Global Forecast Dropout Prediction Tool (GFDPT) in Support of the NCEP Model Evaluation Group (MEG) – A Collaborative Project Between JCSDA/NESDIS &NWS

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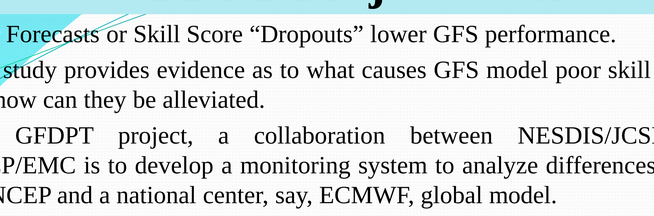
GFDPT Project Goals

- Poor Forecasts or Skill Score "Dropouts" lower GFS performance.
- This study provides evidence as to what causes GFS model poor skill forecasts and how can they be alleviated.
- The GFDPT project, a collaboration between NESDIS/JCSDA and NCEP/EMC is to develop a monitoring system to analyze differences between the NCEP and a national center, say, ECMWF, global model.
- We hypothesize that dropouts originate from QC problems interacting with the GFS analysis system.
- Evaluate dropout event(s) and determine if QC is responsible per particular Observation type both conventional and satellite.
- Implement an improved QC system with the Model Evaluation Group (MEG) and Weather Prediction Center (WPC) operations to detect the QC problem and correct for it in the next forecast cycle through the automation diagnostic tools.

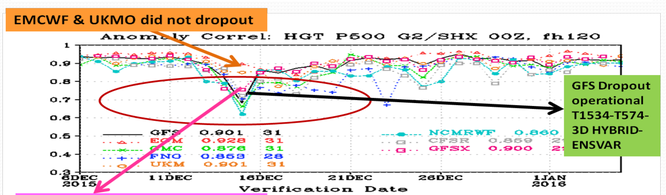
Global Forecast "Dropout" (quality control of observations) Studies at NCEP

- Global Forecast Dropout Prediction Tool Components: Prediction and Detection of Actionable Volumes of conventional and nonconventional observations.
- Diagnosis of Actionable Volumes using the COAT and IAT & its relevance to model evaluation plans of NWS and JCSDA.

GFS Forecast Skill Dropouts - Comparison with other models



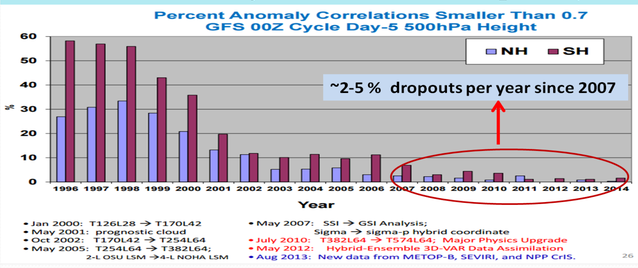
EMCWF & UKMO did not dropout



GFS Dropout operational T1534-T574-3D HYBRID-ENSVAR

GFS Parallel (T1534-T574- 4D HYBRID-ENSVAR) near dropout

GFS History of forecast skill dropouts (1996-2014)



May 2016 – Major upgrade to T1534 Semi-Lagrangian (~13km);

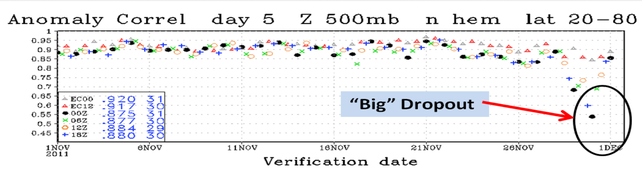
GFS Physics

4DENSVAR GSI Analysis package

GSI Changes: Increase horizontal resolution of ensemble from T254 to T574; reduce number of second outer loop iterations from 150 to 100; upgrade to CRTM v2.1.3; move to enhanced radiance bias correction scheme; correct bug in AMSU-A cloud liquid water bias correction term; assimilate new radiances: F17 an F18 SSMIS, MetOp-B IASI; increase ATMS observation errors; turn on cloud detection channels for monitored instruments: NOAA-17, -19 HIRS, GOES-13 and -14 sounders; changes in assimilation of atmospheric motion vectors (AMV)

GFS Forecast Skill (all cycles) versus ECMWF (current) prior to 3D HYBRID ENSVAR

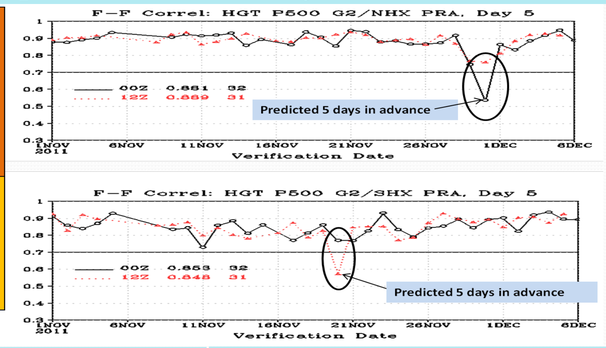
Main goal is to find differences that can lead to algorithms to detect and correct a data quality control (QC) problem, bias correction, and analysis issues in initial conditions before the forecast begins



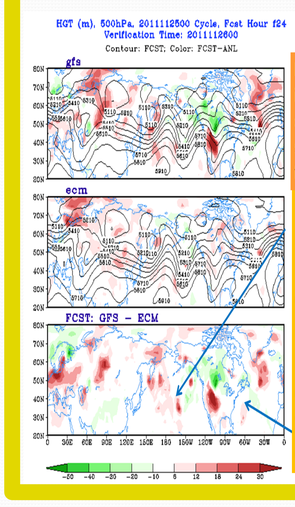
GFS vs ECMWF Forecast Divergence 2011120100 Dropout Prediction 5 days in advance

The Forecast-Forecast (F-F) Correlations may be computed between any two models, eg., GFS and the ECMWF, using the ECMWF as verifying data.

The F-F Correlations can now be used to predict the occurrence of a dropout 5 days in advance as for this dropout case.



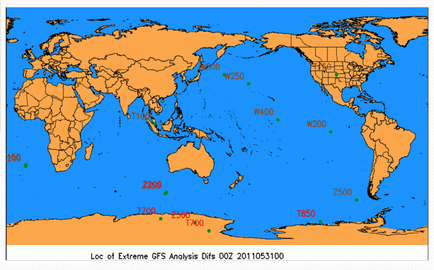
GFS and ECMWF Forecasts and evolution of forecast errors



ICand animated 12-h interval forecasts, NB: changing (m) scale showing amplification of forecast error

The largest difference between GFS and ECMWF ICs is in the Central and North Pacific as well as a lesser amplitude difference in the Western Atlantic and Gulf.

Location of Extreme GFS Analysis Differences vs. ECMWF analysis (20110531 00Z)



Forecast Divergence of GFS and ECMWF operations provides a heads up for model problems and the "Extremes" code analysis to locate and order largest increment/innovation in observations to show potential actionable areas in the GFS analysis compared with ECMWF analyses. Displayed the top dozen ECMWF and GFS analysis differences in a volumetric fashion.

GFDPT Tool Components

The **Forecast-Forecast (F-F) Correlations** between ECMWF & GFS to indicate warning of dropout potential.

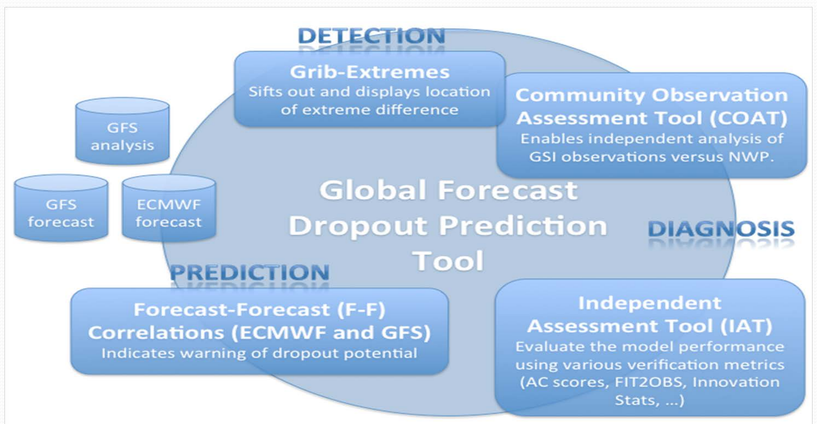
Extremes Code: Sift out and display extreme GFS analysis differences compared with ECMWF and other background guess fields creating analyses minus guess difference plots. This code uses 1x1 degree GRIB files for the NCEP Guess, and the ECMWF and GFS or GDAS analyses as input, with output on extreme differences sorted by approximate volumetric integrals of squared differences in height, temperatures and winds on mandatory pressure levels for input to graphic codes.

Forecast difference maps between GFS & ECMWF NCEP's Verification System Data Base (**VSDB**) and JCSDA's Independent Assessment Tools (**IAT**).

For post-mortem studies – **use ECMWF initial conditions for GFS forecast** - "**ECM**" **cycled Runs** by treating the ECMWF 1° x 1° grid analysis as pseudo observations (eg., RAOBS), and using them as sole input into the GFS (GSI) analysis. ECM results are shown for the near NH and SH GFS dropouts for December 15, 2015.

Community Observation Assessment Tool (**COAT**)

Global Forecast Dropout Prediction Tool

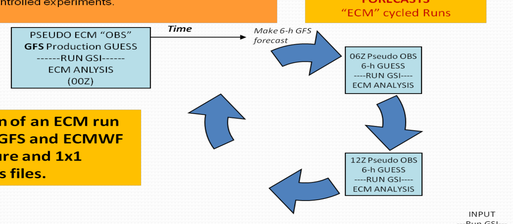


Is the "dropout" due to model problems or assimilation problems?

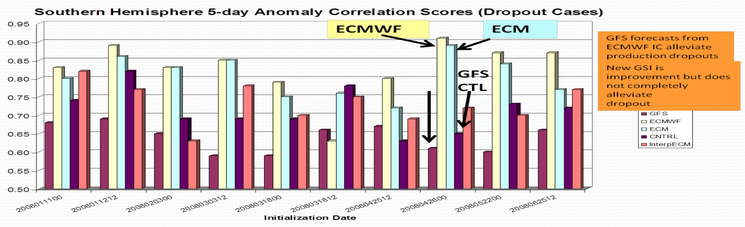
The GSI as a "Grand Interpolator"

Treating the ECMWF 1x1 degree grid analysis as pseudo observations (eg., RAOBS), and using them as sole input into the GFS (GSI) analysis, which then acts as a "grand interpolator", generating new initial conditions that inherit ECMWF analysis (and to some extent ECMWF model) system characteristics. This analysis/forecast is labelled as ECM runs. To analyze forecast skill dropouts, we compare the operational GFS and ECMWF analyses and provide a way to study the impact of observations with controlled experiments.

ECMWF INITIAL CONDITIONS FOR GFS FORECASTS
"ECM" cycled Runs



Representation of an ECM run using the GSI/GFS and ECMWF 14 level pressure and 1x1 degree analysis files.



GFS forecasts from ECMWF IC alleviate production dropouts

New GSI is improvement but does not completely alleviate dropout

GFS: Operational (Production) GFS
ECMWF: Their Operations
ECM: Pseudo Obs from ECMWF analysis using the GSI as a "Grand Interpolator
CNTRL: Updated GSI system with GDAS observations (GSI details change often across the dropout accumulation period)
InterpGES: Updated GSI with previous 3, 6, & 9-hour ECM forecasts as background guess plus GDAS observations **Source: NCEP Dropout Team**

What is the Community Observation Assessment Tool?

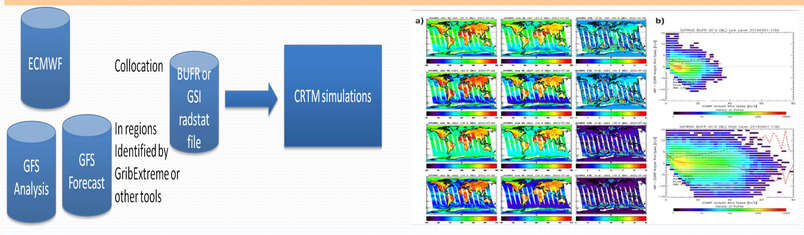
- The community observation assessment tool (COAT) is a set of Fortran 90, IDL and scripts, largely built on the MIIDAPS/CRTM libraries for the forward and Jacobian operators and NWP collocation utilities.
- Version controlled in SVN to maintain compatibility with GSI and MIIDAPS libraries.
- Inputs consist of BUFRized passive microwave observations (ATMS, GPM GMI, GCOMW1, AMSR2, SSMI/S), *broadband and hyperspectral IR measurements (GOES SNDR and IMGR, IRS, Metop-A/B IASI, CrIS)* and atmospheric motion vector data – same data that is used in GSI.
- BUFR is converted into formats that the MIIDAPS/CRTM libraries can utilize. Generally applicable to any instrument that CRTM can simulate.
- Provides the ability to pre-assess observations offline (e.g., O-B, O-A, as a function of various parameters and filtering/QC techniques), before the data gets into the DA environment.
- Enables optimization and the utilization of satellite data for instruments currently in GSI and those not yet installed into the DA.

COAT (Radiance Observation Flowchart)

Inputs consist of ECMWF analysis and/or GFS forecast/analysis, as well as BUFRized passive microwave observations (ATMS, GPM GMI, GCOMW1 AMSR2, SSMI/S), *broadband and hyperspectral IR measurements (GOES SNDR and IMGR, H8-AHI AIRS, Metop-A/B IASI, CrIS* – same data that is used in GSI.

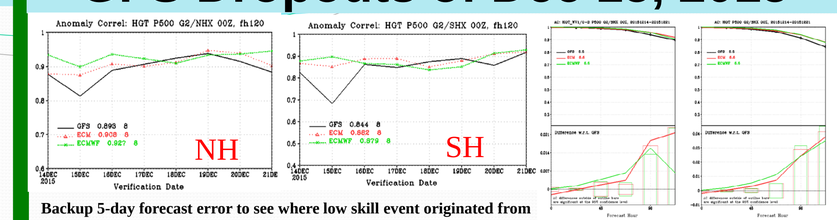
Provides the ability to pre-assess observations offline (e.g., O-B, O-A, as a function of various parameters and filtering/QC techniques), before or after the data gets into the DA environment.

A Data Assessment Report (DAR) consisting of IDL images and tabular statistical summaries is automatically generated using LaTeX.

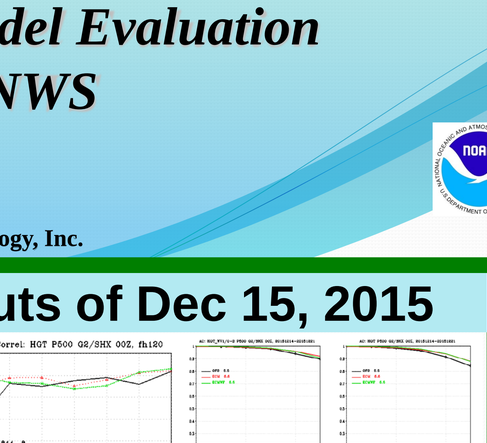


Combine the F-F correlation and GRIB Extreme prediction and detection applications with the COAT to:
- Obtain the radiance values that would be projected from analysis dependent variables as seen from an instrument using each of the analysis source.
- Assess whether assimilated observations and simulations differ by more than established statistical criteria.

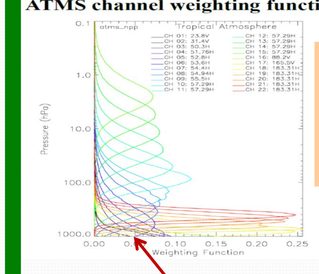
GFS Dropouts of Dec 15, 2015



For a particular satellite platform, using the GSI stat files, one can compare the co-located satellite radiance instrument observations to that derived using the CRTM from the production analysis of the same time. That is, a satellite radiance comparison of the analysis' derived radiance observations compared to the actual observations reported. In a perfect world , the two should be the same and differences could represent retrieval and assimilation error.

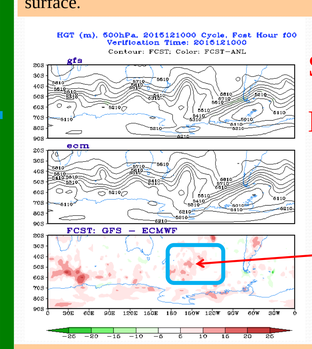


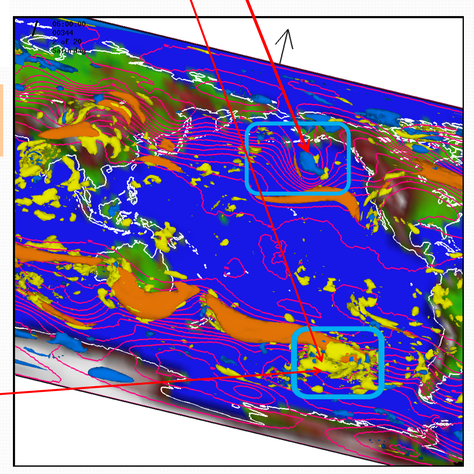
ATMS channel weighting function



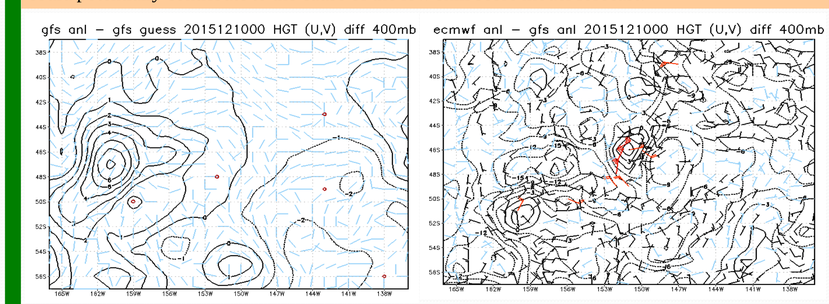
ATMS weighting functions for each channel. Channel 1 is close to the surface.

A 3D re-scaled rendering of the GFS production 6-hour forecast error, showing 500mb height contours (Red) and wind speed iso-surface greater than 50m/s (Orange), associated wind speed forecast error (Yellow), and height forecast error (Blue). Blue boxes indicate a (can be more than one) location of where the 5-day forecast error originated from.

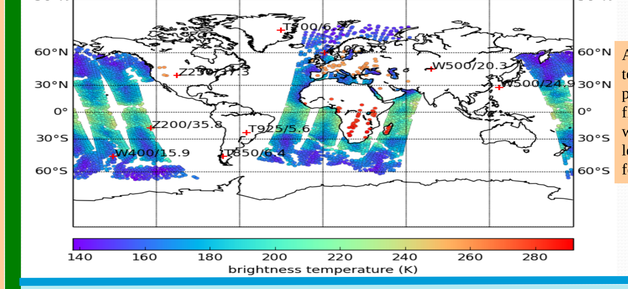




The 3D rendering including animated forecast error iso-surfaces, above, right (animation not shown) as well as the SH 500 hPa pressure level synoptic chart (animations not shown) above left (other levels not shown) show the location/volume of where the low skill event originated. The O-A pattern at the source location for each NH and SH dropouts (blue boxes) are co-located with the region where the radiance observations and the radiance calculated from the GSI production analysis using the CRTM. This is (one) ATMS channel 1 but, if the other tropospheric channels are similar then the reason for this dropout could be delineated: The contamination of observed radiance by cloudy or surface ice or other contamination was not properly quality controlled and could potentially contribute to the cause of the low skill score model forecast!



Displayed here are height and wind differences between GFS guess and analysis (top left) and ECMWF analysis and GFS analysis (top right) at a coordinate found by GRIBEXTREMES on the Initial Condition 20151210. The GFS analysis has only nominal changes from the background, though it differs substantially from ECMWF.



ATMS Channel 1 brightness temperatures for 2015121000 plotted with coordinates flagged by GRIBEXTREMES with the variable, pressure level and variable difference for each coordinate.

Main Points

The GFDPT project shows:

- Poor skill score GFS forecasts can be predicted using a forecast-forecast correlation between GSF and ECMWF
- Compiling the extreme difference between ECMWF and GFS analyses as well differences between the 6-hour forecast (background guess) from the previous cycle and the next cycle analysis (analysis increment) can provide information, in certain regions, if the analysis has accepted contaminated observations.
- The source region in an initial condition that caused a poor GFS forecast can be determined from forecast error information.
- These region's forecast errors cause a poor skill forecast can be confirmed by running a forecast from GFS (ECMWF) analysis/initial condition, and substituting the ECMWF (GFS) information over the actionable volume and checking if the 5 day forecast results return the ECMWF (GFS) forecast skill.
- We show preliminary evidence that contaminated radiances can potentially cause poor skill GFS forecasts when they are assimilated in a region that is sensitive to initial conditions in terms of the 5 day forecast error.