

# Column-Compound Marine Heatwaves and Ocean Acidity Extremes in the Southern Ocean

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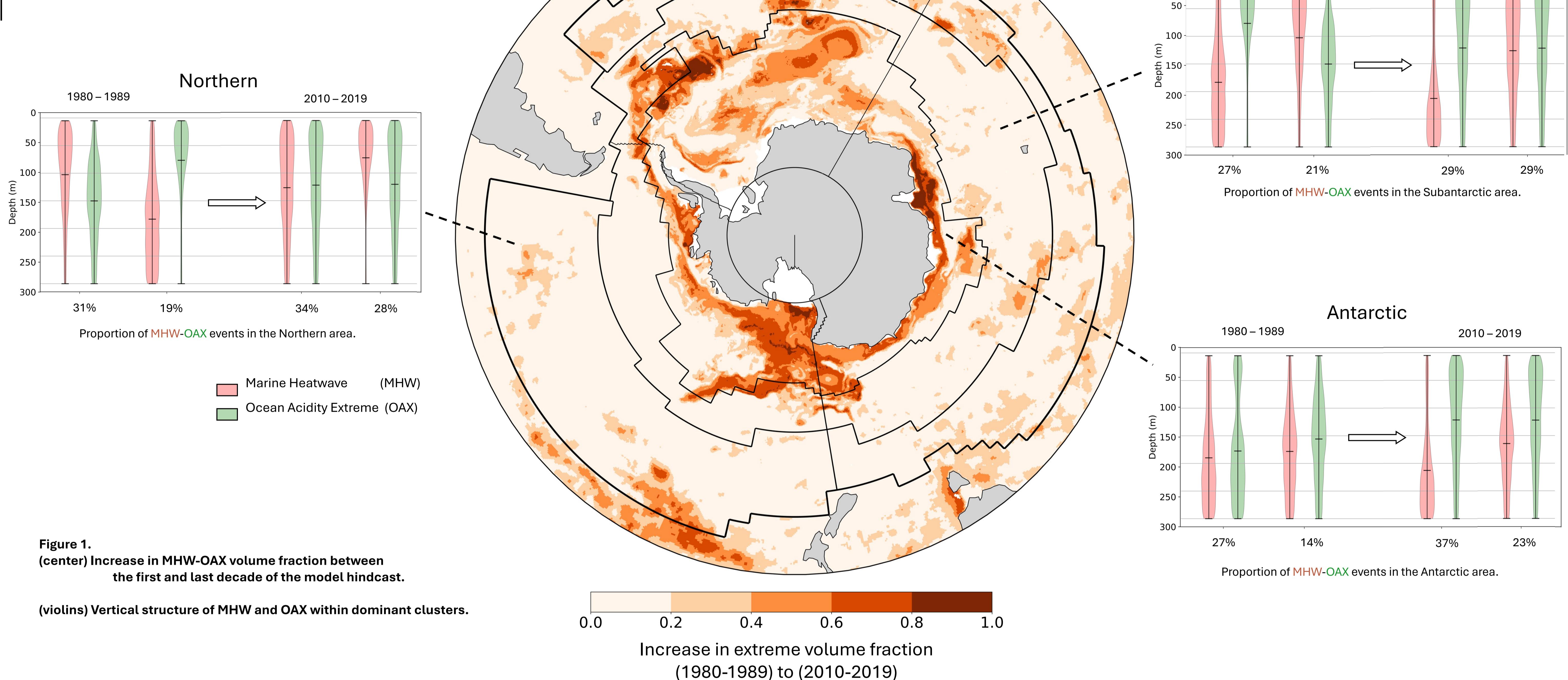
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## Key Points

1. Column-compounded Marine Heatwaves (MHW) and Ocean Acidity Extremes (OAX) has increased in the Southern Ocean between 1980 and 2019.
2. The Antarctic zone has seen a disproportionate increase in MHW-OAX events.
3. Surface-MHWs increasingly contain subsurface extreme conditions.

## Changes in vertical structure of MHW and OAX

- Surface-OAX becomes dominant across all areas
- Increase in subsurface MHW in Antarctic/Subantarctic



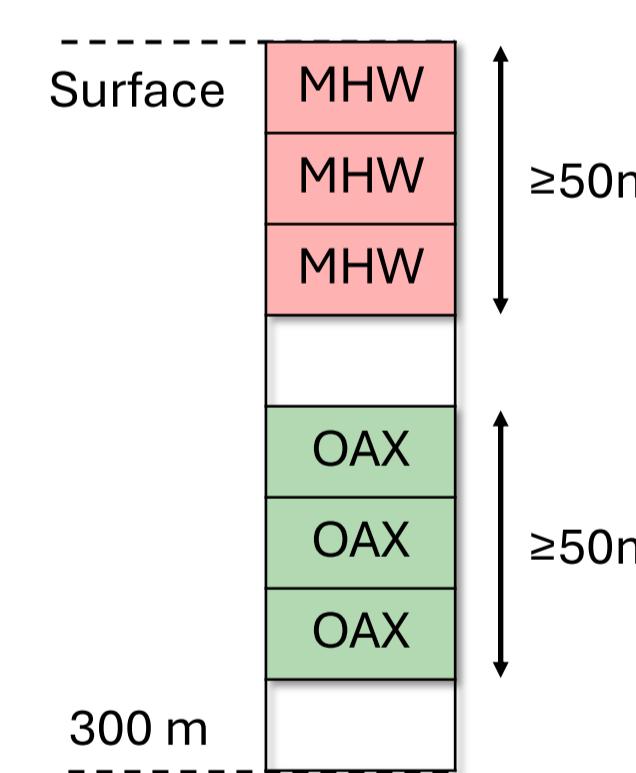
## Model and Methods

### What is a Column-Compound Extreme?

In the grid cell: Above the relative percentile threshold  
In the column: More than 50m of MHW and OAX

Extreme type	Variable	Percentile
Marine Heatwave (MHW)	$T$	95 <sup>th</sup>
Ocean Acidity Extreme (OAX)	$[H^+]$	95 <sup>th</sup>

Table 1. (above) Relative percentile thresholds applied to each variable.  
Figure 2. (right) More than 50m of each extreme type required in the column.



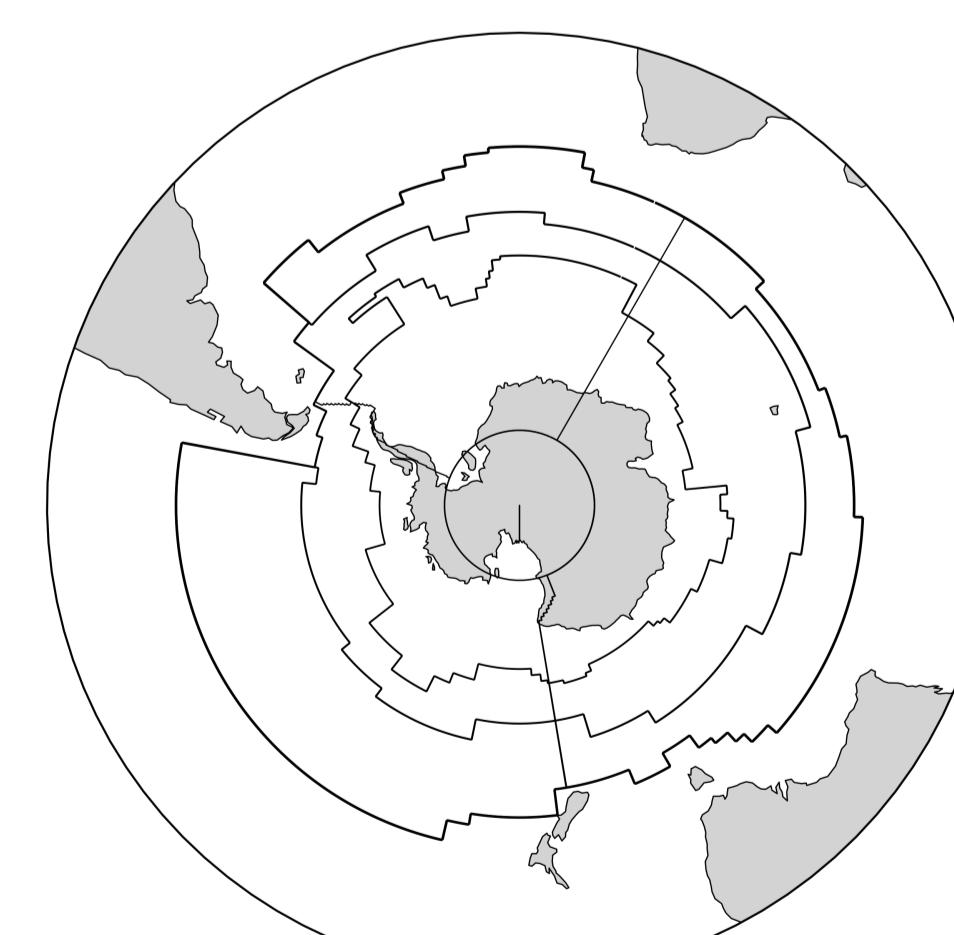
### Daily Hindcast Model (1980-2019)

Regional Ocean Modeling System (ROMS)  
Biogeochemical Elemental Cycling (BEC)

0.25° resolution, 24 – 78°S

Fixed baseline (at 1980)

Marine Ecosystem Assessment for the Southern Ocean Areas



## AGU Advances

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### Column-Compound Extremes in the Global Ocean

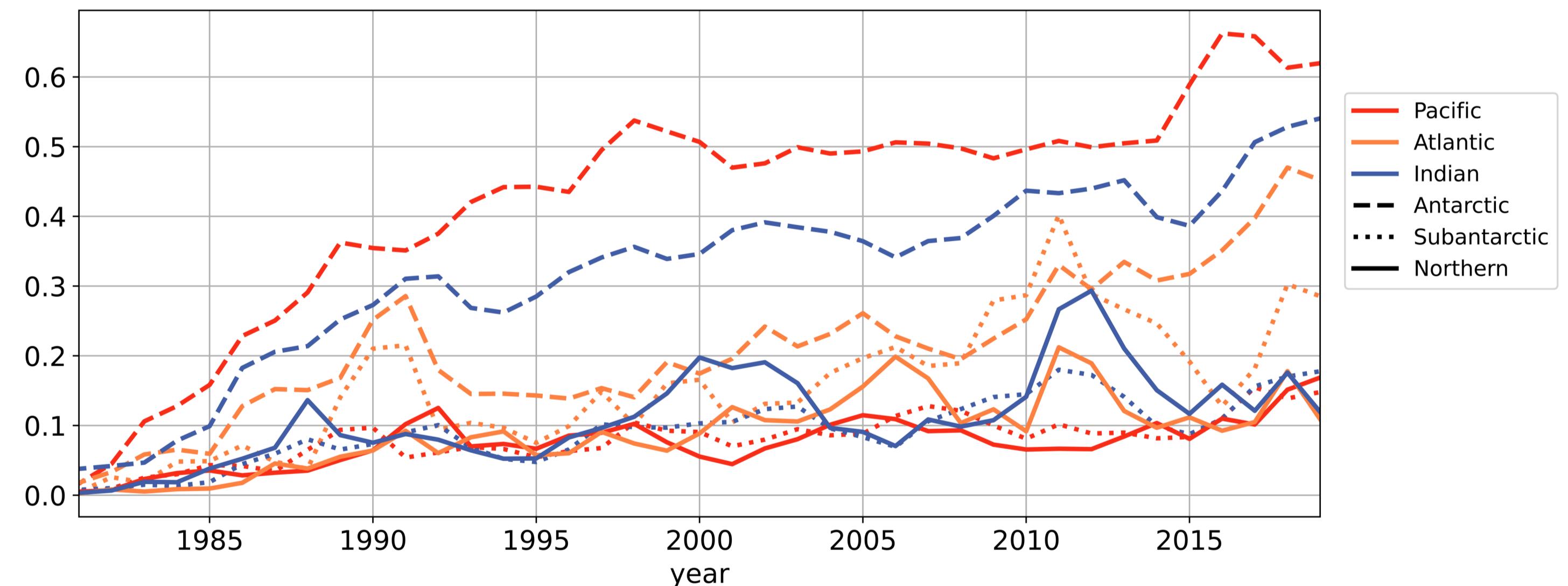
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## Further Results

### Temporal Variability of MHW-OAX

- Volume fraction increases from 5% to 10-60% of the water column
- Antarctic zone sees the greatest increase from 1985 onward



### Beneath Surface-Marine Heatwaves

- From 1980-1989, less than half of surface-MHW contained MHW-OAX
- By the last decade, almost all surface-MHW was a part of MHW-OAX

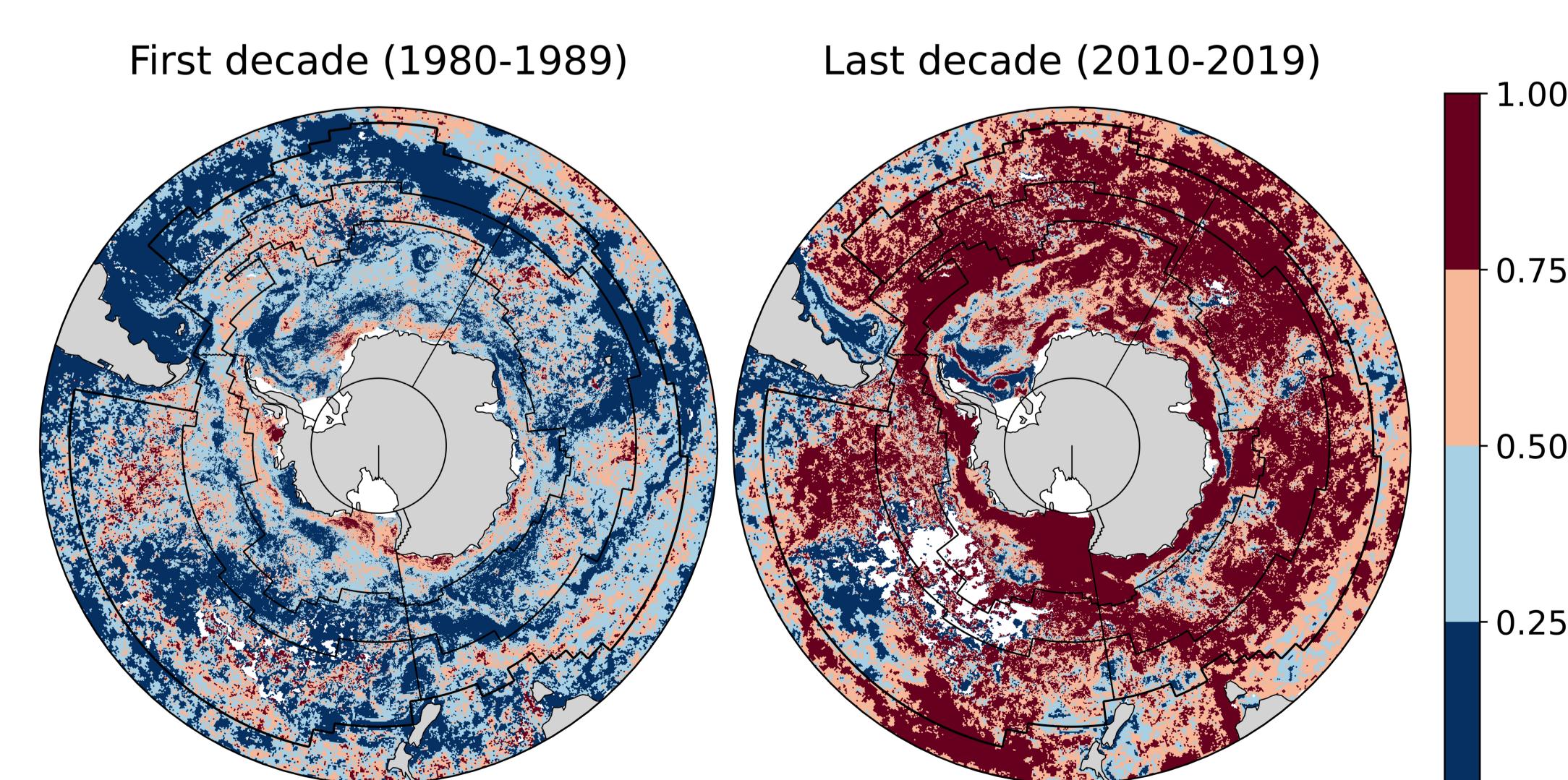


Figure 4. Mean fraction of surface-MHW containing column-compounded MHW-OAX events.