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Relative sea level rise trends and projections up to 2150 along the Italian coasts: implications for coastal flooding

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Relative sea level change

$$\Delta\zeta_{rslc} = \Delta\zeta_e + \Delta\zeta_I + \Delta\zeta_T$$

Eustatic contribution

Isostatic contribution (vertical land movements)

Tectonics (vertical land movements)

Considered by the IPCC AR6

Recorded in the Vup of GNSS data

Neglected in the IPCC AR6

Revised sea level projections

The AR6-IPCC projections underestimate future sea level (SL) along the coasts of the Mediterranean Sea because the effects of vertical tectonics are not considered.

The revised SL projections at 2100 show significant deviations and up to the 62%, from the IPCC AR6 projections with max. and min. differences of 1.09±0.10 m and −0.77±0.11 m, respectively, with an average value that exceeds by about 8 cm that of the IPCC.

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Sea level rise projections up to 2150 in the northern Mediterranean coasts

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Vertical land movements from GNSS

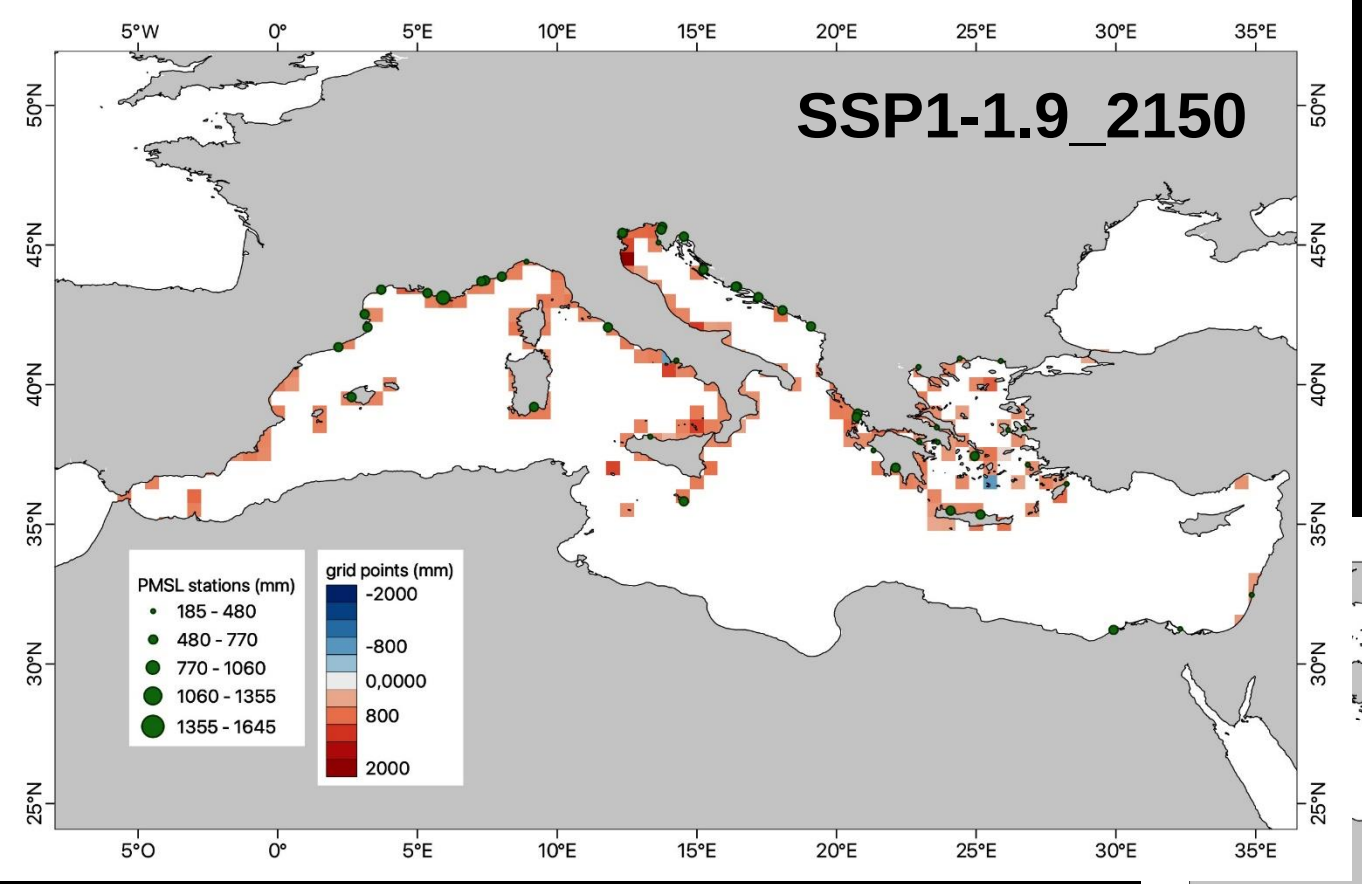
Current rates of VLM at the 638 GNSS stations located <5 km from the coast.
Time series >4.5 years, time interval 1996–2023 (about 27 years).
Data reduction by GAMIT software, GLOBK software and time-series analysis (Herring *et al* 2010).
Reference frame IGS realization of the ITRF2014.

Revised sea level projections

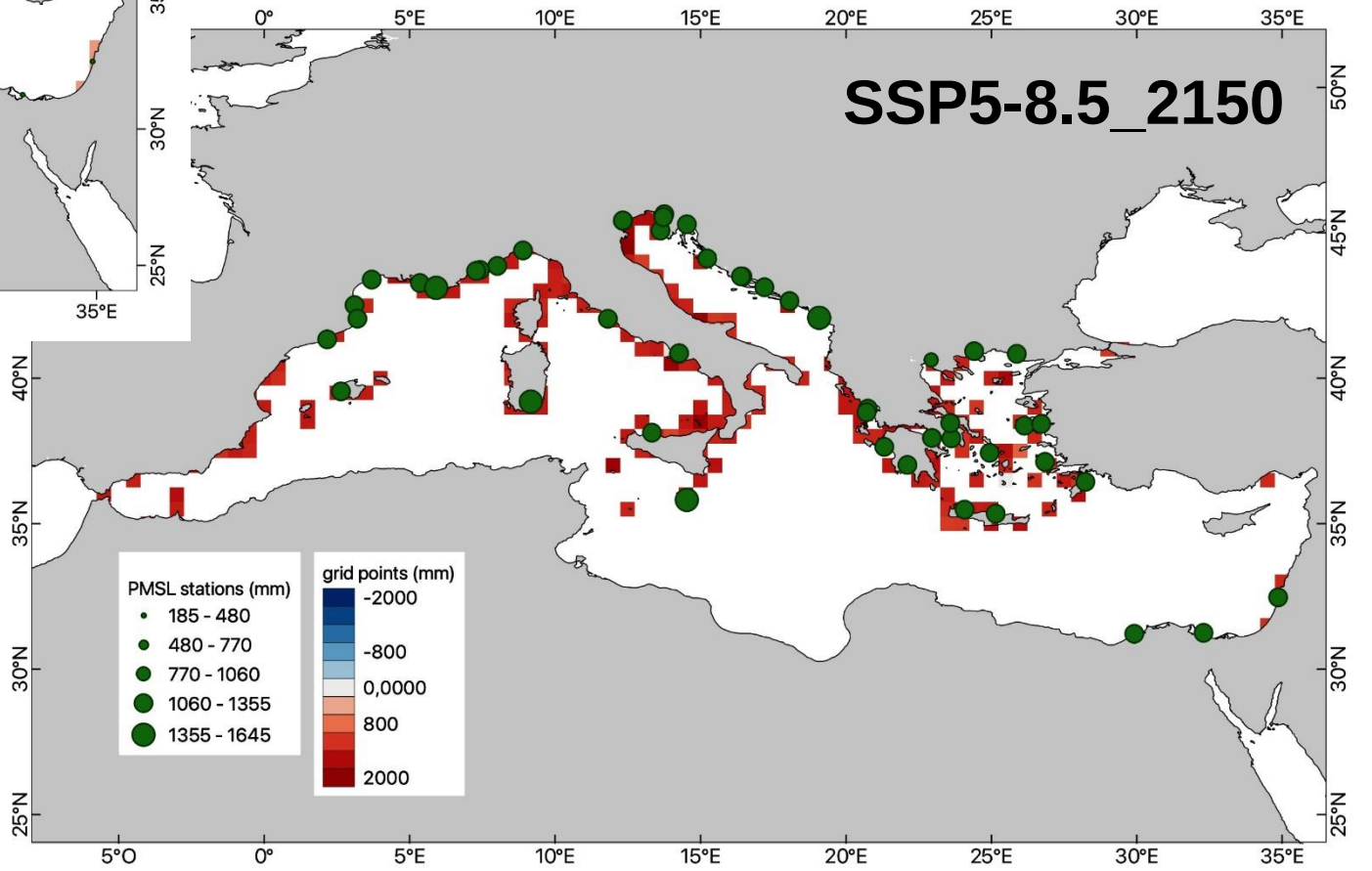
RSLC is evaluated also at each tide gauge of the PSMSL network by considering the VLM rate from the nearest GNSS stations.

After rescaling the IPCC data to a 0.5˚ x 0.5° grid, the VLM contribution in each cell is obtained as the median of the VLM rates from the GNSS stations falling into the cell.

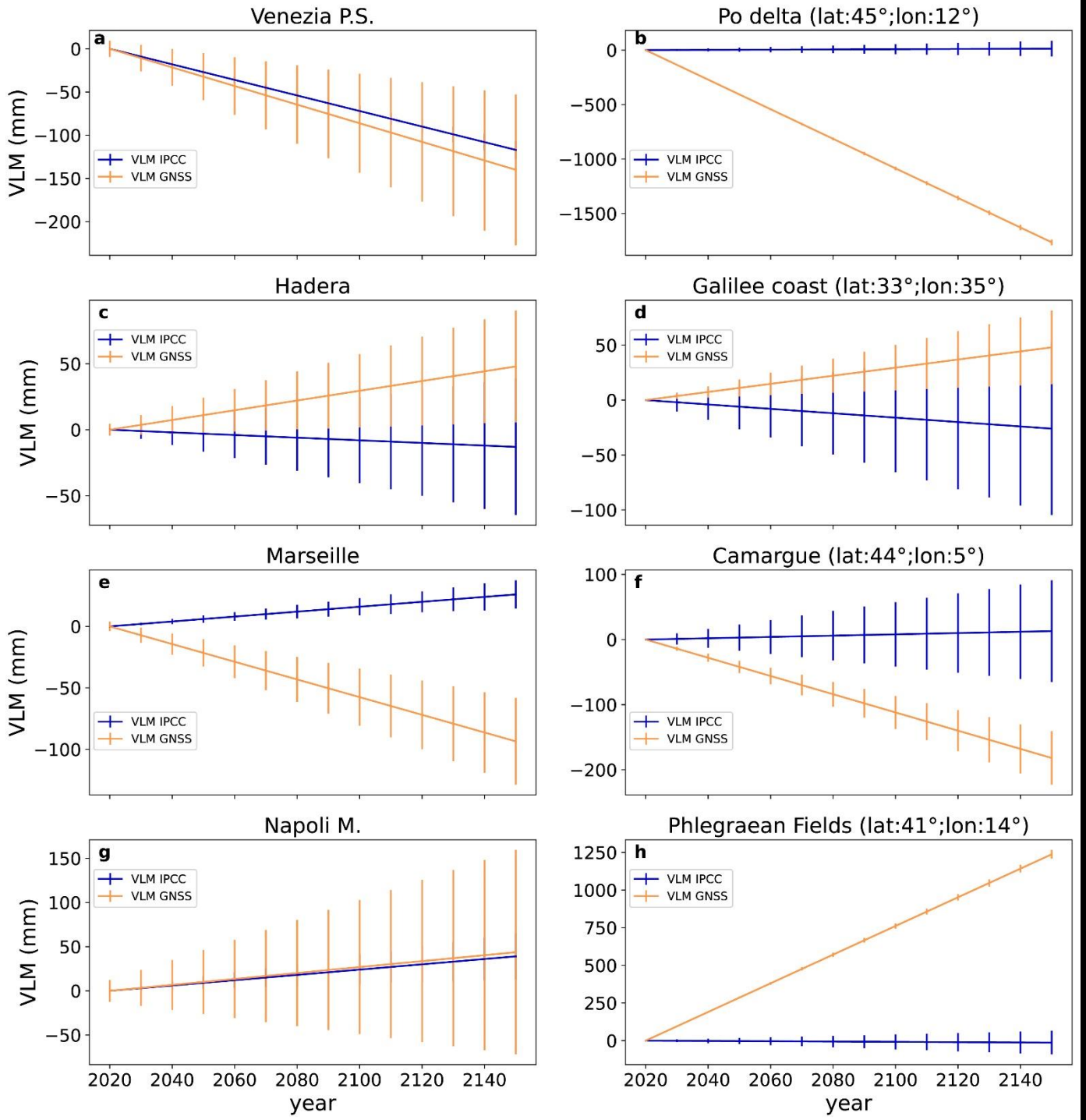
If the cell does not encompass any GNSS station, the corresponding sea level projection is not estimated.



RSLR projections at 2150 relative to 2020, for SSP1-1.9 and SSP5-8.5 scenarios at the PSMSL tide gauges (green dots) and on a geographical grid of 0.5° × 0.5° in the Mediterranean Sea (color scale).



- ✓ Maps are obtained by combining the IPCC AR6 projections at regional scales with the VLM derived from GNSS data.
- ✓ Only grid points that include GNSS stations are represented (no data in N-Africa).
- ✓ The VLM in each cell is obtained by calculating the median of all the GNSS measurements contained in the given cell.



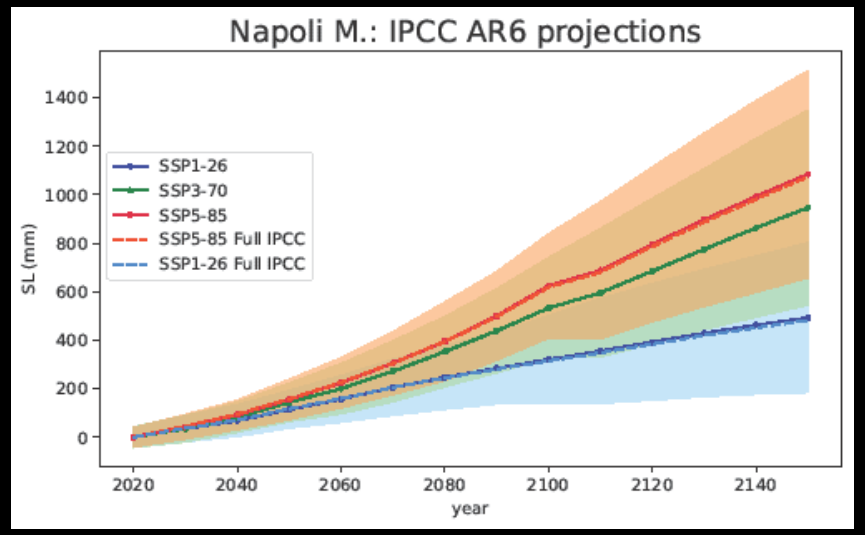
Comparison between the VLM contributions to SLR from the IPCC (blue line) and GNSS (orange line) data at the four PSMSL stations (left column) and grid points (right column).

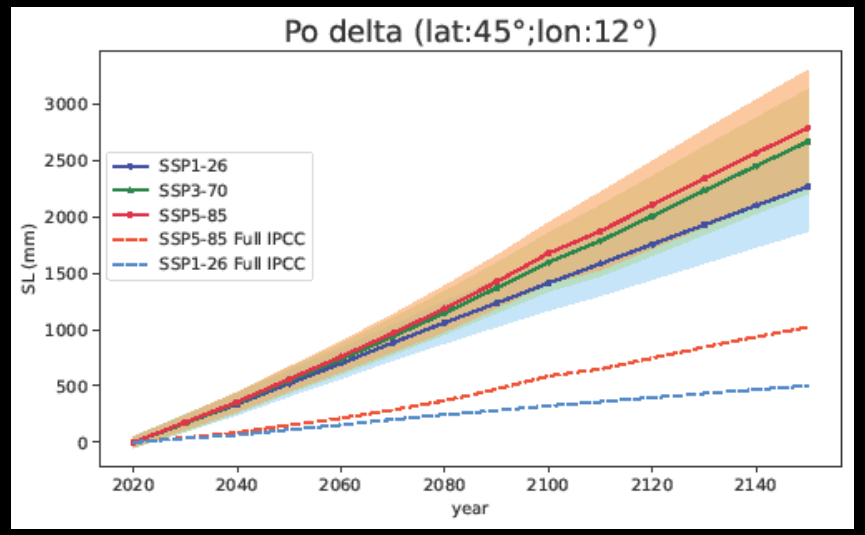
Error bars represent the uncertainty of the measurements of GNSS data.

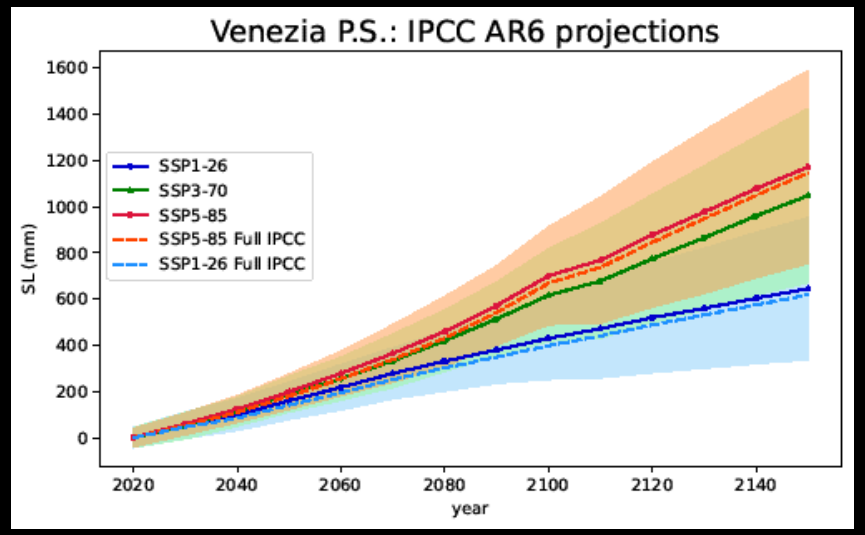
The distribution spread from the 32nd and 68th percentiles for the IPCC VLM contribution.

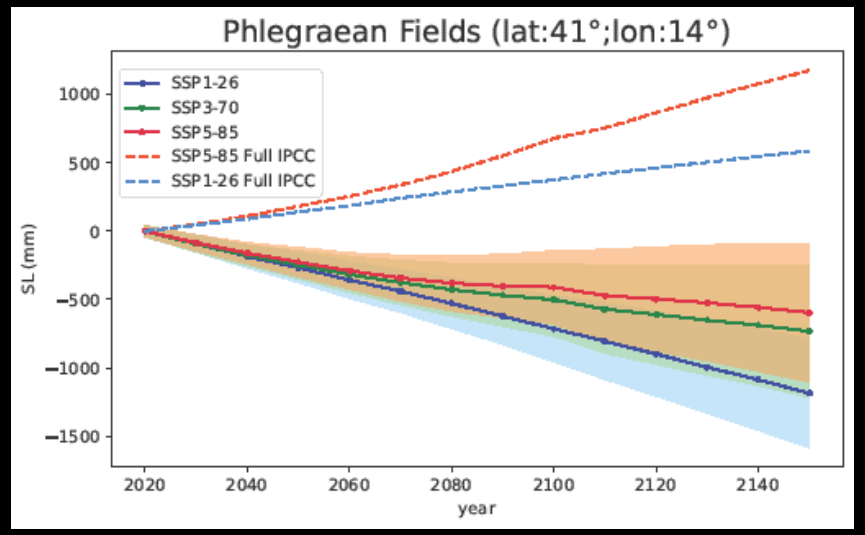
Assumption: VLM is linear up to 2150

Revised sea level projections up to 2150







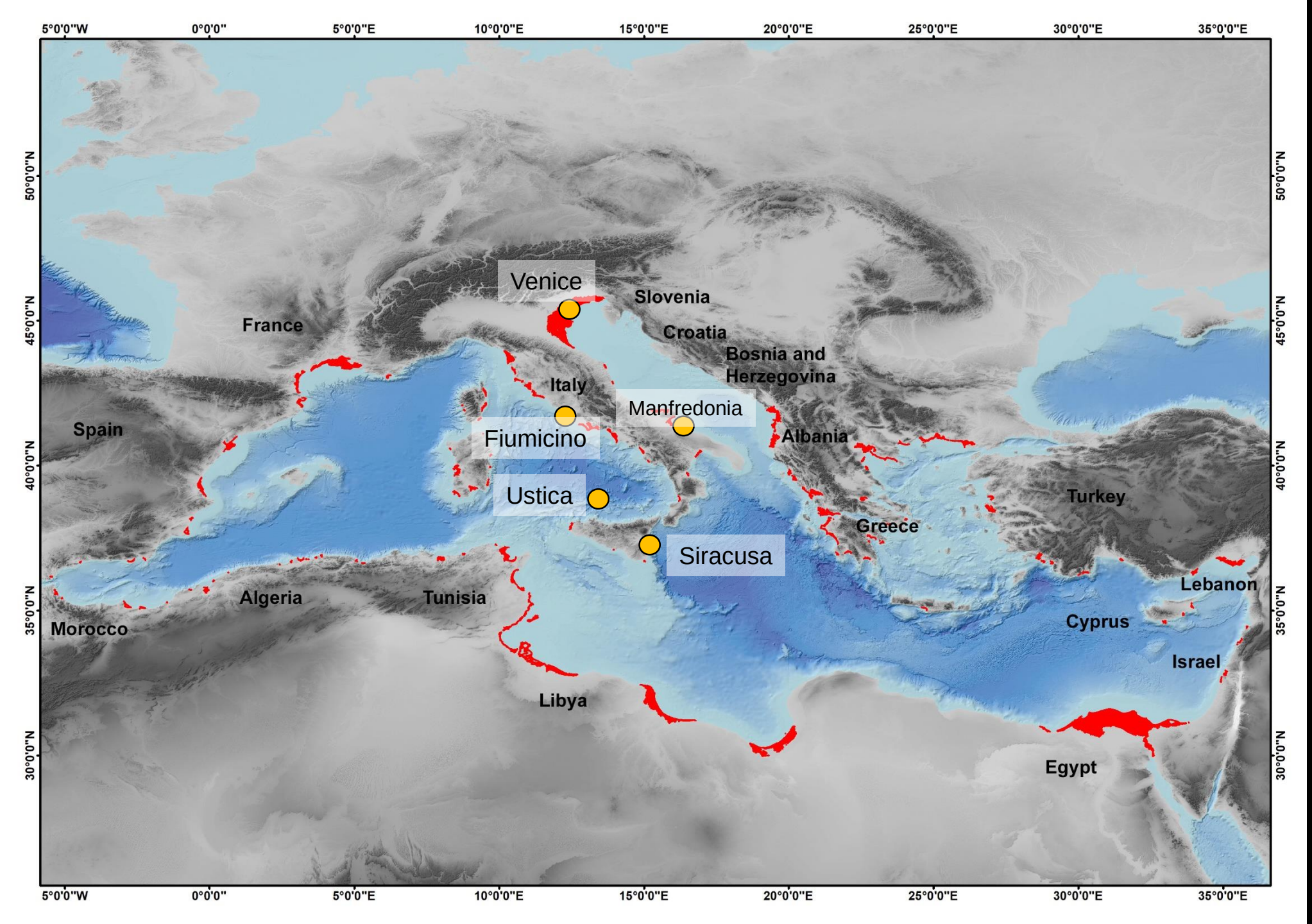


RSLR projections relative to 2020 at PSMSL tide gauge stations and at the cells of the grid encompassing the PSMSL stations.

Each panel shows:

i) the revised RSLR projections in three SSP scenarios (full lines) and corresponding uncertainties (shadowed areas);

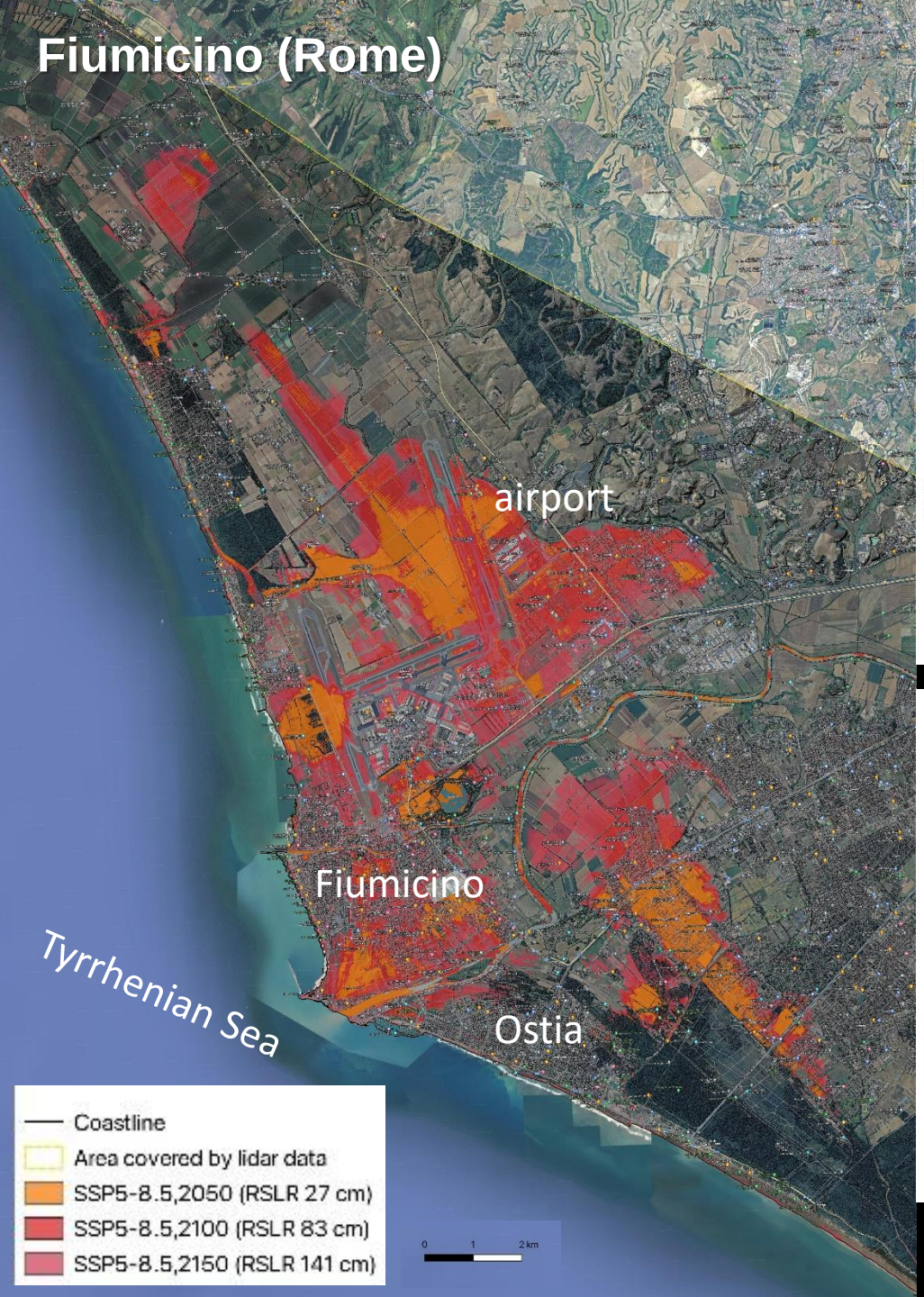
ii) the original IPCC projections for the most optimistic and pessimistic scenario.

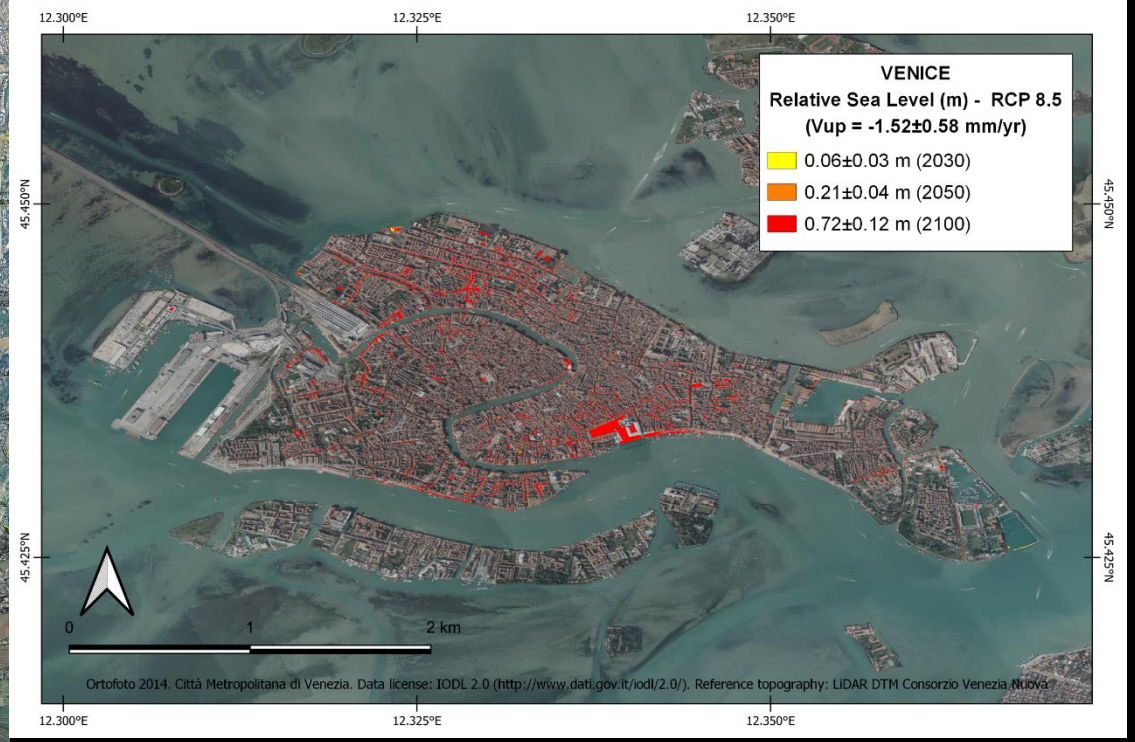


163 main coastal plains in the Mediterranean basin (in red).

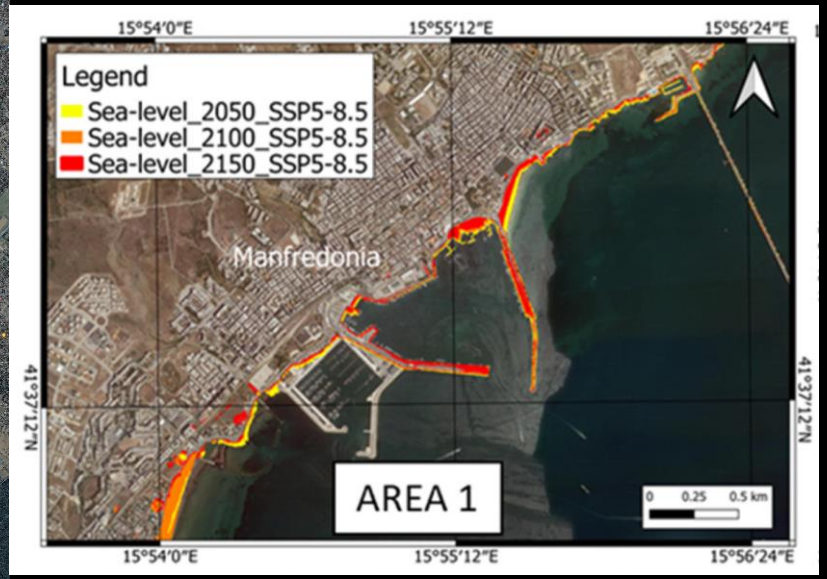
Area exposed to SLR: 38 529 km^2

Italy: 39 zones, 10.060 km^2

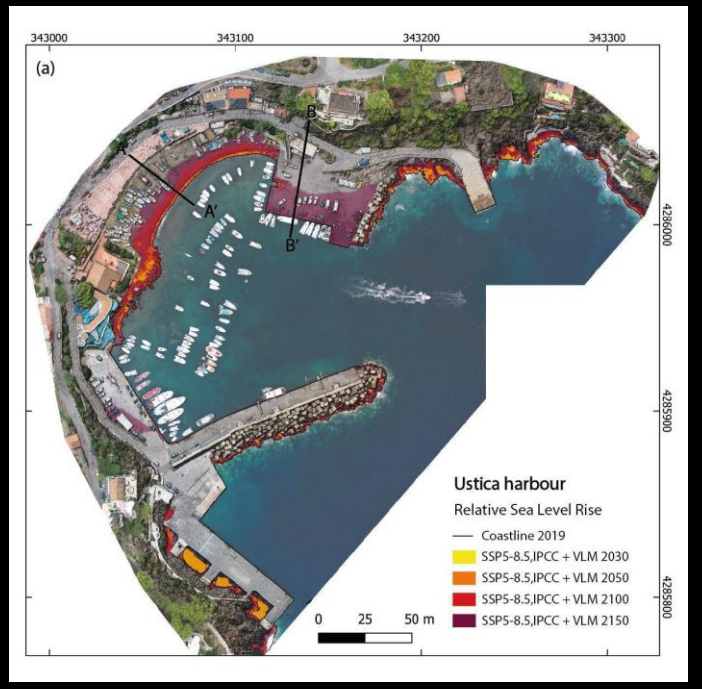




Venice



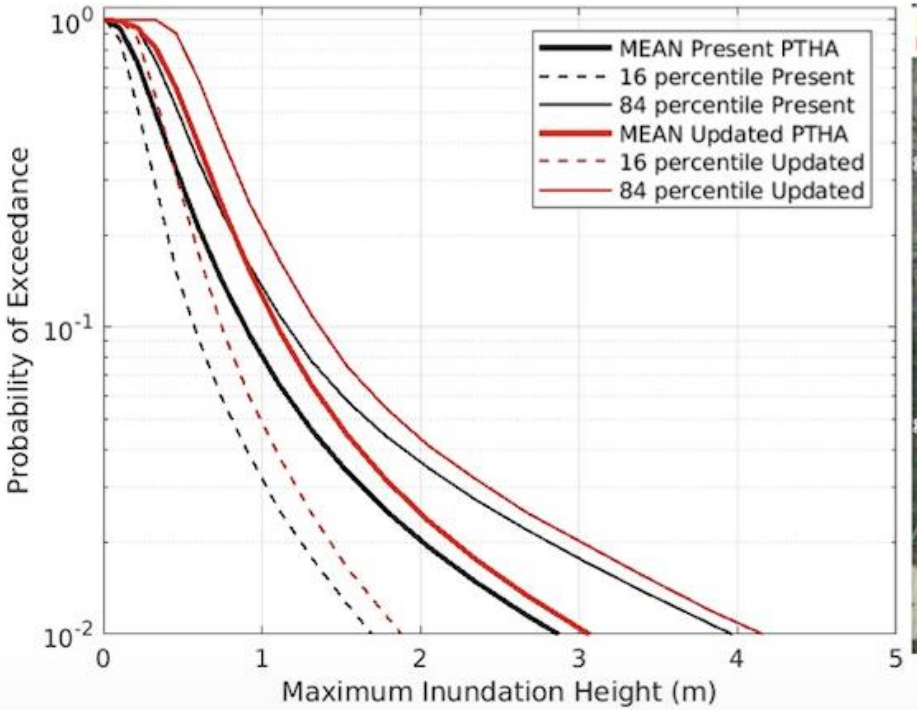
Manfredonia harbor



Ustica Island

Including RSLR and VLM in Probabilistic Tsunami Hazard Assessment (PTHA)

Siracusa



The updated PTHA needs to be <u>recomputed locally</u> to include the effects of future RSLR:

- Probability of Exceedance the Maximum Inundation Height in 50 years generally increases;
- in Hazard Curves the Epistemic Uncertainty is higher;
- in Hazard Maps (complex products) inundation area are wider.

44% more extreme coastal events than in 2023 along the Italian coasts

26 damaging storm surges

Social costs

10 Billion euros in damages

166 euro per capita

Fregene (near Rome): storm surge November 22, 2022

- ✓ The uplifting harbor of Pozzuoli, Campi Flegrei (Italy)
- ✓ 118.5 cm since January 2011
- ✓ Now 10±3 mm/yr

Thank you!