was chosen by comparing the mean of the numerical values of the anomalies for each El Nino year to the mean fields of the composite anomalies.

Results

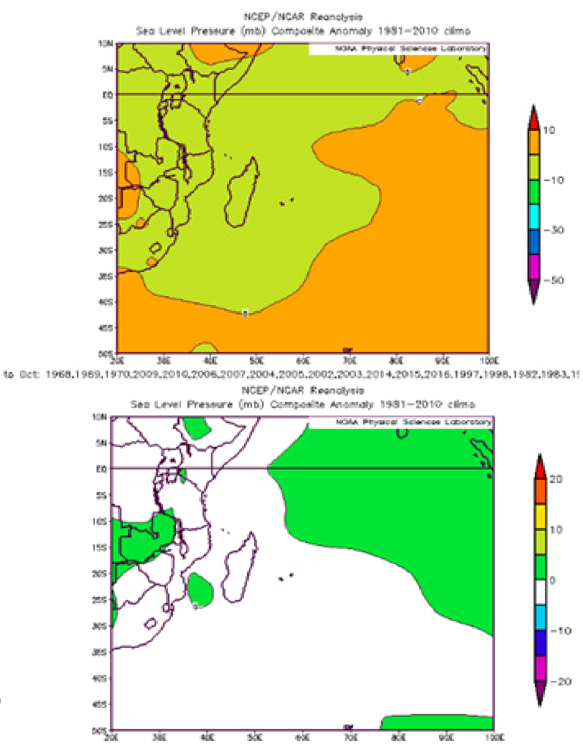
Opposition of East-West sea level pressure field anomalies

The SWOI is divided into two subsets, as far as pressure anomalies are concerned. The western part with lower pressure compared to the eastern part. According to Figure 1, the isobaric figures show negative anomalies in the western part of the SWOI and positive anomalies in the eastern part for both seasons, and the anomalies are more accentuated in winter than in summer. Fig.1a and Fig.b
The decrease in pressure means that evaporation is active especially in summer, and the positive anomaly in the eastern part including the frequent position of the High Pressure of the Indian Ocean (HPOI) implies a pressure increase in its center. And consequently a stronger wind during the southern winter.

Figure 1: Sea level pressure anomalies: (a) in winter and (b) in summer

(a)

(b)



Significance test of the composite fields: t calculated=0.015; ddl=278; p-value=1.645 for α=0.05

Values from 0 to -10 hPa in winter and from 0 to -5 hPa in summer were observed in the western part and from 0 to +10 hPa in winter and from 0 to +5 hPa in summer in the eastern part.

This diagram also shows that there is an opposition between the western and eastern Indian Ocean during the El Nino periods.

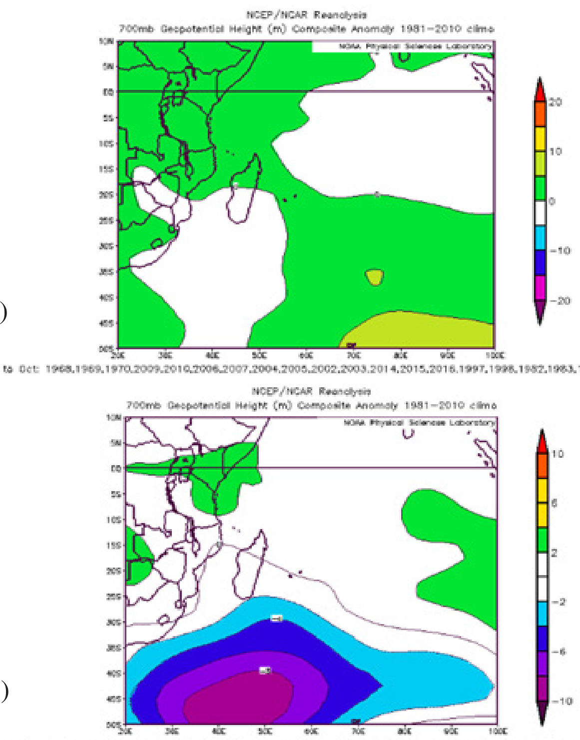
Atmosphere warm in all seasons, with strong air lift

According to Fig.2 the whole atmosphere of the SWOI shows a warm atmosphere. At 700hPa, a NW-SE axis with positive anomalies is observed in winter, Fig.2a, and on either side of this axis, there are negative anomalies. Like the communicating muds, the lower geopotentials associated with colder and higher density air masses feed the higher geopotentials with lower density. In other words, along the axis corresponds a low pressure corridor.

Figure 2: Geopotential level anomalies 700hPa : (a) in winter and (b) in summer

(a)

(b)



Significance test of the composite fields: t calculated=0.015; ddl=278; p-value=1.645 for α=0.05

In summer Fig.2b, positive anomalies are observed in the northern half of the SWOI, indicating warm air and water vapor richness. The southern half with low geopotential, cold air is a zone of air divergence. Also there is north-south opposition in terms of air uplift and subsequently the spatial distribution of rainfall. It can be seen from this Fig.2b that during the El Nino period, the south of Madagascar experiences subsidence and fresh air mass influx, which is the origin of drought.

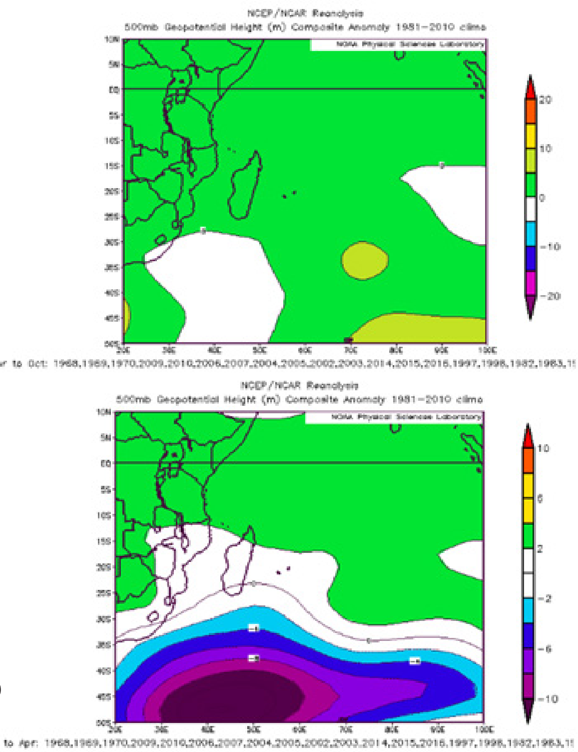
Extension in altitude 500 hPa of the situations in 700 hPa

This is an extension of the situation at 700hPa, but the difference lies, in the winter season, in the fact that the zone where the axis with positive anomalies passes has widened, thus the part with high geopotentials takes an important place dominating almost the whole SWOI. Taking together Fig.1b and Fig.3b, it can be argued that globally, the southwestern part of the SWOI would experience less cyclonic disturbances during the El Nino periods.

Figure 3: Anomalies of the 500hPa geopotential level: (a) in winter and (b) in summer

(a)

(b)



Significance test of the composite fields: t calculated=0.015; ddl=278; p-value=1.645 for α=0.05

This south-western part of the SWOI is at low geopotential and the rest at high geopotential. Thus rainfall of thermo-convective origin develops in the latter. Cyclones born in the central Indian Ocean would only pass through this part of the Indian Ocean. The main reason is that the positive anomalies of the 500hPa geopotential that would guide the movements of these perturbations are located in the north.

Nevertheless, disturbances may occur in the transition zone between low and high geopotentials, as in the northern part of the Mozambique Channel, such as the rare depressions that occur around the latitude of Cape St. André in Madagascar or in the northeast of the Mascarene Islands.

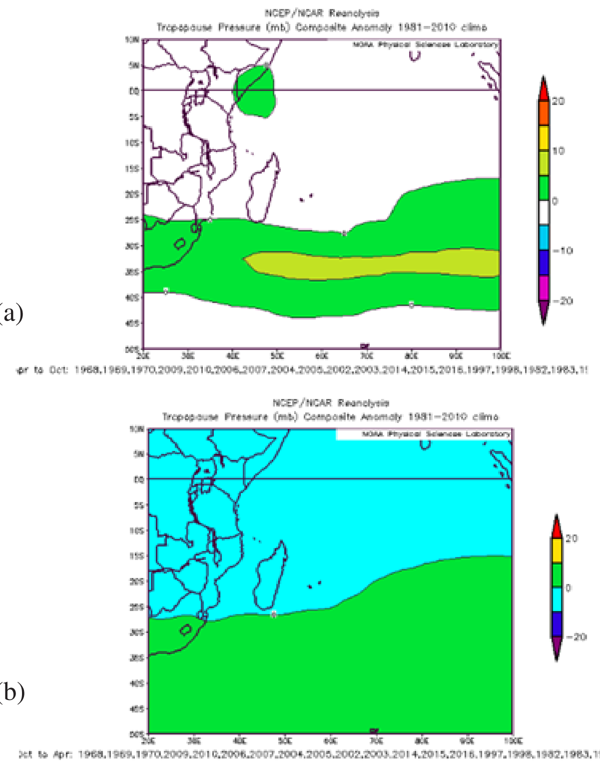
Low anomalies of the tropopause on the equator side and high anomalies on the south pole side

According to Fig. 4, low tropopause anomalies are observed in the north or on the Equator side and high anomalies in the southern part of the SWOI. These anomalies are more significant in southern summer (0 to -10 hPa) (Fig.4a) than in winter (0 to -5 hPa) (Fig.4b).

Figure 4: Pressure anomalies of the tropopause: (a) in winter and (b) in summer

(a)

(b)



Significance test of the composite fields: t calculated=0.015; ddl=278; p-value=1.645 for α=0.05

Discussion

By proceeding to obtain maps of isobaric anomalies at the SWOI scale, the results displayed could not individualize the anomalies at the action centers but the pressure field anomalies. However, these maps, taken at sea level up to the tropopause, reflect all the parameters involved in the characterizations of the weather and further away from seasonal climates during the el Nino periods. The results clearly showed the influence of el Nino climatic episodes on the pressure fields on the ground and at altitude and during the two hot and humid and, cool and dry seasons of the SWOI basin.

Negative sea level pressure anomalies in the western part of the SWOI favour strong evaporation that can cause shallow convection in the southern part of the SWOI and deep convection in its northern part. Moreover, we would see the strength of the southeasterly trade winds carrying an air mass rich in moisture. We note that the more southern parts are experiencing drought due to subsidence. These results at the synoptic scale may be inhibited at smaller scales depending on local conditions, such as topography or sea currents.

The first result extends over the entire Indian Ocean basin following the DOI oscillation or the Indian Ocean dipole thus opposing the eastern part with positive pressure anomaly from the western part with negative anomaly. is generalized during the southern winter, reflecting the strength of the trade winds blowing from the African coast to the Brazilian coast.

As an extension of the sea level pressure anomalies, the 700hPa and 500hPa upper air situations indicate a wetter winter during the southern winter and a less humid southern summer in the south and wetter in the northern part of the SWOI. Low tropopause anomalies in the north or on the Equator side mean a higher temperature on the ground and also strong cyclonic activity or disturbances in this part of the SWOI. The negative anomaly situation for both seasons can be explained by the warming of the atmosphere which is more pronounced in summer. In conclusion, the results showed the manifestation of el Nino climatic episodes in the SWOI basin: there is an east-west opposition of sea level pressure in all seasons: the east experiences stronger pressures than the west. In addition, the northern part of the SWOI experiences much more disturbances than the south during the austral summer but the austral winter is wetter. As a consequence, the places where the relief is a barrier to the trade winds receive a lot of rain, reinforcing the lift of the air mass [1-9].

Acknowledgement

I would like to thank the American website www.cdc.noaa.gov/composite for the composite images: "Monthly composite anomaly". Without this site, we know nothing, at this synoptic scale, about the modifications brought by el Nino climatic events on the SWOI pressure fields.

References

1. DURAND-DASTES F (2004) A propos des notions de type de temps et de type de circulation. Norois, 191: 29-32
2. DONQUE G (1971) Contribution géographique à l'étude du climat de Madagascar. Thèse d'Etat Imprimerie nationale
3. GODART A (2009) Les précipitations orographiques organisées en bandes dans la région Cévennes-Vivarais. Caractérisation et contribution au régime pluviométrique, Thèse Océan, Atmosphère, Hydrologie Université Joseph Fourier-Grenoble1 312p + Annexe
4. JULIAN P R, CHERVIN R M (1978) A study of the Southern oscillation phenomenon. Monthly Weather review, 106: 1433-1451
5. MAHERAS P. et al, (2017) Evolution des méthodes d'analyse des types de temps et des types de circulation en Grèce Durant les 60 dernières années. In BSGLg, 2017, pp109-118.
6. PIRIOU J-M (2005) Représentation de la convection dans les modèles globaux et régionaux: concepts, équations, études de cas. Thèse Météorologie, prévision numérique Université Toulouse III-Paul Sabatier 246.
7. QUENEY P (1936) Recherches relatives à l'influence du relief sur les éléments météorologiques. La Météorologie : 334-353 et 456-470.
8. SHANG-PING XIE, ANNAMALAI H, SCHOTT F A, McCREARY JR J P (2002) Structure and mechanisms of south Indian ocean climate variability in Journal of climate 15: 864-878.
9. SHINODA T, HAN W (2005) Influence of the Indian Ocean dipole on atmospheric subseasonal variability. *J. Climate* 18: 3891-3909.