WEBVTT

1 00:03:49.110 --> 00:04:13.289 Kai Chen: International fear, energy

2 00:04:13.290 --> 00:04:43.020 Kai Chen: and her research uses, computational models, many others. She's also recently published the Fifth National Climate Assessment, and some from

3 00:04:43.020 --> 00:04:44.569 Kai Chen: the process.

4 00:04:48.470 --> 00:05:09.620 Kai Chen: It's nice to meet you all, and it's wonderful to be here, so, as you can tell from the introduction at the time of my talk, I'll be talking a lot about modeling in the next 50 min or so. But before I talk about the models, I want to start with something more personal since I grew up in China, and I guess some of you did probably as well. I wanna start with this question.

5 00:05:09.800 --> 00:05:13.149 Kai Chen: which is, what was China like 40 years ago.

6 00:05:13.900 --> 00:05:40.789 Kai Chen: Most of you probably don't remember me, neither. I wasn't even born. Do remember, I grew up in a city called Changsha, in Southern China, and about 20 years ago we got our first international terminal so that people in my province could travel internationally. About 10 years ago we got our first train station for high speed trains, and about 5 years ago we got our first metro line robbing the city. Now we have 5 of them.

7 00:05:40.910 --> 00:05:46.050 Kai Chen: and Changsha is only a second tier city in China. If you're looking at a larger city.

8 00:05:46.620 --> 00:05:50.000 Kai Chen: That was Shanghai in the 1950 S. And Shanghai today.

9 00:05:50.130 --> 00:06:01.639 Kai Chen: so you can see that the past 30 or 40 years has been really transformational for China. And this is really the story behind it. This is really the background for any story to tell about China.

10 00:06:01.770 --> 00:06:03.490 Kai Chen: Not just rocking case.

11 00:06:04.070 --> 00:06:17.259 Kai Chen: So arguably, China be is the world's worst polluter. Now we get some competitors like India. But China has been the global top couple for a long time. Air pollution has been very severe with a lot of health damages.

12 00:06:17.270 --> 00:06:29.400 Kai Chen: So really, looking behind this economic miracle on the one hand, and also the growing thing. On the other hand. energy that is back for us driving all this.

13 00:06:29.450 --> 00:06:42.490 Kai Chen: So, looking at how the emissions has been going up over the past 40 30 years. You could also see that the energy

consumption is, on the one hand, driving the economic miracle. On the other hand, leading to a lot of environmental problems

14 00:06:43.720 --> 00:06:56.050 Kai Chen: houses in the past. What we need to think more about is the future. So what would China be like? What do you use from now? But this question I'm sure nobody knows.

15 00:06:56.110 --> 00:07:02.539 Kai Chen: but we do know the direction, because the country has pledged to reach carbon neutrality by 2060.

16 00:07:02.690 --> 00:07:11.379 Kai Chen: Looking at how the initial has been going up in the past 4 decades, the country will need to completely reverse that trajectory in the next 40 years.

17 00:07:11.500 --> 00:07:33.309 Kai Chen: and, in fact, China is not the only country in this race to net 0. United States and EU. Both has fled to reach net 0 emissions by 2,050 India pledged to reach net 0 by 2070, and we also have more than 100 countries, and now either have flat or are considering a net 0 target around that mix entry.

18 00:07:34.030 --> 00:07:47.100 Kai Chen: So I'm sure this is the question you have in mind how we get there. Unfortunately, I don't have a superpower to bridge the future. So as a modeler. this is a question that we're more capable of answering.

19 00:07:47.360 --> 00:07:48.769 Kai Chen: How can we get there?

20 00:07:49.340 --> 00:08:10.370 Kai Chen: So this is why energy models have been used widely to understand how, if we just go for the existing policy and we contract better curve. And clearly, we're not so. Models have been also useful to really thinking about what are the additional effort that we needed if we really want to achieve climate decarbonization.

21 00:08:11.010 --> 00:08:23.210 Kai Chen: But looking at this figure, I'm sure you're not not very like all familiar with this figure. For some reason this probably cannot see it. But this is from the Ipcc report. Looking at this, what is the problem?

22 00:08:23.510 --> 00:08:24.849 Kai Chen: In my view.

23 00:08:24.980 --> 00:08:39.759 Kai Chen: the problem here is that all this models are so heavily sending around technology. So if you really looking at the model, it's all about technology competing with each other. We don't have any human face. We don't have any like company faith in a model.

24 00:08:39.919 --> 00:08:42.300 Kai Chen: and that leads to results like this.

25 00:08:42.419 --> 00:08:58.390 Kai Chen: Here is one representative scenario from Ipcc. Report how we can get to the 1.5 gb, so you can see that the model tells us that we need to quickly face down, even phase out fossil fuel, and at the same time quickly scale up on renewables.

26 00:08:58.740 --> 00:09:13.150 Kai Chen: So once we start to move away thinking about just the technology to really thinking about, what does it mean for human and what? And once we start to thinking about this humans, then to transition, there will be new set of questions occur

27 00:09:13.290 --> 00:09:20.420 Kai Chen: first of all, even how dependent we are. Our thoughts of feel today can be really based on fossil fuel that quickly

28 00:09:20.500 --> 00:09:50.210 Kai Chen: and given all of the infrastructure and behavioral inertia around new technology. Can we really scale up renewable and quickly on top of that? If you imagine that net 0 world where we're not going to use fossil fuel anymore. That's going to fundamentally change the way we use energy the way we drive the way we get heating and cooking. And also too many people the jobs of livelihood. So then the question becomes, what does it mean to people, real people? Let us

29 00:09:50.700 --> 00:09:57.020 Kai Chen: who will go who are going to experience this Nazi transition, together with the technologies.

30 00:09:58.340 --> 00:10:05.630 Kai Chen: And in fact, once you started thinking about the human impact, you find that energy is really at the center of sustainability.

31 00:10:05.900 --> 00:10:24.389 Kai Chen: So energy is the way we use energy is not only the major cost of why we have so many great health gases and having this climate problem. It's also the fundamental cause for the air pollution problems and also a lot of related health damages. And there's equity implications embedded in the way we use energy

32 00:10:24.590 --> 00:10:31.559 Kai Chen: on top of that. climate change is the long-term issue, or as a lot of the other issues that near term.

33 00:10:31.710 --> 00:10:39.829 Kai Chen: And to most people worries about global warming is still less pressing than words of their health and the help of the family.

34 00:10:40.260 --> 00:10:42.540 Kai Chen: So then the question becomes.

35 00:10:42.790 --> 00:10:52.809 Kai Chen: can we incorporate? And also, how can we incorporate their quality and health considerations into our energy strategy targeting Netzero?

36 00:10:53.090 --> 00:11:01.480 Kai Chen: And this is really the overarching research question for a lot of work in my research group and also going to be the overarching research question for my talk today.

37 00:11:02.470 --> 00:11:13.040 Kai Chen: So over the past few years, I'm leading this project called the health effects of deep decarbonization. Where we really put together an interdisciplinary team of

38 00:11:13.040 --> 00:11:33.829 Kai Chen: energy system modelers, air quality modelers, epidemiologists, most of decision scientists and putting together a,

a, a role of discipline, trying to understand what are the driving factors to determine the future health and air quality impact from from energy transition. So we see this. But we're going to let me see if I can keep that

39 00:11:34.750 --> 00:11:46.680 Kai Chen: really, anyway, this is the hard new project website, because I recently moved from Penn State to Princeton University, our new project was website will be launched on sometime soon.

40 00:11:48.380 --> 00:11:49.210 Kai Chen: Thank you.

41 00:11:49.410 --> 00:11:57.110 Kai Chen: Okay, so very briefly, what are the fundamental methodological advancement our group would like to tackle.

42 00:11:57.140 --> 00:12:21.499 Kai Chen: So we really focus on energy decarbonization. But we really try hard to couple to kind of analytical frameworks. One is energy modeling. Like, if we really remember the figure I showed you earlier. If we really want to get net 0, what kind of energy transformation and the required technology of deployment would be needed with impact assessment. Where I think the real expert is actually in the in the room today

43 00:12:21.850 --> 00:12:23.080 Kai Chen: was that

44 00:12:23.550 --> 00:12:52.480 Kai Chen: I wanna talk briefly about what is energy modeling. And because if you're really thinking about energy modeling is a very broad rather term where you describe different computational models to understand system transition in energy space. And a lot of our work is focusing on one type of particular energy modeling tools which is called integrate assessment models. In case you're not familiar with this kind of model, I have one slide to quickly give you a high level overview of what this model is all about.

45 00:12:53.010 --> 00:13:12.059 Kai Chen: So this kind of models usually start with exogenous assumptions about Gdp population policy targets, other technology and social economic assumptions. And then all those exogenous assumptions are going to go into a core model where a system of systems are going to be model.

46 00:13:12.060 --> 00:13:36.429 Kai Chen: So, for example, in order to fuel the future economic growth, we need to thinking about how much energy demand will be needed. And in order to meet the energy demand, we need to thinking about what kind of technology portfolio that will be deployed to meet that demand. And because the way we have our energy demand and meet our energy demand using supply that will have implications on not only the

47 00:13:36.430 --> 00:13:50.150 Kai Chen: emissions determine the lab climate feature, but also the land requirement. Is that right? So you can see that here. I use a lot of 2 way out, because that's really what the integrated model hope to capture.

48 00:13:50.150 --> 00:14:14.390 Kai Chen: Just take one as an example, energy, and climate. So the way we use energy will largely change the field emissions.

As a result, the climate future. But, on the other hand, if we end up having a warmer future, then this going to increase our cooling demand during the summer time, and decreasing our heating demand during the winter time, and that will also link back from climate to our energy use.

49 00:14:14.770 --> 00:14:26.139 Kai Chen: So, in short, the cool model over there is really trying to capture that dynamics and interactions across different systems so that we can have a holistic understanding of the system interactions

50 00:14:27.050 --> 00:14:36.860 Kai Chen: coming out of the model. The output usually include economic cost, energy pathways, emissions associated with that land use, requirement, etc.

51 00:14:37.200 --> 00:14:44.490 Kai Chen: So this is a quick overview of what is, I am into good assessment model. And because I'm giving this talk at Yale.

52 00:14:44.600 --> 00:14:46.729 Kai Chen: I think this slide is very important.

53 00:14:46.880 --> 00:15:22.410 Kai Chen: So take any component as an example, just energy. You are actually 2 ways. You can characterize the system. The first way is that I use a very highly stylized representation using one equation as an example to characterize at the styleized level. If we change the the demand, how the energy system will respond, and what are the implications like emissions? And, in fact, the dice model developed by Bill Moorehouse here on this campus is in that category is what we call highly stylized IM or benefit cost. I am.

54 00:15:22.610 --> 00:15:25.659 Kai Chen: That is not the type of model I'll be talking about today.

55 00:15:25.900 --> 00:15:36.650 Kai Chen: The type of model I'll be talking about today is what we call the detailed product. I am where the goal here is really to have a fine grain representation of

56 00:15:37.370 --> 00:15:39.259 Kai Chen: the whole technology system.

57 00:15:39.640 --> 00:15:51.270 Kai Chen: So, for example, how the primary energy is going to go through this complex processing and conversion of energy carriers. As a result, meeting our web and use demand.

58 00:15:51.290 --> 00:16:13.800 Kai Chen: So in a detailed process, I am that I will show some results later. What we really hope to capture is to is to capture those physical flows in order to meet the energy supply and demand, and also in each of this process you can have many different technologies, wing Solar Co and the type of co-power plants all competing to meet the demand.

59 00:16:13.800 --> 00:16:26.860 Kai Chen: So it is those fine grain representation of the technology system that really makes this useful and important and possible actually to capture the down screen, their quality and health implications.

60 00:16:27.560 --> 00:16:28.290 Kai Chen: Okay.

61 00:16:28.680 --> 00:16:31.289 Kai Chen: I'll be back there. I'm aya. Okay?

62 00:16:32.180 --> 00:16:33.080 Kai Chen: So

63 00:16:33.820 --> 00:16:45.800 Kai Chen: wanna just talk. Briefly, using 2 slides about what I see at the key challenges to couple. I am, what is their quality and health impact assessment. So first of all.

64 00:16:46.250 --> 00:16:52.640 Kai Chen: one key challenge is that I am. I'm generally too coarse and don't have the right variables.

65 00:16:52.800 --> 00:17:22.259 Kai Chen: So if you thinking about what Ims can really get out from the model. By the way, in case I didn't mention that I am so used widely in the Ipcc report and also in the national climate assessment that I was contributing to. So this is really kind of like the underlying model that have been driving a lot of like technology debate, even policy debate around decarbonization. So it is a powerful tool, on the one hand. But, on the other hand, we also need to be very careful about what it can do and cannot do.

66 00:17:22.460 --> 00:17:36.150 Kai Chen: So that's really what I hope to achieve here, which is this is the direct output from the I am. But this is really the type of measures we need to have. Once we start thinking about a human impact. Okay.

67 00:17:36.460 --> 00:17:39.809 Kai Chen: from the I am usually only have the global mean temperature.

68 00:17:40.040 --> 00:17:51.819 Kai Chen: But we really care about is local meteorology and climate advantages and also fine skill, representation of heat, exposure, and exposure to natural disasters. Client doesn't have that.

69 00:17:52.110 --> 00:18:03.179 Kai Chen: The second thing second example here is that I am usually give you regional airflow admissions. But if you're really thinking about what we care about at the end of day is low Co pollution, exposure and health impact.

70 00:18:03.250 --> 00:18:04.849 Kai Chen: It doesn't have that either.

71 00:18:04.940 --> 00:18:28.290 Kai Chen: Here's one last example. I am usually can tell you the regional mitigation costs like technology system deployment cost in order to achieve certain mitigation goals. But ultimately nobody really care about the meeting. Aggregate cost is really about the winners and losers and the distribution of the cost that matter in terms of to shape the policy feasibility and the implementation outcomes.

72 00:18:28.290 --> 00:18:44.599 Kai Chen: So to me, that's the first challenge we face, where we have a set of very cool tool being used by the International and National Decision Maker. But at the same time there's a gap between what the models can tell and what we really care about at a living human thing.

73 00:18:45.180 --> 00:18:53.799 Kai Chen: Here's another challenge. In my view, which is, there's that there's very complex relationships between action

and impact.

74 00:18:54.040 --> 00:19:07.110 Kai Chen: So we know that if you're really thinking about global climate, it alternative response to cumulative emissions. As a result, it is determined by the aggregate actions and local, state and national scale.

75 00:19:07.390 --> 00:19:11.459 Kai Chen: But, on the other hand, on the other hand, if you're thinking about the local impact.

76 00:19:11.600 --> 00:19:36.230 Kai Chen: for example, the pollution impact we have here in New Haven is not only determined by what New Haven is doing to eliminate emissions, it also has something to do with what Connecticut is doing as a whole, and how the northeastern region are doing to reduce emissions because ultimately air pollution, the regional problem because of the wind transport. On top of that, the global climate would also matter because we end up having a different climate future

77 00:19:36.230 --> 00:19:42.580 Kai Chen: that would really influence the future temperature patterns. We've got precipitation, pattern, wing pattern, etc.

78 00:19:42.580 --> 00:19:52.150 Kai Chen: Those are the permanent physical determinants of the future pollution level. So, in other words, our local impacts are also affected by this multi-level decisions.

79 00:19:52.400 --> 00:20:05.009 Kai Chen: So once you have this like high level dial web in in line. You already realize that, hey? There's a complex mismatch or match between the actions and the impact.

80 00:20:05.070 --> 00:20:26.019 Kai Chen: And, to make it worse. A lot of the problem we face in this in this phase is that we need to make decisions today, knowing that the impact will last for decades. And that's because that's because energy infrastructure, on the one hand, has very long time. So we have to thinking about. Once you put down a power plant what will happen in the next 30 years?

81 00:20:26.020 --> 00:20:42.080 Kai Chen: On. On the other hand, we will also see co-evolution of the social demographic system, like migration, like urbanization. All those future uncertainty in the technology, in energy and social economic space will collect. You make this picture

82 00:20:42.080 --> 00:20:43.370 Kai Chen: even more complex.

83 00:20:43.580 --> 00:20:59.440 Kai Chen: So in other words, this is another challenge, in my view, to to really thinking about the impact from decarbonization, that we really need to improve our understanding and the capability of characterizing that complexity of the cost effect chain.

84 00:21:00.980 --> 00:21:17.290 Kai Chen: So I hope by now you'll convince that this is a typical problem, so we need to spend time on it. What I want

to do today is to quickly go through 3 examples where we try to improve our modeling capability to answer those decision, relevant questions.

85 00:21:17.510 --> 00:21:41.680 Kai Chen: The first example I'm going to give. It's around effects of global mitigation on regional air quality and health. Then we want to build on that first project, start to thinking about uncertain future uncertainty. So we can identify under what conditions we're going to see more robust current quality effects comparing with, like some of the conditions where we may see more divergence results.

86 00:21:41.900 --> 00:22:04.910 Kai Chen: And finally, we don't only care about global climate mitigation. We also care about that interaction between global and regional action. So the third example is about the effects of domestic and global decarbonization on exposure disparities across the Us. So this will allow us to start to thinking about some of the distributional consequences and the equitable policies, I think.

87 00:22:04.980 --> 00:22:11.519 Kai Chen: Let me pause and add any questions so far about those like overview. I was providing just now.

88 00:22:13.510 --> 00:22:19.009 Kai Chen: Okay, so now I want to go to go through each example fairly quickly.

89 00:22:19.270 --> 00:22:20.300 Kai Chen: So

90 00:22:20.860 --> 00:22:33.969 Kai Chen: the first example is about the effects of global climate mitigation on regional air, quality and health. Remember, I mentioned just now what I am can do and cannot do, what I, highlighting great here at what the I am can do.

91 00:22:34.110 --> 00:22:36.790 Kai Chen: So these models already take.

92 00:22:37.010 --> 00:22:47.390 Kai Chen: Yes, already. Take climbing the what are the climate mitigation efforts you want to achieve? What are the underlying socioeconomic evolutions, and use that to try

93 00:22:47.430 --> 00:22:54.720 Kai Chen: what will be the resulting energy and land use, and also the emissions of emissions of Co. 2 and air pollutants.

94 00:22:54.750 --> 00:23:01.080 Kai Chen: But really, ultimately we care much more about our human health. As a result, we need to fill out

95 00:23:01.150 --> 00:23:15.920 Kai Chen: this brat. I highlight here. How would that emissions influence pollution, exposure, and also, how would the socioeconomic factors shape and influence the future population? Vulnerability as a result, changing the house outcomes

96 00:23:17.480 --> 00:23:23.740 Kai Chen: well, this work is led by my Phd. Student Wayne and her paper, published earlier this year on nature Sustainability.

97 00:23:24.220 --> 00:23:43.019 Kai Chen: Okay, how do we do that? So this is the key model method we have here is to do model coupling and also down scaling. What I have here is really, traditionally what I am model. Having doing so, we have been using a global IM to develop 5 future scenarios.

98 00:23:43.020 --> 00:24:10.209 Kai Chen: And they vary in 2 dimensions. One is the socioeconomic trends as well as the stringency of air pollution, policy. Those are determined by the shared socioeconomic pathways. Ssp, and also the other dimension that we vary is the climate targets, and these are different representative concentration pathways ranging from 1.9 roughly 1.5 degree by the end of the century to Rcp. 8.5. What percentage

99 00:24:10.210 --> 00:24:14.680 square meter that's roughly like 5 each degree warming by the end of the century.

100 00:24:14.690 --> 00:24:20.579 Kai Chen: So and we, that's where the Ims can do. And this is what we really care about

101 00:24:20.640 --> 00:24:29.580 Kai Chen: about the health outcome. Let's just do premature death, for now. So a lot of stuff we do is in the middle, and let me break them down one by one.

102 00:24:30.020 --> 00:24:54.359 Kai Chen: So first of all, we get the using the IM. We then down scale the emissions of CO. 2, and air pollut emissions and put them into a Earth system model. Here we use the GFTL. ESM. 4 model, where we can wrap the epoch system at 100 kilometer by 100 kilometer resolution. So from that we get both the climate variables, which is the future changing temperature, precipitation, etc.

103 00:24:54.360 --> 00:25:05.349 Kai Chen: Those are important because they're going to drive your pollution level, and also the M. The Mvmp. Concentration that responds to that emissions and response to that cloudy future.

104 00:25:05.450 --> 00:25:10.160 Kai Chen: And this is the proxy we use to measure exposure.

105 00:25:10.580 --> 00:25:25.059 Kai Chen: And then it is not. If you're really thinking about health. It's not only about the average exposure level. It's also about your population size, about your vulnerabilities, such as aging. And also what is your base and mortality rate. That's another vulnerability.

106 00:25:25.090 --> 00:25:40.500 Kai Chen: So we also leverage the community efforts to down scale the future population projection to 1 one over 8 degree resolution across the world, and for and also for the aging pattern. At that resolution.

107 00:25:40.500 --> 00:26:00.980 Kai Chen: and for the based on mortality, rage, we use that development forecast model called the international futures, where they use. They establish that in purple relationship, using the historical data like how your income education level predict your based on mortality rate and use that to project for the future based on mortality rate.

108 00:26:00.980 --> 00:26:05.310 Kai Chen: So and this is based on the country level. Everything else is finer scale.

109 00:26:05.310 --> 00:26:16.300 Kai Chen: So through this model coupling and down scaling efforts, we can now really get from that high level IM results to exposure, population, size and population vulnerability.

110 00:26:17.120 --> 00:26:18.999 Kai Chen: Okay, what do we claim?

111 00:26:19.400 --> 00:26:45.509 Kai Chen: So I want to provide 2 findings from this app example. The first is that we did find that with climate, mitigation, pollution, exposure is likely to go down in most regions. For example, this is roughly the 2 degree scenario, and what you're going to see is that by the end of the century relative today you see most places in purple. That means that the pollution level by the end of the century we much lower, largely because we move it from fossil fuel.

112 00:26:46.090 --> 00:27:02.370 Kai Chen: but at the same time we do. We still see house burden may go up in some regions as we highlight in red here and there, and that is because it's not only about exposure, it also has to to do with how many people are exposed to that pollution, and how vulnerable you are.

113 00:27:02.690 --> 00:27:10.550 Kai Chen: So when we're looking at this result, we were thinking, huh! Maybe it's because those places have more people living in that country in the future.

114 00:27:11.230 --> 00:27:31.910 Kai Chen: and that drive us to do the decomposition analysis, really figuring out what what is the most important social demographic factors shaping that result, we actually find that it is the population aging and the declining based on mortality rate, that is, that can potentially play a more important role than population growth or the exposure changes.

115 00:27:32.000 --> 00:27:48.450 Kai Chen: So this is just one example of the result. Same scenario, 2 degree scenario, and the bar here shows you the contribution of each factor to that cumulative, to that 2015 to 2,100 change in the Pm. 2.5 attributable death.

116 00:27:48.450 --> 00:28:03.359 Kai Chen: So, for example, what people usually focus on in my field is about the changing concentration. So you can see that they're negative, meaning that holding everything constant. Yeah. As you, you reduce your pollution level, you bring down the premature deck.

117 00:28:03.940 --> 00:28:32.680 Kai Chen: But if you look through this example, country regions of Africa, India, U.S.A. You can see that it's really the the orange and the blue bar that's driving main makes the results. And that's essentially this, this orange bar here is population aging. So essentially, this is to say, holding everything else at the today's level because of the potential aging that will happen in India. It might be 1,000 like 10 times higher by the end of century. Comparing with today.

118 00:28:33.120 --> 00:28:54.460 Kai Chen: luckily, a lot of those effects will be controlled hopefully, will become directed by this blue over here. That's essentially to say that because of the projected decline in the base and mortality rate, thanks to primarily healthcare, access, etc. That is going to counteract a lot of those effects bring down the premature death

119 00:28:54.490 --> 00:29:06.910 Kai Chen: and the map change are shown over here, and also the result I showed you on the previous slide. So this is really the end of my first example. Let me pause and ask any question about this one.

120 00:29:08.370 --> 00:29:11.250 Kai Chen: Yes. yes, thank you.

121 00:29:12.360 --> 00:29:17.640 Kai Chen: What makes you what made you choose as health outcome.

122 00:29:17.830 --> 00:29:21.619 Kai Chen: mortality rate, as opposed to

123 00:29:22.220 --> 00:29:30.160 Kai Chen: say, quality of life or rate of sickness, or, you know.

124 00:29:30.240 --> 00:29:45.920 Kai Chen: yes, we did quality of life. We also did Dolly. In this. In the supplemental information. The key thing is that projecting the future live lifetime of people becomes tricky. Because, you know, you need to.

125 00:29:45.930 --> 00:29:50.769 Kai Chen: I can talk forever about this one of the challenge. And one of the caveat here is that

126 00:29:50.950 --> 00:30:11.830 Kai Chen: because there are people doing the energy system modeling part. They're doing people doing exogenous demographic modeling for the future. And these 2 has to be. There are interactions between this 2 right? If you have high pollution today, people would die early. As a result, you should have a different population projection and pu different baseline risk.

127 00:30:11.830 --> 00:30:35.379 Kai Chen: Because of that. And we don't really consider that here it's pretty much exonerated energy modeling, exotic, social, demographic modeling. So 1 point we were really making in this paper in the end is really to say, we really need to demographers to work more closely with regional air quality and also energy system, so that we can really start to capture those more ingotness, demographic changes.

128 00:30:35.380 --> 00:30:41.959 Kai Chen: That would be Pusho. If you want to have a more accurate estimate of Dali or years of life loss, or even promotional death.

129 00:30:42.300 --> 00:30:50.910 Kai Chen: So is that. Is that not answer to that. We didn't do it. But we we kind of see this as a as a emerging frontier for 2 fields to work together

130 00:30:51.910 --> 00:30:54.540 Kai Chen: any other questions. Okay.

131 00:30:54.840 --> 00:31:03.769 Kai Chen: so if you're just looking at a previous scenario, everything seems so clean. Right, I said, I showed you a couple scenario from the global. I am.

132 00:31:03.830 --> 00:31:22.669 Kai Chen: And I'm sure that you'll start to asking, okay, is that 5 scenarios going to be representative of the possible future. We'll have the short answer, the course not. And that's really brings that to thinking about the second question, how those conclusions will potentially change. Once we start to thinking about the future uncertainties.

133 00:31:23.720 --> 00:31:39.580 Kai Chen: So just really, we iterate the motivation a little bit more in the previous study. Remember that we we find the pollution exposure will go down and that's pretty much highlighted that there will be a health benefit from displacing fossil fuels.

134 00:31:39.580 --> 00:31:47.420 Kai Chen: But at the same time, once we start to thinking about that Nad 0 world, a world we can only use our imagination to thinking about.

135 00:31:47.420 --> 00:32:09.730 Kai Chen: We need to start to also pay attention to those emerging health risks from our mitigation response. So, for example, people have found that if we use a lot of bio energy to tackle the climate problem that may disrupt land, use patterns, and then may like even increase the food price and intensify food insecurity. They may be dietary, hype health damages associated with that.

136 00:32:10.250 --> 00:32:27.180 Kai Chen: And this is also where the future uncertainties is going to play an important role, because it's not all. It's not really about. Do we know for sure that will happen? It's more about what kind of uncertain, under what kind of plausible future we may see those kind of dynamic and trade offs start to occur.

137 00:32:27.480 --> 00:32:42.389 Kai Chen: So this is really the other important work that we have been thinking about in cooperating future uncertainties. And this is led by my other Pg students, clearly likes ice cream. And his papers published on, this is sustainability earlier this year as well.

138 00:32:42.970 --> 00:32:45.189 Kai Chen: Okay, what did we do?

139 00:32:45.520 --> 00:33:01.249 Kai Chen: So we start with the global. I am here. The model we use is called G cam is the global change. Analysis model is one of the model that Ipcc, that also the national climate assessment has been using to view enough the advantage of scenarios. So we

140 00:33:02.180 --> 00:33:19.479 Kai Chen: constructed it, exploiting on them both. Where we consider one decision labor a very simple one. Do you have compromised or not? But on top of that we overlay a wide range of technology and social economic assessments, uncertainties that people have found to be crucial for mitigation.

141 00:33:19.790 --> 00:33:46.829 Kai Chen: And, for example, for the socioeconomics, we have 5 Ssps. We just got earlier for the energy demand. We have high medium, low for fossil fuel costs and low emission costs. We also have low Median high, so combining those decision lever. Whether or not you have it or not. It's a binary. With the other kind of uncertainties. We end up with a large scale scenario of 28,000, more than 28,000 scenarios.

142 00:33:46.940 --> 00:33:49.170 Kai Chen: Okay? And once we have that

143 00:33:49.250 --> 00:34:04.140 Kai Chen: those like scenarios ensemble, the rest of the assessment is very similar from the previous one, where we try to get the emissions from the Gcn model, and then we try to capture the climate. Health! And also some of the regional distributional questions.

144 00:34:04.200 --> 00:34:30.549 Kai Chen: but I still could imagine. Now we have nearly 30,000 scenarios. There's no way I can convince my Gfd colleagues to say that hey, Romeo Earth, just our system model? For 30,000 times. So because of that in this project we use a reduced air quality model and also a reduced from climate model to get the the climate and health outcomes. I can talk more about this

145 00:34:30.590 --> 00:34:40.289 Kai Chen: trade-off between complexity and simplicity. But just to let you know. In this project we reduce reduce from air quality and reduce from climate models

146 00:34:41.320 --> 00:34:46.459 Kai Chen: just to highlight the potential pathways that will lead to different health outcomes.

147 00:34:46.780 --> 00:35:07.420 Kai Chen: So this is the outcome that people mainly talk about and actually work on this for 10 years before I started thinking about this work. So if you have common pricing as a proxy for climate action, this is going to reduce the fossil fuel consumption. As a result, we reduce your airflow emission. This is the main pathway. How you can get Health Co benefit.

148 00:35:07.750 --> 00:35:09.030 Kai Chen: However.

149 00:35:09.380 --> 00:35:29.079 Kai Chen: it could also have passwords for coharm. If you have carbon pricing that increase the bio energy use. This may not only directly increase the air pollutant emissions because we're now burning biomass, but also it may have indirect effect on your land use as a result leading to like

150 00:35:29.140 --> 00:35:34.360 Kai Chen: like really unfair changes in your air poll emissions from the land sector.

151 00:35:34.390 --> 00:35:52.270 Kai Chen: So really the key thing we hope to discuss, discover in this analysis is that competing have 2 competing pathways for health co-benefits and coharm, and, more importantly, under one uncertain futures we may see that coharm pathways to occur.

152 00:35:52.660 --> 00:35:55.200 Kai Chen: Okay. what did we find?

153 00:35:55.670 --> 00:36:20.500 Kai Chen: So the first we find is that, yes, we did find Consistent Health Co benefits in most countries. Looking at this I this is what I show you. For 2050. All those blue, each colors are the regions where we find Consistent Health Co. Benefit blue regions without the hash. Other regions where we find consistent health benefits. Across the 30,000 scenario we always find that if you cope

154 00:36:20.500 --> 00:36:30.159 Kai Chen: reduces fossil fuel, and that's going to improve your health outcome. Here we use the Pm. 2 point attribute to the death rate snowball. Like our population. Already.

155 00:36:30.570 --> 00:36:31.760 Kai Chen: however.

156 00:36:32.010 --> 00:36:39.420 Kai Chen: we did find out evidence for potential eye intended consequences in some regions under sound scenarios.

157 00:36:39.430 --> 00:37:03.640 Kai Chen: and those are the regions where we show you this, like hash bar over there. This is to say that among those 30,000 scenarios there's a small subset of the scenario where we actually find increasing. Pm. 2.5 attributable death rate. Exactly to say that, hey, you, you have global mitigation. But there are some conditions where we can potentially see. The house risk going up.

158 00:37:03.790 --> 00:37:11.080 Kai Chen: then the question becomes, why and under what? But precisely what are those conditions?

159 00:37:11.630 --> 00:37:28.819 Kai Chen: So this is how models can be useful. What we buy ensure is that the pathways for house coharms? It's really complex. It involves complex interactions between sectors and regions. Here, let me give you a quick roadmap both that complexity.

160 00:37:29.060 --> 00:37:29.890 Kai Chen: Okay?

161 00:37:30.100 --> 00:37:46.599 Kai Chen: So first of all, if we increase, if we impose a cover and pipe, what we're going to see is that across all other countries, we're going to reduce the share of coal. That's awesome. But at the same time we're going to increase the share of renewables and also biomass, because those are lower cover resources.

162 00:37:46.890 --> 00:38:03.420 Kai Chen: And as a result, we're going to see changes in precursor air emissions because different sectors and activities leads to different precursor emissions. So we did find really consistent. So 2 reduction across all the countries, because that's what you get if you shift away from coal.

163 00:38:03.500 --> 00:38:20.379 Kai Chen: But we do see in particular, the organic carbon emissions can increase in some countries, especially Russia and Canada, and that was mainly because there is once you start to use more bio energy has a lot to do with. Does it really intensify your land competition?

164 00:38:20.400 --> 00:38:37.930 Kai Chen: And for some places we find the model is going to let those areas deforest more, as as in order to make the space

for the new bio, energy development and burning down forest is the leading mechanism here that leads to increased organic heart emissions.

165 00:38:38.690 --> 00:39:03.460 Kai Chen: And then the rest of the results is really about how those precursor emissions lead to MB. And Pm. 2.5 concentration, and these 2 changes. Pm. 2.5 attributable death rate. So you can see that, for example, in Canada, Russia, U.S.A. You are going to see very small, but you can see the small subset of your scenarios. That will have the increase. Mbn, pm. 2.5. Concentration.

166 00:39:04.220 --> 00:39:06.300 Kai Chen: So, looking at this results.

167 00:39:06.370 --> 00:39:33.699 Kai Chen: I have to say a lot of them has has something to do with your model assumptions. Right? So is it really the case that your bio energy is going to intensify land competition. And if that's the case, are you really going to deforest in order to make the space for bio energy? So we did a very Co step by step, model diagnostic analysis, in order to understand all this could potentially happen. But is there a assumption

168 00:39:33.700 --> 00:39:38.909 Kai Chen: that is most important in determining the potential health cohorts. This is what we find

169 00:39:39.480 --> 00:39:54.280 Kai Chen: we find the most important assumption is your deforestation approach. So this is the same figure as the previous, the the the last one that changes in Pm. With a attributable death. And this is where you can see that you know.

170 00:39:54.280 --> 00:40:12.189 Kai Chen: and and this is yeah. And here you can see that. Yeah, things like that. Canada. We do see increase in some scenario. There's increase in attributable death rate. And this is partly because in the model the default assumption is that we're still going to use open burning to burn on those forests.

171 00:40:12.540 --> 00:40:33.540 Kai Chen: But that doesn't need to be the truth, because these days clear cutting has become a more popular approach for deforestation in many countries. So if you move away from open burning, but start to do clear cutting. See the changes over there, so you can see that in those regions where we have some cohes now those coal harm are eliminated

172 00:40:33.540 --> 00:40:56.470 Kai Chen: because we're making a different assumption for your deforestation approach. Now, using clear cutting as a result, avoiding those increase in organic carbon emissions. As a result, eliminating those potential Co harps. So this is how we have been using models and especially exploration modeling which large scale scenarios to understand what are the potential determinants for Co harps.

173 00:40:56.470 --> 00:41:04.479 Kai Chen: and also what are the concrete levers in this case? Just change your deforestation approach to avoid those potential Co. Harms of the future.

174 00:41:04.590 --> 00:41:08.510 Kai Chen: Let me pause again and ask any questions for this project.

175 00:41:08.740 --> 00:41:16.899 Kai Chen: Yes, oh, I think maybe first, I'm just wondering beyond the

176 00:41:17.390 --> 00:41:20.700 Kai Chen: the increase in kids point 5 conditions.

177 00:41:20.950 --> 00:41:45.469 Kai Chen: How we consider indoor air sources. Great question. My group haven't done much work for the indoor air pollution, and we just started to work with indoor air pollution modelers to think about that question. So I think that's crucial. And that's also like very important, because we spend more time indoors. So that's really the one of the key. Determine if our exposure ultimately. Great question, we haven't done much.

178 00:41:46.020 --> 00:41:49.819 Kai Chen: Yeah. So since it's an integrated model.

179 00:41:49.910 --> 00:41:53.500 Kai Chen: I assume that this you have your switch.

180 00:41:53.830 --> 00:42:08.930 Kai Chen: your carbon tax, which leads to a switch towards biomass, which leads to deforestation, which has a climate effect in itself. Is that all taken into account? It is great question. Remember, I said, we use reduced air quality model.

181 00:42:08.950 --> 00:42:36.469 Kai Chen: The only thing we consider the study is that you have black carbon. Then you have positive radio forcing. Those kind of single things are there. But it's more complicated than that right. If you have. PC. If you have Oc, then it's going to change your cloud formation and wind transport and precipitation a very different way, comparing with the those like cooling arrows, those it's not considered the reduced form. It just goes beyond the capability of a reduced model to capture. But we do have a

182 00:42:36.470 --> 00:42:44.310 Kai Chen: project that work with the cloudy model. Try to capture that better. Well, what about the simple? Just Co, 2 emissions from deforestation?

183 00:42:44.410 --> 00:42:55.350 Kai Chen: That's there. So it's basically increasing the Co. 2 emission from both land sources and energy sources, and go into that carbon cycle part of the model. That part is there?

184 00:42:55.470 --> 00:43:22.650 Kai Chen: Yes, I'm very interested in the massive bio energy exchange. I know there are, like many models to model indirectly exchange, but the values for, like each of the biomass are very, very exactly so for your model. Are you doing your own assumptions, or you sort of harmonize? That is a great question. So this is where I think, some of my next example would be useful, because if you really think from a biomass

185 00:43:22.770 --> 00:43:37.990 Kai Chen: doing it at the regional scale, it's

not very useful, right? Because if you're really thinking about the United States as an example, we should really do it at the State level at least, or even county level, because the biomass availability at the suitable crop varies so much so. In short, in this project.

186 00:43:38.960 --> 00:43:42.020 Kai Chen: In my, in my view, we need to walk. It won't be wrong.

187 00:43:42.050 --> 00:43:55.219 Kai Chen: This is the project that we walk so essentially, we just treating United States as one region. And we did have aggregated land time, so that there will be different supply curves for different kind of bio crop. But we stop there.

188 00:43:55.220 --> 00:44:16.979 Kai Chen: But we do have actually not me, but the model Chica the there they have a state level version, Gke, U.S.A. And then we're working with the Oak Reach national Map, where we now I think the model is probably ready now. So the paper coming out where we, where they incorporate a State level representation of finance, supply it precisely to tackle the questions we're asking just now.

189 00:44:17.570 --> 00:44:23.410 Kai Chen: Yeah, because of time. I want to move on to my last example. But happy to have more discussions later on.

190 00:44:23.660 --> 00:44:26.559 Kai Chen: Okay, this is a natural transition, because

191 00:44:26.600 --> 00:44:46.619 Kai Chen: everything I showed you just now in an example, one and 2 is at the regional scale. But ultimately nobody really care about the average exposure level for the United States. It's really about this like final resolution, exposure, disparities, and even health disparities that really like shaping the discourse of today's the policy discussion. So

192 00:44:47.190 --> 00:45:03.660 Kai Chen: so in this third example, I want to talk about, this is the last mutual one. So take the results with a grain of salt. We tried to thinking about the effects of domestic and global decarbonization, and then looking at the the changes on the exposure disparities across the United States.

193 00:45:04.210 --> 00:45:12.200 Kai Chen: So I hope by now you're familiar with how I'm going to talk on my work. It's all through. Start with the dial ground, because that's how models work.

194 00:45:12.330 --> 00:45:17.250 Kai Chen: So if you're thinking about your endpoint, which is, I care about exposure disparities.

195 00:45:17.390 --> 00:45:28.009 Kai Chen: but at a very high level is really a correlation of 2 things. One is where the pollution is high and the other is where the advantage coming with your populations live.

196 00:45:28.040 --> 00:45:35.560 Kai Chen: But how does 2 things might evolve in the future. So first of all, if you're thinking about where the pollution is high.

197 00:45:35.850 --> 00:45:55.480 Kai Chen: both global and domestic decarbonization effort would change that patterns because for the domestic decarbonization. We're going to change the future emissions pattern. If we shift away from coal. If we start to cite biomass power plants instead of like coal power plants. We start to see different emission patterns within the country.

198 00:45:56.010 --> 00:46:15.360 Kai Chen: but also global decarbonization effort would also matter because we have not been in like climate. A warmer future. This is going to change the temperature, the precipitation, the wing pattern, etc. All those are going to change the formation and the deposition of your air pollution in the air

199 00:46:15.700 --> 00:46:33.959 Kai Chen: on top of that, this question, where the disadvantaged population live, is, has also something to do with what will be the future? Fine skill, social economic trend, like urbanization, migration, and also what will be the future race and income patents in that broader context? So

200 00:46:34.200 --> 00:46:56.339 Kai Chen: for us, there's no way we can make a good projection for them. But we should be really using this project. We try to demonstrate what are the those important linkages over there, and how those linkages collectively shape the potential exposure disparity in the future. And this work is not by my poster one, as the paper is still in the making, so

201 00:46:57.320 --> 00:47:05.080 Kai Chen: what we try. So this is our model map method. And what we really try to do here is to have a multi-skill modeling approach.

202 00:47:05.570 --> 00:47:35.230 Kai Chen: So for the global decarbonization efforts, we consider an ambitious action where we try to just use the present day meteorological conditions. We also have a limited action case where we end up with some much warmer future and then using that see at them model, which is a global climate model. We get a meteorological conditions for the United States for meet century. And they vary because you have different global decarbonization efforts that drives the temperature and the climate future.

203 00:47:35.800 --> 00:47:57.120 Kai Chen: but the domestic climate efforts. We start with a reference case, which is a visit as usual. Just consider the existing policy, but not additional stuff. And then we consider a net 0 by 2050 case, which is the policy target. That this country is hoping to achieve. Then we use a State level, integrated model Gq. U.S.A. To get a State level English.

204 00:47:57.170 --> 00:48:22.540 Kai Chen: Then we use the national emission inventory from the EPA to down scale that State level emissions to good admissions at 12 by 12 kilometer resolution. And this meteorological condition and a good admissions are going to try a regional air quality model worth cam, so that we can simulate the future. Mvpm. 2.5 and ozone concentrations at already scale and at 12 by 12 kilometer resolution.

205 00:48:23.270 --> 00:48:42.450 Kai Chen: On top of that. We also wanna

make sure that the county level economic, that social, demographic patent, are consistent with the socioeconomic drivers that we have been using to try those energy integrals in the first place. So that's why I added, added a arrow over here.

206 00:48:43.250 --> 00:48:52.990 Kai Chen: and once we have that simulated pollution, concentration and the county level socioeconomic demographic. We can start to thinking about the exposure disparities.

207 00:48:53.010 --> 00:48:56.670 Kai Chen: Okay, so this is the modeling framework we we put together.

208 00:48:57.310 --> 00:49:13.339 Kai Chen: Then the question is what we find I have to say. I have a love and hate relationship with this project, because as a researcher, I was hoping to get some like concrete conclusion, like, if you decarbonize, this is good for equity. But no.

209 00:49:13.470 --> 00:49:25.420 Kai Chen: we, what we find is much more complex for that. So that's why I call them preliminary insight. Because even within the team we are still trying to figure out what exactly did we find? What are the concrete things we can say

210 00:49:25.610 --> 00:49:49.049 Kai Chen: so just quickly summarize what we already find. We find that domestic decarbonization efforts can lower future pollution level. Here's one example, this is annual pm. 2.5 annually ozone. If you just looking at the level, you can see that over time, he's going to decrease shifting to the lab, extension and the rep. If you go for net 0, it's going to be lower than the reference. So far, so good.

211 00:49:49.260 --> 00:49:53.089 Kai Chen: It is the equity assessment that makes the picture very complex.

212 00:49:53.180 --> 00:50:16.919 Kai Chen: So, first of all, is kind of just from the results. Here we differ that the current exposure, disparity may persist into the future. So if you looking so, what I show you here is the solid and the hello dots, and they shows the Median household income for the lowest dice out and the highest dice out. So essentially this says that the high income

213 00:50:17.160 --> 00:50:23.920 Kai Chen: this way low income groups right now have higher pollution level, and we do see the remainder

214 00:50:23.950 --> 00:50:44.829 Kai Chen: on the right side in the future. That's what we meant by annually. Pm. 2.5. Like at least. With this Pm. 2.5, exposure is Friday. It may persist same thing for the ozone, but with the flip side, and this is also some what some other people already find. The ozone concentration. The High income group may have made it higher ozone concentration, and that may proceed in the future as well.

215 00:50:45.470 --> 00:50:58.589 Kai Chen: that's the income results. And you start once we start to looking at the range results. We really didn't really find

significant. Well, I should use that word substantial enough for the disparity between them

216 00:50:58.730 --> 00:51:01.170 Kai Chen: and what? To make it worse.

217 00:51:01.790 --> 00:51:17.279 Kai Chen: we also find that once you start to thinking about the global decarbonization effort. So you use Rpc, 8.5, a warmer future to drive your pollution modeling. You're going to see the results start to look very different, especially in this case, this case and this case.

218 00:51:17.360 --> 00:51:34.659 Kai Chen: So in other words, we did find evidence that once you started thinking about the climate future as a result of global decarbonization future. I mean to global start in, you know, the future meteorological conditions. They may have potentially large impacts on exposure disparities.

219 00:51:35.100 --> 00:51:38.190 Kai Chen: So and try to make it even worse.

220 00:51:38.520 --> 00:51:58.099 Kai Chen: We actually, we did a lot of sensitivity analysis on this, and I'm not going to show you I'm not going to bore you with all of those. But we define there's so much complex relay relationship and so much uncertainty that will make your equity as conclusion about the equity, assessment, even flip under some conditions. And here are some of the major ones.

221 00:51:58.450 --> 00:52:01.930 Kai Chen: First of all, to think about the emissions pathway.

222 00:52:02.150 --> 00:52:05.150 Kai Chen: Where will be the future emissions, hotspots.

223 00:52:05.160 --> 00:52:14.980 Kai Chen: Today the emission house spots are where we have cold facilities in general, but in the future, in the net 0 future all the cold facilities will go away. As a result.

224 00:52:15.000 --> 00:52:20.660 Kai Chen: like we should really be thinking about what are the new technologies we're using and where they sat in this country

225 00:52:21.110 --> 00:52:39.900 Kai Chen: about the meteorology. This is really hard, like, how can we model fine skill patterns for future wind, bounder, layer, high rainfall, and also wildfire? In this study we keep the wildfire emissions at the present level because have talked whatever about that. It's very hard to model fire emissions as the Admon fire scientist.

226 00:52:41.010 --> 00:52:43.580 Kai Chen: If you're thinking about the socioeconomics.

227 00:52:43.810 --> 00:52:54.889 Kai Chen: migration and economic development, those things will really change where people and what's the correlation with the high pollution level. And finally, this is something I find so troubling.

228 00:52:54.980 --> 00:53:06.369 Kai Chen: Sometimes we even find that if you change, the spatial skill of your exposure is for any assessment, county level versus census tract level versus neighborhood level. Even if your input data is the same.

229 00:53:06.440 --> 00:53:09.309 Kai Chen: you may end up having different faculty appointments.

230 00:53:09.640 --> 00:53:20.919 Kai Chen: So that's why I think this is probably the only thing we can say. For now, which is methodologically, we find that model choice and assumptions matter a lot for equity assessment.

231 00:53:22.190 --> 00:53:47.099 Kai Chen: And with that I wanna end by just 2 overarching finding of my group. One is that we really need human centered rehabilitation technology, decarbonization strategies, technologies are cool. But ultimately you care more about people. Second, is that and our models need to get real about people with that. This is a picture of my group, some of their new members. Names are here, and thank you so much for your attention.

232 00:53:55.140 --> 00:54:04.420 Kai Chen: I think due to the interest of time we have. We have 2 whatever quick questions I know all the students on the question. So

233 00:54:04.470 --> 00:54:06.560 Kai Chen: now is the good time to ask

234 00:54:11.850 --> 00:54:17.309 Kai Chen: conceptualized question about the block, though, as you mentioned. It depends

235 00:54:17.380 --> 00:54:30.709 Kai Chen: heavily on the assumption, a lot of things. So I'm thinking about the famously. All the models is useful, but they're wrong. So on your model. How do you prioritize assumptions for the parameters that you choose model?

236 00:54:30.960 --> 00:54:32.619 Kai Chen: That's a good question. So

237 00:54:32.650 --> 00:54:38.760 Kai Chen: I consider model as a hypothesis testing pool. I don't consider model as a predictive model.

238 00:54:39.070 --> 00:54:57.509 Kai Chen: So the way I say hypothesis testing tool is that I think from the empirical research epidemiology research as an example, we already develop some sense? What hypothesis about what might might matter right like aging would matter pollution, scale and pollution pattern would matter. And then I think of a model as hypothetical.

239 00:54:57.510 --> 00:55:10.980 Kai Chen: So we know from the path these factors are going to be important. Can we use model as a way to test on the what conditions this factor would be important to really shape the outcome we care about. So I think that's a long way to say, like

240 00:55:11.130 --> 00:55:24.019 Kai Chen: in in our where we start with the hypothesis, and then try to view the model so that will that will equip us with

the capability to test that hypothesis. I think that's a much better way to use model, especially because of the deep answer into the future.

241 00:55:25.260 --> 00:55:25.950 Kai Chen: Yes.

242 00:55:26.240 --> 00:55:31.969 Kai Chen: when you are creating model relationships, for example between land use and food.

243 00:55:32.140 --> 00:55:34.489 Kai Chen: How? At what scale do you

244 00:55:34.610 --> 00:55:54.540 Kai Chen: think when you were building those things? Okay, great question aggregate it. So practically a lot of modelers are constrained by data as you could imagine. Right? So that's why a lot of the model, a global model. And they have, they just focus on the regional scale. But I really think, just go back to that question. I think it has a lot to do with your question as well.

245 00:55:54.540 --> 00:56:14.529 Kai Chen: so that's why, for some of the questions actually, see the global IM start the right tool. So you have to go for a buyer scale model in order to do that. And maybe in those circumstances that system interaction. Remember, I showed you the system of system. Some of the system interactions might not be that important. As a result, you can use your model just capturing the core things you are

246 00:56:14.530 --> 00:56:29.179 Kai Chen: you? You would think it's important. And then, with the other thing as exogenous assumptions for the boundary initial conditions. So that again, I think the general thought, like my group, has been the guiding principle we have to start with the question, and then thinking about

247 00:56:29.500 --> 00:56:33.360 Kai Chen: what are the main mechanism on? Certain that would matter a view. Don't monopolize

248 00:56:35.400 --> 00:56:36.720 Kai Chen: wonderful! Thank you.