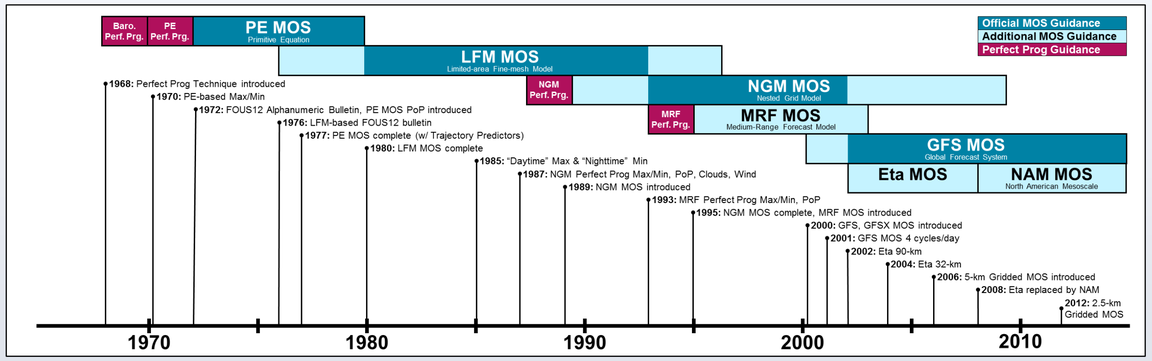
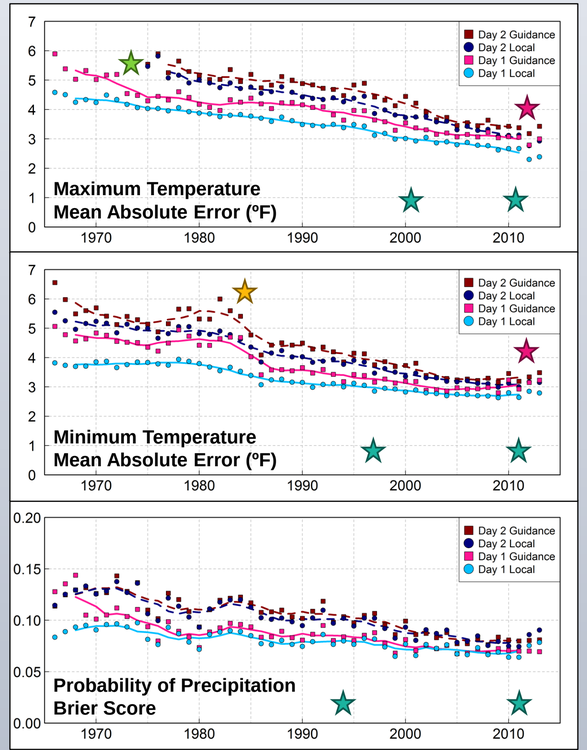
Forty Years of NWS Forecasts: Past Performance and Future Advances

Tabitha L. Huntemann, David E. Rudack, David P. Ruth

Affiliation: NOAA/NWS/OST/Meteorological Development Laboratory

449





Day 1 and day 2 verification scores for cool season (October-March) based on 0000 UTC model cycle guidance for 80 CONUS stations. Labels show year season began. Lines are 5-year moving averages.

Past Performance: Long-Term Verification

The Meteorological Development Laboratory (MDL) of the National Weather Service (NWS) has issued model output statistics (MOS) guidance forecasts for nearly four decades (Glahn and Lowry 1972). The NWS and MDL routinely evaluate official forecasts at stations and compare the skill of the human forecast to the guidance for the same weather element. Dallavalle and Dagostaro (2004) and Ruth et al. (2009) documented the improvement in guidance products that objectively interpreted the output of numerical weather prediction models. The results shown here have been updated through the 2013 cool season for 79 CONUS stations available out of the original 80.

The past four decades of MOS guidance have been compared to official forecasts prepared at local NWS offices for daytime maximum temperature (MaxT), nighttime minimum temperature (MinT), and 12-h probability of precipitation (PoP12). Local forecasts are compared to MOS guidance that is available several hours prior to local forecast issuance. For example, through the 2011 cool season, local maximum temperature forecasts issued at approximately 0400 local time for the next two days are compared to MOS based on the 0000 UTC model cycle.

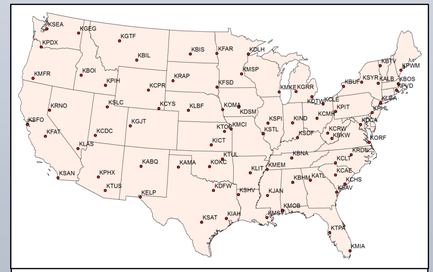
Improvements in NWS public weather forecasts and in statistically post-processed numerical weather prediction can be traced by the verification of the weather element guidance. For example:

- The transition from Perfect Prog guidance to the MOS approach in 1973 resulted in a clear improvement to MaxT guidance scores.
- The implementation of nighttime MinT in late 1984 reduced errors of both local forecasts and guidance.
- Forecasts are continually improving: Day 2 local forecasts (dark blue) are now as good as they were for day 1 (light blue) 10 to 20 years earlier.
- Problems with models contribute to decreases in performance: GFS model changes in 2010-2011 changed bias characteristics and negatively affected MOS. A refresh of the GFS MOS guidance is planned for January 2015, coincident with the GFS model upgrade.

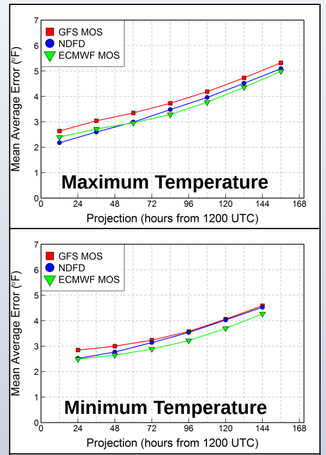
Future Advances: ECMWF MOS

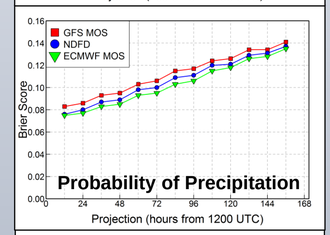
Recently, MDL has applied the MOS approach to the European Centre for Medium-Range Weather Forecasts (ECMWF) model to generate additional station-based guidance (Rudack 2014). While ECMWF model output is widely recognized in the meteorological community for its skill, it can contain systematic bias. Application of the MOS technique to ECMWF model output has produced guidance for weather elements found in MDL's GFS MOS including elements not available directly in ECMWF model output, such as probability of precipitation.

For this analysis, National Digital Forecast Database (NDFD) forecasts from 19 Sep 2012 to 30 Sep 2014 were collected for the 1200 UTC issuance time. The NDFD forecasts are matched with the same day's 0000 UTC model cycle GFS MOS and ECMWF MOS forecasts available to forecasters at the time the NDFD forecasts were prepared. MOS forecasts were collected for 79 verification stations while NDFD forecasts were extracted from the 5-km NDFD grid by using a nearest neighbor technique.



79 stations used in these verifications.

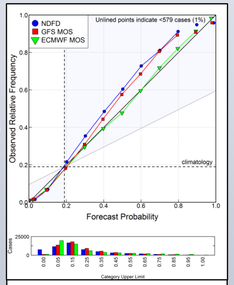




Verification scores 19 Sep 2012 to 30 Sep 2014 based on 0000 UTC model cycle guidance.

The ECMWF MOS MaxT guidance was nearly as accurate as the NDFD forecast. For MinT, the ECMWF guidance is consistently more accurate than the corresponding GFS MOS and NDFD, particularly at later projections. The Brier score assesses the accuracy of probability forecasts (Wilks 2006). A perfect Brier score is zero. ECMWF MOS PoP12 is more accurate than GFS MOS or NDFD. GFS MOS is less accurate than both ECMWF MOS and NDFD.

Reliability diagrams can be used to assess how closely the forecast probabilities of an event correspond to the actual chance of observing the event. In general, the ECMWF MOS is very reliable. NDFD and GFS MOS PoP12 both tend to underforecast higher precipitation categories for this sample. The ECMWF MOS exhibits more sharpness than GFS MOS and NDFD, meaning it is capable of predicting events with probabilities with extreme values relative to the observed event frequency.



Reliability diagram for 72-h projection PoP12.

The ECMWF MOS guidance has not been implemented operationally, but these results suggest that NWS forecasters could add value to their morning updates and afternoon forecast products by considering the 0000 UTC ECMWF MOS.

Conclusions

MDL has continually adapted MOS guidance to meet the needs of NWS forecasters at Weather Forecast Offices (WFO). Both local forecasts and guidance have clearly improved in quality over the last 40 years. Day 2 local forecasts are as good as they were for day 1 about 10 years ago. Guidance quality has been negatively impacted in recent years by model changes, but remains valuable.

Improvements to MOS guidance continue. A refresh of GFS MOS station guidance is ongoing in response to the planned GFS model upgrade in early 2015. NAM MOS will also be refreshed to be better calibrated to the most recent operational version of NAM. ECMWF MOS is planned to be made operationally available to forecasters by mid-2015. In addition, the ECMWF MOS will be used to leverage European models for the National Blend of Models project. We anticipate that NWS forecasters will continue to find MDL's MOS products valuable for many years to come.

References

Dallavalle, J. P., and V. J. Dagostaro, 2004: Objective interpretation of numerical prediction model output – A perspective based on verification of temperature and precipitation guidance. *Symp. 50th Anniversary of Operational Numerical Weather Prediction,* College Park, MD, NCEP, 5.8.

Glahn, H. R., and D. A. Lowry, 1972: The use of model output statistics (MOS) in objective weather forecasting. *J. Appl. Meteor.*, **11,** 1203-1211.

Rudack, D. E., D. P. Ruth, K. K. Gilbert, T. Curtis, 2014: A first look at the Meteorological Development Laboratory's experimental ECMWF MOS system. *26th Conf. on Wea. Analysis and Forecasting,* Atlanta, GA, Amer. Meteor. Soc., J4.1.

Ruth, D. P., B. Glahn, V. Dagostaro, K. Gilbert, 2009: The performance of MOS in the digital age. *Wea. Forecasting*, **24,** 504-519.

Wilks, D. S., 2006: Statistical Methods in the Atmospheric Sciences. Elsevier, 627 pp.

Contact Information: Tabitha Huntemann, Meteorological Development Laboratory, 1325 East-West Highway, Silver Spring, MD 20910; **email:** Tabitha.Huntemann@noaa.gov