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Transhorizon tropospheric propagation in the Saharian Fishing Bank

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ABSTRACT.

In the zone between the Canary Islands (28°N - 13,5°W) and Mauritania (20,5°N - 19°W) the ducting tropospheric propagation in the 900 MHz band has a range longer than 700Km. This is a privileged zone for the analysis of this type of propagation due to the stability of the atmospherical conditions.

Using different data sources, the meteorological conditions that make possible the appearance of a temperature inversion layer will be studied. This inversion layer creates troposferic ducts, which can be the responsible for the long-range communications establishment.

INTRODUCTION.

In the Saharian Fishing Bank (BPS), located between the parallel 28°N and 20°N and the meridian 13°W and 19°W (figure 1), long-range communication by tropospheric propagation is frequently established. During anomalous conditions in the troposphere, a stratification in layers with different characteristics is produced and an increase of the temperature with the height and variation of the relative humidity is detected. This division of the lower part of the atmosphere determines the thermal inversion layer, which is responsible for the modification of the refractivity, N. *N* is a function of the absolute temperature *T* (Kelvins), the atmospheric pressure *p* (mbar) and the water vapour pressure *e* (mbar), according to the expressions [1], [2], and [5]:

$$N = \frac{77.6}{T}(p + \frac{4810}{T}e) \qquad (1)$$

$$e = 6.11xHx\exp(19.7\frac{T-273}{T}) \qquad (2)$$

where H is the relative humidity.

It is better to introduce the modified refractive index M, defined as:

$$M = N + 106\, h/a \qquad (3)$$

being *h* the height on the surface and *a* the radius of the earth.

This modification of the refractivity in height according to its gradient produces refracted beams being removed from the normal and reaching greater distances than initially expected in a standard atmosphere.

The curvature of the beams could even be greater than the curvature of the earth, and these beams could be trapped vertically behaving like a waveguide. In those conditions, a duct is created in which the wave travels with smaller losses than free space. Depending on the profile of M, three types of ducts can arise: evaporative, elevated and surface-based elevated duct.

In our study case, the work frequency is in the 900MHz band where mobile telephony service, TACS, is allocated. Figure 1 shows the coverage map of the TACS:

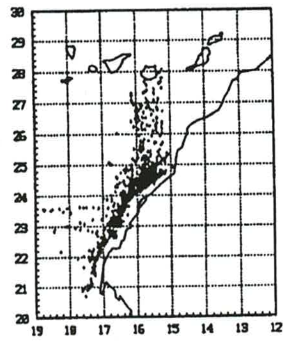

Fig. 1.- Coverage map of the TACS in BPS

The highest reception base station is situated at 1950m, making the line of sight at that point with a latitude 26° 10´. All the data in figure 1 from this latitude southward can only be explained by means of anomalous tropospheric propagation.

CLIMATOLOGIC CONSIDERATIONS

The climate in the Archipielago presents practically stable conditions during all year round, [3] and [4]. Furthermore, the islands are found in the proximities of the African continent and bathed by a cold oceanic current that confers some specific climatic features of temperature, humidity, and hot air invasions. The high pressure center of the Azores is the generating motor of the winds known as "Alisios". Those winds blow with a component N-NE almost during all year round, and their greater intensity and stability arises during the summer months. This regime of winds together with the influence of the oceanic current divide the troposfera into two well distinct layers: a superficial one, with wet and fresh characteristics, and a higher one, that is dry and warm. These two layers, according to their characteristics, allow temperature inversion and creation of the channel. The inversion layer will be created mainly by subsidence or advection [2]. This temperature inversion acts as a refractive layer of energy, and signals remain vertically confined.

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DATA ANALYSIS

Analysing the reached coverage distances and power levels, it's possible to discard the troposcatter propagation due to the highest transmission loss that would imply.

The data have been obtained from different sources: own transceivers, TACS commercial equipment, data provided by fishermen, information obtained from telephony base stations and meteorological radiosonde.

If the obtained data are correlated, a clear relationship between the coverage, temperature inversion layer and ducting can be observed, at least in a 85% of the cases. The remaining 15% depends on another phenomena contributions as well as undetected atmosphere variations caused by discrete data of the radiosonde in space and time (10 and 22 hours only). According to this, a continuous and complete control of the different layers of the atmosphere has not been achieved.

The rate of duct creations and their types have been studied. In figure 2 one of them can be seen, together with its corresponding temperature inversion layer whose inferior and superior level are labelled by the points A and B.

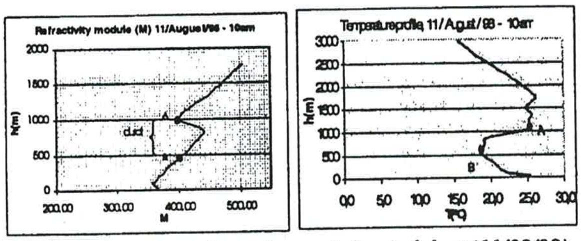

Fig.2.- Temperature inversion and elevated duct (11/08/98)

The conditions in the BPS all year round are quite stable, so the coverage will strongly depend on the climatic conditions in the islands. The temperature inversion layer is almost permanent along the year in the archipelago as well as in the BPS. Don't forget, however, that the refractivity and consequently the variation of the refraction module M, will depend also on the atmospherical pressure and on water vapour pressure, according to (1), (2) and (3).

Some features concerning the most favourable conditions of the propagation have been detected. The propagation is better when a strong anticyclone from Azores is near to its habitual position (more frequently in summer) or when advection from African coast occur. Both cases generate a wide and low inversion. During low coverage days, the duct is high and narrow, moreover, the communication does not occur when the duct is high, no matter its width (the threshold height established to determine coverage is 1200 m approximately for the inferior level of the duct). The trapped layer will depend on the types of duct [2],[7]. Anyway, the larger period detected without communication does not overcome 10 days. Obviously, when the duct is low, the vast majority of the links have also been established also by low stations.

Concerning the communication stability, it's important to mention the often appearance of deep fading, sometimes even nearby to 20dB, due to the atmospherical parameter variations and therefore M, (3). In fact, though the inversion is relatively stable along the day, it might drastically-vary depending on the period of the year and for the day in question. In summer, the propagation is more unstable given the atmospheric dynamic in this season. Also, a better coverage has been observed at night, and during certain months of the year (overcoat in summer). Furthermore, there are periods in which the links are more frequent in certain zones of the archipelago than another. This may be due to diversification of canals in certain occasions, some of them clearer than another. The duct height in May and August of 1998 is shown in figures 3-6, accomplished by 10 hours radiosonde, and its coverage rate. In the figures related to the inversion layer, the inferior and superior levels of the inversion are given (consider the points A and B in the fig.2).

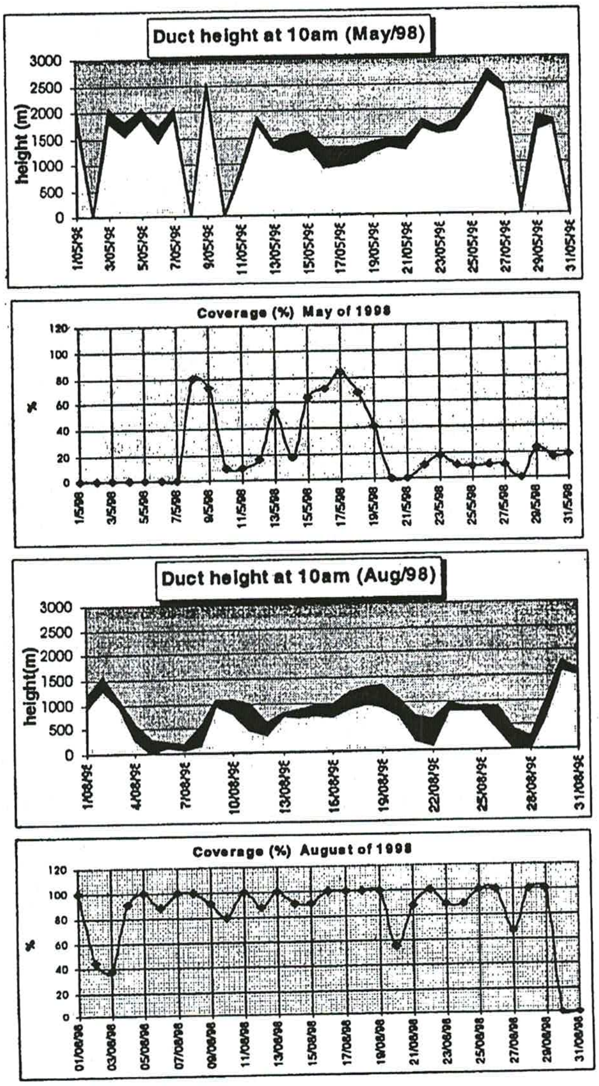

Fig.3-6.- Heights of ducts and coverage during the months of May and August 1998.

As mentioned, a threshold has been established in 1200m height, and in contrast to the corresponding coverage graphics, it is observed that when the duct is above this threshold, the propagation is notably reduced.

As one can see, the May duct height is higher than the August one and so the coverage is much smaller.

Figures 8-9 show the variation of the inversion layer along the year, and its correspondence with the coverage. At the same time, figures 10-11 display the variation of the duct height for the same period of time. The relationship between temperature inversion and ducting can be deduced.

Observing figures 5 and 6, as a sample data, the next power levels were measured between *El Hierro* island and the BPS: about -85dBm on August 28th (24°31'N-16°00'W) and 29th (24°31'N-16°00'W), decreased to approximately -125dBm on August 30th (24°31'N-16°00'W). These data can be contrasted in fig. 5 and 6 in which the relationship of the duct height and the coverage is appreciated. As displayed, on August 30th the duct layer rises above 1200m and the coverage disappears.

Total coverage days (%)	39,92
Irregular coverage days (%)	19,64
No coverage days (%)	40,33

Fig. 7.- Percentage of coverage

Fig. 7 shows that the transhorizon propagation along the year is greater than 50%.

CONCLUSIONS

A great stability in ducting appearance, and a coverage rate greater than 55% have been observed along the year. If the inversion layer is lower than 1200m, the establishment of the communication canal will be more likely to happen. The duct creation is due to the presence of a high, warm, and dry layer, and a lower cold and wet one, which is originated by the sea presence. Above 1200m height, ducting does not seem to have a significant effect in the propagation.

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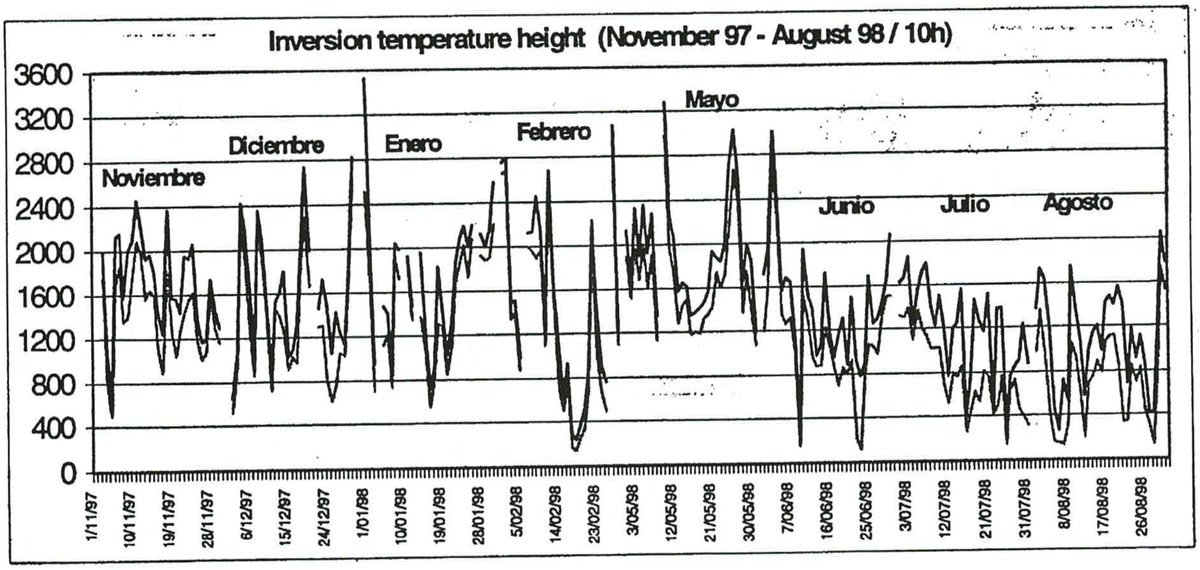

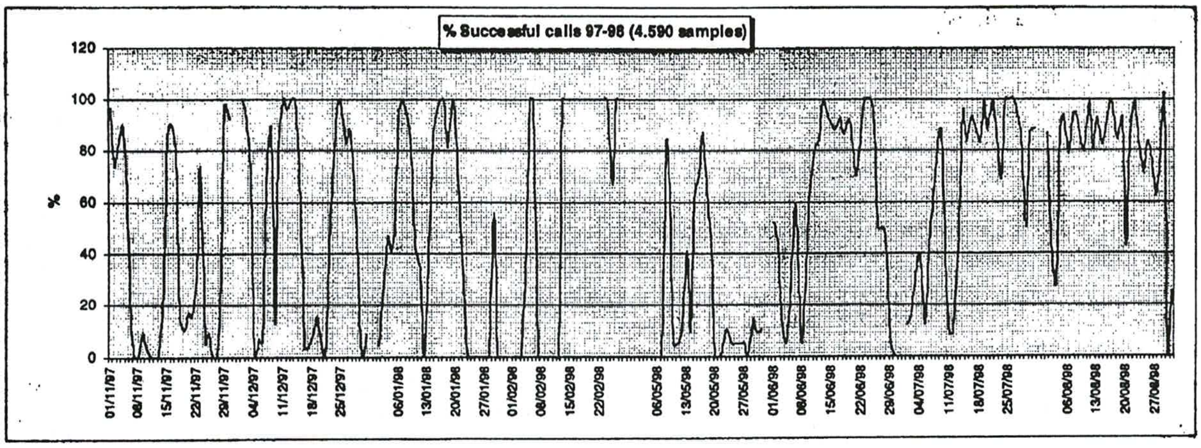

Fig. 8 - 9.- Evolution of the temperature inversion layer and its coverage percentage.

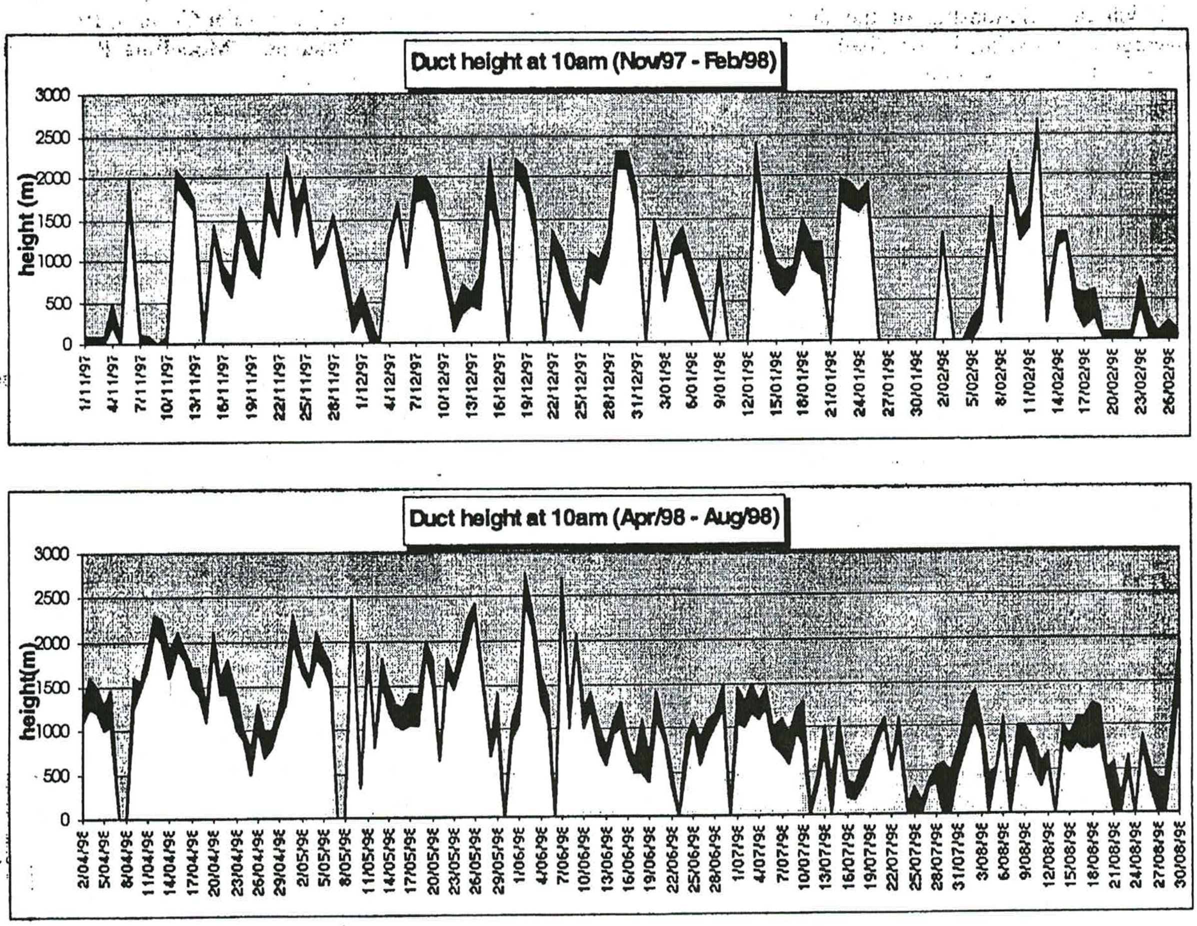

Fig. 10-11.- Evolution of the duct height.