Remote Sensing in the 2000's Transcription

David Le Vine:

OK, so we were successful in demonstrating both that the technology worked, and we obtained improved confidence that we can do this remotely from space in the experiments in the nineties. In fact the Europeans took off with this idea, and they actually proposed to put a synthetic aperture radiometer in space. It launched a couple years ago now, 2009. November 2009.

This is the instrument. Remember it is [?] array. It has three arms in a Y shape. It's called SMOS. Along each of those arms those little circles, those are little tiny antennas. This instrument measures all the signal products between these antennas. It creates the resolution as if you had a big antenna. If you drew a circle around the tips of the three arms, that would be the equivalent antenna that gets the resolution of the structure. That was launched and it's making measurements.

We on the NASA side decided to go a different way. One of the issues with the synthetic aperture is that it is a little noisy, and it didn't have a tool for dealing with the roughness of the ocean which is a bit particular problem. So we began to look at the possibility of going with more conventional radiometer, but including an active channel, a radar, to help us deal with the roughness correction. Gary, are you going to take over.

Gary Lagerloef:

Yeah. So I'll return back to that question of the roughness correction in a moment, but first I wanted to open this one about the JPL pond experiment. Let me just briefly describe that because it's still on the same theme. So what you see here is a picture of the instrument that we call PALS which stands for Passive Active L-band and S-band. There's basically two complete instruments here, a big one and a small one. To give you the scale of the size, the diameter of the opening of the larger instrument was about three feet, about a meter. The other one was scaled down somewhat proportionately.

This instrument was designed to develop the concept of making simultaneous radar measurements and radiometer measurements which was not an easy thing to do. That's what the passive active calls for, so we'll get to some of that in a moment. But first of all we decided that we needed some more data to verify that model function that I described to you earlier, so we set up an experiment in 2001 that we called the PALS pond experiment. What we did is we created an artificial pond and we filled it with sea water of various temperatures and salinities and we made measurements. The way we did this is basically we mixed up batches of saltwater at three different concentrations.

If you open up the graph here for a moment, at three different concentrations. One was 25 psu which is the red curve. The blue curve was at 35 which is if you remember is the median ocean salinity. And then to cap off sort of the high end of the range we did one at 40. Then when we filled the bath with these saltwater we then had a heating and cooling system built into it that allowed us to regulate the temperature of the water. Then we took radiometer measurements with that PALS instrument, and collected all of the data, and processed it, and plotted it up in the way you see here.

If you look very carefully at this diagram you'll see a thin black line plotted through the middle of these curves. Each one of those black lines is from the theoretical model that I showed you earlier. Then the colored x's are actually from the measurements that we actually made. You can see here that the theoretical model was quite well validated with this experiment, so we knew we could go forward with a good solid understanding of the principles of the measurement, and we'd have a good theoretical basis for making the measurements.

Then the next step was to—well let's go down one to this dielectric constant research while we're still on that same subject. One of the key elements of this model is a parameter called the dielectric constant of sea water. It depends on the actual microwave radio frequency that you are using. So we wanted to make measurements very precisely at the radar frequency that we use in the satellite measurements which is 1.413 gigahertz.

There really didn't exist any data precisely at that frequency before this. We had to interpolate between measurements made at other frequencies. So we wanted to verify it one more time so we had set up this laboratory experiment. We're making measurements in what's called this [?resonant] cavity. I won't go into the technical details. David understands it much better than I do.

The point of it all is that we're continuing to research this because we wanted to wring out as much precision in this measurement as we can and remove as much uncertainty as we can, and really understand the physics of this measurement. So getting this dielectric model really nailed down is a very important aspect of the research associated with this. This is an ongoing task.

So if we go back then to the next branch of our tree, the airborne PALS experiment. So we took that instrument PALS that I described to a while ago that was used in the pond experiment. Here you see the same thing again, but now it's mounted in the belly of an airplane. We took this out over the ocean, and we flew some sections.

If you go down to the third diagram we'll go to that first. The third diagram just shows a small research boat tied up near Monterey, California. This went out to sea and collected sea surface salinity observations. We flew the airplane over the ship, and if you pop up to the top graph there I'll show you some of the results of that experiment.

First of all let's look at the dark blue line that's going almost horizontal across the middle of the graph there. One of the differences between this area off the coast of California and the area off of Delaware that David showed you earlier is that there's very little salinity gradient here. The salinity doesn't change much at all. When we flew the PALS instrument over we collected the data that's on the yellow curve. You can see that there are quite a few differences there. As a matter of fact we didn't retrieve the salinity very accurately at all.

That was without correcting for the roughness. What I mean by roughness is that when the wind blows across the water you get waves, and white caps, and foam, and that changes the emissivity of the surface. That changes the brightness temperature. So we have built into this instrument a radar. The radar sends a pulse down to the surface and then measures the intensity of the echo. Now if you think about a radar pulse being sent down to the surface at an angle and it hits a flat surface it's going to bounce off at an angle, and basically propagate away from the radar, and you're going to get very little return signal. But if the sea is rough, there's a lot of wind and wave action out there, then more of the signal is going to be reflected back towards the radar.

That's essentially what we are measuring. By measuring the intensity of the reflected energy we get a direct measure of how rough the sea surface is. Then when we apply that correction to the data from the PALS experiment we get the purple curve you here. There are still a few wiggles in there that we don't quite fully understand, but we certainly did demonstrate that we have enough information to correct for the majority of the roughness that we have to make.