Meteorology 555

Evaluation of the NCEP Dynamical Seasonal Forecast Model's Prediction of Iowa Heating Degree Days

by
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1. Introduction motivating the topic

Our seasonal forecast project deals with the demand placed on utility companies (natural gas companies) with an emphasis on the cold season. Since our attention will be on the cold season, the production of heat will be the focus, to define how many heating degree days will occur for every winter (from first year's October to next year's March) is very important.

The user of our forecast is expected to be the utility companies (providers) and the utility users. They can know easily about how many heating degree days in the coming winter half a year early. The utility companies are interested in the demand for the utility as determined by the customer. If a higher than normal demand is expected, the utility company will be required to purchase more resources to meet the demand. For the user, a higher demand for electricity will result in higher utility bills. A forecast for below average seasonal heating degree day could alert users that they will need to budget more money for the season to account for higher bills.

An accurate forecast of heating degree day can save money for the utility producer, while allowing users to use the money saved for alternate purposes. In addition, this forecast will contribute to future fuel market.

We decided a lead time of 6-months would be enough for the producers of the utility to change policy and increase or decrease the amount of resources needed, and also is enough time for users to adjust their budget for the upcoming cold season. At the same time a 6-month lead time would be good for accuracy of the forecast than one-year forecast.

2. Description of observational data.

Dr. Martyn Clark (University of Colorado) provided a filtered daily precipitation dataset created from the NCDC's daily precipitation summary (Eischeid et. al., 2000). The filtered dataset contains flags indicating missing, incomplete, or otherwise questionable precipitation reports. For this study, only flag-free station reports and stations that contained no more than two missing days of data for a given month were used for the monthly heating degree day calculations. While this technique likely resulted in the removal of quality data from the dataset, it provided a high quality dataset based on stations that consistently provided reliable reports. The table below shows the corresponding number of stations used from Iowa and its neighboring states for each of our three model grid boxes.

State/Box	Box 1	Box 2	Box 3
Iowa	35	45	42
Minnesota	0	0	0
Wisconsin	0	0	1
Illinois	0	0	1
Missouri	0	0	0
Nebraska	17	0	0
S. Dakota	0	0	0

For the rest of this study, this dataset will be referred to as the daily co-op observational dataset.

3. Description of forecast output

The NCEP model domain contains three grid points (GP) in Iowa. We used these grid points to be represent the modeled temperature of Iowa (figure 1). The distance between model grid points is near approximately 190 km (1.87 degrees).

The hindcast simulation was conducted using the NCEP model output for 20 years (10/1979 - 3/1999) to obtain the monthly mean temperature for the 6 months. As a next step, monthly HDD values were calculated from the temperature data. Figure (2) shows the 20 years hindcast HDD of the three grid points where the y-axis is HDD, the x-axis is time, and the time is from first year's October to next year's March. We can see the largest number of HDD occurred in January (1267 HDD) (Table 1.), while the smallest value is 405 HDD in October. Also, the HDD of eastern Iowa (GP3) is larger than that of western Iowa (GP1).

Table 1.: 20-year-averaged model values Mean of the 3 grid points, and the values of GP1, GP2 and GP3 for 6 months (from first year's October to next year's March)

Month	Mean	GP1	GP2	GP3
10	404.6	380.4	402.7	430.9
11	850.5	835.7	851.1	864.5
12	1167.8	1146.8	1172.3	1184.4
1	1267.0	1227.0	1272.5	1301.5
2	1112.0	1070.2	1115.0	1150.8
3	802.7	771.8	802.1	834.4

4. Analysis procedures and tools

Since the NCEP model produces only monthly averaged temperatures and the observation data is daily data, we must first compare the calculation of heating degree days using monthly averaged temperature to heating degree days calculated on a daily basis (standard method). Heating degrees days are typically calculated using a base temperature of 65 degrees Fahrenheit,

$$\# HDD = 65 – [(T_{max} – T_{min})/2],$$

where $(T_{max} – T_{min})/2$ represents the daily average temperature. This number is determined daily and accumulated for each day of a given month to arrive at monthly heating degree days. When using the monthly averaged temperature, the monthly accumulated heating degree days were obtained using

$$\text{Monthly HDD} = (65 – T_{mon\_ave}) * (\text{days in month})$$

where T_{mon_ave} is the monthly average temperature. T_{mon_ave} was reached by averaging the daily average temperature for the observations, and provided as output from NCEP model.

Days or months with average temperatures greater than or equal to 65 degrees Fahrenheit did not contribute to the HDD calculations.

Figure 3 shows the HDD's calculated using the monthly average temperature versus HDD's from the daily accumulation. Most of the observations lie along the 1-1 line indicating there is good agreement between the two methods. For warm months (low HDD's), points tend to lie below the 1-1 line. It is hypothesized that these points are the result of months having periodic cold days and a monthly average temperature close to the 65 degree threshold. In colder months (high HDD's), some points appear above the 1-1 line. It is thought that these points result from months that contain short warming periods, but maintain a low average temperature.

Overall, the agreement between HDD's using the two methods is good. Thus, we feel confident in using HDD's calculated from monthly average temperatures as a proxy for the standard approach.

5. Results

Model hindcast HDD were compared to observation HDD to test whether they make helpful forecasts.

From the Model HDD and Observation HDD figure (4) we get can see obviously the model hindcast out put HDD have good relation with observation HDD, and is near linear relation the angle is also near 45 degree, the standard deviation (SD) band of HDD also show in the figure (5), and it is calculated by SDs of monthly mean temperature from 10 ensemble output. And coefficient of correlation R^2 =0.786 is higher, they have a good relationship, so that model can give a good forecast of HDD.

6. Interpretation of results

- Through our analysis can see the monthly HDD do not have much difference with moth daily HDD.
- Although the linear relation is not so good, the last part, in fact this is in the coldest days, the model output has a warm bias in cold winter, but we can see using the model HDD day is helpful to giving the forecast of HDD in not so cold day.
- In the future, we think consider about model HDD have curve relation with observation HDD in cold winter (December, January) is useful to do the continue studying.

7. Reference

a. http://www.city.ames.ia.us/electricweb/energyguy/degrees.htm

b. Eischeid, J., P. Pasteris, H. F.nDiaz, M. Plantico, and N. Lott, 2000: Creating a serially complete national daily time series of temperature and precipitation for the western United States. J. Appl. Meteor., 39 , 1580-1591

c. Masao Kanamitsu, Arun Kumar, Hann-Ming Henry Juang, et al., 2002: NCEP dynamical seasonal forecast system 2000, A. Meteor. Soc. , July,1019-1037.

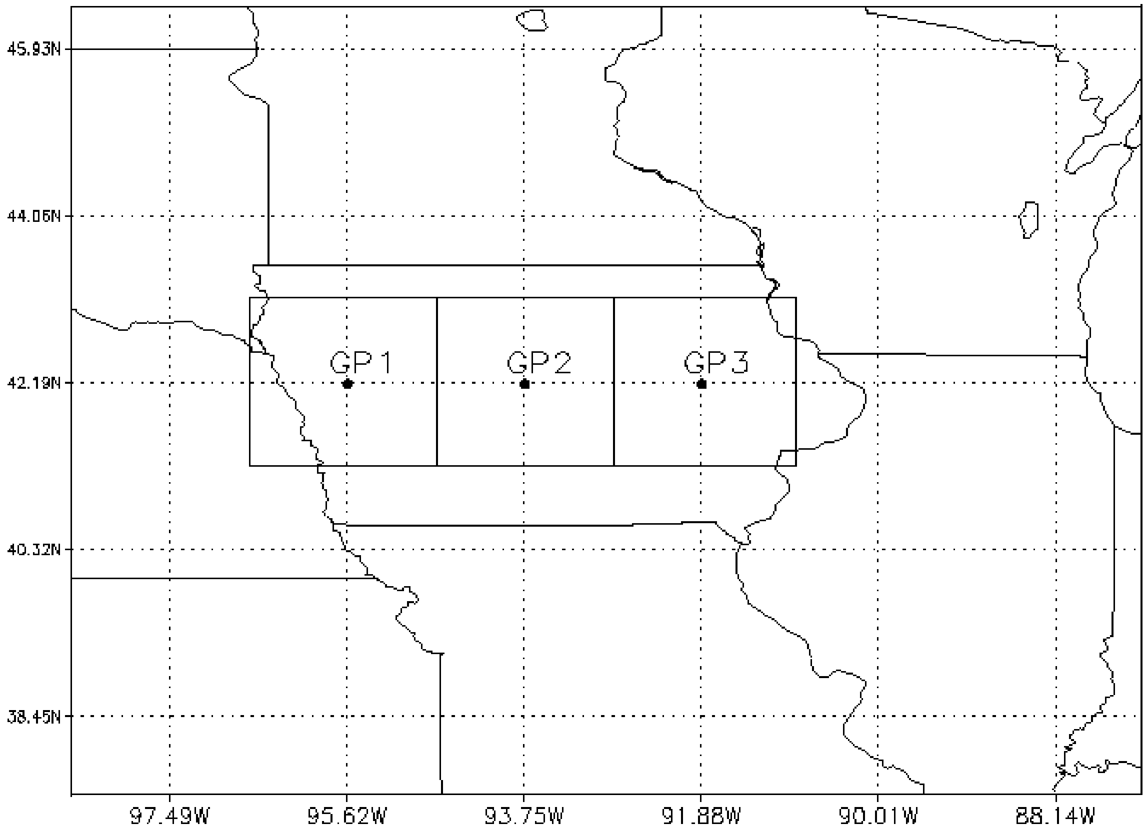

Figure 1: The three model-grid points (GP) in Iowa.

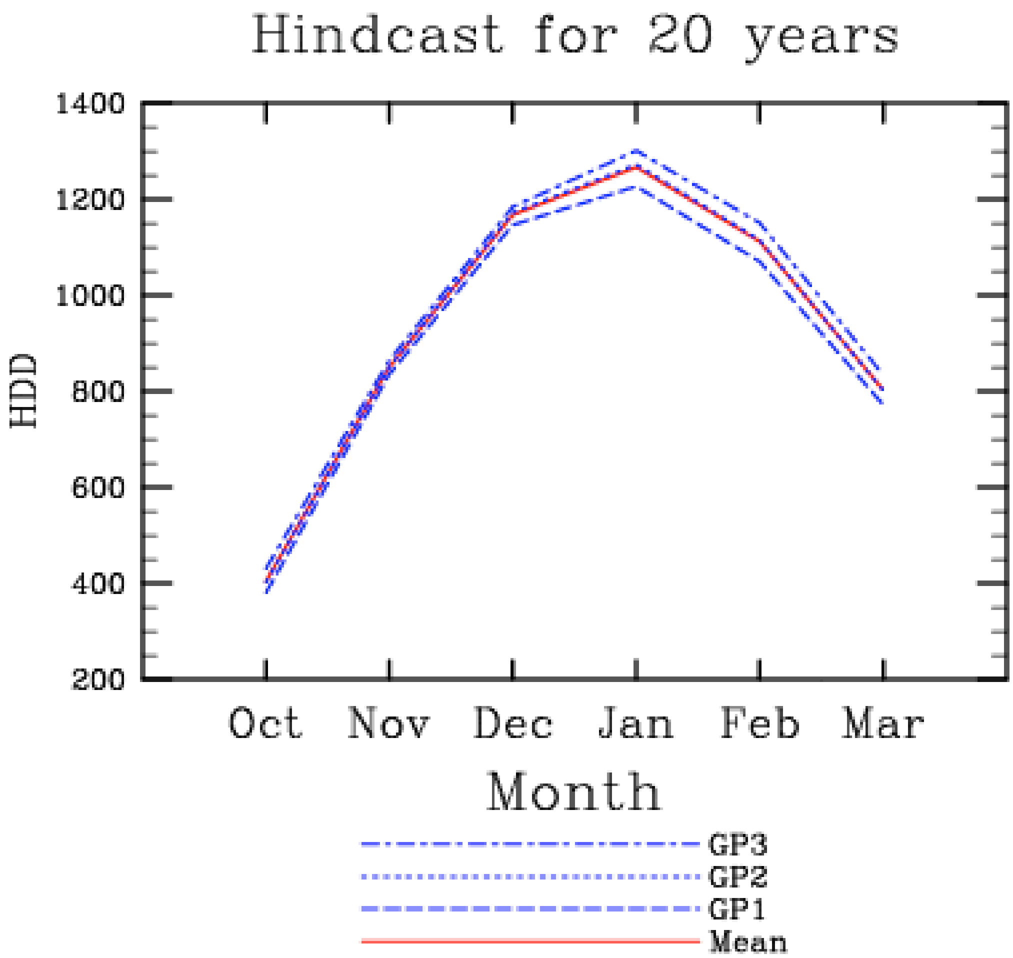

Figure 2: The 20-year hindcast HDDs of the three grid points for 6 months (from October to March). The solid line indicates the mean value of the three grid points and other lines indicate individual point's values.

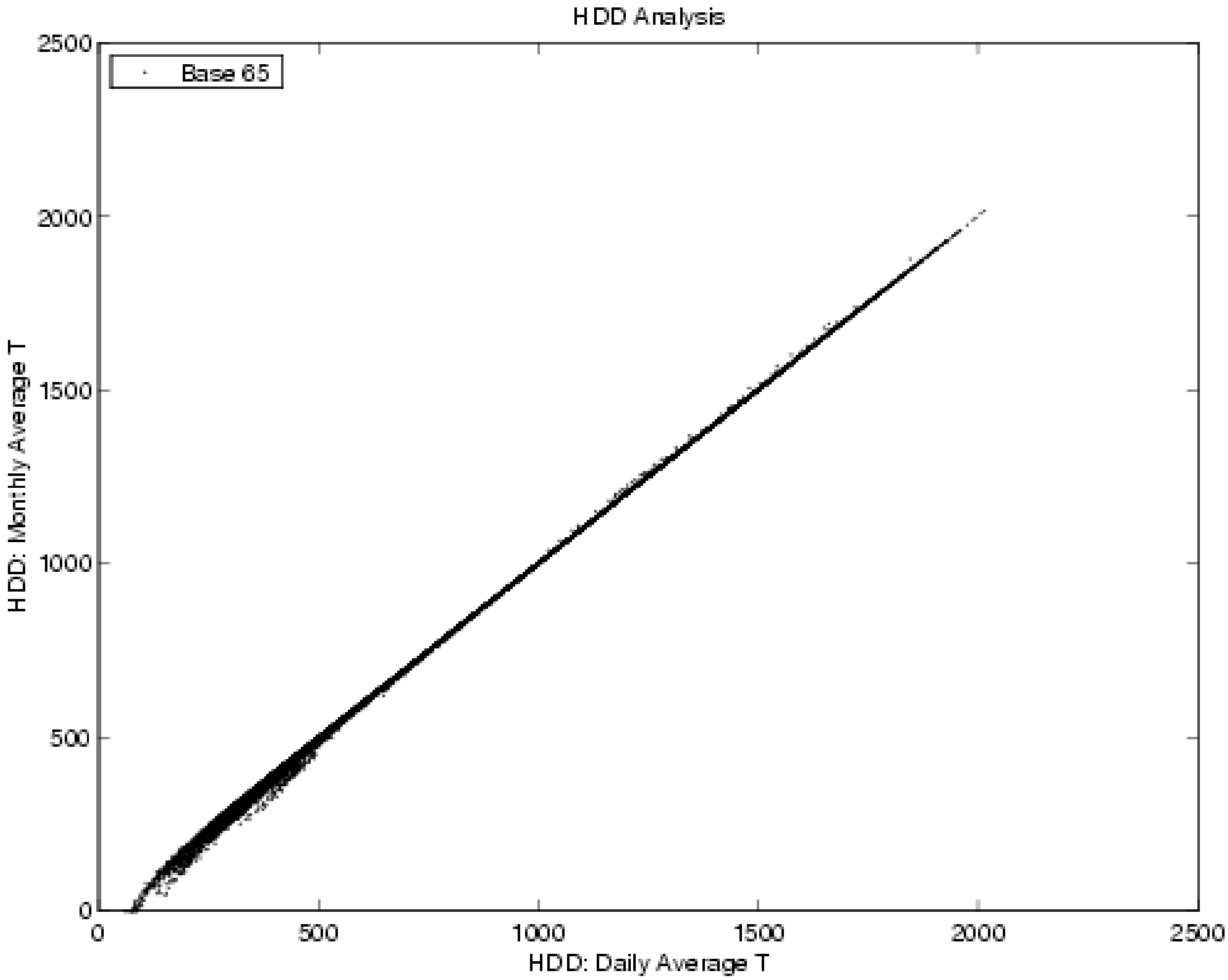

Figure 3: HDD from daily averaged temperature versus HDD from monthly averaged temperature.

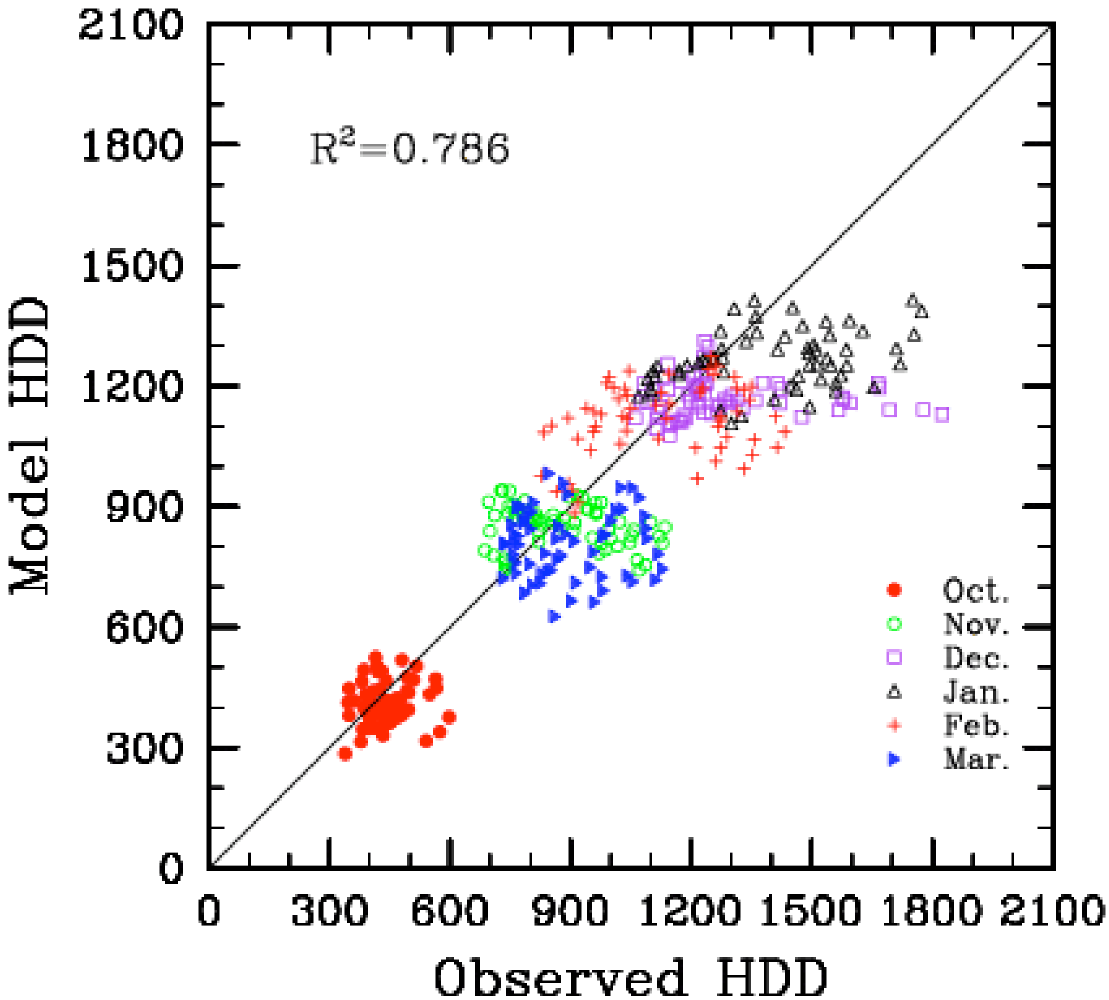

Figure 4: The observed HDD versus the 20-year model HDD (3 grids*20 years * 6 months = 360 points) for each month. R^2=0.786.

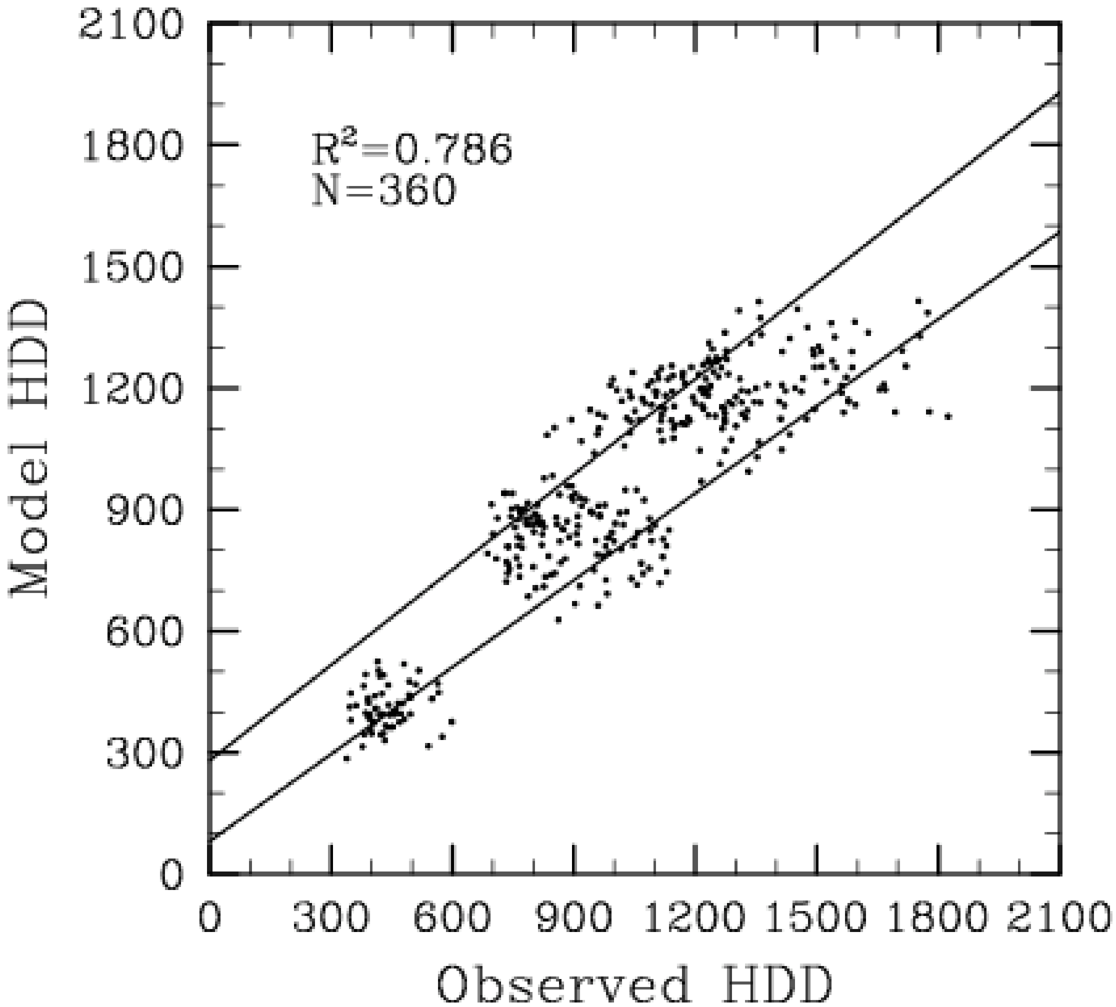

Figure 5: The observed HDD versus the model HDD for 20 years. Two solid lines indicate +1 and –1 standard deviation (SD) lines of HDD. The SDs of HDDs are calculated by SDs of monthly mean temperature from 10 ensemble outputs.