# Effects of Spatial Grid Resolution on the Statistical Power of Testing Earthquake Forecast Models

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# What is CSEP

## The “Collaboratory for the Study of Earthquake Predictability” (CSEP) promotes rigorous research on earthquake predictability

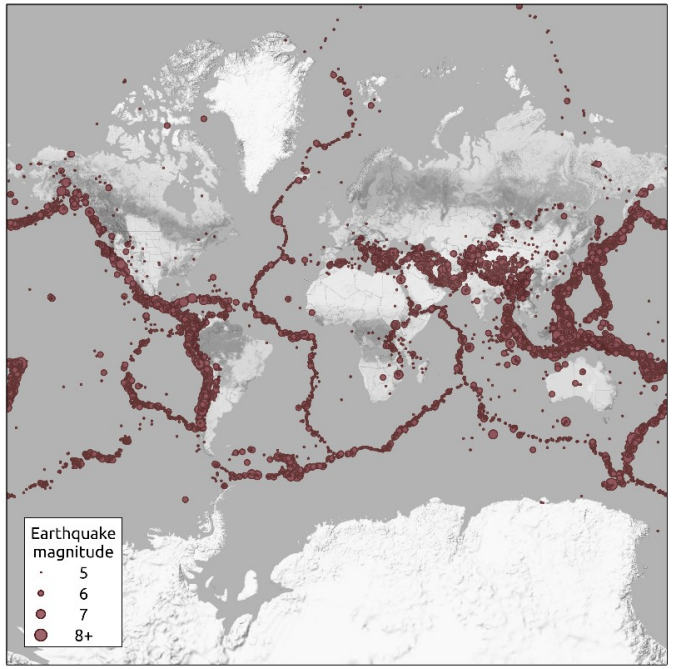
- An open and international collaboratory infrastructure
- Rigorous and prospective testing of earthquake forecast models and hypotheses
- A global program in a variety of tectonic environments

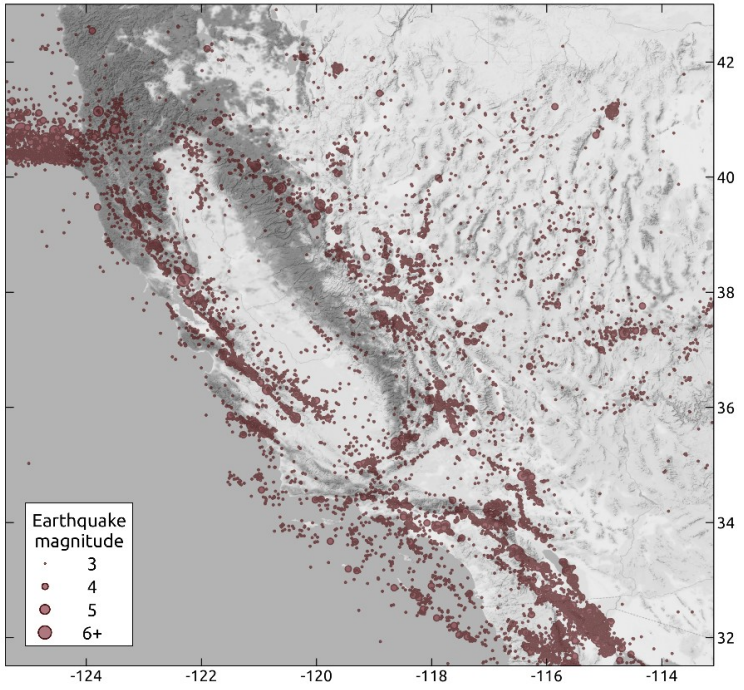
## Essential CSEP components:

- **Testing centers**: facilities with validated procedures for evaluating prediction experiments
- **Community standards**: rules for evaluating forecast models
- **Testing regions**: active fault systems with adequate, authorized data sources for testing forecasts
- **Forecast representation:** expected number of earthquakes for 0.1°x0.1° grid cells

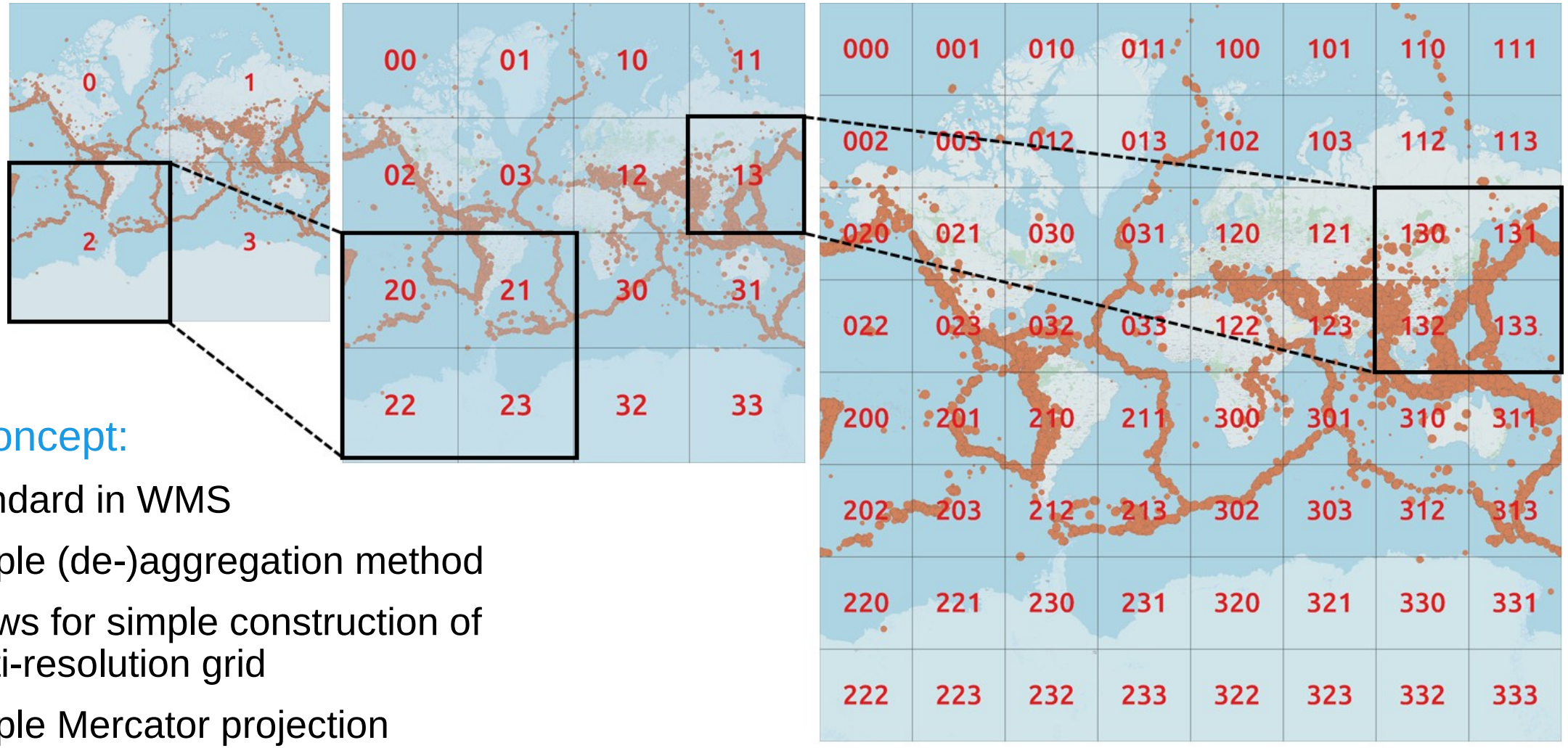
# What do we have?

- Huge number of cells, for example 6.48 million for global testing region
- Forecast generation and evaluation is computationally expensive
- Non-homogenous distribution of earthquakes
- Huge disparity in the number of earthquakes and number of cells
- Less powerful testing



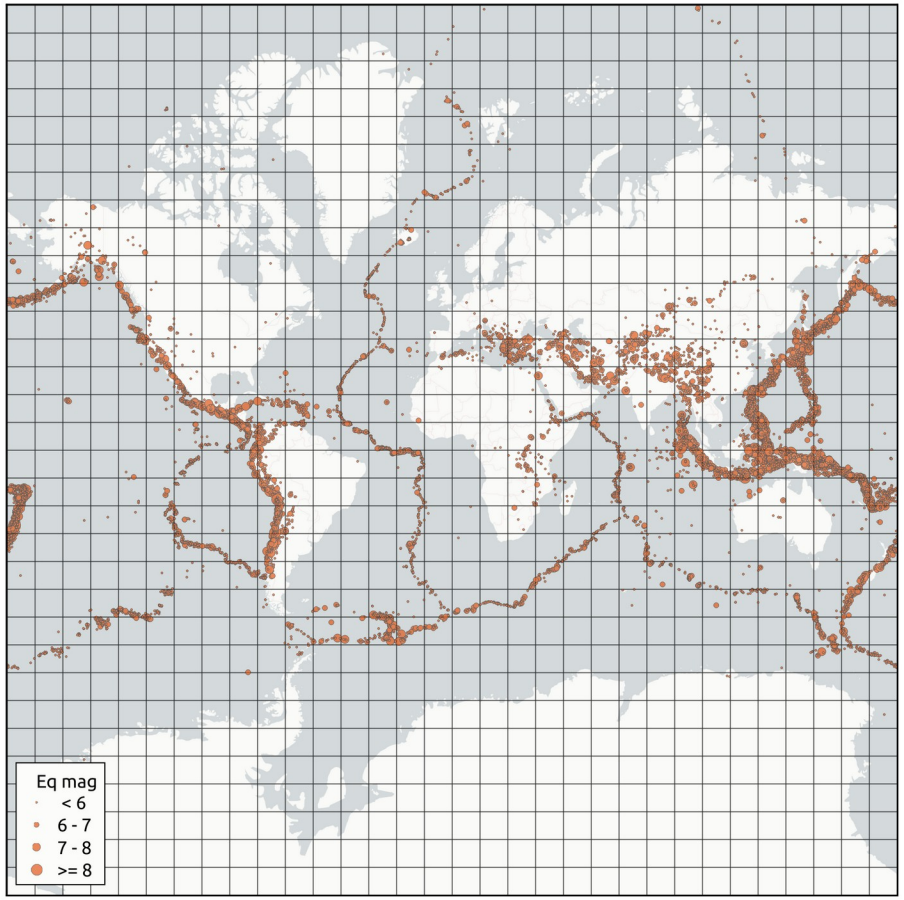
# Alternative Grid Representation: Quadtree



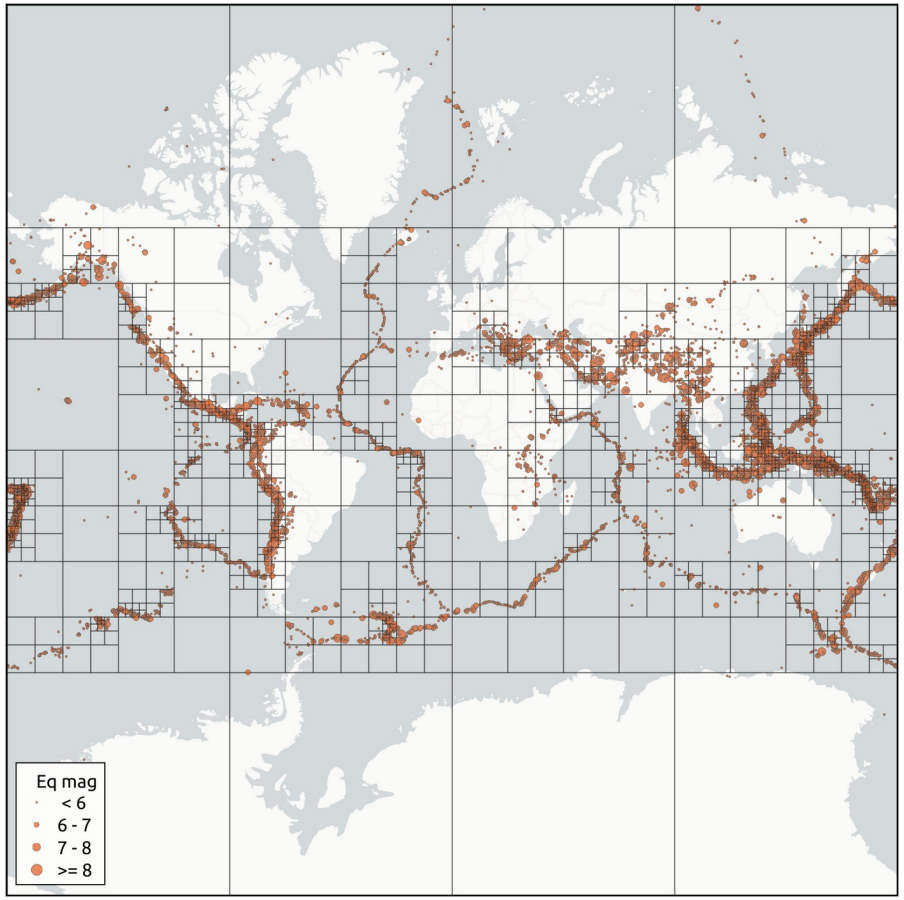

## New Concept:

- Standard in WMS
- Simple (de-)aggregation method
- Allows for simple construction of multi-resolution grid
- Simple Mercator projection

# Alternative Grid Representation: Quadtree




Example single-resolution grid




Example Multi-resolution (Data-based) grid

# Statistical Power Analysis of Spatial-test

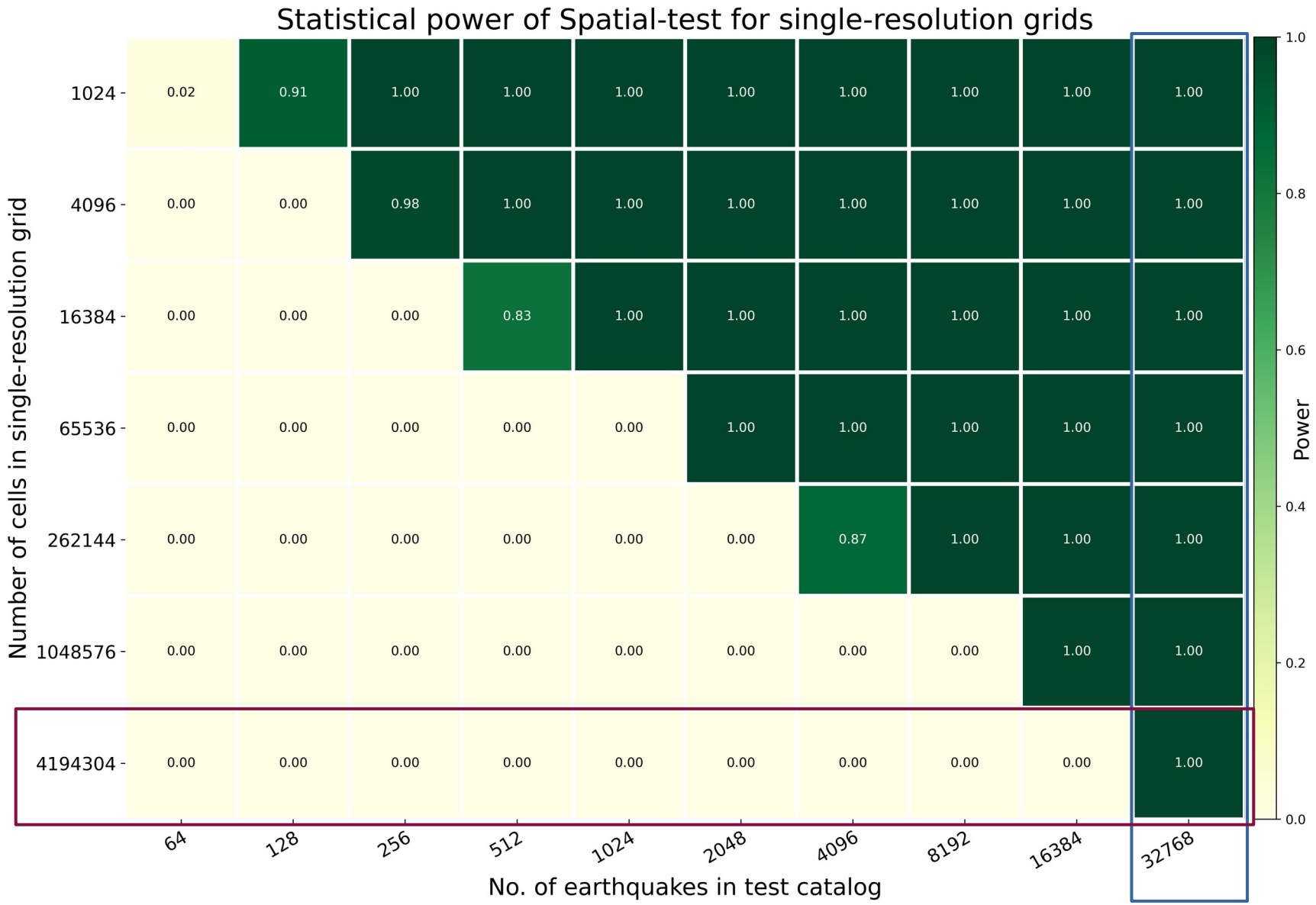
The probability that Spatial-test (S-test) successfully able distinguish between two different distributions

- Power = Pr(True Positive)
- Power = 1 – Pr(False Negative)
- Power = 1 – Type II Error
- Power = 1 – Pr(S-test passing wrongly)
- Power = Pr(S-test fails correctly)

But we do not have any true model of seismicity or ground truth available, so how do we know when a model fails S-test correctly?

# Statistical power analysis: Single-resolution grids

- $\Lambda_1$ = GEAR1, $\Lambda_2$ = Uniform
- S-test is losing power with increasing number of cells
- Ideally, this uniform forecast should be failing the test but passes all tests for a reasonable number of events.
- For 4.2 million cells, we need more than 32000 earthquakes to fail the S-test

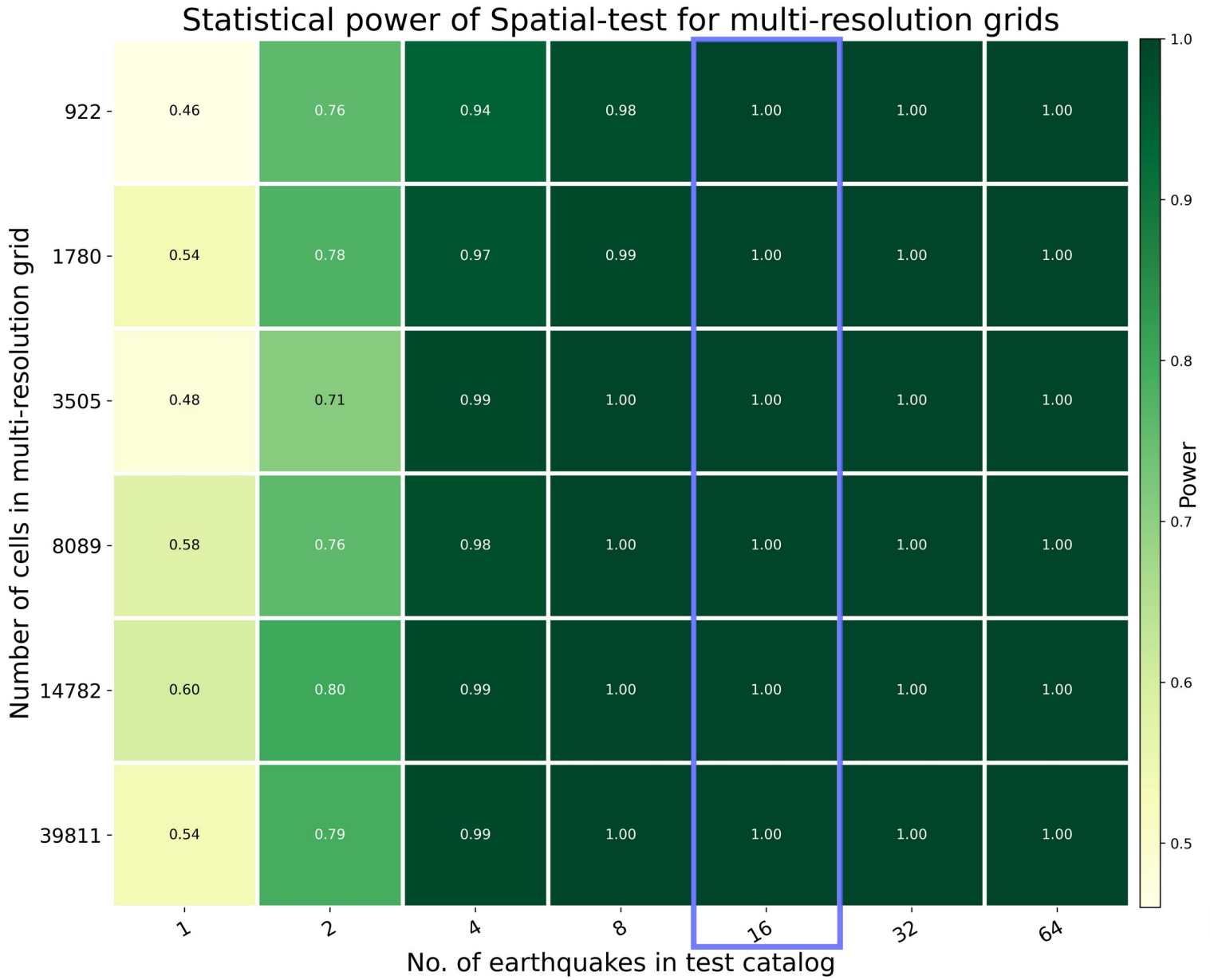


# Statistical power analysis: Single-resolution grids

$\Lambda_1$ = GEAR1, $\Lambda_2$ = Uniform

S-test demonstrate highest power for the grids that can capture spatial information better

With data-based grids only 16 earthquakes are sufficient to provide S-test with highest power



# Way forward

Data-driven grids instead of single-resolution grids for statistically powerful testing