Update on National Soil Moisture Network

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Presented to

NIDIS Working Groups All Chair Meeting

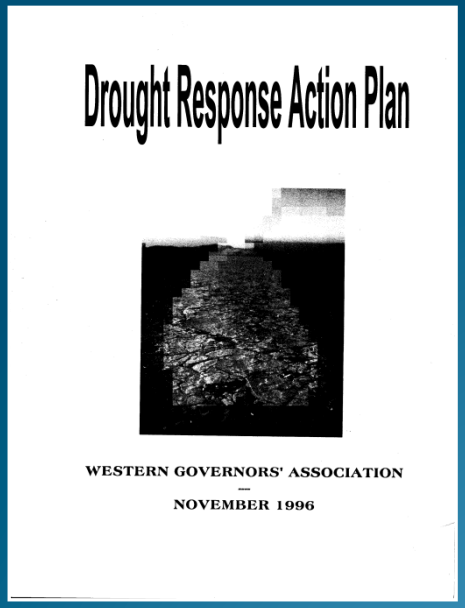
Lincoln, NE

April 27, 2016

Key Highlights:

- Background;
- Networks;
- New Opportunities.

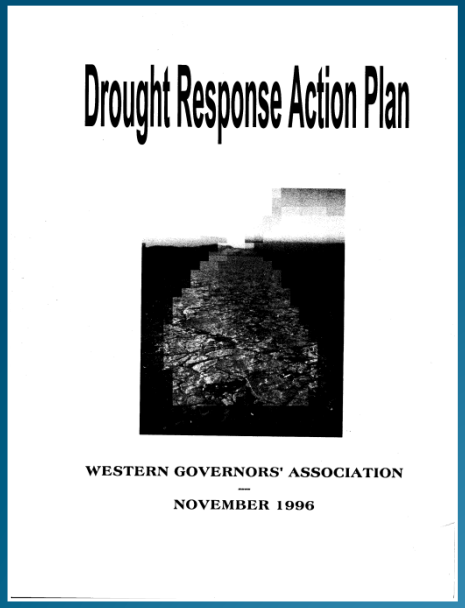
Background



Most ranchers or farmers define an agricultural drought as "any period of time soil moisture is not sufficient for proper plant growth." Damages resulting from the 1995-1996 agricultural drought in the Southwest include crop and livestock herd devastation, low crop yields, abandoned cropland, and severe financial stress for some farmers and ranchers.

Drought Response Action Plan (WGA-1996)

Background



There is an apparent lack of flexibility and coordination of programs for agriculture and natural resources--at both the state and federal levels--in responding to a drought disaster. For example, lands enrolled in the USDA's Conservation Reserve Program (CRP) can provide needed resources during drought. Decisions enabling farmers to use CRP hay and grazing lands have been delayed for weeks or even months, lessening benefits to producers in need.

Drought Response Action Plan (WGA-1996)

Background

PUBLIC LAW 99-198—DEC. 23, 1985 99 STAT. 1509

Subtitle D—Conservation Reserve

CONSERVATION RESERVE

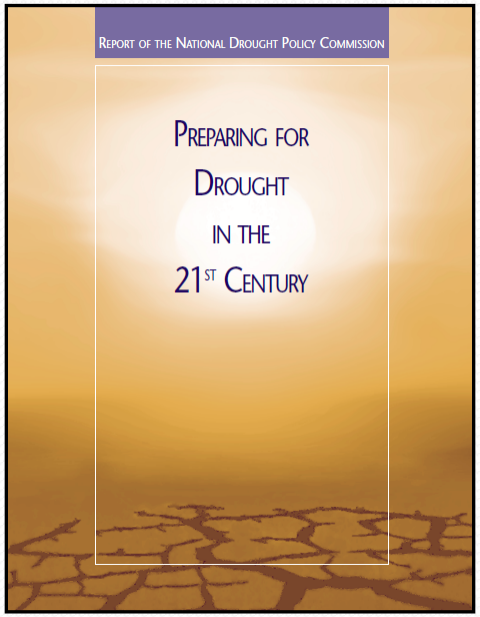
SEC. 1231. (a) During the 1986 through 1990 crop years, the Secretary shall formulate and carry out a conservation reserve program, in accordance with this subtitle, through contracts to assist owners and operators of highly erodible cropland in conserving and improving the soil and water resources of their farms or ranches.

Contracts.
16 USC 3831.

(7) not to conduct any harvesting or grazing, nor otherwise make commercial use of the forage, on land that is subject to the contract, nor adopt any similar practice specified in the contract by the Secretary as a practice that would tend to defeat the purposes of the contract, except that the Secretary may permit harvesting or grazing or other commercial use of the forage on land that is subject to the contract in response to a drought or other similar emergency;

Public Law 99-198 (Food Security Act of 1985)

Background



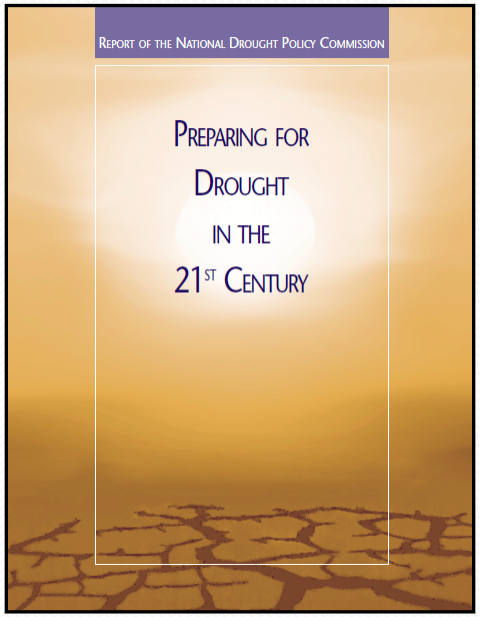
Policy Statement

The Commission believes that national drought policy should use the resources of the federal government to support but not supplant nor interfere with state, tribal, regional, local, and individual efforts to reduce drought impacts. The guiding principles of national drought policy should be:

1. Favor preparedness over insurance, insurance over relief, and incentives over regulation.
2. Set research priorities based on the potential of the research results to reduce drought impacts.
3. Coordinate the delivery of federal services through cooperation and collaboration with nonfederal entities.

National Drought Policy Commission (2000)

Background

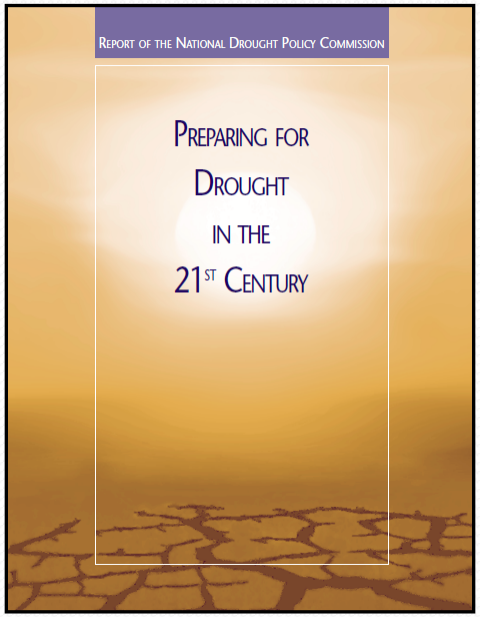


GOAL 2

Improve collaboration among scientists and managers to enhance the effectiveness of observation networks, monitoring, prediction, information delivery, and applied research and to foster public understanding of and preparedness for drought.

National Drought Policy Commission (2000)

Background

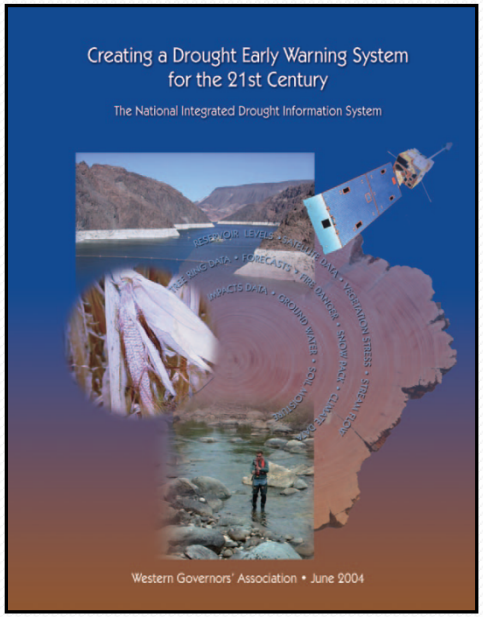


Examples of Critical Observation Networks

- Department of Commerce, National Weather Service, Cooperative Observer (COOP) Program Hydrometeorological Network
- U.S. Department of Agriculture, Soil Climate Analysis (SCAN) and Snowpack Telemetry (SNOTEL) networks
- U.S. Forest Service, Remote Automated Weather Station (RAWS) Network
- U.S. Geological Survey, Streamgaging and Groundwater Network
- Other regional observation networks

National Drought Policy Commission (2000)

Background



Integrating Observations and Data Systems

Key Variables for Monitoring Drought

- climate data
- soil moisture
- stream flow
- ground water
- reservoir and lake levels
- short, medium and long range forecasts
- vegetation health/stress and fire danger

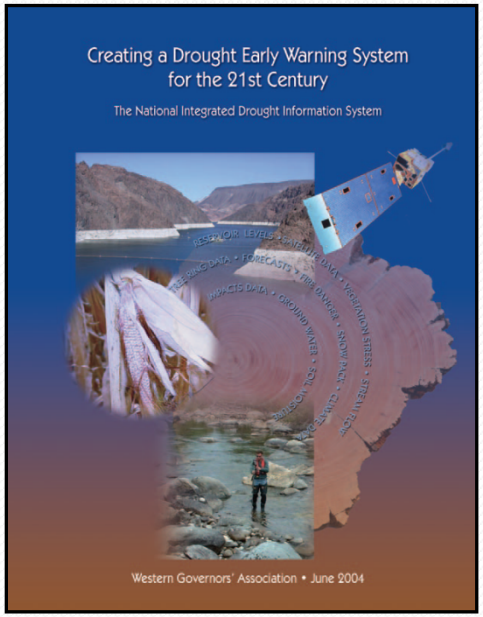
Current Observations and Data Systems

Drought planning and mitigation will be based upon the gathering of high quality information related to a variety of physical, environmental and human conditions. The gathering and integration of data includes making more efficient use of existing data as well as "filling in the holes" in local, state, regional and federal networks. Characterization of drought requires a combination of two types of information:

1. Observations of past and current physical states of the environment and their context within the relevant historical record.
2. Documented impacts on human and natural systems that are a consequence of the physical conditions.

WGA NIDIS Report (2004)

Background



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WGA NIDIS Report (2004)

Networks

Coordination of a Nation-Wide Soil Moisture Network

From the Meeting on Developing a Coordinated National Soil Moisture Network

NOAA's National Weather Service National Training Center

Kansas City MO

November 13-14, 2013

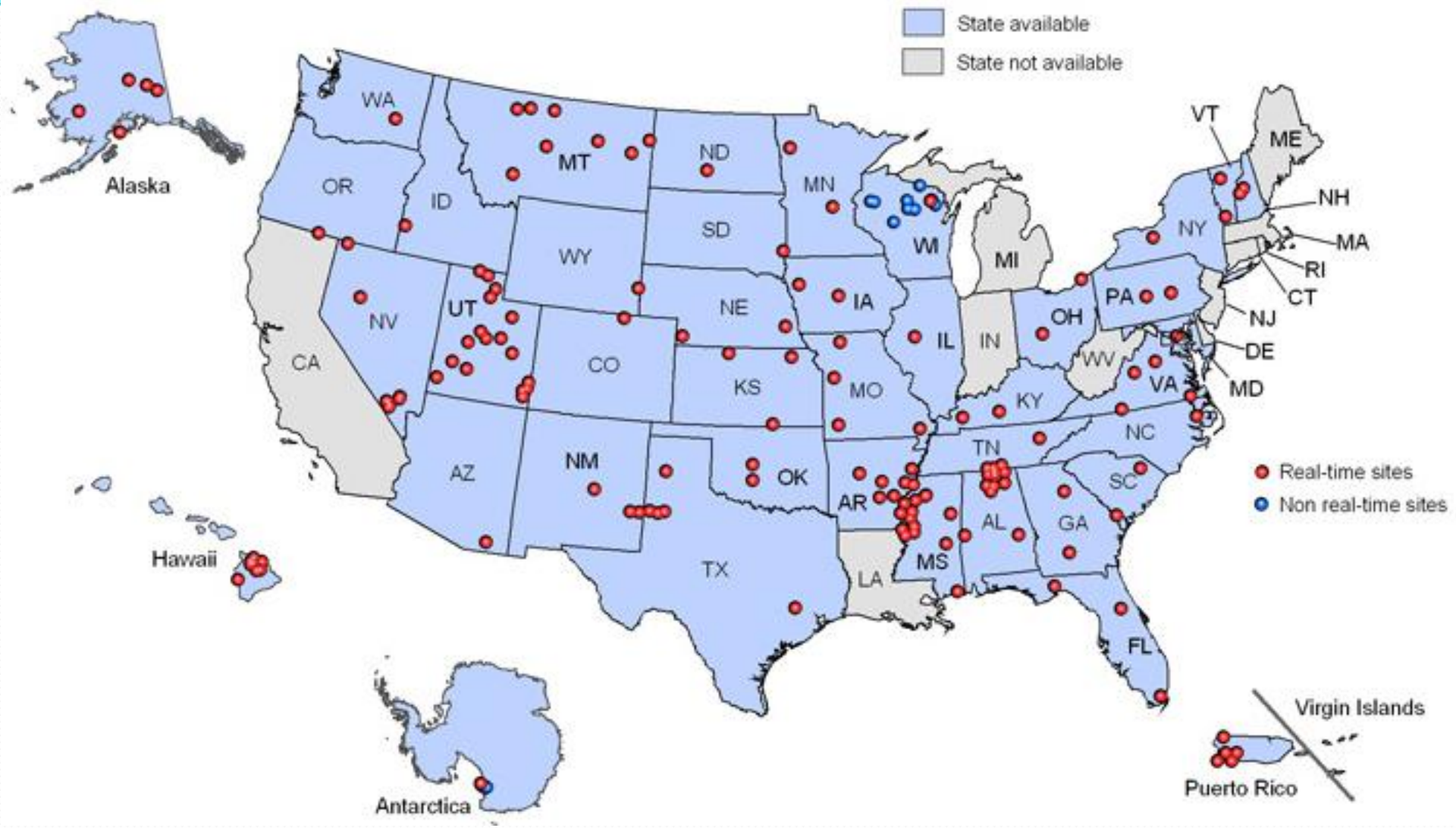
INTRODUCTION

The water in the soil is one of the most critical measures in Hydrology and Meteorology. Plant roots bring soil water to the leaves in response to atmospheric demand and when soil water falls to critical levels the plants will go into stress and produce the first symptom of a potential risk in agricultural drought monitoring. Soil water is also critical in flood forecasting. Higher soil water leads to higher risk of high storm run-off. On a longer hydrological scale, the soil water in high elevation drainage basins has a major effect on the timing and amount of stream flow produced by snowpack. Improvements in the predictions from hydrologic, remote sensing, and agricultural production models await a more robust representation of soil water over wider areas.

The problem is that soil water observations are currently taken in an uncoordinated way leading to wide gaps in spatial coverage, heterogeneity in sampling, a dearth in Meta data (data about the sites and sensors) and questions about representativeness of the data available.

Coordination Meeting White Paper (2013)

Networks



USDA Soil Climate Analysis Network (SCAN)

Networks

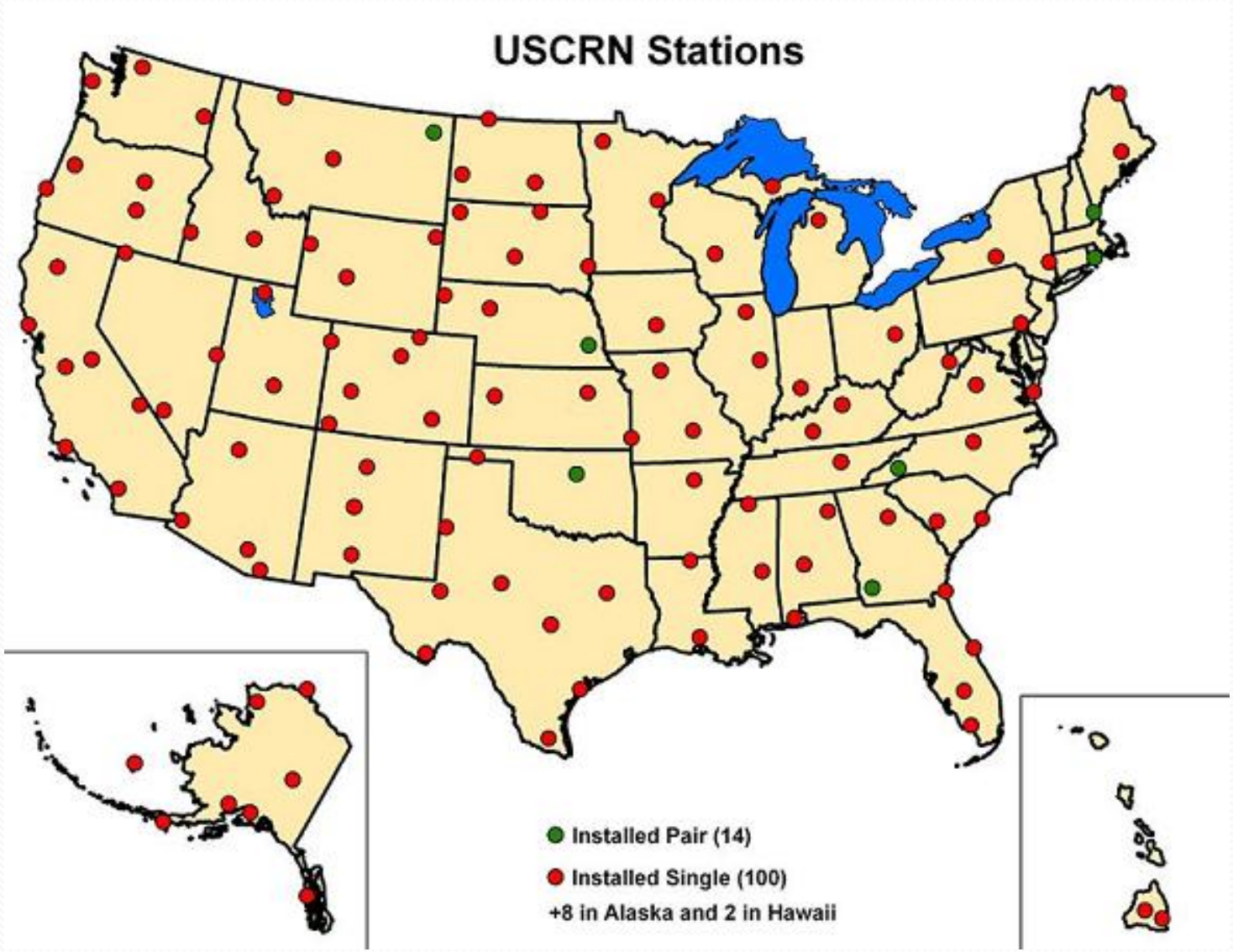
Mahantango Creek – Klingerstown, PA

STANDARD SCAN SITE CONFIGURATION

Parameter Measured	Description
Precipitation	Storage-type gage or tipping bucket
Air Temperature	Collected by a shielded thermistor
Relative Humidity	Collected by a thin film capacitance-type sensor
Wind Speed and Direction	Collected by a propeller-type anemometer.
Solar Radiation	Collected by a pyranometer
Barometric Pressure	Measured by a silicon capacitive pressure sensor.
Snow Water Content	Measured using a snow pillow device and a pressure transducer. (not on all stations)
Snow Depth	Measurement is by a sonic sensor. (not on all stations)
Soil Moisture	Collected by a dielectric constant measuring device. Typical measurements are at 2", 4", 8", 20", and 40" where possible.
Soil Temperature	Collected by an encapsulated thermistor. Typical measurements are at 2", 4", 8", 20", and 40" where possible.

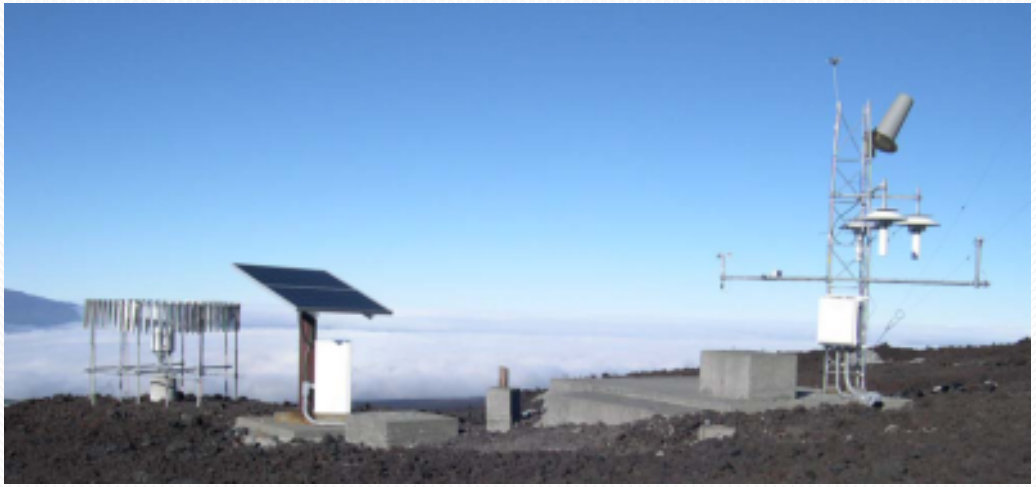
USDA Soil Climate Analysis Network (SCAN)

Networks



NOAA Climate Reference Network (CRN)

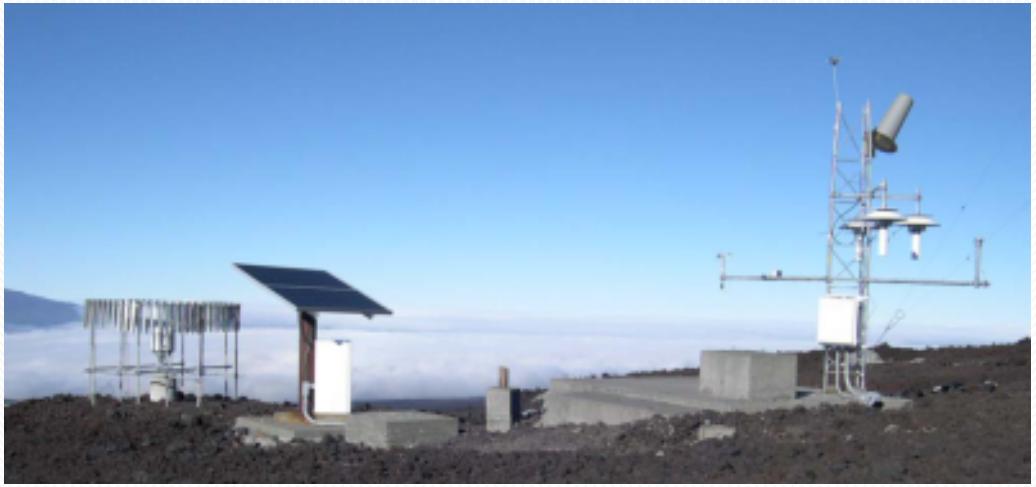
Networks



Primary Measurements:	Secondary Measurements:
Surface Air Temperature	IR Ground Surface Temperature
Precipitation **Data Stream Summary**	Solar Radiation
Soil Moisture and Soil Temperature	Wind Speed
	Relative Humidity
	Wetness
	Miscellaneous

NOAA Climate Reference Network (CRN)

Networks



Soil Moisture and Soil Temperature For every USCRN site with deep soils, a total of 15 Stevens Water Monitoring Systems, Inc., Hydra Probe II (SDI-12) units are placed in the ground in three plots at five depths (5, 10, 20, 50, and 100 cm) to measure soil moisture and soil temperature. These probes use reflected electromagnetic radio waves at 50 MHz to determine the dielectric permittivity of the soil in which the probe is inserted, which can be converted to volumetric soil moisture units (m3m-3) by use of a calibration equation. The probe also contains a thermistor to measure ambient temperature in the face plate pressing against the soil. All 15 probes are interrogated every two minutes and their measurements averaged over 5-minute periods for output purposes.

NOAA Climate Reference Network (CRN)

DEPTH OF PROBES

SCAN (in/cm)	CRN (cm)
2 (5.08)	5
4 (10.16)	10
8 (20.32)	20
20 (50.80)	50
40 (101.60)	100

DEPTH OF PROBES

SCAN (in/cm)	CRN (cm)	OK Mesonet
2 (5.08)	5	5
4 (10.16)	10	
8 (20.32)	20	25
20 (50.80)	50	60
40 (101.60)	100	75 (?)

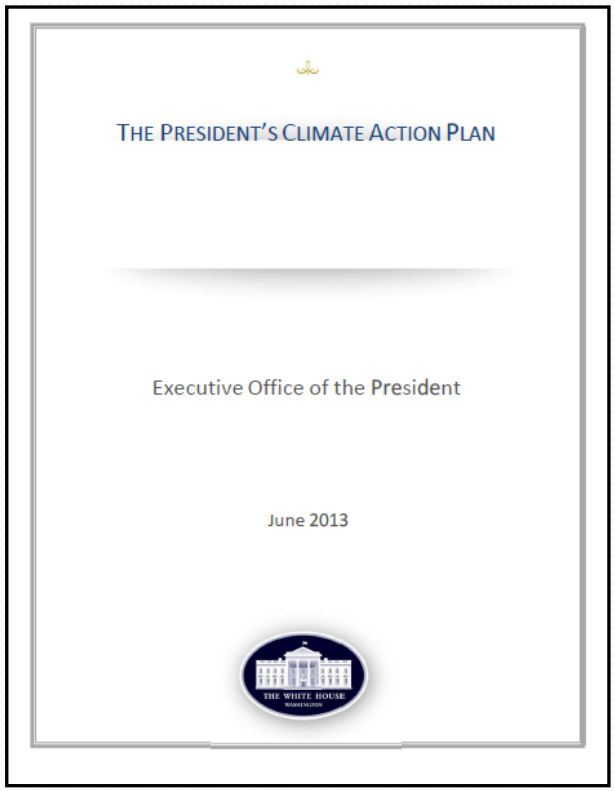
Networks

Other Questions:

- Is soil / chemical analysis being performed?
- How do the recording periods vary?
- What is recording frequency of the data?
- Are algorithms similar for different instruments?
- Who sets the standards for METADATA?

Network Comparisons

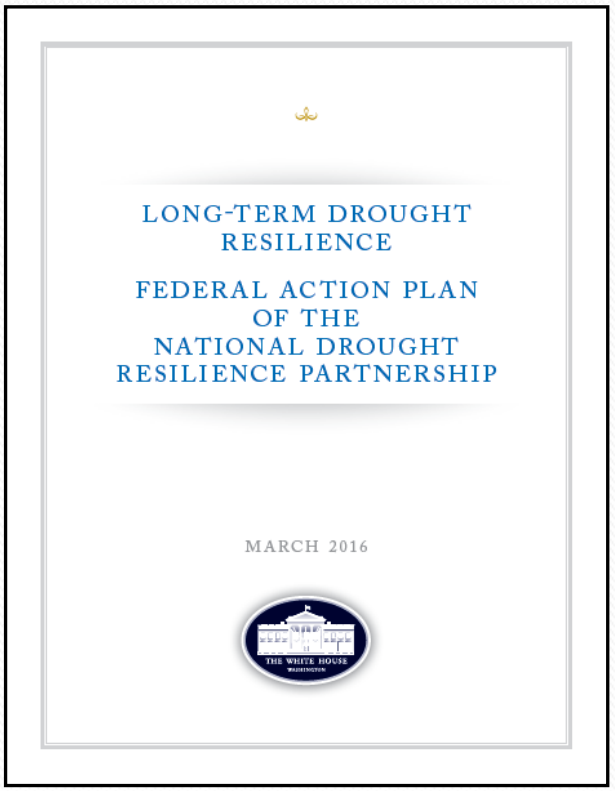
New Opportunities



Managing Drought: Leveraging the work of the National Disaster Recovery Framework for drought, the Administration will launch a cross-agency National Drought Resilience Partnership as a "front door" for communities seeking help to prepare for future droughts and reduce drought impacts. By linking information (monitoring, forecasts, outlooks, and early warnings) with drought preparedness and longer-term resilience strategies in critical sectors, this effort will help communities manage drought-related risks.

President's Climate Action Plan (2013)

New Opportunities



Goal 1: Data Collection and Integration

Objective:

Agencies shall share data and information related to drought, water use, and water availability, including data on snowpack, groundwater, stream flow, and **soil moisture** *with State, regional, tribal, and local officials to strengthen decision making to support more adaptive responses to drought and drought risk.*

NDRP Action Plan (2016)

New Opportunities

Integrate Existing Data and Information Sources for Regional-Level Use

1. **Integrate Data from Key Platforms:** Assess, strengthen, and connect existing space-based, airborne, and terrestrial data-collection and monitoring capabilities for water use and availability (e.g., capabilities at DOI-USGS, USDA, DOC-NOAA, EPA, NASA, and free and open data from the private sector). Major data-collection and monitoring capabilities should include capabilities for assessing: (1) groundwater, including quality and connections with surface waters; (2) soil moisture; (3) snowpack; (4) water use; and (5) surface water, including quality. Using principles of the Open Water Data Initiative, enhance the interoperability of information obtained through these capabilities with data obtained through surveys and reporting, to better characterize water supplies and drought-risk conditions, and to identify information gaps. Make data and information easily accessible to stakeholders in formats compatible for inclusion into existing geospatial data platforms. Integrate data on drought into health platforms, such as the Environmental Public Health Tracking Network.

   - **Lead Coordinating Agencies:** DOI-USGS, DOC-NOAA, USDA, and OSTP
   - **Supporting Agencies:** EPA, NASA, DOE, HHS-CDC

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NDRP Action Plan (2016)

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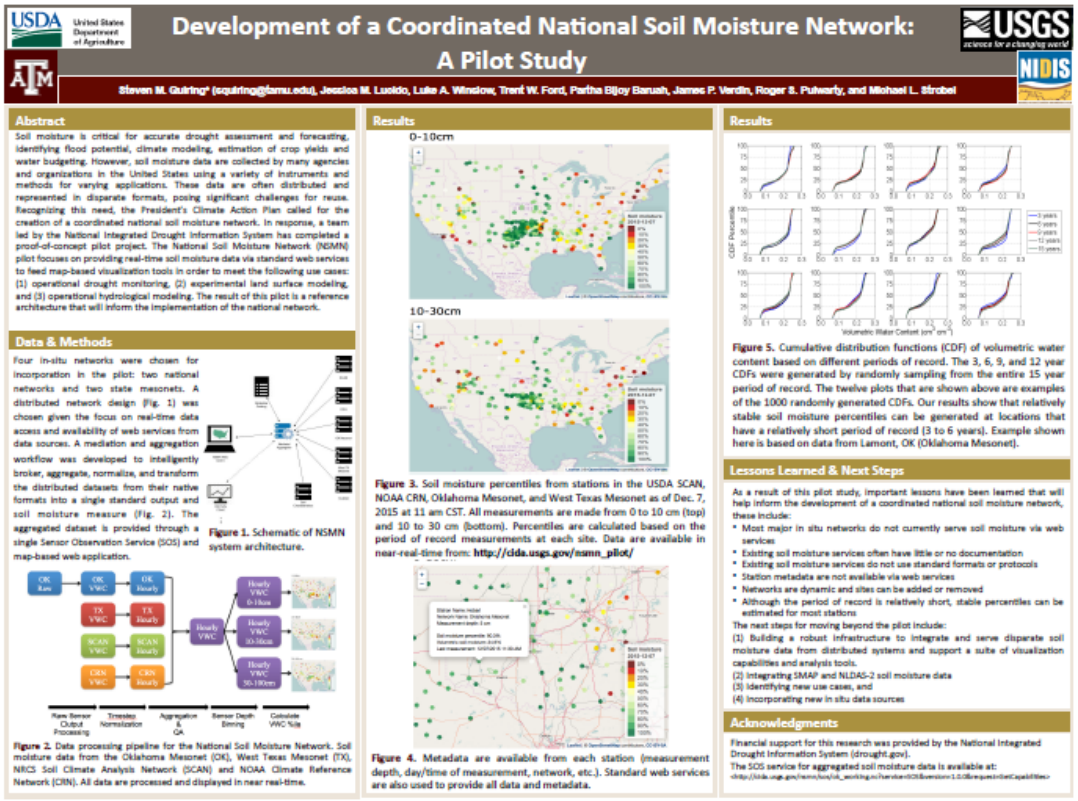

Development of a Coordinated National Soil Moisture Network: A Pilot Study

Steven M. Quiring* (squiring@tamu.edu), Jessica M. Lucido, Luke A. Winslow, Trent W. Ford, Partha Bijoy Baruah, James P. Verdin, Roger S. Pulwarty, and Michael L. Strobel

Abstract

Soil moisture is critical for accurate drought assessment and forecasting, identifying flood potential, climate modeling, estimation of crop yields and water budgeting. However, soil moisture data are collected by many agencies and organizations in the United States using a variety of instruments and methods for varying applications. These data are often distributed and represented in disparate formats, posing significant challenges for reuse. Recognizing this need, the President's Climate Action Plan called for the creation of a coordinated national soil moisture network. In response, a team led by the National Integrated Drought Information System has completed a proof-of-concept pilot project. The National Soil Moisture Network (NSMN) pilot focuses on providing real-time soil moisture data via standard web services to feed map-based visualization tools in order to meet the following use cases: (1) operational drought monitoring, (2) experimental land surface modeling, and (3) operational hydrological modeling. The result of this pilot is a reference architecture that will inform the implementation of the national network.

Data & Methods

Four in-situ networks were chosen for incorporation in the pilot: two national networks and two state mesonets. A distributed network design (Fig. 1) was chosen given the focus on real-time data access and availability of web services from data sources. A mediation and aggregation workflow was developed to intelligently broker, aggregate, normalize, and transform the distributed datasets from their native formats into a single standard output and soil moisture measure (Fig. 2). The aggregated dataset is provided through a single Sensor Observation Service (SOS) and map-based web application.

Figure 1. Schematic of NSMN system architecture.

Figure 2. Data processing pipeline for the National Soil Moisture Network. Soil moisture data from the Oklahoma Mesonet (OK), West Texas Mesonet (TX), NRCS Soil Climate Analysis Network (SCAN) and NOAA Climate Reference Network (CRN). All data are processed and displayed in near real-time.

Results

0-10cm

10-30cm

Figure 3. Soil moisture percentiles from stations in the USDA SCAN, NOAA CRN, Oklahoma Mesonet, and West Texas Mesonet as of Dec. 7, 2015 at 11 am CST. All measurements are made from 0 to 10 cm (top) and 10 to 30 cm (bottom). Percentiles are calculated based on the period of record measurements at each site. Data are available in near-real-time from: **http://cida.usgs.gov/nsmn_pilot/**

Figure 4. Metadata are available from each station (measurement depth, day/time of measurement, network, etc.). Standard web services are also used to provide all data and metadata.

Results

Figure 5. Cumulative distribution functions (CDF) of volumetric water content based on different periods of record. The 3, 6, 9, and 12 year CDFs were generated by randomly sampling from the entire 15 year period of record. The twelve plots that are shown above are examples of the 1000 randomly generated CDFs. Our results show that relatively stable soil moisture percentiles can be generated at locations that have a relatively short period of record (3 to 6 years). Example shown here is based on data from Lamont, OK (Oklahoma Mesonet).

Lessons Learned & Next Steps

As a result of this pilot study, important lessons have been learned that will help inform the development of a coordinated national soil moisture network, these include:

- Most major in situ networks do not currently serve soil moisture via web services
- Existing soil moisture services often have little or no documentation
- Existing soil moisture services do not use standard formats or protocols
- Station metadata are not available via web services
- Networks are dynamic and sites can be added or removed
- Although the period of record is relatively short, stable percentiles can be estimated for most stations

The next steps for moving beyond the pilot include:

(1) Building a robust infrastructure to integrate and serve disparate soil moisture data from distributed systems and support a suite of visualization capabilities and analysis tools.
(2) Integrating SMAP and NLDAS-2 soil moisture data
(3) Identifying new use cases, and
(4) Incorporating new in situ data sources

Acknowledgments

Financial support for this research was provided by the National Integrated Drought Information System (drought.gov).

The SOS service for aggregated soil moisture data is available at:

From Presentation:

MOTIVATION:

President's Climate Action Plan

:

:

National Soil Moisture Pilot (Lucido & Quiring, 2015)

New Opportunities

National Soil Moisture Network Workshop
Progress made and future directions
May 24 - 26, 2016
NOAA/National Integrated Drought Information System
325 Broadway, Boulder, CO 80305

Goals and Objectives

- Communicating and coordinating soil moisture monitoring and assimilation activities across the federal landscape with states and other interests, including the private sector.

- Providing an update on the progress made thus far on a Coordinated National Soil Moisture Network. Reporting on the findings from the NSMN pilot work.

- Crafting a future direction and approach for a coordinated NSMN. Identifying the next steps, addressing who will be involved, and how and what needs to be accomplished. Identifying short-term, medium- term, and long-term goals of coordinating a NSMN.

Workshop Announcement (Strobel, et. al. 2016)

Discussion?

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