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[00:00:00] **Tad Patzek:** The planet is, let's say, one and a half degrees warmer on average than it was in the pre-industrial times. One and a half degrees doesn't sound like much. In fact, people shrug their arms, "What do I care?" But there are several phenomena which may justify a scientific conclusion that the rate of global warming is accelerating.

[00:00:24] The good news is that the oceans dampen the magnitude of that acceleration. The bad news is that heat will stay with us for decades, if not centuries. So even if we stop CO2 injection today, the ocean still will be warmer

[00:00:44] **Nate Hagens:** Today I'm pleased to welcome back physicist and earth scientist, and my friend, Tad Patzek, for an exploration of the foundational physics behind our planet's climate system, including the currently forming Super El Niño, which could be one of the strongest events of its kind in the last 140 years. Tad Patzek is a professor emeritus of chemical and petroleum engineering and director of the Upstream Petroleum Engineering Center at the King Abdullah University of Science and Technology in Saudi Arabia.

[00:01:19] Prior to that position, he was the Lois K. and Richard D. Folger Leadership Professor and chairman of the Petroleum and Geosystems Engineering Department at the University of Texas in Austin. Additionally, he was previously a professor of geoengineering at the University of California, Berkeley, and a researcher at Shell Development, a company managed for 20 years by M.

[00:01:42] King Hubbert. He is also a full presidential professor in Poland, which is the highest honor, and also served as a member of the DOI Macondo Well Advisory Committee. Tad's research focuses on the thermodynamics and ecology

of human survival and the future of food and energy supply for humanity. Most recently, he has cumulated his research into his upcoming book, Thermal Power and Climate Change: A Data-Driven Analysis of Cause and Effect, 1800 to 2100.

[00:02:16] He was recently on TGS to discuss that book, primarily about energy and materials and food and implications. In this conversation, we turn the attention to physics and climate, and we do an earth system speed round on some of the core questions around global heating. We discuss how recent research on declining reflectivity has accelerated heating in the past 10 years.

[00:02:45] we do talk about the upcoming, Super El Niño and the implications, as well as various future warming scenarios. If you're following this story, this is quite a sobering conversation, but right in the fairway of the natural science discussions we have on this platform, and an important one. If you wanna dig deeper into the resources and information referenced in Tad's conversation, or in any conversation on this platform, I encourage you to take a look at the show notes, which are available for every episode in our catalog by visiting thegreatsimplification.com, which is linked in the description of this episode.

[00:03:27] With that, please welcome back Tad Patzek. Welcome back to The Great Simplification.

[00:03:36] **Tad Patzek:** Thank you.

[00:03:36] **Nate Hagens:** A few months ago, you were on the show, talking about energy and the thermodynamic foundations of civilization, including power flows and material fluxes and overshoot and the fossil amoeba. You're a unique guest for me because I've known you for, going on 20 years, and you are one of the smartest Earth system scientists I know, and I've had a lot of climate scientists on the program, but I didn't know most of them personally, so I wanna address global heating.

[00:04:17] And I, I'll ask you, which is probably how you treat me anyways, all the time, to consider me as an earnest and curious high school student, in this conversation. I really wanna understand these things. If you don't mind, I'm gonna do a little bit of a climate basics speed round to keep-- kick off the conversation, but you don't have to give super short answers.

[00:04:45] Are you ready?

[00:04:46] **Tad Patzek:** Yes.

[00:04:48] **Nate Hagens:** So first, can you explain the role of CO2 in the atmosphere? And I've heard this a dozen times, if not 100. Why should we care about a molecule that's only 400 parts, per million total parts of our atmosphere?

[00:05:10] **Tad Patzek:** That is a very good question. So I- let's first start from the basics. CO2 in the atmosphere is the effect of natural emissions and human emissions, anthropogenic emissions.

[00:05:24] And right now, the anthropogenic j-- emissions increase its concentration, from roughly 280 ppm in the pre-industrial era to 435 ppm today. Doesn't look like much, but it's there, and it stays there literally forever, exchanging mass with the oceans, land, and what have you. Half of all emitted CO2 goes into the atmosphere.

[00:05:56] So the more we in-- inject CO2, the more CO2 we have in the atmosphere. Also, because CO2 is such a dilute gas, its concentration throughout the lower atmosphere up to the tropopause, let's say, is uniform. So you have the same 435 ppm here and there, okay? And that's very important. The atmosphere cools down very rapidly as you go up from the Earth's surface to, let's say, when you fly your jet.

[00:06:34] If you fly your jet and you look at the flight report, you will see that your temperature is around minus 40 degree centigrade, 'cause that's what it is at the elevation you fly. And so the main greenhouse gas on Earth is, in fact, water vapor, and liquid water to some degree. But the concentration of water vapor in the atmosphere declines very rapidly with height.

[00:07:07] **Nate Hagens:** Ah, so, so water is something like 4,000 ppm in the atmosphere, so like 10X, what CO2 is, but it's not uniform like CO2 is.

[00:07:19] **Tad Patzek:** No. In fact, it declines exponentially with elevation, okay? So where at the elevation, at the, where Earth, at which Earth emits radiation, which is kind of your tropopause, you know, it's very cold, and there's almost no water vapor, okay?

[00:07:46] It's very dry. So at that elevation, CO2 dominates emissions of the planet, okay? So that's one. Two, the more-- So CO2 is the driver of climate change, and water vapor is the follower. It reacts to the change of CO2 concentration. So if I have more CO2, I warm up the planet, and I have more water in the atmosphere.

[00:08:22] Okay? if I have less CO2, I dry up the planet, and I have less water in the atmosphere. So tiny little changes of CO2 concentration cause relatively large changes of water vapor concentration and the greenhouse effect from water.

[00:08:43] **Nate Hagens:** So when, CO2 was pre-industrial levels, two hundred and eighty parts per million, which was near the lowest it's been, in-

[00:08:53] **Tad Patzek:** Eight hundred thousand years.

[00:08:55] **Nate Hagens:** Okay. Was it a drier world then?

[00:08:59] **Tad Patzek:** No, because the CO2 fluctuated then, and you had essentially Milankovitch cycle driven, so very long-term changes of climate, which occurred, you know, really every 100,000 years over the last 800,000 years. And so the CO2 fluctuated between 280, 300, and 180 ppm during these 800,000 years.

[00:09:32] **Nate Hagens:** And so why is the fact that it's 435 parts per million, instead of 280 parts per million Like to someone that doesn't understand this at all, why is that so unbelievably civilized and biosphere changing?

[00:09:52] **Tad Patzek:** So CO2 has a pronounced greenhouse effect, causing a pronounced greenhouse effect by regulating water and adjusting the temperature of the planet.

[00:10:04] It is the key controller of the climate on the planet. So now we have more CO2, and the planet is, let's say, one and a half degrees warmer on average than it was in the pre-industrial times. One and a half degrees doesn't sound like much. In fact, people shrug their arms, "What do I care?" But that's just an average number of the entire planet.

[00:10:33] **Nate Hagens:** Is that the world average, and it's actually higher than that on land, or is that just land?

[00:10:39] **Tad Patzek:** Yes. It's the world average, and it is higher on the land. You know, when the world is one and a half, let's say, the land will be two degrees centigrade of increased temperature.

[00:10:52] **Nate Hagens:** Right. Okay, so something you just mentioned, I've done so many podcasts, Tad, and I've asked this question four or five times, and I've still not gotten a good answer to it- so I'm gonna try again. You mentioned that CO2 is the main knob for temperature. How do we know that CO2 emissions are

leading warming and not the other way around? 'Cause there's mechanisms in our planetary system that release more carbon dioxide as the planet gets hotter. Maybe you can explain the physics, how we know this relationship is primarily CO2 leads to warming and not vice versa.

[00:11:32] **Tad Patzek:** When you release two trillion tons of CO2 in 140 years, that is a geological force. That's what we have done. We have released between 2.3 and 2.6 trillion or thousand billion tons of CO2 into the atmosphere. That is a huge effect on the planetary climate system. Okay? So there's no doubt about it. Whatever other fluxes of CO2 there are, the Earth tries to keep them in stasis, in equilibrium.

[00:12:10] So whatever gets absorbed by the oceans and emitted by the oceans, in general cancels out. Same thing with the land and the atmosphere. The differential is small and is caused by humans, but that differential accumulates in the atmosphere and in the oceans and on land. And so that is the driver of climate change.

[00:12:38] There's no doubt about it whatsoever. If there weren't human emissions, we would have had the same climate as we had over the last eight hundred thousand years, and in the next twenty thousand years, we would have had or depending how, you know, how you count, we would have had another ice age. But we won't.

[00:13:02] Yeah. In fact, not for a hundred thousand years.

[00:13:04] **Nate Hagens:** So I've also seen graphs and other research that show historical periods in Earth's history that had way higher CO2– Yes ... and we didn't see runaway warming. Can you explain what's going on there? And if this is true, why are we so concerned about today's levels?

[00:13:22] **Tad Patzek:** Well, I mean, runaway warming, you know, i- during the Paleocene–Eocene Thermal Transition about 55 million years ago, the temperature on Earth was higher than Paleocene by about eight degrees or 12 degrees relative to today. A- and that world had no ice and sea level, which was tens of meters higher than it is today, and it was a very different world.

[00:13:57] So it follows that high CO2 concentration causes high temperature. Runaway is a loaded term. It is what it is relative to where CO2 is. and, all the reactions and rearrangements of global circulation, global oceanic currents, and what have you. That is the complex interlinked global climate system, which is now changing slowly to a warmer one because we are driving it to that change.

[00:14:37] Now, my own research, which is a preprint, in, Geophysical Research Letters now, is still in review, showing that it may be changing for all of us and the planet.

[00:14:53] **Nate Hagens:** We're gonna get to your new paper in a moment. I just have a couple more basic questions. You mentioned the 2.3-plus trillion tons of additional CO2 that humans have added to the atmosphere.

[00:15:11] I hear repeatedly that the oceans absorb approximately 90% of the excess heat and a third, plus or minus, of the carbon emissions. Yes. So how has that dynamic affected the impacts of greenhouse emissions and the warming so far? And is there a risk of a tipping point in that system?

[00:15:32] **Tad Patzek:** Again, as I said, roughly half of the emitted CO2 ends up in the atmosphere And in the atmosphere, in effect, it controls the climate of the planet.

[00:15:45] It causes global warming because the atmosphere is our window to the universe. If you dim the window, you warm up the planet. That's as simple as that.

Now, of course, the oceans will absorb more CO2 and will acidify, but they absorb as much as they can, and the CO2 in the atmosphere keeps on rising because we keep on emitting.

[00:16:11] **Nate Hagens:** So this segues into a topic that, I'm most curious about and, why I asked you, back on the show so soon is, I'm reading a lot about not only a strong El Niño, but what some people are referring to as a super El Niño in the Pacific Ocean coming now this summer, and into the fall and into the winter.

[00:16:40] So maybe you can first tell us what an El Niño is and how a regular El Niño affects the climate?

[00:16:49] **Tad Patzek:** Well, again, there are many excellent videos illustrating El Niño from a variety of sources. NOAA, NASA, PBS are some of them. So very briefly, El Niño Southern Oscillation is a natural climate variability occurring in the Equatorial Pacific And it occurs every four to seven years or three to seven years, and then the planet goes back to the normal state, and if it overshoots, it goes the other way, to La Niña, which is the opposite to El Niño.

[00:17:29] Now, in the normal state of the Pacific Ocean, along the equator, the trade winds blow from the east to the west, and they are very strong and continuous. And these winds drag water across the Pacific and push the water towards Australia, Indonesia, and Papua New Guinea. So after a while, there's a lot of very warm water gathered or piled up in the Western Pacific.

[00:18:10] Okay? And that water causes a lot of convection, storms, and a return circulation, Walker circulation, back to the east all the way to the West Coast of Southern America. Okay? And so it goes on. And then those disturbances of the atmosphere over Indonesia and Australia cause the trade winds to weaken.

[00:18:42] They become weak. And then that warm water that piled up there starts flowing back towards the Americas or Southern America. And by doing so, and in fact, it limits the upwelling of very cold water brought along the coast of Chile, the Peruvian current, and causes the water along the western coast of America, of South America to warm up.

[00:19:17] Okay? So now th- you have much warmer temperature, along the South American coast, and the pile of water in the Western Pacific in Indonesia is gone. Okay? So now slowly the reverse is happening, right? The trade winds, recover, and the whole thing is repeated. But before they recover, there could be a La Niña, which then causes the temperature of Western Pacific to be cooler.

[00:19:54] Still warm, but cooler. Now, you can say, "Well, who cares? this occurs only along the equator." But that's not true. The convection from the warm water then spreading across the Pacific causes disruptions to the Walker circulation and moves up and down the jet stream by creating so-called Rossby waves, meanders of the jet stream that can go way north and way south.

[00:20:29] When they go up north, the warm weather and climate go up north, let's say in North America or in Asia. Okay? When they go way down south, there could actually be significant cooling as it occurs, let's say, during winter with the big freezes in Texas and in Florida. Okay? So it's a very dynamic system in which these oscillations of pressure over the Pacific and movement of water go back and forth regularly for thousands and thousands of years. But the background temperature of the phenomenon, which is the average temperature of water in the Pacific Ocean, is increasing.

[00:21:22] In fact, I have a graph showing how much it has increased. So each El Niño is an excursion up in temperature in the West- Eastern Pacific, but relative to a higher background level. So there is another increased base temperature in which we have these spikes caused by El Niño and La Niña.

[00:21:50] **Nate Hagens:** So the 1.5 degrees Celsius average on the Earth is the background, and then the El Niño or Super El Niño is, an increase above that, already– Right

[00:22:02] increased base. Okay, so what does it mean when something, as I've been told, is a Super El Niño year, and what are the risks that come along with this, and should we be as concerned as some scientists are saying we should be?

[00:22:15] **Tad Patzek:** So there's a lot of warm water in the Pacific, and in fact, there are now, images spread all over the web and X which show animations of that water, bubbling up and hitting the surface of the ocean.

[00:22:35] That warm water then warms the atmosphere. If it warms the atmosphere, the atmosphere has more moisture in it, right? So, the warmer the atmosphere, the more water vapor it has. In fact, there is a very nice relationship. It has just enough, more wa– vapor, so that relative humidity of the atmosphere remains constant.

[00:23:01] So higher temperature, more water, same relative humidity, okay? But with more water, things are bound to happen. A, you have more, more powerful cyclones. Actually, I shouldn't say more. You may have fewer, but far more powerful cyclones and hurricanes. You will also have terrible drought, on the western side of El Niño in Australia, Indonesia, parts of Asia, equatorial Africa And you may have terrible deluges on the western side of El Niño.

[00:23:44] **Nate Hagens:** When you said that, with your very endearing Polish accent, I thought you said we would have more delusions on the western side. No. Okay.

[00:23:55] **Tad Patzek:** Okay.

[00:23:56] **Nate Hagens:** So,

[00:23:56] **Tad Patzek:** Delusions we have, too.

[00:23:58] **Nate Hagens:** Yeah. So, so taking a step back, what is a, the Super... I mean, there is going to be a Super El Niño. Do we know that or not?

[00:24:07] **Tad Patzek:** We don't know that for sure, but all indications are that we might.

[00:24:12] **Nate Hagens:** Yeah.

[00:24:12] **Tad Patzek:** it's quite probable. It means as temperatures spike, across your one and a half degrees. Yeah. And how high this temperature spike will be, we don't quite know, but it may be two degrees, it may be more than two degrees.

[00:24:26] **Nate Hagens:** So if we do have a Super El Niño in the coming six months or so, can you tell us about the overall, D- does that tell us anything about the overall stability of the climate system a- and the long-term forecast of where we're headed?

[00:24:41] **Tad Patzek:** First, the good news. The climate system on Earth still appears to be stable, subject to some things that may be changing in it, which actually is my GRL paper, okay? So when I say it's stable, it means it's gonna go back to what it was before.

[00:25:03] **Nate Hagens:** So it means reverting, in a way.

[00:25:06] **Tad Patzek:** It will revert to normal or La Niña, okay?

[00:25:11] **Nate Hagens:** Okay.

[00:25:11] **Tad Patzek:** But since these oscillations occur at an ever higher level of global temperature, they will bring ever more extreme events, extreme temperatures, heat domes, droughts, extreme rainfall, I will not call it, deluge anymore and so on.

[00:25:35] So it will impact the lives of millions, well, hundreds of millions of people.

[00:25:39] **Nate Hagens:** Thank you, for that. So, I wanna move to your, your recent paper, and my understanding is a big focus of, of your research of late has been to distinguish the difference between cumulative emissions and annual emissions and how these metrics surprisingly tell a different story.

[00:26:05] So can you explain what each of those are and which one we should be focusing on in order to understand the actual relationships between, the different aspects of human activity and, global heating?

[00:26:18] **Tad Patzek:** All right. So let me play a high school teacher now.

[00:26:21] **Nate Hagens:** Okay.

[00:26:22] **Tad Patzek:** The temperature of the planet reacts to the cumulative emissions.

[00:26:29] In fact, the rate almost doesn't matter, because what the planet sees is the cumulative effect of CO2 emissions. Having said that, they are very high and they're accumulating very fast, okay? And so if you plot the temperature change of the planet, not versus time, versus years, but versus cumulative emissions since 1850, let's say, you will see that many of the curvature of the increase or kinks in the curves will straighten up, and will become straight lines.

[00:27:10] So every temperature on the planet becomes almost linear with the cumulative CO2 emissions, and that includes extreme temperatures, the hottest and the coldest temperatures on the planet.

[00:27:28] **Nate Hagens:** I have a question, Professor. so, does that imply that if we cut our emissions in half in a given year, that doesn't really make much of a dent in the cumulative emissions to that point?

[00:27:47] **Tad Patzek:** No. That's not really what I said. You have a h- hundred dollar balance in your banking account, right? And e- each year you deposit $100, but you spend only $99. So the difference is very small, just $1. But if you do it for 30 years, well, you're gonna get $30, which is, let's say, a third of your-

[00:28:15] of your principal.

[00:28:17] **Nate Hagens:** Okay.

[00:28:17] **Tad Patzek:** So the accumulating effect of small changes is what matters. But unless you reduce your rate each year, you're not gonna reduce the cumulative.

[00:28:29] **Nate Hagens:** Got

[00:28:30] **Tad Patzek:** it. So it does matter.

[00:28:31] **Nate Hagens:** Yeah. Well, how long does that, that c- I mean, when we add one year's worth, how long will that stay in the atmosphere?

[00:28:42] **Tad Patzek:** It depends. It depends. So the CO2 that stays in the atmosphere is not necessarily identically molecule for molecule the CO2 we injected.

[00:28:52] **Nate Hagens:** Yeah.

[00:28:52] **Tad Patzek:** There's some that goes into the ocean, there's some that comes off the ocean, and there's some that accumulates from our emissions, right? But 46% of w- of what we inject stays in the atmosphere on average.

[00:29:08] Now, the lifetime is, again, it depends where it partitions, is between, let's say, 17 and 30 years, of residence in the atmosphere and longer. But really, on average, the CO2 will come to an equilibrium if we stop injecting it, and some of it will be transported deep into the oceanic water, and its concentration will decline from the 435 PPM to, let's say, 280 over centuries.

[00:29:46] Over centuries.

[00:29:47] **Nate Hagens:** Okay. So getting back to something, in your paper and something you just mentioned, you indicate that the rate of warming per year has been accelerating over the last couple decades. So how fast and why are things accelerating, and do you expect that trend to continue?

[00:30:06] **Tad Patzek:** Right. So, in the paper I propose a very simple model, right, w- which has a steady, a tried component, from the CO2 concentration which is logarithmic, right?

[00:30:23] So it's a logarithm of the current CO2 concentration divided by the pre-industrial value, let's say two hundred seventy-eight ppm. So that kind of keeps on increasing, but ever more slowly as a logarithm, right? And in the plot, you can actually see that between 1880 and now, the increase in... When plotted versus years,

[00:30:47] **Nate Hagens:** okay?

[00:30:48] **Tad Patzek:** The whole increase can be approximated by two straight lines. One between 1880 and 19, let's say, 70, and then another steeper one between 1970 and now. So that's kind of linear. That goes back to my linear increase with cumulative CO2 injection. Another component that is forcing the planet now to help us are aerosols.

[00:31:13] And aerosols come from volcanoes, from natural emissions, and from human emissions. There's also... A– and that component is minus one point four watt per square meter, on average. But then we change the land use, so we, so, and we melt the glaciers. Okay? So these two components are of similar magnitude, and they almost cancel.

[00:31:46] So aerosols plus land use change, plus, melting glaciers, is about minus one watt per square meter. So that dampens the world's heating.

[00:31:57] **Nate Hagens:** Okay?

[00:31:59] **Tad Patzek:** And then there is another component, which is clouds. Okay? And, so that cloud component is not very well defined, and we do not capture it well in the, you know, global climate models.

[00:32:16] But you can approximate it, and I did in the paper, you know, with an average value. So, so from the rest of it, you separate the influence of albedo, of, Earth reflectivity, and you lump everything else into something, right? And that something, is, less than a watt per square meter. and it's an approximate value.

[00:32:43] But in doing so, you actually approximate the real observed temperature of the planet extremely well. That's surprising. With such a simple model, and there you are, you know, a hundred and forty years of temperature increase, it's there. Okay? And you have two choices. Either ignore the change of albedo and fix other parameters, so that you match the increase of CO2

concentration, and that's a pretty good model Or you, you account for the albedo change and you do statistics, and that's a much better model.

[00:33:25] And if you account for the albedo change, you will see that the model does extremely well, repeating the temperature observed on the planet of the last, let's say, 25 years, 26 years.

[00:33:41] **Nate Hagens:** So you said that the CERES instruments on top of the satellites have been mentioned-- have been measuring the albedo, or we can infer the albedo from them.

[00:33:53] Yes. How has the albedo changed in the last 26 years?

[00:33:56] **Tad Patzek:** So first, climate is controlled by the amount of heat or radiation, sunlight absorbed by Earth and the amount of infrared energy emitted by the Earth. Okay? And if the two balance, there's no climate change. If there's more incoming sunlight than leaving infrared radiation, the climate warms.

[00:34:18] Okay? That's where we are right now. And now for the last 26 years or so, we have had very accurate measurements of that delicate balance of energy, radiant energy at the top of the atmosphere. And this is done by the CERES instrument flown on top of many satellites around the world. And CERES means the Clouds and Earth's- radiant energy system.

[00:34:54] **Nate Hagens:** Mm-hmm.

[00:34:55] **Tad Patzek:** The clouds and Earth's radiant energy system. And it's an incredibly sensitive and well-calibrated instrument that tells us small fluctuations of this energy balance, which are of the order of two, five, 10 watts per square meter of the planet, right? So for the last 20 years, we have a deep insight on a planetary scale what's happening with this balance of energy.

[00:35:30] Okay? And so the planet, as you know, reflects some of the incoming sunlight, by clouds, from glaciers, from snow, and what have you, and from other surfaces. And the overall effect of this reflection is called the albedo, right? So about 30%, actually 29% of the incoming sunlight is reflected by the planet.

[00:35:59] Okay? So that's the Earth's albedo. And the Earth's albedo is a miraculous phenomenon. It is uniform around the planet. So the Northern Hemisphere, which has a lot more land, has fewer clouds, which then reflect less because the surface of the Northern Hemisphere reflects more. The Southern Hemisphere has more water.

[00:36:26] It has more clouds. So water absorbs more of the radiation, but clouds reflect more. And this interaction of clouds and the Earth's surface causes the albedo to be preserved within, I don't know, less than a quarter of a watt or tenth of a watt per square meter. That's miraculous. If you disturb that miraculous equilibrium, which we seem to be doing now, and again, the evidence is not full, it's only 26 years of it, then bad things will happen to the Earth's climate.

[00:37:07] And in fact, my paper deals with the acceleration of global warming. So Earth is warming, and the acceleration and the warming itself is accelerating. And what I've linked that acceleration to is the decline of the albedo of the planet. So albedo i– is now declining from, let's say, .29 0.2 or so to 0.28 point something.

[00:37:43] But it keeps on declining with time. But you would say, well, 1% change of albedo is almost nothing. But if you look at how much more solar radiation goes to the surface of the planet, that's a huge effect.

[00:38:02] **Nate Hagens:** So that is concerning, and it makes sense. I understood what you said, though if you tested me tomorrow in your high school class, I would probably get a B minus, and then the next day I would bring you some pierogies or an apple, and then I might get a B plus.

[00:38:21] But, that all made sense. But there is a silver lining of sorts, if I'm understanding you correctly, that changing the albedo, if in the unlikely but hopeful and possible case that humans get our act together and move towards some sort of ecological civilization where we champion regenerative technology and our culture actually cares, changing the albedo, if it were a globally agreed upon thing, we actually could reverse that decline in the albedo.

[00:39:00] Yes?

[00:39:01] **Tad Patzek:** Possibly, yes. However... So, here's the good news and bad news, right?

[00:39:06] **Nate Hagens:** Okay.

[00:39:08] **Tad Patzek:** The effect of this albedo would have shown on a much, much warmer planet right now were it not for the oceanic water. And that absorption of heat which accelerated very rapidly after 2014, and there are several independent conjectures, propositions, that go along this line, is actually accelerating the rate of global warming.

[00:39:41] Okay? And you say, "Oh, well, who cares? We don't have enough evidence," right? But, you know, there are some other things that are happening around the planet. One would be the accelerated melting of ice in Antarctica, which accelerated incredibly. The other one is accelerated, ice melting over Greenland, which also accelerates.

[00:40:10] Okay? There is the change of the albedo. There's the warming of the oceans. So there are several phenomena which happen to be occurring at the same time, which justify or may justify a scientific conclusion that the rate of global warming, in fact, is accelerating. Is accelerating. So our curve is curving up.

[00:40:37] Up, okay? And that's not good. So the good news is that the oceans dampen the magnitude of that acceleration and change a lot. The bad news is that they absorb 90% of all incoming disequilibrium by warming and warming up, and that heat will stay with us for decades, if not centuries. So even if we stop CO2 injection today, the ice- the ocean will still be warmer.

[00:41:08] We'll have to lose that heat into the universe over a prolonged period of time.

[00:41:13] **Nate Hagens:** So you have argued that we crossed the one and a half degree Celsius barrier in 2024, and that we're well on our way to crossing the two-degree barrier by 2050. Lots of people agree with you, but other scientists say that we haven't crossed that threshold, and using a ten or 20 year average is more important to track rather than just one year.

[00:41:37] Sure. Can you maybe speak to both sides of that discussion- Sure ... and, why is that relevant?

[00:41:42] **Tad Patzek:** Climate and weather are two different things, right? So weather can have extremes up and down. When you average weather over a prolonged period of time, ten or 20 years, you get an average, and if that average changes, that's your climate change.

[00:41:58] So there's no doubt about it. There's also no doubt about it that the global temperature keeps on increasing, and with the spikes from each El Niño, it will now be steadily above one and a half degrees centigrade. And I agree that the average, when you average out the spikes, okay, will be lower. But if you live inside of that spike, you don't care.

[00:42:27] It's hot, okay? So the prolonged warm periods or heat waves that will be part of our daily life do matter, and we can squabble if they occur at one point

four five or one point five five degrees of average temperature. But the fact of the matter is that they're getting more extreme and more common, and that's where your life is impacted. So again, science is clear.

[00:43:02] Climate, long time average. Weather, no averaging. Something in between, you know, a couple of years of averaging, let's say five years, will show you the, you know, maybe not very long lasting trends, but still trends, and they're going up.

[00:43:18] **Nate Hagens:** So, I'm gonna put you on the spot. Of course there's a lot of variables, and a lot of unknowns, but where is your Professor Tad Patzek earth scientist midpoint of your distribution in your mind of how, hot, we will eventually, stabilize at or get to like in coming centuries?

[00:43:47] Or is it a huge range and you can't even guess?

[00:43:50] **Tad Patzek:** Well, of course there's a range and... but I will say that the range is centered at plus two degrees centigrade of heating in 2050, and a little bit more than three degrees in 2100, for the planet. And that means that the land will heat by, let's say, six degrees in 2100.

[00:44:17] And six degrees is huge. In fact, it's so large that you will not be able to recognize the planet.

[00:44:25] **Nate Hagens:** And that's centigrade?

[00:44:27] **Tad Patzek:** That's centigrade. So div, multiply it by nine and divide it by five, you're gonna get your Fahrenheits.

[00:44:34] **Nate Hagens:** Yeah. So that's 11 degrees Fahrenheit-ish-

[00:44:37] **Tad Patzek:** Yes ...

[00:44:39] **Nate Hagens:** as a global average. Yes. So if...

[00:44:41] So some places at times would be 20 degrees Fahrenheit hotter

[00:44:45] **Tad Patzek:** than- Right ...

[00:44:47] **Nate Hagens:** That's... I don't think... I think a lot of the viewers of this channel are well aware of that possibility. I don't think many humans have internalized the absolute magnitude of that.

[00:45:03] **Tad Patzek:** Right. a- and I agree with you, and that's what makes this discussion so difficult.

[00:45:09] Because things, the climate changes slowly, and we're not built to accept slow changes. W- we haven't evolved as humans to accept something that is changing relatively slowly. And in fact, the things that are changing, which are most dangerous to us, are changing invisibly.

[00:45:30] **Nate Hagens:** Invisible and slow, not a good combination for Homo sapiens.

[00:45:34] **Tad Patzek:** Right. So for example, the melting of glaciers in the Himalayas, which is catastrophic, which may yield them melted mostly, in the next 30, 50 to 70 years. Well, those glaciers supply water to two billion people. Once that water supply disappears, those people have no drinking water. Okay? And that's happening in real time.

[00:46:03] You look at the pictures of the Himalayas from the satellites, and you have thousands of melt lakes, lakes everywhere, literally dotting the landscape of the mountains. And then in the spring you get catastrophic flooding when the rush of, you know, meltwater goes down the slope in Pakistan and in India, in

Kashmir, or in China, in Tibet And then during the summer you have drought, and those droughts will become bigger and more pronounced.

[00:46:38] So that would be one. The other one is the melting of ice, the land ice on Antarctica and on Greenland. Well, Greenland and Antarctica. Greenland melts much faster than Antarctica. Okay? Well, this melt adds to the average level of water in the ocean, sea level, okay? And again, it's in- imperceptible.

[00:47:01] Well, it's 30 centimeters, since, let's say 1905 or so. But you can see if you live in Texas or in Florida or in Jakarta that-- or in, well, or in parts of Maine, that water invasion on land is becoming more common and more severe. And if you live in Jakarta, well, a lot of time you sit in water in your house, and in fact, the city will be evacuated and changed to another city, elsewhere, right?

[00:47:44] So we neglect these changes, and they keep on accumulating, and they cannot be reversed by a stroke of a pen or snapping fingers. and that's what's so dangerous about climate change. Let me then point out another effect which affects everybody. That's heat waves. So heat waves come from heat domes, and heat domes come from a Rossby wave that goes north, pumps hot, tropical air up north.

[00:48:22] Then this hot air, cl- goes down by gravity, compresses. while compressing heats up, like when you pump your-- the tire in your bike, it becomes warm when you compress it, right? loses moisture, and now you have a lot of hot air and hot and high pressure, preventing cold air and moisture entering a big area, and you have your heat dome and heat wave.

[00:48:54] **Nate Hagens:** I'd never thought about it till this moment, but is a heat dome the inverse or the opposite of a polar vortex?

[00:49:01] **Tad Patzek:** Yes, it's the opposite. So the polar vortex is the Rossby wave bending the jet stream down south and, heat domes, hot air is bending it, north.

[00:49:17] **Nate Hagens:** One way to summarize this then, as your high school student, The planet is warming and it's based on cumulative emissions.

[00:49:27] your new s- research is saying that tiny changes in lower reflectivity or albedo is actually helping accelerate that warming. And so we're at one and a half degrees Celsius and slowly increasing with some spikes in, h- hotter times during, El Niños or Super El Niños. And one of the consequences of that is, more warming or heating, but also a higher standard deviation of rainfall and heat waves and droughts.

[00:50:04] So the m- median and the mean become relevant because the whole thing is increasing, but the standard deviation is also increasing.

[00:50:14] **Tad Patzek:** Correct. So, that's a very nice summary, Nate. That's an executive summary for somebody who doesn't have time to think about this and wants to know what the consequences are.

[00:50:26] But there are many other consequences. So in twenty-two, officially 62,000 people died in Europe from heat waves in one year, okay? Mostly elderly people, vulnerable people. In other countries, these statistics do not exist. They do not exist in the US, okay? So we don't know how many people are dying every year of heat exhaustion in Texas and in Florida, Mississippi, Alabama, y- you know, whatever.

[00:50:57] **Nate Hagens:** Did you read Ministry for the Future for Kim Stanley Robinson, the fiction book?

[00:51:04] **Tad Patzek:** No

[00:51:05] **Nate Hagens:** Okay. It's a fictional book where we finally get our act together, on climate, but only after a mass die-off from a heat wave happens in the Indian subcontinent in 2040 or something like that.

[00:51:20] **Tad Patzek:** Mm-hmm.

[00:51:21] **Nate Hagens:** Presumably those types of events are probably likely in the next 30 to 50 years.

[00:51:28] **Tad Patzek:** Yes. Very much so. And in fact, if you look at the effects of El Niño and changing monsoon patterns, the subcontinent of India will be hitting far faster than other areas of the planet. So will, in fact, Western China, most of China.

[00:51:51] So will Pakistan. So will Bangladesh.

[00:51:54] **Nate Hagens:** Why is that?

[00:51:56] **Tad Patzek:** That's just a confluence of everything that we've talked about.

[00:52:00] **Nate Hagens:** Okay.

[00:52:00] **Tad Patzek:** The Rossby waves, the jet stream, the El Niño, La Niñas, what have you. That's one. Two, the atmosphere has demonstrated, beyond any doubt whatsoever that it can send massive amounts of hot air, hot 40 degree centigrade above the average, or 70 degrees Fahrenheit, all the way from equator to the Arc- Antarctic.

[00:52:30] **Nate Hagens:** 40 degrees Celsius above the average?

[00:52:34] **Tad Patzek:** Yes

[00:52:36] **Nate Hagens:** And has that happened recently?

[00:52:37] **Tad Patzek:** Yes. It happened in March of 2022 in Antarctica, where, this was already the La Niña state, of, the, or still La Niña state of the Indian Ocean. But there were several, big storms which coalesced into a couple of cyclones, and they caused a massive Rossby wave which shot this hot air, all the way to Eastern Antarctica.

[00:53:12] Okay? And the temperature in Eastern Antarctica became 40 degrees centigrade, 70 degrees Fahrenheit warmer than average. Luckily, this happened at the onset of the Antarctic winter. So if your original temperature is −47 and you add 40 degrees to it, it's still −7 in the interior of Antarctica. So you didn't cause massive melting because it happened in March, not at a different time.

[00:53:46] But on the outskirts of Antarctica, on the sea ice, the ice shelves, it caused massive damage and melting of ice. Catastrophic. In fact, one of the glaciers that collapsed was near Dome C, where the venerable ice cores were taken three kilometers deep that told us about the climate of the last eight hundred thousand years on the planet.

[00:54:16] And so those heat waves and those big Rossby waves will be happening more and more often, and they actually have an incredible power to do fast damage to the climate system and to the planet. So if you ask me, Ted Pasek, for my subjective, perhaps not fully still scientifically justified opinion, and that's just my opinion Is climate change accelerating?

[00:54:49] I will tell you, by all means, yes, it is. Okay? If you ask me as a scientist, I will say I did the Bayesian test and Petit test and that test and the other test, and

it appears that it does. But I need more data, okay? I always need more data. However, as an engineer, I will tell you I have enough data to say, "Look out.

[00:55:14] Watch out."

[00:55:15] **Nate Hagens:** So I have some broad boundary questions to ask you, on, your conclusions and the implications. But let me start here. One of the core themes of my work as you're aware, is helping human civilization bend and not break. And this is where as an intermediate phase of societal, triage- Mm-hmm

[00:55:41] civilization would bend and absorb una-una-unavoidable shocks, and that we would downscale our material consumption, and hopefully that we're somehow able to do that without fully breaking into chaos. So similarly, in your work with the climate systems, these break points or tipping points are highly consequential.

[00:56:03] So what are the breaking points for the Earth's albedo and other key areas that you'd like to highlight in our climatic system?

[00:56:13] **Tad Patzek:** So again, I have to be careful here because it's not fully justified with enough time records. But it appears that the Earth has entered a period of an accelerated decline of albedo, right?

[00:56:34] So albedo is declining linearly, whereas before it was constant.

[00:56:40] **Nate Hagens:** Do we have any idea what the albedo was pre-industrial times? No, because we couldn't measure it, but presumably there were more forests and other things.

[00:56:49] **Tad Patzek:** Not really. We can infer it from climate models, but they're very imperfect. Okay. But not really.

[00:56:55] It's the satellites that do the job.

[00:56:57] **Nate Hagens:** Yeah, that, that's one of my wider boundary questions. But stay on this one. Keep going.

[00:57:02] **Tad Patzek:** You say bending, and I say fracturing a-a-and for the following reason. So think of the climate right now. You have, let's say, a prolonged drought in the summer punctuated with very brutal, intensive rainfall, in winter, let's say, right?

[00:57:26] And so the soil, the clays are shrinking in the summer, dewatering, dehydrating in the summer, subsiding, and then rapidly swelling as much as they can because water is running off to the ocean, right, in the winter. What does it do to your infrastructure, to the buildings, the roads, the bridges, the dams?

[00:57:51] Well, it breaks them. In fact, it fractures them everywhere. Everywhere in Europe, everywhere in America, everywhere in Asia. Okay? What does it mean? That means that there will be huge associated costs with repairing our infrastructure when dams start failing. In fact, they already are in many places on the Earth.

[00:58:14] So that's fracturing. That's not bending. The other thing which is not accounted for is the melting of the permafrost in Alaska and Siberia with a giant release of methane. That will take a while. But on land, permafrost, that is... that's measured in decades, centuries, and even millennia for the submerged, hydrates, m-methane hydrates in the subsea.

[00:58:45] But it's happening. In fact, you have giant, methane craters all over Siberia, and you have sloshing coasts in Alaska and Siberia. That's bad. Okay? The hope... Let me just reiterate what we're hoping for. We're hoping that we have the

same planet, the same ocean, the same gases in the atmosphere, the same behavior of water, which is kind of linear with temperature.

[00:59:14] So everything is kind of nice and linear, and so, the effect of what we do is still linear when plotted versus cumulative emissions, right? So a straight line. So that's actually, as bad as it is, that's good. Okay? Now, there are two possible outcomes in the future. The straight line bends down Or it bends up.

[00:59:38] Okay? Now, the optimists among us will say, "Well, there will be, you know, heretofore unknown feedback that will bend it down." I don't believe that. Okay? What I do believe is that the feedback I suspect is occurring will actually bend it up, which makes our reaction to climate change ever so more urgent.

[01:00:06] So you and I live in a very rich society for most people, or at least for the upper 10% of the people, okay? In Europe, many more people live comfortable lives. So let's say you have one billion people who live in relative comfort wherever they live, and there will be means, societal means to displace them elsewhere or to give them air conditioning or to supply them with food.

[01:00:36] But the remaining seven billion people have no such means. So people who do not participate in our orgy of emissions, an orgy of power use, you and I are, as you know from my previous conversation, a 10-kilowatt machine.

[01:00:55] **Nate Hagens:** Everyone in the US is 10 kilowatts. Yeah.

[01:00:57] **Tad Patzek:** Everyone. That's right.

[01:00:59] **Nate Hagens:** Well, I mean, on average.

[01:01:00] On average.

[01:01:01] **Tad Patzek:** On average. Right. So you and I are less, but it doesn't matter, okay? Yeah. and so what will happen– what is happening now is incredible social tensions between the Global South and North and incredible social instability across the Global South, and in fact, it's spilling over to the Global North.

[01:01:24] And so how–– So the question that I'm asking, and that's where my biggest fear and sleepless nights lie, is how in this increased denial, social instability, we can still precipitate actions that will actually decrease our impact on the planet. How is that possible? And I'm not a social scientist.

[01:01:54] I actually don't know the answer to that.

[01:01:56] **Nate Hagens:** I don't either. I, I do h– I do wanna press you on a couple other related– Yes … questions. As an Earth systems scientist, expert on hydrocarbons and the Earth system– It strikes me, and I think I might frankly do this in the near term. You look at all the conferences around the world and there's–– this is the year of the triple COP conferences.

[01:02:23] There's one on land degradation, there's one on biodiversity, and there's one on climate. There's the planetary boundaries, and there's all these international conferences on all the aspects of the metacrisis. And it's basically a bunch of high–status people attending a funeral for the way things used to be.

[01:02:44] And yet at the same time, you have the power structure of what's happening in Hormuz and in Russia and Ukraine and in Washington, D.C. And these people that go to these environmental Earth system conferences are, like, cheerleading for their plan of action. But it's so far down the decision hierarchy in what is actually happening in the world, it almost seems farcical.

[01:03:16] As an Earth system scientist, what are your thoughts on that?

[01:03:20] **Tad Patzek:** I agree. They're farcical. So, there are two aspects to, to, to your question. One, is the science correct? Because people, in the power structures are now actually, telling everybody that the science is incorrect. The science is correct, as correct as it can be.

[01:03:44] But science is a process, right, of finding the truth. If one, just one observation in a billion observations pointed out that something's incorrect with, let's say, thermodynamics or climate science, the whole edifice of the science would crumble down. Because that's the way scientists are. We have to make sure that everything we say is true and nothing but the truth to the best of our knowledge.

[01:04:18] And when we make mistakes, we actually correct them by peer feedback, by thinking more and changing our opinions. And so science is a long, tedious process of discoveries, corrections, mistakes, cor- corrections again. But in the end, we arrive at a product which is as true as it gets given the state of our knowledge.

[01:04:45] That's science. And this science says climate change is occurring, and it can be accelerating. And there are no two doubts, 0% of doubt in that. Okay? Now, where we can start differing, and this is where different people start saying, "Well, but this, well, but that," is, well, how rapid this change will be. Will it accelerate or decelerate?

[01:05:12] Will it be much worse or a little bit worse? We can all do that discussion, and come to different conclusions, but the basics, the fundamentals of this discussion are the same. You have the two figures in my paper, and that's a fact. You cannot dispute that. It's right there in front of your eyes, okay?

[01:05:36] It's warming up, and the warming up may be very likely accelerating, okay? And as a human being who's not a scientist, you can say, "I don't care," or

you can say, "Well, maybe I should start caring." Okay? And our hope, yours and mine, is that conversations like this one and many others will actually get more people to think maybe I should care.

[01:06:04] So let me give you another anecdote just. Recently I was at the Society of Petroleum Engineers meeting in Bakersfield, California, and it was devoted to the energy supply in oil and gas supply of California.

[01:06:19] **Nate Hagens:** So in my experience, petroleum engineers, as a demographic, are usually very skeptical that climate change is happening.

[01:06:30] **Tad Patzek:** Correct. In fact, most are not just skeptical, they are in straight denial. But many present at that conference were not. But I talked to a, I will not mention the name , a very prominent, executive or retired executive from Chevron, who's now a professor at University of Southern California. And I kind of-- And he, he understands.

[01:06:57] He knows, okay? He knows what's happening. And I tried to say, "Well, Paul, let's say, would you consider cutting your personal consumption, you know, not having an SUV, doing some other things a little bit differently? And he looked me in the eye and said, "Why? Why should I do that? Others will not do it, and I have the means of not doing it, okay?

[01:07:25] I will not change my customs. I will burn as much of everything as I can." And he said, "And I'll give you one piece of advice. Become rich, because then you can weather any disruption."

[01:07:38] **Nate Hagens:** That's a microcosm of our whole global situation right there.

[01:07:41] **Tad Patzek:** Exactly. Yeah. Yeah. Why should I change if I can afford not changing?

[01:07:46] **Nate Hagens:** Yeah.

[01:07:46] **Tad Patzek:** And, why should I care if I can afford not caring? That's exactly the microcosm.

[01:07:51] **Nate Hagens:** And I think the challenge is to carve out some percentage of that demographic, that changes their priorities- Okay ... to be in service of life. I think- Right ... yeah.

[01:08:03] **Tad Patzek:** but that percentage of the demographic has to organize outside of conferences- Yeah

[01:08:11] and outside just talking to scientists like me. In fact, scientists like me should be talking a lot more to the skeptical demographic. Unless people organize, nothing will change. Nothing. Y- you see the poster in the back of my room? That's solidarity.

[01:08:30] **Nate Hagens:** O- okay.

[01:08:31] **Tad Patzek:** Right? Well, solidarity has changed the world.

[01:08:34] Why? Because the whole nation organized

[01:08:38] **Nate Hagens:** Yeah

[01:08:39] **Tad Patzek:** Okay? And so if I have to give one advice to people, don't sit on your butts. Stand up and organize

[01:08:48] **Nate Hagens:** So, so let me ask you, about another phenomenon which, I am also technically a scientist, by my degrees, but I'm more of just a cultural observer, and I also host this platform.

[01:09:07] Invariably, when we post this episode, the people who are very interested and aware and concerned about climate change will watch the whole thing, and they will learn some things, and they will like it because I've learned some things from you. Many others, probably without watching it or maybe watching three minutes, will post in the YouTube comments...

[01:09:30] Because every time I do something on climate, I get dozens of emails from the same people saying, "You're losing your credibility, Nate, by posting things on climate," and, "The other things are much more important," et cetera, et cetera. But I almost think that there's some sort of a Homo sapiens antibody that happens- Mm-hmm

[01:09:53] when you have a civilization-altering topic like this. It is, by definition, there will be a counterweight in our culture to it. What are your thoughts on all that?

[01:10:05] **Tad Patzek:** So climate change or, is ca- is explained by climate science, which itself is a mixture of physics, mathematics, geology, cloud physics, chemistry, and so on and so on.

[01:10:27] So you can think of the picture we are painting here as a puzzle that consists of 10,000 pieces.

[01:10:35] **Nate Hagens:** Right.

[01:10:36] **Tad Patzek:** And even if you are very well trained, it's very difficult to put together this puzzle.

[01:10:43] **Nate Hagens:** Yeah.

[01:10:44] **Tad Patzek:** Very. And I spent years putting it together, okay? If you're not trained, two things happen. Many pieces of the puzzle are actually invisible to you.

[01:10:57] You can't see them, okay? So the picture that you have that emerges is full of holes

[01:11:04] **Nate Hagens:** Well, it's, and it's predominantly the five pieces that you've assembled that you can see

[01:11:10] **Tad Patzek:** It's full of holes, and the pieces that you think create a picture because you have the five pieces, a little island in the picture.

[01:11:18] **Nate Hagens:** Mm-hmm.

[01:11:18] **Tad Patzek:** And you have no idea what they actually represent. But then because of your lack of knowledge, you assign scientific value to those five pieces and the value of your beliefs to those five pieces, and you say, "Well, I did my research on the internet, and this is true," blah, blah, blah, blah, blah. And you, Dr.

[01:11:43] Hagens or Dr. Patzek, you are losing your credibility. And there's no way to overcome this. I'm, sorry, Nate. Yeah. I've tried. I really have for the last four years, and I can see, you know, a cement wall which is between you and the listener, and you will not overcome it.

[01:12:04] **Nate Hagens:** Yeah.

[01:12:05] **Tad Patzek:** So to a person who says that, you have to appeal to them, to their greed and to their fear, right?

[01:12:16] Because greed and fear are the two most powerful instincts that govern people. So fear is what climate change is gonna do to me. What will it do to my house insurance? Will I be able to in fact insure my house in Florida or in the forests of California or along the East Coast of the United States, and so on?

[01:12:42] Will I be able to withstand the next hurricane? Will I be able to withstand the next flooding at high tide and hurricane, water brought on land? Will I be able to drink water because my aquifer is getting contaminated with salt water from the rising sea level? Will the Everglades in Florida survive?

[01:13:06] If I have a major hurricane and the grid goes down, will I be able to live in the hot, humid weather where the bulb temperature approaches, let's say, 30 degrees centigrade and I'm barely able to survive? Okay, those things ... Or will I be able to drive away from the climate? Will I get gasoline? right, so the pump will

[01:13:29] Will p- will the pump be working, and so on. Will I be able to get my groceries? These are the kind of elementary things which appeal to people regardless of their other convictions and their statements, you're losing your credibility. So i- if I point out that parts of Texas will become hot desert, everybody will say

[01:13:52] Or not everybody. Many people will say, "Well, but right now it's really wet in Texas." And I will say, "Yeah, that's amplification of the subtropical jet stream ahead of El Niño. What you're getting is in fact moisture from the Pacific all the way to Texas. So right now be happy. It's wet. It's gonna get dry and hot soon enough."

[01:14:12] Okay? And so those discussions will never end. and what we have to do is chip away s- tiny step by tiny step and enable people like this to assemble seven pieces, 10 pieces, 20 pieces of the puzzle and say, "Huh, maybe he had a point."

[01:14:36] **Nate Hagens:** I do wanna give you some time, before we close to talk about some strategies.

[01:14:42] But let me ask you this as a scientist, and I don't wanna get political here– Mm-hmm ... though it's at times impossible to do that. But you and I live in the United States, which one could argue historically, had some of the best scientific instrumentation and websites and data and tracking of the planet, in many different spheres, including the oceans and climate, and that's slowly, with an acceleration, disappearing.

[01:15:19] **Tad Patzek:** Yes ...

[01:15:20] **Nate Hagens:** how do you see the global environmental, ecological Earth science, project continuing with the leader kind of receding?

[01:15:35] **Tad Patzek:** So you just mentioned the possibly largest tragedy in our understanding of climate, which is the shutting down of American satellite programs, or other m– measurement pro– programs, storage of data, and public access of the data.

[01:15:59] And I am also on the receiving end to see how the various struggling agencies, NOAA and NASA, USDA, are coping with, you know, essentially shutting down all their websites, making data very difficult to get. That's another one. Just make it difficult, most people will quit, right? and so other parties, most notably the European Union, are stepping in.

[01:16:31] And the European Union has a very large program in natural sciences and earth science called Copernicus. And Europe is launching more and more satellites which will replace some of the aging and not replaced American satellites such as Aqua and Terra with newer, smaller ones, but more of them. Okay? Japan is also stepping in.

[01:16:56] So is China. But again, and I would want to say Russia, but even though they're stepping in, availability of their data is extremely limited. Everything is so secret, thank you very much, in these countries. Although China is changing for the better, I must say. So the United States will simply be bypassed.

[01:17:19] Is actually being bypassed. And that's a real tragedy because we have been at the forefront, so much so that right now there's this huge disturbance through climate science because our data gathering capability is declining.

[01:17:34] **Nate Hagens:** More than climate science. Oh, yeah. Environmental science, right.

[01:17:39] **Tad Patzek:** Well, all sciences.

[01:17:41] **Nate Hagens:** Yeah.

[01:17:41] **Tad Patzek:** right. Except, the science of making better weapons, because that, will always see an increase of funding.

[01:17:49] **Nate Hagens:** And right there is, kind of an epitaph, potential epitaph for our species, if we cared about power and military more than our home. Yes. Correct. Yeah. So we covered a lot, Tad.

[01:18:05] this could have been a six-hour conversation to cover everything on climate, but I think it's a pretty good overview, and will you be able to share your preprint in our show notes? Absolutely. Okay.

[01:18:20] **Tad Patzek:** the preprint is in fact publicly available. Okay. And hopefully it will be reviewed and published.

[01:18:26] Yeah. Let's cross our fingers. And absolutely, yes, because it's a nine-page paper, so most people will be able to get through it.

[01:18:34] **Nate Hagens:** Is there calculus?

[01:18:36] **Tad Patzek:** no. It's-- no. It's hidden. But, there, there are figures.

[01:18:41] **Nate Hagens:** Okay. So given all this, what sort of actions do you think people can take that are, in effect, no regret strategies for better human futures, regardless of what happens with climate and the 100% or less than that certainty you have on some of these things?

[01:19:06] **Tad Patzek:** I would say get less distracted with irrelevant things which are jamming your head and your brain with irrelevant noise and focus on a few important things. Because that, you know, I do talk now that I lived close to my children and the young people in my milieu, so to speak. I can see how overwhelmed and distracted they are with the onslaught of bad news from everywhere-

[01:19:38] **Nate Hagens:** Yeah

[01:19:40] **Tad Patzek:** and, essentially giving up on their agency and ability to react.

[01:19:46] **Nate Hagens:** I'm seeing that too.

[01:19:47] **Tad Patzek:** So when it comes to the election, do move your butts from your chair, in front of the TV or whatever you watch and go and vote. Because how is it that at best we can count on two-thirds of all people who are empowered to vote actually voting and actually trying to change something?

[01:20:11] But before you vote, understand that we live in an enormously complex system. I just went through the midterm elections in California, and I spent hours studying the ballots and the various aspects. Most people don't do that. And oh,

and trying to learn w– who the candidates are, right? So democracy cannot work if you don't know what you're doing and you vote on the first name on the list.

[01:20:39] I'm sorry. So do a few things or ask others what they've done, and together come up with an answer. Okay? And so I'm not saying anymore just be happy and go, and you know, just try to remain happy. Try to be more active, but active in one direction with a vector, not in every direction, which then dissipates into noise and does nothing.

[01:21:04] **Nate Hagens:** That's good advice, that last bit, especially for me. So we're friends. I will have you back again on another topic. Just out of curiosity, is there anything in the climate system or in the Earth system that right now you are particularly curious about and are going to spend some of your energy and time researching and getting to the bottom of if you were to come back next year?

[01:21:36] What, are you especially curious about right now?

[01:21:38] **Tad Patzek:** So of the highest importance is the rate of heat absorption by the oceans and the possible impacts of that absorption of heat on ocean dynamics, on the oceanic currents and transport of heat between the equator and the mid latitudes. And then is albedo moving, the albedo changing moving more north or more south?

[01:22:05] Because it has very different aspects of climate, droughts and floods, for different important parts of the world Is the ice melting faster in Antarctica? Because if it is, then that is your sea level rise by several meters within decades. Is Greenland collapsing, in terms of the one kilometer or two kilometers of ice that it has in its interior?

[01:22:37] Because that's another three meters or whatever of sea level rise. How fast are the glaciers in the Himalayas melting? And what impacts does it have on

people in India and China and Laos and Vietnam and Cambodia and Bangladesh? Why is climate changing so much and so violently in Europe? I mean, Europe is subject to more and more violent climate change than the US right now.

[01:23:10] What's gonna happen to my home country, Poland, which is not rich in water, when it endures long droughts, deluges or violent rains? And so there's lots of questions I'm gonna be asking.

[01:23:27] **Nate Hagens:** Yeah. Good. Keep researching, my friend. You are a machine when it comes to cranking out papers and books and graphs.

[01:23:36] I've never been able to comprehend how productive you are. Thank you for your time today and your continued, Earth systems research. Do you have any closing comments, for people?

[01:23:50] **Tad Patzek:** Yes. Thank you, Nate. and thank you for your hard work in making many of these things happen, and, because without you, things have be- would've been even worse.

[01:24:04] So you are, in fact, in many ways, a focal point for many people like me to actually share their knowledge with many people out there.

[01:24:15] **Nate Hagens:** Thank you. To be continued, my friend.

[01:24:18] **Tad Patzek:** All right.

[01:24:18] **Nate Hagens:** Take

[01:24:19] **Tad Patzek:** care. All right. Bye-bye.

[01:24:22] **Nate Hagens:** If you'd like to learn more about this episode, please visit thegreatsimplification.com for references and show notes.

[01:24:30] From there, you can also join our Hilo community and subscribe to our Substack newsletter. This show is hosted by me, Nate Hagens, edited by No Troublemakers Media, and produced by Misty Stinnett and Lizzy Sirianni. Our production team also includes Leslie Batt-Lutz, Brady Heyen, Julia Maxwell, Gabriella Sleiman, and Grace Brunfelt.

[01:24:53] Thank you for listening, and we'll see you on the next episode