GESTIONE E PREVENZIONE
DEL RISCHIO COSTIERO
DI UN TERRITORIO
IN EVOLUZIONE

PISA 8 OTTOBRE 2019
Scuola Normale Superiore
Piazza dei Cavalieri
9:00 - 17:30

Analisi di eventi meteomarini estremi nel Mediterraneo Nord-Occidentale

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(2) CNR-ISAC
(3) Max Planck Institut fur Meteorologie
(4) Università dell'Aquila – CETEMPS
(5) CNR - Consorzio LAMMA

CONSORZIO LaMMA

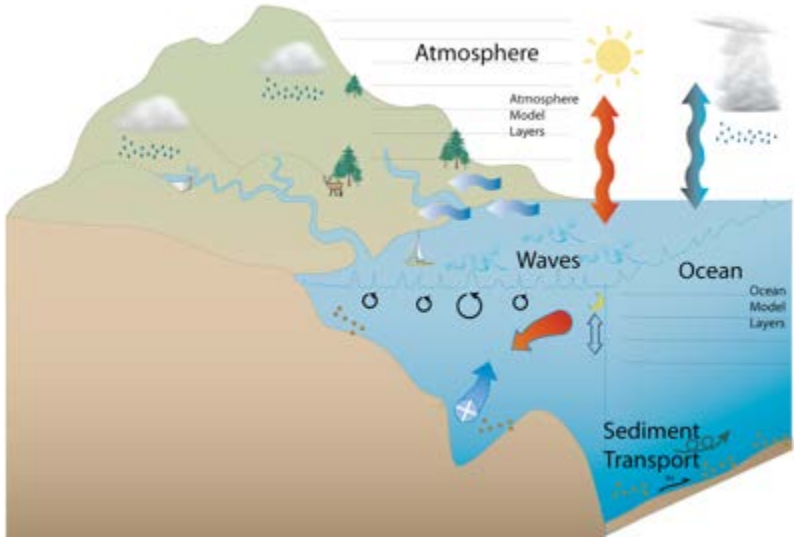
Regione Toscana

La cooperazione al cuore del Mediterraneo

Interreg
UNIONE EUROPEA
MARITTIMO-IT FR-MARITIME
Fondo Europeo di Sviluppo Regionale

MAREGOT

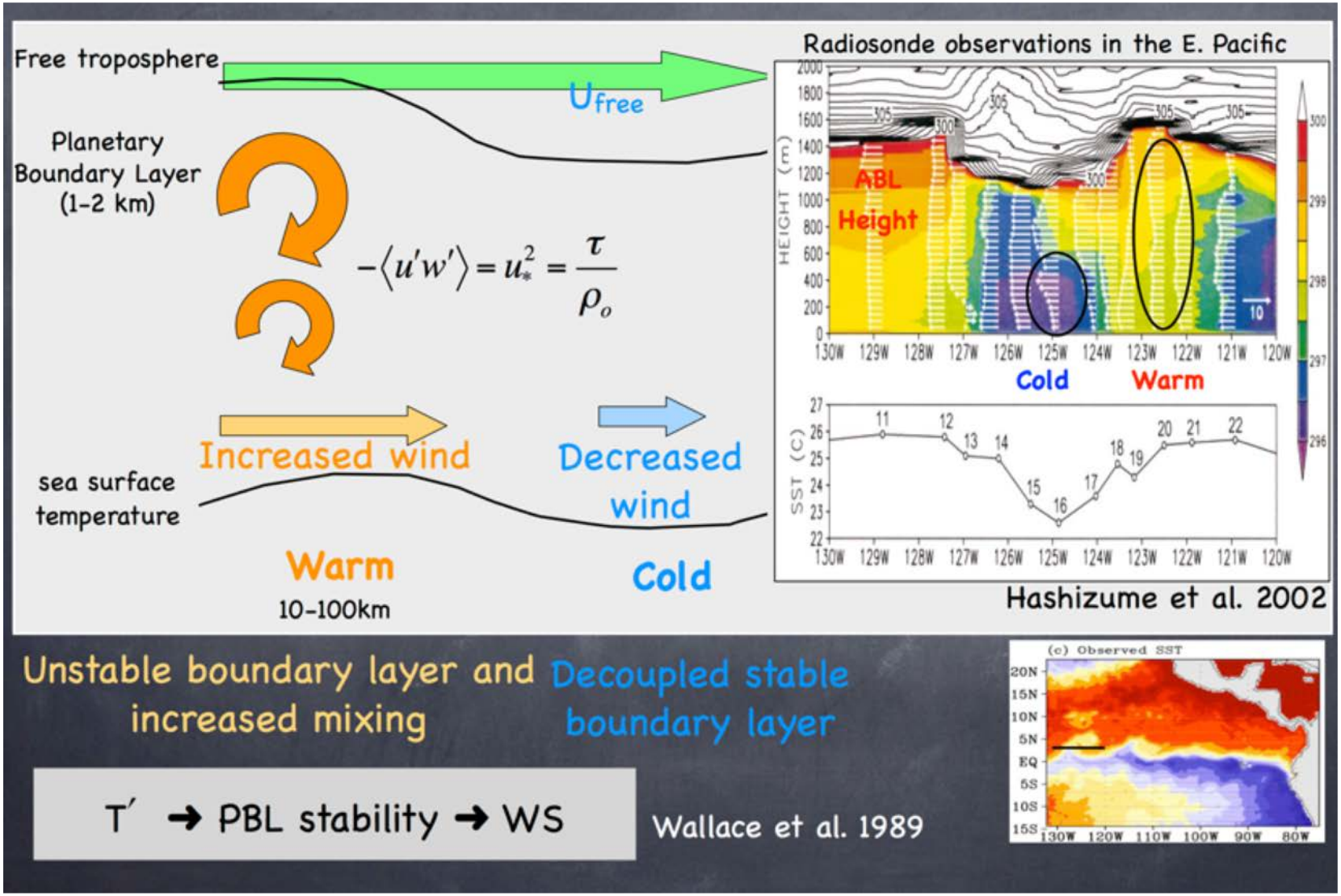
Atmosphere-ocean interactions



The aim of this work is to answer to the question:

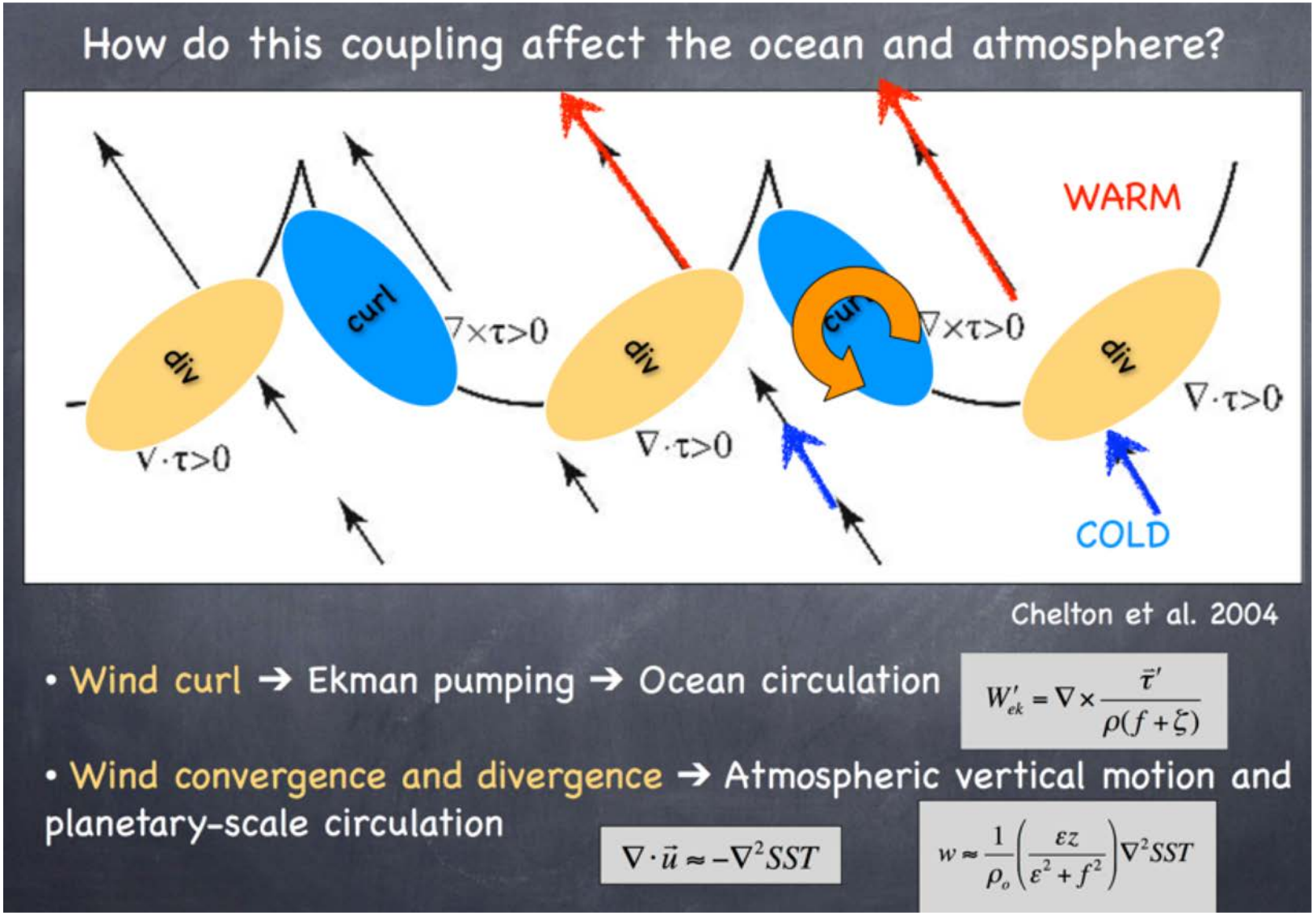
- ***Are coupled numerical models the best solution for the environmental simulations?***
- ***How much does the SST influence the dynamics of the PBL?***
- ***Is it necessary to implement a coupled numerical model to simulate extreme events?***
- ***How important is the role of SST in coastal extreme phenomena?***

Atmosphere-ocean interaction (SST <-> WIND)



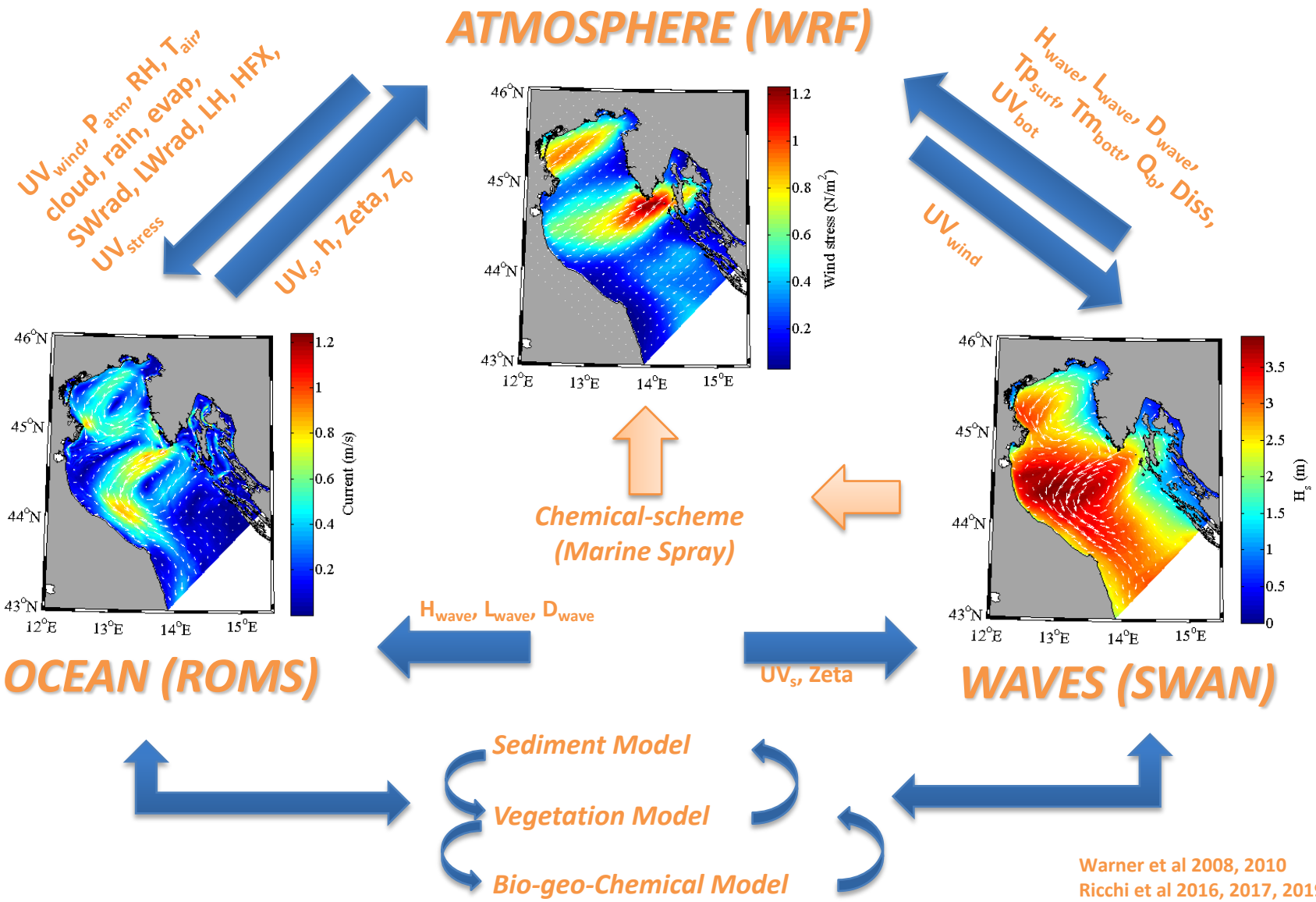
Chelton et al 2001,2005,2007; O'Neill 2005,2010; Neroli et al 2018;

Atmosphere-ocean interaction (SST <-> WIND)



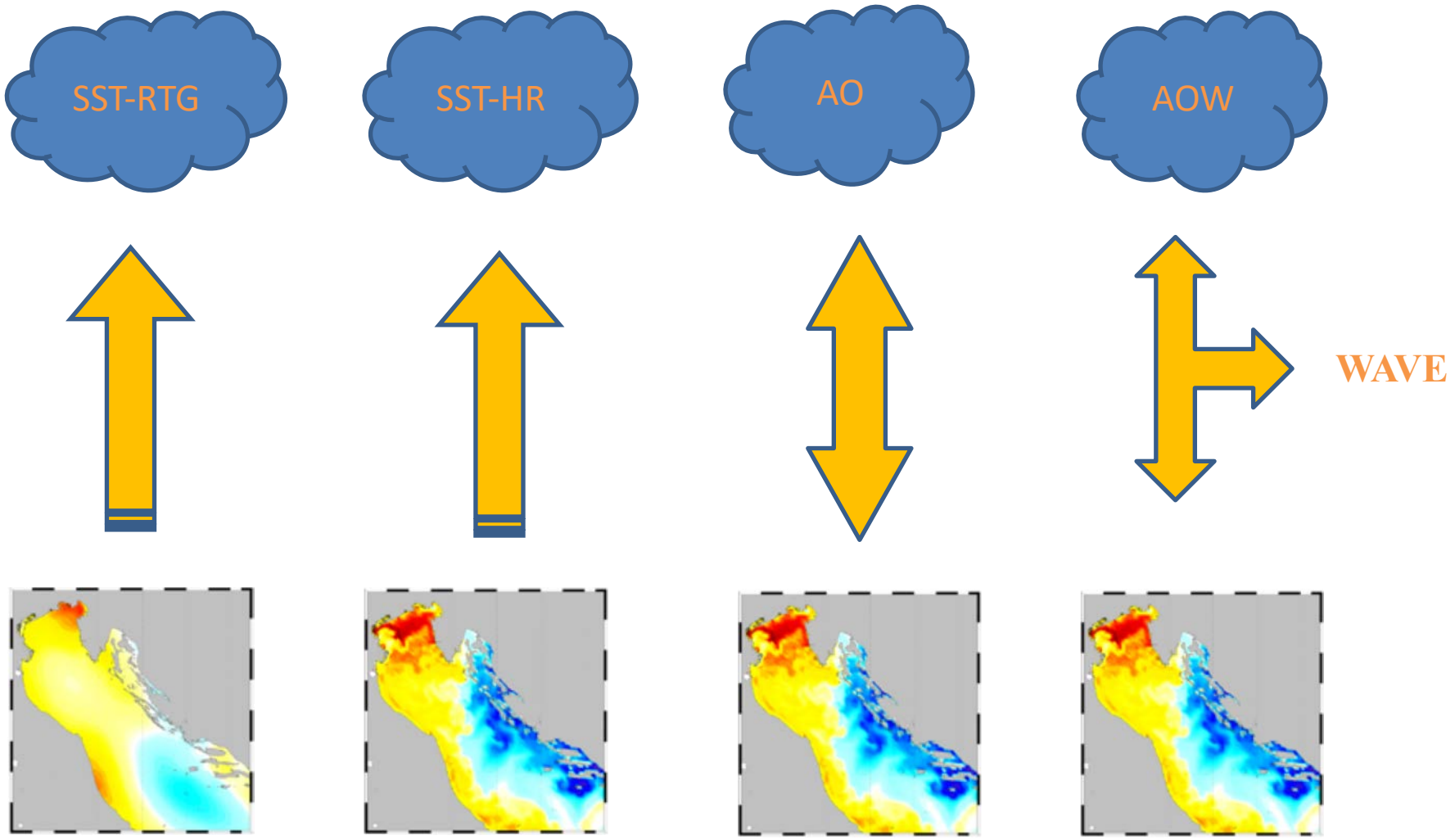
Chelton et al 2001,2005,2007; O'Neill 2005,2010; Neroli et al 2018

COAWST Modeling System



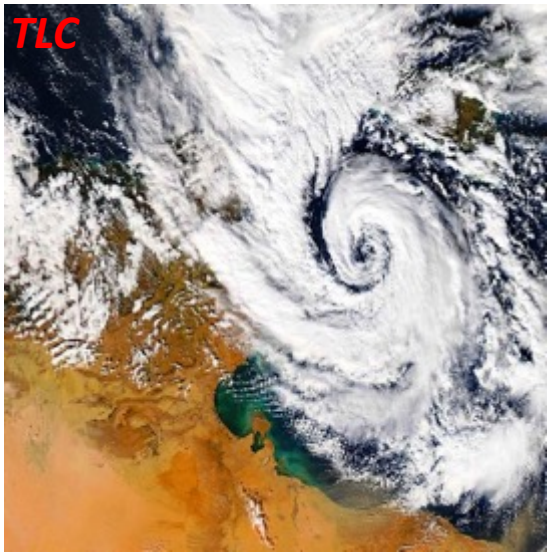
Warner et al 2008, 2010
Ricchi et al 2016, 2017, 2019
Ricchi A., PhD
Carniel et al 2014,2015,2016, 2017

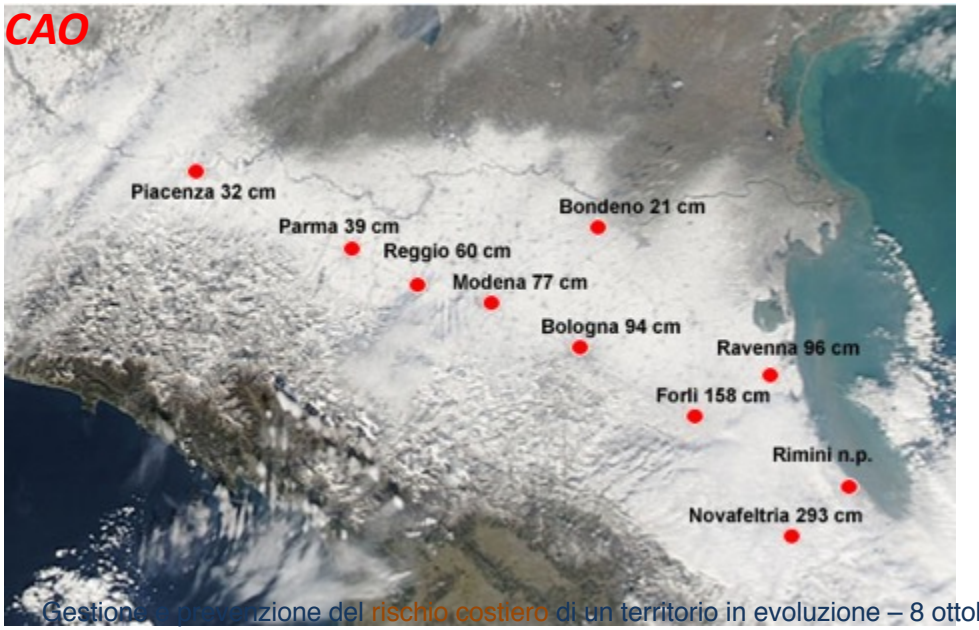
Numerical Approach

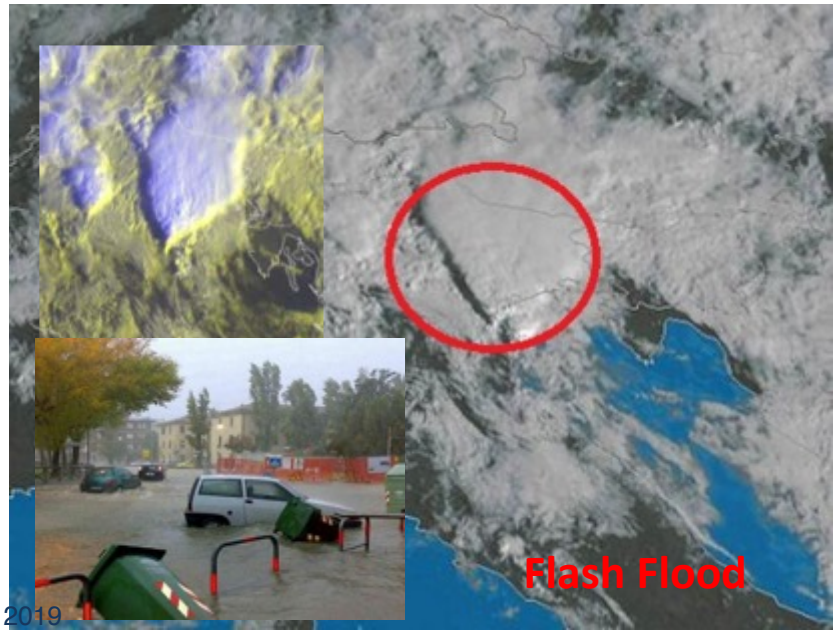


Application

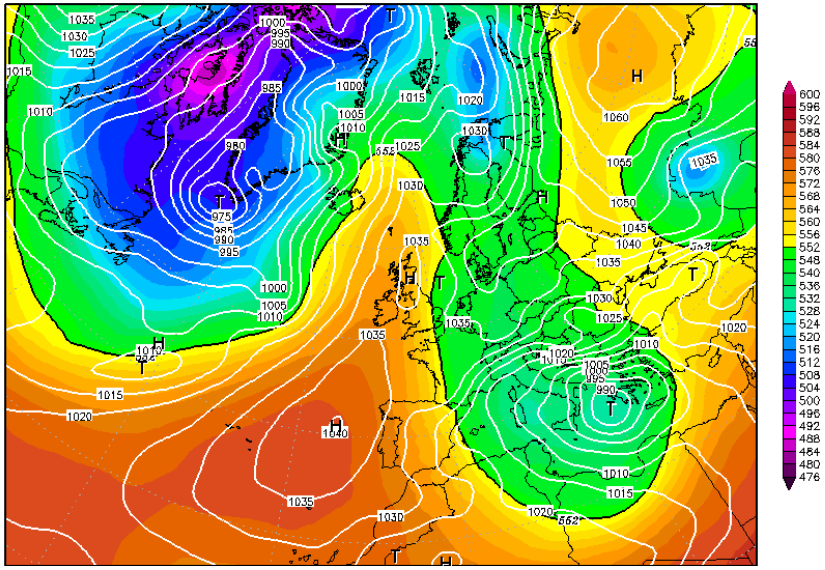
- CAO (Cold Air Outbreak)
- Dense water formation
- TLC (Tropical like Cyclones)
- Flash Flood
- “Rapid” (or ”Bomb”) Ciclogenesys

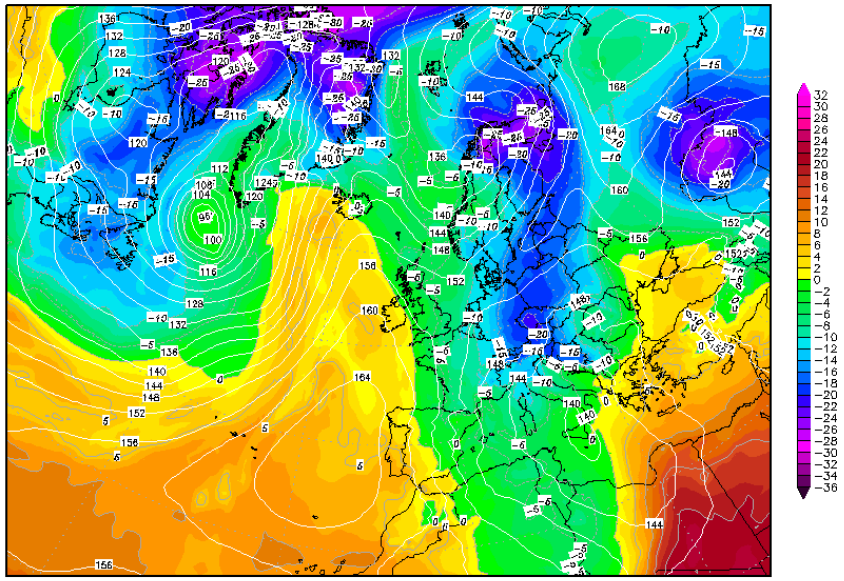


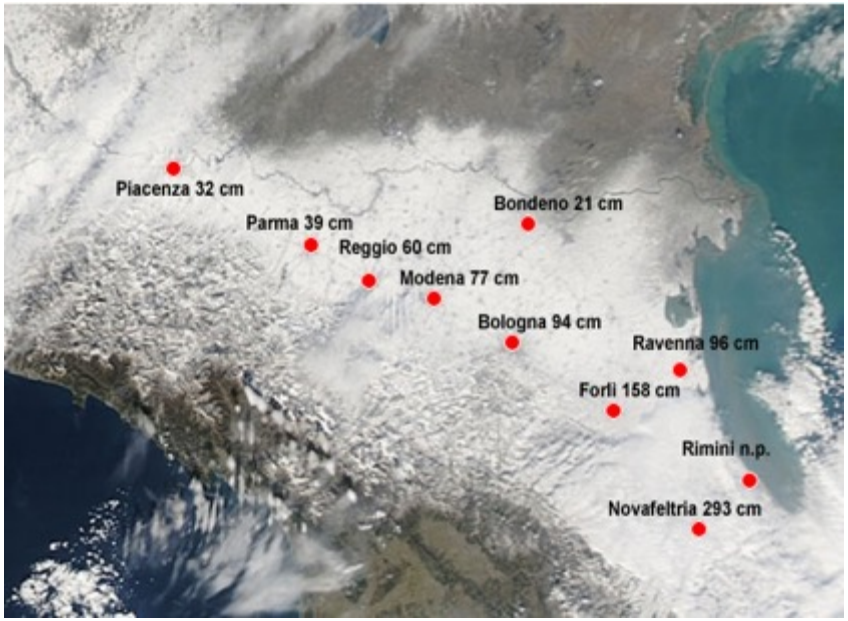




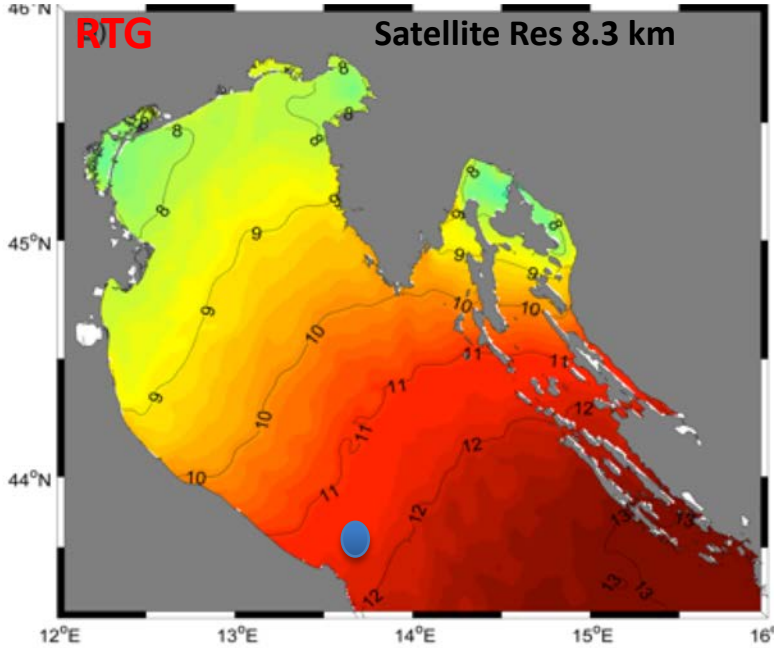
Cold Air Outbreak (CAO)

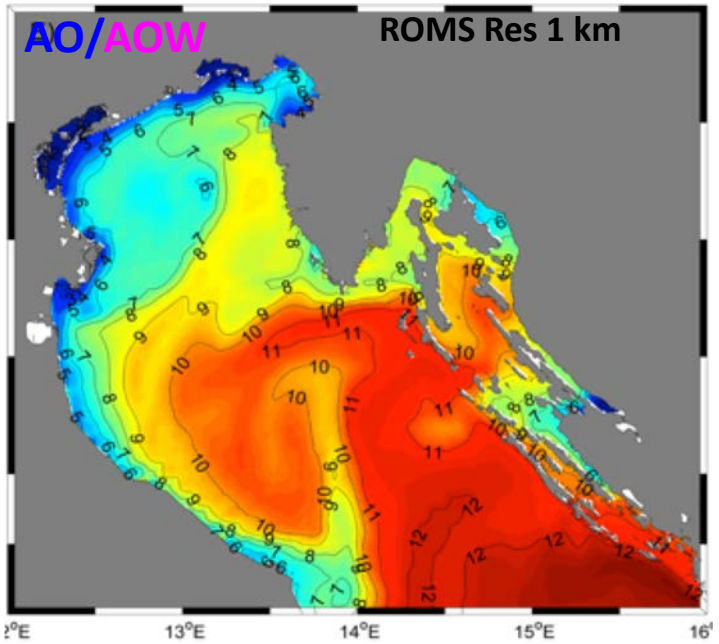




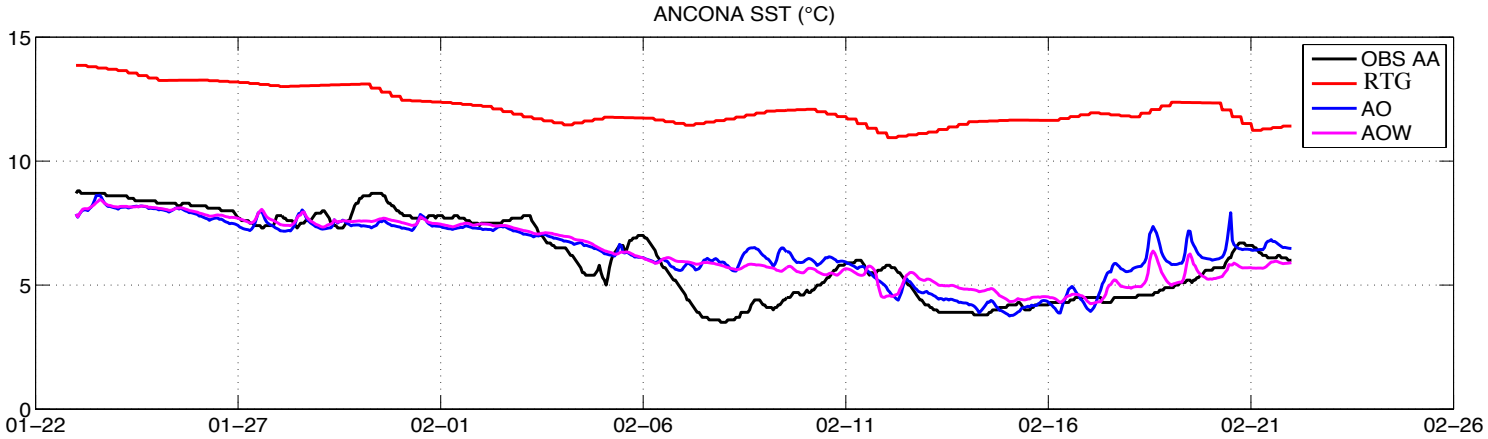


CAO Event. SST in North Adriatic Sea



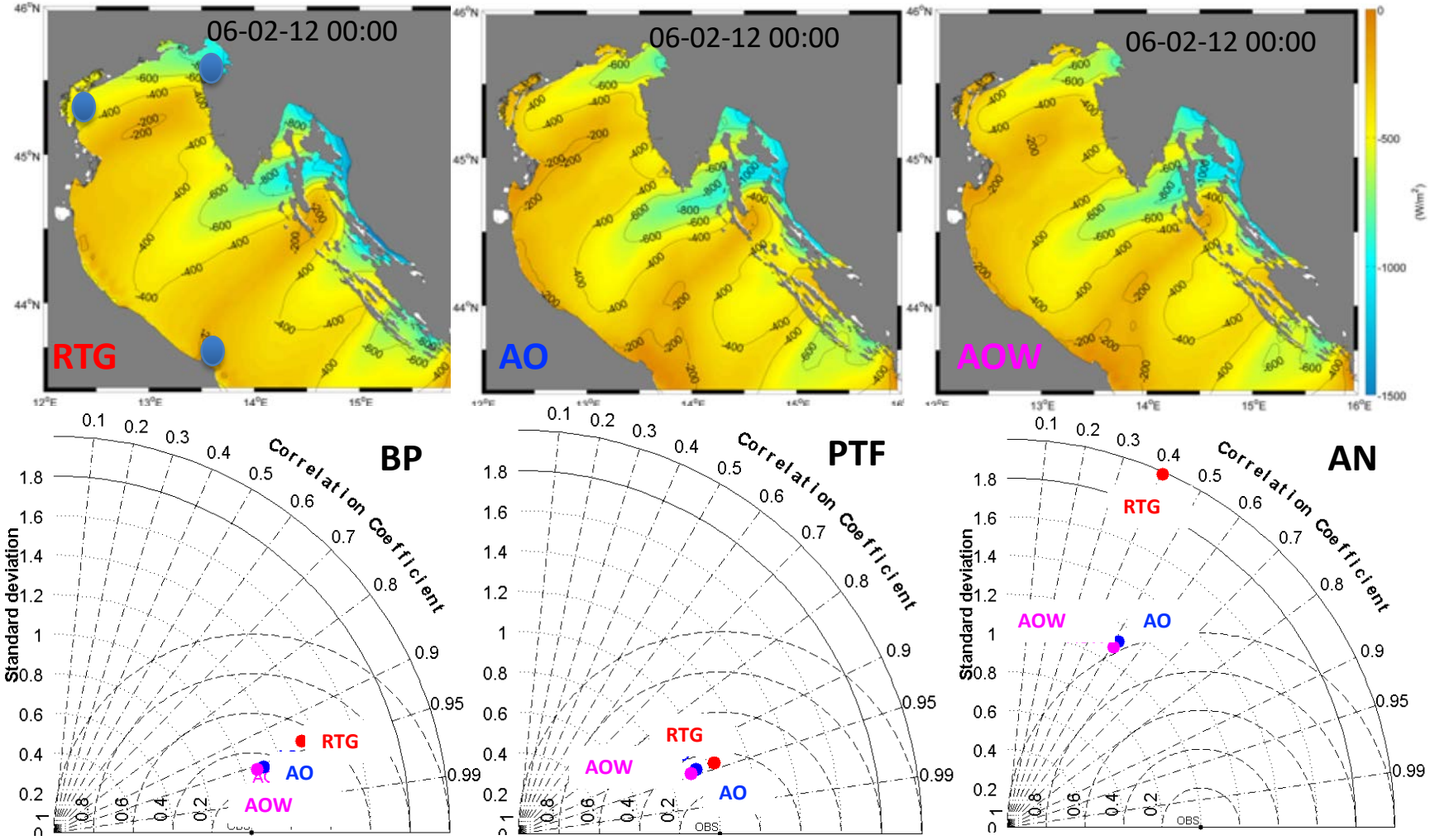


The images show the surface temperature in the northern Adriatic Sea in the 2012 CAO event.
You can see large differences between the data taken from the satellite and the data produced by our model at 1 km resolution. In most parts of the NA
model results match the ground truth observation (Ancona Harbour) much better than the satellite data.



Ricchi et al., 2016

(CAO) Results: Heat fluxes (W/m²)



... and global instantaneous patterns

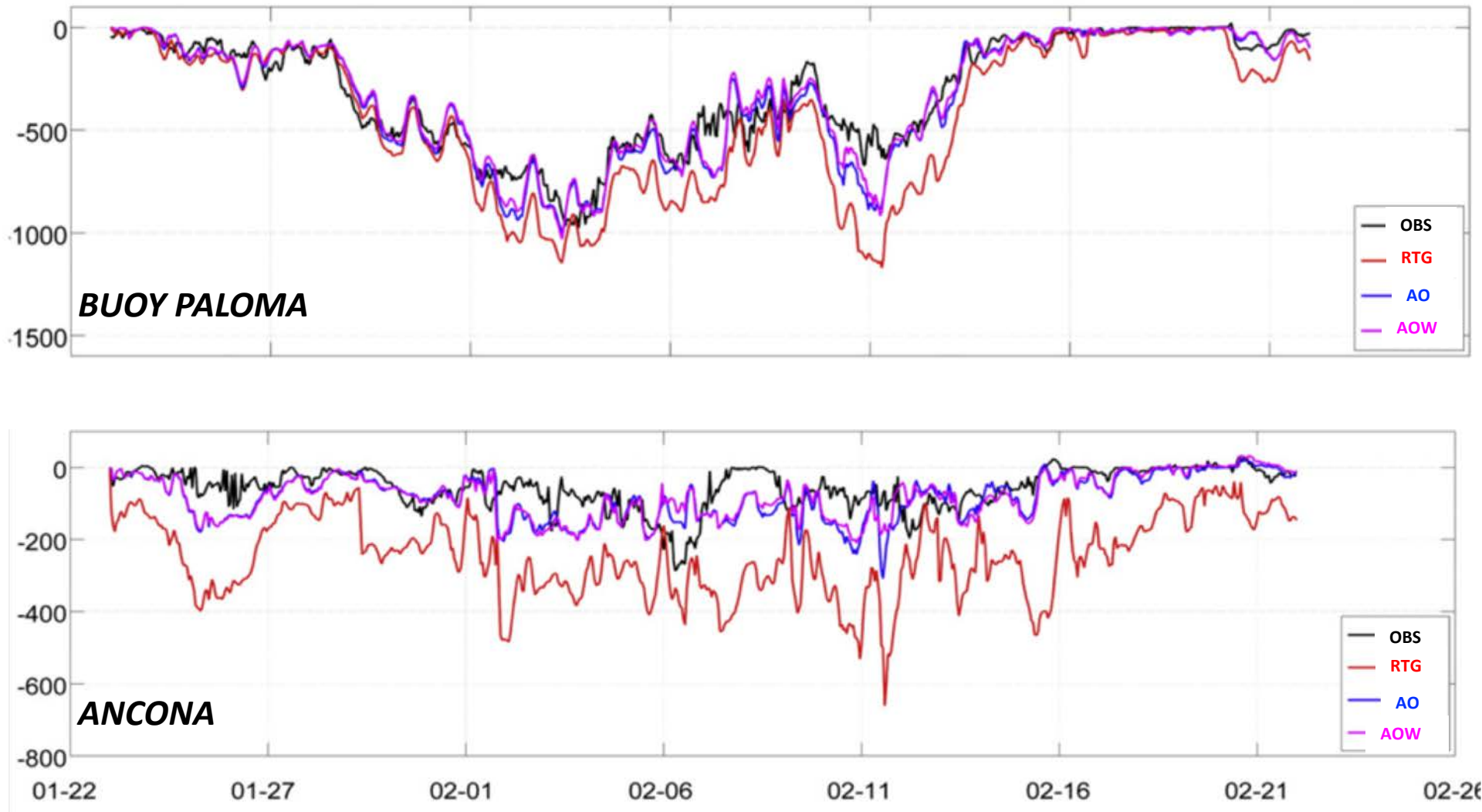
Local evolution statistics

BP : Paloma Buoy

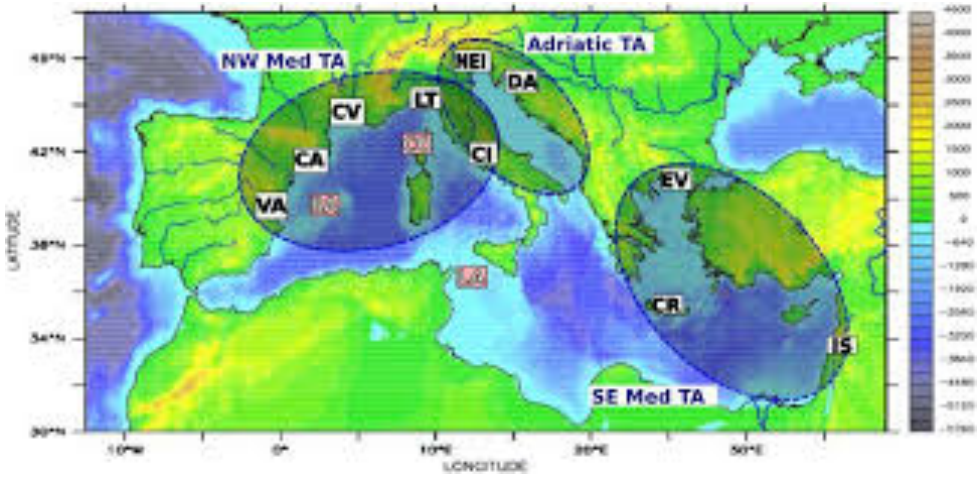
PTF : Acqua Alta plataform

AN : Ancona Harbour

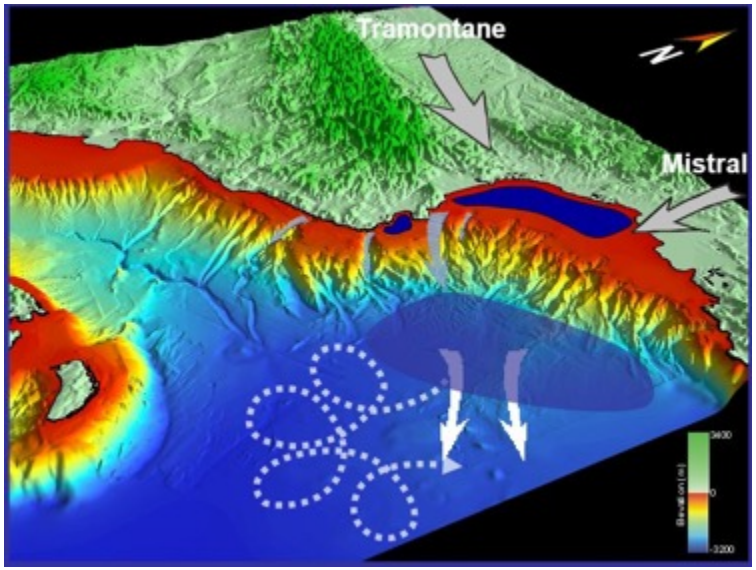
Results : Heat fluxes timeseries



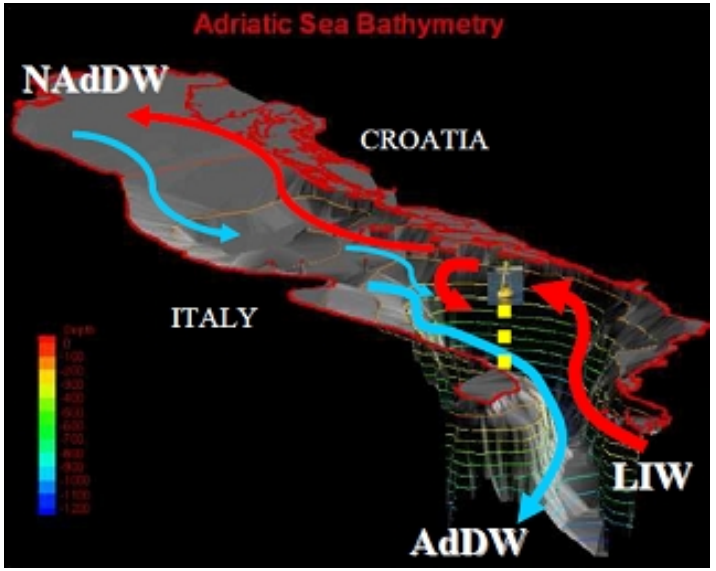
Dense Water formation



GULF OF LIONE

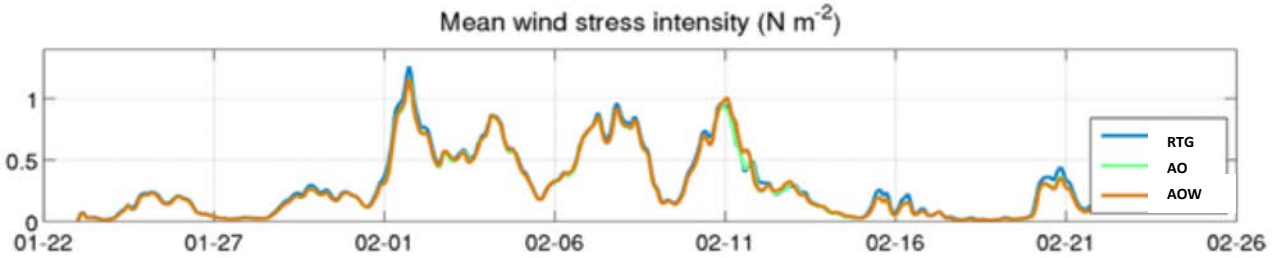


ADRIATIC SEA

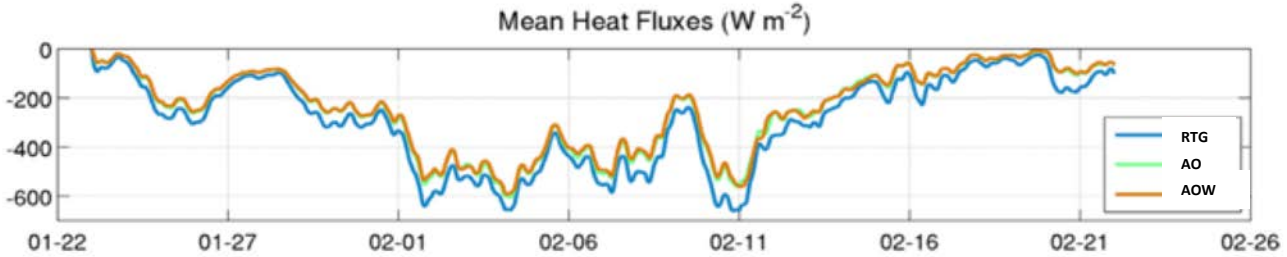


Dense Water Formation

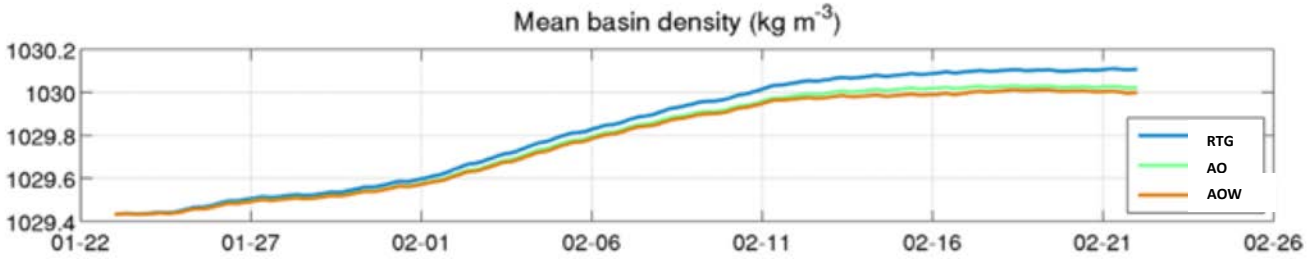
Wind Stress:
Strong wind in Uncoupled runs Caused by highter SST



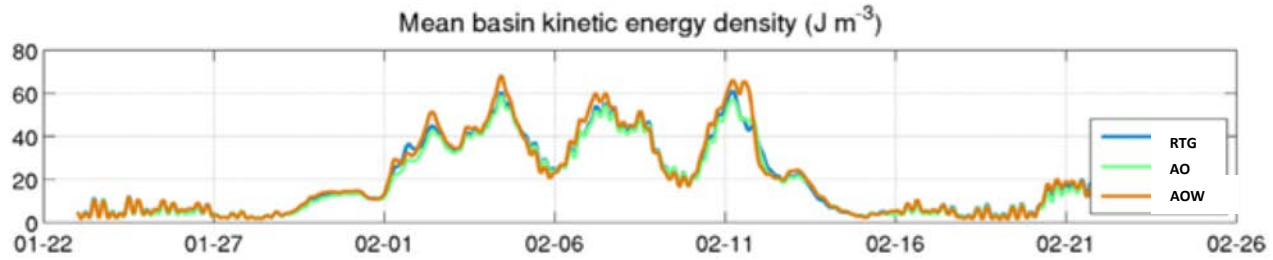
Mean Heat Fluxes:
Higheter HF, in UNCPL Runs caused by large Delta beetwen SST and 2 meters temperature



Mean density basin:
Higheter dense water Formation in UNCL run caused by Higheter HF



Mean TKE basin:
Higheter TKE in AOW Runs caused by wave mixing



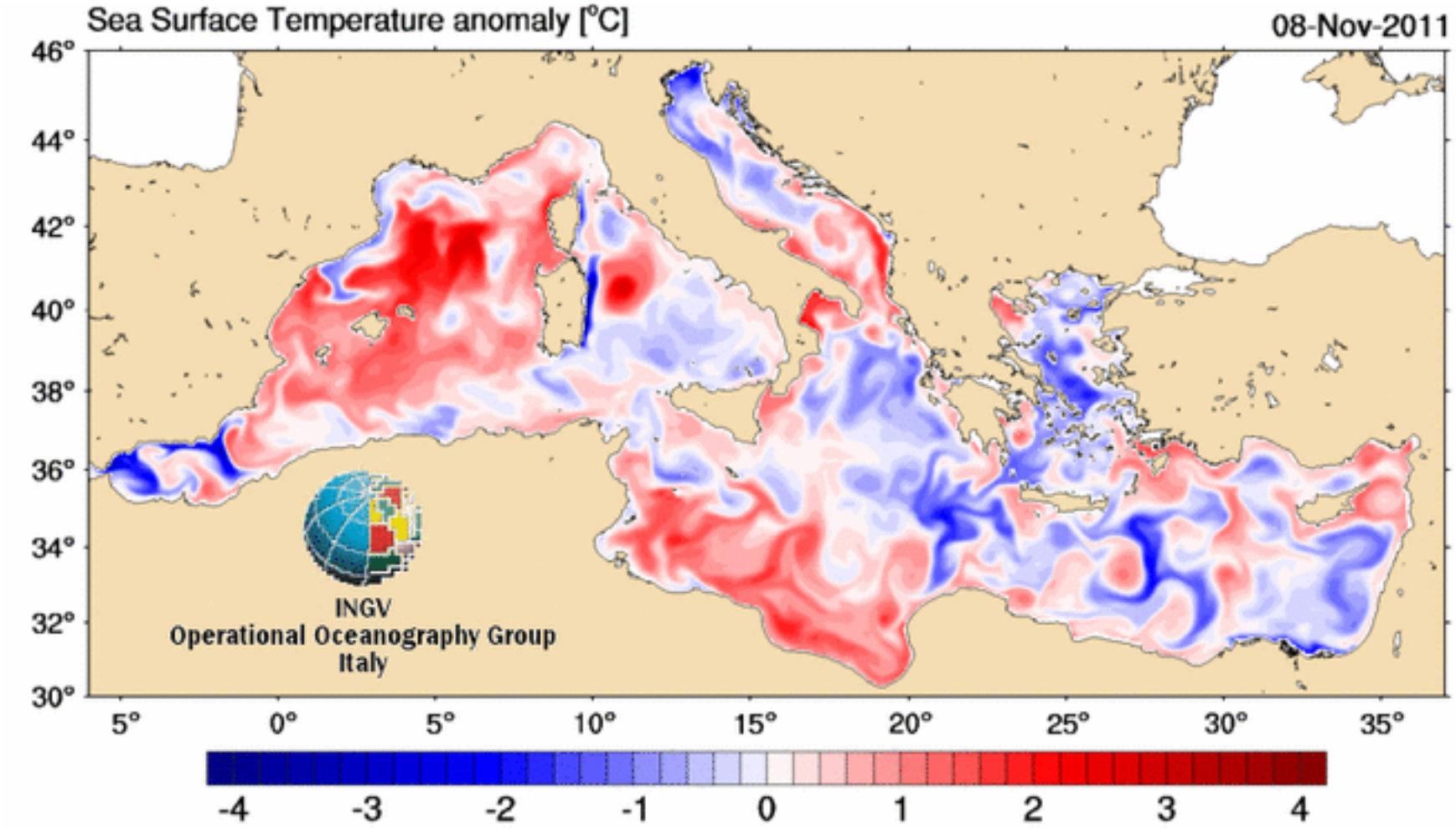
Carniel et al 2016

TLC “ROLF” : 6-9 Novembre 2011

08/11/2011 12 UTC

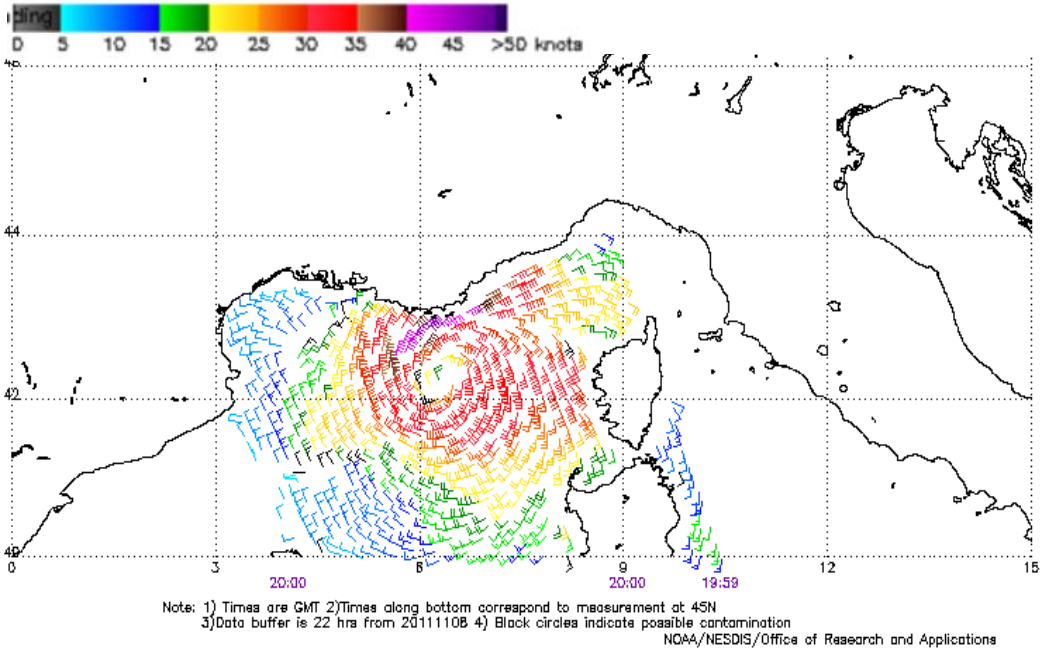
TLC “ROLF” : 6-9 Novembre 2011

Sea Surface Temperature Anomaly: 8th Nov 2011 over the Mediterranean Sea before MEDIcane ROLF generation

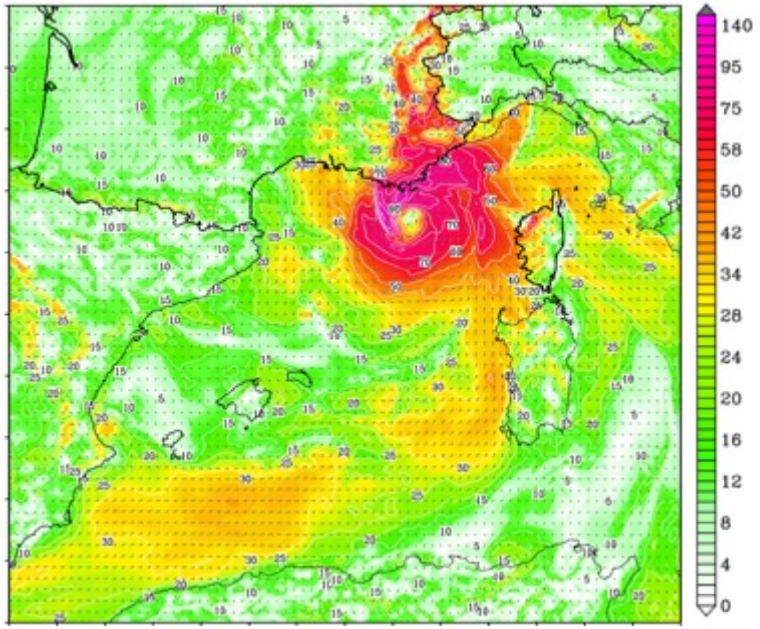


TLC “ROLF” : 6-9 Novembre 2011

Wind speed and direction obtained from scatterometer satellite data (OSCAT-ASCAT) at 20:00 08/11/2011. In the right side it’s proposed the **coupled atm-ocn-wav** model result at the same time.



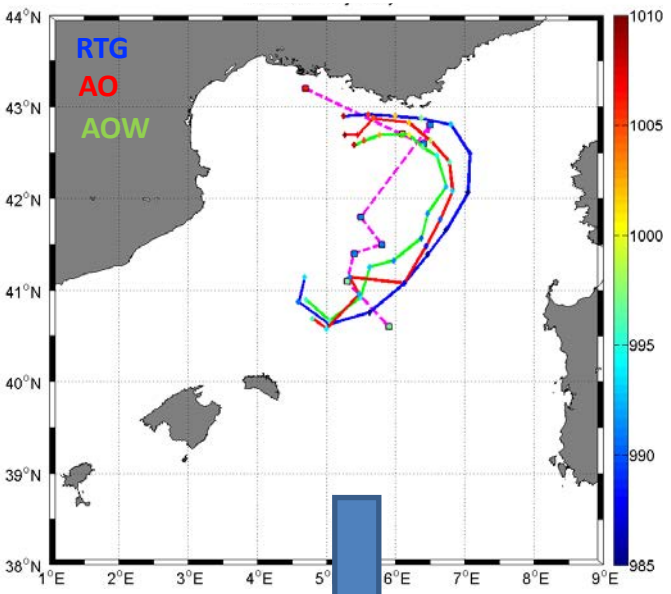
OSCAT-ASCAT scatterometer



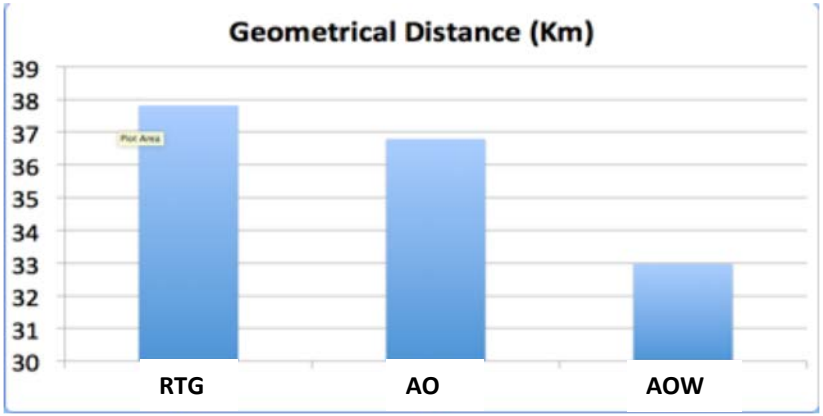
COAWST model coupled atm-ocn-wav

TLC “ROLF” : 6-9 Novembre 2011

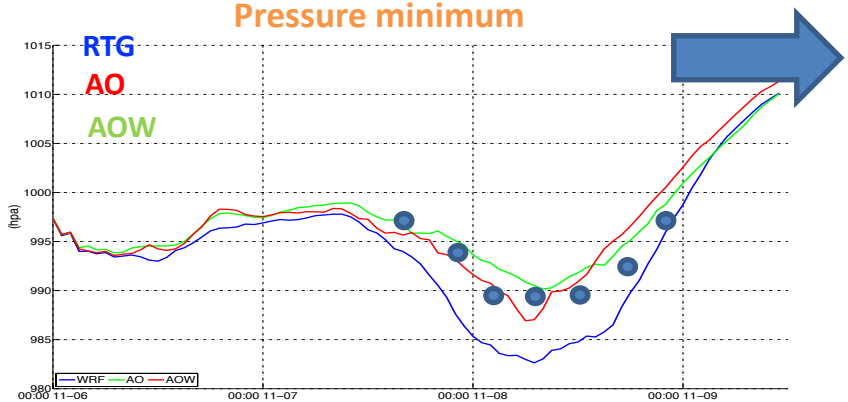
Trajectory of TLC simulated and real (purple)



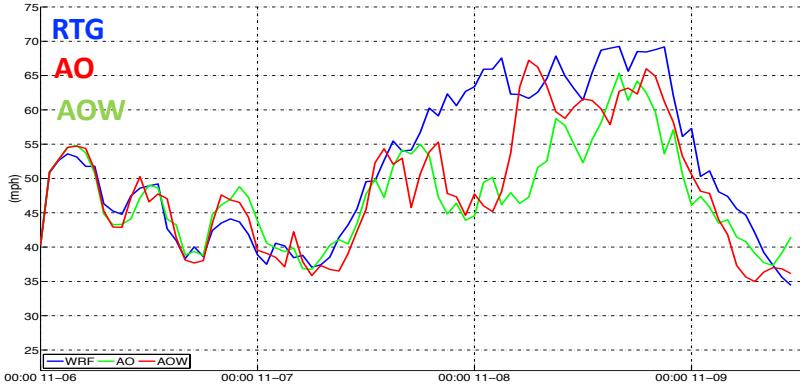
Mean geometrical distance between NOAA traj. and other runs



Pressure minimum



Wind speed around the eye

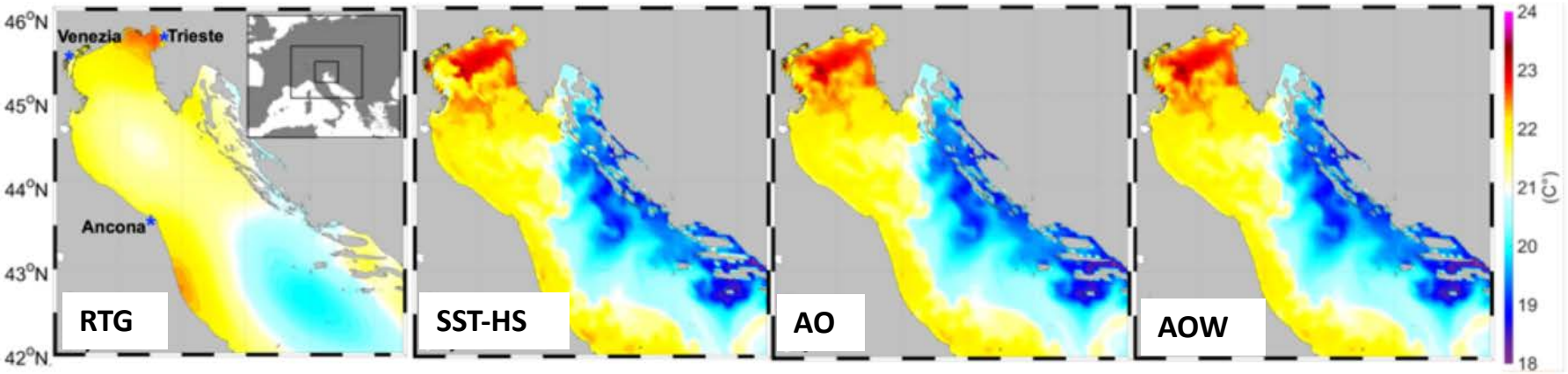


Venice Flash-Flood

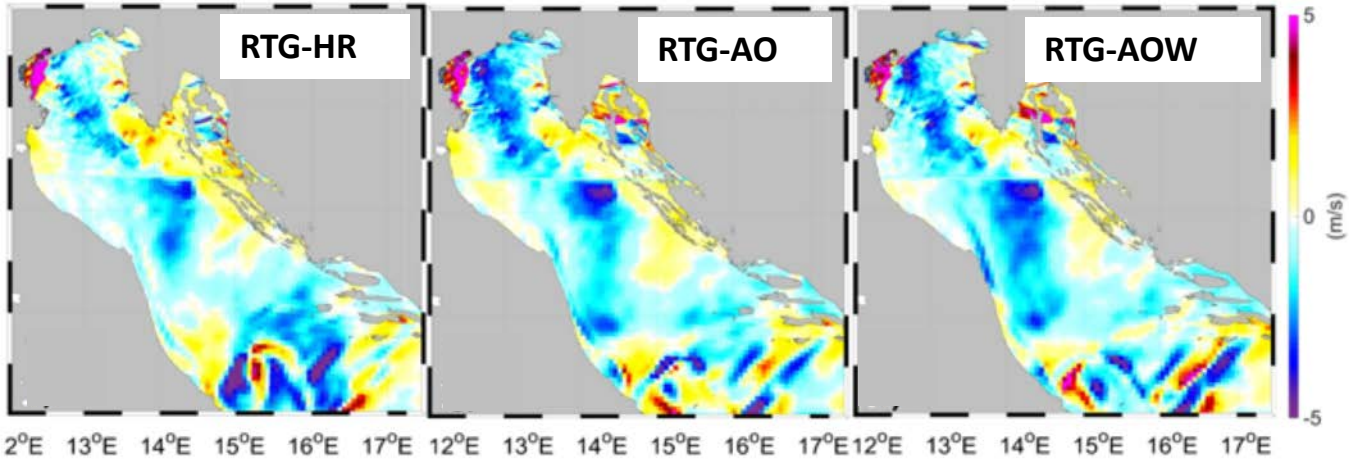
26/09/2007 06:00 UTC
320 mm accumulated
in 3 hours

Venice Flash-Flood

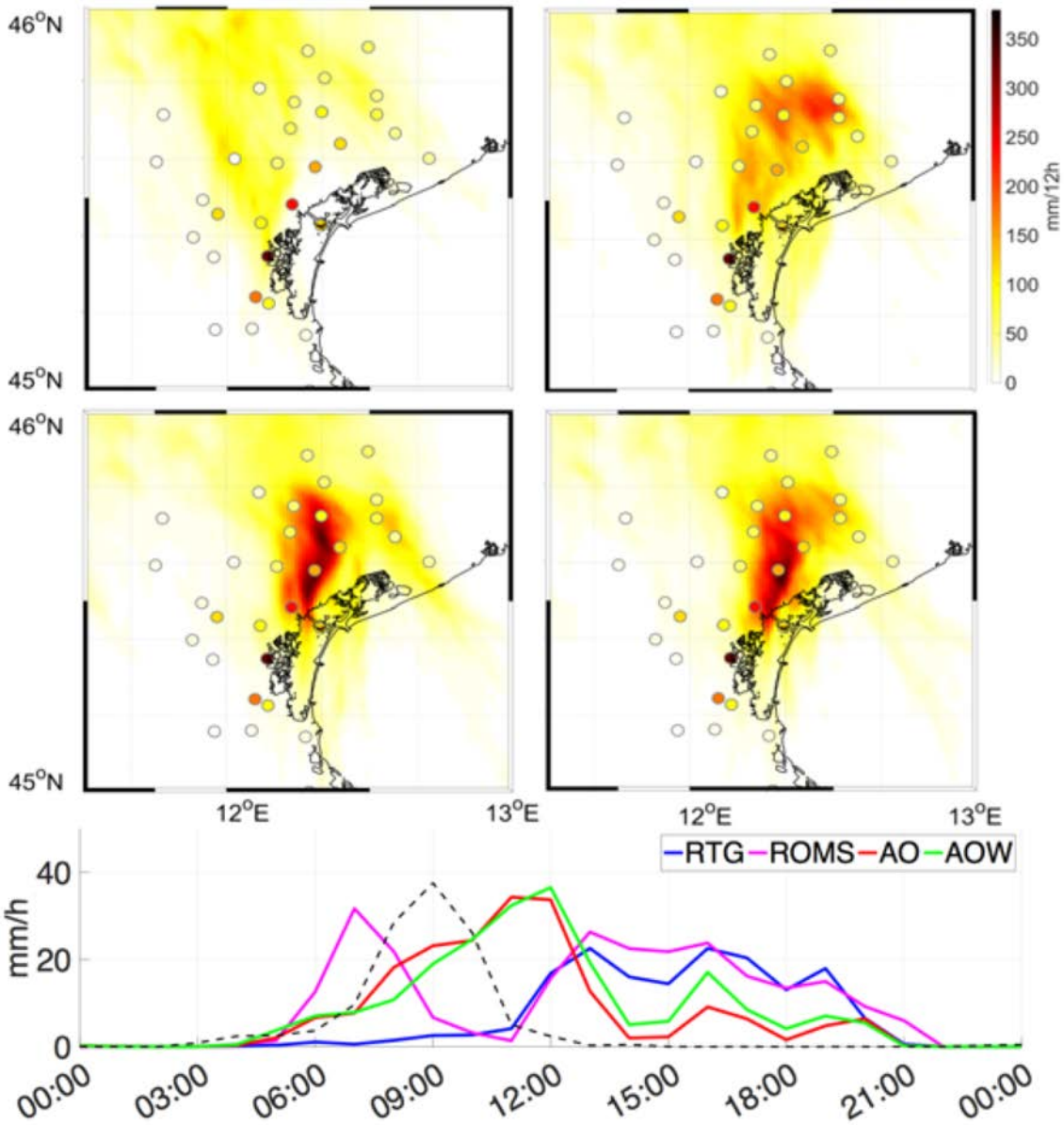
- *Sea Surface Temperature*



- *WINS SPEED (10m) Difference between RTG run and HR, AO, AOW*



Venice Flash-Flood

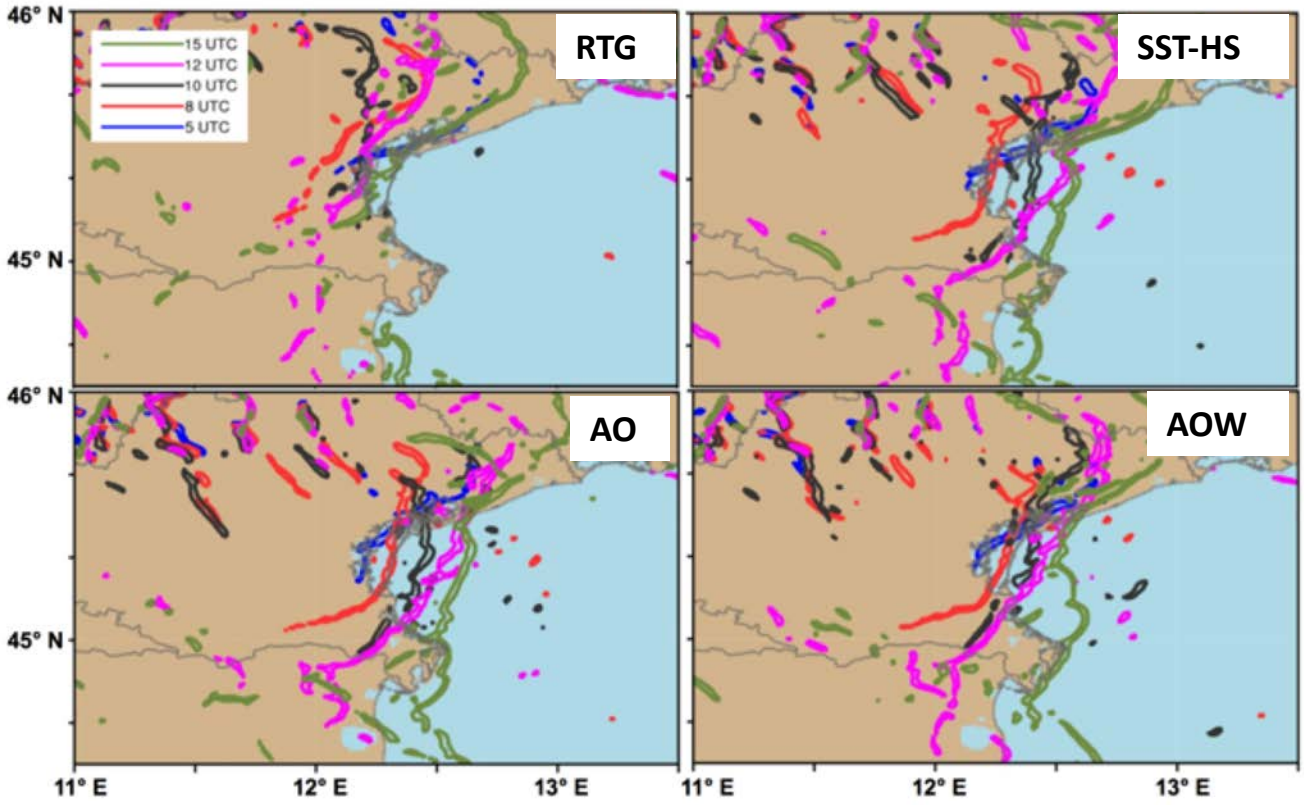


- Shaded :Total accum. rainfall
- Scatter: Observed rainfall

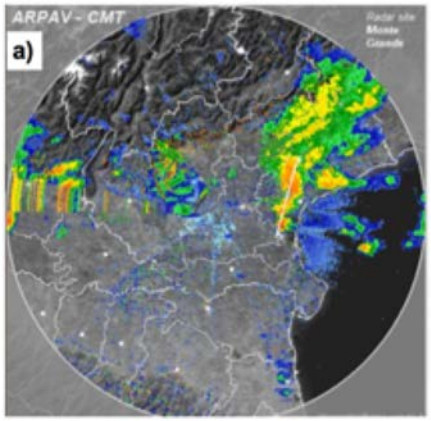
- Hourly mean rainfall value over plotted area

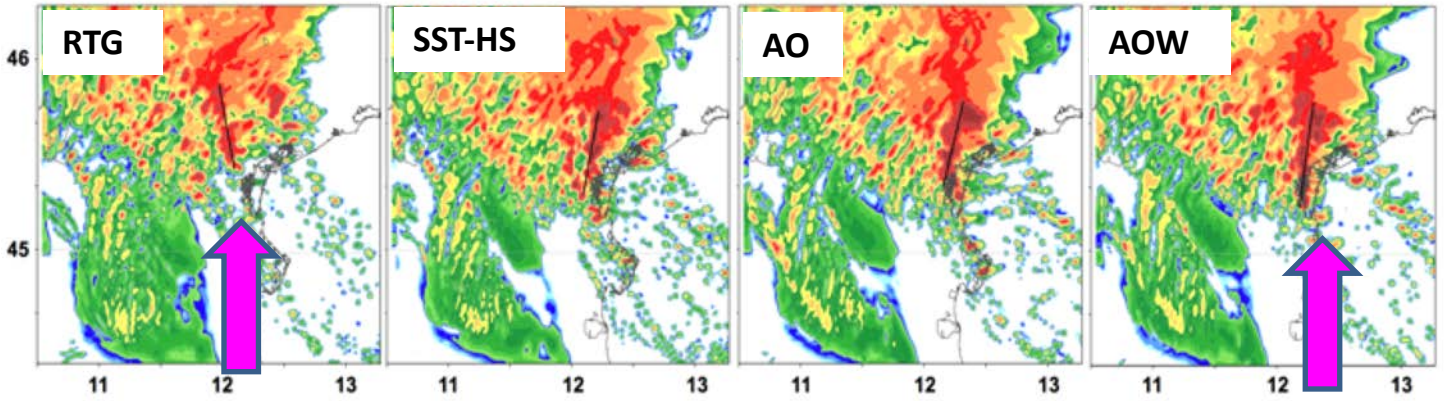
Venice Flash-Flood

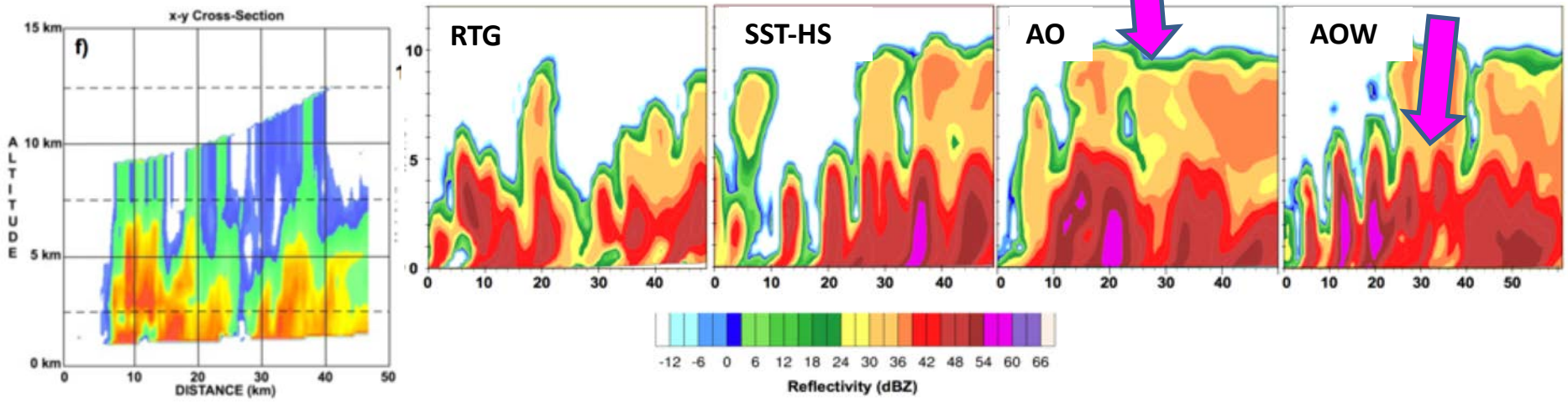
- **Timing of convergence line evolution, from mainland to sea**



Venice Flash-Flood



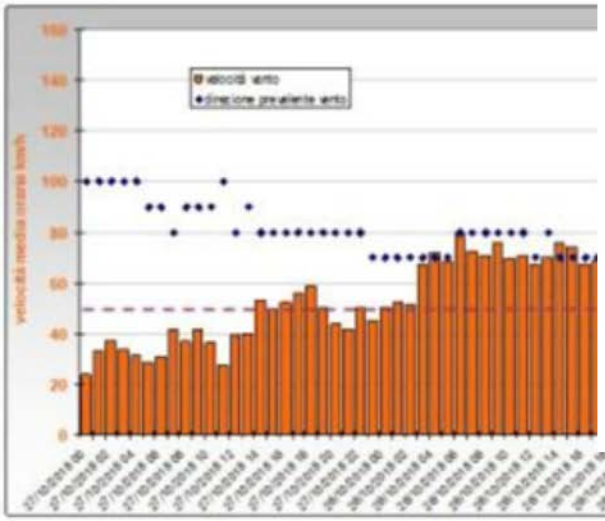


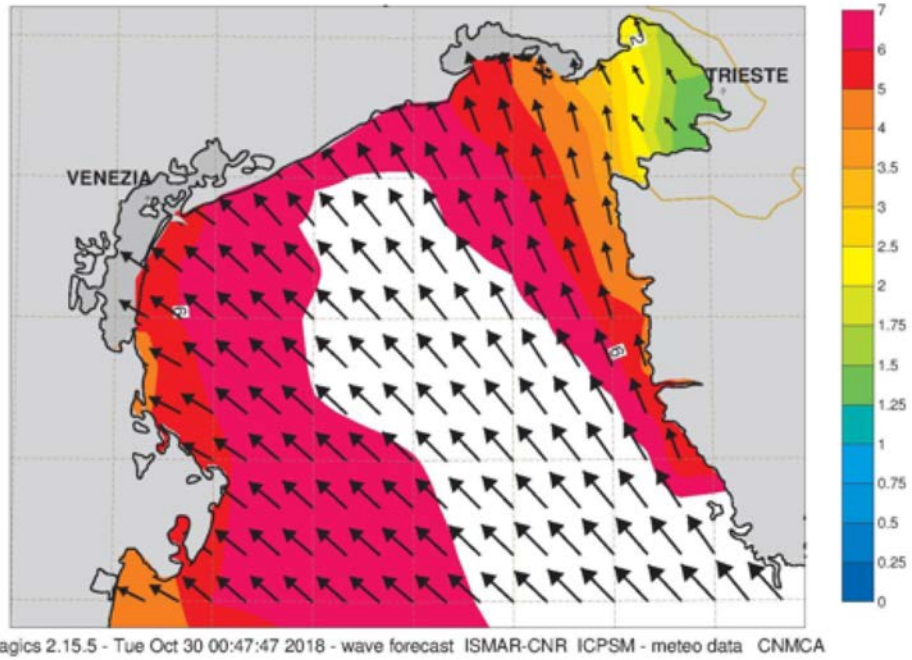


- Flash-Flood development direction
- Multi-cell system and deep convetion
- Coupled runs reproduce more accurately timing, intensity and location of F.Flood

VAIA CYCLONE - FROM 26TH TO 30TH OCTOBER 2018

1. Understanding the causes that have generated this intense cyclogenesis
2. Understanding the role of ocean interaction with atmosphere
3. Understanding the role of high atmosphere dynamics





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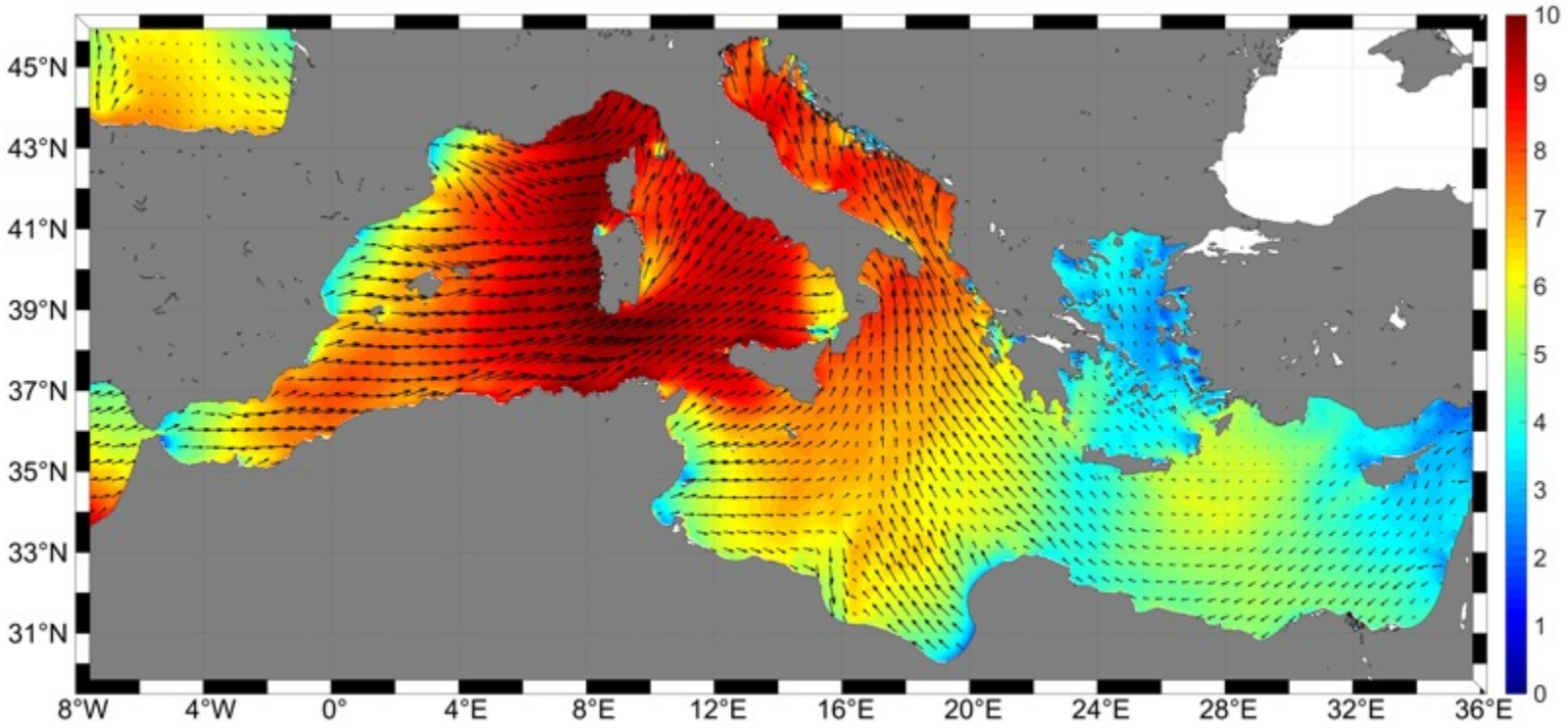
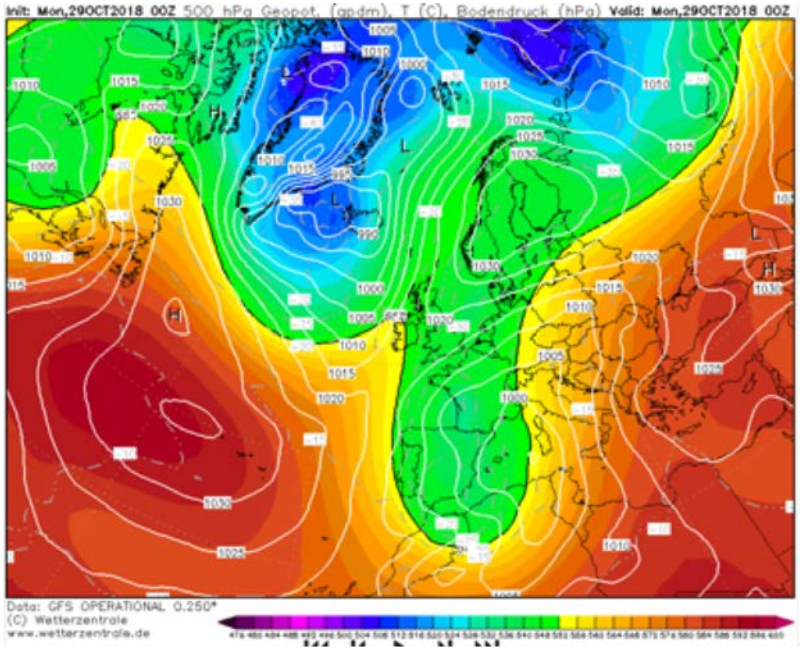
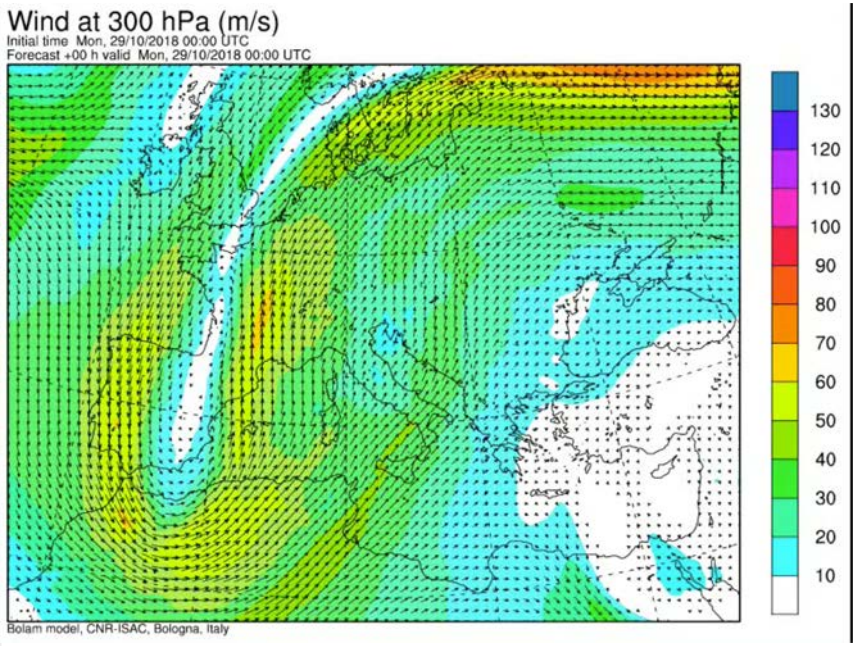


SYNOPTIC ANALYSIS

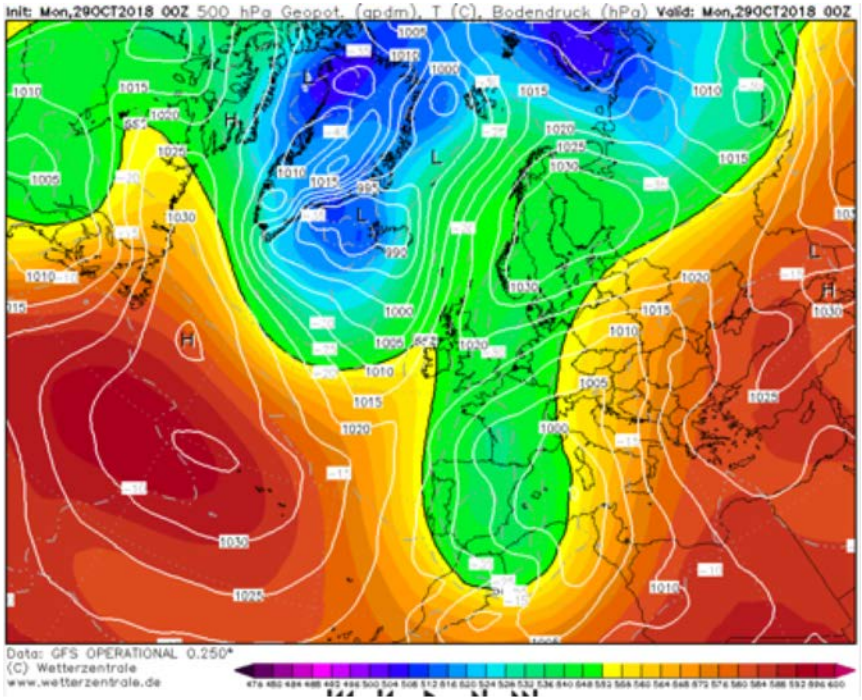




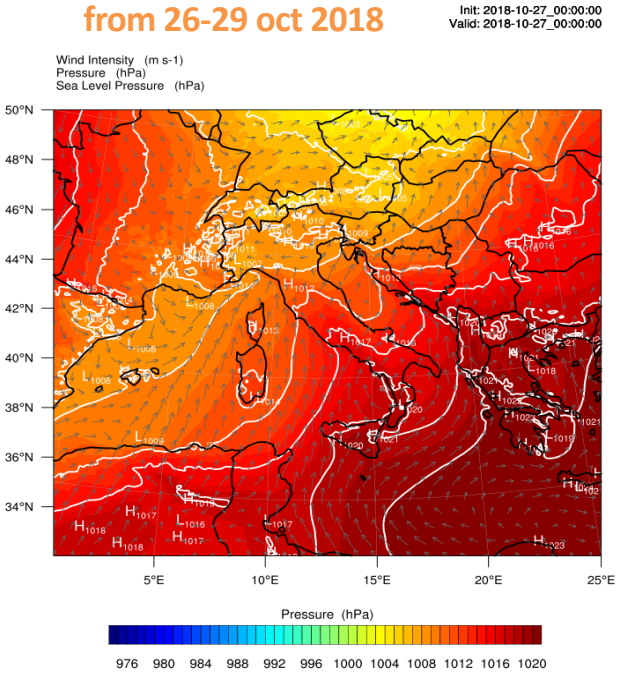
- From 26th to 30th October 2018
- Baroclinic wave was generated inside a strong meridional elongation of Jet Stream
- Characterized by very slow zonal movement
- The last minimum produce a horizontal gradient close to 15hpa (from Genova to Trieste)…20hpa during the landfall (*model data)

FROM SYNOPTIC TO LOCAL ANALYSIS

Sea leval pressuer and geopotential at 500 hpa



Sea level pressure animation over italian sea from 26-29 oct 2018



OUTPUT FROM WRF V3.9.1.1 MODEL
WE = 659 ; SN = 542 ; Levels = 90 ; Dis = 4km ; Phys Opt = 8 ; PBL Opt = 2 ; Cu Opt = 1

- From 26th to 30th October 2018
- Baroclinic wave was generated inside a strong meridional elongation of Jet Stream
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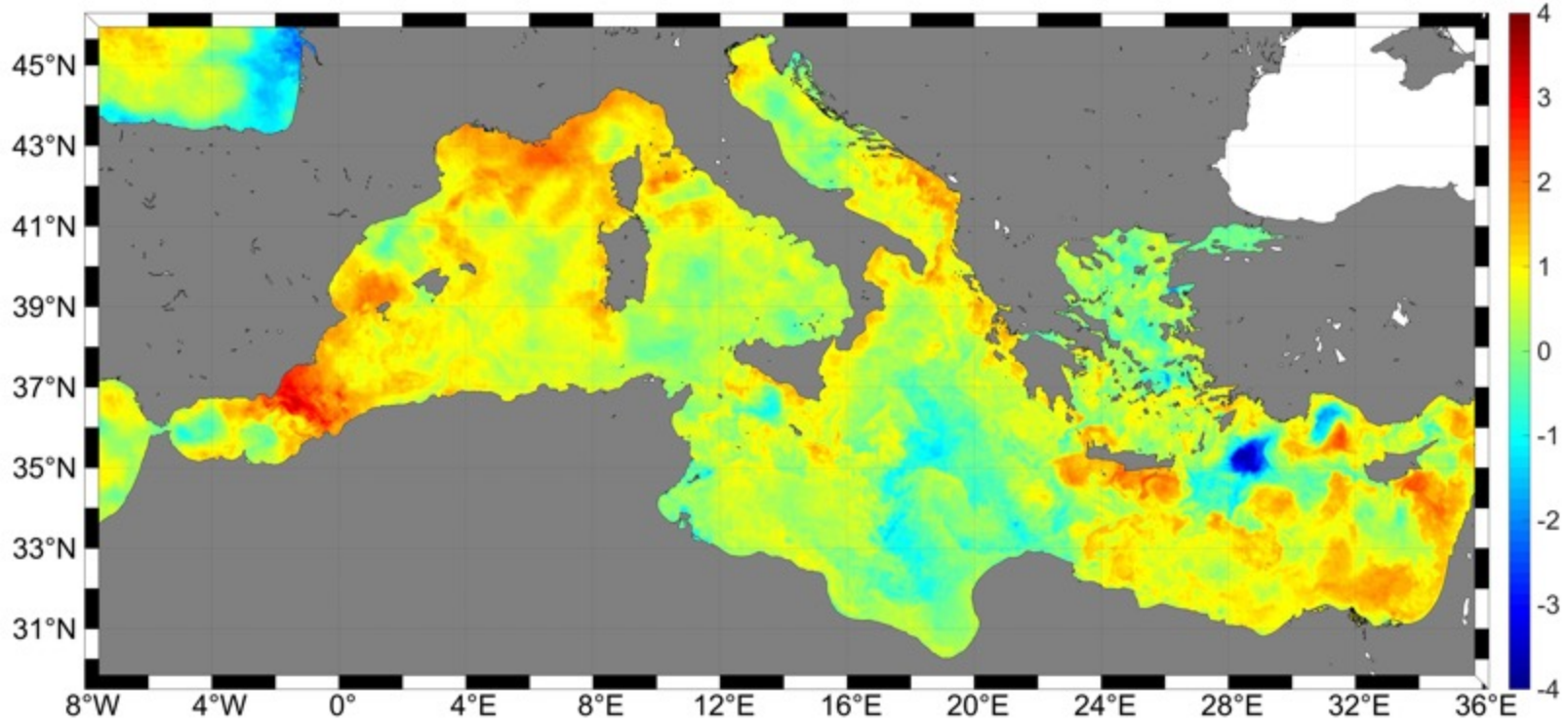
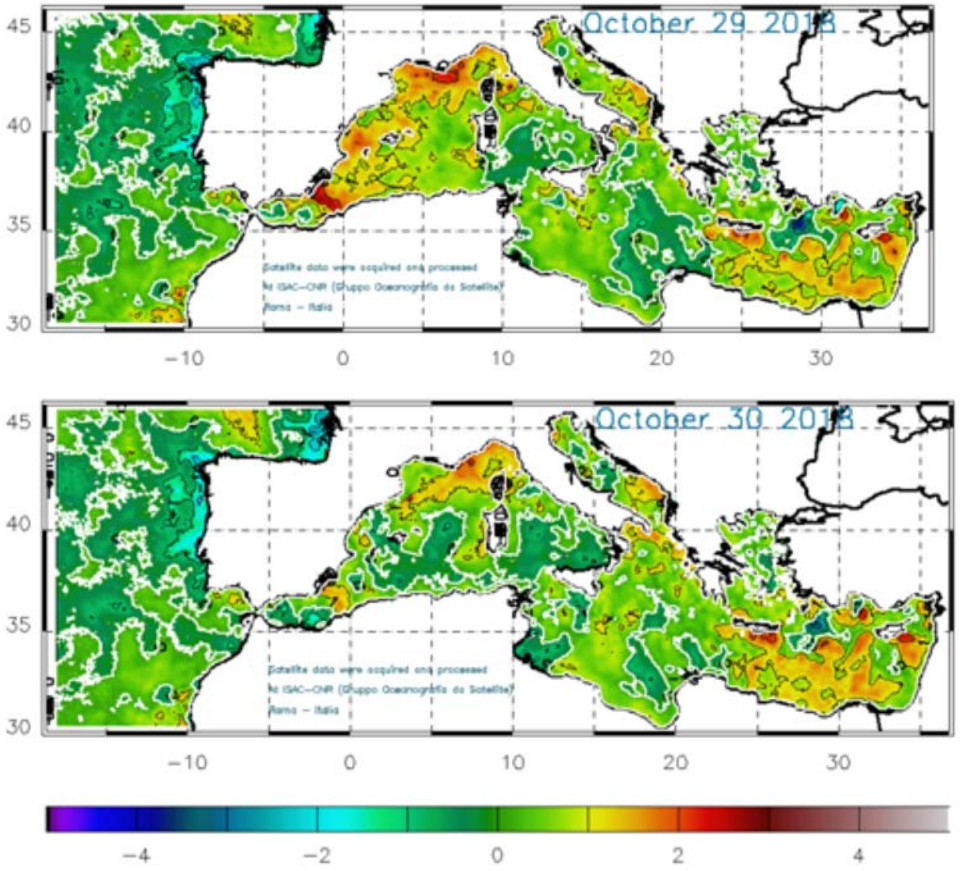
SEA SURF. TEMP ANOMALY

Sea Surface Temperature Anomaly: 27th October 2018 over the Mediterranean Sea before VAIA generation



Data from CNR - ISMAR (GOS)

SEA SURF. TEMP ANOMALY



Daily SST anomaly (GOS – ISAC CNR)

SST decrease by-1.5 °C in 24 h
From 28th to 29th October 2018 over the Western Mediterranean Sea after the VAIA movement

28th Oct

29th Oct

WRF - NUMERICAL APPROACH

WRF SST-ENSEMBLE simulation :

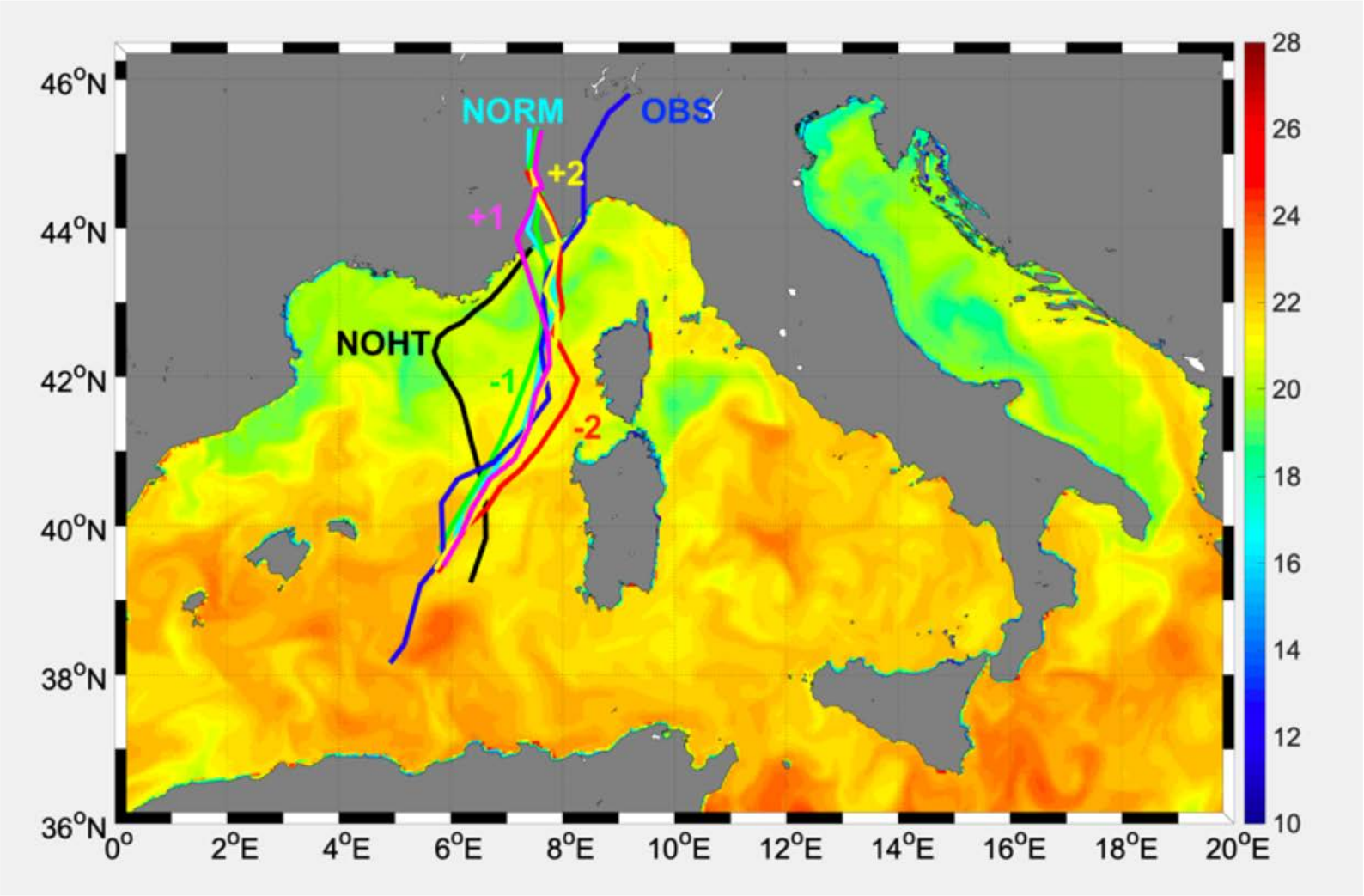
1) *OML 1D (WRF + SST 4km res + Mixed Layer Depth 4km res)*
2) *without HF in Microphysics(same OML1D conf, but remove heat fluxes in MP)*
3) *SST -1°C (same OML1D but decrese SST -1°C)*
4) *SST +1°C (same OML1D but increase SST +1°C)*
5) *SST -2°C (same OML1D but decrese SST -2°C)*
6) *SST +2°C (same OML1D but increase SST +2°C)*

DOMAIN CONFIGURATION :

- **RES : 20-4km (ECMWF init and boundary)**
- **90 vertical hybrid levels**
- **Cumulus parametr. : Kain–Fritsch (KF) (Kain 2004)**
- **Microphysics : Thompson (Thompson et al 2008)**
- **SST and Mixed Layer Depth from Copernicus dataset**
- **(Pinardi et al 2008)**

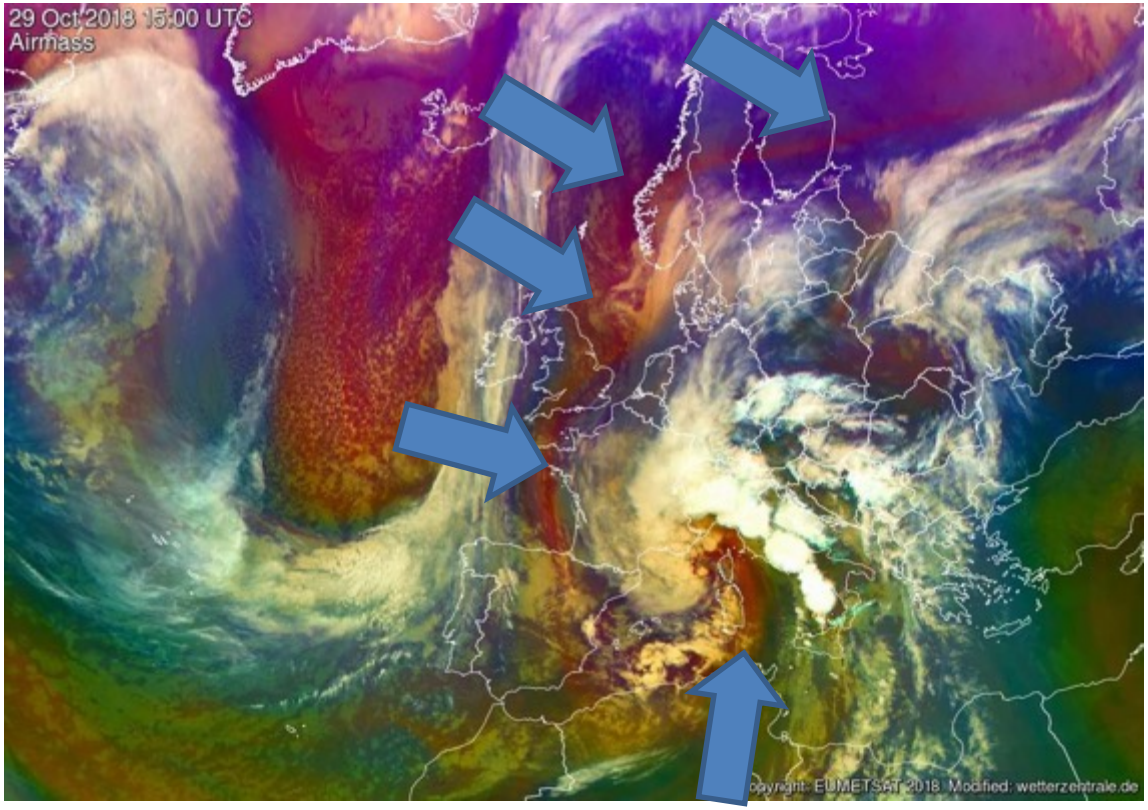
WRF - NUMERICAL APPROACH

WRF-ENSEMBLE SST trajectoryes compared real trajectory (OBS)

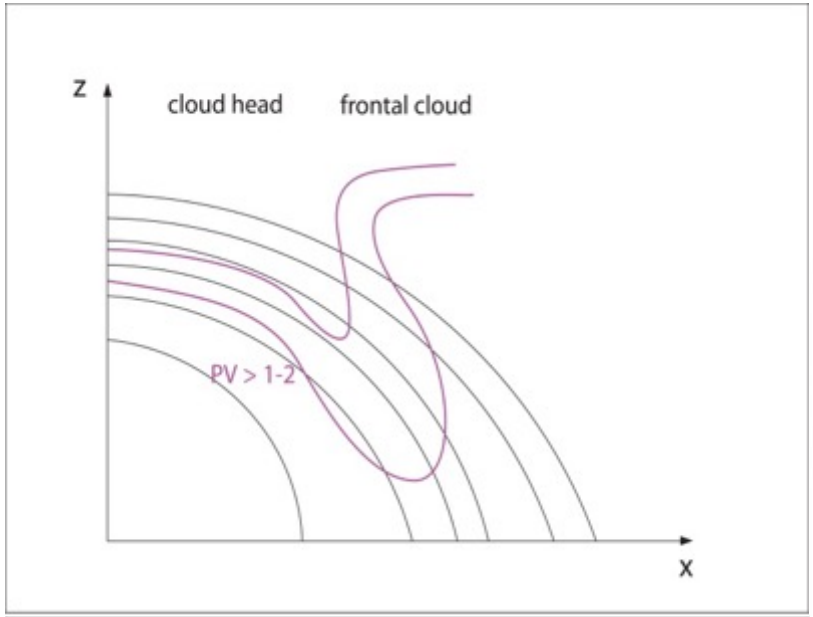


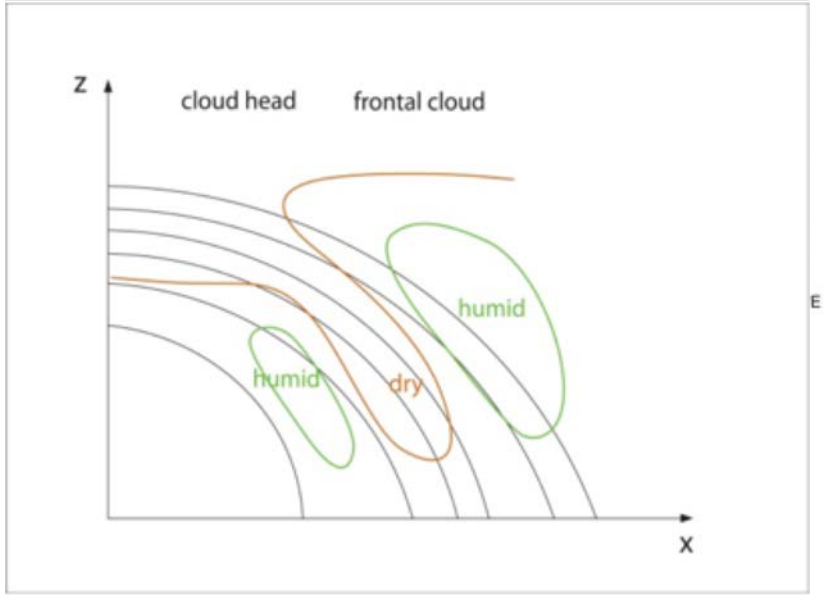
UPPER LAYER ANALYSIS - SATELLITE IMAGE

The intensification of the cyclone is not caused by the SST ... but ... then what caused this sudden increase in speed of cyclone (and therefore horizontal gradient) and intensity of the minimum?

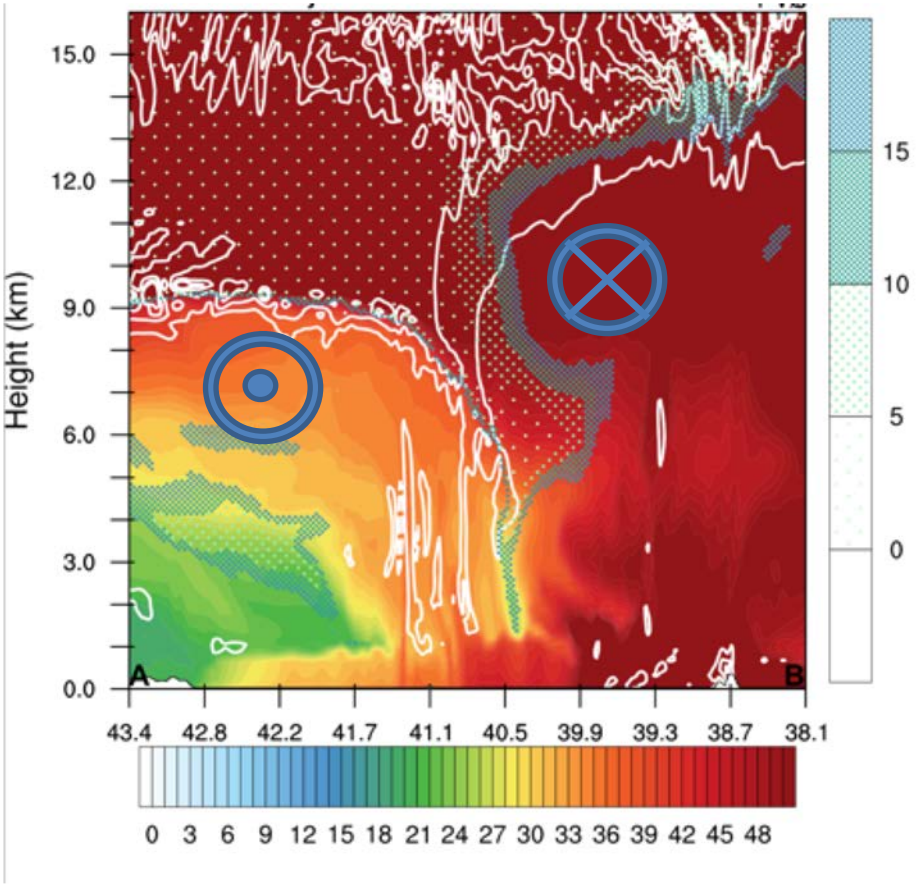


UPPER LAYER ANALYSIS - DRY STRATOSPHERIC INTRUSION





Cross section along line A-B of RH (%), tetha-e and PV



Conclusion

1. In phenomena which are strongly linked to the air-sea interaction, the coupled numerical models play a fundamental role and has the most advanced numerical technology.

2. In the situation analyzed, the SST has a strong impact on the intensity of the wind over the sea (and less impact on its direction) caused by SST horizzontal gradient (O10-100km) and not only by absolute value.

3. The effect of the coupling is transferred up to the PBL by several hundred meters, affecting the amount of humidity that is moving from the coast. Coupling effects are therefore not just limited to the air-sea interface.

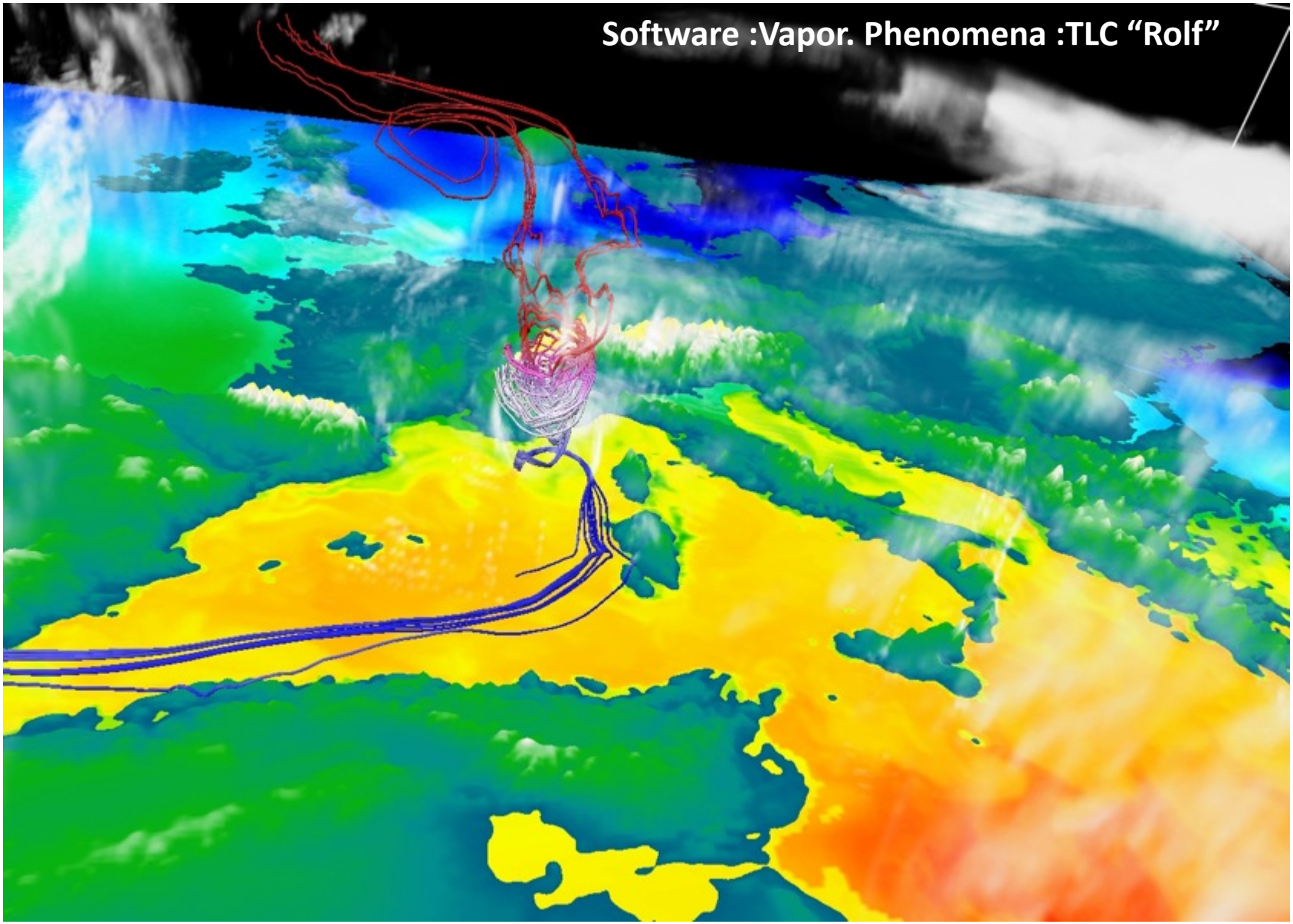
4. Strongly localized and intense events such as the ones described are ideally better analyzed with fully-coupled models in particular because this approach are able to describe a strong gradient of SST area and near the coastal zone.

5. Extreme events (in particularly coastal phenomena) are much more sensitive to the use of coupled model

Future perspectives : Operational application.

Fully Coupled ATM-OCN-WAVES-MARINE SPRAY

Rain effect on waves (white capping) evolution


Software :Vapor. Phenomena :TLC “Rolf”