EOS COST Short Term Scientific Mission (STSM)

at ECMWF, Reading, U.K. from 2nd to 6th July 2018

by A. Storto (CMRE, La Spezia, Italy)

hosted by K. Mogensen, M. Balmaseda (ECMWF, Reading, UK)

GOAL

Implementing a stochastic physics scheme for NEMO-LIM (v3.6) to introduce stochastic model error in the NEMO ocean model

MOTIVATION

Optimal ensemble generation methods are crucial tools for a variety of applications, such as data assimilation, ensemble prediction systems, at different temporal and spatial scales

METHOD

Build a modular Stochastically perturbed parametrization tendency (SPPT) for NEMO that allows flexibility in the choice of the perturbation parameters and sub-grid processes to perturb

The implementation is inspired by that already present in the ECMWF IFS atmospheric model (Palmer et al., 2009, ECMWF RD Tech. Memo. 598)

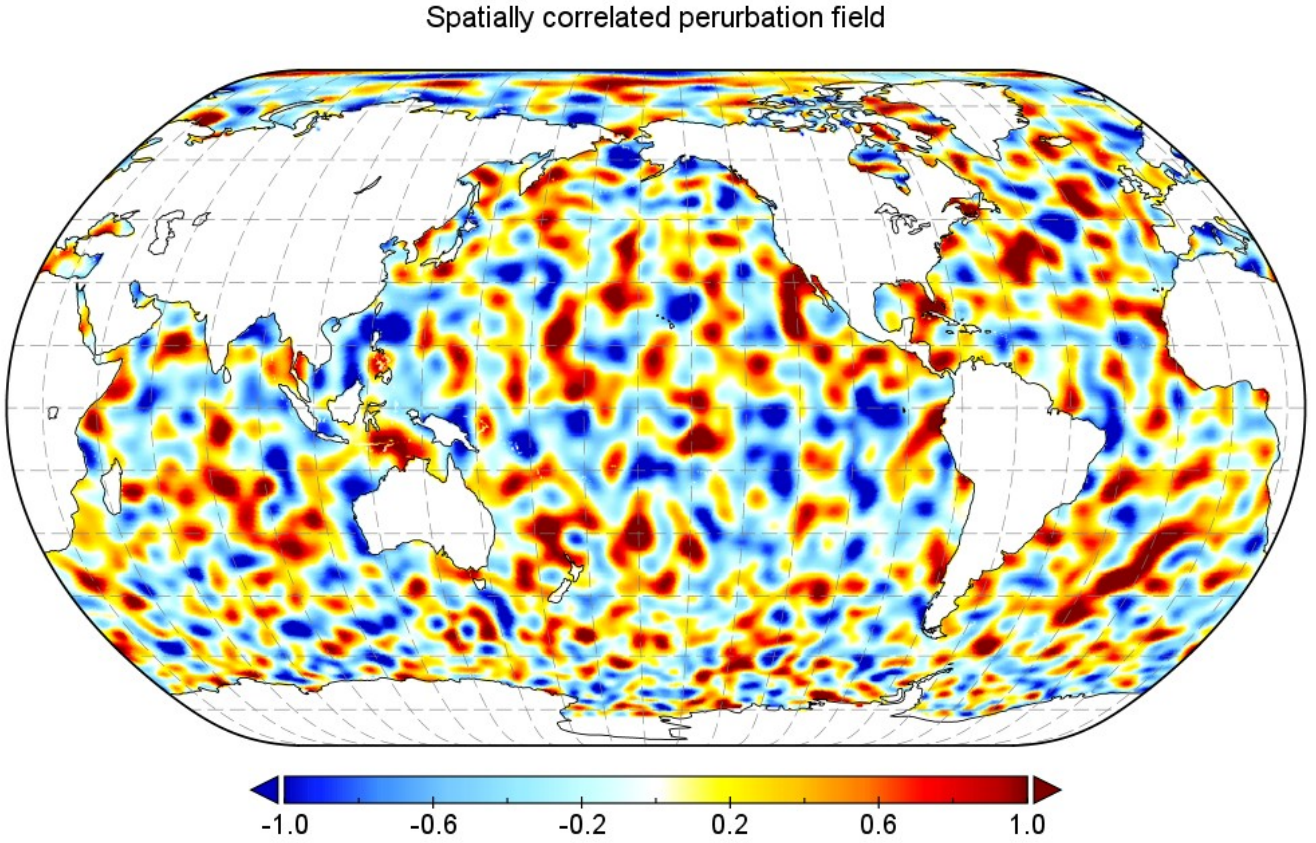
WORK PERFORMED

An SPPT scheme has been implemented in NEMO, which takes the form:

$$\frac{dP}{dT} = M(P) + (1+\xi)S(P)$$

Where the tendency from sub-grid or low-accuracy processes are perturbed col-linearly using a spatially and temporally correlated perturbation field ξ, bounded between +/- 1

The perturbation field (see an example below) is modeled as an AR(1) process with given temporal de-correlation scale. A Laplacian low-pass filter implicitly provide the spatial de-correlation time-scales.



Example of Perturbation field

TECHNICAL IMPLEMENTATION

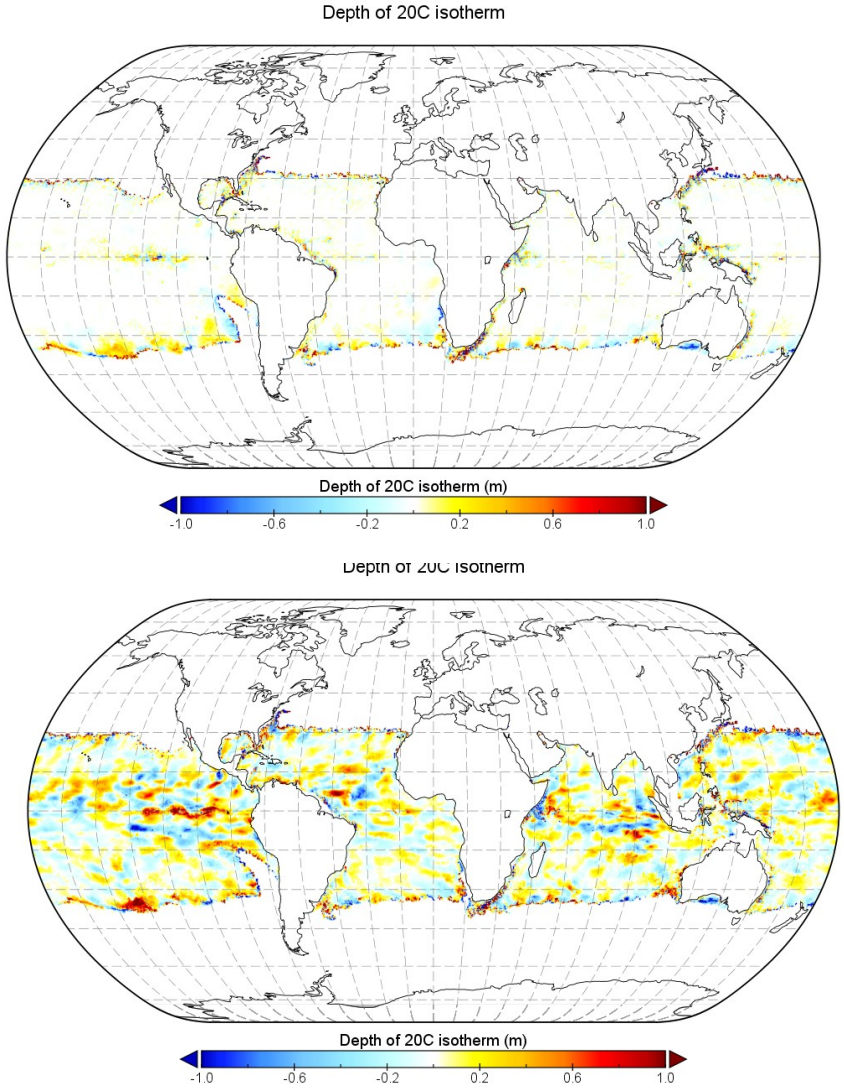
Relying on the TRD (tendency) package of NEMO, the tracer and momentum tendency from the processes to perturb are stored.
The possible options and values chosen after sensitivity tests are given below and beside.

Option	Value
White Noise Standard deviation	0.5
Iterations of Laplacian filter	350
Horizontal Diffusion	YES
Bound White Noise	NO
Bound Perturbation Field	YES
Bounding	+/- 1
Decorr. Time-scale	6 hours
Coastal smoothing scale	50 km
Surface Smoothing	YES
Bottom Smoothing	YES
Frequency of perturbation field generation (in timesteps)	1

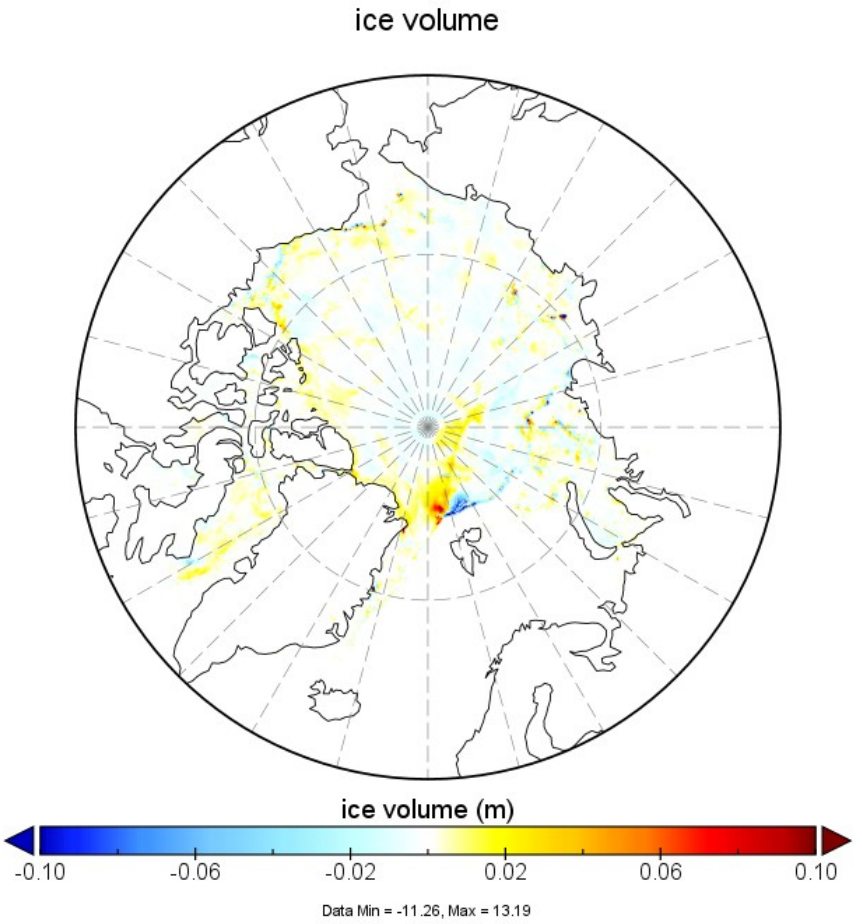
Tracers terms	Default activation
Horizontal Advection	NO
Vertical Advection	NO
Horizontal Diffusion	YES
Vertical Diffusion	YES
Enhanced diffusion	NO
Bottom Forcing	NO
Bottom Boundary layer	YES
Solar penetration	YES
Non-solar Fluxes	NO
Non-penetrative convection	NO
Momentum terms	
Horizontal Viscosity	YES
Vertical Viscosity	YES
Hydrostatic pressure gradient	NO
Surface pressure gradient	NO
Horizontal Advection	NO
Vertical Advection	NO
Bottom friction	NO
Wind stress	NO
Relative vorticity	NO
Planetary vorticity	NO
Sea-ice terms	
Numerical diffusivity	NO
EVP and VP rheology	NO
Lateral accretion	NO
Ice strength	NO
Albedo	NO
Internal vertical thermodynamics	NO

SENSITIVITY TESTS

Several sensitivity tests were performed in order to configure the SPPT scheme.
Two examples are given below:



10-day forecast difference between perturbed and unperturbed fields for the 20°C isotherm depth. Top: when SPPT is activated on tracers diffusion tendencies and solar radiation; bottom: when also momentum viscosity tendencies are perturbed.



3-day forecast difference between perturbed and unperturbed sea-ice albedo for the sea-ice volume

CONCLUSIONS AND FUTURE WORK

A modular SPPT stochastic physics scheme has been coded and implemented in NEMO (v3.6). Several short-range tests were conducted in order to define a reference configuration.

On-going 7-year experiments with 5-member ensembles are being conducted at ECMWF to assess the performance of the SPPT scheme compared to the atmospheric forcing perturbation

Sea-ice perturbations were not included in this preliminary tests and will be considered later

Based on these preliminary results, new experiments with data assimilation will be considered