The reintroduction of mesospheric observations at Aberystwyth

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1. Introduction

The Aberystwyth MST radar is located at 52.4°N. During the mid-summer months it is able to detect mesospheric echo layers (e.g. *Thomas et al.*, 1992) which are similar in nature to the Polar Mesosphere Summer Echoes (PMSEs) observed at higher latitudes (e.g. *Cho and Röttger*, 1997). They are much stronger than those detected at other times of year (typically by 30 dB), have a larger vertical extent (typically several kilometres as opposed to just a kilometre or less), and occur at higher altitudes (typically between 80 and 90 km as opposed to between 60 and 80 km) (*Thomas et al.*, 1996). It is well-known that the occurrence of PMSEs is coincident with the mid-summer high-latitude mesopause reaching extra-ordinarily low temperatures. Collocated Rayleigh lidar observations have confirmed that the mid-summer mesopause above Aberystwyth occurs at altitudes of around 87 km and at temperatures of around 140 K (*Thomas et al.*, 1996). Noctilucent clouds are often seen at this latitude.

There was a peak of interest in the mesospheric summer echo layers observed by the Aberystwyth radar in 1993 and 1994. Special observations were made on an almost daily basis during June and July of these years. However, observations were only rarely made before 08 UT or after 16 UT. Moreover, the number of days on which mesospheric observations were made began to decline after 1995, as the did the number of hours for each day. No mesospheric observations were made at all for the five summers after the 1999 season. Only limited non-summer mesospheric observations had ever been made. In April of 2005, a single vertical beam mesospheric dwell (using 300 m range resolution) was inserted into the continuously-operated ST-mode observation cycle. Although this does not allow any horizontal wind information to be derived for the mesospheric altitudes, it has allowed an unprecedented picture to be built of mid-latitude mesospheric echo layer occurrence. Some surprising results arising from a preliminary analysis of the new dataset are presented here. It is noted that the only comparable dataset is that from the Kühlungsborn radar at 54.1°N (e.g. *Zecha et al.*, 2003).

2. The characteristics of summer echo layers

The mesospheric summer echo layer shown in the top panel of Figure 1 is typical in terms of its strength, its vertical extent and its altitude. It is, however, extra-ordinary in terms of its persistence; continuous durations of more than six hours are relatively uncommon. Although there is a bias in echo layer occurrence towards the middle of the day (Aberystwyth is located at 4.01°W and local noon occurs shortly before 12:18 UT on 21st June), echo layers can occur at any time during daylight hours (sunrise and sunset are at 03:53 and 20:42 UT, respectively, at ground level on 21st June). It can be seen from the bottom panel of Figure 1 that observations made solely between 08 and 16 UT (which accounts for most of the observations made prior to 2005) cannot be used to infer whether or not a mesospheric echo layer exists on a given day. On a few occasions summer echo layers have even seen observed to occur at times between 23 and 01 UT. These tend to be much weaker, of narrower vertical extent and shorter-lived (less than 1 hour) than those occurring during daylight hours. However, they occur at the same altitudes as the daytime summer echo layers. Night-time summer echo layers have only been observed at Kühlungsborn in association with a strong geomagnetic event (*Zecha et al.*, 2003).

The earliest instance of a summer echo is 27th May (in 2005) and the latest is 8th August (also in 2005).

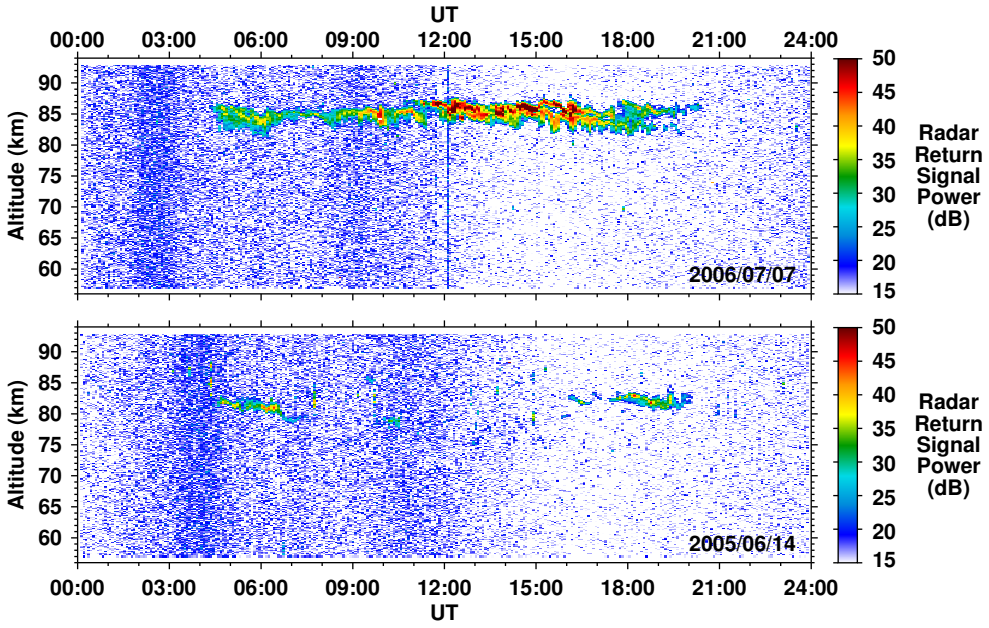

Figure 1: Mesospheric summer echo layers observed (top panel) on 7th July 2006 and (bottom panel) on 14th June 2005.

Whereas the onset of the summer season is sharp, the end of the season is less well-defined. In early August the occurrence of mesospheric echo layers becomes less frequent. Although echoes can occasionally be seen at altitudes above 80 km in the middle of August, they are not as strong or as persistent as those seen during June and July. It is not entirely clear whether such echo layers can still be classified as being summer echoes - see section 4 below.

3. The characteristics of "winter" echo winter layers

Although mesospheric echo layers are seen on approximately one day in three between August and April, many are only just detectable and have durations of less than one hour; those seen in the top panel of Figure 2 are (collectively) amongst the more persistent and well-defined. Moreover, their occurrence is highly sporadic and there can be gaps of several weeks between sightings. The minimum detectable power spectral density for a radar return signal undergoes a quasi-diurnal variation of 4 dB amplitude. This is caused by variations in the 46.5 MHz galactic noise map. The pattern regresses over 24 hours during the course of one year. The peak in the pattern occurs around 12 UT during February. Despite the fact that the occurrence of echo layers is biased towards the central hours of the day, detectable echo layers have been seen at this time of year. The variations described above will only have an effect on marginally detectable signals.

During an exceptional period between 3rd and 15th November 2005, mesospheric echo layers were seen on 10 out of the 13 days. As can be seen from the middle and lower panels of Figure 2, the echo layers were stronger, of larger vertical extent, and more persistent than is typical for non-summer months. During a second exceptional period, between 3rd and 17th November 2006, mesospheric echo layers were observed on 12 out of the 15 days. They were similar in nature to those observed in November 2005. It is not clear whether there is something special about this time of year or whether it is a coincidence that both exceptional periods occurred in November.

4. The distinction between summer and winter echo layers

Winter echo layers are primarily observed at altitudes of between 70 and 80 km. They occur to a lesser extent at altitudes of between 60 and 70 km and at altitudes of above 80 km. Although several winter echo layers have been seen at altitudes of just above 80 km, the one shown in the top panel of Figure 3 is exceptional in reaching an altitude of 85 km. Even when winter echo layers occur at altitudes more

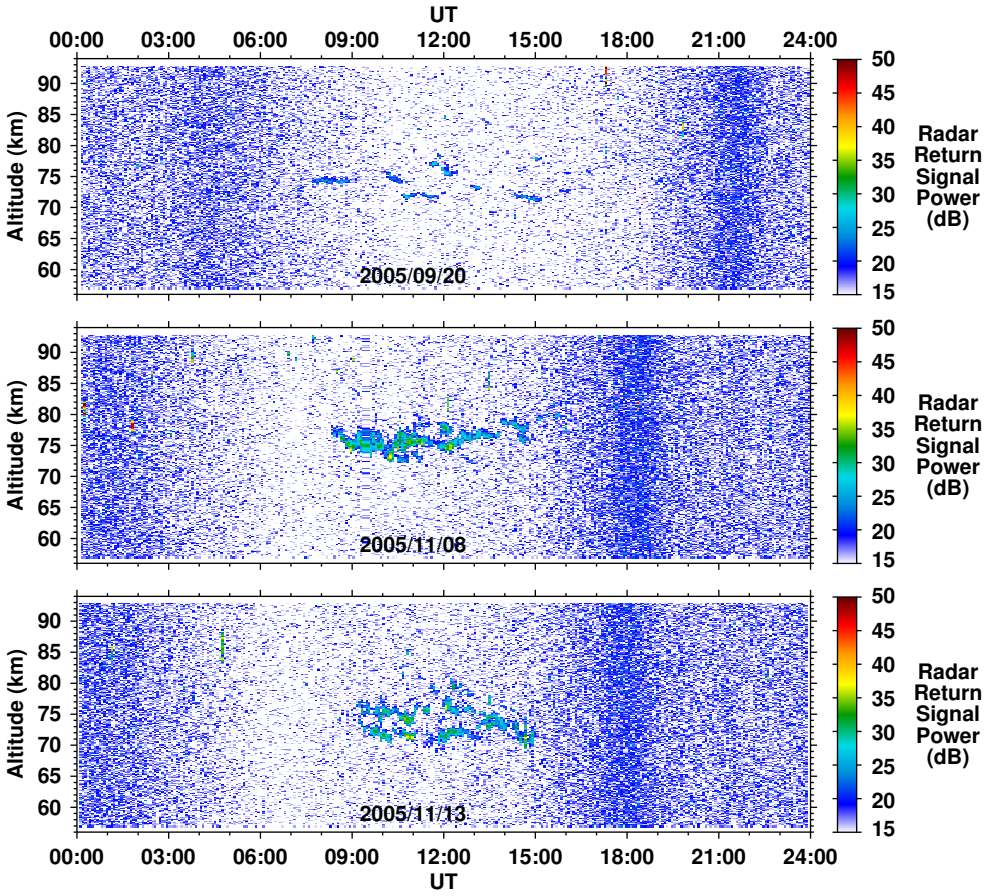

Figure 2: Mesospheric winter echo layers observed (top panel) on 20th September 2005, (middle panel) on 8th November 2005, and (bottom panel) on 13th November 2005.

typical of summer layers, their strength remains typical of winter returns. This is not surprising since extra-ordinarily strong echo layers are an exclusive feature of the mid-summer months. However, as can be seen from the middle panel of Figure 3, not all (day time) echo layers observed during the mid-summer months are extra-ordinarily strong. Whereas the summer echo layer observed after 12 UT is typical in terms of strength and vertical extent, those observed prior to 12 UT are more similar in nature to the winter echo layer seen in the panel above.

Even more surprising is the behaviour of the summer echo layer seen prior to 09 UT in the bottom panel of Figure 3. This is initially typical in terms of its strength, its vertical extent and its altitude of occurrence. Although it is common to see summer echo layers descending with time, it is rare for them to reach as low as 80 km. Not only does this echo layer descend significantly below 80 km, its strength and its vertical extent become much more characteristic of a winter echo layer as it does so. This appears to confirm the expectation that the PMSE-like radar return mechanism is exclusively linked to the extremely low temperatures found in the vicinity of the summer mesopause (c.f. *Cho and Röttger*, 1997).

References

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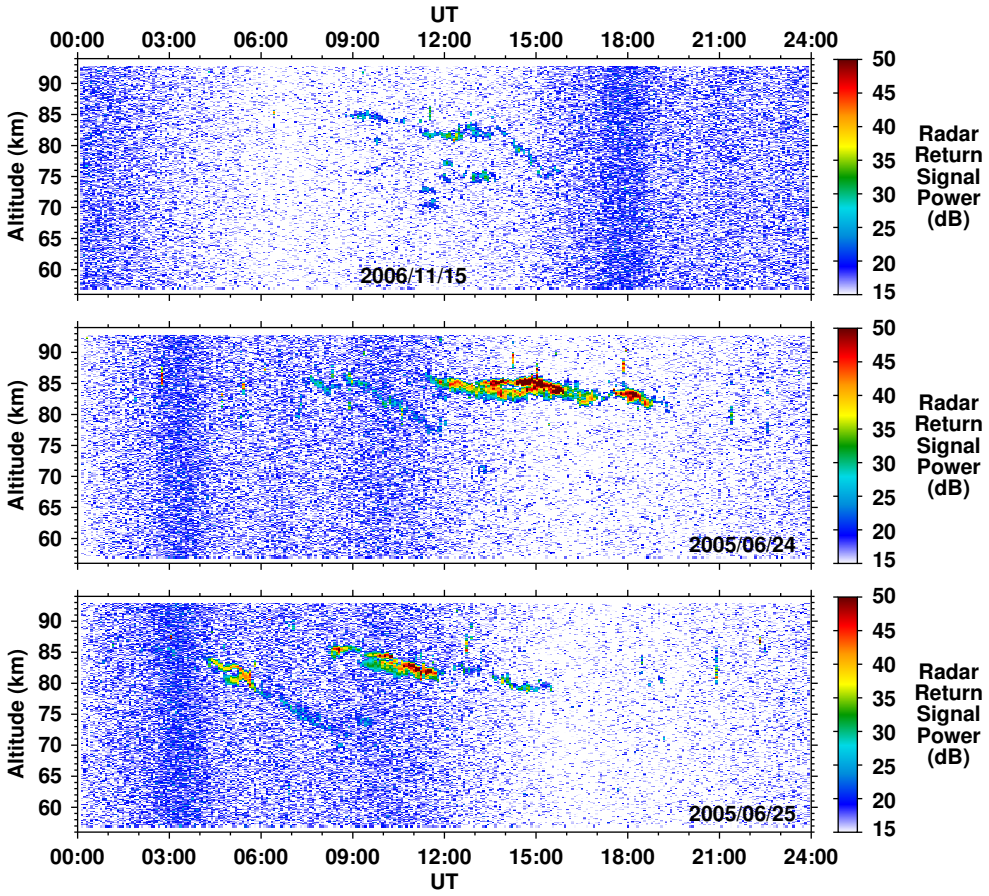

Figure 3: Mesospheric echo layers observed (top panel) on 15th November 2006, (middle panel) on 24th June 2005, and (bottom panel) on 25th June 2005.

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