Notes on Cloud Time

Architectural design and educator ***V. Mitch McEwen*** *and climate scientist* ***Nadir Jeevanjee*** *met online on April 8th to talk about clouds and how they might alter our ideas of time or present another model of time.*

V. Mitch McEwen: No coordinate system is positivistic on its own terms right? You have something very abstract. Then what actually matters [to produce simultaneity] is the intersection. It has to be that something mattered to something else.

Nadir Jeevanjee: Yeah and then I'm just thinking about sort of the arbitrariness of some of these things [coordinate systems]. You know it's the intersection that's meaningful, you know.

You know just the fact that even I mean, how do we reckon years right? It's zero at BC right, birth of Christ was meaningful for a certain part of the world, and so that becomes you know the intersection point relative to which you measure things.

It is the intersection of events that makes coordinates meaningful.

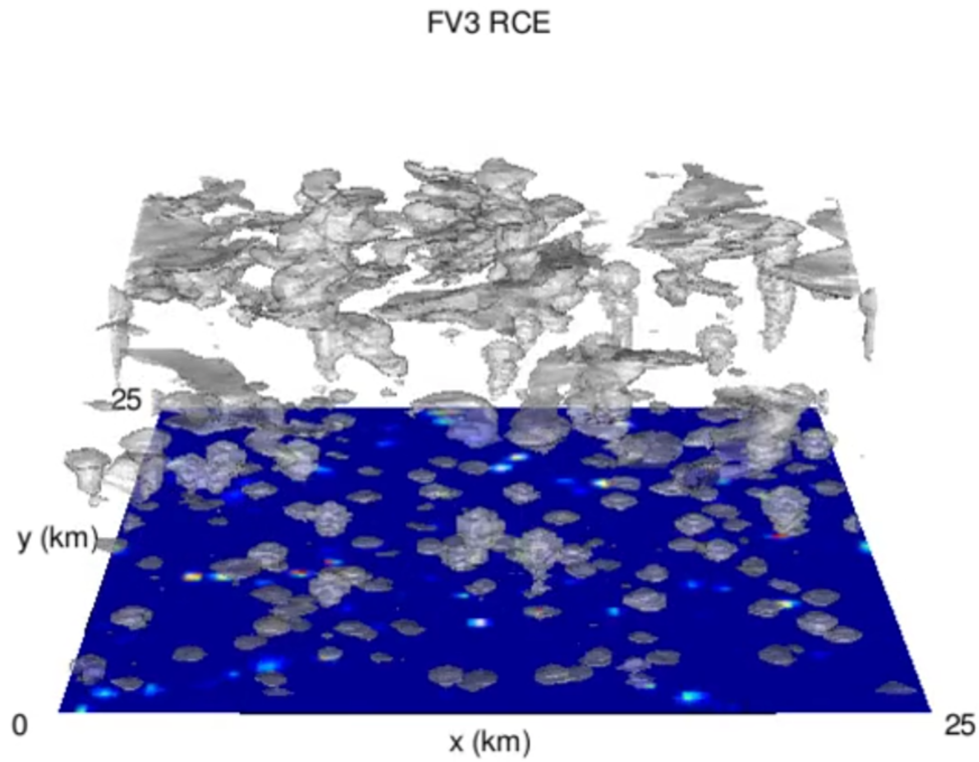
VMM: Hmm and not the other way around, yeah yeah.

NJ: Exactly, and you can forget that, but if you kind of step back and think about it, then you'll find that in every instance.

VMM: So i'm looking at the notes that I have. And I really like this quote: "The single cloud on the left, should be thought of as compressing multiple convective blooms which may not be spatially contiguous but which all have the same thermodynamic properties, at a given height."

So that's where you make the shift from sort of vertical space to temperature coordinates for the cloud, which gives you another way to think what constitutes a cloud, a single cloud. Right? But it's all its kind of equilibrium space?

NJ: Yeah so actually there's two separate things there. One: a conceptual shift. What I'll do is i'll send you a video like an animation from my website. Okay. So if you watch this movie. It's sort of an idealization of the tropical atmosphere.



http://nadirjeevanjee.com/movies.html

NJ: It's a patch of ocean surface.

VMM: On the surface.

NJ: The colors on the bottom that are kind of flashing in and out the shades of blue.

VMM: yeah.

NJ: Those tell you how much rain is falling at those locations on the patch of ocean.

And of course underneath these clouds are rising. You've got this population of clouds.

Well, all these clouds you know they're all– if I sort of sample them at the same height when they're rising up I say: Okay, when the cloud is five kilometers high, let me take a slice through it and look at its moisture and conversation, and all that.

And you know, statistically there'll be some variations between the different clouds that you see here but there'll be a lot of similarities. And so what this conceptual picture that you're referring to this cartoon does it says all right– let's just think of all those clouds as really just being one entity.

VMM: yeah yeah yeah yeah.

NJ: –with more or less the same properties at any given height.

In reality there's actually 15 of them, you know in this little patch and they're not all happening at the same time and they're spread out in.

VMM: …space.

But it's actually useful to just collapse them.

NJ: …into one. I know, in a kind of statistical average.

Now okay so that's one simplification or–

VMM: …individuation. yeah okay.

NJ: yep yeah exactly, and so, so this process of collapsing them, so what we call the resulting kind of single cloud we call that a bulk flume.

VMM: Oh yeah, that's the name. Okay.

NJ: So that's one step. Now you read this bulk plume that we imagine this sort of instead of like these individual clouds that are in constantly you know rising and falling in and being birthed and dying, we think of this bulk plume, as you know, kind of always existing.

The clouds viewed in bulk do always exist– individual members are born and die but cloudiness itself, through time exists in kind of a steady way. Bulk plume is always there, it has these steady properties.

But now you can ask yourself: What coordinates do I want to use to describe these properties?

VMM: Yes.

NJ: Properties change as you go up and down. And, and now you're confronted with this arbitrariness of coordinates. I could, I could just like take a meter stick– Measure, like, random space between two marks on a bar of lead. In whatever it is, in Paris.

VMM: Right right right.

NJ: So I can do that. I could use pressure– that's another coordinate that people use um but it turns out, actually, that what the cloud itself cares about...

You know you could draw an analogy between what the cloud cares about, in terms of its physics, and what humans care about right in terms of what matters to them. What the cloud cares about, in terms of its physics, is mostly the temperature.

Temperature determines how much moisture you have. When it is very cold you just have to be very dry. That's a sort of fundamental aspect of the atmosphere.

VMM: Right.

NJ: And so, as the cloud rises, it has to condense out its moisture. You know from–

VMM: –The raindrop being a little bit of condensed sunshine, I like that from your lecture to yeah.

NJ: And so, and it's really the temperature drop, as you go up because, as you move up you know I mean. The temperatures drop extremely fast right this it's 20 degrees Fahrenheit for every kilometer you go up.

NJ: And when you go in airplanes, check this. You know, you have your own personal screen, the most boring screen you can get to is like the flight statistics.

VMM: Yeah.

NJ: And it tells you your altitude, you know, whatever 40,000 feet, but the temperature is like minus 50 Celsius or–

VMM: yeah.

NJ: We're talking, you know minus 80 or minus 100 Fahrenheit.

VMM: Right right okay.

NJ: Just just like way way, way below freezing you know colder than colder than the Antarctic winter.

VMM: Well okay.

NJ: So the point is that there's this big temperature drop, as you go up. And that temperature drop is what affects clouds behavior the most– more than the pressure. Clouds have no idea how high in the air they are. Don't know 1000 kilometers– They don't know where the ground is they don't–

VMM: Right right.

NJ: So anyway, so the temperature ends up being the most useful coordinate because it's The thing that clouds care about.

VMM: I like looking at your equations on that because it becomes so clear when you just start going with the T. Capital T. Why temperature matters, so much so much of it, like in your calculations is about equilibrium.

And it makes sense right because thermodynamics it's like conserving energy, and all this um and then, the place where it seems like you acknowledge that the system might break equilibrium– because you're already talking about climate change, the whole time is like, then, where the atmosphere gets deeper.

I want you to talk about that because, within the physics models, it's hard to relate that to human experience or human consciousness, because it's like we have no equilibrium right like we're always out of equilibrium.   Like who knows where consciousness is going to go at a collective level, or evolutionary level, or our own personal experiences at any minute>

So, within your ability to model even at that formal level model, the atmosphere itself getting deeper. There seems like a way that even the equilibrium can acknowledge something beyond itself. So, can you just explain what that is?

NJ: Yes, I think there's there's two ideas here.

This is really fun. Some of these like very fundamental ideas that we kind of use in the background, every day, just have such you know built in assumptions.

So there's right, so you know as with you know sort of humans in the human condition there's there's many different interacting components in the physical system and.

The point is, is that I think: Equilibrium is never instantaneous. It always takes a certain amount of time. For one piece to come into equilibrium with another piece.

But the point is is that some of those timescales can be really short compared to others.

So so One example is so i'll give a couple examples, so one is the cloud moves up expands cools down i'm going to cools down. Some of us water vapor wants to condense on the cloud drops.

VMM: cloud drops.

NJ: Yeah so basically when it's too cold right, I mean, so you know this from your own breath right you breathe out. That water vapor wants to condense and that's why you can, and it makes a little fog right that's where you can see your breath.

VMM: Okay.

NJ: Okay, so. So those Those are just tiny little cloud drops. In your breath that you see.

VMM: Okay okay.

NJ: Because because water vapor itself is invisible, so if you're seeing drops–

VMM: Okay okay.

NJ: – um and so right to that process of the invisible vapor molecules which are always around, kind of coagulated into tiny, tiny drops that, then you can see as a cloud or as your breath or as steam from a part.

That takes time, but it actually takes a really small amount of time, you know, like on the order of you know, is fractions of a second for those thermodynamics. The molecules say: oh it's too cold, for us to be in equilibrium is vapor so we have to condense.

VMM: got it okay okay.

NJ: So that happens super fast. Um and so on sort of timescales now if you're a human observer and you're watching the air rise up and the air actually takes a 20 minutes to rise up and move through the atmosphere.

Well then, that that condensation of the water of the of the of the vapor to droplets you can view that as essentially instantaneous. You can say the cloud air is always in equilibrium.

VMM: Okay.

NJ: You know, because it happens so fast that from the from our viewpoint of a longer process. Yeah we can think of it as instantaneous.

So what we think of as equilibrium is always relative to some longer timescale. Or what we're talking about isn't equilibrium.

VMM: Because it involves change, I mean right, you need something to change in order to reach equilibrium okay yeah.

NJ: So um so with the temperature coordinate the atmosphere The point is, is that, and I think you highlighted the fact that there's these two timescales of global warming right the time over which the the surface ocean adjust.

VMM: And that's many years. For the deep ocean, that's 600 years.

NJ: I mean it's mind blowing right the things that we're doing now will have ramifications for hundreds of years.

VMM: Even if we get to you in the 1.5 Celsius in 600 years, like the planet and humans and other species are still fucked?

NJ: They're not– I mean, that's actually not quite true. The temperatures will stay flat, which is why the UN has set this target, so–

VMM: The UN knows what you're doing? Okay, thank you.

NJ: UN reads all the senior scientists from my lab and every other lab and you know–

VMM: Okay, great great great okay.

NJ: Okay, so right so there's these two timescales over which just the ocean warms. So the surface ocean will warm you know, on the order of a handful of years. Okay well, just for the sake of conceptualization, let's say that we just instantly dumped a bunch of CO_2 into the atmosphere. So, not the gradual thing that we're doing where we're constantly admitting.

As a thought experiment let's just say we instantly double the amount of CO_2 in the atmosphere.

So, all of a sudden there's a bunch of heat trapped and that's going to start warming the ocean.

Now it turns out that that surface ocean in the span of say five to 10 years is going to warm up and then it's going to come into a kind of what we call quasi-equilibrium, which means that the temperature is going to get–

VMM: Steady. Okay.

NJ: But that steadiness if you watch the ocean over 500 years you'd see that it would gradually be getting warmer.
VMM: I don't know if it's an analogy, or if we're just talking about how complex systems work but, like the way that the ocean has this quasi-equilibrium, with the mixed layer and the deep ocean– I was thinking about that as a model of presence. It's kind of like part of the assumption for clock time, for this kind of colonial framework, is that when I show up on time I'm fully

present. But I might not be. I might still be thinking about you know, my partner who has brain surgery, you know it might take me an hour to be fully be present in something.

You know, or I might be on my phone half the time or I might be feeling terrible you know what I mean. There's like different models of present.

I think in the ocean– and this comes up in equilibrium here, but I think i'm interested in where does a model acknowledge this atmospheric shift. You're walking us through right now with like the doubling of CO2.

And where does that change other models?

NJ: yeah totally that's right, I mean you're kind of you're putting this added to next to the surface ocean and, as soon as you do, they're feeling each other, but they haven't had time to adjust and react to each other. There is an inherent timescale, a map for that to happen.

So the CO2 and the surface are coming to a quasi equilibrium in a handful of years.

And, and then what happens is that the surface is sort of caught between the CO2 up high and the deep ocean down low. And it's warmed up. And shedding energy to both and it comes into a little bit of a steady state. But that steady state itself will slowly change as the deep ocean starts to warm.

VMM: The steady state will slowly change.

NJ: As the deep ocean starts to warm.

VMM: Deep ocean.

NJ: And so, and as the deep very slowly shifts, the surface ocean will shift with it a little bit. But that happens on a much longer time scale. It's like there's this fast adjustment which kind of comes into like a quasi steady state.

VMM: yeah.

NJ: But then that steady state itself will slowly shift with time and–

VMM: What is the distinction between steady state and equilibrium in your work? Are they different equations, or the equations bring together the steady state? Like when you go to the capital T when you move to this temperature coordinate system you're modeling that in equilibrium, or in the steady state?

You know you have this graph that shows, like the graph itself getting this deep.

The coordinates that we're looking at on your graph are also spatial like are we talking about the deep ocean like it's not just showing that the deep Ocean is what absorbs it's extra heat or in thought that there was something more abstract happening in that graph.

NJ: A cartoon that shows the mix layer in the deep Ocean and the energy transfers between them.

VMM: The atmospheric change of climate change, shows up.

NJ: All right, so let's say that the surface ocean has warmed right in response to CO_2.

NJ: Right, and so you've got this sort of this fast part of the global warming has happened. So you know you have a temperature change, and the question is now, how do you want to describe that– what coordinates do you want to use to describe it.

So what people often do is they say okay well, let me use pressure as a coordinate. Okay, in the atmosphere and then they say okay well at each pressure level it's gotten warmer.

VMM: Okay.

NJ: And furthermore, the troposphere – the part of the atmosphere that has weather and clouds–

VMM: mm hmm.

NJ: If you're in pressure coordinates, from pressure coordinates in the bottom, the atmosphere stays fixed at the surface pressure and then the top of the troposphere, the part of the atmosphere that has weather– that's going to move to a lower pressure.

That's just something that we find.

VMM: A lot of pressure.

NJ: The depth of the atmosphere of the troposphere expands, so the part of the atmosphere that has weather is deepening. So, so it happened, it turns out that it deepens, no matter how you slice it. So in these older coordinates of your global warming, the troposphere deepens at the top, when the temperature rises up.

VMM: I guess part of what I'm getting from this temperature model is that there's always multiple times, even within the time of the deep ocean, there's these quasi and steady states emerge because there is a need, even at the level of the formula, to accommodate for these multiple versions of what is instantaneous or not.

NJ: Exactly exactly.

VMM: And I guess I guess part of, then what that might mean for us when we think about time, as far as what kind of time– So many things open up. One is like a model of the world that needs to be water. For everything about "the world" it seems we need to think about it as watery

Today, we're now thinking about the planet as not just human but the troposphere, as you're calling it, is always multiple species. Even if we're just talking about consciousness like we're already talking about multiple steady states of consciousness, if we're going to think about different species inhabiting it right. Like my cat knows that it's dinner time if I feed him at the same time, every day. He knows if it's a machine making a sound, or me feeding him.

What if we just take this cloud time as something that we might be able to access in a planetary way?

The other thing that we haven't talked about– temperature. I feel like we need to talk about it more. What is temperature even? A kind of energy, I think? There is another thing that I took a note about that I want to understand, which is the flux divergence. What does that flux divergence mean?

NJ: That is just when energy is either deposited somewhere or escaping somewhere, so it just means that energy is converging or diverging flux. It's just a flow event– literally flux, is the flow of energy.

In this case, it's thermal infrared energy, so thermal infrared light. Because anything that has a temperature emits infrared light. That's how night vision goggles work. The definition of a greenhouse gas molecule is that it absorbs and emits this thermal infrared light.

NJ: So, you have so all around us right now in the atmosphere in the room there's these fluxes of thermal infrared energy. And, and they're just traveling through space. And if you had the right detector you would see them you could take an infrared camera and, if you look through it, you would see these fluxes of infrared light. There's a ton of it coming from the sun as well, and the point is that if any region of space that fluxes converging then it's going to heat that whatever's there is going to heat up and if the flux is diverging then it's going to cool down.

And so the way the atmosphere works is that when a raindrop condenses it releases that sunshine that's stored in it.

VMM: mm hmm.

NJ: And then you have a divergence, then the greenhouse gas molecules there cause a divergence of this infrared flux, they are sending out infrared energy to space. The flux is diverging and so that energy that came from the raindrop is now leaving.

The energy that comes from the raindrop gets sent out to space as infrared light.

And that's that's this, that's exactly this cartoon.

The water molecules condense– they release their heat. That's what these red squiggles are.

Then these greenhouse gas molecules here send this energy out to space.

Essentially, a flux divergence is thermal infrared energy leaving the atmosphere and heading out to space.

So this is the flux divergence here.

VMM: Which is–

NJ: sending this energy outwards.

VMM: So it's almost like– if cloud time were something that we could access we would also need to be able to let it not be accessed. It would be kind of like not this mechanical time we can always tap into that is always going to be there. But like it would be a multiple temporality that would we would we would have to participate in at some kind of energy level.

Whether that's a feeling energy or physically some kind of energy level, you know we have to kind of tap into it, but then also it would let ourselves be divergent in it as well. Greenwich Mean Time reminds me of electricity and other kinds of energy infrastructures. Electricity has taken over our sense of how things work– like they always need to be able to turn on. That's a kind of late 19th century idea, that things should always turn it on.

But cloud time would disrupt that kind of electrical aspect also. If we could tap into quantum effects that could be measurable or real in the sense of that thing impacts this thing, butit also would need to be measurable in a divergent way.

NJ: Yeah and, if I understand what you're saying it's you know this, you know this flux, is a flow. And if you could, if you had a way of interacting with the flow, then you would measure time that way right because you would just know.

You know how much has flowed past you or through you, in whatever way you're able to do that right would be a measure of how much time has passed.

Right in the same way that if there's some flow of water, and you can count on that flow is being steady, then you could measure time in buckets right like.

VMM: You know.

NJ: Like all right i'll catch you back here, you know one bucket from now.

You know, similarly there's a flow of energy through the system which is depicted in this diagram you know, and if there was a way of interacting with it, you know that that would be a way of measuring time.

Because, because this flow of energy is just energy per unit time. Climate climate is just how does energy flow through the system with time.

And one thing we see in the climate system is that you know when things are coupled to each other when you have the atmosphere coupled to the surface ocean, coupled to the deep ocean– You get these modes of variability, that there's always things sloshing back and forth and shaking things up.

VMM: Very cool I think I think that's a good place to start to wind down um I think one of the things that I want to take away, is that the surface is not just a means of accessing the deep, but it has its own kind of fuzzy and steady state, and you know and that there's a way that we might think about how time might be surface time. Maybe surface time also does a kind of work.

It may be part of the way of dealing with these legacy systems. They are a kind way that we're organizing ourselves, but that maybe maybe it's surface. Maybe part of the work to be done is to really start to model other deep layers or other more kind of atmospheric layers of a time.

Not to do that old thing of we're demolishing this because we're proclaiming it's a new world that we discovered. No, this GMT time is happening, but maybe it's all just surface and maybe there's other other ways to create coordinates amongst each other.

So yay i'm excited about that.