Q&A with oceanographers
Dr. Burke Hales and Dr. Dave Hebert

FlukePlus learned that several Fluke tools had been spotted aboard a NOAA science vessel near Antarctica. While the ship withstood yet-another storm, mission scientists Dr. Burke Hales and Dr. Dave Hebert graciously traded emails explaining their experiments and measurements. They are on the *Ronald H Brown* in the South Atlantic Ocean (50^{o}S, 40^{o}W), approximately 100 km north of South Georgia Island. A group of approximately 30 scientists are onboard the ship to study gas exchange between the atmosphere and ocean under high wind conditions. The experiment is known as ``Southern Ocean Gas Exchange''. The goals of the experiment, what different type of studies are being conducted and a daily blog of what is happening on the ship can be found at http://so-gasex.org. This program is funded by the National Oceanic and Atmospheric Administration (NOAA), who are supporting our work, the National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA).

Icebergs in the background, testing the CTD (conductivity-temperature-depth) instrument with the Fluke 1577 Insulation Multimeter with a rosette containing water sampling bottles above.

Q. FlukePlus
Can you describe your mission for us?

A. Dr. Dave Hebert
I'll let Dr. Hales explain what we are doing out here in the middle of the South Atlantic. I have enclosed a screen from the oscilloscope that I am using to help debug my equipment (fig 1). This one was an example of the transceiver not working properly. I send screens to the developer of my instrument and he provides suggestions of things to check. He commented that I should not send any blurry ones - it is a bit hard to get a close-up of the screen on a rolling ship.

Fig. 1

A. Dr. Burke Hales
The mission is intended to study exchange of CO_2 between the ocean and atmosphere at high wind speeds and in high sea-states. The reason for doing this is that in global carbon budgets, it appears that the oceans are taking up somewhere between 1/3 and 1/2 of the CO_2 emitted by man every year. This is based on measurements of CO_2 in ocean waters, and gas-transfer rates based on wind-speed relationships.

The problem is that the wind-speed relationships have been developed based on study of low wind-speed conditions. Most of these suggest that the dependence is on the square of the wind speed, but recently some researchers have suggested that the dependence should be on the cube of the wind speed. The difference between these two relationships is very large at high wind speeds, and there isn't much data to back things up in those conditions. But the oceans do experience these high winds fairly often.

If it turns out that we've been using the wrong wind speed dependence, that means that the estimates of ocean uptake of CO_2 are wrong, and the difference will have to be accounted for elsewhere in the global CO_2 budget. So that's why we're down here in the Southern Ocean with (austral) winter approaching looking for lousy weather.

The general approach is to inject an inert chemical tracer in the water, follow it around as it moves and spreads, and study the gas exchange while we do that.

The project that Dave and I are working on was intended to make comprehensive, high-resolution measurements of the carbon in the water in dissolved and particulate, organic and inorganic forms (my part), in conjunction with detailed measurements of the physical transport (mixing and currents; Dave's part). From these we were going to construct a mass-balance for carbon that would tell us about how much was going across the air-sea interface.

For my part, we use a towed vehicle that looks like a cross between an airplane and a submarine. The 'SuperSoar' glides up and down through the water as it's towed by the ship, and carries a suite of electronic instruments and a high-pressure pump. The pump sends water back up to the ship via a tube in the core of the towing cable, where we do high-speed chemical analyses. Dave's instrument measures turbulent mixing, and I'll let him describe it for you.

Unfortunately, we've been having some trouble... after towing for about 7 hours early in the cruise, we hit something underwater that pretty well finished us. So we've been spending a lot of time troubleshooting...

Q. FlukePlus
What are you measuring?

A. Dr. Dave Hebert
As a follow-up on what Dr. Hales has written and to give you an idea of what we planned to do, I have attached a picture from a previous cruise (fig2). The instrumentation as seen is pretty similar to what we had planned to use. There is the SeaSoar (the airplane-like towed body) with my turbulence measuring platform (the black cylinder) attached underneath.

On the outside, the new towed body, now called SuperSoar, had bigger wings to allow it to get deeper in the ocean. All of the other modifications to make it better are hidden inside the towed body. Additional sensors were added as well. Burke can provide more details on those components.

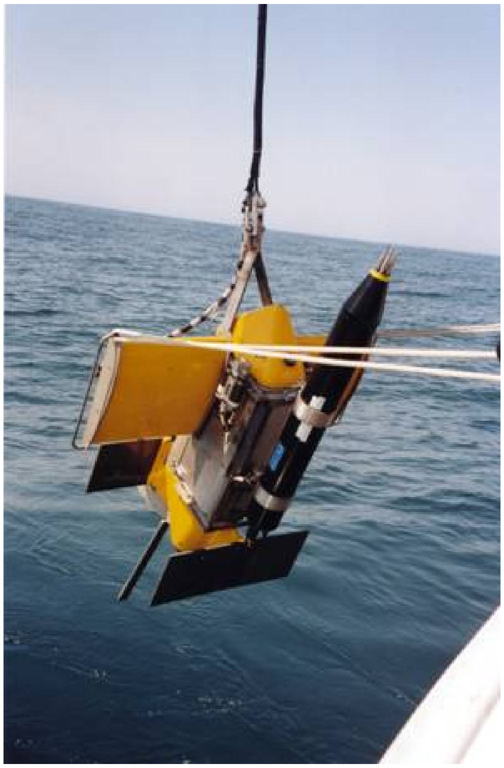

Fig. 2

My package, called TOMASI for Towed Microstructure and Auxiliary Sensors Instrument, measures small-scale (< 5 cm) temperature and conductivity fluctuations in the ocean. These fluctuations are due to turbulent mixing in the ocean. Those sensors are located at the front end of TOMASI. This instrument was built by Rolf Lueck, now at Rockland Scientific International, in Victoria, BC, Canada.

The system consists of the sensors and electronics in the pressure case. It's powered by sending 275 V dc down from the ship to a 300V dc to 15 V dc converter on two conductors. Two other conductors are used for communication between a computer on the ship and a transceiver in the instrument.

The computer, through a deck unit, the UTRANS, requests a sample of a specified channel and TOMASI measures the voltage on that channel and send the digital value back up the same pair of conductors. The sampling rate we use is 4096 Hz (different channels are sampled at different rates, ranging from 32 Hz to 1024 Hz); this sampling rate requires a baud rate of 250 Mbits/s over the 500 m sea cable.

We have been using the oscilloscope to look at this communication signal and determine any problems due to attenuation loss or influence of the capacitance/inductance of the cable. Likewise, the sea cable carries 480 V 3-phase power to the pump located inside the towed body and power (250 V dc) and data communication (a phase-shift key on a 34 kHz carrier frequency on the power lines) for the CTD (conductivity-temperature-depth) instrument inside the towed body. The CTD also measures many other sensors (Burke can provide that information) and also sends that data up the cable. I believe all of those channels are sampled at 24 Hz.

Q. FlukePlus
I would like to know more about the signal analysis. Do you have any scope screen samples that capture/indicate problems?

A. Dr. Dave Hebert
I have attached a picture (figA) from tests done at Oregon State University before the equipment was shipped off for the cruise. The view here is down near TOMASI after the signal had traveled through the sea cable. The signal from the UTRANS (USB Transceiver) is attenuated by the sea cable. The RTRANS (Remote Transceiver) in TOMASI provides a stronger response since the scope is next to its output.

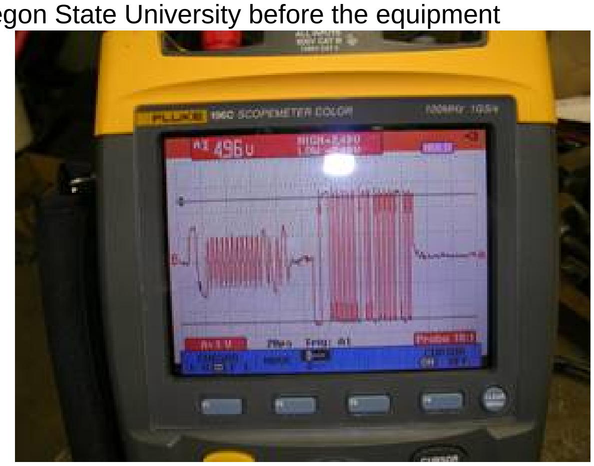

Fig. A

A critical problem with the present setup and, possibly, the source of communication problems, is that communication signal is symmetric in this picture and offset in the earlier screen shot (fig1). The other image showed the influence of the 34 kHz carrier frequency on the return signal. Sometimes the response from TOMASI does not show up and we are not sure why not.

I have attached another screen shot (fig B). This is the signal from another UTRANS. As is obvious in this picture, the blue trace is much weaker and one-sided. The green trace in this picture and the previous picture is the difference between the red and blue tracers. These traces are the signal from one of the communication lines relative to ground. The green tracers of the picture here should be compared to the pictures with only the red trace - which the difference between the two communication lines.   The Fluke oscilloscope can automatically take the difference between two signals (e.g. the green trace is the difference between the red blue traces).

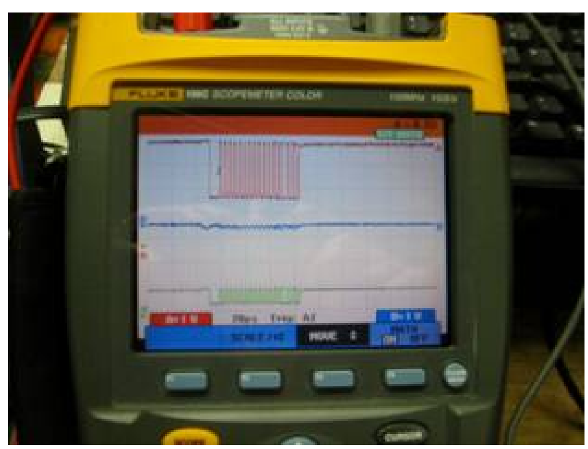

Fig. B

Q. FlukePlus
And what have you been using the Insulation Multimeter for?

A. Dr. Burke Hales
We were verifying the integrity of the insulation on the conductors in the cable. The cable has two dozen 24-gauge conductors that carry power and data between the ship and SuperSoar. Some of these power lines are very high power. We pump water back to the ship for chemical analyses using a submerged 1 hp well-pump motor and a pressure-washer pump-head. That motor draws about 2 A at 480 V from a 3-phase supply. We bundle three sets of four conductors to carry each phase.

Dave's instrument is powered by a 275 V dc supply, and the other instrument (a SeaBird 9+ CTD unit; check out <http://seabird.com>) has a 250 V dc supply. You don't want any of those seeing each other or the data lines while submerged in the ocean. We've never trusted a regular multimeter to find insulation breaks, so we use a kV meg-ohmeter to test for that.

Q. FlukePlus
What are the chances of SuperSoar gliding again?

A. Dr. Burke Hales
100 % by September when we have a test cruise off the Oregon coast in preparation for some fieldwork in summer '09. 0 % before then. The cable has lost a lot of its strength members, and I think it's likely to break if we put any strain on it again. Why don't I have a spare cable, you ask? Well, I do, but it's sitting in customs limbo in Punta Arenas, where it arrived four days after we sailed and two weeks after it arrived in Santiago by airfreight. After that LANChile (the airline) put it on a truck to nowhere, and made the 2-5 day journey in only triple the time. Now we'll see if they can be bothered to ship it back by September.

Q. FlukePlus
If you can't send SuperSoar back down, what will you be doing on the remainder of this "cruise"?

A. Dr. Burke Hales
Aside from feeling sorry for myself? We've moved our high-speed chemical analyzers to the sample stream that the ship draws from the surface, so we're mapping the CO_2, nitrate, O_2, chlorophyll, and organic carbon distributions in the surface waters with great detail. With these maps we're helping the other scientists understand how representative their sampling sites are.

Dave is processing the shipboard acoustic Doppler current profiler data and helping the tracer guys pick the best place to do the injection, and then helping them figure out where it's going to go once it's in the water. We are also trying to get Dave's instrument working in a limited capacity so we can deploy it on a stripped-down SuperSoar chassis at low-speeds.

Q. FlukePlus
What electronic test tools are you using for the rebuild?

A. Dr. Burke Hales
Multimeters, meggers, scope. Dave's got an issue with the communications driver for his instrment, and the scope has been indispensable in trouble-shooting that.

Q. FlukePlus
Can you elaborate on the setup in the enclosed image? (Fig. 3)

A. Dr. Dave Hebert
This is a picture from the main lab of the NOAA ship **Ronald H Brown**. Behind the scope is the desktop computer that communicates with TOMASI. The computer monitor is displaying the 'calibration screen' which shows the response to requests to sample different channels. The red squares show the lack of receiving a valid response for each channel. To the right of the computer are two black boxes, the UTRANSes. The top one has a DB9 serial connector going to two conductors of the sea cable, Next to the UTRANS is the 300 V dc power supply which is connected to two other conductors of the sea cable. Burke's computers and electronics for controlling the SuperSoar and collecting the data are located to the left of this picture. To the left of that equipment is all of the instrumentation for sampling the water pumped up to the ship, or now, from the ship's underway system. We have about 16' of bench top space in the main lab for all of our equipment.

Fig. 3

Bios
Q&A with oceanographers Dr. Burke Hales and Dr. Dave Hebert. Burke, a professor at the College of Oceanic and Atmospheric Sciences, Oregon State University, studies the chemistry of the ocean, mainly the carbon cycle.

Dave is a physical oceanography professor at the Graduate School of Oceanography, University of Rhode Island. He is interested in the processes that mix the water properties of the ocean.