JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 105, NO. D14, PAGES 18,053–18,066, JULY 27, 2000

A comparison of Northern Hemisphere winds using SuperDARN meteor trail and MF radar wind measurements

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Abstract. The main purpose of the Super Dual Auroral Radar Network (SuperDARN) is to use paired radars to deduce the F-region convection from Doppler measurements of backscatter seen at large ranges, typically beyond $\sim$ 900 km. Nearer to each HF radar, the nearest ranges at $\sim$ 165–400 km are dominated by meteor trail echoes. Once formed, the motion of these meteor trails is normally controlled by neutral winds in the 80–110 km altitude range. By combining the line-of-sight velocities from all 16 receiver beams ($\sim$ 52° in azimuth) of a given SuperDARN radar, it is possible to determine the full horizontal wind vector field over the meteor trail height range. Elevation angles are also measured using an interferometer mode and as such height information can, in principle, be obtained from the combined range and elevation angle data. A comparison with neutral wind measurements from a colocated (Saskatoon, Canada) MF wind radar indicates good agreement between the two radar systems at heights of $\sim$ 95 km. Based on these detailed comparisons, a simple common method for determining two-dimensional winds for all SuperDARN radars, which have extensive longitudinal coverage, was developed. Comparisons with other systems used for dynamical studies of tides and planetary waves are desirable and prove to be essential to obtain a good SuperDARN neutral wind motion analysis. The MF radars at Saskatoon and Tromsø, Norway, are located near the western and eastern ends of the Northern Hemisphere network of six SuperDARN radars. Comparisons between the two types of radars for two seasonal intervals (September and December) show that the SuperDARN radars provide good longitudinal coverage of tides in support of the more detailed MF radar data. The two systems complement each other effectively.

1. Introduction

The main focus of this paper is the use of Super Dual Auroral Radar Network (SuperDARN) observations of meteor trails, which drift at neutral wind velocities, to study tidal and planetary waves. This work is a significant extension of an initial preliminary comparison of SuperDARN and MF radar neutral winds measurements by *Hall et al.* [1997]. Although there are a number of MF wind radars throughout the world, any additional wind measurements, especially from a large global network of identical instruments such as SuperDARN, is a desirable option for tidal and planetary wave studies.

Paper number 2000JD900272.
0148-0227/00/2000JD900272$09.00

The Saskatoon MF (medium frequency) radar views directly upward, operates at 2.2 MHz, and has a 3-km height resolution. The antenna system consists of a four-by-four half-wave folded dipole transmitting array and a four-antenna (folded dipoles) receiving array. For a full description of the Saskatoon MF wind radar and Tromsø MF wind radar, see *Meek and Manson* [1987] and *Hall et al.* [1998].

Since the SuperDARN radars are new to neutral wind analysis, a brief description follows. For a full description of the SuperDARN radars, see *Greenwald et al.* [1985] and *Greenwald et al.* [1995]. At each SuperDARN site, there is a 16-antenna main array connected to a phasing matrix which permits the single beam to be swept through 16 successive positions in increments of 3.25°, giving an azimuth extent of $\sim$ 52°. For a single beam the horizontal beam width is 3.25°, and the vertical beam width is $\sim$ 21° at 14 MHz [*Huber*, 1999]. The first sidelobe is $\sim$ 27 dB down from the main lobe

[*Greenwald et al.*, 1985]. These radars are pulsed systems and under normal operation or "common time" operation, for which data from all SuperDARN sites are available to collaborators and in which all radars operate much of the time, the range resolution is 45 km (pulse width 300 μs), and measurements are taken for 7 s at each beam position. As such, it takes 2 min for a complete 16-beam scan. For a specific beam during the 7-s measurement time, about 70 multipulse sequences are transmitted. The autovariance and cross-covariance functions (ACF and CCF) are determined for each multipulse sequence transmitted during the 7 s, and then all the ACFs (CCFs) are averaged to give a mean ACF (CCF) for that beam.

As the SuperDARN radars are optimized as high-latitude ionospheric research systems, the antenna arrays view obliquely approximately to the north. The six SuperDARN sites used in this paper are formed from three radar pairs, each of which nominally views the same region of the ionosphere from two vantage points. At the near ranges of interest in this study, however, there is no overlap, but horizontal winds can be calculated for each of the six sites by combining the line-of-sight velocities from the 16-beam scans. Table 1 gives the geographic locations and antenna headings for the six SuperDARN sites. Phase differences between received signals on the main array and a secondary smaller array placed $\sim$ 100 m behind it allow measurement of the echo angle of arrival or elevation angle (90°− zenith angle). The SuperDARN radars can operate at any radio frequency between $\sim$ 8 and 18 MHz. In normal operation the radars actively select a frequency within a smaller preset frequency band depending on the background interference conditions.

The paper by *Hall et al.* [1997] established that the majority of SuperDARN near-range echoes were due to scattering from meteor trails except during periods of high K_p (an indicator of geomagnetic disturbance). However, since the neutral wind analysis discussed here is over a period of days and auroral scattering does not have the same strong diurnal characteristic of neutral wind motions, such interference is expected to be minimal in a "mean-day" analysis. As well, motions larger than 100 m/s, which are usually associated with ionospheric plasma wave motions, are discarded, although future work is planned to further minimize any ionospheric contamination at the lower velocities which may alter the wind analysis. Nevertheless, neutral wind speed values are allowed to be greater than 100 m/s as they are calculated from the radar radial velocities which, in general, only measure a component of the wind. Mathematically, rejection of selected meteor trails does not affect the calculated wind velocity vector, but in practice, if there are real neutral winds greater than 100 m/s, this rejection will reduce the resulting fit speeds somewhat (see section 2).

In summary of the *Hall et al.* [1997] findings the near-range SuperDARN echoes occur randomly in echo intensity and presence from one integration period to the next and from one range gate to the next but exhibit a diurnal occurrence characteristic peaking near sunrise. This is unlike the associated scattering from plasma irregularities in the E and F regions, suggesting scattering at the near ranges for SuperDARN are often dominated by meteor trails.

Since the SuperDARN radars were not designed to measure meteor trails, the spatial (usually 45 km) and time (usually 7 s integration per beam, and 2 min between measurements at the same beam) resolutions are not sufficient for examination of meteor trail scatter signal risetimes or extent in range. Thus a positive identification with meteor trails using traditional meteor trail radar methods is not possible and selection of data has to be based on their unique occurrence at near ranges and their radial velocities. Additionally, spectral width, also measured and used for ionospheric scattering studies, should give some estimate of trail duration, at least in the case of underdense trails, which is related to diffusion rates at the height of the trail. However, since meteor trail echoes are expected to last only tenths of seconds most of the time at these frequencies, significantly less than the 7 s integration time, the spectral width measurement was not used to identify meteor trails in this study.

While the paper by *Hall et al.* [1997] clearly established the observation of meteor trails by the Saskatoon SuperDARN radar, it only verified neutral wind motions in a one-dimensional comparison: the velocity

Table 1. Geographic Coordinates and Antenna Headings of Northern Hemisphere Radars in the SuperDARN Network

SuperDARN Radar	Latitude	Longitude	Antenna Heading (East of North)
Saskatoon, Canada	52.2°N	106.5°W	23.1°
Kapuskasing, Canada	49.4°N	82.3°W	-12.0°
Goose Bay, Canada	52.3°N	60.5°W	5.0°
Stokkseyri, Iceland	63.9°N	22.0°W	-60.0°
Pykkvybaer, Iceland	63.9°N	20.5°W	33.0°
Hankasalmi, Finland	62.3°N	26.6°E	-12.0°

component along one of the SuperDARN radar beams with the appropriate component from the Saskatoon MF radar. An extension of this comparison to two-dimensional wind analysis using SuperDARN meteor trail observations and MF wind measurements was the motivation behind this paper. The global extent of the SuperDARN radars and the potential for additional neutral wind measurements was another factor.

2. SuperDARN Wind Analysis

As the SuperDARN radars have been optimized for ionospheric scatter it will be present and must be eliminated. The meteor trail data selection criteria are simple at this point. The best criterion for this is to restrict the analysis to near-range gates as already mentioned above and as discussed in more detail later. In an effort to further divide meteor trail and ionospheric scatter observations, histograms of S/N (signal to noise) and $|V_r|$ (radial velocity with respect to the radar), along with parameters such as height (calculated from elevation angle and range and assuming the echo is from the center of the range gate), spectral width, and elevation angle, were plotted against range gate. Unfortunately, there were no readily apparent differences to enable the division of these histograms into meteor trail and ionosphere scatter observations. Nevertheless, based on the expectation that neutral wind velocities are less than $\sim$ 100 m/s below 100 km [*Meek et al.*, 1997], only observations where $|V_r| < 100$ m/s were selected. Only data with S/N > 3 dB were used to reduce the effect of noise.

Calculation of a two-dimensional wind vector requires a two-dimensional distribution or grid of velocity data. The ranging and azimuthal scanning properties of a SuperDARN radar give such a grid of radial velocities, with a grid point defined by a given range gate and azimuth. In addition, the angle of arrival or elevation angle is required to determine the meteor trail height and the horizontal wind magnitude. However, it will be shown that inclusion of this latter parameter can be relaxed, and in fact ignored, if the angle-of-arrival information is effectively unavailable or if the height resolution is not adequate. It will be demonstrated (section 4) that the majority of meteor trail echoes can be assumed to come from an altitude of $\sim$ 95 km, an assumption still used by several VHF CW radars.

Refraction can be significant at HF frequencies and, in fact, is essential for the F-region monitoring for which SuperDARN was designed. The meteor trail echoes occur predominately in and below the lower E region (i.e., $\sim$ 95 km) where refraction or ray bending is not significant. The daytime E region will cause the greatest refraction, but ray-tracing calculations indicate that even this is negligible at the near ranges used in this study. Under geomagnetically disturbed conditions refraction will be more significant, but then coherent (ionospheric) scattering will completely dominate over meteor trail scattering. These ionospheric scatterers act as contamination for the wind analysis, and an attempt has been made to exclude them using the previously mentioned meteor trail echo selection technique.

In this paper we are interested in long-term averages, i.e., seasonal changes in the diurnal variation (e.g., tidal oscillations). There are two approaches to calculating these long-term wind averages: (1) calculating hourly wind vectors using a least squares fit and then averaging these vectors over a period of a few weeks or (2) collecting all meteor trail measurements for a particular hour of day over a period of a few weeks and then calculating the hourly wind vectors from a single least squares fit. The latter technique is preferred because the first technique can lead to noisy hourly wind vectors if only a few meteor trails are detected during the hour. Either way, the "mean-day" analysis should essentially eliminate any nondiurnal variations. Harmonic analysis of these wind vectors then provides tidal amplitudes and phases.

The presentation is as follows: Section 3 compares winds from the Saskatoon MF and SuperDARN radars; in section 4, interferometric height resolution problems are dealt with by careful data selection; then in sections 5 and 6 this methodology is applied to all the Northern Hemisphere SuperDARN radars for periods in September and December 1997, respectively.

3. Saskatoon SuperDARN/MF Comparison, September 1997

The Saskatoon MF radar is located $\sim$ 35 km west of the Saskatoon SuperDARN site. However, since the MF radar samples vertically and SuperDARN obliquely, the separation between sampled regions amounts to $\sim 2°$ in longitude and $\sim 1°$ in latitude. Fortunately, there is considerable agreement on neutral wind measurements over this spacing of $\sim$ 500 km as indicated by *Hall et al.* [1997]. For this data set the SuperDARN range resolution was 45 km. Initially, data from the first four range-gates (165–300 km) and with elevation angles > 15° (height depends on the range gate and elevation angle) were used. At the interferometer spacing of 100 m (five wavelengths at 15 MHz), elevation angles cannot be determined unambiguously beyond the first grating lobe ($\sim$ 38° for the radar frequencies used at Saskatoon). We expect the directionality of the antenna array, the limited height of the meteor trail echo layer (say 80–100 km), and the range gates selected ($\geq$ 165 km), to significantly limit scatter from greater elevation angles (but not eliminate it completely).

Figures 1 and 2 compare MF and SuperDARN radar winds, respectively, at a height resolution of 3 km (this is the MF radar height resolution) calculated over a 2-week period of SuperDARN "common time" data (i.e., 45-km range gate and 7 s temporal resolution) from September 1997. This period was chosen because the tides, especially the semidiurnal tide, are invariably large at this time of year. The SuperDARN heights

(a)

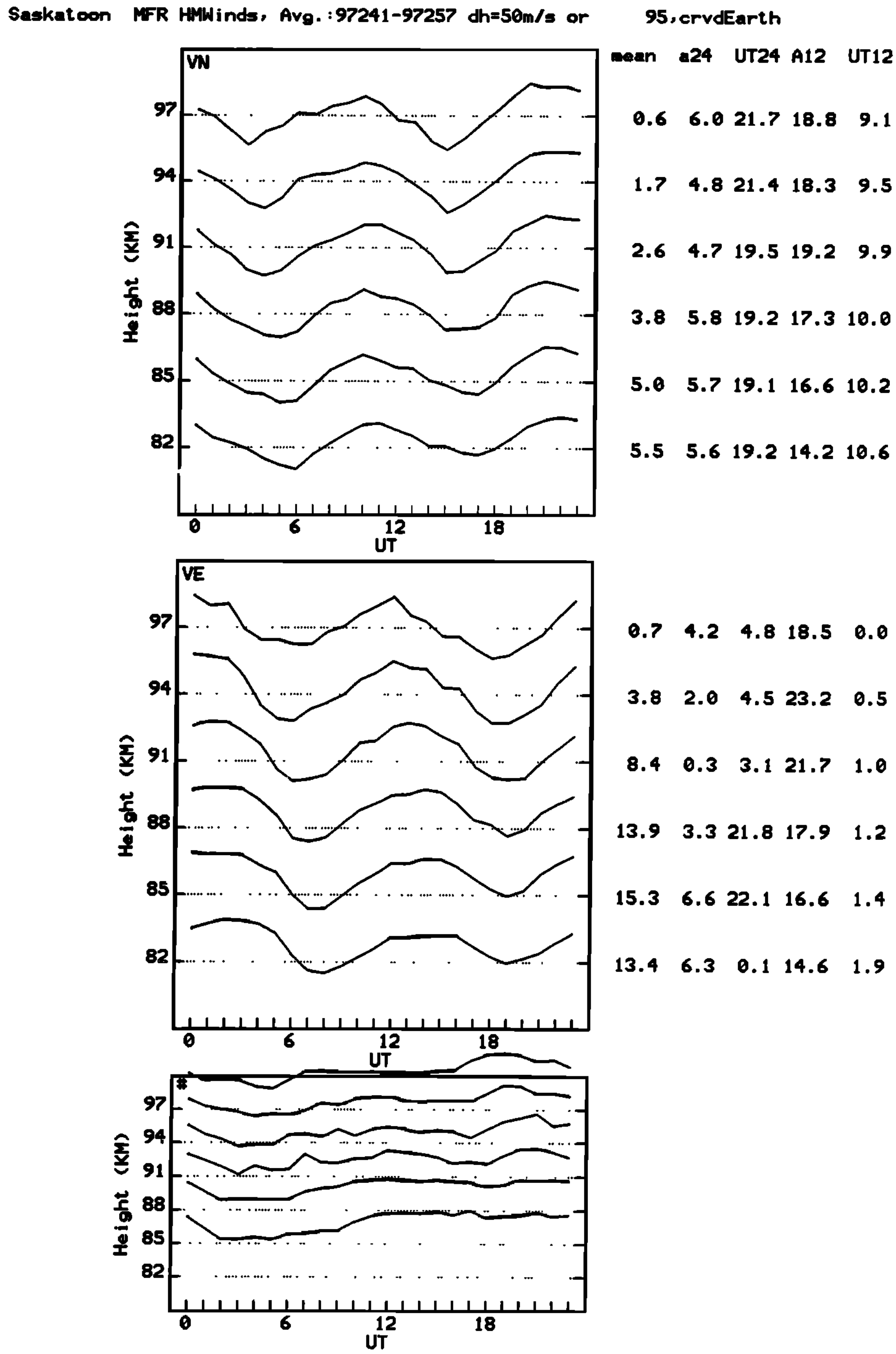


Figure 1. (a) Saskatoon MF radar 24-hour northward/eastward mean wind profiles from 82 to 97 km (3-km resolution) calculated for the period August 29 to September 14, 1997. The top and middle panels present the NS and EW wind velocity components, respectively (distance between height ticks is 50 m/s), and the bottom graph presents the number occurrence of MF observations per hour of day (distance between height ticks is 95 values). Immediately to the right of the wind component graphs (top and middle) are the height-tabulated tidal fits to the "mean day." From left to right: 24-hour mean wind (m/s), amplitude (m/s), and phase (hour, UT, of northward/eastward maximum) of diurnal (24-hour) and semidiurnal (12-hour) tides. (b) Wind vectors for the data presented in Figure 1a.

(b)

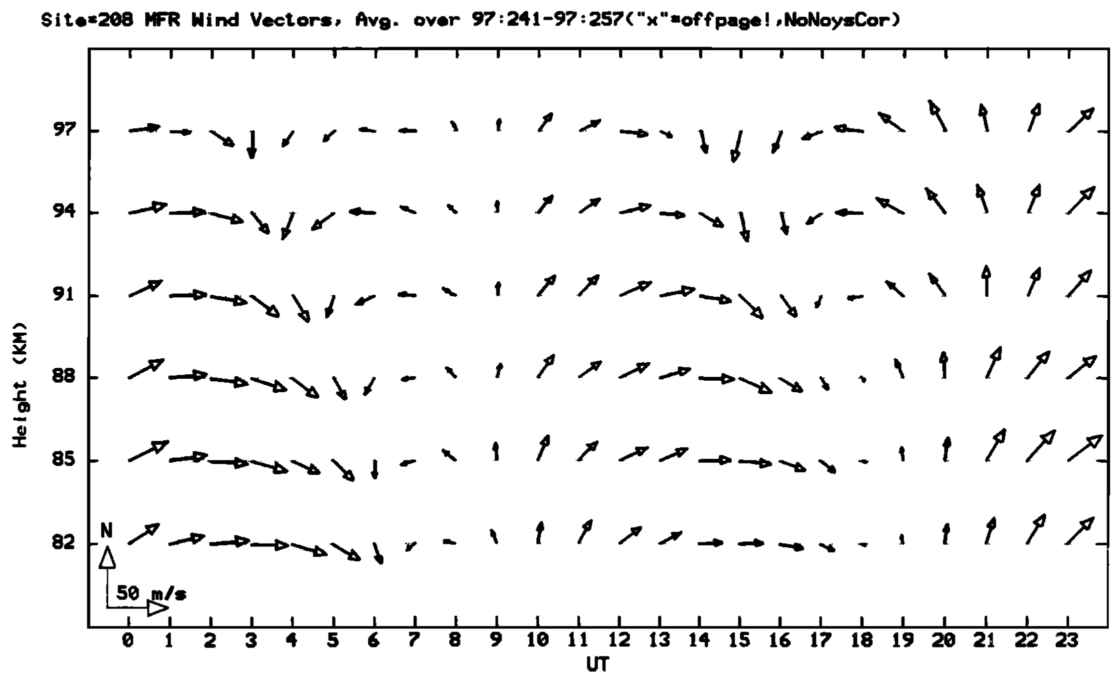


Figure 1. (continued)

were calculated using the range gate and elevation angle information with a correction for curvature of the Earth ($R_e = 6365$ km); ray bending was assumed to be negligible at the nearest ranges as stated above. Time sequences for a mean day are shown for each wind velocity component (NS, EW) with tidal fit values tabulated on the right (Figures 1a and 2a) and also vector plots of winds (Figures 1b and 2b).

The MF radar data clearly show a semidiurnal tide vertical wavelength (downward phase propagation) of $\sim$ 100 km. However, little height variation is seen in the SuperDARN wind data, although the tidal fits do show phase/time variations in the same sense as those for the MF radar. This lack of height variation for SuperDARN may be explained by the fact that for typical elevation angles the height resolution, as opposed to the range resolution, was 15–20 km (this is the difference between the geometric heights of the ends of a range bin). It is possible, however, to set the range-gate resolution at 15 km rather than the normal 45 km during "discretionary time" (periods when the SuperDARN radars may be operated in a different mode from that during "common time") at individual radars. For such a case the height resolution is then $\sim$ 5–10 km, much closer to the height resolution of the MF radar and as such better able to show phase/time variations with height. Currently, the number of such discretionary days are few, and comparisons will require a year of SuperDARN observations.

Figure 2a shows that the eastward wind component is noisier than the northward component. This would be expected from the observing geometry associated with the Saskatoon SuperDARN radar. The viewing direction or antenna heading of the Saskatoon SuperDARN is 23.1° east of north, and so the radial Doppler velocity is influenced most strongly by the wind component in this direction. The perpendicular wind component effectively depends on differences in these radial velocities over the 16 beams, which is only a spread of $\sim$ 52°. There is additional variability induced in the velocities by assuming that the center of the geometrical beam in which the meteor trail echo is seen is its azimuth. It is possible that a strong meteor trail echo in an adjacent beam could also be seen. However, as mentioned previously, the elevation angle is unlikely to be ambiguous.

The best wind agreements, based upon the phases of the 12-hour tidal oscillations in Figures 1a and 2a and also the wind vectors in Figures 1b and 2b, are seen to be near 94 km where the meteor trail occurrence is expected to peak. The harmonic fits to the 12-hour tide, as tabulated in the figures, also show excellent phase agreement near 94 km, and the phase differences between the NS and EW maxima (northward, eastward) are close to 90° ($\sim$ 3 hours) for both radar systems. This is very typical of the 12-hour tide at 52° N [*Manson et al.*, 1989].

It is worth noting that there have been many comparisons between neutral wind measuring systems [e.g., *Manson et al.*, 1996; *Meek et al.*, 1997] (MF radar versus Fabry-Perot interferometer (green and OH lines) and satellite data (HRDI-UARS)); *Manson et al.* [1992] (MF radar versus rockets and VHF/EISCAT systems); and *Turek et al.* [1995] (HF radar versus incoherent scatter radar). The former ground-based optical-radar

(a)

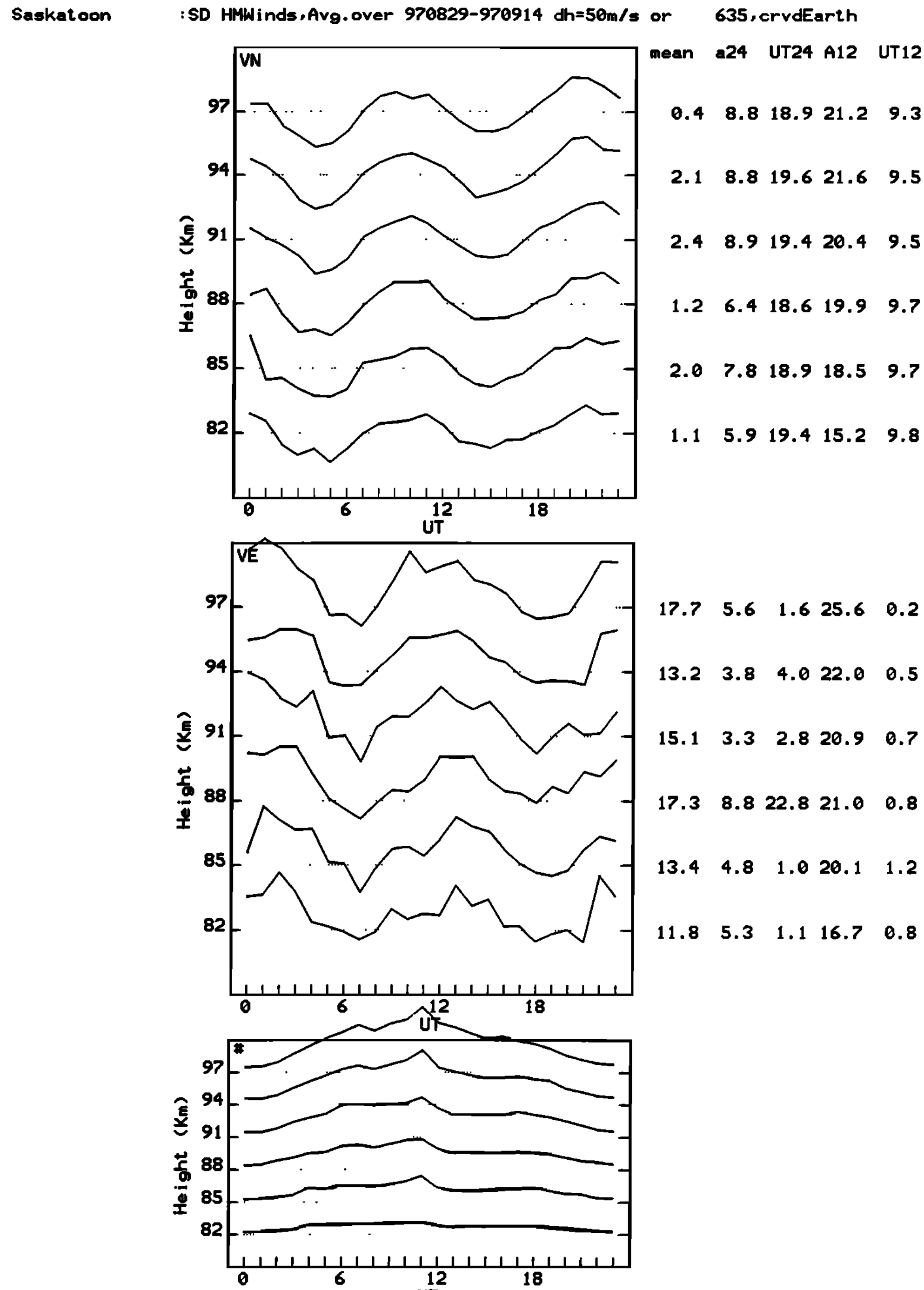


Figure 2. Presentation format is identical to Figure 1 except here the winds are calculated using meteor trails from the four nearest range gates (45 km resolution) of the Saskatoon SuperDARN radar.

comparison showed very good phase agreements, and no speed bias, while satellite and the latter Tromsø (VHF/EISCAT) comparisons showed the MF radar velocities to be lower by 15–35%. For this comparison the differences are consistent with the previous comparisons, showing the MF radar speeds (based on means of the 12-hour oscillations) to be smaller by ~ 10%. This small difference is not significant considering that the MF data are not noise corrected and that at this stage a careful investigation of potential biases in the SuperDARN results has not been made. Also, the variations in tides over the ~ 350 km separation of the Saskatoon MF and SuperDARN radar scattering volumes are expected to be smaller than this difference [*Hall et al.*, 1995].

4. Elevation Angle Considerations

Beyond the 45-km range-gate resolution consideration, there were further concerns with regard to the

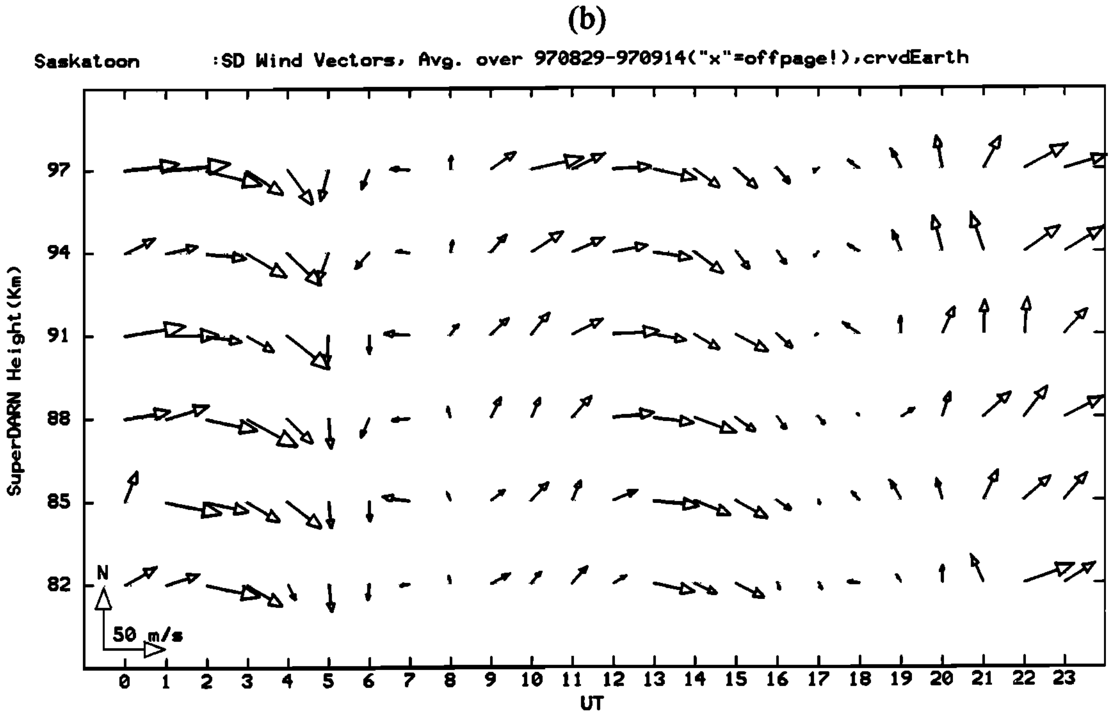


Figure 2. (continued)

angle-of-arrival or elevation angle measurements at some of the Northern Hemisphere SuperDARN radars. As such, histograms of elevation angles, signal strengths, radial velocities, and spectral widths were plotted for each of the near range gates (gates 1 to 4). The elevation angle distributions indicated the likelihood of calibration problems with the interferometers at some of the sites. This was especially so at the first two ranges, which are essential to our meteor trail study, at some SuperDARN radars. These systems will be further checked and calibrated in the near future.

As a result of this, it was decided, especially since height resolution is lacking even with reliable interferometer data, to combine all meteor trail data at a given SuperDARN radar and use this information for a single-height wind product. Investigation into the best method for this purpose was accomplished using the Saskatoon SuperDARN data.

A variety of methods were tried: (1) using the local interferometer to select all meteor trails in range-gates 1–4 with heights 82–97 km and averaging the results, (2) assuming 95 km as the meteor trail height and using only range-gates 1–4 to obtain elevation angles, and (3) modifying method 2 by using the first two ranges only. In method 2, only meteor trail echoes having interferometer elevation angles (i.e., consistent cross correlations) were used, while in method 3 all meteor trail echoes were used.

In each case the product was compared with the MF radar winds for all height gates. The final comparison is shown in Figure 3 where the SuperDARN time series (NS, EW), calculated according to analysis method 3, are plotted against all MF radar height data. The sequences are, as expected from Figures 1 and 2, in excellent agreement near-MF radar heights 94–97 km according to the phase differences for the 12-hour oscillation. The harmonic fit values confirm this, giving a 9.5 hour UT NS phase (time of maximum northward flow) for both the Saskatoon SuperDARN radar (not listed in Figure 3) and the Saskatoon MF radar (from Figure 1a) at 94 km.

The results for the Saskatoon SuperDARN wind measurements shown in Figure 3 using method 3 were very similar to results obtained using methods 1 and 2, which did use elevation angles either directly as in method 1 or as an (unused) product of the interferometer (method 2). As such, the advantages of the chosen method are clear. The results use no interferometry data, and as such may be used for all SuperDARN radars. As range-gates 3 and 4 are more likely to contain significant E-region coherent scatter, deleting them is a way of rejecting nonmeteor trail echoes. At this time there is no automatic method of eliminating such echoes on the basis of their characteristics. This will be explored at some length for a later seasonal study.

5. Global SuperDARN Comparison, September 1997

Using the first two range gates and an assumed meteor trail scattering height of 95 km, as discussed in section 4, winds were calculated using all the SuperDARN radars in the Northern Hemisphere. Plots of the NS and EW components for a mean day of the September

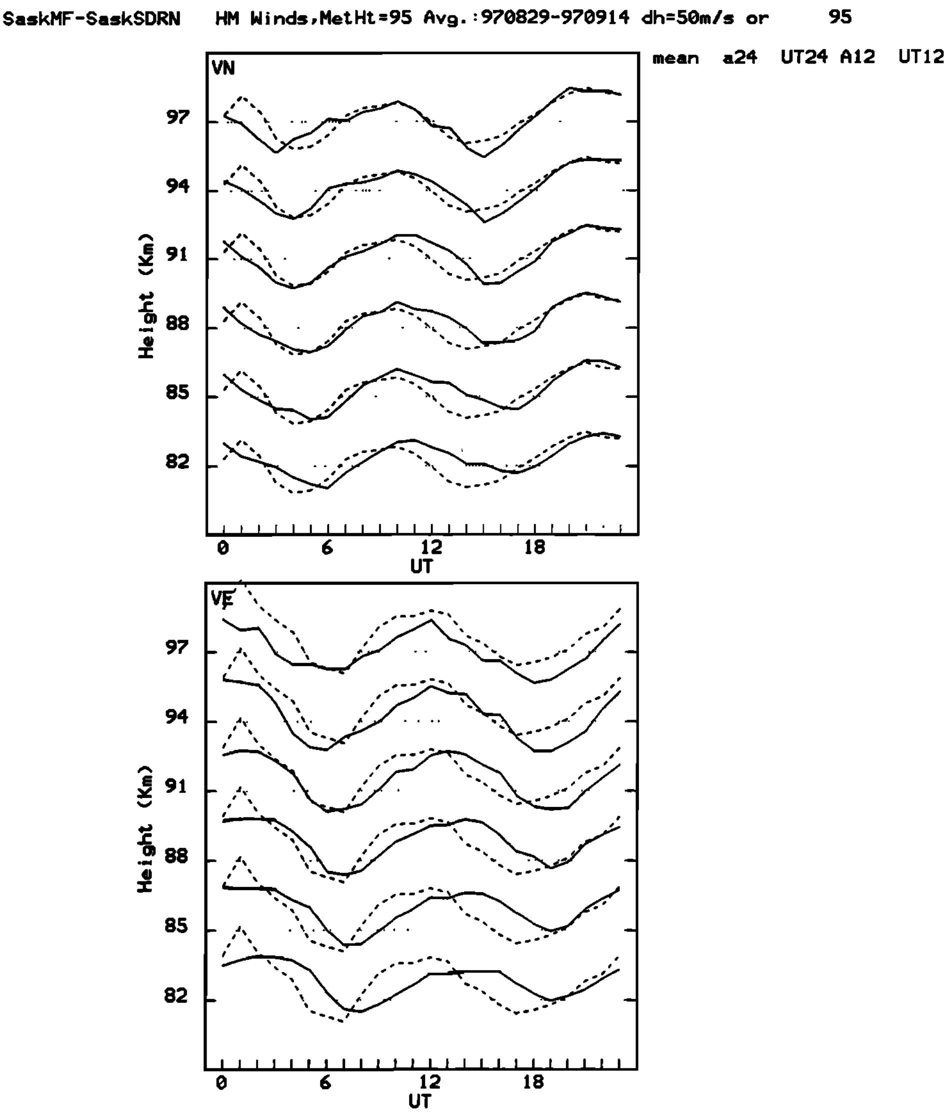


Figure 3. Comparison of Saskatoon MF (solid lines) and SuperDARN (dashed lines) wind measurements for the period August 29 to September 14, 1997. The top and bottom panels are for the NS and EW wind components, respectively. Here the SuperDARN winds were calculated using the first two range gates only and by assuming all meteor trails in these gates are at 95 km altitude.

interval (August 29 to September 14, 1997) are shown in Figure 4. The tabulated harmonic fit values (12- and 24-hour tidal oscillations) are also included immediately to the right of the plots. In these plots the local time (LT is based on station longitudes) is used for the time axis since LT governs the development of the locally observed tide (providing it is migrating-mode dominated). The latitudes of the six Northern Hemisphere SuperDARN radars vary from 51° to 64°.

The similarities in oscillation phases are considerable; the 12-hour tide dominates at all six SuperDARN radars. The mean amplitudes/phases for the NS and EW components are {20.9±6.5 m/s, 3.13±0.66 LT} and {20.2±8.4 m/s, 5.53±0.77 LT}, respectively. These amplitude/phase values obtained using the SuperDARN radar are quite similar to longitudinal variations shown by *Jacobi et al.* [1999] who used five MLT radars (MF, meteor, LF radars) between Sheffield (2°W) and Kazan (49°E) plus Saskatoon.

It is clear that for the interval 1200–2400 LT, when the meteor trail counts are low, the sequences are much noisier. In Figure 5 the vector plots show this even more clearly; here the vector directions are very similar at all radars for 0000–1200 LT but increasingly erratic after 1200 LT. It is to be noted that useful consistency, with clear tidal oscillations, are available from just 17 days of data when the average number of meteor trail observations (Figure 4) are quite large. It appears that tidal variability and planetary wave effects will be resolvable using even shorter data sets.

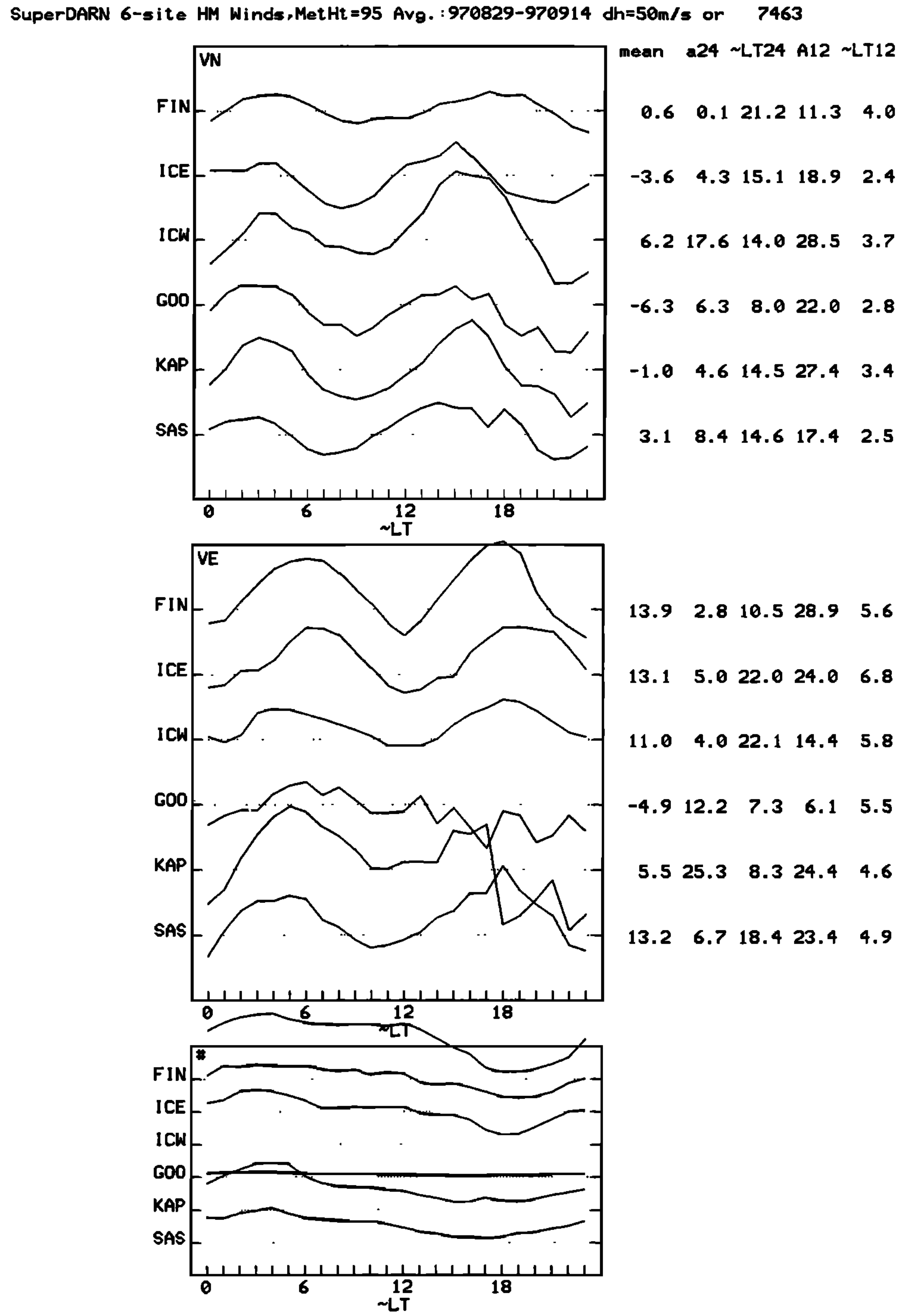


Figure 4. Twenty-four-hour mean wind profiles expressed in local time (LT) to the nearest hour for all six Northern Hemisphere SuperDARN radars for the period August 29 to September 14, 1997. The top and middle panels present the NS and EW wind velocity components, respectively, and the bottom panel presents the number occurrence of meteor trail observations. In the bottom graph the tick for each radar site represents zero, and the distance between adjacent ticks is 7463 meteor trail observations (per hour of day). Note the decrease in number occurrence around 1800 LT as would be expected. The tabulated tidal fit values have the same meaning as in Figures 1 and 2 except they are expressed in local time.

Lastly, since the Tromsø MF radar (70° N, 19° E) is close to the Hankasalmi, Finland, SuperDARN radar, we show comparisons in Figure 6 of all MF radar heights with the single-layer average winds calculated for the Finnish SuperDARN radar as presented in Figure 4. The latter wind data are merely copied to each MF height to facilitate comparison. Generally, the SuperDARN NS amplitudes/fits are favored because of

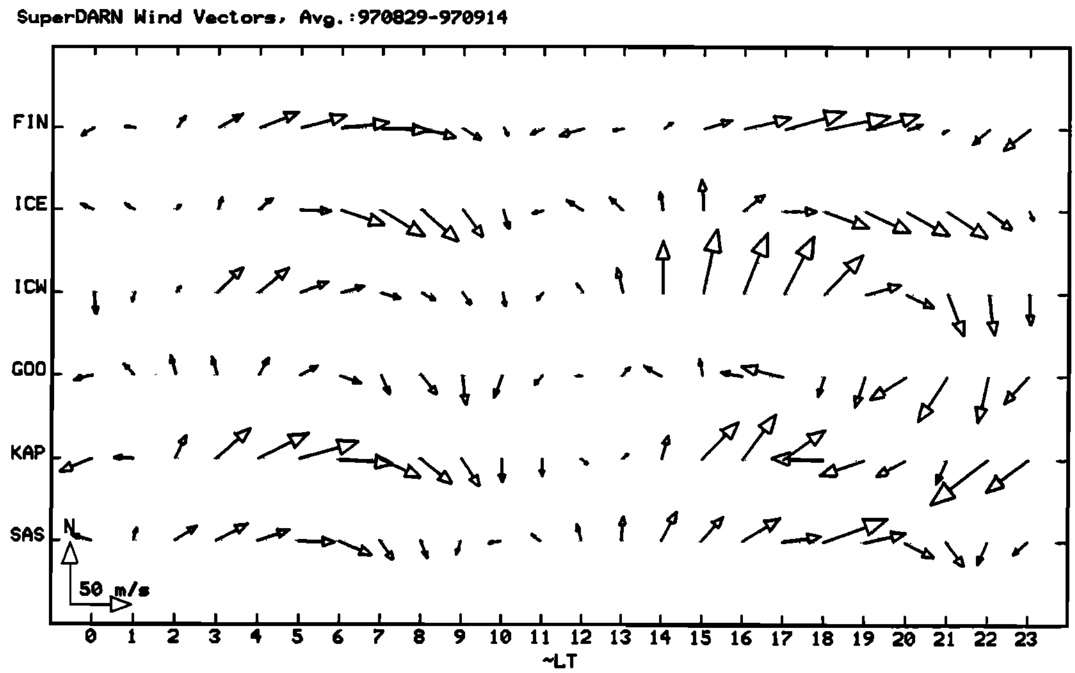
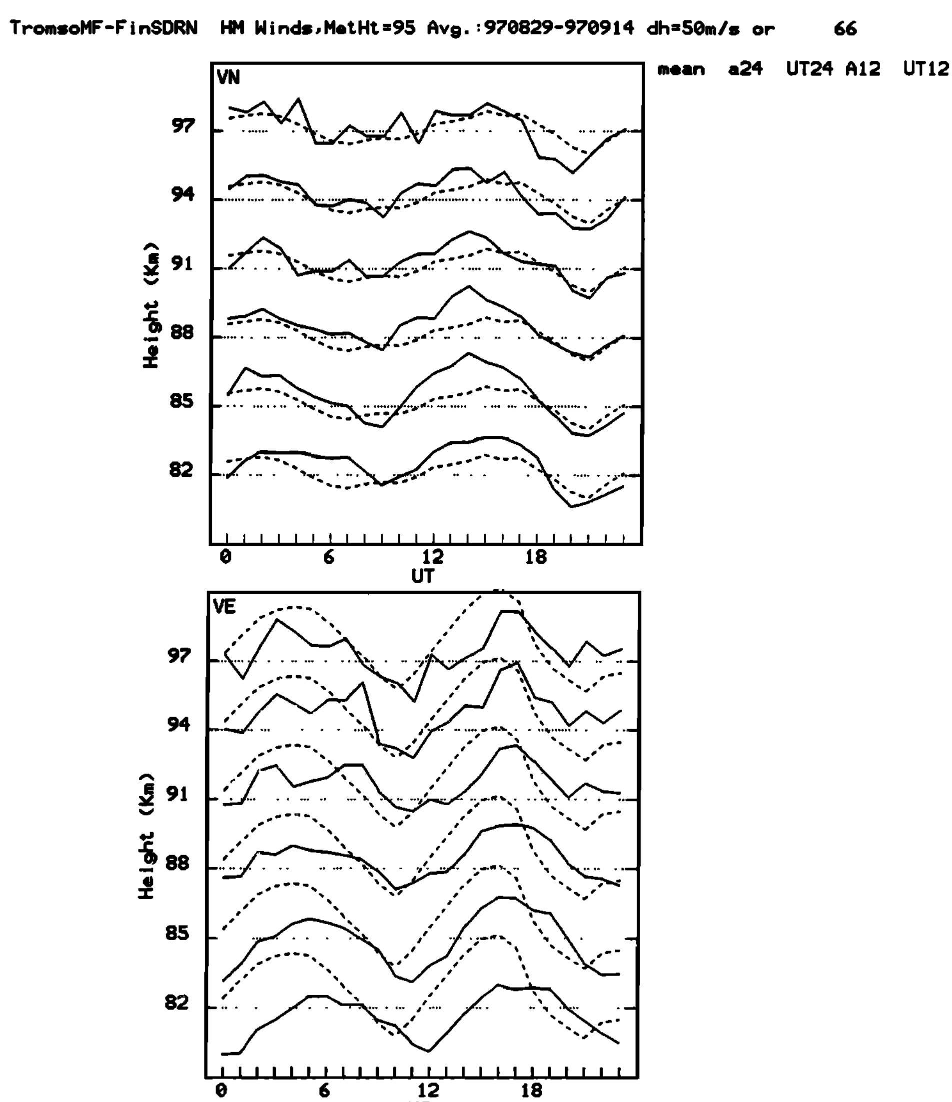


Figure 5. Wind vector plots for six Northern Hemisphere SuperDARN radar observations presented in Figure 4.



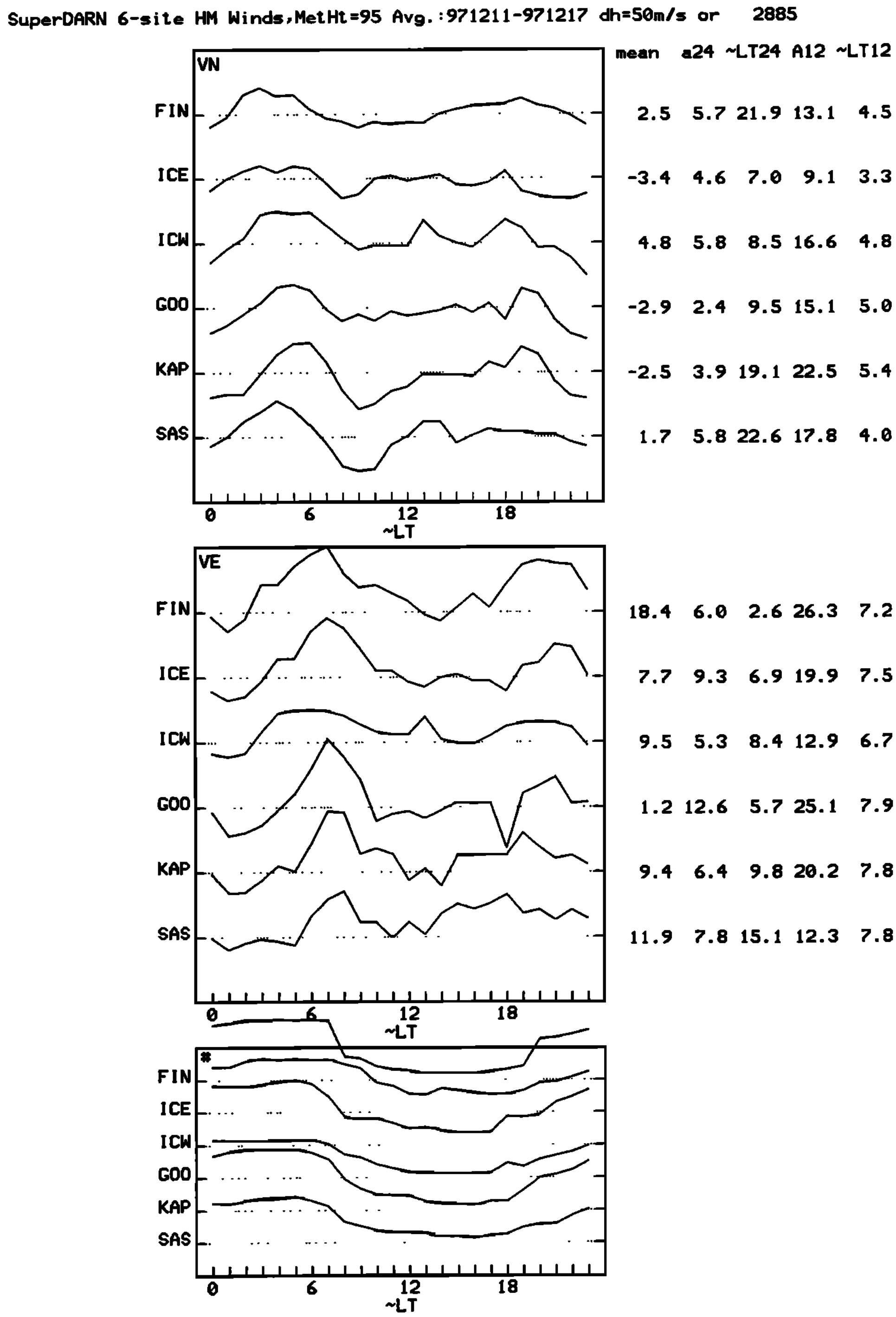


Figure 7. Twenty-four-hour mean wind profiles expressed in local time (LT) for all six Northern Hemisphere SuperDARN radars for the period December 11 to 17, 1997. Format is identical to that in Figure 4. In the bottom panel the tick for each radar site represents zero, and the distance between adjacent ticks is 2885 meteor trail observations.

Figure 6. (opposite) Comparison of Tromsø MF (solid lines) and SuperDARN (dashed lines) wind measurements for the period August 29 to September 14, 1997. The top and bottom panels are for the NS and EW wind components, respectively. Here the SuperDARN winds were calculated using the first two range gates only, and it is assumed all meteor trails are at 95 km altitude.

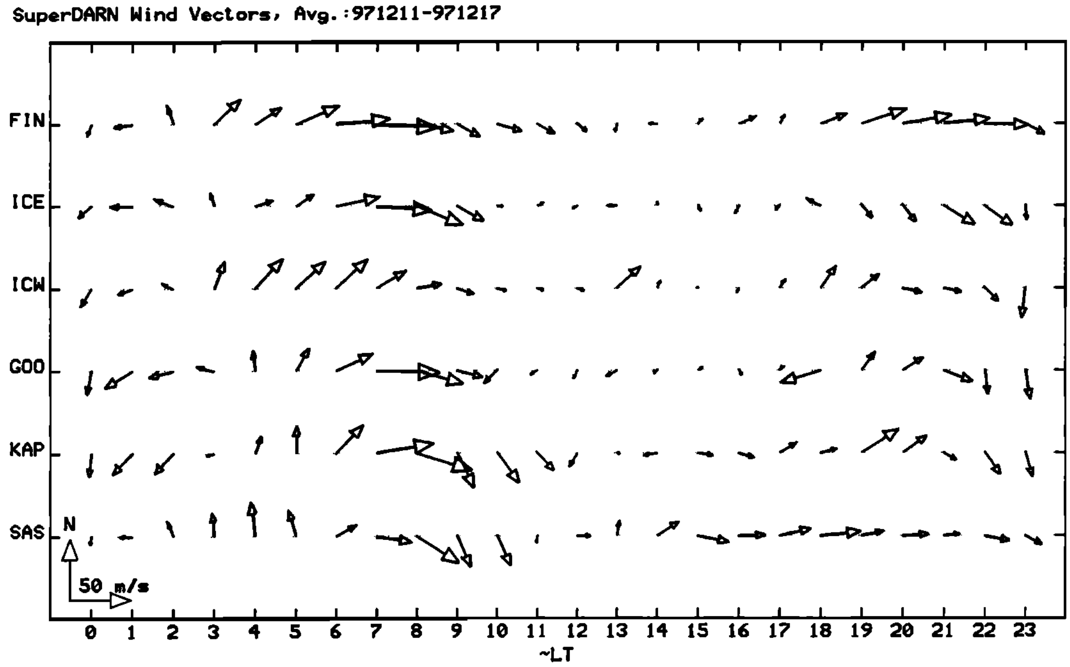


Figure 8. Wind vector plots for six Northern Hemisphere SuperDARN radar observations presented in Figure 7.

the northward looking orientation of the radar. Once again, there is a reasonably good agreement between the MF and the SuperDARN observations; the differences mininize near 94–97 km (the MF radar data yield is quite low above 91 km, and the time variability increases there).

6. Global SuperDARN Comparison, December 1997

The same methodology as that presented in section 5 has been used for a more limited sample of only 7 days in December 1997 (December 11–18) and the analyses are presented in Figures 7 and 8. The semidiurnal tidal amplitudes are known to be somewhat smaller in December than in September as well [*Manson et al.*, 1989, 1999]. This expectation is met by Figures 4 and 7.

Nonetheless, the SuperDARN time sequences are apparently quite robust, although both components and especially the EW one are noisier than in the September data. The average NS/EW phases for the 12-hour tidal oscillations are indeed in quadrature (4.5 ± 0.75 LT, 7.5 ± 0.46 LT). Again, the vector plots in Figure 8 show greater variability in the latter half of the day. In this case, the data yield from meteor trails minimizes from 1000 to 1800 LT. The direct Tromsø MF–Finland SuperDARN radar comparison is again satisfactory (not shown) despite the MF radar having its best data when the SuperDARN data were the weakest. The amplitudes/phases for the 12-hour tidal oscillation were {13.1 m/s, 4.4 LT} / {15.2 m/s, 7.1 LT} NS/EW at 97 km compared to {13.1 m/s, 4.5 LT} / {26.3 m/s, 7.2 LT} NS/EW for the SuperDARN radar. As well, the Saskatoon MF radar amplitudes/phases at 95 km for the NS and EW components are {17.0 m/s, 4.6 LT} and {15.0 m/s, 7.2 LT} respectively. These values are in reasonable agreement with those of the Saskatoon SuperDARN (Figure 7) of {17.8 m/s, 4.0 LT} and {12.3 m/s, 7.8 LT} respectively.

7. Summary and Conclusions

Although SuperDARN radars were designed to detect coherent scattering from plasma irregularities in the ionosphere (specifically the *F* region), they also detect scatter from meteor trails in the *D*- and lower *E*-regions. This gives the opportunity to use the large network of SuperDARN radars, in addition to MF wind radars for example, for tidal and planetary wave wind studies.

This paper significantly extends the initial comparison of *Hall et al.* [1997], wherein it was shown that line-of-sight SuperDARN meteor trail measurements, which drift at neutral wind velocities, correlated well with the corresponding wind component determined using MF radar measurements. Here the two-dimensional aspect of the SuperDARN data (scanning in azimuth and range), using the near range-gates which are dominated by meteor trail echoes, was used to generate two-dimensional wind vectors over the meteor trail height extent. For the simultaneous global data the SuperDARN echoes were combined into one assumed meteor trail echo layer because some sites did not have reliable elevation measurements for this study.

A comparison of the Saskatoon SuperDARN radar, which does have elevation data, with the nearby MF wind radar showed good agreement between the two systems at about 94 km; however, there was little height variation seen in the SuperDARN analysis, although the variations were in the same sense as those for the MF radar. The lack of height variation is due to the fact that the SuperDARN is an oblique looking radar with a range resolution of 45 km in normal operation mode, which translates into a height resolution of 15–20 km for typical elevation angles, i.e., the entire vertical extent measured by the MF radar. Because of this (and other reasons concerning ionospheric research) a new 15-km range resolution mode with an average height resolution of $\sim$ 5–10 km is being run during "discretionary time." This has only recently been initiated, and since "discretionary time" is limited, it will take some time for a sufficient data set to be collected for such an analysis.

At this time, not all the SuperDARN sites have completely calibrated interferometer systems. For a global tidal and planetary wave study (Northern Hemisphere only in this paper), one wants to consider all sites at once. Nevertheless, it was found that assuming a meteor trail height of 95 km for all SuperDARN measurements allows for an analysis which can be applied to data from all SuperDARN sites. Such an analysis using 8–17 day intervals was performed for all the Northern Hemisphere SuperDARN radars (separated in longitude by $\sim 90°$), and the results obtained were consistent with expectations: (1) the 12-hour tide dominated the wind field, (2) September 12-hour tides were larger than those in December, and (3) longitudinal variability was consistent with the more limited studies using MF and meteor trail radars.

The results were more erratic during the 1200–2400 LT period. This is a result of the reduction of meteor trail echoes during this time and also due to some contamination by coherent plasma wave scattering from the E-region. If it were possible to select "good" hours, i.e., periods without ionosphere echoes, the tidal analysis would be improved. This could be accomplished by visually examining range-power or range-radial velocity plots, but it would be much more practical to have an automatic selection process. Efforts in this direction will proceed as the 15-km range resolution data are being accumulated. An automated process might not be perfect and would probably reject some meteor trails, but there are many available. Anything that selects meteor trails over ionosphere coherent scatter on the average would be helpful.

The SuperDARN meteor trail wind data have already been designated as part of the SCOSTEP's PSMOS (Planetary Scale Mesopause Observing System). This was done on the basis of the first published paper by *Hall et al.*, [1997]. One of the main themes of PSMOS is investigation of the longitudinal variation of tidal amplitudes and the effects upon these tidal oscillations by planetary and gravity waves. These first tidal studies using the SuperDARN network have shown the potential of these data. Further studies, using data from all seasons and months and improved operations, e.g., 15 km range resolution, removal of ionospheric scatter, are in progress.

Acknowledgments. The authors would like to thank Matthias Huber for helpful discussions and SuperDARN data analysis. The financial support of the Natural Sciences and Engineering Research Council and Atmospheric Environment Service, both of Canada, is gratefully acknowledged. The University of Saskatchewan, through the Institute of Space and Atmospheric Studies, has also supported this work.

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(Received June 8, 1999; revised January 24, 2000; accepted April 9, 2000.)