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EXCELENCIA SEVERO OCHOA

Towards an optimal use of numerical precision in Earth Sciences models: ~~the case of NEMO~~

Oriol Tintó Prims

PhD Candidate

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Outline

- Motivation
- Method
- Proof of concept
- Discussion and collaboration

Motivation

Motivation

"Mixed precision algorithms **can easily provide substantial speedup for very little code effort**. "

Motivation

- There are smart strategies to **use less precision to solve problems that originally required higher precision**.
- Many times**, that's not even necessary** because the higher precision is not required in the first place.

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Motivation

- We need a **method to find which variables can effectively use less precision** without compromising the quality of the outputs.

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Method

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Reduced Precision Emulator

- **Fortran Library** developed by the Atmospheric, Oceanic & Planetary Physics group, within the **University of Oxford** Department of Physics

Geosci. Model Dev., 10, 2221–2230, 2017
https://doi.org/10.5194/gmd-10-2221-2017

Geoscientific
Model Development
Open Access
EGU

rpe v5: an emulator for reduced floating-point precision in large numerical simulations

Andrew Dawson and Peter D. Düben

Atmospheric, Oceanic & Planetary Physics, Department of Physics, University of Oxford, Oxford, UK

Correspondence to: Andrew Dawson (andrew.dawson@physics.ox.ac.uk)

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Abstract. This paper describes the rpe (reduced-precision emulator) library which has the capability to emulate the use of arbitrary reduced floating-point precision within large numerical models written in Fortran. The rpe software allows model developers to test how reduced floating-point precision affects the result of their simulations without having to

in supercomputing power have not come from increasingly fast processors but from increasing the number of individual processors in a system. This has led to HPC applications being redesigned so that they scale well when run on many thousands of processors, and effort will be required to make sure models are efficient on the massively parallel su-

Reduced Precision Emulator

- **Fortran** ... ry Physics group, v...

Overview

The library contains a derived type: `rpe_var`. This type can be used in place of real-valued variables to perform calculations with floating-point numbers represented with a reduced number of bits in the floating-point significand.

Basic use of the reduced-precision type

The `rpe_var` type is a simple container for a double precision floating point value. Using an `rpe_var` instance is as simple as declaring it and using it just as you would a real number:

```
TYPE(rpe_var) :: myvar

myvar = 12
myvar = myvar * 1.287   ! reduced-precision result is stored in `myvar`
```

Controlling the precision

The precision used by reduced precision types can be controlled at two different levels. Each reduced precision variable has an `sbits` attribute which controls the number of explicit bits in its significand. This can be set independently for different variables, and comes into effect after it is explicitly set.

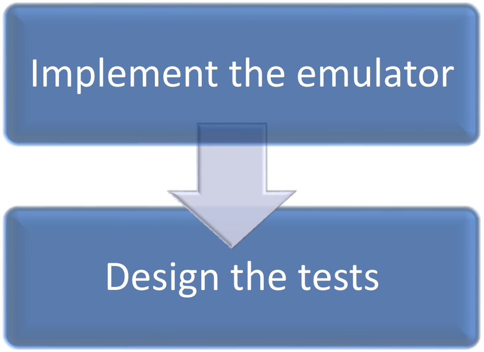
```
TYPE(rpe_var) :: myvar1
TYPE(rpe_var) :: myvar2

! Use 16 explicit bits in the significand of myvar1, but only 12 in the
! significand of myvar2.
myvar1%sbits = 16
myvar2%sbits = 12
```

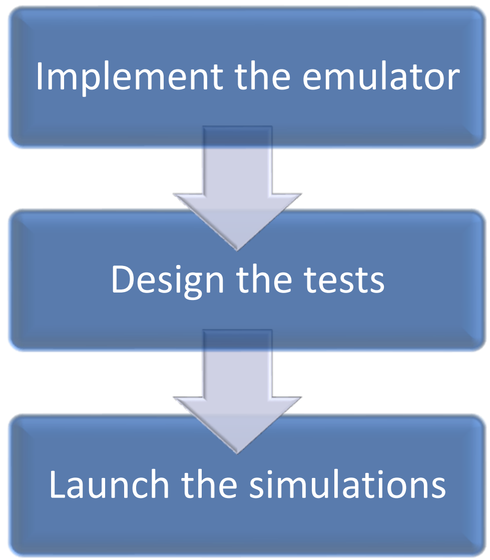
Method

Implement the emulator

Method



Method


Implement the emulator
Design the tests
Launch the simulations

Proof of concept

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Proof of concept

NEMO v3.6

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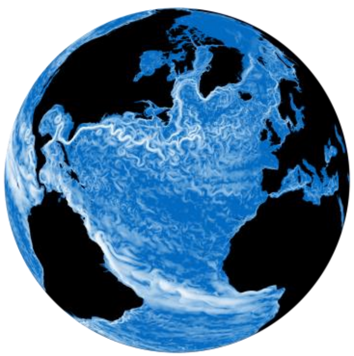
Proof of concept

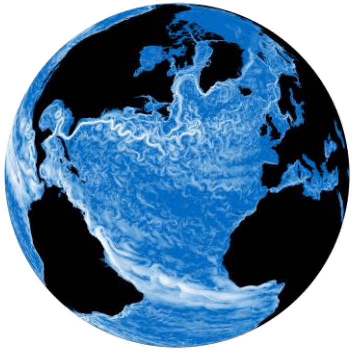
NEMO v3.6



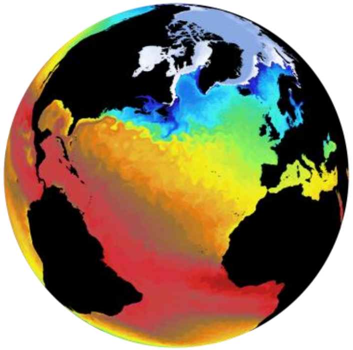
Current
Velocity

Proof of concept

NEMO v3.6



Current
Velocity



Sea Surface
Temperature

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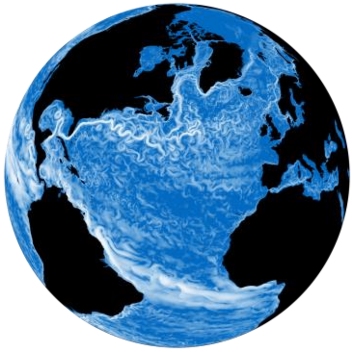
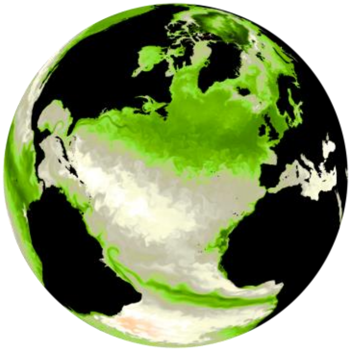
Proof of concept

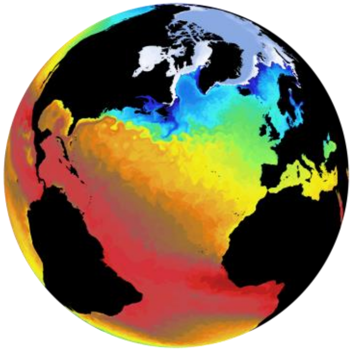
v3.6



Current Velocity



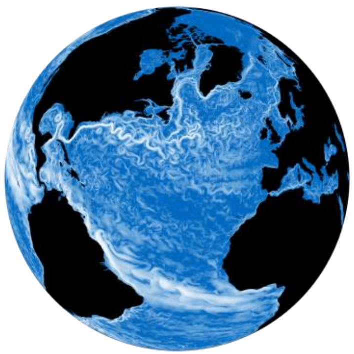
Chlorophyll



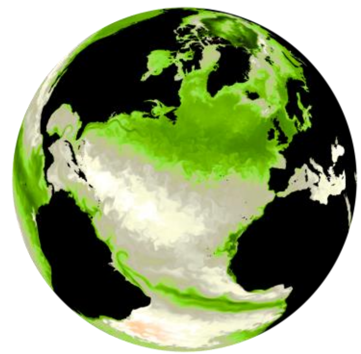
Sea Surface Temperature

Proof of concept

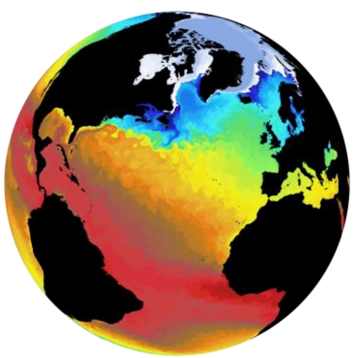
NEMO v3.6



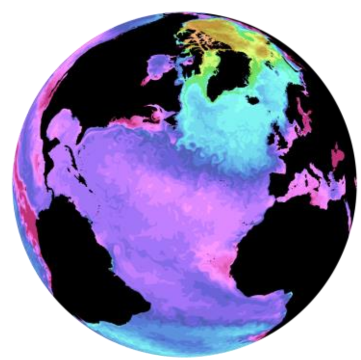
Current Velocity



Chlorophyll



Sea Surface Temperature



PH

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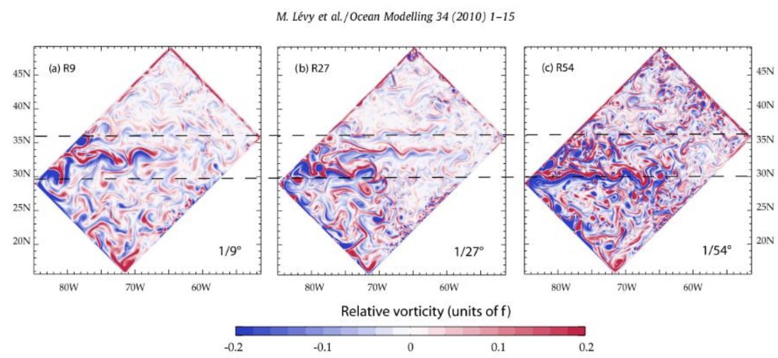
Proof of concept

NEMO

v3.6



GYRE 1

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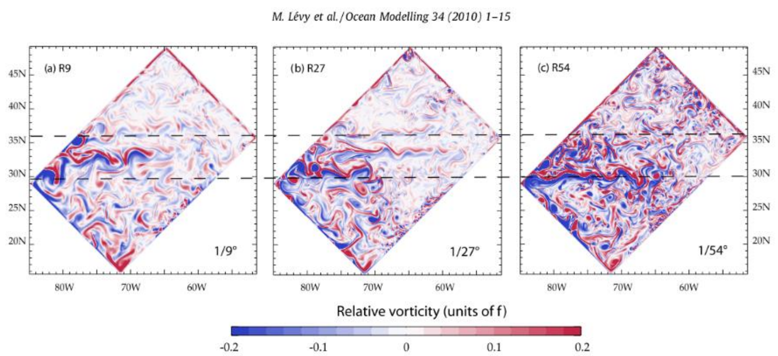
Proof of concept

NEMO **v3.6**



GYRE 1

This configuration uses **3509** real variables

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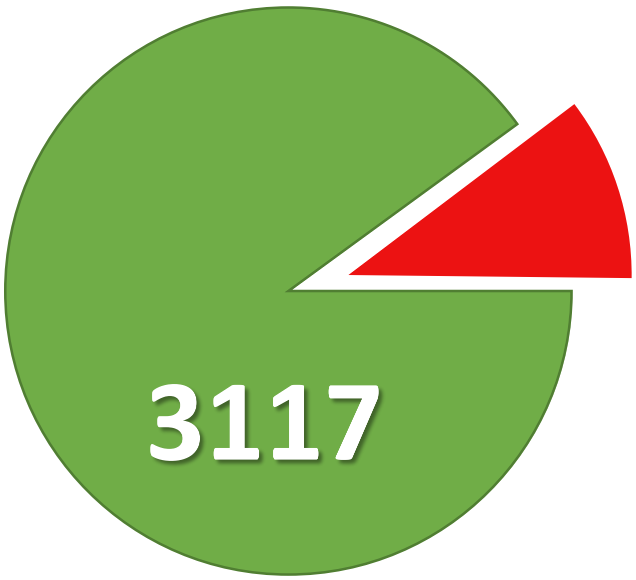
Proof of concept

3509

Proof of concept

Proof of concept



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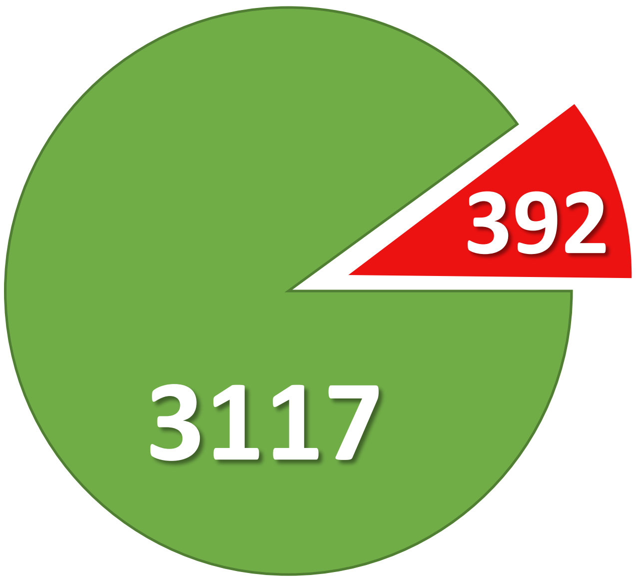
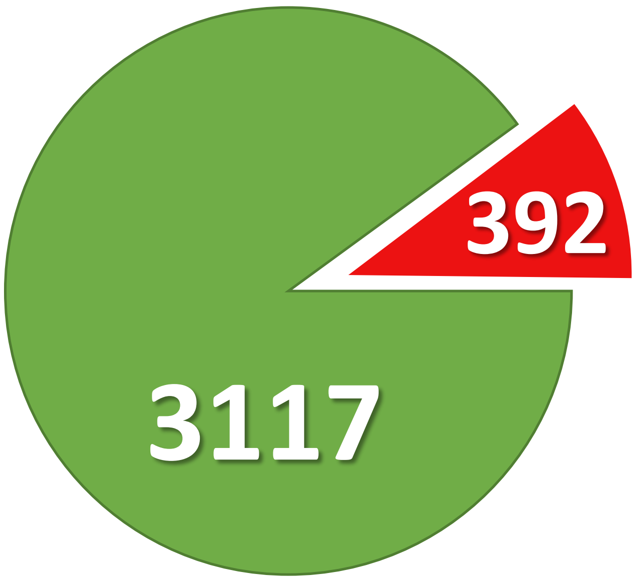
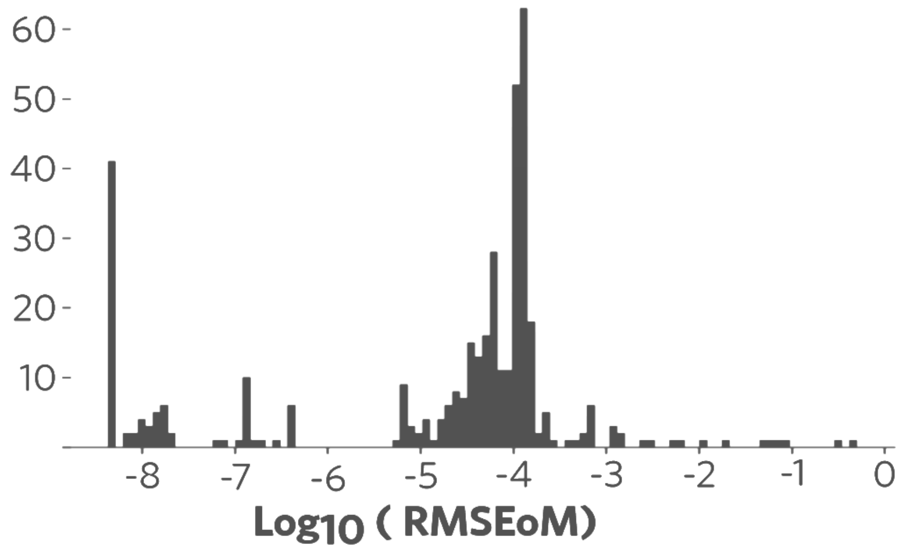
Proof of concept



89% of the variables **can use 10 bit** for the significand without adding significant error

Proof of concept





89% of the variables **can use 10 bit** for the significand without adding significant error

Discussion

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Possible points of collaboration

- **CONCLUSIONS:**
  - There is a huge room for precision reduction in Earth Science models without affecting the accuracy of the results.
  - The proposed methodology proved to be useful.

- **POSSIBLE COLLABORATIONS AND OPEN ISSUES:**
  - Bring the results to an actual mixed-precision implementation.
  - Anybody using (FORTRAN) models and willing to test the same approach.
  - Extrapolativity of the results:
    - Configuration, resolution, initial conditions, long term effects, ...
  - Identifying and correcting algorithms that have less precision-dependant alternatives.
  - Study further ways to exploit precision reduction (fixed-point representations, adaptive precision, ...).
  - All the steps in the general workflow can be improved.

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Thank you

oriol.tinto@bsc.es