The Great Simplification

Nate Hagens (00:00:02):

You're listening to The Great Simplification. I'm Nate Hagens. On this show, we describe how energy, the economy, the environment, and human behavior, all fit together, and what it might mean for our future. By sharing insights from global thinkers, we hope to inform and inspire more humans to play emergent roles in the coming Great Simplification.

(00:00:28):

I'd like to welcome climate scientist, Leon Simons, to the program. Leon most recently was a co-author of James Hansen et al.'s paper, Global Warming in the Pipeline. Leon is also a board member of the Dutch Chapter of Club of Rome. Most specifically, what we're going to talk about today is Leon's contribution to this paper, which is breaking out the emissions and the aerosol contribution from human activities. Aerosols and emissions have been going up in tandem, but the aerosols are masking the expected warming from the thermal impact of a higher energy imbalance.

(00:01:13):

Leon looked at how global ships now have new regulations to reduce the sulfur particulate emissions, and when that happened in the global shipping routes, measured by satellites, the ocean temperatures went up, they were absorbing more heat, because there was less aerosol masking. So this is a difficult conversation, because the implications are that we're about to have more warming in the pipeline than expected, and also because Leon is a scientist and had scientific answers which were quite dense. And yet, it's a very important hypothesis to put out there on how human particulate aerosols have been masking the warming so far. Please welcome Leon Simons.

(00:02:19):

Leon Simons, Goedemiddag.

Leon Simons (00:02:20):

Goedemiddag.

Nate Hagens (00:02:23):

How are you today?

Leon Simons (00:02:24):

I'm good. How are you doing?

Nate Hagens (00:02:26):

I am good. I am nervous for this conversation. Nothing you say will change what's happening in the world, the physical climate world, but what you say may act as a bunker buster to my prior assumptions of my own analysis of the future. And I'm nervous because I expect, I know the things that you're going to say, because I've watched and read some of your materials. So let me preface this conversation by saying this. You are a climate scientist, but you're also a human that cares about our future, and you're also a human that's living during this time.

Leon Simons (00:03:03):

Yes.

Nate Hagens (00:03:04):

So you, like many of us, wear three different hats. Part of our problem is that a lot of people merge the science and the response on various things, and it ends up being muddled. I'm going to break this interview into three pieces, and the first piece I want you to wear your scientist hat, and then you can speculate in the second piece about the future and responses, and then finally, I'll ask you some personal questions.

(00:03:31):

So we have a lot to unpack, can you start out with your broad expertise, your particular specialty in climate research, and maybe a couple minute umbrella of your main thesis?

Leon Simons (00:03:44):

Yeah. So my expertise originates from first traveling the world and trying to understand our impact on the world, which I did after high school when I was 19 years old. I traveled the world because I knew things were changing rapidly and I wanted to understand them. And then, I started studying, I wanted to change the world for the better by studying tropical forestry. But what I've seen in developing countries, that about three billion people still use biomass for cooking, and I saw that this can cause rapid deforestation and change the place where people live and destroy the environment. So then I decided to drop out of school and to start my social business focusing on developing clean energy technologies, especially around cooking for

Ethiopia. But in the meantime, I've always kept up to date with the science. I got involved with a think tank called Club of Rome in the Netherlands, and then through that, I kept always doing research, both on the science, but also visiting climate conferences and trying to understand these changes that are happening.

(00:04:52):

And while doing that, I learned that the most biggest uncertainty in climate science is the effect of small dust particles, both natural, like sea salt or desert dust, but also anthropogenic, so human-caused dust. These are called aerosols, and they change how much sunlight is reflected by the planet, by directly reflecting sunlight, but they also interact with water vapor in the atmosphere. This water vapor condenses to these aerosols, and then clouds form. And without these particles, there wouldn't be any clouds. So I learned that this crucial aspect within climate science, and also the biggest uncertainty, because it's so uncertain how clouds respond to these particles.

(00:05:34):

But then, you see that in the communication and in the science, it's very rarely this aspect is being discussed. I think we'll get to that. But I started looking into that, and then I found that, in 2019, I learned that in 2020, there will be this very big policy change over the oceans of reducing sulfur in the fuels, and that that would change how much sulfur is being emitted. And sulfur is a very important aspect of sulfate particles, which are the strongest cooling agent of our climate. And I got into touch with James Hansen, and I explained to him what was happening. First he was skeptical about it, then I explained the science and the policy and how this is implemented, and then he asked me to do the research with him on that, and that's how it is. I got more involved into the science, and I started spending more time on it.

Nate Hagens (00:06:30):

And that led to you being a co-author of the recent paper, Hansen et al., Global Warming in the Pipeline, which I've read, and is terrifying, to say the least. Could you give just an overview of the main thrust of that paper, and then we're going to unpack the aerosol component?

Leon Simons (00:06:49):

Yeah, sure. It's a very big paper and it brings together many different fields within the science, and the co-authors that represent different fields which come together. So there's, for example, Norman Loeb is a scientist from NASA, he has the CERES team which provides satellite data which we use in the paper. But the paper also looks at the paleoclimate, for example. So all these different parts of the climate system, the different sciences to understand all these different parts, come together, and they strengthen the findings from one part of the paper to the other.

(00:07:27):

So what we learned, for example, from paleoclimate data, that it was much with a less strong climate forcing, the effect on climate was stronger than was previously thought. That's what we learned from the climate data from millions of years ago. But then also, if you look at thousands of years ago, for example, after Last Glacial Maximum, so the ice age, so to say, how fast the planet warmed, and how long it stayed warm, and what caused that. Of course, we can learn from air bubbles captured in ice sheets to see what the greenhouse gas concentrations are.

(00:08:04):

And then, if we look at how the climate changed over time, some models don't understand what's happening. For example, the models take into account greenhouse gas concentration of the past, say, 6,000 years, and the climate should be warming. Instead, there has been a slight cooling, if you look at the climate proxy. So some other scientists analyzed the climate of the past 6,000 years from three-year rings, et cetera, and then they noticed a slight cooling, especially over the Northern Hemisphere.

(00:08:36):

What we looked at is, for example, the aerosols, so these particles I talked about, might have been cooling the planet, while these greenhouse gas have been causing warming off the planet, and then these two effects, these two forcings, they interact, and has been a net, more or less, stable, or a bit cooling, climate, while these greenhouse gases kept increasing. And those increasing greenhouse gases, from Ruddiman et al., that research shows that it might be, or could likely be, because humans spread across the planet, and started deforesting the world, and they started producing rice, which creates methane, and this deforestation, of course, results in CO_2 entering the atmosphere. And these effects, of course, increase the greenhouse gas concentration, especially if you compare it to other interglacials, other warm periods after a glacial and after an ice age. So we would expect it.

(00:09:34):

Now, if you look at just this, the greenhouse gas concentrations, you should expect the planet to warm up until the pre-industrial times. But now, we see that the planet, so the proxy show that the planet has been cooling down instead. And then, of course, industrial revolution happened, and then there was a big increase in greenhouse gas emissions, but also an increase in aerosols.

Nate Hagens (00:09:57):

And so, the implications of the Hansen paper, the conclusions and implications?

Leon Simons (00:10:02):

Yeah. Well, what we showed with the paper led by James Hansen is that the rate of warming is already increasing, so the planet is now warming faster than it was in the recent decades. We show that, through satellite data mainly, that the rate of planetary heat uptake is rapidly increasing, and that is mainly caused by the planet absorbing more sunlight. And that's not because the sun is starting to shine brighter, but that's because there's less light being reflected, and that's because there's less clouds, there's less aerosols, and there's less ice and snow reflecting the sunlight. And the cloud effect includes the effect of these aerosols, but there's, of course, uncertainty by how much. This is the greatest uncertainty in climate science, this data helps us, the data from what we call inadvertent aerosol experiment of rapidly reducing the sulfur emissions, this helps us to reduce the uncertainties within climate science.

(00:11:09):

And then, while we're reducing these uncertainties, it shows, together with all the other data I already talked about, it shows that the warming from greenhouse gases is very likely stronger than we thought before because aerosols cooled more and the glacial periods were cooler than we thought, that means that the change from greenhouse gas concentrations is also stronger, the forcing effect is stronger. So the greenhouse gas will warm more if the aerosols cooled more. And then, that means that we can expect maybe a few degrees, it's like what you call a Gedankenexperiment, so more a thought experiment, what would happen if the greenhouse gas would stabilize at the current rate?

(00:11:51):

Of course, that's not what's happening at the moment, the greenhouse gas are rapidly increasing and the aerosols are rapidly decreasing. But we look at what would happen if, hypothetically, the greenhouse gas concentration would stabilize, and with and without aerosols, and then we could have four to five degrees warming by the end of the century. And then, further in the future, that's, of course, very hypothetical, because greenhouse gas concentrations will not stay at this very rate indefinitely, but then we could see eight to 10 degrees Celsius warming. But that means then if all the ice sheets around the planet would melt.

(00:12:31):

And one thing to take into account there is that also the sun is shining brighter and brighter over millions of years, so after about 50, 60 million years, the sun is shining about one and a half watts more brighter over time, so the greenhouse gas concentration of 50 million years ago, it's only part of the story compared to today.

Nate Hagens (00:12:51):

Yeah, I didn't think about that. So the PETM mass extinction due to volcanic activity that took thousands and thousands of years, that happened when the sun was less bright. So if we have the same CO2 in the atmosphere from our Volkswagens and Volvos instead of volcanoes, that's going to be meeting a brighter sun as well, so a higher sensitivity could be presumed?

Leon Simons (00:13:22):

Yeah, you have to take that into account, indeed.

Nate Hagens (00:13:24):

So this is horrible news, because there's two phenomenon, and we've been focused on one. Let me unpack what you just said and throw it back with some questions. So humans burn stuff, and the resulting CO2 and methane act as a thermal blanket on the planet, absorbing more infrared heat, and ultimately heating the earth because there's a higher energy imbalance.

Leon Simons (00:13:53):

Yeah.

Nate Hagens (00:13:53):

And we've recognized that, and we're focused on that, and we're worried about that. Some people who don't believe in climate change point out things like the Little Ice Age, or, "Why isn't the climate warming because you have all this CO2? There's not the correlation that you thought," and there's stories like that out there. But what you're saying is there were two phenomenon, two things that humans were doing, in addition to the sun and other natural things, that were offsetting forcings, the CO2, but then the aerosols that were created long, long ago, you mentioned up to 6,000 years ago, from burning of forests, or riding horses and kicking up dust, and anything that humans do, and that that particulate matter heightened the reflectivity of clouds and reflected more of the incoming sunlight back into space so that we didn't warm the planet as much as the CO2 science would have predicted. Is that correct?

Leon Simons (00:15:04):

Yeah. What you started off saying is that this is not taking into account the aerosol, but it is. So for recent climate, the changes since The Industrial Revolution, since, let's say, 1750, the IPCC, for example, especially the part of the IPCC report, it's a very big report, the most recent one, for example, it's split up in three parts, and then there's a census report, but the first part, aerosols are an important part of that, because otherwise, without these aerosols, you cannot understand the changes that are happening, as you just described. But of course, the scientists who are trying to understand, they do take this into account, and I can show that effect with one of my slides, for example.

Nate Hagens (00:15:50):

Sure.

Leon Simons (00:15:50):

There's this slide showing the main drivers of global warming, and that's from IPCC assessment report, from the Summary for Policymakers, and I've taken out the two main drivers. And if you see it on the left, it says "total human influence," that's up to about 2019, and it shows about 1.1 degrees Celsius of warming globally since The Industrial Revolution, so since 1750 I think this is, or 1850.

Nate Hagens (00:16:21):

Okay.

Leon Simons (00:16:23):

And then, there's one bar which shows that there's about one left degree warming from mixed greenhouse gases. And then, one might think, "Okay, why didn't it warm 1.5

degrees Celsius yet?" And the main cause of that is the emissions of sulfur dioxide, which cools the planet by about half a degree, and by the way, with a very large uncertainty. So that's for this IPCC estimate saying that there's a half degree cooling from sulfur, but with an uncertainty range of about 0.2 to 0.9 degrees. And that's sulfur cooling to date, so that doesn't take into account the present energy imbalance. So if all these concentrations of greenhouse gas and sulfur emissions and all the other particles would stay the same, they would still be warming because there's an energy imbalance, so there's still more energy coming in than going out. So until there's a balance, then there will be no more additional warming. Still, there's more heat radiation going out and sunlight being absorbed, there's no balance.

Nate Hagens (00:17:28):

So the IPCC does include aerosols in their math, but you think that the cooling effect, the dampening effect, of what we would've seen as warming is larger than the IPCC core models?

Leon Simons (00:17:45):

So before we started this research, we didn't think anything really, we just thought, "Okay, this uncertainty which IPCC shows in their graphs and in their text, this uncertainty is so large, especially with the interaction of particles, these aerosol particles and clouds, it's the largest uncertainty within climate science, so it's important to reduce this uncertainty to understand how our climate will change." And this natural experiment, which I'll talk about, of rapidly decreasing the sulfur emissions over the oceans by 80%, that provides climate science with an experiment, a natural, or we call it inadvertent experiment, to reduce this uncertainty and to understand what the real warming effect of greenhouse gases is.

Nate Hagens (00:18:39):

And how fast do you see a response if you stopped aerosols, how fast is the cooling masking disappear and we see warming?

Leon Simons (00:18:50):

Yeah. So we see a direct effect. So you would expect, for example, these particles stay in the atmosphere for days to weeks, so they rain out, because it's solid and liquid particles compared to greenhouse gases, the name says it, which are gases, which stay in the atmosphere until they react with other gases. But then the aerosols, they rain out, as I mentioned, they cause cloud formation, and they interact with clouds, and they rain to the ground, and then they are out of the atmosphere and their effect is gone.

(00:19:26):

But then, how long does it take? So we expect this to cause a forcing change, so this cooling effect of these particles to reduce right away. But then it takes time, of course, for the system to respond. So if you take these particles out of the atmosphere, the sun will shine, instead of that it will reflect it, it will be absorbed by the oceans. But of course, it takes a long time for the oceans to heat up, because it's a very large mass of water with a high thermal capacity, so it takes a lot of heat to heat up. It also influences the climate as well, because if it's warmer, there's also a change in clouds, because there's less cloud condensation and clouds evaporates faster. So these are feedbacks which also take time to come into effect. There's more evaporation, so there's more water vapor in the atmosphere, which also causes warming, but also if the planet heats up, there's more thermal radiation, so that reduces the warming. So all these different aspects should be taken into account.

(00:20:31):

And now, now we have about three, almost four years of data, of what happens when you reduce the sulfur emissions over the oceans by about 80%, and the data has been coming in. Of course, we've only mainly had three years of La Nina, another aspect is a negative Pacific Decadal Oscillation, which our co-author, Norman Loeb, wrote a paper about, where he says, "Okay, if this Pacific Decadal Oscillation will be negative, we expect the earth's energy imbalance to decrease, but it has been increasing instead." So that's also a worrying sign that the effect might be even stronger.

Nate Hagens (00:21:10):

I want you to unpack what happened with the sulfur emissions, but let me just ask a question on what you just stated. This kind of is a testable hypothesis, because if we don't have the sulfur emissions from shipping the way we used to-

Leon Simons (00:21:24):

Yeah.

Nate Hagens (00:21:25):

… so that we have less particulate matter and the dampening forcing is less, and we shift into El Nino, we can predict with high confidence that we're about to have another spike in temperatures, like in the next six months as we move into El Nino.

Leon Simons (00:21:47):

Yeah. So that's what we also show in our paper and in other communication, that we expect this El Nino, because we now have entered an El Nino, and we are now starting… What we've seen this year is in part an El Nino, but more even just the end of La Niña. So La Niña and El Niño is a cycle in the Equatorial Pacific where sea surface temperatures increase and they result in … during El Niño it increases and it results in net global higher temperatures. And during La Niña, the sea surface temperatures in Equatorial Pacific are lower, and that translates generally to lower global surface temperatures. So we have had three years of La Niña-

Nate Hagens (00:22:35):

And three years of lower emissions too. I mean, not carbon emissions. Sulfur emissions.

Leon Simons (00:22:42):

Lower sulfur emissions, indeed, but also higher greenhouse gas concentration increase, especially with methane and nitrous oxide. So there's of course many things happening.

Nate Hagens (00:22:51):

That's the problem with all this, isn't it? It's this giant ten-dimensional jigsaw puzzle that people focus on one piece of it. Then it's just climate, and then there's economy and geopolitics and money and energy. The whole thing, our species can't figure it out.

Leon Simons (00:23:09):

So you also have these environmental regulations and health regulations, which I'm now talking about from the shipping, but we do know where the ships are going. So if you look, again, at this graph I was showing-

Nate Hagens (00:23:23):

On slide three?

Leon Simons (00:23:24):

I think slide three, yeah. So where you see the main drives of global warming on the left, and there on the right you see the sulfur dioxide from the anthropogenic sulfur dioxide emissions. And there you see that these emissions over the oceans, over the Northern Hemisphere, especially over the North Atlantic and North Pacific oceans are very high.

Nate Hagens (00:23:46):

So that's the yellow and orange swaths over the ocean.

Leon Simons (00:23:50):

Yes, between the landmasses of Europe and North America.

Nate Hagens (00:23:52):

And what are the red?

Leon Simons (00:23:55):

That's over land. The dark red is over land, which is mainly coal- fired power plants. Mainly coal-fired power plants, other large sulfur sources.

Nate Hagens (00:24:05):

And then the yellow straight lines that go into the Southern Hemisphere, those are the shipping routes, presumably.

Leon Simons (00:24:12):

Yeah. So the ship routes, especially around Africa. You can see that there's shipping routes going around Africa. And of course through the Suez Canal, through the Mediterranean, there's high ship traffic as well.

Nate Hagens (00:24:25):

And so how did you use this data to test your hypothesis?

Leon Simons (00:24:30):

So let me show a different ... this is from the next slide. We have this in our paper, and it's from Jin et al., who's also a co-author of our paper. This shows total sulfate, so sulfur dioxide forms sulfates in the atmosphere. The left map shows sulfate in the atmosphere, petroleum volume, and then you see that of course there's a lot of sulfur again over the Northern Hemisphere because that's where seven of the eight billion people live. But there's also natural sources. But then on the right map it shows the sulfates from shipping.

Nate Hagens (00:25:05):

As a percentage of the total.

Leon Simons (00:25:07):

Exactly, yeah, thank you. So there's indeed the sulfate of shipping as a percentage of total natural human anthropogenic sulfates.

Nate Hagens (00:25:17):

So in the North Pacific it's like 80 or 90%.

Leon Simons (00:25:20):

Yeah. Over the North Pacific and over the North Atlantic it's 70 to 80 or 90% even at places. And that's because there's very little algae. So the natural source of sulfur in the atmosphere, it's from algae, but algae need nutrients. So without these nutrients, there's little algae. But over the vast oceans, there's not so much nutrients. So if there's no nutrients, there's no natural source of sulfur. And then the effect of this sulfur from ships is much stronger because it doesn't have to compensate with other sources of sulfur, of other natural aerosols.

Nate Hagens (00:25:55):

God. I mean, this could be a five-hour conversation. I know your family's coming, so it can't be, but I'm going to ask a couple of naive questions. Earlier in the conversation you said that if there wasn't aerosols like sulfur, there would be no clouds. But we had clouds millions of years ago. So is that from the sulfates and aerosols from algae and phytoplankton and other natural sources?

Leon Simons (00:26:22):

Yeah. So natural sources of aerosols also create clouds, of course. So there's sea salt, there's algae-producing sulfur through dimethyl sulfide and then there's all chemistry there. That's what the science is still learning about how it works.

Nate Hagens (00:26:38):

Are there more clouds today, can you speculate or do we know, than there was 10,000 years ago because of all the particulates that humans have kicked up and burnt up?

Leon Simons (00:26:49):

Yeah. 10,000 years ago, of course you also have to take into account the different temperatures, but of course we don't know for sure. But we do know that if you increase the amount of particles, you increase how much condensation nuclei there are. So there's more particles for the water vapor to condense. And also, especially there's some things to consider as well, that some particles, they are better for ice clouds, for ice crystal formation. So there's more ice crystals forming around sulfate particles than around sea salt particles, which you can understand, because especially in the Netherlands, we put salt to keep the road from freezing. So that's an example of sea salt reduces freezing. But then the sulfate doesn't do that, and that causes more crystals in clouds and causes whiter clouds. And you can see, if you know clouds, you know that white clouds often are ice clouds and dark clouds are more water clouds. Also these rain out faster. If you see a dark cloud, okay, often you know there's rain coming. So these are all things to consider. Aerosols overall cause clouds to be bigger, brighter and longer lasting overall. And again, there's a lot of uncertainty there, which this inadvertent experiment will help to reduce.

Nate Hagens (00:28:17):

Right. The inadvertent experiment of regulating how much sulfur emissions in our global ships-

Leon Simons (00:28:24):

From our global ships. Yeah.

Nate Hagens (00:28:26):

I'm going to get to that in a second, but let me ask you one more naive question. There's lots of people from different stripes and backgrounds watching this show. You just mentioned on these graphs that the aerosols are parts per trillion one, two, five. The real bright, highly concentrated are 10 parts per trillion. Is that correct?

Leon Simons (00:28:49):

Yeah.

Nate Hagens (00:28:50):

I'm a scientist and it's even hard for me to conceptualize that the difference between two parts and five parts per trillion can actually significantly change both the clouds and the dampening effect and the albedo. And it's a similar thing that three, four or five parts per 10,000 on climate can change the thermal imbalance on earth. Could you talk to me like I'm a sixth grader?

Leon Simons (00:29:19):

If you see clouds, that's about the same order of magnitude in particles. There's very little condensated water inside a cloud. It's also in the parts per trillion volume level.

Nate Hagens (00:29:31):

Oh, that's helpful. So when I see a cloud, it's not like 50% of the mass of the sky. Visually it is, but the actual condensation and particulate is in the parts per trillion. The rest is just air molecules.

Leon Simons (00:29:47):

Yeah, yeah. Or water vapor, of course. So there's gas. Water vapor is also a gas. Because you can see a cloud, of course. But CO2 is in the parts per million, so that you can see clouds when the concentration of water inside a certain volume within a cloud is much less than the concentration of greenhouse gases in the air. But you can see a cloud. You cannot see gases. You cannot see greenhouse gas. But if you would be able to see greenhouse gases, if you could see in the wavelengths greenhouse gas absorb infrared radiation, it would be black. The sky would be black because it has much more particles of greenhouse gases in the atmosphere than there's water inside the cloud.

Nate Hagens (00:30:33):

So let's get to this inadvertent experiment. So what happened? A massive reduction in sulfur in global shipping. Can you explain slide five?

Leon Simons (00:30:46):

Yeah. There's these emissions called sulfur emissions, which are harmful for health, for the environment. For example, I'm from a nice town called ′s-Hertogenbosch in the south of the Netherlands with this beautiful cathedral. And these statues on the cathedral, they were dissolving because of acid rain, and that was mainly because of the sulfur emissions from our coal plants. So in the 1980s, there was sulfur regulation to reduce the emissions from coal plants, but over the oceans, this regulation took a long time to come into effect. Around North America and around Europe, especially the North Sea, these regulations have come into effect in the past decades and have become tighter and tighter. And especially in 2015, the maximum amount of sulfur in fuels of these areas was reduced from 1% to 0.1%. So reducing the amount with 90%. But globally, there was still a lot of sulfur being emitted.

(00:31:48):

But then in 2020, on January 1st, 2020, the regulation, which is called IMO 2020, came into effect, regulating how much sulfur is allowed to be used over open seas by ships. And this decreased from a maximum of 3.5% to 0.5%. As the graph showed, there's a big decrease all of a sudden, a sudden decrease in how much sulfur the ships are allowed to carry unless they use what we call scrubbers, which wash this sulfur from the exhaust gases. So that started in 2020 over these regions. So here you can see, the next slide shows, since 1900s to today, how much sulfur dioxide in thousands of tons shipping globally was emitting every year. And that nosedived again in 2020 because of these regulations.

Nate Hagens (00:32:46):

How much of that international shipping sulfur is that of all of the sulfur from humans? A good percentage?

Leon Simons (00:32:55):

So from the total amount of sulfur emitted globally, the shipping, before 2020, it was about at 10%. And that might seem like not so much, but as I showed you, the effect is much stronger if it's emitted directly over the oceans because there's no other sources. These ships, they're all by themselves. There's very little algae. There's no coal plants there. They are the only source there. So if you want to understand this effect, you have to take that into account.

Nate Hagens (00:33:28):

So while the sulfur dioxide emissions from shipping have been plummeting, the sulfur dioxide from coal plants in China and everywhere around the world are continuing.

Leon Simons (00:33:41):

China has also been decreasing its sulfur emissions very rapidly in the past two decades, especially since the Olympics, also through the installation of these de-sulfurization systems. So all these new coal plants, they have a system which uses chalk to wash the sulfur from the exhaust from the coal plants, and then the product is gypsum, and the gypsum is sold on the market. And then through that, it's also relatively a cost-effective way to reduce these emissions.

Nate Hagens (00:34:13):

But what I was getting at is if we had a steep drop in sulfur from shipping, the rest of the world is still producing a lot of warming masking sulfates.

Leon Simons (00:34:27):

Yeah.

Nate Hagens (00:34:28):

So this is the real Faustian bargain. We have to presume that civilization continues, and as soon as it stops, as soon as the musical chairs game stops and sulfates stop, we have an immediate spike in temperatures coming our way.

Leon Simons (00:34:48):

Yeah, but that's already what we're starting to see now.

Nate Hagens (00:34:51):

Even with just this little stop, we're seeing that?

Leon Simons (00:34:54):

Yeah, but it's not a little stop. I think that's really important to understand, because I think there's been a lot of confusion around that, very understandably, of course, because it's not easy to understand. It's 10% and you think, "Okay, it's only 10%," but it's 10% over the oceans. And 70% of the earth's surface is oceans, but 90% of the global heat uptake is by the oceans. So the ocean is 90% of the heat from global warming. So global warming is mainly ocean warming. And then if you reduce the aerosols over the oceans with 80%, the effect is expected to be much stronger than if you would do the same over land, because the oceans are dark, they have a dark surface, because there's no other aerosols to compete with. And because there's more clouds over the ocean and because they take up much of the heat, if the sun is shining on the oceans, it's not just heating the first centimeter or the first layer of the surface like when the sun is shining on the land. The land absorbs the surface. The first centimeter of the land absorbs the heat from the sun and it radiates it back as heat to space. But if the sun is shining on the water, the radiation of the sun, it enters the water into a depth of about 40 meters. Some of the radiation even deeper.

(00:36:24):

So that's also important to understand, that this all contributes to the effect of changes of aerosols over the oceans to be much stronger than if you would do a globally average reduction of this effect.

Nate Hagens (00:36:38):

Mm-hmm. So how about the next slide, which I see as slide number seven.

Leon Simons (00:36:41):

So what we did to try and understand what's really happening, because before this inadvertent experiment, there were just models to try and understand what's happening. But without data, the models have of course limited value. And that was clear by the big uncertainty between models. So some say there wouldn't be much of an effect. Some say there will be a very strong effect, about equal to 10 years of greenhouse gas emissions. But we don't know. We didn't know, and we still don't fully know what the real world effect will be and is. And for that, we now have the experiment in the real world where we changed this, which is still taking shape, of course. And what we did was we looked at this North Pacific ocean and the North Atlantic ocean to see how much additional sunlight is being absorbed, because there's less sunlight being reflected by these particles, less clouds reflecting sunlight back to space. That means there's more sunlight being absorbed. And we compared this to the region of the Southern Hemisphere with the same latitudes where there's no shipping or much less shipping. So there's also less of a forcing change.

(00:37:57):

And then we see, if you see the purple and the red line, of course there's variability, there's this effect on the Pacific Decadal Oscillation, which I mentioned, which around 2016 increased how much sunlight was being absorbed because the oceans were warmer and there was less cloud formation. But now the PDO is negative so that we would expect the red line to go much lower, but it has been increasing very rapidly. And it's likely that this is because of this change in aerosols, in sulfate aerosols. And the same over the North Atlantic. After 2020, we see a big spike, a big increase in how much sunlight is being absorbed. And then over the Southern Hemisphere, we don't see this happening.

Nate Hagens (00:38:39):

So the difference on this chart between the red line and the black line, the red line representing the North Pacific and the black line the Southern Oceans, is around three watts per meter squared. Three watts per meter squared is like ... RCP 8.5 is eight and a half watts per meter squared. I mean, it's a big deal, three watts per meter squared.

Leon Simons (00:39:03):

Yeah. So the total greenhouse gas forcing, so how much heat, more or less, all the greenhouse gas humans have put into the atmosphere since 1970 ... So there's CO2, but there's also methane and nitrous oxide, but also stratospheric water vapor and ozone. So all these combined effects is about four watts per square meter. Indeed. And if you have then now a three watts per square meter increase over the North Atlantic and North Pacific Oceans, which are areas of 40 to 50 million square kilometers, that's really an enormous increase in how much heat these oceans are absorbing. And of course, we expect that to increase the ocean temperatures. And in the end, I can show you what we're starting to see now with that regards.

Nate Hagens (00:39:54):

Okay. So this graph showing the ocean absorb solar radiation, did you make that graph? Was that your data and discovery?

Leon Simons (00:40:03):

Yeah. So this is what we presented in the "Global warming in the pipeline" paper.

Nate Hagens (00:40:07):

So when you found this, were you like, "Holy shit." When you found this, was this like the smoking gun of fitting together a lot of explanations that had previously been lacking?

Leon Simons (00:40:20):

Yeah. So again, we didn't know what would happen. We didn't know what we will be seeing. The hypothesis from the climate research models looking at this in the past was that there will be a decrease in how much sunlight is reflected, an increase in absorbed solar radiation, but a very high uncertainty in how big this effect is. And now we see indeed the spike happening. We are now starting to see it. And this is the 48-month running mean. If you look at it from the past years, it's even higher. You see that by the end of the graph; it starts increasing more even. It's still spiking. So indeed, yeah, you say holy shit, I think that's quite an appropriate way to put it, because this implies that the cooling effect of these aerosols was much stronger and that the warming effect of greenhouse gases is also much stronger than previously thought, or the best estimates, let's say. The best estimates of the IPCC or of a lot of climate research underestimates this effect.

(00:41:31):

And of course, until now, it seems to be more or less in the range. But what worries me, I'm still not certain that this is the end of it. I'm not certain that this is how bad it really is, because the oceans are still quite cold, relatively to other years, because we had three years of La Niña and this negative PDO I mentioned. So now we are starting to see what happens with an El Nino, and what we see is worrying, because that's what I mentioned. It's this spike still going up. But we still don't know what will happen when the Pacific Decadal Oscillation, this other large cycle which takes longer to variate, we don't know what will happen then. And the hypothesis from NASA and NOAA together is that it will increase even further. So that's really worrying.

Nate Hagens (00:42:24):

Well, it's beyond worrying.

Leon Simons (00:42:25):

Yeah. My scientific assessment is that it's worrying.

Nate Hagens (00:42:29):

Okay. Could you walk through the next two graphs please? Earth's energy imbalance. So here we're looking at the yellow is the absorbed solar radiation and the red is the outgoing long-wave radiation over the last 20 years or so. Can you explain what this means?

Leon Simons (00:42:50):

Yes. So this is the global average absorbed sunlight. So there's about 340 watts of sunlight coming in, and about 30 to 29% of that sunlight is being reflected back to space. And then about 240 watts per square meter was absorbed by the planet 23 years ago, but as the graph shows, this has increased by two watts per square meter. So the earth is absorbing two watts per square meter more heat than it was 23 years ago. And then that has been balanced a bit, only a little bit, by an increase in outgoing long-wave radiation. And you might think, "Okay, why is there more heat going out while the greenhouse gas concentration is increasing?" That's because the temperature has been increasing. Without increasing greenhouse gas emissions, there will be about four watts per square meter more heat going out at the current temperatures than we see on this graph. So it'll be off the chart and there will be more heat being radiated to space than there is being absorbed from the sun. But now we see there's more heat being absorbed than is being radiated to space and you see that the yellow part is growing bigger. That means that there's more heat is absorbed faster, so the rate of heat uptake is increasing and that's what the next graph shows the rate of which we call the Earth's energy imbalance or the rate of accumulation of heat is increasing very rapidly. So it was beginning of the century, this millennium, it was about 0.6 watts per square meter and now it's over 1.8 watts per square meter. Over the past, let's say two or three years, it's 1.5 watts. So that's really rapidly increasing and especially in recent years has been going up, and up and up.

Nate Hagens (00:44:51):

So I have a profound question to ask here. At one point in this graph, the global net heat flux, the energy imbalance was zero in around 2010. Why was that?

Leon Simons (00:45:06):

Yeah. Then we can go back and see that the red part was touching, almost touching the yellow part. That means that there was not much more heat being absorbed than being radiated to space.

Nate Hagens (00:45:20):

Is that because of the global recession?

Leon Simons (00:45:23):

No. Yeah, I think that's mainly natural variability. So yeah, if I would take for example, a 48-month mean you wouldn't see that. So it's really of course this really 12 months and there's just variability in the system. So it's an interesting question to ask, and you could assess that, right? You could do an analysis and see, okay, where was it? How hot and why is that? Maybe it was more hot over land, which increases outgoing thermal radiation, but it was still colder over the oceans, which caused more clouds to be over the ocean. Something like that I would assume is my expert judgment. But that's not really what to look at. Of course, it's more the long-term trend to look at and then that's really going up.

Nate Hagens (00:46:13):

Right. No, I understand. Okay. So what we've learned so far is that the Earth's energy imbalance is increasing, the climate temperature response is not as high as it would be without aerosols, and a big component of those was just reduced in global shipping regulations.

Leon Simons (00:46:37):

Yes. Without the decrease of greenhouse gas emissions.

Nate Hagens (00:46:40):

Right. So talk to me as if I'm a sixth grader right now. What are the big picture implications of this and the Hansen et al. paper?

Leon Simons (00:46:50):

Yeah, so what you would think would happen if the planet is warming, so I think there's three things to take into account. So what we call a forcing is greenhouse gases are forcing, so the climate is pushed in a direction where it's warming, aerosols are a negative forcing and push the climate into a direction of cooling. So we've been of course pushing the climate into a warming state while also pushing in the other direction. So that's the forcing agents. But then what happens as a result of this net effect is an imbalance, so there's a climate response and is warming and when it heats up and a certain moment we expect there's a new equilibrium. So as much heat going out as coming in as you mentioned, okay, around 2010. So if there's always around zero, there's an imbalance going around zero, then there's no more warming.

(00:47:50):

But now we are faster pushing it, so we stopped some of the cooling effects. So we call this a termination shock of rapidly reducing part of cooling, which causes a rapid warming effect. And we expect this to translate to of course higher surface temperatures as well, and more ice melt and faster sea level rise because there's more heat in the system. But we haven't seen that yet in the past years. That's why some are skeptical about if this effect is real. But now we are starting with this El Nino, this additional heat is starting to surface. So if this data from NASA is correct, which it really seems it is, then that should contribute to the rapid increase in the rate of surface warming as well.

Nate Hagens (00:48:40):

So there are two opposing camps at different extremes. One is all those people, especially in the United States, who think that climate change is some Great Reset hoax that is not based in science, and the Earth has always warmed and they don't believe this, per se. And the other is the climate scientists themselves who have perhaps underestimated the role of aerosol as a cooling forcing.

Leon Simons (00:49:10):

And underestimated, you can underestimate the cooling effect. And we're starting to learn whether this has been underestimated and it seems it is generally. So the best estimate has more and more likely been underestimating the warming effect of decreasing these aerosols. But what's also being underestimated is that the rate at which these aerosols can be reduced, because it was always thought, James Hansen wrote in 1990 about the effect of reducing fossil fuel use and then there will be warming, because this would coincide with the decrease in aerosols. But now we continue to use the fossil fuels, we continue the increasing CO2 and methane going into the atmosphere and the concentration increase, but we are rapidly reducing the amount of sulfate aerosols and that's combined. That's of course we couldn't, every expert who understands this should expect the rate of warming to increase. And that will also, now we're starting to see that happening. And if that goes on for the next years, I think that will also help some skeptics, maybe not, or some will double down on that.

Nate Hagens (00:50:30):

That's what I was just going to say is that in a horrible way, this may be a science communication global alert. If you're right, we are going to see a spike in temperatures next year with the change in the PDO, and a shift to El Nino on top of lower sulfur emissions. And if we don't, you have something wrong in this story?

Leon Simons (00:50:55):

I hope I'm wrong. So maybe I can show you, just a second. This graph, I think the next graph shows a lot. I don't know if you can see it.

Nate Hagens (00:50:59):

Okay. Yep.

Leon Simons (00:51:01):

There's a lot of information on this, but I think it's quite clear if you know what it shows. So the top shows global emissions of sulfur dioxide since 1950. So we can see it had been increasing from 1950 to 1980. The global sulfur dioxide emissions have been increasing, and then it more or less stabilized, and there was a dip and then it increased again up to 2010, and then it started to decrease. And in 2020 there was a big dip. The second part of the figure shows global ship emissions of sulfur dioxide, which show a more or less steady increase up to 2010. And then the sulfur regulations came into effect step by step, and really coming into effect in 2020 when it nose-dived. And then yeah, you see that there's almost no more sulfur being emitted over the oceans.

Nate Hagens (00:51:57):

Sharp drop.

Leon Simons (00:51:58):

Yeah, it's a very sharp drop. And then I show three different sea surface temperature monthly graphs and warming stripes, for the Northern Hemisphere mid-latitudes, it's not only warming stripes, it's also cooling stripes because you see the temperature has been decreasing since 1950 with the increase of sulfur. Coinciding with the increase in global, but also ocean sulfur dioxide emissions. Yeah, that's what we would expect. So if there's a lot over the Northern Hemisphere mid-latitudes where most of the 8 billion people living today live, that's where most of the cooling from these particles was happening. And that's once these emissions started to decrease, the warming effect of greenhouse gases were stronger than the cooling effect of aerosols. And we see a rapid increase. But now in the recent years, you see it has been increasing more and more and faster than the other region I show in the second-lowest region, which is the mirrored region of the north, so the Southern Hemisphere mid-latitude, where we see only a gradual increase in temperature over the oceans without much of an effect of the sulfates.

(00:53:12):

And then the bottom, we show the global effect. And there you also see that there wasn't much warming in the beginning up to 1980. And then there was a gradual, the warming started to increase, and then recently started to increase faster. But then now in the past, now also coinciding with the start of the El Nino, we see a big spike again. And we can expect with this continuing decrease because there's also other places where the sulfates decreased, we can expect the warming to increase further and that could also have other effects. For example, the aerosols could have been keeping the AMOC stronger than it would've been without these aerosols. So the Atlantic meridional overturning circulation could also be impacted indirectly by these changes in sulfate.

(00:53:58):

So we really have to prepare ourselves for a lot of very big changes to come to our climate and weather systems. We already started seeing this in 2023 with a lot of crazy weather storms that formed within 12 hours from a storm to hurricane five hitting Acapulco in Mexico, stuff like this, these high sea surface temperatures impacting coral reefs, all these things happening. So you're right, it could help to open some eyes, maybe some eyes will shut even more because it's very inconvenient to believe this, that we are responsible for this.

Nate Hagens (00:54:37):

I agree.

Leon Simons (00:54:38):

Who should have seen this coming, and who haven't seen this coming are already starting to bury their head deep inside the sand, or inside the models and pretending there is variability.

Nate Hagens (00:54:48):

Well, it affects their built identity and all the decisions they've made in the world. So I want to get back to the paper, but first let me ask you this. So yes, if we do get another half degree of warming and even temporarily, because then it'll go back down after the El Nina starts again at some point.

Leon Simons (00:55:08):

It might.

Nate Hagens (00:55:08):

But it won't go all the way back down probably it'll just retreat higher highs and higher lows sort of thing.

Leon Simons (00:55:14):

Yeah, maybe. But of course we don't know with this forcing. The temperature might not even go below 1.4 ever again, global average increase in surface temperature, it might stay very high.

Nate Hagens (00:55:27):

Well ever is a long time.

Leon Simons (00:55:29):

Yeah, ever okay, sure. But yeah, it's a good point.

Nate Hagens (00:55:33):

In the next few thousand years.

Leon Simons (00:55:35):

Yeah. I like to focus personally, I like focusing on this century because it's what we understand most and it's also what we can impact.

Nate Hagens (00:55:46):

I actually don't like focusing on this century, because I think the climate won't stop warming in the year 2100. And I think one of the implications of Hansen paper where you were a coauthor, is the earth's system sensitivity to a doubling in CO2 is now, based on your research, much higher than is conventionally accepted. That if we double CO2, there's a transient equilibrium and an earth system effect after all the feedbacks are measured. And if we only care about the transient one, because that's when we and our children are alive, we're neglecting what happens to all the other species, and ecosystems, and the human species thousands of years from now.

Leon Simons (00:56:35):

I agree on that, but I think also, I think most people don't care about that that much. And then if you want to take that into account, if you want the long-term effect to be less strong or less bad, it's also important for people to understand that the near term effect is likely much worse than most think, right? Because most don't know about these aerosol effects. It's like in the COP in Dubai, very few people were talking about it and the word aerosols are not in the agreement. So people are very blind to this effect, because they don't know if this could impact the overturning circulation. They don't know that this could cause really rapid warming where they live themselves in the very near future. And if they would know, if people would know, they might, I don't know, but they might, get their shit together faster.

Nate Hagens (00:57:35):

Emphasis on might. Let me ask, I have so many questions, Leon, I know your family's coming home soon, but there's 1,000 questions. So first of all, yes, we might say that a half degree additional warming Celsius in the next six months due to the combined effect of the PDO switch and the sulfur would be an alarming, Don't Look Up, asteroid-hitting-us sign that would wake people up. But on the other side, is it possible either in the near term or in coming decades that the positive feedbacks from nature, from low-lying methane producing areas and some of the feedbacks that are triggered from warming start to make human emissions not the dominant story? In other words, could we trade off some alarm and political awakening to this with pushing into a higher percentage of biological feedbacks dominating the process?

Leon Simons (00:58:38):

Yeah, so well what worries me personally is the Atlantic Ocean where most of the heat flow from Southern Hemisphere to Northern Hemisphere happens through the ocean and through the atmosphere over the Atlantic. And then so that's transported heat from south to north. And then because we decreased the sulfates, the ocean is absorbing more heat than it was without. And then there's less need of heat transporting from the south to the north. And we already see in the hypothesis I have, that this might contribute to the melting of Antarctic sea ice, so faster because there's more heat staying in the south, which contributes to melting of Antarctic sea ice, but also keeping it from freezing. And then if the AMOC shows on, of course that could influence global weather systems, could impact the monsoons, it could impact the weather we have in Europe. It could impact the weather all around the world.

(00:59:40):

So that's really something to take into account. And some part of the system might be less affected by it than others. And of course we have the Canadian forest, another paper I was a co-author of this year by Ripple et al, present also the different things happening through the climate system this year. And one enormous spike in forest burning over Canada was part of this. And it's really off the chart, combined with the sea surface temperatures, and the surface set temperatures and the Antarctic sea ice. I think it's already very worrying even without what we might expect happening in the years to come and how people will respond to that.

Nate Hagens (01:00:25):

Do you feel some vindication that you've been devoting a lot of your life's energy to researching this and now it turns out that what you've been writing about and talking about for the last 20 years is happening? Or is it kind of bittersweet because humanity just didn't do anything?

Leon Simons (01:00:45):

Yeah, so it's very, in a way, of course it's for everyone it's personal. 30% of my country is already below sea level and that's increasing. So I might lose my country because of this.

Nate Hagens (01:00:59):

I was right, but I lost my country.

Leon Simons (01:01:02):

Yeah, exactly. So I'd rather be wrong. I think that's very important. But whatever people say, I think the data shows that it's likely worse than most people think. And I cannot argue with the data. I can try, but the data is there.

Nate Hagens (01:01:18):

So what would the very senior respected IPCC scientists say about the slides that you've shared with me today, and your paper and your explanation, and your prediction that we're going to have another spike in temperature likely in coming first half of 2024?

Leon Simons (01:01:37):

I think it depends whether they are listening and whether they are reading the paper before they respond. I think that's important. I think the first response might be this can't be right, because I think the first response of James Hansen when I talked to him about this was also this can't be right.

Nate Hagens (01:01:54):

I respect him for that. He's a puzzle solver and he's skeptical and he's like a pit bull. He wants to understand it.

Leon Simons (01:02:01):

Exactly.

Nate Hagens (01:02:02):

And here's the thing, I don't know him well, but I would never discount what he said because he did this almost 40 years ago, was talking about this. And what a burden that guy must carry trying to explain all this to the public, and to policy people for 40 years, and all time emissions, all time new coal capacity building in 2023. Sorry to interrupt. Keep going.

Leon Simons (01:02:28):

No, you're right. And I think that's also maybe a reason why Hansen is sometimes using stronger language than he has in the past.

Nate Hagens (01:02:36):

He said that your research is a big fucking deal is what he said on some recent podcasts.

Leon Simons (01:02:42):

Exactly. Yeah. So I think that's the research, but I mean the findings, it's not just our research. Even before we present this research, our co-author, Norman Loeb from NASA wrote a paper in 2021 showing that until 2019 there was an increase in the rate in the Earth's energy imbalance rate, in which the Earth is doubling in the rate of warming. And it didn't get much attention. But this data is worrying. It's not just how we present it. It's the data itself that is worrying. And I wish people would look at this data and come with different conclusions and explain us why we are wrong using the data. But I haven't seen that yet. So that's what I think what's important to see. If you say, okay, what would be the response of IPCC authors, which some are even part of our paper, but what would be the response of some IPCC authors? I think please look at this data and tell us we are wrong. I think that's what we all want to hear.

Nate Hagens (01:03:48):

Thank you. So I have so many more questions for you. Let's move into the second part. You've been full scientist talking about the data and your research so far. Now I still want you to kind of have your scientist hat on, but also speculate. I'm going to ask you some questions. So given what you know now, and of course this can't be proven, this is just your opinion as a very well-informed person, under the default scenario, where do you think the ultimate, what I'm referring to with my colleagues, Holocene, and Anthropocene, Thermal Maximum will be? Where are we headed temperature wise as the centuries unfold if we do nothing and the default? And I'm not talking about RCP 8.5, bio-physically implausible coal and oil and gas availability, but even a near-term, next decade or so, peak and decline in emissions. What are we looking at?

Leon Simons (01:04:48):

So you want me to guess?

Nate Hagens (01:04:50):

Yes. And then attach a confidence interval to your guess.

Leon Simons (01:04:55):

So I think it's very, very uncertain what will happen.

Nate Hagens (01:04:58):

Well, you've already told me that we're headed to 1.5, and James Hansen has said that in the next two decades we'll hit two degrees and that will be kind of the baseline. So we've got that.

Leon Simons (01:05:09):

Even though what we show in our paper, we assume that the AMOC will not stop. There will not be a shutdown of the-

Nate Hagens (01:05:17):

Well, it's already stopped 20 to 25%. So it's slowed significantly.

Leon Simons (01:05:22):

Yeah, exactly. But it has stopped before, right? So after the last Ice Age, but it has stopped many times. So we know that's possible. Almost stopped. We know it can slow down significantly and that within years, the weather in Europe can change. A place where people are producing food, it can change. And I don't know what will happen. I don't know, maybe we might increase coal use again, because we need to eat, we need to heat our homes. That's a response, right? It's not something I think should happen or I want to happen, but that's what humanity might refer to with the situation that--

Nate Hagens (01:06:00):

Or we would chop down forests, which would mean a smaller sink for carbon.

Leon Simons (01:06:05):

Yeah. If you look what happened in Canada, which I already mentioned, that we maybe cannot even cut it down fast enough before it started burning, right? So, that's also something to consider. So indeed, there's a lot of known unknowns. And then, personally, of course, surface temperatures are interesting. But for me, living in the Netherlands, I think sea level rise is much more important than... Global surface average surface air temperatures are not what people really care about, it is not what they feel strongly about: it's a storm Category 6 hurricane or stuff which we never knew could happen, or the floods hitting Germany a few years ago, which are still rebuilding, and all these things we cannot really prepare for.

(01:06:56):

What happens if our solar panels are blowing from the roofs, and the windmills are being destroyed in the North Sea when we are getting some super storms, which we or at least the engineers didn't expect, weren't warned about? So, all these things contribute to change that could happen, and I think that's what really I think will happen. I expect it more or less to happen this century already. And I think that's really something we should take into account.

Nate Hagens (01:07:24):

Your recent paper with James Hansen clearly states that temporary solar radiation management, SRM, will probably be needed in the future. In other words, we're going to have to purposely inject atmospheric aerosols to limit warming in the future. How do you see this happening? This is speculation, of course, this isn't your core thing:

using what techniques, under what scale, what timeframe and under whose governance and control? Do you think this is coming?

Leon Simons (01:07:56):

Let me first start with saying this: it's not something Jim or we want, right? We don't want this to happen-

Nate Hagens (01:08:02):

Oh, of course.

Leon Simons (01:08:03):

... but I think that's important to note, or that we think this is an alternative to reducing greenhouse gas emissions. It's what we see already, we see now happening is that we are not decreasing greenhouse gas emissions. People are not decreasing greenhouse gas emissions at the rate needed. And because they are not doing that, because of what we see happening in Dubai, just some weak tea and no real action happening relative to the problem at hand, we realize that people and governments and companies will likely revert to sunlight reflection methods, SRM or whatever you call it, and that's what we expect.

(01:08:44):

And then, we'd better prepare for that, we'd better learn from what's happening. Do not do it without the knowledge, do not have agents trying to cool stuff down and causing a lot of terrible things to happen elsewhere or even where they're trying to do it. So, I think that's really important. And then, how it'll happen, I think that's very uncertain, but I think that also really depends on where the effects are taking place. So if certain countries are, for example, I think India, I think likely will be one of the countries which will consider it maybe before others because it has over a billion, I think 1.4 billion people now living in a country that's generally quite hot already, and it's still being cooled by a lot of coal plants putting a lot of sulfur in the atmosphere.

Nate Hagens (01:09:41):

Isn't this also, it wouldn't have to be global? Could India do SRM solar radiation management to alter the temperature?

Leon Simons (01:09:49):

Yeah, they're already reflecting a lot of sunlight with their sulfur emissions at the moment. So, they are already putting a lot of sulfur in the atmosphere, and not just sulfur but also a lot of brown carbon and black carbon. And that has health effects, so they already have policy like China did and has and what's happening over the oceans, they had policy to reduce the amount of air pollutants including sulfur.

Nate Hagens (01:10:17):

Here's a dumb question, Leon: if India does some policy to change the sulfates or their emissions, it's globally mixed. Won't it be a little bit more impactful in India but basically be diluted around the world?

Leon Simons (01:10:34):

It depends on how they do it, right? If they put it into the stratosphere, there's much more global effects than if they would do it over the surface of the oceans, like to what the ships have been already doing as a byproduct: put the ships and the coal plants and all the cooking fires which kill 4 million people a year, all the biomass cooking fires also cause all these particles in the atmosphere and absorption of sunlight in the atmosphere, but the decrease in how much heat is reaching the surface. And this all has to be taken into account to understand how India has even cooled, or at least not warmed a lot in the past decades as it's developed industrially when all these emissions increased.

Nate Hagens (01:11:24):

Let's assume that there is a technology to use solar radiation management and it's effective, and that society around the world are seeing how bad the climate forcing from emissions are and its warming, and the energy imbalance is so high that we have to do something. But isn't that like some modern equivalent of the stone heads on Easter Island? Because as soon as we stop it, then the heat comes back with a vengeance. So, wouldn't it have to be done in perpetuity?

Leon Simons (01:11:58):

Yeah, we are already stopping it, so that's what's happening now. Not intentionally, but we have been cooling the climate. We have been limiting the warming, especially where we live. And now, we stopped doing that, and then we're learning what will happen now. And then of course, just doing it intentionally, I think that's a very big discussion, and I think that should be held on a lot of levels, and-

Nate Hagens (01:12:25):

Well, here's the thing, Leon, this podcast, this conversation is December 13th, this will come out in January: we are going to know by March, April, June, July of 2024 whether you're really right about this. And I imagine that next year, next summer, you and Jim Hansen and others are going to be bombarded with, "What the hell do we do?", sort of questions. Or you're wrong and this doesn't happen, but I find your logic quite compelling on this.

Leon Simons (01:13:00):

Yeah, the data is wrong because we're just presenting the data, and then it will be the causation is wrong: there's a correlation for sure, that's what the data shows, but then there's no causation. It was just all a stupid coincidence and everything will be fine, I hope so. But then, you're right: I think if this in the coming months will take shape more and more, and if more and more people will be affected by this, of course we already see that there's stronger voices of intentionally cooling the climate.

Nate Hagens (01:13:35):

And so on that note, I know you're not an expert on this per se, but can you speculate, are there other ways that humanity could use technology to create global cooling, like regenerative agriculture that sucks in carbon into the soil and artificial whale poop and other things? Is there anything out there that you think might play a decent role?

Leon Simons (01:14:01):

I am all for whale poop and increasing the biosphere. I'm a big fan of James Lovelock and his theory about Earth being a living system because of course, we know there's life on planet Earth, and we know that plants grow, and that life interacts with its environment, and the environment impacts life, but life impacts the environment as well. And in a way, we are the conscience of this planet: we can have a positive effect on the planet. And I think I do believe in that and I think it's not easy, it requires stewardship, it's an enormous responsibility. And we can do a lot of things wrong, which we are doing at the moment, but in the end I think I do believe that humans can have a net positive effect on the planet.

(01:14:50):

And maybe that's very hard for many people to think about, even to see humans as a positive force for the good overall, but I think that is possible and we have a lot to learn on how to get there. And yeah, I think that an important part in getting there is increasing the biosphere and to increase the potential of life itself to create a better climate.

Nate Hagens (01:15:15):

Well, the other additional piece is we have to increase the number of people that actually understand what's going on and how dire the situation is, not only for our economies but for the oceans and the biosphere. We've been treating the oceans like a garbage dump: out of sight, out of mind, and it's invisible CO2 that's just being absorbed by these giant bodies of water. So, we're not going to have time for the 50 other scientific questions I have for you, I want to keep my promise to you on time, but I would like to ask you now just wear your hat as a human. And by the way, I don't think you can really do that, you're always going to be a scientist, I can just tell by the way you think, but that's okay. I really value your contribution and your heart on this.

(01:16:03):

I'm sure a lot of people watching this specifically tuned in to hear you because they know of your work with James Hansen and they're very worried about climate change and probably many other issues as well: do you have any personal advice to the listeners of this program at this time of environmental disruption and global anxiety, what some people might call the metacrisis, but you could maybe even say specifically climate and what's coming? Any advice?

Leon Simons (01:16:31):

That's a good question. I think it's important to do what you're good at, and to not despair, to not take everything too personally, to not internalize everything you see and read, and maybe what I talked about, to take it to heart but not to not let it affect you personally too much, but also try to work on solutions with the best of your capacity. I think that's really important to see, "Okay, where can I be a force of good in the world?", because I think that's for everyone different, so everyone would answer that question differently, but I think that everyone can add value to this world. And I think it's important to see also to look at the scale of the problem. Of course, I believe in small steps, but if everyone does a little, only a little happens, I think that's true. So, take into account the scale of the planet of the problem at hand and try to add value there.

Nate Hagens (01:17:34):

And you have children, right, young children?

Leon Simons (01:17:37):

Yeah. Seven and five years old.

Nate Hagens (01:17:39):

Seven and five. What advice do you give for teenagers and people in their twenties who are learning about all this and having to make decisions about their career and their lifestyles and choices? Would you change your advice for young people or add to it?

Leon Simons (01:17:54):

Yeah, I think for young people, I think it's important to, again, try to do it from your own perspective. So, do what you're good at because if you, not everyone likes to do science or do data analysis or be an entrepreneur or whatever. I did, what I'm good at and what I like to do, and I think that's really important if you want to do this for the long run because we need people to really be committed because the challenges ahead of us are very complex and require commitment. I think that's important, and it helps if you do what you like to do or if you do what you're good at, that will help you. To build a career is important, but it's much easier to build a career around something which you're good at and which you like to do it, which also fulfills you in a way.

Nate Hagens (01:18:41):

Well, you and I are both doing that: I'm educating the broader public on a system science with an environmental ethic, and you are solving deep, complex biogeochemical Earth system puzzles with your research. What do you care most about in the world, Leon?

Leon Simons (01:18:59):

That's a big question: I care about the planet itself, about life, and about my personally, of course, my family and friends. But I also know that if we want to conserve a future worth living, we have to be very conscious about the reality of this. And sometimes it's confronting, but I think it's important to understand the reality and take that into account to build solutions for the future, and really look at the large scale things. And I like to look at it from the really macro, large scale perspective because that's where things are changing and why we have to change that for the good.

Nate Hagens (01:19:37):

I agree. I don't think you've probably watched any of my podcasts, we had conversations offline, but this is a question I ask all my guests: if you had access to a magic wand and you could change one thing and there was no personal recourse to your decision, no status loss or anything like that, what is one thing you would do to improve human and planetary futures?

Leon Simons (01:20:04):

If I could change how humans interact with reality, that would be great. So of course, humans are not rational beings: they think they are, but generally they're not, otherwise we wouldn't have had this conversation because rationally, we know what our effects are, and we know how it impacts, and we know we should do things differently, but we are not. We know the potential is enormous, but we are not living up to that overall. I think I would like that to change so that we can use the tools which physics, for example, gave us. For example, I don't like it, there's some subjects which even if you mention it, you'll be put into a certain corner, so-

Nate Hagens (01:20:54):

Including this subject.

Leon Simons (01:20:56):

This subject is a very good example of that, indeed.

Nate Hagens (01:20:58):

Yeah.

Leon Simons (01:21:00):

If you even talk about aerosols, even when you talk about it from a climate perspective and you say, "This is a large uncertainty in climate science, and we need to understand this better. This provides us an opportunity to reduce the largest uncertainty in climate science," people say, "Ah, you must be pro-geoengineering and you want more fossil fuels," totally ridiculous, of course, but that's what happens. And there's many subjects like that. For example, nuclear energy: if you even mention the word, some people might already, just because I didn't say anything about it, people might think, "Okay, you are like this or you're like that."

Nate Hagens (01:21:35):

Nuclear energy, renewable energy, climate change, they're all polarized. All of them.

Leon Simons (01:21:41):

Yeah, exactly. So I would like if I could have a wand and could change that, just for things to be less polarized and more based on the physical reality of this world.

Nate Hagens (01:21:52):

Hear, hear. We covered a lot here. You are a scientist and know a huge amount about this topic. I would love to have you back at some point in the future if you would come and we did a round two. What is one specific topic, and it could be as narrow as you like, that you think is relevant to human futures, that you would want to take a deep dive and unpack and tell a story about that one thing? Anything come to mind?

Leon Simons (01:22:22):

Yeah, what I would like to assess further, I think that's how in the past thousands of years humans have interacted with the planet, and how they change the planet in many different ways, and how that could take shape in the future. I think that to me is very interesting, and I think that's, so how can we be a net force of good?

(01:22:43):

For example, one can think of his own carbon footprint and often people say, "Okay, I have to fly there," and they complain about the carbon footprint. But I then say, "Okay, what is your net footprint?" If you make sure that some technology can decrease carbon emissions by a billion tons, for example, you could fly anywhere in the world, hypothetically, right? So, I think there's many ways humans as individuals could be a force of good in the world, but overall humans can be as well. And I think that's an interesting question to dive into further.

Nate Hagens (01:23:19):

Thank you. Do you have any closing comments for the people watching and listening who kind of understand, or maybe some people, this is the first they've heard that aerosols have been masking the warming in the pipeline? Do you have any closing words?

Leon Simons (01:23:35):

Yeah, so if you are skeptical, I think many people watching this might be, try to look at the data yourself. I think the data is quite accessible and I almost, when I share my figures on X for example, I always add a reference. And whether you have 10 followers or 1 million followers, if you respond, I always try to respond back. And if you have questions, I can share that my expertise in how to access the data and how to try and understand it because really, I would love that more people looked at this and tried to understand what's happening. And then with the knowledge they gain, do what they can within their expertise to further the cause of humanity on this planet.

Nate Hagens (01:24:20):

Bedankt, thank you so much, Leon.

Leon Simons (01:24:22):

You're welcome. Graag gedaan.

Nate Hagens (01:24:26):

If you enjoyed or learned from this episode of The Great Simplification, please follow us on your favorite podcast platform and visit thegreatsimplification.com for more information on future releases. This show is hosted by Nate Hagens, edited by No Troublemakers Media and curated by Leslie Batt-Lutz and Lizzy Sirianni.