Thank you all for standing by and welcome to our first webinar this fall entitled "Exploring Snowfall in the United States". [unclear :13] an initiative of the Ohio State University climate change outreach team, a multi departmental effort within the University led by OSU extension Ohio Sea Grant Bird Polar Research Center and six other OSU departments to help localize the climate change issue for Ohioans and Great Lakes residents. I'm Christina Dierkes from Ohio Sea Grant and Stone Laboratory stepping in for Jill today, and joining me today is Dr. Daria Kluver from Central Michigan University. Dr. Kluver holds a Bachelor's Degree in meteorology and a PhD in climatology. Her research interests include the climatology of snowfall using physical models to project snowfall and the influence of large scale atmospheric phenomena on regional climate. She has been an Assistant Professor of Climatology at Central Michigan University since 2011. Give me just a second. I'm hearing a lot of no audio today. If you're having problems with that, if you go to communicate and click on audio broadcast, that should reconnect you. I would also suggest checking your speakers. Maybe that's part of the problem.

We're happy to have these great researchers here today to discuss climate change impacts on snowfall, but before we get started, a few logistical issues just to have you be familiar with WebEx. During our presentation, all participants will be in a listen only mode. Afterwards at 12:45, I'll conduct a question and answer session. If you'd like to ask a question during the presentation, please feel free to use the chat feature located on the right hand side of your screen and I'll collect and post those questions out to Dr. Kluver at the end of the presentation. If that chat feature isn't showing for you, there should be a gray speech bubble at the top right hand of your screen where it says 'chat'. If you click on that, the box should pop up and the speech bubble should turn blue. We have more than 200 participants on this webinar today, a great diverse group representing governmental agencies, academia and nonprofit groups from the Great Lakes and around the country. Please keep those questions coming throughout the presentation and we should have a great Q&A session. As a reminder, this webinar is being recorded and will be posted onto our website for later viewing. Also, we will post a webinar survey in the chat feature towards the end of the hour. Please take a few minutes after the webinar to fill out that survey as it helps us to continue to bring you good webinars.

Without any further delay, I would like to introduce Dr. Daria Kluver, who will talk to us today about snowfall trends in the US and you should be good to go.

Great. Thank you Christina. First of all, I'd like to thank OSU for inviting me to speak on this webinar and I'd like to thank everybody who is tuned in to hear about snowfall. It's a topic that I love so I hope you'll enjoy listening to me talk. Today I'm going to talk specifically about trends in snowfall frequency and I'll show you a little bit about a new interface that we're working on where the public can actually explore some of this snowfall data.

Here's the outline for my talk today. First of all, why should we be interested in snow and snow frequency? I don't think I'll have a problem convincing people from the Great Lakes region of this, but just in case. I'll tell you about a research project where we're doing a regionalization and then the trends in snowfall frequency that we found during that project and then I'll talk a little about this interface that we're working on, but first, why should we be interested in snowfall frequency?

Let me show you a few maps from this year, of this past winter I'm sure many of you have seen before. First of all, this is from the mid-west regional climate center and this is showing normal annual snowfall amounts for the mid-western states and usually in Michigan where I'm sitting right now, it can range from amounts near 100" just to the [unclear 4:42] of Lake Michigan to amounts in the 30" range per year near the [unclear 4:48]. So that's normally what we would see. This is the map also from mid-west regional snowfall last winter, so July 1, 2013-July 20, 2014 and here you can see a huge amount of snow above and beyond the normal amount that we would get in this area and it's much easier to see on this next map and this is also from the mid-west regional climate center and this is the departure from the mean for last winter. So the green and the blues are more snow than normal and the yellows are less snow than normal and you can see that there are several places in the Great Lakes region that had 50-60" more snow than normal. One more image about snowfall amounts.

This is from the National Weather Service office in Cleveland and it's sort of just a zoom in of those 2013-14 snowfall totals and since this webinar is hosted by OSU, I thought we'd look at Ohio a little bit and Toledo actually set a record for the number one snowiest year of 86.3". Their normal snowfall amount is 37.6" so quite a large difference. Several other cities on this map were on the top ten rankings for snowiest years on record and in this area they experienced several light and moderate snowfall amounts so not really huge blizzards. It was sort of this accumulation of small events and the result of this was that the Ohio DOT spent more than $119.8 million in labor, materials and equipment to deal with the winter weather and the road maintenance and the year before it was $80 million. So this is a substantial difference in the amount of Ohio DOT had to pay to take care of this.

I'm very interested in the DOT maintenance practices and how they prepare for snowfall conditions and winter road maintenance accounts for normally 20% of state DOT's maintenance budgets, but during a year like last winter, DOT and the states really had to dip into other sources of funding, so when you're driving on those roads that has the sign Rough Road, there are a lot of those in Michigan, the reason why they aren't fixing those roads a lot of times is because they had spent that money to take care of the plowing the winter before, but just to bring this to sort of a scale that everybody can relate to, imagine the snowfall the winter maintenance that you have to do on your own personal driveway.

Okay, let's say where we have a winter where you just have one large snowfall event. Let's say it's like 20". That's a pretty good sized snowfall event so you're going to go out and you're going to shovel and maybe you have to spend the morning shoveling. I guess it depends on how long your driveway is, but say you spend about three hours shoveling your driveway and you're going to put some salt down maybe on the end of your driveway, maybe some of your sidewalk. So let's say you do a whole bag of salt. So your maintenance cost for that one large snowfall event was three hours of time plus one bag of salt. Now let's consider if you have several smaller snowfall events. So let's say we've got like ten events, but they're only 2-3" apiece. So several smaller events. Okay, let's say you shovel eight of those ten days. So I have eight little shoveling guys on here and maybe it doesn't take as long since there's not as much snow so you only spend somewhere between 5-8 total hours shoveling, but let's say maybe, I lost my, there we go. Let's say you spread salt every time. Maybe it's a little icy and so you're going to go through more salt and you spread maybe like five bags of salt so you can see that just for your driveway, the economic impact would be greater for having more frequent, smaller events than one really large event and of course there are other impacts of really large snowfall versus small snowfall, but that's a different webinar.

So this is essentially why I'm interested in snow frequency. I like all types of snowfall, but snow frequency is very important for the economic well being of our states and DOTs. Of course, one snowy winter like the awesome winter we had last winter, does not equal a change in climate and if we want to understand how snow is changing, how the climate of snow is changing, we really have to look at long term statistics that describe the climate's behavior.

So that brings me to the first project that I want to share with you all and the goal for this project was to create a snowfall frequency regionalization and then look at how those region frequencies are changing through time. My collaborator on this project is Dr. Dan Leathers from the University of Delaware and I'm sort of explaining this to the broad audience that we have here. The technical details of this manuscript of this project are in a manuscript that's currently under review and it's titled Regionalization of Snowfall Frequency over the Continuous United States.

Okay, so first let's talk about the data that we used. We used 440 United States historical climatology network stations and they were selected from in this paper Kunkel et al (2009), they were selected because that paper determined they were high quality stations through time and high enough quality to look at trends, so look at how snow changes in time. In this paper in 2009, they used these stations to look at trends in snowfall amount, so how much snowfall they were getting from 1930-2007 and this figure is showing the trend in snowfall in percentages of their snowfall mean. In this figure, the filled in circles are positive trends so an increase in the percent of snowfall per year over time and the open circles indicate negative trends. Now I want to point out just a few stations because we're going to be talking about them later. Let me get my little laser pointer here. Can you guys see that laser pointer? Oh wait, you can't talk to me. Never mind. I'm just going to assume you can see this laser pointer.

So I want to point out the South East US because we'll see this later in the regionalization that there are decreasing trends in snowfall amount and these are .9-1.2% per year. I want to point out the Pacific Northwest, which is a very large area with decreasing snowfall amounts. Some of them are greater than 1.2% per year and then another area that we're going to look at today is this northern mid-west area and I'll show you what I found with frequency data, but I just want to point out as far as snowfall amount, there aren't too many stations with huge trends and it's not totally consistent. We see some increasing trends, some decreasing trends and some that are very close to zero. So this is the data that we're using.

Now onto the snowfall frequency study that I did. We're looking at the frequency of snowfall events and we only used events that were greater than or equal to 2" of snowfall and the idea is ultimately we're hoping to inform a winter road maintenance planners so we guess that 2" is about the amount where some sort of action would need to be taken. So we're looking at the frequency of snowfall events that are equal to or greater than 2" and in this plot, I have color coded the average frequency of these events. So for example, the light green area is in the Great Plains and mid-west. We see areas where there's between 10-15 events of this size per year and the [unclear 14:32] snow area has these events not very often and then some of the largest, we have 20-25 events on the western side of Michigan and I should say that at this point because I'm going to start comparing all of the stations, I standardized the data. So this means I subtract the mean value for the station and divide by it's standard deviation. So all of the yearly values that I'm looking at is standardized where the mean is zero and the standard deviation is one.

Okay so this shows the different regions that we came up with. First we took that standardized data we saw on the previous map and we did principle components analysis and we used this to identify and score the main modes of variation among the stations and then I used the PC score time series at each station to do the clustering. So basically I did clustering solely based on how this snowfall frequency varies through time. That's what the clustering analysis used so it didn't have latitude. It didn't have longitude. It didn't have any other information. Just how snowfall frequency varied with time. So the resulting regions, we'll go through each of them. First is the southeast and so all of these stations, snowfall frequency varied at the same time and you can see that a lot of these resemble paths of storm systems, storm tracks. So this resembles where we might have a nor'easter or a sort of gulf flow swing up from the gulf out to the east coast. We have the south central plains and the southwest. This was a pretty large area that all clustered together. We also have in yellow here the Ohio River Valley and the mid-Atlantic and you can see this yellow swatch kind of resembles the spacial footprints of Colorado lows and so likely those are bringing snowfall to all of these stations with about the same frequency. In green we have the Pacific Northwest and we also saw this in the Kunkel et al paper that this region is experiencing declines in snowfall amounts and the frequency that it gets snowfall also clusters that area together. And then we have the upper mid-west and let me zoom in on that. The upper mid-west, this area which several of the people participating are from the mid-west so we know it's really sensitive to the position to those Alberta Clipper storm tracks and when you look in detail at the frequency of snowfall, you see that this is enough to actually split the mid-west into three separate regions and this has also been done with snow covered relations so therre have been some other snow studies that split up this area. So we have a southerly track and that's the sort of medium blue. We have a middle track over here, here we go, that is this light blue. So the southern track would maybe be when those Colorado lows are coming from the southwest and the dark blue is our northern track and this would be more those Alberta Clipper type storms coming in this way.

So here are our seven regions and I'm counting each of those three in the upper mid-west and at this point, I have all of this data for each station and I want to get a regional average and so this is why it was really important for me to standardize the data because you can't take the 100" of snowfall that you get in western Michigan and average that station with the 30" of snow that we get in Mt. Pleasant so that's why we standardized and at this point, I create regional averages from the standardized data.

The next step to look at the trends, we didn't want to use [unclear 19:15] linear regression because that basically just uses the conditional means. We used Quantile regression and this estimates those conditional Quantile functions to look at how the entire distribution changes and I'll show you pictures of these if that kind of sounded, if that didn't make much sense. So we want to look at the entire distribution of snowfall frequency, not just the mean and I'll show you some plots and we plotted the 10th, 25th, 50th, 75th and 90th percentiles and I will go through and highlight in green slopes that are statistically significantly different from zero.

Okay so the first region is the southeast and for this one, let me get out the laser pointer. On the bottom here is the 10th percentile regression line. Here's the 25th percentile, the 50th so this is our median, the 75th and the 90 percentile. So now I've highlighted just the 90th percentile. This is the only trend line that was statistically different from zero. So we see that in the southeast, the frequency of those extreme snowfall frequency years is declining and on the right I've created box [unclear 20:53] because I think people maybe are more familiar with picturing a distribution in this way so I used these estimates to create a [unclear 21:06] 1930 and then I used these line estimates for 2010 to create this [unclear 21:14] just so you could easier see how the distribution has changed over the period of record. So you can see this drastic change in those 90th percentile events. So now remember from the Kunkel et al paper that first used this data and the southeast snowfall amounts are on the decline and we can see that it's also experiencing a reduction in those extreme frequency years so they aren't having as many high frequency years.

Now the time series on the left with the Quantile regression line is the average for the whole region and I also wanted to look at the individual stations so I wanted to sort of put together all of the stations in that region so on the right, I've plotted for each decade the distribution of all of the station data and I plotted an identity strip so the areas where it's dark blue, like here, is where you have the most observation and they gray areas are the extremes, so the highest value observation and the lowest value. So you can see when we look at all of the station data that the majority of the distribution isn't changing too much, except it sort of broadens the inner [unclear 22:50] broadens in the 60s here, but since the 60s onward, there is this decline in the more extreme values and that's really what we're seeing in the Quantile regressions, is this right here.

Now for the south central plains and the southwest, there were no statistically significant trends in the Quantile regression. Also for the Ohio River Valley and the mid-Atlantic states, so that big yellow swatch that sort of resembled Colorado lows, there was again no statistically significant trends in the Quantile regression. Now in the Pacific northwest, you can see these pretty drastic decreases and there is statistically significant decreasing trends in the 50th, 75th and 90th percentiles and then on the right, the figure on the right here when I [unclear 24:00], remember it's the estimated values for 1930 and the estimated values for 2010. You can see the impact. You can really visually see how the distribution changes because of these trends. So in 1030 in what would have been considered even a median snowfall event would be an extreme event in 2010. Again for this one I plotted all of the stations and these density strips on a decadal basis and that's here on the right where the dark blue indicates a lot of observations and the gray would be sort of the tail ends of these extremes and we can see if sort of where it's blue is where we have kind of the inner Quantile range. You can see this narrowing of the areas where we have a lot of observations. You see a very small area of extreme events are on the decline as well.

In the mid-west for the middle track, that middle blue color, there were no statistically significant trends in the Quantile regression. In the southern track of the mid-west there were also no statistically significant trends. However, in the northern track, so this is the part that is North and South Dakota, Minnesota and northern Wisconsin, we did see significant trends and we saw them statistically significant trends in all Quantiles. So I've highlighted all of those in green. You can see they're all statistically significant increases in snowfall frequency. So on the right we have those estimated values from the line used to make a [unclear 26:15] 1930 and one for 2010 and you can see here that there's almost a complete shift in the distribution of snowfall frequency. So a snowfall frequency that would have been a median event in 1930 here would be a very small, almost an outlier event in 2010. So also like the median event in 2010 would have been an extremely high snowfall frequency year in 1930. So we can see this huge change in what the distribution of snowfall frequency looks like in the northern part of the mid-west. If I plot the decadal plots of all of the individual stations together, you can see where the dark blue, so where we have most of our observations, we can think of this like the [unclear 27:12] range, you can see how it spreads throughout time so not only do we see an increase in these different Quantile regression lines, but they're also spreading apart where the higher percentiles are increasing at a greater rate and you can see that where the [unclear 27:32] range here is spreading further apart.

So we're seeing a huge change, especially in the Pacific northwest region and the mid-west northern track region, but there are many people who are trying to plan and make decisions, not just at a regional level, but maybe for a particular city, so this sort of information may be helpful, but maybe you need something a little bit more specific and so that brings us to the second project that I wanted to share with you today.

This is a project that I'm currently working on with Dale Kaiser and Kefa Lu from ORNL Carbon Dioxide Information Analysis Center and we're working on a snow data interface really that's for the public so it's easy to use, you'll be able to generate your own graphs and of course you can get the data. We just try to make it an easy to use format and this project is through the Carbon Dioxide Information Analysis Center, which is part of the Climate Change Science Institute at Oak Ridge National Lab and this is the primary climate change data and information analysis center for the USDOE and it's sponsored by the DOE Office of Science.

So I've put the website up here for you, cdiac.ornl.gov and there's tons of data on here. I really encourage you to go check it out. If you haven't used it before, you should go look at it. So for climate data at the top bar on that home page, you would go to data and there's a button for climate so you click that and that's where you'll find all this stuff and first there is an interface that's currently up and running that's very similar to what we're working on, but for temperature. So I would encourage you to go take a look at it. This is called DayRec and it's interfaced to look at US Stations Record Maximum/Minimal Daily Temperatures. So the snow interface will be set up pretty similar to this, but we're going to add some additional features to snow data, but like I said, this is up and running so you can go and check that out.

Now if you're in DayRec, if I go back, it's an interactive map so you can select the state. You can see where they're located. You can get their information. If you click on get data, to go and actually get the temperature data and what will soon become snow data, you will come to a page where you can choose your options for the different types of graphs and data and analyses that you want to do. So for the DayRec interface, you can do plots of the year when records were sent. So the year when they were the hottest maximum temperatures or the coldest maximum temperatures or the hottest minimum temperatures or the coldest minimum temperatures. You can also look at the number of records that were set per decade. You can look at record values for each day of the year or you can just access the data, but it's more interactive. It's easier to use especially for the lay person because you don't have to deal with all of the data and processing by yourself.

So for the snowfall product, it is based on the USHCN, United States Historical Climatology Network data and it has snowfall and snow depth data. Right now the data is updated to 2013 and we've done an example. We've started working with Colorado. It's still under construction so this website is not open to the public yet. We're thinking early 2015 it will be ready, but I wanted to show you a few images, especially from Colorado because there's snow that we can actually look at just so you can maybe start planning to use this resource because we're really developing it so people can use it. Some examples, useful things you could generate plots of snowfall per month and you can select different time periods and this might be useful if you're looking at sort of the decisions you need to make and what time period is your data based on. What are you using for your averages and you can break it down by month.

We've also done trends per month and again you can select a time period. So for this particular station, this is Dillon, Colorado. The dark blue indicates the significantly different trends and you can see that there's been a decline in several of the months of snowfall amounts and in February and March, it's statistically significant and in March it's a larger trend than any of the other months and then what we're currently working on and this is one of my favorites, is calculating the probability of exceeding a particular threshold, in this case on a particular day of the year. So we were estimating that 2" would be the threshold at which you would have to do some sort of maintenance action, but depending on your city, that might be different. So in this case, you'll be able to select the threshold that you're interested in and the period of record and then you can get the probability of exceeding that threshold on any of those days. So for this example, this is Dillon, Colorado again. You can see that in February or early March here that you have the probability of exceeding 1.5" of snowfall is 20-25%. A 20-25% chance on those days of exceeding 1.5" of snowfall.

So my conclusions from these two projects that I shared with you, we did a regionalization based on snowfall frequency and it resulted in seven individual regions and these sort of resemble those footprints of common storm tracks and when we looked at the trends for these different regions, we saw that the southeast has a decreasing trend, but it's statistically significant only for those same frequency years, so we're having less of the extreme frequency years. The Pacific Northwest is experiencing a decline in the median, the 75th and the 90th percentiles so actually all of the percentiles above the 50th are declining, so not having as many average or larger snowfall frequency years and in the mid-west, we're seeing just in the northern part of the mid-west that there are increases in all Quantiles of the snow frequency distribution and that they're sort of spreading the higher, percentiles are increasing at a greater rate, so that [unclear 35:23] range is spreading and the entire distribution has almost totally shifted to higher snowfall frequency values.

We also showed that having these monthly data available through the CDIAC interface could be very useful for planning purposes and it will allow users to access snowfall, snow depth data and create custom plots on there as well as probabilities and we really hope that the regional frequency information that I've shown you here as well as the ability to sort of dig in to your own, you know your own station data and select the data that you need. We really hope that that will help in resource management and planning in the future.

So with that, I would like to thank you for tuning into this webinar and I would be happy to answer any questions you might have.

Christina: Thank you very much for that. I do want to start by apologizing for the sound issues that some of you guys have had. I'm not quite sure what was going on with the audio broadcast, but hopefully everyone who wanted it got the information and we'll look into that for next month because that is just strange.

We've gotten a couple of questions. If anyone still has questions, please send them through the chat box, but we'll start with "what is causing the increased frequency of snow events across the northern mid-west track" and "also have you broken down that trend by month".

Dr. Kluver: Oh that's a really great question and actually we have not. We are, our plan is to look at these areas in depth by sort of 30 year periods and we did do correlations with some of the larger [unclear 37:27] pattern, the NRO, the PDO, the PNA, the AO and northern hemisphere temperatures and oddly enough, that northern part of the mid-west did not have significant correlations with any of those so that is an area that we're going to continue to look into. Some of it could be temperature. Sometimes it can be too cold to snow and I lived in that northern track and I can attest to that. It really can be too cold to snow, so sometimes if you're seeing a temperature change, everything else can stay the same, but that temperature change could allow you to get snow or reach that 2" threshold when maybe you wouldn't have before.

Christina: Alright. Are the data in this snowfall database adjusted for observation time changes or does that just apply for air temperature?

Dr. Kluver: Oh that's a really great, great question. I'm not 100% sure because there are quality control checks that are done even before it makes it to this United States Historical Climatology Network and I would guess though that if you're looking on the web interface and you're just looking at one station, it's not as big of a deal if other stations are checking the snow at the same time. It only becomes a big deal when you're comparing, when you're comparing stations. So I'm not sure about that. You could check USHCN on QC procedures.

Christina: Is the daily snowfall probability in the CDAIC website updated with newer data? So is that a continuously updated website or does it get changed every few years?

Dr. Kluver: Yeah, that's a really good question. That data would only include the newest USHCN data so this past summer my colleague Dale Kaiser updated it to include the 2013 year, so it's only updated when somebody goes in and updates that USHCN data. So you would not be able to get daily updates from that website. You may be glad that you're behind.

Christina: Did you see any trends in the Great Lakes area specifically?

Dr. Kluver: Well for significant trends, there's part of the Great Lakes area around in that northern mid-west area so there was Minnesota and northern Wisconsin so those do border some of the Great Lakes. So those areas so increase in all frequencies. I would love to have some Canadian data to look at the other side of the Great Lakes and see exactly how far that sort of northern mid-west track actually extends and that could help tell us quite a bit more about what's going on around all of the Great Lakes, but not on the eastern part, so like the area in Michigan was not experiencing trends in snowfall frequency.

Christina: What [unclear 41:27] snowfall interface? I know that you talked about having it be accessible to the public and assuming there is research that will be going on with that data. Are you thinking about taking that information say to businesses as well? You were talking about Colorado. I was thinking being in Colorado, would that be another application of that particular information?

Dr. Kluver: It certainly could be. It's freely available to the public, so anybody who would like to go on that website and access that data certainly can. So yes, businesses, if you're thinking skiing, like what months would be best to hit the slopes and that sort of thing. Also energy companies. I guess I think more of you know winter road maintenance, but that's just because I like to be able to drive to work when it's snowing, but yeah. There are tons and tons of applications and since it's freely available, anyone can access and use it.

Christina: There's one question about, are snowfall and rainfall trends moving in the same direction or is the precipitation coming in the form of rainfall instead of snowfall in some regions?

Dr. Kluver: I would say yes, in some regions, absolutely. It's a temperature issue so in some cases we're getting rain instead of snow. So think about the Pacific Northwest. Off the top of my head, I don't know what the liquid precipitation trends are, but that's an area where it does not help them to get more of their precipitation as rain because they rely on the snow to sort of stick around in the snow pack and then when it melts, they can use it as a fresh water source. So yes, that is an issue for some areas and it's a sticky problem because it's just temperature that's changing.

Christina: There were a couple of questions. I'm assuming we have people from Cleveland or Buffalo on about lake effect snow patterns and the extent of ice cover on the Great Lakes and whether those are accounted for in the model and if those impact the trends that you're showing.

Dr. Kluver: Yes. So the lake effect areas, originally when we were starting this work, we expected the lake effect areas to pop out their own regions because you would think that you know those areas are going to get a higher frequency of snowfall just because of lake effect and they didn't show up and we're planning on in the future looking at this regionalization over different periods of time to see if sort of the region that a station belongs to changes with time and I suspect that those lake effect areas will show up when we sort of zoom in to a smaller time. As far as the lake being covered in ice, this last year, that wasn't as big of a deal so that the map that I did show of the snowfall amounts in Toledo and Cleveland was on there, it's not so much attributed to lake effect because the lake was covered so much longer this winter and the predominant wind direction I think was from like

[sounds like a glitch in audio]

Christina: station and whether they are representative for their region that [unclear 45:32]?

Dr. Kluver: Oh that's a really good question. Let me see. I'm going to guess. Let's go back to the map. No. Nope. Did you guys like that drawing? I did that.

Christina: I know I loved it.

Dr. Kluver: Well there was no clip art that was just right. Okay so this is the stations that we were using. They're from this Kunkel et al paper and yeah the question was about where they're located and whether or not they represent the region and obviously there are some areas like the Dakotas that are seriously lacking in stations, but the thing is you don't want to use a station because of where it's located if it's bad quality. So if it has a lot of missing data or it had station moves and so you'll have sort of a jump in the station because of a station move. You'll get spurious trends and so it's better for this project to not have data rather than have wrong trends and wrong data, but for a lot of the areas, so like the Ohio River Valley has a really good sample. The Central Plain and the Pacific Northwest by the cascades is pretty good, but certainly not everywhere. So this is always a problem with snow data. I would love to have snow samples you know every lat and long degree intersections, but that's not going to happen and especially if we want to go back to 1930 with high quality data. This is sort of our option.

Christina: Now with the snow data, are you looking solely at snowfall or are you also looking at the persistence of the snow, how long it stays on the ground once it has fallen?

Dr. Kluver: So that, with the first project, I'm only looking at snowfall frequency so as far as I'm concerned after it hits the ground and it gets plowed up, then I don't care because you know I'm interested in plowing the roads, but for the interface, the snow data interface that we're working on at CDIAC, we are definitely including snow cover and this is where you would clock things like duration, how long was the snow cover. So if you're interested in things like water resources from the snow, you'd want to know how long the snow was sticking around and also changes to the energy budget. So having the snow cover versus exposed ground, you'll have really different energy budget. So I did not do any snow cover work and snow duration or snow depth work, but with the snow interface, you absolutely could look into that on your own for a particular station.

Christina: Okay. I guess we'll do one last question. Have you accounted for changes in how snowfall measuring has changed from a manual method prior to [unclear 49:08] weather service implementation more estimated methods were used instead of accurate measurement.

Dr. Kluver: Well the USHCN data should be quality controlled so that you said something. Sorry, there's this beeping so it's a little hard to hear sometimes. You said something about accurate versus estimated snowfall.

Christina: They're basically looking for some adjustment of measuring methodology between, we're looking at prior to 1990s to today. If there was a change in that adjustment.

Dr. Kluver: I didn't do any sort of adjustment for that and that would be something to double check because they're all USHCN stations so they're quality controlled and double checked before they're even allowed into that first network and then they're subset by Kunkel et al further. So off the top of my head, I don't know what you know in the event that other QC did for that. I'm sorry I don't know, but I will look into that. That's a good question.

Christina: And I think your point gets them in a good direction for finding that out from the people that run those sites I believe.

Dr. Kluver: Yes absolutely.

Christina: Alright. Those are actually all of the questions that we've received. So I wanted to thank you again Dr. Kluver for your willingness to talk to us today. Also thank you to Noah, the national [unclear 50:59] program and Ohio State University for funding this webinar. One more time I apologize for the sound issues. We'll definitely look into those before next month's webinar. I did want to remind you that our survey URL is in the chat feature so if you could take a few minutes to fill that out. I also want to refer you to resources and [unclear 51:23] previous webinar presentations. They are located on our [unclear 51:28] website, as well as our new regional site at GreatLakesClimate.com. We're still working with our speakers to finalize the schedule for the rest of the year so you will receive emails when the actual dates for November and December are set. Thank you again Dr. Kluver and everyone on this. We hope it was beneficial and hopefully you'll join us again in November. Thank you very much and have a good afternoon. Thank you Daria.

Dr. Kluver: Thank you. Thank you for having me.