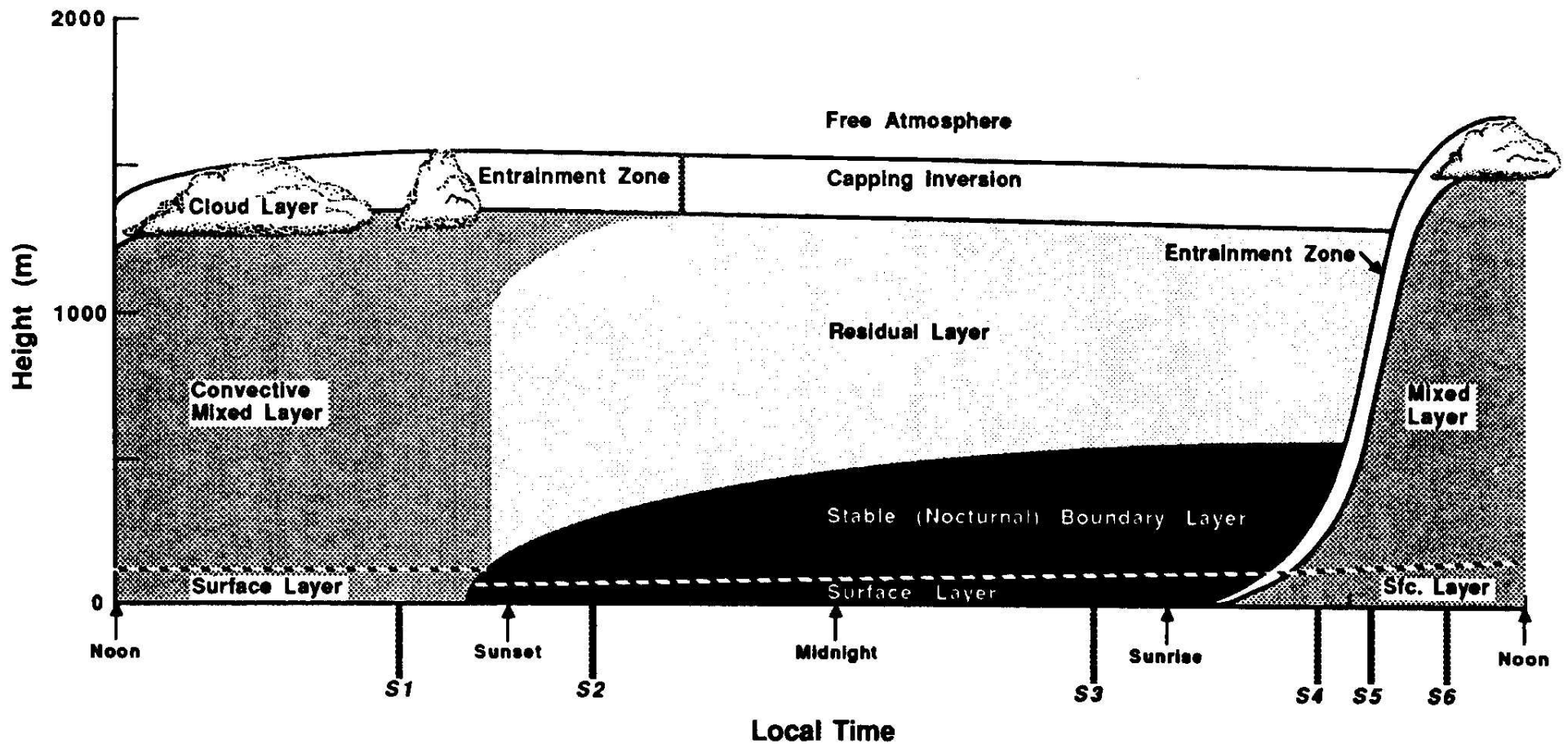


# Deciphering Weather Forecasts for Making IPM Decisions



*Jeff Andresen*  
*Dept. of Geography, Environment, and Spatial Sciences*  
*Michigan State University*

# Idealized Boundary Layer Cross-Section



(Stull, 1992)

# Basic Concepts of Weather Forecasting

# Primitive Equations

The primitive equations are a set of nonlinear differential equations that are used to approximate global atmospheric flow and are used in most atmospheric models:

1) Conservation of momentum

$$\frac{D\vec{v}}{Dt} = \vec{g} - \frac{1}{\rho}\nabla p - 2\vec{\Omega} \times \vec{v} - \vec{D}.$$

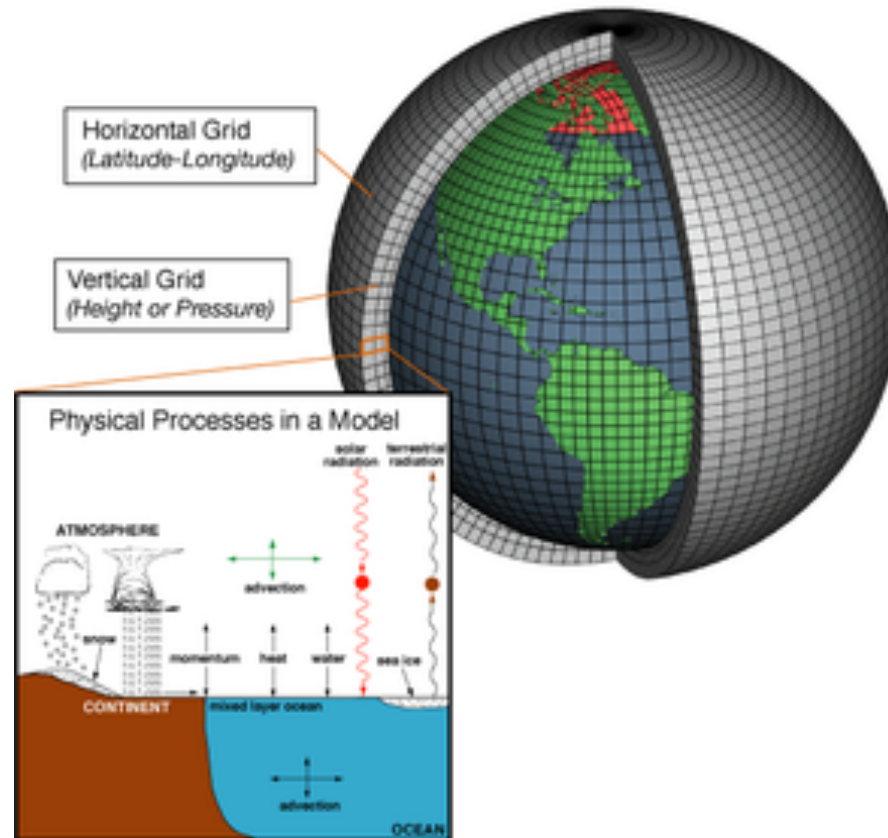
2) Continuity

$$\frac{D\rho}{Dt} + \rho\nabla \cdot \vec{v} = 0,$$

3) Thermal energy

$$\rho c_v \frac{DT}{Dt} = -p\nabla \cdot \vec{v} - \nabla \cdot \vec{F} + k\nabla^2 T + \rho\dot{q},$$

# Numerical Weather Prediction



# Characterizing the Atmosphere at Time 0

## Surface Data

**MICHIGAN STATE UNIVERSITY** | **Enviro-weather**  
Weather-based pest, natural resources, and production management tools

Tools for: Field crops | Fruit | Trees | Turfgrass | Vegetables | Landscape & Nursery | More weather

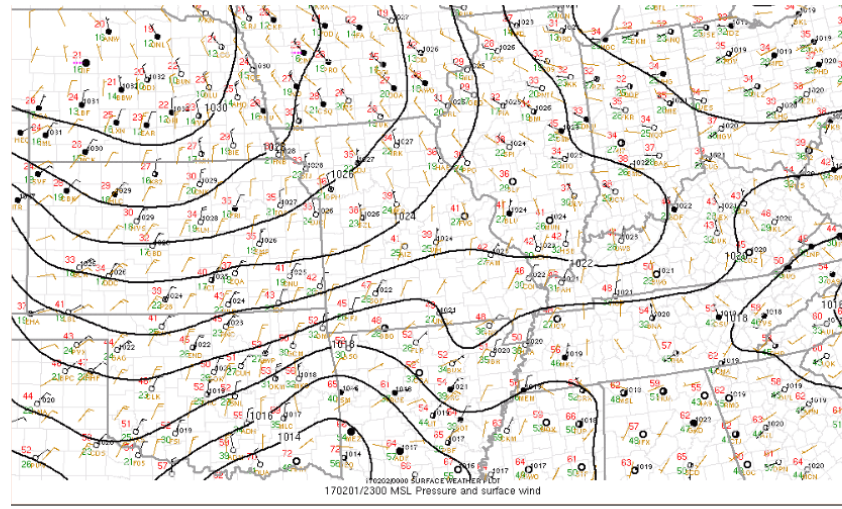
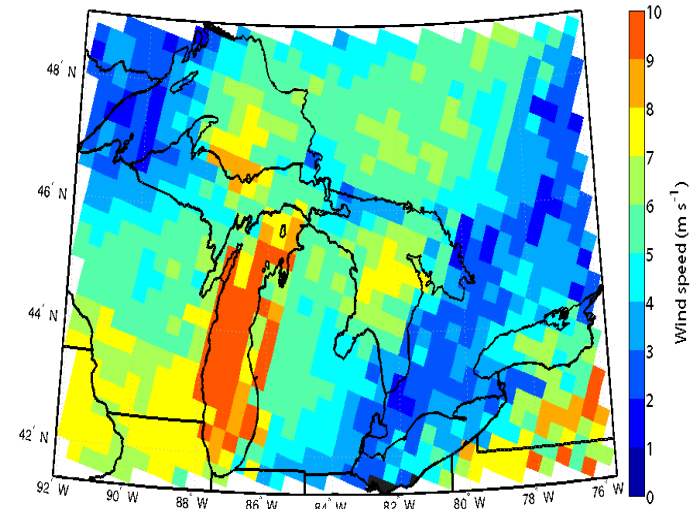
Show magnifier

Welcome to Enviro-weather!  
For weather-based tools: Click on a station on the map.  
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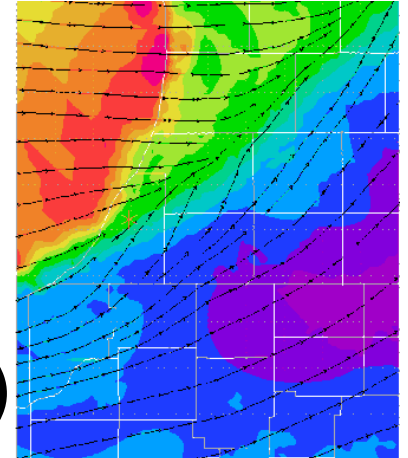
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Extension  
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Project GREEN

Contact information  
Website or text: [weather@msu.edu](mailto:weather@msu.edu) or (517) 432-6030  
Phone: (517) 432-6030  
Fax: (517) 355-4128



# Gridded Reanalysis Datasets



- Real Time Mesoscale Analysis (RTMA)
  - Generated at the National Centers for Environmental Prediction (NCEP), a division of the National Weather Service (NWS)
  - First guess (i.e., background): 1-hr forecast from
    - Rapid Update Cycle (RUC) / Rapid Refresh (RAP) models
  - Large number of observations assimilated (ASOS\*, mesonet, satellite wind, etc.)
  - Includes precipitation analysis (Stage II)
  - Grid spacing: 2.5 km (5 km recently phased out)
  - Temporal frequency: hourly

\* Automated Surface Observing System

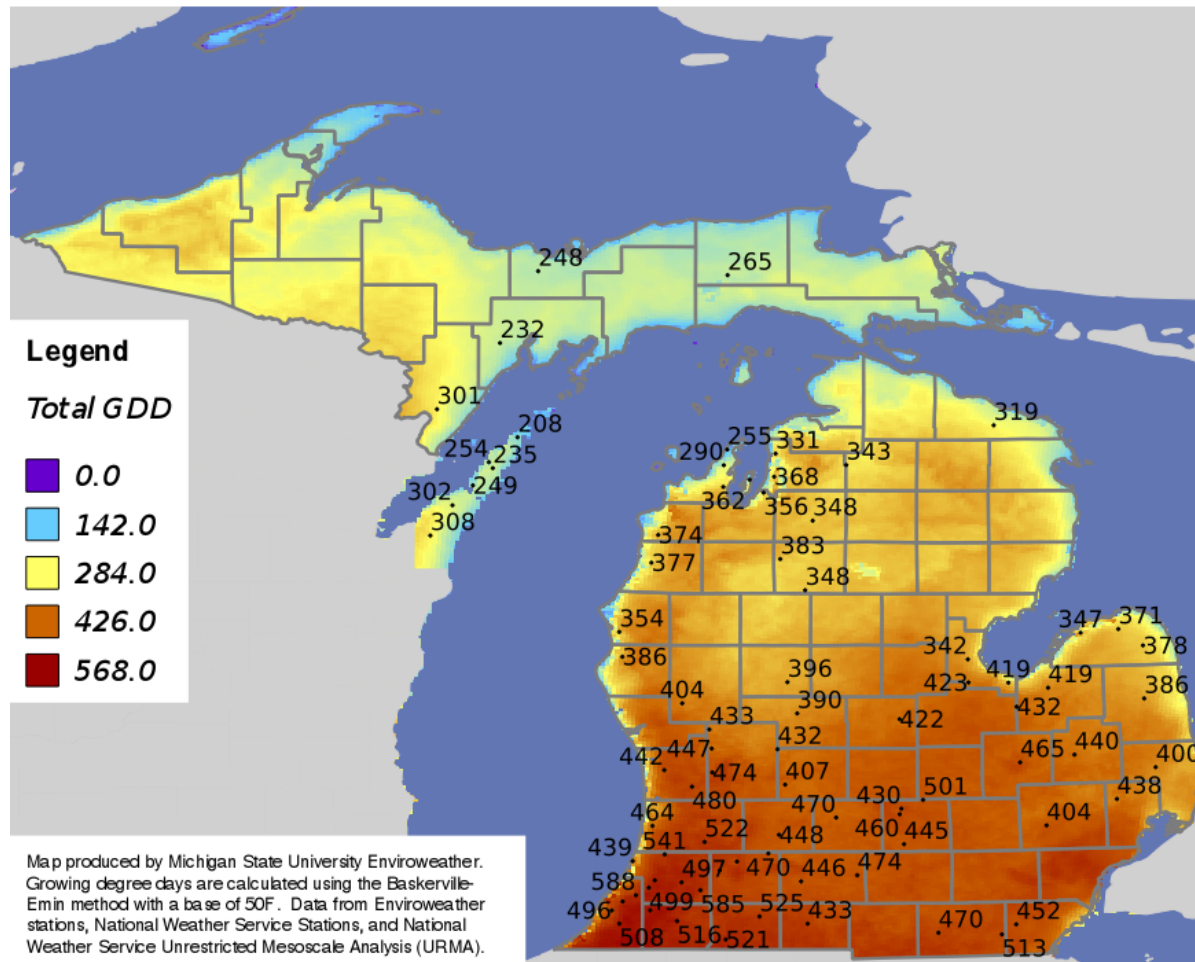
## 'Off-Site' Weather Data

- Uses objective analyses to estimate variable at desired site(s)
- May offer cost effective alternative to on-site instruments
- Effectiveness may be limited by sensitivity of management application used



# New Combined Enviro-weather/Gridded Data Products

## Cumulative Growing Degree-Days (50F) March 1 - May 30, 2016



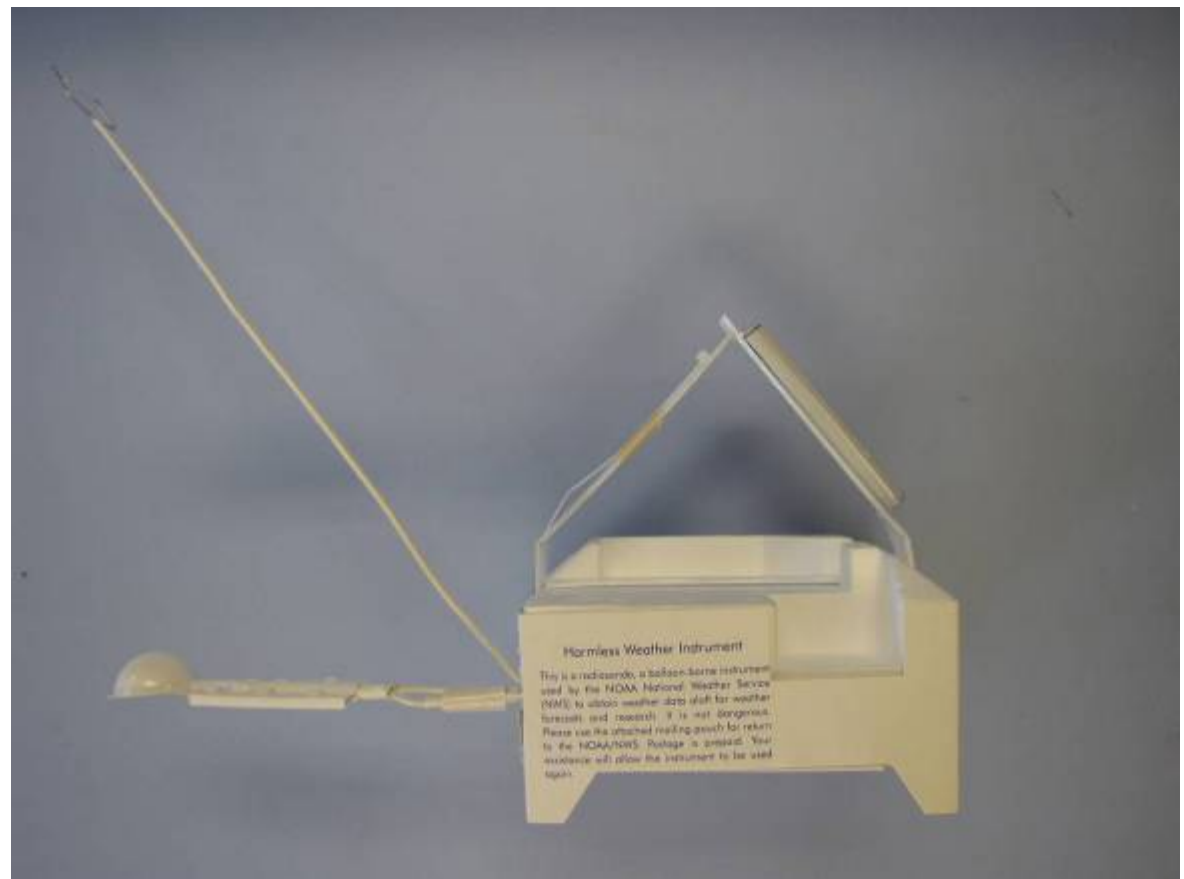
# Limitations of Reanalyses and Gridded Data Sets

- “Reanalyses inherit the errors of their constituent observing systems, though they have the advantage of seeking a degree of consensus among various observing systems through the constraints of model physics.” [CCSP Synthesis and Assessment Product 1.1]

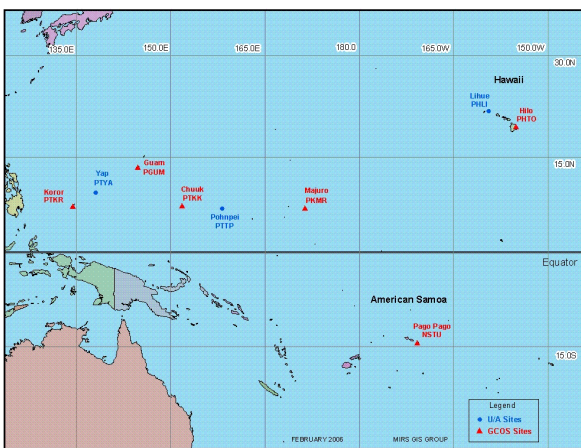
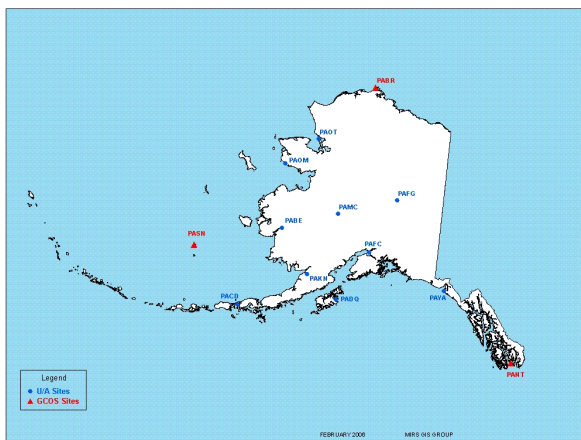
Moral: while they may be spatially and temporally continuous, be very cautious in their application as they may not contain any more base information than what you would have from the original data series.

# Characterizing the Atmosphere at Time 0

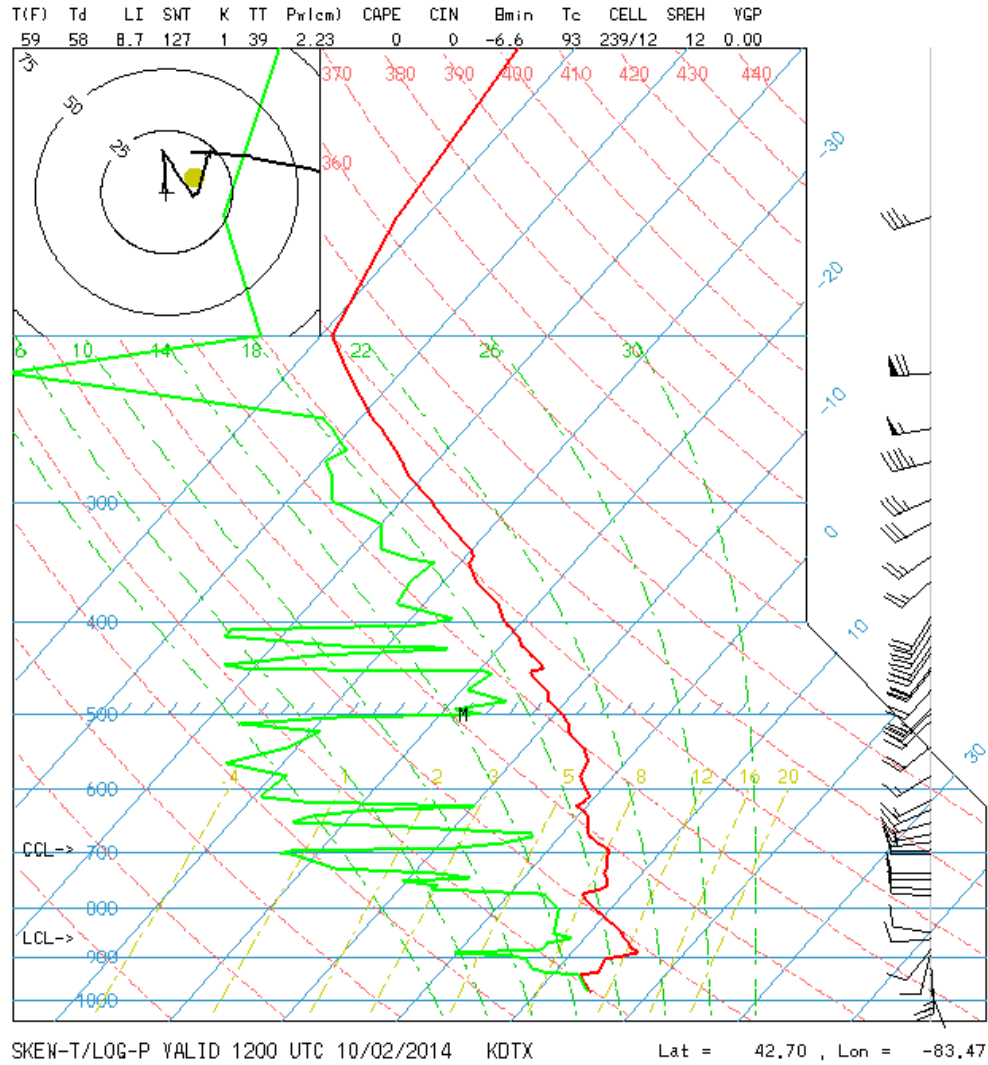
## Radiosonde Basics



# The NWS Radiosonde Network 2014



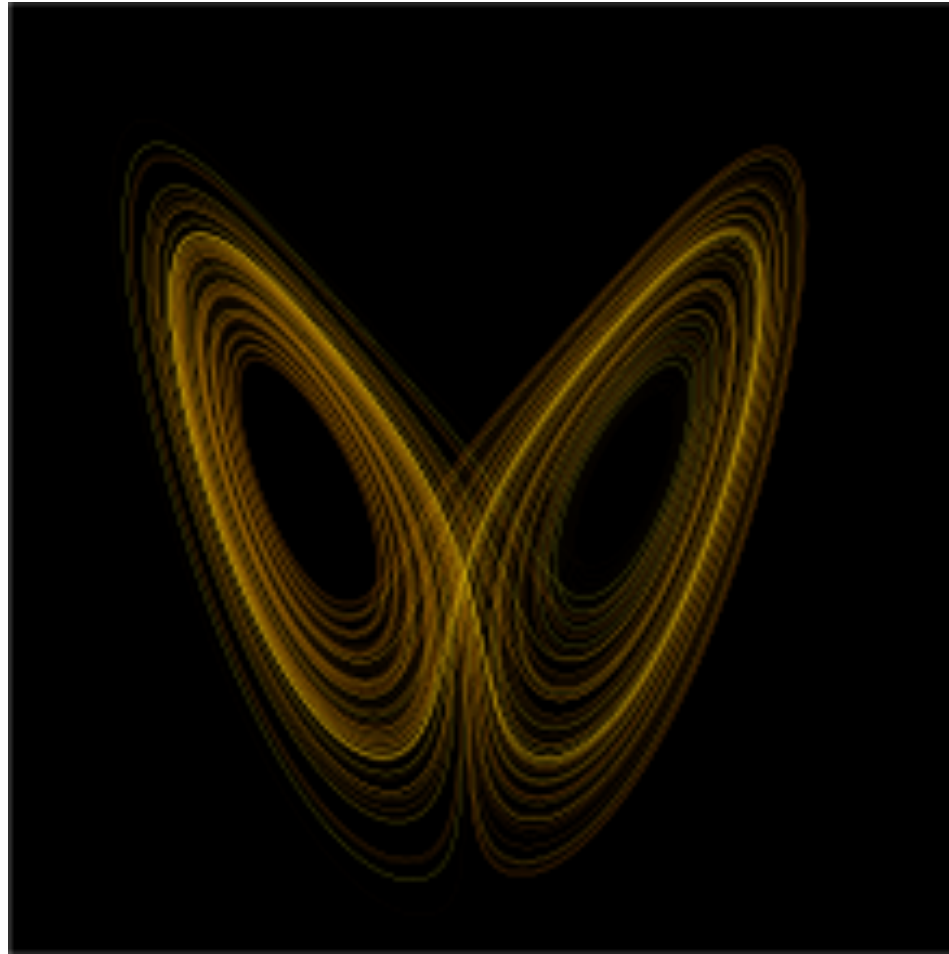
# Radiosonde Data



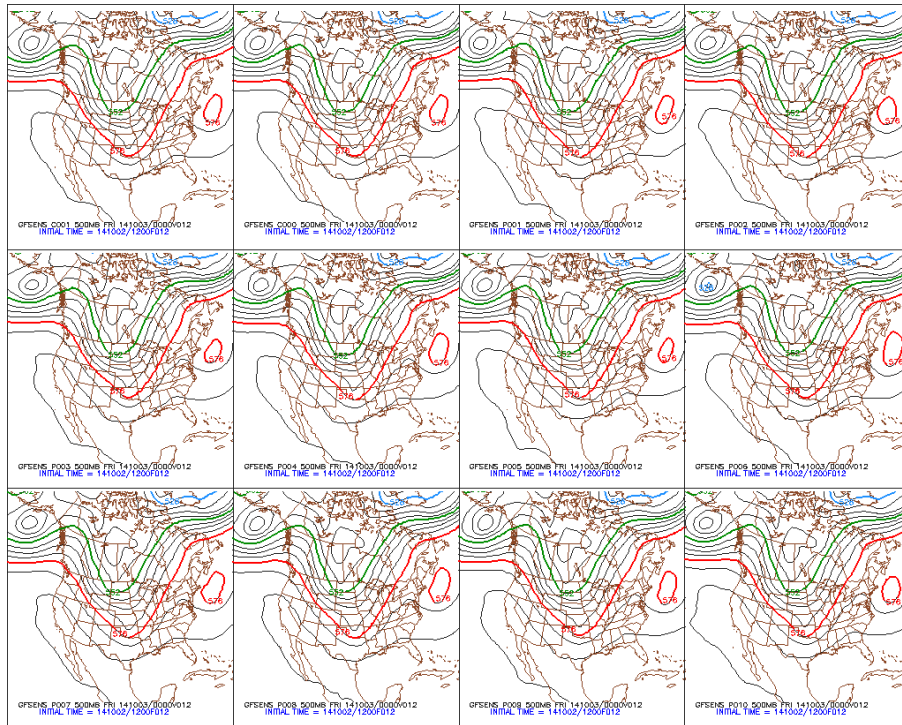
# Limitations to Numerical Forecast Lead Time Length

- Observation systems
- Numerical models (understanding of the atmosphere)
- Computing power

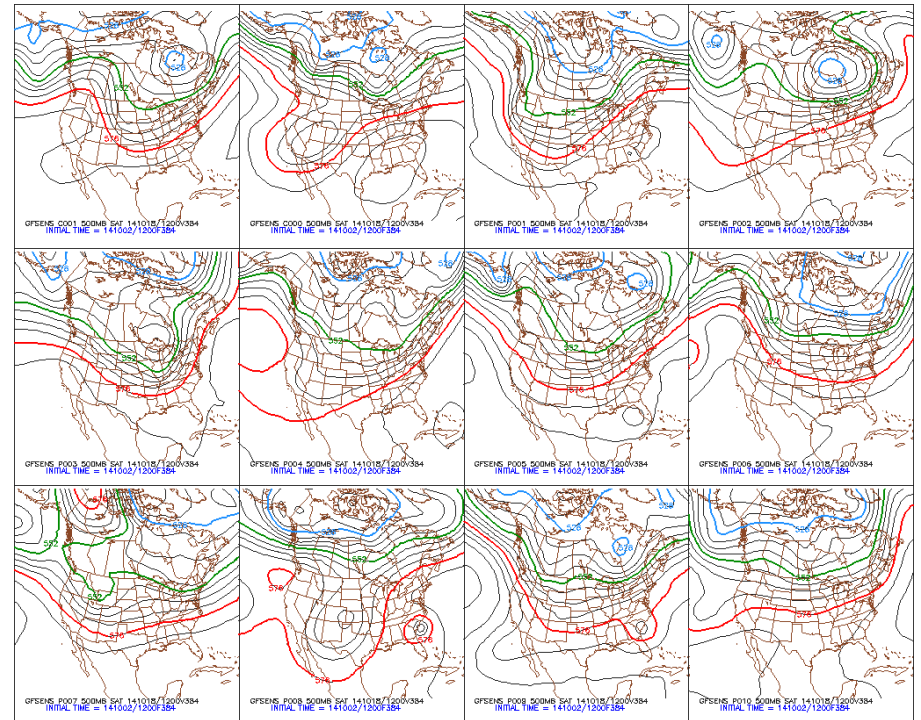
# Weather Prediction and Chaotic Dynamics



# Ensemble Forecasts



GFS 12 hour forecast ensemble

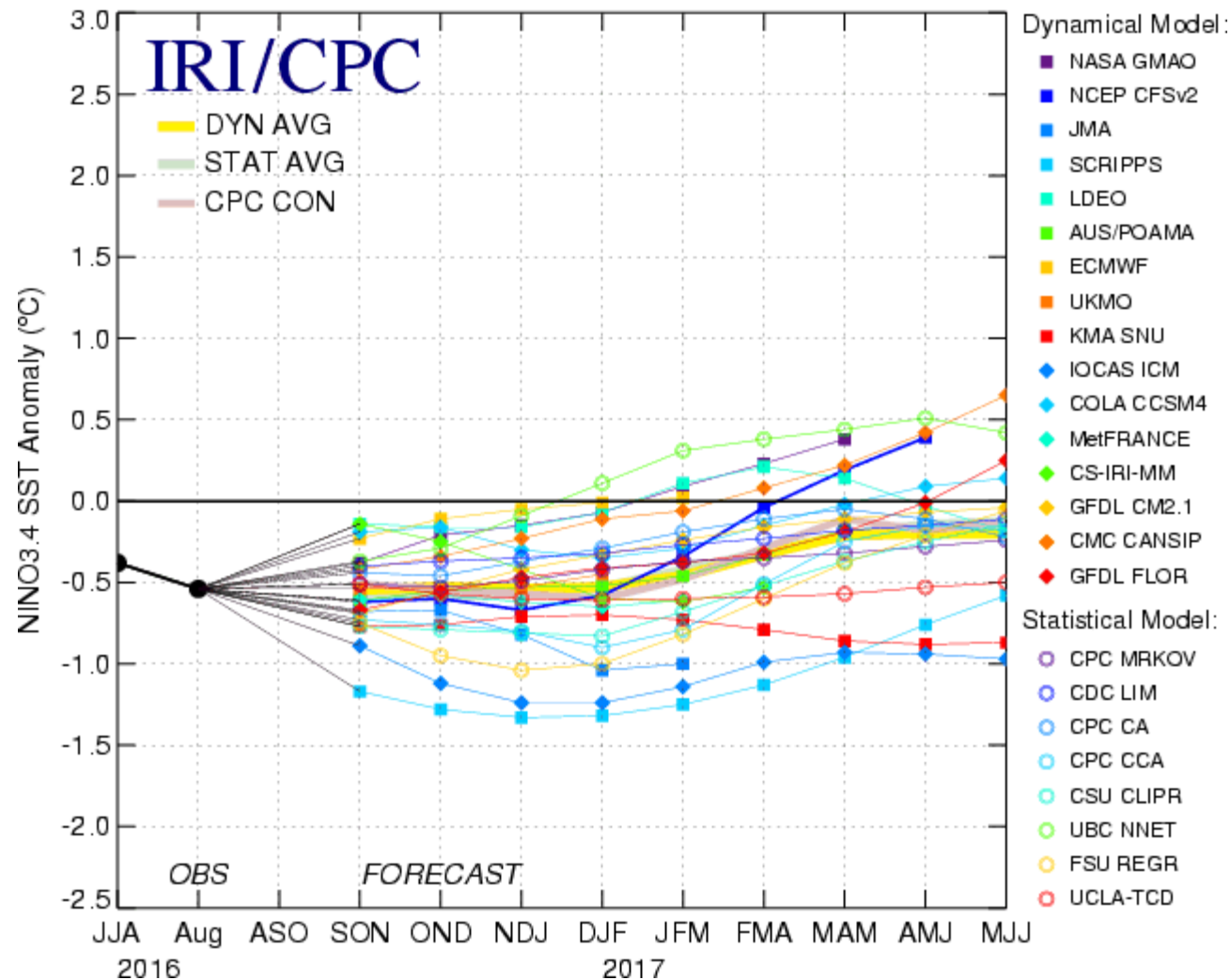


GFS 384 hour forecast ensemble



# Superensemble Forecasts

Mid-Sep 2016 Plume of Model ENSO Predictions



# Current Weather Forecast Technologies

# Forecast Lead Times and Approaches



Statistical

Hybrid



Dynamic,  
Numerical  
Forecast  
Guidance

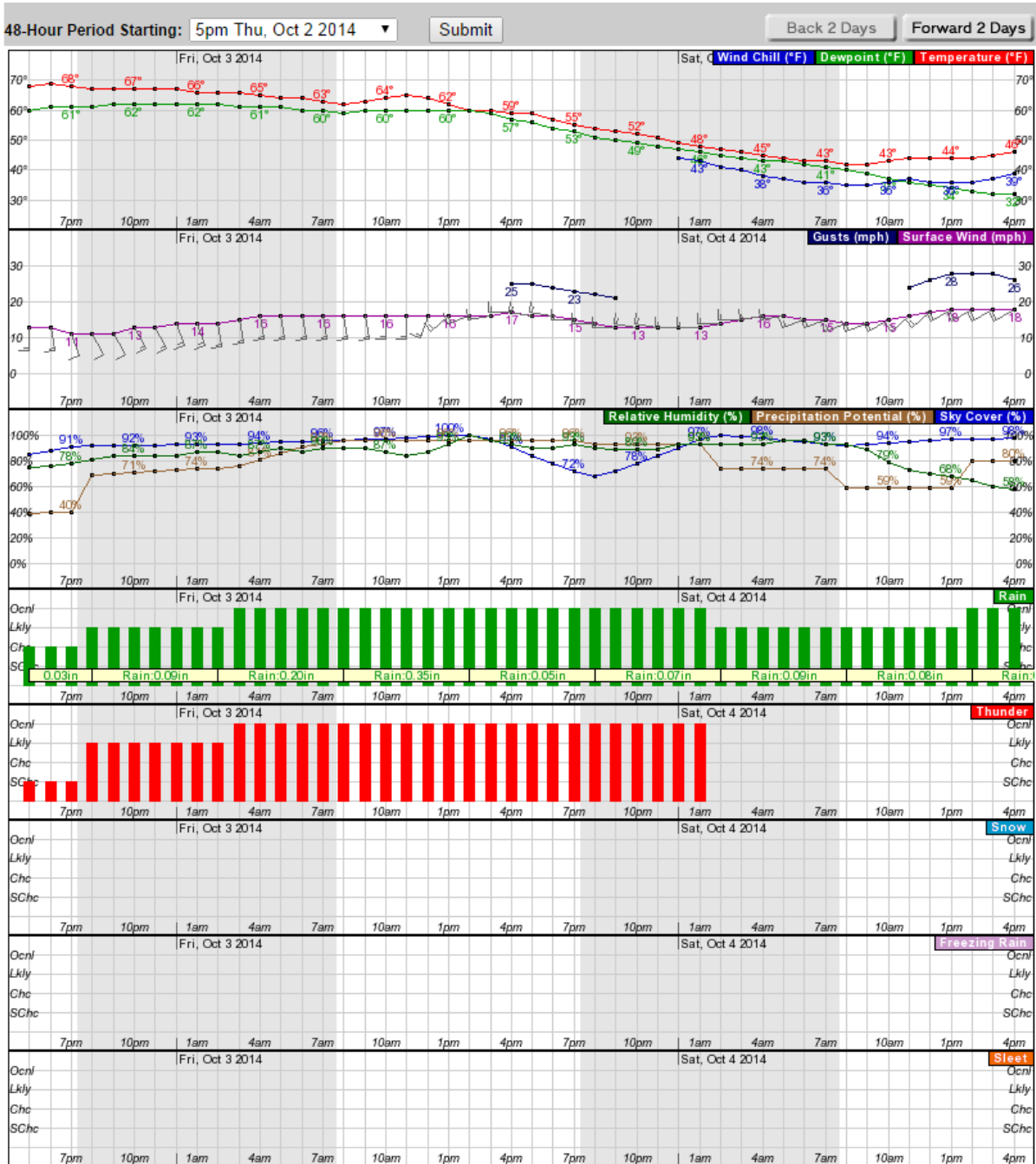
# Traditional NWS Forecast Format

MIZ067-110815-  
INGHAM-  
INCLUDING THE CITY OF...LANSING  
339 PM EDT MON OCT 10 2016

.TONIGHT...PARTLY CLOUDY. LOWS IN THE UPPER 40S. SOUTH WINDS 5 TO  
10 MPH.  
.TUESDAY...PARTLY SUNNY. HIGHS IN THE UPPER 60S. SOUTH WINDS AROUND  
10 MPH.  
.TUESDAY NIGHT...PARTLY CLOUDY. LOWS IN THE LOWER 50S. SOUTH WINDS  
AROUND 10 MPH.  
.WEDNESDAY...MOSTLY SUNNY UNTIL MIDDAY...THEN SHOWERS AND  
THUNDERSTORMS LIKELY IN THE AFTERNOON. HIGHS IN THE LOWER 70S.  
SOUTHWEST WINDS 10 TO 20 MPH. CHANCE OF RAIN 60 PERCENT.  
.WEDNESDAY NIGHT...SHOWERS AND THUNDERSTORMS IN THE EVENING...THEN A  
CHANCE OF RAIN SHOWERS OVERNIGHT. LOWS IN THE UPPER 40S. SOUTHWEST  
WINDS AROUND 15 MPH BECOMING NORTHWEST OVERNIGHT. CHANCE OF RAIN  
90 PERCENT.  
.THURSDAY...MOSTLY SUNNY. HIGHS IN THE MID 50S.  
.THURSDAY NIGHT...MOSTLY CLEAR. AREAS OF FROST. LOWS IN THE UPPER  
30S.  
.FRIDAY...SUNNY. HIGHS IN THE UPPER 50S.  
.FRIDAY NIGHT...MOSTLY CLEAR. LOWS IN THE MID 40S.  
.SATURDAY...MOSTLY SUNNY. HIGHS IN THE MID 60S.  
.SATURDAY NIGHT...PARTLY CLOUDY WITH A 40 PERCENT CHANCE OF RAIN  
SHOWERS. LOWS IN THE MID 50S.  
.SUNDAY...PARTLY SUNNY WITH A 40 PERCENT CHANCE OF RAIN SHOWERS.  
HIGHS IN THE UPPER 60S.  
.SUNDAY NIGHT...PARTLY CLOUDY. LOWS IN THE LOWER 50S.  
.MONDAY...MOSTLY SUNNY UNTIL MIDDAY THEN BECOMING PARTLY SUNNY.  
HIGHS IN THE UPPER 60S.

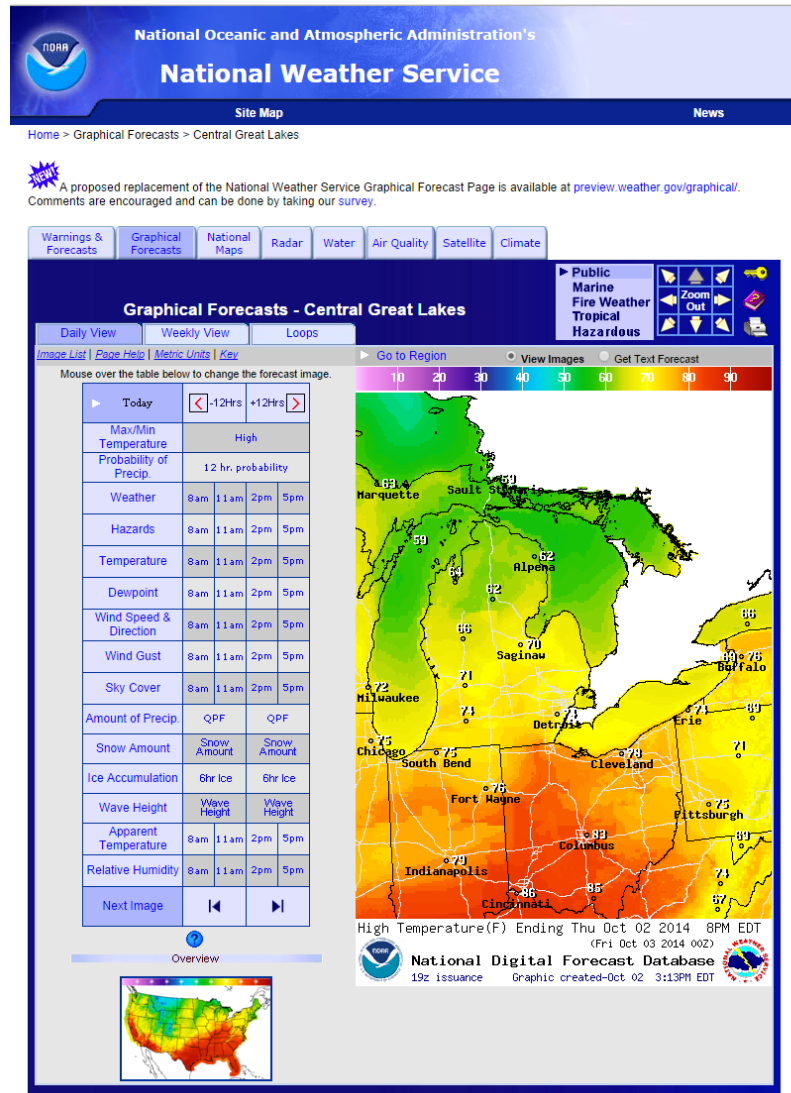
##

# NWS Detailed Short Term Guidance




**Saturday, October 4 at 11am**  
 Temperature: 44 °F Dewpoint: 36 °F Wind Chill: 37 °F Surface Wind: SW 16G24mph  
 Sky Cover (%): 95% Precipitation Potential (%): 59% Relative Humidity (%): 73%  
 Rain: Likely (60%-70%) Thunder: <10% Snow: <10% Freezing Rain: <10% Sleet: <10%


# Current National Digital Forecast Data



# New NWS Graphical Forecast Format (March 2017)



**NATIONAL WEATHER SERVICE**  
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION



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## Graphical Forecasts

Weather.gov - National Digital Forecast Database Graphical Forecasts

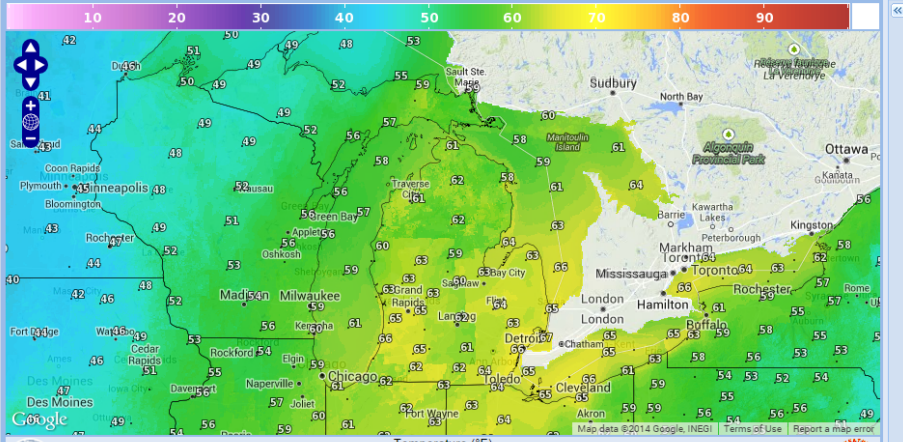
National Weather Service  
National Headquarters


Below is a proposed replacement of the National Weather Service Graphical Forecast Page, a product of the National Digital Forecast Database. Comments are encouraged and can be done by taking our survey. Assistance with using this experimental product can be found by clicking here or on the Page Help Link below the map.

National Digital Forecast Database Experimental Display

National (CONUS) Temperature (°F)
At Oct 3, 8 AM EDT

Thu
Fri
Sat
Sun
Mon
Tue
Wed






Temperature (°F)

Valid at: Fri, 03 Oct 2014 12 UTC (Fri, Oct 3 2014, 8 AM EDT)

Issued: Oct 02 at 20 UTC



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National (CONUS)
Alaska
Hawaii
Guam
Puerto Rico
Tropical Atlantic
Tropical Pacific

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- NWS CAP Feeds

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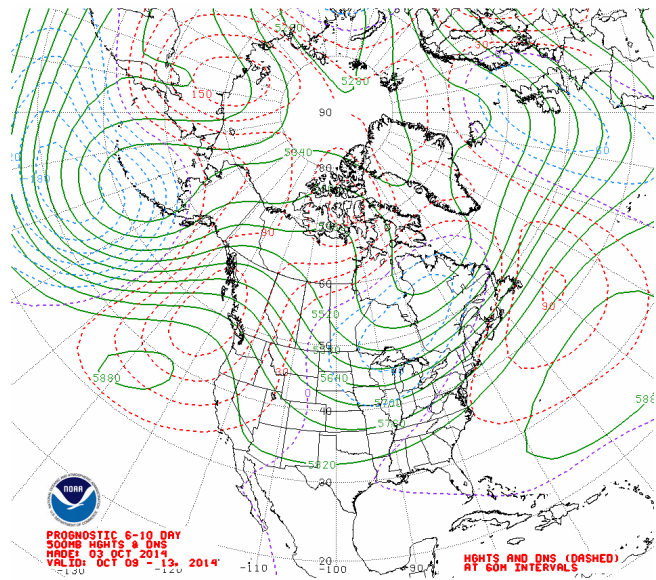
**EDUCATION**

- NOAA Economics Brochures
- NOAA Education Resources
- For Teachers
- For Students
- Play Time for Kids
- NOAA Library
- NWS Training Portal
- JetStream
- Glossary
- Other Links

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- International
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- Products and Services
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# CPC Medium Range Outlooks



## 6 to 10 Day Outlooks

Valid: October 08 2014 to October 12 2014

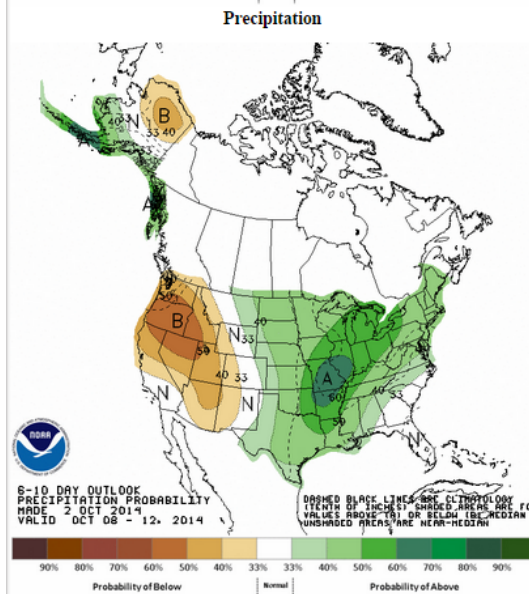
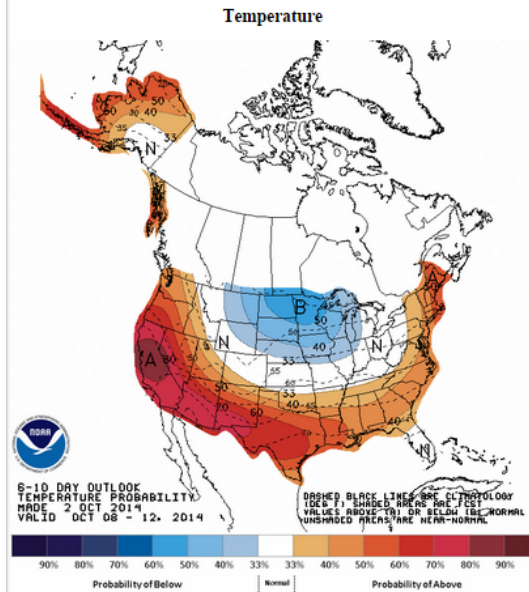
Updated: 02 Oct 2014

Click below for information about how to read 6-10 day outlook maps

[Temperature](#) [Precipitation](#)

Click below for archives of past outlooks (data & graphics), historical analogs to today's forecast, and other formats of the 6-10 day outlooks

[Archives](#) [Analog](#) [Lines-Only](#) [Format](#) [GIS Data](#)



## 8 to 14 Day Outlooks

Valid: October 10 2014 to October 16 2014

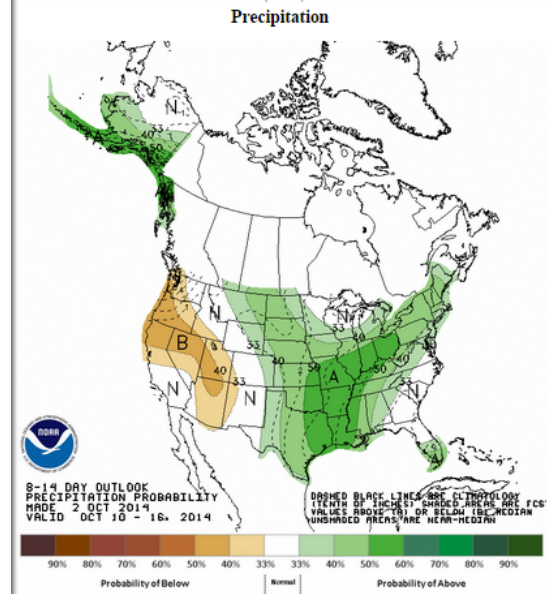
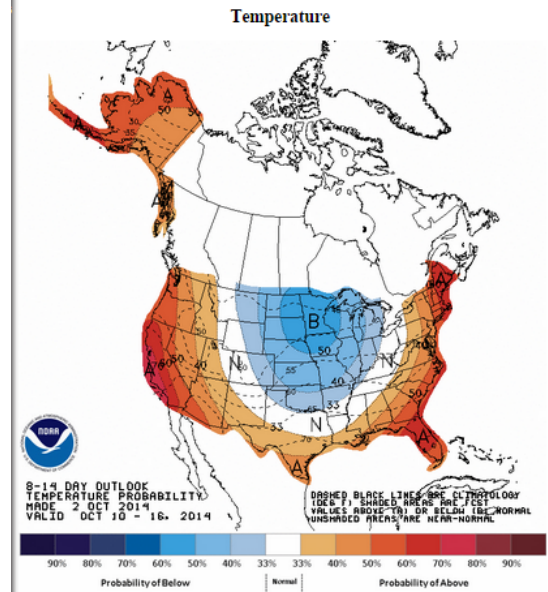
Updated: 02 Oct 2014

Click below for information about how to read 8-14 day outlook maps

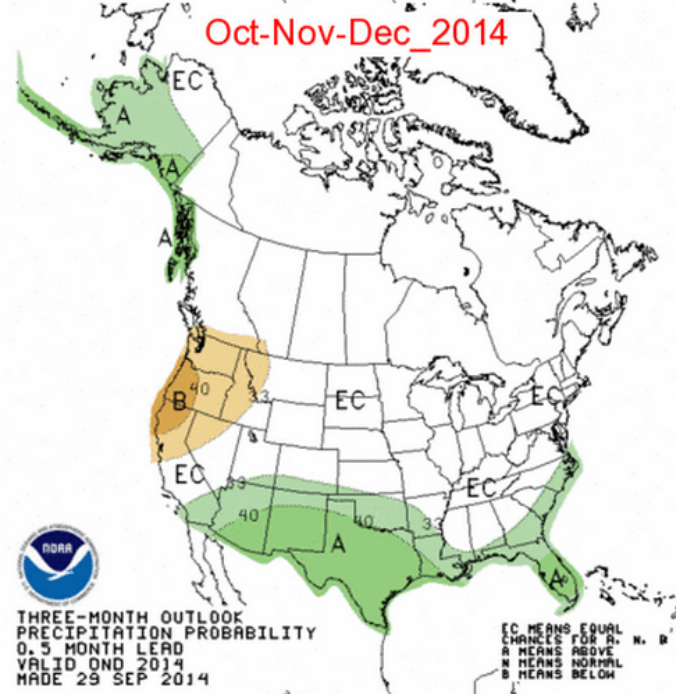
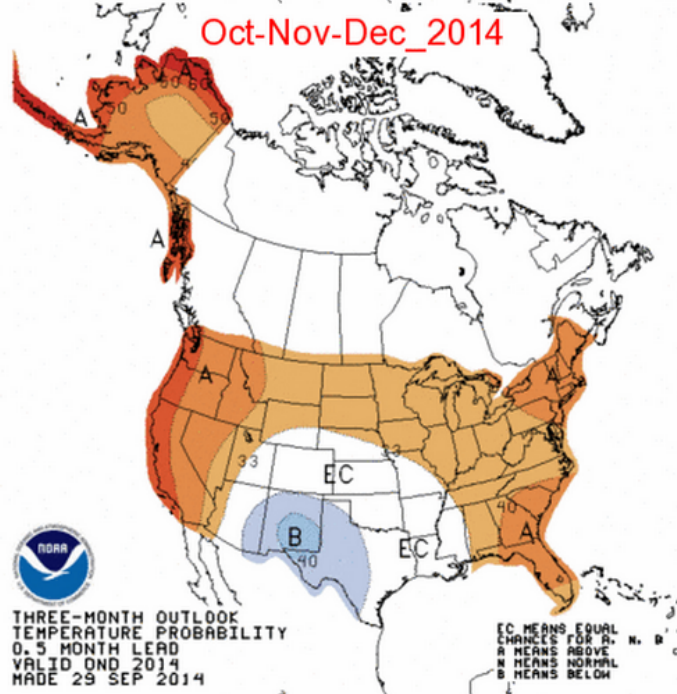
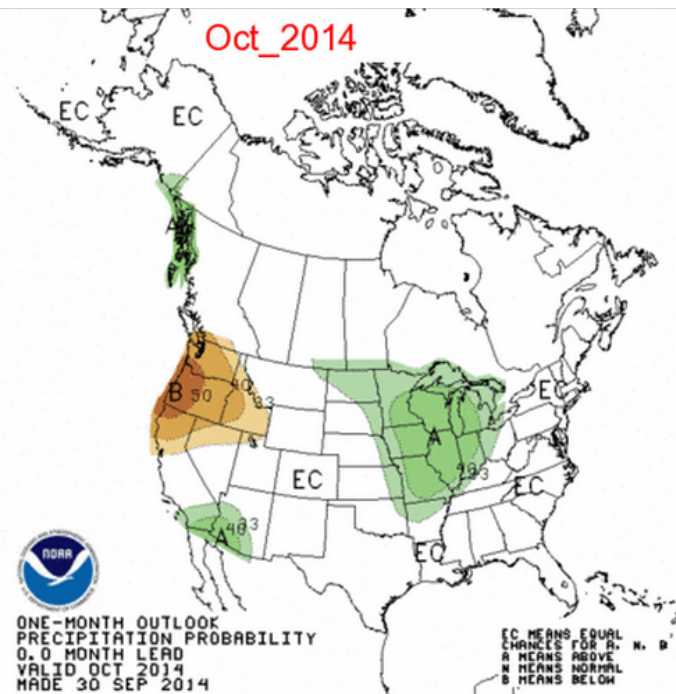
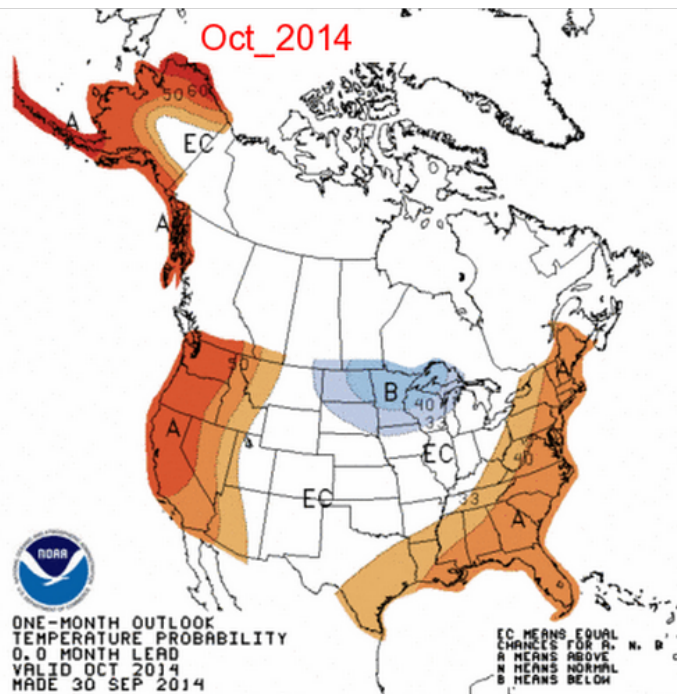
[Temperature](#) [Precipitation](#)

Click below for archives of past outlooks (data & graphics), historical analogs to today's forecast, and other formats of the 8-14 day outlooks

[Archives](#) [Analog](#) [Lines-Only](#) [Format](#) [GIS Data](#)







# Expected Forecast Skill

# Forecast Skill Generalities

- The longer the forecast lead time, the less the expected skill of the outlook
- For most of the mid-latitudes, there is a discernible seasonality of the forecast products. In the USA, most skillful outlooks are generally associated with the winter season.
- Expected forecast skill also depends on the variable being forecast. Best skill is with temperature. Skill with precipitation and wind forecasts is significantly less.

## Weather forecast accuracy details for Lansing, Michigan

These are the one- to three-day out accuracy percentages for high temperature, low temperature, icon forecast precipitation (both rain and snow), and text forecast precipitation (both rain and snow). Temperature accuracy is the percentage of forecasts within three degrees. Precipitation accuracy is the percentage of correct forecasts. The forecasts are collected in the evening.

*Click on the headers to sort by that column.*

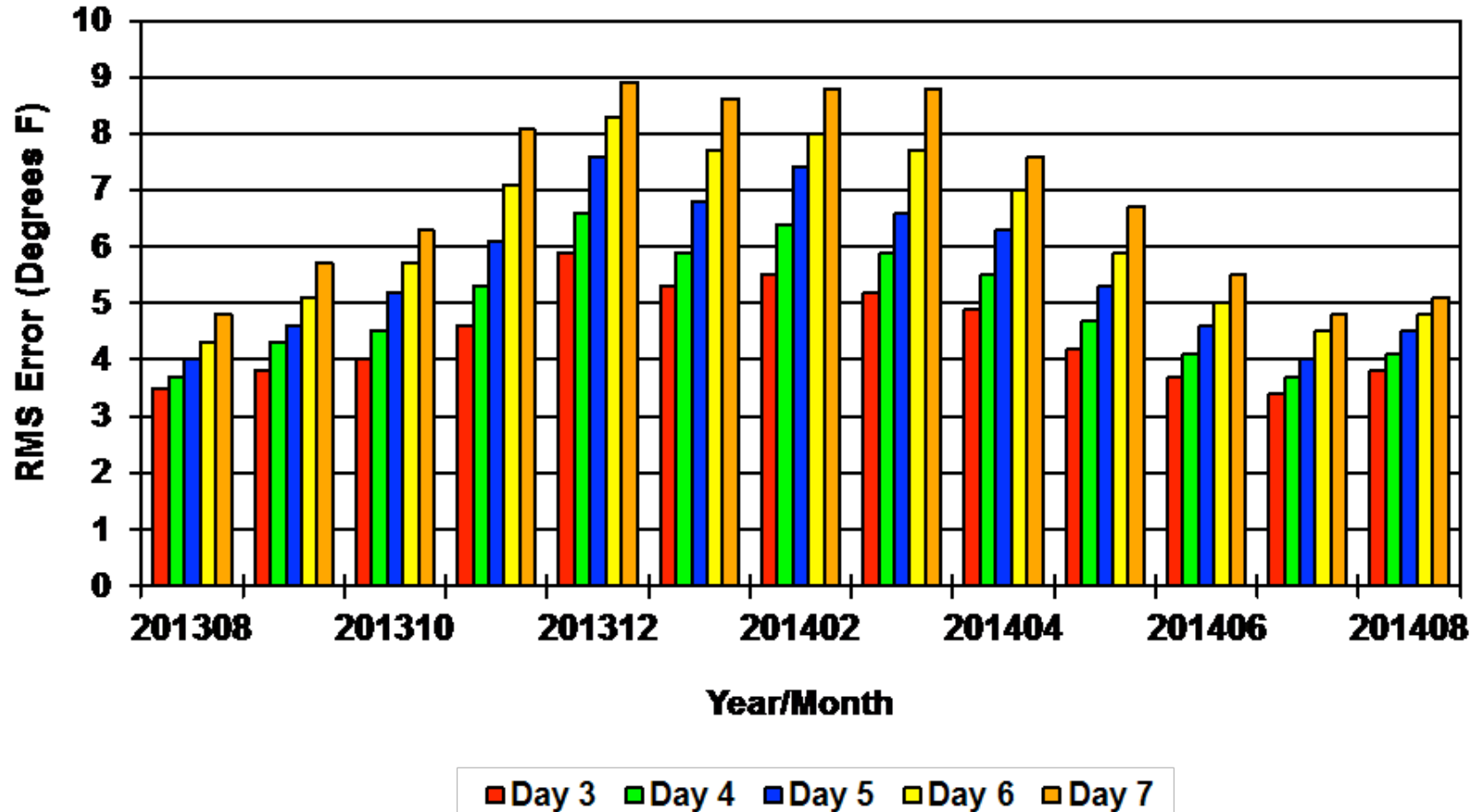
### Weather Forecast Accuracy Data Last Month

Provider	High Temp	Low Temp	Icon Precip	Text Precip	Overall
<a href="#">The Weather Channel</a>	84.44%	88.89%	70.00%	70.00%	78.33%
<a href="#">Weather Underground</a>	85.56%	86.67%	70.00%	70.00%	78.06%
<a href="#">Dark Sky (forecast.io)</a>	85.56%	74.44%	72.22%	72.22%	76.11%
<a href="#">MeteoGroup</a>	76.67%	75.56%	75.56%	75.56%	75.83%
<a href="#">AccuWeather</a>	79.31%	74.71%	72.41%	75.86%	75.57%
<a href="#">Foreca</a>	80.00%	75.56%	72.22%	72.22%	75.00%
<a href="#">NWS Digital Forecast</a>	83.33%	70.00%	67.78%	67.78%	72.22%
<a href="#">World Weather Online</a>	56.82%	33.33%	68.18%	68.18%	56.63%
<a href="#">Persistence</a>	44.83%	36.78%	59.77%	59.77%	50.29%

### Weather Forecast Accuracy Data Last Year

Provider	High Temp	Low Temp	Icon Precip	Text Precip	Overall
<a href="#">Weather Underground</a>	73.60%	72.35%	82.18%	82.18%	77.58%
<a href="#">The Weather Channel</a>	73.80%	72.54%	81.89%	81.89%	77.53%
<a href="#">AccuWeather</a>	72.17%	73.14%	79.90%	81.74%	76.74%
<a href="#">MeteoGroup</a>	71.58%	75.43%	79.00%	79.00%	76.25%
<a href="#">Foreca</a>	67.63%	68.89%	78.36%	78.36%	73.31%
<a href="#">Dark Sky (forecast.io)</a>	65.13%	64.07%	78.52%	78.52%	71.56%
<a href="#">NWS Digital Forecast</a>	67.39%	66.93%	70.83%	70.83%	68.99%
<a href="#">World Weather Online</a>	63.26%	33.24%	70.76%	70.76%	59.50%
<a href="#">Persistence</a>	28.67%	22.65%	53.70%	53.70%	39.68%

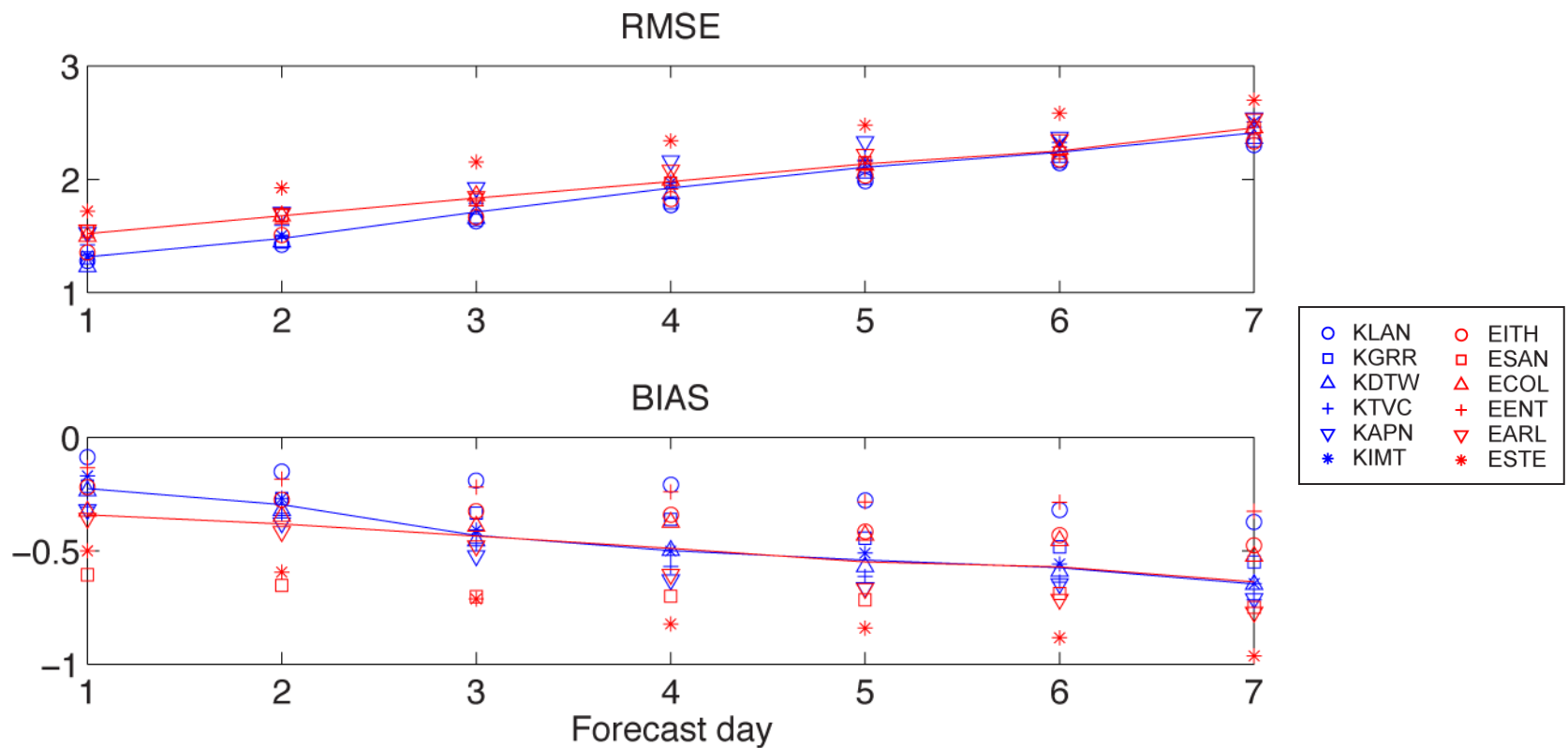
## WPC Medium Range RMS Errors Maximum Temperatures



# NDFD: Growing Degree Days\*

00 UTC forecast

\*Baskerville-Emin method

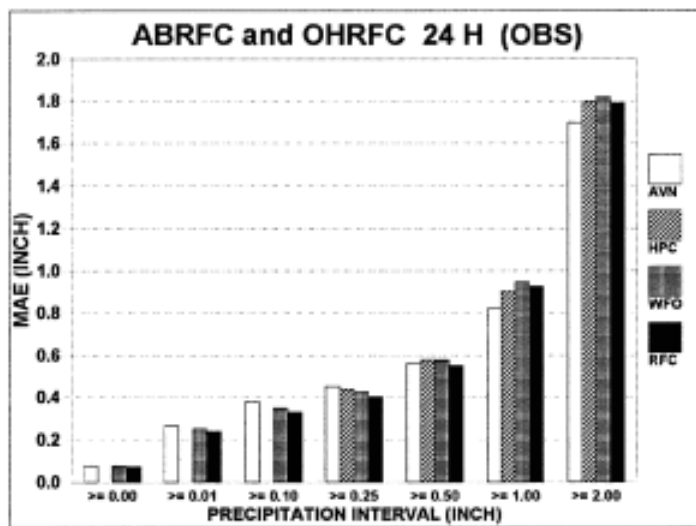


# Applications of MOS Guidance

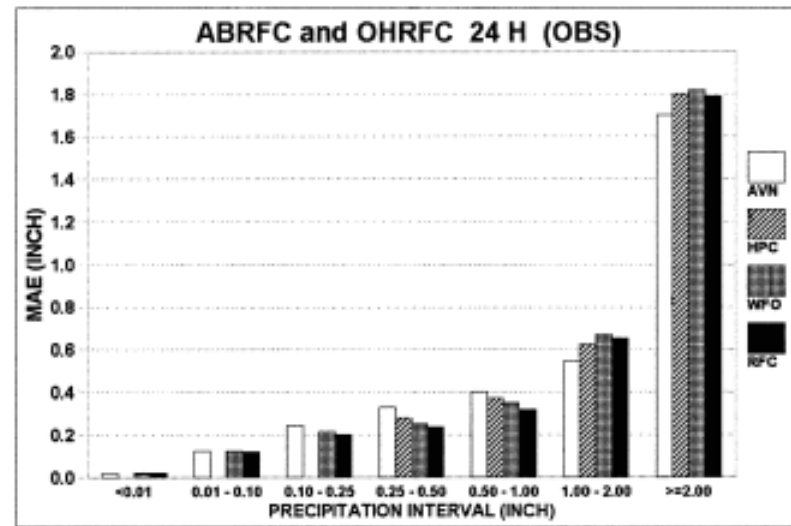
NO APPLY: 70% or greater chance of 0.5"+ in 24-hour period, or any % chance of 1"+ in 24-hour period

KLAN	<u>MOS 2-year-total</u>	<u>MOS Winter</u>	<u>MOS Spring</u>	<u>MOS Summer</u>	<u>MOS Autumn</u>
HIT (YES APPLY)	652	171	161	159	161
HIT (NO APPLY)	19	5	5	7	2
FALSE ALARM	14	0	3	3	8
MISS	21	0	11	6	4
KGRR	<u>MOS 2-year-total</u>	<u>MOS Winter</u>	<u>MOS Spring</u>	<u>MOS Summer</u>	<u>MOS Autumn</u>
HIT (YES APPLY)	649	167	164	157	161
HIT (NO APPLY)	18	3	5	5	5
FALSE ALARM	12	1	2	4	5
MISS	28	4	10	11	3
KDTW	<u>MOS 2-year-total</u>	<u>MOS Winter</u>	<u>MOS Spring</u>	<u>MOS Summer</u>	<u>MOS Autumn</u>
HIT (YES APPLY)	633	164	166	148	155
HIT (NO APPLY)	14	3	2	3	6
FALSE ALARM	13	1	5	4	3
MISS	28	6	6	9	7
KTVC	<u>MOS 2-year-total</u>	<u>MOS Winter</u>	<u>MOS Spring</u>	<u>MOS Summer</u>	<u>MOS Autumn</u>
HIT (YES APPLY)	662	172	167	163	160
HIT (NO APPLY)	10	2	5	0	3
FALSE ALARM	5	0	1	2	2
MISS	25	1	6	9	9
KAPN	<u>MOS 2-year-total</u>	<u>MOS Winter</u>	<u>MOS Spring</u>	<u>MOS Summer</u>	<u>MOS Autumn</u>
HIT (YES APPLY)	656	168	167	157	164
HIT (NO APPLY)	13	1	6	4	2
FALSE ALARM	8	0	5	2	1
MISS	21	3	2	9	7

# Forecasting Precipitation Amounts



(a)



(b)



# Forecast Skill Scores Have Increased Over Time

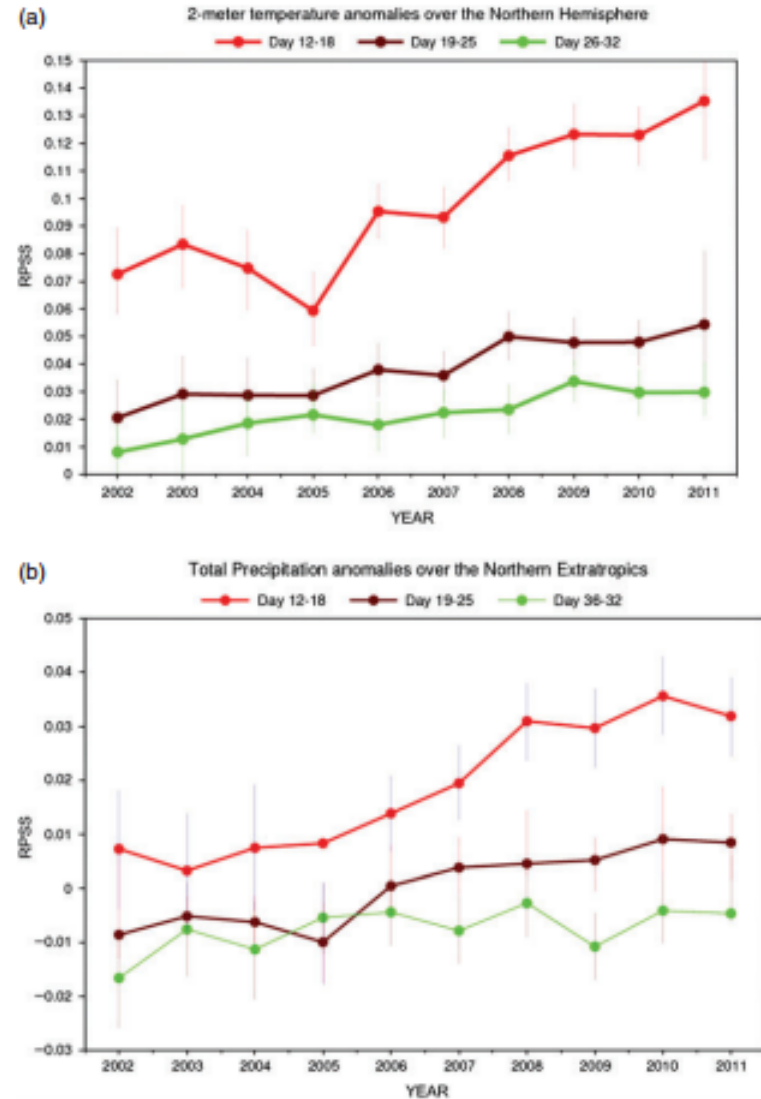


Figure 12. Evolution of the discrete ranked probability skill score (RPSS) of (a) 2 m temperature and (b) precipitation weekly mean anomalies over the Northern Extratropics (north of 30°N) since 2002. Only land points have been scored. The RPSS has been computed from terciles and for all the ECMWF reforecasts covering all seasons. The red line shows the RPSS of days 12–18, the brown line represents the RPSS of days 19–25 and the green line the RPSS of days 26–32.

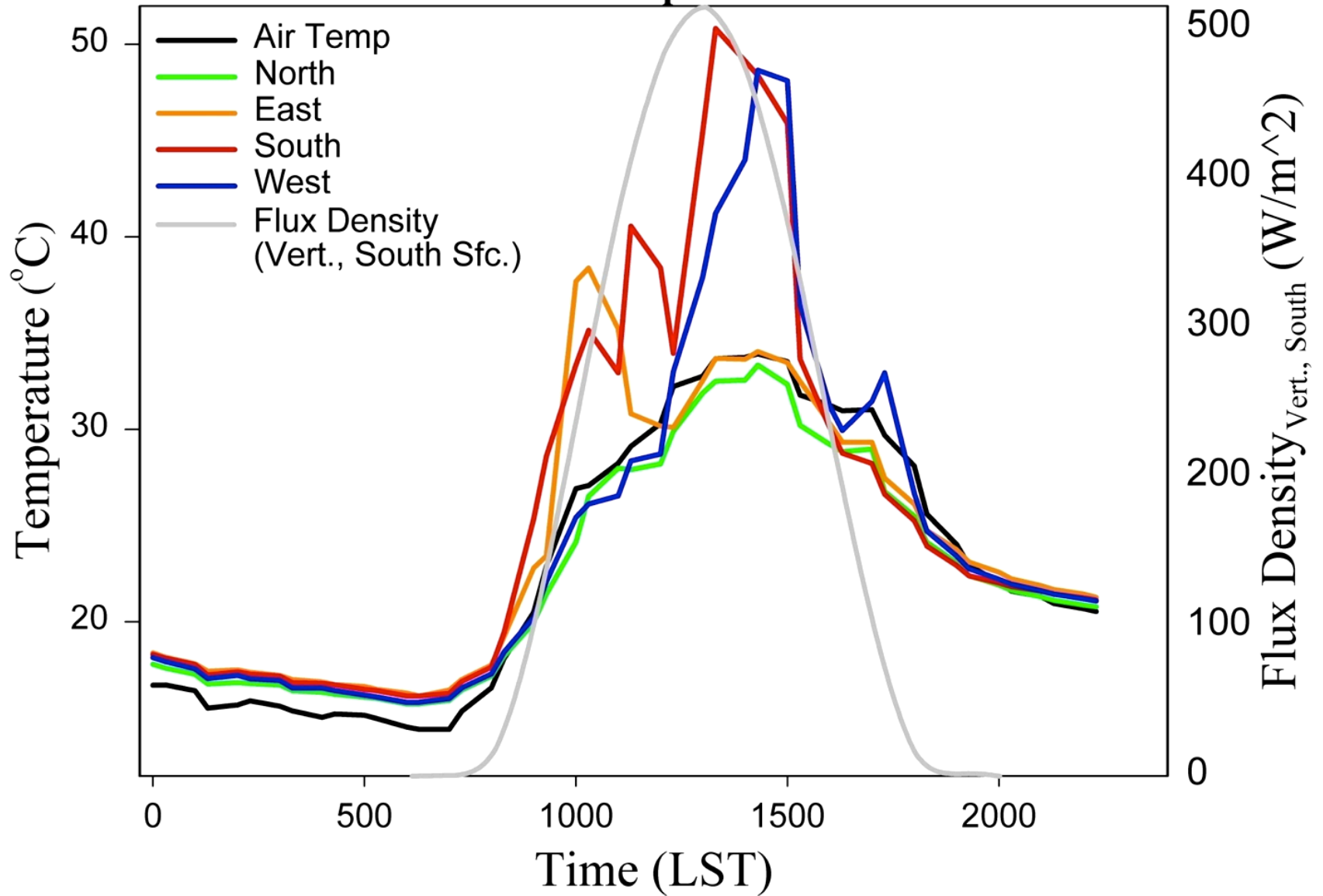
(From Vitart, 2014)

**Remember to Consider  
Microclimate!**

# 100cm Egg Mass Temperatures vs. Aspect

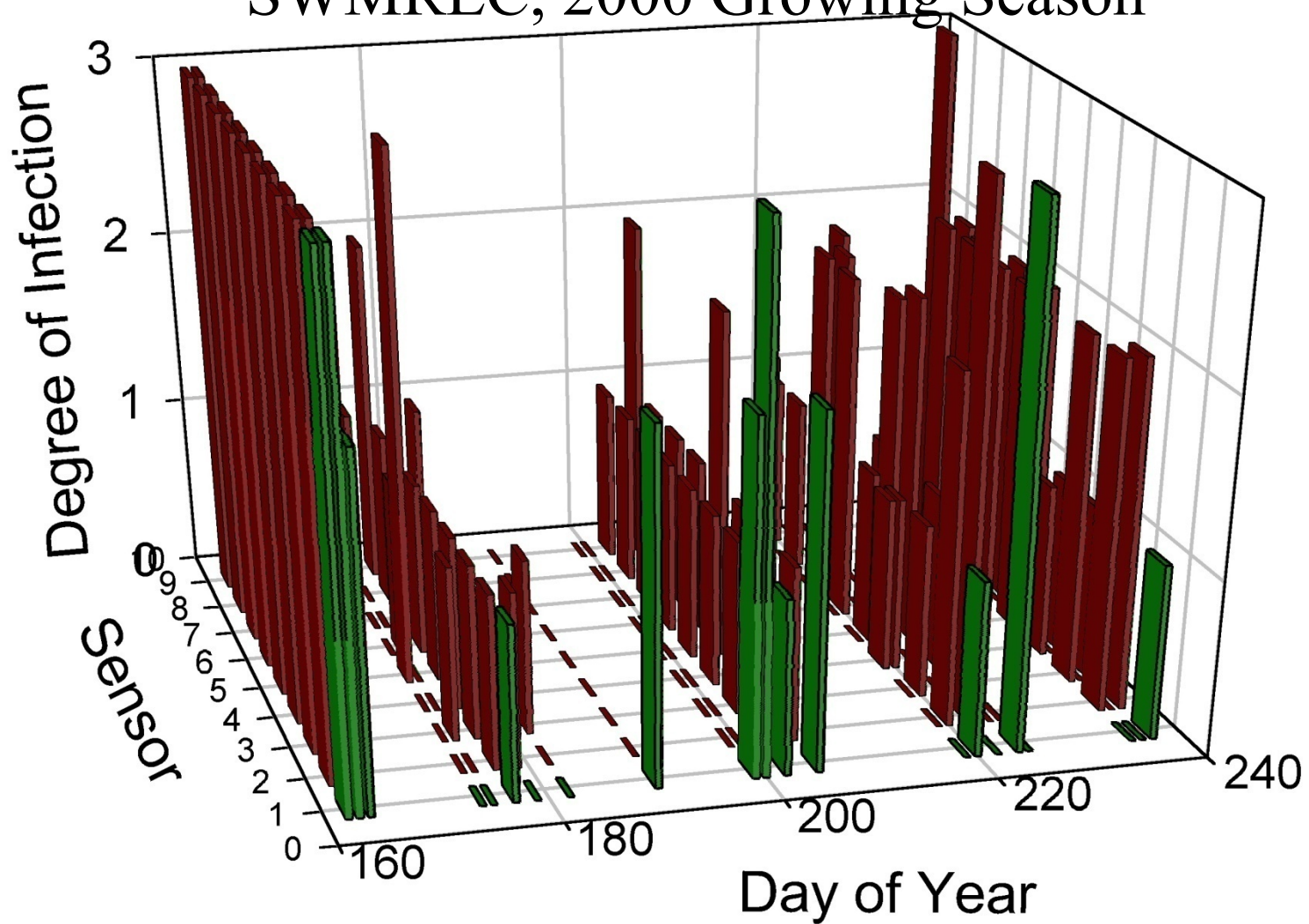
Kellogg Forest

12 Sep 1998



# Apple Scab Infection Frequency

SWMREC, 2000 Growing Season



# Summary

- Gridded reanalysis data may offer a cost effective option to on site observations. However, the applicability of the data depends on the sensitivity of the application to errors.
- Forecast skill decreases with increasing lead time. Expected skill may vary by the type of variable forecast, season, and region.
- Local microclimates can complicate weather-dependent decisions. Microclimates are most likely in relatively clear, calm conditions.