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3.6B MESOSPHERIC MEASUREMENTS OF IRREGULARITY PATCHES USING A 3-ANTENNA INTERFEROMETER

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We have isolated three very interesting events of mesospheric radar returns to illustrate the potential of a three-antenna interferometer in the study of the neutral atmosphere. The first plot (Figure 1) shows contour plots of echo intensity and the presence of irregularities in isolated and well-defined regions. These measurements were carried out using the SOUSY radar in the Harz mountains in Germany, on September 9, 1980. The system frequency is 53.5 MHz. Local time is 2 hours in advance of Universal time. The irregularities wavelength is 2.81 m and the three arms of the interferometer were sampled with 167 ms of time difference.

To provide precise estimates of vertical velocities, the measured (radial) Doppler shift has to be corrected to subtract the contribution due to the horizontal motions. For near-vertical observations (zenith angle less than about 10°) it is readily shown that the rate of change of the measured phases are related to the velocities V_{ew}, V_{ns} (in the East-West and North-South directions, respectively) as indicated

$$V_{ew} \approx \frac{r}{kl}\dot{\rho}_{12} \; ; \; V_{ns} \approx -\frac{r}{kl}(\dot{\rho}_{13} + \dot{\rho}_{23})$$

with $l \approx 24.1$m, k the radar wave number, r the range (or height) and $\dot{\rho}$ the rate of change of the phase of the signals arriving at the antennas specified by the different subscripts. The geometrical arrangement of the antennas which constitute the interferometer is shown in Figure 2. The signals, after decodification, are Fourier analyzed and multiplied to form the spectrum and cross-spectrum (e.g. FARLEY et al., 1981).

Selected but representative examples of spectra and cross-spectra (coherency and phase) are presented in Figures 3a-c. All the transforms are averaged by 40 s and they have a rang of ±1 Hz with a frequency resolution of 0.083 Hz. There are some observations on the data that are worth bringing out. Figure 3a (event I) shows clearly a continuous change of Doppler shift with time and also illustrates frequency aliased spectra. The coherency maximizes within the energy containing frequency ranges and the corresponding computed phase changes, increasing steadily. Event II (Figure 3b) is more complex because it shows double-peaked spectra. From the graphs of phase it is clear that the opposite Doppler shifts are associated with physically separate regions of the atmosphere (about 4 km apart). In this example we can appreciate the great resolving capability of the interferometer. Figure 3c (event III) presents sharp and well-defined spectra and includes all (3) combinations of cross-spectra. From the high values of the coherency it can be deduced that the echoes are coming from horizontally localized regions or "blobs" (ROTTGER, 1983). The horizontal velocities for each event can be estimated measuring the rate of change of the phases. From the data, Table 1 was constructed for the horizontal velocities.

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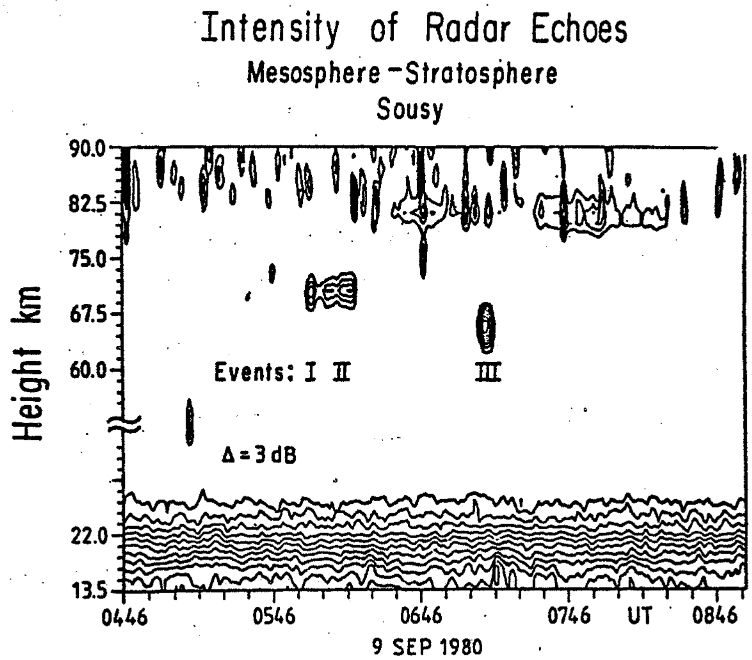

Figure 1. Contour plots of the intensity of mesospheric backscattered signals. Three events are distinguished for further study.

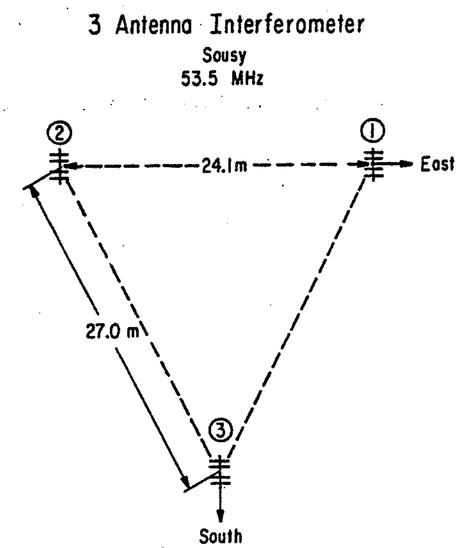

Figure 2. Geometrical configuration of SOUSY interferometer system.

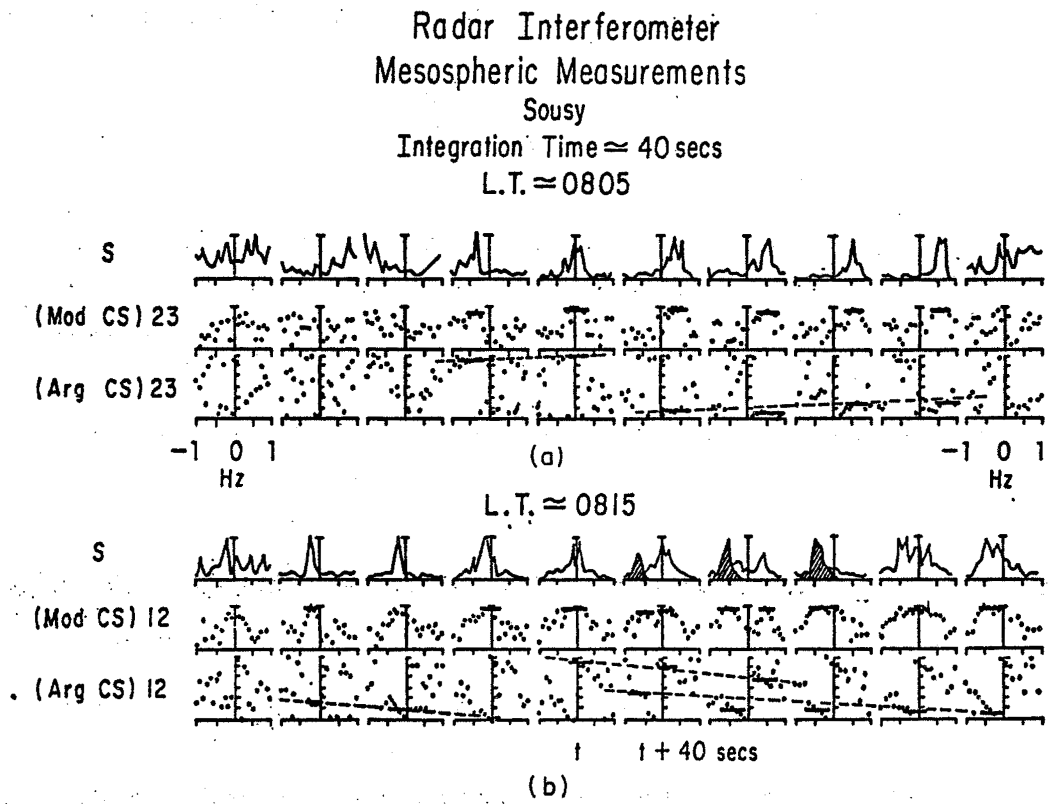

Figure 3. Measurements of spectra (s) and cross spectra (cs).
(a) Example with frequency aliased spectra.
(b) Example with double peak spectra.

Table 1.

Event	V_{ew}(m/s)	V_{ns}(m/s)	Time (LT)
I	15.4	4.7	~0803
II	30.8	15.4	~0815
III	24.2	7.8	~0915

Knowledge of the horizontal component of the velocity and of the radial (line-of-sight) velocity allows for an unambiguous estimate of the vertical component. For the data at hand and during the time that the "blobs" were observable the vertical Doppler shift changed from negative to positive in a reasonably linear fashion (to first order) and with the following parameters where T_s time within sight, V_v vertical velocity, $\dot{V}_v$ rate of change of the vertical velocity. The events tabulated in Table 2 occur within a vertical extent between 3 and 4.5 km. The third event is characterized because it has the largest values of the intensity of the echoes as well as of the coherency of the cross-spectra.

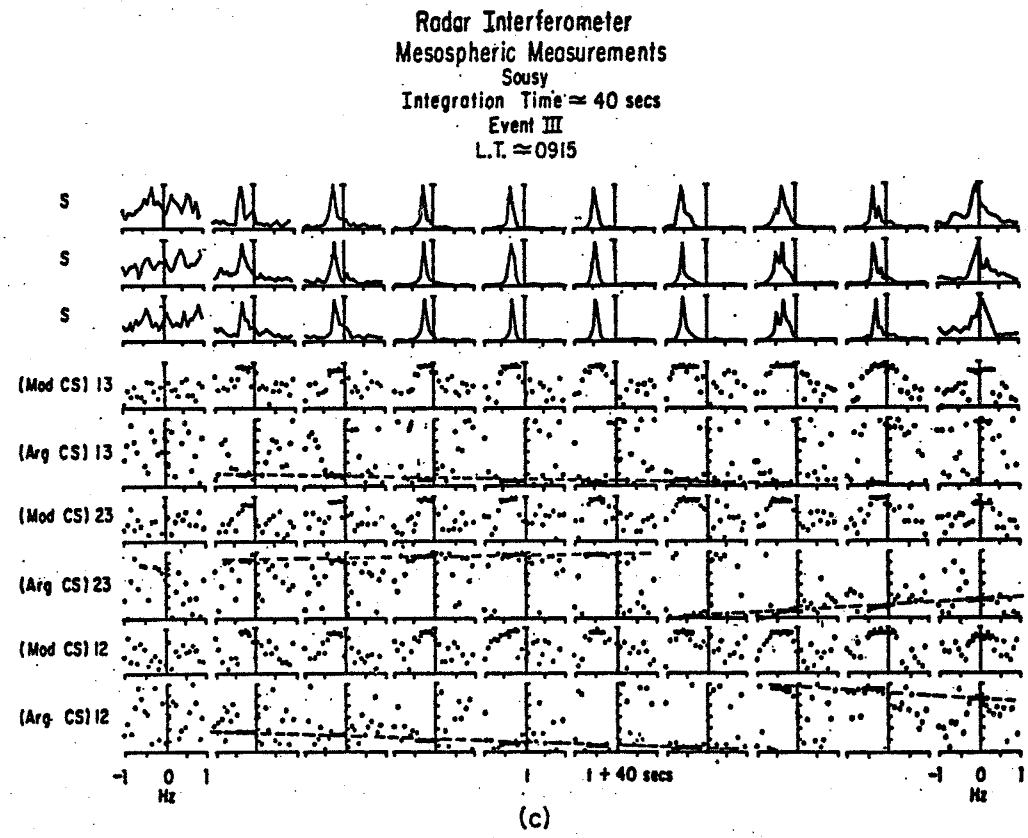

Figure 3(c). Measurements of spectra (s) and cross spectra (cs). Example of a "compact" backscattering region.

Table 2.

Event	T_s(min)	V_v(m/s)	$\dot{V}_v$(cm/s^2)
I	5.0	-3.9 → 2.2	2.0
II	4.3	-2.5 → 2.8	2.4
III	5.7	-1.9 → 1.0	0.8

The technique used here makes possible some understanding of the morphology of the scattering medium. In fact the data suggest that patchy regions ("blobs") fairly localized (to within about 3 km) exist. Moreover these blobs are carried away by (or they ride on) prevalent winds and waves. The origin of the blobs has not been investigated yet, but some preliminary notions are worth mentioning. They could result from short-scale turbulence due to the breaking of solitary waves. It is interesting to note that irregularities were observed always when the blobs were lifted upward, soon to be pushed downward. Another possibility relies on the presence of ("frozen") local deviations in the value of the index of refraction relative to the spatial average. This last interpretation is, in a sense, analogous to the well-known ionospheric holes phenomena.

Figure 4 presents, for the data analyzed, the (two-dimensional) horizontal trajectories followed by the irregularities. Event II is composed of two sub-events with geometrical separation of about 4 km. A more extended data base will be necessary to establish the frequency of occurrence of the events here described as well as their spatial distribution. This will allow better characterization of the physical picture presented and also will help to decide if estimates of the vertical profiles of the velocities are feasible.

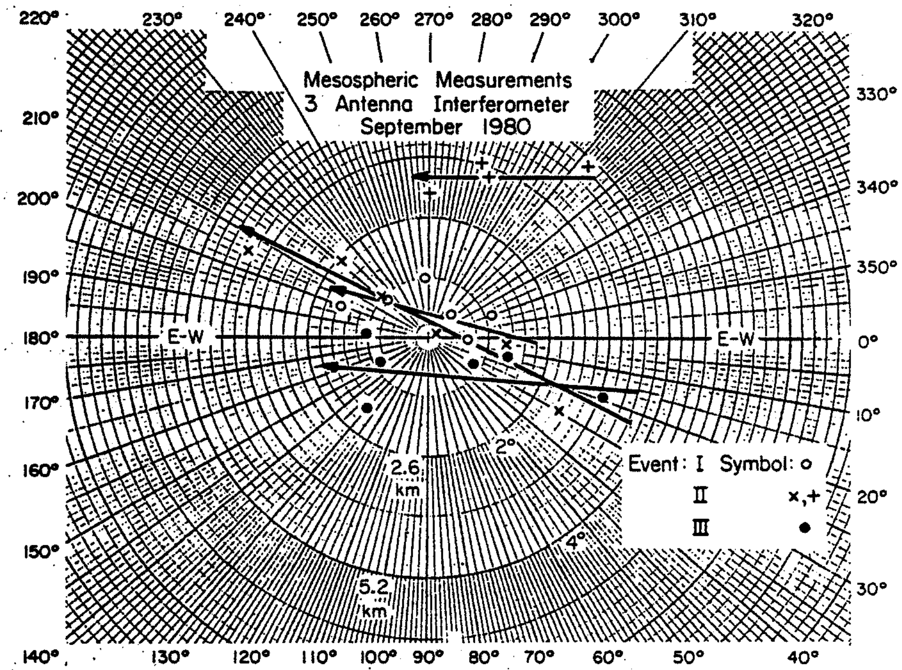

Figure 4. Horizontal trajectories of observed irregularity patches.

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