

Ionosphere Properties and Behaviors - Part 8

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In this episode I shall continue with some seasonal properties of the ionosphere and make a start of the daily cycle and its propagation and ionospheric properties variations. There exist spectacular and drastic differences during a one-day cycle concerning the better frequency to use, reachable path distances, and favored circuit choices.

Radio Communication Characteristics by Seasons

Winter Period

Northern hemisphere: 15 October – 15 February – Southern hemisphere: 15 April – 15 August.

Winter is characterized by high daytime foF (MUF's), but low dark-time MUF's, shorter days, and lots of darkness, sun rising slowly, and longer grayzone duration and less electrostatic discharges. Conversely, these lesser QRN conditions will not exist in the opposite hemisphere where they have local summer. This is the season and the conditions for low band DX communication. High band communication opening are much shorter, a few hours of the day only. This season gives good **"Oblique trans-equatorial propagations"** on the NW-SE and NE-SW paths during common grayzone periods.

At mid-winter month the F-region does not split-up into two layers, the F1 does not develop. **Fig. 58.1a, 58.1b.**

Note the ionograms are taken from ionosonde Dourbes (Belgium) year 2006 and represent typical mid-latitude values. The SSN is rather low at this year, nearly at its lowest of cycle 23.

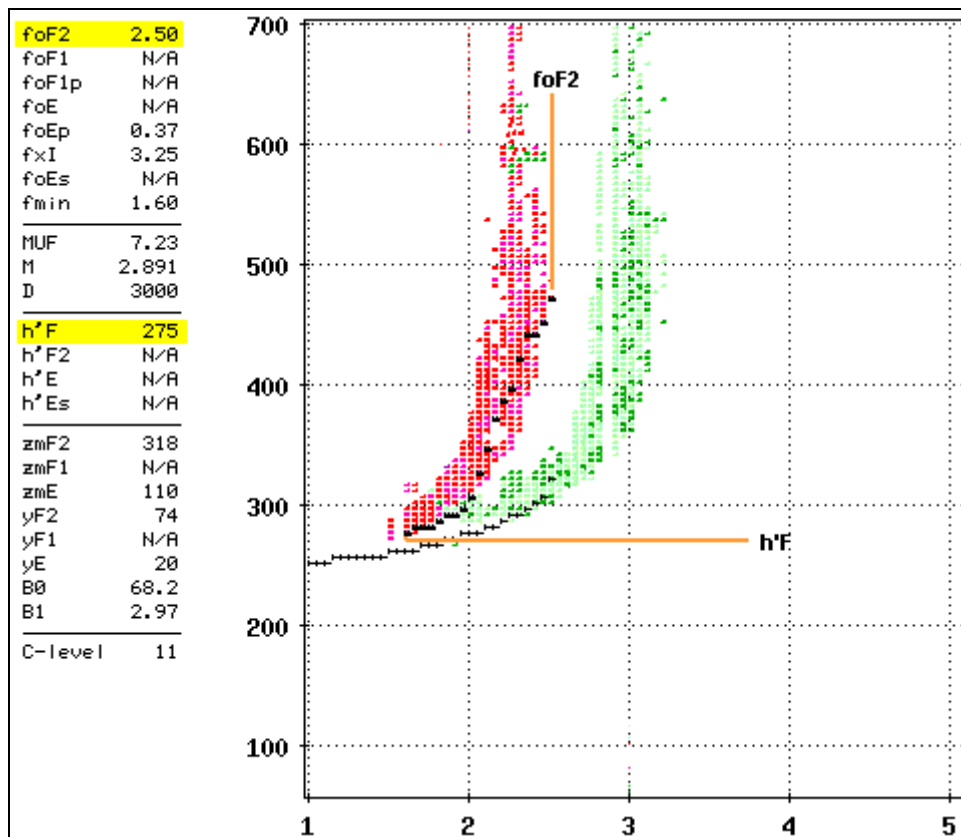


Fig. 58.1a. December midnight ionospheric properties.

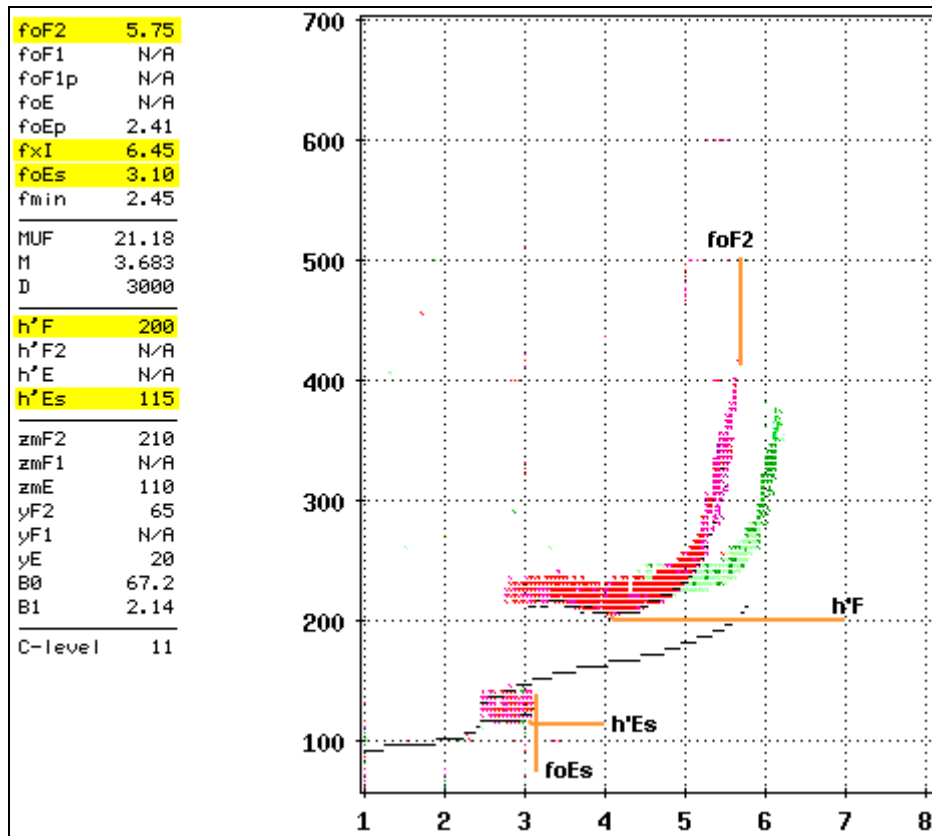


Fig. 58.1b. December midday ionospheric properties.

Summer period

Northern hemisphere: 15 April – 15 August - Southern hemisphere: 15 October – 15 February.

Summer is characterized by rather high MUF's, longer days, fast rising sun, increased D-layer activity at dusk and dawn and frequent probability of QRN due to local thunderstorms. These factors create the worst conditions for low band communications. In contrast, high band communication is possible over a long hours range and, depending on the sun activity cycle period, also at the highest HF frequencies.

This season gives good **“Oblique trans-equatorial propagations”** on the NW-SE and NE-SW paths during common graytime periods.

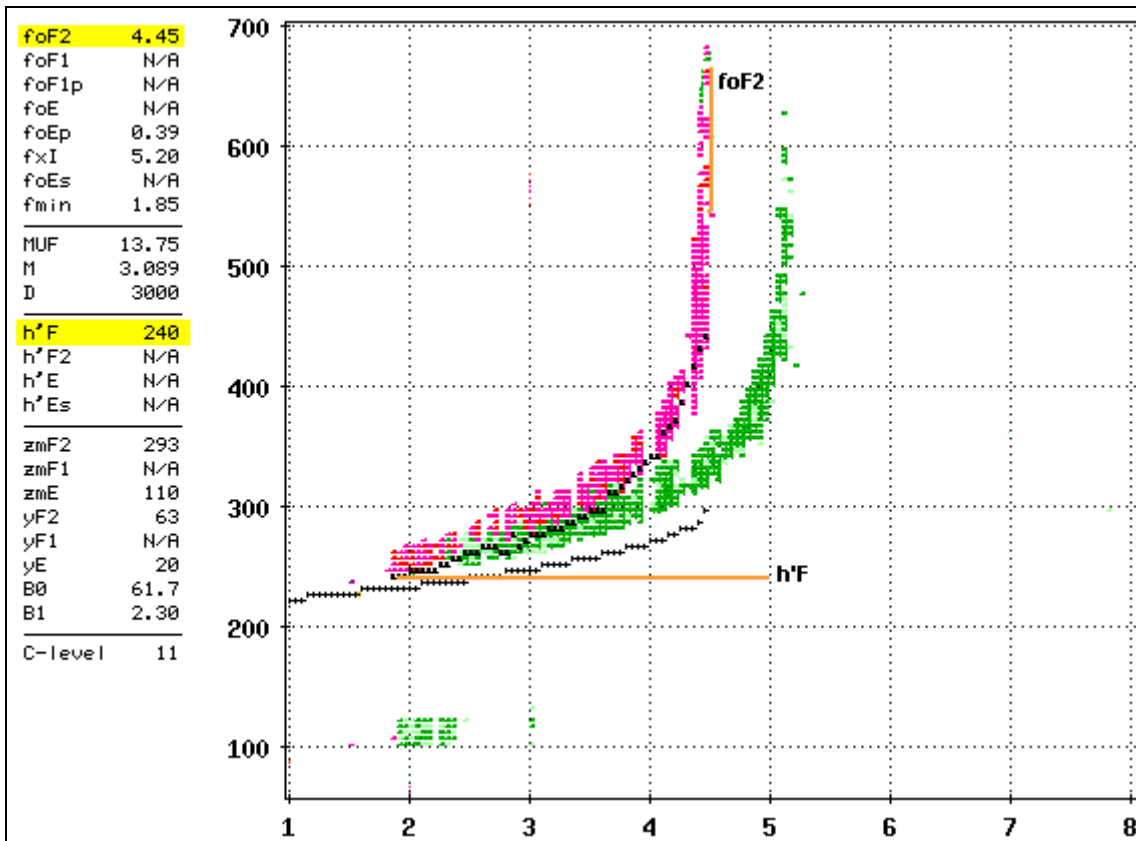


Fig. 58.1c. June midnight ionospheric properties.

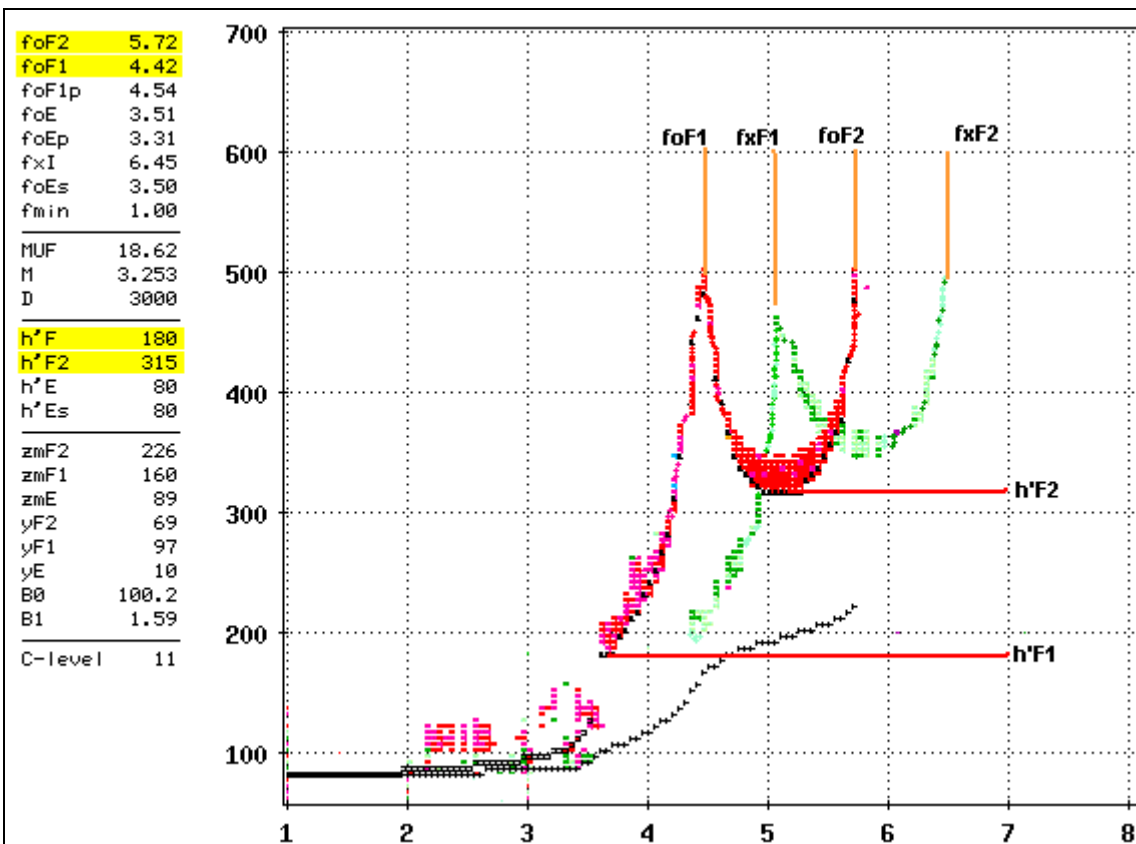


Fig. 58.1d. June midday ionospheric properties.

Equinox period.

15 Augustus – 15 October and 15 February – 15 April.

During these periods the ionospheric conditions are fairly similar in both the northern and the southern hemisphere. They are characterized by reduced QRN, rather similar MUF's, rather equal days and nights of approximately 11 to 13 hours long anywhere on the globe. Good opportunities for high band TEP and for the low frequency bands occur in this the ideal season due to "**Oblique trans-equatorial propagations**" on the NW-SE and NE-SW paths during common grayzone periods. This is also a season for low band DX communication. Some typical examples are: Europe to New Zealand (Europe and/or New Zealand morning or evening) and West Coast US to SE Asia (NA morning) or East Coast NA to Indian Ocean (NA evening).

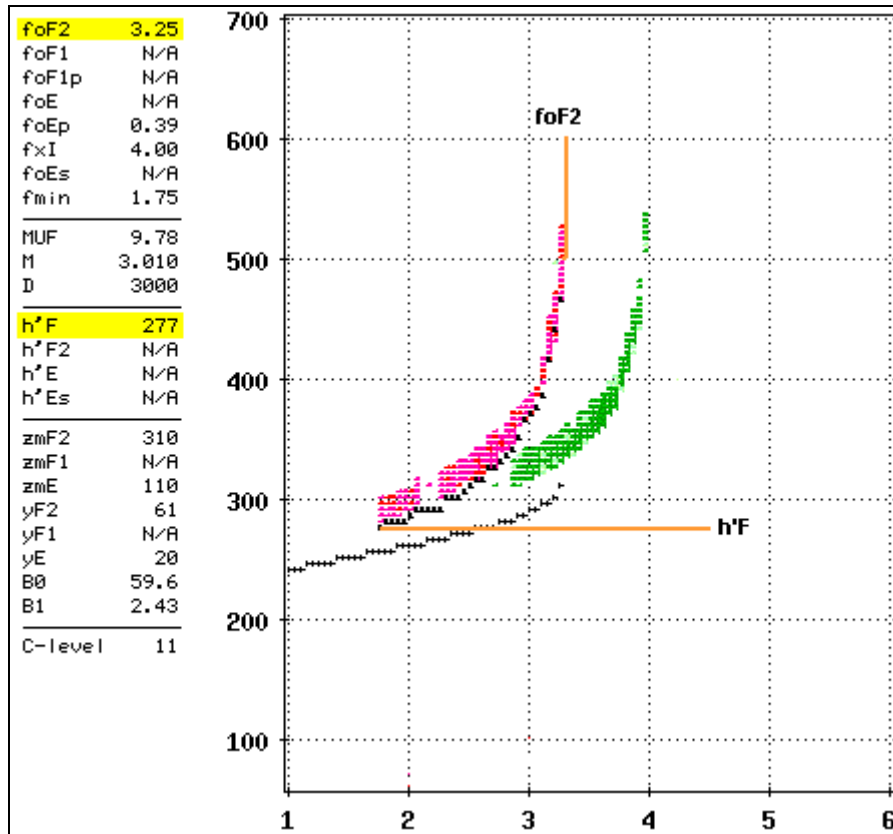


Fig. 58.1e. March midnight ionospheric properties.

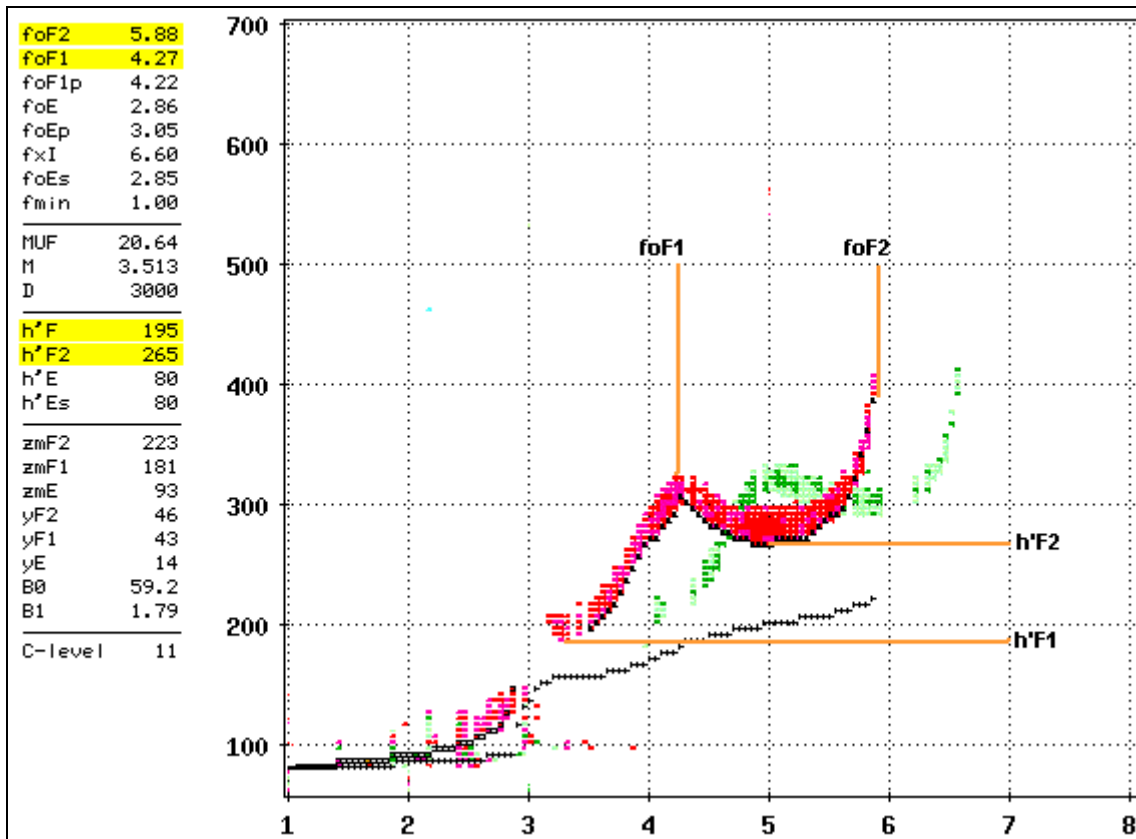


Fig. 58.1f. March midday ionospheric properties.

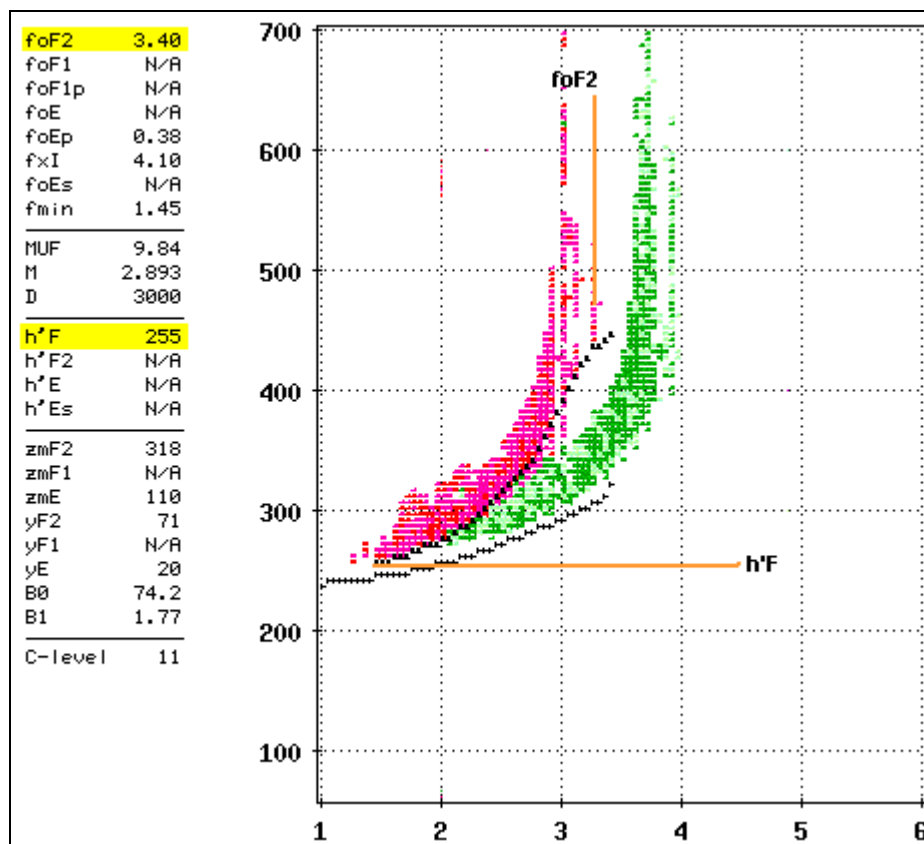


Fig. 58.1g. September midnight ionospheric properties.

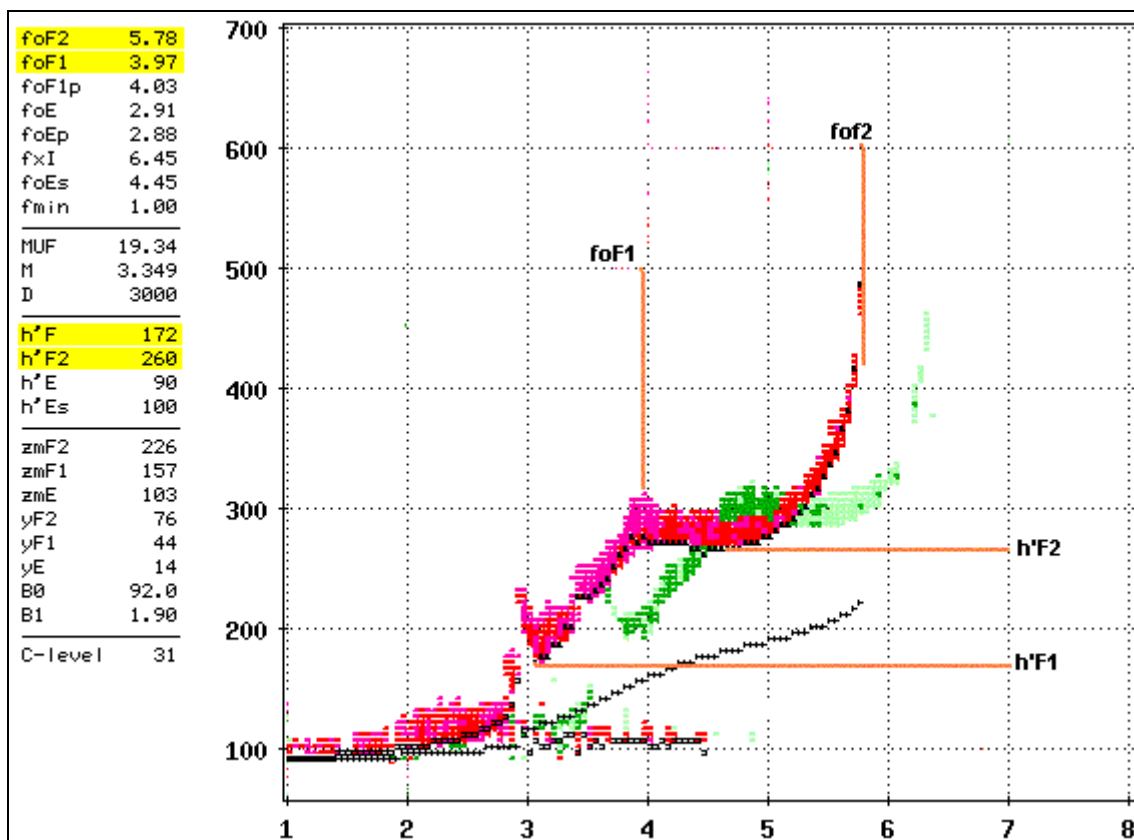


Fig. 58.1h. September midday ionospheric properties.

Season	h'F1 (km)	h'F2 (km)	foF1 (MHz)	foF2 (MHz)	MUF(3000) MHz	SNN
Winter	NA	200	NA	5.75	21.18	24
Spring	195	265	4.27	5.88	20.64	17
Summer	180	325	4.42	5.72	18.62	17
Autumn	172	260	3.97	5.78	19.34	11

Table 58.1a. Seasonal midday data.

Midday summary:

The **h'F1** is varying not much between seasons.

The **foF1** is also varying not much between seasons.

Note that the F1 is absent at winter season.

The **h'F2** is varying spectacularly between seasons, the highest at summer and the lowest at winter. Spring and autumn give rather equal results.

The **foF2** is varying negligibly.

The **MUF(3000)** is varying in spite of the fact that foF2 is practically equal and stable. The reason is the varying h'F2; remember lower refraction heights give higher MUF's, (the secant law, the lower the height with equal critical frequency the higher the resulting MUF).

The **SNN** values are for the year 2006. Other SSN value will of course lead to different values but the trends will display equal behaviors.

Season	h'F1	h'F2	foF1	foF2	MUF(3000)	SNN
Winter	NA	275	NA	2.50	7.23	24
Spring	NA	277	NA	3.25	9.78	17
Summer	NA	240	NA	4.45	13.75	17
Autumn	NA	255	NA	3.40	9.84	11

Table 58.1b. Seasonal midnight data.

Midnight summary:

No F1 during nighttime, both F-layers recombine to one layer. The F1 and F2 become in fact F, but often keep the indication of F2.

The **h'F2** is the highest at winter and spring and the lowest at summer and autumn.

The **foF2** is the lowest at winter, lots of dark hours lead to longer recombination time of the free electrons. The opposite we notice during summer time. There we find the highest remaining electron density, because of long days and short nights.

The **MUF(3000)** is again varying a lot and stays the highest at summer season this due to its high foF2 and its low h'F2. The opposite happens during the winter season, low foF2 and high h'F2. The spring and autumn seasons display characteristics rather equal to each other.

Note: at a later coming issue I will supply a throughout summary of seasonal propagation characteristics spread over each HF ham band and different sun activity periods.

The Daily Cycle

The Earth's rotation around its axis creates day and night. The transition time from day to night is not everywhere on earth the same and varies also with the season. The sun rises and sets very quickly in equatorial zones, and that leads to very abrupt and short day-to-night or night-to-day transitions. The opposite is true in the polar zones. For convenience lets subdivide the day into three periods:

1. Daytime: from after sunrise (dawn) until before sunset (dusk).
2. Nighttime: from after sunset (dusk) until before sunrise (dawn).
3. Dawn/Dusk: the sunrise and sunset twilight periods (grayzone).

Daytime

From local sunrise, the D- and E-layer ionization builds up and the remaining low ionized F-layer ionization starts to increase steadily. Maximum ionization of the layers is reached shortly after local noon. The rate of ionization buildup time and ionization density depends on the location and the season. This process changes many propagation properties.

- ❑ **The D-layer.** The minimum absorption from before sunrise gradually increases until a maximum is reached just after noontime. The degree of absorption will depend on the height of the sun at any given time. During typical daytime conditions, when the D-layer ionization is very intense, low-angle signals will be totally absorbed or most strongly attenuated, while high-angle signals will get through and be refracted by the E- or F-layer(s). The lower the used frequency the higher the attenuation.
- ❑ **The E-layer.** Some frequency bands might now be refracted by the E-layer instead of the F-layer during nighttime. This means shorter skip distances and lower signal strength, (more hops are needed to span the same distance). Therefore, they also pass more often through the absorbing D-layer.
- ❑ **The F-layer.** The use of much higher frequency bands compared to nighttime conditions is now possible. In low sun activity years (low SSN) the 20 meters band will open which was not the case during nighttime (due to low F2 ionization densities) and probably higher frequency bands might support communication as well. In higher sun activity years (high SSN) the 12- and 10-meter bands open frequently. The F-region splits also up into two layers the F1- and the F2-layer. The height of the F2-layer is also much higher compared to the single F-layer height during nighttime. This allows much longer hop distances. The 20- and 17-meter bands are mostly refracted by the F1-layer while the 15-, 12-, and 10-meter bands will penetrate the F1 zone and be refracted by the F2-layer. The F-region does not divide into F1 and F2 during the mid-winter months, and the single F-layer height is then much lower compared to the other month periods.

Nighttime

Nighttime is the time to communicate on lower frequency bands. The non-existence of the D-layer and its attenuations to our signals changes dramatically the propagation properties.

- ❑ **The D-layer.** From sunset the D-layer dissipates gradually and disappears almost completely. The low frequency bands are now usable for DX communications as long as the path is in the dark side or within the grayzone.

- ❑ **The E-layer.** Dissipates also from sunset gradually but remains very weakly and still refracts MF waves (160 meters band).
- ❑ **The F-layer.** The ionization density decreases (free electron recombination) slowly to reach its minimum just before sunrise. Its MUF suffices mostly to support the low frequency bands and at period of high solar activity the ionization remains often high enough to support the 20 and 17 meters band

Dawn and Dusk: Grayzone periods

As mentioned before, the grayline or terminator is the dividing line between on half of the earth in daylight and the other half in darkness. The visual transition from day-to-night and vice versa happens quite abruptly at the equatorial zones and much more slowly at the polar zones. The gray zone (twilight zone) is the area between day and night around the earth and is characterized by producing very interesting propagation conditions that are not limited to the low bands only. However, the mechanisms involved can differ substantially between the high bands (20, 17, 15, 12, and 10 meters) and the low bands (40, 80, and 160 meters). It is extremely important for low band operators in particular to know exactly where the grayzone and dark zone are situated. Using worldwide sunset-sunrise timetables or even better visualizing world maps showing the grayzone are a must to low band DXing.

At dusk and dawn zones the F-layer in particular, is tilted and moving either upwards or downwards. This is the onset to the twilight effect, characterized by lower signal strength loss than the standard multi-hop model. The ducting mechanism onset is found at tilted environments as explained in detail at earlier issues (TEP).

Besides the role of the ducting mechanism at dusk and dawn times, there is another reason why DX propagation at low band frequencies is much better during twilight periods. When the sun is rising in the morning, all the signals coming from the east are greatly attenuated by the D-layer already existing in the east. During night, stations from the east often cause a great deal of QRM. The same happens at evening when the sun sets then there is a much better signal-to-noise ratio by weaker stations coming from the opposite west direction. This does not mean that we will be heard better, the signal-to-noise ratio is self evidently only influencing the receiving site and not the transmitting site.

Obviously, it is also important to know how long these special propagation conditions exist. The rate of change from darkness to daylight and vice versa depends upon the rate of sunrise or sunset. Two factors determine this rate: the season (the sun rises faster in summer than in winter) and the latitude of your location (the sun rises very high near the equator and much lower more toward the poles).

For low band communications it is also a fact that the signals departing or arriving at an angle perpendicular to the grayline or terminator display the greatest signal enhancements. These paths travel the shortest distance through the D-layer (traveling for the most part in the dark site where no D-layer exists).

For high frequency band communication it is found that signals traveling along or parallel to the terminator but mainly at the daylight side profit of the lesser D- and E-layer ionization. The good DX propagation properties at and along the terminal at the daylight site exist practically only if the path is within a maximum 11- to 12-degree range from the terminator or \pm 45 minute after sunrise. Once outside this range the conditions vanish rather suddenly and abruptly.

The ionosphere variations at sunrise and sunset periods

The ionospheric properties variations at the sunrise grayzone

The series of ionograms represents the march equinox time. The sun rises at 5:44 and sets at 17:55 at the ionosonde location, **Fig. 58.2a, and 58.2b.**

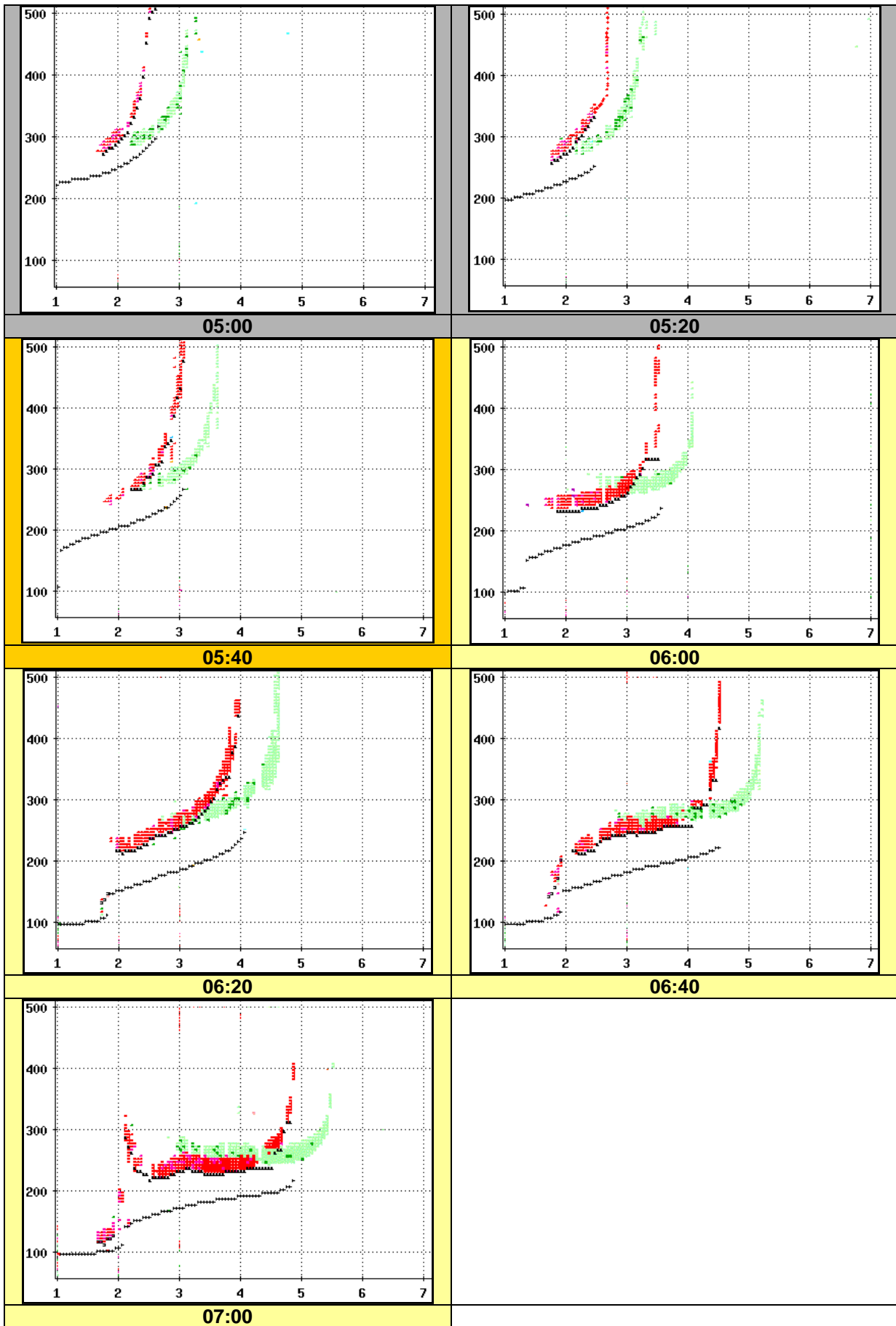


Fig. 58.2a. A two hours sunrise range, sunrise at 05:44.

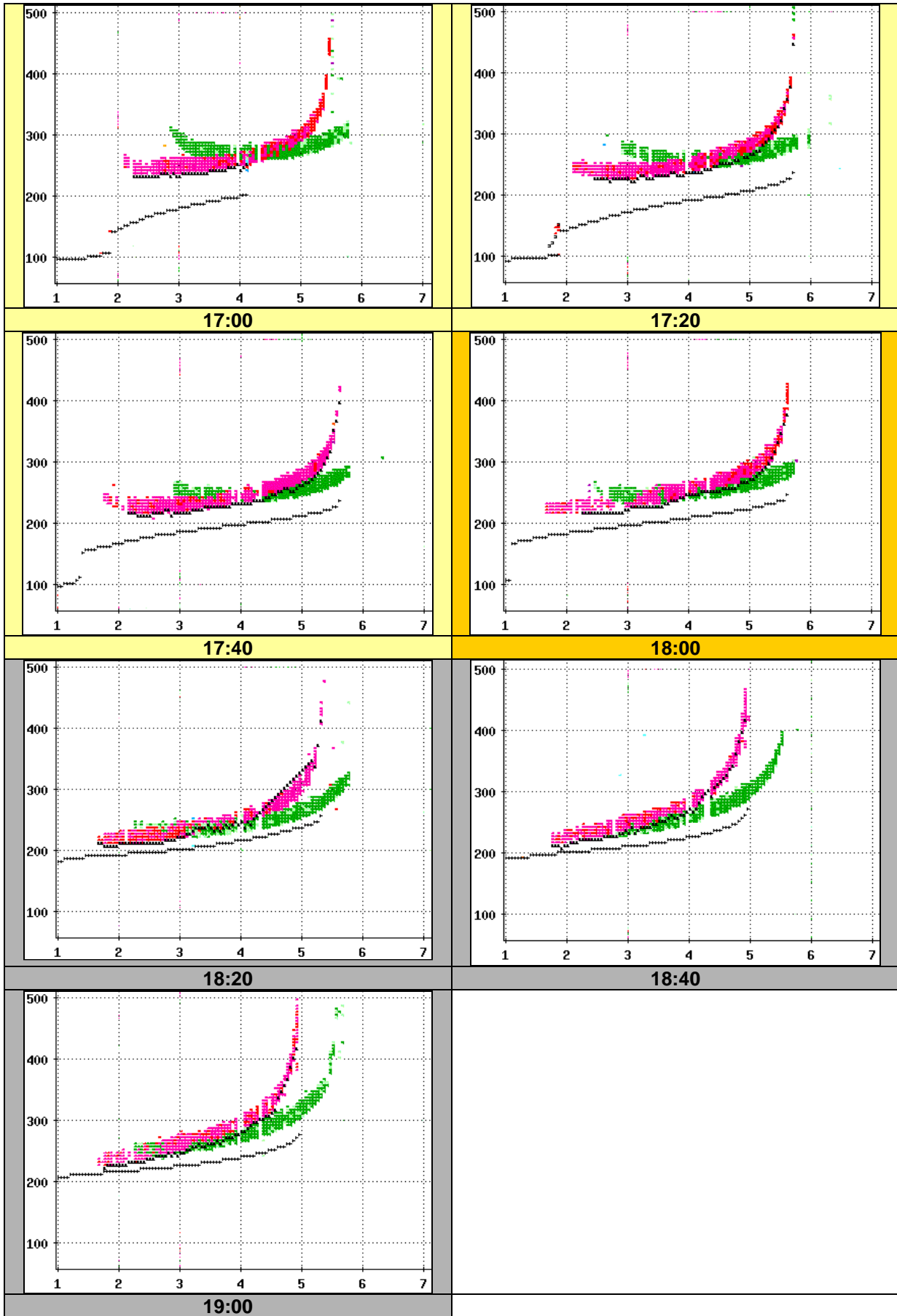


Fig. 58.2b. A two hours sunset range, sunset at 17:55.

Summary sunrise

We notice that at sunrise the h'F2 decreases 50 kilometers within approximately a 30-minute period, (from ± 275 km to ± 225 km). Also the foF2 increases in the same time period about 1 MHz. About 1 hour after sunrise the F1-layer develops already. These are for sure the ingredients to a tilted whirling ionosphere and ideal for the onset of the ducting propagation mode.

Summary sunset

We notice that at sunset the h'F2 decreases only 30 kilometers but slowly and steadily and over a 2-hour time range. During that time the foF2 is also decreased only 0.5 MHz. We have a tilted ionosphere but with a more obtuse angle compared with the sunrise tilt. We may also conclude that the F1-layer has already vanished one hour ahead the sunset.

This period of the grayzone is a good time to make communications spread over most frequency bands. Very low signal attenuation occurs due to the much decreased E-layer ionization and disappeared D-layer right after sunset. Here at my QTH location we notice this frequently with communications to New Zealand and Australia. Two year ago when I was visiting ZL-country I noticed the phenomenon each time I had a 20-meter band schedule with the homeland Belgium. You could predict the onset of the circuit opening in less than a quarter hour time. The sunrise grayzone was at Belgium after sunrise and the sunset grayzone at New Zealand was after sunset.

In the next issue, we shall study propagation properties at and along the grayzone, illustrated by ray tracing models and transverse Plasma frequency diagrams; stay tuned. **-30-**

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