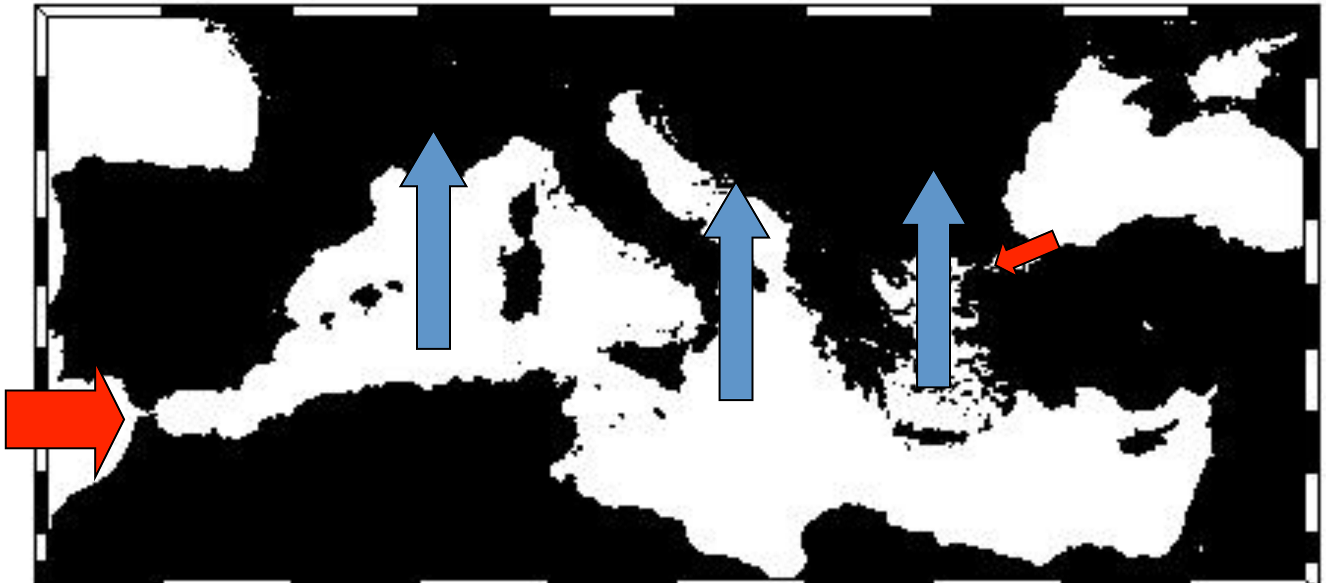
Review of observational upper-ocean heat content estimates (Matt Palmer)

Semi enclosed Sea (The example of the Mediterranean Sea (Gabriel Jorda)

Workshop conclusion (Pierre-Philippe)

The Mediterranean as a test case for Heat budget closure



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

<u>SATELLITES</u>: Complex coastline but cloud free

<u>IN SITU</u>: ARGO + many national programs and coastal observatories

<u>GIBRALTAR</u>: Routinely observed by University of Malaga

<u>MODELS</u>: 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

Ocean models

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

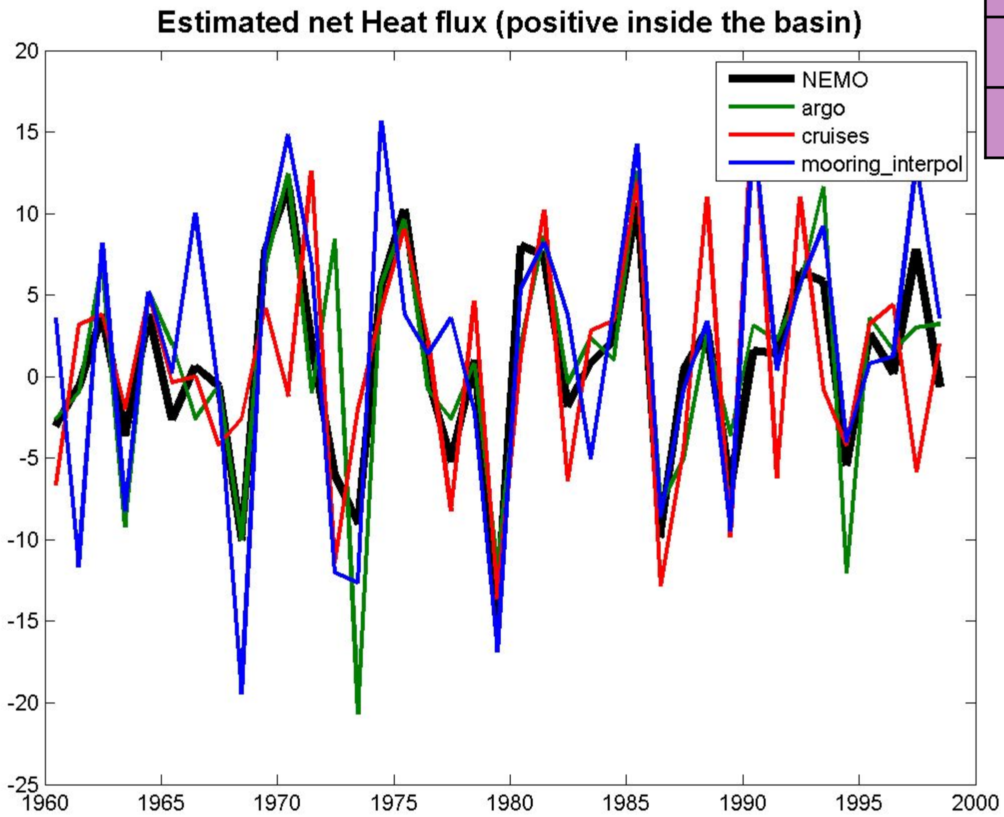
Accuracy of different estimates

Med Heat Content as estimated from different observational networks

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

	RMSE (W/m²)	Correlation
ARGO	4.11	0.81
CTD	5.70	0.64
MOORING	5.23	0.82
Statistics from yearly time series		

Estimated net Heat Flux (yearly data)



With typical observational systems we could reach 5-6 W/m² of uncertainty for yearly estimates

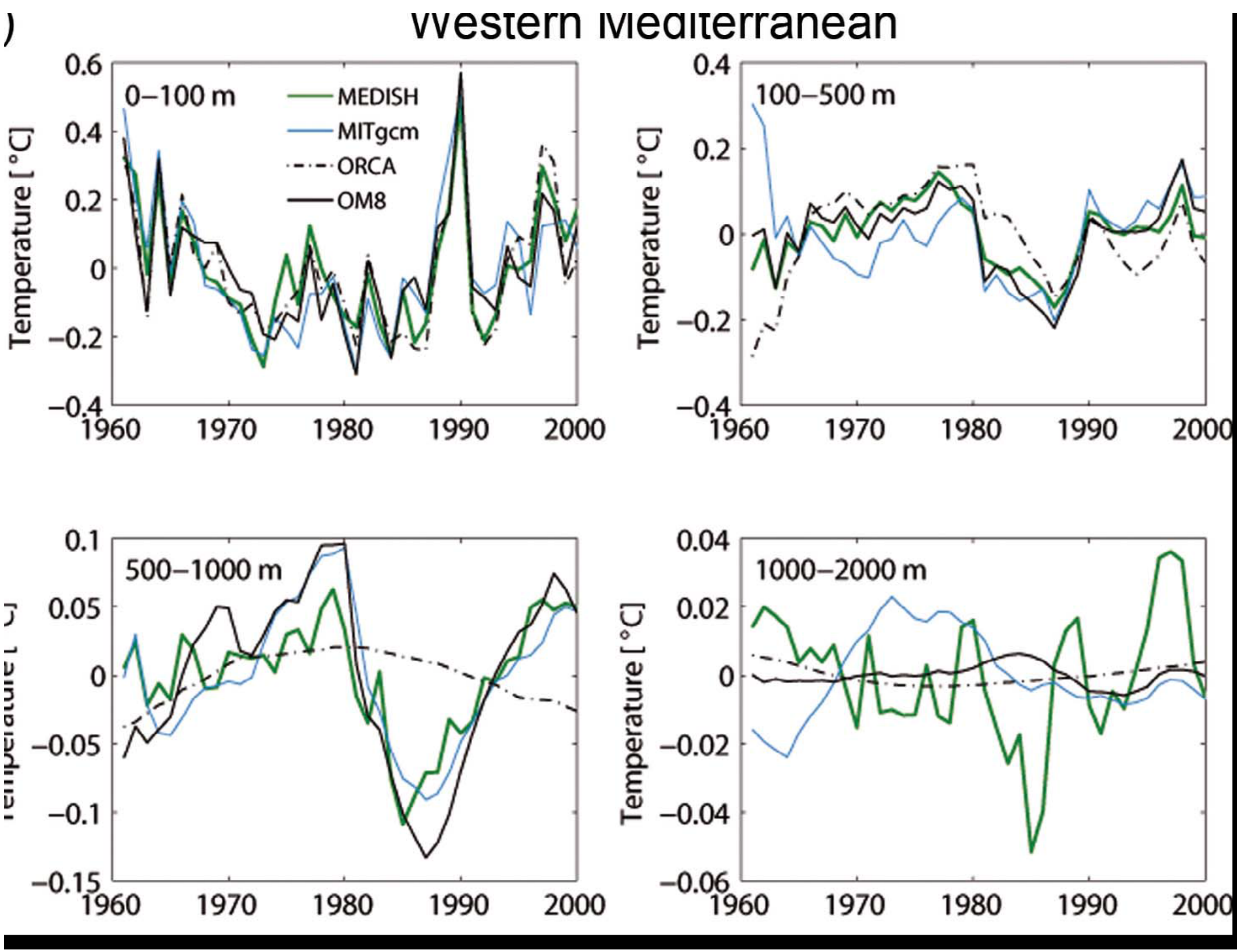
Llasses et al., 2013

Accuracy of different estimates

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

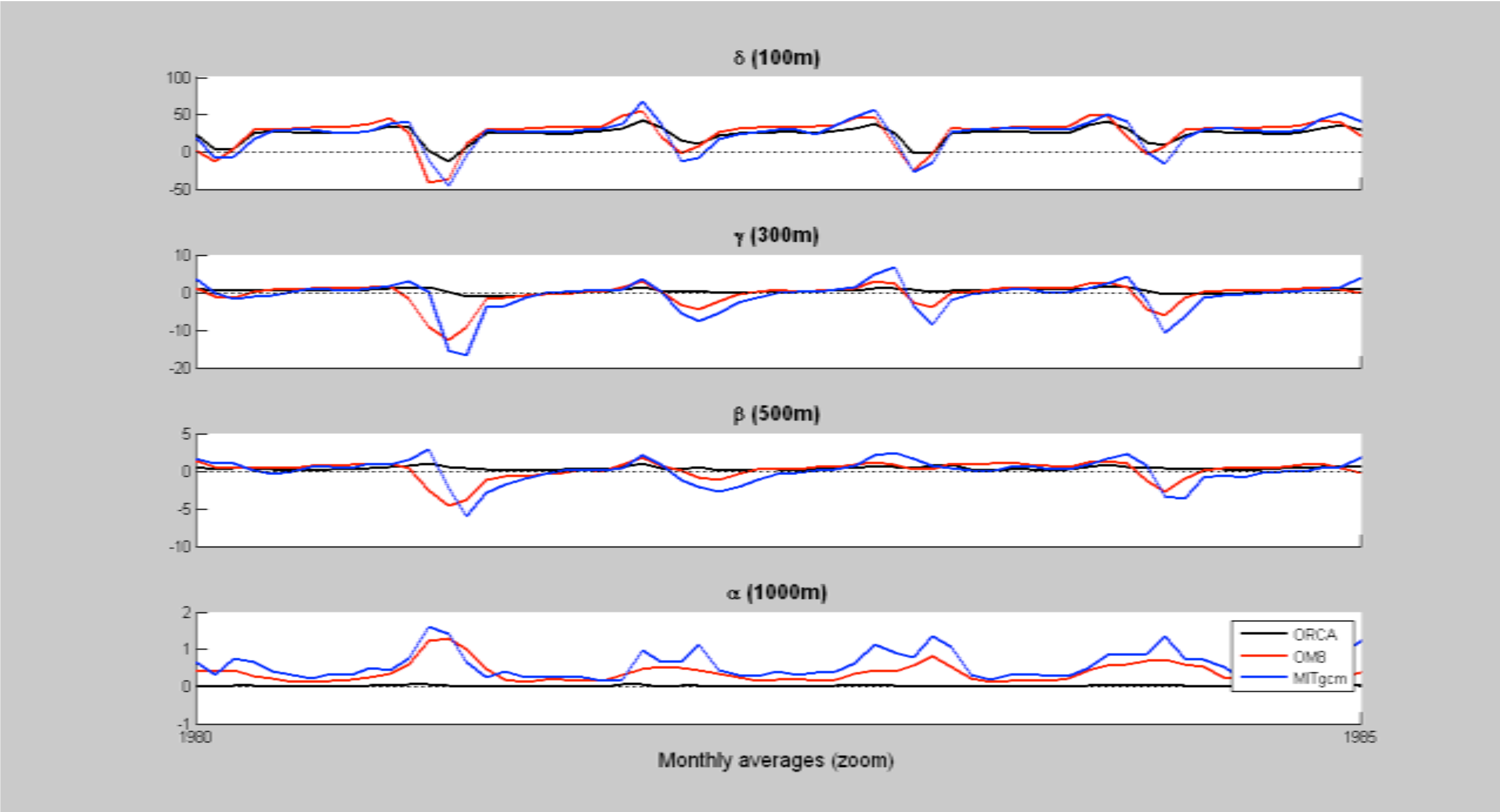
We could get yearly indirect estimates of surface heat fluxes with un uncertainty of 5-7 W/m^2

Models Performance at different layers



Calafat et al., 2012

Models Vertical heat transfer



Reasonable results can be obtained for the deeper layers if high resolution is used for ocean model and its forcings (temporal and spatial)