ATENEO VENETO

Collegio degli Ingegneri di Venezia

ORDINE DEGLI INGEGNERI DELLA CITTÀ METROPOLITANA DI VENEZIA

Autorità di Sistema Portuale del Mare Adriatico Settentrionale
Porti di Venezia e Chioggia

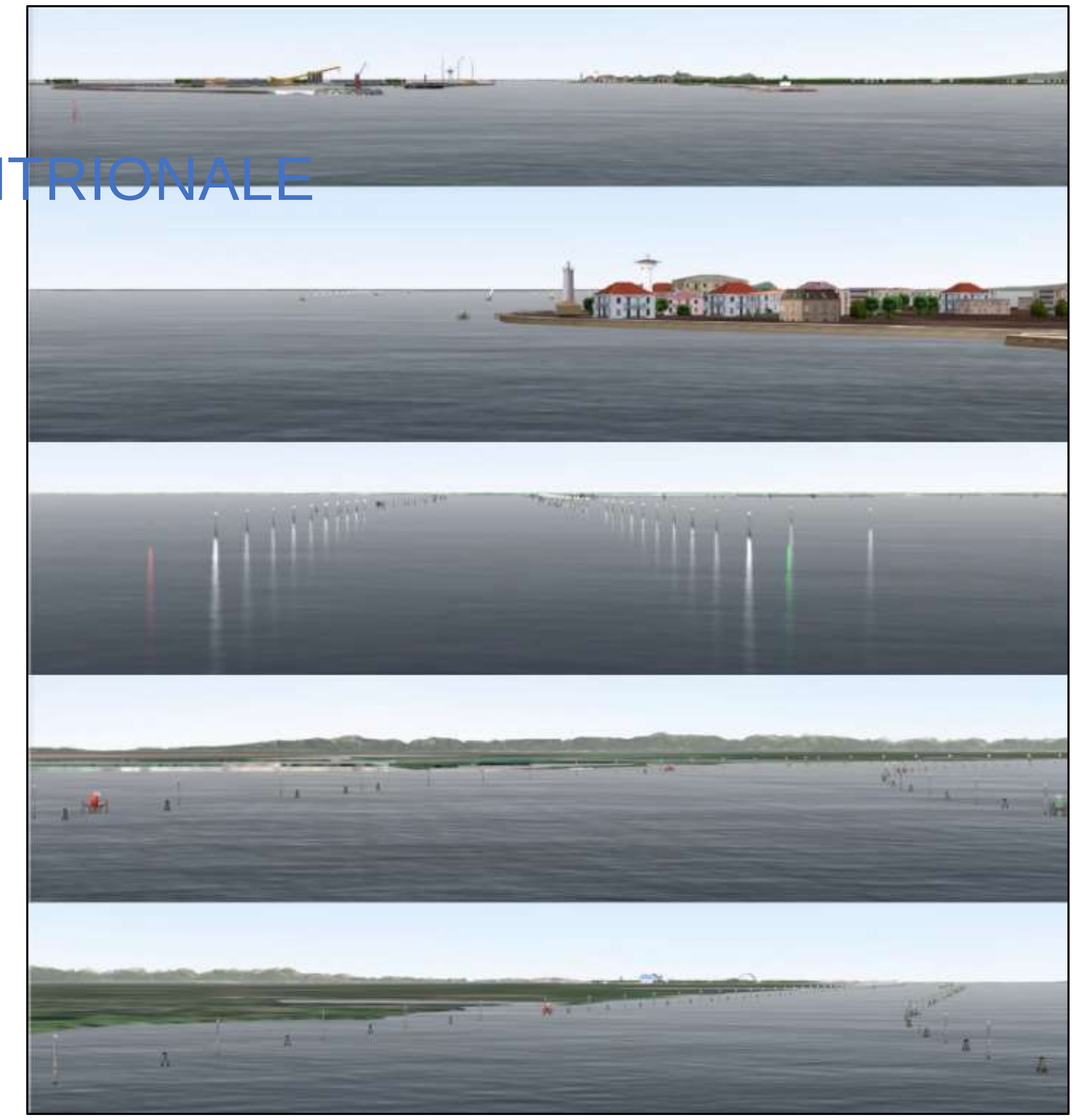
LE PROSPETTIVE DI RILANCIO DEL PORTO DI VENEZIA

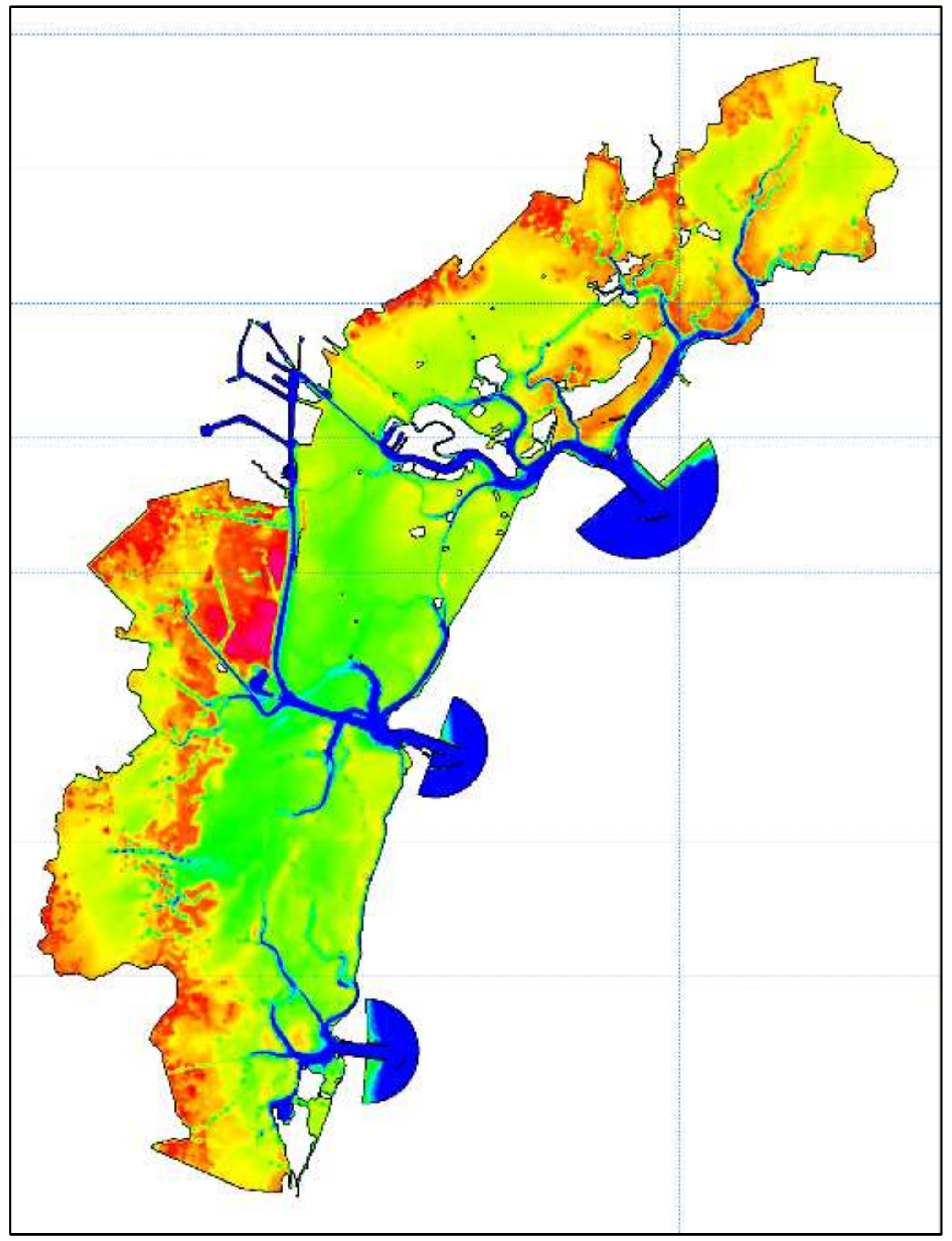
Venerdì 4 novembre 2022 ore 14:30

Ateneo Veneto - Aula Magna

«CHANNELING THE GREEN DEAL FOR VENICE». UN PROGETTO INNOVATIVO PER CONIUGARE L'ACCESSIBILITA' NAUTICA CON I VINCOLI AMBIENTALI (CEF ACTION N.2019-IT-TM-0096-S)

ANDREA PEDRONCINI – DHI S.r.l.
PAOLO MENEGAZZO - AdSP DEL MARE ADRIATICO SETTENTRIONALE





Framework and objectives

- The project activities fit into the “**Channeling the Green Deal for Venice**", a Connecting Europe Facility European funded project (2020-2023) that tackles the present limiteded navigational accessibility of the ports of Venice and Chioggia, fully respecting the environment and the Venice Lagoon.

- Following Public Tender procedures, North Adriatic Sea Port Authority – Ports of Venice And Chioggia assigned to a Consortium led by DHI S.r.l. a multi-disciplinary study is ongoing aiming at identifying **possible solutions to achieve sustaniable navigation along the Malamocco-Marghera Channel.**

Inter-connection of tasks

NAVIGATION MODEL OF THE CHANNEL

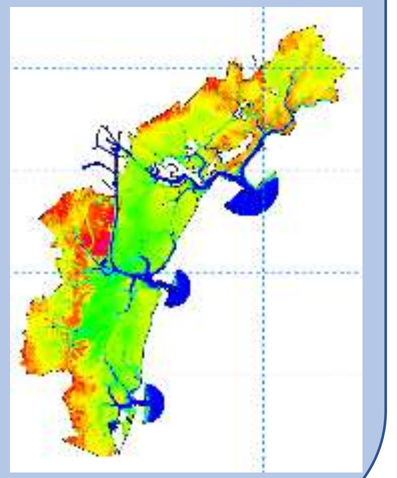
combination of fast time, NCOS and full bridge simulations: different vessel types, load conditions and geometry of the channel

Limiting weather conditions, UKC, identification of critical stretches of the MM Channel

FORCE TECHNOLOGY — DHI — CETENA

2D LAGOON MODEL

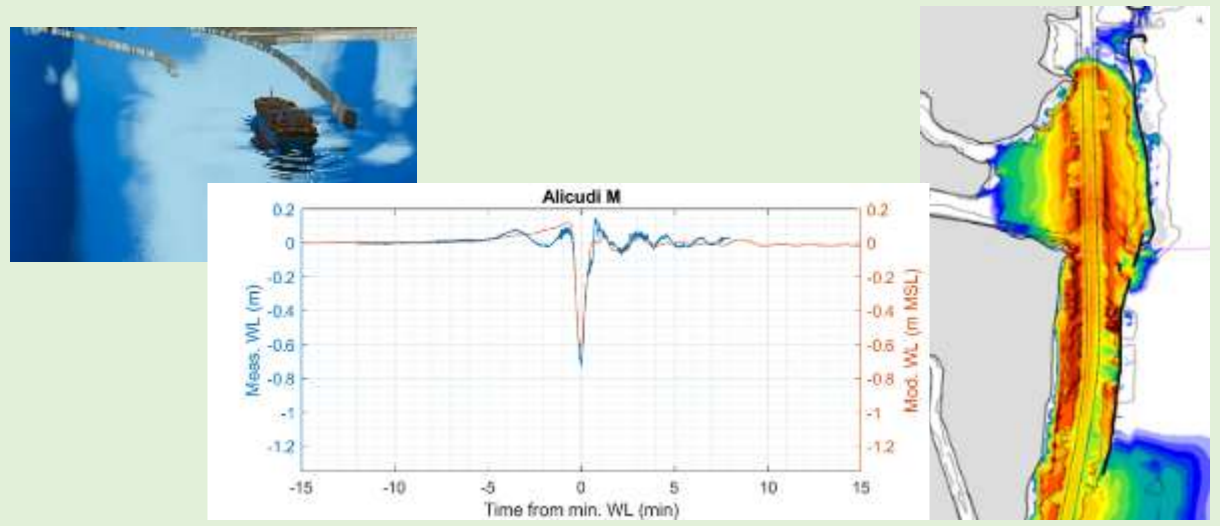
Establishment of frequent and extreme conditions at lagoon scale: tide, wind, wave, rivers discharge



DHI

3D MODEL OF THE CHANNEL AND SURROUNDING AREAS

Hydrodynamic and moprhological effects of passing vessels



DHI — AROUND WATER di Andrea Zamariolo, Ph.D. Geol.

DEVELOPEMENT OF COORDINATED SOLUTIONS

Sustainable vessel traffic
Maximization of navigation safety
Mitigation of erosion of the tidal flats

- WIDER CHANNEL?
- LOWER VESSEL SPEED?
- MORPHOLOGICAL STRUCTURES ON TIDAL FLATS

HS marine srl — DHI

2D model of Venice lagoon

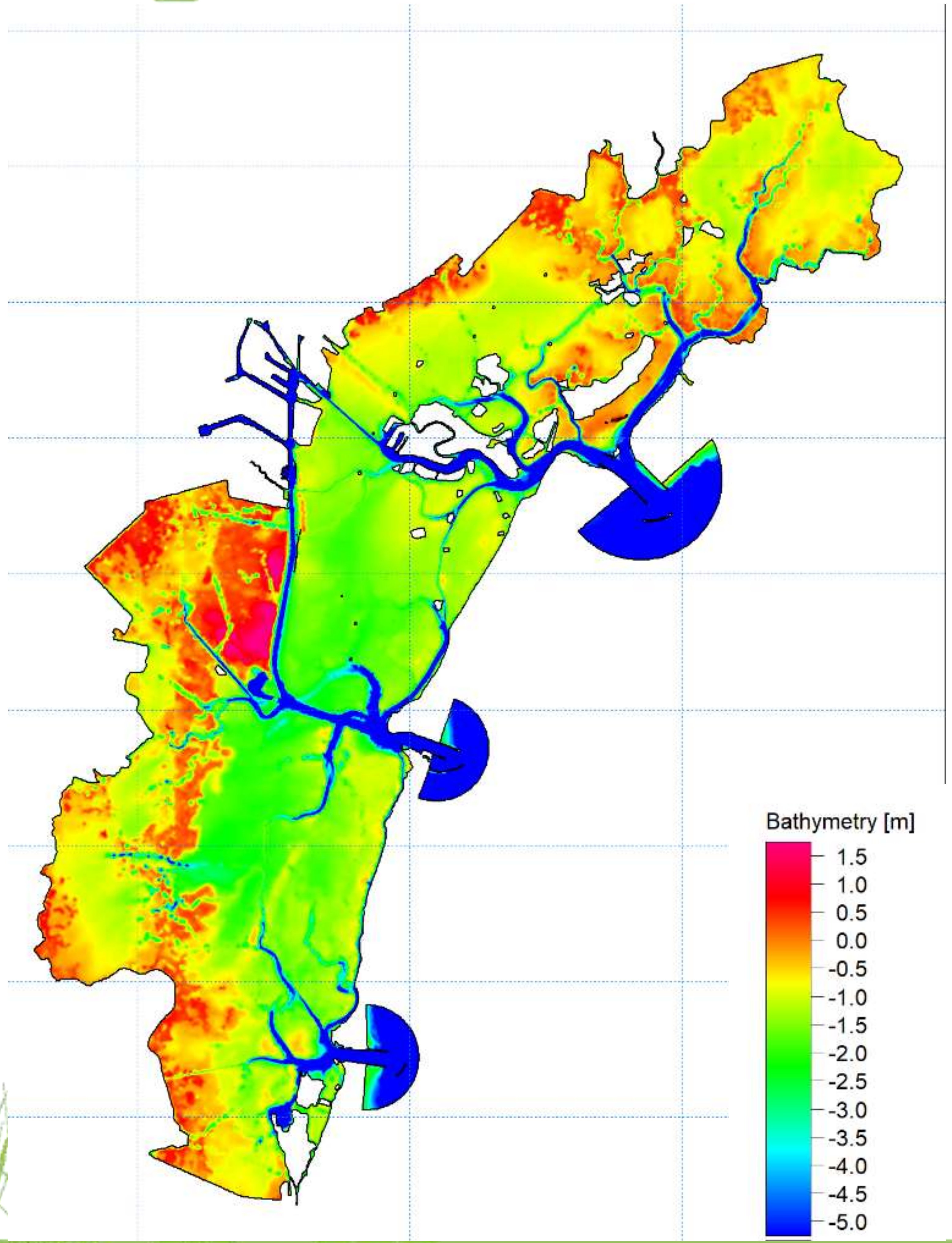
Establishment of meteomarine conditions at lagoon scale

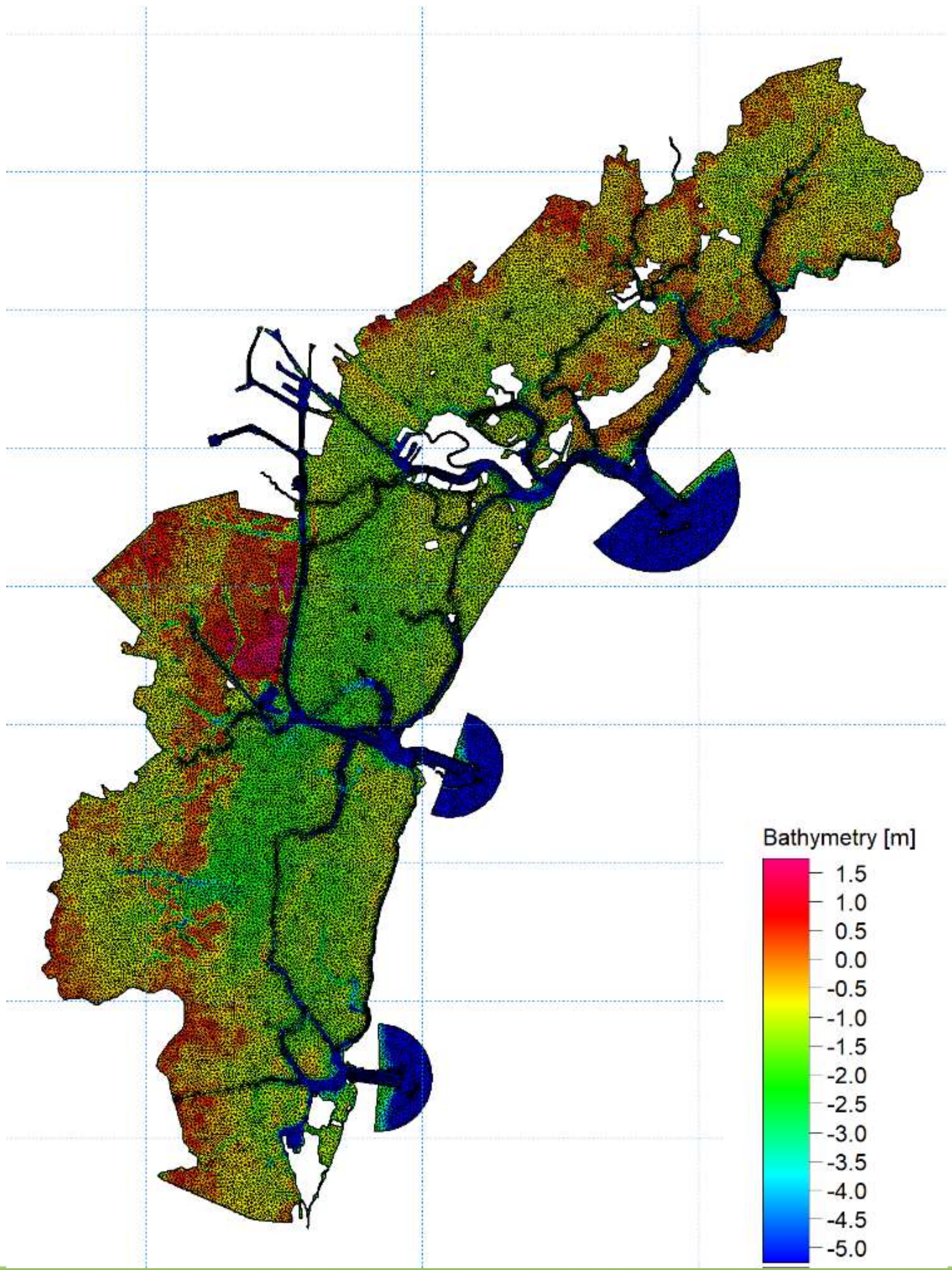
Development of an **integrated modelling system (hydrodynamics + waves)** capable of reconstructing, over a sufficiently long time and after proper calibration and validation, the **spatial and temporal distribution of the main meteomarine variables of interest at lagoon scale (mainly wind, water levels, currents and wave conditions**)

- the lagoon model **feeds the 3D model of the Channel and surrounding areas**
- the lagoon model **feeds the NCOS simulations** (Under Keel Clearance) + **fast time and full mission simulations**

2D model of Venice lagoon

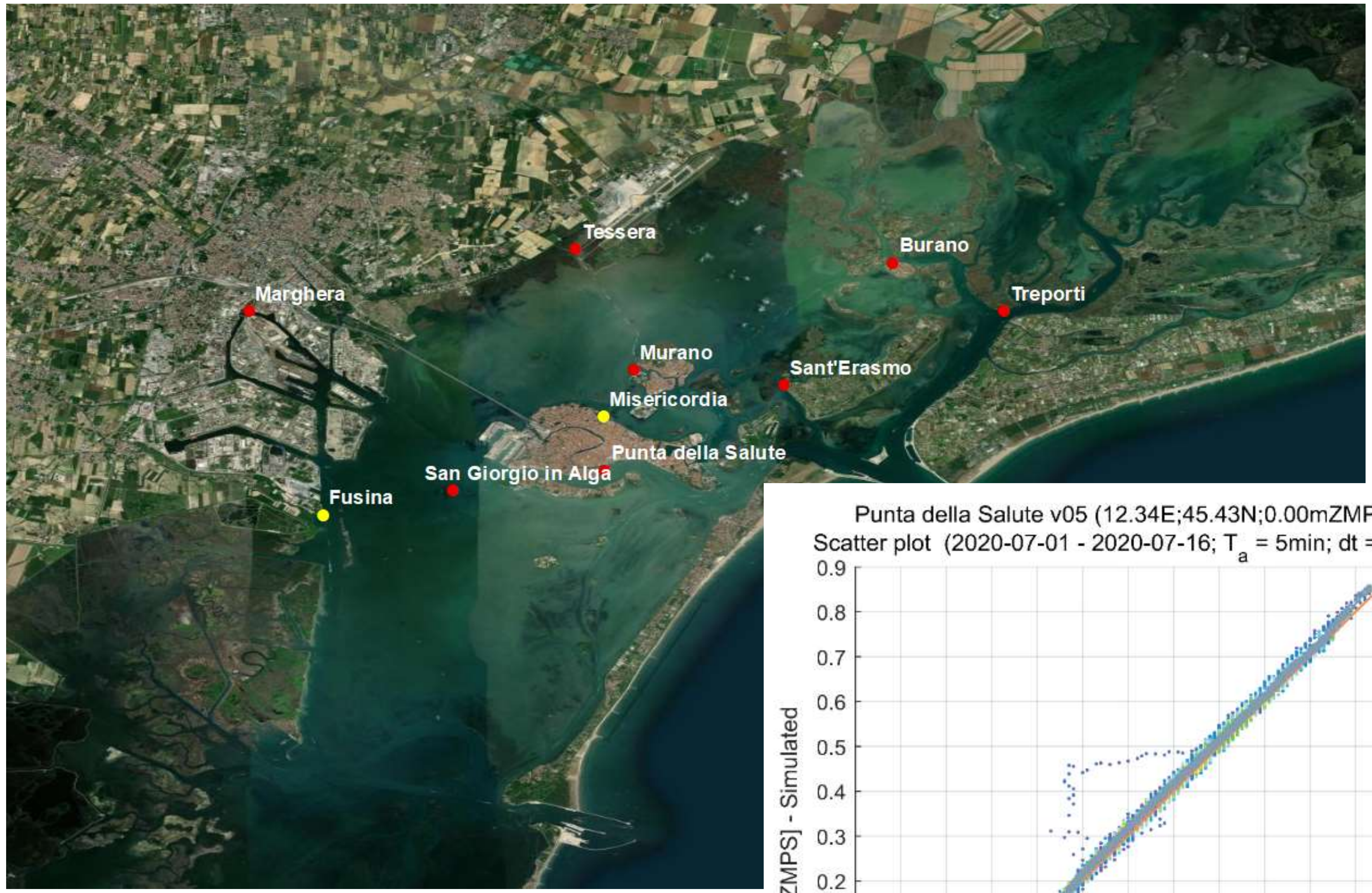
Establishment of meteomarine conditions at lagoon scale

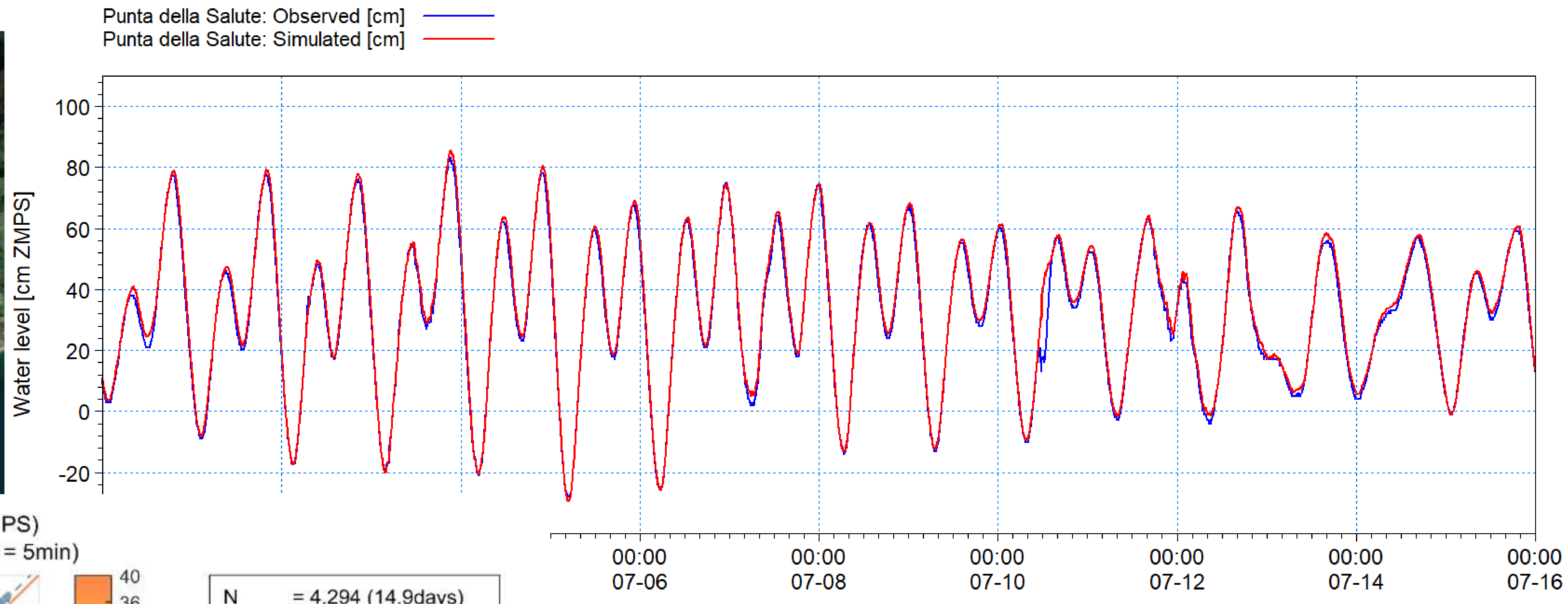


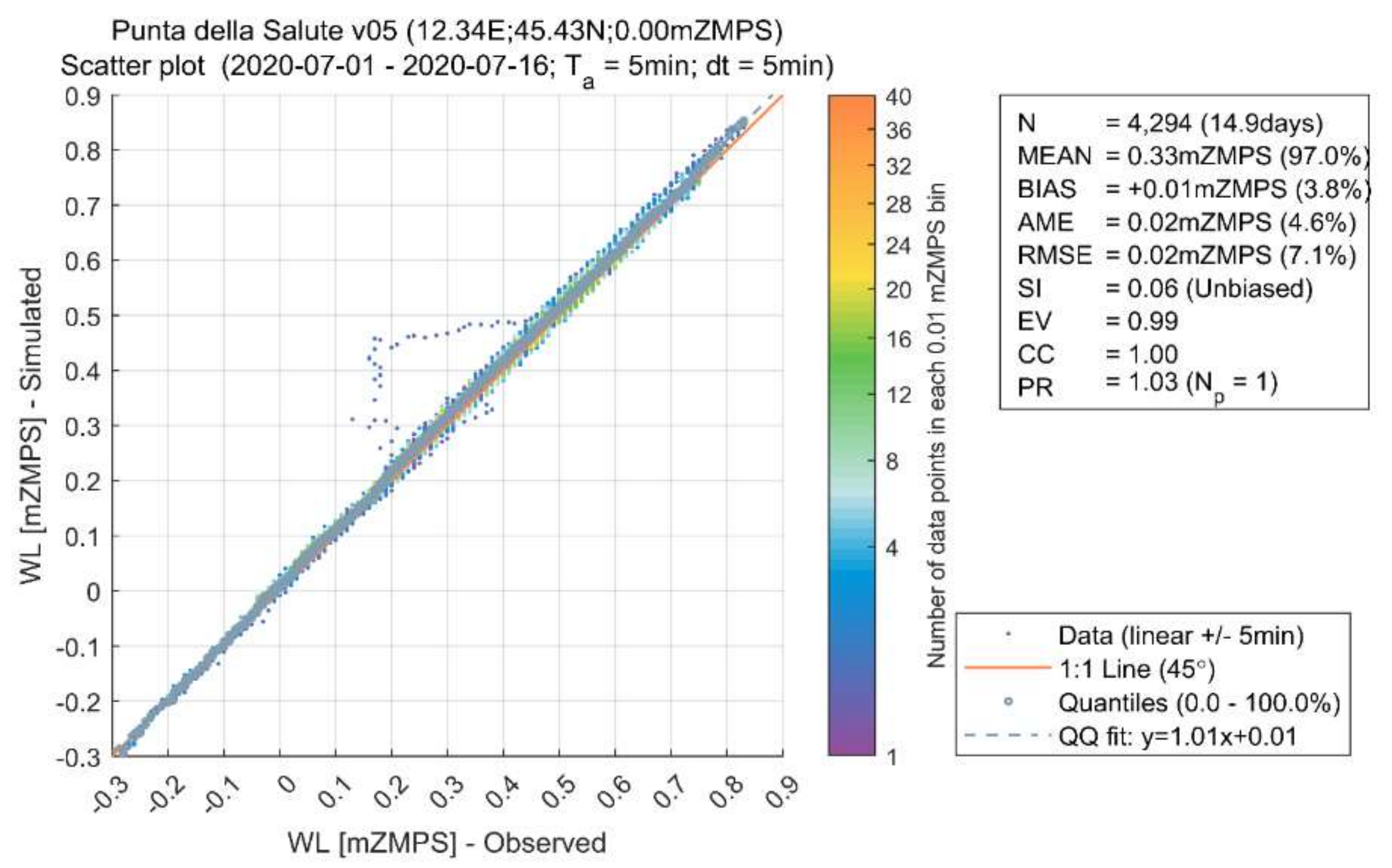


2D model of Venice lagoon

Establishment of meteomarine conditions at lagoon scale

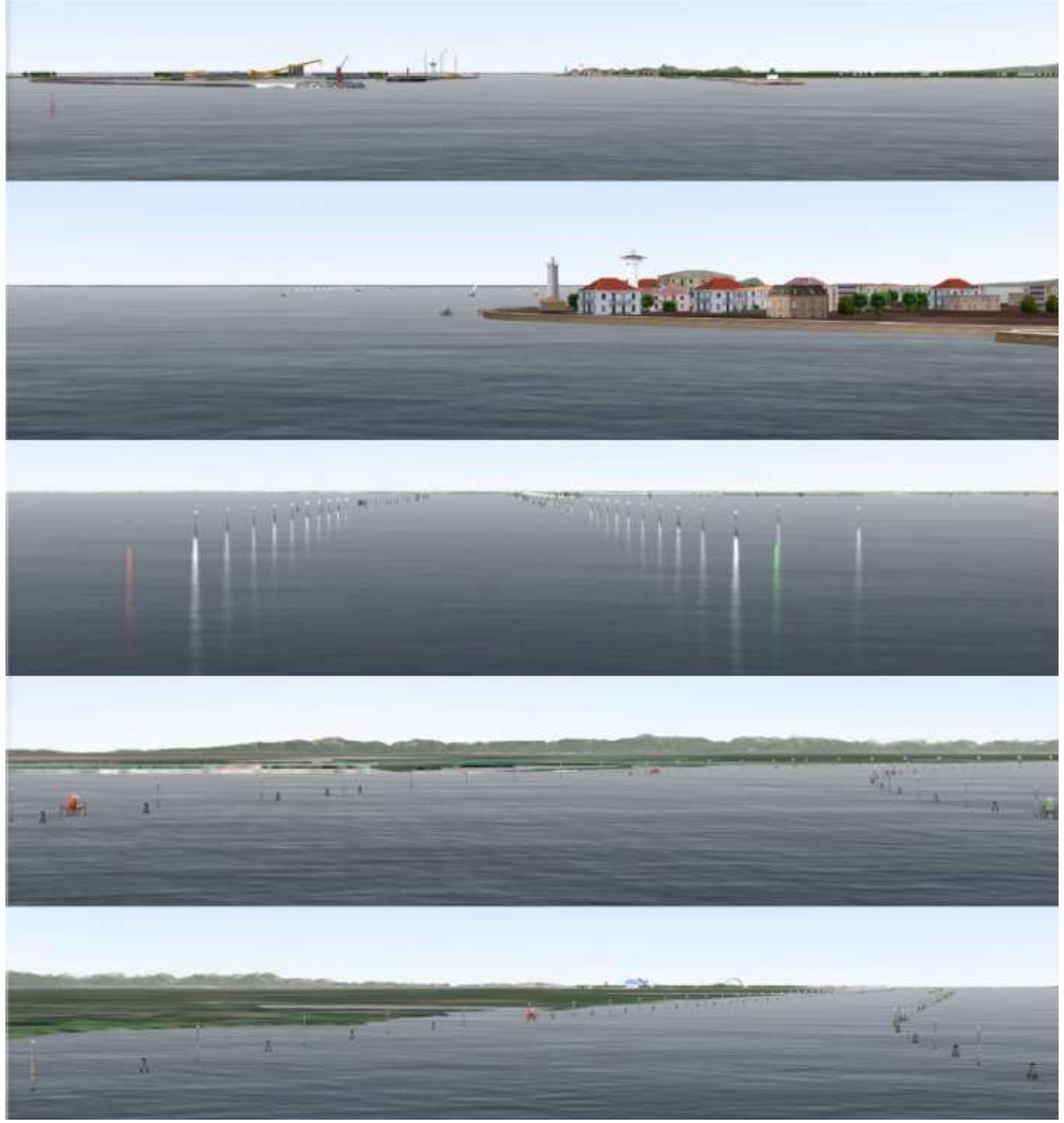






Navigation models of the MM channel

Full mission navigation simulations for the existing channel



Development of a **3D visual database**

Navigation models of the MM channel

North Adriatic Sea Port Authority
Ports of Venice and Chioggia

Full mission navigation simulations for the existing channel

Run no	Ship	Type	Cond	Wind speed (m/s)	Wind dir (deg)
101	3644	Cruise	294 m	5	23
102	3644	Cruise	294 m	10	45
103	3644	Cruise	294 m	10	67
104	3644	Cruise	294 m	10	67
201	3644	Cruise	294 m	10	23
202	3644	Cruise	294 m	12.5	67
203	3644	Cruise	294 m	10	67
204	3481	Bulker	200 m	7.5	23
205	3481	Bulker	200 m	7.5	23
206	3481	Bulker	200 m	7.5	23
207	3481	Bulker	200 m	10	45
301	3481	Bulker	200 m	12.5	67
302	3481	Bulker	200 m	10	67
303	3481	Bulker	200 m	7.5	23
304	3481	Bulker	200 m	10	45
305	3481	Bulker	200 m	12.5	67
306	3481	Bulker	200 m	12.5	67

Run no	Ship	Type	Cond	Wind speed (m/s)	Wind dir (deg)
401	3601	Container	294 m	7.5	23
402	3601	Container	294 m	10	45
403	3481	Bulker	200 m	12.5	67
404	3601	Container	294 m	15	67
405	3297	RoRo	200 m	12.5	45
406	3297	RoRo	200 m	12.5	45
407	3297	RoRo	200 m	12.5	45
408	3556	Cruise	295 m	10	45
409	3556	Cruise	295 m	10	45
501	3297	RoRo	200 m	10	45
502	3601	Container	294 m	7.5	23
503	3601	Container	294 m	10	45
504	3297	RoRo	200 m	10	45
504	3601	Container	294 m	15	67
505	3556	Cruise	295 m	15	67
601	3297	RoRo	200 m	10	45
602	3435	RoRo	220 m	10	45
603	3601	Container	294 m	12.5	67

- **Cruise Ships**
- **Bulker**
- **RoRo**
- **Container Ships**

<u>Tugs</u> have also been used to achieve fully realistic conditions

2 main goals:

Thorough understanding of the navigation conditions in relation to increasing wind speed (up to 12.5 m/s – around 24 knots)

Identification of critical areas along the Channel (in combination of fast-time and NCOS simulations)

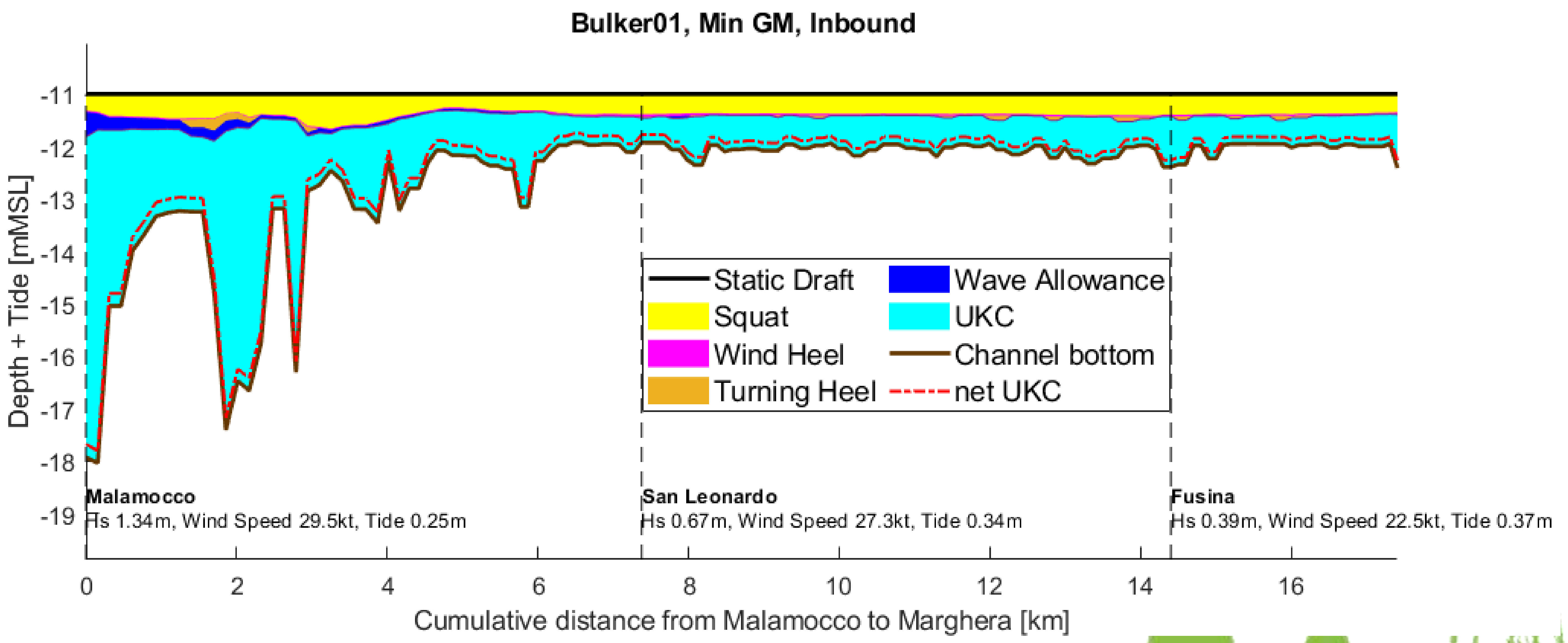
Navigation models of the MM channel

Advanced UKC study along the Malamocco-Marghera Channel using NCOS

The one-year long time series of meteomarine conditions along the Channel derived from the 2D model of the lagoon (**wind conditions, water levels, tidal currents and waves, in the form of 2D spectral information**) have been used as direct input for the Nonlinear Channel Optimisation Simulator (NCOS).

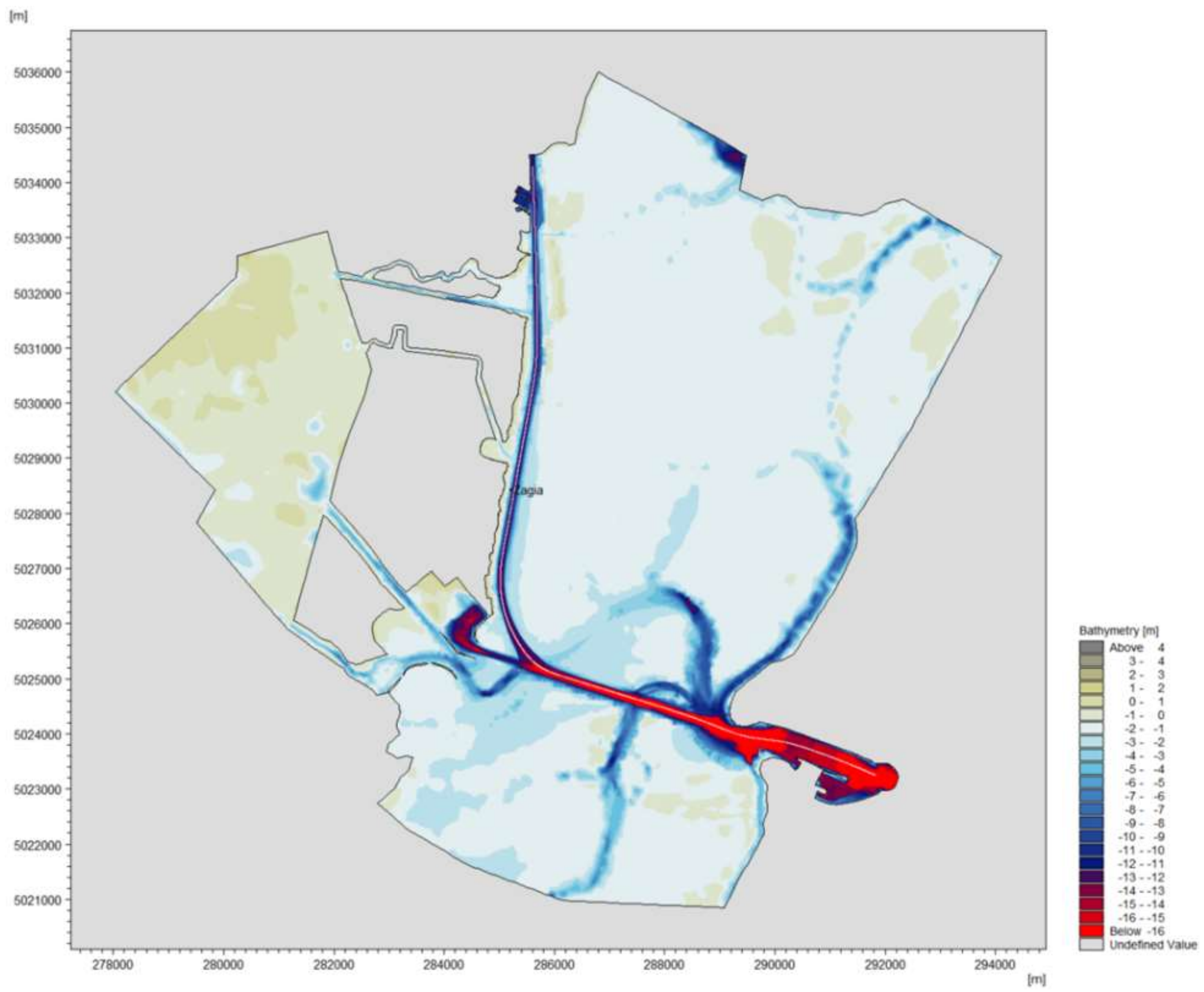
Vessel	LOA [m]	Beam [m]	Draught [m]
Bulk carrier	260	37	11.00
Container ship	220	32.2	11.00
Cruise ship	293	32.2	7.85

The detailed analysis of NCOS results was used to support the proper selection of meteomarine and transit conditions of the navigation simulations



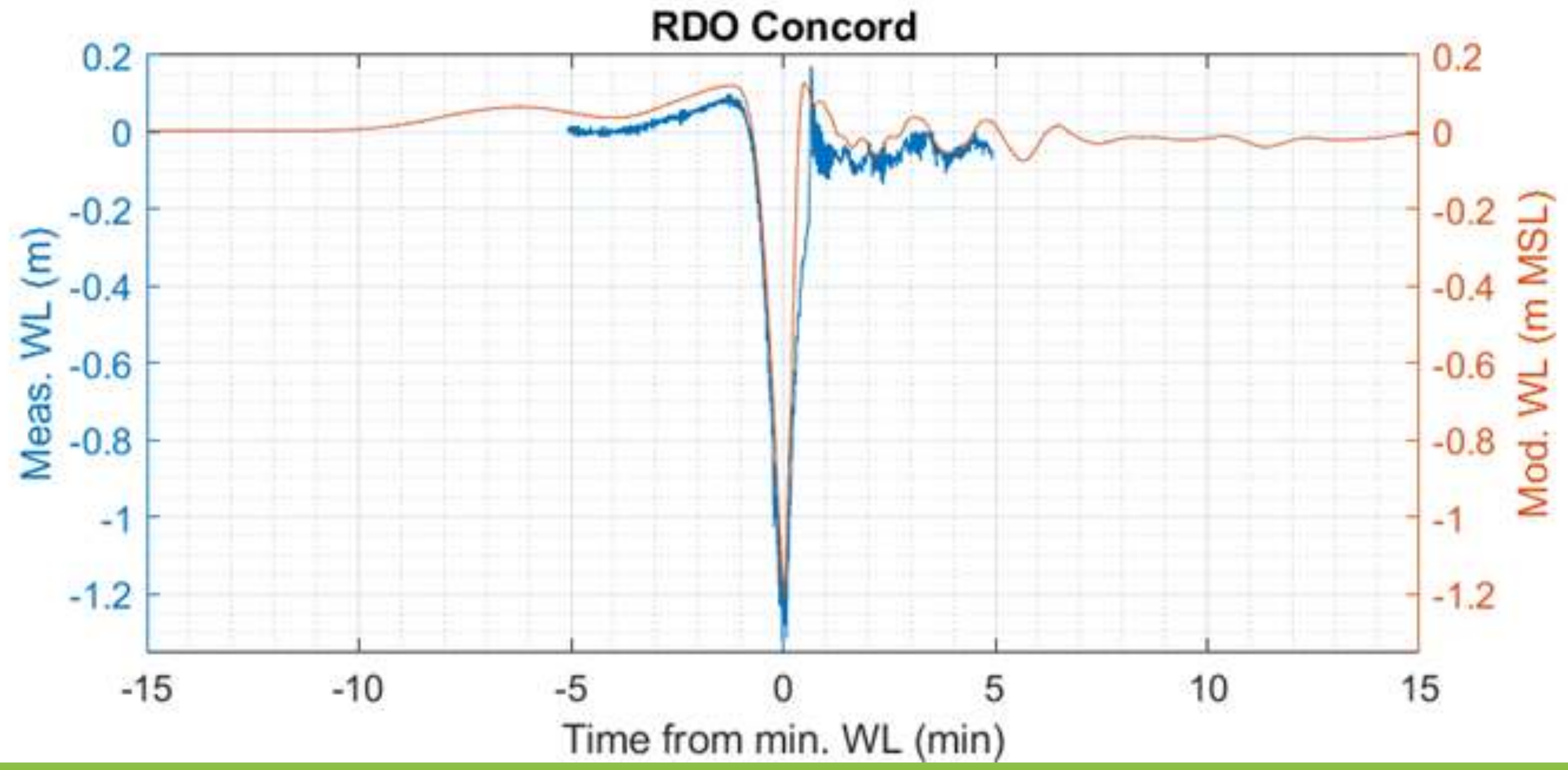
3D model of Channel and tidal flats

Establishment of 3D hydrodynamic model of the Channel and surrounding areas (navigation forcing)



The numerical model for modelling draw-down has been calibrated against two datasets of measurements:

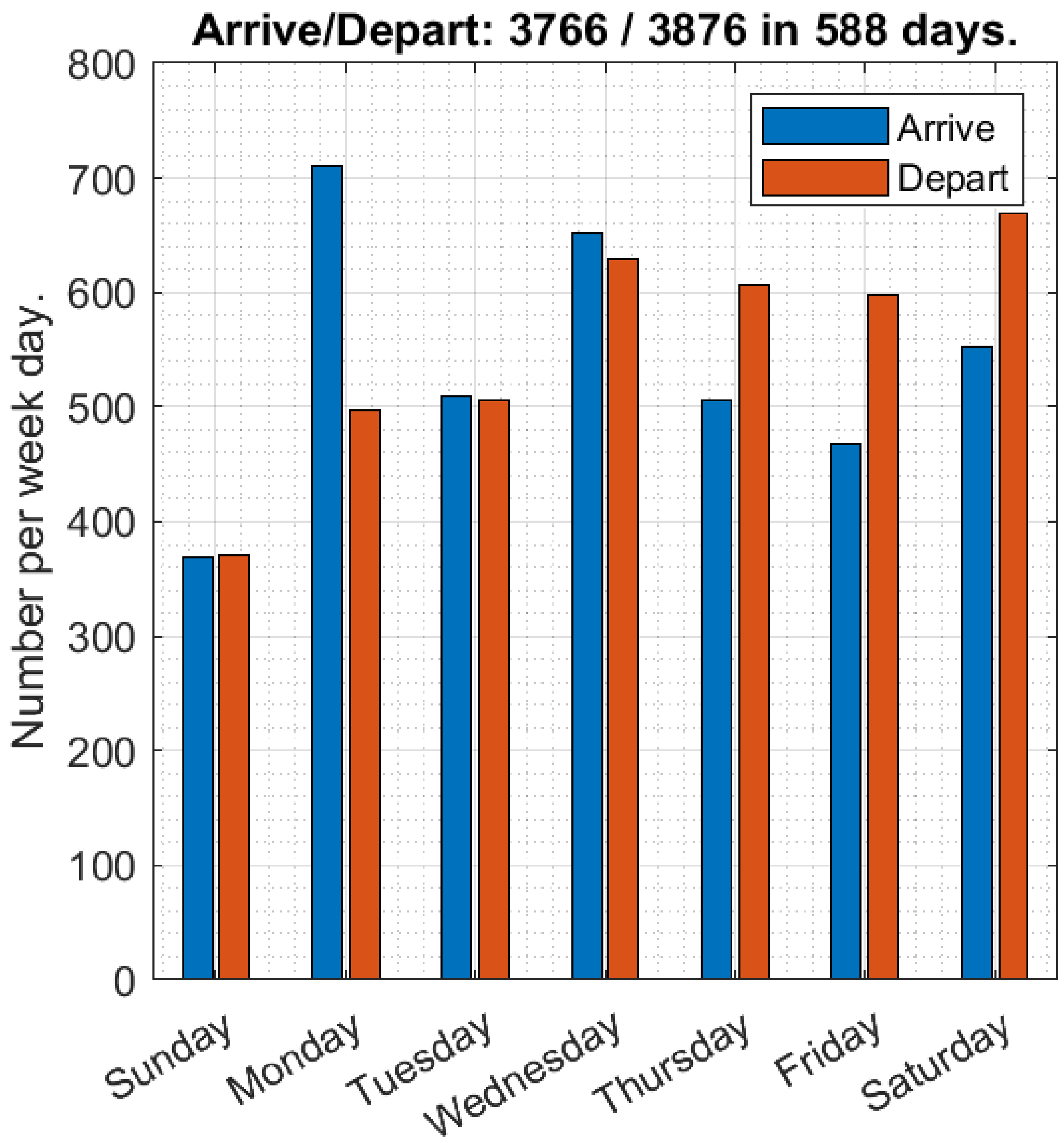
- wave data measured by CNR in the proximity of “Cassa di Colmata B” between August 2019 and February 2020: a selection of “events” (vessel passages creating significant displacement waves);
- new wave data from a dedicated campaign (May 2022) executed by the JV.



Matrix of representative traffic (from PoV 2021-2022)

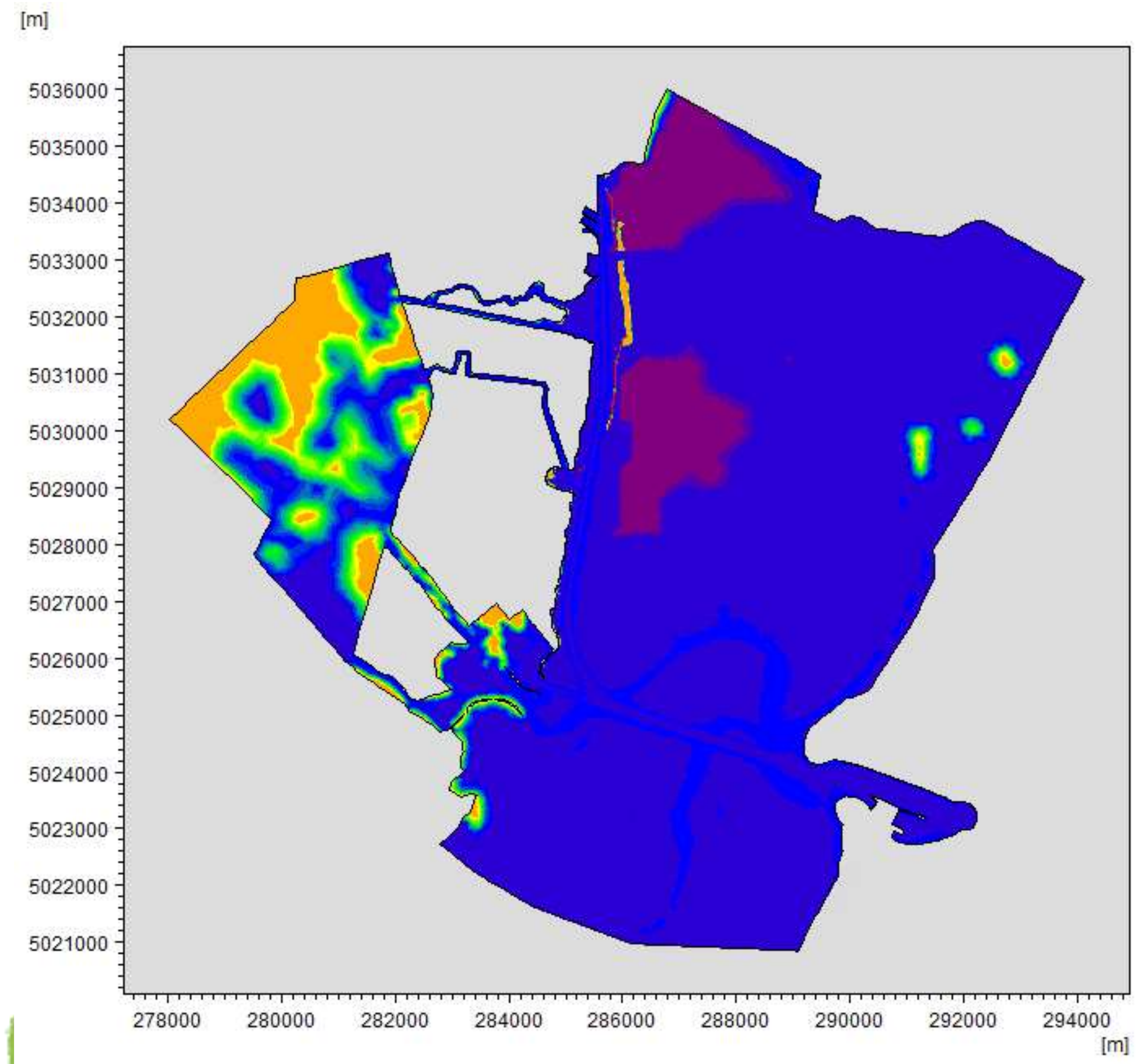
Investigation of PoV Vessel Database

- 5 Categories
  - Container vessels: 27.1% of events
  - Tank ships: 20.5% of events
  - Bulk carriers: 15.5% of events
  - General cargo vessels: 15.3% of events
  - Ro-Ro vessels: 14.6% of events
- Plus 1 category (not included in database)
  - Cruise vessels, two lengths: 300 and 230 m
    - 1 passage per week each from 1st April to 1st November (30 weeks)
    - Relative to total number of events in database this yields ~2% of events.

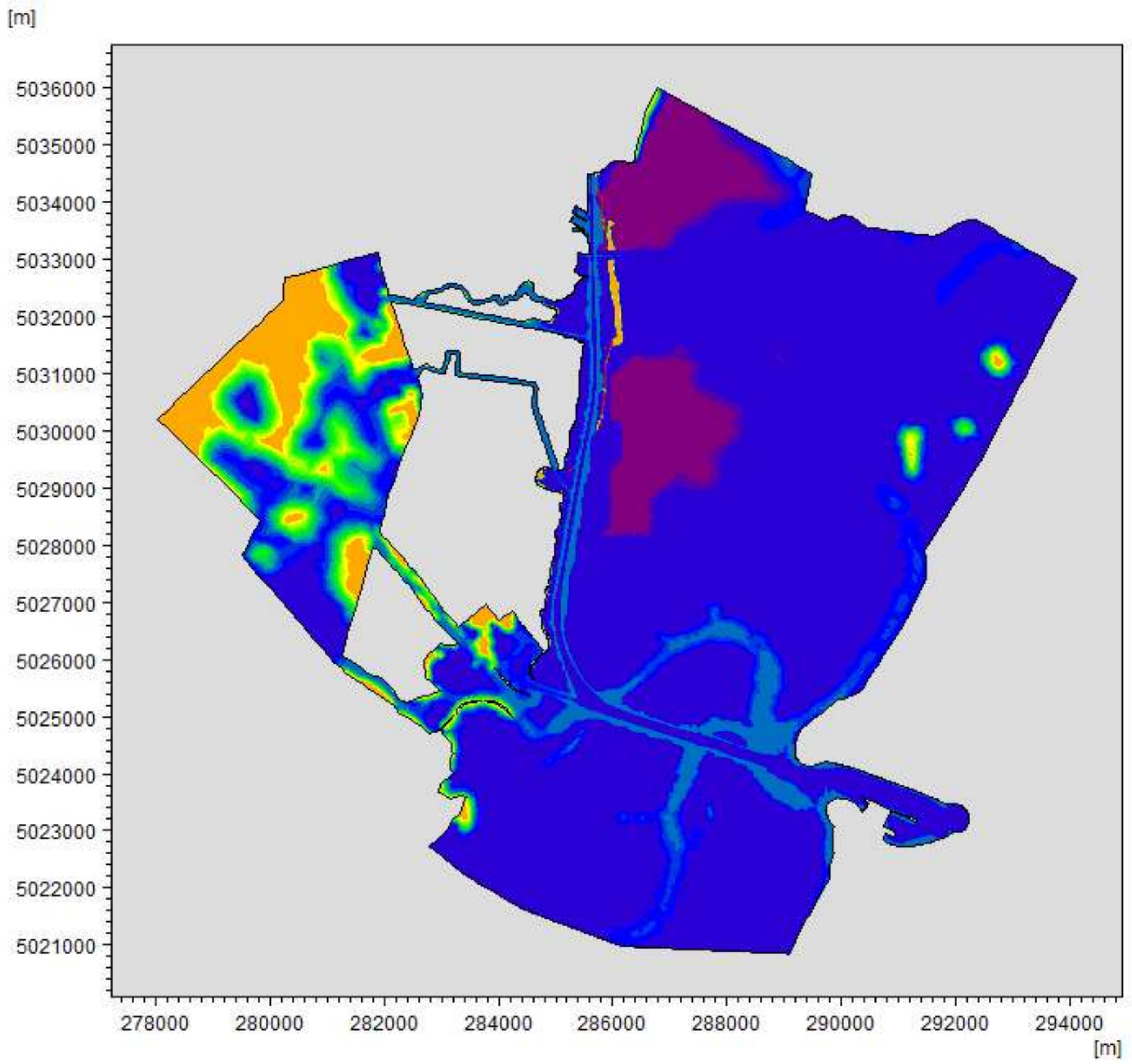


Model shear stress for erosion

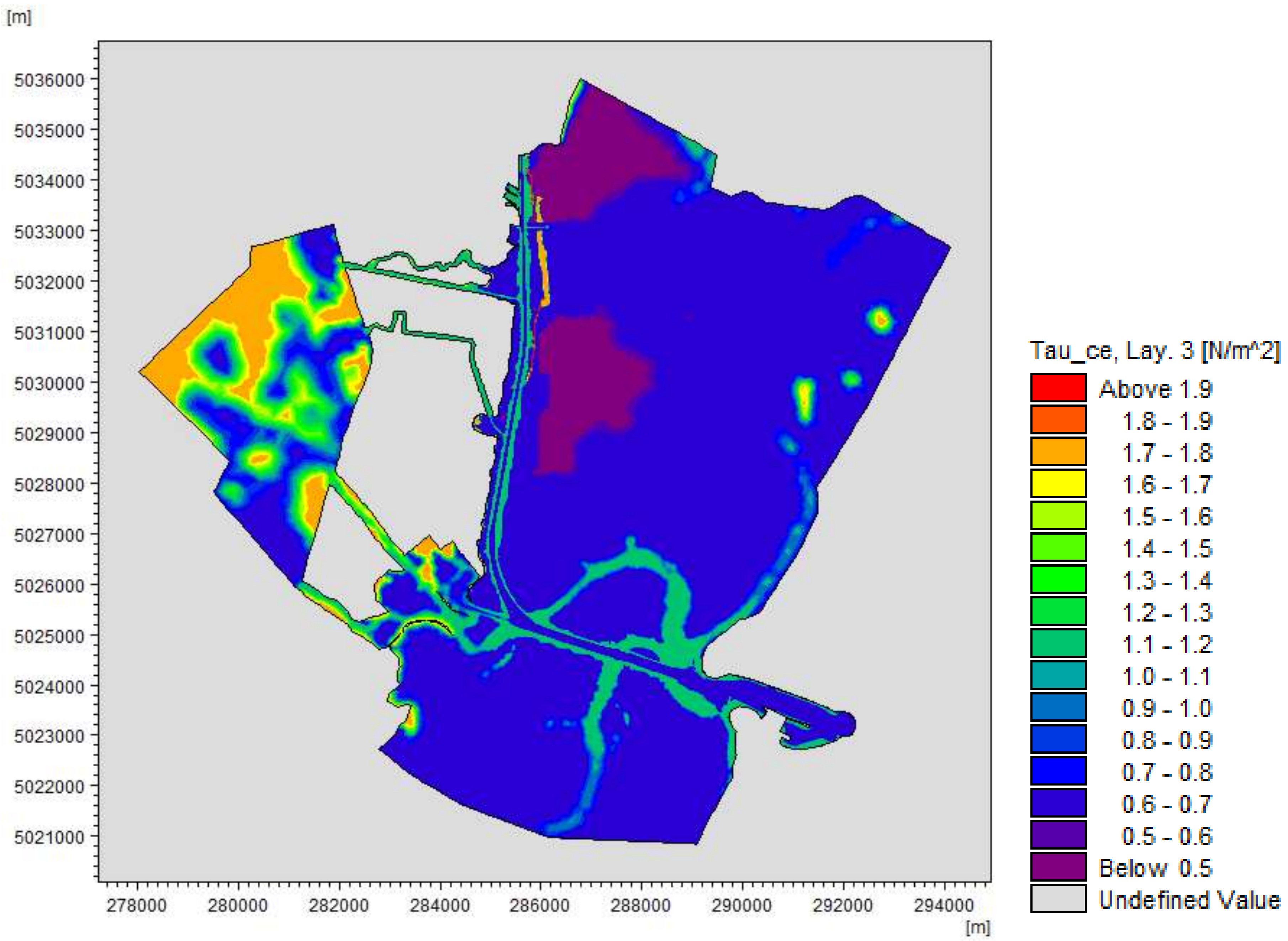
The bed shear stress for erosion is set to 1.8 Pa in salt marsh areas, 1.2 Pa on the channel banks in the consolidated bed layer (Layer-3), 0.7 Pa on the flats in general and 0.5 Pa in the clam collection areas.



Bed Layer-1



Bed Layer-2



Bed Layer-3

Importance of Kelvin Waves and Propeller Wash

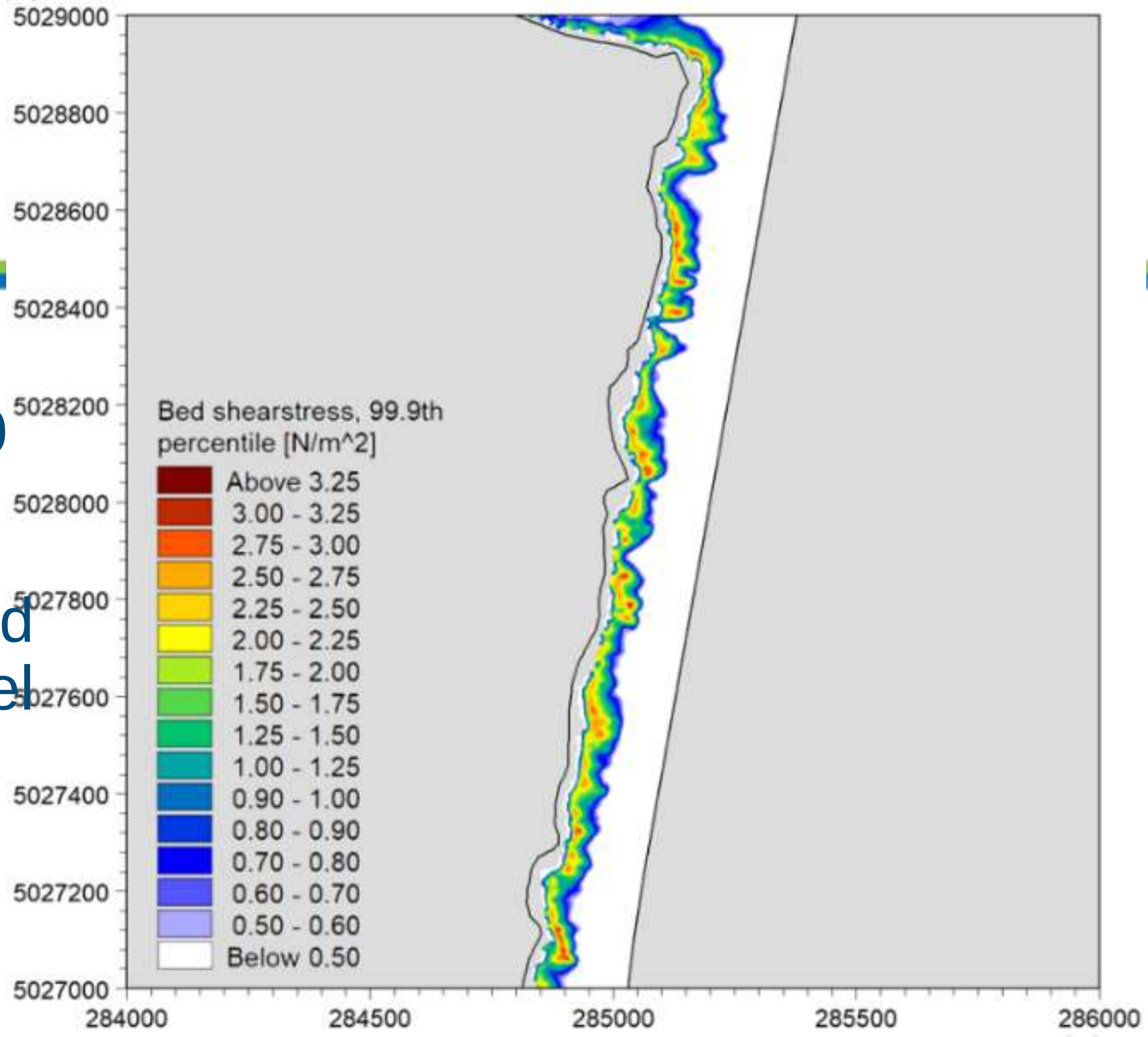
TOP RIGHT: Bed shear stresses from out-bound Kelvin waves. Wave height at boundary (0.26 m) calculated as weighted average of all production vessels at 10 knots.

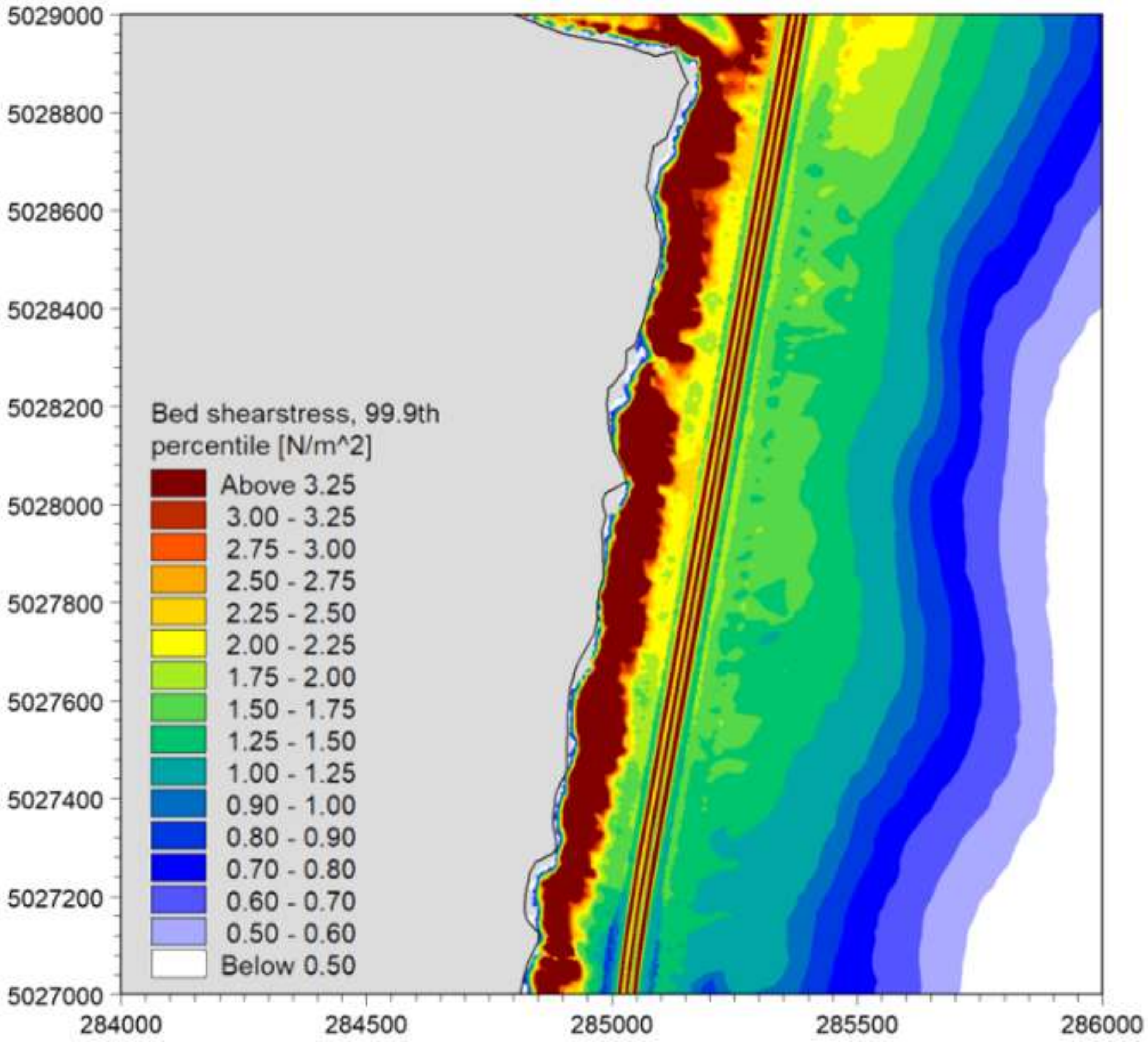
BOTTOM RIGHT: Bed shear stress associated with primary wave from outbound passage of Nervion Valley at 9 knots (case used for hydrodynamic model calibration).

- Kelvin waves have an insignificant effect on the erosion of the channel banks and mud flats.
- Propellor mainly has a stirring effect. The bed shear stresses from the propellor are an order of magnitude smaller than those from the primary wave.
- In the model, the erosion is regulated by the bed shear stress, in this regard the propellors will have no significant influence on the sediment transport.
- The model already reaches high sediment concentrations in the water column of the channel only by including the primary waves.

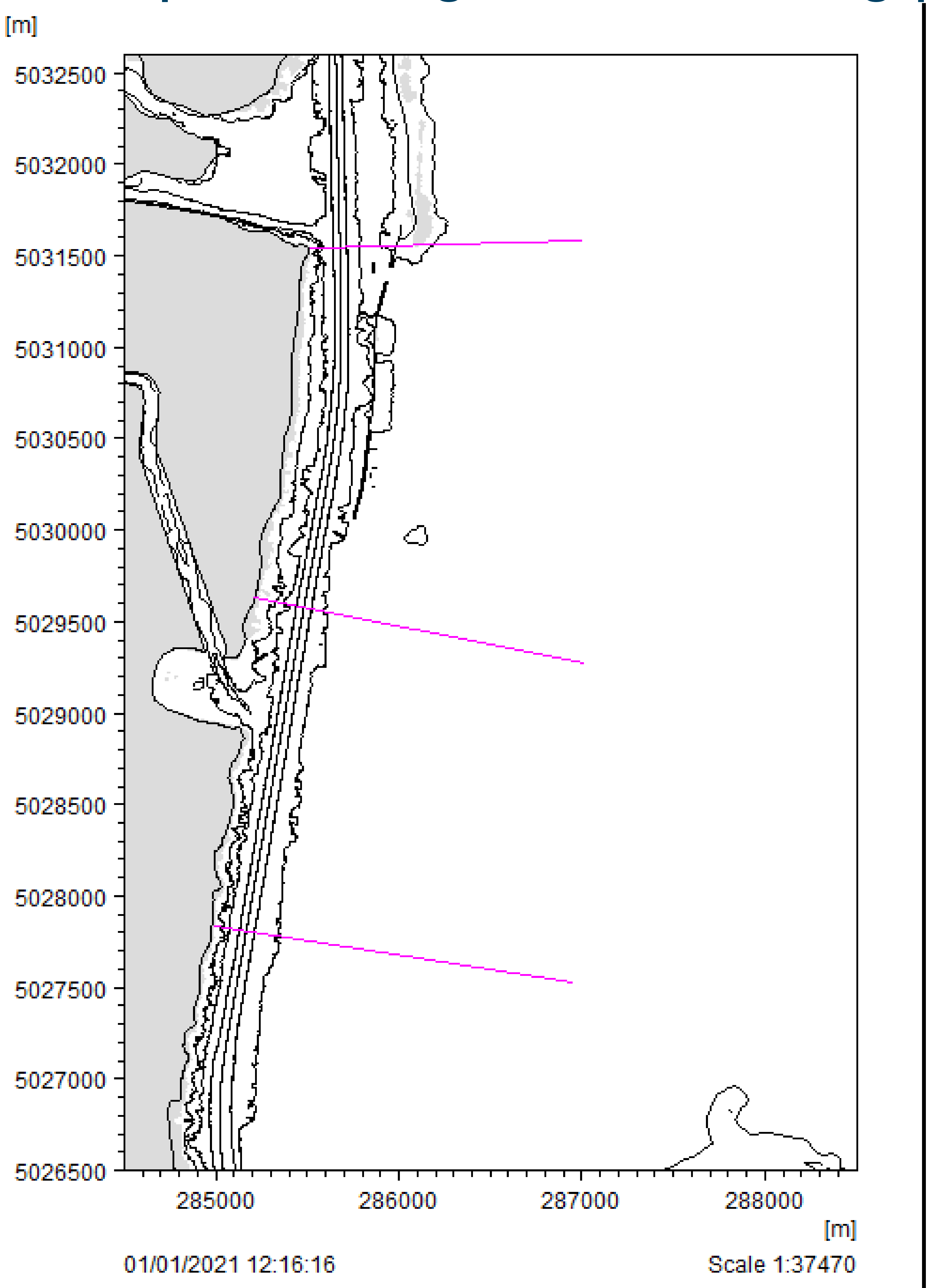
Rpm (minute^{-1})	D (m)	r (m)	Vo (m/s)	Um (m/s)	T_b max (N/m^2)
250	2.5	10	6.3	0.29	0.25
250	2.5	9	6.3	0.32	0.31
250	2.5	8	6.3	0.36	0.39
100	4.5	8	4.2	0.42	0.50
100	4.5	7	4.2	0.47	0.65
100	4.5	6	4.2	0.55	0.89
45	6.0	6	2.7	0.46	0.65
45	6.0	5	2.7	0.56	0.93
45	6.0	4	2.7	0.69	1.45

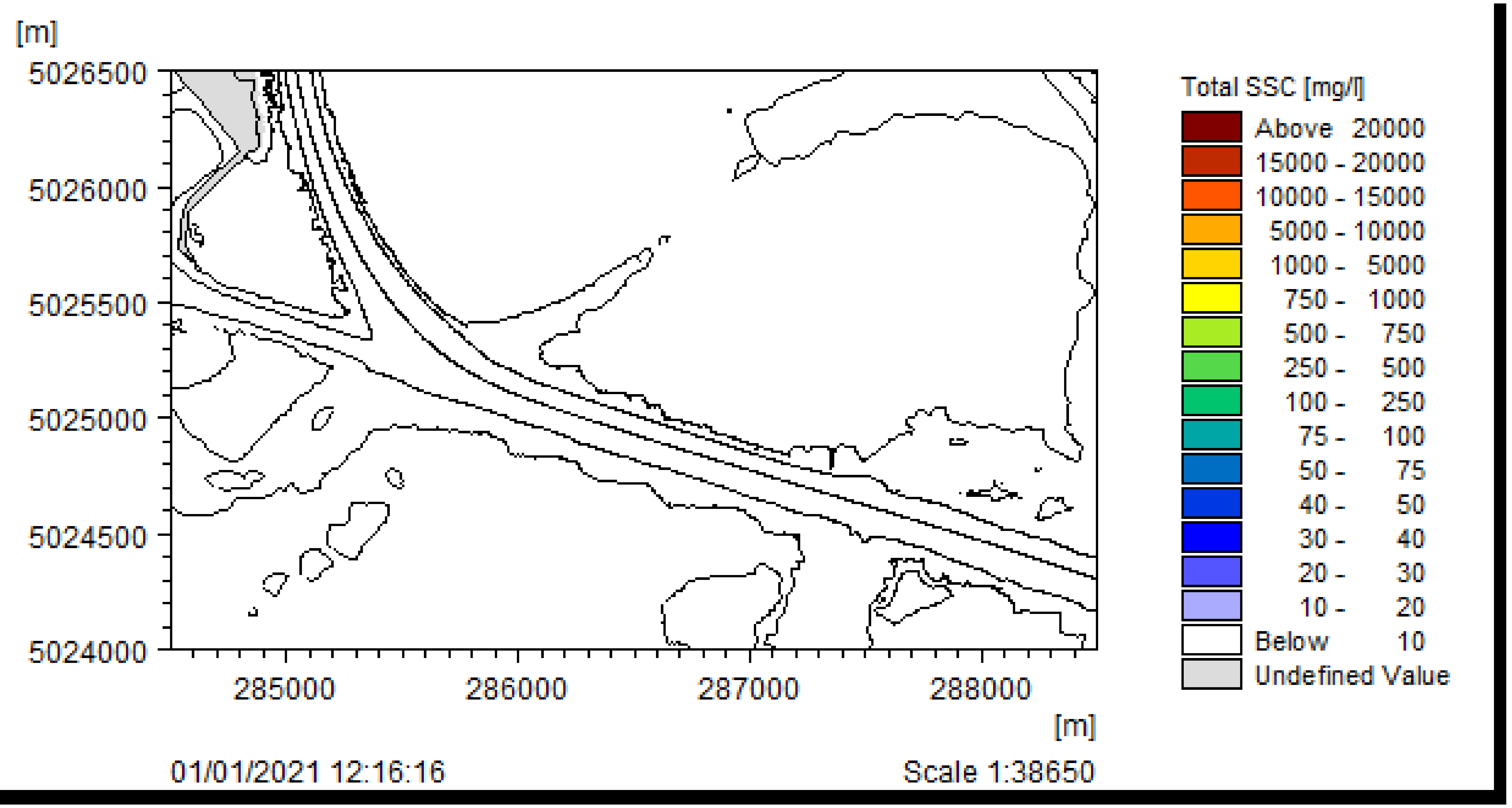
Bed shear stress varying propellor sizes and distances from bed.





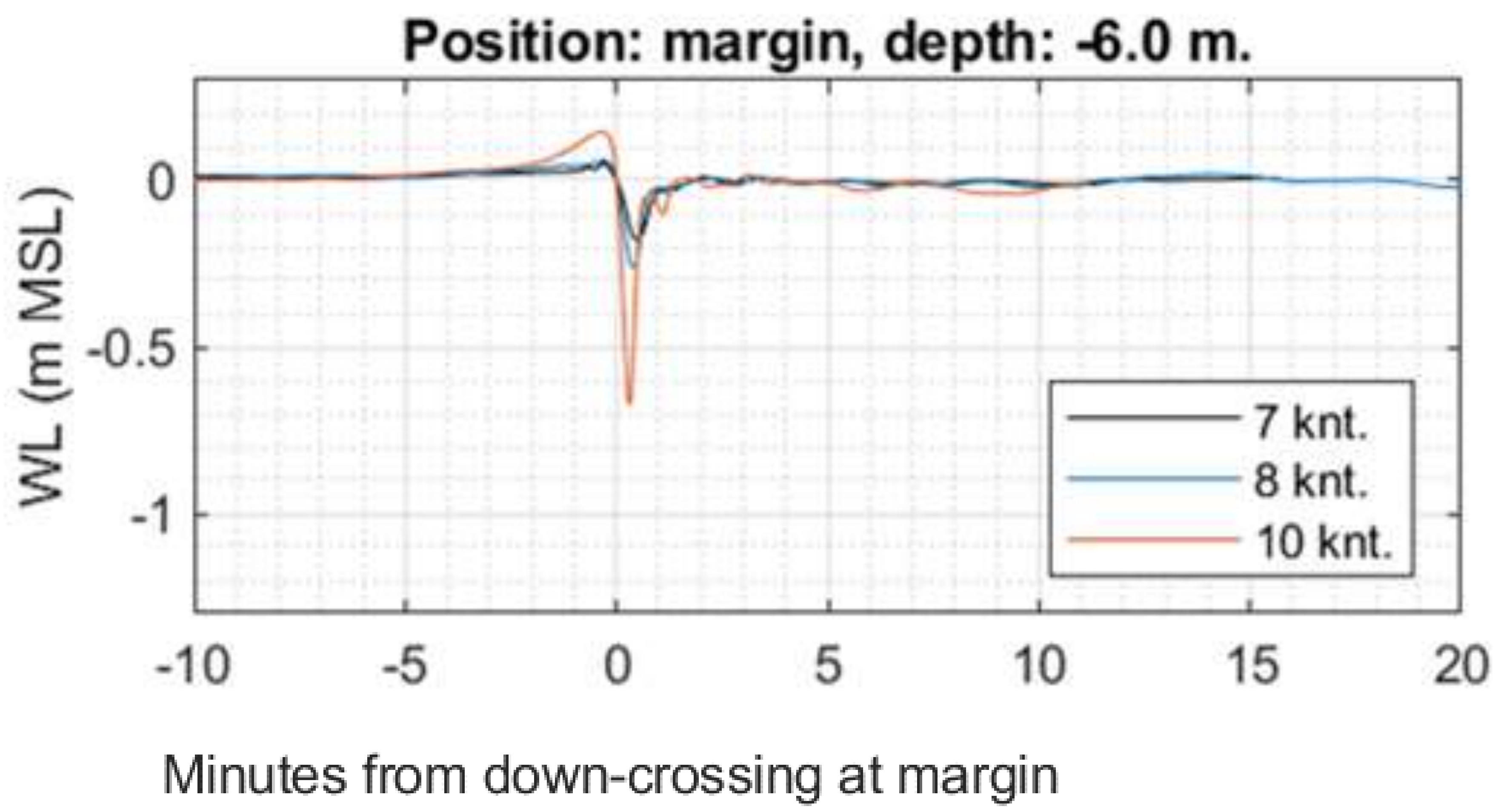
Depth averaged SSC during passage

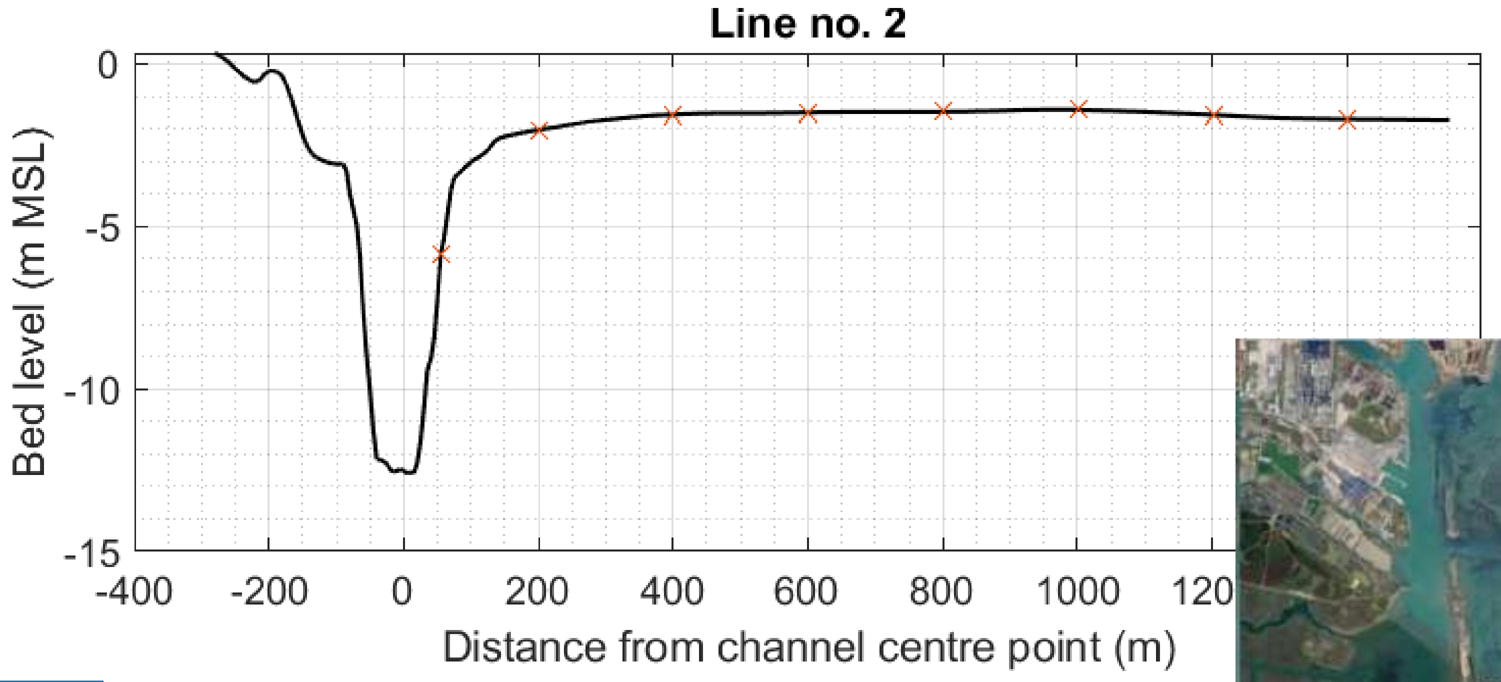




Varying speed, existing channel

Line-2

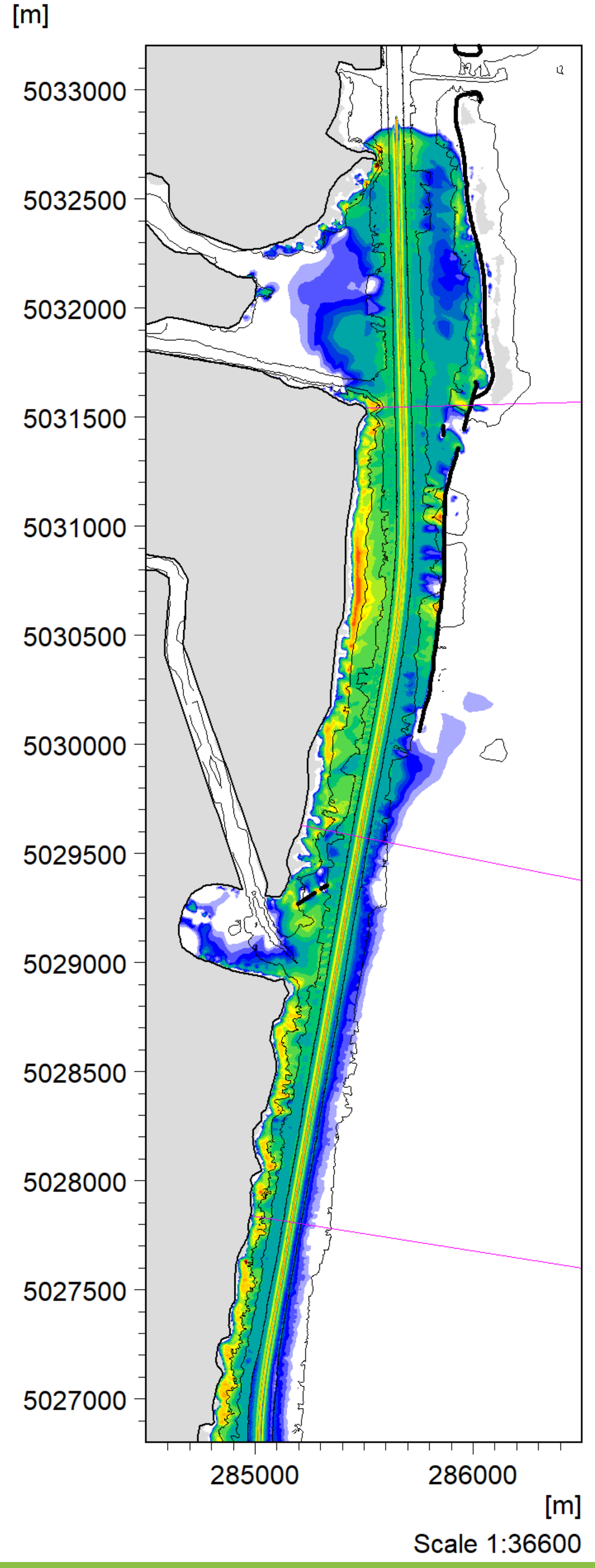


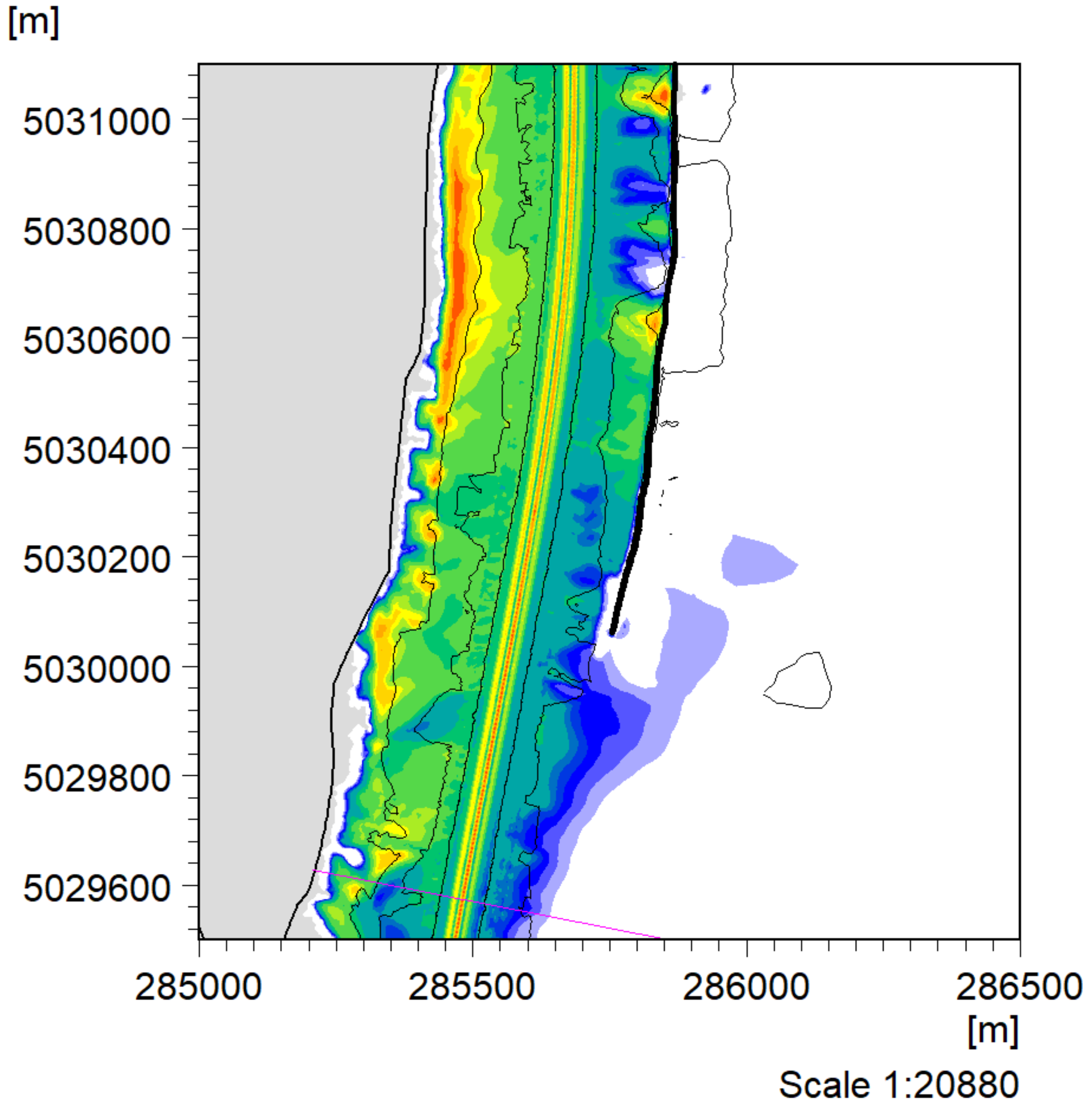


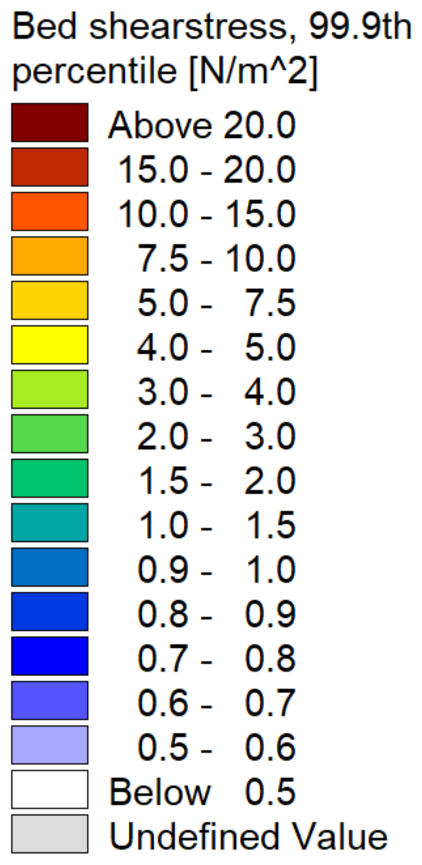
- Reducing the speed from 10 to 8 knots has a significant influence on the draw down magnitude – close to and far away from the channel.
- With 10 knots draw downs of 10 cm are modelled about 1,500 m from the channel.
  - Reducing the speed to 8 knots the draw down level decreases by a factor 5.
  - Even though a draw down of 10 cm is modelled 1,400 m from the channel with a speed of 10 knots, the modelled bed shear stresses are below the erosion threshold of 0.7 Pa after approximately 1,000 m.

Line no. 2	Draw down level (m MSL)							
Speed (knot)	Margin	200 m	400 m	600 m	800 m	1000 m	1200 m	1400 m
7	-0.18	-0.07	-0.03	-0.03	-0.02	-0.01	-0.01	-0.01
8	-0.26	-0.11	-0.09	-0.07	-0.04	-0.03	-0.02	-0.02
10	-0.67	-0.49	-0.28	-0.22	-0.18	-0.14	-0.12	-0.1

Con-S at 8 and 10 knots, existing channel



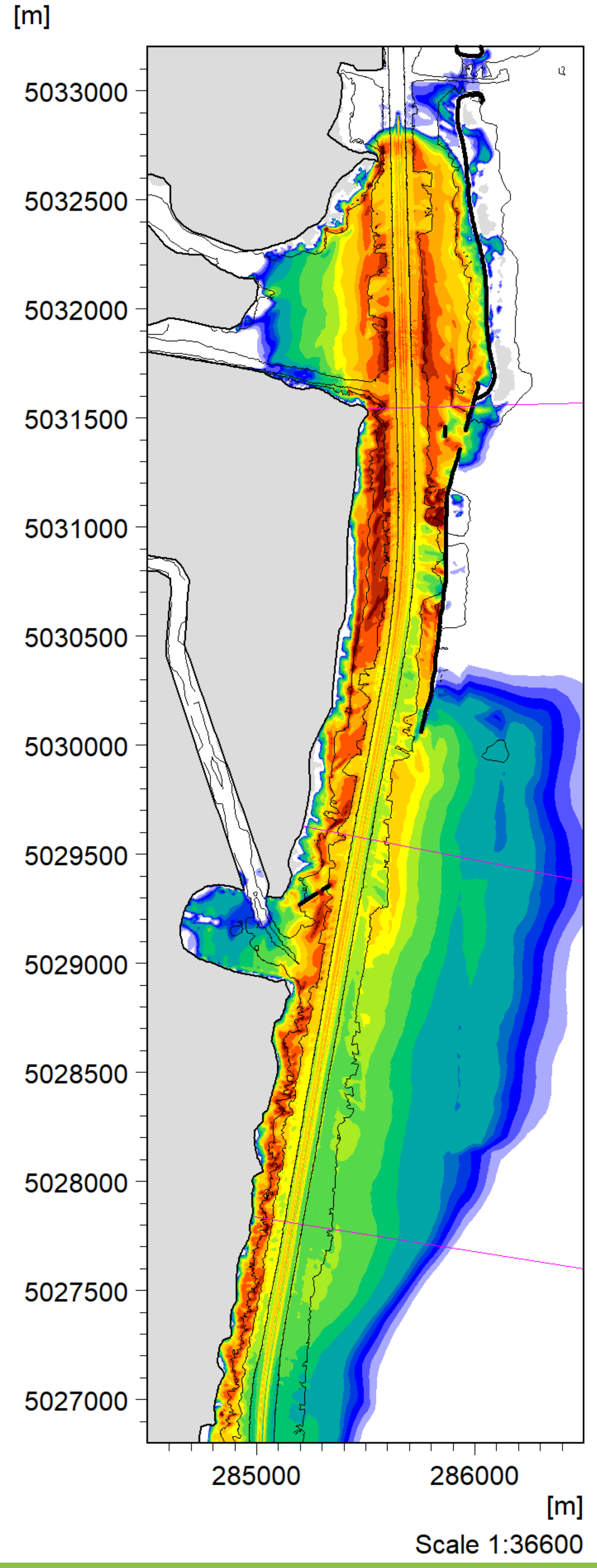


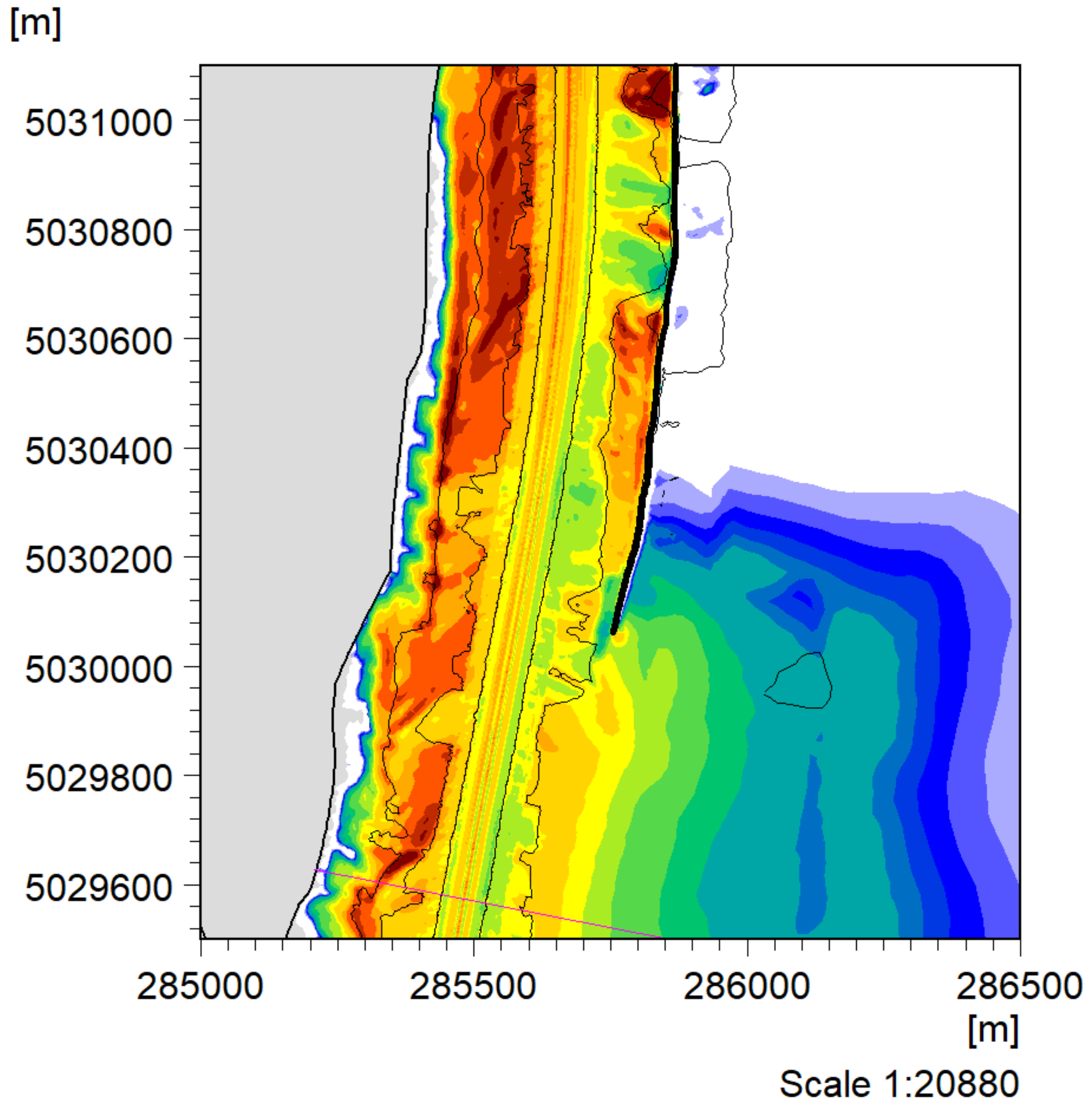


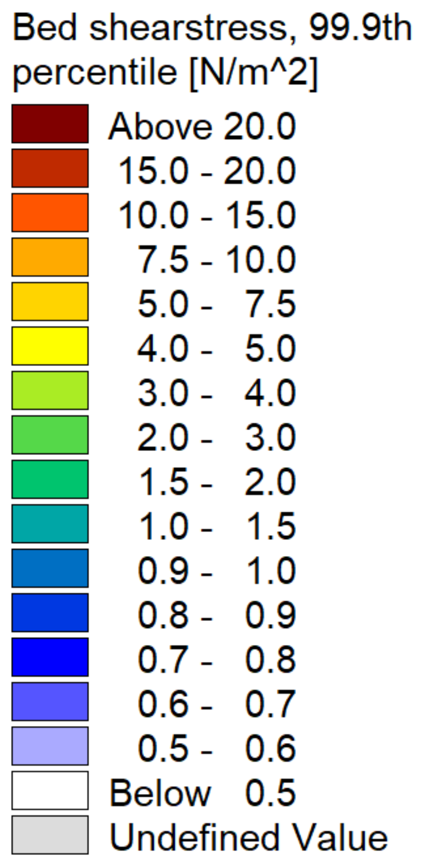
Maximum Shear Stress

Con-S

- WL = 0 m MSL
- V = 8 knots.







Maximum Shear Stress

Con-S

- WL = 0 m MSL
- V = 10 knots.

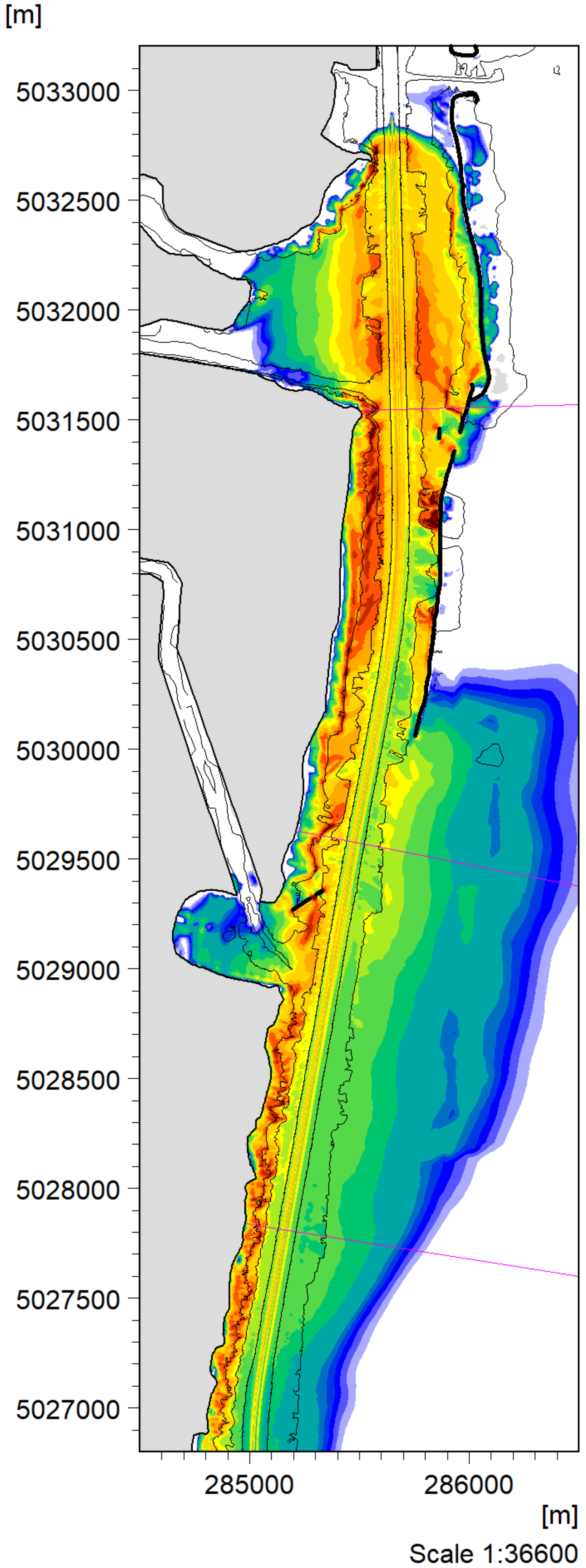
Existing versus 80 m channel

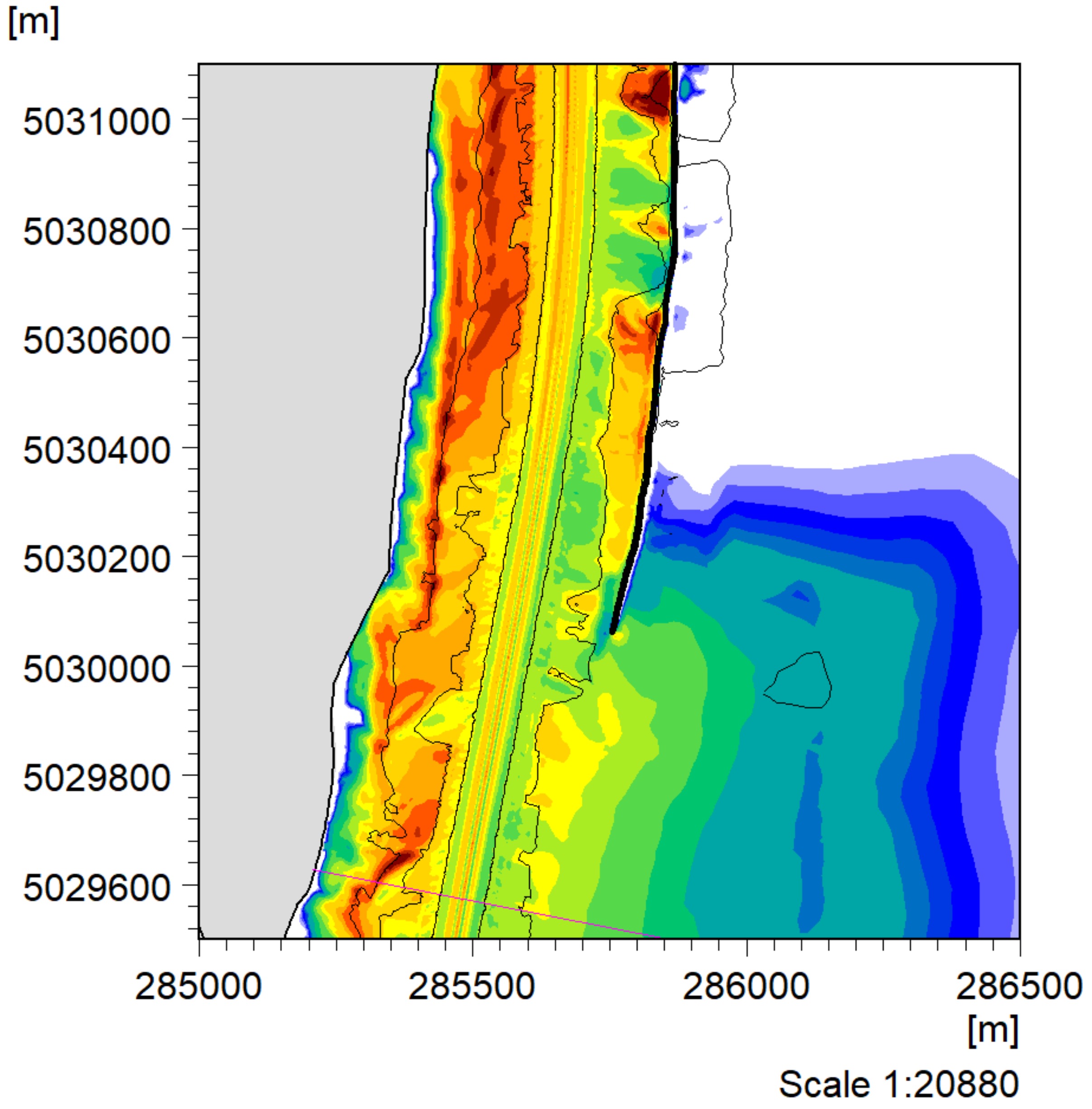
Line no. 1	Draw down level (m MSL)							
	Margin	200 m	400 m	600 m	800 m	1000 m	1200 m	1400 m
Existing Channel	-0.89	-0.78	-0.14	-0.06	-0.06	-0.07	-0.08	-0.08
80 m Channel	-0.84	-0.74	-0.14	-0.06	-0.06	-0.07	-0.08	-0.08
Change	-0.05	-0.04	0.00	0.00	0.00	0.00	0.00	0.00
Line no. 2	**Draw down level (m MSL)**							
	Margin	200 m	400 m	600 m	800 m	1000 m	1200 m	1400 m
Existing Channel	-0.67	-0.49	-0.28	-0.22	-0.18	-0.14	-0.12	-0.1
80 m Channel	-0.57	-0.41	-0.28	-0.23	-0.19	-0.14	-0.11	-0.09
Change	-0.10	-0.08	0.00	+0.01	+0.01	0.00	-0.01	-0.01
Line no. 3	**Draw down level (m MSL)**							
	Margin	200 m	400 m	600 m	800 m	1000 m	1200 m	1400 m
Existing Channel	-0.49	-0.41	-0.31	-0.19	-0.1	-0.06	-0.05	-0.04
80 m Channel	-0.48	-0.4	-0.31	-0.19	-0.1	-0.07	-0.05	-0.04
Change	-0.01	-0.01	0.00	0.00	0.00	+0.01	0.00	0.00

The re-design of the channel mainly has effect close to the channel – more than 200 m from the channel hardly any effect is seen.

Reducing the speed from 10 to 8 knots, changes to the draw down magnitude are noticeable (around 10 cm) more than 1,000 m from the channel.

Con-S, existing versus 80 m channel





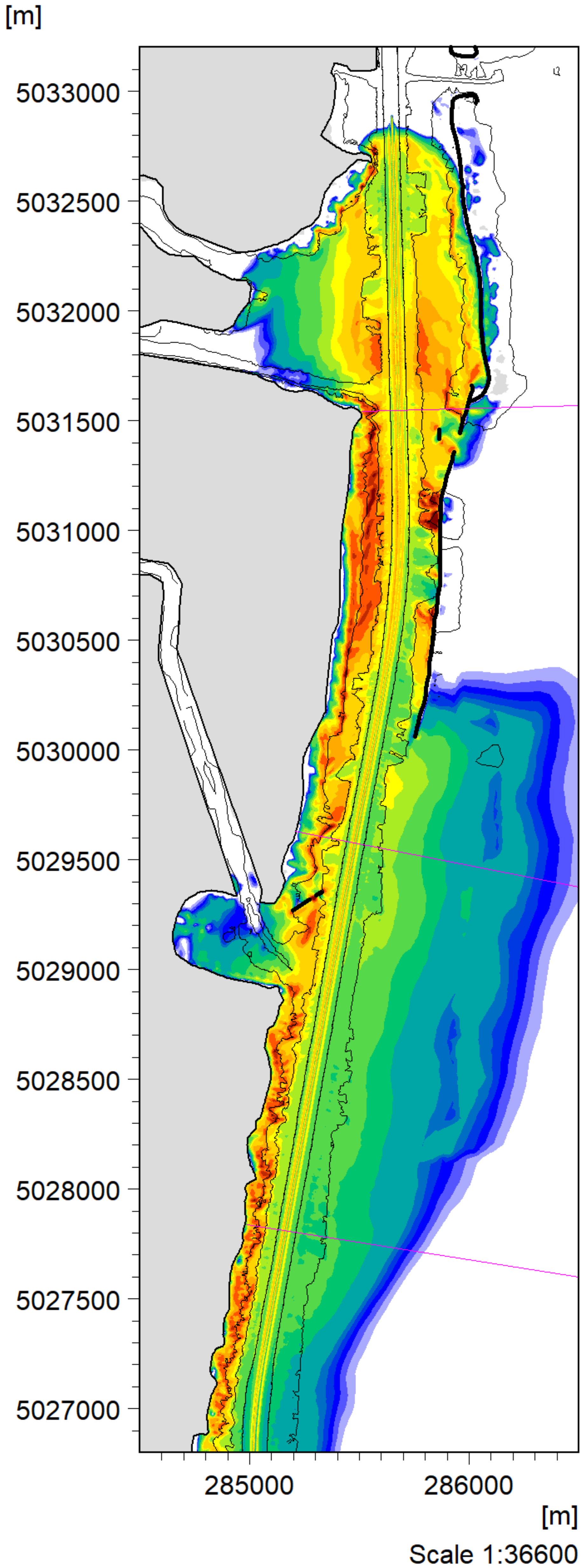
Bed shearstress, 99.9th percentile [N/m^2]

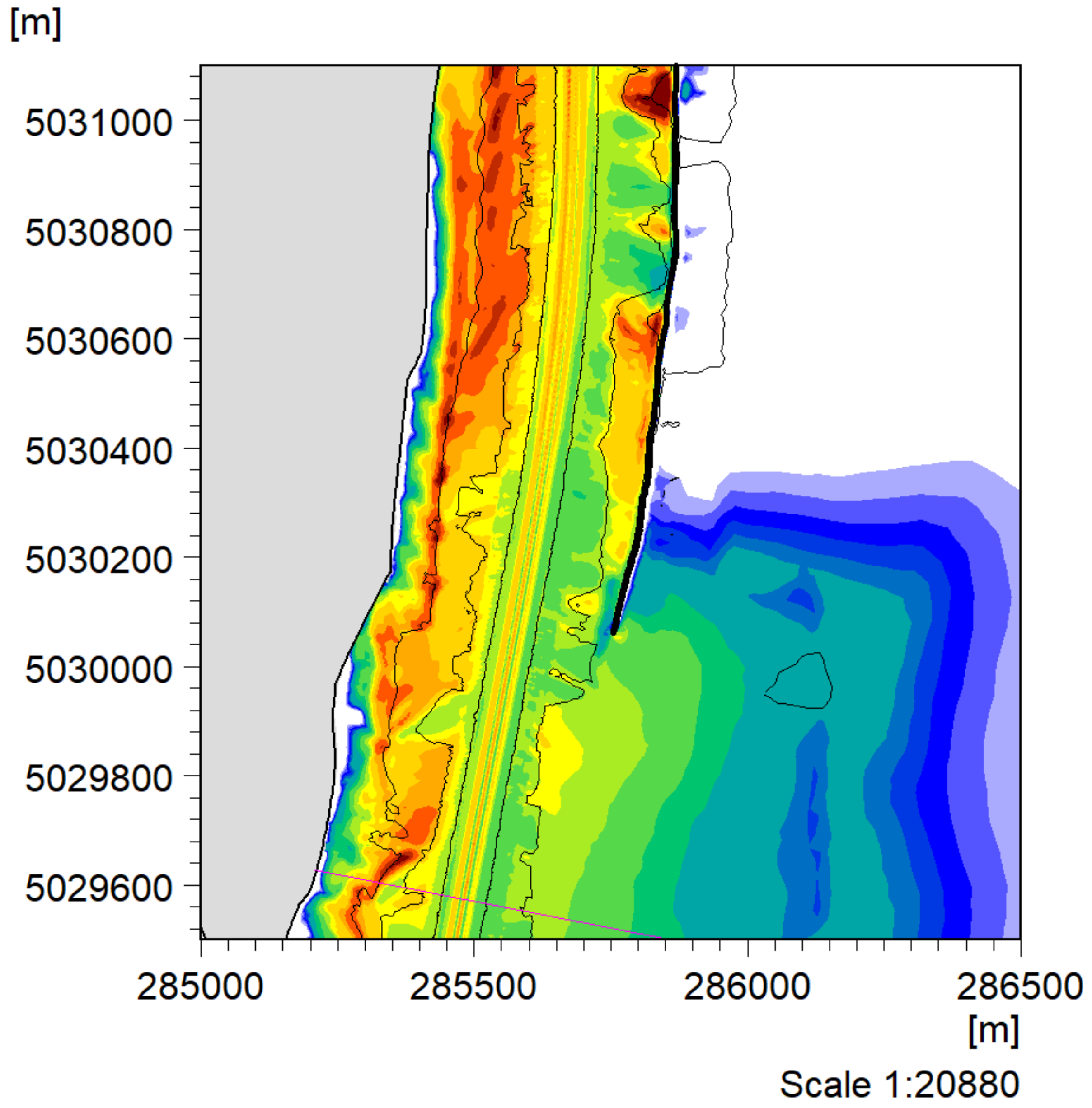
- Above 20.0
- 15.0 - 20.0
- 10.0 - 15.0
- 7.5 - 10.0
- 5.0 - 7.5
- 4.0 - 5.0
- 3.0 - 4.0
- 2.0 - 3.0
- 1.5 - 2.0
- 1.0 - 1.5
- 0.9 - 1.0
- 0.8 - 0.9
- 0.7 - 0.8
- 0.6 - 0.7
- 0.5 - 0.6
- Below 0.5
- Undefined Value

Maximum Shear Stress

Con-S

- WL = 0.2 m MSL
- V = 10 knots
- Existing channel





Bed shearstress, 99.9th percentile [N/m^2]

- Above 20.0
- 15.0 - 20.0
- 10.0 - 15.0
- 7.5 - 10.0
- 5.0 - 7.5
- 4.0 - 5.0
- 3.0 - 4.0
- 2.0 - 3.0
- 1.5 - 2.0
- 1.0 - 1.5
- 0.9 - 1.0
- 0.8 - 0.9
- 0.7 - 0.8
- 0.6 - 0.7
- 0.5 - 0.6
- Below 0.5
- Undefined Value

Maximum Shear Stress

Con-S

- WL = 0.2 m MSL
- V = 10 knots
- 80 m channel

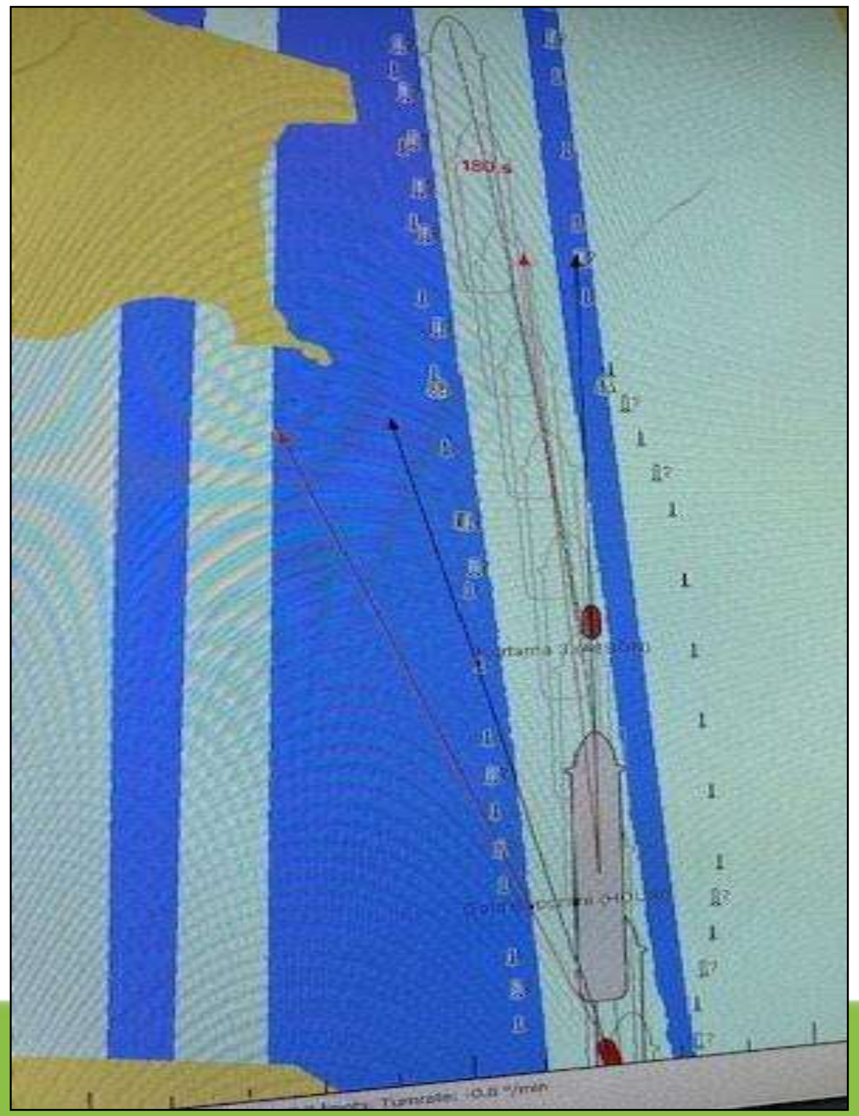
Next Step

To identify:

A solution both for infrastructure and management, from the output of the developed models.

A solution based on a combination of nautical needs, speed, re-shaping, etc

A solution based on strong scientific evidence, that combines port activities and enviromental protection



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Autorità di Sistema Portuale del Mare Adriatico Settentrionale
Porti di Venezia e Chioggia

LE PROSPETTIVE DI RILANCIO DEL PORTO DI VENEZIA

Venerdì 4 novembre 2022 ore 14:30

Ateneo Veneto - Aula Magna

Grazie per l'attenzione

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