The Great Simplification

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[00:00:00] Stefan Rahmstorf: We have to have the awareness that we are homo sapiens, we are one species on one earth, which is our common home. And we shouldn't be fighting each other, we should work together to secure our survival and our well being on this planet. We now have to all unite to find this threat to our civilization and our future on earth.

[00:00:29] Nate Hagens: A few days ahead of Climate Week in New York City where I will be next week, I am joined by renowned climate scientist and communicator Stefan Ramsdorff for a conversation on all things related to global heating and ocean issues. Stefan is the co head of the Research Department on Earth System Analysis for Planetary Science.

[00:00:50] Potsdam Institute for Climate Impact Research in Potsdam, Germany, which I learned from the last episode is not a suburb of Berlin. He is also the professor of physics of the oceans at the University of Potsdam. Stefan's research focuses on paleoclimate, ocean circulation, sea level, extreme weather events, and earth systems modeling.

[00:01:13] This episode is a factually dense overview of all things climate, including a speed round on frequently asked questions by people outside of this growing choir of climate aware humans, including how we understand so much about the past and present climate. What are the risks for the future? What does a three degrees Celsius world look like?

[00:01:37] And some corrections of common misunderstandings of climate science. Stefan is at the top of this field, and there's perhaps no better expert to answer these complex questions. If you learned from this episode, I suggest sharing it with some people in your family or your community who are curious about global heating, climate change, and the biosphere implications of our emissions.

[00:02:03] Not as a hay watch this, but as a way to learn more. Let's watch this together and have a conversation. I think we need to do more of that with these

presentations and podcasts. With that, please welcome Stefan Rahmstorf. This is a good one. Stefan Rahmstorf, welcome to the program. My pleasure. Hi, Nate.

[00:02:25] I follow you on Twitter, but I only read about every fifth tweet because the rest are in German. You are one of the prominent climate scientists in the world. I'm very happy that we found time to get you on the program. I have a zillion questions for you, including I recommend that we start with a speed round.

[00:02:48] But first, before we get to that, you have decades of research as a climate scientist and a communicator. Can you share with our audience about the moment that you or moments in your early years that you became fascinated with these subjects and decided to dedicate your life to this work?

[00:03:11] Stefan Rahmstorf: Yeah, that was a clear moment when I was 22 years old.

[00:03:15] Before that I already really wanted to become a scientist already since I was 12 years old. And as a schoolboy, I, always went to our local university library and get university books on astronomy out because I was fascinated by that. And so I always knew I wanted to study physics. And but, The moment where I actually switched to doing physical oceanography and climate science that happened after I had studied for two years physics and went for a year abroad in North Wales, in Great Britain.

[00:03:57] And there I did a master course on physical oceanography, which, you know, I, until then I hadn't, Known even that it existed as an option for specializing in physics and ocean physics. And so in during that year, I decided that's it, that's really what I want to do with my life. And so I'm very happy that I managed to really get a career in this really exciting field.

[00:04:27] Nate Hagens: You're a climate scientist, but you're mostly known for expertise on oceans, ocean currents, ocean cycles. Have you you know, in addition to the computer models and spreadsheets and data and science, have you had time to scuba, scuba dive and see whales and some of the amazing life which is in most of Earth's livable habitat in the oceans?

[00:04:54] Stefan Rahmstorf: Well, I haven't done scuba diving, but yes, I've done whale watching, but more as a tourist or on a, I actually, during my PhD, I did see going oceanography and we did see also many dolphins and whales et cetera, on our research cruises in the South Pacific. yeah, that, that is really fascinating.

[00:05:16] But, you know, I'm a physicist, I'm not a biologist, so the biology is not something I know a lot about.

[00:05:26] Nate Hagens: Well, I, wasn't interested in the biology as much as the emotional connection to life in the oceans, because I think that our society, unless you live on a coast, is generally disconnected from what's going on in the oceans, and yet, It's so important to the entire biosphere, our current lives and our futures.

[00:05:46] And when you spend time in the ocean, you form a bond with it, I'm told.

[00:05:52] Stefan Rahmstorf: Absolutely. And of course, our planet is 71 percent covered by oceans. So it's, it really should be called ocean rather than earth. Right, right.

[00:06:04] Nate Hagens: Well, the people that labeled it happened to live on land.

[00:06:07] Stefan Rahmstorf: Yes, that's what Homo sapiens tends to do.

[00:06:11] Nate Hagens: Okay, so I, again, I really want, you have a new book chapter out on a three degree Celsius world. I want to ask you about that. I want to ask you about your, your current work on the oceans and about the future. but. First since you're such a good climate communicator, I'm going to ask you a speed round, which we sometimes do on this show.

[00:06:36] I've, got a list of questions. If you could just give a short, you know, two minute response to these because there are a lot of misconceptions in the media. And questions about how the climate works that people get confused about. so, so, so do your best. First of all, where are we now in 2024 with respect to CO2 levels in the atmosphere and global temperature relative to earth's past, you know, over the past many millions of years?

[00:07:08] Stefan Rahmstorf: Yeah. CO2 level in the atmosphere is now the highest in at least 3 million years, but probably with less accurate data, even 15 million years. And last week we had the hottest day ever recorded on earth, which does mean it was likely the hottest in 120, 000 years. That's since the Eemian interglacial that preceded the last glacial.

[00:07:36] And how do we know that? Well, we know that because we have. A lot of data from ice cores, from sediment cores and other sources that go back millions of years. I actually teach paleoclimatology and just had an exam before coming here about that with a student and these. late, this earlier data from before temperature measurements, they're not on a daily resolution obviously, so they are kind of longer term averages, but we know that we are now well out of the Holocene, that is the last 10, 000 years, way above that, and unless there was some freak hot days earlier in the Holocene that are way outside the range of usual variability, then we're now the It was the hottest day at least in the Holocene in the last 10, 000 years, but that was preceded by an ice age where it's exceedingly unlikely that there has been a warmer day in global average temperature.

[00:08:41] And so you have to go back to the interglacial before the last ice age, the Eemian interglacial 120, 000 years ago when it was likely slightly warmer than in the Holocene.

[00:08:55] Nate Hagens: I am sure that if I would have taken your paleoclimate class which is kind of a combination of detective work and ecology it would be my favorite class, but I, would still have gotten a C but I'm sure, I'm sure that's a wonderful class.

[00:09:13] You mentioned the CO2 parts per million. Um, how can A three or 420 parts per million, which is four parts per 10, 000. How can going from three parts to four parts per 10, 000 be dangerous and four parts to five parts per 10, 000 be potentially catastrophic to a non scientist that just seems implausible.

[00:09:39] can you just simplify that for us?

[00:09:42] Stefan Rahmstorf: Well, there are various ways you could say. One thing is just try putting four parts per 10, 000 ink in water and you will see that it does color the water. So it does change the color. light absorption and therefore also the

infrared absorption. A more funny way to put it is that if you take a, there's an Olympics on our standard size Olympic swimming pool and you put 300 gallons of piss into it, that would be four parts per 10, 000.

[00:10:20] So happy swimming there, I would say. But of course, the more important thing. in terms of physics is that we actually measure the increasing back radiation coming from the increasing carbon dioxide in the atmosphere. So that is just a measured fact and you know, whether it's against people's intuition or not, it's just a fact of physics and it doesn't actually matter whether it's a fact or not.

[00:10:52] Surrounded by 10, 000 parts of other air or so which doesn't absorb infrared or a million because only those CO2 molecules count and not how many other molecules that don't absorb are also around it.

[00:11:09] Nate Hagens: You know, just as an aside for whatever reason, I've known of you and your work for the last 20 years.

[00:11:15] This is the first time we've ever spoken and I think of you as just a scientist, but now in our email exchanges and just briefly on this 300 gallons of piss in a swimming pool, I know that you're funny. and that you're a human. And it's, a dissonance for me because obviously you are both a scientist and a human, but I never think about the human.

[00:11:37] I only look at your scientific work. but what, an interest, interesting juxtaposition. I'm, sure you experience it all the time.

[00:11:46] Stefan Rahmstorf: Well, scientists are people and we are in many ways pretty normal, even though our brains are trained to work somewhat differently to most people. So we, really like analyzing evidence and basing decisions on rational evidence rather than on emotions.

[00:12:06] I think that is probably the biggest difference to most normal quote unquote people.

[00:12:13] Nate Hagens: But you also like pizza and beer and soccer, probably.

[00:12:16] Stefan Rahmstorf: I like pizza. I don't like beer. I'm a wine drinker, but yes, I do watch soccer.

[00:12:22] Nate Hagens: Okay. Moving on with the speed round, which I have interrupted with other questions.

[00:12:27] So we frequently hear in the news that climate has changed, warmed and cooled often in the past. How do we know that it's the burning of fossil hydrocarbons that is leading to our current temperature rise?

[00:12:40] Stefan Rahmstorf: Well, we know because we understand the energy balance of our planet and of planets in general. It actually goes back 200 years now, because it was in 1824 when the French scientist Joseph Fourier first understood how the energy balance of planets works and the importance of the greenhouse effect in setting planetary temperatures.

[00:13:05] That's not all. Exclusive to the Earth, it applies to all planets that have an atmosphere. And then somewhat later, these great Swedish Nobel laureate Svante Arrhenius actually calculated for the first time how much warming. You would get globally when you double the CO2 concentration. That's more than a hundred years ago.

[00:13:31] And he arrived at four degrees warming for a doubling of CO2, which is within the range of what we think now with our, all our modern knowledge. And it just illustrates that you just have to have. A basic understanding of physics like they had even in the late 19th century in order to do this calculation.

[00:13:52] And that's why global warming was predicted long before it was observed in the data. And it was predicted, you know, even since the 1970s, 80s by scientists from ExxonMobil, for example, that totally correctly. predicted even the amount of global warming expected from fossil fuel use, but they decided to basically tell the public a, another story, you know, sowing doubt, et cetera, even though their own scientists clearly knew better.

[00:14:27] Nate Hagens: That's because at that time and still today, we had a human centered cultural aspiration instead of an earth centered one. So their, priorities and their goals and aspirations were different than saving the future. But

we can talk about that later. So, so what about the claims that I hear in the news that increasing solar activity or orbital movements are, are the main drivers and CO2 is secondary.

[00:14:54] How do we know that's not the case?

[00:14:57] Stefan Rahmstorf: Well, we know because we are monitoring solar activity constantly. We have a global radiation measurement network, which constantly measures how much solar radiation is coming in, how much long wave radiation is going out, that's known from dedicated satellite missions.

[00:15:14] And So we know that solar activity has not gone up in the last 70 years. If anything, it has gone down slightly and counteracted some of the warming that we have been causing by the increase in CO2. As I said, that's a measured fact that we're doing that. And the orbital cycles, they are too slow.

[00:15:37] The fastest one is has a period of 23, 000 years and the changes we are witnessing now, the warming is already. at least 10 times faster than the past changes in Earth history caused by these orbital cycles, which is actually one of my research topics for many years. In our climate model, we can predict the onset of all the ice ages of the last 3 million years correctly simply by putting these orbital cycles into our climate model as a driver.

[00:16:11] These orbital cycles, by the way. have also been understood for about a hundred years now by Milutin Milankovitch in the 1920s understood that these are the causes of the ice ages. That's why they're called Milankovitch cycles. Anyone can look that up on, on

[00:16:29] Nate Hagens: Wikipedia or so. And real briefly, without humans and our fossil burning and, other emissions, when would that next orbital ice age be due?

[00:16:42] Stefan Rahmstorf: The next one would be due in 50, 000 years from now. That would make that the Holocene a very exceptionally long interglacial, and simply because of the particular orbital configuration we have now. So humanity could, in principle, benefit from a really long interglacial for tens of thousands of years to come from a stable climate if we are not messing it up.

[00:17:08] Nate Hagens: What about volcanoes? Every once in a while I see something in the news where people claim that a certain underground volcano is responsible for the current warming. How does the emissions, part of which are CO2 and methane, from active volcanoes relate to the amount of emissions from human commerce globally?

[00:17:30] Stefan Rahmstorf: Well, we are actually emitting with our human activities with fossil fuel burning about 100 times more CO2 than the world's volcanoes. And of course, that's why the warming has only taken off recently in the last 50 years or so. And volcanoes have been going all the time. There's no particularly strong volcanic activity.

[00:17:53] And Actually, the direct effect of volcanic eruptions is a cooling, as we have seen after Pinatubo and others that will last a few years. And even the very recent underwater Hunga Tonga eruption has had a little bit of a cooling effect.

[00:18:13] Nate Hagens: So carbon is food for plants, carbon dioxide. they breathe in carbon dioxide, they breathe out oxygen.

[00:18:22] So one would think if one didn't have a paleoclimatology professor like yourself, that carbon dioxide is. Net good for net primary productivity on the planet, warmer climate on the surface, longer growing seasons, expansion of the range that we can grow food. What's the story there?

[00:18:46] Stefan Rahmstorf: Well, the story is really mainly the impact on us humans.

[00:18:50] if, you had. a whatever four times higher carbon dioxide level in the atmosphere and you leave that for a million years or so, the biosphere would totally adapt to that and probably thrive. We have a much more short term problem. In that everything we have now in human infrastructure, agriculture, even the existing forest, natural ecosystems, are highly adapted to the climate that we've had the last hundred or a thousand years.

[00:19:23] think of all our cities, they are where the coastline is now. Now, if you have a few degrees warmer, eventually, The coastline, the sea level will be many meters higher. If I just remind your listeners to the last ice age, that was about

seven degrees Celsius colder up till about 15, 000 years ago, and in the transition to the warmer Holocene climate, the global sea level rose by 120 meters.

[00:19:55] So the coastline shifted to a completely different place. That would be a huge problem now, where we have a lot of cities with more than 100 million people sorry, not 100 million, more than a million people right at the coast. We have 200 nuclear power plants that are cooled by seawater that are sitting directly on the coast.

[00:20:18] And so if we have a warmer CO2 levels then we'll all be inundated. And of course, all our agricultural plants are highly bred for the present climate that we've had in the last centuries. And they are not very good in a different climate.

[00:20:40] Nate Hagens: Since you're so succinct in your answers, I'm going to ask a quick follow up to that.

[00:20:45] what about the wicking of salt on the coastlines that as sea level rises and the saltwater touches more of the soil. Does the saltwater then go inland? I'm thinking places like Bangladesh that their agriculture areas are a couple hundred kilometers inland, but it affects not only the higher standard deviation of drought and flood, but the actual salt is coming into the soil.

[00:21:15] Is that an important thing?

[00:21:18] Stefan Rahmstorf: Well, yes, in some, under some conditions in coastal regions, there can be intrusion of salt water into the groundwater. And that's especially, of course, a problem for smaller island nations. I'm, not very familiar with Bangladesh, but For Bangladesh, the big problem is, of course, that it's in a region of tropical cyclones and a very low lying river delta region.

[00:21:47] So with higher sea levels and also increasing intensity of cyclones, they are definitely very endangered by global warming.

[00:21:58] Nate Hagens: not to mention wet bulb risks and other things, which we'll get to. Okay, final question in the speed round is the science of our overall climate situation and the risk trajectories generally understood and accepted or settled

among the broad swath of natural scientists, or is there still huge room for uncertainty?

[00:22:22] Stefan Rahmstorf: Well, the basic facts have long been settled. I just remind you that already the first report by the Intergovernmental Panel on Climate Change, the IPCC, which is a consensus effort of thousands of scientists around the world, the first report from 1990 already said that it is certain that the CO2 emissions cause global warming.

[00:22:46] So that has long been settled science but the fact That we still have a public debate about this, which is totally disconnected from the debate in the scientific community, is really due to special interests, fossil fuel interests that have launched a huge disinformation effort, simply to sow doubt about this.

[00:23:09] Stefan Rahmstorf: There's a famous slogan, doubt is our product, which is basically. sums up what they have been doing. And of course, many people are just happy to believe that because it gives the impression there is no problem. We can just continue as we're used to and that we don't have to change. But that unfortunately is an illusion.

[00:23:35] Nate Hagens: When did you first have the gut punch moment looking at the future trends? Like, Oh my gosh, this is the trajectory we're on. This is going to happen in my lifetime and in the lifetime of my Children. And, looking back to whenever that was 20 years ago, could you have imagined that yes, this actually did happen and the debate would still be happening publicly in 2024 as it is now, even witnessing what we're seeing with fires and droughts and floods, et cetera.

[00:24:09] Stefan Rahmstorf: Well, that's actually more like 40 years ago for me. I was very concerned about a global warming already in the 1980s. The science was already there. And I just remind people, 1988 NASA scientists Jim Hansen famously said in a Senate hearing, global warming is here. It was at the time it was just predicted, but.

[00:24:37] He was the first who said we can now really see it in the data. And I was so concerned by this that for the four years that I spent in New Zealand doing my PhD in oceanography, I never flew home, not even to my sister's wedding, because I was too worried about the flight emissions of CO2. Now, the second half of your

question, as a young scientist, of course, I thought, You know, when this information is more widely known in the public we will stop this.

[00:25:13] I could not, by the life of me, have imagined that such a massive disinformation campaign would confuse people, that people would be so rigidly in denial of reality, basically, just because they don't want to, you No inconvenient truth. I would not have thought that possible.

[00:25:35] Nate Hagens: Let me ask you this. I think there's two separate aspects to the climate communication issue.

[00:25:42] One is what you've been doing really well in this conversation so far is just neutral, objectively describing what is happening. And I think a lot of people, even people that are politically not inclined to believe this because their tribe doesn't believe it, you can have a conversation about that, but then if they agree, then there's, here's what we do about it.

[00:26:07] And that is so threatening to the identity, to their built um, world and what would have to change that then part of their brain goes back to the science and then starts to dispute it. And question it. Have you experienced something similar? Yeah,

[00:26:25] Stefan Rahmstorf: sure. I mean, there's also this big mismatch by people.

[00:26:30] We have that, like, more in German politics. People that pay the lip service and say, yes, climate change is a serious problem. And You know, in, in German politics, apart from the far right wing AFD party, we have, we've had nobody who disputes that global warming is a serious problem. But we have a lot of politicians who say, yeah, it's a serious problem and we're doing something about it.

[00:27:01] And then they propose solutions that are not working and pretend we have still lots of time, even though it's now really a race against the clock to get the emissions down. And they're not. acting according to what they are saying. And so that's a different level of denial. Basically, you don't deny the science, but you just don't do what you are promising to do.

[00:27:28] This is a much bigger problem here. And I think that's, really misguided because in the meantime in comparison to say the 1980s or 1990s, we have the, solutions. We have largely technological options for generating electricity with renewables, for doing our mobility with electric vehicles, for heating our houses with heat pumps.

[00:27:58] We do have the technological solutions that we can live a really comfortable, good life. Without really drastic changes, but without the fossil emissions. And so I think that makes me actually a lot more optimistic than I was in the 80s or 90s, because yeah, there's not going to be drastic behavioral changes necessary to get this problem under control.

[00:28:24] We just have to make it our priority.

[00:28:27] Nate Hagens: except we now have 8 billion people, which we didn't have in the 1980s, and there's a distribution and an inequality and a, you know, That is true,

[00:28:38] Stefan Rahmstorf: but most of the emissions come from the wealthy countries, basically.

[00:28:45] Nate Hagens: Yeah. I was gonna ask you this later, but I'll just ask you now.

[00:28:51] You know, if you, I have a problem with your car. You go to an auto mechanic. They identify the problem and then they fix it. If you're sick, you go to a doctor and they do some tests and then they give you a pill or a surgery. You have spent your entire life understanding the biosphere, the oceans, the climate system.

[00:29:12] Why do people have to ask you on what the solutions are? It's not Your expertise, you are a scientist that is trying to describe what is happening to the earth. do you find that in your interviews and your public experience um exposure and presentations and such that you're always asked for some optimistic thing at the end, because that's the way humans are and you've described the problem, so you should know the solution.

[00:29:43] Stefan Rahmstorf: yeah, but I, think that is in a way a more recent phenomenon. I think in the early days. Climate scientists were just describing the problem, but increasingly you're right. And, I also have served on a government advisory panel appointed by the German cabinet for eight years. And there I was working with experts for the solution, you know technology experts, economists, and we were writing reports what the government could do.

[00:30:16] And so since then I also feel comfortable to some extent talking about the solutions because I learned it all by being together with this team of experts.

[00:30:26] Nate Hagens: I have lots of specific climate questions for you, but let's take a uh, let's move to the next phase here. You have a book chapter that's out, part of a book talking about what a three degrees Celsius world which is certainly in the realm of possibilities would look like.

[00:30:48] So if. one day this century or beyond, three degrees Celsius relative to pre industrial average occurs. Can you describe for us your key findings in as much detail as you would like?

[00:31:05] Stefan Rahmstorf: yeah, you know, that, that could be a long story, but I, want to just summarize it briefly so you can ask me more questions about what's particularly interesting.

[00:31:16] But we have we've now reached a little bit more than a one degree warming and I was asked to write this book chapter on what would the world be like if we reach three degrees. And. Let me stop

[00:31:30] Nate Hagens: you right there. we're at more than one degree warming. Isn't some people saying that we're at 1. 5 now?

[00:31:38] or is that just the summer?

[00:31:40] Stefan Rahmstorf: 1. 5 Celsius relative to late 19th century. That is true. If you look at the last 12 months, we've exceeded that, but we typically, when We climate scientists talk about this or when you think about the Paris Agreement limit, this is about a longer term average and not an individual unusually warm

year, which we've now had because of to some extent the El Nino event in the tropical Pacific.

[00:32:08] In the long term trend, we're now at more like 1. 3 degrees. So we're actually approaching the 1. 5 quite rapidly.

[00:32:17] Nate Hagens: And we can already see the impact. So, so please go on. What does a three to three degrees world look like?

[00:32:23] Stefan Rahmstorf: Exactly. So the impacts in a way are more of what we're already beginning to see.

[00:32:32] But you know, if you think three degrees is three times worse than one degree, that's wrong, you think again, because as I mentioned earlier, it is what our infrastructure can cope with and. The further, the damage grows really not linearly but more like exponentially or so, the more warming there is.

[00:32:57] Think of a good example, Hurricane Sandy when it hit New York City. At that point where it flooded subway tunnels because the water had never been so high and they hadn't been built for that. Then it got really expensive. And so there are many threshold processes like that, where, stuff gets basically damaged, destroyed, or whatever, when you cross a threshold that hasn't been crossed before.

[00:33:26] And so with one degree, that rarely happens because it's Not so far out of natural variability and the kind of safety margins that we have in our infrastructure, but it's gonna get rapidly much, much worse than what we have seen so far. Another aspect is that if you think about extreme weather events something which may have been a one in a thousand year event, extremely rare, wild, extreme, has now become a one in 50 year event.

[00:34:04] But the one in 50 year event for the current climate, we probably haven't seen yet because it hasn't been As warm as now for 50 years, so even if we stopped further warming and left it at what we are now at that level of warming, we will see still a lot of extreme events that we've never seen before because all these events that are now whatever 20 times more likely than they used to be we've only seen a very small part of those as yet.

[00:34:34] And yeah, that's one aspect. Another aspect that I emphasize in this article, because still many people have not understood this is that we are 71 percent ocean planet at the global mean. Temperature that we are talking about here is actually made up of 71 percent ocean surface. And the oceans warm more slowly than the land areas because of the thermal inertia.

[00:35:02] What that means is that land areas typically are warming twice as fast as the global average temperature. And when we're talking about a planet that is six sorry, that is three degrees warmer. In global mean, for most land areas, that is more like 5 or 6 degrees Celsius warmer, and that is really a drastic change.

[00:35:24] It means that all your vegetation is not adapted, the forest will probably die near your house, or I

[00:35:34] Nate Hagens: actually didn't know that. So if we go to a three degrees Celsius climate change, which is a global average, the land where I am in Minnesota or where you are in Germany or India or wherever on average will increase six degrees Celsius, which is almost, which is over 10 degrees Fahrenheit.

[00:35:56] Stefan Rahmstorf: Yeah, and I mean, that is not new, this has been known already since the 80s, 90s, I mean it's obvious, it's very basic physics, but it tells you something about how the media are discussing the climate issue that Most lay people that I talk to when I give talks, et cetera, they don't know this very basic fact, and they wonder what's so bad about two degrees warming, because they don't realize that's then four degrees where they live on land, for example.

[00:36:26] And so it's weird how the things that have been known to the scientists for many decades, the basic facts are not out there in the public. Instead, all kinds of pseudo debates about whether global warming is actually caused by CO2 and all this stuff is been going on for decades in the media because interested parties are pushing that and the media are not doing their job properly in my view.

[00:36:51] Nate Hagens: Yeah, I, knew the joviality and the jokes at the beginning of this interview would, would quickly dissipate. because this topic is inescapably not funny. what, can you just describe for us using as, as much examples as possible, a three degrees difference? means six degrees on land. So what would that mean for Germany or Minnesota or India?

[00:37:24] six degrees Celsius. What does that mean?

[00:37:27] Stefan Rahmstorf: Well the most simple basic consequence that anyone will understand is we will get much more severe heat waves. And in fact, there are studies that look at the, limits of heat that a human body can withstand before it becomes life threatening when you spend a few hours outside and already at about Two and a half degrees global warming, large areas of the tropics will get such heat waves where for weeks on end you can't be outdoors, basically.

[00:38:06] And that means these regions will become too hot to live there. People will want to move

[00:38:12] Nate Hagens: away. Except for people that can afford totally climate controlled environments.

[00:38:18] Stefan Rahmstorf: Yeah, uh, I mean, we are talking about tropical regions in India, etc., where hundreds of millions of people live, more than a billion people live, many of which cannot afford air conditioning or the like.

[00:38:35] It also means you cannot work the fields outdoors, you cannot be on a building site outdoors, etc. It will just be, the heat will be lethal and this will just increase. Even in Europe, in 2003, we had a big heat wave you might remember seeing news pictures of the city of Paris having to put up cool tents for all the dead bodies because they didn't know where to put them otherwise.

[00:39:07] there were 70, 000 heat fatalities in this heat wave in, August 2003 in Europe. And so that is actually a silent killer, you, I mean, you don't see these people falling over in the middle of the street or so, but you'd see it in the mortality statistics later on, that the mortality spike of that European heat wave 2003 in France is much higher than the COVID mortality spike.

[00:39:33] Nate Hagens: And that was when we were under, well under one degree Celsius globally, and you're talking about a three degree world.

[00:39:42] Stefan Rahmstorf: Yeah, so heat is simply a big problem and lethal, but there are other extremes as well that we will get into big trouble and already are. The one side is drought. We see that the drought.

[00:39:57] increases a lot with warming. The main reason being that evaporation is much faster in, in warmer weather. that's why like now in California with the wildfires, people are really concerned when it's hot because it's fire weather, it's a part of fire weather that it's hot, stuff really gets tinder dry because of the evaporation, when there's no rainfall and the weather's hot, you get drought much faster than in cooler conditions.

[00:40:26] And that is because. The air can take up more moisture when it's warmer and this goes up exponentially so that's another law of physics from the 19th century, from 1834, the Clausius Clapeyron law that tells you how the saturation vapor pressure increases with temperature. exponentially. And so that's the reason why in a warmer climate we get a lot more drought.

[00:40:53] There's also, of course, a redistribution of the rainfall, which unfortunately tends to mean less rainfall in the already dry subtropical regions and more rainfall in the already wet higher latitudes. And then there is also the increased flooding problem, which we have seen already also in the past year around the world in many places big flood events, because If the air can take up more moisture, it can also rain down more, and that is the reason again the Clausius Clapeyron equation, why we get more extreme rainfall events with flooding.

[00:41:33] We've seen that in Germany in the last 12 months as well but you know, I lost track of the Many cities in the Mediterranean region in China, whatever, that saw horrendous flooding recently, and this will only increase with every 10th of a degree of further warming.

[00:41:51] Nate Hagens: So several questions here, Stefan.

[00:41:54] First of all, so a warmer world will Increase the standard deviation of extreme events, both heating and I mean, drought and, extreme rainfall. And the mechanism of that is because warmer air holds more moisture. So two days ago, three days ago, I went for a bike ride, three hour bike ride, which I often do on weekend mornings.

[00:42:22] It was 85 degrees. warm, but not ridiculous. But I came back and then I, a few hours later, I got really sick and I had 103 temperature, sorry, I don't know

the Celsius. us Americans are a little behind on that, but I had a fever. I had chills and I thought I had COVID. but then the next day I was fine.

[00:42:45] And I think what ends up happening is I had a miniature heat stroke from biking when it was 75%. humidity out. So in a warmer world with the the Clausius Clapeyron equation that you said, will it be a more humid world on average and what are the implications of that?

[00:43:08] Stefan Rahmstorf: Well, we don't expect overall the relative humidity to increase.

[00:43:15] And the relative humidity, as you say, is 75%, that is relative humidity, that means you have 75 percent of the maximum amount of moisture, of water vapor that the air can hold. And that relative humidity will stay approximately constant in a warming climate, simply because When the relative humidity gets too high, the water just falls out as rain.

[00:43:41] And so that's why the atmosphere, the amount of moisture in the atmosphere is not set by evaporation, it is set by, you know, when it's full, it rains out. So how much you can fit in. And that's why relative humidity remains constant. But that means with constant relative humidity, the absolute amount of water vapor in the atmosphere increases 7%.

[00:44:05] per degree Celsius of warming according to that Clausius Clapeyron equation. And that's why the absolute amounts of rainfall coming down get bigger and bigger. Now for the, for your body, I mean, for your heat stroke, what you call the heat strike for, your body, it's actually the relative humidity that counts because that determines your ability to cool down by sweating.

[00:44:33] And what the, number that is most relevant there is the so called wet bulb temperature. And that is, can be measured with a thermometer that is wrapped in a wet cloth with a fan, so you can really evaporate that moisture to keep it cool. And that's also what our body does. We evaporate sweat by keeping the surface cool.

[00:45:00] And this, if the wet bulb temperature. is above 35 degrees Celsius, then it becomes life threatening to spend time outdoors of more than a few hours.

[00:45:12] Nate Hagens: With every degree Celsius of warming, we get 7 percent more moisture, um trans, trans, I forgot what you said, but if 1 degree to 3 degrees Celsius, is that 14 percent more rainfall globally?

[00:45:31] Stefan Rahmstorf: Yeah, that's a, you know, because it's only one degree step, it's approximately linear, but actually it goes up exponentially. But for, yeah, two degrees, about 14%, a little bit more than that.

[00:45:42] Nate Hagens: So because of this in a three degrees Celsius world, which I'm going to ask you your opinion on are we headed that way in the, a little bit later in this conversation, but do you expect then I mean, I I'm, I hate to state an obvious question, but in a three degree Celsius world, do you expect some regions and the world to become uninhabitable?

[00:46:10] not even because the hotter temps per se, but rather because of the combination of hot temps and wet bulb and humidity, wet bulb, the droughts and the floods increasing, et cetera.

[00:46:22] Stefan Rahmstorf: Yes, I mean, I do expect that if, it becomes too hot to go outdoors for long stretches of time, and that means you probably have heat waves with really bad mortality events, et cetera I think people will start to move away from these regions.

[00:46:45] There's a study in proceedings of the National Academy of Sciences of the USA that really maps these areas that will become too hot to live and that is quite disturbing to see that. Other things like flooding, like hurricane damage that are typically then catastrophic events which will make people move away like from New Orleans after Hurricane Katrina.

[00:47:13] A large number of people hasn't returned after that. Actually, I forgot the number, but it's quite large, the people that moved away and never returned to New Orleans after this. And this kind of migration that people flee from a disaster and then they decide not to return, that will also be increasingly the case.

[00:47:35] And I fear also because of the drought issue that leading to harvest failures, extreme rain can also lead to harvest failures, we've seen this in Germany,

but also Greece, etc., that We will get a hunger crisis in some regions with, because of harvest failures, which will also make people basically migrate.

[00:48:02] Nate Hagens: We have migration issues now with economic problems. This is going to be that on steroids. I mean, the more I think about it, I mean, I'm a scientist as well, and I think of systems, but a lot of the insights you're providing here today are things that I've not really thought about, but climate in a three degrees Celsius world is going to be the mother of all forcing functions for more inequality on this planet, because not everyone will be able to afford to move.

[00:48:32] Stefan Rahmstorf: Yeah, and more migration, as you said, so I would say those people that really are worried about migration, they should really be big fans of climate protection measures. So unfortunately, that's not how it works because these people are not, they're not Rational, they are acting out of emotions, but all the right wing parties in Europe, they should be fighting climate change like hell, but they're denying it because these are not people that are looking for real solutions to problems, unfortunately.

[00:49:08] Nate Hagens: Read a quote from your chapter on a three degrees Celsius world, and then I'll ask you to comment on it and explain it. Estimates of the carbon stored in living and dead plant material in the Amazon region range from 80 to 120 billion tons above and below ground. If this stored carbon were to be completely released in an extreme case, this would correspond to the amount of fossil CO2 emissions that are Currently released into the atmosphere in eight to 12 years.

[00:49:41] The result of the calculations was that a warming of two degrees could become a warming of up to two and a half degrees. So can you unpack this and discuss how positive biologic feedbacks may contribute to the increasing of a warmer world, irrespective of what humans do?

[00:50:03] Stefan Rahmstorf: Yeah, I would actually when I talk to a lay audience, I call them amplifying feedbacks because if you say positive feedback people think it's a good thing rather than an amplifying thing.

[00:50:17] We call a positive feedback in physics, of course, something which amplifies and a negative feedback, something which dampens the, original

response. And so that's a it's just a little communication thing to make people understand what we're talking about. yeah, there, there are amplifying feedbacks.

[00:50:38] And one of them is with the vegetation cover of the earth, which is actually now really helping us by taking up about a quarter of our CO2 emissions. a quarter roughly is taken up by the land biosphere, a quarter by the oceans, and only half of it goes to increasing the atmospheric CO2 content. And so we're actually emitting twice as much as remains in the atmosphere, but this, the oceans, both the oceans and the land biota ecosystems are really helping us, but what they will only continue to do so when they are healthy and growing well, but when they reach their stress limits for drought in the Amazon, for example or other stressors, then they will not be as productive and not be taking up as much CO2 as they used to.

[00:51:33] And then the increase in the atmosphere will be even faster. More of our emissions will remain in the atmosphere and that will increase the amount of global warming that we are witnessing. And so this is one big concern, especially because The ecosystems, they have their tipping points, and because they have limits of how much stress, how much drought they can withstand, and we're already seeing, of course, in regions where there are much bigger bushfires than there used to be that the drought limits are exceeded, the vegetation gets too dry, okay?

[00:52:14] and easily becomes a victim of fire. In other regions, the trees, like in parts of Germany, they've become a victim of bark beetles, which are really spreading a lot as a result of drought as well, because the trees are too stressed to withstand the bark beetles. And then you have a large scale die off of forest, which the forest is a big carbon store.

[00:52:41] So when, the forest dies and the biomass either burns or rots, that also puts CO2 back into the atmosphere and increases global warming further. And these are these amplifying feedbacks that we know have operated in natural climate changes like the end of the last ice age as well. And they just kick in with a certain amount of delay, so we haven't seen them yet.

[00:53:06] So far, the biosphere is still helping us by taking up CO2, but it's not guaranteed to go on to this extent in the future. And they're already First signs

that for example, the, Amazon forest parts of that are turning from a carbon dioxide sink into a source.

[00:53:29] Nate Hagens: and if, the whole Amazon would turn from a sink to a source, that would accelerate warming and, Well, chaos to put it lightly, right?

[00:53:41] Yeah,

[00:53:41] Stefan Rahmstorf: that's, that is the kind of nightmare scenario that this could happen.

[00:53:46] Nate Hagens: I'm gonna ask you offline if there are some scientists that you know that are particular experts on the Amazon as its own ecosystem, as it's creating its rain and, You the lungs of the planet and all that, because I haven't had anyone on the program to discuss the Amazon and what a central part of the planetary ecosystem.

[00:54:08] Most of it resides in one country. Um, and you know, that brings up another issue. I mean, some of the, you know, national entities have a fiduciary or a responsibility for the planet. as a whole. And how does that national versus planetary commons dialogue start or be effective?

[00:54:33] Stefan Rahmstorf: That, should be a topic of another podcast that you're doing.

[00:54:36] We actually have a whole group in my department at the Potsdam Institute working on the Amazon rainforest stability, but probably you should interview some experts from Brazil like Carlos Nobre or people like that.

[00:54:49] Nate Hagens: Yeah. Thank you. Um, okay. So you've painted enough of what a three degrees Celsius world might look like.

[00:55:00] it's basically a disaster. I mean, it's, Not a world that any of us can imagine because of all of our history and poetry and stories and experiences of our past and our ancestors, the world was nothing like that. So let me ask you this, as someone who's been worried about climate change and studying it closely, professionally, your entire career since the 1980s, in your professional opinion, how

likely is it that Earth is headed towards a 3 degrees Celsius increase versus pre industrial times?

[00:55:35] Stefan Rahmstorf: There are two kinds of answers to that. The first one would be would the global economy collapse before we even reach it? And therefore we don't reach it. So because the emissions stop by, by disaster rather than by Organized transition to renewables some colleagues believe we, we simply wouldn't reach three degrees because already long before we'd be in such deep trouble that basically the economy collapses.

[00:56:06] There's another way of looking at it which is more positive, which is if we look at the climate protection policies that have made some progress, albe too slowly, but there is real progress and from the implemented policies in the past like before the Paris Agreement, we would've been definitely heading towards three degrees.

[00:56:30] But now the outlook is actually a lot more positive, so that I'm not, I haven't got the latest number in my head, but there's a climate action tracker where you can look it up where we're heading with Current implemented policies and currently announced climate policies. And I think we're already below 2.

[00:56:53] 5 or so at least, but we certainly need to redouble our efforts to keep the warming as close to 1. 5 as we possibly can.

[00:57:03] Nate Hagens: I have a bunch of follow ups to that, Stefan. first of all, would it be accurate to think of, let's say that we, have a baseline of a plus two C, would it be accurate to think of the scale between plus two C and plus three C, not as a linear thing, but almost like a logarithmic, like a an earthquake um, scale that 2.

[00:57:30] 1 is. twice as bad as two and 2. 2 is twice as bad or, something like that. because will the, will every 10th degree be you know, significantly worse than before?

[00:57:45] Stefan Rahmstorf: Yes. That's what I tried to say before that because we, we increasingly hit thresholds that have never been crossed before where real new things happen.

[00:57:56] extremes that we've never seen before damage we've never witnessed before. That is true, with every tenth of, every added tenth of a degree is worse than the previous one. And the same is true for sea level rise. see that in in, in hurricanes, for example, with a storm surge, as I mentioned, with Hurricane Katrina every additional inch of higher storm surge is more expensive than the previous inch.

[00:58:29] and then there are thresholds like where the subway tunnels get flooded, et cetera, where the costs suddenly jump up by a big margin.

[00:58:36] Nate Hagens: So you mentioned economic collapse might forestall a three degrees Celsius world Let me ask a two part question about that. Let's just say, hypothetically, that we were able to stop emitting carbon by human commerce in 2025.

[00:58:56] Not gonna happen but there is a pipeline of warming that's built in because of the prior burning of fossil carbon and the emissions sitting in the atmosphere. Can you explain the mechanics of why the climate will continue to warm for some time, even if we were to stop or significantly reduce emissions today?

[00:59:23] Stefan Rahmstorf: no, because I'm going to tell you that it won't continue warming once we have reached zero emissions. what, you were saying is a wide widely um, yeah, a wide misunderstanding that people think. there is further warming in the pipeline for decades, which has some origin in the fact that in the past people have scientists, colleagues have done a number of calculations for so called constant CO2 concentration scenarios.

[00:59:59] And if you hold all the greenhouse gases constant from 2025, say, then there will be further warming in the pipeline because of the oceans catching up. They take time to come to equilibrium. That's called thermal inertia. And it's like when you put on The, the heat on your stove, it takes actually time to warm the water and we have kind of ramped up the heating with the greenhouse gases, but the oceans take some decades to catch up with their temperature.

[01:00:31] That's why they're, that's one, one of two reasons why they're now cooler than land areas and that's where the land warms more than the global average.

That's a thermal inertia issue. But. If we go to zero emissions, we won't have constant concentration in the atmosphere of CO2. Let's just talk about CO2 at this point, which is the main factor, because there's not only a thermal inertia, because the oceans take time to take up the heat, there is also an inertia in the oceans taking up carbon dioxide out of the atmosphere.

[01:01:11] As I said earlier, the oceans take about 25 percent of the extra CO2 we pump into the atmosphere by gas exchange at the sea surface. And that's a, that's of course, in a way, very similar to the heat exchange at the sea surface. And so these two effects that the oceans will take up some of the CO2, and then they still keep warming up.

[01:01:37] They roughly balance. So that means. In practice, the CO2 in the atmosphere will start to drop to some extent for several decades while the oceans are still catching up with their CO2 concentration in the upper ocean. And that balances that thermal inertia effect so that in a whole suite of climate model simulations, the further the warming, the basically stops around about the same year as we reach zero emissions.

[01:02:08] Nate Hagens: Thank you for that. So let me understand since that was a hypothetical I don't think we're going to hit zero emissions soon, maybe because of technology and some economic shrinkage. We could decline in the next 30 years by 50 percent of emissions. And you said that 25 percent of emissions currently are absorbed by plants on land and 25 percent by the ocean.

[01:02:37] So that would mean we're down to, you know, not adding additional extra in the atmosphere, right? So would that would that scenario avoid a three degrees Celsius future?

[01:02:52] Stefan Rahmstorf: you say 50 percent emission reductions by in 20 years, but that's, too slow. But there is, in a way there's another misunderstanding that is promoted by some climate skeptics that they say, well, because the oceans and the biosphere are taking up half of our emissions, we only have to reduce them by half and then the concentration will stay constant.

[01:03:18] That's wrong. Because even if we reduce them by half. The ocean will still only take up 25 percent of that reduced CO2 emissions. So it will always be 25

percent in the biosphere, 25% approximately that, so it will go down in parallel as our emissions go down because that uptake is only because the system is in disequilibrium because of the rapid rise.

[01:03:46] Nate Hagens: Understood. So 50 percent reduction in CO2 emissions by 2050 is too slow.

[01:03:54] Stefan Rahmstorf: To keep within the 1. 5 degree Paris limit, we would need to cut emissions in half by 2030. Now, that is kind of, I mean, we haven't even necessarily reached the peak emissions yet. we may have This year, we're kind of close to it.

[01:04:14] That's sort of a semi good news that it's better than before, but there's no way we will cut it in half by 2030. That's only six years away, but that's what we would need to do. To stay in the 1. 5 degree limit, but we have a bit more actually significantly more leeway if we say we go to 1. 6, 1. 7, that is more feasible still.

[01:04:43] but we have to be around about zero emissions by 2050, definitely to stay well below the two degrees.

[01:04:53] Nate Hagens: You mentioned this earlier. Let me ask you a followup to this. at what point do the. Amplifying biological feedbacks in the world, you mentioned the Amazon, there's permafrost in Siberia and Canada, there's the the plants in the shallows in the oceans that are already reducing oxygen content in the oceans, all those things together, at what point, two degrees 2.

[01:05:22] 5 degrees. Does it become that these amplifying feedbacks are themselves greater than all of, what humanity produces in terms of emissions? I,

[01:05:35] Stefan Rahmstorf: couldn't say that because again, that, that depends a lot on tipping points of ecosystems like the Amazon or the boreal forest or the methane. And there is a big uncertainty of exactly when This will happen.

[01:05:53] That's unfortunately a characteristic of climate tipping points because they are very nonlinear phenomena, threshold phenomena. we, it's very difficult to say where exactly is this threshold. But let me say one thing, because there is

sometimes this fear that these amplifying feedbacks become so strong that we get a runaway warming.

[01:06:20] I would say this is a very small risk. Of course, if it were to happen, that would be the absolute worst case disaster. but thankfully that is exceedingly unlikely in my view. Also looking at the earth's history we have had much warmer climates if you go back enough millions of years with higher CO2 levels, et cetera.

[01:06:44] and it hasn't caused any runaway effects that, so it I think that that's not our main worry at this point. there, but there are worries about other tipping points that are much more high probability and closer by.

[01:07:03] Nate Hagens: Like what?

[01:07:05] Stefan Rahmstorf: Well, for example, the Western Arctic ice sheet, the Greenland ice sheet tipping points, Western Arctic may already be crossed, which means the world is now dedicated to Irreversible three meter global sea level rise unfolding over the next centuries with the Greenland ice sheet, we're at least in the risk area where the tipping point could already be crossed.

[01:07:30] There are some studies that claim it is already crossed, because these are very slow responding systems. This melting of ice takes a long time you wouldn't. see it directly in the data whether the tipping point is crossed. Having crossed the tipping point just in that case means that from now on, the further melting is inevitable.

[01:07:54] It's unstoppable basically, unless we cool the earth back down, which is not a realistic option really. And so it means that from now on the ice would melt until it's gone. And for Greenland, that is seven meters global sea level rise.

[01:08:12] Nate Hagens: That changes everything if, such a thing were to happen. So let, let me switch to your core area of expertise, which believe it or not, is not what we've been discussing.

[01:08:25] your, colleague and former PhD student Lev K. Sezer was recently on the show. to discuss the core of yours and her work, the, the AMOC ocean current and viewers can go watch her episode for a deep dive. But what is, since I had her on

and not you what is your brief core message about the Atlantic meridional overturning circulation current that has already slowed some 15 to 20%?

[01:08:53] Do you have any summary message there?

[01:08:56] Stefan Rahmstorf: Yes, my short summary would be that we have very strong evidence now that it has slowed in response to human caused warming, even though we don't have very long direct measurements. There's very strong indirect evidence for that most clearly. A strong cold blob in the northern Atlantic which is actually the only region on earth that has cooled since the 19th century while the whole rest of the globe has warmed.

[01:09:26] And that is a fingerprint of a slowdown of the AMOC, which brings huge amounts of heat into that region. Now we also know the AMOC has a tipping point or maybe even several tipping points where it changes. Fundamentally, and maybe even break down altogether. And if that were to happen, that would be a huge catastrophe, basically, which would be a level bigger than the kind of regular linear global warming effects that we've been discussing so far.

[01:10:00] It would be especially catastrophic for Northern Europe, Great Britain, Scandinavia, Iceland, of course. But also for the tropics, because in the tropics, it would shift the rainfall belts. It also has impacts on marine biology on sea level. And that is a kind of risk that in the past, I've studied this since actually 1991, and we used to call this a low probability, high impact risk.

[01:10:29] Now, due to recent research in the last five years or so. I don't call it low probability anymore because it looks increasingly likely that we are actually heading for this tipping point probably even in this century.

[01:10:44] Nate Hagens: When's the last time that the AMA completely shut down and how do we know that?

[01:10:50] Stefan Rahmstorf: Well it was at the end of the last ice age when also we had a warming due to the orbital cycles at the time with ice sheets melting, a lot of.

[01:11:01] Melt water going into the Northern Atlantic, which dilutes the ocean water. Melt water is fresh water, not salty, and therefore lighter than salt water. And the AMOC is driven by relatively high density water sinking down to two and three thousand meters depth in the Northern Atlantic. And that drives this vertical overturning of the ocean.

[01:11:25] And you have these sinking regions, and then the Water spreads in the deep ocean and upwells somewhere else. And this overturning can be stopped if you add a lot of melt water into the northern Atlantic or increasing rainfall in the current global warming. and yeah, at the end of the last ice age, that called a big, caused a big regional cooling in the northern Atlantic, the so called Younger Dryas event, which lasted about 1, 000 years.

[01:11:54] Nate Hagens: So my understanding is that oceans, you, you said that they have absorbed about a quarter of annual of the emissions, but they've absorbed around 90 percent of the warming that has occurred due to the emissions, especially the top few meters of the oceans. My understanding is that They store as much heat as the entire atmosphere.

[01:12:18] How long is this possible? At what point would the ocean no longer be able to absorb further heat? And it is, it possible at some point that it reverses and it actually, like you mentioned about the Amazon turns from a sink to a source that the oceans actually start to re emit the heat that they had stored over all these decades and centuries of human activity.

[01:12:43] Stefan Rahmstorf: No, I think that is actually sometimes also misunderstood, you know, if you hear the oceans are absorbing 90 percent of the heat and you, might think, Oh God, what happens if they don't? the fact that they do that is simply their thermal inertia. It means they just need a lot of heat to warm up.

[01:13:09] If the oceans didn't do that, if they had already caught up with the warming of the atmosphere, then that heat would simply not be absorbed. I mean, not by the oceans and not by anything else. It would not be absorbed. It's just so

[01:13:24] Nate Hagens: it would just be hotter.

[01:13:26] Stefan Rahmstorf: It would just be warmer, exactly, it would be hotter.

[01:13:29] And so when we actually go to zero emissions and stop the warming, the oceans also will stop absorbing so much heat, which just means they stop warming further. Because that 90 percent refers to the net uptake of heat by the earth system. And because the oceans, the water has the biggest heat capacity That disequilibrium, that heat uptake is almost entirely in the ocean.

[01:13:59] And per cubic meter. The heat required to warm a cubic meter of ocean water by one degree is about 3, 000 times the amount of heat for one cubic meter of air, and that's why the oceans are absorbing so much heat. It is simply too hot. means they are warming. They are actually warming less than the atmosphere in terms of temperature, but that takes a hell of a lot of heat.

[01:14:25] Nate Hagens: If, we were an earth centered species, every human on the planet right now should say a prayer of gratitude for the oceans because they have been saving us from a lot of negative effects from our impacts on the biosphere, and we don't talk about it much. Would you agree? Absolutely.

[01:14:42] Stefan Rahmstorf: I mean, there are a big heat buffer, there are a big carbon dioxide buffer, and we have to make sure they remain healthy because some of what they are doing for us including that carbon dioxide uptake is thanks to the biological pump.

[01:14:58] So it requires healthy ocean ecosystems.

[01:15:01] Nate Hagens: Stefan, this is like my 140th interview. I've never had an interview quite like this because you are so smart wide and deep on these things that I feel like I've just had the chance to walk into a professor's room and ask questions that I want to know the answer to.

[01:15:19] So this is less of a human to human. I'm just trying to pepper you with as much. Questions on this as I have, because I know my viewers and others that will share this video are also curious about these things. let me ask you about oxygen. so my understanding is that oxygen in the atmosphere is declining a little bit because of our burning of of carbon, but that oxygen in the ocean has actually declined 2 percent in the last 50 years or such.

[01:15:52] and up to 20% in the shallows. Um, and fish as one example, are already starting to swim poleward due to what a friend of mine professor Daniel Polly calls Gill Oxygen Limitation Theory. At what point could ocean oxygen levels become insufficiently low for marine animals? Have you looked at that at all?

[01:16:19] Stefan Rahmstorf: Well, I have a colleague in my department, Matthias Hofmann, who has done model simulations on this. let me first give you some good news and dispel a myth that is also quite popular in the public, that the public thinks we need, the forest or the ocean ecosystem to supply us with oxygen and when they die, we will kind of suffocate.

[01:16:46] That's not the case because the oxygen content in the atmosphere has built up over millions of years. it's not gonna vanish on any near future, even if we kill all the biosphere. that's a myth. but I mean, what you are, Mentioning that is a real problem, namely the de oxygenization of the oceans, which is spreading.

[01:17:14] There are already oxygen depleted zones in some ocean areas, some open ocean areas that has to do with global warming and reduced vertical mixing because the ocean actually also in, in the deeper waters. Oxygen is being used up there by the decay of biomass, you know you have the productive zone and near the surface where the sunlight is where you have photosynthesis and then a lot of biomass kind of slowly sinks down to deeper levels where, it is decomposed and that uses up oxygen and that's why you get these oxygen depletion there.

[01:17:57] And. But by the ocean being stirred by the winds, et cetera, you get more oxygen rich waters brought down to the deeper levels again. And this process is basically being slowed down by global warming because if you heat the surface, warm water likes to stay on top. it, it doesn't you reduce the mixing and also biological changes that contribute to these oxygen depleted zones.

[01:18:26] And a similar problem happens actually near coastal regions where rivers come into the ocean and that has to do a lot with fertilizer runoff in, from agriculture in these rivers that create algal blooms. And then again, when that biomass decomposes, that uses up oxygen. So there are several different contributors to that oxygen depletion problem.

[01:18:56] And it's, it's not my research area, but the model simulation show that this will, the further we push global warming the, the bigger. oxygen depleted regions we will get in the ocean. So that's another good reason to stop global warming as fast as we can.

[01:19:15] Nate Hagens: Everything is just so connected. And I was just, you weren't there that day, but I was at the Potsdam center last month.

[01:19:26] And the 300 scientists plus or minus that you work with are working on other connected planetary boundaries like nitrogen cycling and biodiversity and novel entities like phthalates and endocrine disrupting chemicals is climate kind of like the one ring from Tolkien's book that. controls and impacts all these others is the, amplifying feedback from climate enough to influence all these other planetary boundaries or most of them.

[01:20:00] what are your thoughts on that?

[01:20:02] Stefan Rahmstorf: Yes, I mean, many interact of these planetary boundaries, but in, in principle, some of them are really independent problems. Like if you think of say all the microplastic that ends up, or plastic in the first place, then ground down to microplastic that ends up in the ocean and basically ends up anywhere and anywhere.

[01:20:28] I recently, there was a, is a. This is not really funny, but maybe it sounds a little bit funny. There was a study earlier this year where some medical scientists had investigated a tissue from penises from men that had an operation for some other reason. And in most of them they found microplastic.

[01:20:54] Maybe we'll get some men worried about the microplastic problem if they know they, they have it in their penis even, but It's

[01:21:02] Nate Hagens: everywhere. It's in our blood. It's in mother's milk. It's, in all of us, the microplastics which also come from fossil carbon. I would be more worried about

[01:21:13] Stefan Rahmstorf: it in my brain, actually, as a scientist, but it is, in any case, it is a worry that, that is independent of climate change and also other issues like the, nitrogen cycle due to the fertilizer use, et cetera.

[01:21:28] This is also, and it has also threshold limits where it becomes really dangerous. And so there, there are several planetary boundaries like that. Concerning the ocean, there's the ocean acidification issue, which is simply because if you dissolve carbon dioxide in water, you get carbonic acid like like in, in your coke or so.

[01:21:58] And That is not climate change, you know, it's a purely chemical problem, but also caused by the carbon dioxide. So that problem means the oceans are gradually becoming more acidic. And in this, in the second half of the century, some regions will become so acidic if we don't stop this in time that the seashells basically dissolve in the seawater because it detects the calcium carbonate shells.

[01:22:26] And that alone, in my view, as an ocean scientist would be enough reason to cut down our CO2 emissions as fast as we can, even if it wasn't causing climate change. completely independent problem.

[01:22:40] Nate Hagens: Let me ask you this, because you talked about in the second half of the century. Of course, there has to be boundaries on our science, but there is 2100 kind of a arbitrary boundary for such an enormously important planetary issue as, climate change and all that it entails.

[01:23:01] From an ethical perspective, do you think 2100 and most modeling is, is arbitrary because we'll all be gone by then, but the climate is going to continue to have impacts from our activities.

[01:23:15] Stefan Rahmstorf: Absolutely. The CO2 increase that we are causing now will persist for Tens of thousands of years, probably hundreds of thousands of years, if we just rely on the natural processes to remove the CO2 from the system again into the deep sea sediments, that takes

[01:23:35] Nate Hagens: as long.

[01:23:36] So if we do nothing, we will be, the climate will continue to warm for tens of thousands of years.

[01:23:43] Stefan Rahmstorf: no, it will, I mean, if we stop emitting, it will remain warm for tens of thousands of years. It will not continue to warm further, but it will not go back to what it was for hundreds of thousands of years, basically.

[01:23:58] It's again something that people don't realize, but the IPCC. In its headline statements in the latest report clearly says that what we decide in this decade will determine the climate future for thousands of years to come. That is a huge burden of responsibility, which I think most politicians don't live up to actually.

[01:24:21] And that's one reason why we, of course, Look beyond 2100. There are many model simulations, including we have done them looking thousands of years ahead. We even uh, do model simulations for the Swiss and the German agencies that are responsible for dealing with nuclear waste who are of course interested in hundreds of thousands of years into the future because these waste deposits have to be safe.

[01:24:50] And so they want to know when the next. Big Ice Age might carve them up, etc. And so we are able to do that because we can we have a fast climate model. But there is a trade off with the climate modeling the climate models are very expensive to run in terms of the computer effort. They are run on the fastest supercomputing systems available.

[01:25:15] And of course you like to run them at a high resolution to get as much regional detail as possible. And that's why a lot of runs stop in 2100 because already that takes many months of supercomputer time to do that. But you can also run coarser, simpler models that are good for paleoclimate research for doing thousands of years or even hundreds of thousands of years simulations.

[01:25:45] And they, are also done into the future because of course there are slow responding parts of the climate system like ice sheets, like the sea level rise that will go on for thousands of years after we have stopped warming because. Antarctica will take so long to melt to a new equilibrium state, for example, and the IPCC says, you know, sea level rise is probably half a meter to a meter by 2100,

but it could be up to two meters, but by 2150 it could already be up to five meters, and for the year 2300.

[01:26:27] They can't rule out even more than 15 meters of global sea level rise. So there are simulations for these slow responding aspects like sea level that actually have been done for much longer into the future.

[01:26:41] Nate Hagens: How often does this become too much for you to bear as a human? because I really enjoy this conversation.

[01:26:49] we've shared some warmth and a few jokes and quite a few scientific insights, but when you just described 2150 and beyond, I got that pit in my stomach that I often do when my brain started to visualize some of the things that are going to happen to this earth after we're gone. how, do you manage this over your whole career?

[01:27:11] Stefan Rahmstorf: Well, you know of course I do worry about my children and their children if they have some one day, I do worry about that. Otherwise I try to take just a professional attitude and, Look at this in a professional, rational way and you know, I can tell you it's not these projections of climate change and the scientific results that really get me down.

[01:27:46] Does get me really down and depressed is the people denying it all the politicians that basically rolled back. The urgently needed climate protection measures that I find really shocking and often really depressing.

[01:28:04] Nate Hagens: Yeah. I want to ask you some closing questions and be respectful of your time, but I have a couple more content questions.

[01:28:13] What if, for instance, Germany, the United Kingdom, the United States, where I live, did everything perfectly according to what the politicians at the Paris Accord agreed to, to adopt net zero plans by 2050 with appropriate technologies and cuts. Would that even make a dent in the temperature and some of the impacts you've discussed by the year 2100 if the rest of the world all the other countries continued a business as usual pace?

[01:28:44] Stefan Rahmstorf: Well, this is of course, completely fictional scenario, right? Because, um for example, of course, the biggest emitter now has become China simply because their population is so large, but they are also the absolute leader in deployment of renewable energy. solar power, wind energy, electric vehicles.

[01:29:13] So it's not like they are not doing anything. And the projections by the, I think the international energy agency and others is that probably they will peak their emissions this year and they will start to fall. Of course, the second biggest emitter is the United States, and number three is Europe.

[01:29:37] And so, when you have China, the US, and Europe implementing climate policies, then that is already a big part of the solution.

[01:29:45] Nate Hagens: Embedded in my question is, for us to head towards an Earth centered aspirations and goal and recognition that we're at a species level threshold and the future is at risk, does it have to be a global conversation?

[01:30:04] does there have to be something akin to your colleague, Johan Rockström um, talked about a planetary commons?

[01:30:13] Stefan Rahmstorf: Absolutely, I mean, we have to have the awareness that we are homo sapiens, we are one species on one earth, which is our common home, and we shouldn't be fighting each other, we should work together to secure our survival and our well being on this planet.

[01:30:34] And so absolutely, this is an issue, you know, if we were attacked by If global warming were caused by aliens attacking the earth, we would of course all unite to fight them. And we now have to all unite to find this threat to our civilization and our future on earth. And yeah, there's this awareness, I think kind of, Common awareness for the human family altogether is unfortunately not very widespread yet.

[01:31:14] Nate Hagens: Do you think that with the political climate today with respect to CO2 and global warming that it might be easier to convene a planetary commons sort of scenario for the oceans, because people are recognizing plastics

and a lot of the other things you mentioned in the oceans. People are starting to recognize the importance of the oceans.

[01:31:37] Is there something special there that could emerge as a precursor to something larger on the global climate?

[01:31:46] Stefan Rahmstorf: Well, there are already. ongoing formats for this. And as we speak, actually, there is the global conference on the deep sea floor, which may or may not come to an agreement on limiting deep sea mining.

[01:32:06] So these Global negotiations already exist, but they are of course really difficult like the climate negotiations. Also, the biodiversity convention, for example, is another one that is ongoing, but they are unfortunately still always marred by the problem that humanity is split into so many nations with short term economic interests and not really united to look after the common good enough.

[01:32:42] Nate Hagens: I agree. let me ask you one more scientific question and then I'll, get to the closing questions from the perspective of your expertise as an ocean scientist, are there any geoengineering things on the horizon, even speculative that might work? I've, looked at the green sands and you know, other things in the ocean that seem kind of energy and systems blind, but is there anything in your work and all your connections in the world that seem promising from a geoengineering perspective with respect to the oceans?

[01:33:23] Stefan Rahmstorf: Short answer is no, I don't see any promising geoengineering solutions. And I think the best. What we can and should do is make sure that our ocean ecosystems are remaining as healthy as we can manage, which means of course limiting ocean acidification, limiting overfishing and exploitation of the ocean.

[01:33:50] And the same with our land ecosystems, with the natural forests and other ecosystems. We need to keep them healthy because they are already doing a big job in buffering global heating and helping us in this way. And that is the main thing that we need to even, you know, keep going, but also enhance as we can.

[01:34:15] So the European union has this nature restoration law, which is really having the focus to restore. already damaged ecosystems to a healthy state, also

with a view of helping the climate, but also, of course keeping up the biodiversity, which we also need for human survival.

[01:34:45] Nate Hagens: Thank you. I think most of our viewers are generally familiar with the things that you've outlined here but hearing them again from someone who spent their whole life working on them and the gravitas and, reality of it, can be uh, an additional, you know, punch in the gut.

[01:35:09] As a human, do you have any personal advice to the listeners and viewers of this program who are living through the trends that you're describing as they sink in emotionally? What, do you recommend to people?

[01:35:23] Stefan Rahmstorf: Well, definitely, Talk about it, get informed, talk about it to others, look for like minded people, maybe join some local initiative and then of course vote.

[01:35:38] I mean, one of the most important things you can do if you live, if you are lucky enough to live in a democracy is cast your vote for climate protection and for preserving our life support systems on earth.

[01:35:55] Nate Hagens: And you have children and you're a college teacher of 20 year old Germans and other international students.

[01:36:03] What specific recommendations would you add to young humans who are learning about this and all the other economic, political, energy, environmental concerns of our day?

[01:36:15] Stefan Rahmstorf: Well, the same what I just said, basically, also maybe join initiatives, become politically active, but if you're a young person looking for a career, also consider what kind of job you would like to take where you can actually make a difference, a positive difference.

[01:36:32] Nate Hagens: What do you care most about in the world, Stefan?

[01:36:37] Stefan Rahmstorf: That's a difficult question. So, what do I care most about? On a personal level, I would say my children. But on the if you're talking about the world as a whole, I mean, I, care about You know, I have a dream of

humanity becoming wise and becoming good stewards of our planet and having a thriving earth full of life, plant life, animal life of a zillion forms, thriving together with humans that live peacefully and happy, basically.

[01:37:21] Nate Hagens: It's a good dream. if you could wave a magic wand and there was no personal recourse to your reputation or status or well being, what is one thing that you would magically do to improve the future, human and planetary?

[01:37:40] Stefan Rahmstorf: Well, I mean, if this is a powerful magic wand, Harry Potter style I would say change the mindset of.

[01:37:51] All leading politicians in the world to make climate protection a top priority.

[01:37:59] Nate Hagens: So wearing your scientist hat if you were to come back on the show in the future, what is one singular topic that you are passionate about, curious about, that's relevant to human futures that you would like to discuss?

[01:38:14] Today I just rapid fired all kinds of questions, but what is one topic that you're really interested in that deserves a deep dive?

[01:38:23] Stefan Rahmstorf: Well, I would say the AMOC, but you have done it already with Liefke, but maybe next year because there is actually a lot of interesting new work in the pipeline on this problem that you know, might be worth discussing next year.

[01:38:41] Nate Hagens: And what are you spending most of your hours, your professional hours, working on right now? I mean, you probably have a bunch of papers in the works what are you spending your days on right now?

[01:38:51] Stefan Rahmstorf: Well, I, seem to spend my days mostly catching up with huge email backlogs, so.

[01:38:57] Nate Hagens: Many of which were from me, so sorry about that.

[01:38:59] But lately,

[01:39:00] Stefan Rahmstorf: I guess you probably ask me more about the science. And indeed, I have had different phases, you know, working on phases, working more on paleoclimates phases, working more on extreme weather events. But in the last few years, I've, come back to this topic that I've started it in about 1990, which is the AMOC stability issue, because it, has.

[01:39:26] Yeah, there's a lot of exciting but worrying developments there in the science.

[01:39:32] Nate Hagens: Any closing comments for our viewers today?

[01:39:36] Stefan Rahmstorf: Don't give up,

[01:39:38] Nate Hagens: make a positive

[01:39:39] Stefan Rahmstorf: difference.

[01:39:40] Nate Hagens: Thank you so much for your time today and thank you for your lifetime of dedication to this important and central topic. You are, are one of my heroes you and people that are dedicating their life to understanding how the biosphere works.

[01:39:55] To be continued, Stefan. Thank you

[01:39:58] Stefan Rahmstorf: very much for this very interesting podcast opportunity.

[01:40:03] Nate Hagens: If you enjoyed or learned from this episode of The Great Simplification, please follow us on your favorite podcast platform. You can also visit thegreatsimplification. com for references and show notes from today's conversation.

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