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SUBTROPICAL JET STREAM NOMOGRAMS

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ABSTRACT

Two nomograms, based on the data of six jet stream cross-sections (Spillane, 1965) are presented. Nomogram A determines the strength and location of the jet core relative to known winds north and south of it, at the level of maximum wind. Nomogram B determines the wind speed at points in the region around the jet core.

1. INTRODUCTION

From the mean, with respect to the jet stream core, of six subtropical jet stream cross-sections obtained during Project "Topcat" in July 1963 (Spillane, 1965) two nomograms have been constructed to give the strength and location of the winter subtropical jet stream core and wind speeds within 6° of latitude normal to the jet axis and within a layer from 10,000 ft above to 10,000 ft below the jet core.

The validity of these nomograms is based on the assumption that the subtropical jet stream's cross-section, and therefore also the wind profile at the level of maximum wind, are shape conserving.

Conservation of shape with jet core latitude is not inconsistent with the mean shears over 5° of latitude on either side of the subtropical jet core at 200 mb according to Muffatti (1963). Those data were derived from routine synoptic analysis on a constant pressure surface, the separation of which from the mean jet core height is, as yet, an undetermined function of the latitude of the jet core. This fact coupled with the meridional asymmetry of the jet prevents positive quantitative deduction on the variation, or otherwise, with latitude of the average shape of the subtropical jet. Nevertheless, it is considered that the assumption that shape is conserved is unlikely to produce errors in core speed greater than 8 percent. Also the six subtropical jet cross-sections used to construct the nomogram all related to jet streams whose axes were within 30° of west-east. The nomograms may not be appropriate for use with jet axes far from a west-east orientation.

The polar front jet profile described by Morley (1957) is based on aircraft flights at the constant pressure level of 300 mb through 12 polar front jet streams over North America. While it is considered that this mean profile contains the same deficiency as the shears reported by Muffatti, it remains, at present, the best guide available for polar front jets in the Australian region.

2. NOMOGRAM A

Nomogram A will determine the strength and location of the jet core relative to known winds north and south of it, at the level of maximum wind. In this nomogram the symbols used are (see Fig. 1):-

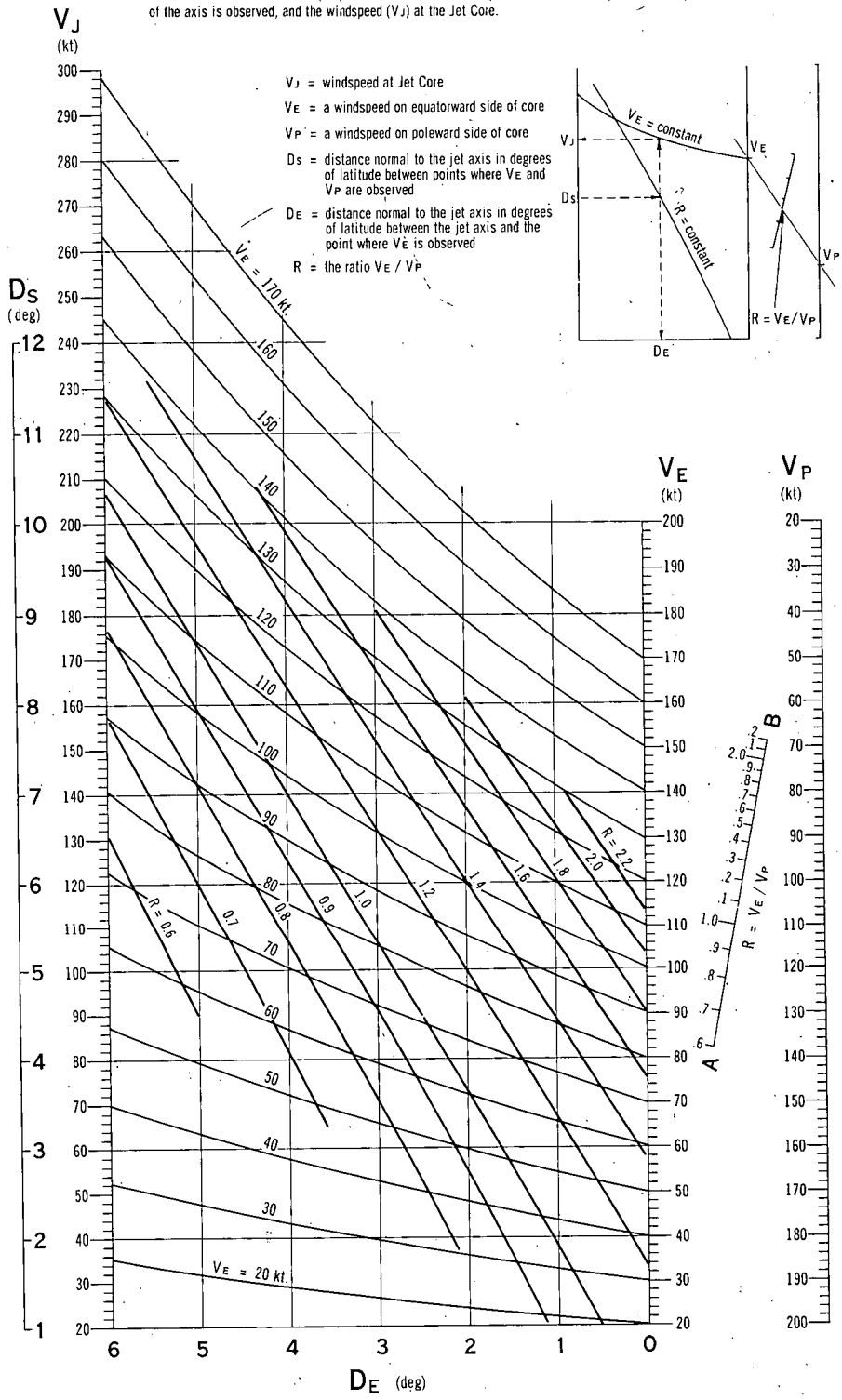
V_J windspeed at jet core.

V_E a windspeed on equatorward side of core.

V_P a windspeed on poleward side of core.

SUBTROPICAL JETSTREAM NOMOGRAM A

For estimation of the distance (D_E) between a Jet Axis and a point where the windspeed on the equatorward side of the axis is observed, and the windspeed (V_J) at the Jet Core.



D_S distance normal to the jet axis in degrees of latitude between points where V_E and V_P are observed.

D_E distance normal to the jet axis in degrees of latitude between jet axis and the point where V_E is observed.

R the ratio V_E/V_P

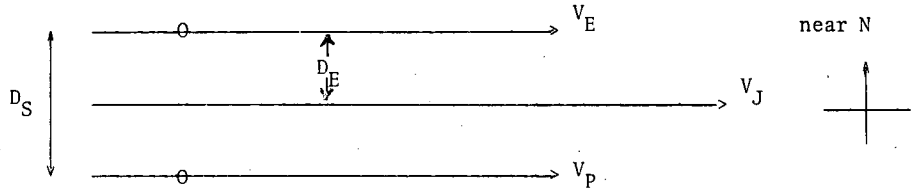


Fig. 1. Definition of wind speeds and distances used in the nomograms.

A jet can be located between V_E and V_P only if:

(i) $D_E \leqslant 6$ degrees of latitude,

(ii) $D_S \leqslant 12$ degrees of latitude,

(iii) $0.6 \leqslant R \leqslant 2.3$,

(iv) the combination of D_S and R fits the nomogram.

If a particular combination of the above parameters will not fit onto the nomogram, then either,

(i) the jet axis does not lie between V_E and V_P for

(ii) the jet has a substantially different profile from that which is used in this nomogram; a possible but unlikely event.

Method of using Nomogram A

(i) Select V_E, V_P and associated D_S from the maximum wind analysis chart.

(ii) Place a straight-edge on the right hand section of the nomogram, to pass through the selected values of V_E and V_P on the appropriate scales. Read off the value of R at the intersection of the straight edge with the scale AB.

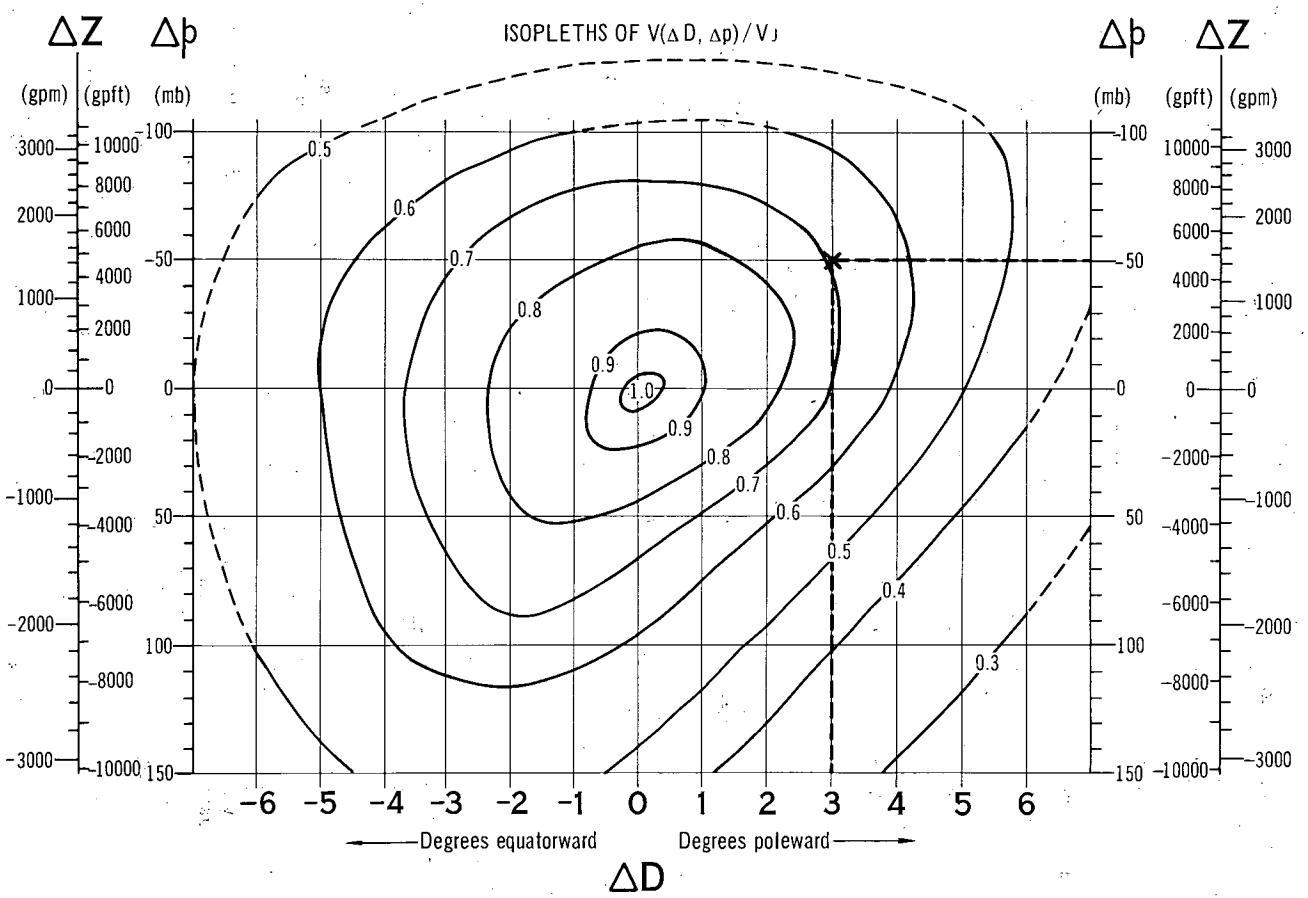
(iii) Using this value of R and the selected D_S in the appropriate line and scale in the left hand section of the nomogram, find the corresponding value of D_E on the horizontal scale as shown in the inset.

(iv) Using the values D_E and V_E in the appropriate scale and curve of the left hand section again, find the corresponding value of V_J on the vertical scale as shown in the inset.

Example 1 V_E = 90 kt, V_P = 100 kt, $D_S = 4.5^o$ of lat.

Using these values of V_E and V_P in the right hand section of nomogram A, we obtain R = 0.9.

Entering the left hand section of the nomogram with the values R = 0.9 and $D_S = 4.5^o$ gives $D_E = 3^o$ of lat., and the line D_E = 3.0 intersects the curve V_E = 90 at V_J = 118 kt, i.e. the windspeed at the jet core is 118 knots.



SUBTROPICAL JETSTREAM NOMOGRAM B

For determination of windspeeds at any point relative to a Jet Core. V(ΔD, Δp) is the wind ΔD degrees of latitude distant from, and Δp millibars (or Δz geopotential metres or feet) above or below the subtropical jet core. Isopleths are constant values of V(ΔD, Δp) / VJ, where VJ is the windspeed at the jet core. For example, the windspeed 50 mb above and 3 degrees poleward of the jet core is about 0.7 VJ.

Example 2 V_E = 160 Kt, Vp = 80 kt, D_S = 10.5° of lat.

In the right hand section of the nomogram these values of V_E and Vp give R = 2.0. In the left hand section the line D_S = 10.5 does not intersect the curve R = 2.0, and it is concluded that either there is no jet between V_E and V_p, or if there is one, its profile is very different from the one used for this nomogram.

Windspeeds on the equatorward side for D_E from 0° to 6° may also be found from the nomogram, by noting V_E values appropriate to D_E values for V_J = 118 kt. On the poleward side linear interpolation will be adequate. All the winds referred to or found from this nomogram are at the level of maximum wind.

3. NOMOGRAM B

Nomogram B determines windspeeds in the region around the jet core. In this nomogram the symbols are:-

Δp pressure difference between constant pressure surface and core level pressure,

Δz height difference between geopotential surface and geopotential of core,

ΔD distance north or south of jet axis.

There are three vertical scales, Δp in mb and Δz in gpm and gp ft. The horizontal scale is in degress of latitude. The concentric closed curves are isopleths of $V(\Delta D, \Delta p)/V_J$, where V_J is the wind speed at the jet core and $V(\pm\Delta D, \pm\Delta p)$ is the windspeed ΔD south/north of and Δp below/above the jet core.

Method of using Nomogram B

After the position* and strength of the jet core have been found with Nomogram A, fix the point on Nomogram B corresponding to the location relative to the core at which the windspeed is required, using the vertical scale for the value (Δp or Δz) below or above the jet core and the horizontal scale for the amount (ΔD) south or north of the core.

The value of this point measured on the isopleths of $V(\Delta D, \Delta p)/V_J$ gives the ratio of the windspeed here to the windspeed at the jet core.

Example: To find the wind speed at a point 50 mb above and 3 degrees south (poleward) of a jet core with a speed of 120 kt (obtained with Nomogram A); the plot of this point on Nomogram B (as shown) gives approximately 0.7 as the value of $V(\Delta D, \Delta p)/V_J$ and therefore about 84 kt. as the required wind speed.

ACKNOWLEDGEMENT

My thanks are due to Mr. J.N. McRae in pointing out the special advantage of using the level of maximum wind in applications as attempted here and Mr. K.T. Spillane for his advice and interest.

REFERENCES

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* From nomogram B it can be seen that the height of the jet core is approximately the same as the level of amximum wind on the equatorward side of the jet.