

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE
NATIONAL METEOROLOGICAL CENTER

OFFICE NOTE 229

How to Manufacture Charts of the Maximum Wind Speed
and
Level of Maximum Wind

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MARCH 1981

This is an unreviewed manuscript, primarily
intended for informal exchange of information
among NMC staff members.

Introduction

In response to interest expressed by the international aviation community, in the person of the ICAO, we undertook to construct (a) values of the maximum wind speed at each gridpoint output from the spectral forecast model and (b) the pressure level at which the maximum wind was found. In doing this we assumed that the available input data was the u and v wind components at the mandatory levels of the atmosphere, as produced, in gridded form, by either the operational analysis program (at present the Hough system) or the spectral forecast model, SMG3C. The latter information is available at any of the standard forecast output hours (F00 - no forecast, just in and out of the model's sigma coordinates, F06, F12, F18, F24, etc.).

We also decided that we would make use of already available programmes (i.e. a tropopause finder that had fallen into disuse) rather than attempt any extensive development. The results of this patchwork activity are presented here and, at first blush, appear to be adequate.

Method

The principal tool available was a collection of strictly mathematical codes (part of the IBM SSP, and other OMCS supplied codes) which will:

1. fit a 4th order polynomial exactly to 5 points of data;
2. calculate the derivative;
3. find the real (and imaginary) roots of the derivative polynomial;
4. using the real roots, find the largest of the maxima (or smallest of the minima) of the original 5 point polynomial.

The available data are, as mentioned previously, the wind components at the mandatory levels; we chose to find the level of maximum speed, of course, and not the level(s) of maximum u and v components. Further we elected to use $\ln(p)$ rather than p as the independent variable of the polynomial fitter.

Codes were then constructed to find the maximum speed at three overlapping sets of 5 adjacent speed vs $\ln(p)$ points between 500 mb and 100 mb, inclusive. We were not interested in any wind maxima existing below the 500 mb level; forecast data fields were not available above the 100 mb level. Given that wind speeds are available at 500 mb, 400 mb, 300 mb, 250 mb, 200 mb, 150 mb, and 100 mb (or their $\ln(p)$ equivalents), the three maxima of the three sets of five points from 500 to 200, 400 to 150, and 300 to 100 are found by repeated applications of the mathematical tools. Then the greatest of those three maxima, and the corresponding pressure, is selected as the maximum wind value and the pressure level of that wind. This process repeats for all the gridpoints in the field.

It turned out, as you will see in the examples to follow, that the field of maximum speed showed a quite satisfactorily coherent pattern, the pressures to some extent did not. In the regions of a well defined jet, as found in the max wind field, the pressures are quite coherent; in areas where the calculated max winds are light the pressures were extremely variable with two and three hundred millibar changes from point to neighboring point not uncommon. Presumably without a well defined and strong maximum wind in the input data, the mathematical tools act erratically. The saving grace, however, is that where the winds are not particularly strong, it matters little where any maxima may be. Clearly the best of all possible worlds. Incidentally the difficulty in generating a coherent max wind level chart from the computer reflects experience of some operational meteorologists attempting the same activity subjectively.

In order to improve the esthetics of the output maps the pressure fields were twice smoothed by the NMC "Operational" 9-point smoother-desmoothing. (That's the one that does three passes: once with a smoothing coefficient of 0.5, once with a complex coefficient of $-0.22227 + 0.64241i$, and once with the complex conjugate of the second pass coefficient). The wind fields were left alone.

Sample Results

Here are some examples of how the fields in question look when gridprinted. Figure 1 shows the geographical location of the fields for reference. Figures 2a and b are the max wind speed (in knots, contoured in 20 kt intervals) and max speed level pressure (in millibars, contoured every 25 mb). Both are derived from the Hough Analysis for 00Z 20 Mar 81. As can be seen the wind field is very well behaved as is at least a portion of the pressure field. Recall the pressure (but not the winds) have been smoothed.

Figures 3a and b are the speed and pressure again (draw your own contours - mine don't look so good) but derived from the information on the F00 file, that is after the information have been interpolated into and back out of the 12 sigma layers of the spectral model. The loss of intensity is observable but a not unexpected consequence of two vertical interpolations.

Finally Figure 4a and b are the 24 hour forecasts of the wind and max level. No surprises there.

A couple of more general remarks.....

These examples show a tendency for the pressure patterns to be more chaotic to the north of the jet stream than south. This is characteristic of other days and regions I have looked at, but I can't say that it has any particular significance. It does agree conceptually with various zonal mean cross sections of winds one can see in textbooks - north of the jet core the isotachs are often drawn nearly vertical while south of the jet they show a more pronounced maximum. A no vertical shear wind pattern would certainly cause the mathematical maximum finder some difficulty and could lead to the erratic results of the figures. The

climatological cross-sections also show the south-of-the-jet maximum level climbing as one follows it southward - this agrees with the figures in hand.

Use of These Fields

The current ICAO interest in these max wind determinations centers on adding an hhfff group to the aviation digital forecast. Perhaps, as was suggested by others, it would be wise to include the hhfff group only when the wind speed exceeds a critical value, 70 kts says, to avoid transmitting meaningless "light" wind level information. On the figures the 70 kts isotach seems to be sort of a boundary between the chaotic and coherent regions of the max level map.

If graphical display of this information was desired a similar end could be obtained by surpressing the contouring of both the max wind chart and the max wind level chart wherever the 70 kt threshold was not exceeded.

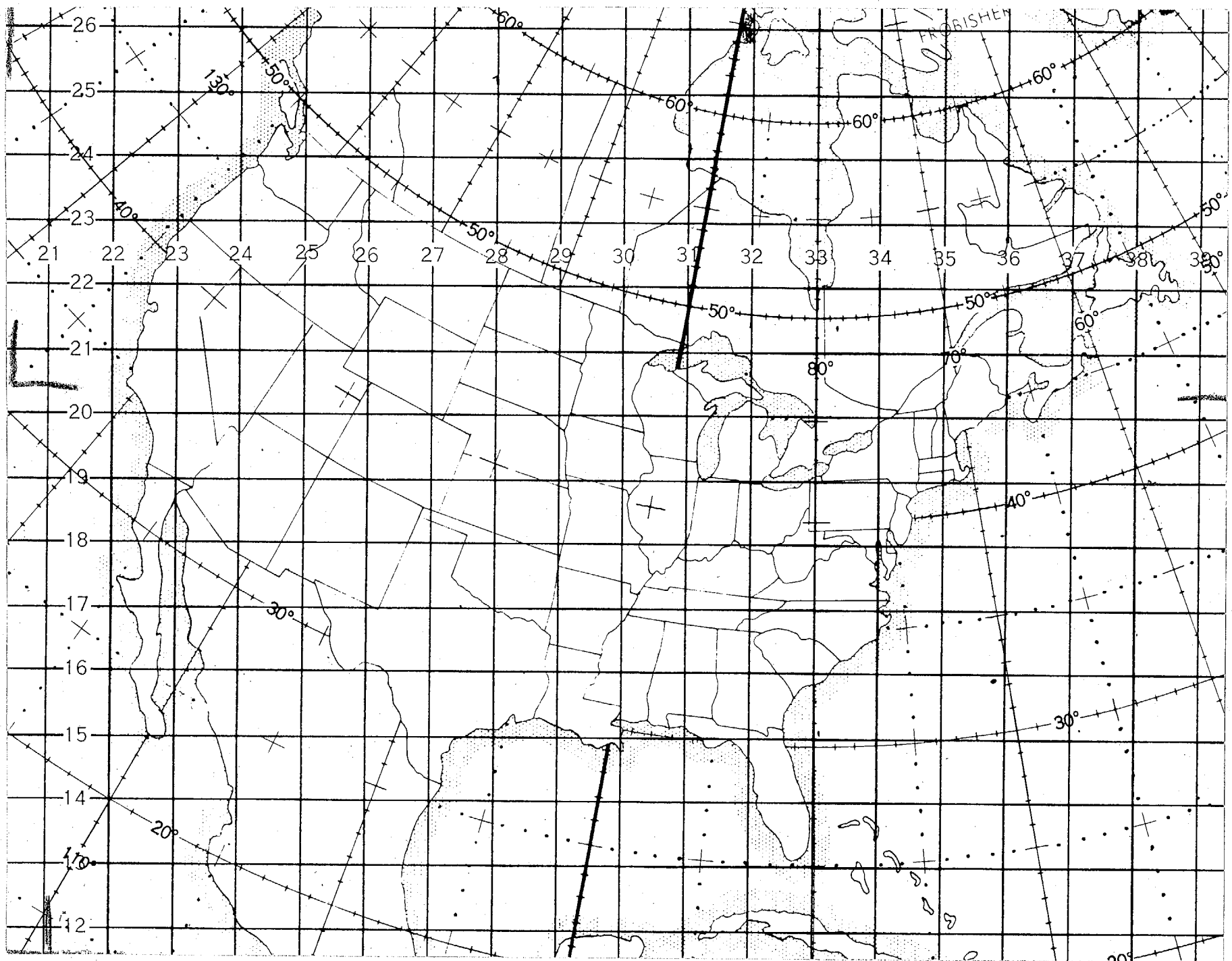


Figure 1. Geography

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Fig 2-a Analysis

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ANL

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Fig 3-b F00

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Fig 4-a F24

MAX

WIND FOR 024 HRS AFTER 00Z 20 MAR 81

WMC/NMC WASHINGTON.

TCM

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DDU C DD EEE FFFFFFFF FF GG HH AAAAAAA H G FFFF
+21 +0187+0184+0174+0137+0144+0200+0213+0218+0266+0266+0230+0275+0358+0400+0397+0338+0273+0249+0231 +2
DDD DDD EEEEEEEE FFFFFFFF FF GG HH HHH GGG FFFF E
DDDD DDD EEE FFFFFFFF FF GG HHHHHHHH GGGG FFFF EE
+20 +0166+0170+0189+0157+0134+0174+0189+0186+0225+0260+0271+0305+0336+0324+0301+0303+0297+0256+0207 +2
DDDDDD DDD DDD EEE FFFFF GGGG GGGG GGGGGG FF EE
DDDDDD DD DDD EEEE FFFF GGGG GGGG GGGGGGGG FF E
DDD E DD DDDDD EEEE FFF GGGGGGGGGGGG GGGGGGGGGG FF E
+19 +0178+0185+0205+0169+0126+0150+0173+0177+0199+0232+0275+0315+0319+0289+0274+0300+0319+0287+0228 +1
EEEEEEEEE DD DDDDDDDDD EEEE FF GGGGGGGG FFFF GGGG FFF
EEEEEEEEE DD DDDDDDDDD EEEE FFF FFFFFF FFFFFF FFFF
+18 +0238+0229+0193+0144+0127+0154+0170+0170+0187+0211+0235+0261+0274+0270+0262+0251+0243+0260+0275 +1
EEE DD DDDDDDDDDDDDDDD EEEEE FFFFFFFF FFFFFF EEEEE FFFF
EEE DD CC DDDDDDDDDDDDDDD EEEEE FFF FFF EEE EE FF
+17 +0221+0205+0153+0120+0135+0166+0171+0160+0170+0196+0210+0220+0230+0227+0212+0176+0139+0175+0256 +1
DD DDDDDDDDDDDDDDDDDDDDD EEEEEEEEE EEEEE DDD DD EE
DDDDDDDD DDDDDDDDDDDDDDDDDDDDD EEEEEEEEEEEEEEE DDD DDD EE
+16 +0119+0140+0152+0162+0172+0175+0168+0158+0164+0181+0189+0201+0222+0218+0190+0166+0159+0180+0216 +1
CCC DDDDDDD DDDDDDDDDDDDDDDDDDDDD EEEEEEEEEEEEEEE D EEEE
CCC DDD DDDDDDDDDDDDDDDDDDDDD EEEEE EEEEE EEEEEEE
CC DDD EEEEEEEEE DDDDDDDDDDDDDDDDDDDDD EEEEE EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE
+15 +0118+0163+0207+0224+0210+0179+0157+0149+0160+0182+0189+0195+0219+0233+0226+0219+0227+0228+0215 +1
DD EEEE EEEE DDDDD DDDDD EEEEE DDD EEEEE EEEEE
DD EEEE EEEE DDDDD DDD EEEEE EEEEE EEEEE
+14 +0211+0214+0224+0226+0202+0161+0137+0128+0149+0194+0211+0205+0212+0222+0226+0234+0234+0219+0206 +1
EEEEEEEEEEEEEEEEEEEE DDD CC DDD EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE EEEEEEEEE
EEEEEEEEEEEEEEEEEEEE DDD CCCCC DDD EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE EEEEEEEEE
+13 +0222+0195+0170+0169+0170+0150+0125+0117+0137+0179+0204+0207+0209+0203+0196+0203+0203+0199+0221 +1
EE DDDDDDDDDDDDDDDDDDDDD CCCCCCCCC DDD EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE EEE
DDDD CCCCC DDDDD CCCCCCCCC DDD EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE EEE F
+12 +0164+0144+0109+0111+0142+0141+0120+0111+0115+0147+0200+0220+0210+0195+0186+0175+0151+0189+0292 +1
DDDD CCCCC CCCCCCCCC DDD EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE DDDDDDD EEE FF

+21 +22 +23 +24 +25 +26 +27 +28 +29 +30 +31 +32 +33 +34 +35 +36 +37 +38 +39

Fig 4-b ~~NO~~ F24

21