MDL Postprocessing Data Needs, Techniques, and Skill

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Meteorological Development Laboratory (MDL)

Digital Forecast Services Branch
- National Digital Forecast Database (NDFD)
- Localized Aviation MOS Product (LAMP)
- Evaluation of forecasts and guidance

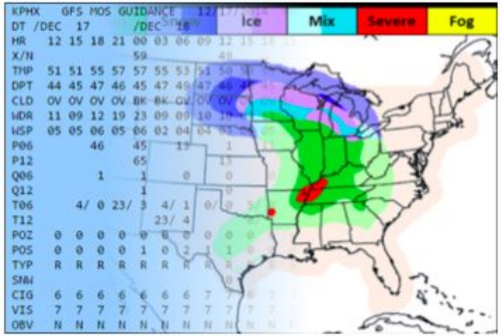
Statistical Modeling Branch
- National Blend of Models
- Model Output Statistics (MOS)
- High-quality model and observation archives

MDL

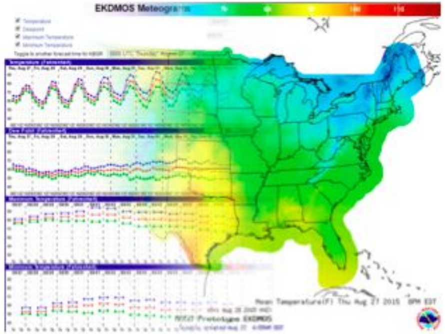
Weather Information Applications Branch
- Web services
- Metadata
- Data modeling

Decision Support Branch
- IRIS/Impacts Catalog
- Storm Surge
- Virtual Laboratory (VLab)

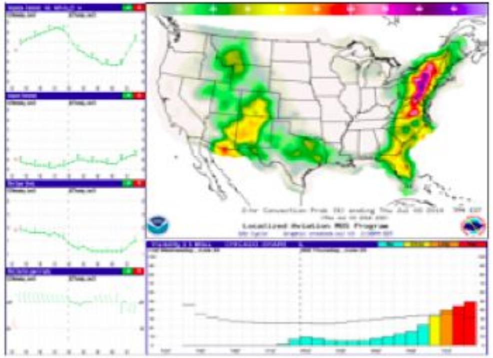
Overview of Statistical Postprocessing At MDL



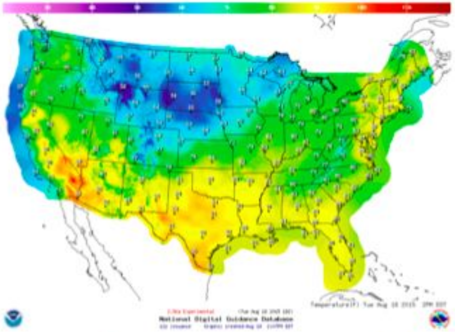
Model Output Statistics



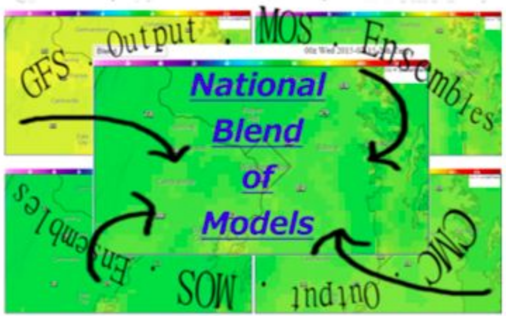
Ensemble Kernel Density MOS (EKDMOS)



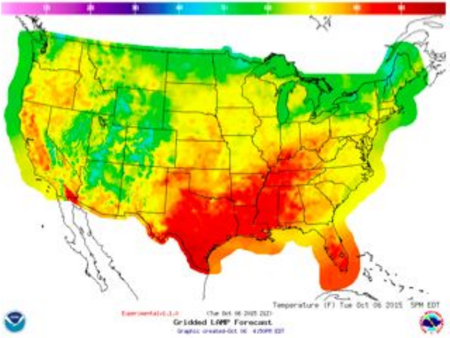
Localized Aviation MOS Program (LAMP)



Gridded MOS (GMOS)



National Blend of Models (NBM)



Gridded LAMP (GLMP)

Model Output Statistics (MOS)

- MOS relates observed weather elements (predictands) to appropriate variables (predictors) via statistical methods
- Multiple Linear Regression with Forward Screening Selection

$$Y = b + a_1X_1 + a_2X_2 + a_3X_3 + \ldots + a_nX_n$$

- Often apply non-linear transformations to the predictor variables
  - Grid Binaries -- PQPF
  - Logistic Transformations -- GMOS Precip Type (Shafer 2010)
  - Interactive Predictors -- HiRes GMOS QPF -- (Charba and Samplatsky, 2011)

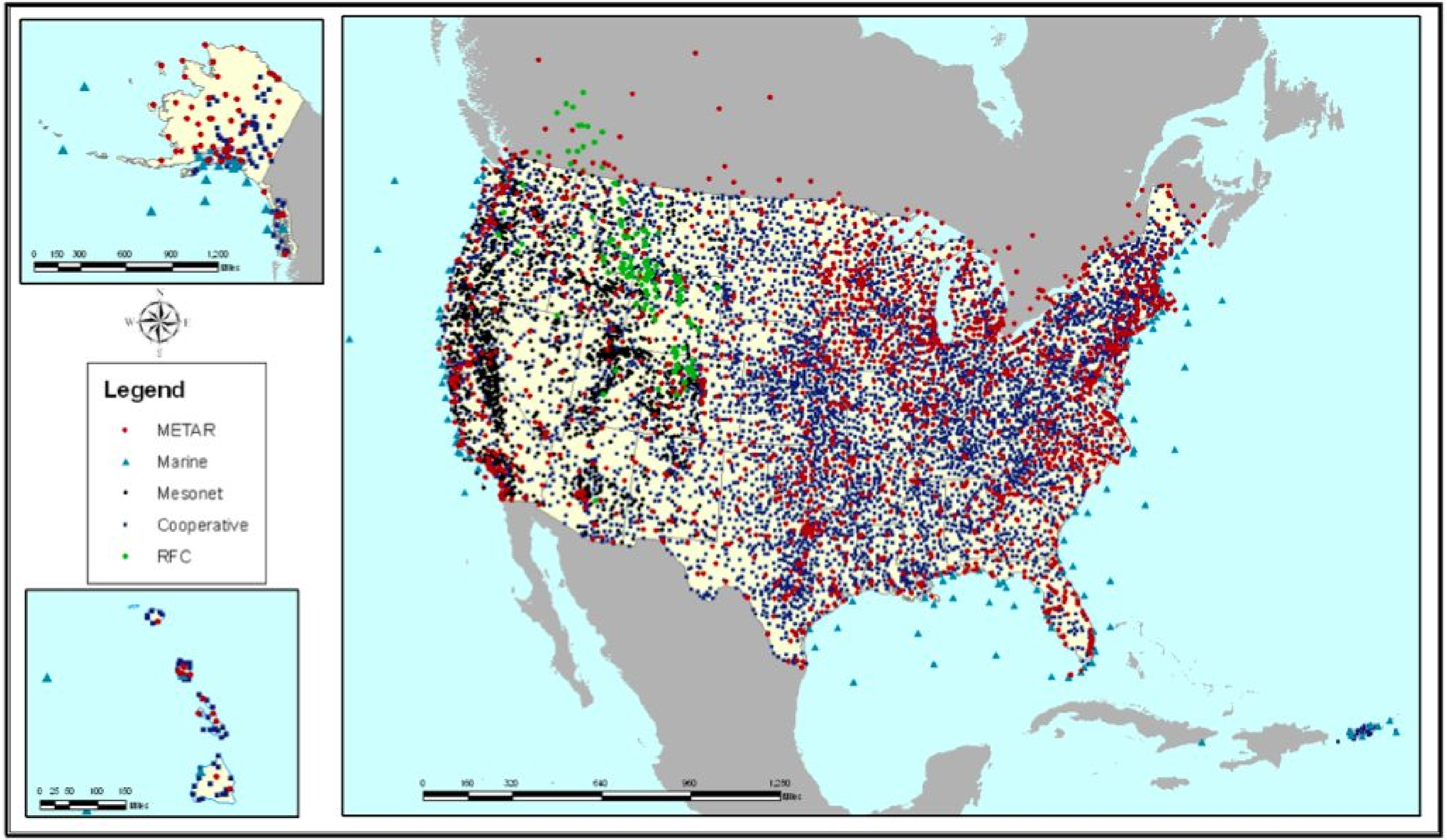
Predictor Data Sources

- Predictors usually obtained from
  - Numerical Weather Prediction (NWP) Output
  - Prior Surface Weather Observations
  - Geoclimatic Information

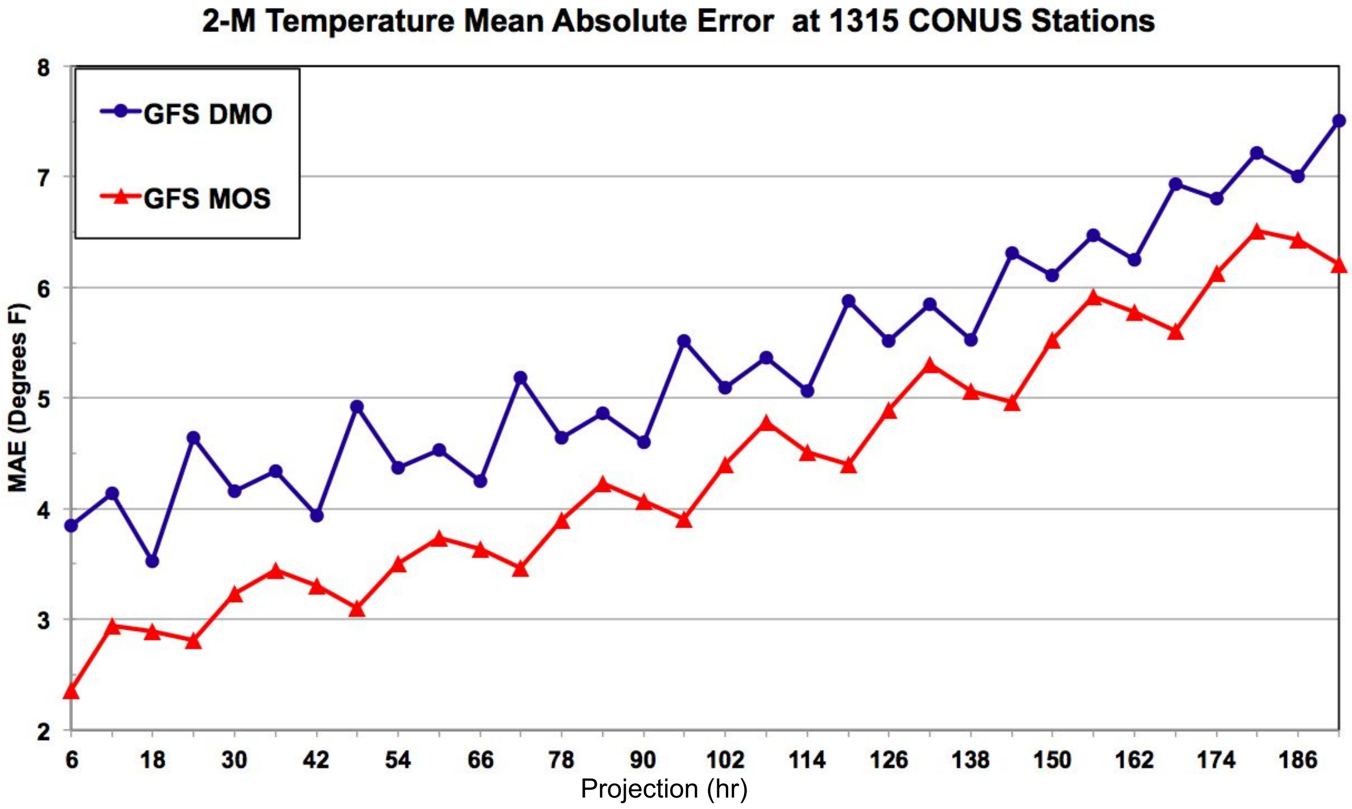
Observational Data Sources

- METAR
- Marine - buoy and Coastal-automated Marine Networks (CMAN)
- Lightning Data
  - Vaisala's National Lightning Detection Network
  - Bureau of Land Management
  - Earth Networks Inc. Total Lightning
- NCDC cooperative observer data - (COOP)
- GOES Satellite Cloud Product (SCP)
- MADIS mesonet observations
- Multi-Radar/Multi-Sensor System (MRMS)
- Geophysical data - terrain, land cover, climatology, station metadata

Station-based Data Sources



Why Use MOS?



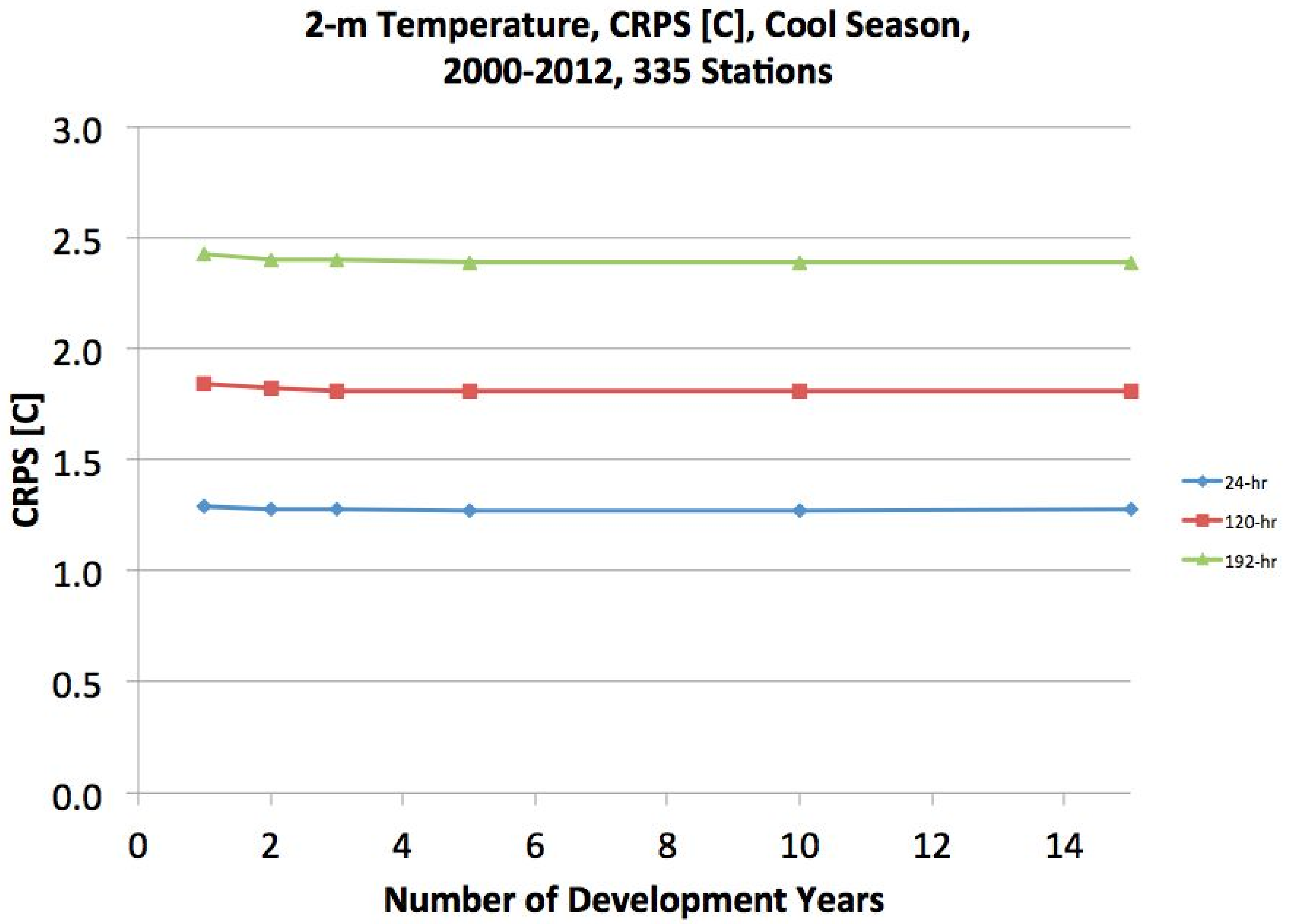
Temperature Verification - 0000 UTC GFS MOS vs. GFS DMO (10/2011 - 3/2012)

MOS Development Challenges

- Rapidly evolving NWP systems and observation platforms
  - Model upgrades can alter underlying model biases and degrade MOS
  - Short, unrepresentative forecast samples
  - Difficulty collecting appropriate predictand data
- Reforecast datasets would benefit MOS development

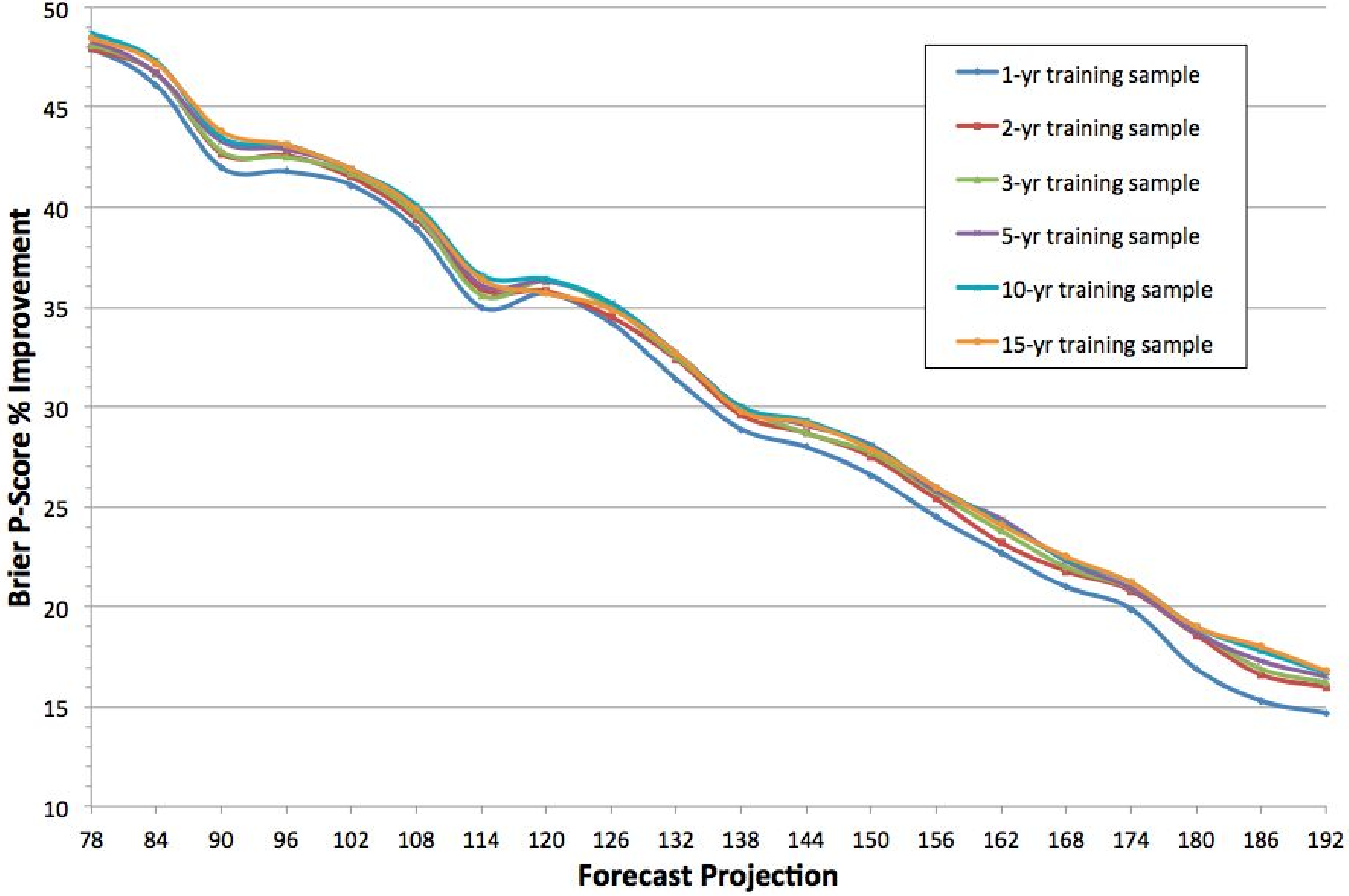
How much reforecast data is ideal for MOS?

- Conducted sample size sensitivity tests using the second generation GEFS 30-year reforecast dataset (Hamill et al. 2013)
- Developed station-based MOS/EKDMOS equations
  - Training Samples Sizes: 15 years, 10 years, 5 years, 3 years, 2 years, and 1 year
  - Temperature (EKDMOS)
  - Wind Speed and Precipitation Type (MOS)
- Generated 13 years of independent forecasts
- Hamill et al. 2014 -- “A Recommended Reforecast Configuration for the NCEP Global Ensemble Forecast System”


2-m Temperature, CRPS [C], Cool Season,
2000-2012, 335 Stations
CRPS [C]
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
2
4
6
8
10
12
14
Number of Development Years
24-hr
120-hr
192-hr

Cool Seasons: 2000/2001 - 2012/2013
Wind Speed ≥ 10 Kts - 00Z GEFS MOS - MAE
Overall (334 Stations)

0000 UTC GEFS MOS Probabilistic Precipitation Type (3-category) Sample Size Testing: 2001-2012 Cool Seasons



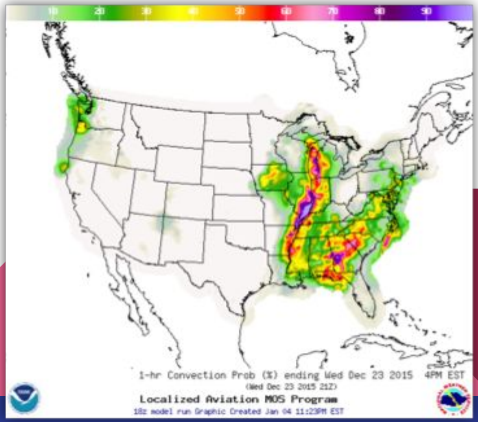
Sample Size Sensitivity Experiment Summary

- 3 to 5 years of reforecast data was sufficient for developing MOS equations
  - Temperature
  - Wind Speed
  - Precipitation Type

- Results may vary for other elements

The Localized Aviation MOS Program (LAMP)

- Objective -- Improve on MOS forecasts and persistence out to at least 25 hours through rapid infusion of current observational data
- 24 cycles of LAMP per day
- Focus on weather elements that are critical to the aviation community, such as: ceiling height, visibility, winds, and convection

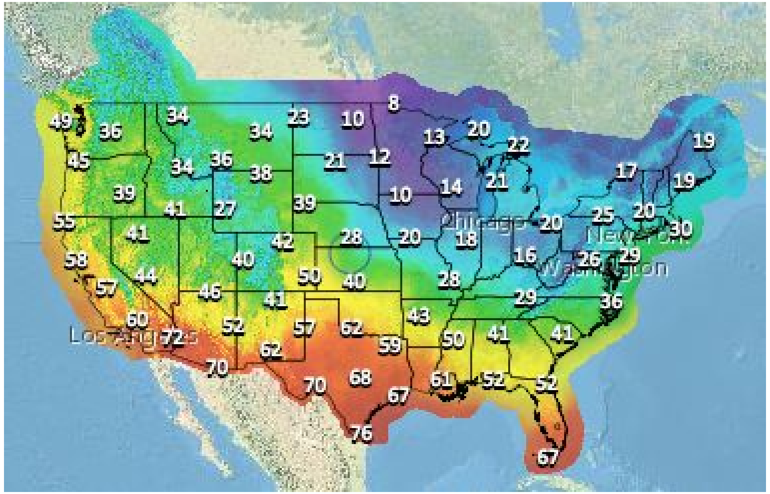


LAMP Statistical Postprocessing Challenges

- Good observations are critical to the LAMP process.
- Many aviation elements are non-normally distributed and discontinuous in nature.
- Rapidly-changing models are problematic for LAMP since hourly cycles are very time-intensive to re-develop (24 cycles, 2 seasons, backup & primary eqns).

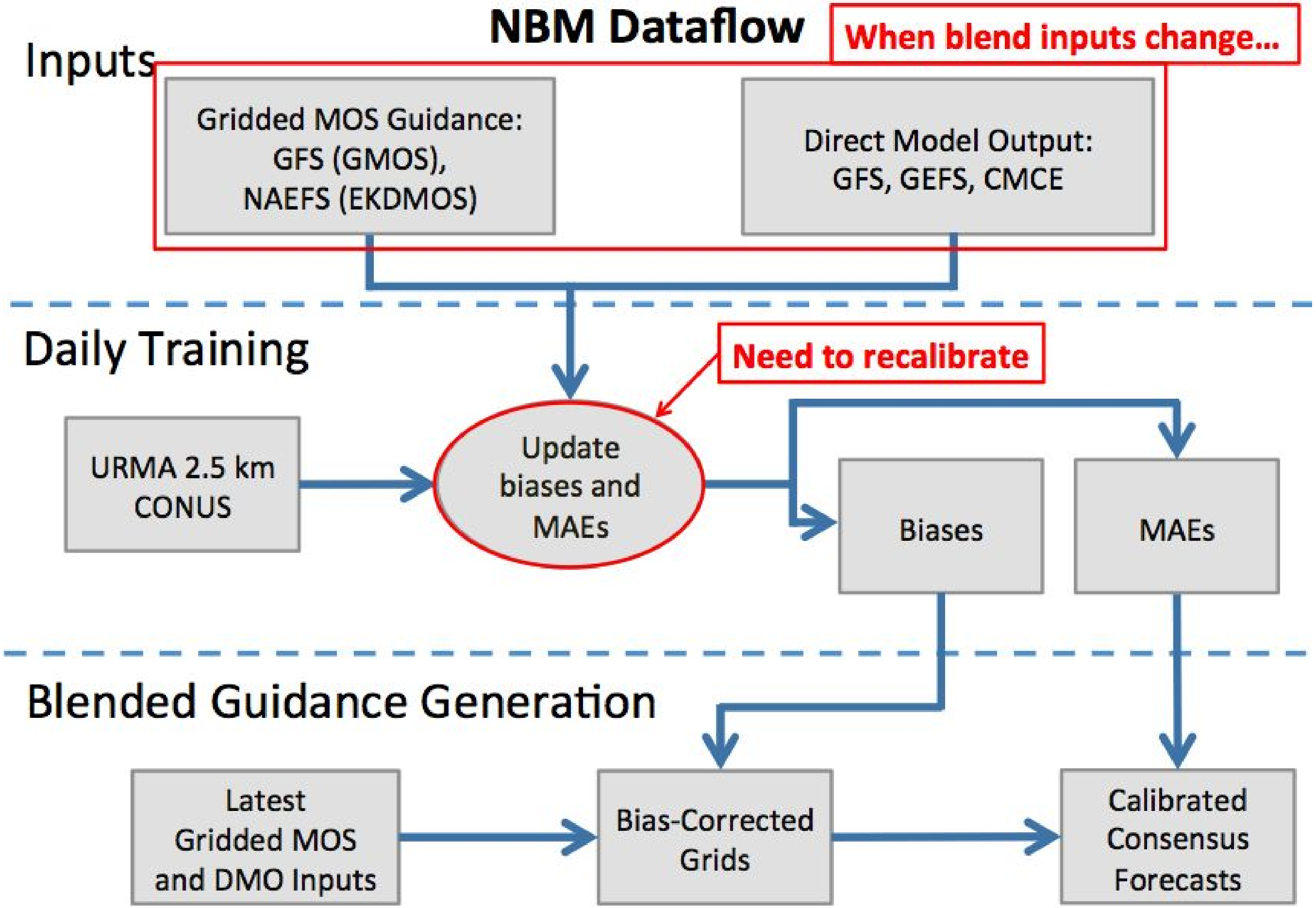
The National Blend of Models (NBM)

- Combines forecasts from multiple NWP models to create calibrated, blended guidance on the NDFD domains
- The UnRestricted Mesoscale Analysis (URMA) is used for calibration
- Components are blended based on recent MAEs (prior ~20 days)



NBM 48-hr Max T: Issued 18 Jan. 2016 00z Cycle

NBM Dataflow



Conclusions

- Greatest challenges for statistical postprocessing at MDL
  - Rapidly-changing models
  - Requirement to produce gridded guidance without adequate gridded observations for training and verification
  - Obtaining a sufficient sample or reanalysis of gridded observations (i.e. URMA)

- For each major model change
  - MOS/LAMP require 3-5 years of reforecasts to recalibrate
  - The National Blend of Models requires 30 days to recalculate biases and MAEs

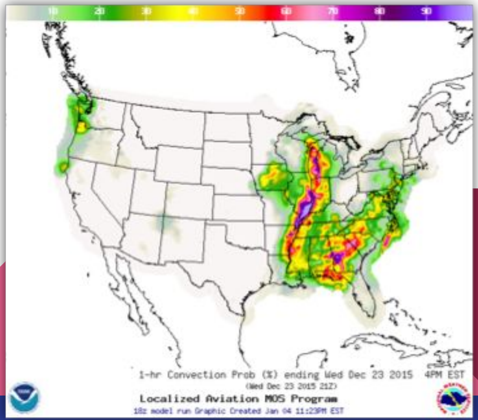
References

- **Charba, J.P., and F.G. Samplatsky, 2011: High resolution GFS-based MOS quantitative precipitation forecasts on a 4-km grid. *Mon. Wea. Rev.*, 139, 39-68.**
- **Hamill, T. M., G.T. Bates, J. S. Whitaker, D. R. Murray, M. Fiorino, T. J. Galarneau, Y. Zhu, and W. Lapenta, 2013: NOAA's Second- Generation Global Medium- Range Ensemble Forecast Dataset. *Bull. Amer. Meteor. Soc.*, 94, 1553-1565.**
- **Shafer, Phillip E., 2010: Logit transforms in forecasting precipitation type. *Preprints, 20th Conf. on Probability and Statistics in the Atmospheric Sciences,* Atlanta, GA, Amer. Mieteor. Soc.**

Backup Slides

The Localized Aviation MOS Program (LAMP)

- Objective -- Improve on MOS forecasts and persistence out to at least 25 hours through rapid infusion of current observational data
- Project Goals:
  - Develop improved LAMP guidance for use in aviation forecasting
    - Provide station-based LAMP guidance valid at NWS TAF stations
    - Provide gridded LAMP guidance for inclusion in NWS Enhanced Digital Services
  - Focus on weather elements that are critical to the aviation community, such as: ceiling height, visibility, winds, and convection



LAMP Statistical Postprocessing

- LAMP combines METAR, radar, satellite cloud product, and lightning observations with forecasts from MOS and direct model output to create station-based and gridded guidance via multiple linear regression.
- LAMP runs hourly and includes the most recent observations to produce valuable guidance in the short-range period for the aviation community.
- Good observations are critical to the LAMP process.
- Many aviation elements are non-normally distributed and discontinuous in nature, which poses unique challenges for statistical postprocessing.
- Rapidly-changing models are problematic for LAMP since hourly cycles are very time-intensive to re-develop (24 cycles, 2 seasons, backup & primary eqns).

MOS Operational System on WCOSS

- 9 million regression equations
- 75 million forecasts per day
- 1200 products sent daily
- 400,000 lines of code – mostly FORTRAN
- 180 min. of supercomputer time daily