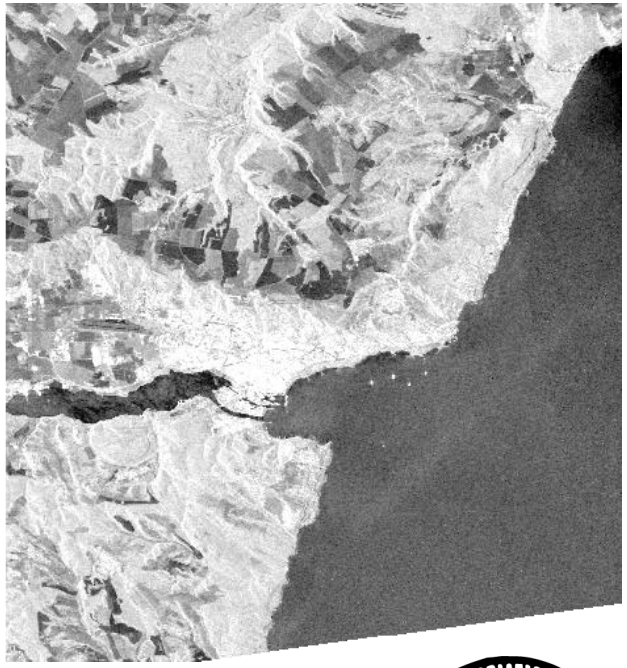
3-ти семинар „Физика и Химия на Земята, Атмосферата и Океана “,
3-5.Октомври 2021, с. Баня;
финансиран от СУ-ФНИ, проект 80-10-120/26.03.2021

Satellite detection of wastewater contamination in the Black Sea coastal areas



Irina Gancheva[1,2], Elisaveta Peneva[2], Gordon Campbell[1]

[1] European Space Agency

[2] Sofia University “St. Kliment Ohridski”

Section: Ocean Science

Time: Вторник 10:30часа

Motivation and background

- Poorly treated or completely untreated wastewater discharges close to the shoreline can cause serious environmental treat
- Challenges for remote detection of effluent plume:
  - Small scale of the events
  - Resolution of the data
  - Strong influence of local events

Use a case study for creating sound methodology for wastewater detection

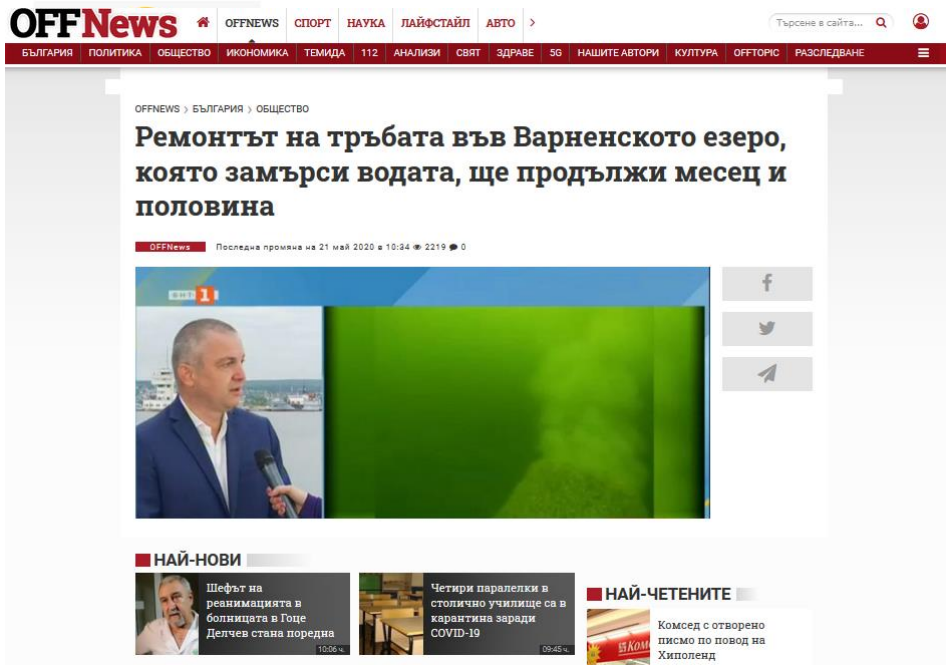
Take the case of a broken sewage pipe which discharged significant amount of untreated wastewater into the Varna lake, directly connected to the Black Sea.

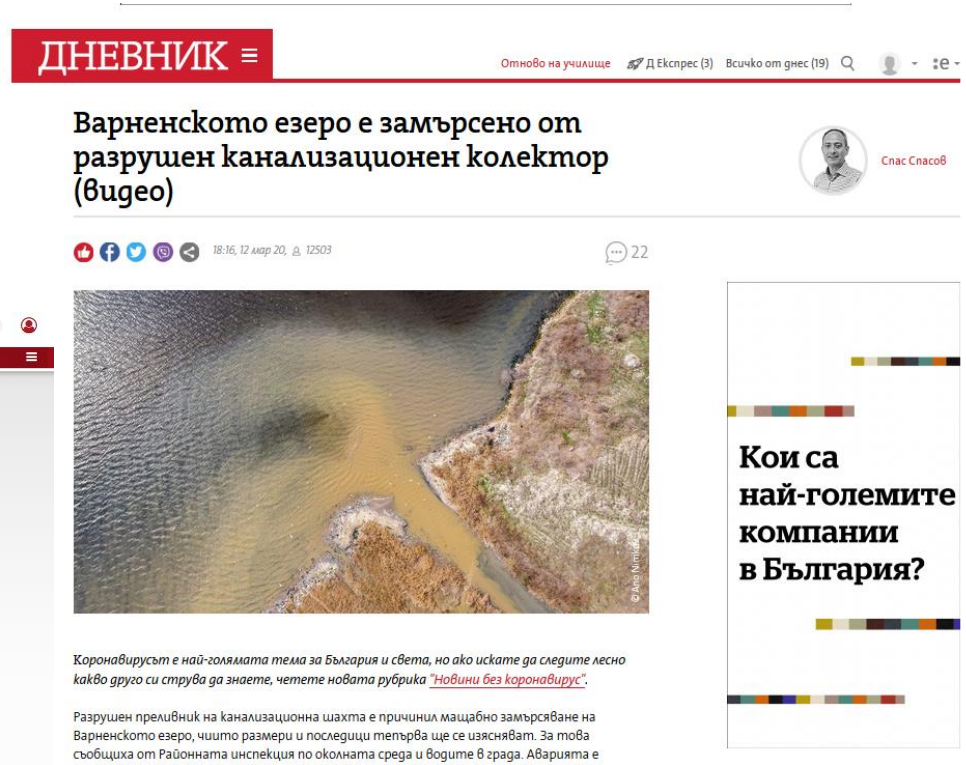
The case of a broken sewage pipe on the Bulgarian Black Sea coastal zone

- In March 2020 Bulgarian media firstly reported about the broken sewage pipe. By May 2020 the contamination has caused serious environmental impact.

https://www.maritime.bg/

https://offnews.bg/





https://www.dnevnik.bg/

Images of areas, affected by the broken sewer

https://www.dnevnik.bg/bulgaria/2020/03/12/4040413_goliamo_zamurdsiavane_na_varnenskoto_ezero_e/

https://offnews.bg/obshtestvo/ribata-vav-varnenskoto-ezero-izmira-izvazhdat-avariralata-fekalna-tra-729031.html

Methods for detecting sewage discharge from satellite data

- First step: compare two time periods – **with** and **without wastewater discharge**, in order to detect difference in the signal
  - Test time period 1: August 2018 – July 2019 – without wastewater discharge
  - Time period 2: August 2019 – July 2020 – with discharge from broken sewage pipe
- Analysed satellite data:
  - Optical change in ocean colour and inherent optical properties (IOPs) – Sentinel 2
  - Change in sea surface roughness – Sentinel 1

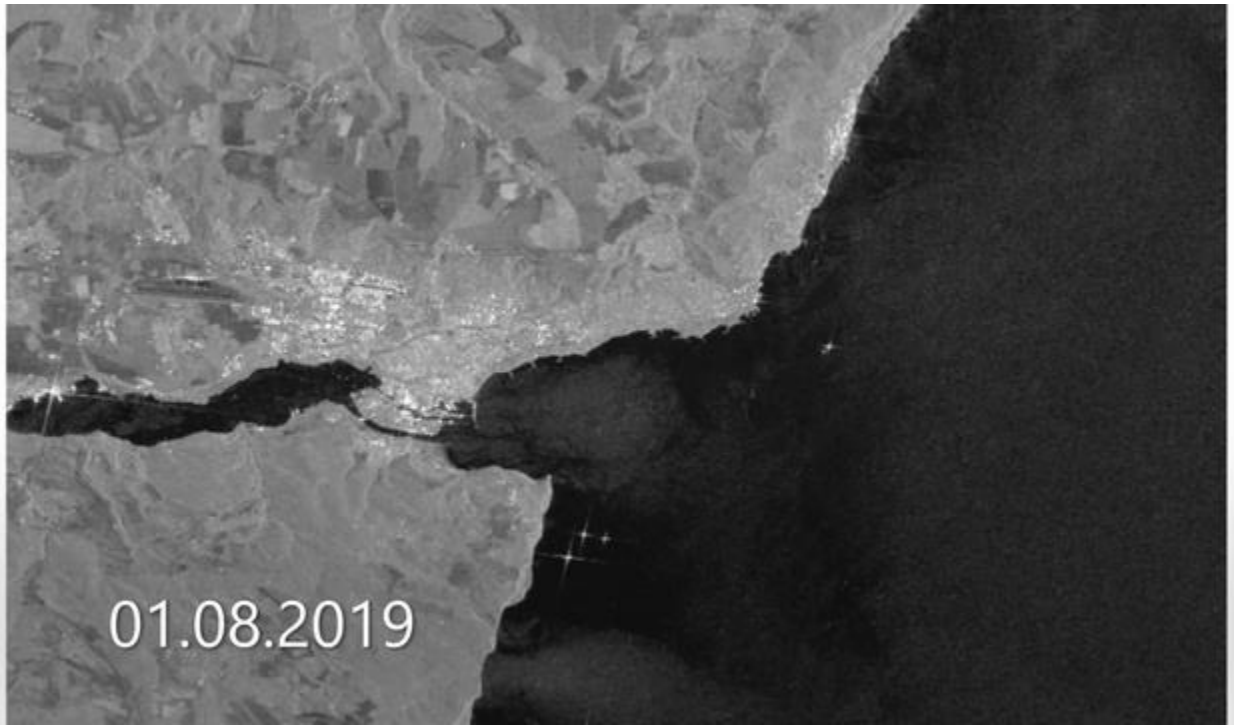
Optical data – Sentinel 2 → time-lapse

Test time-period:
August 2018 – July 2019

Time-period with accident:
August 2019 – July 2020

Videos generated with Sentinelhub – EO browser

Sea surface roughness from SAR – Sentinel 1 → time-lapse



Test time-period:
August 2018 – July 2019

Time-period with accident:
August 2019 – July 2020

Descending pass only; orbit 36; backscattering in dB

Преждевременни изводи

- Само цвят на морската повърхност и радарни изображения не са достатъчни за разграничаване между замърсени отпадни води и речни води

→ Проследяване на промени в Inherent Optical Properties (IOPs) с време

- 3 IOPs:
  - Коефеициент на абсорбция на **Coloured Dissolved Organic Matter** (CDOM) при 443nm
  - Коефеициент на абсорбция на **Phytoplankton pigment** при 443nm
  - Коефеициент на абсорбция на **Detritus** при 443nm
- **Total absorption coefficient** at 443nm = **CDOM + Phytoplankton pigment + Detritus**

RGB композити от IOPs дроби

- Кой е доминиращият абсорбер в крайбрежни води?

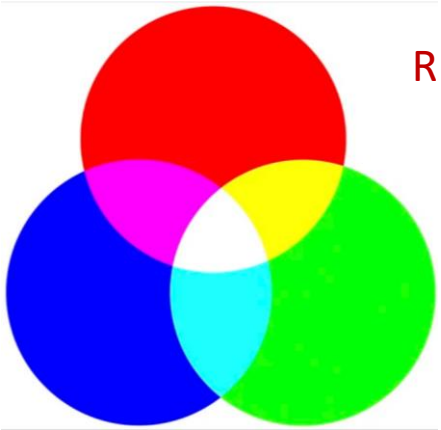
$$\frac{Single\ absorber}{Total\ absorption}$$

$$\frac{CDOM}{Total\ absorption}, \frac{Detritus}{Total\ absorption}, \frac{Phytoplankton\ pigment}{Total\ absorption}$$

Направи RGB композити за 3те абсорбционни дроби

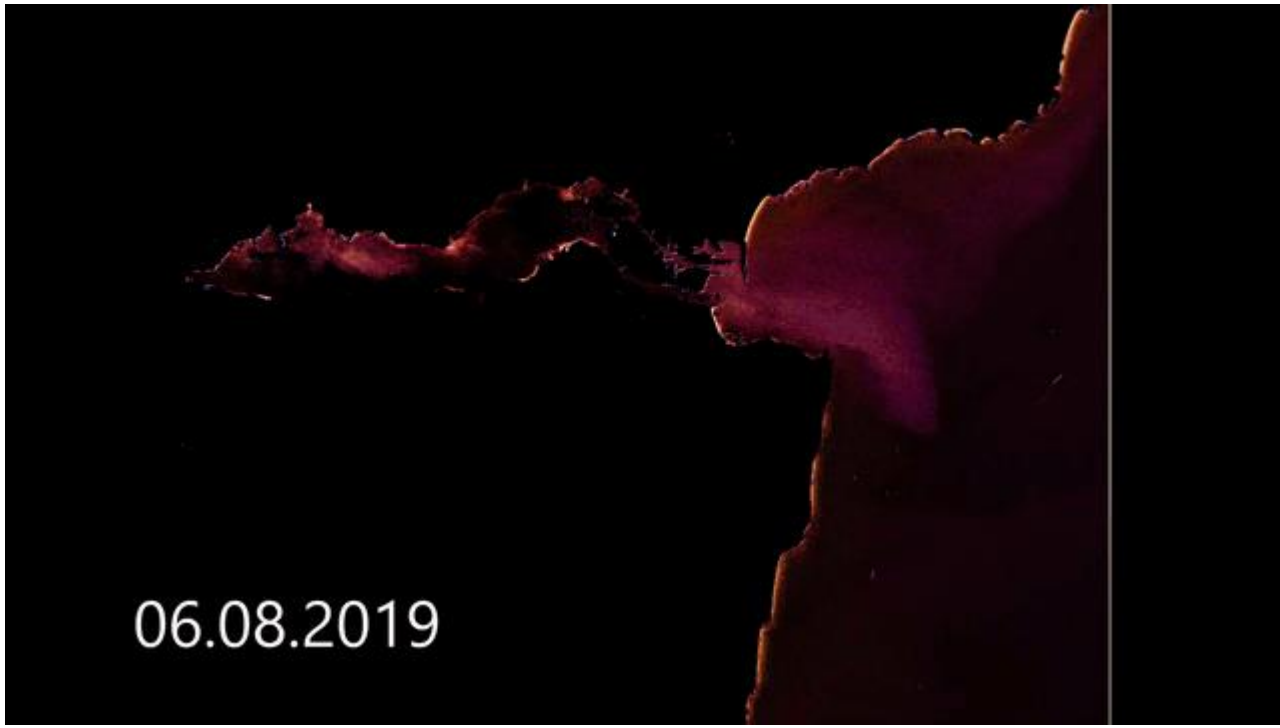
R: $\frac{CDOM\ abs.}{Total\ absorption}$

B: $\frac{Detritus\ abs.}{Total\ absorption}$



G: $\frac{Phytoplankton\ pigment\ abs.}{Total\ absorption}$

RGB colour composites of IOPs fraction



Test time-period:
August 2018 – July 2019

Time-period with accident:
August 2019 – July 2020

IOPs calculated from Sentinel 2 data with the C2RCC processor, build in SNAP

От дневни към годишни осреднени стойности

- Дневните стойности варират силно

Пресмятане на средни стойности за двата периода:

- Годишно средно
- 4 месеца средно – Март-Юни за двете години

→ максимумът на замърсяване/изтичане беше между Март-Юни 2020

Анализ на всяка фракция за време / пространство

RGB композити на всяка фракция към общата абсорбция, за да се види нейния принос към общата абсорпция

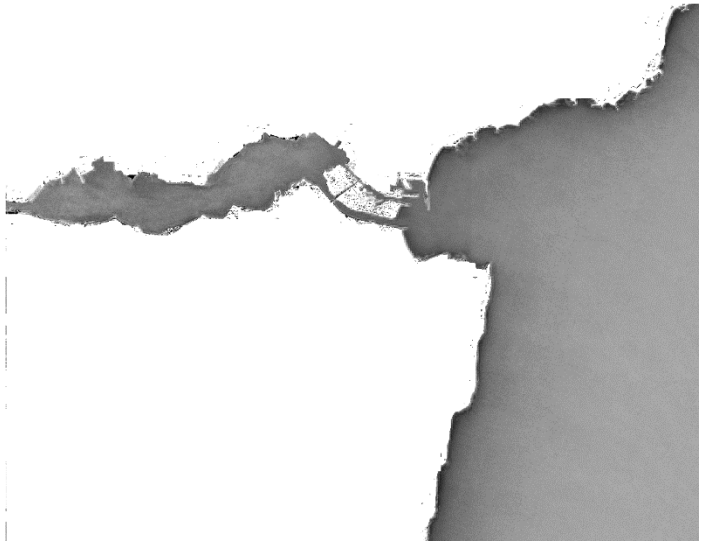
Annual mean – IOP fractions to total

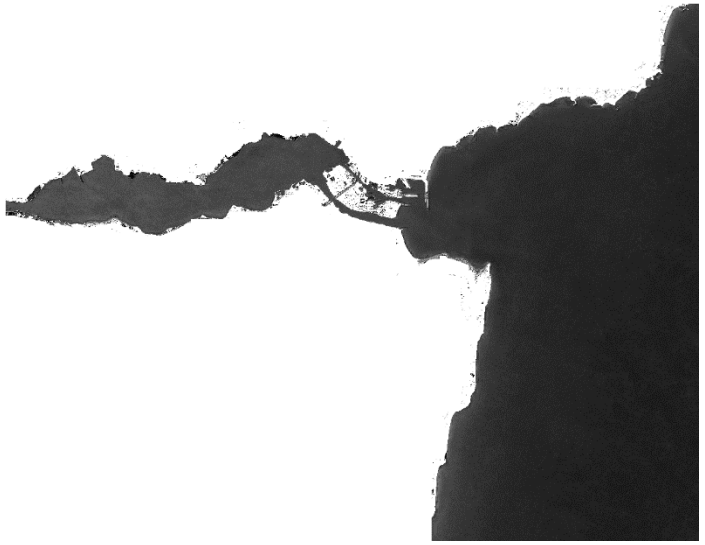
Detritus abs. / Total abs.

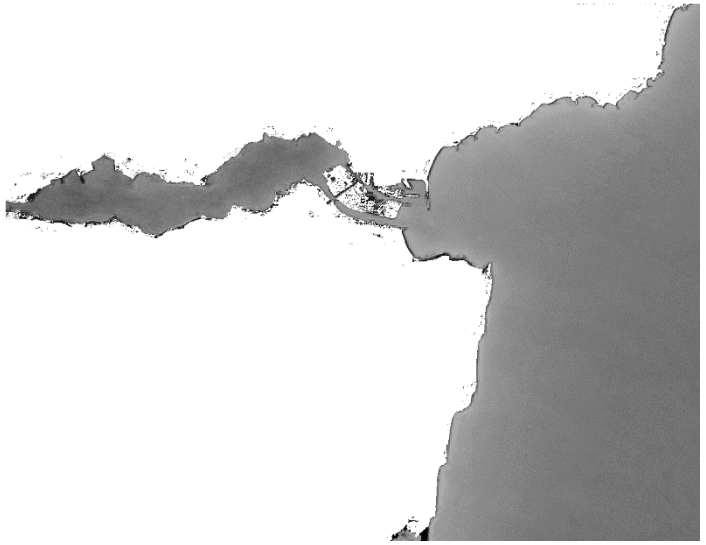
Phyto. pigment abs. / Total abs.

CDOM abs. / Total abs.

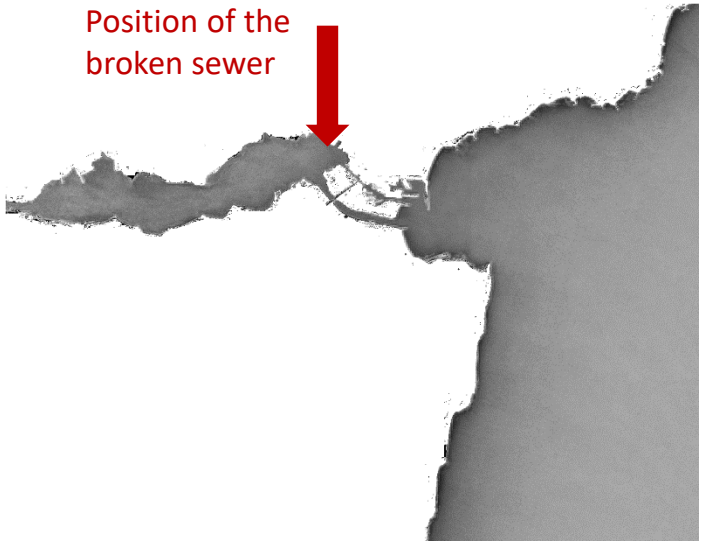
Test time-period: August 2018 – July 2019

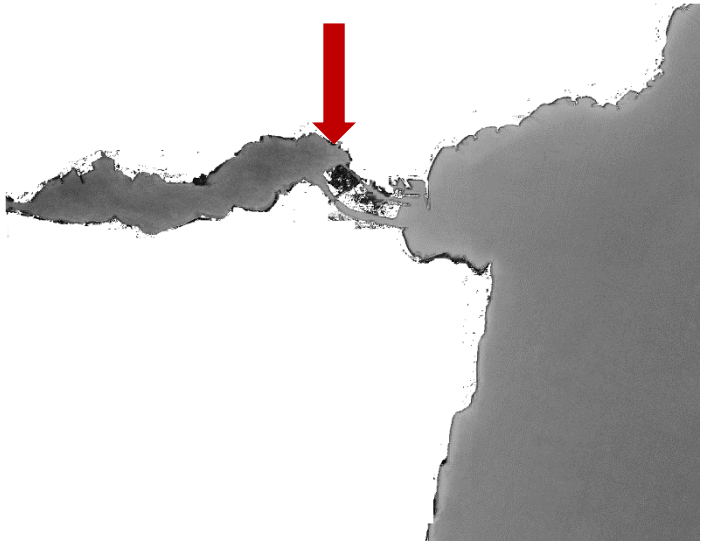






Time-period with accident : August 2019 – July 2020





Преждевременни изводи за годишни осреднени

- Най-силните колебания между двата периода се наблюдават за абсорбция на фитопланктон и детритус; колебанията на CDOM са минимални

Нарастване / намаляване на абс. при детритус води до намаляване / нарастване на абс. фитопланктон

Взаимовръзката детритус – фитопланктон се вижда ясно на осреднените стойности за 4 месеца – Март-Юни

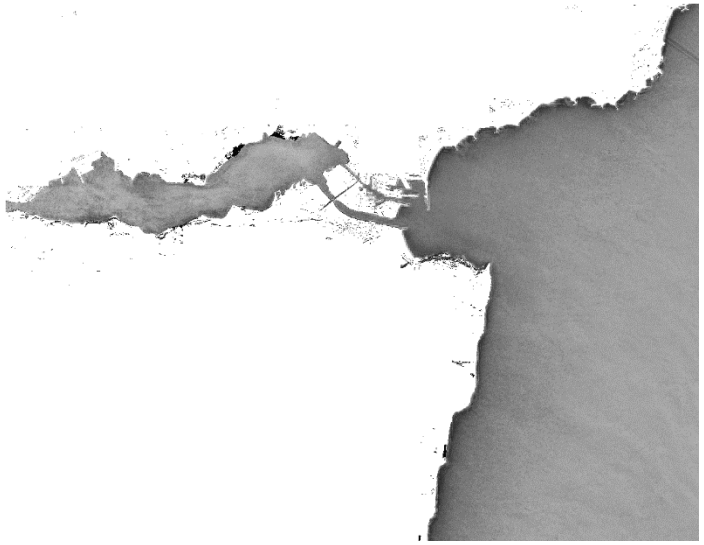
March-June: 4 months mean – IOP fractions to total

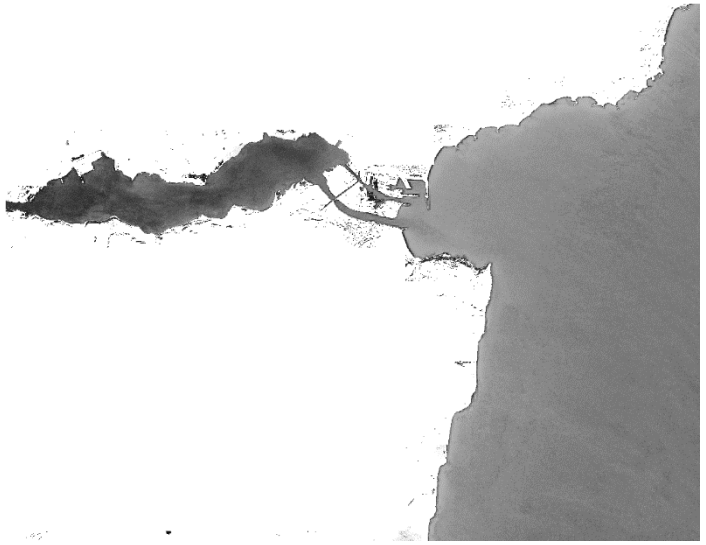
Detritus / Total

Phyto. pigment / Total

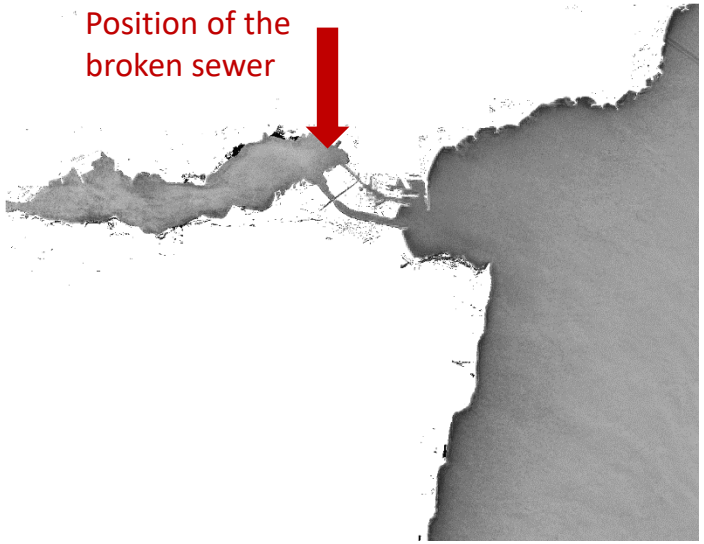
CDOM / Total

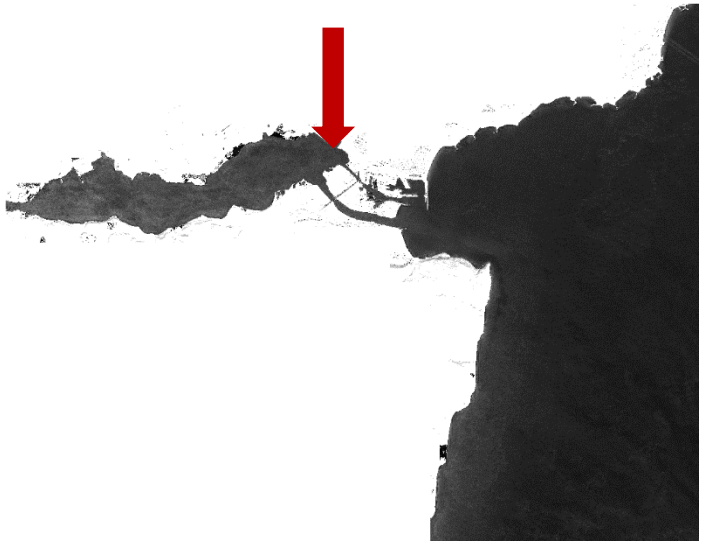
Test time-period: March – June 2019

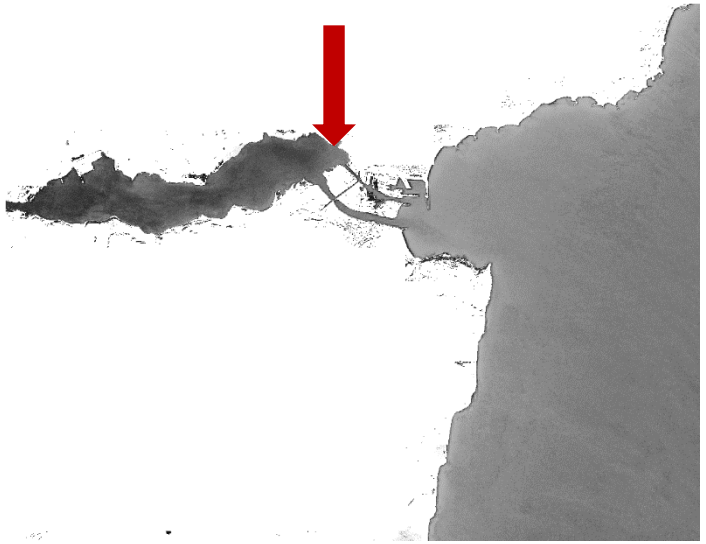




Time-period with accident : March – June 2020





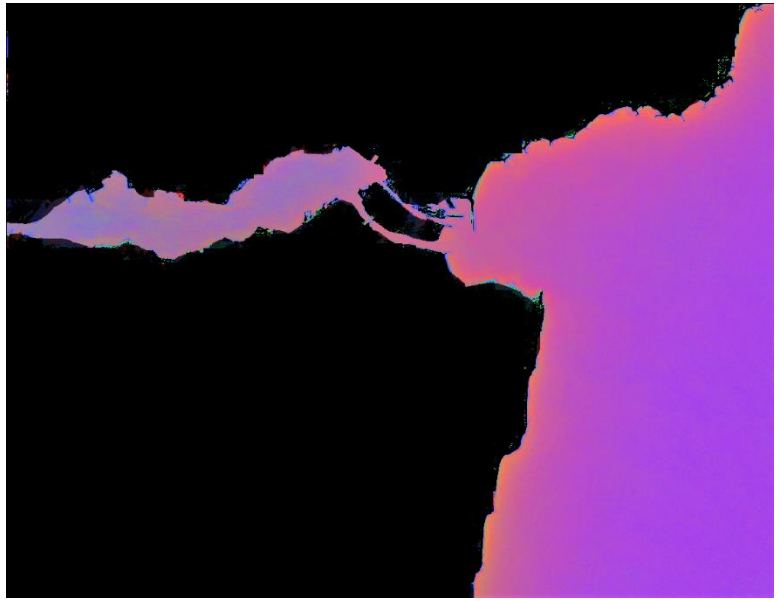


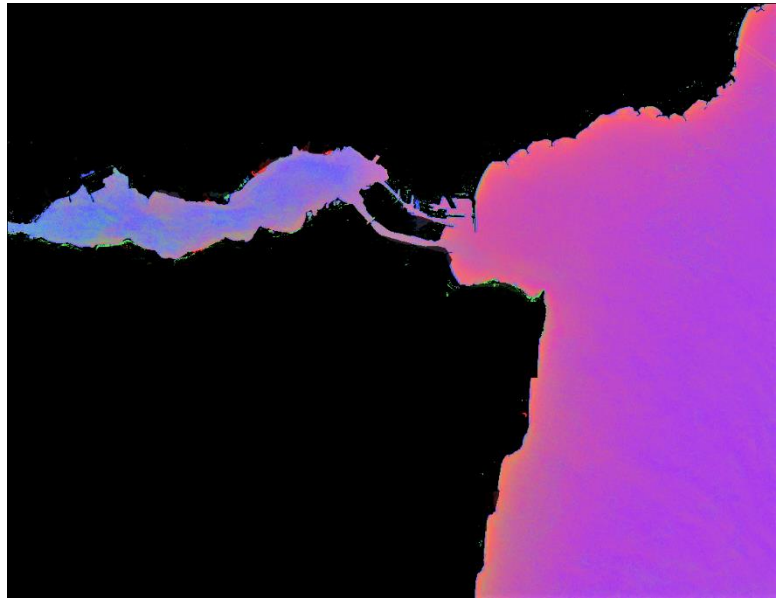
RGB composites annual and 4 months mean – IOP fractions to total

Annual mean

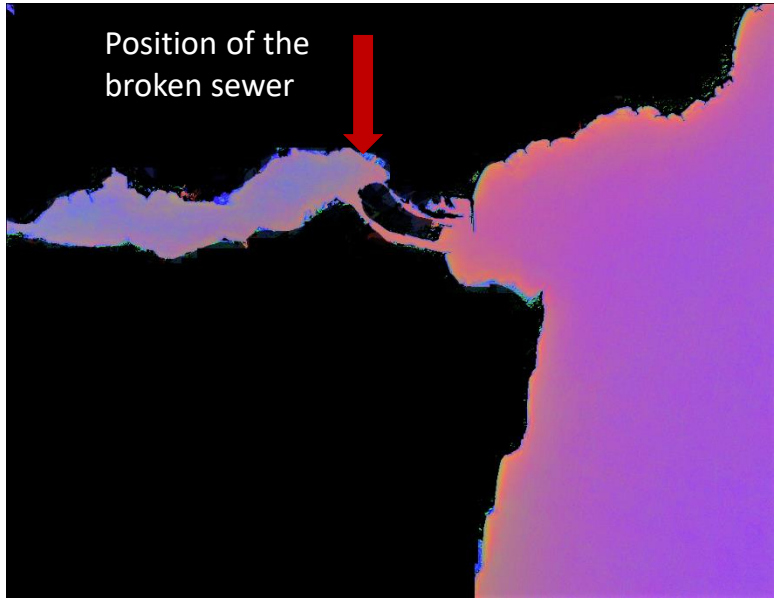
4 months mean

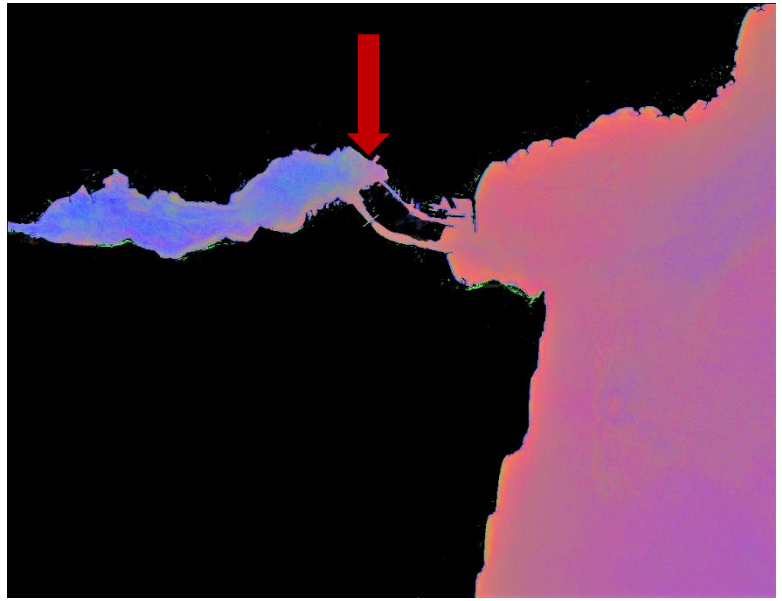
Test time-period: August 2018 – July 2019





Time-period with accident : August 2019 – July 2020





Изводи

- От предишни наши изследвания знаем, че:
  - В крайбрежни райони CDOM е доминиращата компонента; детритус и фитопланктон имат равни фракции помежду си
  - Далече от брега, в открито море, доминиращата компонента е детритус.
- Наблюдаваните източници от реки/потоци и обработени отпадни води се детектират по увеличение на фракцията на фитопланктон и намаляване на фракцията на детритус.

Изводи

- В това изследване видяхме, че наземен източник, като езеро, свързано с морето, в което се изливат непречистени отпадни води, може да се наблюдава по следните параметри:
  - Увеличение на фракцията на поглъщане на фитопланктон към общото
  - Намаление на фракцията на поглъщане на детритус към общото
  - Фракцията на CDOM към общото остава с еднакви стойности за целия период за крайбрежния район
- От RGB композите за района за Варненския залив промяна от лилаво към розово би могло да е сигнал за замърсена вода.
- Близко до брега, увеличение в фракцията на фитопланктон би могло да бъде индикатор за замърсяване, ако няма речен източник в близост.

Future work

- Extend the time period of observation in order to confirm the visibility without sewage discharge
- Determine the extend of the impact of the local phytoplankton bloom on the detectable discharge

Thank you for your attention!