Genesis of Marine Heatwaves in the Southern Java and Karimata Strait, Indonesia

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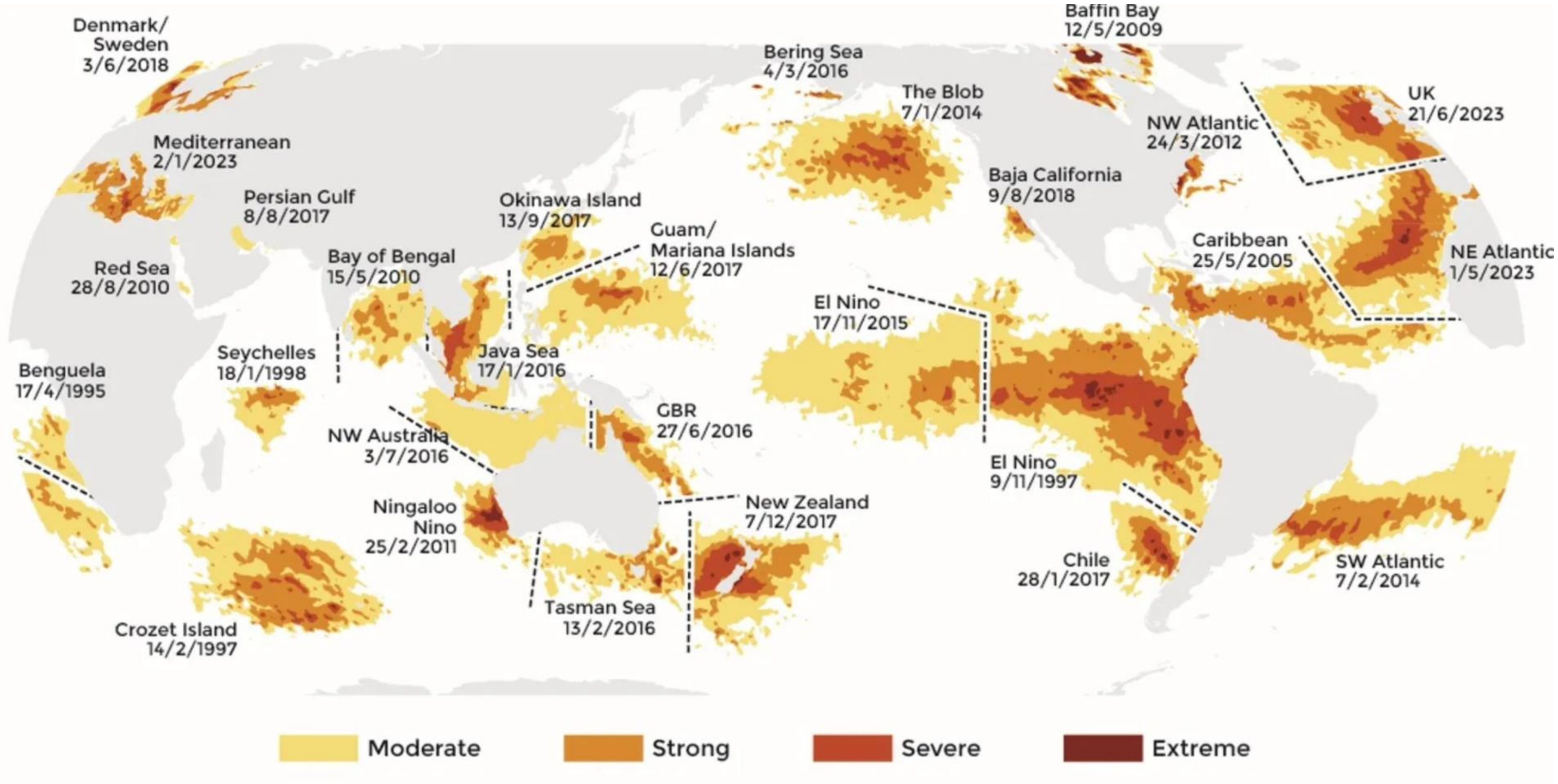
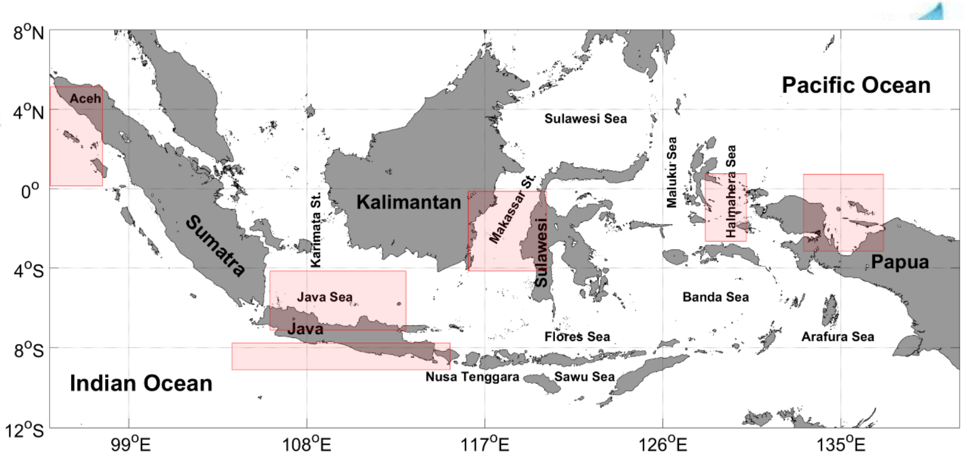
Introduction



Global Marine heatwaves since 1995 (Smith et al. 2021)

Marine heatwaves around Indonesia I



Beliyana et al 2023

- Benthuysen et al 2018
  - Tropical Australia
  - Austral Summer 2015–2016: strong El Nino
    - Temporal and spatial evolution
- Iskandar et al 2021
  - South of Java
  - Statistics and casual comparison with ENSO
- Beliyana et al 2023
  - Seas around Indonesia
  - Statistics and casual comparison with ENSO and IOD
  - Governing processes: net surface heat flux

Marine heatwaves around Indonesia II

- Characteristics
  - Limited to specific areas or time periods.
- Governing processes
  - ENSO and IOD
    - Air-sea interaction
      - Clear sky ➔ short wave radiation
      - Weakening of monsoon ➔ latent heat flux
      - Rather qualitative
  - Quantification is required.

Purpose

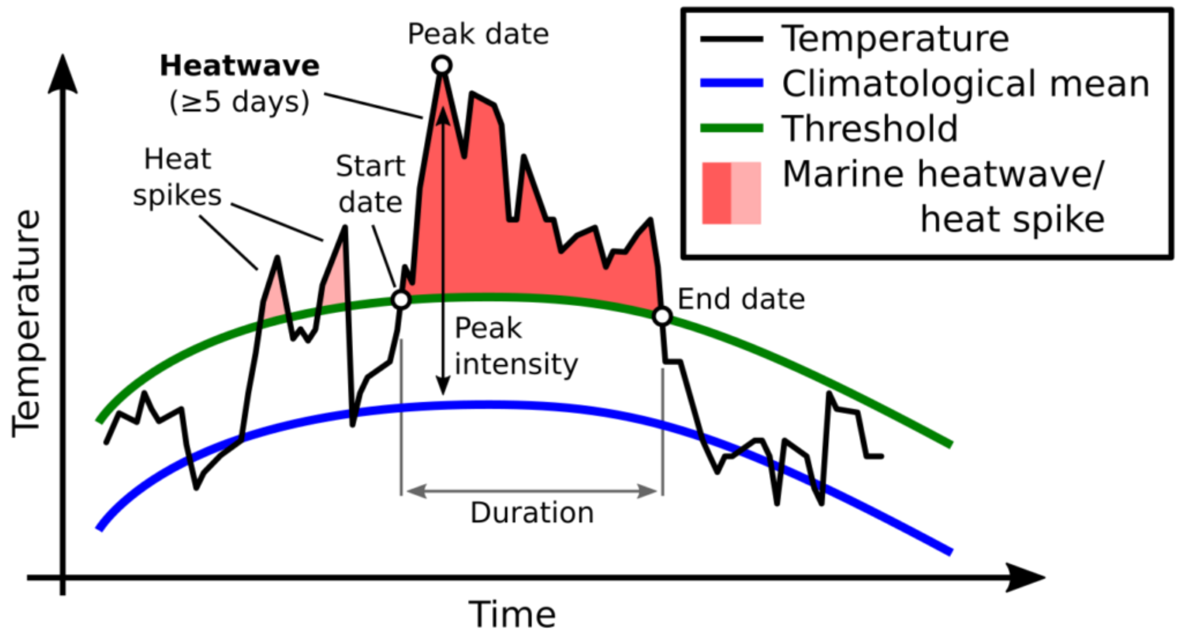
- Quantification of MHWs around Indonesia
  - Statistics
    - Better characterization
    - Comparison with IDO and ENSO
  - Governing Processes
    - Heat budget analysis

Data

- Period: 1982 to 2021
- SST:
  - Optimum Interpolation of Sea Surface Temperature (OISST) (Reynolds et al., 2007)
- Atmospheric Variables
  - European Centre for Medium-Range Weather Forecasts (ERA5)
- Oceanic Variables
  - Global Ocean Physics Reanalysis (GLORYS),

Method I: Marine Heatwaves (Hobday et al., 2016)

- 90th percentile for five consecutive days
- Frequency, duration, intensity



from http://www.marineheatwaves.org/all-about-mhws.html

Method II: Mixed Layer Heat Budget

change of mixed layer temperature T_m

advection

$$\frac{\partial T_m}{\partial t} = \frac{Q_{net}}{\rho_o c_p h} - \boldsymbol{u}_m . \nabla T_m + Res.$$

Surface heat flux

various unresolved processes

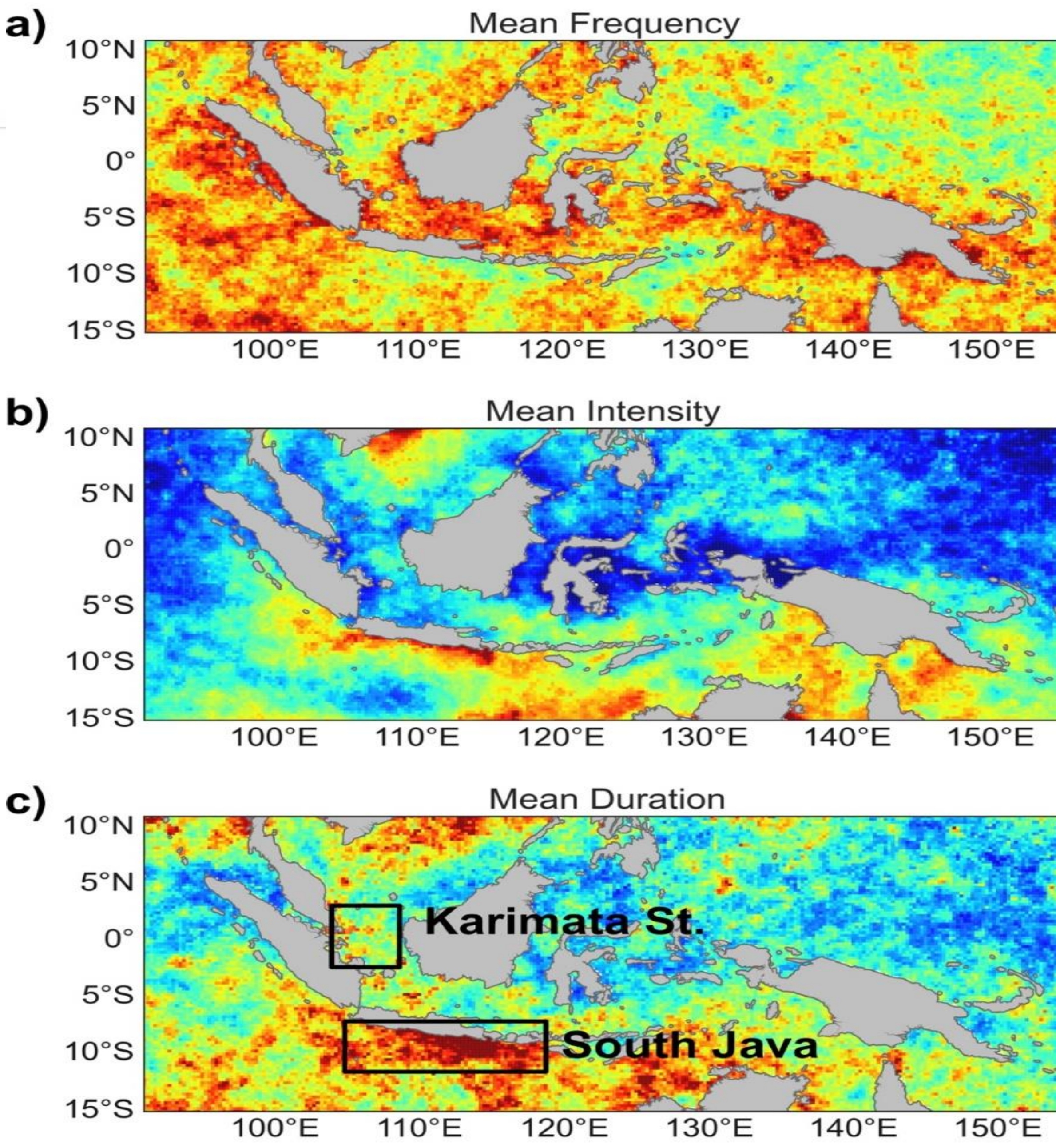
Penetrative short wave radiation below the bottom of the mixed layer is ignored.

Procedure

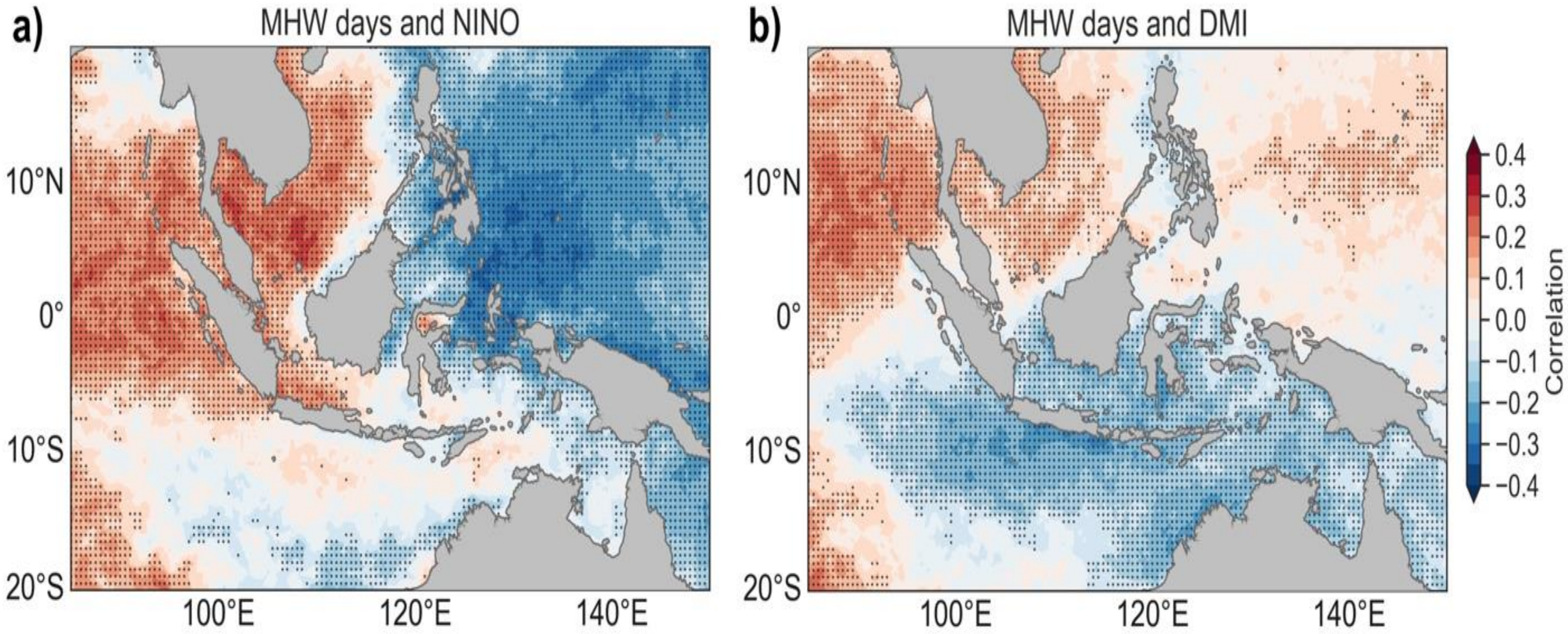
- Locate areas of strong MHWs
- Statistics and comparison with climate indices
- Heat budget analysis

Mean Properties of HMWs (1982-2021)

- Two prominent areas based on duration
  - Southern Java
  - Karimata Strait



Correlation with NINO and DMI

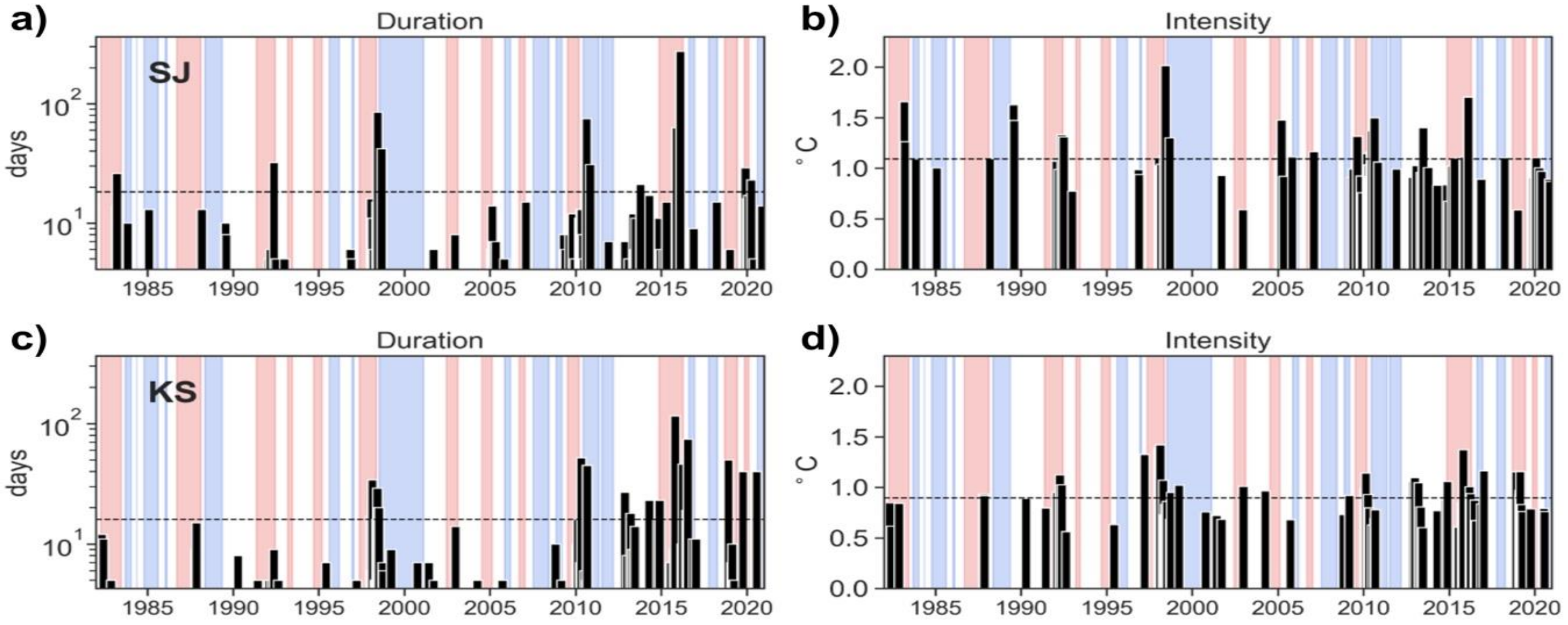


Time series of NHWs

El-Nino
La-Nina

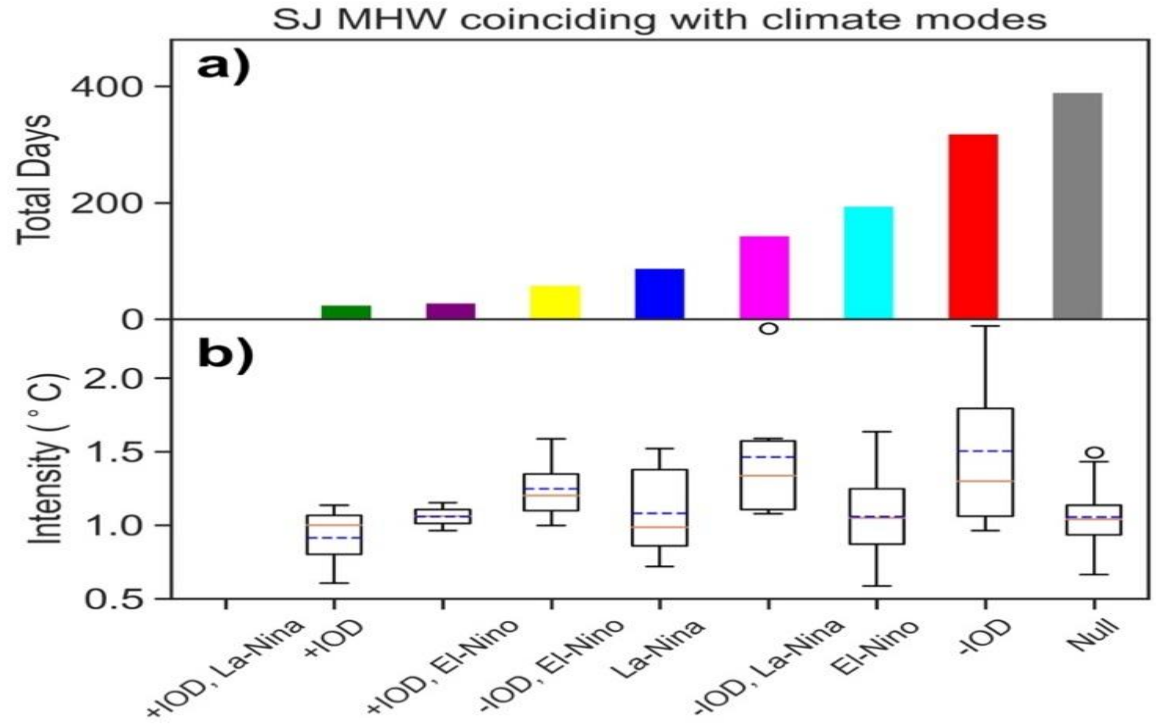
Southern Java (SJ)

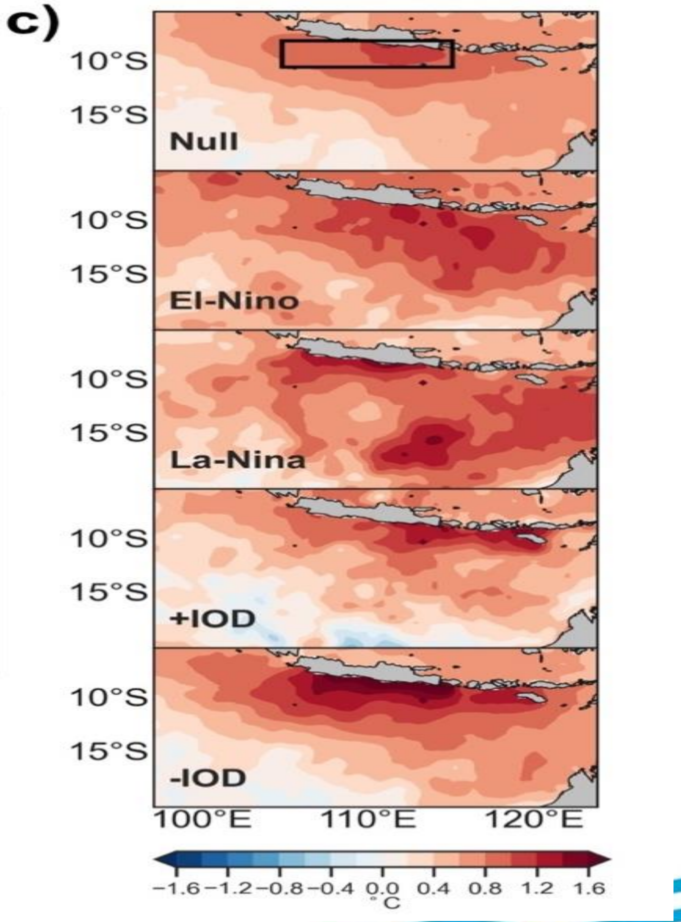
Karimata Strait (KS)



Comparison with climate indices I: SJ

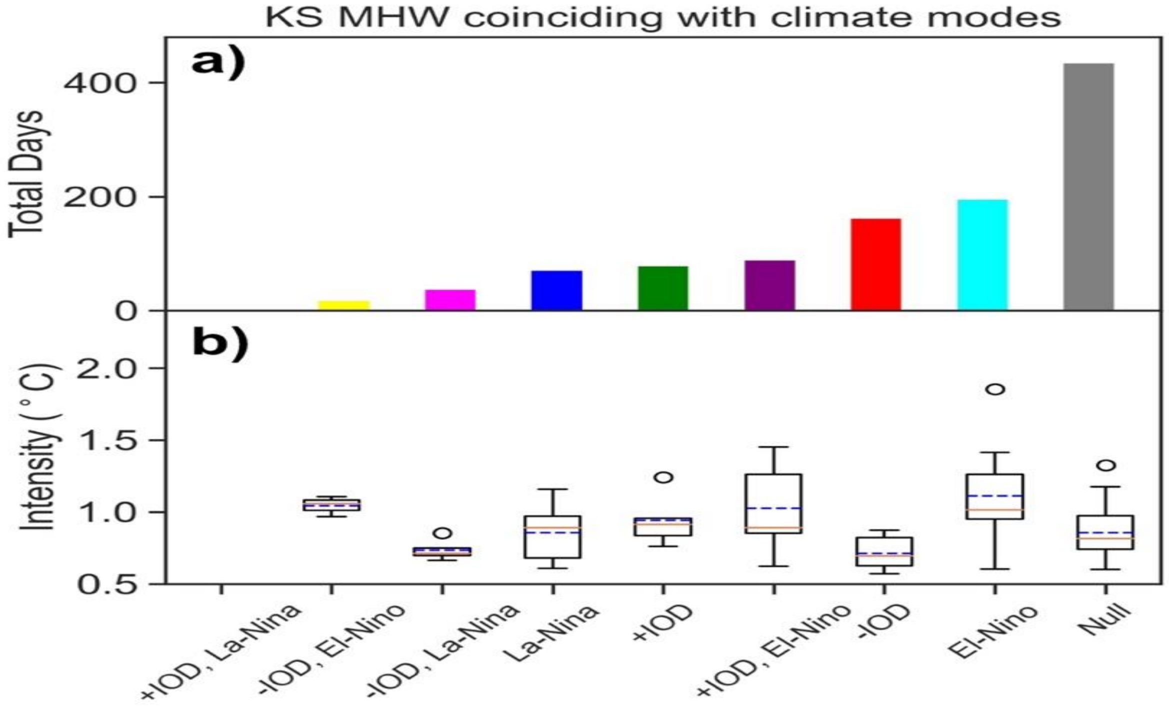
Southern Java (SJ)

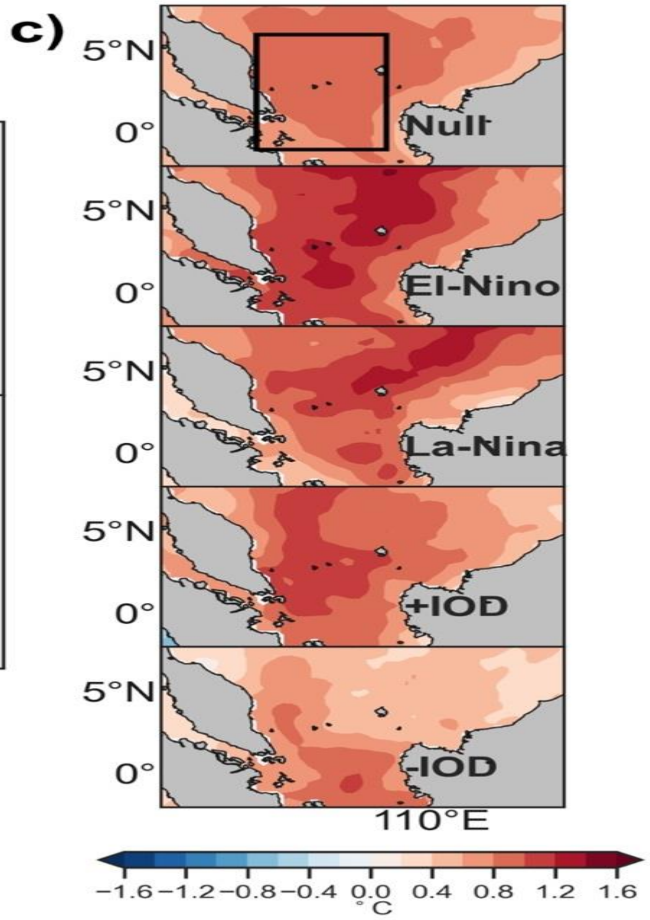




Comparison with climate indices II: KS

Karimata Strait (KS)

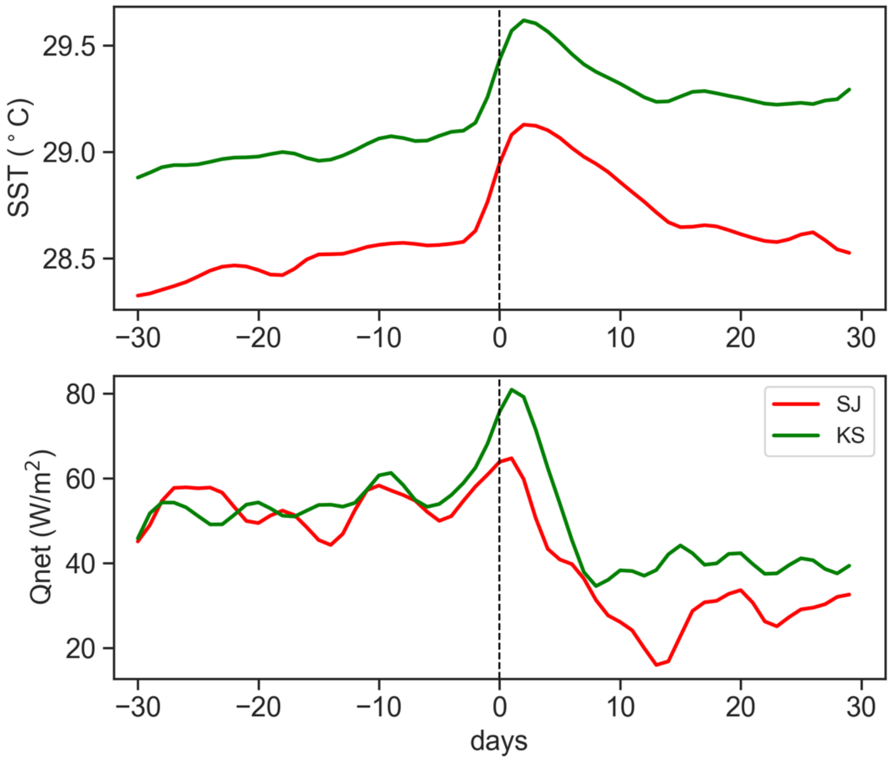




Heat budget analysis

$$\frac{\partial T_m}{\partial t} = \frac{Q_{net}}{\rho_o c_p h} - \boldsymbol{u}_m \cdot \nabla T_m + Res$$

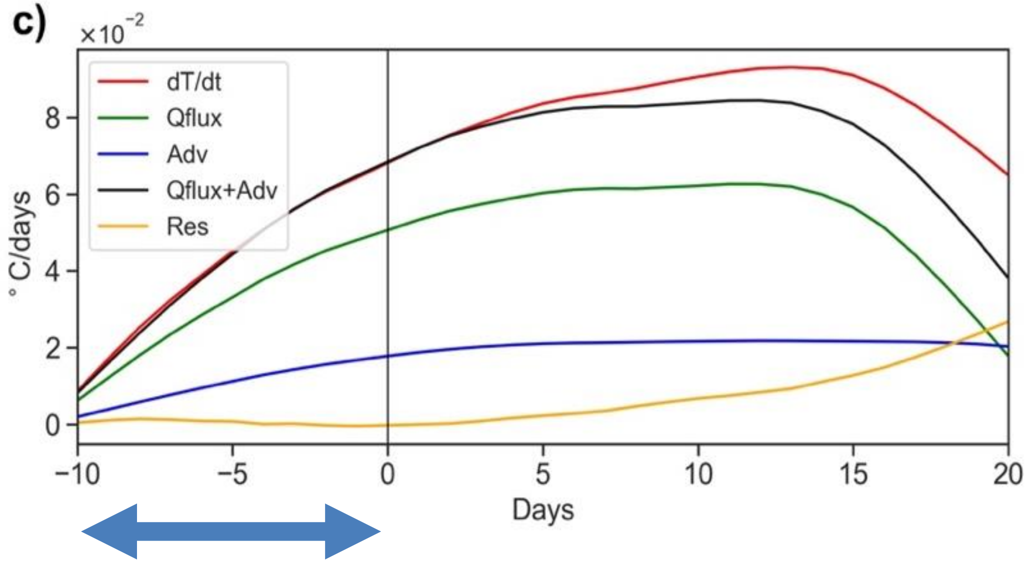
Composite

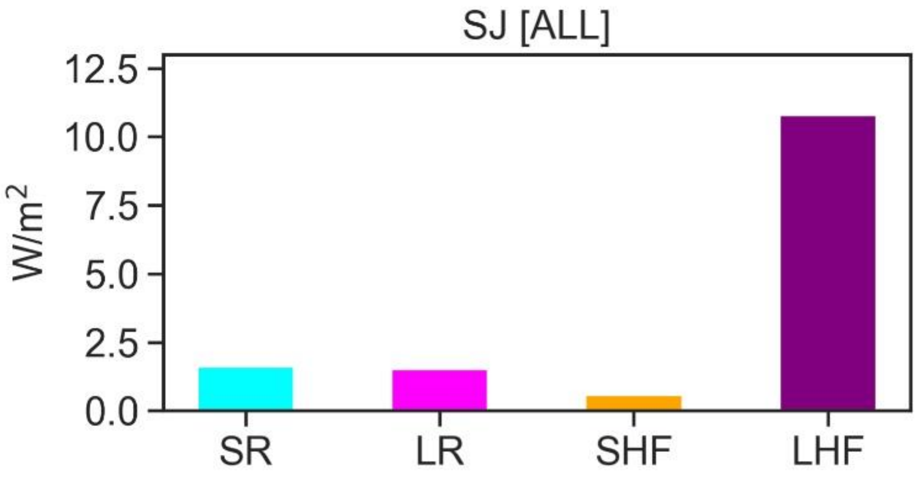


Karimata Strait (KS)

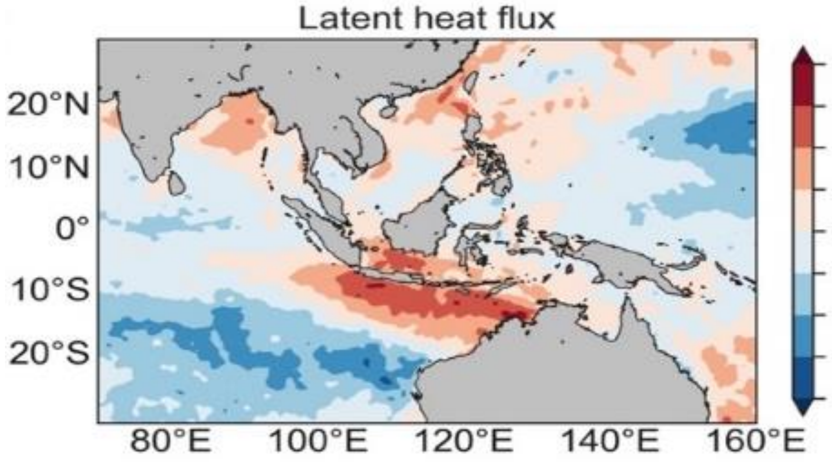
Southern Java (SJ)

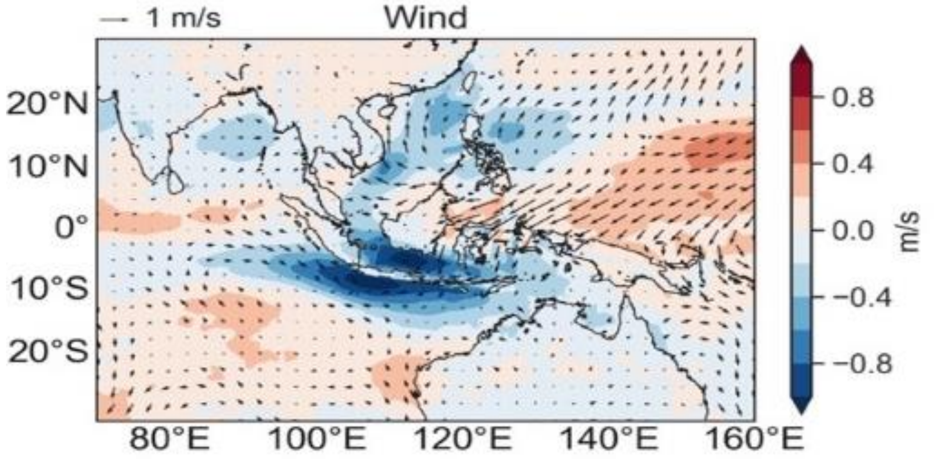
Southern Java

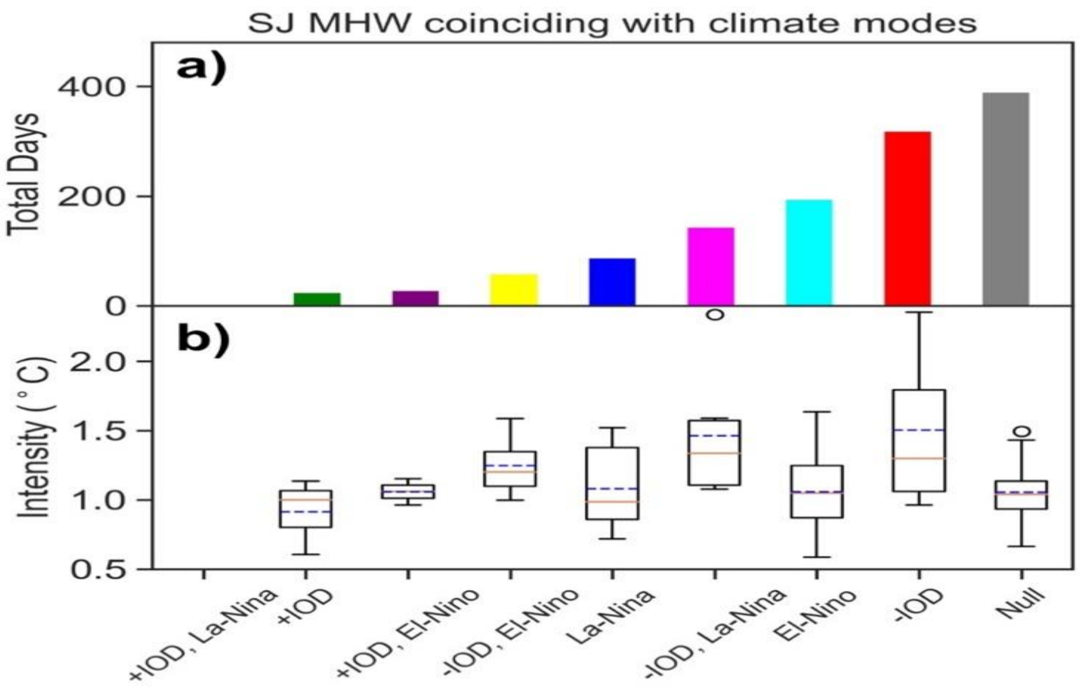


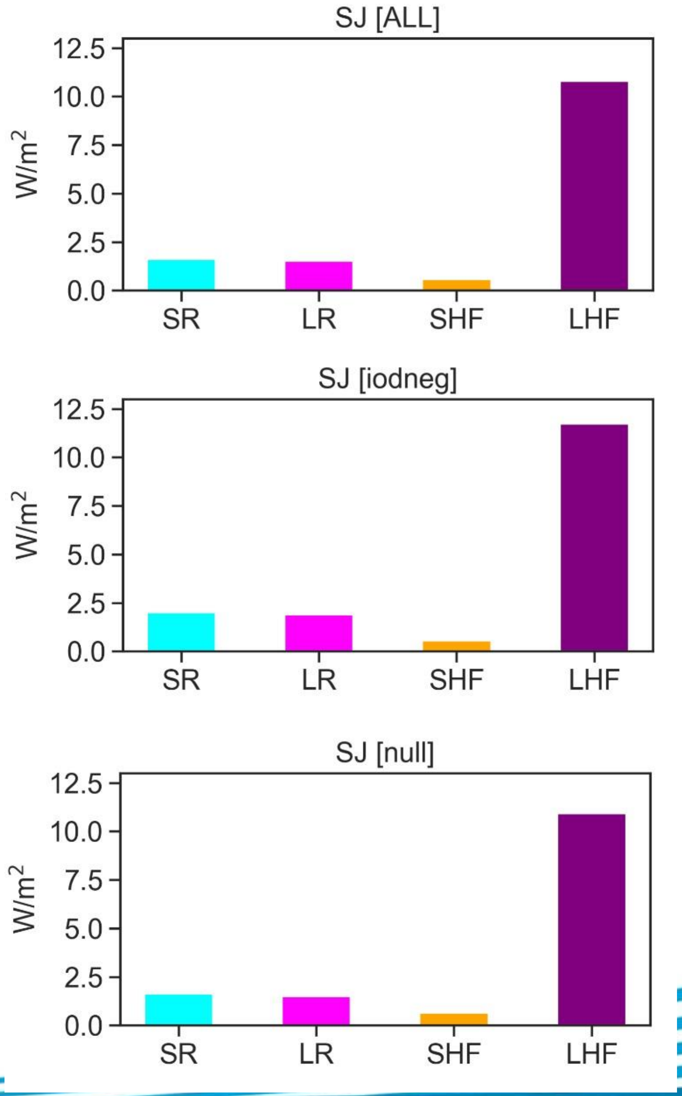


Q_{net} = SR+LR+SHF+LHF

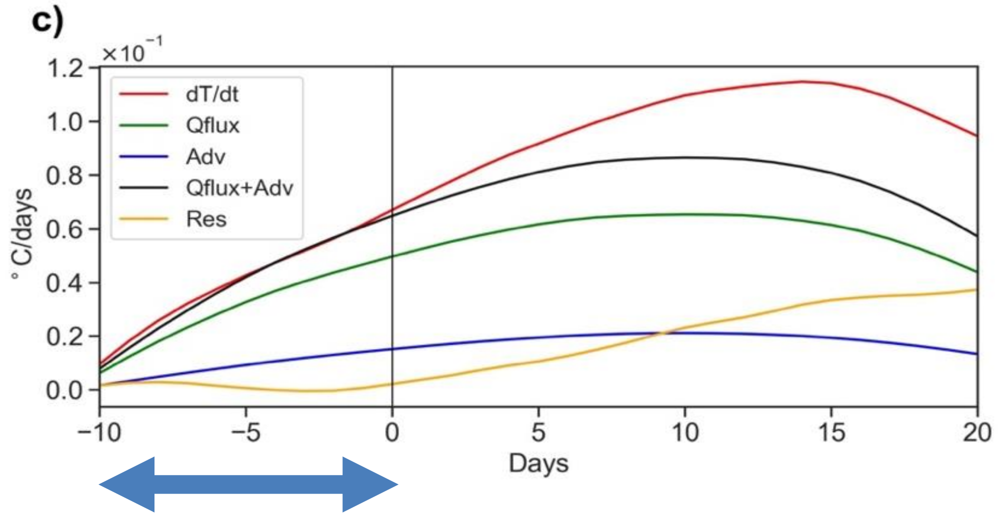

Latent heat flux
20°N
10°N
0°
10°S
20°S
80°E
100°E
120°E
140°E
160°E
20
15
10
5
0
−5
−10
−15
−20
W/m²

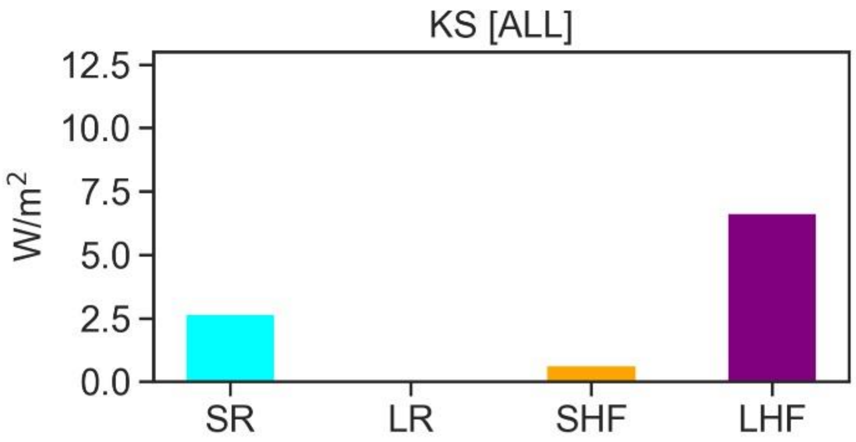

1 m/s
Wind
20°N
10°N
0°
10°S
20°S
80°E
100°E
120°E
140°E
160°E
0.8
0.4
0.0
−0.4
−0.8
m/s


SJ MHW coinciding with climate modes
a)
Total Days
b)
Intensity (°C)
+IOD, La-Nina
+IOD
+IOD, El-Nino
-IOD, El-Nino
La-Nina
-IOD, La-Nina
El-Nino
-IOD
Null

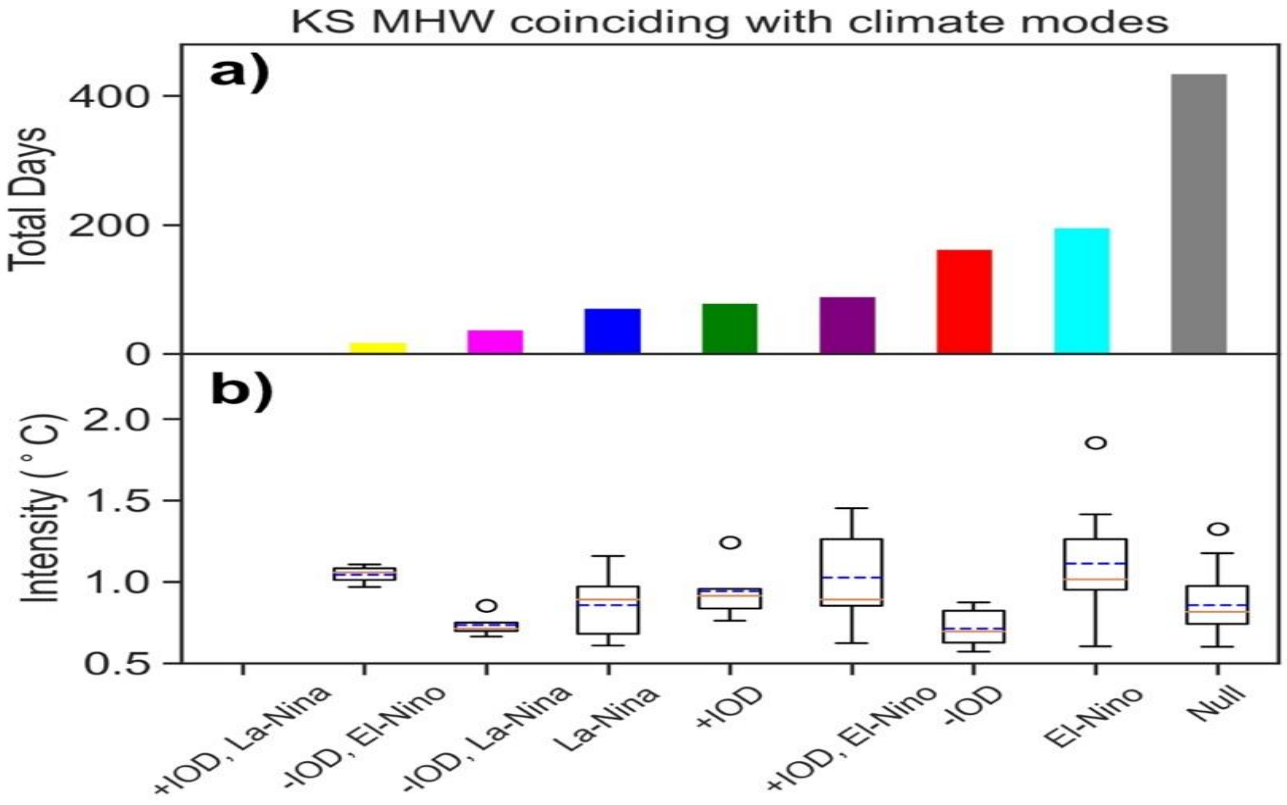

SJ [ALL]
SJ [iodneg]
SJ [null]
W/m2
SR
LR
SHF
LHF

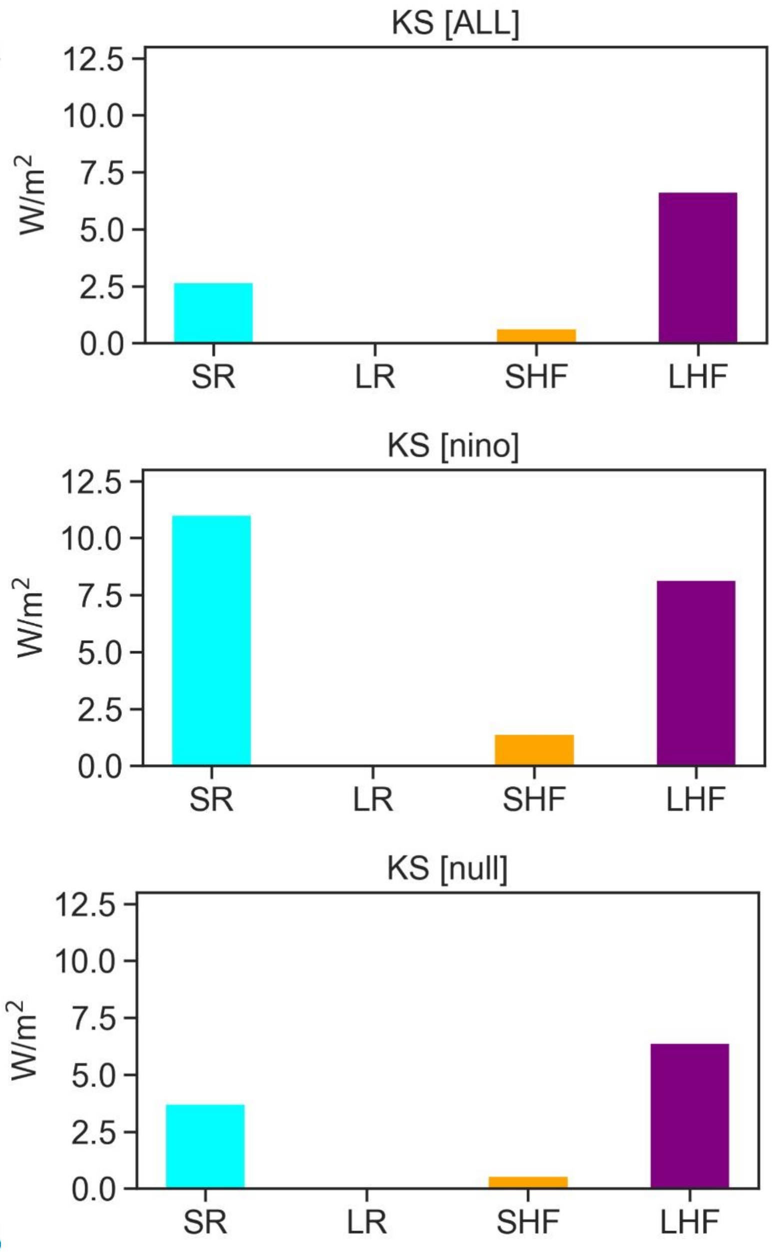
Karimata Striat

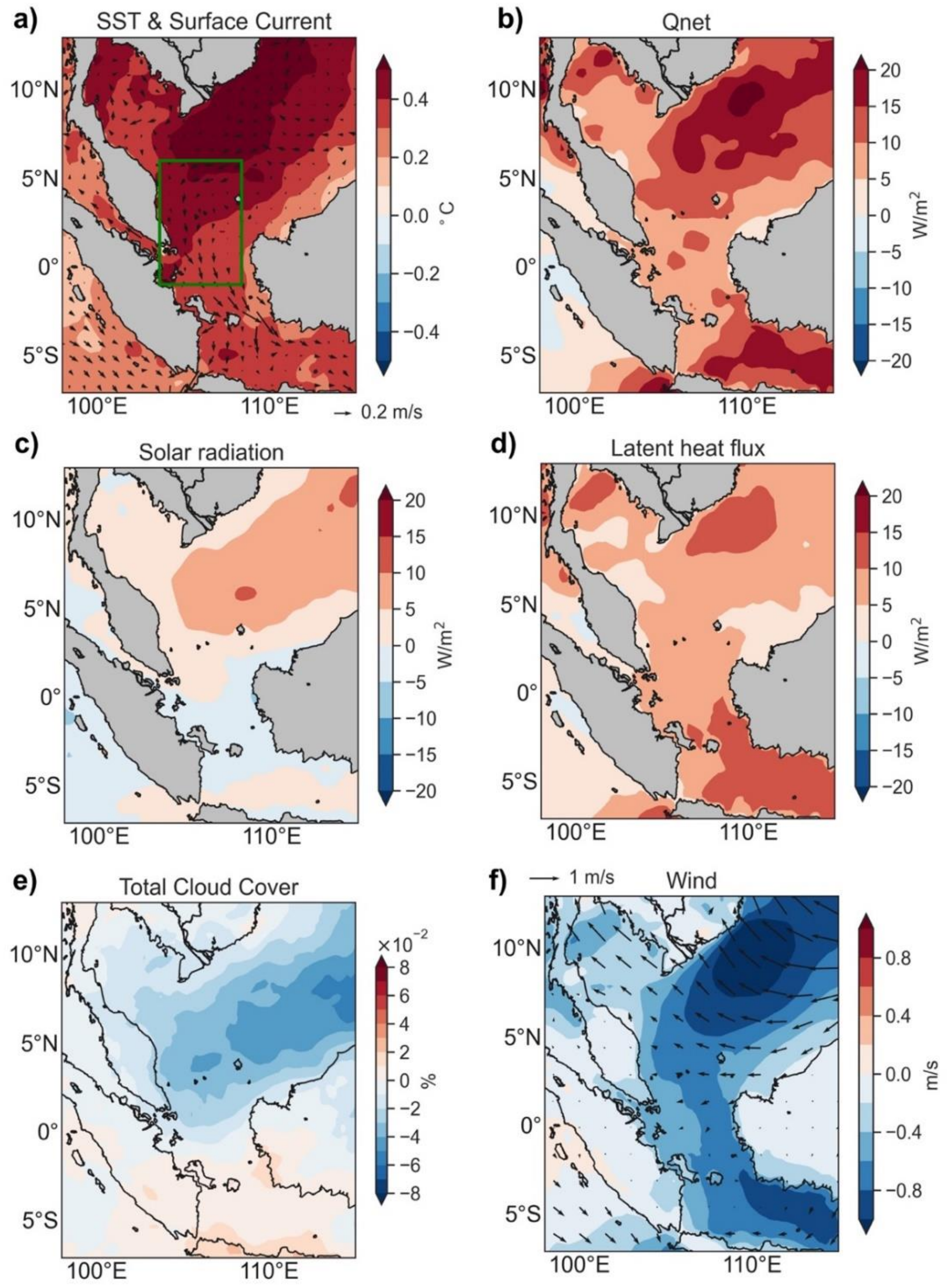




Q_{net} = SR+LR+SHF+LHF


KS MHW coinciding with climate modes
a)
b)
Total Days
Intensity (°C)
400
200
0
2.0
1.5
1.0
0.5
+IOD, La-Nina
-IOD, El-Nino
-IOD, La-Nina
La-Nina
+IOD
+IOD, El-Nino
-IOD
El-Nino
Null


KS [ALL]
KS [nino]
KS [null]
W/m2
12.5
10.0
7.5
5.0
2.5
0.0
SR
LR
SHF
LHF


a) SST & Surface Current
b) Qnet
c) Solar radiation
d) Latent heat flux
e) Total Cloud Cover
f) Wind
0.2 m/s
1 m/s
°C
W/m2
%
m/s
10°N
5°N
0°
5°S
100°E
110°E

Summary and Conclusion

- Around Indonesia MHWs are frequent.
  - Irrespective of ENSO or IOD
- South of Java
  - Strongest
    - IOD negative due to weakening of Monsoon and reduced LHF.
  - Overall
    - Reduced Latent heat flux due to weakening of wind
- Karimata Strait
  - Strongest
    - El Nino due to short wave radiation due to clear sky
    - Reduced Latent heat flux due to weakening of wind
  - Overall
    - Reduced Latent heat flux due to weakening of wind
    - Enhanced short wave radiation due to clear sky