

# Rhymes and Reasons: The Promises of Geosciences in a Complexful World

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## Abstract

Probably the founding father of Geology, Sir James Hutton was raised as a doctor but his passions for the nature surrounding his farm led him to rocks, then specimens, then fossils. The result was what we might call a comparative physician – the first paleontologist, in fact. His upbringing in medicine had given him the classical knowledge of his time, from Latin to mathematics, and from biology to drawing. Not only did the lack of a specific scientific discipline bring Sir Hutton to devise a novel field of study of his own – it also molded strands of his formal learning into a synthesis of intellectual tools. These days, hyper specialization has brought upon novel discoveries of paramount importance and marvel, from graphene to vaccines. It also is a means of necessity in applying for academic positions and to publish in ever nascent journals. This architecture, however, reflects a system of parallel disciplinarity, with scientific fields somehow on their own course. On the other hand, complexities at stake require solutions that may well evade any given single field, at times astray from usual avenues. Such approach not only entails multi-disciplinarity (diverse teams – yesterday), but it also requires cross-disciplinarity (across specific disciplines – today) and, especially, trans-disciplinarity (beyond firm disciplines – today and tomorrow). For their very nature, geosciences are bound to glean lessons learned from the past to provide insight into the future. Geoscientists were once thought to study ancient rocks, fiddle with very slow-moving tectonic plates, and bantering about invisible earth's features, too large, or too deep, or too far away to even imagine for us earthlings. But the geosciences are more than ever side by side with some of the most pressing issues surrounding contemporary societies – after having been at the heart of a couple of global energy revolutions. From a series of examples, this work thus tries to put into perspective: Hazards stemming from multiple, at times unpredictable sources; The precious role of geosciences to decipher them – and to forecast them; The complexity of natural hazards, the (need of) flexibility in human planning; Modern issues challenging societies and economies – today, tomorrow, and thereafter.



## A world full of complexities

This is a difficult world, one could well say – and a **complex** one, too, with Nature being ingrained with complexities in the behavior of processes, hazards, cascading effects, and feedbacks between geosphere and biosphere...

All of this occurs with a population projected at 10 billion by 2100, dwindling natural resources, expected temperature rise, shifting societies, worldwide migrations, and a climatic crisis.

Is this, then, a terrible world? "It ain't necessarily so". Of course, it's up to a range of stakeholders

OPEN

## (Multiple) challenges foster insight

### 1. Natural hazards - of all sorts

**Disaster on Disaster: Unique Challenges for Natural Catastrophe Preparedness**

"While the rapidly evolving COVID-19 pandemic upended operations around the world last year, enterprises had to scramble to **prepare** for hurricanes, typhoons, wildfires and other **natural disasters**."

"While the prospect of weathering natural disasters in 2021 seems more **complex** and potentially daunting than ever, risk management, emergency preparation and disaster response have made tremendous **progress** since the beginning of 2020."

▶ 0:00 / 4:46

### 2. Geosciences are cool

**Aquifer systems extending far offshore on the U.S. Atlantic margin**

"A remarkably **newly** aquifer is hiding under the salty Atlantic **ocean**, just off the northeastern coast of the United States. [...] It may be the largest of its kind, stretching for nearly 350 kilometers, at ca. 200-400 m below seafloor."

"Evidence suggests that such aquifers might potentially represent a **resource** to supplement other **resources** elsewhere, from southern California, Australia or the Middle East." (source: LiveScience)

▶ 0:00 / 3:49

## Forward to the future (quandaries)

### 3. Natural, but complex

**Impact of future tsunamis on household welfare: merging geophysics, economics and catastrophe modelling**

"Integration of tsunami **hazard** and **resilience** consequences may be of substantial interest to Governments and agencies in charge of evaluating the **economic risk** and formulating **mitigation policies**."

"Such products may contribute to sustainable **development** in countries where private insurance is insufficient to mitigate such disasters. This analysis could be utilized, for instance, with vessels in port where fishing is a key part of the **economy** of the local **community**."

▶ 0:00 / 3:37

### 4. Societies, continents, planets

**Geosciences Supporting a Thriving Society in a Changing World**

Climate Change Resilience, Adaptation, Sustainability  
Natural Hazards, Global Change, Infrastructure  
High Quality Geospatial Data and Maps  
Energy, Technology, Engineering  
Ocean, Coastal, and Health

▶ 0:00 / 4:19

## A world in transition

### Where in this *complex* world?

**Beauty is the land of hope – what about trust?**

Every human being dreams about hoping. So, better start taking notice of keywords: Rhythm, and *rhyme*, even with little *reason*. Is this the key to a successful narrative? Maybe. Hard facts, tables, diagrams? Maybe (not).

How are we going to inject evidence into the public discourse? Can we mend the fault between rhyme and reason? In fact - is reason ever going to sound with rhyme?

We might not need to constantly reaffirm factual evidence as a *totem*. Of course, we are to *rhyme* by crafting the message in a *rhyme*. *Imaginative* was *renewed* by *rhyme*. Geosciences have to turn forecasting

▶ 0:00 / 4:33

## An old science for a novel task

...as long as they are not blindly sacrificed

"Earth sciences are **fundamental** to tackling **climate** change, natural **hazards** and the **energy** transition, yet universities worldwide are putting geoscience departments on the chopping block – right when they are needed most. [...] **Without** geoscientists there will be **no** sustainable future."

"The interest is there, as shown by pupils striking and fighting for climate action. They demand educational reforms to learn about the urgency, severity and **science** of the climate crisis, showing there is a desire to study Earth science en masse."

▶ 0:00 / 3:14

## Alpha and Omega

On one hand, geoscientists hold a precious knowledge of time (from milliseconds to million years), of space (from microscopes to satellites), and we know how delicate the Earth System is.

On the other hand, we strive for cross-disciplinarity, a broader set of skills, proactive networking with colleagues not just across disciplines but also throughout Social, Economic, and Operational Sciences. We thus need to pursue a novel mindset, while offering the best of our enduring knowledge.

# Rhymes and Reasons: The Promises of Geosciences in a Complexful World

**Rhymes and Reasons: The Promises of Geosciences in a Complexful World**  
Umberto Fracassi  
Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy

**A world full of complexities**  
This is a difficult world, one could well say... and a complex one, too, with Nature being exceptionally complex in the behavior of processes, trends, cascading effects, and feedbacks between geosphere and biosphere...  
All of this occurs with a population projected at 10 billion by 2100, demanding natural resources, expanded temperature rise, shifting weather, multidecadal migrations, and a climate crisis...  
Is this, then, a terrible world? It isn't necessarily so! Of course, it's up to a range of stakeholders and participants in the future. But the geosciences are at the frontier of the truly global effort and transdisciplinary challenge, requiring broad, novel resources in the ground truth, before hand.

**Multiple challenges foster insight**

**1. Natural hazards - of all sorts**  
Disasters and Disasters: Unique Challenges for Natural Geoscience Professionals  
Natural hazards, such as earthquakes, tsunamis, volcanic eruptions, and hurricanes, are complex phenomena that require a multidisciplinary approach to understand and mitigate their impacts.

**2. Geosciences are cool**  
Geoscience education: Inspiring the Next Generation  
Geoscience education is essential for understanding our planet and its resources. It provides a foundation for careers in environmental science, resource management, and public policy.

**Forward to the future (quandaries)**

**3. Natural, but complex**  
Impact of Natural Hazards on the Built Environment  
Natural hazards pose significant challenges to the built environment, including infrastructure damage, economic losses, and human casualties. Understanding these impacts is crucial for developing resilient communities.

**4. Societies, continents, planets**  
Geoscience: A Key to Understanding Our Changing World  
Geoscience provides a holistic view of our planet, from the local to the global. It helps us understand the interactions between the Earth's systems and the human impact on the environment.

**A world in transition**

**Alpha and Omega**  
On one hand, geoscientists hold a precious knowledge of our planet's resources to sustain growth, of space for our communities to flourish, and of how to best advance the Earth System...  
On the other hand, we strive for cross-disciplinary, a broader set of skills, greater understanding with colleagues not just across disciplines, but also throughout Social, Economic, and Operational Systems. We thus need to pursue a novel mindset, while offering the best of our existing knowledge...  
This, certainly in a complex world, but it can also be a beautiful one, with our knowledge at the service of contemporary and future societies.

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# A WORLD FULL OF COMPLEXITIES

This is a difficult world, one could well say – and a **complex** one, too, with Nature being ingrained with complexities in the behavior of processes, hazards, cascading effects, and feedbacks between geosphere and biosphere...

All of this occurs with a population projected at 10 billion by 2100, dwindling natural resources, expected temperature rise, shifting societies, worldwide migrations, and a climatic crisis.

Is this, then, a terrible world? "It ain't necessarily so". Of course, it's up to a range of stakeholders and policymakers to do their part. But the geosciences are at the frontline of this truly global effort and transformative challenge, requiring a broad, novel awareness in the geoscientists beforehand.

# AN OLD SCIENCE FOR A NOVEL TASK

[VIDEO] [https://res.cloudinary.com/amuze-interactive/video/upload/vc\\_auto/v1639391341/agu-fm2021/02-F7-8B-FE-DE-1C-BB-DF-8A-07-42-5C-D7-54-11-F2/Video/Rhymes\\_Reasons\\_Intro\\_q3uwi1.mp4](https://res.cloudinary.com/amuze-interactive/video/upload/vc_auto/v1639391341/agu-fm2021/02-F7-8B-FE-DE-1C-BB-DF-8A-07-42-5C-D7-54-11-F2/Video/Rhymes_Reasons_Intro_q3uwi1.mp4)

# (MULTIPLE) CHALLENGES FOSTER INSIGHT

## 1. Natural hazards - of all sorts

[VIDEO] [https://res.cloudinary.com/amuze-interactive/video/upload/vc\\_auto/v1639395055/agu-fm2021/02-F7-8B-FE-DE-1C-BB-DF-8A-07-42-5C-D7-54-11-F2/Video/Rhymes\\_Reasons\\_1\\_dilufw.mp4](https://res.cloudinary.com/amuze-interactive/video/upload/vc_auto/v1639395055/agu-fm2021/02-F7-8B-FE-DE-1C-BB-DF-8A-07-42-5C-D7-54-11-F2/Video/Rhymes_Reasons_1_dilufw.mp4)

## 2. Geosciences are *cool*

[VIDEO] [https://res.cloudinary.com/amuze-interactive/video/upload/vc\\_auto/v1639395883/agu-fm2021/02-F7-8B-FE-DE-1C-BB-DF-8A-07-42-5C-D7-54-11-F2/Video/Rhymes\\_Reasons\\_2\\_mioi8d.mp4](https://res.cloudinary.com/amuze-interactive/video/upload/vc_auto/v1639395883/agu-fm2021/02-F7-8B-FE-DE-1C-BB-DF-8A-07-42-5C-D7-54-11-F2/Video/Rhymes_Reasons_2_mioi8d.mp4)

# FORWARD TO THE FUTURE (QUANDARIES)

## **3. Natural, but complex**

[VIDEO] [https://res.cloudinary.com/amuze-interactive/video/upload/vc\\_auto/v1639396814/agu-fm2021/02-F7-8B-FE-DE-1C-BB-DF-8A-07-42-5C-D7-54-11-F2/Video/Rhymes\\_Reasons\\_3\\_wf2gai.mp4](https://res.cloudinary.com/amuze-interactive/video/upload/vc_auto/v1639396814/agu-fm2021/02-F7-8B-FE-DE-1C-BB-DF-8A-07-42-5C-D7-54-11-F2/Video/Rhymes_Reasons_3_wf2gai.mp4)

## **4. Societies, continents, planets**

[VIDEO] [https://res.cloudinary.com/amuze-interactive/video/upload/vc\\_auto/v1639397482/agu-fm2021/02-F7-8B-FE-DE-1C-BB-DF-8A-07-42-5C-D7-54-11-F2/Video/Rhymes\\_Reasons\\_4\\_hfduwx.mp4](https://res.cloudinary.com/amuze-interactive/video/upload/vc_auto/v1639397482/agu-fm2021/02-F7-8B-FE-DE-1C-BB-DF-8A-07-42-5C-D7-54-11-F2/Video/Rhymes_Reasons_4_hfduwx.mp4)

# A WORLD IN TRANSITION

**Where in this *complexful* world?**

[VIDEO] [https://res.cloudinary.com/amuze-interactive/video/upload/vc\\_auto/v1639400636/agu-fm2021/02-F7-8B-FE-DE-1C-BB-DF-8A-07-42-5C-D7-54-11-F2/Video/Rhymes\\_Reasons\\_Alpha-Omega\\_nvgsur.mp4](https://res.cloudinary.com/amuze-interactive/video/upload/vc_auto/v1639400636/agu-fm2021/02-F7-8B-FE-DE-1C-BB-DF-8A-07-42-5C-D7-54-11-F2/Video/Rhymes_Reasons_Alpha-Omega_nvgsur.mp4)

# ALPHA AND OMEGA

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This certainly is a complex world, but it can also be a **beautiful** one, with our knowledge at the service of contemporary and future societies.

A **complexful** world, if you will.

## AUTHOR INFORMATION

A tectonic geomorphologist tackling seismogenic sources, merging data from field, earthquake, subsurface and marine geology, historical and instrumental seismicity - with a global outlook on the interplay among risk, energy, safety, complexities.

My current interests straddle: seismicity models and zonation for seismic hazard assessment; the overlap between seismological, historical, and geological records to

assess the shifting landscape and human siting; the geological contribution to global change; the terrestrial energy budget, geosphere-biosphere feedback, and physical complexities to address medium/long-term safety/relocation of the built environment.

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# ABSTRACT

Probably the founding father of Geology, Sir James Hutton was raised as a doctor but his passions for the nature surrounding his farm led him to rocks, then specimens, then fossils. The result was what we might call a comparative physician – the first paleontologist, in fact.

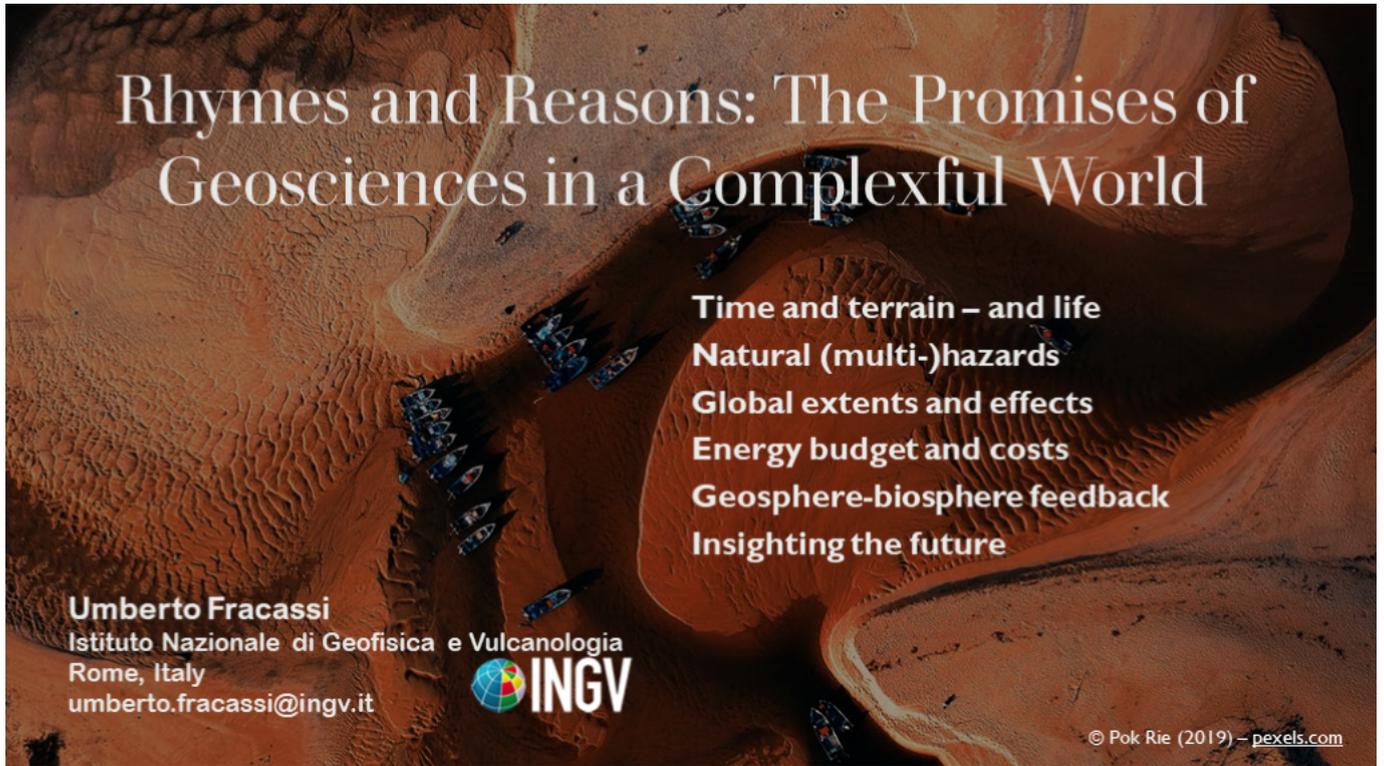
His upbringing in medicine had given him the classical knowledge of his time, from Latin to mathematics, and from biology to drawing. Not only did the lack of a specific scientific discipline bring Sir Hutton to devise a novel field of study of his own – it also molded strands of his formal learning into a synthesis of intellectual tools.

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2. The precious role of geosciences to decipher them – and to forecast them;
3. The complexity of natural hazards, the (need of) flexibility in human planning;
4. Modern issues challenging societies and economies – today, tomorrow, and thereafter.



# Rhymes and Reasons: The Promises of Geosciences in a Complexful World

**Time and terrain – and life**  
**Natural (multi-)hazards**  
**Global extents and effects**  
**Energy budget and costs**  
**Geosphere-biosphere feedback**  
**Insighting the future**

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