mercator-ocean.eu

marine.copernicus.eu

WP1 – Task 1.1: Global 20th century analysis

Production of the ocean carbon component

[MERCATOR] *Coralie Perruche*, Aurélie Albert, Yann Drillet

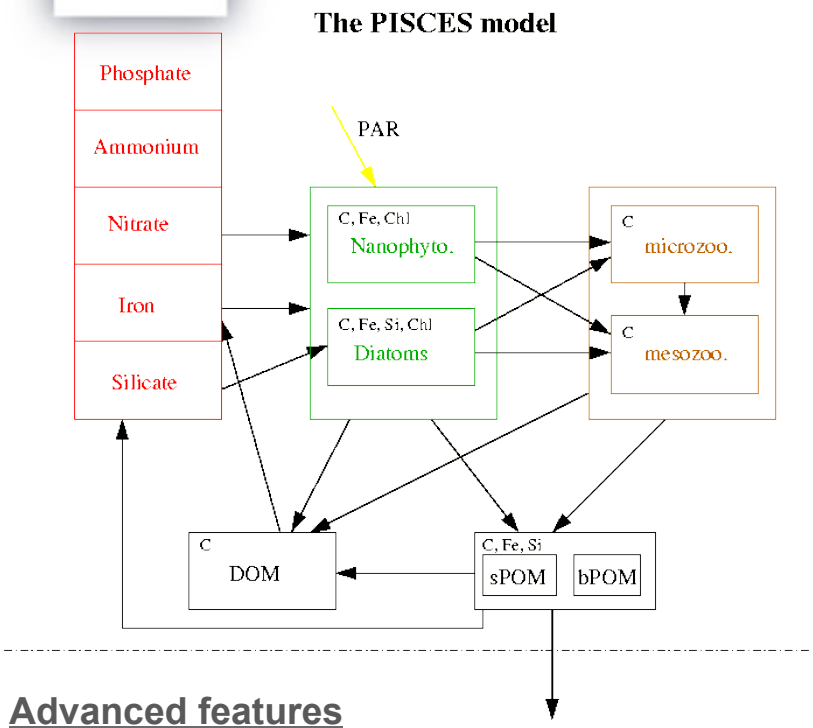
[UVSQ/LSCE] Marion Gehlen

Objectives and Strategy

Objectives:

- set up of the coupling of Ocean Biogeochemistry with CERA-20C
- production of a 20th century analysis of ocean biogeochemistry

Objectives and Strategy



Basic Features

- PISCES = model of the low trophic levels embedded in a model of ocean circulation
- 24 prognostic variables, 5 limiting nutrients, 2 phytoplankton and 2 zooplankton species, 3 detrital compartments
- Ocean dynamics (mostly vertical transport) put together/split nutrients and light (inversely distributed in the water column) which allow phytoplankton to do photosynthesis

Community model
Available on the NEMO platform:
http://www.nemo-ocean.eu/

Advanced features

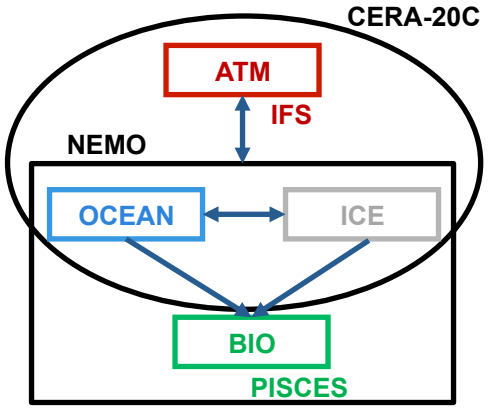
- Redfieldian model (constant C/N/P ratio)
- variable C / Chl, C/Fe, C/Si ratios
- Carbon and oxygen cycles
- No feedback of chlorophyll concentration on temperature profile
- Mixed Monod/Quota model (Monod, 1942): no diurnal cycle
- Closed mass balance for C, N, Si, P
- External inputs: rivers (Fe, Si, and P), dust (Fe, Si, P, N) and sedimentary iron

Objectives and Strategy

Objectives:

- set up of the coupling of Ocean Biogeochemistry with CERA-20C
- run 20th century analyses of ocean biogeochemistry

3 strategies for the coupling were considered:
(contribution to WP2 – Task 2.4)



- online coupling : we provide code, namelists & biogeochemical inputs and ECMWF integrates PISCES in CERA-20C
- offline coupling : CERA-20C ocean & atmospheric outputs as forcings
- "offline" NEMO-PISCES : CERA-20C atmospheric outputs as forcings
  - Called hereafter CERA-20C/ Ocean Carbon simulation

Configuration

The “offline” NEMO-PISCES configuration:

- Atmospheric Forcing: CERA-20C (only the reference stream used)
- Time period: 1900 - 2009
- Latest NEMO 3.6_STABLE, PISCES v2 (Aumont et al., 2015), LIM3 for ice
- New set-up from IPSL configuration (OR1L3PIS-V1)
- 1° resolution, ORCA grid, 75 vertical levels, vvl option (water column volume variable)
- Updated external input fluxes: river input, sediment Fe supply, atmospheric deposition of Fe, Si, N and P, Fe input from sea ice

- Initial state from an IPSL 100-year climatological run (same NEMO code)
- Spin-up 1870-1899 with a daily mean climatology of CERA-20C, and then interannual CERA-20C (1870 = beginning of industrial era)
- Anthropogenic carbon emissions since 1870

Outputs & Download

- Monthly means over 1900 – 2009 of
  - Alkalinity
  - Air-to-sea CO2 flux
  - Surface pCO2
  - Chlorophyll
  - Dissolved Inorganic Carbon
  - Iron
  - Nitrate
  - Phosphate
  - Silicate
  - Net primary production
  - Photosynthetically Available Radiation (PAR)

And more variables in annual means

- User documentation
- Available on the Mercator FTP (1.3 To data set):

ftp://ftp.mercator-ocean.fr/download/eraclim2/

Assessment of CERA-20C/Ocean Carbon

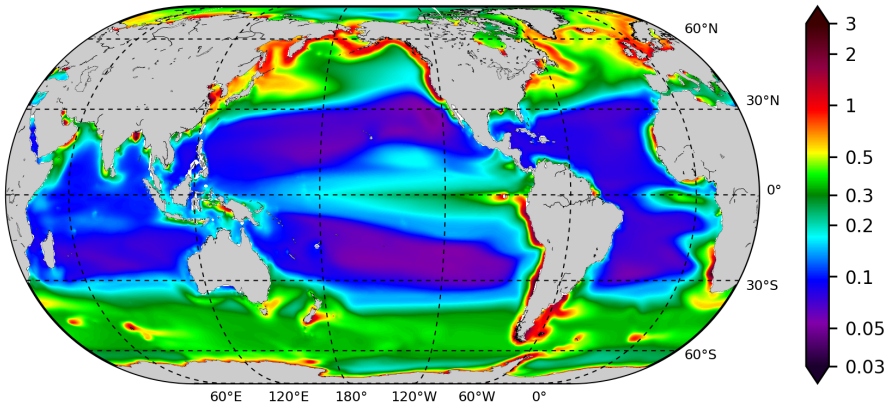
Surface annual mean

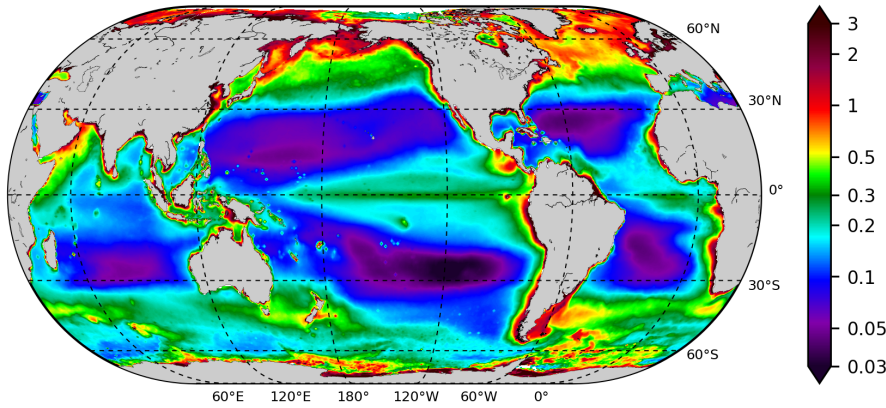
Satisfying CHL and CO_2 fluxes

MODEL clim 1998 - 2009

Globcolour DATA clim 1998 - 2009

CHL (mg/m^3)

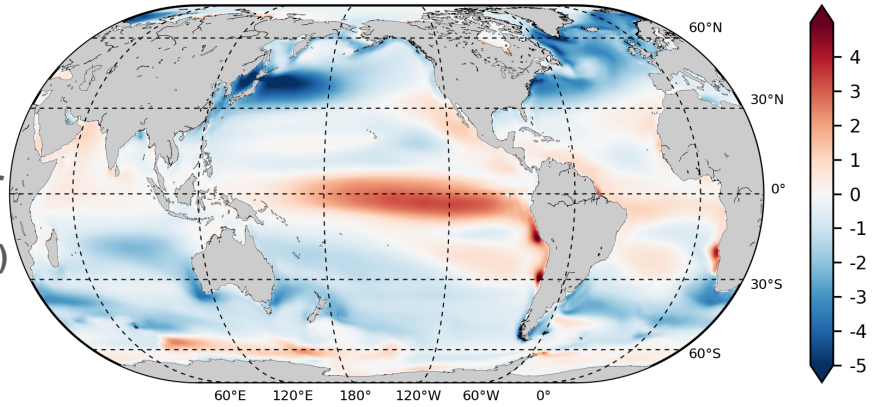


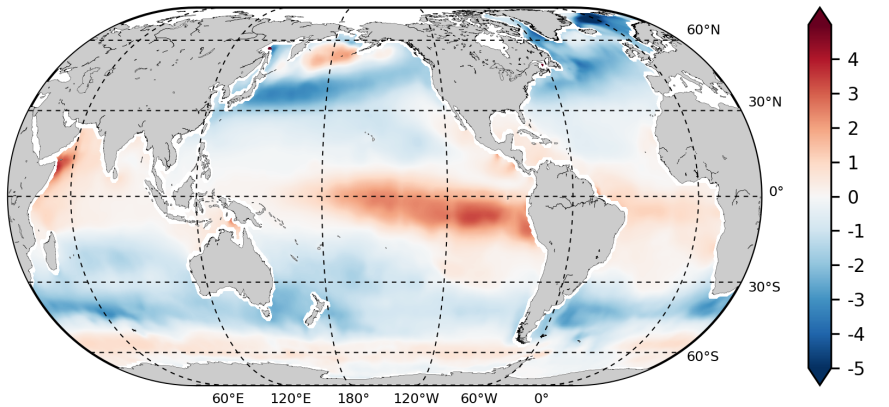


MODEL clim 1998 - 2009

Landschützer clim 1998 - 2009

Sea-to-air CO_2 flux ($gC/m^2/yr$)





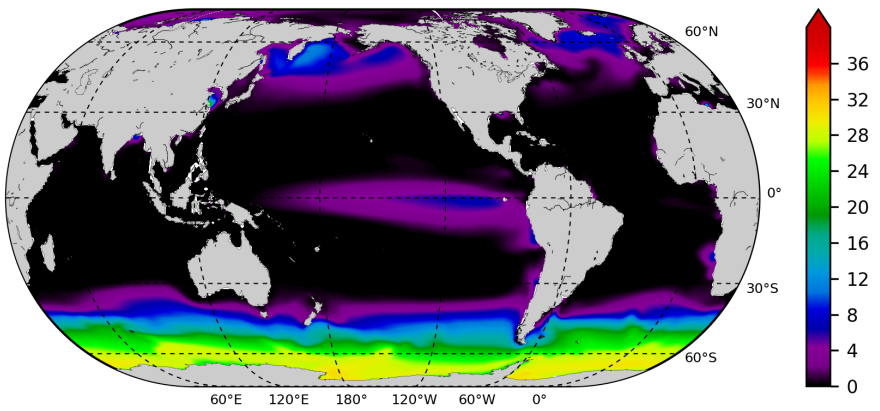
Assessment of CERA-20C/ Ocean Carbon

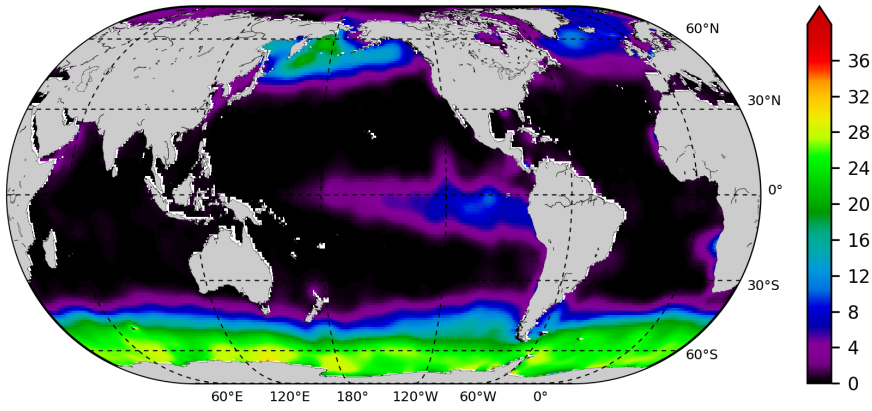
Surface annual mean

Accordance of large scale structures

MODEL clim 1998 - 2009 | **WOA 2013 clim**

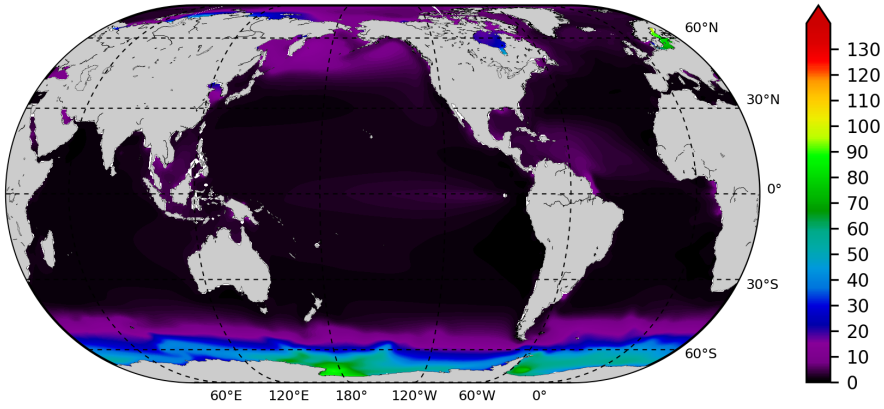
NO3 (mmol/m^3)

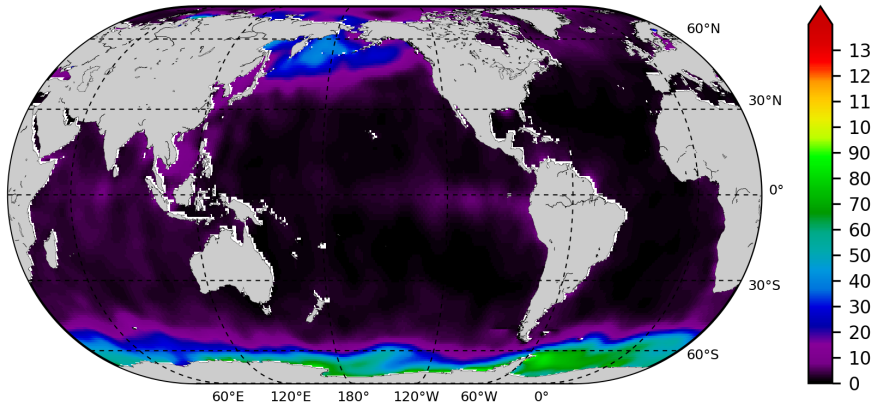




MODEL clim 1998 - 2009 | **WOA 2013 clim**

$Si(OH)_4$ (mmol/m^3)





Assessment of CERA-20C/ Ocean Carbon

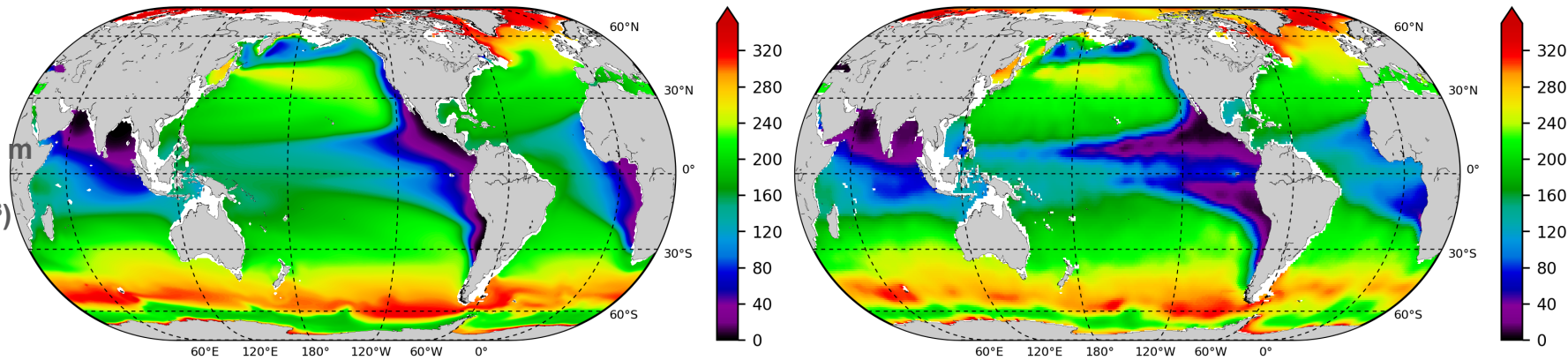
200m depth annual mean

Oxygen Minimum Zones are not extended enough westwards

MODEL clim 1998 - 2009

WOA 2013 clim

O2 at 200 m depth (mmol/m^3)

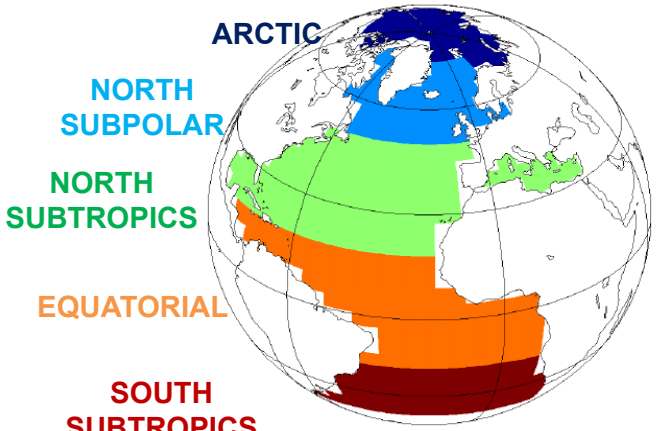


Assessment of CERA-20C/ Ocean Carbon

Atlantic and Arctic sea-to-air CO_2 fluxes

Regional sources and sinks in line with published estimates

	Arctic		North Subpolar		North Subtropics		Equatorial		South Subtropics	
Units	PgC y^{-1}	mol m^{-2} y^{-1}	PgC y-1	mol m^{-2} y^{-1}	PgC y^{-1}	mol m^{-2} y^{-1}	PgC y^{-1}	mol m^{-2} y^{-1}	PgC y^{-1}	mol m^{-2} y^{-1}
Model	-0.07	-0.59	-0.29	-2.2	-0.27	-0.87	0.05	0.18	-0.18	-0.79
Landschützer			-0.28	-2.14	-0.26	-0.86	0.11	0.36	-0.17	-0.76



From Schuster et al. (2013)

Underestimation of equatorial source

Landschützer 1998 – 2011 climatology

CERA-20C/carbon 1998 – 2009 climatology

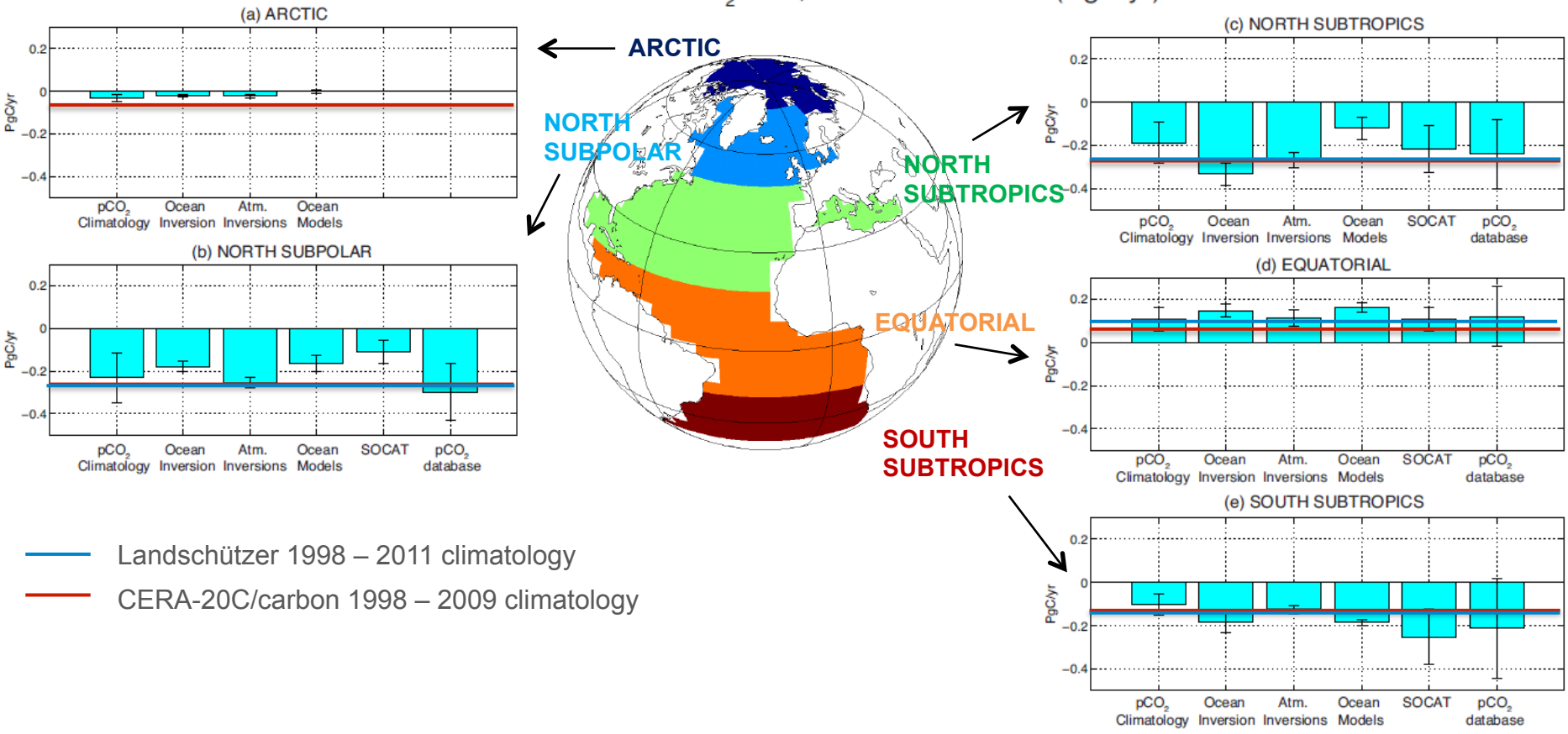
Assessment of CERA-20C/Ocean Carbon

Atlantic and Arctic sea-to-air CO_2 fluxes

Regional CO_2 sinks and sources in line with published estimates

From Schuster et al. (2013)

1990-2009 Mean CO_2 Flux, Atlantic and Arctic (PgC/yr)



Landschützer 1998 – 2011 climatology

CERA-20C/carbon 1998 – 2009 climatology

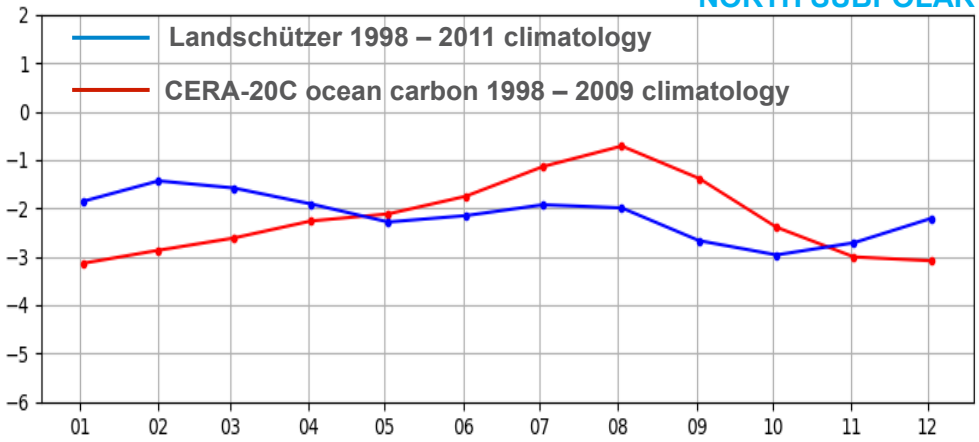
Assessment of CERA-20C/Ocean Carbon

Seasonal cycle of sea-to-air CO_2 flux in Atlantic

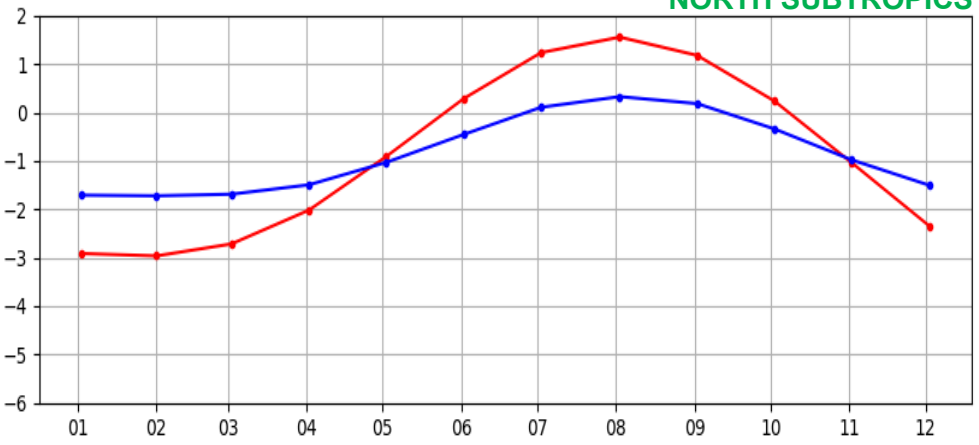
Good consistency in subtropical gyre, and less in subpolar gyre

But the products in Schuster et al. are also very scattered in this region

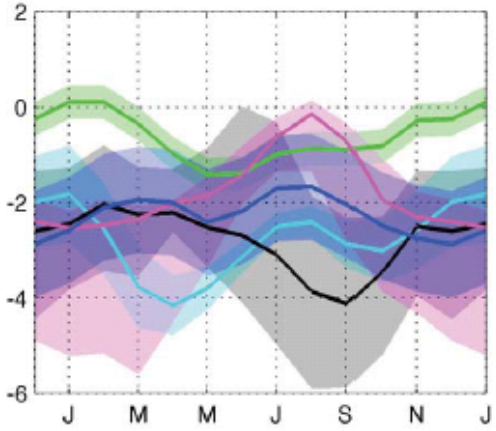
NORTH SUBPOLAR

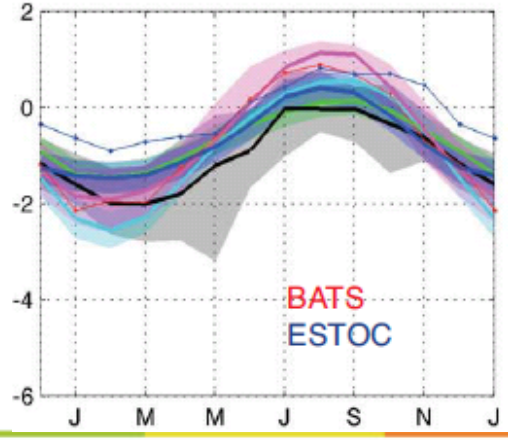


NORTH SUBTROPICS



From Schuster et al. (2013)





Pco2 clim
Atm inversion
Ocean models
SOCAT MPR
pCO2 database

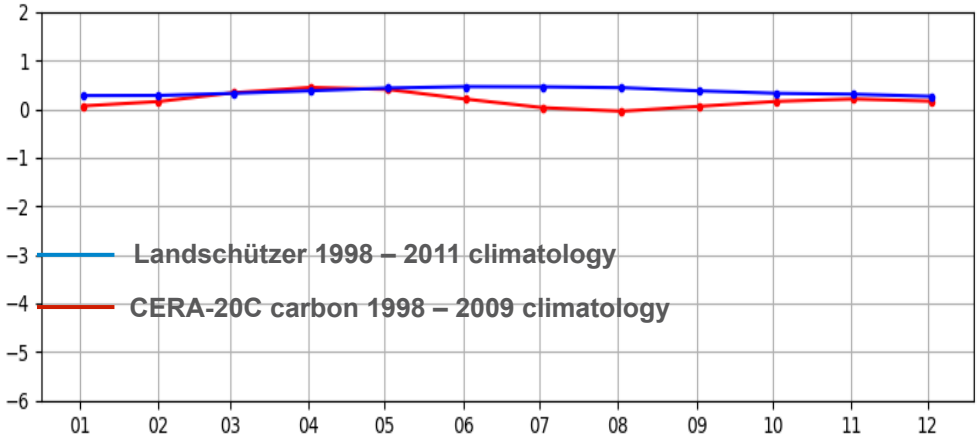
Assessment of CERA-20C/Ocean Carbon

Seasonal cycle of sea-to-air CO_2 flux in Atlantic

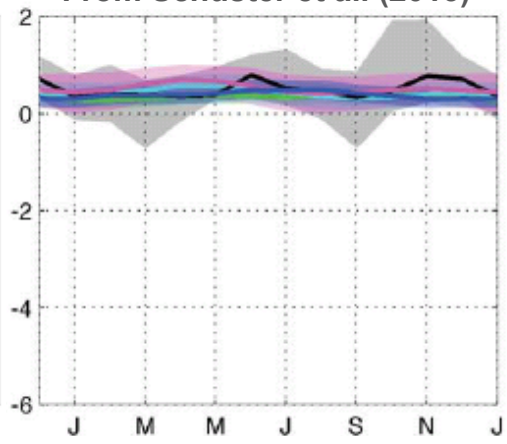
Equatorial region = low source of CO_2, no clear seasonal cycle

South subtropics = in line with obs. and previous studies

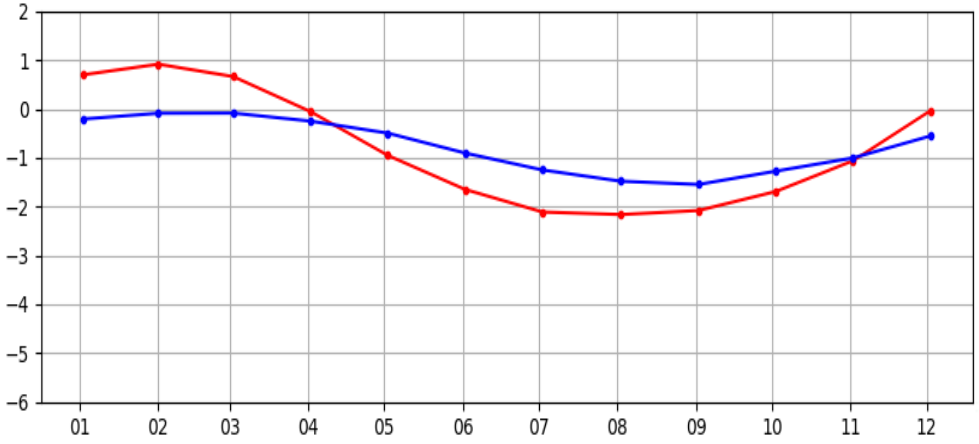
EQUATORIAL

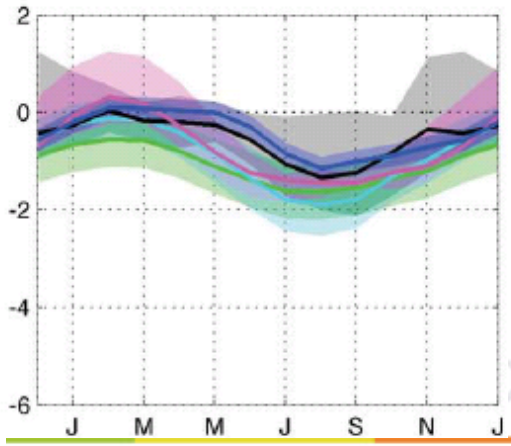


From Schuster et al. (2013)



SOUTH SUBTROPICS



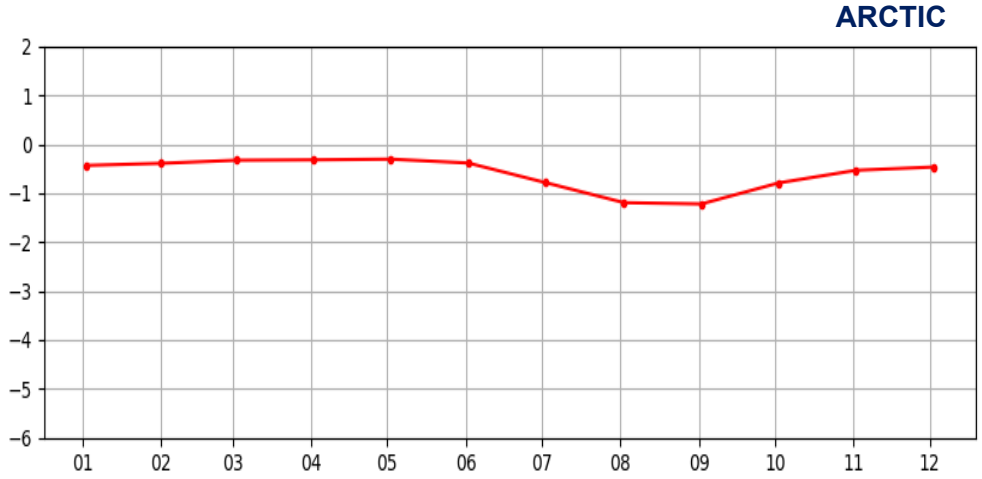


Pco2 clim
Atm inversion
Ocean models
SOCAT MPR
pCO2 database

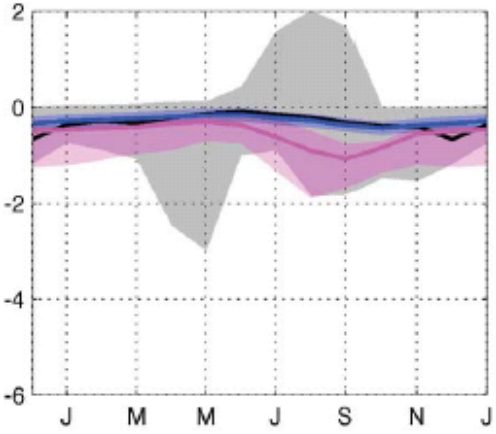
Assessment of CERA-20C/Ocean Carbon

Seasonal cycle of sea-to-air CO_2 flux in Arctic

Arctic region: model very close to model ensemble of Schuster et al. (2013)



From Schuster et al. (2013)

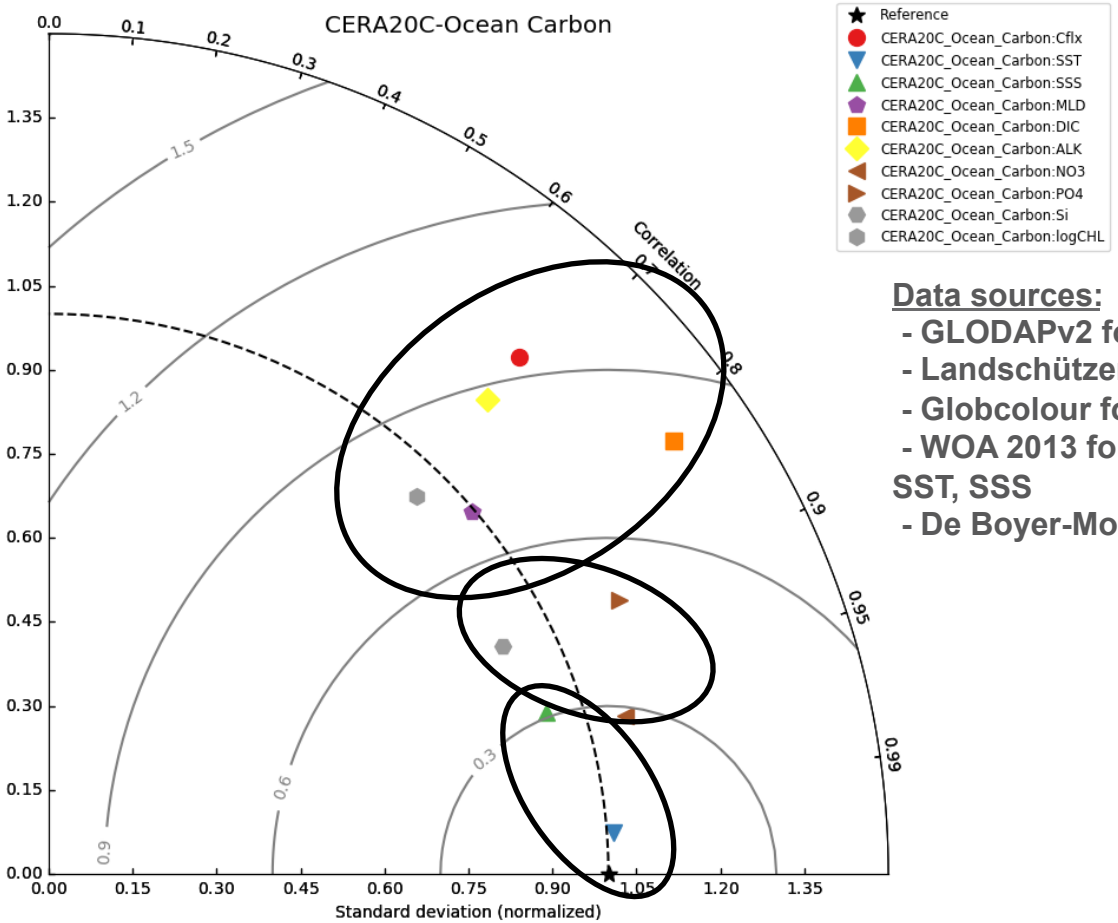


Pco2 clim
Atm inversion
Ocean models
SOCAT MPR pCO2 database

Assessment of CERA-20C/Ocean Carbon

Global statistics: Taylor diagram

- SST, SSS: +++
- Nutrients ++
- Chl, MLD, carbon variables: significant correlations but still work to do (on data and model)



Data sources:

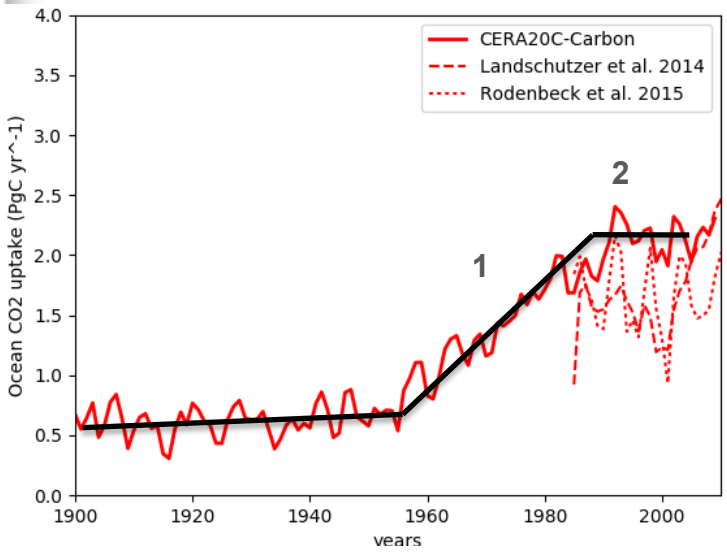
- **GLODAPv2 for DIC, ALK**
- **Landschützer for Cflx = CO_2 flux**
- **Globcolour for logCHL**
- **WOA 2013 for NO_3, O_2, PO_4, Si, SST, SSS**
- **De Boyer-Montégut for MLD**

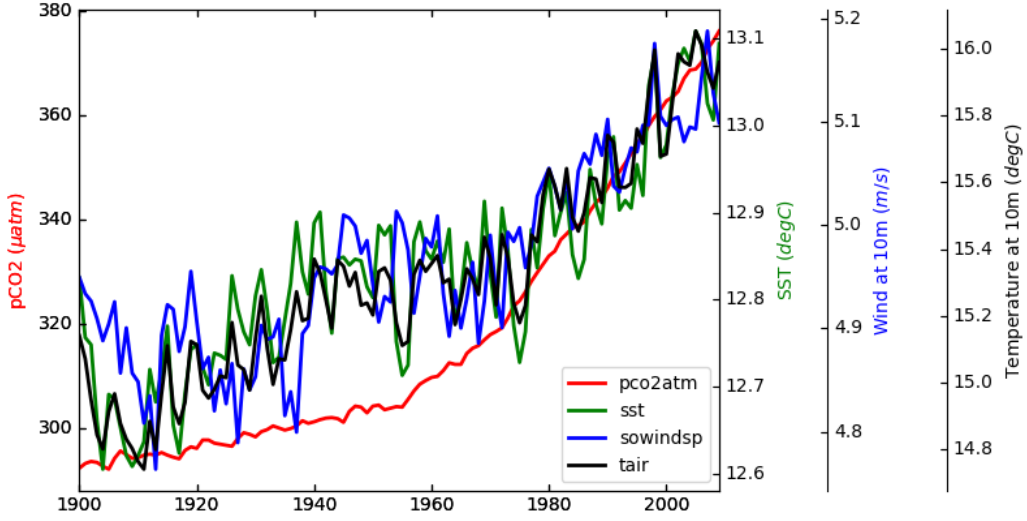
Taylor diagram computed with surface monthly climatologies (1998 – 2009 years if available)

Assessment of CERA-20C/Ocean Carbon

Interannual time series of the CO_2 flux

Net air-to-sea CO_2 flux



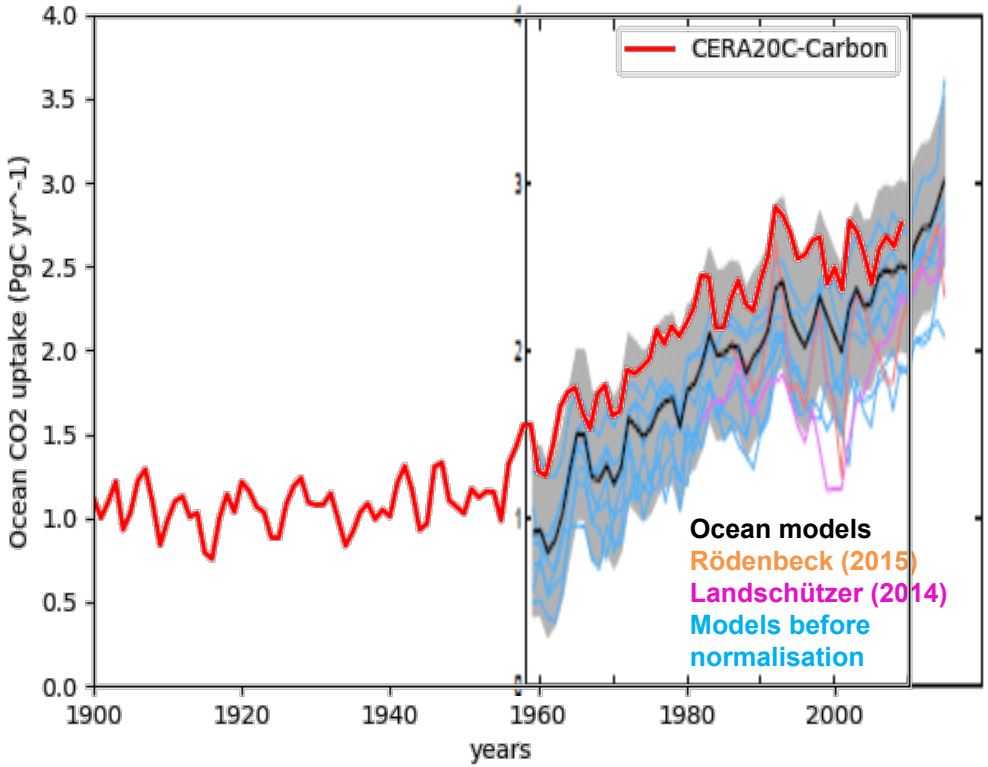


1) Intensification of the carbon uptake
2) Stagnation in carbon uptake in the 90s (De Vries et al. 2017)

Assessment of CERA-20C/Ocean Carbon

Interannual time series of the CO_2 flux

Anthropogenic air-to-sea CO_2 flux



From Le Quéré et al. (2016) In the Global Carbon Budget

We add 0.45 PgC/yr to withdraw the natural outgassing from rivers (Jacobson et al. 2007)

Conclusions & Perspectives

Conclusion:

- Evaluation of CERA20C/Ocean Carbon gave rather promising results over the period covered by observations (1998 – 2009)
  - At the global scale (annual mean, Taylor)
  - At the scale of Atlantic basin: seasonal cycle and subbasin integrated values
  - Globally yearly integrated air-to-sea flux of CO_2 over the period 1960 to 2009
- Interannual variability needs to be further studied to disentangle the different processes

Perspectives:

- Publication in preparation
- Use of this 1° biogeochemical simulation to initialize future Mercator PISCES simulations

Thank you for your attention !

Assessment of CERA-20C/Ocean Carbon

Spin-up vs interannual time series

- Spin-up phase is necessary
- PISCES is very long to equilibrate