CLIVAR GSOP/GODAE Ocean View Ocean Reanalysis Inter-comparison ORA-IP

Magdalena Alonso Balmaseda (ECMWF)
Takahiro Toyoda (MRI-JMA)
Maria Valdivieso (UoReading)
Andrea Storto (CMCC)
Gregory Smith (Environment Canada)
Matthew Palmer (UK MetOffice)
Fabrice Hernandez (Mercator Ocean)
Li Shi (BMRC)
Keith Haines (UoReading)
Tony Lee (JPL)
Yosuke Fujii (MRI-JMA)
Kirsten Wilmer-Becker (MetOffice)
Matthieu Chevallier (Meteo-France)
Alicia Karsperk (NCAR)
Nico Cantalbiano (CLIVAR)

… And all the reanalyses producers and data providers

This talk

- Introduction to ORA-IP
- OHC (and related variables) in ORA-IP
- Lessons learnt and concluding remarks

ORA-IP Objectives

- To Quantify Signal/Noise from Ensemble
- To gain insight into the ocean variability and trends
- To identify current deficiencies
- To measure progress
- To exploit existing multi-ORA ensemble
  - For climate indicators
  - For model validation
  - For real-time monitoring
  - For initialization of coupled models

Next: make ORAIP variables publicly available, with version control

CLIVAR GSOP/GODAE Ocean View
Ocean Reanalysis Inter-comparison (ORA-IP)

- 6 Observation only products
- 13 Low resolution models
- 8 High resolution models (1/3 or ¼ degree)
- 4 Coupled DA products
- 6 Long reanalyses, starting 1950's

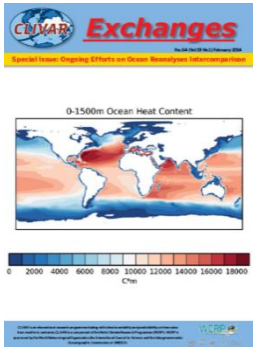
Summary Paper

Balmaseda, M.A. et al., The Ocean Reanalysis Intercomparison project (ORA-IP) J.Op.Oceanogr. Volume 8, supplement 1, 9 June 2015

Special Issue Climate Dynamics:

7 papers accepted so far, 2 under revision

+ other papers with sensitivities



http://www.clivar.org/sites/default/files/documents/Exchanges64.pdf

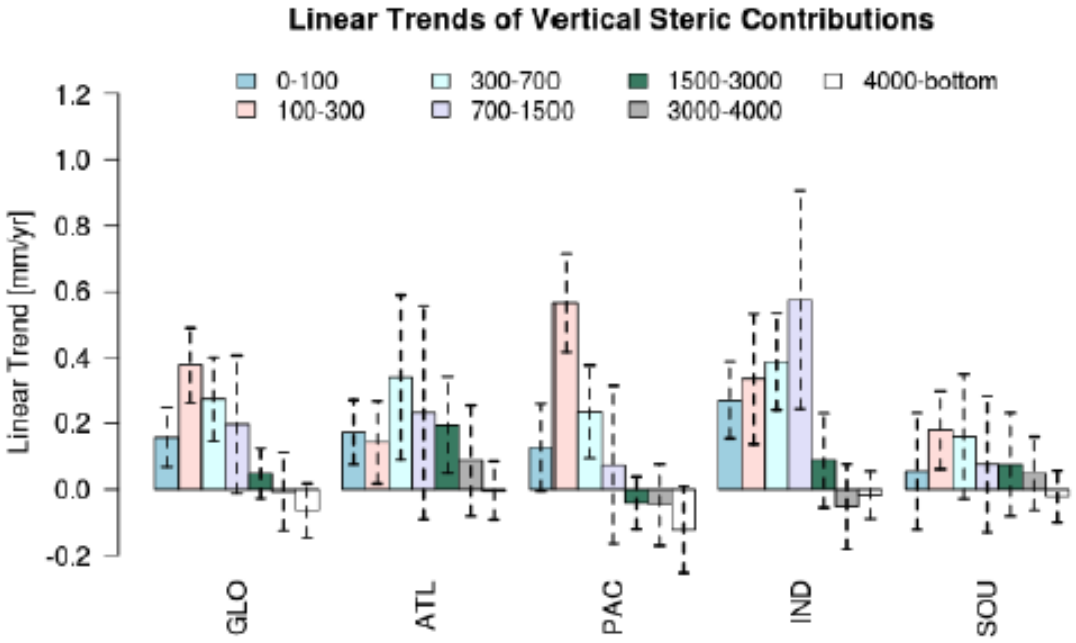
Variable	
Ocean Heat Content	MetOffice
Steric Height	CMCC
Sea Level	Mercator Ocean
Surface Heat Fluxes	University Reading
Mixed Layer Depth	MRI/JMA
Salinity	CAWCR
Depth of 20 degree Isotherm	Mercator Ocean
Sea Ice	Env Canada
AMOC	NCAR
MyOcean ¼ degree	CMCC

The Ocean Reanalyses Intercomparison Project (ORA-IP)

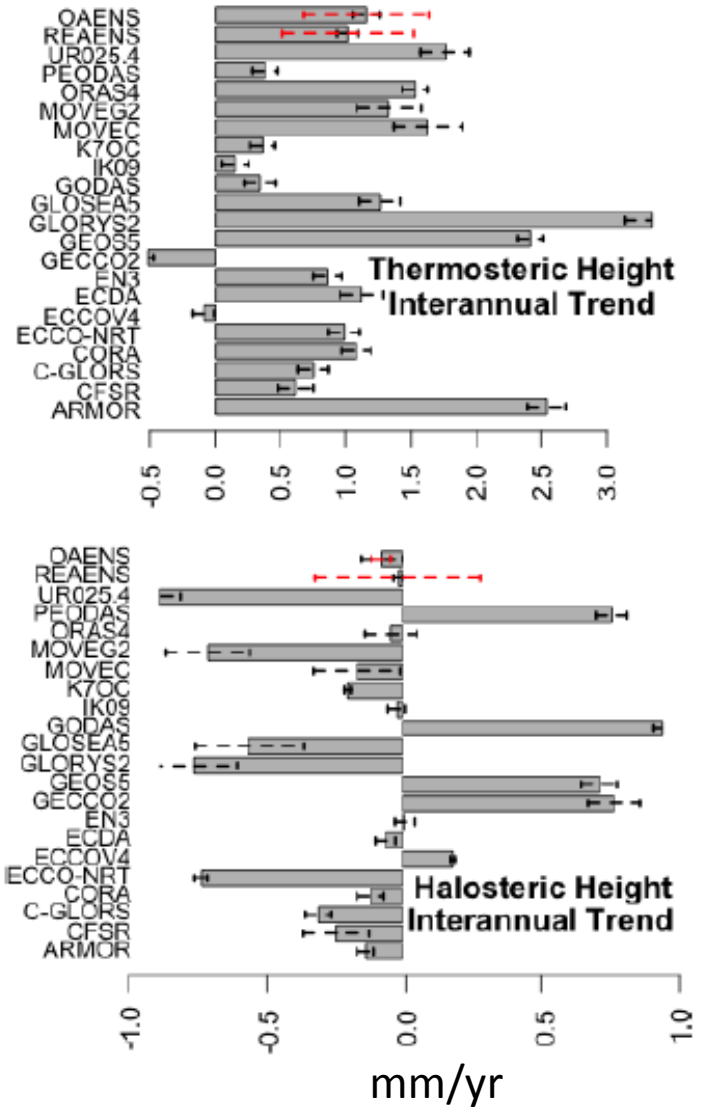
Product	Forcing	Configuration	Data Assim. Method
ARMOR3D[aa] CLS	N/A	1/3° Obs-Only (T/S/SSH/U/V)	OI (SLA/MDT/T/S/SST)
CFSR[c,d] NOAA NCEP	Coupled DA	1/2° MOM4 coupled	3DVAR (T/SST/SIC)
C-GLORS05V3[e] CMCC	ERAi corr+ Bulk	1/2° NEMO3.2	3DVAR (SLA/T/S/SST/SIC)
ECCO-NRT[f] JPL/NASA	NCEP-R1 + CORE Bulk	1° MITgcm	KF-FS (SLA/T)
ECCO-v4[gh] MIT/AER/JPL	ERAi+CORE Bulk	1° MITgcm	4DVAR (SLA/SSH/T/S/SST)
EN3 v2a[i] Hadley Center	N/A	1° Obs-Only (T/S)	OI (T/S)
GECCO2[j] U. of Hamburg	NCEP-R1+Bulk	1°x1/3° MITgcm	4DVAR (SLA/T/S/MDT/SST)
ECDA[kj] GFDL/NOAA	Coupled DA	1/3° MOM4 coupled	EnKF (T/S/SST)
GloSea5[mn] **UK MetOffice**	ERAi+CORE Bulk	1/4° NEMO3.2	3DVAR (SLA/T/S/SST/SIC)
MERRA Ocean GSFC/NASA/GMAO	Merra + Bulk	1/2° MOM4	EnOI (SLA/T/S/SST/SIC)
GODAS[o] NOAA NCEP	NCEP-R2 Flux.	1°x1/3° MOM3	3DVAR (SST/T)
GLORYS2V1 (G2V1) Mercator Océan	ERAi corr+CORE Bulk	1/4° NEMO3.1	KF+3DVAR (SLA/T/S/SST/SIC)
GLORYS2V3(G2V3) Mercator Océan	ERAi corr+ CORE Bulk	1/4° NEMO3.1	KF+3DVAR (SLA/T/S/SST/SIC)
K7-ODA(ESTOC)[p] JAMSTEC/RCGC	NCEP-R1 corr. Flux	1° MOM3	4DVAR (SLA/T/S/SST)
K7-CDA[q] JAMSTEC/CEIST	Coupled DA	1° MOM3 coupled	4DVAR (SLA/SST)
LEGOS[r] LEGOS	N/A	1/4° Obs-Only (SL)	OI+EOF (SLA/SSH)
NODC[s] NODC/NOAA	N/A	1° Obs-only (T/S)	OI (T/S)
PEODAS[t] CAWCR(BoM)	ERA40 to 2002; NCEP-R2 thereafter. Flux	1°x2° MOM2	EnKF (T/S/SST)
ORAS4[uv] ECMWF	ERA40 to 1988; ERAi thereafter. Flux.	1° NEMO3	3DVAR (SLA/T/S/SST)
MOVE-C[w] MRI/JMA	Coupled DA	1° MRI.COM2 coupled	3DVAR (SLA/T/S/SST)
MOVE-G2[x] MRI/JMA	JRA-55 corr+ Bulk	0.5°x1° MRI.COM3	3DVAR (SLA/T/S/SST)
MOVE-CORE[yz] MRI/JMA	CORE2 Bulk	0.5°x1° MRI.COM3	3DVAR (T/S)
SODA[aa] U. of Maryland and TAMU	ERA40 to 2002; ERAi thereafter. Bulk	1/4° POP2.1	OI (T/S/SST)
UR025.4[bb] U. of Reading	ERAi + CORE Bulk	1/4° NEMO3.2	OI (SLA/T/S/SST/SIC)
AVISO[cc] CLS	N/A	1/4° Obs-Only (SSH/SLA)	OI (SLA)
SLCCI[dd] ESA	N/A	1/4° Obs-Only (SSH)	OI (SSH)

ORA-IP: Steric Height

by Andrea Storto et al, Clim Dyn 2015, online)



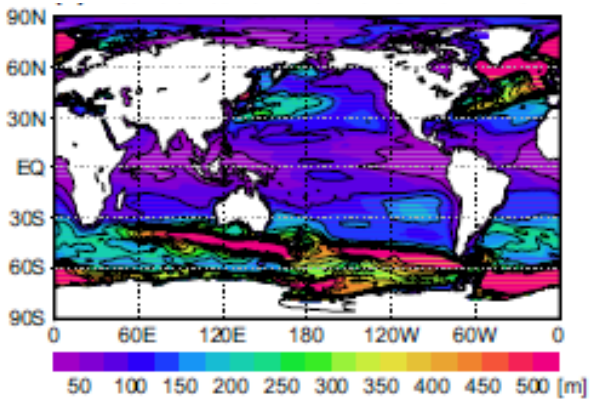
1993-2010: Trends



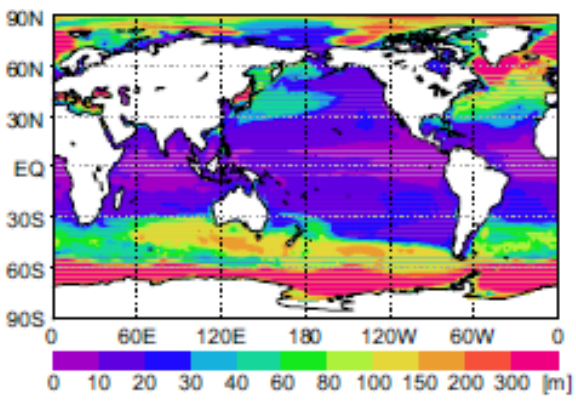
- **Large uncertainty in Steric trends below 700m**

- **Halosteric trends can be large in some products. Large dispersion among products.**

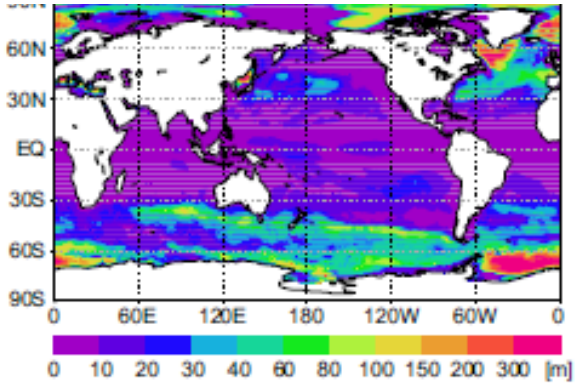
EnsMean Winter Max



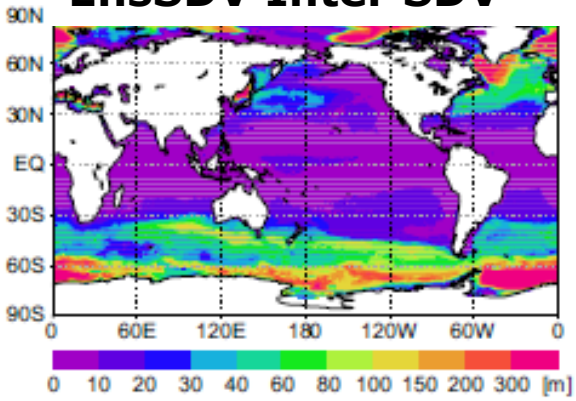
EnsSdv Winter Max



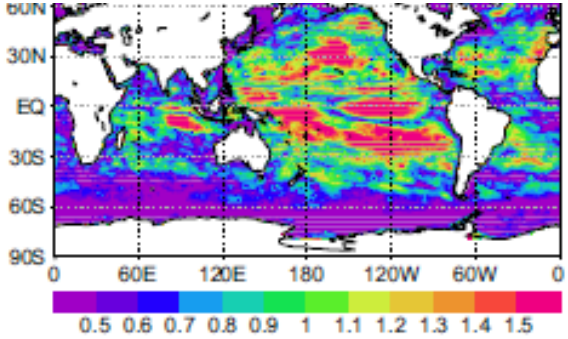
EnsMean Inter SDV



EnsSDV Inter SDV



Signal/Noise ratio



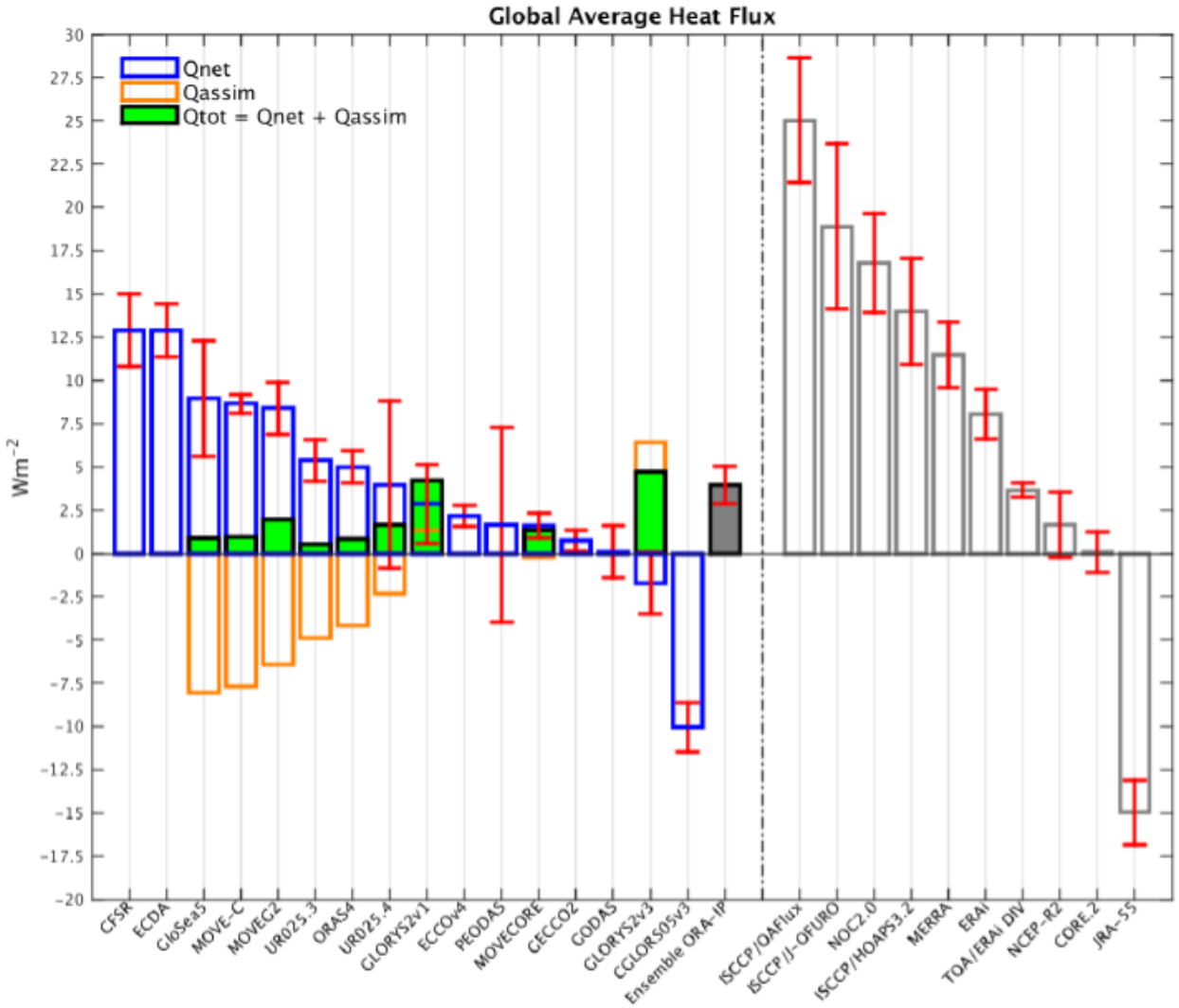
ORAIP MLD

Interannual-Decal Variability of Mixed Layer Depth Winter Maximum

By Toyoda et al 2015, Clim Dyn

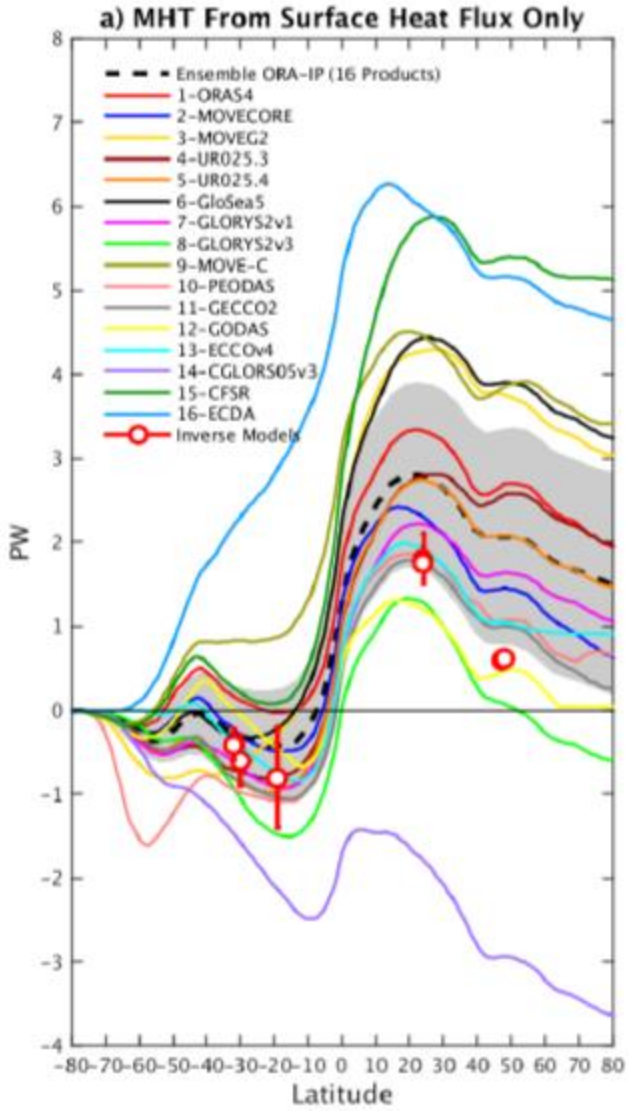
- Variations in Winter time MLD maximum important for ocean heat-uptake at different depth ranges.
- The paper also provides insight into the origin of decadal changes in MLD in the North Pacific.
- Two modes are indentified: One related to the PDO and other with the WP index

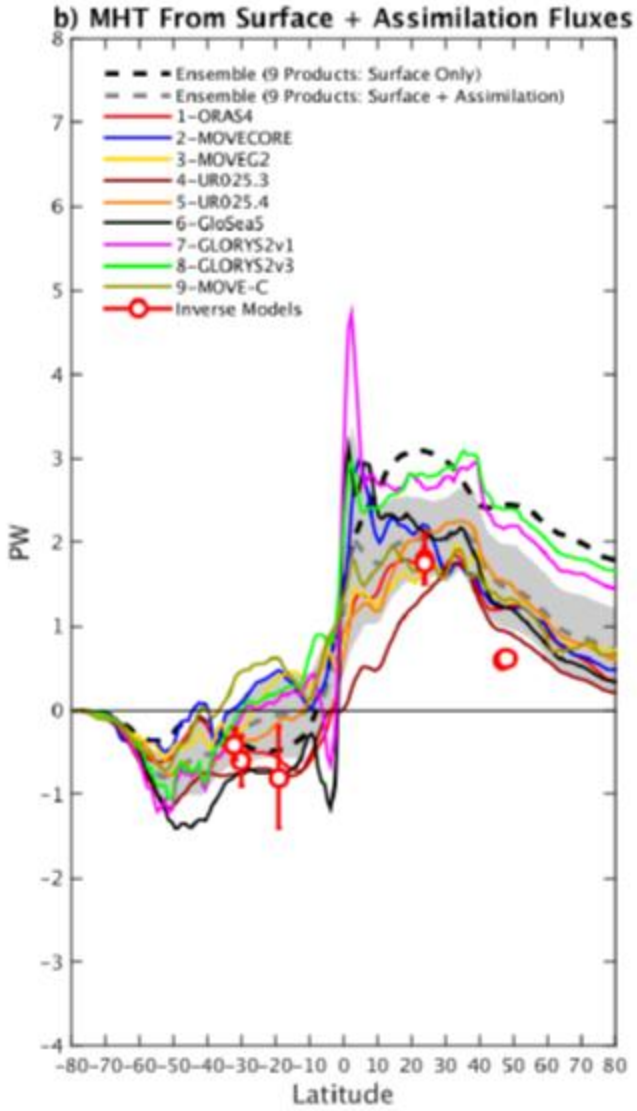
ORA-IP: Surface Heat Flux



Valdivieso et al, 2015, Clim Dyn

ORA-IP: Meridional Heat Transports

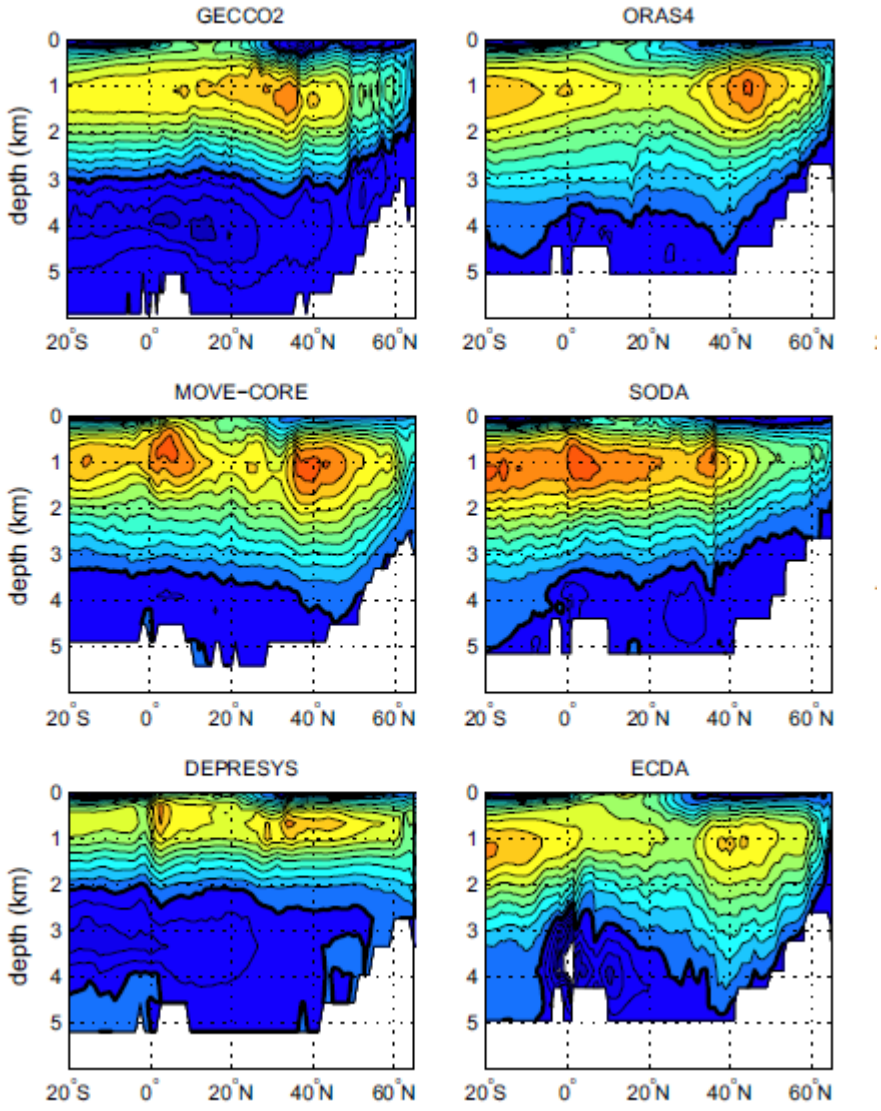




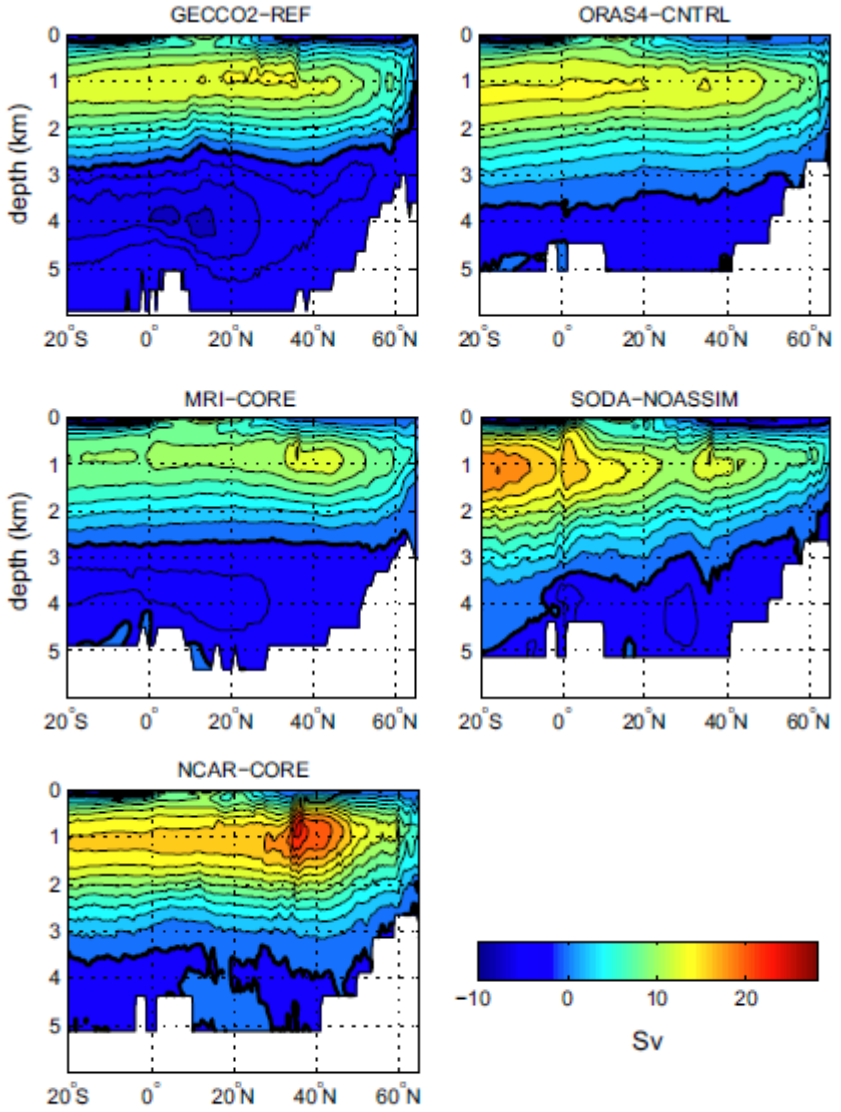
Valdivieso et al, 2015, Clim Dyn

ORA-IP: MEAN AMOC

Assim



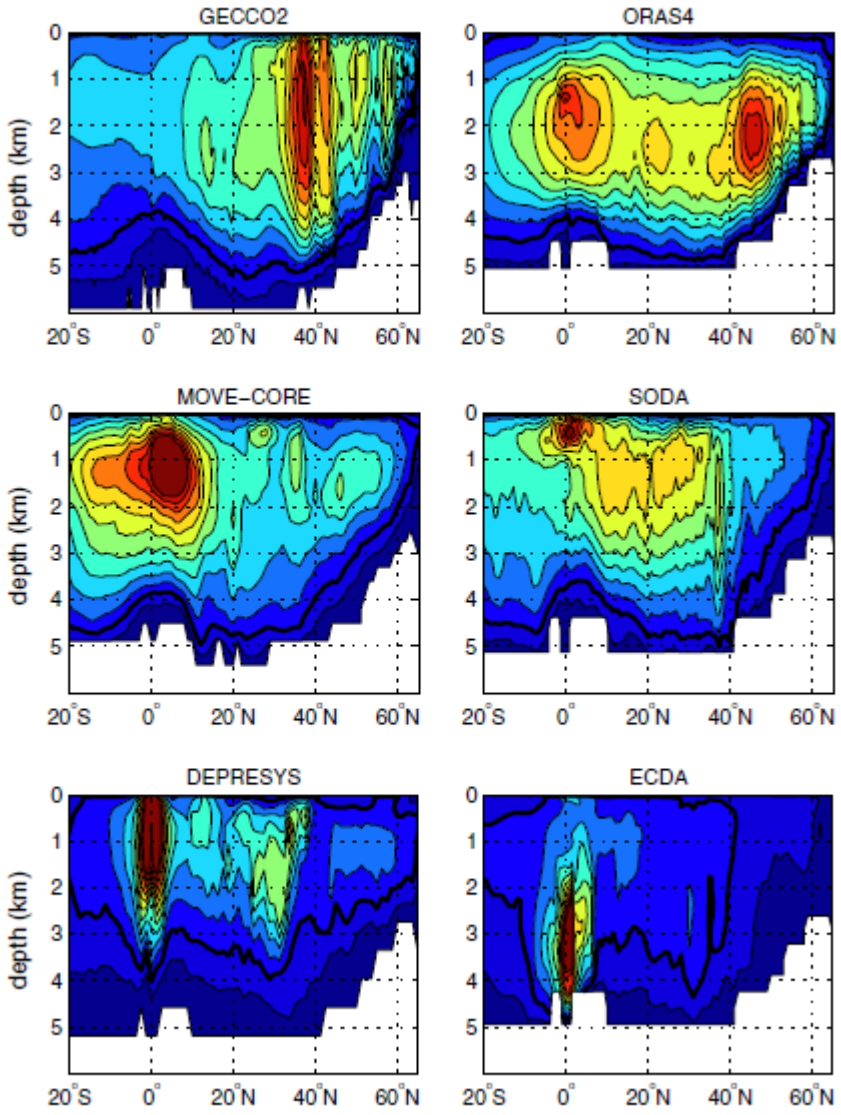
No Assim



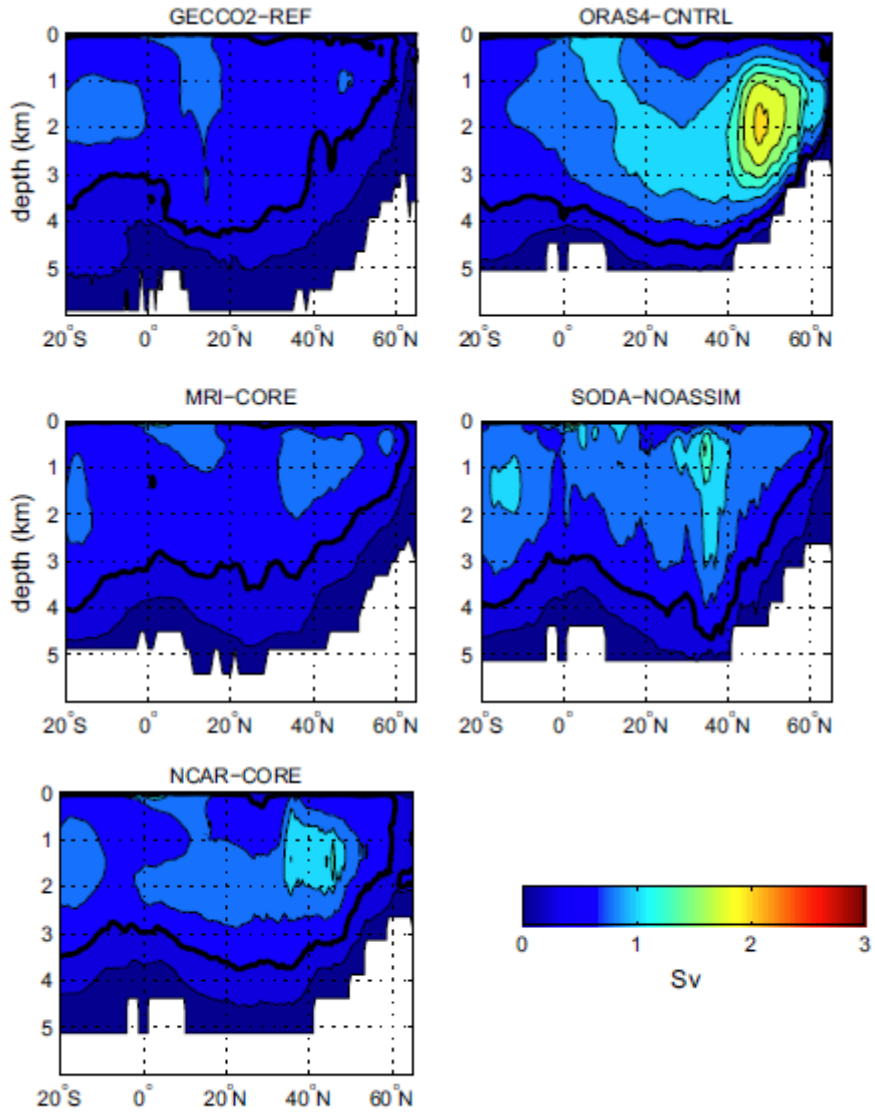
Karspeck et al, 2015, Clim Dyn

ORA-IP: Interannual AMOC

Assim



No Assim

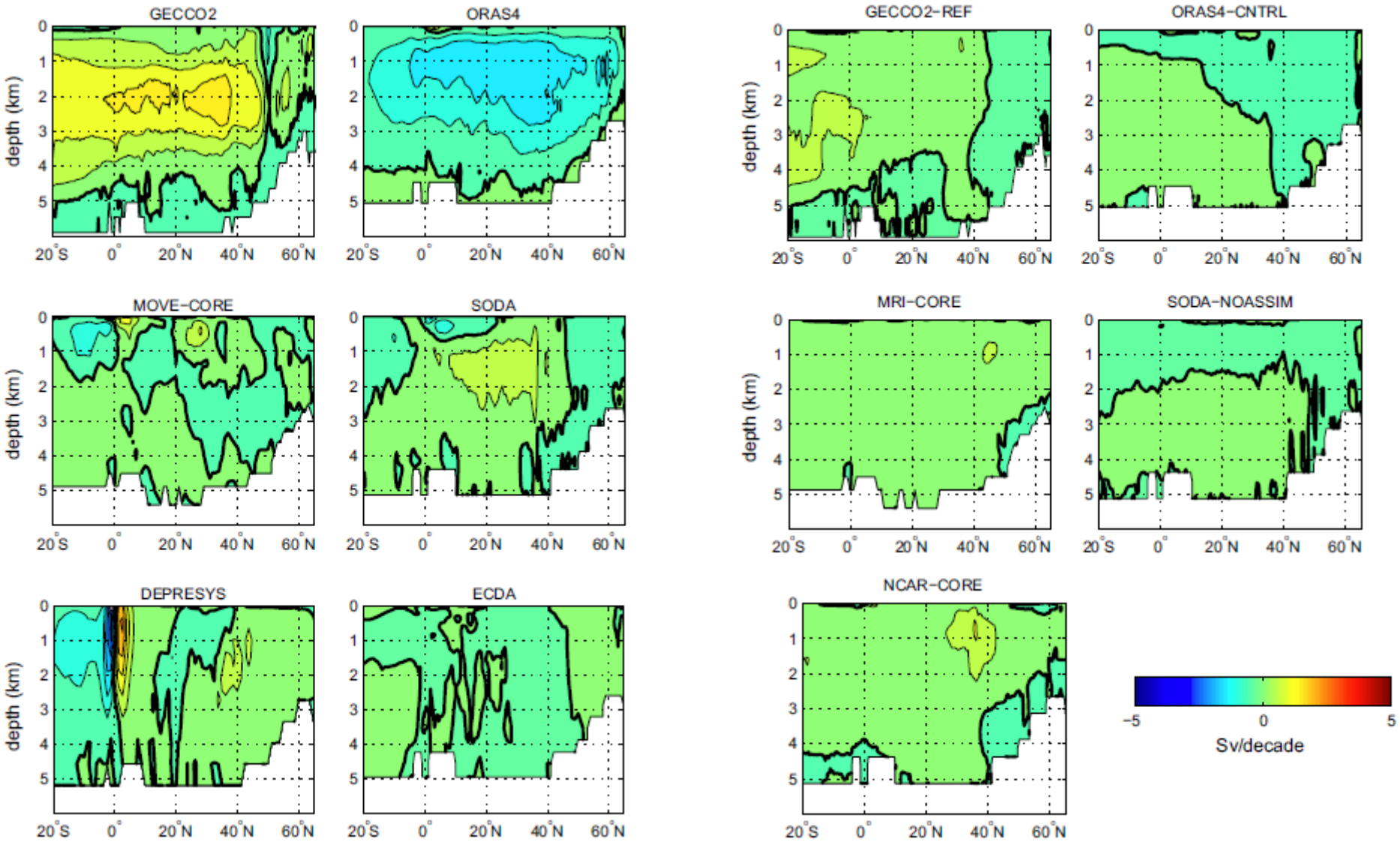


Karspeck et al, 2015, Clim Dyn

ORA-IP: Trends AMOC

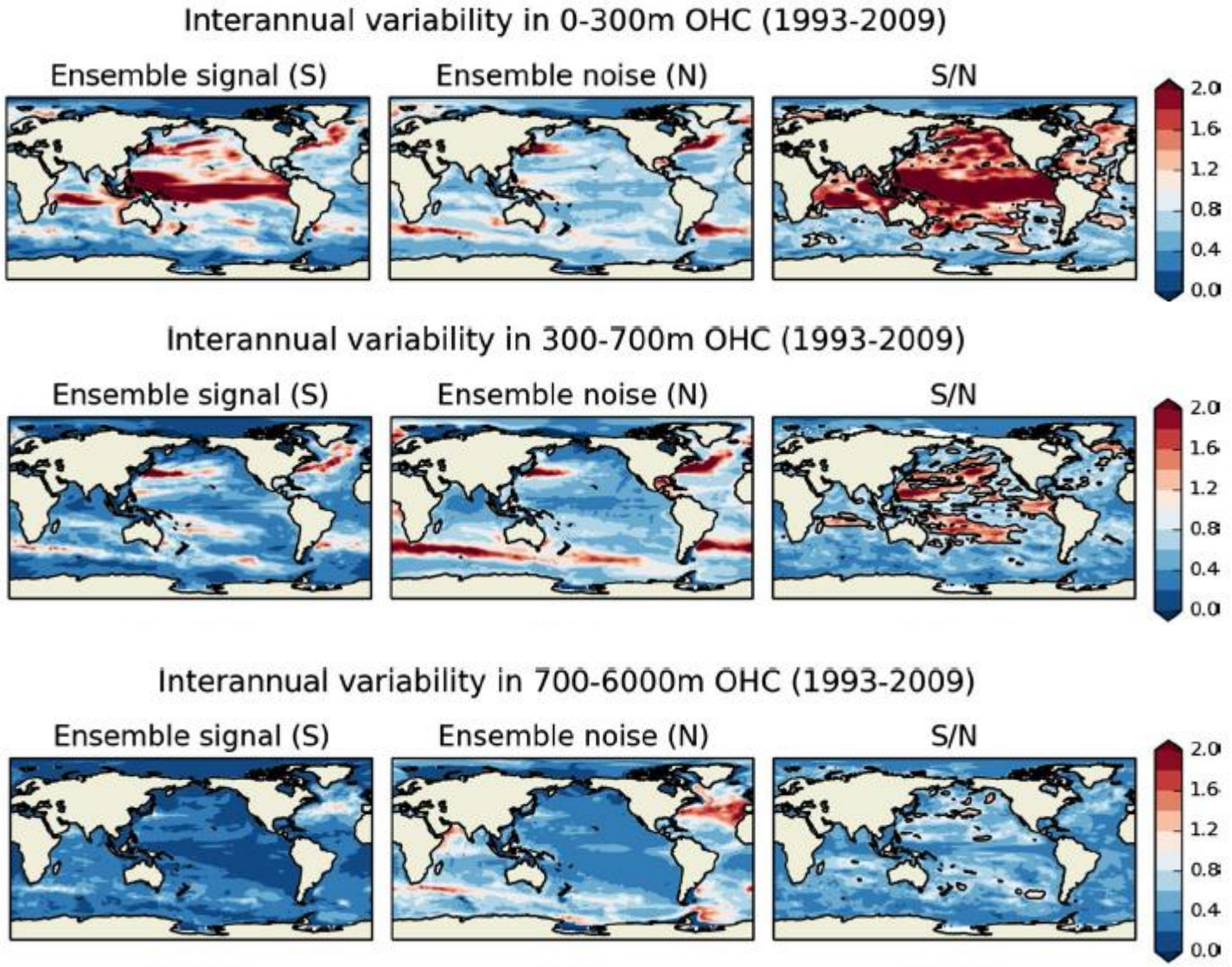
Assim

No Assim



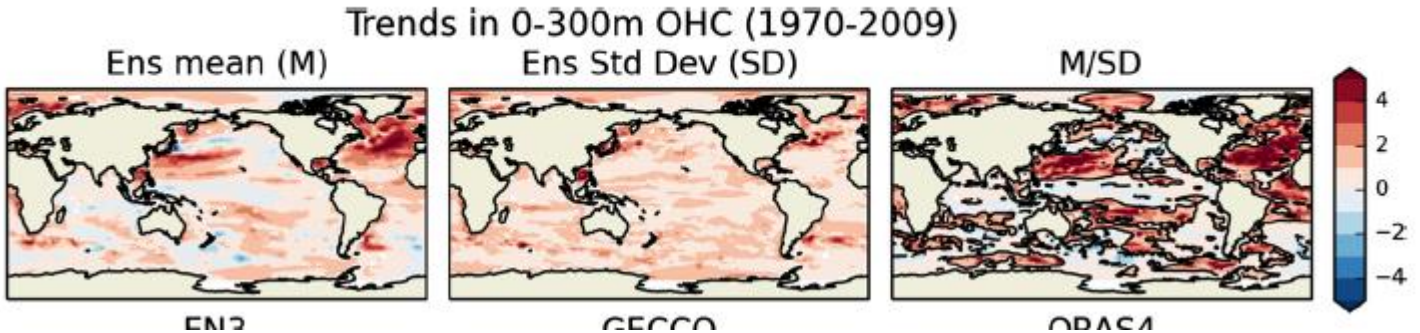
Karspeck et al, 2015, Clim Dyn

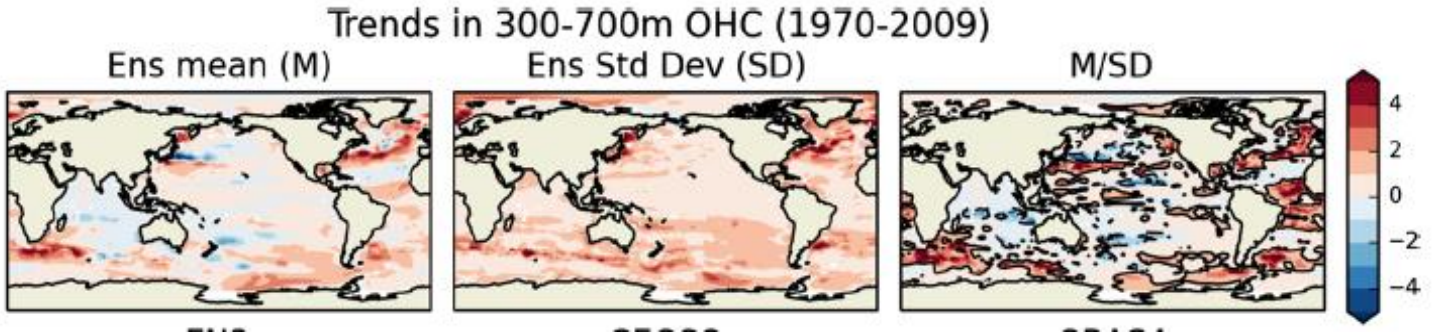
ORA-IP: OHC Interannual variability

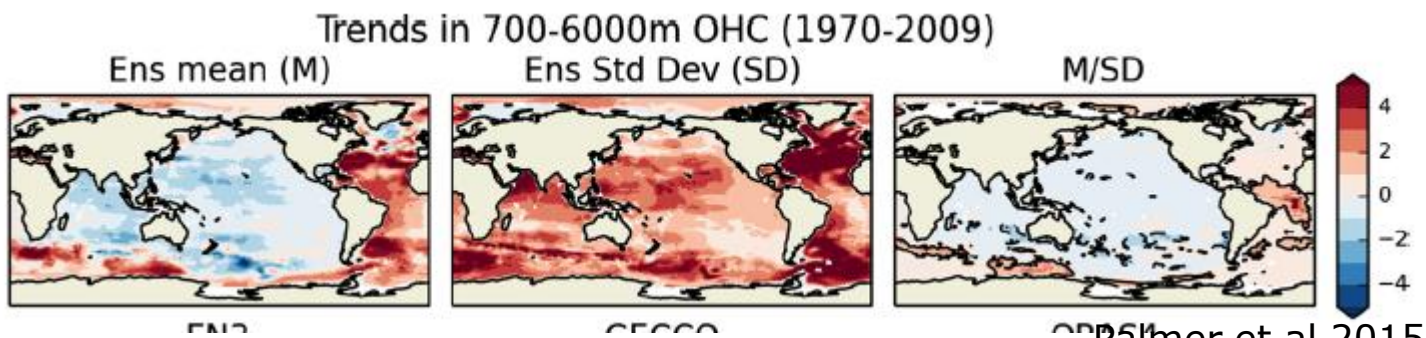


Palmer et al 2015, Clim Dyn

ORA-IP: OHC trends 1970-2009

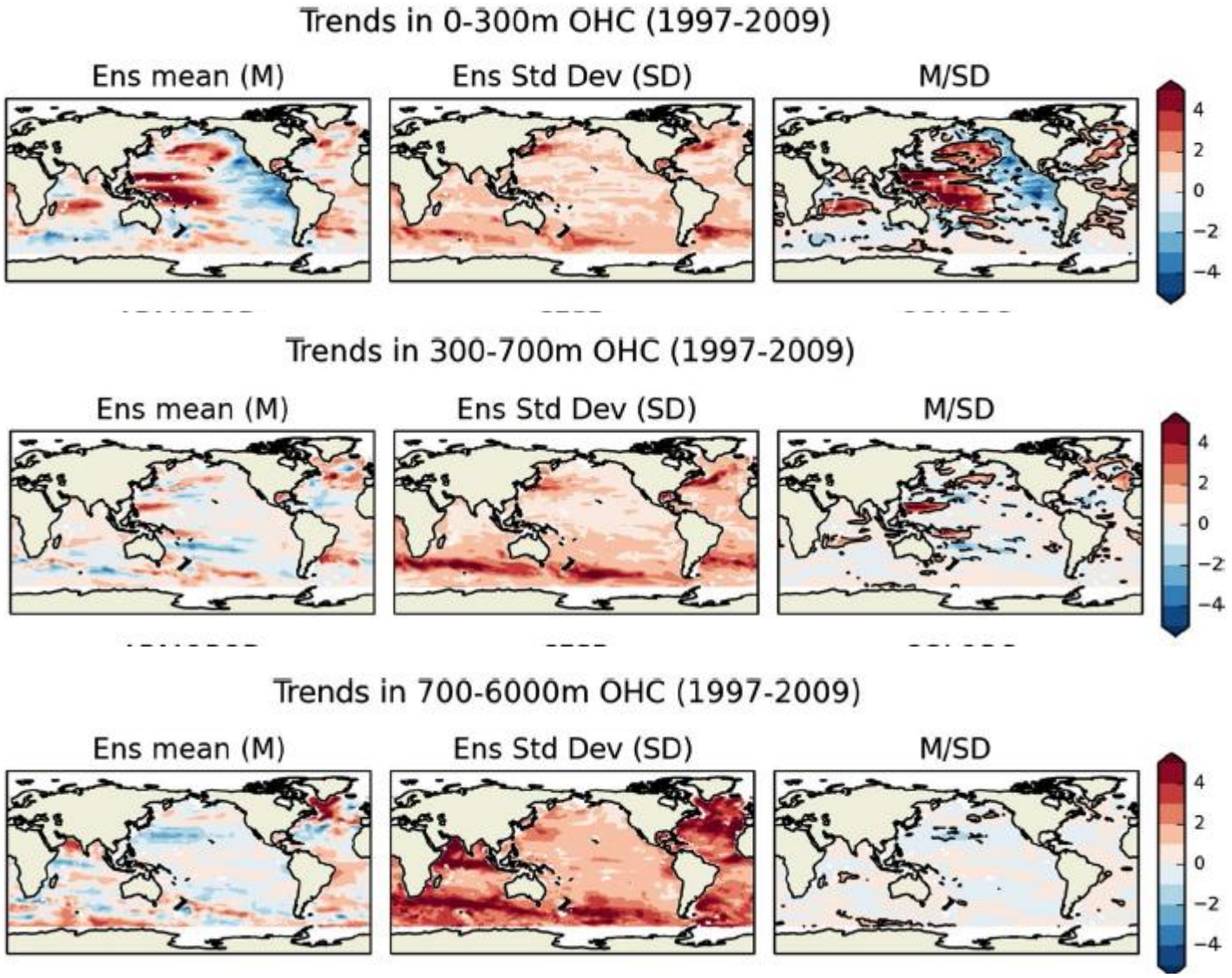






Palmer et al 2015, Clim Dyn

ORA-IP: OHC Tends 1997-2009



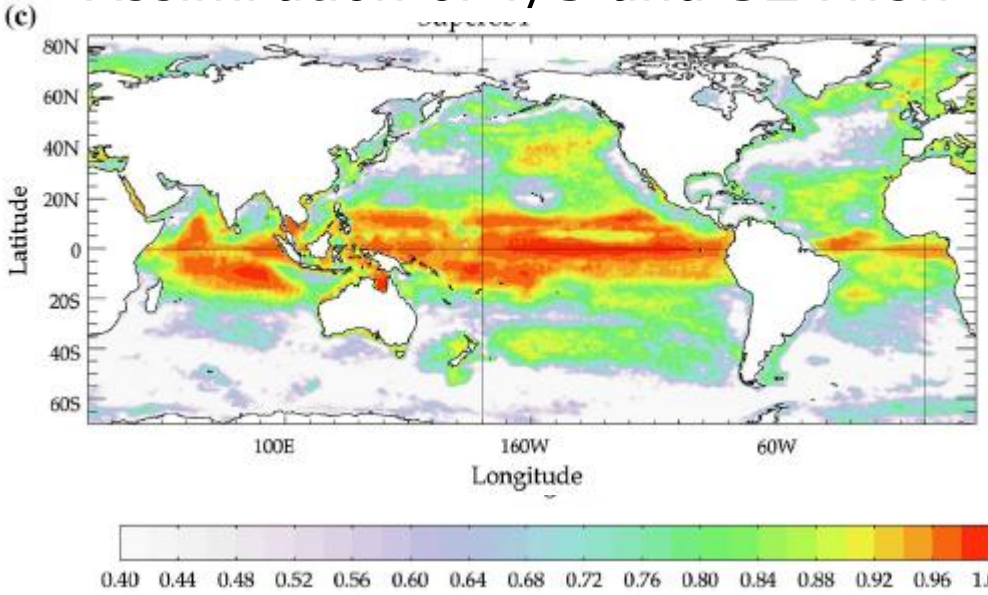
Palmer et al 2015, Clim Dyn

Learning from Sensitivity Studies

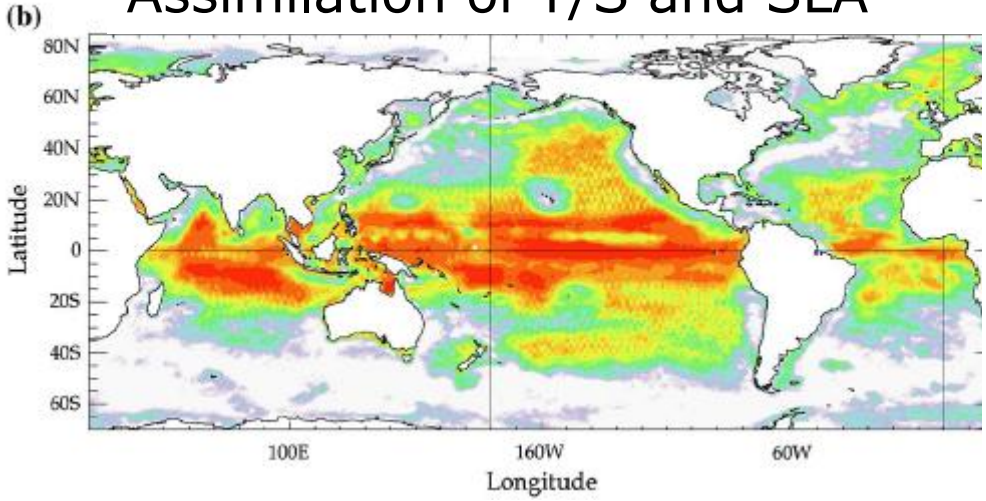
and failures

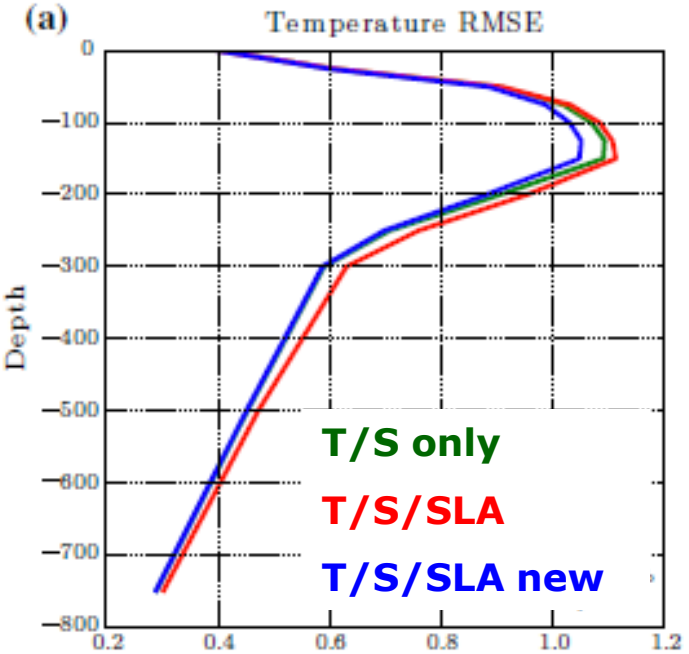
Correlation with Altimeter SL

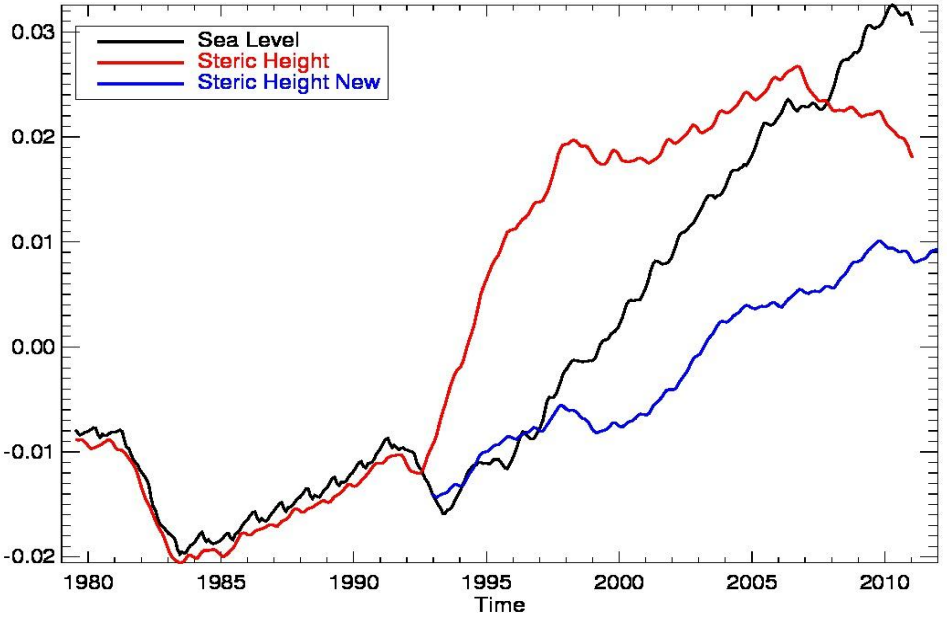
Assimilation of T/S and SLA new



Assimilation of T/S and SLA







Zuo et al 2015, Clim Dyn

Summary

- ORAIP Special Issue contains a lot of relevant information, opens questions and directions for further work
- ORAIP data repository is planned. Hopefully useful
- Ocean Reanalysis have strengths and weakness which need to be exploited and identified respectively.
  - Identifying the weakness is the first step towards improvement.
- Information on assimilation increments can be very informative.
- Progress in ocean reanalyses expected from more than one direction:
    - Physically sound DA methods and models
    - Good Observations with error estimates
    - Improvement in surface fluxes
    - Better ocean models (vertical mixing)
    - Discerning evaluation metrics (and more stringent criteria)
- Ongoing activities
  - Reanalyses using coupled models: not a panacea, but a first step
    - Consistent surface data sets, air-sea interaction, high-frequency processes
  - Higher resolution ocean-atmosphere models (important for heat-exchange over sharp fronts)