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A BRIEF STUDY OF WIND GUST FACTORS

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INTRODUCTION

Forecasts of the magnitude of surface wind gusts, in excess of the mean wind, are of importance to aviation interests, construction and insurance companies, and the public in general. However, little qualitative information pertaining to gustiness and the meteorological factors which influence it is available.

The Techniques Development Laboratory (TDL) of the National Weather Service (NWS) has provided forecasters with objective surface wind guidance for the conterminous United States since May of 1973. This forecast is based on Model Output Statistics (MOS) and is a single-station forecast of the mean wind at a given time. An objective estimate of wind gusts is not provided since the data necessary for derivation of forecasting equations were unavailable.

It is the purpose of this note to briefly convey information pertaining to the general magnitude of the gusts which might be expected with TDL's automated forecasts of surface wind.

BACKGROUND

Several investigations (e.g., Durst, 1960; Huss, 1972) have been conducted by meteorologists and engineers concerned with the characteristics of wind gustiness in relation to the dynamic loading produced on structures. However, a lack of standardization exists in these studies (Davis and Newstein, 1968). Thus, it is difficult to apply the majority of information pertaining to the gust factor, the ratio of the peak wind speed (of a given duration) to the mean wind speed (for a given averaging period), to the NWS surface wind reports used in the derivation of TDL's objective forecasting equations.

In general, the gust factor appears to be inversely related to the mean wind speed (Sissenwine et al., 1973) and the factor increases as the atmospheric stability decreases (Monahan and Armendariz, 1970). However, the precise nature of the relationship between gustiness and stability seems unclear at present. Also, gust factors will be higher and shorter the increment of time over which the peak wind speeds are averaged and/or the greater the averaging time for the mean wind speed under consideration.

OBSERVATIONS AND ANALYSIS

In order to obtain more information concerning gust factors which are applicable to the forecasts based on MOS, hourly aviation reports during March and April of 1973 from 12 stations in the Washington WSFO forecast region (see Table 1) were examined. Since this is a relatively small sample of data, diurnal trends were not examined, and the data for all 24 hours were combined for each station. Here due to the nature of NWS observing procedures, the gust measurement was instantaneous in duration and the averaging time for the mean wind was of the order of one minute.

Separate graphs of the observed gust versus the mean wind speed were prepared for each station. For all cases where gusts were present, the range of gust factors at each station was tabulated. In addition, average gust factors associated with different categories of mean wind were determined by pooling the data from all 12 stations.

In Figure 1, the relationship between the mean winds and the corresponding gusts at Baltimore (BAL) is depicted. On this figure, all mean winds of 20 knots or greater are plotted regardless of whether or not a gust was reported. As shown here, gusts are associated with most of the mean winds of 20 knots or greater. Also, the largest proportional gusts and hence largest gust factors are associated with mean winds of less than 25 knots.

Graphs for the 11 other stations revealed similar patterns as those in Figure 1. However, a larger number of gusts occurred at coastal stations than at stations farther inland.

The summary of the range of gust factors listed in Table 1 indicates a relatively wide variation among stations. The value of 3.15 at Washington (DCA) is extremely high and is associated with convective activity.

Average gust factors for mean wind of from 10 to 19 and 20 to 29 knots are shown in Table 2. Here, as was the case in Table 1, only winds with gusts present were used in the tabulation. This table reveals a slight tendency for the gust factors to decrease as the mean wind increases.

CONCLUSION

This brief study and/or previous literature pertaining to wind gusts, suggests the following concerning the gust factor:

(a) It is inversely related to the mean speed,

(b) It is inversely proportional to atmospheric stability, and

(c) It is influenced by terrain effects.

Since gusts were associated with most of the mean winds of 20 knots or more for these NWS observations, a factor of 1.4 can, in general, be applied to all of the objective surface wind forecasts of 20 knots or greater. However, modifications should be made by the forecasters in the field depending on any known diurnal trends and local terrain effects. For wind forecasts of less than 20 knots, any gust estimates should be based primarily on local experience.

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Figure 1. Plot of Observed Surface Wind Gusts Versus Corresponding Mean Winds During March and April of 1973 at Baltimore.

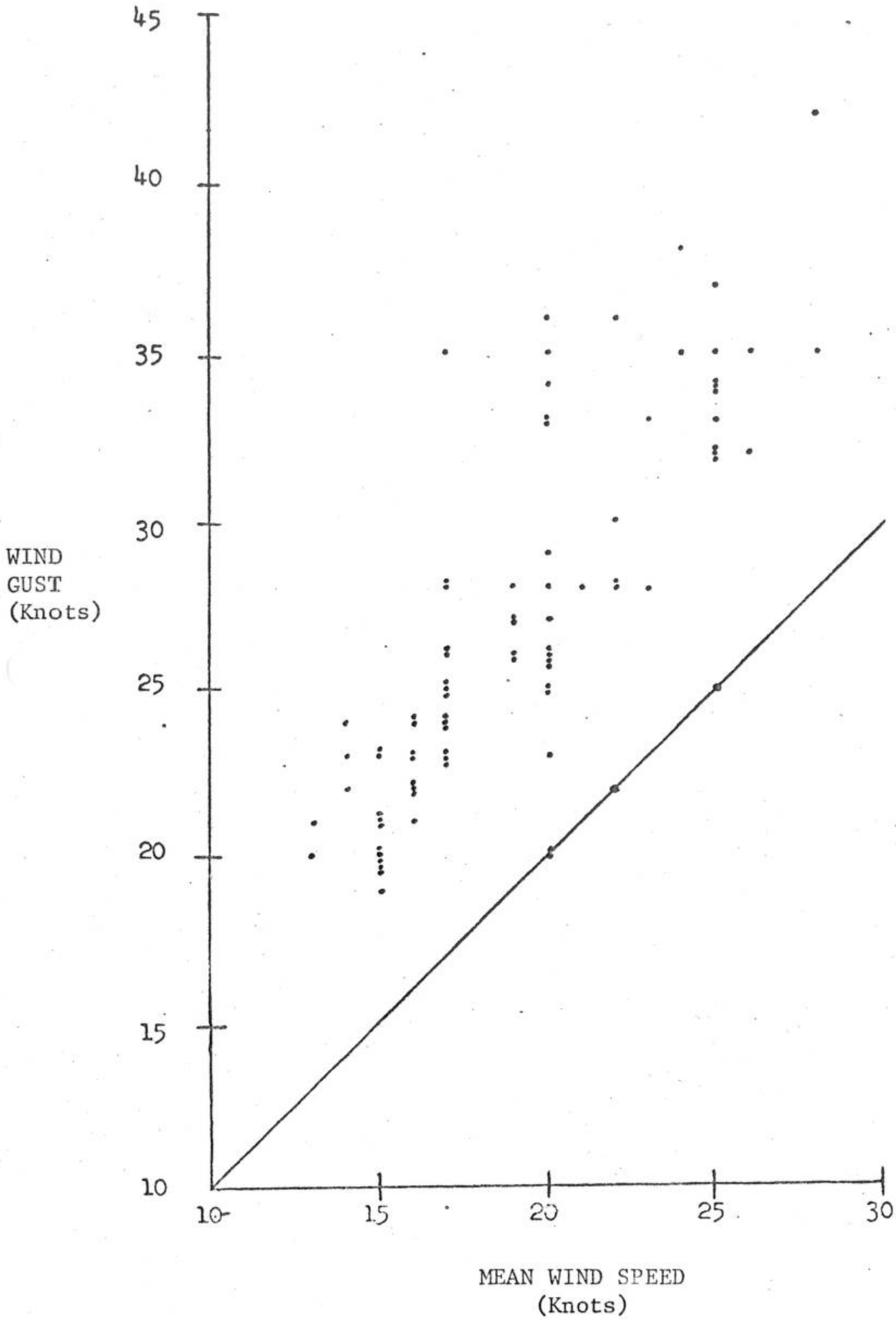

Table 1

Summary of the Range of Gust Factors Obtained from NWS Hourly Aviation Observations at 12 Stations During March and April of 1973.

		Gust Factor Range
Washington, D.C.	(DCA)	1.29 - 3.15
Washington Dulles	(IAD)	1.15 - 2.54
Baltimore, Md.	(BAL)	1.15 - 2.06
Wilmington, Del.	(ILG)	1.22 - 2.28
Roanoke, Va.	(ROA)	1.15 - 1.83
Lynchburg, Va.	(LYH)	1.25 - 2.64
Danville, Va.	(DAN)	1.33 - 2.40
Richmond, Va.	(RIC)	1.25 - 2.38
Charlottesville, Va.	(CHO)	1.42 - 2.50
Salisbury, Md.	(SBY)	1.28 - 1.85
Newport News, Va.	(PHF)	1.25 - 2.80
Norfolk, Va.	(ORF)	1.16 - 2.00

Table 2

Average Gust Factors Associated with Mean Observed Winds from Hourly Data at 12 Stations During March and April of 1973.

Mean Wind Speed	Average Gust Factors (Range)	No. Obs.
10-19 knots	1.6 (1.5 - 1.9)	1156
20-29 knots	1.4 (1.3 - 1.5)	268