FURTHER OBSERVATIONS OF PMSE IN ANTARCTICA

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1. Introduction

Here we present and analyze PMSE data from the 2001 Antarctic summer campaign. Observations were performed at the Artigas Uruguayan Station using a 15m x 15m Yagi array. We compare the Artigas results with those obtained in our previous Antarctic summer campaigns (published or reported at MST conferences). Previously we had used the Machu-Picchu Station radar using a 50m x 50m COCO array. Machu-Picchu and Artigas stations are separated 30 Km, both located on King George Is. in Antarctica.

A strong difference in the magnitude of PMSE between the 2001 and the previous campaigns can be observed for the whole season. Furthermore, it is surprising and intriguing that the ~10 dB smaller Yagi array at Artigas (225 m^2) detected stronger echoes than the COCO array at Machu-Picchu (2500 m^2). Although a Yagi array can be more efficient than a COCO array of similar dimensions, we have found from calibration experiments that this is not enough to explain such a discrepancy (see companion paper). After reviewing the alternatives to explain these differences, we conclude that there is evidence that the intensity difference is due to annual variability in the scattering phenomena

2. The Machu-Picchu and Artigas radar facilities

The MST radar facility located at the Machu-Picchu Peruvian Station, in Antarctica (62°06'S, 58°28'W), was used by the Peruvian Atmospheric Research Group in collaboration with the University of Colorado at Boulder, to make the first PMSE measurements in the Southern Hemisphere (1994). Results from the 94-99 PMSE observation campaigns have been published or reported in the literature (Balsley et al., 1995 and Woodman et al., 1999). Among the contributions of Machu-Picchu radar, we can mention the conclusions concerning the existence of an Arctic-Antarctic inter-hemispheric asymmetry in PMSE intensity.

Motivated by these findings, a new VHF radar was installed by the same research group nearby the Artigas Uruguayan site (62°11'S 58°54'W) in December, 2000. This radar was used to perform PMSE observations during the 2000-2001 austral summer.

Figure 1: (left) MST radar antenna (2,500m2 COCO array) located at Machu-Picchu Peruvian Station, Antarctica. **(right)** 4x4 Yagi array (225m2) during the test stage at Jicamarca Radio Observatory in Lima, Peru. It was installed nearby Artigas Station in Antarctica, in December, 2000.

The Artigas and Machu-Picchu Stations are located some 30 Km apart, both on King George Island. The COCO antenna array used at Machu-Picchu (2500m2) and the Yagi array used at Artigas (225m2) are shown in Figure 1.

3. Mesospheric observations at Artigas Station in Antarctica

During the 2000-2001 austral summer, Tropospheric-Stratospheric as well as Mesospheric observations were carried out using a VHF radar installed at Artigas Station in Antarctica. These observations provided 51 days of measurements during the appearance of polar mesospheric summer echoes (PMSE). A typical RTI report from this radar is shown in Figure 2.

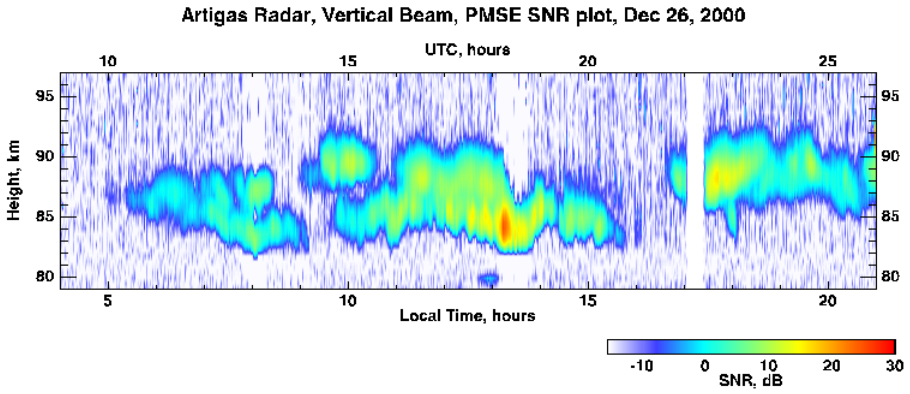

Figure 2: Range-time-intensity plot for the mesospheric region observed by the Artigas radar, December 26, 2000. A typical layered-PMSE event was registered during this day.

4. Comparison of PMSE intensities from Machu-Picchu'98 and Artigas'2001 campaigns

Figure 3 shows the almost-continuous 50-day records of maximum power levels, observed at any PMSE altitude, for the Machu-Picchu'98 (left) and Artigas'2001 (right) campaigns. Evident from this figure is a strong difference in the magnitude of PMSE between the two campaigns; which can be observed for the whole season. What is surprising and intriguing is that the smaller Yagi array used at Artigas (225m2) detected about ~11 dB stronger echoes than the COCO array at Machu-Picchu (2500m2). There are two alternatives to explain the difference between the Machu-Picchu'98 and Artigas'2001 campaigns:

1) unexpected Machu-Picchu poor performance characteristics of the COCO array that have not been accounted for; or
2) an inter-annual variability in the scattering phenomena (i.e., PMSE).

***Arguments against the first alternative*:**

a) we have analyzed Stratosphere-Troposphere power data from Machu-Picchu and Artigas and have found that echo strengths are very similar for the two radars;
b) the results are similar for the four different antenna systems that we have used at Machu-Picchu; i.e., the three original pointing directions installed in 1993 and the new vertical array installed in 1998; and
c) we have found from calibration experiments that a COCO array is ~2.2 dB less efficient than a Yagi array (see companion paper.) However, this is not enough to explain an 11dB discrepancy in the PMSE intensity.

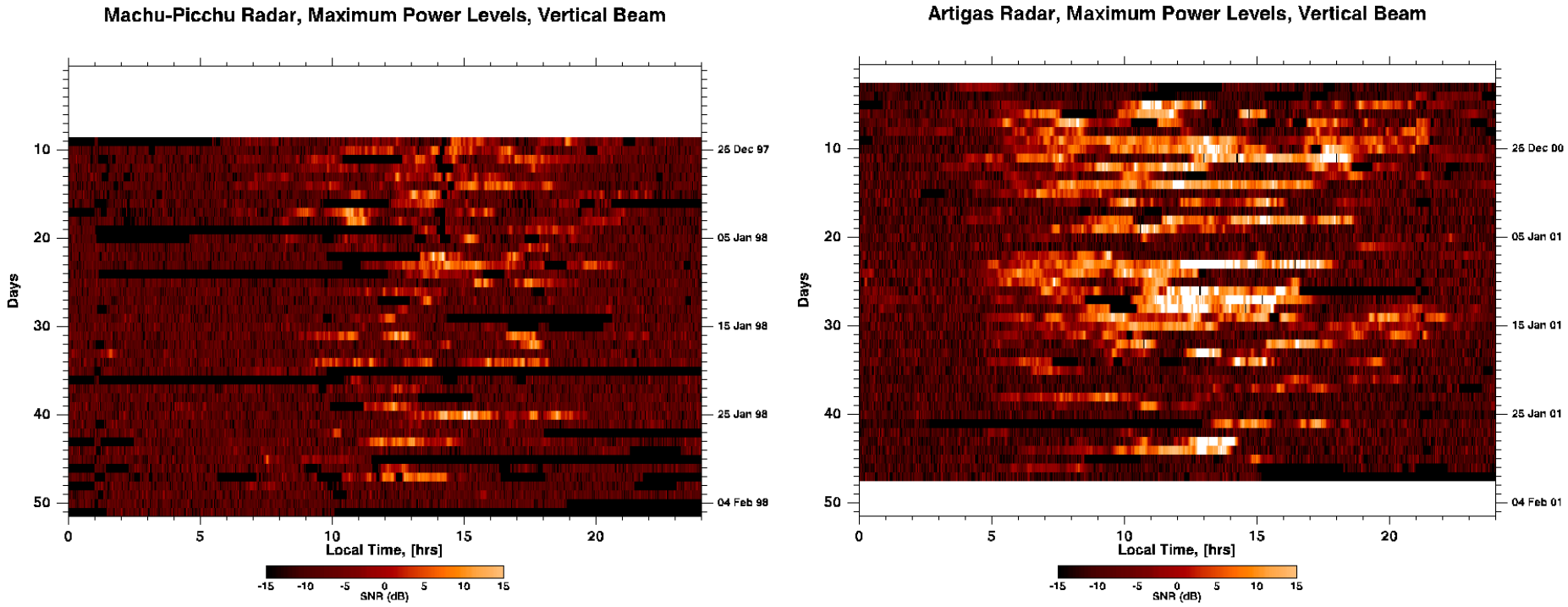

Figure 3: Almost-continuous 50-day records of maximum power levels, observed at any PMSE altitude, for the Machu-Picchu'98 (left) and Artigas'2001 (right) campaigns, both starting a few days before the Summer Solstice. Evident in this picture is a strong difference in the magnitude of PMSE between the two campaigns that can be observed for the whole season. What is surprising and intriguing is that the smaller Yagi array used at Artigas (225m2) detected stronger echoes than the COCO array at Machu-Picchu (2500m2).

Arguments against the second alternative are:

a) Machu-Picchu observations from 1993 to 1999 do not show significant echo strength differences between campaigns; and
b) annual variations in PMSE have not been reported from the Poker Flat data base (B. Balsley personal communications)

Arguments in favor of the annual variability alternative:

a) The results from Svalbard radar in the Northern hemisphere (K. Kubo personal communications, 2002), that report a ~10 dB stronger reflectivity from the 2000 PMSE season with respect to the 1999 and 2001 seasons;
b) Other evidence of long-term variation of mean yearly occurrence of PMSE has been published by Bremer et al., 2003, for the Alomar SOUSY (1994-1997) and ALWIN (1999-2001) radars; and
c) Additional interesting results have been reported by Huaman et al., 2001, from Resolute Bay radar (75N, 95W). Despite its higher latitude, the observed PMSE intensities are weaker than those from Poker Flat. Is this due to annual variability of PMSE?

5. Conclusions

- PMSE have been observed almost every day within a 50-day period, centered on January 5th, 2001, using a small (4x4) yagi array installed at Artigas Station in Antarctica.
- The PMSE observed at Artigas are ~11dB stronger than those from our previous Antarctic campaigns.
- Although there are antenna differences between campaigns, there is evidence that the intensity difference is due to annual variability in the scattering phenomena.
- A 4x4 Yagi array plus a 25 KW transmitter are sufficiently sensitive to obtain PMSE. And since it is an antenna design that many stations already have or could easily implement, it could be used for comparisons of the strength of the PMSE at different latitudes and longitudes.

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References

Balsley, B.B., R.F. Woodman, M. Sarango, R. Rodriguez, J. Urbina, E. Ragaini, J. Carey, M. Huaman, and A. Giraldez, On the lack of southern hemisphere polar mesosphere summer echoes, *J. Geophys. Res., 100(D6)*, 11685-11693, 1995

Bremer, J., P. Hoffmann, R. Latteck, and W. Singer, Seasonal and long-term variations of PMSE from VHF radar observations at Andenes, Norway, *J. Geophys. Res., 108(D8)*, 8438, doi:10.1029/2002JD002369, 2003

Huaman, Mercedes M., Michael C. Kelley, Wayne K. Hocking and Ronald F. Woodman, Polar mesosphere summer echo studies at 51.5 MHz at Resolute Bay, Canada: comparison with Poker Flat results, *Radio Sci.*, 36(6), 1823-1837, 2001

Sarango, M.F., R.F. Woodman and D. Cordova, On the radiation efficiency of COCO antennas, *in this volume*, 2004

Woodman, R.F., B.B. Balsley, F. Aquino, L. Flores, E. Vasquez, M. Sarango, M. Huaman, and H. Soldi, First observations of polar mesosphere summer echoes in Antarctica, *J. Geophys. Res., 104(A10)*, 22577-22590, 1999