JP1.22 A STUDY ON THE CHARACTERISTICS OF PERCEIVED TEMPERATURE OVER THE KOREAN PENINSULA

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1. INTRODUCTION

Interest in the impact of weather condition to human health has increased dramatically in recent years (Kalkstein et al, 1996). Therefore, it is important to recognize a weather condition of threat that affects human life and health and make a preparation for guidelines.

Thermal indices commonly used up to now are discomfort index, heat index, and wind chill temperature. Heat index and discomfort index have been described by combinations of temperature and humidity in summer, while wind chill temperature which considers temperature and wind velocity is used to express the heat exchange between human beings and thermal environment in winter. These indices have a limitation to adopt for all climates, regions, and seasons.

Heat stress of human beings works organically by means of individual component related with energy exchange of human beings and environment, such as movement of air, transfer of temperature, evaporation of water vapor, radiative balance of shortwave and longwave, and respiration. Clothing type also contributes as a major component of heat exchange. Thus there is a limitation to describe the heat stress of warm and cold using a combination of dependent variable such as temperature, wind velocity, and humidity. It is essential to use heat budget model which calculate physiological process of heat exchange (heat loss or heat load) to take into account heat load and cold stress more realistically.

Germany Weather Service developed a biometeorological model which is based on a heat budget model of the human body. The model is named as Klima-Michel model and Perceived Temperature (PT) is introduced as a thermal index (Jendritzky et al., 2000). PT has been applied for operation of heat-health warning system, heat flow in urban planning, diagnosis of thermal variation in Germany.

National Institute of Meteorological Research (2005, 2006) analyzed heat stress over the Korean Peninsula using perceived temperature, and studied the sensitivity of perceived temperature against input variables such as temperature, wind speed, humidity and cloud amount.

This study aims to analyze the characteristics of perceived temperature over the Korean Peninsula and to verify the forecasted PT using mesoscale model.

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2. DATA

Perceived temperature is calculated from meteorological observational data or numerical weather prediction. The input variables of observational data are temperature, humidity, wind velocity, and mean radiant temperature. We used the data observed from 41 meteorological stations in South Korea during summer and winter, 2007. The numerical weather prediction from mesoscale model, Weather Research and Forecasting (WRF) model, is used for forecast of PT. WRF predicts twice per day and it has a 10-km grid resolution.

3. CHARACTERISTICS OF PERCEIVED TEMPERATURE

The relationship between perceived temperature and input variables such as temperature, wind speed, humidity and cloud amount is examined. The correlation coefficient between PT and air temperature is about 0.86 and PT is higher than air temperature with a 4-5℃ in the summer and shows a colder tendency than air temperature in the winter.

While there are no apparent relations between wind speed and PT, PT tends to slightly go down with increase of wind speed. Effect of wind velocity is large in the clear day-time.

Spatial distribution of PT shows that it increases in the low latitude, and decrease northward. The lowest PT happened in the east central region, with the appearance of the highest PT in the inland of southern region in Korea (Fig. 1). It seems that the PT is affected by sea, land and latitude rather than topography in Korea.

We examined the spatial distribution of meteorological input variables such as temperature, relative humidity, and wind speed. Temperature is lower in the eastern land region with the effect of topography. Humidity is maximized in the coastal region and dry in the inland region. Maximum wind velocity is shown in the southern coastal region. Lower temperature, mean radiant temperature, and strong wind speed in the southern coastal region is contributed to the lower PT.

4. VALIDATION

Forecast of PT and meteorological input variable is validated against observation data in South Korea. Correlation coefficient, bias, RMSE is employed as a verification method. Correlation coefficient for temperature and wind velocity decreases as the forecast time increases. Distribution of correlation coefficient in temperature is 0.85-0.9, and maximum correlation in wind speed is about 0.5. Relative humidity shows lower correlation at initial forecast time, and the correlation is maximized after 12 hour forecast. Correlation coefficient for PT is similar to that of temperature and decrease at later forecast time.

Bias result is shown in Fig. 2(b). Temperature forecast is underestimated and bias of wind velocity is lower than other meteorological variables. Bias of relative humidity increases with increasing of forecast time. Prediction of PT is similar to temperature forecast and the PT is lower than predicted PT calculated from observation.

A variation of RMSE is little regardless of forecast time (Fig. 2(c)). The lowest RMSE is shown at initial forecast time and the error increase at later forecast time. This tendency is also shown in the wind velocity analysis. Relative humidity shows a maximum RMSE at initial forecast time. The RMSE of relative humidity is the lowest magnitude at 12 hour forecast. The RMSE of PT is also consistent regardless of forecast time and the magnitude of RMSE is about 7-8℃.

Spatial distribution of predicted PT from mesoscale model is validated with observed PT. Latitudinal decrease is also shown in the predicted PT. PT is minimized in the eastern coastal region. Underestimation of PT forecast is presented in inland and eastern coastal region. Temperature is minimized in middle eastern region. Strong wind velocity is located in the eastern, but wind speed in southern region is weaker than observation. Compared with PT and air temperature, decrease of PT in the higher latitude and maximum in the southern inland is similar to the distribution of temperature.

Maximum PT error takes place in middle eastern region which the temperature error is maximized. Prediction of PT is dependent on meteorological input variables. Therefore, we need to improve the accuracy of forecast result for the improvement of PT forecast. It can be a kind of method to use Kalman filter temperature in the future study.

5. CONCLUSIONS

The Perceived Temperature (PT) which is produced by Klima-Michel model of Germany Weather Service is examined over Korean Peninsula. The PT is forecasted for 48 hours and it is verified against observed PT.

The PT is higher than air temperature in summer and colder than air temperature in winter season. Humidity increases PT in summer, while the PT is decreased as wind velocity increases. Distribution of PT is consistent with temperature and mean radiant temperature. PT is decreased in northward. Observed PT in inland is lower than coastal region. The highest PT is observed in southern inland in summer and east-southern coastal region in winter. PT is mainly affected by latitude and sea.

Temperature and wind velocity present the best result at the initial forecast time. It is shown a higher error in relative humidity during initial forecast time and it decreases with forecast time. Minimum error is presented at 15 hour forecast due to spin up time. Therefore, the RMSE of PT is minimized at 9 hour forecast with a 7～8℃ during summer. But spin up effect did not appear in the winter forecast. The predicted PT during winter shows higher accuracy at initial forecast time.

Spatial distribution of perceived temperature is consistent with observation that PT decrease in northward and the coldest PT is located in middle-eastern region. Forecasted PT is lower than observation because the temperature in WRF model is colder than observed temperature. Wind velocity is overestimated in middle-eastern region and this strong wind decrease the PT in this region.

PT based on the heat budget model of human beings can be a proper thermal index. Temperature is used for the analysis of health to heat wave or cold stress. But it is necessary to study the effect of mortality and sickness using PT. PT is also can be used to make bioclimatic map that shows comfortable and stress region in Korean Peninsula. We plan to analyze the PT for a long period to make bioclimatic map over the Korean Peninsula.

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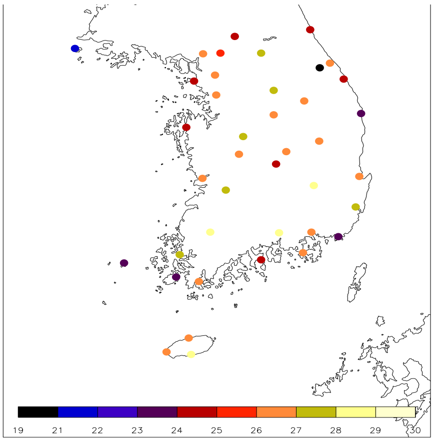


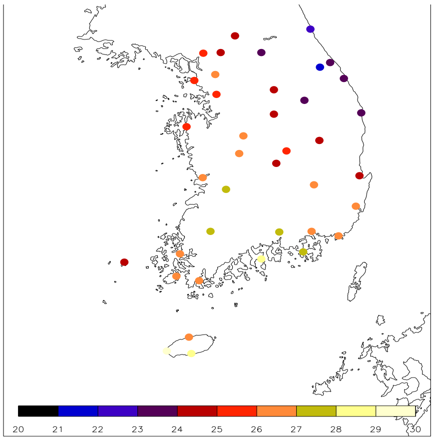


Fig. 1. Comparison of perceived temperature (℃) between station observation (upper) and WRF model (lower) during 2007 summer.

(c)

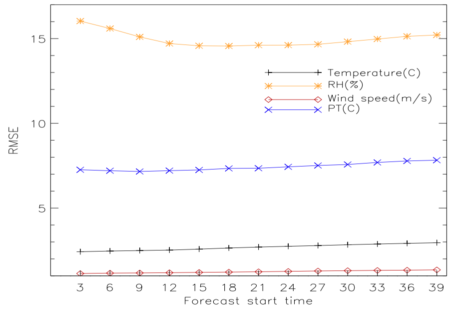
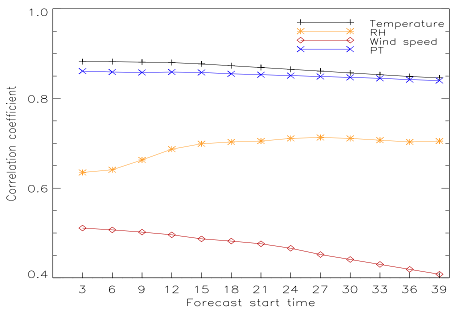


Fig. 2. (a) Correlation coefficient of perceived temperature and meteorological input variable (temperature, relative humidity and wind speed) between WRF model and station observation over the Korean Peninsula during 2007 summer. (b) Same as (a), except for bias. (c) Same as (a), except for RMSE.

(a)



(b)