

## Verification Information

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### Observations

The observational data used for verification and analysis with respect to forecast tools is outlined below for 500-hPa height, 2-m temperature and total precipitation.

#### ***500-hPa Height:***

Name: R1 / CDAS

Spatial Resolution: 2.5 x 2.5

Temporal Resolution: Daily

Domain: Global

Duration: 1948 - present

Realtime: Yes

Reference: Kalnay et al. (1995)

#### ***2-m Temperature:***

Name: CPC Unified global land only temperature dataset

Spatial Resolution: 1x1

Temporal Resolution: Daily

Domain: Global

Duration: 1981 - present

Realtime: Yes

Reference: In preparation

#### ***Total precipitation:***

Name: CPC Unified global land only precipitation dataset

Spatial Resolution: 0.5x0.5

Temporal Resolution: Daily

Domain: Global

Duration: 1979 - present

Realtime: Yes

Reference: Chen et al. (2008)

## Skill metrics

The official verification of the temperature and precipitation outlooks currently includes two metrics, the Heidke Skill Score (HSS) and the Ranked Probability Skill Score (RPSS) based on two week mean temperatures and two week total precipitation.

### ***Heidke Skill Score***

The HSS compares how often the forecast category correctly matches the observed category, over and above the number of correct "hits" expected by chance alone. This score utilizes the number of correct and incorrect category hits. The values range from -100 to 100. A score of 100 indicates a perfect forecast and a score of -100 indicates a perfectly incorrect forecast. Scores greater than 0 indicate improvement compared to a random forecast and indicate skill and added value.

The equation for the HSS is:

$$\text{HSS (\%)} = 100 * (H - E) / (T - E)$$

where H = Number of correct forecasts, E = Expected number of correct forecasts (1/2 of total), and T = Total number of valid forecast-observation pairs.

The equation for the score including EC (equal chances) forecasts is:

$$\text{HSS}_{\text{withEC}} (\%) = \text{HSS} * \text{coverage}$$

where coverage = (number of non EC forecast grids) / (number of total forecast grids).

### ***Rank Probability Skill Score***

The RPSS measures the improvement of multi-category forecasts relative to a reference forecast and takes into account the probability for each category.

Ranked Probability Score (RPS) is a squared error score with respect to the cumulative probabilities for multi-category forecasts and whether or not the event occurred. The RPSS measures the improvement of the multi-category forecast relative to a reference forecast (the sample climatology). RPSS values range from -Infinity to 1. Forecasts made with higher probabilities are penalized heavily if they are wrong, and forecasts made with lower probabilities are penalized less severely if they are wrong, since they aren't expected to be correct as often. Conversely, forecasts made with higher probabilities are rewarded more heavily if they are correct, and forecasts made with lower probabilities are rewarded less heavily if they are correct.

The equation for the score is:

$$RPSS = 1 - RPS_{\text{forecast}}/RPS_{\text{reference}}$$

The RPS score representing a collection of forecasts in space or time is:

$$RPS = \frac{1}{n} \sum_{k=0}^n [(probBk - obsBk)^2 + (probAk - obsAk)^2]$$

where  $n$  is the total number of valid forecast-observation pairs. Each forecast grid point in space is evaluated and represents each  $k_{th}$  value.  $probBk$  and  $probAk$  are the probabilities of the below normal and above normal forecast categories respectively at each point  $k$ , and  $obsBk$ , and  $obsAk$  are either 0 if that category was observed, or 1 if that category was not observed at each point  $k$ .

The score is the sum of the squares of the difference between the forecast probability of each category and either "0" or "1" for the category observed at that point over all forecast points, divided by the total number of forecast points used,  $n$ . To get  $RPS_{\text{forecast}}$ , the forecast probabilities are used. To get  $RPS_{\text{reference}}$ , forecast probabilities of 1/2 are used for each category.