Written Testimony of
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Before the
House Committee on Science, Space and Technology Subcommittee on Environment

On
Reauthorizing the Weather Act: Users of Weather Data and Areas for Improvement by Sector

June 6, 2023

Section 1.: Opening Statement

Chairman Miller, Ranking Member Ross, and Members of the Subcommittee, thank you for the opportunity to testify today and to speak on the use of weather data in agriculture.

My name is Eric Snodgrass, and I'm the Senior Science Fellow and Principal Atmospheric Scientist at Nutrien, the world's largest provider of crop inputs and services. As a global agricultural retailer, our aim is to provide everything the producer needs at the farm level through our over 1,200 retail locations nationwide. My role in this industry is to provide accurate and timely weather forecast information - which is critically important in every decision our grower customers make. At present, my forecasts are delivered to over 25,000 farmers daily, I maintain an ag-weather website with 4 terabytes of traffic each month and speak at over 120 conferences and grower meetings each year on weather risk in production agriculture. Accurate and timely weather predictions that our farmer customers rely on are dependent on accurate and timely weather data.

Weather risk is ubiquitous in agriculture. In a recent survey published by the University of Illinois' FarmDocDaily[1] – a widely read publication in the agricultural community – weather was identified as the main source of risk for farmers by more than double the next highest category (output price). The United States has nearly 900 million acres of farmland[2] that contribute over $1.26T to the US economy[3] and it is the uniqueness of the geography of this country that creates the variety of weather that sustains US agriculture.

The atmosphere can be unforgiving at times. High impact weather events like the Midwest tornado outbreak on March 31 of this year, or the derecho that hit Iowa in August 2020, or drought in Fall 2022 that dropped the Mississippi River to historic low levels, or the persistent onshore flow of the Atmospheric Rivers that hit the West Coast this January and March delivering over 900" of snow to some of the Western Mountains, determine the success of US crops.

We often focus on NOAAs life-saving efforts in each of these events – which it is unmatched at providing - but I see NOAAs utility as something significantly more vital to the US economy. The severe storm outbreak in March also aided in the reviving of Midwest soil moisture. It was NOAAs radars and rain gauges that captured every move of these storms. NOAAs monitoring of the hydrology of the Mississippi River was strategically used in the repositioning of barge traffic carrying grain and fertilizer during the drought last Fall. And the incredibly deep Western US snowpack has filled reservoirs this spring allowing California, which leads the nation in the production of over 40 different fruits and vegetables (and milk), to precisely and responsibly use this water for agricultural.

I prepared a list of all the resources from NOAA that my team at Nutrien uses daily to provide weather insight to our grower customers and that list has over 30 products. These data and analyses are compulsively consumed by the agricultural industry. Nearly every decision a grower makes is about the future success of their crops and the future success of their business. Weather is uncontrollable, but it is observable and predictable at certain time scales, and our customer-growers consume NOAAs products as a part of every on-farm decision. An average Midwest corn and soybean farmer averages $800/acre in expenses resulting in $1-$1.5M in annual cashflow through their farm. Weather impacts everything from crop type to ideal planting windows, to optimal fertilizer application timing, to how vegetative and reproductive crop stages will impact yield, how the market will react, and how insurance premiums are set just to name a few examples.

Agriculture is pushing the limits of atmospheric science by increasing the demand for sub seasonal-to-seasonal forecasting. Successful farming requires accurate and skillful long-term planning and long-range weather forecasts provided by NOAA are essential to crop planning and marketing. Just as valuable are NOAAs incredibly rich historical weather and climate records. Farmers study and examine historical weather and climate data to understand climatic shifts that could impact their farming decisions. These same data are used to compile sustainability metrics which are of high demand in food production in the US.

The US is a global powerhouse in agricultural productivity, and we are integral to the food security of this nation and the world. NOAAs data and forecasting are mission critical to the success of US agriculture. Investment in computing infrastructure, data assimilation, increased capacity for observation, and industry partnerships are vital to the continued success of NOAA.

Section 2.: Supporting Information

Section 2.a: NOAA - World Class Organization With Global Competition

Data Access and Ease of Use

NOAAs data collection, quality control, and dissemination are world class. Data are easy to access via ftp servers[4], APIs[5], and numerous https websites. Their quality control measures are the industry standard, and it is rare that their services are unavailable. When comparing the access and ease of use of the products NOAA curates to foreign government weather agencies (i.e., Australia's Bureau of Meteorology, Environment Canada, ECMWF, UK MET Office, Brazil's

National Institute of Meteorology to name a few) NOAA's data delivery and access methods are second to none. They offer data in numerous formats including GIS-ready shapefiles and kml/kmz files, GRIB, NetCDF, ASCII, text, JSON, GeoJSON, TIFF, HDF, and many others. This variety allows the user community to build efficient systems to process and analysis these data to turn them into actionable weather insights for the private sector. As an example, please visit https://www.ag-wx.com and see the list in the Appendix of all the NOAA products currently used by Nutrien's team of meteorologists.

Comments on the Competition with the ECMWF

It is well known that the ECMWF (a.k.a "European Model") has an advantage over all weather forecast models due to its data assimilation technique, 51-member ensemble, and higher resolution. The ECMWF routinely outperforms the US flagship forecast model, the Global Forecasting System Model (GFS), by ~3% on an anomaly correlation skill score. Farmers know about its superior performance and prefer to use it daily to make their on-farm decisions and to judge market reaction. Figure 1 shows 500 hPa Anomaly Correlation skill score computed by Dr. Ryan Maue. This score compares the forecast from two flagship models, the ECMWF (blue) and GFS (red), from 5 days ago for today's mid-level atmospheric flow.

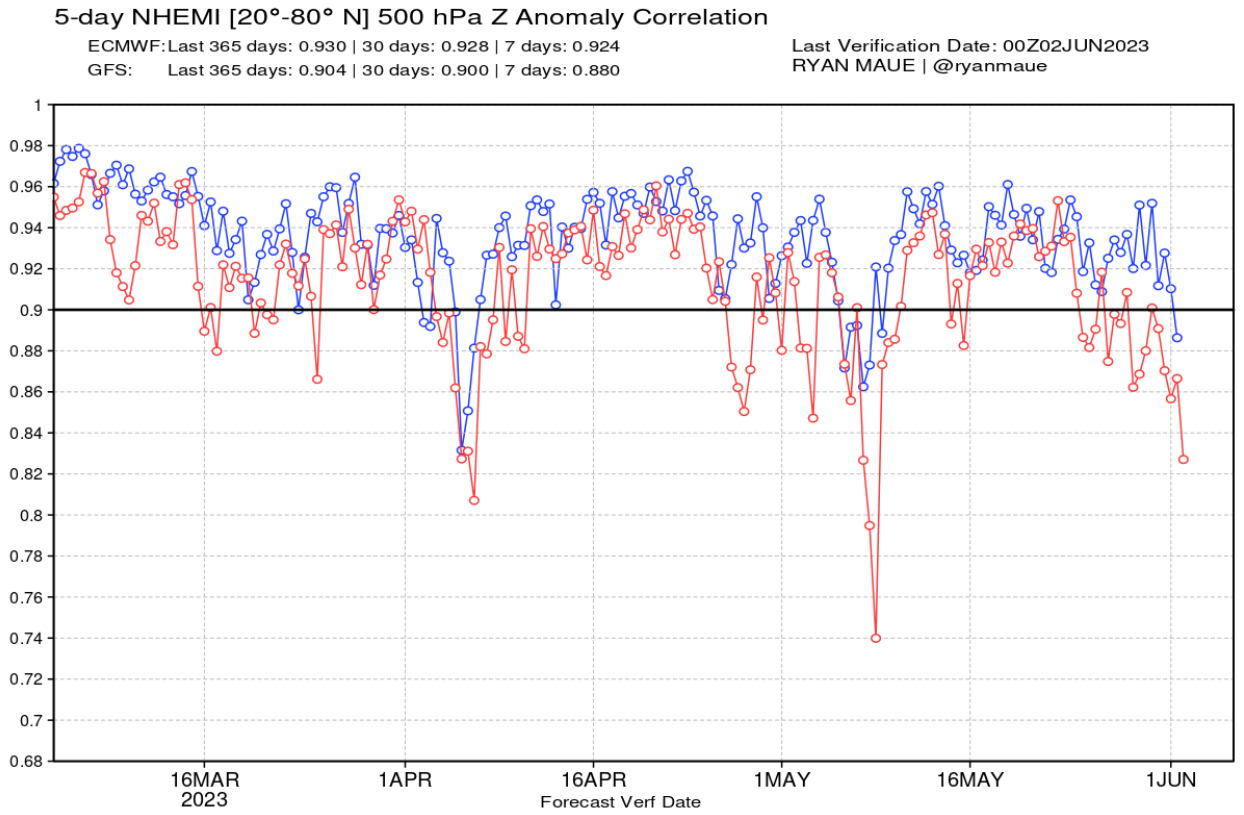

Figure 1. 5-Day Northern Hemisphere 500hPa Geopotential Height (Z) Anomaly Correlation. Over the last 365 days, the ECMWF has a ~3% advantage in skill over the GFS. Image courtesy of Ryan Maue https://climatlas.com/temperature/ecmwf_gfs_nh_f120_recent.png

The US forecast model suite maintained by NCEP could greatly benefit from a re-tooling and computing infrastructure upgrade to be able to adopt the techniques used by the ECMWF. This would be a strategic investment in forecast skill and accuracy and would allow NOAA's suite of models (GFS, NAM, HRRR, RAP, etc.) to collectively outperform the ECMWF.

Section 2.b: Investment in Meteorological Observations

The accuracy and skill of a dynamical weather forecast model is highly dependent on the quality and density of the observations used to initialize the model. It is typical for a farmer to plan their operations on a 10-day forecast horizon for activities such as planting, harvesting, making strategic in-season hiring decisions, contracting truck drivers and applicators, and making certain insurance purchases (like additional severe weather coverage) just to name a few.

One of the most critical aspects of farming - application of fertilizer, pesticides, fungicides, and herbicides - can only be done under strict meteorological guidelines. These guidelines are in place to prevent chemical drift, runoff, or deactivation due to weather conditions. Higher spatial resolution meteorological observations (i.e., a national mesonet) would ensure they are applying within the optimal range of meteorological conditions. Nutrien has built tools using high resolution weather forecast models (i.e., the North American Mesoscale Model or NAM) to forecast temperature inversions, surface humidity, wind speed and direction, plus precipitation timing to provide the best meteorological guidance to a grower during application. Predicting optimal application timing would not be possible without NOAAs high resolution forecast models. Figure 2 shows an example of a forecast from the Nutrien's Pocket Spray Smart mobile application which uses the high-resolution NAM forecast model to predict vital weather conditions for applying chemical to a field.

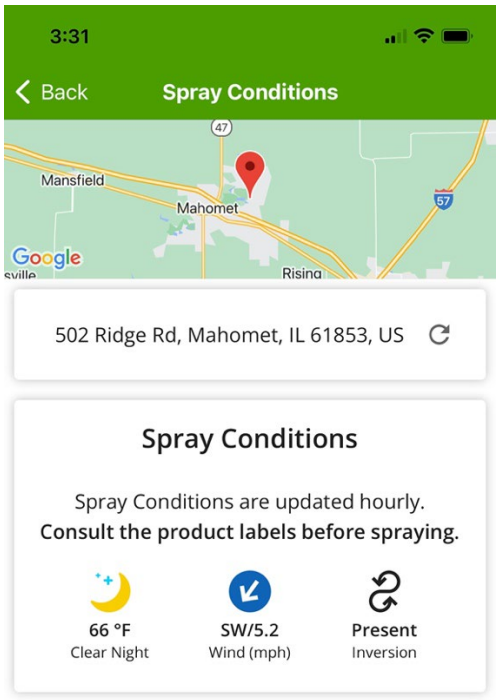

Figure 2. A screen capture of Nutrien's Pocket Spray Smart mobile application.

National Mesonet

There are a few states that have a high spatial density network of surface weather stations. These "mesonets" are critical to the observation and nowcasting of high-impact weather events but they are also extremely valuable for monitoring weather conditions that impact farming decisions. For example, farm irrigation systems are designed to optimize water application to not waste water. A mesonet provides real-time evaporation, wind, humidity, temperature, and weather conditions reporting to optimize that timing and therefore improve the efficiency of irrigation. A nation-wide mesonet would also increase weather model forecasts accuracy through better model initialization. Additionally, a mesonet enhances record keeping during farm applications of fertilizer, pesticides, and herbicides to prove that the farmer completed the application of these chemicals during weather conditions specified by the product labels. Building a national mesonet maintained by NOAA and its high standards for equipment and data quality would be a massive benefit to US agriculture.

A critical but missing piece across the US weather observation network is surface and sub-surface soil moisture monitoring. Soil moisture is a critical variable for farming, but it is poorly observed. A mesonet with soil moisture probes would greatly improve forecast model performance by more accurately capturing the hydrology and mass transfer of water into the lower atmosphere through evaporation. Farmers test soil moisture routinely throughout growing season and make several decisions based upon those measurements. Figure 3 shows a soil sample taken in Champaign, IL on June 1, 2023, in a field that has not received rain in 23 days. The farmer was concerned about flash drought and is potential impact on yield but as you can see, the sub-surface moisture content was still adequate (noted by the wet, black dirt). Additionally, soil moisture measurements will improve irrigation efficiency which can reduce farming's use of precious water resources like the Colorado River or Ogalala Aquifer. It would also inform the decisions by ranchers as they move livestock between pastures across the US rangelands.

Figure 3. A close look at a 12” soil sample in Champaign, IL on June 1, 2023. Image courtesy of Eric Snodgrass

NEXRAD Radar Network

The US has 160 WSR 88-D radars that use the latest technology in dual-polarization observations to monitor nearly every aspect of precipitation. It is arguably the most reliable and best covering radar network in the world, yet key growing areas are missed. This is not only a potential problem for the issuance of severe storm and tornado warnings, but it reduces that accuracy of rainfall estimations across highly productive farm and rangeland. This is a well-known shortcoming of the NEXRAD radar network. For example, notice the lack of coverage parts of the Midwest like northern Missouri, Nebraska, and in the Northern Plains, Western Plains, and Lower Mississippi River Valley. Investment in additional radars to fill in these holes is tremendously valuable to farmers in these areas and help with insurance (ie., the National Pasture, Rangeland, and Forage Insurance Programs), crop planning, in-season application, and severe weather monitoring. It would also enhance the accuracy of tools that growers use that are powered by NOAAs NEXRAD system. For example, one of Nutrien’s most popular mobile application is called Pocket Rain

Gauge which we developed using NEXRAD and MRMS (Multi-Radar/Multi-Sensor System) to accurately record field level precipitation statistics.

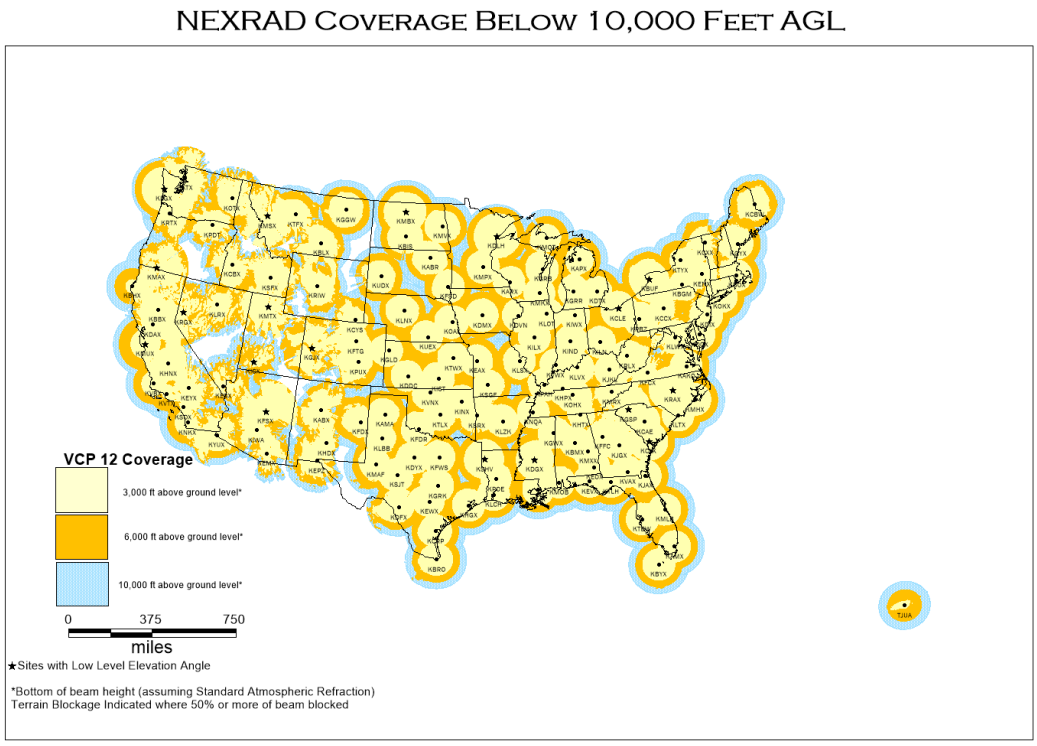

Figure 4. NEXRAD radar coverage below 10,000 feet Above Ground Level from its network of 160 WSR 88-D radars. Source: https://www.roc.noaa.gov/WSR88D/maps.aspx

Meteorological Soundings

The US launches weather balloons twice per day at 92 National Weather Service (NWS) Offices. These data are vital for weather forecast model initialization, high-impact weather prediction, aviation, and farming. During special events, like a landfalling hurricane or severe weather outbreak, the NWS will perform additional weather balloon launches to enhance weather model performance. This practice should be done routinely. It is also recommended that we increase the number of locations that launch weather balloons to better capture the atmospheric profile and greatly improve weather forecast accuracy[6].

Section 2.c: NOAA and the Success of US Agriculture – Sub-Seasonal to Seasonal Forecasting

I cannot stress enough how vital NOAAs operations are to the success of US agriculture. Decision support using weather analysis and forecasting is mission critical across all aspects of agriculture, from the grower to the businesses and industries supporting agriculture like Nutrien. Successful food production and security rely on NOAA's timely and accurate observations and predictions. The agriculture industry would benefit immensely from improved forecast skill in the Sub-Seasonal to Seasonal (S2S) time scale of 2 weeks to 2 months. More accurate weather forecasts at this time scale would improve market stability, improve prediction of high-impact events like

drought, flood, heat waves, and cold air outbreaks, and improve crop planning decisions. The "S2S Prediction Gap" as noted in Figure 5 represents one of the greatest challenges to atmospheric science and NOAA is well-equipped to conquer this gap and provide the needed skill for all weather sensitive aspects of the US economy – especially agriculture.

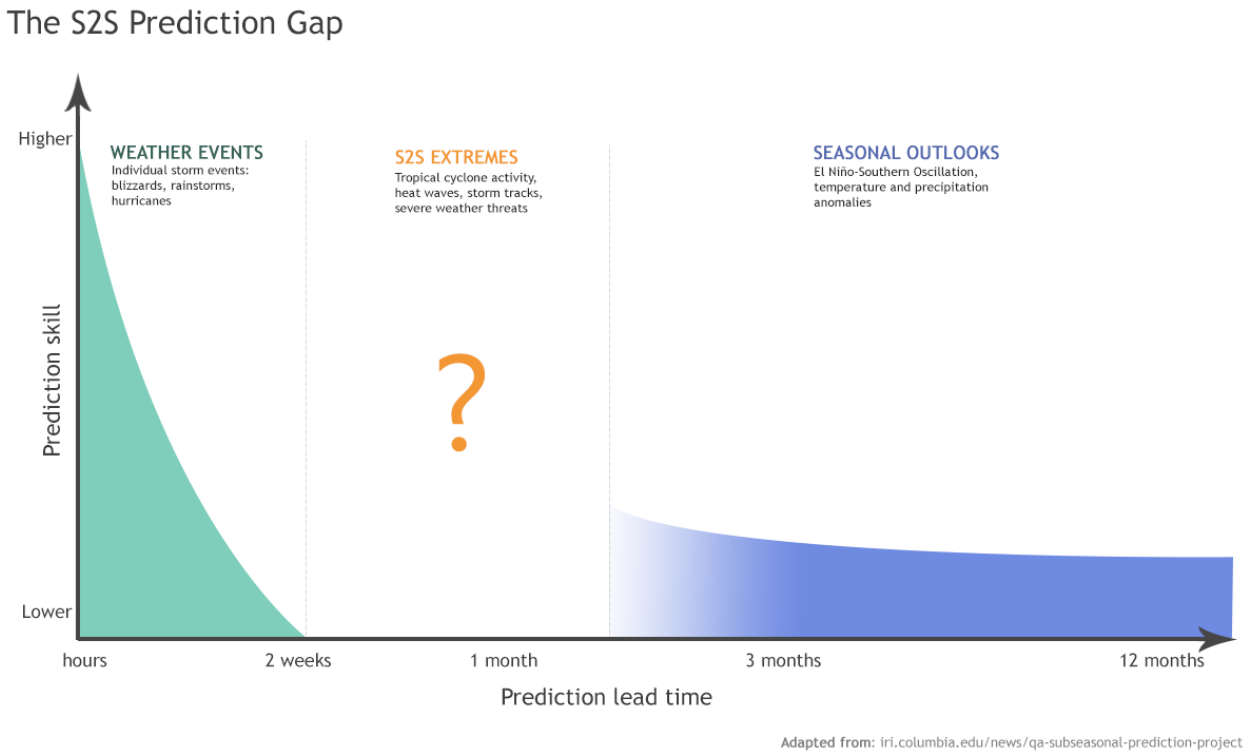

Figure 5. Prediction skill plotted again prediction lead time. Source: https://cpo.noaa.gov/Divisions-Programs/Earth-System-Science-and-Modeling/MAPP/ArtMID/6170/ArticleID/818/Advancing-the-Prediction-of-Subseasonal-to-Seasonal-Phenomena

Section 2.d: Conclusion

I want to conclude by thanking the Subcommittee for inviting me here today to share with you the importance of weather data to the agriculture industry. The success of US Agriculture is dependent on accurate and skillful weather analysis and prediction and NOAA represents the industry standard for world class meteorology. Continued adequate funding plus strategic investment as outlined in my statement would ensure its continued success and be in the best interest of US businesses and the general population. NOAAs data and services are mission critical to farmers, our food supply, and businesses like Nutrien that support US agriculture.

1 https://farmdocdaily.illinois.edu/2023/01/the-use-of-climate-information-in-midwest-agriculture-results-from-a-farmer-survey-part-i.html
2 https://www.nass.usda.gov/Publications/Todays_Reports/reports/fnlo0222.pdf

3 https://www.ers.usda.gov/data-products/chart-gallery/gallery/chart-detail/?chartId=58270#:~:text=Agriculture%2C%20food%2C%20and%20related%20industries,0.7%20percent%20of%20U.S.%20GDP.
4 https://nomads.ncep.noaa.gov/
5 https://www.weather.gov/documentation/services-web-api
6 Privé, N. C., R. M. Errico, and K. Tai, 2014: The Impact of Increased Frequency of Rawinsonde Observations on Forecast Skill Investigated with an Observing System Simulation Experiment. *Mon. Wea. Rev.*, **142**, 1823–1834, https://doi.org/10.1175/MWR-D-13-00237.1.

Appendix.

List of current NOAA agencies, models, observations, and products routinely used by the team of meteorologists at Nutrien.

CPC - Climate Prediction Center
CFSR - Climate Forecast System Reanalysis
MRMS - Multi-Radar/Multi-Sensor System
AHPS - Advanced Hydrologic Prediction Center
NAM - North American Mesoscale Model
GFS - Global Forecast System Model
GEFS - Global Ensemble Forecast System
SREF - Short Range Ensemble Forecast
HRRR - High Resolution Rapid Refresh
RTMA - Real-Time Mesh Analysis
NLDAS - North American Land Data Assimilation System
GLDAS - Global Land Data Assimilation System
NOAA VIIRS - Visible Infrared Imaging Suite
NMME - National Multi-Model Ensemble
NEXRAD - Next Generation Radar
SPC - Storm Prediction Center
NHC - National Hurricane Center
WPC - Weather Prediction Center
NOHRCS - National Operational Hydrologic Remote Sensing Center
METAR (ASOS/AWOS) - Meteorological Aerodrome Reports, Automated Surface Observing System, Automated Weather Observing System
NDFD - National Digital Forecast Database
CDAS - Climate Data Assimilation System
NOAA SSTs (Coral Reef Daily Watch)
Drought Monitor
CFSv2 - Climate Forecast System Version 2
CFS - Climate Forecast System
GHCN - Global Historical Climatology Network
Observed Soundings
Fire Weather

MOS - Model output Statistics
NAEFS - North America Ensemble Forecast System
RAP - Radii Refresh Model
Hysplit Trajectory Model
NBM - National Blend of Models
URMA - Unrestricted Mesoscale Analysi
GLERL - Great Lakes Environmental Research Laboratory
GOES - Geostationary Operational Environmental Satellites