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AN EFFICIENT WIND SHIELD FOR THE PROTECTION OF TELESCOPES

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A semitransparent wind shield to protect telescopes against wind is described and some measurements and experiences during a site-testing campaign are reported.

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For financial reasons, telescopes are used in the open air in temporary stations, for instance for site testing. Another reason to abandon conventional domes is to keep the air mass in the vicinity of the telescope as homogeneous as possible. However, telescopes do need some protection since otherwise wind may generate troublesome vibrations in the instrument. As an attempt to a simple solution a wind shield was designed for and used during site-testing campaigns for the Joint Organization for Solar Observations (JOSO) at Madeira (cf. Dekker, Houtgast, and Zwaan 1972).

A closed wind shield produces a volume with almost stagnant air behind the shield, and behind and above this stagnant air a turbulent region with counter flows develops. Consequently a temperature difference between the ground surface and the wind causes temperature inhomogeneities behind the shield. Therefore sufficient flow through the wind shield should be allowed for in order to keep the air in the vicinity of the telescope as homogeneous as possible.

A semitransparent wind shield consisting of vertical boards with equally wide spaces in between offers a good compromise. Eddies are formed directly behind the windshield. The kinetic energy of the wind is largely transferred into these eddies, which loose their energy over some distance behind the shield. For example, the wind speed is reduced to one-third over a distance of 3 m behind a shield 2 m high, which consists of boards 10 cm wide with gaps of also 10 cm in between. The energy dissipation through the hierarchy of eddies causes some rise in the temperature of the air, but the simple relation $c_p \, \Delta T = v^2/2$ shows that annihilation of a wind speed of $v = 10$ m sec^{-1} (22 mi hr^{-1}) produces a temperature rise of only $\Delta T = 0.05°$ K at the most (c_p is the specific heat per unit of mass). The region with a strongly reduced wind speed is fairly large: it ranges from the ground to a height slightly above the height of the shield and horizontally from three meters behind the shield up to more than ten times the height of the shield, provided that the shield is wide enough and that the wind direction is perpendicular to the shield.

A shield with horizontal boards is less practicable than a shield with vertical boards. The reason is that horizontal boards produce eddies with vertical velocity components. This permits energy transport from the wind flow above the shield into the eddies. Consequently behind the shield the wind speed is less reduced and the turbulence extends over a larger volume than in the case of vertical boards. A shield with vertical boards produces an almost horizontally stratified airmass with a minimum of turbulence.

In the practical application twelve wooden panels 1 m wide and 2 m high were constructed. These panels were tied together with iron wire and arranged in a semicircle with a radius of 4.5 m around the telescope. The structure was tethered with ropes. The stability of the shield was increased by tapering the panels by a few cm, so that the panels leaned inwards. Measurements with a portable anemometer showed that the shield reduced the wind speed by a factor between 3 and 4 in the region within a radius of 1.5 m around the center of the semicircle and from the ground to 2.0 m high (= height of shield), provided that the space between the bottom ends of the vertical boards and the ground is less than a few cm. The reduction factor in the wind speed was practically independent of the wind speed incident on the shield, which ranged from 3 to 12 m sec^{-1} (7 to 27 mi hr^{-1}) during the wind-speed measurements. On the basis of the Reynolds number we expect that the efficiency of the wind shield holds for wind speeds up to about 30 m sec^{-1} (67 mi hr^{-1}). Since the wind pressure varies quadratically with the wind speed, the wind force on the telescope was reduced by a factor between 9 and 16.

The image motion of the solar limb caused by seeing could be measured with confidence during wind speeds up to at least 10 m sec^{-1} (22 mi hr^{-1}), whereas without the wind shield no measurements were possible during wind speeds above 5 m sec^{-1} (11 mi hr^{-1}) with the instrument in question. The shield and telescope, on top of the second highest mountain on Madeira (1818 m), survived average wind speeds of 30 m sec^{-1} (67 mi hr^{-1}) and gusts up to at least 50 m sec^{-1} (112 mi hr^{-1}) measured by a recording anemometer.

Some questions require further investigation. It is not known how the distance behind which the shield becomes effective varies with the height of the shield and the width of the boards and the spaces in between. Neither do we know how the characteristics of the wind shield change if the panels were arranged in a closed cylindrical structure. In that case the effects of the windward-side and of the lee-side parts may couple.

We suggest mounting the vertical boards in such a way that they may be removed easily. If the wind is very light, all available wind is needed to keep the ambient air mass as homogeneous as possible. During a storm the force on the shield construction can be reduced.

In conclusion, the advantages of a semi-transparent wind shield with vertical boards in comparison with a completely closed shield are: (1) smaller disturbance in the air flow above the telescope, no counter flow; (2) smaller temperature fluctuations in the air behind the wind shield; (3) smaller forces on the wind shield, which allows a lighter construction.

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REFERENCES

Dekker, K. J., Houtgast, J., and Zwaan, C. 1972, Report JOSO MET 54.

National Aerospace Laboratory (N.L.R.), Amsterdam, Report A A.157.