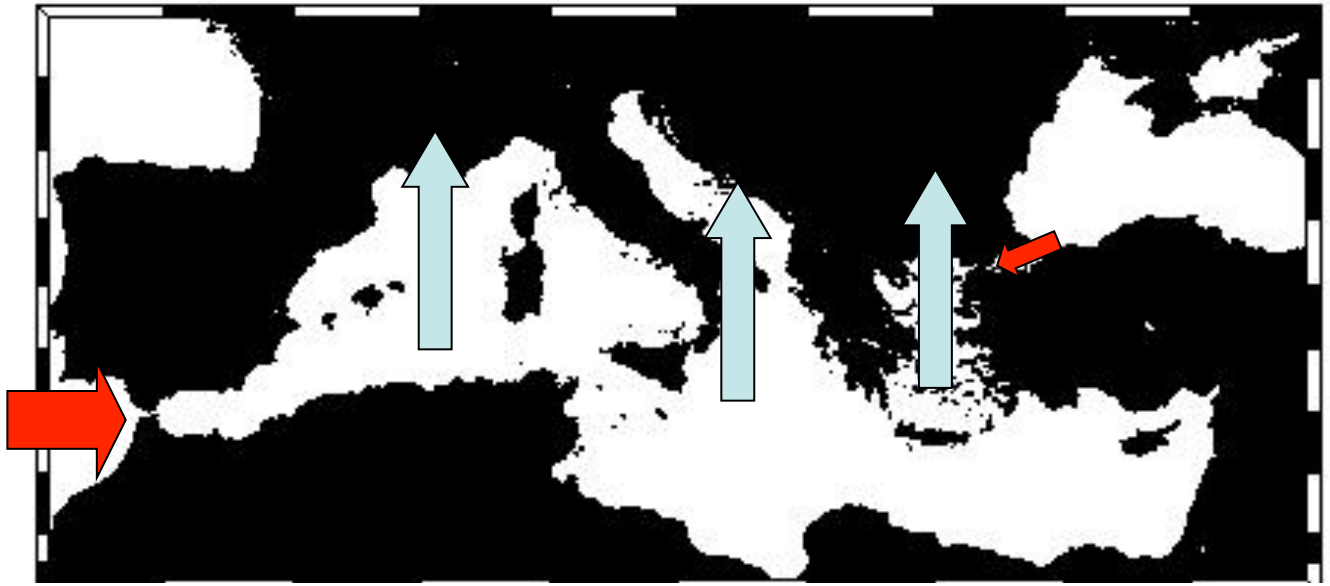
The Mediterranean as a test case for Heat budget closure



Med Heat content determined by surface HF and Gibraltar HF
(+ other very minor contributions)

SATELLITES: Complex coastline but cloud free

IN SITU: ARGO + many national programs and coastal observatories

GIBRALTAR: Routinely observed by University of Malaga

MODELS: Several innitiatives already running (Mercator, My Ocean, Hymex, Med Cordex). ***Forced and coupled ocean model with and without data assimilation***

Accuracy of different estimates

Surface Heat flux from Atmospheric Models

Table 4 Long term annual mean estimates for the different terms of the Mediterranean Sea heat budget for the RCMs driven by ERA40

	C4I	CNRM	DMI	ETHZ	ICTP	KNMI	METNO	METOHC	MPI	SMHI	OURA	UCLM	MEAN
ERA40 forced runs													
Q_{SW}	190 ± 2	190 ± 2	154 ± 2	157 ± 3	185 ± 4	165 ± 6	178 ± 3	214 ± 3	162 ± 2	190 ± 3	202 ± 3	180 ± 4	181 ± 18
Q_{LW}	78 ± 2	80 ± 2	70 ± 2	72 ± 2	74 ± 2	77 ± 4	100 ± 2	85 ± 1	90 ± 1	78 ± 2	80 ± 2	74 ± 2	75 ± 6
Q_{LH}	97 ± 4	90 ± 4	109 ± 4	108 ± 3	128 ± 5	88 ± 7	112 ± 4	100 ± 1	85 ± 5	90 ± 3	96 ± 6	91 ± 4	100 ± 13
Q_{SH}	10 ± 1	8 ± 1	15 ± 1	13 ± 1	22 ± 2	10 ± 2	15 ± 1	8 ± 1	9 ± 1	9 ± 1	18 ± 2	20 ± 2	13 ± 5
HB	+5 ± 3	+12 ± 3	−40 ± 3	−36 ± 3	−39 ± 4	−10 ± 3	−14 ± 3	+21 ± 3	−22 ± 3	+13 ± 3	+8 ± 3	−5 ± 3	−9 ± 21

In the table Q_{SW} is the shortwave flux, Q_{LW} the longwave, Q_{LH} and Q_{SH} the latent and sensible heat fluxes respectively. The heat budget estimates have been calculated according to eq. (2). Values have all been converted to W/m^2

Sánchez-Gómez et al., Clim Dyn 2011

Large discrepancies in the fluxes from atmospheric models alone but ….

Ocean models

W/m²	Mean	STD
ORCA	-3.83	3.34
OM8	-3.37	3.86
MITgcm	-2.70	4.77

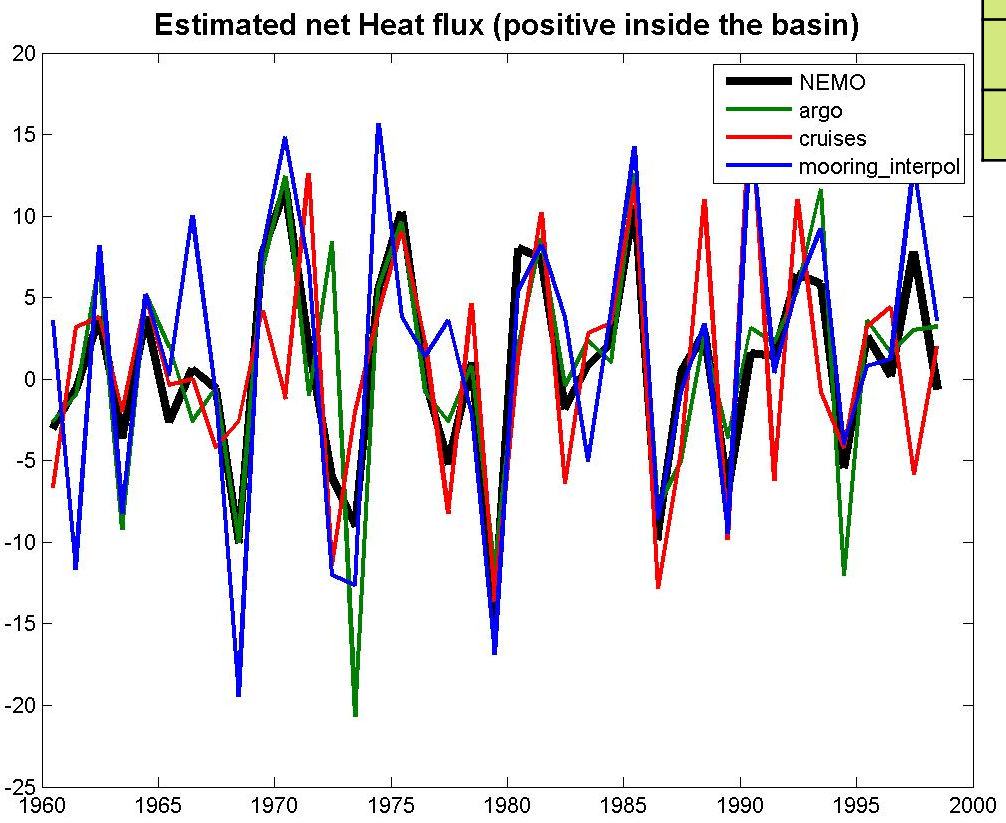
Coupled models are promising

Accuracy of different estimates

Med Heat Content as estimated from different observational networks

Using a "virtual" reality from a numerical model – NEMOMED8

Estimated net Heat Flux (yearly data)



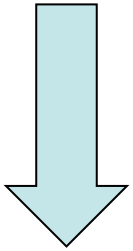
	RMSE (W/ m^2)	Correlation
ARGO	4.11	0.81
CTD	5.70	0.64
MOORING	5.23	0.82
Statistics from yearly time series		

With typical observational systems we could reach 5-6 W/m^2 of uncertainty for yearly estimates

Llasses et al., 2013

Accuracy of different estimates

Gibraltar HF uncertainty ~ 1-3 W/m^2



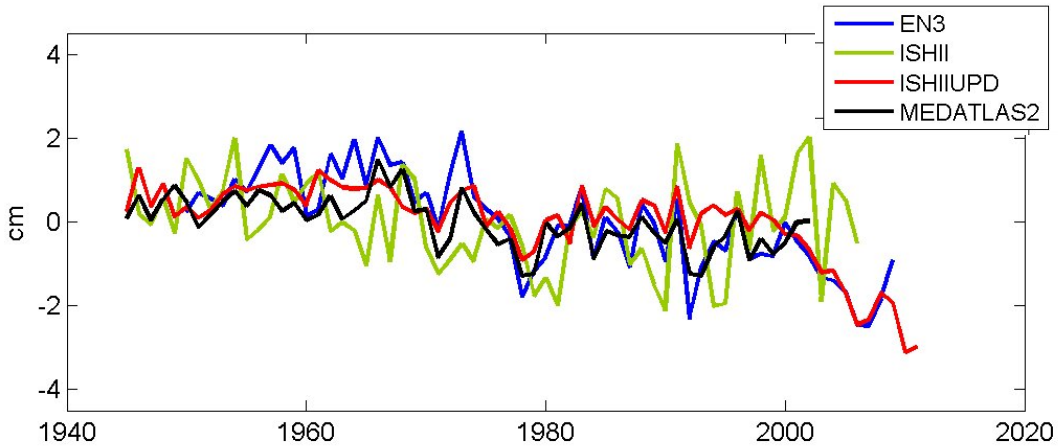
We could get yearly indirect estimates of surface heat fluxes with an uncertainty of 5-7 W/m^2

Indirect estimate of Mediterranean Heat Content using sea level

Total sea level (altimetry) – Mass (Grace) = Steric sea level

Steric sea level gives a measure of changes in the density field, thus in the temperature field

However, in the Mediterranean the salinity contribution to the density variations is very important. Unfortunately salinity is poorly sampled



Halosteric time series from four hydrographic datasets

Jordà and Gomis, 2013