On the Job Training on

Tsunami Inundation Modelling and Mapping and Development of Tsunami Hazards Maps for Implementation of UNESCO-IOC Tsunami Ready Pilot Sites in Madagascar, Maldives, Seychelles and Sri Lanka

Hyderabad – India, 16–21 March 2026

TIMM 3.1: Model Setup, Grid Nesting & Boundary Conditions

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Learning Objectives

By the end of this session, participants will be able to:

Understand Model Run Structure

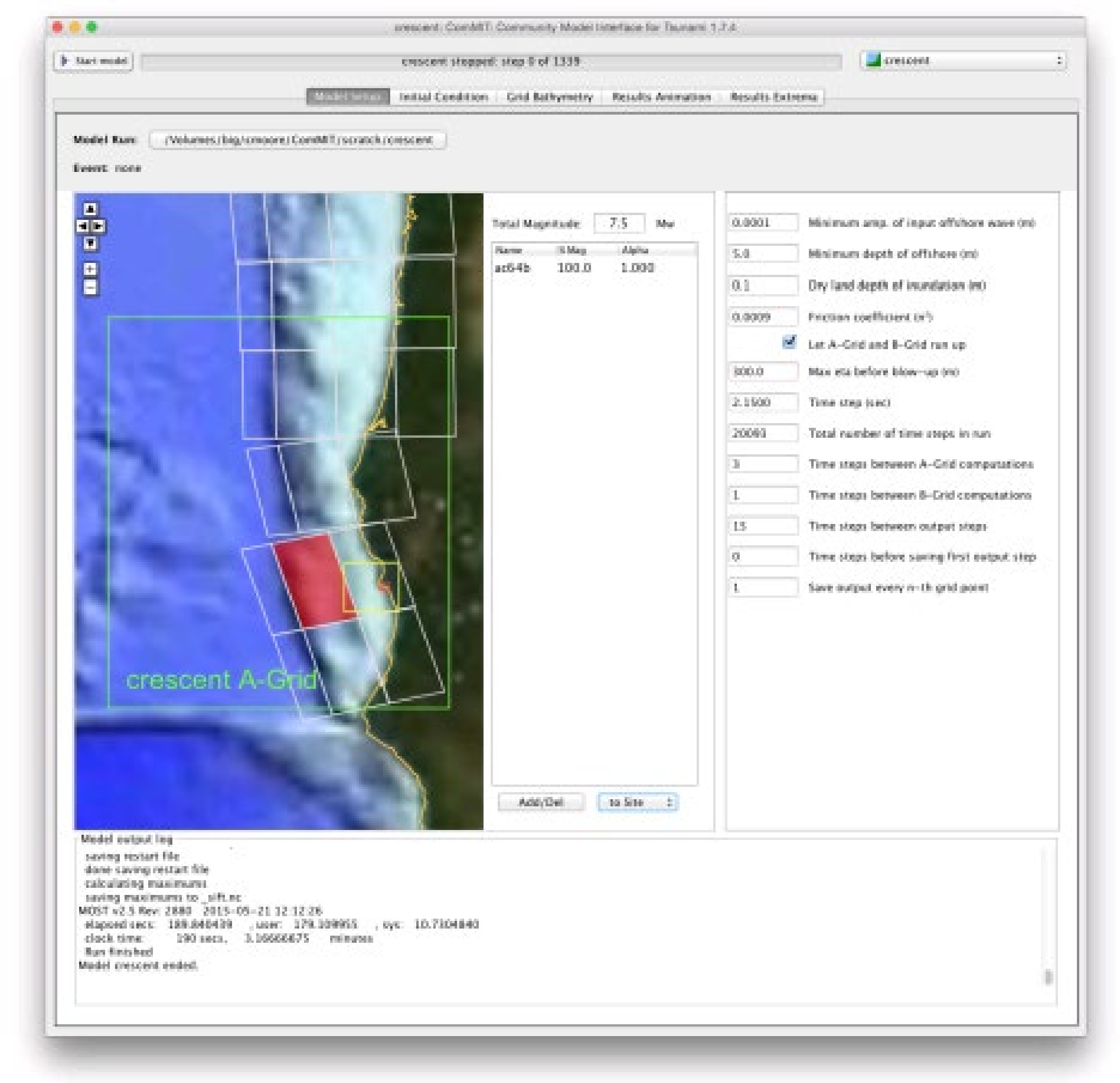
- Describe the three-grid nested system (A, B, C) used in ComMIT/MOST
- Explain how grid resolution increases from outer A to inner C grid

Navigate the ComMIT Interface

- Use all 5 tabs: Model Setup, Initial Condition, Grid Bathymetry, Results Animation, Results Extrema
- Load a Model Run, select Unit Sources, and configure model parameters

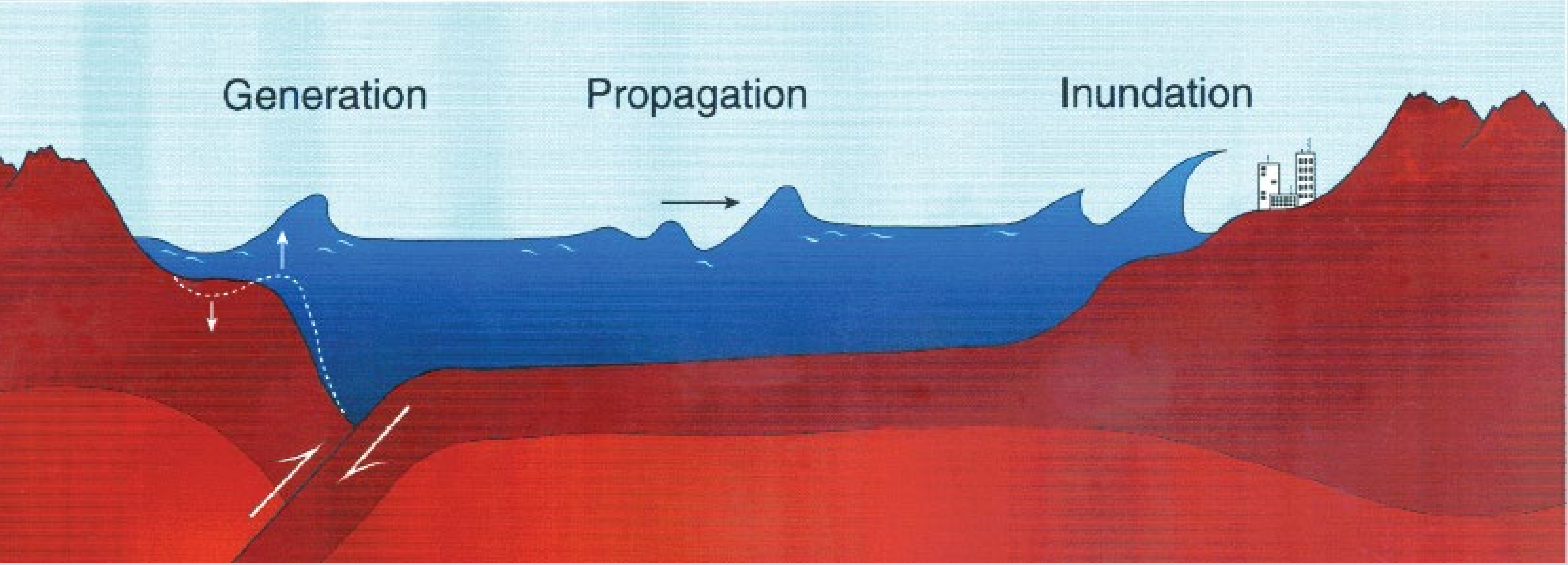
Create and Configure Model Runs

- Use the New Model Run Wizard to define A, B, and C grids
- Set boundary conditions and key MOST model parameters correctly



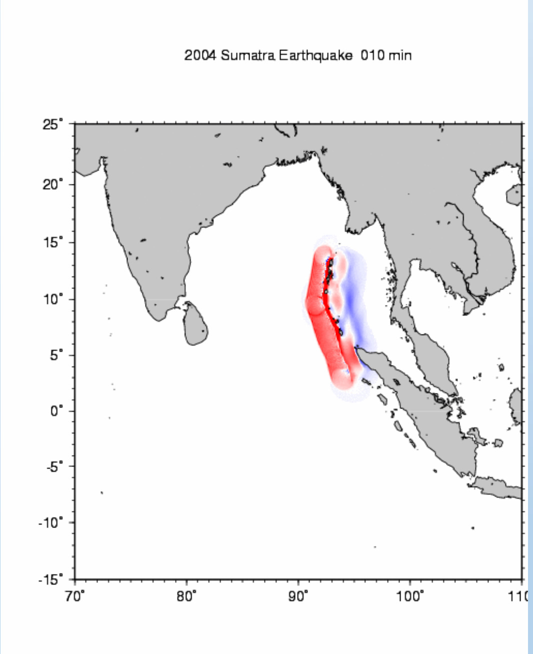
Tsunami Modelling and Forecasting

Tsunami Models



Tsunami Modelling and Forecasting

What are the required inputs to modelling software and outputs from modelling software?



inputs:
- source
- deepwater bathymetry
- nearshore bathymetry (50m resolution)
- onshore topography

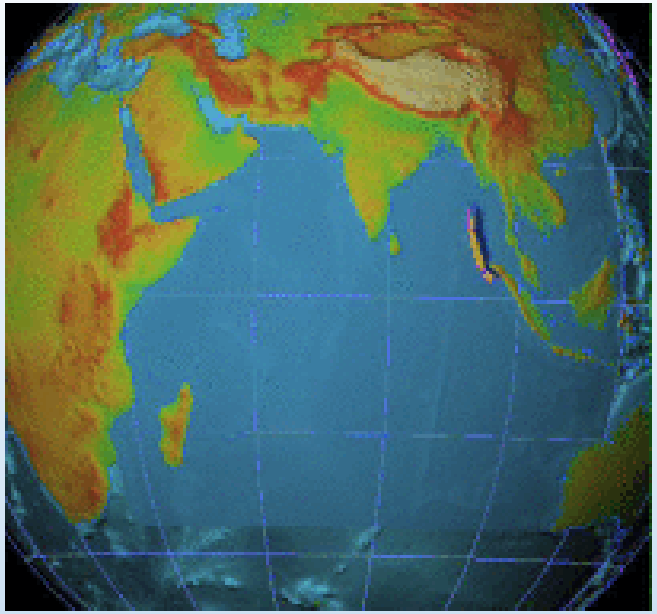
outputs:
- distribution of wave heights
- run-up heights
- given locations

Tsunami modelling framework

- Source ← Sub-sea earthquake, landslide
- Deep water propagation ← Offshore bathymetry (refraction, reflection)
- Near shore propagation ← nearshore bathymetry (refraction, reflection)
- Inundation ← onshore topography

ICG/IOTWS Working Group 2

Modelling, Forecasting and Scenario Development



- Provide benchmarked and validated numerical modelling methods and software applicable for use in the Indian Ocean
- Develop and sustain national and regional capacity to apply numerical modelling for tsunami source generation, wave propagation, and coastal inundation in the Indian Ocean

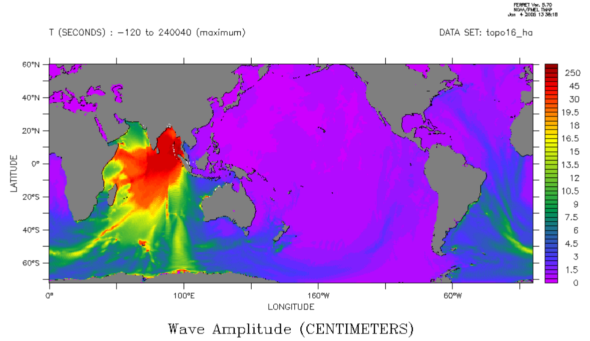
ICG/IOTWS Working Group 2

Facilitate the development of a web-based Community Model Interface for Tsunami (ComMIT)

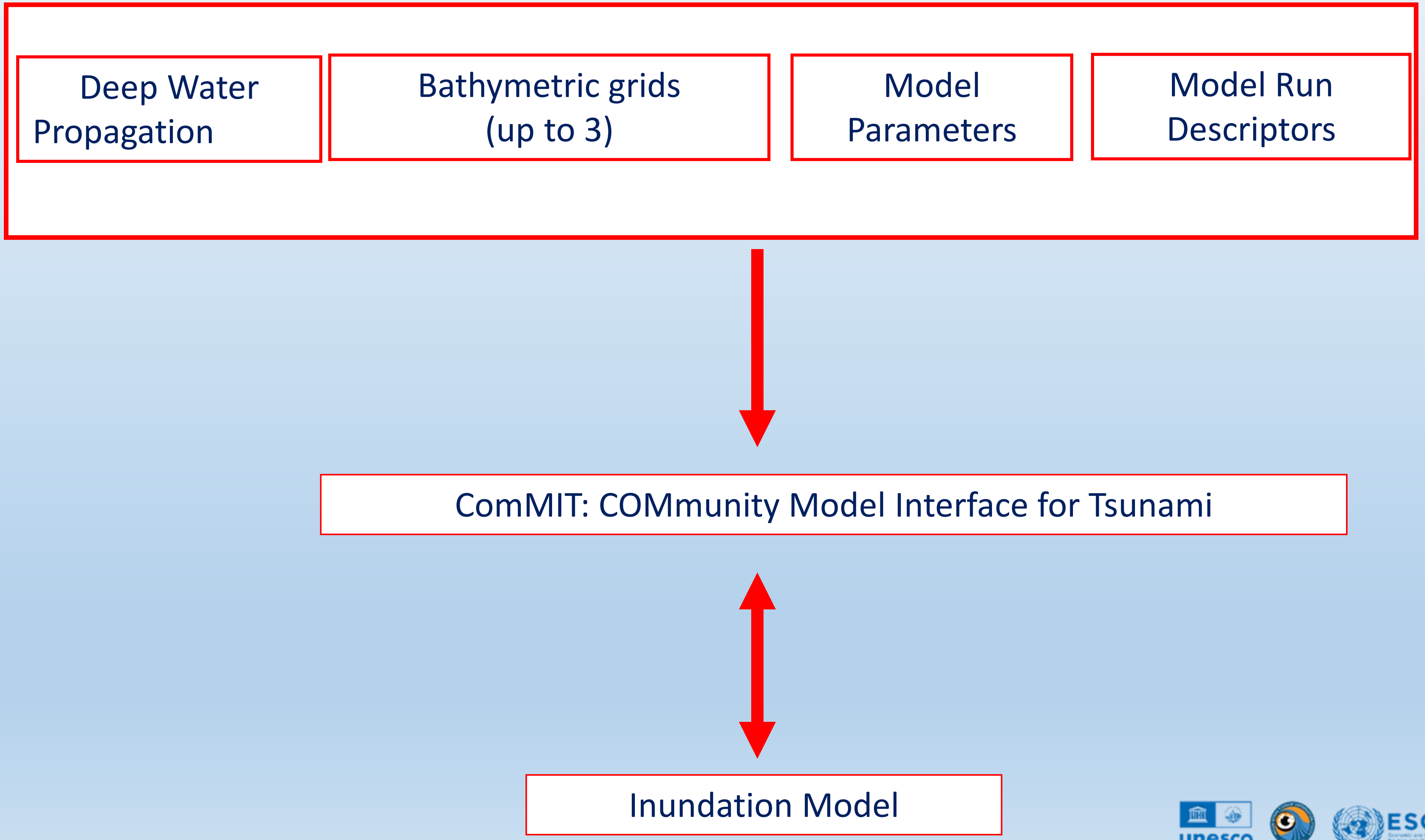
(developed by NOAA/PMEL through USAID funding) model

- ComMIT provides propagation and inundation mapping capability to countries of the Indian Ocean region.

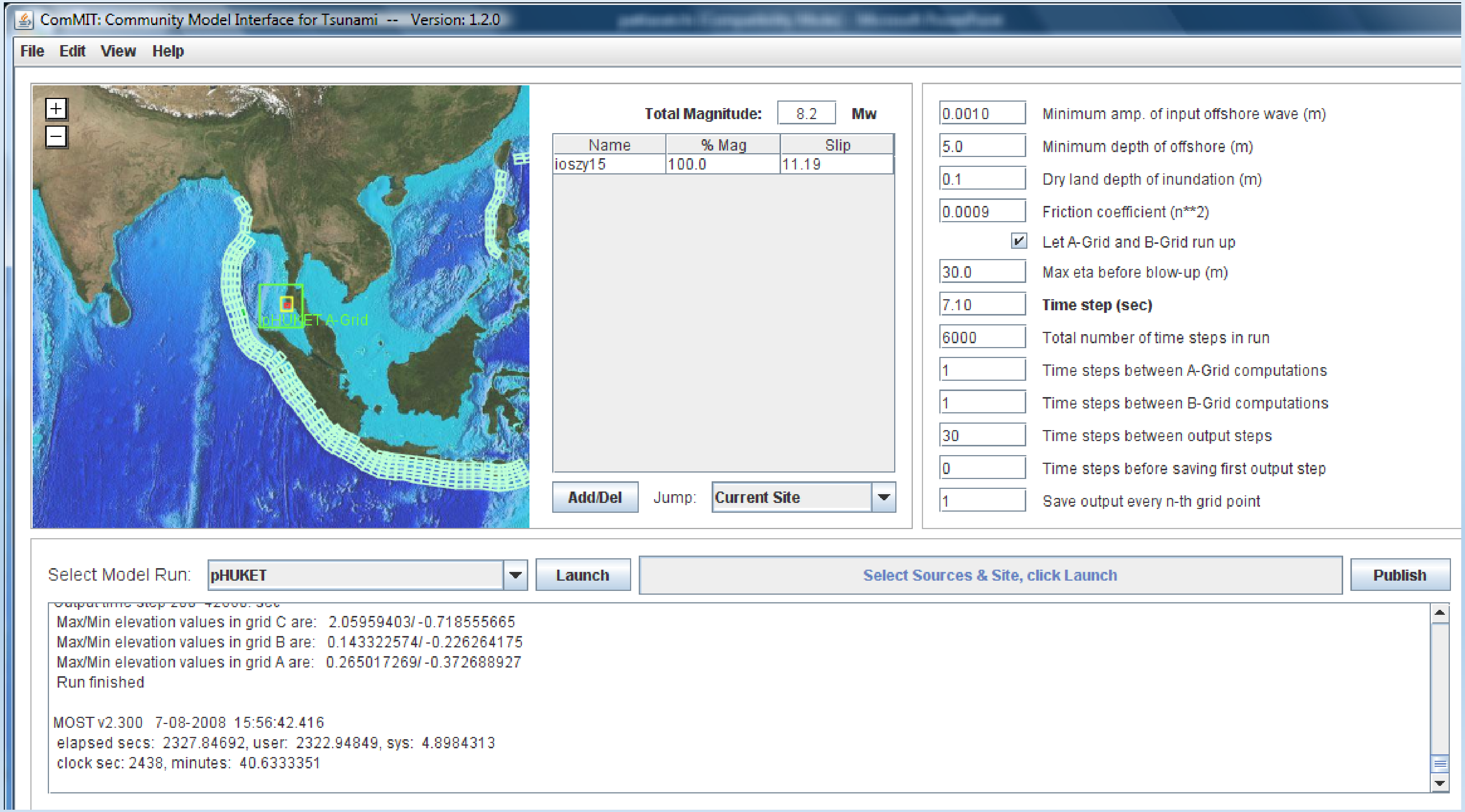
- The model system includes access to pre-computed deep water propagation scenarios.



ComMIT


Deep Water Propagation
Bathymetric grids (up to 3)
Model Parameters
Model Run Descriptors
ComMIT: COMmunity Model Interface for Tsunami
Inundation Model

ComMIT
Community Model Interface for Tsunami



What is a Model Run?

Definition

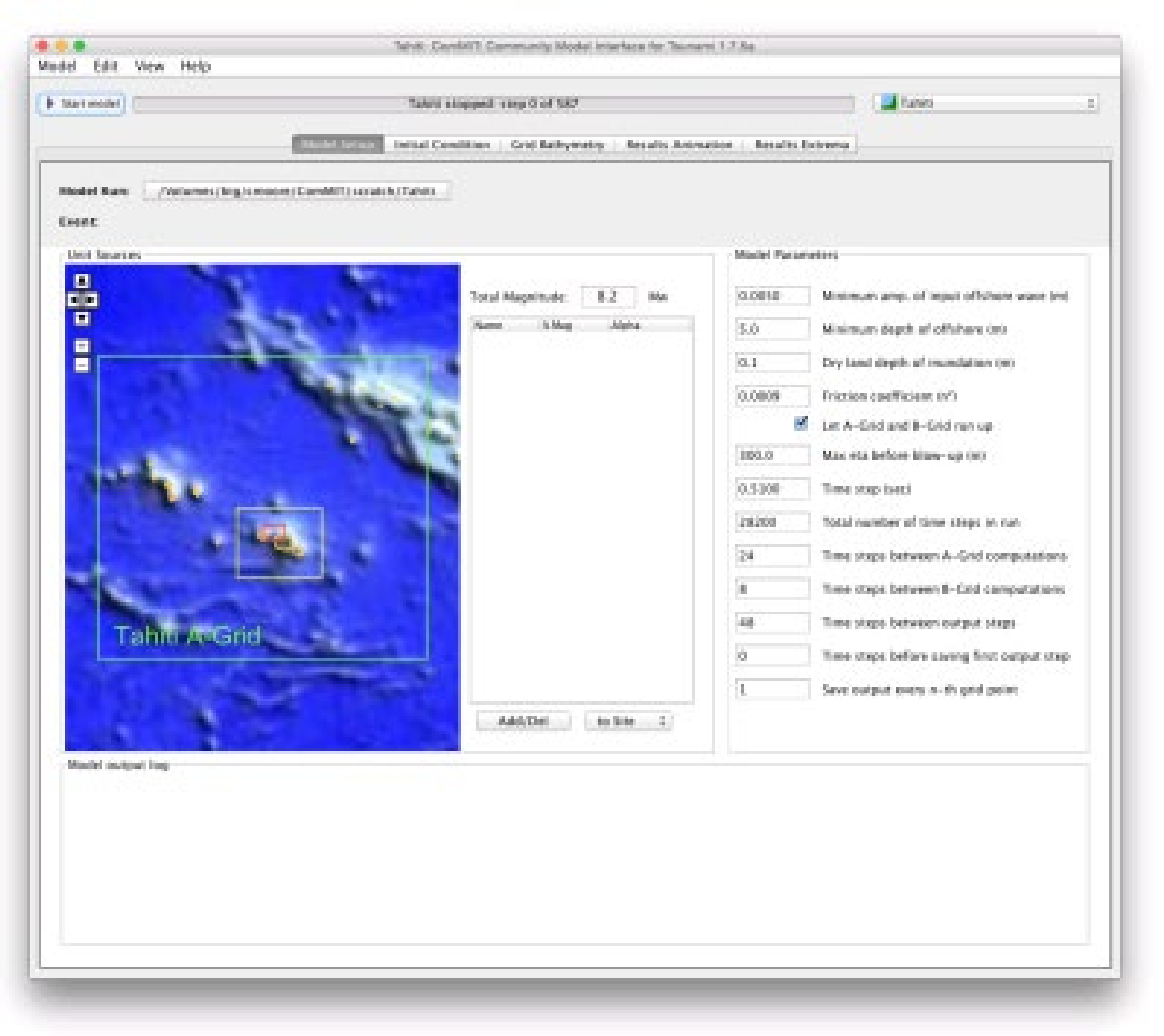
- A Model Run is a folder containing all files needed to run a tsunami inundation simulation
- Contains three nested bathymetry grid files (A, B, C) and a MOST model parameters file
- Results are preserved unless explicitly cleared — can be opened, closed, or exported at any time

Three Key Components

- A-Grid: Low-resolution outer grid — captures regional wave propagation
- B-Grid: Medium-resolution intermediate grid — resolves nearshore wave dynamics
- C-Grid: High-resolution inner grid — computes detailed coastal inundation

Quick Test

- Go to Model > Open Model Run > “Crescent” — a ready-to-run example for Crescent City, California
- Click any white Unit Source rectangle, then press Start Model to run



The Three-Grid Nested System (A, B, C)

Why Nested Grids?

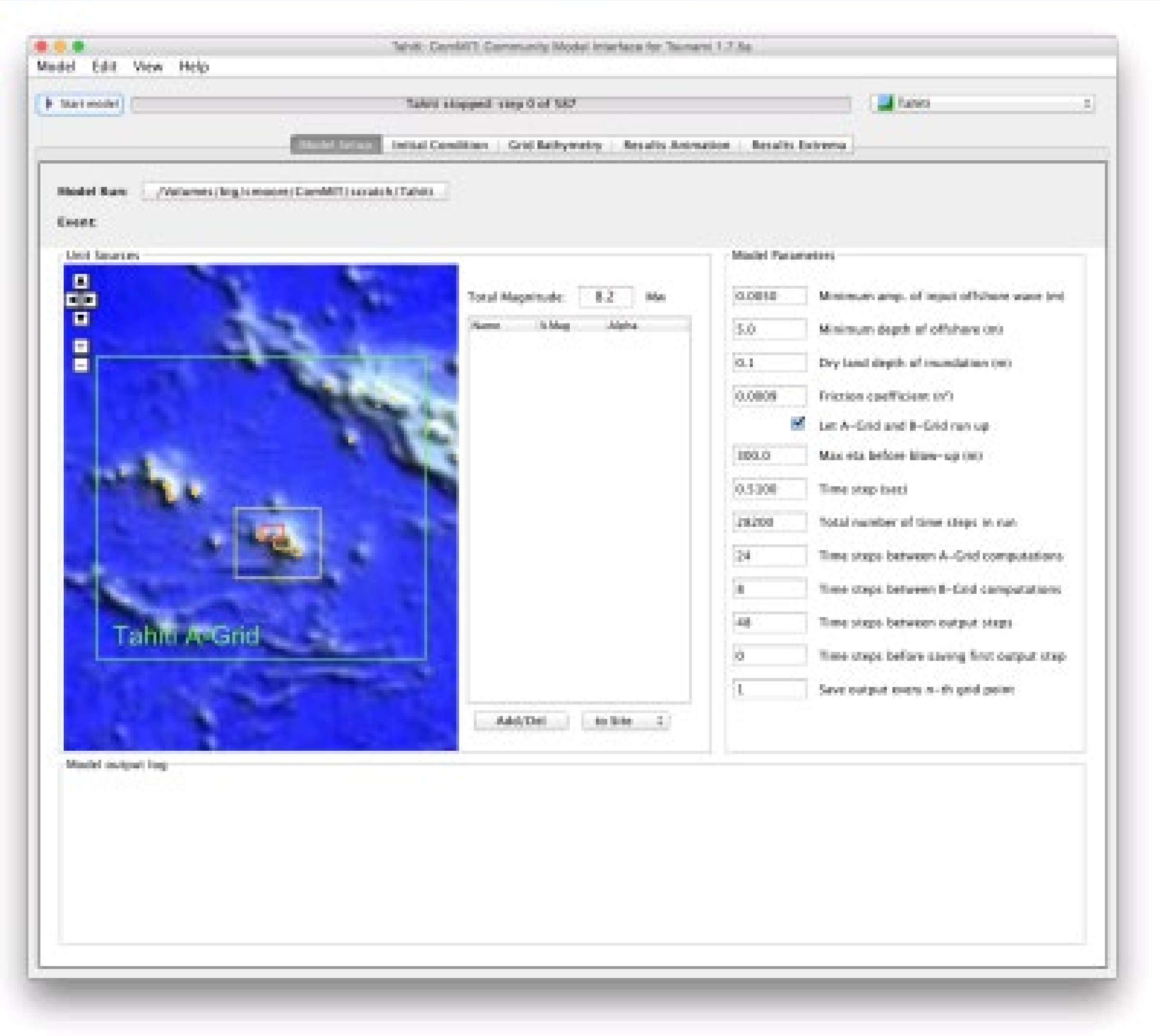
- Nested grids balance computational efficiency with local accuracy
- Allows simulation from ocean-basin scale down to individual street level
- Each inner grid receives boundary conditions computed by the outer grid

Grid Characteristics

- A-Grid (green): Coarse ~120 arc-sec; spans the tsunami propagation basin
- B-Grid (yellow): Medium ~10-30 arc-sec; captures nearshore shelf and wave transformation
- C-Grid (red): Fine ~2-3 arc-sec or less; resolves inundation, run-up, and flow depth

Nesting Rule

- C-Grid must be entirely inside B-Grid; B-Grid must be entirely inside A-Grid
- Resolution ratio between adjacent grids: typically 3:1 to 10:1 for numerical stability



The ComMIT Interface — Overview

Main Controls at the Top

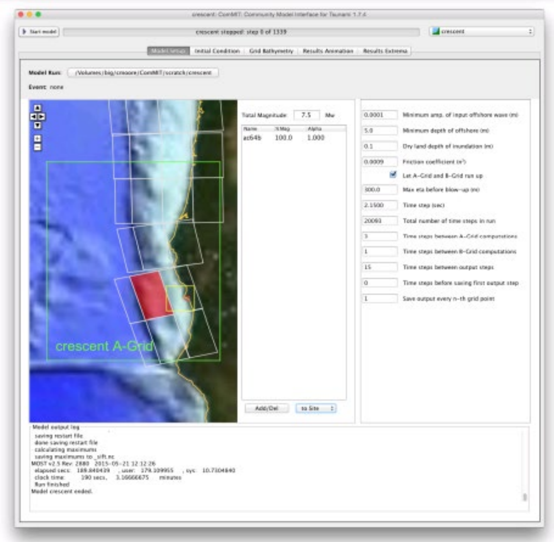
- Start Model button — initiates the tsunami model run
- Progress Bar — shows real-time completion percentage at the top of the window
- Model Run Selector — dropdown to choose which Model Run is currently active

Five Interface Tabs

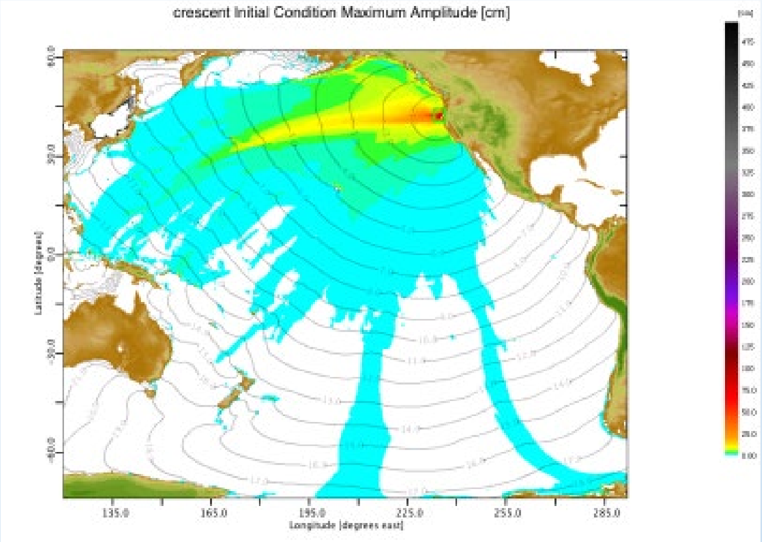
- Model Setup — Unit Source map, grid overlay, model parameters
- Initial Condition — pre-computed propagation wave amplitude and arrival time map
- Grid Bathymetry — color-contour plots of A, B, C grid bathymetry and topography
- Results Animation — animate wave amplitude, velocity vectors, and time series
- Results Extrema — Max Amp, Flow Depth, Min Amp, Max Speed over the run

Platform

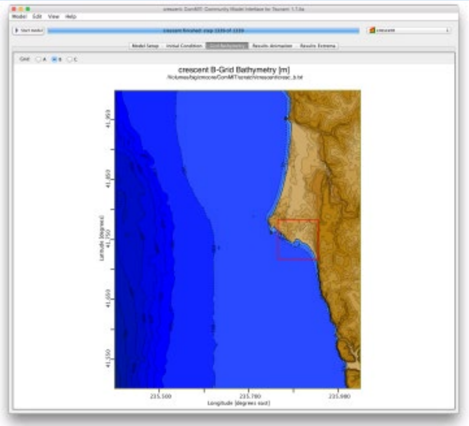
- Written in Java — platform-independent: runs on Windows, Mac, and UNIX
- Uses netCDF file format for all model input and output



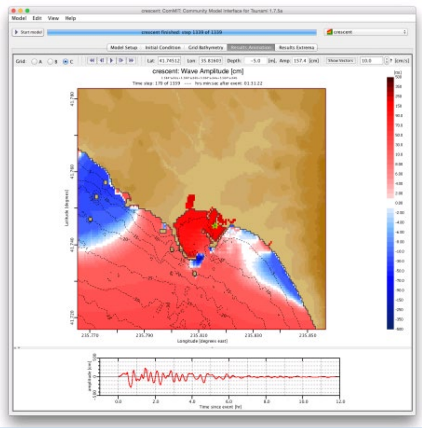
Model Setup



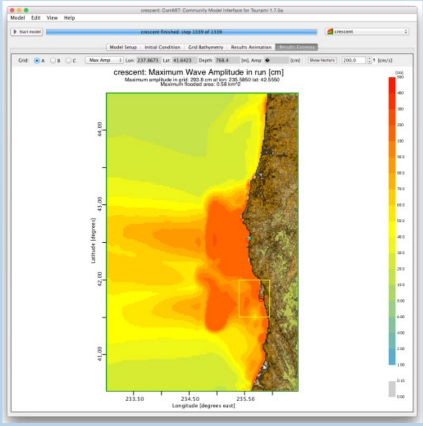
Initial Condition



Grid Bathymetry



Results Animation



Results Extrema

Model Setup Tab — Unit Source Map

Map Display

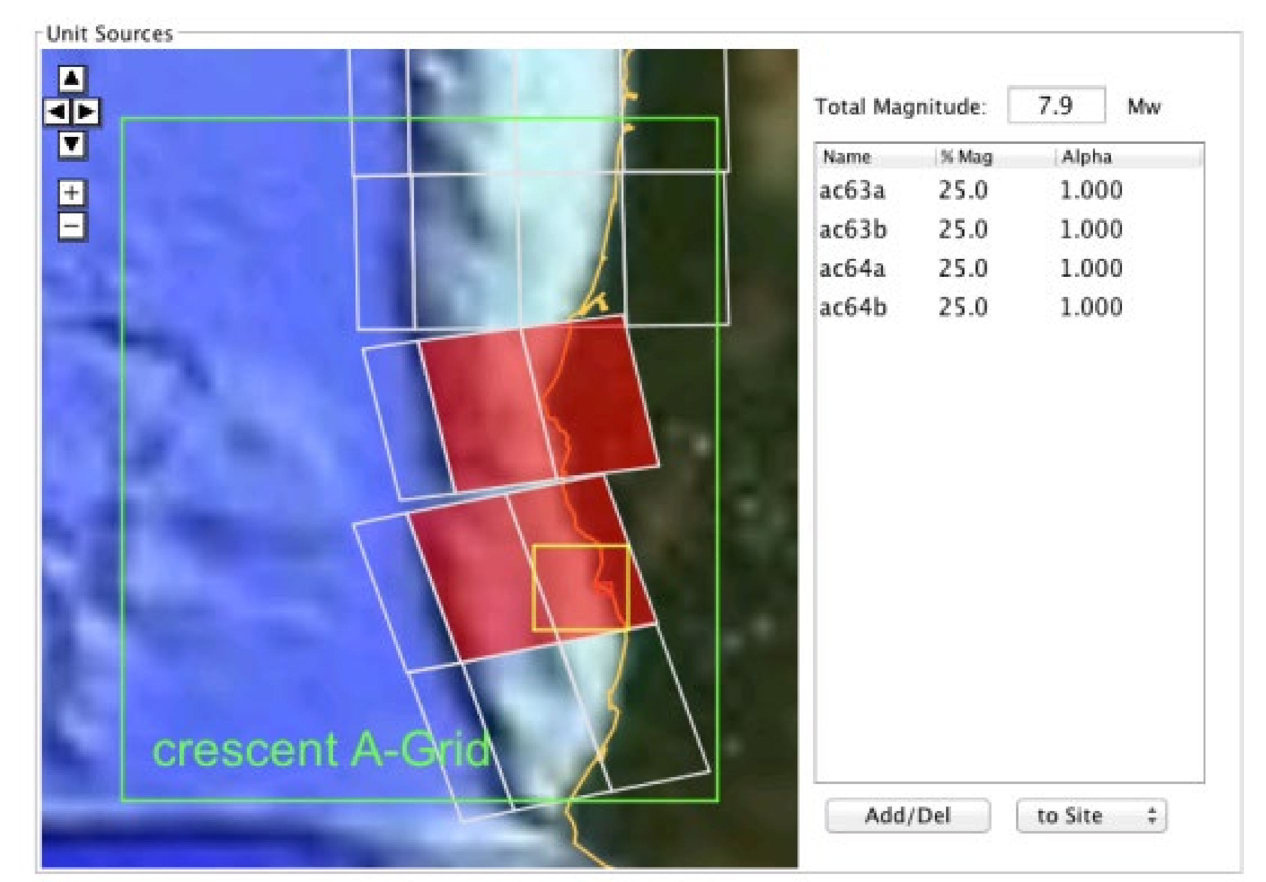
- Shows current Model Run with all three nested grids overlaid on a regional map
- Pan by clicking and dragging; zoom with mouse wheel or +/- buttons
- Drop-down list to jump between model site and distant Unit Sources

Unit Sources (White Rectangles)

- Each white rectangle = a seismic fault plane from NOAA's propagation database
- Identified by subduction zone code: "ac" = Aleutian-Cascadia, "ki" = Kamchatkai-Yap, etc.
- Click to select — selected sources turn red on the map
- Use Add/Del button to search and select Unit Sources by name

Alpha Coefficient Table

- Controls the relative energy contribution of each selected Unit Source
- Default Alpha = 1.0 per source; adjust to scale the magnitude contribution
- Total moment magnitude (Mw) displayed in table — can be edited directly



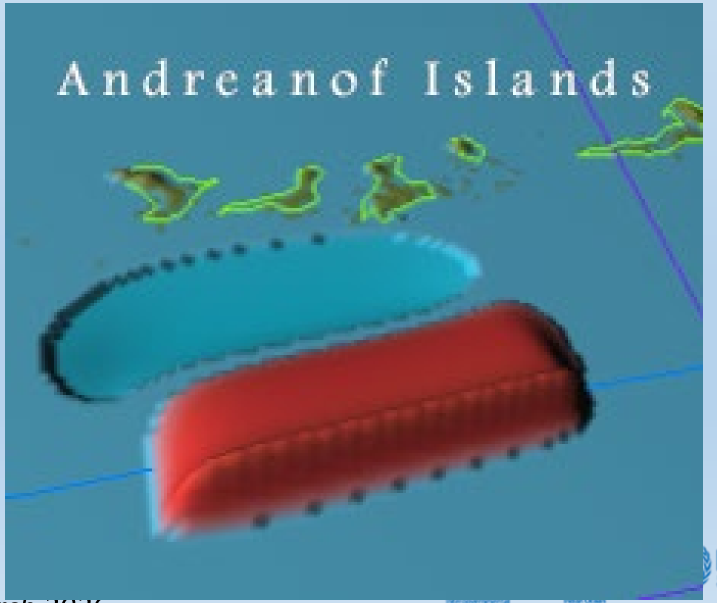
Source Characterisation: Unit sources

Guidelines for maximum moment magnitude (M_w)

Maximum slip ~30m (2004 was 20 m)

1 unit = 100x50 km

1 unit	8.5
2 units	8.7
4 units	8.9
6 units	9.0
10 units	9.2



Unit sources: Examples

1 unit

Total Magnitude: 9.20 Mw

Name	% Mag	Slip
ioszb13	100.0	353.97

2 units

Total Magnitude: 9.2 Mw

Name	% Mag	Slip
ioszb12	50.0	176.99
ioszb13	50.0	176.99

4 units

Total Magnitude: 9.2 Mw

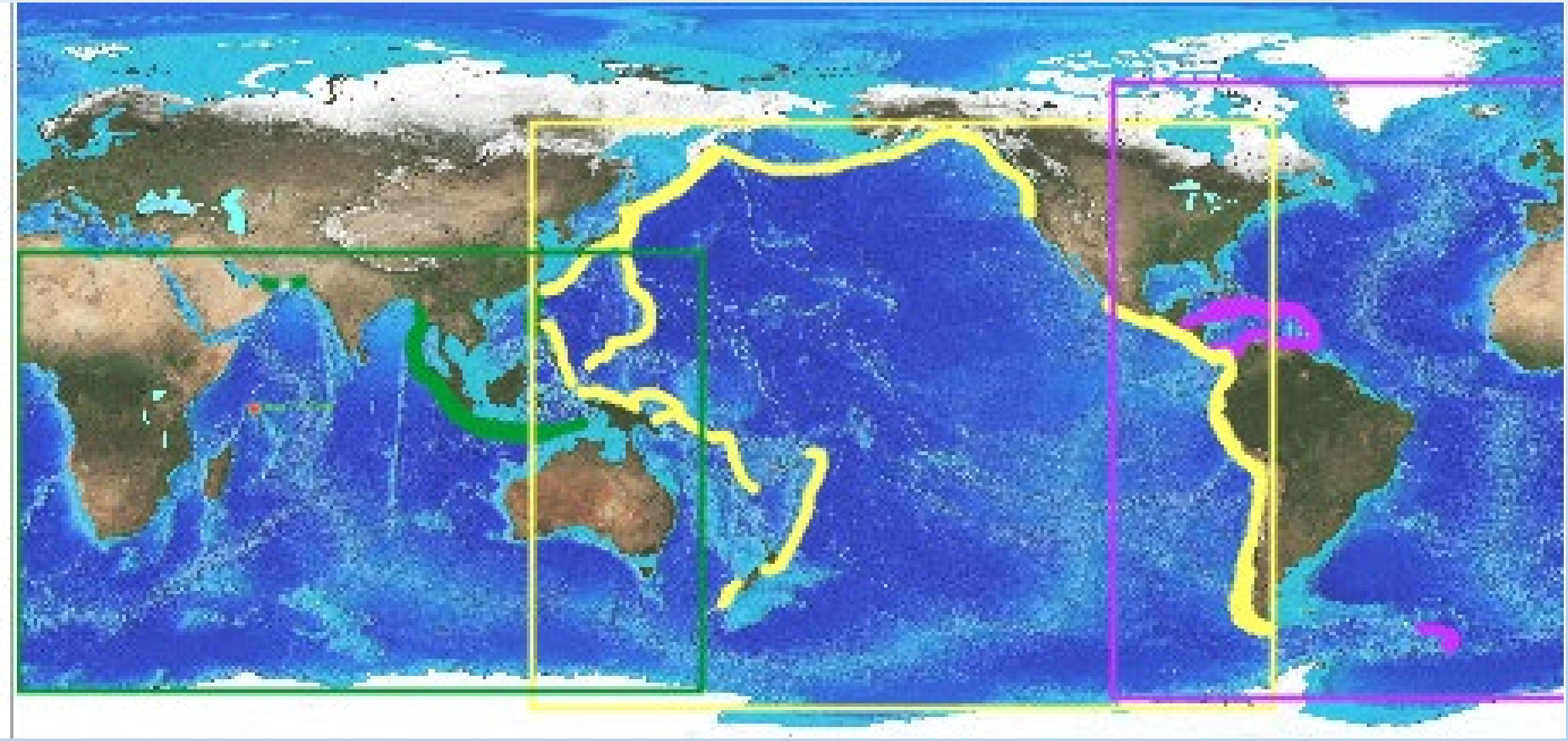
Name	% Mag	Slip
ioszb10	25.0	88.49
ioszb11	25.0	88.49
ioszb12	25.0	88.49
ioszb13	25.0	88.49

10 units

Total Magnitude: 9.2 Mw

Name	% Mag	Slip
iosza9	10.0	35.40
ioszb9	10.0	35.40
iosza10	10.0	35.40
ioszb10	10.0	35.40
iosza11	10.0	35.40
ioszb11	10.0	35.40
iosza12	10.0	35.40
ioszb12	10.0	35.40
iosza13	10.0	35.40
ioszb13	10.0	35.40

Tsunami Propagation model data base



Selecting and Weighting Unit Sources

Single vs. Multiple Sources

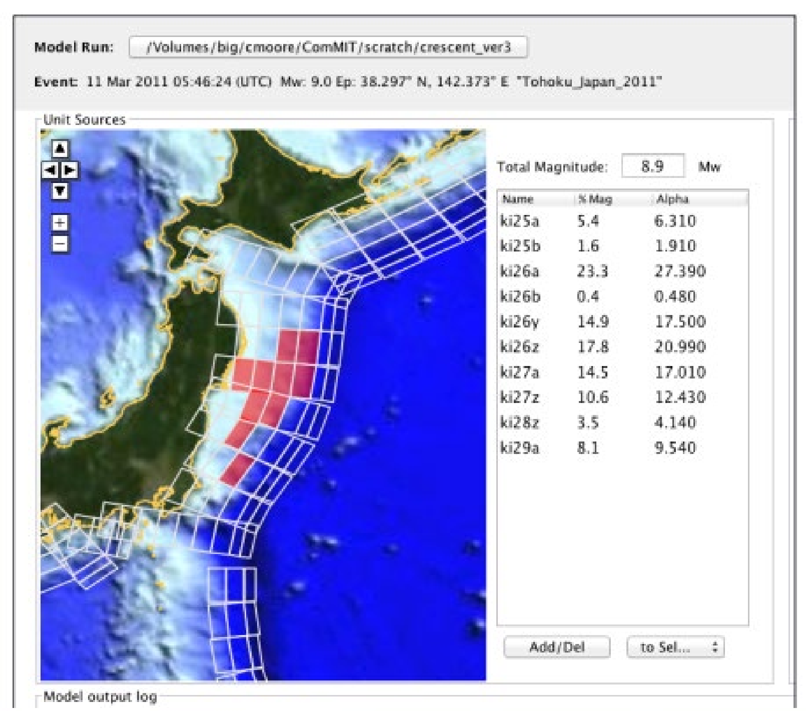
- Single Unit Source: point-source scenario — simple but may underestimate hazard
- Multiple adjacent sources: simulates extended fault rupture — more realistic for great earthquakes
- Example: 4 sources (ac63a, ac63b, ac64a, ac64b) with Alpha=1.0 each → Mw=7.9

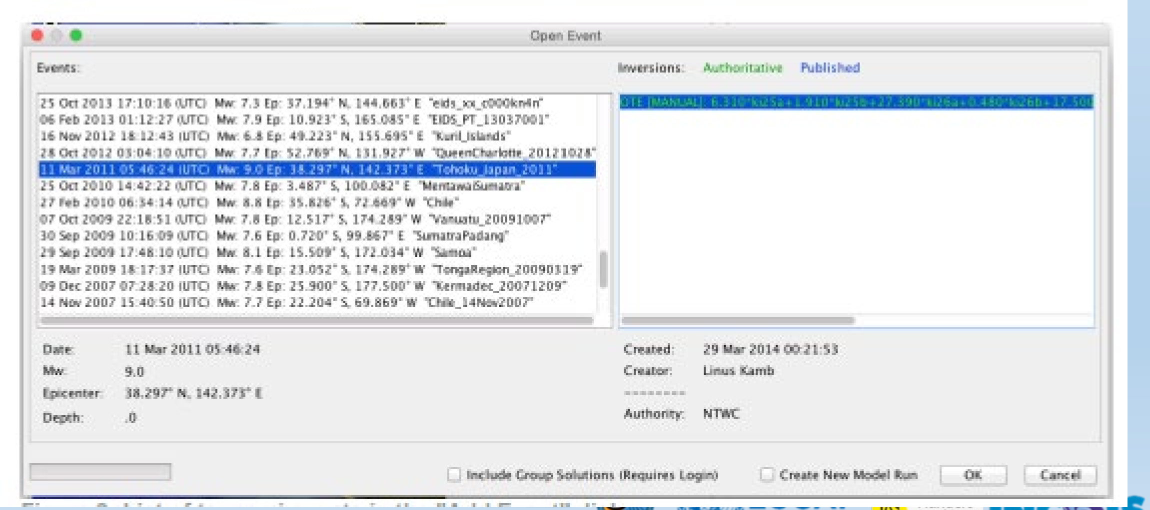
Adjusting Total Magnitude

- Method 1: Increase Alpha coefficient to scale energy of selected sources
- Method 2: Add more adjacent Unit Sources to extend the rupture length
- Method 3: Edit the Mw field directly — ComMIT recalculates Alpha automatically

Indian Ocean Sources for Pilot Sites

- Sunda Trench (Sumatra): primary source for Maldives, Sri Lanka, Seychelles, Madagascar
- Makran Subduction Zone: secondary source for western Indian Ocean sites
- Document your source selection rationale for the Tsunami Hazard Map report





Model Run Parameters — Part 1

Minimum Amplitude of Input Offshore Wave (m)

- Typical value: 0.0001 m — amplitudes below this threshold are ignored at A-grid boundary
- Set slightly above machine zero to prevent spurious activation from numerical noise

Minimum Depth of Offshore (m)

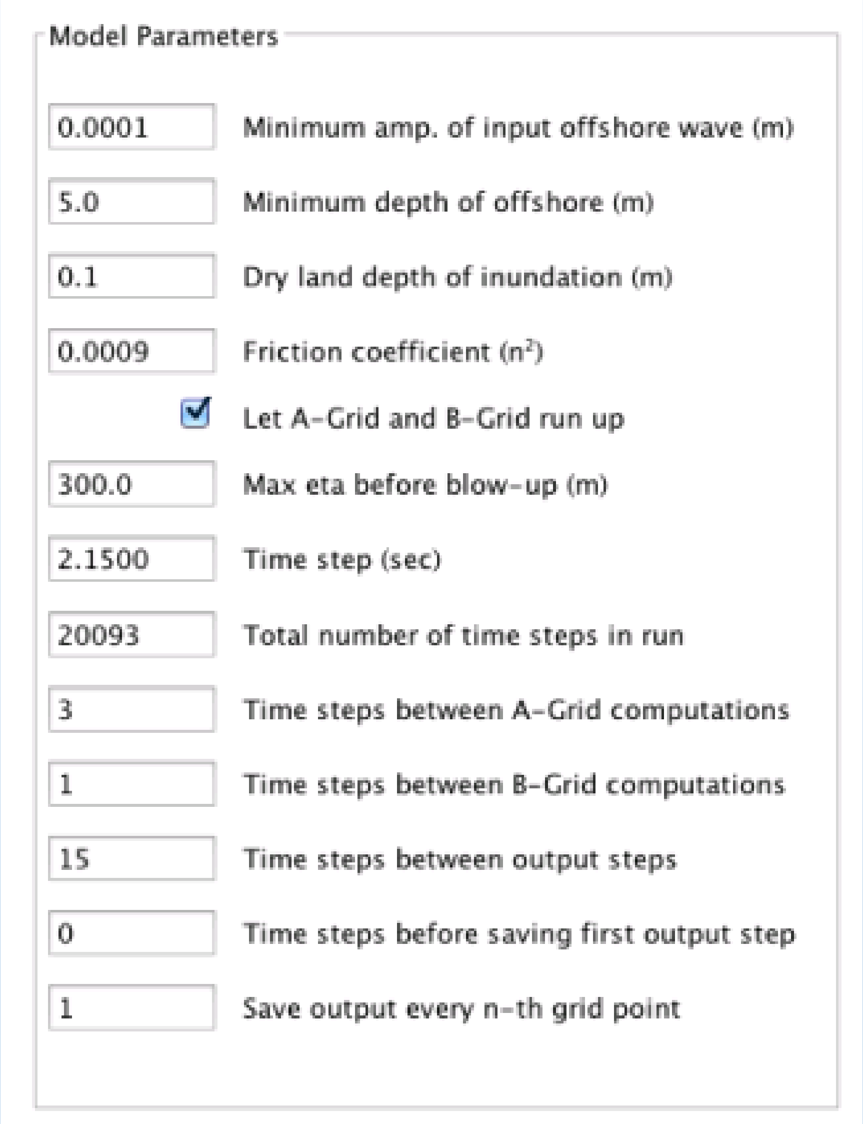
- Typical values: 5 – 10 m — depth at which reflective boundary conditions apply for A and B grids
- Defines the open-ocean/nearshore boundary treatment transition

Dry Land Depth of Inundation (m)

- Typical values: 0.1 – 0.3 m — minimum water depth for a cell to be computed ("wet")
- Cells below this threshold are treated as dry — sets the position of the moving shoreline

Friction Coefficient (n^2)

- Manning's n^2 — controls bottom friction retarding the flow through the model
- Default: 0.0009 — increase for vegetated or rough terrain if local data is available



Model Run Parameters — Part 2

Let A-Grid and B-Grid Run Up

- Checked (default): runup computed for all three grids
- Unchecked: A and B grids use a fixed reflective boundary — only C-grid computes inundation

Max Eta Before Blow-Up (m)

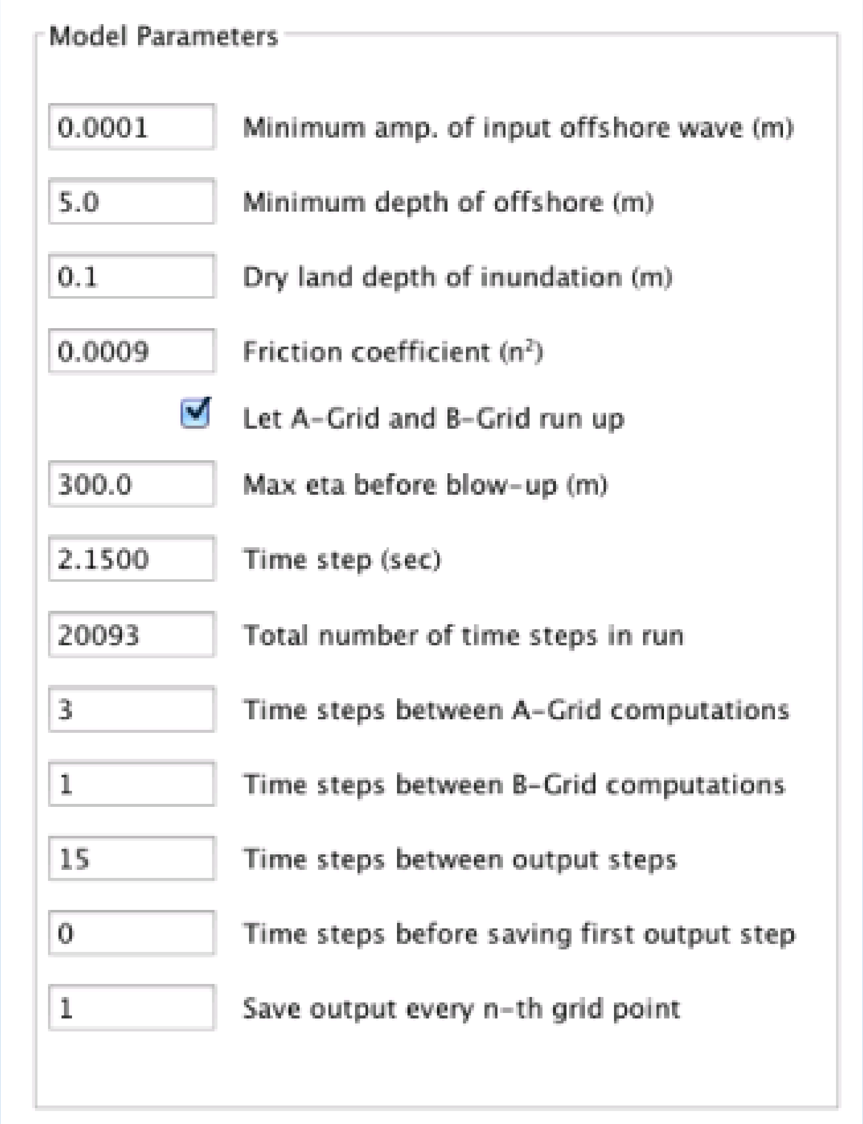
- Computation stops if amplitude exceeds this value — prevents runaway instability
- Recommended: 30 – 100 m

Time Step (sec)

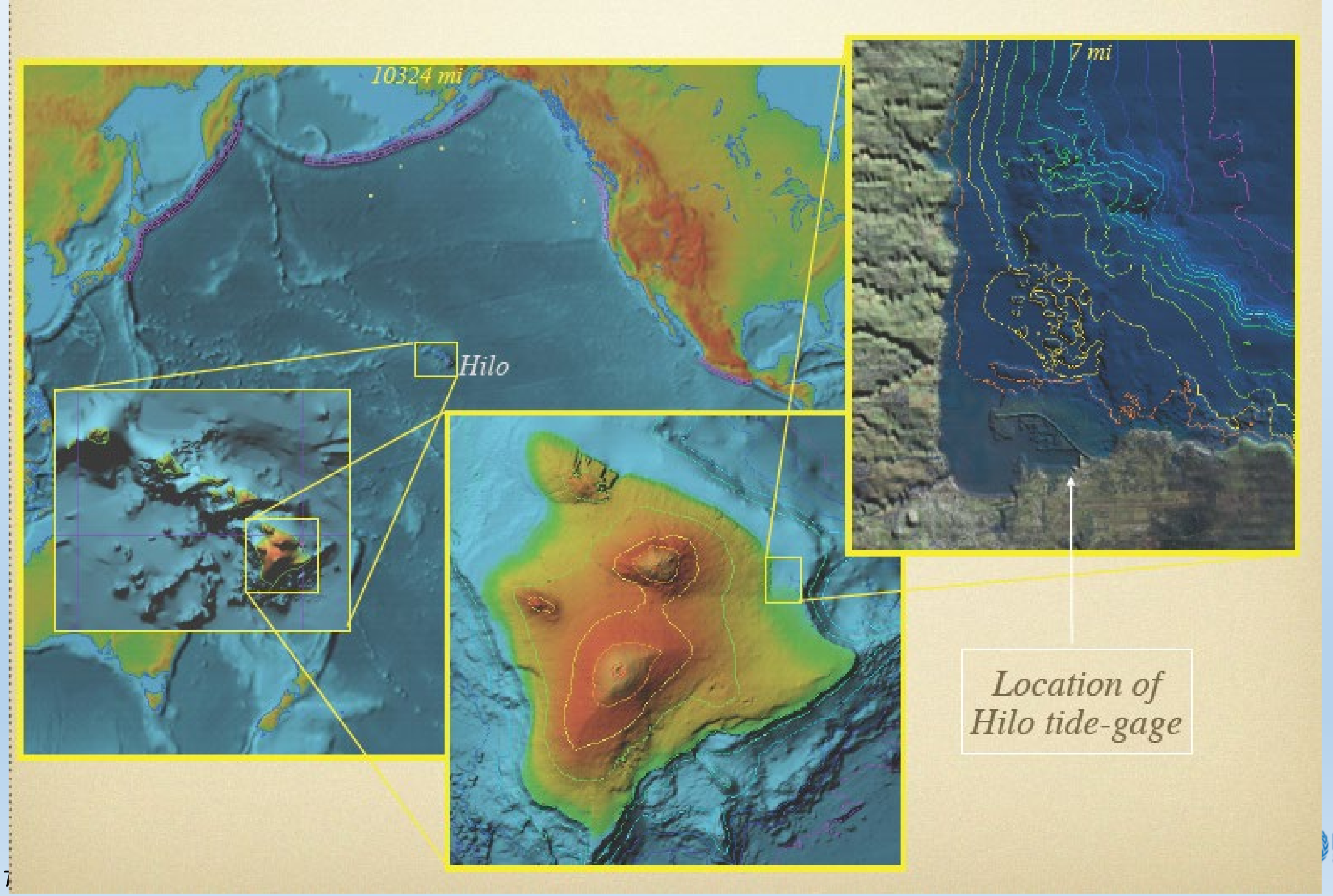
- Specifies C-grid time step — the finest and most demanding grid is computed every step
- A-grid and B-grid use larger effective time steps (computed every N C-grid steps)

Output Control Settings

- Total Number of Time Steps: sets total simulation duration
- Time Steps Between Output Steps: controls frequency of saved amplitude/velocity fields
- Time Steps Before Saving First Output: skip early zero-amplitude steps to save storage
- Save Output Every n-th Grid Point: sub-sample fields to reduce file size



ComMIT Grids: A, B, C at different scales



ComMIT Grids: A, B, C at different scales

MOST Stage	Recommended Resolution	Lowest Required Resolution*
Deformation/Propagation	1 arcminute (~1800 m)	4 arcminutes (~7300 m)
Inundation: Grid A (Outer)	36 arcseconds (~1080 m)	2 arcminutes (~3600 m)
Grid B (Intermediate)	6 arcseconds (~180 m)	18 arcseconds (~500 m)
Grid C (Inner)	≤ 1 arcsecond (≤ 30 m)	2 arcseconds (60 m)

*Note: Equivalent meter value on the Equator.

Notes:

- Ideally grids should have ratio 1:6 (1:10 maximum)
- Boundaries should not intersect

Creating a New Model Run — Wizard

Launching the Wizard

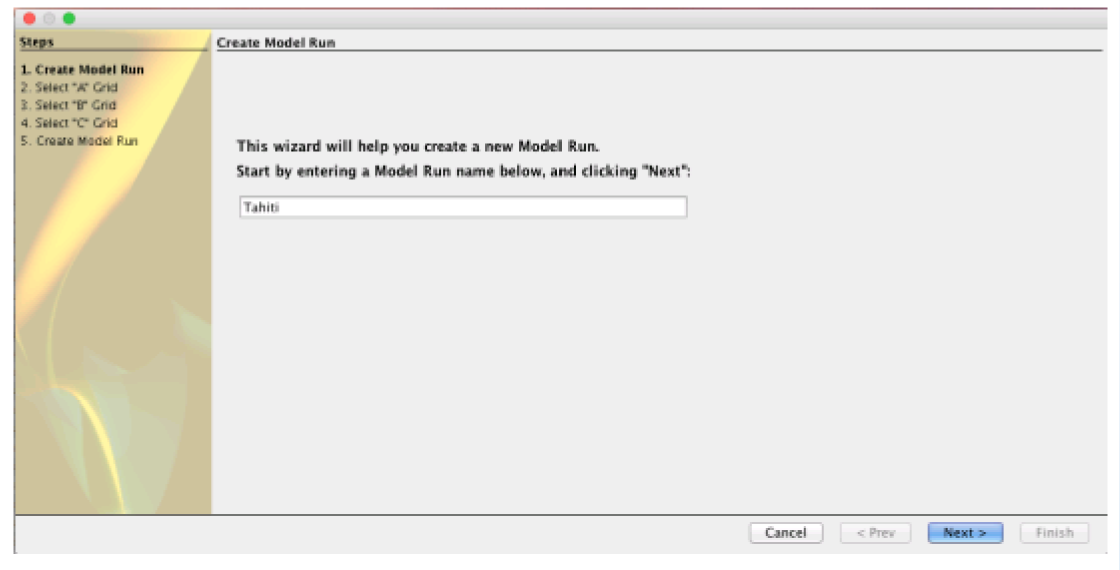
- Go to: Model > New Model Run to open the 5-step wizard
- Step 1: Enter a Model Run name (e.g., Maldives_Male) and click Next
- Steps 2-4: Select A-Grid, B-Grid, and C-Grid in sequence
- Step 5: Click Finish — ComMIT requests bathymetry and loads the new run

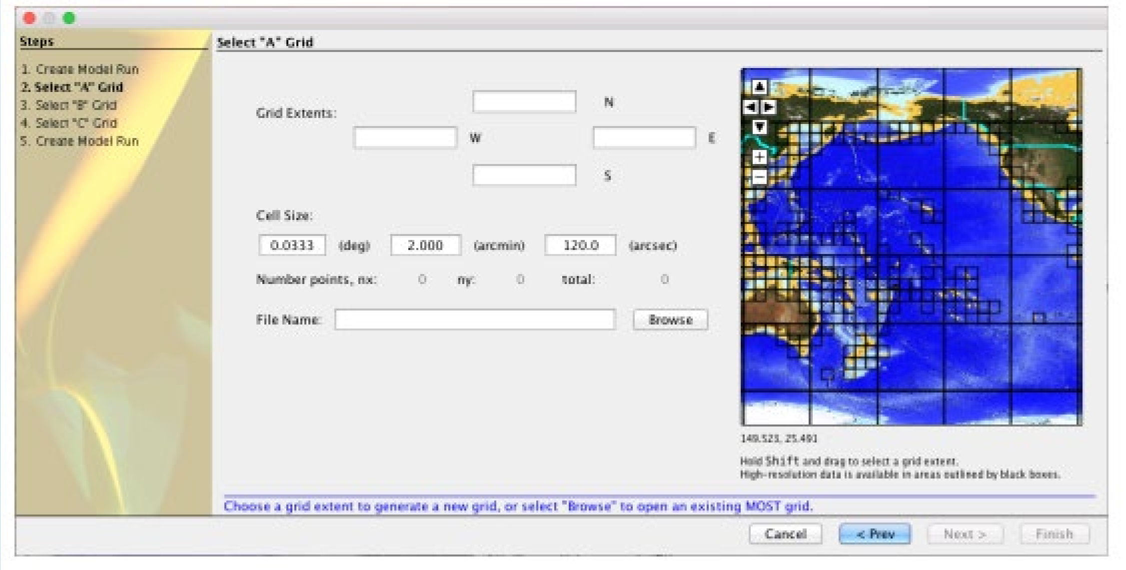
Grid Selection Options

- Browse: Load a user-supplied bathymetry file (recommended for hazard mapping)
- Rubber-band: Hold Shift and drag on map — requests training data from ComMIT Server

Key Limitations of Server Data

- ComMIT Server provides ETOPO1 bathymetry + SRTM 90m topography — training use only
- For TIMM pilot sites, use country-supplied high-resolution bathymetry data
- Maximum grid size from server: 160,000 points (e.g., 400 x 400)





Selecting the A-Grid

Purpose of the A-Grid

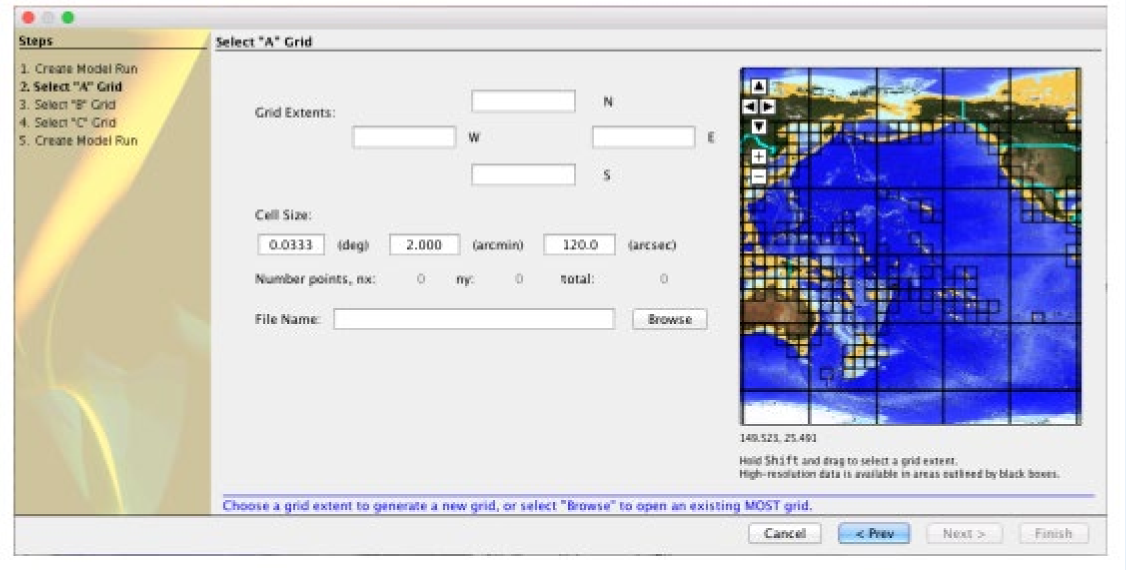
- Outermost, coarsest grid — captures the regional propagation of the tsunami wave
- Must be large enough to encompass the entire wave propagation path from source to site
- Should be at least as large as the 5° x 5° Unit Source blocks visible on the ComMIT map

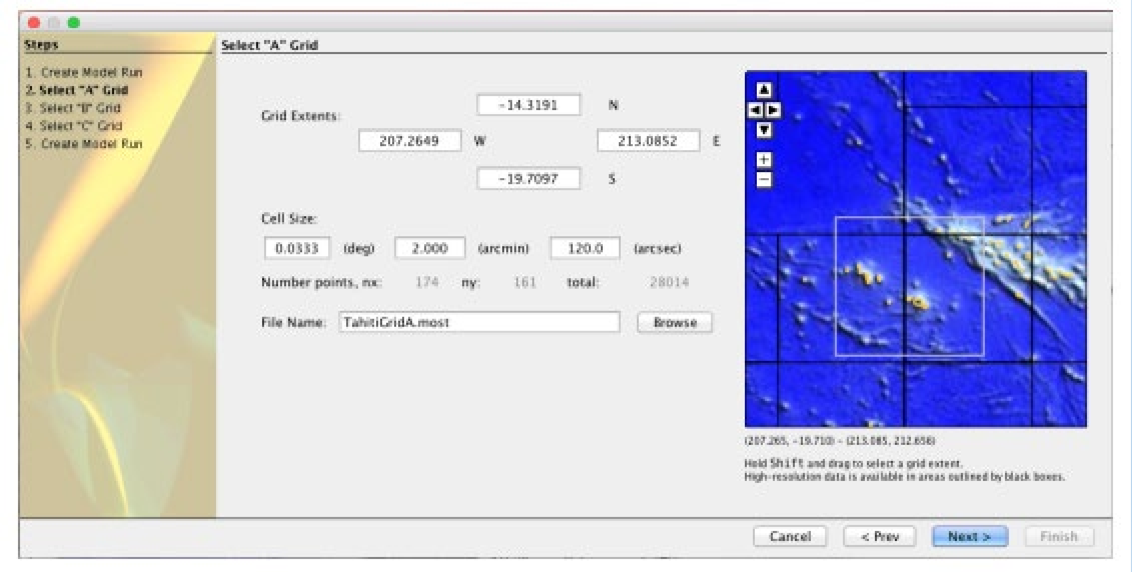
Grid Extents and Resolution

- Grid Extents (N/S/E/W) shown after rubber-banding or browsing — can be edited manually
- Default cell size: 120 arc-sec (~3.7 km at equator) — standard for A-grid
- Grid dimensions (nx, ny) and total point count are calculated automatically

Best Practice for Indian Ocean TIMM Sites

- A-Grid should span the northern Indian Ocean to capture Sunda Trench and Makran sources
- Ensure A-Grid corners extend well beyond B-Grid region to avoid boundary artifacts
- Verify extents in the Grid Bathymetry tab after wizard completes





Selecting the B-Grid and C-Grid

B-Grid — Intermediate Resolution

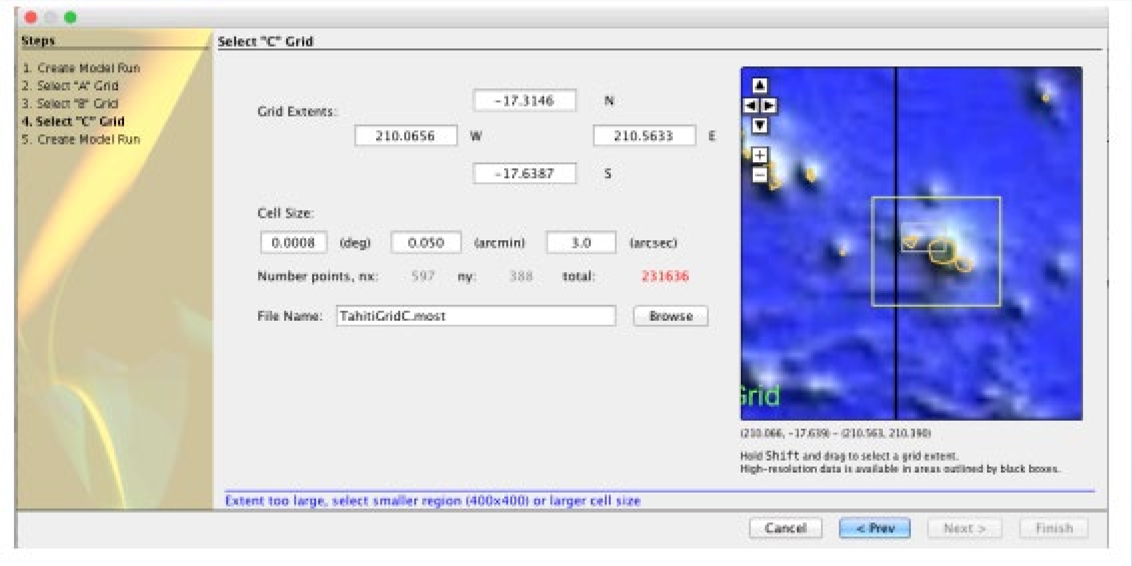
- Must be entirely inside the A-Grid extent — no overlap at boundaries
- Typical resolution: 10-30 arc-seconds; resolves nearshore wave transformation and shelf effects
- Use Google Earth alongside the wizard to accurately identify the coastal zone to cover

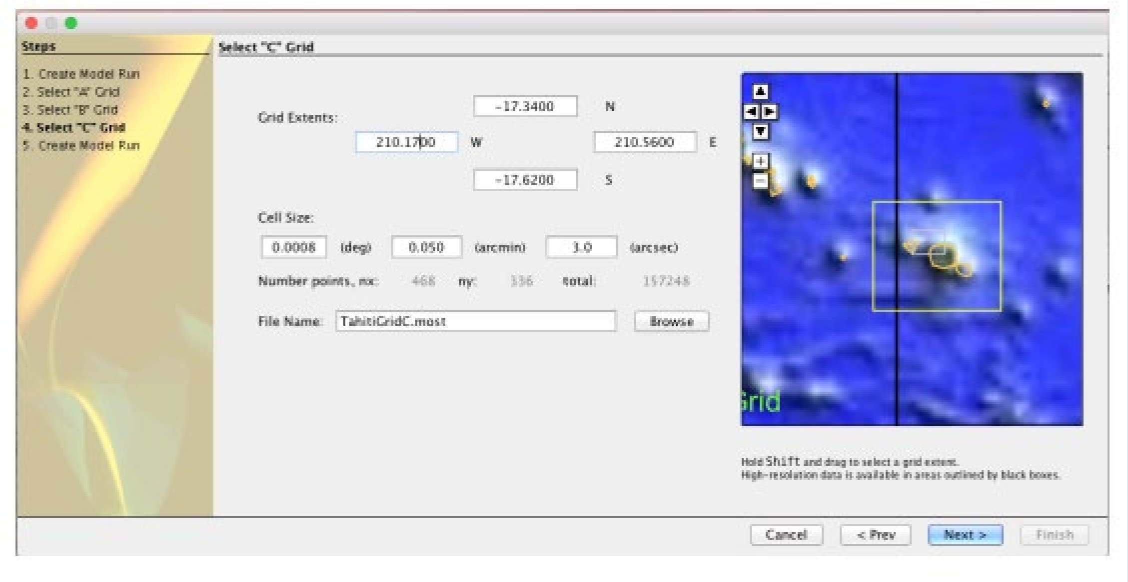
C-Grid — High-Resolution Inundation Grid

- Must be entirely inside the B-Grid extent
- Typical resolution: 2-3 arc-seconds or finer — resolves streets, harbors, and structures
- Most critical grid for the final Tsunami Hazard Map — use best available data
- Edit extents manually after rubber-banding for precise coverage of target community

Grid Nesting Summary

- C inside B, B inside A — no exceptions; violating this breaks boundary conditions
- Resolution ratio between adjacent grids: 3:1 minimum, 10:1 maximum for stability
- Run CFL check (Edit > View Grid Info) after creating to confirm stability





Grid Bathymetry Tab & Boundary Conditions

Grid Bathymetry Tab

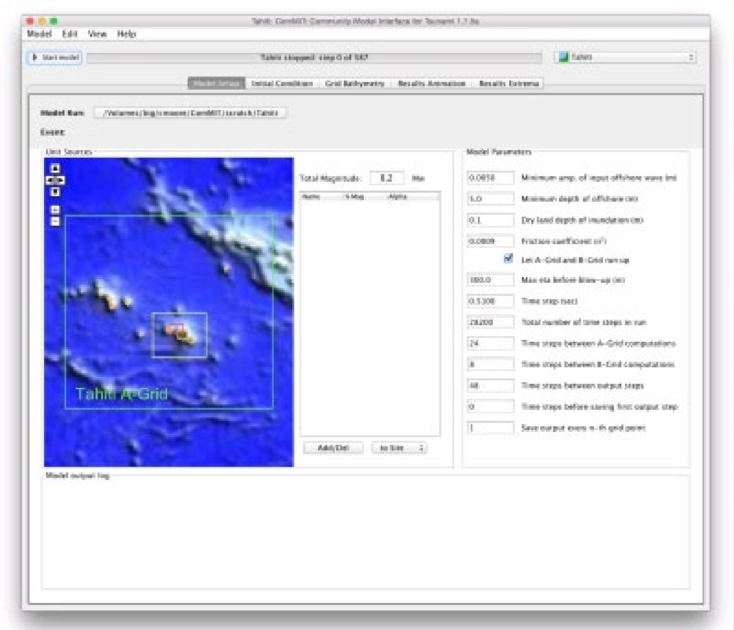
- Color-contour bathymetry/topography plot for the selected grid (A, B, or C)
- Overlays nested grid outlines: green (A-Grid), yellow (B-Grid), red (C-Grid)
- Grid file name shown below title; use Grid: A/B/C buttons to switch between grids

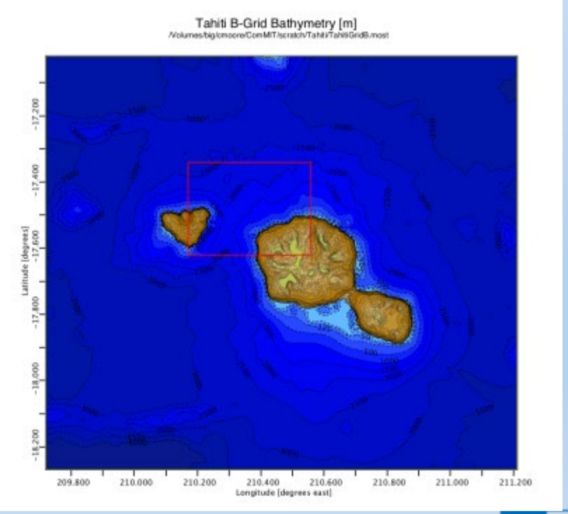
Boundary Conditions in ComMIT/MOST

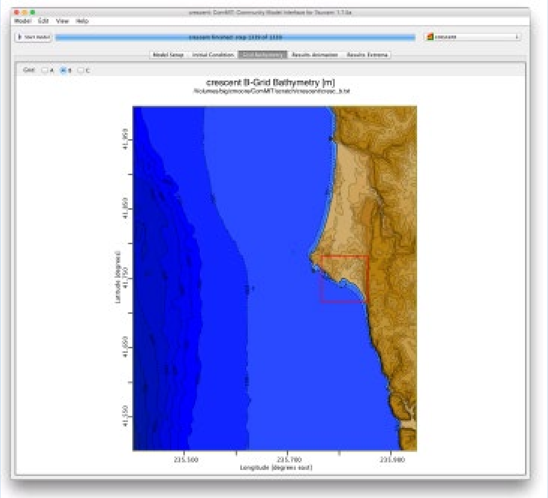
- A-Grid receives incoming wave energy from Unit Source propagation database
- B-Grid boundaries receive time-series data computed by A-Grid — cascade coarse to fine
- C-Grid boundaries receive time-series data computed by B-Grid
- Reflective boundary applied at Min Depth Offshore threshold for A and B grids

Pre-Run Checklist

- Verify grid extents and nesting are correct in Grid Bathymetry tab
- Confirm Unit Sources selected and Alpha values set correctly in Model Setup
- Review model parameters (time step, friction, depth) before pressing Start Model
- Check CFL condition via Edit > View Grid Info to ensure numerical stability







Grid Information and CFL Condition

What is the CFL Criterion?

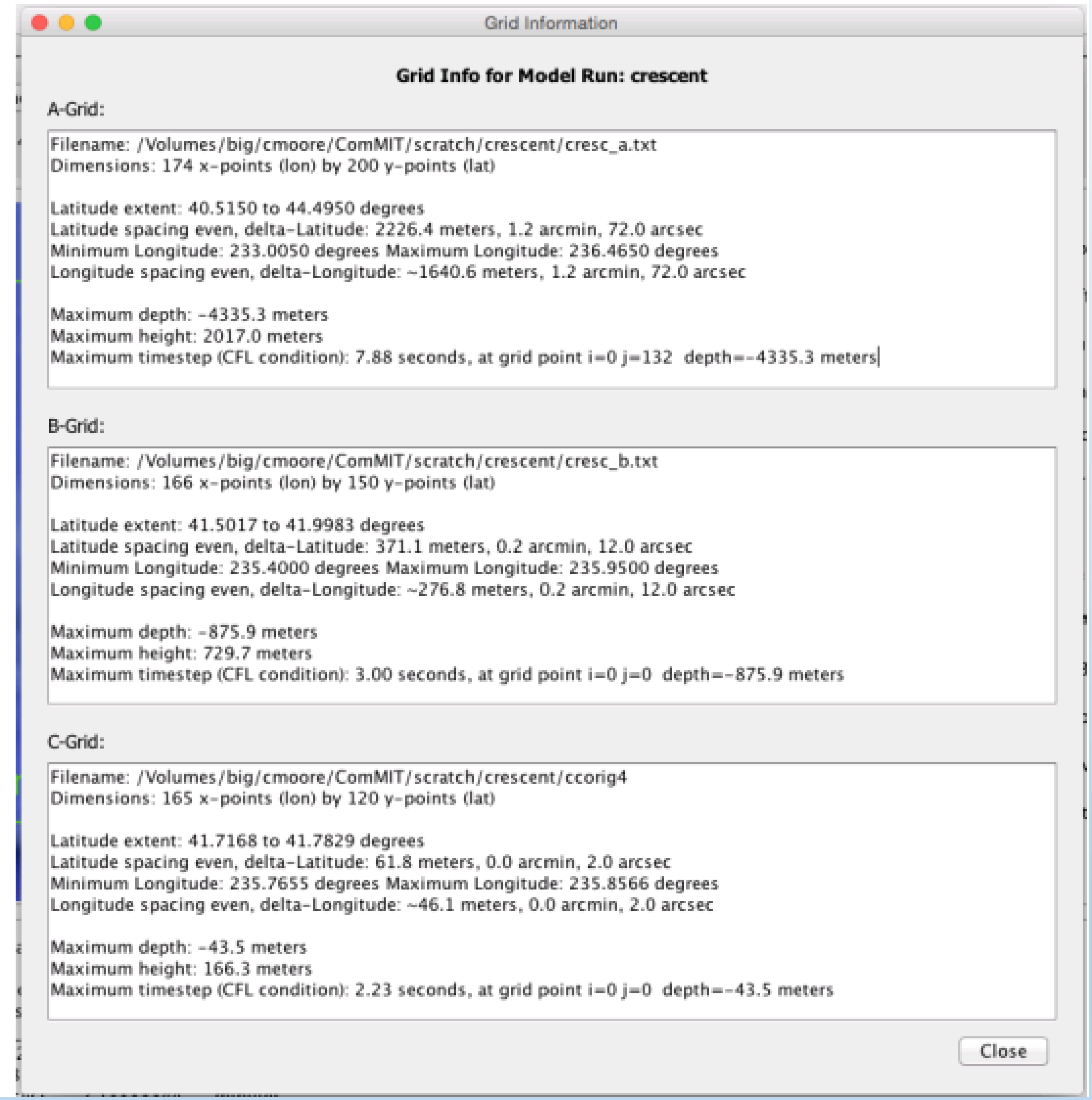
- CFL (Courant-Friedrichs-Lewy) — ensures numerical stability of the model
- Maximum stable time step depends on grid resolution and local water depth
- Finer grids (C) need smaller time steps; coarser grids (A) can use larger effective steps

Viewing Grid Info in ComMIT

- Navigate to: Edit > View Grid Information (CFL)
- Shows: filename, dimensions (nx x ny), lat/lon extents, cell spacing, max depth, CFL limit
- Use this before running to verify grid extents and confirm numerical stability

Example — Crescent City

- A-Grid: 174 x 200 pts, spacing 1.2 arcmin (~2226 m), max depth 4335 m, CFL = 7.88 sec
- B-Grid: 166 x 150 pts, spacing 0.2 arcmin (~371 m), max depth 876 m, CFL = 3.00 sec
- C-Grid: 165 x 120 pts, spacing 0.03 arcmin (~62 m), max depth 44 m, CFL = 2.23 sec



ComMIT Common Grid Format (text file)

Coordinate system: Latitude/Longitude

Nx Ny (max400x400) — Size of Array

Nx lines of longitude

Ny lines of latitude lines

Matrix of bathymetry/topography data (size: Nx by Ny)

Note: depths are negative land is positive

ComMIT Common Grid Format (text file)

Coordinate system: Latitude/Longitude

Alternative

ARC ASCII Grid

ncols	249
nrows	190
xllcorner	79.77292048
yllcorner	6.955485971
cellsize	0.000449943
nodata_value	-9999

23.441 23.302 23.2 23.306 23.193 23.106 ....Matrix

Note: depths are negative land is positive

Thank you