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WORKSHOP ON PHYSICS OF MESOSPHERE-STRATOSPHERE-TROPOSPHERE INTERACTIONS WITH SPECIAL EMPHASIS ON MST RADAR TECHNIQUES

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AN UPDATE ON THE SOUSY SVALBARD RADAR: OBSERVATIONS OF POLAR MESOSPHERE SUMMER ECHOES

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An update on the SOUSY Svalbard Radar: Observations of Polar Mesosphere Summer Echoes

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Polar Mesosphere Summer Echoes (PMSE) are some of the most prominent features of the high latitude mesopause in summer. They depend on temperature, water vapor and electron density and are observed with radars operating at frequencies between a few MHz and some GHz (e.g. Cho and Röttger, 1997). The latitudinal dependence of temperature and the water vapor mixing ratio lets assume that PMSE show a latitudinal dependence, too. There exists also the assumption for a strong 12-hour oscillation in the very high-latitude mesosphere. It needs to be investigated whether this is a tide or a long-period wave. PMSE also depend on frequency and, therefore, collocated observations with radars at different frequencies are needed to study this dependence. In addition to studies of the lower atmosphere, these were the major reasons to establish the SOUSY Svalbard Radar (SSR) close to the EISCAT Svalbard Radar (ESR) in Longyearbyen on Spitzbergen, which is the largest island of the Svalbard archipelago. The maps on Fig. 1 show the locations of these radar sites (see also Fig. 1 of Röttger, 2000, for photos of the radar antenna systems). PMSE observations with the ESR are briefly outlined in that by Röttger (2000) and Hall and Röttger (2000) and the troposphere and lower stratosphere observations with the SSR are described by Röttger and Trautner (2000). First latitudinal differences of PMSE were described by Latteck at al. (2000), and typical structures of PMSE at Svalbard were initially investigated by Rüster et al. (2000).

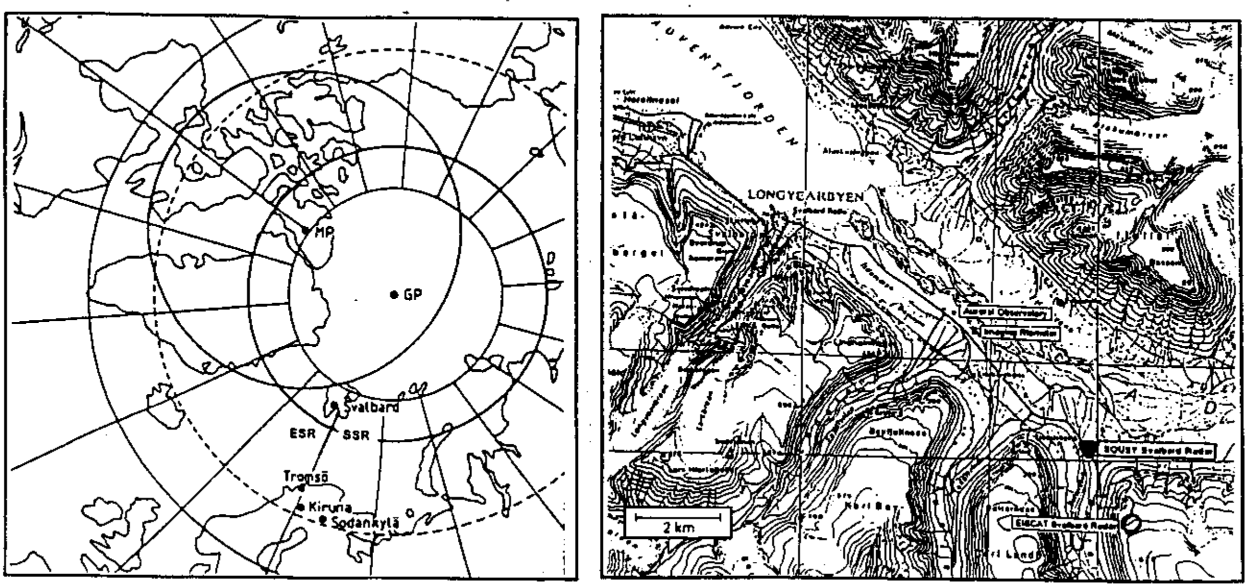

Fig. 1 Polar projection map (left) showing the locations of the EISCAT radars in northern Scandinavia and on Svalbard. The right-hand map shows the vicinity of Longyearbyen with the SOUSY Svalbard Radar and the EISCAT Svalbard Radar (78°N, 16°E), as well as the close-by Auroral Observatory with instruments for middle and upper atmosphere and ionosphere observations.

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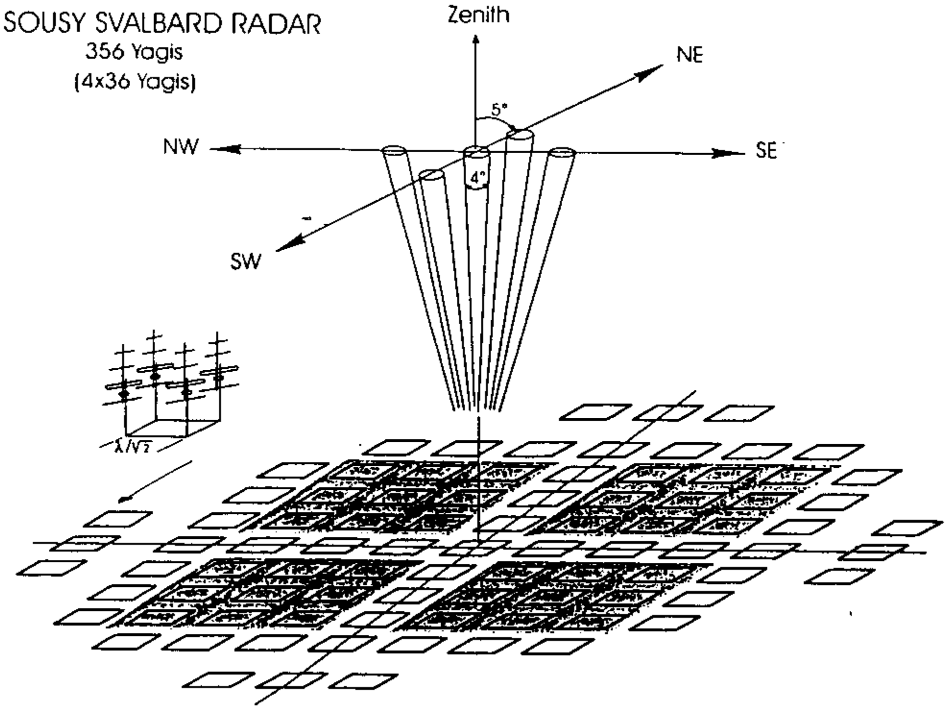

Fig. 2 Schematic view of the antenna array of the SOUSY Svalbard Radar showing the five beam pointing directions and the four quarters of 4x36 Yagis to be used for spaced antenna and interferometry applications in the receiving mode. See antenna photo in Röttger (2000).

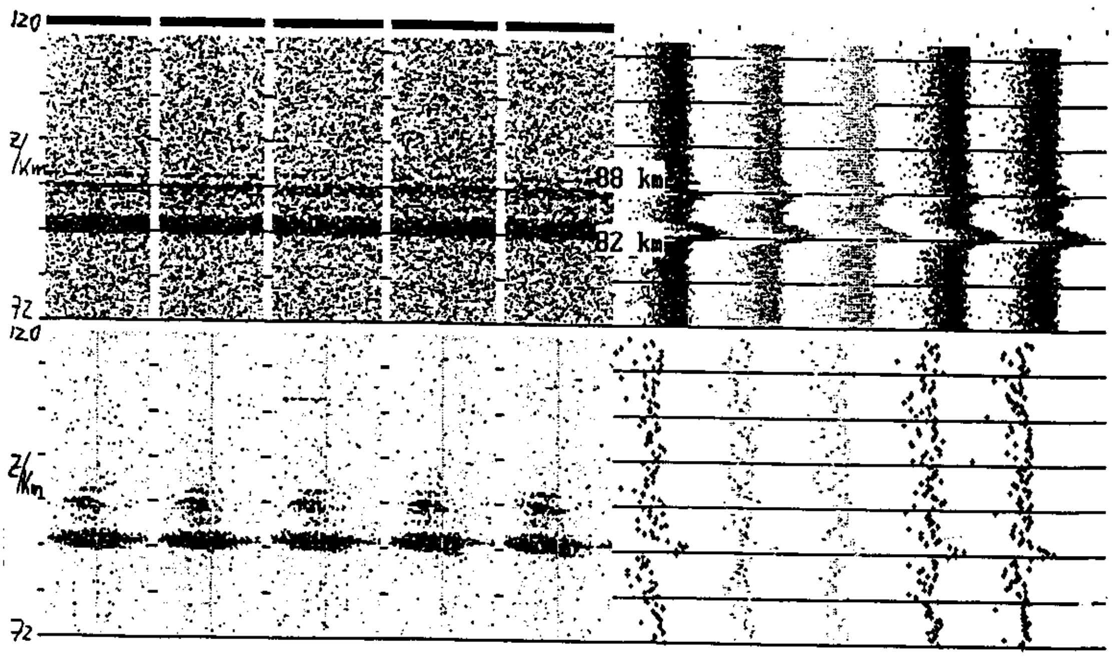

Fig. 3 Display of test analysis of the first PMSE observations with the SSR on 10 June 1999, 10:31:47 - 10:32:35 UT. It shows the results of five sequences with the antenna beam was kept vertical direction (in the operational mode these are vertical, NE, SE, SW, NE). These records cover the heights 72 km to 120 km. Upper panels: height-time-intensity and scatter plots of received power (logarithmic units with maximum signal at 20 dB above the noise level). Lower panels: dynamic spectra (± 5.8 Hz) and power in the zero frequency bin (to check for potential DC level components).

The SOUSY Svalbard Radar is an MST radar operating on 53.5 MHz and is optimized in its original design for observations of PMSE (Czechowsky et al., 1998). It consists of an antenna array (lower photo of Fig.1 in Röttger, 2000) of 356 four-element Yagi antennas with a gain of 33 dBi. The antenna with a beam width of 4° is steerable in five directions: towards zenith, and at 5° zenith angle to NE, SE, SW and NE. Fig. 2 shows the scheme of the antenna. The shaded four quarters indicate those parts of the array, which will be used for reception in the spaced antenna interferometer mode after the end of summer 2000. In the mesosphere mode the Doppler beam swinging method has been applied. A 20-bit complementary code has been used and a coherent integration was performed over 91 ms. Following on-site installation and tests in 1998 the experiment operation started on 10 June 1999 after antenna repair had been completed, which was necessary due to snow drift damages. The system parameters of the SSR and the ESR for mesosphere observations are summarized in Table 1 of Röttger (2000), where also cross section estimates for PMSE observed with the ESR (500 MHz) and the SSR (53.5 MHz) are briefly introduced.

Fig. 3 contains first test results of PMSE observations on 10 June 1999. It shows two strong dominant layers of PMSE, exceeding the noise level by some 20 dB. This double layer structure has been noted as a typical feature of the observations on Svalbard (Latteck et al., 2000) and seems to be related to the temperature profile of the mesopause (Klostermeyer, 1997) The lower layer has a larger spectrum width than the upper one. The latter is somewhat atypical for the PMSE, which usually show narrower spectra in the lower layers. Typical standard plots of PMSE are presented in Fig. 4, which show the three standard parameters signal-to-noise ratio, radial velocity and spectrum width. We again note the indication of a prevailing double layer structure, which is modulated by longer period variations due to wave events. The radial velocities show shorter oscillations at periods of about ten minutes or larger, which are also reflected in the up-and-down lifting of the layer bottom (see SNR plot). The spectral widths, presented in the lower panel, are in general quite narrow, which is an indication of only weak turbulence intensity. More intense turbulence is only observed intermittently in patches and mainly in the upper part of the PMSE structures around 16 UT and 18 - 20 UT. This again confirms earlier suggestions that active turbulence is not the main PMSE generator.

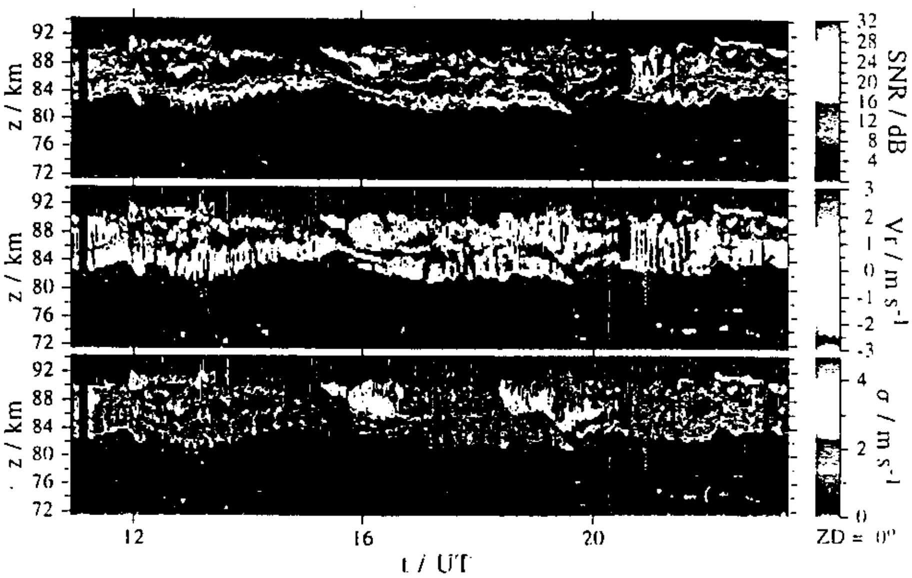

Fig. 4 Plots of signal-to-noise ratio SNR, radial velocity V_r and spectral width σ, measured on 13 June 1999 with the SSR antenna beam pointing into zenith direction.

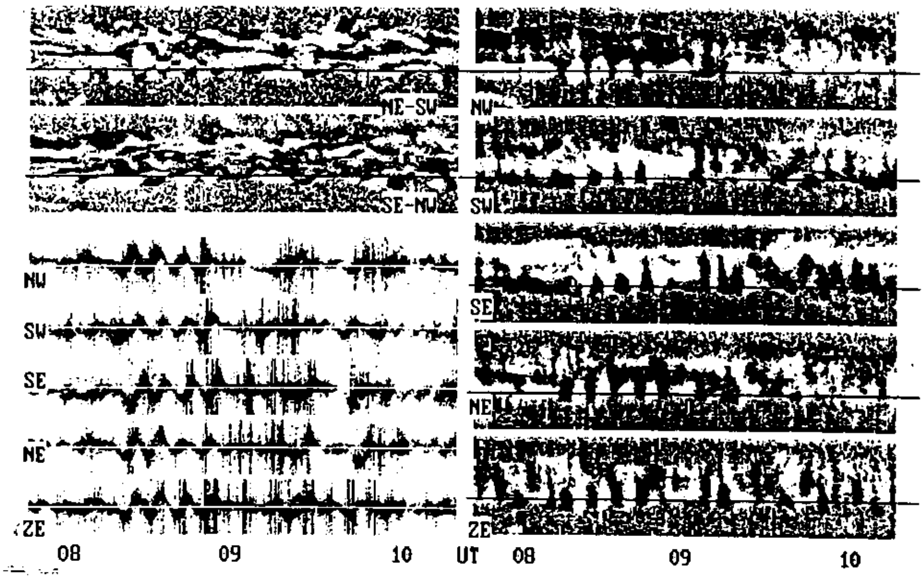

Fig. 5 Observations with the SSR on 27 June 1999 showing wave events and spatial inhomogeneity in PMSE. Upper left-hand panels: The difference in power observed in the opposite coplanar antenna beams NE-SW and SE-NW (max. ±3 dB). Lower left-hand panels: dynamic spectra of signals in the range gate indicated by the continuous line in the upper plots. The spectra are for the five antenna directions. The right-hand panels represent radial velocities in the five different antenna beams (max. ± 8 m s^{-1}). The height-time-intensity plots cover the heights 78-94 km.

We frequently observe an enormous spatial inhomogeneity, which is depicted in Fig. 5, particularly resulting from waves and turbulence modulating the PMSE structure and dynamics. It is important to consider this carefully in analyses of short-period events, which will follow. The five-beam pointing allows us to obtain an image of this structure. The in-volume imaging will be performed in summer 2000 using the four spaced-antenna receiving modules of the SOUSY Svalbard Radar.

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