Interannual variability of temperature over 50 years described by global simulation

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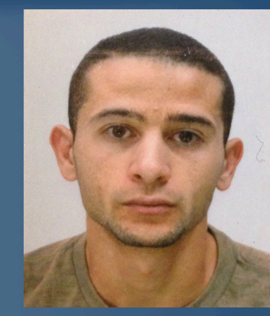

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Introduction

The aim of this study is to better understand the different overriding mechanisms that control the evolution of the temperature in the Bay of Biscay, through realistic simulations over a period of 50 years. Based on the work of Michel *et al. (*2009) on the variability of temperature in the Bay of Biscay (Fig1). We will extend the understanding of the interannual variability to the haline contents and the circulation at regional scale.

Here we compare two global simulations, ORCA-G70 and ORCA-GRD100 (¼° resolution), that differs mainly in the vertical resolution and we show their variability.

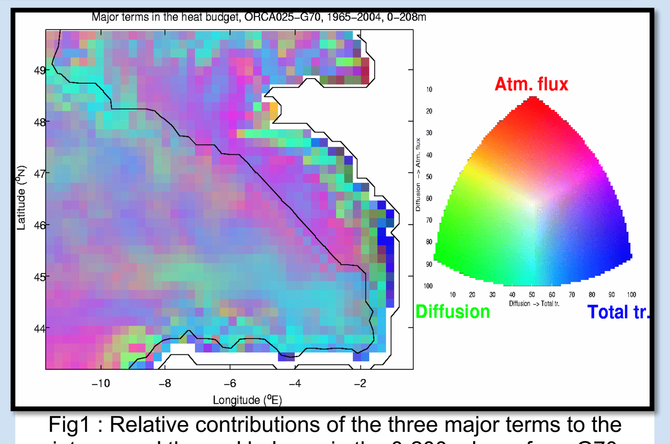


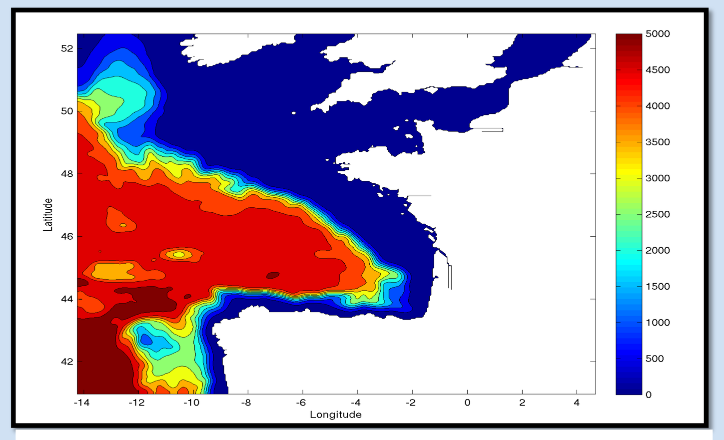
Fig1 : Relative contributions of the three major terms to the interannual thermal balance in the 0-200m layer from G70 simulation (Michel *et al* 2009)

Conclusions and perspectives

The variability, trend and TS diagram are better represented in the simulation GRD100. Therefore, this simulation will be used as the initial and boundary condition for long term 3D regional simulation BACH4000 with 4km horizontal resolution (Charria *et al.* 2014; Theetten *et al.* 2014).

The future works will be :

- Refine the analyzes of the global simulations with the study of the circulation (Navidad, IPC; Iberian Polward Current) and the haline budget in the Bay of Biscay.
- The analyze of BACH4000 in the aim to understand what controls the variability in the Bay of Biscay and to see the contribution of the increase of the horizontal resolution in this variability.



bathymetric map of our future regional simulation BACH4000

1- Data

The 3D circulation model used here is based on the NEMO (Nucleus for European Modelling of the ocean; Barnier *et al.* 2006) model. The domain of this study covers the area 1°-15°W and 43°-50°N.

The G70 simulation has 46 vertical levels (z-coordinates) and is covering the periode from 1958 to 2004, using DFS3 (Drakkar Forcing Set ; Brodeau *et al.* 2010) atmospheric forcings.

The GRD100 simulation has more vertical levels (75) and is covering the period from 1958 to 2010 with DFS4.3 and DFS5 atmospheric forcing (Brodeau *et al.* 2010).

The WOA2004 climatology is a set of measurements from different kind of sensors with 1° spatial resolution from 1955 to 2003 and from surface to 700m depth.

2- Temperature interannuel variability

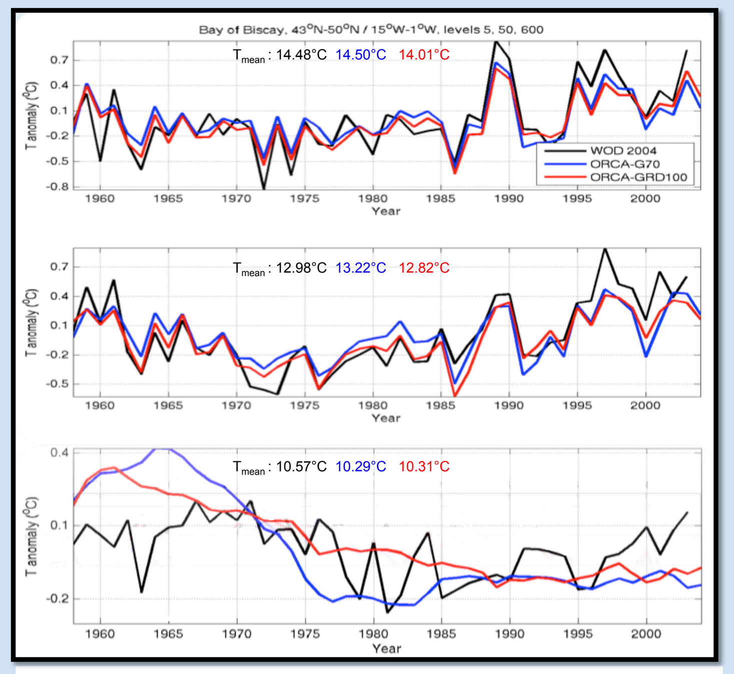


Fig2 : Time series of annual temperature anomalies between 1958-2004 in the Bay of Biscay: (a) surface (5 m), (b) mixed layer (50 m), (c) intermediate waters (600 m).

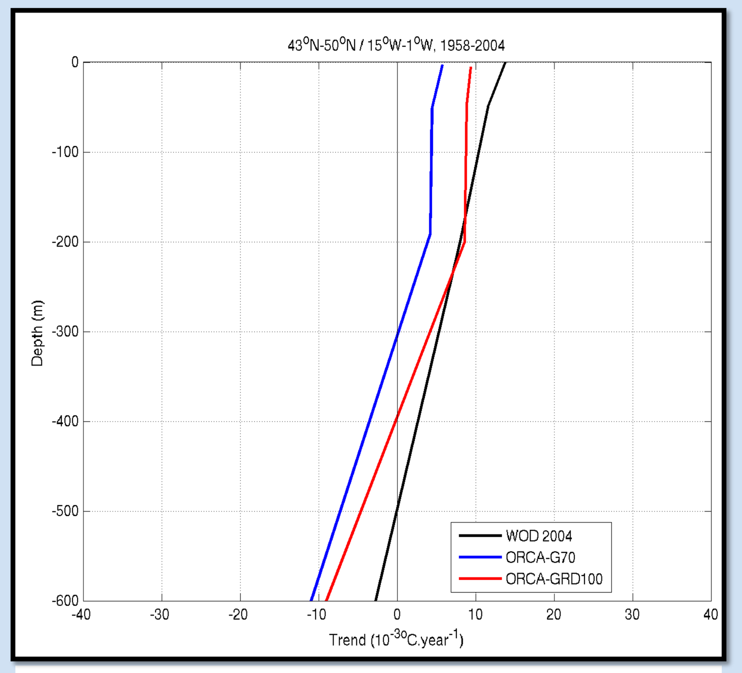


Fig3: Vertical profile of the linear trend of temperature per year calculated between 1958 and 2004.

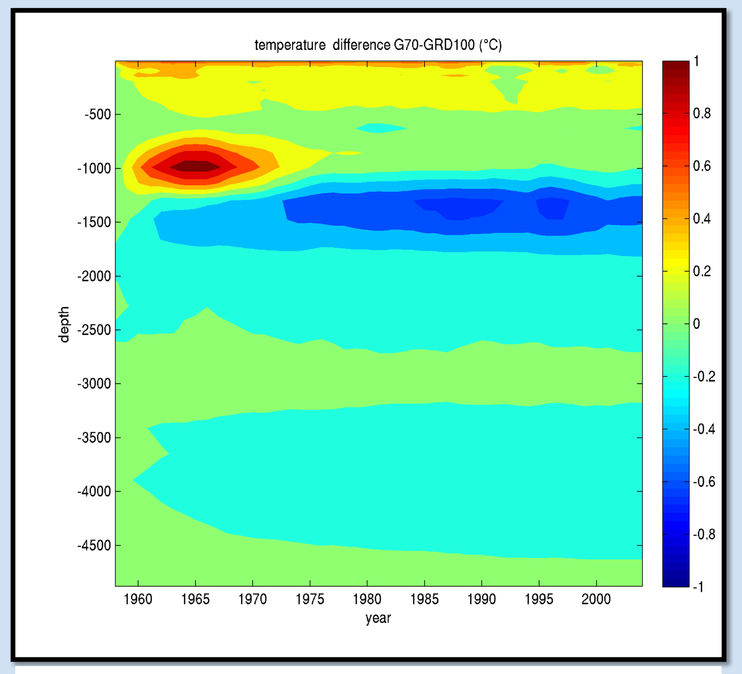


Fig4 Vertical section of the of the temperature difference per year between G70 and GRD100.

- The temperature variability is well reproduced compared to the climatology (Fig2) and we can distinguish two periods : a cooling until mid 1970 and a warming after this date (in agreement with Michel *et al.* 2009).
- In GRD100 simulation, the trend has been improved (Fig3) and can be partly attributed by the increase in the vertical resolution.
- In the map of temperature difference, we can distinguish three zones (0-400m with 0.4°C, 750-1250m with 1°C 1250-1750m with -0.8°C).

How could we explain the difference between the two simulations?

3- Different explanations?

- Assumptions hold:
  - The oceanic initial condition is the same for both simulation,
  - atmospheric heat flux (explained in the fourth part of heat budget),
  - The intensity of the wind.
- Untested assumptions:
  - The relaxation in the Mediterranean (the difference of temperature between 750-1250m, Fig4),
  - Vertical levels number.

It is difficult to explain the differences, because we can't verify some assumptions but one way to better understand is to compare the heat budget.

4- Heat budget

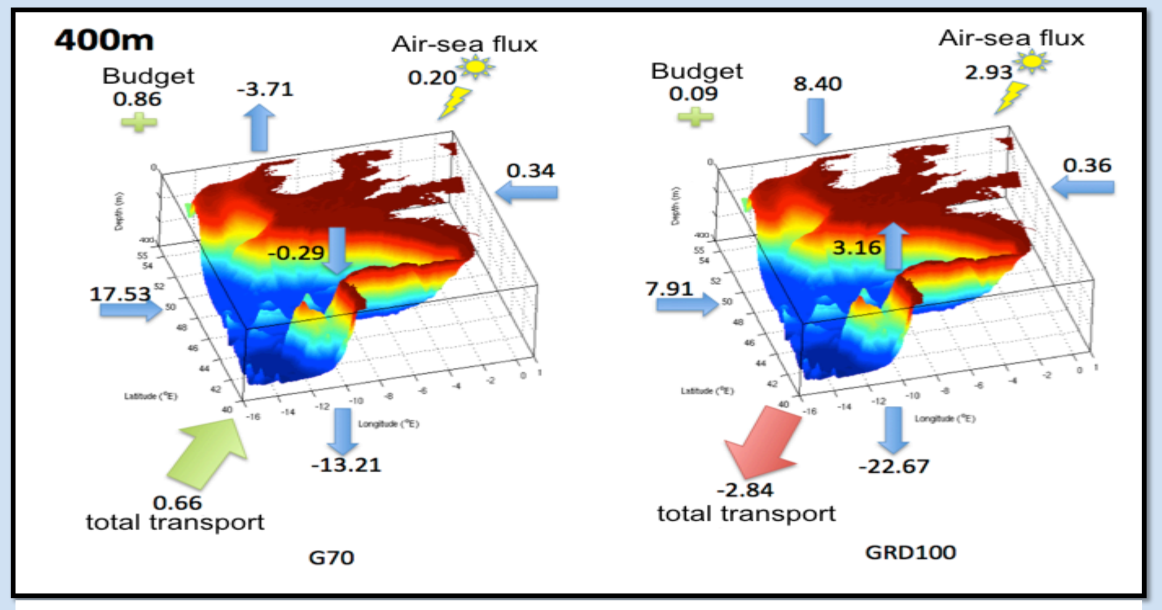


Fig 5 : Heat balance between 0-400m depth averaged over a period from 1965 to 2004 for the G70 and GRD100 simulation. Values are in terawatt (TW). Blues arrows represent transport on open borders (N, S, E, W) and transport from the bottom (400m).

A heat budget was computed for the both simulations (Fig5), integrated from 1965 to 2004, to explain the gap of 0.4°C in the first 400m.

- The atmospheric heat flux is 15 times greater in GRD100 than G70, despite the fact that G70 receives more heat (budget difference 0.77TW). The wind in GRD100 is 8% stronger than G70 (not shown here) may explain a part of this completely different dynamic.
- The atmospheric forcings don't control directly the temperature in the Bay of Biscay.
- The heat transport over the domain is completely different between the two simulations.
- The ocean transport drives directly the temperature budget in the Bay of Biscay.

Based on this results, we have to wonder :

Which simulation is more physical?

5- T/S diagram

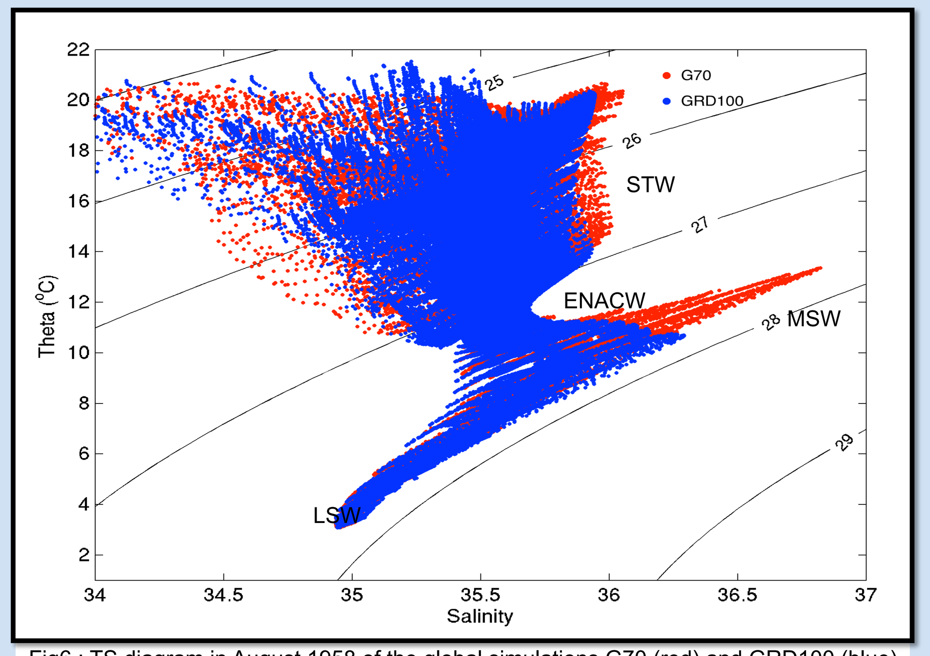


Fig6 : TS diagram in August 1958 of the global simulations G70 (red) and GRD100 (blue) until 2000m depth. Water types : STW, Surface Thermocline Water, ENACW, Eastern North-Atlantic Central Water, MSW, Mediterranean Sea Water, LSW, Labrador Sea Water

As an example, the T/S diagram has been computed for August 1958 Fig6 (beginning of the simulation).

- All water types are presented in T/S diagram in both simulations.
- Mediterranean Sea Water (MSW) are more warmer and saltier in G70 until 1975 and after that it represent better the MSW.
- GRD100 represent better the MSW (Fraile-Nuez *et al.* 2008).

GRD100 simulation seems to be more physical

Acknowledgements and references

This study is part of three projects : EPIGRAM, funded by CNRS (LEFE/IDAO) and ANR (grant ANR-08-BLAN-0330-01), COMODO, funded by Agence Nationale de la Recherche (ANR-11-MONU-005-03), and ENIGME funded by (LEFE/GMMC)

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