Climatological Analysis of Model Precipitation from NCEP GEFS Reforecast

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Introduction

ESRL/PSD GEFS Reforecast V2 is an extensive dataset of historical weather forecasts generated with NCEP's 2012 operational Global Ensemble Forecasting System (GEFS) version for past 29 years. It is developed mainly for the purpose of a number of applications, including statistical post-processing, diagnosis of the forecast ability of uncommon phenomena and initialization of regional model reforecasts. In particular, this long reforecast dataset gives us an unprecedented opportunity to develop a dataset of model precipitation climatology for GEFS, which could be used for forecast calibration and verification studies and anomaly forecast guidance. Due to non-Gaussian feature and heavy-tailed distributions of precipitation amount, the L-moment method with Gamma distribution as a fitting function was employed to derive the NCEP Climatology-Calibrated Precipitation Analysis (CCPA) daily climatology in our previous study, and also is utilized here to calculate model daily climatology based on 26 years (1985-2010) of the GEFS Reforecast as well.

Furthermore, it is necessary to evaluate model climatology from the Reforecast dataset. In this study, CCPA climatology for a period of 8-years (2002-2010) is used to evaluate Reforecast climatology with the coincident period for the Contiguous United States (CONUS) domain and each River Forecast Center (RFC). These datasets are compared at 1-deg grid resolution and various time scales ranging from daily, monthly to seasonal time scales. Detailed comparisons are provided to decide a selection of sampling methods in the calculations of daily climatology, to assess the quality of Reforecast and to understand the error characteristics associated with the Reforecast precipitation.

GEFS Reforecast Configurations

- ❑Model version
  - ➢GFS v9.01 – last implementation – May 2011
  - ➢GEFS v9.0 – last implementation – Feb. 2012
- ❑Resolutions
  - ➢Horizontal – T254 (0-192hrs – 55km); T190 (192-384hrs – 70km)
  - ➢Vertical – L42 hybrid levels
- ❑Initial conditions
  - ➢CFS reanalysis
  - ➢Advanced Ensemble Transform with Rescaling (ETR) for initial perturbations
- ❑Memberships
  - ➢00UTC - 10 perturbations and 1 control
  - ➢12UTC – 1 control forecast
- ❑Output frequency and resolutions
  - ➢Every 6-hrs, out to 16 days
  - ➢Most variables with 1*1 degree (and 0.5 degree, too)
- ❑Data is available
  - ➢1985 - current
- ❑GEFS operational futures
  - ➢Tropical storm relocation (TSR) was not included
  - ➢Improved Stochastic Total Tendency Perturbation (STTP) was included
- ❑Reference
  - ➢Hamill, T. M., G. T. Bates, J. S. Whitaker, D. R. Murray, M. Fiorino, T. J. Galarneau, Jr., Y. Zhu, and W. Lapenta, 2013: "NOAA's Second-generation Global Medium-range Ensemble Reforecast Data Set" Bull Amer. Meteor. Soc. Vol. 95 1553-1565

Objective

❑To develop model precipitation climatology for each day of the year and each forecast lead time
- ➢Based on precipitation ensemble forecasts of 26-year (1985-2010) reforecast
- ➢Globally, 1x1 degree
- ➢Out to 15 days: 15 lead times (12-36,36-60,60-84,84 108,108-132,132-156,156-180,180-204,204-228,228-252,252-276,276-300,300-324,324-348,348-372hour)
- ➢Mean and stddev (or every 10 percentiles) for anomaly forecast (or extremely forecast)

❑To validate the methodologies to generate model climatology
- ➢CCPA as reference

Climatology Calibrated Precipitation Analysis (CCPA)

❑Background
- ➢Need of best precipitation analysis for QPF/PQPF bias correction and down scaling in NCEP
- ➢CPC unified analysis at 1/8 degree, daily, global land – reliability
- ➢RFC/QPE (stage IV) 5km resolution, 6-h(CONUS) – resolution

❑Methodology
- ➢Use regression method to generate a and b from above two datasets
- ➢Produce CCPA analysis (CCPA = a*QPEifc + b)
- ➢Resolution is 5km (HRAP) grid (and subsets) for CONUS
- ➢Update every year by applying longer stage IV to produce better regression coefficients

❑Important Applications
- ➢ Improving QPF/PQPF bias correction – GEFS, NAEFS, SREF and etc…
- ➢Statistical downscaling QPF/PQPF forecast for GEFS, NAEFS, SREF and etc…
- ➢HPC daily precipitation analysis products – CCPA web products (2012)
- ➢Daily precipitation verifications
- ➢Hydrological application – OHD and RFC
- ➢Research Communities

❑Reference
- ➢Publication: http://journals.ametsoc.org/doi/abs/10.1175/JHM-D-11-0140.1
- ➢Web display (EMC): http://www.emc.ncep.noaa.gov/gmb/yluo/CCPA.html

Reforecast Precipitation Analysis Method

❑Model climatology calculation
- ➢L-moment method with Gamma fitting distribution

❑Sampling methods: (consider data smooth and filter)

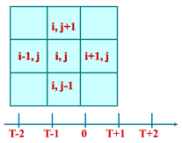
- ➢Method 1: Refcst_26yr
  - Samples: 26years (1985-2010) * 11 members = 286
- ➢Method 2: Refcst_8yr_5pts
  - Samples: 8years (2002-2010) * 5 points * 11 members = 440
- ➢Method 3: Refcst_8yr_5dys
  - Samples: 8years (2002-2010) * 5days' time window * 11 members = 440
- ➢Method 4: Refcst_8yr_5x5
  - Samples: 8years (2002-2010) * 5 points * 5days' time window * 11 members = 2200

Will be validated against

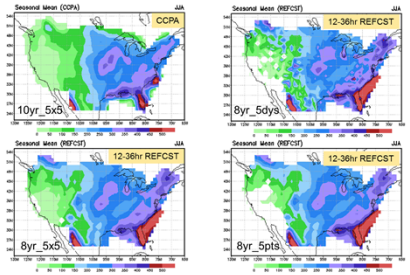
- ➢CCPA_10yr_5x5
  - Samples: 10years (2002-2012) * 5days' time window * 5 points =250

❑Increase sample size by using

- ➢5 points (neighborhood locations)
- ➢5 days' time window
- (T-2, T-1, T0, T+1 and T+2)

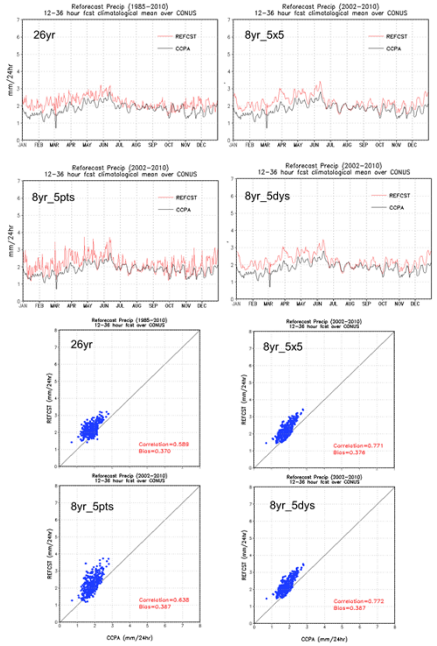


Comparison of Mean Seasonal Precipitation



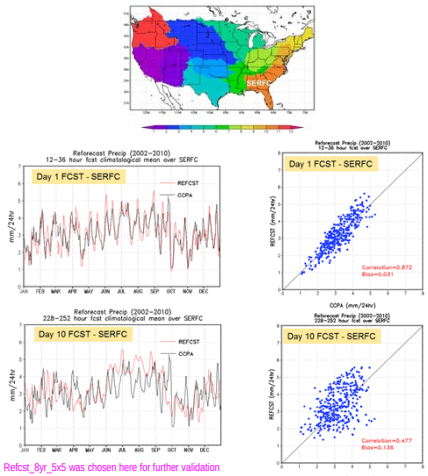
Refcst_8yr_5x5 is the best one closest to CCPA_10yr_5x5

Comparison of Mean Annual Cycle over CONUS



Refcst_8yr_5x5 is the best one closest to CCPA_10yr_5x5

Comparison of Mean Annual Cycle over SERFC



- Refcst_8yr_5x5 was chosen here for further validation
- Over CONUS and each RFC (SERFC is shown as an example here):

For longer lead forecast, the forecast signal is smaller, has comparatively large noise due to chaos and model error.

Correlations between Reforecast and CCPA

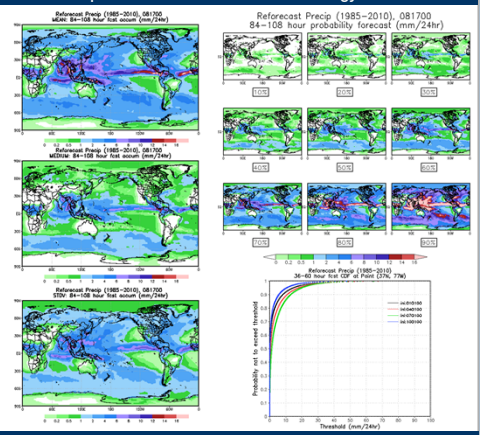
Lead Time	CONUS	CNRFC	CBRFC	MBRFC	ABRFC	WGRFC	NCRFC	LMRFC	OHRFC	NERFC	MARFC	SERFC	NWRFC
12-36 hour	0.771	0.96	0.855	0.916	0.931	0.899	0.842	0.856	0.818	0.806	0.729	0.872	0.944
36-60 hour	0.826	0.953	0.817	0.933	0.885	0.842	0.903	0.78	0.844	0.777	0.747	0.855	0.944
60-84 hour	0.833	0.956	0.801	0.938	0.864	0.821	0.909	0.73	0.813	0.745	0.725	0.81	0.936
84-108 hour	0.833	0.95	0.747	0.942	0.863	0.802	0.912	0.694	0.742	0.724	0.657	0.771	0.93
108-132 hour	0.842	0.94	0.705	0.943	0.828	0.74	0.914	0.632	0.69	0.669	0.563	0.771	0.924
132-156 hour	0.816	0.926	0.638	0.937	0.794	0.662	0.905	0.578	0.702	0.636	0.613	0.779	0.915
156-180 hour	0.776	0.906	0.608	0.906	0.786	0.631	0.898	0.474	0.647	0.626	0.64	0.716	0.911
180-204 hour	0.714	0.881	0.568	0.896	0.758	0.604	0.883	0.372	0.484	0.509	0.451	0.629	0.902
204-228 hour	0.694	0.879	0.539	0.902	0.748	0.557	0.882	0.344	0.415	0.334	0.3	0.56	0.886
228-252 hour	0.646	0.88	0.487	0.892	0.698	0.469	0.873	0.27	0.381	0.331	0.254	0.477	0.879
252-276 hour	0.606	0.884	0.459	0.872	0.662	0.443	0.831	0.184	0.293	0.312	0.173	0.478	0.879
276-300 hour	0.527	0.874	0.454	0.864	0.607	0.388	0.841	0.113	0.282	0.302	0.125	0.511	0.882
300-324 hour	0.45	0.856	0.467	0.869	0.619	0.333	0.828	0.076	0.32	0.344	0.129	0.489	0.882
324-348 hour	0.449	0.846	0.461	0.886	0.594	0.329	0.842	0.058	0.301	0.331	0.137	0.487	0.874
348-372 hour	0.491	0.841	0.502	0.886	0.632	0.325	0.868	0.056	0.324	0.327	0.126	0.483	0.869

Preliminary results show good overall agreement between CCPA and the Reforecast from 8yr_5x5 over CONUS in the shortest lead time. However, agreement has a wide variety from one RFC to another and from short to long forecast lead time, as we find that the correlation and model bias vary significantly from one RFC to another.

A Model Climatology Data Set for Future Applications

❑Reforcast at 1*1 degree and 24 hours accumulation (12-12UTC)
- ➢Accumulate 6-houly analysis into daily with 24 hours accumulation
- ➢Period – 25 year (1985-2010)
- ➢Domain – Globally
- ➢Increase sample size by using
  - 5 points (neighborhood locations)
  - 5 days time window (T-2, T-1, T0, T+1 and T+2)
- ➢Up to 6875(=25yrs*5dys*5pts*11mbs) samples in total for each day of the year and each lead time at each grid point

Examples of the Reforecast Climatology Data Set



Summary and Future Work

❑Statistical analysis of precipitation forecasts through various methodologies to produce daily, monthly climatological mean (1st moment), standard deviation (2nd moment) and high moments.

❑Through comparison of observed (8-year CCPA) and model forecast climatology to evaluate the difference of seasonal variations, spatial distributions and uncertainties. It suggests GEFS reforecast precipitation climatology:
- ➢Well represented (reliable) model daily climatology
- ➢Utilized as the diagnosis of model physics development
- ➢Utilized as the reference for model forecast evaluation

In the future, based on GEFS reforecast precipitation climatology we will work on:

❑Model bias and variance analysis

❑QPF/PQPF calibration

❑Anomaly forecast products generation
- ➢Amount of precipitation above climate mean/median of ensemble mean/median
- ➢Probabilistic anomaly forecast