Complex Risk Science

Exploring new frontiers and a new community for understanding risk

Ryan McGranaghan

Jet Propulsion Laboratory, California Institute of Technology

+ an entire open collective of researchers and colleagues

The Flourishing Commons

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Complex Risk Science

Jet Propulsion Laboratory
California Institute of Technology

Risk = likelihood * exposure * vulnerability

Probabilistic characterization of hazard (natural phenomenon) alongside quantification of exposure and susceptibility

Risk Science is the set of approaches and research areas that bridge from the fundamental understanding to concrete and quantitative impacts that inform decision-making

-Adam Sobel (Columbia)

…and we are doing risk science wrong

Complex Risk Science

An approach driven by complexity science, critical transitions, and resilience -> understand the interconnections between hazards and infrastructures and the way those interconnections alter risk

YouTube

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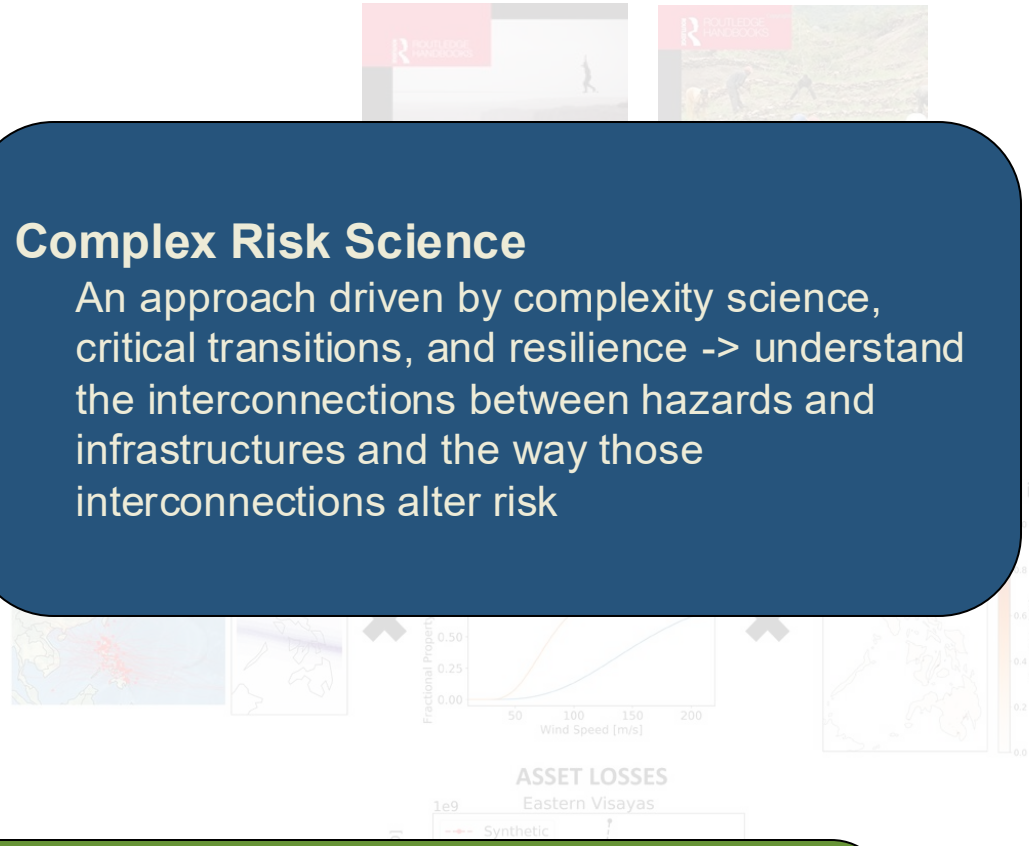


Central question of these seminars

What happens to risk as we acknowledge and account for more interconnections?

The need these seminars serve

(sustained) *Interaction* among a more plural community

Seminars

Upcoming Seminars

- Reframing resilience-oriented urban water management
  Dr. Elizabeth Krueger, University of Amsterdam — October 14, 2025 at 1:00 PM ET
- Climate Extremes and Complex Risks
  Dr. Jane Baldwin, UC Irvine — October 28, 2025 at 1:00 PM ET
- What Digital Twins (alone) will not Answer for Risk Science
  Dr. Ryan McGranaghan, JPL — November 04, 2025 at 1:00 PM ET
- Multihazards Scenario Generator: A Network-Based Simulation of Natural Disasters
  Dr. Alexandre Dunant, EURAC Research — November 18, 2025 at 1:00 PM ET
- Accounting for Sociopolitical Feedbacks to Identify Barriers and Opportunities for Collective Climate Action
  Dr. Sara Constantino, Stanford & Dr. Elke Weber, Princeton — December 02, 2025 at 1:00 PM ET

Past Seminars

- Resolving Risk in a Nonstationary World: Large Ensembles, Extremes, and Sustainability
  Dr. Sai Ravela, MIT — September 23, 2025
- Complex Interconnected Systems:Risk-Informed Decisions for Situations of Compound Extremes
  Dr. Auroop Ganguly, Northeastern University — September 16, 2025

Today!

https://risk-seminar.ryanmcgranaghan.com/seminars/

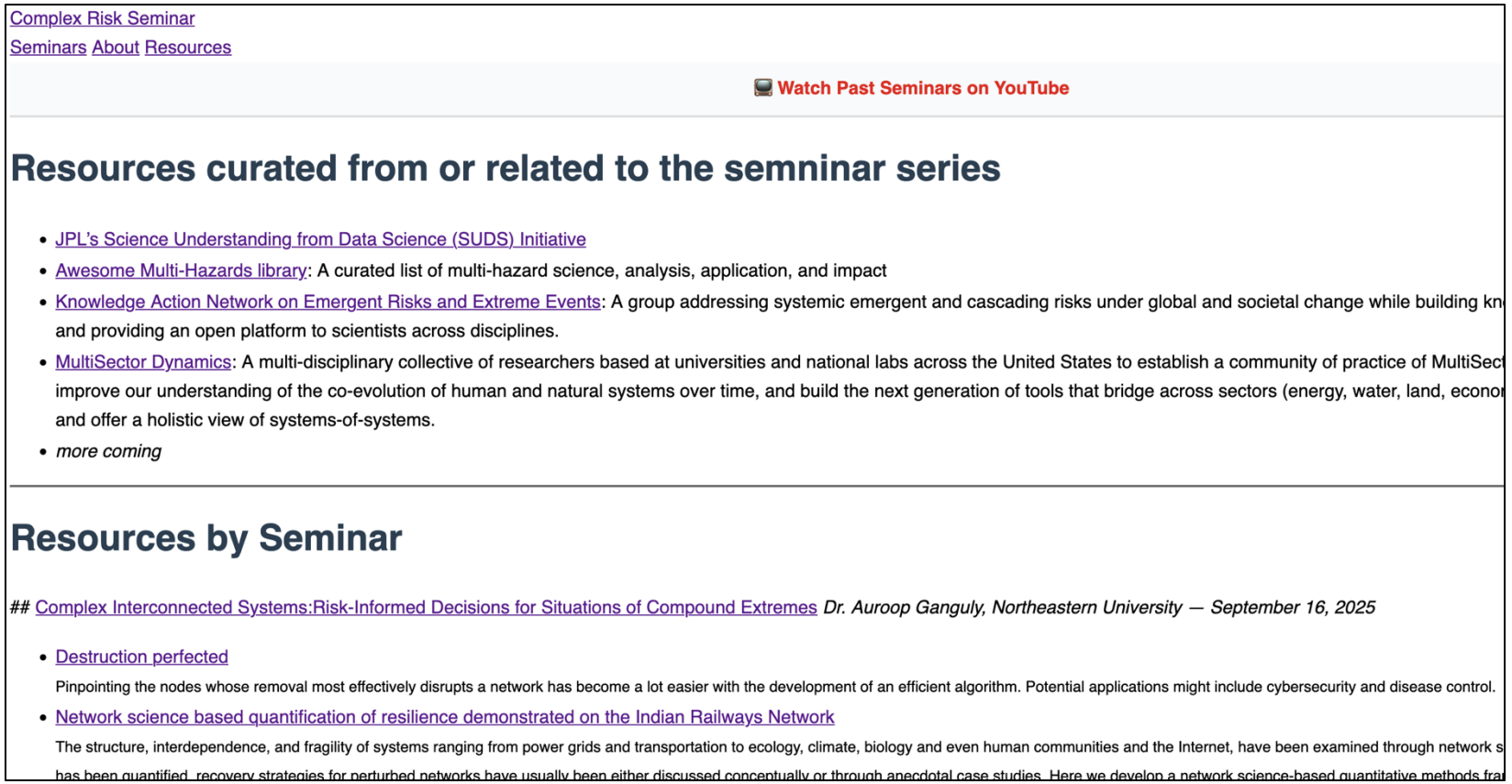
Resources, Curated

Towards a *knowledge commons*

Jet Propulsion Laboratory
California Institute of Technology

There is no excellent ‘library’ for complex risk science resources, so we are creating it (as we go)

Emphasis on curation, on care with what we choose to share



Complex Risk Seminar

Seminars About Resources

Watch Past Seminars on YouTube

Resources curated from or related to the semninar series

- JPL’s Science Understanding from Data Science (SUDS) Initiative
- Awesome Multi-Hazards library: A curated list of multi-hazard science, analysis, application, and impact
- Knowledge Action Network on Emergent Risks and Extreme Events: A group addressing systemic emergent and cascading risks under global and societal change while building kn
  and providing an open platform to scientists across disciplines.
- MultiSector Dynamics: A multi-disciplinary collective of researchers based at universities and national labs across the United States to establish a community of practice of MultiSect
  improve our understanding of the co-evolution of human and natural systems over time, and build the next generation of tools that bridge across sectors (energy, water, land, econo
  and offer a holistic view of systems-of-systems.
- *more coming*

Resources by Seminar

Complex Interconnected Systems:Risk-Informed Decisions for Situations of Compound Extremes *Dr. Auroop Ganguly, Northeastern University — September 16, 2025*

- Destruction perfected

  Pinpointing the nodes whose removal most effectively disrupts a network has become a lot easier with the development of an efficient algorithm. Potential applications might include cybersecurity and disease control.
- Network science based quantification of resilience demonstrated on the Indian Railways Network

  The structure, interdependence, and fragility of systems ranging from power grids and transportation to ecology, climate, biology and even human communities and the Internet, have been examined through network s
  has been quantified, recovery strategies for perturbed networks have usually been either discussed conceptually or through anecdotal case studies. Here we develop a network science-based quantitative methods fra

https://risk-seminar.ryanmcgranaghan.com/resources/

Key: Cultivating forums for sustained interactions

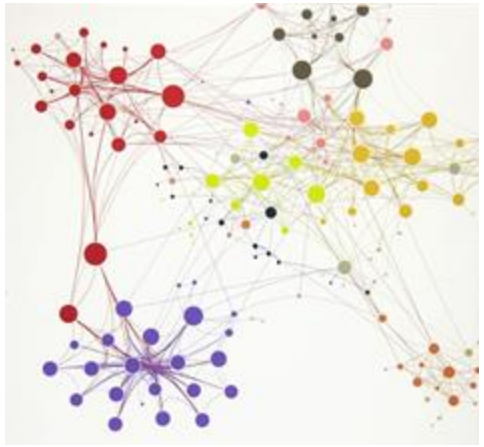
slack

https://tinyurl.com/join-SUDS-slack

→ #suds_network

Complex Risk Seminars

Fractal Gathering



Analysis Working Group Model

Jet Propulsion Laboratory
California Institute of Technology

The solution to building capacity and collectivity for key topics in Complex Risk Science is to organize ‘analysis working groups’

Pioneered by Sylvain Costes* at NASA Ames for the global Biological and Physical Sciences community, AWGs are forums for research interactions around a shared dataset or datasets and for creating FAIR risk science resources to improve risk science understanding and disaster risk reduction

All risk science data are priceless planetary resources that all should be able to access and should serve as grounds for connecting across groups (emphasis is on *bridging*), and their curation is a challenge

Purpose

- AWG members contribute to making FAIR risk science resources (datasets, processing pipelines, metadata, notebooks, etc.) and processes for improving open science of them
- AWG members collaborate to mine-reuse cleaned data to conduct scientific analysis

Activities

- Monthly meetings
- Work together on a cleaned, standardized dataset or datasets; focused on **collective scientific discovery** (and e.g., not on data wrangling)
- Publish data, capabilities, and results open source

Other notes

- All open source data storage and results publication expenses covered for the group
- Computational environments provided
- Emphasis is on the generation of results AND flourishing of the groups who meet to work together

**Costes, S.V., Gentemann, C.L., Platts, S.H. et al. Biological horizons: pioneering open science in the cosmos. Nat Commun 15, 4780 (2024). https://doi.org/10.1038/s41467-024-48633-2*

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Ryan M McGranaghan 11:49 AM

Analysis Working Groups – Interest Poll

We're organizing working groups to deepen our efforts across key themes. Please vote for as many as you'd like to indicate where you'd be interested in contributing.

1 **WG1: Indicators of Systemic Fragility** – Shared, interpretable measures of fragility and recovery.
2 **WG2: Context-Aware Risk Metrics** – Hybrid qualitative + quantitative approaches communities can trust.
3 **WG3: Complexity Methodologies for Risk** – Complexity-informed tools (ensembles, recovery metrics, participatory modeling).
4 **WG4: Cascading Risk & Interconnected Infrastructure** – Data, scenarios, and modular models of coupled systems (e.g., grid ↔ comms ↔ transportation).
5 **WG5: Timescales, Narratives, & Decision Horizons** – Modeling, planning, and communication methods that reflect real-world timing + deep uncertainty.
6 **WG6: Post-Event Protective Actions & Success Mapping** – Studying protective mechanisms during adverse events and how to sustain/scale them.

Vote below with the corresponding numbers! (edited)

1 4 2 4 3 4 4 4 5 3 6 3

2 replies Last reply 21 hours ago

slack

Report from the June 9, 2025 "Complex Risk Science Summit" in Boston that details these working groups
https://zenodo.org/records/17122711

Key: Cultivating forums for sustained interactions

“

One thing that is not a scarce resource in this world is imaginative people with possible solutions to intractable problems.

”

- David Graeber

Sai Ravela

Resolving Risk in a Nonstationary World

Large Ensembles, Extremes, and Sustainability

Understanding and managing risk in today's world requires more than averages—it demands careful attention to the extremes. Dr. Sai Ravela (MIT) develops methods to resolve such risks by producing detailed, large-ensemble process representations that link hazards to decisions in what he calls the "sustainability stack": from hazard, vulnerability, and exposure to impact, risk, and ultimately policy action. This talk will highlight how simplifications in modeling ("just a little physics") shape our ability to capture risk, how downscaling alters return periods and confidence levels, and why the past is only weakly predictive of the future.

JPL