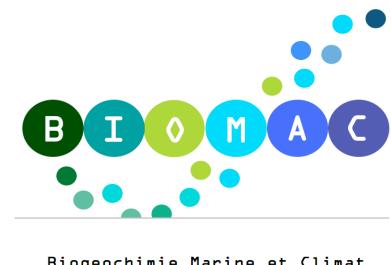


Ocean biogeochemical response to Climate Change: a multi-stressor approach in CMIP5

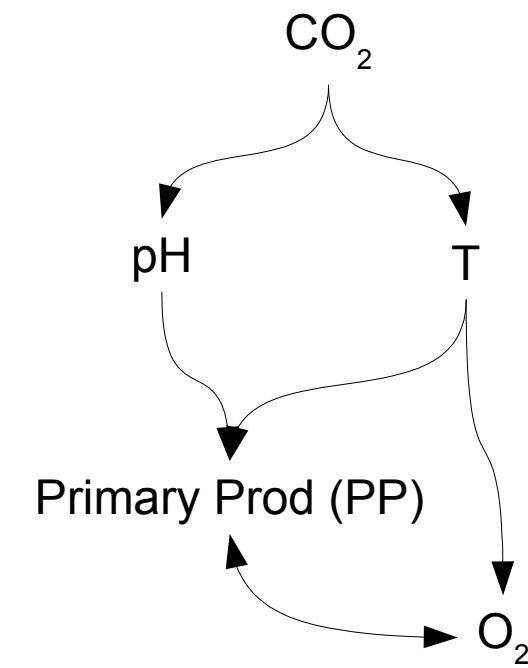
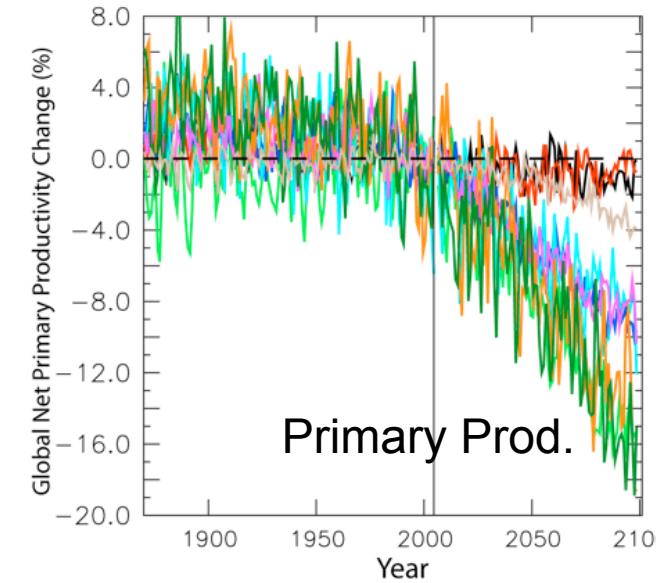
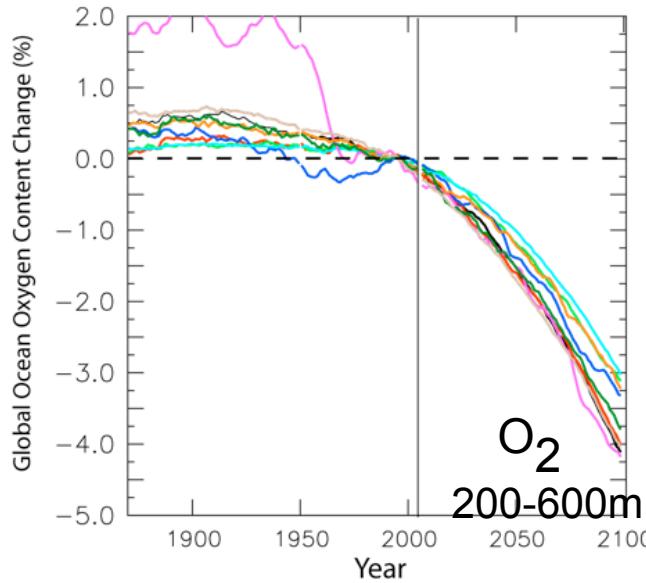
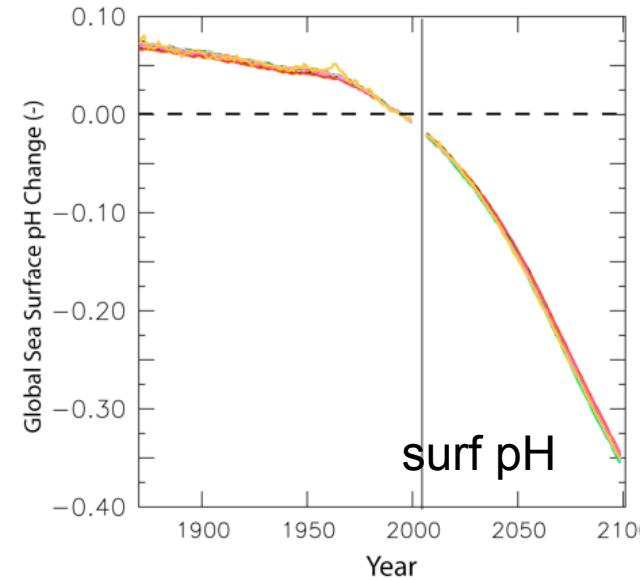
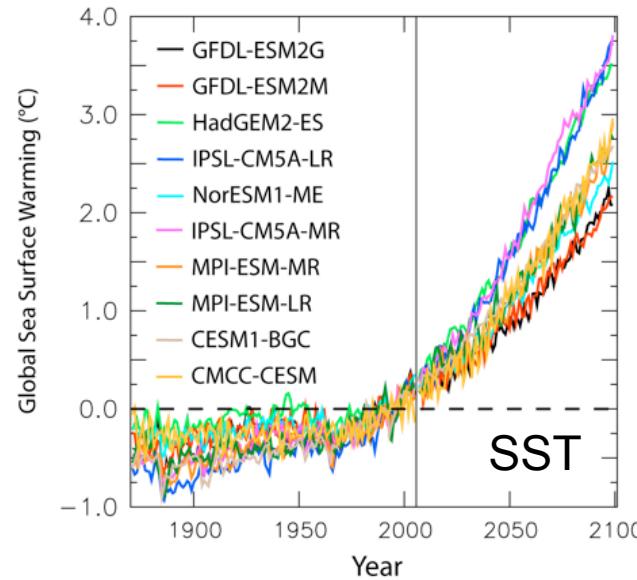
Laure Resplandy, Laurent Bopp, James Orr

Novembre 2012 - MISSTERRE



Oceanic biogeochemical response:

common drivers & interactions with Climate Change

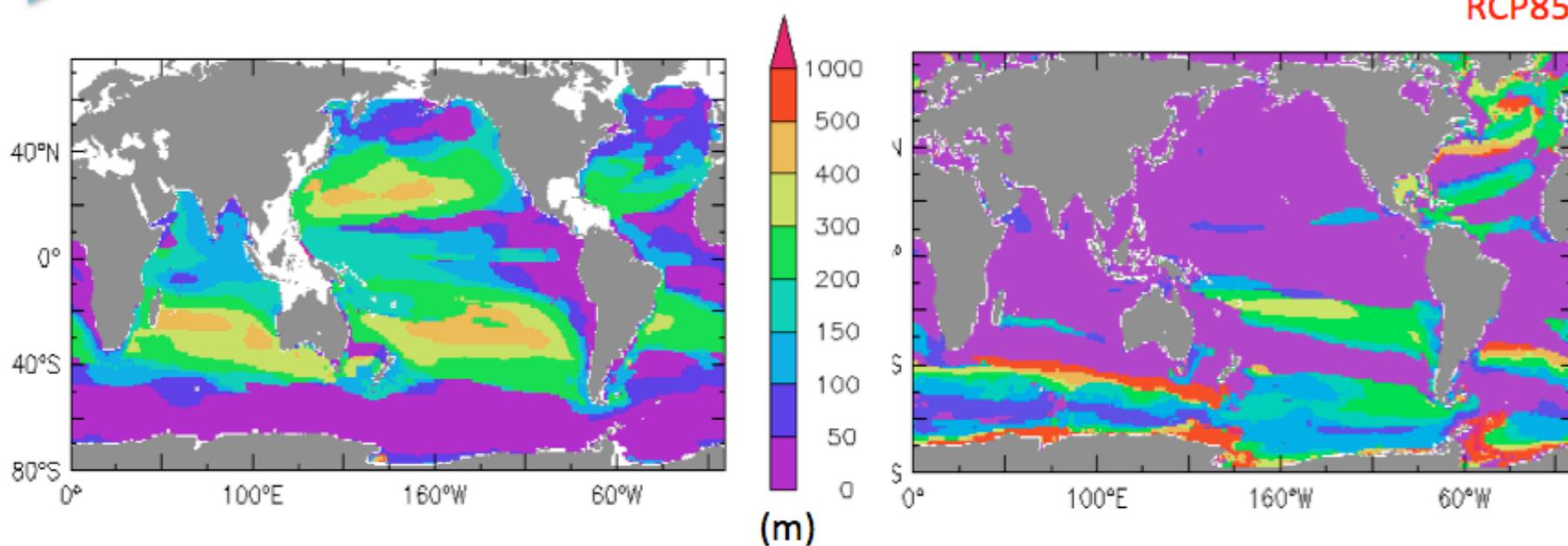


Response reflects physical circulation and water masses



Depth of at which ΔpH and $\Delta T_{\text{in-situ}}$ are maximum in 2100 (11 model-mean)

RCP85



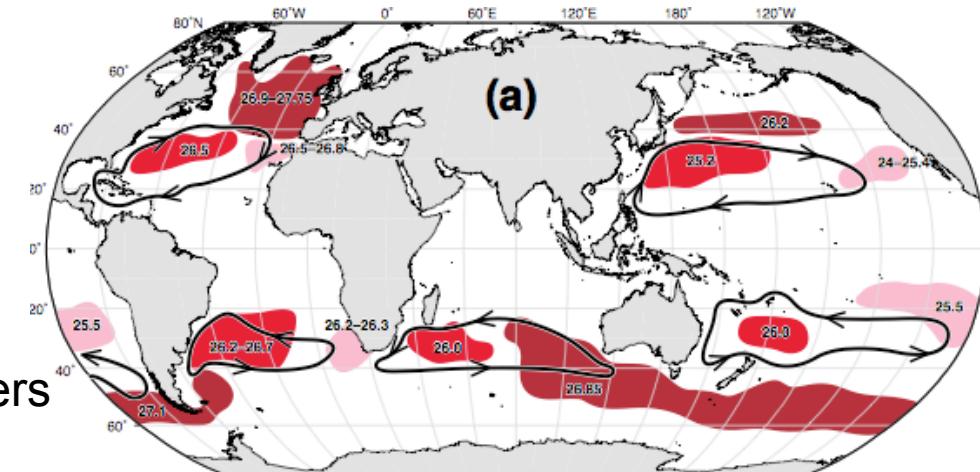
ΔT max at surface apart from high-lat/deep MLD

ΔpH max at sub-surface i.e. mode and intermediate waters
(observed at BATS station, Bates 2012)

Physical context to study the changes in ocean interior: water masses

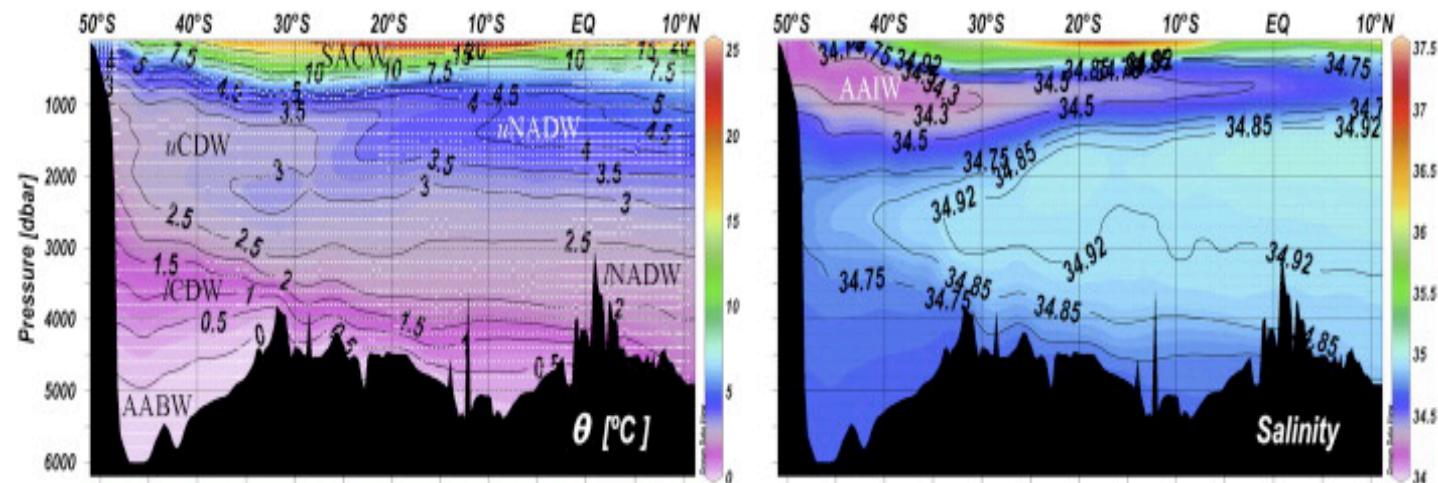
Water-mass framework

- global ocean
- multi-model approach
 - different physics
- multi-tracers (or stressor) approach



Mode waters

Atlantic section WOCE



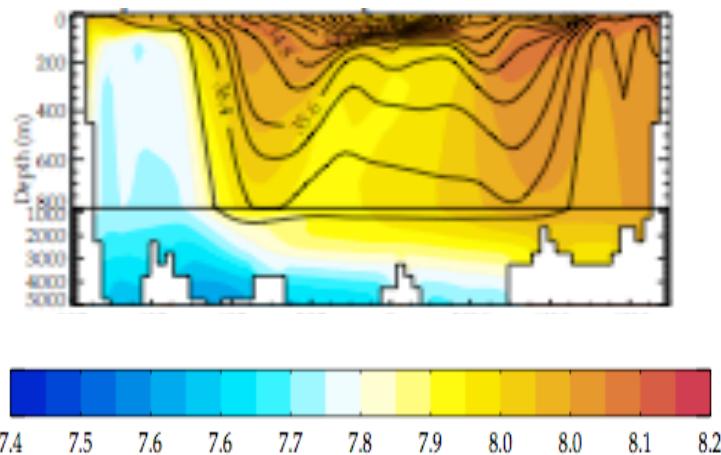
Sigma-2 criteria defined for each basin and merged into global framework:

- **Tropical Waters (TW)**: stratification
- **Mode waters & Intermediate (MW and IW)**: salinity minimum (North Atlantic: + meridional velocity)
- **Deep waters (DW) and Bottom waters (BW)**: meridional velocity

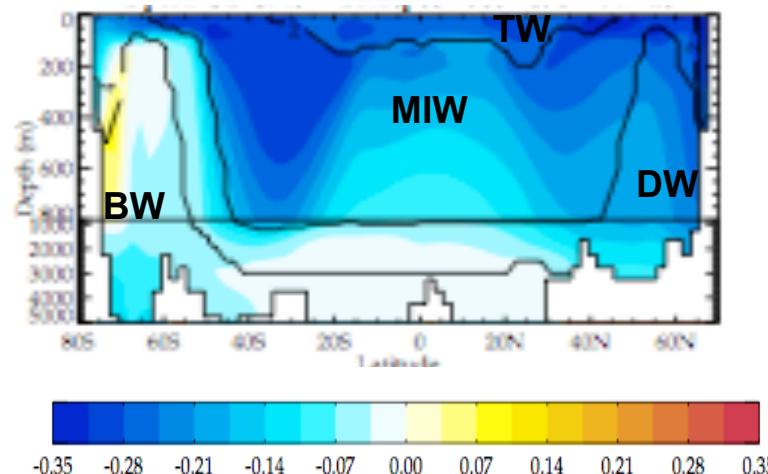
Water-mass framework

IPSL-CM5A-LR Atlantic Section

pH
2006



ΔpH
2100-2006



TW: Thermocline waters
MIW : Modal / intermediate
DW : Deep waters
BW : Bottom waters

CMIP5 Models with oxygen

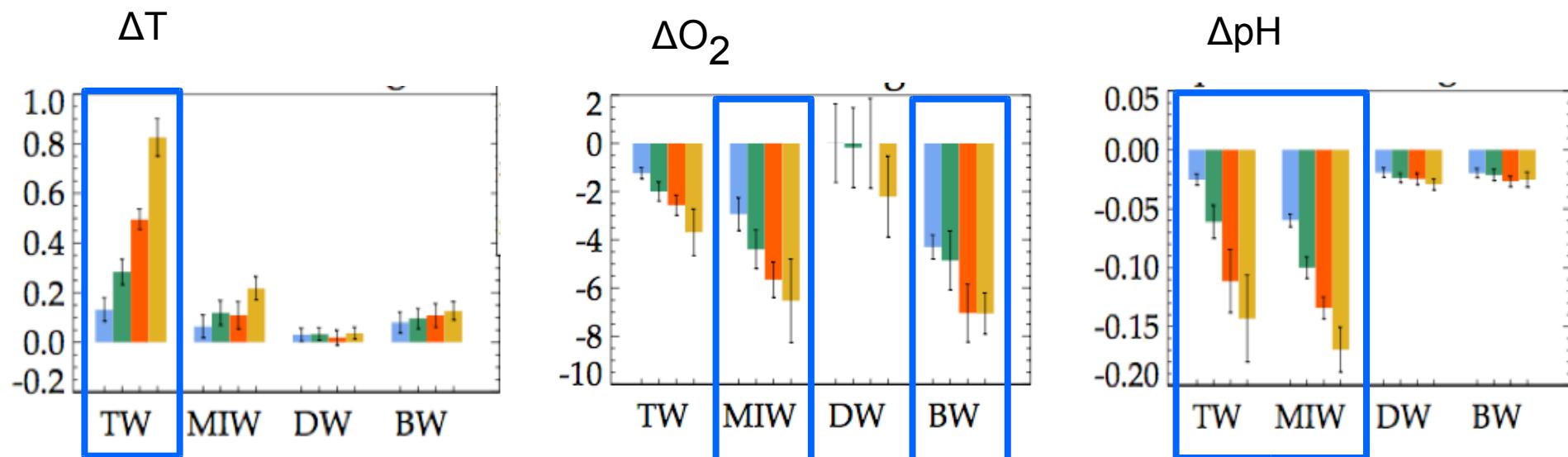
GFDL-ESM2G
GFDL-ESM2M
HadGEM2-ES
IPSL-CM5A-LR
IPSL-CM5A-MR
IPSL-CM5B-LR
MPI-ESM-LR
MPI-ESM-MR
NorESM1
CESM1-BGC
(BNU-ESM)
(CMCC-CESM)

Rcp8.5, esmFixClim2,
esmFdbk2, historical

First results: distinct processes in water masses

Change 2100-2006

10 models mean +/- std



TW: Thermocline waters
MIW :Modal / intermediate
DW :Deep waters
BW : Bottom waters

rcp26

rcp45

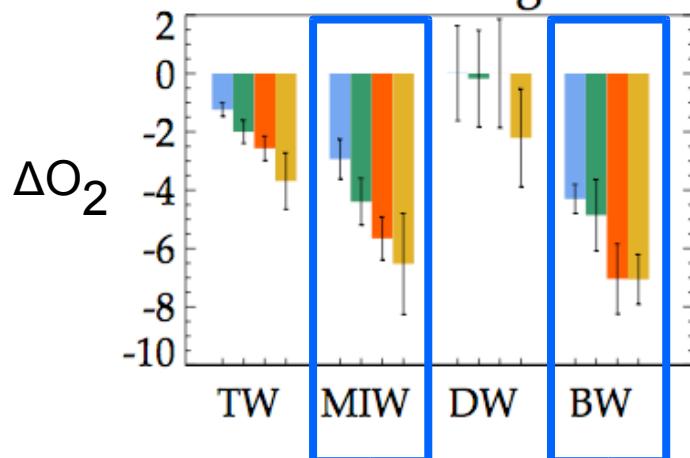
rcp60

rcp85

Ventilation

- decreased solubility
 - increased stratification
 - decreased outcrop surface
- => decreased ventilation of Mode-Intermediate and Bottom waters

Change 2100-2006



TW: Thermocline waters
MIW :Modal / intermediate
DW :Deep waters
BW : Bottom waters

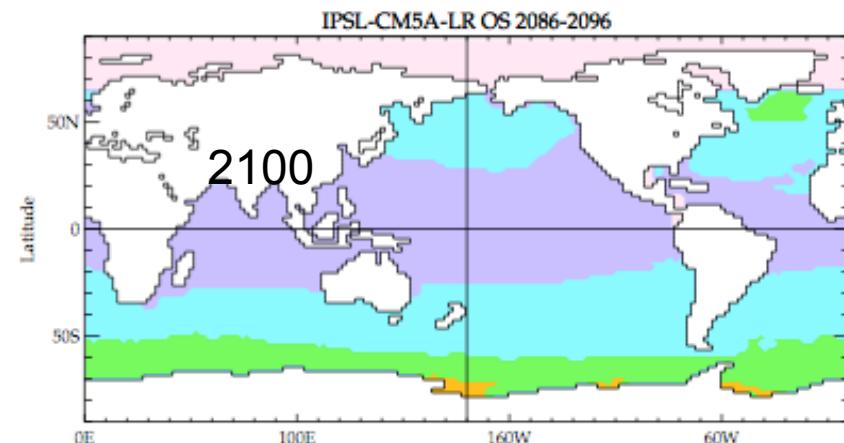
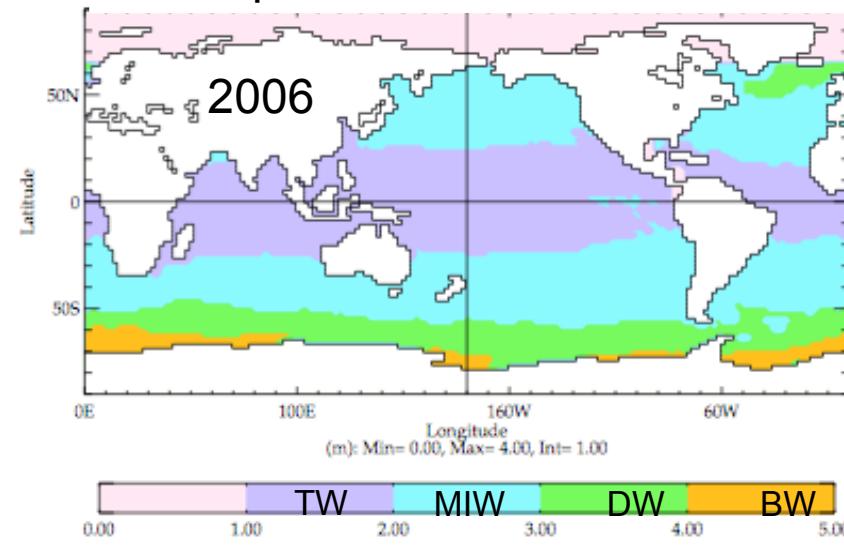
rcp26

rcp45

rcp60

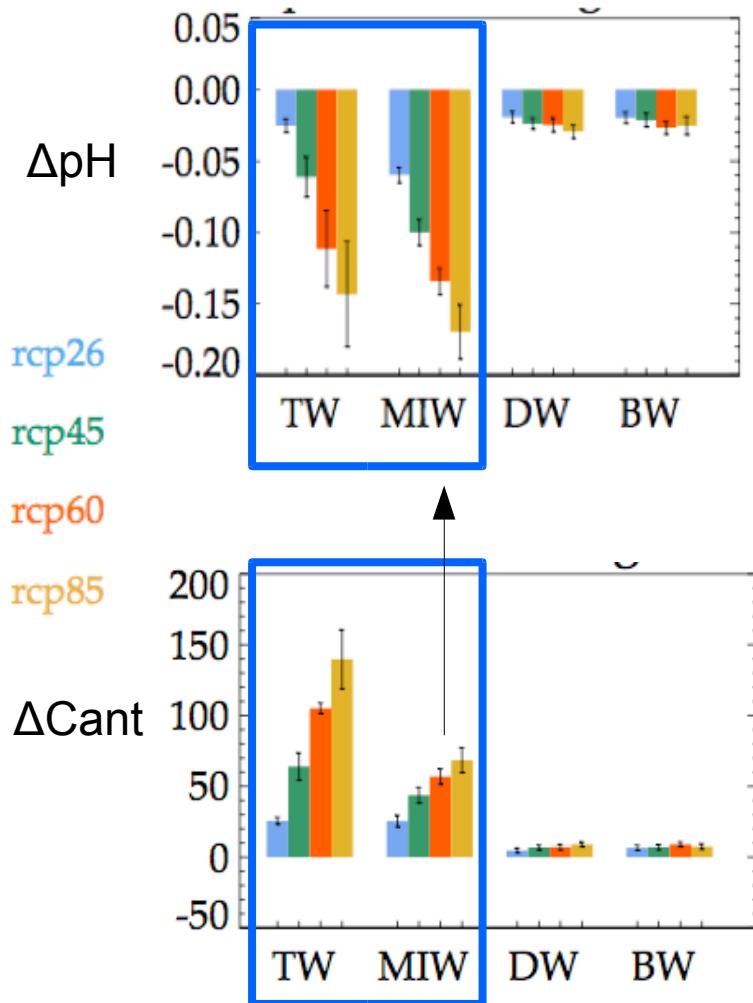
rcp85

Outcrop Surface of Water masses



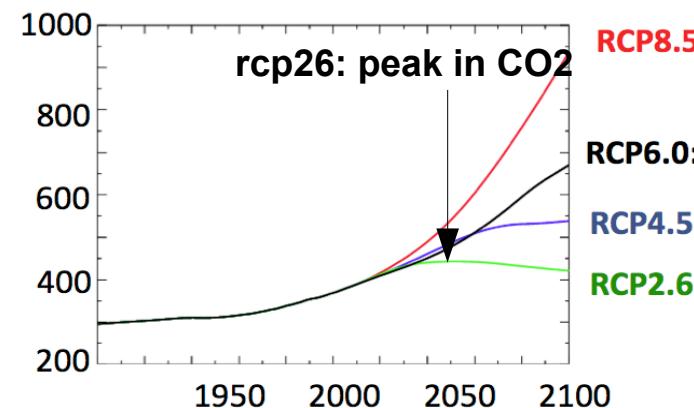
Ocean acidification: major role of mode and intermediate waters

Lower ΔC_{ant} but large ΔpH
... difference in carbonate chemistry

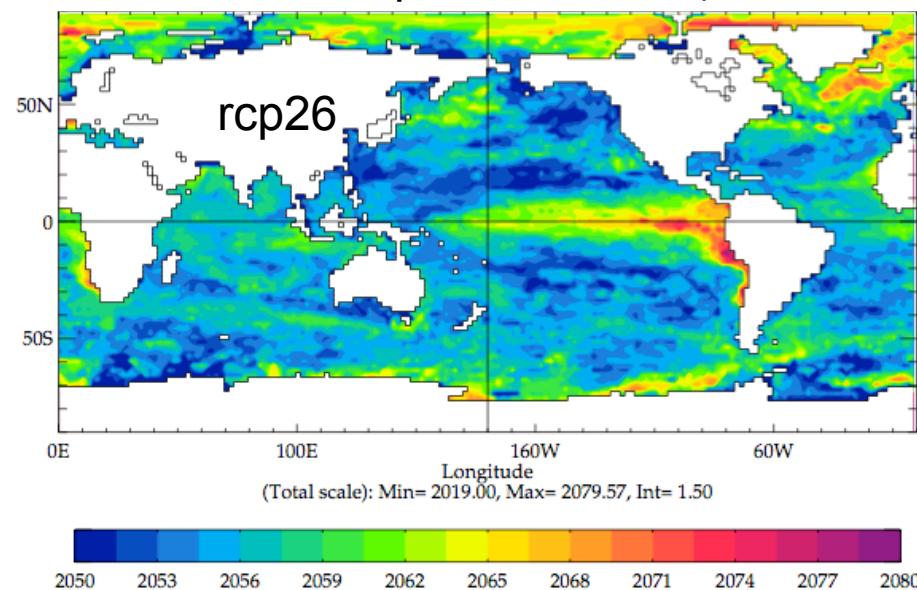


TW: Thermocline waters
MIW :Modal / intermediate
DW :Deep waters
BW : Bottom waters

Main pathway for acidification
into ocean interior



Year of minimum pH at surface (models mean)



Conclusions and perspectives

- Global water mass framework
- Early results show contrasted changes in pH/T/O₂/PP
- Different dynamical and biogeochemical processes
(equilibration time, mixing, buffer factor...)
- Scenarios offer the opportunity to identify dynamical/biogeochemical processes
(rcp26, esmFixClim2, esmFdbk2)