

Réchauffement anthropique des océans et montée du niveau des mers

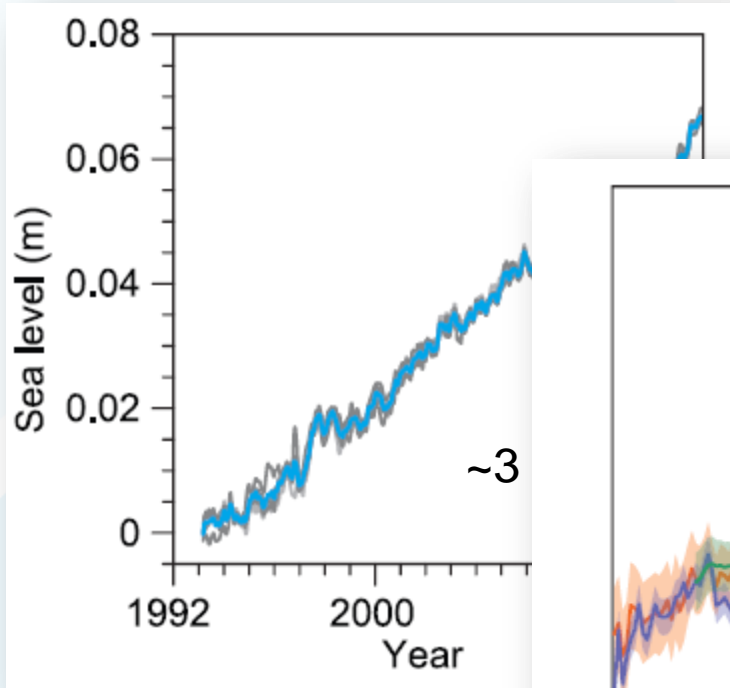
Marta Marcos



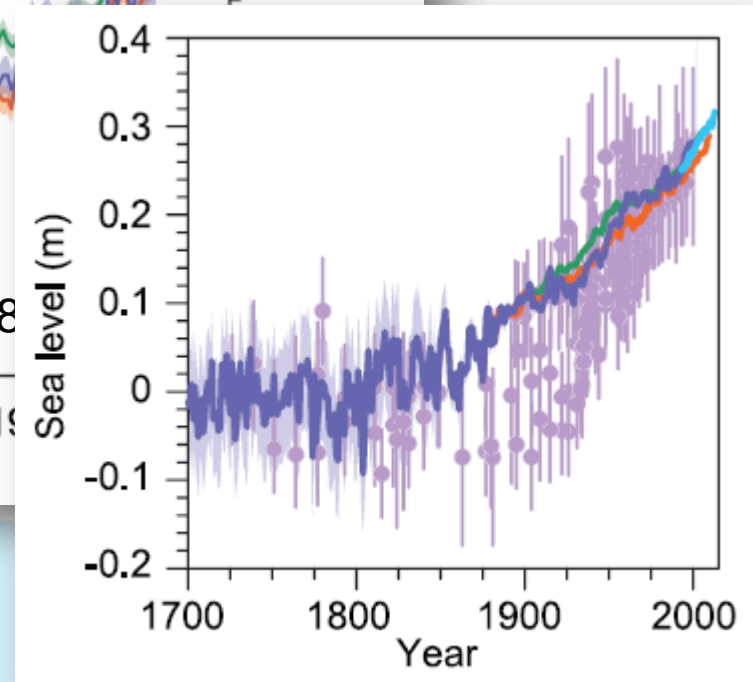
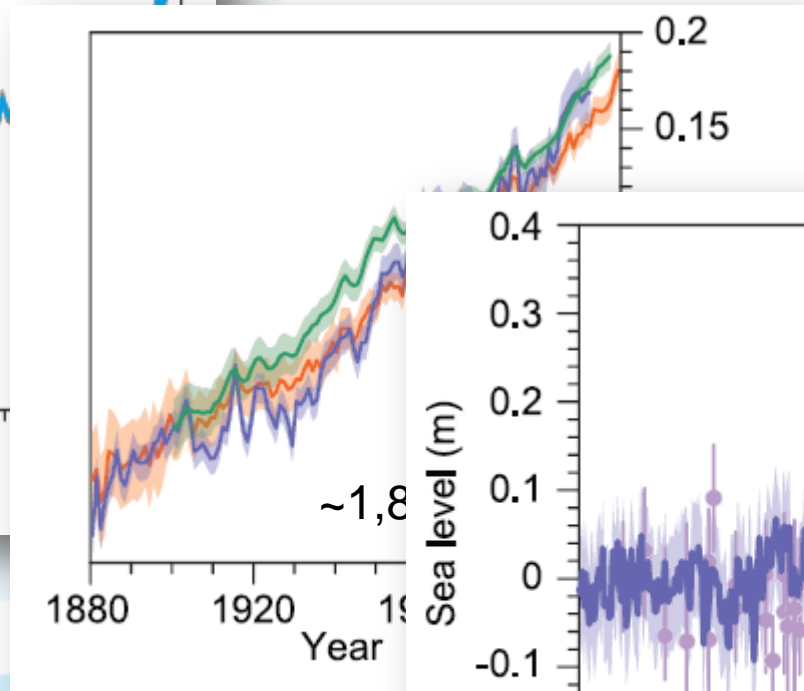
**MEDITERRANEAN INSTITUTE
FOR ADVANCED STUDIES**

With contributions from:
S. Dangendorf
F. M. Calafat
A. Amores

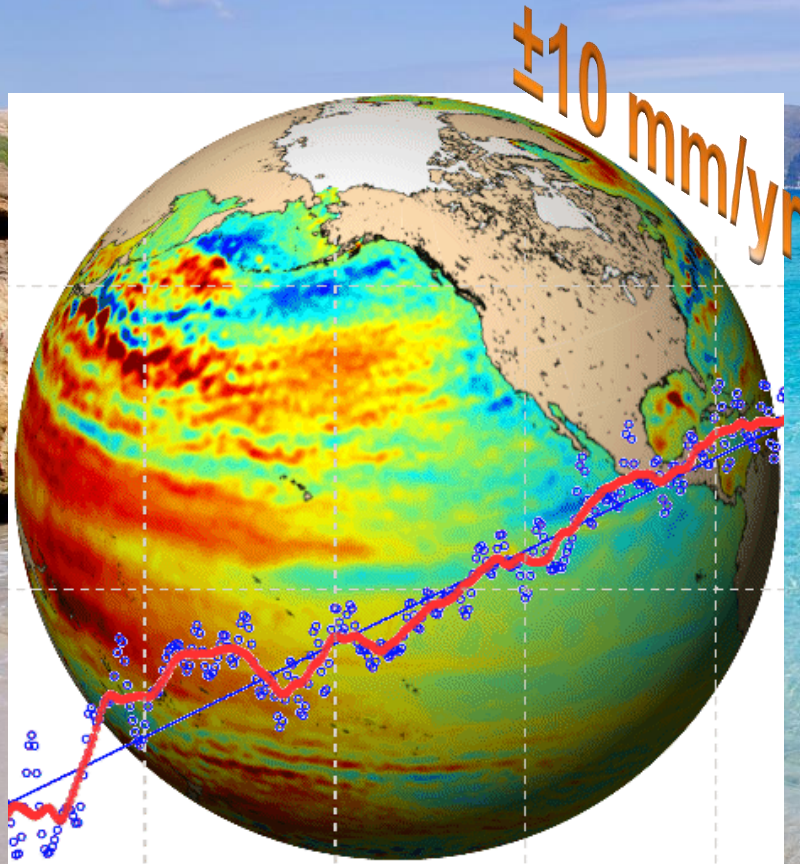
Global sea level rise



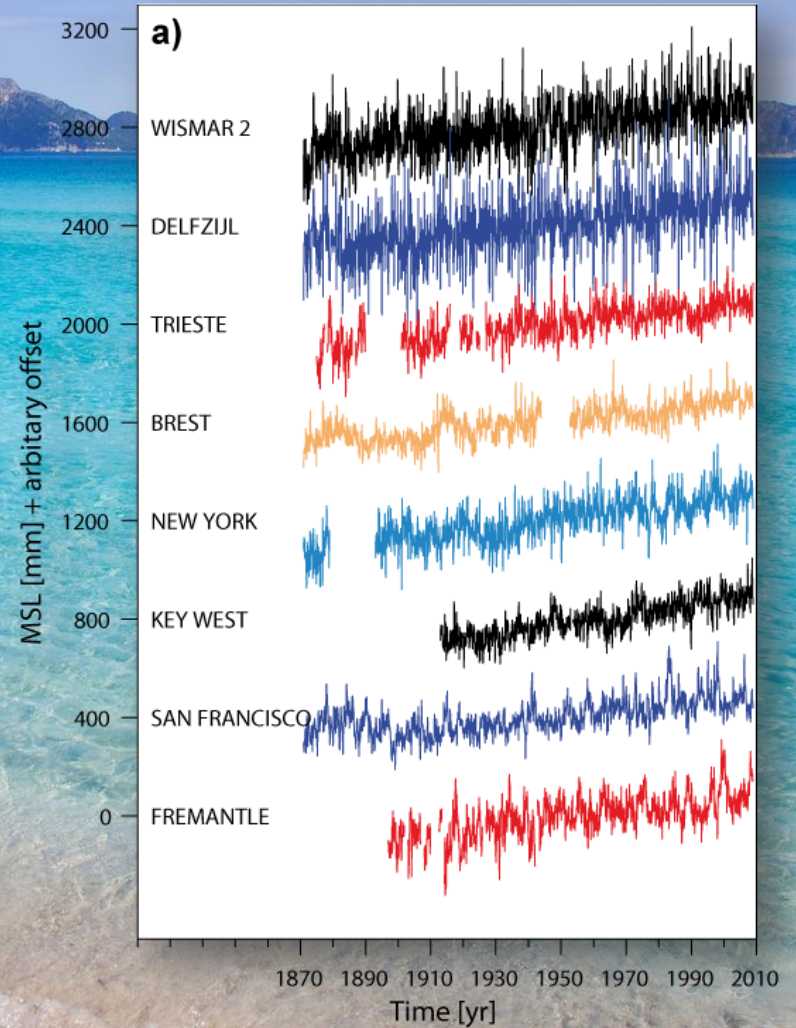
IPCC AR5



Regional sea level rise



Credits: CNES



Dangendorf et al 2014

A man in a dark suit stands with his back to the camera, looking into a large, complex maze. The maze is made of grey concrete walls and is set on a light grey floor. Above the man, the word "Challenge" is written in a large, black, sans-serif font inside a white rectangular box with a black border. The background of the maze is a repeating pattern of the same maze structure, creating a sense of depth and complexity.

Challenge

Detection of anthropogenic signals in sea level records

Are the observed trends larger than the distribution derived from natural variability only?



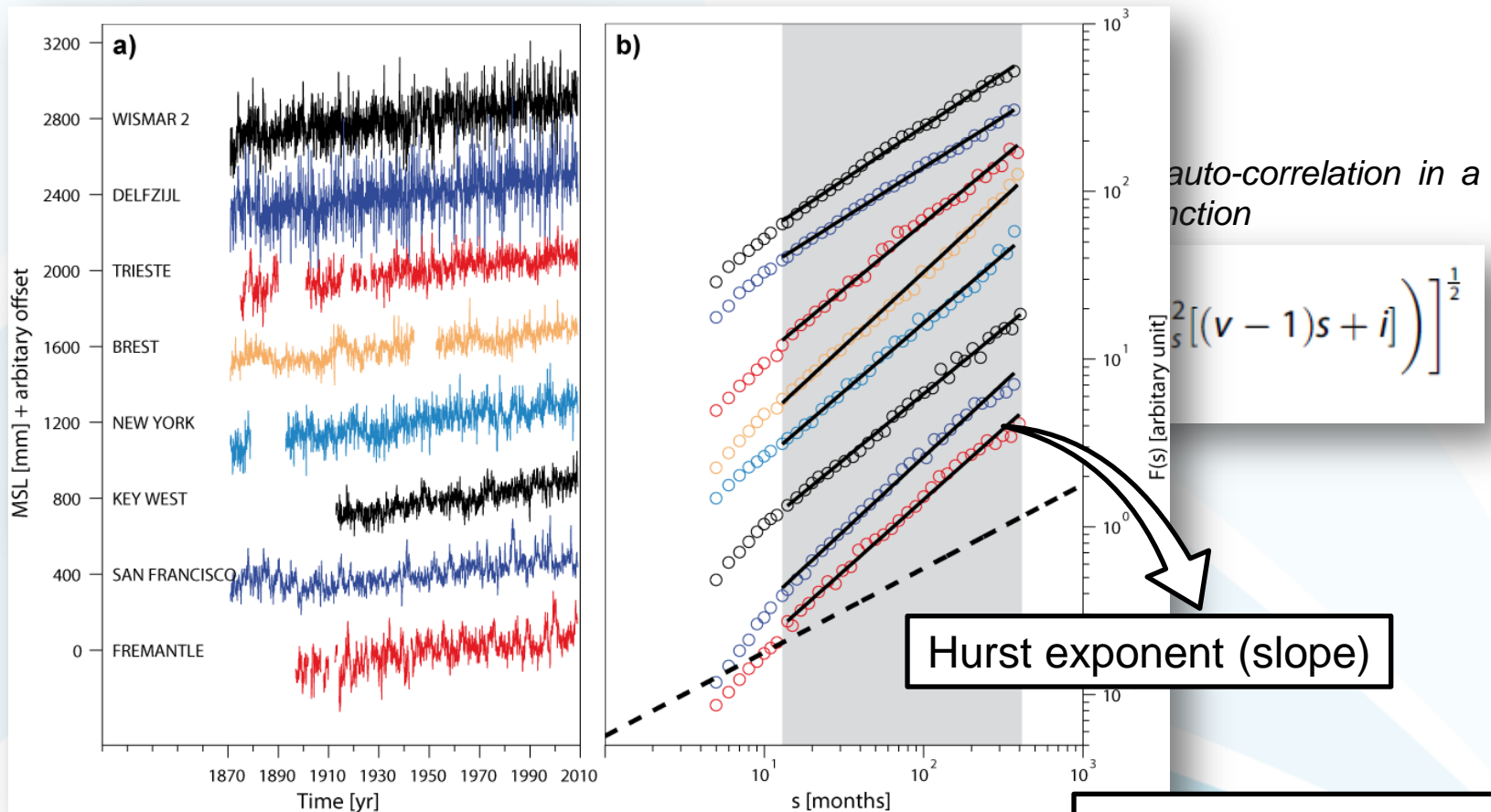
What is natural variability??

Natural variability is derived from the noise of the series, i. e., the energy distribution at different frequency bands, i.e. the autocorrelation of the observations

Natural variability may differ from one site to another

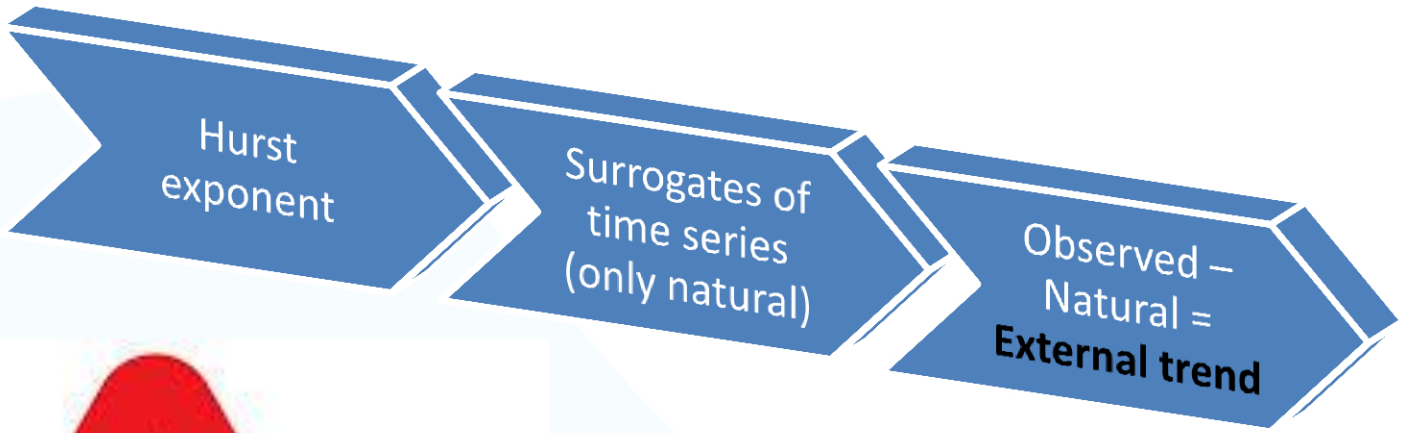
Characterising natural variability ...

Detrended Fluctuation Analysis [Peng et al., 1995; Bunde et al., 2001; Dangendorf et al, 2014; Becker et al., 2014]

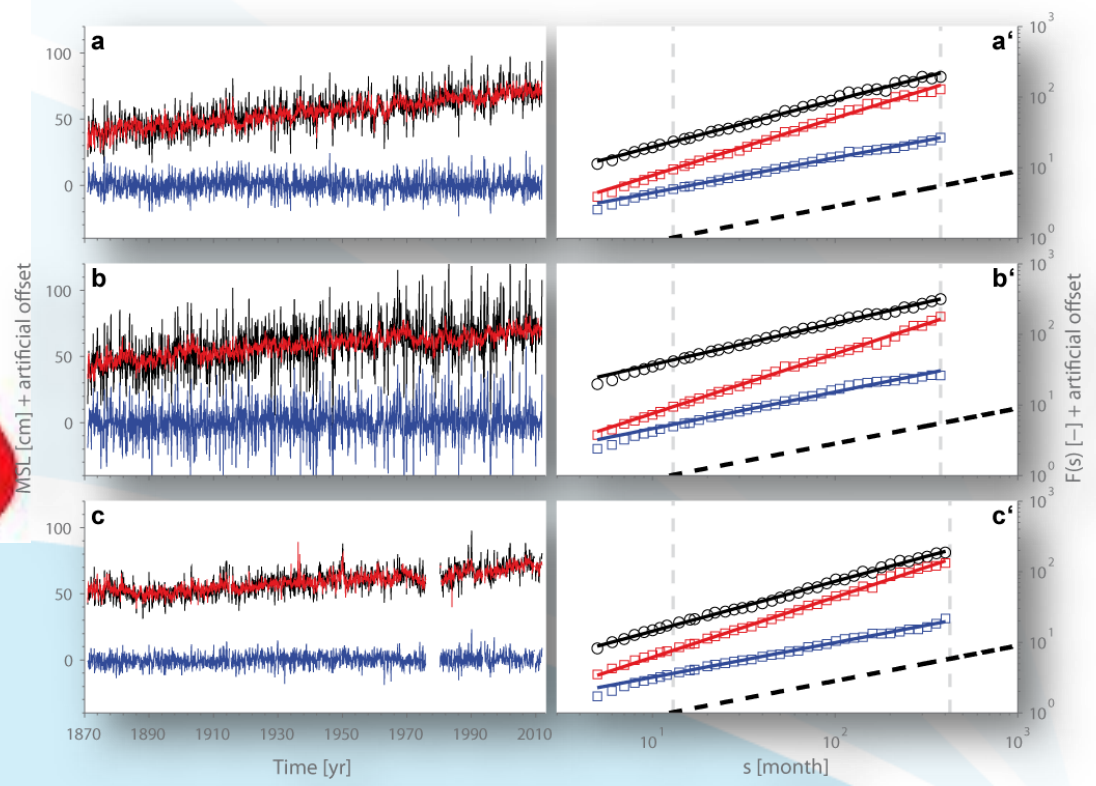


Dangendorf et al 2014

$\alpha \leq 0,5$ non-correlated
 $\alpha > 0,5$ long term correlation



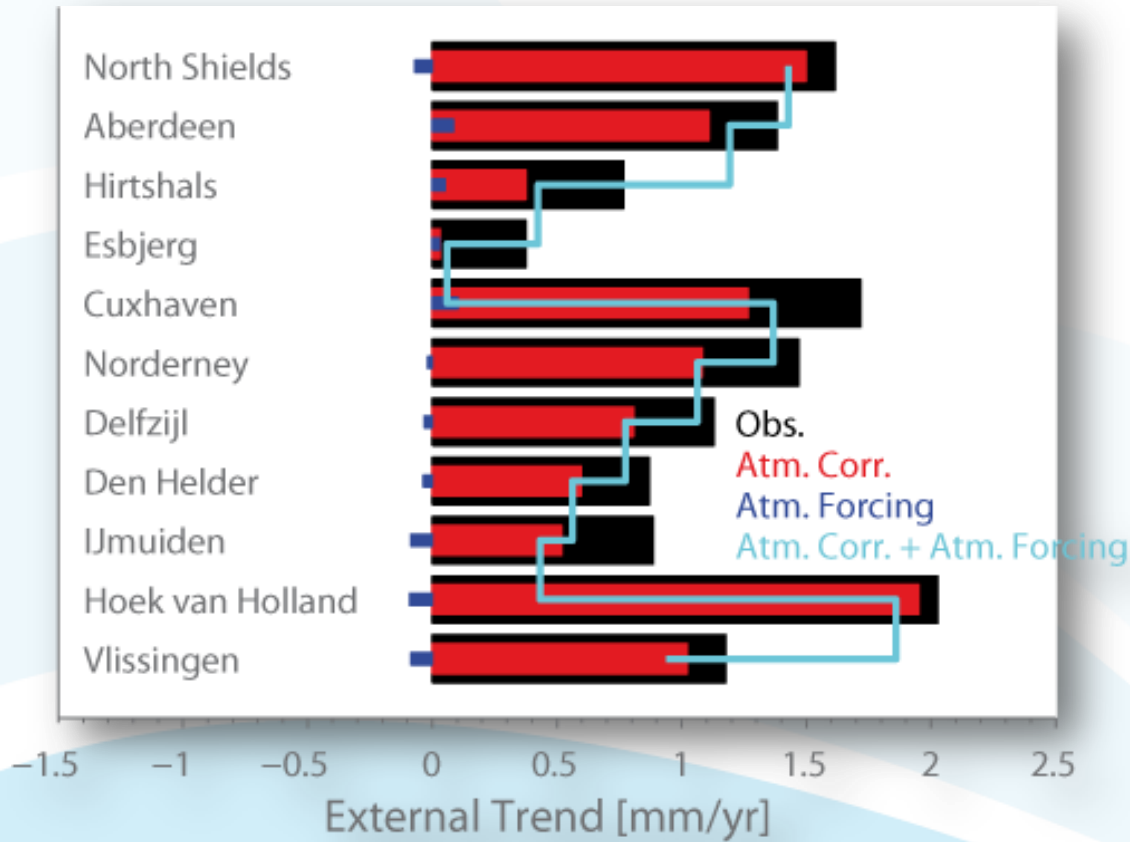
High-frequency, high energy processes



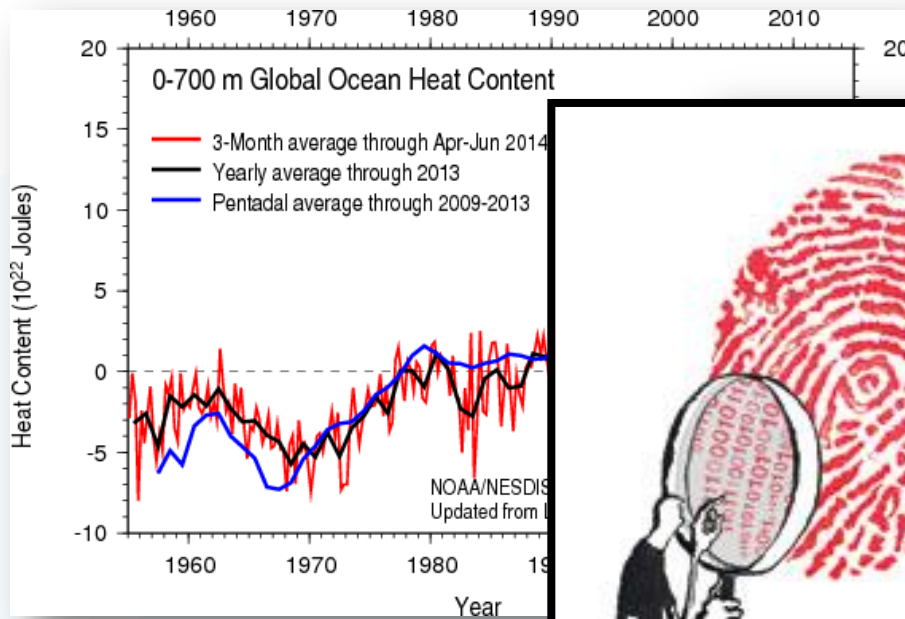
Credits: S. Dangendorf

External sea level trends

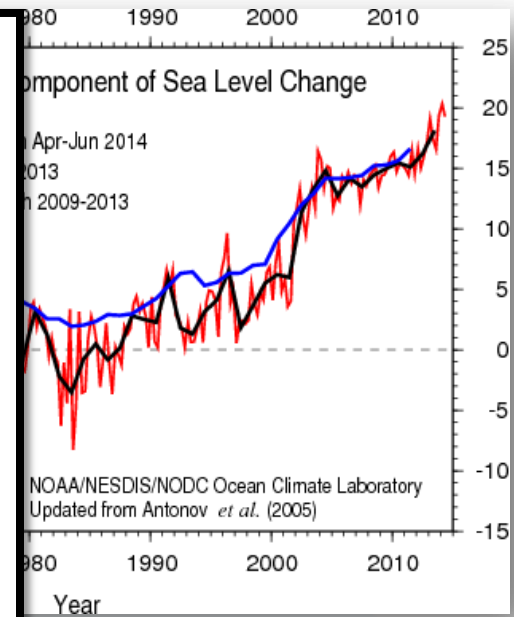
Minima anthropogenic sea level trends in the North Sea



Ongoing work...



Credits: NOAA

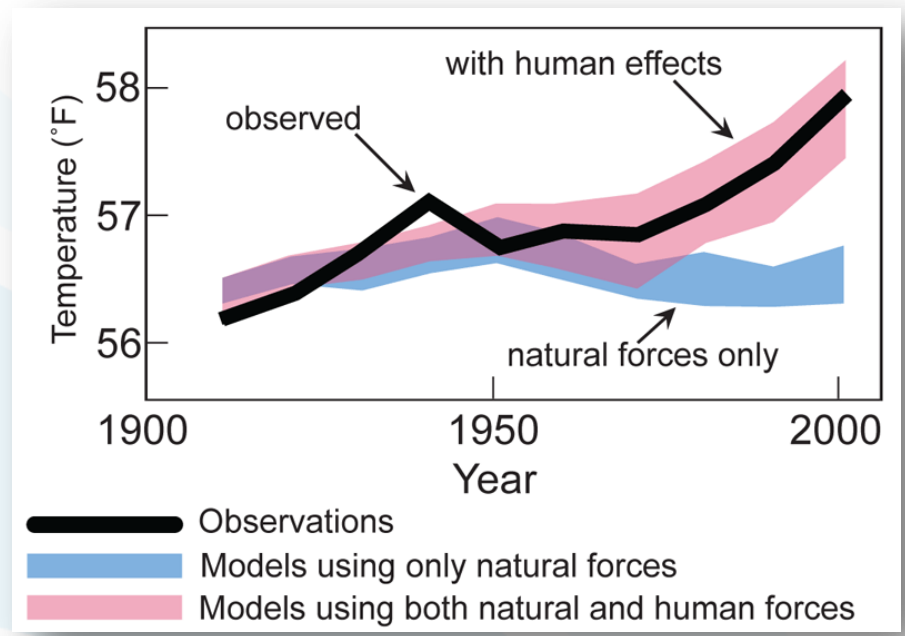


A step further: **Attribution** of observed changes in sea level to anthropogenic forcing

Climate models and simulations

Model name	AOGCM				ESM				
	Atmos	Land Surface	Ocean	Sea-ice	FC	Aerosol	Atmos Chem	Land Carbon	Ocean BGC
ACCESS1_0, ACCESS1_3	Australia								
BCC-CSM1.1, BCC-CSM1.1m	China								
BNU-ESM	China								
CanCM4	Canada								
CanESM2	Canada								
CCSM									
CCSM1 (BGC)									
CCSM1 (INMCM)									
CCSM1 (FSTOCHM)	USA	HT							
CCSM1 (CANM)									
CCSM1 (CANM3-FV2)	USA								
CMCC-CM, CMCC-CMS	Italy	HT							
CMCC-CESM	Italy	HT							
CMRM-CM5	France								
CMRO-MR3.6.0	France								
EC-EARTH	Australia								
FGOALS-g2	Europe								
FGOALS-g2	China								
FIO-ESM v1.0	China								
GFDL-ESM2M, GFDL-ESM2G	China								
GFDL-CM2.1	USA								
GFDL-CM3	USA								
GISS-E2-R, GISS-E2-H	USA	HT							
GISS-E2-R-CC, GISS-E2-H-CC	USA	HT							
InmCM2-ES	USA	HT							
InmCM2-CC	USA	HT							
InmCM3	UK					p2,p3*	p2,p3*		
InmCM3-AO	UK	HT				p2,p3*	p2,p3*		
InmCM4	Korea								
IPSL-CM5A-LR / CM5A-MR / CM5B-LR	Russia								
IPSL-CM5A-MR, MRCS	France								
IPSL-CM5M	France	HT							
IPSL-CM5M-CHEM	France	HT							
MIROC-ESM-LR / ESM-LR / ESM-MR / ESM-P	Japan	HT							
MIROC-ESM1	Japan	HT							
MIROC-CGCM3	Germany	HT							
MIROC-CGCM3	Japan	HT							
MIROC-CGCM3	USA	HT							
MIROC-CGCM3	USA	HT							
MIROC-CGCM3	Norway								
MIROC-CGCM3	USA								

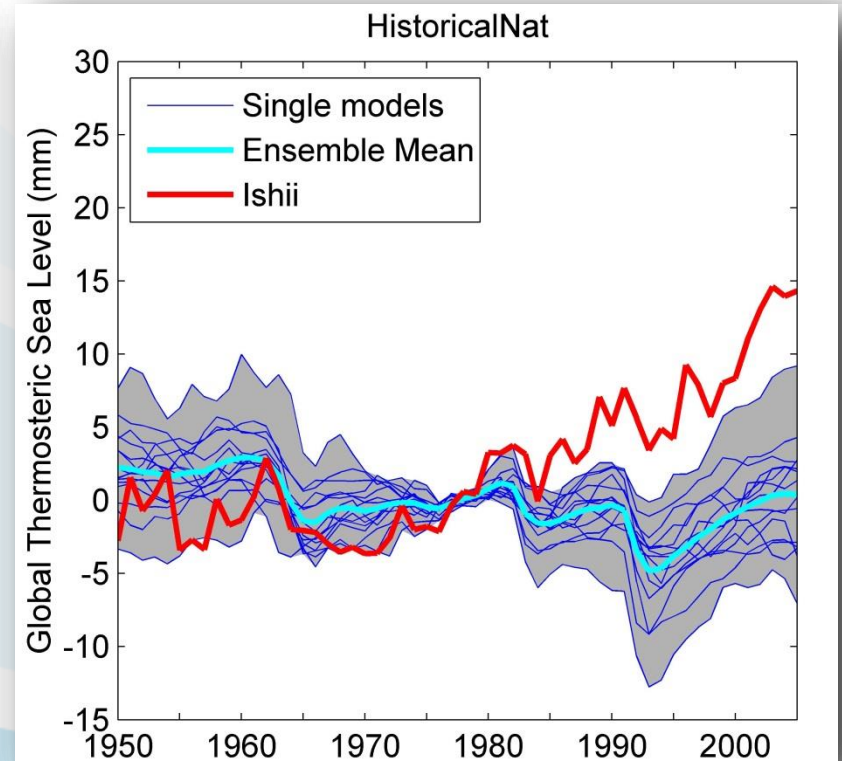
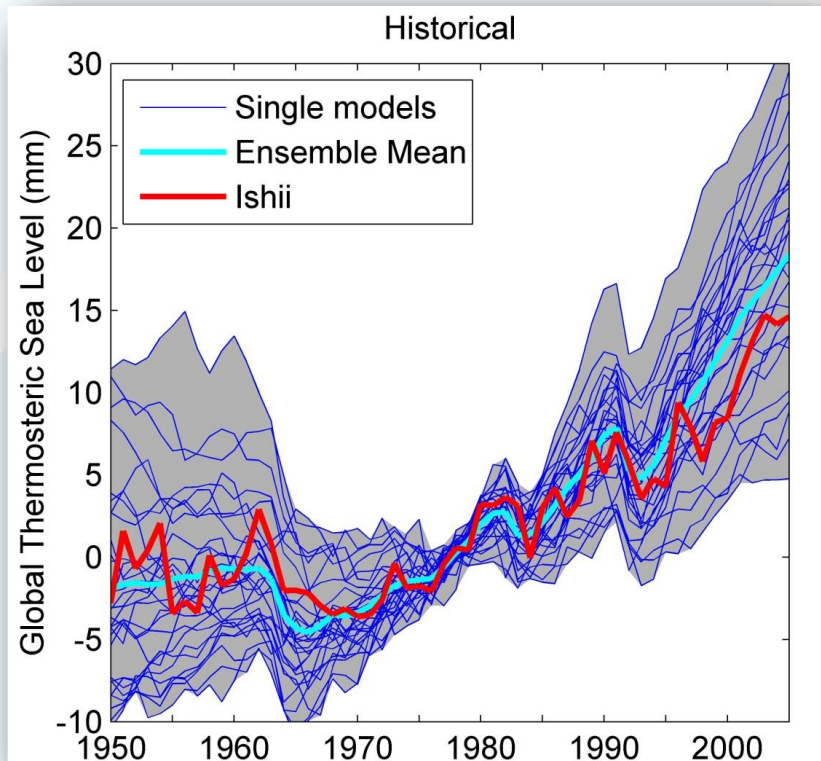
AOGCM and ESM available at the CMIP5 data base



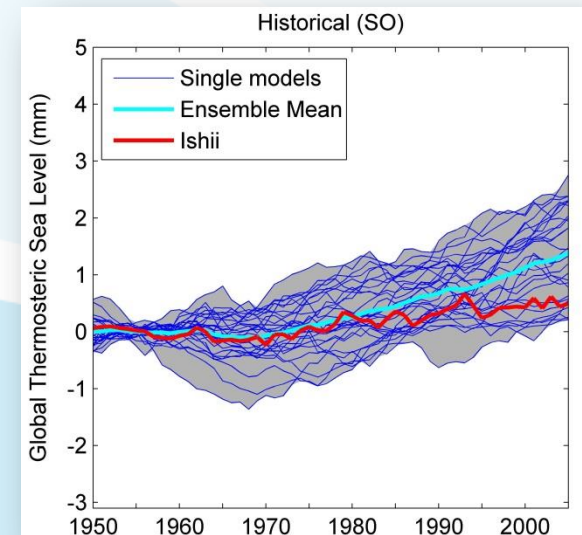
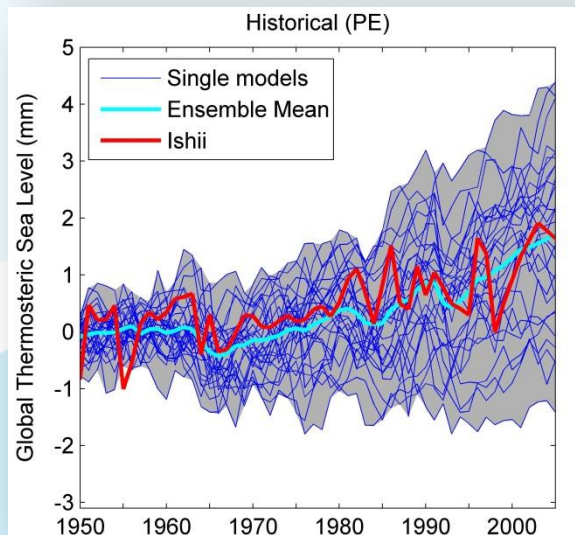
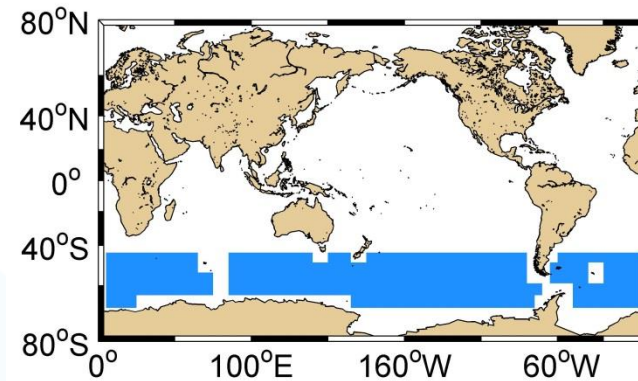
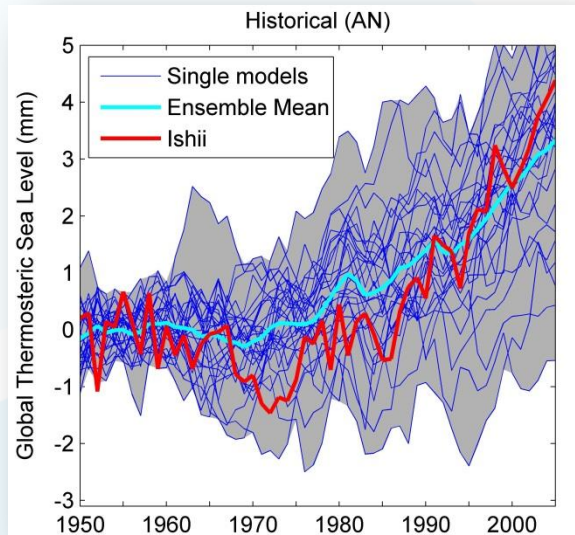
- Observations
- Models using only natural forces
- Models using both natural and human forces

Credits: NOAA

Global thermosteric sea level rise



Basin scale thermosteric sea level rise

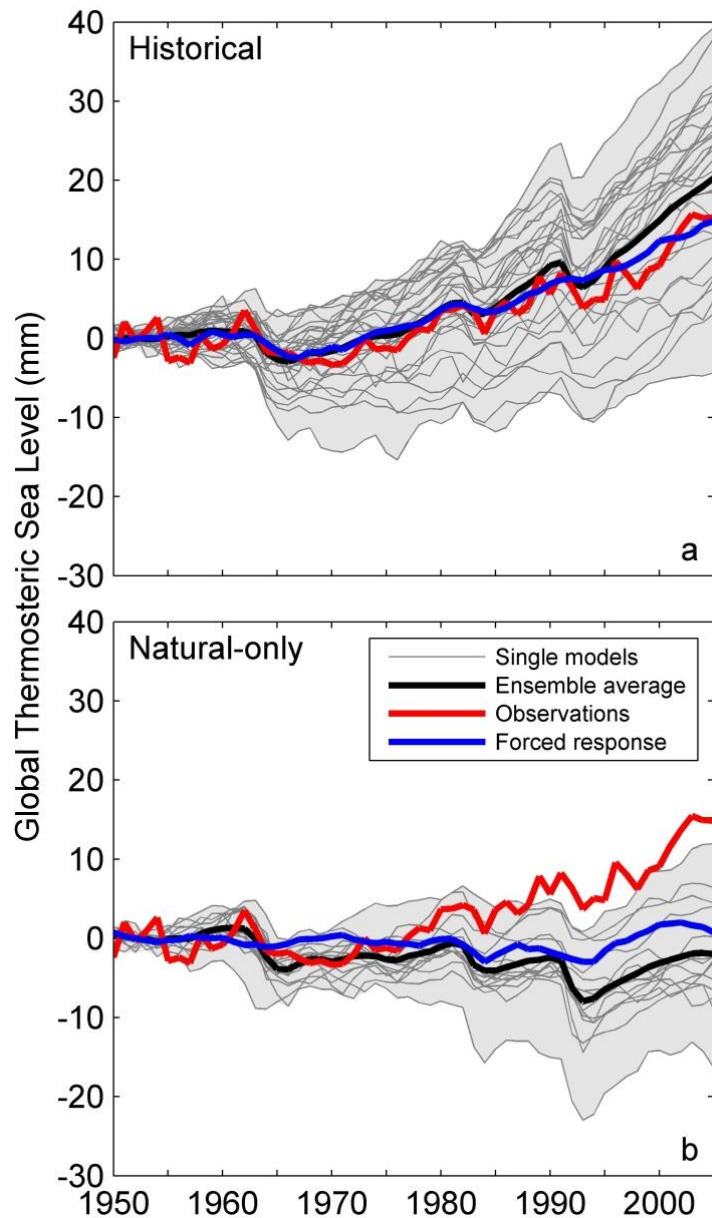


Attributing observed changes to human activity...

Signal-to-Noise (S/N) maximising EOFs [Venzke et al., 1999; Chang et al., 2000; Kelley et al., 2011; Marcos and Amores, 2014]

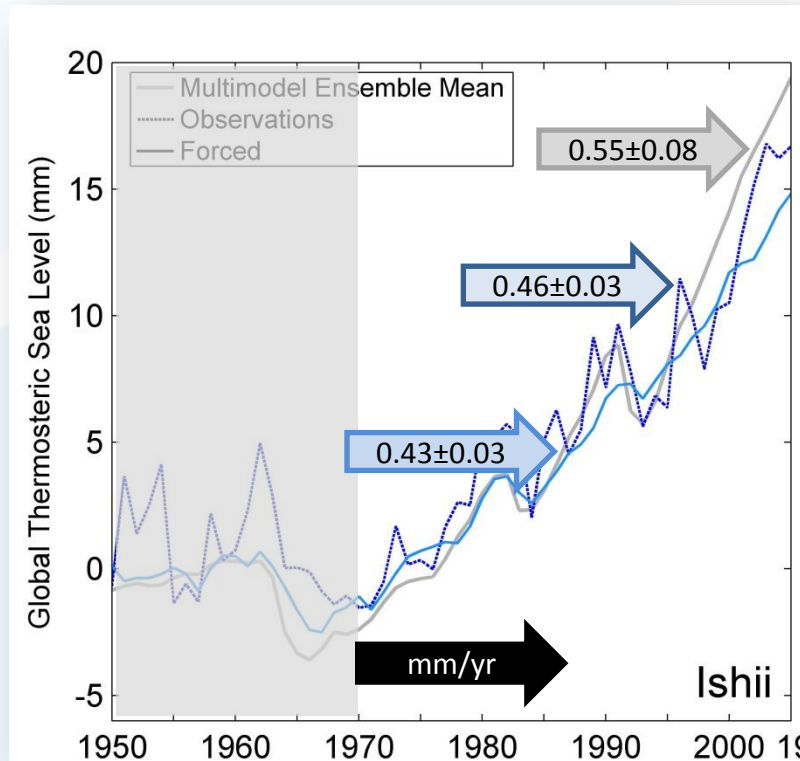
Characterizes the time-varying response to a time-varying forcing in a system with internal variability.

*Allows identification of the “common” response to the external forcing from an ensemble of numerical integrations (dominant **forced response**)*



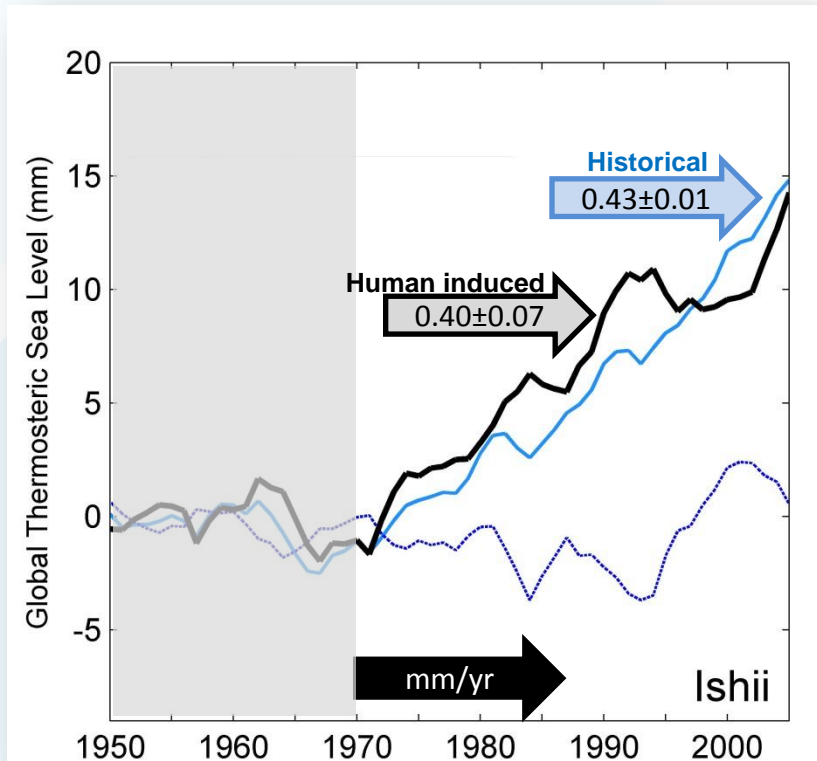
Ensemble average
vs.
“Forced response”

Externally-forced global thermosteric sea level rise



Ensemble average overestimates global thermosteric sea level rise (since 1970) by 20%

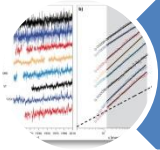
Global thermosteric sea level of anthropogenic origin



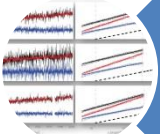
Trends in global average (mm/yr)	
Observations	0.46 ± 0.03
Ensemble-mean	0.55 ± 0.08
Historically-forced	0.43 ± 0.03
Anthropogenic	0.40 ± 0.07

~87% (with 95% confidence interval of 72-100%) of the observed warming-related sea level rise in the 0-700 m of the global ocean is of anthropogenic origin

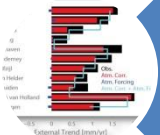
'Take away' messages



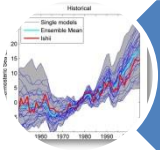
There is long term correlation in sea level observations. It is sometimes masked by short term high energy processes



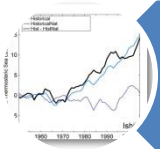
Characterizing the variability is essential to estimate anthropogenic impacts. It is a local issue for sea level



Observed sea level trends are larger than those expected from natural variability only



Thermosteric sea level rise since 1970 has a clear anthropogenic impact



Globally, human activity is responsible for 87% of the oceans warming for the top 700 m and its derived sea level rise

The background features several overlapping, wavy, light blue shapes that create a sense of movement and depth. The shapes are layered, with some appearing more prominent than others, and they all curve towards the right side of the frame. The overall effect is clean and modern.

Merci de votre attention