The WCRP / JCOMM Workshop on Coordinated Global Wave Climate Projections.
11-13 April, 2011
Venue: Hall B, WMO Secretariat Building,
Geneva, Switzerland.

Regional wave climate projection studies in the Mediterranean Sea

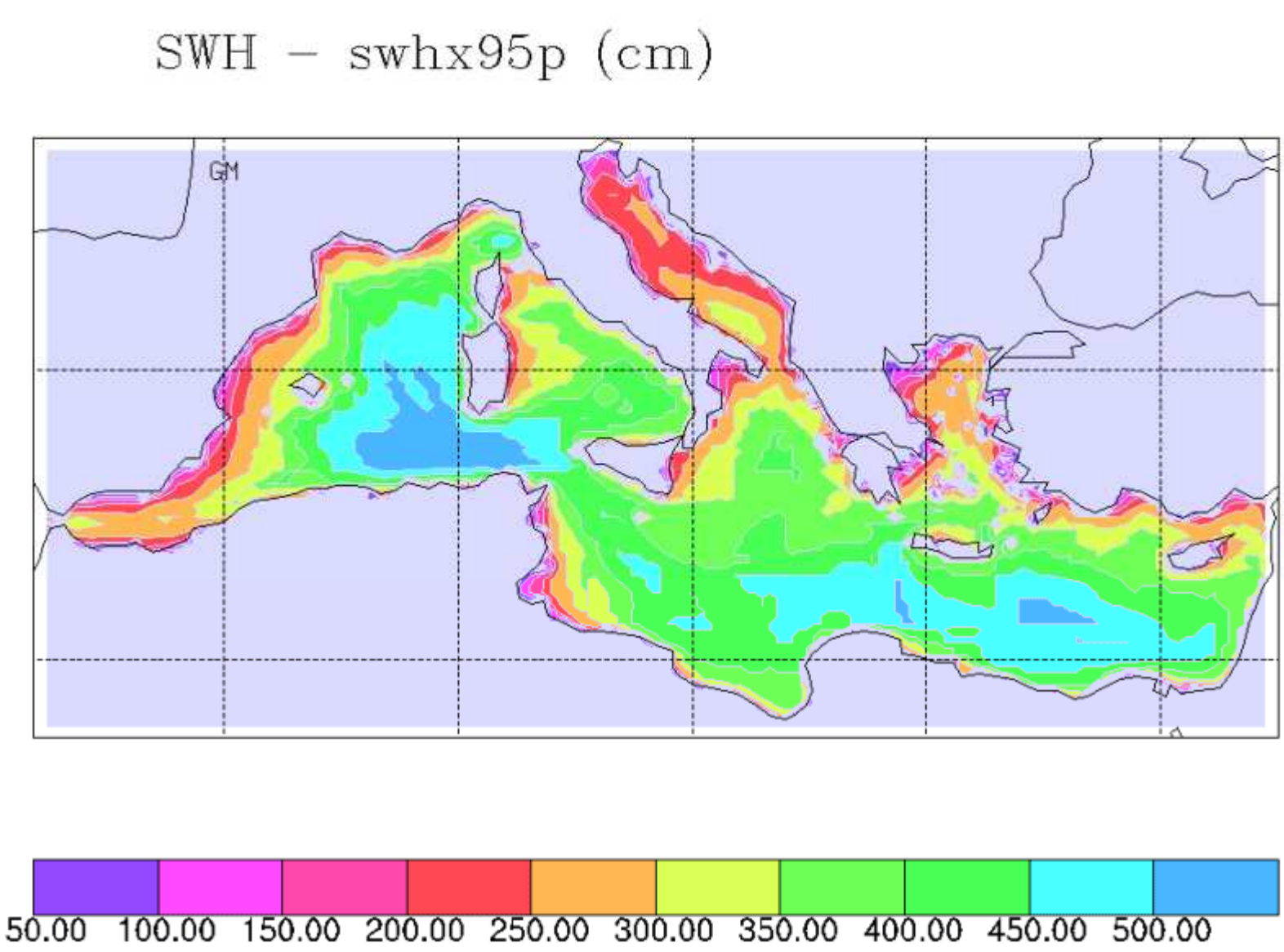
P.Lionello
Univ. of Salento and CMCC, Italy

Plan of the talk

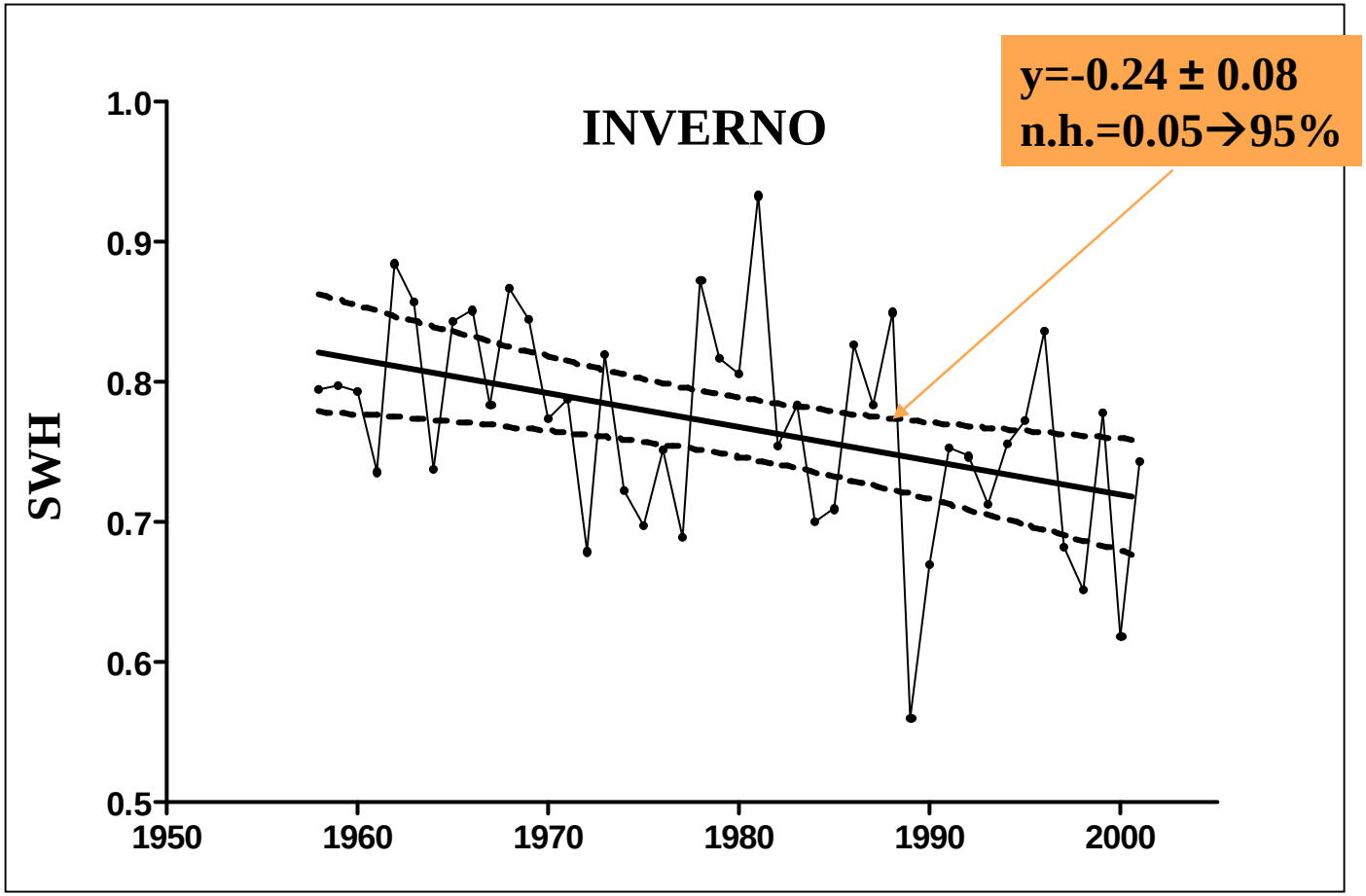
- Present trends in the Mediterranean Sea

- Results from a former climate projection study, analysing time slice for A2 and B2 scenarios (2071-2100 versus 1961-1990)

- A new seamless wave climate simulation for the period 1950-2050, A1B scenario


SWH – swhx95p (cm)
GM
50.00
100.00
150.00
200.00
250.00
300.00
350.00
400.00
450.00
500.00
swhx95p (cm)

Mean SWH: present trends

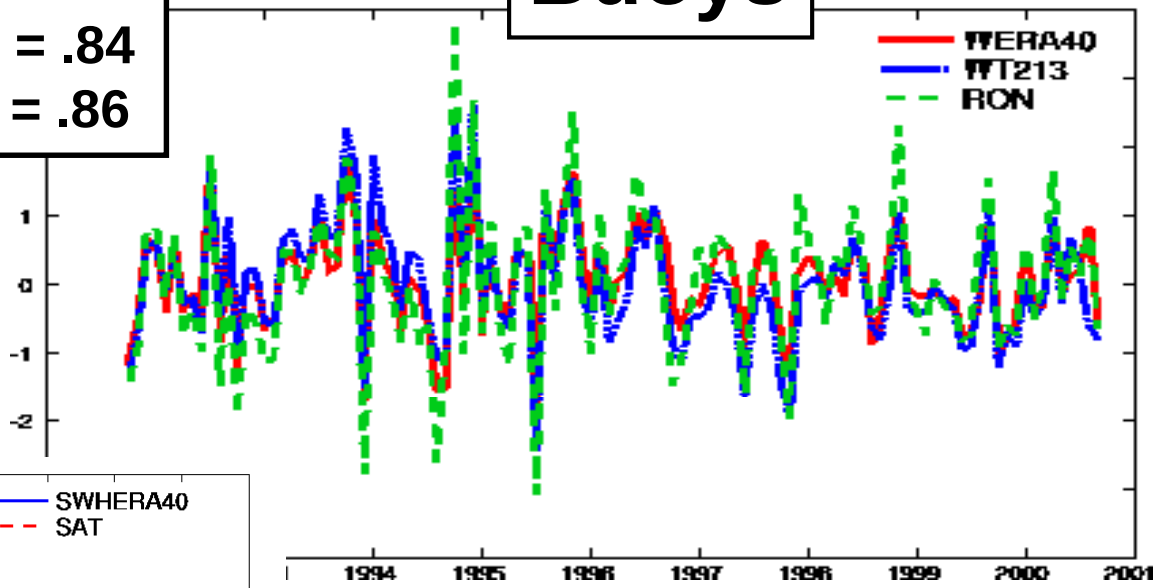


From Lionello and Sanna 2005

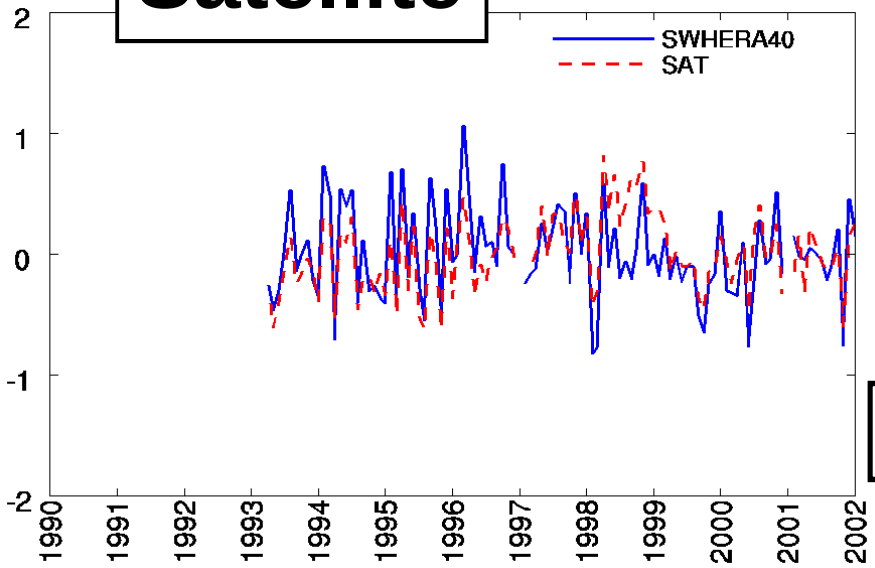
Model validation

correlazione ERA 40-T213 = .88
correlazione ERA 40-RON = .84
correlazione RON-T213 = .86

Buoys



Satellite



correlazion ERA 40 – SAT = .72

SWH climate change indicators:

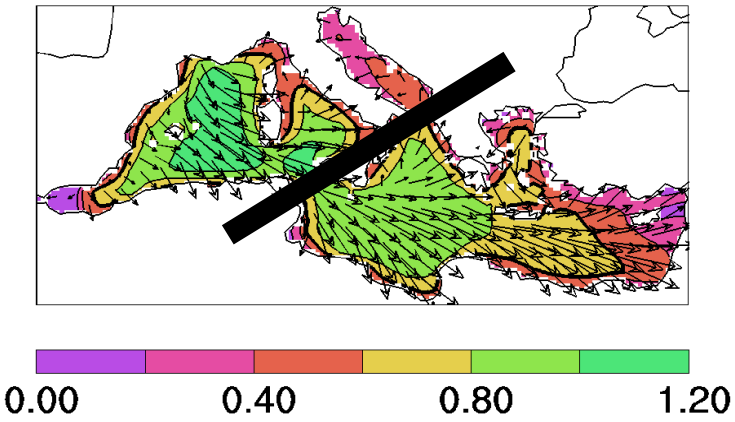
SWHX95p: 95th percentile of the daily maximum SWH (significant wave height).

SWHG50p: 50thp of the daily average SWH

SWHN5p: 5p of the daily minimum SWH

SWH_AVE: average monthly SWH

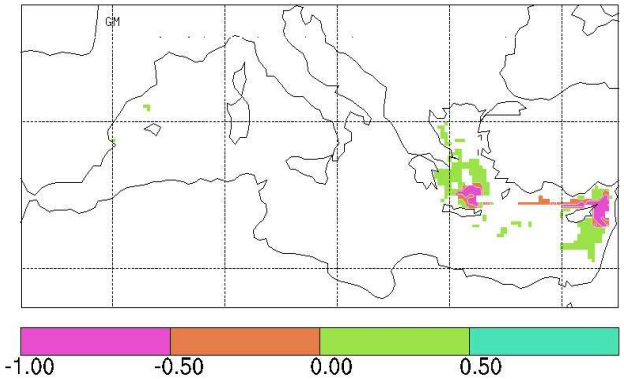
swhx5gev, … ,swhx100gev: 5, …, 100year SWH return values.

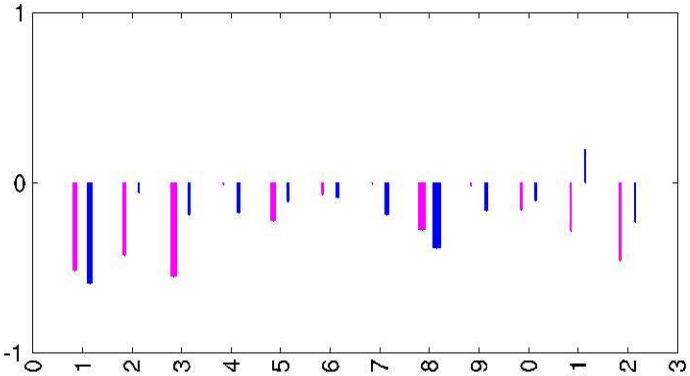


areas with significant annual trend cm/year (99% confidence level).

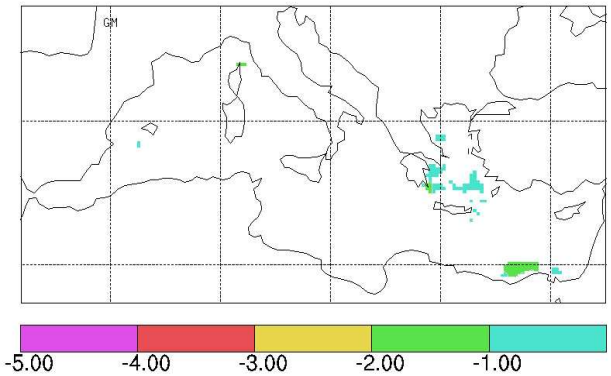
Average trends (cm/year) during the annual cycle, pink (west), blue(east) . Thin/medium/thick bars denote trends statistically significant at 95% confidence level in n<20%/20%<n<40%/n>40% of sea points

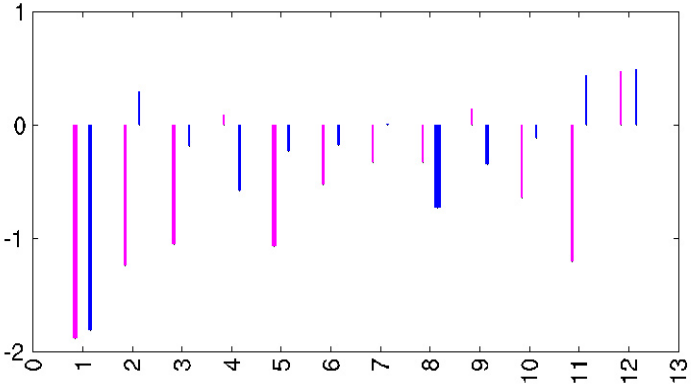
50p

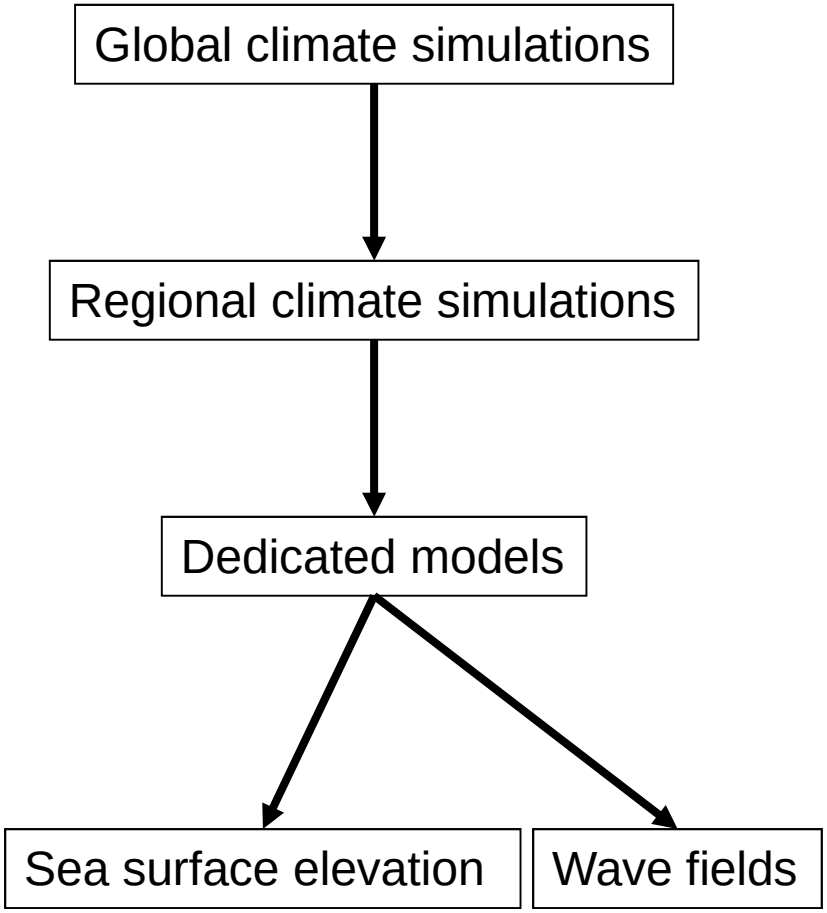


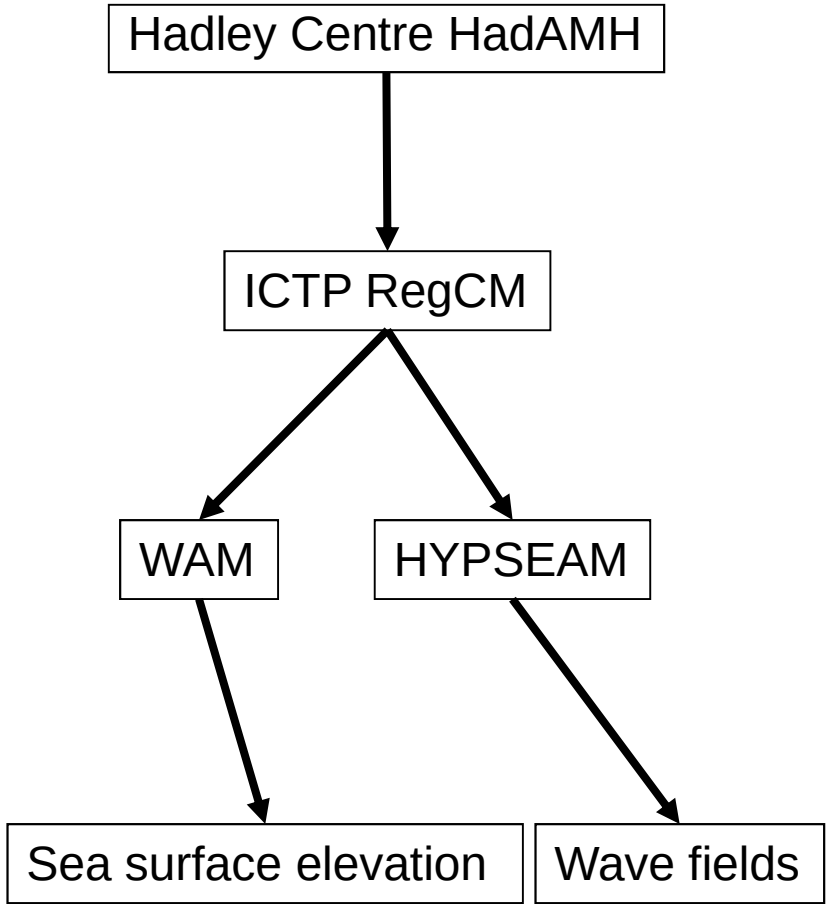


95p





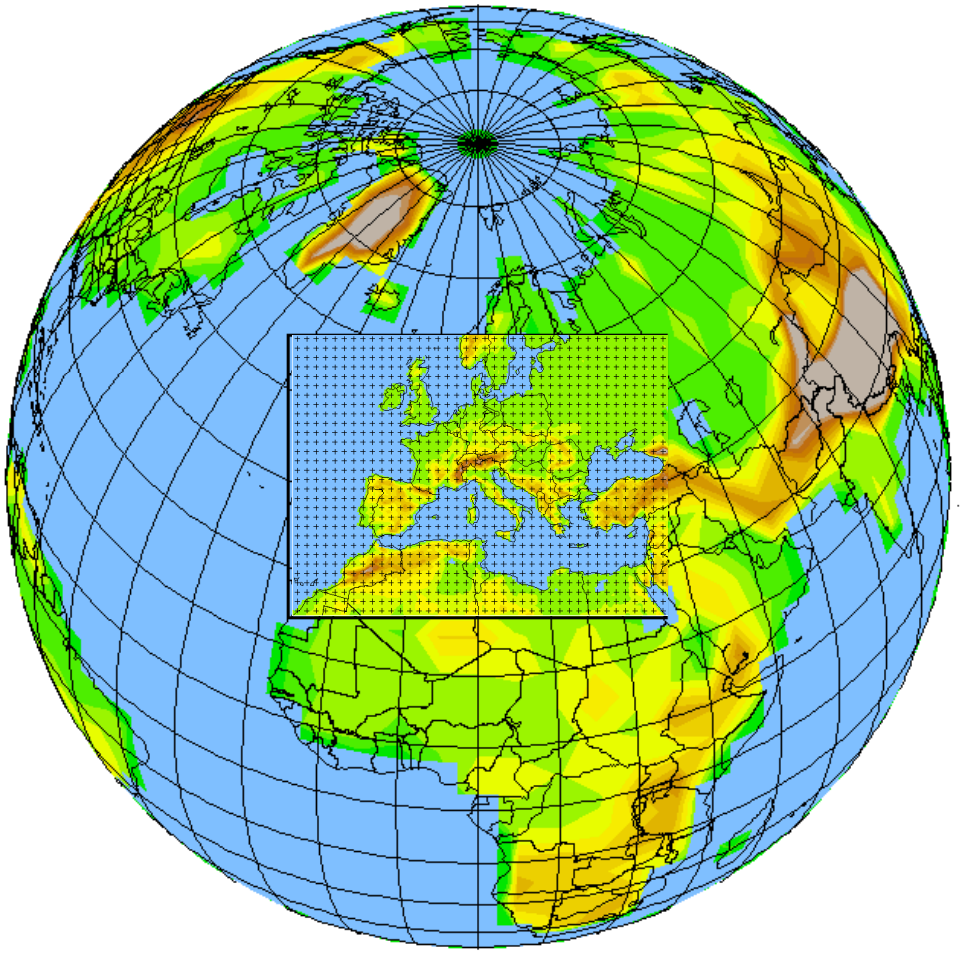

Global climate simulations
Regional climate simulations
Dedicated models
Sea surface elevation
Wave fields


Hadley Centre HadAMH
ICTP RegCM
WAM
HYPSEAM
Sea surface elevation
Wave fields

RegCM experiment design

Giorgi, F., X. Bi and J.S. Pal , 2004 a and b

- Global Model: Hadley Centre HadAMH
  - Dx = 1.25 lat x 1.875 lon
  - SST from HadCM3 run
  - Coupled sulfur model
- Regional model: ICTP RegCM
  - Dx = 50 km
  - SST, GHG and sulfate from HadAMH
  - aerosol effects
- Simulation periods
  - 1961-1990 : Reference run
  - 2071-2100 : Scenario run
- Scenarios: A2, B2

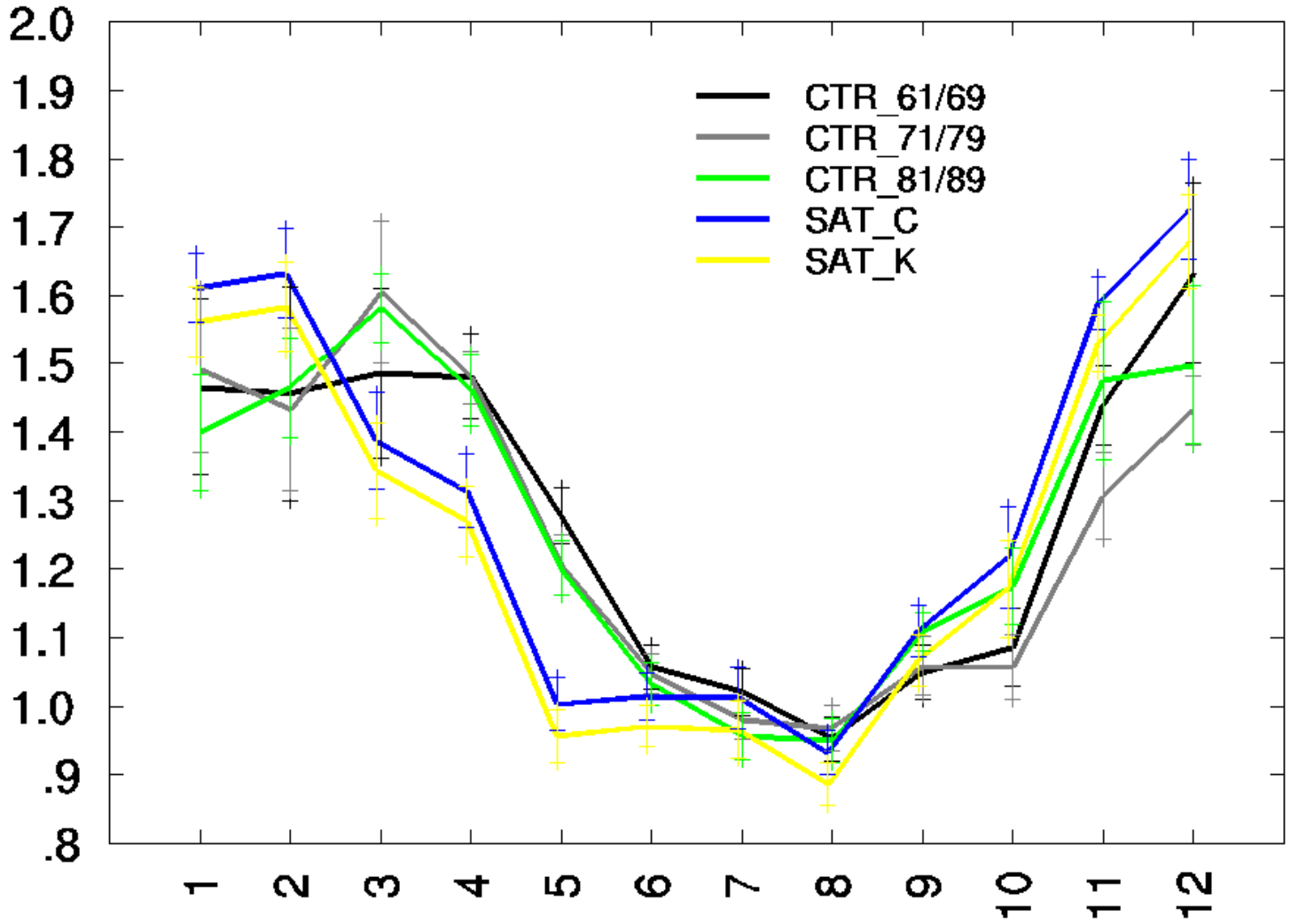


Results are based on 30-year long simulations of the wind-wave field in the Mediterranean Sea carried out with the WAM model.

Wave fields have been computed for 2071-2100 period of the A2, B2 emission scenarios and for 1961-1990 period of the present climate (REF).

The wave model has been forced by the wind field computed by the RegCM regional climate model at a 50km resolution

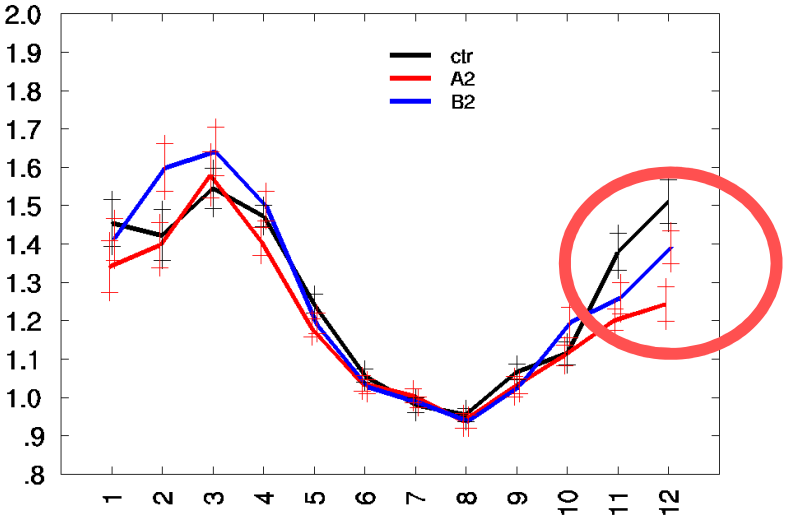
REF simulation: Comparison between satellite data and model results. Annual cycles are plotted separately for each decade of the simulation. Vertical bars show the standard deviation. Values in meters.



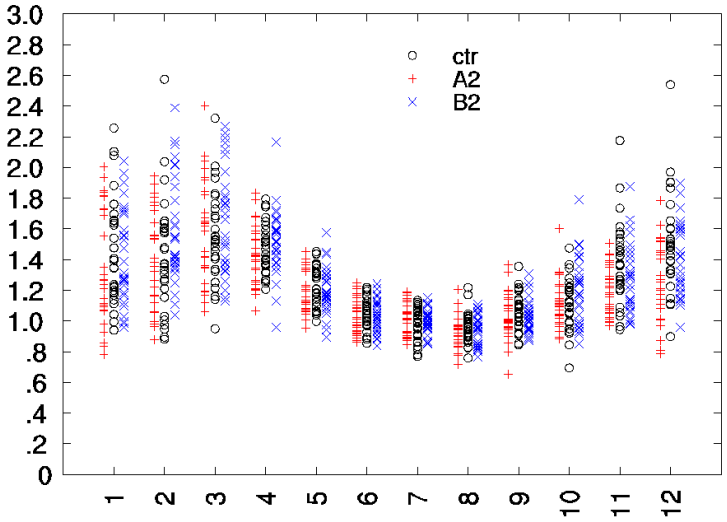
from Lionello et al.2008

average SWH of REF, A2 and B2 scenario simulations

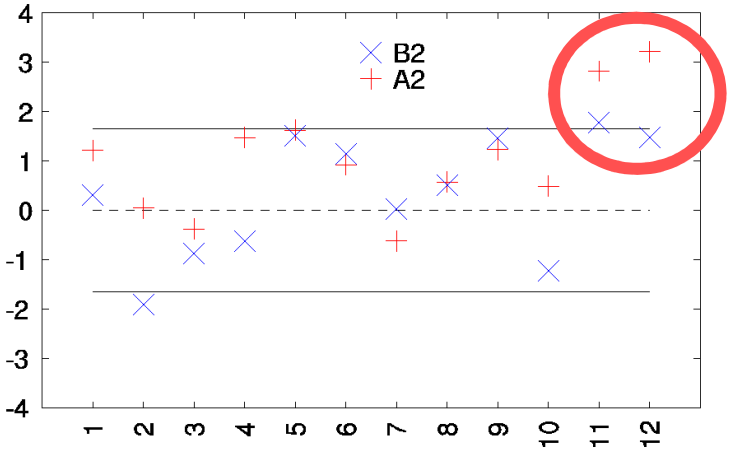
mean annual cycle; vertical bars show the monthly standard deviation (in meters, from Lionello et al.2008)



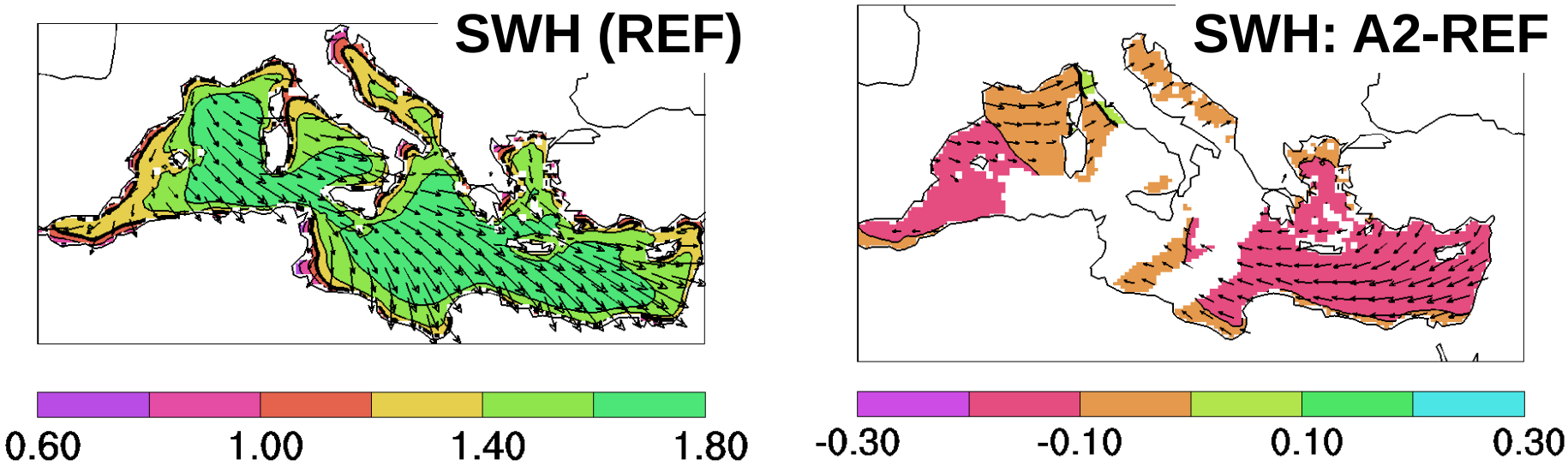
single monthly values (in metres).



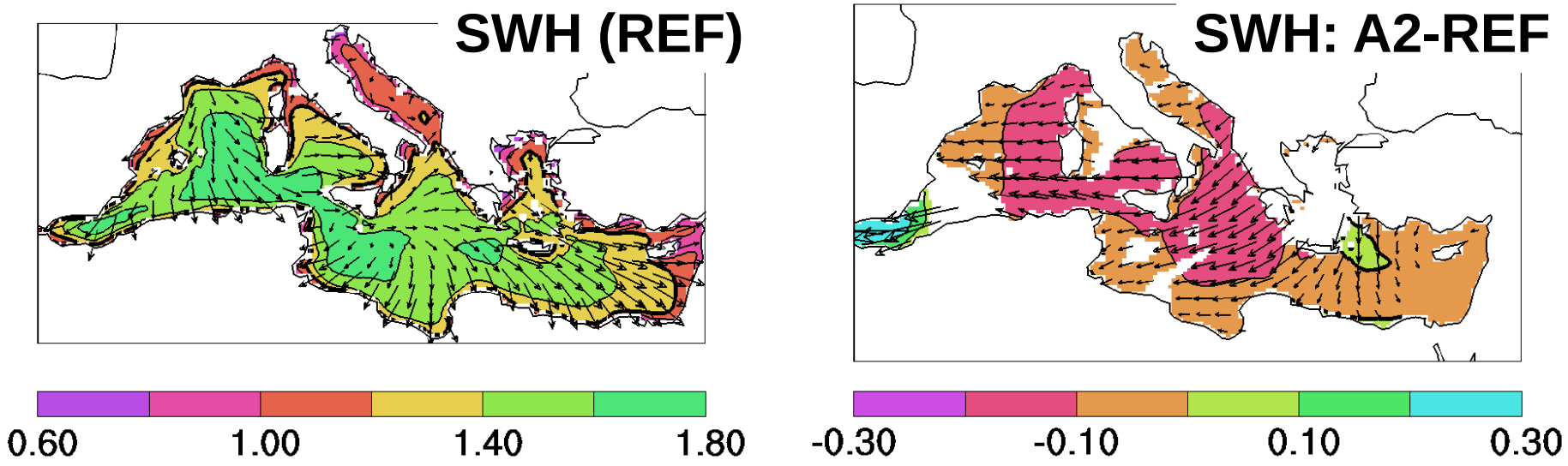
Mann-Whitney test: (ranks)



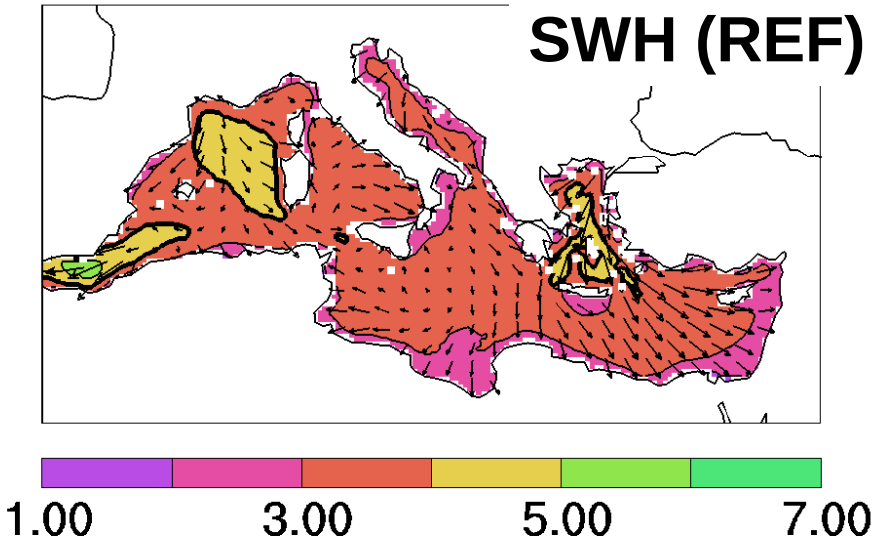
WINTER

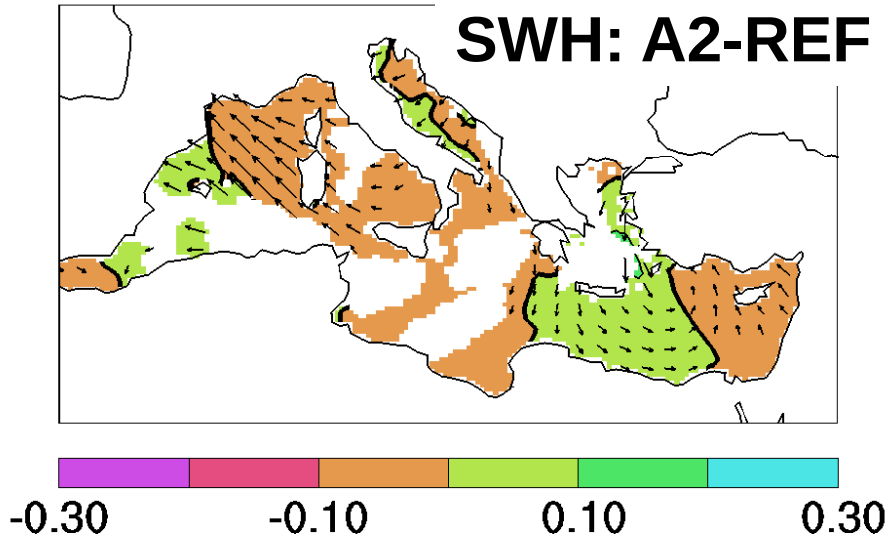


SPRING

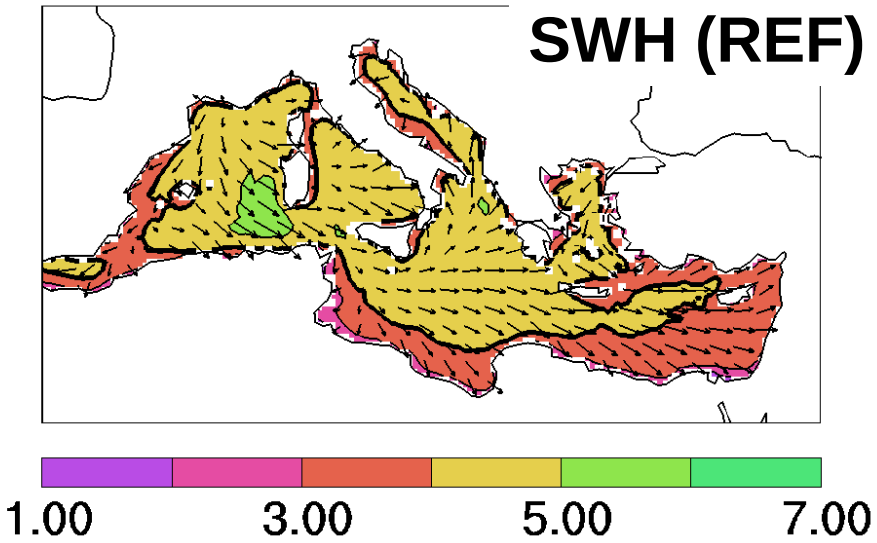


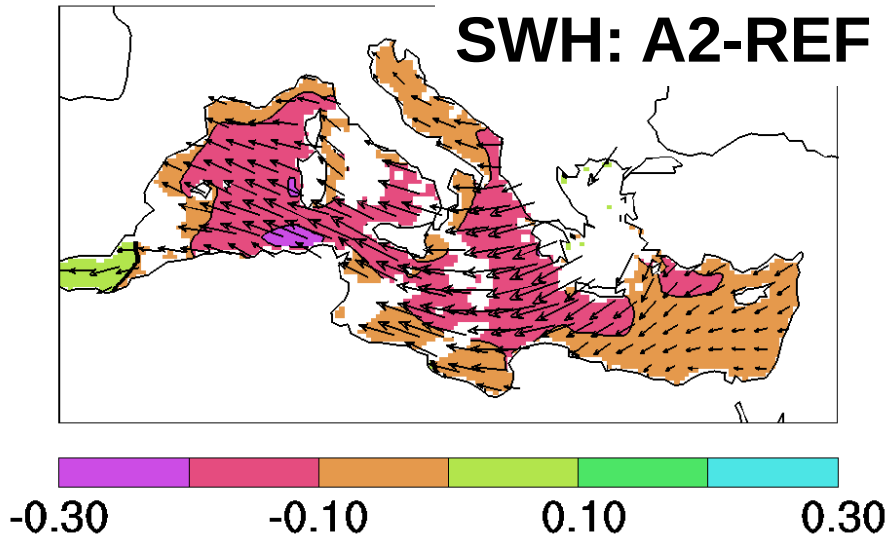
SUMMER



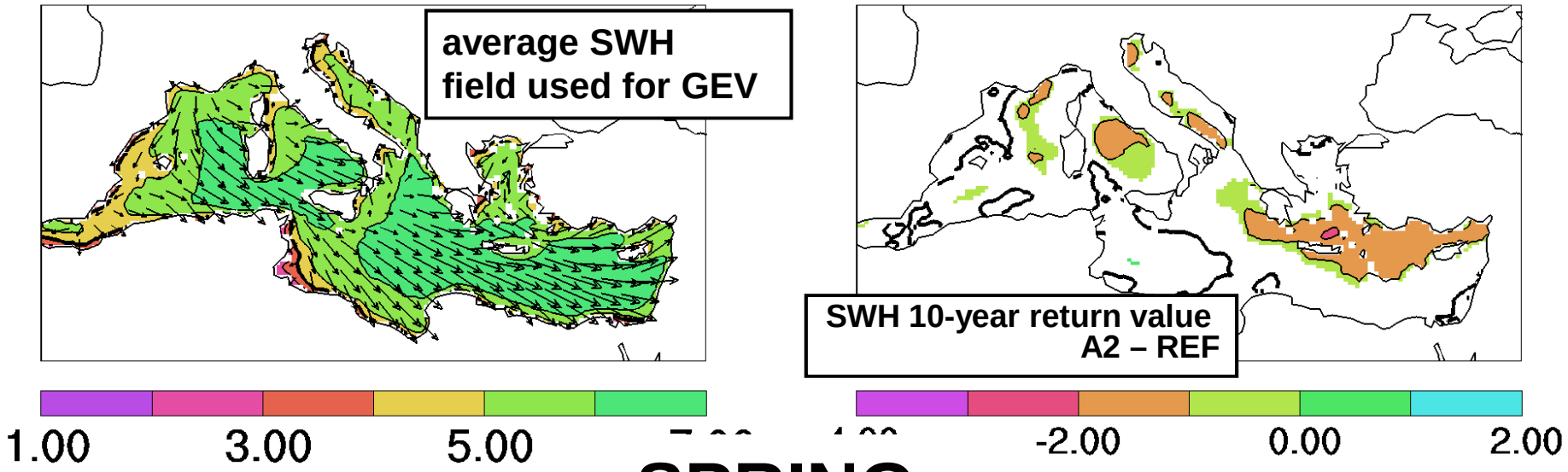


AUTUMN

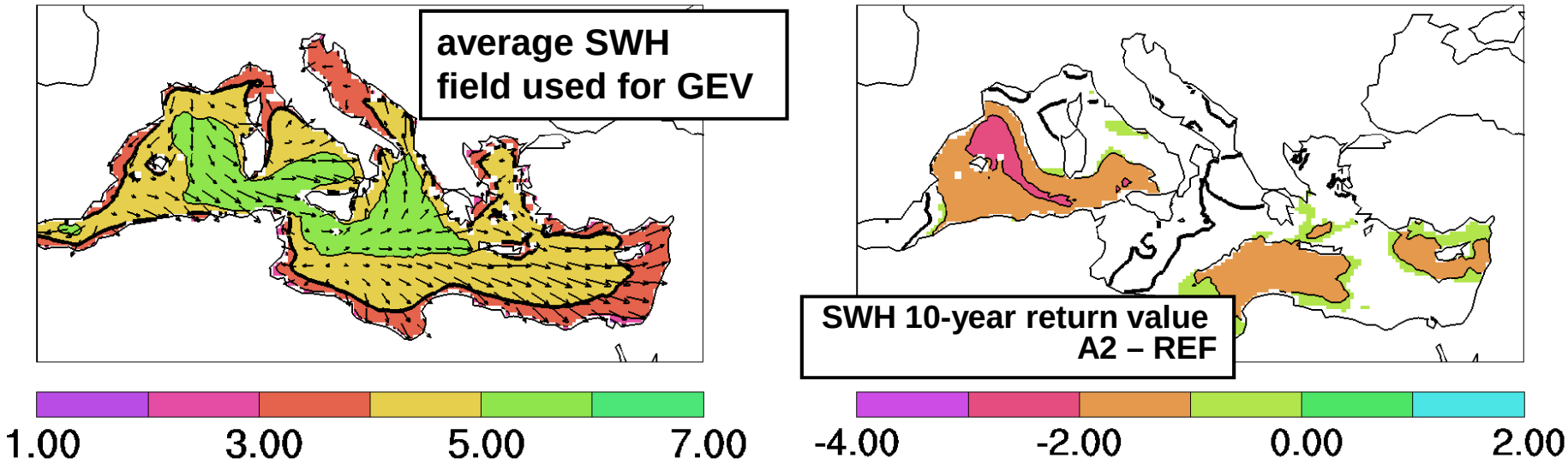




WINTER

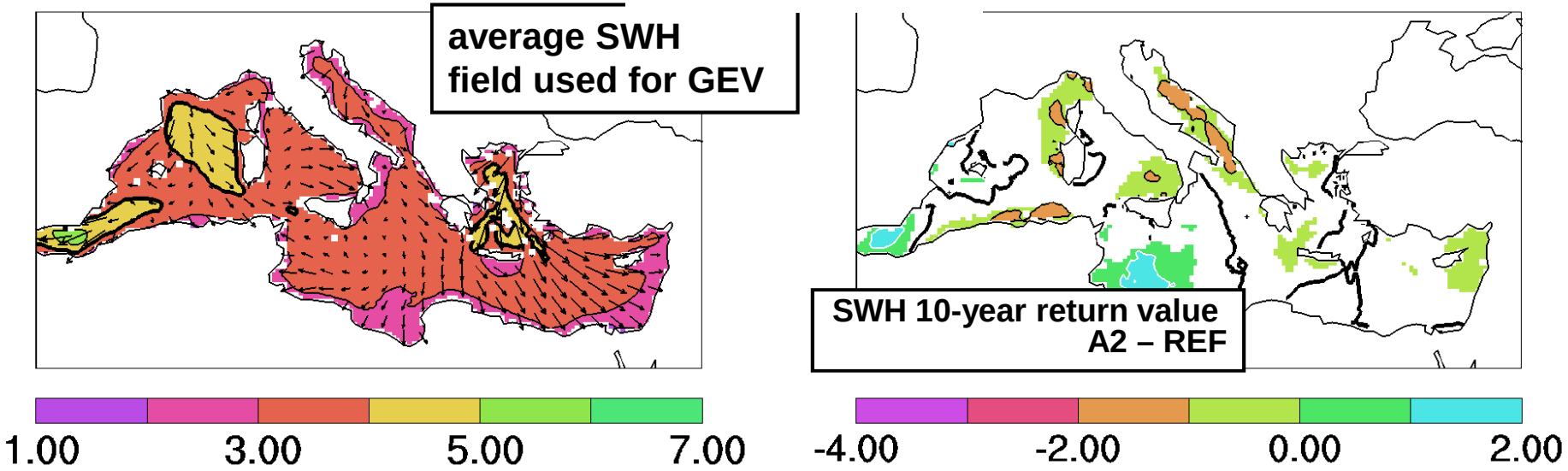


SPRING

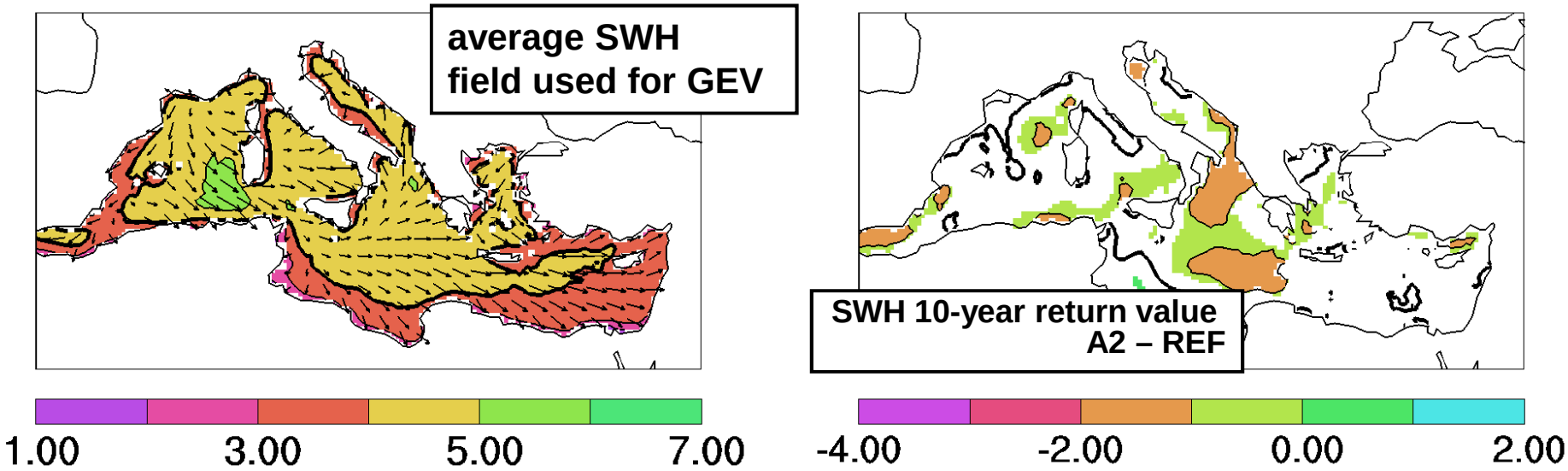


from Lionello et al.2008

SUMMER



AUTUMN



from Lionello et al.2008

“CIRCE” Med Wave simulation

The WAM (WAMDI, 1988) model has been implemented in the Mediterranean Sea with a resolution of 0.25degs.

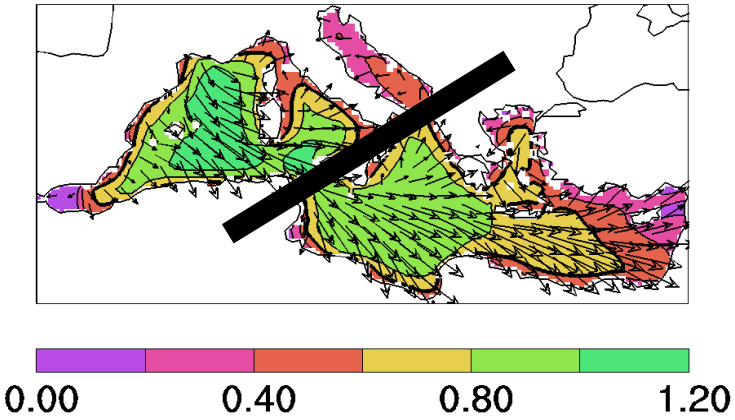
Output fields were saved every 3 hours, following the same procedure adopted in Lionello et al 2008.

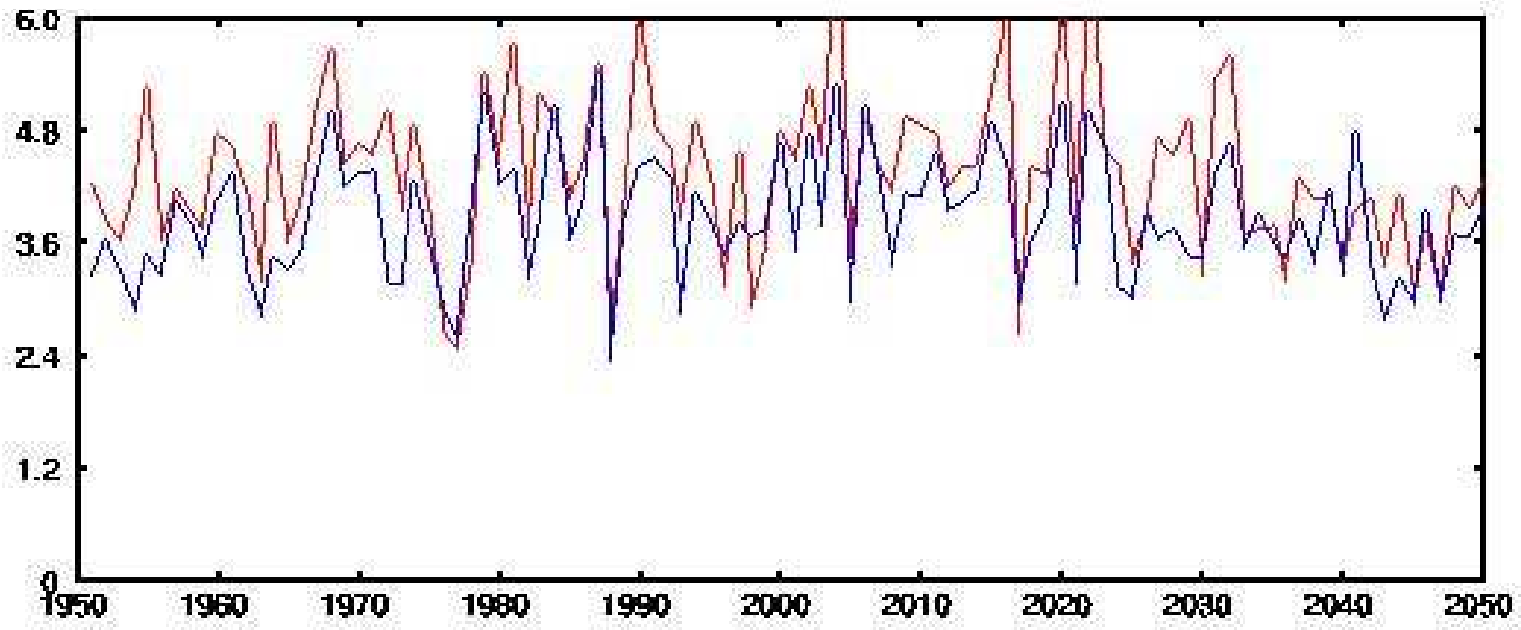
The 6- hourly 10m-level wind fields driving the wam model simulation were provided by a regionally coupled climate model for the Mediterranean region (Elizalde et al, 2010) based on the regional atmosphere model REMO

The regional model includes an active ocean circulation model simulating the Mediterranea Sea evolution with a two way feedback to the atmosphere

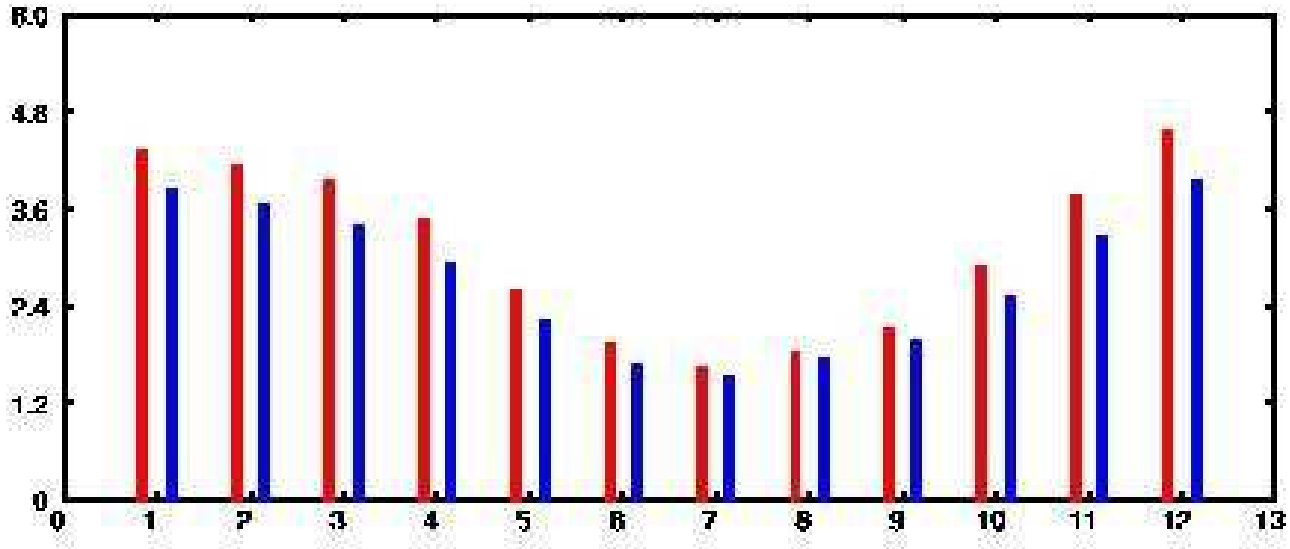
A climate simulation for the A1B IPCC scenario was performed covering the period from 1950 to 2050.

It has been forced at the boundary using the global scenario simulation produced explicitly for CIRCE using ECHAM/OPA by INGV-CMCC group.

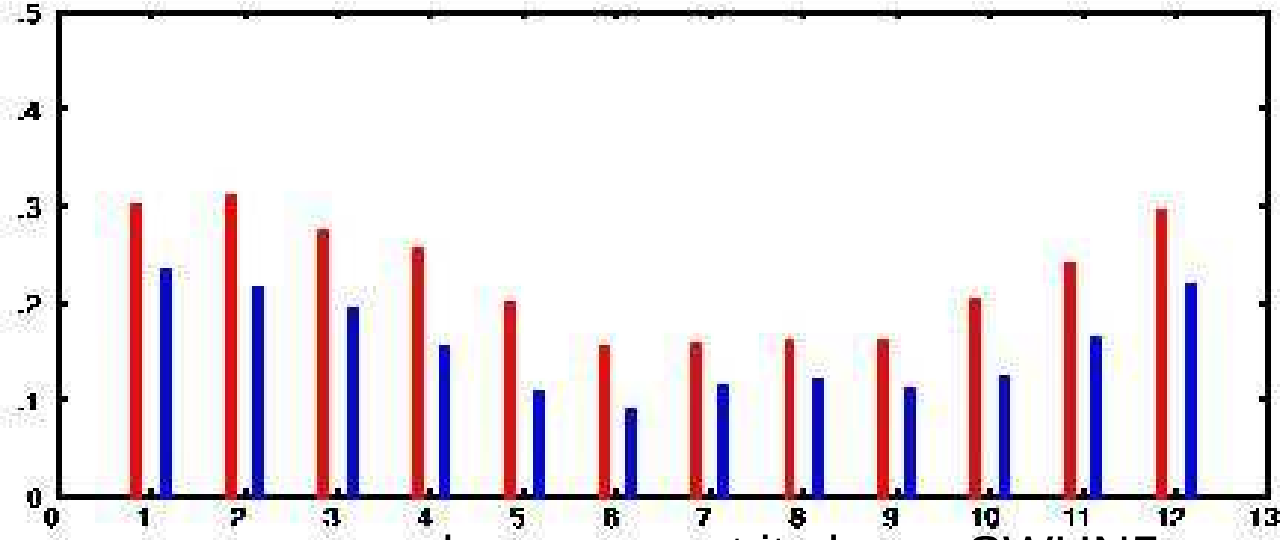




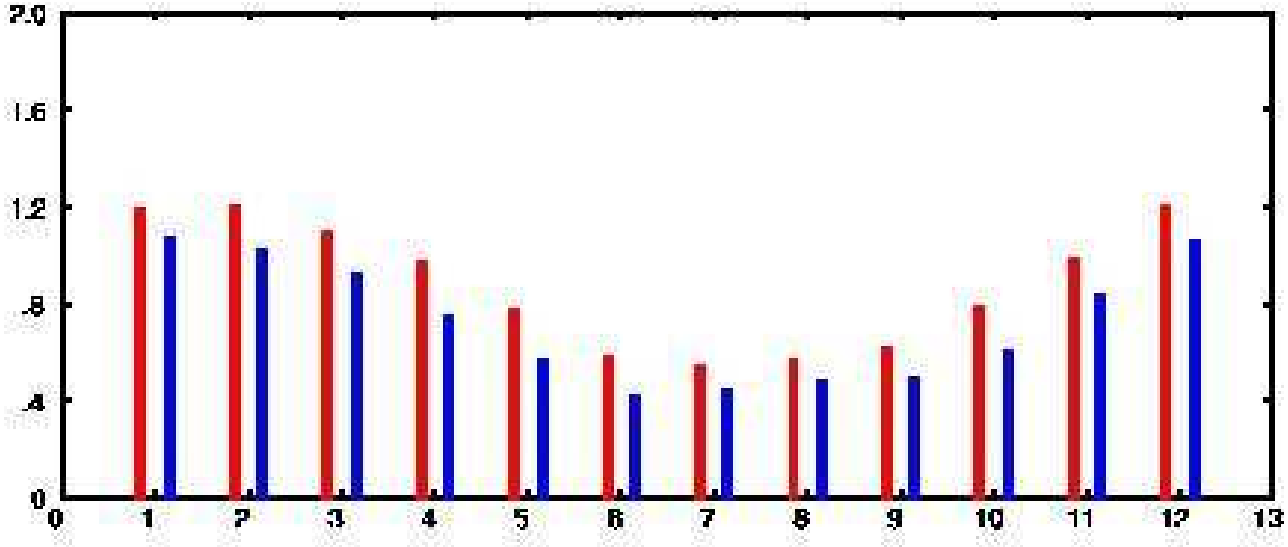
January, SWHX95p: 95th percentile of the daily maximum SWH (significant wave height), average values for the **western** and **eastern** Mediterranean



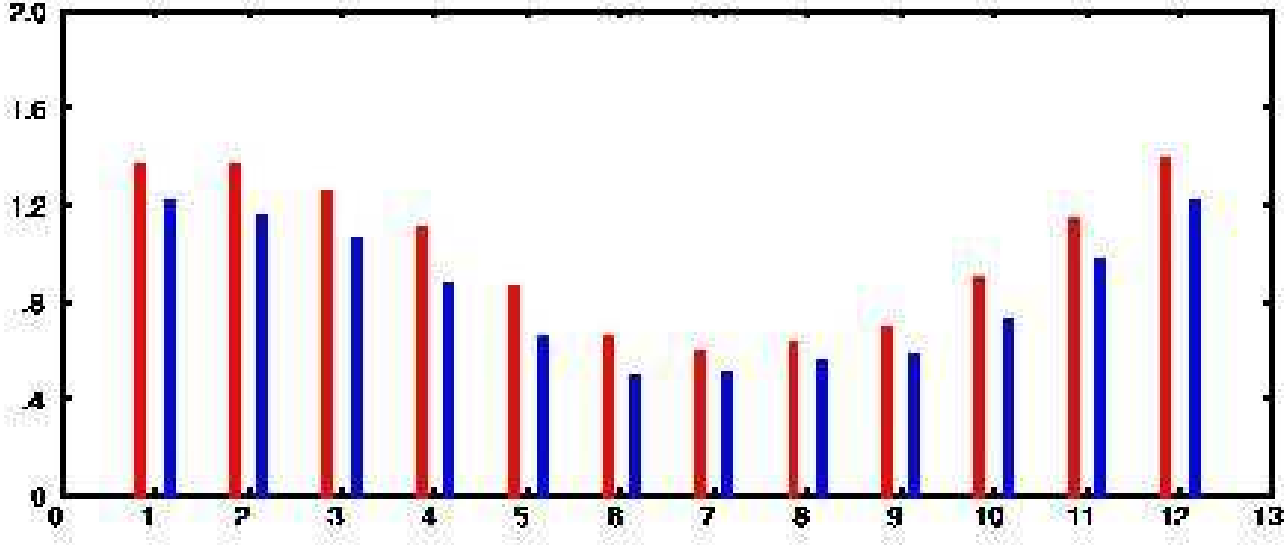
annual cycle of SWH95p for the west (red bars) and east (blue bars) Mediterranean. Calendar months on the x-axis, swh values (m) on the y-axis in the 100-year A1B wave simulation



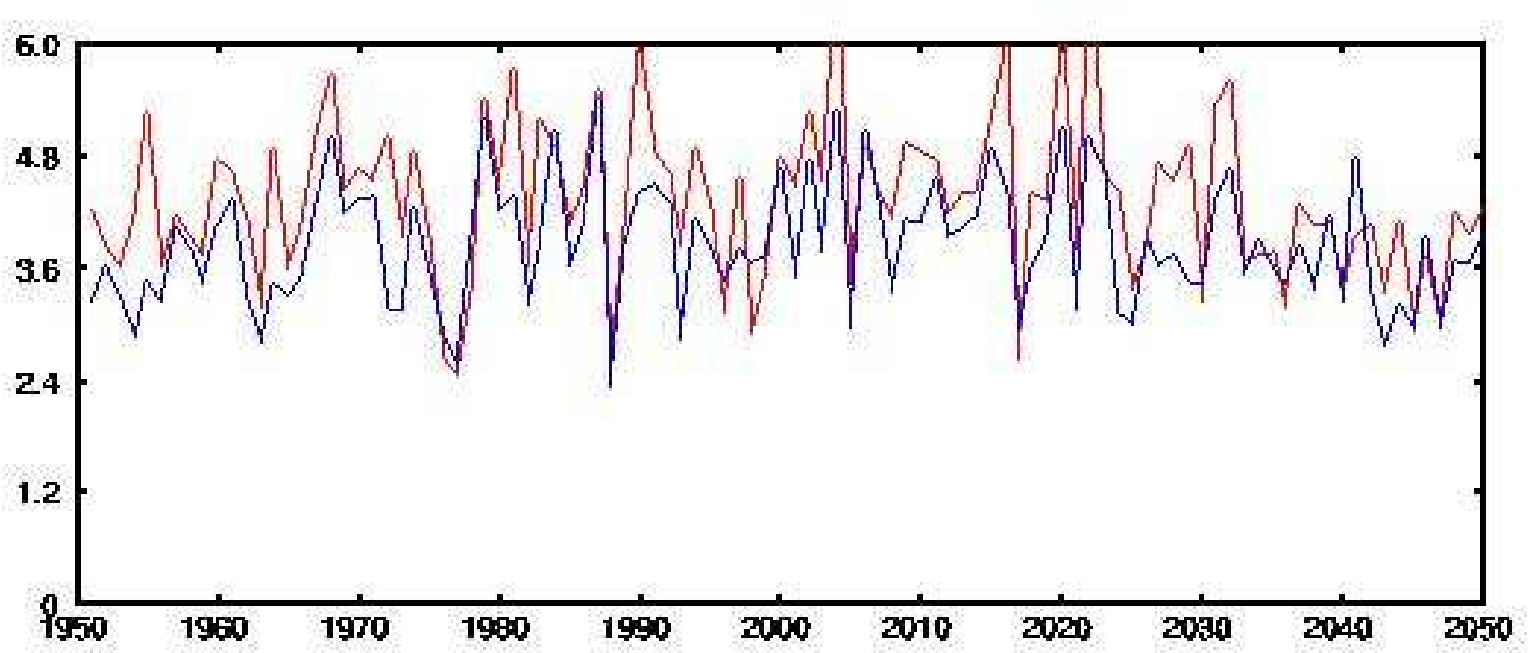
same as above except it shows SWHN5p



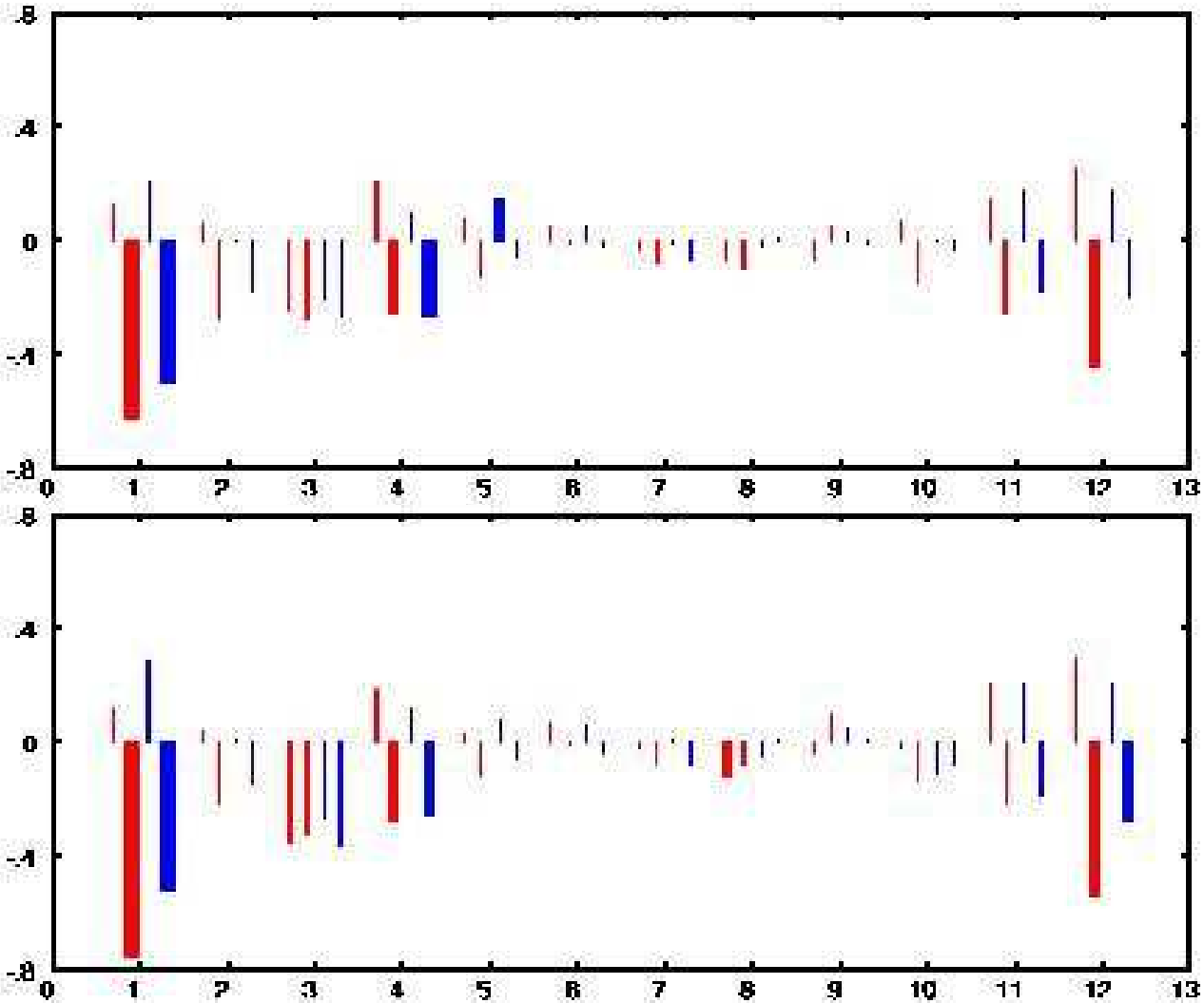
annual cycle of *SWHG50p* for the west (red bars) and east (blue bars) Mediterranean. Calendar months on the x-axis, swh values (m) on the y-axis in the 100-year A1B wave simulation



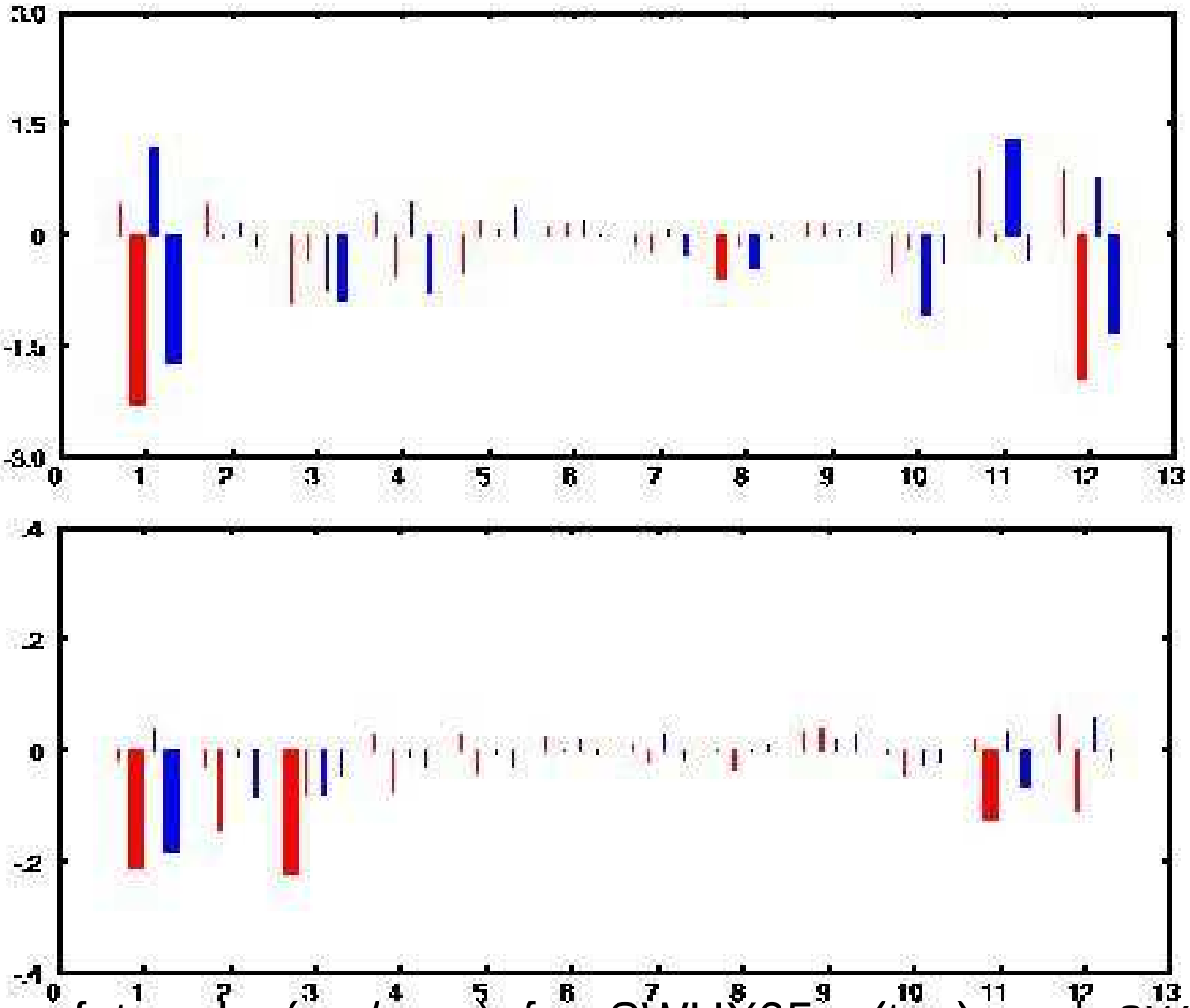
same as above except it shows the monthly average SWH.



January, SWHX95p: 95th percentile of the daily maximum SWH (significant wave height), average values for the **western** and **eastern** Mediterranean



annual cycle of trends (cm/year) for SWHG50p (top) and for the monthly mean SWH. the Blue/red bar pairs refer to the eastern/western Mediterranean. The left/right bar of each pair refers to the RP/NF periods. The thickness of the bars denotes the significance level of the trend with 4 different levels (not significant, 90%, 95%, 99%),



annual cycle of trends (cm/year) for SWHX95p (top) and *SWHN5p*. the Blue/red bar pairs refer to the eastern/western Mediterranean. The left/right bar of each pair refers to the RP/NF periods. The thickness of the bars denotes the significance level of the trend with 4 different levels (not significant, 90%, 95%, 99%),

Summary of this “CIRCE” simulation

Mean wave conditions: SWHG50p and SWH_ave

For mean wave conditions, almost all negative trends occur in the NF period. Results show a decease of mean wave values particularly in December in the western Mediterranean (significance 95%) and in January in both western and eastern Mediterranean (significance 99%). A significant decrease takes place also in March in the NF period.

High wave conditions SWHX95p

In general high wave behaviour is similar to that of the mean wave conditions, with a decrease in the NF in the winter months (December and January). However, note that there are months showing a different behaviour. An example is January, which shows a negative trend in the RP for both western and eastern Mediterranean that disappears in the NF. Note that in the period from November to January in the western Mediterranean high waves show a positive trend according to this simulation.

Low wave conditions SWHn5p

The negative trends in the NF in January occurs also for low wave conditions. Note that the whole period from November to February is characterized with the onset of negative trend in the NF period, though the statistical significance is not as large as in December.

Conclusions:

The WAM model has been driven by the wind fields produced by the REMO model for the CIRCE analysis. A seamless simulation of the wave field covering the period 1951-2050 has been performed.

Results have been analysed separately for west and east Mediterranean, and for the periods 1951-2000 (Recent Past) and 2001-2050 (Near Future). The two periods show a distinct behaviour with no important significant trends in the Recent Past and widespread negative trends in the winter months in the Near Future.

Therefore results suggest a shift of the whole SWH statistical distribution towards low values, implying a future decrease of average and extreme SWH values in winter.

The results of this new seamless simulations are substantially consistent with the previous analysis, which was based on 30-year long time slices representing present (1961-1990) and future (2071-2100) conditions (though the climate simulation does no detect the winter negative trend, during the 2nd half of the 20th century)

References

•Lionello P., M.B.Galati, E.Elvini (2010) **Extreme storm surge and wind wave climate scenario simulations at the Venetian littoral** *Phys. Chem. Earth* 10.1016/j.pce.2010.04.001

•Martucci, G., Carniel, S., Chiggiato, J., Sclavo, M., Lionello, P., Galati, M.B. (2009): **Statistical trend analysis and extreme distribution of significant wave height from 1958 to 1999 - An application to the Italian Seas** *Ocean Science Discussions* 6, pp. 2005-2036

•Lionello P., S.Cogo, M.B.Galati and A.Sanna, (2008), **The Mediterranean surface wave climate inferred from future scenario simulations** . *Global and Planetary Change* doi:10.1016/j.gloplacha.2008.03.004

•Lionello P. and M.B.Galati (2008), **Links of the significant wave height distribution in the Mediterranean sea with the North Hemisphere teleconnection patterns** , *Adv. Geosci.* 17, 13-18

•Lionello P. and A.Sanna (2005) **Mediterranean wave climate variability and its links with NAO and Indian Monsoon** *Clim.Dyn*. , 25, 611-623