Scenario-Based Landslide-Generated Tsunami Modeling in the Gulf of Aqaba

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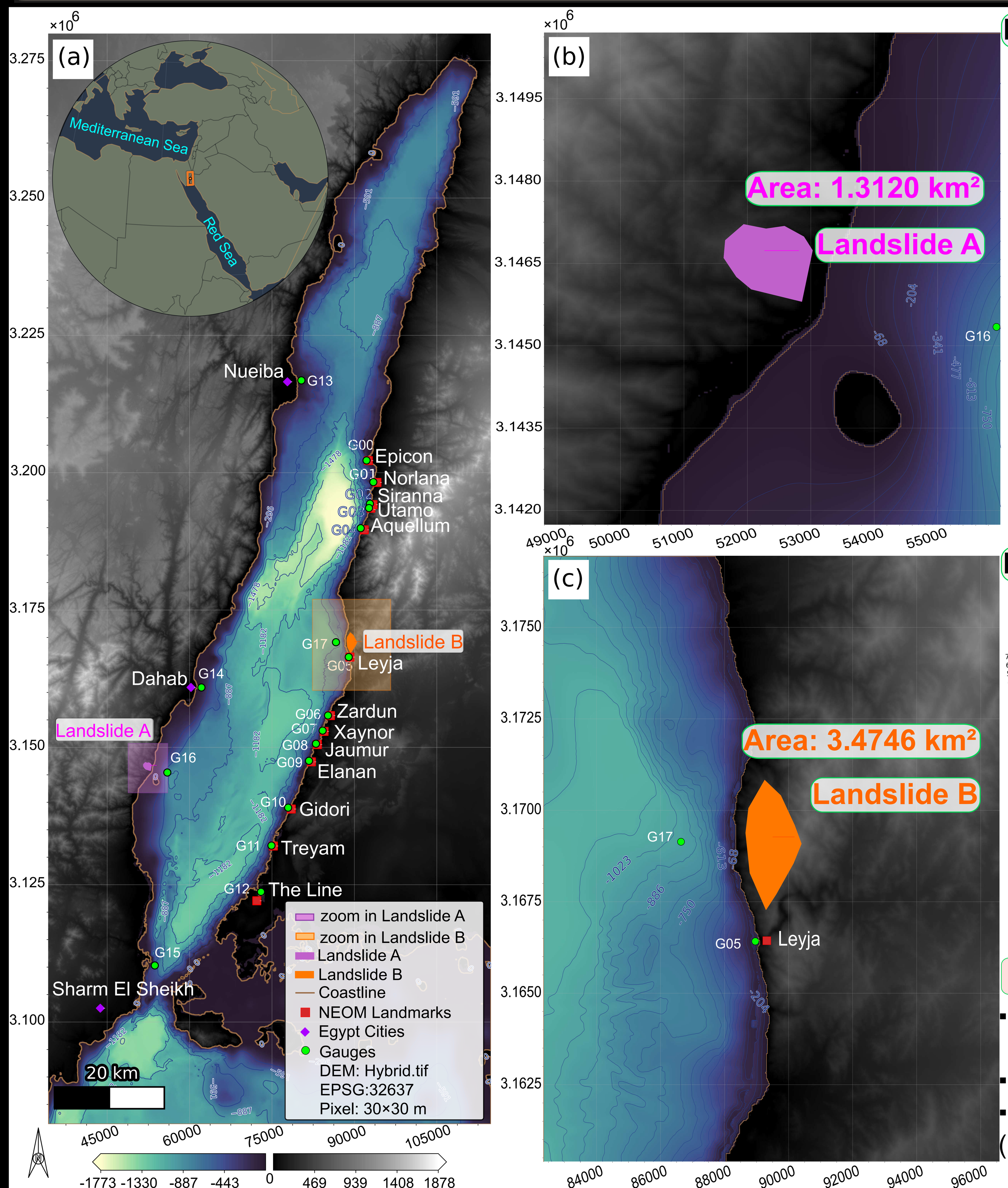
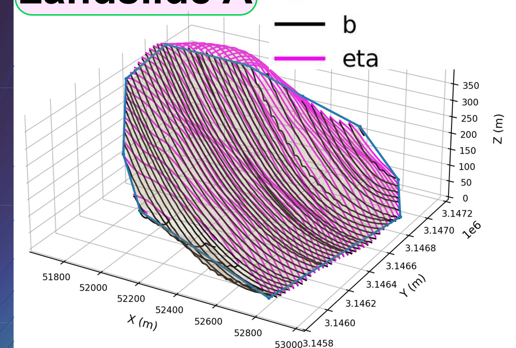
Motivation & Aim

- The Gulf of Aqaba has historical records of earthquake- and submarine landslide-generated tsunamis, but **subaerial landslide-tsunami hazard** remain poorly constrained (*Purkis, 2022*).
- Sparse observations and rapid coastal development, including **NEOM** and tourism expansion, motivate improved regional tsunami hazard assessment.
- We simulate **multiple hypothetical landslide-tsunami scenarios** to examine the effects of **landslide source properties and locations**.
- We quantify **first arrival time**, **maximum tsunami wave height**, **inundation depth**, and **flow velocity** to support coastal hazard and design assessment.

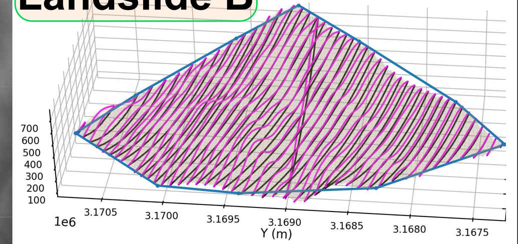


Landslide A



Slide Angle (°)	Volume (m³)
-15	7.77E+07
-20	1.05E+08
-25	1.32E+08
-30	1.60E+08
-35	1.89E+08

Landslide B



Slide Angle (°)	Volume (m³)
-21	1.55E+08
-25	2.16E+08
-30	2.90E+08
-35	3.83E+08

Data source

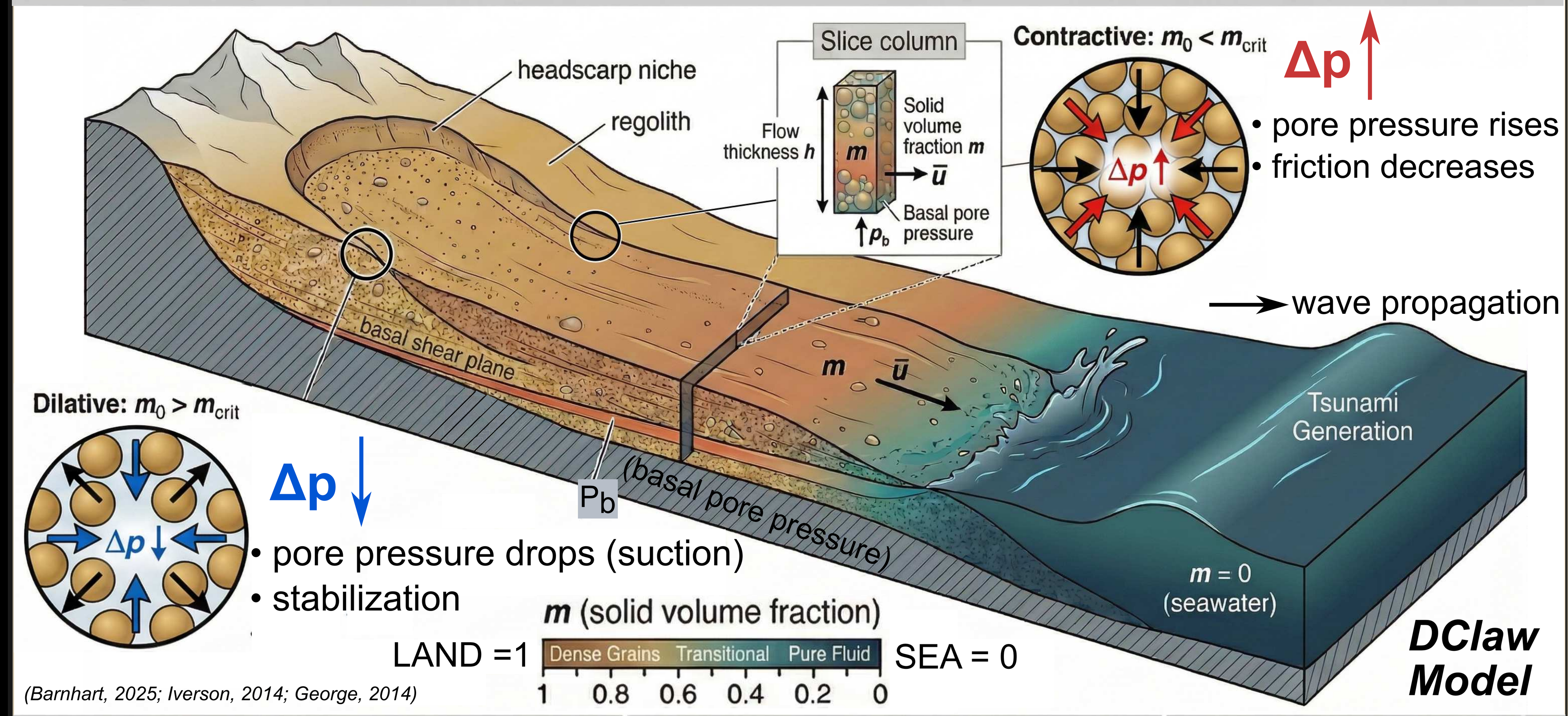
- Copernicus DEM45 GLO-30 (Topo 30 m)
- GMRT (Topo-Bathy 54 m)
- Multibeam bathymetric data (East Aqaba 30 m, *Ribot, 2021*)

Acknowledgments: This work used Shaheen III, managed by the KAUST Supercomputing Core Laboratory. We thank KAUST and ESSE for support.

Scan me! Abstract — Linkedin — Group Website — References

Methodology

Change in m_0 → Pore fluid pressure → Basal friction → Flow mobility → Tsunami

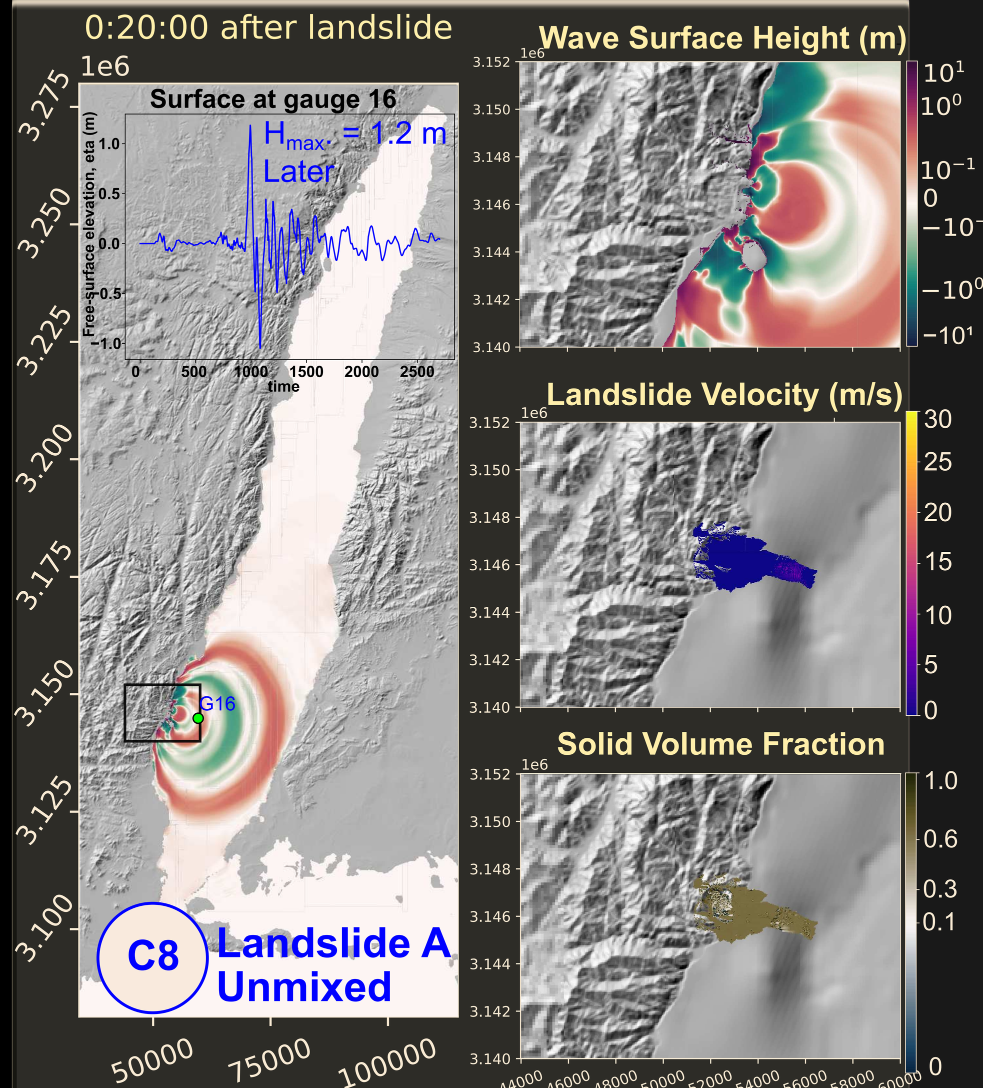


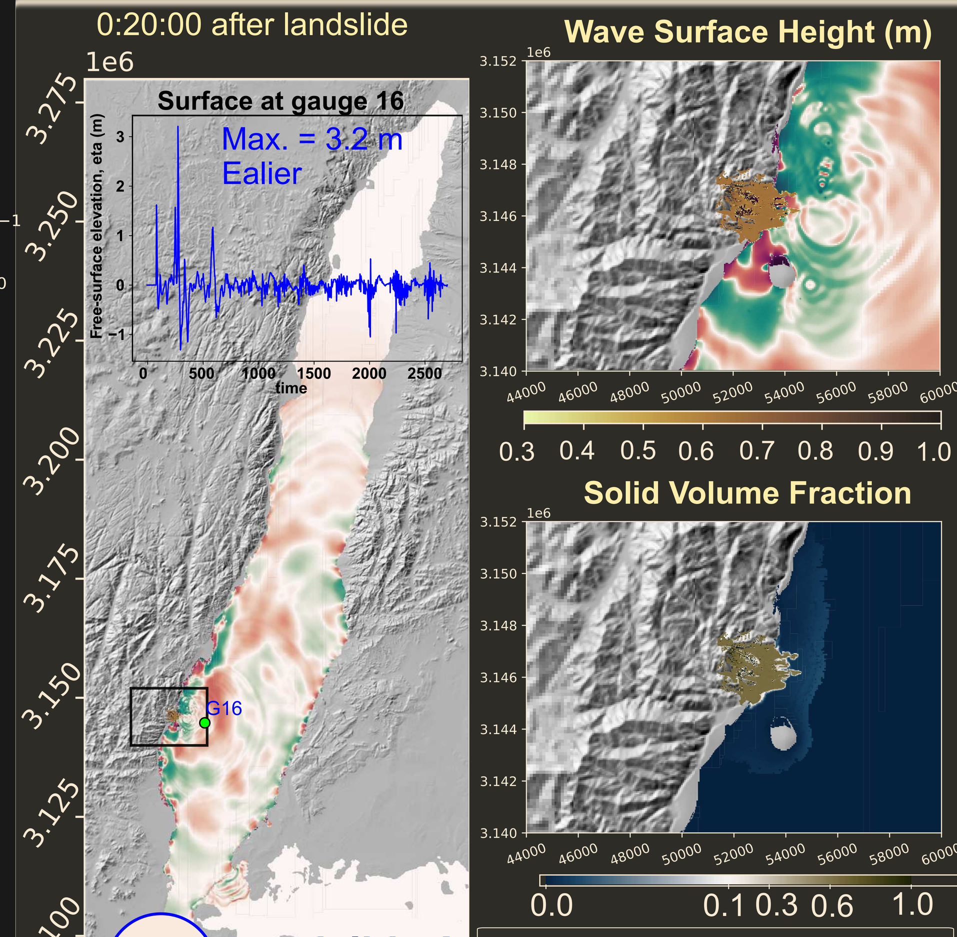
All Cases → Angles → Flow Model → Material Behavior m → Permeability K

- Flow Model: Mixed, Unmixed
- Material Behavior m: Contractive, Non-Contractive
- Permeability K: 10^{-8}, 10^{-10}

No. cases = N angles × 2 × 2 × 2 , for each landslide site

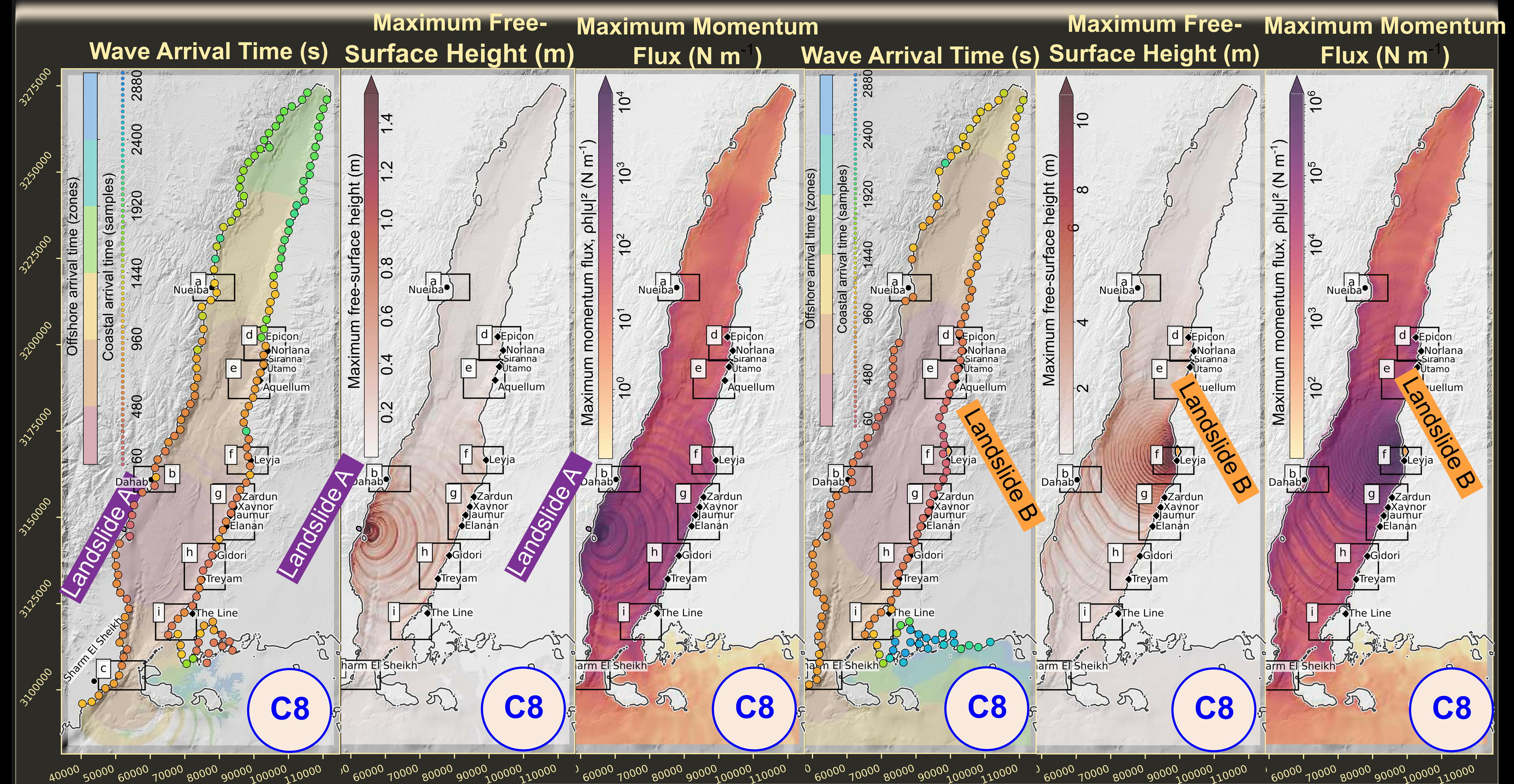
Results



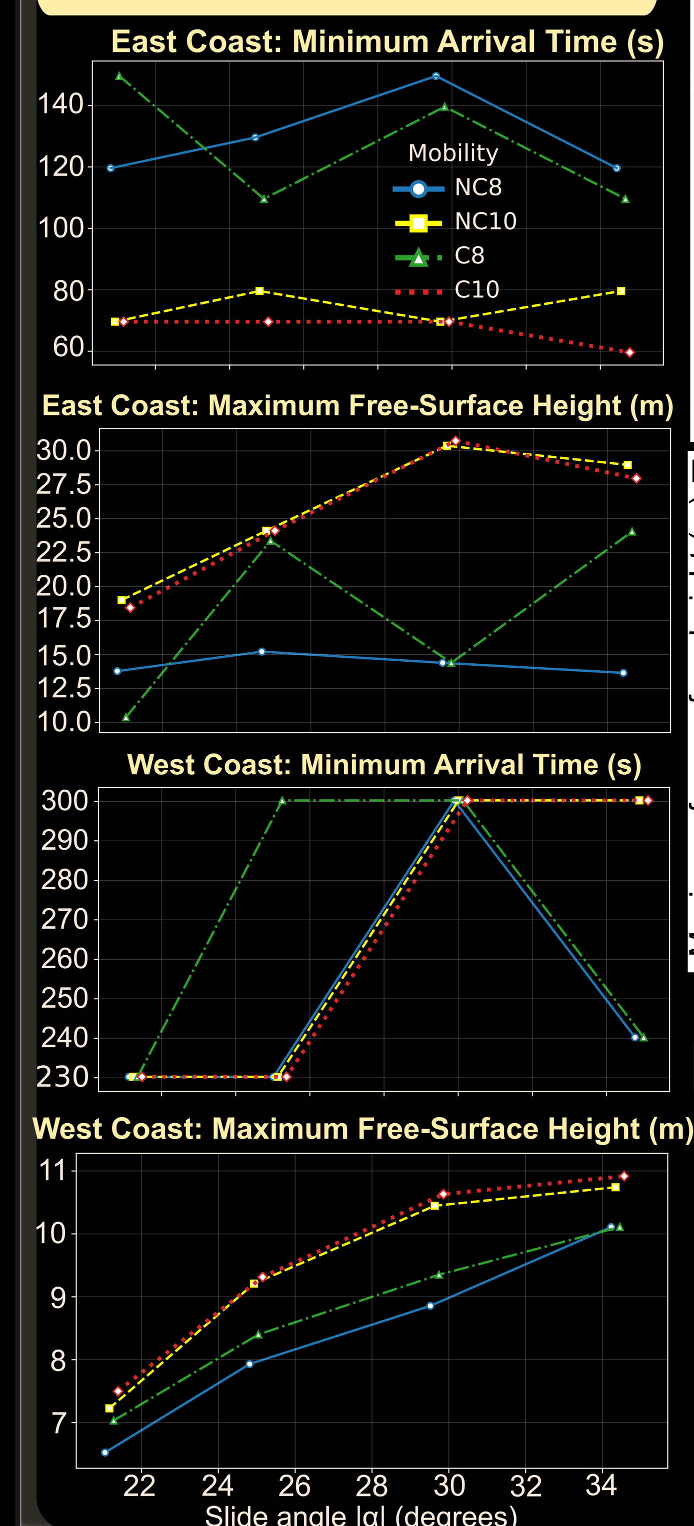


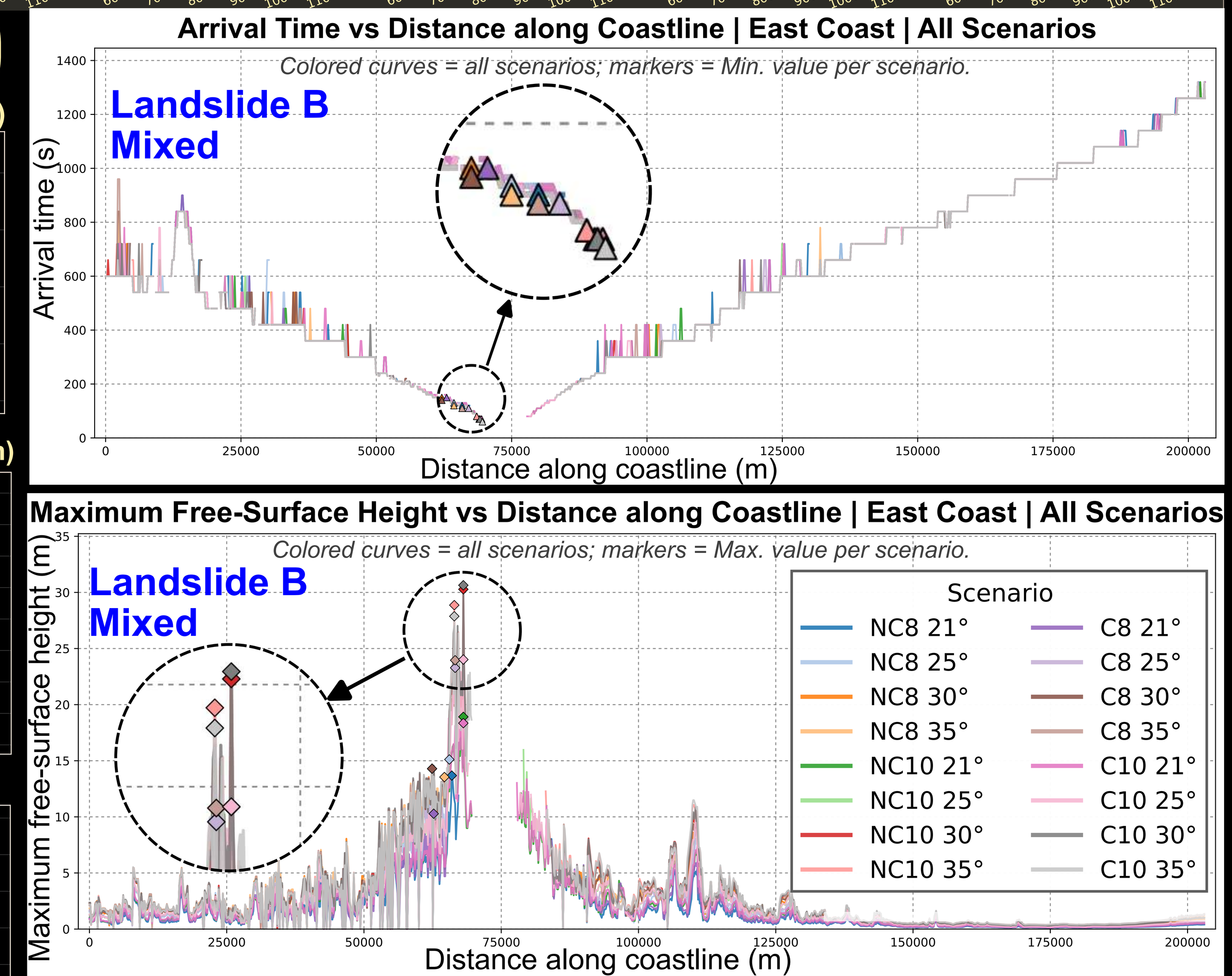
Plow-type landslides
D-Claw → dtopo → GeoClaw
✗ incomplete source coupling
⇒ not guaranteed conservative

Discussion



Landslide B, Mixed



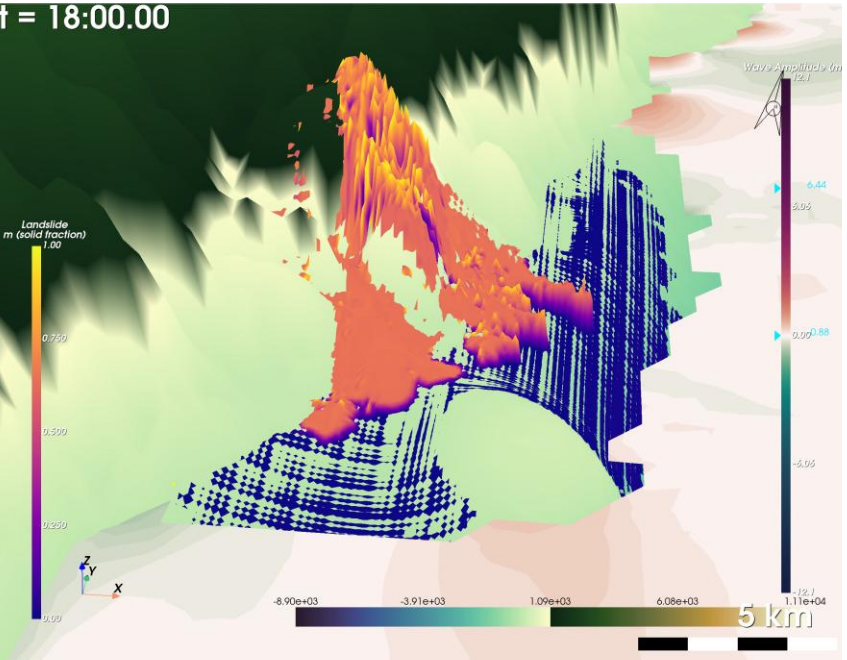


Conclusions

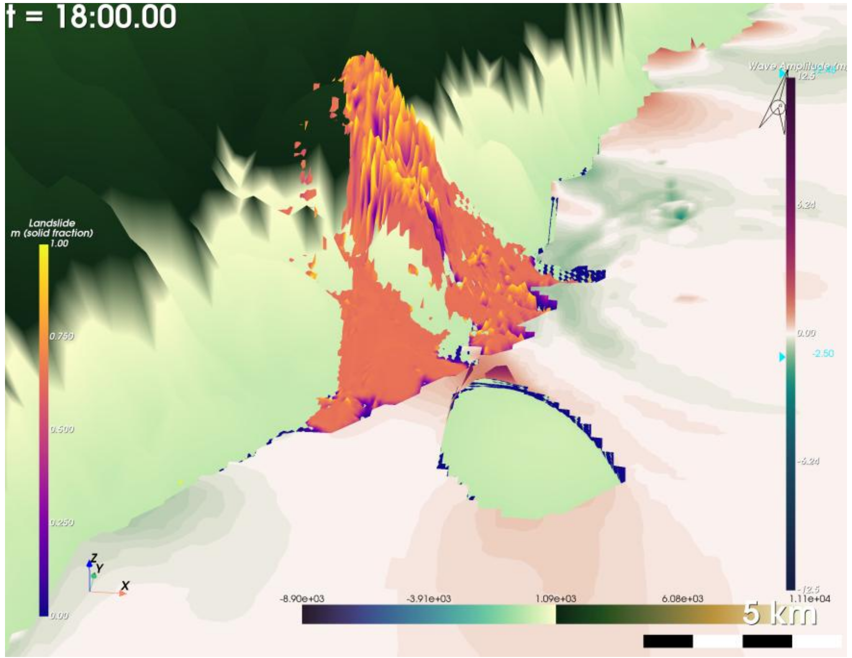
- Wave generation is controlled by landslide volume and mobility. Contractive, low-K material can sustain pore pressure and prolong rapid motion, amplifying plow-type tsunami generation.
- Source location controls coastal wave heights; the narrow Gulf produces rapid arrivals and ~50 min of reflected/sloshing waves, strongest near the source.

Postprocess & Analysis for LS A: *visual aids, physical quantities*

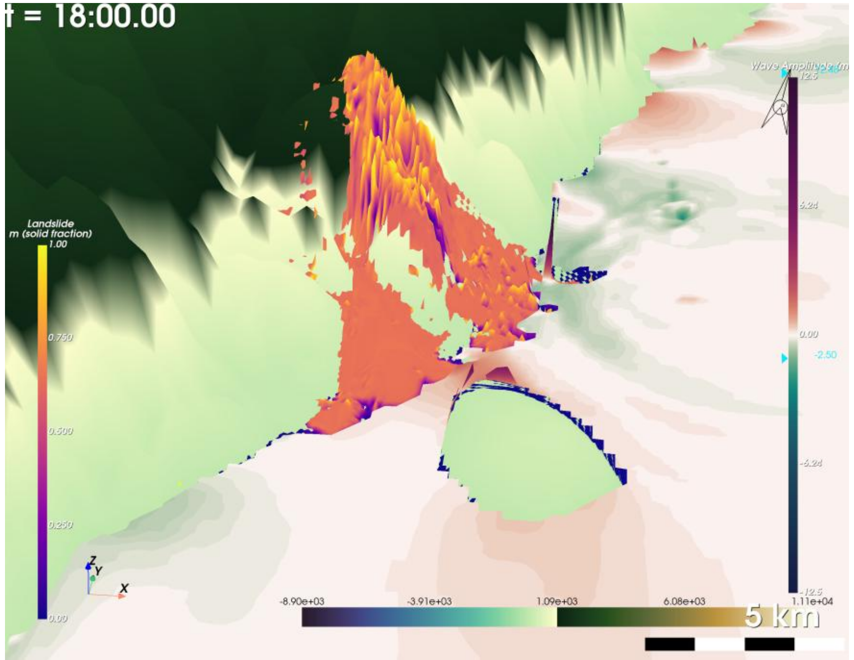
3D view, FGOUT



mw = 0.001



mw = 0.1



mw = 0.3

- When ‘m’ is close to pure seawater, the water surface nearfield is missing!
- ‘m’ = 0.3 is good enough to reconstructed water surface in that zone.

Non-landslide inundation

- Fgmax is '*online recording*' → time can be varying
- Fgout is frame by frame → time is fixed & coarse

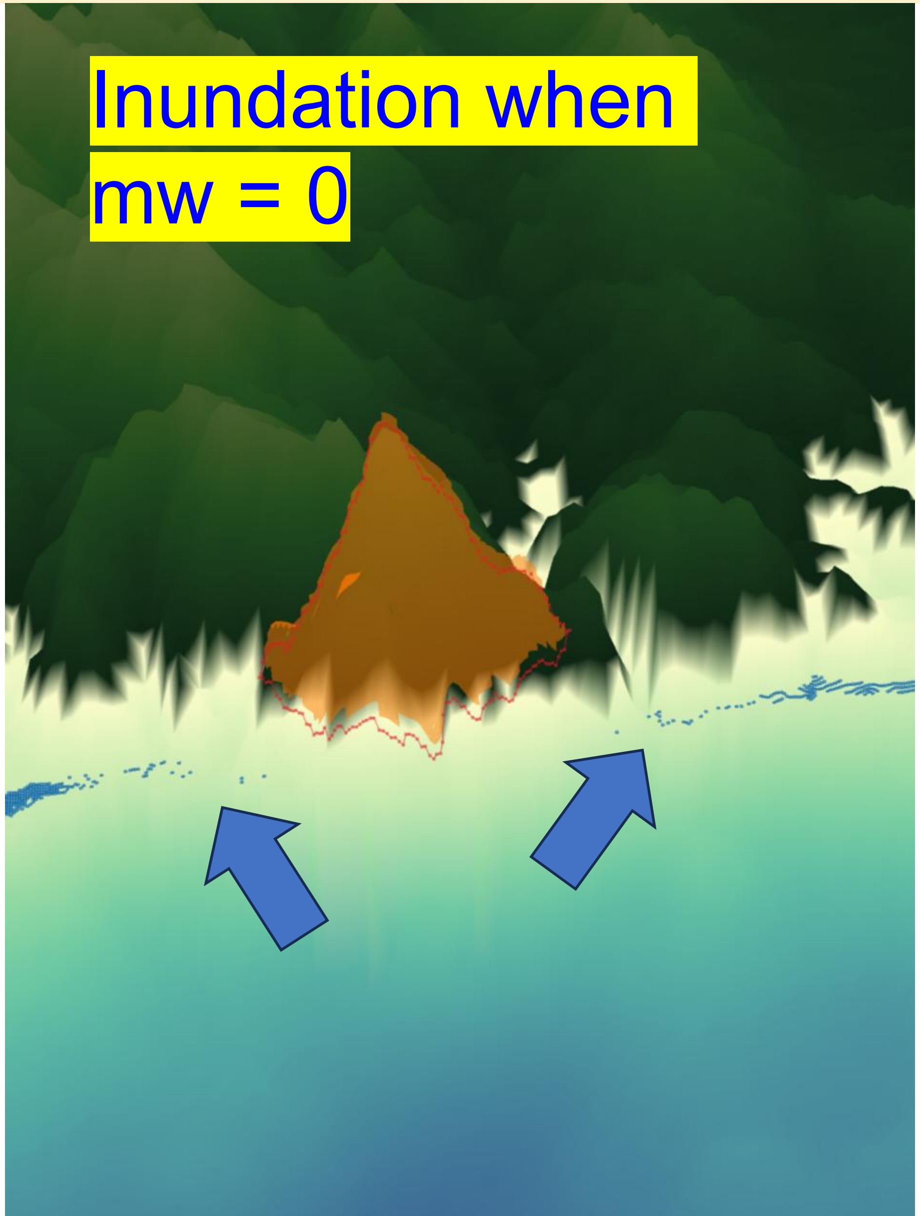
Before revision:
All wet cells
(m < 1)

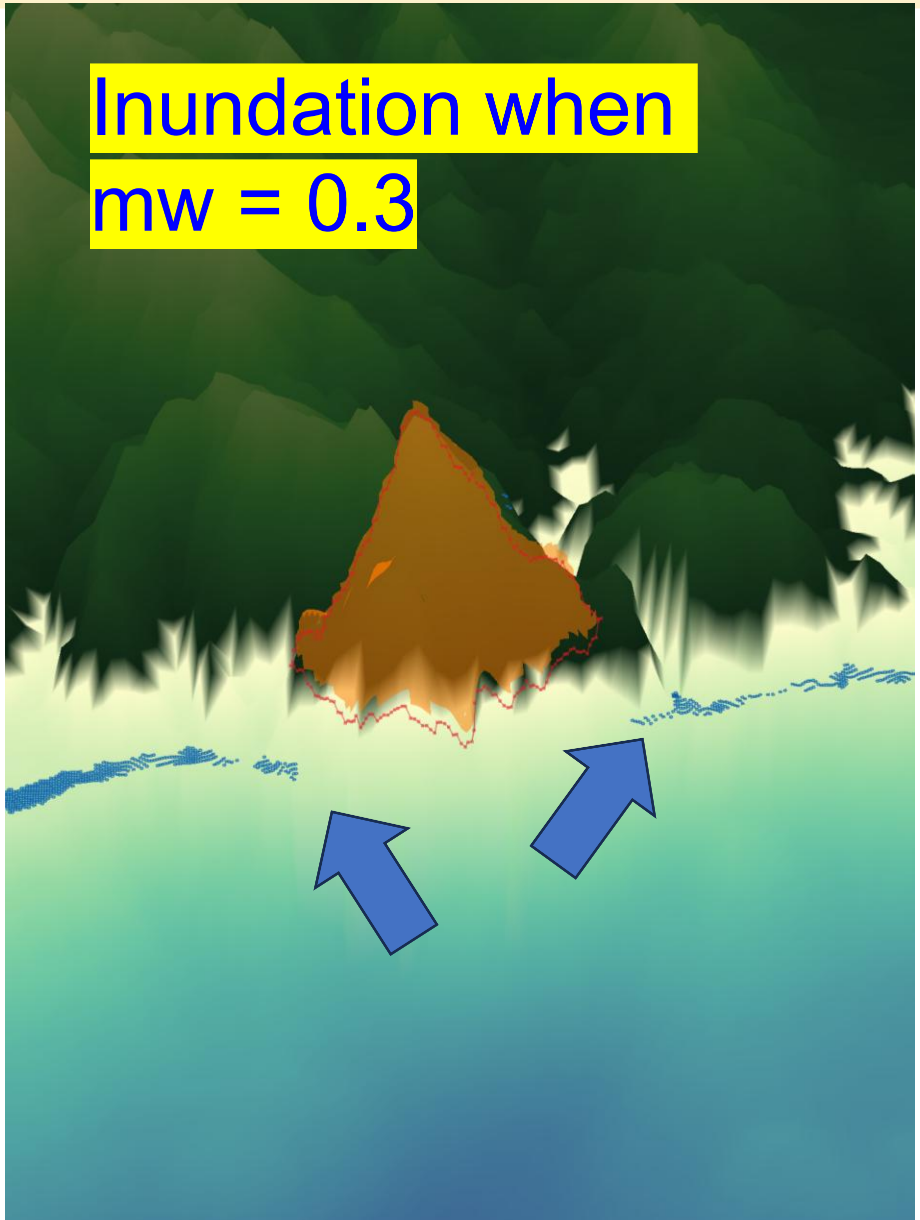
Inundation criterion:

1. inland = (B > sea_level)
2. wet = (hmax > h_thr)
3. water_only = (m_at_hmax <= m_thr) ← The key to "rule out landslide, but also include $m_{0.3}$"
4. mask_water = inland & wet & water_only

Now:
Collect right cells for inundation (m <= 0.3)

Postprocess & Analysis for LS B： *inundation map*





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Supplement

Postprocess & Analysis for LS B: *inundation map*

Intuition fails

- "Wet" does **not** mean "water-only" in D-Claw.
- In the full FGMAX grid, landslide-related cells look negligible: **2.19%**.
- In the actual **inundation-relevant inland-wet subset**, they jump to **27.44%**.

What we changed

- We patched FGMAX to save **m_at_hmax** at the exact moment when **hmax** is updated.
- This lets us split inundation into:
  - **Water-only**
  - **Landslide-related**

Why it matters

- Otherwise, inundation footprints are systematically biased by mixed-phase cells.

References

1 Gulf of Aqaba and tsunamis

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2 Data source

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3 Model description

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