

# MT Floods of 2011: RFC River Model Performance

the good, the bad and the ugly

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Missouri Basin River Forecast Center

Montana Hydrology Workshop  
August 28-30, 2012



# This presentation will cover the following:

- Overview of NWS river forecast verification program
- Milk snowmelt flooding March-April 2011
- QPF verification May-June 2011
- Milk rainfall flooding May-June 2011
- Yellowstone flooding May-June 2011
- Musselshell flooding May-June 2011
- Bonus Section (if time permits)
  - Upper Missouri flooding May-June 2011
  - Post Flood Activities
    - Forecast Services
    - Data Needs
    - Model Improvements
  - Other Types of Statistics/Plots

# Overview of NWS River Forecast Verification Program

- Implemented in 2001... software package, IVP, delivered to all the RFCs
- Prior to 2001 RFCs had their own in-house verification procedures
- Statistics for RMSE, MAE, ME, sample size done each month on all forecasts that were issued. The statistics made available to weather service offices via a “stats on demand” website

# Interactive Verification Program (IVP)

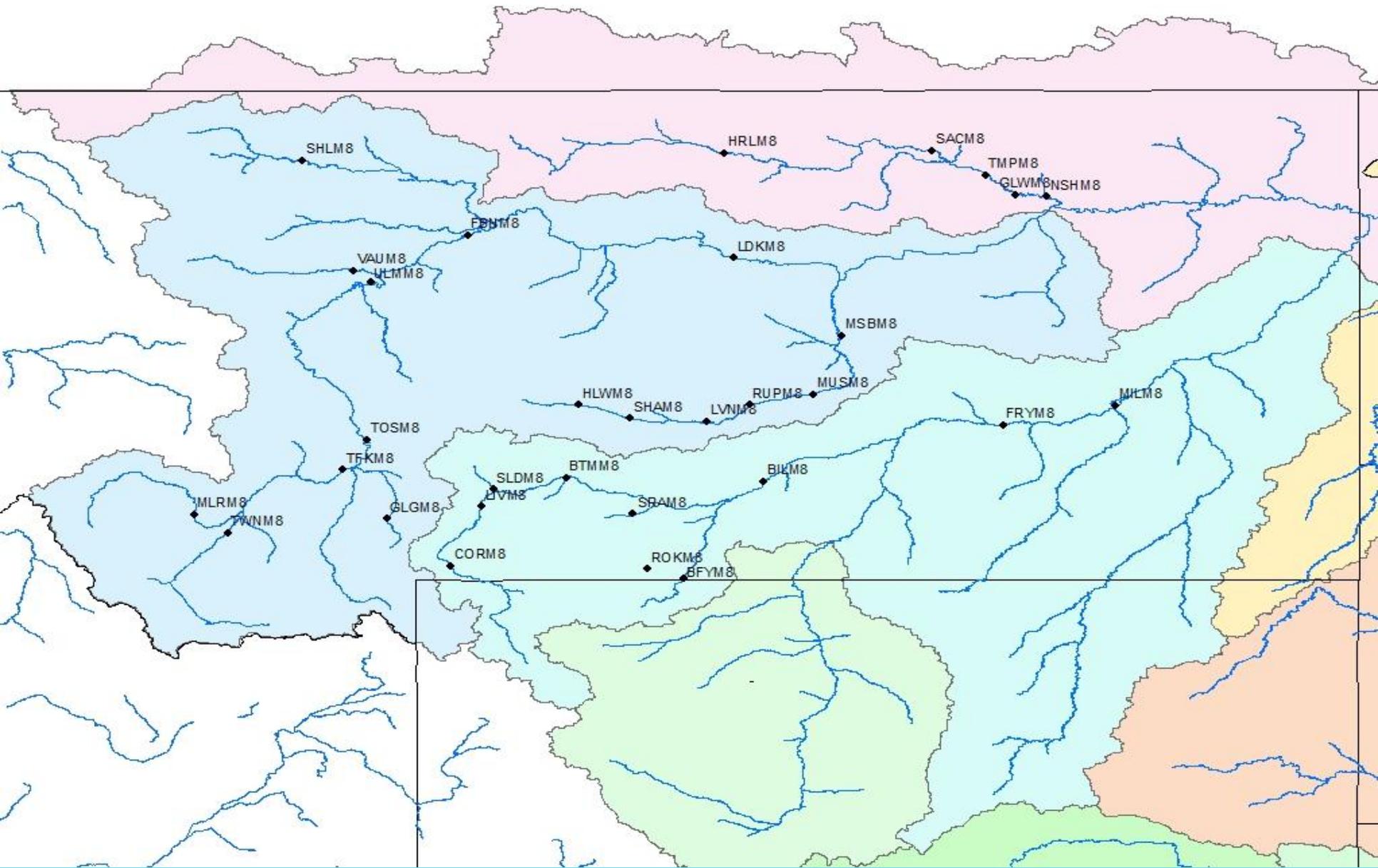
- *Scatter plot*
- *Time series plot*
- *Error Stats*
  - RMSE
  - ME
  - MAE
  - Max Error
- *Moments*
- *Sample Size*
- *Categorical Stats*
  - POD
  - HFAR
  - FAR
  - Over Fcst Rate
  - Under Fcst Rate
  - CSI
  - Gilbert
- *Leadtime Stats*
- *Correlation/Bias/Skill*
  - Pearson's Correlation
  - Bias
  - RMSE-SS
- *Special Plots*
  - CDF Plot
  - PDF Plot
- *Quartiles & Extremes*

# How good were the forecasts?

Used IVP application for the analysis:

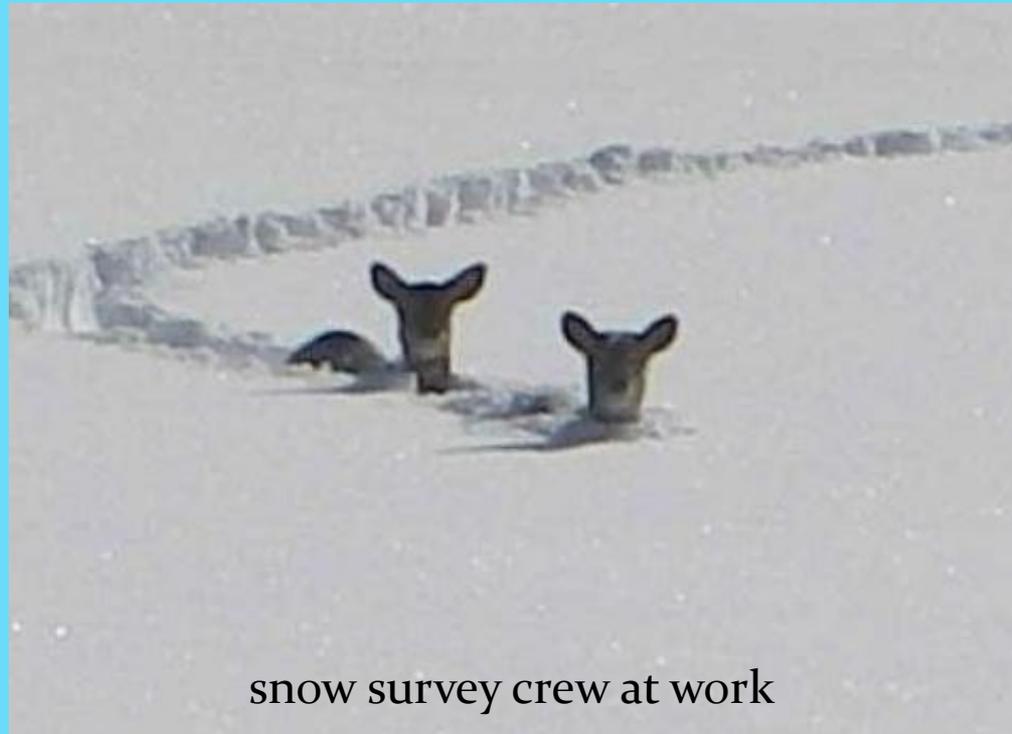
- MAE, lumped and by leadtime
- ME, lumped and by leadtime
- Pearson's Correlation (CORR) by leadtime
- RMSE-Skill Score

# Locations by RFC Forecast Groups



# Milk Forecasts

## Snowmelt flooding March-April 2011



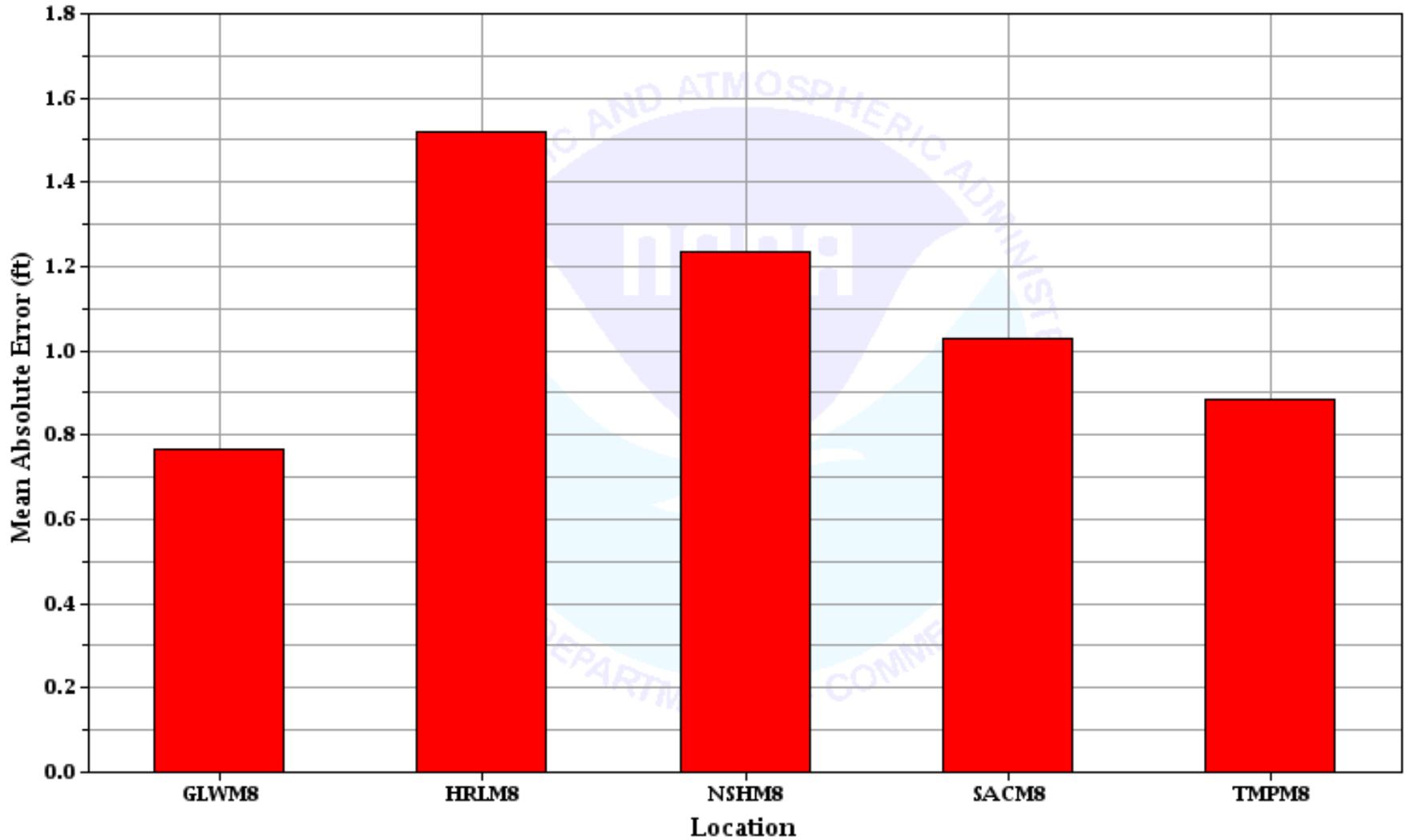
snow survey crew at work

# Milk Mainstem

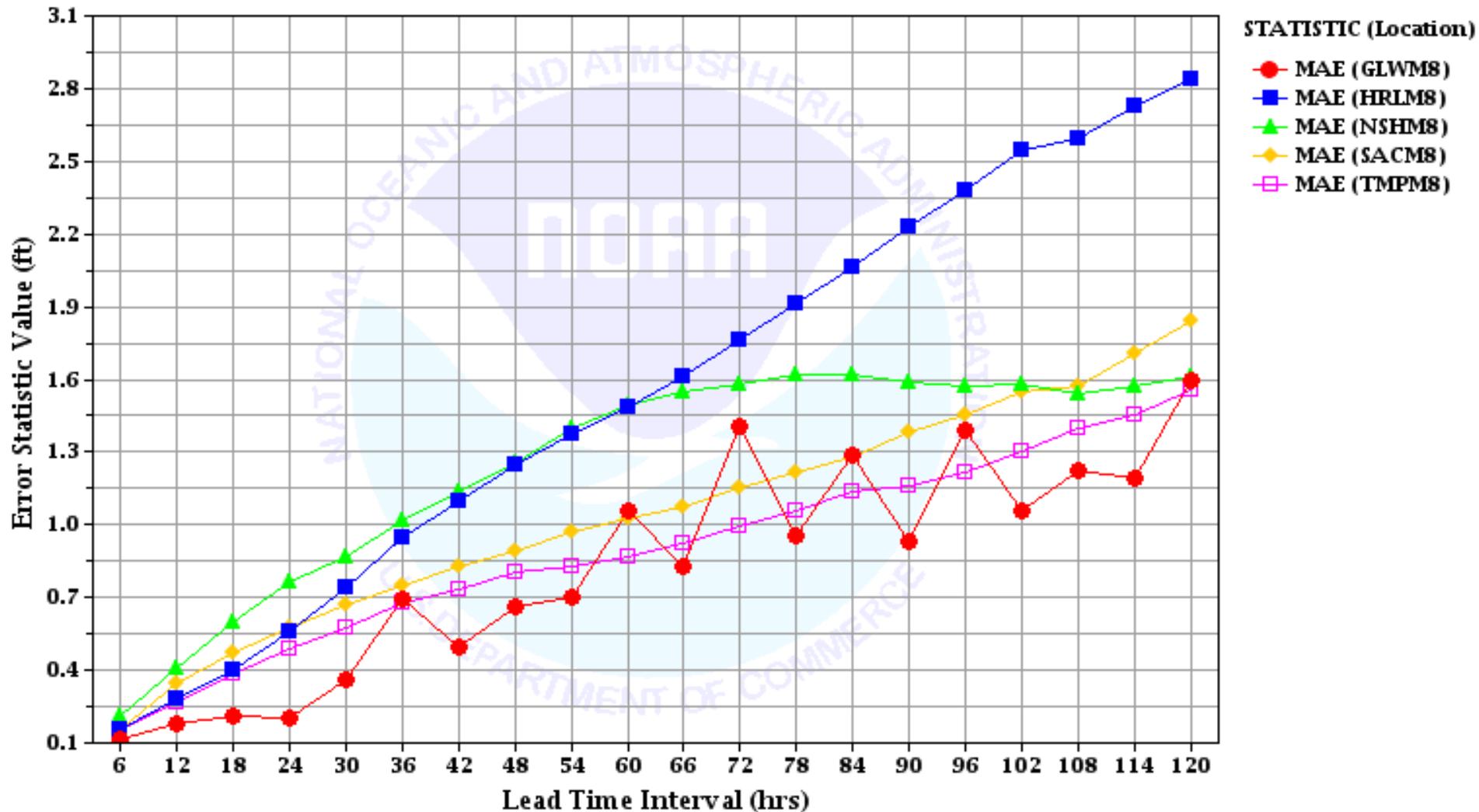
Locations looked at are:

HRLM8	Harlem MT	FS 21.0 FT
SACM8	Saco MT	FS 20.0 FT
TMPM8	Tampico MT	FS 23.0 FT
GLWM8	Glasgow MT	FS 25.0 FT
NSHM8	Nashua MT	FS 20.0 FT

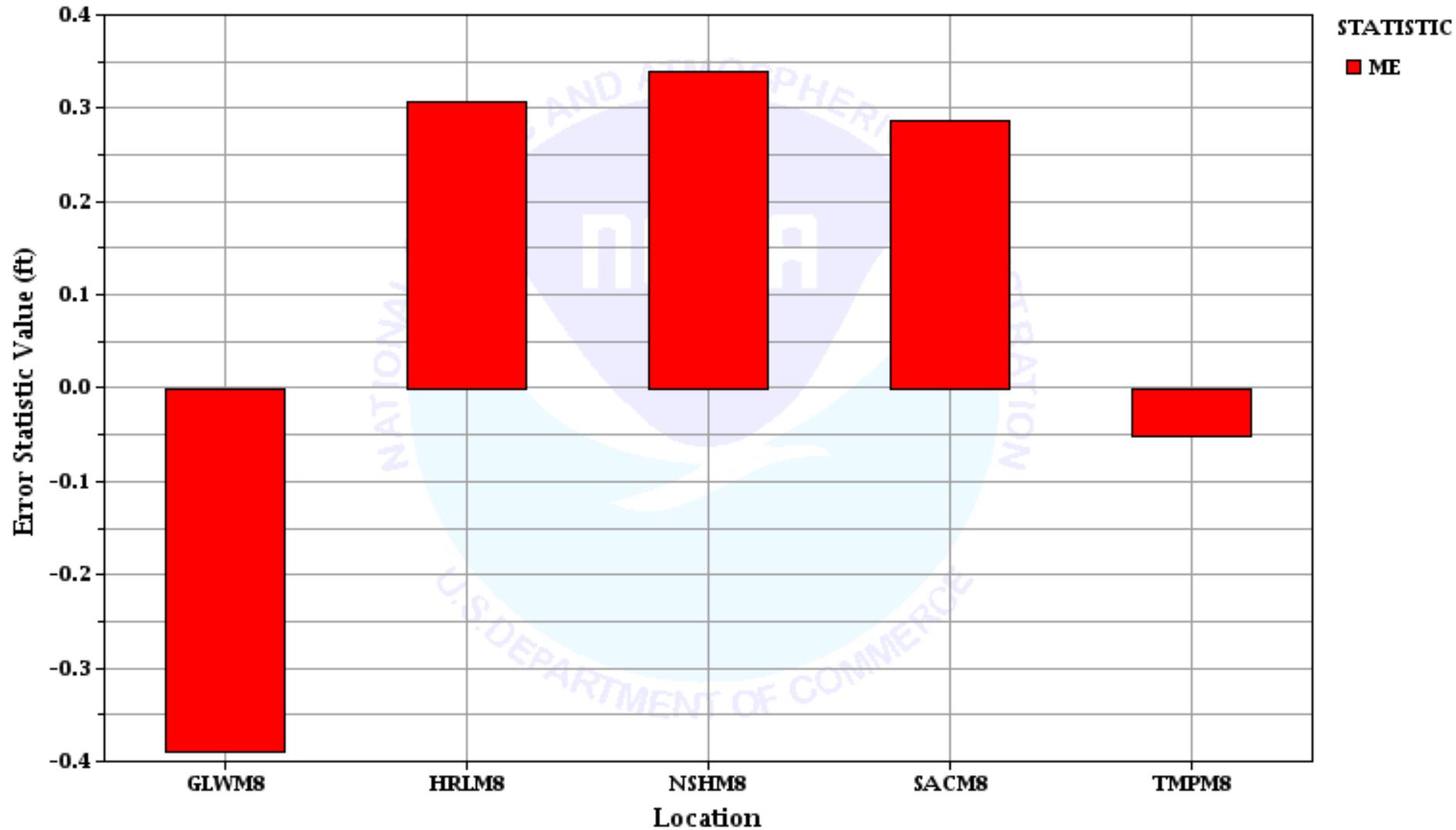
# Mean Absolute Error (MAE)



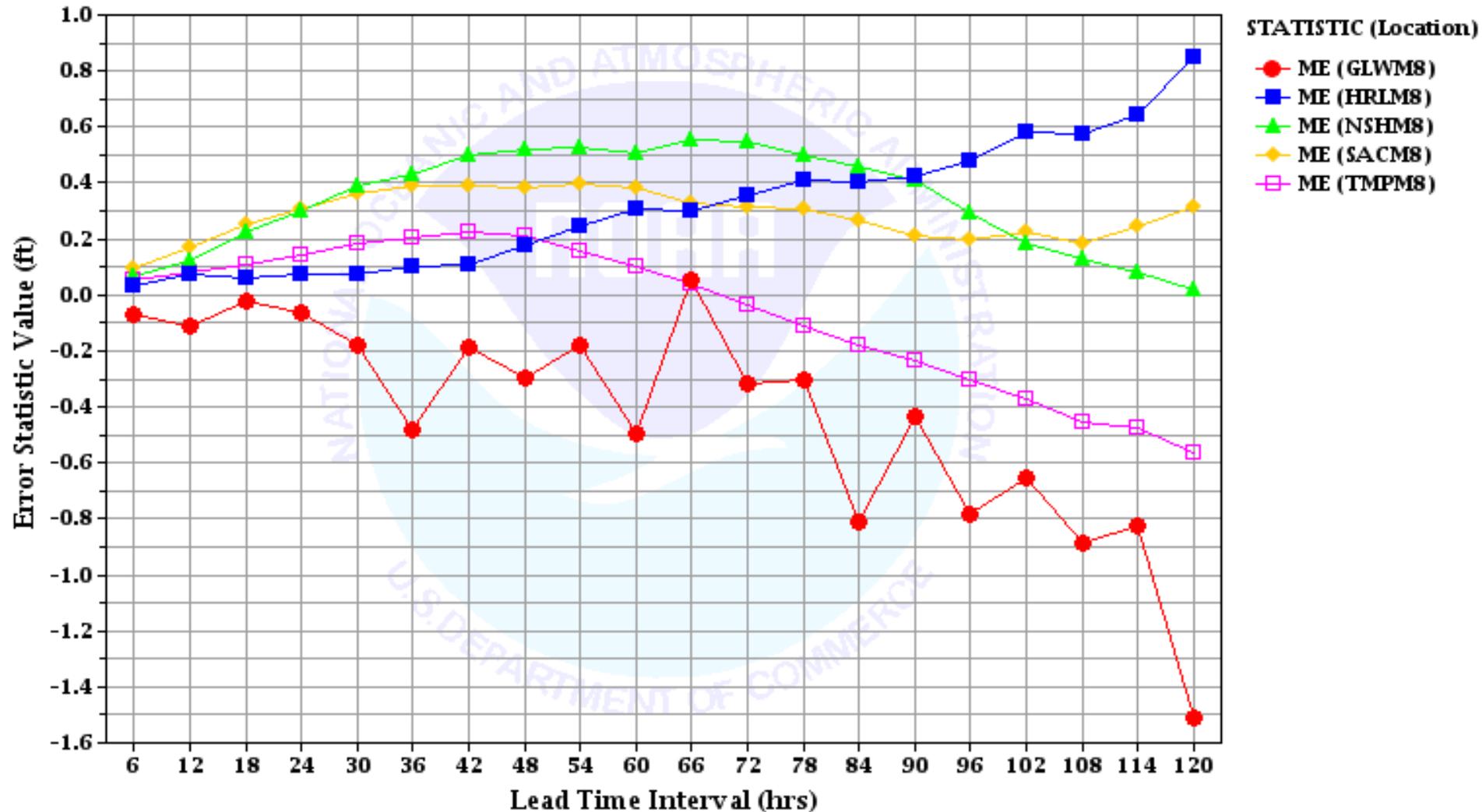
# Mean Absolute Error (MAE) By Lead Time



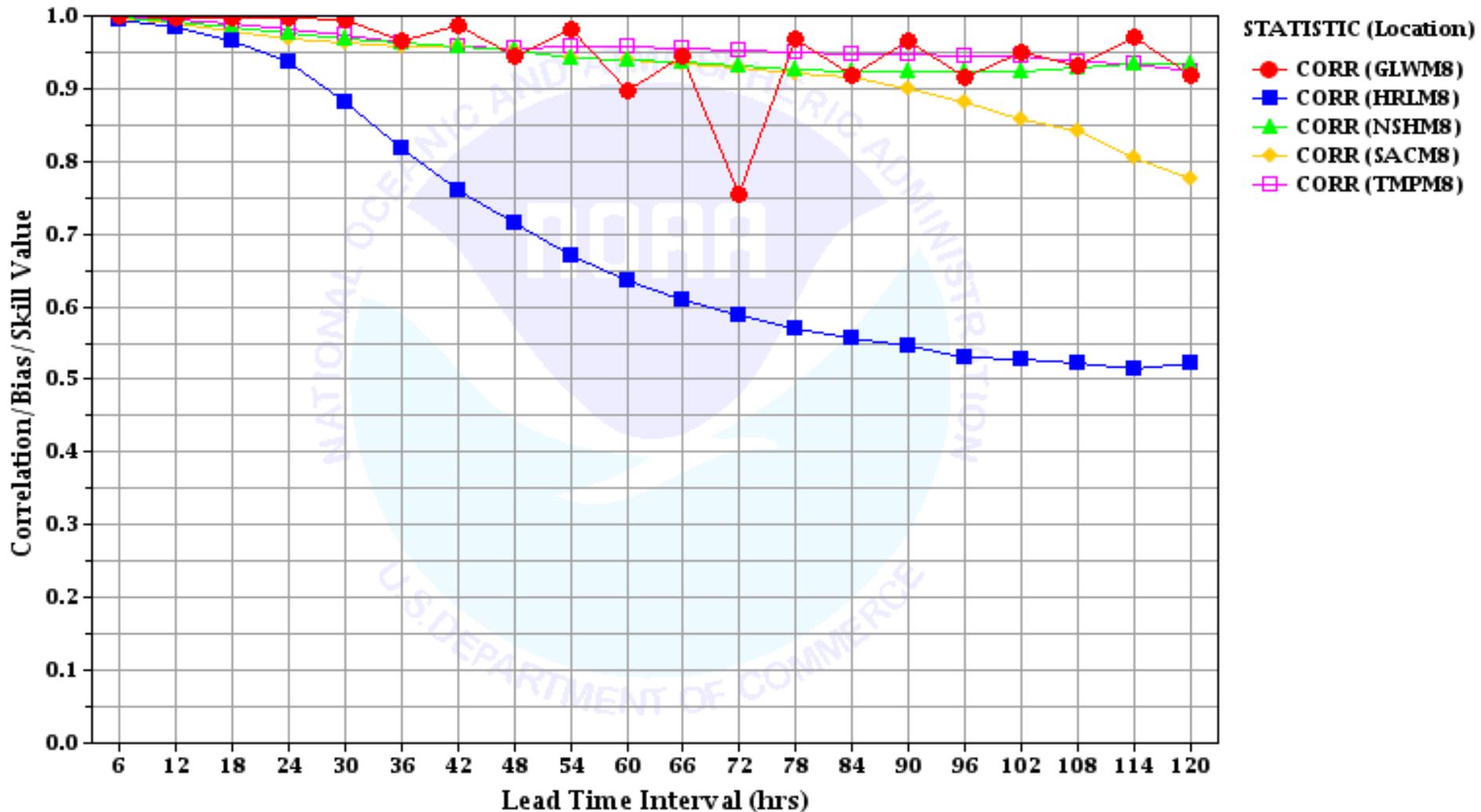
# Mean Error (ME)



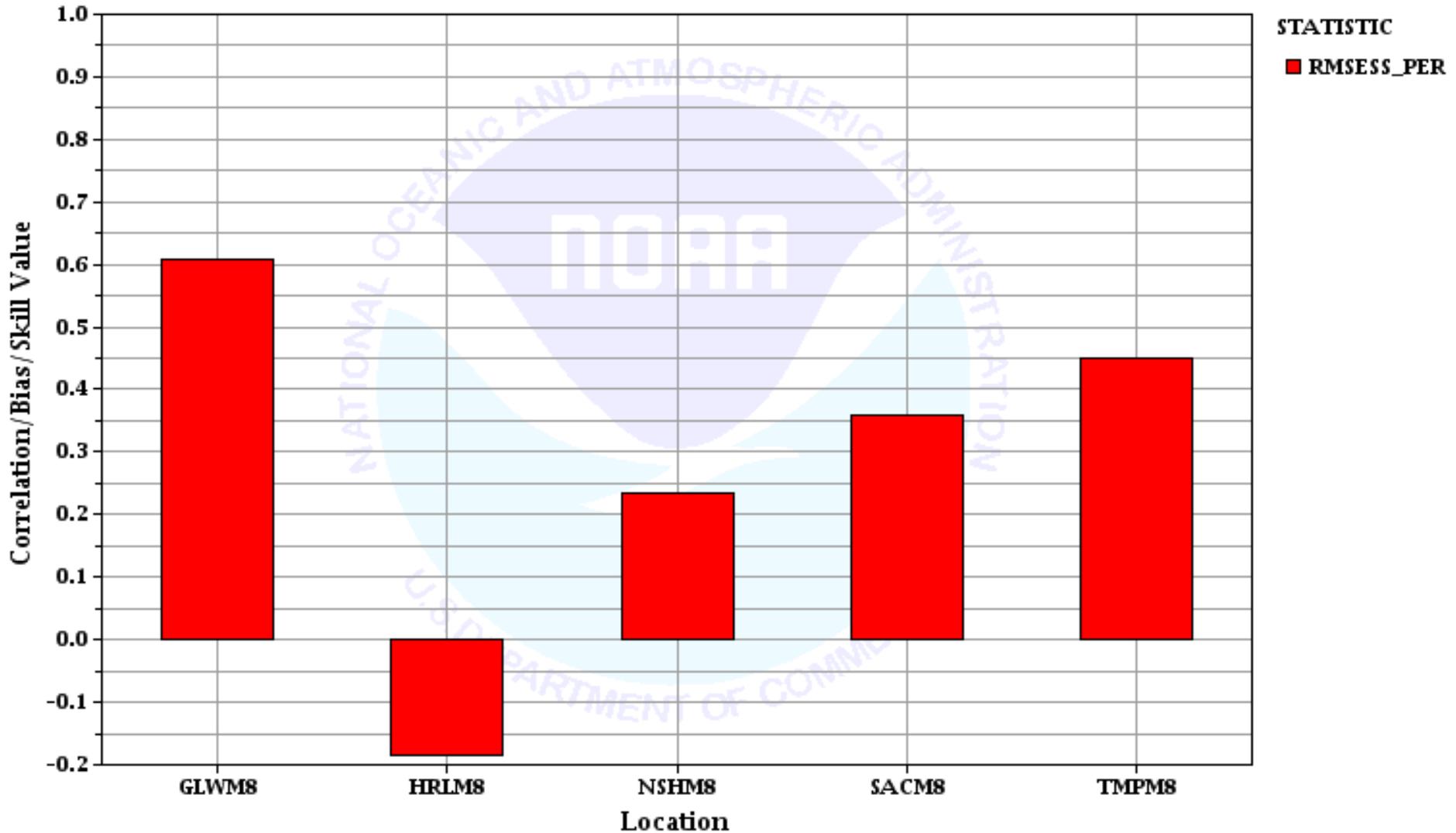
# Mean Error (ME) By Lead Time



# Pearson's Correlation (CORR) By Lead Time

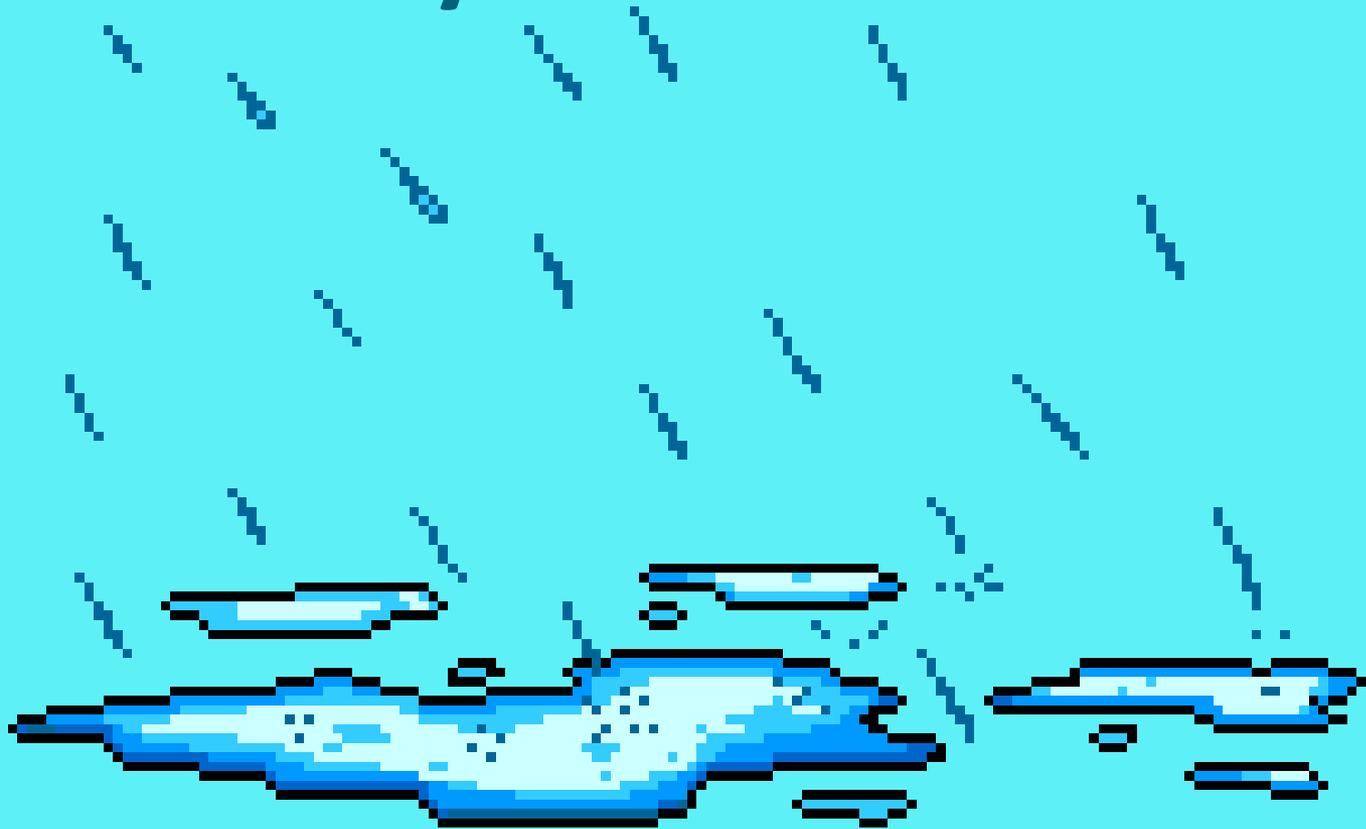


# Root Mean Square Error Skill Score (RMSE-SS)



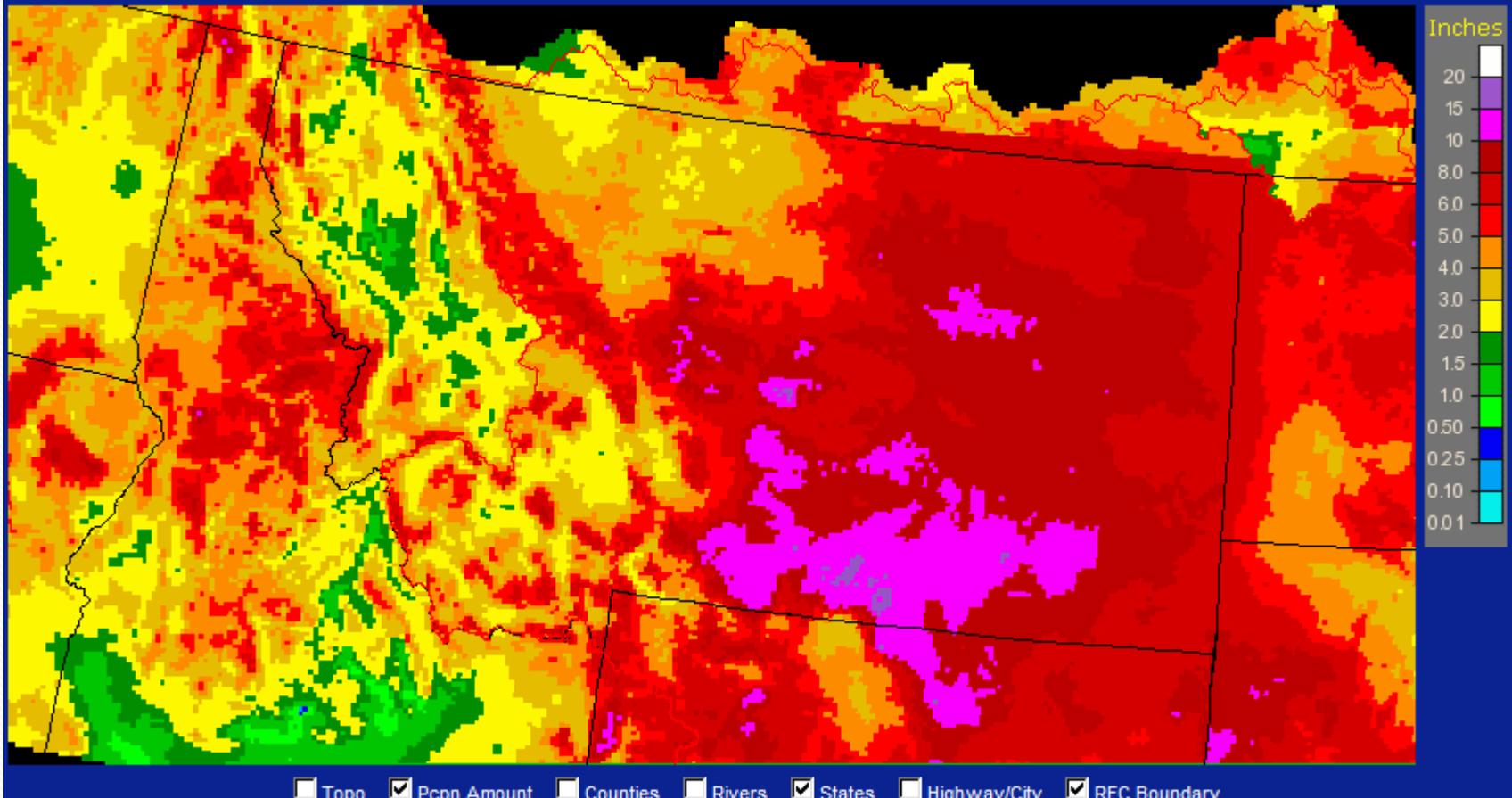
# QPF verification

## May-June 2011

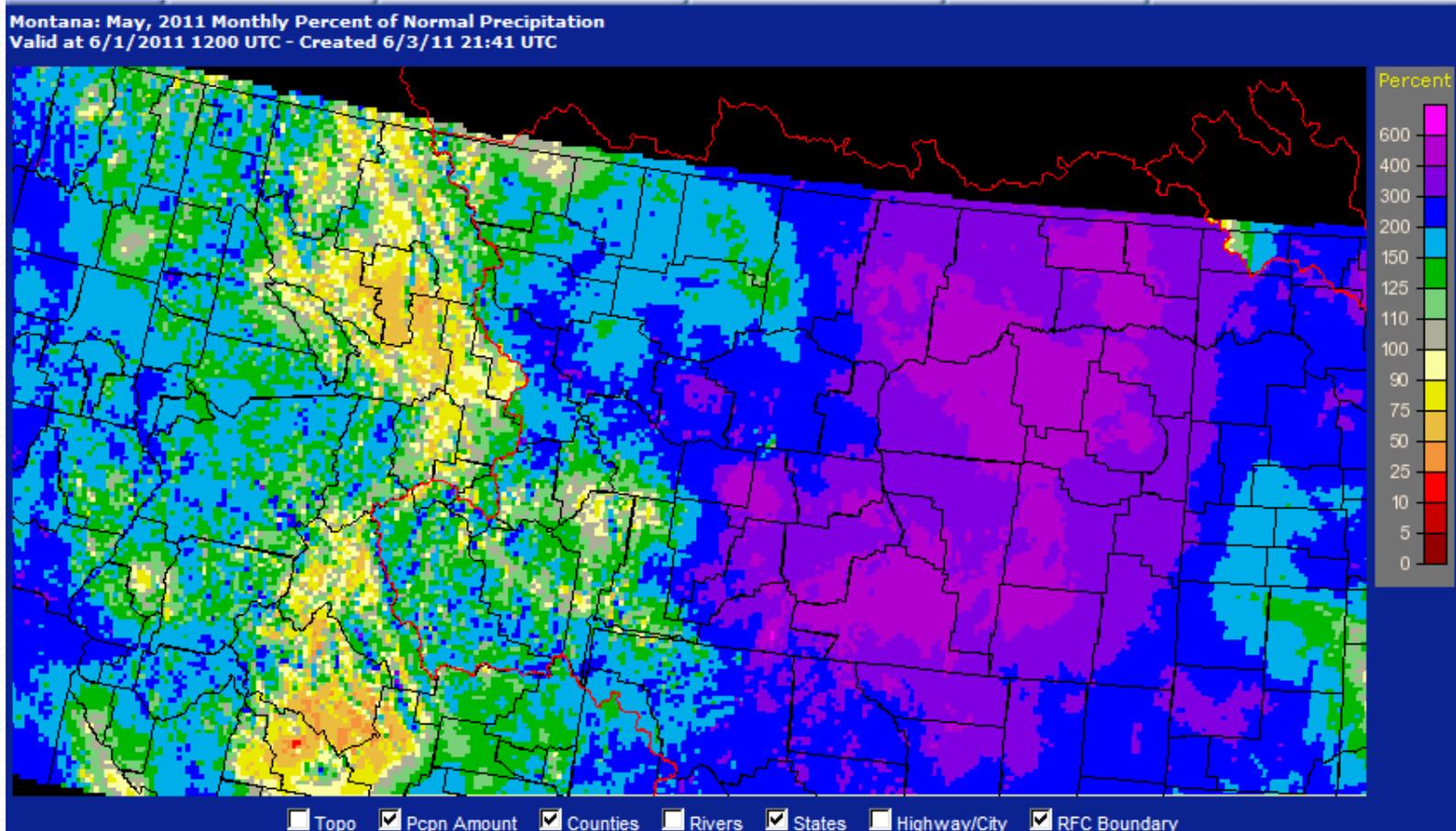


# Montana Monthly Precip Totals May 2011

Montana: May, 2011 Monthly Observed Precipitation  
Valid at 6/1/2011 1200 UTC - Created 6/3/11 21:37 UTC

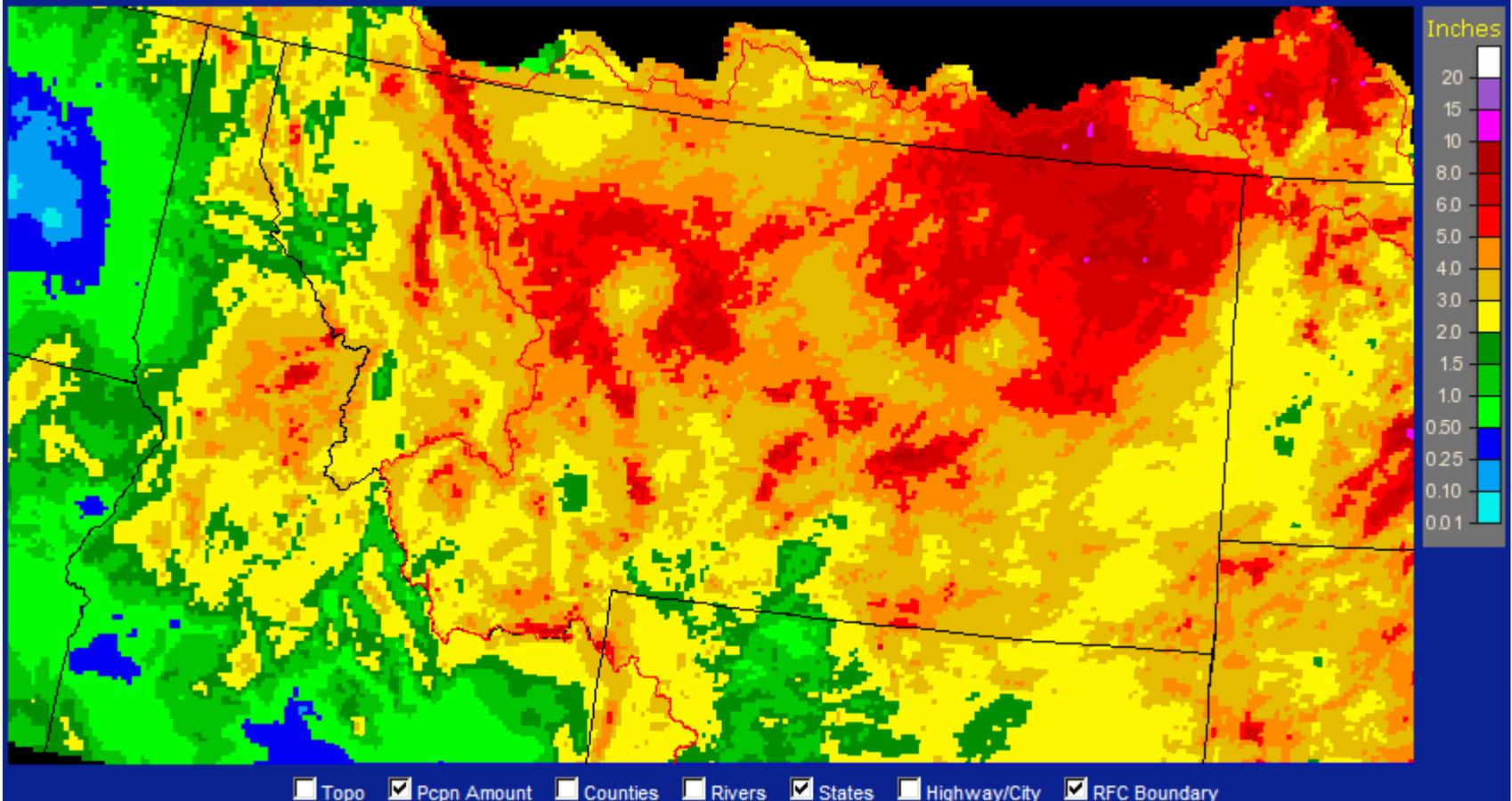


# Montana May 2011 Percent of Normal Precipitation

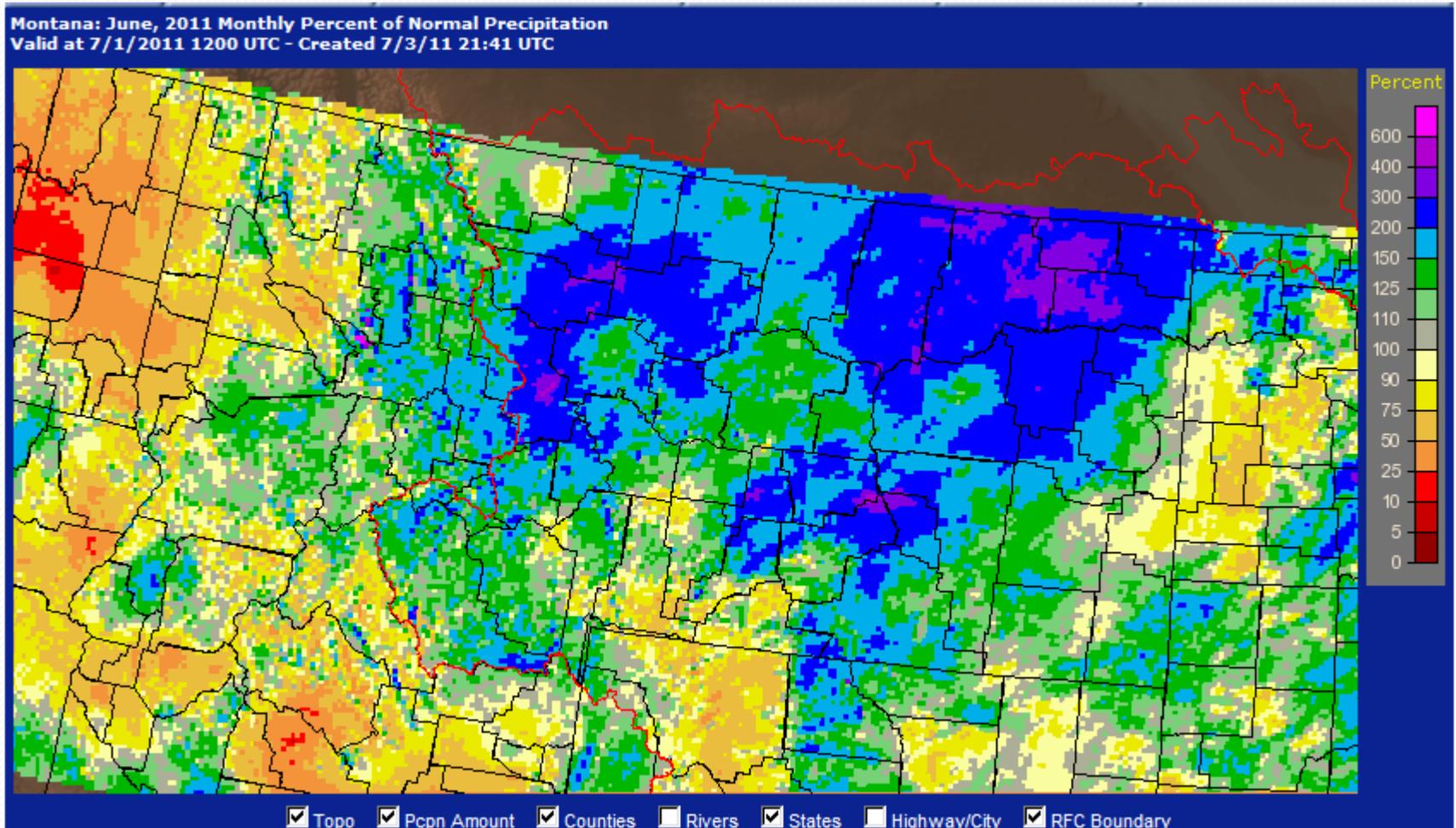


# Montana Monthly Precip Totals June 2011

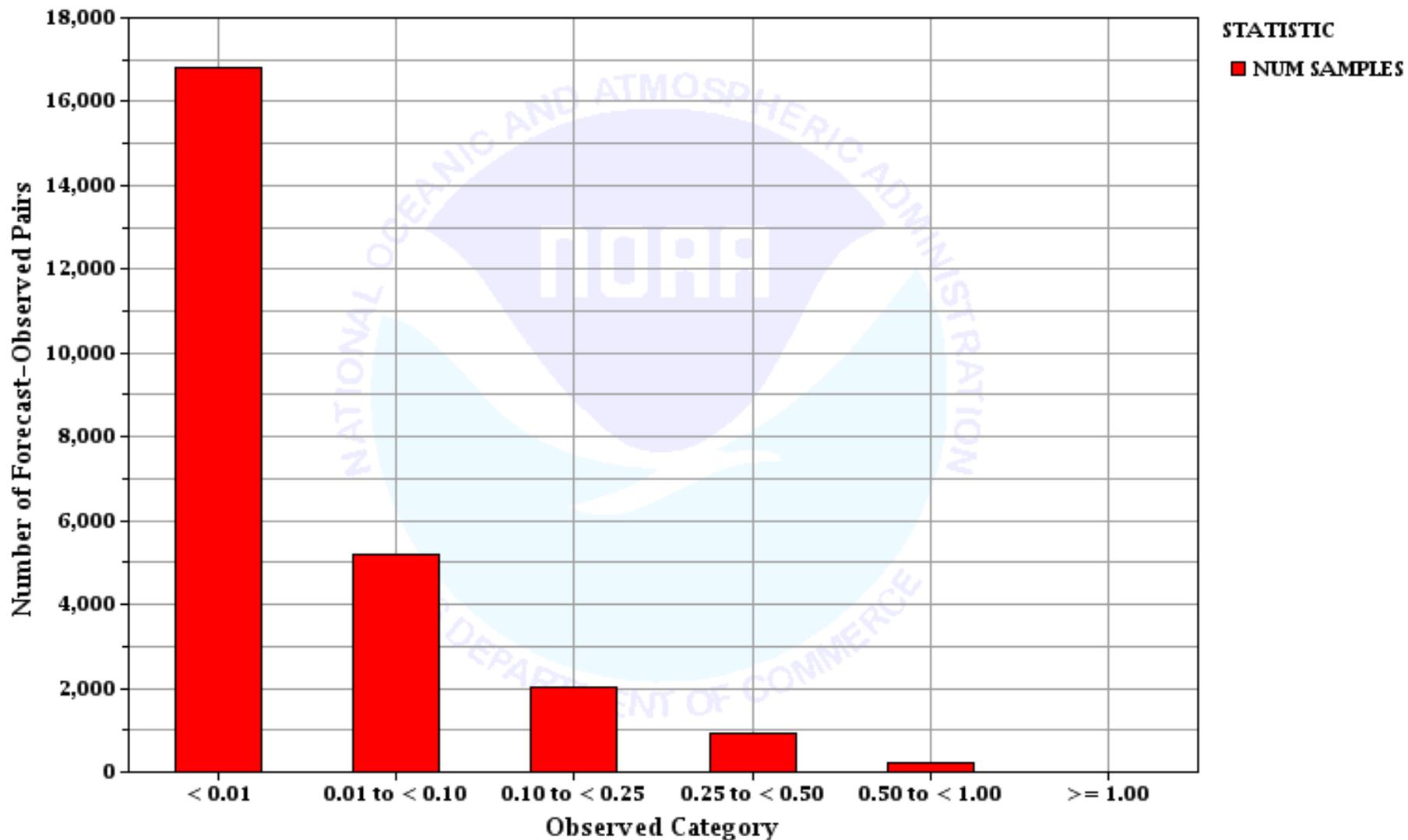
Montana: June, 2011 Monthly Observed Precipitation  
Valid at 7/1/2011 1200 UTC - Created 7/3/11 21:37 UTC



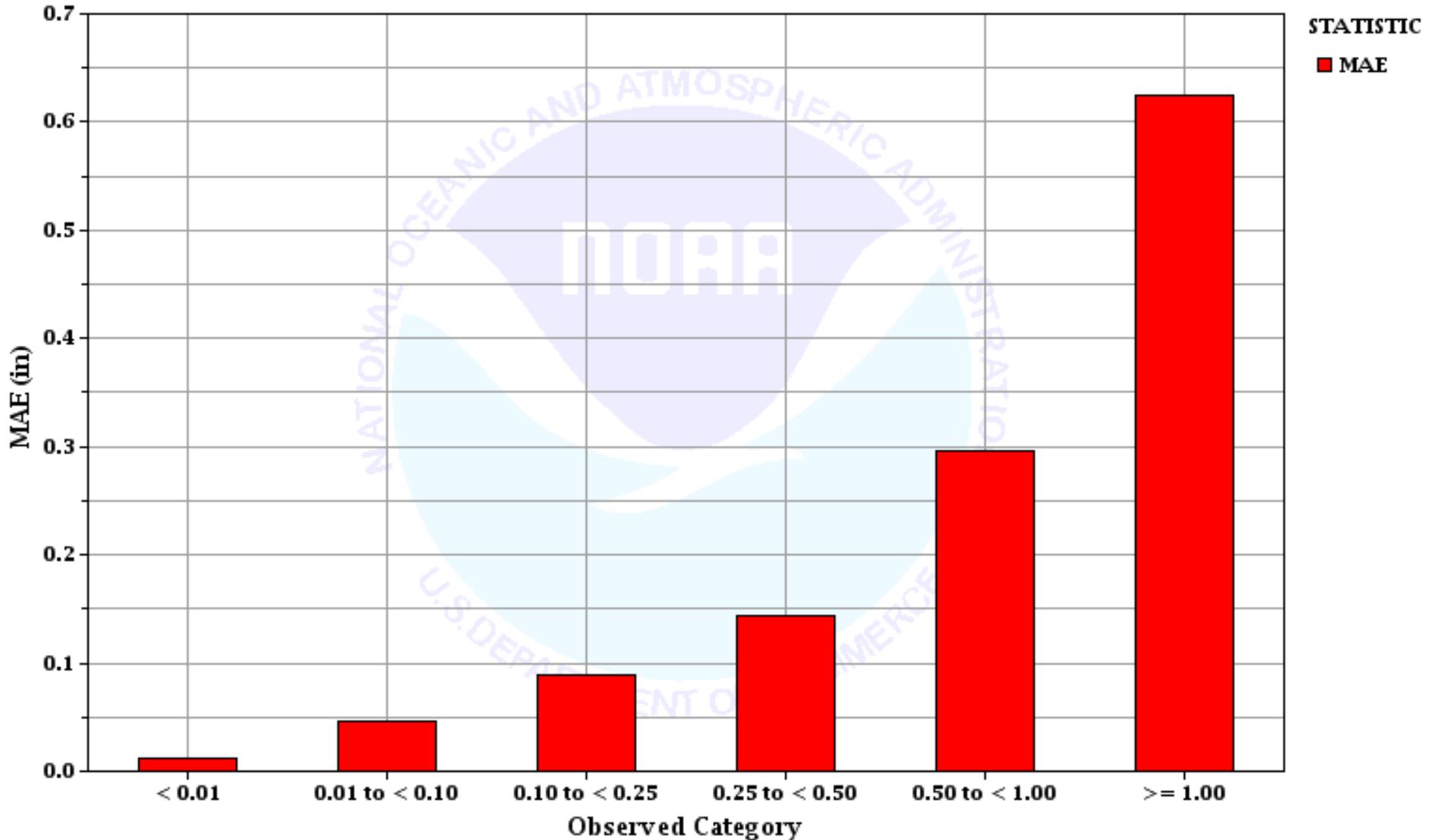
# Montana June 2011 Percent of Normal Precipitation



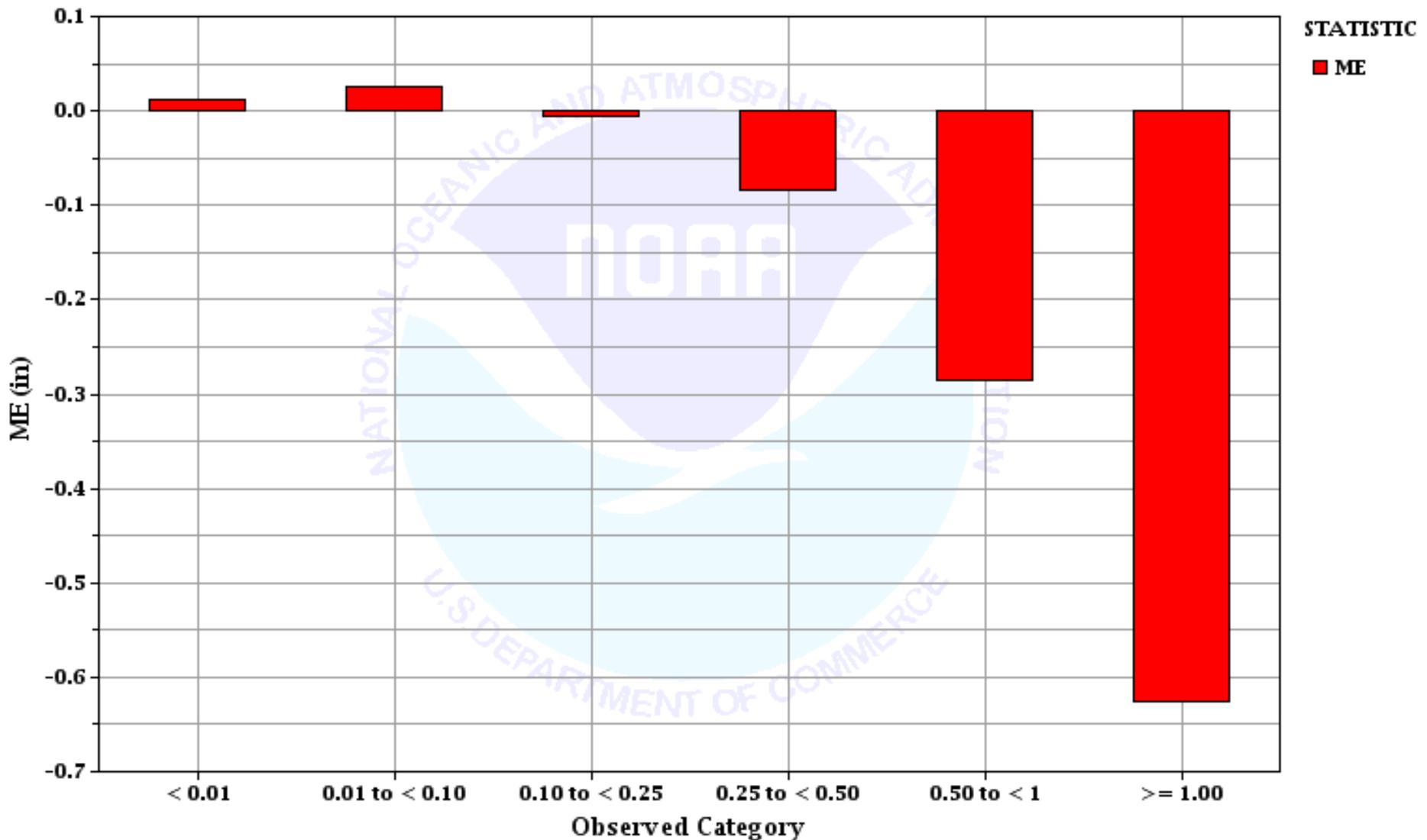
## Sample Size by Observed Categories May and June 2011



## Mean Absolute Error for 24-hr QPF 6-hourly precip values May and June 2011 for UMO, MIL and YEL runoff zones



## Mean Error for 24-hr QPF 6-hourly precip values May and June 2011 for UMO, MIL and YEL runoff zones

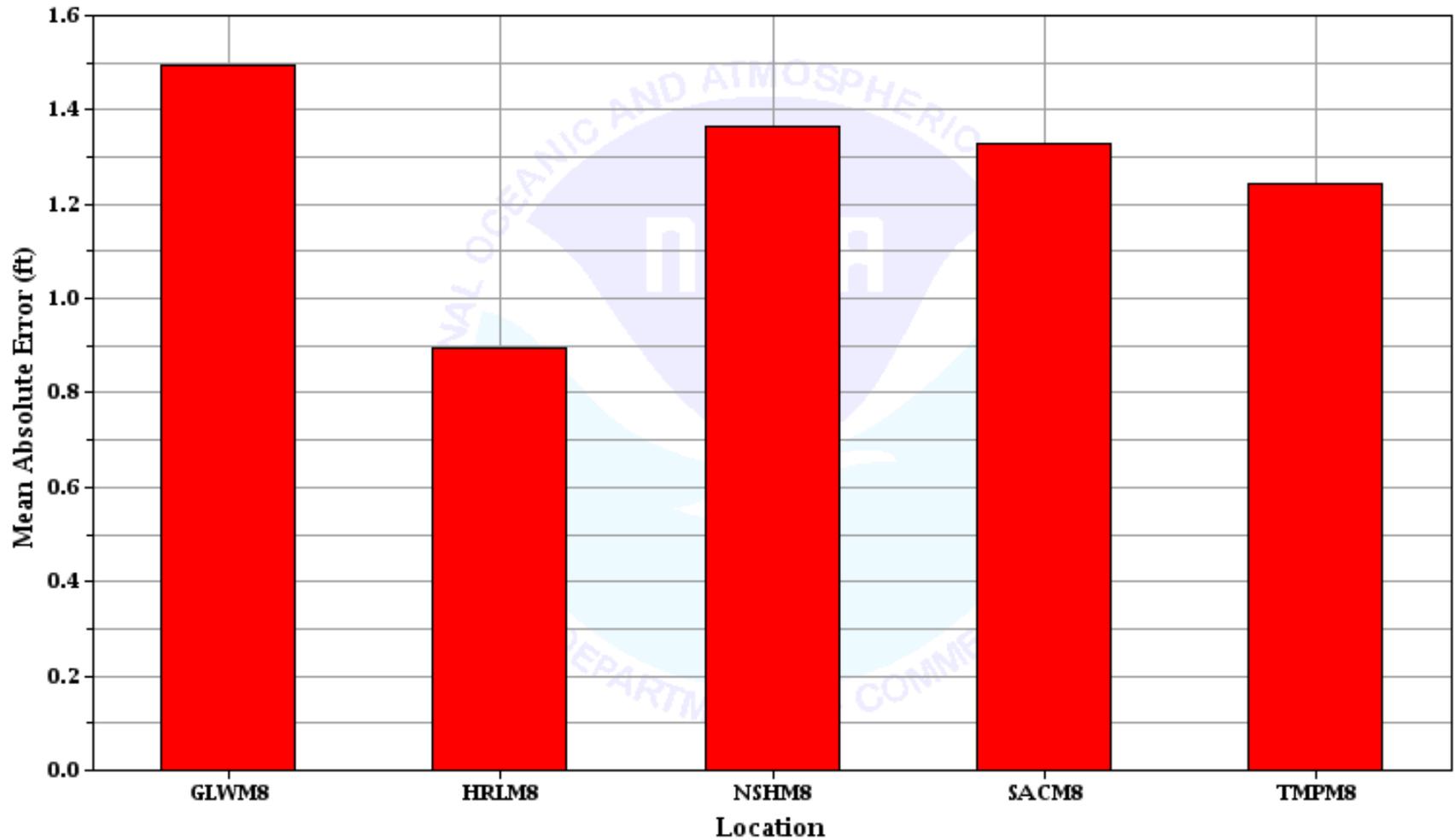


# Milk Forecasts

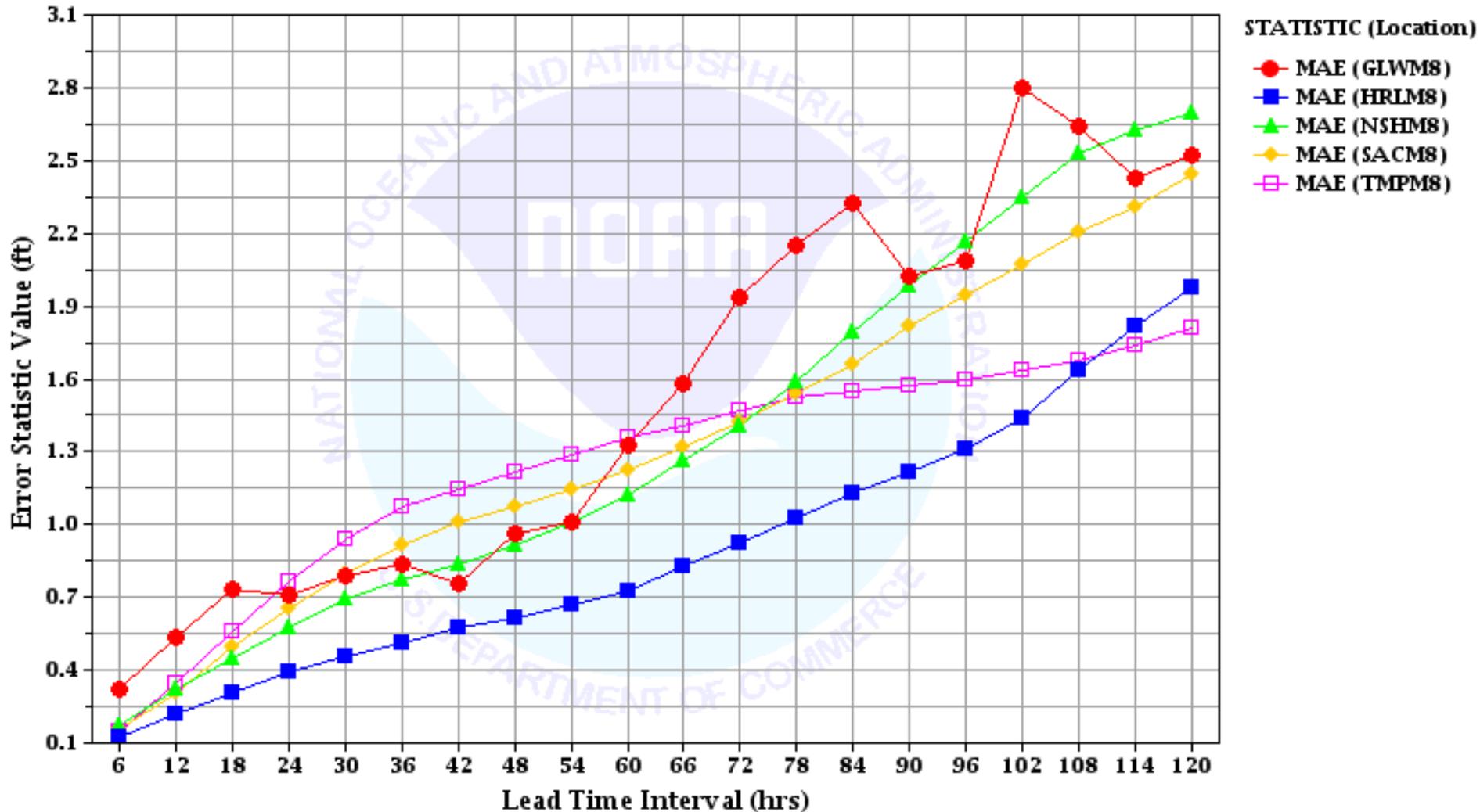
Rainfall flooding May-June 2011



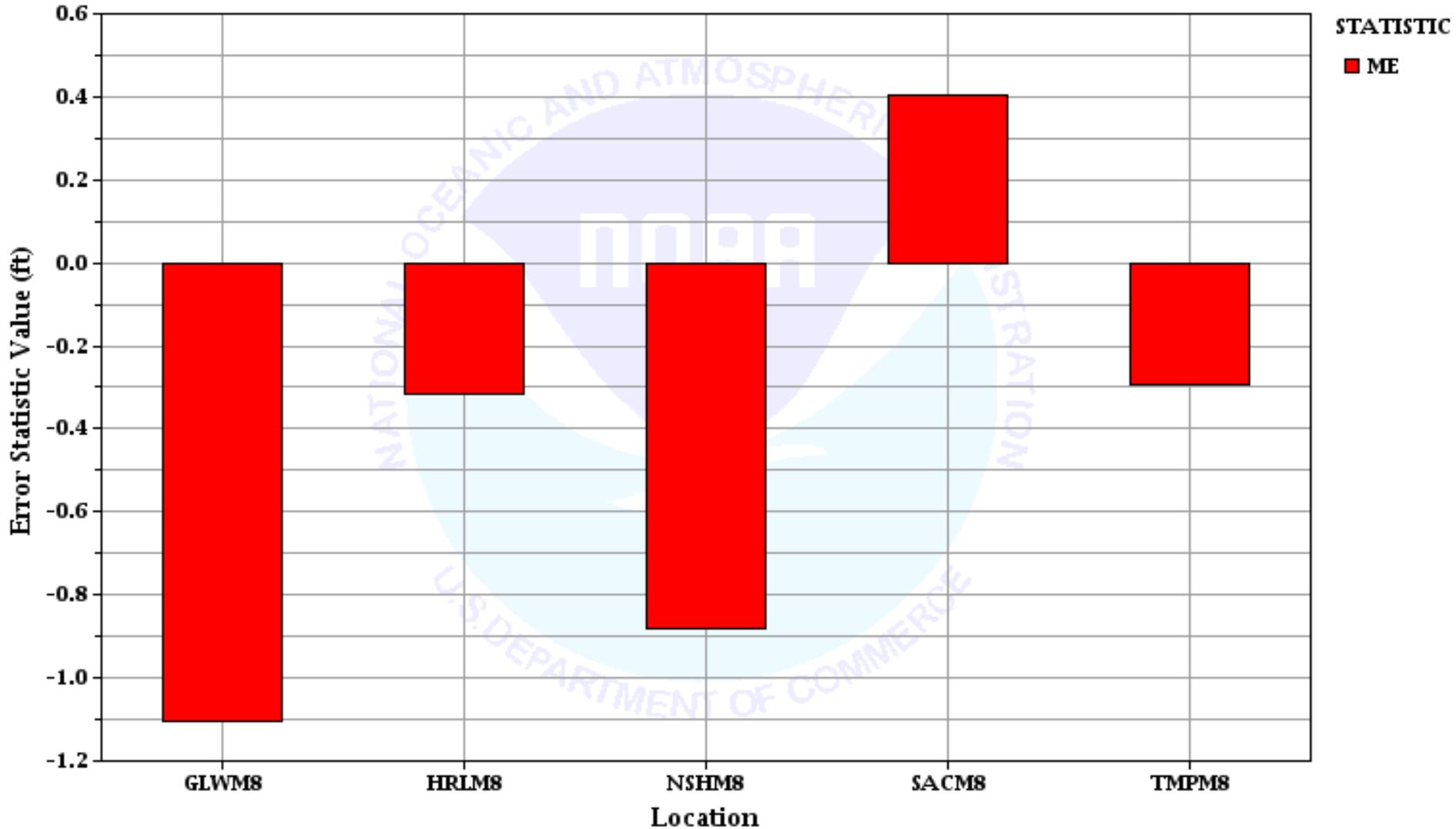
# Mean Absolute Error (MAE)



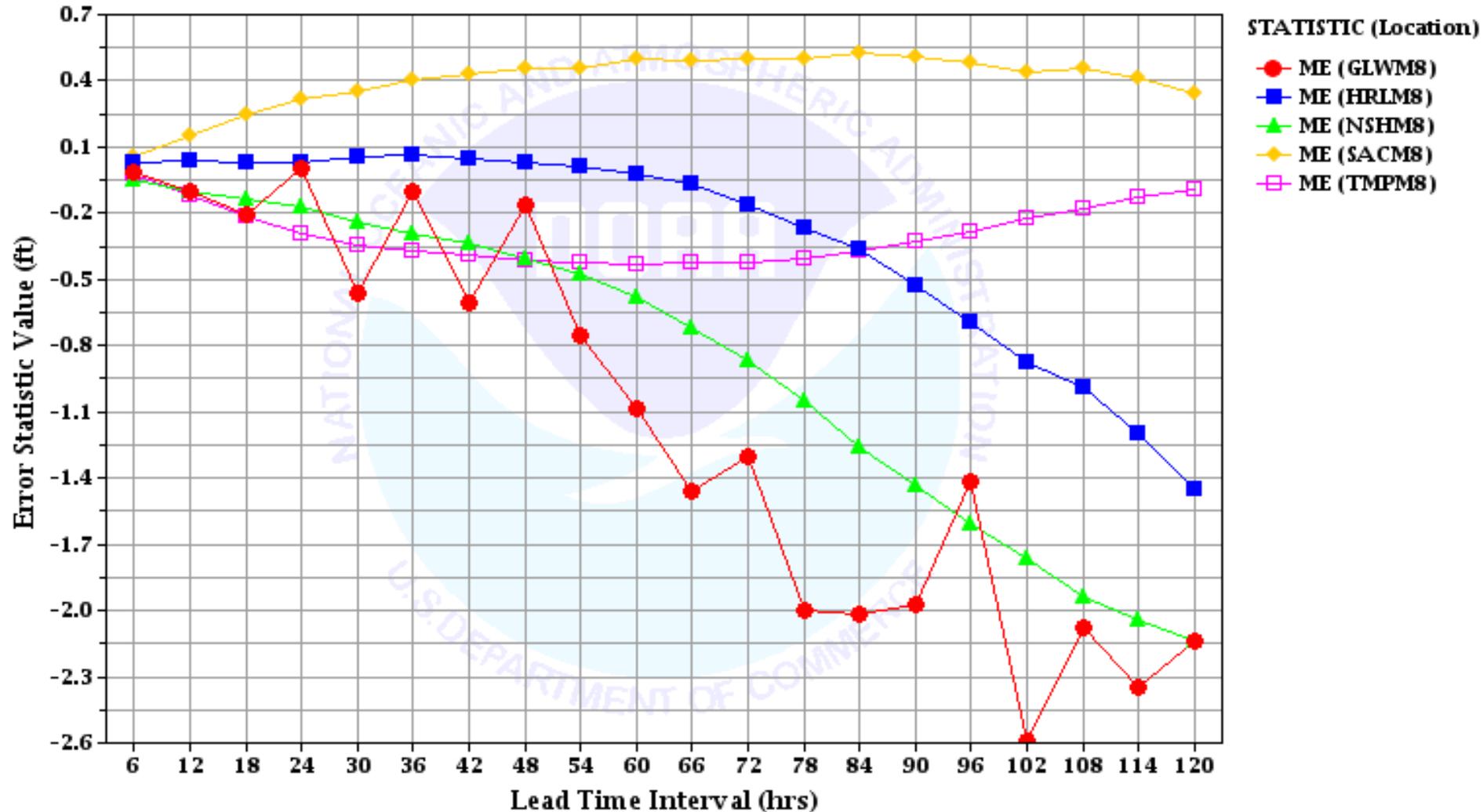
# Mean Absolute Error (MAE) By Lead Time



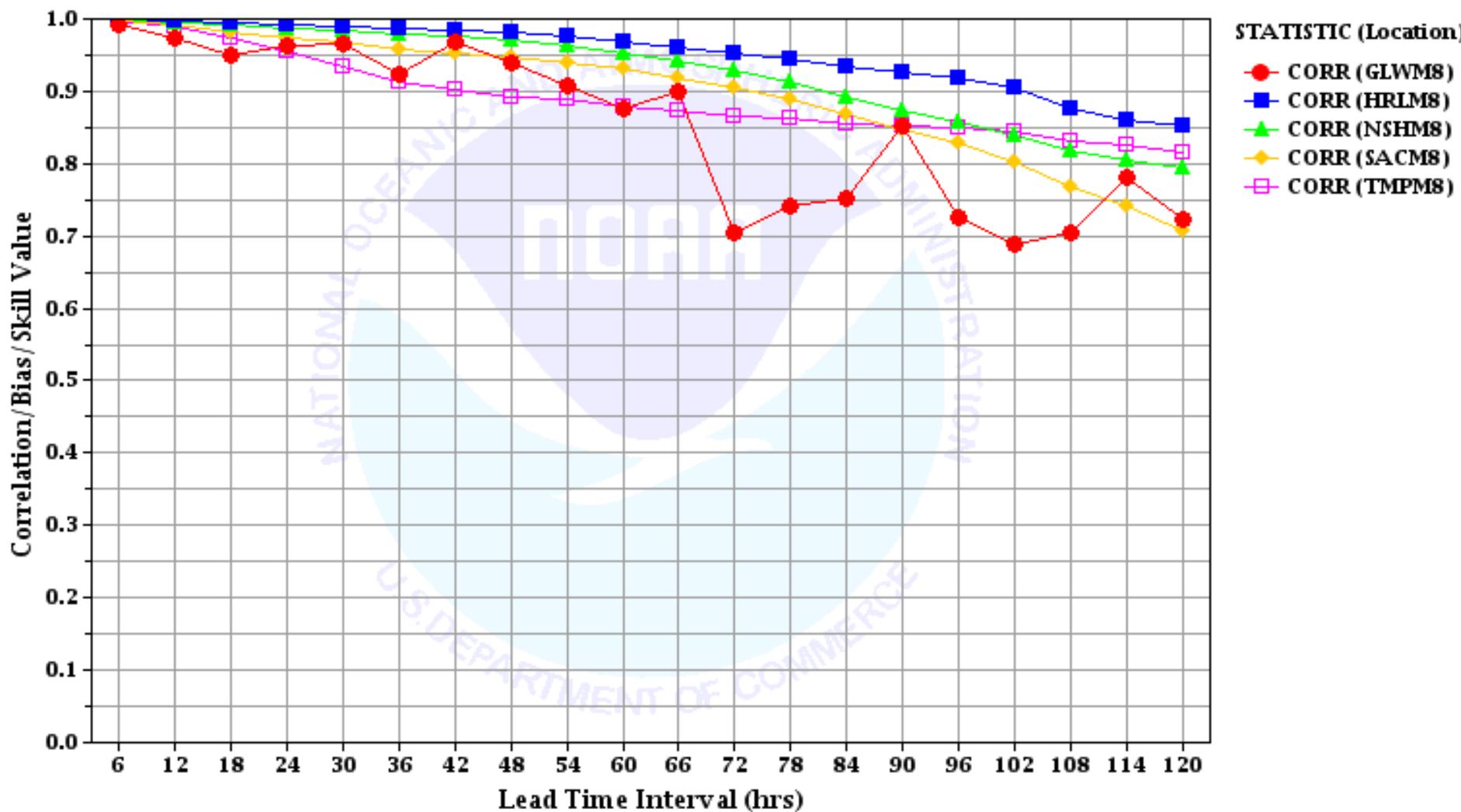
# Mean Error (ME)



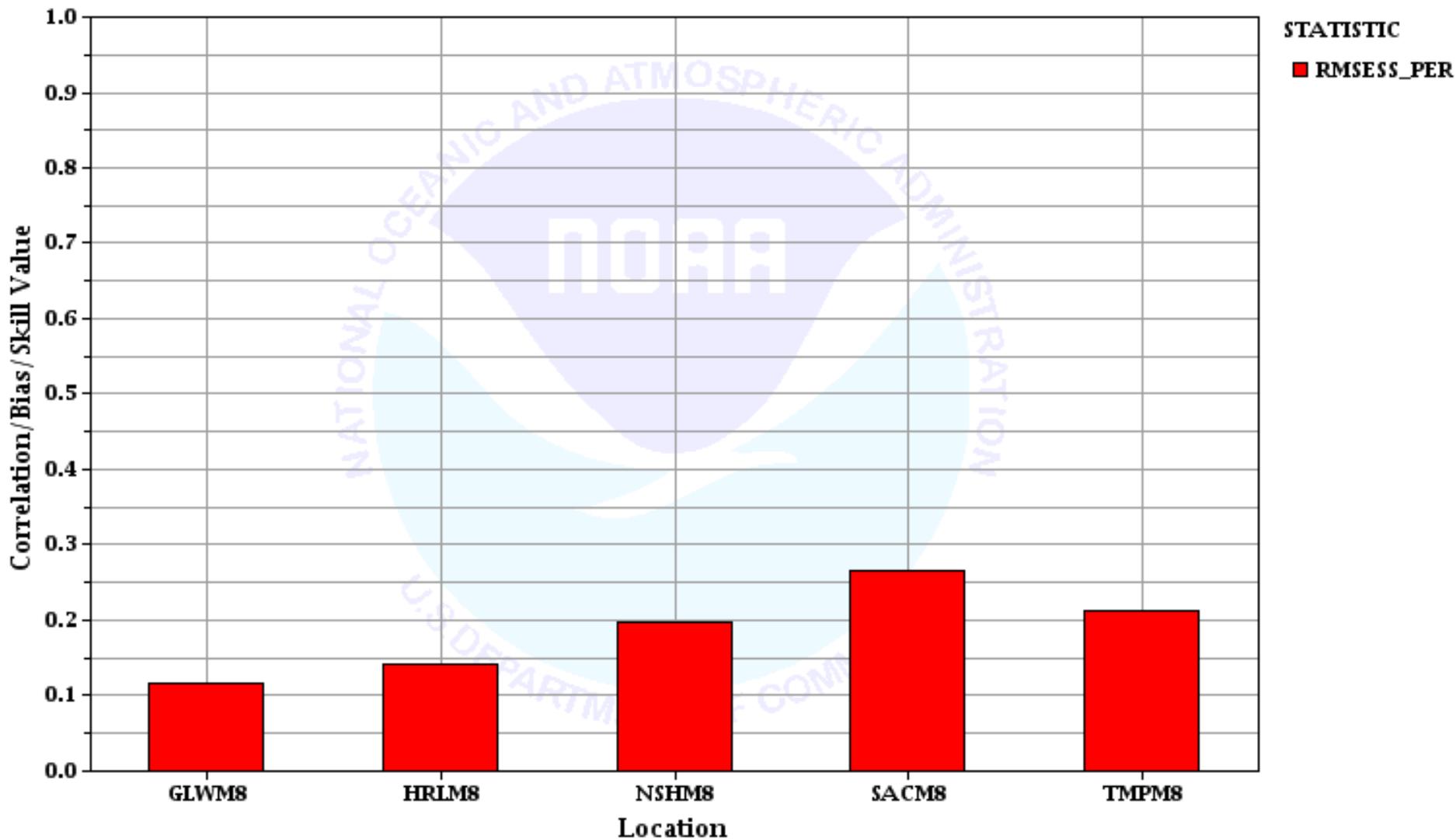
# Mean Error (ME) By Lead Time



# Pearson's Correlation (CORR) By Lead Time



# Root Mean Square Error Skill Score (RMSE-SS)



# Yellowstone Forecasts

## May-June 2011

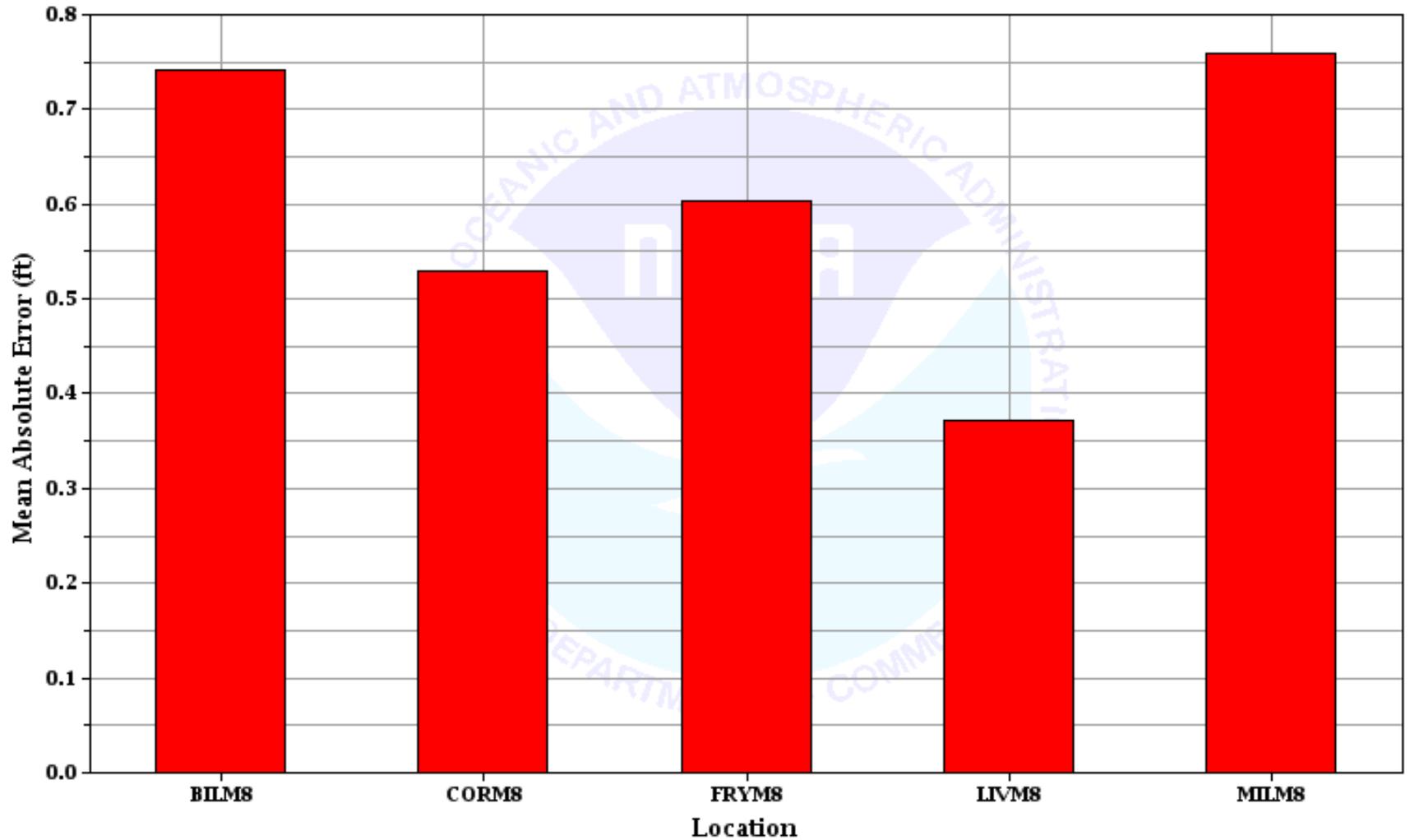


# Yellowstone Mainstem

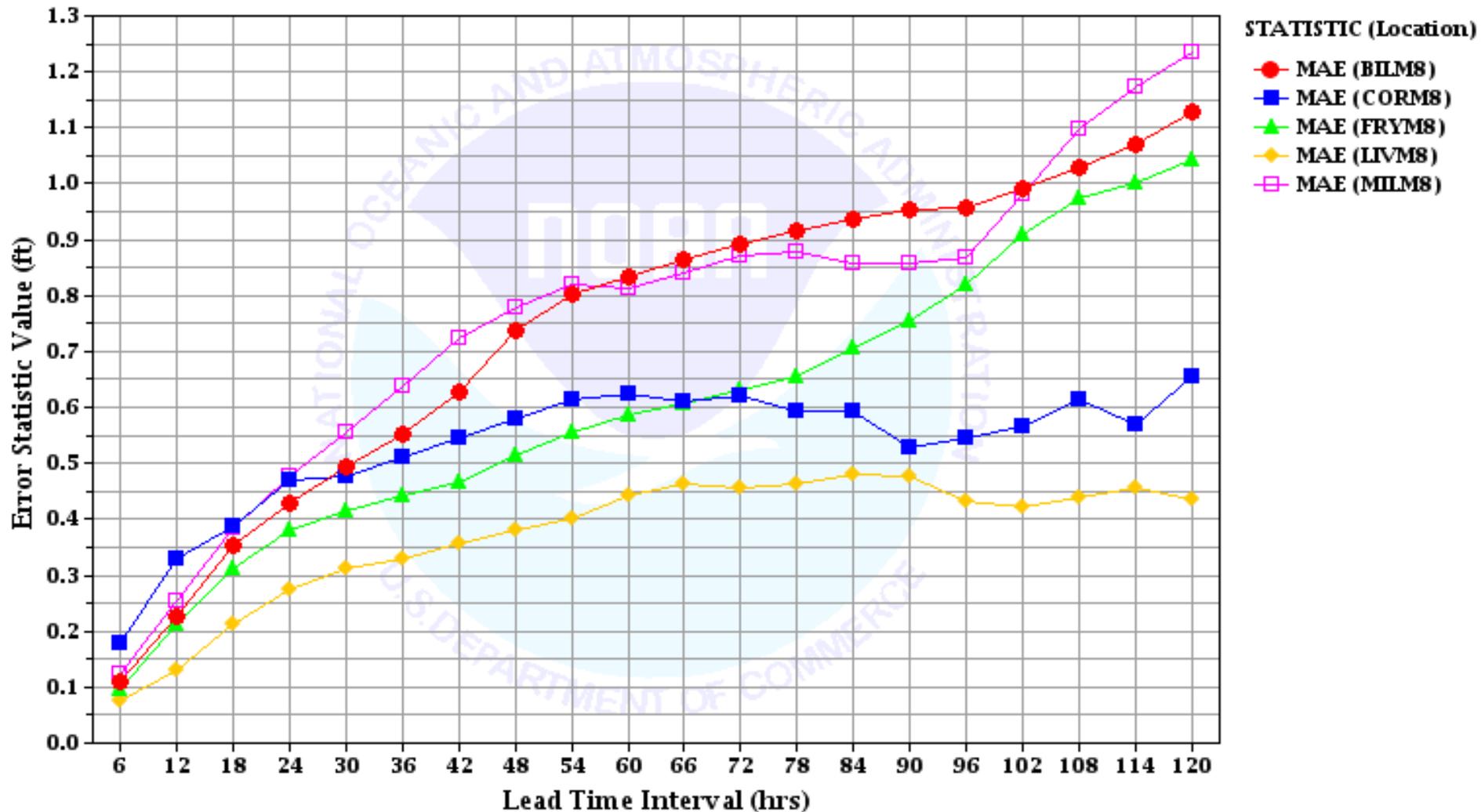
Forecasts points looked at were:

CORM8	Corwin Springs MT	FS 11.0 FT
LIVM8	Livingston MT	FS 9.0 FT
FRYM8	Forsyth MT	FS 10.0 FT
BILM8	Billings MT	FS 13.0 FT
MILM8	Miles City MT	FS 13.0 FT

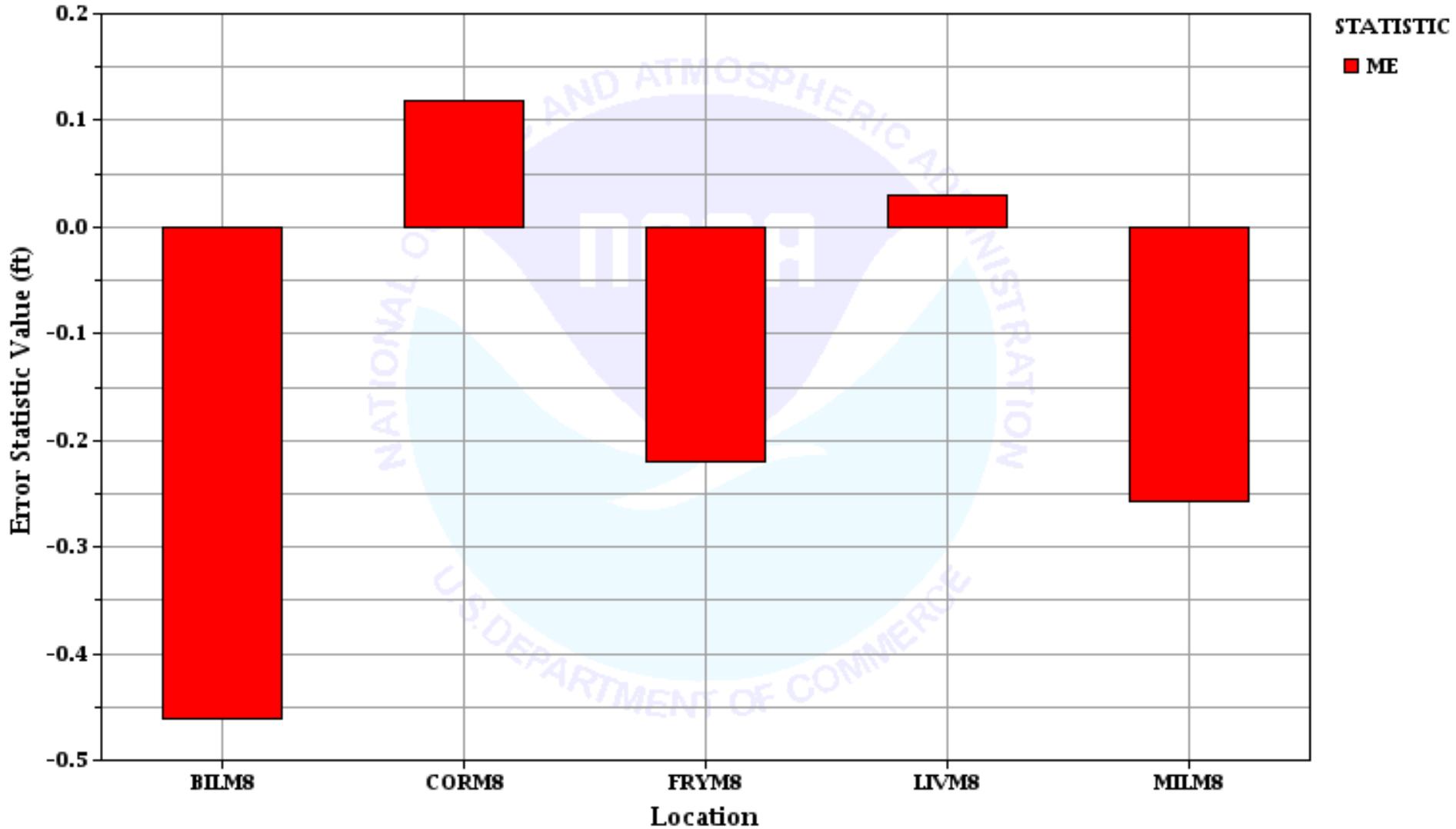
# Mean Absolute Error (MAE)



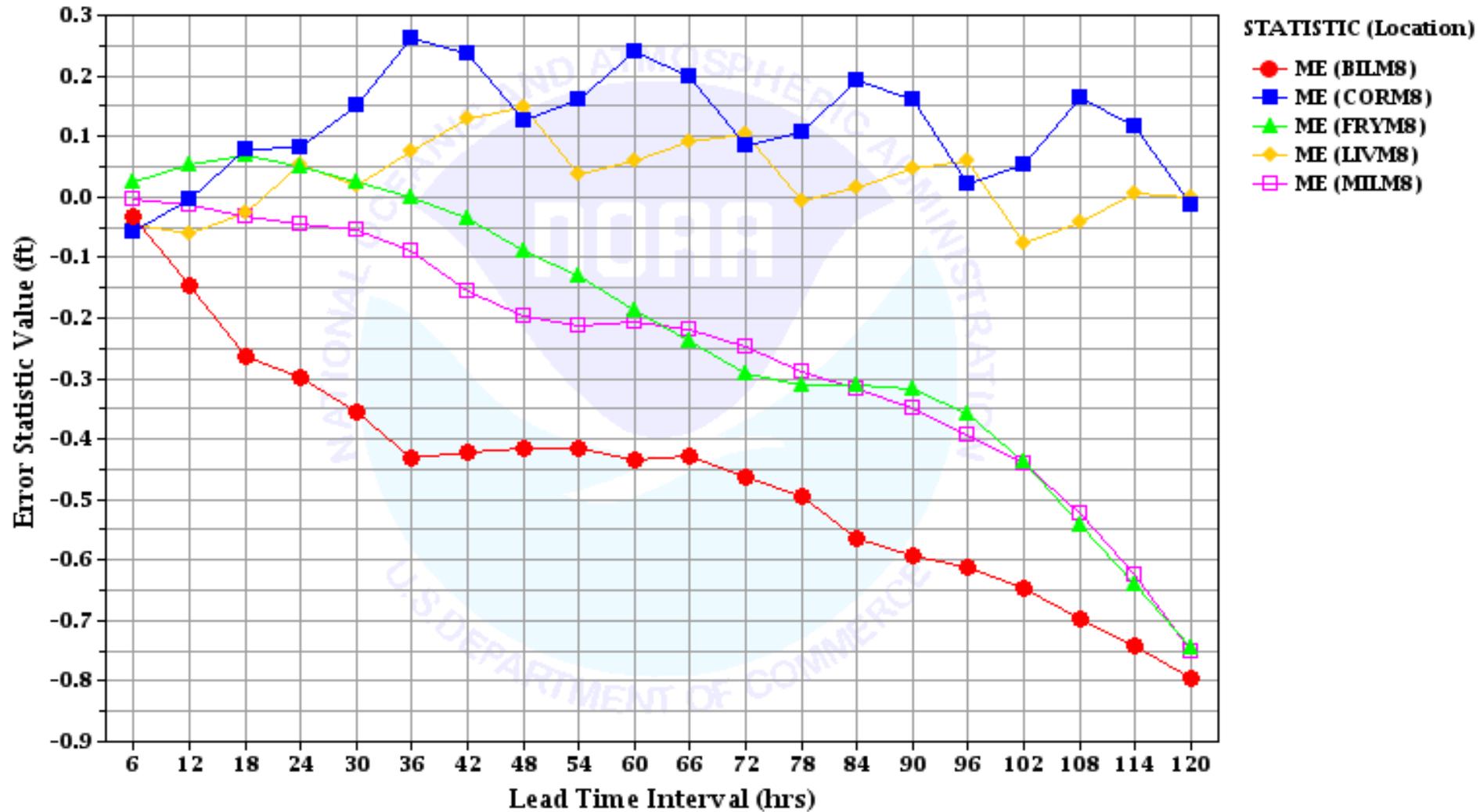
# Mean Absolute Error (MAE) By Lead Time



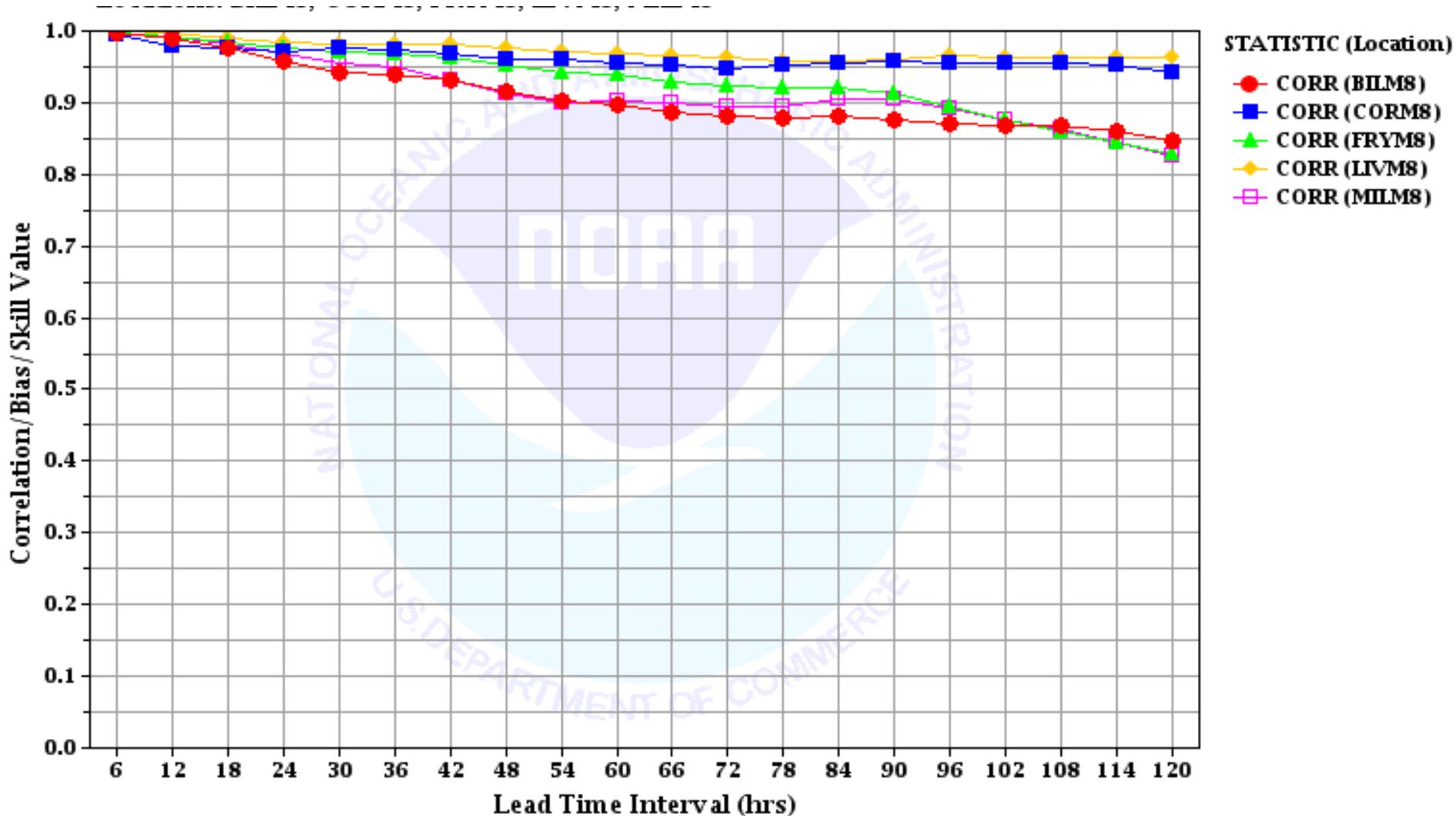
# Mean Error (ME)



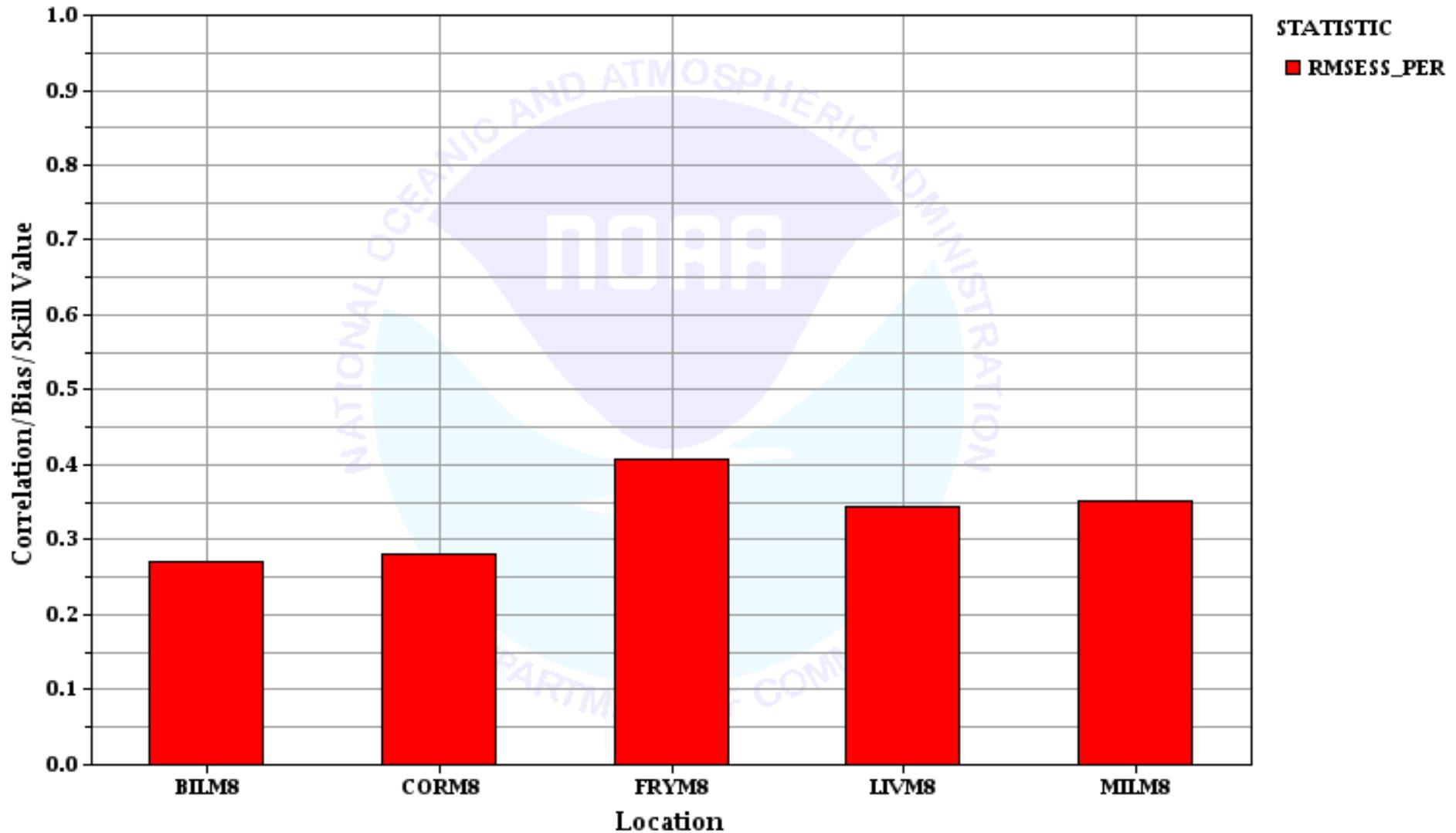
# Mean Error (ME) By Lead Time



# Pearson's Correlation (CORR) By Lead Time



# Root Mean Square Error Skill Score (RMSE-SS)



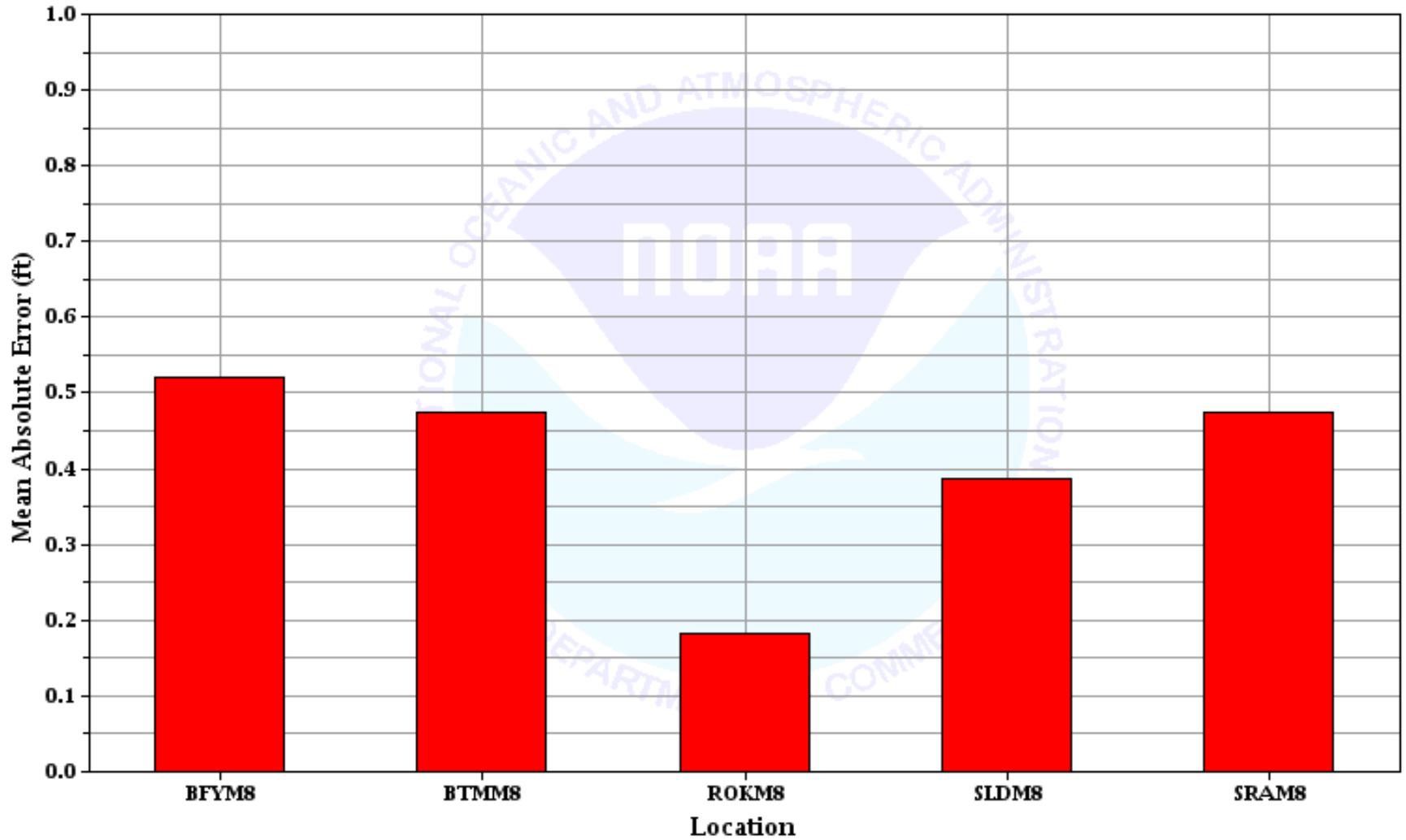
# Yellowstone Tributaries

Tributary forecast points looked at were:

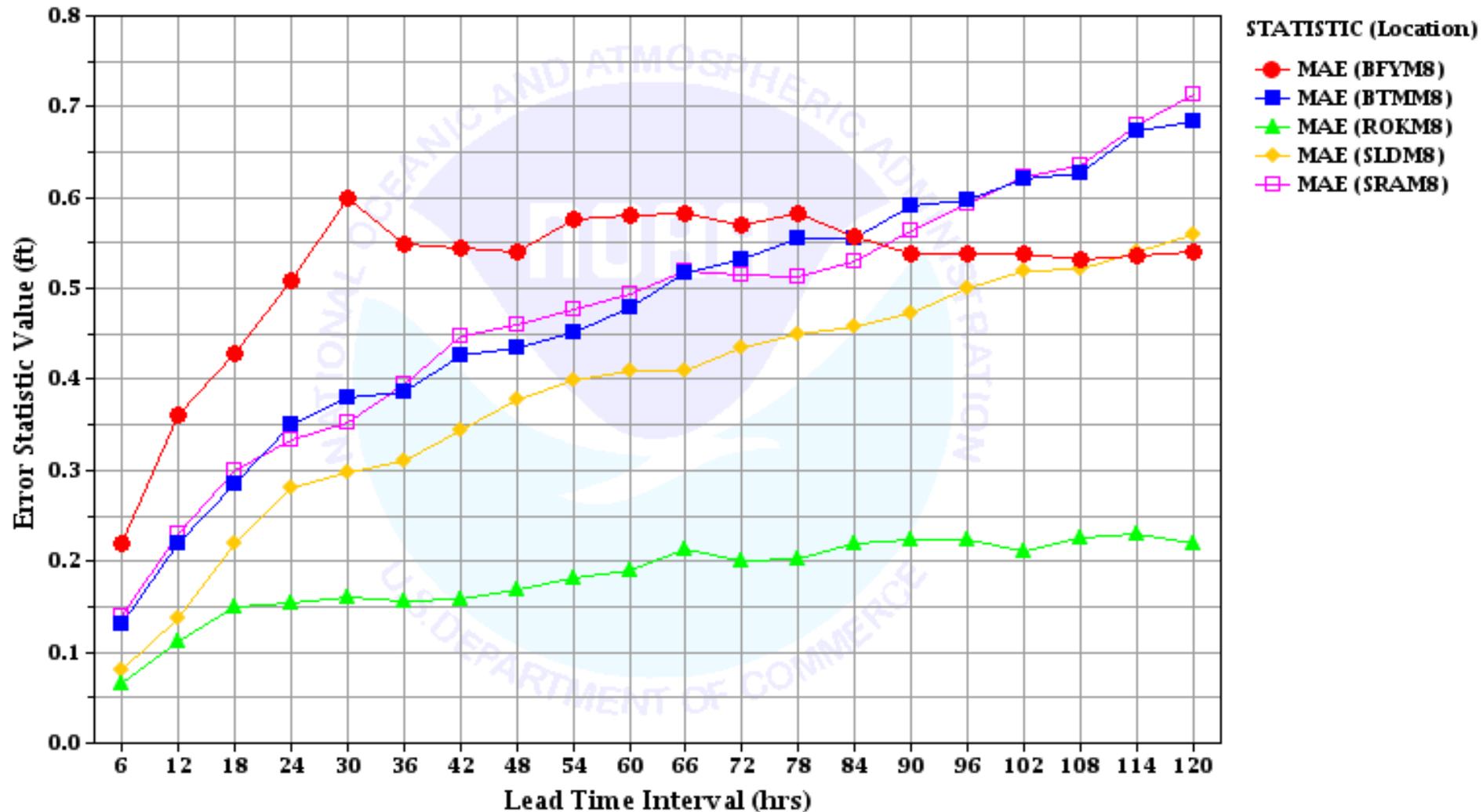
SLDM8	Livingston MT – Shields River	FS 5.5 FT
BTMM8	Big Timber MT – Boulder River	FS 7.0 FT
SRAM8	Absarokee MT – Stillwater River	FS 6.5 FT
ROKM8*	Red Lodge MT – Rock Creek	FS 7.5 FT
BFYM8	Belfry Mt – Clarks Fk Yellowstone	FS 7.5 FT

\*ROKM8 no longer a forecast point

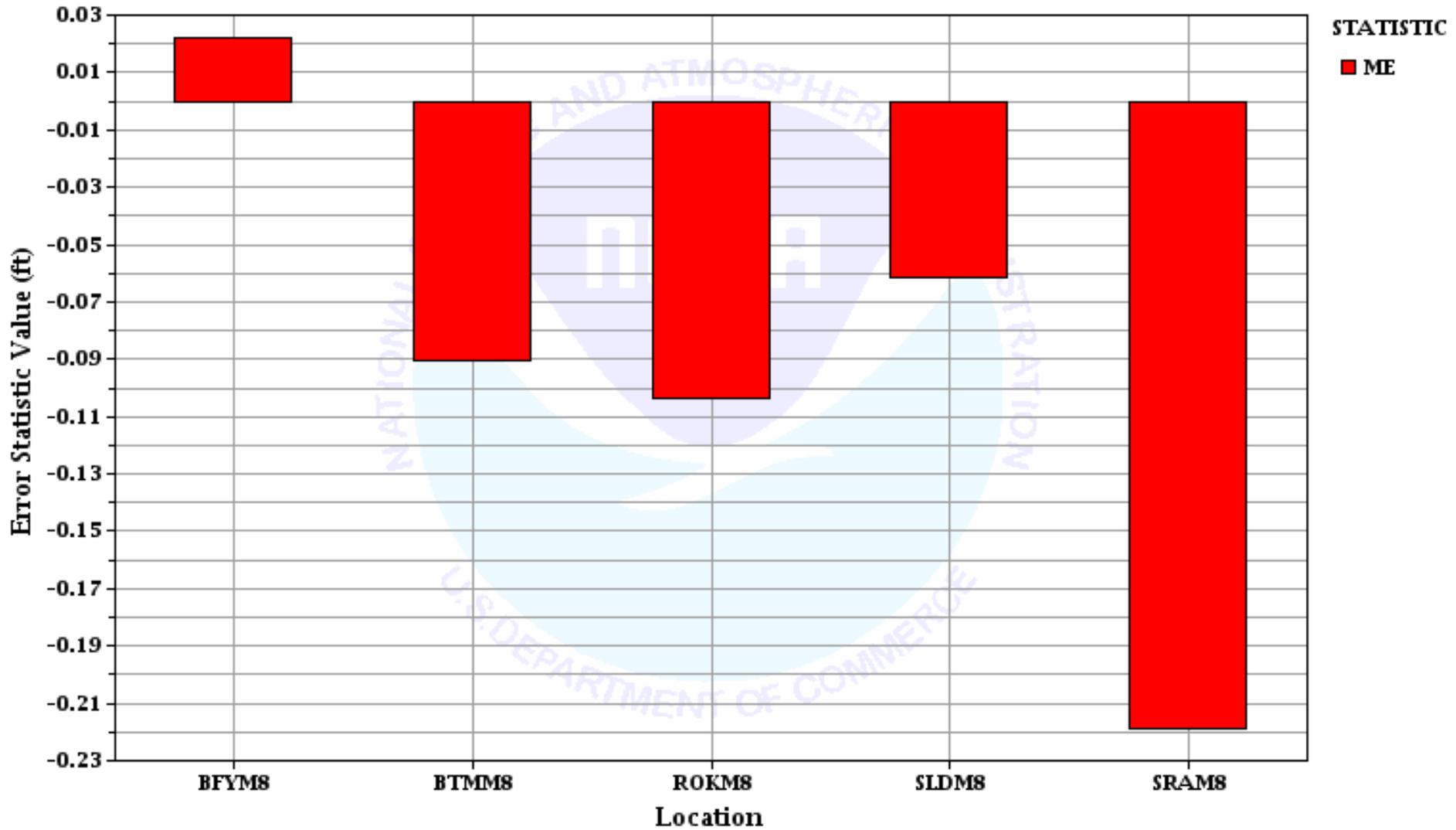
# Mean Absolute Error (MAE)



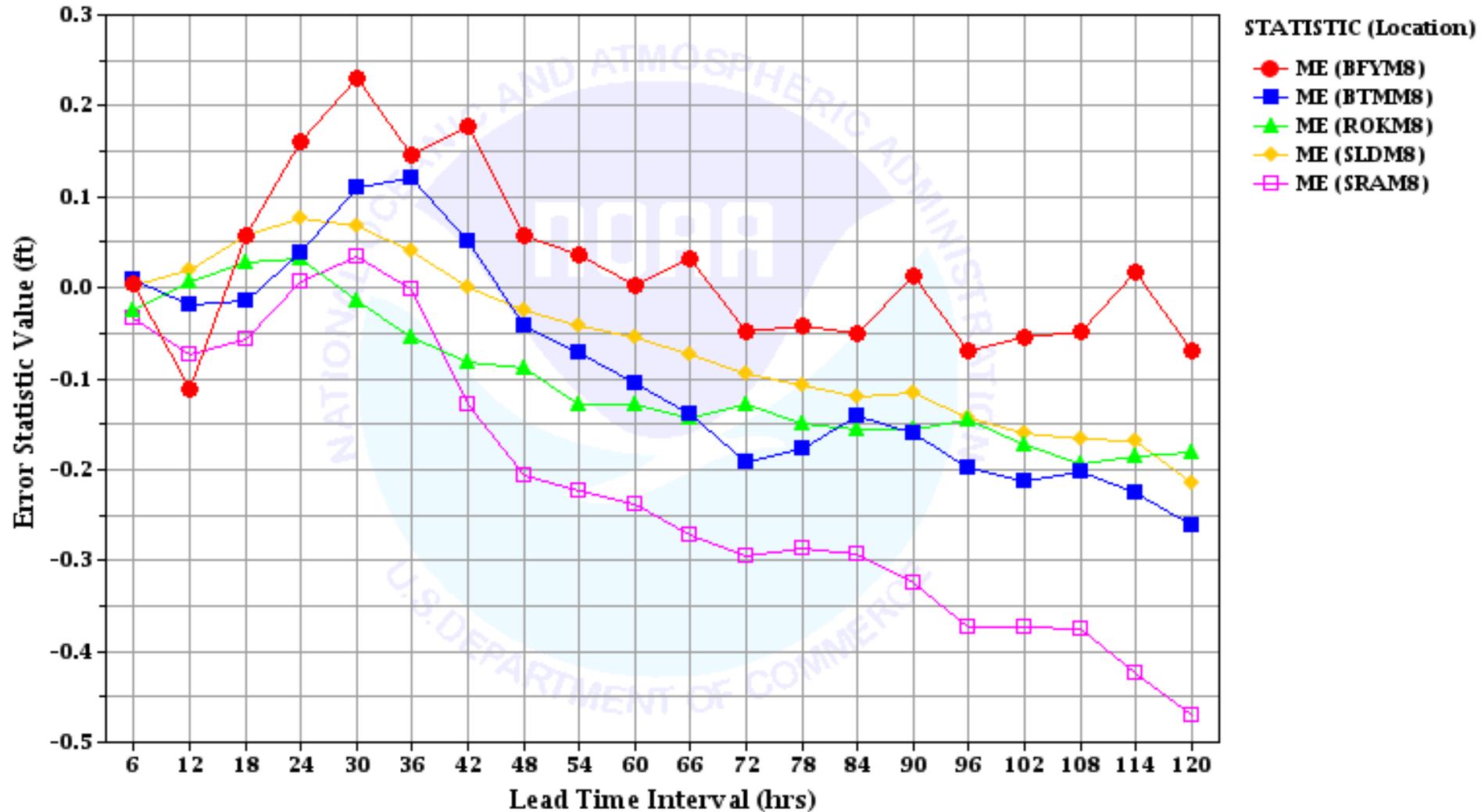
# Mean Absolute Error (MAE) By Lead Time



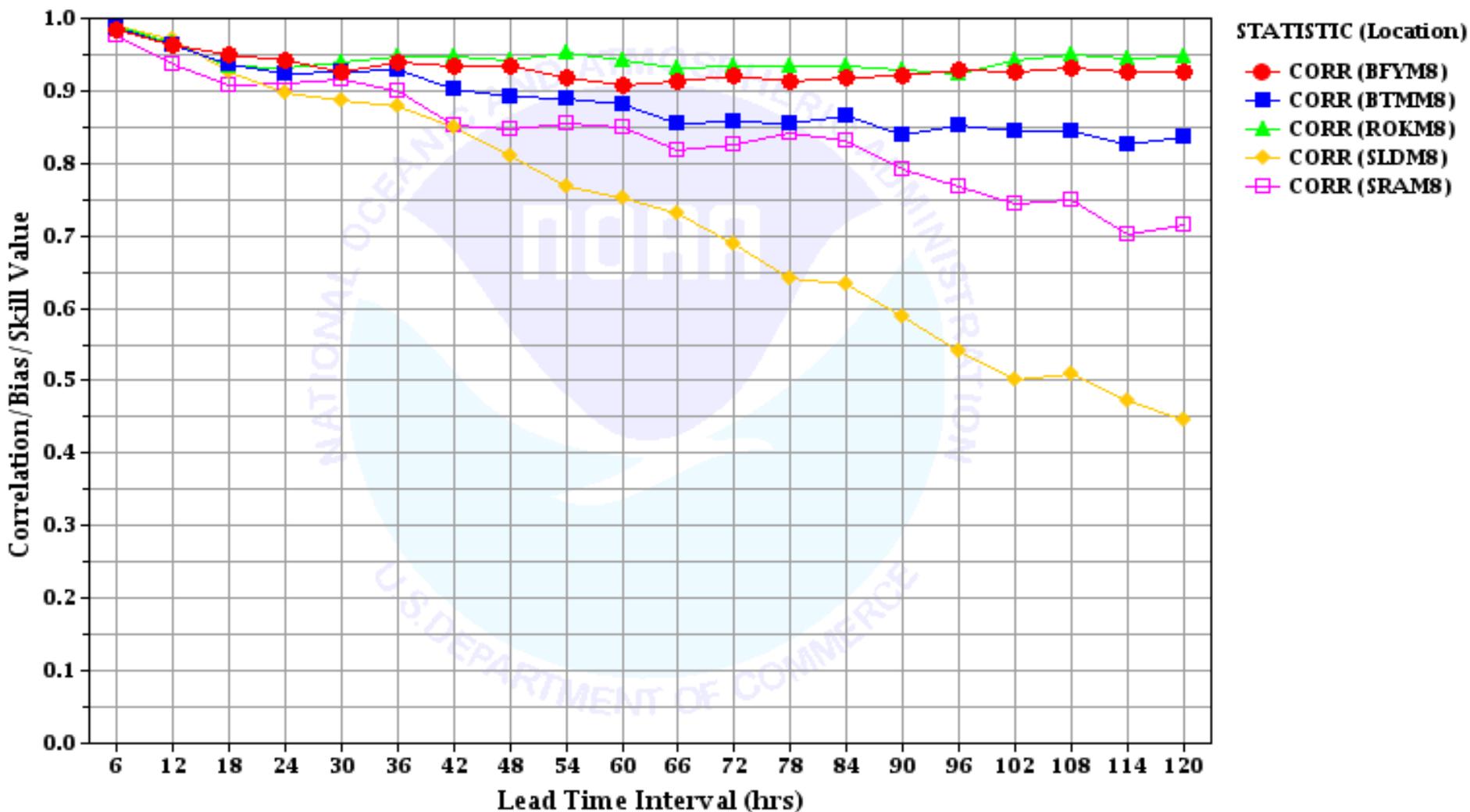
# Mean Error (ME)



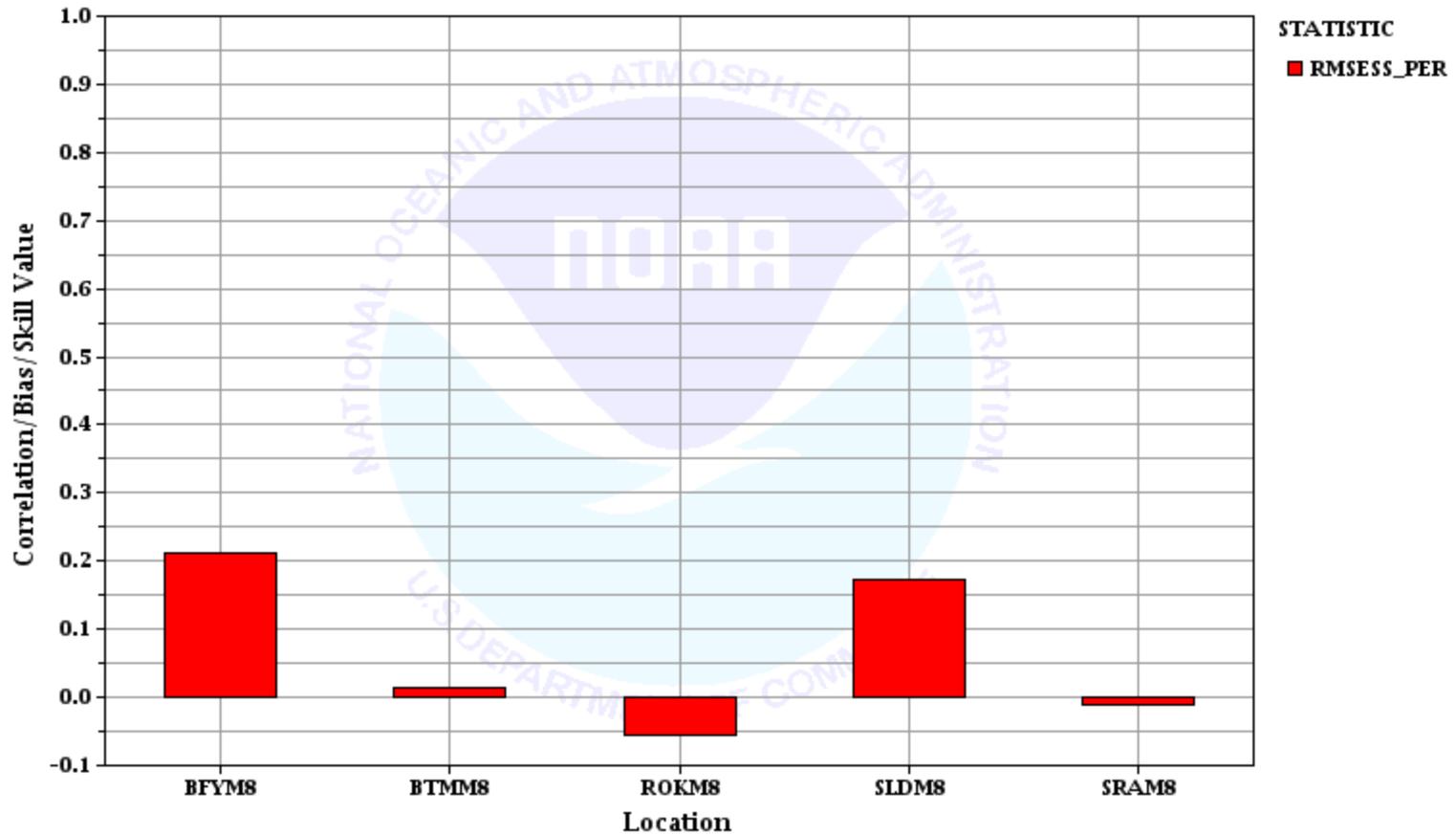
# Mean Error (ME) By Lead Time



# Pearson's Correlation (CORR) By Lead Time



# Root Mean Square Error Skill Score (RMSE-SS)



# Special Requests Forecasts May-June 2011



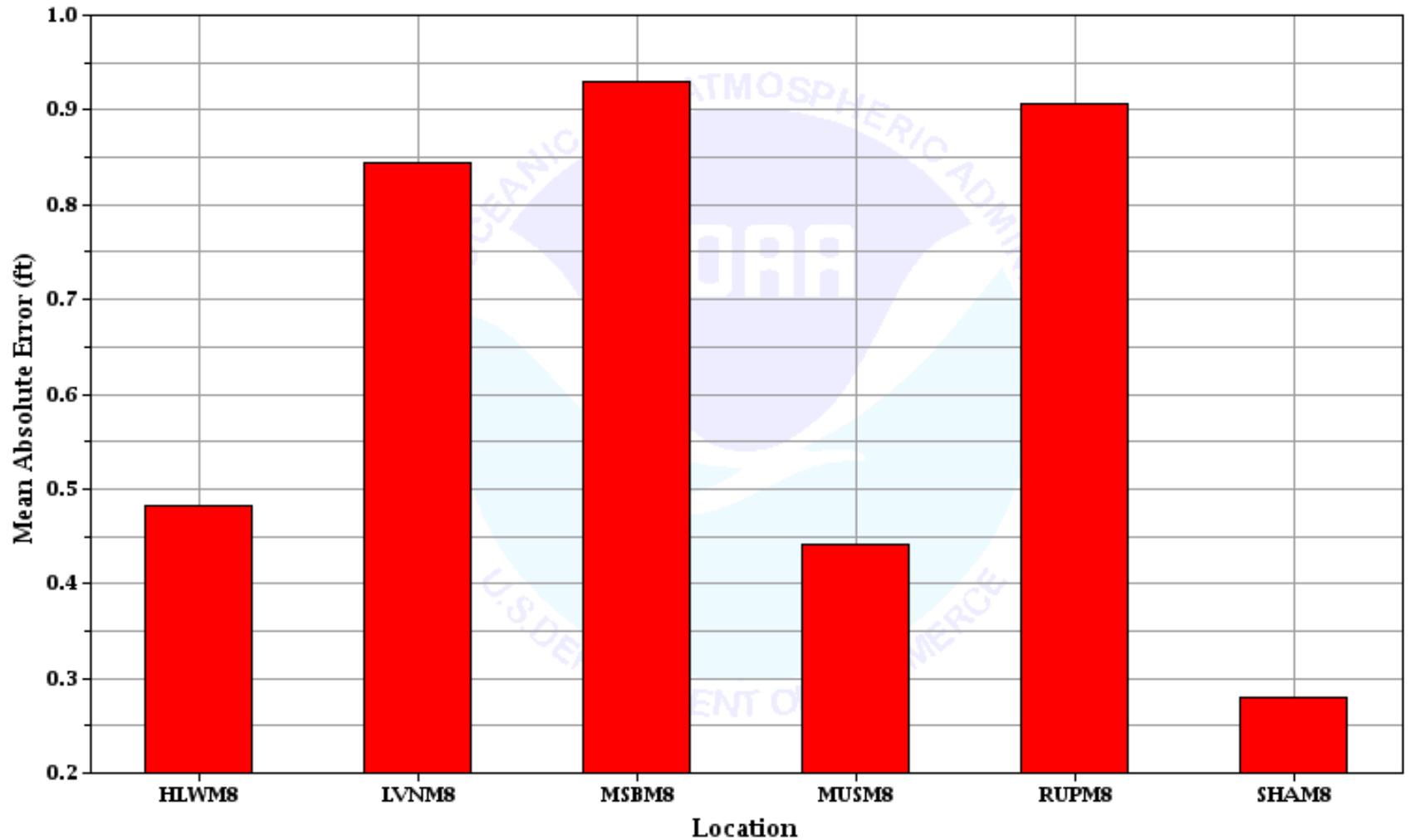
# Musselshell Forecasts

These locations were not RFC forecast points in 2011:

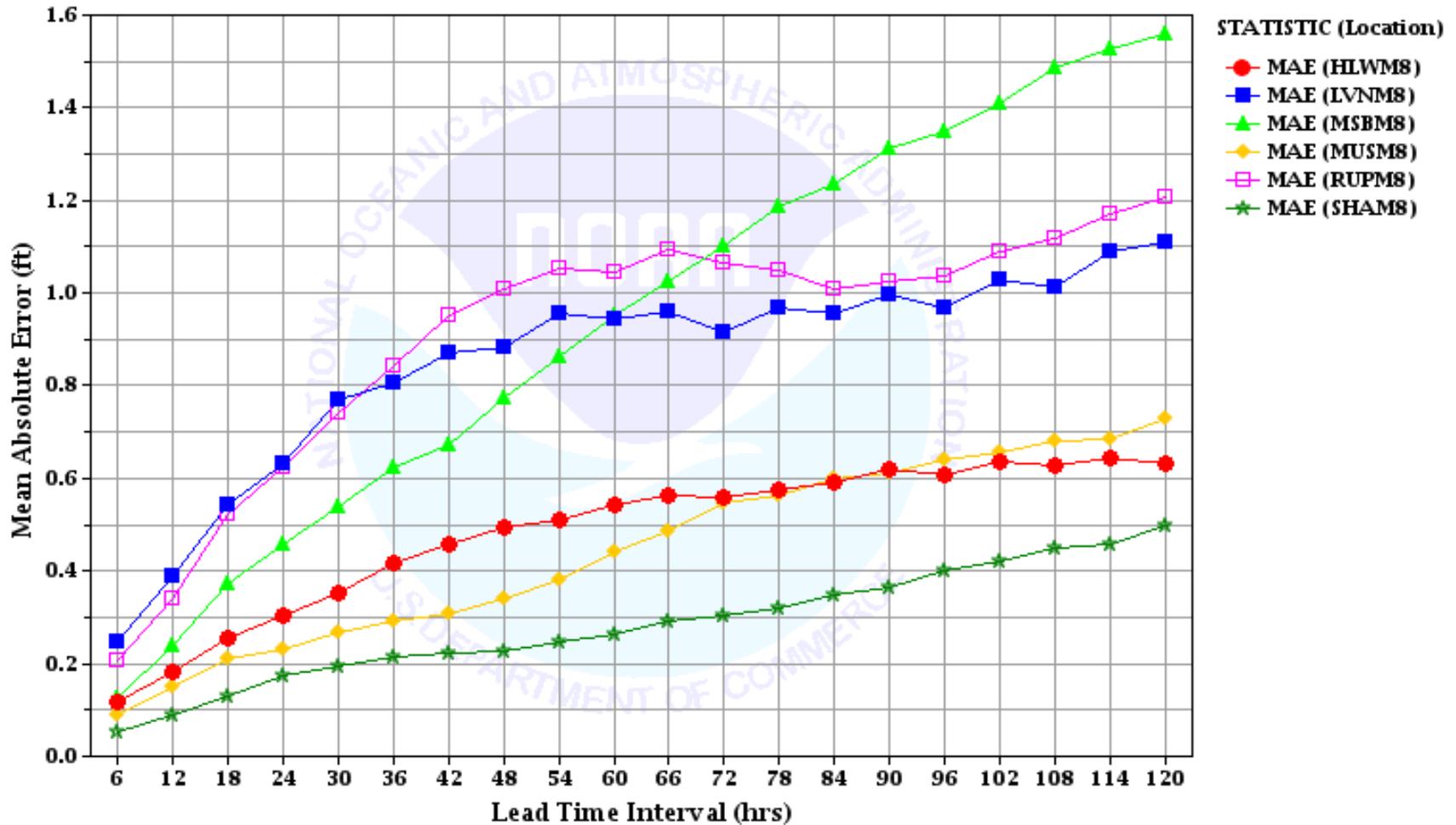
HLWM8	Harlowton MT	FS 7.0 FT
SHAM8	Shawmut MT	FS 6.5 FT (no FS at the time)
LVNM8	Lavina MT	FS 8.5 FT (no FS at the time)
RUPM8	Roundup MT	FS 10.0 FT
MUSM8	Musselshell MT	FS 11.0 FT (no FS at the time)
MSBM8	Mosby MT	FS 10.0 FT (2011 FS was 8.0 FT)

These are now all RFC forecast points

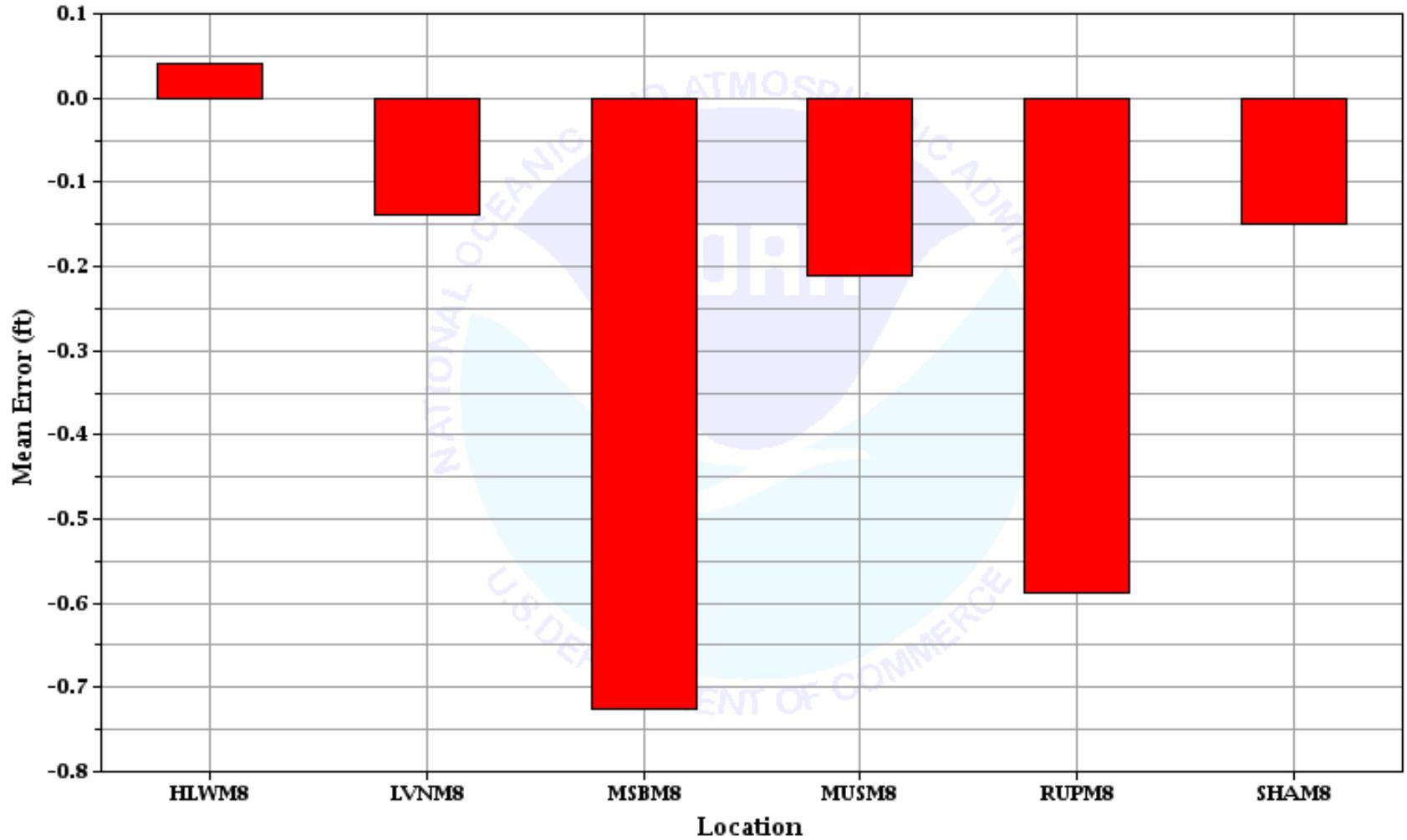
# Mean Absolute Error (MAE)



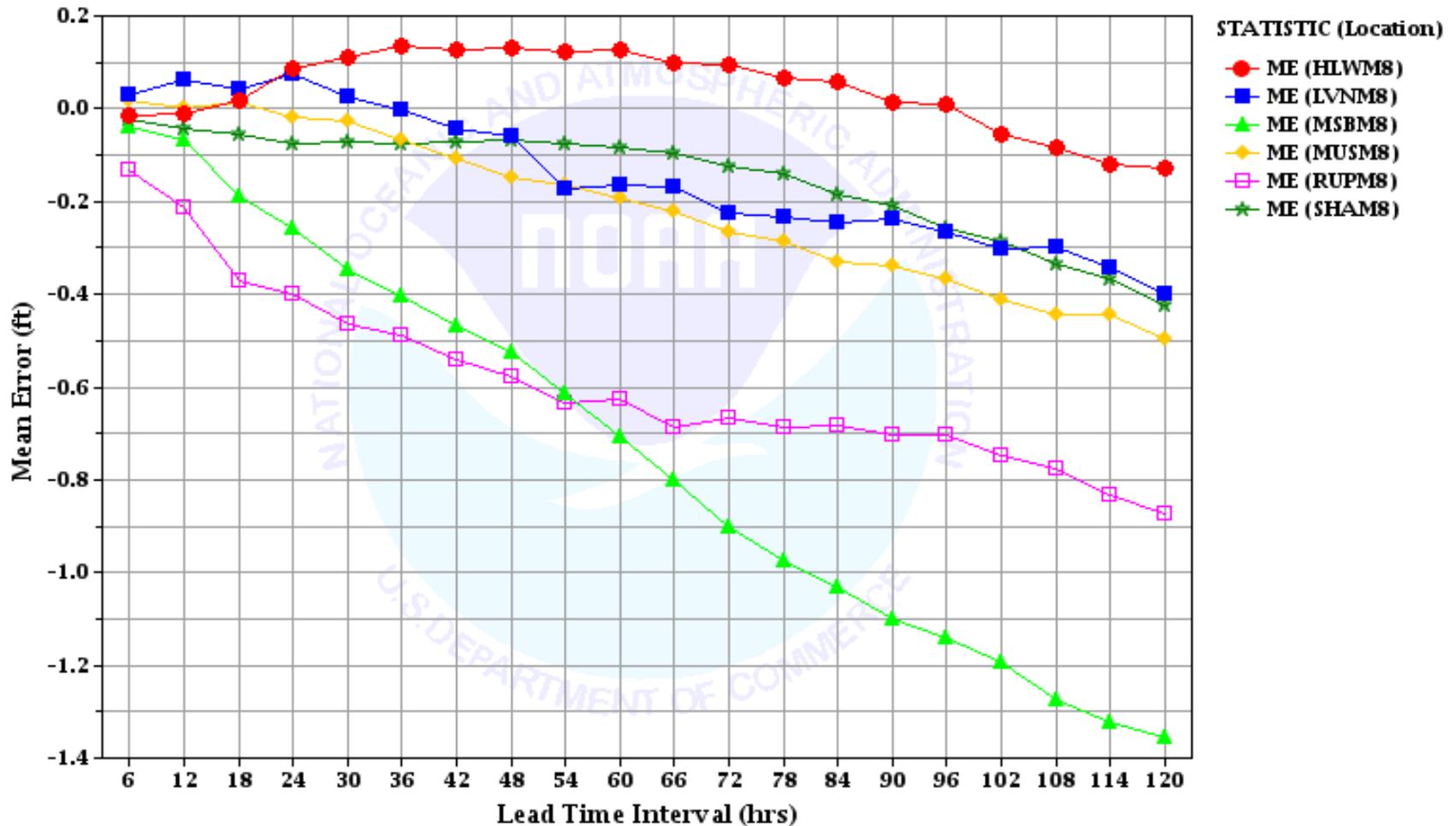
# Mean Absolute Error (MAE) By Lead Time



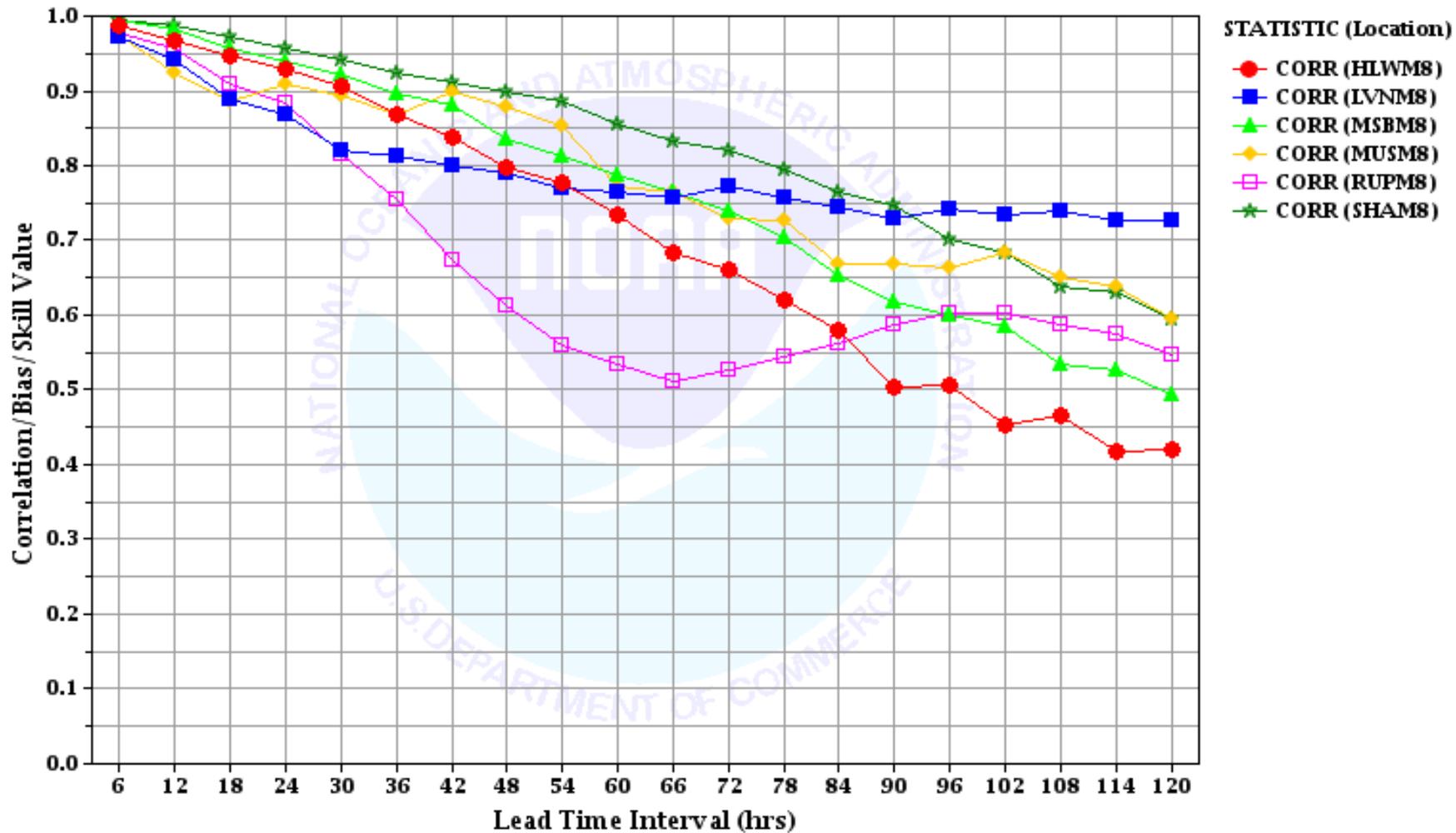
# Mean Error (ME)



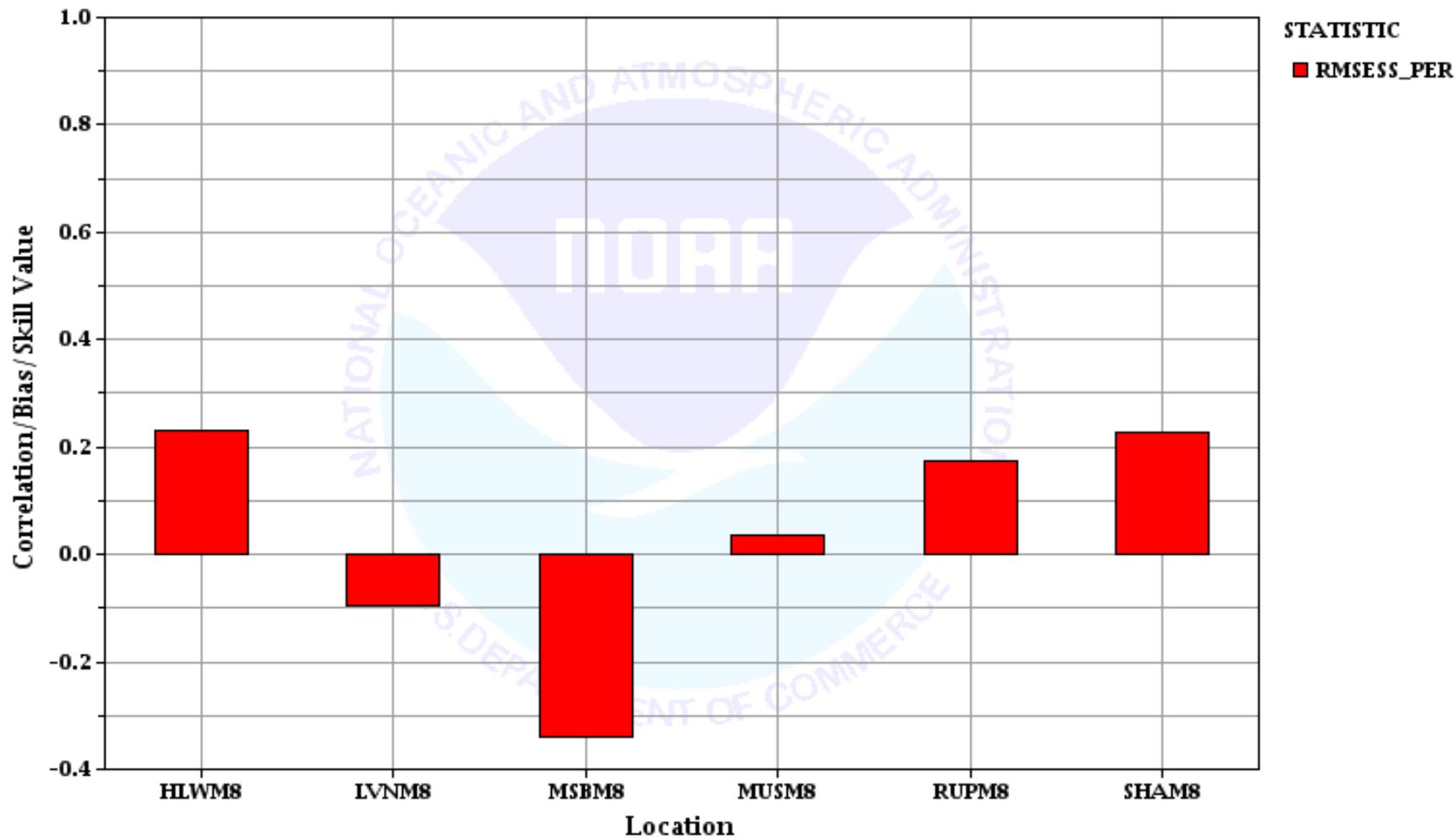
# Mean Error (ME) By Lead Time



# Pearson's Correlation (CORR) By Lead Time

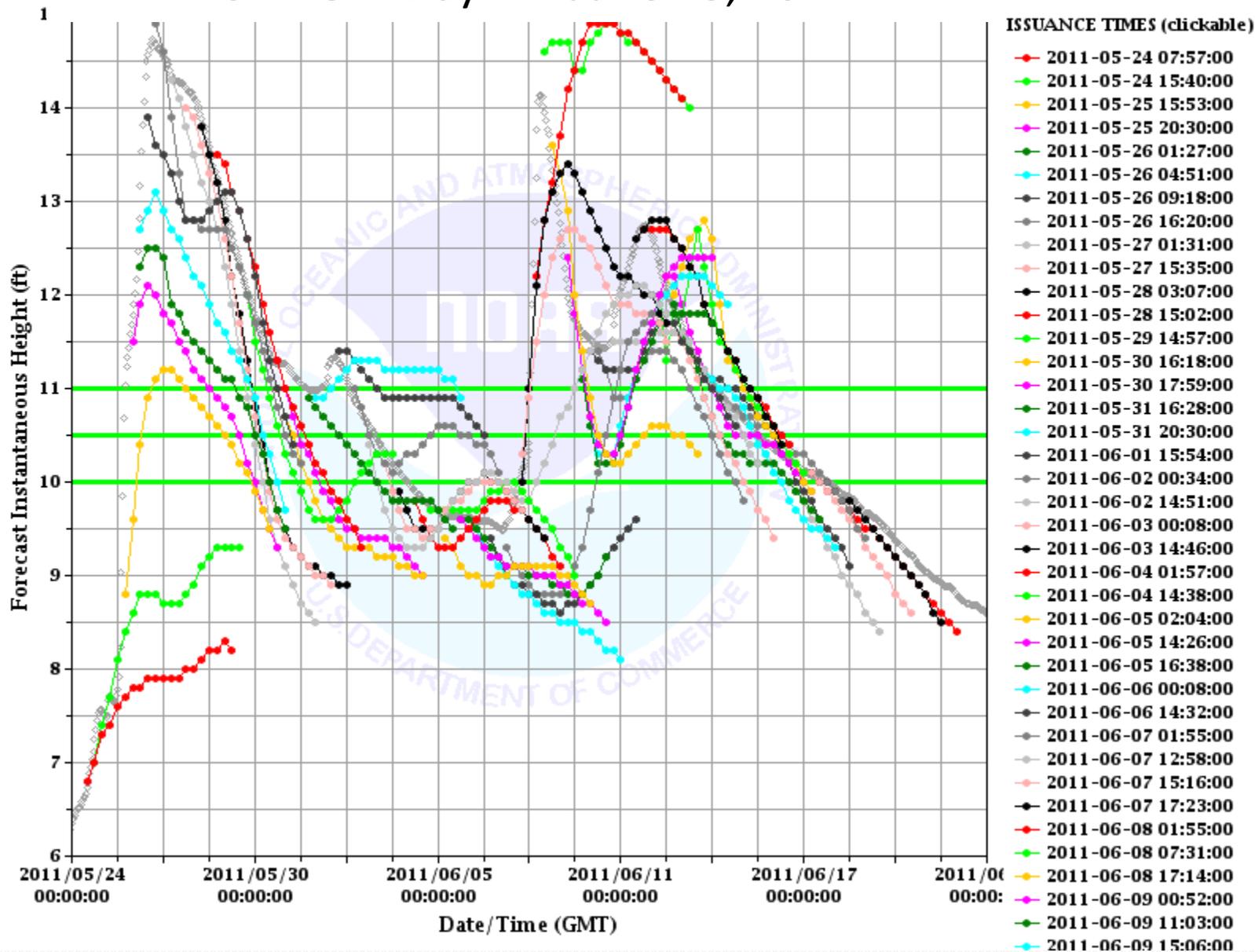


# Root Mean Square Error Skill Score (RMSE-SS)



# Time Series Plot

## RUPM8 May 24- June 23, 2011





## Contact Information

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Missouri Basin River Forecast Center  
1803 N 7 Hwy  
Pleasant Hill, MO 64080

### HAGAR THE HORRIBLE



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# Start of Bonus Section



# Upper Missouri Forecasts May-June 2011



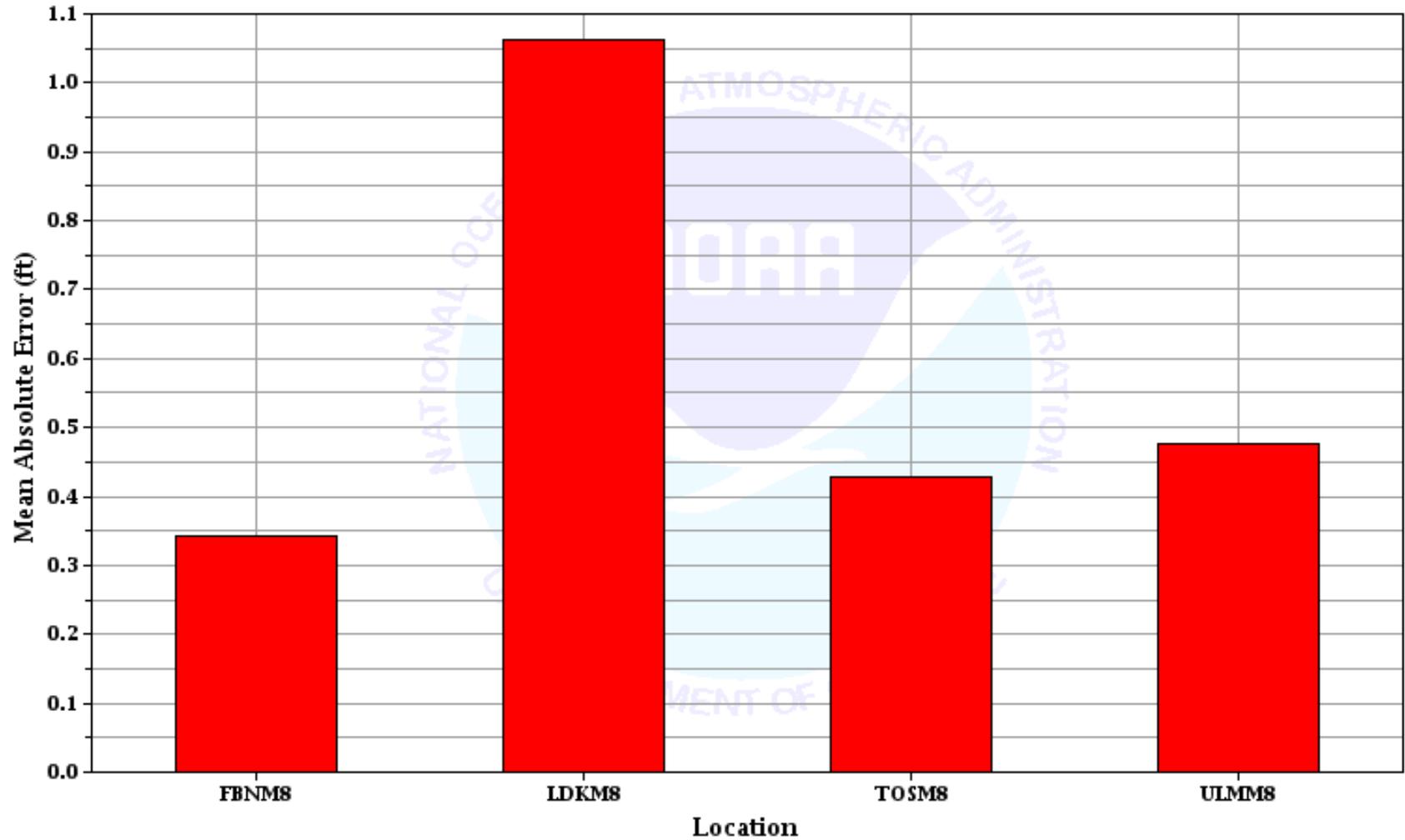
# Upper Missouri Mainstem

Forecasts points looked at were:

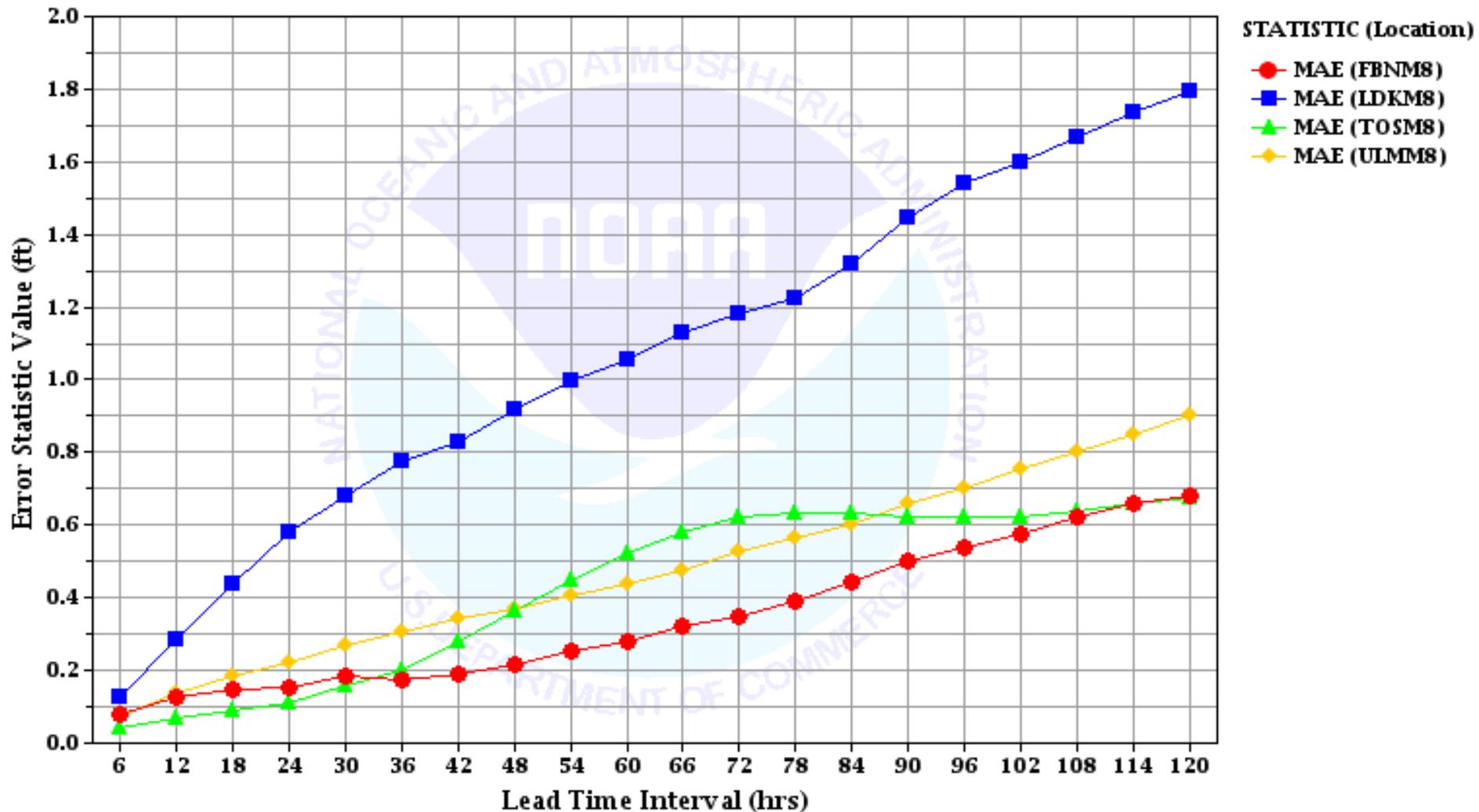
TOSM8	Toston MT	FS 10.5 FT
ULMM8	Ulm MT	FS 13.5 FT
FBNM8	Fort Benton MT	FS 13.5 FT
LDKM8*	Landusky MT	FS 25.0 FT

\*LDKM8 was a special request in 2011, it has since become a forecast point

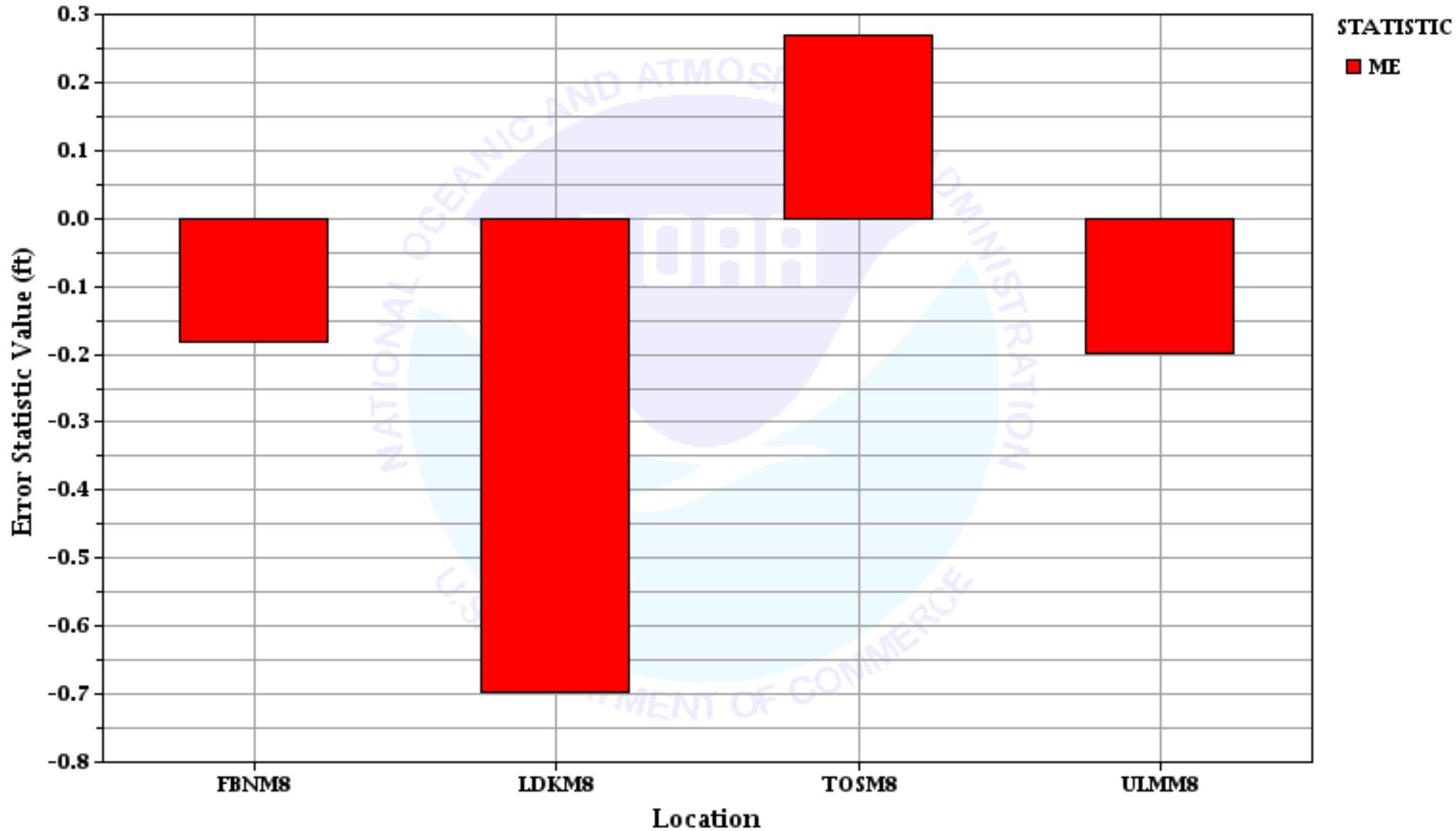
# Mean Absolute Error (MAE)



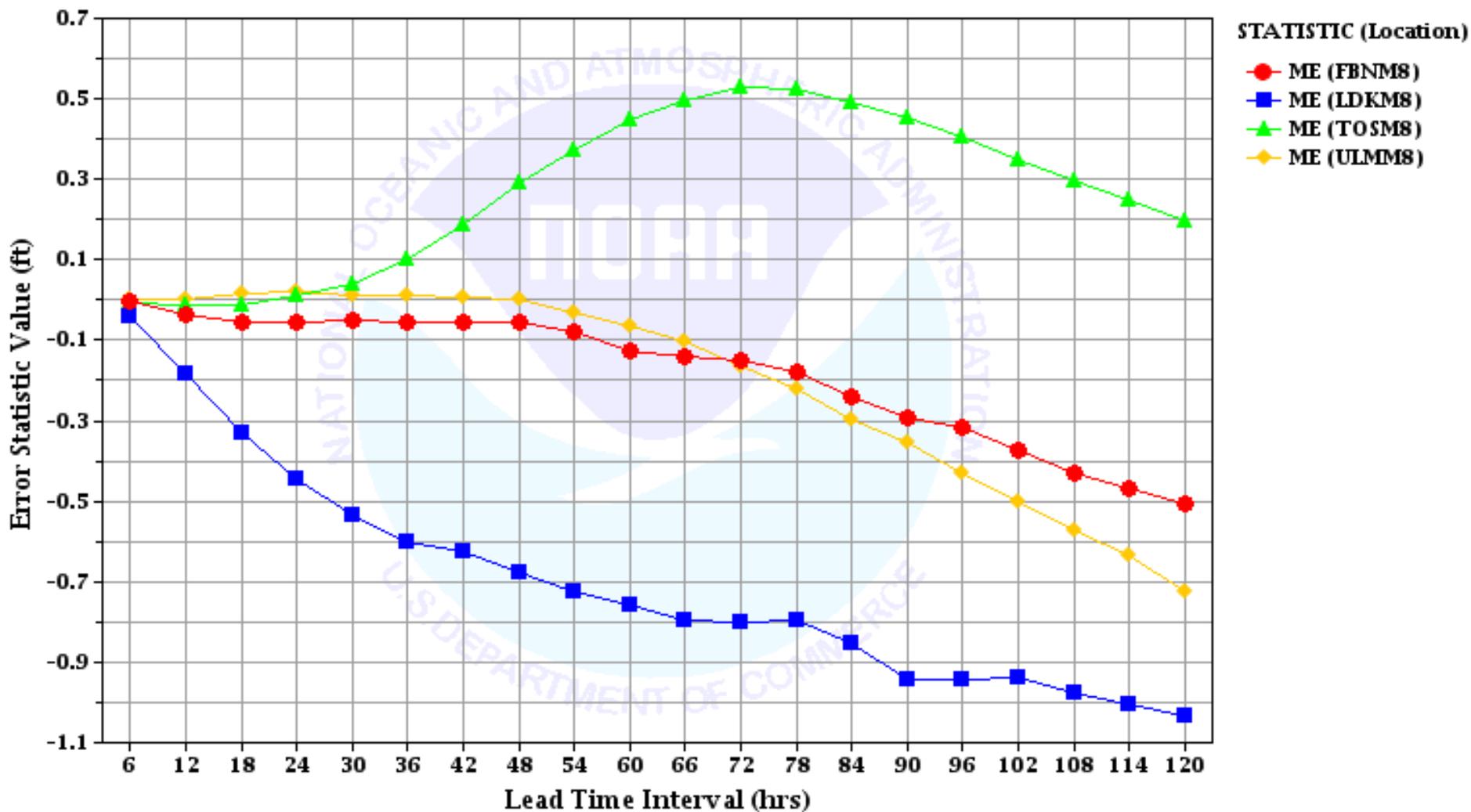
# Mean Absolute Error (MAE) By Lead Time



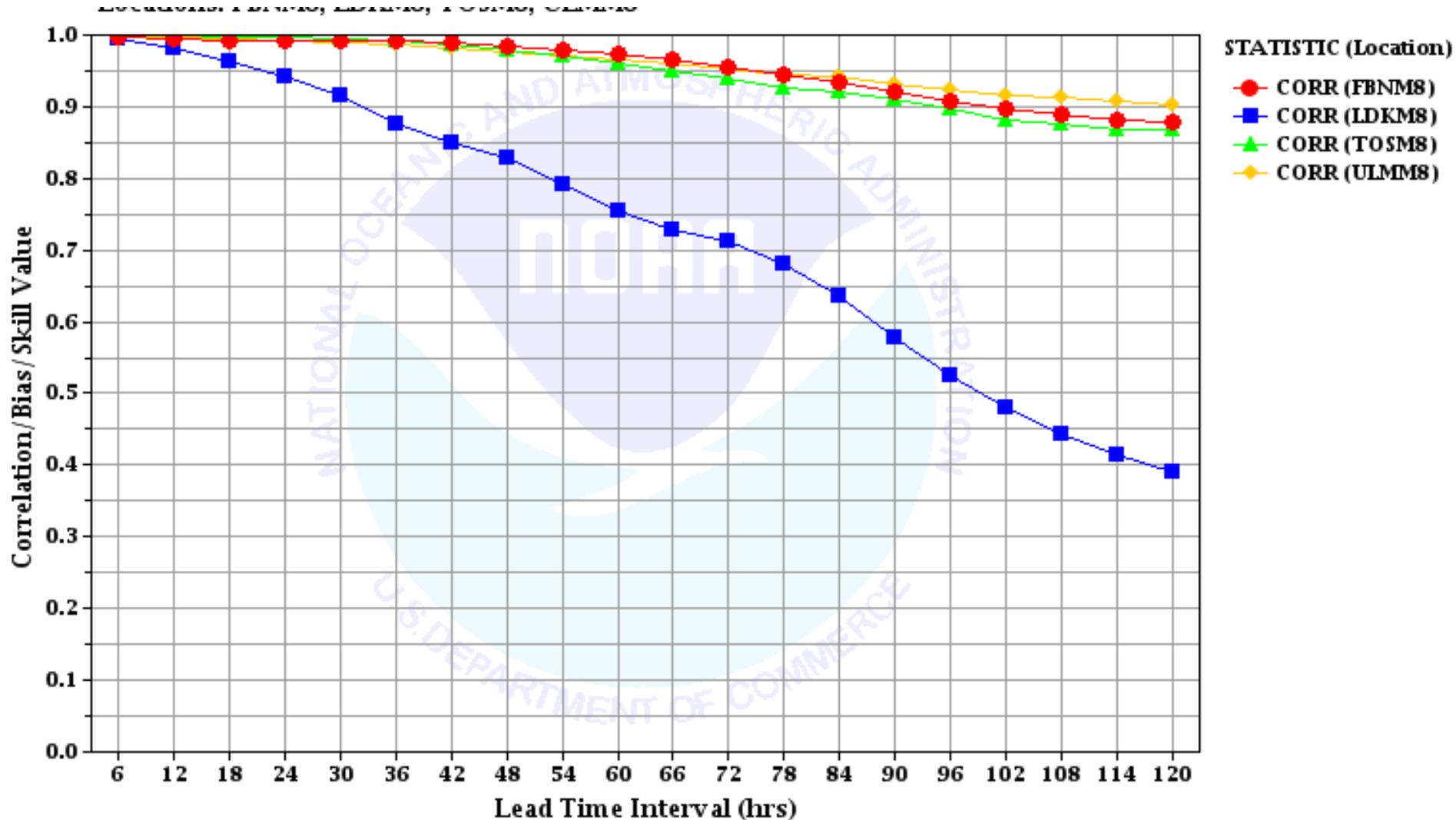
# Mean Error (ME)



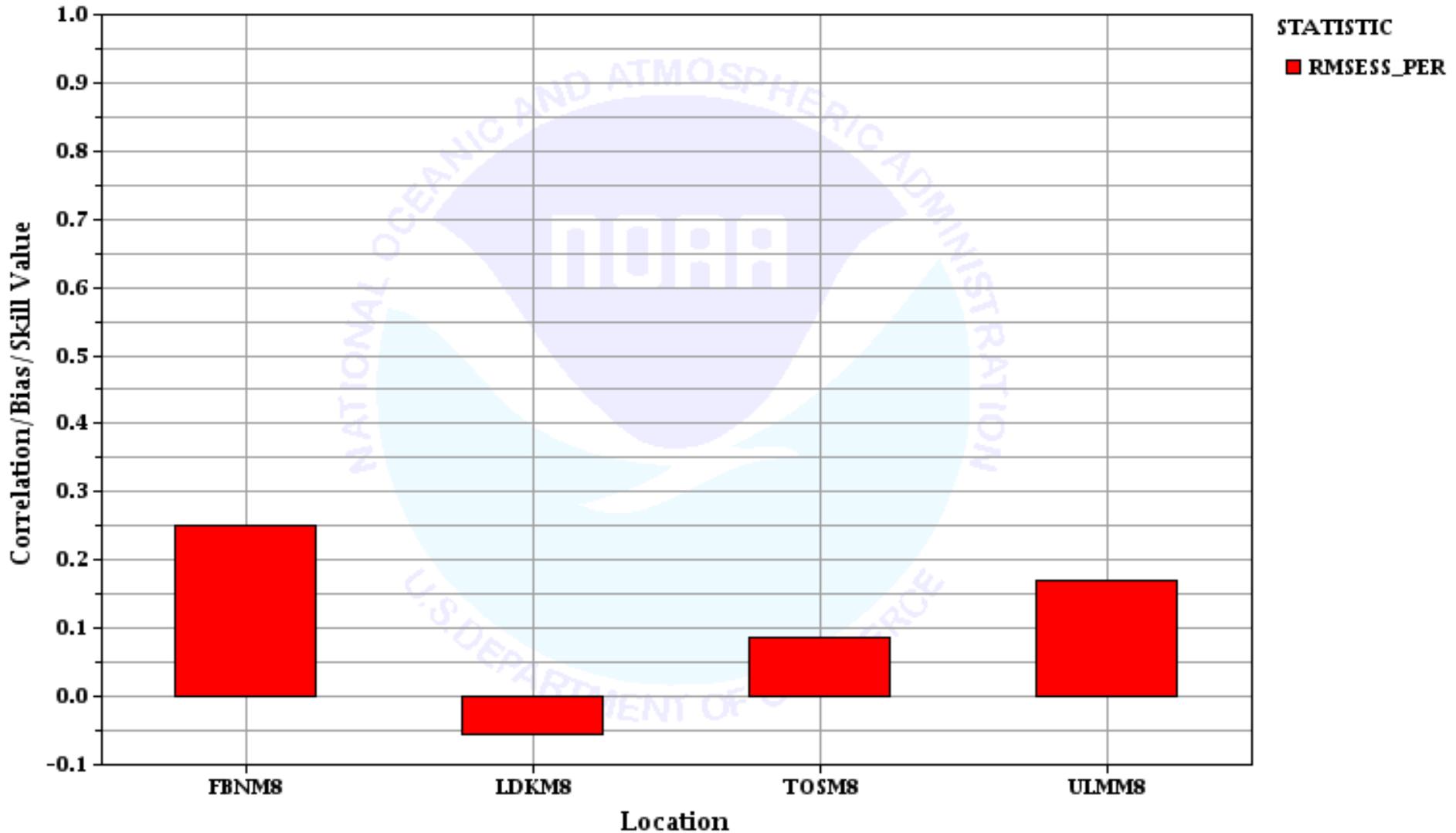
# Mean Error (ME) By Lead Time



# Pearson's Correlation (CORR) By Lead Time



# Root Mean Square Error Skill Score (RMSE-SS)

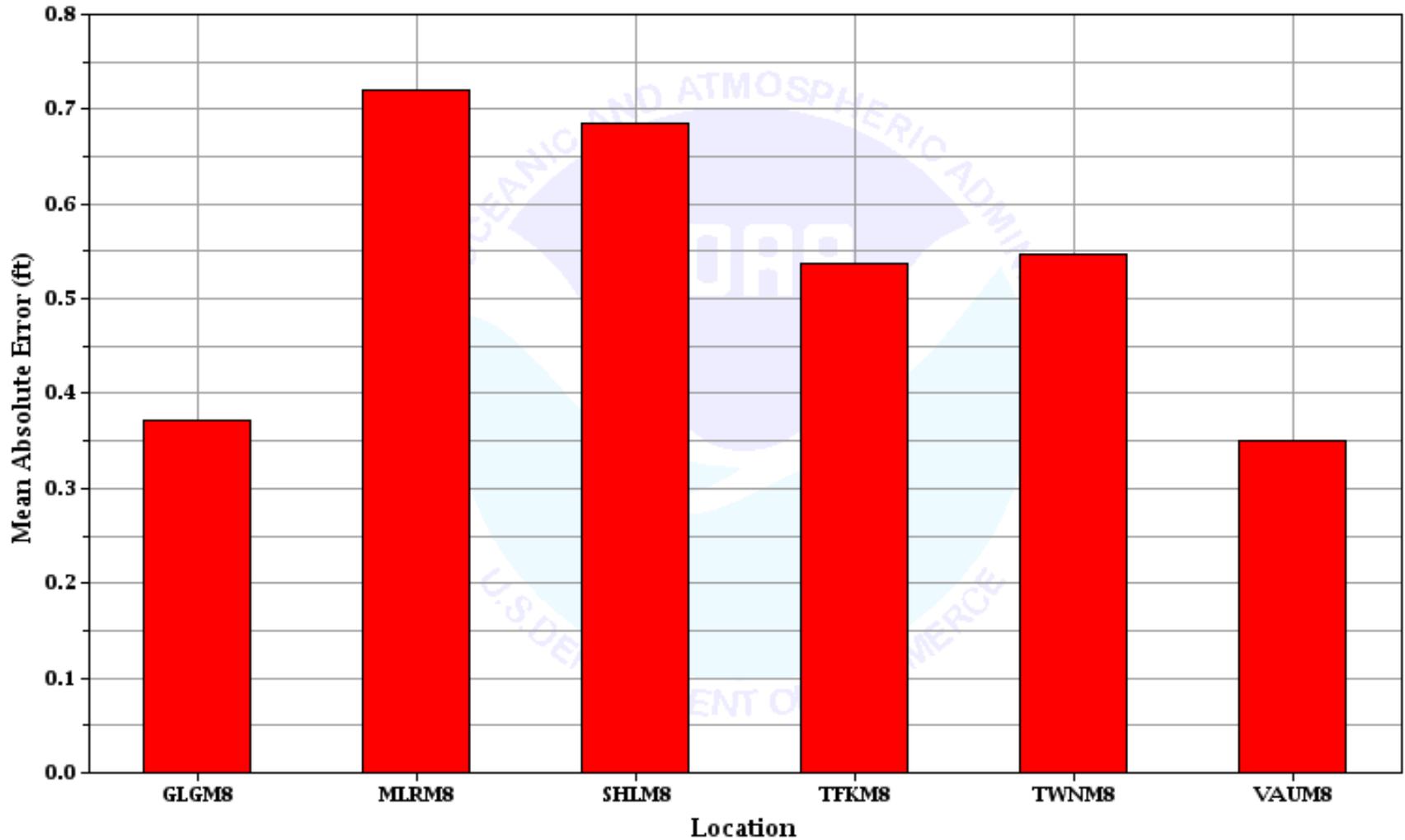


# Upper Missouri Tributaries

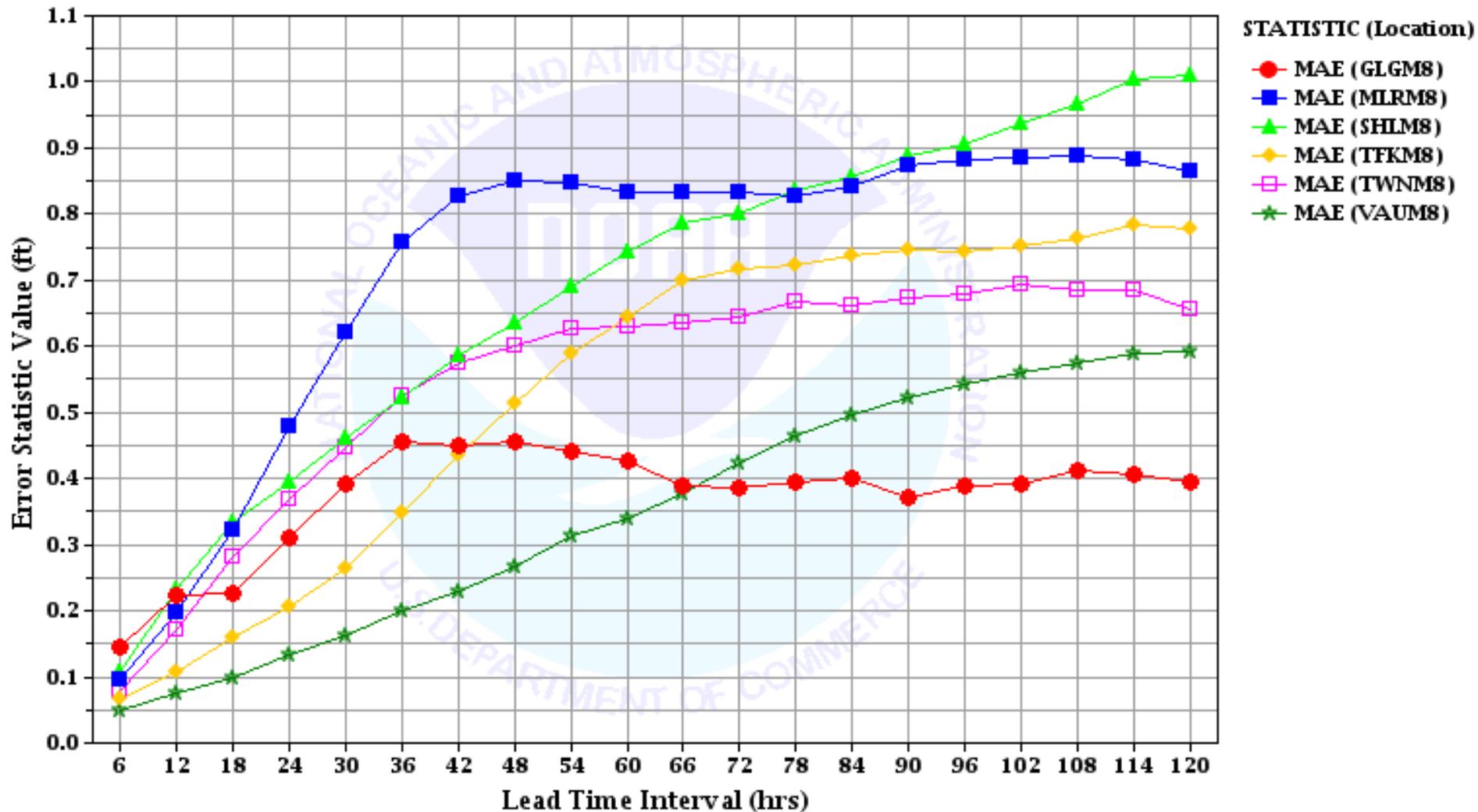
Forecasts points looked at were:

MLRM8	Melrose MT – Big Hole River	FS 6.0 FT
TWNM8	Twin Bridges – Beaverhead River	FS 7.0 FT
TFKM8	Three Forks MT – Jefferson River	FS 8.0 FT
GLGM8	Gallatin Gateway MT – Gallatin River	FS 6.0 FT
VAUM8	Vaughn Mt – Sun River	FS 6.0 FT
SHLM8	Shelby MT – Marias River	FS 9.0 FT

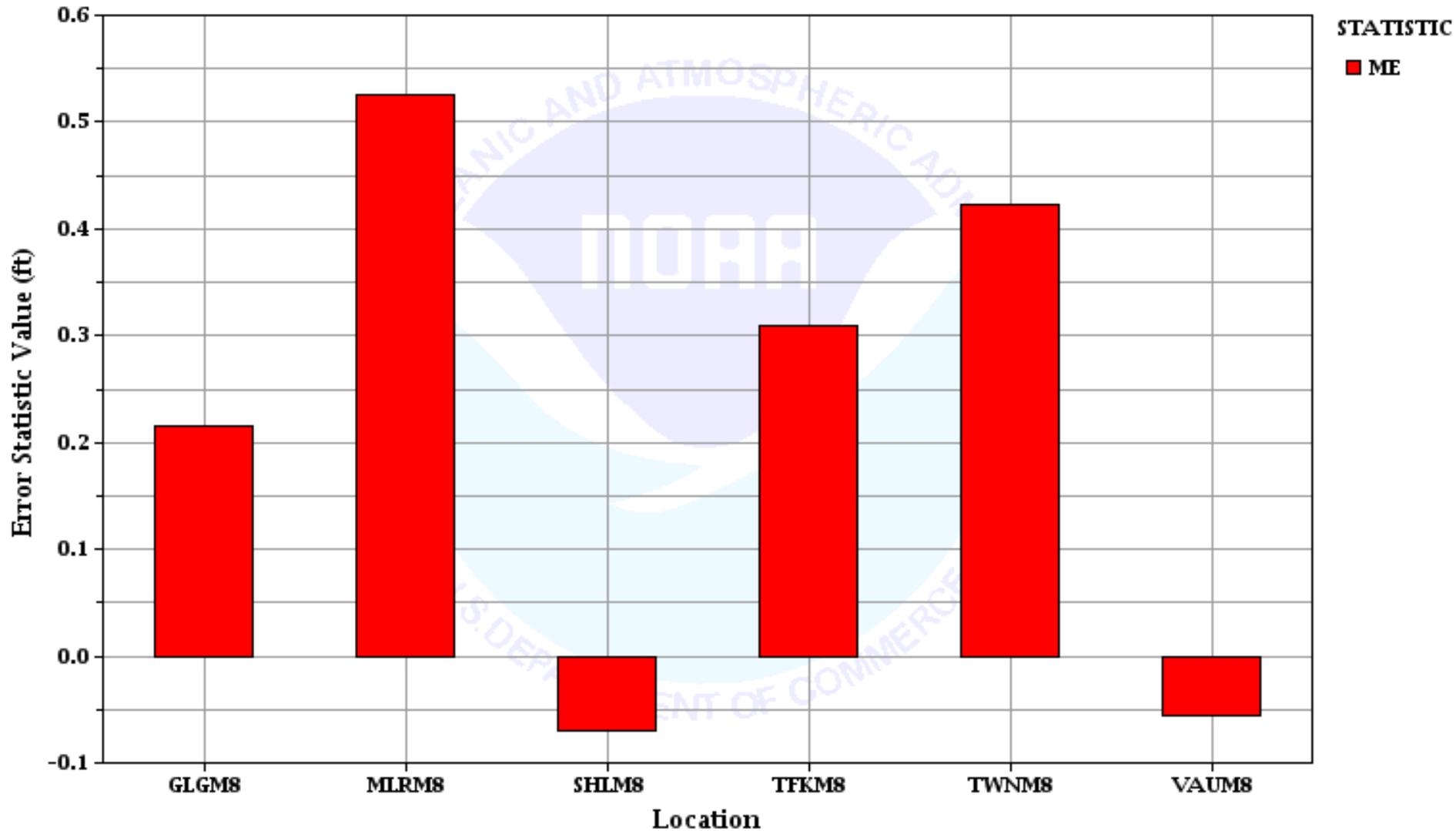
# Mean Absolute Error (MAE)



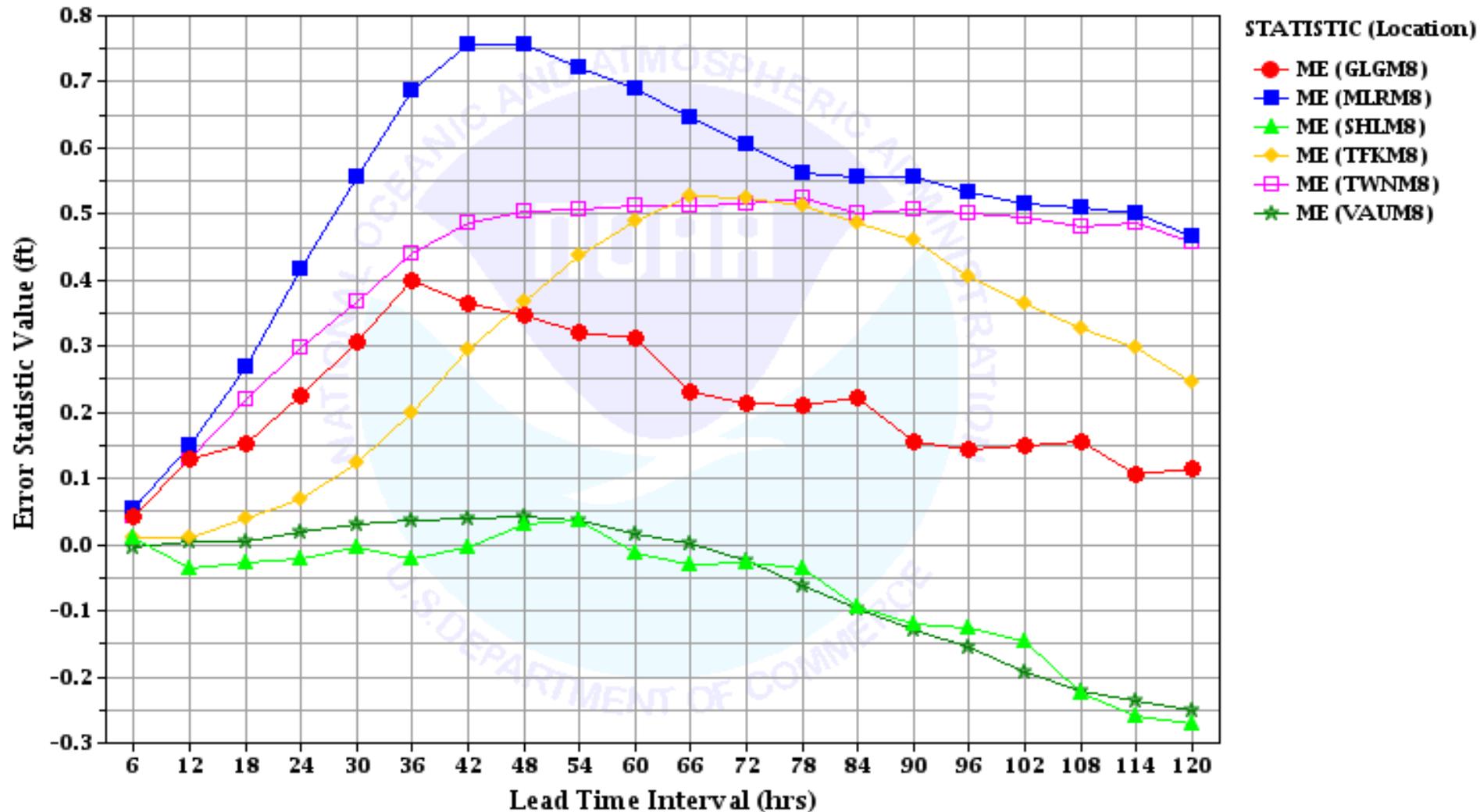
# Mean Absolute Error (MAE) By Lead Time



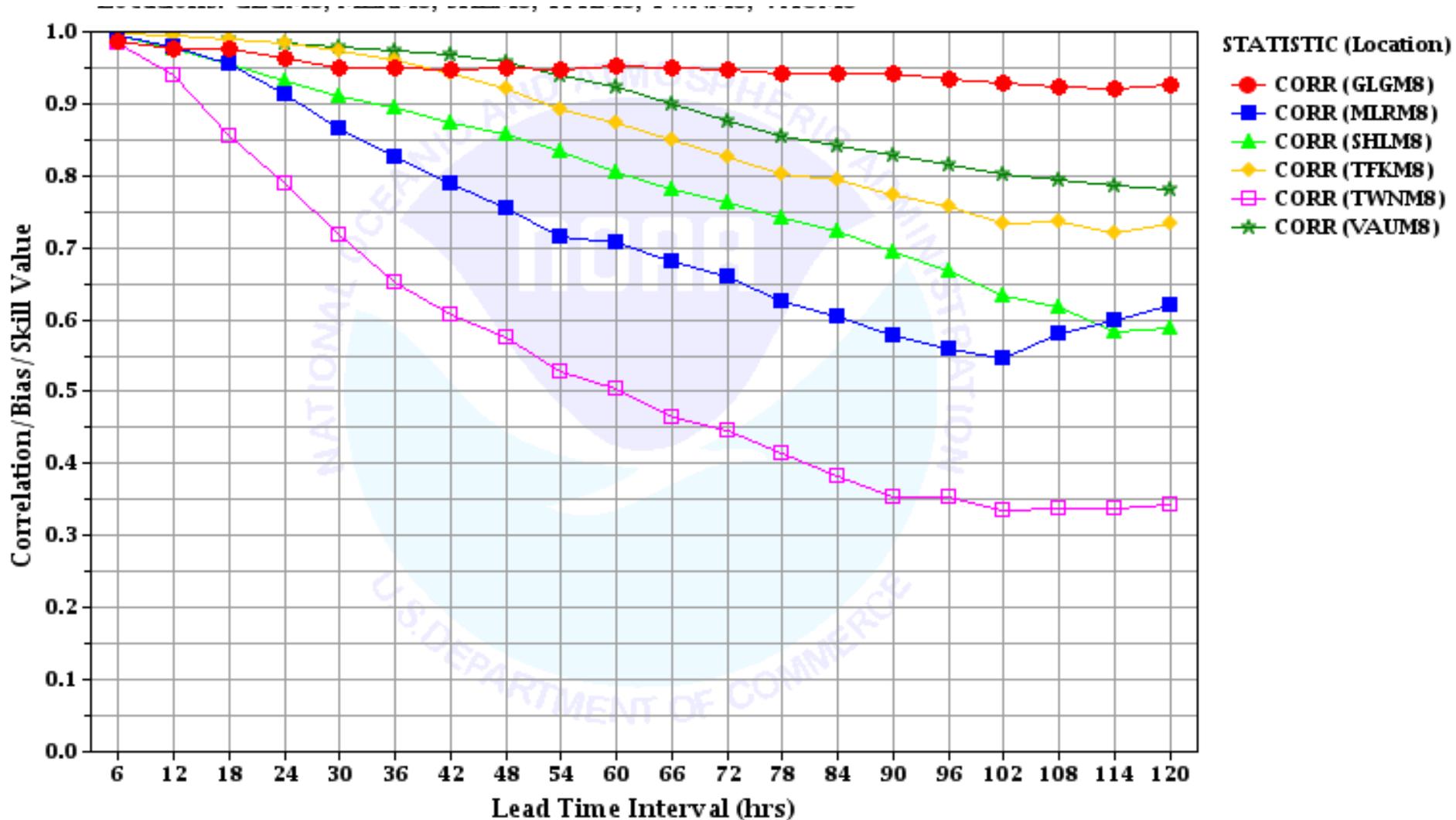
# Mean Error (ME)



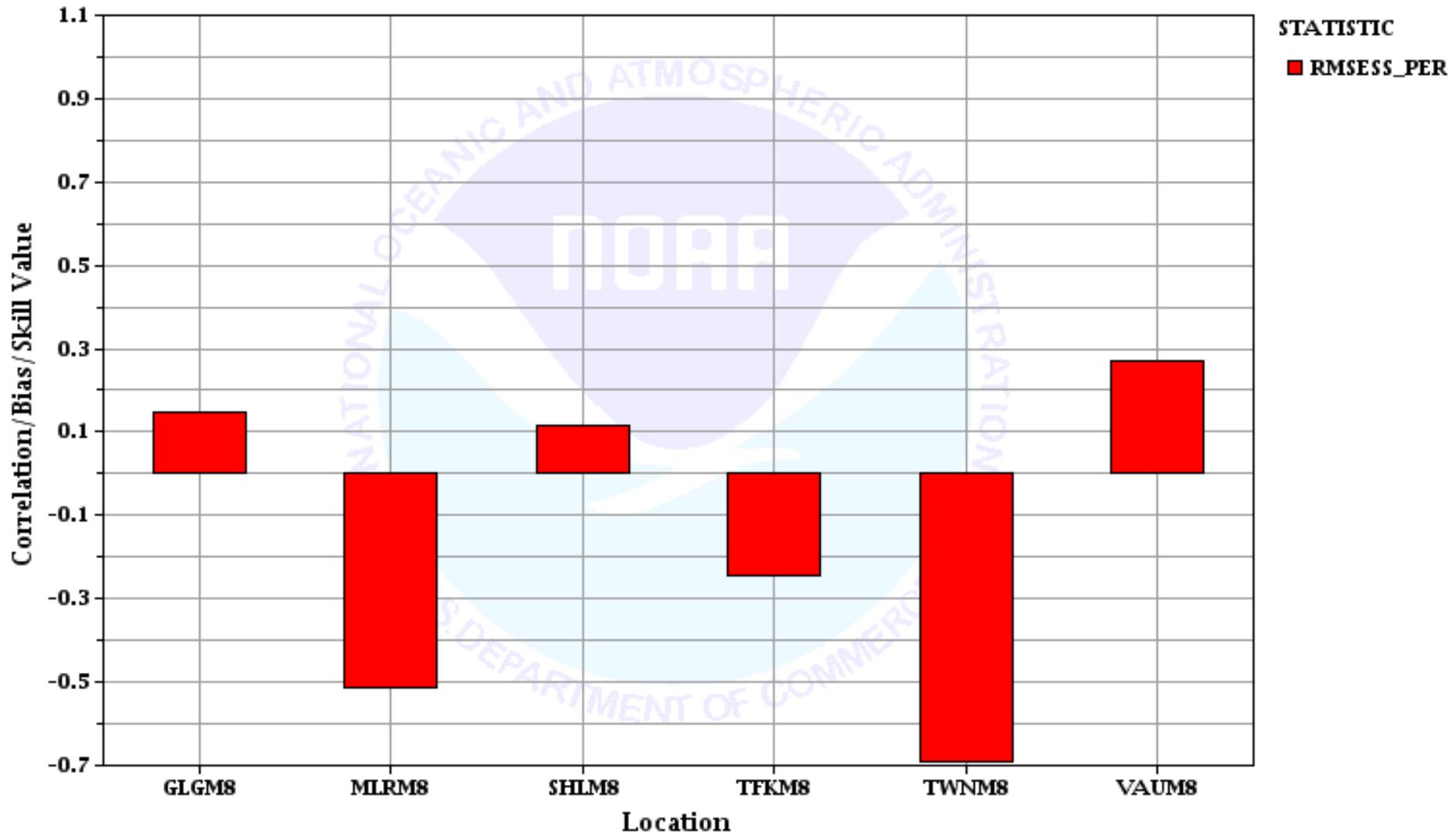
# Mean Error (ME) By Lead Time



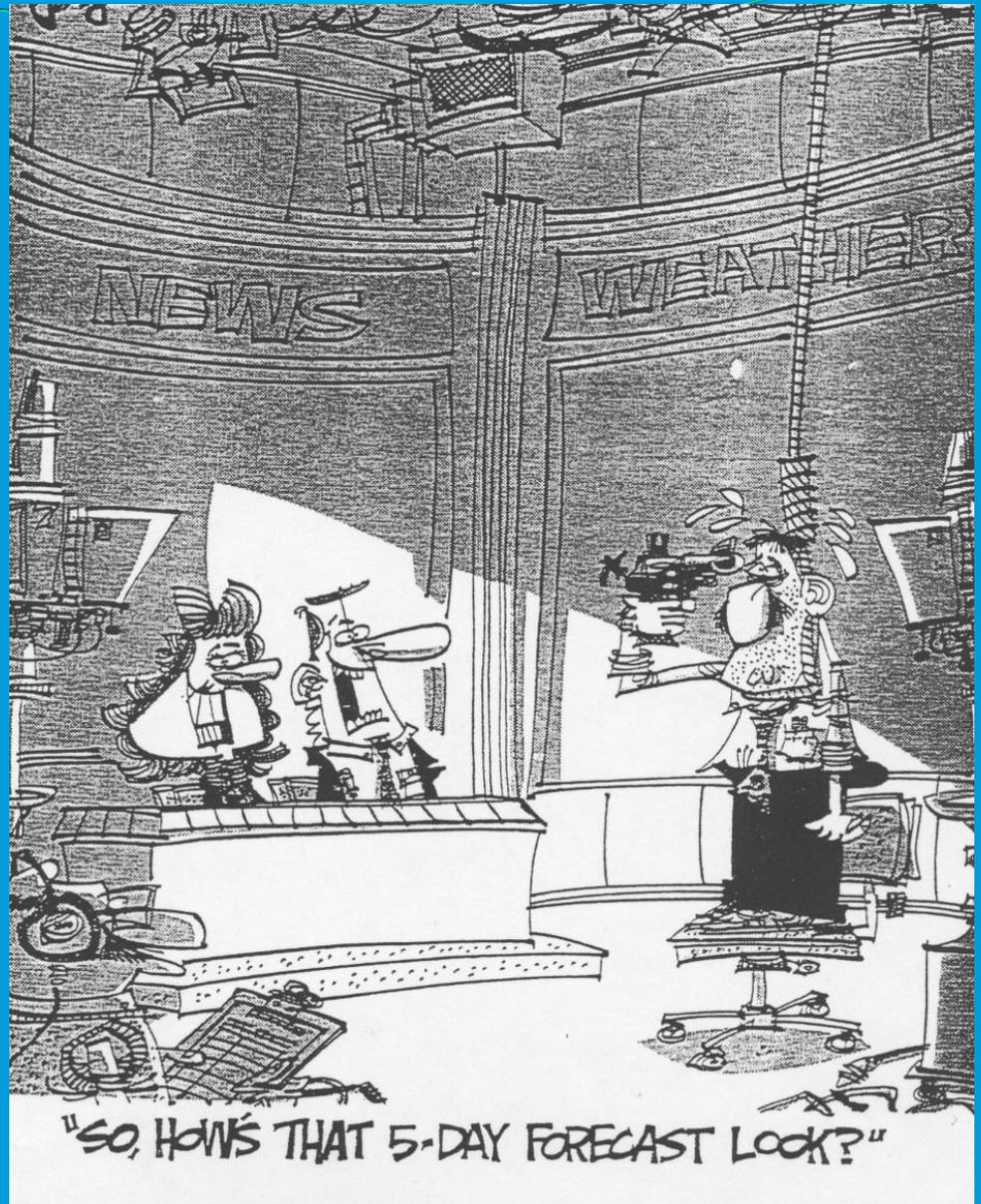
# Pearson's Correlation (CORR) By Lead Time



# Root Mean Square Error Skill Score (RMSE-SS)



# Post Flood Activities



# Forecast Services

- Added several new forecast points
  - WFO-BYZ 6 locations
    - HLWM8 Harlowton – Musselshell River
    - SHAM8 Shamut – Musselshell River
    - LVNM8 Lavina – Musselshell River
    - RUPM8 Roundup – Musselshell River
    - MUSM8 Musselshell – Musselshell River
    - PMKM8 Miles City – Pumpkin Creek
  - WFO-GGW 5 locations
    - DMRM8 Dodson – Milk River
    - BCHM8 Hinsdale 4NW – Beaver Creek
    - WPTM8 Wolf Point – Missouri River
    - CLBM8, Culberson – Missouri River
    - MSBM8 Mosby – Musselshell River

# Forecast Services

- Added several new forecast points continued
  - WFO-TFX 9 locations
    - ERNM8 Eastern Crossing – Milk River
    - BSMM8 Havre - Big Sandy Creek
    - BCMM8 Chinook – Battle Creek
    - LGEM8 International Boundary – Lodge Creek
    - CCMM8 Chinook – Clear Creek
    - TWIM8 Twin Bridges – Jefferson River
    - DBRM8 Craig – Dearborn River
    - ULLM8 Ulm – Smith River
    - LDKM8 Landusky – Missouri River
- Discontinued services
  - WFO-BYZ 1 location
    - ROKM8 Red Lodge – Rock Creek

# Data Needs

- Rain and temperature gage network
  - In coordination with MT WFOs added nearly 150 precipitation gages to the model's gage network
  - In coordination with NOHRSC added about 50 new precip and/or temperature gages in Canada to the model's gage network
- SWE data
  - USACE is leading an effort to recruit volunteer SWE observers
  - NOHRSC added 24 new flight lines in Montana and Canada
- diversion and return information
- stage and reservoir data, in particular, in the Canadian portion of the Milk and Poplar basins

# Model Improvements

## Upper Missouri forecast group

- RTI contract – recalibration of the Upper Missouri fcstgrp above Canyon Ferry Reservoir
- on the Musselshell portion ....
  - Investigate breakup Harlowton runoff zone...
    - add Musselshell River nr Martinsdale, MT
  - consider adding the 3 dams if sufficient data
  - Consider breaking up Mosby zone
  - Only HLWM8 and SHAM8 have upper and lower zones, investigate LVNM8 to see if elevation split makes sense
  - Calibrate the Musshelshell portion of the forecast group, it is currently using regionalized parameters
- Landusky Reach...
  - Add Judith River near mouth, nr Winifred MT... Area is already broken out in model.
- Shelby, Dutton zones...
  - Breakup, add diversions and returns , recalibration

# Model Improvements

## Milk Forecast Group

- possibly add gages/dams above international boundary in the Frenchman basin
- review routings

## Yellowstone Forecast Group

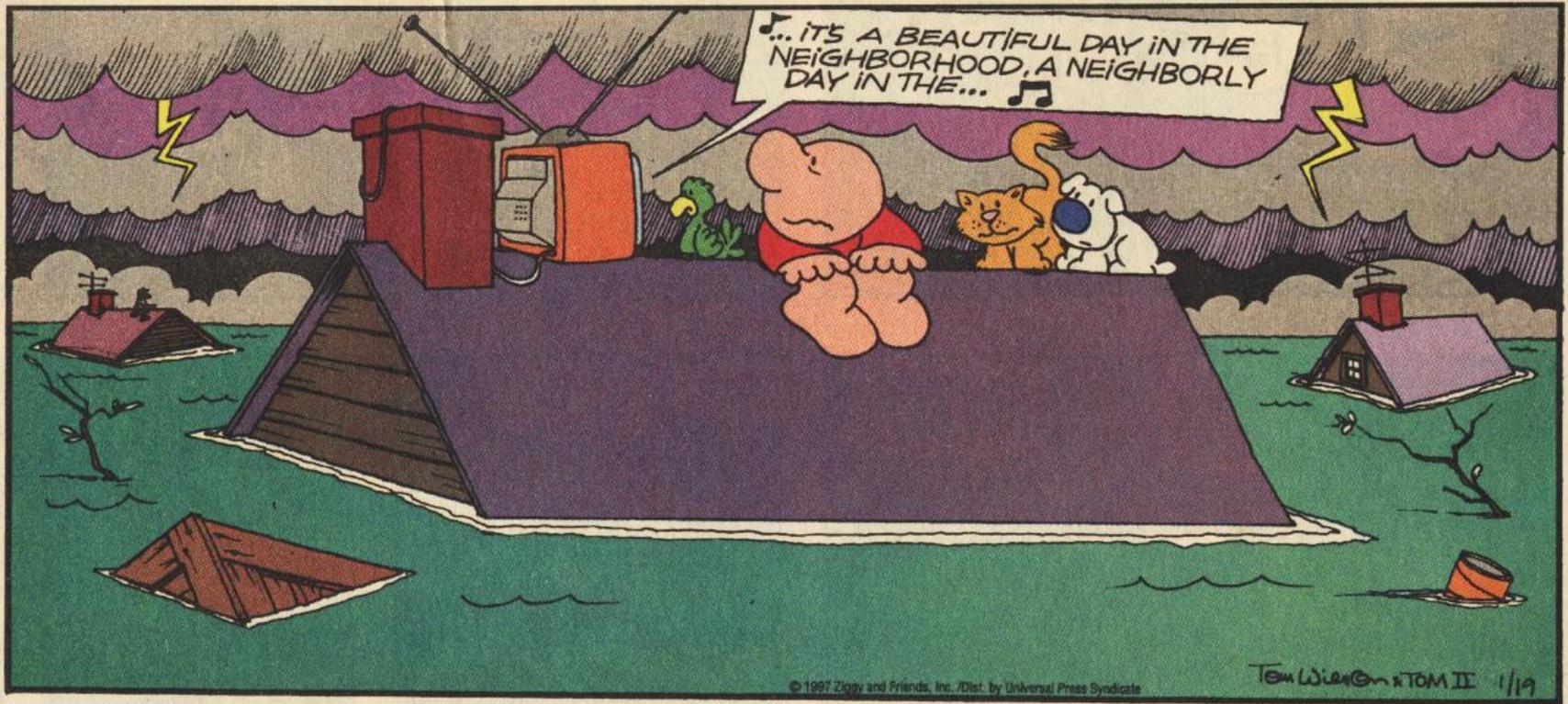
- Goose Creek...
  - Currently working on adding the Goose Creek basin above Sheridan, WY (~5 gages) in the headwaters of the Tongue Basin
- review routings
- Powder River Basin...
  - needs to be recalibrated
  - look to see if there are river gages that could add as data points upstream of forecast points
  - Lack of precip data.. For parts of the Powder basin there is no radar coverage and due to the sparse population, not many observers.

## For all Forecast Groups

- Review and update Climate Data – ongoing (used by ESP and calibration)

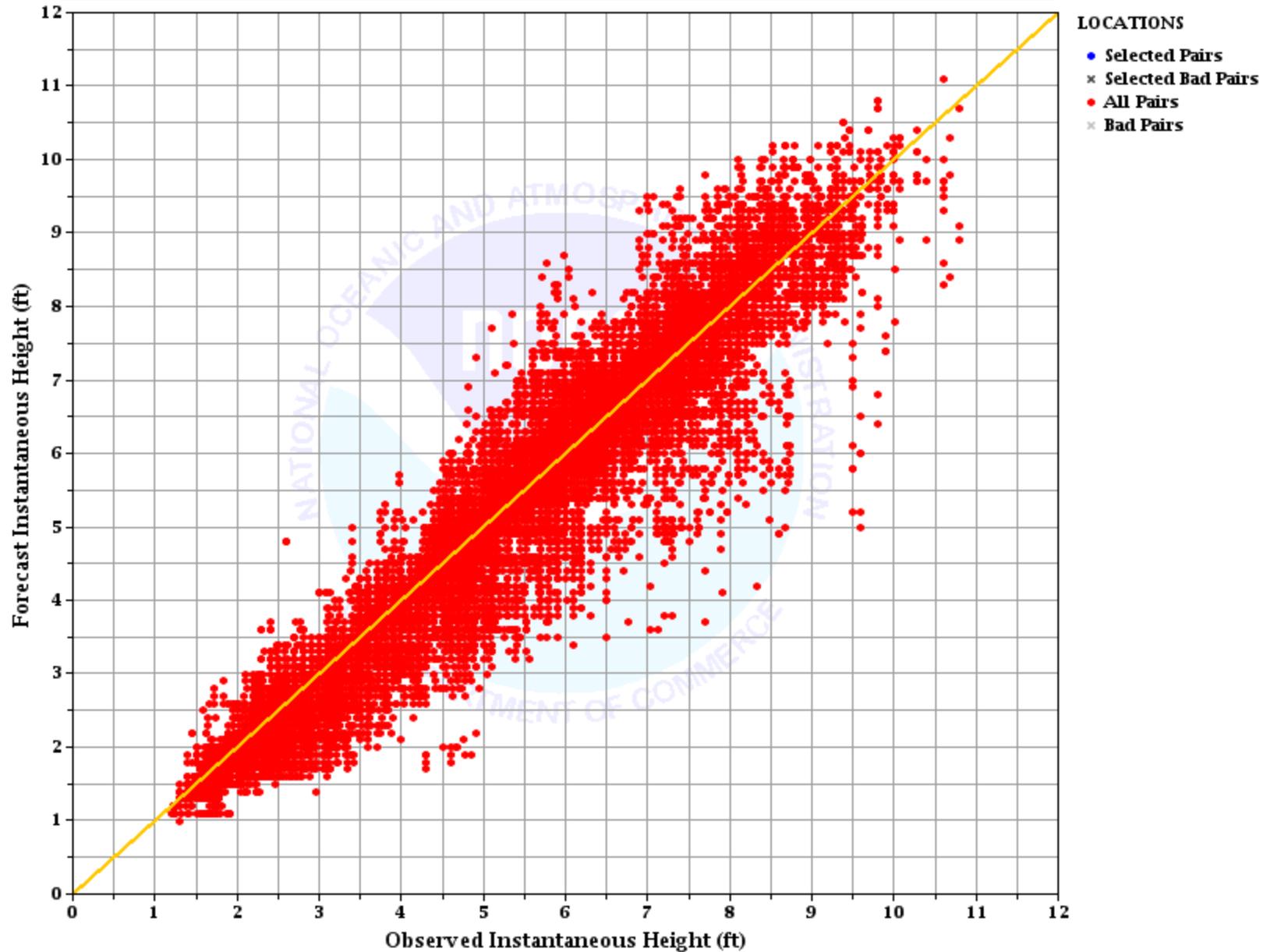
# Other Types of Statistics/Plots

ZIGGY/ by Tom Wilson



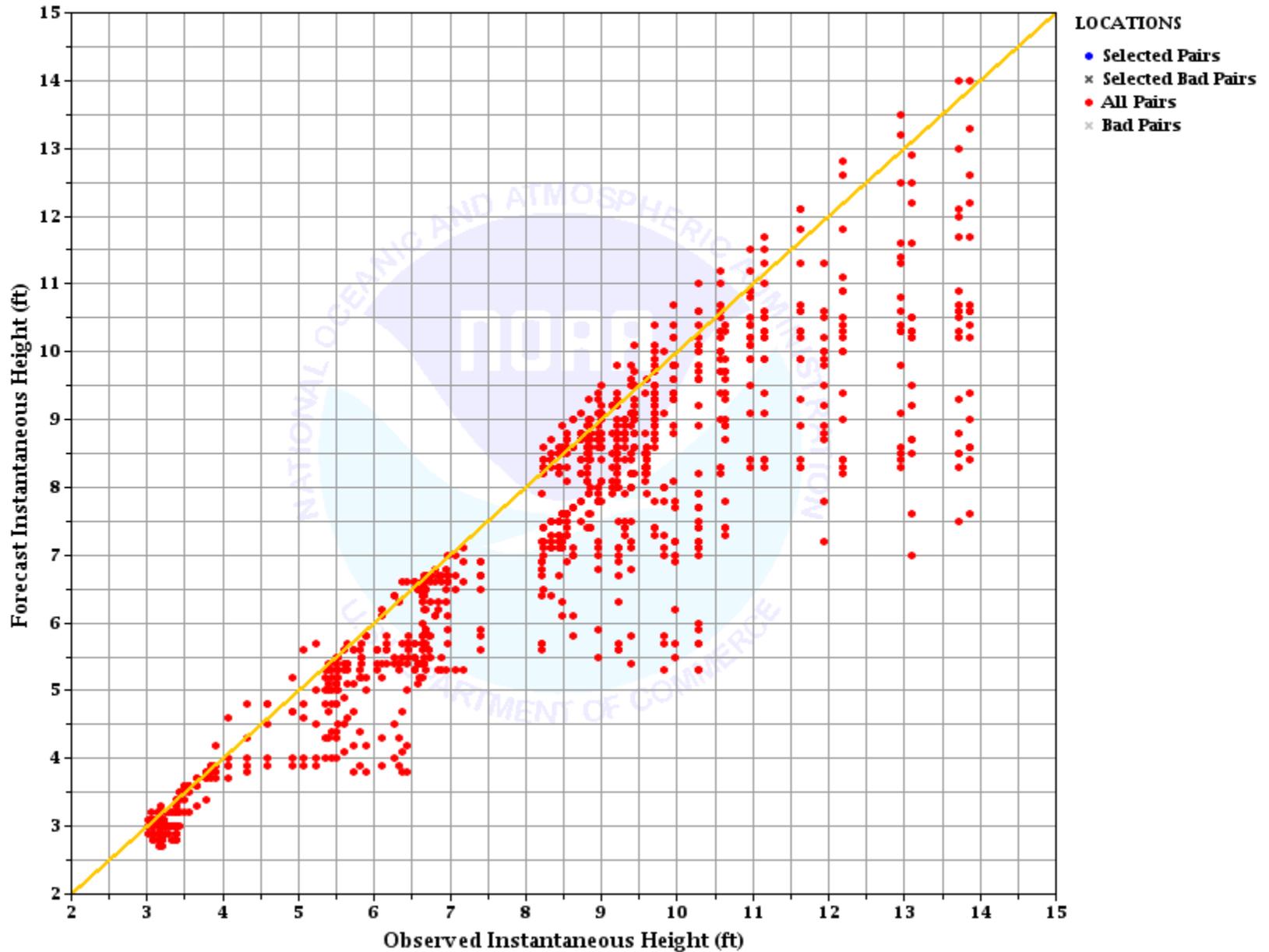
# Scatter Plot

## CORM8 1996-2012



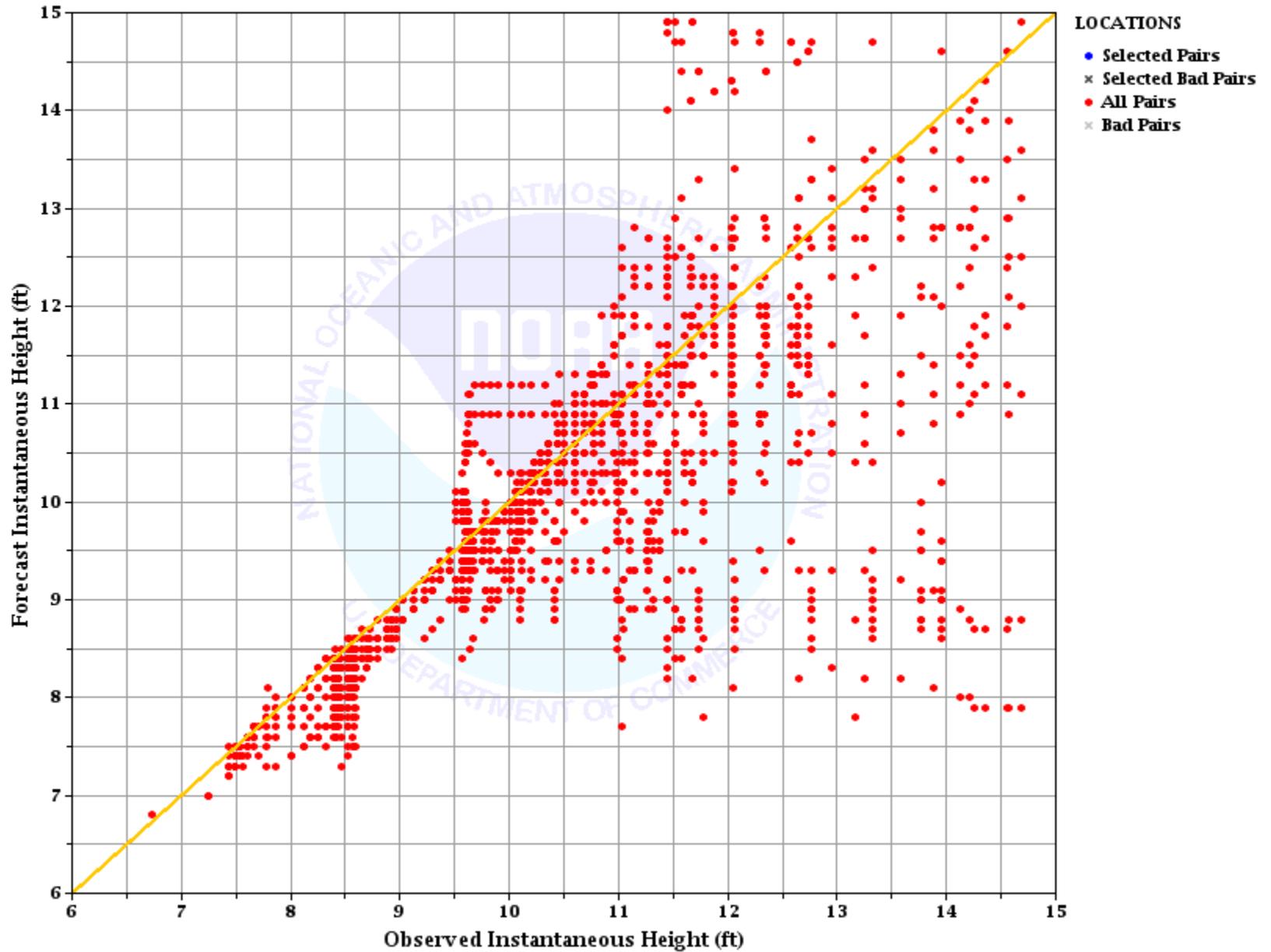
# Scatter plot

## BILM8 May 2011



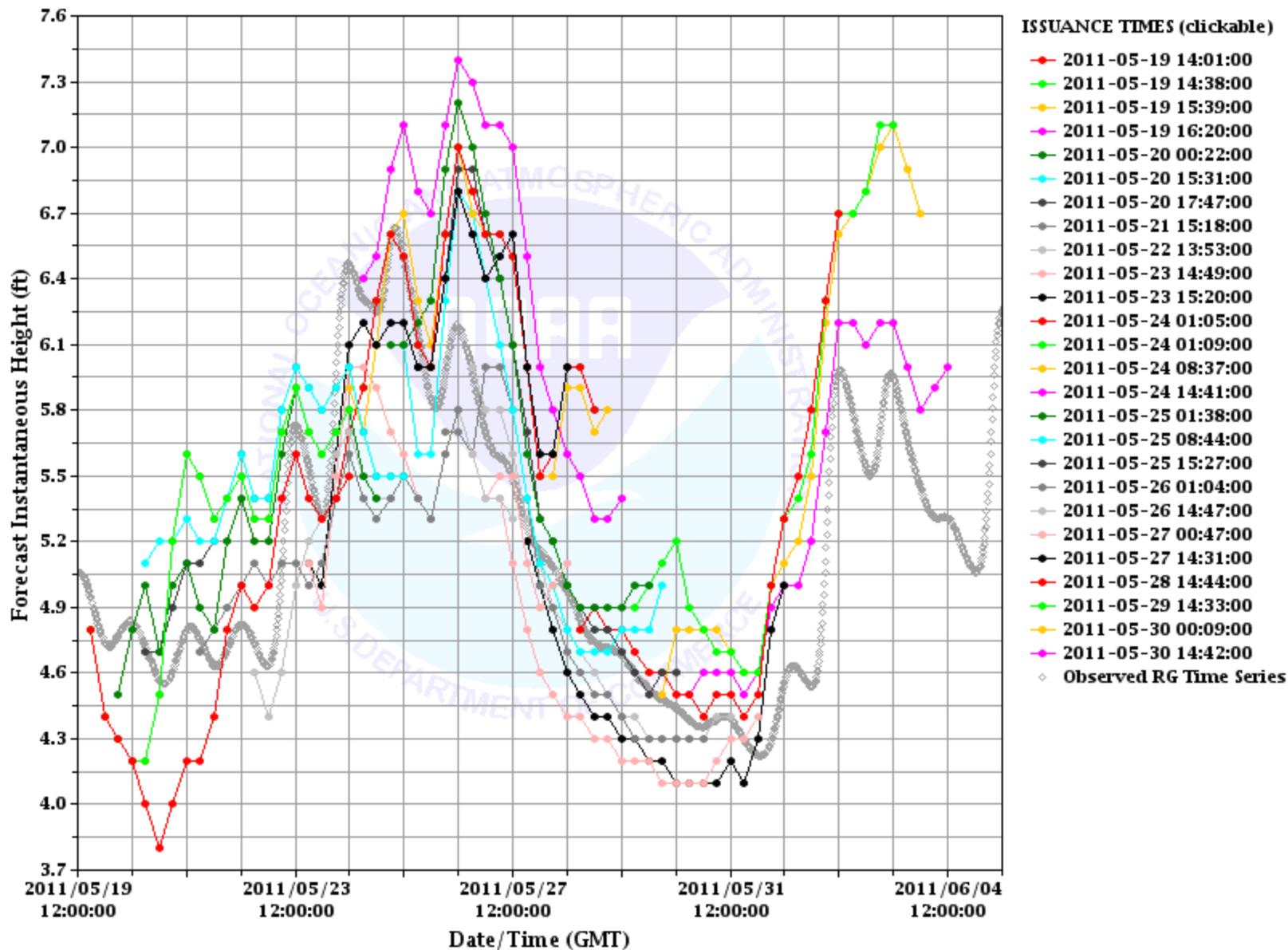
# Scatter plot

## RUPM8 May-June 2011



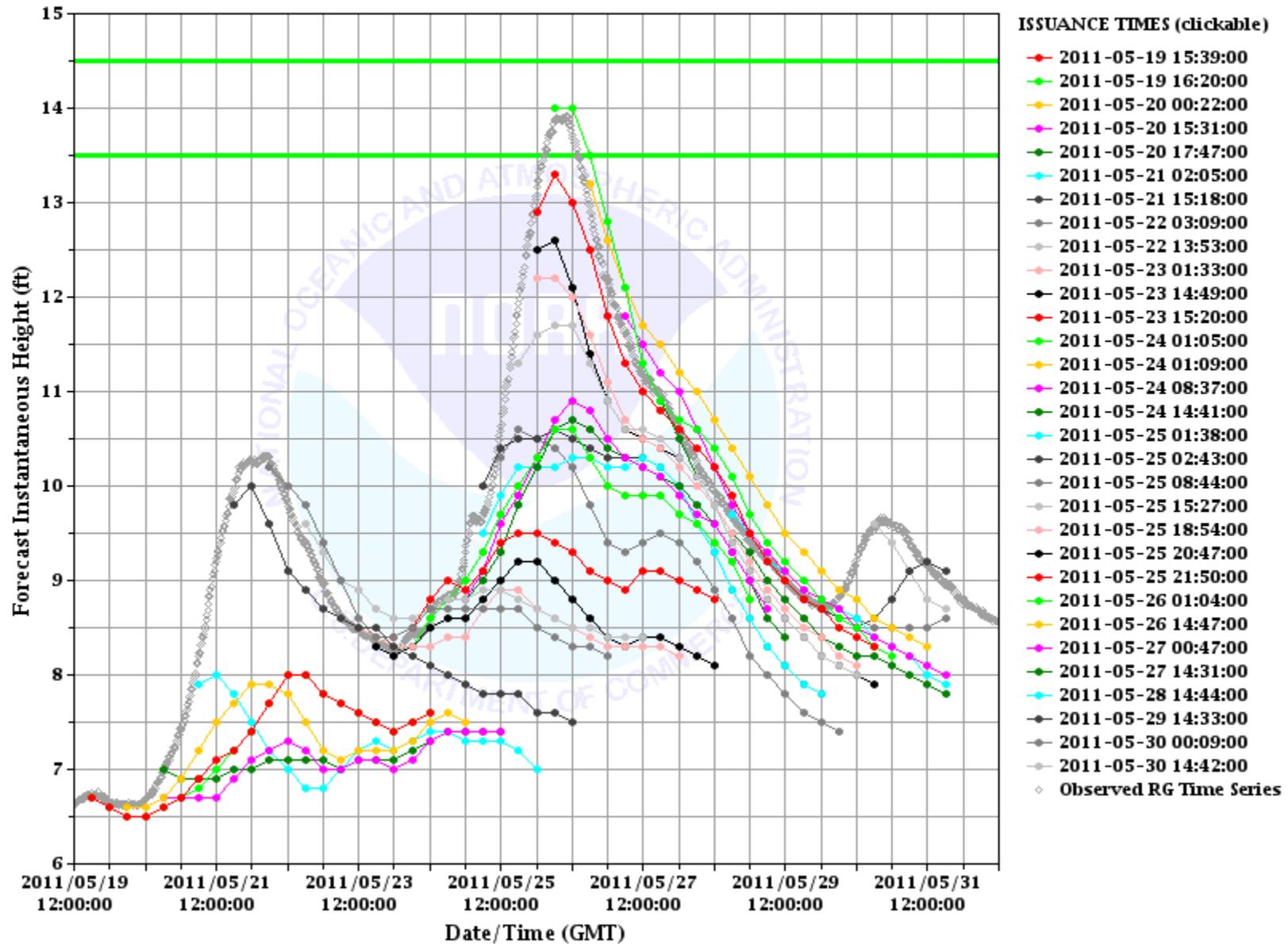
# Time Series Plot

## CORM8 May 19-30, 2011

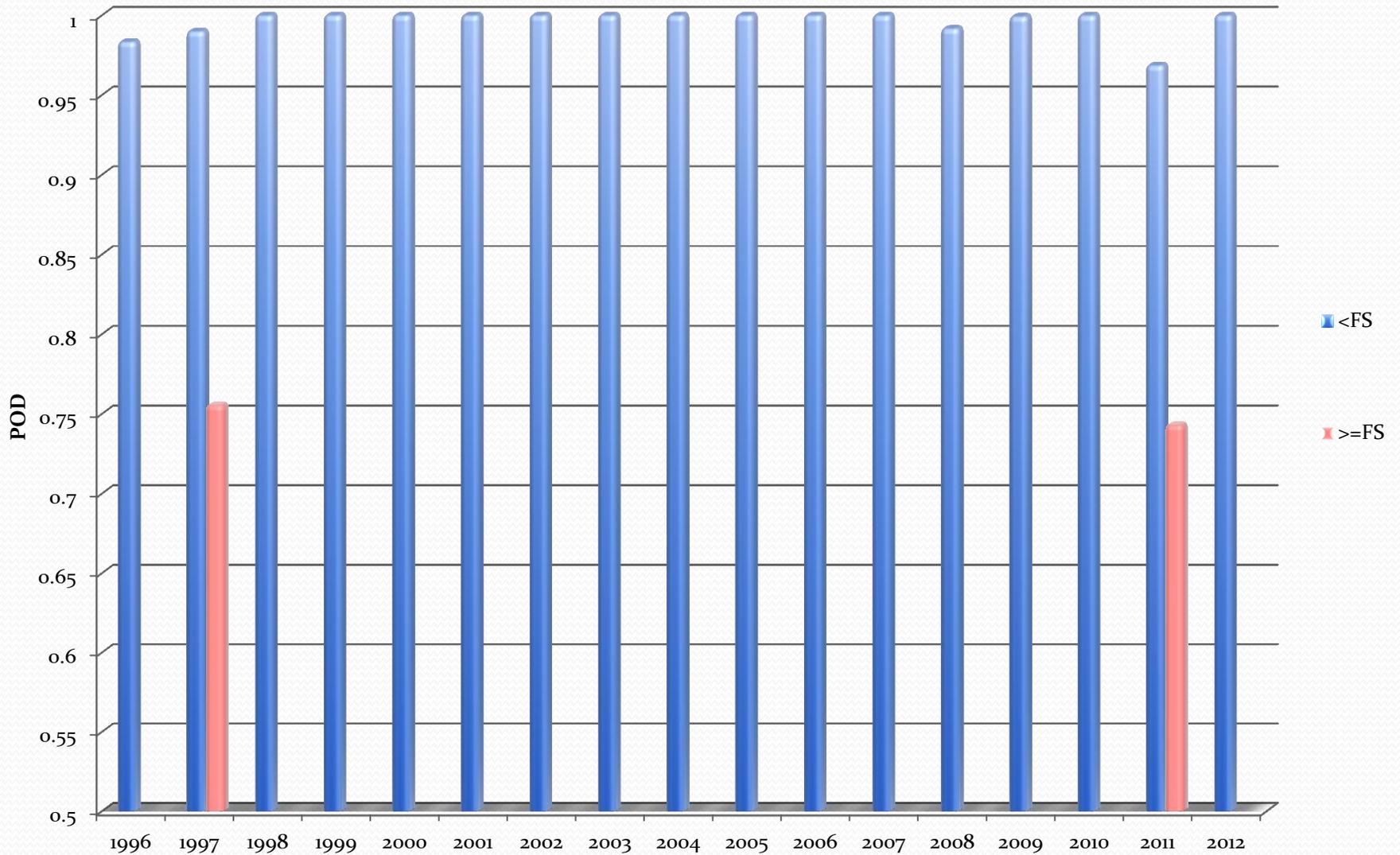


# Time Series Plot

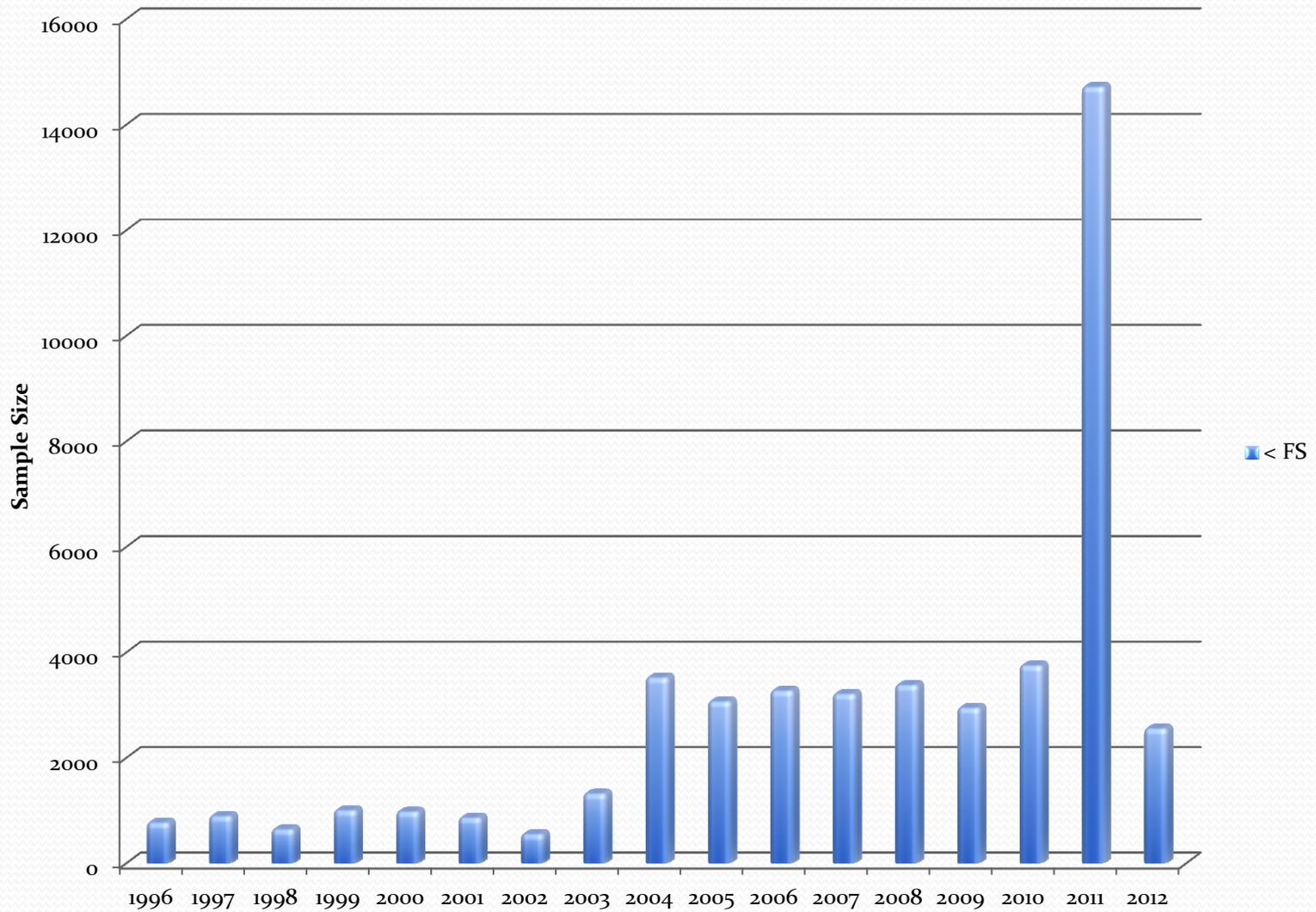
## BILM8 May 19-30, 2011



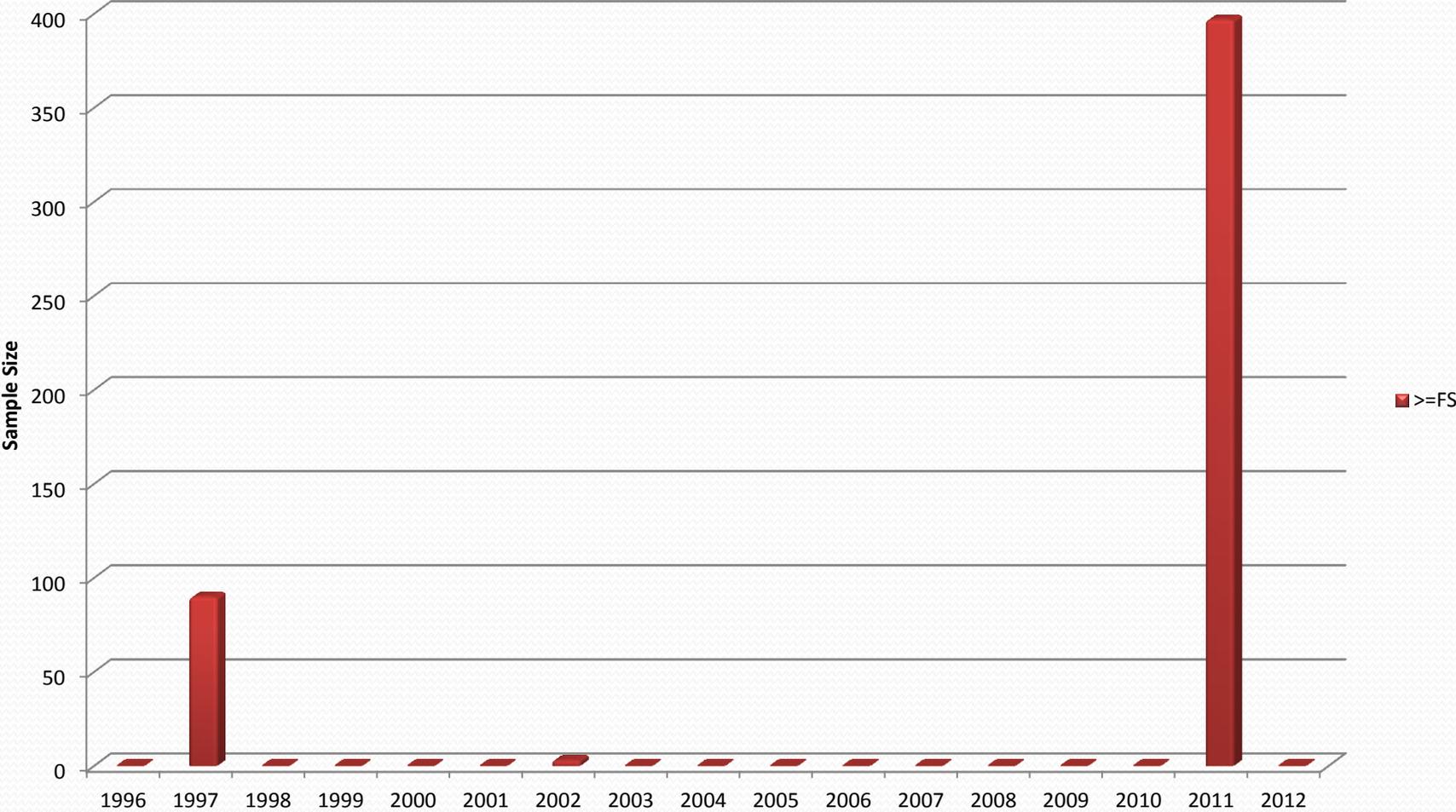
# Probability of Detection



# Sample Size < Flood Stage



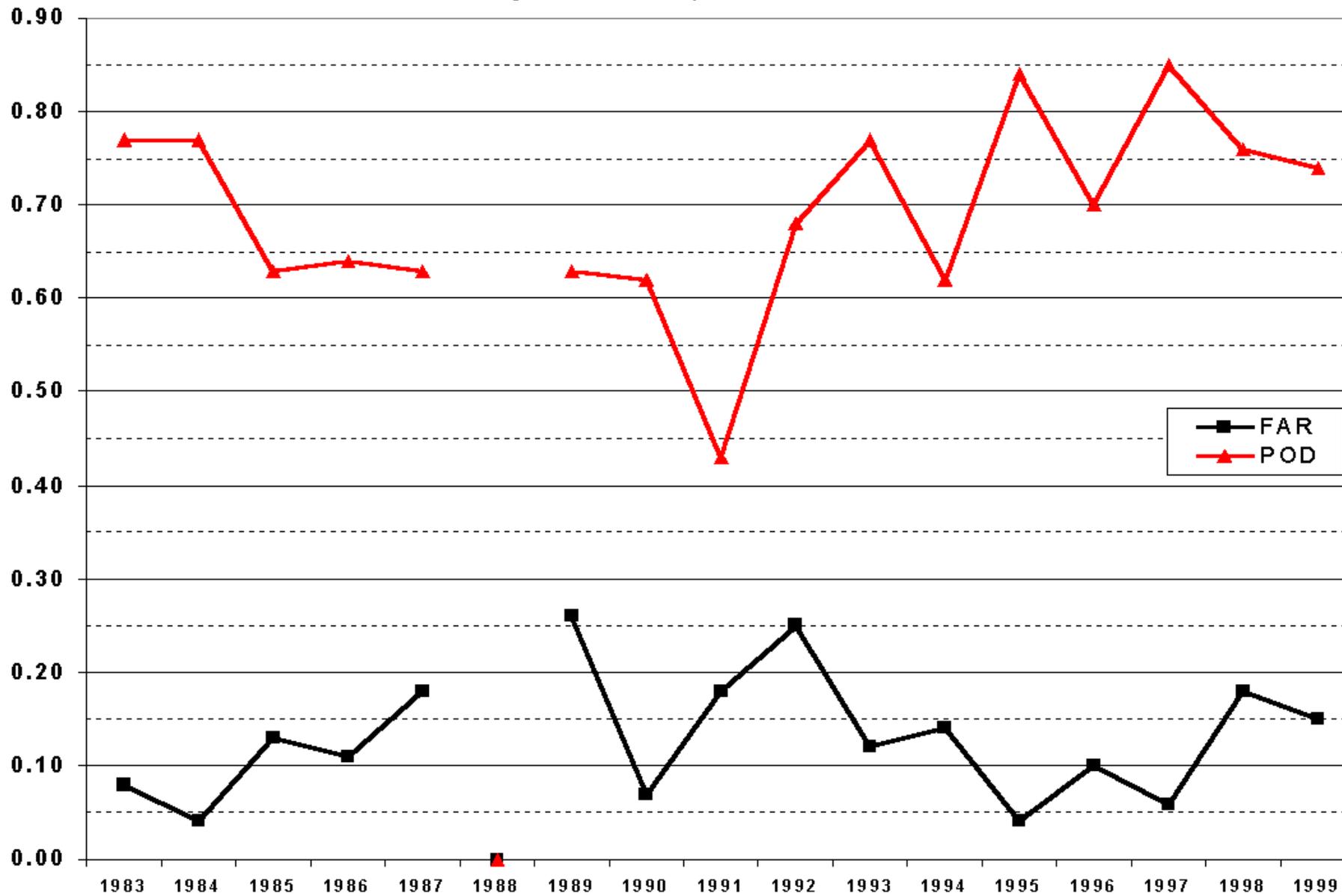
# Sample Size $\geq$ Flood Stage



# MBRFC RIVER FORECAST VERIFICATION

## For Six Selected Missouri River Mainstem Locations

Flood / No Flood Categorical Probability of Detection & False Alarm Rate



# End of Bonus Section

ZIGGY/ by Tom Wilson

