immerse
IMPROVING OCEAN MODELS
FOR THE COPERNICUS PROGRAMME

RK3 time-stepping implementation in NEMO

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Computational efficiency is crucial for ocean models !

RESOLUTION TENDS TO INCREASE
MORE CONCERNED ABOUT CARBON FOOTPRINT

HOW TO IMPROVE EFFICIENCY ?

By improving stability

stability constraint (CFL) constraints the time step lenght

the longer the time step the better the efficiency

Time-scheme for advection	n_{rhs}	Stability constraints			
		$\alpha^{\star}_{c2}$	$\alpha^{\star}_{up3}$	$\alpha^{\star}_{Co4}$	$\beta = \frac{\alpha^{\star}_{up3}}{\alpha^{\star}_{c2}}$
LFRA ($\nu = 0.1$)	1	0.904	0.472	0.522	0.522
LFAM3	2	1.587	0.871	0.916	0.548
AB2 ($\varepsilon = 0.1$)	1	0.503	0.554	0.29	1.108
AB3	1	0.724	0.397	0.418	0.548
RK3	3	1.73	1.626	1	0.93

CLF condition for several space and time scheme combination

from Stability constraints for oceanic numerical models F. Lemarié et. al OM 2015

Implementing RK3 in NEMO : a long process

2019

NEMO time-stepping modularity

D. Storkey & A. Coward

G. Madec

2020

Study of barotropic mode splitting stability

N. Ducousso, F. Lemarié

2021

RK3 implementation with single 1st splitting

G. Madec & S. Téchené

J. Chanut, C. Ethé, A. Coward

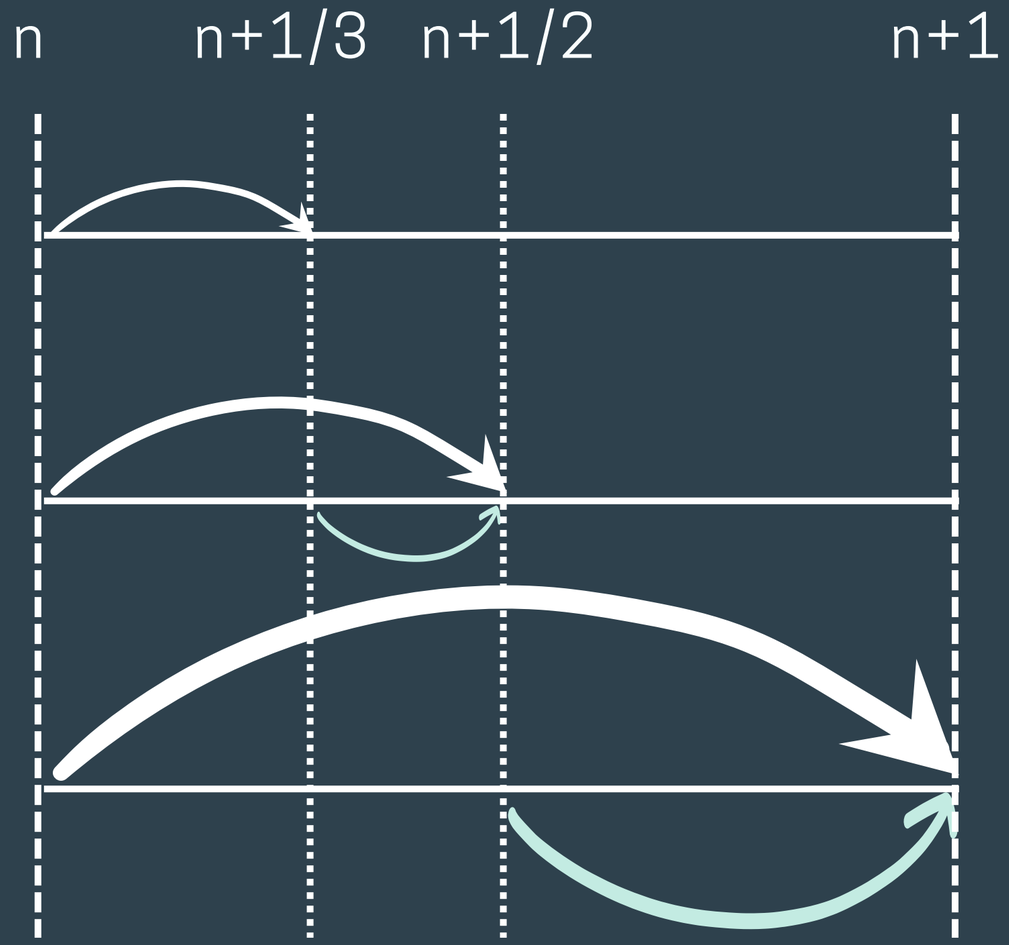
2022

RK3 in NEMO trunk with most of NEMO options

G. Madec & S. Téchené

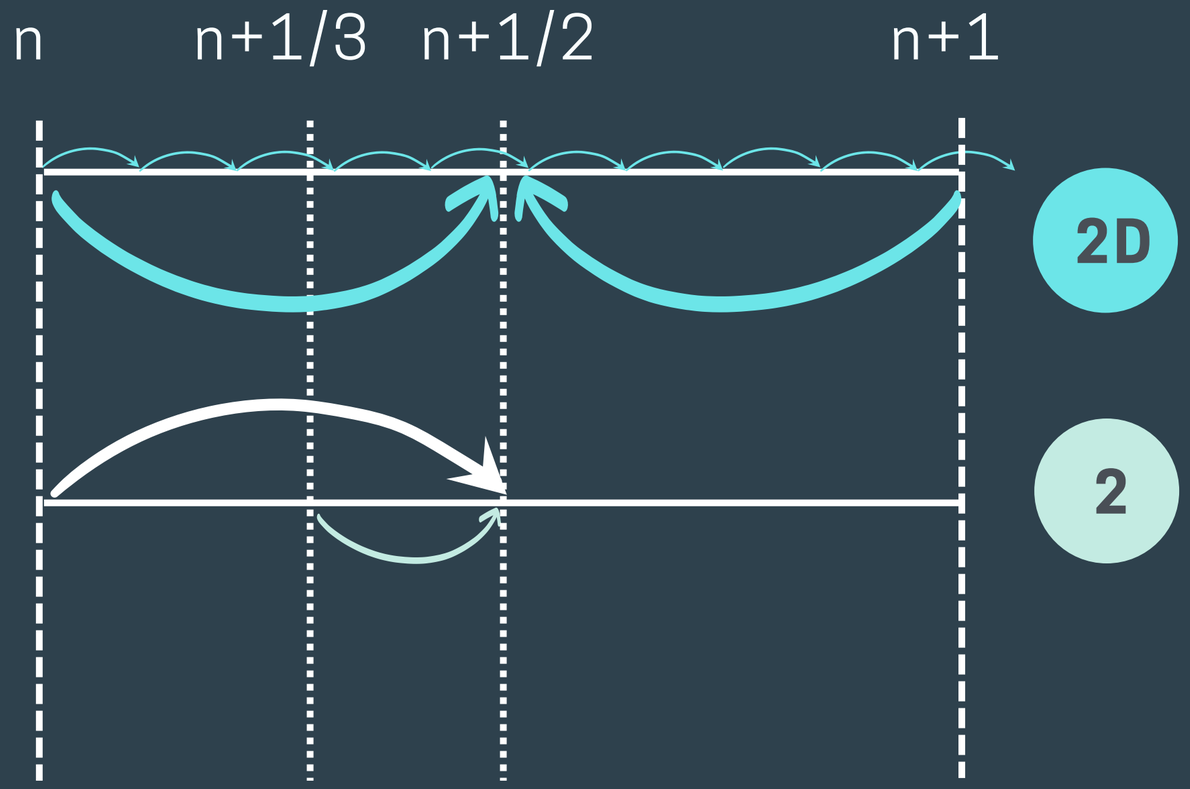
J. Chanut, A. Coward, S. Masson, C. Rousset

What is NEMO's RK3 ?



1. ADVECTIVE PROCESSES ONLY
2.
3. FULL EQUATION WITH FORCINGS

Coupling with barotropic splitting mode



BAROTROPIC EQUATIONS
integrated with 2D Demange solver

BAROCLINIC ADVECTIVE PROCESS
fed with **linearly intepolated** barotropic variables

PRELIMINARY RESULTS

30%

RK3 SPEED UP

eORCA025 (A. Coward)	MLF	RK3
time step (min)	24 min	36 min
time step duration	0.71	0.78
simulation duration	**4h20 min**	**3h10 min**
simulation year/day	5.43	7.69

RK3 in NEMO

IMPLEMENTATION AND
VERIFICATION IN NEMO

Analysis

PERFORMANCE AND
SCIENTIFIC VALIDATION

Not much left

BUT DEVIL IS IN THE DETALS