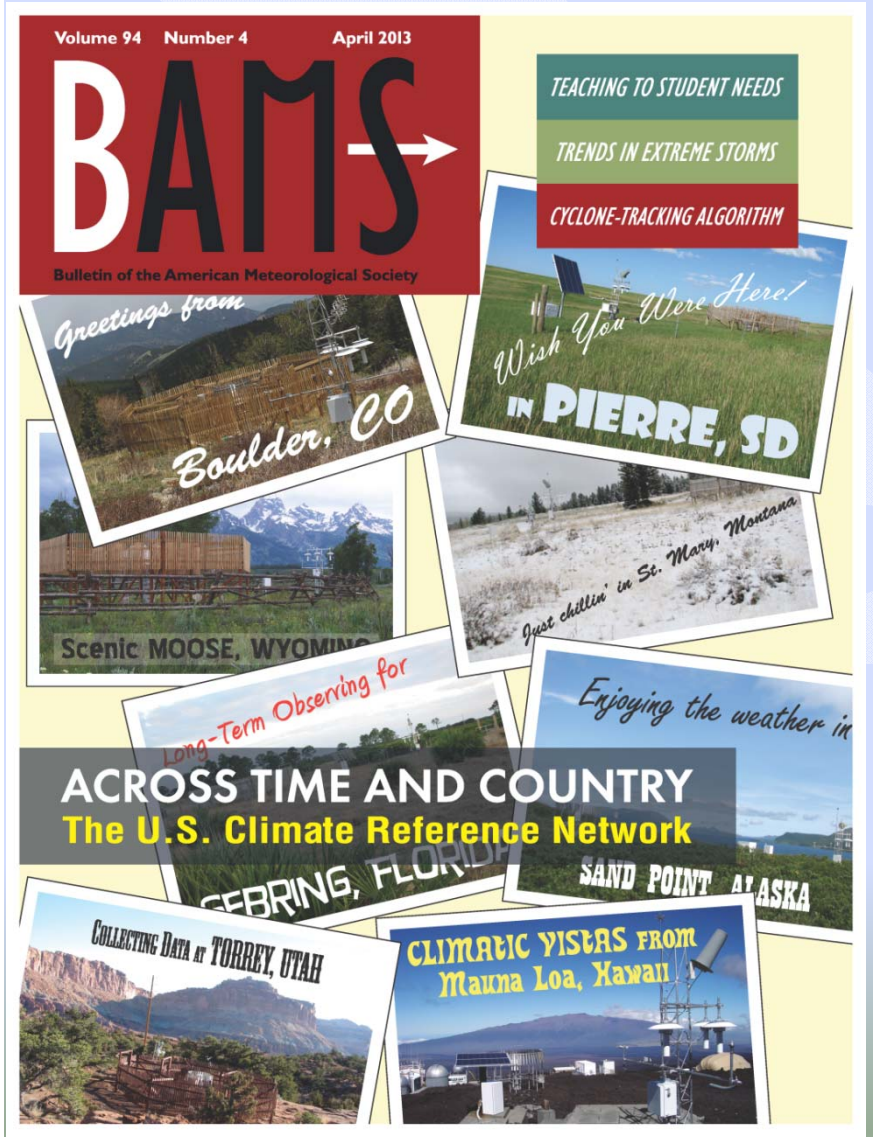
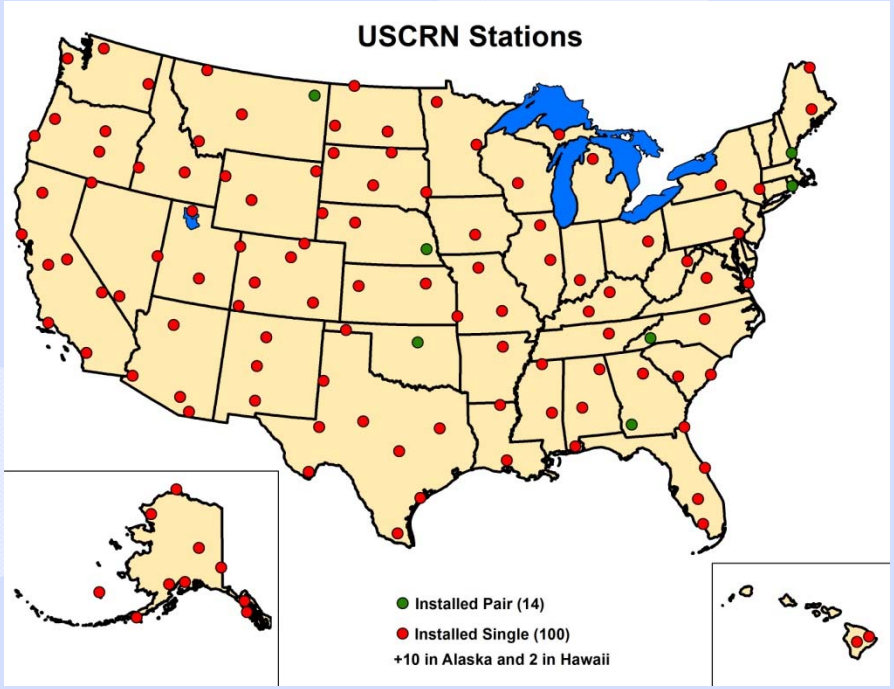
U.S. Climate Reference Network (USCRN) - Western States Water Council Workshop on Hydroclimate Observing Systems





Howard J. Diamond, USCRN Program Manager
June 24, 2014

Agenda

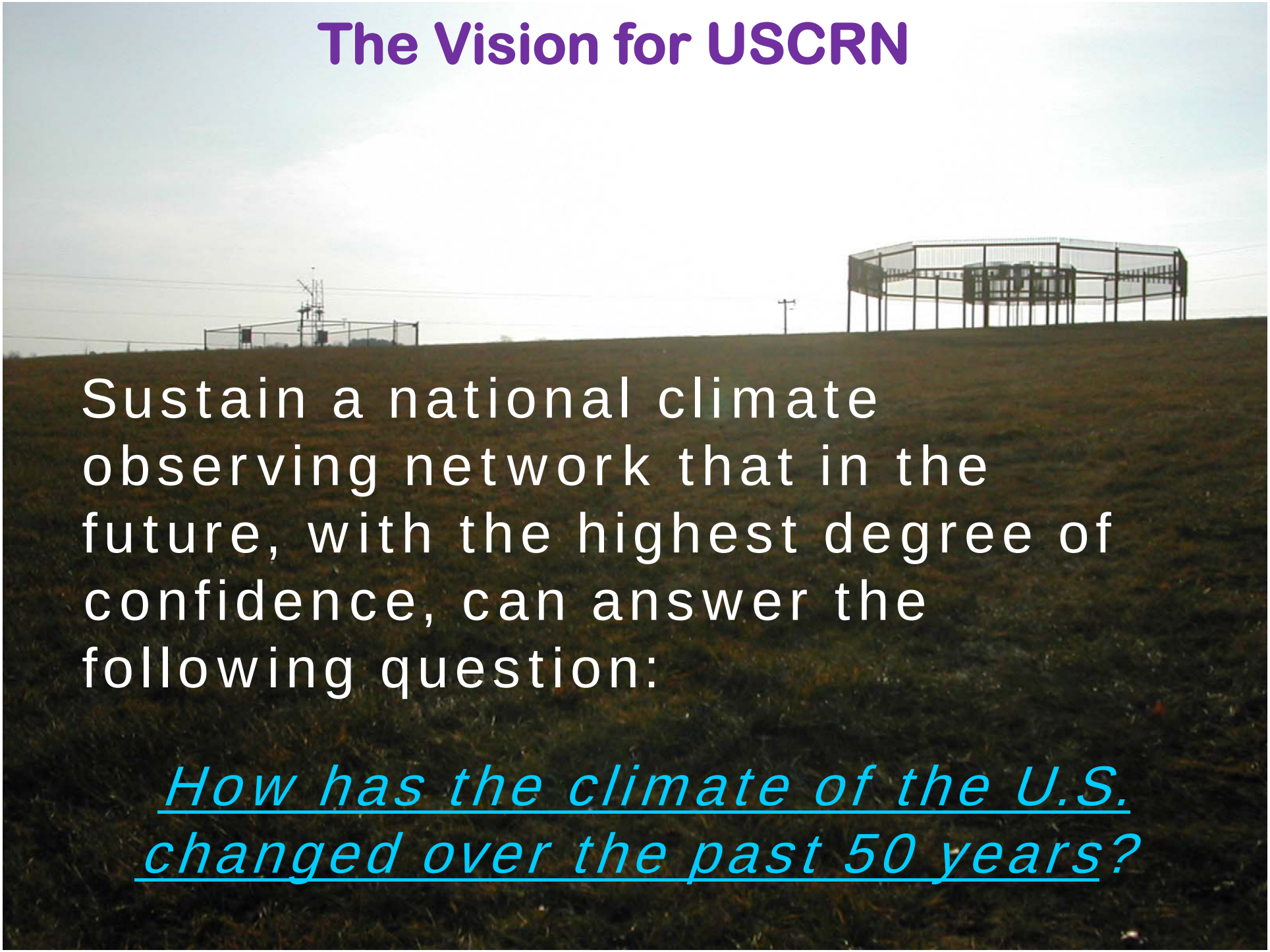
- **Vision and Brief Overview of the Program**
- **Roles, Responsibilities, and Program Governance**
- **Science Program; Instrumentation and Testing**
- **Summary**

NOTE: USCRN is NOT USRCRN

Paper on USCRN published in April 2013:

Diamond, H. J., T. R. Karl, M. A. Palecki, C. B. Baker, J. E. Bell, R. D. Leeper, D. R. Easterling, J. H. Lawrimore, T. P. Meyers, M. R. Helfert, G. Goodge, and P. W. Thorne, 2013: U.S. Climate Reference Network after one decade of operations: status and assessment. *Bull. Amer. Meteor. Soc.*, **94**, 489-498. doi: 10.1175/BAMS-D-12-00170.1

The Vision for USCRN



Sustain a national climate observing network that in the future, with the highest degree of confidence, can answer the following question:

How has the climate of the U.S. changed over the past 50 years?

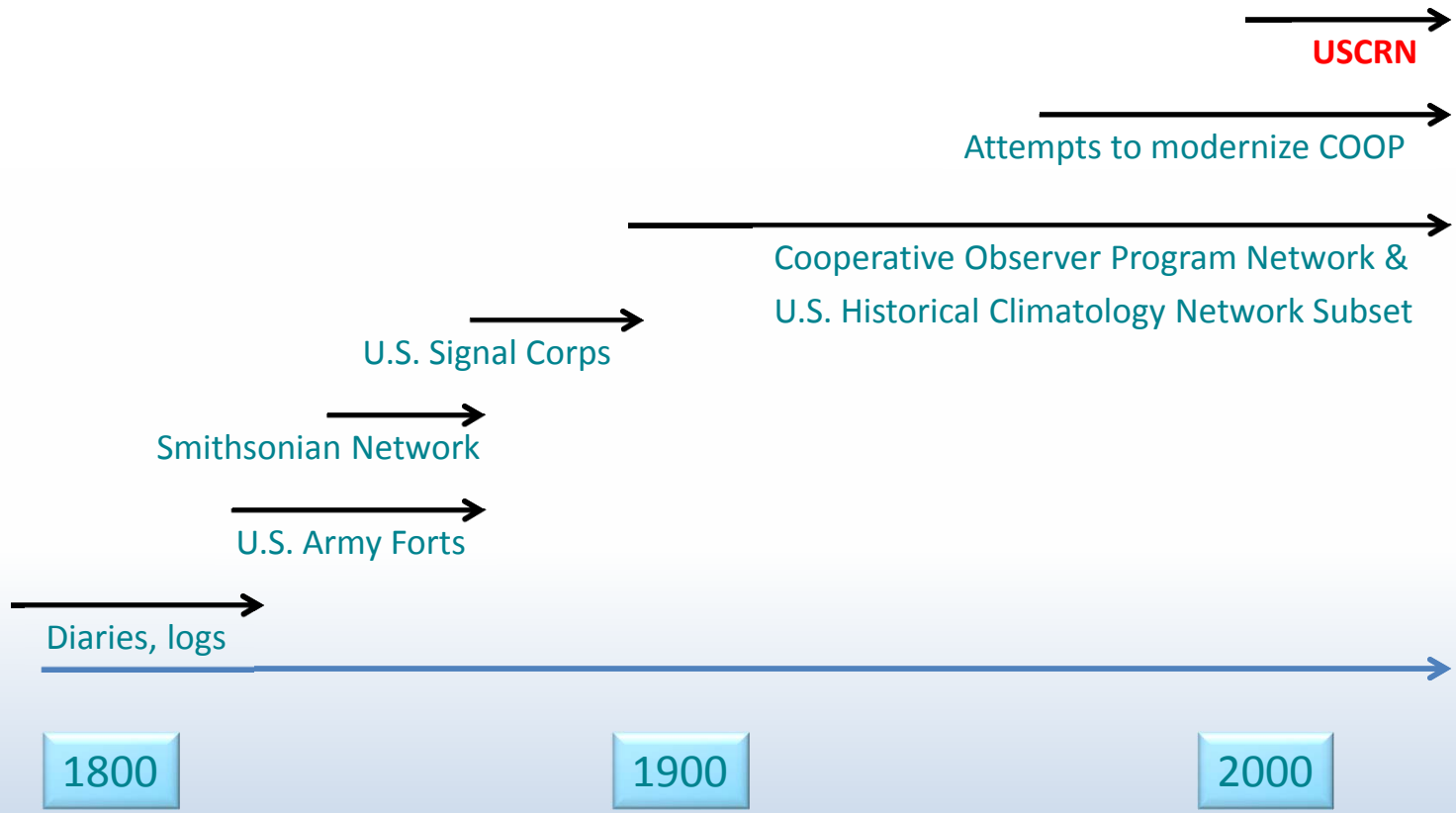
U.S. Climate Reference Network

NOAA's Benchmark USA Climate Observing Network

Designed to answer questions about National Air Temperature, Precipitation, and Soil Temp and Moisture changes with the highest confidence

- Siting:
  - 114 CONUS and ultimately 29 Alaskan stations at pristine sites; shouldn't change in >50 years
- Instruments:
  - Triple configuration air temperature and precipitation sensors; and soil measurements
  - Real time data and equipment monitoring
- Surface observations every 5-minutes
  - Hourly transmission via GOES
- Standards
  - Meets GCOS Climate Monitoring Principles - **http://www.wmo.int/pages/prog/gcos/index.php?name=ClimateMonitoringPrinciples**
  - Follows NIST calibration standards
- Science Performance Measures
  - Explain temp (98%) and precip (95%) variance

Evolution of Surface Climate Observing Systems in the U.S.



Program Overview – Station Profile

- Total Operational Stations: 128 (plus 4)

- 114 stations installed at 107 sites in the CONUS
  - 7 stations are dual sites
  - Last station was commissioned in 2009

- 14 stations installed in Alaska (12 commissioned)
  - 4 stations installed from 2002-05 as test sites
  - 10 stations installed since 2009

- Four additional stations
  - 2 in Hawaii (Mauna Loa and Hilo)
  - 1 in Ontario, Canada – bilateral test station
  - 1 in Tiksi, Russia – from IPY bilateral agreement (U.S. GCOS-funded)
  - Plus NCAR's Marshall Test Facility (Boulder, CO)

Program Overview – Station Profile

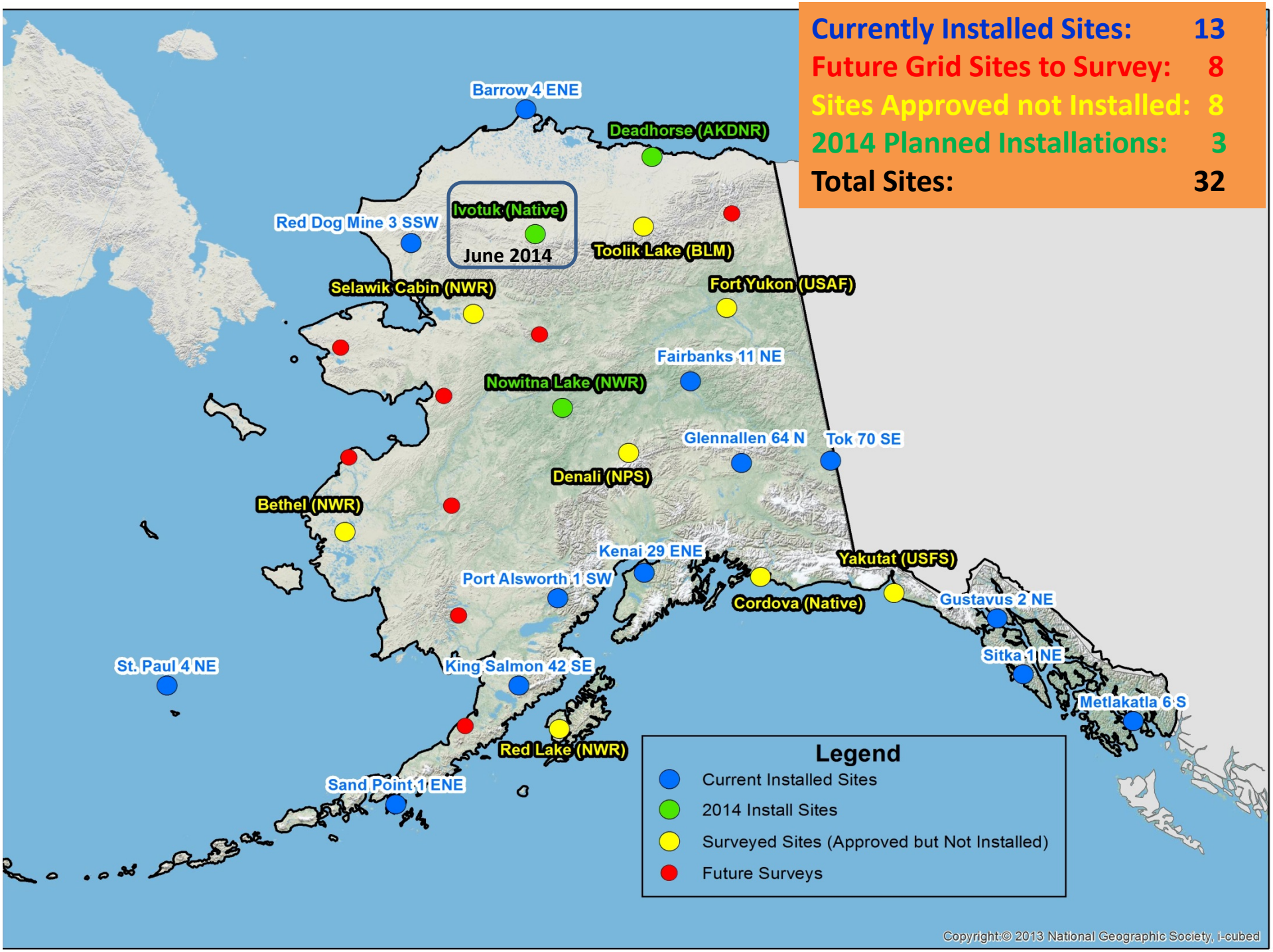
- Three stations planned for installation in Alaska during the summer 2014 building season (one down two to go)
- Plan is to install an additional 13 stations in Alaska from 2015-2022 – fully populates the defined 29 station grid
- NIDIS Soil and Relative Humidity Sensors
  - Installed at all CONUS sites from 2009-11
  - Installed at one station in Alaska - Kenai
  - Plan is to install at other sites as we gain experience with unique permafrost environment across Alaska; may require a different kind of soil sensor
- Budgets for USCRN come from NOAA/OAR's Climate Program Office [including the NIDIS Program Office - soil sensors]; Program executed by NCDC and ATDD
  - PPA: Regional Climate Data and Information [PPA stands for Program, Project, and Activity]

Program Overview - Alaska Site Selection

- Goal is to install 29 Total Sites in Alaska by 2022; pending funding we have 3 additional sites (total of 32) that would be good to consider.

- To do this we need good stable sites that are
  - Representative of the various climate regimes across AK;
  - Adequately cover a grid spacing in Alaska to best measure temperature and precipitation across the state;
  - Practical to install; and
  - Affordable to maintain and operate.

- Not an easy task; and involves a year-long process of
  - Surveying sites in the summer;
  - Evaluating sites in the fall;
  - Preparing selection paperwork and site license paperwork during the fall and winter;
  - Procuring and shipping equipment in the spring; and
  - Installing new station(s) in the following summer.


Currently Installed Sites: 13
Future Grid Sites to Survey: 8
Sites Approved not Installed: 8
2014 Planned Installations: 3
Total Sites: 32
Barrow 4 ENE
Deadhorse (AKDNR)
Ivotuk (Native)
June 2014
Red Dog Mine 3 SSW
Toolik Lake (BLM)
Selawik Cabin (NWR)
Fort Yukon (USAF)
Fairbanks 11 NE
Nowitna Lake (NWR)
Glennallen 64 N
Tok 70 SE
Denali (NPS)
Bethel (NWR)
Kenai 29 ENE
Yakutat (USFS)
Port Alsworth 1 SW
Cordova (Native)
Gustavus 2 NE
Sitka 1 NE
St. Paul 4 NE
King Salmon 42 SE
Metlakatla 6 S
Red Lake (NWR)
Sand Point 1 ENE
Legend
Current Installed Sites
2014 Install Sites
Surveyed Sites (Approved but Not Installed)
Future Surveys
Copyright:© 2013 National Geographic Society, i-cubed

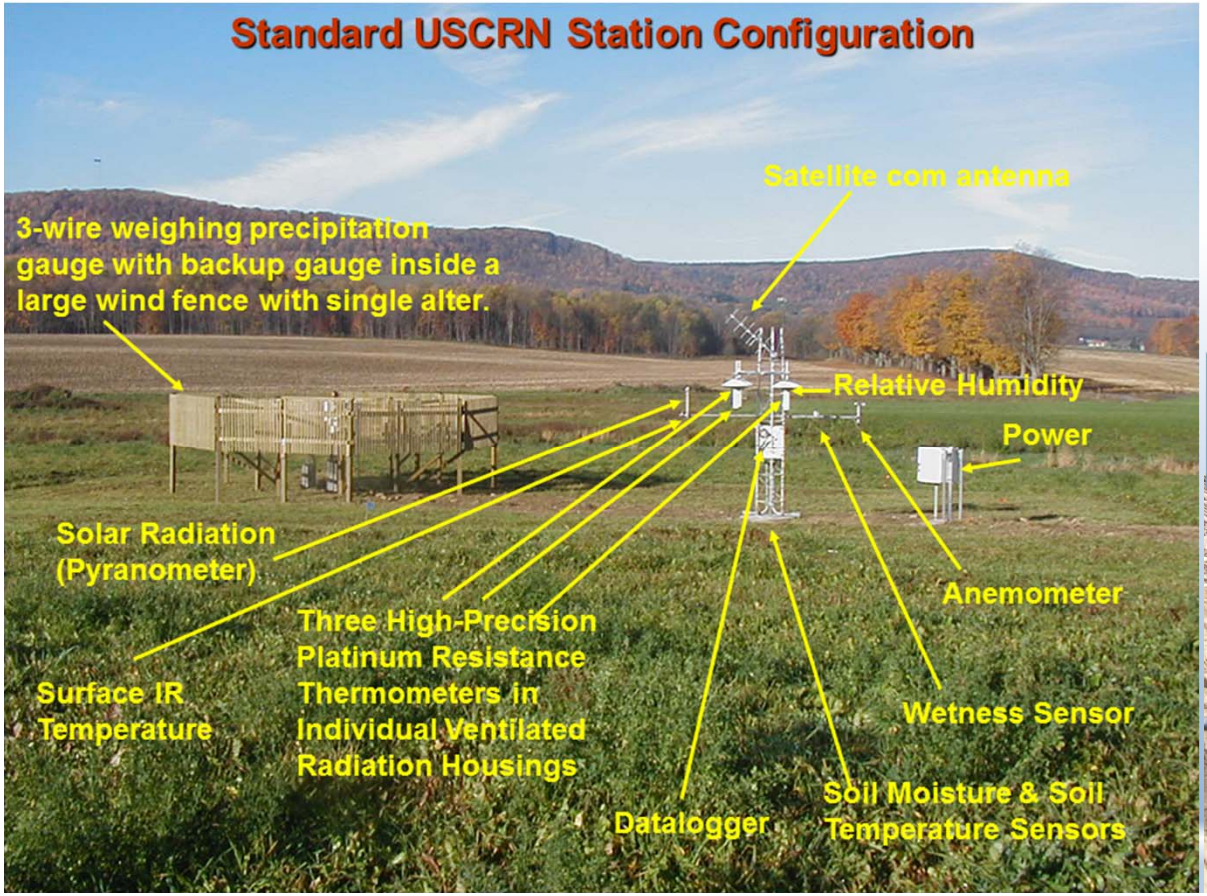
Program Overview – Sensors

- Primary Measurements (triple redundancy)
  - Air Temperature (platinum resistance thermometers)
  - Precipitation (3-wire weighing gauge)
  - Soil Moisture and Temperature

- NIDIS Soil and Relative Humidity Sensors
  - Installed at all CONUS sites from 2009-11
  - Installed at one station in Alaska
  - Triple redundancy at 5,10,20,50, and 100 cm – standard WMO soil depth levels

Program Overview – Sensors

- Ancillary Measurements (no redundancy)
  - Surface infrared radiation
  - Solar radiation
  - 1.5m anemometer (not WMO standard for wind)
  - Wetness sensor and Relative humidity sensor



Typical soil sensor installation

Roles and Responsibilities

- NCDC (Federal)
  - Overall Program Manager – H. Diamond
  - Science Project Manager – M. Palecki
  - Data Management and Monitoring – J. Lawrimore
  - Finance – L. Cholid/J. McGill

- NCDC (Contract) – Federal Task Manager – J. Lawrimore
  - Data ingest and Web – S. Embler
  - Monitoring and Science Assistance: N. Casey
  - Site licensing; AK surveys; & metadata – R. Bilotta and K. Thomas

- OAR's Air Turbulence and Diffusion Division [ATDD] (Federal)
  - Management – B. Baker
  - Testbed oversight and sensor testing – T. Meyers
  - Science – J. Kochendorfer
  - Budget and Finance – B. Shifflett

Roles and Responsibilities

- ATDD (Contract)
  - QC – G. Goodge (60 hours/month)
  - Finance – G. Land
  - Engineering and Maintenance – M. Hall, M. Black, M.Potter, and B. French (via ORAU)
  - Science – T. Wilson (soils)

- Cooperative Institute for Climate and Satellites - NC partnership (CICS-NC via NC State University)
  - QC & research on temperature, precipitation, and secondary variables – R. Leeper
  - QC & research on soil moisture & temperature – J. Bell

- Engineering work is accomplished via ATDD contract with ORAU – Oak Ridge Associated Universities (U.S. DOE consortium)

Program Governance

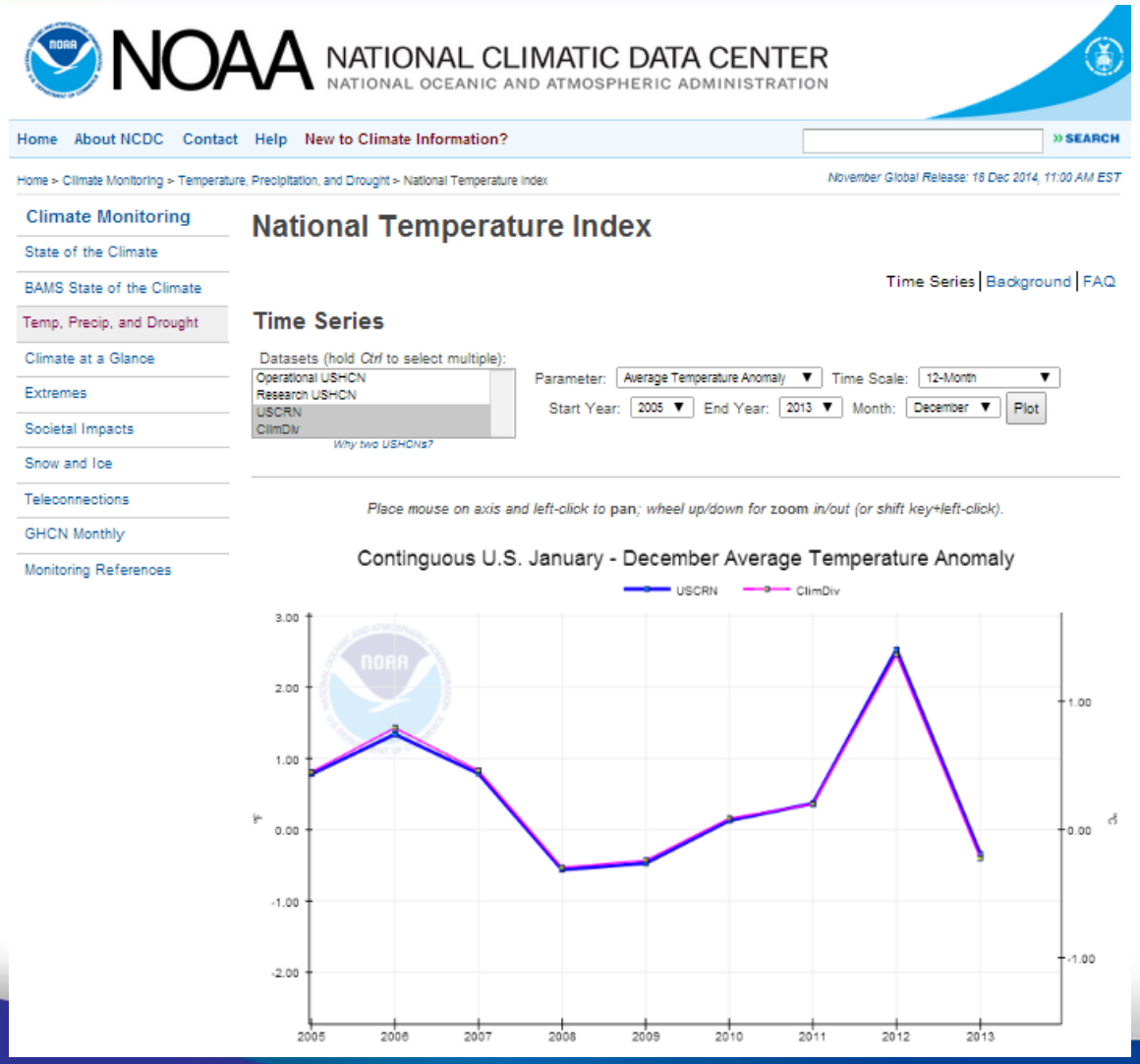
- Overall program, policy, and budget issues are the PM's responsibility
- Annual reports from FY03-13 posted on USCRN web site
- The day-to-day operations & maintenance is undertaken:
  - For station operations – ATDD engineers
  - For data monitoring – NCDC staff
  - To supplement monitoring – science and QC leads provide input
  - Resolution of issues is part of an on-going dialog
- For coordination
  - Regular monthly teleconferences
  - Semi-annual NCDC/ATDD meetings (face-to-face when possible)
  - Shared GoogleDocs log of system issues implemented
  - Other on-going communication as required
- Issues elevated to NCDC senior management as warranted for situational awareness (e.g., unique and large outages)

FY14: USCRN Science Activities

- **Science**
  - **Climate**
    - Launch the national temperature index web site
    - Examine the 2012 Midwest Drought with USCRN soil data
    - Identify lag relationships between soil moisture & climate
    - Relate soil temperature to plant phenology
    - Measure the representativeness of USCRN soil obs
    - Validate soil moisture models & products
  - **Instruments and Algorithms**
    - Implement improved precipitation calculation algorithm
    - Compare USCRN and COOP station climate observations
    - Improve and update air freezing index (AFI)
    - Study the effect of oil on weighing gauge evaporation
    - Serve as a validation partner for NASA SMAP mission

USCRN Science:
National Temperature Index

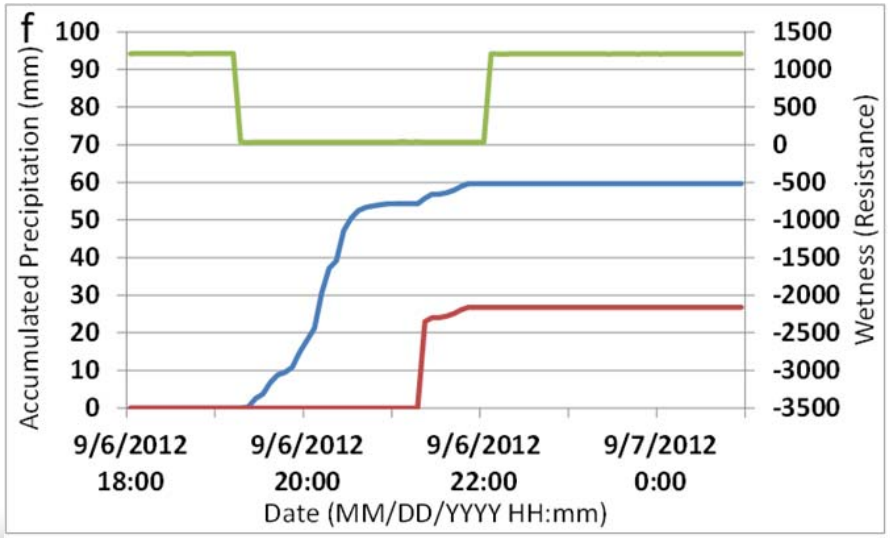
http://www.ncdc.noaa.gov/national-temperature-index/

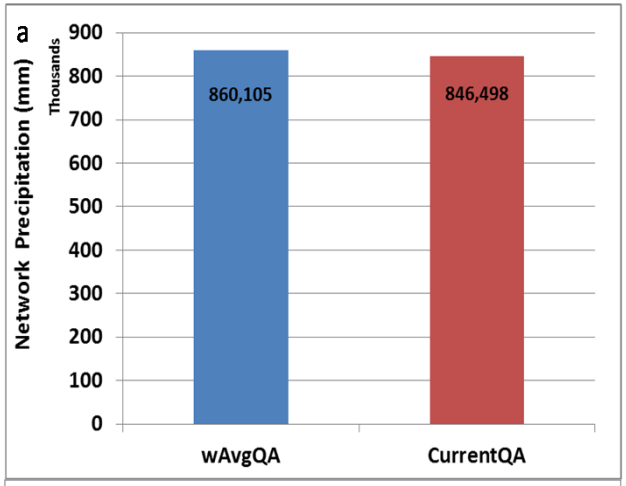


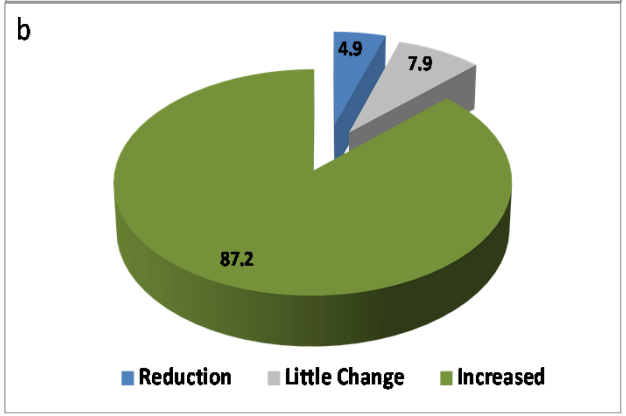
USCRN Science:
New Precipitation Calculation Algorithm

USCRN current precipitation algorithm has some weaknesses that lead to reduced amounts being calculated and some unrealistic 5-minute distributions

Improved algorithm has been developed, tested, presented in a paper for publication, and approved by the USCRN CCB; now beginning external review portion of ORR … **look for this at the EC in early FY15**

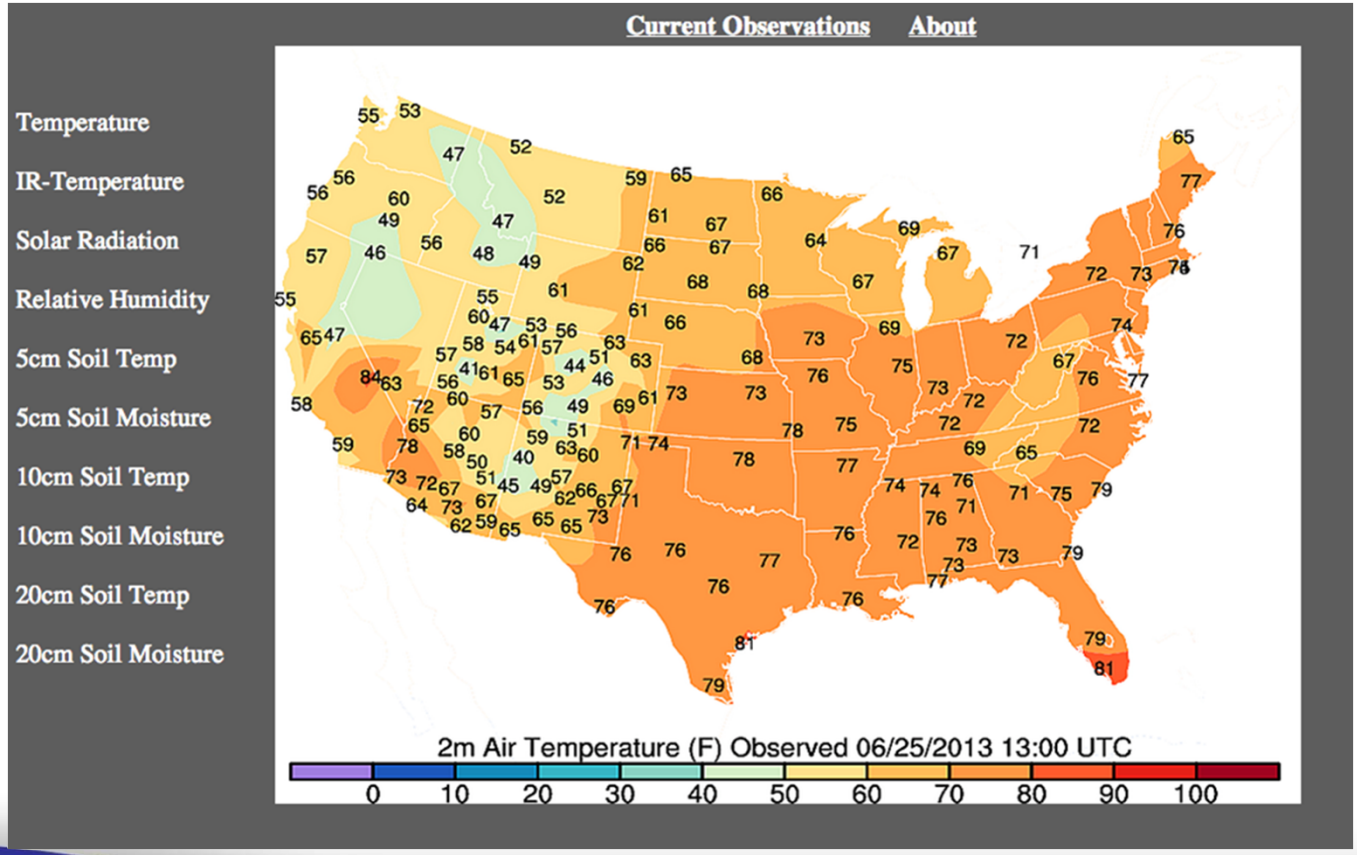






USCRN Science: Designing Spatial Products

Experimental USCRN spatial product that updates hourly with latest station observations
Available over the web at http://www.cicsnc.org/pub/CRNSpatial/



Science Program

- **Papers prepared recently or under preparation in FY14:**

Bell, J.E., M.A. Palecki, R..D. Leeper, S. Embler, R.E. Bilotta, and T. Wilson Evaluation of the 2012 drought with a newly established national soil-monitoring network. For *Geophysical Review Letters* (under preparation for FY 14 Q4 submission)

Bell, J.E., and J.L. Matthews. Evaluation of air and soil temperatures for determining the onset of growing season. For *International Journal of Remote Sensing* (under submission)

Bilotta, R., E. Shepherd, A. Arguez, and J.E. Bell. Calculation and evaluation of an air-freezing index for the 1981-2010 climate normals period in the coterminous United States. For the *Journal of Applied Meteorology and Climatology* (under final internal review for FY 14 Q3 submission)

Leeper, R.D., Rennie, J., and Palecki, M.A. Observational perspectives from U.S. Climate Reference Network (USCRN) and Cooperative Observer Program (COOP): Temperature and precipitation comparison. For *Journal of Applied Meteorology and Climatology* (under final internal review for FY 14 Q3 submission)

Leeper, R.D., Palecki, M.A., Davis, J. USCRN quality assurance methods for weighing bucket precipitation gauges with triplicate depth measurements. For *Journal of Atmospheric and Oceanic Technology* (under final internal review for FY14 Q3 submission)

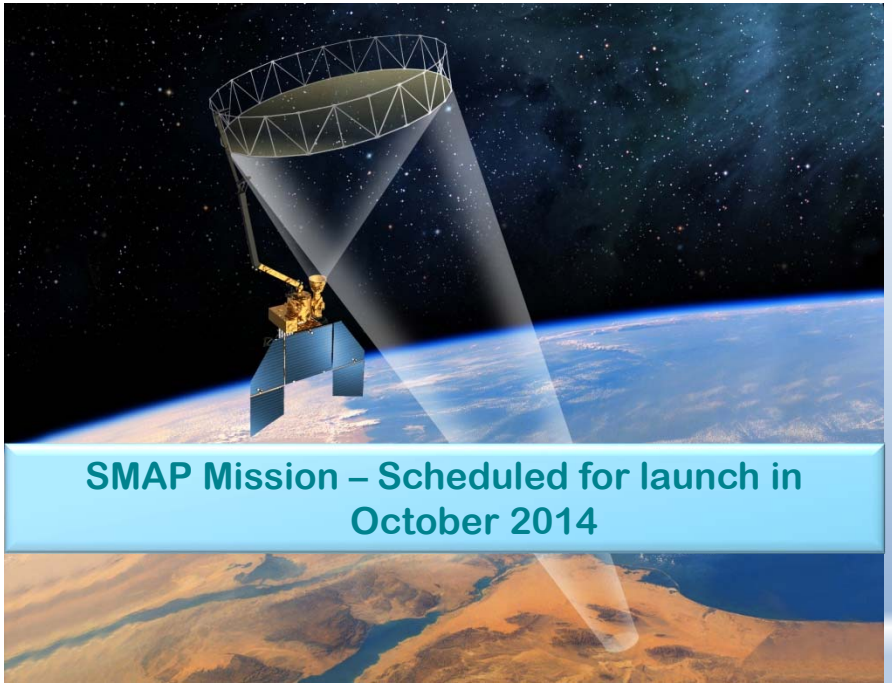
Palecki, M.A., J.E. Bell, and R. Bilotta. Monitoring the 2012 Central U.S. drought with two national soil moisture networks. Invited paper for a special edition of the *Soil Science Society of America Journal* (under preparation for FY 14 Q4 submission)

- **Planned Paper for Q1 of FY15**

Palecki, M.A., J.E. Bell, and R. Bilotta. Identifying lag relationships between soil moisture, climate variables, and drought status using USCRN and SCAN soil moisture observations. For the *Journal of Climate* [research underway].

Calibration/Validation Application of USCRN Soil Moisture/Temperature Data

- In preparation for NASA's Soil Moisture Active Passive Mission (SMAP), USDA has established a testbed in Stillwater, OK; USCRN participates in this
- Intercomparison testing will not only benefit the cal/val work in support of SMAP once it is launched, but will also help improve USCRN instrumentation and input to models



Several modelling groups are already using USCRN soil data to compare to observations from the European Space Agency's Soil Moisture and Ocean Salinity Satellite

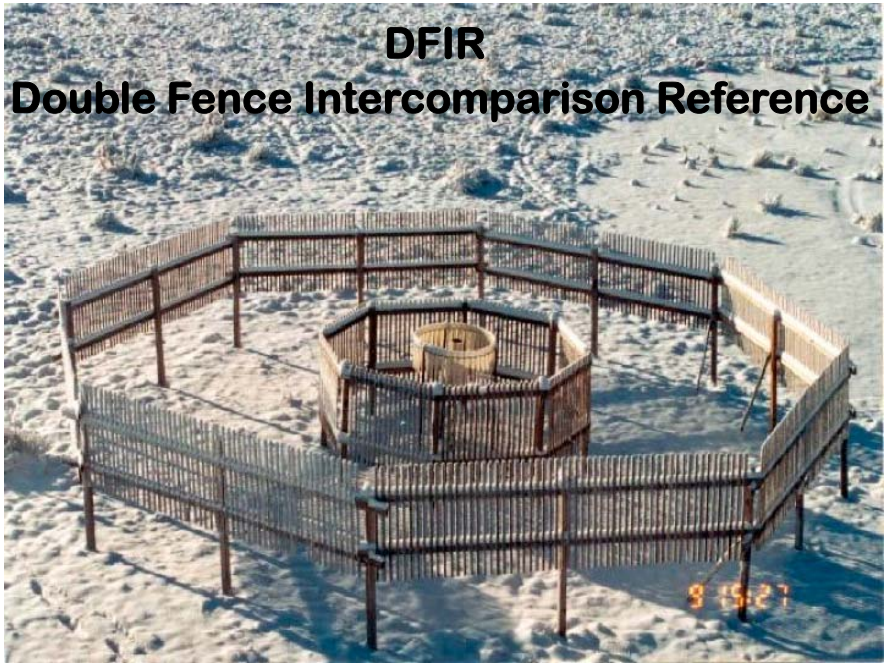
Extensibility for other purposes

- Detailed knowledge of the spatial and temporal distribution of incoming solar radiation (insolation) at the earth's surface has the potential utility for a wide range of energy, hydrologic and agronomic applications,
  - These include including the estimation of regional evapotranspiration (via modeling) and carbon fluxes, management of water supply, implementation of precision farming practices, and validation of satellite insolation estimates (Otkin et al. 2005).
- Solar & IR instruments support satellite cal/val efforts, weather forecast model users, and the solar energy sector
- Use of phenology cameras – some limited work by J. Bell

Otkin, Jason A., Martha C. Anderson, John R. Mecikalski, George R. Diak, 2005: Validation of goes-based insolation estimates using data from the U.S. Climate Reference Network. *J. Hydrometeor*, 6, 460–475. doi: 10.1175/JHM440.1

USCRN Instrumentation Testing and Evaluation

USCRN Precipitation Testbed (Boulder, CO) site with DFIR and Alter shielded snow gauges


DFIR
Double Fence Intercomparison Reference

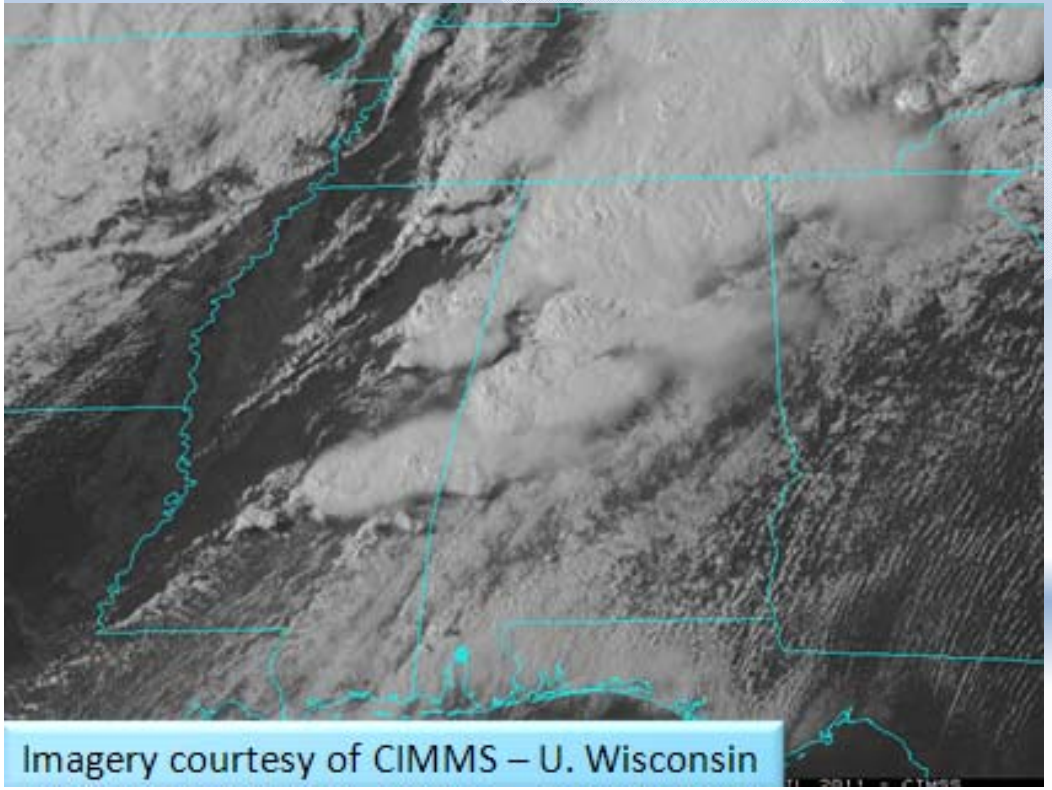

Double alter (4 ft, 8 ft shields)
50% porosity


Belfort Double Alter (25 – 30% porosity)


Single Alter (4 ft, 50% porosity)

USCRN System Resilience in Extreme Weather – Southeast Tornado Outbreak of April 25-28, 2011

- Several systems in the area of Alabama and Tennessee
- None lost any data as a result of local and regional power outages
- Only 1 station briefly lost the ability to transmit for one hour – data was logged on site



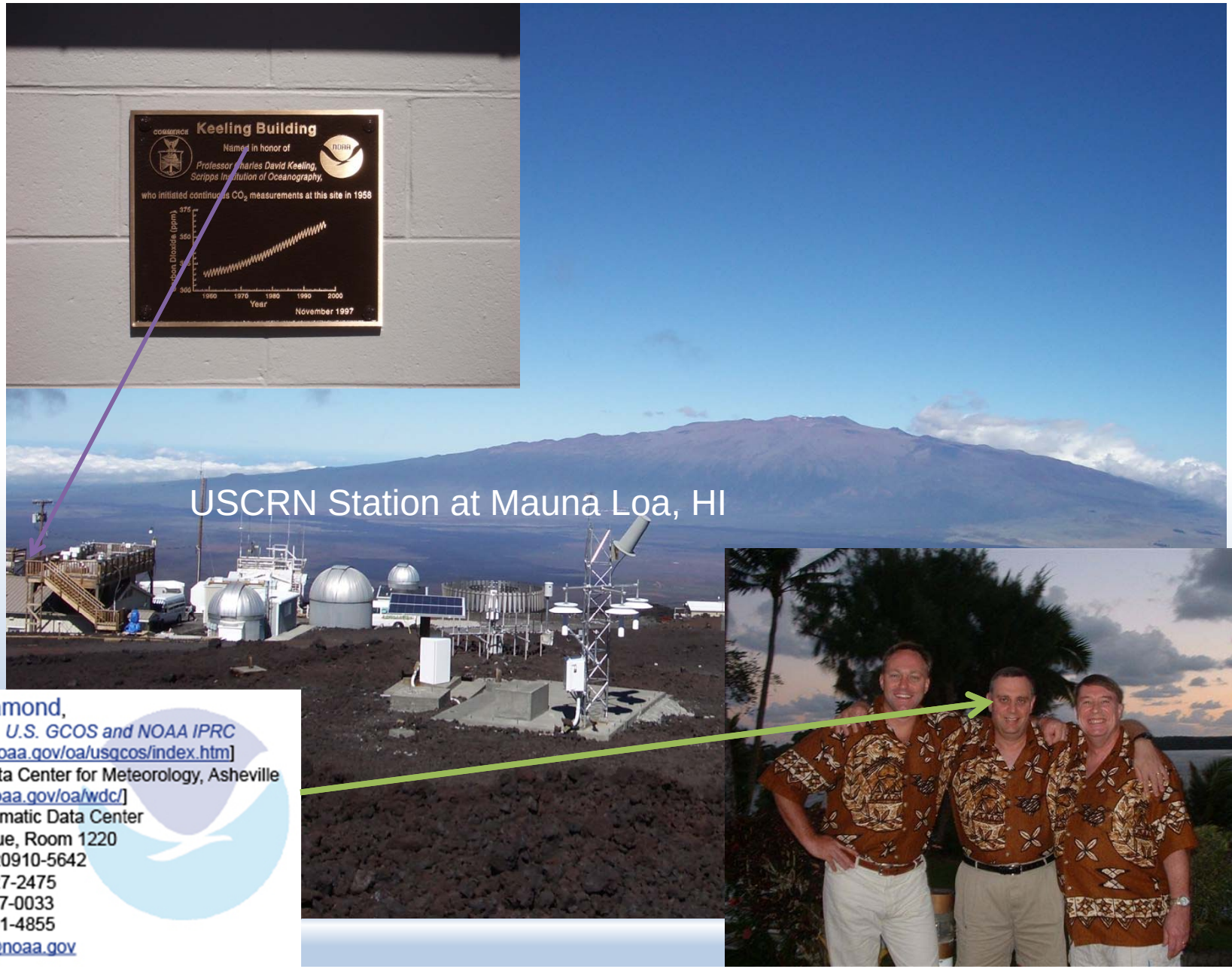
This system resilience is quite a testament to:

- robust engineering design
- the good fortune of not getting a direct hit from the tornadoes

Summary

- USCRN continues to perform quite well and the NOAA partnership between NCDC, ATDD, and CICS-NC is working well
- Science program is active and productive
- Priority is to have more USCRN data utilized in climate products – we are making some progress there
- Expansion into Alaska continues
- Threat to the GOES DCS frequency band is an issue to watch; may require contingency planning to explore alternative communication paths (e.g., Iridium or cell)
- Continued good relations with site hosts is key to sustainability – successful to date, but needs continued attention.
- Overall – program doing well, but working to continually improve and plan as budgets allow
- All data and program information are freely available on the USCRN web site at: http://www.ncdc.noaa.gov/crn

Thank you



Howard J. Diamond,
Program Manager, U.S. GCOS and NOAA IPRC
[http://www.ncdc.noaa.gov/oa/usgcos/index.htm]
Director, World Data Center for Meteorology, Asheville
[http:/www.ncdc.noaa.gov/oa/wdc/]
NOAA/National Climatic Data Center
1100 Wayne Avenue, Room 1220
Silver Spring MD 20910-5642
Phone: +1-301-427-2475
Fax: +1-301-427-0033
Cell: +1-301-801-4855
howard.diamond@noaa.gov