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COMMENTS ON "WIND CHILL ERRORS": PART II

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DCIEM No. 94-44

[Reprinted from BULLETIN OF THE AMERICAN METEOROLOGICAL SOCIETY, Vol. 76, No. 9, September 1995]
Printed in U. S. A.

Comments on "Wind Chill Errors": Part II

Since its publication, the popularity of the wind chill index has easily survived several bouts of unfavorable scientific criticism. The latest assault appeared in the *Bulletin of the American Meteorological Society,* initiated by Kessler (1993). He questioned its use because it was derived from the cooling rate of a small cylindrical container of water and had not been validated by measurements of heat loss from humans. He also objected to the use of equivalent temperatures, calling them "hyperbole" and "technological glitter," which scientists should not support. Although the wind chill index is old and faulty science, its use can be defended. However, I agree that the wind chill equivalent temperature must either be dropped or amended.

Siple and Passel (1945), the originators of the wind chill index, were not trying to estimate the heat loss from a human body in wind. They were looking for a way to assess the hazard presented by different combinations of wind and low temperatures. They were surprisingly successful, given their limited resources and the difficulties of carrying out the experiments in the depths of the Antarctic winter. Although the experiment was crude and imperfectly analyzed (Molnar 1960), the wind chill index worked. One early critique of the index admitted, "The index of 'wind-chill' has enjoyed a considerable, and deserved, popularity, for it has been proved in the field that it does indeed provide an index corresponding quite well with experience in the cold, that is, of the discomfort and tolerance of man in the cold" (Burton and Edholm 1955).

The index is simply a scale that is proportional to the cooling power of the weather. Siple and Passel were able to calibrate it. They asked Antarctic field parties to keep note of comfort at different wind chills, and they carried out a small number of human experiments to determine how comfort was related to wind chill. They found that the sensations of coldness and the danger of frostbite were associated with certain values of the index regardless of how wind and temperature had combined to create it. Later, their threshold value for frostbite was independently confirmed (Wilson 1964). Soon after publication, Siple realized that it had been a mistake to put units of heat flow [$kCal(m^2\,h)^{-1}$] on the index values, for the index was simply a scale, not a valid calculation of heat flow from exposed flesh. He recommended that the units be dropped (Molnar 1960), but his advice has not been followed.

Wind chill equivalent temperature is a subsequent development. It is currently defined as the temperature that would produce the same heat transfer if there were no wind. "No wind" is usually defined as a wind speed of 5 mi h^{-1}, although 4 mi h^{-1} is also commonly encountered. This definition has lead to the hyperbole and confusion that Kessler and others have objected to, for every winter day that is not "calm" must be said to feel colder than the temperature says it is. While the index conforms to experience, equivalent temperature does not.

It might make better sense to define the equivalent temperature as the temperature at which the heat loss would be the same if the wind were average. Winds that are stronger than average make the day feel colder than it normally does at that air temperature. Lighter-than-average winds make it feel warmer than one would expect from the thermometer reading. During the hours that people are active outside, a reasonable value for a continent-wide average wind speed might be 13 mi h^{-1} (20 km h^{-1}) at the standard height of 10 m. While this value might not be appropriate for some locations, it will usually be more appropriate than 5 mi h^{-1} (8 km h^{-1}), if no less arbitrary.

The wind speed must be corrected to face height, for it is much stronger at the standard height of 10 m where it is measured for meteorological purposes. Steadman (1971) suggested a correction factor of 0.55 for open prairie (Buckler 1969); however, it might be operationally simpler to just divide the wind speed by 2. Although parks and residential areas have much larger scales of roughness than prairie and should require a greater correction, a factor of 2 is conservative and would therefore provide a margin for safety and make some allowance for the possibility of venturi effects in cities.

With this definition, below-average winds would result in equivalent temperatures higher than the actual air temperatures. This might seem odd at first, but it would correspond with reality. A morning weather report might say: "In Metro this morning the temperature is 0°F, but because of the lighter than average winds, it feels more like +10°F." What this means, of course, is that it will feel like an average +10°F, which has an average wind speed.

One difficulty with this formulation is that temperatures that are much lower than average are commonly associated with lighter-than-average winds. Some adjustment of the average wind speed with temperature might therefore be necessary. Some people might be disappointed because equivalent temperatures calculated in this way might be tens of degrees higher than those calculated from the old definition, "100 below," would disappear forever. On the other hand, those who disparage hyperbole and techno-glitter might be pleased.

There are alternatives. One is to eliminate equivalent temperatures and report the index values, without units. Guidance should be offered: 800 is cold, 1000 is very cold, 1200 is bitterly cold, 1400 can produce frostbite, 1800 is challenging even for warmly dressed individuals, and 2000 is dangerous and can result in frostbite in less than a minute. People will personally calibrate this scale with experience, as they have in some parts of northern and western Canada, where only the wind chill index values are routinely reported.

Another alternative is to calculate a "face temperature." Human beings do not sense air temperature. The best they can do is to sense the temperature of their skin. Skin temperature depends on the balance between the heat supplied to the skin from the body and heat lost to the air. The latter depends largely on air temperature and air movement. If we could calculate and report the temperature of some sensitive part of the face in wind, the cheek perhaps (Osczevski 1994), it would be harder for the person in the street to confuse it with air temperature, for it would usually be much higher. It would also give a direct reading of hazard, for skin temperatures below the freezing point are obviously associated with the risk of frostbite. Skin temperatures below 60°F (15°C) are very cold, and those below 50°F (10°C) are painful.

It has been said too often that everyone complains about the weather but no one ever does anything about it. Now, at last, there is an opportunity to make a change. While the next winter might not actually be any warmer, a change in wind chill reporting might dramatically improve our perception of it.

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