COSMOS Simulated Ground-Motion Data Working Group Activities

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What is COSMOS?

COSMOS = Consortium of Organizations for Strong Motion Observation Systems

- **History**
  - Established in 1997
  - Traditionally focused on issues related to utilization of earthquake strong-ground data in the United States, especially California
  - Published guidelines on siting and operation of free-field and structural strong-motion instrumentation
- **Mission**: COSMOS promotes use of instrumentation and simulations for ground-motion, geotechnical and structural response analysis to foster resilient communities empowered by international guidelines, state-of-the-art processes, and global collaboration.
- **Vision**: COSMOS strives to be a leader in the global earthquake community by elevating the standard of practice for seismic hazard assessment and risk reduction.

COSMOS Ground-Motion Simulation Working Group

- **History**
  - Formed in 2021 to organize COSMOS's efforts related to simulated ground-motion data
  - Nucleated from November 2021 COSMOS Technical Session
  - Held online workshops in June and October 2022
  - Building a community with special sessions and presentations at international meetings
- **Purpose**
  - Make simulated ground-motion data as easy to use as recorded ground-motion data
  - Establish international guidelines and standards for archiving and disseminating simulated earthquake ground-motion data
  - Promote guidelines for validating simulated earthquake ground-motion data
- **Current leaders**

  Aysegul Askan (METU), Brad Aagaard (USGS), Sanaz Rezaeian (USGS)

2022 COSMOS Ground-Motion Simulation Workshops

Workshop report: `strongmotion.org/simulation-working-group`

- **Workshop #1, 7–8 June 2022**
  Archiving and disseminating simulated ground-motion data
- **Workshop #2, 20 October 2022**
  Validating simulated ground-motion data for engineering applications
- **Over 100 people attended each workshop**
  - Strong participation from Europe, western Asia, and the United States
  - Time of day limited participation from east Asia (Japan and China) and south Pacific

Archiving and Dissemination Workshop, Key Point #1

Numerous groups are generating simulated earthquake ground motions and making them openly available, however there is very little coordination among groups to provide consistent interfaces for searching and retrieving data.

Difficulties with simulated data

- Often have multiple realizations of an earthquake rupture for a given magnitude, fault(s) $\rightarrow$ need metadata to describe earthquake rupture
- May have multiple realizations of Earth structure $\rightarrow$ need metadata to describe Earth structure
- Simulations typically have dense spatial coverage and topology information $\rightarrow$ simulated ground motions are not stored in the same way as recorded ground motions

Archiving and Dissemination Workshop, Key Point #2

Users expressed support for standard interfaces for searching and retrieving simulated ground-motion data, including metadata and delivery formats.

- Users want to easily find ground-motion data for given magnitude, rupture distance, site condition, etc.
- Users want simulated ground-motion data delivered like recorded data

Archiving and Dissemination Workshop, Key Point #3

Participants advocated for a distributed architecture that would allow institutions to host and manage their own data while broadcasting their holdings to a combined catalog.

- Similar to International Federation of Digital Seismic Networks (FDSN)
  - Standard web services interface for querying for stations, earthquakes, and waveforms
  - Standard formats for delivery of data (engineers prefer ASCII formats like CSV)
  - IRIS federator automatically handles queries across multiple FDSN data centers
- Likely need data centers for simulated ground-motion data
  - Not all researchers have IT resources to archive and serve data publicly
  - Data centers (such as CESMD, IRIS, ORFEUS) have the IT infrastructure to archive and serve the data efficiently

Archiving and Dissemination Workshop, Key Point #4

Interfaces for accessing data continue to change as large data storage and cloud computing technologies advance, and an effort to standardize data access will want to consider agile approaches that can adapt to changing capabilities and user needs.

- Web services are the current "standard" mechanism for querying and downloading data; underlie web-browser data access
- Cloud-based access is becoming more common (find and use a bucket of data)
- Want data access mechanisms that can adapt along with IT infrastructure

Archiving and Dissemination Workshop, Key Point #5

Efforts to develop community standards for searching and retrieving simulated ground-motion data should build upon existing efforts and leverage the best features from these existing efforts.

Role of COSMOS

- COSMOS can facilitate coordination among existing groups and identify best practices
- COSMOS can help develop international standards and guidelines and make it easy for new groups to join the effort

Validation Workshop, Key Point #1

Validation of ground-motion simulations applies to the entire workflow for simulating earthquake ground-motions.

- Earthquake rupture model
- Seismic velocity model
- Wave propagation software

Validation Workshop, Key Point #2

Validation of ground-motion simulations for rarely observed circumstances require special care.

“Gold standardard” for validation

- Validate workflow for more common circumstances (sufficient observations)
- Constrain components of simulation physics associated with rare circumstances (extrapolation)
- Compare simulations against empirical models for rare circumstances

Most validation efforts have not achieved this level of care.

Validation Workshop, Key Point #3

Metrics to evaluate the validation are application dependent.

- Structural models span a wide range, from SDOF linear models to 3D nonlinear models.
- More research is needed to tie structural response characteristics to ground-motion characteristics for general situations.
- If we could achieve that goal, then we would base validation on ground-motion metrics.

Validation Workshop, Key Point #4

Validation results should provide a clear, transparent, quantitative assessment of the simulated ground motions.

- Many participants favored open-source, community software for computing validation metrics
- Most participants favored a multi-level grading scheme (A, B, C, D) or a continuous scale (0-100)
- We want a clear mapping of validation results to appropriate user applications

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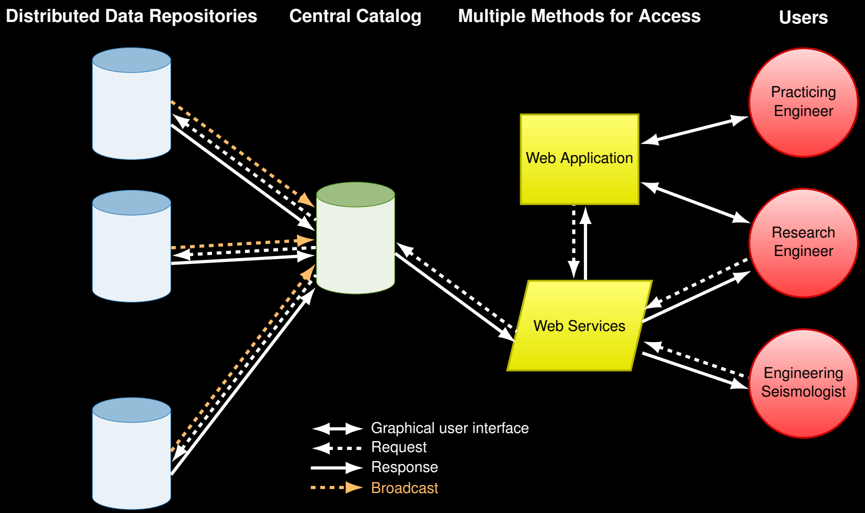
Community Building

Engage ground-motion simulators, users of ground-motion data, and data managers

- **Special sessions**
  - 2023 SSA Annual Meeting, Puerto Rico
  - 2023 SSA Physics-based ground-motion modeling meeting, Vancouver, Canada
  - 2023 7ICEES-18WCSI, Antalya, Türkiye
  - 2024 WCEE, Milano, Italy
- **Presentations**
  - 2022 COSMOS Technical Session, Los Angeles, USA
  - 2023 COSMOS Site Characterization workshop, online
  - 2023 IUGG, Berlin, Germany
  - 2024 University of L'Aquila, Italy

Vision

Want architecture for data access similar to seismology data centers (FDSN)



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Next Steps

- **Continue to engage the community**
  - Leverage other meetings and target all geographic regions
  - Focus select gatherings on early-career scientists and engineers
- **14 November 2024 Workshop** (day before COSMOS Technical Session)
  - Compile world-wide list of ground-motion simulation projects, related efforts, and public data lakes
  - Establish working groups and define directions and goals for the next year
    - Archiving and dissemination
    - Validation
    - Application and utilization
  - Lay foundation for making progress on developing standards and guidelines

Join us!

- **Contact information**

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- **14 November 2024 Workshop**
  - In person (Oakland, California, USA) and online
  - Registration announcements will be going out soon