Natural and social scientist.

Original training was in geology and geochemistry.
Work now primarily as a social scientist: a historian of science attempting to understand both the development and also the rejection of scientific knowledge.

Question:

What is the value of integrating social science into Earth system science?

Obvious and superficial answer: **the Earth includes people**.

But, historically, we have not included the human dimension in our definitions of Earth science.
Opposite: where people appeared, that is where natural science ended.

Once, that approach may have worked. But it is no longer working now.

My argument:

Two essential reasons:

The first one is extremely basic.

1) As scientists, we want to get the **right answers** to our questions. When we ignore the social/ cultural components of the systems we are studying, often we get the wrong answers.

   The most basic consideration of science—how do we get the right answer—compels us to consider the social dimensions of the problems we are addressing.

   (Some examples of this)

   The second reason in important, too.

2) Communication:
   When we don't incorporate the social dimensions of the issues we are studying, we may end up—accidentally--communicating in ways that are misleading.

   (one very important example of this)

Getting the right answer:

First example (outside Earth science)
(easier to see a problem when someone else is making it)

First example: GHSI. Global Health Science Index.

Assess preparedness of 195 countries.
Based on a complex set of indicators.
Using a panel of experts, primarily people in public health.

Concluded:
US was most prepared country to face a pandemic.
UK was second.

New Zealand: 35th
Vietnam: 50th.

And so on.

These experts got it totally wrong.
The countries they judged to be most prepared have had some of the worst outcomes, and some countries judged to have been quite unprepared have done extremely well.

In fact, results were so wrong, that there have already been two peer-reviewed papers demonstrating how wrong they were,
One: " not predictive"
The other: "it was predictive, but in the opposite direction."

What happened?

We all know now that the terrible outcomes we have witness here in US was not because we didn't have good scientific expertise, or good medical infrastructure.

In fact—rapildity of Pfizer vaccine development is testament to our prodigious scientific capacity.

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> The U.S. failed to mobilize this capacity for reasons that were largely political. Initially, the President did not take the pandemic seriously, and then, by his own admission, played it down for political reasons. More than a few politicians and celebrities flouted public health advice, appearing in public without masks well after the evidence of their benefits had been communicated. Our layered and decentralized system of government let to varied policies, some cases putting state governments in conflict with their own cities. And many American citizens refused—in some cases belligerently—to practice social distancing, interpreting it as an unacceptable infringement on their freedom.

The GHSI got incorrect answers because it did not adequately consider and incorporate the social and political dimensions of the problem.

Second example: Hydrological modelling

Some years ago, in fact 20...

Oreskes, Naomi and Kenneth Belitz, 2001. "Philosophical Issues in Model Assessment," in *Model Validation: Perspectives in Hydrological Science,* edited by M.G. Anderson and P.D. Bates (London: John Wiley and Sons, Ltd.), pp. 23-41.

We wanted to try to answer two questions;

1) How well do hydrological models perform in real life?
2) When they don't do well, why is that?

Reviewed available literature, and discovered something that we had not anticipated:

1) Many models did very poorly. Often the model forecasts diverged from real life very quickly, sometimes in as little as a matter of months.

2) The reasons for the divergences, when they could be determined, were almost always the same: failure to adequately recognize and incorporate the human component of the system.

Example: Population growth that led to higher pumping rates than expected.
Or physical changes, like changes in rainfall, that led to changes in human behavoir.

Both these examples, one from earth science, one from outside earth science, but a field that has to think in systems terms, show how failing to account for human behavoir can cause you to get the wrong answer to your question.

Communication:

Because the systems we look at include both human and non-human components, the way we communicate about them needs to convey that as well. But often natural scientists, who have been trained to focus on the non-human component—and to discount or even ignore human behavoir—don't in fact communicate effectively with respect to the human part.

Seismology, the tragic story of the L'Aquila earthquake, in Italy.

Italy of course an area of known seismic activity.
Also the case that small earthquakes occur all the time.
Most are not particularly dangerous.

On April 6, 2009, a magnitude 6.3 quake struck L'Aquila, the main city in the Abruzzo region.
Thousands of buildings—many historic—were destroyed.
309 people were killed, many more injured.

Three years later, seven men—six scientists and a former government official—were sentenced to six years in prison for involuntary manslaughter in connection with those deaths.

The convictions outraged scientists around the world—the Us and British press reported the story as an attack on science, a case of scientists being expected to predict the unpredictable.

Several scientific societies issued formal statements defending the scientists and condemming the convictions as travesties.

With the help of an Italian-speaking graduate student, I undertook to study the case, to try to understand what had happened.

But what became clear in studying this case, was that the scientists were not prosecuted for failing to predict the unpredictable. They were prosecuted for offering misleading information.

Indictment alleged that they had given "Inexact, incomplete, and contradictory" information.
Particularly, they had stated (factually) that scientists were not able to predict when the next quake would come, so people should just go home and have a glass of wine.

Montepulciano.

At the trial, it became clear that lay people ha*d interpreted this as meaning there was no danger. (*which clearly was not the case).

They had interpreted the statement that scientists could not predict when the next quake would come as meaning that no big new quake was imminent.

And they interpreted the reassurance as suggesting that their *buildings* were safe—which was clearly not the case. In doing so, they encouraged people who might otherwise have evacuated to stay home.

> Trial: testimony from people, including one man whose wife and child had been killed, that he would have evacuated had the scientists not put out a reassurance that very day.
>
> Felt a shock in middle of night. He and his wife discussed whether to leave. But Recalling the reassurance, they went back to sleep.
> Then big one hit, and building collapsed. His wife and daughter were killed.
>
> Testified to tradition of going out to the Piazza for safety. In other words, there were cultural traditions in that region that helped to keep people safe in the face of scientific uncertainty, but those traditions were trumped by the scientific reassurance.

Because the scientists were members of a government commission whose task included public communication, they were judged to have been derelict in their duty to inform.

I do not wish to suggest that I support the prosecution of these scientists.
This was a very complicated case, and I think reasonable people could come to different conclusions about it.

But one thing is clear: the ways in which scientists discounted/ misinterpreted how the public would understand what they were saying. And this misunderstanding—rooted in a lack of expertise in psychology, or local history—led to the deaths.

Not a question of intelligence or hard work

All these examples, the people involved were intelligent people, who had worked hard on the questions they addressed.

Problem of conceptualization.