Geographical Variation in the Wind Resource

by Edvard

Geographical Variation in the Wind Resource (photo by Chris Jones @ Flickr)

Wind

Ultimately the winds are driven almost entirely by the ***sun's energy***, causing ***differential surface heating***.

The heating is most intense on land masses closer to the equator, and obviously the greatest heating occurs in the daytime, which means that the region of greatest heating moves around the earth's surface as it spins on its axis.

Warm air rises and circulates in the atmosphere to sink back to the surface in cooler areas. The resulting large-scale motion of the air is strongly influenced by ***coriolis forces*** due to the earth's rotation. The result is a large-scale global circulation pattern.

Certain identifiable features of this such as the trade winds and the 'roaring forties' are well known.

The non-uniformity of the earth's surface, with its pattern of land masses and oceans, ensures that this global circulation pattern is disturbed by smaller-scale variations on continental scales. These variations interact in a highly complex and nonlinear fashion to produce a ***somewhat chaotic result***, which is at the root of the day-to-day unpredictability of the weather in particular locations.

Clearly though, underlying tendencies remain which lead to clear climatic differences between regions. These differences are tempered by more local topographical and thermal effects.

Hills and mountains result in local regions of increased wind speed. This is partly a result of altitude – the earth's boundary layer means that wind speed generally increases with height above ground, and hill tops and mountain peaks may 'project' into the higher wind-speed layers.

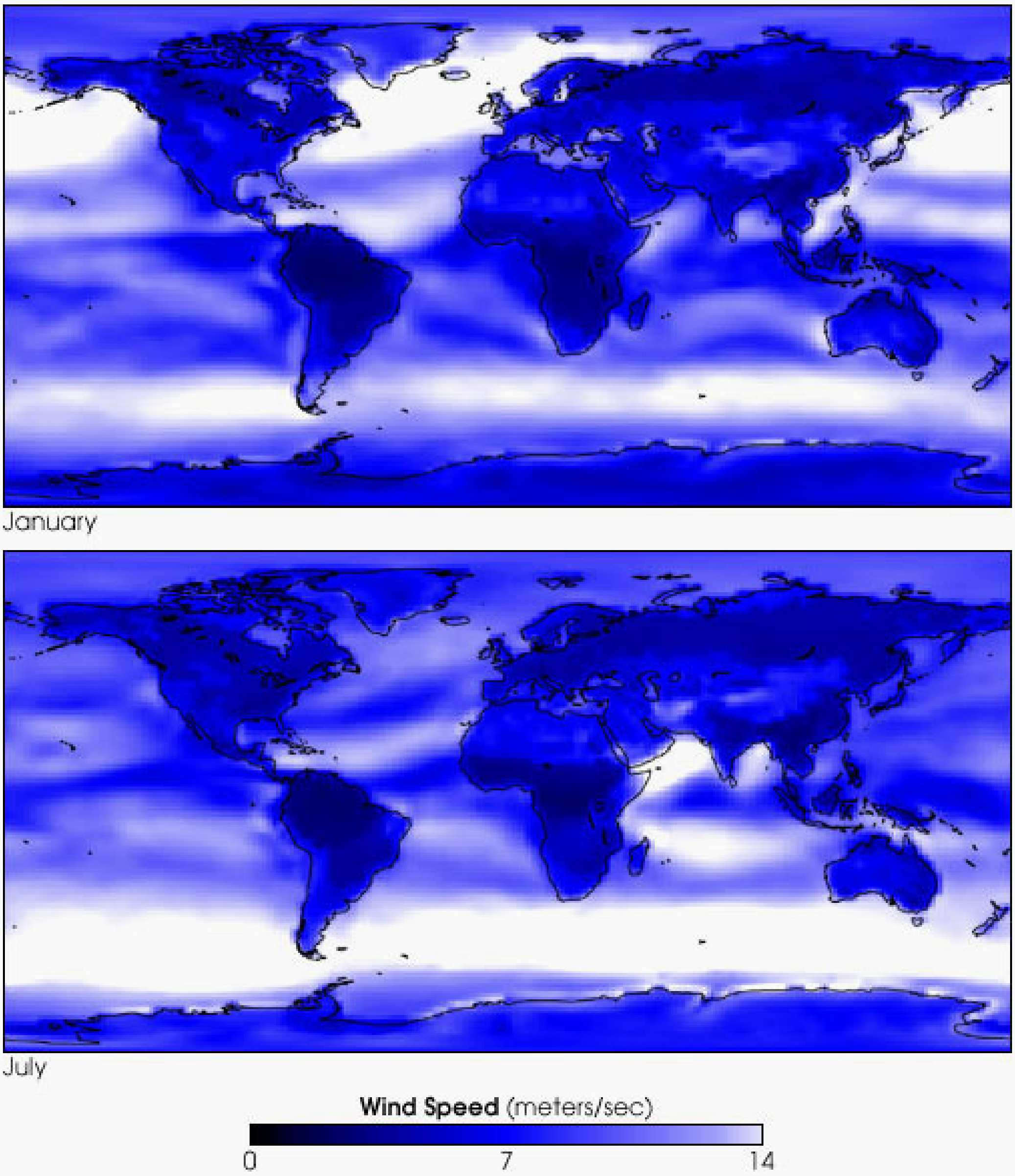
It is also partly a result of the acceleration of the wind flow over and around hills and mountains, and funnelling through passes or along valleys aligned with the flow.

Equally, topography may produce areas of reduced wind speed, such as sheltered valleys, areas in the lee of a mountain ridge or where the flow patterns result in stagnation points.

Thermal effects

Thermal effects may also result in considerable local variations. Coastal regions are often windy because of differential heating between land and sea.

While the sea is warmer than the land, a local circulation develops in which surface air flows from the land to the sea, with warm air rising over the sea and cool air sinking over the land. When the land is warmer the pattern reverses. The land will heat up and cool down more rapidly than the sea surface, and so this pattern of land and sea breezes tends to reverse over a 24 h cycle.



Seasional World Wind Resource Map (in january and july)

These effects were important in the early development of wind power in California, where an ocean current brings cold water to the coast, not far from desert areas which heat up strongly by day. An intervening mountain range funnels the resulting air flow through its passes, generating locally very strong and reliable winds (*which are well correlated with peaks in the local electricity demand caused by air-conditioning loads*).

Thermal effects may also be caused by differences in altitude. Thus cold air from high mountains can sink down to the plains below, causing ***quite strong*** and ***highly stratified 'downslope' winds***.

Long-term Wind speed Variations

There is evidence that the wind speed at any particular location may be subject to ***very slow long-term***

variations. Although the availability of accurate historical records is a limitation, careful analysis by, for example, Palutikoff, Guo and Halliday (1991) has demonstrated clear trends.

Clearly these may be linked to long term temperature variations for which there is sample historical evidence.

There is also much debate at present about the likely effects of global warming, caused by human activity, on climate, and this will undoubtedly affect wind climates in the coming decades.

Apart from these long-term trends there may be considerable changes in windiness at a given location from one year to the next. ***These changes have many causes.*** They may be coupled to global climate phenomema such as ***el nin˜o***, changes in atmospheric particulates resulting from ***volcanic eruptions***, and ***sunspot activity***, to name a few.

These changes add significantly to the uncertainty in predicting the energy output of a wind farm at a particular location during its projected lifetime.

Resource: Wind Energy Handbook – Tony Burton (Wind Energy Consultant, Carno, UK)
(Get this book from Amazon)

Source: http://electrical-engineering-portal.com/geographical-variation-in-the-wind-resource