SOUSY RADAR AT JICAMARCA: SYSTEM DESCRIPTION

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The Max Planck Institute fur Aeronomy has donated the SOUSY radar, to the Instituto Geofisico del Peru. This radar was previously working in the Harz mountains, Germany since 1977. The radar has now been installed at the Jicamarca Radio Observatory (JRO) in Lima, Peru (see Figure 1).

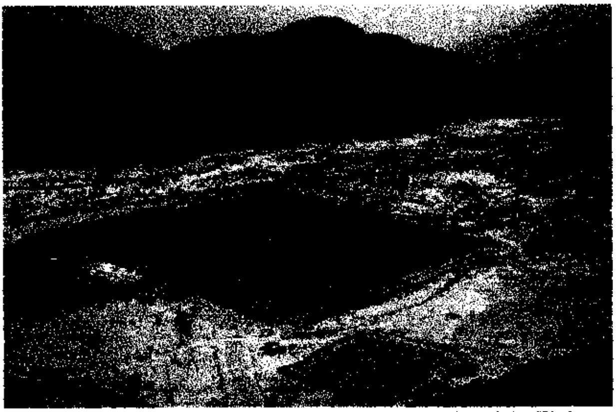

Figure 1. The Sousy Radar at Jicamarca in the foreground, with JRO main antenna in the center. The trasnmitter and receiver trailers are in between.

The main characteristics that differentiate the SOUSY radar from the Jicamarca radar are: (1) its bandwidth (4 MHz against 700 KHz for the Jicamarca radar) and (2) its steerability. The wider bandwidth allows an altitude resolution of at least 75 meters. The Sousy radar is a phased array that allows for a wide and agile steerability of its antenna ($\pm 15^o$). In order to satisfy our scientific need, we have redesigned the antenna to have two main positions, zenithal and 15° south.

The addition of SOUSY to the JRO would make possible the following number of new studies:

1. Measurements of meridional winds at ionospheric heights, taking advantage of the larger zenithal angles that the SOUSY radar can be steered. The meridional wind is the only ionospheric parameter of importance that has not been reliably measured at Jicamarca.
2. High range resolution of Mesospheric, Stratospheric and Tropospheric (MST) measurements, taking advantage of the broad bandwidth of the SOUSY radar and the possibility of a wide frequency allocation in Peru.
3. High–power wide-angle meteor radar interferometric studies. The behavior of meteor trails at the equator, because of the Electrojet electrodynamics, is different than at other latitudes.

In addition, its relative mobility should allow it to be placed, in the future, at other convenient locations near the magnetic equator, for instance the Punta Lobos rocket ranges, at the edges of the Equatorial Electrojet at (± 300 km from magnetic Equator), etc. This in turn will allow us the following experiments:

1. Concurrent observations, with radar and in situ probes, of the same mesospheric scattering volume probed by rockets launched from the Punta Lobos rocket range. Neutral turbulence in a stratified atmosphere is now being numerically modeled with success. Equatorial mesospheric turbulence is the best testing ground for these simulations since the Reynolds numbers are low and comparable to those of the models. What we will learn at equatorial latitudes should benefit our understanding of the more complicated Polar Mesospheric Summer Echoes.
2. Concurrent rocket and radar observations of *E*- and *F*- region irregularities. Common volume observations have not been done in the past because of the distance between Jicamarca and Punta Lobos rocket range, and moving the SOUSY radar will solve this problem in future rocket campaigns.
3. Measurements of the *E*-region irregularities at the foot of the field lines passing through the "150 km echoes" region above Jicamarca. Such observations might give us a clue about the physical mechanism responsible for these irregularities, for which there is as yet no accepted theory. For such measurements we would have to move the radar to location about 300 km north (or south) of Jicamarca, a location that also happens to be edge of the equatorial electrojet.

Some changes have been made to the original design of the SOUSY radar, as we can see in the block diagrams of Figure 2. As far as the antenna design, we have used the same Yagi elements used in the original SOUSY radar but in a 64 m x 64 m square array (Figure 3) rather than circular. The new antenna is composed of 64 (8 x 8) modules. Each module is composed of a 2 x 2 Yagi array, with fixed phasing. Each module will have a centrally controlled 3 bit phase shifter allowing arbitrary phasing in λ/8 steps. The square array demanded 60 additional Yagi elements than the original circular design, which were constructed locally using the same design.

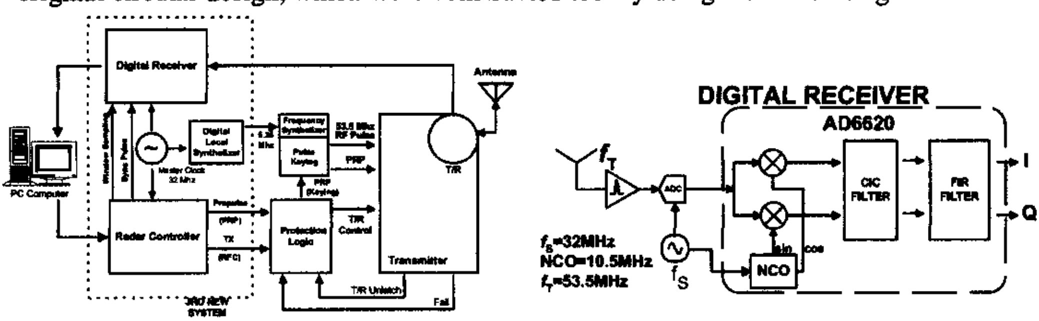

Figure 2: (a) Block diagram of the SOUSY radar (b) Block diagram of the digital receiver

The booms of the Yagis have been bent to allow two main directions (zenithal and 15°S off-zenith). The two pointing positions are obtained by flipping the boom up-side down with respect to the other, as we can see in Figure 4. The antenna modules are phased in accordance to the particular on axis direction, by properly phasing their elements. We achieve this by interchanging the same set of cables feeding each of the four Yagis that conform them. In Figure 5 are presented the radiation patterns for the mentioned main directions.

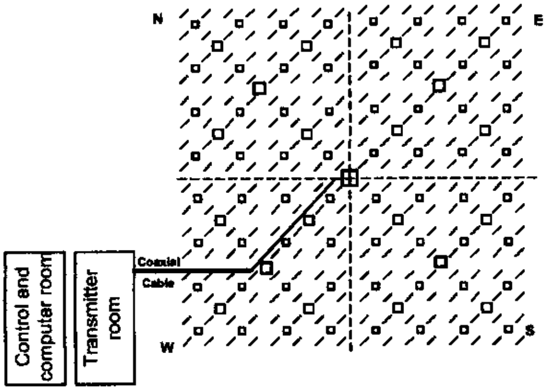

Figure 3. Distribution of the antenna array. The squares represent divide-by-four power dividers. Different sizes correspond to different power levels.

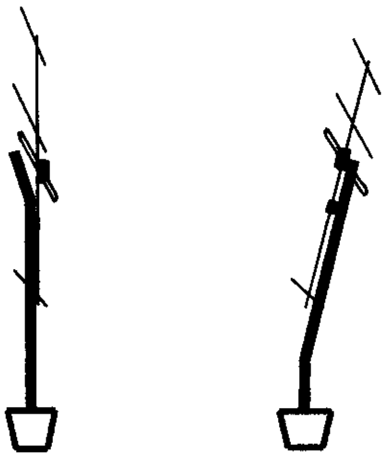

Figure 4. Two alternatives for mechanical mounting of the Yagis. Left point to zenith, right 15° S off-zenith.

At present, we are operating the antenna in a fixed 15°S off-zenith configuration. Fixed cable sections are used instead of the phase shifters. This will allow us to perform the IS experiment to obtain the meridional projection of the ionospheric wind, one of the experiments of maximum priority, without having to wait until the phase shifters are installed in each of the modules

For transmission we are using the original SOUSY transmitter in its own trailer with no modification [See Czechowsky et al., 1976 and Czechowsky et al., 1984]. For the control, signal receiving and processing, we are using a complete new system similar to the one currently being developed for the Jicamarca radar.

For the sampling of the received signal and transmitter control we are using the same design of the radar controller used at Jicamarca (Figure 2(a)). This is a modern version of the first unit designed and built in the earlier 1970's. Similar units are described in Tobaja et al. [1978] and Woodman et al. [1980]. In this new configuration we are using PLD (Programmable Logic Device) technology, which has the advantage of containing controller electronics in a single chip and can be upgraded by software.

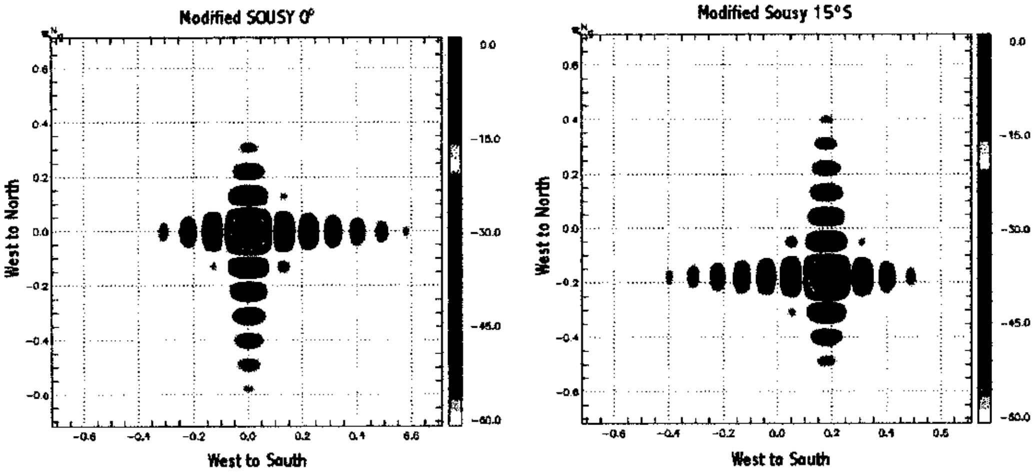

Figure 5. Radiation patterns of Sousy antenna for the 0° and 15° South center modes. Phase shifters set for 0° off-set..

For reception we are using the newly designed Jicamarca digital receiving system (Figure 2(b), for details see Micchue and Woodman this issue). In short, it uses the evaluation card of an Analog Devices chip (AD6620) designed mainly for the cellular phone industry. This board uses software developed by the manufacturer to configure the different chip parameters, such digital filters, NCO (Numeric Controlled Oscillator) and digital attenuation. The main advantages compared with an analog receiver are: 1) high sampling rates, 2) higher dynamic range, 3) programmable filters with very flexible designs, and 4) an ideal quadrature between real and imaginary outputs of the receiver. The output of the receiver is channeled directly to a PCI interface card working at 80 Mbytes per second. Processing is done on a PC working under Windows.

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