Sanity checks of the final earthquake scenario linear combinations

1. Introduction

In a previous report from 5.2017 we presented an integrity check of BS/PS scenarios from the preliminary results of the test run based on ASTARTE zonation and the 140 priority POI. In this document we present similar results, but for TSUMAPS zonation (110 zones) and the complete set of seismicity types in all basins for the full set of POI (BLK: 137, MED: 1107, NEA: 1092, tot: 2336).

2. Table of contents

3. Seismicity type description

In TSUMAPS, there are several types of seismicity models.

Type	Name	Affected basins	Regions	Comment
1	BS	MED, BLK, NEA	1..36, 40, 42..60, 81, 91, 93..99, 106, 107, 110	Background Seismicity, ES modeling, ca. 38e6 scen. of which ca. 19e6 active (affect water)
2	PS	MED	3, 10, 16, 24, 27, 33, 35, 36, 44, 48, 49, 54	Predominant Seismicity, ES modeling with given initial uplift (heterog. slip), 3 MED subductions (Hellenic, Cyprian, Calabrian), ca. 102e3 scen.
3	CAR	NEA	83	Caribbean subduction, subfault modeling, ca. 2e3 scen.
4	SBS	MED, NEA	60	Special Backgr. Seis., ES modeling, for large events offshore Cadiz not in BS, ca. 6000 scen.
5	MARGLO	NEA	62, 64..69, 71:80, 84..86, 100, 101, 104..106, 110	Mid Atlantic Ridge and Gloria fault, subfault modeling, ca. 800 scen.
6	SPS	NEA	106, 110	Special Predominant Seismicity, ES modeling, for small events Azores near field not in MARGLO, ca. 300

By far most scenarios are related to type 1. However, the largest scenarios are from type 2. Type 3 and 5 are not modeled using Gaussian elementary sources but subfault-sources and contain fewer scenarios since they are sufficient for far field impact at the NEA coast. Type 4 are rather large scenarios of ‘predominant’ type, but since there is no geometry defined, they are technically modeled as BS. Type 6 contains very few scenarios which are too small to be modeled by subfaults of fixed size and might have minor local impact (Azores).

4. Overview on ‘Deterministic production chain’

We very shortly describe the procedure of computing the indundation metrics from earthquake scenario. The so called ‘deterministic production chain’ was implemented in C++ by A. Babeyko and runs on *auriga*, where also source codes are located: @auriga:/home/babeyko/dev/ProdChain. More detailed description will be provided with source codes.

4.1. Initial Condition

This depends on seismicity type. For BS, SBS, SPS, the sources are described in an Okada-fault manner, so first sea floor uplift and then weights for the elementary sources (ES) have to be computed. For PS, the uplift is provided based on a more complex slip model and ES weights are computed. For CAR and MARGLO, the ES are not used, but more traditional subfault-ES (SES) are applied whose weights are defined in tables. All scenarios are defined on: @auriga:/scratch/projects/cat/SPTHA/TSUMAPS/results/step1.

4.2. Mareograms

Based on initial condition of an earthquake scenario, the linear combination of the ES (or SES) is performed. Only mareograms above threshold of 3cm are stored (in POI-oriented manner) in binary format on @auriga:/scratch/projects/cat/SPTHA/TSUMAPS/results/step2/mrg_t*.

4.3. Inundation metrics

In the last step, the mareograms are analyzed and results for different inundation metrics: offshore value (OS), maximum inundation height (MIH) based on amplification factor approach (AF) and Green's law (GL)(actually more related to run-up) are stored in asci format on @auriga:/…/results/step3/mih/t*. The size of these files is about: t1: 56 GB, t2: 1.7 GB, t3: 71 MB, t4: 317 MB, t5: 20 MB, t6: 1.3 MB.

4.4. Automatic Sanity / Plausibility checks

During linear combination process, log and stat files are generated and stored at ../step2/mrg.bas_t*. Then, automatic sanity/plausibility check is performed and outcome stored in files 'all.check' @auriga:…/step2/mrg_t*. More detailed description will be provided together with code documentation.

5. Note: NEA-POI W of Gibraltar

For the preliminary results shown in Tunis in September 2017, a couple of POI west of Gibraltar were erroneously related to the Mediterranean ES set. Those POI were identified, replaced by NEA POI, and deterministic computations re-done. Following NEA-POI were added: 00276, 00284, 00292, 00300, 00307, 00316, 00323, 00330, 00337, 05194, 05210, 05221, 05229, 05236, 05242, 05249, 05257, ,05265, 05273, 05282, 05289, 05297.

6. Maximum wave height offshore

Colored areas show maximum wave height offshore (OS) induced by all the earthquake scenarios of the respective seismic zone at any one of POI. Colored dots show maximum wave height at the respective POI caused by any scenario.

6.1. BS BLK / MED / NEA

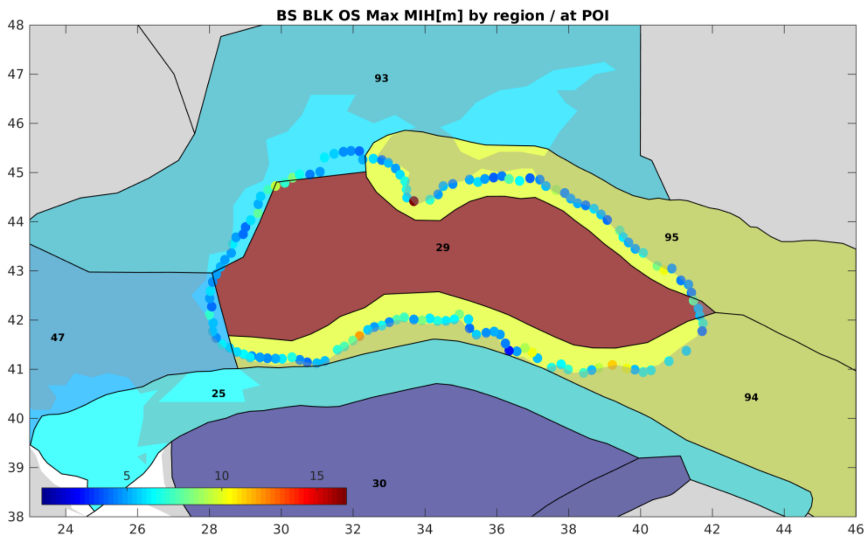

Figure 1. Maximum offshore wave height from region / at POI in Black Sea by BS.

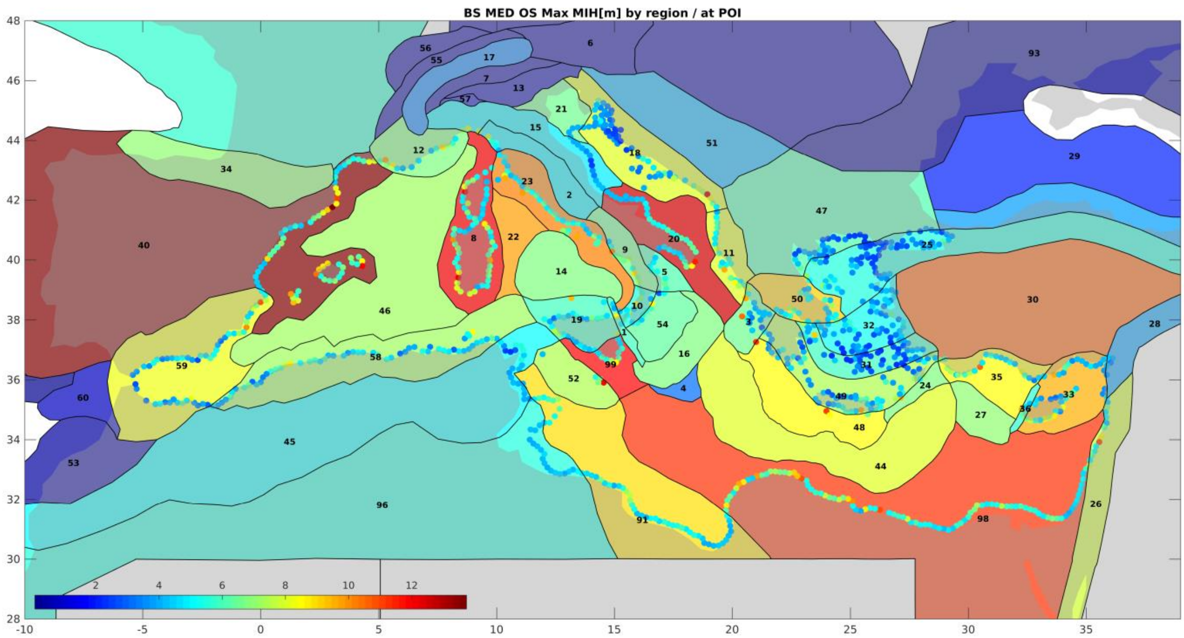

Figure 2. Maximum offshore wave height from region / at POI in Mediterranean by BS.

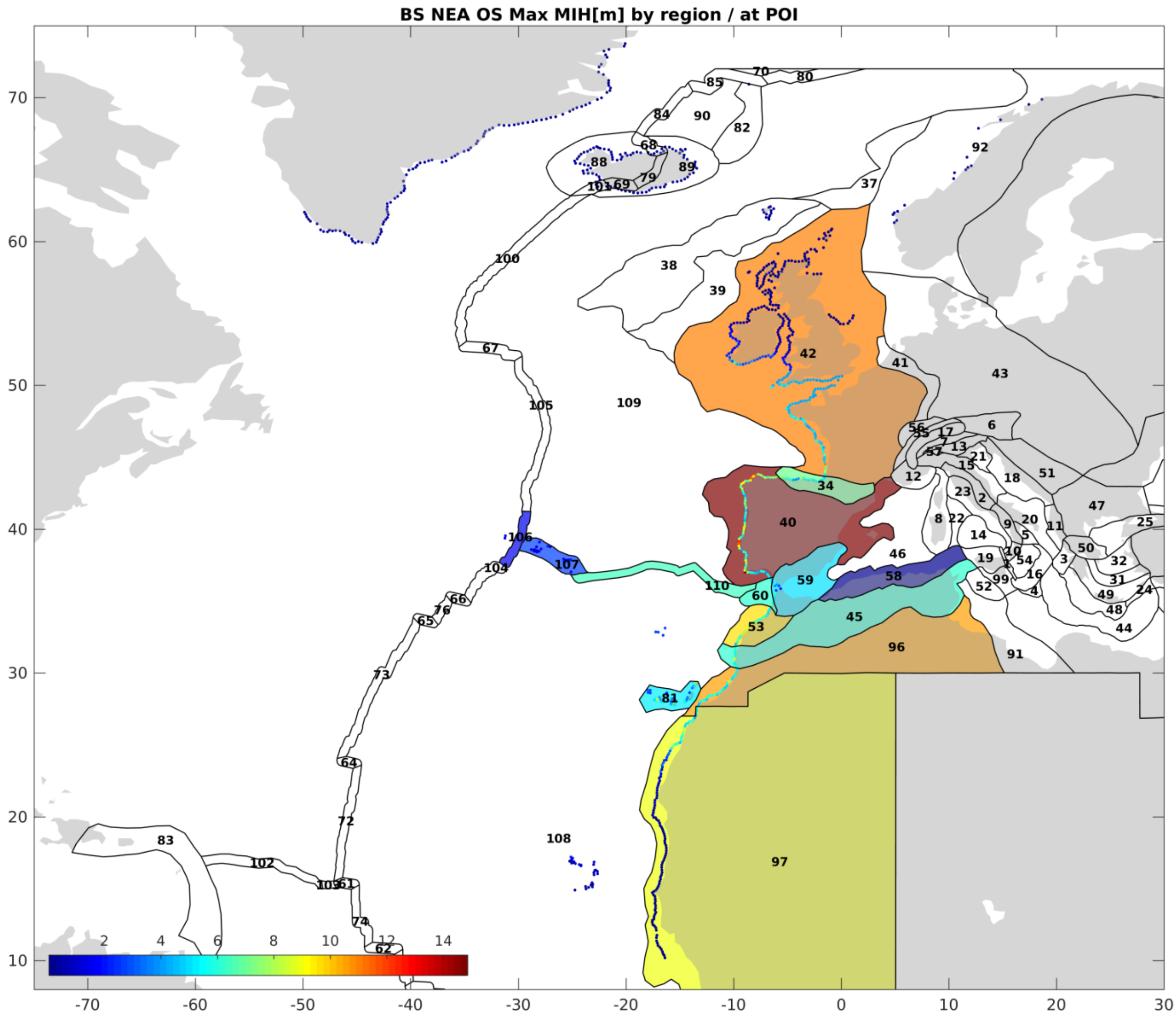

Figure 3. Maximum offshore wave height from region / at POI in North East Atlantic by BS.

6.2. PS MED

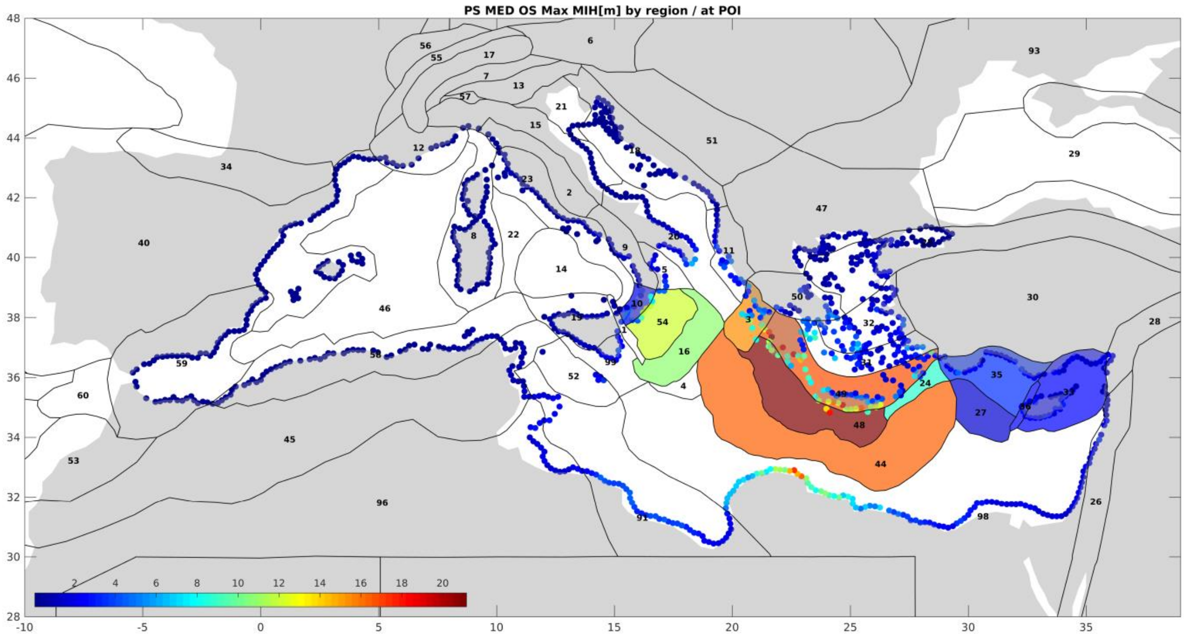

Figure 4. Maximum offshore wave height from region / at POI in Mediterranean by PS.

6.3. CAR NEA

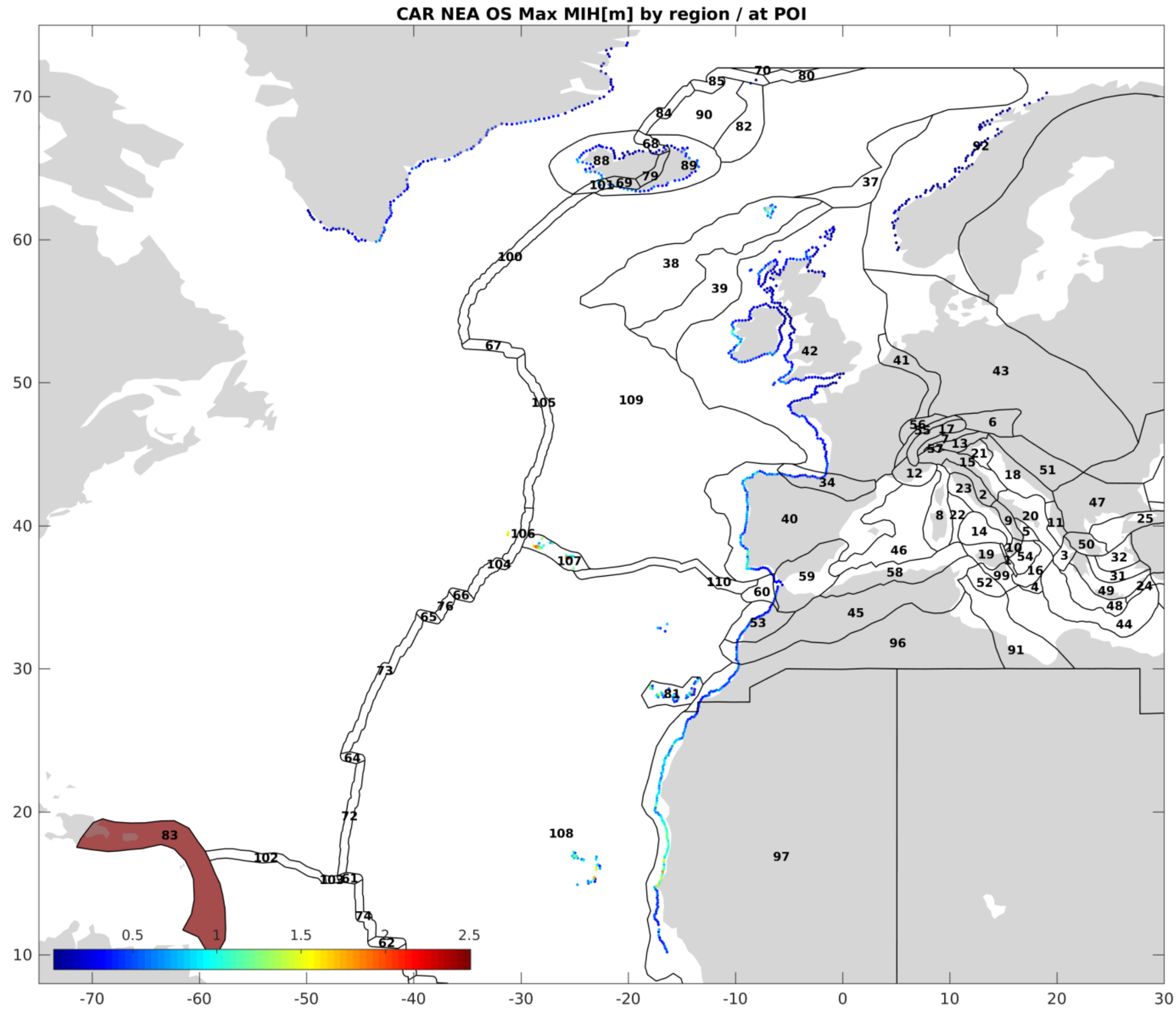

Figure 5. Maximum offshore wave height from region / at POI in NEA by CAR.

6.4. SBS MED / NEA

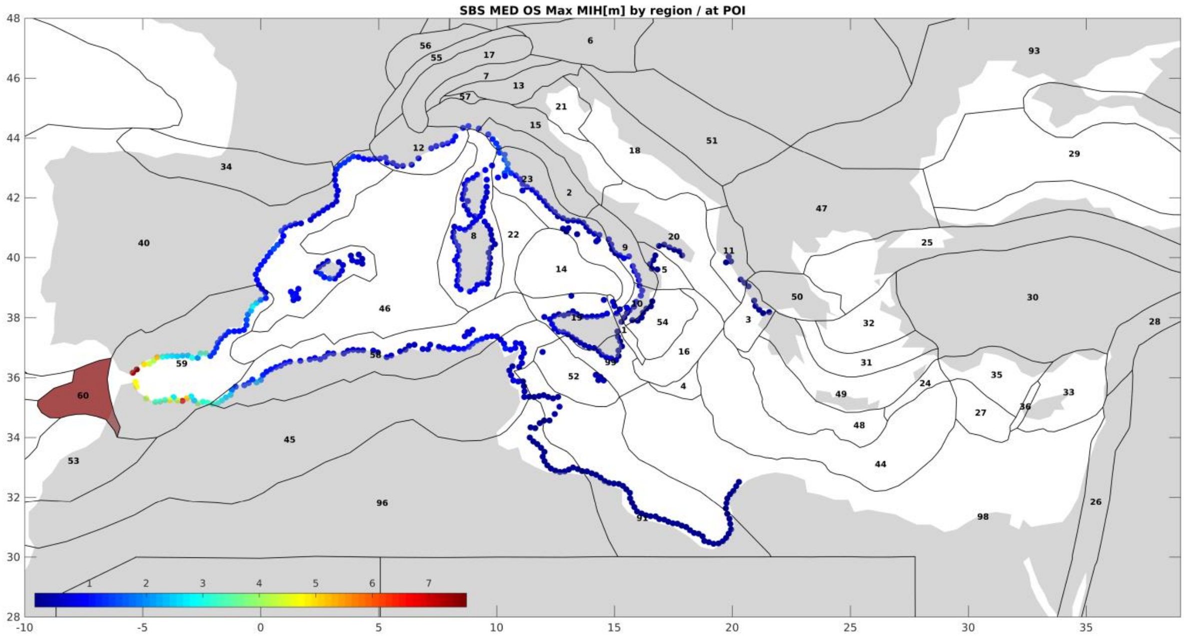

Figure 6. Maximum offshore wave height from region / at POI in Mediterranean by SBS.

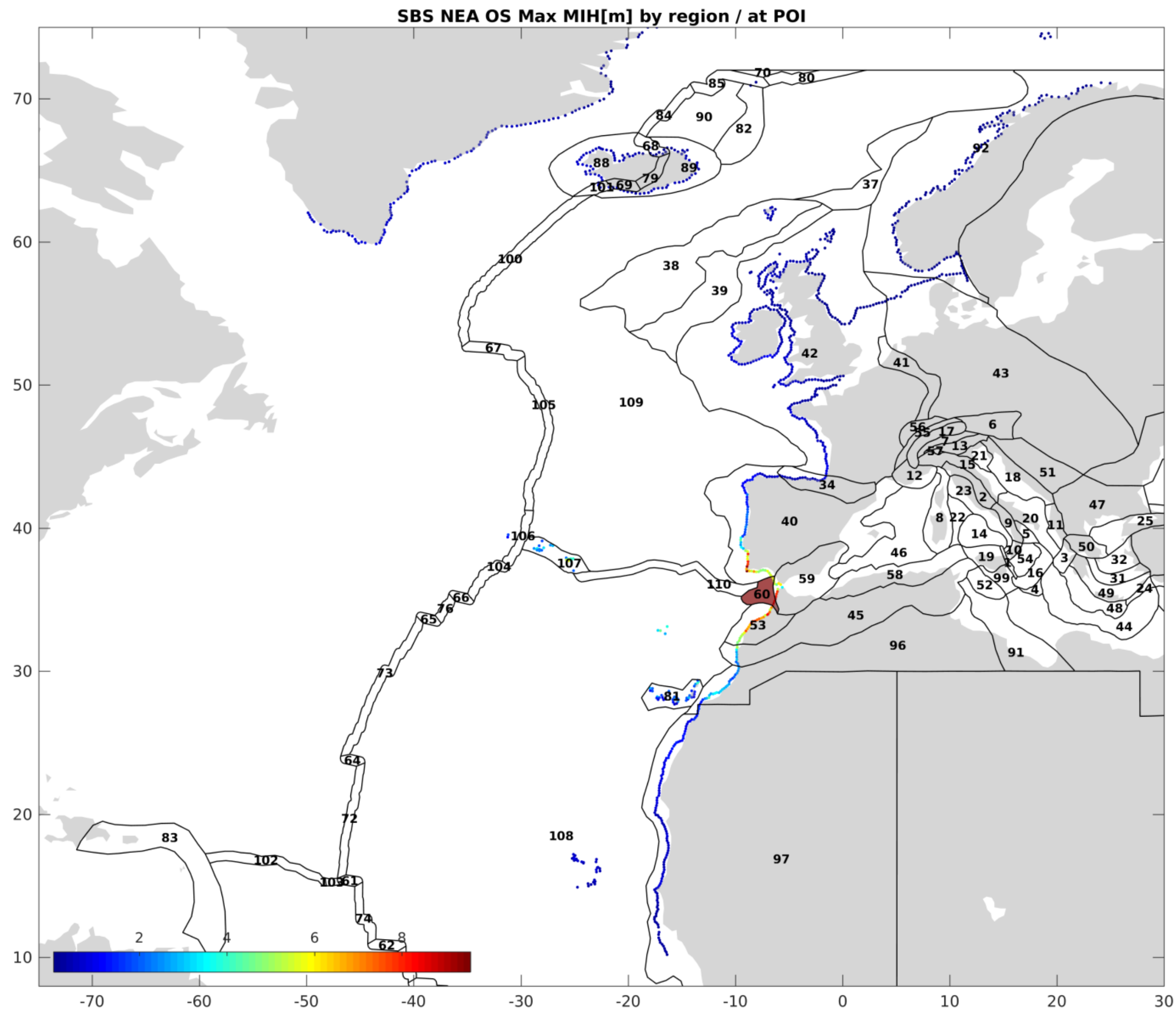

Figure 7. Maximum offshore wave height from region / at POI in NEA by SBS..

6.5. MARGLO NEA

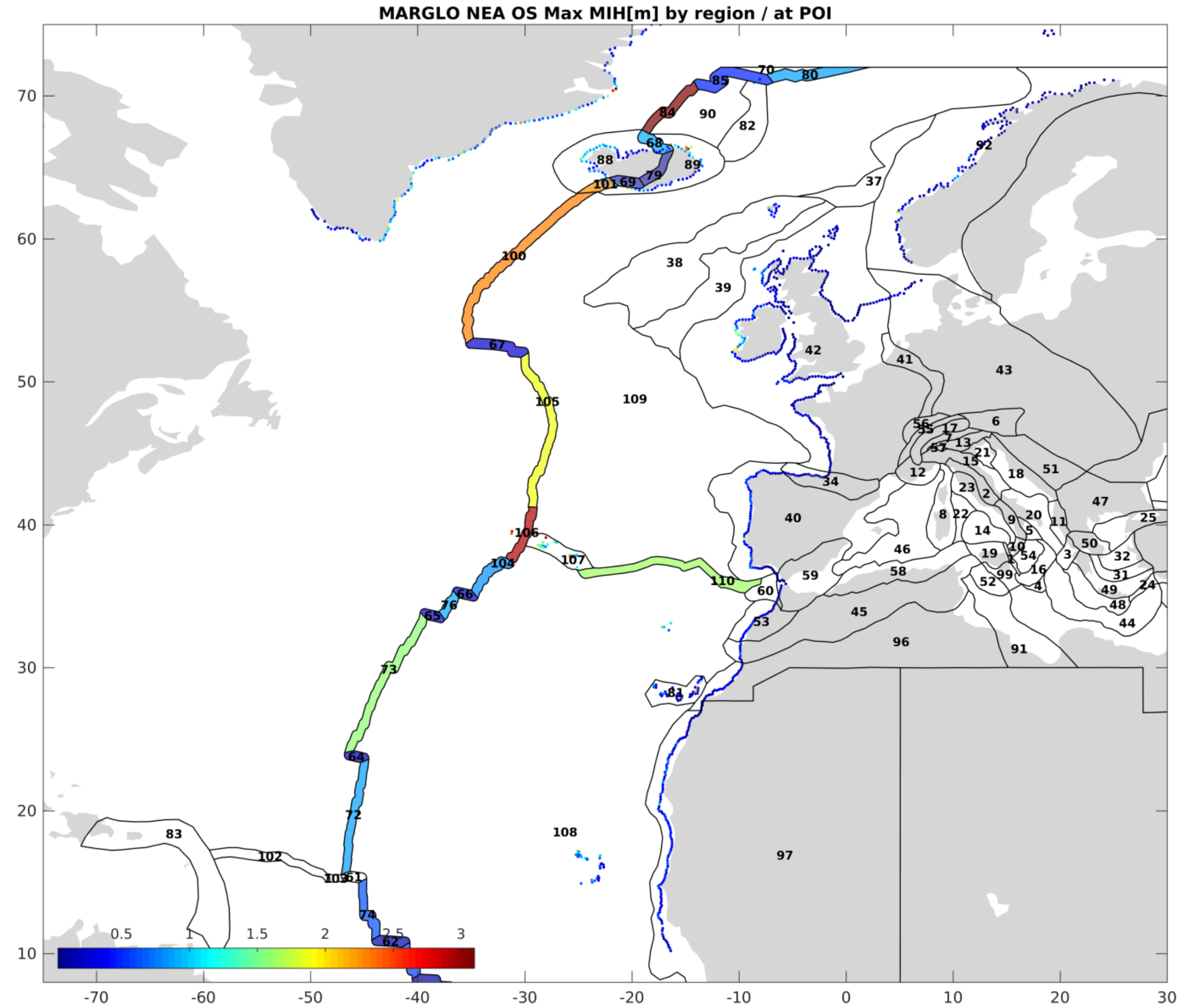

Figure 8. Maximum offshore wave height from region / at POI in NEA by MARGLO.

6.6. SPS NEA

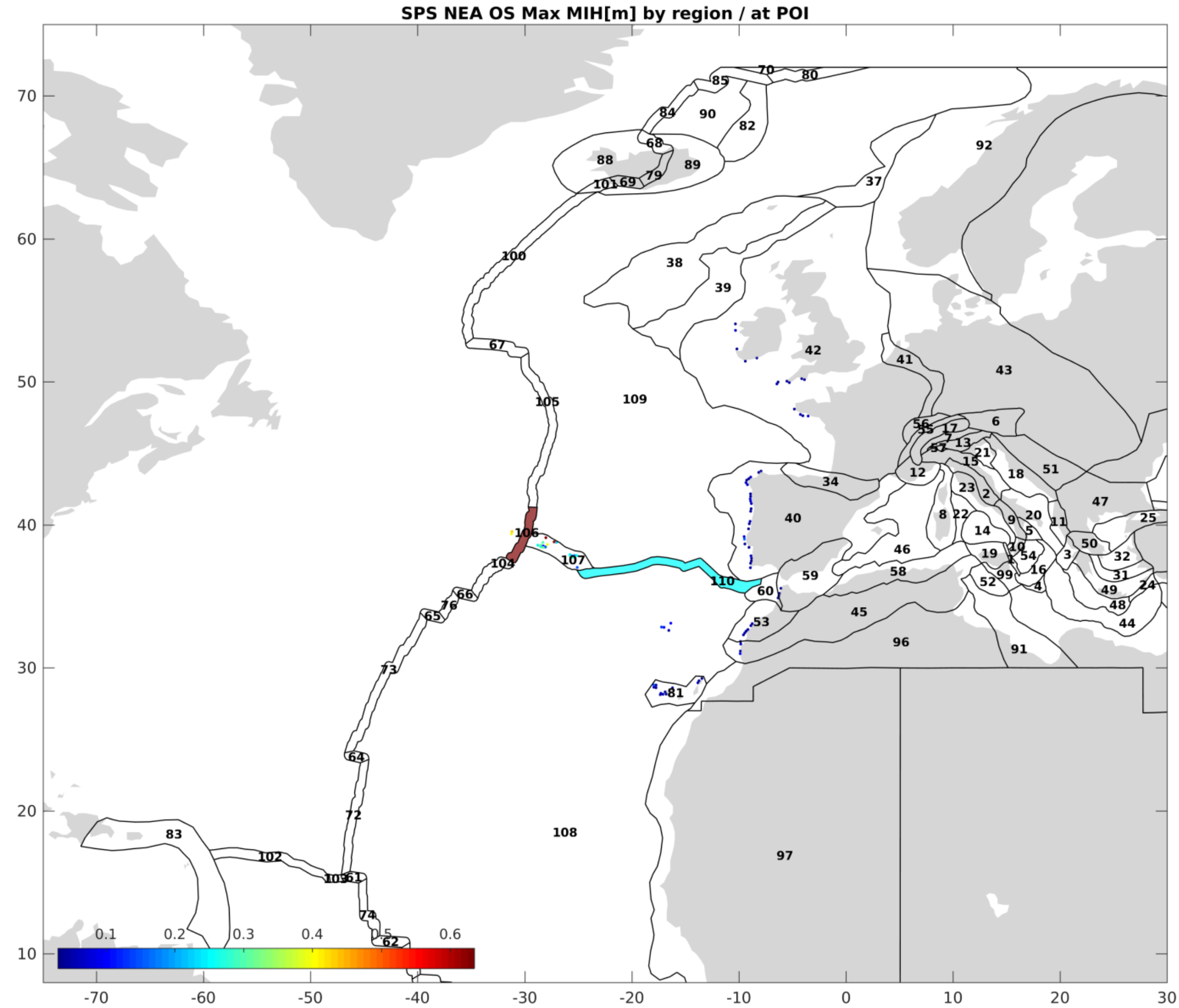

Figure 9. Maximum offshore wave height from region / at POI in NEA by SPS.

7. Maximum values overall

Overall maxima caused by regions at POI and induced at POI by zones for offshore wave height, amplification factor method and Green's law.

7.1. Offshore (OS)

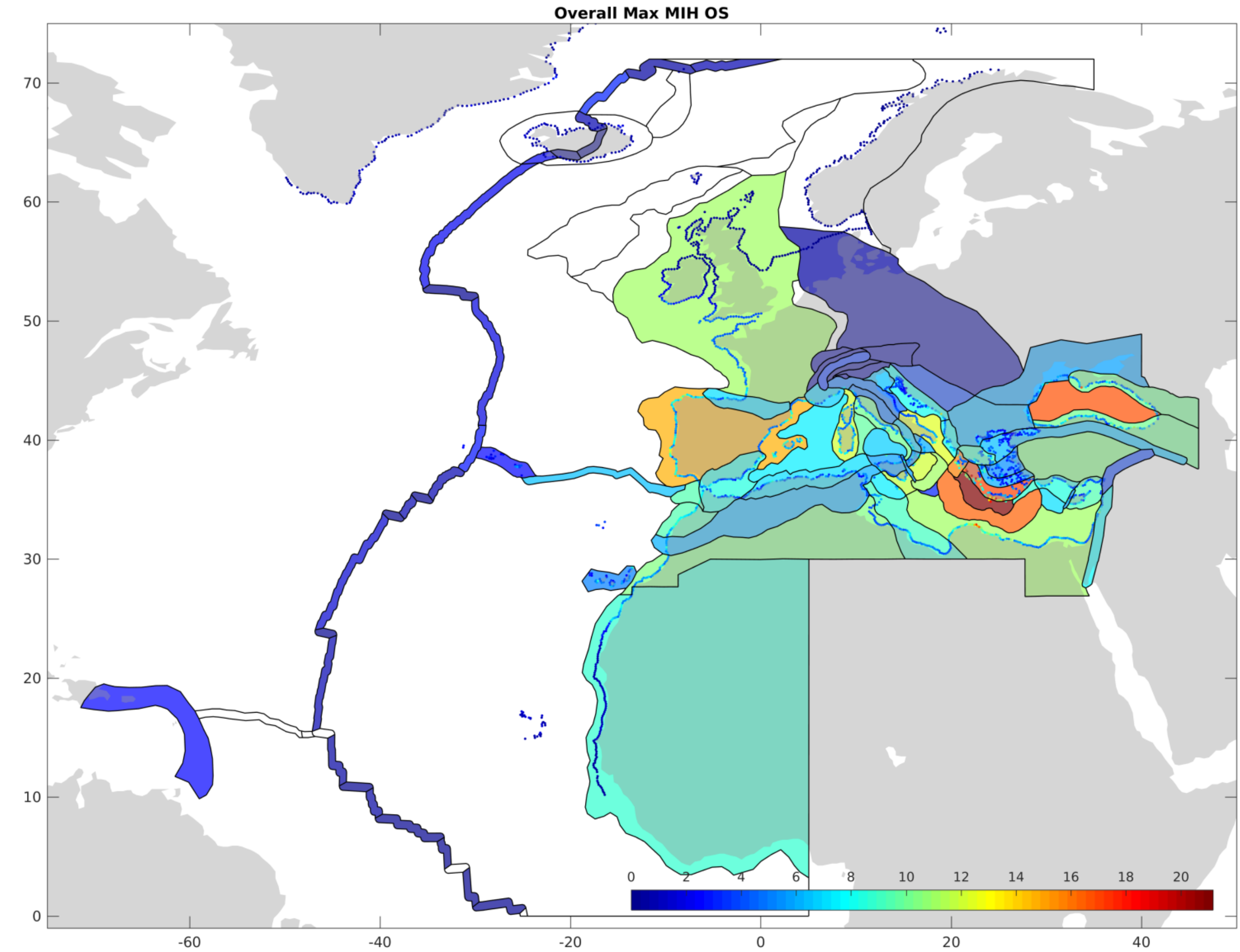

Figure 10. Maximum offshore wave height from region / at POI in all basins by all source types.

7.2. Amplification factors (AF)

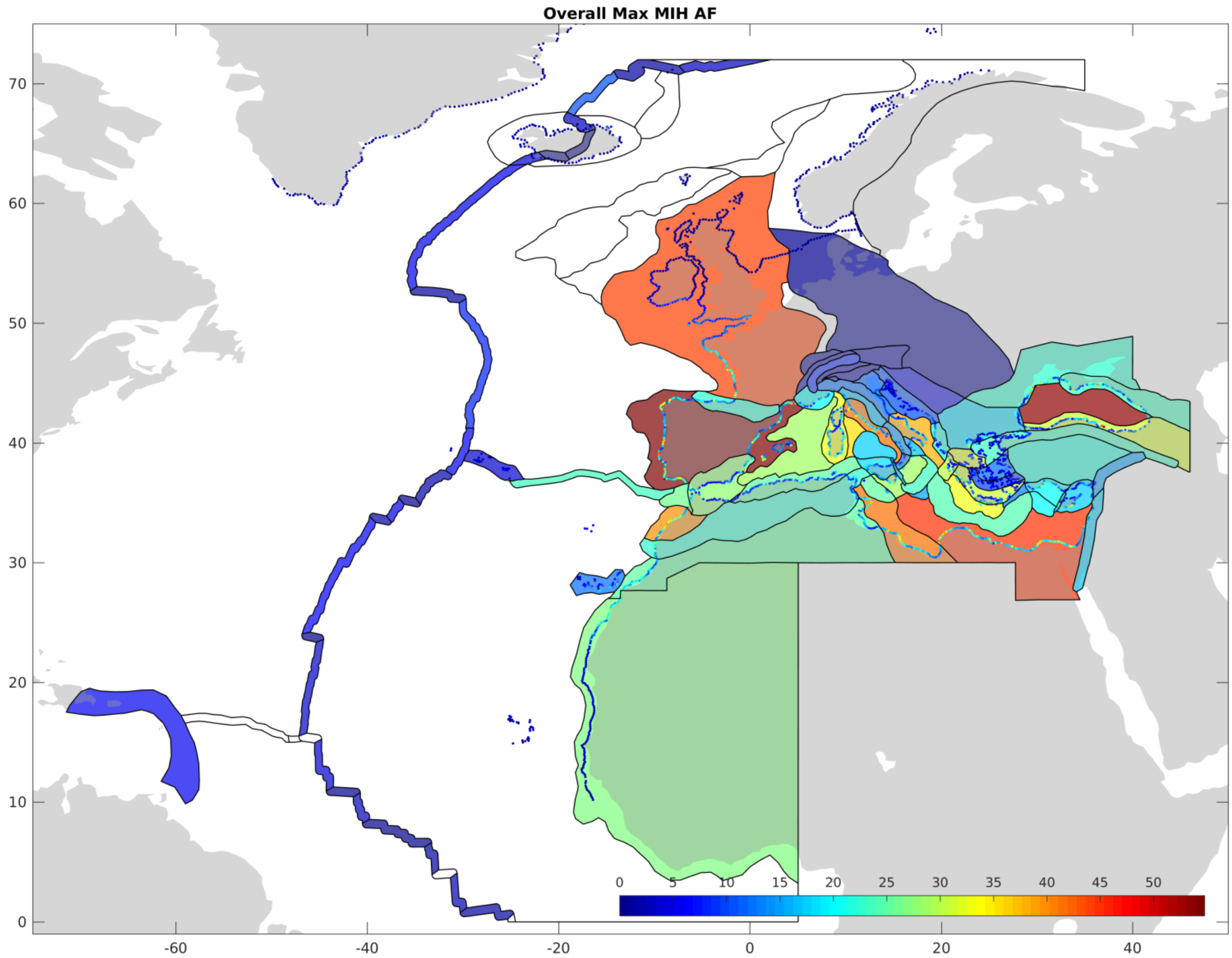

Figure 11. Maximum inundation height (MIH) by amplification factor method from region / at POI in all basins by all source types.

7.3. Green's law (GL)

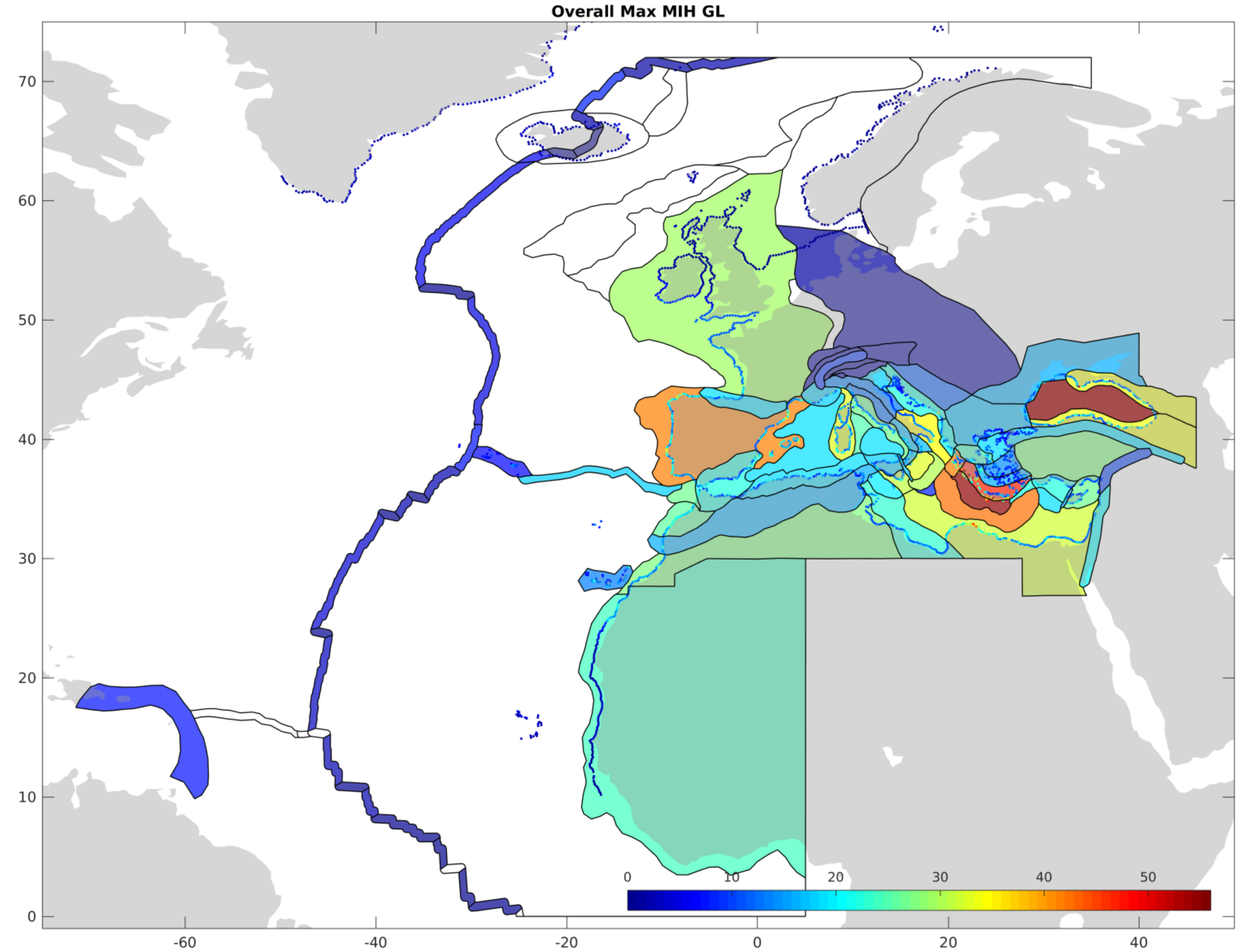

Figure 12. Maximum wave height by Green's law (≈run-up) from region / at POI in all basins by all source types.

7.4. AF, only POI, log10 scale

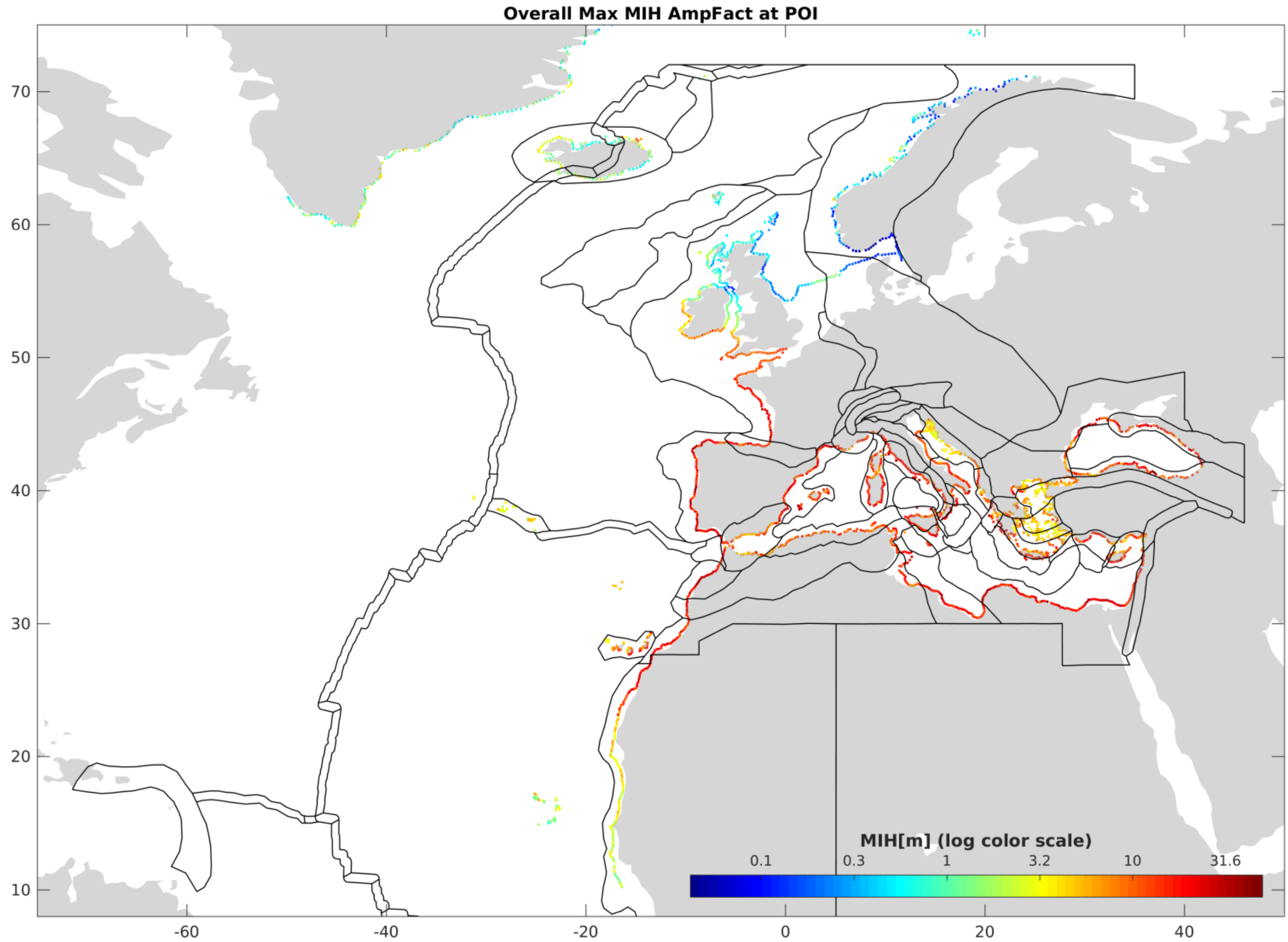

Figure 13. Maximum inundation height (MIH) by amplification factor method at POI in all basins by all source types with logarithmic color scale.

8. Cluster analysis

Starting from a matrix of size *m* x *n* with *m* number of zones and *n* number of POI containing maximum wave height of zone-POI combinations, cluster analyses are performed, once comparing rows, resulting in zone clustering, and once comparing columns, resulting in POI clustering. Matlab linkage and clustering functions are used with weighted average as cluster distance and correlation as similarity measure. Zones in the same cluster have a similar effect on POI, POI in same cluster are influenced by similar zones.

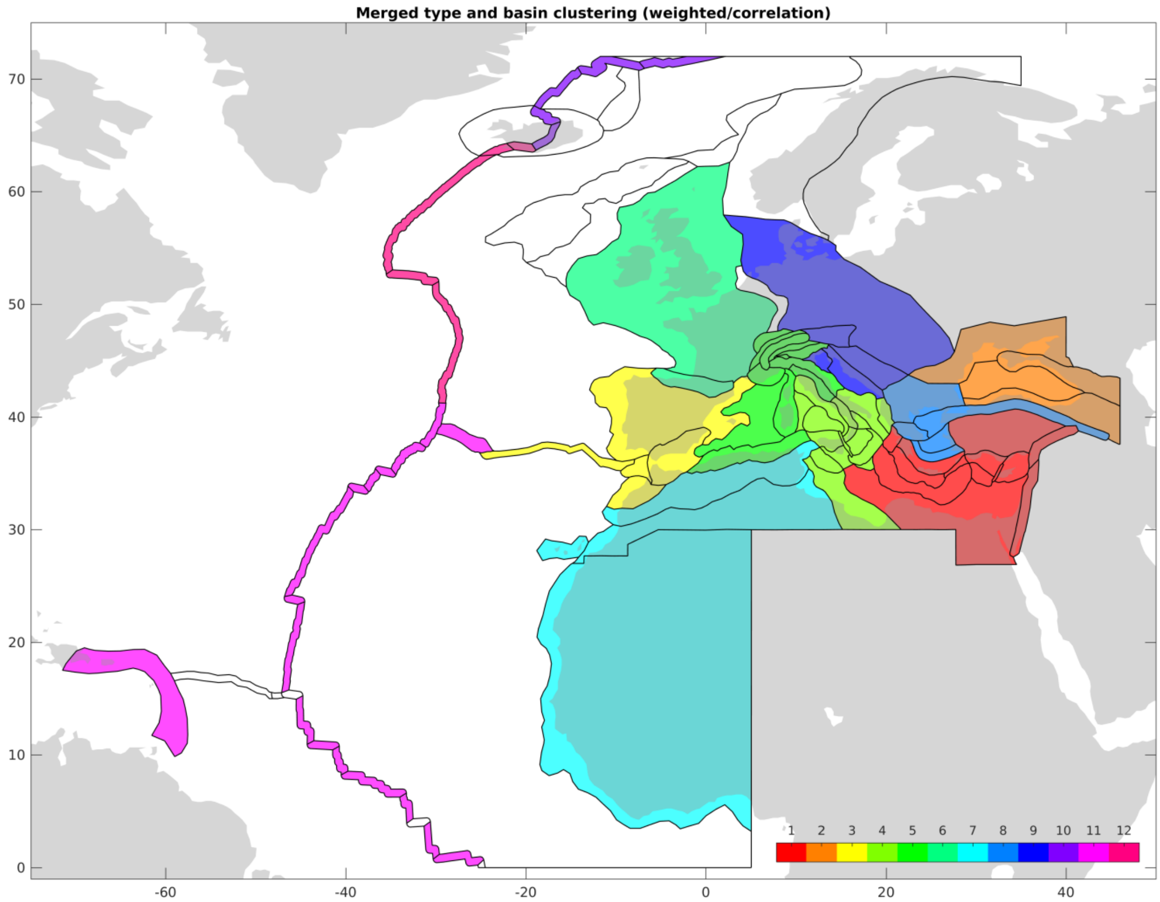

Figure 14. Clustering by region (similar impact on POI).

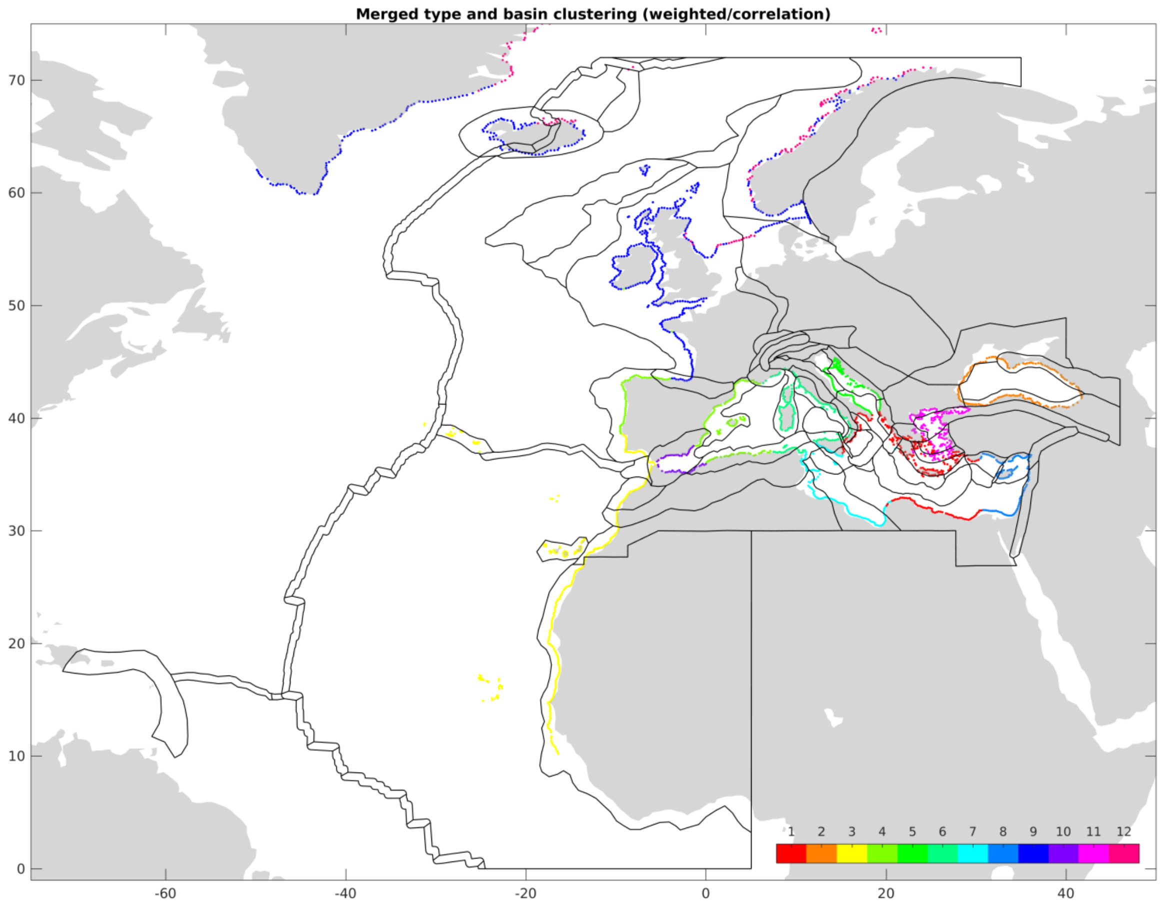

Figure 15. Clustering by POI (affected by similar regions).

9. Summary

Various tests and visualizations were done on the deterministic wave height results. Neither automatic sanity checks mentioned in section 4.4 nor manual inspection revealed inconsistencies.

Maximum values by amplification factor method and Green's law are similar, but spatial pattern is quite different. That is not per se a problem as first metric is related to maximum inundation height and second to run-up. It can be expected that difference will be smaller in hazard results due to weighting with scenario probabilities.