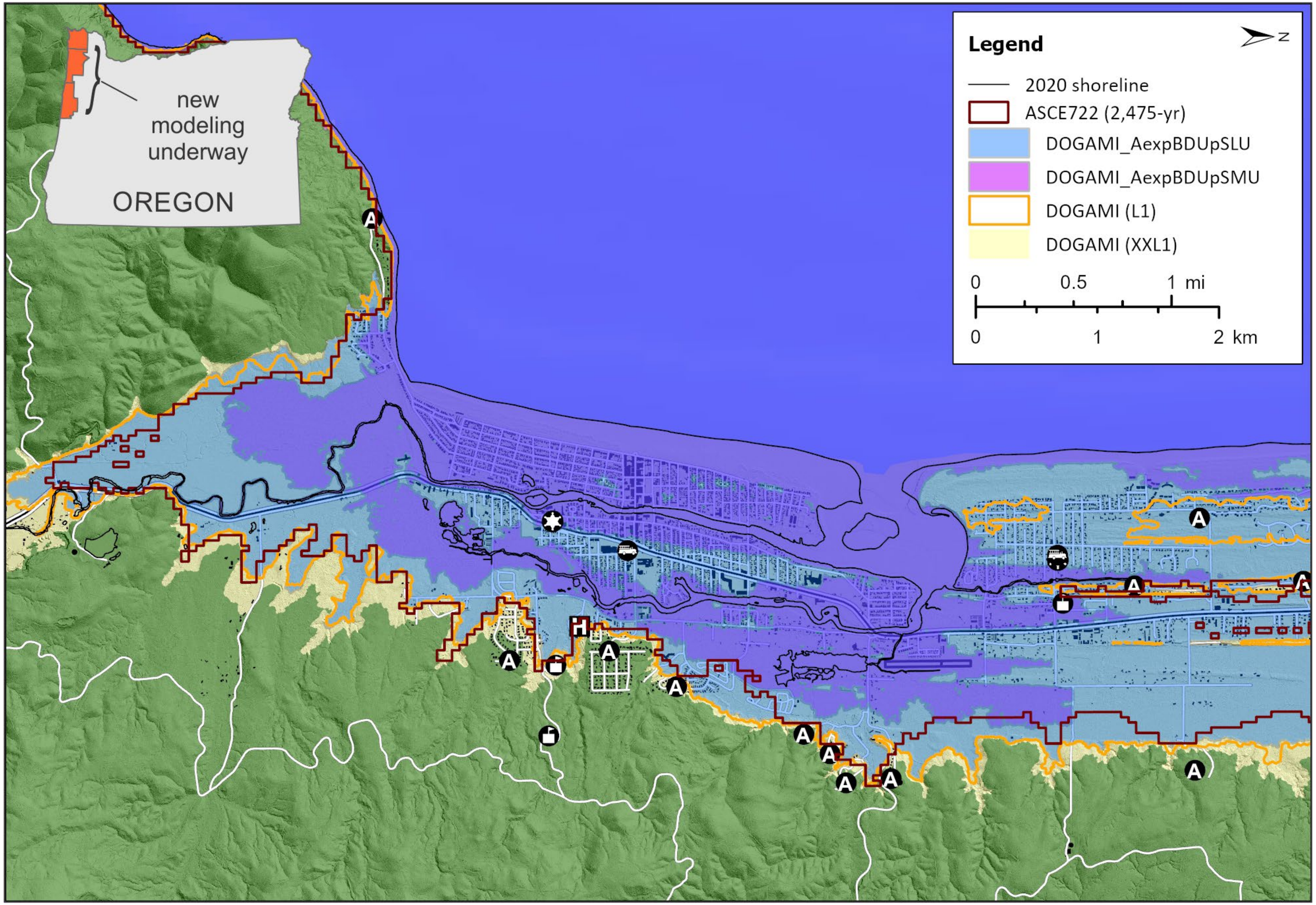
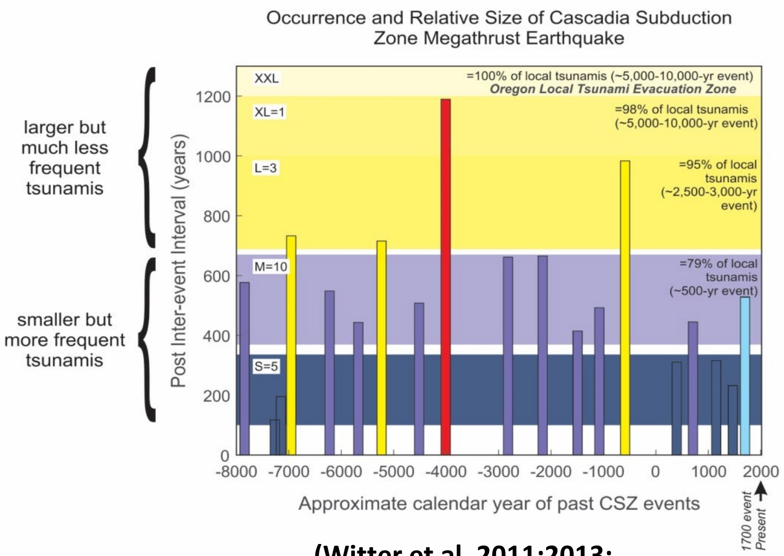


Developing Next Generation Tsunami Products for the Oregon Coast

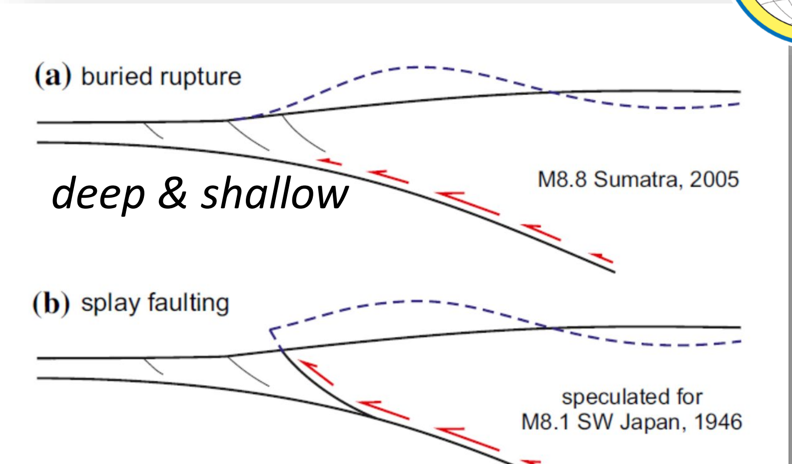
Jonathan Allan[1], Joseph Zhang[2], Hong Kie Theo[3], Fletcher O'Brien[1], George Priest[2]

[1]Oregon Department of Geology and Mineral Industries
[2]Virginia Institute of Marine Science, College of William & Mary
[3]AECOM Technical Services

Oregon Tsunami Mapping and Modeling (T-shirt sizes)

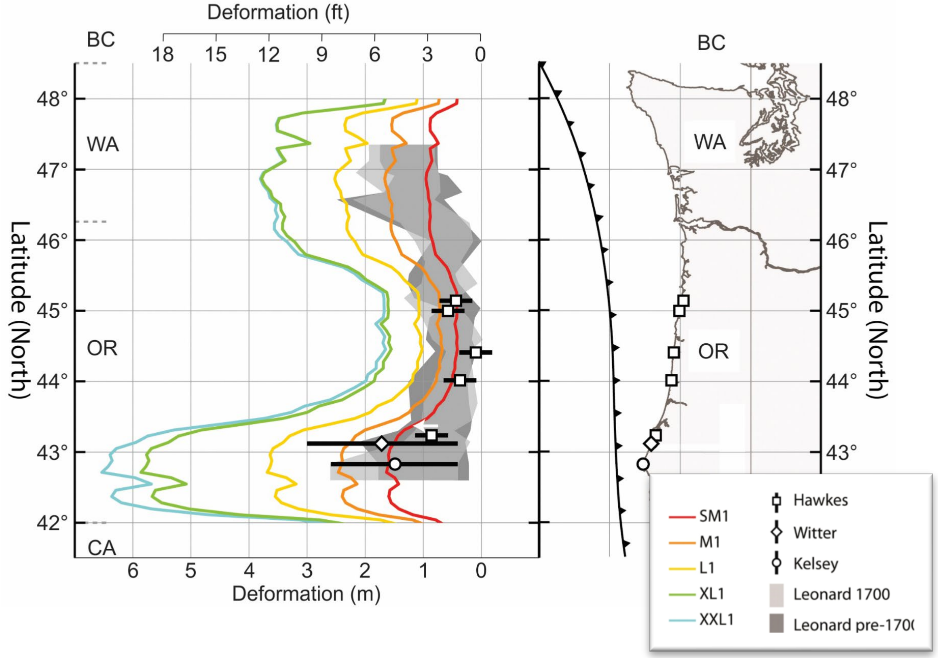


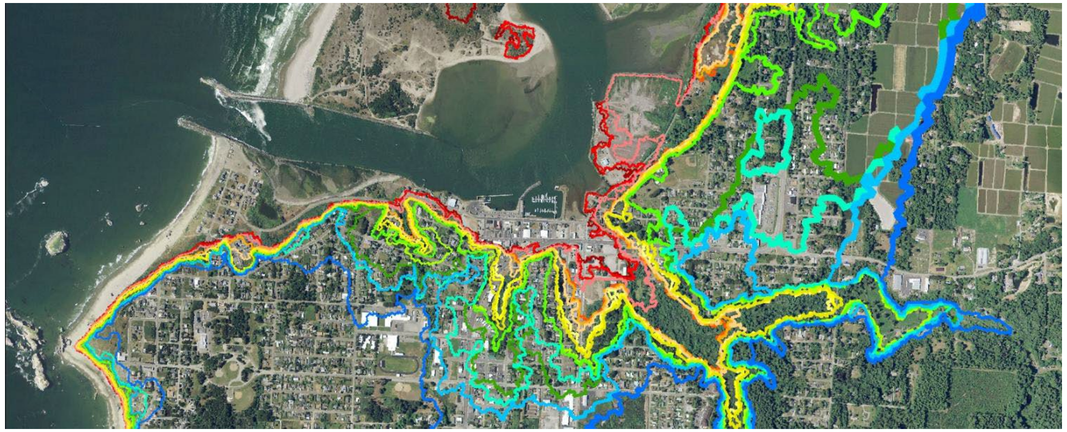
(Witter et al, 2011;2013; Priest et al., 2013)



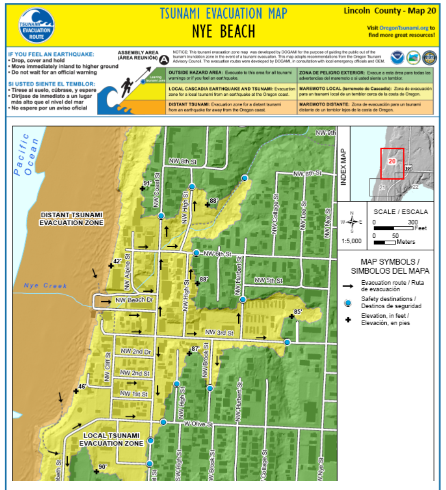
Gao et al., 2018

15 deterministic scenarios

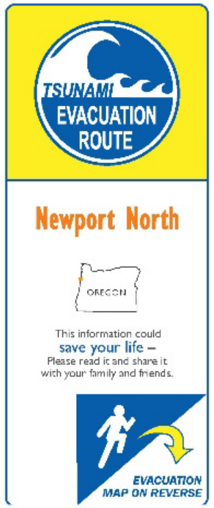


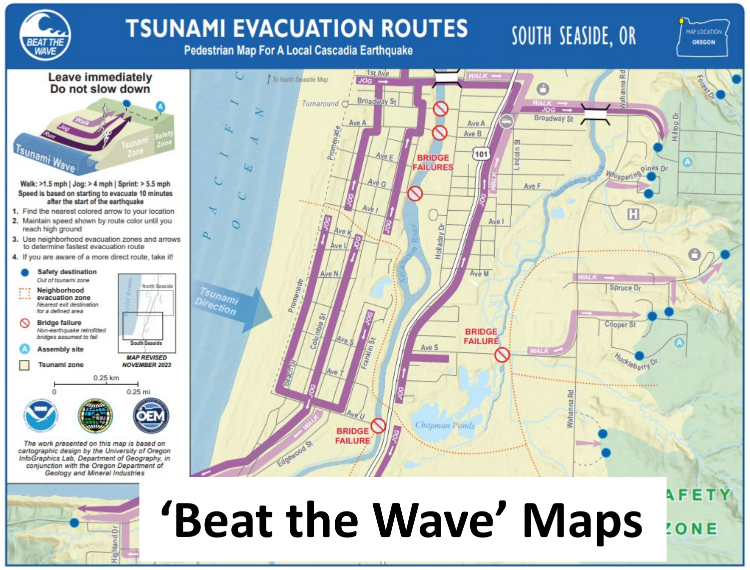


Existing Oregon Products



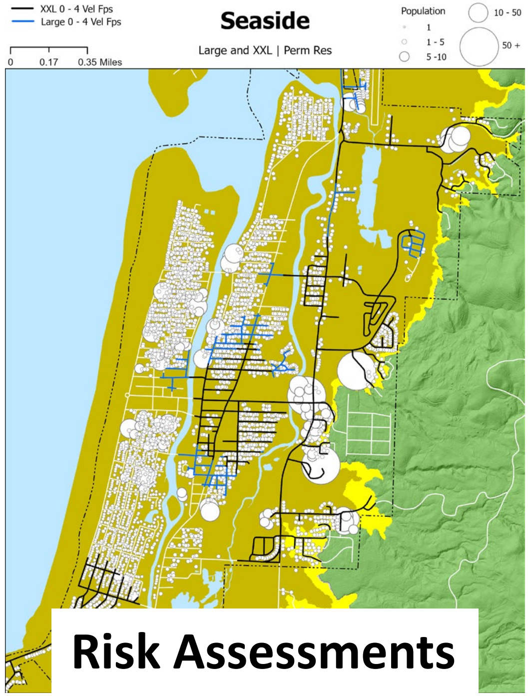
Evacuation Maps





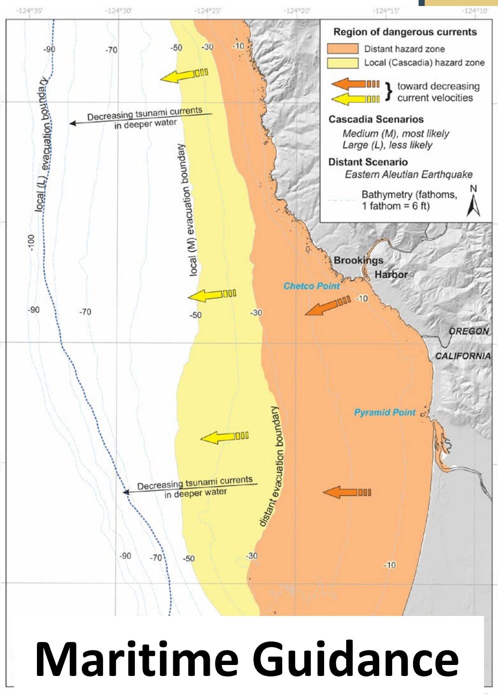
'Beat the Wave' Maps

'On-the-fly evacuation routing'



Risk Assessments

Signs



Maritime Guidance

Probabilistic Tsunami Hazard Analysis

Transition to PTHA (considers thousands of likely scenarios)

accounts for uncertainty in the physical processes (rupture characteristics, DEMs, tides etc.)
and earthquake geophysics, and is risk-based (e.g., 975-yr, 2,475-yr, 4,950-year scenarios)

Why now?

- **Refinements to Cascadia sources** (USGS/NTHMP Powell Center workshop, 05/2022; Sypus and Wang, 2024)

  New CASIE21 seismic imaging data of the CSZ (*Carbotte et al., 2022; Canales, et al., 2023*)

  → refinements to the fault zone geometry and earthquake rupture types:
    - **Modified splay model constrained by new CSZ data** (*Ledeczi et al., 2024; Lucas et al., 2025*)
    - **Inclusion of Tohoku type trench breaching scenario (guided by new seismic data)**
    - **Modifications to buried rupture models and floating slip models (i.e., dip, fault depth)**
- **Improvements to coastal DEMs**

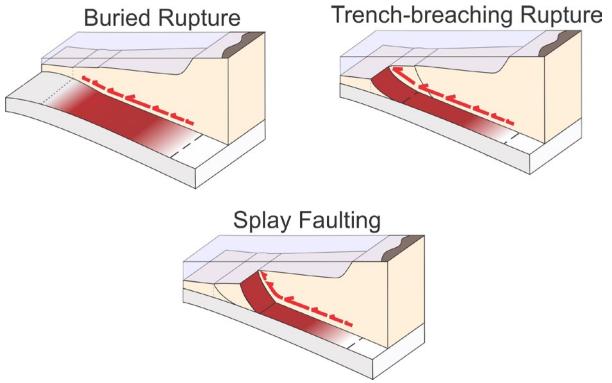
Approach:

Produce new CSZ deformation models (Sypus and Wang, 2024) → input for revised PTHA
Undertake new 2,475-yr tsunami modeling (central to north coast); similar for WA.
} NTHMP supported

Future – Simulate a suite of CSZ tsunami inundation scenarios. Would allow for developing full PTHA hazard curves on land for any variable (e.g., Momentum flux, flow depth, currents, runup)

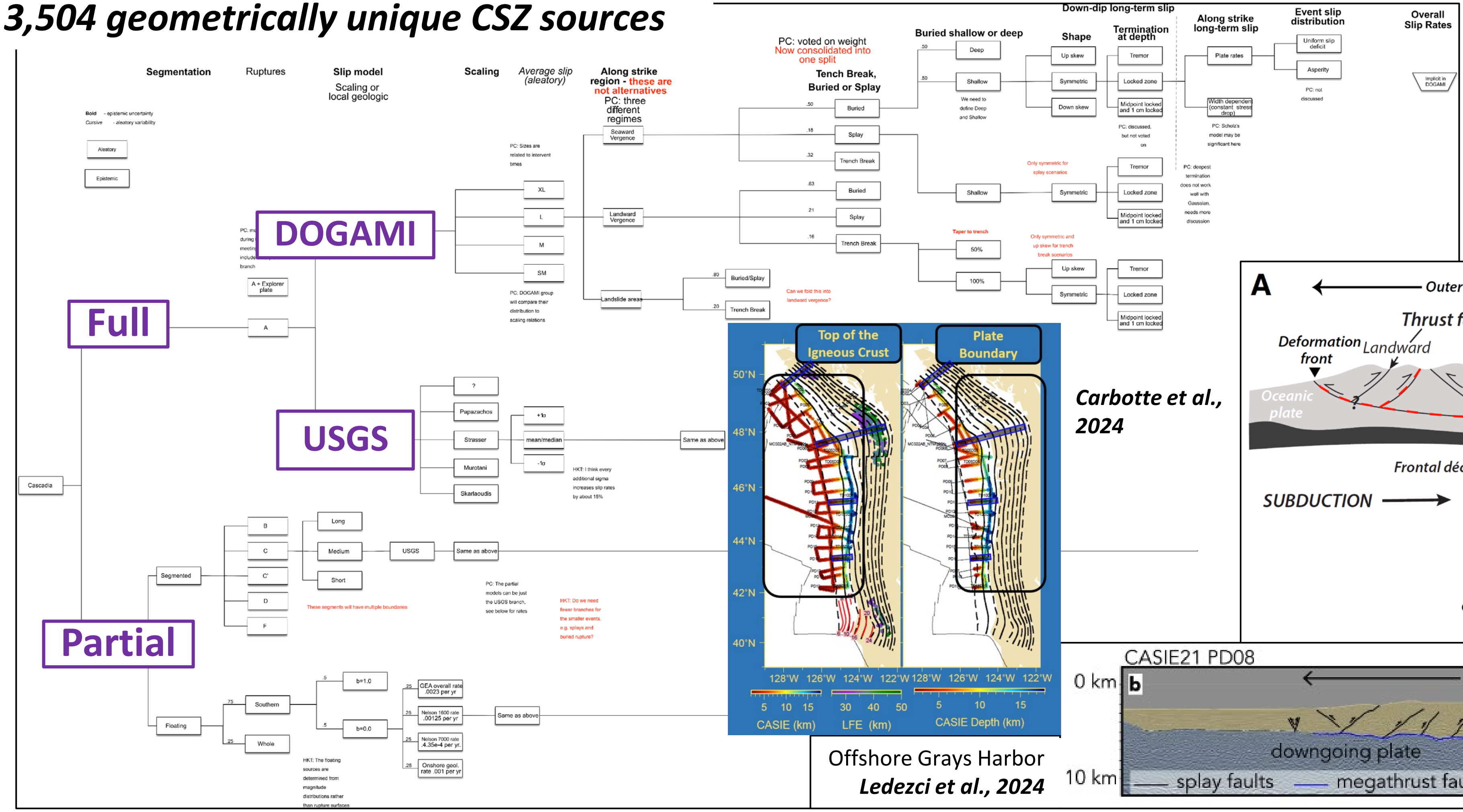
2024 Logic Tree for Probabilistic Hazard Assessments

- Updated Cascadia probabilistic tsunami hazard model (***extensive community input***)
- Revised offshore (100 m) 2,475-yr tsunami amplitudes completed for Cascadia

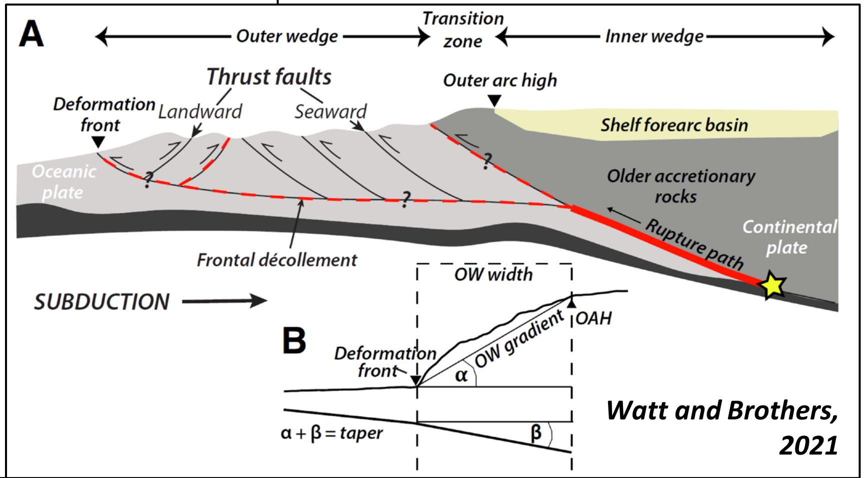


Sypus and Wang, 2024

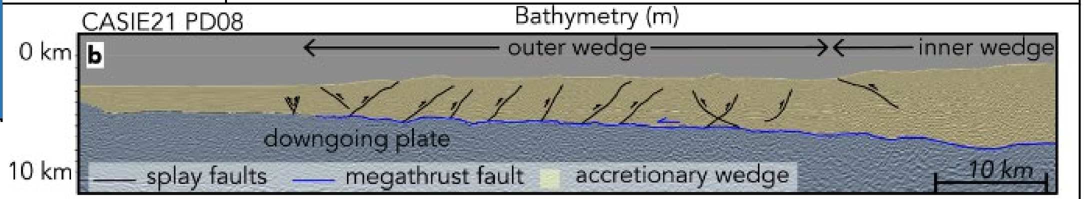
3,504 geometrically unique CSZ sources



Carbotte et al., 2024

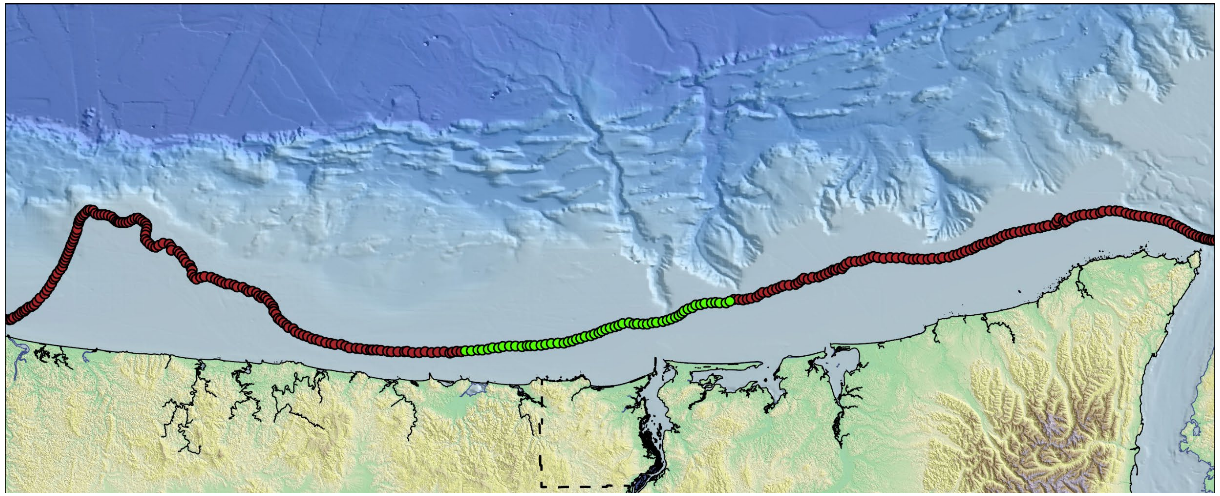


Watt and Brothers, 2021



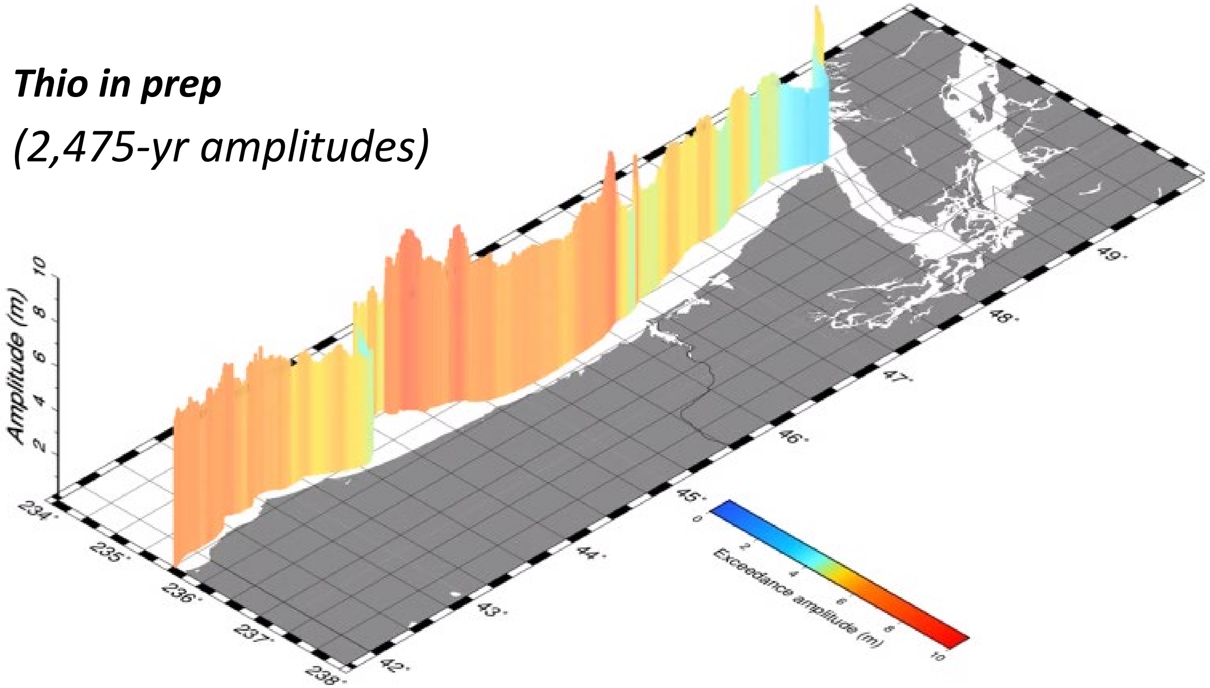
Offshore Grays Harbor
Ledezci et al., 2024

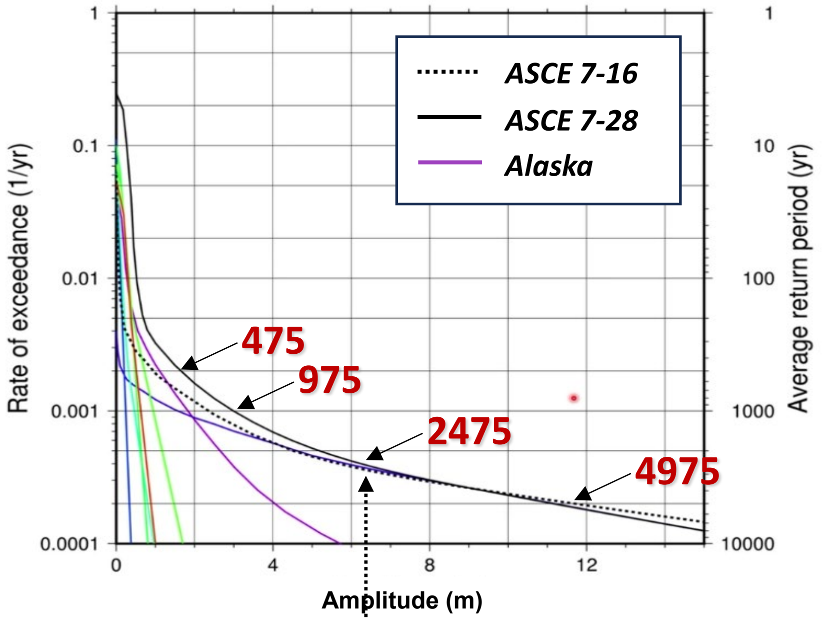
Offshore PTHA for the Pacific Northwest

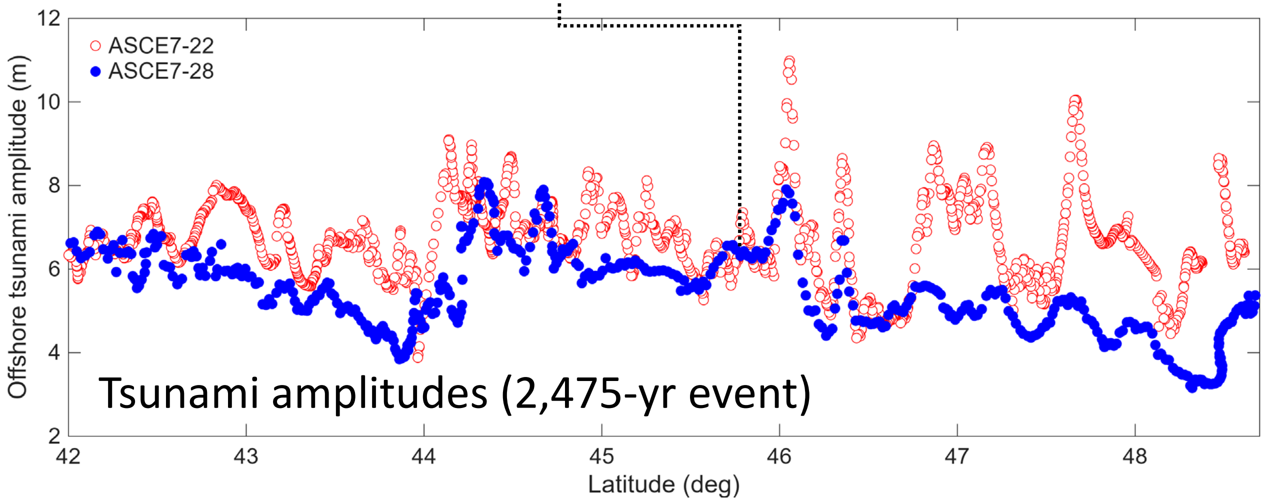


Thio in prep

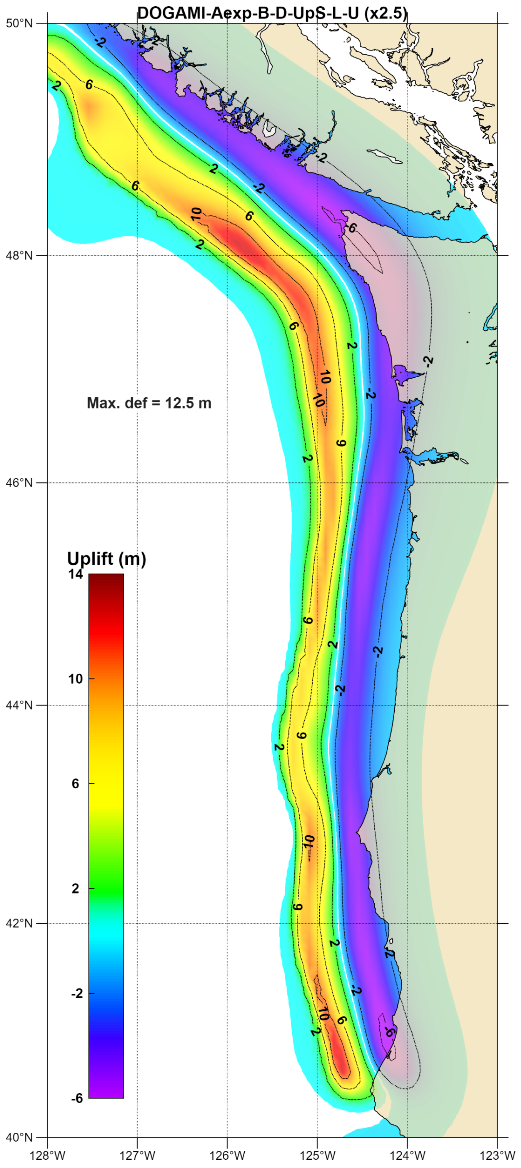
(2,475-yr amplitudes)

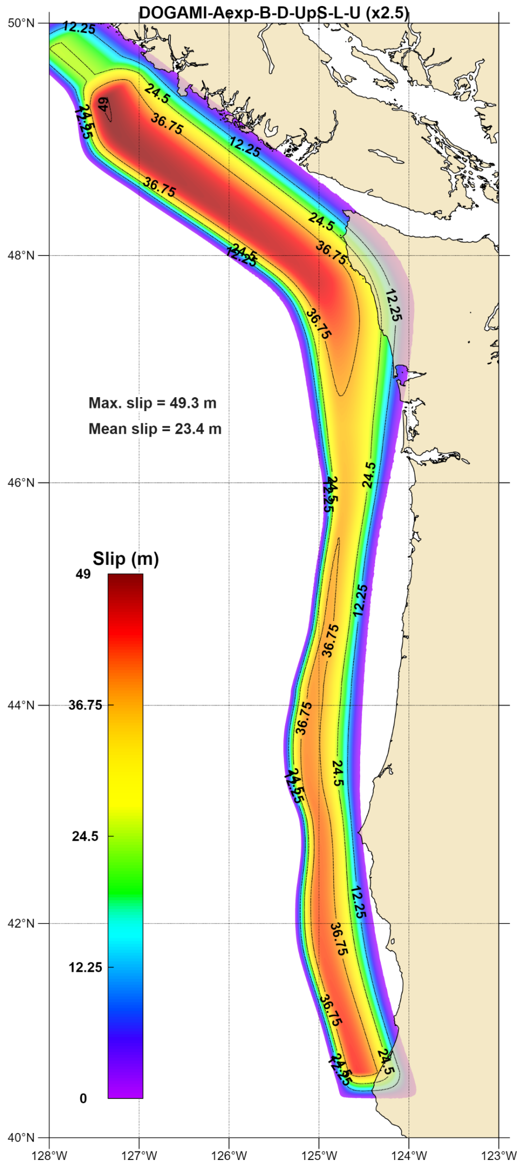




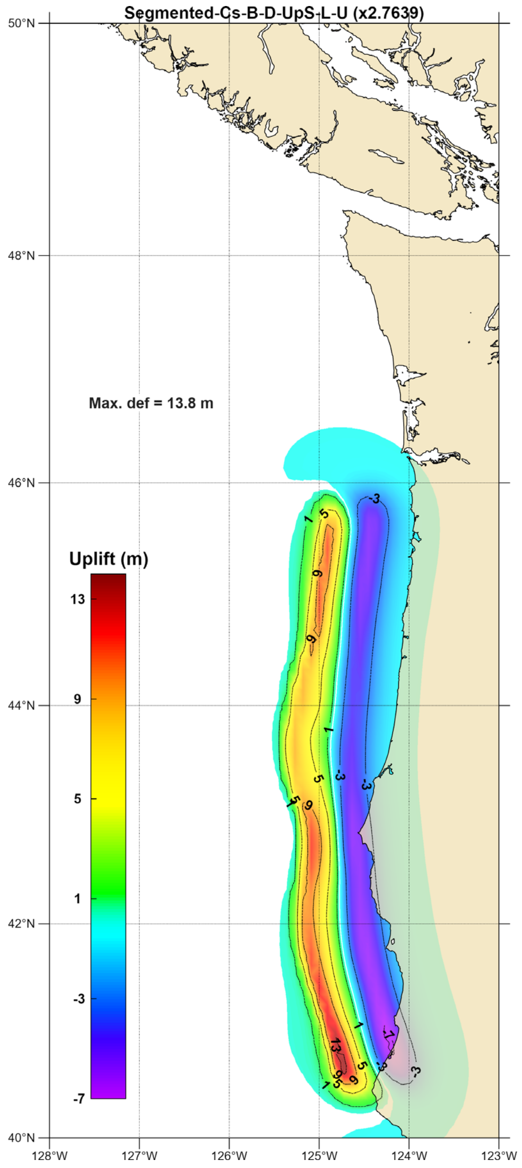


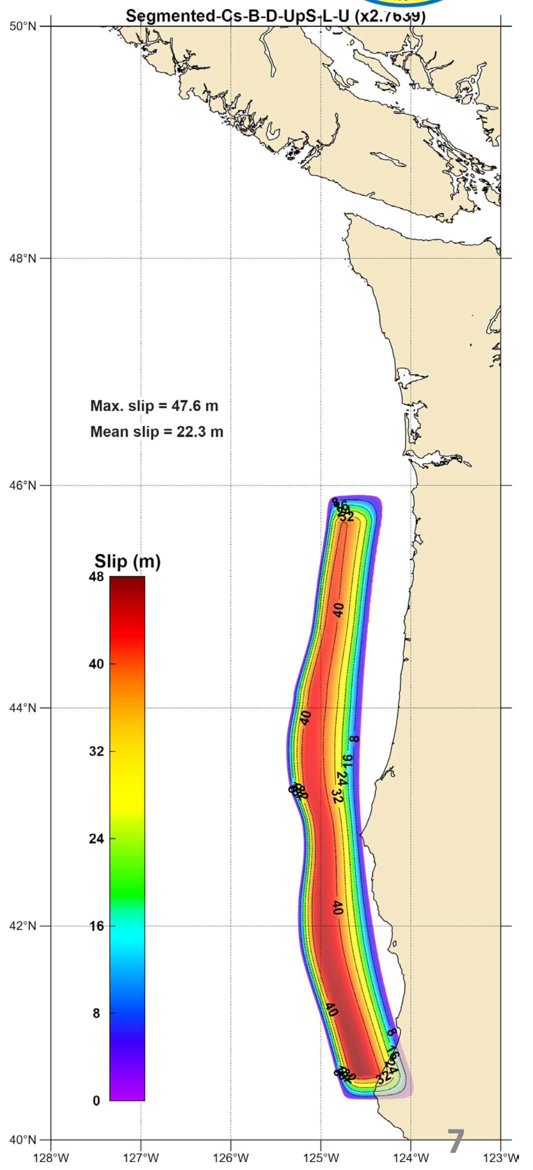
2475-yr CSZ Source Models





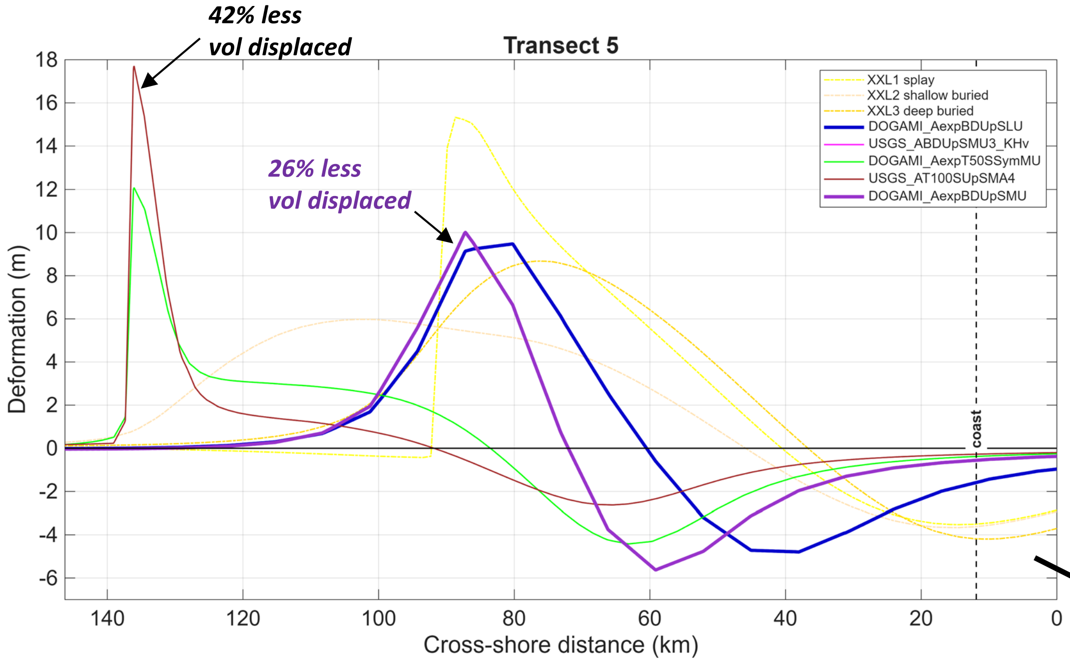
Full margin deep buried upskew downdip extent = locked zone

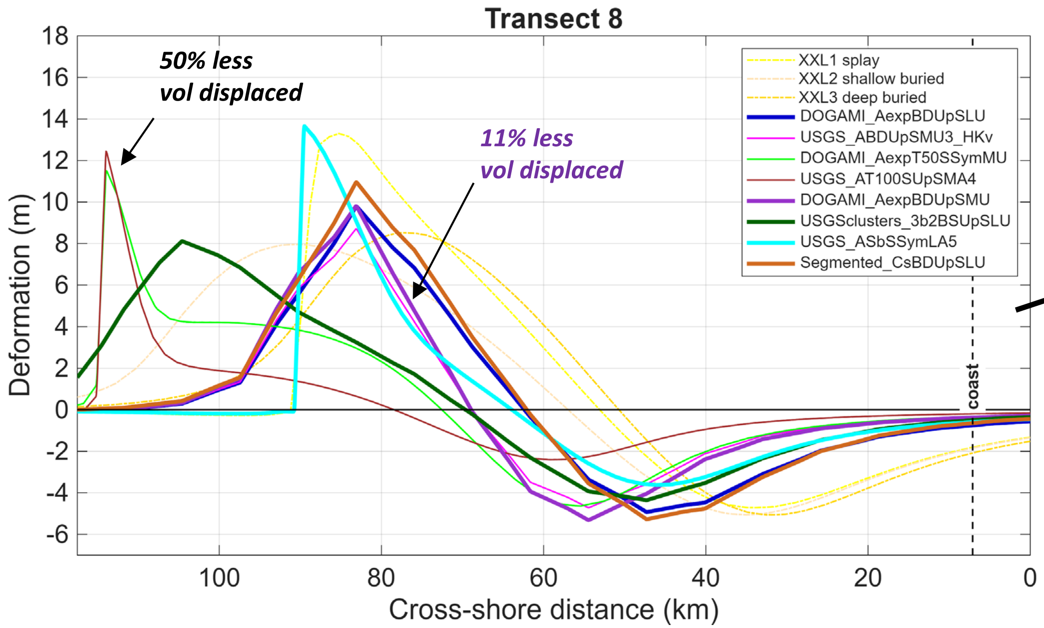


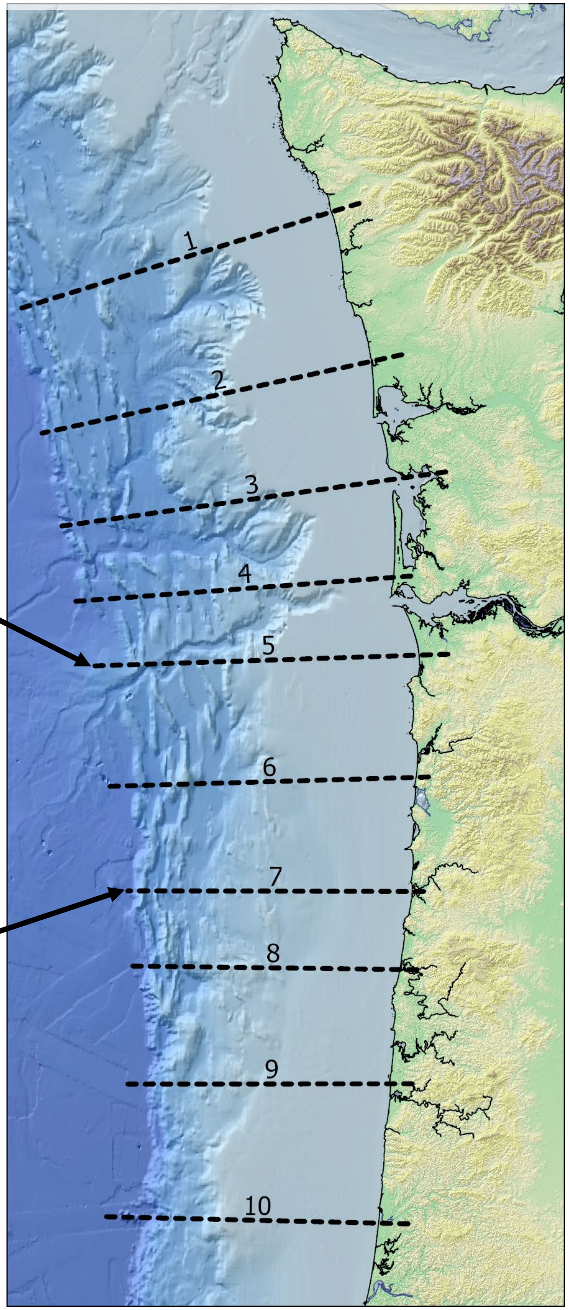


Segment C, deep buried upskew downdip extent = locked zone

CSZ Source Models in Cross-section

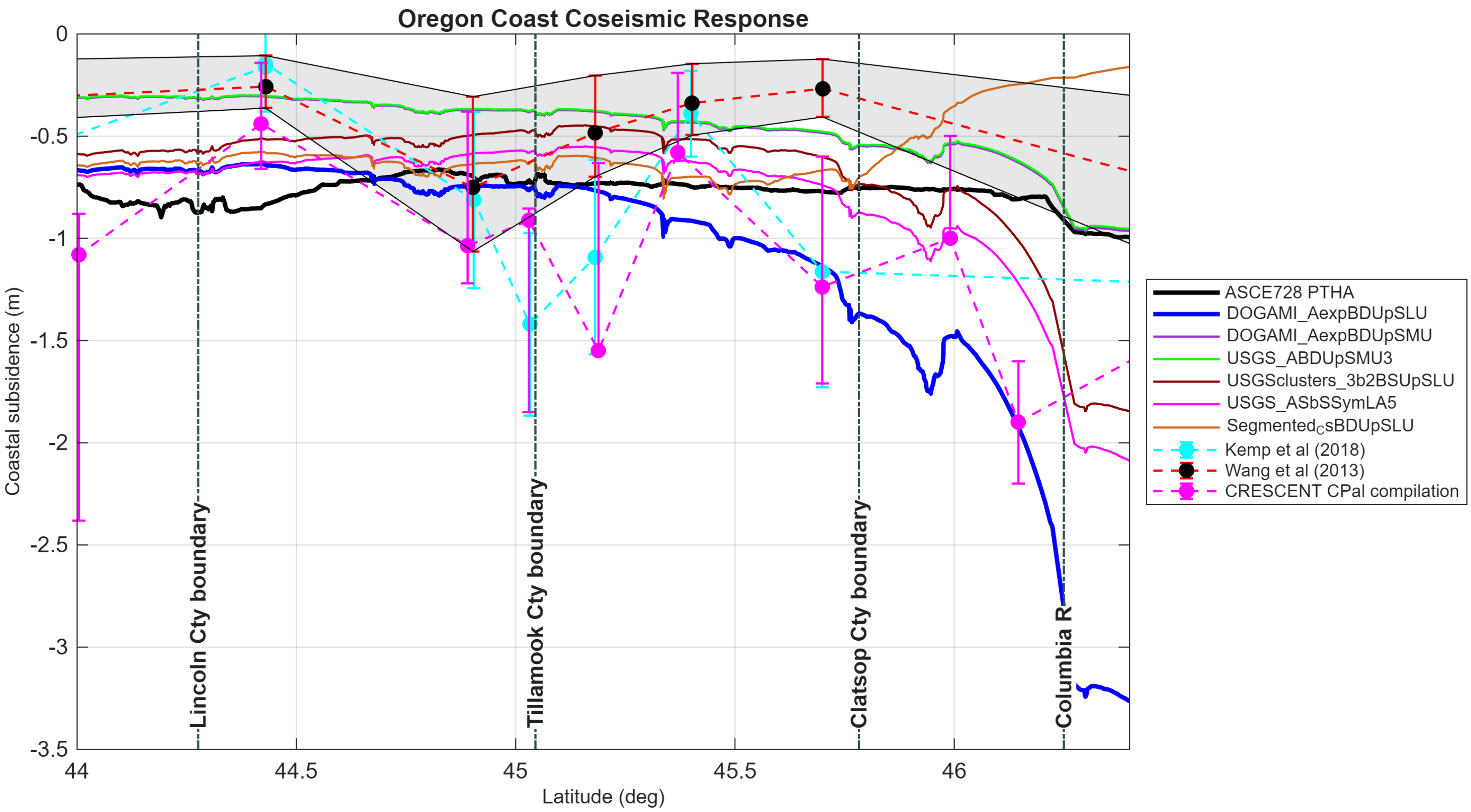






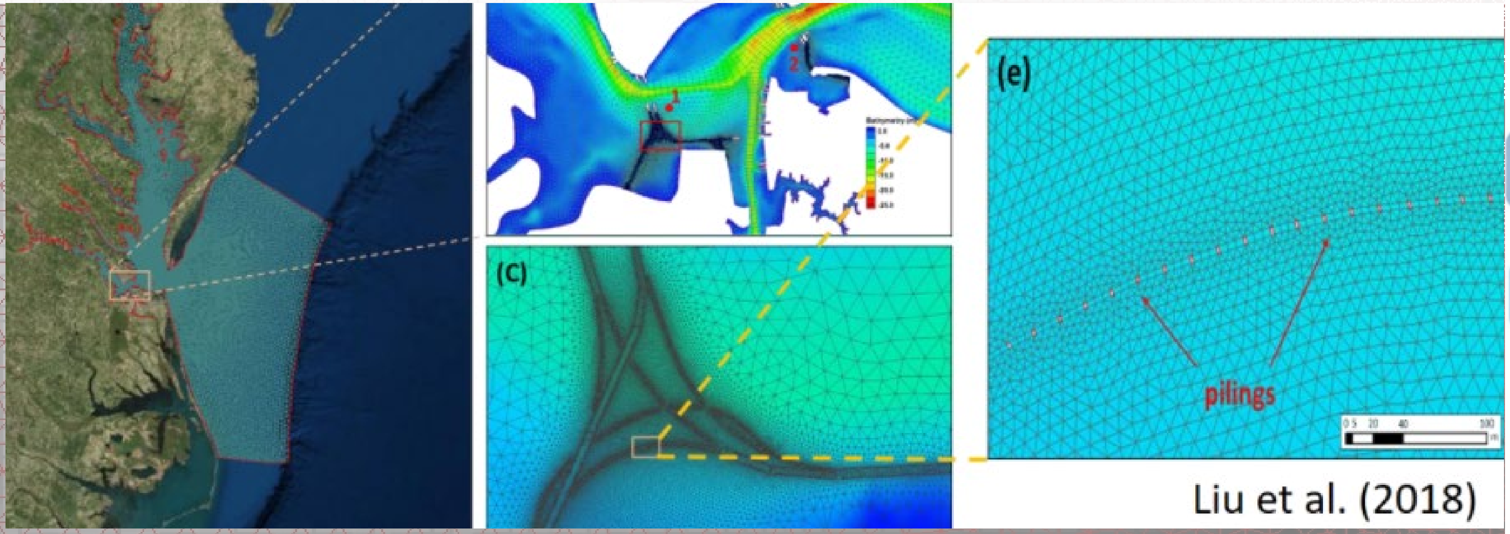
General comments:

- Trench breaching models (T50 and T100) produce negligable tsunami in Oregon (consistent with Gao et al 2018).
- Subsidence between deformation models better constrained with the paleo data … improvement on previous DOGAMI models
- Coseismic response in northern WA is poorly constrained compared with southern WA and Oregon.

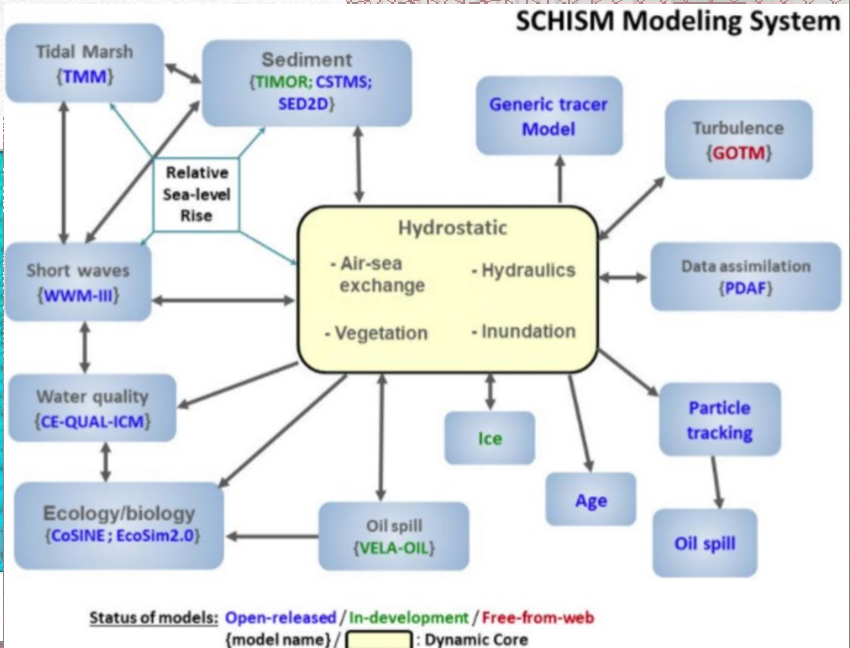

Oregon Coast Coseismic Response
Coastal subsidence (m)
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
44
44.5
45
45.5
46
Latitude (deg)
Lincoln Cty boundary
Tillamook Cty boundary
Clatsop Cty boundary
Columbia R
ASCE728 PTHA
DOGAMI_AexpBDUpSLU
DOGAMI_AexpBDUpSMU
USGS_ABDUpSMU3
USGSclusters_3b2BSUpSLU
USGS_ASbSSymLA5
Segmented$_{C}$sBDUpSLU
Kemp et al (2018)
Wang et al (2013)
CRESCENT CPal compilation

Tsunami Modeling

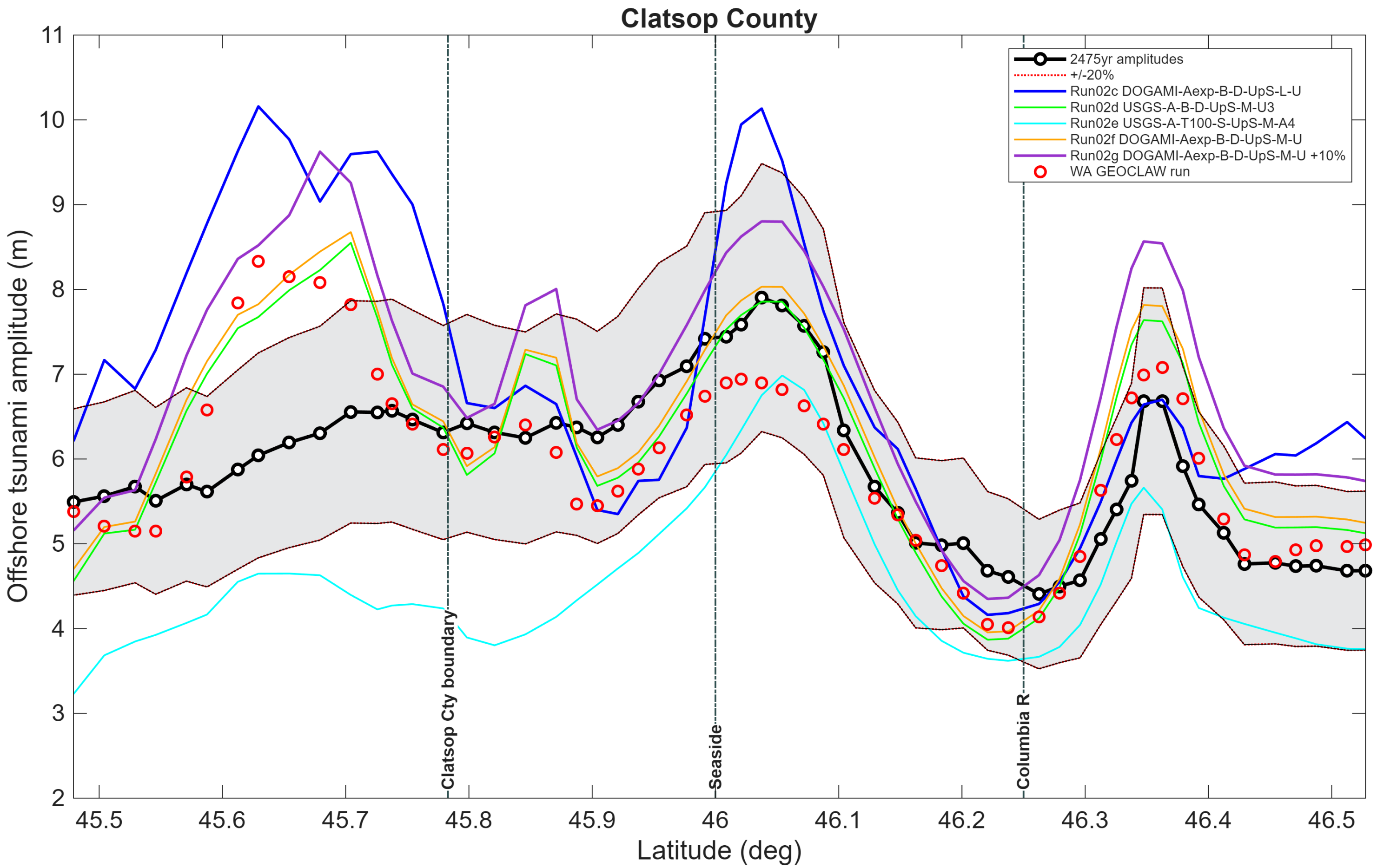
- ***SCHISM*** (Semi-implicit Cross-scale Hydroscience Integrated System Model) … hydrodynamic finite element model.
- Solves 3D Reynolds-averaged Navier–Stokes equations. Model can be run in either ***hydrostatic*** or non-hydrostatic form.
- Uses ***unstructured grids***. Ideally for areas involving complex geometry and bathymetry (e.g., reefs, mouths of jetties, barrier spits, populated areas).
- ***Passed multiple NTHMP Benchmarking simulations*** (e.g., Horillo et al., 2015; Zhang et al., 2016; Zhang, 2025).
- Runs use static ***mean high water*** *tide* and ***friction n=0.025***.

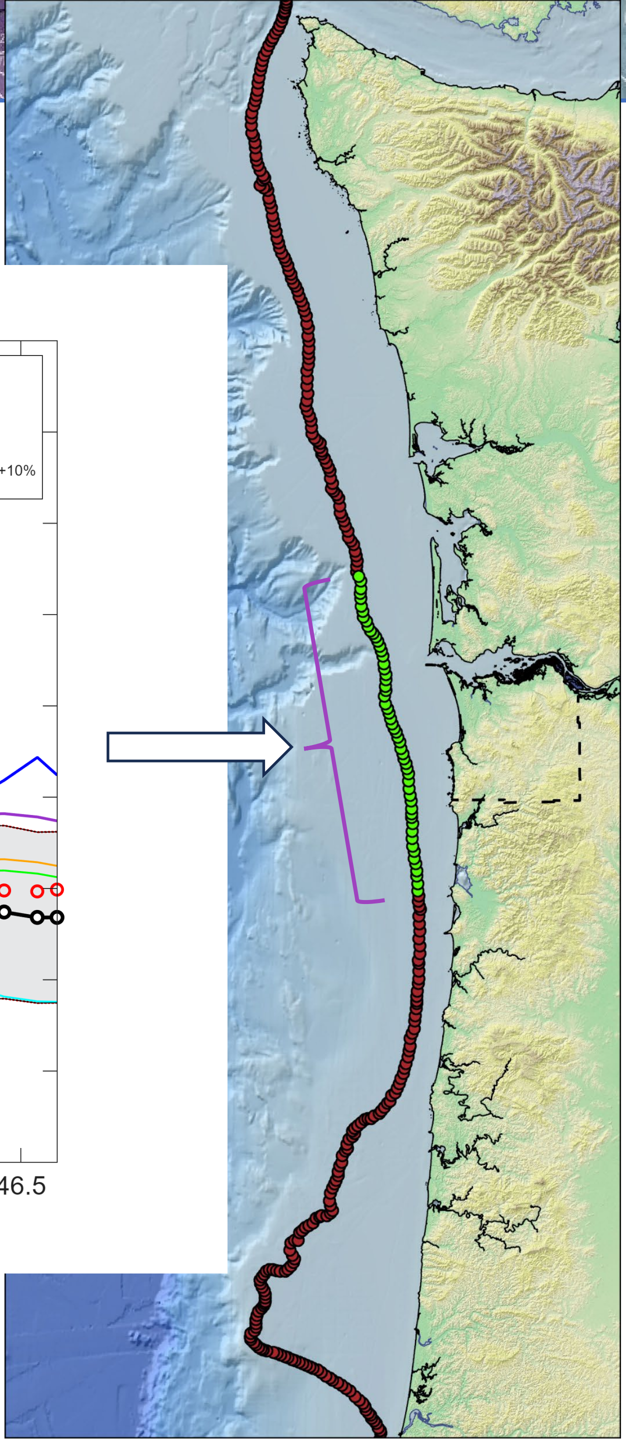


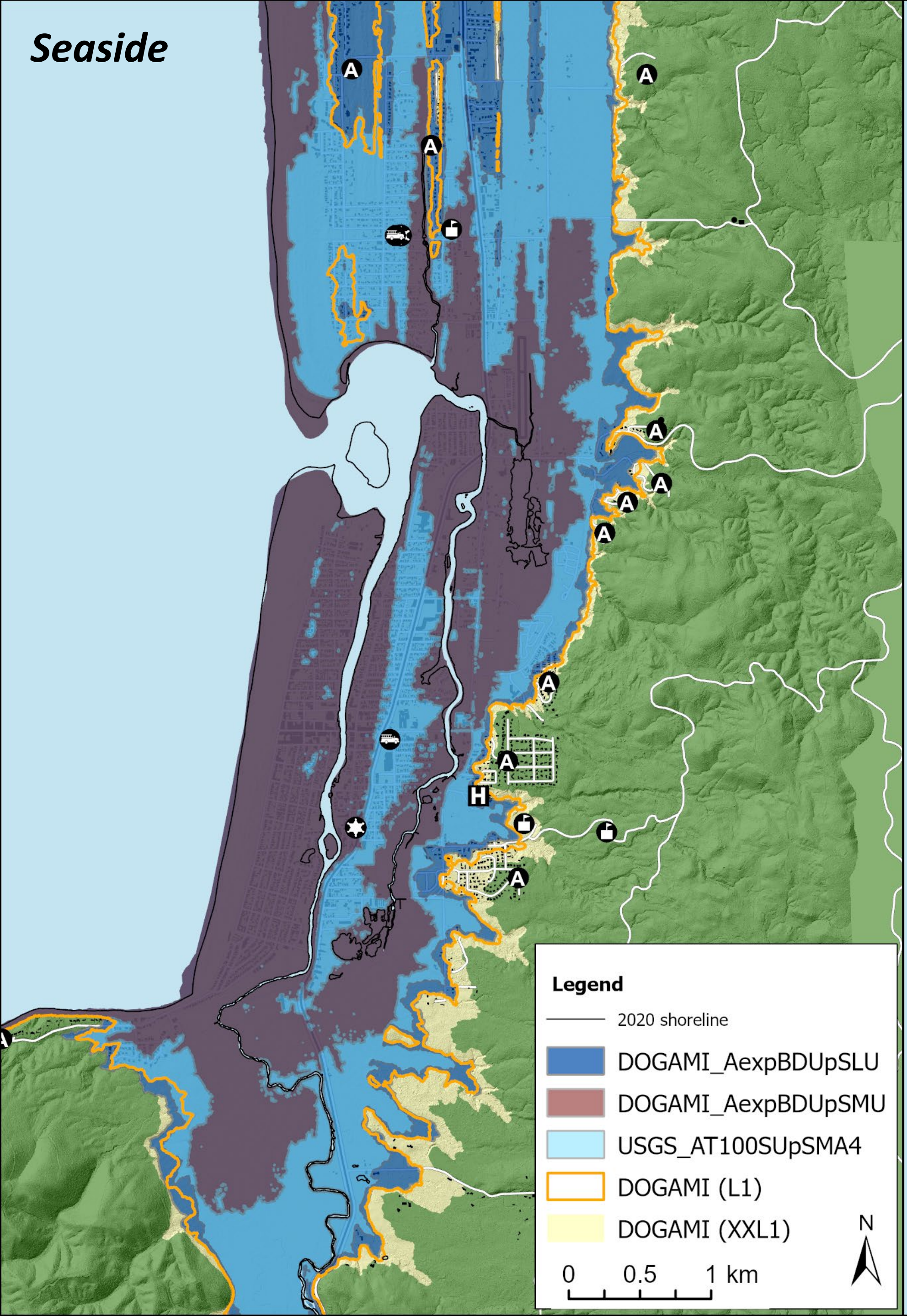
Liu et al. (2018)

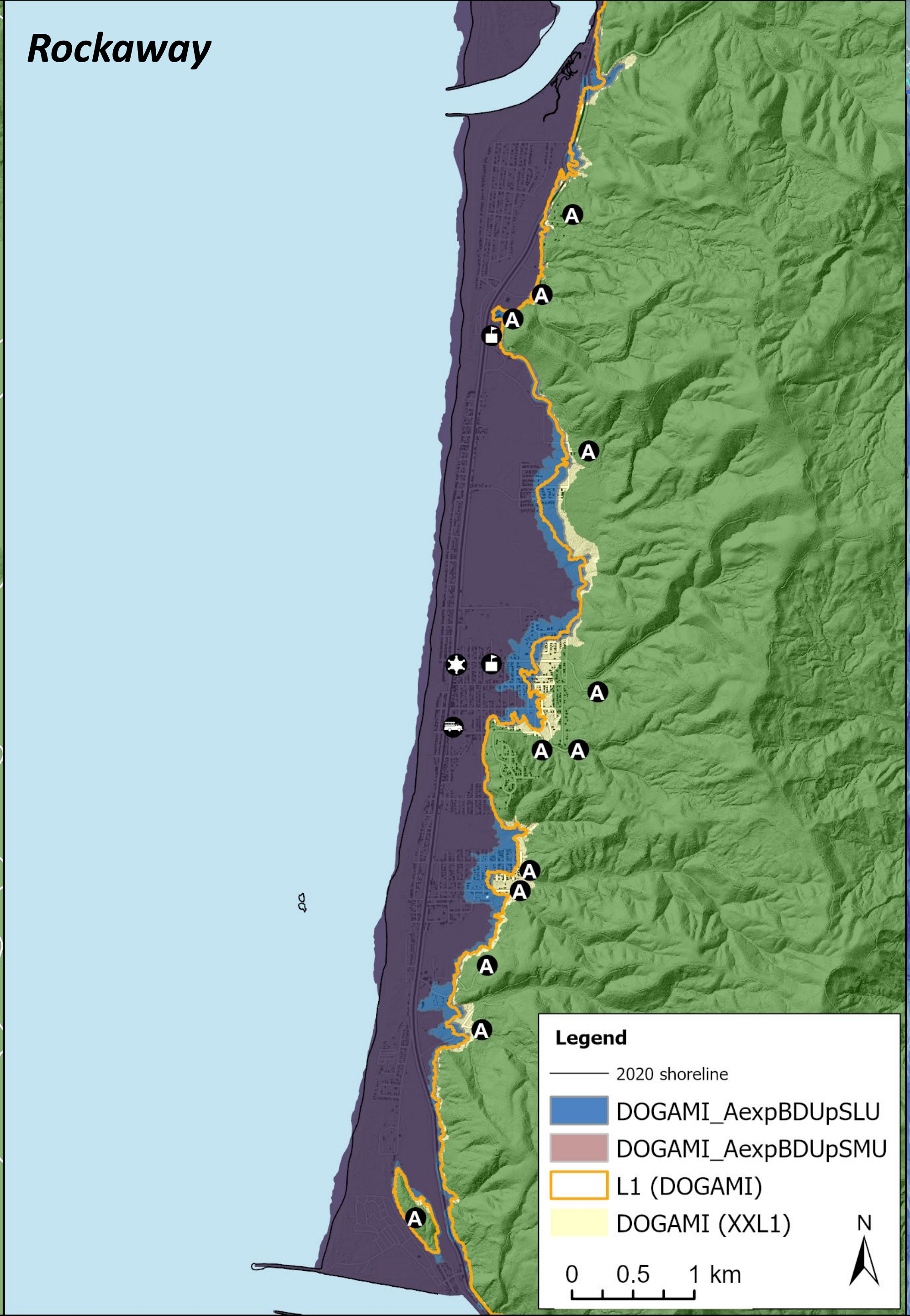


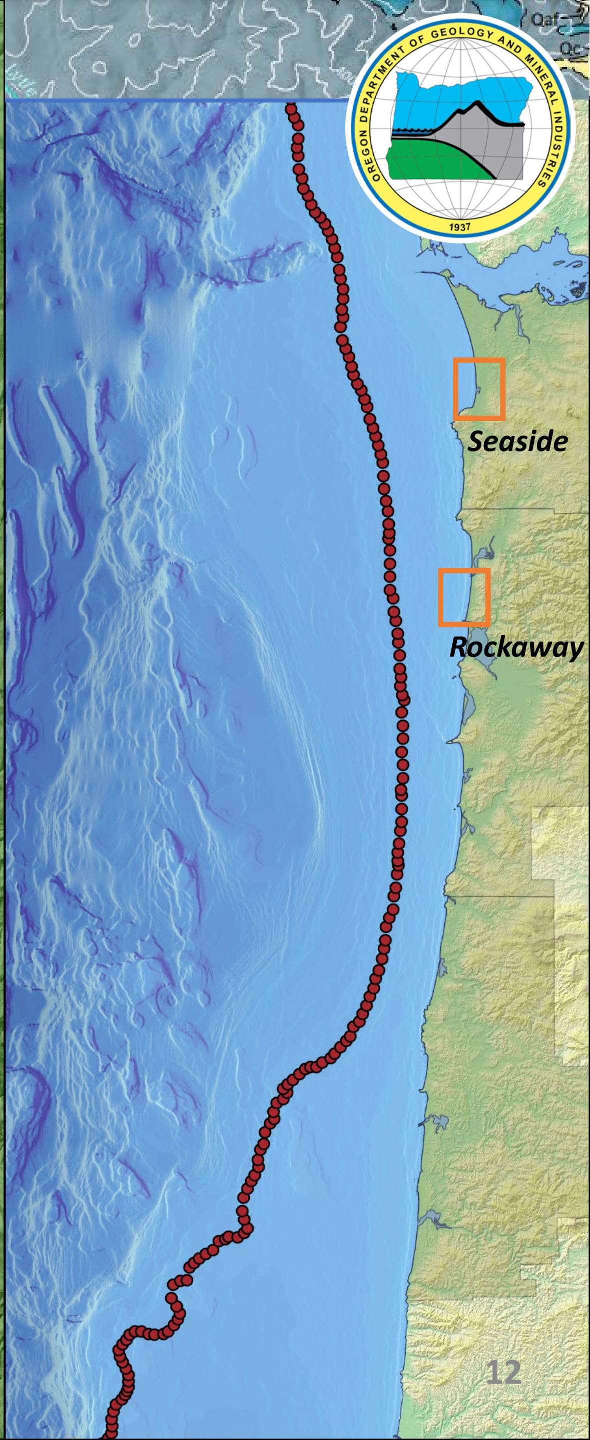
Clatsop Offshore Design Wave Wiggle Matching



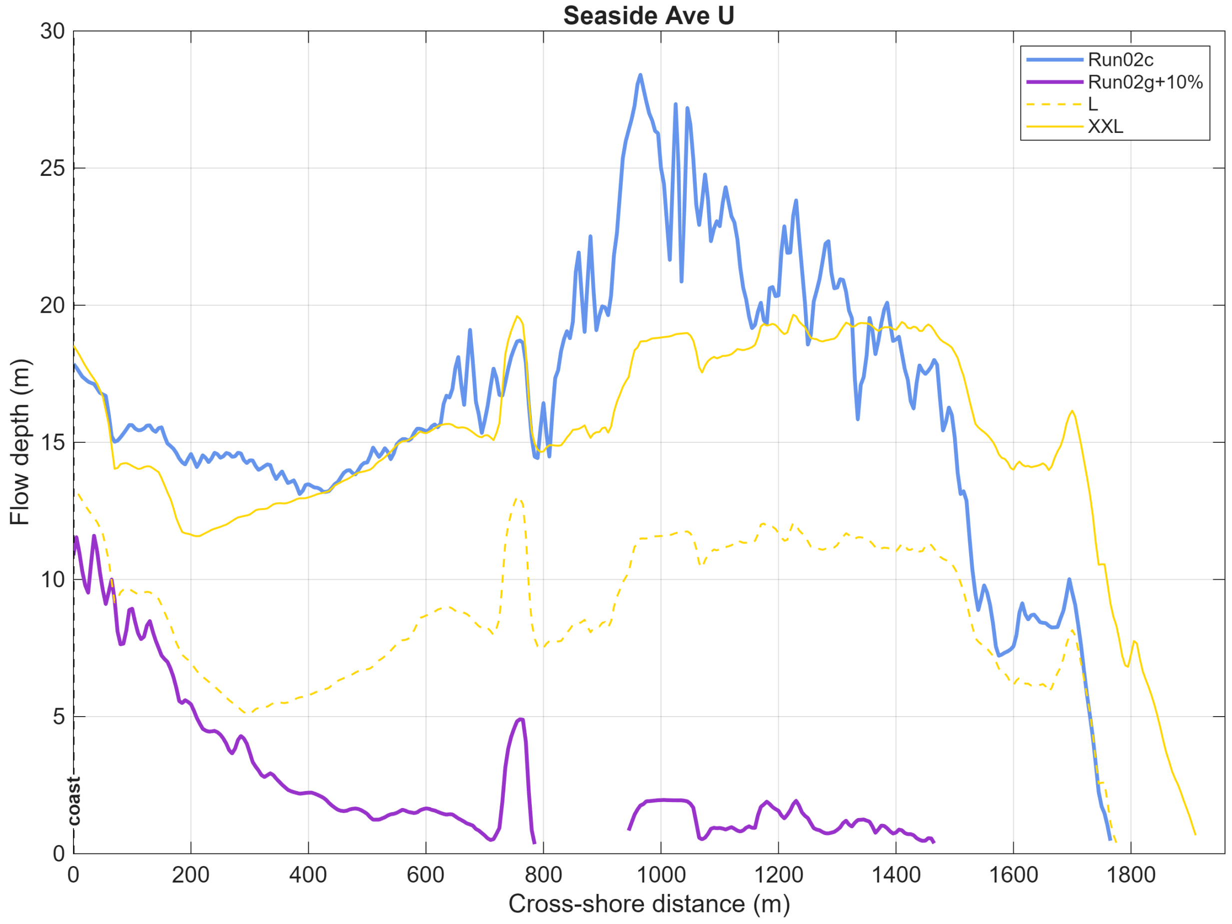


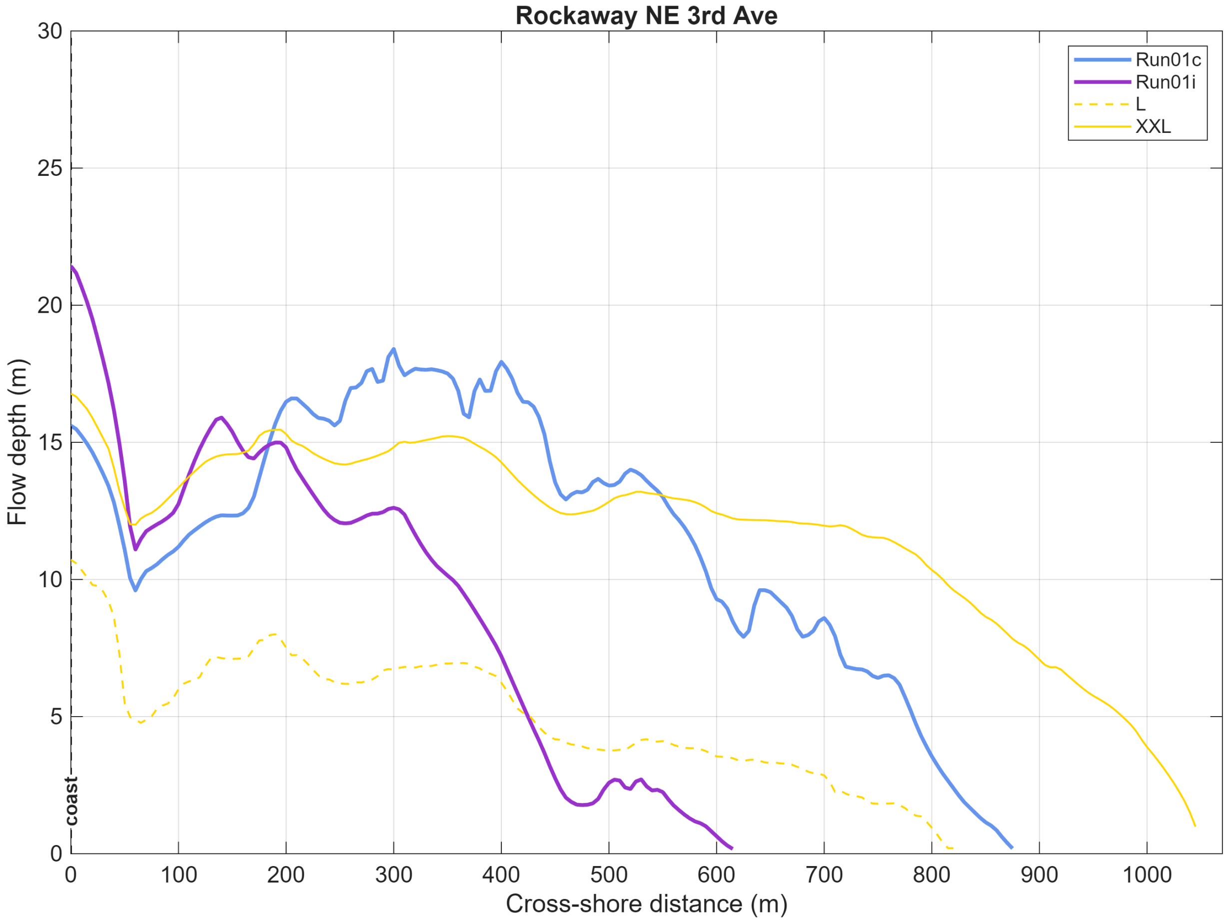

Seaside
Legend
2020 shoreline
DOGAMI_AexpBDUpSLU
DOGAMI_AexpBDUpSMU
USGS_AT100SUpSMA4
DOGAMI (L1)
DOGAMI (XXL1)
N
0 0.5 1 km


Rockaway
Legend
2020 shoreline
DOGAMI_AexpBDUpSLU
DOGAMI_AexpBDUpSMU
L1 (DOGAMI)
DOGAMI (XXL1)
N
0 0.5 1 km


Seaside
Rockaway

Flow Depths Comparison

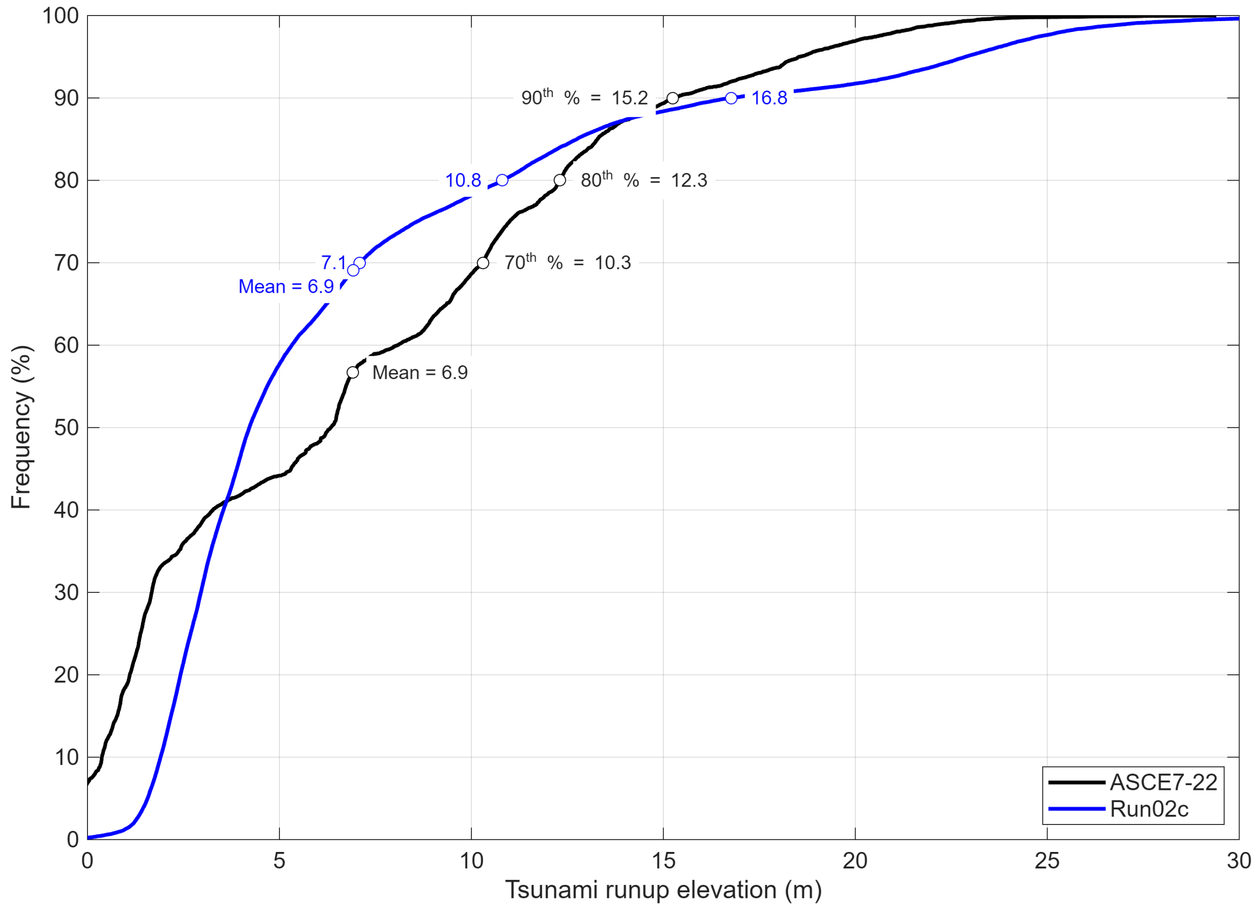




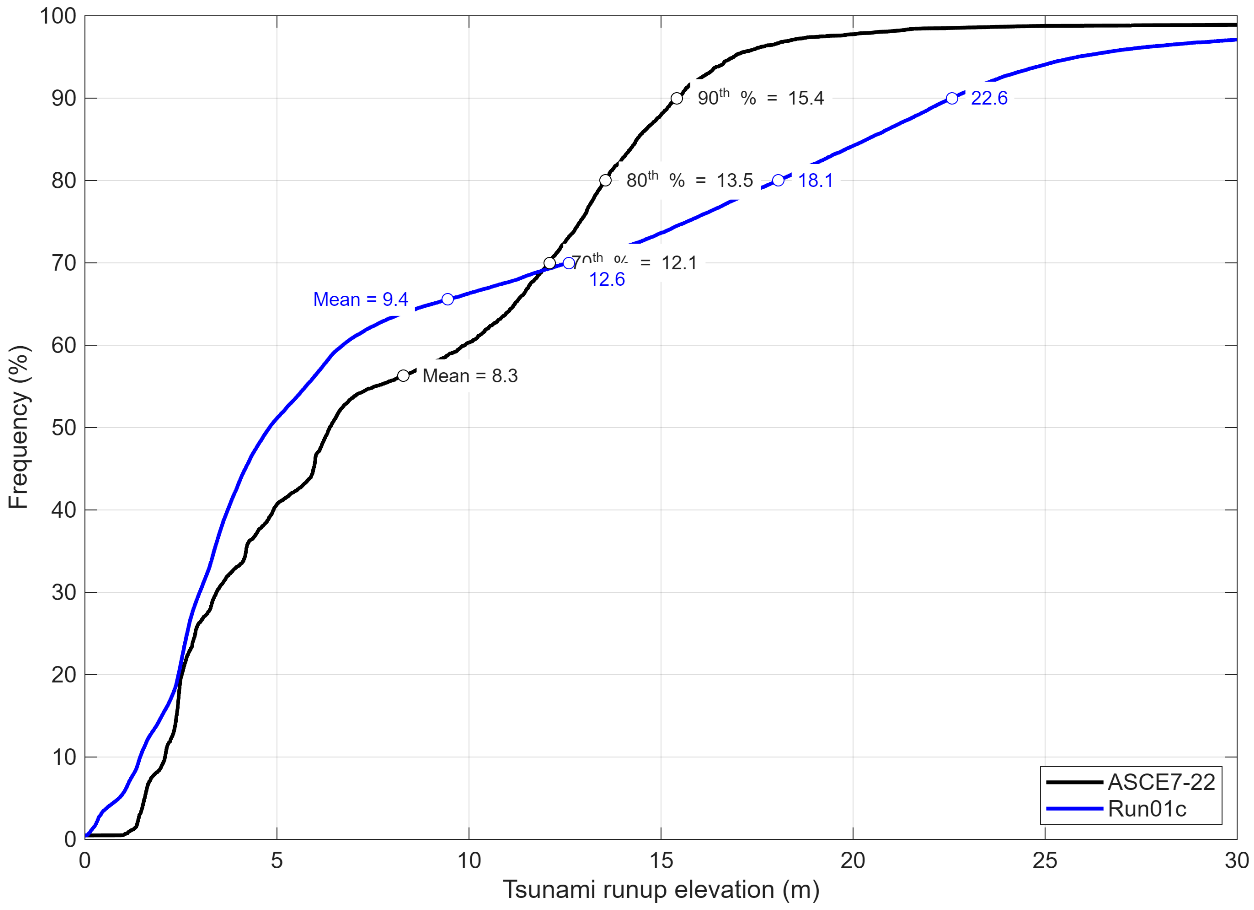
Landward

Runup Comparisons

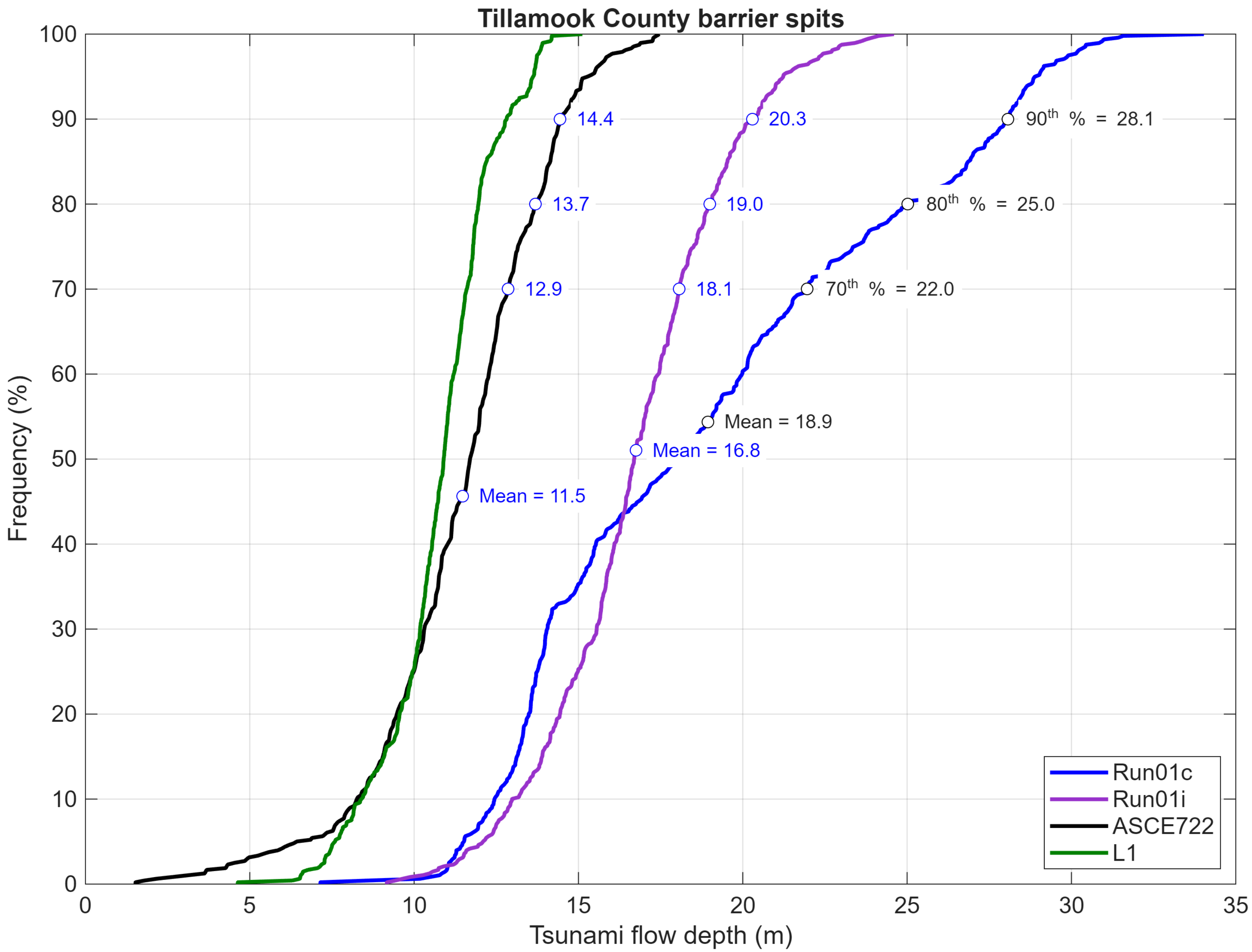
Clatsop

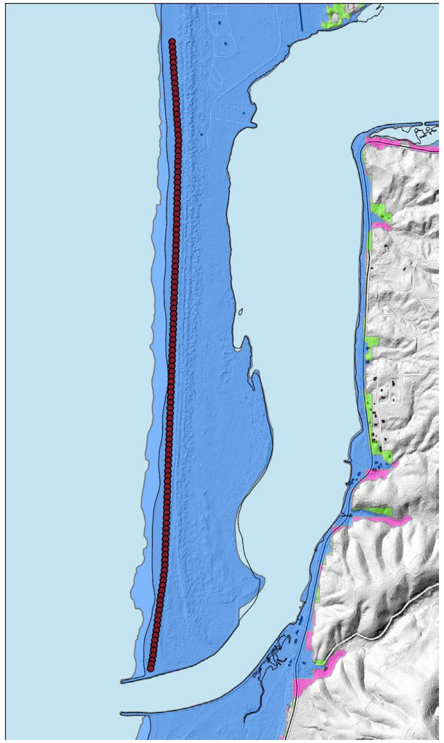


Tillamook



Flow Depths (barrier spits backed by estuaries)

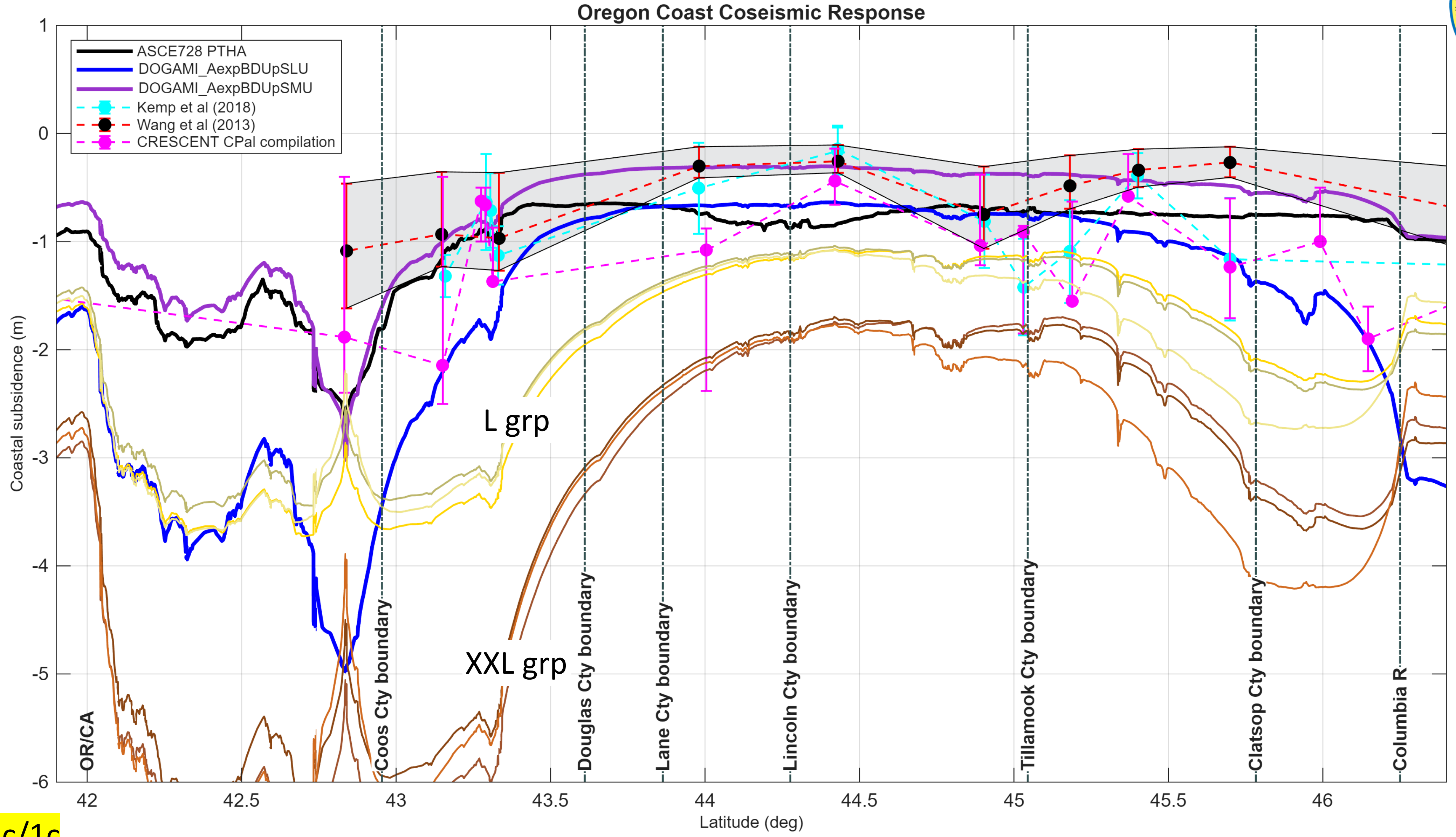




Conclusion:

- Previous OR tsunami modeling used several deterministic CSZ scenarios. Recent efforts are shifting toward probabilistic tsunami hazard analysis (PTHA) and risk-based modeling.
- New 2,475-yr tsunami hazard zones are presently being simulated for both OR and WA (update the existing ASCE7-22 tsunami design zone and geodatabase).
- Model results to-date using high resolution grids indicate generally comparable to greater inundation extents when compared with the DOGAMI L1 scenario. However, modeled flow depths are significantly larger than L1 (and in some cases XXL1).
- Differences in the 2,475-yr disaggregated sources yield very different inundation in northern Oregon but become broadly similar as one progresses south toward the central Oregon Coast.
- Coseismic responses in the new source models appear to show better adherence to the paleo data (not so good in NW WA (lack of data)).
- Although PTHA looks promising, the 2,475-yr source models are indicating large slip that exceed the t-shirt DOGAMI (e.g. L1 and XL1) source models (are these reasonable?).

Extra slide



Run2c/1c

Run2g/1i

New modelling underway