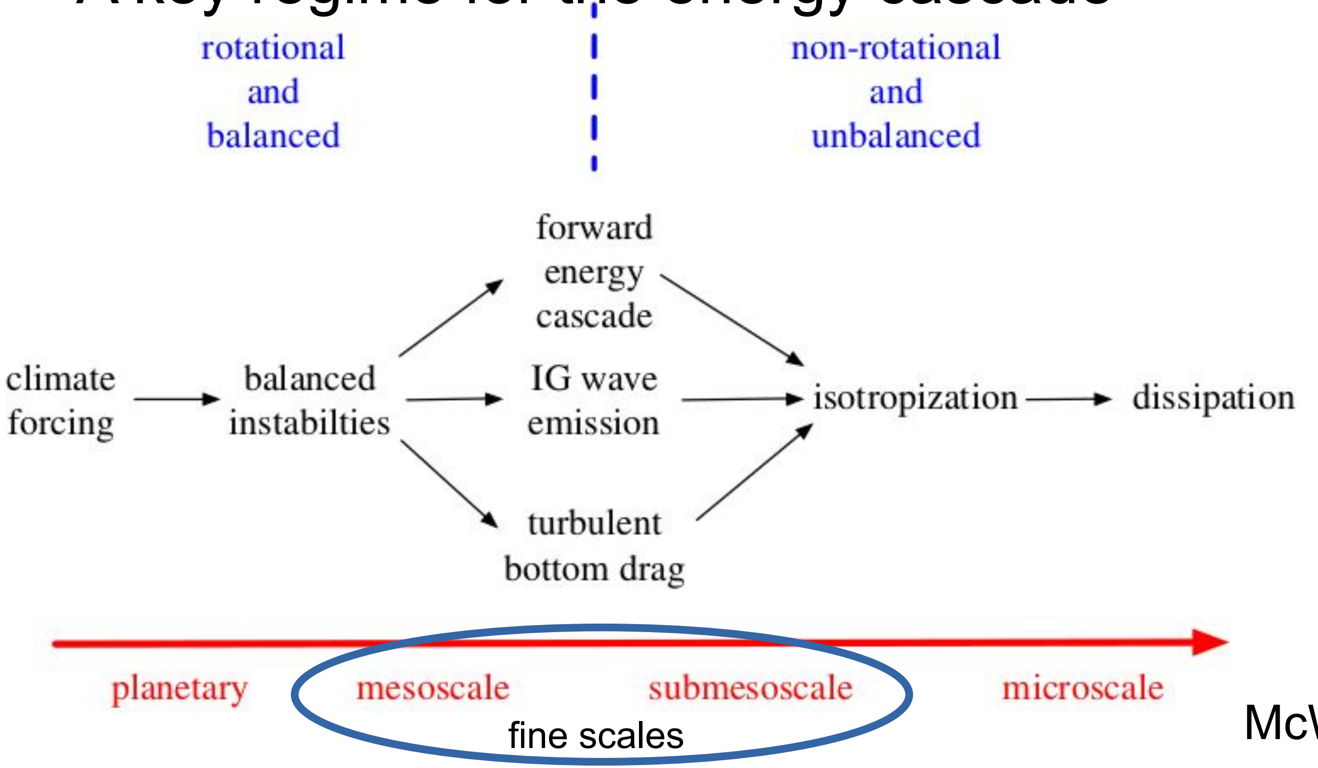
Regional Validation Working Group Splinter Session

F. d’Ovidio, J. Wang, A. Pascual – slides from R. Rolland, L. Rousselet, SWOT Science Team

The « Fine Scales »
mesoscale and submesoscale (1-100 km, days – weeks)
A key regime for the energy cascade



McWilliams, 2016

A key regime for the energy cascade and for creating contrasted properties

First hints the ’60-’70.

« Blind » discover of the fine scales

Deep-Sea Research, 1974, Vol. 21, pp. 499 to 528. Pergamon Press. Printed in Great Britain.

Energy partition in the large-scale ocean circulation and the production of mid-ocean eddies

A. E. GILL,* J. S. A. GREEN† and A. J. SIMMONS‡

OVER THE past century, a picture of the mean circulation of the ocean has been built up from temperature and salinity measurements (DEFANT, 1961). The mean currents (see Fig. 1) are only a few centimeters per second except in special regions of concentrated currents like the Gulf Stream. However, direct measurements of currents have shown that the kinetic energy in time-dependent currents is greater than the kinetic energy of the mean currents and that currents of 0·1 m s^{-1} are commonly observed. The first direct current measurements over a long period (14 months)

Deep-Sea Research, 1974, Vol. 21, pp. 499 to 528. Pergamon Press. Printed in Great Britain.

« Blind » discover of the fine scales

Energy partition in the large-scale ocean circulation and the production of mid-ocean eddies

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observed. The first direct current measurements over a long period (14 months) in mid-ocean were made in 1959 and 1960 in a region 5000 m deep about 250 km west of Bermuda. These measurements have been reported and discussed by CREASE (1962) and SWALLOW (1971). It appears that the eddies observed have wavelengths (PHILLIPS, 1966) of 300–400 km and periods (SWALLOW, 1971) of 50–100 days.

« Blind » discover of the fine scales

An impression of how the eddies may be distributed in the horizontal at a particular time comes from measurements (Fig. 3) of sound velocity at 800 m made by BECKERLE (1972) (see also BECKERLE and LA CASCE, 1973). The sound velocity is related to density

The large eddies also appear as 'noise' on closely spaced hydrographic sections

eddies can play an important role in the general circulation of the ocean. Future observational and model studies should aim to clarify this role in detail for different parts of the ocean.

VOL. 81, NO. 15 JOURNAL OF GEOPHYSICAL RESEARCH MAY 20, 1976

Eddy Energy in the Oceans

KLAUS WYRTKI, LORENZ MAGAARD, AND JAMES HAGER

Department of Oceanography, University of Hawaii, Honolulu, Hawaii 96822

Observations of surface drift currents made by merchant ships are used to calculate the kinetic energy of the mean flow as well as the kinetic energy of the fluctuations, which is interpreted as eddy kinetic energy. The distribution of these properties is charted for the North Atlantic Ocean based on 1° squares and for the world oceans based on 5° squares. Both distributions show essentially the same features, namely, high values in the western boundary currents and in the equatorial current system and low values in the subtropical gyres. The ratio between mean energy and eddy energy is high (about 1 to 2) in the strong currents and low (about 1/20 to 1/40) in the central and eastern portions of the gyres. Comparing mean and eddy energies in ocean and atmosphere, it becomes apparent that eddy energies in the two systems are uncorrelated. The results are consistent with the idea that eddy motion in the ocean is generated in areas of strong mean shear flow and is subsequently distributed over the whole ocean.

First maps of the fine scales

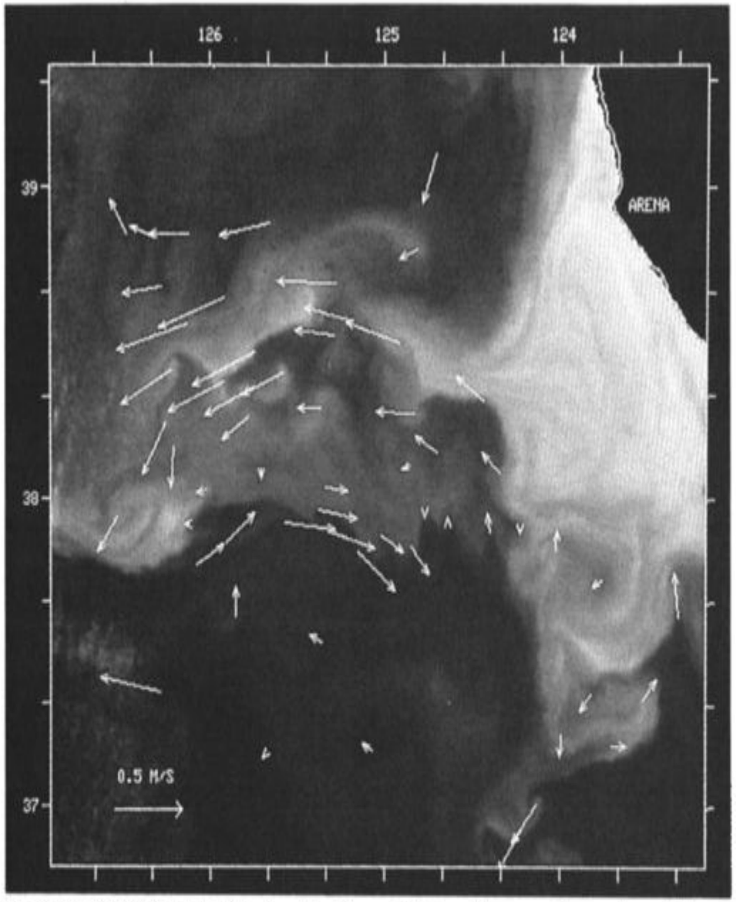
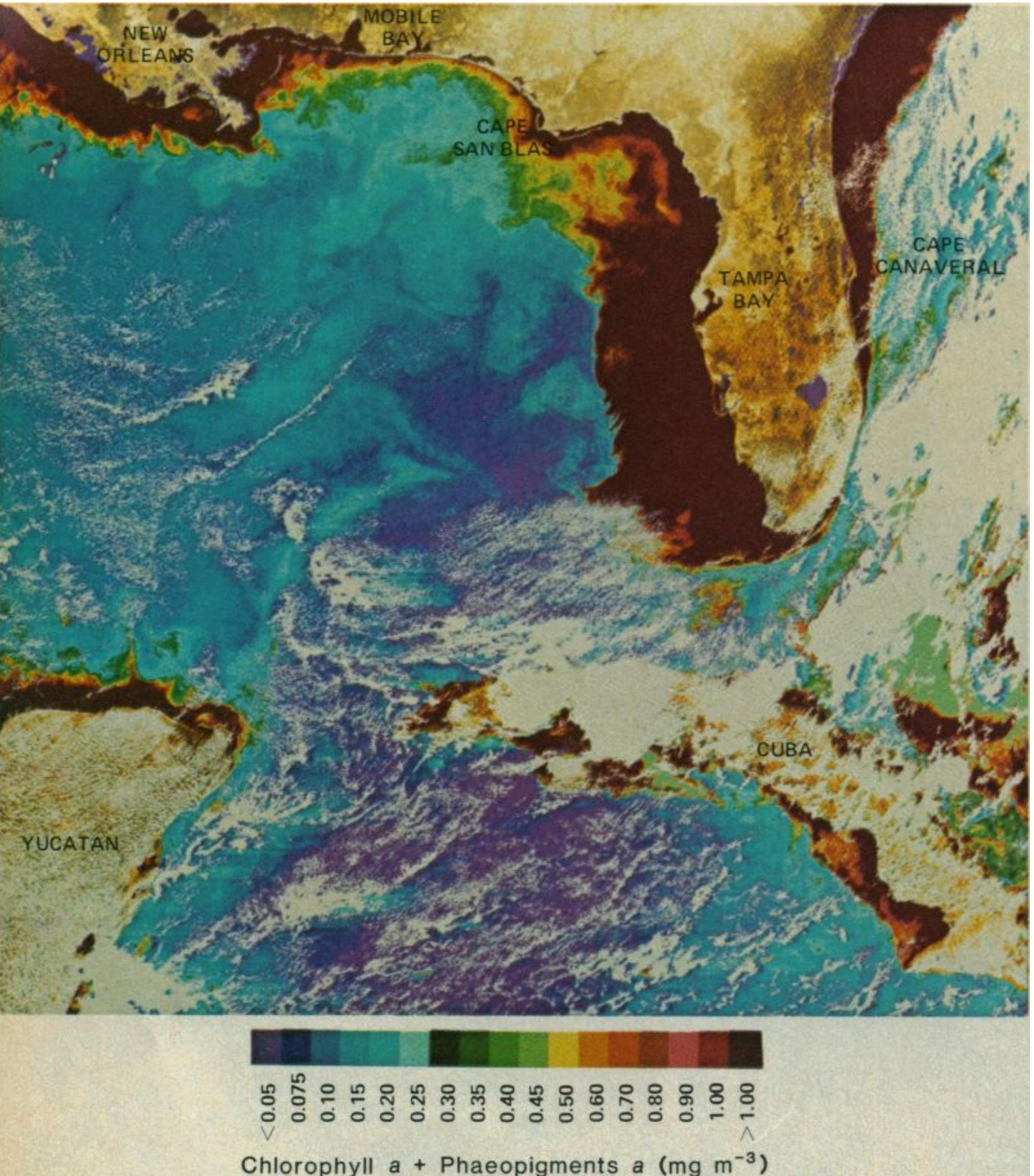


Fig. 8. Mean surface velocity field obtained by tracking thermal features between Figures 6*a* and 6*b* and between 6*b* and 6*c* overlaid on the image for July 22, 1100 UT.

During the ‘70-’80, filaments (submesoscale) also started to emerge from ocean color and sea surface temperature images, suggesting further physical processes as well as the importance of the fine scales on the marine biosphere.

Flament et al. 1985

First maps of the fine scales



During the ‘70-’80, filaments (submesoscale) also started to emerge from ocean color and sea surface temperature images, suggesting further physical processes as well as the importance of the fine-scale variability for the marine biosphere.

«.. to improve our understanding of the state of the standing crop of phytoplankton. This new information may, in turn, lead to improved methods for managing and exploiting fisheries. Another poten- .. »

Nimbus 7 Coastal Zone Color Scanner (2 November 1978)
From Hovis et al. 1980

Fine-scale challenges

1. Energy cascade, heat/material transport, air-sea fluxes, coast-open ocean continuum

Fine scales not resolved, must be parameterized

Earth System Models CMIP6

	Model name	Ocean component	Horizontal	Vertical	
1	ACCESS-CM2	MOM5	1 x 1	z* 50	
2	ACCESS-ESM1-5	MOM5	1 x 1	z* 50	
3	BCC-CSM2-MR	MOM4-L40	1 x 1	z 40	
4	BCC-ESM1	MOM4-L40	1 x 1	z 40	
5	CAMS-CSM1-0	MOM4	1 x 1	z 50	
6	CESM2	POP2	1 x 1	z 60	Dan
7	CESM2-FV2	POP2	1 x 1	z 60	Danabasoglu et al. (2020)
8	CESM2-WACCM	POP2	1 x 1	z 60	Danabasoglu et al. (2020)
9	CESM2-WACCM-FV2	POP2	1 x 1	z 60	Danabasoglu et al. (2020)
10	CNRM-CM6-1	NEMO3.6	1 x 1	z* 75	Voldoire et al. (2019)
11	CNRM-ESM2-1	NEMO3.6	1 x 1	z* 75	Séférian et al. (2019)
12	CanESM5	NEMO3.4.1	1 x 1	z 45	Swart et al. (2019)
13	EC-Earth3	NEMO3.6	1 x 1	z* 75	N/A
14	EC-Earth3-Veg	NEMO3.6	1 x 1	z* 75	N/A
15	GFDL-CM4	MOM6	0.25 x 0.25	ρ - z* 75	Held et al. (2019)
16	GFDL-ESM4	MOM6	0.5 x 0.5	ρ - z* 75	N/A
17	GISS-E2-1-G	GISS Ocean	1.25 x 1	z 40	N/A
18	GISS-E2-1-G-CC	GISS Ocean	1.25 x 1	z 40	N/A
19	GISS-E2-1-H	HYCOM	1 x 1	z - ρ - σ 32	N/A
20	HadGEM3-GC31-LL	NEMO-HadGEM3-GO6.0	1 x 1	z* 75	Kuhlbrodt et al. (2018)
21	INM-CM5-0	INM-OM5	0.5 x 0.25	σ 40	Volodin and Gritsun (2018)
22	IPSL-CM6A-LR	NEMO3.6	1 x 1	z* 75	Lurton et al. (2020)
23	MCM-UA-1-0	MOM1	2 x 2	z 18	N/A
24	MIROC-ES2L	COCO4.9	1 x 1	z - σ 62	Hajima et al. (2020)
25	MIROC6	COCO4.9	1 x 1	z - σ 62	Tatebe et al. (2019)
26	MPI-ESM-1-2-HAM	MPIOM1.6.3	1.5 x 1.5	z 40	Mauritsen et al. (2019)
27	MPI-ESM1-2-HR	MPIOM1.6.3	0.4 x 0.4	z 40	Müller et al. (2018)
28	MPI-ESM1-2-LR	MPIOM1.6.3	1.5 x 1.5	z 40	Mauritsen et al. (2019)
29	MRI-ESM2-0	MRI.COM4.4	1 x 0.5	z* 60	Yukimoto et al. (2019)
30	NESM3	NEMO3.4	1 x 1	z 46	Cao et al. (2018)
31	NorCPM1	MICOM	1 x 1	z - ρ 53	Counillon et al. (2016)
32	NorESM2-LM	MICOM	1 x 1	z - ρ 53	Tjiputra et al. (2020)
33	NorESM2-MM	MICOM	1 x 1	z - ρ 53	Tjiputra et al. (2020)
34	SAM0-UNICON	POP2	1 x 1	z 60	Park et al. (2019)
35	UKESM1-0-LL	NEMO-HadGEM3-GO6.0	1 x 1	z* 75	Sellar et al. (2020)

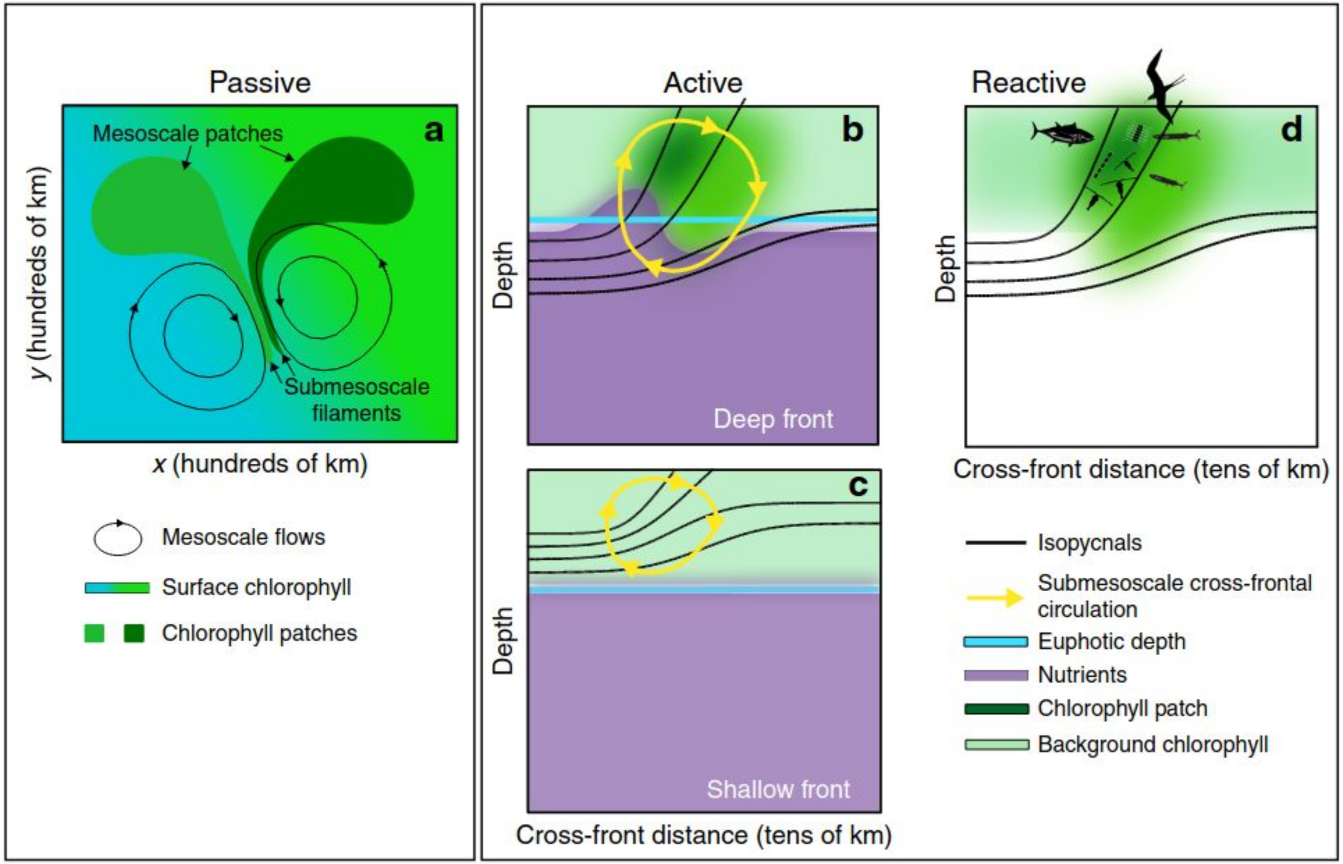
Fine-scale challenges

2. Biogeochemistry and marine ecology

Quite well understood

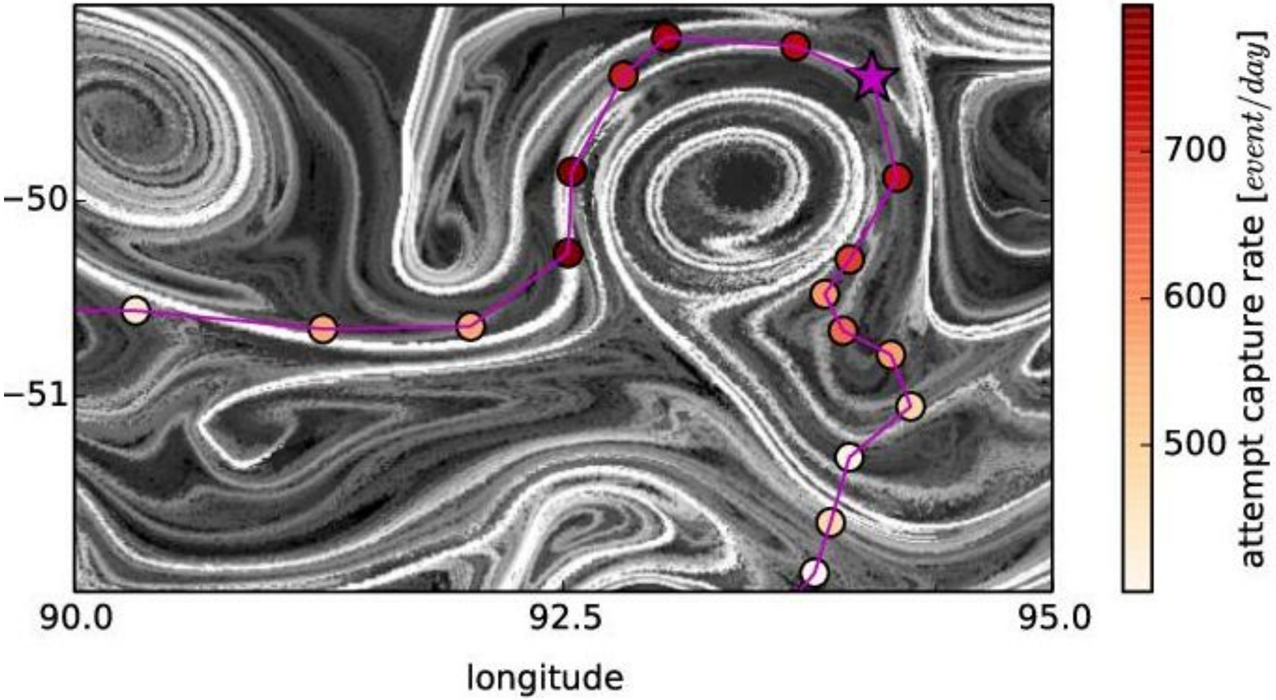
In large part understood

Largely unknown !



Lévy et al. 2018

Fine-scale challenges
2. Biogeochemistry and marine ecology



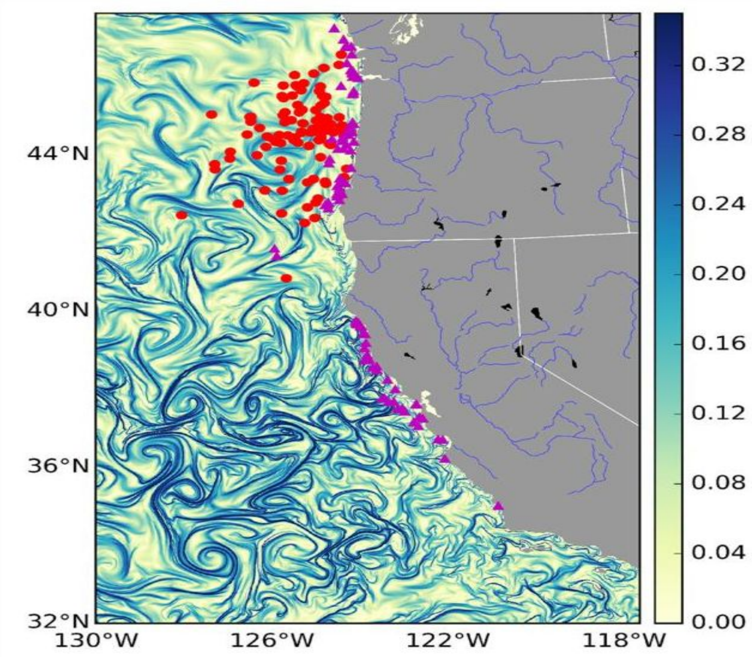
Della Penna et al. Scientific Report 2016

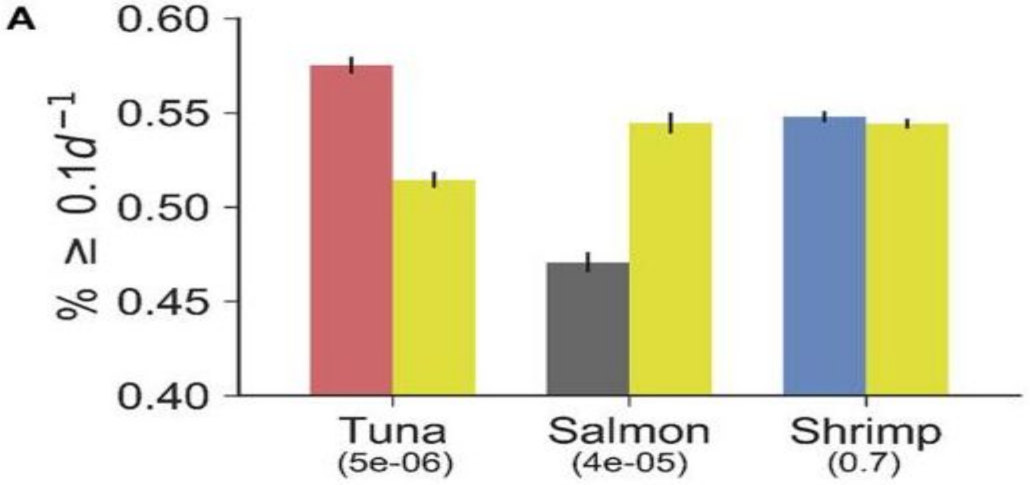
Fine-scale challenges

2. Biogeochemistry and marine ecology

Fishermen Follow Fine-Scale Physical Ocean Features for Finance

James R. Watson[1,2], Emma C. Fuller[3], Frederic S. Castruccio[4] and Jameal F. Samhouri[5]*





Front. Mar. Science 2018

Conservation and management in the open ocean need 1-100 km scale information, and need it soon

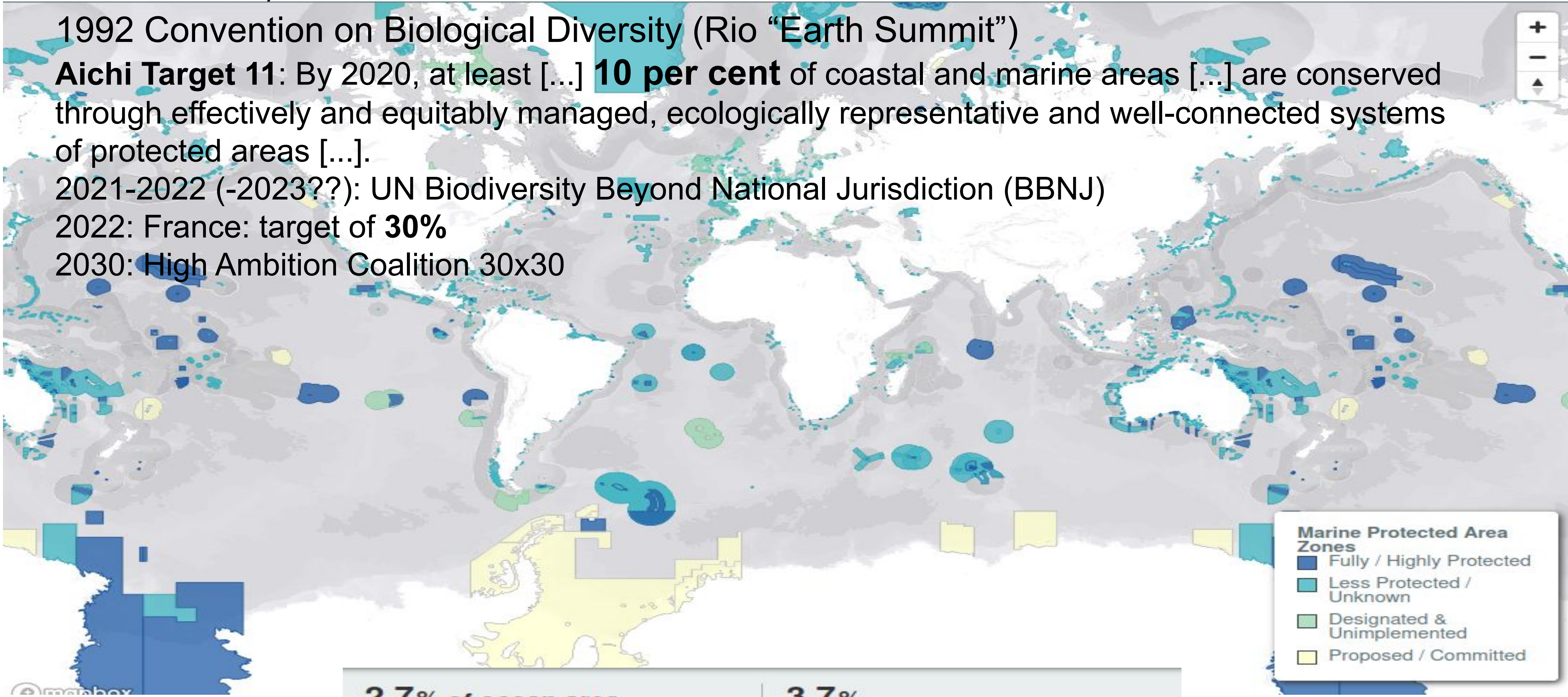
1992 Convention on Biological Diversity (Rio “Earth Summit”)

Aichi Target 11: By 2020, at least […] **10 per cent** of coastal and marine areas […] are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas […].

2021-2022 (-2023??): UN Biodiversity Beyond National Jurisdiction (BBNJ)

2022: France: target of **30%**

2030: High Ambition Coalition 30x30



MARINE CONSERVATION INSTITUTE

MARINE PROTECTION ATLAS

2.7% of ocean area is in implemented and fully / highly protected zones

3.7% is in implemented but less protected zones

Conventional Altimetry

Jason-type constellation

All-weather, global Sea Surface Height, resolution down to 70-100km, ~1 week

Scales <70-100km, <~1 week

Coastal areas

Ageostrophic dynamics

Positional errors ~10+ km

Underestimation of gradients

Large uncertainties in coastal dynamics

Conventional Altimetry

Jason-type constellation

All-weather, global Sea Surface Height, resolution down to 70-100km, ~1 week

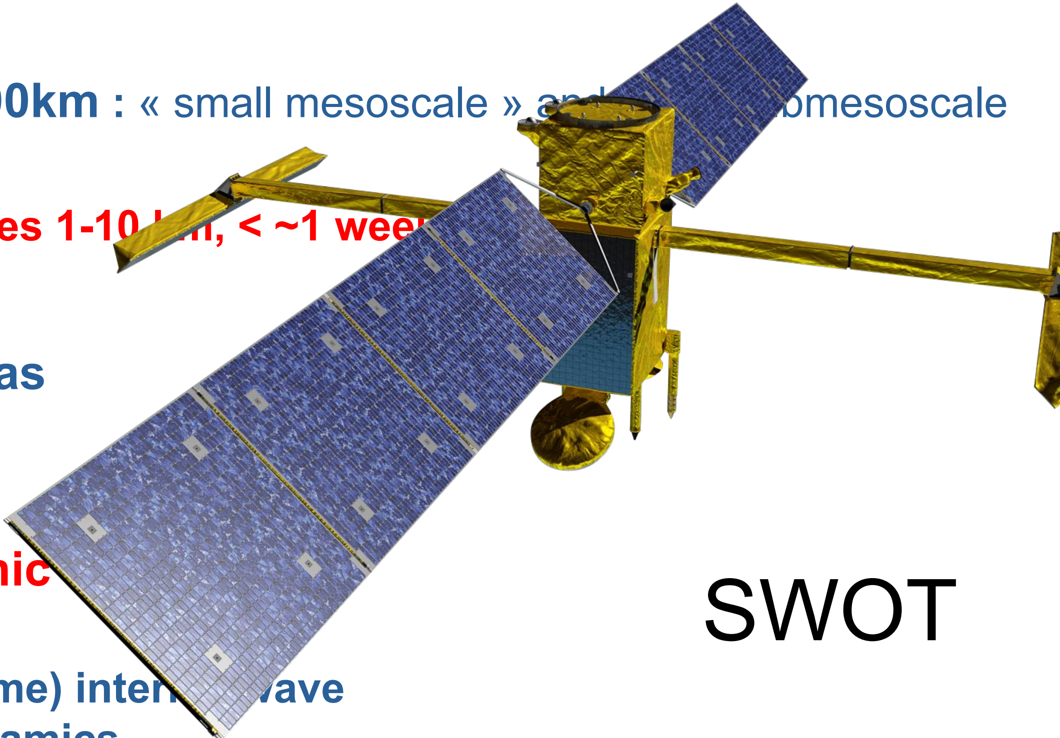
Scales 10-100km : « small mesoscale » an ... bmesoscale

Scales 1-10 ... , < ~1 wee

Coastal areas

Ageostrophic

(some) inter ... wave
dynamics



SWOT

Conventional Altimetry

Jason-type constellation

All-weather, global Sea Surface Height, resolution down to 70-100km, ~1 week

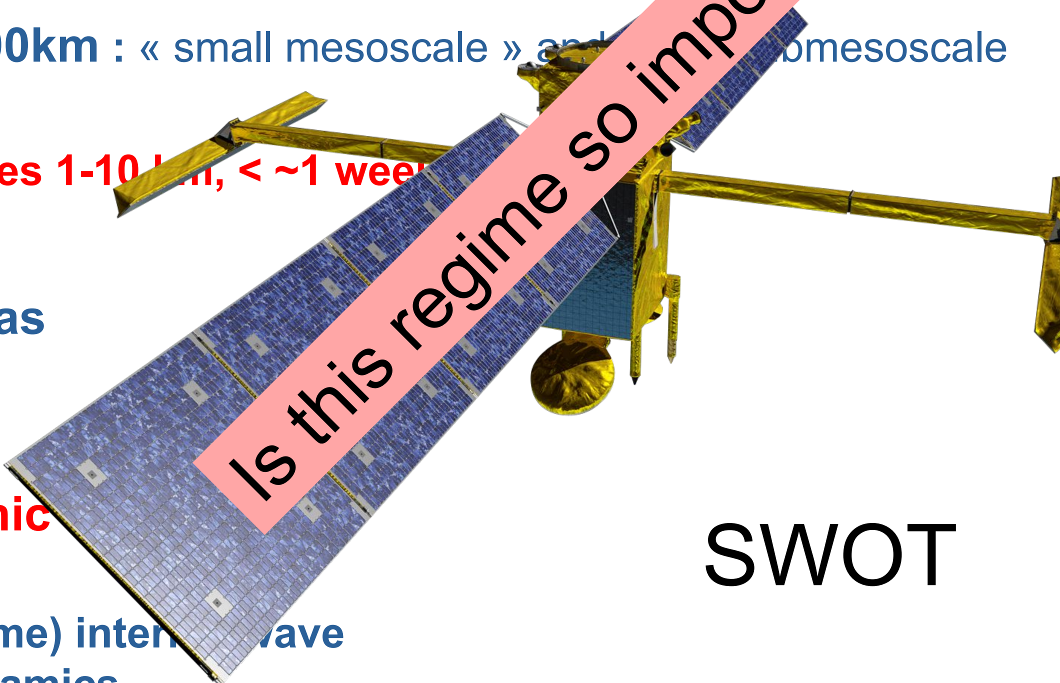
Scales 10-100km : « small mesoscale » an... ...omesoscale

Scales 1-10 ...m, < ~1 wee...

Coastal areas

Ageostrophic

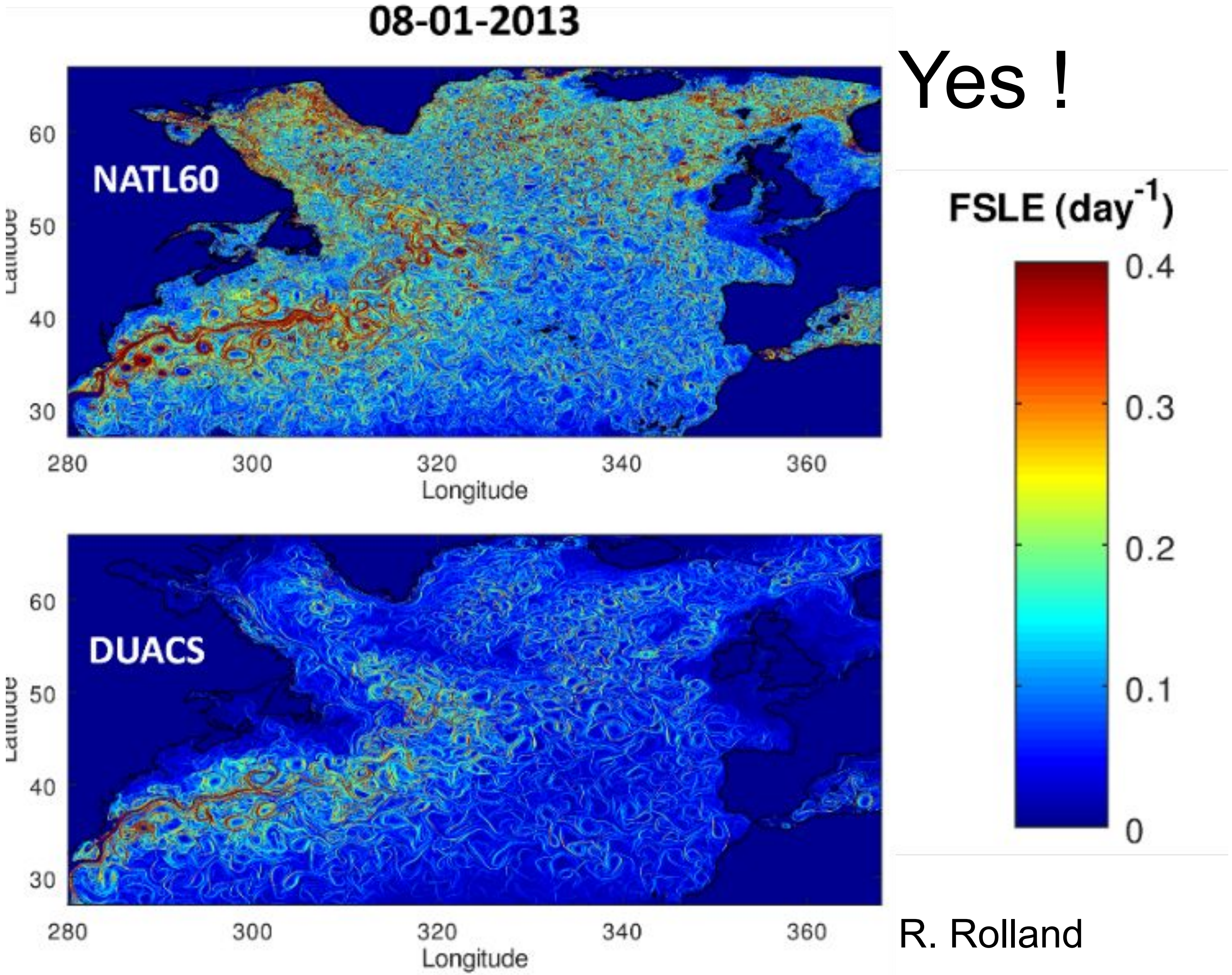
(some) inter... ...wave dynamics



Is this regime so important ?

SWOT

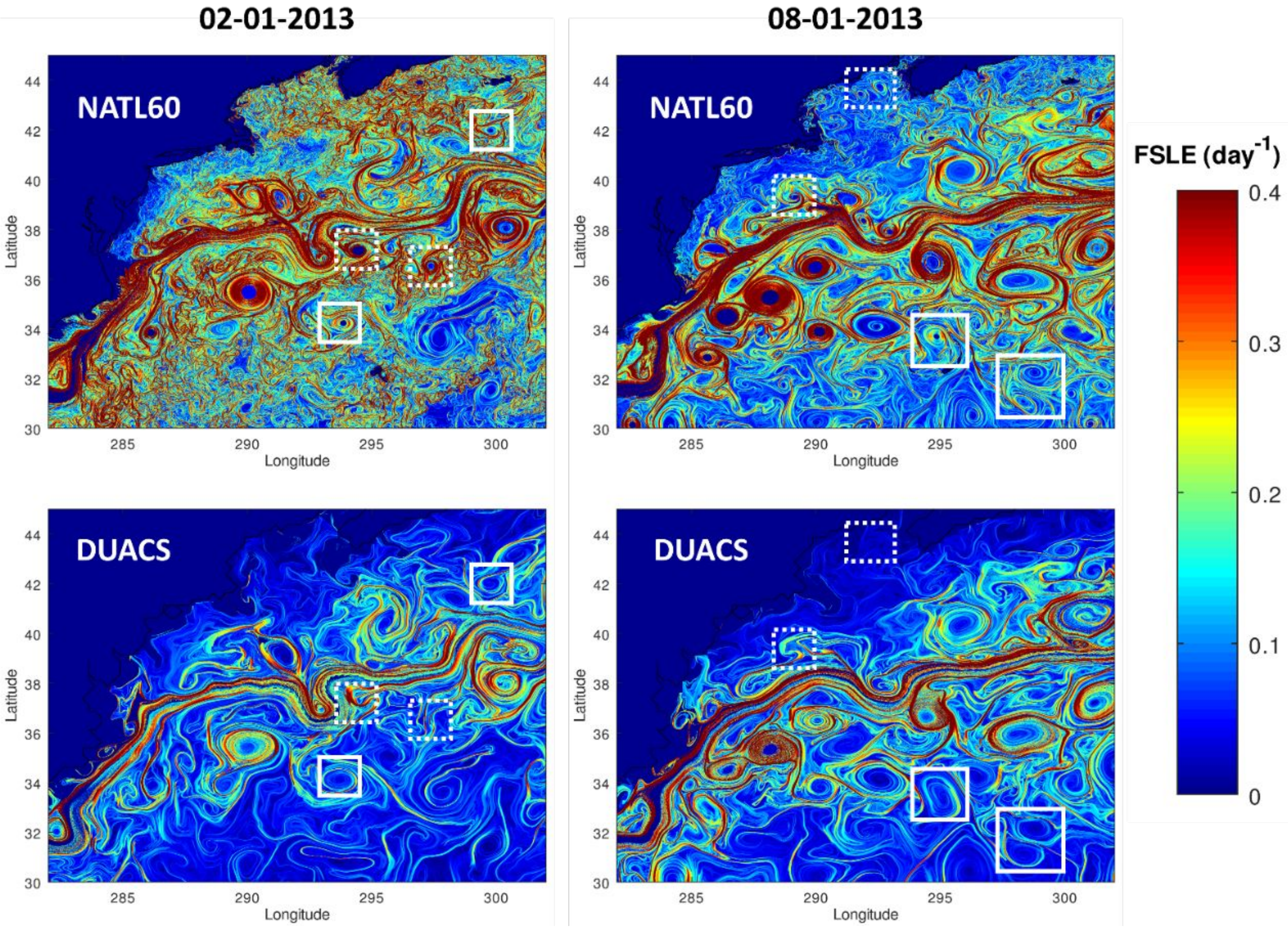
Model prediction of what we can expect from SWOT in terms of frontogenesis



Yes !

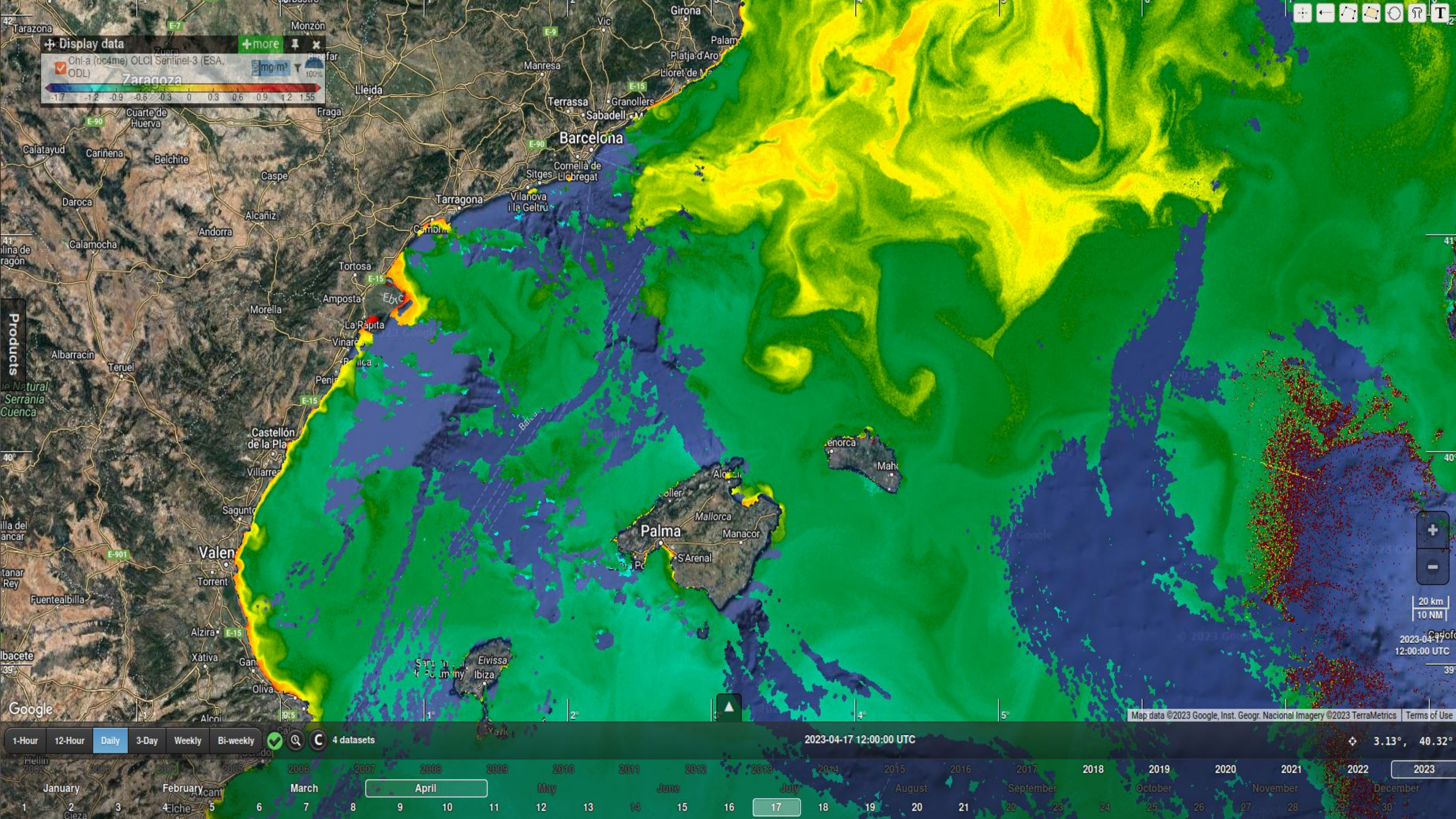
R. Rolland

Model prediction of what we can expect from SWOT in terms of frontogenesis



R. Rolland

.. and what about real cases ?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mg/m³
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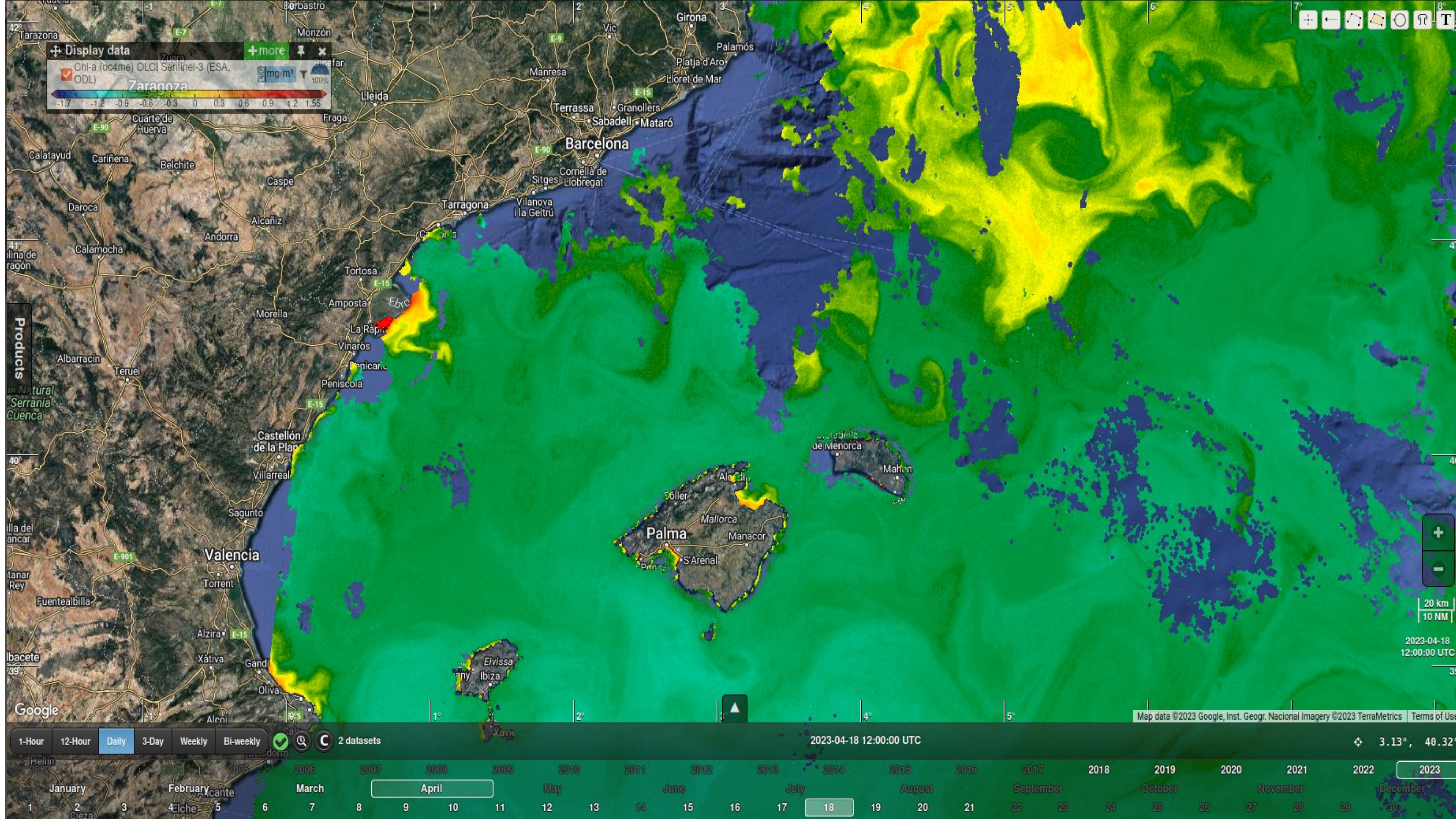

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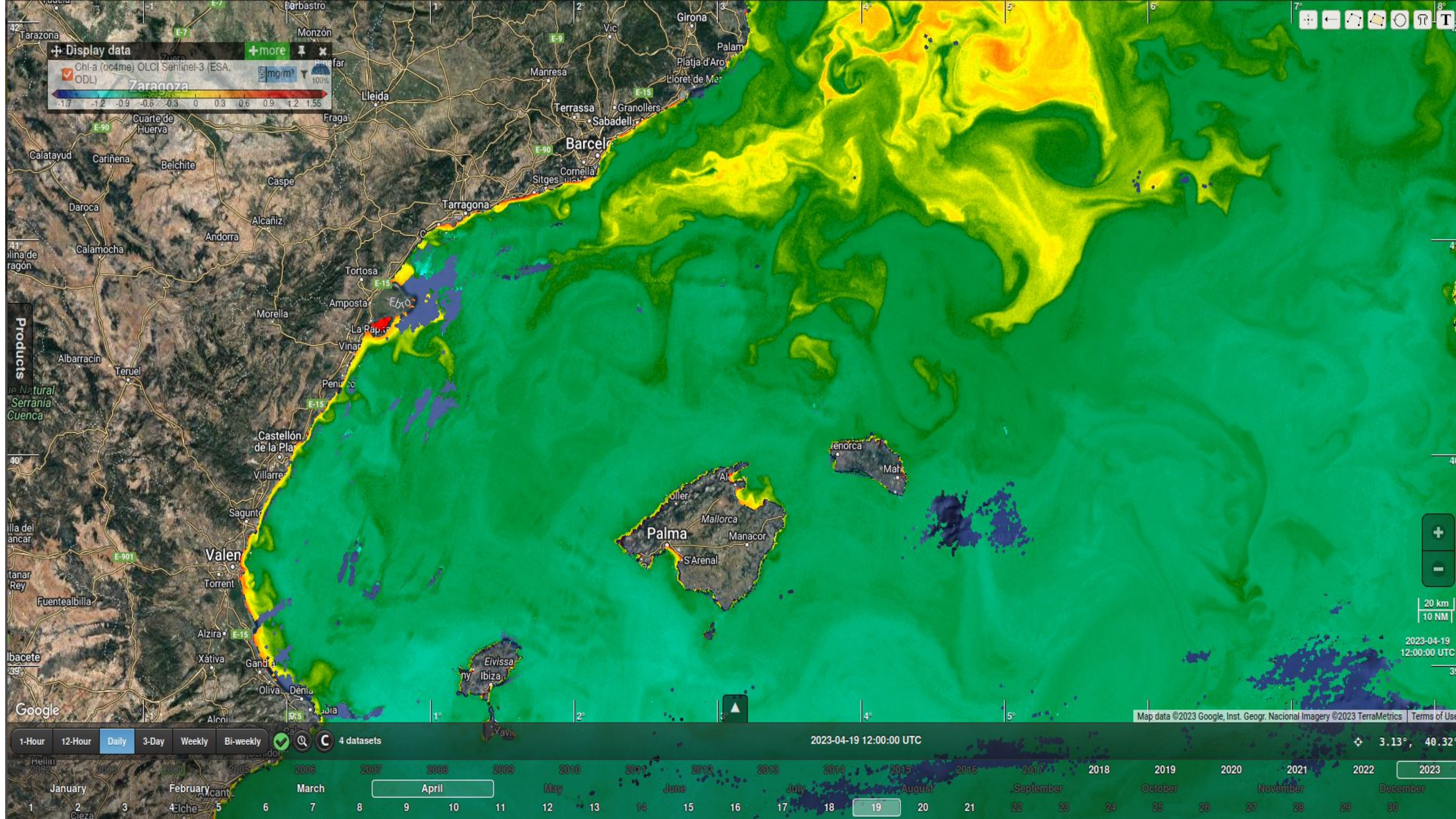
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Cuarte de Huerva
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Villarre
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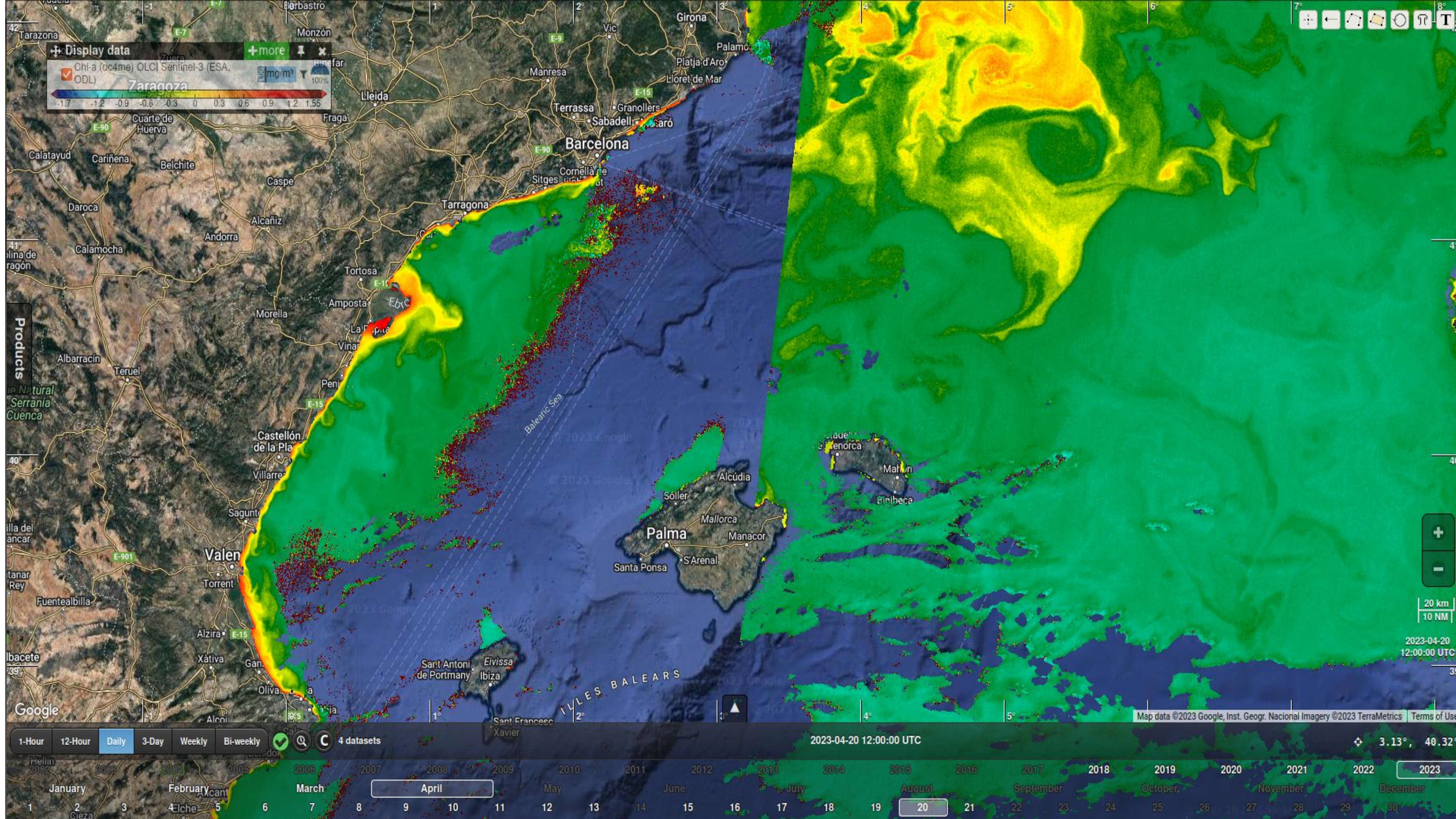
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Chl-a (oc4me) OLCI Sentinel-3 (ESA, ODL)
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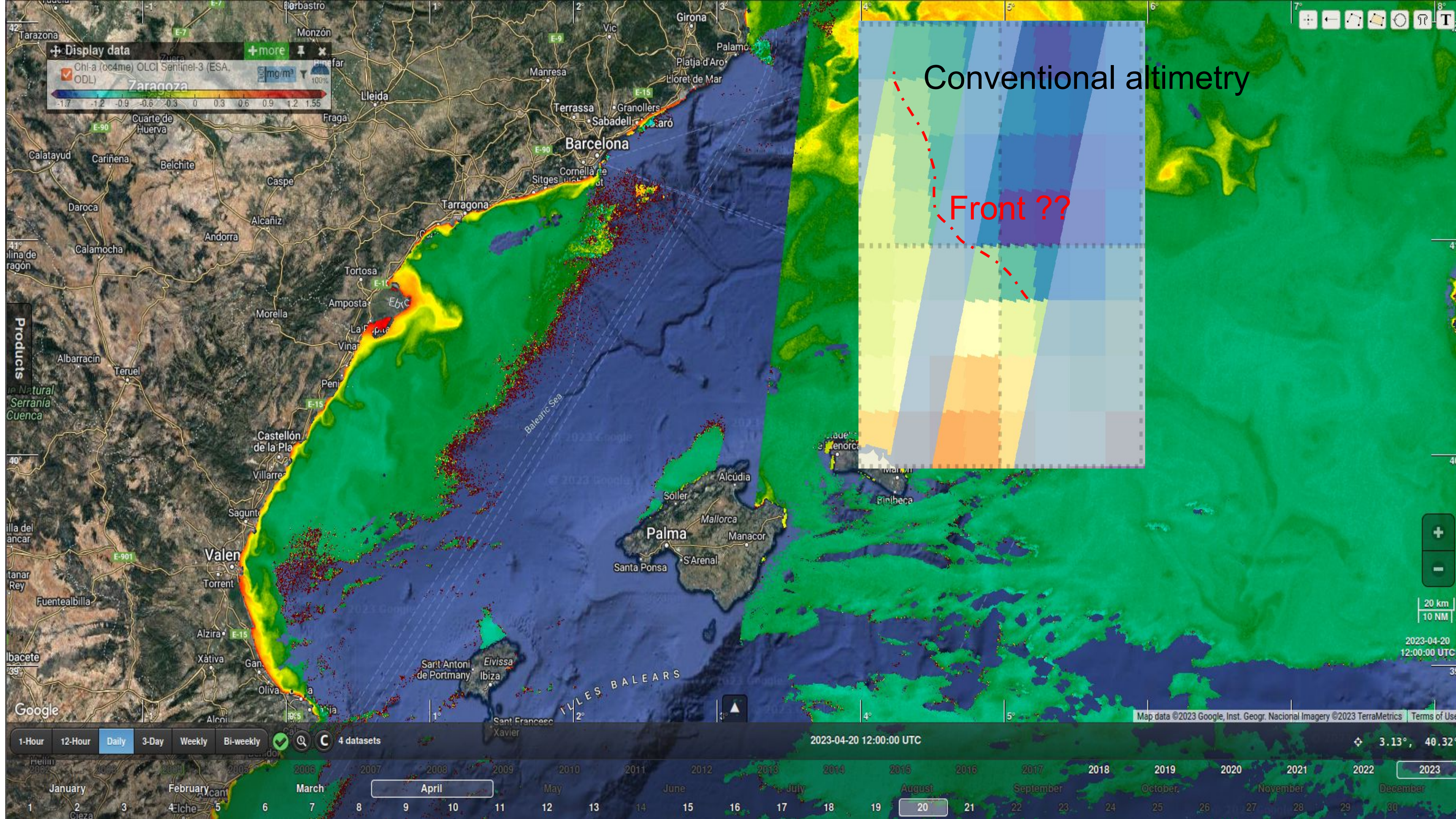
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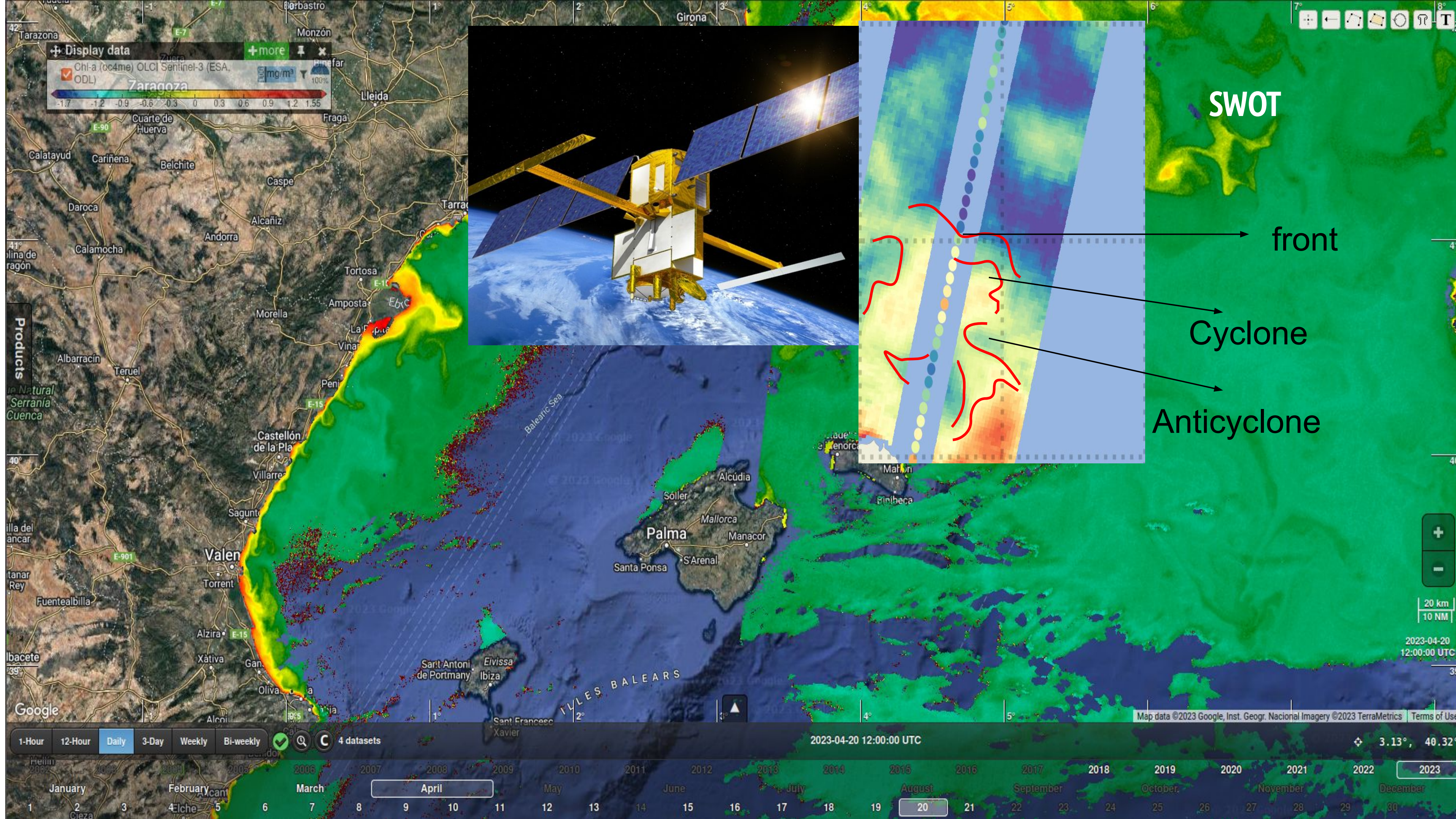
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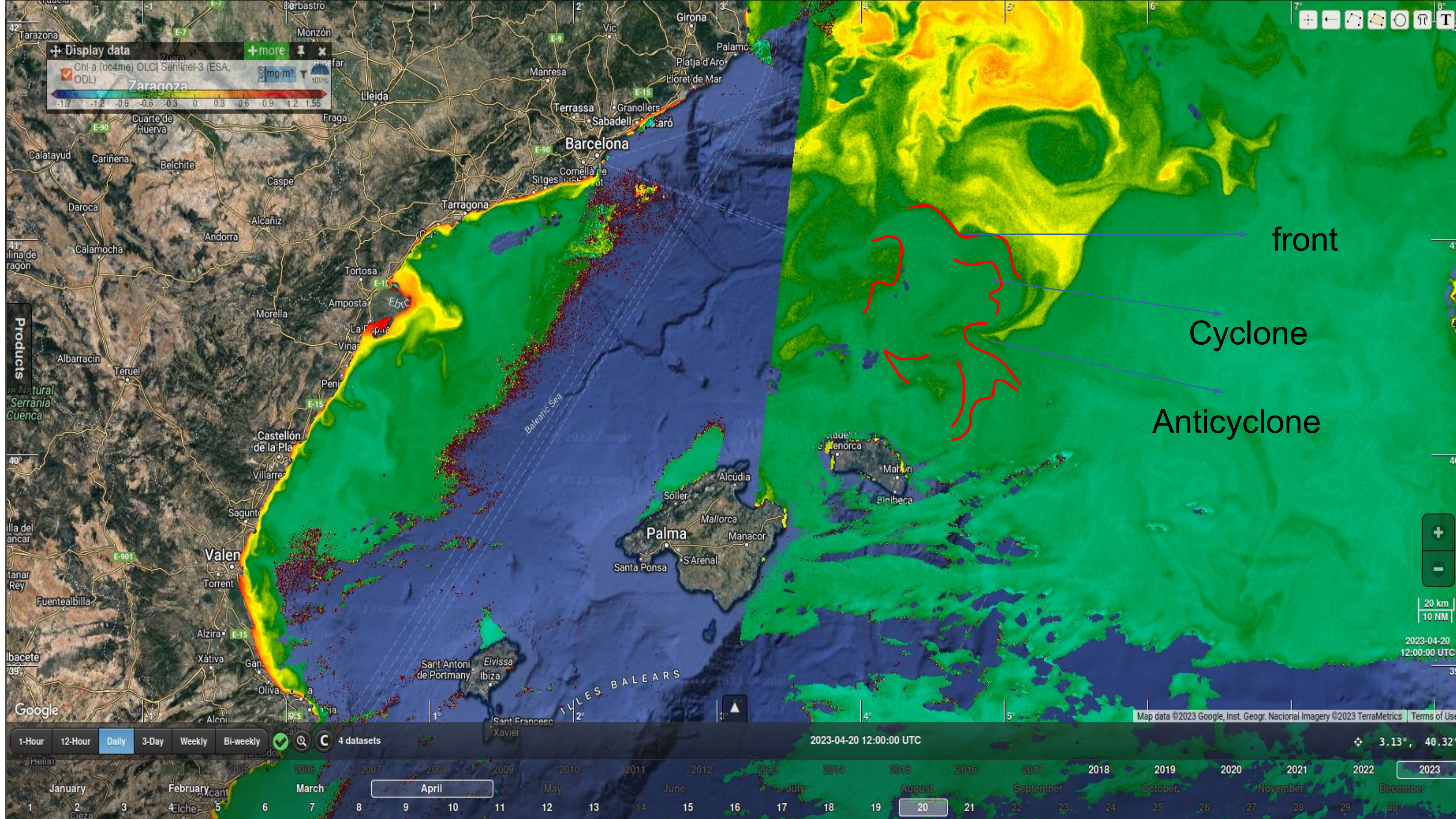
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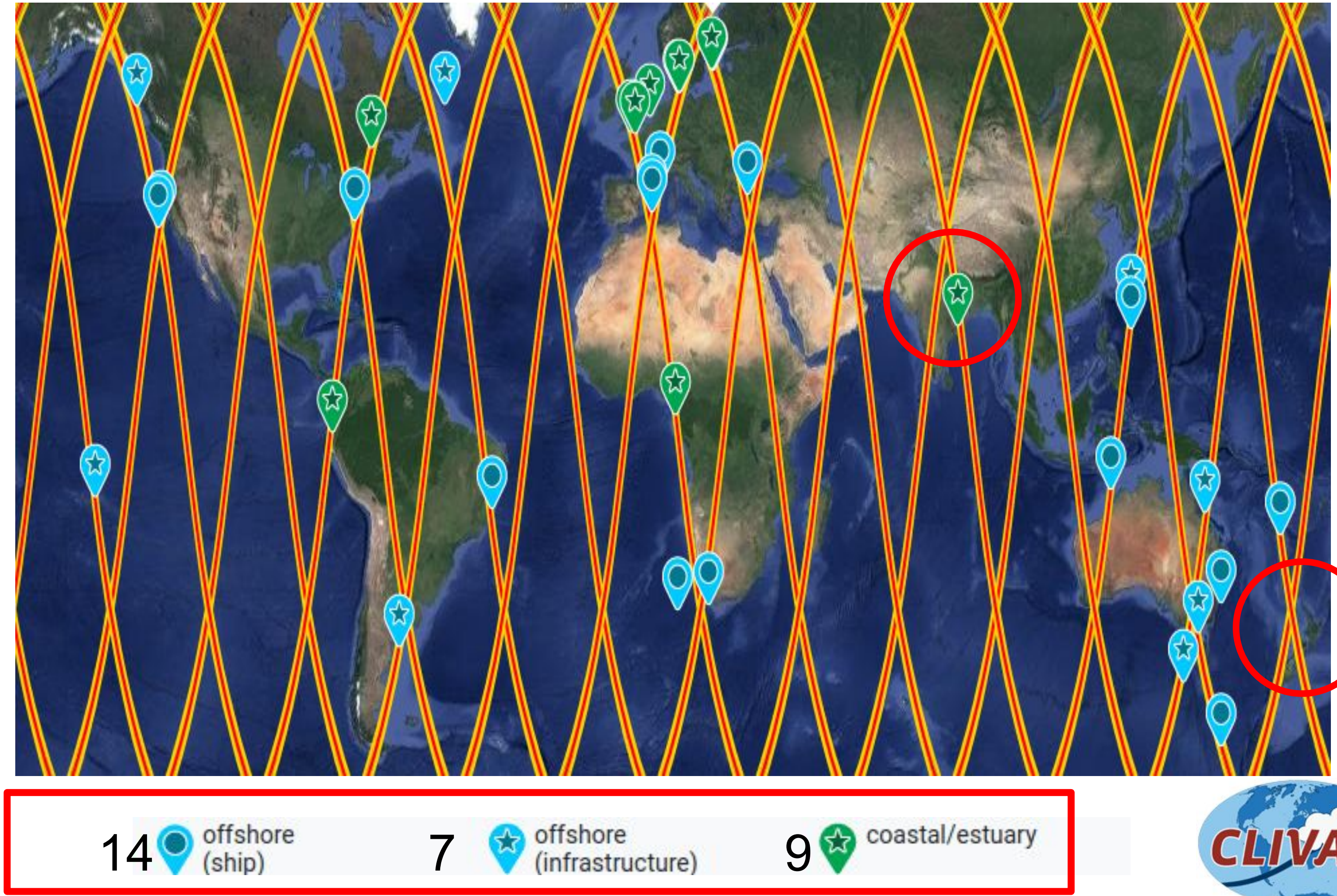
SWOT Adopt-a-Crossover Consortium

https://www.swot-adac.org

SWOT AdAC



What is the future of AdAC and Regional Validation WG after the fast sampling phase ?

1. AdAC still needed ?

2. What are the best way of using in situ data ?

3. what are the possible synergies with other WG ?

4. Which plan for conferences, special issues, etc. ?

1-day orbit		21-day orbit
SWOT **Adopt-A-Crossover** (AdAC)	→	SWOT **Adaptive-Campaigns** (AdaC) as part of Center for Topographic studies of the Ocean and Hydrosphere

1. Community

Pis of campaigns in SWOT swaths/crossovers	→	Pis of campaigns with strong fine-scale component

2. Science support

- Multi-satellite products, SPASSO and other software tools for sampling strategy. 1 Science Officer (Louise)	→	- Multi-satellite products, SPASSO and other software tools for sampling strategy + Support for SWOT L3/L4 products handling + Support for in situ data qualification 1 Science Officer (Louise) 1 Data Officer (Lloyd Izard)

3. Comm support

Comm Officer