



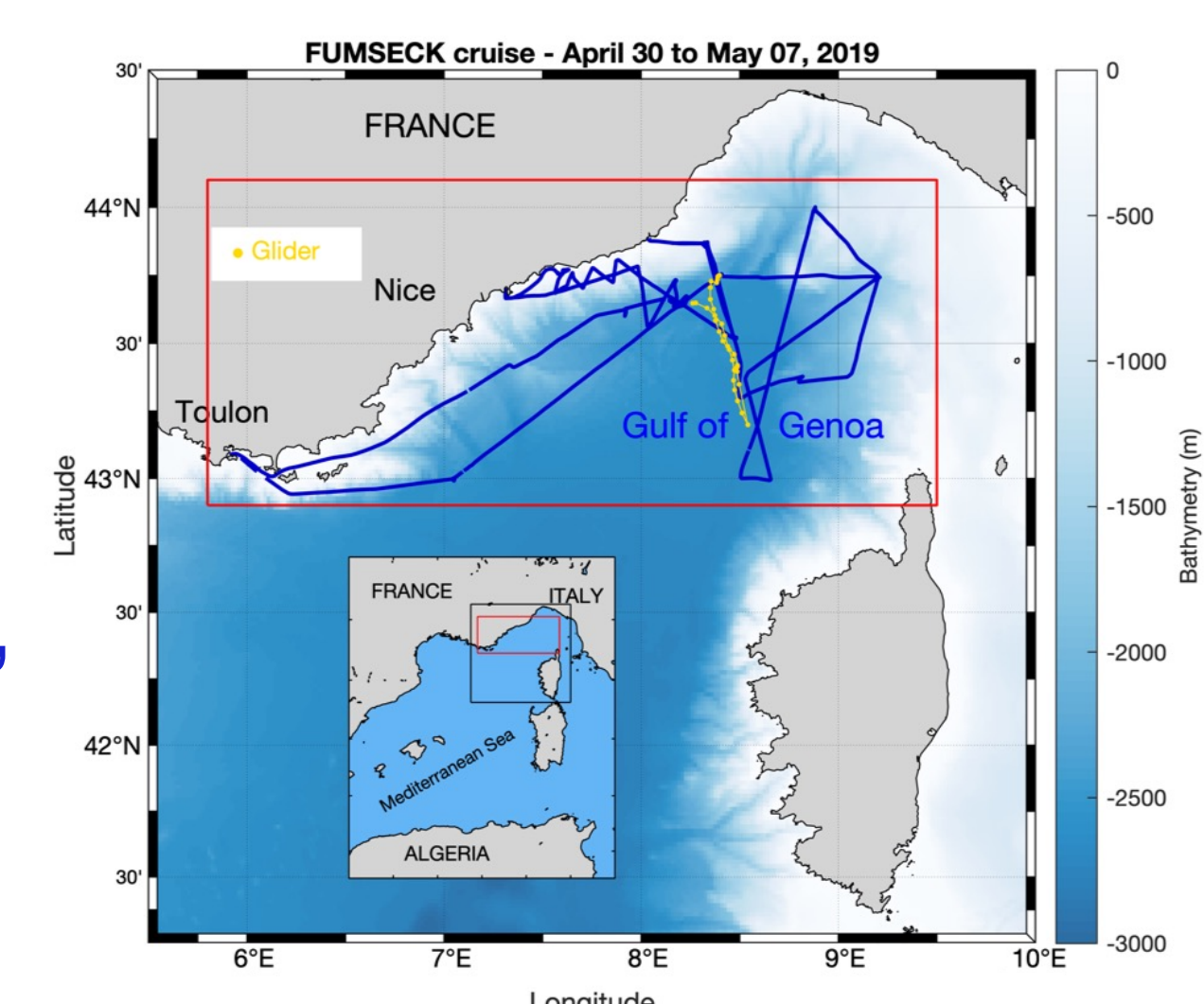
Phytoplankton reaction to an intense storm in the north-western Mediterranean Sea

Stéphanie Barrillon¹ (stephanie.barrillon@mio.osupytheas.fr), Robin Fuchs^{1,2}, Anne Petrenko¹, Caroline Comby, Anthony Bosse¹, Christophe Yohia³, Jean-Luc Fuda¹, Nagib Bhairy¹, Frédéric Cyr⁴, Andrea Doglioli¹, Gérald Grégori¹, Roxane Tzortzis¹, Francesco d'Ovidio⁵, and Melilotus Thyssen¹

Biogeosciences, 20, 141–161, 2023 <https://doi.org/10.5194/bg-20-141-2023>

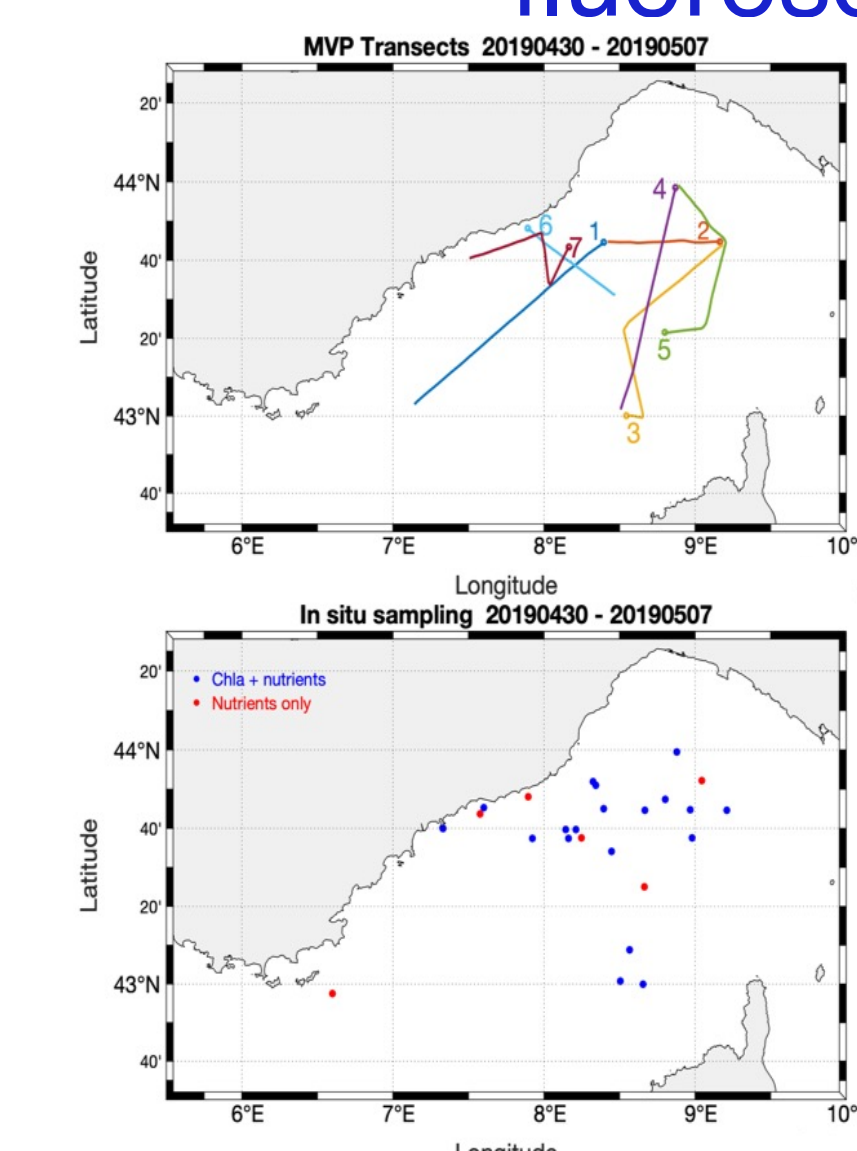
Context

- Storms → affects ocean physics and biogeochemistry
- Poorly explored in situ
- Intense wind episode - Spring 2019, Ligurian Sea, FUMSECK cruise



Methods

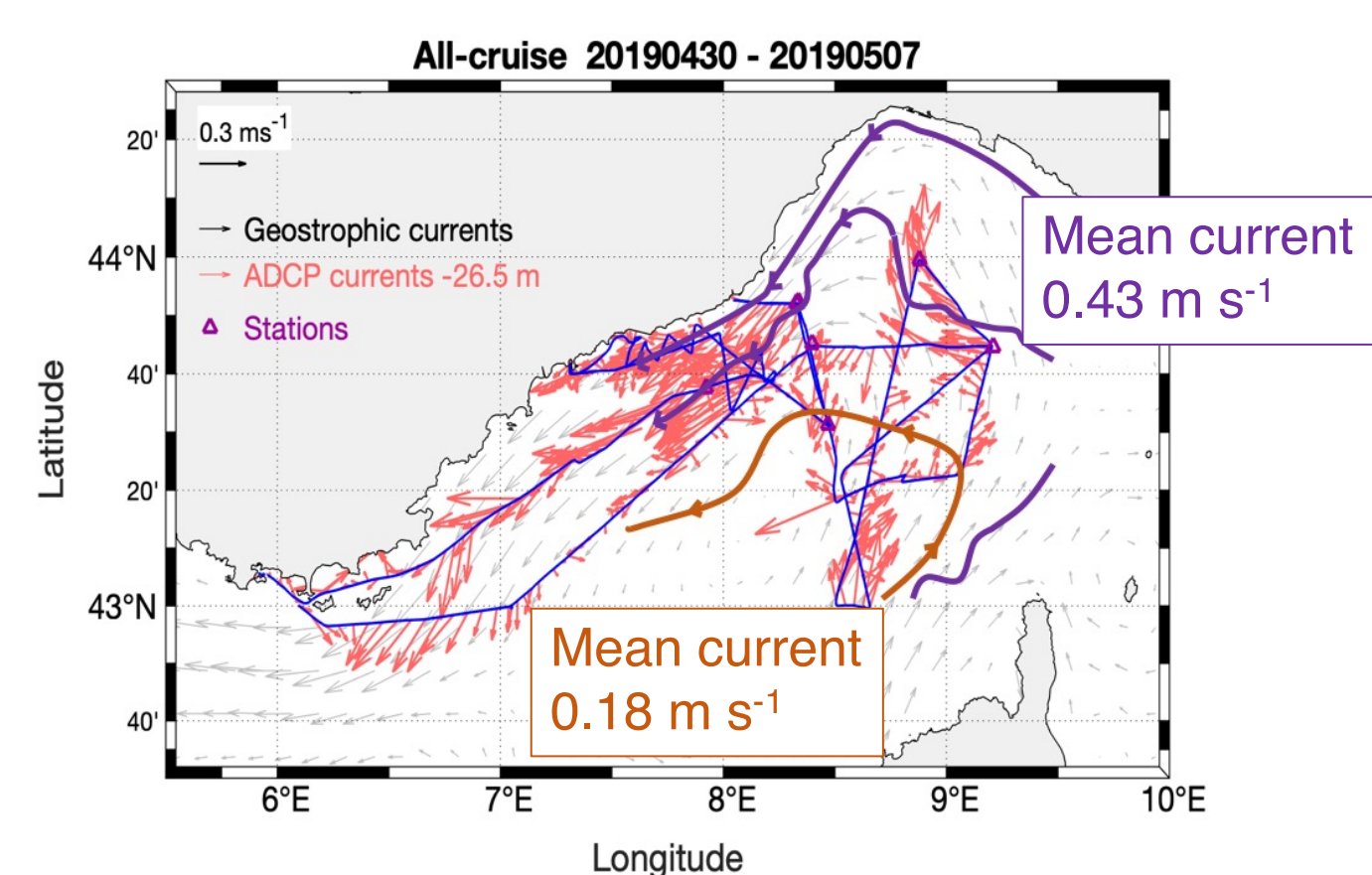
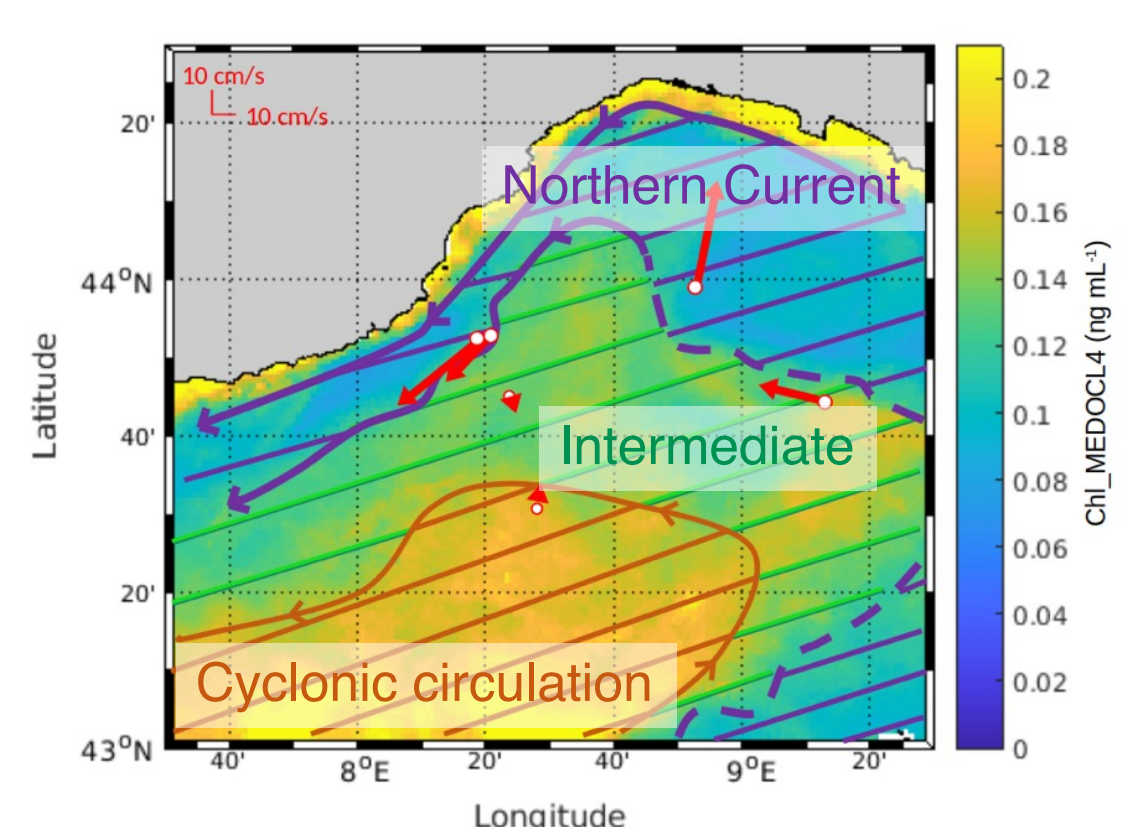
- High-resolution physical and biogeochemical measurements
- Meso(sub)scale dynamics
- In situ multi-platform: Vessel-Mounted ADCP, thermosalinometer, fluorometer, automated flow cytometer, MVP with multi-sensor towed vehicle, glider + satellite, 3D-atmospheric model
- Physics : currents, salinity, temperature
- Biogeochemistry: nutrients, Chl a, fluorescence, phytoplankton groups



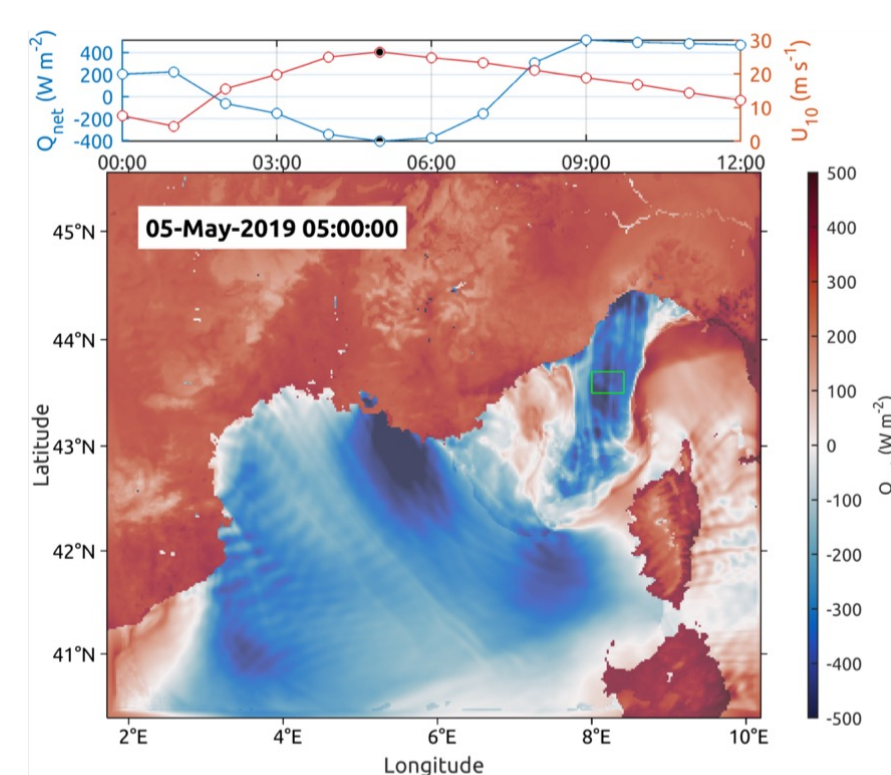
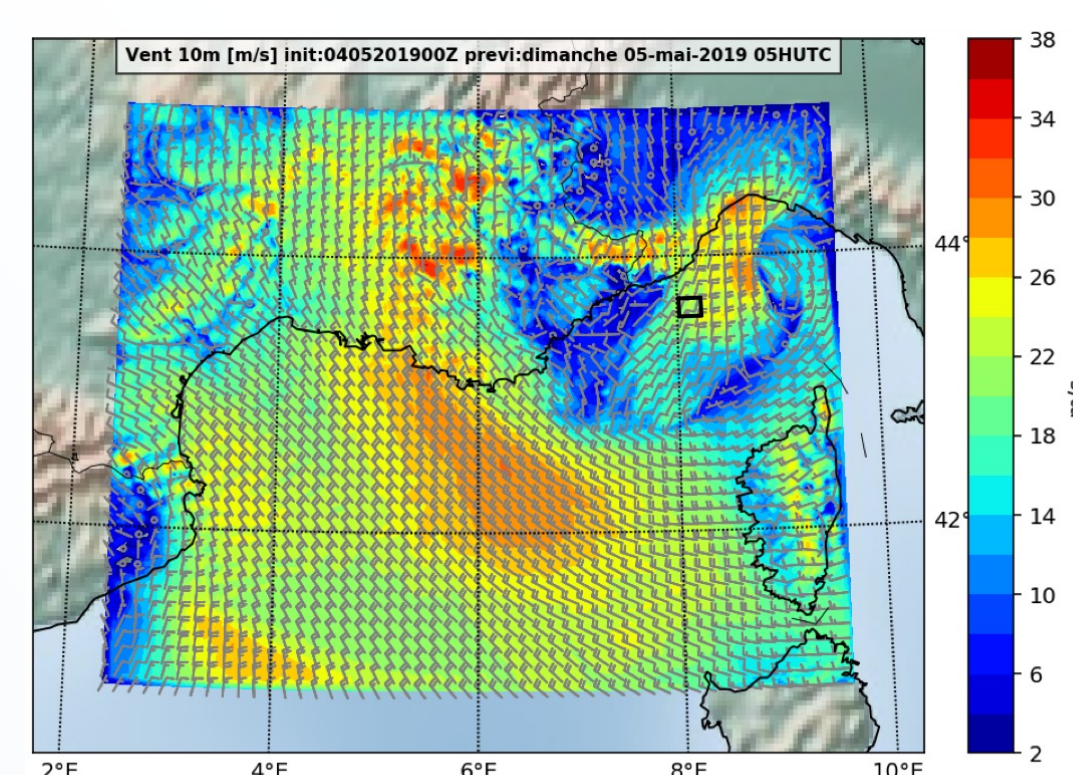
Observable	Abbreviation/name	Vertical range	Sampling resolution	Source
Horizontal currents	ADCP currents Geostrophic currents	18–562 m First metres	Entire cruise, 0.4 km resolution Daily, 2 April to 3 July 2019	VM-ADCP Satellite
Conservative temperature	Θ_{tsg} Θ_{mvp} Θ_{glider}	2 m 0–308 m 0–600 m	Entire cruise, 0.2 km resolution Seven transects, 1.3 km resolution Two transects, 1 km resolution	TSG MVP Glider
Absolute salinity	S_{tsg} S_{mvp} S_{glider}	2 m 0–308 m 0–600 m	Entire cruise, 0.2 km resolution Seven transects, 1.3 km resolution Two transects, 1 km resolution	TSG MVP Glider
Fluorescence	RFluo_tsg RFluo_cyto FLappi	2 m 2 m 0–600 m	Entire cruise, 0.2 km resolution 400 samples, 3.9 km resolution Two transects, 1 km resolution	TSG AFCM Glider
Chlorophyll a	Chl_tsg (converted) Chl_mvp Chl_cyto (converted)	2 m 2 m 2 m	Entire cruise, 0.2 km resolution 20 samples 400 samples, 3.9 km resolution	TSG MVP AFCM
Nutrients	Chl_ACR1 Chl_MEDOCL3 Chl_MEDOCL4	First metres	Daily, 2 April to 3 July 2019	Satellite
Phytoplankton	Abundance, size, biovolume, biomass	2 m	400 samples, 3.9 km resolution	AFCM
Wind intensity	U_{10}	10 m above surface	Entire cruise, hourly, 2 km resolution	Model
Heat flux	Q_{net}	Surface	Entire cruise, hourly, 2 km resolution	Model

Results

Overall circulation

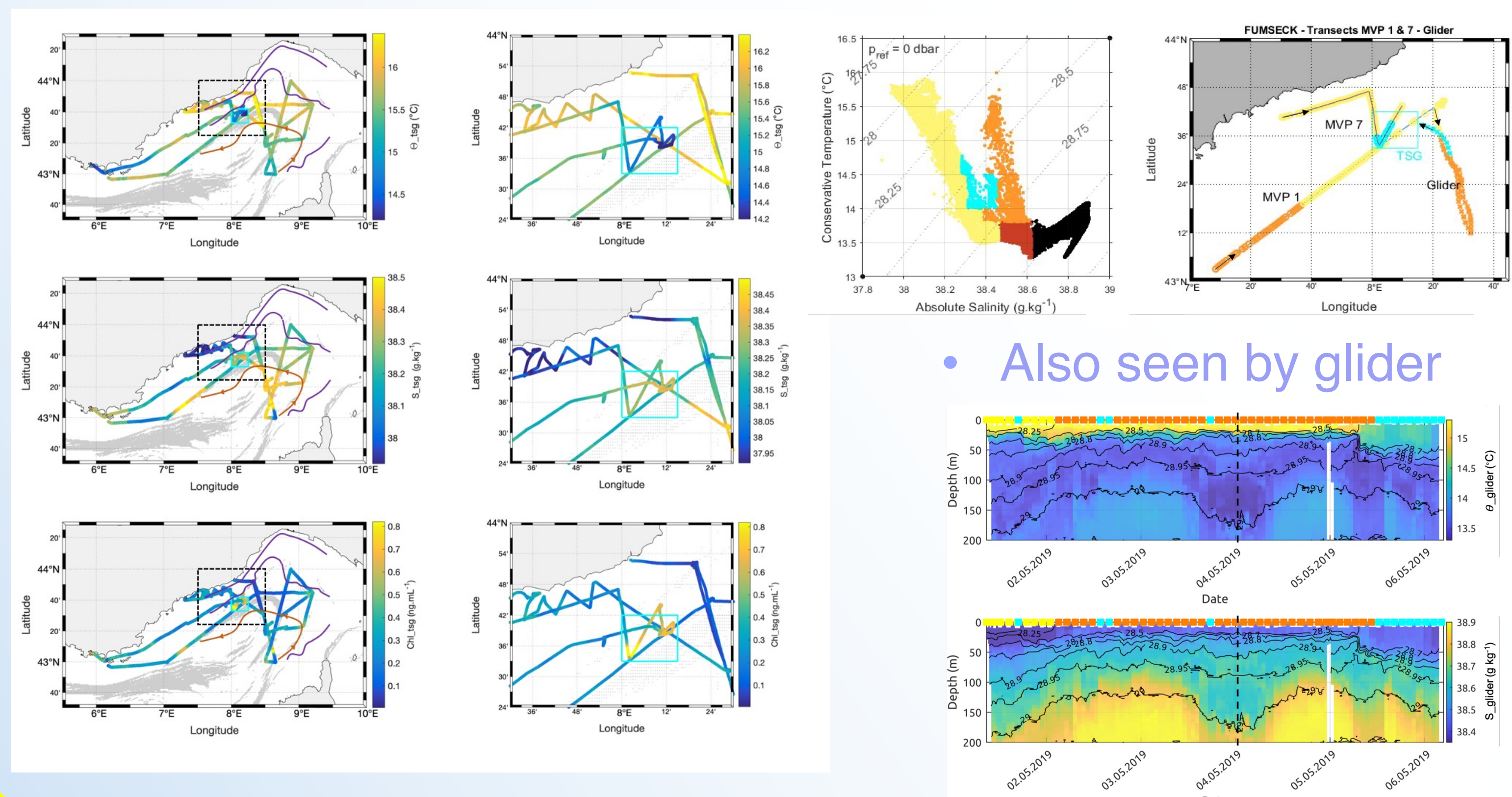


- Storm (model), sampling zone: max 5 May 5:00 UTC, wind intensity = 26 m s^{-1} , heat flux = -400 W m^{-2}

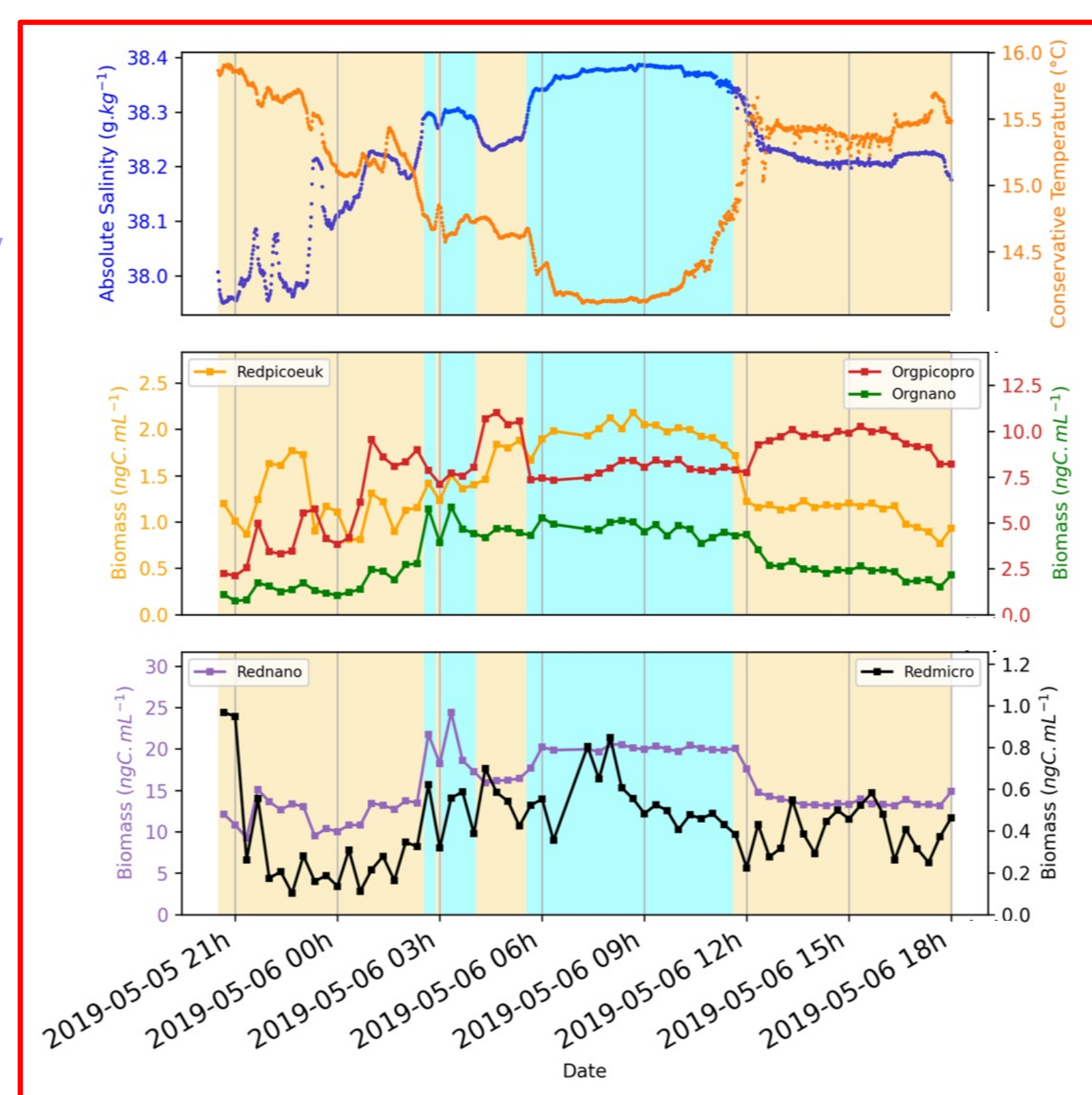


Surface hydrodynamics and hydrology

- After storm: patch low temperature / high salinity
- high Chl a / high nutrient concentrations
- With sharp horizontal gradient → newly mixed waters (cyan)



Also seen by glider



Observable	Water	Organicpro mean ± SD	Redipocouk mean ± SD	Rednans mean ± SD	Organo mean ± SD	Redmicro mean ± SD
Abundance (cell mL ⁻¹)	Overall	51556 ± 21827	1017 ± 473	3686 ± 887	211 ± 192	3 ± 2
	NC surrounding	63239 ± 29087	1175 ± 397	2746 ± 546	169 ± 84	4 ± 2
	Newly-mixed	61162 ± 4898	2334 ± 392	4897 ± 333	325 ± 34	6 ± 1
Size (ESD, μm)	Overall	0.98 ± 1.02	2.18 ± 1.76	3.30 ± 2.45	5.22 ± 4.50	11.38 ± 10.72
	NC surrounding	0.96 ± 0.97	2.14 ± 1.69	3.18 ± 2.35	4.91 ± 4.40	9.98 ± 8.46
	Newly-mixed	0.94 ± 1.02	1.92 ± 1.61	3.02 ± 2.29	4.83 ± 4.45	9.64 ± 8.16
Biovolume (μm ³)	Overall	0.50 ± 0.56	5.53 ± 2.95	19.16 ± 7.91	75.24 ± 47.90	1051.26 ± 1586.96
	NC surrounding	0.47 ± 0.50	5.24 ± 2.58	16.97 ± 6.86	62.6 ± 45.00	585.94 ± 566.35
	Newly-mixed	0.45 ± 0.57	3.72 ± 2.18	14.54 ± 6.32	59.33 ± 46.46	470.97 ± 286.68
Biomass (pgC cell ⁻¹)	Overall	0.14 ± 0.16	1.13 ± 0.66	5.52 ± 2.57	18.00 ± 12.30	165.31 ± 216.90
	NC surrounding	0.14 ± 0.14	1.08 ± 0.59	4.98 ± 2.28	15.36 ± 11.36	105.26 ± 90.60
	Newly-mixed	0.13 ± 0.16	0.90 ± 0.61	4.36 ± 4.12	14.68 ± 11.82	87.70 ± 58.49
Chl_cyto (ng mL ⁻¹)	Overall	0.061 ± 0.051	0.006 ± 0.006	0.184 ± 0.104	0.014 ± 0.015	0.003 ± 0.002
	NC surrounding	0.109 ± 0.060	0.009 ± 0.005	0.173 ± 0.083	0.012 ± 0.001	0.004 ± 0.001
	Newly-mixed	0.160 ± 0.014	0.025 ± 0.005	0.256 ± 0.079	0.032 ± 0.000	0.006 ± 0.001
Biomass (ngC mL ⁻¹)	Overall	7.47 ± 3.97	1.12 ± 0.43	20.30 ± 5.58	3.77 ± 3.75	4.81 ± 4.82
	NC surrounding	7.72 ± 2.71	1.22 ± 0.29	13.58 ± 2.18	2.38 ± 1.69	3.77 ± 1.84
	Newly-mixed	7.90 ± 3.61	1.36 ± 0.24	20.05 ± 1.39	4.77 ± 4.81	5.34 ± 1.26
BiomassChl_cyto	Overall	158.10 ± 56.3	268.4 ± 99.2	127.4 ± 43.2	292.1 ± 71.6	206.4 ± 202.5
	NC surrounding	86.8 ± 36.3	158.8 ± 40.9	87.5 ± 21.8	218.5 ± 53.2	115.6 ± 94.2
	Newly-mixed	40.6 ± 3.8	76.8 ± 9.5	38.6 ± 4.3	145.4 ± 9.9	93.6 ± 142.0

Surface fluorescence →
Same integrated fluorescence
Mixed-layer depth → (15 to 50 m)

Conclusion / Discussion

- Rare and intense storm → abrupt changes in water and surface phytoplankton, mixed-layer depth deepened from 15 to 50 m, Deep Chlorophyll Maximum diluted
- Biomass ↗, carbon/Chl a ratio ↘ → significant changes in cell composition
- Only short term, importance of coupling physics / biogeochemistry at high resolution for improving knowledge of the impact of storms

