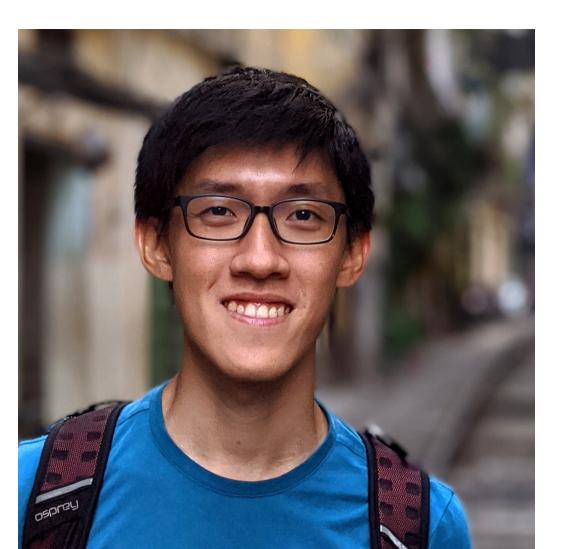


# Recent Column-Compound Extremes in the Global Ocean



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## Background and Motivation

Marine extreme events can be detrimental to organisms and ecosystems across the global ocean. When they occur together in the same vertical column at the same time, habitable space decreases, exacerbating the impact on marine organisms<sup>1</sup>.

Marine heatwaves (MHW), ocean acidification (OAX) and low oxygen (LOX) extremes are investigated.

## Research Questions

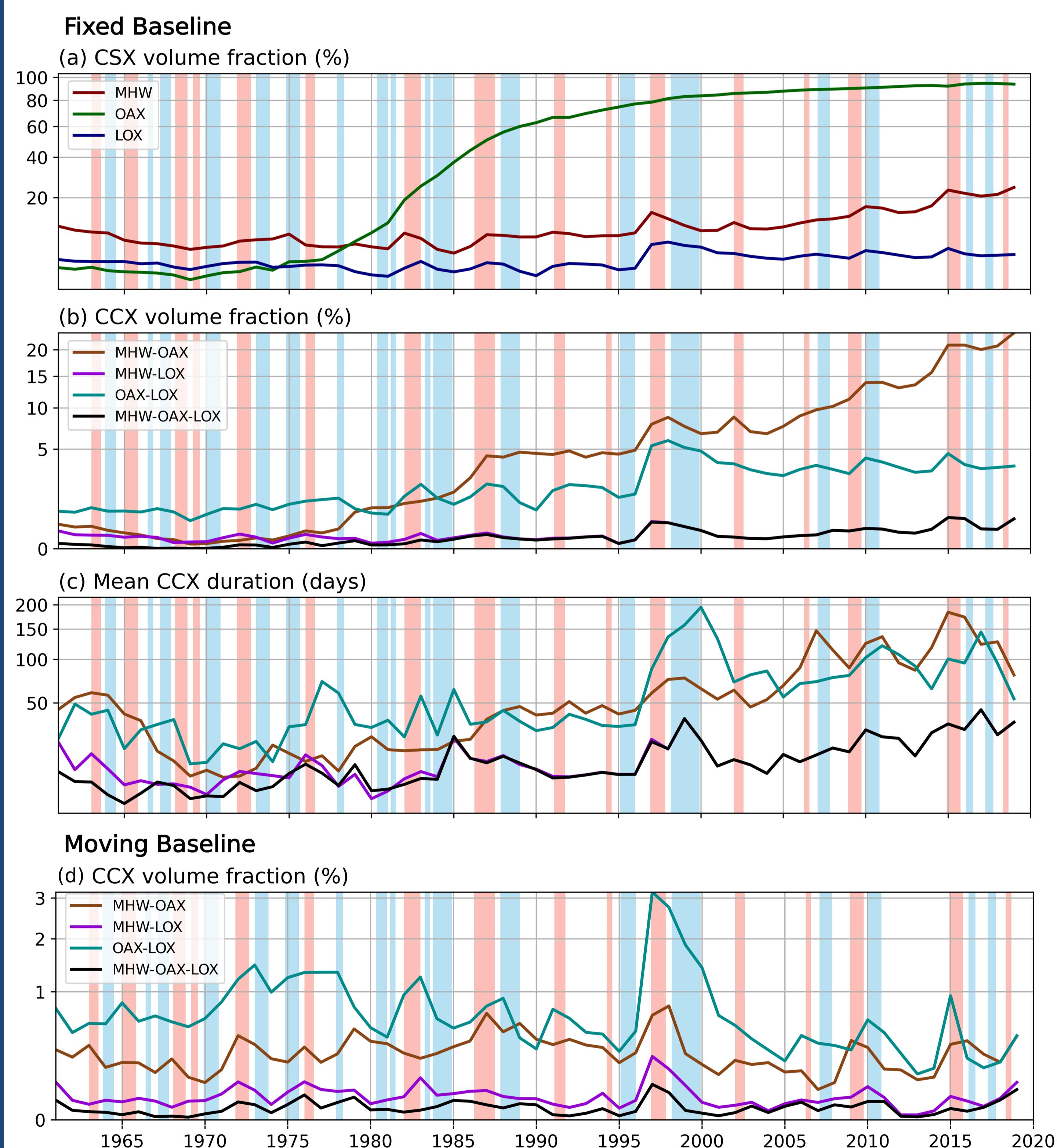
- How can we study compound extremes in the vertical water column?
- Where have column-compound extremes occurred in the oceans?
- What were the drivers behind them?

## Single Extremes Types and Definitions

- Relative, seasonally-varying thresholds<sup>2</sup>
- Moving baseline with a quadratic trend

Extreme Type	Variable	Percentile Threshold (%)	Absolute Threshold
Marine Heatwave (MHW)	T	> 95 <sup>th</sup>	-
Ocean Acidification (OAX)	[H <sup>+</sup> ]	> 95 <sup>th</sup>	-
Low Oxygen (LOX)	[O <sub>2</sub> ]	< 5 <sup>th</sup>	< 150 μM

## Results - Annual Timeseries



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## References

- [1] Gruber, N., Boyd, P. W., Frölicher, T. L., & Vogt, M. (2021). Ocean Biogeochemical Extremes and Compound Events. *Nature*, 600, 395–407. <https://doi.org/10.1038/s41586-021-03981-7>
- [2] A. J. Hobday *et al.*, "A hierarchical approach to defining marine heatwaves," *Prog. Oceanogr.*, vol. 141, pp. 227–238, 2016, doi: 10.1016/j.pocean.2015.12.014.

## Compound-Column Extreme (CCX) Definitions

- Single extremes occurring in the same vertical column (top 300m)
- Minimum 50m of each single extreme type

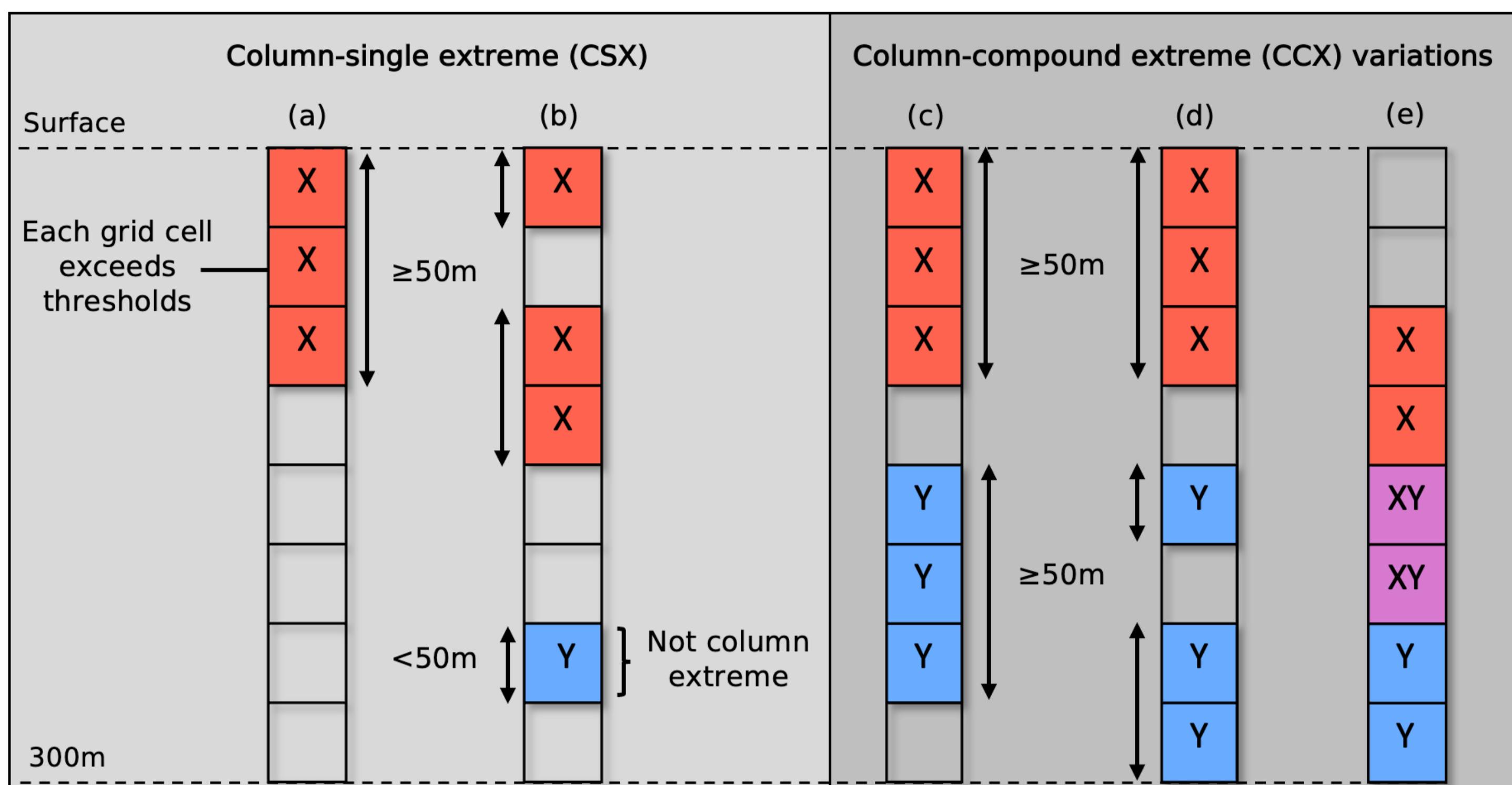


Fig.1: Marine extreme detection in the vertical column.

## Results – Clustering and Spatiotemporal metrics

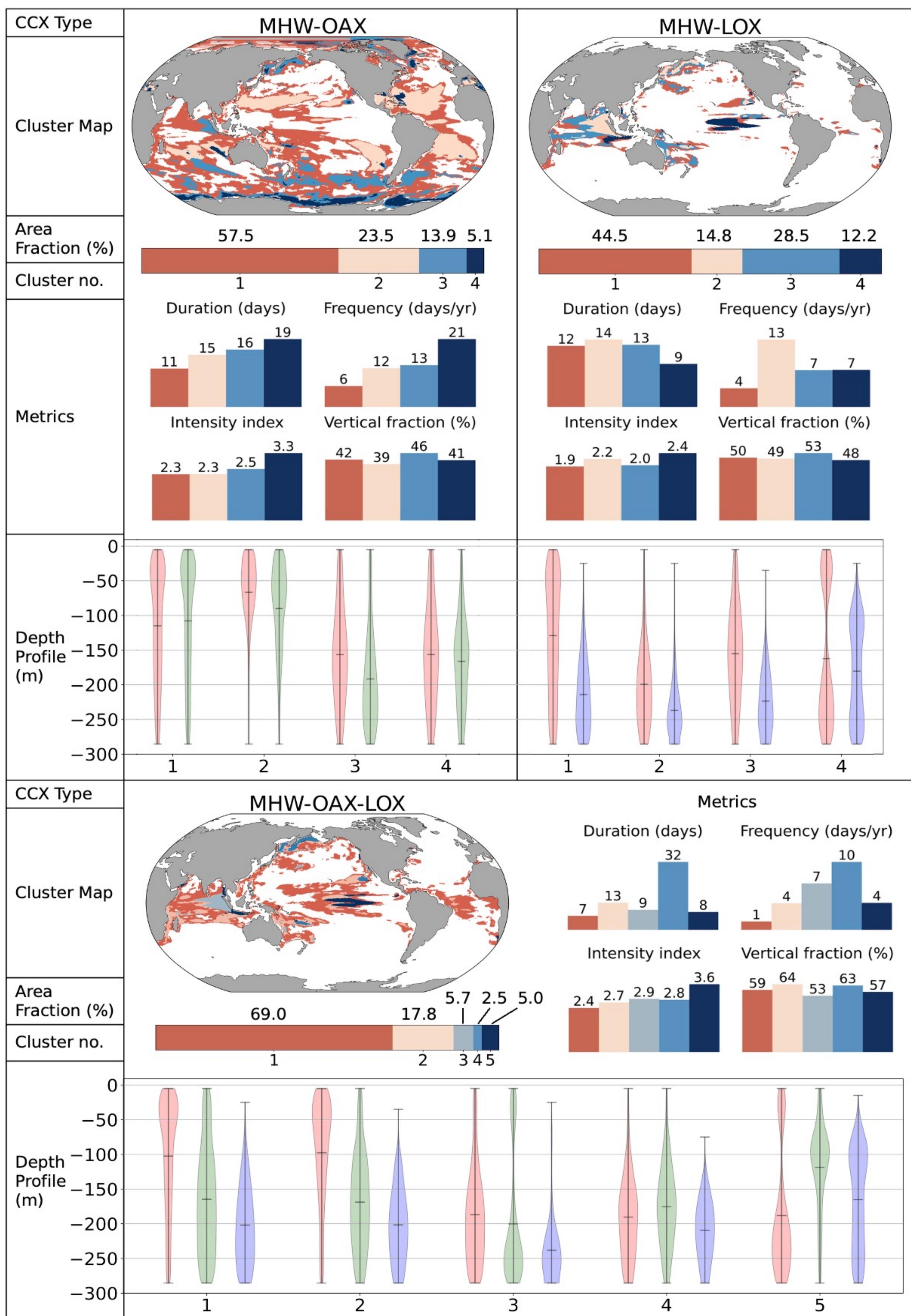


Fig.3: CCXs clustered by vertical location of single extremes. Key metrics are presented averaged by clusters. The depth profiles show where single extremes occur during CCXs.

## Key Findings and discussion

- Large volume of CCXs associated with ENSO
- Driving mechanisms:
  - Air-sea heat flux
  - Thermocline displacement
  - Horizontal advection
- More than 50% of the column is extreme during many CCXs