Atmospheric forcing data sets to drive eddy-resolving global ocean general circulation models

Raphael Dussin[1,2] , Bernard Barnier[1] and Laurent Brodeau[3]

[2]*Institute of Marine and Coastal Sciences, Rutgers University, New Brunswick, New Jersey, USA*

[1]*Laboratoire de Glaciologie et Géophysique de l'Environnement, Centre National de la Recherche Scientifique, Université Grenoble-Alpes, Grenoble, France.*

[3]*Department of Meteorology, Stockholm University, Stockholm, Sweden*

http://www.drakkar-ocean.eu/

1. INTRODUCTION

• Ocean General Circulation Models (OGCM) need Air-Sea Fluxes as surface boundary condition (Fig. 1).

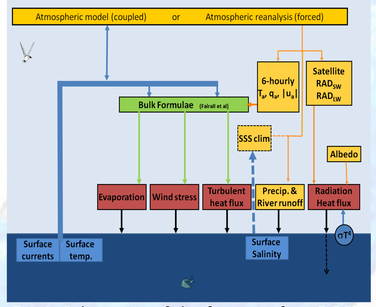


Fig.1: Schematic of the forcing of an OGCM

Global Atmospheric Reanalyses have made possible to carry out hindcast simulations of the ocean general circulation of the recent decades (from 1950's to present).

•Small biases in heat or freshwater flux climatological means may induce serious drifts in the solution of ocean models (Fig.2).

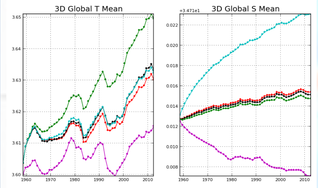


Fig.2: Time evolution of the global ocean temperature and salinity in 3 global model simulations (DRAKKAR configuration ORCA05 at ½° resolution) driven with the DFS5.2 forcing set. Differences between simulations are driven by changes in precipitation of ~10%

2. CONTEXT

DRAKKAR collaboration

Scientific and technical coordination between modelling groups in Europe (LGGE, LPO, LOCEAN, MERCATOR-Ocean, GEOMAR, NOCS, SIO-RAS, MISU) with objectives to:

- develop and maintain a hierarchy of state-of-the-art ocean/sea-ice model configurations for operational and research applications based on the NEMO OGCM,
- design, carry out, assess, and distribute high-resolution global ocean/sea-ice numerical simulations performed over long periods (five decades or more),
- ***develops consistent global forcing datasets based on a combination of ECMWF analyses and reanalysis and observed flux data, called "Drakkar Forcing Sets" (DFS).***

List of Relevant Surface Atmospheric Variables in DFS

- •2m air temperature t2m (°C)
- •2m air specific humidity (g/kg)
- •Downward shortwave radiation radsw (Wm^{-2})
- •Downward longwave radiation radlw (Wm^{-2})
- •10m zonal wind speed component u10 (ms^{-1})
- •10m meridional speed wind component v10 (ms^{-1})
- •Precipitation (liquid, snow) (mm/day).

3. OBJECTIVE: DFS5.2

To Construct of a new atmospheric surface data set to drive the global ocean models used by the DRAKKAR modelling community.

The forcing set presently used in DRAKKAR is DFS4.3. It covers the period 1958-2010. Radiations are from ISCCP satellite estimates, Precipitation from GXGXS data set, and other surface variables are from ERA40 reanalysis and Operational ECMWF analyses.

The DFS5.2 forcing set presented here is based on ERA_interim and ERA40 reanalyses covering altogether the period 1958 to 2013.

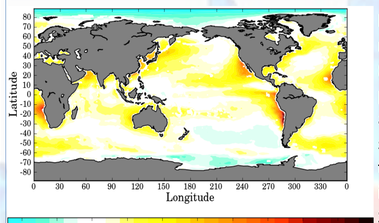
4. ERA_interim:

Description

Recent ECMWF reanalysis (Dee et al., 2011)
Period: 1979-2013 Resolution: 0.7°×0.7°, 3-hourly
Represents an improvement compared to former reanalyses (e.g. ERA40)

Brief assessment of ERA_interim surface variables

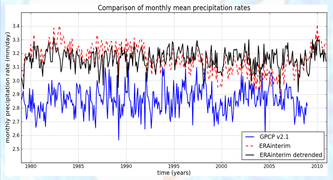
Short wave downward radiation (Fig. 3)



ERA_interim downward shortwave radiation shows too much isolation (when compared to ISCCP satellite products) in the regions of atmospheric subsidence in eastern side of ocean basins. This is related to a misreprentation of low stratus in the model.
Similar behaviour is seen in the longwave.

Fig.3: Difference (Wm^{-2}) in the mean short wave radiation (period 1989-2001) between ERA_interim and ISCCP satellite estimate.

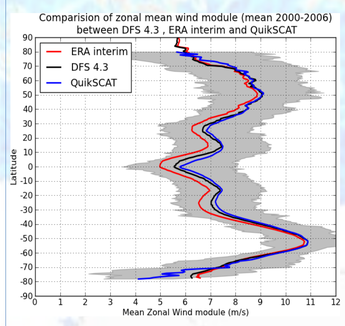
Precipitation (Fig. 4)



ERA_interim precipitation is very different from GPCP in terms of mean value, inter-annual variability and long term trends.

*Fig.4: Monthly averaged global precipitation estimates over the ocean for 1979-2010 from **ERA_interim (red)**, **ERA_interim detrended (black)** and **GPCP (blue)**.*

Wind speed (Fig. 5)



There are indications that ERA_interim winds are underestimated in the inter-tropical region (40°S-40°N). Differences in zonal average with the QuickScat satellite estimates can be as large as 0.8 ms^{-1} at the equator.

Fig.5: Zonal average of the mean (2000-2006) 10m wind speed. In **red the original ERA_interim** wind. In **blue the QuickScat** wind speed and its weekly variability in **Grey shading**. In **black** the wind speed from **DFS4.3** (that has been corrected relatively to QuickScat).

5. DRAKKAR FORCING SET DFS5.2: Summary

The comparison of ERA_interim with satellite products (Frame 4) suggests that corrections/adjustments are necessary before the surface atmospheric variables could be used as surface boundary conditions of a global OGCM.

Corrections are applied to ERA_interim fields to produce DFS5.2.
Because ERA_interim begins in 1979, ERA40 is used for the period 1958-1979 (Table 1).

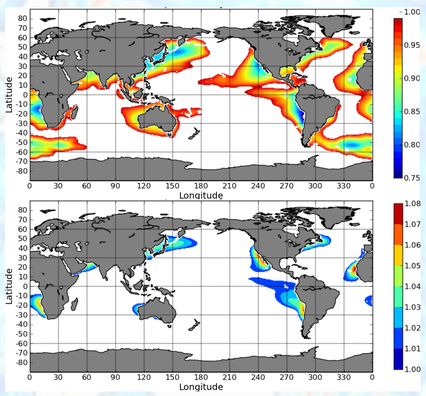
Variable	Units	DFS5.2 origin, time and grid resolution	
		1958-1978	1979-201à0(extended to 2013)
u10 v10 t2 q2	ms^{-1} ms^{-1} °C kg/kg	ERA_interim* daily climatology combined with ERA40** 3-hourly synoptic scales 0.7° resolution	ERA_interim* 3-hourly 0.7° resolution
radsw radlw P snow	Wm^{-2} Wm^{-2} mm/day mm/day	ERA_interim* daily climatology 0.7° resolution	ERA_interim* Daily 0.7° resolution

** ERA-interim variables after implementation of the corrections described below.*
*** ERA40 resolution is 6-hourly and 1.125°. To provide a homogeneous record, ERA40 have been interpolated at the resolution of ERA-interim (3-hourly and 0.7°).*

Table 1: Main characteristics of the DFS5.2 atmospheric forcing data set.

6. CORRECTION OF ERA_interim SURFACE VARIABLES – PERIOD 1979-2010

Radiation fluxes radsw and radlw



Shortwave and Longwave radiation fluxes are multiplied by a factor to correct for their deficiencies in eastern ocean basins.

The multiplication factor (Fig. 6) is calculated from the ratio between the ISCCP and ERA-interim climatological radiation fluxes calculated over the period 1984-2006.

Fig.6: Multiplicative ratio applied to ERA_interim radsw (top) and radlw (bottom). Values equal to 1 are white.

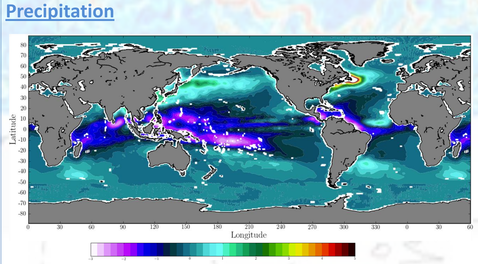
Air and specific humidity at 2mt2 and q2

Correction to the POLES climatology in the Arctic. Linear reduction such that a progressive cooling occurs from 60°S to the Antarctic continent (2°C).

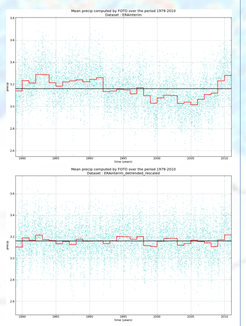
Wind u10 and v10

Rescaling according to QuickScat

Precipitation



Re-scaling to GPCP (Storto, pers. Comm.) between 30°S-30°S then de-trending.



7. DFS5.2 _ PERIOD 1958-1978

Radiation fluxes and Precipitation

ERAi* corrected daily climatology is used

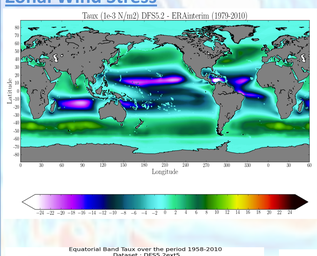
t2, q2, u10 and v10

ERAi* daily climatology (period 1979-2010) combined with the 3-hourly "synoptic scales" of ERA40, calculated as the de-trended 3 hourly anomaly to the 3 hourly value minus the daily climatology of ERA40 calculated over the period 1958-1978.

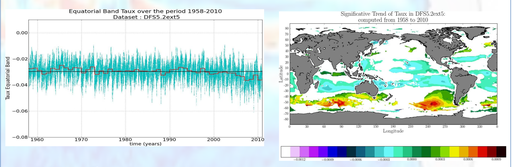
The "Climatological Mean" of DFS5.2 over the period 1958-1978 is exactly the same as the one for the period 1979-2010.

7. IMPACT OF CORRECTIONS ON FLUXES

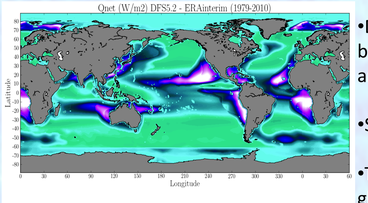
Zonal Wind Stress



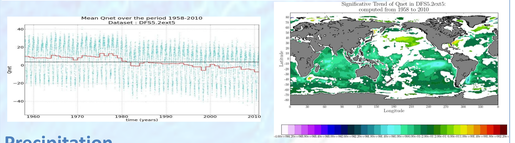
- •Differences between DFS5.2 and ERA_interim.
- •Significant trend in SouthernOcean
- •Time-series of zonal average in the equatorial band (5°S-5°N)



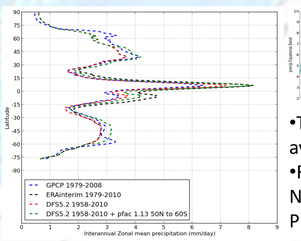
Net Heat Flux



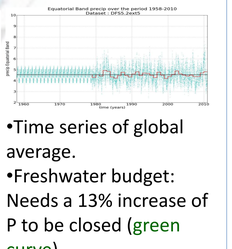
- •Differences between DFS5.2 and ERA_interim.
- •Significant trend
- •Time series of global average



Precipitation



Zonal mean P for different data sets



- •Time series of global average.
- •Freshwater budget: Needs a 13% increase of P to be closed (green curve).

REFERENCES

ISCCP: Zhang et al., JGR, 2004. GXGXS: Large and Yeager (2004). ERA40: Uppala et al., QJRM, 2005.
POLES: Rigor et al., J. Clim, 2000. ERA_interim: Dee et al., QJRM, 2011.
DFS4.3: Brodeau et al., Ocean Modelling, 2012. DFS5.2: Dussin et al., LGGE Report, 2014.