Problems of using mean pressure differences for the correction of trends in wind speed

R. Lindau Meteorological Institute of Bonn University e-mail: rlindau@uni-bonn.de

Meteorologisches Institut Universität Bonn

The mean pressure gradient is not proportional to the mean scalar wind.

Spatial gradient of the temporal averaged pressure field	Mean vector wind	Mean scalar wind

$$\sqrt{\left\langle \frac{\partial p}{\partial x}\right\rangle^2 + \left\langle \frac{\partial p}{\partial y}\right\rangle^2} \propto \sqrt{\langle u\rangle^2+\langle v\rangle^2} \neq \left\langle \sqrt{u^2+v^2}\right\rangle$$

Motivation (Upper box)

Marine wind reports from merchant ships provide valuable information about the climate trends over the world ocean during the last century. However, spurious trends in the data may affect the true climate signal. In this situation, pressure reports are a suitable mean to calibrate the wind data. However, the appropriate method to derive pressure gradients from ship data is controversial. The use of spatial gradients of the monthly mean pressure field is actually adequate to calibrate the vector mean wind. But for many applications the scalar wind trend is the crucial parameter. If mean pressure differences shall be used also for the correction of the scalar wind it has to be assured that the wind steadiness, which is defined by the ratio of scalar and vector wind, is constant throughout the years.

Steadiness (Middle box)

Fig. 1 shows the change in wind steadiness for the 10°-by-10°field between 40°N and 50°N and between 20°W and 30°W in the month of January. The dashed line denotes the year-to-year fluctuation based on the 10°-by-10°averages. Here, one value for the steadiness is obtained for each year. The solid line denotes the mean steadiness within the 10°-by-10°field based on the 100 individual 1°-by-1°values. Through all years, this estimate is higher than the first, since any change in wind direction within the 10°-by-10°field reduces the total steadiness additionally. However, both time series show a similar pattern. The mean steadiness varies considerable between 0.8 and 0.3, the total steadiness attains in some years even values near zero. The behaviour found in this specific 10°-field is characteristic for a broader region. The extension of the analysis to the entire 10°-zone between 40°N and 50°N in the Atlantic provides similar results (Fig.2), only the total steadiness is further decreased due to the larger area considered here, which increases the spatial variety of included wind directions. These results show that wind steadiness is strongly fluctuating from year-to-year at least in the mid-latitudes. Assuming its temporal constancy may be not appropriate.

Is the wind steadiness constant in time?

Fig. 1

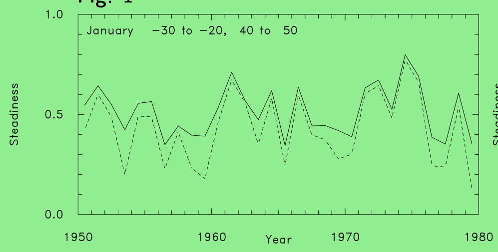
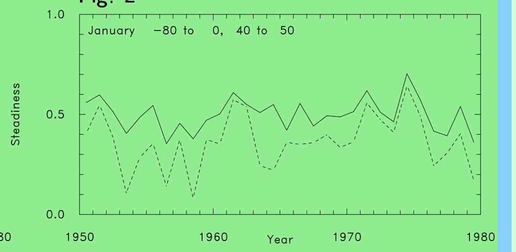


Fig. 2



Trends (Lower box)

If at least the trends of vector and scalar wind are highly correlated the first could be used to correct the latter. To check this possibility we computed wind trends in the North Atlantic for the period 1950 to 1980. The result for the month of May within the area between 40°and 50°North and 40°and 50°West is shown in Fig. 3. The trend in the vector wind differs significantly from that in the scalar wind. In fact, both trends are contrary, negative in the scalar wind by -2.3 m/s per century, but positive in the vector wind by 3.2 m/s per century. In order to show that the coupling between both trends is generally loose, the method is applied to every month of the year and seven 10°-by-10°fields in the Atlantic between 40°N and 50°N (Fig. 4). In this way, 84 trend pairs are available so that a statistical comparison of both is possible. The correlation coefficient is found to be as low as 0.598, implying that less than 36% of variability in the scalar wind can be explained by trends in the vector wind. The use of the vector wind trend as calibration for the scalar wind trend is therefore not possible.

Conclusion

Mean pressure differences are indeed highly connected with the corresponding vector averages of the wind. However, the connection between vector and scalar wind is very low. The wind steadiness, defined as ratio between both, is by no means constant in time. Even decadal trends in scalar and vector wind show at least in the mid-latitudes only a low correlation of about 0.6, which is much too small for the use of the vector wind as calibration for the scalar wind.

Are at least the trends in vector and scalar wind correlated?

Fig. 3

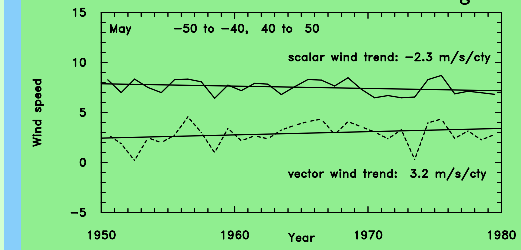


Fig. 4