Deciphering Weather Forecasts for Making IPM Decisions

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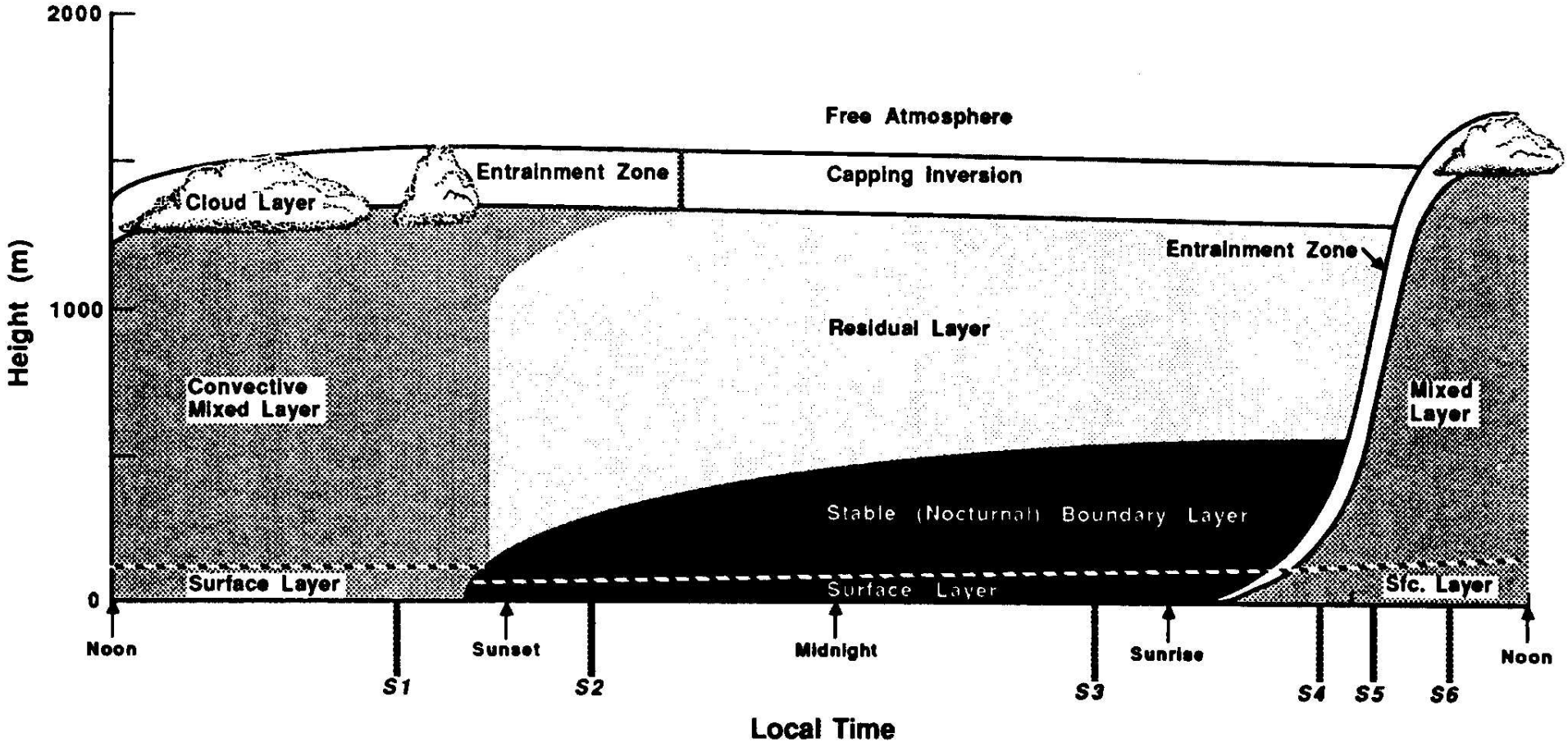
Idealized Boundary Layer Cross-Section



(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

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

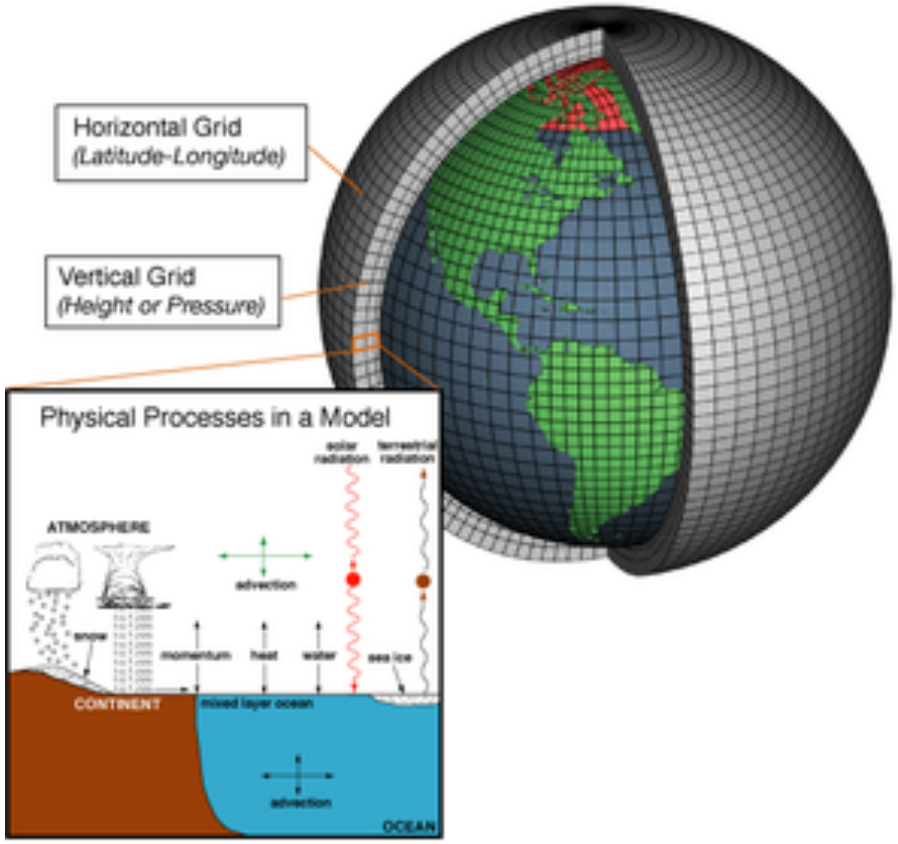
2)Continuity

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

3)Thermal energy

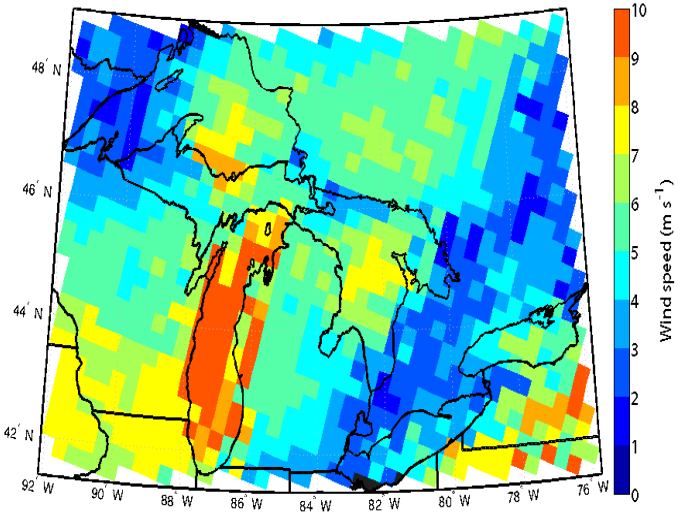
$$\rho c_v \frac{DT}{Dt} = -p\nabla \cdot \vec{v} - \nabla \cdot \vec{F} + k\nabla^2 T + \rho\dot{q},$$

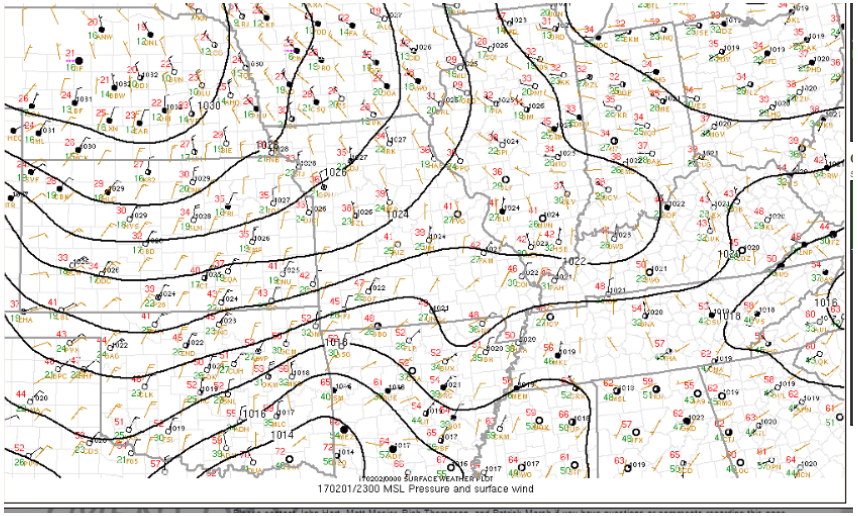
Numerical Weather Prediction



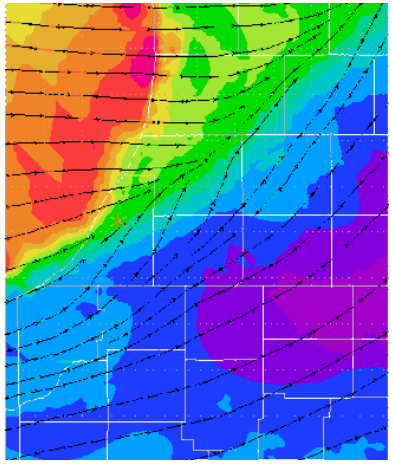
Characterizing the Atmosphere at Time 0

Surface Data





Gridded Reanalysis Datasets



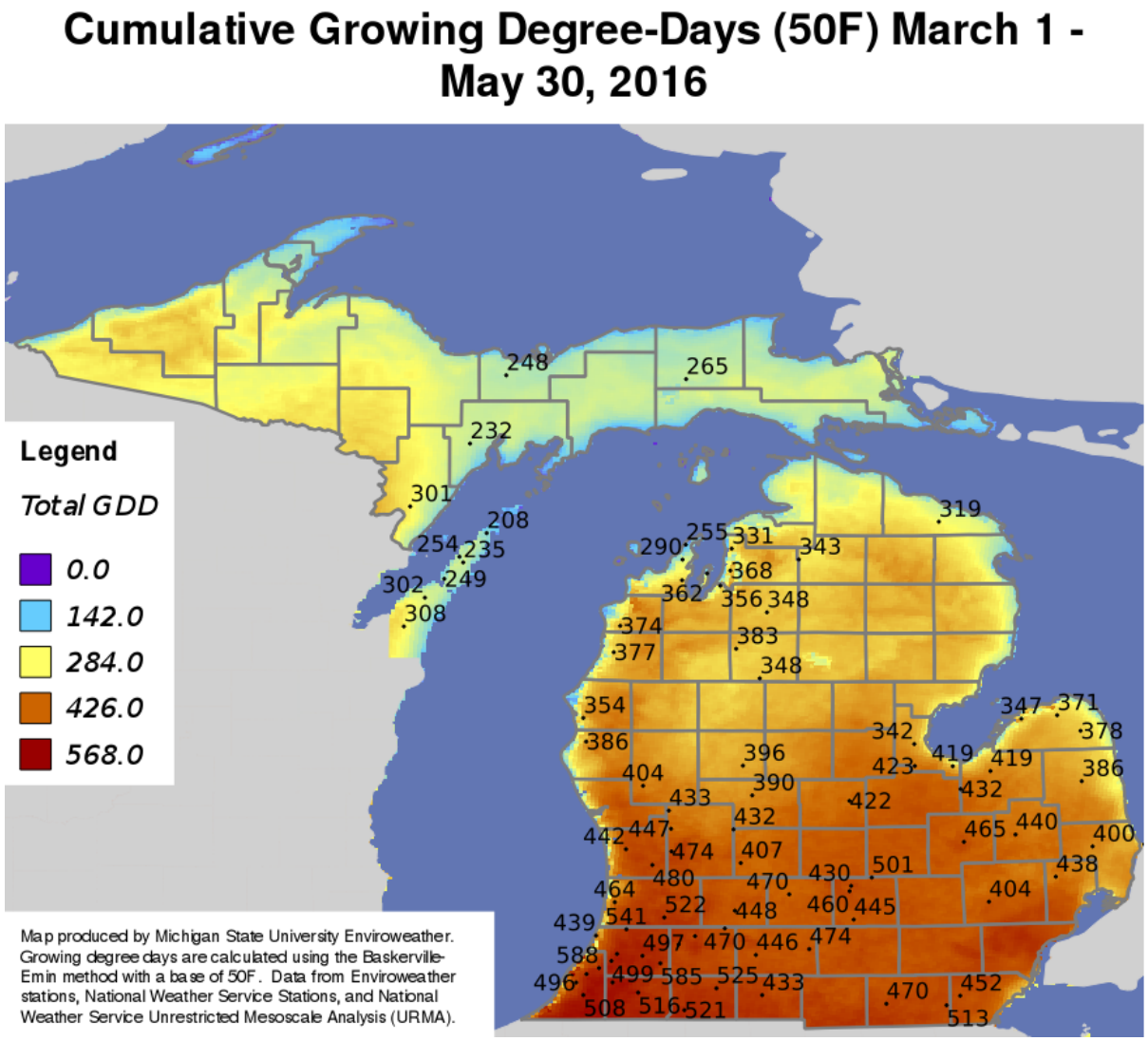
- Real Time Mesoscale Analysis (RTMA)
  - Generated at the National Centers for Environmental Prediction (NCEP), a division of the National Weather Service (NWS)
  - First guess (i.e., background): 1-hr forecast from
    - Rapid Update Cycle (RUC) / Rapid Refresh (RAP) models
  - Large number of observations 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 aplication used

New Combined Enviro-weather/Gridded Data Products



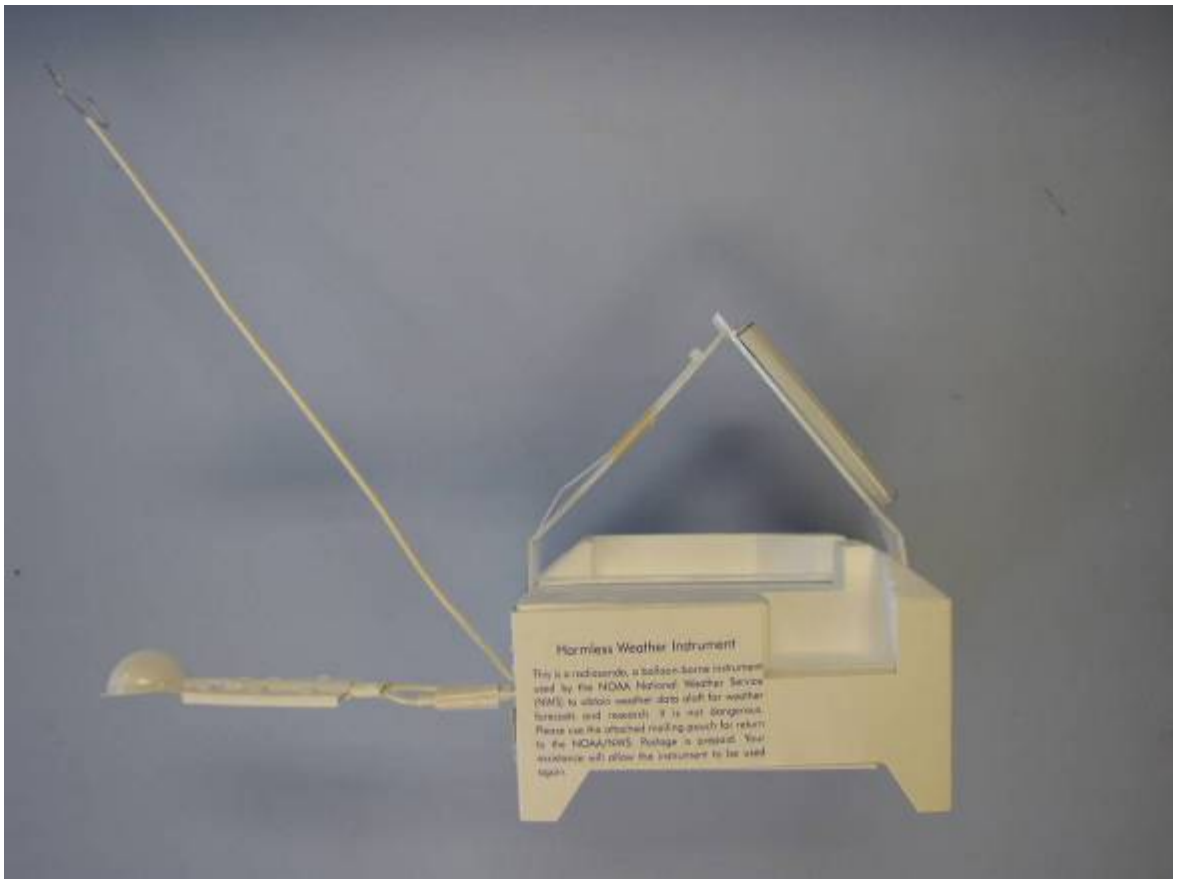
Limitations of Reanalyses and Gridded Data Sets

- “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.

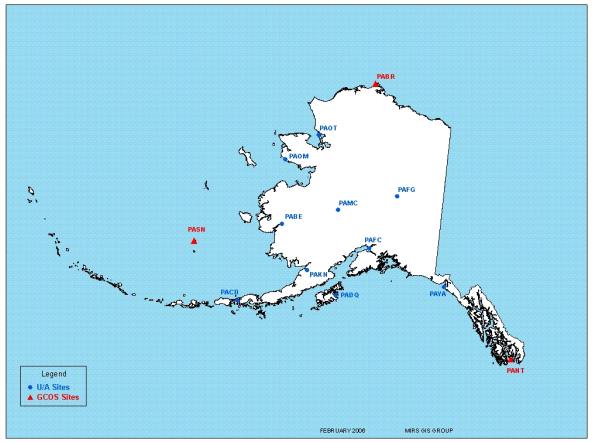
Characterizing the Atmosphere at Time 0

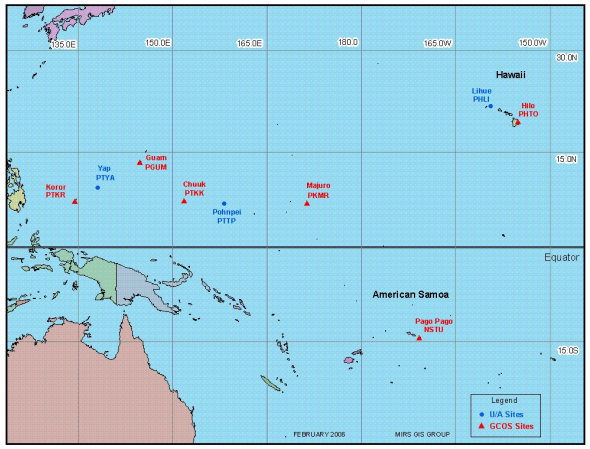
Radiosonde Basics

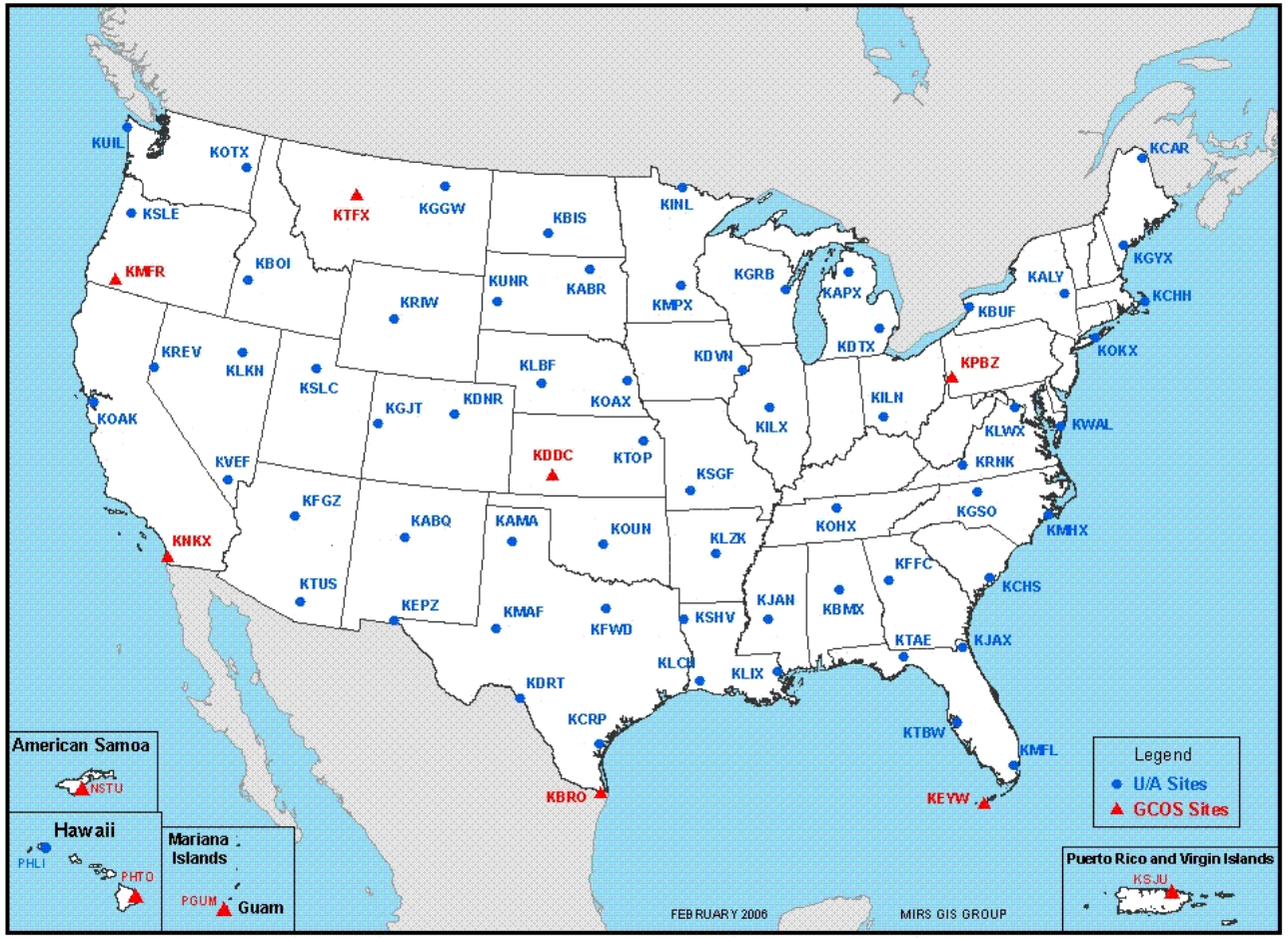


The NWS Radiosonde Network

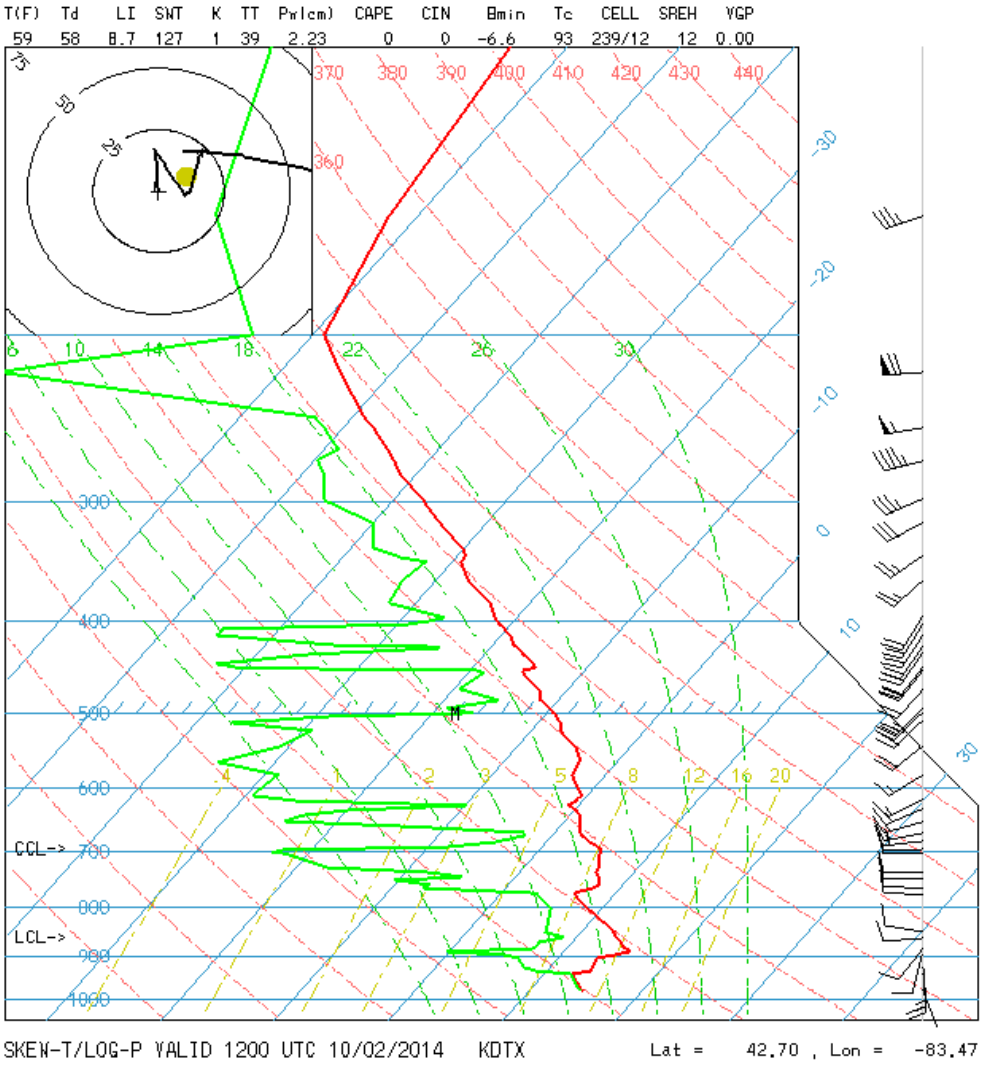
2014







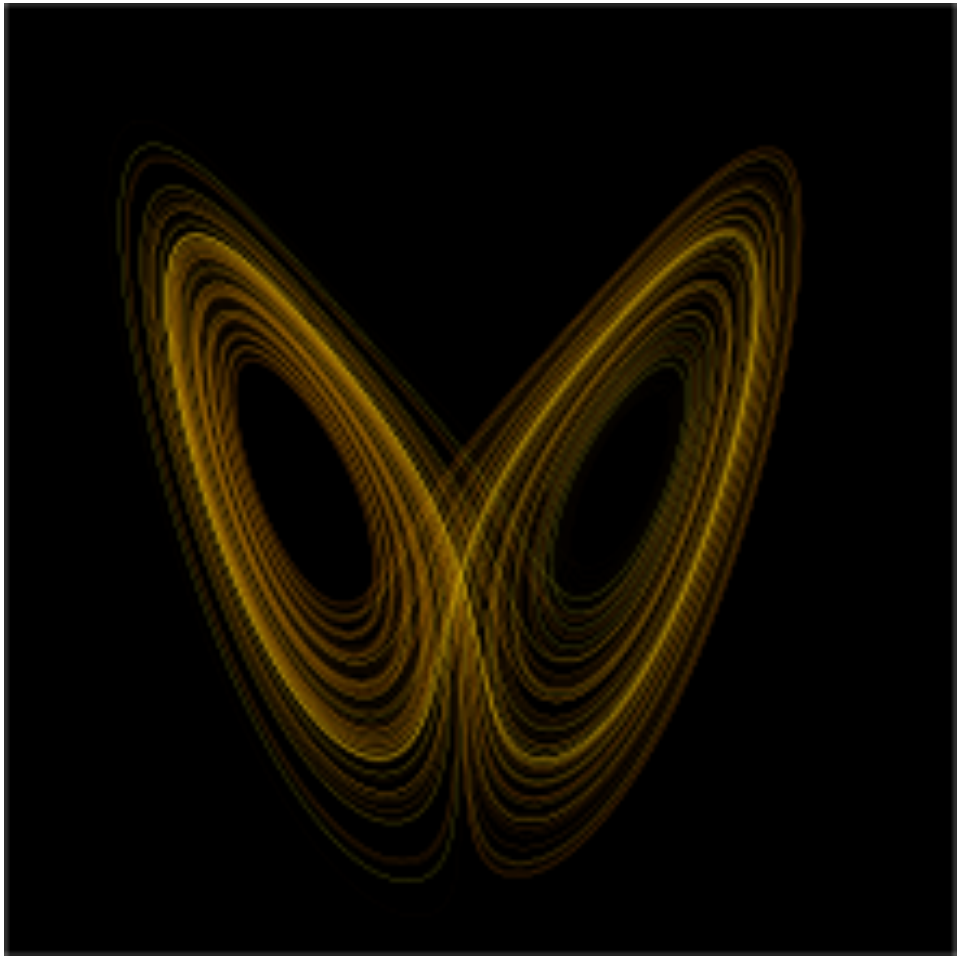
Radiosonde Data



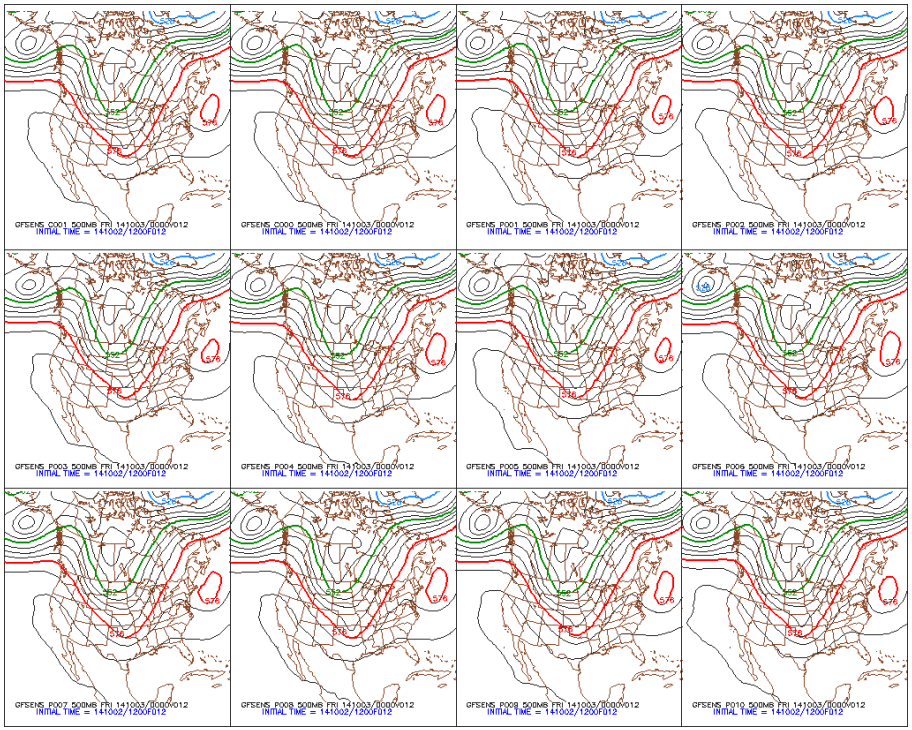
Limitations to Numerical Forecast Lead Time Length

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

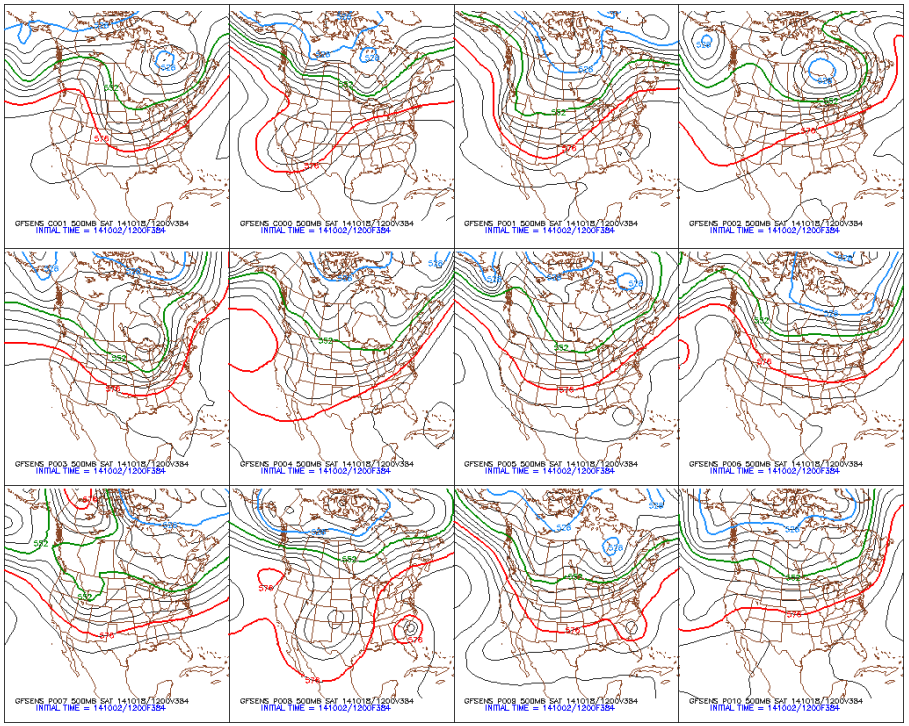
Weather Prediction and Chaotic Dynamics



Ensemble Forecasts

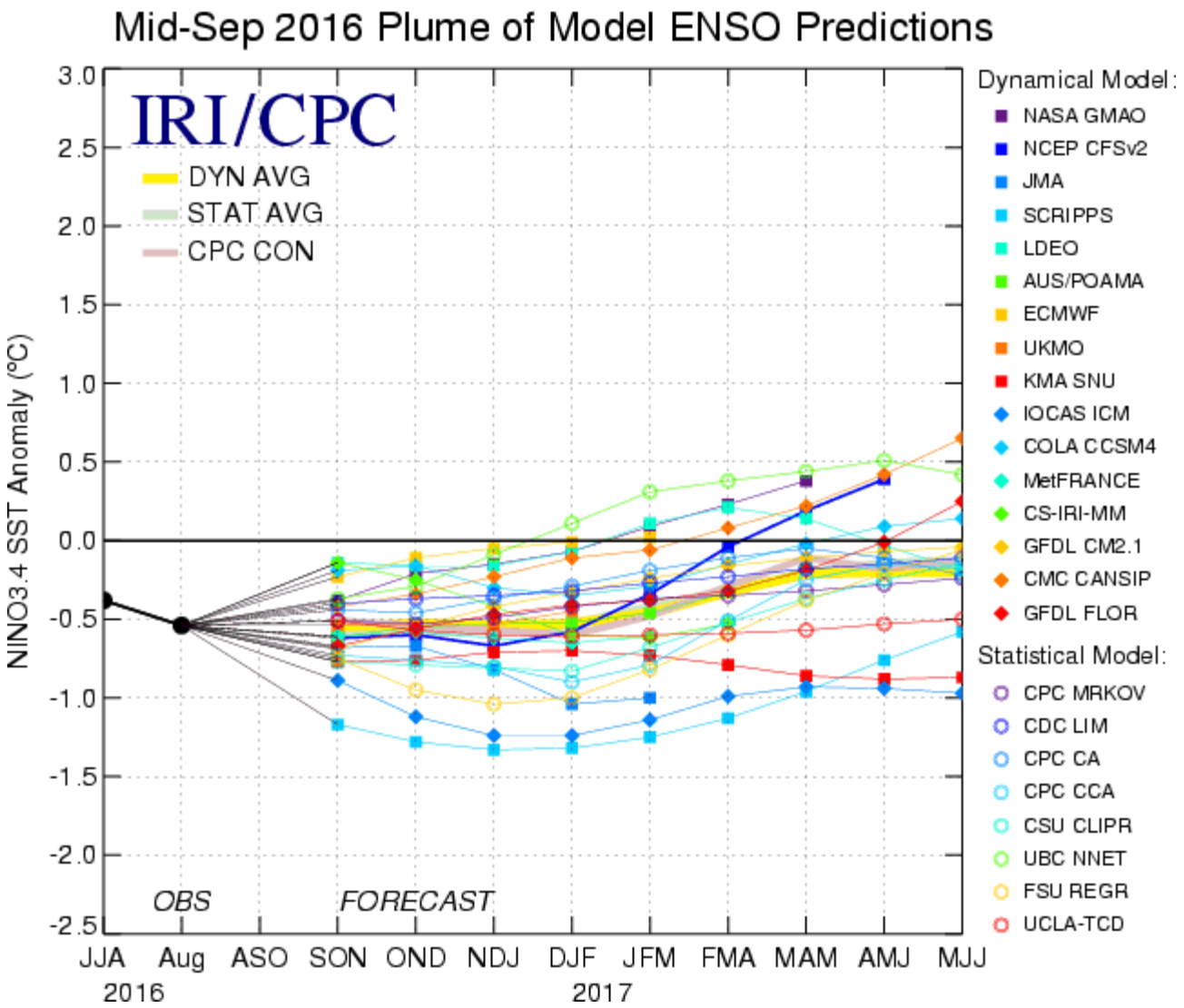


GFS 12 hour forecast ensemble



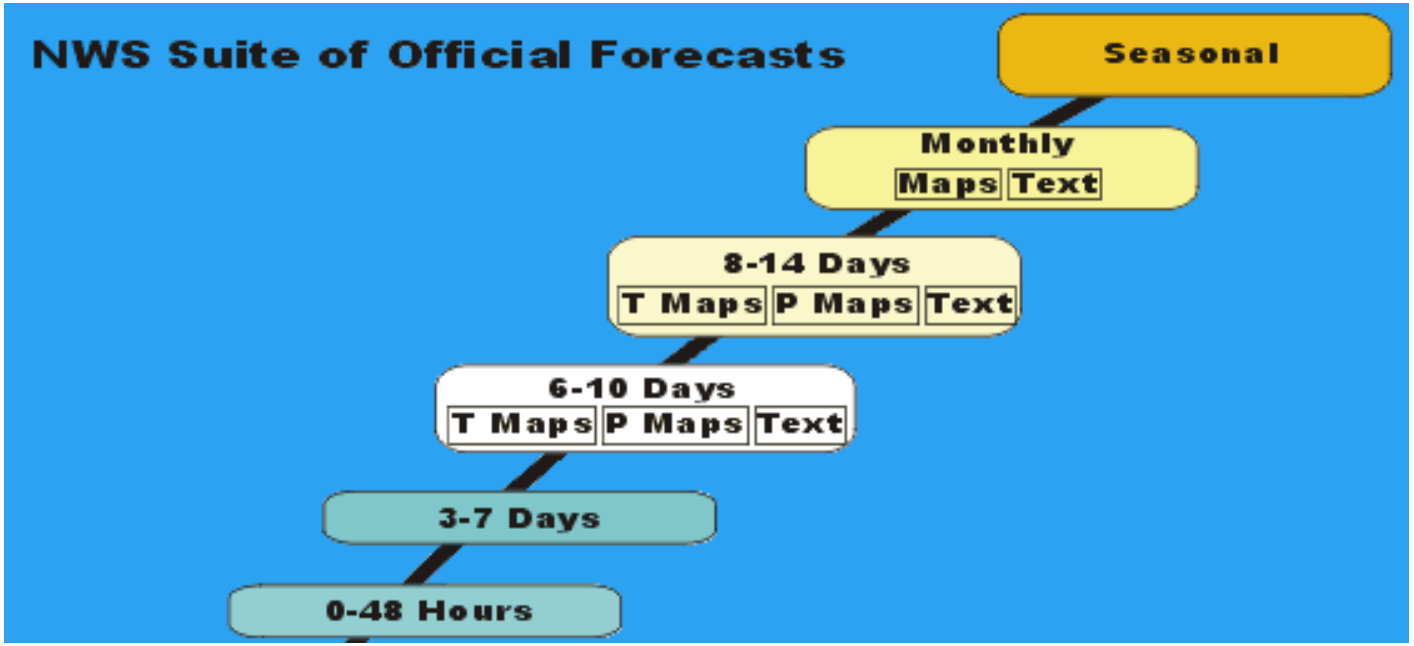
GFS 384 hour forecast ensemble

Superensemble Forecasts



Current Weather Forecast Technologies

Forecast Lead Times and Approaches



Statistical

Hybrid

Dynamic, Numerical Forecast Guidance

Traditional NWS Forecast Format

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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.

$$
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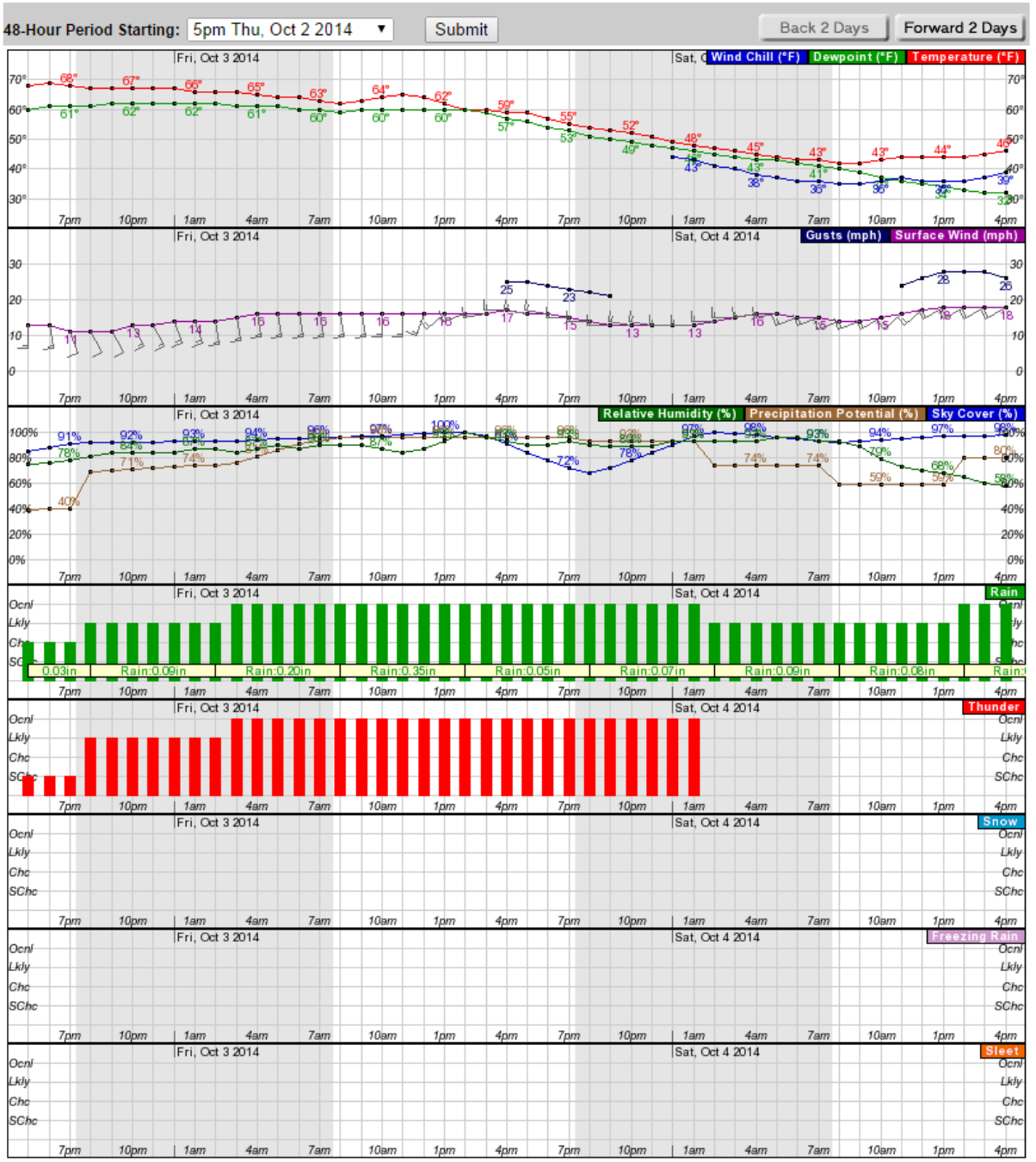
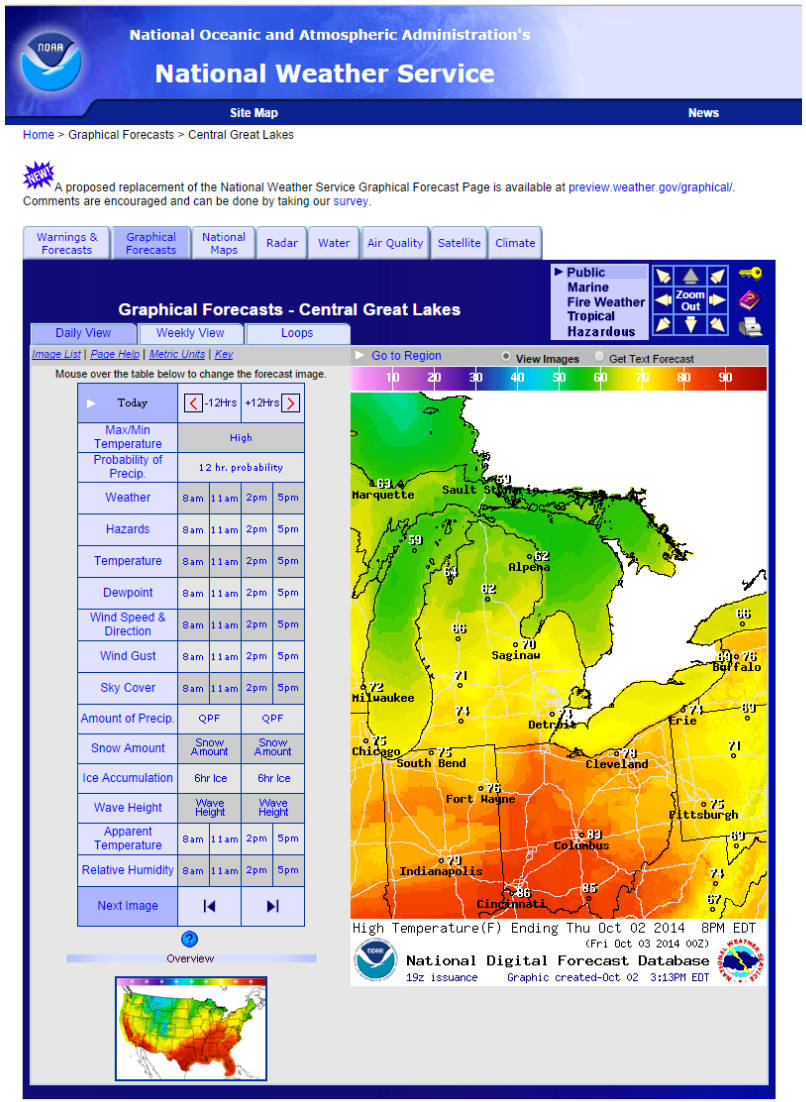
NWS Detailed Short Term Guidance

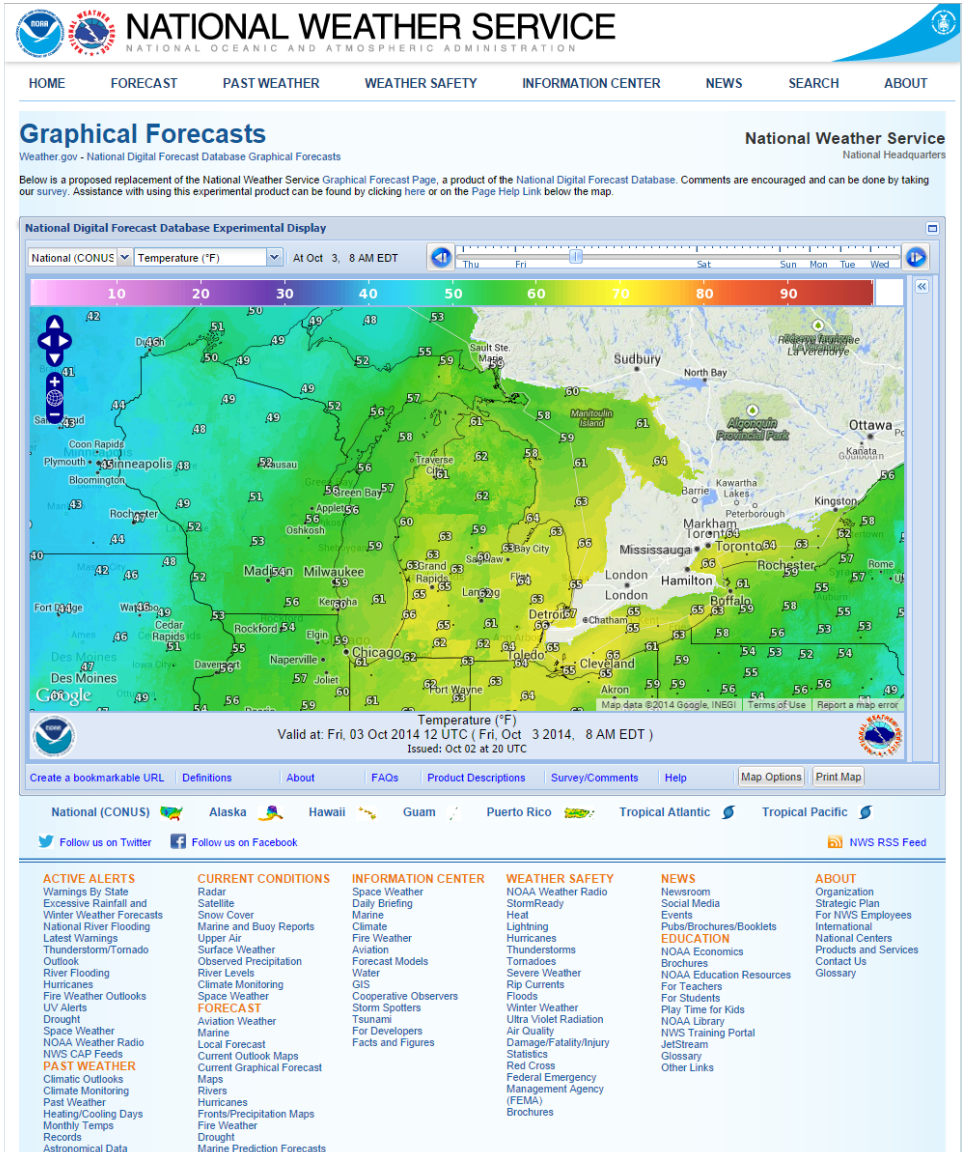


Saturday, October 4 at 11am
Temperature: 44 °F Dewpoint: 36 °F Wind Chill: 37 °F Surface Wind: SW 16G24mph
Sky Cover (%): 95% Precipitation Potential (%): 59% Relative Humidity (%): 73%
Rain: Likely (60%-70%) Thunder: <10% Snow: <10% Freezing Rain: <10% Sleet: <10%

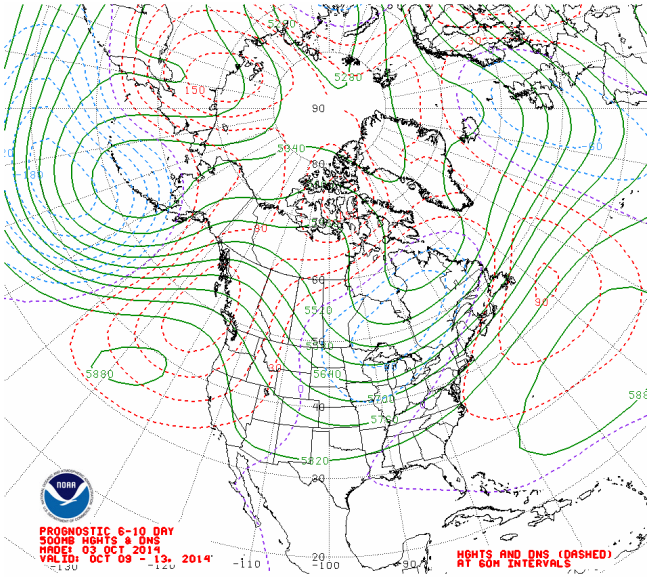
Current National Digital Forecast Data



New NWS Graphical Forecast Format
(March 2017)



CPC Medium Range Outlooks



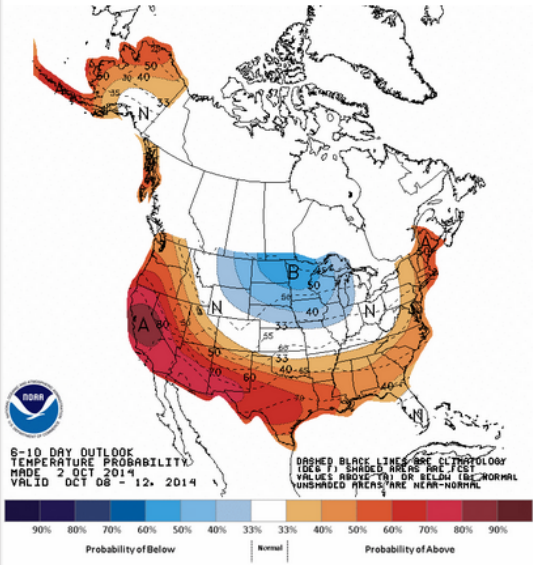
6 to 10 Day Outlooks

Valid: October 08 2014 to October 12 2014
Updated: 02 Oct 2014

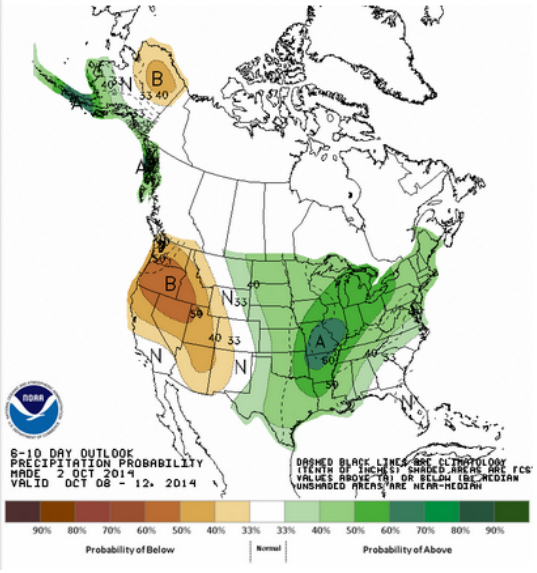
Click below for information about how to read 6-10 day outlook maps
Temperature Precipitation

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 Analogs Lines-Only Format GIS Data

Temperature



Precipitation



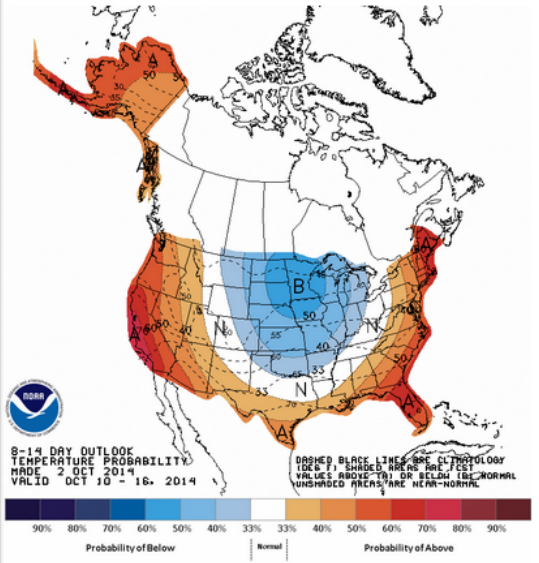
8 to 14 Day Outlooks

Valid: October 10 2014 to October 16 2014
Updated: 02 Oct 2014

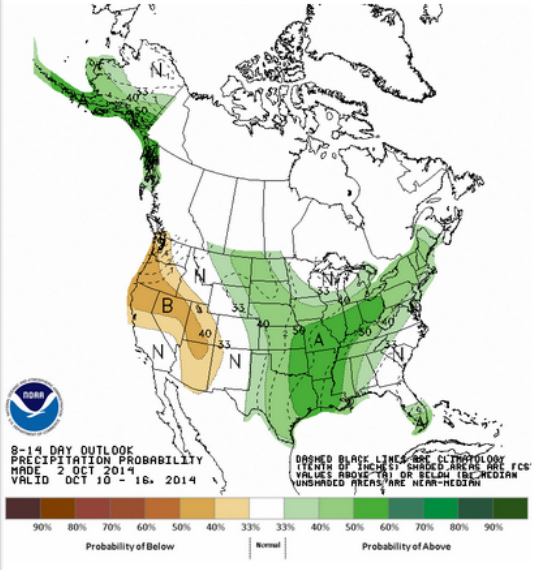
Click below for information about how to read 8-14 day outlook maps
Temperature Precipitation

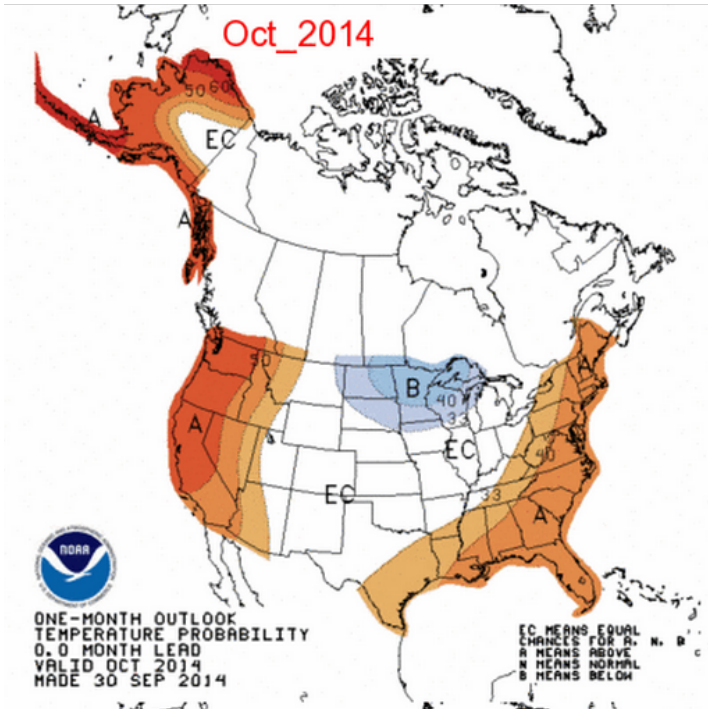
Click below for archives of past outlooks (data & graphics), historical analogs to today's forecast, and other formats of the 8-14 day outlooks
Archives Analogs Lines-Only Format GIS Data

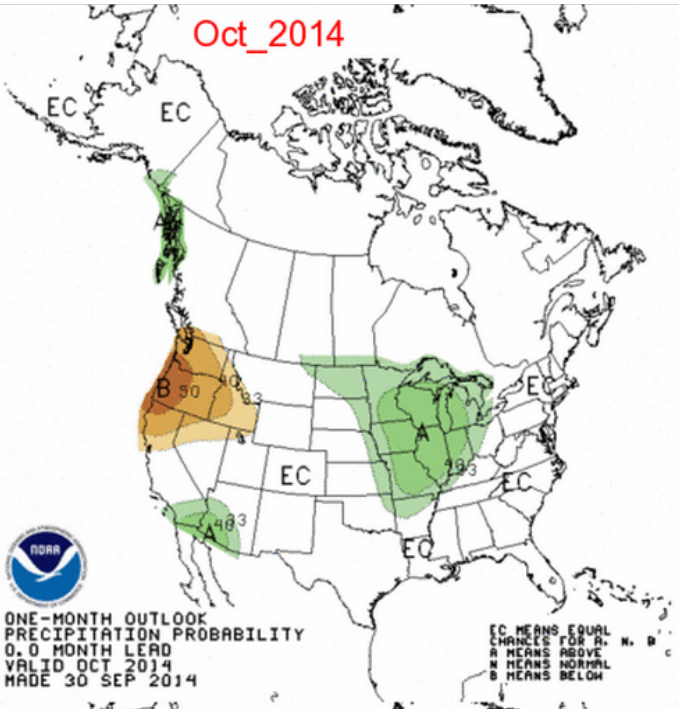
Temperature



Precipitation




Oct_2014
ONE-MONTH OUTLOOK
TEMPERATURE PROBABILITY
0.0 MONTH LEAD
VALID OCT 2014
MADE 30 SEP 2014
EC MEANS EQUAL CHANCES FOR A, N, B
A MEANS ABOVE
N MEANS NORMAL
B MEANS BELOW


Oct_2014
ONE-MONTH OUTLOOK
PRECIPITATION PROBABILITY
0.0 MONTH LEAD
VALID OCT 2014
MADE 30 SEP 2014
EC MEANS EQUAL CHANCES FOR A, N, B
A MEANS ABOVE
N MEANS NORMAL
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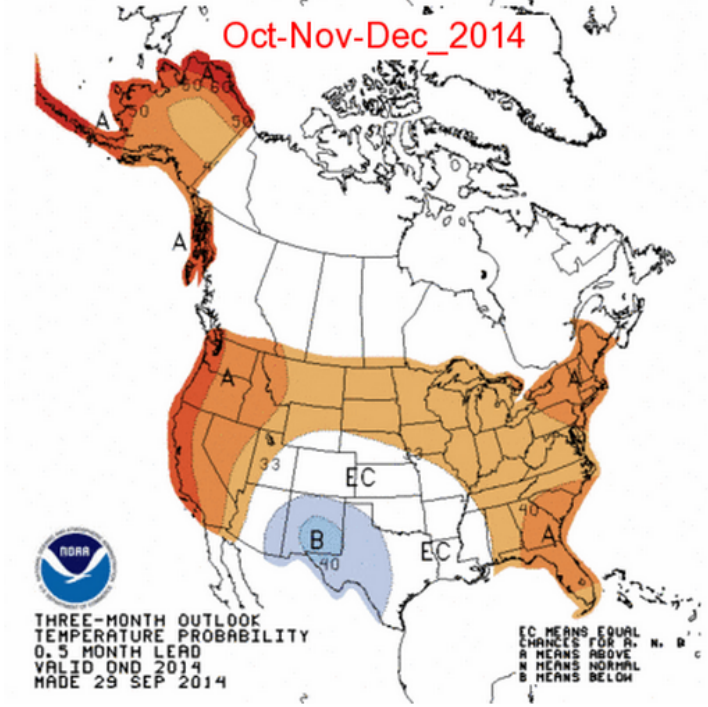
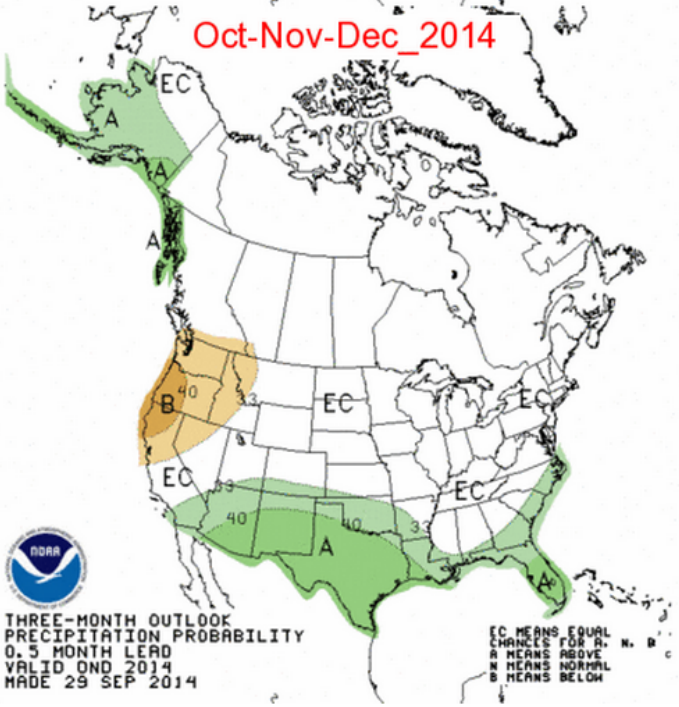

Oct-Nov-Dec_2014
THREE-MONTH OUTLOOK
TEMPERATURE PROBABILITY
0.5 MONTH LEAD
VALID OND 2014
MADE 29 SEP 2014
EC MEANS EQUAL CHANCES FOR A, N, B
A MEANS ABOVE
N MEANS NORMAL
B MEANS BELOW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EC MEANS EQUAL CHANCES FOR A, N, B
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Expected 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.

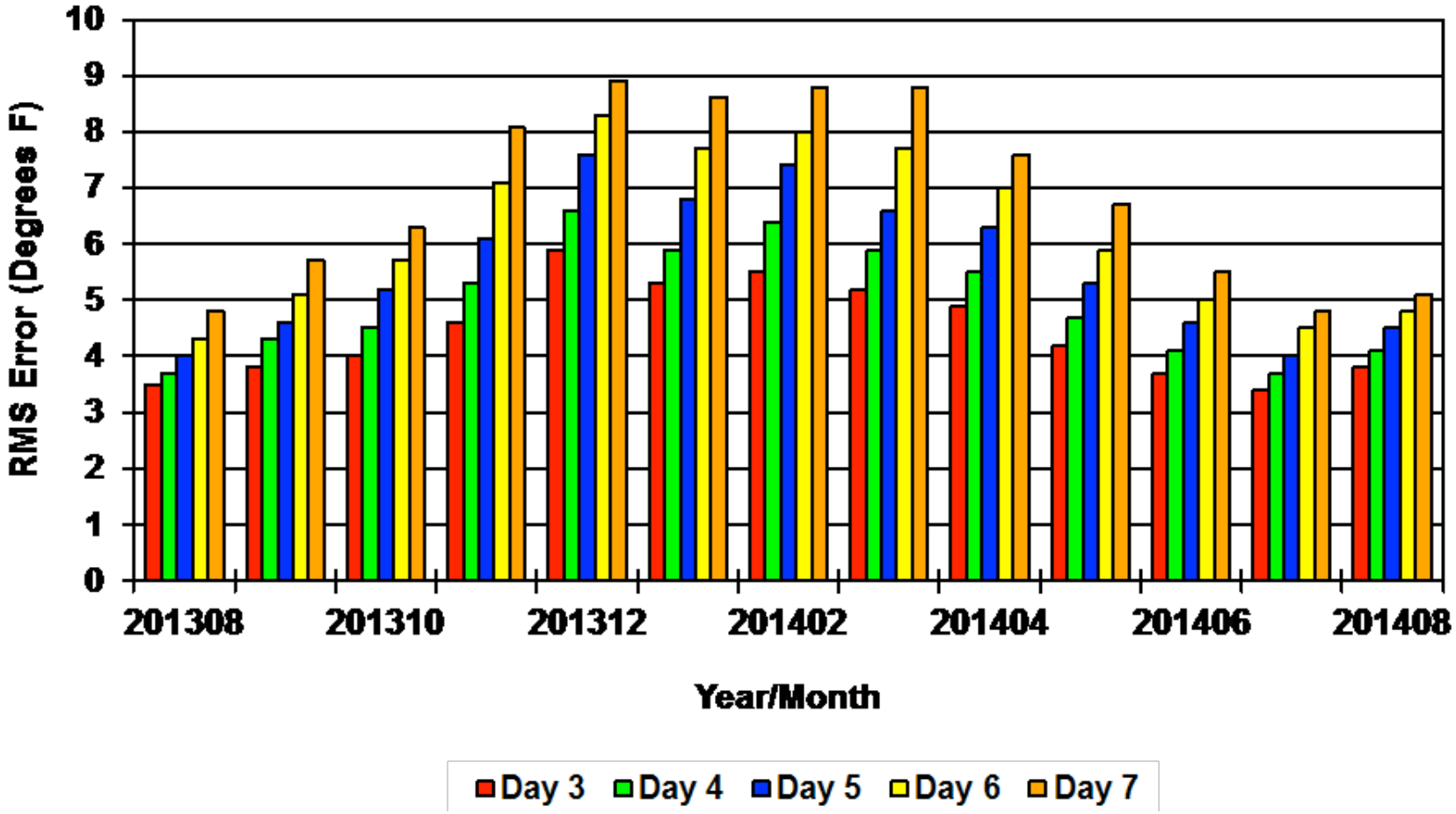
Weather Forecast Accuracy Data Last Month

Provider	High Temp	Low Temp	Icon Precip	Text Precip	Overall
The Weather Channel	84.44%	88.89%	70.00%	70.00%	78.33%
Weather Underground	85.56%	86.67%	70.00%	70.00%	78.06%
Dark Sky (forecast.io)	85.56%	74.44%	72.22%	72.22%	76.11%
MeteoGroup	76.67%	75.56%	75.56%	75.56%	75.83%
AccuWeather	79.31%	74.71%	72.41%	75.86%	75.57%
Foreca	80.00%	75.56%	72.22%	72.22%	75.00%
NWS Digital Forecast	83.33%	70.00%	67.78%	67.78%	72.22%
World Weather Online	56.82%	33.33%	68.18%	68.18%	56.63%
Persistence	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
Weather Underground	73.60%	72.35%	82.18%	82.18%	77.58%
The Weather Channel	73.80%	72.54%	81.89%	81.89%	77.53%
AccuWeather	72.17%	73.14%	79.90%	81.74%	76.74%
MeteoGroup	71.58%	75.43%	79.00%	79.00%	76.25%
Foreca	67.63%	68.89%	78.36%	78.36%	73.31%
Dark Sky (forecast.io)	65.13%	64.07%	78.52%	78.52%	71.56%
NWS Digital Forecast	67.39%	66.93%	70.83%	70.83%	68.99%
World Weather Online	63.26%	33.24%	70.76%	70.76%	59.50%
Persistence	28.67%	22.65%	53.70%	53.70%	39.68%

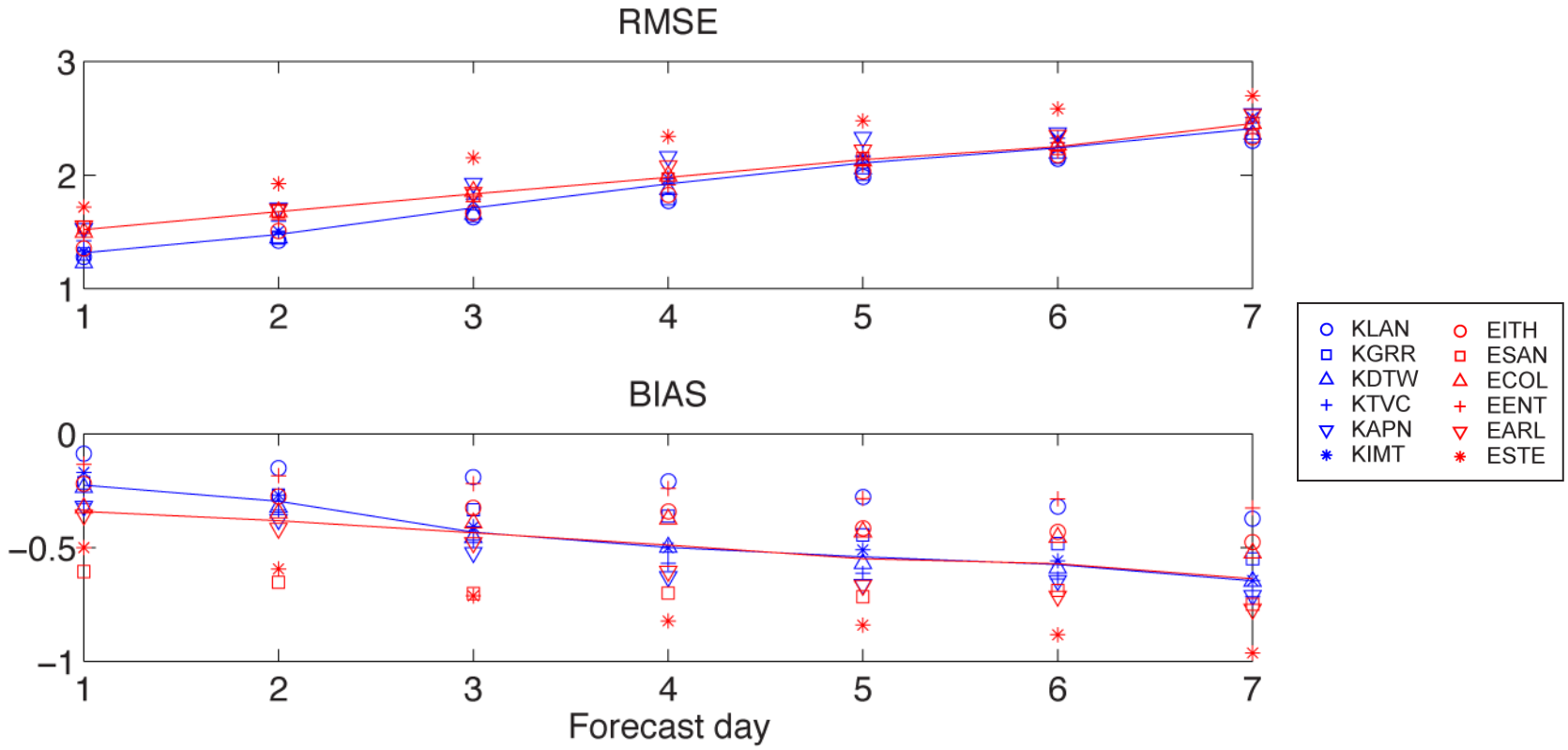
WPC Medium Range RMS Errors
Maximum Temperatures



NDFD: Growing Degree Days*

00 UTC forecast

*Baskerville-Emin method

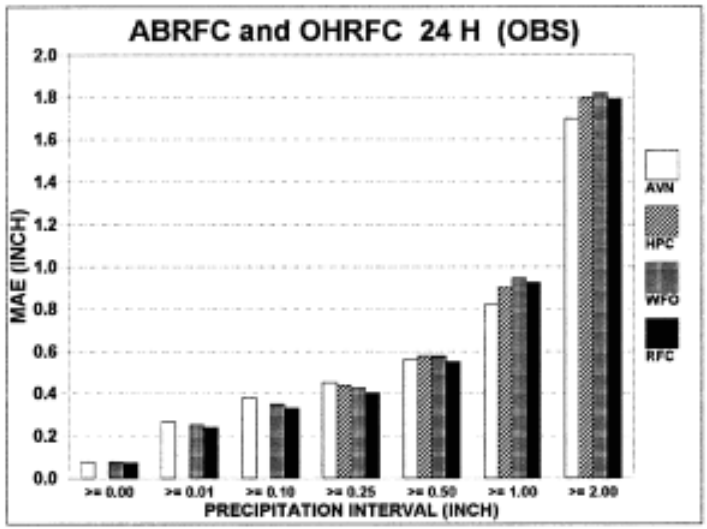


Applications of MOS Guidance

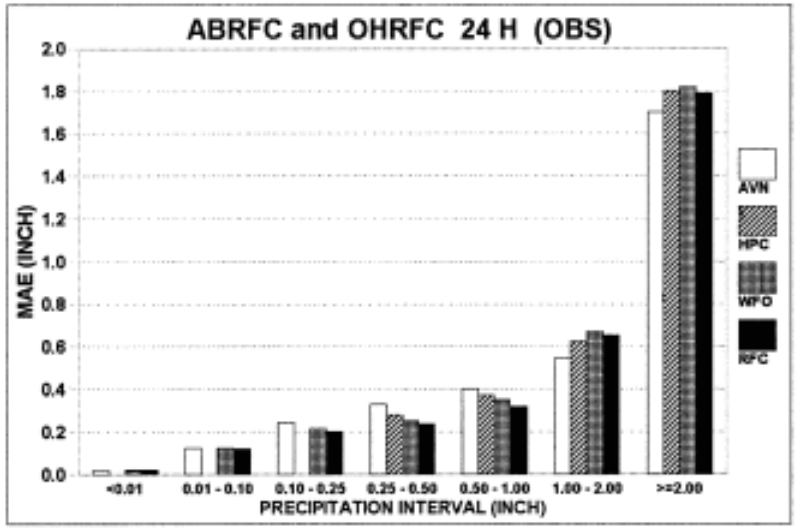
NO APPLY: 70% or greater chance of 0.5”+ in 24-hour period, or any % chance of 1”+ in 24-hour period

KLAN	MOS 2-year-total	MOS Winter	MOS Spring	MOS Summer	MOS Autumn
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	MOS 2-year-total	MOS Winter	MOS Spring	MOS Summer	MOS Autumn
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	MOS 2-year-total	MOS Winter	MOS Spring	MOS Summer	MOS Autumn
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	MOS 2-year-total	MOS Winter	MOS Spring	MOS Summer	MOS Autumn
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	MOS 2-year-total	MOS Winter	MOS Spring	MOS Summer	MOS Autumn
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)

(From Charba et al, 2003)

Forecast Skill Scores Have Increased Over Time

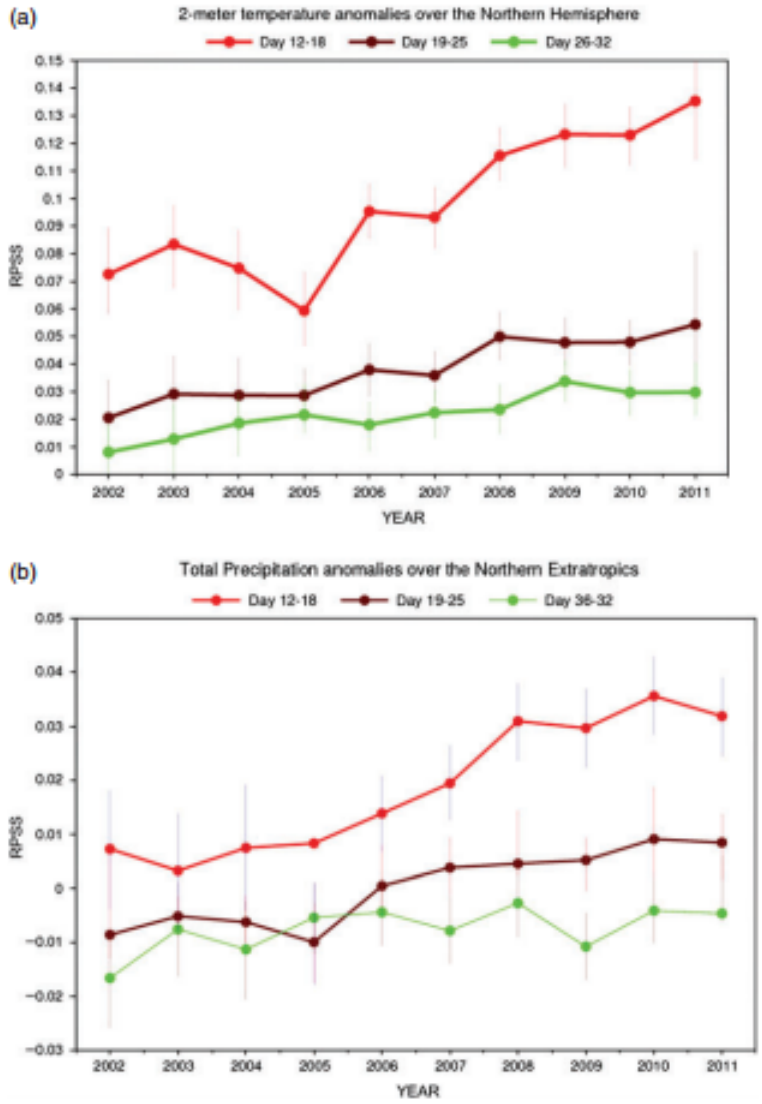
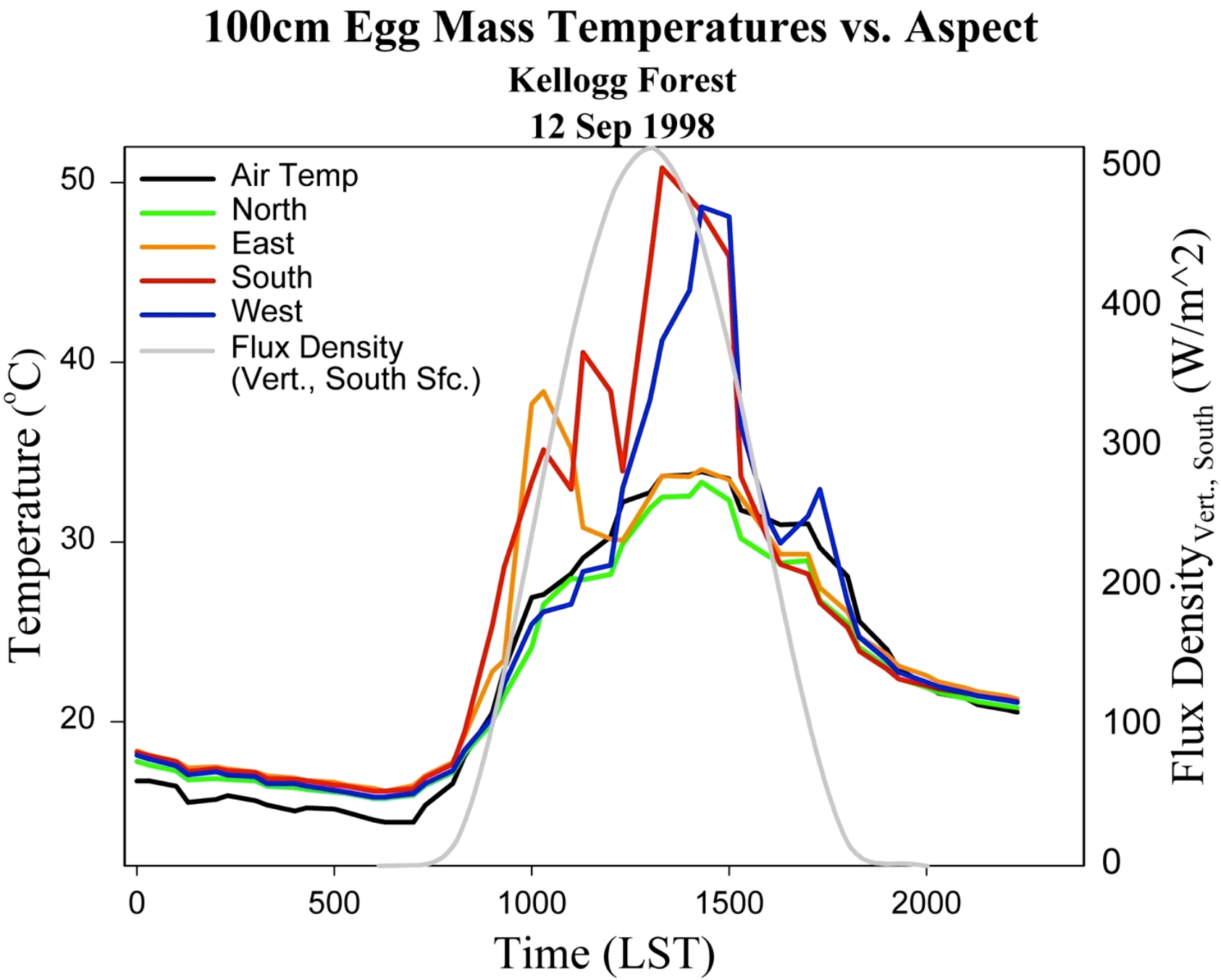


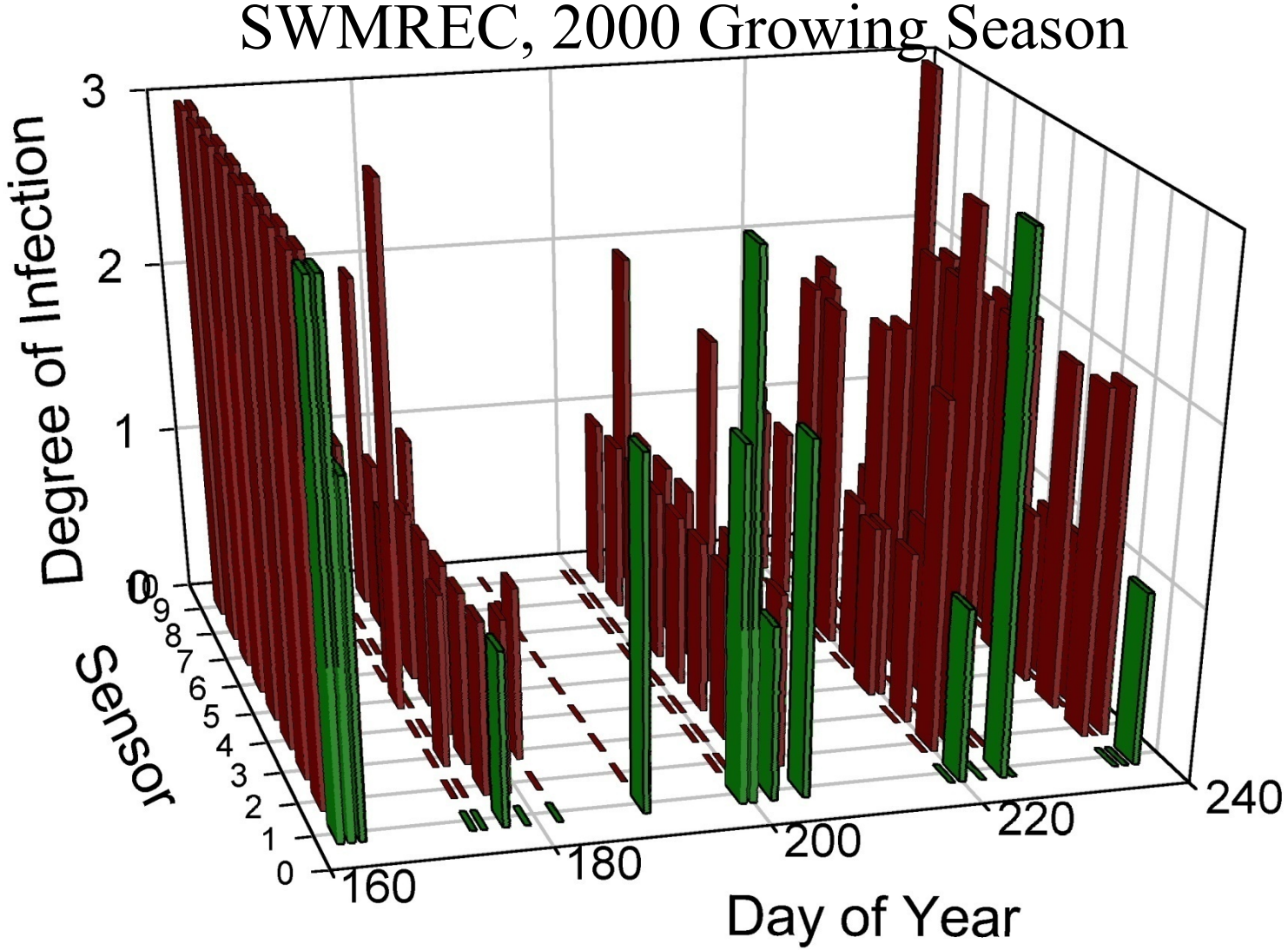
Figure 12. Evolution of the discrete ranked probability skill score (RPSS) of (a) 2 m temperature and (b) precipitation weekly mean anomalies over the Northern Extratropics (north of 30°N) since 2002. Only land points have been scored. The RPSS has been computed from terciles and for all the ECMWF reforecasts 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
Air Temp
North
East
South
West
Flux Density
(Vert., South Sfc.)
Temperature (°C)
Flux Density Vert., South (W/m^2)
Time (LST)
50
40
30
20
500
400
300
200
100
0
0
500
1000
1500
2000

Apple Scab Infection Frequency



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.