Canada-United States Law Journal

Volume 44 | Issue 1 Article 5

6-1-2020

Opening Lecture - Climate Chage: The Facts

Dr. Eugene Takle

OPENING LECTURE –

CLIMATE CHANGE: THE FACTS

Speaker: Dr. Eugene Takle

DR. TAKLE: Thank you for those kind words. So we are going to jump right into the background, and not being presumptuous in that you studied this, you have probably seen fragments of this, but I am trying to pull this together, the core of why we understand climate change and the significance of it. So I am going to be going in two sections here.

We'll look, first of all, at fundamental science, and then we will look at some of the issues and impacts so we can look at some of the factors that are going to be driving the impacts and things that we have to think about trying to develop resilience to, because some of these are going to be very serious, and we will get into that.

We have a lot of good foundational documents to draw on, to look at both the science and the impact. So for instance, the intergovernmental panel on climate change issues, which is about every five years, state of the climate on the global scale and an update on the science of climate change, and so we have the 2004 issue of that.

And then, we have national documents that parallel the international document. The one for Canada is put out by Natural Resources Canada, and so that's an updated document that you have at your disposal. In U.S., we have two documents, one that was issued about a year ago which covers the science of climate change. So it is just the IPCC document and then updates and focuses on the science for the U.S. And then, the one that was just issued the day after Thanksgiving was the fourth national U.S. climate change assessment, and I was involved in that one as well.

So we will look at some of the fundamentals of why we have this issue, and then, we will look first globally, and then we will look at North America and a few words about the Great Lakes. Well, the clim -- when we talk about the climate system, we are really talking about land, ocean, atmosphere, and ice masses. Those are the four components of the climate system, and energy moves between these and among these reservoirs then.

And so to understand the climate system, we have to understand how energy and mass is moved among these reservoirs. So ice melts, and it takes energy to melt ice. So part of this increase in energy that we are seeing is used to melt ice. And so that's the way we look at it.

We use the same laws of physics to build airplanes, to build nuclear power plants, and we have confidence in these laws. Because we ride in airplanes, we have confidence. We can live in the vicinity of nuclear power plants because we know -- we use the laws of physics to design these. These same laws are used to look at our climate.

Now, there is a lot of uncertainty because the climate system is a big system, and we need a lot of observation. So there is a level of uncertainty, which is also a part of our science, to quantify our level of confidence in these various statements that we make.

And so when you read these documents, you will see references to how confident we are in the results. Well, there is ten indicators, at least ten that we can look at, and so this is just warming of the globe, but it is sea surface temperatures; it is sea level; it is water vapor in the atmosphere, just going up in the warmer world. The near surface, the lowest two, three miles of the atmosphere, we look at the temperatures of that.

We look at glaciers that are melting. Snow covers are going down sea ice is going down; look at temperature over land, and a very important one is ocean heat content, which doesn't give it much attention, but 90 percent of the heat that comes into the climate system goes into our ocean.

So that's a reservoir that is sitting there, waiting, and could be redistributed in ways that we are only beginning to understand. So that's an important factor in the climate system. So the basic concept, then, is that they meet the greenhouse house, and it is a natural effect, and we are glad we have that because that's what keeps us from having global average temperature of about minus 10 degrees Celsius, or something like that.

So it has a blanket of these gases, mainly carbon dioxide but also nitrous oxide, methane that trap some of the heat and keep it from going back out to outer space, and so it is redirected toward the earth.

Now, what we are doing is we have increased the levels of carbon dioxide, methane, nitrous oxide, and other gases to the point where more of this solar radiation is being trapped, and that means that the temperatures in this vicinity are rather small.

Now, it is always important for me to point out that this cartoon here shows that we have this big thick layer here. In fact, if the earth was the size of a basketball, this layer would be the thickness of two sheets of paper. That's all it is. And it is that thin sheet, and there are two gases: There is carbon dioxide and ozone. If it weren't for those gases in that thin sheet of atmosphere, we couldn't survive. People could not survive.

Lack of ozone means that the ultra-violent light would fry us. And carbon dioxide, not having the right amount of carbon dioxide, means that we know we could not exist. So this very thin sheet of atmosphere is what we are doing, is a gigantic chemistry experiment. Well, we don't know the outcome. So that's the sobering reality of it.

So if we look at carbon dioxide, which I am going to focus on carbon dioxide, but we will talk a little bit about the others, but carbon dioxide, if you look at the record and it is hard to see from where you are at, this is an 800,000-year record. So it goes back 800,000 years, and this is the present.

And you can see that over that time period carbon dioxide has never gone above the blue line. The blue line is 300 parts per million, and so about 1,900 with the industrial revolution having begun 120 years earlier, we introduced a lot more carbon dioxide in the atmosphere. So it went up to about 300 parts per million.

Well, about a year ago we finally got up to 400 parts per million, so we increased the carbon dioxide, this key gas that regulates the heat of our planet. We raised it by over 35 percent, and it is going up.

There is no sign that it is going down anytime soon here, so we are now up here at about 400 parts per million. So here is sort of an iconic figure that is often used to show how the temperatures on the planet have changed. And this is a case from 1880 to 2018.

So we can see there has been variability over the -- from year to year, but then starting in about 1970, we started on this upward trend of very monotonic upward trend of fluctuations with year to year, even with decades -- there will be a decade that will have an average that maybe haven't gone on quite as much as some decades as others but, generally, upward rise.

And with our model is studies, we know that it is these greenhouse gases, the increase of these greenhouse gases that are the cause of this rise that we are seeing now. You can say, well, maybe it is natural variability. Well, let's look at natural variability.

There is the impact of volcanos in the last 60 years. We have had three major volcanos. We have Mount Agung, 1963; Mount El Chichon in Mexico, 1983; Mount Pinatubo, Philippines in '91, and you can see every time we have a volcano, we see a drop in the global average temperature by about one or two degrees Celsius. It drops, and then it gradually comes back over a period of about two years, back to whatever the pre-existing trend was.

So it has a temporary effect by putting lots of particles in the atmosphere that reflect more solar radiation, so it forms kind of a shield or a reflective area, but it is transient, and it does not have a long-term effect, but it is important nevertheless.

We also have El Nino events or ENSO, E-N-S-O, which is referred to down here, which the El Nino and La Nina is a combination. El Nino is an event where the tropical Pacific ocean, for reasons that are not fully understood, goes through a warming period, which may last for a few months to maybe even a year, and during that period, this extra warming we get in the tropical Pacific has a global impact. It causes the temperature to rise.

And so we see every time we have an El Nino we see a spike. It may last a year, it may last even a little bit longer than a year. I should point out I haven't listed all the El Ninos. I just listed some that demonstrate what a strong El Nino can do. But nevertheless, that's part of natural variability.

Now, if we also look at the La Nina, which is the opposite effect -- that is a cooling of Central Pacific -- it also has a global effect, and so you see that for the blue arrows, every time there is a blue arrow, you see there is a decrease in the global average temperature, again for maybe a few months or maybe it will be for a year.

So this, then, this is a measure of some of the natural variability because a lot of the climate sceptics say, well, it is just natural variability. We have natural variability, but look at the scale of natural variability versus the scale of the greenhouse gas extra greenhouse gases that we have introduced. So science is clear.

We know the thermodynamics well enough that if you put heat into a system, the temperature goes up. And so that's what we are doing, and that's what we are studying here, and these are the consequences that we have.

And so we have to conclude, then, that there is really no known natural phenomenon that is influencing our global and regional climate on scales of a century that is as large as the influence caused by emission of these greenhouse gases.

I am going to talk today also about carbon dioxide, but let me just say a word about methane. Methane is about 20 times as potent as CO2, but its concentration is a lot lower, about a thousand times lower. However, it has a short lifetime.

So if we are making policy, one of the low hanging fruit areas is reduction of methane. So that may be something to think about. The sources of methane as to sources are from animals and fermentation in animals, cattle, dairy cattle, goats, beef cattle primarily, also from natural sources of wetlands, landfills, rice cultivation. These are sources of methane, and we have some and are doing some work on those.

Diets of animals can be twiddled to reduce the amount of methane produced and so on. Nitrous oxide is a very potent greenhouse gas, about two or three times as potent as carbon dioxide but, again, even in much lower concentration, but it results from agricultural activities and some other sources that could be addressed also, should be addressed as we look at all options for reducing greenhouse gases. Let's look at the consequences.

The observed -- this is the observed surface temperature, 2001 to 2012. We don't have data on the polar regions over that region of time, but you can see that the warm spots are primarily in the northern hemisphere, high latitudes, and in some areas in South America, so we have good evidence that the planet is warming. Only there are a few regions that actually cooled over that period of time.

And we know pretty well why those are occurring as well. Precipitation over land, same period basically or actually two periods here. If we look at the whole period of 110 years, you can see there has been precipitation increases as would be expected in a warming climate. You have more heat, you are going to evaporate more water, you are going to have more humidity in the atmosphere, and you are going to get more rainfall. So you just speed up the hydrological cycle. You see it has been intensified and polarized more in the last 50 years. We have seen that the eastern half of the U.S., the eastern half of North America has seen increases as have the northern parts of Europe but also the dry areas have gotten dryer.

So again, kind of a warning sign, a heads up that some of the extremes, the wet regions get weather, the dry regions are getting dryer, and we have to look at populations that are influenced by these regional changes.

Other changes that have been observed, snow covered in the northern hemisphere is going down. Arctic sea ice we will come back to that. That's also going down dramatically. We will come back -- this one also, ocean heat content is going up.

As I mentioned, a lot of the heat is coming from this track and like greenhouse gas, it goes into the oceans, and sea level is rising, and we will come back to that. So let's look at ocean heat content.

These are huge numbers. This is 10 to the 21st joule; another: One zettajoule, that's a new one. We have gone from megabytes to terabytes to exobytes and petabytes, and if you go out a couple more, you get to zettabytes. Well, this is zettajoules.

But at any rate, you can see that your ocean, the lowest or the upper 2,300 feet is warming quite rapidly. It went up abruptly, rapidly at the beginning of the 21st century but also now the deep ocean is getting involved. And so heat is being distributed through the ocean.

And we don't really know what the consequences of this continued warming of the oceans are. It is certainly going to change the overturning. One of the worries is that we might slow down some of the global ocean circulation that moves warm air from–warm water from the tropics to the polar region, so we may have some changes in the Gulf Stream, for instance, which is a major source of moving heat from the tropics to the poles.

The northern hemisphere, sea ice, our observation period here maps on to the satellite period, so we can see that there is a substantial drop in Arctic sea ice, which is continuing, and we will see a projection of that in just a minute. So looking at Canada, now, this is a bit washed out, but these are observations in Canada. So this is temperature, so these are the proprietary provinces here, the Arctic up here, and you see that there has been some substantial warming in the West.

And you can see there is kind of a heads up about forest fires and so on in that region, also some warming in the southern provinces. Overall average mean temperature has gone up substantially in the last 60 years. If we look at precipitation, we also see that coastal areas have had precipitation increases, and so some of the flooding has been seen there in Alberta here, had some major flooding in recent years.

Overall, again, there is a rise in precipitation over Canada, and this -- and Arctic sea ice, shows both a summer demise of sea ice but also even in the winter. In March, they ended a cold season. You can see that even the extent of ice has gone down during that period.

Great Lakes, the Great Lakes, of course, it is the largest fresh water body, about 20 percent of the fresh water surface area, and it certainly plays a role in the economy of the Midwest for shipping, industries, water supplies, fishing, recreation, and so on, but it is under siege now because of the stress from pollution, nutrients, indicia and sediments from agriculture systems, and also invasive species are becoming more problems moving forward.

Let's move into future climates. So if we are talking about future climates, first of all, we have to consider it is going to depend on greenhouse gases are going to be in the future. Are we going to adopt a really good renewable energy future that reduces the amount of fossil fuels we burn, or are we going to just do business as usual?

If we do business as usual, we follow this red curve here, and you will see this RCP, the radiation constructive pathways, that can go from very low emission of carbon dioxide and greenhouse gases to a very high.

So 2.6 is low; 8.5 is high, and you will see that referenced in some of the scenarios that I have applied here. So if we go ahead and continue this, then we can expect the global average temperature to rise between 4 and-a-half and 5 degrees Celsius, way beyond where we have been with temperatures on the planet in the last many centuries.

If we adopt a 4 -- say a 4.5 scenario, that's the blue, then we would be able to keep it down to about 2 and-a-half. But the agreement that was reached in Copenhagen -- and I can't remember the year now -- but there was an estimate to what would be a guardrail that we could set, and that was -- that we would not have major impact on water supplies, agriculture systems, natural systems, and that was estimated to be two degrees Celsius.

Well, we don't have much head space even now so if we are going to keep the planet more than what has been estimated to cause major interference with a natural climate system, we have to get on with this battle to reduce greenhouse gases. So let's look at some scenarios. These are from the IPCC reports.

Here is a low output scenario. Here is a high emission area. You can see generally we are seeing that the Arctic regions are going to warm much more than average on the scale upwards to 10 degrees Celsius, very large rise, enormous impact on ice masses, and if we start to warm and start to melt Greenland, we could go into an irreversible condition there that leads to a melting of Greenland over several centuries, very worrisome scenario.

Precipitation, we see that precipitation is likely to increase. Primarily this is percent wise now, so if it is small and you double it, then it doesn't lead to a big increase in absolute amount but a big increase in percentage wise, but however, it does have a big impact on the polar regions, and also some tropical regions would likely be impacted strongly.

This is sea level, and sea level rise generally would be expected to be on the order of close to a meter, a little less than a meter. If we look at some other factors, also again from the IPCC -- by the way, I will give you a copy of this or get it from the conference organizers, the citations are all listed in here, so you know where they come from. If it is not listed, then it is something that I created, so -- but here is then the two pathways, that if we follow this 2.6, RCP 2.6, you see that we can make this temperature level out by the end of the century.

However, if we go business as usual, we will be about in this 40 Celsius range. If we look at sea ice extent, the only way we can keep sea ice from disappearing in the summer is to adopt this very efficient strategy of low caliber emissions in our future. Otherwise, we are going to lose our Arctic sea ice by 2060 or 2070.

PH, the ocean acidity is often overlooked, but it has become a very important factor, too, now because some of this carbon dioxide is dissolved in sea water, and so it raises the acidity or lowers the pH of sea water, and that's -- we are already seeing that the warming and the acidification in the oceans is having an impact on coral reefs, very sensitive structures in our oceans that lead to a lot of very rich and diverse ecosystems in shallow and coastal areas, but they are already being affected.

So here is some simulations and looking at the pace of climate change -- and these are simulations by the Canadian center for climate modeling and analysis, and I want to point out that we have very, very good relationships in the scientific community between Canada and the U.S., and these go back a long ways.

My own group that out of state we have worked with the Canadians -- and Michael might say a little more about that this afternoon -- but a team that works directly with stakeholders to say what is it that you need and what kind of climate products can we generate to help you make those decisions, very good people to work with, and we worked with them back in the late 1990s.

But this was not from -- it was from the climate modeling analysis center, but it shows you the trend, and you will see how the warming starts in the Arctic regions and progresses down, just works its way down through the whole continent.

If you go on this website that is listed there, you will actually get this as an animation, so you can just -- it marches through year by year, and you can just watch it progress. It gives you better insight as to how and where these are going to be -- that's three minutes. Okay. Well, we will big time. Okay.

Precipitation, these are from the group that I work with in the U.S. showing precipitation changes that are expected by the end of century. This is a high-emission scenario, but you see, again, precipitation and projected increase pretty substantially in the Arctic area, but also we are seeing continental drying in the summer that is going to be problematic for -- particularly toward the end of the century with regard to agriculture, and we looked at this in the Midwest.

Let's look at some other impacts of, for instance, heat. Projections are with a high emission scenario in some regions of our country are going to see on average over 120 days with temperatures about 100 degrees Fahrenheit. When you consider water supplies for Las Vegas and Phoenix, you have to consider that this is what they are going to have to provide. This is what the outdoor environment is going to be, pretty sobering.

If we look at one of my colleagues out of state, Craig Anderson has looked at heat and violence, particularly assaults and murders. Now, he separates those from non-violent, the car thefts and petty theft and so on.

Assaults and murders scale upward with temperature increases, a very distinct – looked at many populations. There is an increase in violence with temperature. There is no increase in non-violent crime, but there is with violent crime. So that's something we have to consider, particularly as we move forward, and we find that some of our heat waves, five-day heat waves are going to be much larger. This is something we looked at in the 2018 climate assessment of the impact of heat waves.

I don't have time to talk about that now, but sea level rise, we could be seeing on the order of a meter rise in sea level by the end of the century. A meter rise in sea level would take out these areas, would inundate these areas in red, so we would lose the Keys, lose Cape Canaveral, and many of the favorite cities here in the winter would be inundated, so we have some real challenges.

Miami is already looking into their problems in sea level rise. The military has a hundred billion dollars at risk, naval facilities only for a rise of sea level of three feet, one meter, so the military has a big relocation problem on their hands. This is something we better start planning for now.

This is the kind of thing that we get, this is Iowa, this is not the current year, but we are seeing a flood now in progress right now as we speak. It is estimated already to be over a billion dollars in damage just this week. Here noteworthy, this is an Iowa town downstream of Cedar Rapids. Here is a hog confinement facility. Here are grain storage facilities, so it is not just people that are at risk; it is our storage; it is our fruit supply; it is animals that are under confinement that multiply the effects of these events, which now are at historic levels.

Great Lakes, what's going to happen there? Well, what we have observed so far is there is lower ice cover in the winter, warmer summers, more frequent, more intense storms. Water levels are influenced by warmer air temperatures and drought and changes in precipitation pattern.

Also very important is that, as the warming progresses, it changes the cycling of the water, and so it changes the transport of nutrients from deep water to the surface, and so that has a profound effect on ecosystems. There is a natural cycle, an annual cycle of about a foot or so, and the historic highs and lows are about a five-foot difference.

If we look at projections for the future, we can see about a six to seven-degree Celsius rise in surface temperature by 2100. They will fluctuate at a lower level probably, more widely around the lower mean, and there will be a decrease in the ice mass.

If we look at some of the economic and social disruption we have already seen -- and this is the 21st century, so these are all since 2000, this is Canada -- you can see here they had a billion-dollar flooding event in Alberta

In 2013, and others, primarily hurricanes, tornadoes, flooding, wild fire and wind storms. If we go to the U.S., we see the same thing. This is just 2018 alone, one year, $14 billion in economic damage: Wildfires, flooding, we have drought, tornadoes, storms, hurricanes.

And so if we look at the changes that we have seen here, this is 1980 to 2018, the big ones, up here in the $12 to $16 billion dollars have all been since the year 2000. So we are in a different realm. We have got to start planning for this. We have to develop resilience policies that will enable us to avoid this kind of economic disaster.

And so, finally -- and my last slide here -- is climate change hotspots. This was work done by a colleague of mine, Filippo Giorgi from Italy, looking at regions around the globe, which, according to this regional climate change index, he has developed where there's a big red spot, it means there is a big climate change, and it is important to recognize that our societal structures are all tooled to the global climate that we have had during the 20th century, the rainfall patterns, the temperature patterns, the seasonality and so on.

Now, those are all changing, which means that the agriculture that we finally tuned for a particular area is going to have to change. You raise soybeans in Iowa, the center part of Iowa, you take those soybeans and put them in Minnesota, they won't grow well. They won't produce because it has been so finally tuned for that specific location.

You can find your favorite structure of society, that also is very finally tuned. So we have to start thinking, and as I just pointed out that what's going to happen, then, when we have people in these high impacted areas, what are they going to do if their food supply is being threatened or as was the case in Syria, two back-to-back droughts, led to people migrating to cities, overwhelming city services, and leading to unrest and terrorism and so on.

So in summary, science is clear, climate change is real, it is already here. It has had a negative impact on our society, both of our countries. There are some aspects of climate change that we are taking a benefit from, and that's good, but they are not going to last. The projections of future climate scenarios point to costly impacts on infrastructure, forest and agricultural productivity and health and societal instability.

Thank you very much for allowing me to speak to you.

(Applause.)

MR. PETRAS: Thank you very much, Gene, for that very interesting report. Does anybody want me to turn the heat up in this room right now? We have time for, let's say, two questions for Dr. Takle.

Peter Mackay?

MR. MacKAY: Thank you very much, Doctor. Fascinating presentation. One of the things that you said that struck me as quite stark was this increase in violence, and clearly, you have the data that shows this, but can you unpack that a little further and attribute why that is having that particular effect?

DR. TAKLE: Yeah, yeah. Craig Anderson, a colleague at Iowa State, did this, a paper published this present year, just a couple months ago, and he shared some of this information with me.

Now, he has just used annual temperature, but we -- what we need to do now is to look at heat waves, specific heat waves because we know that it is a five-day period, or it is day after day. That's what really gets to people. You can usually take one really hot day, but it is these extended periods.

And so what they have done is, they looked at -- they looked at various cities, and they have made the corrections for demographics, for different factors that anyone would say, well, people are just more outside in the summer time.

They made corrections for that, and they teased out the climate-only factor. I am not an expert on that, but I can point you to the literature and help you work with that.

MR. PETRAS: One more question.

Terry Fitzpatrick.

MR. FITZPATRICK: Dr. Takle, I am not sure if you ever heard of an author by the name of Tom Nichols called "The Death of Expertise." He is a professor, I think, at the Naval Academy.

He talks about the skepticism in our society of experts and the fact that the irony of the fact that with all of the different means that we have of getting information out through the internet, that people are actually becoming very much in their silos just getting things sort of confirmed, the biases that they have.

I was just wondering if someone like you has any ideas how the scientific community can communicate or policymakers can communicate more effectively with people to try to get these facts out there to overcome some of the skepticism that we have.

DR. TAKLE: Yeah, that's a question we recognize that we dropped the ball early. We were not communicating early, and we were too focused on our own research, but the facts -- people will -- when you present facts to people, they will back off, and they will go to further and further away kinds of arguments.

So it basically then comes down to what is known as personal beliefs. It could be based on religion, the God that I believe in wouldn't let this happen to us, but we can't do scientific research on that. That's not something that is fact checkable.

So then, we are kind of left there; that they just -- they are presented with all the facts, and they are not -- we are seeing this with vaccinations; we are seeing it with pasteurized milk. You know, it is just a part of the society that we live in, that experts and science is not held in high value the way it used to be.

MR. PETRAS: Thank you very much, Dr. Takle, appreciate it.

(Applause.)

MR. PETRAS: Dr. Takle will be available, and he is staying here at our conference throughout the day, so we can ask him more questions. Well, to try to get back on track as quickly as we can, we are going to call up our next panel. If we could have Consul General Comartin; next is Mr. Blanchard, Mr. Peterson, and Minister MacKay, please come forward.

(Pause.)