CLIVAR-SPAIN CONTRIBUTIONS:
Atmospheric contribution to Mediterranean sea level variability under different climate change scenarios

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(1) IMEDEA (2) Gobierno de España, Ministerio de Fomento, Puertos del Estado (3) METEO FRANCE Toujours un temps d'avance

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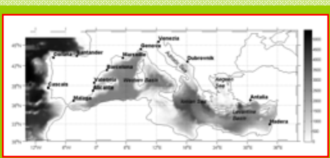
ABSTRACT

We investigate the contribution of atmospheric pressure and winds to Mediterranean sea level variability under different scenarios of greenhouse gases (GHG) emissions (B1, A1b and A2). The analysis focus on low frequency processes (monthly time scales and lower) and also on extreme events.

The results for the XXI century indicate that the contribution of atmospheric pressure and winds to Mediterranean sea level would be negative, with a decrease that would be especially strong in winter. The trends obtained for the XXI century are of up to -0.8 mm/year in the central Mediterranean under the A2 scenario. Trends in summer are barely significant but positive, then leading to an increase in the amplitude of the seasonal cycle. The interannual variability shows a widespread standard deviation increase of up to 40%. An increase in the frequency of positive phases of the NAO explains part of the winter negative trends. Also, an increase in the NAO variability would be responsible for the projected increase of the interannual variability. Conversely, the intra-annual variability (1-12 months) does not show significant changes.
Concerning the extreme events, results reveal a reduction of 50% in the number of episodes and up to 8 cm in the 50-year return levels. The analysis shows a progressive decrease in the return levels not fully explained by a negative trend in the mean atmospherically-induced sea level and a linear dependence with winter NAO. Likewise, negative events show an increase in their frequency and magnitude although more moderate than for positive surges

MODEL SETUP AND VALIDATION



Ocean model
2D version of HAMSOM at 1/4º x 1/6º resolution

Atmospheric forcing
6-h SLP and winds from ARPEGE (Météo-France)
~50km resolution

RUNS

Hindcast (1958-2001): Modelling system validation against coastal observations

Control (1950-2000): Forced by radiative forcing. Observed GHGs and aerosols concentrations

Scenarios (2000-2100): Changes in the GHGs and aerosols concentrations following SRES B1,A1b,A2

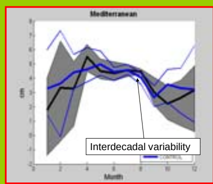
Station	Length of common period (days)	RMS error (cm)	Correlation
ALICANTE	12099	2.79	0.84
ANTALIA	5238	3.20	0.76
BARCELONA	3062	2.86	0.84
CASCAIS	3175	3.56	0.77
A CORUÑA	15579	4.03	0.84
DUBROVNIK	15923	3.66	0.83
GENOVA	1081	2.20	0.88
HADERA	2256	2.64	0.74
MÁLAGA	3255	3.02	0.75
MARSEILLE	1842	3.23	0.78
SANTANDER	15314	3.94	0.83
VALENCIA	2745	2.98	0.82
VENEZIA	1274	3.39	0.80

Comparison of model results with tide gauges.

THE CONTROL RUN

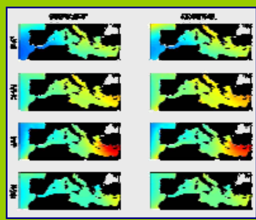
Can a simulation only forced by GHGs produce realistic results ?

Sea Level Annual Cycle



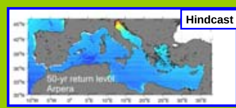
Good agreement with the hindcast in the range of interdecadal variability

Seasonal patterns



The control run is also able to capture the spatial structures of variability

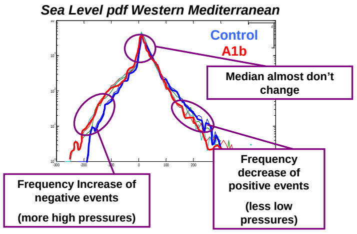
50 yr Return Level



The control slightly overestimates the strength of extreme events although the spatial structure is correct

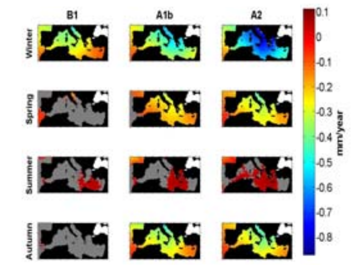
SCENARIOS RESULTS

Sea Level pdf Western Mediterranean



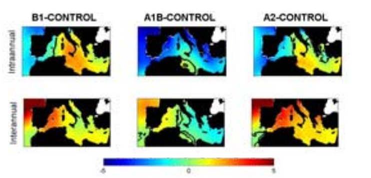
Good agreement with ENSEMBLES project projections: Increase of positive SLP over southern Europe

Seasonal trends



Winter decrease (up to 8 cm at the end of the century in the Adriatic) and summer slight increase
Larger GHGs concentrations induce larger trends

Low frequency variability

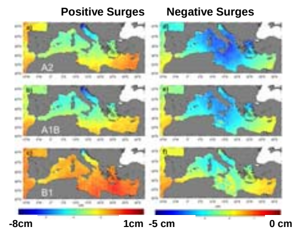


Difference between scenarios and the control run in the standard deviation of the atmospheric component of sea level: (Top) Intrannual variability (1 day -12 months) (Bottom) Interannual variability (>1 year). The black line indicates the zero difference. Units are cm

The intra-annual variability (1-12 months) does not show significant changes (< 5 % of total variability at those frequencies)

The interannual variability shows a widespread standard deviation increase of up to 40% of total interannual variability

Changes in the 50 yr Return Level



Decrease up to 8 cm in the positive surges
Increase in the magnitude of negative surges
Under B1 scenario changes are almost negligible

ORIGIN OF THE PROJECTED CHANGES

Impact on trends

Sea level trends in the Western Mediterranean (mm/year)				
	WINTER	SPRING	SUMMER	AUTUMN
Trend	*-0.57 ± 0.16*	*-0.27 ± 0.08*	*NS*	*-0.26 ± 0.08*
Trend after NAO decorrelation	*-0.40 ± 0.08*	*-0.25 ± 0.06*	*NS*	*-0.25 ± 0.06*

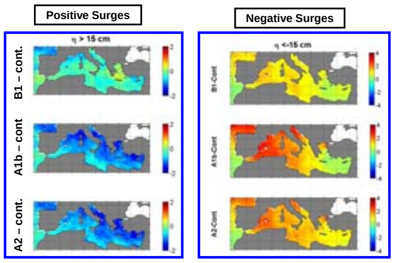
NAO only partially affects winter trends

Impact on interannual variability

STD of sea level averaged in the Atlantic Sector (cm)				
	CONTROL	B1	A1B	A2
STD	*1.06*	*1.18*	*1.15*	*1.21*
STD after NAO decorrelation	*0.75*	*0.72*	*0.65*	*0.63*
STD of sea level averaged in the Western Mediterranean (cm)				
	CONTROL	B1	A1B	A2
STD	*1.26*	*1.26*	*1.31*	*1.46*
STD after NAO decorrelation	*1.08*	*0.86*	*0.79*	*0.96*
STD of sea level averaged in the Eastern Mediterranean (cm)				
	CONTROL	B1	A1B	A2
STD	*1.09*	*1.08*	*1.01*	*1.28*
STD after NAO decorrelation	*1.00*	*0.85*	*0.79*	*1.06*

Changes in NAO explains the projected changes in sea level inerannual variability

Changes in the number of extreme events/yr



Reduction of the number of cyclones

Increase of the number of anticyclones

CONCLUSIONS

- The modelling system has been successfully validated against coastal observations.
- The control simulation is realistic in the range of interdecadal variability
- Under all scenarios we find a sea level negative trend (up to ~ -0.8 mm/year for A2) during winter and almost no change in summer
- The return level for positive extreme events is reduced a 10%. For negative events, its magnitude is increased a 20 %
- Changes in the variability are only noticed for the interannual variability with an increase of up to 40% of standard deviation
- The projected changes in trends are only partially explained by changes in NAO
- Changes in NAO explain changes in the interannual variability
- A reduction of cyclones and an increase of anticyclones also contribute to the projected changes

Atmospheric contribution to Mediterranean and nearby Atlantic sea level variability (…). G. Jordà, D. Gomis, E. Álvarez-Fanjul, S. Somot. *Glob. Plan. Change (conditionally accepted)*
Changes in storm surges in southern Europe from a regional model under climate (…)
M. Marcos, G. Jordà, D. Gomis, B. Pérez. *Glob. Plan. Change 77 (2011) 116-128*