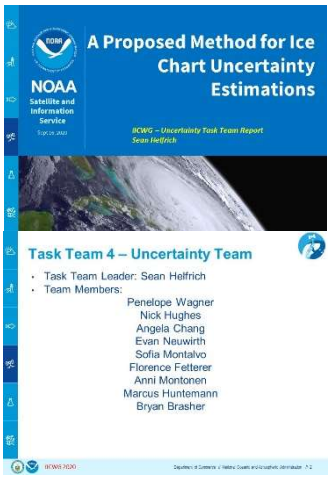
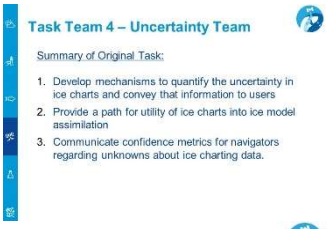
# APPENDIX J: TASK TEAM 4 - UNCERTAINTY

## Sean Helfrich (NOAA STAR)

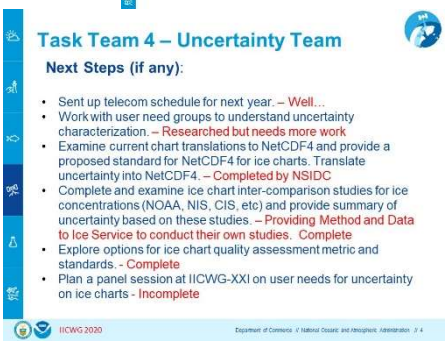



Hopefully, we're going to be able to close this task out. I want to give a little bit more context as to why I think that's the case. Here's our task team members.

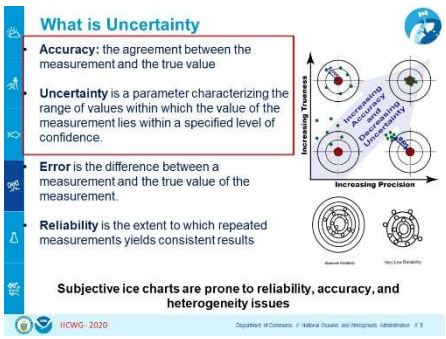
The original task that we had was to develop mechanisms to quantify the uncertainty in ice charts and convey that information to users, provide a path for a utility of the ice charts into ice model simulation, and communicate confidence metrics to navigators regarding unknowns about ice charting data.

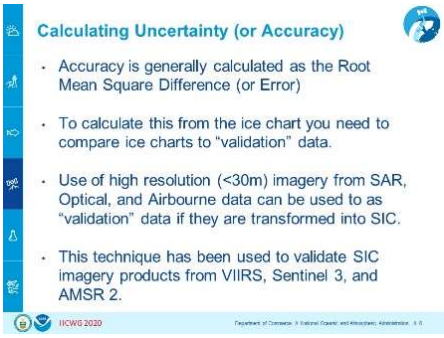



These were the steps we had to try and complete. I must say that setting up of the telecom schedule, I completely failed at this year. But it wasn't without some results, at least in some of the work, because I kept on digging into the concepts of uncertainty characterization and how other groups do it. We set out to be able to examine the current ice chart translation to NetCDF format. That was actually completed by Florence Federer at NSIDC. We examined an ice chart inter-comparison study. So, we're providing the method and data to the services in this presentation so that they can conduct their own studies. We consider that complete. Explore options for ice chart quality assessment and metrics - that's complete, as you'll see. And then plan for a panel session which, of course, we never had.

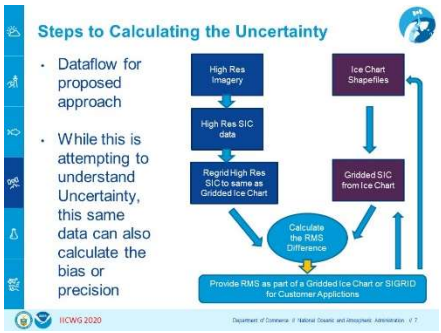



So just a little bit of historical context for those that are wondering what uncertainty is and what are we actually getting at. Uncertainty and accuracy are actually both opposite sides of the same coin. The greater the uncertainties, the less accuracy. Accuracy is the agreement between the measurement and the true value. In this case, we have to come up with what is a true value. So, in this case, we were going to try and calculate the root mean square difference or error. I prefer difference in this case. There are other metrics but I think this one's a widely accepted one. Then we want to calculate this from ice charts, you need to have that validation data. Examining how a lot of other groups have examined lower resolution data sets, they've often compared it to higher resolution data sets. And there are data sets with less than 30 meters from SAR, optical and airborne data that can be used for this validation if they're

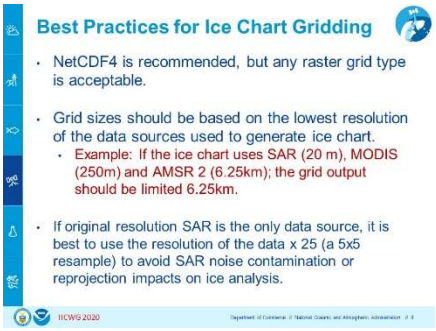


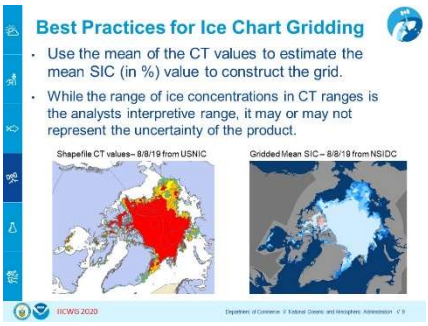
transformed into something that's common, like sea ice concentration. This technique has been used before to validate VIRS, Sentinel-3 and AMSR-2.




Here's a data flow diagram of how to calculate it. It's basically transform that high resolution data into sea ice concentrations. You take the ice chart shape files and turn those into a gridded sea ice concentration. Then you re-grid the high res ice concentrations into the same grid as the ice chart. Once you have this common format and common variable, you can calculate the RMS difference. You're hoping to close the loop to make sure that is part of a process for the gridded ice chart or SIGRID, so customers can apply the uncertainty data.




I'm coming up with best practices for ice chart gridding. A lot of this is based on the things that Florence's work has done. But also what others done in their gridding process. While we're recommending NetCDF-4, any raster grid type will really work. It's not about the format type. It's about the data and making sure you have a common grid space and applying best practices. The grid size should be based on the lowest resolution of the data source used to generate the ice chart. If you had SAR, very high-resolution MODIS and AMSR-2, unfortunately, you're bound by the grid output of the AMSR-2, provided that made up some substantial portion of your polygon. If you were using original resolution SAR data, you might want to be cognizant that there's a lot of noise contamination in the original sampling. You either have to eliminate the noise, there are methods for doing that, or you could just use a lower resolution sample set. I'm recommending a five by five resample of the data. If you're already using resampled SAR anyway, then you don't have to worry about that step. What you're wanting to do is transform the CT values into the mean value of the CT into an estimated mean sea ice concentration value. A lot of the ice chart concentrations in CT have ranges, and while this is based on the analyst interpreted range, it may or may not represent the uncertainty of the product. We'd rather try and calculate what is that uncertainty on its own rather than just saying that these are the ranges that the analyst is assessing or saying that the data lies within.




Best practices for the optical data imagery. I'm not going to get into these, in general, because people can read it on their own afterwards. I do recommend downloading the data if you're looking to do this. But the nuts and bolts of it is that we're going to use the normalized snow difference - it's also called the Normalized Difference of the Ice Index. It's basically using the difference of the green channel of the visible and shortwave IR channels. As long as it has that, you can calculate this.

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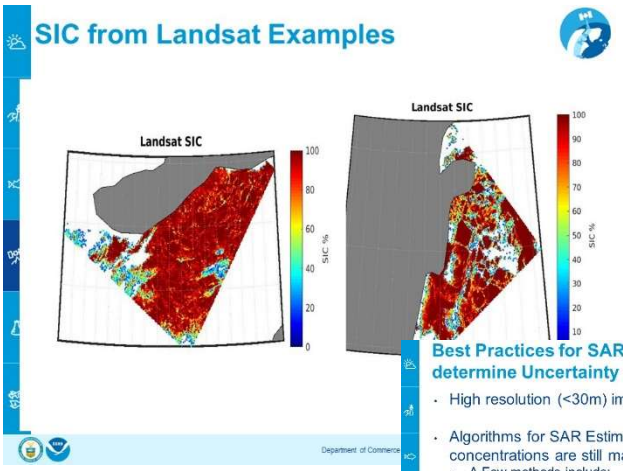
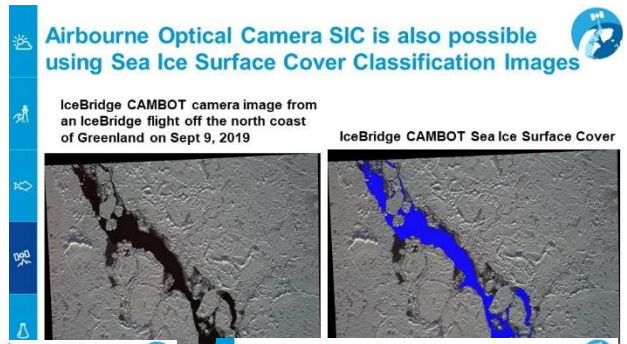
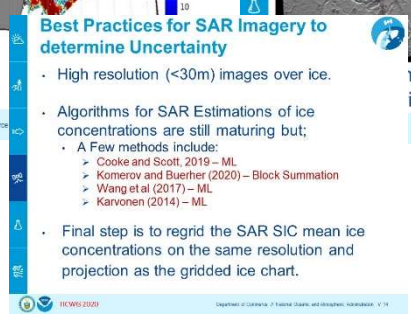
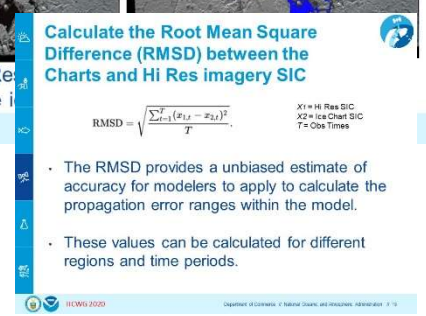
Here are some examples from Landsat that had been processed. Another way, if you have high resolution optical data, you can sum all the pixels of ice versus no ice and use those as your estimate because they're so high in resolution - getting down to less than meter. You do have to be careful as to what is new ice versus what is no ice.

You could also use SAR imagery. There are some methods that I'm putting out here. This is still a maturing science so I don't want to recommend a particular algorithm or process. But there are a few methods, I'm outlining that you could use for calculating SAR ice concentrations.



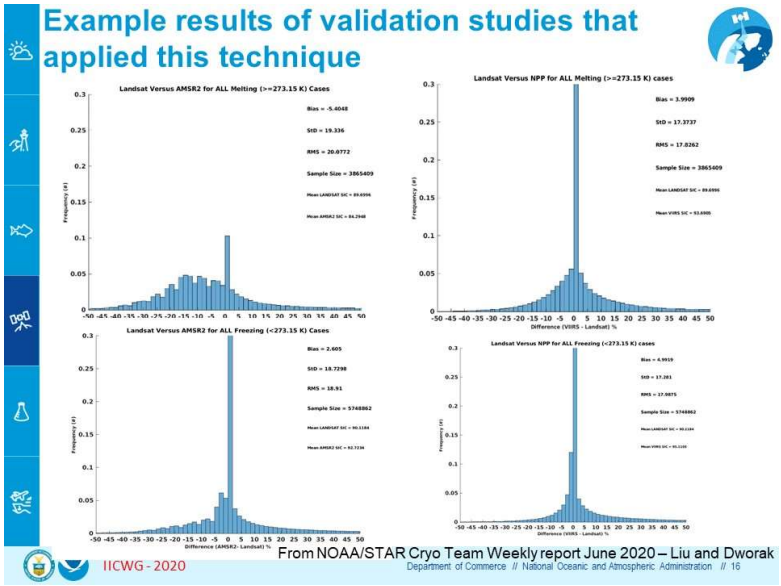



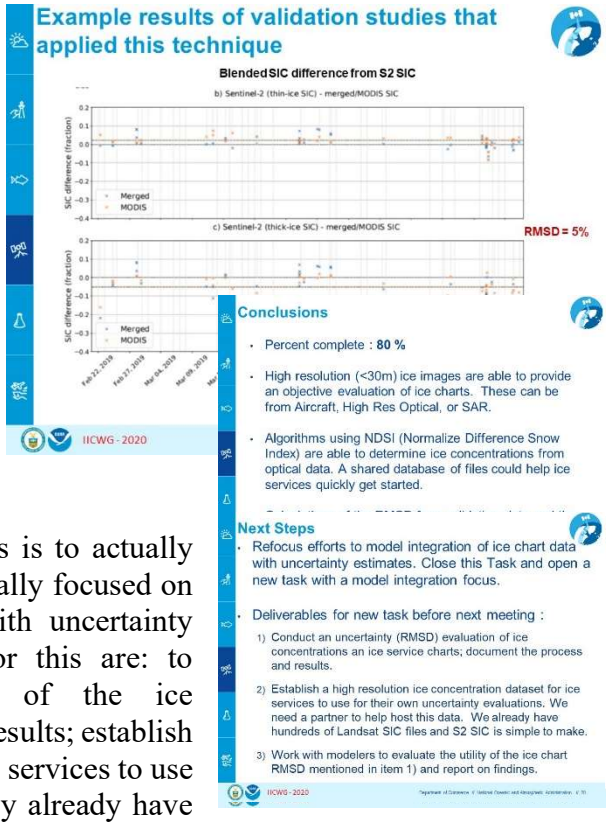

Calculation of the RMSD is basically the difference between those two and number of observations. Here's the formula.

Here's some results of other studies that have applied this method. Not to ice charts, but to AMSR-2 as well as VIRS ice concentrations. You can see that you have a calculated RMS. You can see the distribution of the data. You're trying to capture the best outline of how the data falls within that.



Here's another example of a group that had done a similar study, except they had a blended ice concentration and they used Sentinel-2 sea ice concentrations to derive the RMSD.

So, conclusions. I would consider it 80% complete. There were a few things we hadn't really gotten into but if I look at the original context of what we set out to do, we actually achieved most of that. We just haven't really generated the data sets at this point. We're looking to have a crowd-sourcing approach to that. The high-resolution data sets can provide this objective analysis that the calculated RMSDs from validation data provides a good measure of uncertainty in the ice charts. This can be customized to meet the needs of the ice services so you can have seasonal values or regional values or do it by ice type and then apply those onto your charting data or provide that to your customers. Then the uncertainty metrics will help modelers to assimilate the data because it's very common to be able to use things like RMSD for assimilation. You could also take the RMSD and assign categorical uncertainties or confidence metrics, which would help navigators to understand the data. You could say it has high, moderate, or low confidence.




What we're proposing for some of the next steps is to actually close this task and then open a new task that is really focused on model integration of the sea ice chart data with uncertainty estimates. The deliverables we're proposing for this are: to conduct an uncertainty RMSD evaluation of the ice concentrations and document the process and the results; establish a high-resolution ice concentrations dataset for ice services to use for their own uncertainty evaluations. We actually already have hundreds of these Landsat ice concentration files and there are Sentinel-2 ice concentrations that we can work to make available. And then lastly, to work with modelers to evaluate the utility of the ice charts, the RMSD, as mentioned, and report the findings. We also ask to be able to work with Task Team 10 since they're a model data assimilation group. Thank you.

I could lead that task but I'd certainly want others to help me with it or to work with their ice services to evaluate the process.

**Nick Hughes**

I'll second you in leading that task.

*CHAT LINE*

*Helen Beggs*

*Hi Sean, I am interested in being involved in Task 4. My email in helen.beggs@bom.gov.au. I am a satellite oceanographer at the Bureau of Meteorology and am working on assessing sea ice data sets for ocean model data assimilation and verification.*

# Appendix J: Task Team 4 - Uncertainty

**Neal Young**

Sean, how much is there in what you described that it really relates to the variability when you go to a detail scale underneath the AMSR-2 sea ice concentration? And how much is the uncertainty of whether you might be biased high or low or whatever? Especially when we talk about model things into the future?

**Sean Helfrich**

That was another consideration that I certainly had was with the bias. That will actually come out within the calculations. So, there's nothing preventing that same bias from turning around and being made available for modelers to assimilate as well.

*CHAT LINE*

*Thomas Lavergne (MET Norway)*
*Excellent presentation on Uncertainties, thank you. I have two comments: 1) did you consider directly comparing the HRes data to the polygons, instead of a gridded version of the ice chart? 2) a dataset of high-resolution (LandSAT, S2) SIC will be interesting not only for the ice services, but also for people developing models and other automatic sea ice products. I would be interested, at least.*