Runoff Risk:
A Decision Support Tool for Nutrient Applications

Current & Planned Ecosystem IDSS Utilizing NWS Modeling to Help Improve the Nation's Water Quality

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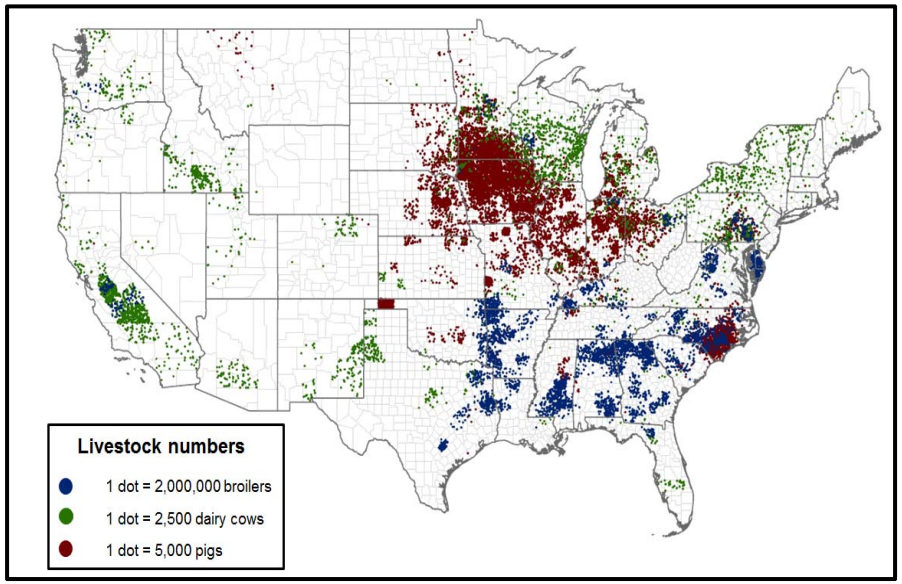
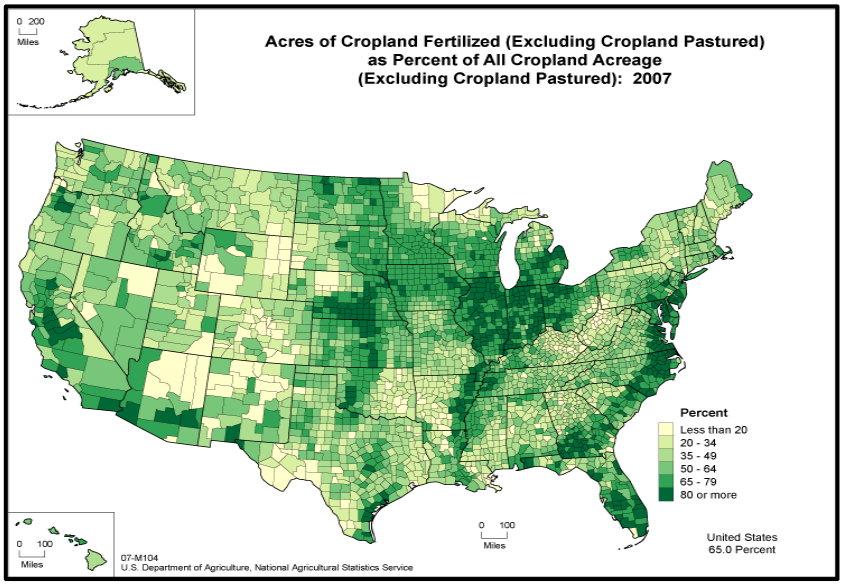
Overview

- The Nonpoint Source Nutrient Problem
- NOAA and NWS Strategic Interest
- Application Timing and the NWS Contribution
- NWS Hydrological Modeling
- Creating the First Runoff Risk
- Increasing Attention and Building Awareness
- Expansion and 2nd Version of Runoff Risk
- Near-term and Long-term Plans

Agriculture Prominent Source of NPS Nutrient Pollution



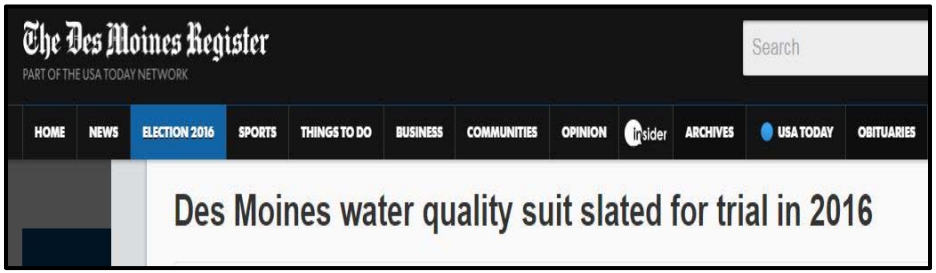
Livestock intensity

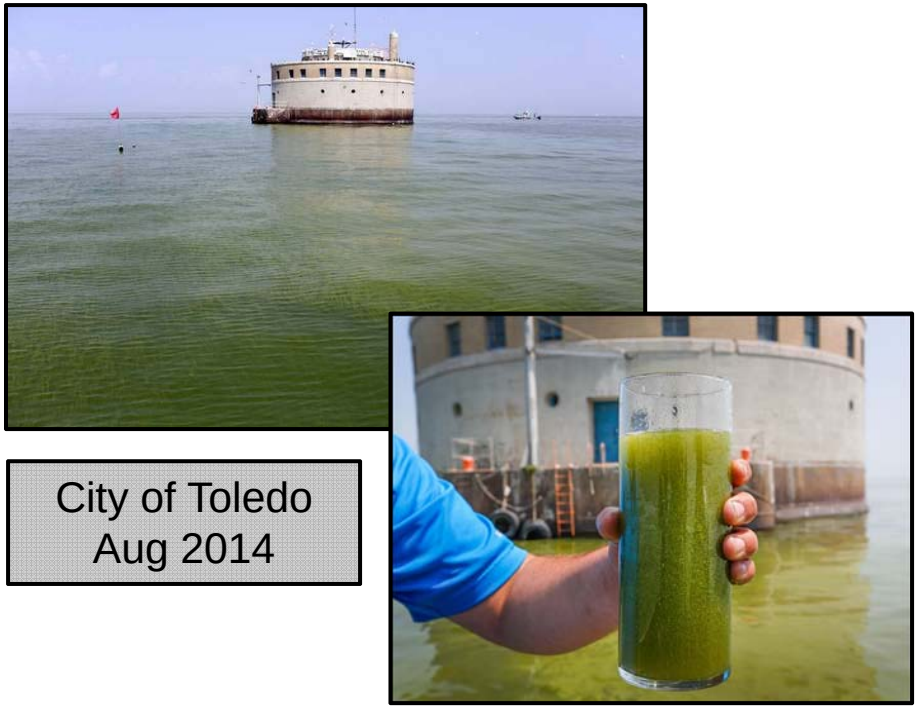


Fertilization Intensity

- Agriculture necessary with increasing demand on more production
  - Applying nutrients is a requirement that isn't going away
- USA has ~10% arable/cultivated land, ~17% world grain production
- USA produces ~50% of world corn and soybean exports

Impacts of Nutrient Pollution Increasingly in the News

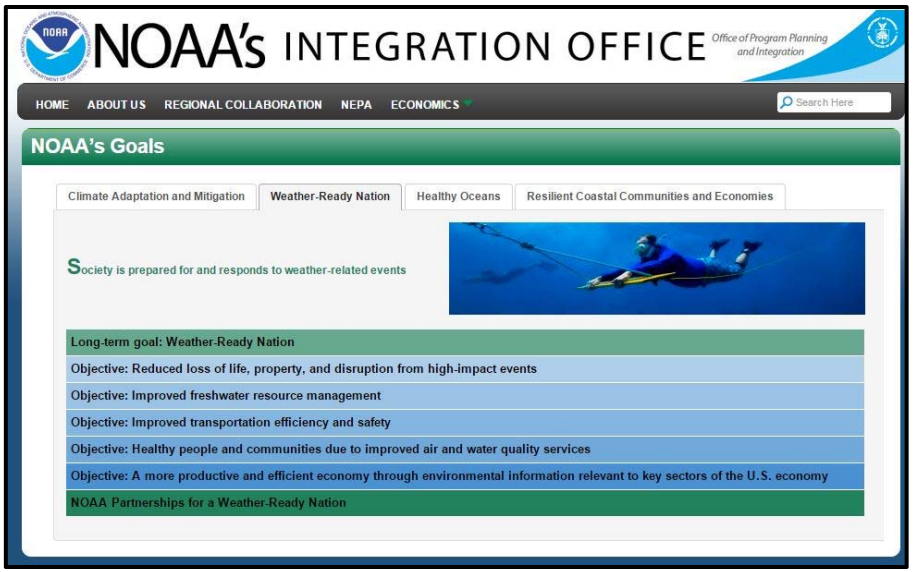


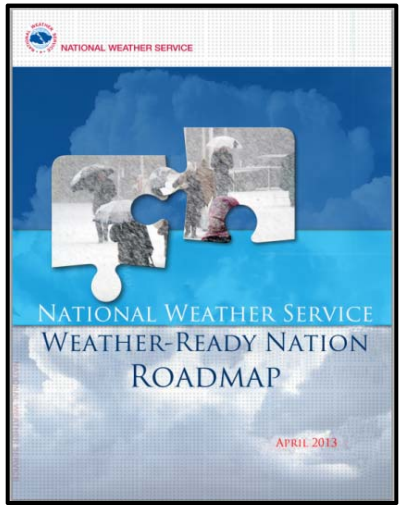


City of Toledo
Aug 2014

- Highly visible events driving support for action
- What combination of practices will enable reduction goals to be met?

NOAA and NWS Strategic Plans and Goals

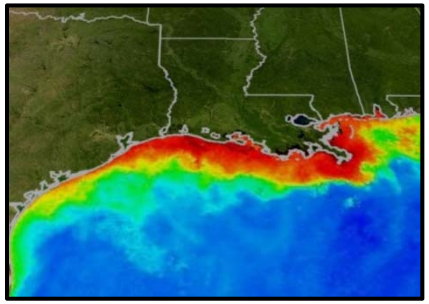




- Nutrient reduction, and the runoff risk concept, support numerous goals and objectives in both NOAA and NWS strategic plans:
  - Improving water quality
  - HAB and hypoxic zone reductions
  - Decision support tools
  - Building collaboration on local-regional-national levels
  - Leveraging existing NWS capabilities in new ways with new partnerships

Runoff Risk Supports Ecological Focus for NOAA

Goal: Utilize NWS modeling to warn farmers of future conditions unsuitable for application with intention to reduce nutrient transport from fields over time



The Importance of Nutrient Application Timing

- Many studies have shown the timing of applications relative to runoff can have significant impact on nutrient transport
  - A few large events can transport majority of annual load from fields
  - Focus farmers on high impact events:
    - *IA ARS: field site observed 50% of the cumulative 11-year study runoff in less than 48 hours → What if someone applied 3 days before?*
  - Applying before significant events could negate year-long adherence to BMPs
- Many practices exist for where and how to apply or landscape modification
  - No organized assistance exists to help farmers with the when *(not to)* apply

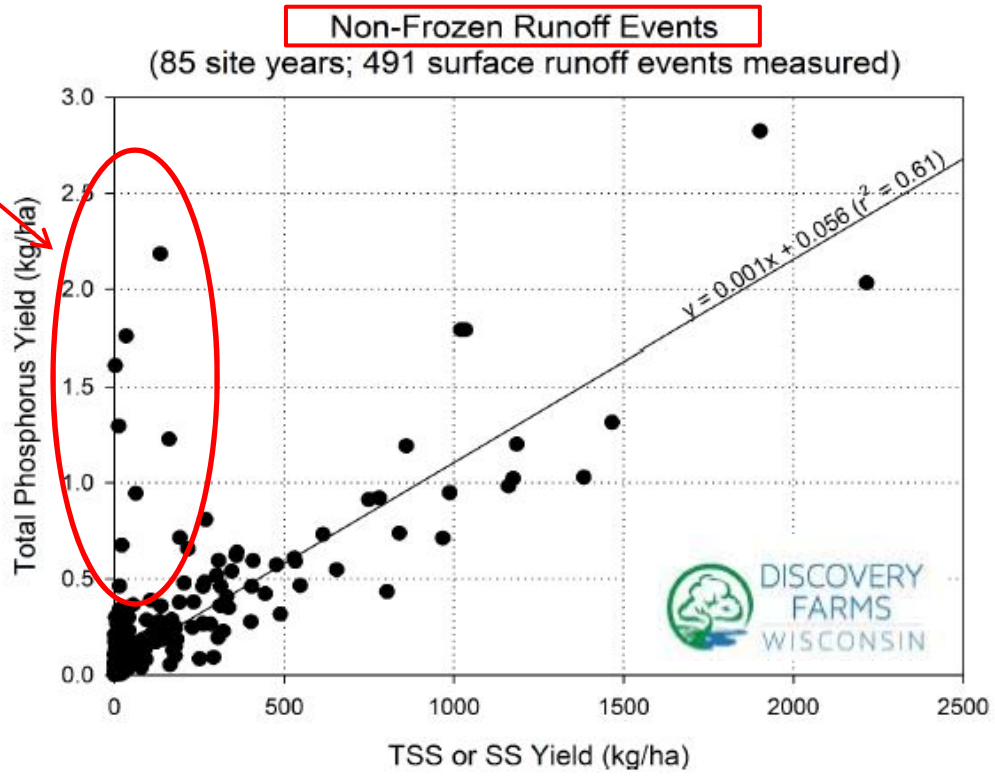
Timing: Concentrate on the Critical Periods

- Importance of runoff risk even more apparent during critical runoff periods:
  - Winter → early spring is most vulnerable time
  - Frozen soils, snow on ground, rain-on-snow events, rapid warm-ups
- Wisconsin USGS studies: on average ~50% of runoff occurred in February and March (frozen ground)
  - Nitrogen & Phosphorus yields also highest during these two months
  - Vegetation based conservation practices to limit soil/nutrient loss not helpful → **Timing major factor during this period**
- WI USGS also determined timing of field-management practices strongly influenced nutrient yields
- WI USGS noted that application of manure and/or tillage (incorporation) within week of runoff were significant factors for increased nutrient loss

Timing Impacts During Non-Frozen Periods

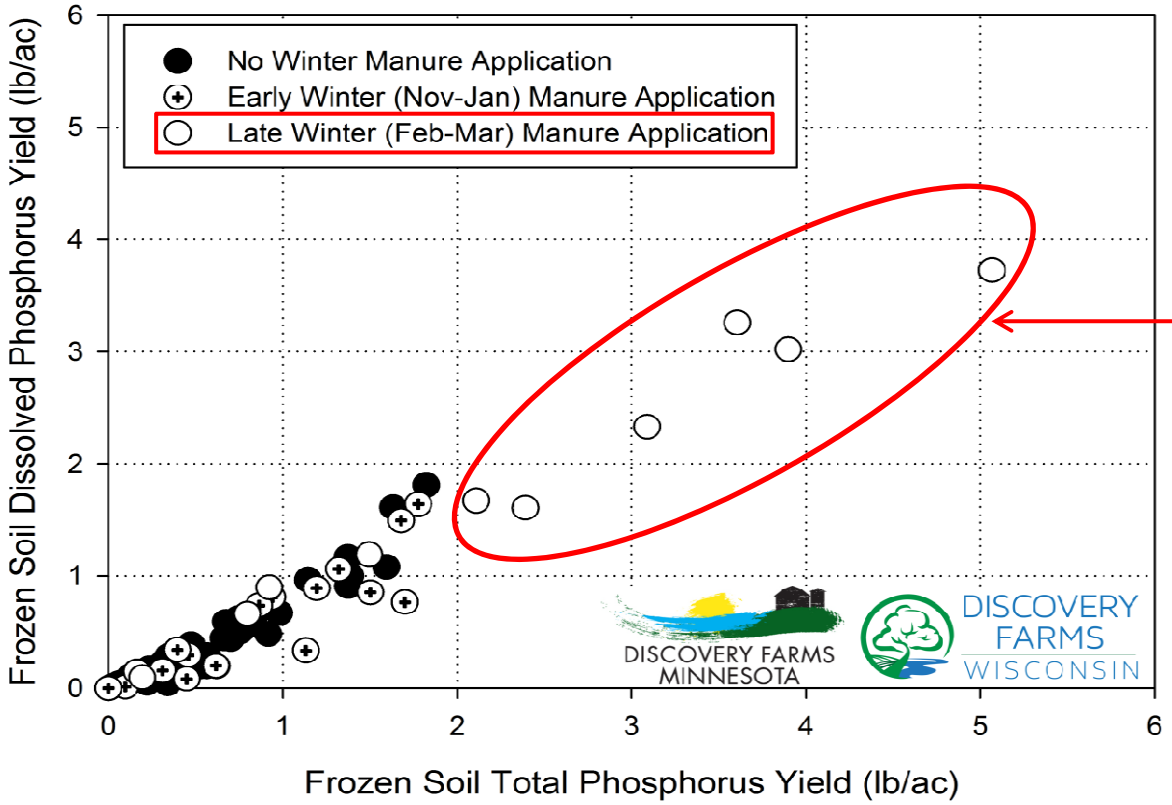
High P Losses but very low sediment

➔ P fertilizer or Manure applications shortly before runoff



- During non-frozen periods P loss generally tied to soil loss.
  - Many practices aimed at holding soil in place for this reason
- However, timing of applications also important during early summer

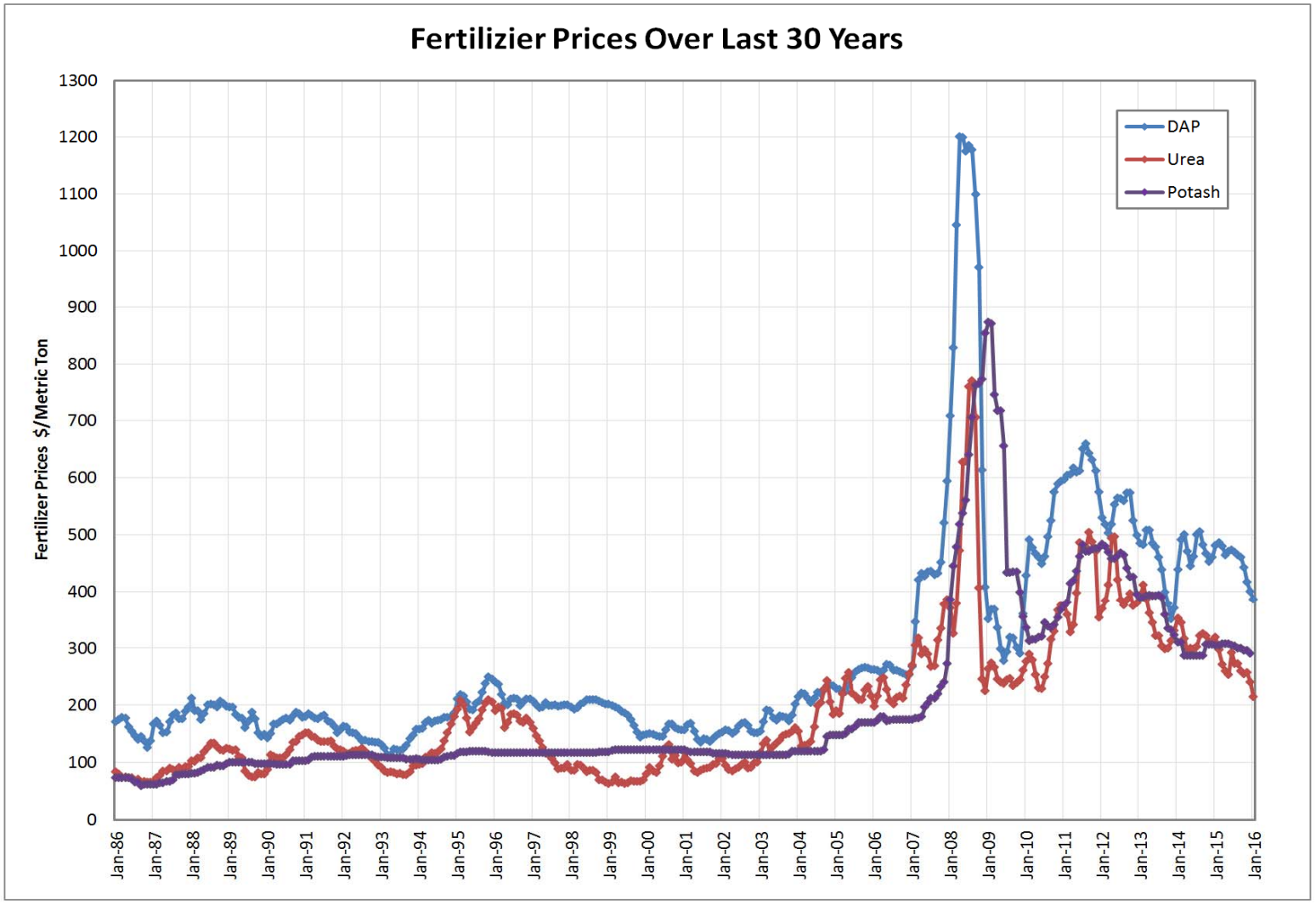
Timing Especially Critical in Late Winter – Early Spring



50-60% of Later Winter applications ***are higher than ALL*** Non-Applied or Early Winter applications

- Applying manure on frozen-ground: 83% TP lost was as dissolved P
  - Most land-based conservation practices can't help → Timing matters
- Late winter applications can increase P loss by 2 to 4 times

Nutrient Loss Still an Economic Issue



NWS Can Add Value to Timing Decisions

- NWS has *unique capability* of national scale real-time atmospheric and hydrologic forecasting to drive decision support tools in natural resources
  - Capable of meeting the increasing desire for tools in multiple regions
- Specifically: focused on week-to-10 day short-term window
- NWS, via runoff risk, supplements the 4-R Approach

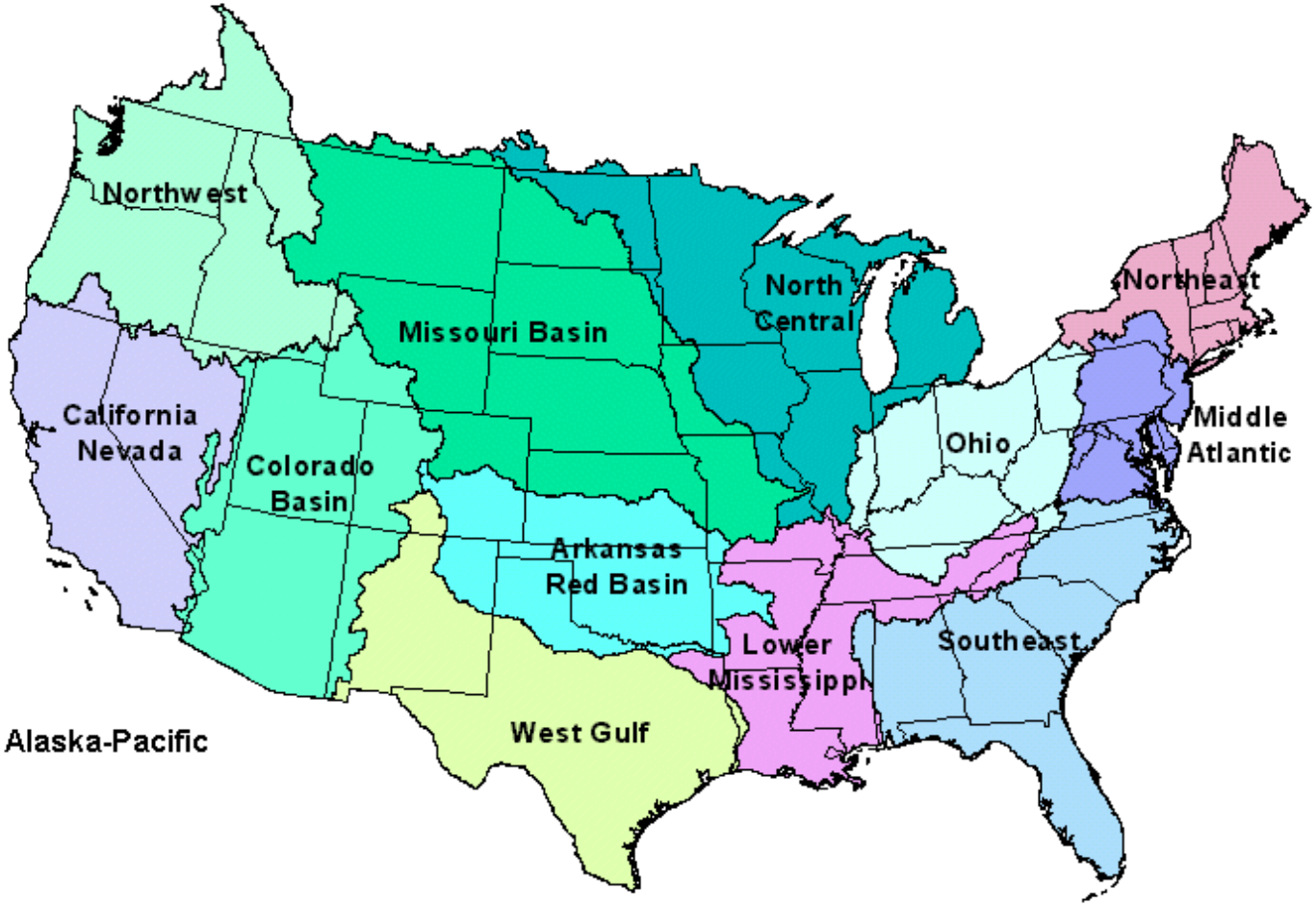
Right Source **Right Rate** **Right Time** **Right Place**

- Warn when risk is high

→ Reduce applications before runoff

→ Potentially reduce nutrient losses

NWS Hydrologic Modeling

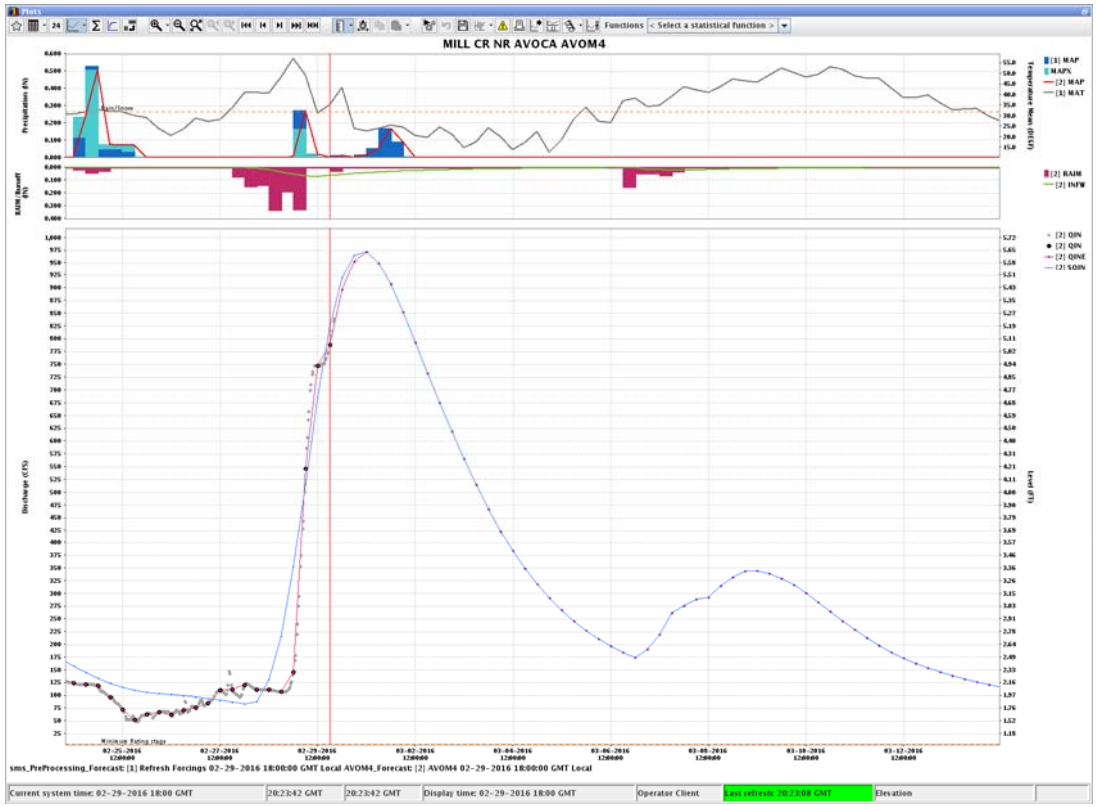


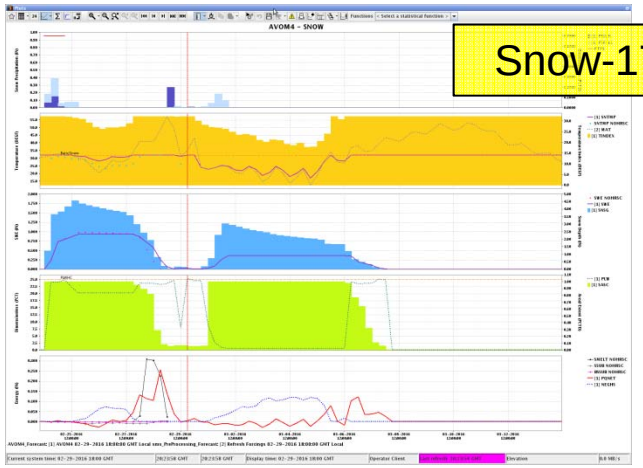
- 13 River Forecast Centers across U.S.
- Focus on real-time modeling & forecasting of river flow & stage

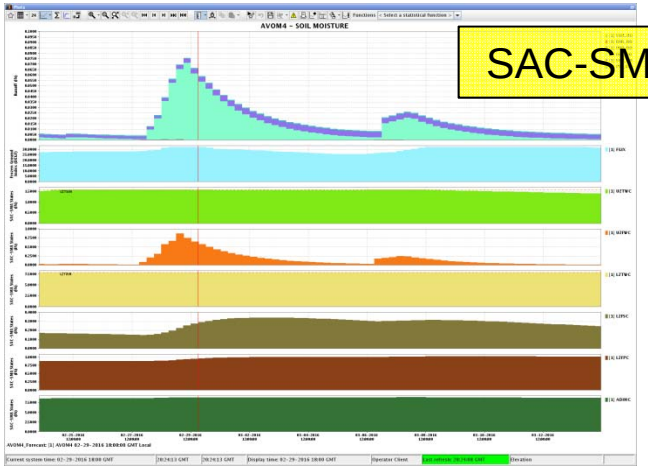
North Central RFC

- Cover 341k mi^2 over 9 states
- Staff of 19
- Open 0600 – 2200L daily
- Real-time modeling of 1170+ basins [6-3,000 mi^2]
- Ran on 6-hr time-step
- 426 Forecast Points

NCRFC Modeling







- Forecasters review for quality control and balance basins with modifiers when necessary

What is the Runoff Risk Tool?

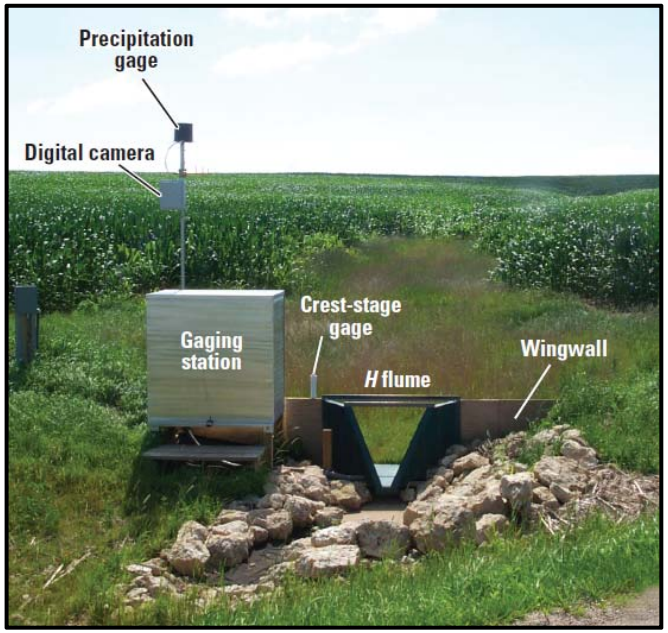
- Decision support tool that identifies threat of significant *future runoff* in both space and time
  - → ***Not*** modeling nutrient transport/loads
- Developed in collaboration with states and partners to incorporate *state specific application rules* and guidelines
- Partnering *States make an investment* and act as the tool owner and presenter to the public
- Currently produced multiple times daily with forecast out 10 days into future

How Runoff Risk Started

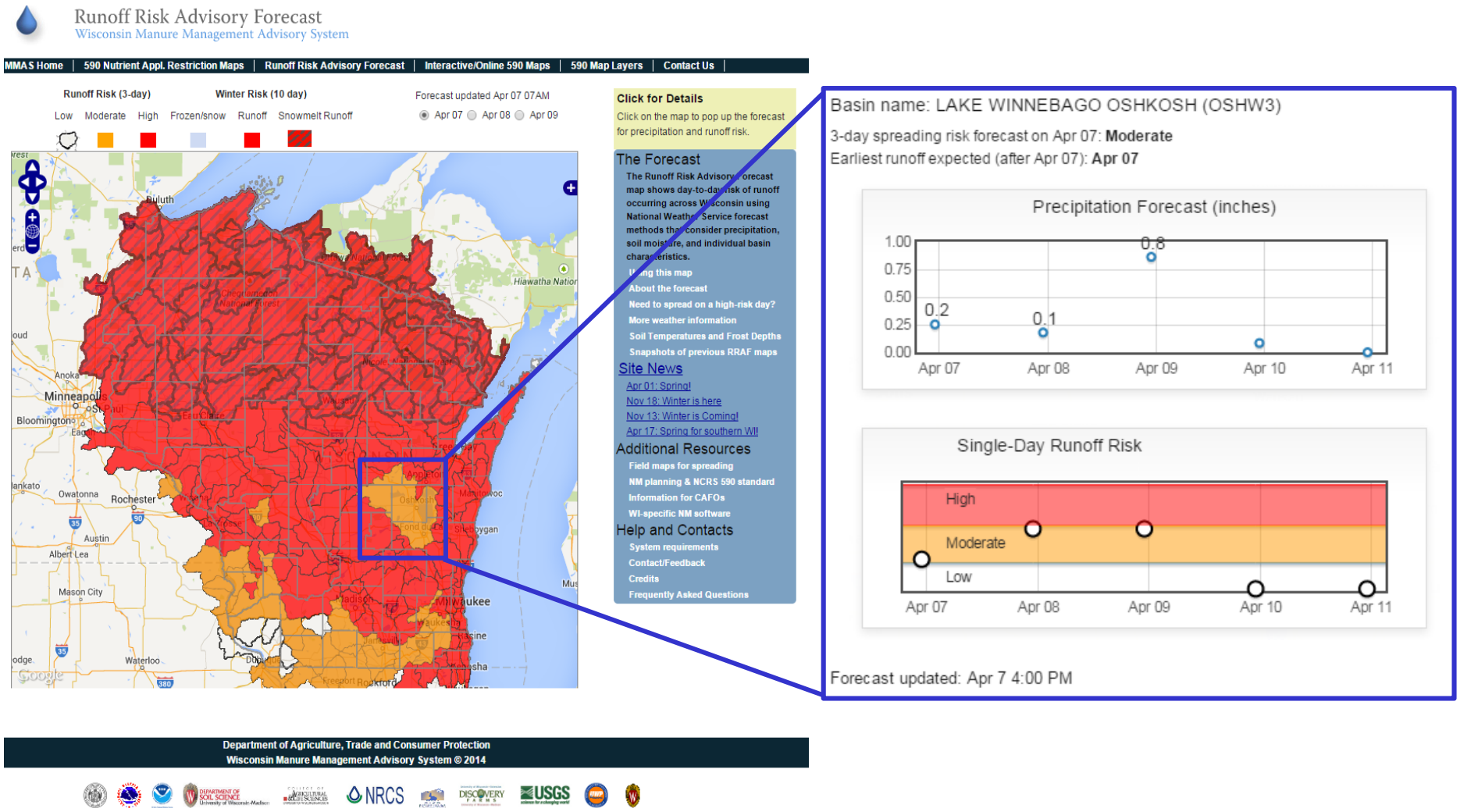
- Numerous well-publicized manure spills caused fish kills and well contamination in Wisconsin during the winter of 2005-2006
  - State Legislature directs Department of Agriculture (DATCP) to implement online advisory system to assist farmers and applicators
- WI Dept of Ag, Trade, and Consumer Protection contacts NWS
  - NCRFC meets with taskforce
  - Runoff Risk Advisory Forecast (RRAF) Working Group formed
    - *Federal, state, academic, and farming community representatives*
- Runoff Risk incorporates factors already used by farmers
  - Modeled soil moisture, precip, snowpack, temperatures
  - Provides farmers with second opinion → back-up perspective
  - "It indicates high risk in my area, did I miss something?"
    - *Have to apply → divert to safer fields*
    - *Don't have to → delay until threat is over*

Current RRAF in Wisconsin

- Started collaborating in 2009, went live in 2011
- DATCP built, owns, maintains the website (Public Face)
- RRAF is first-generation tool using operational lumped model
  - Proof-of-concept → restricted to current capabilities, would it work
- RRAF approach is conditioned by reality
  - Front-loaded with analysis of historical model runs & observed EOF runoff
  - Algorithm includes selected model states & thresholds based on basin specific historical biases



First Generation RRAF in WI



RRAF Validation

- Spatial scale was always a concern in implementation
  - Average lumped-model basin in WI = 300 mi^2
  - Validated model with EOF runoff*:*
    - *Model hit 80% EOF events*
    - *Missed events << Hits*
    - *Thresholds help reduce false alarms → focus attention on largest events*

- Caution required with EOF observations as ground truth against model
  - *"No one trusts a model except the man who wrote it; everyone trusts an observation, except the man who made it."* -- Harlow Shapely
  - Models have issues, but observations can have issues as well
  - Comparing 10's acres against model representing 100's of square miles
    - *0.01% model basin vs. EOF basin in lumped approach*

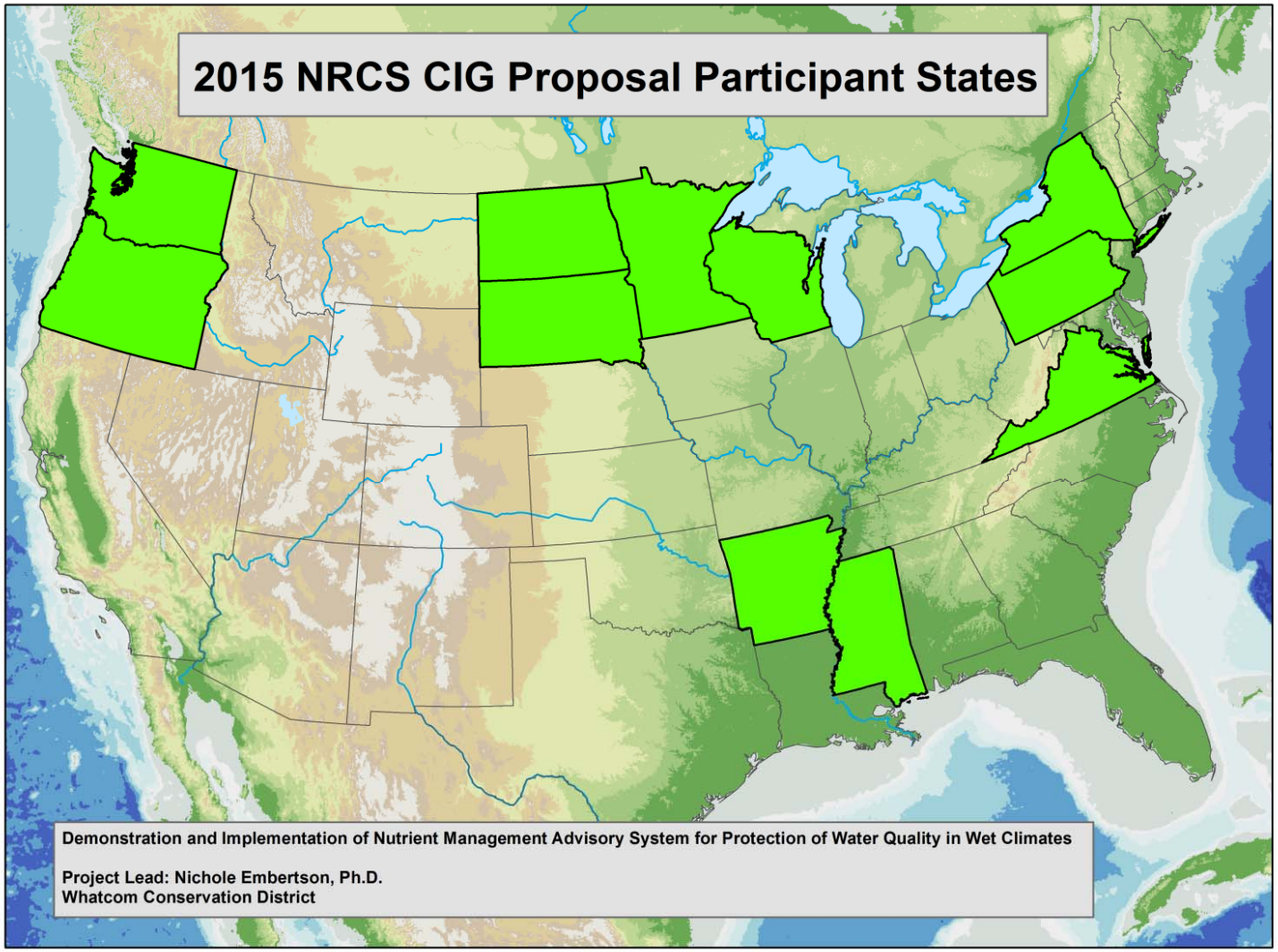
Communicate & Educate

- RRAF first real-time, science based, state level (soon regional) decision support tool for short-term nutrient application timing
  - However, just one tool focused on one component of the larger problem
- Extremely important to be open with farming community, educate them how to use it and understand its limitations
  - RRAF incorporates many factors, but not only info a farmer should use
  - Models are not perfect and can't be held to that standard
  - Just because high risk doesn't mean can't apply
    - *Look closer, be cautious, use safer fields*
  - Always considered as decision support → Not regulatory

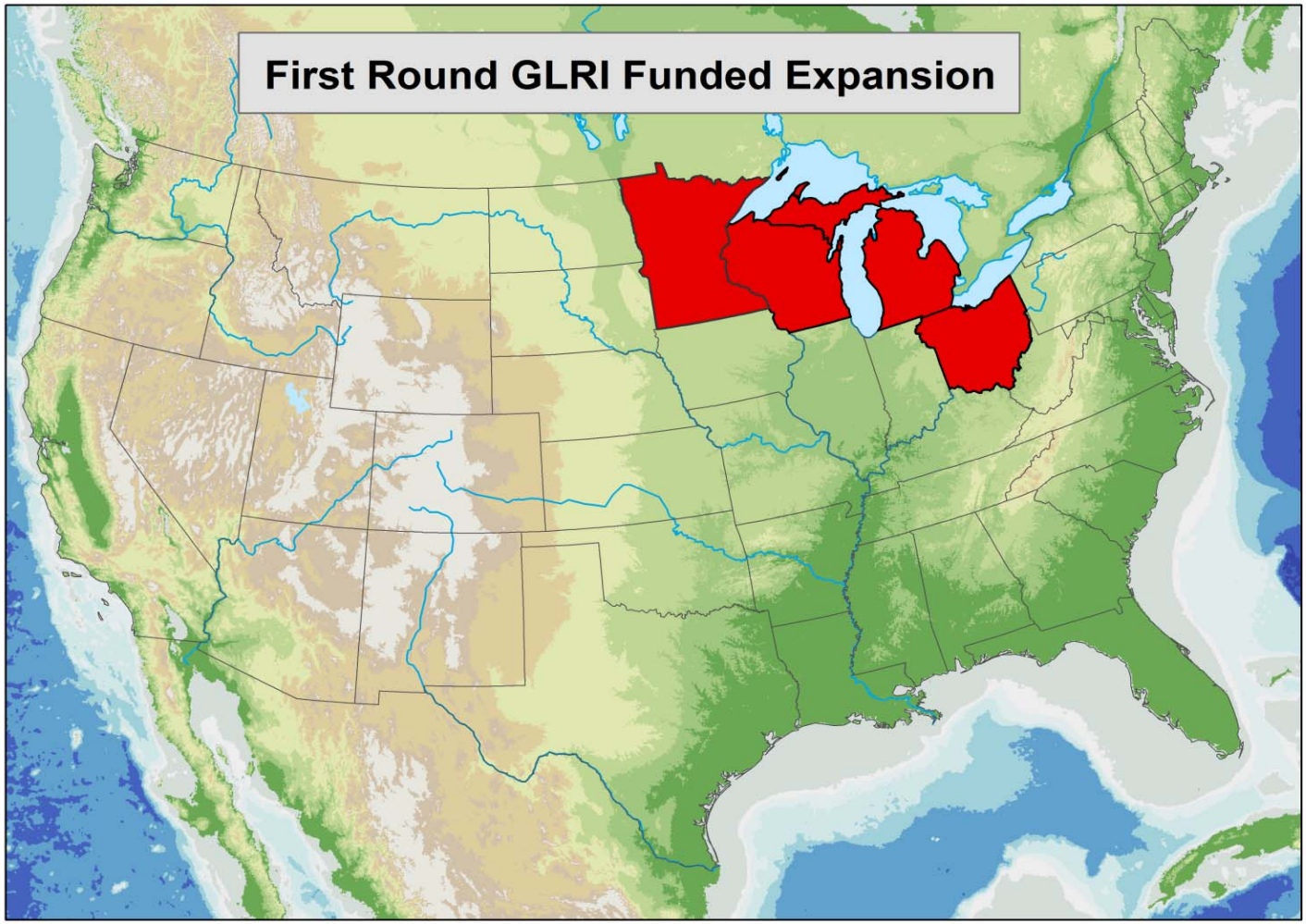
Attention & Awareness in Runoff Risk is Growing

- Government Accountability Office (GAO) 2014 Report
  - "*Freshwater: Supply Concerns Continue, & Uncertainties Complicate Planning*"
  - Highlights RRAF in "*Developing Water Management Tools*" section
- Invited to brief Federal partners at 2015 Hypoxia Task Force Meeting
- Briefed senior scientists at USDA-NRCS
- Inquiries from additional States (MN, OH, MI, IN, IL, IA, KY, NE)
- Formed partnership with EPA and the Great Lakes Restoration Initiative (GLRI)
- Partner in NRCS Conservation Innovation Grant (CIG) to investigate runoff risk type tools in different areas of the U.S.

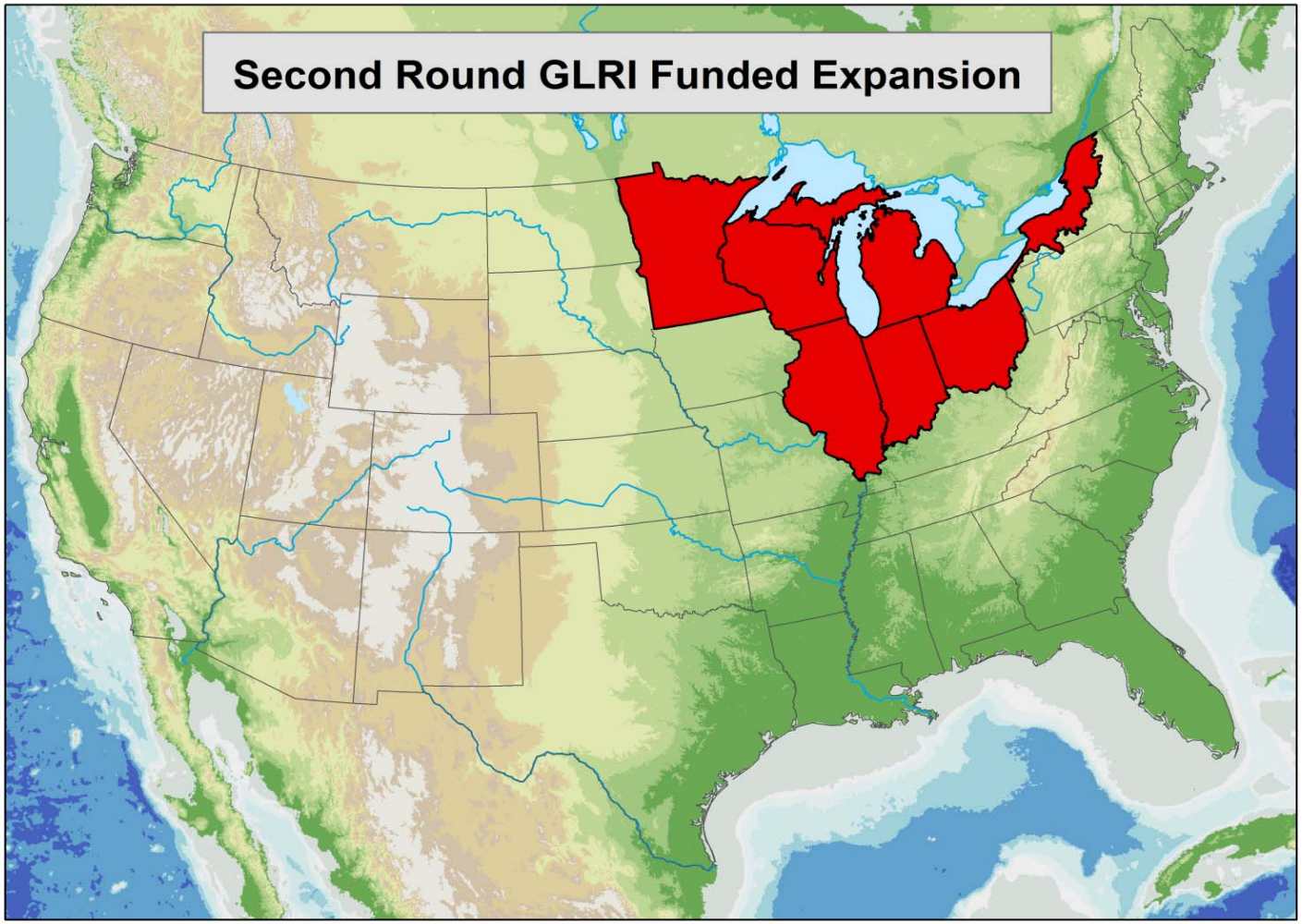
NRCS CIG Project



Expand into MN, MI, & OH

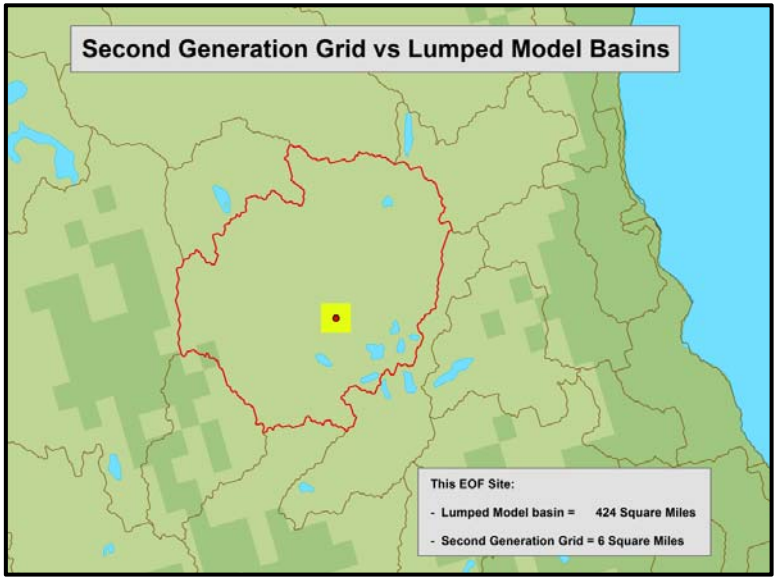


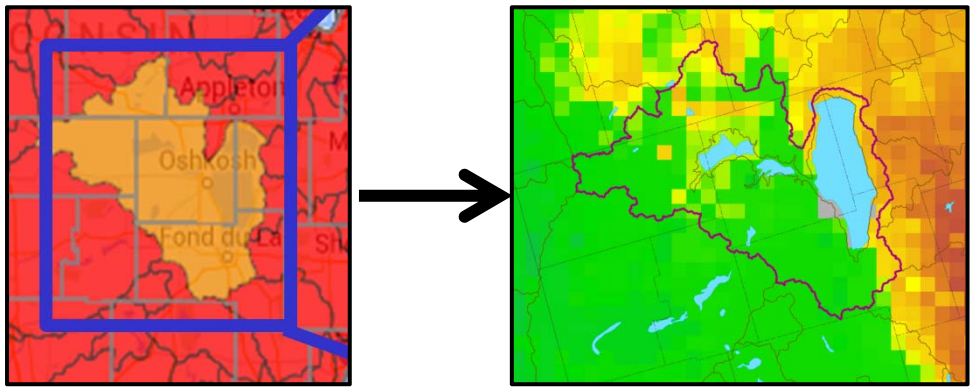
Complete Great Lakes Drainage



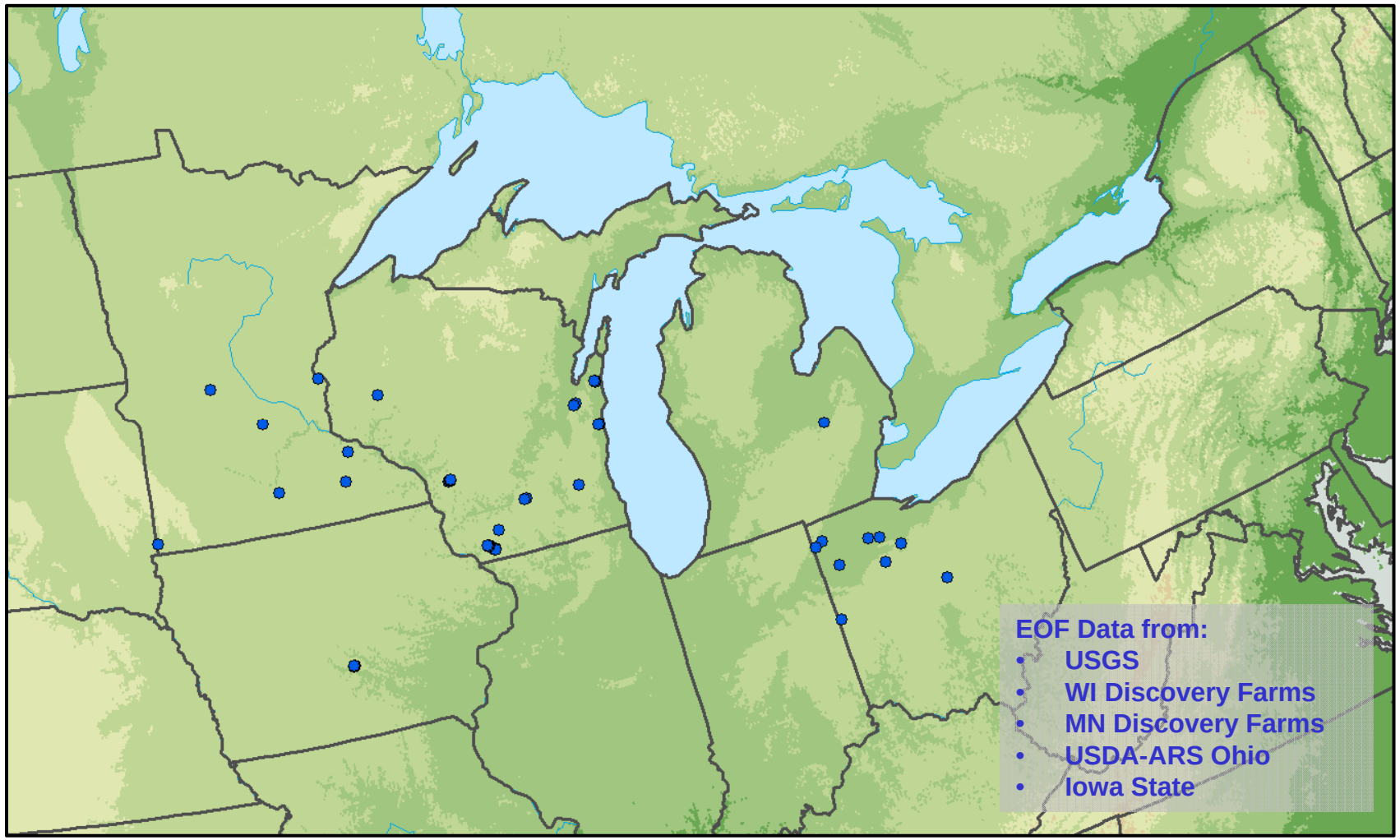
2nd Generation Runoff Risk

- GLRI funds used to hire contractor and purchase equipment to spur development in MI and OH first, then rest of Great Lakes
- Goal :: Use consistent model framework across the region
  - Allow individual states to build websites and tailor tool for their needs
- Transition to new 4km x 4km gridded model to address scale concerns
  - Requires new setup and analysis (ongoing)

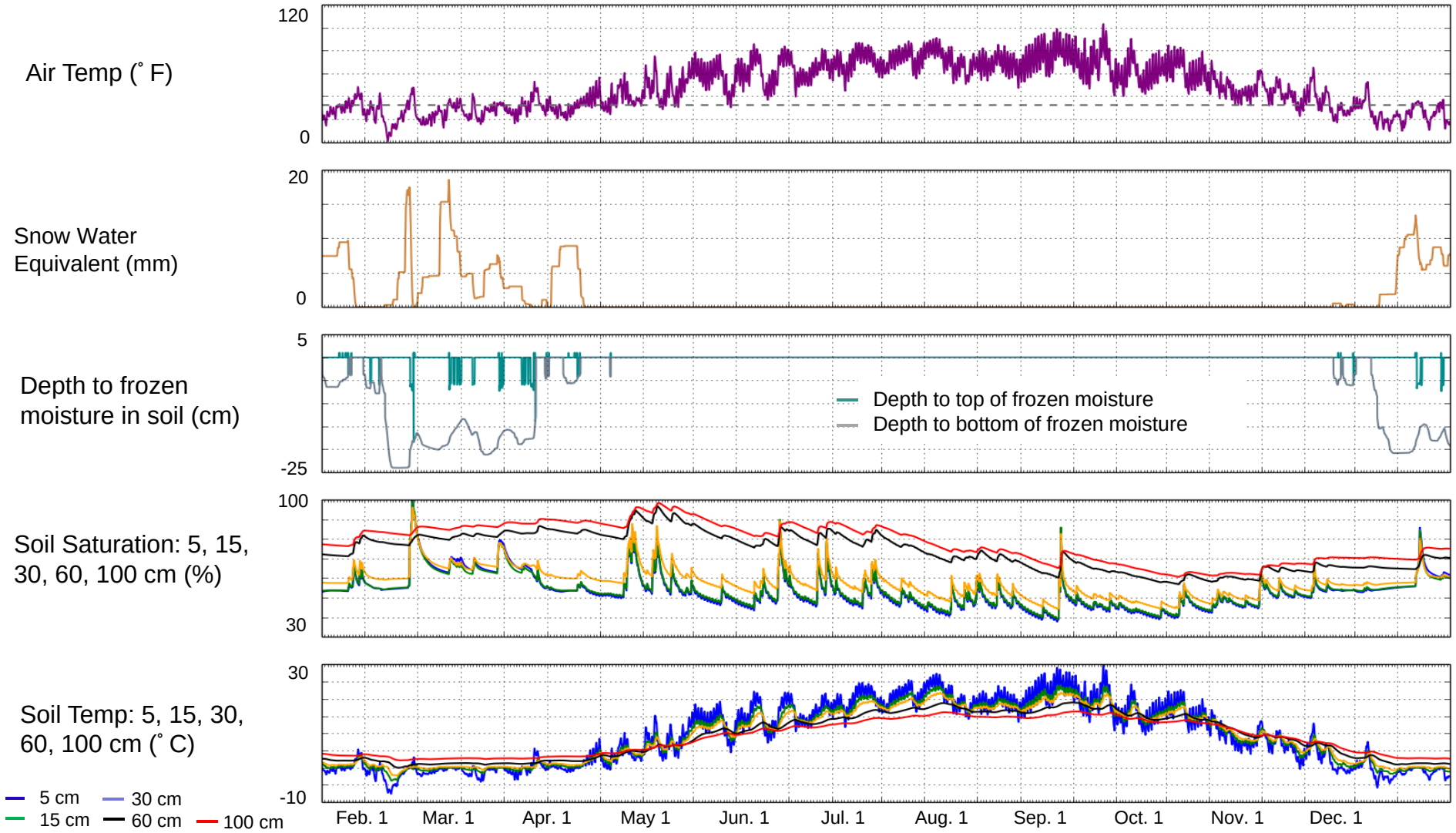




Always Looking for More Observed EOF Data



Gridded Model with SAC-HTET Provides More Soil Information



Analyzing Model Grid Cell vs EOF Data

Air Temp

Days with Obs Runoff

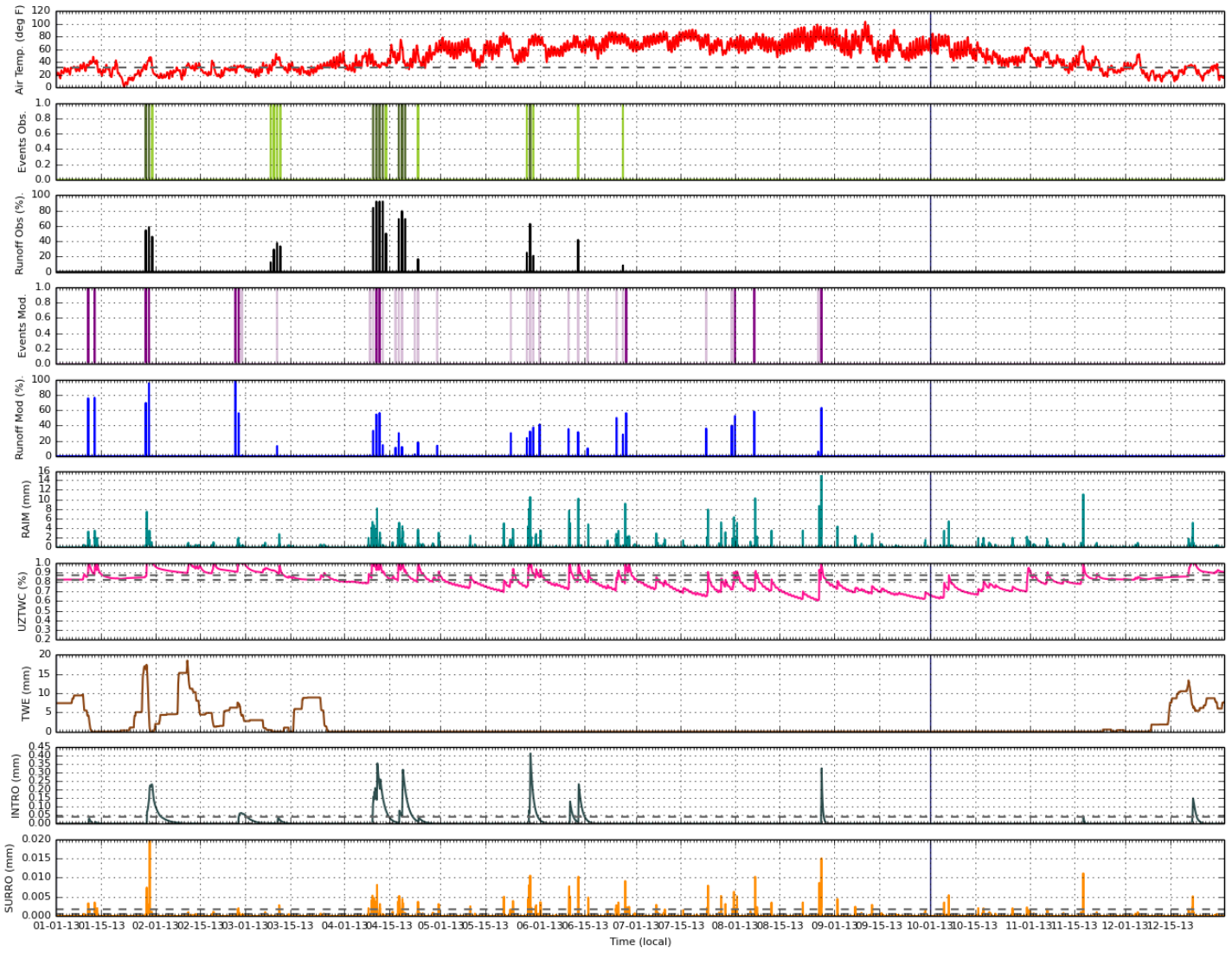
Day with Model Runoff

Rain and/or Snowmelt

Top soil layer Saturation

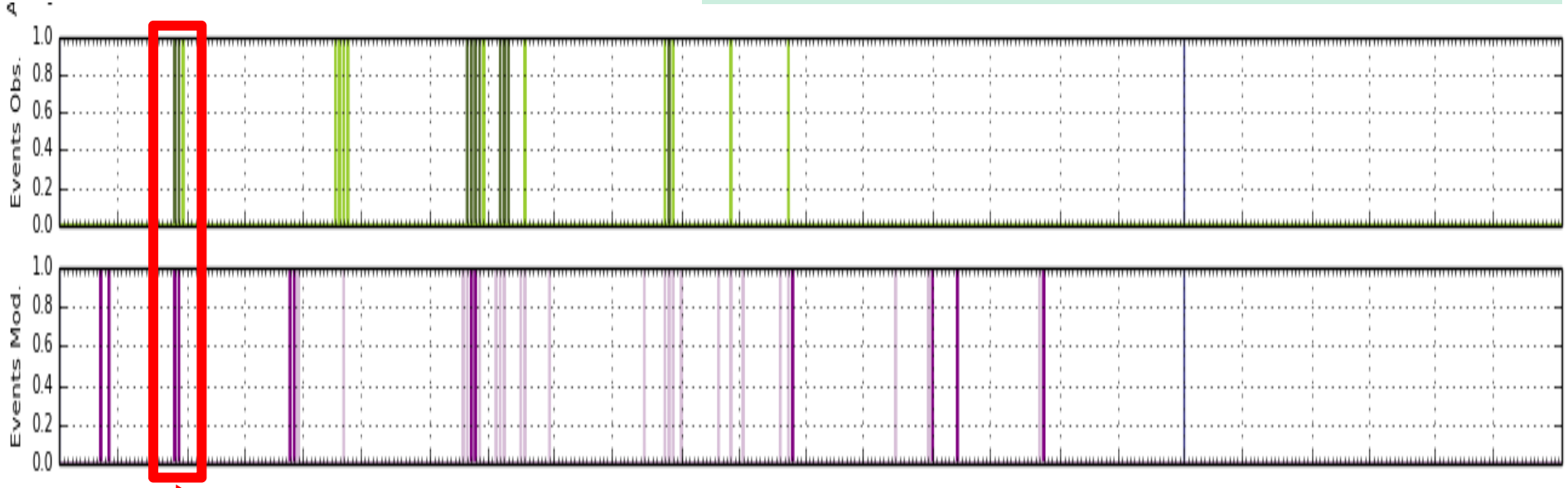
Snow Water Equivalent

Types of Runoff



Test Runoff Risk Against EOF

EOF Observed Runoff – Daily Presence (Binary)

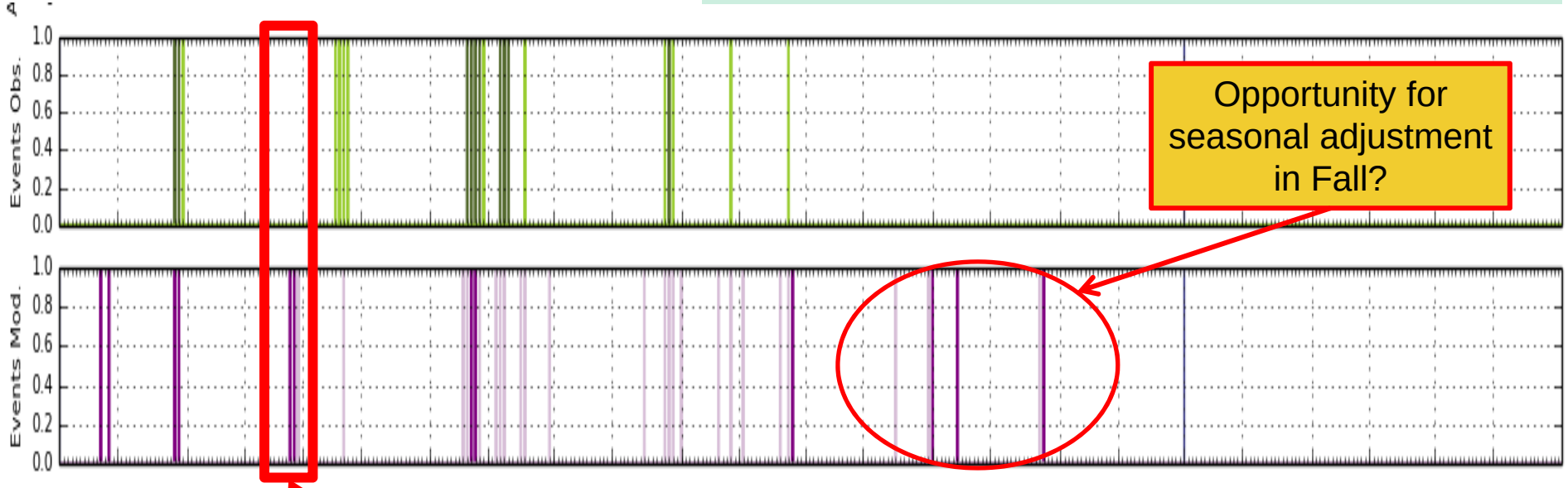


Modeled Runoff Risk Event – Daily Presence (Binary)
(First version runoff risk algorithm)

Model Hit

Test Runoff Risk Against EOF

EOF Observed Runoff – Daily Presence (Binary)



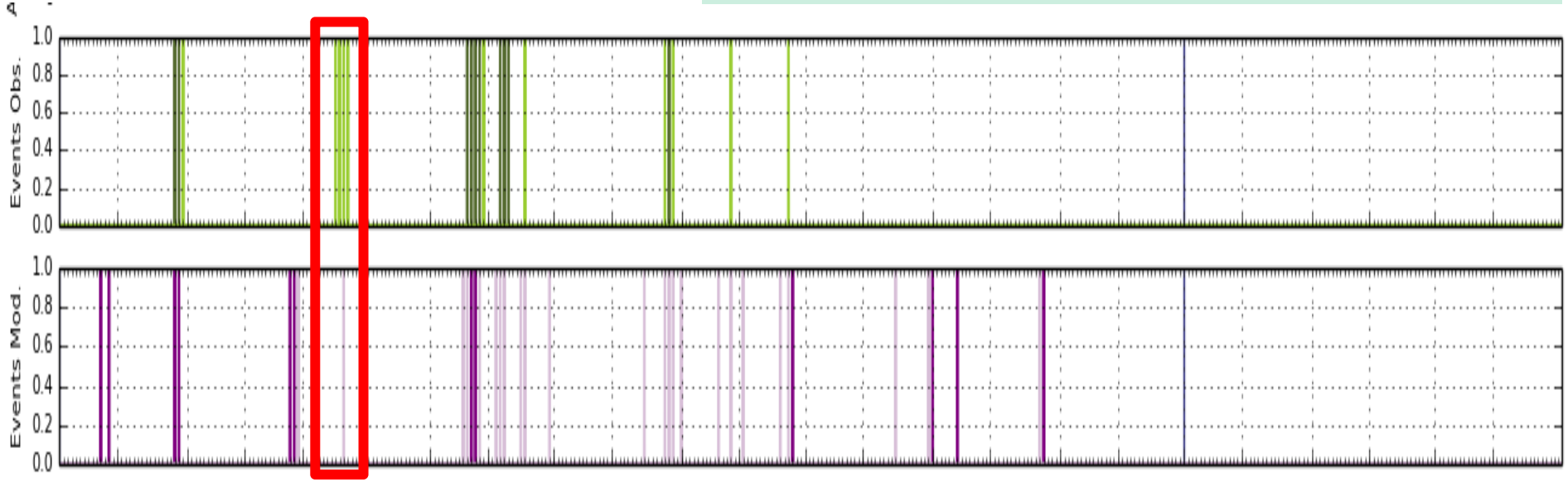
Opportunity for seasonal adjustment in Fall?

Modeled Runoff Risk Event – Daily Presence (Binary)
(First version runoff risk algorithm)

False Alarm

Test Runoff Risk Against EOF

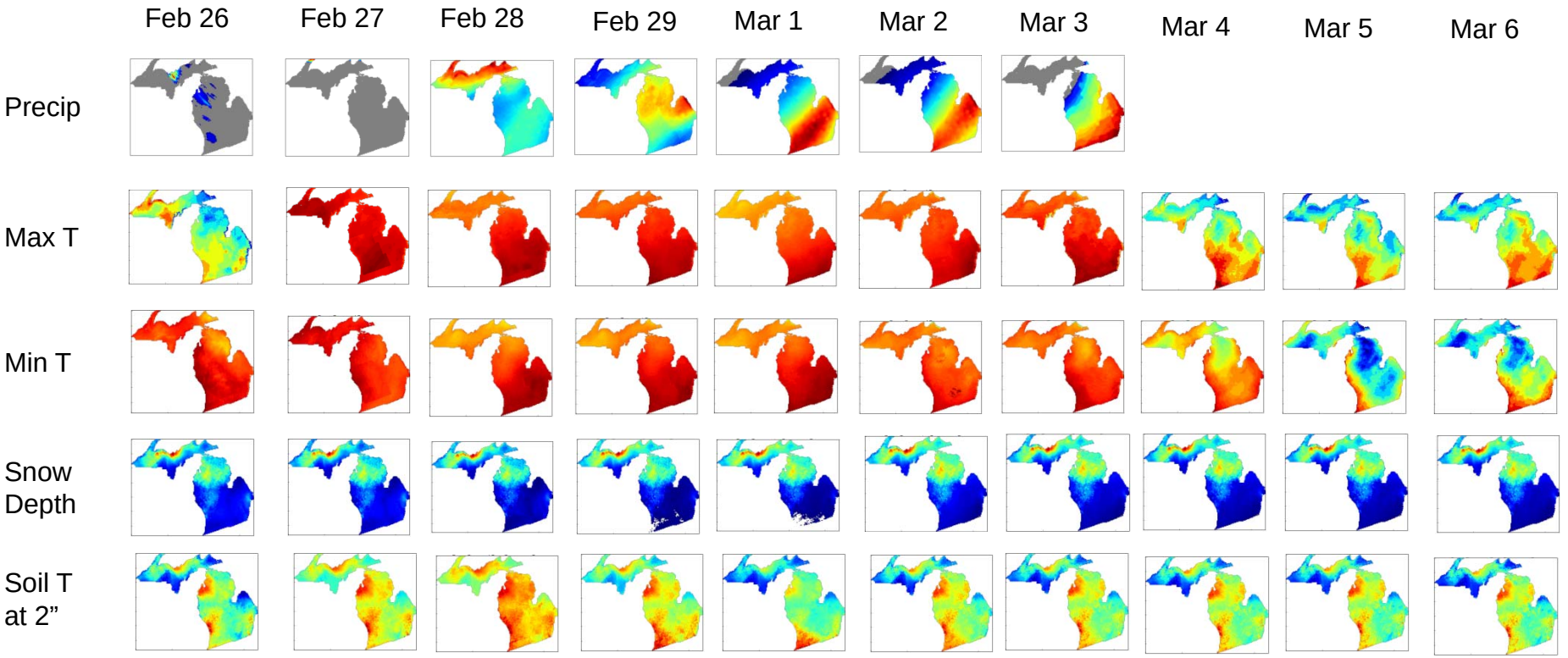
EOF Observed Runoff – Daily Presence (Binary)



Modeled Runoff Risk Event – Daily Presence (Binary)
(First version runoff risk algorithm)

Model couple days too late → miss?

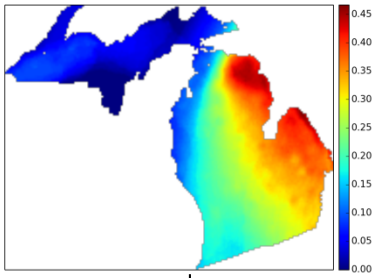
Sending Daily Grid Suites to States



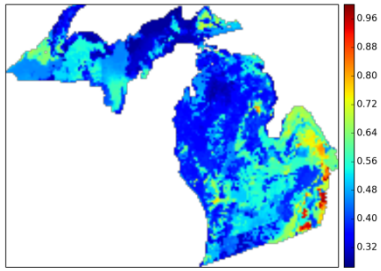
- Daily Grid packages can be tailored by requirements of each State
- Grids are re-projected into Google Web-Mercator (EPSG 3857) in geoTIFF
- Pushed to SFTP site for automated retrieval

Different Flavors of Runoff Risk

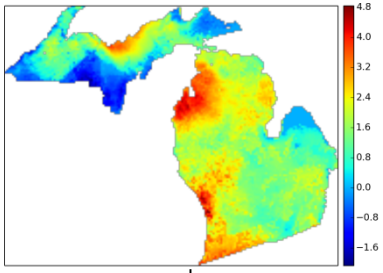
Daily Precip



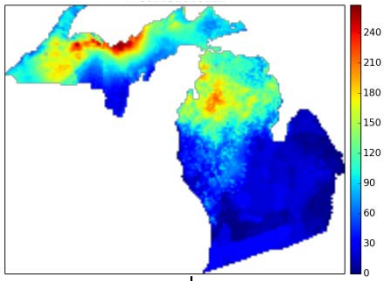
2” Soil Saturation



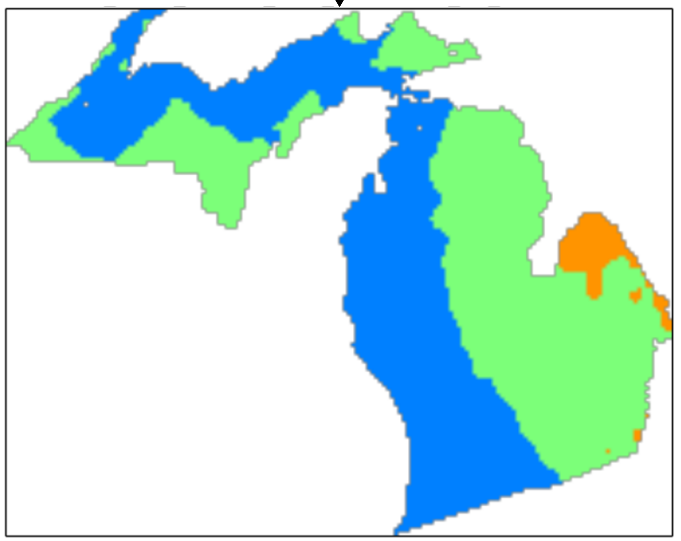
2” Soil Temp



Snow Water Equivalent



- In addition to “classic” runoff risk based on NCRFC analysis, state specific guidelines can be incorporated:
  - No frozen ground
  - No snow
  - precip > 1”
- Example Daily Criteria:
  - Daily precip. >= 0.25”
  - SWE > 0 mm
  - Soil temp. <= 0 degrees C
  - Soil saturation = 100%



- No criteria met, no risk
- 1 criteria met, mild risk
- 2 criteria met, medium risk
- 3 criteria met, moderate risk
- 4 criteria met, high risk

Multi-Agency Partnerships are Essential

THE UNIVERSITY of WISCONSIN MADISON

DISCOVERY FARMS WISCONSIN

USGS science for a changing world

Great Lakes RESTORATION

MINNESOTA DEPARTMENT OF AGRICULTURE

DISCOVERY FARMS MINNESOTA

USDA ars
United States Department of Agriculture
Agricultural Research Service

Ohio Department of Agriculture

THE OHIO STATE UNIVERSITY

NRCS
Natural Resources Conservation Service

NOAA NOS

Sea Grant Michigan

Sea Grant
Ohio Sea Grant College Program

MICHIGAN STATE UNIVERSITY EXTENSION

Michigan Department of AGRICULTURE & Rural Development

Established

Starting

Near-term Plans & Coordination

- First four states set with state departments taking lead:
  - DATCP, MDA, ODA, MDARD + Others
  - NOAA Sea Grant also involved in MI and OH outreach
- Great Lakes Commission involved as regional coordinator?
  - Encourage website design consistency
  - Coordinate outreach across state boundaries
- Beginning to send daily grid packages for states to build websites
- Summer :: Finalize runoff risk algorithm, begin state working group discussions
- Summer :: Ramping up second round state working groups (IL, IN, NY)
- Fall :: First round state runoff risk websites go live

Long-term Plans

- Social Science evaluation of Runoff Risk
  - UW Environmental Resources Center Evaluation Unit
- NRCS CIG Project
  - Compare and evaluate 4 runoff risk tools across multiple states
  - Led by Nichole Embertson, Whatcom Conservation District, WA
- Quantify Effect of Runoff Risk Usage on Water Quality
  - GLRI FY17 funding to work with Ohio State and Maumee SWAT model
- Expansion to Mississippi River and the Coasts?
  - Federal partners with support and funding needed
- Always open for new improvements, techniques, or models
  - Are there regional methods that are better?
  - NWS National Water Center (NWC) and transition to WRF-Hydro?

Questions?

- Wisconsin RRAF
  - Google “Wisconsin RRAF”
    - *www.manureadvisorysystem.wi.gov/app/runoffrisk*
  - Background Information
    - *NOAA Tech Report NWS 55*
    - *http://docs.lib.noaa.gov/noaa_documents/NWS/TR_NWS/*
- Further Questions & Comments
  - Dustin Goering *dustin.goering@noaa.gov*
  - Liz Houle *liz.houle@noaa.gov*
  - Steve Buan *steve.buan@noaa.gov*