Does the air get colder when the wind blows?

Questions should be of general interest and be about temperature measurement techniques and/or heat transfer.

QUESTIONS ANSWERS

QUESTION: In winter I feel it's much colder when the wind is blowing than when it's still. Does the air really get colder when there's a wind, or what's going on?

Johan H

ANSWER: We must distinguish between when the cooling involves a living body and when it happens to an inanimate object. The former case is more complex because heat is continually being generated in the body, and the body's heat transfer system is complex. The heat flow from an unprotected area of skin to its surroundings is influenced by radiation and convection. This heat flow is matched by an equal heat flow from the body's core to its surface, and this transfer is governed by such factors as the body's control mechanisms.

In the case of forced convection, the heat flow increases with the wind velocity. The heat flow via radiation is influenced by such factors as the skin temperature. The air does not become colder when the wind blows but the heat flow from the body increases with the wind velocity. The moisture transfer to and from the body can also influence the heat transfer. How we experience cold and our risk of getting frostbite also varies to some extent between individuals.

To characterise the wind's influence on the cooling process, we can use the concept of effective temperature (T_{eff}). An air temperature (T) and wind velocity (v) means a heat flow ($\dot{Q}$). If the body is moving at walking speed when the air is still, the result is the heat flow ($\dot{Q}$) at the air temperature (T_{eff}). Determining T_{eff} is done mainly by experiment, which means that the effective temperature is method dependent. An example of $T_{eff} = T_{eff}$ (T, v) is shown in the table. Other conditions will give other values and recommendations.

A full beard insulates

The body's temperature sensors can feel when the temperature drops – we start to freeze. When body tissue gets too cold there is a risk of frostbite. If bare skin is exposed for half an hour to an effective temperature that is lower than about -25 °C there is a great risk of frostbite. If bare skin is covered by fabric the heat flow is reduced and thereby also the risk of frostbite. A bushy beard provides a similar insulating effect.

Table. Effective temperature (T_{eff}) as a function of air temperature (T), and wind velocity (v), according to the Swedish Meteorological and Hydrological Institute.

T \ v	v=5 m/s	v=10 m/s	v=15 m/s	v=20 m/s
T= -5 °C	-11 °C	-14 °C	-15 °C	-16 °C
T= -10 °C	-17 °C	-20 °C	-22 °C	-23 °C
T= -15 °C	-24 °C	-27 °C	-29 °C	-31 °C
T= -20 °C	-30 °C	-34 °C	-36 °C	-38 °C

If you have comments or questions, contact Professor Dan Loyd at the Institute of Technology at Linköping University: dan.loyd@liu.se