

# Comparison of Polar Mesosphere Summer Echoes observed with the ALWIN MST Radar at 69°N, the SOUSY-Svalbard-Radar at 78°N, and ESRAD at 68°N in Summer 1999

R. Latteck<sup>(1)</sup>, R. Rüster<sup>(2)</sup>, W.Singer<sup>(1)</sup>, J. Röttger<sup>(2)</sup>, P.B. Chilson<sup>(3)</sup>, V. Barabash<sup>(3)</sup>

(1) Leibniz-Institut für Atmosphärenphysik, Schloss-Str. 6, D-18225 Kühlungsborn, Germany  
(2) Max-Planck-Institut für Aeronomie, D-37191 Katlenburg-Lindau, Germany  
(3) Swedish Institute of Space Physics, S-98128 Kiruna, Sweden



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## Introduction

Two new VHF radar systems were put in operation for investigation of the dynamics and structure of the lower and middle atmosphere in the northern polar region in 1998: the ALWIN radar at Andenes/Norway (69°N, 16°E) and the SOUSY-Svalbard-Radar near Longyearbyen/Svalbard (78°N, 16°E). Together with the Esrange VHF radar outside Kiruna (68°N, 21°E) in northern Sweden, there are three MST radars operating in northern Europe now.

The ALOMAR wind radar (ALWIN) has been installed in October 1998 as successor of the former ALOMAR SOUSY radar. The system is designed for unattended and continuous observation in the troposphere and lower stratosphere as well as in the mesosphere. The radar operates at a frequency of 53.5 MHz with a peak power of 36 kW and a best range resolution of 150m. 144 Yagi antennas arranged in 36 squared subsystems of four Yagis form the whole antenna. A flexible antenna steering unit allows radar operation either in the Spaced Antenna (SA) or in the Doppler Beam Swinging (DBS) mode.

The SOUSY-Svalbard-Radar (SSR) has been installed in summer 1998. The system is based on the main components of the mobile SOUSY radar: a 150 kW transmitter with 4% duty cycle and phase-coding capabilities with less than 1ms baud length, radar controller, receiver and digital signal processing units. It operates on 53.5 MHz with a high-gain Yagi-antenna array of 92 m diameter, allowing five beam pointing directions at and close to the zenith.

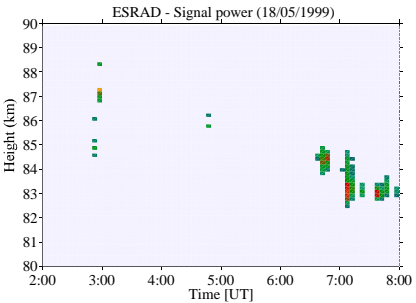
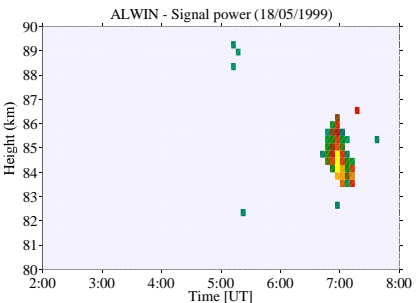
The Esrange MST radar (ESRAD) began operations in July 1996. The transmitter frequency is 52 MHz and 72 kW peak transmitter power is available with at least a 5% duty cycle. Pulse repetition rates from 100 Hz to 16 kHz and pulse lengths corresponding to height resolutions between 150 m and 3 km are possible. The antenna is a 12x12 array of 5-element yagis. Each group of 4 nearest-neighbour yagis is separately connected to a patchboard which allows a large number of different antenna configurations in SA and DBS mode.

We present comparative studies of Polar Mesosphere Summer Echoes obtained at 68°N, 69°N, and 78°N in summer 1999.

## Basic radar parameters and experiment configuration for PMSE observation in 1999

| Radar                           |                  | SSR                |  | ALWIN              |                   | ESRAD              |                                |  |
|---------------------------------|------------------|--------------------|--|--------------------|-------------------|--------------------|--------------------------------|--|
| Basic parameters                |                  |                    |  |                    |                   |                    |                                |  |
| Frequency                       |                  | 53.5 MHz           |  | 53.5 MHz           |                   | 52 MHz             |                                |  |
| Peak power                      |                  | 60 kW              |  | 36 kW              |                   | 72 kW              |                                |  |
| Antenna                         | Number of Yagis  | 356                |  | 144                |                   | 140                |                                |  |
|                                 | Half-power-width | 4°                 |  | 6°                 |                   | 5°                 |                                |  |
|                                 | Gain             | 33 dBi             |  | 28.8 dBi           |                   | 28 dBi             |                                |  |
| Experiment                      |                  | DBS                |  | SA                 | DBS               |                    | SA                             |  |
| Parameter                       |                  |                    |  |                    |                   |                    | 04/05 - 19/07    20/07 - 31/08 |  |
| Pulse repetition frequency      |                  | 1.0 kHz            |  | 1.5 kHz            |                   | 1.45 kHz           |                                |  |
| Number of coherent integrations |                  | 100                |  | 64                 |                   | 64                 | 128                            |  |
| Number of data points           |                  | 64                 |  | 256                | 128               | 640                | 512                            |  |
| Height range [km]               |                  | 72.0 - 120.0       |  | 73.2 - 96.6        |                   | 80.0-89.9          | 80.0-90.2                      |  |
| Pulse width                     |                  | 300m/ 2μs          |  | 300m/ 2μs          |                   | 150m               | 300m                           |  |
| Pulse shape                     |                  | 0.2 μs rise        |  | „normal“           |                   | „normal“           |                                |  |
| Code                            |                  | 20 bit complement. |  | 16 bit complement. |                   | 16 bit complement. |                                |  |
| Beam off-zenith                 |                  | 5°                 |  | 0°                 | 7°                |                    | 0°                             |  |
| Beam azimuth                    |                  | V, NW, SE, NE, SW  |  | V                  | V, NW, SE, NE, SW |                    | V                              |  |

## First PMSE over Andenes and Kiruna on May 18, 1999



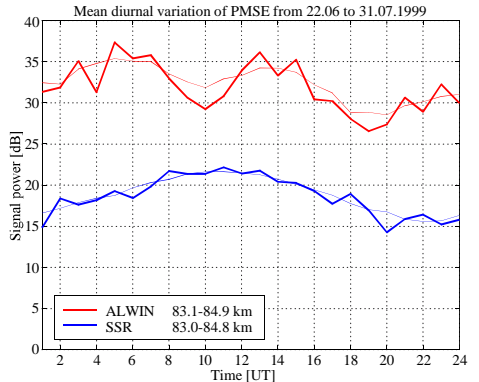
The first seasonal appearance of PMSE was observed in 1999 on May 18 at Andenes and at Kiruna at the same date and also within the same hour indicating that the mesopause temperature is below 145 K at both sites. The same situation was observed at Andenes and Kiruna on May 20, 1997 (table below). The left panels show the radar signal power (power minus the background noise) of ALWIN and ESRAD on May 18, 1999 from 02:00 to 08:00 UT.

The SOUSY-Svalbard-radar started the PMSE observation 1999 at June 16 and finished the observation at August 27, so that the really beginning and the end of the PMSE season over Svalbard can not be shown. Therefore the corresponding values are written within parentheses in the table below.

| Radar location                       |      | Svalbard      |         | Andenes       |        | Kiruna        |       |
|--------------------------------------|------|---------------|---------|---------------|--------|---------------|-------|
| Radar operation for PMSE observation |      | 16/06 - 27/08 |         | 12/05 - 15/09 |        | 04/05 - 31/08 |       |
| Radar operation mode                 | SA   | 79 d (1896 h) | 126 d   | 3024 h        | 119 d  | 2845 h        |       |
|                                      | DBS  | -             | 125.8 d | 3020 h        | 91 d   | 2053 h        |       |
| Days with PMSE                       |      | 79            |         | 110           |        | 49            |       |
| First and last PMSE                  |      | (10/06)       | (27/08) | 18/05         | 04/09  | 18/05         | 18/08 |
|                                      | 1998 | -             | -       | -             | -      | 23/05         | 26/08 |
|                                      | 1997 | -             | -       | 20/05*        | 28/08* | 20/05         |       |

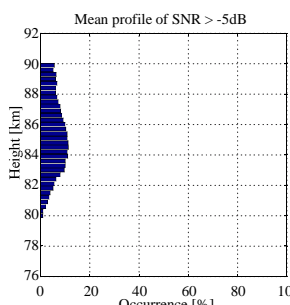
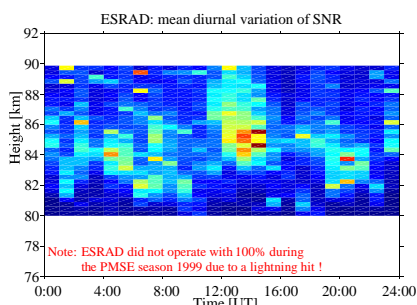
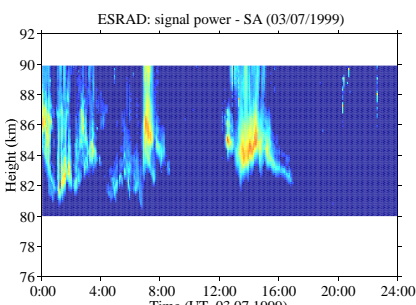
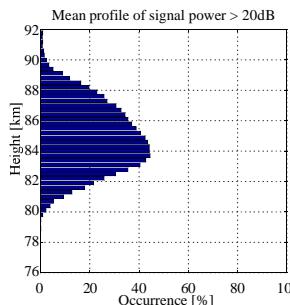
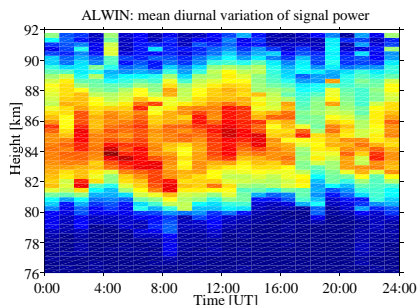
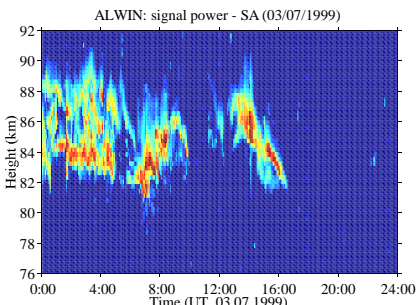
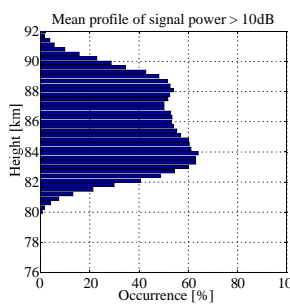
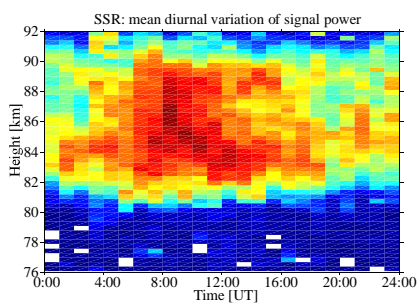
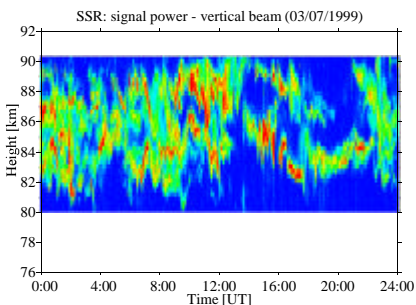
\* ALOMAR SOUSY radar

## Mean diurnal variation of PMSE



Comparison of the mean diurnal variation of PMSE observed from ALWIN and SSR in a height range between 83km and 85km. The ALWIN results (red curves) show the typical variation of PMSE over Andenes with a maximum around noon and a second maximum after midnight, known from previous observations. The SSR results (blue curves) have one maximum before noon only. This could be caused by increased particle precipitation when the Svalbard radar is in the auroral zone near noon.

## Characteristics of PMSE occurrence at different latitudes



The characteristics of the PMSE occurrence in dependence on the latitude is shown in the left figures. The representations are based on the signal power (echo power minus the background noise level) for ALWIN and SSR and the signal-to-noise-ratio for ESRAD from June 22 to July 31, 1999. It must be noted that ESRAD was down at times and it never really performed at 100% during the PMSE season of 1999 due to a lightning hit!

## Results

The figures in the left panel show a typically PMSE event between 80km and 90km at the three radar sites on July 03, 1999. The PMSE over Svalbard is characterised by a clear double layer varying in height and long lasting over the whole day. The echos over Andenes and Kiruna show several single layer structures.

The figures in the middle panel show the mean diurnal variation of the PMSE echos for several heights as contour plots. As a result of the ALWIN radar (middle figure) we find the known double maximum in mean echo power with one peak during noon and a second peak after midnight as already published, a clear echo minimum around late afternoon and a variation in height too. The echos over Svalbard (upper middle figure) are present over the whole day and the whole area between 80 and 90 km with a maximum before noon.

The mean profiles of PMSE occurrence are shown in the right panel. Different thresholds depending on the maximum mean values were used. The ALWIN and ESRAD PMSEs occur in a height area between 80 and 92 km with a strong maximum around 84 km. This value is approximately one kilometre below the maximum known from former statistics and may depend on the selected time interval. The SSR PMSE occurrence shows the mentioned double layer characteristic with two peaks near 84 km and 88 km which could be typically for PMSEs in high latitudes.