Building a Coordinated National Soil Moisture Monitoring Network: Bringing Together Federal, State, Local, Academia and Private Research and Data Collection to Meet a Common Goal of Drought Assessment and Precision Agriculture (sounds easy enough)

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Meeting a critical need

Soil moisture data are critical for assessing:

- Drought conditions and operational drought monitoring
- Flood potential
- Experimental land surface modeling
- Estimates of crop yields
- Water supply forecasting
- Operational hydrologic models
- Impacts of climate change

Goal

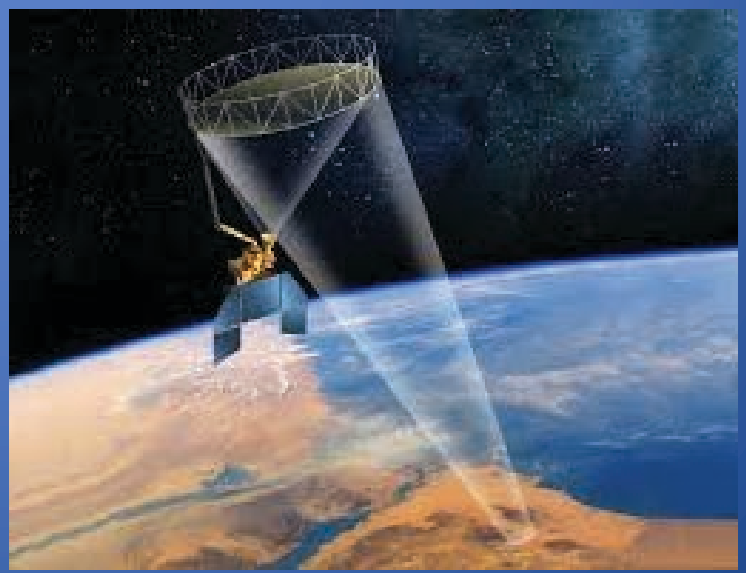
- President's Climate Action Plan
- National Drought Resilience Partnership
- National Integrated Drought Information System (NIDIS)
- Develop a Coordinated National Soil Moisture Network
- "As a U.S. Drought Monitor author, I want to see a map of percentile ranking of current volumetric water content (VWC) at discrete and common depths, related to the 30-year record, for sites colored using the drought monitor legend so that I can determine the necessary changes to be made to this week's DM map"

Data-rich: Data-challenged

- Many sources of information
- Highly variable:
  - Spatial distribution
  - Vertical data collection
  - Sensor types
  - Scale
  - Time
  - Data storage (format, distribution)
  - Applications

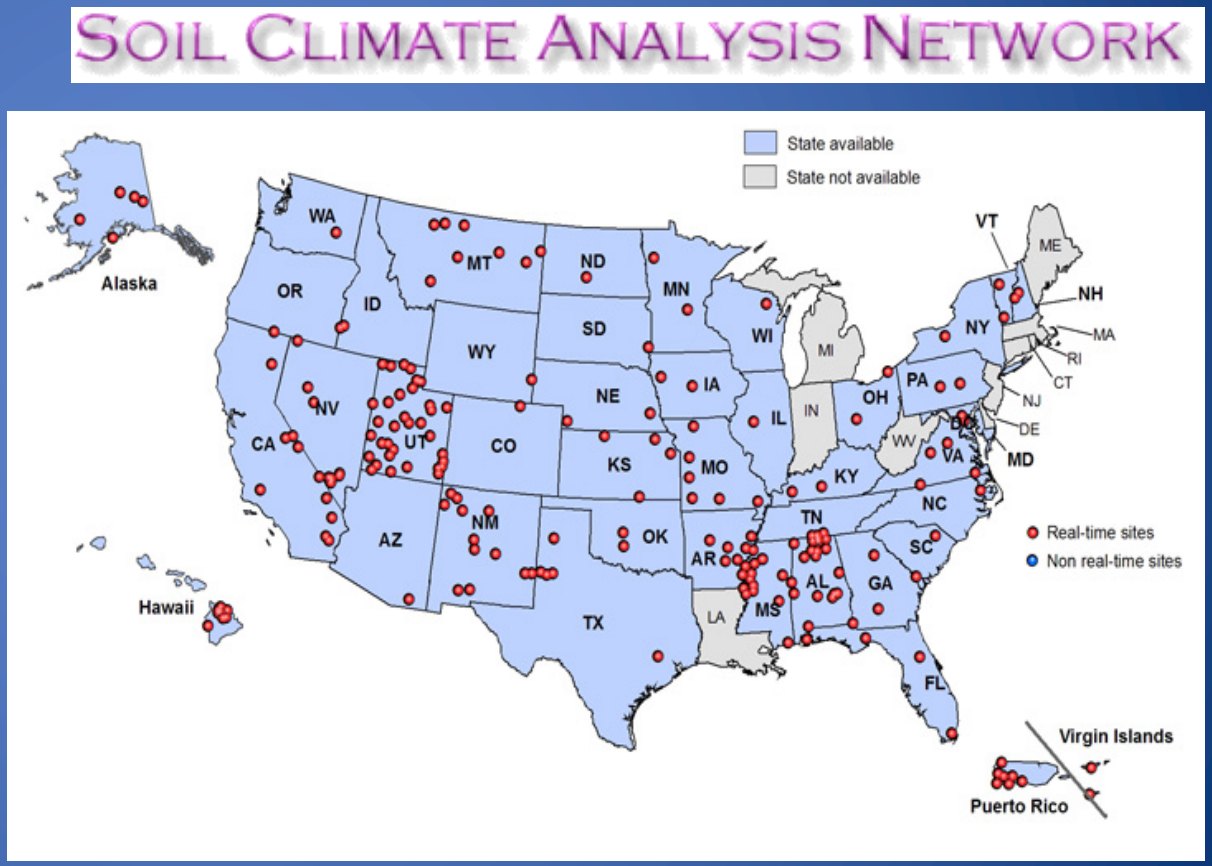
Integration

- In situ stations collecting point data
- Remote sensing at various scales
- Models



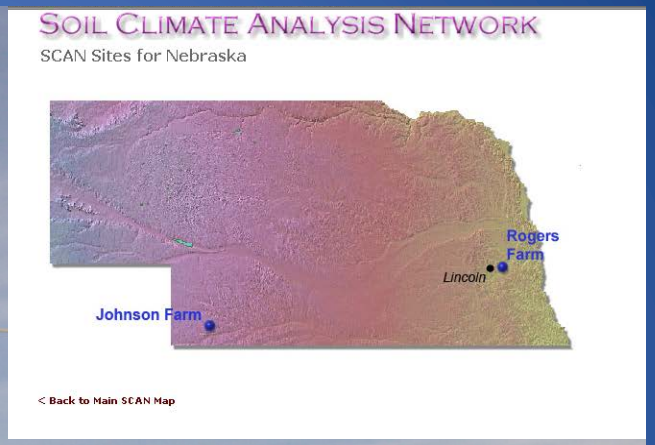
Soil Climate Analysis Network

- **SCAN** (Soil Climate Analysis Network)
  - 221 sites in 40 States and US Territories
  - Soil-climate monitoring
  - Uses meteor burst, cellular and satellite telemetry
  - Critical for drought monitoring

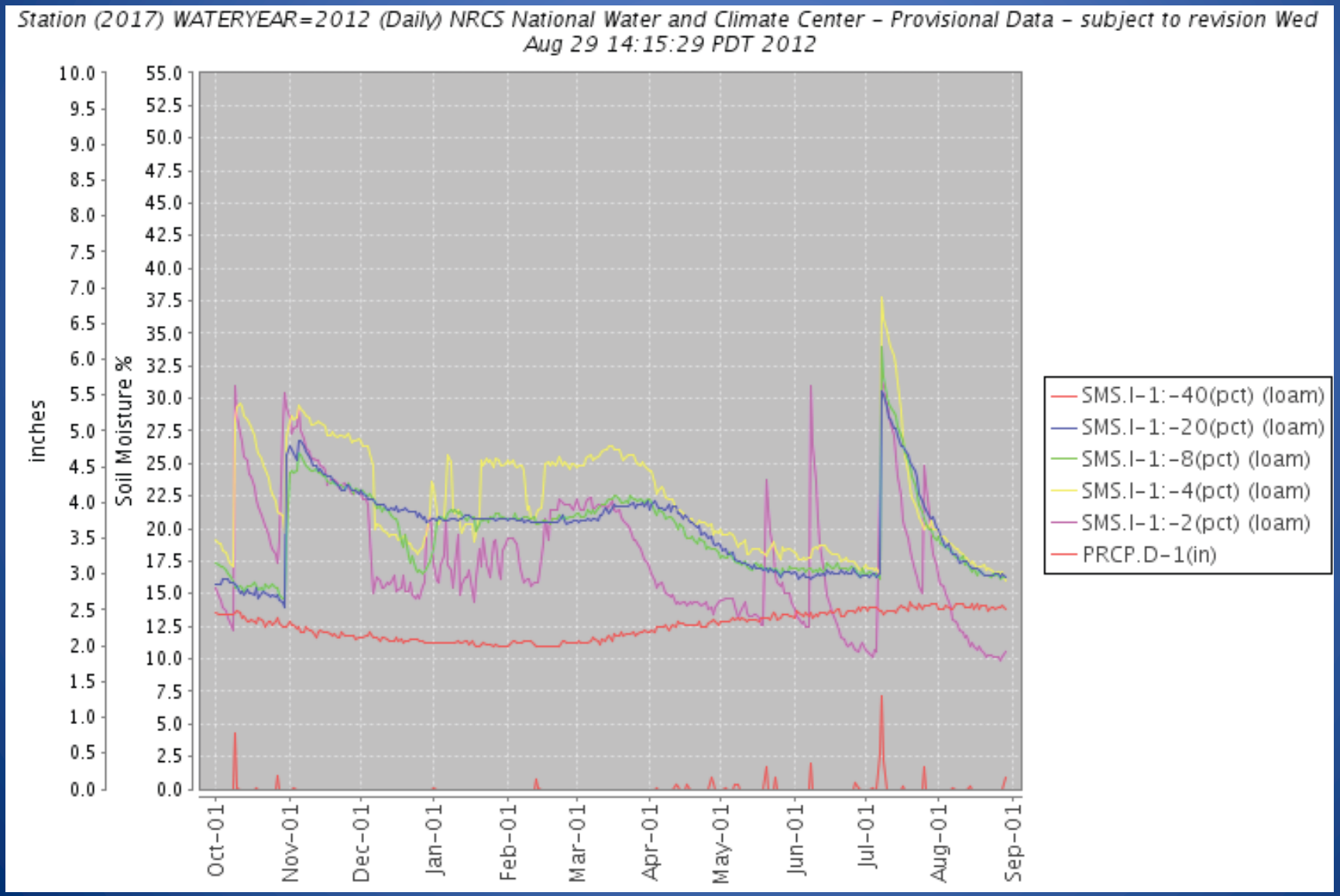


www.wcc.nrcs.usda.gov/scan/

Johnson Farm, Nebraska SCAN Site



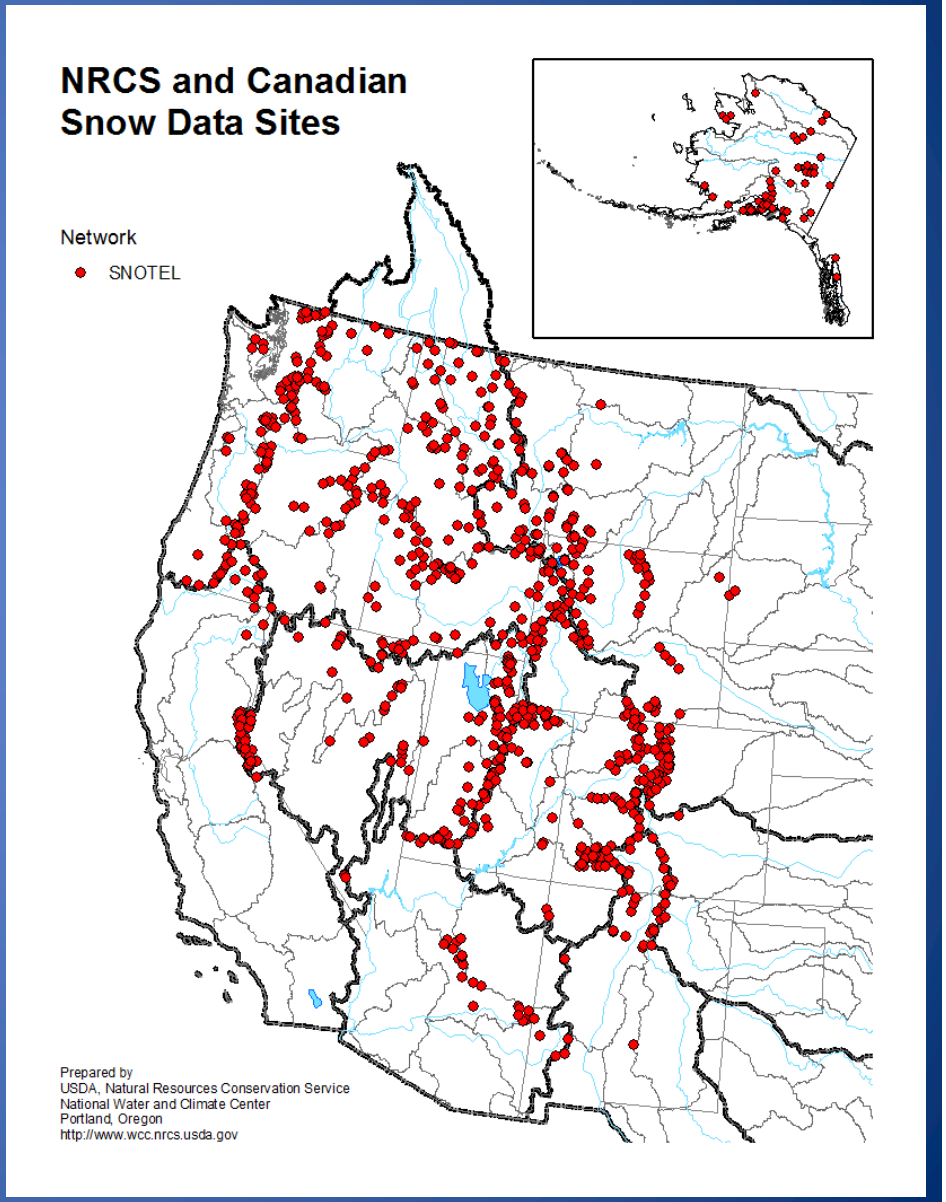
SCAN Data Plot



Colorado
SCAN
Site
NUNN

NRCS SNOTEL Network

- SNOTEL network
  - 13 Western States
  - 885 sites (includes SnoLite)
  - More than 16 million observations/year
  - Data transmitted in near real time every hour for most stations
- Snow courses = 1 measurement/ month SWE and depth
- SNOTEL = 720 transmissions/month of multiple sensors
- Safety

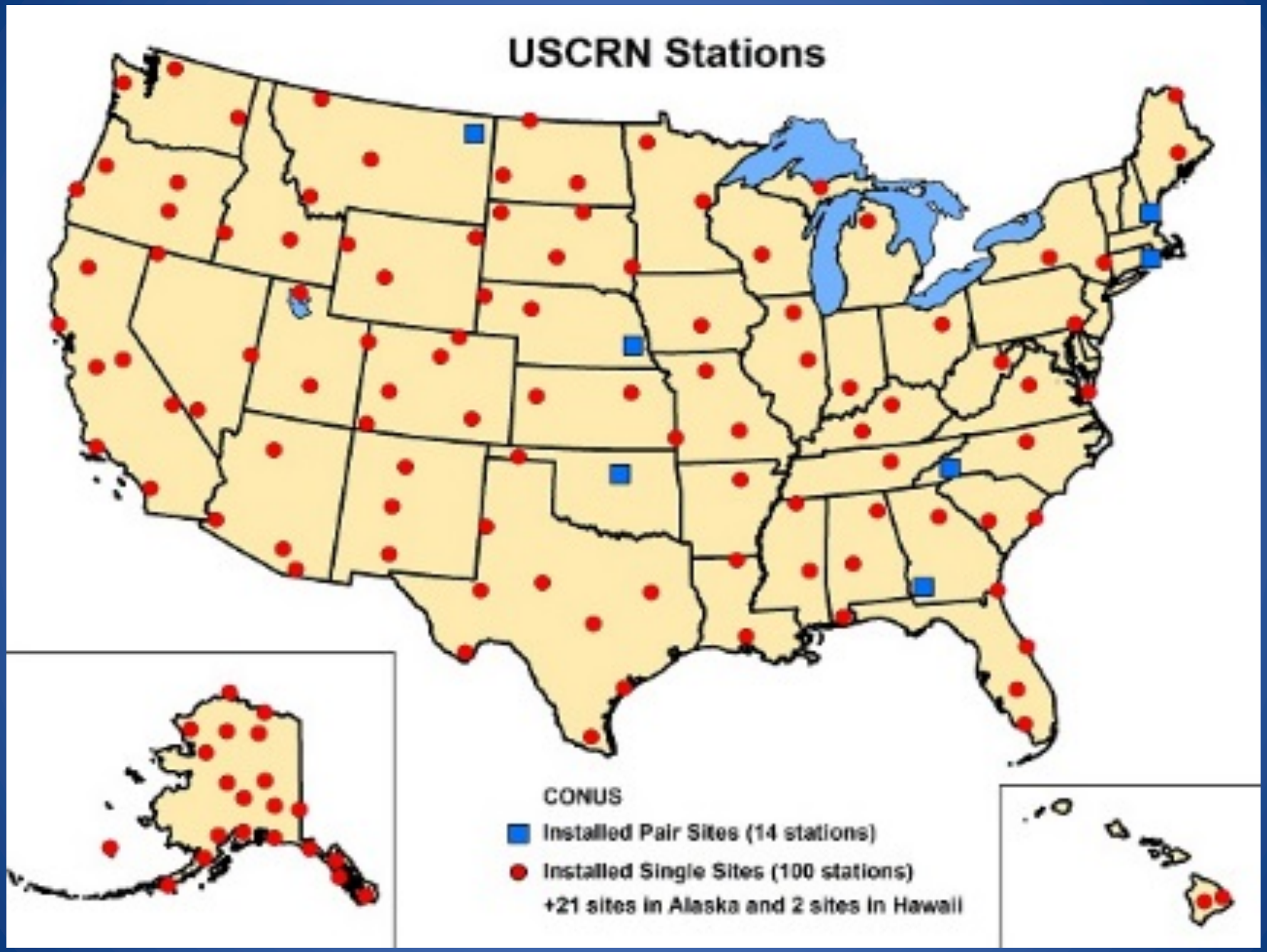


http://www.wcc.nrcs.usda.gov/snow/

NOAA Climate Reference Network

- The U.S. Climate Reference Network (USCRN) is a network of climate stations developed by the National Oceanic and Atmospheric Administration (NOAA). The USCRN's primary goal is to provide future long-term homogeneous temperature and precipitation observations that can be coupled to long-term historical observations for the detection and attribution of present and future climate change.

  MADIS has been collecting data from 130 sites over the US including Alaska and Hawaii since April 16, 2010. The data is NOAA Port data received via the SBN.


USCRN Stations
CONUS
Installed Pair Sites (14 stations)
Installed Single Sites (100 stations)
+21 sites in Alaska and 2 sites in Hawaii

Remote Automatic Weather Stations (RAWS) - NIFC

These solar-powered units gather important weather information on an hourly basis.

RAWS sensors monitor:

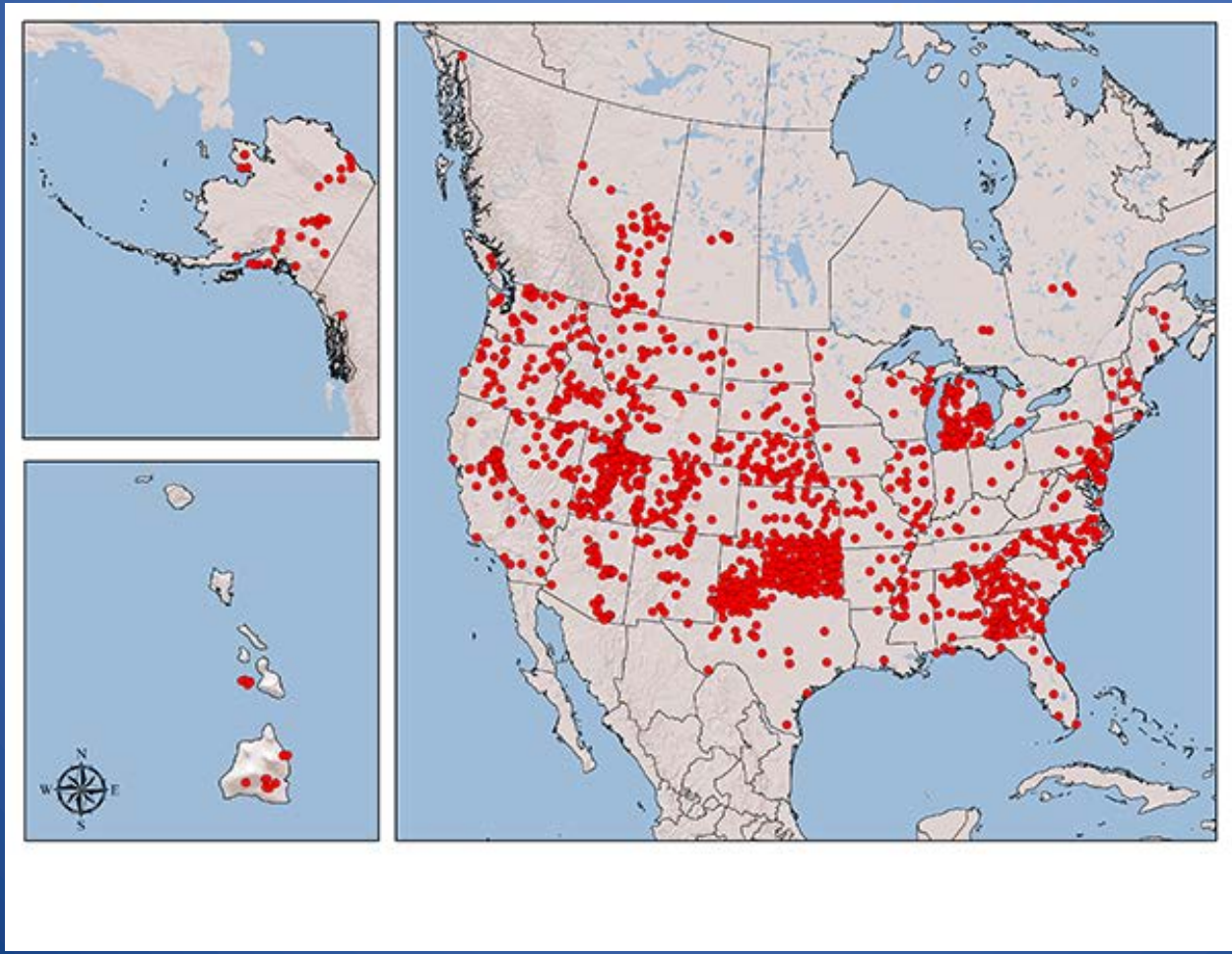
- Wind speed and direction
- Wind gusts
- Precipitation
- Air temperature
- Solar radiation
- Relative humidity
- Fuel moisture
- Soil moisture and temperature.

About 2,200 RAWS are strategically positioned throughout the United States and its territories.

Selected Representative In Situ Soil Moisture Networks in the United States

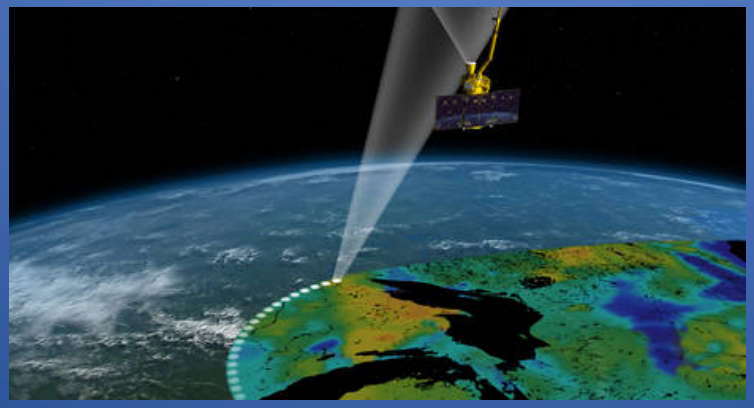
Network Name	Geographic Region	Number of Stations	Period of Record	Observing Depths (cm)
Agricultural Research Service (ARS)	Oklahoma	44	2005-present	5, 25, 45
AmeriFlux	United States	39	1997-present	Variable
Atmospheric Radiation Measurement (ARM)	Kansas, Oklahoma	17	1996-present	5, 15, 25, 35, 60, 85, 125, 175
Automated Weather Data Network (AWDN)	Nebraska	52	2006-present	10, 25, 50, 100
Climate Reference Network (CRN)	United States	114	2009-present	5, 10, 20, 50, 100
Cosmic Ray Soil moisture Observing Station (COSMOS)	United States	54	2008-present	Variable
Delaware Environmental Observing System (DEOS)	Delaware	29	2004-present	5
**Georgia Automated Environmental Monitoring Network (GAEMN)	Georgia	79	1992-present	Variable
Illinois Climate Network (ICN)	Illinois	19	1988-present	5, 10, 20, 50, 100, 150
Kansas Mesonet	Kansas	15	2008-present	5, 10, 20, 50, 100
Michigan Enviro-weather (Automated Weather Network, MAWN)	Michigan, Wisconsin	80	2000-present	5, 10
Missouri Agriculture Weather Network (MAW)	Missouri	8	2002-present	5, 10
**New Jersey Mesonet	New Jersey	10	2003-present	5
NOAA Hydrometeorological Testbed	Western U.S.	25	2004-present	Variable
North Carolina EcoNet	North Carolina	36	1999-present	20
Oklahoma Mesonet	Oklahoma	113	1998-present	5, 25, 60, 75
**Remote Automated Weather Stations (RAWS)	Western U.S.	50	1983-present	Variable
Snowpack Telemetry (SNOTEL)	Western U.S.	414	2000-present	Variable
Soil Climate Analysis Network (SCAN)	United States	203	1996-present	5, 10, 20, 50, 100
South Dakota Automated Weather Network (SDAWN)	South Dakota	11	2000-present	5, 10, 20, 50, 100
UA Fairbanks Water and Environmental Research Center (WERC)	Alaska	24	2000-present	Variable
West Texas Mesonet	Texas, New Mexico	64	2000-present	5, 20, 60, 75

Texas A&M University (and now The Ohio State University) North American Soil Moisture Database



Remote Sensing Observations

- NOAA – soil moisture remote sensing through microwave and thermal infrared observations
- NASA – Soil Moisture Active/Passive (SMAP) satellite
- University of Arizona - Cosmic-Ray Soil Moisture Observing System (COSMOS)



Modeling

- Major land surface models:
  - The Noah
  - Variable Infiltration Capacity (VIC)
  - Sacramento (SAC)
  - Mosaic
  - Catchment
  - CPC Leaky Bucket (CPC LB)
  - Simple Biosphere (SiB)
  - Tiled ECMWF Scheme for Surface Exchanges over Land (TESSEL) LSMs
- NASA and NOAA – The North American Land Data Assimilation System (NLDAS-2) - multi-model approach

Coordination of Data Collection

- Models and remote sensing data provide spatial coverage of soil moisture for the U.S., but have coarse resolution
- Models generally only model near-surface soil conditions
- Models need to be calibrated to in situ measurements
- Different in situ networks provide differing data sets, sensor configurations, data format

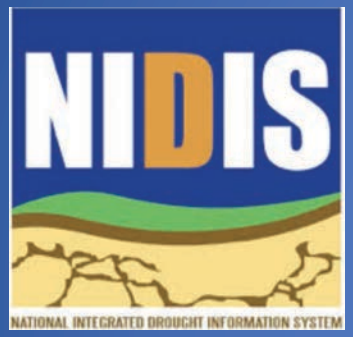
Next Steps: Moving Beyond the Concept

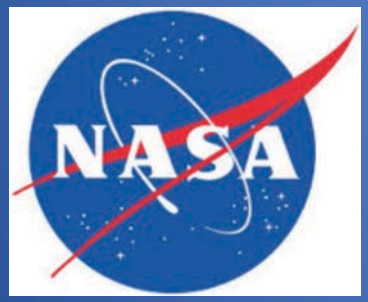
- Develop framework for national network, basing direction from the workshops held at NOAA in 2016 and MOISST meeting in 2017 and 2018
- Design organizational structure/leadership/tasks
- Build-out operational system infrastructure
- Survey federal, state, and local agencies to identify soil moisture data sources and new use cases
- Develop standards and specifications for networks (sensors, depths, soils, data format, data access)

Next Steps: Moving Beyond the Concept - continued

- Incorporating new data sources
- Integrate SMAP and NLDAS-2 data, other data
- Build industry partnerships and citizen science
- Develop new tools, visualizations, and data products
- Build on two ongoing pilots; MAPP and NOAA
- Visualization paper
- Develop daily map product

National Soil Moisture Network (initial set of players, but growing rapidly)





Thank you