Sea level change and extreme events in the Mediterranean Sea

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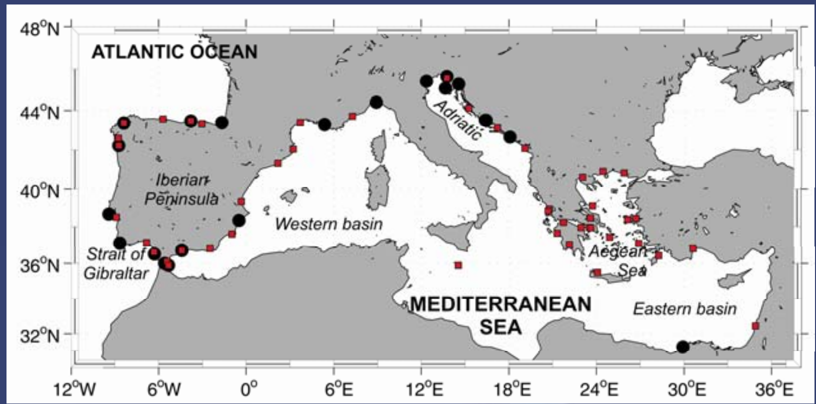
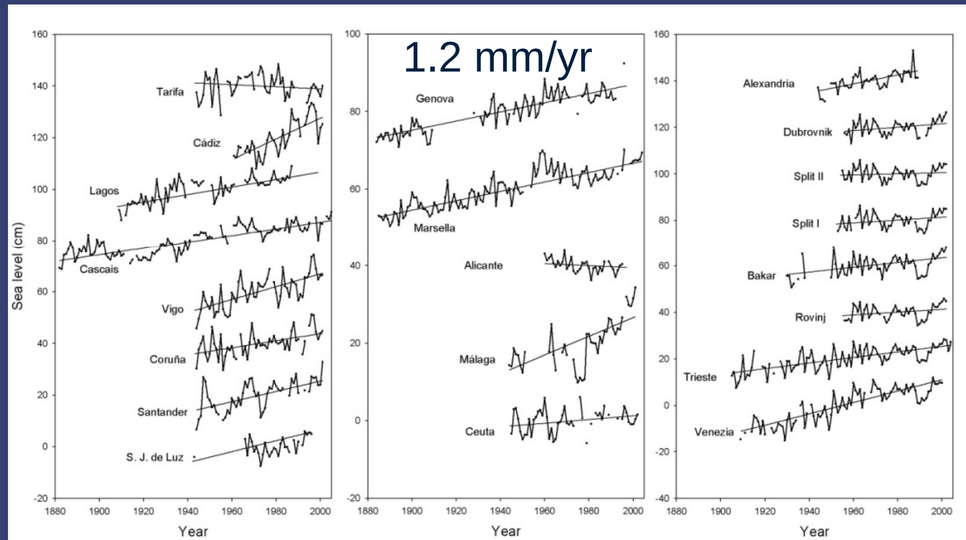
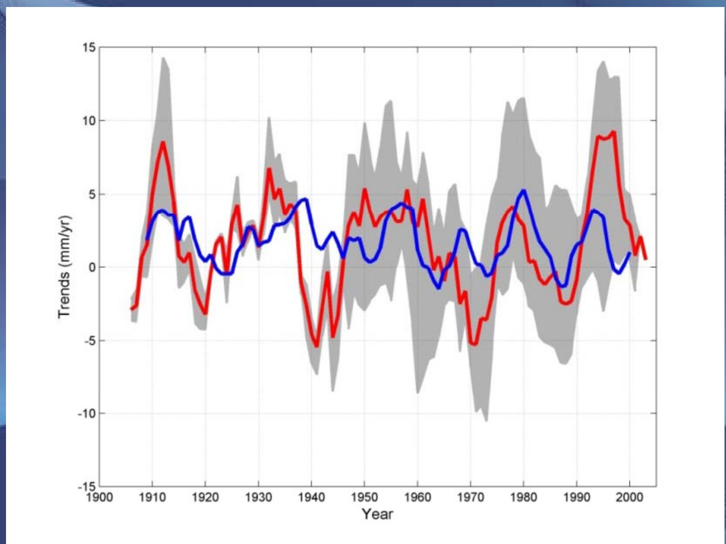
Sea level in the Mediterranean in the past

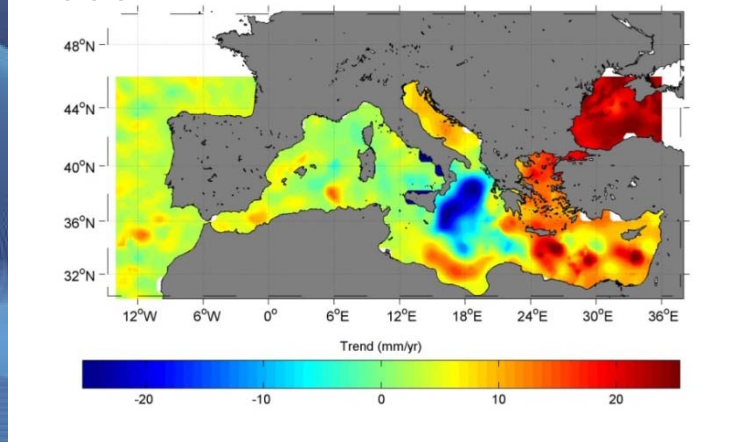




Decadal sea level trends



Sea level trends (mm/yr) 1993-2000.



Objectives

Need to evaluate risks at coastal sites due to future changes in sea level in the Mediterranean Sea

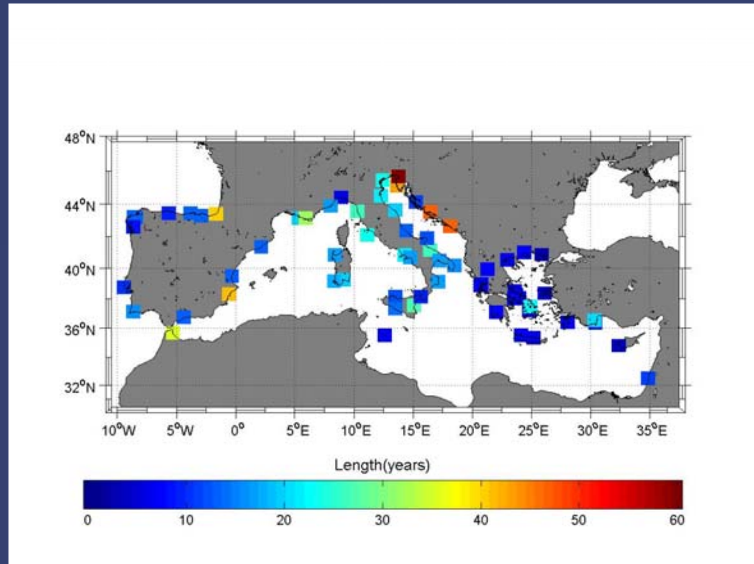
- Estimation of the sea level extremes distribution: mapping of the return levels and exploring the temporal variability of extreme events

- Estimation of changes in mean sea level using projections of atmosphere-ocean general circulation models to determine the range of thermohaline changes and its associate steric sea level

Sea level extremes

DATA

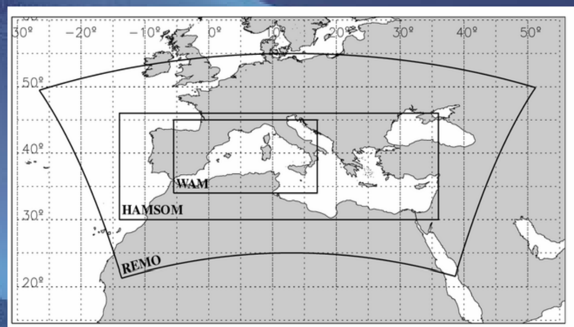
Tide gauge data with hourly sampling:
73 stations < 68 yrs



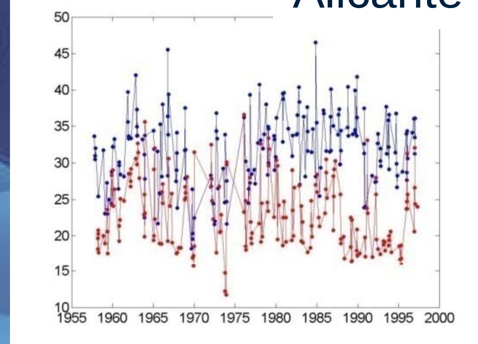
Hindcast

The barotropic model HAMSOM is forced by a downscaling of atmospheric pressure and wind fields generated by the model REMO (from a NCEP re-analysis)

44 years (1958-2001) of a homogeneous, high resolution data set of atmospheric and sea level data



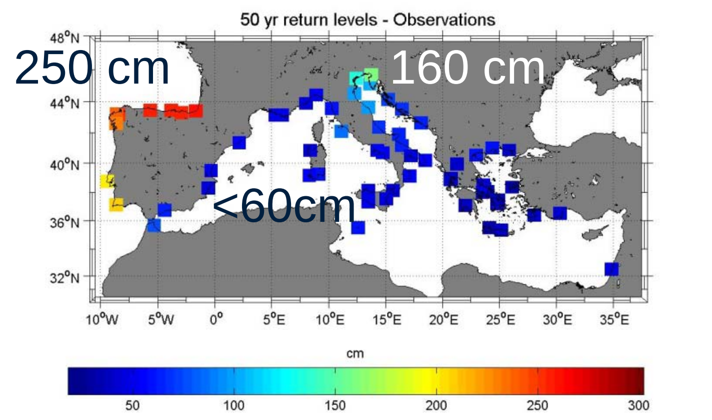
Alicante



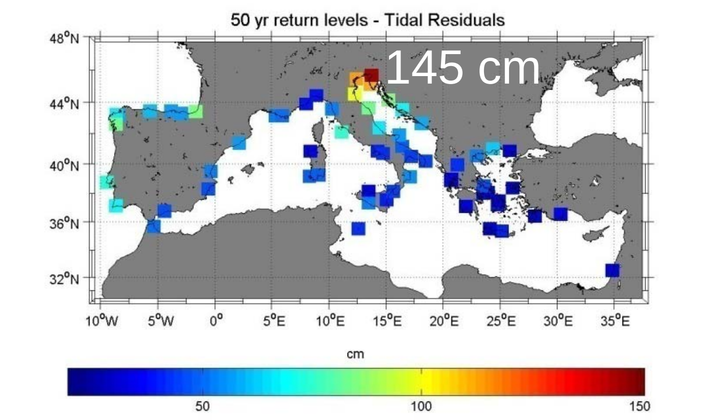
Sea level extremes – Return levels

50-yr return levels (5 extremes per year)

Observations



Tidal residuals

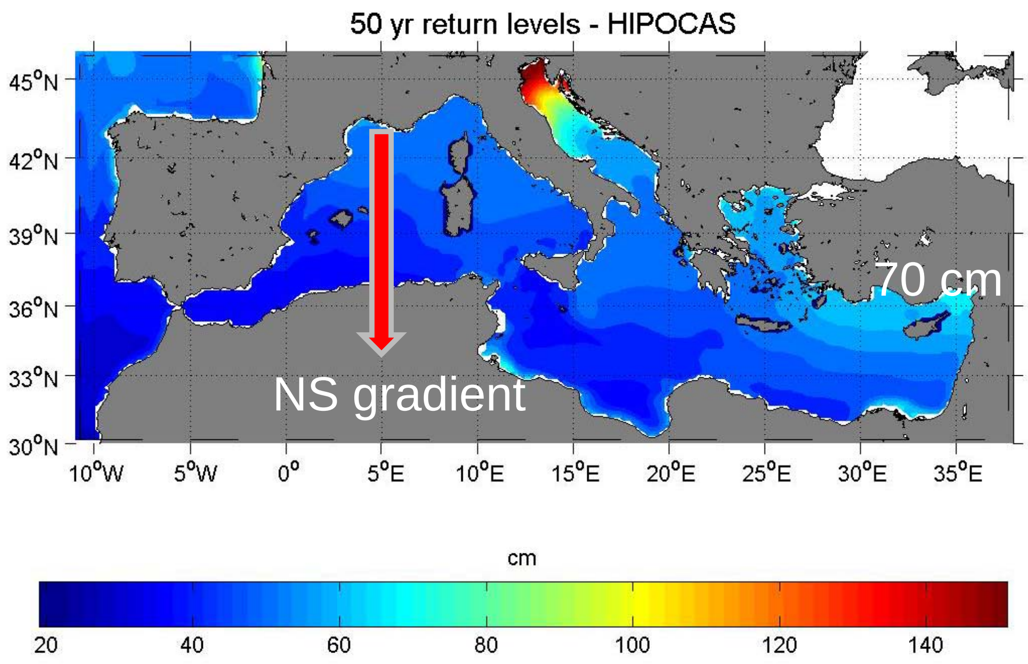


Higher extremes are found in the Atlantic coasts due to the presence of large tides

Values become consistent between Atlantic and Mediterranean sites when tides are removed

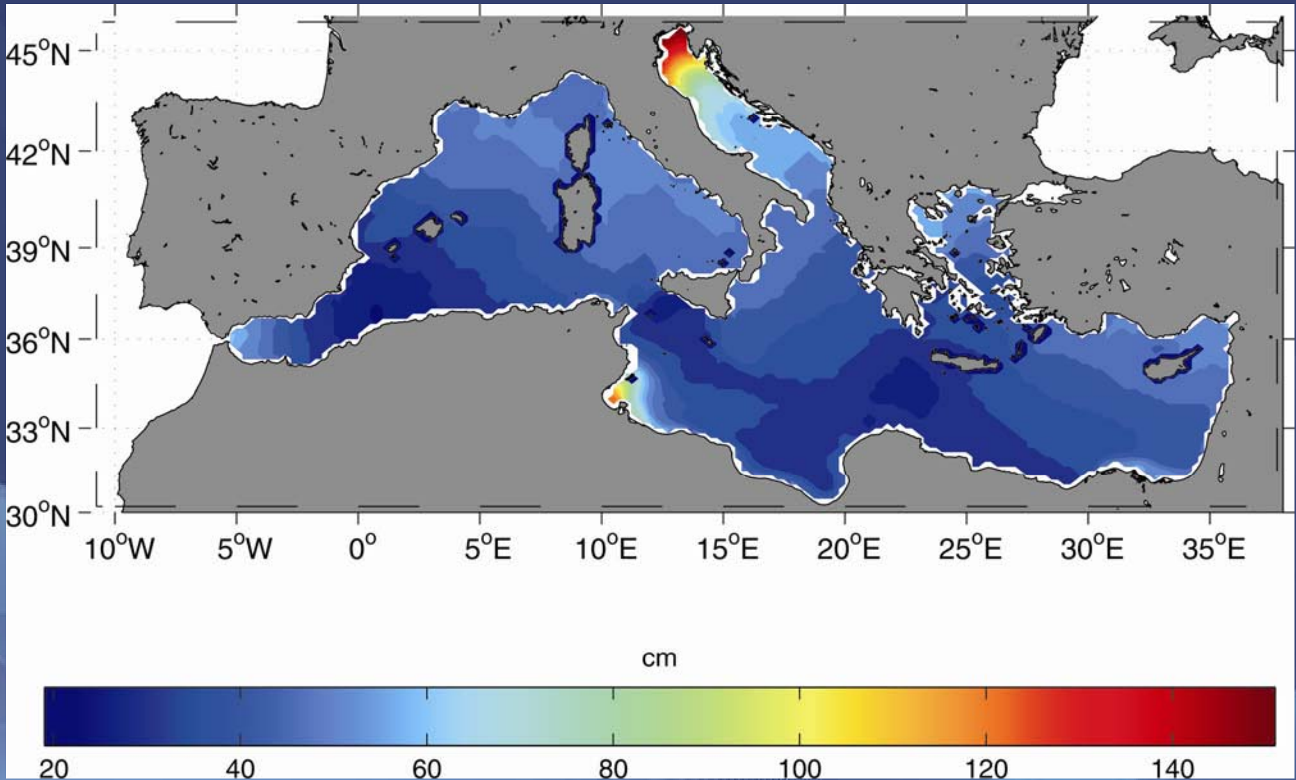
Sea level extremes – Return levels

50-yr return levels of hindcast data



Sea level extremes – Return Levels

50-yr return levels – tides+surges

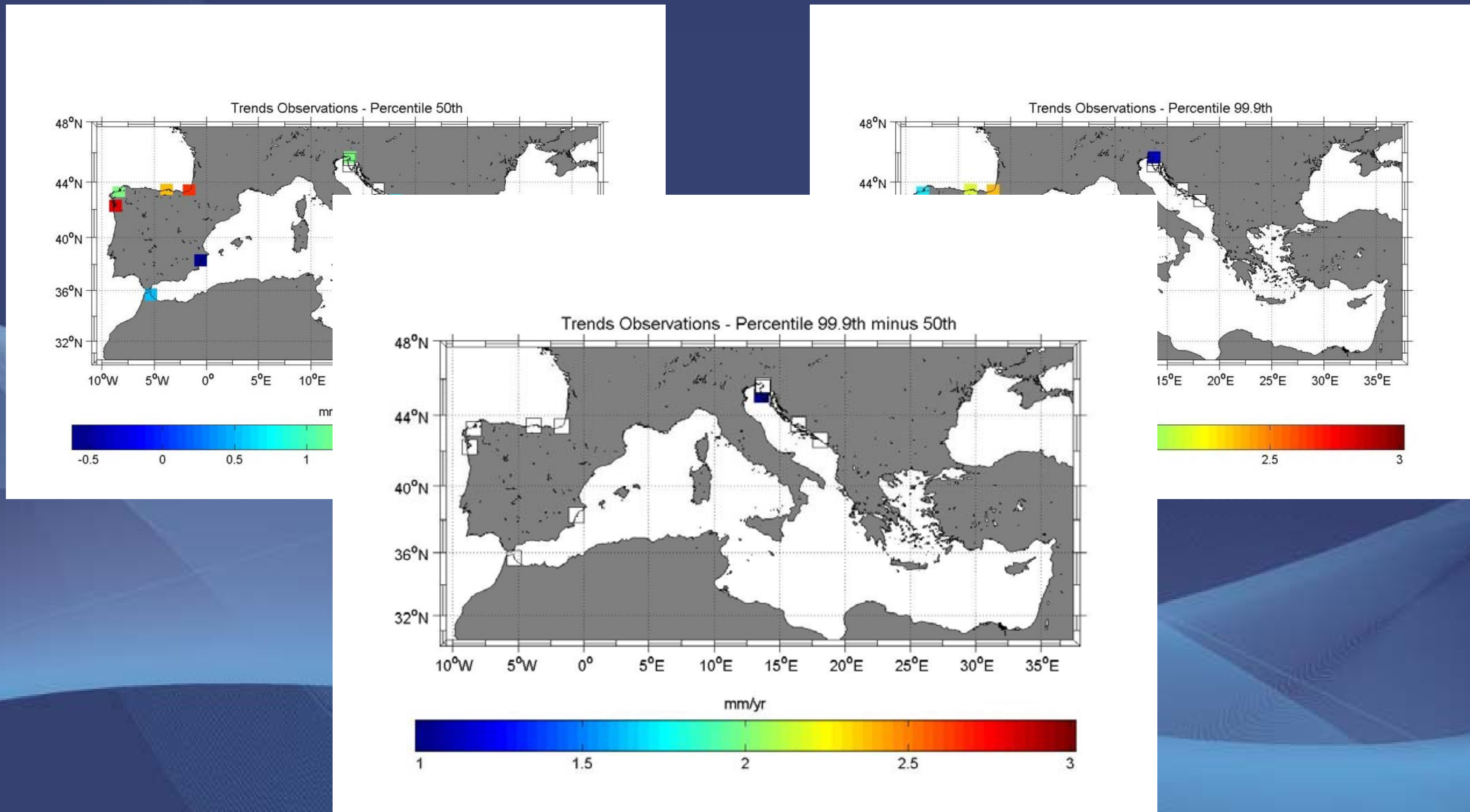


Consistent pattern with observed return levels
The advantage of the hindcast is the length and consistency of the time series and the spatial coverage

Sea level extremes

Do sea level extremes change in time?

How do they change in relation to MSL?



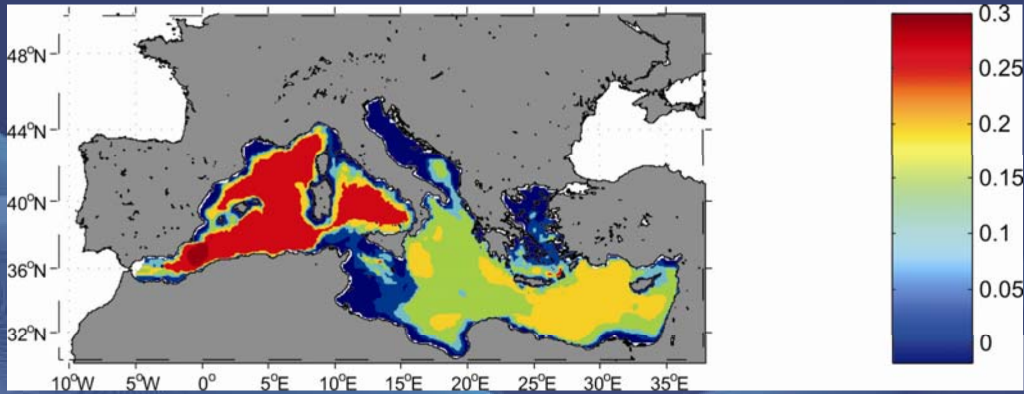
Changes in Mean Sea Level

Results from an Atmosphere-Ocean Regional Climate Model provide with a value of 13 cm in average of steric sea level rise in the Mediterranean for the 21st century.

Resolution 1/8° x 1/8° and 43 vertical levels

Simulations: SRES A2 scenario for the 21st century

Somot, S., Sevault, F., Déqué, M. 2006. Transient climate change scenario simulation of the Mediterranean Sea for the 21st century using a high-resolution ocean circulation model. Clim Dyn (in press), DOI :10.1007/s00382-006-0167-z



Tsimplis, M, M. Marcos, S. Somot, 2008. 21st century Mediterranean sea level rise. Regional model predictions. Glob and Planetary Change

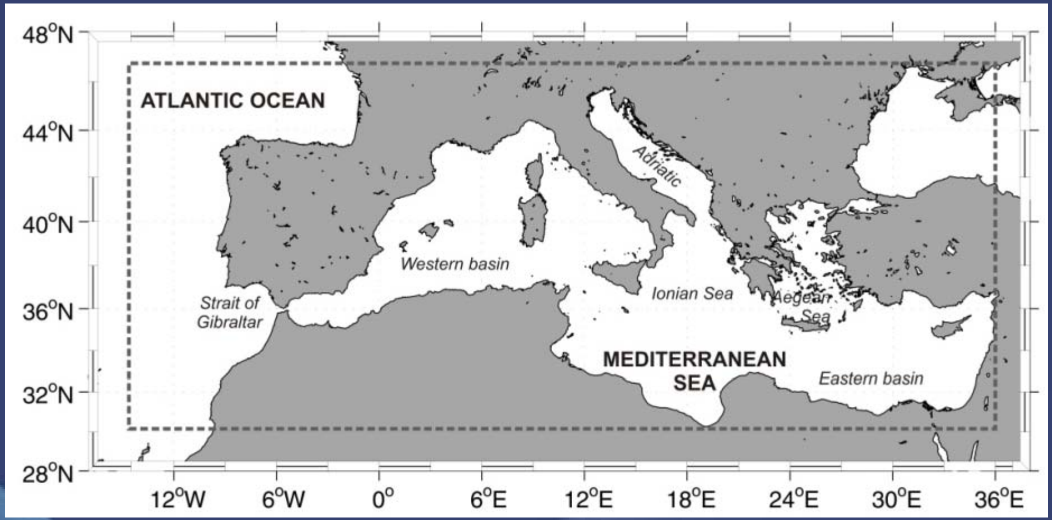
Changes in MSL - Models

Model	Institution	Resolution
UKMO-HadCM3	Hadley Centre for Climate Prediction and Research / Met Office	1.25ºx1.25ºx20 V.L.
BCCR-BCM2.0	Bjerknes Centre for Climate Research	1ºx1º 33VL
CNRM-CM3	Météo-France / Centre National de Recherches Météorologiques	2ºx1º 33VL
CSIRO-Mk3.0	CSIRO Atmospheric Research	~2ºx1º 31VL
ECHAM5/MPI-OM	Max Planck Institute for Meteorology	1ºx1º 40VL
GFDL-CM2.0	US Dept. of Commerce / NOAA / Geophysical Fluid Dynamics Laboratory	1ºx1º 50VL
GFDL-CM2.1	US Dept. of Commerce / NOAA / Geophysical Fluid Dynamics Laboratory	1ºx1º 50VL
GISS-ER	NASA / Goddard Institute for Space Studies	5ºx4º 33VL
GISS-EH	NASA / Goddard Institute for Space Studies	1ºx1º 33VL
MIROC3.2(medres)	Center for Climate System Research (The University of Tokyo), National Institute for Environmental Studies, and Frontier Research Center for Global Change (JAMSTEC)	~1.5ºx1º 33VL
MRI-CGCM2.3.2	Meteorological Research Institute	1.5ºx2º 23VL
CGCM3.1	Canadian Centre for Climate Modelling & Analysis	~2ºx2º 29VL
PCM	National Center for Atmospheric Research	1ºx1º 32VL
FGOALS-g1.0	LASG / Institute of Atmospheric Physics	1ºx1º 33VL

Changes in Mean Sea Level

1. Monthly T and S data are extracted from the global models for the domain -15º to 36ºE and 30º to 47º N

2. Steric sea level is computed for each grid point as the vertical integration of the specific volume anomaly from surface to bottom



$$\eta = \frac{1}{g}\int_{-H}^{0} \alpha \, dp$$

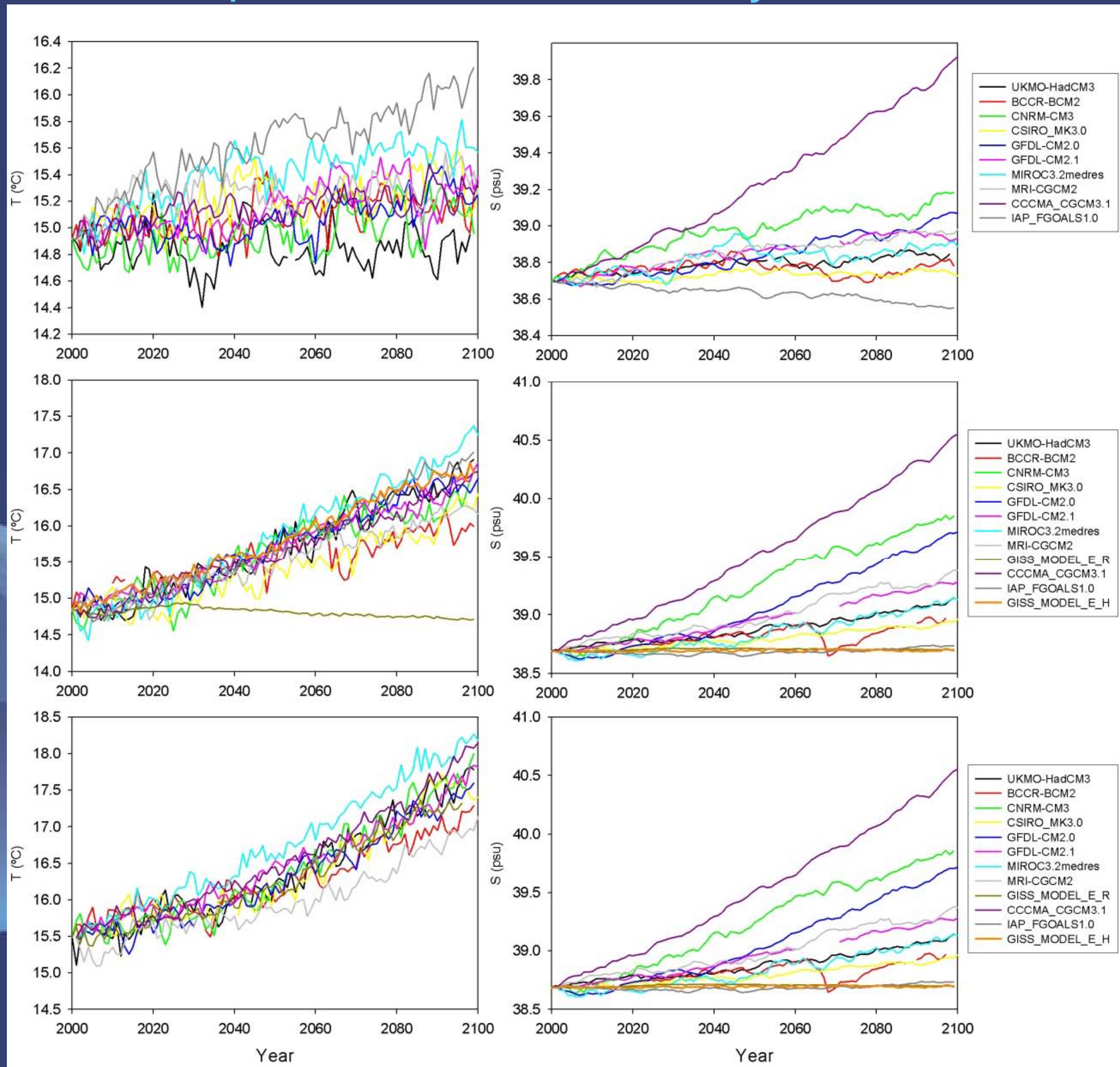
Changes in Mean Sea Level

Temperature Salinity

Committed CC

SRES A1B

SRES A2



T changes 0-2.5 ºC

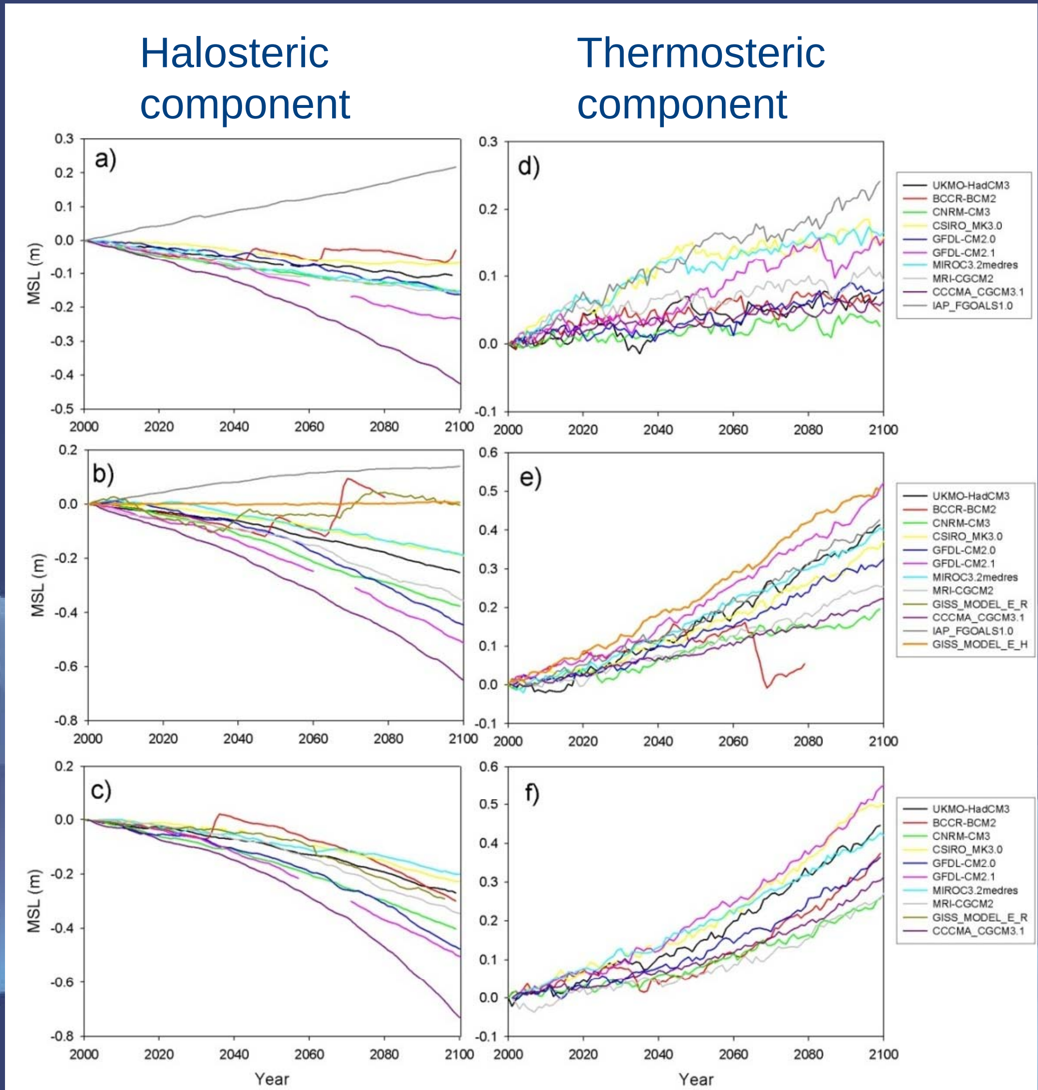
S changes 0-2 psu

Changes in Mean Sea Level

Commited CC

SRES A1B

SRES A2



Halosteric sea level:
-70 to 20 cm

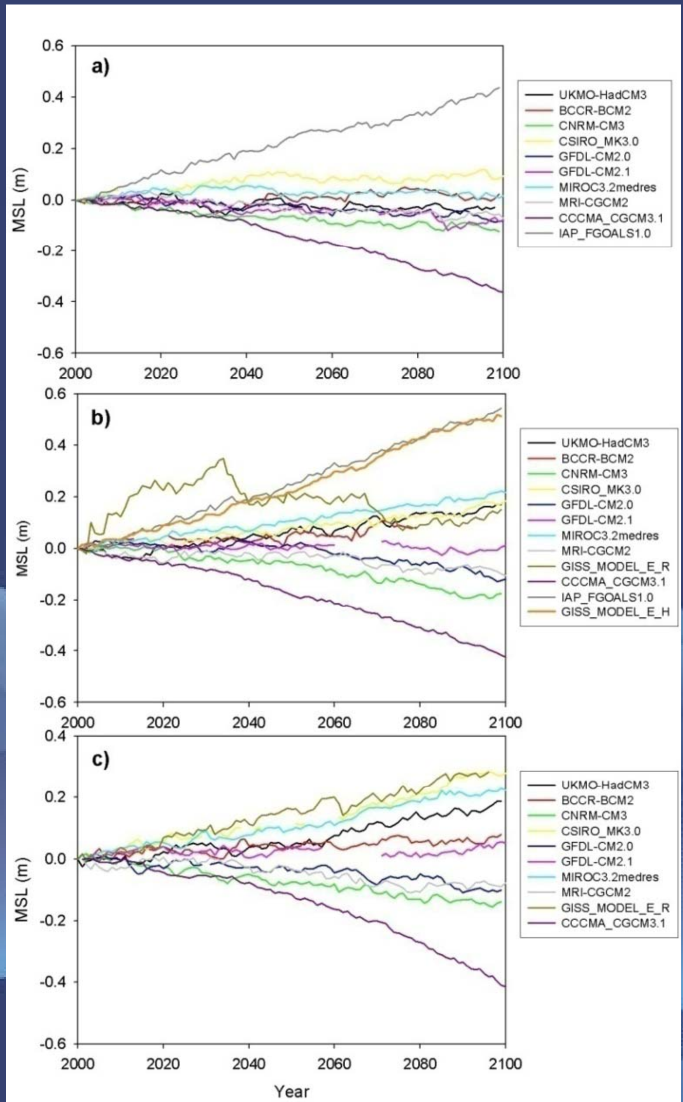
Thermosteric sea level:
5 to 55 cm

Changes in Mean Sea Level

Committed CC

SRES A1B

SRES A2



Range of variation:

-42 to 52 cm in average

Ignoring the two non-consistent models:

The steric contribution of sea level in the Mediterranean Sea is in average from -42 to 22 cm

Conclusions

o Spatial and temporal patterns of sea level extremes together with long term changes in sea level have been examined in the Mediterranean Sea

o A total of 73 tide gauge stations with hourly data have been used to estimate sea level extremes, covering periods of up to 68 yrs

o Within the Mediterranean the largest return levels are found in the Adriatic (150 cm). In the rest of the domain the return levels are < 70 cm

o The hindcast data presents the same spatial pattern as the tide gauges, but underestimates significantly the sea level extremes

o Changes in sea level extremes are consistent with changes in MSL

o T and S projections from AOGCMs for the 21st century predict warming and salinification of the Mediterranean Sea in the 3 scenarios considered of up to 2.5 ºC and 2 psu in average.

o The effects on sea level are opposite. Thermosteric and halosteric changes compensate each other thus keeping the steric sea level component nearly constant during the 21st century.