Final Event –ECCLIPSE Project

26 April

Puertos del Estado, Madrid

Interreg Sudoe

EUROPEAN UNION

ecclipse

Port of Aveiro Ocean climate projection

José Chambel Leitão

Managing partner at HIDROMOD

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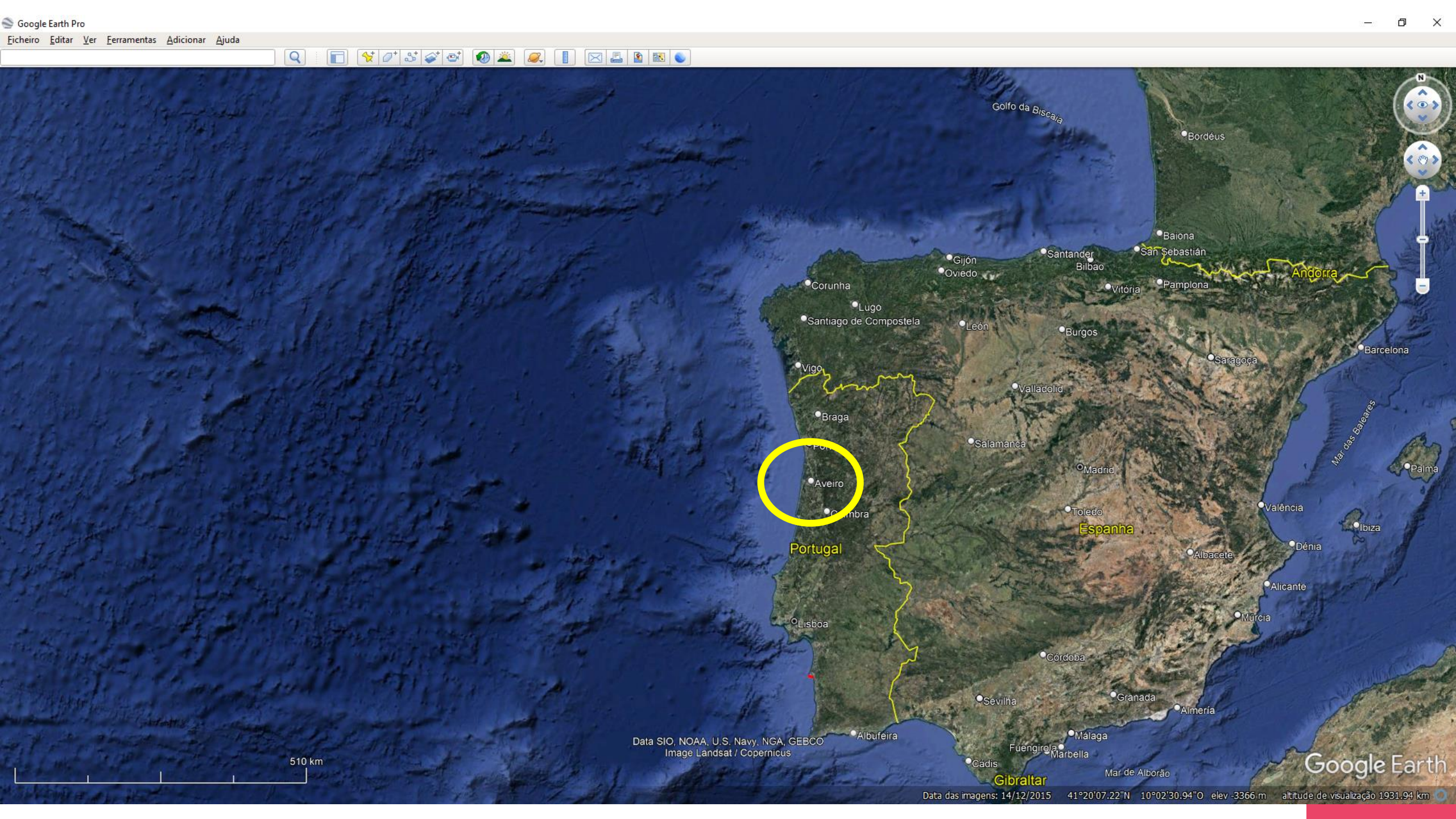
- João Ribeiro
- Sofia Cardoso
- Theo Moura
- João Miguel Dias (IDAD Aveiro)
- Carina Lopes (IDAD Aveiro)
- João Pinheiro (IDAD Aveiro)


Google Earth Pro
Ficheiro Editar Ver Ferramentas Adicionar Ajuda
Golfo da Biscaia
Bordéus
Baiona
San Sebastián
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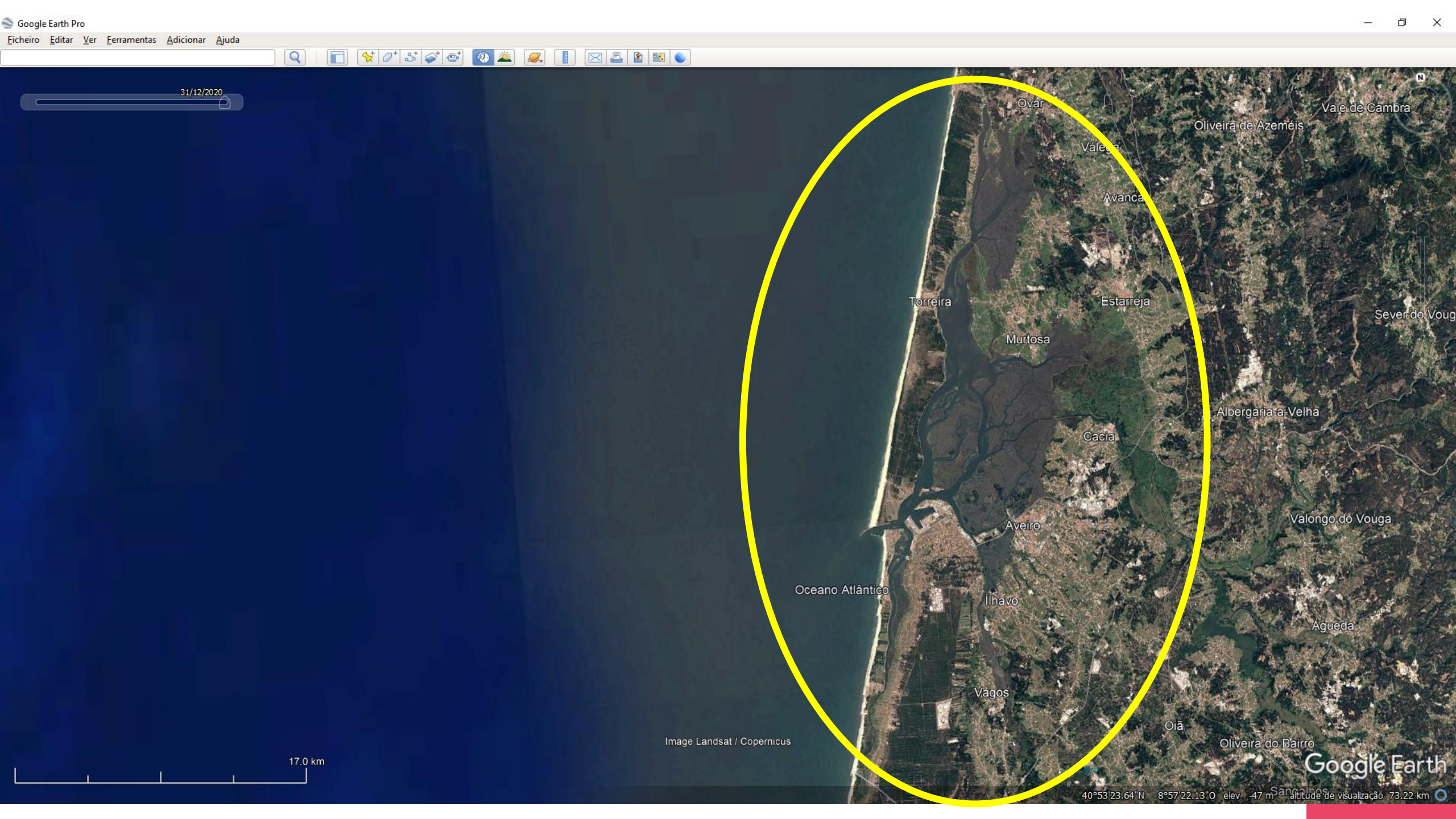
Múrcia
Córdoba
Sevilha
Granada
Almería
Albufeira
Málaga
Fuengirola
Marbella
Cádis
Gibraltar
Mar de Alborão
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
510 km
Google Earth
Data das imagens: 14/12/2015 41°20'07.22"N 10°02'30.94"O elev -3366 m altitude de visualização 1931.94 km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31/12/2020
Ovar
Vale de Cambra
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Avanca
Torreira
Estarreja
Murtosa
Albergaria-a-Velha
Cacia
Aveiro
Valongo do Vouga
Oceano Atlântico
Ílhavo
Águeda
Vagos
Oiã
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17.0 km
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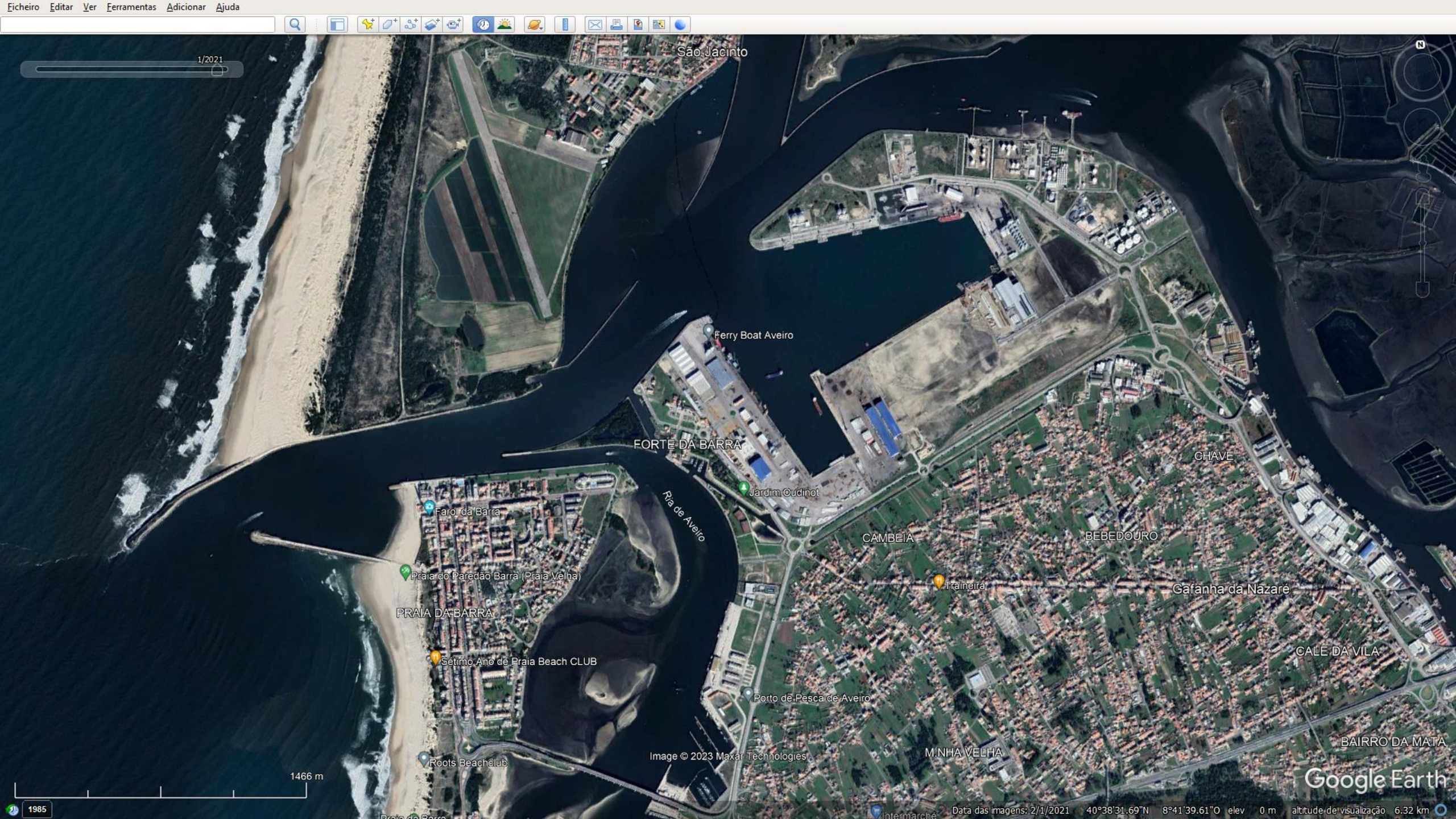
40°53'23.64"N 8°57'22.13"O elev -47 m altitude de visualização 73.22 km


Ficheiro Editar Ver Ferramentas Adicionar Ajuda
1/2021
São Jacinto
Ferry Boat Aveiro
FORTE DA BARRA
CHAVE
Jardim Oudinot
Farol da Barra
Ria de Aveiro
CAMBEIA
BEBEDOURO
Praia do Paredão Barra (Praia Velha)
Trafaleira
Gafanha da Nazaré
PRAIA DA BARRA
Sétimo Ano de Praia Beach CLUB
CALE DA VILA
Porto de Pesca de Aveiro
BAIRRO DA MATA
Image © 2023 Maxar Technologies
M.NHA VELHA
Roots Beachclub
1466 m
Google Earth
1985
Data das imagens: 2/1/2021 40°38'31.69"N 8°41'39.61"O elev 0 m altitude de visualização 6.32 km

Climate Information Needs

- Critical asset, operations or systems.
- Historical impact of extreme weather events.
- Climate risk thresholds that entail a risk to the port.
- Definition of specific indicators (based on frequency and intensity) of exceedance of the thresholds.

	Currents	Waves	Wind	Sea level	Visibility
Restrictions to navigation					
Description	The currents generated near the inlet are mainly driven by tide. It has been identified that the mean water level is crucial to determine the tidal prism and as consequence the intensity of the currents. Two thresholds of current velocity have been established: (1) Above 1 knot for ships over 150 m length and 9.0 m draft; (2) Above 4 Knot for ships over 135 m length and 7.5 m draft.	Port of Aveiro is located inside the Ria de Aveiro and is well protected from swell, however the pilot's operation (boarding vessel at sea) is impacted by the waves. During periods of Hs above 4 meters pilots do not board vessels at sea.	Strong winds also affect ship's entrance and exit. The Port adopts two thresholds: (1) 30 knots for vessels larger than 135 meters; (2) 40 knots for all vessels.	--	Visibility shorter than 500 m restricts the entrance of ships longer than 135 meters.
Processing	Evaluate the navigation windows available with currents below 1 knot, based on high resolution modelling for the navigation channel.	Basic wave statistics and evaluate events where Hs exceeds 4 m, their duration and frequency.	Basic wind statistics and evaluate events where wind exceeds 30 and 40 knots, their duration and frequency.	--	Evaluate events (duration and frequency) where visibility is lower than 500m, using a visibility proxy (difference between air temperature and dew point).
Operational Threshold					
Description	--	--	Land operations limited by winds higher than 54.4 knots. Exception: Beyond 28.8 km/h the operation with solid bulk in North Terminal could be suspended by the Port Authority if the wind direction is from SSO (180° to 225°) or NNW (315° to 360°).	--	It may occur due to fog or heavy rainfall. Visibility shorter than 200 m restricts road traffic operations.
Processing	--	--	Basic wind statistics and evaluate events where wind exceeds 28.8 and 54.4 knots, their duration and frequency. Evaluate if wind direction is expected to change above 28.8 knots, their duration and frequency.	--	Evaluate events (duration and frequency) where visibility is lower than 200m, using a visibility proxy (difference between air temperature and dew point).
Infrastructure's thresholds design					
Description	--	Wave climate change leading to higher or more frequent damages in harbour protection structures	--	Sea level increase: (1) impacts in low level dock structures; (2) reduces rainwater drainage capacity in low land areas	--
Processing	--	Wave climate statistics and extreme event analysis	--	Extreme events of sea level (including tide, meteorology and mean sea level)	--

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	Sea level
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Description	Sea level increase: (1) impacts in low level dock structures; (2) reduces rainwater drainage capacity in low land areas
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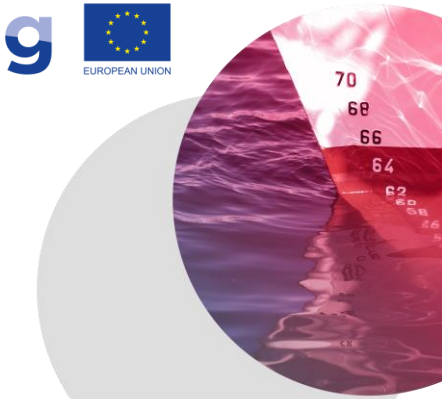
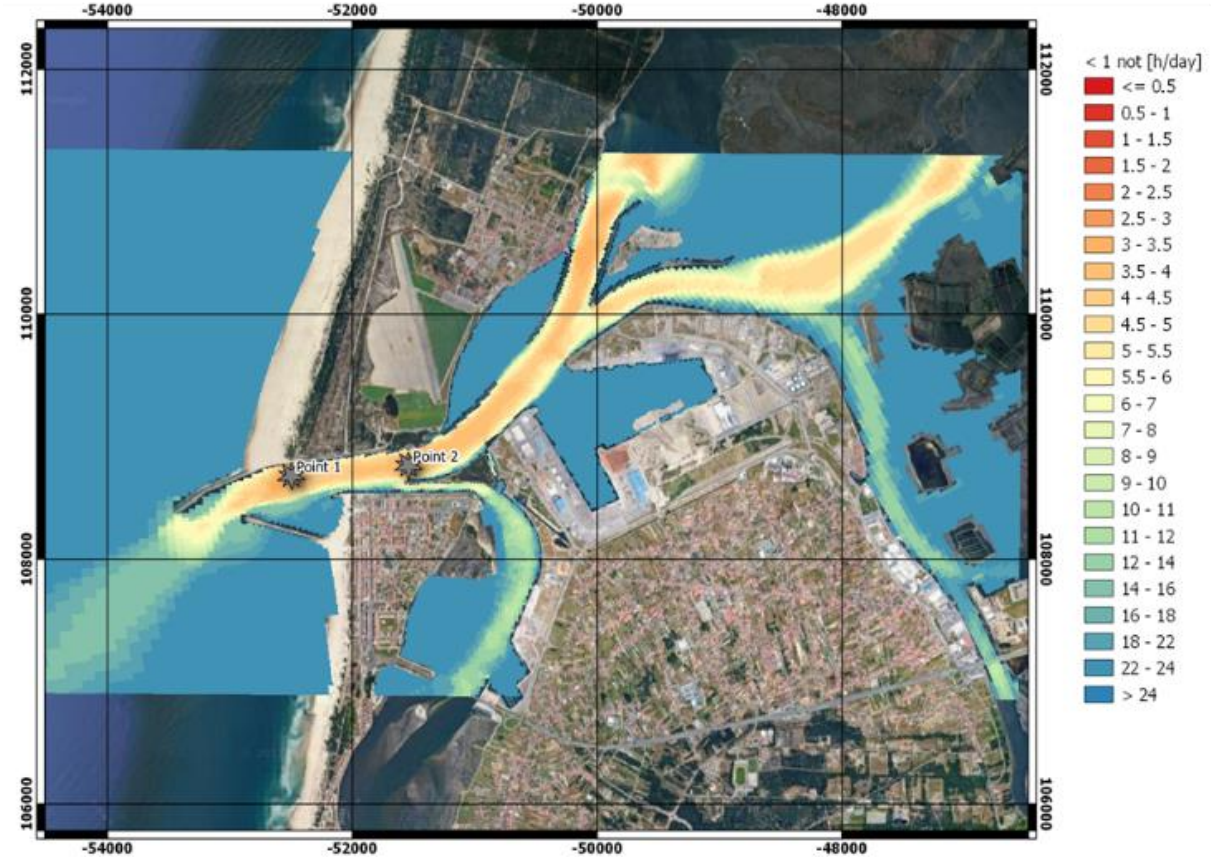
Numerical models



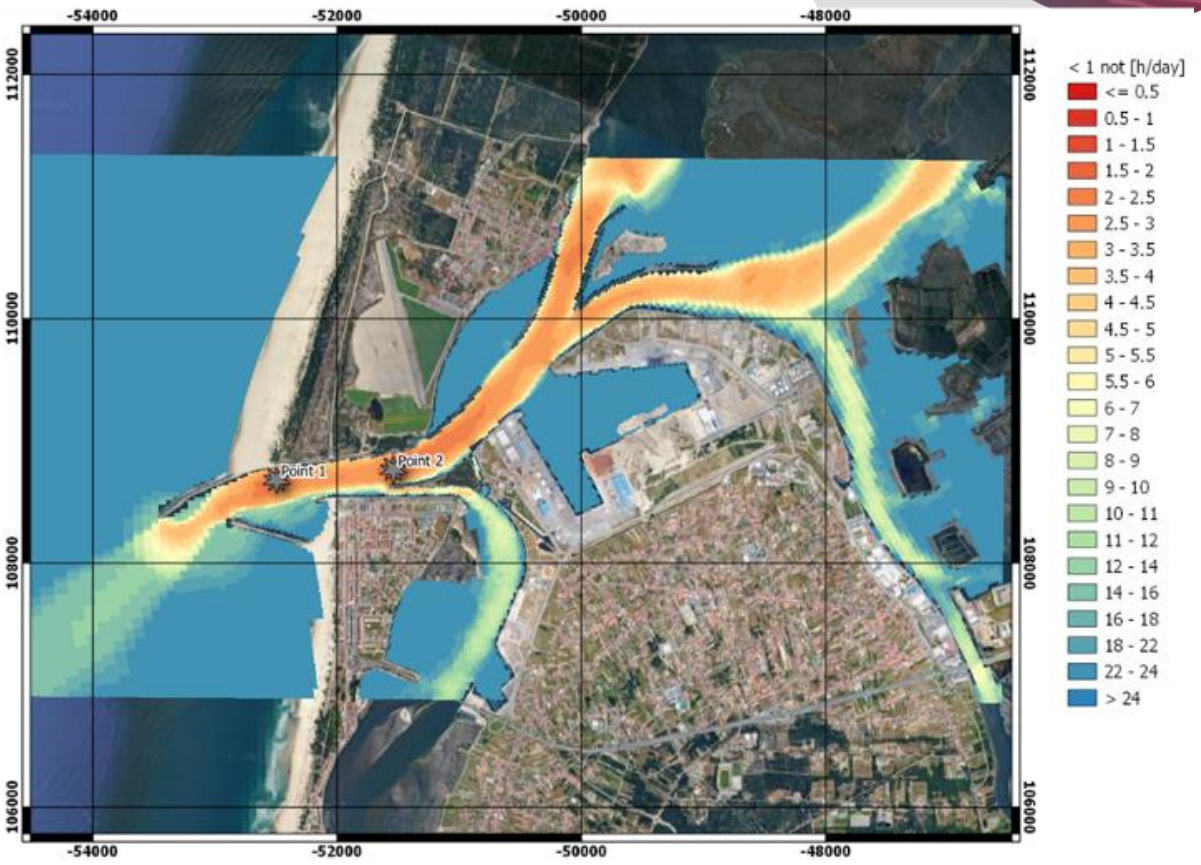
- Currents
  - High resolution modelling for the whole Ria de Aveiro - MOHID
  - Joint validation work with IDAD (local R&D institute)
- Waves
  - ECMWF's Wave Model (Baseline, RCP 4.5 and 8.5) – 30 km res.
- Sea Level
  - Combined result of changes in
    - MSL - Oppenheimer et al., 2019
    - Storm surges - calculated with regional models PCOMS and GTSM
    - Astronomic tide inside Ria de Aveiro – High resolution MOHID

Currents

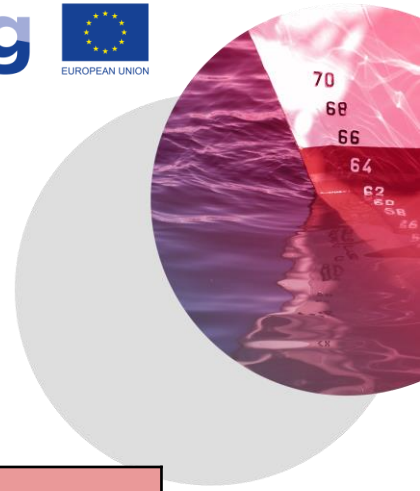
Neap tide



Spring tide

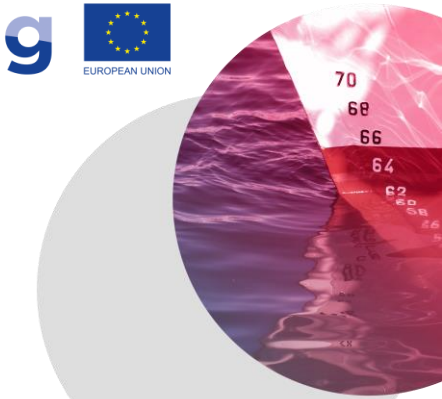


Currents < 1 not (hours/day)



Window of operation < 1 not	Present [h/day]	RCP 4.5 (2040-2060) [h/day]	RCP 8.5 (2040-2060) [h/day]	RCP 4.5 (2080-2100) [h/day]	RCP 8.5 (2080-2100) [h/day]
Point 1 - Spring Tide	3.2	2.8 - 3.0	2.7 - 2.9	2.5 - 2.8	2.2 - 2.6
Point 2 - Spring Tide	3.3	2.8 - 3.0	2.7 - 2.9	2.4 - 2.8	2.1 - 2.6
Point 1 - Neap Tide	6.5	5.5 - 5.9	5.4 - 5.8	4.8 - 5.5	4.3 - 5.1
Point 2 - Neap Tide	6.8	5.7 - 6.1	5.5 - 6.0	4.8 - 5.7	4.3 - 5.2

Currents < 4 nots (hours/day)



Window of operation < 4 nots	Present [h/day]	RCP 4.5 (2040-2060) [h/day]	RCP 8.5 (2040-2060) [h/day]	RCP 4.5 (2080-2100) [h/day]	RCP 8.5 (2080-2100) [h/day]
Point 1 - Spring Tide	14.2	12.1 - 12.9	11.8 - 12.7	10.6 - 12.1	9.3 - 11.2
Point 2 - Spring Tide	18.2	14.8 -16.1	14.3 - 15.8	12.5 - 14.8	10.6 - 13.5
Point 1 - Neap Tide	24.0	24.0	24.0	24.0	24.0
Point 2 - Neap Tide	24.0	24.0	24.0	24.0	24.0

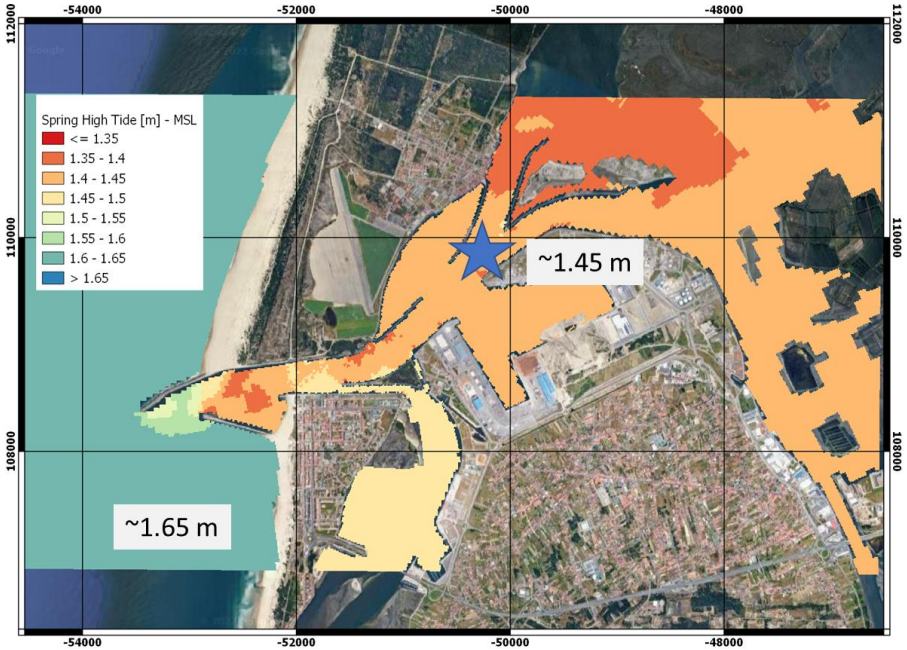
Sea Level

Mean Sea Level
(literature)

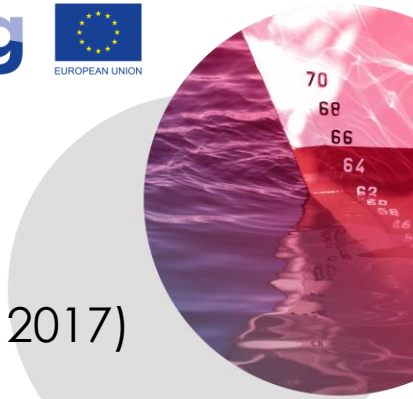
IPCC 5 Scenarios	Global Mean Sea Level [m]
RCP 4.5 (2040-2060)	0.19-0.34
RCP 8.5 (2040-2060)	0.23-0.40
RCP 4.5 (2080-2100)	0.34-0.64
RCP 8.5 (2080-2100)	0.51-0.92

Storm Surge
(average of 2 regional models)

Astronomic tide
(high res model)



Storm surge

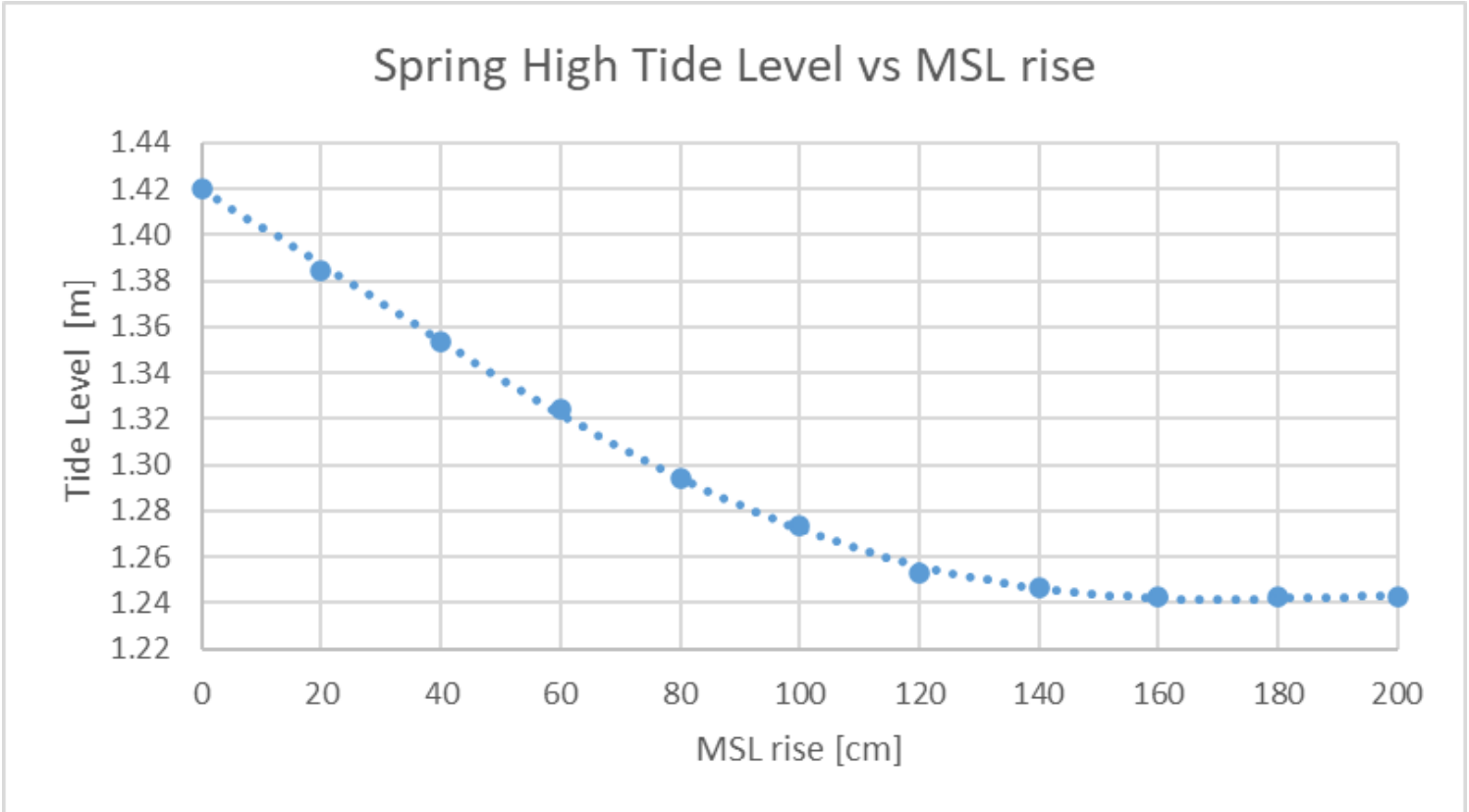


- Baseline: PCOMS and GTSM models using ERA5 meteorological reanalysis (1979 to 2017)
- Validation period 2015-2017, for 7 tidal gauges along the Portuguese coast
- RCP4.5 and 8.5 scenarios using 4 simulations to define a range of values: PCOMS with CNRM, IPSL and MOHC, and GTSM (with EC)

Return period	Present [m]	RCP 4.5 (2041-2070) [m]	RCP 8.5 (2041-2070) [m]	RCP 4.5 (2071-2100) [m]	RCP 8.5 (2071-2100) [m]
2	0.43	0.39 - 0.47	0.39 - 0.47	0.44 - 0.49	0.4 - 0.46
5	0.54	0.47 - 0.57	0.46 - 0.58	0.51 - 0.59	0.48 - 0.58
10	0.61	0.52 - 0.64	0.51 - 0.65	0.55 - 0.65	0.53 - 0.66
25	0.70	0.58 - 0.72	0.57 - 0.74	0.61 - 0.73	0.59 - 0.76
50	0.76	0.62 - 0.79	0.61 - 0.81	0.66 - 0.8	0.63 - 0.84
100	0.83	0.67 - 0.85	0.65 - 0.87	0.7 - 0.86	0.67 - 0.91

Astronomic tide

- MSL rise increases the dampening effect the Ria de Aveiro inlet has on the astronomic tidal wave
- Values represent height above MSL for a 3.1 m spring tide



Sea Level

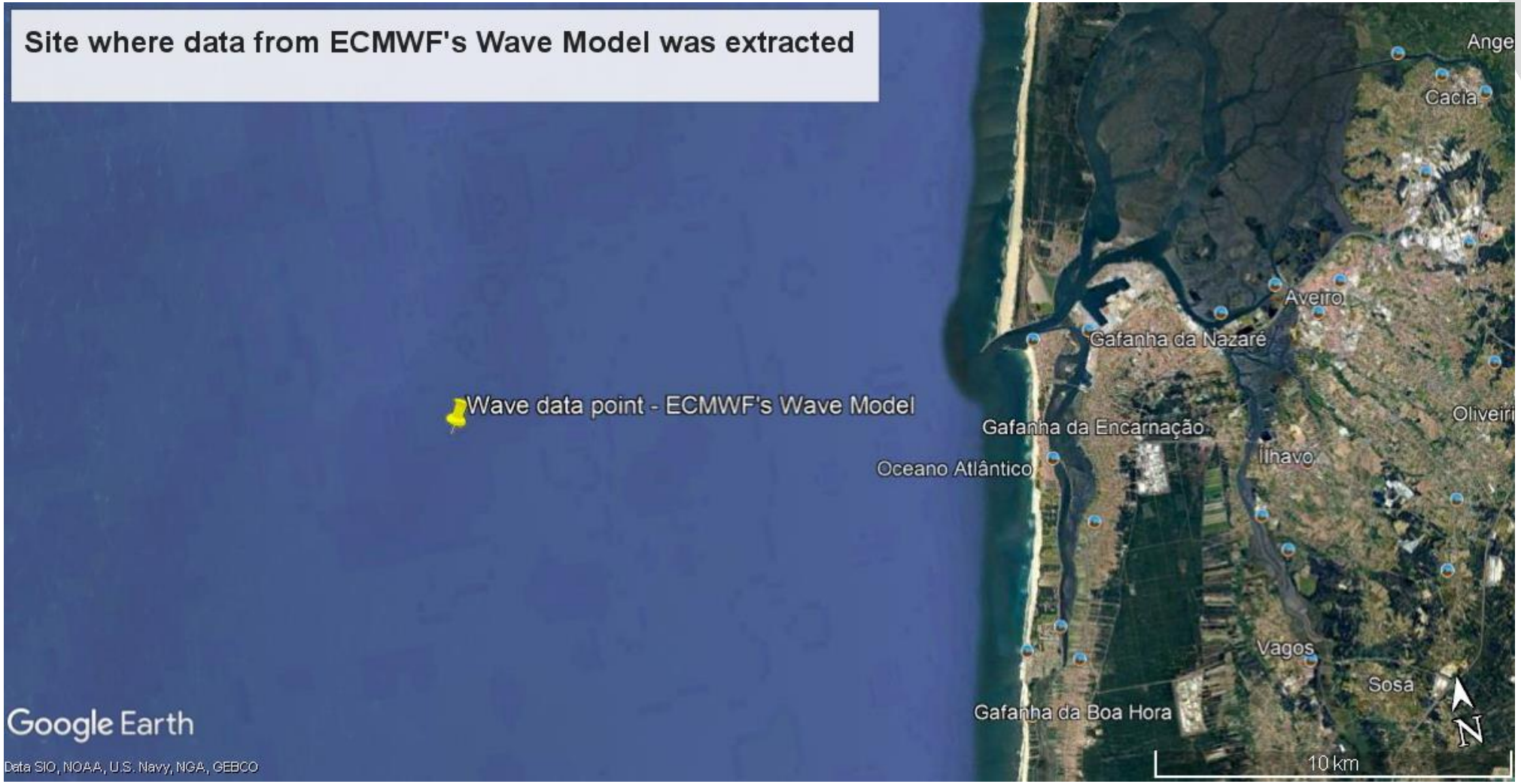
Estimated range for the extreme sea level events for the navigation and dock area of the port of Aveiro.

Combined result of changes in:

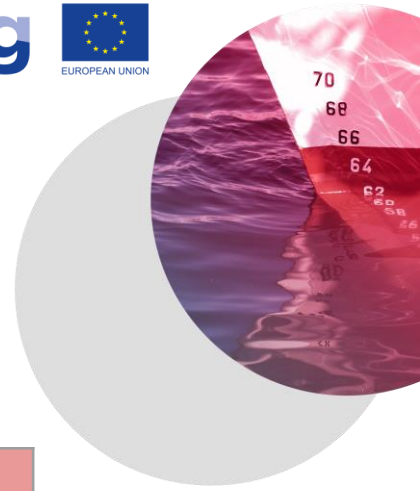
- mean sea level
- storm surge
- astronomic tide

Return period [years]	Present	RCP 4.5 (2040-2060) [m] min - max		RCP 8.5 (2040-2060) [m] min - max		RCP 4.5 (2080-2100) [m] min - max		RCP 8.5 (2080-2100) [m] min - max	
2	4.07	4.19	4.30	4.32	4.45	4.37	4.69	4.48	4.92
5	4.16	4.26	4.38	4.38	4.55	4.43	4.78	4.56	5.03
10	4.22	4.31	4.45	4.43	4.61	4.47	4.83	4.60	5.11
25	4.30	4.36	4.52	4.48	4.70	4.52	4.91	4.66	5.21
50	4.35	4.39	4.58	4.52	4.76	4.57	4.98	4.70	5.29
100	4.41	4.44	4.64	4.56	4.82	4.60	5.03	4.73	5.36

Wave data

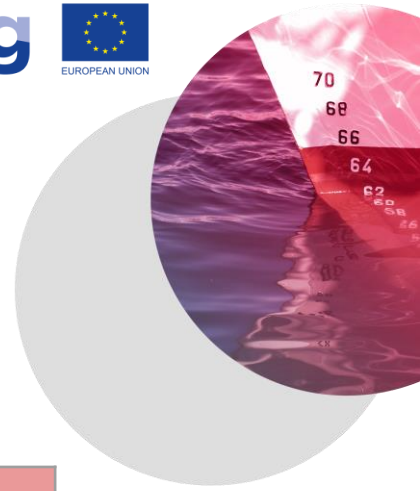

Site where data from ECMWF's Wave Model was extracted
Wave data point - ECMWF's Wave Model
Oceano Atlântico
Ange
Cacia
Aveiro
Gafanha da Nazaré
Gafanha da Encarnação
Ílhavo
Oliveir
Vagos
Sosa
Gafanha da Boa Hora
N
10 km
Google Earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Waves - Statistics



	Present	RCP 4.5 (2040-2060)	RCP 8.5 (2040-2060)	RCP 4.5 (2080-2100)	RCP 8.5 (2080-2100)
Hs mean (m)	1.95	2.16	2.19	2.18	2.09
Tp mean (s)	11.17	11.31	11.24	11.27	11.11
Hs 90% (m)	3.3	3.73	3.77	3.84	3.59
Hs 95 % (m)	4.0	4.60	4.57	4.69	4.38
Hs max (m)	9.36	10.85	10.30	11.86	12.08

Waves – Extreme events



Scenario	Present	RCP 4.5 (2040-2060)	RCP 8.5 (2040-2060)	RCP 4.5 (2080-2100)	RCP 8.5 (2080-2100)
Number of events	**312**	**485**	**507**	**478**	**440**
Mean Event duration (days)	**1.15**	**1.21**	**1.20**	**1.30**	**1.14**
Mean Interval between events (days)	**22.2**	**13.8**	**13.2**	**13.8**	**14.9**

Recommendations for future work

- Flood propagation studies, including flow & water level monitoring and model validation, in river Vouga and eventually in other tributaries
- Evaluation of freshwater influence in extreme sea levels inside Ria de Aveiro
- Evaluation of freshwater influence on navigation channel currents

Obrigado