Accuracy and uncertainty of global ocean reanalyses in reproducing the OHC

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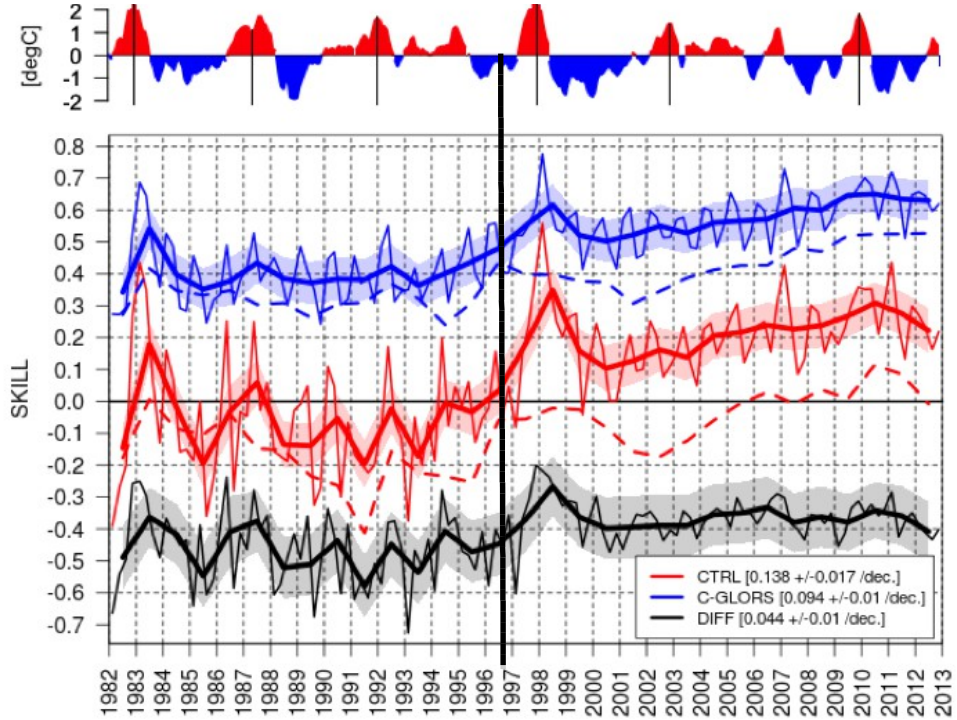
CONCEPT-HEAT

Exeter, UK
29/09-1/10 2015

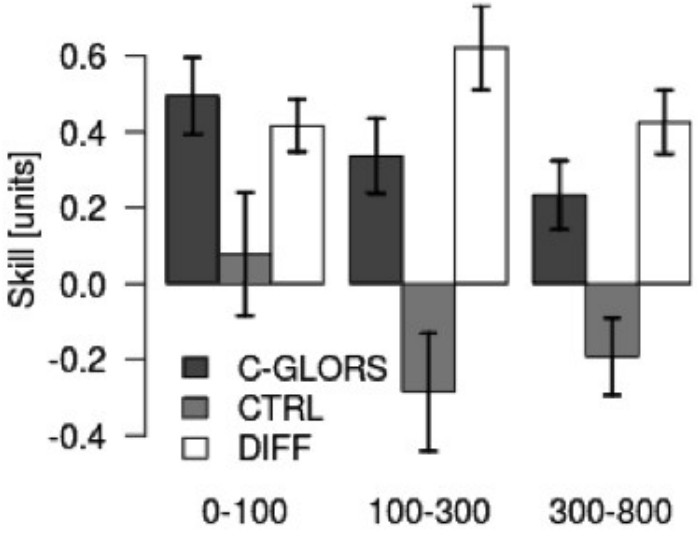
C-GLORS Reanalysis: Skill assessment
V4.1, eddy-permitting (¼), 1982-2013 [HYD+SLA+SST+SIC]

Non-assimilative integrations show no skill (w.r.t. to climatology) before 1997 or below 100 m of depth.

Skill calculated through bootstrapping validating observations to prevent the observation amount and sampling to affect the skill scores



Skill vs time in the top 100 m

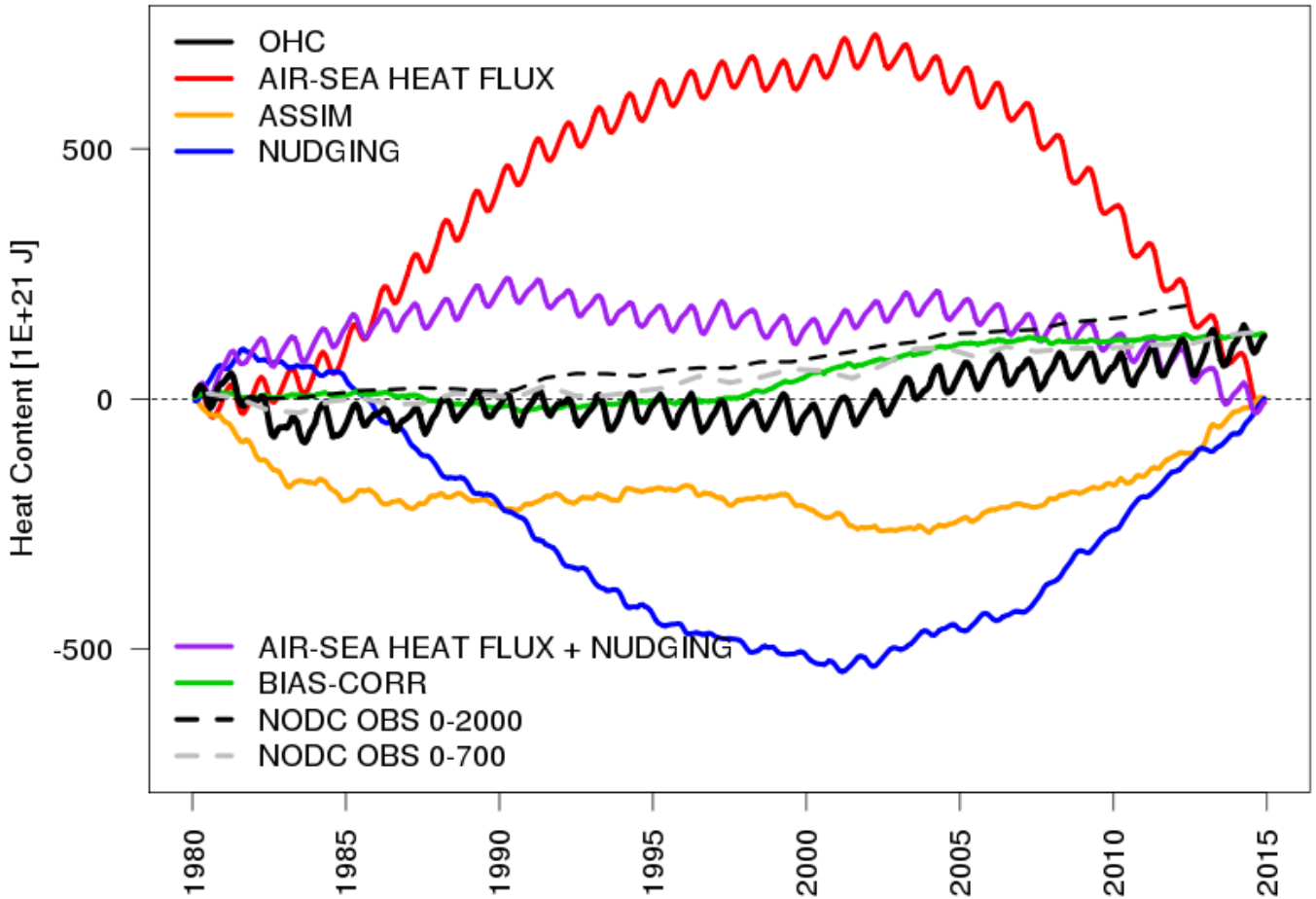


Skill vs vertical layers

Storto et al., 2015, QJRMS

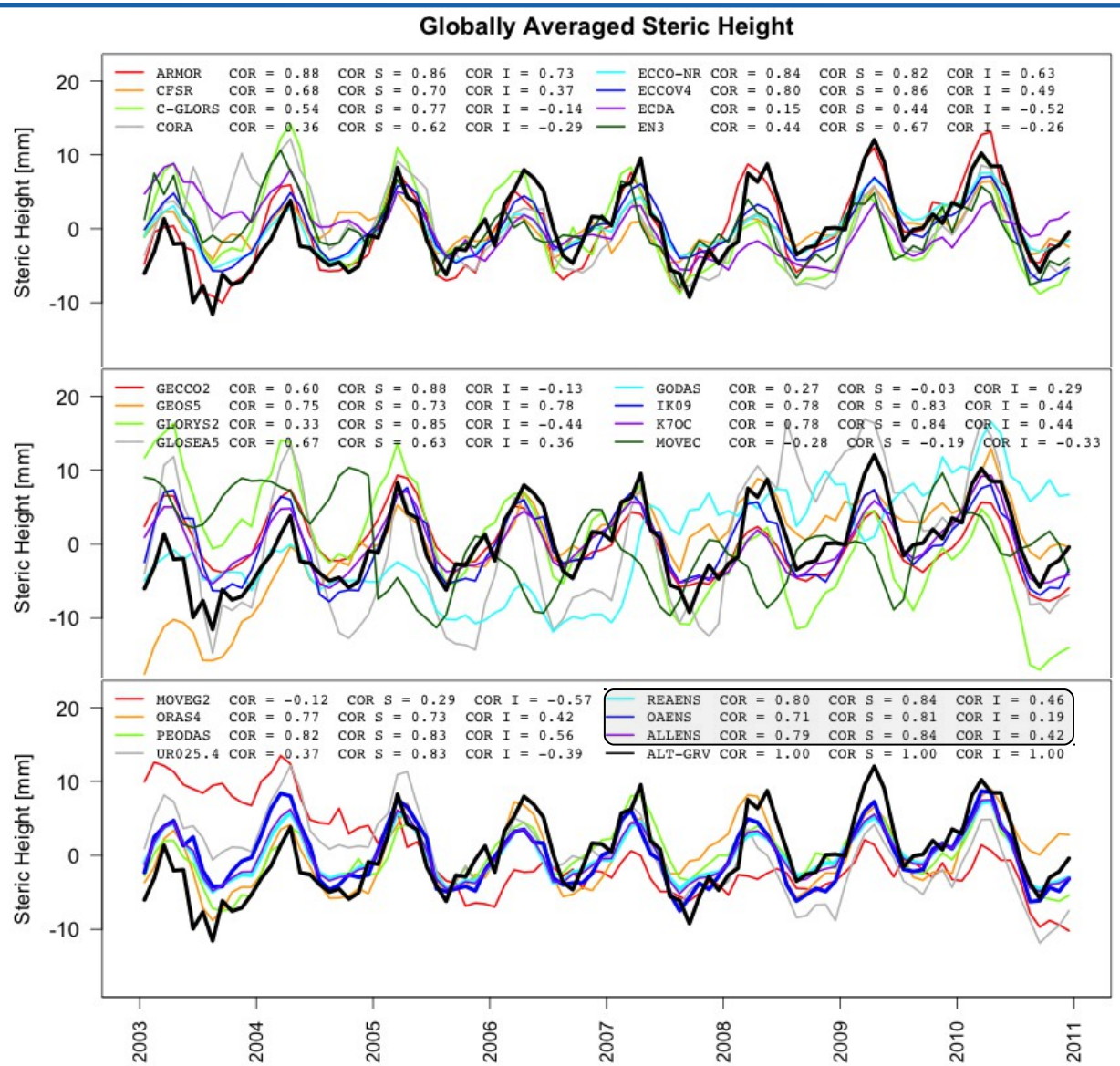
C-GLORS Reanalysis: Evolution of OHC components

Comparison of the global OHC components (atmospheric forcing and assimilation source/sink)



Cross-covariances and compensation effects between different assimilation components prevent from robust conclusions

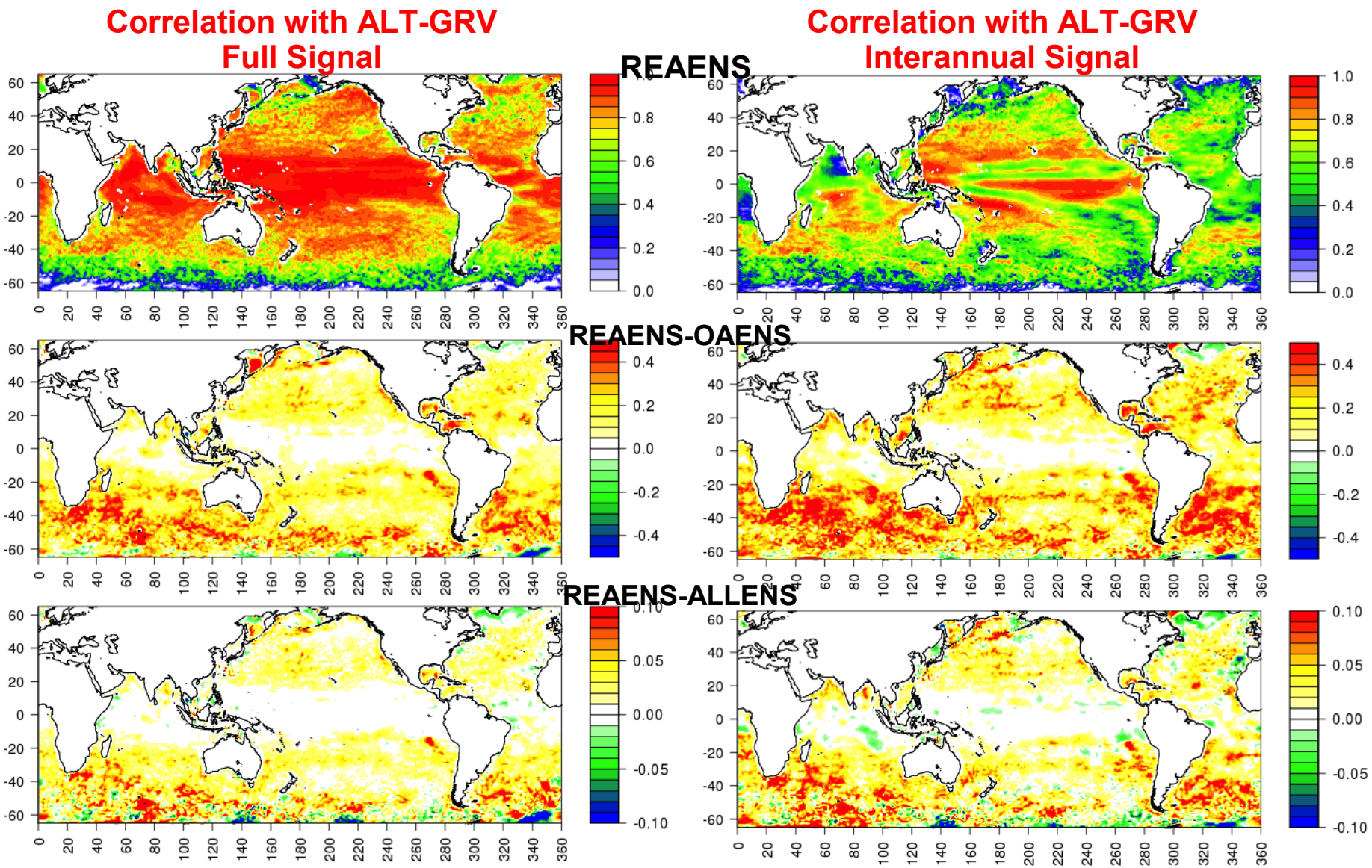
ORA-IP Global SSL (2003-2010) vs Satellites



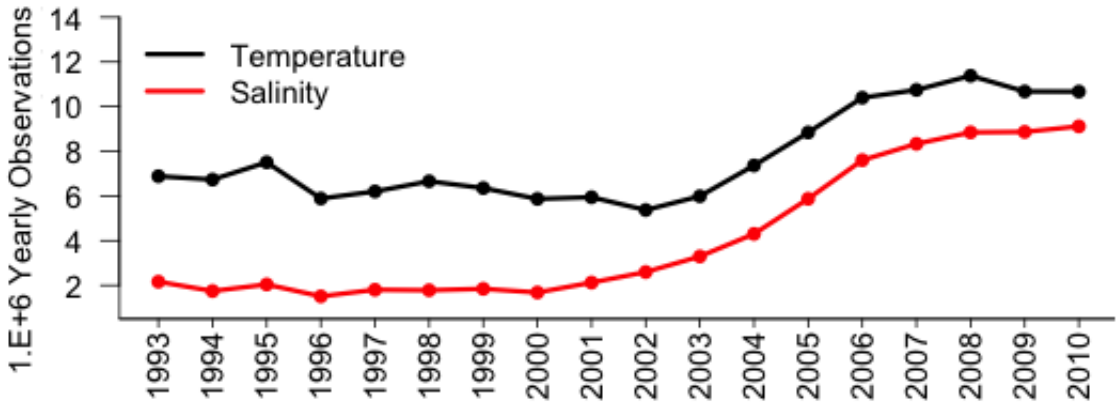
From the **ORA-IP** Inter-Comparison of Steric sea level
(Storto et al. 2015, Clim.Dyn.)
[20 products, 16 REAs]

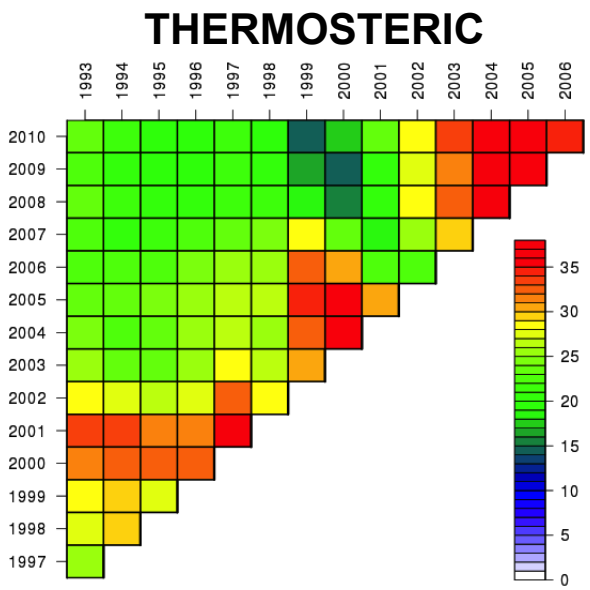
- ***All products except 4 exhibit significant correlations wrt to validation dataset***
- ***Seasonal signal correlations are larger than inter-annual ones***
- ***REAENS outperforms OAENS and ALLENS***
- ***Particularly at inter-annual scale***

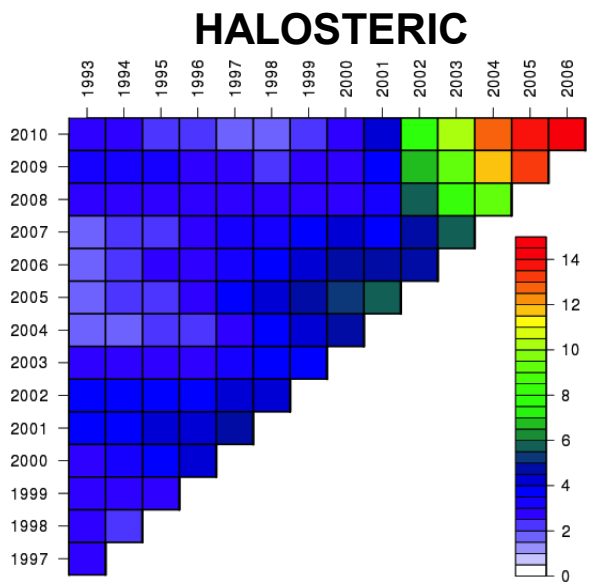
ORA-IP Regional SSL (2003-2010) vs Satellites



SSL 1993-2010: Significance of regional trends (halo/thermo)

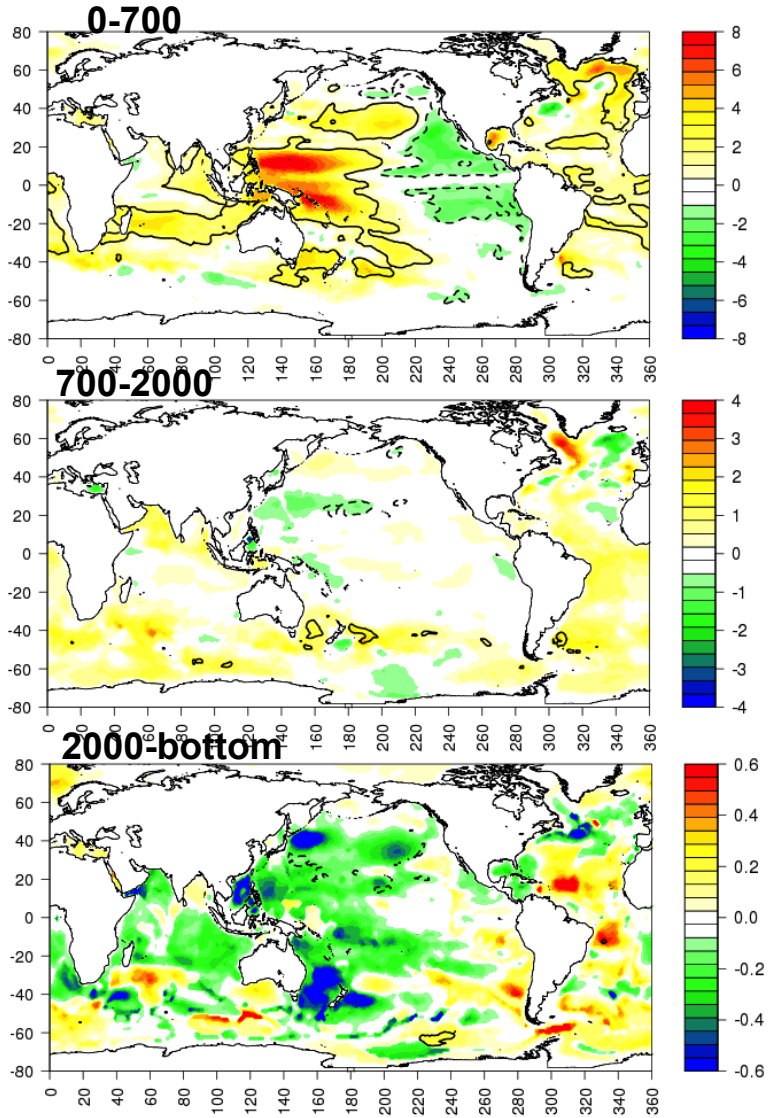


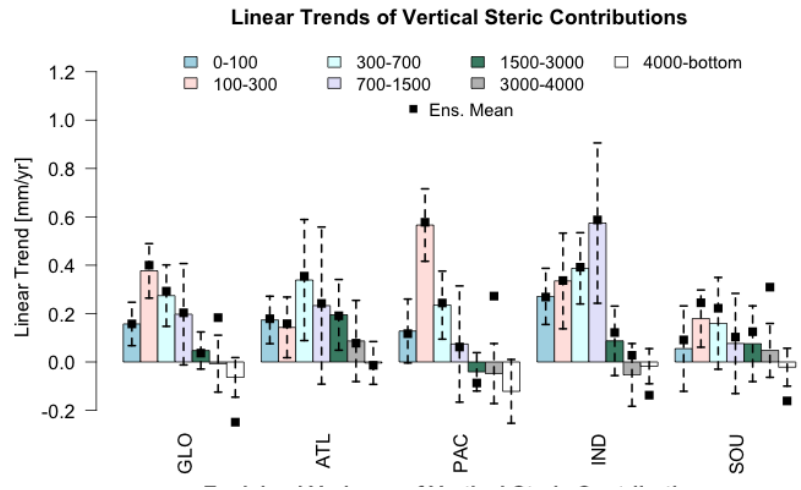




Percentage of the Ocean having significant steric trends (wrt to the ensemble spread)

SSL 1993-2010: Significance of regional trends (depth)





Below 700 m of depth, trends are generally non significant (w.r.t. to the spread)

Same results qualitatively apply to the halosteric trends

Similar results found in the MyOcean reanalyses (all with NEMO/ORCA025) at depth and for salinity fields (*Masina et al. 2015, Clim. Dyn.*)

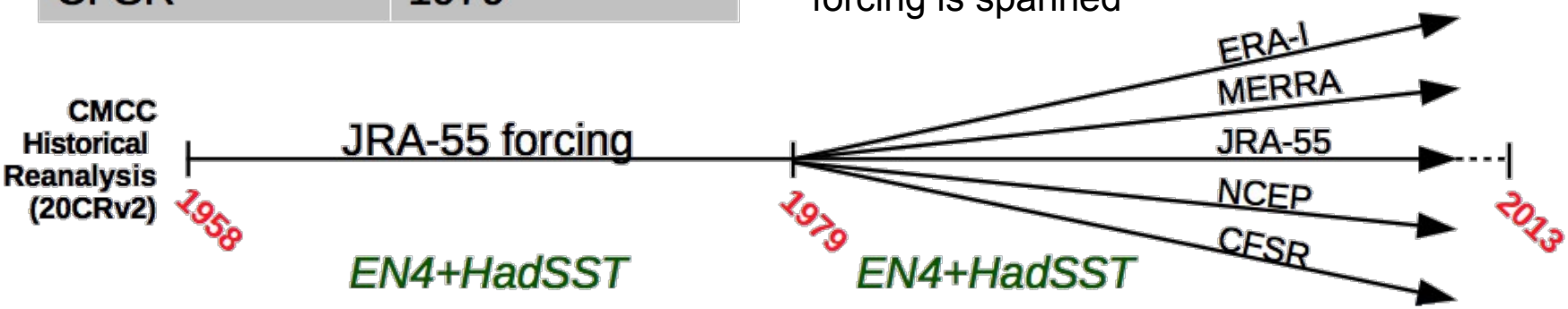
Multi-forcing Ensemble Reanalysis System

- **Goal: to assess the impact of atmospheric forcing on ocean reanalyses using state-of-the-art atmospheric products**

Forcing	Starting Year
ERA-Interim	1979
MERRA	1979
JRA-55	1958
NCEP-R2	1979
CFSR	1979

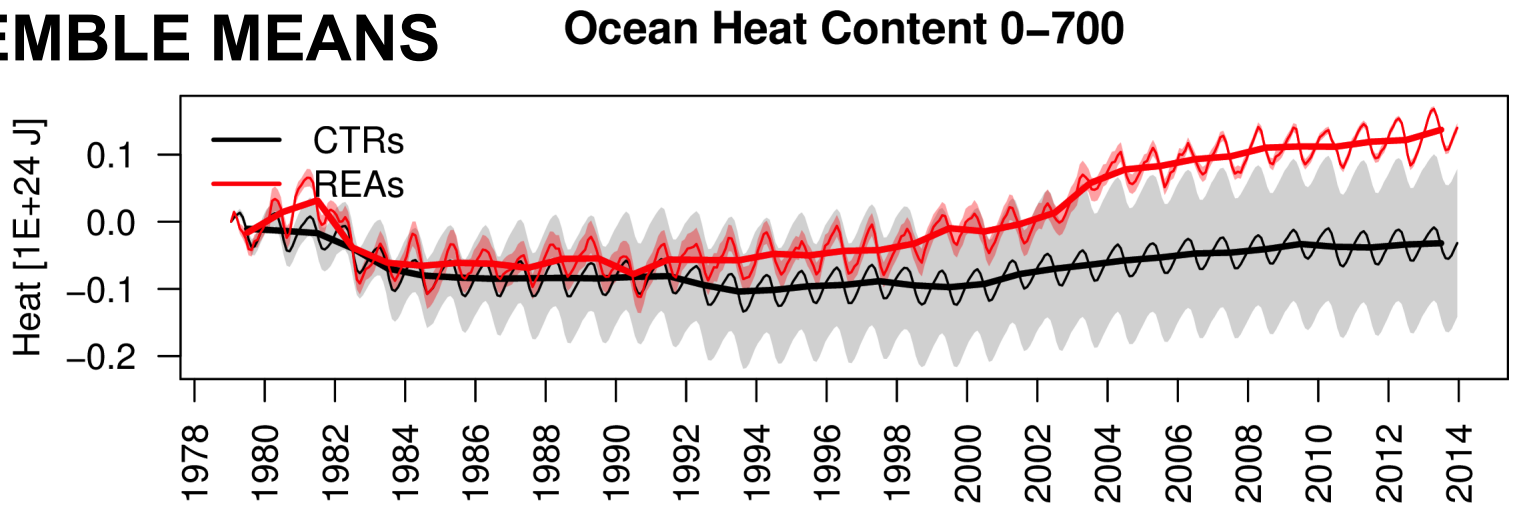
Pros:
- Straightforward ensemble generation
- Implied assessment of atmospheric reanalysis accuracy from the ocean point of view

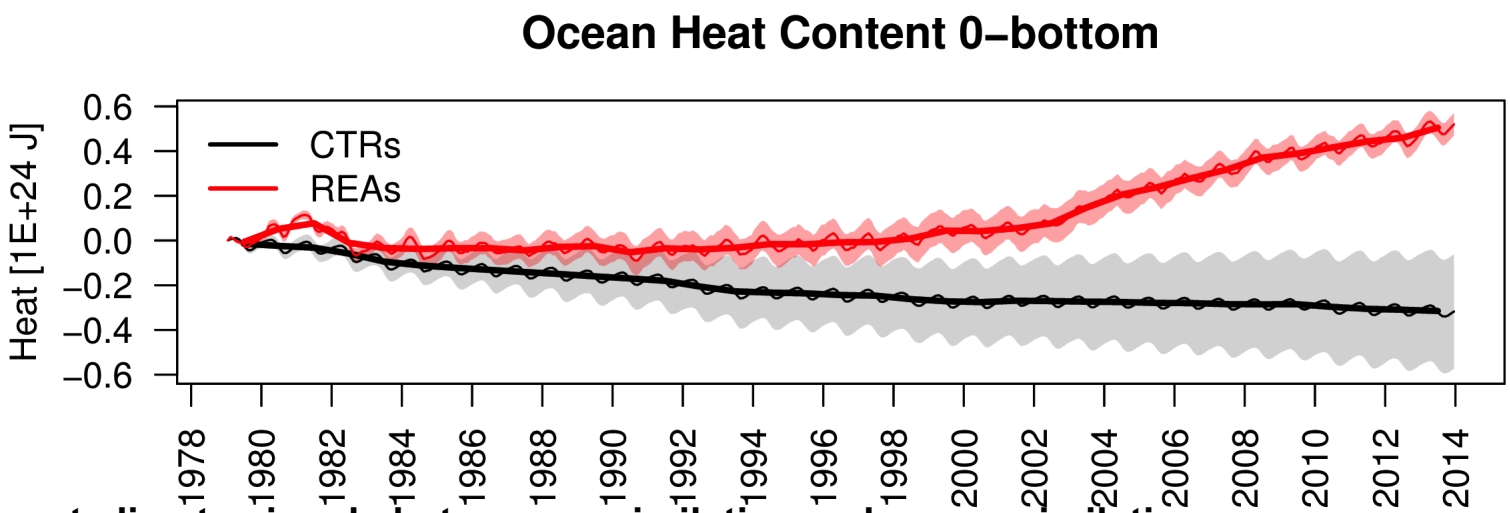
Cons:
- The ensemble is under-dispersive, ie only the uncertainty in the atmospheric forcing is spanned



Multi-forcing Ensemble Reanalysis System

ENSEMBLE MEANS

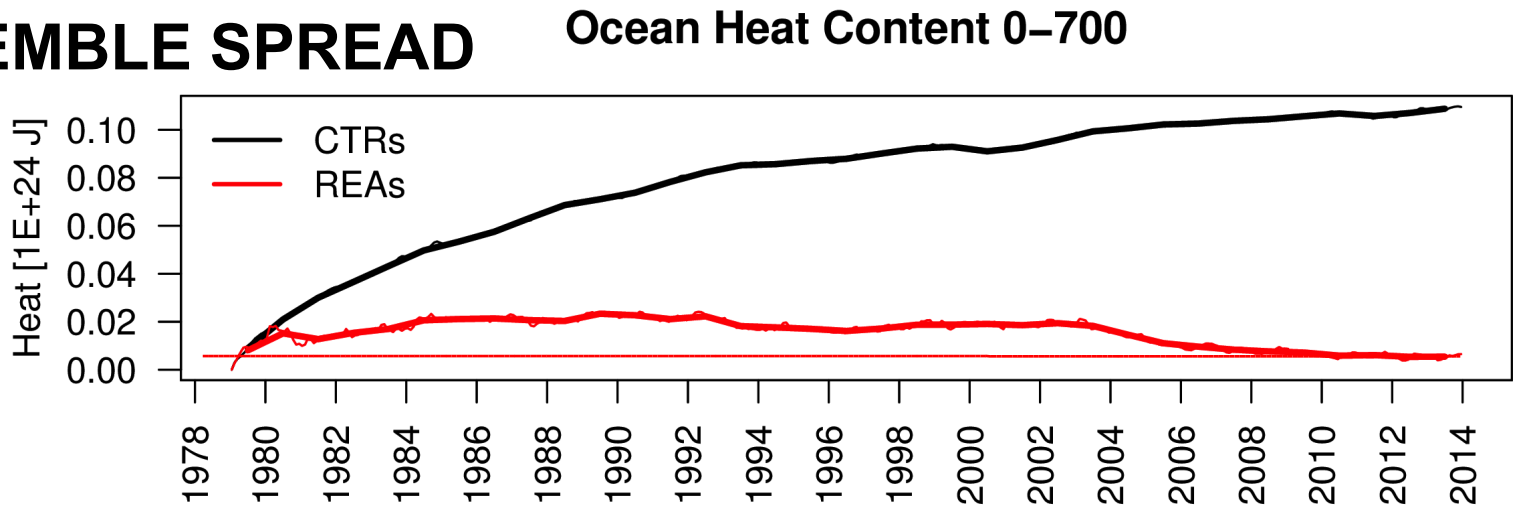


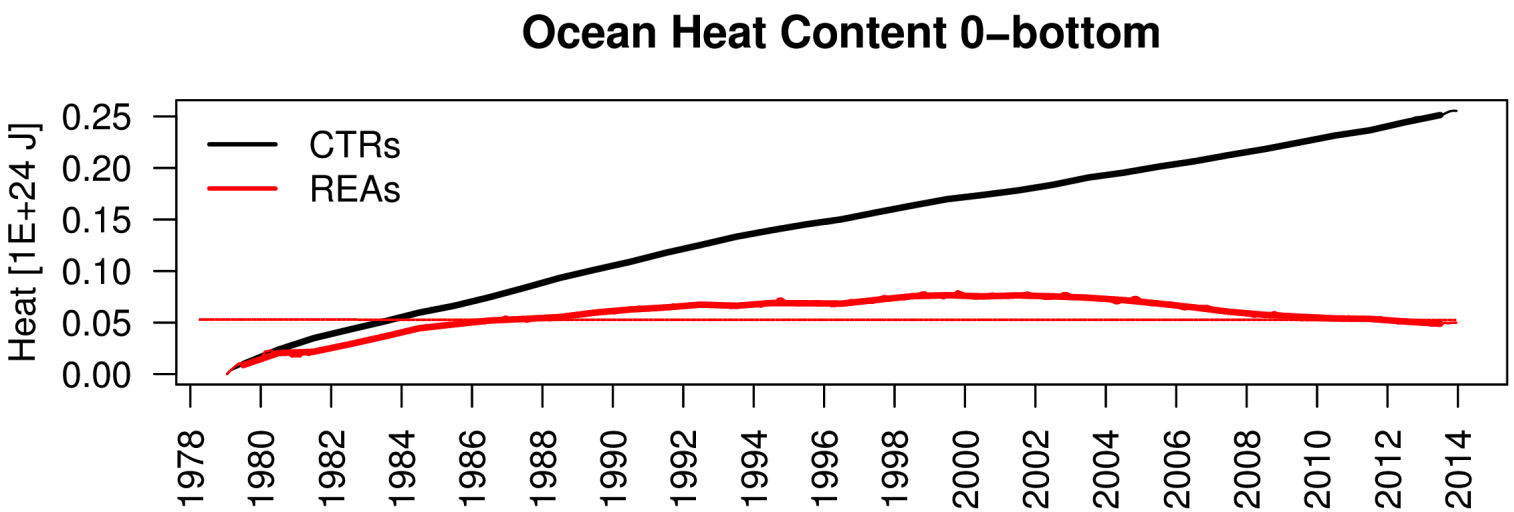


Very different climate signals between assimilative and non-assimilative runs
Heat flux from atmospheric reanalyses *(heat flux inter-comparison, Valdivieso et al. 2015, Clim. Dyn.)* **have large diversity. 0-bottom signal affected also by ICs**

Multi-forcing Ensemble Reanalysis System

ENSEMBLE SPREAD





Very different spread behaviors: in-situ network (Argo in particular) are an attractor for the ensemble system

Multi-forcing Ensemble Reanalysis System

Heat Content Trend from the multi-forcing ensemble [W/m²]

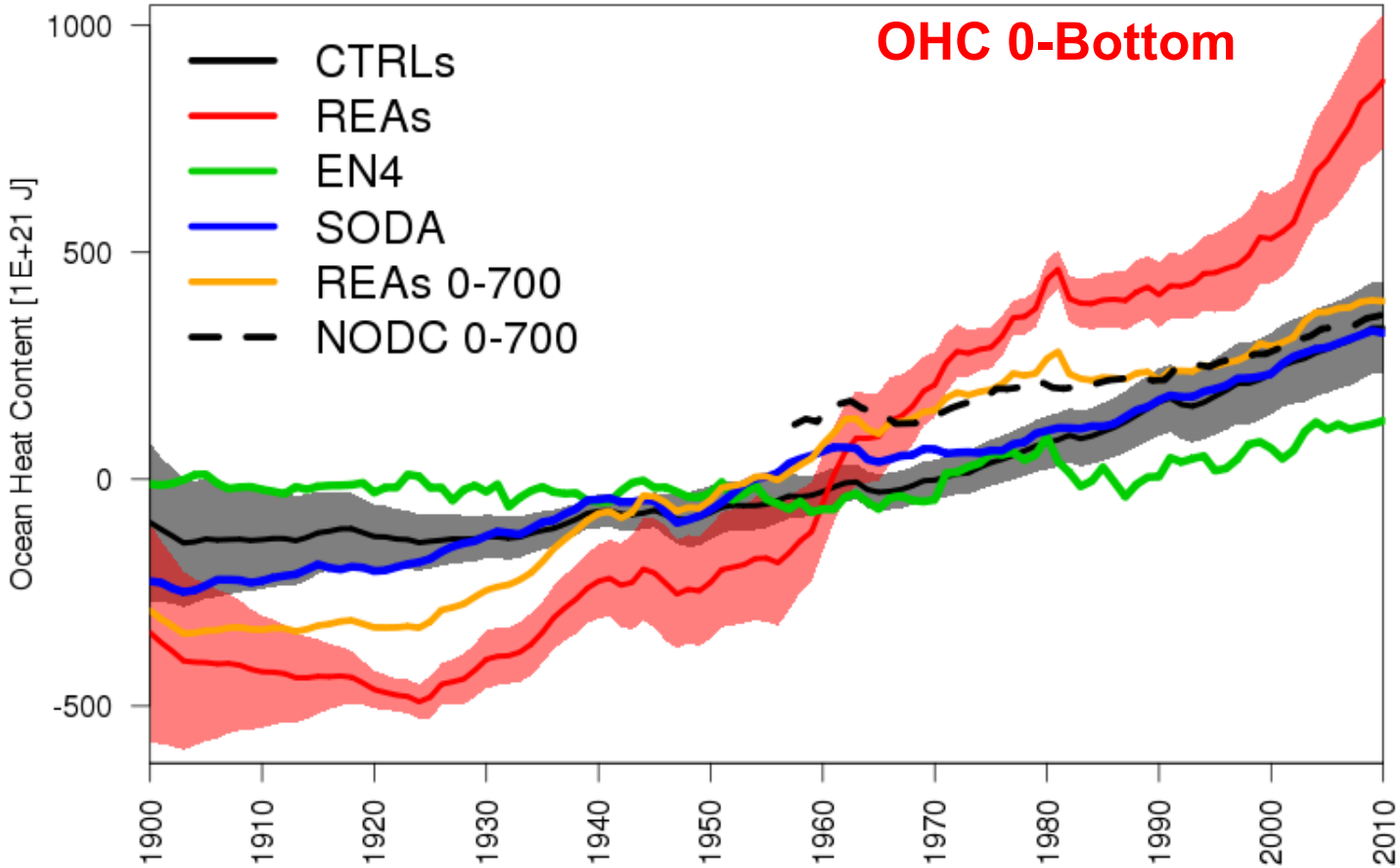
Layer	1979-2013	2000-2013
0-300	0.26 +/- 0.02 [8%]	0.41 +/- 0.08 [18%]
0-700	0.48 +/- 0.04 [7%]	0.93+/- 0.12 [13%]
0-2000	1.16 +/- 0.04 [4%]	2.48 +/- 0.24 [10%]
0-bottom	1.26 +/- 0.11 [8%]	3.26 +/- 0.23 [7%]

Based on our reanalysis system, the atmospheric reanalysis forcing impacts the OHC trends only marginally

Their impact increases for the last period, namely for the more rapidly warming and shorter period, atmospheric reanalyses lead to larger relative spread

CMCC Historical reanalyses (CHOR): ½ degree REA during XX century

Historical reanalyses (assimilating ICOADS SST, EN4 hydrographic profiles) as an ensemble of realizations with different atmospheric forcing (ERA-20, 20CRv2) and different SST assimilation strategies



Promising approach vs OAs or model-only integrations or assimilation of surface observation only

Historical reanalyses are an initial value problem

Yang et al., 2015, in preparation

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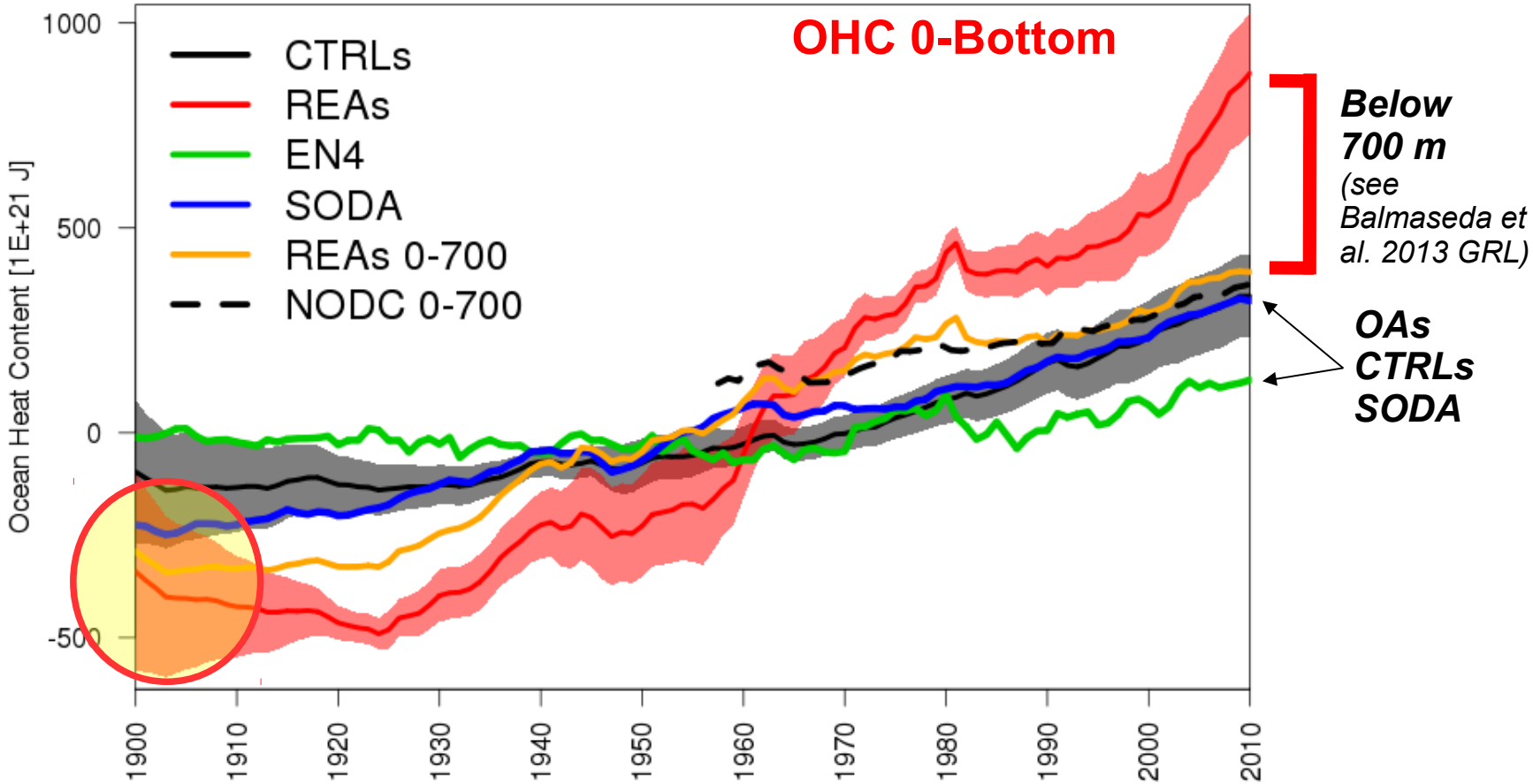

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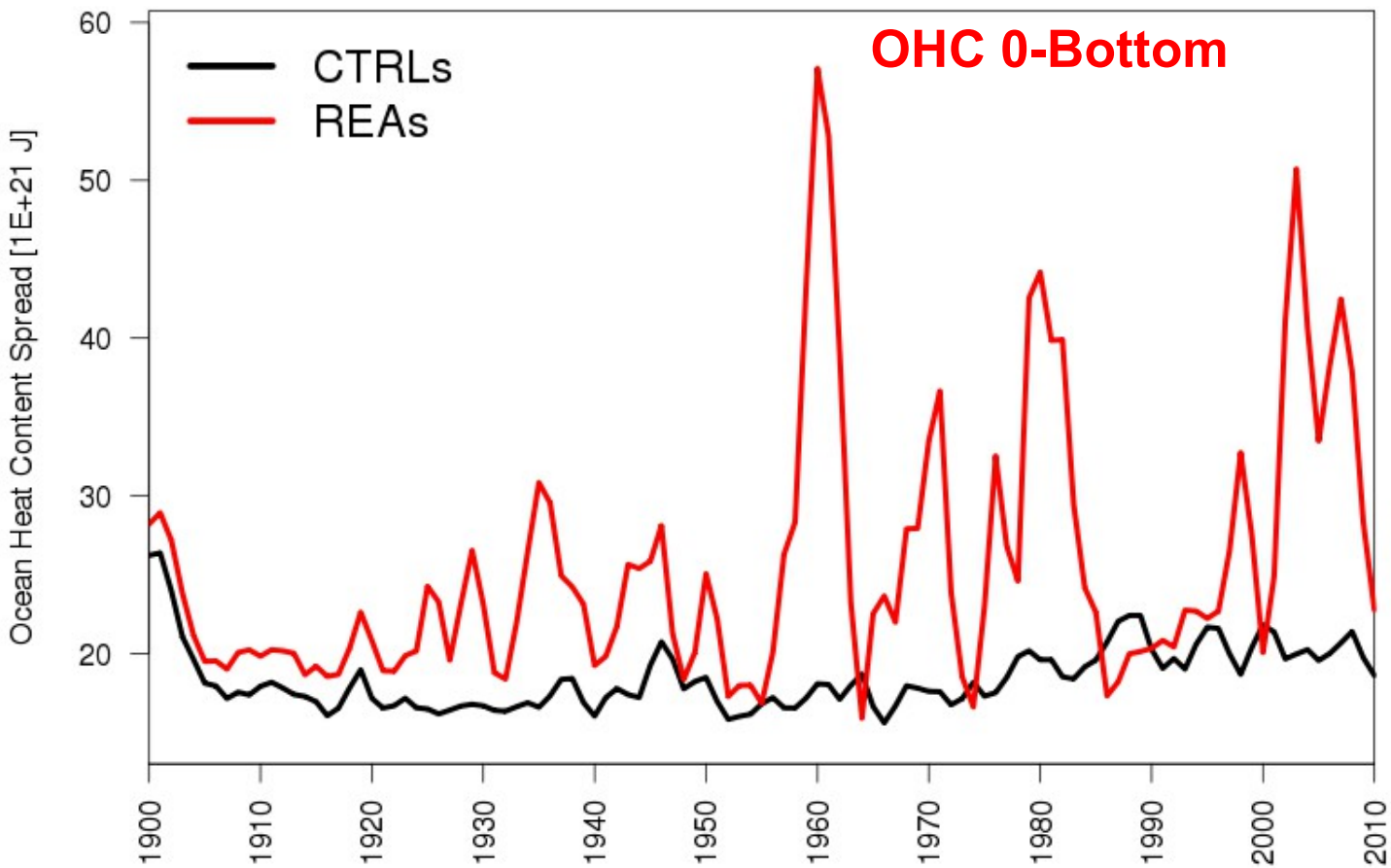
CMCC Historical reanalyses: observational homogeneity

Comparison of short temporal variability
[3-year running standard deviation]



Historical reanalyses: observational inhomogeneity vs natural variability

Conclusions

- Ocean reanalyses are becoming a robust tool to investigate ocean variability, at all time scales (decadal to centennial)
- During observation abundant period (2000s) at least, ocean reanalyses may outperform OAs
- During the last decades (satellite era), the deep ocean (below 700m) results much too unconstrained in reanalyses to provide robust and significant trends (in an ensemble sense)
- The uncertainty of atmospheric reanalyses in ocean reanalyses seems marginal during observation abundant periods
- Historical reanalyses are a promising way to investigate long-term OHC variability. However, ICs and temporal observation inhomogeneity need to be better addressed

Thank you

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Info about CMCC reanalyses at
www.cmcc.it/c-glors