NEBRASKA: AN EXAMPLE OF HIGH PRODUCTIVITY AND SUSTAINABLE GOVERNANCE OF WATER FOR AGRICULTURE

Christopher M. U. Neale

Director of Research

Daugherty Water for Food Global Institute

University of Nebraska

University of Nebraska System

THE DAUGHERTY WATER for FOOD GLOBAL INSTITUTE at the University of Nebraska

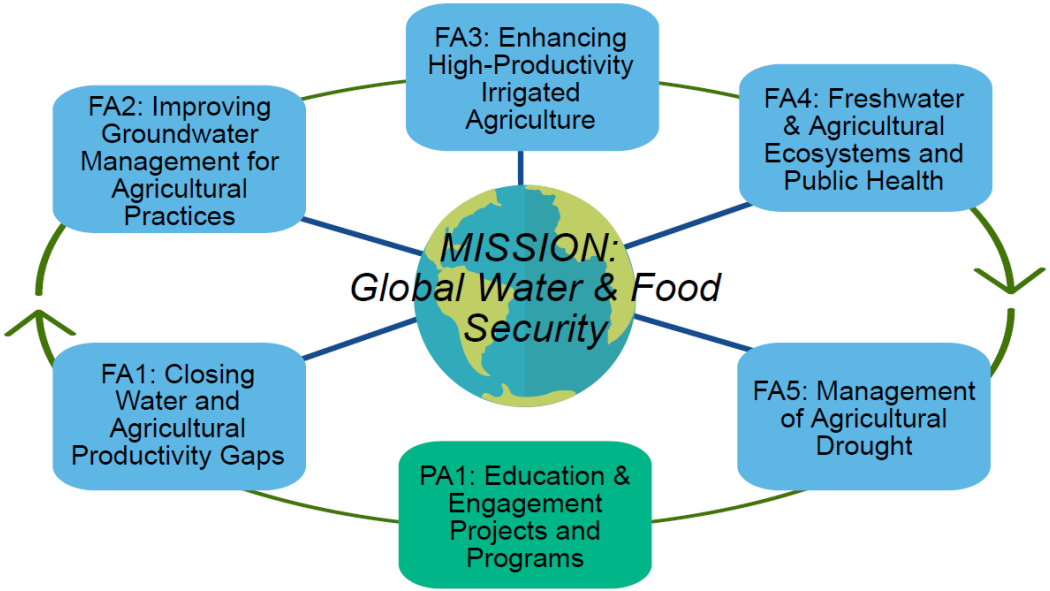
Outline

- Describe Daugherty Water for Food Global Institute
- Discuss Agriculture in Nebraska and the System of Water Governance
- Describe the GLODET Daily ET product
- How it can be used for drought monitoring
- Partner: National Drought Mitigation Center
- Summarize other relevant activities

Daugherty Water for Food Global Institute

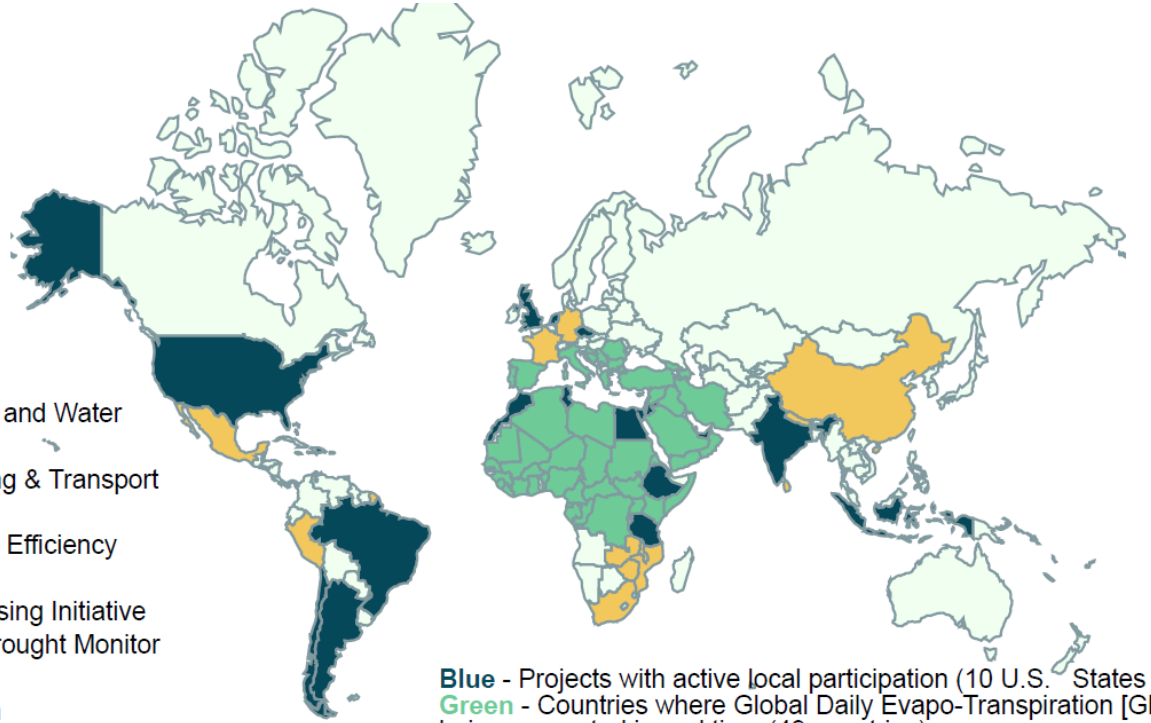
- Founded in 2010 at the University of Nebraska

- **Vision:** A food and water secure world: one in which global food security is ensured without compromising the use of water to meet other vital human and environmental needs.
- **Mission:** Lasting and Significant Impact
- **Five Focus Areas** for research and policy
- **Education & Engagement**
- **Distributed** institute across 4 campuses
- More than 120 faculty and global fellows, plus postdoctoral researchers, and students
- Collaborations with other universities, industry, non-governmental organizations, and government agencies around the world to address issues on a global scale.



Who we work with: DWFI partners

DWFI: Where We Work



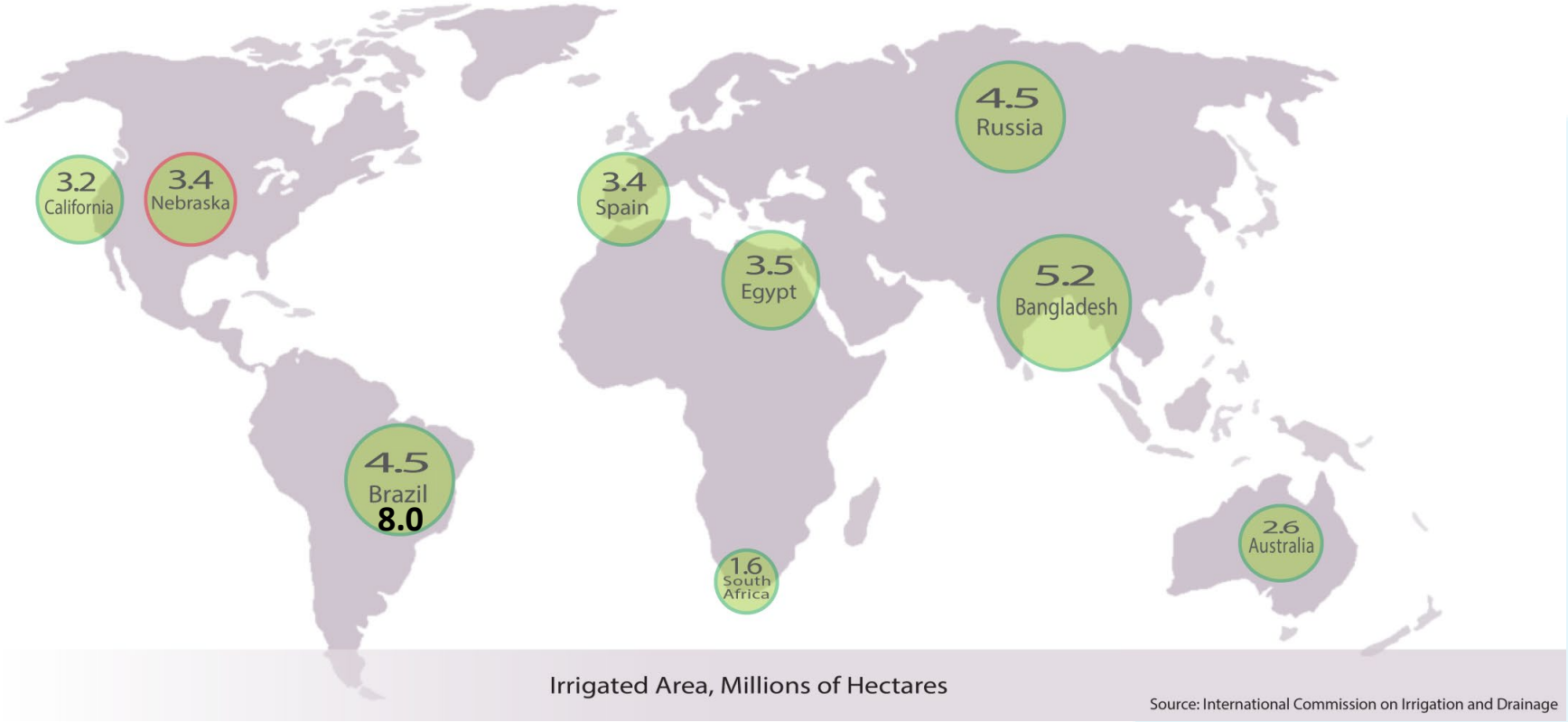
Highlights

- Global Yield Gap Atlas and Water Productivity Report
- Vadose Zone Monitoring & Transport Analysis
- Variable Rate Irrigation Efficiency Improvements
- Water for Food Processing Initiative
- Global Daily ET and Drought Monitor
- Water Markets
- IHE-Delft Collaboration
- Water Advanced Research & Innovation (WARI) Fellowship Program

Blue - Projects with active local participation (10 U.S. States & 19 countries)
Green - Countries where Global Daily Evapo-Transpiration [GloDET] products are being generated in real time (49 countries)
Yellow - Countries, not otherwise identified, represented at the Water for Food International Forum (29 countries total)

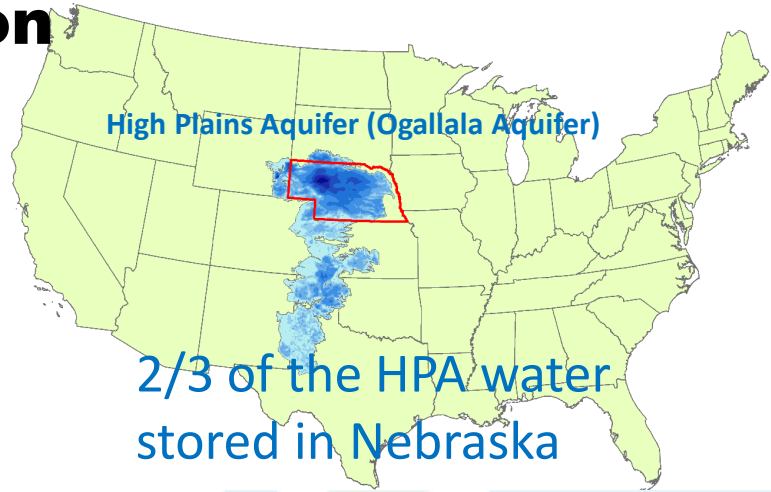
Current as of June 30, 2018

Nebraska: A Substantial Irrigator

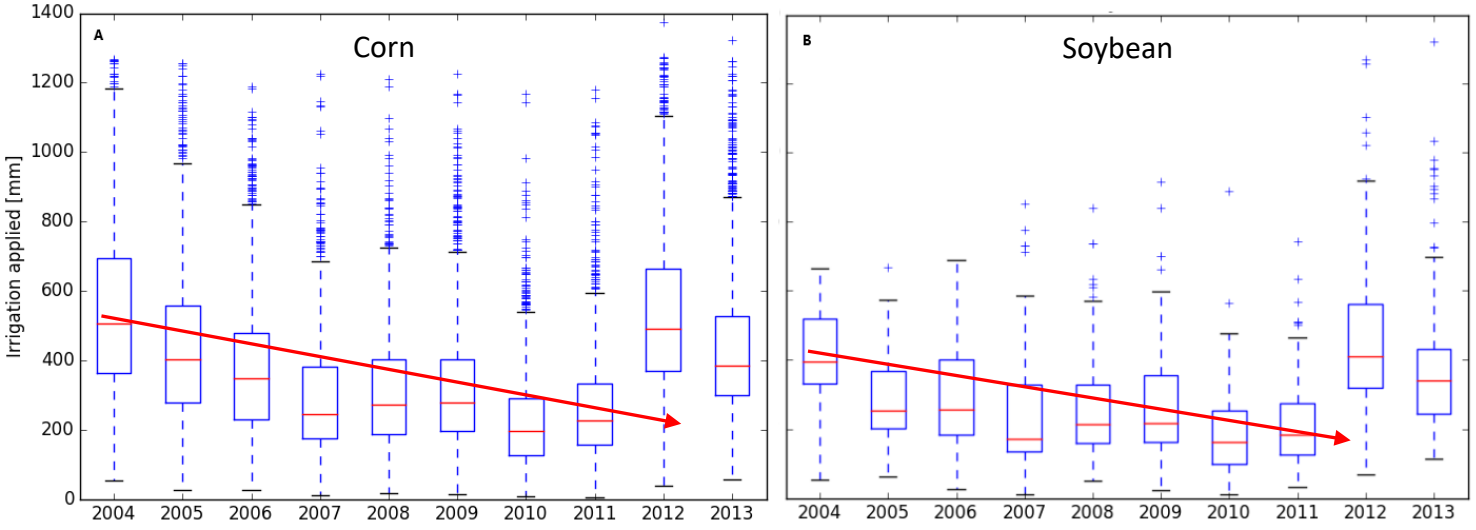


Nebraska's agriculture - irrigation

- Nebraska leads the nation in total irrigated area (3.4 million ha)
  - >90% of irrigation water from groundwater
  - > 96000 active registered irrigation wells
- Irrigation application rate is dropping



2/3 of the HPA water stored in Nebraska



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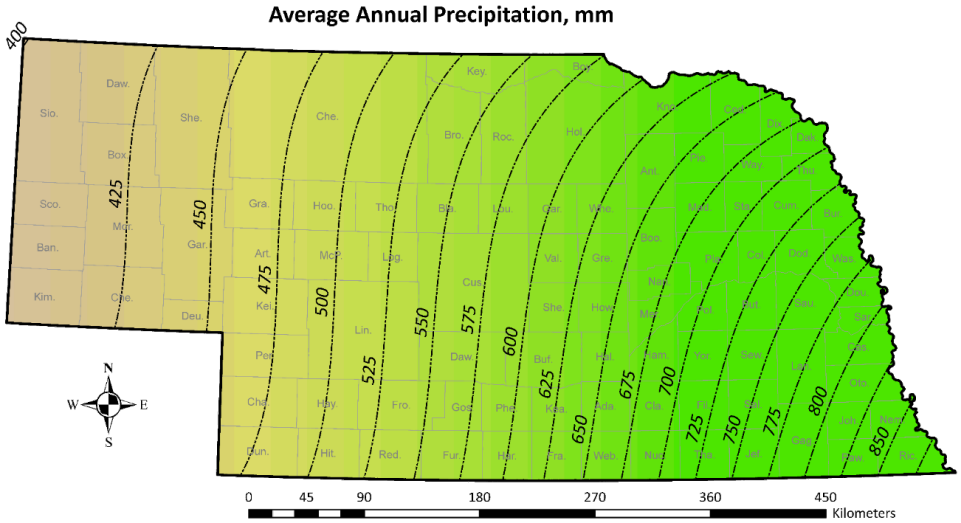
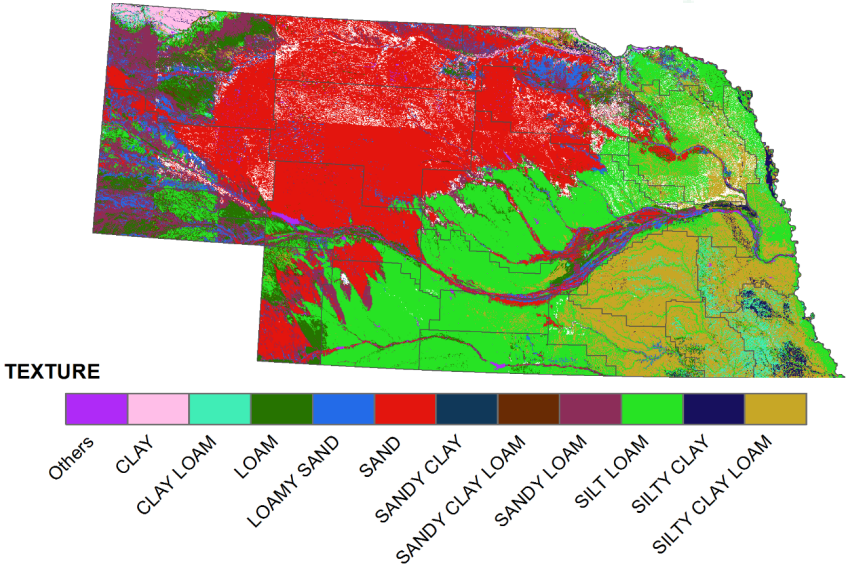
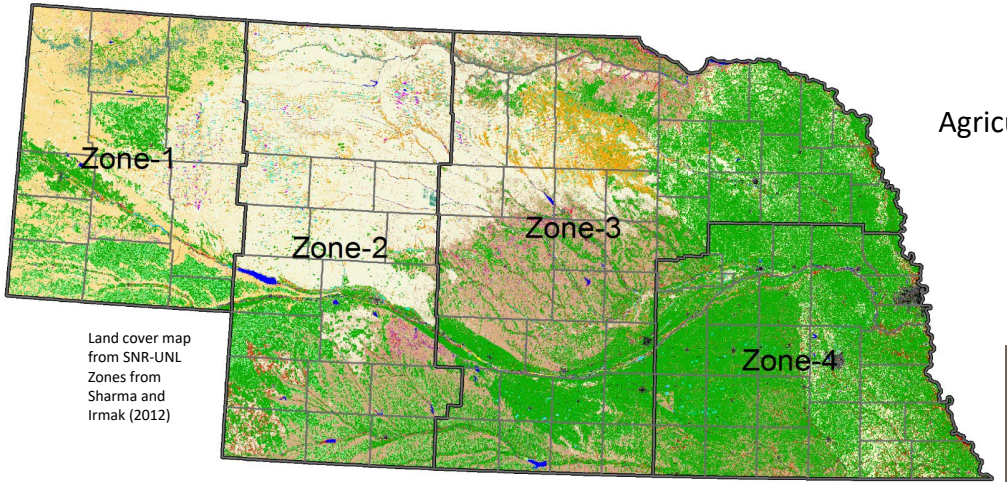
Nebraska agro-climate zones







Land cover map from SNR-UNL Zones from Sharma and Irmak (2012)

Agricultural Climatic Zones (Sharma and Irmak, 2012)

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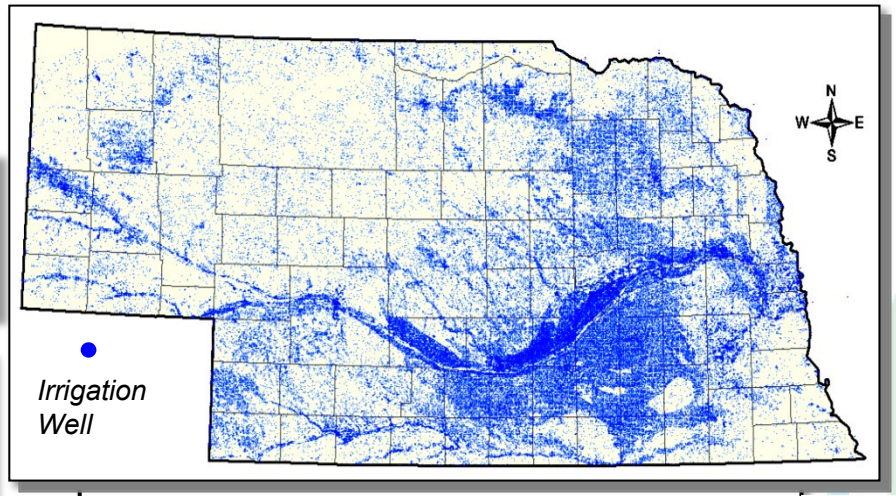
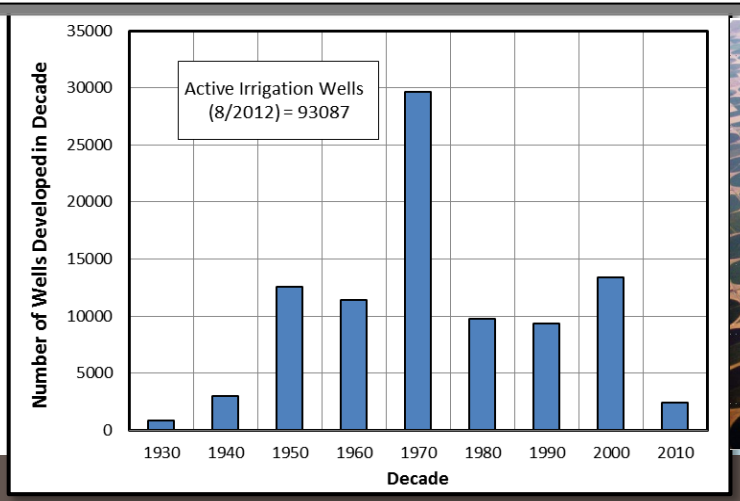
Irrigation Development

Active Irrigation Wells
~ 96,000
$6-8 Billion Investment





Major development occurred in 70's, but growth continues at about 2000 wells per year

Courtesy of Derrel Martin

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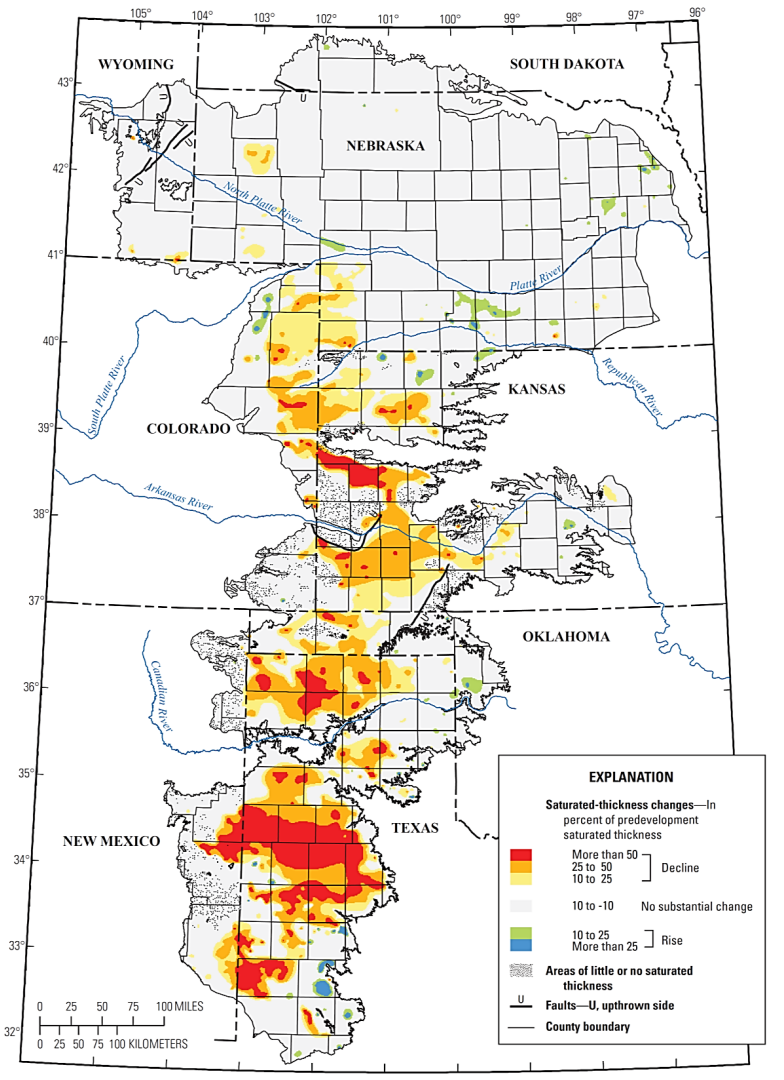
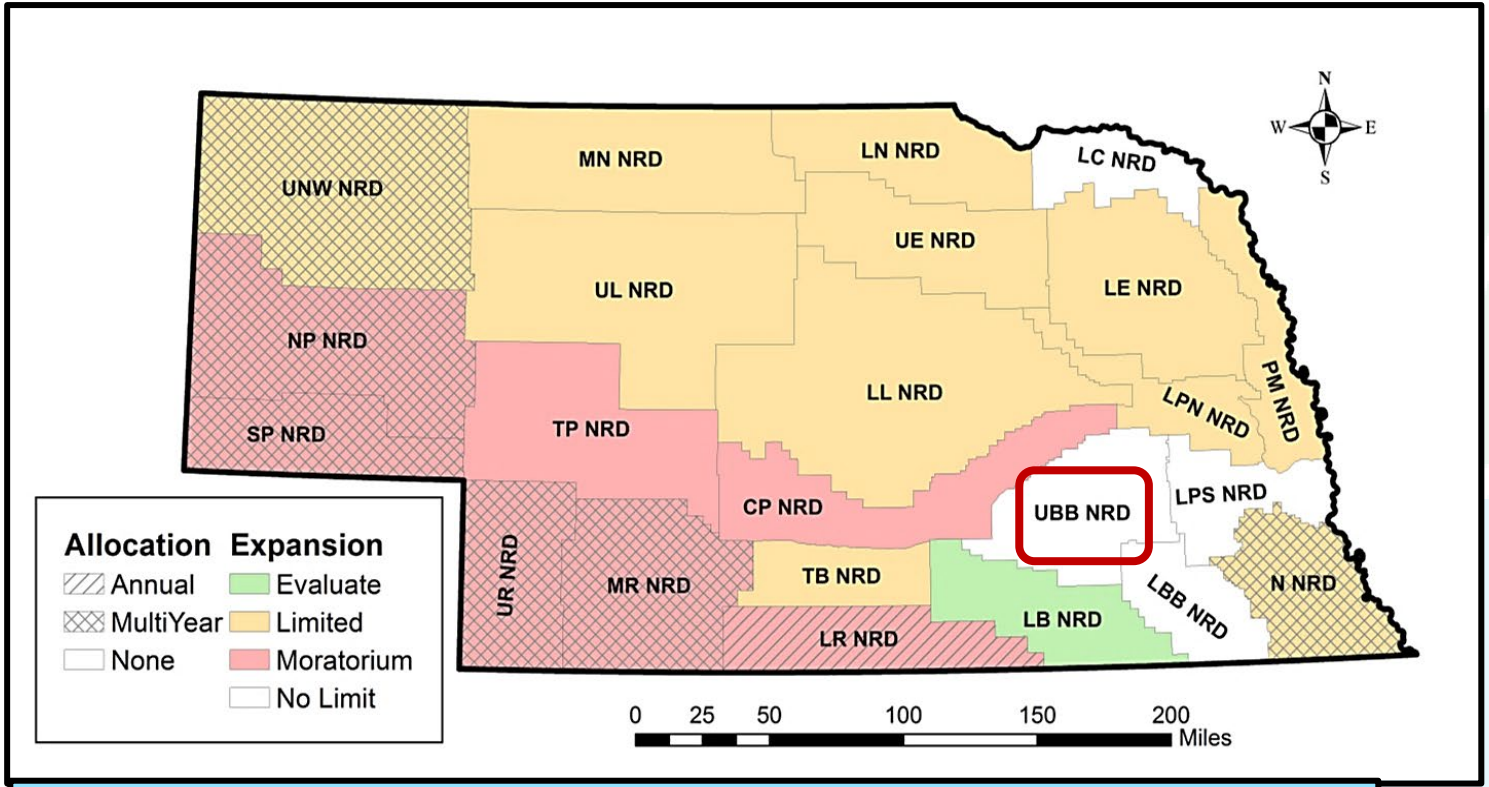
Depletion as Fraction of Saturated Thickness of the Aquifer
(McGuire , 2011)

Depletions in southern High Plains > 50% of saturated thickness

Small area in Nebraska > 25% of saturated thickness



Natural Resource Districts and Water Control Programs in Nebraska



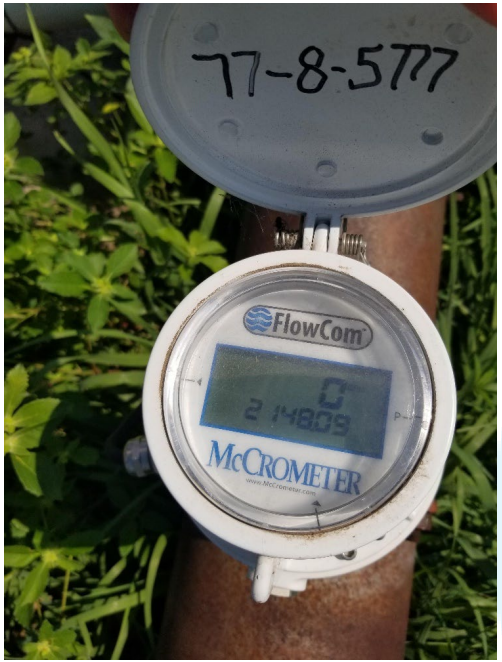
- Allocation Programs Limit Volume of Pumpage Over a Period of Time
- Expansion Limits Restrict Development of New Wells or New Irrigated Areas
- Upper Big Blue Considering Allocation Program
- Other Western States Have Similar Issues/Programs

Upper Republican NRD

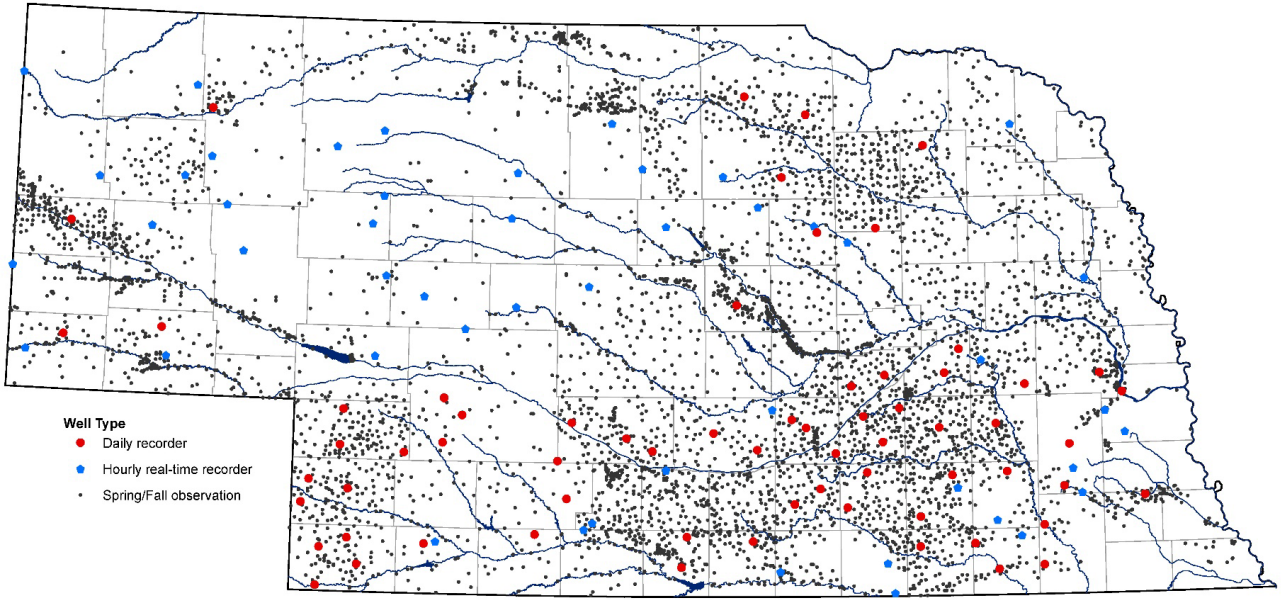
- All irrigation wells are equipped with flow meters

- There is a pumping cap of 300 mm/year (12 inches), or 1500 mm over 5 years.

Flow meter with real time telemetry



Location of Observation Wells by Type



For an explanation of information presented on this map, see the 2018 Nebraska Statewide Groundwater-Level Monitoring Report, available for download at ***go.unl.edu/groundwater***

CONSERVATION AND SURVEY DIVISION (http://snr.unl.edu/csd)
School of Natural Resources (http://snr.unl.edu)
Institute of Agriculture and Natural Resources
University of Nebraska-Lincoln

Aaron Young, Survey Geologist, CSD
Mark Burbach, Water Levels Program Supervisor, CSD
Les Howard, GIS Manager, CSD

Data provided by:

Nebraska Natural Resources Districts

Central Nebraska Public Power and Irrigation District

U.S. Geological Survey
Nebraska Water Science Center

U.S. Bureau of Reclamation
Kansas-Nebraska Area Office

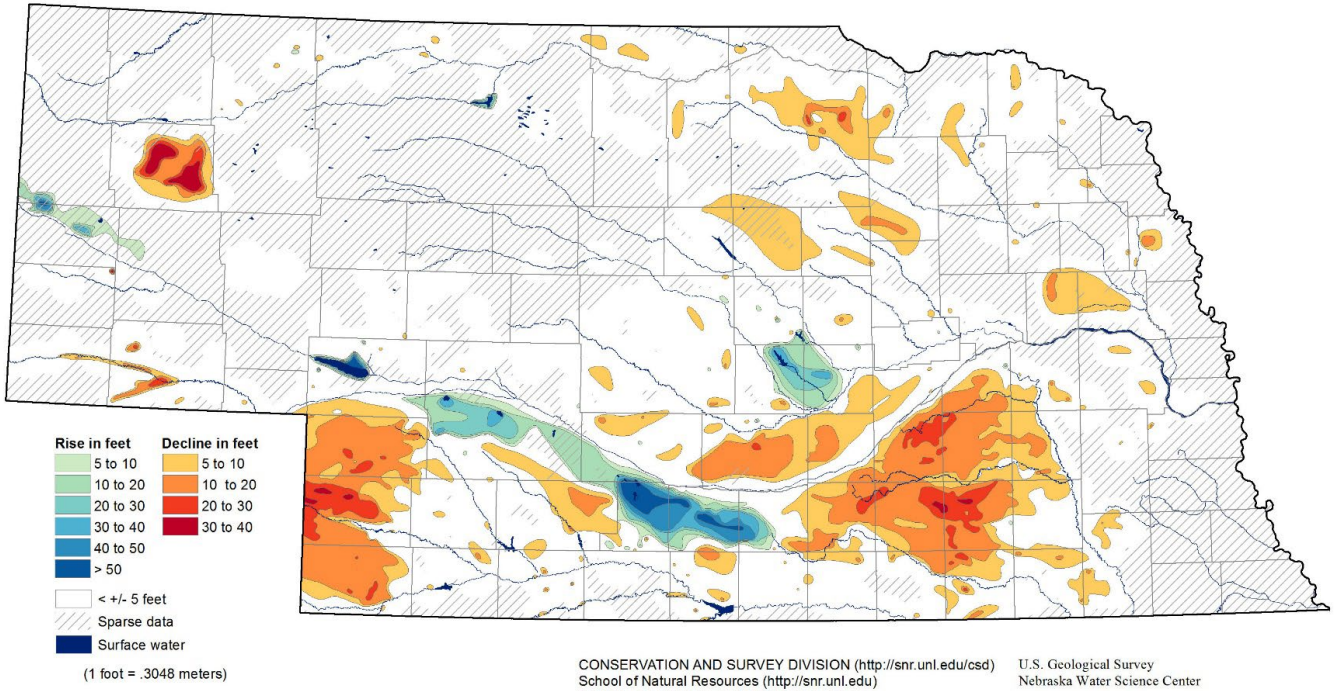
Conservation and Survey Division,
University of Nebraska - Lincoln

December 2018

Disclaimer: wells on this map are depicted at a small scale. They are intended to provide only approximations of well locations.

Manual water level observations are typically conducted in late winter/early spring, prior to the beginning of the irrigation pumping season

Groundwater-level Changes in Nebraska - Predevelopment to Spring 1981



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School of Natural Resources
Institute of Agriculture and Natural Resources
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December 2011

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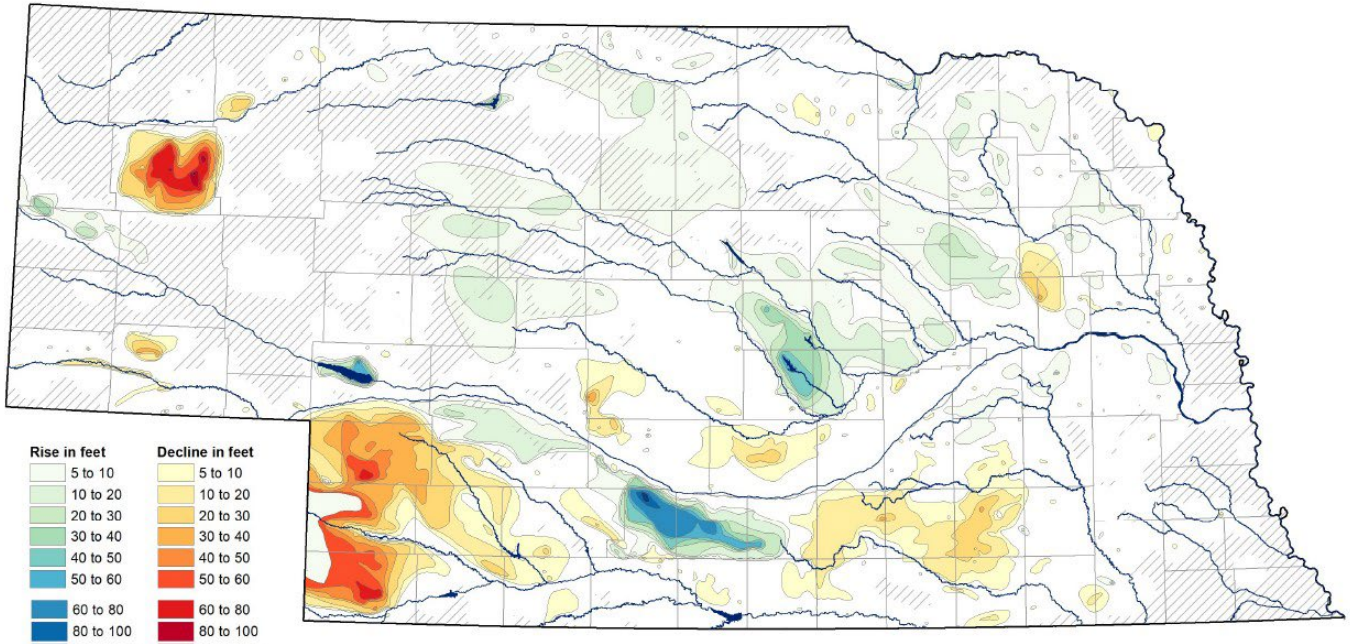
Groundwater-Level Changes in Nebraska - Predevelopment to Spring 2021



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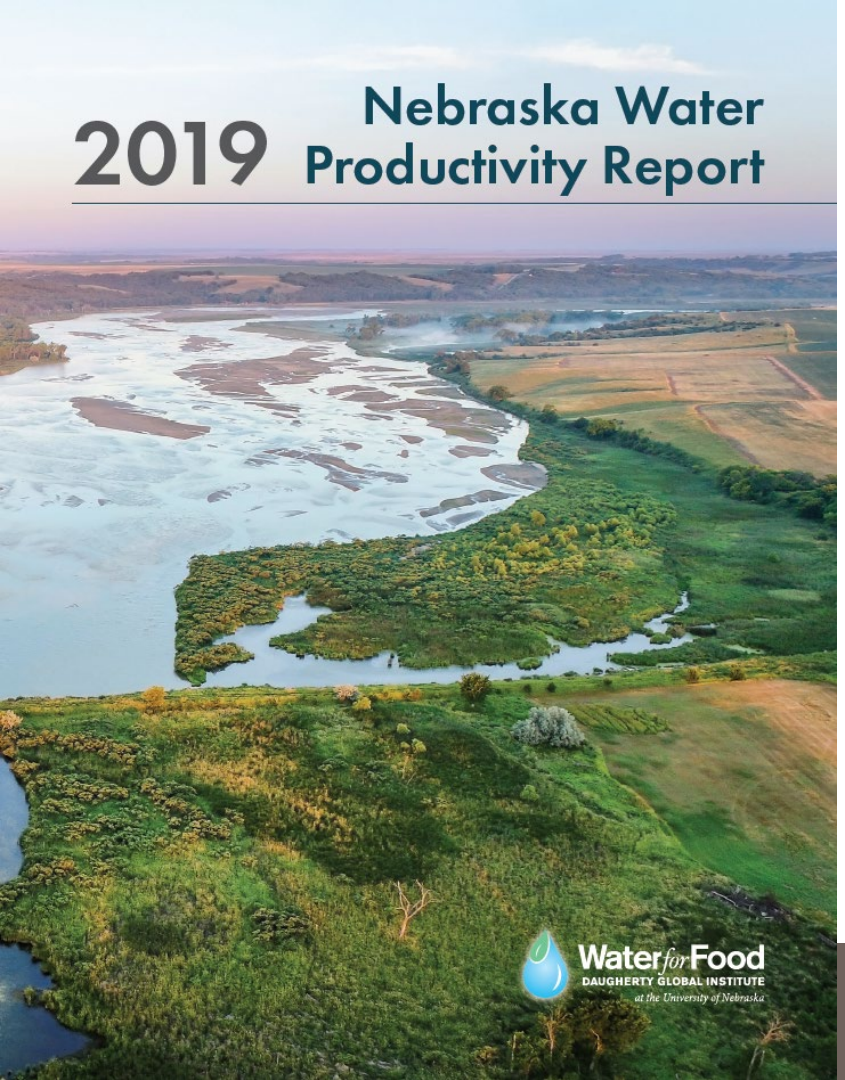
Kansas-Nebraska Area Office

Conservation and Survey Division,
University of Nebraska - Lincoln

February 2022

Disclaimer: groundwater-level changes on this map are depicted at a small scale. They are intended to provide only a general overview of regional variation.



Objective: Assess WP at different spatial and temporal scale

https://waterforfood.nebraska.edu/resources

Reports and Working Papers

Work components:

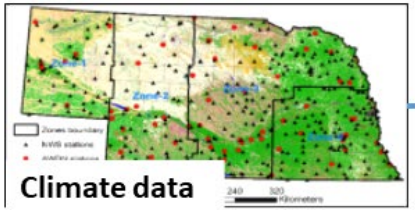
1. Crop water productivity
2. Livestock water productivity
3. Water, energy, and carbon footprint of bioethanol from corn compared to sugarcane

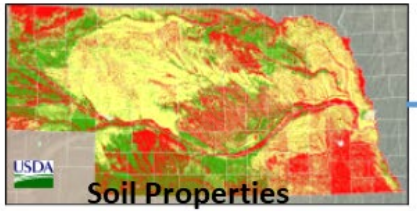
Crop water productivity (WP) indicators

- WP is generally defined as a yield or biomass output over water input
- Example of Four WP indicators:

	Total water productivity		Irrigation water productivity	
	Total available WP	Total consumed WP	Applied irrigation WP	Consumed irrigation WP
Equation	$WP_{t,a} = \frac{Y}{(P + I + SW)}$	$WP_{t,c} = \frac{Y}{ET}$	$WP_{i,a} = \frac{Y_{ir} - Y_{rf}}{I}$	$WP_{i,c} = \frac{Y_{ir} - Y_{rf}}{ET_{ir} - ET_{rf}}$

Crop water productivity methodology



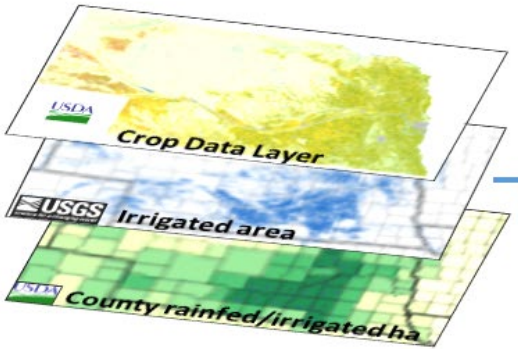


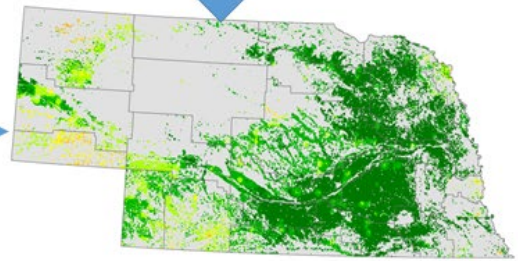
AQUACROP

Crop parameter and field management

1375 grids

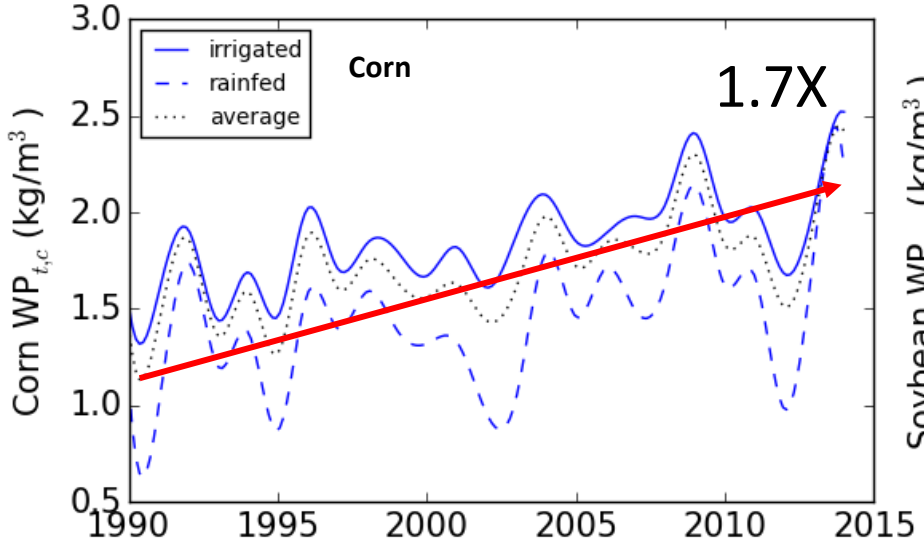
Crop yield and ET for each grid

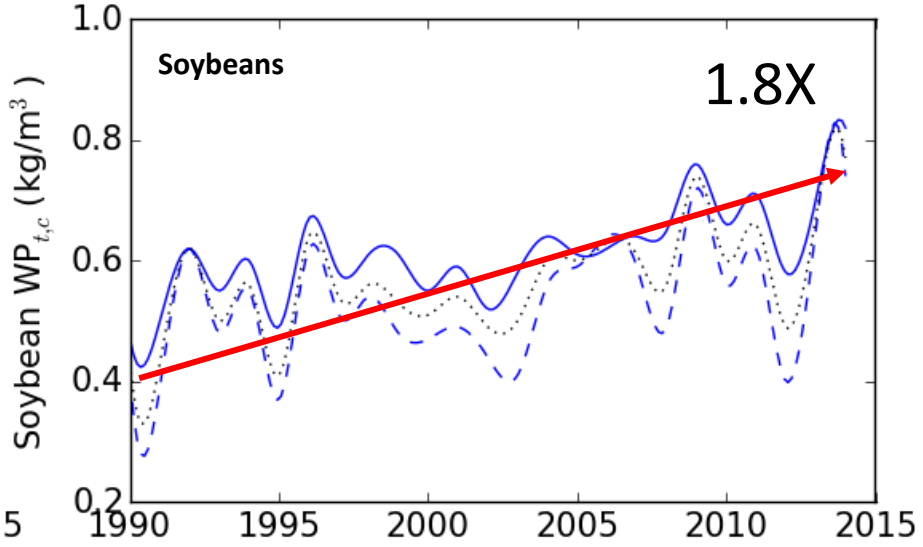


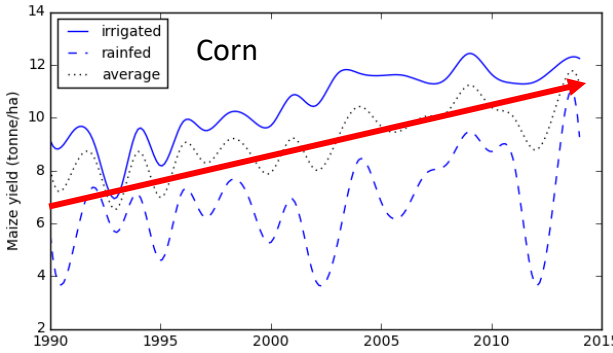


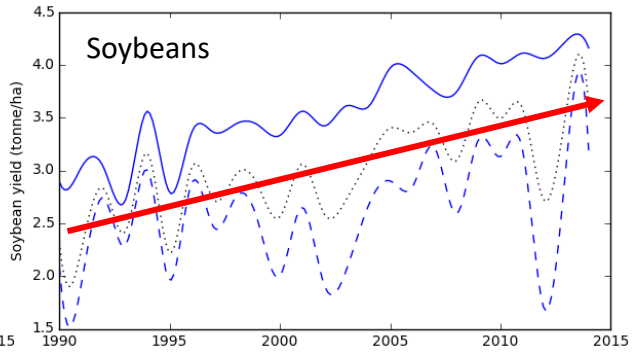
Water productivity

Temporal variation in WP of corn and soybeans









$$WP_{t,c} = \frac{Y}{ET}$$

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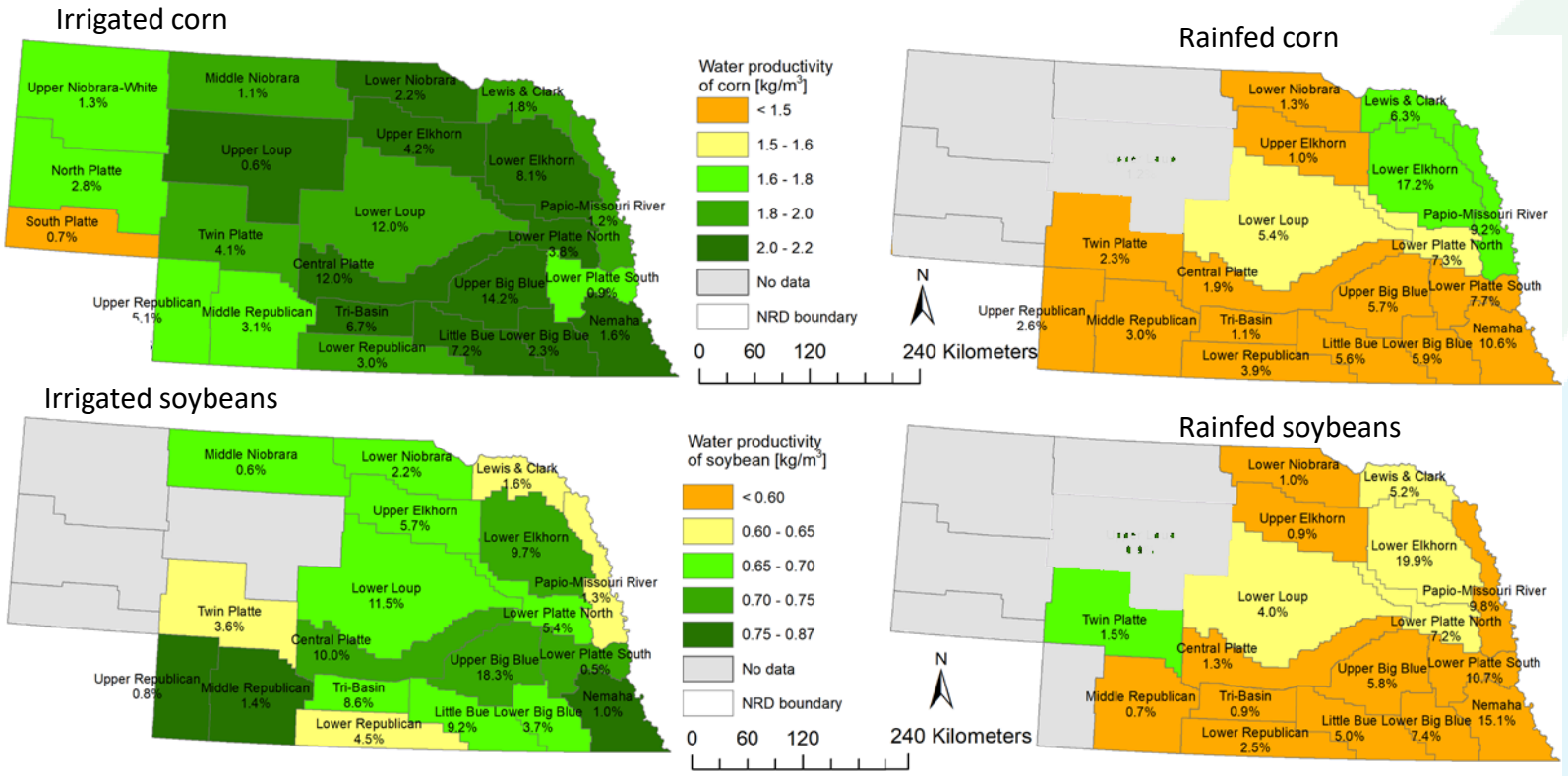
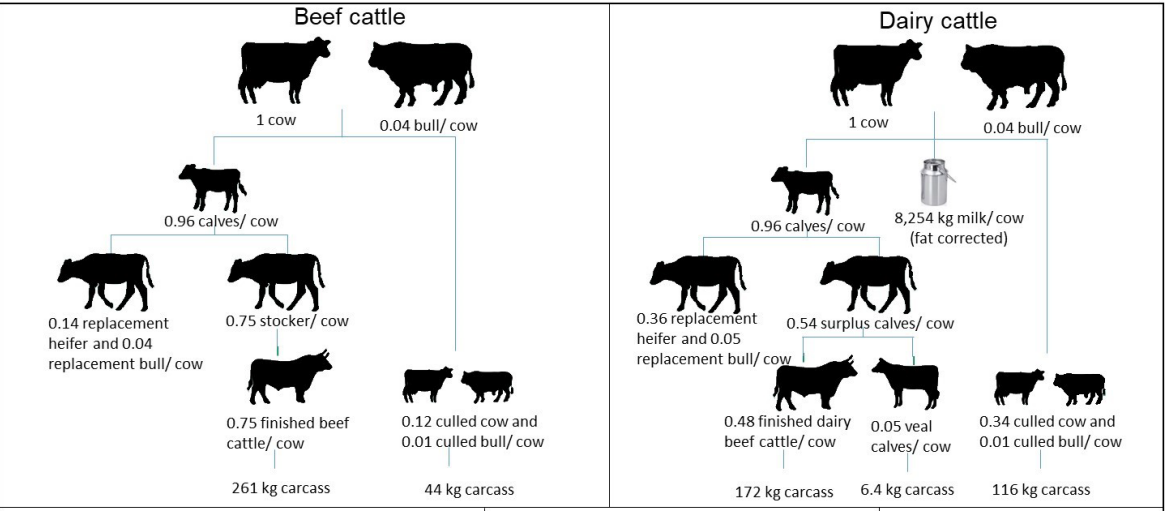
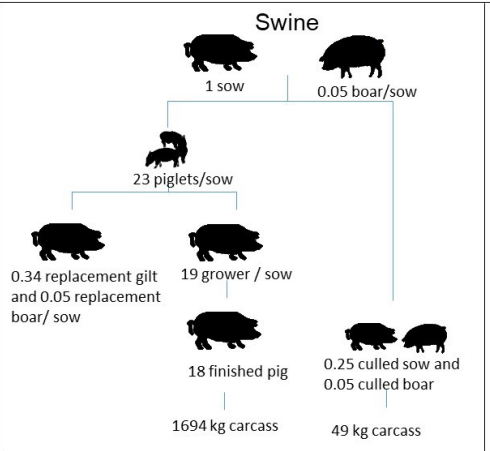
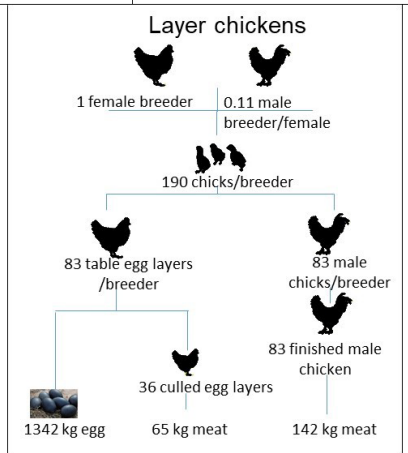
Spatial variation of WP of corn and soybeans

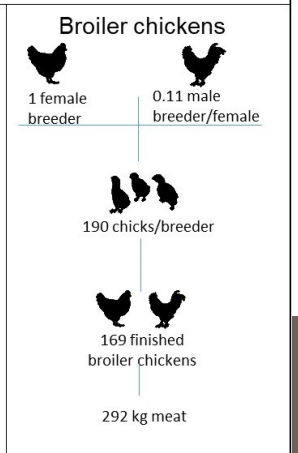


Livestock products WP





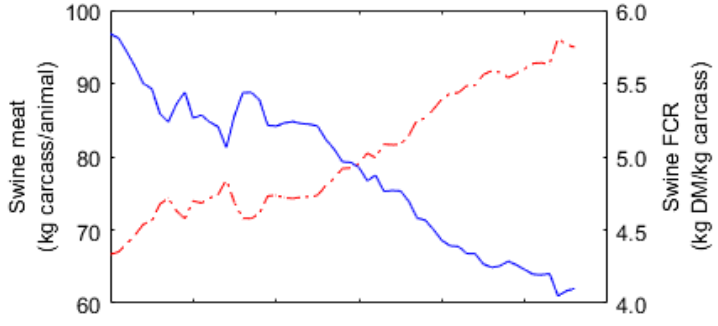


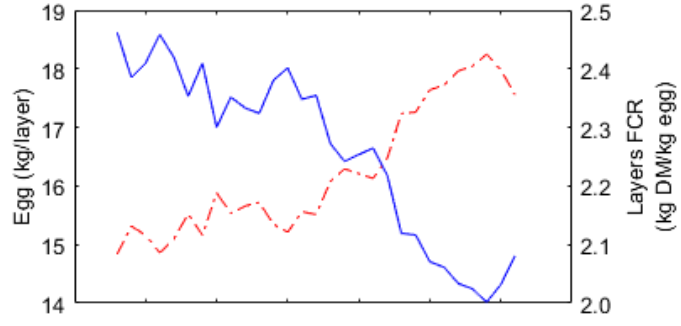


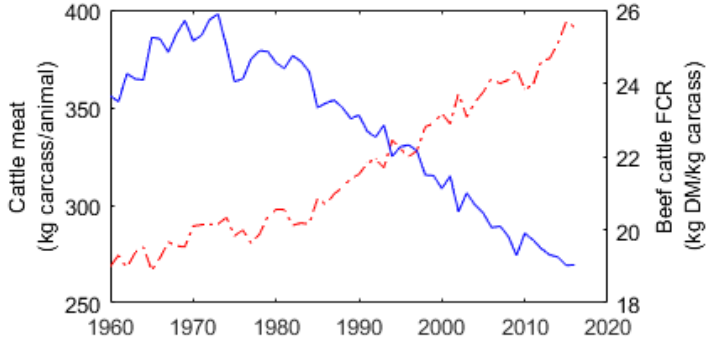
$$WP = \frac{Total\ output\ (meat, milk, or\ egg)}{Water\ consumption}$$

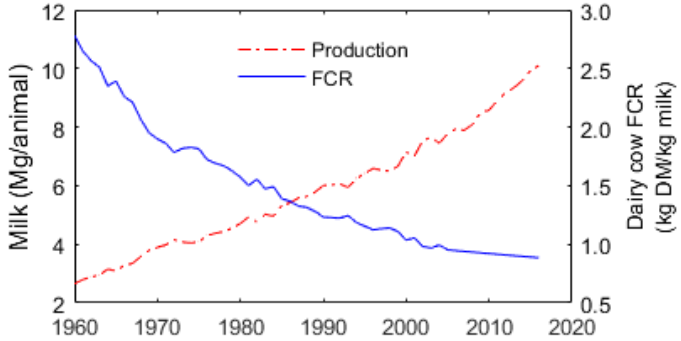
Water consumption = WF of feed
+ drinking water
+ service water

Change in livestock productivity and Feed Conversion Ration (FCR)





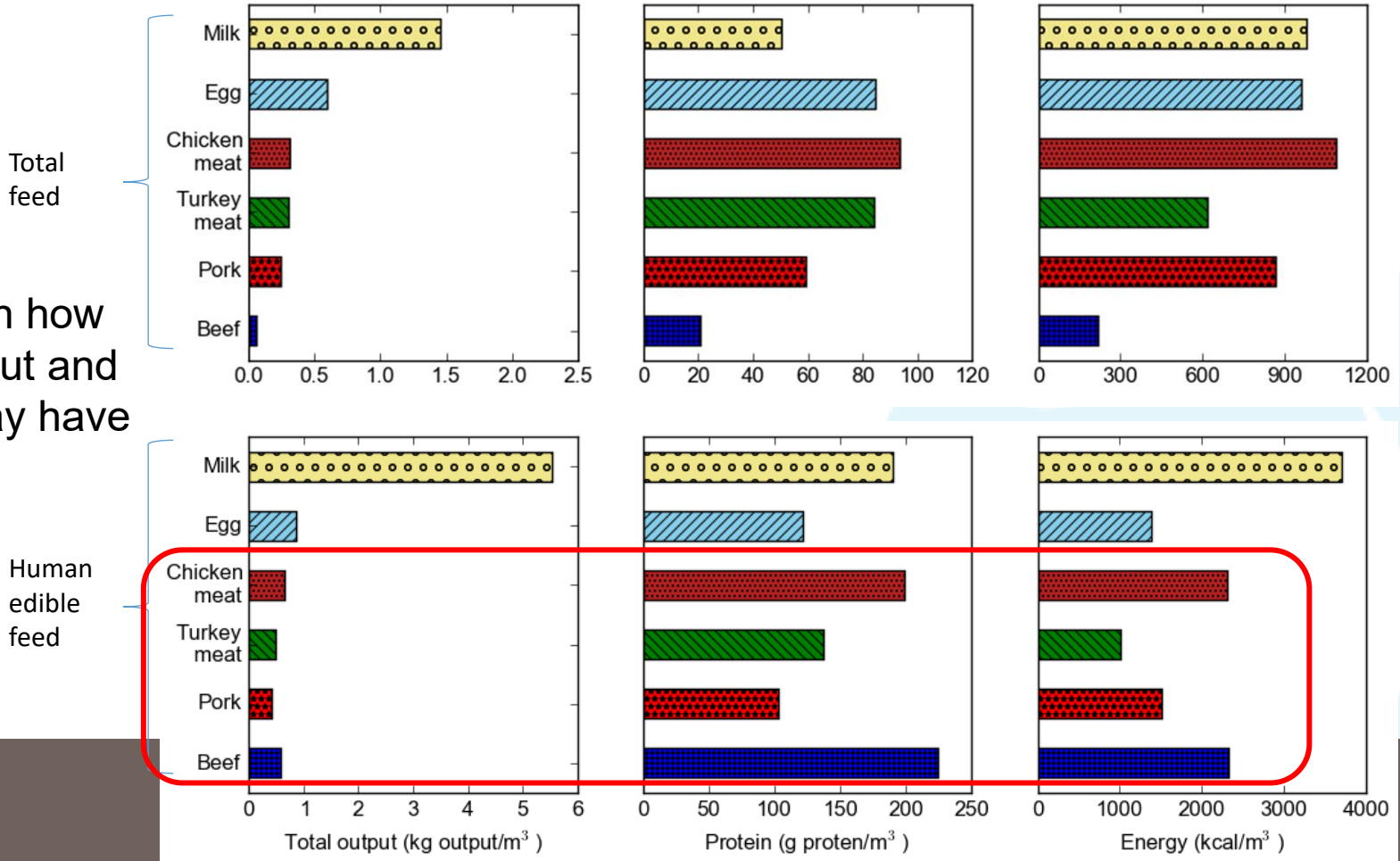




- In 2016, fewer animals were needed to produce relatively large quantity of livestock products.
- In 2016, less feed required per unit of livestock products.

WP of livestock products

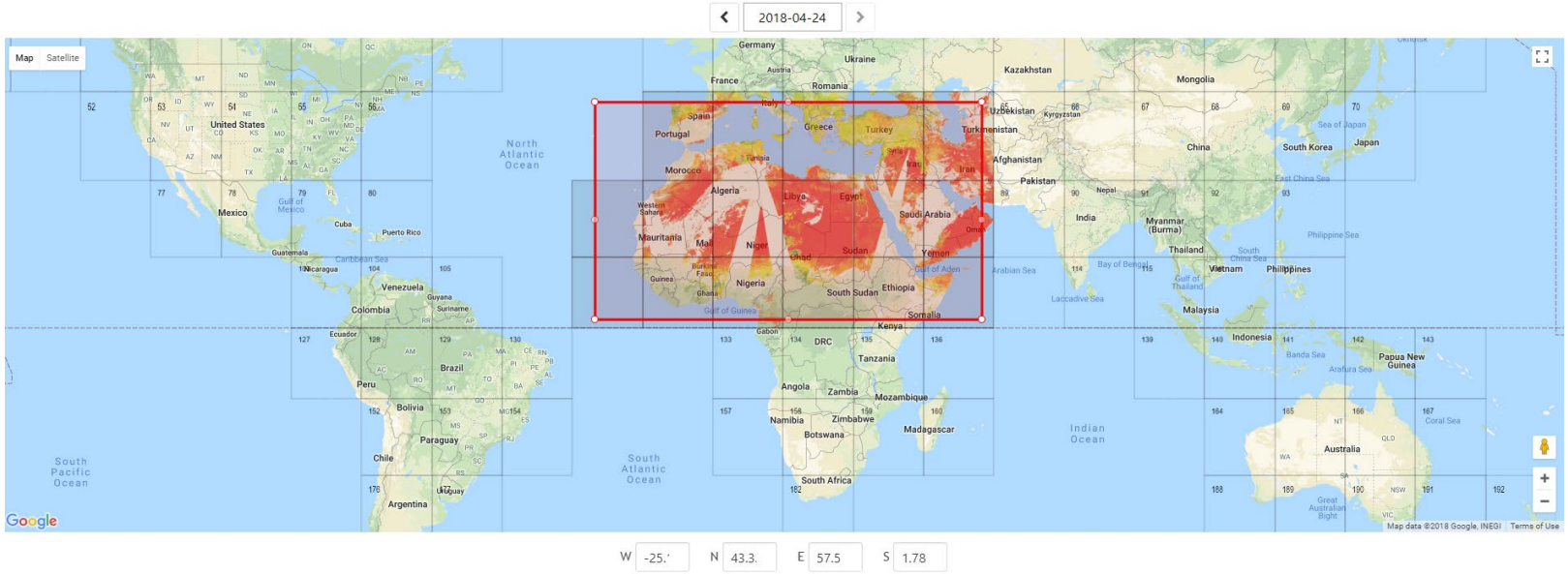
- Depending on how we define input and output we may have different WP



ALEXI/VIIRS Satellite Global Daily ET Product (GLODET) WEB Interface

- Users will register to view and download the product
- Updates, track the applications and research using the product
- Model runs at HCC supercomputer center at University of Nebraska-Lincoln

https://glodet.nebraska.edu/index.html#/



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USDA Agricultural Research Service

NASA

Earth System Science Interdisciplinary Center, University of Maryland

NDMC National Drought Mitigation Center, University of Nebraska

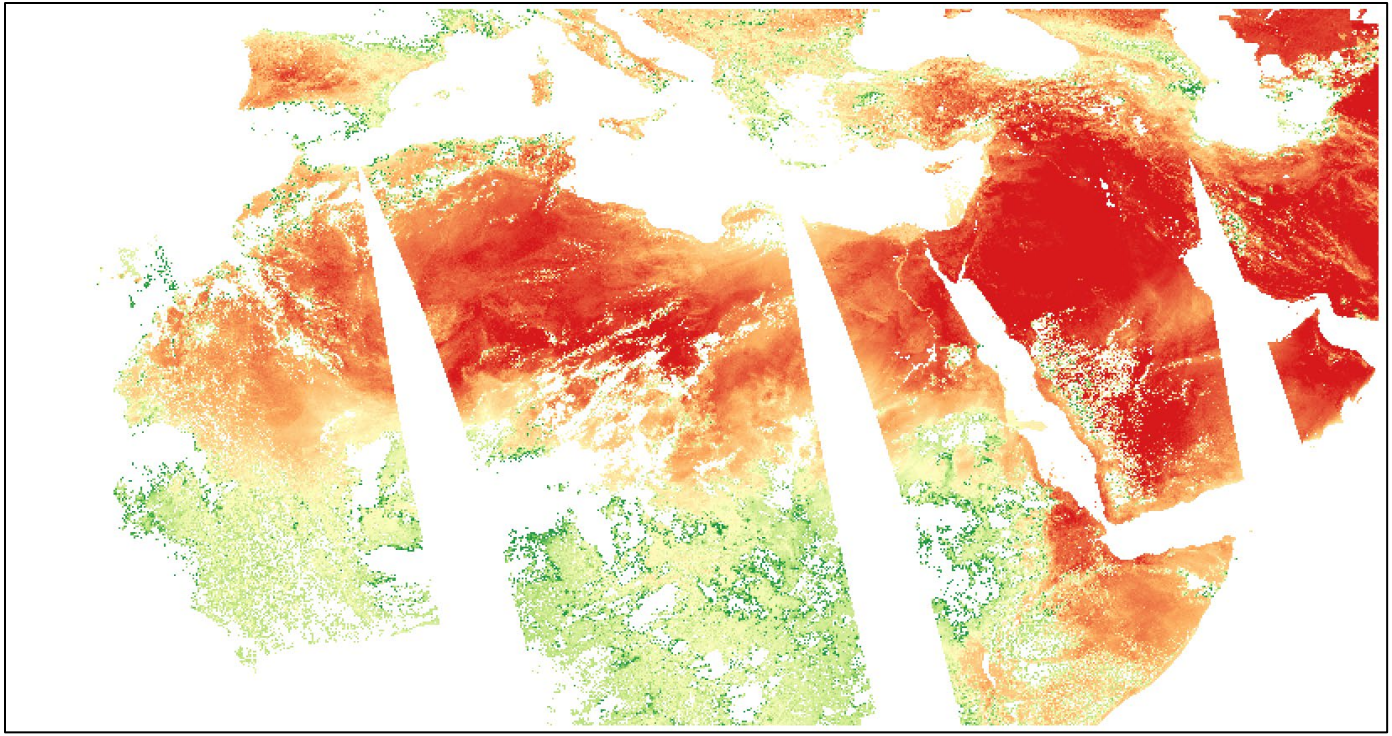
USAID From the American People

ICBA

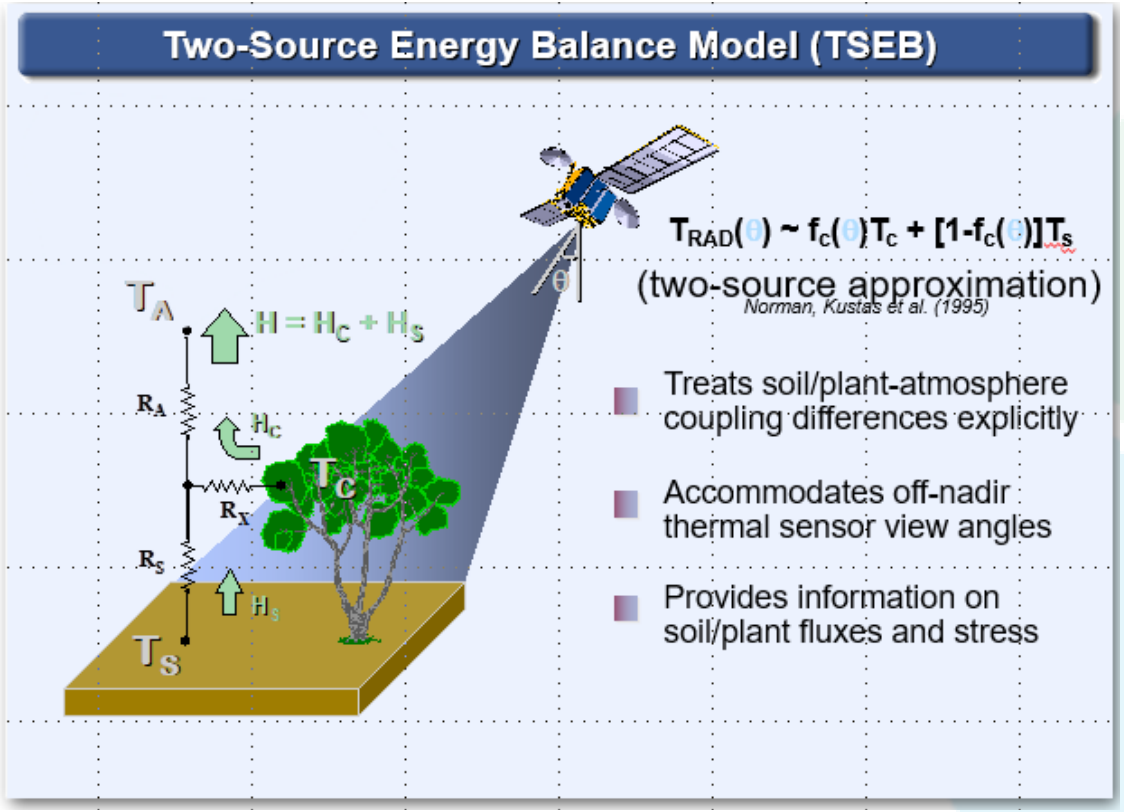
IWMI

Clear Sky Land Surface Temperature from VIIRS

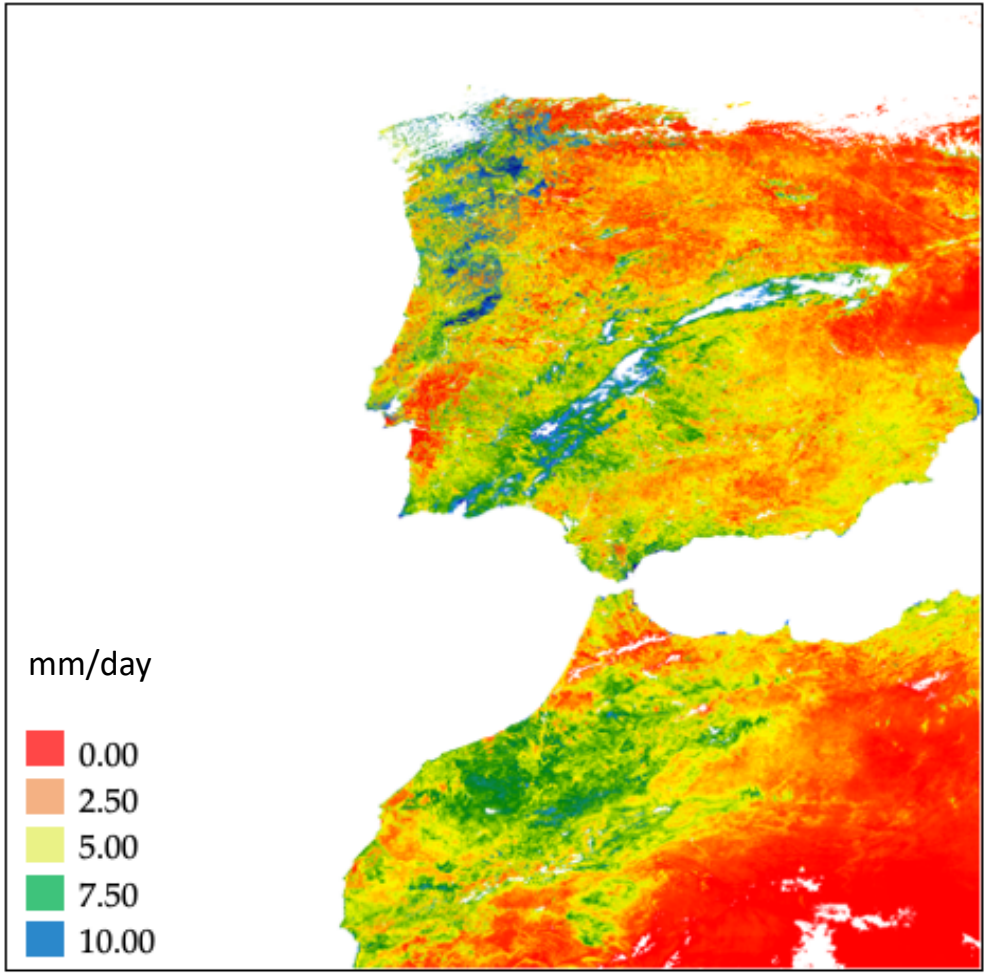
Clear-sky land surface temperature valid at 0900 UTC on 1 August 2015. LST and cloud masks were generated from VIIRS I5 BT band. LST was computed using a single channel retrieval based on an atmospheric correction of the I5 band with CFSR atmospheric water vapor data. **Thermal IR band spatial resolution is 375 m.**



The ALEXI model runs the TSEB



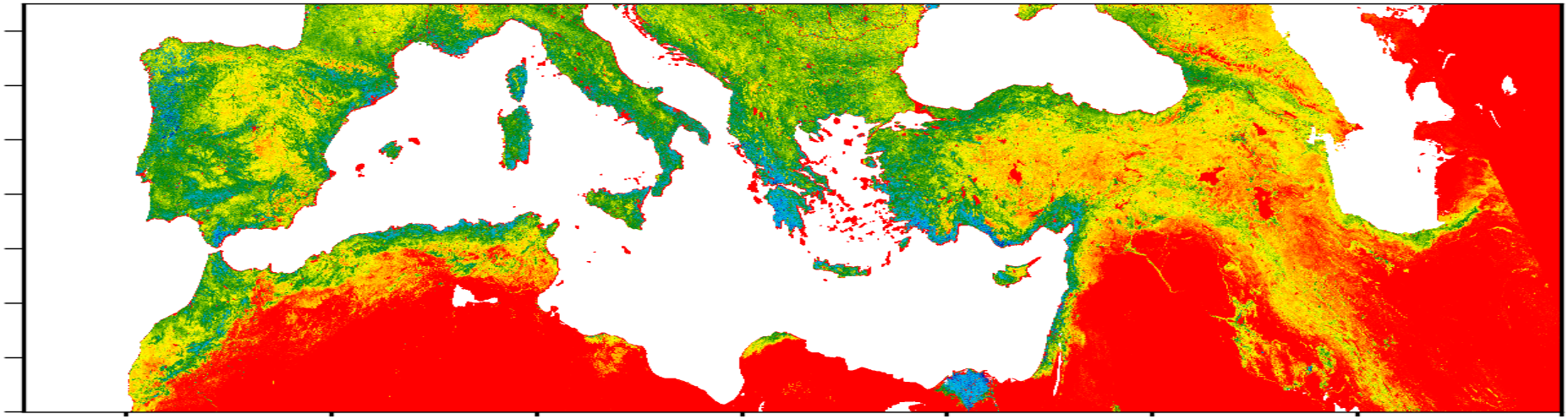
Daily Evapotranspiration from VIIRS



Spatial distribution of daily ET on May 1, 2015, produced by the ALEXI model at ~400 m resolution

Development of a High-Resolution (375-m) VIIRS ET Product

Annual ET estimated from integrating daily values for 2018



mm/year

EARTH SYSTEM SCIENCE INTERDISCIPLINARY CENTER
ESSIC
UNIVERSITY OF MARYLAND

USDA

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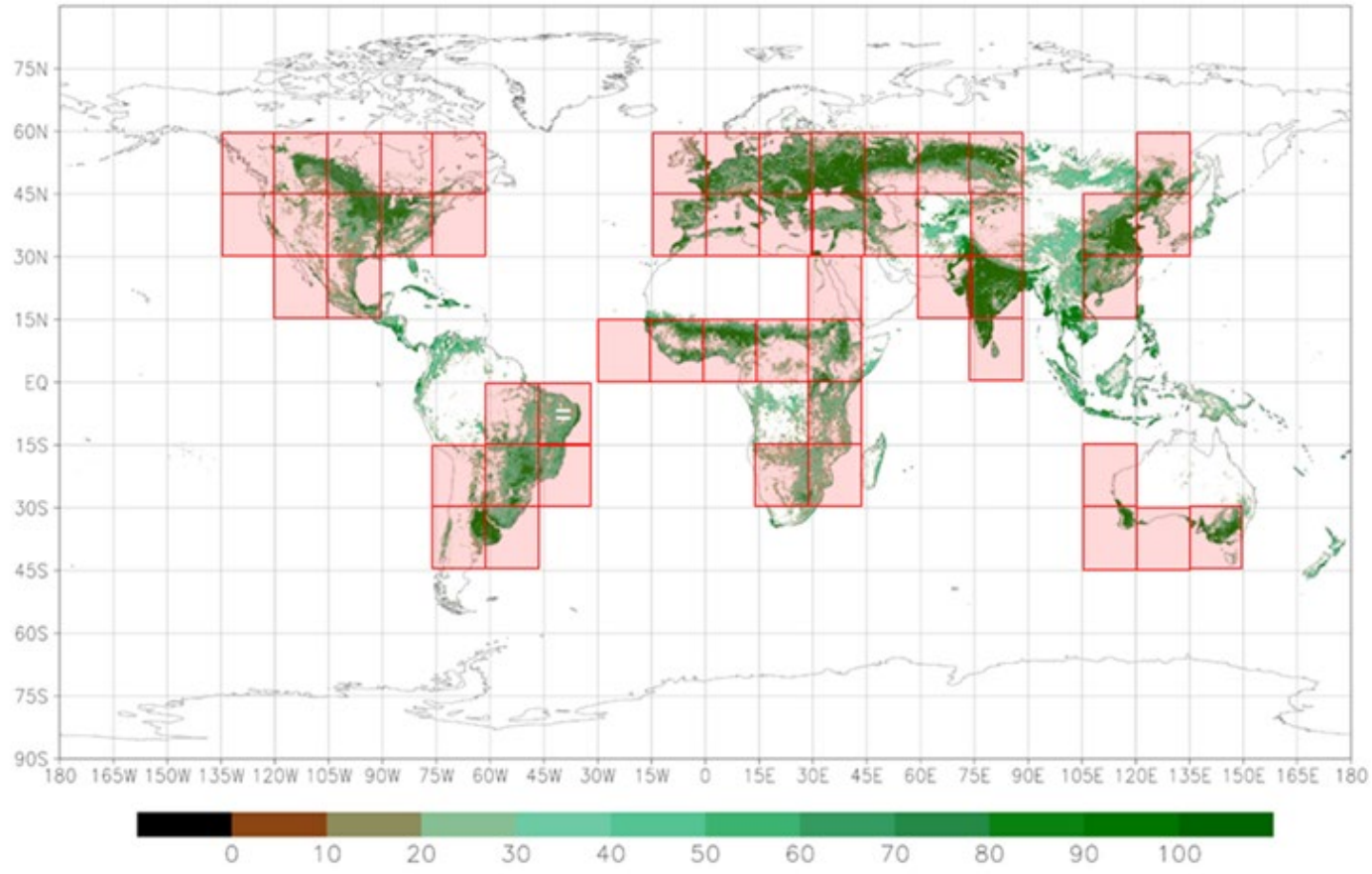
NASA

Proposed 15 x 15-degree processing tiles (375-m) VIIRS ET Product for Major food producing areas of the world



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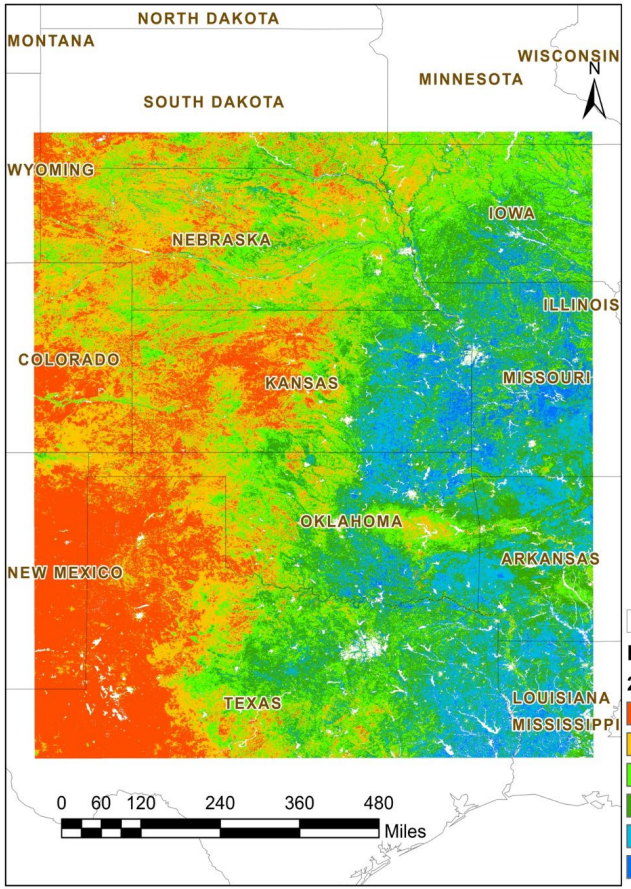
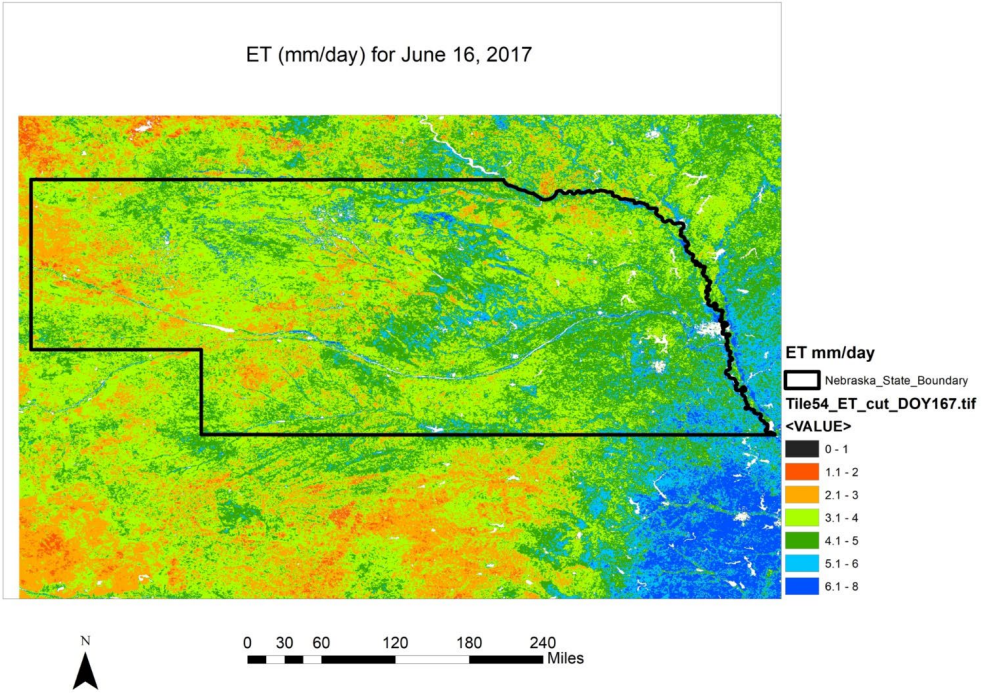
VIIRS ALEXI Daily ET for Tile 54 at 400 m pixel resolution over the Central Plains of the USA

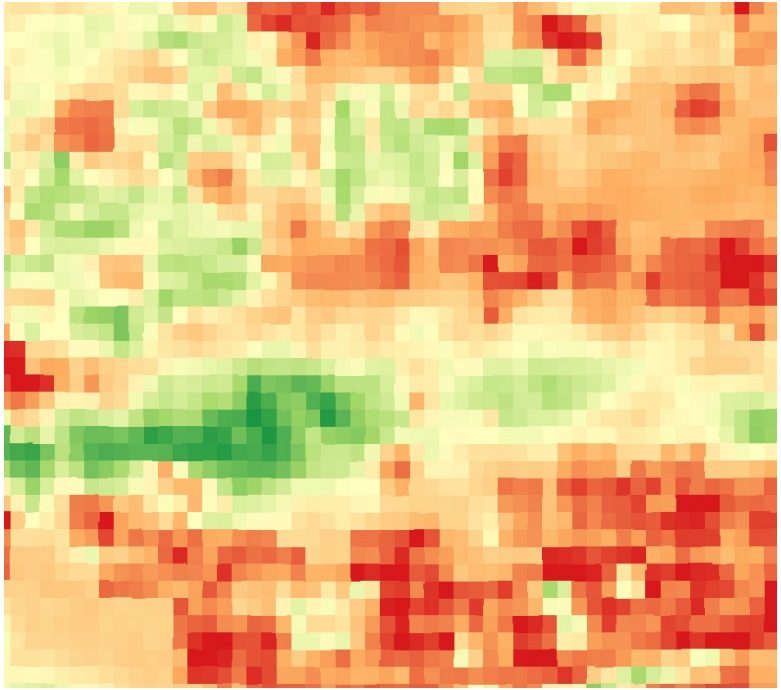




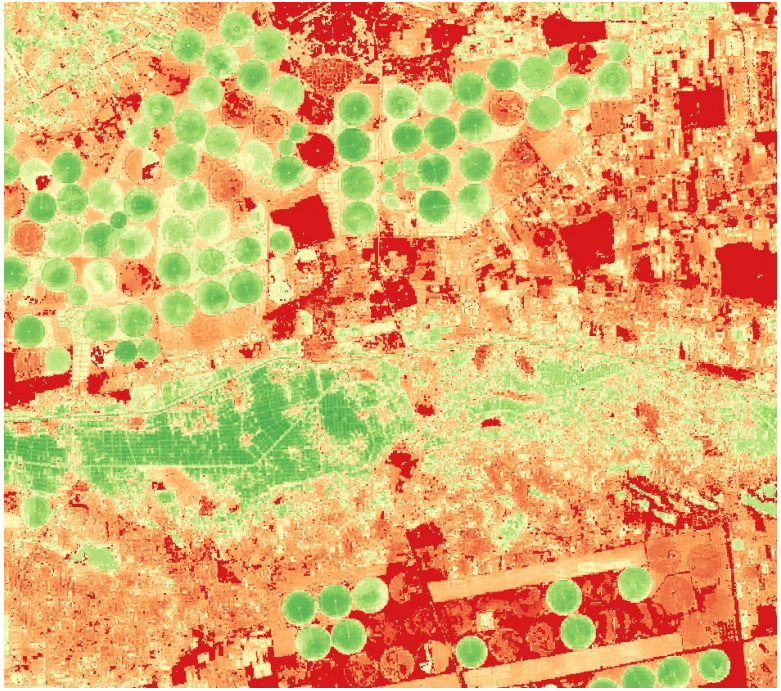
Nile Delta Irrigation

VIIRS daily ET mm/d

Daily ET calculated at VIIRS 375 m using the ALEXI model.



Daily ET downscaled from ALEXI using the PyDisALEXI model and Landsat Imagery.



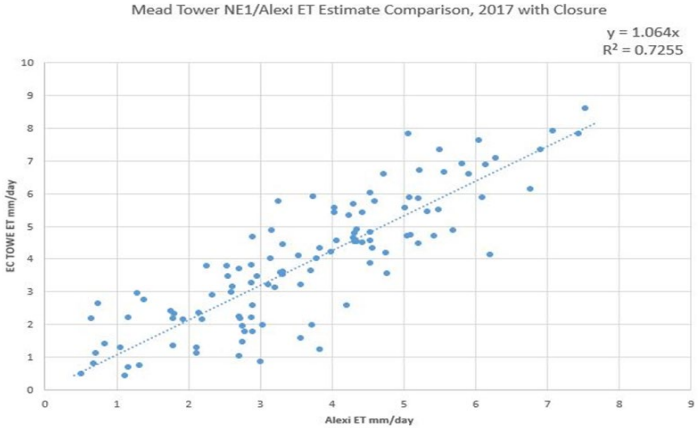
EARTH SYSTEM SCIENCE INTERDISCIPLINARY CENTER ESSIC UNIVERSITY OF MARYLAND

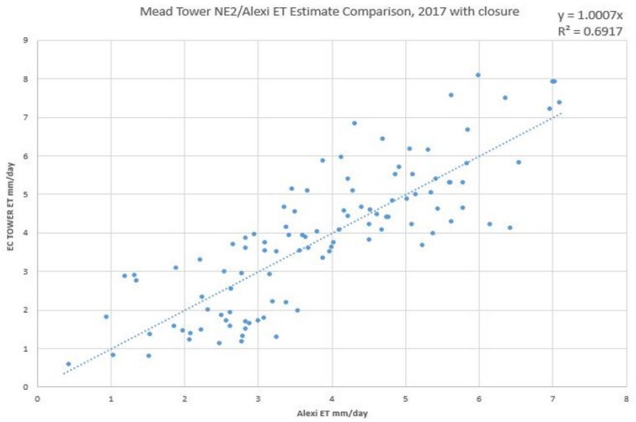
USDA

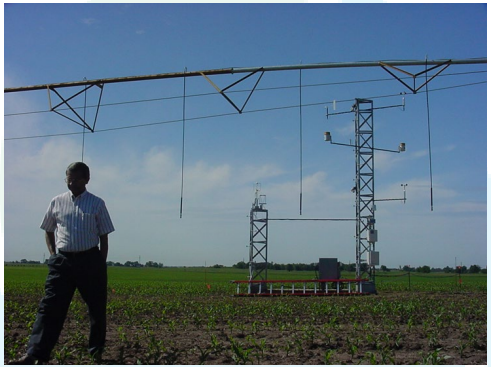
Water for Food ROBERT B. DAUGHERTY INSTITUTE at the University of Nebraska

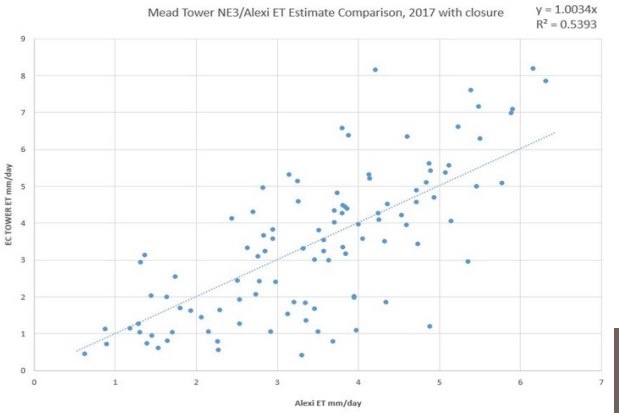
NASA

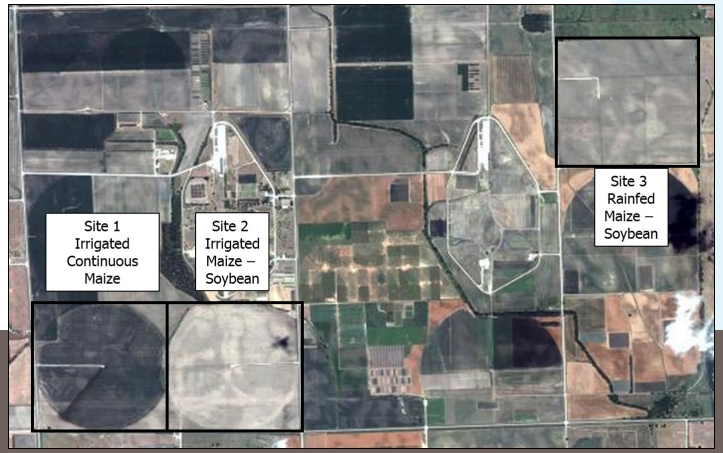
Preliminary Ground Verification of ALEXI VIIRS ET Values @375 m, Tile 54, Carbon Sequestration Ameriflux Site, Mead NE also on Parallel 41 Flux Network









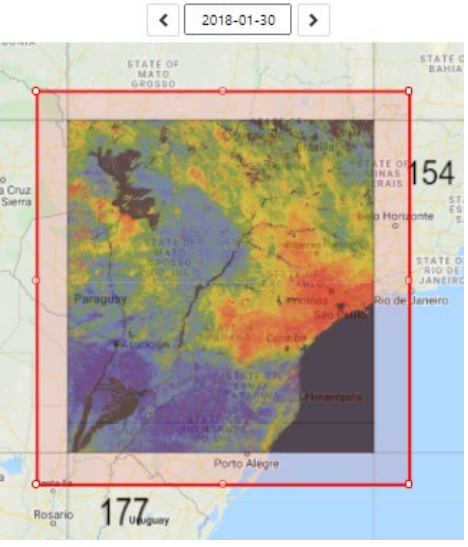


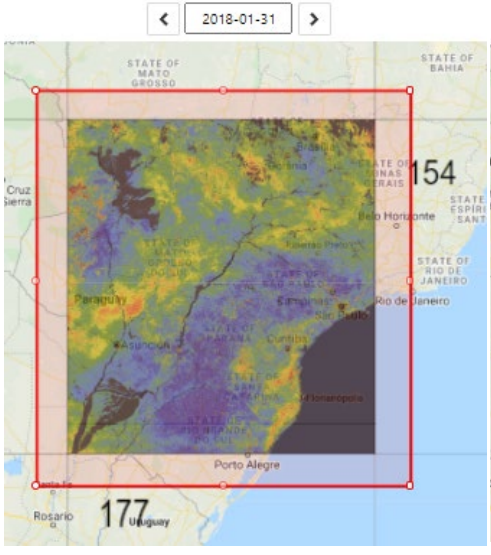
NE1 Continuous maize crop:
RMSE= 1.09, MAE=0.87;
NE2 Soybean/Maize rotation with Maize:
RMSE= 1.0, MAE=0.81
NE3 Rainfed Soybean/Maize rotation with Maize:
RMSE= 1.34, MAE=1.03.

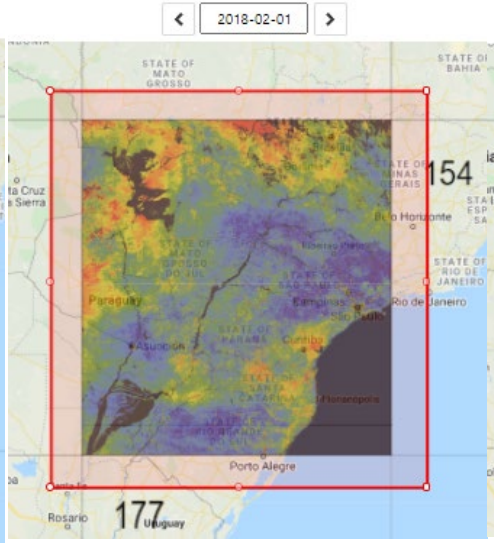
System

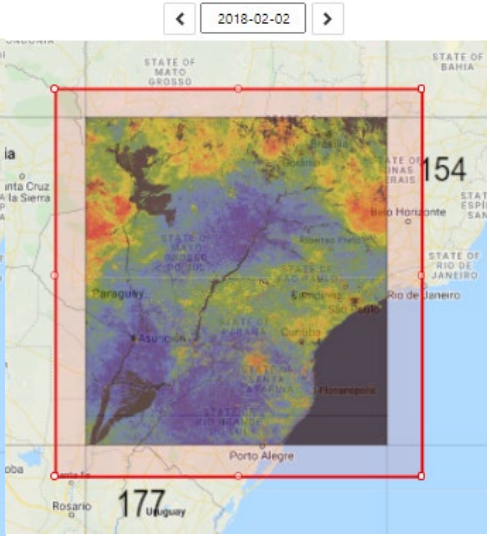
THE DAUGHERTY WATER for FOOD GLOBAL INSTITUTE at the University of Nebraska

Sequence of Daily Evapotranspiration over Tile 153 Brazil

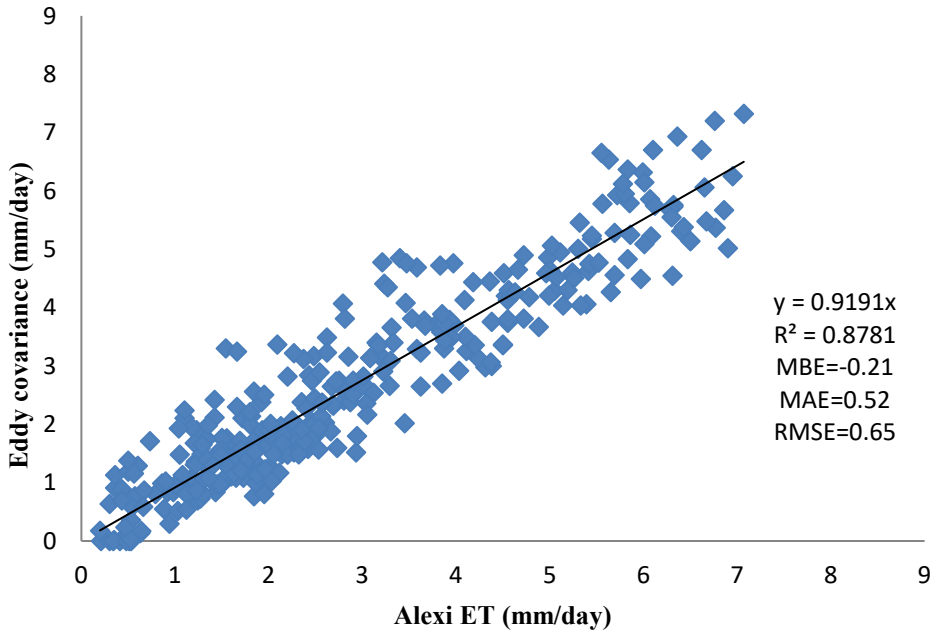






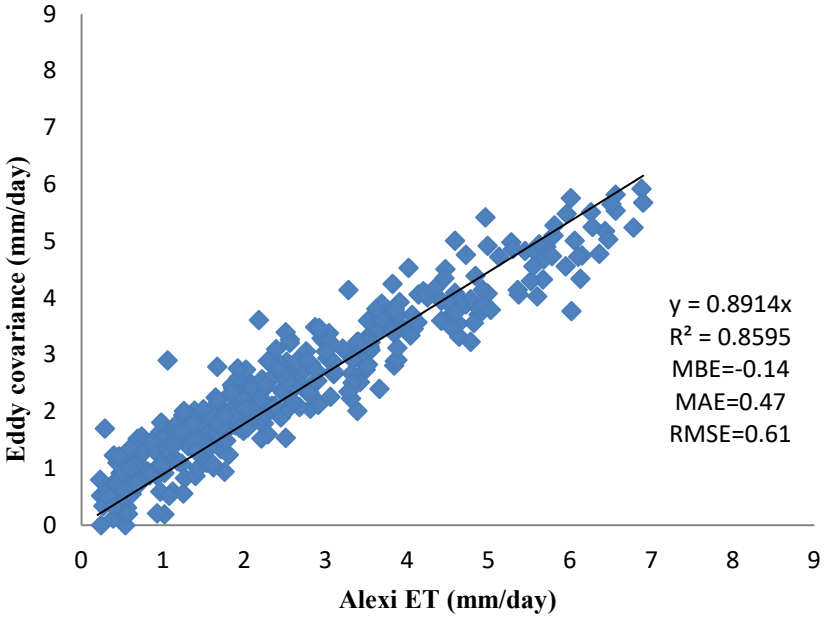


Comparison of ALEXI Daily ET with EC Flux Tower ET in Southern Brazil
Santa Maria EC Tower (SMA) /natural grassland

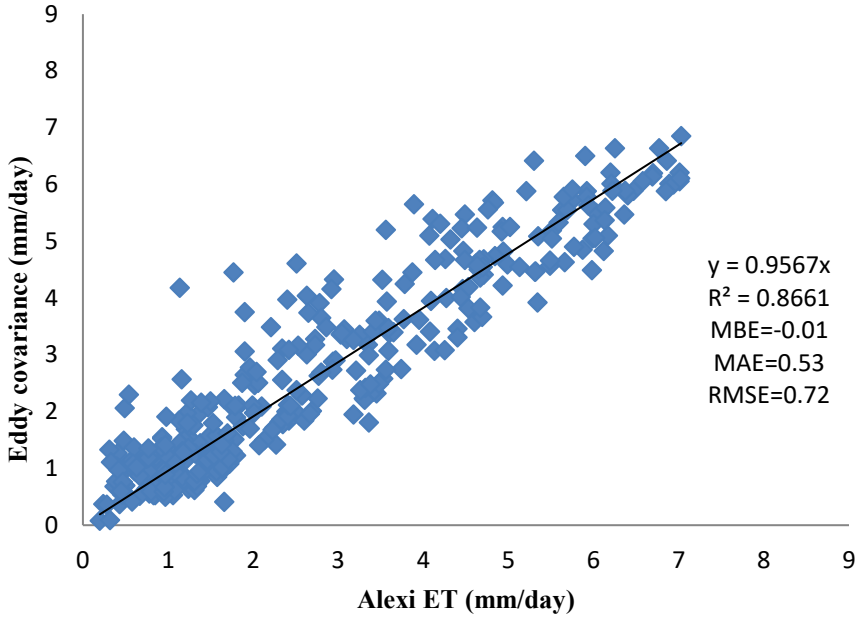


Comparison of ALEXI Daily ET with EC Flux Tower ET in Southern Brazil
Santa Maria EC Tower (SMA) /natural grassland

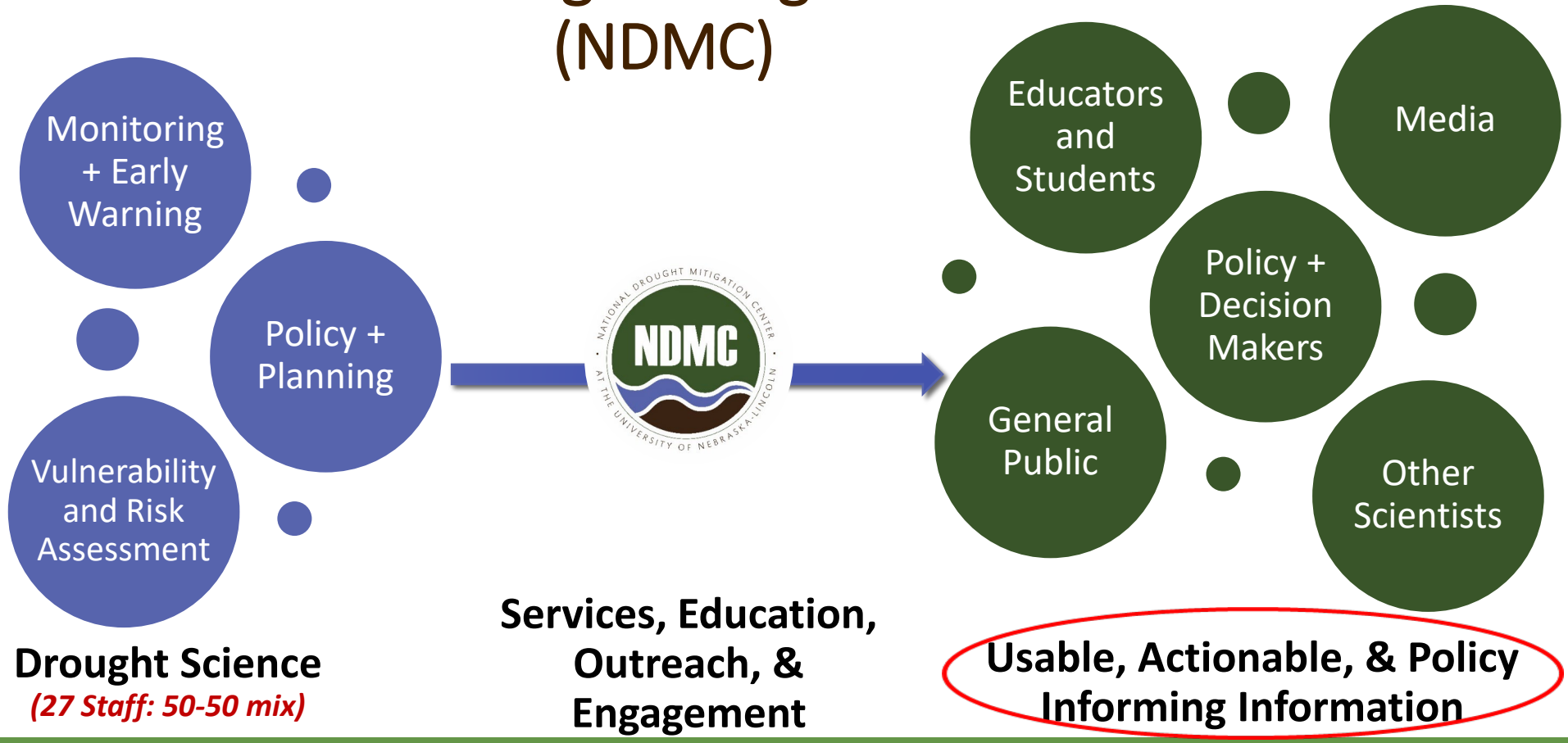
SMA EC Tower vs ALEXI 2015



SMA EC Tower vs ALEXI 2016



National Drought Mitigation Center (NDMC)



Drought Science
(27 Staff: 50-50 mix)

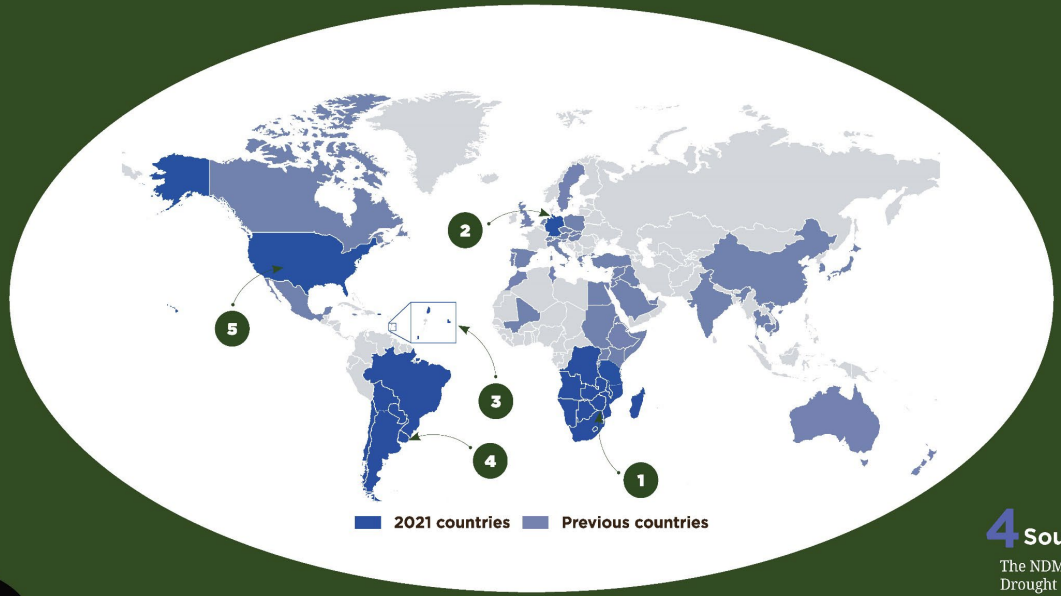
Services, Education, Outreach, & Engagement

Usable, Actionable, & Policy Informing Information

Global Engagement 2021

1 Africa (World Bank/SADC)

The World Bank and the National Drought Mitigation Center are teaming up to work with the countries of the Southern African Development Community to enhance drought preparedness. The work will include helping countries develop composite drought indicators based on available data, tailored for key sectors and vulnerabilities, with an aim to help better trigger mitigation measures.



2 United Nations (Germany)

The NDMC is working with the United Nations' Science-Policy Interface, with the Intergovernmental Working Group of the Convention to Combat Desertification, and with the Integrated Drought Management Programme. Both efforts are centered on developing and recommending actionable policy measures to build and/or enhance resilience to drought, desertification and land degradation.

3 Caribbean

The NDMC and long-time partner, the Caribbean Institute of Meteorology and Hydrology, with backing from the U.S. Agency for International Development, are hosting a series of workshops to enhance annexes to agricultural drought risk management plans for Grenada, Saint Lucia and other countries, with drought response stages incorporating information about historically observed impacts in each nation.

4 South America (SISSA)

The NDMC continued its work with the Drought Information System for southern South America (Spanish acronym, SISSA) and the World Meteorological Organization. At a virtual workshop focused in Uruguay, country representatives assessed how well their nations were prepared for drought. The overall aim is to help countries in this region implement an integrated, proactive risk management approach in dealing with drought. Participating countries are Argentina, Bolivia, Brazil, Chile, Paraguay and Uruguay.

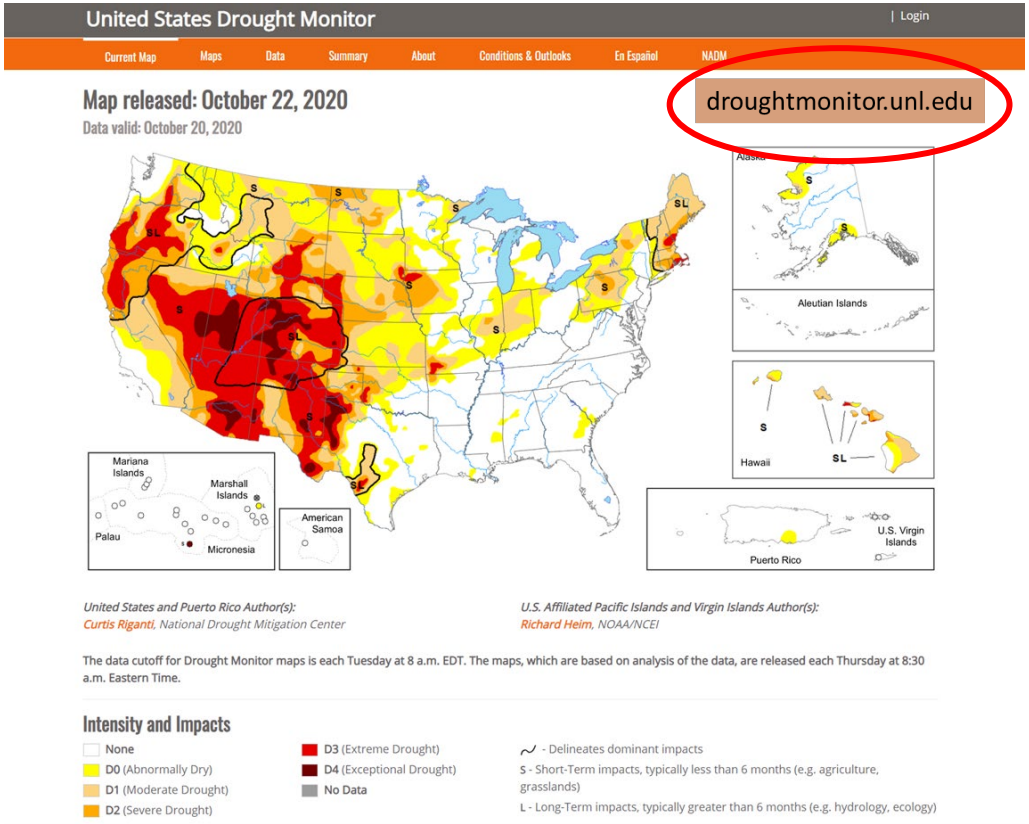
5 United States

The Drought Center continues to work with the U.S. Department of Agriculture's Office of the Chief Economist and Climate Hubs, as well as states, tribes, and many other agencies and organizations that are involved in drought monitoring, response, preparedness, and planning. The center also recently wrapped up a 5-year project with the National Integrated Drought Information System (NIDIS) in 2021.

U.S. Drought Monitor (USDM):

(Science before Policy)

- ***State-of-the-science*** **drought assessment in the U.S. since 1999**
  - ***Collaborative effort between NOAA, USDA and NDMC***
- **Composite indicator blends objective indicators and indices with field input from over ~450 experts**
- **"Convergence of Evidence" approach**
- **Policy implications in Farm Bill (USDA), IRS, Federal Reserve Board, CDC, FERC, NOAA-NWS and several state drought plans and task forces**
- **"Go to source" for media and the public**
  - **~12+ million page views annually**

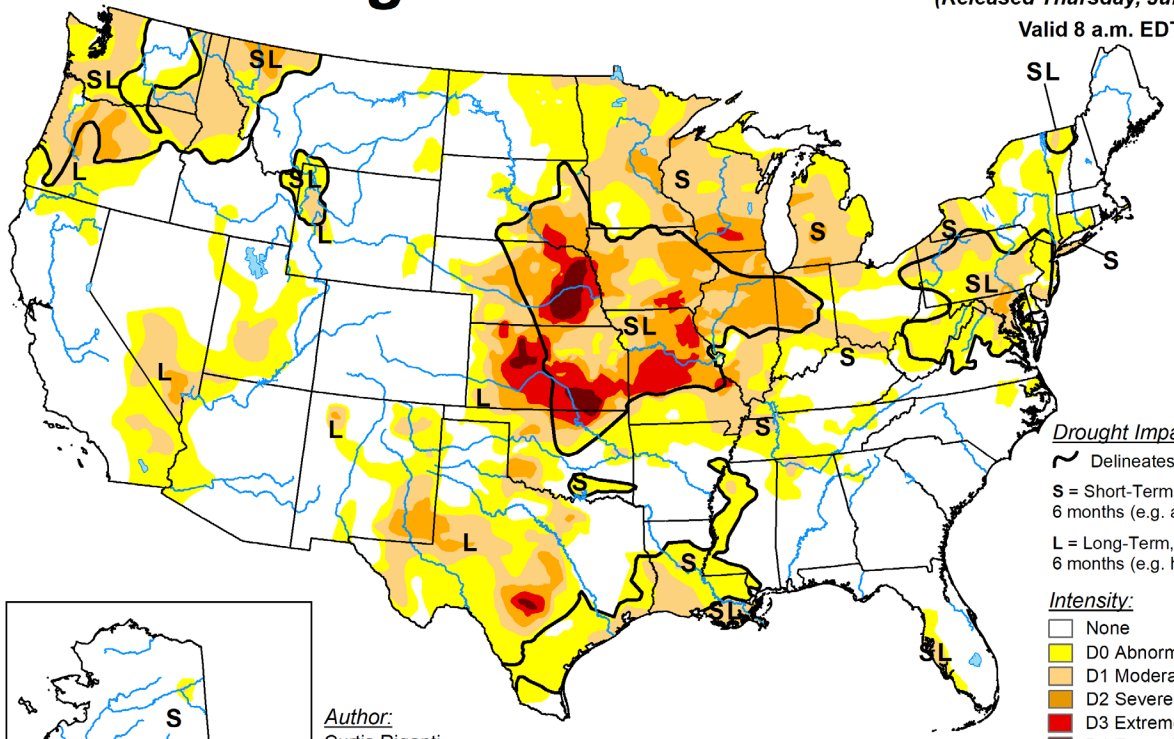


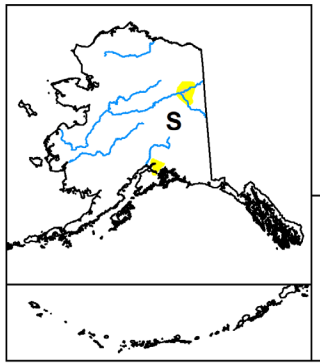
U.S. Drought Monitor

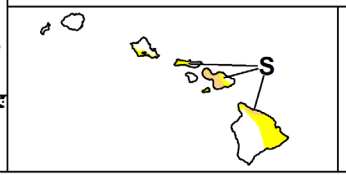
July 4, 2023

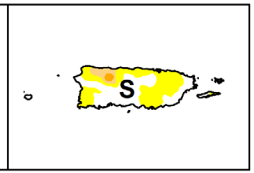
(Released Thursday, Jul. 6, 2023)

Valid 8 a.m. EDT









Drought Impact Types:

~ Delineates dominant impacts

S = Short-Term, typically less than 6 months (e.g. agriculture, grasslands)

L = Long-Term, typically greater than 6 months (e.g. hydrology, ecology)

Intensity:

- None
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

Author:

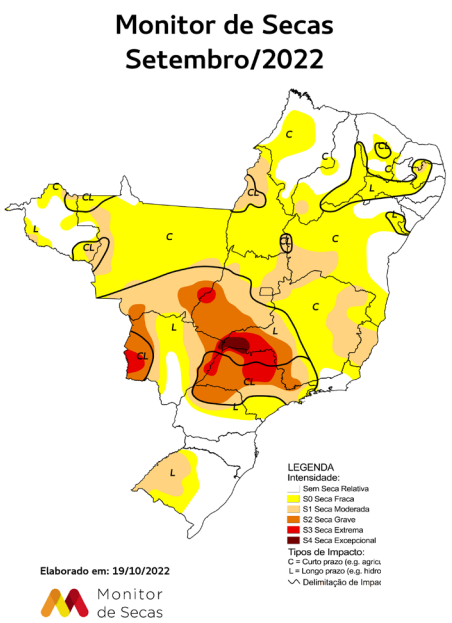
Curtis Riganti

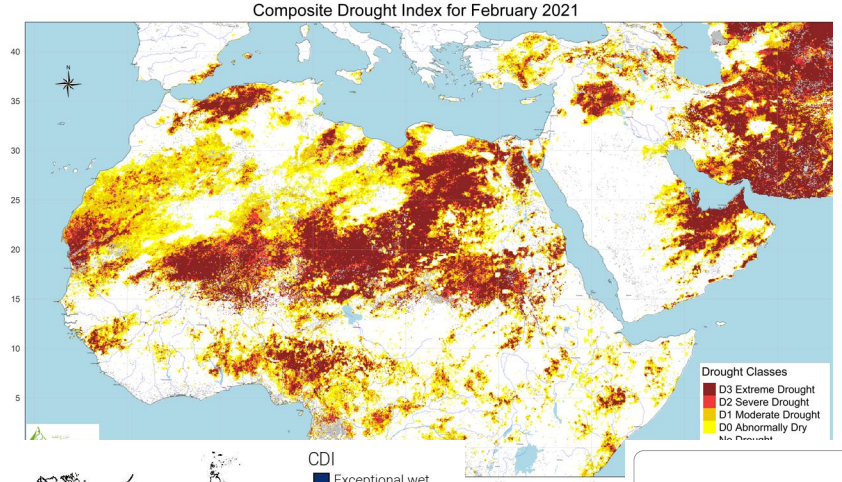
National Drought Mitigation Center

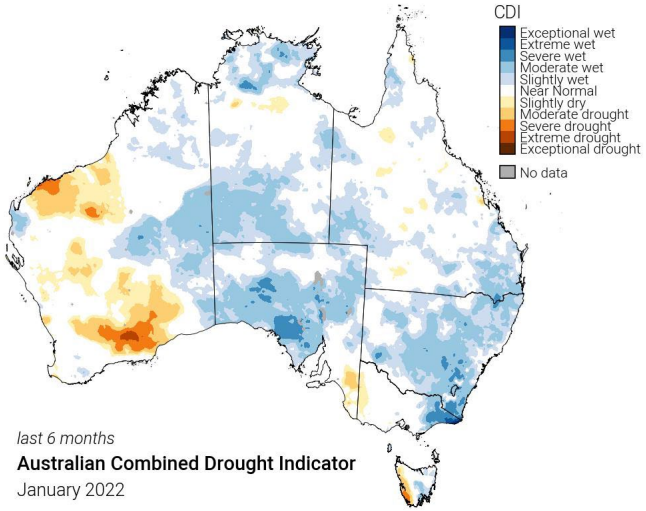
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to https://droughtmonitor.unl.edu/About.aspx

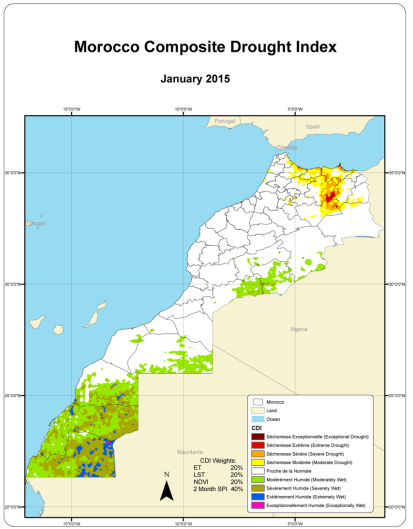
droughtmonitor.unl.edu

Past and Present NDMC International CDI Activities



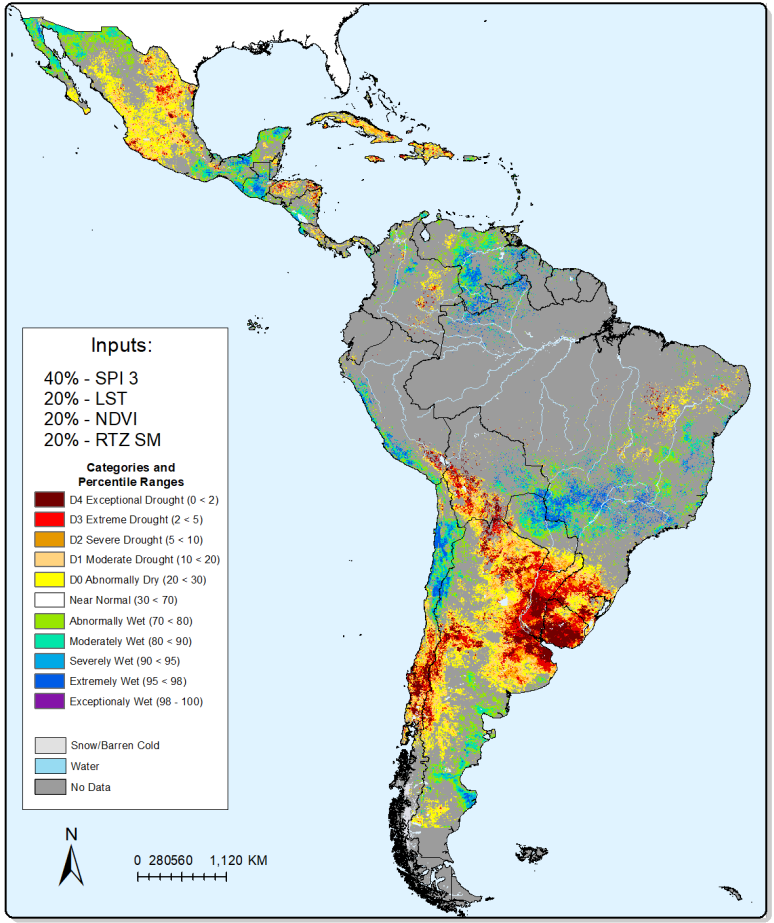






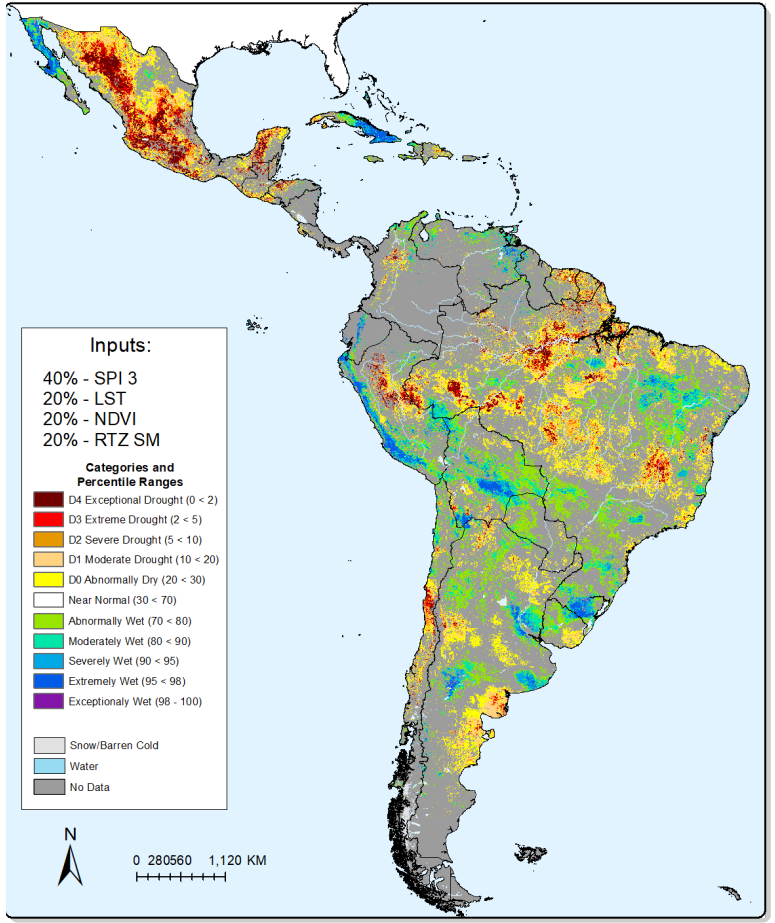
Latin & South America Composite Drought Index

Feb 2023



Latin & South America Composite Drought Index

Jul 2023



NATIONAL DROUGHT MITIGATION CENTER
NDMC
UNIVERSITY OF NEBRASKA

University of Nebraska Lincoln

Final Comments

- DWFI is represented on the World Water Council board of governors by Peter McCornick and Christopher Neale
- Involved in the organization of the next World Water Forum in Bali, Indonesia (May 2024). Leading the theme Water for Food and Agriculture, involved in the Regional process of the Americas (invited IICA to join the effort)
- DWFI is partnering with IICA on their new initiative on Water and Agriculture
- Other examples in Latin America:

- Dominican Republic: Partnering with PUCMM, NRCE Fort Collins on several international tenders by INDRHI, funding from IDB and World Bank: National Irrigation Plan, updating the Irrigation Water Users Database, Design of Irrigation Canal

- Brazil: Recently signed and agreement with the government of the State of Mato Grosso to study surface and groundwater availability to intensify existing agricultural area through sustainable irrigation (APROFIR and UFV are partners). Had a similar project for the western State of Bahia.

- We are open for cooperation with country, state, regional governments, NGO's, private companies etc. as long as it leads to furthering our mission of water and food security

Water for Food
ROBERT B. DAUGHERTY INSTITUTE
at the University of Nebraska

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