2-DIMENSIONAL FLOW VECTORS FROM 3 PAIRS OF SUPERDARN RADARS IN THE SAME IONOSPHERIC REGION

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Abstract

Three SuperDARN radars look over a large common area in Antarctica. This allows the determination of 2-dimensional flow ionospheric flow vectors in the same volume from different pairs of radars. Using this opportunity we compare the results of the three possible pairs of radars for several periods between March and September 1999. Generally we find reasonably good agreement between the three pairs. However, there were a few periods during which the 2-dimensional velocity vectors derived from the three different pairs did not agree. The implications of this will be discussed in detail.

Introduction

During the last few years the SuperDARN network of HF ionospheric radars has become a major contributor to the ionospheric monitoring effort. SuperDARN is ideal for monitoring the high-latitude ionosphere on a continuous basis, as the radars have a large field of view and are almost all deployed in pairs, overlooking the same area. This allows the derivation of 2-dimensional velocity vectors for the ionospheric convection, thus enabling true convection vectors to be derived. All radars are of identical design, using the frequency band between 8 and 20 Mhz. The antenna array consists of 16 antennae, which are operated as a phased array, producing 16 beams of about 3.3 degrees width, aligned to the magnetic meridian. Under good conditions return signals from a distance larger than 3000 km can be detected. Thus a field of view of about 4 million square kilometers can be monitored continuously. For a detailed description of SuperDARN and the radar operations see references [1]-[3].

The unique configuration of three HF radars in Antarctica looking over a large common area has been utilised to derive 2-dimensional convection velocity vectors for the same ionspheric region using three different pairs of radars. The radars at Halley, SANAE and Syowa South radars, are operated by the British Antarctic Survey, the South African National Antarctic Expedition and the National Institute for Polar Research of Japan at Syowa, respectively. Fig. 1 shows the fields of view of the three radars, indicating the area which is seen by all three radars.

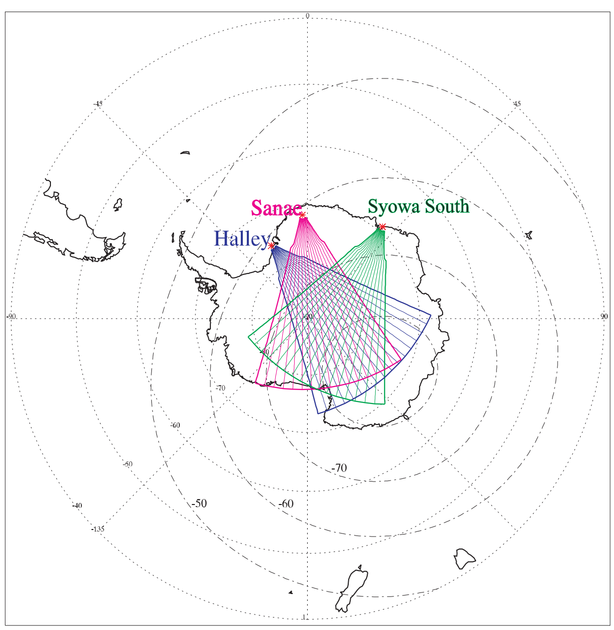

Fig. 1: Fields of view of the radars making up the Antarctic triple.

Three different sets of 2-dimensional ionospheric convection velocity vectors in the same region of the high-latitude ionosphere were derived. These sets are compared to each other and to what one would expect for the polar ionosphere convection at the time of the observations. A detailed analysis of the findings is made and their implications are discussed.

Observations and Discussion

169 2-hour periods were initially selected from the summary plots of the three radars from data recorded between 18 March and 14 September 1999. The former date is determined by the resumption of operation of the Syowa South radar, the latter date being the date of major damage to the SANAE radar antenna array due to high winds. All periods during which one of the three pairs did not produce common vectors (10 periods) were excluded, as were all periods during which the radars were not operating in "common mode", the standard mode of operation of the SuperDARN network (77 periods). All other periods were used to produce so-called merge plots, which are plots of the 2-dimensional velocity vectors derived using the line-of-sight velocities from the two radars in each pair. These remaining periods are spread over the months March to June 1999 and span the night sector of the auroral oval. During the period July to September 1999 the data from the SANAE radar were mostly not very good, partially due to the severe weather conditions experienced at SANAE during late winter and early spring.

In interpreting the results of the merging process, it is imperative to remember that the process assumes that the angle between two radar beams used for the calculation of the 2-dimensional velocity vectors is larger than 30 degrees. While this restriction does not pose any problems for either the Halley/Syowa South or the SANAE/Syowa South pair, the angle between the beams is less than 30 degrees for a large part of the common field of view of the Halley and SANAE radars, especially at great ranges. However, in general we find that the region of backscatter for Halley and SANAE lies closer to the respective station than the range for which the angle between the beams drops below 30 degrees.

Figure 2 shows 2-dimensional convection vectors for the period 6:16 – 6:32 UT on 8 May 1999. Shown are all vectors derived for the pairs Halley/SANAE (red), Halley/Syowa (blue) and SANAE/Syowa (green). The polar grid is a geographic grid, with the three geomagnetic latitude lines at 60^o, 70^o and 80^o shown as well. Comparing these plots to Fig. 1 we see that the area where common vectors are found is situated where the 3 radars see the same area closest to the radar sites.

Typically, as shown in Fig. 2, the flow velocities derived from the 3 pairs agree with each other and with the convection flow expected for the given conditions of the ionosphere. This means that we can have great confidence in the processes used to derive these flow velocities, and the consequent flow pattern. Also, typically, the three pairs do not produce flow vectors in exactly the same region, but rather in regions which are adjacent and sometimes overlapping. This is not neccessarily a draw-back as the data from the three radars can be used to increase the area for which 2-dimensional vectors are available.

In our data set there are however a few occasions when the flow velocities derived for the 3 pairs of radars do not agreewith each other. Fig. 3 shows the flow vectors for such a period (1:36 – 1:52 UT , 8 May 1999), colour-coded the same as Fig. 2. While in many ways very similar to Fig. 2, we see that the only the red vectors (Halley/SANAE) show the expected convection. The blue vectors (Halley/Syowa) show hardly any convection at all, whereas the green vectors (SANAE/Syowa) apper rotated by 90^o northward compared to the red ones. We conclude that for at least one radar the data recorded are not what they are assumed to be.

A few possible causes for this are a radar malfunctioning, operator error in setting up one of the radars, a large-scale precipitation event which has not been recorded elsewhere, or the fact that one (or more) of the radars receive strong signals from directions other than the radar's nominal field of view. A malfunctioning radar could certainly be an explanation. A careful inspection of the line-of-sight velocity plots for each radar of the pair as to the expected 2-dimensional velocity, yields in all cases qualitatively the same result as the merge plots, which seems to indicate that these vectors are real. The same conclusion can be reached by the observations that in at least one case the disagreement between the 3 pairs appears self-correcting. In this case, shown in Figs. 2 and 3, the flow vectors for the three pairs do not agree around midnight LMT (Fig. 2) whereas a few hours later they do agree with each other (Fig. 3). Similar, a check of the quality parameters produced by the merging process does not reveal any significant difference

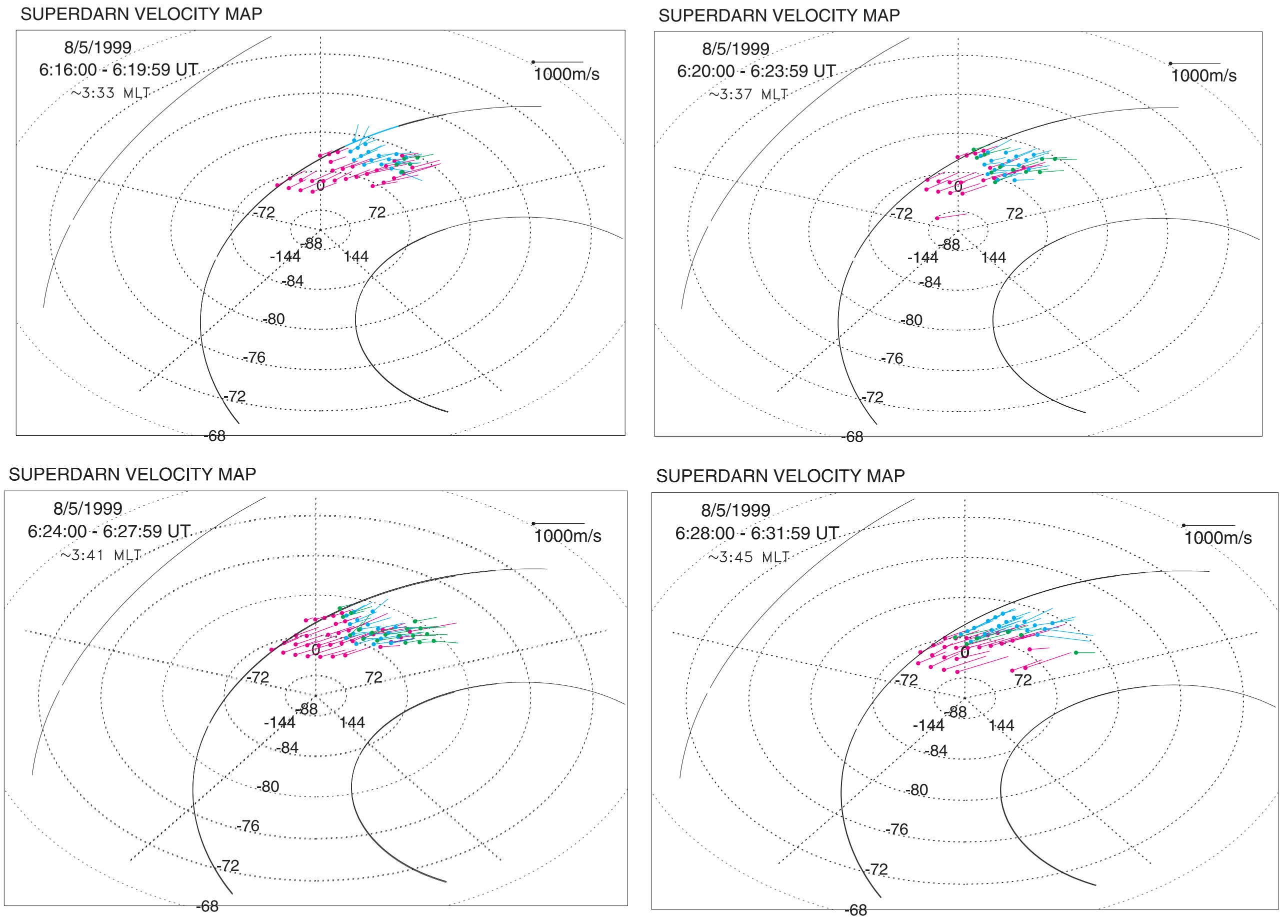

Fig. 2: 2D convection velocity vectors for 8 May 1999, 6:16-6:32 UT. The derived velocities agree fairly well with each other and expectations.The vectors are from the pair Halley/SANAE (red), Halley/Syowa (blue) and SANAE/Syowa (green). As can be seen the vectors do not occupy the exact same area.

between the periods where the vectors agree and those where the vectors do not agree. Also, an examination of the radar logs does not reveal that at any radar site there was a logged operator intervention to rectify errors in the setup or operaation of a radar. Which should reasonably exclude an operator error in setting up any of the radars, as in the case of the apparently self-correcting event an operator intervention would have been required to correct any error in setting up any one of the radars.

Similarly, a cursory evaluation of the precipitation necessary to produce the desired effects reveals that magnetic disturbances of the order of the Earth's magnetic field would be required. It seems quite ridiculous to assume that such an event would go unnoticed.

This leaves the last option as an explanation. The standard processing software obviously assumes that the ionospheric backscatter is received from the nominal field of view. If this is not the case then one or more of the three radars receives signals from other directions and the calculated velocity vectors do not make any sense at all, as the line-of-sight velocities are not measured in the same ionospheric region. Since neither of the 3 radars is equipped with an interferometer, it is impossible to say whether or not this explanation is in fact true. However, judging from other radars in the northern hemisphere, backscatter received from other directions is quite common. Therefore there is a strong possibility that under the correct ionospheric conditions strong backscatter may be received from either a sidelobe or from behind the radar. Thus we could reasonably assume this to be the case in periods where the convection vectors derived from the three pairs of radars overlooking the Antarctic continent do not agree.

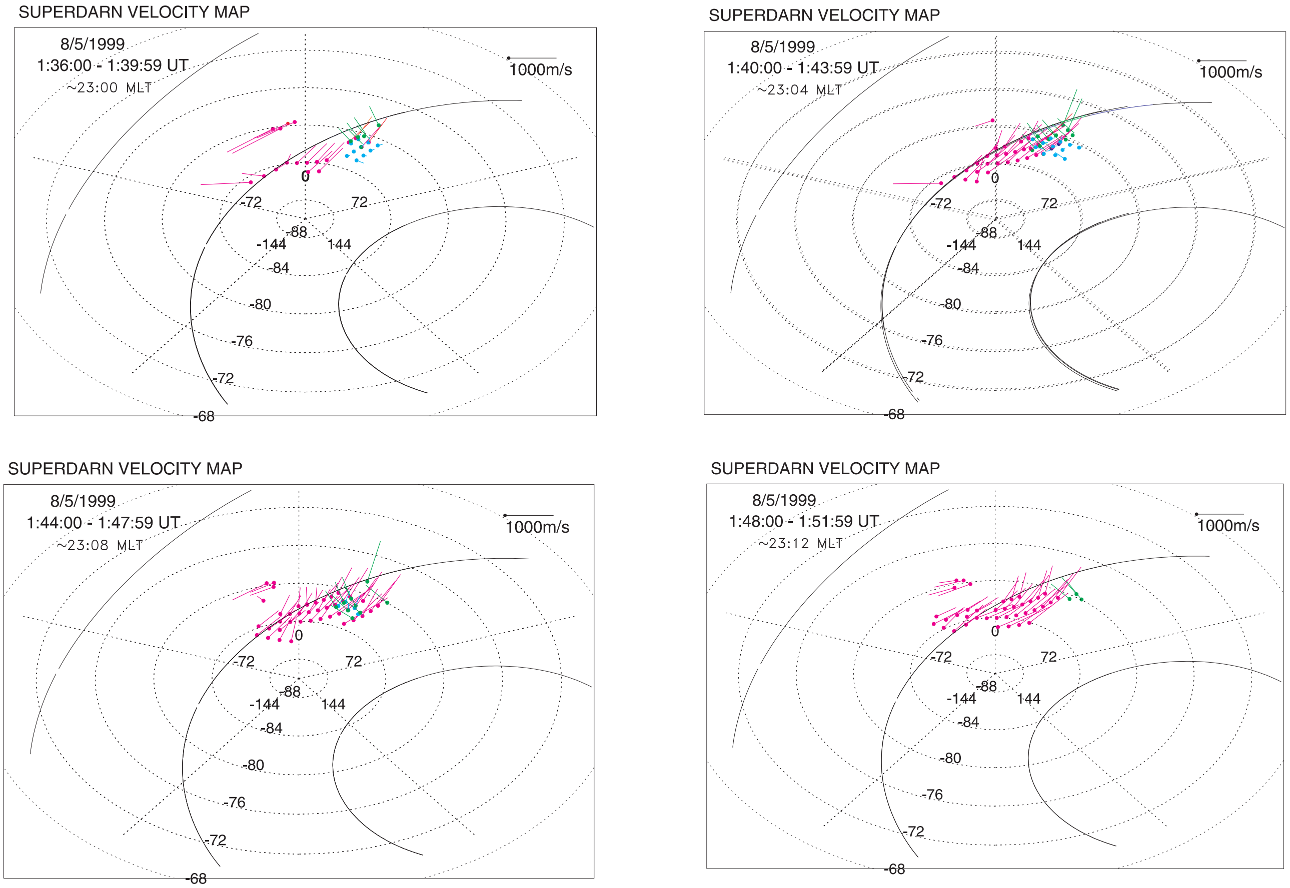

Fig 3: 2D velocity vectors for 8 May 1999, 1:36 – 1:52 UT. The vectors from the three pairs (colours as in Fig. 2) do not agree. While the red vectors agree fairly well with the expected convection flow, the blue vectors show hardly any magnitude and the green vectors indicate a flow at an angle of 90^o.

Conclusion

In conclusion, a large number of periods during 1999 were examined and 2-dimensional ionospheric convection velocities derived for the three radar pairs looking over the Antarctic continent. Typically we find good agreement between the different pairs and with the theoretical expectations. Mostly the three pairs do not produce vectors in identical locations, but usually in adjacent areas, which often overlap. This fact can be used to extend the region for which 2-dimensional velocities are available. In some cases the vectors of the three pairs do not agree. In this case a comparison of the 2-dimensional velocities could be used to determine when the backscatter received by a radar is not coming from the nominal field of view of that radar.

Acknowledgements

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References

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