Klimatsko modeliranje Jadrana združenim modelskim sustavom AdriSC

Climate modelling of the Adriatic Sea by the AdriSC modelling suite

Clea Denamiel[1], Ivica Vilibić[1], Petra Pranić[1], Iva Tojčić[1], Hrvoje Mihanović[1], Damir Ivanković[1], Jadranka Šepić[2]

[1] Institute of Oceanography and Fisheries, Split, Croatia
[2] Faculty of Science, University of Split, Croatia

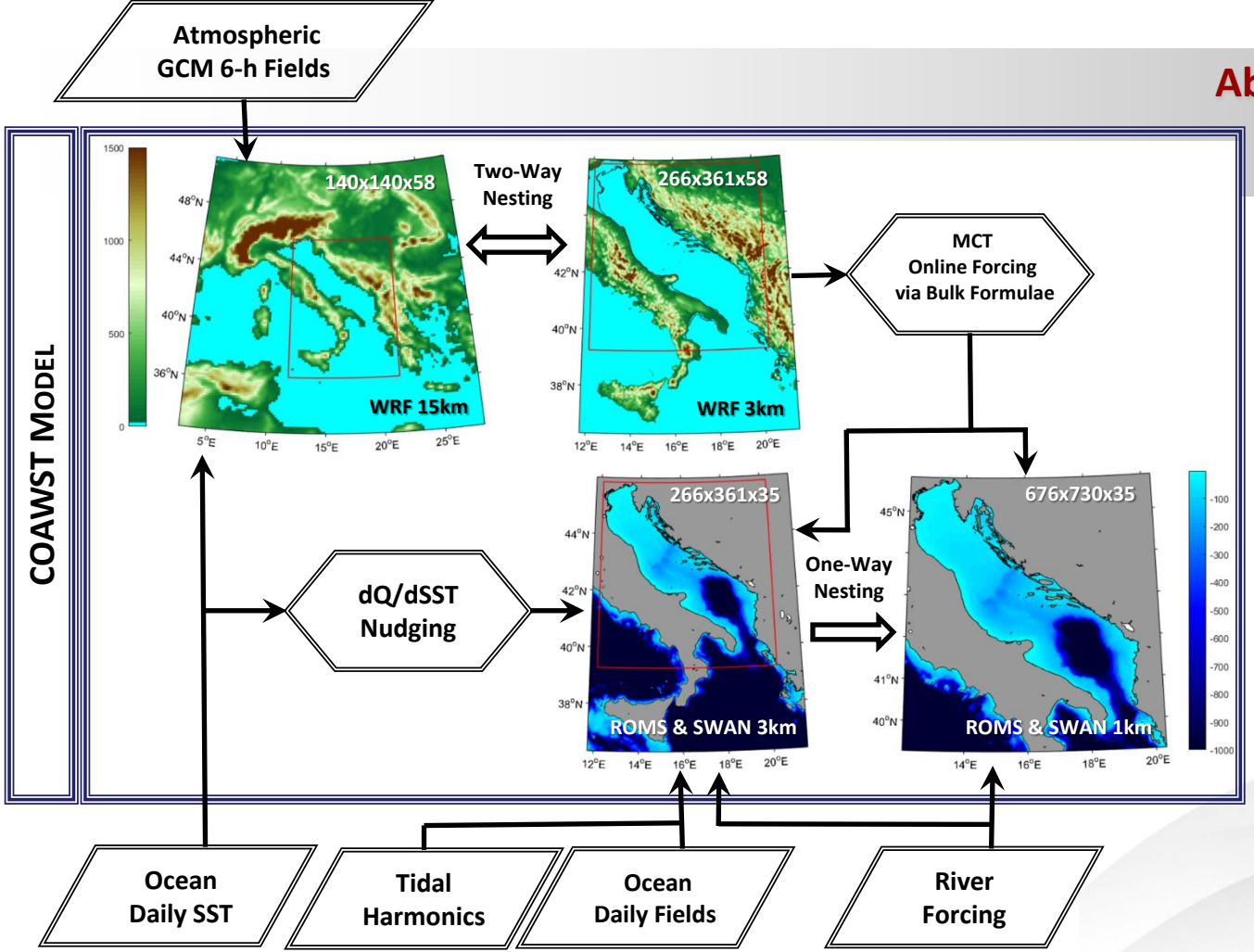
This work has been done on projects:

- ✓ Motivation
- ✓ About AdriSC climate suite
- ✓ AdriSC climate applications
- ✓ Perpectives

Motivation

- ✓ Climate change is a global societal problem reflected in: (1) the appearance of more violent weather phenomena, drought, fires, (2) the death of animal and plant species, (3) flooding from rivers and lakes, (4) the creation of climate refugees, (5) destruction of the food chain and economic resources, especially in developing countries, (6) etc ...
- ✓ To mitigate climate impacts we need first to quantify them,
- ✓ Global climate (and even regional climate) models are not providing the details at the coastal scale,
- ✓ Therefore, a need for high-resolution atmosphere-ocean models is a must,
- ✓ The Adriatic might be a case study area for high-resolution climate modelling.

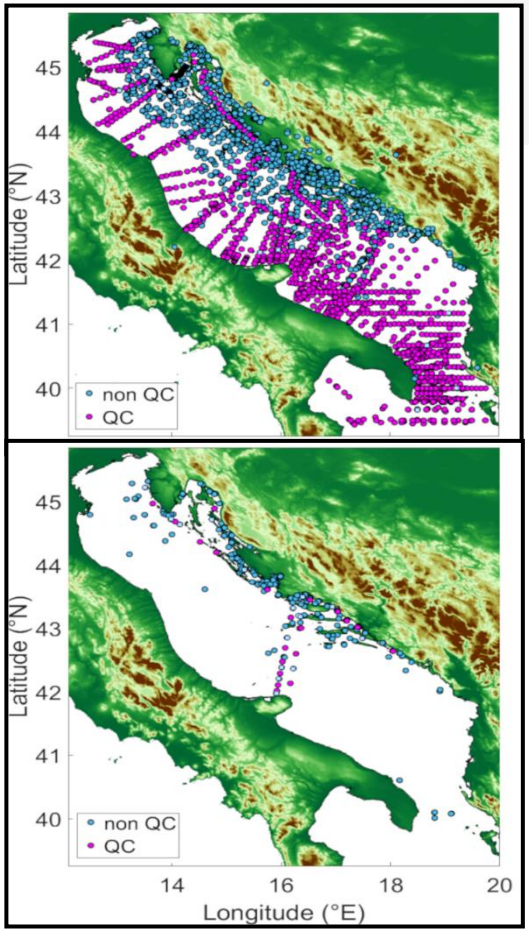
About AdriSC climate suite



AdriSC climate applications

AdriSC present climate run (1987-2017)

CTDs (temp+sal)



ADCPs+RCMs (currents)

Present climate run

- ✓ AdriSC general circulation module used without waves
- ✓ 31-year continuous long term evaluation simulation between 1987 & 2017
- ✓ Evaluation run forced with 6-hourly ERA-I fields in the atmosphere and daily MEDSEA reanalysis for the ocean

Climate change projection

- ✓ 31-year continuous long term future RCP 8.5 projection between 2070 & 2100 forced with PGW method

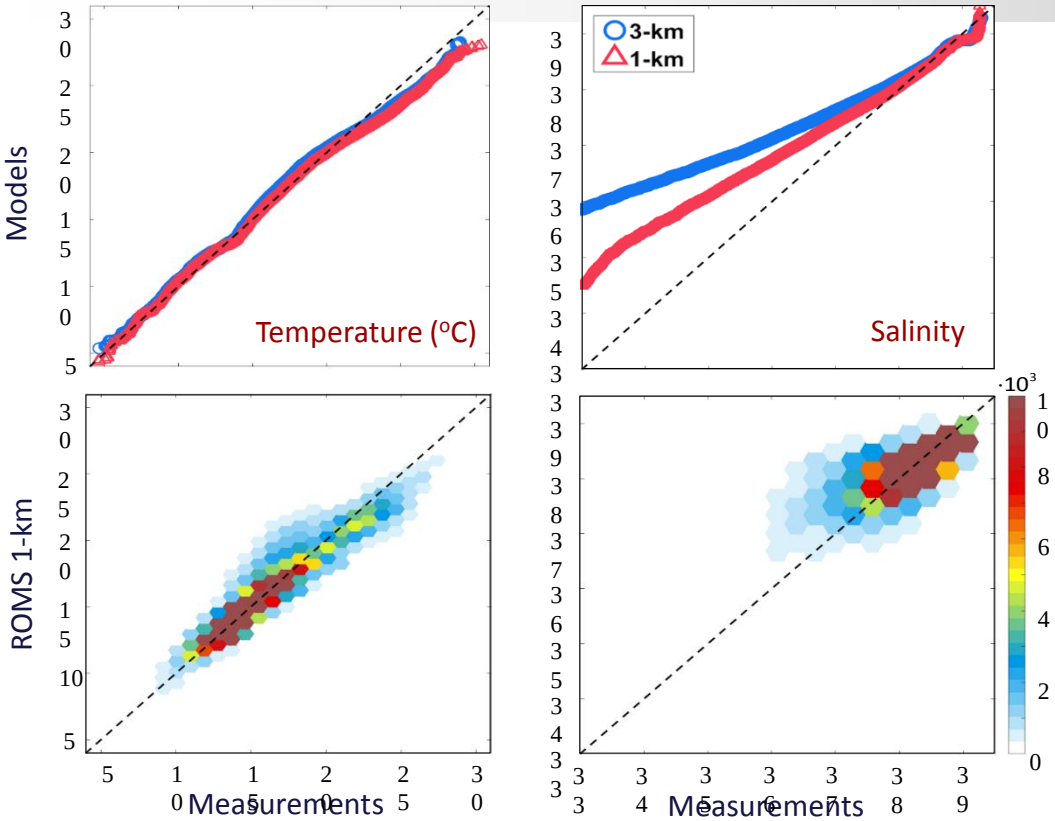
Observations used for evaluation

1) For the atmosphere: E-OBS 0.1° gridded dataset, ground station data (from NOAA), satellite products (CCMP, TRMM)
2) For the ocean: compilation of measurements including CTD, RCM and ADCP measurements either moored for several months or along some boat transects, satellite products (SST, SSH)

AdriSC climate applications

AdriSC present climate run (1987-2017)

Ocean verification

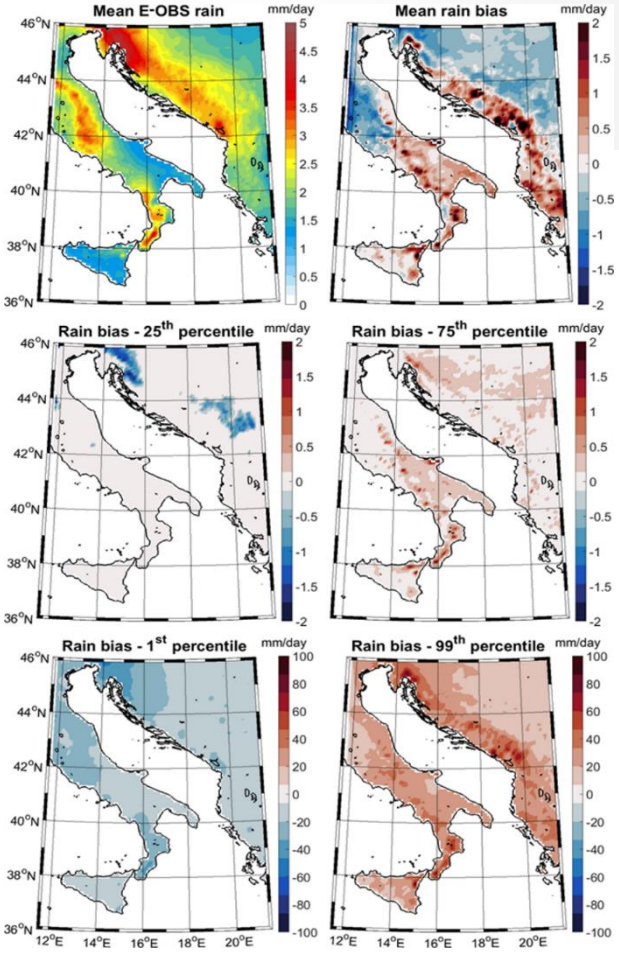


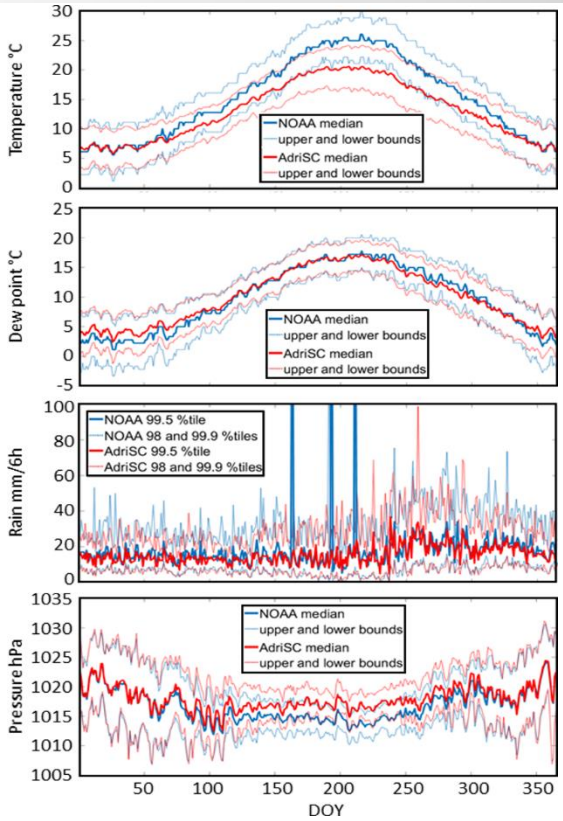
✓ Nice matching between ocean model and observations, in particular with temperature

AdriSC climate applications

AdriSC present climate run (1987-2017)

Atmospheric verification





- ✓ Nice matching between atmospheric model and observations, aside summer temperature
- ✓ We found data flaws in E-OBS and NOAA products

AdriSC climate applications

AdriSC future climate run (2071-2100)

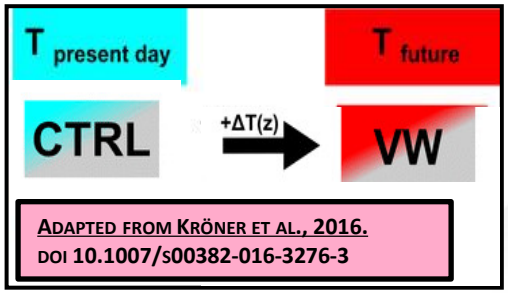
Pseudo-global warming (PGW) method

BASIC IDEA (FOR THE ATMOSPHERE):

- ✓ apply large-scale changes of temperature, relative humidity, wind, etc. to the lateral boundary conditions of a present-day reference simulation of a regional climate model (RCM)
- ✓ the mean perturbation is taken from a mean climate change signal of the driving GCM run. The resulting pseudo-global warning follows the large-scale circulation of the reference period (variability is unchanged) but with a warmer climate for example (mean is shifted).

EXTENSION OF THE METHOD TO THE OCEAN:

(1) Modified variables: salinity, temperature, currents and sea surface height
(2) Stability of the forcing imposed to be ≥ 0
(3) Wave forcing not modified as not enough high resolution information was available
(4) River flow discharges modified with monthly percentage changes



ADAPTED FROM KRÖNER ET AL., 2016.
DOI 10.1007/s00382-016-3276-3

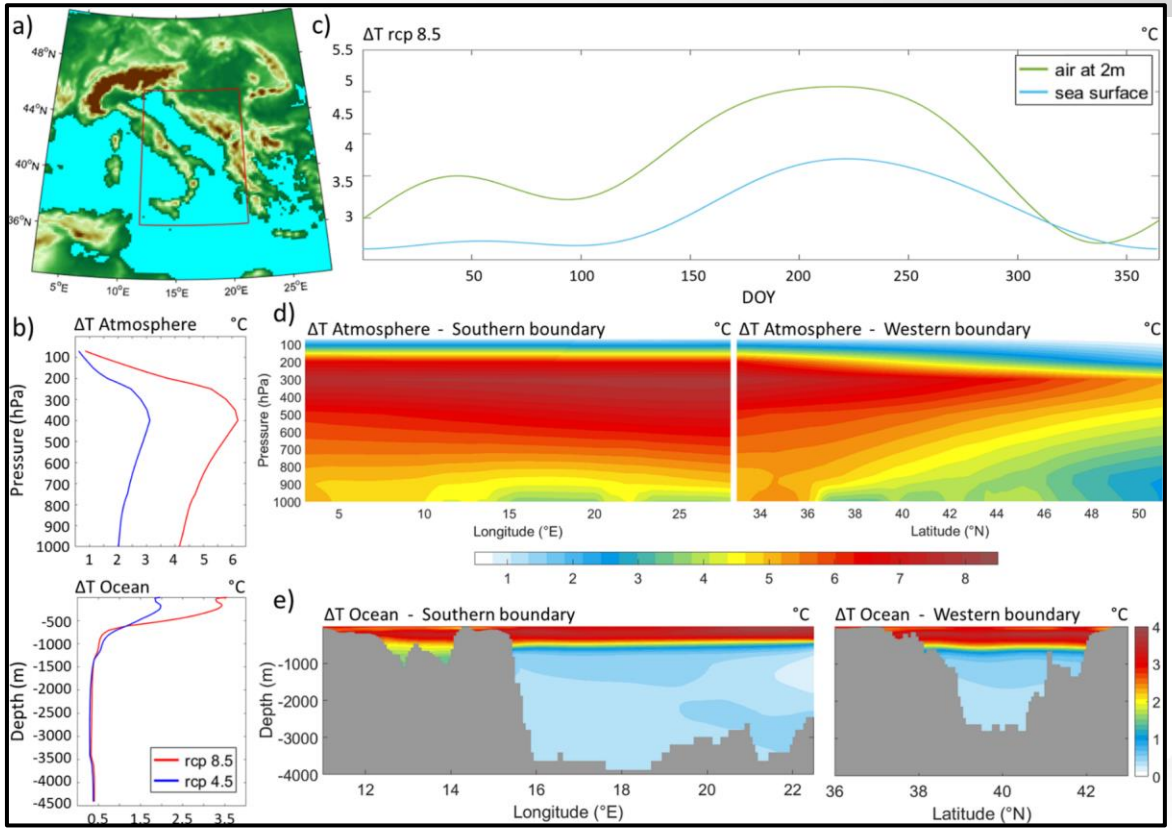
PGW FORCING:

- ✓ Initial and boundary conditions modified with historical + RCP 4.5 + RCP 8.5 daily/monthly results extracted from the Med-CORDEX coupled ocean-atmosphere RCM: LMDZ4-NEMOMED8
- ✓ River flow discharges modified following Macias et al. (2018)

AdriSC climate applications

AdriSC future climate run (2071-2100)

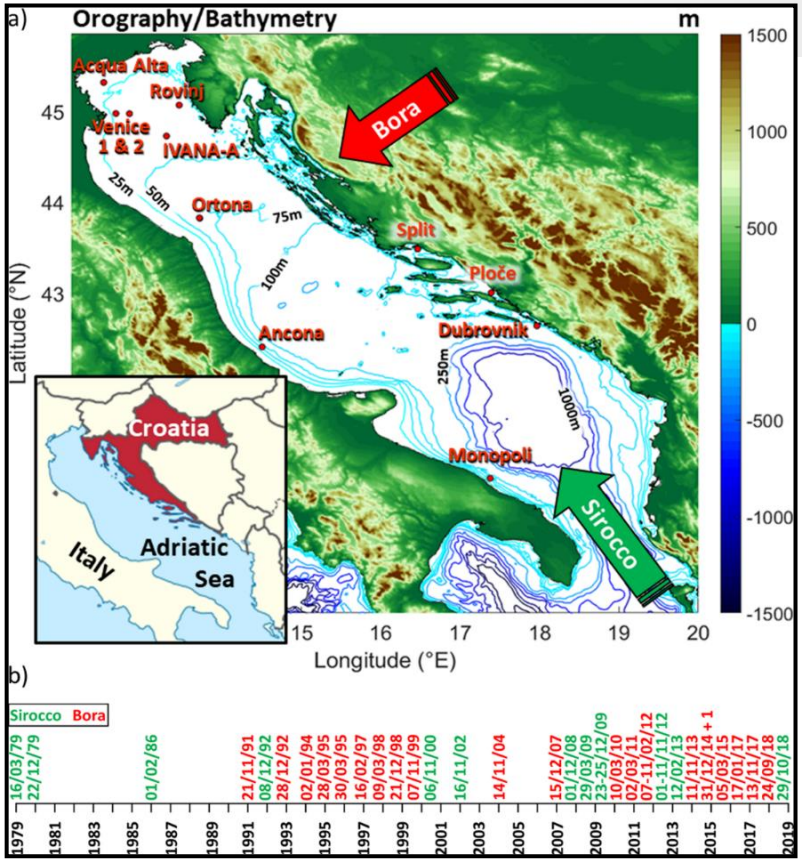
Pseudo-global warming (PGW) method



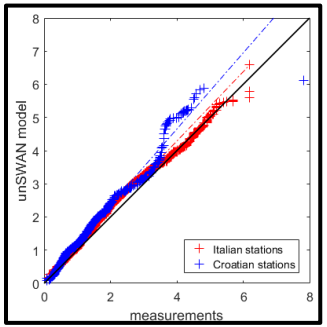
AdriSC climate applications

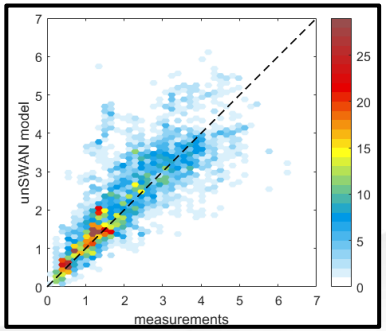
AdriSC extreme wave events

Evaluation



- ✓ 36 wave storms selected in the Adriatic between 1979-2019:
- ✓ 14 Sirocco events & 22 Bora events
- ✓ Evaluation of the unSWAN wave model: 6 and 5 wave buoys along the Italian and Croatian coastlines, respectively
- ✓ Future climate: RCP 8.5 Pseudo Global Warming (PGW) corrections used to re-run the 36 storms



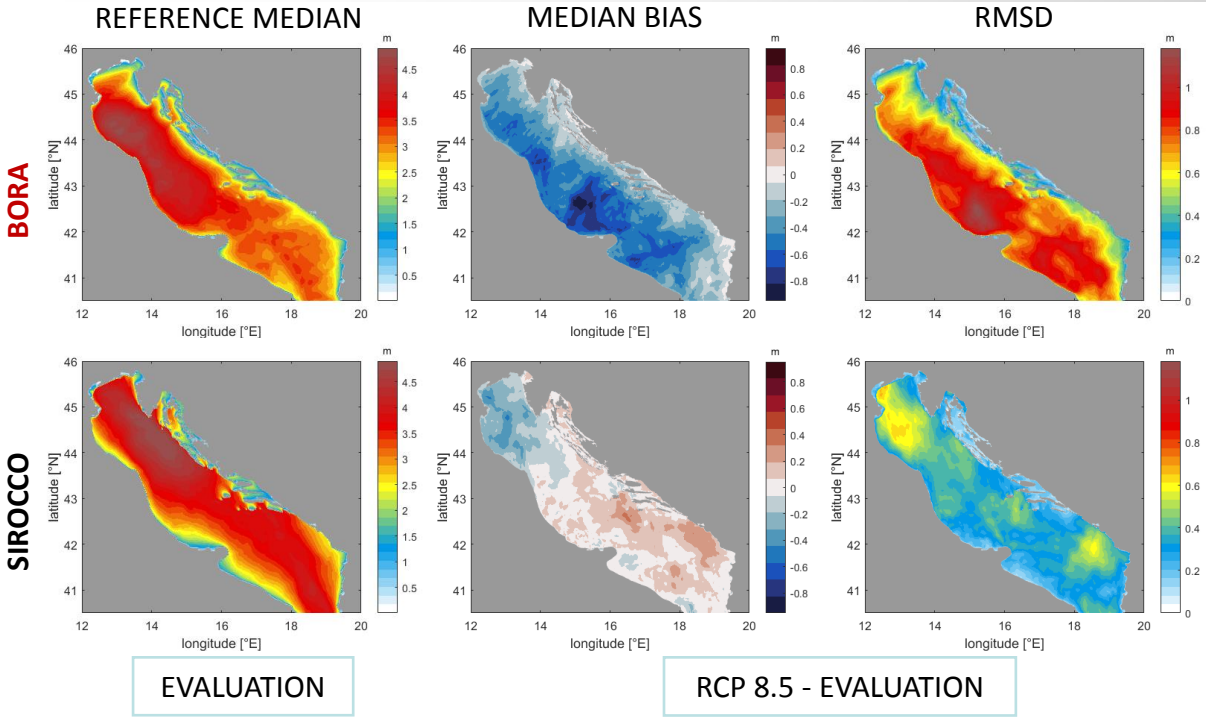


- ✓ 36 events well represented for lower values of SWH (significant wave height)
- ✓ Italian side is overall better represented by the unSWAN model
- ✓ Slight overestimation for values between 2 and 4 m

AdriSC climate applications

AdriSC extreme wave events

Future climate

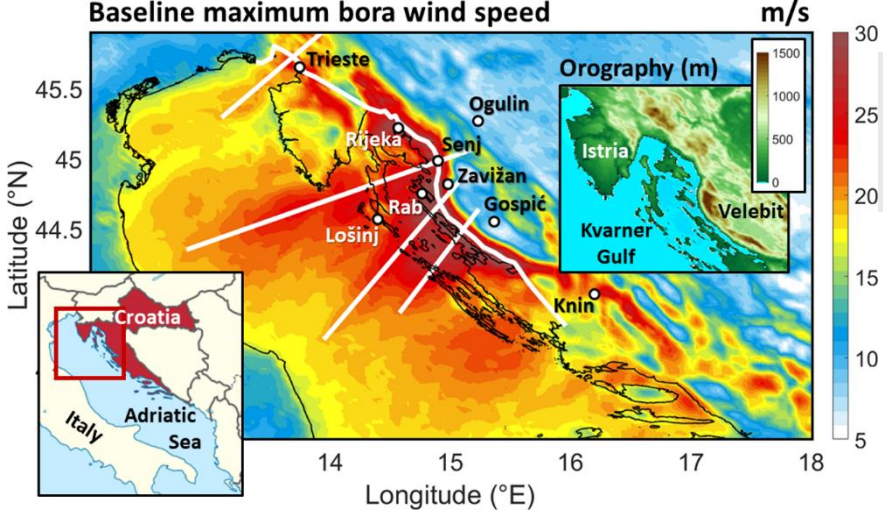


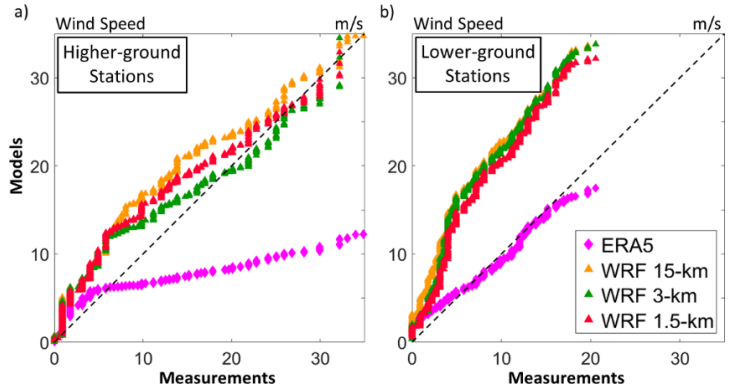
- ✓ decrease in Bora produced maximum SWH and Tp under RCP 8.5
- ✓ Sirocco less conclusive

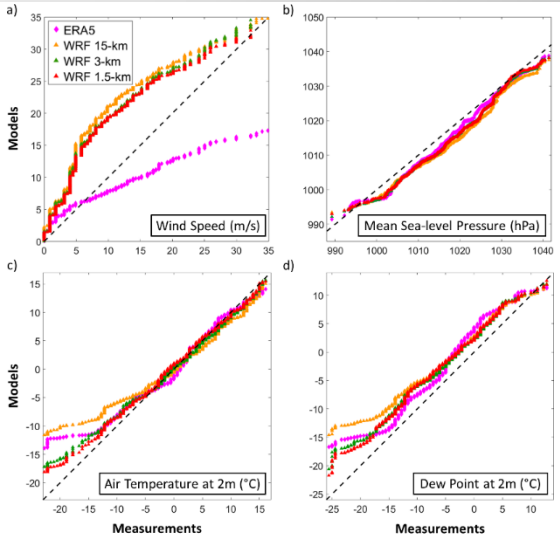
AdriSC climate applications

AdriSC extreme bora events

Evaluation





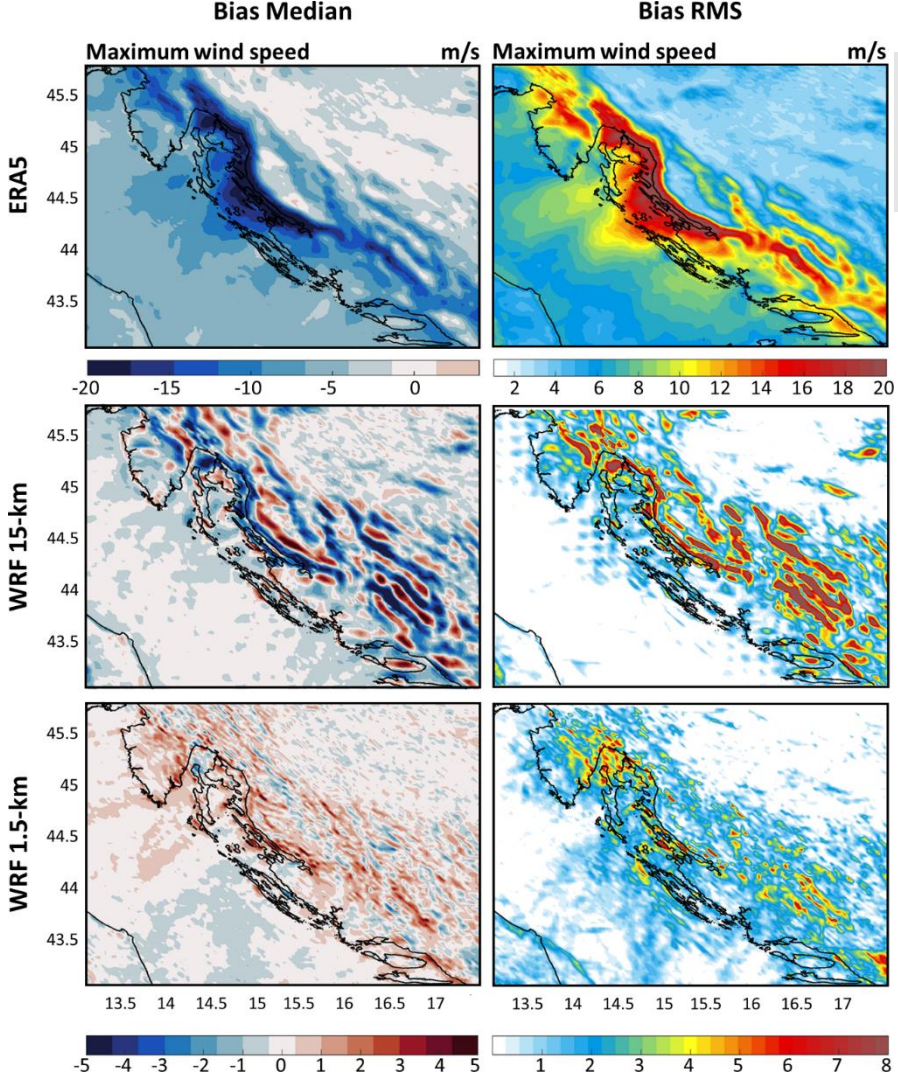


- ✓ Underestimation of wind speed measurements at low-ground stations → particularly true for Senj!
- ✓ RH and T are properly reproduced

AdriSC climate applications

AdriSC extreme bora events

Evaluation

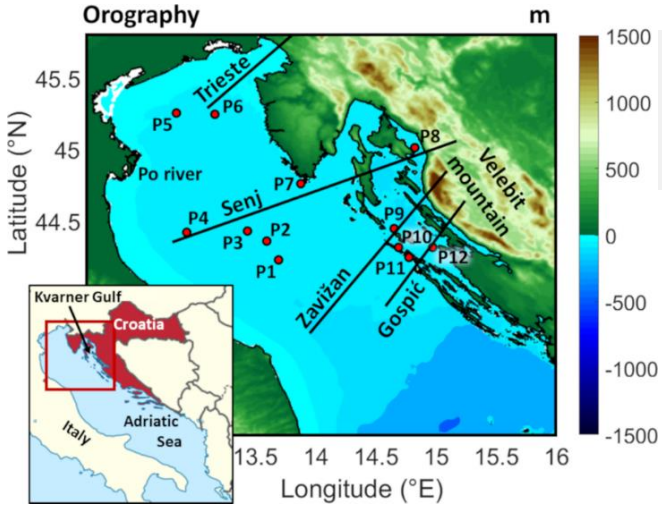


- ✓ Strong underestimation of bora by ERA5
- ✓ Higher resolution → stronger bora in the Velebit Channel

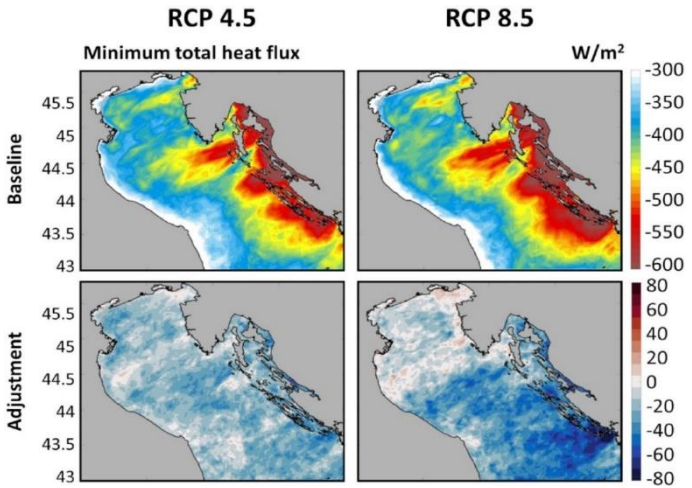
AdriSC climate applications

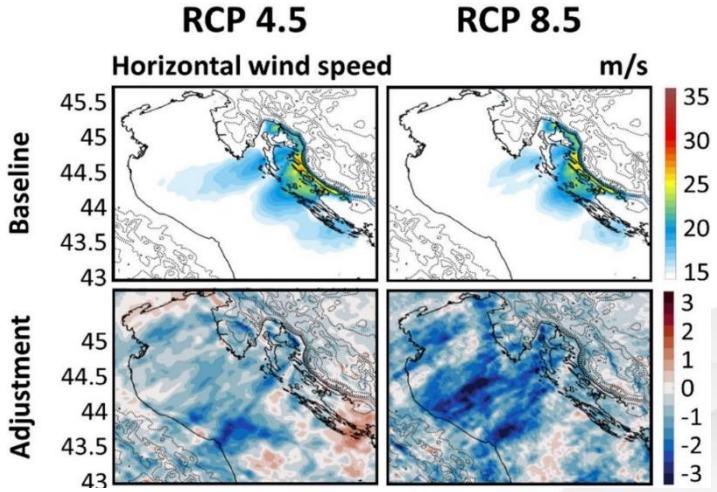
AdriSC extreme bora events

Future climate



- ✓ 22 bora events selected in the Adriatic between 1979-2019
- ✓ Future climate: RCP 8.5 Pseudo-global warming (PGW) corrections used to re-run the 22 storms

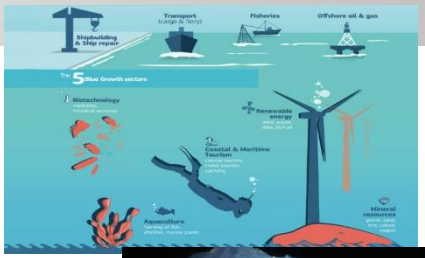




- ✓ Bora will weaken in the future climate
- ✓ However, cooling of the surface and the dense water formation (→ then the Adriatic thermohaline circulation) would not significantly change, due to decrease in bora humidity

Perspectives

- ✓ A substantial progress in climate modelling of the Adriatic Sea, going down by an order of magnitude higher resolutions – 1 to 3 km vs. 10 to 20 km (in RegCMs)
- ✓ New methodology (pseudo-global warming, PGW) applied in assessment of future climate of extreme events
- ✓ Long-term high-resolution climate runs (present and future climate) still to be investigated, but first results are promissing ...
- ✓ Hopefully, climate modelling will be the tool used by decision-makers and policy-makers, in shaping the future of the Adriatic regions, coastal areas and sea resources



Further reading

- ✓ Denamiel, C., Tojčić, I., Vilibić, I., 2020. Balancing accuracy and efficiency of atmospheric models in the northern Adriatic during severe bora events. *Journal of Geophysical Research Atmospheres*, under review
- ✓ Denamiel, C., Pranić, P., Quentin, F., Mihanović, H., Vilibić, I., 2020. Pseudo-global warming projections of extreme wave storms in complex coastal regions: the case of the Adriatic Sea. *Climate Dynamics*, https://doi.org/10.1007/s00382-020-05397-x
- ✓ Denamiel, C., Tojčić, I., Vilibić, I., 2020. Far future climate (2060–2100) of the northern Adriatic air–sea heat transfers associated with extreme bora events. *Climate Dynamics*, https://doi.org/10.1007/s00382-020-05435-8
- ✓ Denamiel, C., Šepić, J., Ivanković, D., Vilibić, I., 2019. The Adriatic Sea and coast modelling suite: Evaluation of the meteotsunami forecast component. *Ocean Modelling*, 135, 71-93. https://doi.org/10.1016/j.ocemod.2019.02.003