

# Variability of Marine Heat Waves over different coastal environments: applications in South Florida and NE Mediterranean Sea

Androulidakis Y.<sup>1,2</sup>, Kourafalou V.<sup>3</sup> Krestenitis Y.<sup>1</sup>

*<sup>1</sup>Laboratory of Maritime Engineering and Maritime Works, School of Civil Engineering, Aristotle University of Thessaloniki, Greece*

*<sup>2</sup>Laboratory of Physical and Chemical Oceanography, Department of Marine Sciences, University of the Aegean, Greece*

*<sup>3</sup>Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, Miami, FL, USA*



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# Marine Heat Waves

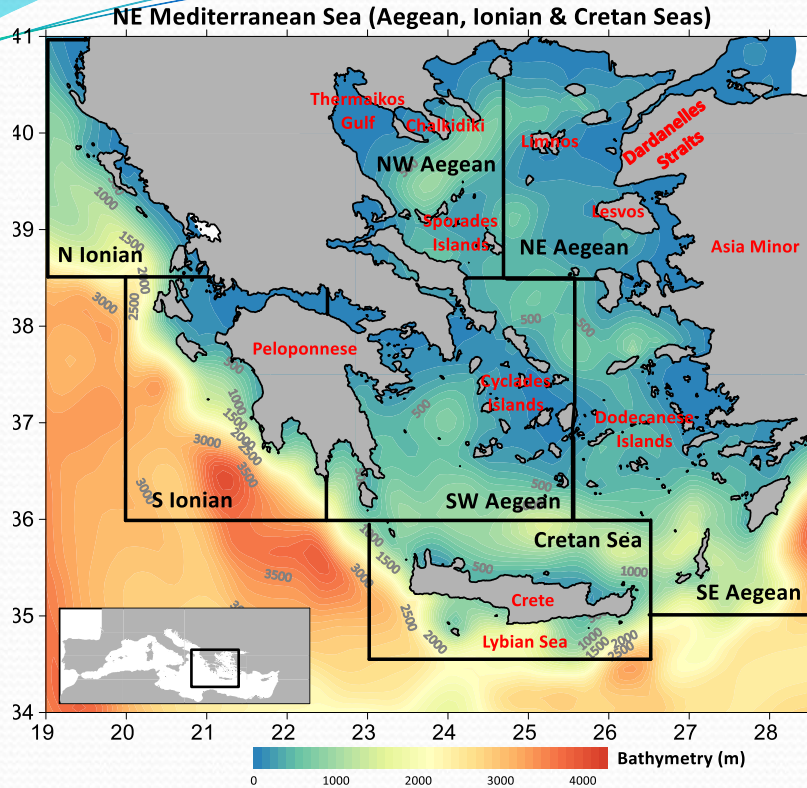
*“Marine Heat Wave (MHW) events are extreme climatic episodes affiliated with warm Sea Surface Temperature (SST) values that persist for days to months over a specific oceanic area“*

## Definitions

- Hobday et al. (2016)
- **MHW** is related to an abrupt SST increase above a "climatologic" value (the baseline temperature) for a certain time period
- A **MHW** is defined as a discrete and prolonged anomalously warm ocean-based event.
- ‘discrete’ → MHW is an identifiable event with clear start and end dates
- ‘prolonged’ → it has a duration of at least 5 days
- ‘anomalously’ → temperature is warmer compared to the baseline temperature
- The intensity of the MHWs → Categories based on the multiplies of local difference between the climatological mean and the 90th percentile baseline (e.g. moderate, strong, severe etc).

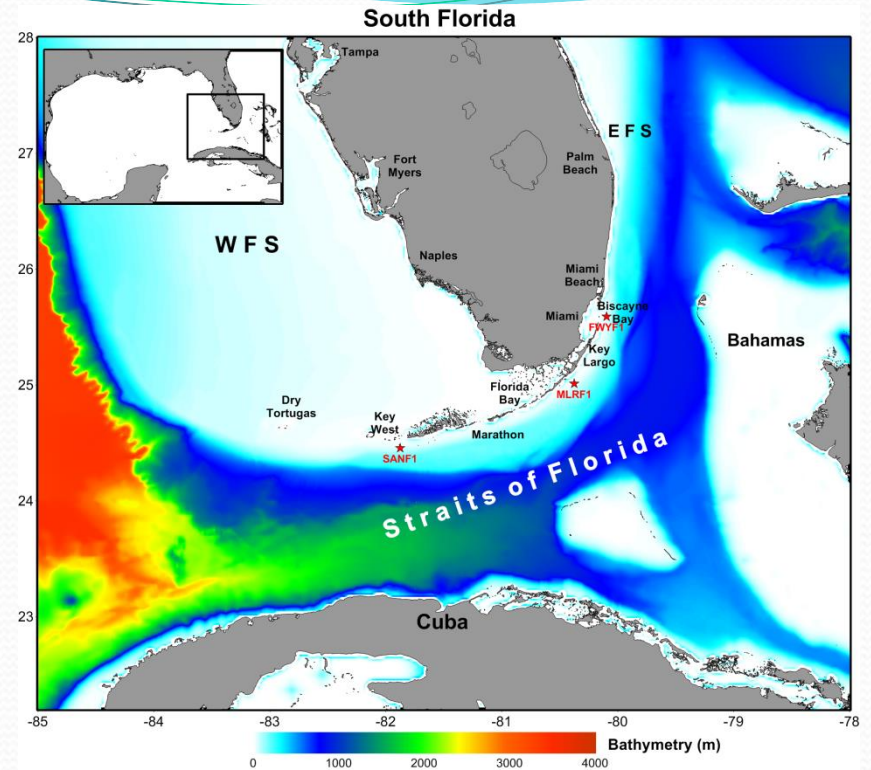


# Two study regions



SST Satellite-observations ~1 km  
2008-2021

*Androulidakis & Krestenitis (2022, JMSE)*



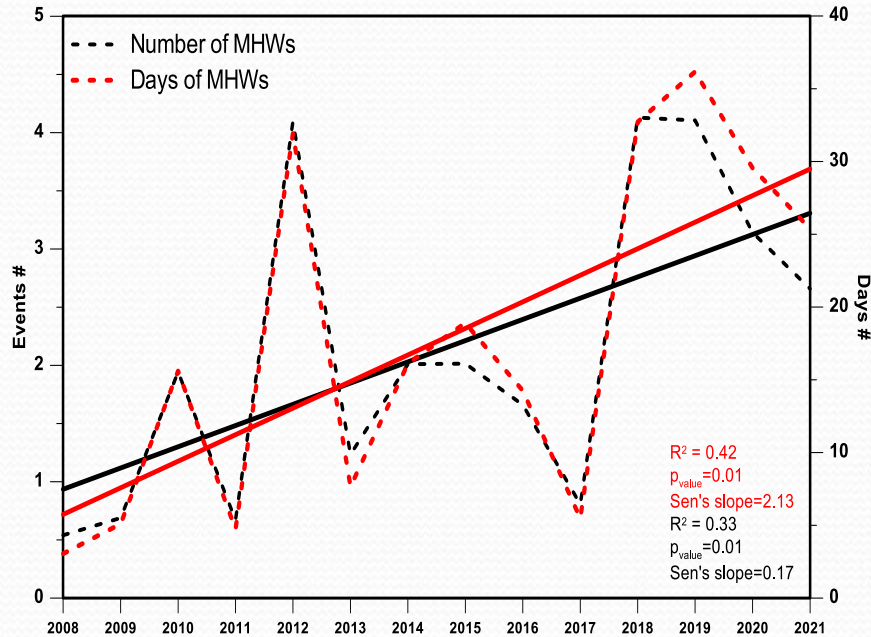
SST Satellite-observations ~5 km  
1982-2021

*Androulidakis & Kourafalou (2023, Water)*

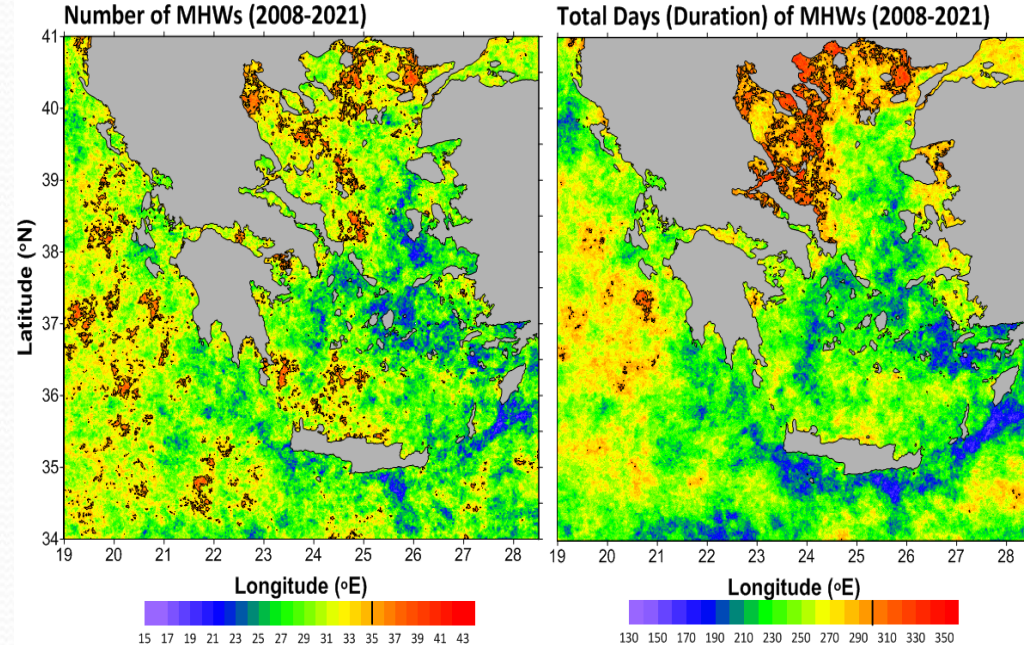
***The main motivation is to examine a climate related coastal effect that is influenced by open ocean circulation.***

## Formation of Marine Heat Waves

### Interannual variability



### Spatial variability

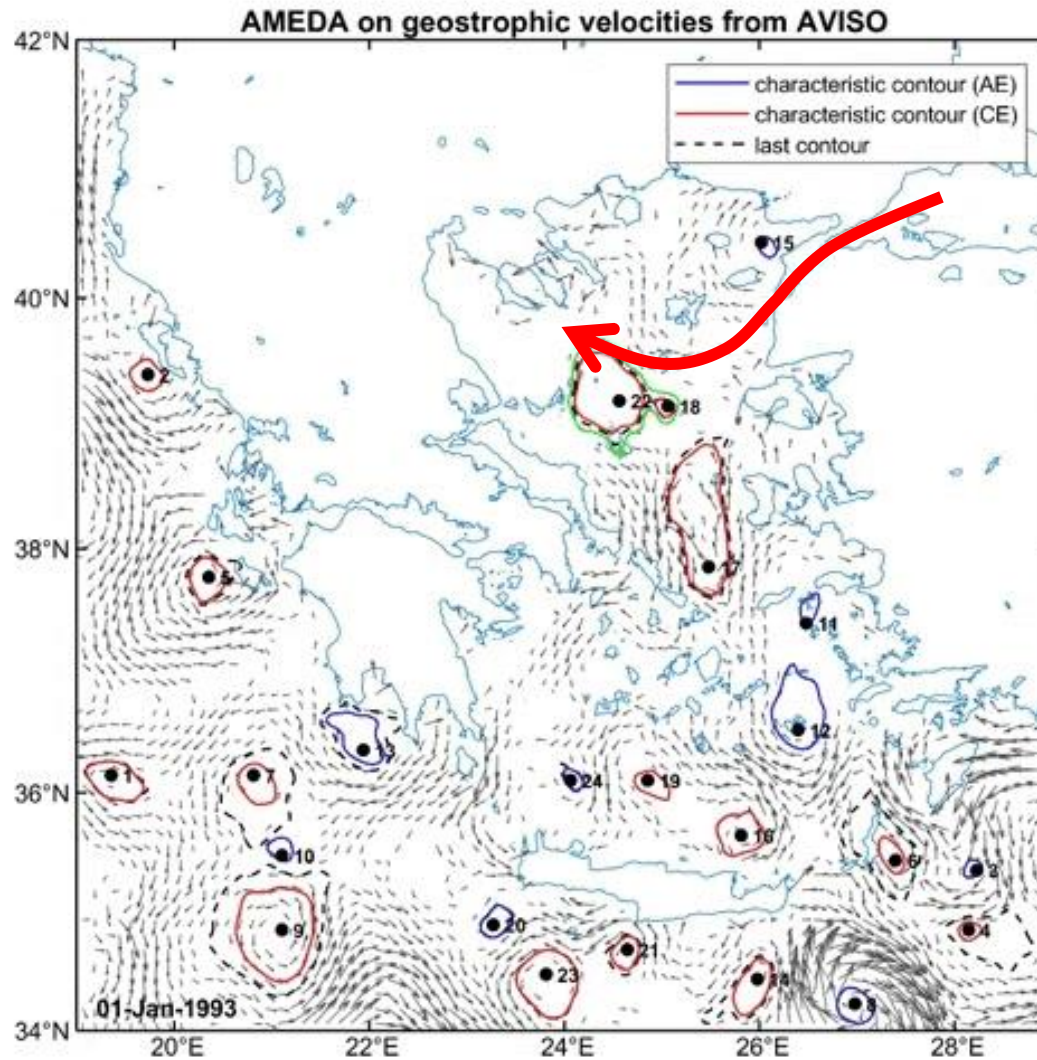


- Both trends are statistically significant ( $p_{\text{value}}=0.01$ ) with relatively high coefficients of determination
- Highest levels during 2018-2021

- Thermaikos Gulf can be characterized as a "hot spot" of MHWs
- Dodecanese archipelago and Crete → lowest number and duration



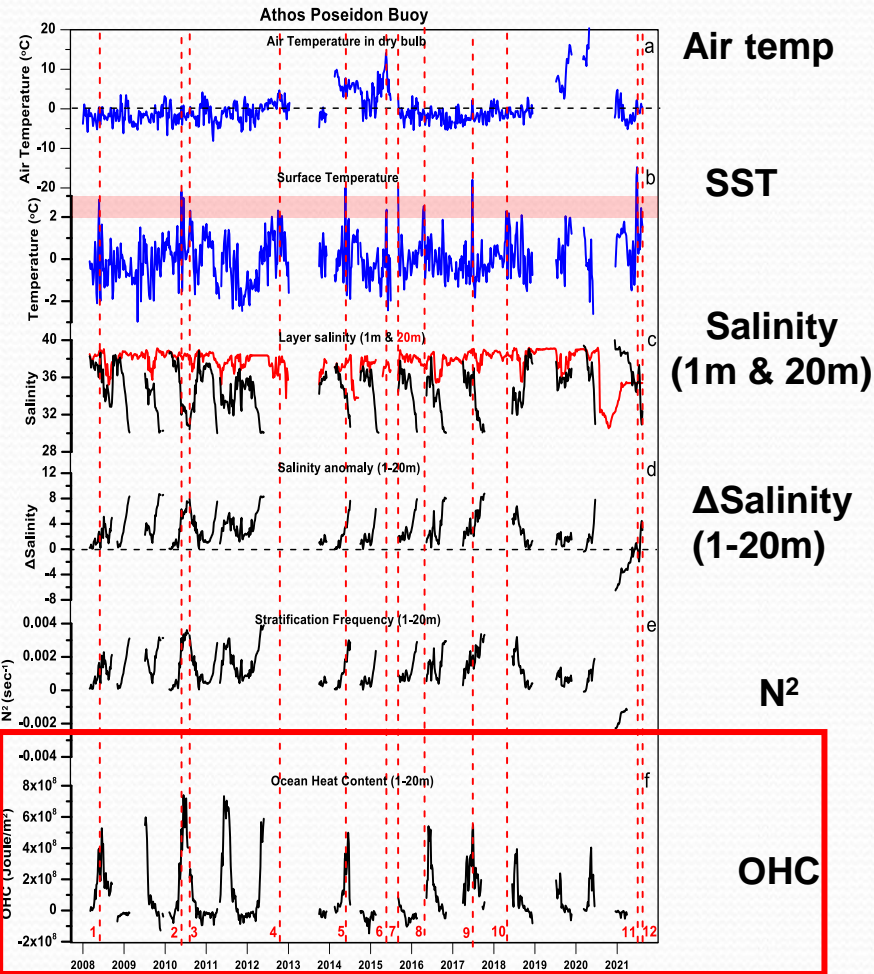
## Ocean circulation effects



Black Sea Water (BSW) intrusion (low salinity plume)

## Ocean circulation effects

2008 -2021 N. Aegean



### 12 extreme SST events:

- Very low salinity values at the surface (BSW)
- Higher salinity at the deeper 20 m layer
- Large  $\Delta$ Salinity anomalies (1 and 20m)
- Strong stratification frequency at the upper-ocean

$$N^2 = \frac{(-g/\rho_1)(\rho_1 - \rho_2)}{\Delta z}$$

**Apparent but shallow BSW layer at the surface**

- Computation of Ocean Heat Content over this layer
- Peaks during the BSW presence

$$Q = \int_{h_1}^{h_2} C_p \rho_z T_z dz$$

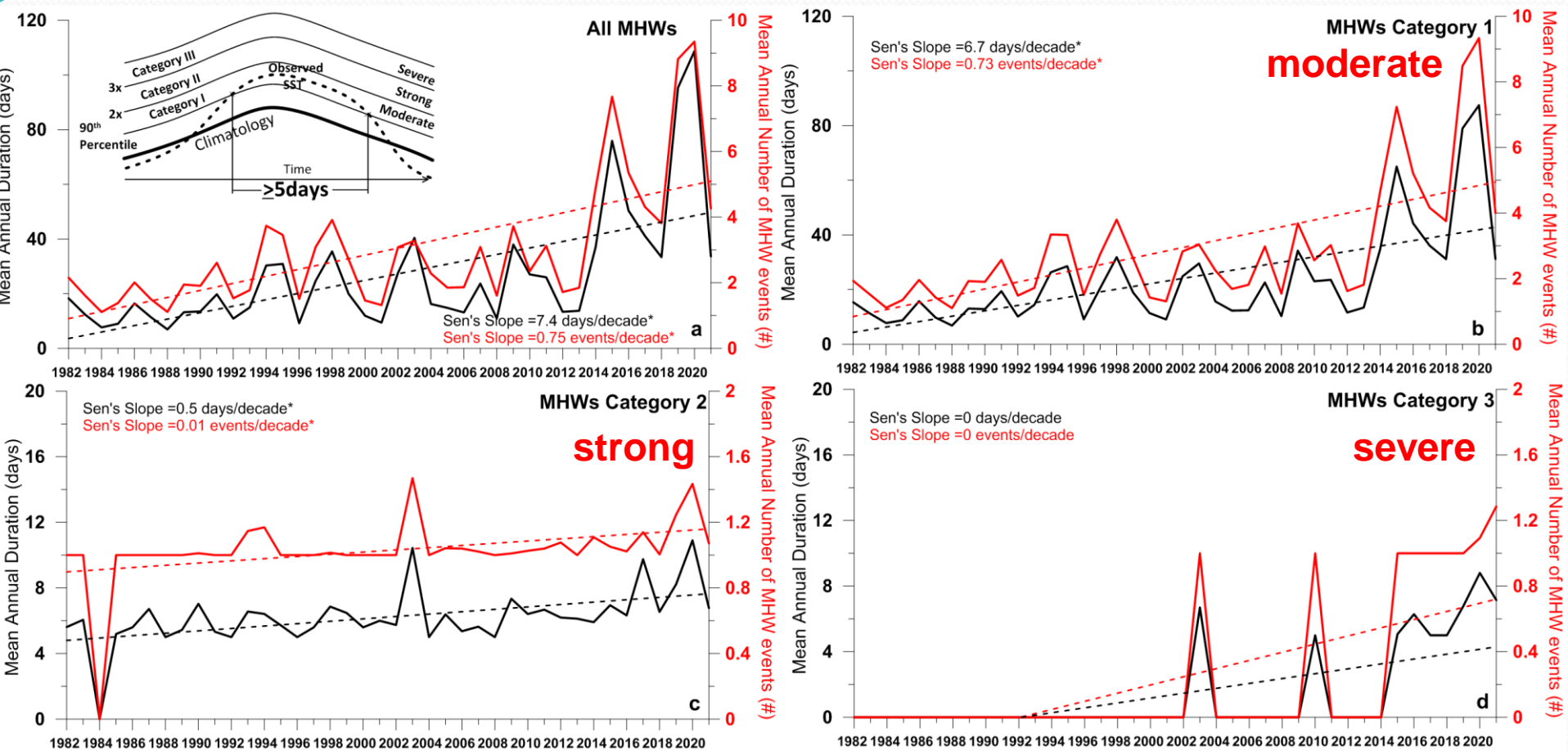
**Increasing of the heat storage capacity of upper layers  $\rightarrow$  further warming of the surface water masses of the NAegean**





# South Florida

## Formation of Marine Heat Waves

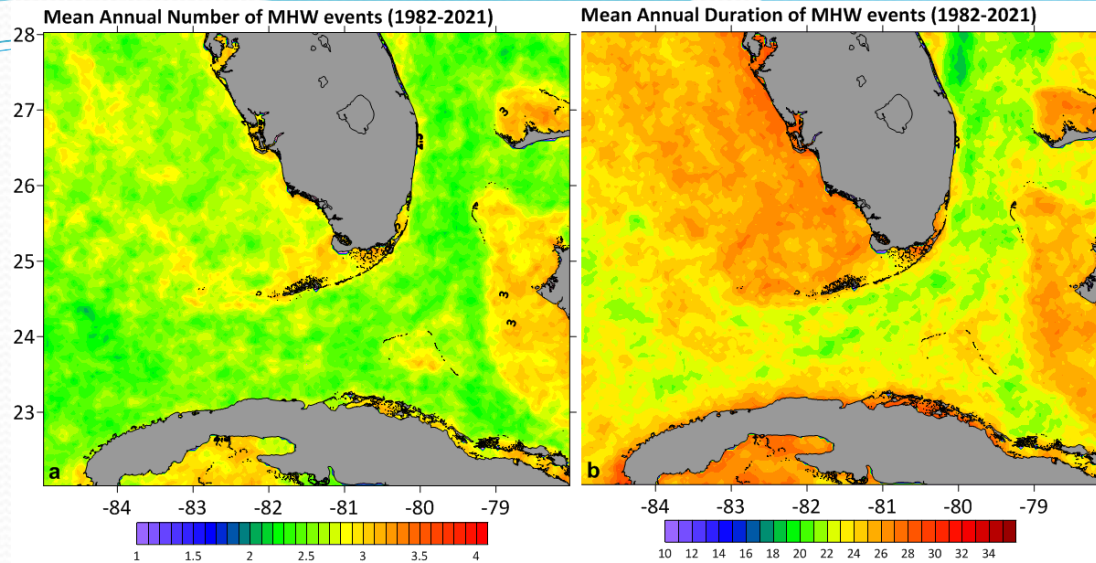


The interannual positive trend of the MHWs is 0.75 events/decade with 7.4 days/decade duration increase.

Although the majority of the MHWs of South Florida are "moderate" events, based on the Hobday et al. (2018) categorization, in the years after 2015, "severe" MHW were also formed.

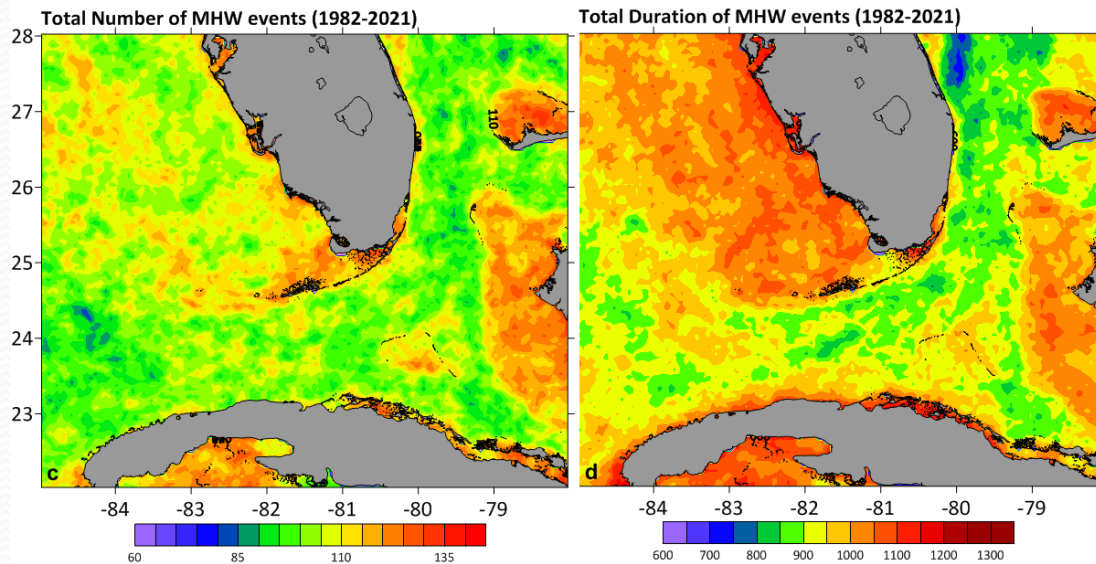
# South Florida

Mean Annual Number



Mean Annual Duration

Total Number



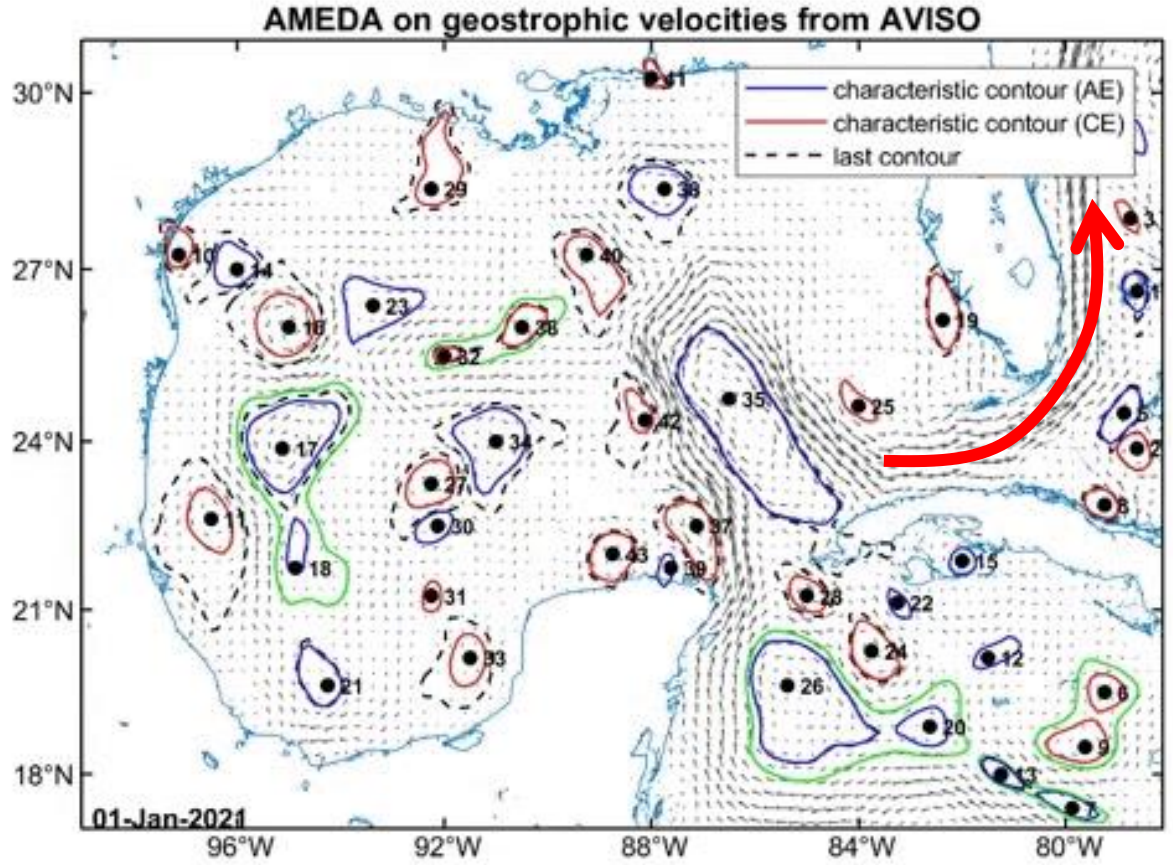
Total Duration

The south WFS and Florida Bay showed the highest number of events during the 40-year period but significantly long MHW also occurred at the northern parts of WFS.



# South Florida

## Ocean circulation effects



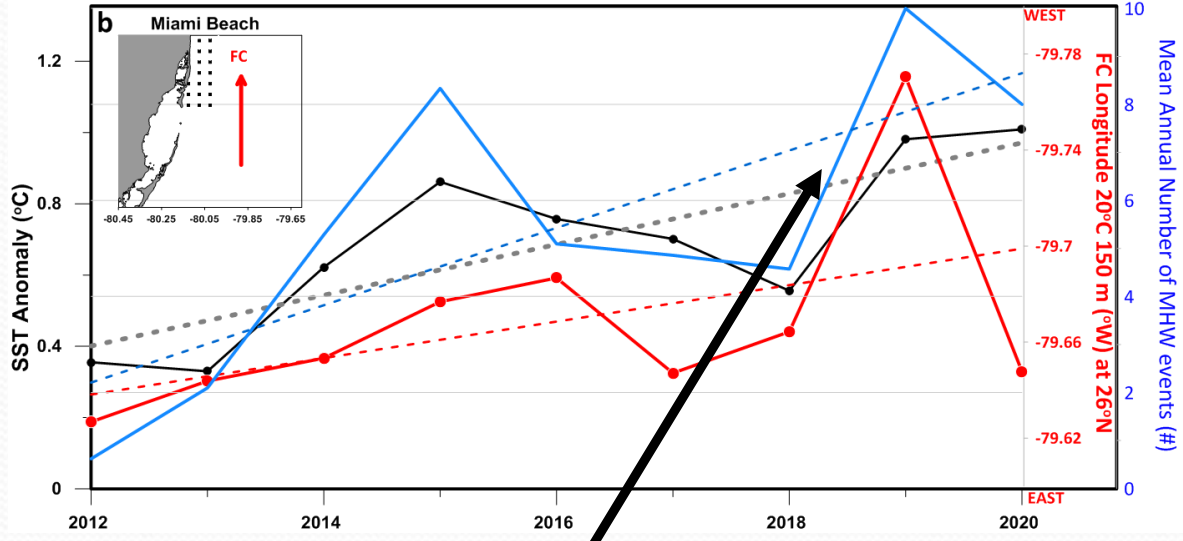
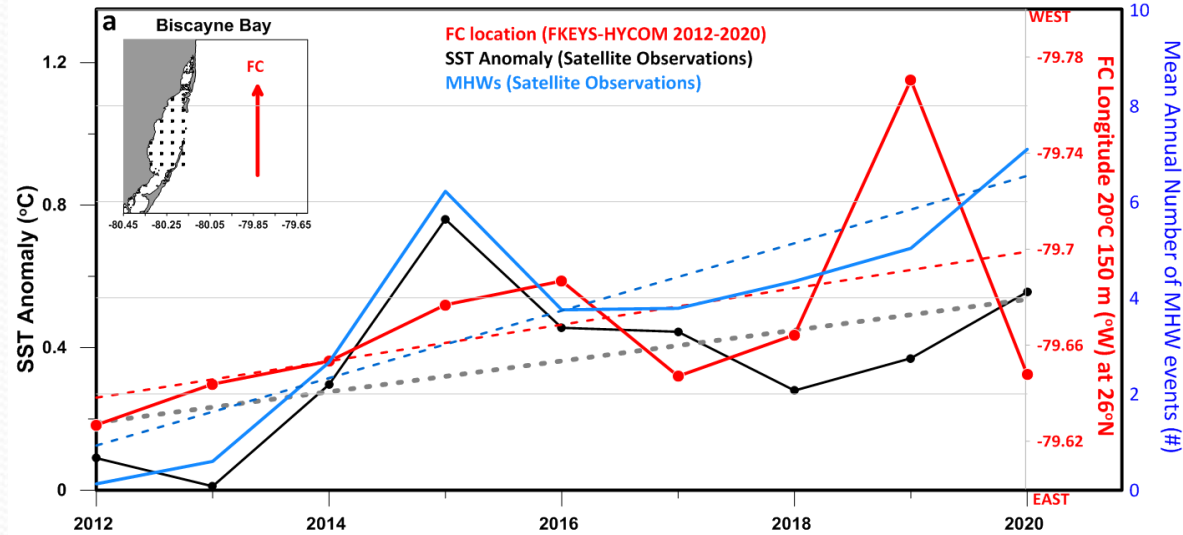
Loop Current & Florida Current (Gulf Stream)

The evolution of the FC may affect the formation of MHWs in South Florida

# South Florida

## Gulf Stream (Florida Current) effects on MHW formation at Miami area

	Mean Annual Duration	Mean Annual Number MHW	Mean Annual SST
Coastal Area	Days/decade	Events/decade	°C/decade
Miami Beach	10	1.1	0.15
Biscayne Bay	7.2	0.9	0.1



Peaks of MHWs when Florida Current (Gulf Stream) evolved closer to the coasts (especially at Miami Beach)



# Conclusions

- Both regions showed increasing trends of Marine Heat Waves
- NE Med → 1.7 events/decade (21 days/decade)
- South Florida → 0.75 events/decade (7.4 days/decade)
- Increasing trend of winter temperatures for AIC Seas
- Increasing trend of summer temperatures for South Florida
- Both areas showed significantly high peaks during the last 5 years
- Strong spatial variability → related to oceanic conditions and circulation patterns

## Examples

Formation of shallow barrier layer in Northern Aegean (BSW) →

Gulf Stream proximity to the coasts of South Florida →

***Enhance the formation of MHWs***

# Conclusions

- **Offshore circulation patterns** (e.g. Gulf Stream) may control the physical processes and MHW formation of coastal waters that leads to the need of coastal modeling improvements:
  - offshore-shelf-coastal coupled modeling
  - high resolution ocean modeling covering coastal areas in detail
- MHW events are increasingly recognized as an **important factor** in the sustainability of coastal natural and urban environments, in the context of **climate change**
- The **detected positive trends** may enhance the loss of specific heat-sensitive species, **damaging the biodiversity** of both tropical (e.g. coral bleaching) and Mediterranean (e.g. mussel mortality) coastal environments.





Thank you for your attention

*“Due to the very high temperatures that exist at sea, we observed **mortality in the mussels** of the production of **2021 at a rate of 50%**, which had not been sold until then. What was worse, however, was that in August, we also saw **infant mortality**, that is, the mussels that we put in to have production in '22”*

Kontantinos Vervitis

President of the Shell Fishing Association "Poseidon" of the Municipality of Thermaikos Delta (Northern Aegean Sea)