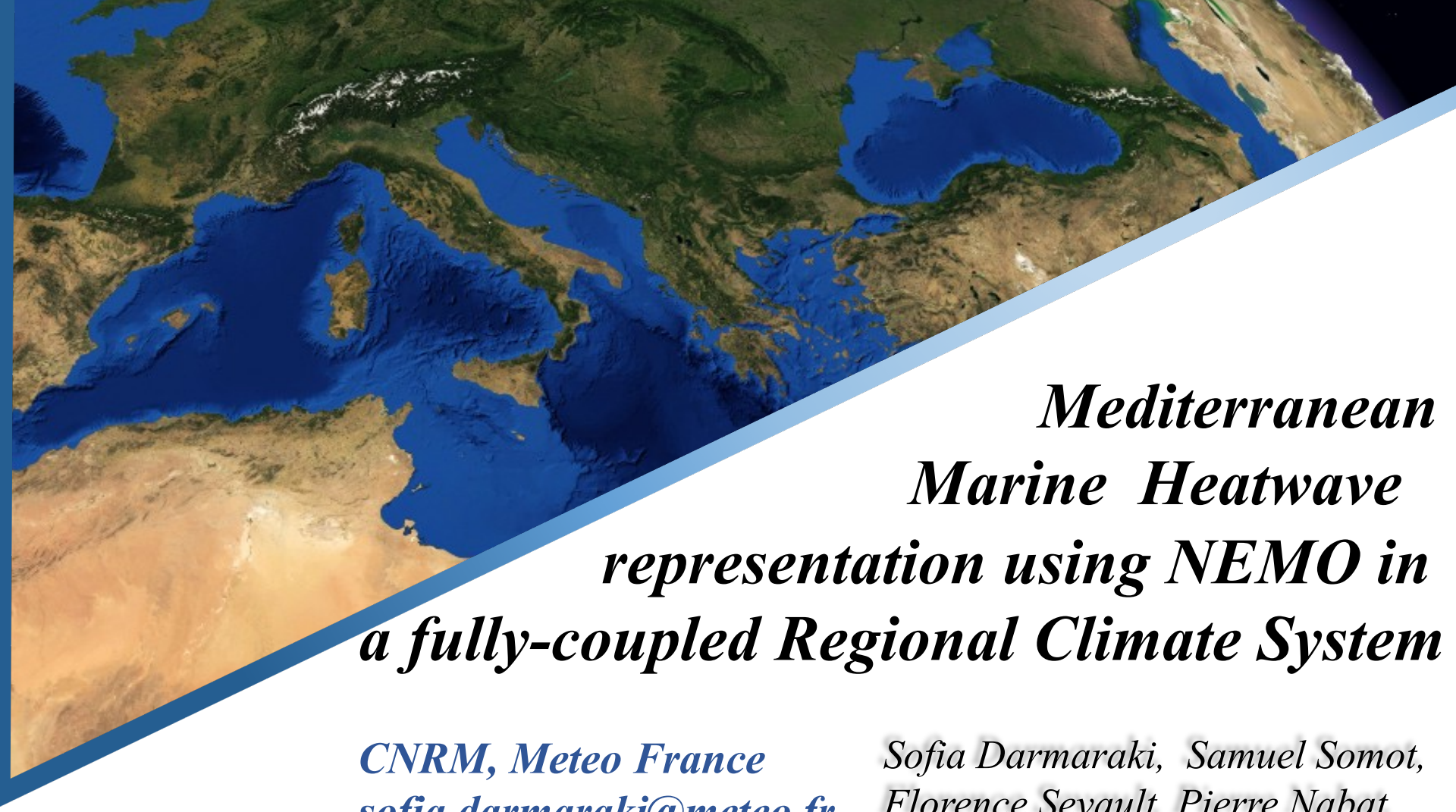

Mediterranean Marine Heatwave representation using NEMO in a fully-coupled Regional Climate System

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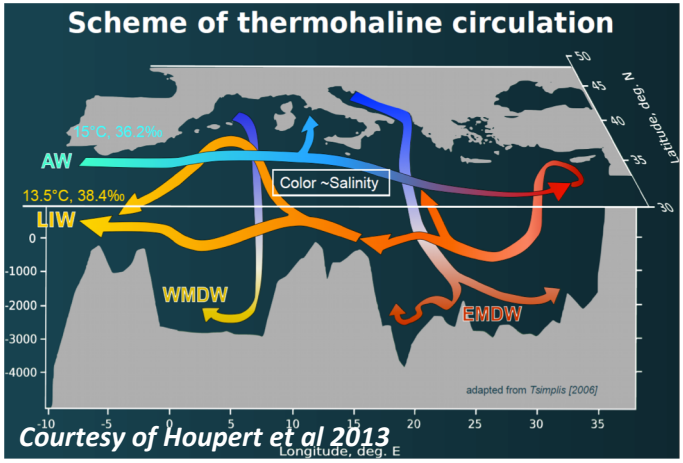
Introduction

Mediterranean Sea :

- Semi-enclosed basin (active THC circulation)
- Large marine biodiversity
- Climate Change "***Hot Spot***"

(Giorgi et al 2006)



Ligurian Sea: 2-4 °C > normal

NW Med.Sea: 2-3 °C > climatology

N.Adriatic Sea: > 23 °C for 30 days

Record sea water temperatures

Mass mortality of benthic invertebrates e.g. sponges gorgonians, red corals ***(Garrabou et al.2009,2001)***

👉 Med.Sea lacking systematic MHW assessment in the past.

Methodology

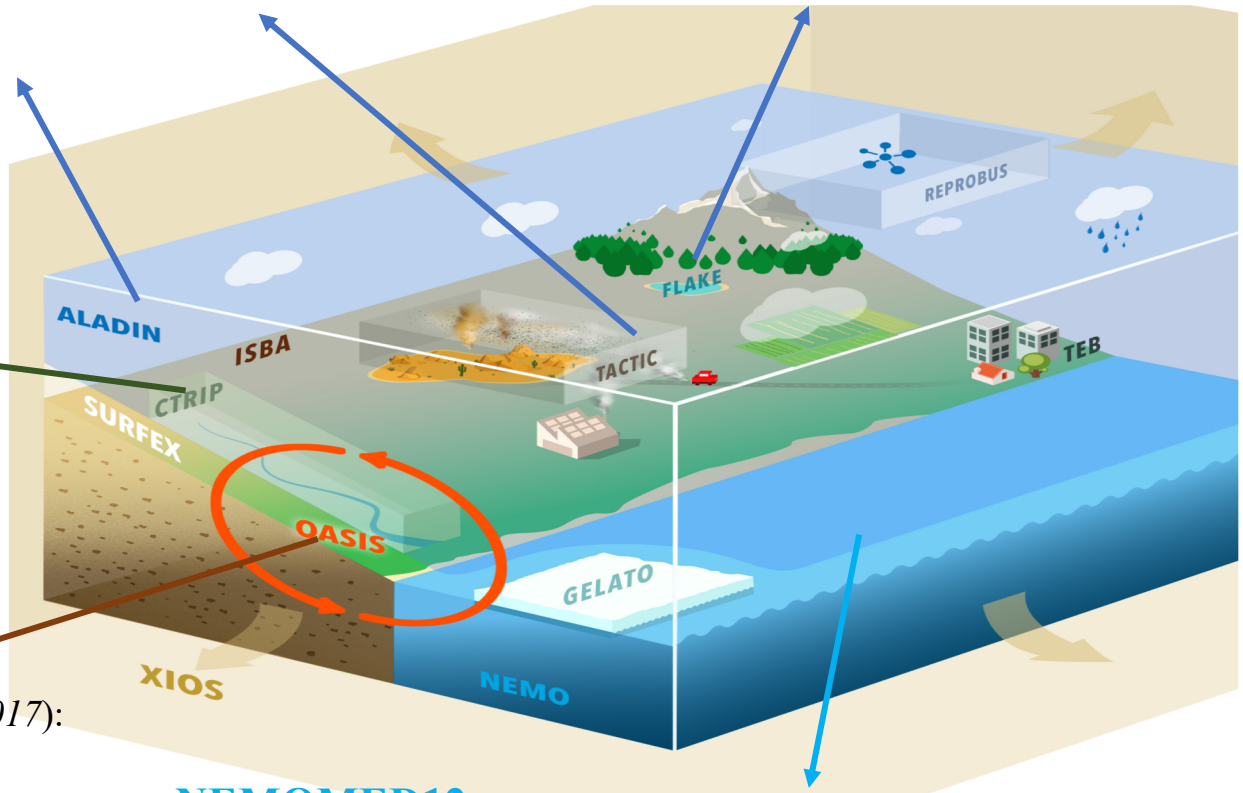
- **Fully coupled Regional Climate System Model: CNRM-RCSM6**

ALADIN_Climate V6 **:** (*Daniel et al., 2018*): ***12 Km, 91 L,*** **Atmosphere Model** New physics, turbulence, convection, radiation scheme, clouds,

(TACTIC (Nabat et al 2015)) : **Interactive aerosols**

SURFEX v8 *(Masson et al., 2013, Voldoire et al., 2017)*: **Land surface model *12 Km* ,** New physics, new bulk formula, lake model FLAKE

CTRIP (Decharme et al., 2010): Interactive **river** scheme, ***50 Km*** Floodplains, groundwater diffusive scheme, variable velocity



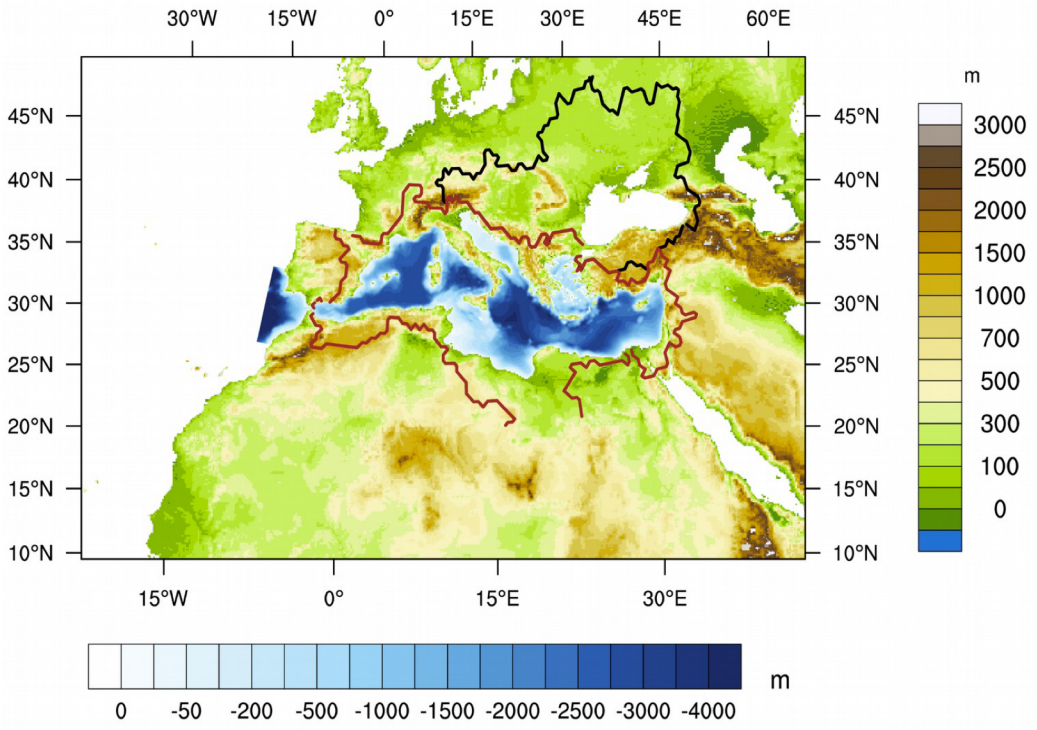
OASIS3-MCT (*Craig et al., 2017*): ***1 hour*** **coupling** frequency

NEMOMED12 (*Hamon et al., 2016 for v3.2*): Regional version of NEMOv3.6 *(Madec et al., 2008),* ***6-8 Km, 75L*** new physics

Methodology : Simulation Strategy

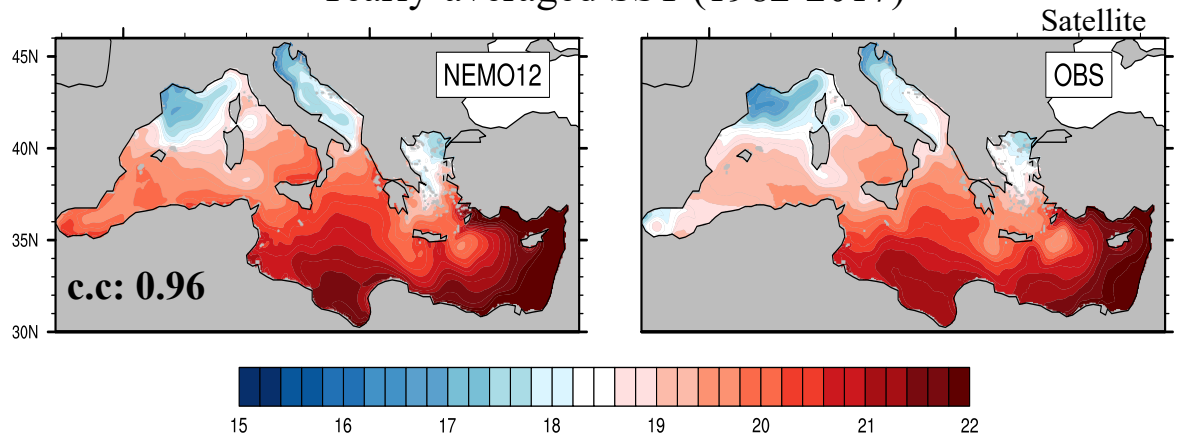
- **NEMOMED12**: Hindcast (**1982-2017**)
- Initial Conditions: **Medhymap Dataset** (1975) (10yr-smoothed average), Courtesy of G.Jorda, **ORAS4 1970-1980 average** in the Atlantic (Balmaseda et al 2013)
- Ocean spin up: 7 years (3D Damping)
- Atlantic Forcing : 1) Temperature and Salinity 3D Damping towards ORAS4 (Global Ocean Reanalysis) 2) SSH relaxation : ORAS4+seasonal cycle of CCI-ECV (Adloff et al 2017)
- Black Sea: Simple parametrization (E-P-R)
- Nile river : 12 month Climatology (After the Aswan dam)

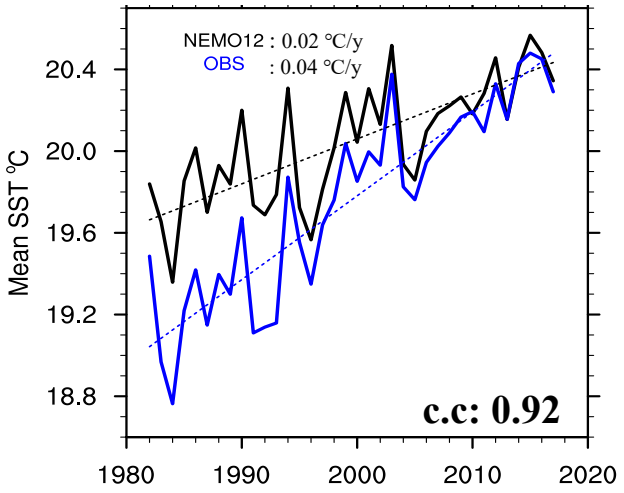
- **Observational SST (OBS)**: Mediterranean Sea High Resolution (0.04 º) L4 SST Reprocessed (**1982-2017**) by Copernicus Marine Service *(Generated/provided by Copernicus Marine Service and CNR - ISAC ROME) (Pisano et al 2016)*



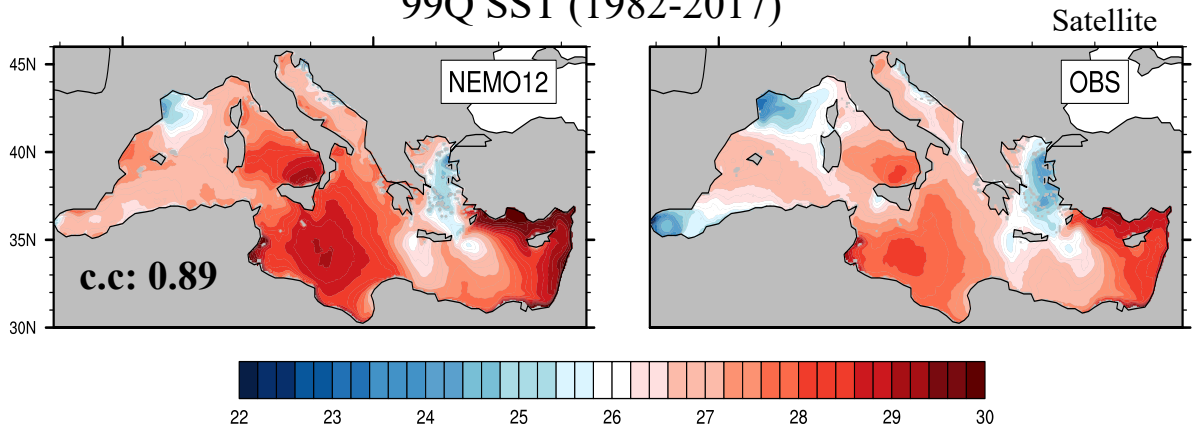
Evaluation : SST

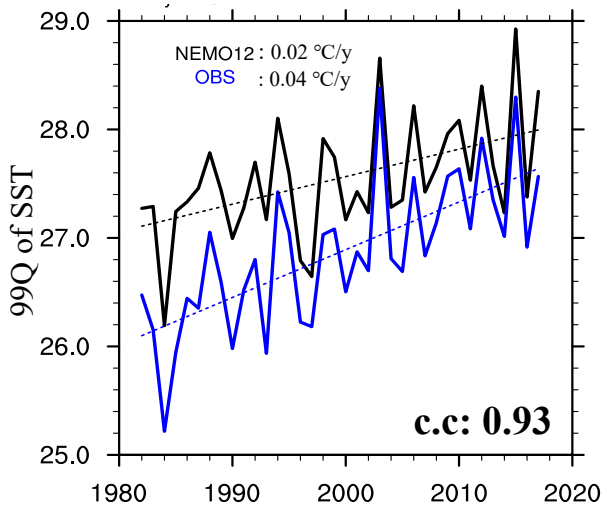
Yearly-averaged SST (1982-2017)





99Q SST (1982-2017)





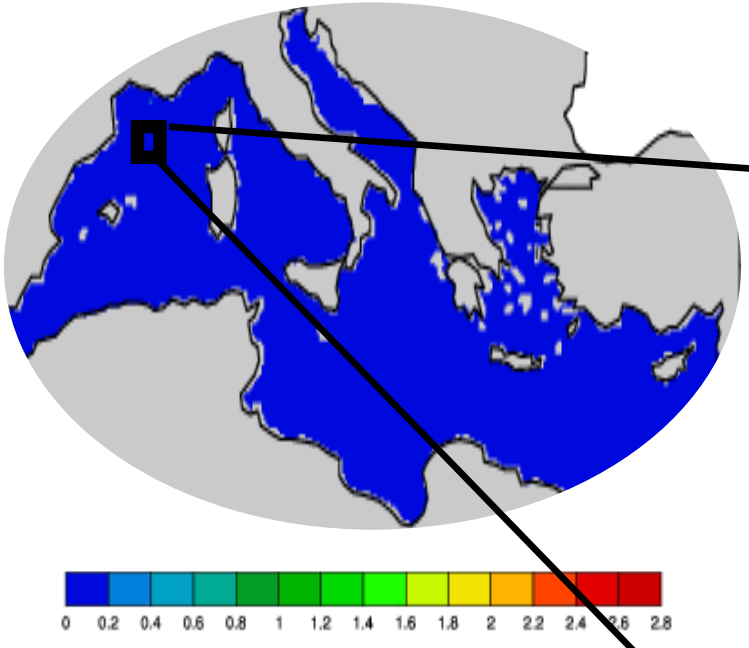
SST bias (**Model - OBS**)

Yearly AV	0.28 °C
99th Quantile	0.68 °C

Methodology :MHW Definition

- ***Theoretical Definition*** : (*Hobday et al. 2016*): **Marine Heatwave (MHW)** →

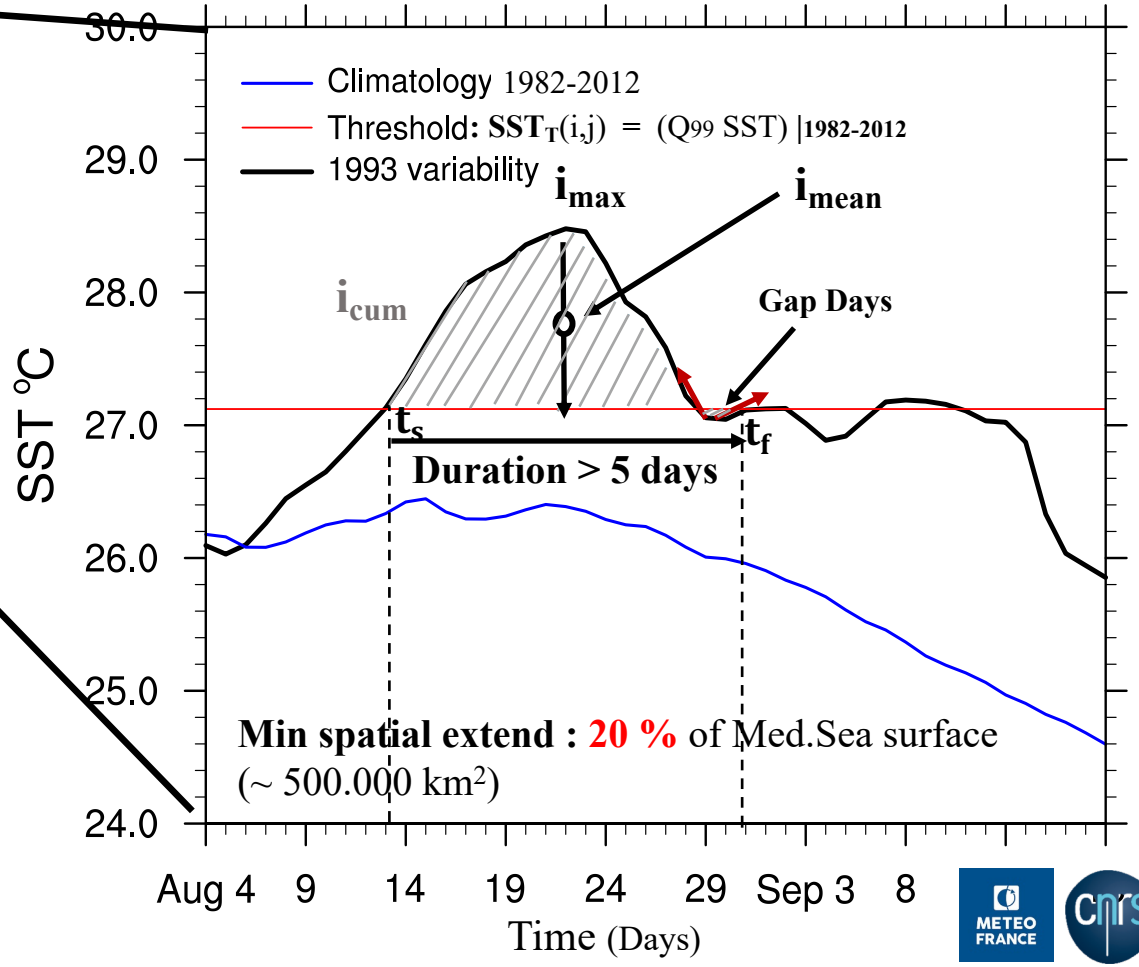
"A discrete, prolonged anomalously warm water event in a particular location"



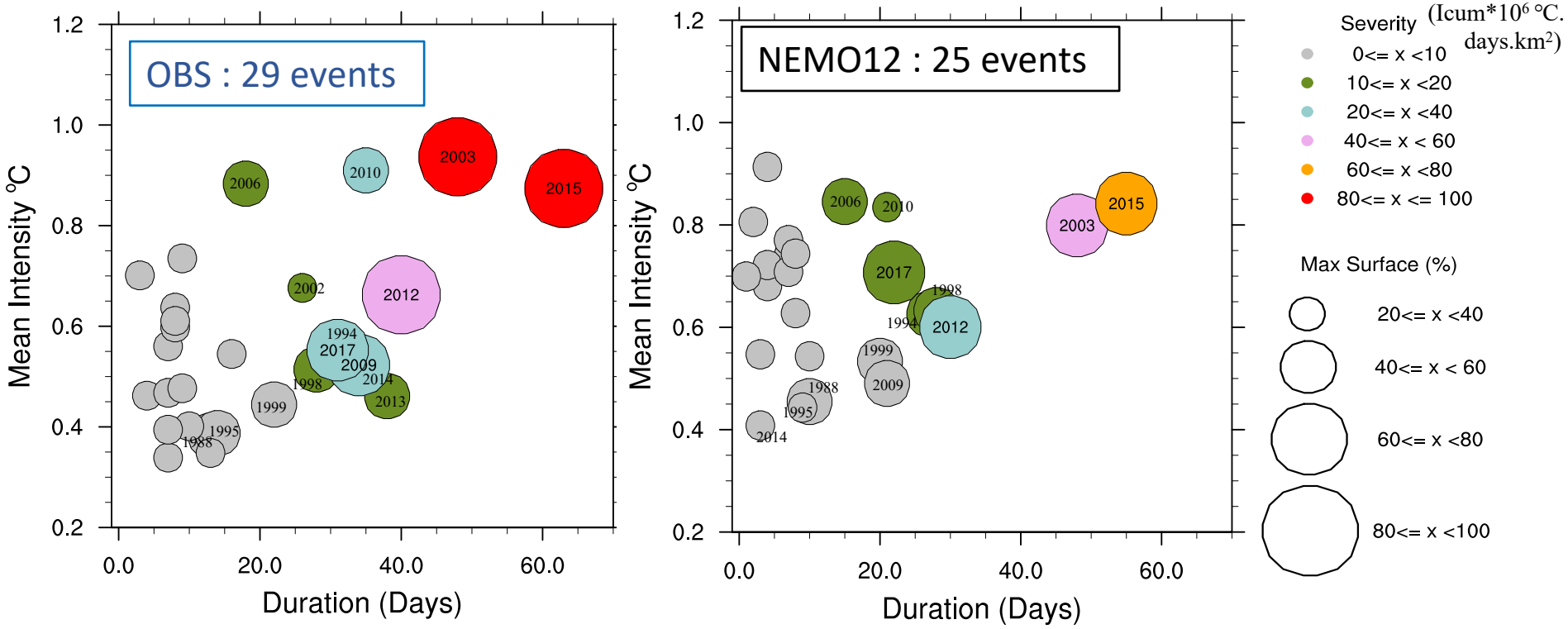
Is it possible to have one Universal Index? *NO !*

- ✓ Large-scale events
- ✓ Summer
- ✓ Long-Lasting

- ***Our local definition***



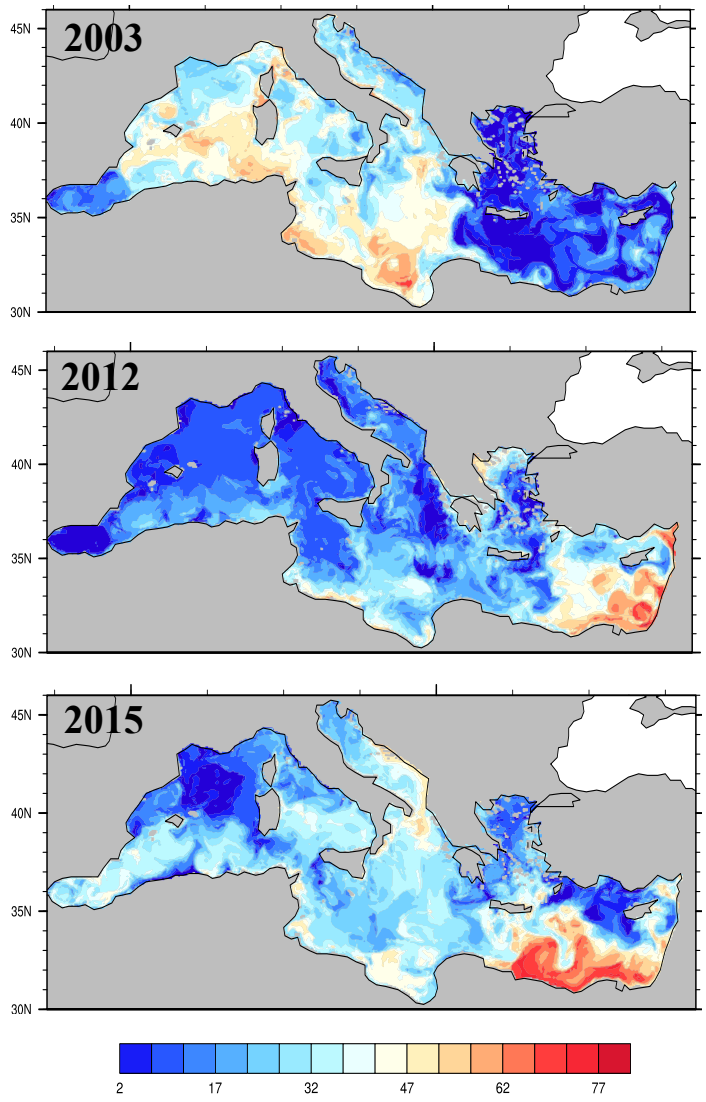
Past Surface MHWs (1982-2017)

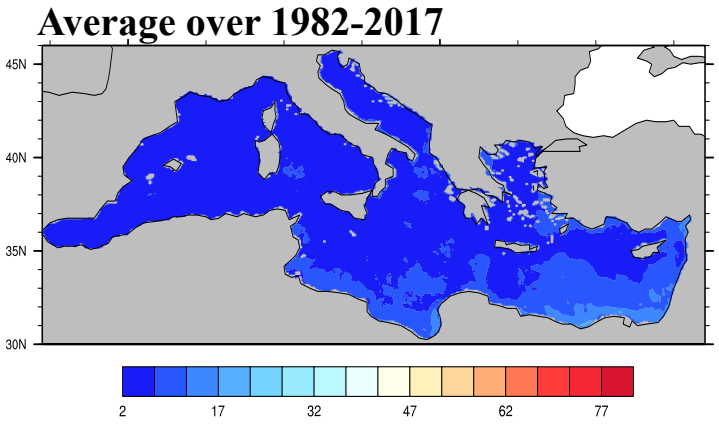


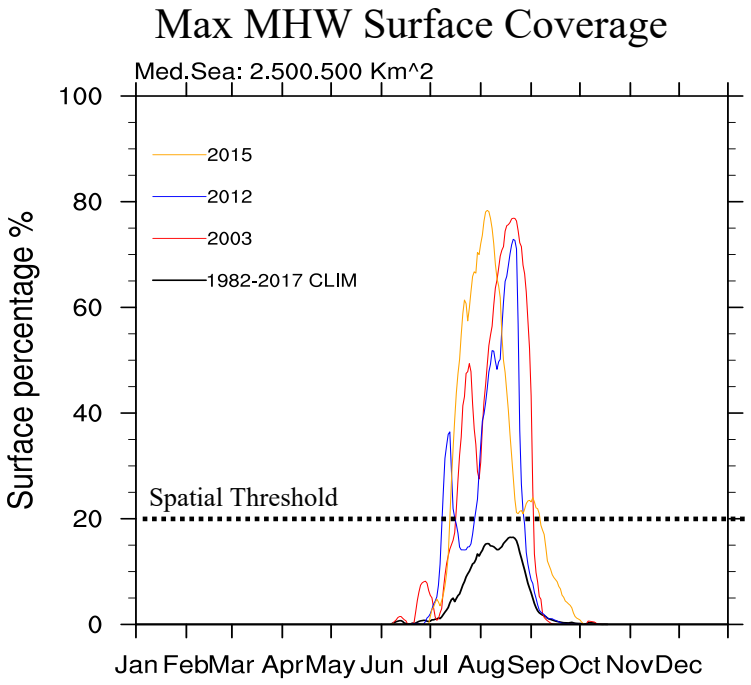
- ✓ Mean Duration : 15 days (NEMO12) , 20 days (OBS)
- ✓ Imean : 0.67 °C (NEMO12) , 0.57 °C (OBS)
- ✓ Mean Severity **(Icum)** : ~ $11*10^6$ °C.days.km^2 (NEMO12), ~$15*10^6$ °C.days.km^2 (OBS)
- ✓ Mean Max Surface Coverage : 39% (NEMO12), 44% (OBS)
- ✓ Most severe events: 2003, 2012, 2015 (Model underestimates severity and spatial extent)

Most Severe MHWs

Total Number of MHW days per year







- **2003**: Central/NW Med.Sea, Jul – Sep
- **2012**: SE Med.Sea, Aug – Sep
- **2015**: SE/Central Med.Sea, Jul – Sep
- ***SE Med.Sea*** more prone to MHWs

Conclusions

- **Evaluate** coupled regional CNRM-RCSM6 for Mediterranean **Marine Heatwaves**

- **Detect** Large-scale, long-lasting, summer MHWs based on climatological 99th percentile and local characteristics. Darmaraki et al., 2018 *Future evolution of Marine Heatwaves in the Mediterranean Sea, Climate Dynamics* (**in review**))

- **Good representation** of mean and extreme Mediterranean SST, average MHW characteristics by the model.

- **Simulated** MHWs over 1982-2017: Duration: ~15 days, Imean (~0.5 °C), Max Surface Coverage (~39%), Severity (~ 11 °C.days.km^2)

- **Most severe** events : **2003, 2012, 2015** between July-September. Last >2 months in some areas.

- **SE Mediterranean** more vulnerable to MHWs

- ***Perspective***
- **Explaining** factors of surface MHWs
- MHWs at **depth**
- MHW detection used in **forecasting**
- Applications for marine **ecosystems**

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