# A multiplatform analysis of wind- and river-driven surface circulation in the Gulf of Trieste (northern Adriatic Sea)

Davide Lombardo, Fabio Giordano, Emanuele Ingrassia, Milena Menna, Lise Dekoster, Giorgio Bolzon, Antonio Bussani, Davide Deponte, Simone Martini, Massimo Pacciaroni, Stefano Querin, Laura Ursella

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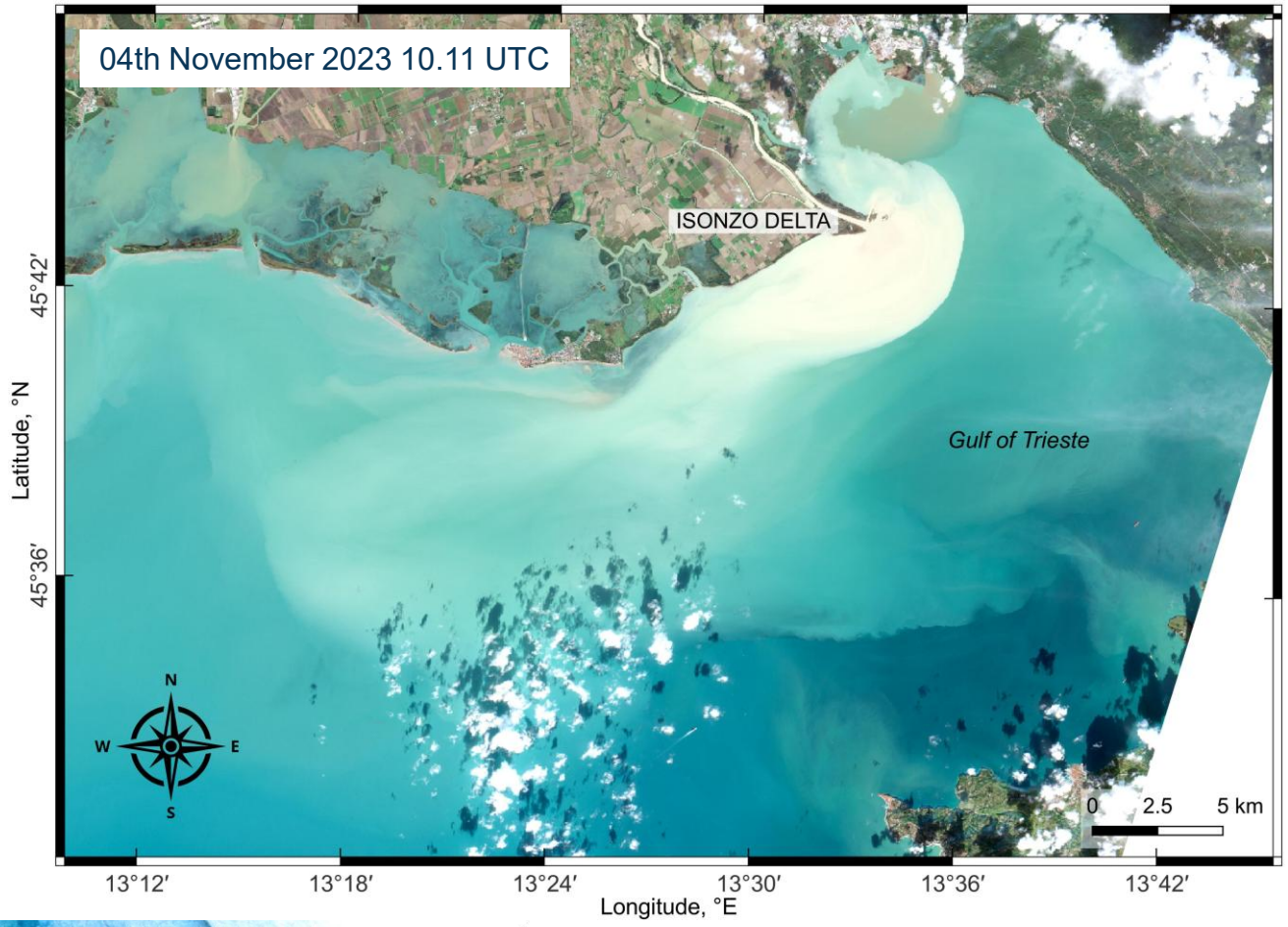
2 – 4 December 2025
Lisbon (Portugal)

# THE INFLUENCE OF THE ISONZO PLUME

**Period**: October – November 2023


Sentinel-2 image from Copernicus website: https://link.dataspace.copernicus.eu/l3n1

- Heavy rainfalls;
- Strong southerly winds;
- Strong river discharge;
- Coastal storm and coastal flooding.



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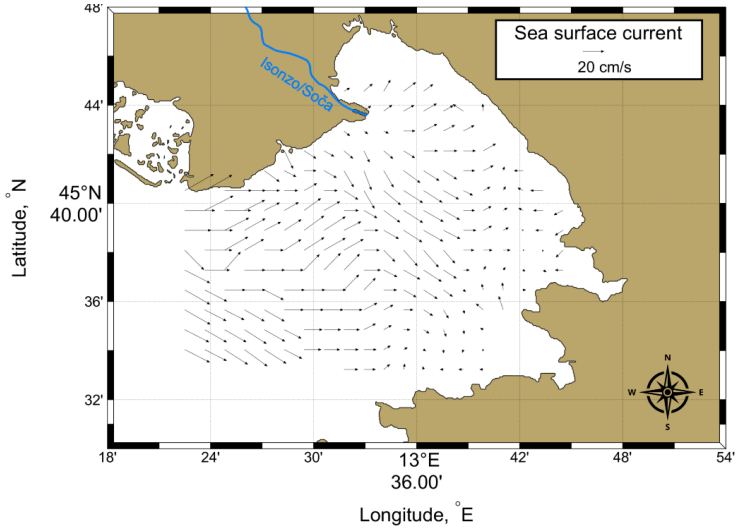
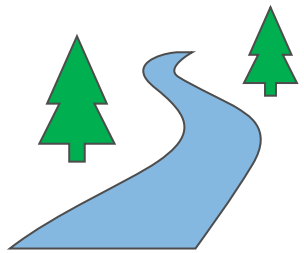
# RESEARCH QUESTION

Can intense river outflows from the Isonzo/Soča, triggered by heavy rainfall, dominate over wind-induced effects?



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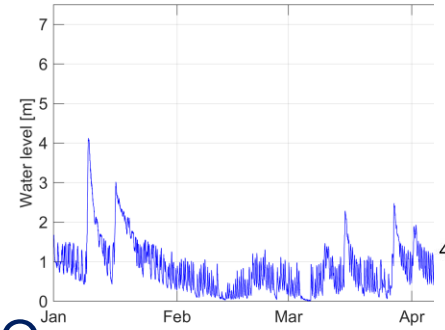
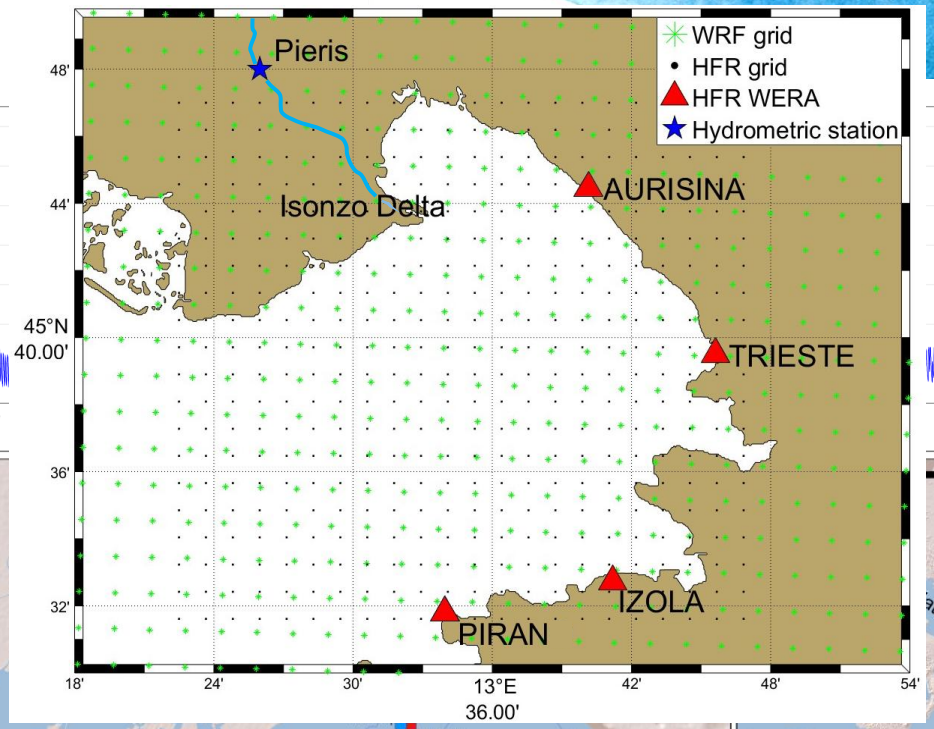
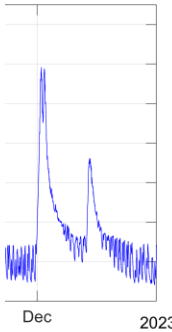
# THE INFLUENCE OF THE ISONZO PLUME

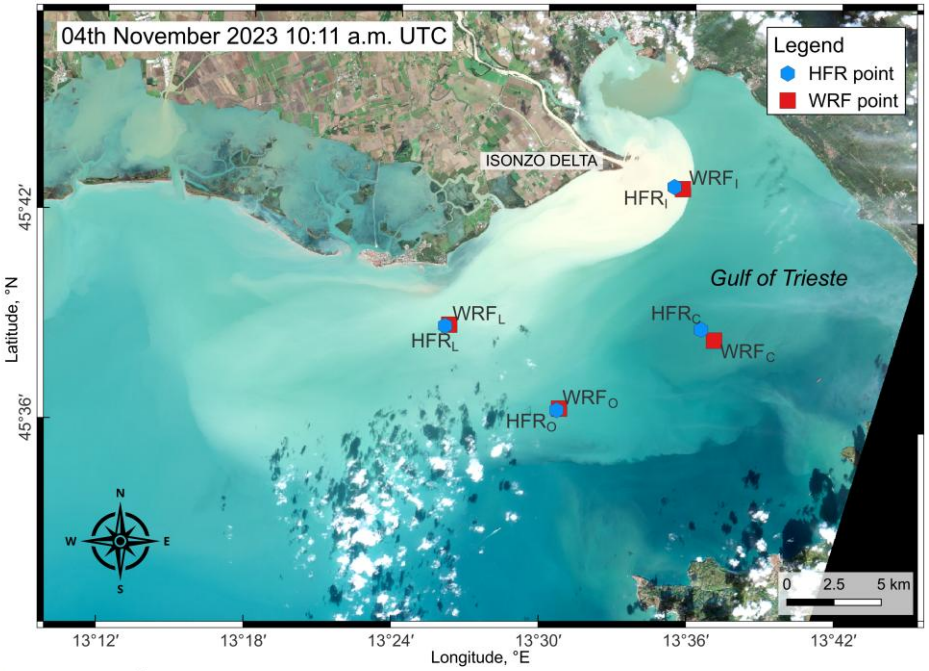
## INTEGRATED ANALYSIS

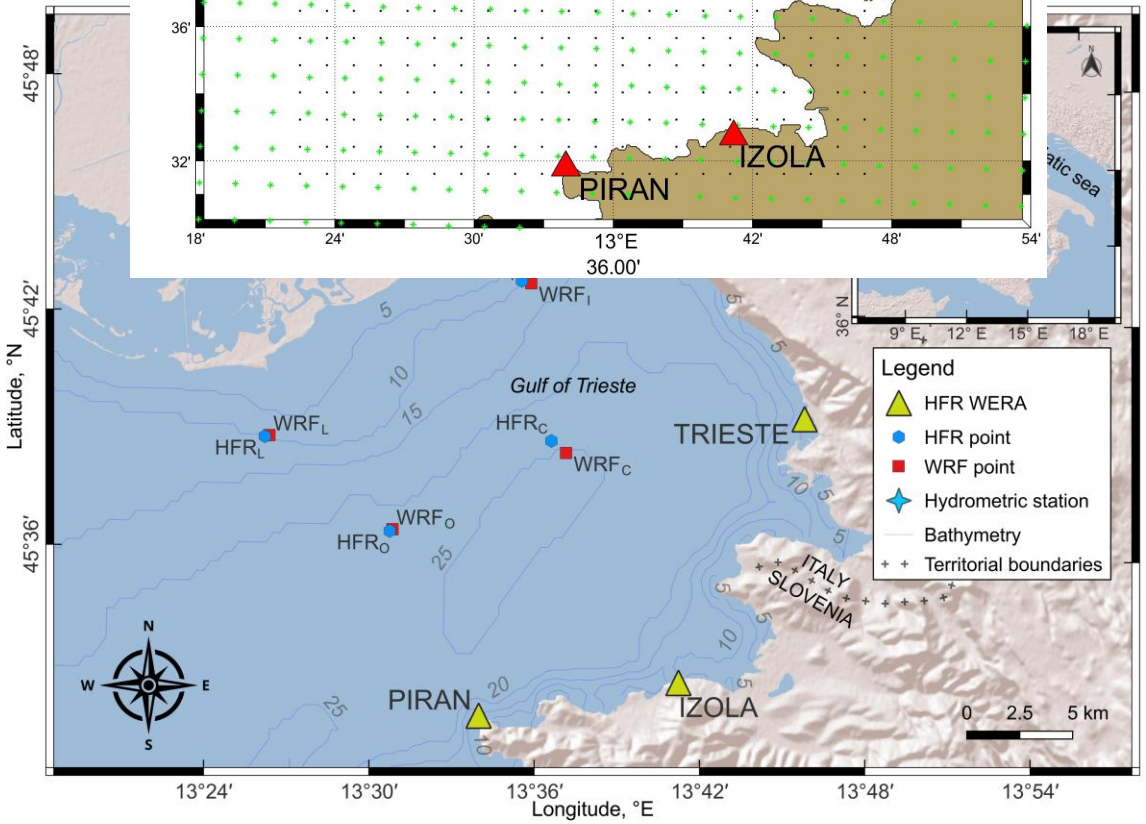
- Hydrometric data (ARPA FVG);
- WRF model - wind data (ARPA FVG);
- HFR data (OGS, ARPA FVG, NIB, ARSO https://www.hfrnode.eu/networks/hfr-nadr-2/): currents and waves.

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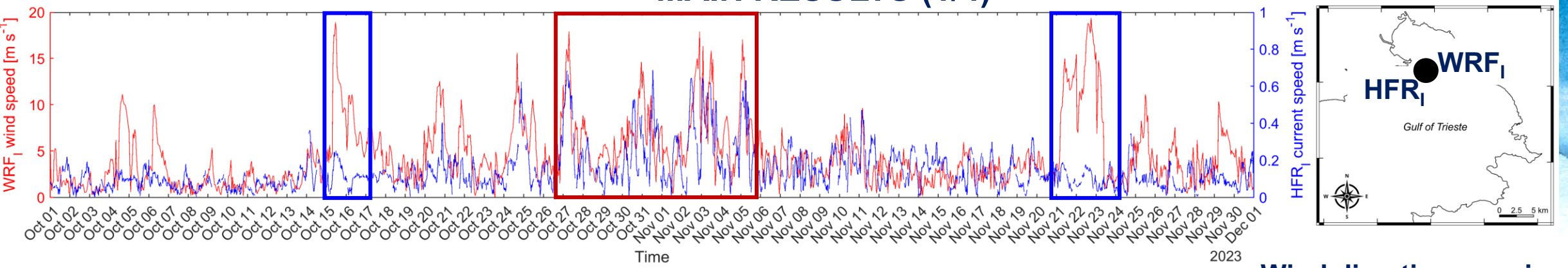
# THE INFLUENCE OF THE ISONZO PLUME

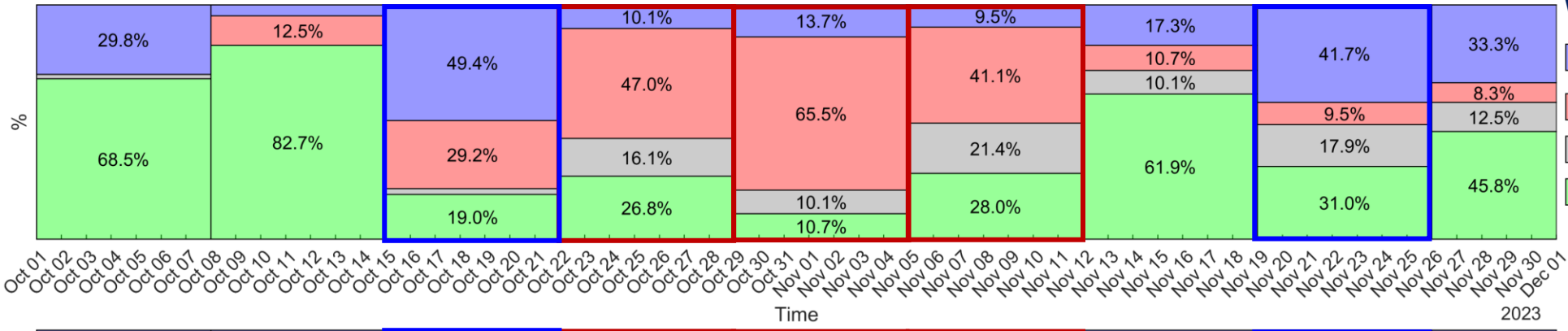
## MAIN RESULTS (1/4)

Lombardo et al., 2025



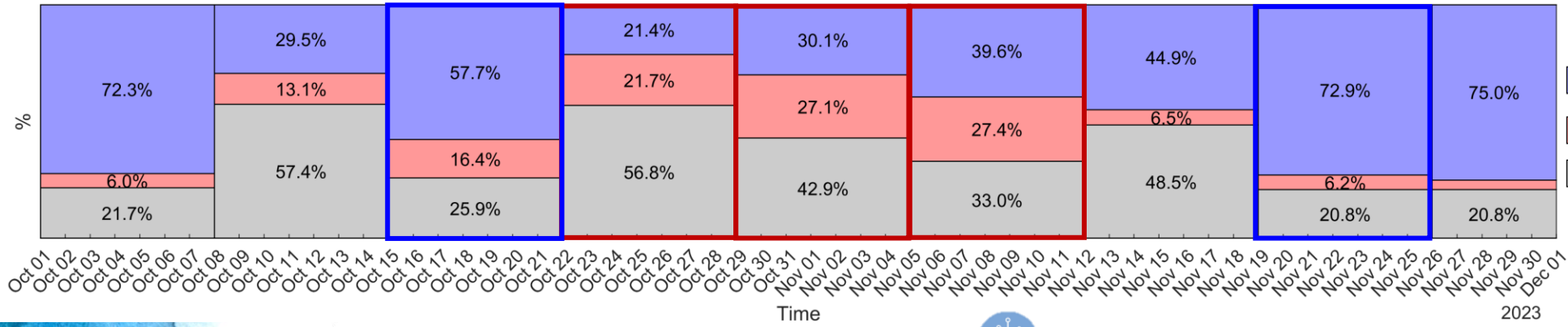


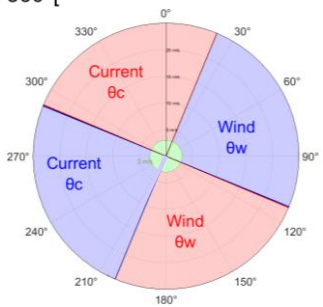





## Wind direction: coming from

- Bora: $\theta_w \in [22.5°, 112.5°[$
- Southerly Wind: $\theta_w \in [112.5°, 206°]$
- Other Directions
- Low Winds: $\theta_w \in [0°, 360°[$




- $\theta_c \in [202.5°, 292.5°[$
- $\theta_c \in [292.5°, 360°] \cup [0°, 26°]$
- Other Directions

## Currents direction: is going

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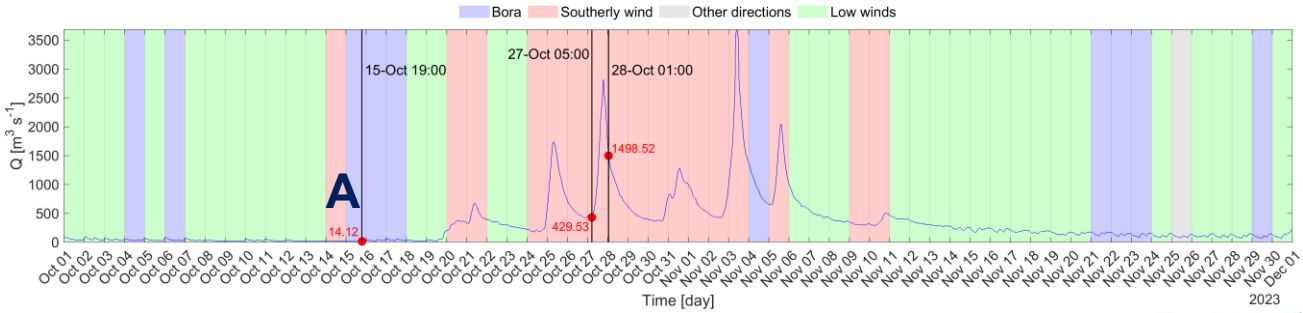
# THE INFLUENCE OF THE ISONZO PLUME



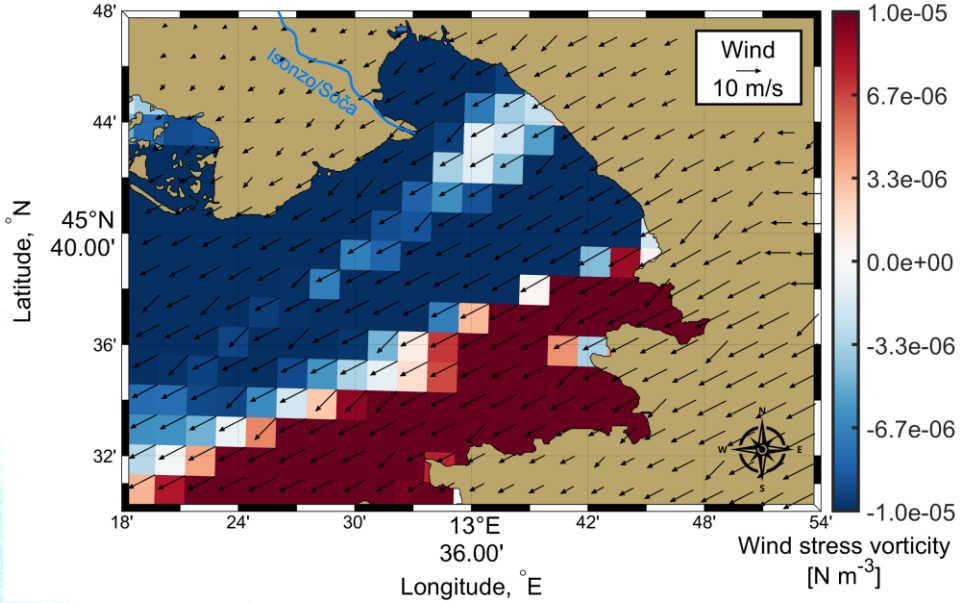
## MAIN RESULTS (2/4)

## CASE A

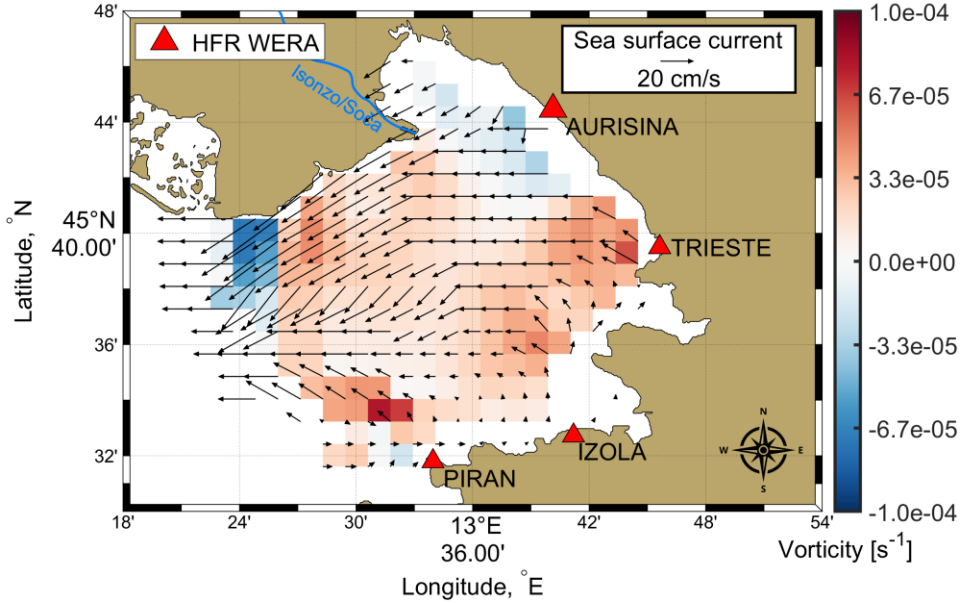
**Bora wind and no outflow** on 15 October at 19:00 UTC.
Discharge 14.12 $m^3s^{-1}$.




## Wind field and vorticity




## Currents and vorticity




## Bora wind ⇨ Intensified cyclonic circulation

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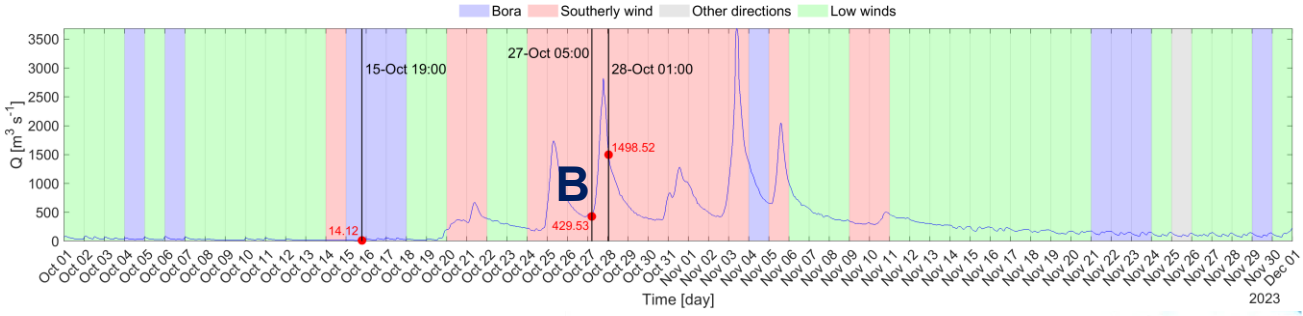
# THE INFLUENCE OF THE ISONZO PLUME

Lombardo et al., 2025

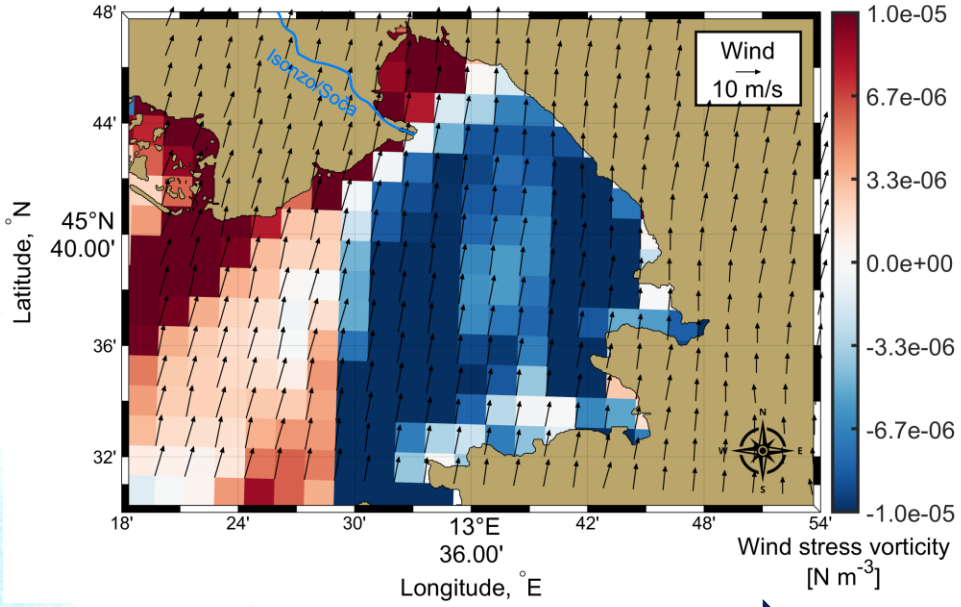
## MAIN RESULTS (3/4)

## CASE B

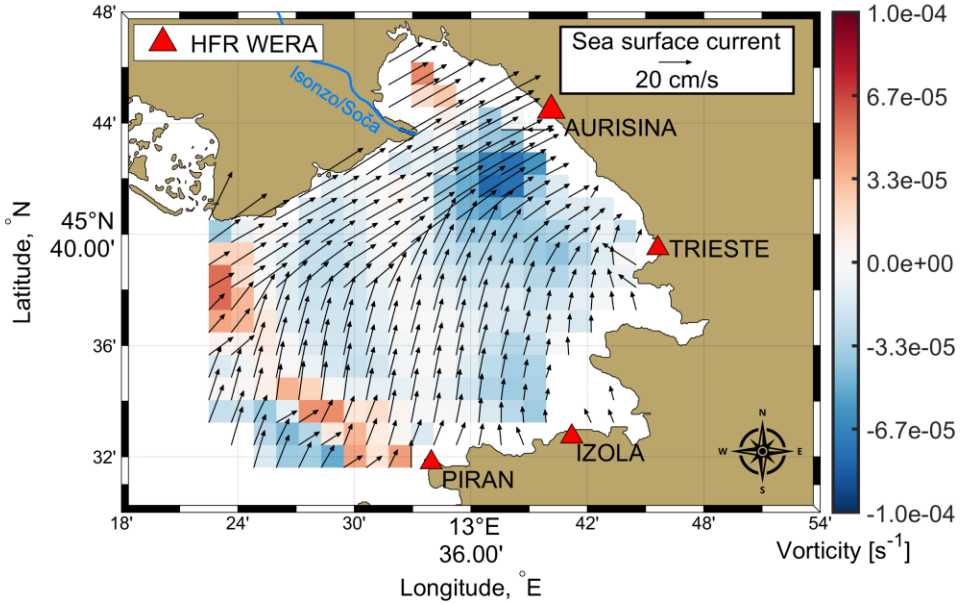
**Southerly wind and weak outflow** on 27 October at 05:00 UTC.
Discharge 429.53 $m^3s^{-1}$.




### Wind field and vorticity




### Currents and vorticity




**Southerly wind** ⇨ **Circulation shift in anticyclonic**

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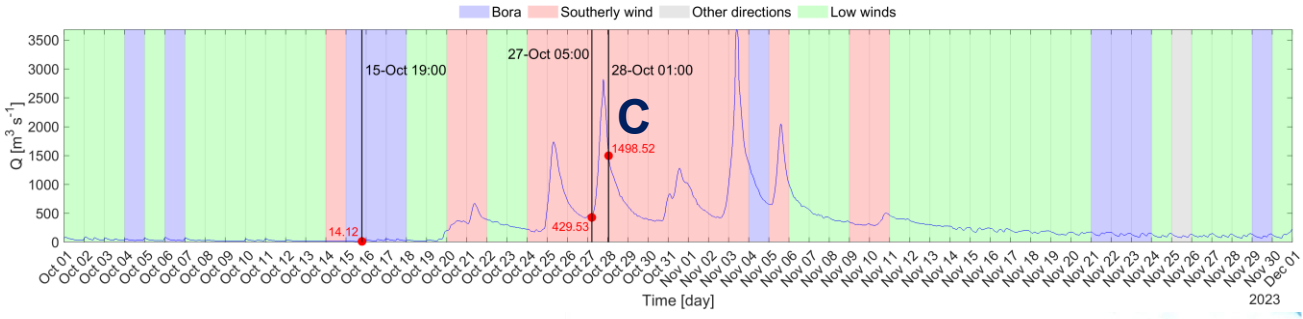
# THE INFLUENCE OF THE ISONZO PLUME



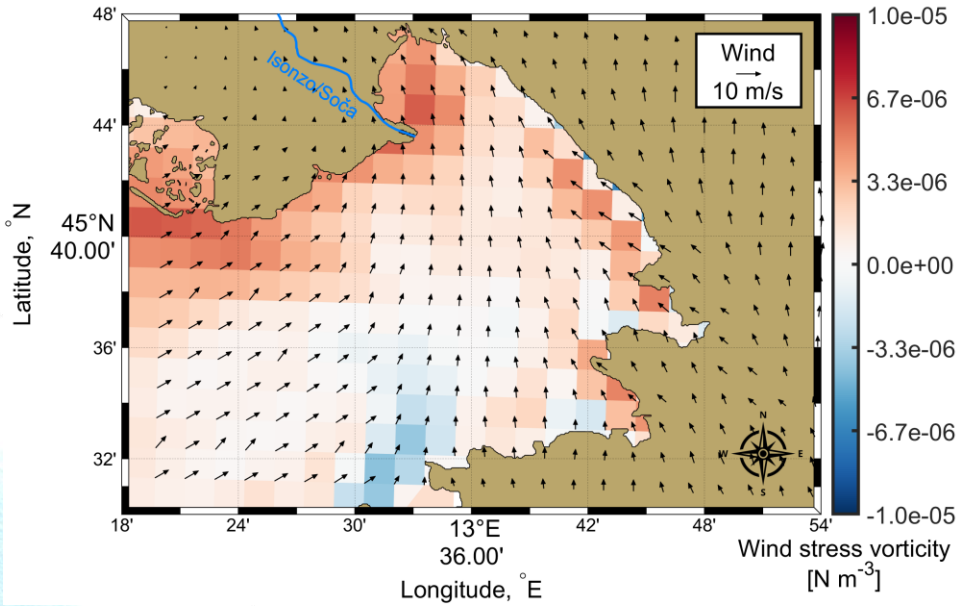
## MAIN RESULTS (4/4)

## CASE C

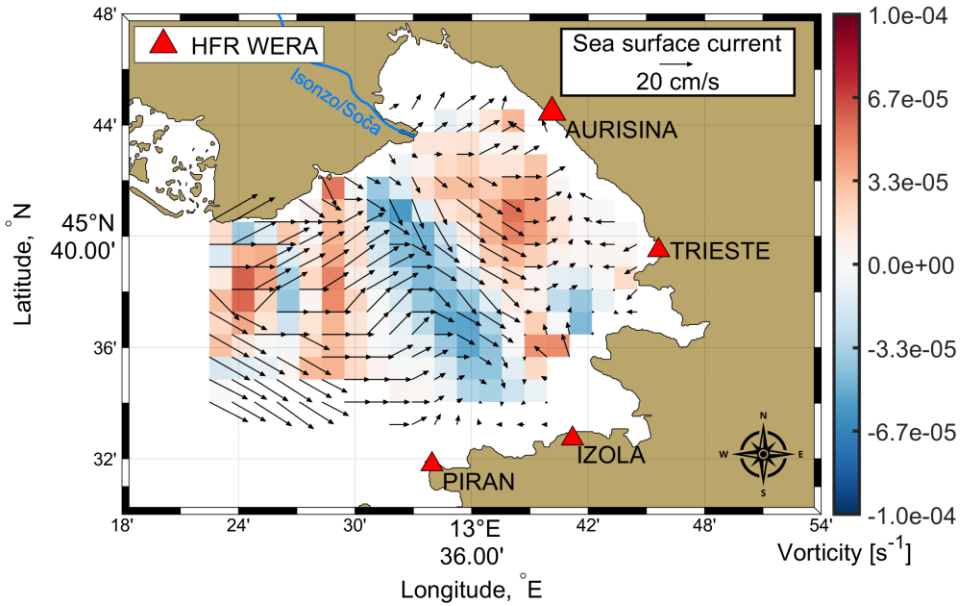
**Southerly wind and strong outflow** on 28 October at 01:00 UTC.
Discharge 1498.52 $m^3s^{-1}$.




### Wind field and vorticity




### Currents and vorticity




**Dominant circulation patterns could be triggered by periods of intense river outflows**

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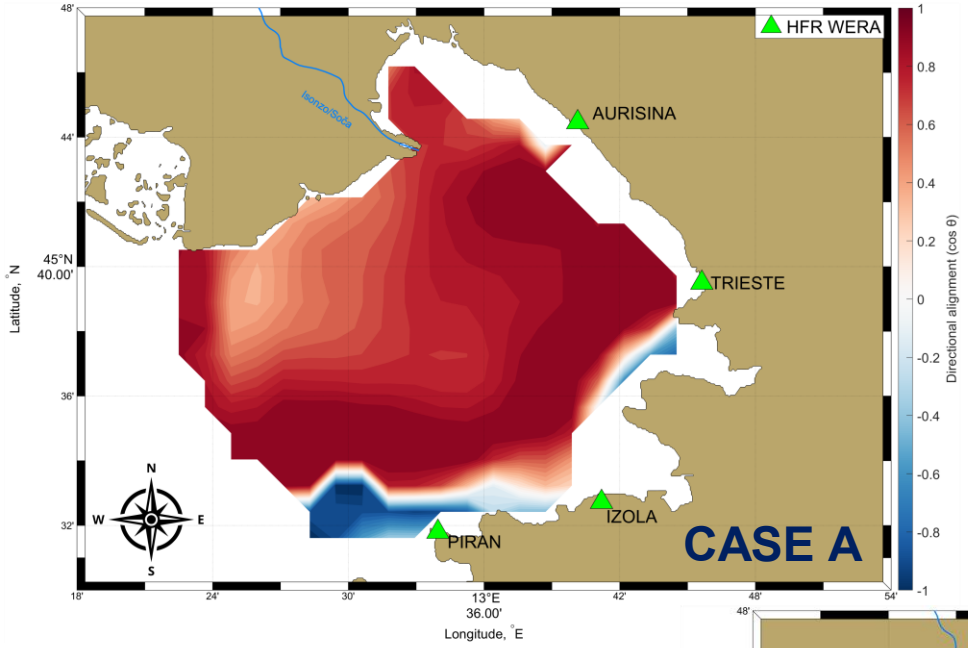
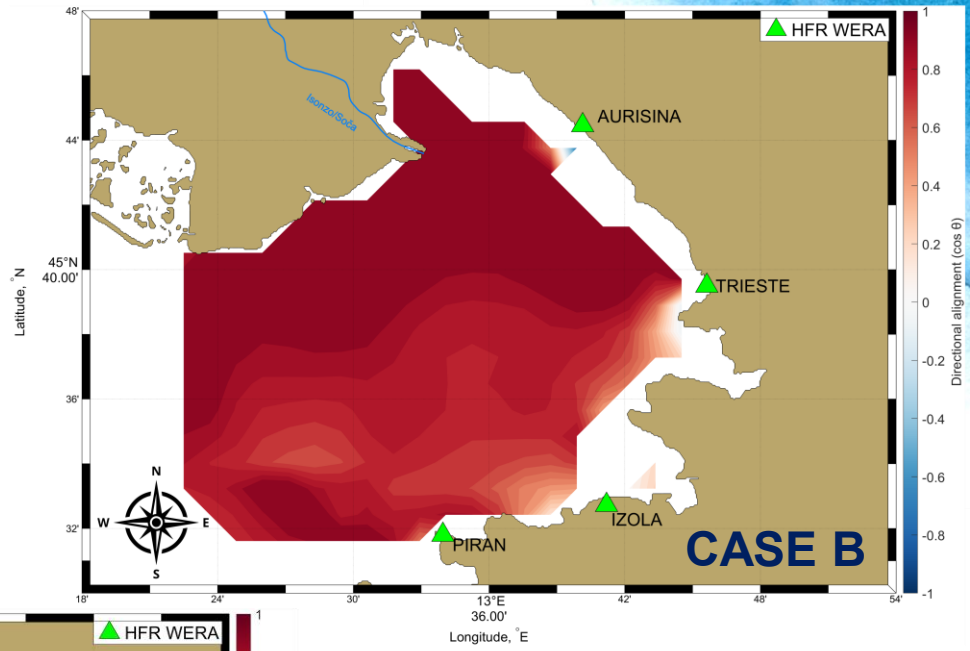
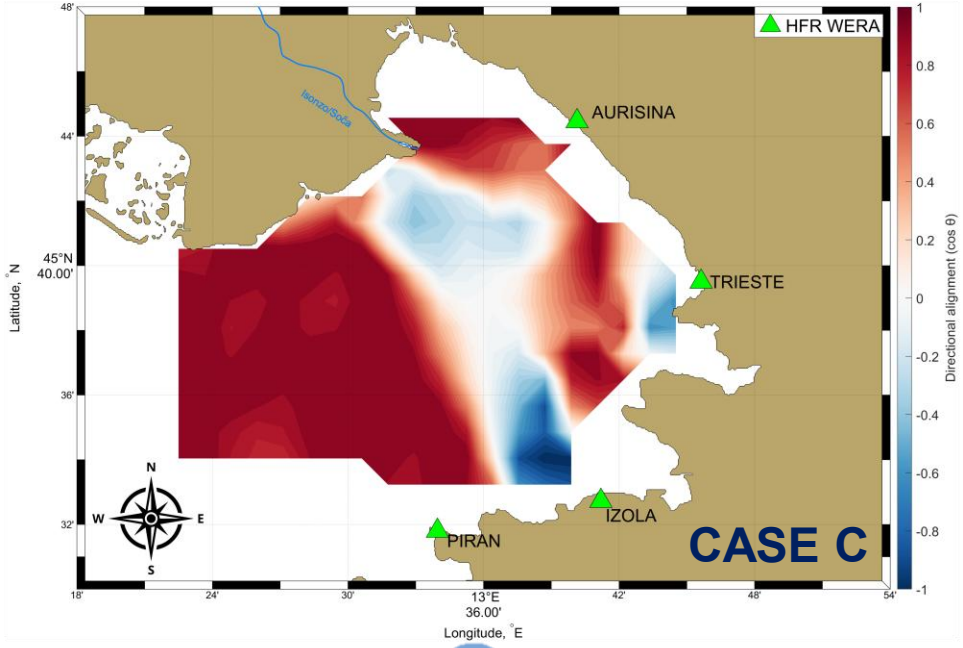
# THE INFLUENCE OF THE ISONZO PLUME

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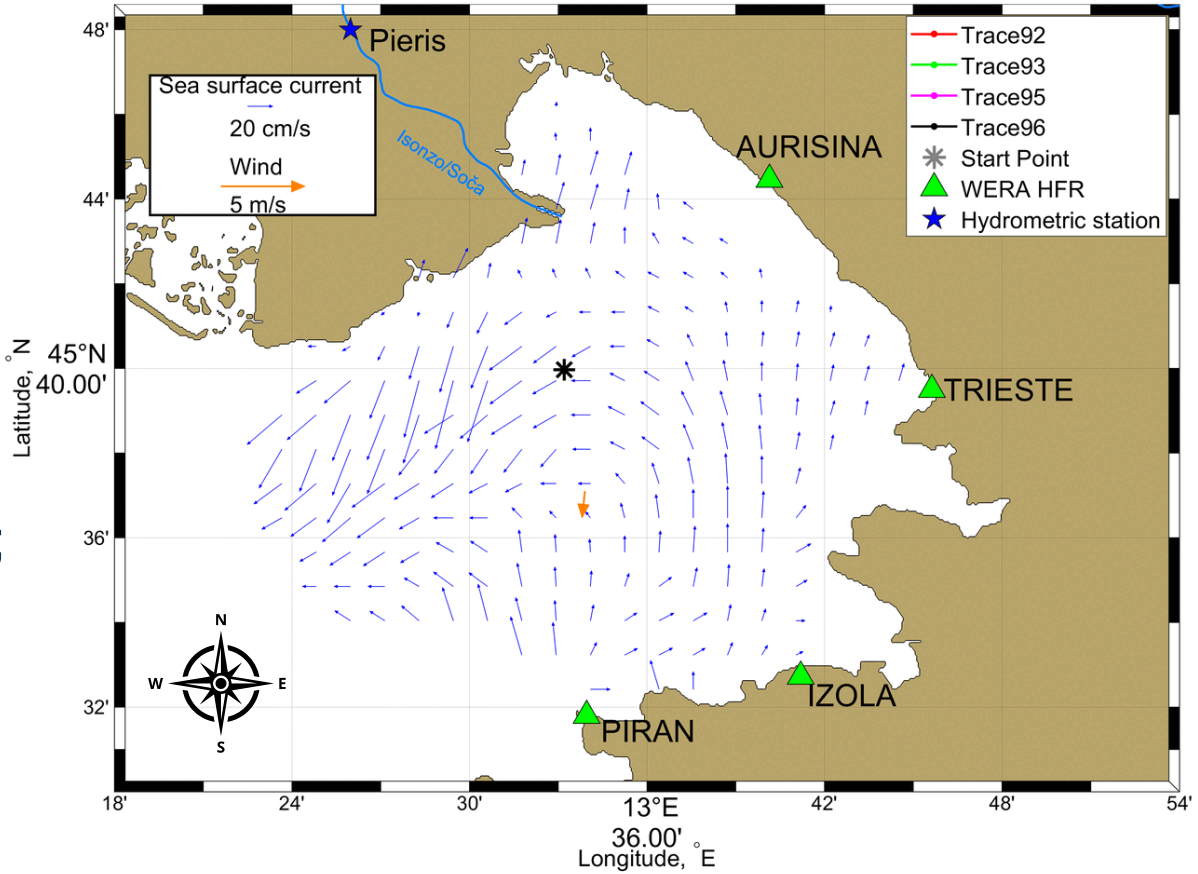
# DRIFTER CODE DEPLOYMENT

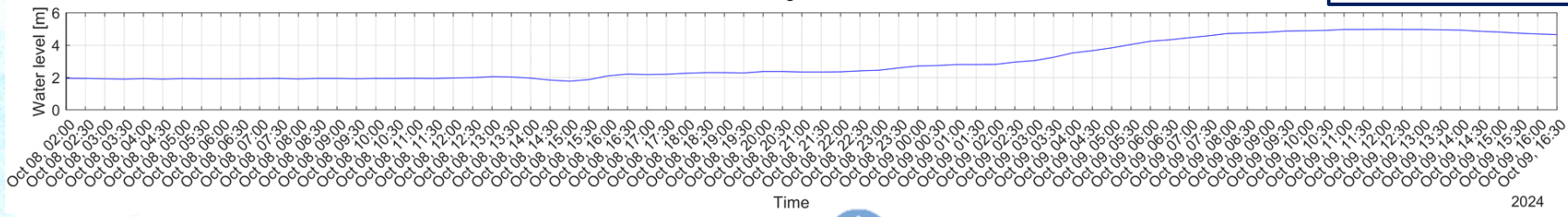
8-9 October 2024 | Southerly wind

- **4 drifters**;
- Maps every **30 min**;
- **Sea surface currents**: WERA HFR;
- **Wind**: Paloma buoy;
- **Water level**: Pieris hydrometric station.




**QUALITATIVE ASSESSMENT**

Drifter trajectories **follow** the surface currents measured by HF radar.

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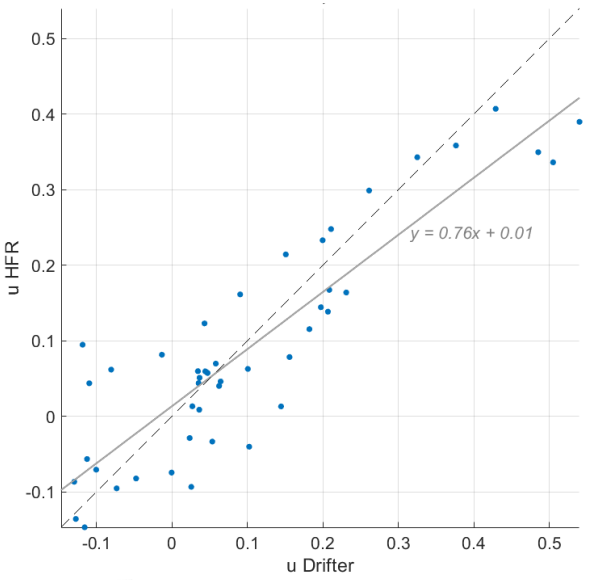
# STATISTICAL ANALYSIS DRIFTER – HFR AND DRIFTER – MODEL

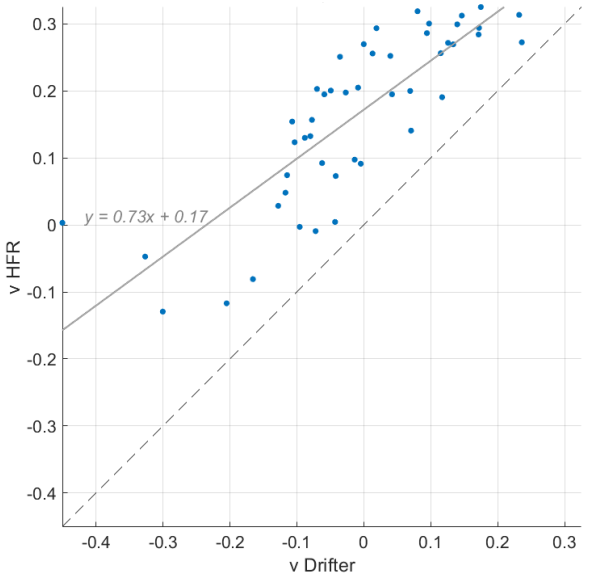
OCTOBER 2024

## Trace 92

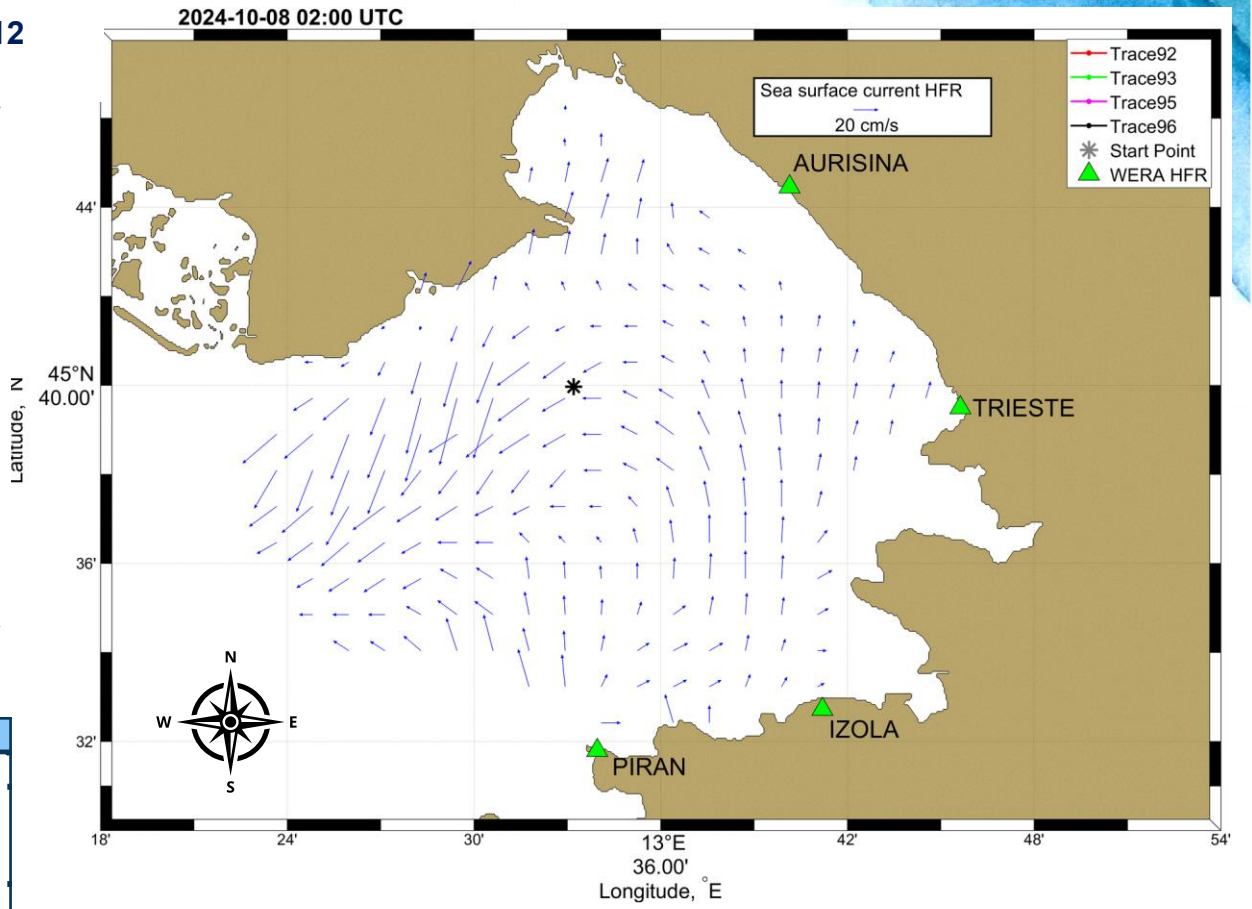
**u**
**#47**
**R=0.89, $R_L$=0.8, $R_U$=0.94, p=1e-16**
**RMSE=0.079, Bias=0.011**




**v**
**#47**
**R=0.82, $R_L$=0.7, $R_U$=0.9, p=1.3e-12**
**RMSE=0.19, Bias=-0.18**




| Drifter name | R | |
|---|---|---|
| | $u_{HFR}$ *VS* $u_{drifter}$ | $v_{HFR}$ *VS* $v_{drifter}$ |
| Trace 92 | 0.89 ($R_L$=0.80, $R_U$=0.94) | 0.82 ($R_L$=0.70, $R_U$=0.90) |
| Trace 93 | 0.87 ($R_L$=0.60, $R_U$=0.96) | 0.49 ($R_L$=-0.12, $R_U$=0.83) |
| Trace 95 | 0.98 ($R_L$=0.92, $R_U$=1.00) | 0.91 ($R_L$=0.64, $R_U$=0.98) |
| Trace 96 | 0.78 ($R_L$=0.64, $R_U$=0.87) | 0.78 ($R_L$=0.65, $R_U$=0.87) |




**Comparison of HFR and drifter data shows good agreement**

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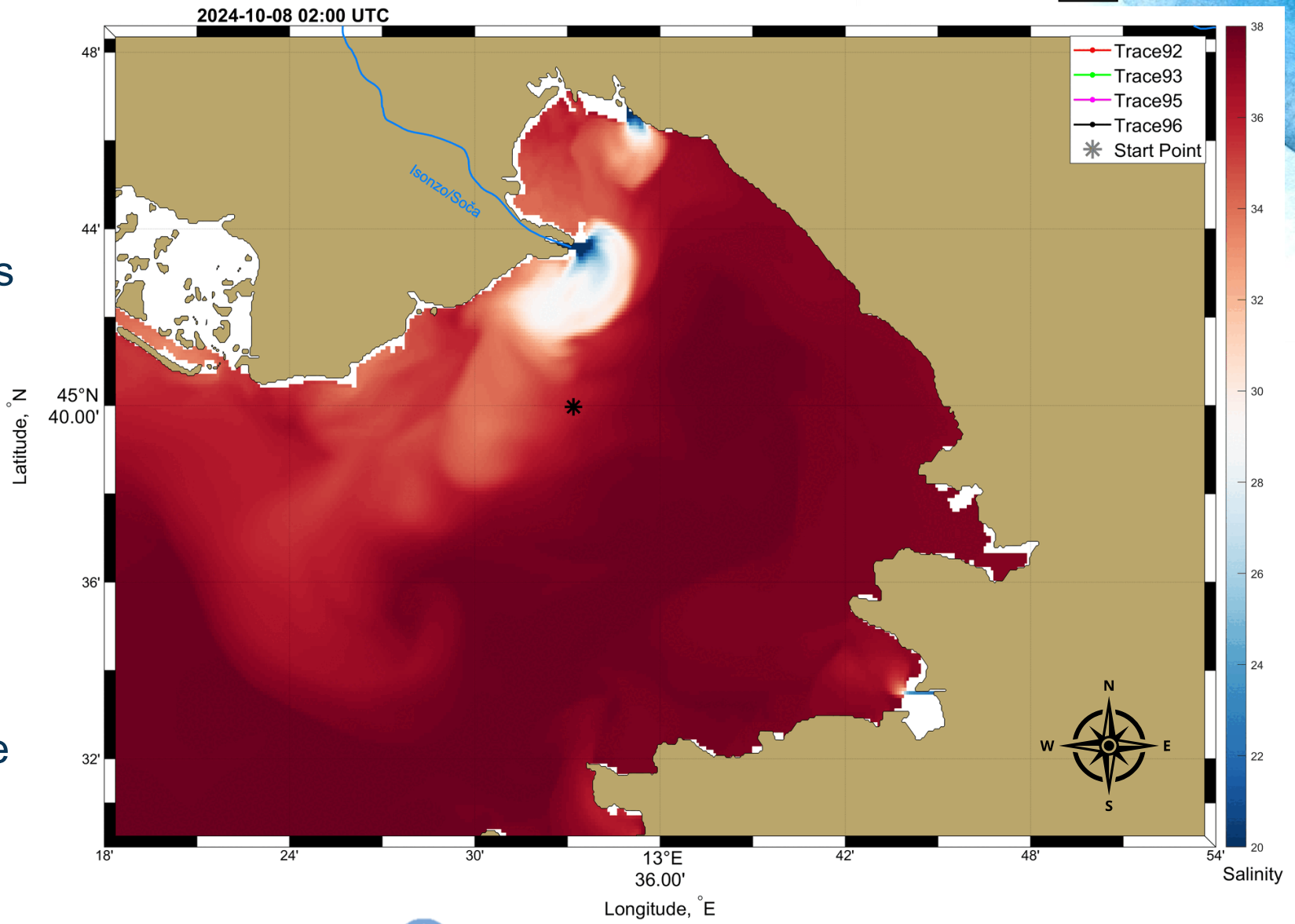
# DRIFTER TRAJECTORY – SALINITY MODEL

OCTOBER 2024

## Visual analysis of drifter trajectories and salinity

- Statistical analysis didn't provide satisfactory results → adopted a visual approach;
- Drifter paths overlaid with hourly salinity maps;
- Drifters initially follow the Isonzo plume with low salinity;
- Two drifters later leave the plume towards Trieste.

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# DRIFTER TRAJECTORY – SALINITY MODEL

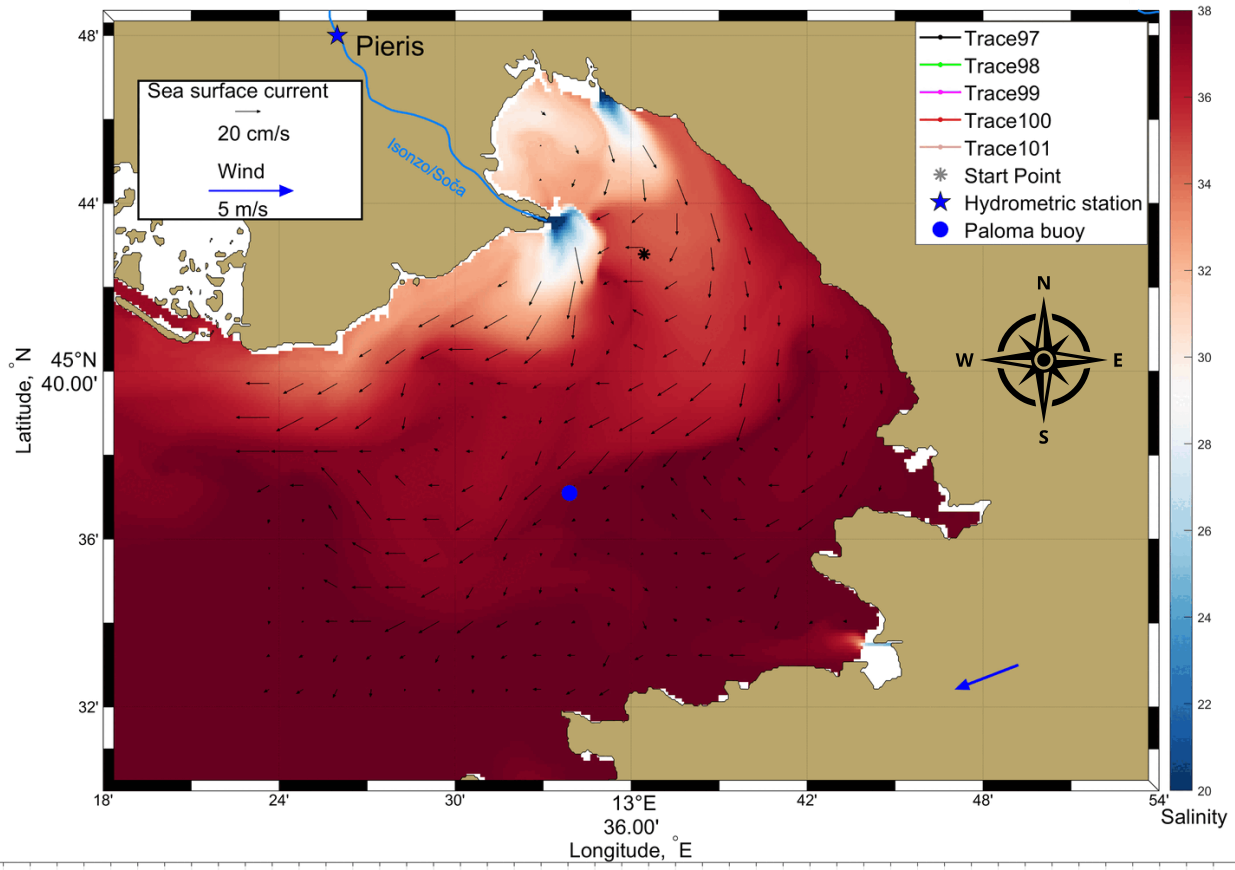
MAY – JUNE 2025

No HFR data ✗

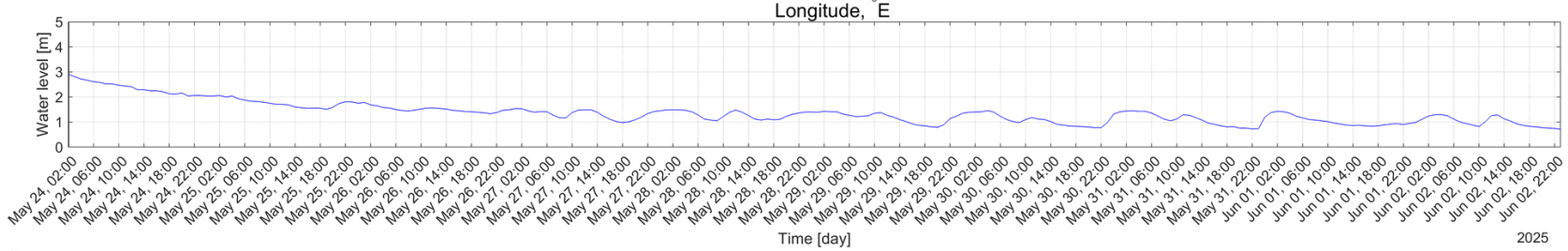
Statistical analysis ✗

24 May – 2 June 2025 | Variable

- **5 drifters**;
- Maps every **1 hour**;
- **Sea surface currents**: MITgcm;
- **Salinity**: MITgcm;
- **Wind**: Paloma buoy;
- **Water level**: Pieris hydrometric station.




Drifters **follow** low-salinity areas, showing even like-eddy trajectories.

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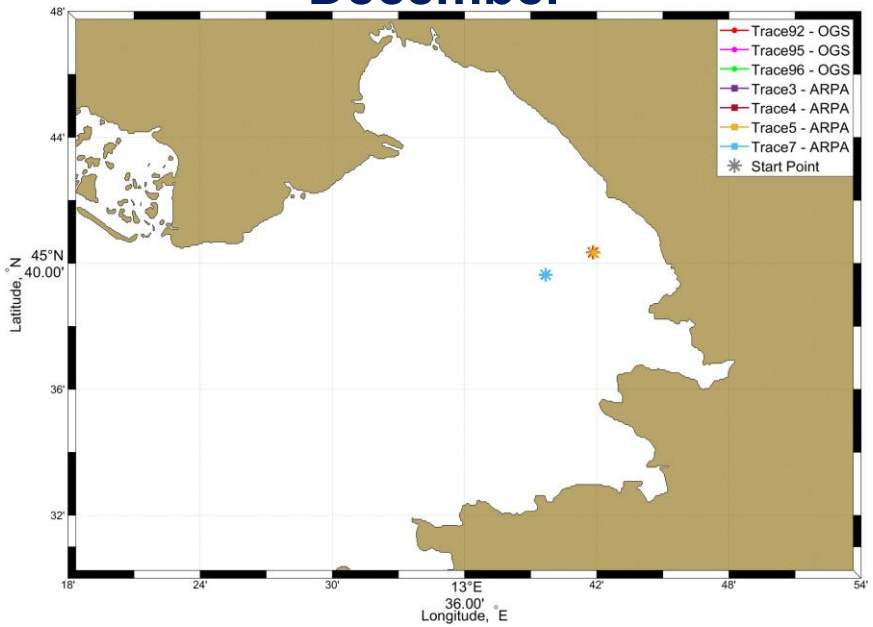
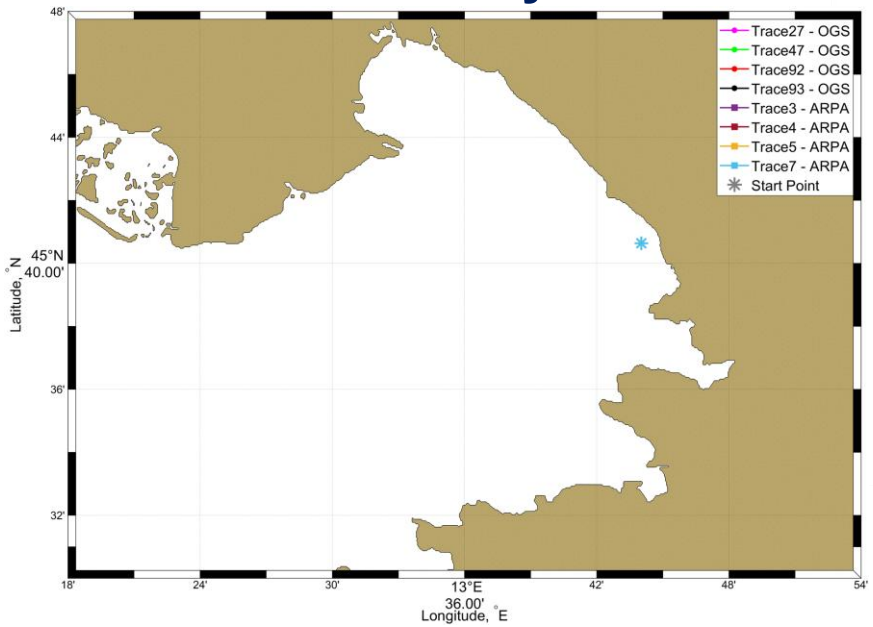
# JOINT DEPLOYMENTS OGS – ARPA FVG

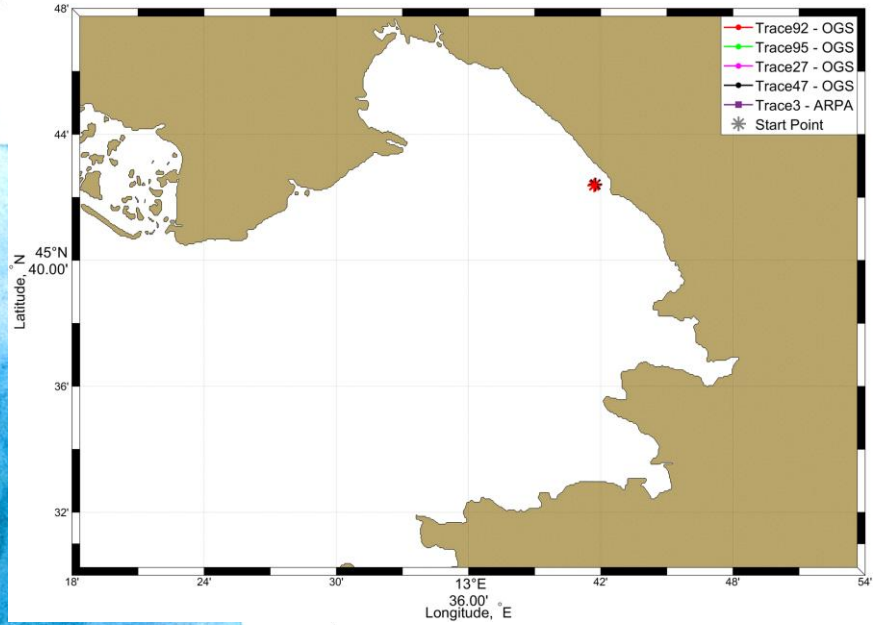
## December



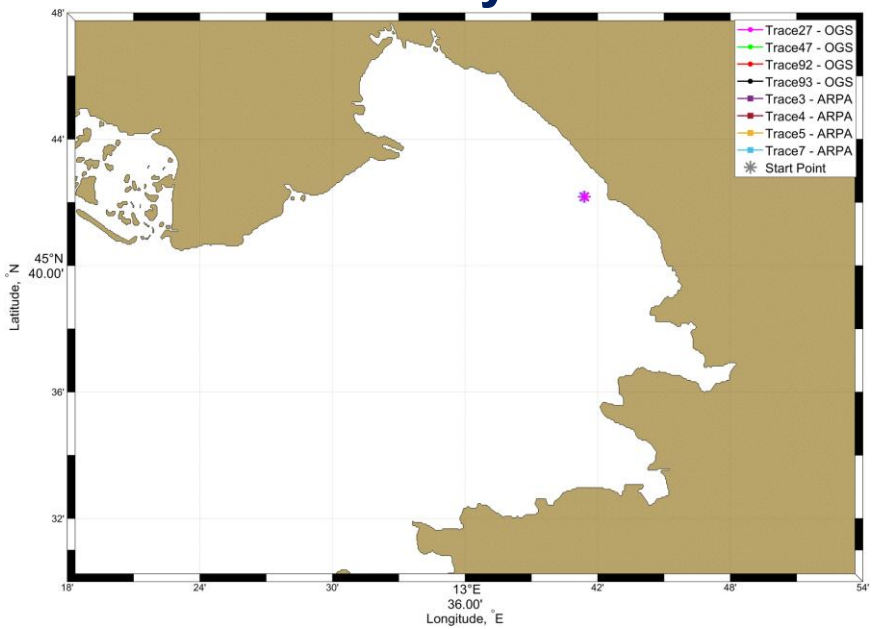

## February

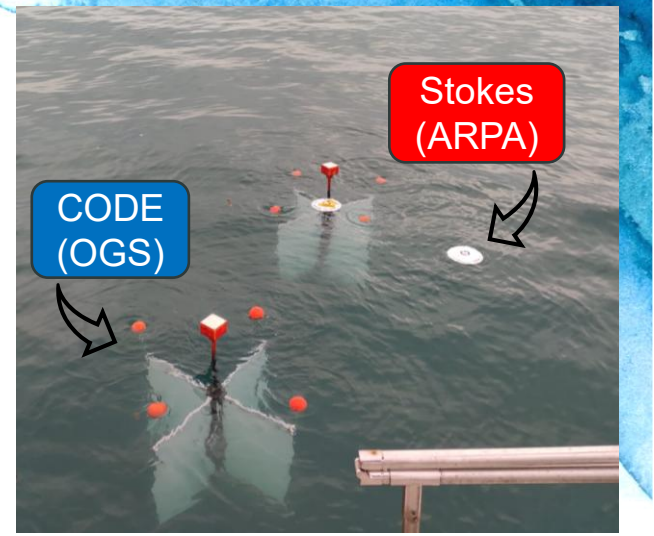



## March




## May




## DRIFTER

| CODE | STOKES |
|---|---|

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arpa FVG

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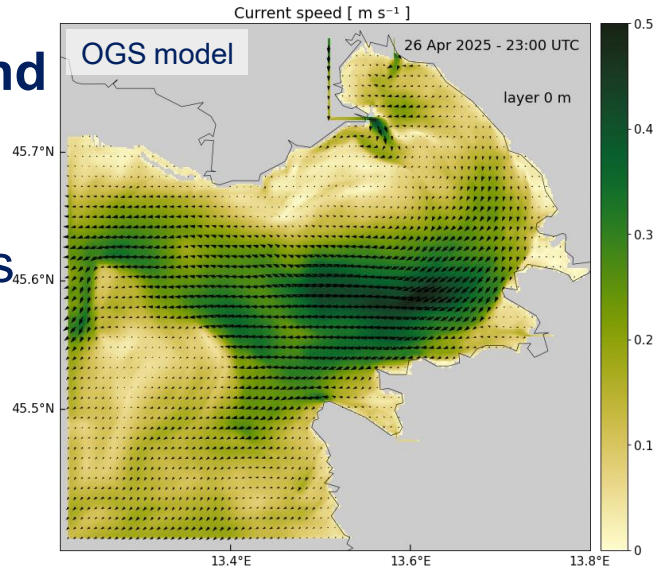
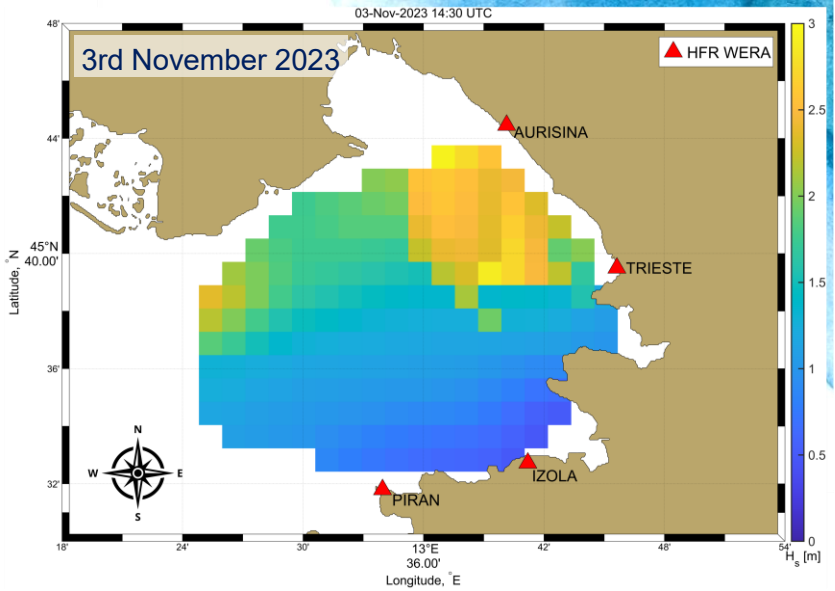
# IMPLICATIONS/ONGOING WORK

- **Understanding and realistic analysis and simulation of river plume dynamics**: essential for accurate modeling of currents in the Gulf of Trieste and, in general, in ROFI areas.
- **Multi-platform integrated approach**: for the analysis of surface ocean dynamics and possible extreme events in coastal areas.
- **Practical implications**: results relevant for coastal forecasting and management in case of extreme weather events.




Mediterranean Ecosystem Analysis and Forecast: https://medeaf.ogs.it/got




Hight significant wave from HF radar – 3rd November 2023 14:30 UTC



https://www.triesteprima.it/foto/cronaca/mareggiata-a-barcola-i-danni-4-novembre/

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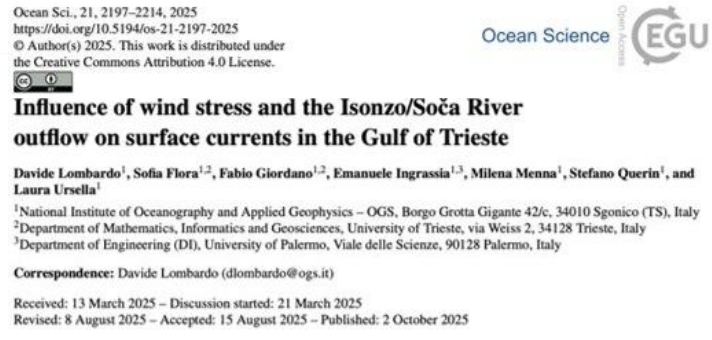
# THANK YOU FOR YOUR ATTENTION

dlombardo@ogs.it



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Ocean Science

**Influence of wind stress and the Isonzo/Soča River outflow on surface currents in the Gulf of Trieste**

**Davide Lombardo[1], Sofia Flora[1,2], Fabio Giordano[1,2], Emanuele Ingrassia[1,3], Milena Menna[1], Stefano Querin[1], and Laura Ursella[1]**

[1]National Institute of Oceanography and Applied Geophysics – OGS, Borgo Grotta Gigante 42/c, 34010 Sgonico (TS), Italy
[2]Department of Mathematics, Informatics and Geosciences, University of Trieste, via Weiss 2, 34128 Trieste, Italy
[3]Department of Engineering (DI), University of Palermo, Viale delle Scienze, 90128 Palermo, Italy

**Correspondence:** Davide Lombardo (dlombardo@ogs.it)

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