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Analyzing consistency of interannual variability in air-sea sensible and latent heat fluxes in CMIP5 model simulations

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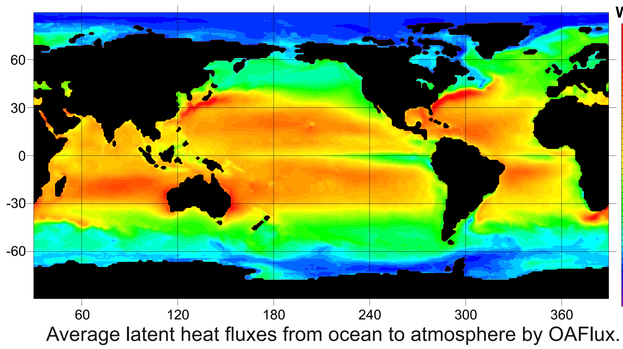
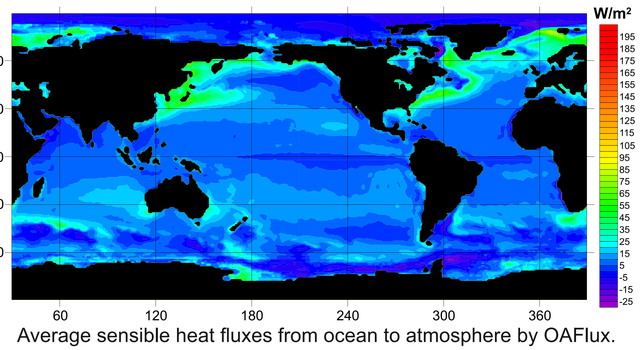
Motivation and outline:

Surface turbulent heat fluxes are critically important in climate model experiments, since they represent a language of communication of the ocean and atmosphere. Interannual variability of surface turbulent heat fluxes is believed to be the major contributor to the changes in the ocean surface heat balance, at least in mid latitudes. Being relatively well assessed and validated in reanalyes, surface turbulent heat fluxes always were of a lesser attention in diagnostics of climate model experiments. We analysed interannual variability of sensible and latent heat fluxes in historical and prognostic climate simulations with several CMIP5 models. Variability in surface turbulent sensible and latent heat fluxes in model simulations has been analysed during several last decades (from 1950s to 2005) and for the 21st century scenario runs (RCP45) with the emphasis on different scales of variability (short-term, interannual, decadal).

	Global (60S-60N)x(0-360)			North hemisphere (30N-60N)x(0-360)			Tropics (30S-30N)x(0-360)			South hemisphere (60S-30S)x(0-360)		
Correlations between hfls and hfss	All periods	Inter-annual period	Inter-decadal period	All periods	Inter-annual period	Inter-decadal period	All periods	Inter-annual period	Inter-decadal period	All periods	Inter-annual period	Inter-decadal period
OAFlux	*0.54*	*0.44*	*0.51*	*0.90*	*0.69*	*0.94*	*0.72*	*0.61*	*0.78*	*0.86*	*0.58*	*-0.11*
ICOADS	*0.57*	*0.50*	*0.73*	*0.86*	*0.59*	*0.26*	*0.78*	*0.46*	*0.76*	*0.73*	*0.59*	*0.75*
ACCESS1.0	0.60	-0.32	-0.18	0.88	0.07	-0.79	0.78	0.39	0.23	0.80	0.76	0.15
BCC-CSM1.1	0.43	-0.34	**-0.84**	0.87	0.28	**-0.76**	0.49	-0.13	**-0.66**	0.76	0.61	**-0.69**
BNU-ESM	0.53	**-0.42**	**-0.84**	0.88	0.45	-0.57	0.67	-0.21	-0.40	0.74	0.42	**-0.78**
CMCC-CMS	0.46	**-0.69**	**-0.85**	0.91	0.68	**-0.80**	0.60	**-0.48**	**-0.83**	0.78	0.55	-0.58
CNRM-CM5	0.60	-0.18	-0.08	0.87	0.47	-0.17	0.61	-0.09	0.19	0.79	0.46	0.18
CSIRO-Mk3.6	0.62	-0.43	0.27	0.91	0.26	-0.16	0.69	-0.33	0.18	0.82	0.49	0.75
GFDL-CM3	0.63	-0.04	-0.05	0.89	0.63	-0.20	0.78	0.54	0.16	0.80	0.61	-0.22
HadGEM2-CC	0.65	-0.30	-0.40	0.83	0.40	-0.30	0.75	0.30	-0.30	0.74	0.58	-0.24
INM-CM4	0.81	-0.29	**-0.89**	0.94	0.72	0.22	0.82	-0.01	**-0.82**	0.92	0.84	**-0.60**
IPSL-CM5A-MR	0.52	**-0.61**	**-0.86**	0.89	0.49	-0.37	0.68	-0.06	**-0.81**	0.80	0.17	**-0.64**
MPI-ESM-MR	0.54	**-0.63**	**-0.84**	0.88	0.82	**-0.63**	0.63	**-0.47**	**-0.79**	0.81	0.44	-0.33
MIROC-ESM-CHEM	0.58	-0.33	0.29	0.93	0.41	0.50	0.73	0.27	0.24	0.85	0.58	-0.13
MRI-ESM1	0.78	-0.15	0.21	0.87	0.66	0.26	0.83	0.19	0.37	0.70	0.66	0.01



Average latent heat fluxes from ocean to atmosphere by OAFlux.



Average sensible heat fluxes from ocean to atmosphere by OAFlux.

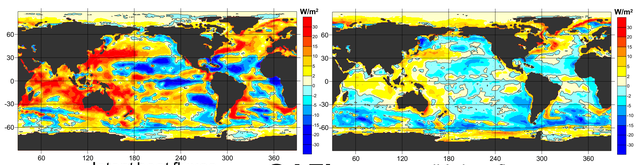
Conclusions:

At all scales it has been found a little consistency between the changes in turbulent surface fluxes diagnosed by the reanalyses (ERA-Interim) and blended data sets (OA-FLUX) on one hand and model simulations on the other.

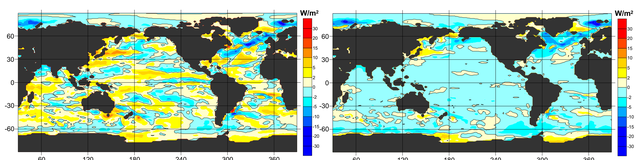
Some models (e.g. ECHAM, IPSL, INM) surprisingly demonstrate large regions with negative correlations between sensible and latent heat fluxes, which is not the case in observational data sets (reanalyses and OAFLUX).

Interestingly, variability in air temperature and surface humidity (which could be potentially considered as the reason for anticorrelation between sensible and latent fluxes) demonstrates consistency with each other at most scales. However, the vertical gradients of surface temperatures and humidities do demonstrate interconnections similar to those found in senasible and latent fluxes.

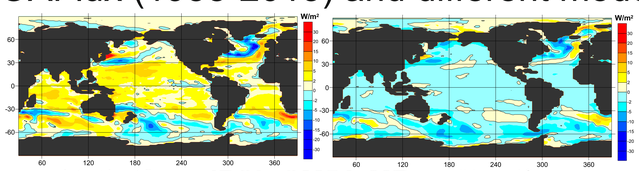
Linear trends in the latent and sensible heat fluxes for OAFlux (1958-2013) and different models (1950-2005)



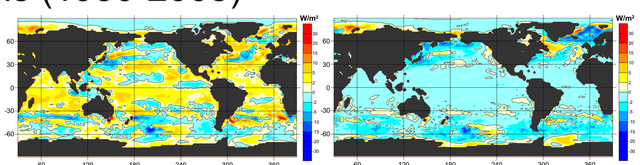
latent heat fluxes **OAFlux** sensible heat fluxes



latent heat fluxes **INM-CM4** sensible heat fluxes

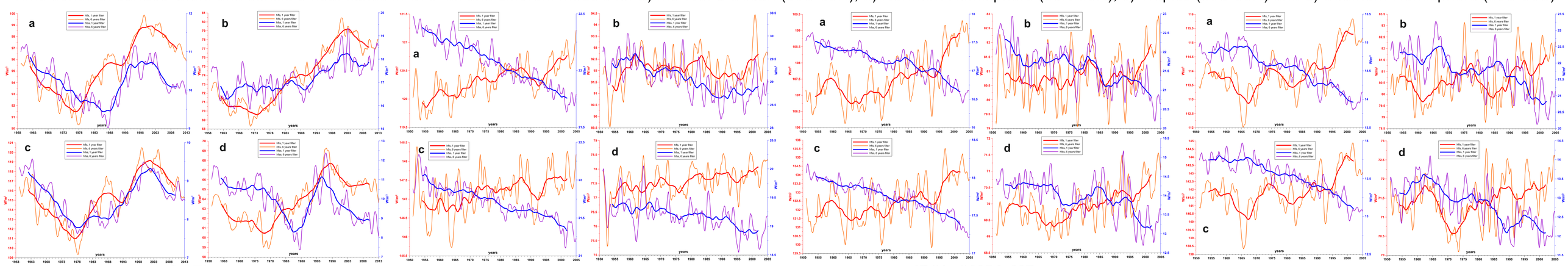


latent heat fluxes **IPSL-CM5A-MR** sensible heat fluxes



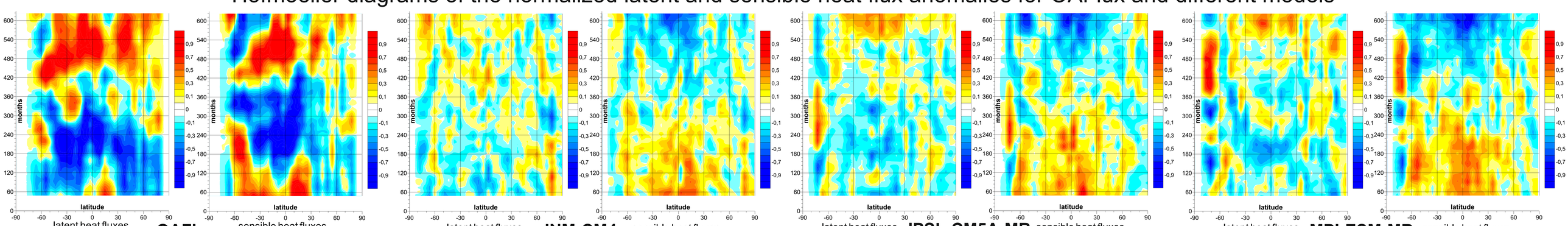
latent heat fluxes **MPI-ESM-MR** sensible heat fluxes

Time series of surface latent and sensible heat fluxes in OAFlux and different models for a) the World Ocean (60S-60N), b) Northern Hemisphere (30N-60N), c) Tropics (30S-30N) and d) Southern Hemisphere (60S-30S)



OAFlux **INM-CM4** **IPSL-CM5A-MR** **MPI-ESM-MR**

Hofmoeller diagrams of the normalized latent and sensible heat flux anomalies for OAFlux and different models



latent heat fluxes **OAFlux** sensible heat fluxes latent heat fluxes **INM-CM4** sensible heat fluxes latent heat fluxes **IPSL-CM5A-MR** sensible heat fluxes latent heat fluxes **MPI-ESM-MR** sensible heat fluxes