

ATM 401/501 – Synoptic Laboratory II
Homework Assignment #4: Ensemble Forecasts
Due: Tuesday, 9 April 2019

Purpose:

The purpose of HW #4 is to help you familiarize yourself with the application of probability density functions (PDFs) and ensemble spread concepts to the understanding, interpretation, and communication of weather forecasts.

Instructions:

Please answer all questions and remember to quantify your answers where possible. Relate your answers to specific features on specific images, and if necessary, provide these images in your write-up. Please type your responses and submit your answers electronically to both Lance and Marshall. Remember that homework assignments are graded 75% on your responses and 25% for scientific writing.

1. Probability Density Functions and Ensemble Forecast Systems

- a. Using the tabular data below, create a PDF of 1000–500-hPa thickness at ALB from the GFS Ensemble Forecast System (GEFS) 120-h forecast (valid 1800 UTC 7 March 2011). The corresponding “postage stamps” of this ensemble forecast are [shown here](#).

1000-500-hPa thickness (dam) forecast for ALB (valid 1800 UTC 7 Mar 2011)

Control	534.9									
Ensemble Members	551.7	542.0	529.7	547.9	543.5	547.2	541.9	551.8	552.0	553.6
	548.0	549.3	530.6	544.1	526.1	548.3	537.0	527.9	533.0	545.2

- b. Your news director or meteorologist-in-charge wants to know the probability of rain versus snow at 1800 UTC 7 March and you only have the above data. Use the GEFS data given above in (a) to calculate and describe this probability to your boss.
- c. Discuss how having additional ensemble forecast data (i.e., access to the ECMWF, WRF, Canadian, UKMET models) and access to additional information (e.g., 850-hPa temperatures, 1000–850-hPa thickness, etc.) could help refine the probability of rain versus snow in (b).
- d. Describe the structure of the GEFS PDF (e.g., Is the PDF normally distributed?)
- e. Discuss the differences between hypothetical 1000–500-hPa thickness PDFs that are:
- normally distributed^[1]
 - horizontally confined (i.e., “tall and skinny”)
 - horizontally extensive (i.e., “short and fat”)
 - bimodally distributed
 - skewed either to the right or to the left^[2]

In your discussion, elaborate on dynamical structures that may cause different PDF structures and use the terms: **underdispersive** and **overdispersive**.

2. Application of Ensemble Forecasting Concepts to a Real Event: 17 February 2013

- a. Describe what is meant by ensemble spread and indicate how it is calculated.
- b. Why do the major operational forecast centers like NCEP and the ECMWF overlay shaded values of normalized standard deviations or normalized anomalies on top of contoured ensemble mean forecast fields?
- c. Richard Grumm often says that the GFS ensemble forecast system (GEFS) acts as a "slave" to the GFS model dynamical core by which he means that the GEFS ensemble member solutions will struggle to converge on the correct solution until the solution provided by the GFS deterministic model run begins to approach the truth. What arguments can be advanced for and against this interpretation of the relationship between the GFS and GEFS ensemble member solutions when all model runs are generated from the same dynamical core?
- d. When confronted with a challenging weather forecast situation, a forecaster may experience angst along the following lines: (1) a sense of impending doom (cue the [Jaws movie theme song](#)), and (2) a feeling that he/she has been given a "mission impossible" task and that his/her forecast will self-destruct in five seconds (cue the [opening theme from the old Mission Impossible TV series](#)). Your task, should you choose to accept it, is to provide a weather forecast for the Northeast on 17 Feb 2013 in which you address forecast uncertainty issues that can contribute to forecaster angst. In your forecast, please discuss how representations of: (1) ensemble forecast spread, (2) spaghetti contours of SLP and 500 hPa heights (apply rigor and not Ragu in your thinking and no "saucy" answers, please), (3) phase and amplitude errors, and (4) precipitation plume diagrams can help you identify and determine the likely relative importance of significant synoptic-scale features associated with the potential forecast uncertainty, as well as the dynamical and thermodynamical processes that will likely contribute to large ensemble forecast spread. To assist you in preparing your weather forecast discussion, the following figures are provided (see links on next page):

[Fig. 1:](#) ECMWF 144 h forecast verifying 1200 UTC 17 Feb 2013 of mean SLP (contours; hPa) ensemble mean and normalized standard deviation (shaded; sigma) (left panel) and deterministic mean SLP and standard deviation (shaded, hPa) (right panel).

[Fig. 2:](#) As in Fig. 1 except ensemble mean 500 hPa geopotential height (dam) and normalized standard deviation (sigma; left panel) and the deterministic 500 hPa geopotential height (dam) forecast and standard deviation (m) (right panel).

[Fig. 3:](#) GFS 150 h deterministic 300 hPa geopotential height (contours), wind (barbs), and isotachs (m s^{-1} shaded) forecast verifying 1200 UTC 17 Feb 2013.

[Fig. 4:](#) As in Fig. 3 except for the 156 h forecast verifying 1800 UTC 17 Feb 2013. 

[Fig. 5:](#) GFS 156 h deterministic SLP (contours; hPa), 1000–500 hPa thickness (dashed contours; dam), and 6 h QPF (inches; shaded) verifying 1800 UTC 17 Feb 2013.

[Fig. 6:](#) As in Fig. 5 except for 500 hPa geopotential height (dam, contours), absolute vorticity ($\times 10^{-5} \text{ s}^{-1}$ shaded), and winds (kt; barbs).

[Fig. 7:](#) (Top): GEFS 156 h SLP (hPa, contours) spaghetti plot and ensemble spread (hPa; gray scale) verifying 1800 UTC 17 Feb 2013. (Bottom): GEFS 156 h ensemble mean SLP (hPa, contours) and normalized anomaly (hPa shaded, sigma) verifying 1800 UTC 17 Feb 2013.

[Fig. 8:](#) (Top): As in Fig. 7 (top) except for 500 hPa geopotential height (dam, contours) and ensemble spread (m; gray scale) verifying 1800 UTC 17 Feb 2013. (Bottom): As in Fig. 7 (bottom) except for ensemble mean 500 hPa geopotential height (dam, contours) and normalized anomaly (m; shaded) verifying 1800 UTC 13 Feb 2013.

[Fig. 9:](#) GEFS ensemble member 6 h precipitation amount (inches) plume forecast for Windsor Locks (BDL), CT initialized 0600 UTC 11 Feb 2013.

[Fig. 10:](#) GEFS 150 h ensemble control and 20-member postage stamp forecast of SLP (solid contours every 2 hPa), 1000–500 hPa thickness (dashed contours every 3 dam), and 6 h precipitation (inches; shaded in the color bar) initialized 0600 UTC 11 Feb 2013 and verifying 1200 UTC 17 Feb 2013.

[Fig. 11:](#) As in Fig. 10 except for the GEFS 156 h ensemble forecast verifying 1800 UTC 17 Feb 2013.