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Oceans and Sea Ice

Water Turbidity: The Example of Venice and the Impact in the Media

V. E. Brando, CNR-ISMAR, Rome, Italy

Outline

Water Turbidity: The Example of Venice and the Impact in the Media

- slides by F. Braga et al presented at the Ocean from Space conference:
“Impact of the COVID-19 lockdown on water transparency in the Venice Lagoon using Sentinel 2 imagery”
- Impact on the media

Recent example of water turbidity visualization: imagery of North Adriatic Sea river plumes





OCEANS FROM SPACE

Scuola Grande di San Marco, Venezia
24 - 28 October 2022

Science of the Total Environment 736 (2020) 139612



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Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv



COVID-19 lockdown measures reveal human impact on water transparency in the Venice Lagoon



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<https://doi.org/10.1016/j.scitotenv.2020.139612>



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Outline

- Introduction
- Data and Methods:
 - Satellite imagery
 - Ancillary data
- Results - Before and during the SARS-CoV-2 outbreak:
 - February – May 2020
 - April 2019 – April 2020
- Final remarks
- Conclusions

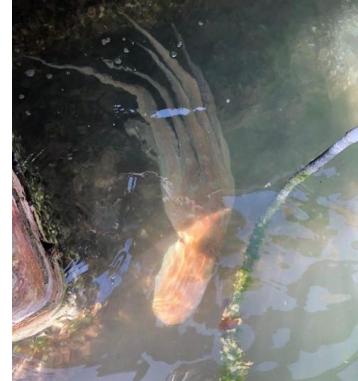
Introduction

- When the first confirmed cases of COVID-19 were identified in Italy on Feb 23rd, 2020, the city of Venice was celebrating the last days of its famous Carnival with tens of thousands of revellers.
- Regional authorities cancelled all remaining events in an effort to halt the spread of coronavirus infections.
- Since March 10th, the Italian government announced widespread lockdown measures for the whole country, restricting social contacts, limiting the individual movement, and closing most businesses, with the exception of those essential to the country supply chains.
- The tourism industry in the city suddenly stopped and Venice experienced a major breakdown of its economy, that was mostly based on this single source of revenue.



Introduction

- As a consequence of the isolation measures and the reduction of the tourists, the ordinary urban water traffic around Venice, one of the major pressures in the lagoon, came to a halt.
- Public transportation services, tourist and leisure boats stopped completely, while commercial boats and other public boat services reduced their runs.



Introduction

- As a consequence of the isolation measures and the reduction of the tourists, the ordinary urban water traffic around Venice, one of the major pressures in the lagoon, came to a halt.
- Public transportation services, tourist and leisure boats stopped completely, while commercial boats and other public boat services reduced their runs.
- The unprecedented water transparency in the city canals was widely covered by international news outlets and social media

Venice's canal water looks clearer as coronavirus keeps visitors away

By Jack Guy and Valentina Di Donato, CNN

Published 12:45 PM EDT, Mon March 16, 2020



See landmarks and
cities deserted
worldwide



Traveling while Asian
during the pandemic



Travelers react to UK
restriction on travel
from Spain



Introduction

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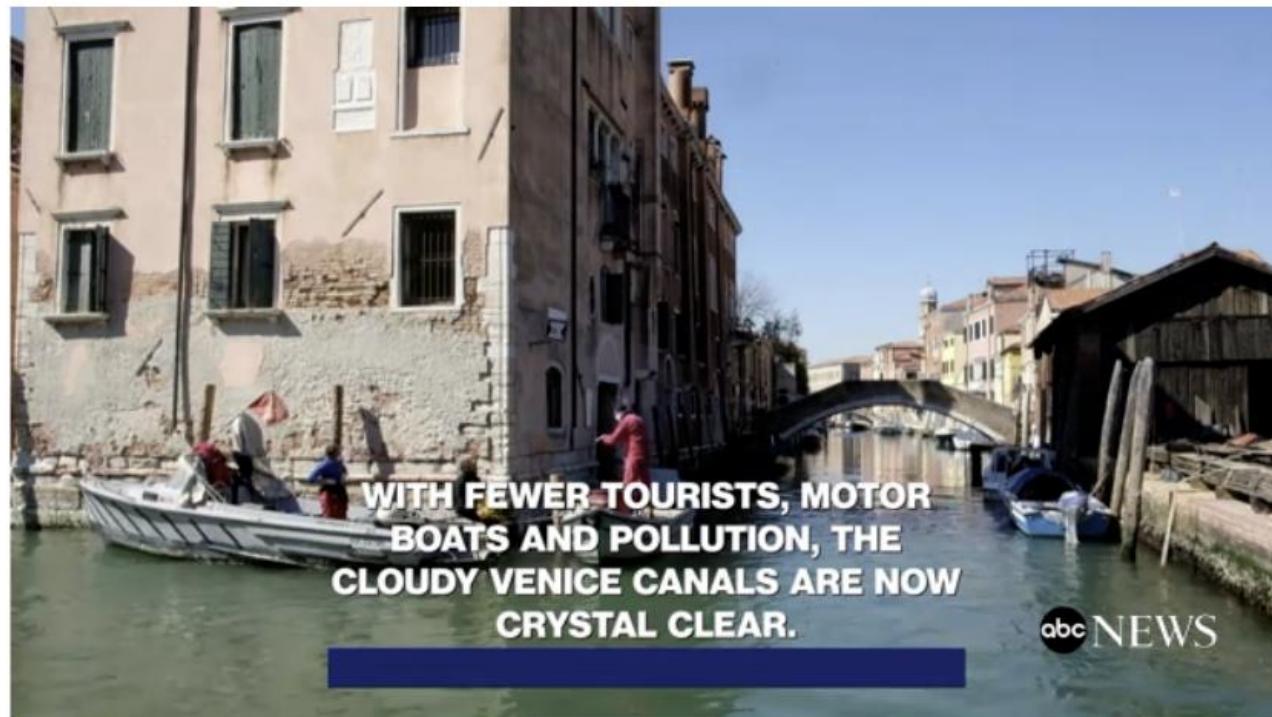
Coronavirus economic impacts

Venice canals are clear enough to see fish as coronavirus halts tourism in the city

Swans have returned to the canals and dolphins have been spotted in the port.

By [Julia Jacobo](#)

March 18, 2020, 8:34 PM



Introduction

- As a consequence of the isolation measures and the reduction of the tourists, the ordinary urban water traffic around Venice, one of the major pressures in the lagoon, came to a halt.
 - Public transportation services, tourist and leisure boats stopped completely, while commercial boats and other public boat services reduced their runs.
 - The unprecedented water transparency in the city canals was widely covered by international news outlets and social media



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10

According to #Venice's 🇮🇹 citizens, waters have cleared following the #COVID19 lock-down. But what can we see from #Sentinel2 🛸?

A notable difference in boat traffic between 8 February & 19 March, as well as seemingly less turbid/agitated waters. What do you think?

#EUSpace



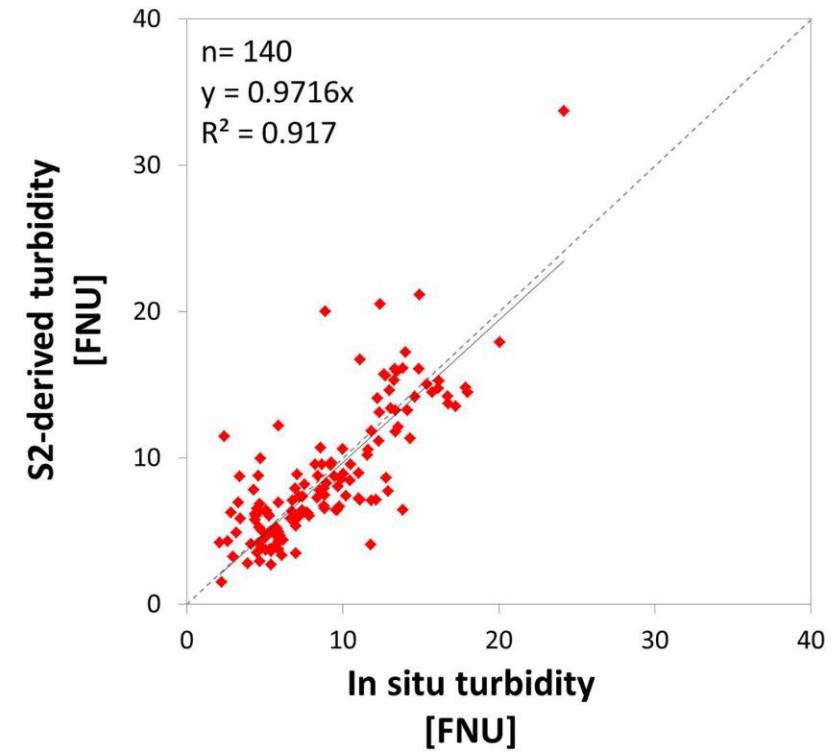
 DG DEFIS #StrongerTogether and 9 others

11:13 AM · Mar 24, 2020

<https://twitter.com/CopernicusEU/status/1242393973559304193?s=20>

Data and Methods: Satellite imagery

- Pseudo true-colour composites and turbidity maps at 10 m resolution were obtained from Sentinel-2 data.
- S2 imagery was radiometrically calibrated [1] and atmospherically corrected with ACOLITE, applying the dark spectrum approach [2,3].
- Pseudo true-colour composites with the same stretching were used for qualitative visual interpretation.
- Water leaving reflectances were converted into turbidity (expressed in FNU) [4] and validated with in situ data.
- A total of 14 cloud-free S2 images were acquired over the lagoon of Venice during the period from February to April 2020.
- A S2 image acquired on April 19th 2019 was also used to assess the situation of one year prior to the SARS-CoV-2 outbreak.



Results

Can you spot all
the differences?



February 20th 2020: the last cloud-free image
acquired before any restrictive measure



March 19th 2020: 1 week after the Italian
lockdown began

Results

On February 20th, the density of white wakes was relatively high alongside the large channels: Giudecca and the Grand Canal.

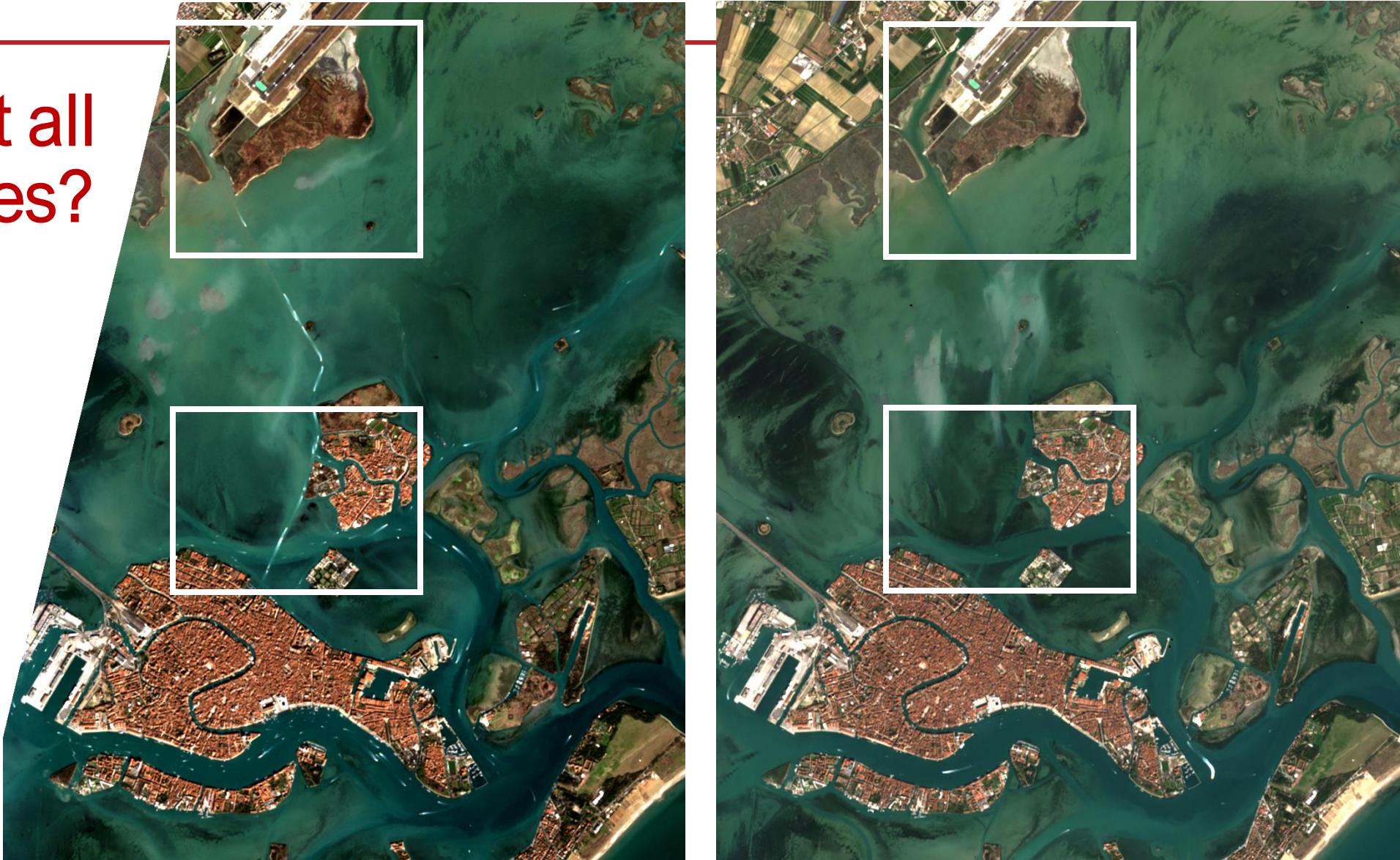


On March 19th, few boat wakes were still visible around the city of Venice.



Results

Can you spot all
the differences?



February 20th 2020: the last cloud-free image
acquired before any restrictive measure

March 19th 2020: 1 week after the Italian
lockdown began

Results

On February 20th, particularly evident were also the wakes of speedboats and waterbuses connecting the city to the airport.

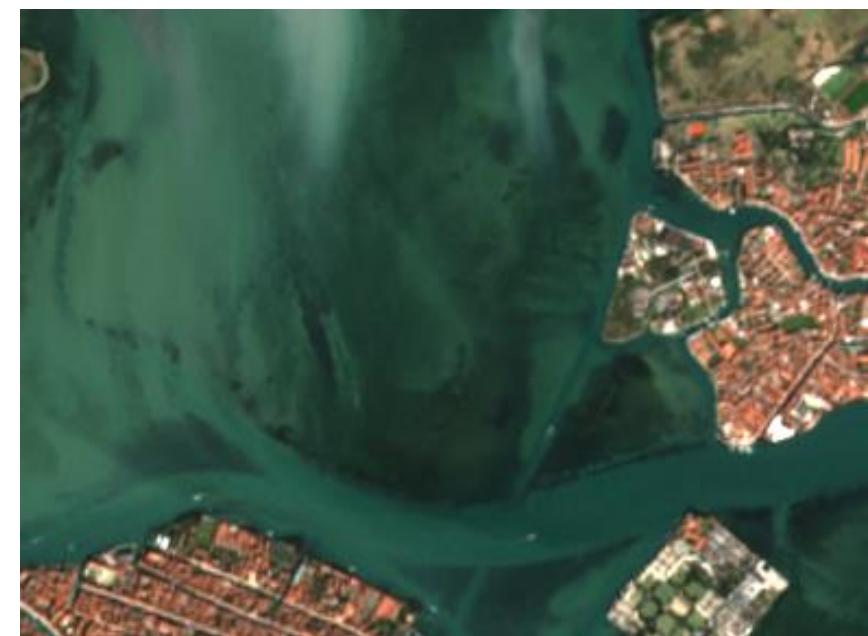


February 20th 2020



March 19th 2020

On March 19th, the lagoon water was clearer with less suspended matter in the channels surrounding the city and from Venice to the airport.



Results

The comparison of the traffic intensity during the Easter weekend of 2019 and 2020, a typical period of peak tourism influx similar to the conditions during the summer months.

In the April 19th 2019 image, the boat traffic was more sustained than on February.



April 19th 2019



April 10th 2020

Results

Cruise ships are visible in the passenger terminal on April 19th, 2019, and absent in the 2020 imagery.

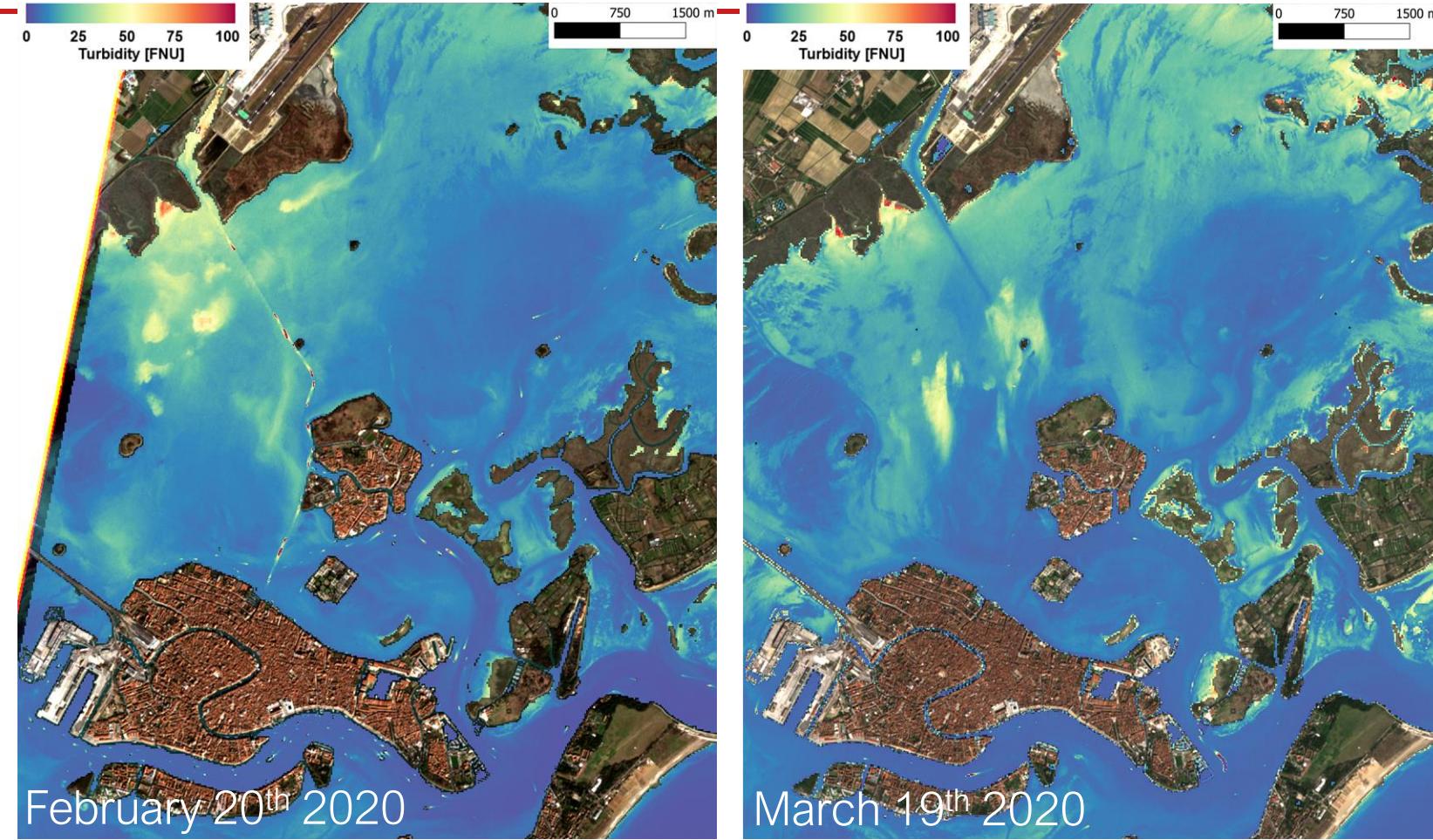
In February 2020, the cruise season had not started yet and in the following months the cruise industry underwent a deep worldwide crisis.



April 19th 2019

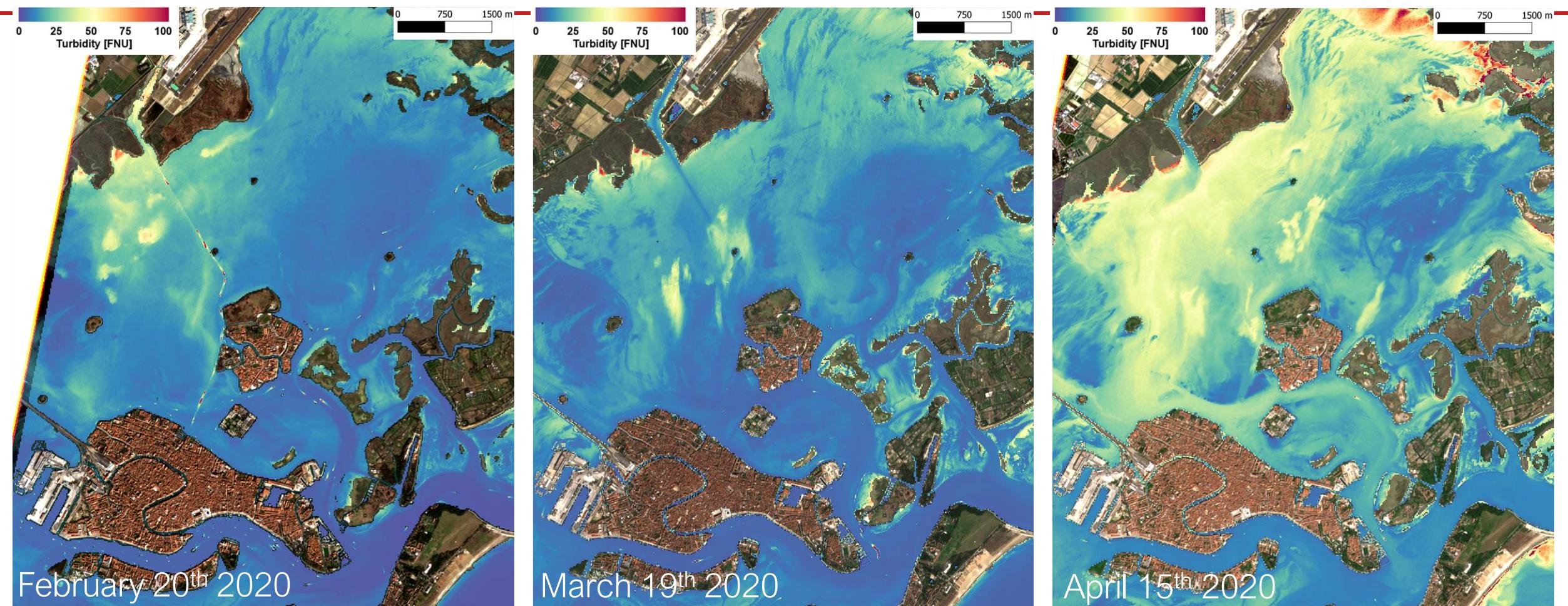
April 10th 2020

Quantitative results



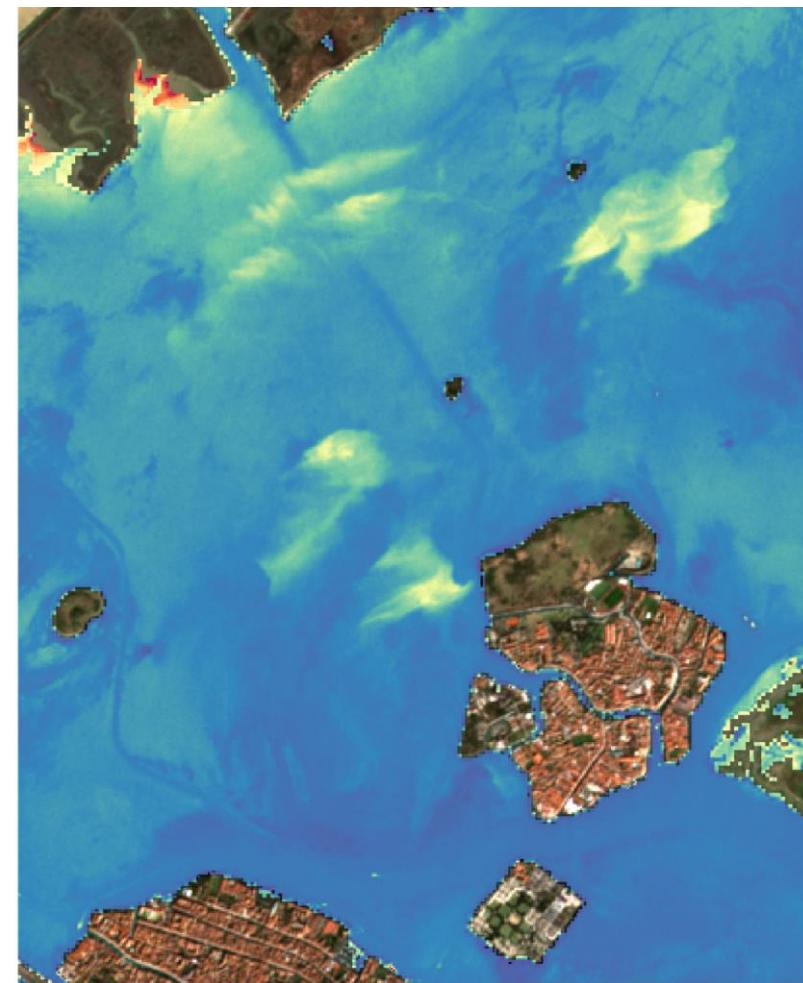
On February 20th 2020, the resuspension due to the wakes of speedboats, water taxis and airport shuttles, was quite intense in the channel connecting the airport water terminal to the city and in the nearest areas of the adjacent sub-tidal flats, where the turbidity reached about 50 FNU. In the map of March 19th, when the lockdown was in place and boat traffic almost stopped, the turbidity in the channel and the airport harbour was comparable to that observed around the city (~5 FNU).

Quantitative results

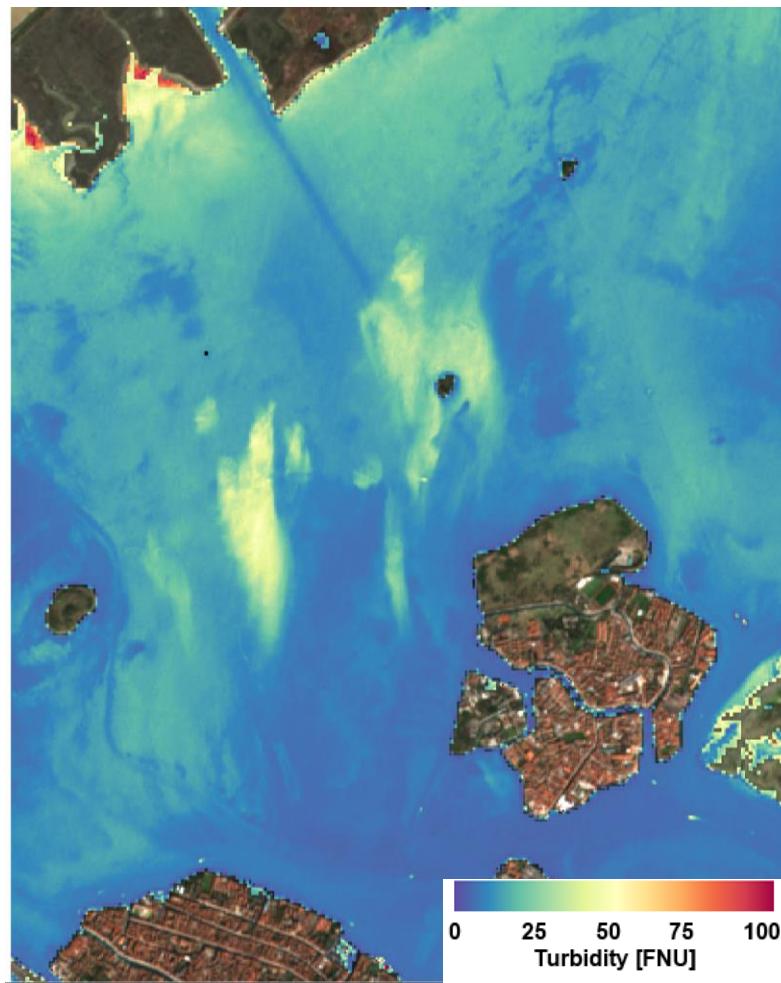


In the hours before the April 15th satellite overpass, northeasterly winds (Bora, N-NE) reached 20 m/s and determined a Hs of 0.3 m at the Misericordia gauge station. Wind- and wave-driven resuspension increased turbidity to a range of 25–50 FNU in the northern lagoon.

Quantitative results



March 16th 2020



March 19th 2020

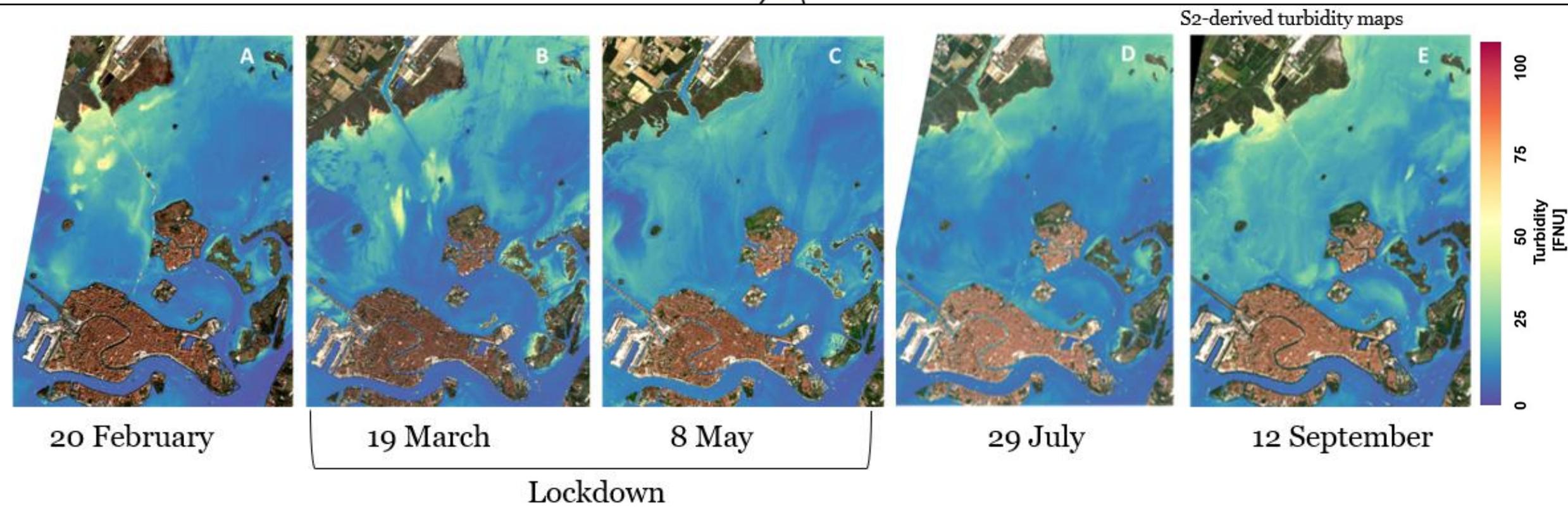
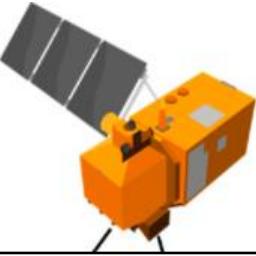
IN VENICE S2 IS ACQUIRED EVERY 2-3 DAYS

In the sub-tidal flats north of the Island of Murano, small plumes of brown and grey suspended sediments are visible in the true-colour composites and in the turbidity maps (35–50 FNU).

These originate within the clam harvesting concession areas where bottom sediments are mobilized by the shellfishing gears as point sources.

Clam harvesting was one of the essential activities that continued throughout the lockdown and was not subjected to restrictions.

Final remarks



After the lifting of the lockdown in June, the situation slowly returned to pre-COVID-19 lockdown conditions.

Conclusions

- The COVID-19 lockdown has provided a unique opportunity to observe the lagoon of Venice without water traffic, one of the main anthropic disturbances.
- The major environmental effect of the worldwide COVID -19 lockdown was reported in most cases as an improvement of air quality and environmental noise due to reduction in vehicular traffic. Here, we observed an increasing of water transparency.
- In terms of spatial, radiometric and temporal resolutions, Sentinel-2 imagery proved useful for qualitative visual interpretation and quantitative analysis of suspended matter patterns.





COVID-19 lockdown measures reveal human impact on water transparency in the Venice Lagoon

Citation Data: Science of The Total Environment, ISSN: 0048-9697, Vol: 736, Page: 139612

Publication Year: 2020

119	312	4	583
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The research paper linked to the seminar has been published in the journal "Science of The Total Environment"



11:08 AM · Nov 10, 2022

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For sustainable transformation, education must address how to live responsibly

17 May 2021 | SEI - Stockholm Environment Institute 

Share In April 2020, as societies worldwide locked down in response to the spread of COVID-19, Google Trends reported a 4,500% increase in searches on

[Article Description](#)

The lagoon of Venice has always been affected by the regional geomorphological evolution, anthropogenic stressors and global changes. Different morphological settings and variable biogeophysical conditions characterize this continuously evolving system that rapidly responds to the anthropic impacts. When the lockdown measures were enforced in Italy to control the spread of the SARS-CoV-2 infection on March 10th 2020, the ordinary urban water traffic around Venice, one of the major pressures in the lagoon, came to a halt. This provided a unique opportunity to analyse the environmental effects of restrictions to mobility on water transparency. Pseudo true-colour composites Sentinel-2 imagery show

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[Bibliographic Details](#)

DOI: [10.1016/j.scitotenv.2020.139612](https://doi.org/10.1016/j.scitotenv.2020.139612) 

PMID: [32470688](https://pubmed.ncbi.nlm.nih.gov/32470688/) 

URL ID:

<http://www.sciencedirect.com/science/article/pii/S0048969720331326> 
<http://dx.doi.org/10.1016/j.scitotenv.2020.139612> 
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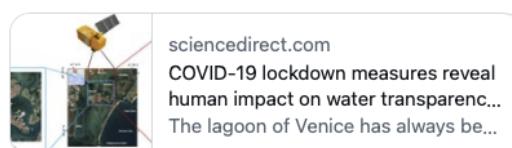
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It has received 14 tweets and 66 retweets.

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The research paper linked to the seminar has been published in the journal "Science of The Total Environment"



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Replying to @Moltazskriver
eller se'n har vi vetenskapen som komplicerar bilden 😂



9:37 AM · Apr 18, 2022

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@RoalzApps · [Follow](#)

Replying to @Gandalf0980 and @BartoszMilewski
It's not, and it's basically destroying the laguna.

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Replying to @expatlvnv @agentjtag and @peterdaou
The canals in Venice became crystal clear.

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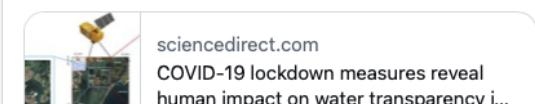
4:31 PM · Jul 29, 2021

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Dall'insolita limpidezza delle acque della laguna di Venezia (bit.ly/3eTMCbM) al **#disastroambientale** di Norilsk, in **#Russia**: gli scatti di **#Sentinel2** ci raccontano una storia che mai avremmo voluto per questa **#giornatamondiale dell'ambiente**.

 **Francesca Larosa**
@FrancescaLaros1 · [Follow](#)

Replying to @defis_eu @CopernicusEU and 9 others
On this matter, I recommend this paper:



Outline

Water Turbidity: The Example of Venice and the Impact in the Media

- slides by F. Braga et al presented at the Ocean from Space conference:
“Impact of the COVID-19 lockdown on water transparency in the Venice Lagoon using Sentinel 2 imagery”
- Impact on the media

Recent example of water turbidity visualization: imagery of North Adriatic Sea river plumes



Recent example of water turbidity visualization: imagery of North Adriatic Sea river plumes

- Following the massive floods in Emilia Romagna of mid May 2023, all the small rivers started flowing in the Northern Adriatic Sea.
- The Sentinel2 truecolour imagery and the Turbidity products in the CMEMS Ocean Colour catalogue provide a striking overview of how the single river plumes evolved from 15 May 2023.



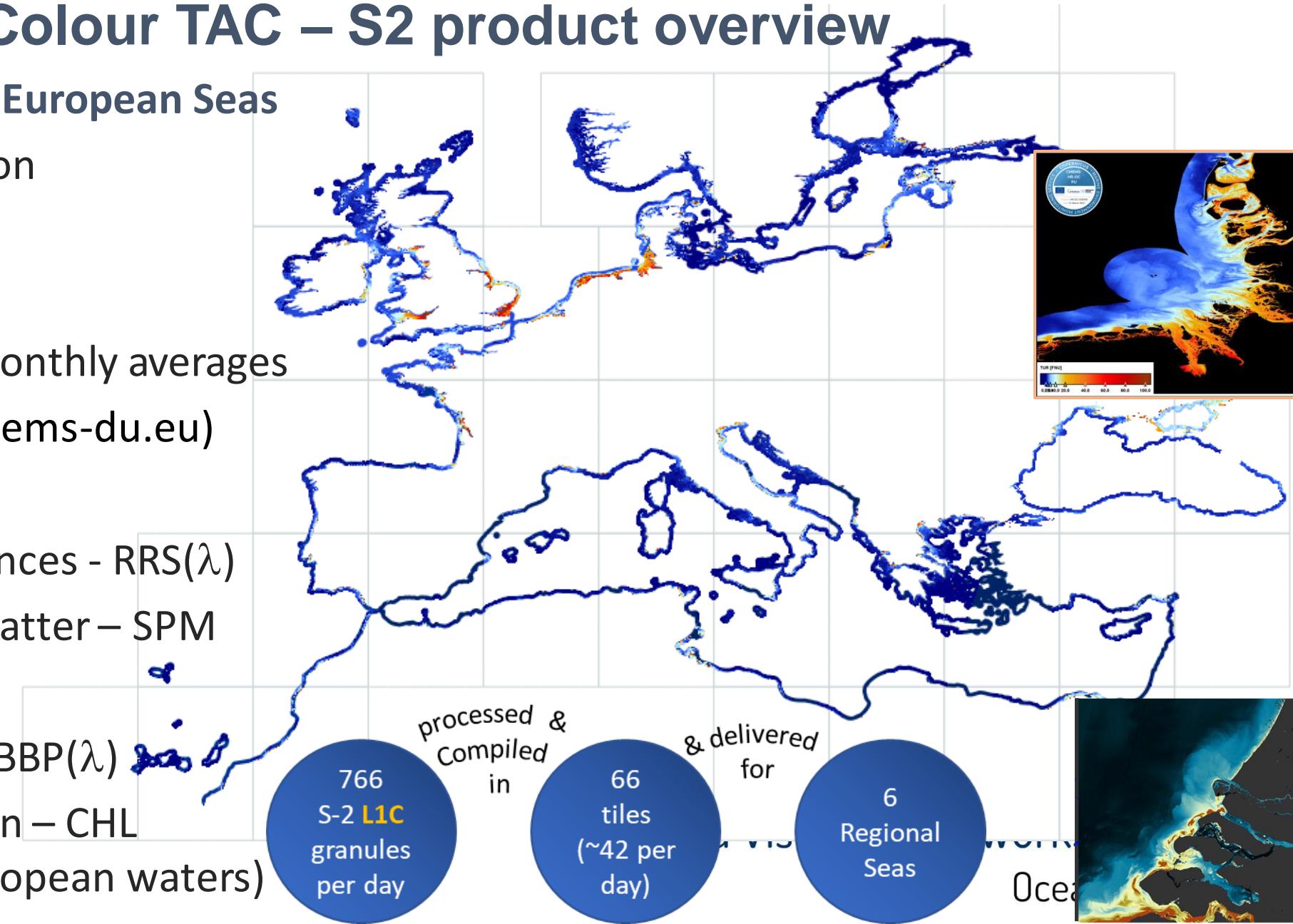
The Ocean Colour TAC – S2 product overview

Coastal stripes of 20km for European Seas

- S2 A&B at 100m resolution
- NRT 1/1/2020 ->
- L3: daily;
- L4: daily gap-filled and monthly averages
- Download via ftp (nrt.cmems-du.eu)

Parameters

- Remote Sensing Reflectances - $RRS(\lambda)$
- Suspended particulate matter – SPM
- Turbidity - TUR
- Particulate Backscatter - $BBP(\lambda)$
- Chlorophyll Concentration – CHL
(one algorithm for all European waters)



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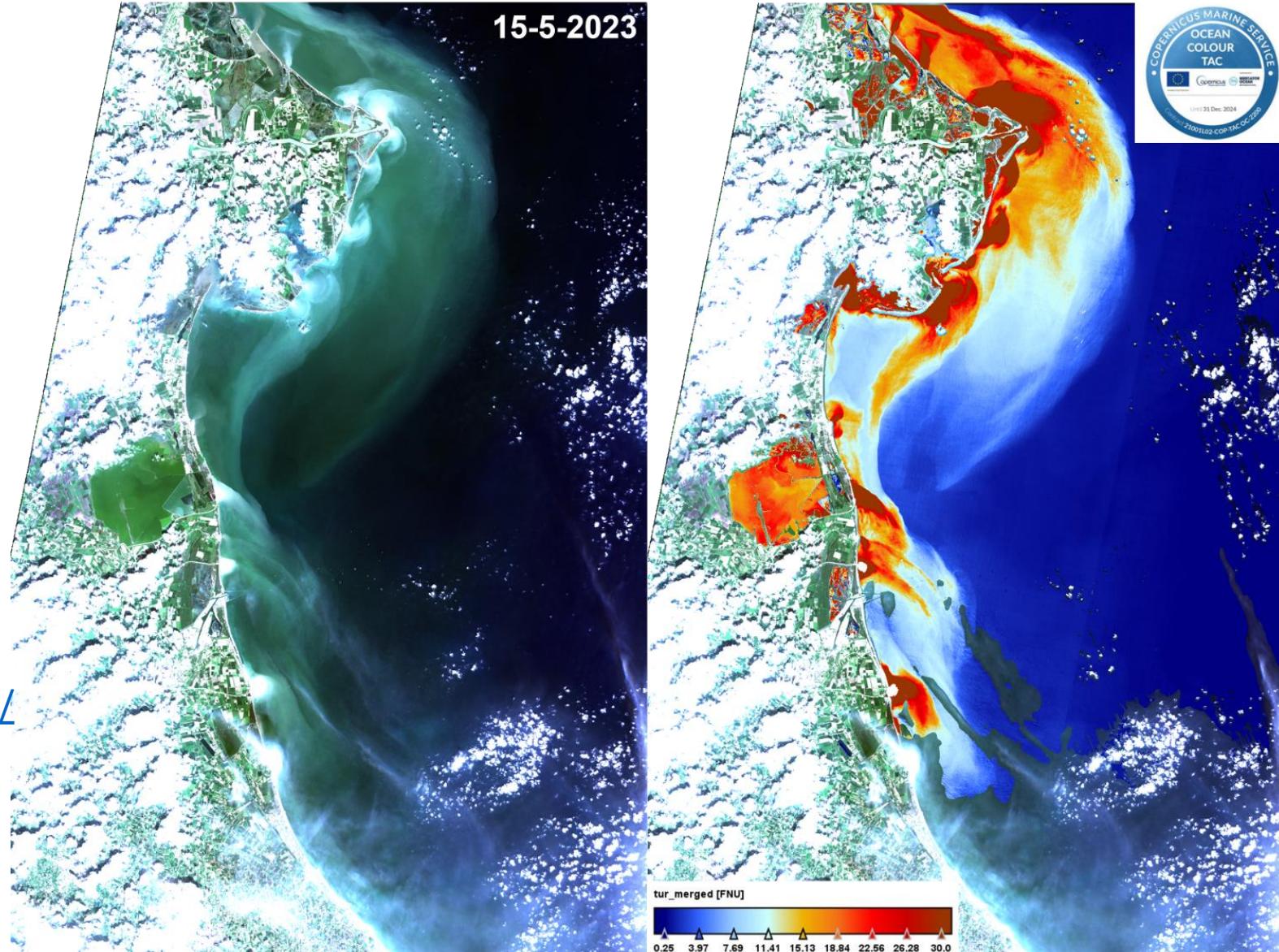
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- Turbidity - TUR
- Particulate Backscatter - BBP(λ)
- Chlorophyll Concentration – CHL
(one algorithm for all European waters)



Recent example of water turbidity visualization: imagery of North Adriatic Sea river plumes

On 15 May the single river plumes were still kept close to coast of Emilia Romagna by the winds that blocked the water flow and caused the widespread flooding inland.

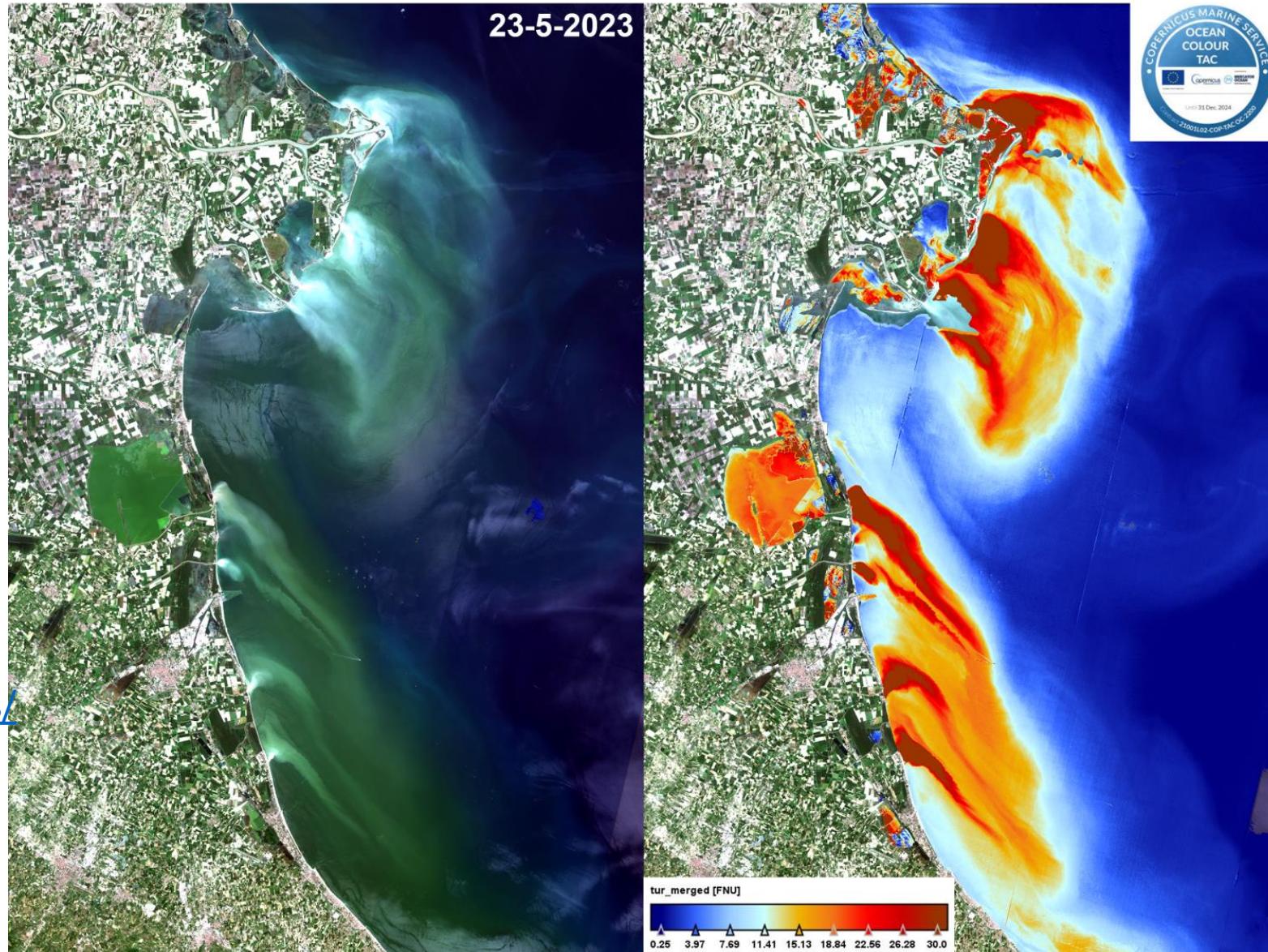


<https://twitter.com/VittorioBrando/status/1661652252342329345?s=20>



Recent example of water turbidity visualization: imagery of North Adriatic Sea river plumes

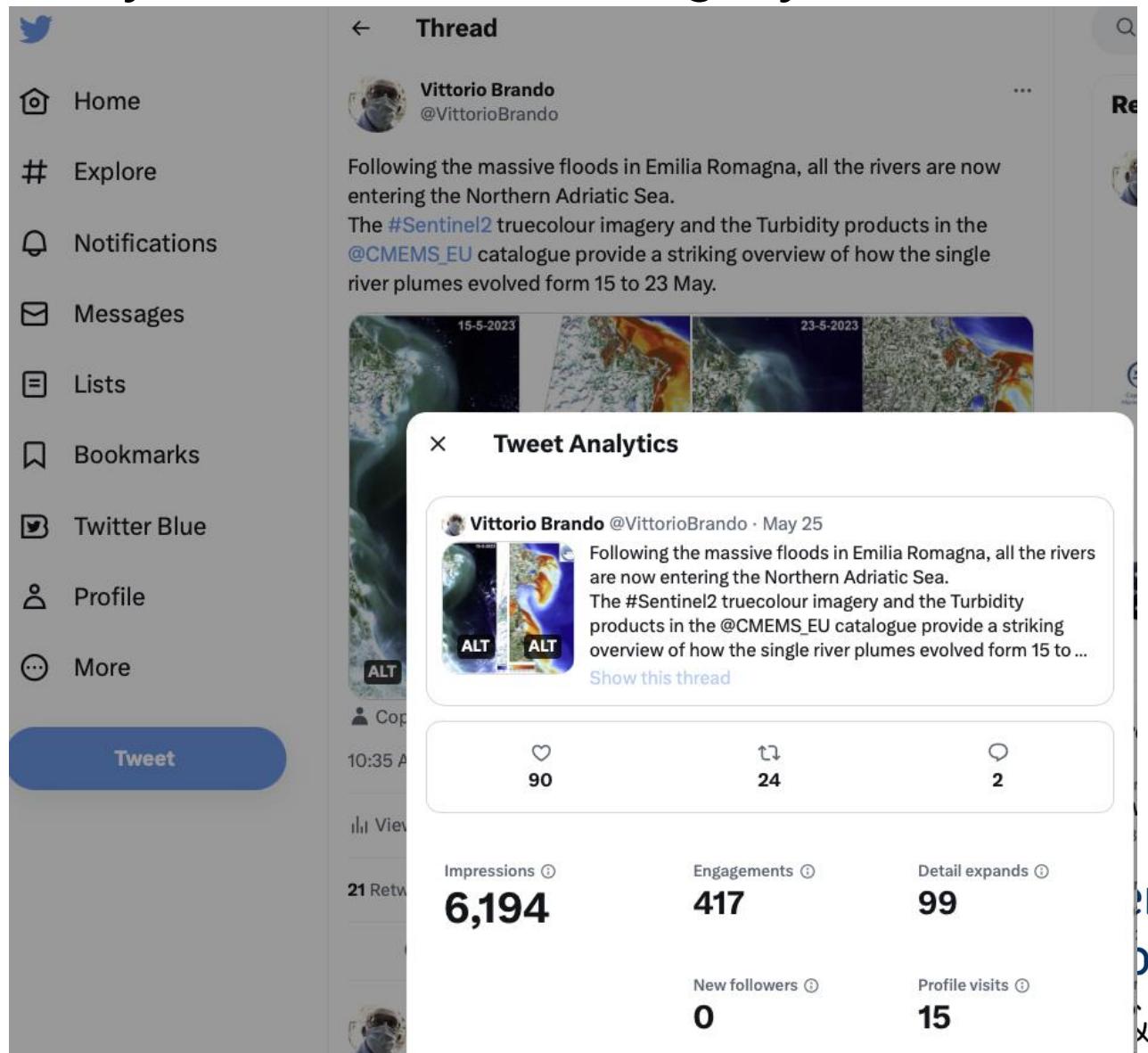
On 23 May the turbid plumes merged and were reaching the clearer shelf waters showing optical variability



<https://twitter.com/VittorioBrando/status/1661652252342329345?s=20>



Recent example of water turbidity visualization: imagery of North Adriatic Sea river plumes



The screenshot shows a Twitter thread from user @VittorioBrando. The tweet text reads: "Following the massive floods in Emilia Romagna, all the rivers are now entering the Northern Adriatic Sea. The #Sentinel2 truecolour imagery and the Turbidity products in the @CMEMS_EU catalogue provide a striking overview of how the single river plumes evolved from 15 to 23 May." Below the tweet are three small satellite images labeled 15-5-2023, 16-5-2023, and 23-5-2023, showing the progression of river plumes. A modal window titled "Tweet Analytics" displays the following engagement metrics:

Impressions	Engagements	Detail expands
6,194	417	99
New followers	Profile visits	
0	15	

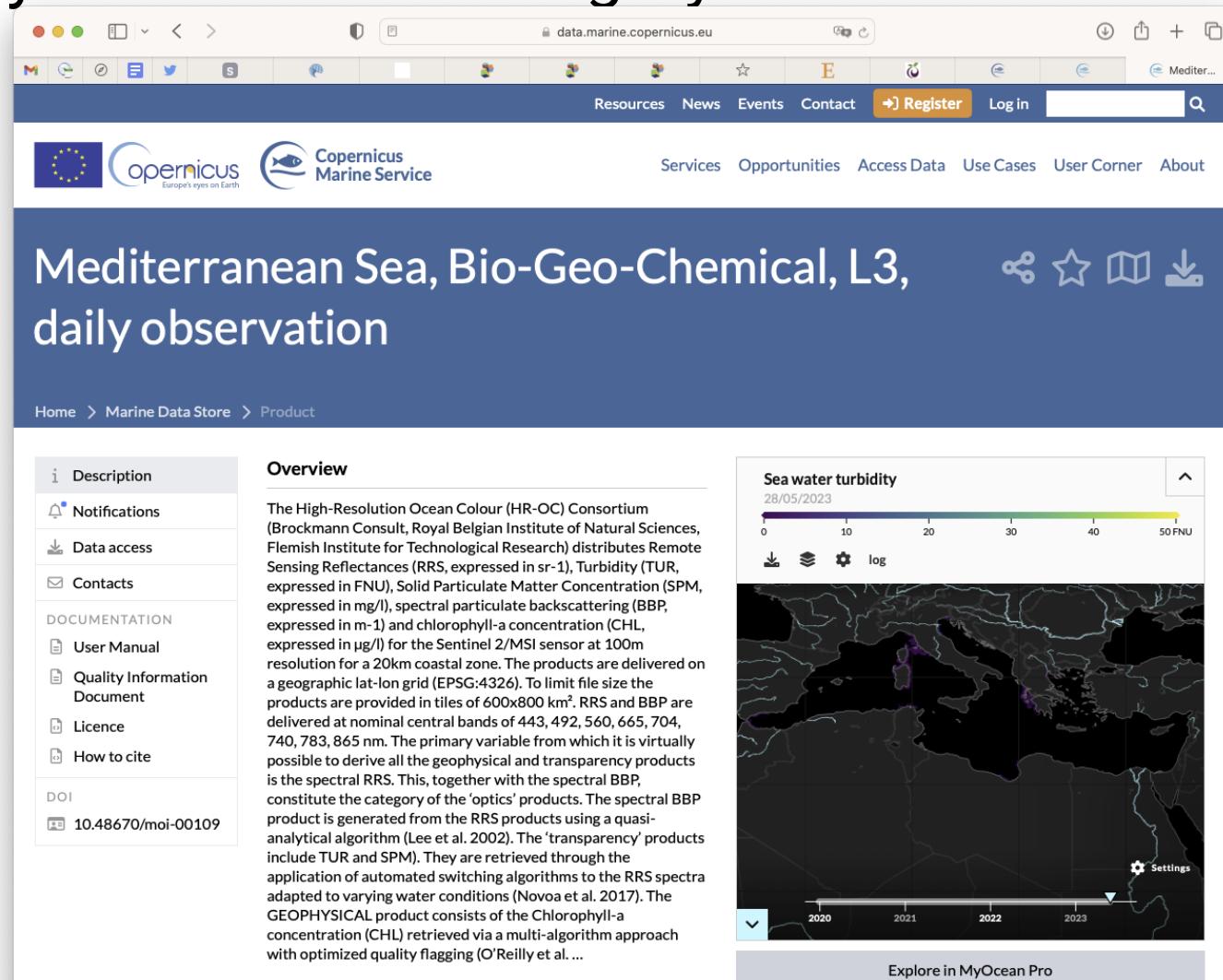
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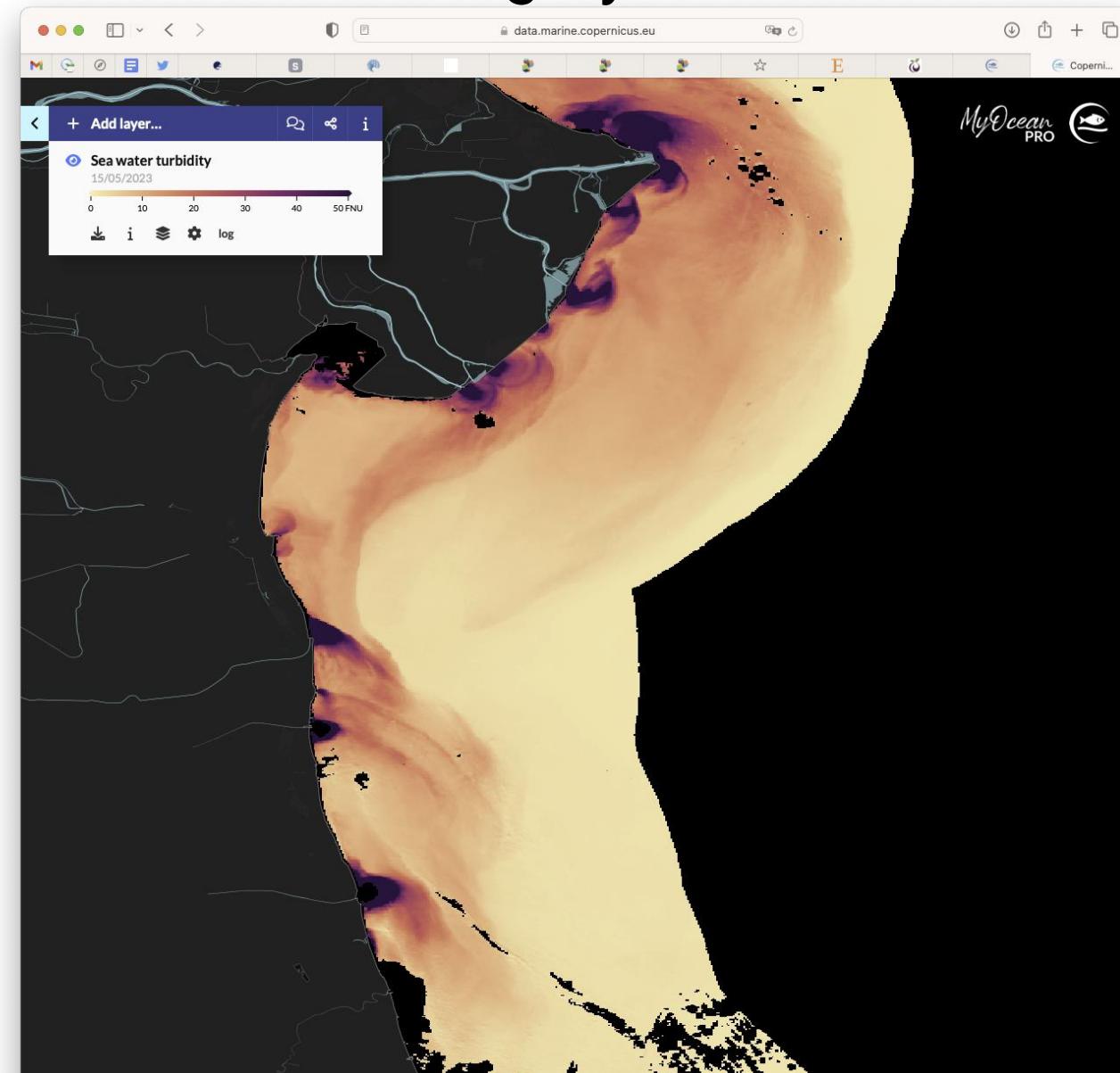
But that tweet was a week ago
... how did the plume evolve?

the CMEMS S2 Turbidity fields
can be visualized on
myOceanPRO by clicking on the
map on the product description
page [https://data.marine.copernicus.eu/product/
OCEANCOLOUR_MED_BGC_HR_L3_NRT_009
_205/description](https://data.marine.copernicus.eu/product/OCEANCOLOUR_MED_BGC_HR_L3_NRT_009_205/description)



Recent example of water turbidity visualization: imagery of North Adriatic Sea river plumes

On 15 May the single river plumes were still kept close to coast of Emilia Romagna by the winds that blocked the water flow and caused the widespread flooding inland.



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Marine Service

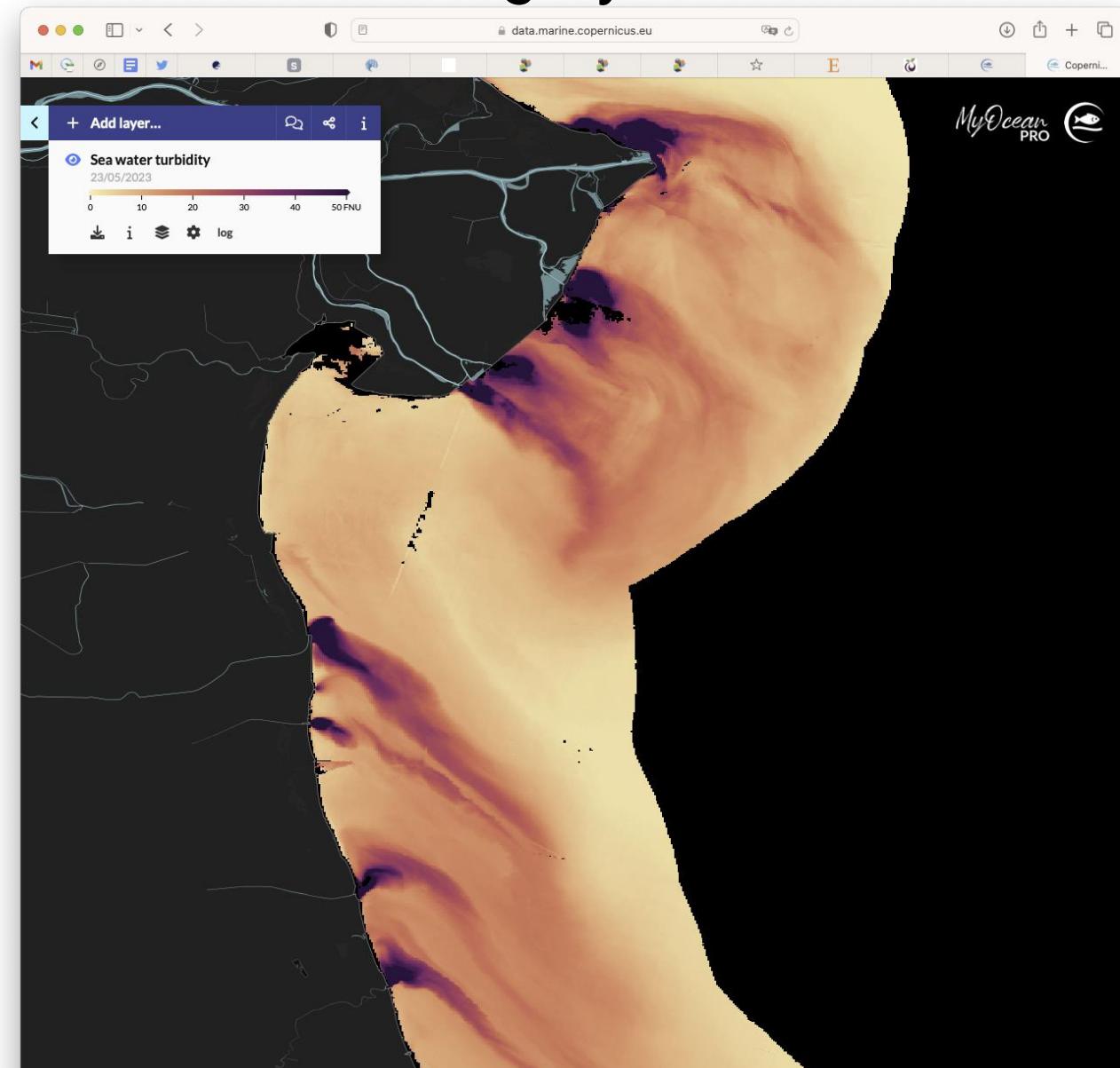
Mediterranean Sea, Bio-Geo-Chemical, L3,
daily observation

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Recent example of water turbidity visualization: imagery of North Adriatic Sea river plumes

On 23 May the turbid plumes merged and were reaching the clearer shelf waters



Copernicus
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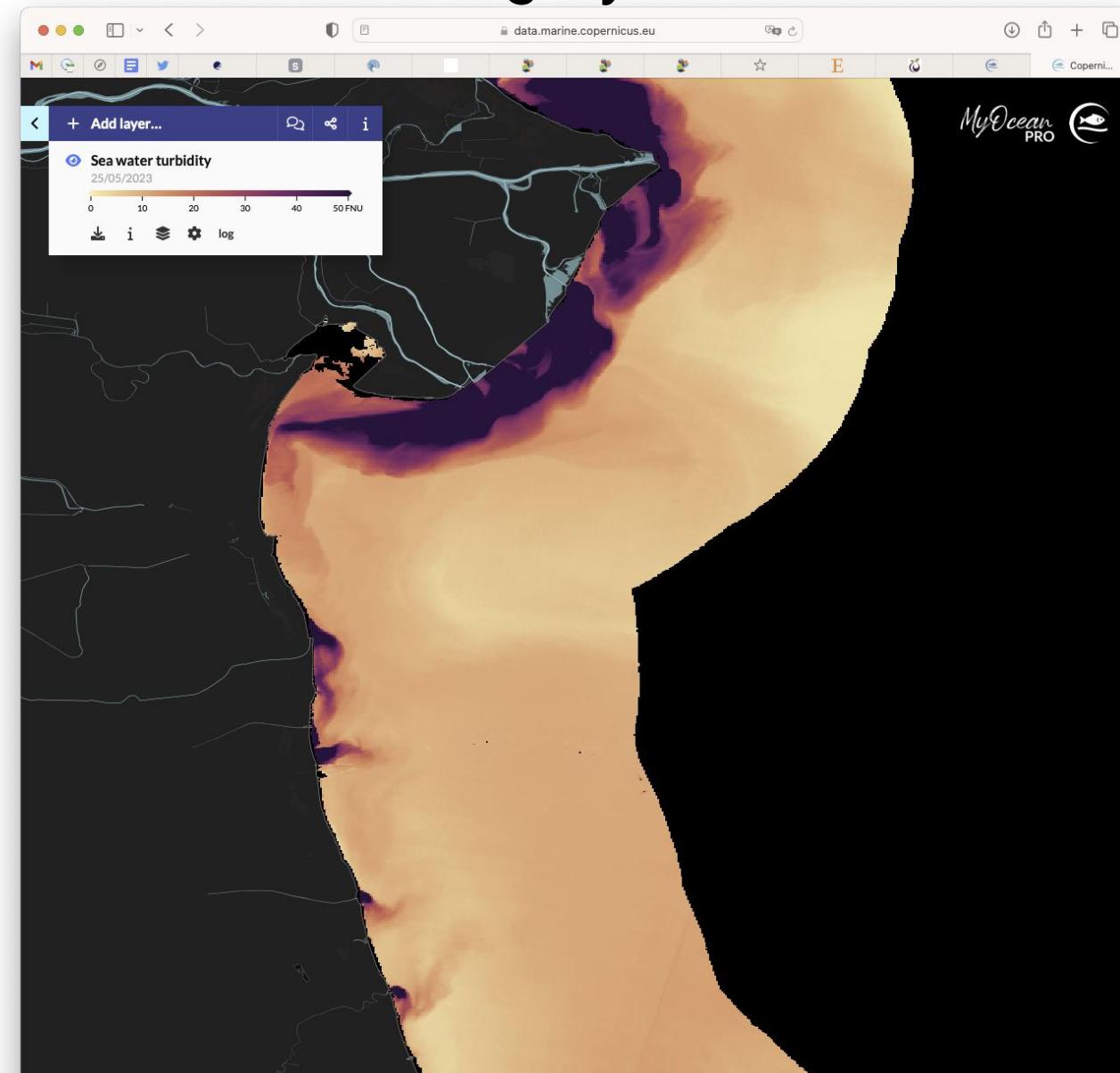
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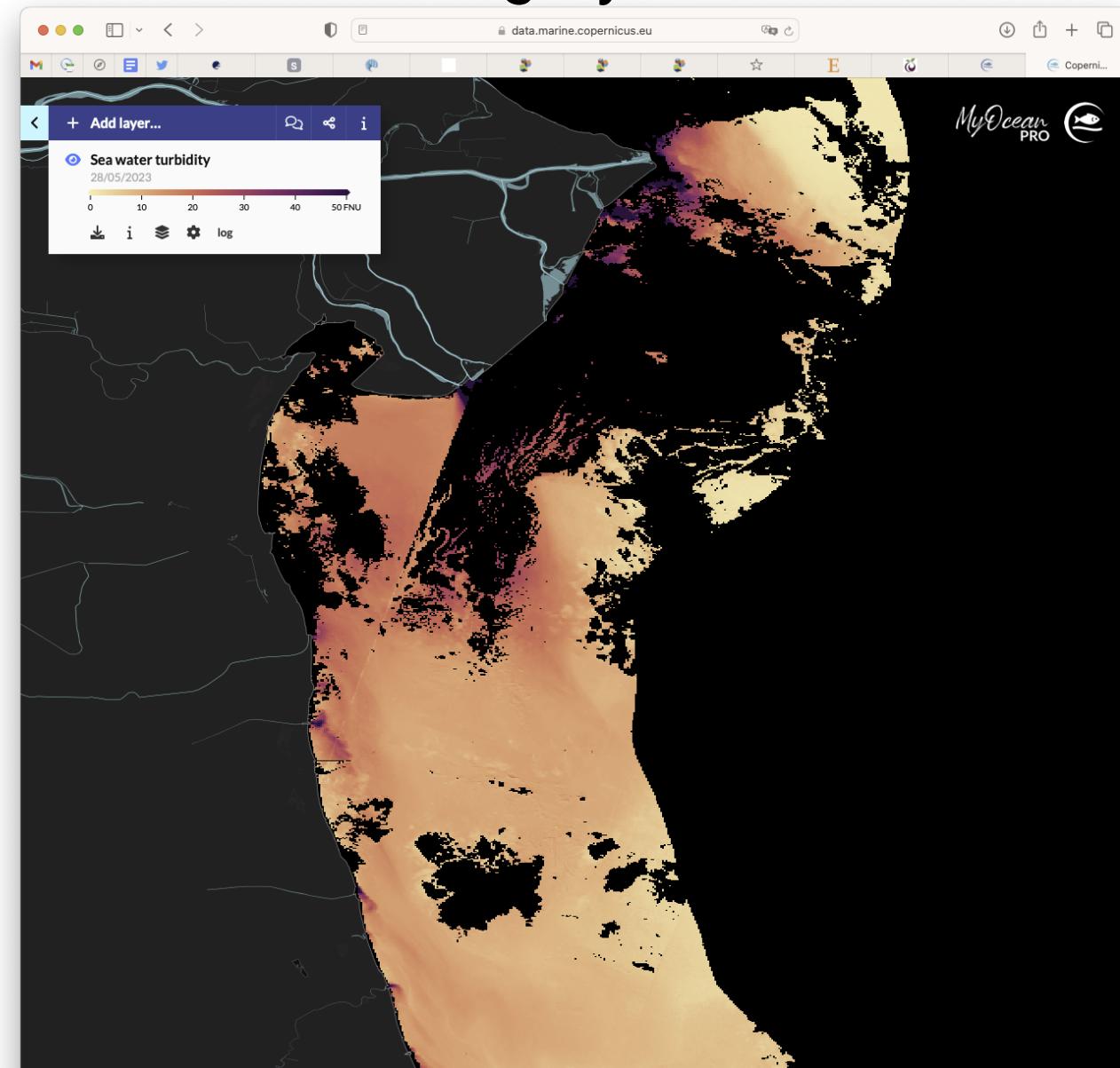
On 25 May the turbid plumes form the Po river and the small rivers were again kept close to the coast by the winds



The screenshot shows the Copernicus Marine Data Store interface. At the top, there are links for Services, Opportunities, Access Data, Use Cases, User Corner, and About. Below that, a banner displays the text "Mediterranean Sea, Bio-Geo-Chemical, L3, daily observation". To the right of the banner are icons for download, star, and other data management functions. At the bottom left, there is a breadcrumb navigation: Home > Marine Data Store > Product.

Recent example of water turbidity visualization: imagery of North Adriatic Sea river plumes

On 28 May the S2 image was a bit cloudy over the Po river but the small rivers are still visible



The screenshot shows the Copernicus Marine Data Store interface. At the top, there are links for Services, Opportunities, Access Data, Use Cases, User Corner, and About. Below that, a banner displays "Mediterranean Sea, Bio-Geo-Chemical, L3, daily observation". To the right of the banner are several small icons: a gear, a star, a document, and a download arrow. At the bottom of the screenshot, there is a navigation bar with links for Home, Marine Data Store, and Product.

Summary

Two different visualisation approaches for Water Turbidity:

Water Turbidity in Venice

- Sentinel 2 imagery at 10 m radiometrically calibrated and atmospherically corrected with ACOLITE
- Water leaving reflectances converted into turbidity with ACOLITE
- Pseudo true-colour composites and turbidity maps in QGIS

Water turbidity in North Adriatic Sea river plumes

- Sentinel 2 true-colour imagery and the turbidity products at 100m resolution from the CMEMS Ocean Colour catalogue





Thanks for your attention

V. E. Brando

CNR-ISMAR, Rome, Italy

Vittorio.brando@cnr.it



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