Tropospheric Ducting

The speed of a radio wave in the atmosphere is determined by the dielectric property of the air. This property depends on the pressure, temperature and humidity of the air. In general as we move upwards through the atmosphere the pressure decreases and temperature falls. This means that the dielectric property changes with height and allows a slight increase in the speed of a radio wave as we move upwards through the atmosphere. This in turn means that if a radio wave moves away from the earth at an angle less than 90 degrees, then the upper part of the wave travels faster than the lower part. Therefore even under normal conditions this can in effect bend, or refract, the wave back down to earth.

The normal rate of change of dielectric constant with height refracts the wave so that it follows a curved path of about 1.3 times the radius of the earth. Therefore, we typically can receive signals which are 1.3 times further than we can see by line of sight.

Tropospheric ducting occurs when we get a sharp rate of change in the dielectric constant as we move upwards through the atmosphere. This occurs when we get a rapid increase of temperature and a rapid decrease in humidity (dew-point) with height.

If we look at a vertical profile of the atmosphere showing ducting potential, we can see that there is a sharp increase in temperature (an inversion), coupled with a sharp fall in dew-point (indicating a fall in humidity). The duct occurs below this inversion in the yellow shaded area.

Figure 1

Under these conditions we now have the radio wave bent back towards the earth. However, the radio wave can then reflect back of the earth and become refracted again to return earthwards once more. This can sometimes occur a number of times.
with little attenuation but some fading. The result can be long distance reception of radio waves that would normally have been far beyond the radio horizon.

Typical conditions required for a good duct to occur are:

1. An increase in temperature by 3°C or more per 100ft.
2. A rapid decrease of RH (dew-point) with height.

The depth of the duct required for varying wavelengths is:

1. 50ft for wavelengths around 3cm (approx. 1000MHz)
2. 600ft for wavelengths around 1m (approx. 300MHz)

Typical meteorological conditions which can be favourable for ducting are:

1. Warm dry air over a cooler surface, especially a cool sea
2. Surface cooling under clear skies overland
3. Anticyclone (high pressure) or developing high pressure ridges with a cold surface
4. Sea breezes undercutting warm air overland
5. At fronts with a strong thermal contrast
6. In cold down draughts associated with cumulonimbus clouds (indicated by heavy showers or thunderstorms)

To decide if there may be potential for ducting then first consult the Met Office forecast synoptic charts. If they are showing hints of high pressure building or a weak ridge crossing the area then there could well be potential.

Other sources of information can come from radiosonde ascents. These show the vertical profile of temperature and dew-point up through the atmosphere. They can be displayed in varying ways, but typically we are looking for a profile which looks like that in Figure 1. That is a sharp increase in temperature coupled with a sharp drop off in dew-point.

These diagrams often have a vertical scale measured in pressure rather than height, Table 1 is a short conversion table covering the heights we would be interested in.
These are ICAO pressure/heights and have a standard MSLP (Mean Sea Level Pressure) of 1013.2hPa. Therefore MSLP's different to this would affect the heights:

<table>
<thead>
<tr>
<th>Pressure in hPa</th>
<th>Approximate height in metres (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1013.2</td>
<td>0 (0)</td>
</tr>
<tr>
<td>1000</td>
<td>111 (364)</td>
</tr>
<tr>
<td>950</td>
<td>540 (1773)</td>
</tr>
<tr>
<td>900</td>
<td>988 (3243)</td>
</tr>
</tbody>
</table>

**Table 1**

Here are some links to sites where these ascents can be found:

- [University of Wyoming](http://example.com) (simply click on a location)
- [Infomet](http://example.com)

Finally, a good guide to a duct occurring can be seen by viewing rainfall radar output. As these operate at a high wavelength and there is some automated correction to filter out incorrect radar returns they may not always be suitable. Nevertheless, if you look at the site when you think conditions may be favourable and see very strong returns where it should be dry then either the forecast is very wrong, or there is a duct. You can view the [Met Office](http://example.com) radar system via the [BBC](http://example.com) site.

Good duct hunting!