Alright, I think we should start, welcome everyone and welcome to our fourth seminar of the Yale Center on Content in 2020, and so today we are very pleased that you have Dr. Xuhui Lee from the Yale School of Environment. So he’s the Sara Shallenberger Brown Professor of Meteorology, he’s also a director of the Yale Center for the Earth Observation, he also received the 2015 award for outstanding achievement in Balm meteorology from the American Meteorological Society. So without further ado, let me see if we can turn out the lights, so the title of my talk is Urban Heat Island Theory Measurement and Mitigation. Thank you, Kai and also thank you Rob for having me in this event. Let me see, how do I, can you see my screen Okay? Yes. Okay good. So I’m gonna go talk about some of all the work done on Urban Heat Island. Let me see if we can turn out the lights. So the title of my talk is Urban Heat Island Theory Measurement and Mitigation.
So somewhere in that order, let me see if I can turn off my screen here. Okay, now that’s much better.

The work I’m presenting today is really a collection of things done by folks in my lab, current members and also past members so far.

Some of them are actually attending this event. I noticed that this event is being recorded, that’s fine with me.

There are a few slides where we don’t have where we can… Where I showed you a sort of unpublished results.

If you want to share this recording, please refrain from perhaps not sharing that part to people.

So many of you are familiar with this kind of projections right? Projecting for temperature into the future depending on whether we take the aggressive mitigation or scenario or more of a business as usual scenario.

We will end up with very different temperature projection in the low emissions scenario, we expect maybe 1.5 degrees of increase, decrease dialysis.
but in a more sort of aggressive emission scenario RCP 8.5, the projection is that four degrees of decrease of warming towards the end of the century. So that’s the kinda big picture. So what I would argue is that Heat stress is actually perhaps the most, the biggest climate threat to humans in stress associated with climate change. The reason is simple that we humans are warm blooded animals, we have a biological limit we cannot overcome, so we are warm blooded, we keep our body temperature at a constant value of the property 37 degrees Celsius and in a warm climate we need to maintain a temperature differential of at least two degrees between the thick body and the skin in order to for the metabolic heat to get discredited in the environment right? So that’s a physiological limit barrier we cannot overcome if conditions cannot maintain in such that we cannot maintain a skin temperature lower than 35 degrees then we will suffer serious health consequences even death without of course the help of air conditioning. So that’s the kind of the motivation for this kind of work off
and of course we know that residents in the Urban Environment, urban residents suffer an additional Heat stress due to the Urban Heat Island. This is sort of classic depiction by Jumoke of what an urban heat Island looks like. If you have a bicycle for example your attach or sensor, something I would talk about it, you'd end up with this lecture and you move across a transect from rural to urban core. You would record temperature variations such way lower temperature in outside city, as you move to the center of city you'll register very high temperature while relative to high temperature and this difference between urban versus rural temperature temperature is really what we call Urban Heat Island or intensity of therapy to time. So that's a well accepted sort of depiction of this phenomenon and so this is added heat that urban residents would experience, and this is a sort of spatial view for urban heat island here actually in the city of New Haven, the urban unite is very patchy.
I have high spots here and there and some low spots there.

So the high spots in the archaea shotguns area, right?

And then that’s this downtown area and then near the fringe of the city where you have a lot of trees, temperature is much lower.

So that’s the kind of urban heat island parent that you see in New Haven.

So why Urban heat island is a concern?

Well, you can just simply consider a probability distribution of temperature, this is a probability distribution temperature of maybe a rural background and Urban heat Island would shift this probability distribution just by a little bit, maybe by one degrees on average, right?

But that one degree of shift in the mean would actually create a serious consequence in terms of heatwave frequency and let’s suppose the Heatwave threshold is here, now this is per heatwave threshold beyond which we will see problems with mobility and mortality and for Rural background, rural location, this is the area under this curve is your Heatwave frequency.

Now for urban land, the simple shift in mean due to our heat would change that frequency a lot, on it, would change that frequency a lot,
we increase that frequency a lot, right?

And the other thing that you should notice of course as the urban heat Island,

urban residents will actually experience a record temperatures not being seen by rural residents

so again rural temperature stops here on,

so this is a spread.

So, but in the city,

you will see temperature beyond the record, right?

The record registering in the background sites.

So that’s also another issue

that we should be concerned about Bob.

So that is really the motivation

for why we study the theory of urban heat island

and why we want to come up with strategy
to mitigate urban heat island, alright?

So let me switch to give you a sort of review of theory

of the urban heat island phenomenon.

So this traits, they can be trace back to me many years ago

to team Oaks textbook,
in his textbook he listed the seven causes

of urban heat Island of the seven,

I highlight the four causes people consider it to be the major ones.

The first one is increased absorption

of short-wave radiation due to urban morphology
and maybe due to the color of the landscape so they're committed...
The conventional wisdom is that urban land tend to trap more solar radiation so that's a source of urban heat island. A second source of urban heat island of course is very easy to understand because there's an additional heat, anthropogenic heat from anthropogenic sources from automobile driving, driving automobiles bills, converts chemical energy in fossil fuel to mechanical energy that mechanical energy eventually dissipates as heat to the environment, right? And so another important source of anthropogenic heat is a space heating. We heat our houses or use of air conditioning and they will generate heat and dissipate heat to the environment. The third course is increased sensible heat storage on buildings and other facial structures can store energy solar energy, solar radiation energy in a daytime and that then they were released that energy at night causing nighttime urban warming and finally not a major course is decreased evaporation.
You know that you’ll replace natural vegetation,
replacing, replace trees with artificial imperious surface
you reduce evaporative cooling power right?
So those are the four
187 sort of major causes of Urban heat Island
and so the, we understand
those concepts in a conceptual way,
in a qualitative way for a long time
and so what we did was with a few years back
was try to quantify those causes in a quantitative way.
We believe, we know only by quantifying those causes
that will then lay the foundation
for sensible sort of measure of how to mitigate Binky Don.
So I need to sort of take a step back
and introduce this theory called
The theory of intrinsic biophysical mechanism,
this is theory was first developer to actually,
to understand how perturbation changes surface temperature,
changes near surface temperature amid arm,
this theory is extended to talk,
to the study of urban heat Island
so some key points here.
So this theory,
This mechanism really is concerned with the process
which how surface temperature responds
to external perturbation by external perturbation, I mean a number of things. It could be addition additional aerosols to the atmosphere that will block sunlight penetration and an intercept sunlight penetration. And it could also be a change of urban, change of landscape a land use change replacing say, forest, we some open-end or natural land by urban man so those are considered to be external perturbation and he helped Bob understand this process. There are two key components to that. Why is one called a local Longwave radiation feedback? And the other one is a change in energy redistribution but in the service in the overlaying atmosphere, I’m gonna explain those two processes in a little bit, so the way it quantified the surface temperature response is really just to do this sort of experiment or numerical experiment and then it goes quantified through measurement as well to the surface response really is the difference between temperature of old state before the perturbation and a new state after perturbation.
So that’s what the perturbation temperature signal is really the key here and we’re trying to quantify. So let’s take a look at, so let’s go back to the case of deforestation study, right? The interest here is motivate your part by the new trying to send whether removing trees or adding trees or warm or cool the local temperature. So I, this is my favorite numerical example. This is a actual data collected over forest in Israel, semi arid climate conditions. This is how much solar energy reaches the forest and this is how much get reflected through its albedo reflected away from the surface, some escape of course to outer space, this is just a top of atmosphere. Now if you remove the forest and replace for us with some Shrub land, shrub land is much brighter, has higher albedo and so it’s a short wave radiation well reflection will increase so naturally you would think that the temperature would go down, right? Because now you have more or less short wave trapping solar radiation and so when the surface
when we undergo what we call radiative feedback
because when you have low absorption solar radiation,
the surface cool and therefore they will have
less Longwave radiation escaping to the from surface
and eventually you will establish
a new radiation liberate, right?
Cause that process, the longwave adjustment,
it’s called Longwave feedback, that’s a negative feedback
this is you can come up with a simple prediction
So the change of straight away radiation is dead ass
that’s your perturbation signal
and the change of surface temperature Delta Ts right?
This is a parameter called Local climate sensitivity,
that’s more or less a constant the number
and so in this particular numerical example
you would predict by replacing for us Shrub land
and you expect a coin of dot four degrees
about five degrees, right?
So that’s an argument some people used
to promote deforestation,
they're saying deforestation actually maybe a good thing
cause helps cool the local climate
because a lot because of albedo effect,
but of course that picture is not complete
because in the real world,
you not only how a radiative process irradiated feedback,
you also have too what I called energy redistribution
occurring between the surface and the atmosphere.
So there are two processes;
One is evaporation.
Evaporation is a process where liquid water is converted to water vapor near, at the surface.
so evaporation that will take away energy
and then when vapor gets to the top
above the atmospheric boundary layer
and condenses to form cloud,
that energy latent heat get released.
So the process is a process of energy redistribution.
It reduced screwed energy, taking away energy away
from the surface, and then put the energy back
into the atmosphere above the boundary layer.
So that’s one energy redistribution process.
A second energy redistribution process is connection,

is really is due, is the result of an emotion result

of triplet motion in the boundary layer.

That process is dissipating energy from the ground

to the lower atmosphere.

So you can set up this kind of thought experiment

right?

In this thought experiment

Or you can also do this in numerical, in the motto as well.

You put a forest next to an open land

and the two patches of landscape are influenced

by same atmospheric conditions in terms of temperature,

background temperature,

in terms of incoming solar radiation, long wave radiation

and so basically the value

that those quantities are the same

across the two patches of land

at this order called a Blending height

which is typically taking its first mode

of great height about 50 meters

to a 100 meters above the surface right?

And then, so in this kind of site pair analysis

all a space for a time analysis that the contrast open land
the contrast in temperature which an open land
and the forest land is really your, is really the deforestation signal
cause that’s how we approach this particular problem, right?
And so I don’t want to get into too much
of a mathematical details except to say, this is how we frame the problem,
we combined what we call the one source of a model for heat transfer,
surface energy balance conservation of energy at the surface
to formulate our solution for surface temperature
so in this One source Model heat is dissipated from the ground to Reference height
and using some kind of resistance analog right?
So the heat of efficiency of heat flux is really proportional to temperature difference
between difference in temperature between the surface and temperature at a lower atmosphere
at a per landing height.
So you combine those two sort of considerations.
You’ll come up with a solution for surface temperature
And then you do a sort of the perturbation to decide
mathematically it’s just,
that’s equivalent to differentiating this equation
and so you then get perturbation signal.
That’s your temp deforestation signal by replacing it four of this open land, you get a temperature change, that’s the temperature change mathematically and then the temperature changes then it’s partitioned into three components. The first component has to do with changing albedo. I mentioned earlier using that Israel example, the second component has to do is back. The energy redistribution efficiency has changed due to a change of reference. So forest landscape is very rough and very efficient in generating triplets, It’s very efficient in dissipating energy by triplets but open land, it’s very smooth so it’s not as efficient. So that itself will cause change in temperature and then the third component contribution is change of energy redistribution due to evaporation change or change of evaporation and that can go either way when you compare forest to open land depending a forest cover to open land depending on which one has higher evaporation potential. So that is the approach we use to study a deforestation and it later turns out that we have two prompters here,
one is this local climate sensitivity prompter which is more or less constant but this prompt F is energy redistribution factor. Some people have done quite a bit of work on this prompter and turns out this prompers more like a property of the landscape. So for example, this is a study by Bright et al looking at Energy redistribution factor for different ecosystem. This is evergreen needle-leaf forest, deciduous broad-leaf forest evergreen broad-leaf forest and this is a two types of crop lands, rain fat irrigated and this is grassland. Typically when you compare a forest versus the grass open land, you find the energy redistribution factor much high for forest especially for tropical evergreen broad-leaf forest meaning that they are a disturbance, just external sort of perturbation will not change his temperature as much same perturbation occurring over grassland because over or at this kind of landscape, the energy is can be dissipated very quickly to the atmosphere and therefore is more resistant to change in temperature,
and then later on TC from my lab did this calculation

mapping the energy redistribution factor across the globe
given the current distribution of vegetation types
of course and you find a high value in tropical places
and low elsewhere
and then Nighttime value is much lower
so there’s, when you look at tables
night contrast Daytime energy redistribution factors
is much higher than at Nighttime
meaning that same amount of changes
of a disturbance would cause much higher response
in temperature at nighttime than in the daytime.
So that kind of day and night symmetry
is also very important in the consideration
of how land use change affects the surface temperature.
So basically then we’d say okay well,
let’s just extend this to urban landscape right?
You’ve sent the urban landscape now
instead of contrasting for us was open ended.
We are contrasting a natural land versus urban land.
That’s the urban heat Island signal right?
And so you go through that little model you find
then you have five contributions
five factors contributing.
One is changing the albedo or radiation convection effect,
evaporation effect changing storage and change your anthropogenic heat.

So a few years ago, my former student lays out, did this attribution analysis based on
this model and then did a partitioning of urban heat island intensity
to and partition the urban heat Island intensity to different factors
and this is a very complex plot that maybe I should show you
I tend to just read this particular diagram.

This diagram is daytime
urban heat island on in situation for four cities
in East,
Southeast United States including where we are
and this is sort of wet climate.
So and this is the modis settling observed over here.
He did in intensity,
this a climate model calculate intensity.
This is the summation of the in individual terms,
individual contributions right?
So in the case of cities, this part of the world actually
Albedo effect is cooling
so contrary to what many people believe
turns out cities in this part of the country
our axe is brighter than the background,
but then the rural background is mostly forests are dark so the Albedo effect is cooling but what’s surprised us actually, is this connection effect right? It turns out in this kind of climate, this region urban land is not efficient in dissipating heat than the background forest land and so as a result of loss of convection efficiency you have an obviously a lot of warming. So it’s actually this loss efficiency dominates urban heat Island intensity, is much stronger than the effect of loss of evaporative cooling, right? So that’s the that kind of interpretation of the based on that model and so this kind of attribution. this kind of practitioner is obviously very important when you’ve tried to formulate a mitigation strategy whether you want to say for example, you want to change our Albedo or change in evaporating client trees by improving evaporation. So you can use this to help determine which one is more efficient whether Albedo of change or change of gray infrastructure.
or tangible green infrastructure which one gives you more cooling power. And then so that study was done prior to Google earth engine not always before Google earth engine error. So we’ve hand picked a 60 some cities and we manually select a satellite data and that was a lot of work right? But now we Google Earth Engine the marking of Urban heat island much easier. I just want to draw your attention to the work done by TC again, he used the Google App Engine to map out basically the urban heat island for all the cities in the world. You can go to this link and you can pick any city. I can then, there’s this interface allows you, this Explorer allows you to map out local urban heat Island and also variation of time change of urban heat island. You can go to this link and you can pick any city. Now let me switch gear here and speak about mitigation right? Mitigation and we know urban heat Island is not a a good thing, especially in hot weather conditions, it exacerbate the heat stress on our urban residents so we like to perhaps modified urban landscape to comeback, to control,
to reduce the intensity of Urban heat island. So this is a sort of a summary of the kind of strategies that people are considering right? One strategy is white roof, you basically convert a dark roof to replace dark roof with some kind of a white shiny bright material to increase Albedo so you then cool the urban climate. The other strategy is strategy promoted by the city of Chicago you know, putting green vegetation on rooftop like indicate this case is a City Hall and a third strategy is the one that our school used is to convert a rooftop to Solar Panel to cover the rooftop with Solar Panel. The benefit there is that instead of allowing radiation to turn into heat, you actually capture solar radiation and convert some of it into electricity and therefore avoiding heating the local environment right? So that would also bring cooling benefits. It’s a fourth approach is to use Street trees to help cool whenever you can.
wherever you can plant trees to cool the local climate.

So the question is which one is more effective, right?

And if so how do you quantify that before I do give you a solid quantification, I just want to draw your attention to this case in Chicago.

It turns out changing roof top albedo is not a theoretical concept, it’s actually been actively promoted in many cities,

city of Chicago was one of the pioneer cities promoting this idea, promoting this approach using a brighter reflective materials to help cool the local climate.

So he quantified change in urban out Albedo this is a work done by a former student of professor Ron Smith and myself.

So he quantified change in urban out Albedo in Chicago after 1995, after that notorious heat wave that kills a hundreds of people and turns out we can actually, we were able to quantify change of the citywide Albedo to help control the local urban heat Island.

The city Albedo has increased by a little bit by 0.02, but, so you can actually quantify, this is a homework exercise.
I’ll ask my students to do when they do my class, and this isn’t in my book, sort of homework exercise. You know the question ask, the question we’re asking students to do is that, when the albedo, if Albedo is increased by this much estimate how much temperature reduction you get, right? So you can basically go back to that model that I presented you earlier but now the situation is much simpler, you don’t need to worry about changing energy redistribution because we have not changed urban form. We all only did, only what we did was just to change the roof of Albedo. So you have that single prompter problem and if you put numbers together, you’ll find that the 0.02 change increase in Albedo would cause a cooling on average of 1.5 degrees Celsius. That could be quite important in the event of a heat wave. Now let me share with you the pertinent results, right? So, in the case of Chicago, there’s what’s really a local example and then we with lays work, we use climate models.
and in with fall, all kinds of scenarios considerations, climate consideration, climate scenarios also mitigation scenarios using our partition efforts. So this is a... Let me help you interpret this diagram a little bit. This is the condition for Mid summer day for cities in the United States average condition of all the cities in the United States, not also the 60 some cities in the United States. So this is, would be the current background temperature. You get on a hot summer, at summer noontime in rural background, okay? And this is then the urban temperatures here on a hot summer, in a future climate near the end of century, the rural background will be up here. And urban temperature would be up here. So we will forever residents, we were gonna expect this much of a temperature, right? We referenced to current rural background and so by implementing core roofs we are, we stay in the model, we change all the roofs to core to highly reflective roofs. We get this much of cooling,
that’s substantially right?

Basically you raise all the urban heat Island effect

and all some greenhouse effect

and then we say, okay, let’s plant street trees,

well, there’s only a limited space

for planting street trees,

but we planted street trees in the model anywhere we can

and also we change reflect your pavements

change your pavements to reflect your material.

So this is what we call additive effects,

it’s like the IBL from mitigation wedge, right?

People talk about when we talk about dealing

with greenhouse mitigation here,

you can use the same idea of a wedge idea

to see the attitude of strategies

for mitigating urban heat Island.

So in this is very aggressive scenario of course

we can raise all the Urban heat island

and greenhouse effect.

We actually have some additional cooling

of course, it’s highly idealized and real world,

we cannot achieve this maximum cooling

but it’s instructive to show that indeed

a core roof Australia is much more effective

than street tree or reflect your pavement.

So spatially, this is what this looks like, right?

If you don’t do

any change to the urban landscape at the end of the century
you will still have a lot of urban heat Island. This is circle, warm color circles indicate Urban heat island. We have a few cities that actually have cool like Island indicated by the cold color, they never that’s on average, you’ve got quite strong urban heat Island but if you use EPA white roof everywhere in this cities, you actually now have a cold Island almost across the whole country. This is of course in a Daytime situation but the white roof does not work as well for nighttime obviously, right? White roof works because it reflects sunlight in the daytime but at nighttime there’s no sunlight took to stick off so you don’t get much of a benefit at nighttime. So that still would be still is an important hurdle to overcome how do you call a nighttime temperature? The white roof would not be an effective approach for that. So that the calculation is done really theoretical right, in the theoretical calculation and we don’t really get a sense of the kind of change we are calling for, the change Urban land form is really substantial.
If you really want to follow this strategy, I’ll be implementing white roof everywhere. So for that, we decided to well the triplets, do some visualization. This visualization is based on sense fly a data source sort of drawn data collected by this company over a neighborhood in a city in, I think in Switzerland and so we then use this to it to some animation. Let me see if can turn the animation over here. It does not, let me see way by control here. Okay there it’s go So this is the current landscape, right? We’re doing a fly by as if we were a bird looking at the landscape from different angles. It’s a very pleasant landscape, you know, have a dark roof green lawn and street trees and then we say, okay well, we’d like to change this landscape because we are very concerned about urban heat Island. So we then, we can artificially digitally alter the roof material a white shiny high albedo material and then we’d do a fly by, right?
So that, this is kind of landscape we are looking at if we do implement that white roof strategy and of course, it’s this very alien landscape, we are not very used to, a lot of people criticize us for saying that because they said, this is not a pleasant landscape to a city to be in and pass maybe you wouldn’t be detrimental to pilots because they can’t see the ground well and maybe they will get blinded and maybe they will get blinded by the Brighton yourself the roof. But anyway, so that's obviously a big change we need, we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expecting we will be expectation
So strictly you should, we should be using some kind of combined index, index that can combine both air temperature, not surface temperature but air temperature and also air humidity so that a perspective from the thermodynamic person, turns out the best way of measuring the combined effect is to use one called Wet-bulb temperature, in meteorology, this is how we measure Wet-bulb temperature, right? So we cover the thermometer with some kind of Wet cloth allowing the surface of the thermometer to be wet all the time and so, and allow the evaporation to occur at the surface and so the temperature you imagine that this situation is Wet-bulb temperature and so that’s a thermodynamic parameter that meteorologists use a lot to characterize the thermal environment. It turns out though in a hot environment sweating is obviously is a way, it’s the only way actually for us to maintain low skin temperature, a person who is sweating a lot can be considered essentially a big wet bulb cause we assume the body is exposed,
no clothing and the whole body is covered with sweat
so analogous to a wet bulb.
So then you can use wet bulb temperature to see the effect
of heat stress on human body
and as I said earlier
to stay alive
just to survive hard environment
we need to maintain a two degree difference
between skin and a deep body temperature
so that our body can dissipate heat
to the environment right?
But then it turns out if the We-bulb temperature
of the environment goes beyond 35 degrees,
we cannot, we wouldn’t be able to be able
to maintain a two degree difference.
Our skin temperature would be higher than 35 degrees
and if we don’t have air conditioning.
So without air conditioning we cannot survive
when external environmental temperature
goes beyond 35 degrees.
That’s really the physiological barrier
the limit that you know, determines the survivability
or habitability of the law of the environment.
So we are knowledge high trying to come up with a strategy
of studying using a wet bulb
instead of the surface temperature to quantity that’s undergoing a new project, it’s a collaborative project happening here at Yale, it’s called Biking for Science and Health and so the idea is that we can use bicycles to help out map out temperature and humidity across urban and rural landscape and use that as a way of collecting data to validate a model calculation of course the project or the objective of this project is much broader than only measuring temperature. So the broad objective is to integrate smart sensor technology with public bicycles or maybe private bicycles as well for urban environmental monitoring so T-Mobile for scientists including professor Dubrow as part of the team and so this is that the idea right? So we, what we want to do is to convert bicycles into measurement platform either volunteer cyclist bicycles, planning to volunteer cyclist or public bicycles. So and then, the smart sensor would sense the environmental conditions temperature humidity and in the future, we also want to measure air pollutants
and so the sense of what, then you turn a cyclist smartphone
into some kind of geolocation and data collection device and that data can then try
and get transmitted to some kind of a server to allow
then in the case of public bicycles the data will be automatically transmitted to a data server,
and then the data server would then dispatch data to different users
and so that’s the idea.
So we are having some success in terms of designing a sensor,
a smart sensor for temperature humidity.
This is a patch of smart temperature humidity sensors,
very small and this is a picture
of all this smart sensors calibrate it against commercial sensors right?
(indistinct)
This is, oh sorry.
Before I share with you some data,
this is the kind of sensor right?
It’s very small
or this is the interface, smartphone interface
and this is to give you a scale of the sensor,
a cache to the bicycle handlebar
and so I’ll show you that the idea we have
is to recruit volunteer cyclists
and eventually we can also implement sensors
on public bicycles but in case of volunteer cyclists we are hoping, we are defining sort of kind of data interface. This is work by TC and Yichen interface to so that when the data is sent to some kind of data center, the cyclist would receive a link. The link then allows the cyclist to view the bicycle route as well as the conditions, temperature condition and humidity and maybe in the future also air quality parameters and along the route by spiked we are still having trouble with the color scale yet but if this is the kind of general idea, right? And so you can actually look at data, put the data this kind of spaghetti plot under different map background. This is just pure simple map background. You can put it in a, you know, satellite background map background or you can put down in street map background. So this is not place still very much a work in progress. So I was up here and see if we have questions.

I like leave some time to engage. I was discussion and questions. Thank you very much.
Thank you, (indistinct) for the wonderful presentation.

We do have a lot of questions from the students. But if people, if you have your own questions, please type your question in the chat box while Dr. Lee was answering to the students’ questions.

So the first question actually don’t be you showed a very very interesting with us about them, why the core roofs and I had received a lot of question from the students asking about the comparison between a white roof versus a green roof. They were particular interesting in whether, what do you think about like the disadvantage of the white roof compared to the green roof? So my White roof is not very pleasant, right? You don’t like that in your neighborhood and if I showed you with that, a drone sort of animation the landscape’s not that pleasant to look at but in terms of cooling this surface climate, white roof is much much more effective than green roof.

I’ll tell you why, in green roof, you have to, first of all, it’s very difficult to plant trees on a roof right? So trees tend to sustain evaporation much more.
than than shrubs and so, but if you just planted shrubs and grass on rooftop, you have to constantly irrigate them in order to get cooling benefit and then your irrigation is not easy especially if you have a tall buildings and think about pumping water up to the rooftop and irrigate right? So that’s itself is a very energy intensive endeavor. So absence of the radiation green roof really won’t do much to the local temperature but I should have knowledge of obviously green roof is much more pleasant right? It’s maybe has other benefits beyond just cooling the local landscape. So that’s a debate obviously that’s people should, that aspect should be considered when you look at a white roof versus a green roof. So if you look at the cooling power street vegetation is more effective than green roof. So you’ve put green roof here, the effect is really tiny compared to a quarrel for white. Thanks, I think we will get more questions on these from the audience,
but I will move on to the other question from the students.

The other questions students are wondering is like

you introduce us about the concept of urban heat Island

and students are wondering like a lot of the mitigations

we take for the urban area that’s that has also impact

for the adjacent rural areas.

Like if we do all these, why move

in urban area, does it also like

simultaneously reduce

the heat exposure in the rural area?

- Yeah, that’s a very good question.

I think, so that really the question maybe can be brought

in a little bit to say that’s changing urban forms

whatever way does the have effect

on regional climate or even global climate?

Right?

The answer is probably no,

because we are we are talking about change,

intensive changes that’s

but the intensive change,

is only occurs in a very tiny fraction of the landscape.

Urban land is what 2% of the whole terrestrial land surface
and so, and in that we have intensive modification
that intensive modification will manifest itself
in localized response but outside of urban area
that the benefit is really really not that bad.
So the answer is probably, no,
unless we are dealing with like a huge metropolitan region
maybe in India, where you have clusters of cities,
a lot of cities cluster together
maybe then there, you might have some effect
on background temperature.
- Thanks, I think, yeah.
I think if we got a follow up customer
regarding the green roofs
so they were asking one of your paper,
The Jaw and The Shoes article,
in that paper, there’s mixed implementation
of the white and green roofs
and the given the green roofs lead
to increase the evaporation
and likely increase humidity with wide roofs
and green roofs have under
donor’s state effects
due to green roofs contributing to the Web-bulb temperature
- Yeah, yeah, that’s an excellent point
and so if you take that humidity into consideration
you probably don’t actually,
you want to avoid a green roof
946 00:49:50.050 --> 00:49:50.970 because green roof
947 00:49:52.590 --> 00:49:55.470 on one hand you will reduce the air tempera-
948 00:49:55.470 --> 00:49:59.780 but on the other hand, it will increase humid-
949 00:49:59.780 --> 00:50:03.290 So the reduction air temperature could be
totally erased
950 00:50:03.290 --> 00:50:06.070 or the effect of temperature reduction could
totally raise
951 00:50:06.070 --> 00:50:08.910 by enhanced humidity factors.
952 00:50:08.910 --> 00:50:12.430 And so, and of course in this analysis,
953 00:50:12.430 --> 00:50:14.710 the solid dollar analysis
954 00:50:14.710 --> 00:50:18.070 we have not brought in the concept of wet
bulb,
955 00:50:18.070 --> 00:50:20.150 but if we bring wet bulb into consideration
956 00:50:20.150 --> 00:50:23.133 that may be an argument we should consider
seriously.
957 00:50:24.896 --> 00:50:27.180 - Yeah, I'll also from the audience
958 00:50:27.180 --> 00:50:30.823 a question regarding the implement of the
959 00:50:32.119 --> 00:50:34.450 core roof policy,
960 00:50:34.450 --> 00:50:38.140 have you considered whether you paint all the
roofs white
961 00:50:38.140 --> 00:50:41.367 or use how they are scattered
962 00:50:41.367 --> 00:50:43.710 painting within the city?
963 00:50:43.710 --> 00:50:47.770 So do you consider the difference of the paint-
ing
964 00:50:47.770 --> 00:50:52.270 depend all the buildings, all you does a scat-
tered because.
965 00:50:52.270 --> 00:50:57.270 - So in this calculation, we except hypothetical
calculation
966 00:50:57.370 --> 00:51:02.370 we just combine all the routes to a high Albedo
material,
967 00:51:03.400 --> 00:51:06.410 in actual implementation I think you cannot
do that
968 00:51:06.410 --> 00:51:08.980 because there's no point actually doing
a one size fits all situation

because if you have North facing roofs right, then the deflections doesn’t matter as much

I saw spacing roof.

So maybe you need to differentiate North facing versus South facing roofs.

In the city of Chicago, they actually have grades, if you have very steep roof, they ask you, they recommend certain kind of Albedo values when you have less steep roofs, they recommend other kind Albedo so he said, it’s mixed of strategy.

By now all lot of cities actually aggressively promoting spokes, those kinds of reflect humid roof materials. - Thanks, I guess the audience and the students are very interested in this topic though.

They have accurately both the students and audience ask a question regarding have you ever considered all these heat Island mitigation matters? They may have some side effects on the air quality so how you kissing that in your own modeling?

- Yeah, there’s a...
So people say maybe for white roof material implementation it’s best to it in clean cities where there’s no, air quality is not a big concern in proagic cities When you put in a white roof, you can change the way that the structure of the boundary layer essentially what happens is if you have a white roof you are not heating the low atmosphere as much. You’re reflecting a lot of sunlight away without us to the upper atmosphere and to the outer space, right? So what happens then is you end up with a shallow a boundary layer but there’s less mixing power, less mixing volumes, so you end up with higher air pollution concentration. So that’s the, it could be a serious societal effect especially imploded seedlings. So that’s another, this the harm you could say perhaps caused by air quality. That’s a very good point. Thanks, another aspect of the students are wondering like you showed a little bit about the different like riddles from the satellite,
from the modeling and the students are particularly interesting in wanting these kind of modeling.

So how can you actually simulate the interactions with the global warming and also all the biophysical drivers of the urban heat Island in the continent models?

Okay, so in the climate models right, a lot of models don’t actually have what we call a city landscape that so, but the the model we use have what we call subgrid parameterization, so within each Greek cell you have different parches for that type of land so some great cells were contained urban land tile, urban tile and some would have no, if there’s no urban. So this model actually can calculate within which is great cell, temperature, humidity, and so on within for each tile. So typically when you download a data though, the data is aggregate to the Greek cell that was so you don’t see subgrade kind of a pattern. You don’t see a subgrade pattern but we are able to re redo the calculation and retrieve data within each Greek Model grade data.
for vegetations tile and offer urban tile. So that essentially set up the problem for us to have to do then compare those subgrade tile data to get the urban heat Island calc apart from the climate models. That’s how a client model handles landscape heterogeneity within a model grid cell.

Thanks, I think due to the time limitation, final question is the students and audience are very interested that in like, what’s your recommendations for our daily life in as an individual, is it more eco-friendly to have solar panels or have a quarter of a solar. Solar panels are very interesting, right? You need to do a very sort of a careful calculation, to look at the benefits. So solar panel dependent if it’s true false for why is that you, like I said you convert a local solar radiation to electricity and in doing so, you don’t heat the environment, you don’t allow radiation to heat the environment but the commercial efficiency is not very high. It’s not as high as reflection by core roof.
So on its own, you would say the cooling benefit of solar panel is not as high as core roof, but then you have an added benefit of electricity generated by solar energy right? So you offset the demand for fossil fuel energy. So that benefits more broad modular views is you’re offsetting energy demand for fossil fuel and therefore you cool the whole club global climate. So there’s that, there’s a benefit to that so that you need to consider both sides local Coolig versus global cooling versus and offsetting energy and so that’d be a hard subject that need to be debated, right? But I think if you are, if you want to conserve your electricity bill, if you want to reduce your electricity bill in your house that you’re, the best approach is actually having a core roof. If you have at a core roof on your rooftop, then the demand for AC will be substantially reduced. You will have a lot of electricity saving in that way. That’s has to be demonstrated by a lot of people actually
One fourth session.

Thank you for all the insightful discussion and also the presentation.

And with that, I think we thanked Dr. Lee for this wonderful presentation.

I thank you all for coming for our seminar.

Bye - See you guys.