The influence of hydrodynamic processes on zooplankton distributions and displacements in the North Western Mediterranean Sea: estimates from a Lagrangian model

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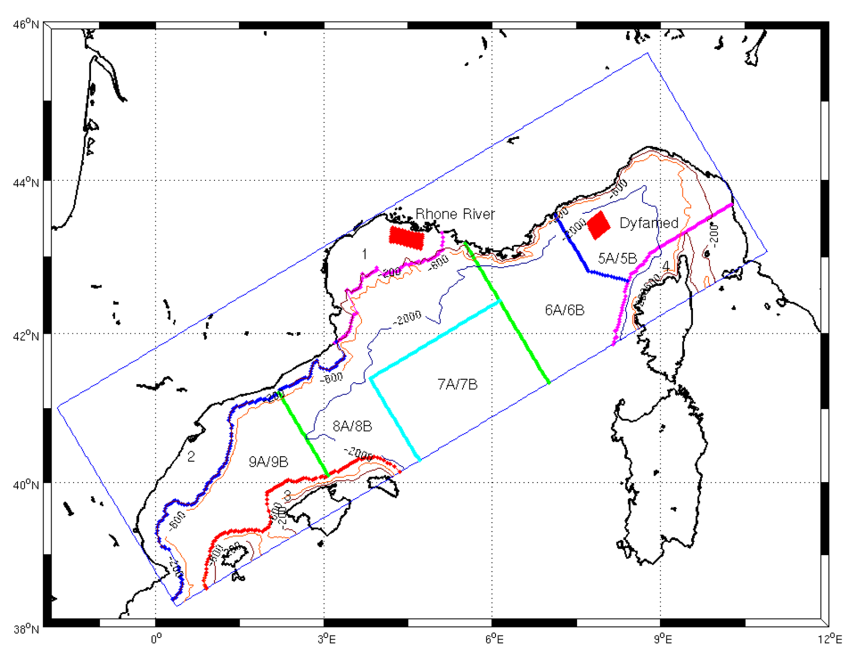
Introduction

Hydrodynamic processes are crucial for zooplankton transport and distribution. Investigating the relationships between zooplankton distribution and hydrodynamic processes provides a rational to understand the influence of such physical structures on the dynamics of local ecosystems.

A Lagrangian model is used to investigate zooplankton distributions in relation to hydrodynamic processes in the North Western Mediterranean Sea (NWMS), coupled with the 3-D culation Symphonie model (described by Marsaleix et al., 2008 and references therein)



Domain of the North Western Mediterranean Sea considered in the model and the corresponding bathymetry. Red squares: particles release locations. The model domain is divided into 9 sectors for the analysis of particle distribution. Sectors indicated with A/B considered the layer upper 200 m depth (A) and the layer below 200 m depth (B).

A preliminary estimation of zooplankton transport and distribution is provided during the spring and summer period (March-August, 2001). And zooplankton diel vertical migration (DVM) has been considered by a primary scheme compare to zooplankton has been taken as passive drifter.

Materials and methods

Symphonie model:

simulate for one year from Jan. 1st, 2001

use the ALADIN wind forcing , every 3 hours

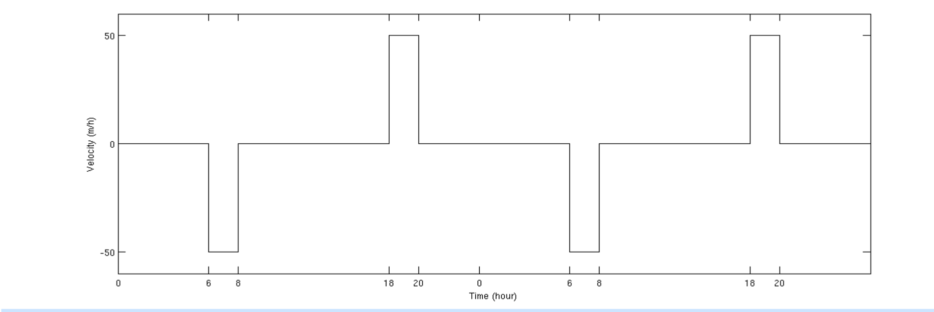
output variations every day:

depth, daily averaged velocity fields, temperature, salinity and so on

Lagrangian model:

We use an advanced lagrangian particle-tracking code (ROFF, detailed introduced by Carr, 2007) to simulate zooplankton (particle) trajectories from stored Symphonie velocity fields.

A particle reflection condition is implemented at the model rigid boundaries in all simulations. And particles leaving the model domain through the open boundaries are assumed to be lost.



Parameters and settings:

Time step: 300s

Symphonie data: temporal resolution of 24h

Starting time:

March 1–August 31,2001,every 3 days

Simulating time: 40 days

Particles release information:

Location: Rhone river and Dyfamed

Depth: -5m (Rhone River and Dyfamed)

-20m (Rhone River) -100m(Dyfamed)

Number:100 particles at each layer in each location

Vertical migration:

1. (Without DVM) passive particles
2. (With DVM) the DVM considered during two time periods:

6:00-8:00: a particle only if the depth is upper than -50m (on 6:00), sinking with 50m/h;

18:00-20:00: all particles going up with 50m/h

Results

1. Influence of hydrodynamic processes on zooplankton transport without DVM

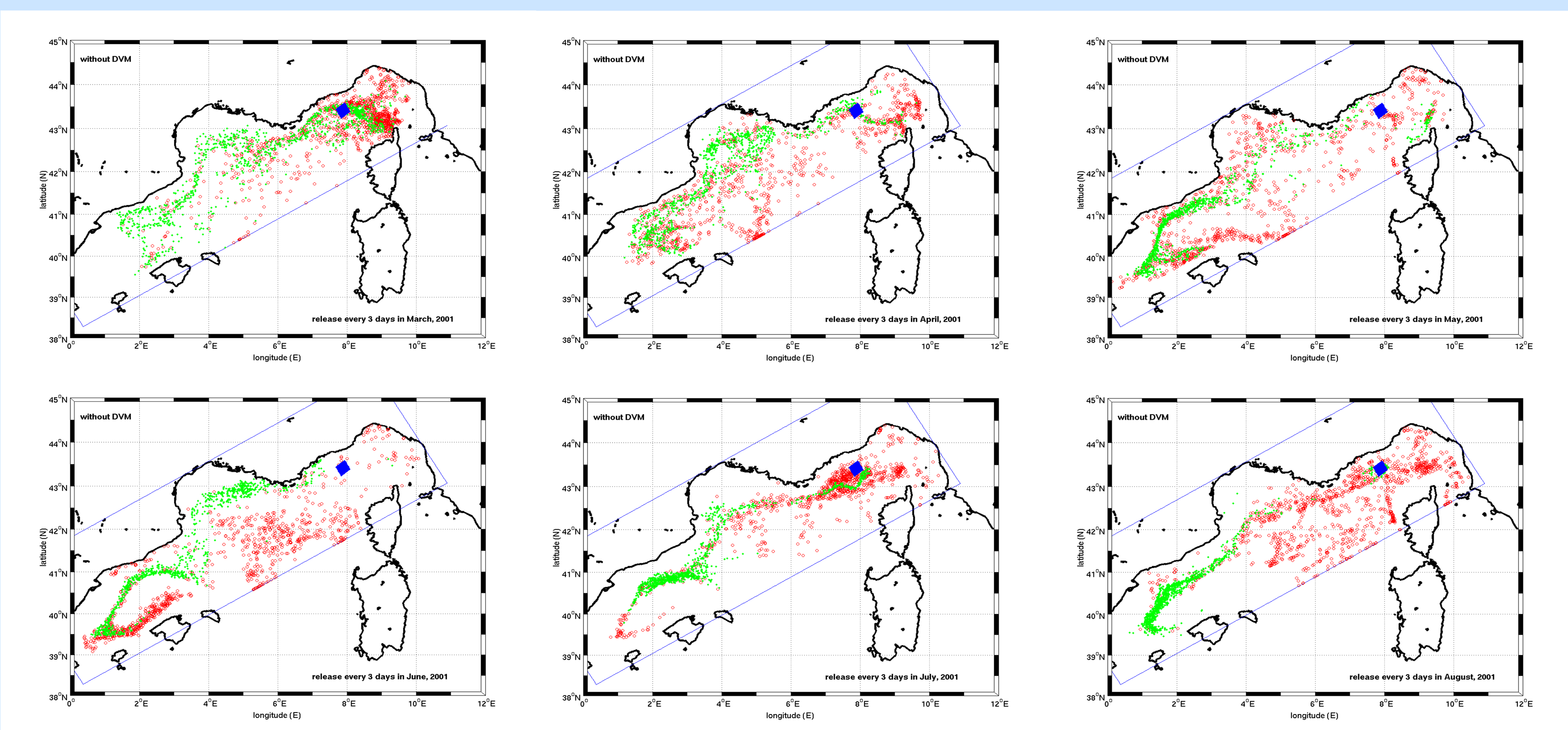
Particles release at Dyfamed

Affected by the hydrodynamic processes and especially the strong North Current (NC), the particles could launch almost anywhere in the NWMS, after being transported for 40 days.

Strong seasonal patterns appear in the final distributions of the particles, which dues to the seasonal variability of the circulations, especially the North Current.

With the influence of the vertical variability of the currents, the final distributions are different with the particles released at different depths.

During the simulations, very few particles can enter into the GoL. The North Current is a barrier for particles entering the continental shelf in the GoL from the offshore seas.



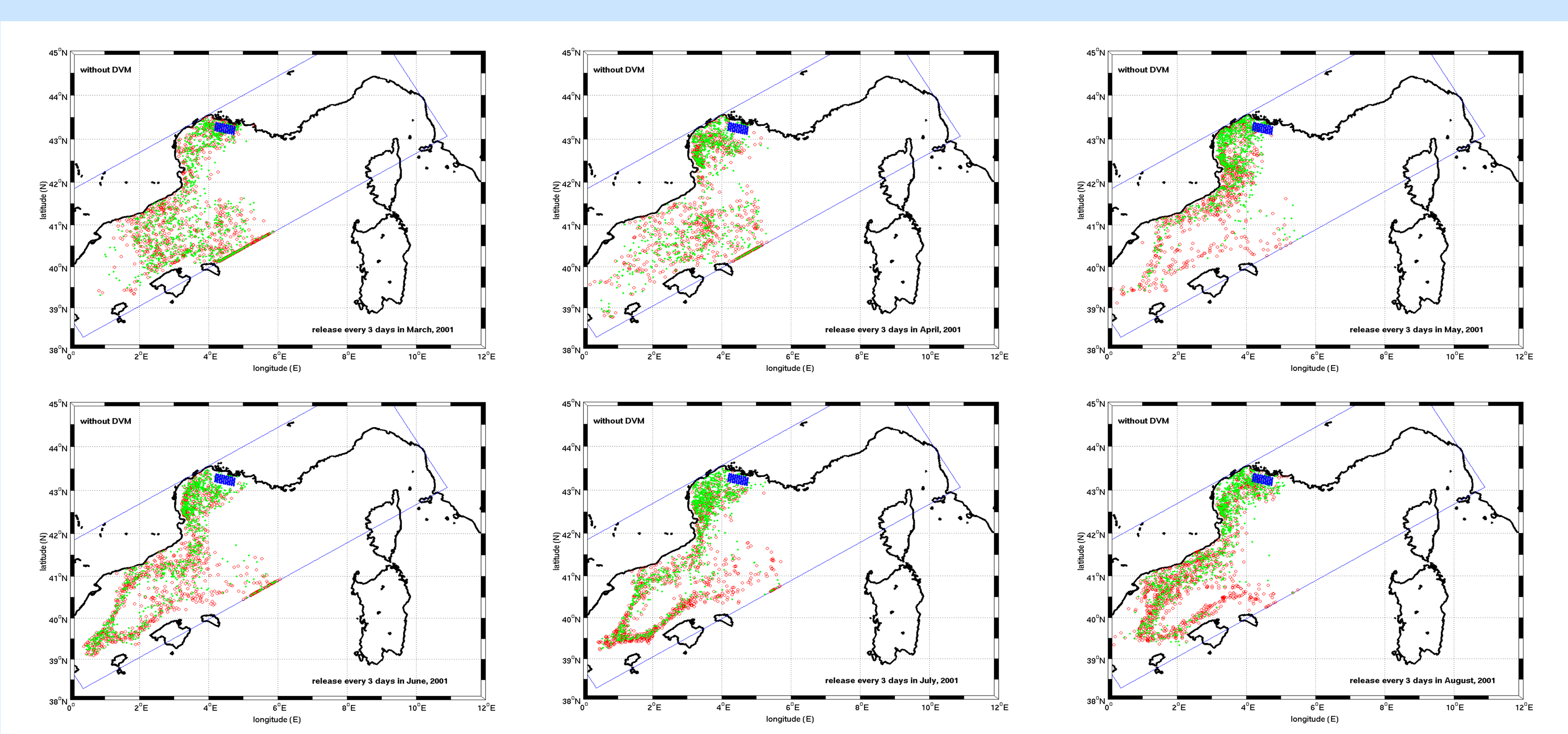
The locations of particles released at Dyfamed in different months without DVM. Red points: final positions after 40 days of particles released at -5m; Green points: final positions after 40 days of particles released at -100m; Blue square: release locations.

Particles release at Rhone River

At the end of the simulations, the distributions of the particles are separated into two parts: one remains in the GoL and the other goes out. The out-going particles scatter in the path of the North Current and in the Catalan Sea.

During the simulations from March to August 2001, affected by the current fields in the GoL, 1/3~1/2 particles remain in the GoL after 40 days. So the GoL could be considered as a retention area for the zooplankton transport and distributions.

Weak seasonal patterns appear in the final distributions of the particles. No one particle enters into the Ligurian Sea during the simulations.



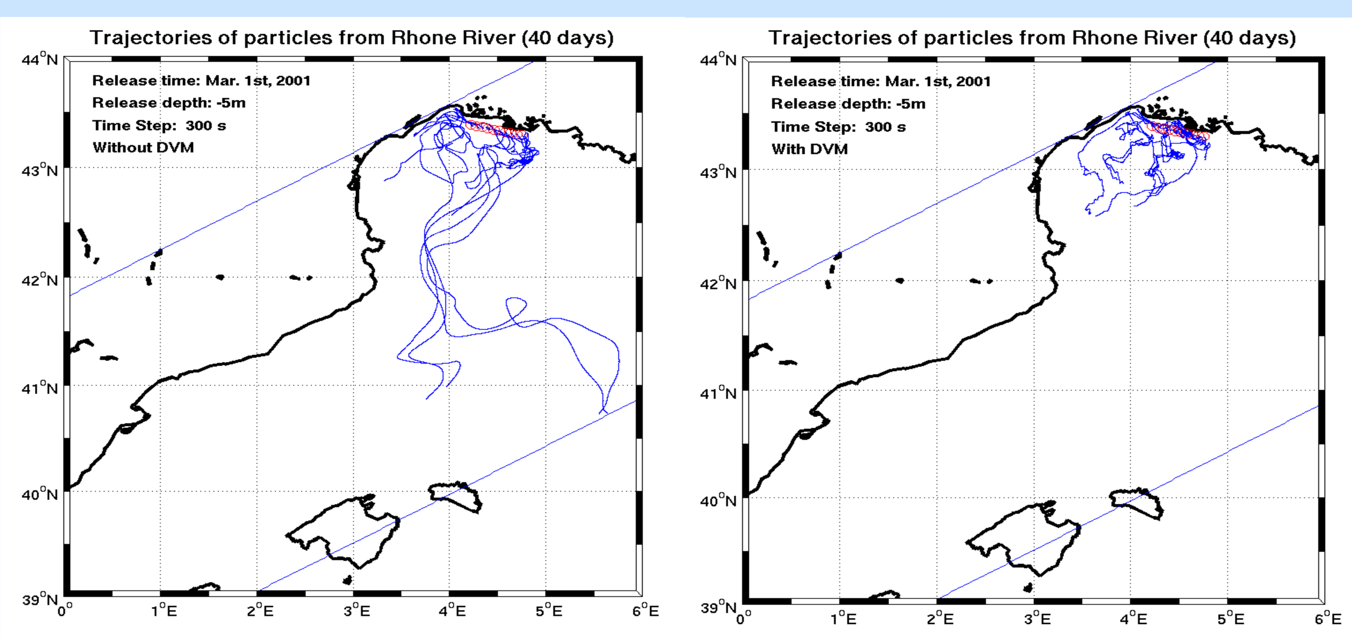
The locations of particles released at Rhone River in different months without DVM. Red points: final positions after 40 days of particles released at -5m; Green points: final positions after 40 days of particles released at -20m; Blue square: release locations.

2. Influence of hydrodynamic processes on zooplankton transport with DVM

The distributions of the particles released at Dyfamed with DVM are similar with the cases of the particles without DVM. However, DVM is important for the transport and distributions of the particles released at Rhone River. From the below table, less particles remain in the GoL at the end of the simulations and more particles go into the NC and enter in the Catalan Sea. As the directions and the velocities of the current are different at the different vertical layers in the GoL, and the DVM scheme will make the particles remain longer at the surface and at the bottom of the water, the transport and distributions of the particles with DVM will be different from those without DVM.

Distributions (%) of the particles after 40 days released at Rhone River in every 3 days from Mar. 1st to Aug. 31st , 2001. Numbers in black represent the percentage of the particles simulated without DVM and red is with DVM. Numbers with green background remark the percentages of the particles is over 1/3 without DVM, and the yellow background is for the particles with DVM.

	1		2		3		4		5A		5B		6A		6B		7A		7B		8A		8B		9A		9B	
March	24	10	3	3	5	7	0	0	0	0	0	0	0	0	0	0	16	<1	0	0	38	46	<1	<1	14	32	<1	<1
April	47	32	1	2	1	3	0	0	0	0	0	0	0	0	0	0	12	6	0	0	26	22	0	<1	12	32	<1	2
May	56	42	4	2	<1	<1	0	0	0	0	0	0	0	0	0	0	2	<1	0	0	29	51	0	<1	10	4	0	0
June	35	16	2	<1	2	<1	0	0	0	0	0	0	0	0	0	0	7	0	0	0	27	47	0	<1	28	36	0	<1
July	34	23	1	<1	3	<1	0	0	0	0	0	0	0	0	0	0	5	<1	0	0	25	49	0	<1	32	28	0	0
August	36	20	7	<1	3	<1	0	0	0	0	0	0	0	0	0	0	<1	0	0	0	23	39	0	<1	30	39	0	<1



The trajectories comparisons between the particles released without DVM and with DVM. Here for instance, only the trajectories of 10 particles released at Rhone River are shown.

An example to the particles remain in the GoL with DVM while go out of the GoL without DVM. The reason is the directions of the currents are different vertically in the southeastern areas of the GoL, and the particles depths with DVM are different from without DVM.

Conclusions

Up to now, we have developed a lagrangian tool to simulate the transport and distributions of particles using the Symphonie model output. The particles could be zooplankton, sediments and other passive particles. A primary DVM scheme has been considered for zooplankton. Simulations in the NWMS show that particles transport and distributions are strongly related to the hydrodynamic structures on the shelf and to the offshore circulations associated with the NC.

Acknowledgements

We thank Dr. Capet for kindly providing the ROFF codes.

Dr. Qiu is funded by CNRS.

References

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2. Carr, S.D., Capet X.J., Mcwilliams, J.C., et al., 2007. The influence of diel vertical migration on zooplankton transport and recruitment in an upwelling region: estimates from a coupled behavioral-physical model. Fisheries oceanography, doi:10.1111/j.1365-2419.2007.00447.x