PACIFIC REGION TECHNICAL NOTES

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Hovmöller Diagram Re-Examined at the Pacific Weather Centre
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INTRODUCTION

The Hovmöller diagram was introduced over 30 years ago, and since then has fallen in and out of popularity. Prior to the introduction of modern day numerical weather prediction products, this diagram was considered a good aid in understanding the atmospheric wave motions. The popularity of the Hovmöller waned with the introduction of numerical weather prediction models, and did not reappear until the early seventies when the theory of energetics of baroclinic development came to the educational forefront of meteorology in Canada. At that time the concept of "waves of amplification" or energy pulses was introduced. This phenomenon will be reviewed a little later, but the Hovmöller diagram proved to be an effective medium for identifying these waves. Its renewed popularity was short lived not only because of the laborious nature of analysing the diagram, but, more importantly, the promise of the sophisticated numerical weather prediction models that would provide all the accurate information required to satisfy the needs of the operational forecasters. The fever of dependency on the numerical weather prediction still runs high among meteorologists today, however the computer has also made the Hovmöller a much easier tool to interpret.

The intent of this first note is to briefly review what the Hovmöller actually attempts to say, highlighting the techniques of analysis. Subsequent notes will introduce other concepts in regards to the Hovmöller data.

WHAT IS A HOVMOLLER DIAGRAM?

The Hovmöller is actually an X-T diagram where 500 millibar (50 kilapascal) heights are mapped in time. The diagram actually portrays a little more information than just 2 dimensions such as the common use of an X-T diagram with respect to frontal motions at the surface.

The heights are computed for various longitudes, but the values do not represent a single point. The height over a band of latitudes is averaged and even though this is often thought of as smoothing, the diagram is more sensitive to changes in time than it would be if values were computed for a single latitude circle.

In Canada, there are actually two bands of interest, the first represents 500 millibar means between 30°N and 65°N. Most of the time, this is the region which is considered to encompass the strong westerly stream where baroclinic development is being frequently observed. The second latitude band is over the Arctic between 50°N and 75°N. In most parts of the country this data is often ignored. However, during winter especially, most of the major features which control the circulation over North America are located in this band.

ANALYSIS

The task of compiling, storing and displaying these mean 500 millibar heights has been made simple by the computer. At the PWC, the computer produces a completely analyzed display, centred and labelled. An example of this is shown in Figure 1. This diagram is curvilinear, since the edges of the diagram containing the height data can be joined to form a cylinder.

The diagram depicts a complex series of troughs and ridges of varying wavelengths. Specifically, these can be catagorized into large and small wavelengths in much the same fashion as we know them on a 500 millibar vorticity chart. Long waves refer to the lowest wave numbers (1-4) which are progressive or retrogressive, while the higher wave numbers are referred to as shortwaves and are always progressive. Figures 2 and 3 illustrate the diagnosis of these waves. A detailed examination of the diagram suggests that a linear line such as it is drawn is only an approximation of a "group" of waves which are moving in a particular direction and speed (given by the slope in degrees of longitude per 12 hours). The longwaves depicted on figure 2 are very slow moving waves which can be progressive, retrogressive or stationary. The shorter wavelength disturbances shown on Figure 2 are always progressive and moving at a faster speed compared to the longwaves. However, it is noteworthy to mention, that the life of these short wave disturbences during January were on the average of seven days, with their speeds quite variant. Therefore the Hovmöller does provide diagnostic information about atmospheric wave disturbances which can be useful in determining their forecast positions and intensities.

The last point to be discussed in regards to diagnosis, is the concept of "waves of amplification". On the diagram, there are also a series of maximums (H) and minimums (L) which are rythmic in nature. The intensities of these features also vary. However when the various wavelengths come into phase, the resultant wave usually has a large amplitude, and in some future time, this effect does appear at some other longitude downstream. This phenomenon is referred to as "waves of amplification" or pulses, which have been loosely correlated with the speed of energy transport (group velocity). Figure 4 shows an example of such a pulse. The speed of the pulse, which is depicted by the straight line, shows a remarkable conservative property. This property makes it a useful tool for extrapolation. Figure 5 illustrates how this method is applied.

SUMMARY REMARKS

The intent was to refamiliarize meteorologists with what information can be obtained from a Hovmöller diagram, highlighting the depictions of long waves, short waves, and the concept of the pulse.

The advantage of the diagram is that it provides a simple depiction of how the 500 millibar is changing within the latitude band of interest. It also provides an independent source for checking the validity of the changes suggested by numerical prediction models.

There are several disadvantages with the diagram as well. The complexity of the wave patterns do not always make the diagnosis of the long wavelength and short wavelength disturbances clear. For example, a longwave pattern which has been nearly stationary over a length period of time, now starts to retrogress. Prior to this time, the diagram has not provided any obvious telltale signs, and extrapolation would become dubious. It is difficult to predict the life cycles and intensities of shortwaves strictly from the diagram. Since the heights are averaged over a large latitude band, smaller synoptic storms could be missed, or greatly underestimated on the Hovmöller diagram.

To assume the diagram will actualy make a correct prediction, both in location and intensity assumes that the energy transfers are operative in a closed environment. In other words, energy is only allowed to be transported along the 500 mb surface and, it is not allowed to escape the impermeable boundaries of the latitude band. This is the major failing in the diagrams prediction ability.

In conclusion, the usefulness of the diagram is in the short term. It is primarily a diagnostic chart and the only one at the Pacific Weather Centre which gives a hemispheric perspective. The wave analysis provides the meteorologist with further insight into the interpretation of the current 500 mb analysis. Understanding the historic pattern and the current trends have provided the operational forecaster with added confidence in deciding the future prognotic patterns (whether done dependently or independently of the numerical prediction models).

REFERENCES

1. Hovmöller Diagram, TIP 173 October 31, 1975
   (this gives a good reference list of Hovmöller applications)

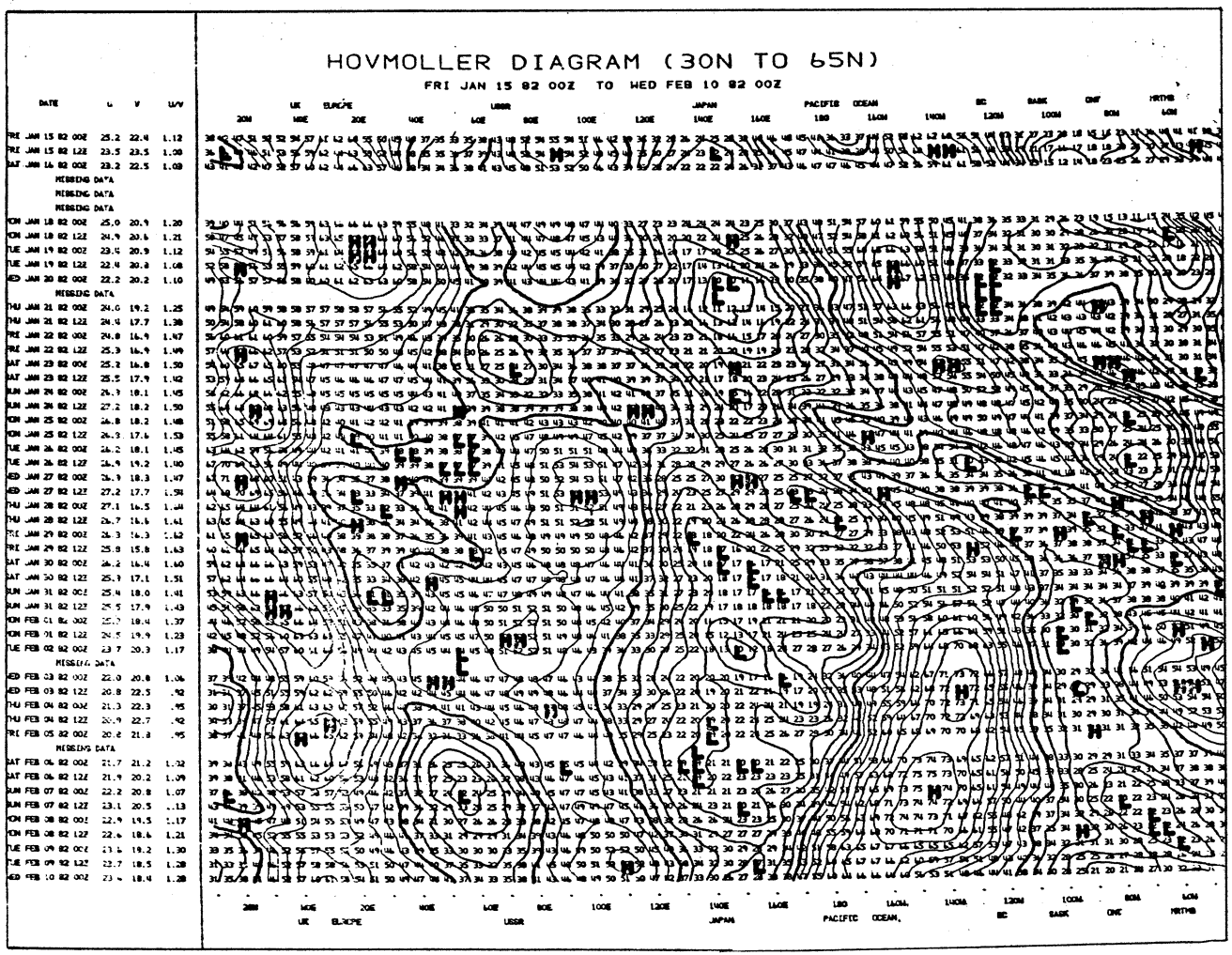

FIGURE 1.

EXAMPLE OF PACIFIC WEATHER CENTER COMPUTER PRODUCED AND ANALYZED HOVMÖLLER DIAGRAM

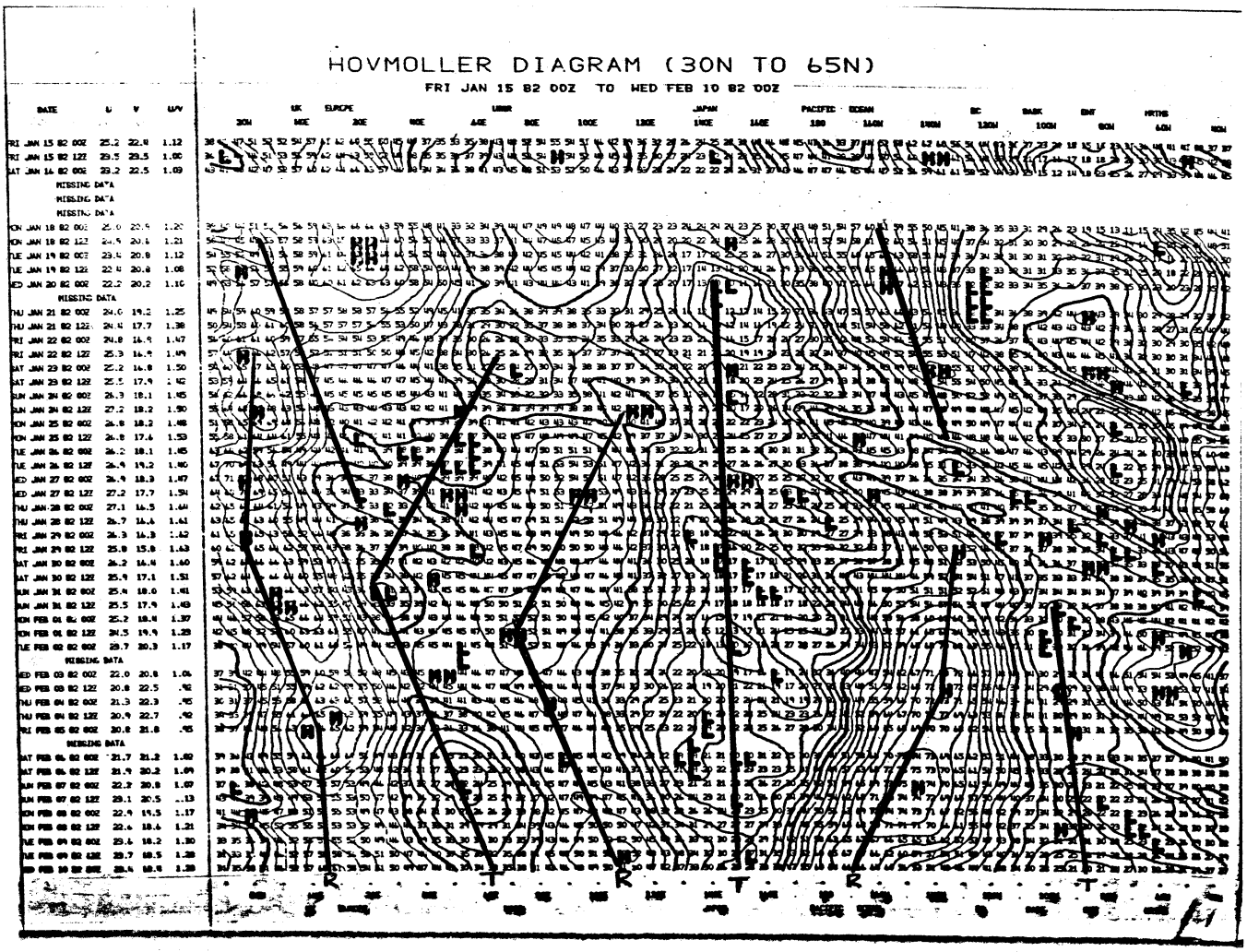

FIGURE 2.

LONG WAVES

Slope of line indicates direction and speed

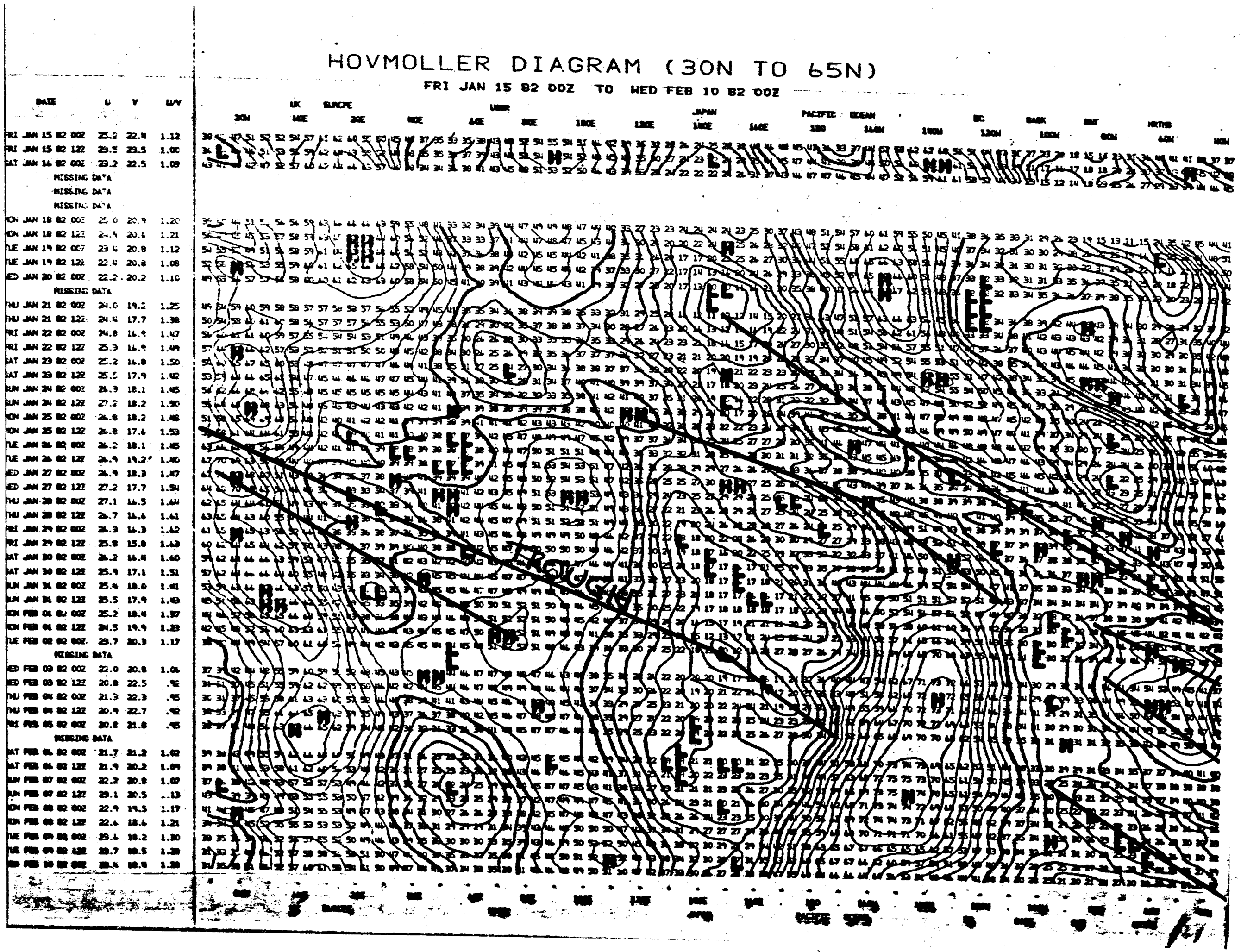

FIGURE 3.

SHORT WAVES

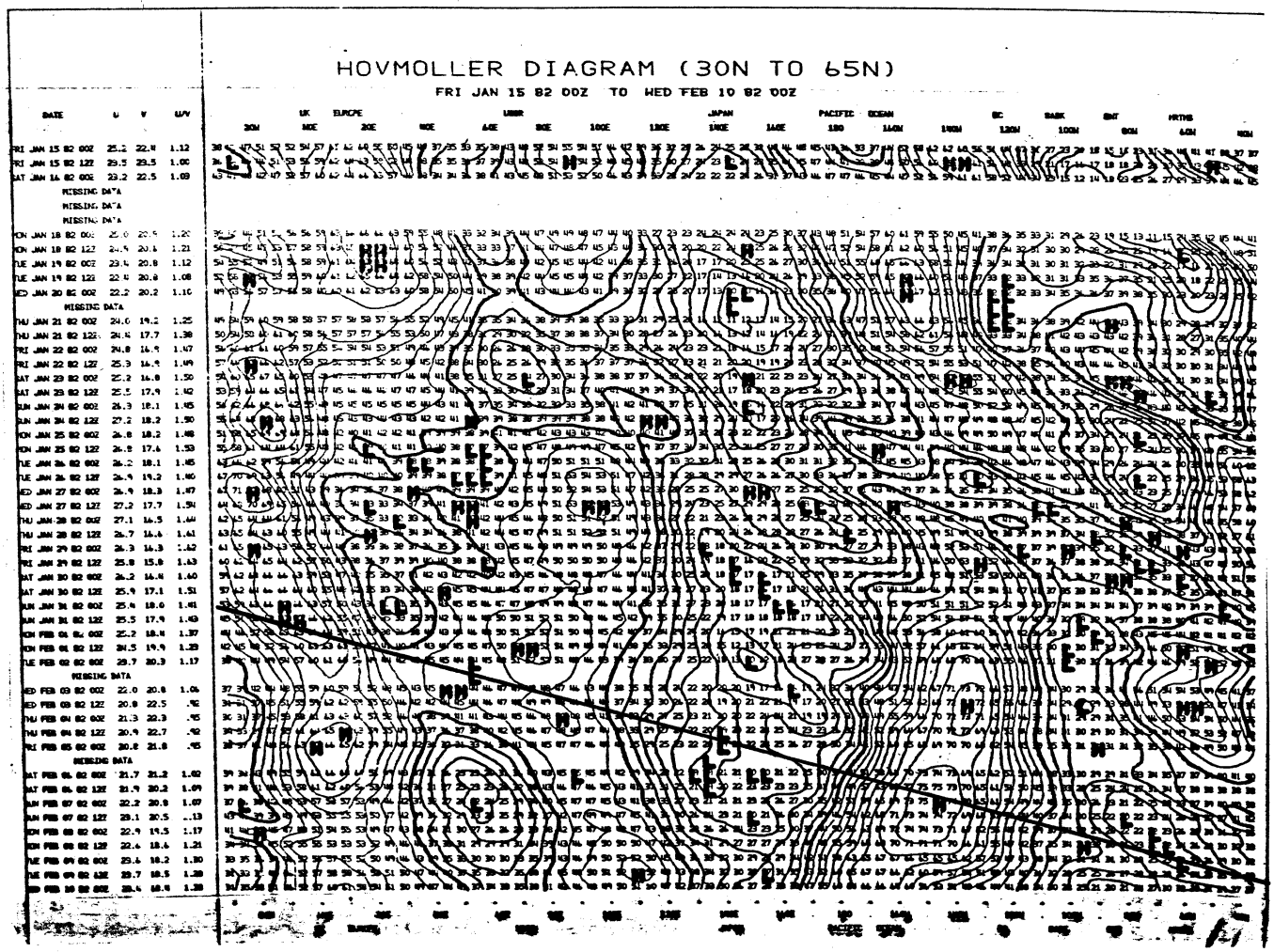

FIGURE 4.

WAVE OF AMPLIFICATION OR PULSE

Speed (slope) related to Group Velocity

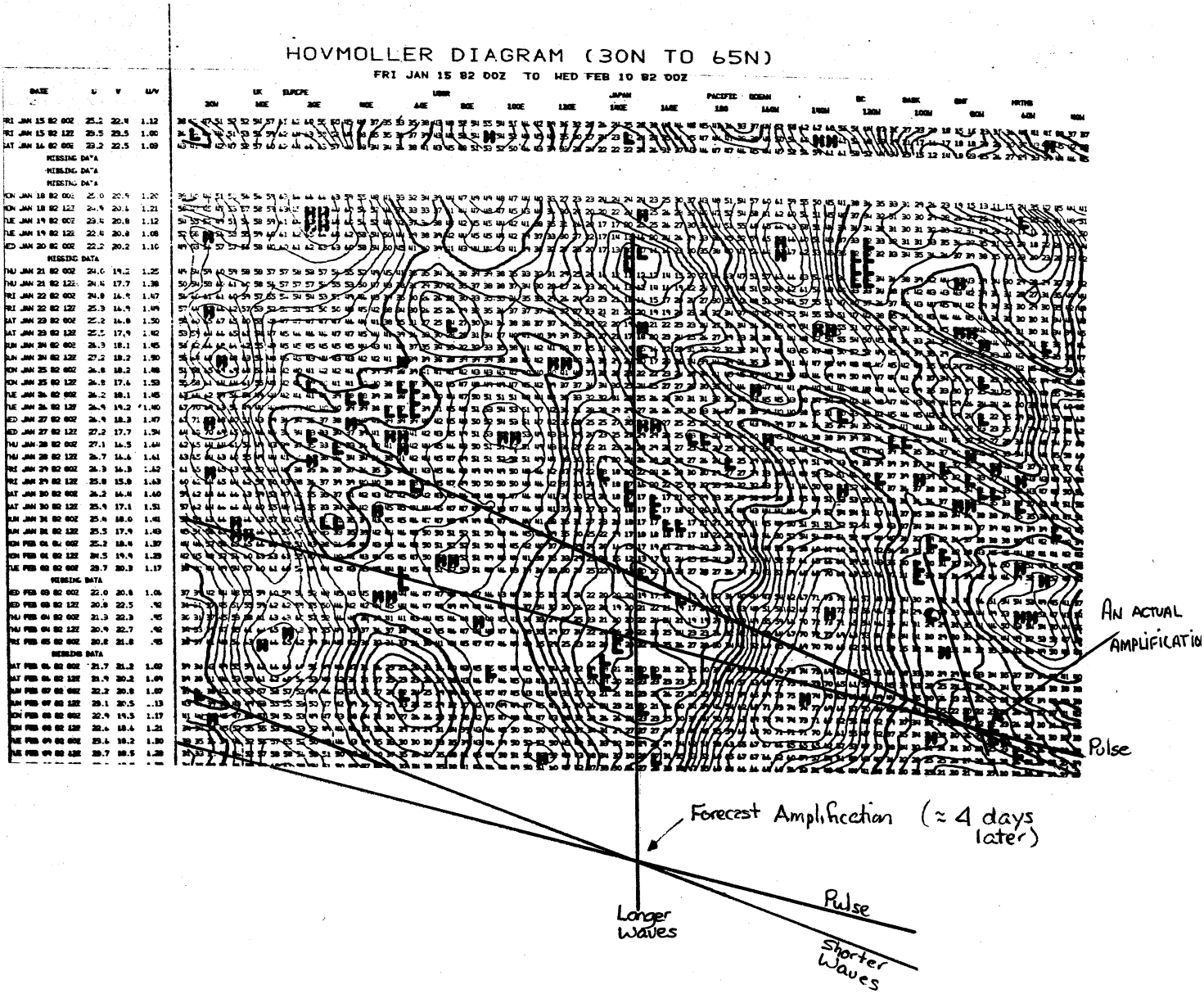

FIGURE 5.

ILLUSTRATION OF METHOD OF EXTRAPOLATION