**E-MAIL RESPONSES FOLLOWING JAN. 20, 2015 LTAR CALL AND REQUEST FOR INSTRUMENTS UPDATE**

**TOPIC: LTAR APPROACH AND PHILOSOPHY**

**From:** Sadler, John

**Sent:** Thursday, January 22, 2015 6:53 PM

**Subject:** Discussion during the LTAR Research Committee Call

We have visited and re-visited the standardization question so many times none of us really wants to do it again. However, immediately after the call today, Ken Sudduth outlined a couple of things that cleared up some of my thinking, and perhaps a bit of discussion about that would be useful for a more reflective consideration of the issue. For those of you who don’t know Ken, he is an Agricultural Engineer with extensive graduate training and research experience in sensing technologies. He also sees his way to the bottom of things pretty well. So, altogether, he is quite a valuable asset to us here and to ARS in general.

He asked first what is wanted. We think we can answer that fairly well, but perhaps we haven’t actually defined it as well as is needed. LTAR is a nationwide observation network that produces measurements of a master list of states and fluxes of a number of environmental characteristics relevant to agriculture. For it to be truly a network, it needs to be scientifically defensible as producing data that are comparable throughout. It needs to be recognized from above (agency leads and above) as being sound, productive, and worthy of continued funding. While it might not be immediately apparent that the data are, we must also be able to show that the network produces publication-quality data. [There may be more requirements here, but these are the ones that came to mind.]

We generally think we know what is on the master list, but writing them down becomes a challenge. We immediately see that the variation across sites in what is grown and how it is managed makes a lot of measurements that are required in some places irrelevant or impossible to obtain in others. Thus, comparisons across sites with this much variation mean that what is comparable must be expressed in high-level terms that enable comparisons across the variation. So we look for something like net productivity. Further, physical differences among sites in elevation, slope, latitude, temperature, humidity, solar radiation, wind, pressure, rainfall, or streamflow (not a comprehensive list) characteristics mean that some measurements will likely require a great deal of attention in some sites and very little or none (really, not needed) elsewhere. In some cases, variation is so great that a measurement approach valid in one site produces unpublishable data in others. So, site-specific variations in common, core measurements are unavoidable. But we know generally that there must be some core measurements, and many of those are in our list.

The second question is how accurately we need to know those states and fluxes. Quoting Doebelin’s Measurement Systems, which is widely touted as the definitive work, “If you are trying to choose, from commercially available instruments, the one most suitable for a proposed measurement ... then the subject of performance criteria assumes major proportions. That is, to make intelligent decisions, there must be some quantitative bases for comparing one instrument … with the possible alternatives.” This is the crux of ‘scientifically defensible’. [*While it has in my experience with networks always been attractive to claim that the same make/model of instrument in all places meets that condition, it can be demonstrated to not be the case – see soil moisture example below.*] Although we have discussed at length the specific brand of instruments, we haven’t developed performance specifications for any of them yet. Until we define that, we can’t answer the question of what brand. It is easier to look at other sites and say if it works there, then we’ll go with that. However, doing that may not produce the required accuracy to meet the needs described in the upper question. Refocusing the discussion around the quality of the information instead of the instrument make and vendor would help a great deal here. That will inform the specification process and once properly documented, will provide validation of our claim to scientifically rigorous.

The third step is procurement. Once specifications are developed, the procurement process can launch, and if our focus is on the data quality, the procurement regs take care of themselves. And if anyone thinks Tim’s comments about other vendors might not matter, bear in mind that after I specified the Campbell IRGASON to compare to the Li-Cor 7500a/Gill I had also bought, a vendor I had never heard of responded with the assertion that one characteristic of that 3-D anemometer was documented in the literature to produce bias, and provided the citation to the reference. While we can, as Kris stated, choose a single device, the justification has to be pretty sound. People pay attention.

Back to the compelling argument for our choices… We, individually and as a network, would need to have, ready at hand, whatever support would be needed to demonstrate the suite of instruments at a site meet the accuracy specifications. In some cases, accuracy specifications are fairly simple. My example of measuring temperature to a given accuracy was just that. But even that example was just about instrument accuracy. Environmental exposure, calibration checks, and data reduction may actually matter more, so our supporting processes need to be documented for that too. Once we get to a complex instrument, and the eddy flux towers are a prime example, even specifying accuracy isn’t so simple (it depends on all kinds of environmental conditions) and corrections in post-processing really dominate the attention needed. But, these things are all part of establishing a network such as LTAR. Some of them, such as discussed in the CMRB examples, may require additional research (whether publishable or not).

Mark will need to have available a condensed version of the collective demonstration of quality and comparability so that he can manage expectations of the people in ARS and other agency leadership. This will be an important document for the LTAR to create and maintain.

The accumulated scientific expertise represented in the LTAR is very impressive. I am confident that once we decide what we need to do, the compelling argument for why we did it will follow very easily.

These examples illustrate our thinking and what we are doing about such issues.

***Example of soil moisture in the CMRB context****.* I have raised this before, but probably not written down anywhere. The Stevens hydroprobe is a common instrument for soil moisture, and is in fact the NRCS SCAN standard, and therefore installed in our site (CMRB-LTAR-MO, station id 2195 if interested). However, local expertise (MU soil physics person) has observed that TDR measurements of soil moisture in the subsoil here are not accurate because of 2:1 clay mineralogy. He has found them to also be recalcitrant to correction using the standard equations through further calibration. We understand that a competing vendor has an instrument that may work. I have acquired a set and plan to install in parallel and proximal with the SCAN station to develop the comparison that would eventually be the support for the claim of scientifically defensible. We expect to see decent accuracy in the topsoil and degraded accuracy in the 2:1 lattice clays in the subsoil. So this one example is expected to show that actually changing sensors in the suite of 5 in a profile actually improves the accuracy, and would increase both the data quality and the chances of the data being publishable. Note that I am taking ownership of this deviation from the expected choice of the one instrument, and developing the support for the choice, because it does not yet appear to be in the literature.

***Example of legacy rainfall gauge issues.*** I have both tipping bucket and weighing rain gauges in our network, and the SCAN station has a tipping bucket. There are documented differences between those methods caused by the dynamics of the moving mechanism at high rainfall rates. Further, the SCAN instrument is much higher than the others, and the effect of wind increases with height because the wind does. Further, none of the instruments are shielded. I expect our sensor group to recommend either shielded or pit (ground-level) gauges to reduce the interaction of wind and droplet size. Therefore, I have acquired additional tipping bucket and weighing gauges, plus shields, to set up a CMRB-specific cross comparison. I will need that to retain the value of the 45 years of weighing, unshielded rainfall data, and to compare the SCAN data with our other network. That also will help us support our choice going forward.

These steps will determine how we handle cross-network differences and help retain the longitudinal relevance of existing data. It will also inform whether we add shields to the current gauges or have a suitable correction. My expectation, assuming shielded weighing rain gauges are specified for LTAR, will be that we’d add shields going forward. Then, we’d use the information from our test to develop a derived rainfall product for the historical data that is corrected for the shield effect (expected to be windspeed dependent and perhaps either seasonal or different for rain/snow). We would publish the raw rainfall and the derived product in our database. The metadata would reflect the methods and also the expected accuracy of the derived product.

***The separate question of data communications***. I mentioned that communications were standardized to a level well beyond the measurements, and in fact, how to do that doesn’t appear to be a scientific question at all. I still think knowing how others have solved the challenges would be educational, particularly to those who have not yet gone to telemetry. However, the standardization that matters to the recipient is that it goes over the internet, in the specified transport format, with specified metadata tied to it. We do not know what that is yet, but I expect we will (perhaps it has already happened?) inform the process through inspection of networks like Ameriflux or NEON.

While this discussion is in front of us, we need to know very soon exactly what has been committed re the flux data going to NAL. We at CMRB intend to telemeter the 30-minute averages to our server inside our own telecom infrastructure, from where the PC attached would push data to NAL on some frequency. This could be daily, or perhaps even on the 30-minute basis, but we need to make it known that anything in near real time is provisional. The only post-processing on the 30-min real-time data would be what is on-board the datalogger. I expect human intervention for inspection and choices of other corrections, if needed, would be a batch operation.

For many reasons, both data QA and cybersecurity related, we don’t intend for any operational connection of a sensor or logger directly to the internet. Instead, all data going out would be ‘pushed’ from the PC attached tour server, under timed, automatic programmed control. We will preserve the ability to manually disconnect our net and directly connect a sensor or logger for diagnostic purposes by a vendor, but that would be done in isolation.

**Response to J. Sadler Jan. 22 e-mail above:**

**From:** <Strickland>, Tim <[Tim.Strickland@ARS.USDA.GOV](mailto:Tim.Strickland@ARS.USDA.GOV)>

**Date:** Friday, January 23, 2015 at 5:20 AM

**Subject:** RE: Discussion during the LTAR Research Committee Call

Thanks John, this is very well thought out and stated!  I would make one additional comment.  I hope the LTAR network is not just a nationwide observation network.  I view it as a nationwide, regional, and local network for research that includes observational tools that help us fit our research in a broader context scalable at multiple levels.  I think this is a very important distinction that we must always keep at the fore, because system ecology and farmers don’t much care whether we are trying to draw national conclusions.

**TOPIC: GENERAL COMMENTS FORWARDED BY TIM STRICKLAND (GACP) – included in the edited draft report – removed from report and placed here)**

1. The general approach of sending these materials out to the entire group is not likely to yield results that justify single-system justifications.  More success is likely using smaller, focused, and most importantly committed groups working on each sub-area.
2. It would be more desirable to encourage flexibility on manufacturer selection and focus on listing the specifications that a given instrument needs to meet (accuracy, durability, range, etc.), then present a list of specific model/manufacturers that meet those specifications for a specific measurement.
3. Where there is overlap between the ‘met’ and the ‘flux’ instruments, we should come to agreement on their recommendation.  The two files don’t need to give conflicting messages.
4. It really is not necessary to specify the power source or the data transmission method (although some may appreciate the suggestion).  These type of things could be listed elsewhere as suggestions rather than requirements.
5. We question the need for the LTAR network to commit to wet/dry deposition. The NADP programs cover wet-deposition of major cations and anions well. It is doubtful that monitoring for these analytes is needed at LTAR sites. One alternative for LTAR sites that are not close to an NADP site is to pay NADP to add a site. NADP also does some dry-deposition work, although it is not a major thrust. This in part because dry-deposition is technically difficult. There are too many variables.
6. It would be valuable to add a monitoring system for pesticides and or other organics (perhaps at selected sites). This includes both wet deposition and gas phase measurements. These compounds are certainly drivers of agricultural ecosystem impacts, and such an addition would provide a baseline attracting many ecological and community studies to the LTAR network.
7. We also suggest adding at “Remote Sensing Platforms” expert working group for a remotely sensed class of instruments so that we can more effectively address the spatial-temporal scale questions central to an “Ecosystem” program. We can add Alisa Coffin to this list from the GACP site.
8. We will be required to write sole source justifications to purchase specific instruments. Such instruments have to be really proven and those with experience in long-term use need to guide the discussion/selection. ARS might be exposing itself to critics (may be law suits) adopting a rigid policy of uniformity.
9. We should consider establishing several (3-4) instrument calibration and testing sites representing the range of environmental conditions across the network. It would be more effective to buy a few instruments and select the best overall performers under specific sets of environmental conditions. Use these sites as the core of an LTAR QA/QC program that carries the task of developing calibration models that would be used to provide first stage processed data into the LTAR database.
10. It should be possible to use the experts assigned to the Sensor QA/QC program as central coordinators for all sensor platforms in LTAR…and for liaison to other monitoring programs such as NEON. This would then limit the FTE requirements at each site to maintenance technicians.
11. We should not underestimate the resources (material financial and human) needed to insure longevity of use (maintain, replace, etc.), not to mention sensitivity, accuracy, etc.
12. Has ARS expertise outside of the 18 locations been sought for contributions? Bushland-TX has real experts on soil water and ET measurements.
13. For soil sensors, installation below 50 cm might become an issue if just one type of sensor is used. This will of course vary depending on location and soil type. We will need to develop a protocol and QA/QC program for comparison and standardization. For short length sensors dig a pit and install into the exposed face and backfill, or dig a hole and insert vertically down and backfill? Note: NRCS has experience on this from its SCAN program.
14. We need to prioritize the order for “bringing a system on-board” among all sites. The order should be married to the data requirements of the Common Experiment.

**TOPIC: PROCESS – FOCUS ON FLUX AND MET SENSOR ONLY AT THIS TIME**

**From:** <Bosch>, David-ARS <[David.Bosch@ars.usda.gov](mailto:David.Bosch@ars.usda.gov)>

**Date:** Tuesday, January 27, 2015 at 11:50 AM

There appears to be considerable overlap between the ‘Met\_Soil Climate..’, the ‘Met-Flux-Meas’, and the ‘Met-flux-meas-inst-table1’ files.  Why not have just one guidance file?  There will be cases where folks have just a met station, but I think the flux stations will always include the met station measurements.  It would seem that by having multiple files we just allow for duplication or differences.

I also think at this point I’d avoid establish guidelines for data transmission.  Folks are going to end up doing it whatever way works for them.  Sometimes this is site visits, UHF, cell modem, land line, etc. I think simply providing connections to folks with this expertise (you’ve already started a list), would be sufficient.  I wouldn’t make this any more complicated than it absolutely needs to be.

Finally, I think I’d focus on the met and flux sensors at this point and leave the wind erosion stuff for later.

**TOPIC: WET-DRY DEPOSITION**

**From:** <Potter>, Tom - ARS <[Tom.Potter@ars.usda.gov](mailto:Tom.Potter@ars.usda.gov)>

**Date:** Monday, January 26, 2015 at 5:50 AM

I was wondering if the LTAR network is committed to wet/dry deposition. I believe that NADP programs cover wet-deposition of major cations and anions well. Thus I doubt that more monitoring for these analytes is needed at LTAR sites. One alternative for LTAR sites that are not close to an NADP site is to pay NADP to add a site. I think that this is still possible. NADP also does some dry-deposition work, although it is not a major thrust. This in part because dry-deposition is technically difficult. There are too many variables. While I don’t think that LTAR needs to duplicate NADP, I do feel that some work on pesticides and or other organics (perhaps at selected sites) may be appropriate. This includes both wet deposition and gas phase measurements. I have many years of experience with this and will be happy to provide input.

**TOPIC: PROGRESS AT MANDAN**

**From:** <Sanderson>, Matt <[Matt.Sanderson@ARS.USDA.GOV](mailto:Matt.Sanderson@ARS.USDA.GOV)>

**Date:** Thursday, January 29, 2015 at 10:51 AM

We at Mandan have adopted nearly all the initial recommendations for instrumentation and are in compliance with those recommendations for our 2 Eddy Flux stations, the Met/Soil Climate Station, and the Wind Erosion tower, so we do not have any recommendations on those. We have one deviation from the recommended soil moisture instrumentation for which we added an explanation and justification (in the spreadsheet you provided, attached) for the use of our current (new; ENVIROSCAN model) soil moisture measurement system. We purchased this new system in FY13 with end of year funds from ONP (from Walbridge; which we also matched). I have also attached the justification and some explanation by Mark Liebig.

**TOPIC: PROGRESS AT CPER**

**From:** <Smith>, David <[David.Smith@ARS.USDA.GOV](mailto:David.Smith@ARS.USDA.GOV)>

**Date:** Wednesday, February 4, 2015 at 8:19 AM

I am the technician working with Justin Derner and David Augustine to build out the CPER LTAR instrumentation.  Justin and David are both at SRM and may have already forwarded this information to you.  Attached are the LTAR recommended sensor tables with a column I added to indicate what we have existing and what was purchased.  I merged the pertinent LTAR worksheets into one CPER spreadsheet.  You’ll see in the tables, but at the end of FY14 we purchased 2 Eddy Covariance towers from Campbell.  The systems are their standard pre-configured setup using the EC150 open path IRGA.  Our EC configuration is slightly different than the recommended systems, mainly the EC150 vs IRGASON.  At that time we also ordered 2 Wind Erosion towers with the configuration recommended by the group at Jornada.  Finally, we have had our current CPER Meteorological station in place since 2004 and it contains many of the sensors in the LTAR Met recommend list.  We may need to fill in some of the measurements with additional sensors as needed.  I manage our current instrumentation and have managed BREB systems in the past, so am familiar with most of the instruments on the lists.  Please let us know if you have any questions.

**TOPIC: WIND EROSION – NEW DOCS FROM JORNADA**

**From:** Nicholas Webb <[nwebb@nmsu.edu](mailto:nwebb@nmsu.edu)>

**Date:** Tuesday, February 3, 2015 at 12:45 PM

**Subject:** Updated Wind Erosion Network

As requested, please find attached updated documents for the National Wind Erosion Research Network. Included are:

- Updated presentation

- Updated manual

- Updated parts list

- Updated time requirements / task list for the wind erosion network.

PLEASE NOTE: the parts list is still a work in progress. Although some have, I do not recommend that sites purchase until we have finalised.