Using Weather Forecasting For Decision Tools For Animal Agriculture

Steve Buan

National Weather Service
North Central River Forecast Center

Minnkota Agri-Builders and Equipment Suppliers Association
11 March 2016
• Cattle Heat Stress Forecast Using National Digital Forecast Database
  • http://www.ars.usda.gov/Main/docs.htm?docid=21306

• Enhanced Hazardous Weather Outlook
  • http://www.weather.gov/mpx/hwo

• Activity Planner
  • http://forecast.weather.gov/wxplanner.php?site=mpx

• Wet Bulb Globe Temperature
  • Accounts for insolation, temperature, humidity, and wind. Is used by schools, marathon organizers, the military, and others to determine health risks for those who are unable to avoid conditions due to their occupation or activity.
  • http://www.srh.noaa.gov/tsa/?n=wbgt

• Runoff Risk Advisory Forecast
  • http://www.manureadvisorysystem.wi.gov/app/runoffrisk

• Local Research Partnerships
Cattle Heat Stress Forecast

http://www.ars.usda.gov/Main/docs.htm?docid=21306
### Enhanced Hazardous Weather Outlook

**Product Suite Last Updated:** Thursday March 30, 2016, 04:29 AM

#### Risk Level - Legend

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<th>Limited</th>
<th>Elevated</th>
<th>Significant</th>
<th>Extreme</th>
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#### Frost and Freeze Risk - Today/Tonight

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#### Risk Level

<table>
<thead>
<tr>
<th>Risk Level</th>
<th>Definition</th>
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<tbody>
<tr>
<td>None</td>
<td>No danger of frost or freeze causing damage to vegetation.</td>
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<tr>
<td>Limited</td>
<td>Patchy frost during the growing season with minor damage to unprotected vegetation.</td>
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<tr>
<td>Elevated</td>
<td>Frost expected during the growing season with damage to unprotected vegetation. This may include temperatures less than or equal to 32 degrees F for less than 3 hours.</td>
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<tr>
<td>Significant</td>
<td>Freeze expected (less than or equal to 32 degrees F for 3 or more hours) during the growing season with significant damage to unprotected vegetation.</td>
</tr>
<tr>
<td>Extreme</td>
<td>Hard freeze (less than or equal to 28 degrees F) during the growing season with catastrophic damage to unprotected vegetation.</td>
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</table>
Welcome to the Weather Activity Planner. Please enter the range of weather parameters required for your activity. Then, either click the approximate location on the map below, or enter the specific latitude and longitude and hit submit. This will query the forecast grids to find when your weather requirements will be met at the nearest grid point over the next 7 days. Public comments and suggestions are encouraged.

This application generates products from a digital forecast database. It is intended to allow a user to define and produce a forecast for general planning purposes only. As any weather or hydrologic event evolves, updated forecasts and warnings are issued by the NWS. Customers are urged to obtain the latest official forecast information prior to engaging in any weather-sensitive activity, and to monitor forecasts for updates during such activities.

The Weather Activity Planner is NOT meant to replace a spot forecast request. Weather Activity Planner surface winds are a gridded representation of projected, local surface winds at a 5km or 2.5km resolution. The surface winds returned do NOT account for fuel type, sheltering, or slope aspect. Users can select either surface wind speeds or 20 foot winds (if the 20 foot wind grid is available). If precise wind forecasts are needed, please submit a spot forecast request to your servicing Weather Forecast Office.

Read watches, warnings & advisories
Hazardous Weather Outlook
Hydrologic Outlook

Latitude/Longitude Entry
decimal degrees (i.e. 42.134) or deg min sec (i.e. 42 23 34)

Latitude:
Longitude:

Use "-" (negative sign) in longitude for locations in Western Hemisphere

Submit
Weather Activity Planner

Wet Bulb Globe Temperature

(Prototype - Under Development. Not to be used for operational use.)

The Wet Bulb Globe Temperature (WBGT) is a measure of the heat stress in direct sunlight, which takes into account temperature, humidity, wind speed, sun angle and cloud cover (solar radiation). This differs from the heat index, which takes into consideration temperature and humidity and is calculated for shady areas. If you work or exercise in direct sunlight, this is a good element to monitor. Military agencies, OSHA and many nations use the WBGT as a guide to managing workload in direct sunlight.

Comparison with Heat Index

<table>
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<th>WBGT Assumed in the sun</th>
<th>Heat Index Assumed in the shade</th>
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Examples

<table>
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<th>RH %</th>
<th>Sky %</th>
<th>Wind mph</th>
<th>Heat Index</th>
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Runoff Risk Advisory Forecast

- The Nonpoint Source Nutrient Issue
- NOAA and NWS Strategic Interest
- Application Timing and the NWS Contribution
- Creating the First Runoff Risk
- Increasing Attention and Building Awareness
- Expansion and 2nd Version of Runoff Risk
Agriculture One Source of NPS Nutrient Pollution

- 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
Highly visible events driving support for action

What combination of practices will enable reduction goals to be met?
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 alert farmers of future conditions unsuitable for application with intention to reduce nutrient transport from fields over time.
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 needs to be 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 & how to apply or landscape modification

- No organized assistance exists to help farmers with the when (not to) apply
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 and 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
During non-frozen periods P loss generally tied to soil loss.

- Many practices aimed at holding soil in place for this reason

Timing of applications also important during early summer

High P Losses but very low sediment

⇒ P fertilizer or Manure applications shortly before runoff
Applying manure on frozen-ground: 83% TP lost was as dissolved P
  - Many land-based practices can’t help on frozen-ground → Timing matters

Late winter applications can increase P loss by 2 to 4 times

50-60% of Later Winter applications are higher than ALL Non-Applied or Early Winter applications
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
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
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 \(\rightarrow\) 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

http://www.manureadvisorysystem.wi.gov/app/runoffrisk

Basin name: LAKE WINNEBAGO OSHKOSH (OSHW3)
3-day spreading risk forecast on Apr 07. Moderate
Earliest runoff expected (after Apr 07): Apr 07

Precipitation Forecast (inches)

Single-Day Runoff Risk

Forecast updated: Apr 7 4:00 PM
Spatial scale was always a concern in implementation

- Average lumped-model basin in WI = 300 mi²
- 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
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.
- GLRI funds used to hire contractor and purchase equipment to spur development in MI and OH first, then rest of Great Lakes
- Transition to new 4km x 4km gridded model to address scale concerns
  - Requires new setup and analysis (ongoing)
- Goal: Use consistent model framework across the region
  - Allow individual states to build websites and tailor tool for their needs
Always Looking for More
Observed EOF Data

EOF Data from:
• USGS
• WI Discovery Farms
• MN Discovery Farms
• USDA-ARS Ohio
• Iowa State
Air Temp (°F)

Snow Water Equivalent (mm)

Depth to frozen moisture in soil (cm)

Soil Saturation: 5, 15, 30, 60, 100 cm (%)

Soil Temp: 5, 15, 30, 60, 100 cm (°C)

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 couple days too late → miss?

Opportunity for seasonal adjustment in Fall?
Multi-Agency Partnerships are Essential
Local Research Partnership with U of M

- If we were provided with statistics/information on mortality and morbidity cases involving the livestock of interest we could work to develop some sort of index/parameter specific to them. We could use archived weather data and correlate it with the livestock data, and determine the best statistical approach.
Questions?