Impact of intraseasonal waves on Angolan warm and cold events

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HELMHOLTZ
RESEARCH FOR GRAND CHALLENGES

BANINO Spaces II

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Motivations

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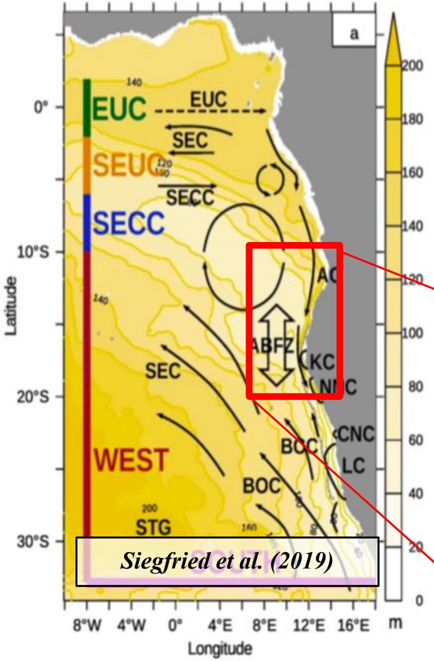
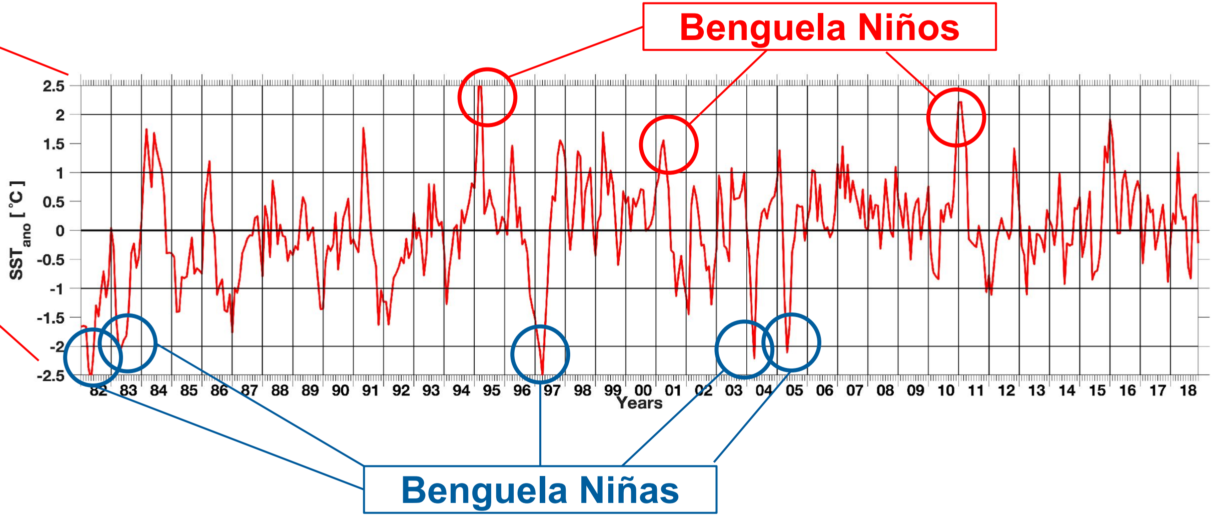


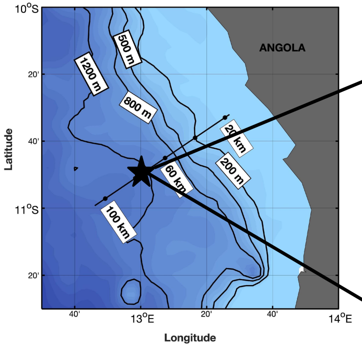
✔ **The Angola current (AC)** flows southward establishing the connection between the equatorial Atlantic and the Benguela upwelling System.

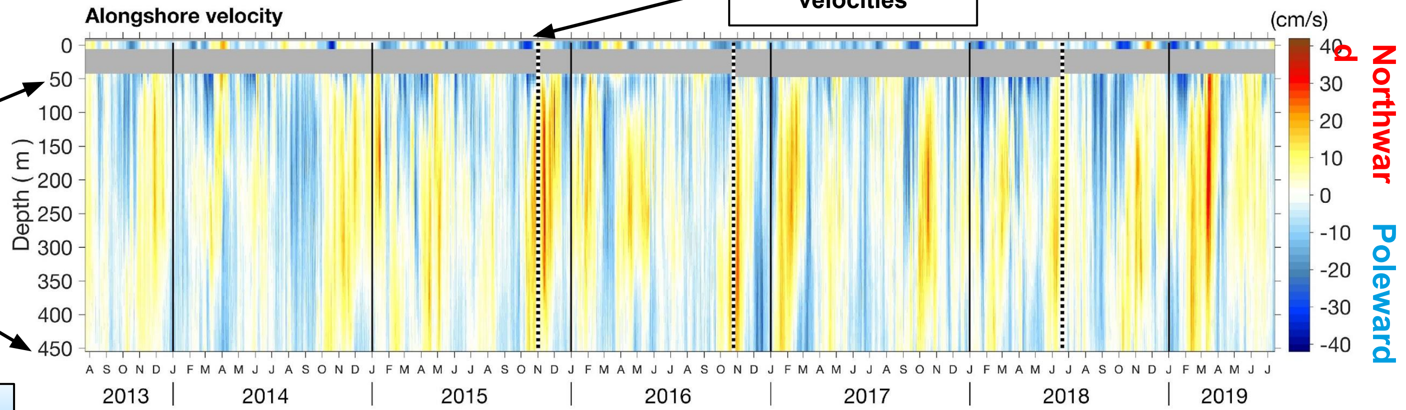
What drives the SST variability?

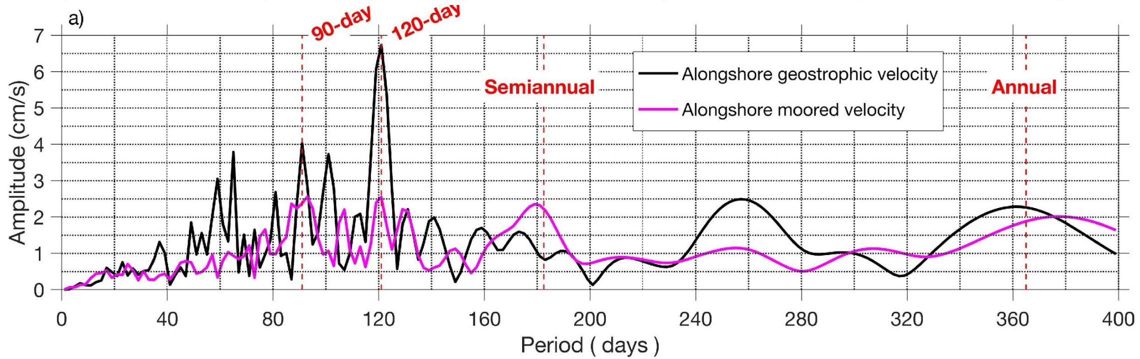
- **Local forcing (alongshore wind, heat and freshwater fluxes)**
- **Remote equatorial forcing (EKWs ➡ CTWs)**



Observed variability in the alongshore velocities at 11˚S (July 2013-July 2019)







Strong intraseasonal to seasonal variability in the Moored velocities at 11˚S.

The amplitudes at **90 and 120-day periods** for the moored velocities are the largest.

Data & Methods

Data

- ❖ Mooring records (July 2013 - July 2019).
- ❖ Aviso sea level anomaly ($\frac{1}{4}^{\circ}$ horizontal resolution, daily, from 1993 - 2019).
- ❖ Optimum Interpolation sea surface temperature Version 2 (OI-SSTv2, $\frac{1}{4}^{\circ}$ horizontal resolution, daily, from 1982 - 2018).

Methods

- Hilbert Empirical Orthogonal Functions (HEOF).
- Harmonic analyses
- Ueg = [- $\frac{g}{\beta}$. $\partial_{yy}ADT$] for the zonal equatorial geostrophic currents (1˚S - 1˚N) calculated using **A**bsolute **D**ynamic **T**opography.

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Resonant condition

$$T_{m,n} = \frac{4L}{mC_n}$$

- **T** is the resonant period
- **L** is the basin width ($5.8*10^6$ m)
- **m** represents the rank of the equatorial basin mode (for instance m = 1 is the gravest basin mode (maximum sea level variability at the boundaries).
- C_n is the gravity phase speed of the n^th baroclinic mode (Fu, 2007; Han et al., 2011; *Brandt et al., 2016;* Kopte et al., 2018; Imbol Koungue et al., 2021).

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Key questions

What is the origin of the intraseasonal variability (90-day and 120-day periods) in the alongshore moored velocities at 11˚S?

Do these intraseasonal waves have an impact on the sea surface temperature in the Angolan upwelling system?

Representation of the 90-day and 120-day harmonics of the alongshore velocities at 11˚S (2013-2019)

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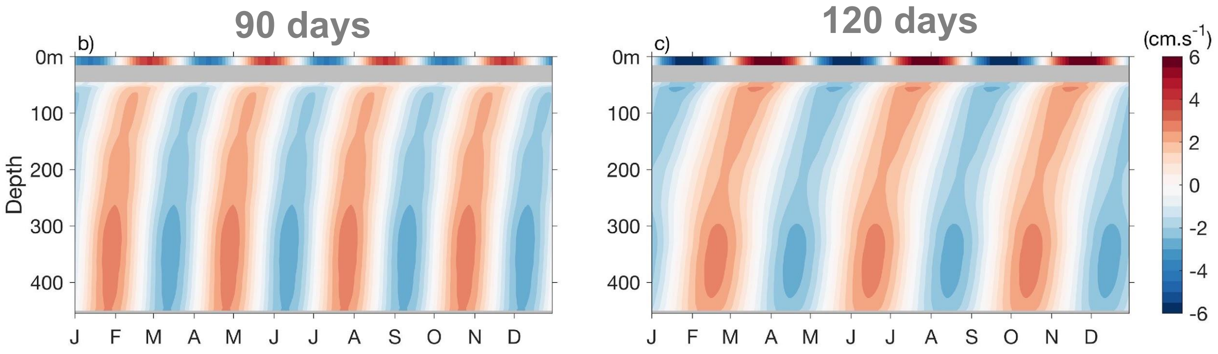

- **Low vertical baroclinic** structure
- Baroclinicity is **more pronounced** in the 120-day harmonic compared to the 90-day one.

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Representation of the 90-day and 120-day harmonics of the alongshore velocities at 11˚S (2013-2019)

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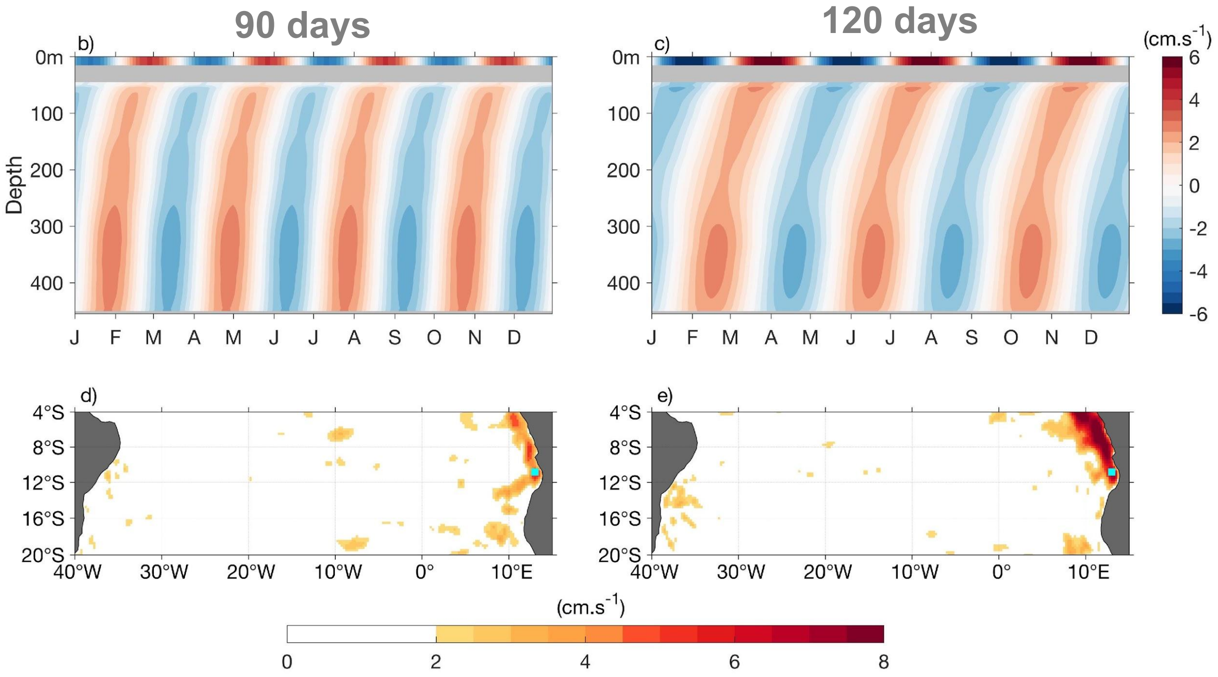

- **Low vertical baroclinic** structure
- Baroclinicity is **more pronounced** in the 120-day harmonic compared to the 90-day one.

- **Maximum amplitude** of the meridional geostrophic current is observed **along the west coast of Africa, north of 18˚S.**

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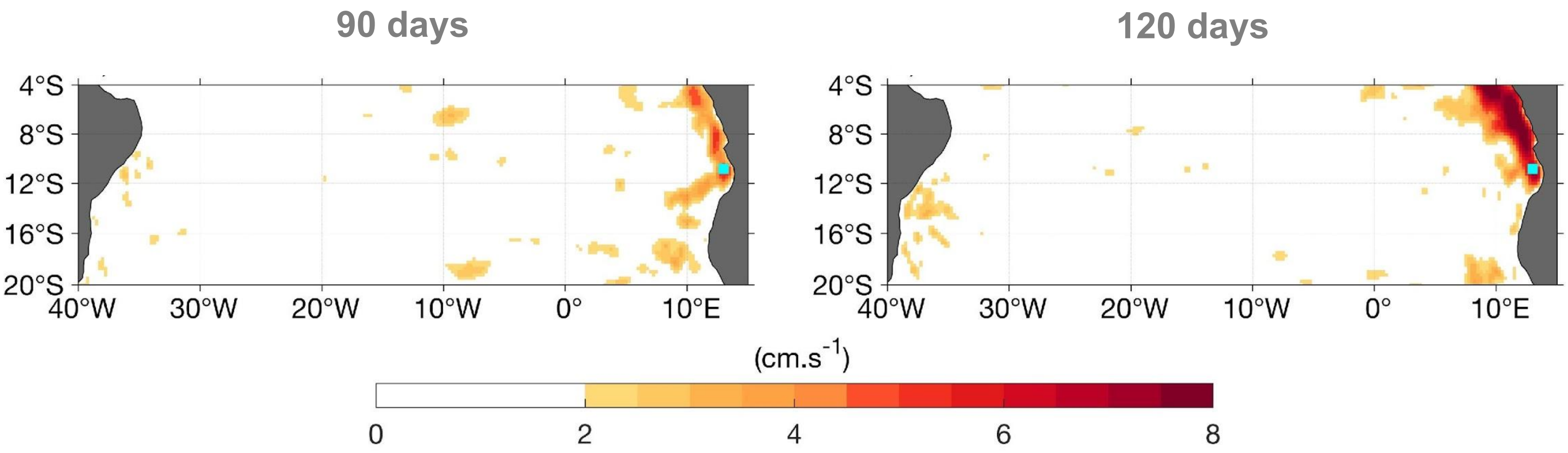
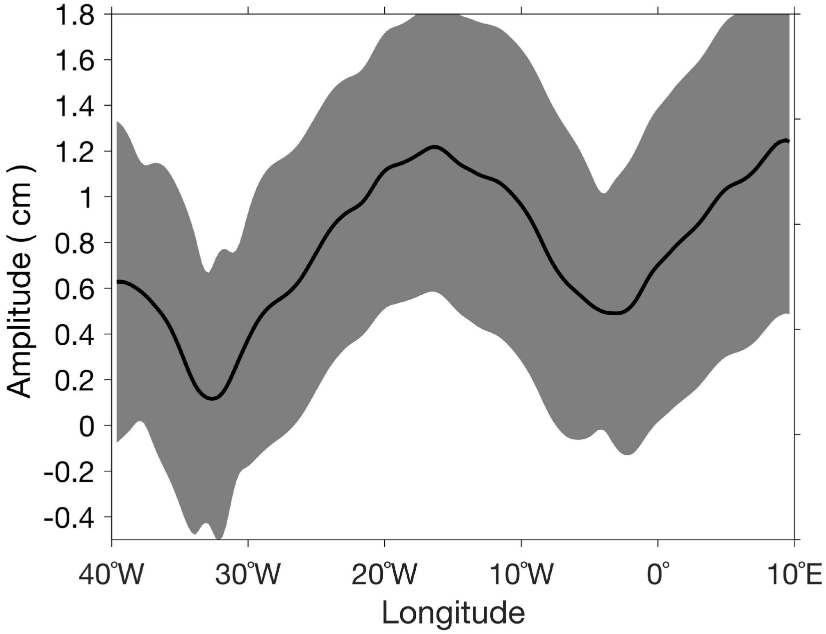
Representation of the 90-day and 120-day harmonics of the **meridional velocities** (2013-2019)



Maximum amplitude of the absolute meridional geostrophic current is observed **along the west coast of Africa, north of 17˚S.**

Amplitudes of the **120-day harmonics** of the equatorial **SLA,** from 1993-2018

SLA



Amplitudes of the **120-day harmonics** of the equatorial **SLA** , **Ueg** from 1993-2018

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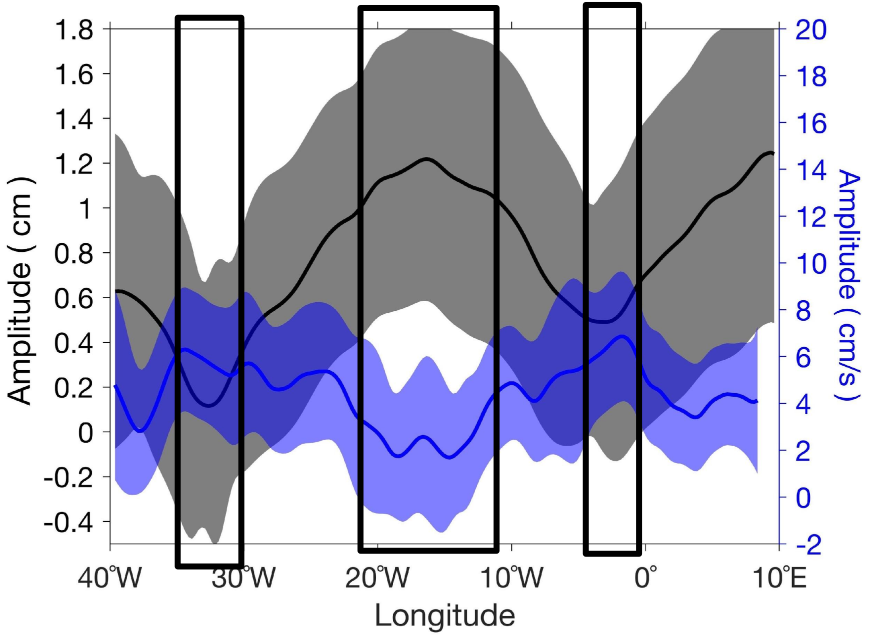
SLA
Ueg



Spatially out phase patterns between maxima and minima in the amplitude of **SLA** and **Ueg** along the equatorial Atlantic.

The **120-day oscillation** is associated with the **2nd equatorial basin mode of the 2nd baroclinic mode.**

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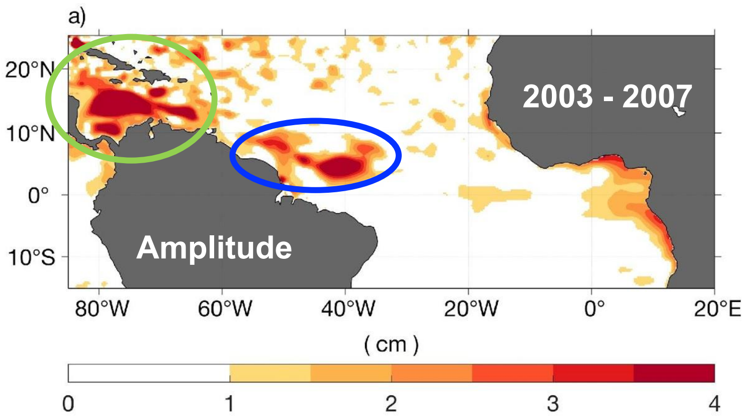
Illustration of the horizontal structure of the amplitude and phase of the 120-day variability of SLA



Forcing of the 120-day equatorial basin mode

- Caribbean basin (*Hughes et al.*, 2016)
- NECC region (wind-forced Rossby waves)

Impacts on sea surface temperature (SST) off Angola: HEOF1 of intraseasonal (75-135d) SLA in the South-east Atlantic

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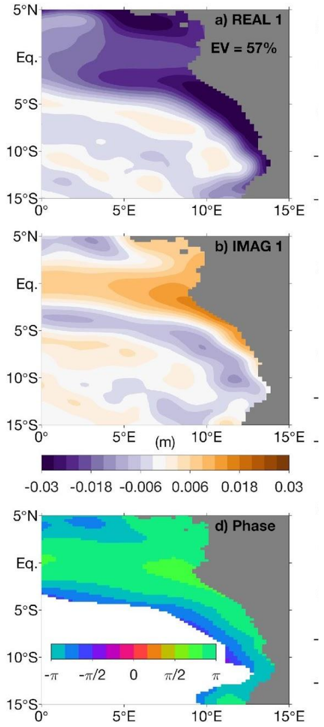

Coastally trapped waves propagate along the northwest and Southwest coast of Africa

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Impacts on sea surface temperature (SST) off Angola: HEOF1 of intraseasonal (75-135d) SLA in the South-east Atlantic

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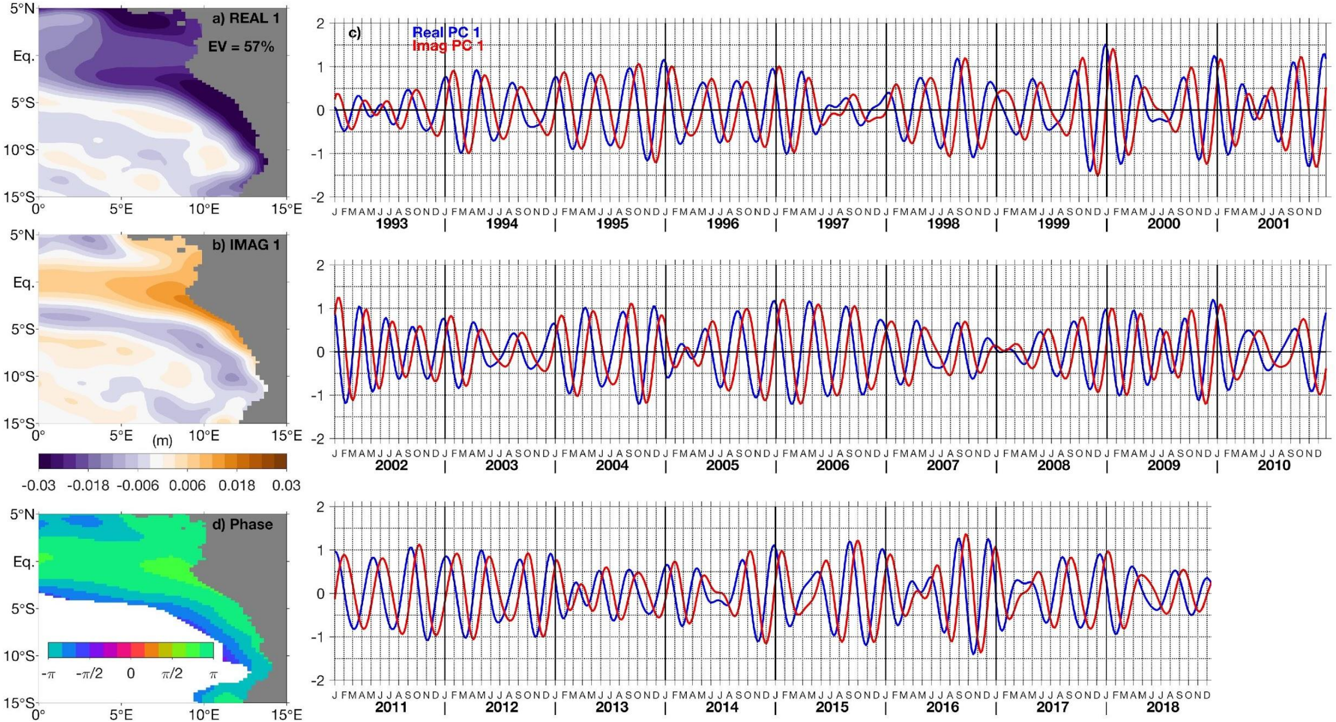

Coastally trapped waves propagate along the northwest and Southwest coast of Africa

- Signal is mostly dominated by 120-day oscillations
- Year to year variability

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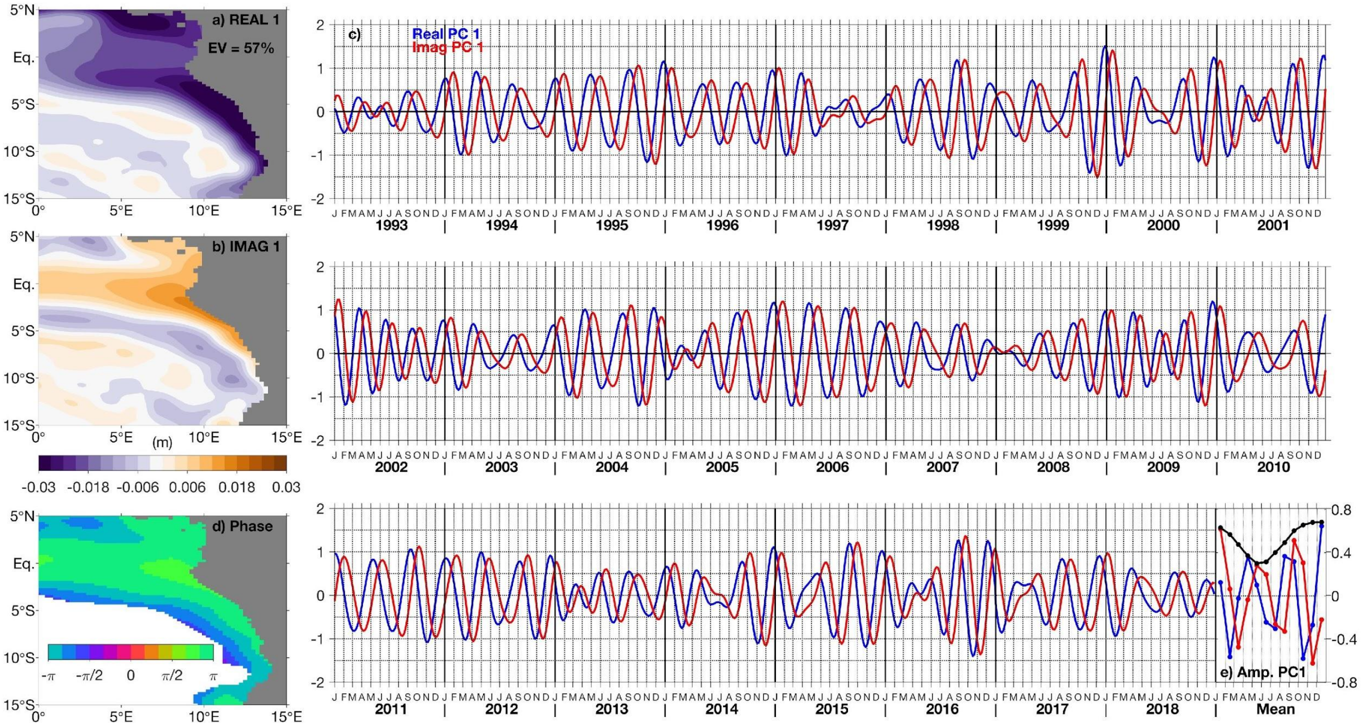
Impacts on sea surface temperature (SST) off Angola: HEOF1 of intraseasonal (75-135d) SLA in the South-east Atlantic



Coastally trapped waves propagate along the northwest and Southwest coast of Africa

- Signal is mostly dominated by 120-day oscillations
- Year to year variability

Part of the variability of the intraseasonal wave is phase-locked to the seasonal cycle

Impacts on sea surface temperature (SST) off Angola: Regression of **SST** onto **PC1** of intraseasonal (75-135d) SLA in the South-east Atlantic

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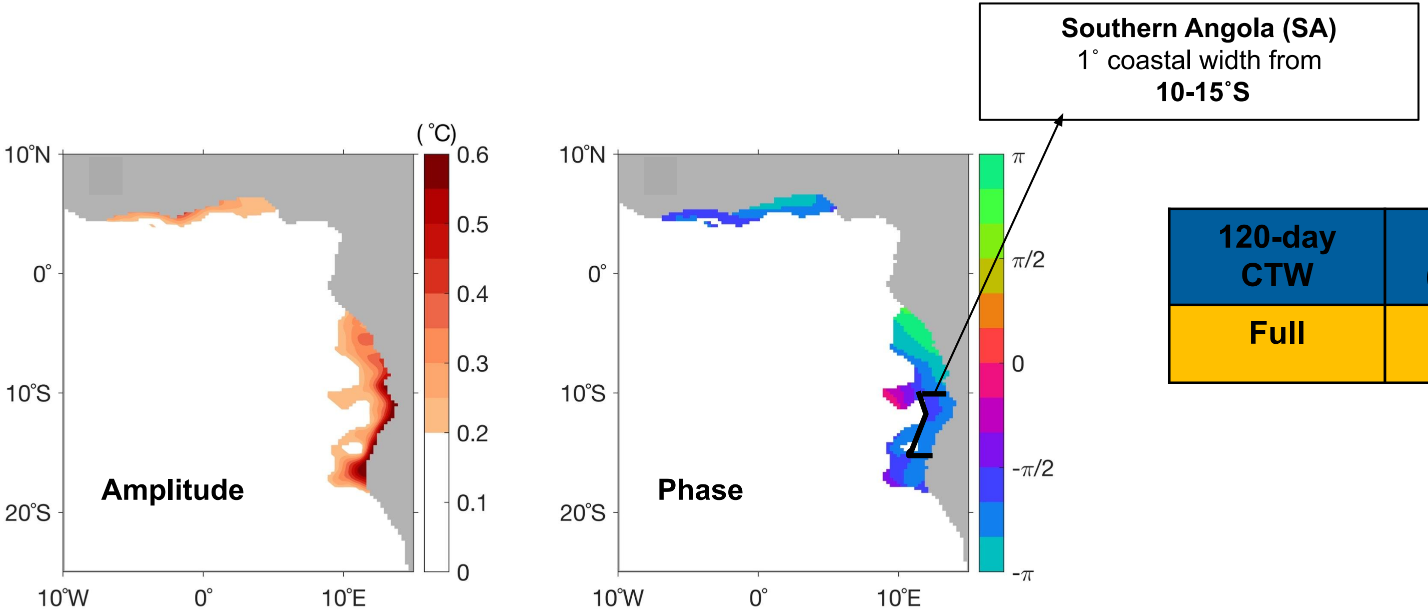

120-day CTW	Lags (SLA -> SST)
Full	~ 14 days

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Impacts on sea surface temperature (SST) off Angola: Regression of **SST** onto **PC1** of intraseasonal (75-135d) SLA in the South-east Atlantic

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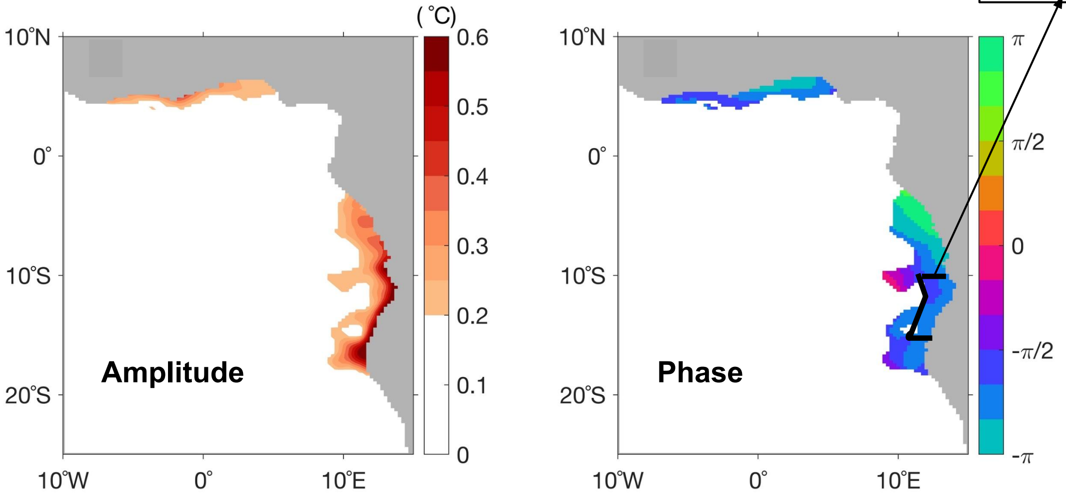
Southern Angola (SA)
1˚ coastal width from
10-15˚S



Downwelling seasons

Upwelling seasons

120-day CTW	Lags (SLA -> SST)
Full	~ 14 days
JFM	~ 17 days
AMJ	~ 14 days
JAS	~ 8 days
OND	~ 20 days

Impacts of intraseasonal CTWs on sea surface temperature in Southern Angola

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Coastal events in Southern Angola	Peak time (date)	SST anomalies during the peak time	BP SLA anomalies 2 weeks before the SST peak	Associated SST anomalies corresponding to intraseasonal CTW	Effects of the intraseasonal waves.
1995 (warm)	March, 27	+ 2.23 ˚C	+ 2.86 cm	0.73˚C	Strongly enhanced
1997 (warm)	October, 28	+ 1.45 ˚C	+ 0.30 cm	+ 0.08˚C	Enhanced
1998 (warm)	June, 30	+ 1.73 ˚C	+ 1.45 cm	+ 0.37˚C	Enhanced
2001 (warm)	April, 16	+ 1.73 ˚C	- 0.87 cm	- 0.22˚C	Damped
2010 (warm)	March, 2	+ 2.05 ˚C	+ 1.15 cm	+ 0.29˚C	Enhanced
2016 (warm)	February, 20	+ 1.88 ˚C	+ 2.73 cm	+ 0.70˚C	Enhanced
1997 (cold)	April, 6	- 2.65 ˚C	- 1.49 cm	- 0.38˚C	Enhanced
2010 (cold)	March, 7	- 1.57 ˚C	+ 0.82 cm	+ 0.21˚C	Damped

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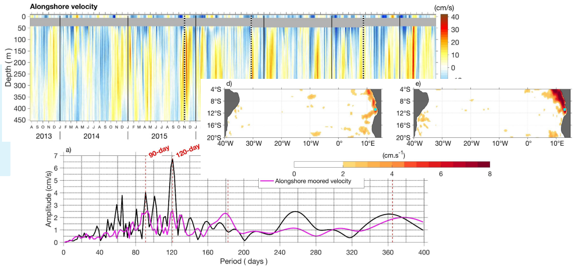
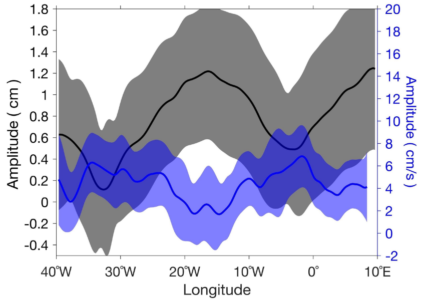
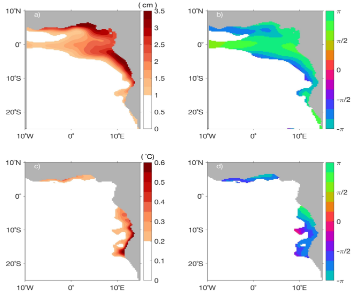
Conclusion



The AC flow is dominated by periods of near AC, SAC, 90 and 120 days.



The 120-day variability is linked to the 2nd equatorial basin mode of the 2nd baroclinic mode.



Intraseasonal coastally trapped waves impact sea surface temperature variability off Angola and in the Gulf of Guinea via thermocline feedback.

Thank you for your attention !!!

Imbol Koungue, R. A., & Brandt, P. (2021). Impact of intraseasonal waves on Angolan warm and cold events. Journal of Geophysical Research: Oceans, 126, e2020JC017088. https:// doi.org/10.1029/2020JC017088.