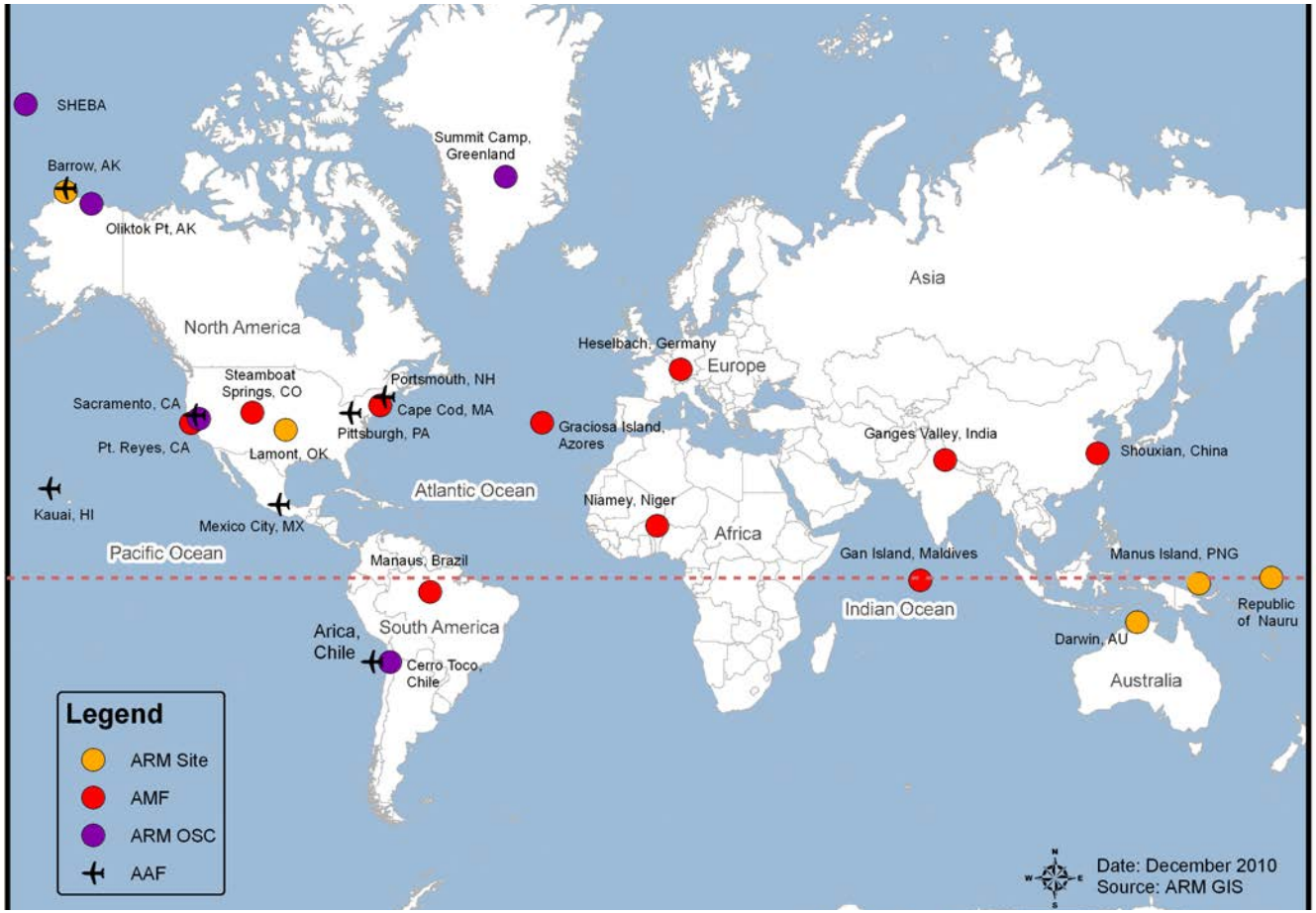
Overview of ARM Sites, Studies, and Collaborations (www.ARM.gov)



Doug Sisterson
U.S. DOE ARM Climate Research Facility

Highlights: Sites

- ARM has also focused on the measurement of clouds (new ARM cloud microphysics and precipitation radars) and aerosols (some trace gases) with ARRA finds received in 2009. Most of those instruments have now been added to all ARM fixed sites and mobile facilities.

- ARM will add two new sites beginning in 2013: A fixed site in the Azores at Graciosa Island in the Eastern North Atlantic and a long-term deployment of a mobile facility at Oliktok, Alaska, in the Arctic.

- The SGP site has just completed a 2 year activity that restructured the size of the overall study from 325 km x 275 km to 150 km x 150 km. There were no changes to the location of the Central Facility.

- The SGP Central Facility has a new neighbor: a large wind generator farm. Also, drilling for oil by hydraulic fracking has resulted in excavations very close to the Central Facility.

- The ARM Nauru Site will been closed in August 2013.

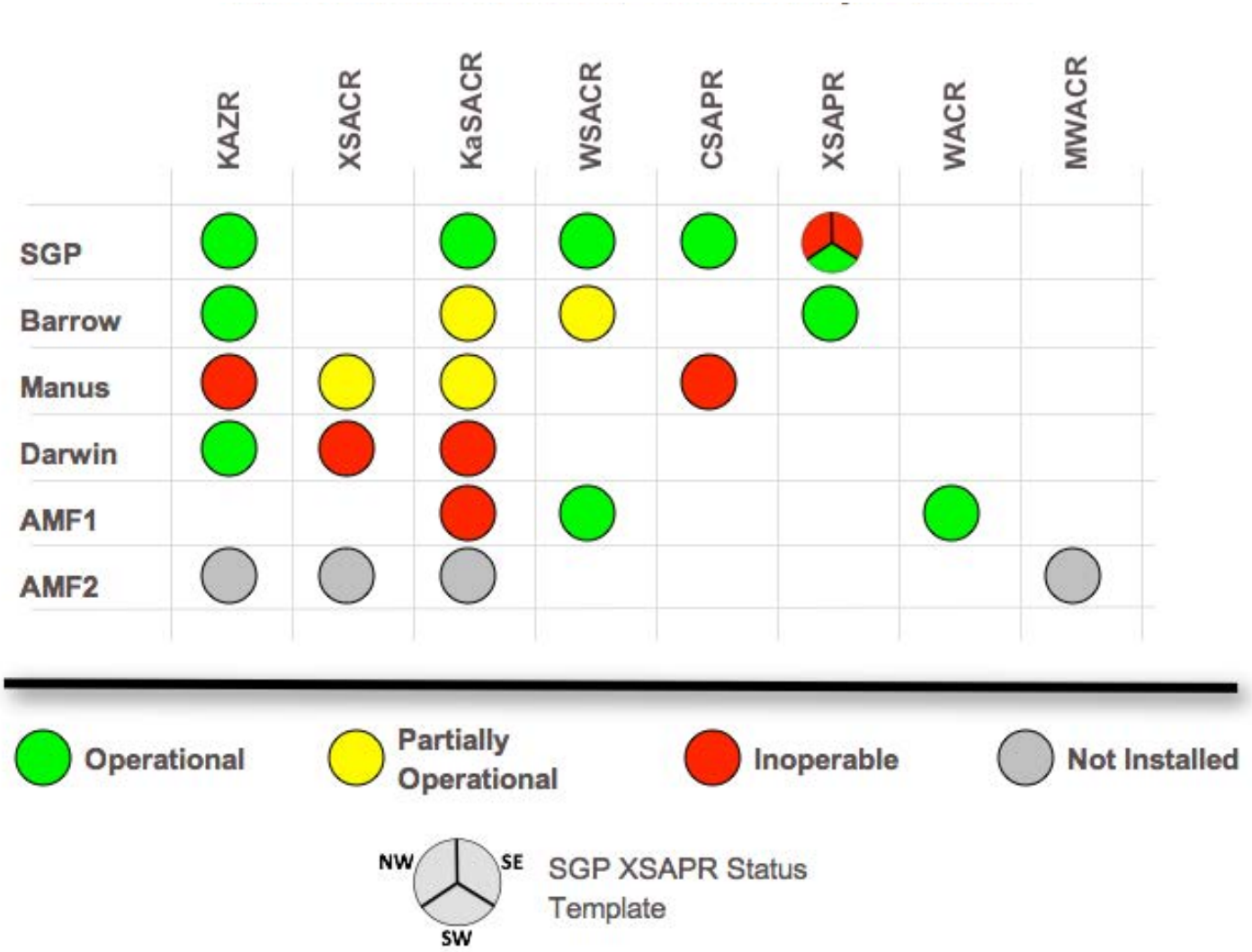
New ARM Site: Azores in the Eastern North Atlantic

The new location for ARM's Eastern North Atlantic (ENA) fixed site in the Azores is shown in relation to the original mobile facility deployment site near the airport on Graciosa Island.

New ARM Facility: Oliktok Point, Alaska, in the Arctic

As shown in this aerial photo of Oliktok Point, Alaska, the USAF Long Range Radar Station - also known as Dew Line Station - is situated at the edge of the Arctic Ocean. Instrumentation for the ARM Program's M-PACE experiment was located just south of the station, near the aircraft hangar. (Photo courtesy of Aeromap U.S.)

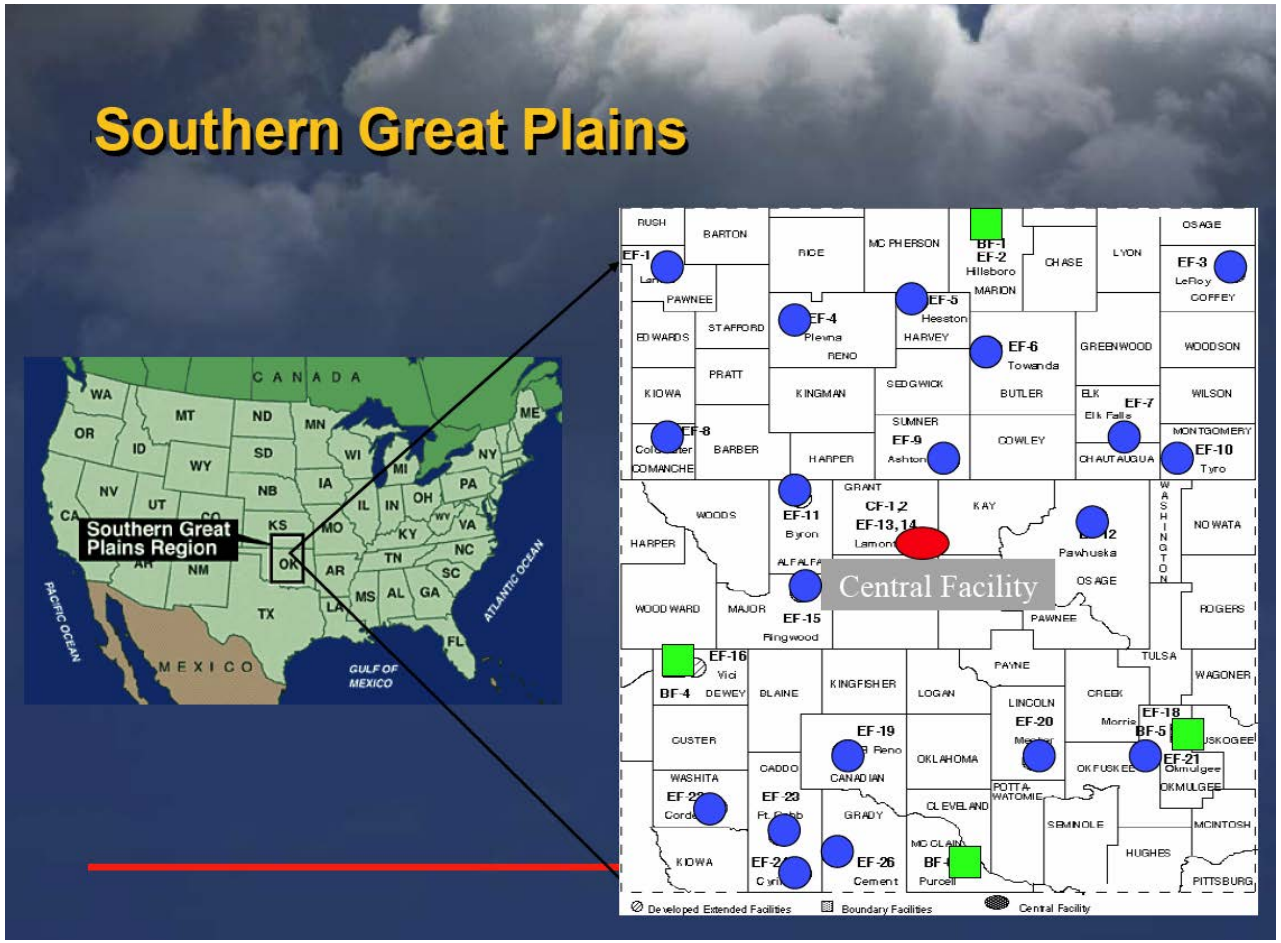
New ARM Radars Locations



New ARM Aerosol and Trace Gas Instrumentation

- Aerosol Chemical Speciation Monitor
- Ambient Nephelometer
- f(RH) Wet Nephelometer
- Cloud Condensation Nuclei
- Condensation Particle Counter
- Hygroscopic Tandem Differential Mobility Analyzer
- Photo Acoustic Soot Photometer (3 wavelength)
- Particle Soot Absorption Photometer
- Scanning Mobility Particle Sizer
- Ultra-High Sensitivity Aerosol Spectrometer (Hemispheric and Zenith)
- Single Particle Soot Photometer
- Particle-Into-Liquid Sampler
- Proton Transfer Reaction Mass Spectrometer
- Ozone
- SO2
- N2O/CO Analyzer (for CO, H2O, and N2O)
- Chemiluminescence for NO/NOx/NOy:

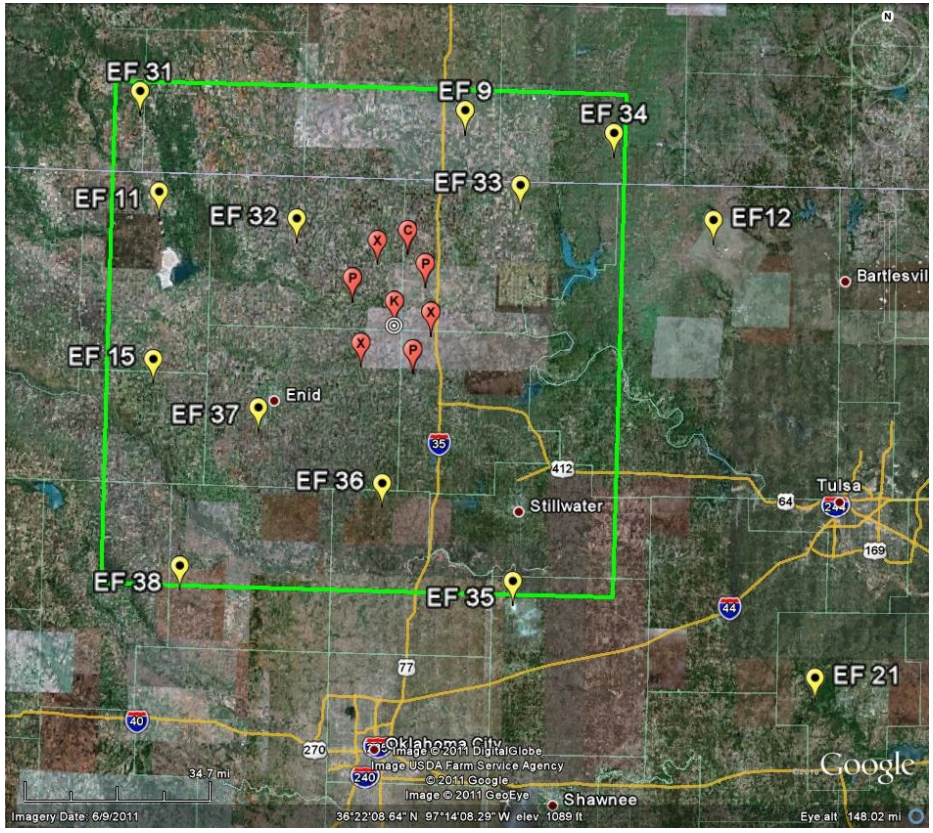
Southern Great Plains (SGP) 1990-2010 With Focus On Radiation Measurements



Grid size: 325 km x 275 km (89,375 square kilometers)

Southern Great Plains (SGP) 2010-2012: Transition To Expanding Observations That Focus On Clouds and Aerosols

After 2 years and the *completion of all SGP ARRA projects*, the new and improved SGP Facility is now fully operational. The new configuration provides unprecedented opportunity for the alignment of especially cloud and aerosol observations for improving climate model predictions.



Original SGP Footprint:

- Observations designed to challenge climate models
- 31 instrumented sites
- ~55,000 square miles
- 31 sites visited every 2 weeks

New SGP Footprint:

- Climate models used to design observation strategies for cloud and aerosol measurements
- 21 instrumented sites
- ~10,000 square miles
- 21 sites visited every week being planned

Southern Great Plains (SGP): Grouping of Multiple Instruments Moves From Soda Straw To 3-D and 4-D Cloud Scale Coupled Observations

- The SGP has 7 of the new cloud and precipitation radars that provide unparalleled observational capabilities of cloud processes to the scientific community. The operation and maintenance of these new systems are extremely complex and will be operated differently than all other instruments.
- The ARM radars world-wide will be operated by the ARM Radar Operations Group and the ARM Radars Science Group. Together, they will determine how to utilize the radars for routine climate measurements, as well as for research needs for field campaigns.

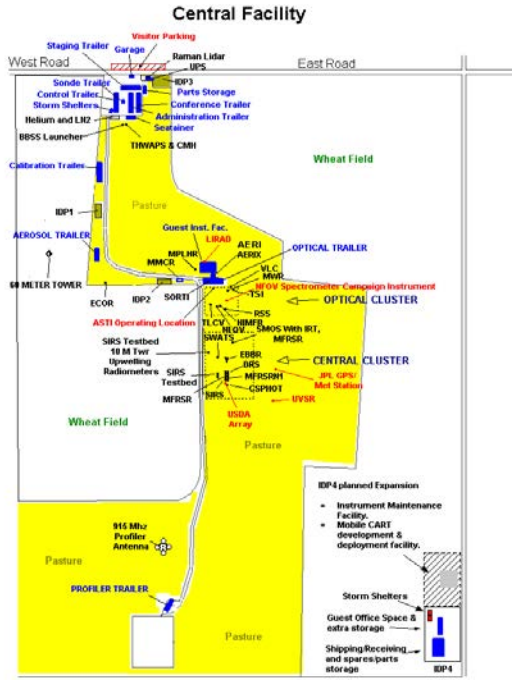
SGP ARM radars.

Southern Great Plains (SGP): Challenges and Opportunities-Oil Exploration

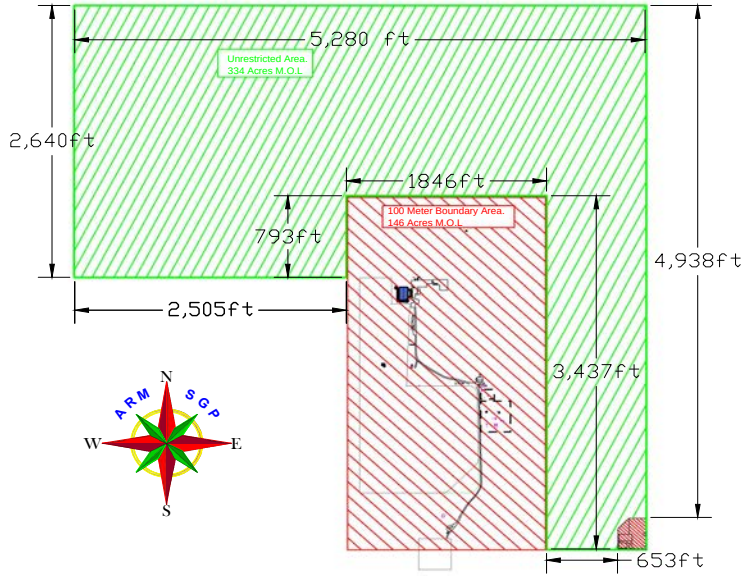
The large drilling equipment (left) is used for oil exploration by hydraulic fracking. Usually the drilling rig is place for up to 90 days, then the only infrastructure that remains is a small pump and the storage containers. One of the ARM radar sites is to the right in this photo.

Southern Great Plains (SGP): Challenges and Opportunities

- Oil exploration by hydraulic fracking in the area has resulted in a measureable increase to our background diesel emissions aerosol measurements.
- Completed a survey with all Instrument Mentors for the possibility of oil exploration at the Central Facility that allowed us to illustrate where hydraulic fracking would be permissible with minimum impact.



Central Facility instruments (left) are represented by the no drill "red zone" (right) and the permissible drill "green zone" is the balance of the 480-acre land leased.

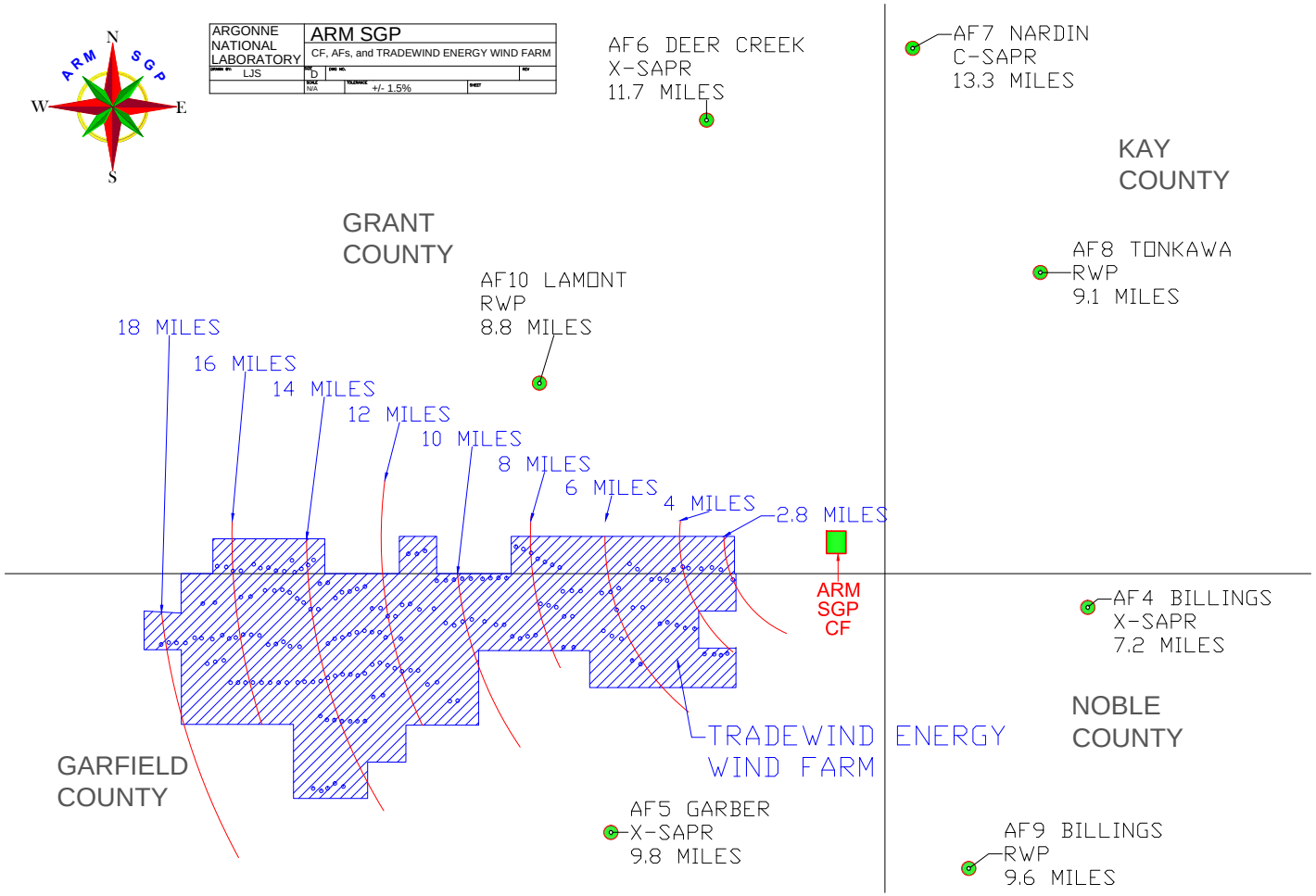


Southern Great Plains (SGP): Challenges and Opportunities-Wind Power Farms

The installation of a large wind turbine farm has an impact on our radars (i.e., causes false targets that look like convective clouds). ARM is not alone in this issue. Algorithms are being developed to address this problem. But, it is also an opportunity to study the impact of large wind farms on local meteorological parameters and weather.

KZAR and Ka-W SACR in the foreground, looking WSW at our new neighbors.

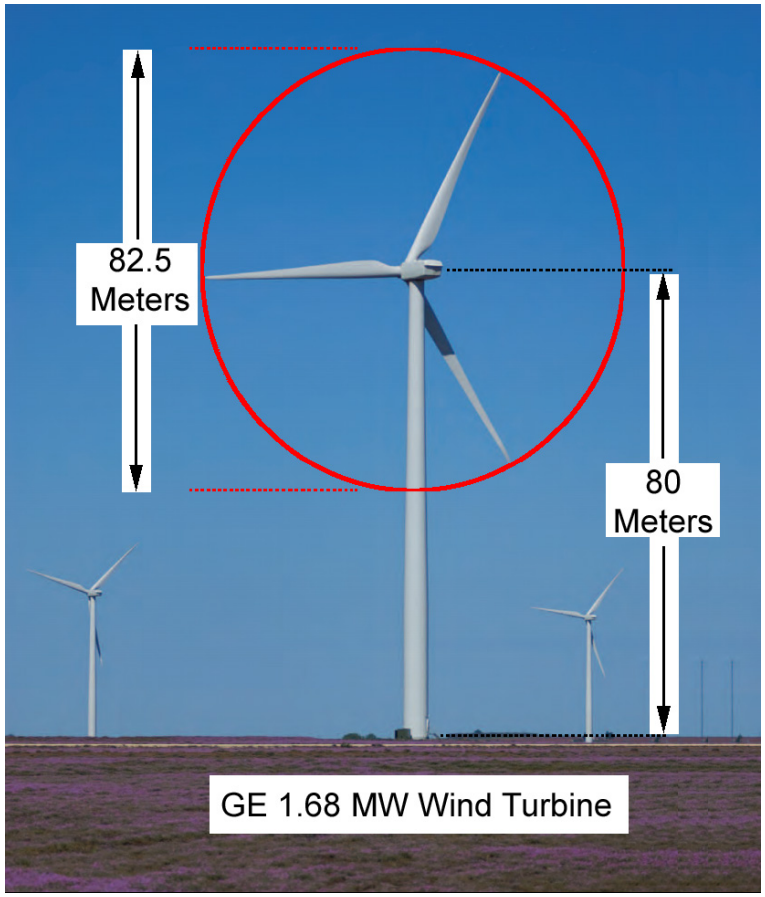
Southern Great Plains (SGP): Challenges and Opportunities



The location of the Central Facility and ARM radars and radar wind profilers in relationship to the 144 wind turbines. Installation has been from East to West.

Southern Great Plains (SGP): Challenges and Opportunities

Perspective!

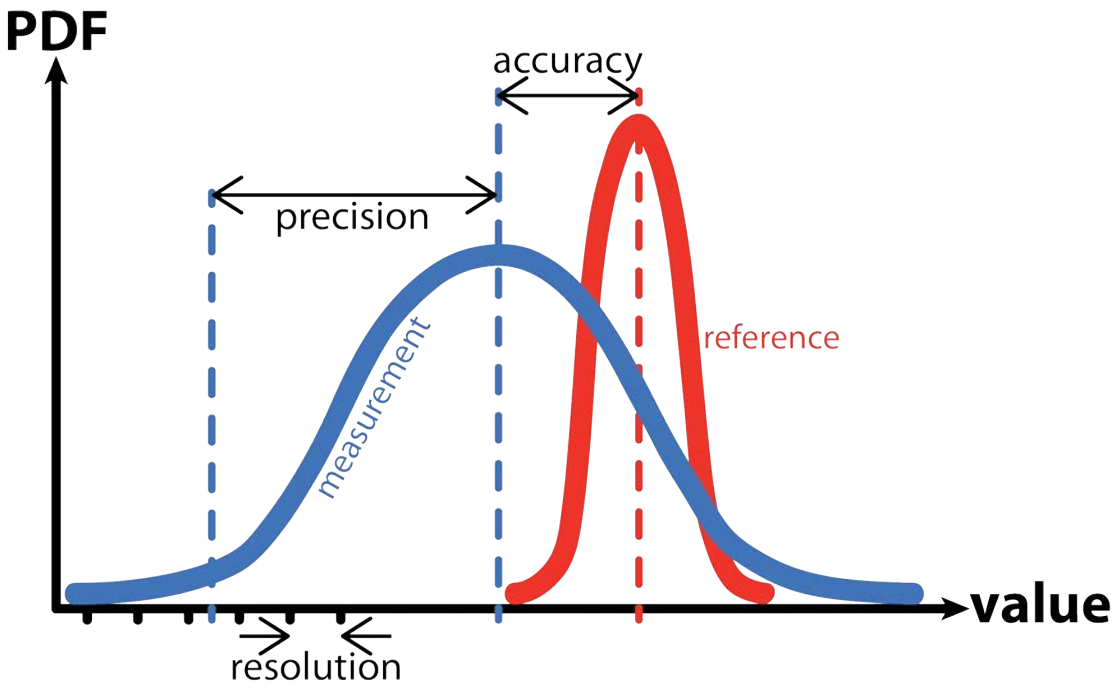


The Central Facility structures and instruments are no longer the prominent silhouette driving in on the East road!

Highlights - Continued

Studies

In 2012, ARM began a detailed study of the uncertainty of all ARM data streams with the intent of standardizing the reporting of uncertainty for Users of the ARM Climate Research Facility data. This includes the estimate of uncertainty for engineered data products (Valued Added Products or VAPS).



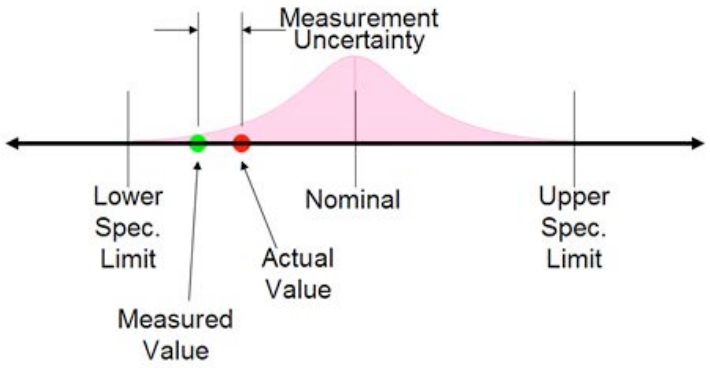
ARM Measurement Uncertainty Study

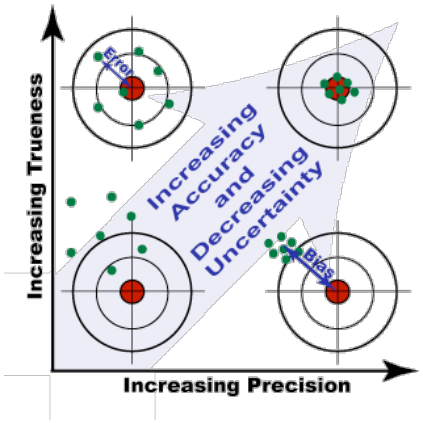
The Problem:

- ARM has, as a high priority, the challenge to address the uncertainties of all instrument measurements and Value Added Products (VAPS).
- Although much of measurement uncertainty can be extracted for the ARM Instrument Handbooks, the information is not presented in a consistent manner.
- There is no documented information about VAP uncertainty.

The Challenge:

- What is needed is an easily accessible, high-level summary table of instrument measurement and VAP uncertainty.





ARM Instrument Uncertainty Study

- The Guide to the Expression of Uncertainty in Measurement (GUM) is a document that establishes general rules for evaluating and expressing uncertainty in measurement.
- One of the basic premises of the GUM approach is that it is possible to characterize the quality of a measurement by accounting for both systematic and random errors.
- Another basic premise of the GUM approach is that it is not possible to state how well the true value of the measurement is known, but only how well it is believed to be known. (Example: Radiometers can be calibrated precisely in ideal conditions, but radiometers in the field acquire dust *or worse* on the domes and therefore the true value is not well known.)
- Therefore results of measurement need to be considered and quantified in terms of probabilities that express degrees of belief.
- Most importantly, we need to educate users that uncertainty should NOT be interpreted as how poor a measurement is, but rather how well the measurement is believed: A measurement with +/- 25% uncertainty means that we are 75% sure that the measurement is good.

ARM Instrument Uncertainty Study

Path forward:

- First, clearly define the methodology that ARM will use to represent uncertainty.
- Gather instrument measurement uncertainty information for all ARM instruments.
- Sort and report the information in some form.

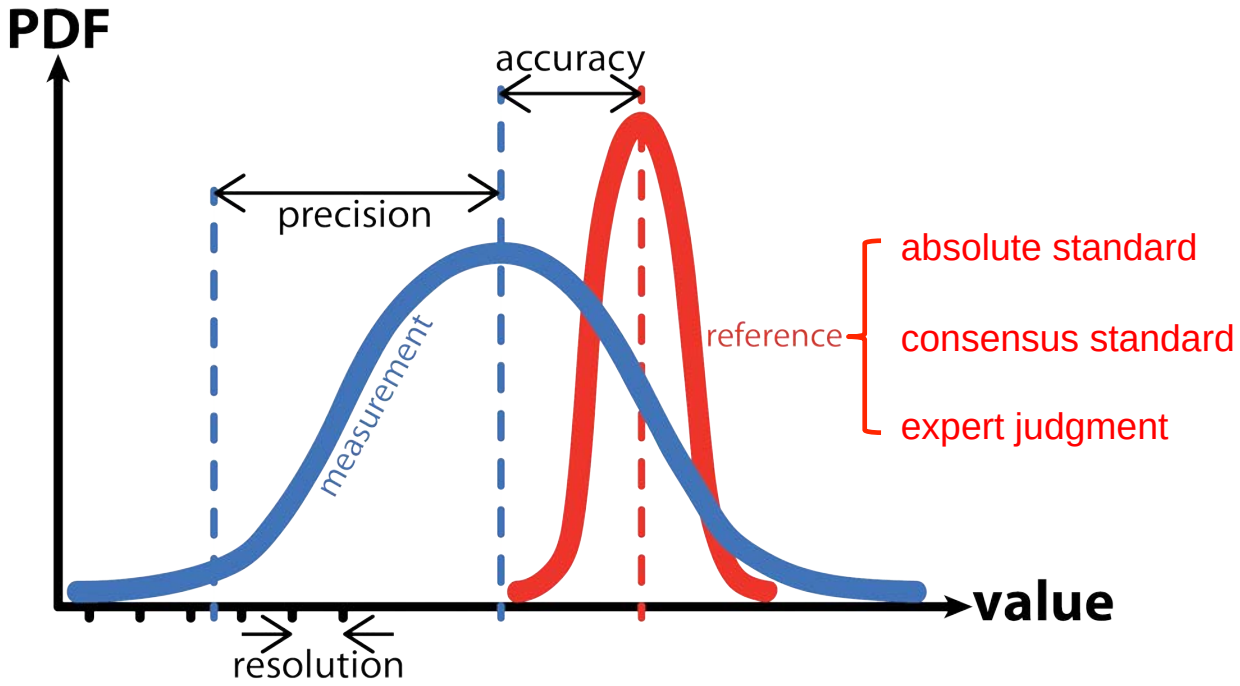
Information Needed:

- Bias
- Precision
- Resolution
- Traceability to 1) a standard calibration reference, 2) a standard calibration procedure, or 3) expert judgment.

✓ We had 100% participation by all Mentors who provided slides of their instrument measurement uncertainty at the ASR Science Team Meeting this year.

ARM Instrument Uncertainty Study

Toward the expression of uncertainty in the ARM facility measurements: (Sisterson and Campos)



The model used to sort the Mentor provided information.

ARM Instrument Uncertainty Study

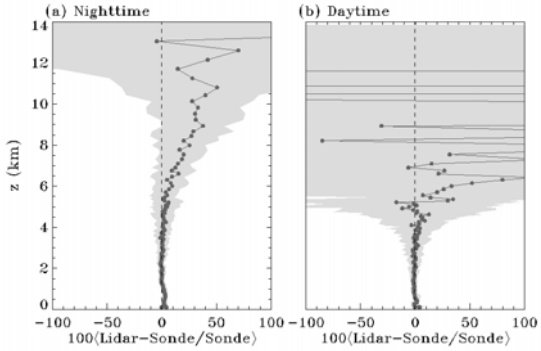
Preliminary results for Multifilter Rotating Shaddowband Radiometer (MFRSR)

Mentor (40+ mentors)	Instrument (Over 77 different types)	Measurement (multiple measurements per instrument)	Uncertainty Estimate (absolute or % units)	Uncertainty Type (resolution, precision, or accuracy) and Traceability
Gary Hodges	MFRSR: Multifilter Rotating Shadowband Radiometer	Clear Skies total horizontal irradiance	± 2.1 %	Accuracy from a consensus standard, 95% confidence
…	…	…	…	…

ARM Instrument Uncertainty Study

- Not all of the ARM Instrument Mentors provided complete information, so iterations will be needed.
- There is an wide range of complexity of ARM Instruments that will not be a simple as the MFRSR sample shown, so additional information may need to be added to our table.
- We will be able to fill in a spread sheet (previous slide) with the information at hand quickly (the “low-hanging fruit”), but more complex systems like the ARM radars will require iterations with the Mentors.
- The ARM Data Quality Office is addressing the VAP uncertainties.
- We will work with the Data Quality Office to determine if there is a way to visually display uncertainty. For example, there is a range of uncertainty for Raman Lidar water vapor mixing ratios based on the dryness of the atmosphere (see example below).

Newsom: ARM Raman Lidar water vapor mixing ratio error estimates based on comparisons with radiosondes.



Highlights - Continued

Collaborations

The U.S. DOE Office of Science, Office of Biological and Environmental Research, Climate and Environmental Sciences Division (that sponsors ARM and ASR) recently hosted an *U.S./European Workshop on Climate Change Challenges and Observations (Report DOE/SC-0154)* aimed at identifying outstanding climate change science questions and the observational strategies for addressing them.

The science focus was clouds, aerosols, and precipitation, and the required ground-based and aerial-based observations. The workshop findings will be useful input for setting priorities within the U.S DOE and the participating European centers.

Strategies for enhancing collaboration among the ARM Climate Research Facility and European programs were identified, including the “harmonizing” of the data.

Questions?

www.ARM.gov