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M51 image from the New Mexico Skies visit by Chris Longthorn

Image Details are,
Date April 13th 2010, I took 3 off 15 minute exposures, the last one finished at 21:47. The telescope was a 16" Meade LX200 Schmidt Cassegrain on an equatorial mount controlled by The Sky 6 Professional software. The images were all captured with an SBIG ST-2000XCM one shot colour CCD camera operated using SBIG CCDOPs capture software. The telescope was also guided using the same capture software. All images were automatically calibrated on download also by the capture software. The 3 images were stacked on the following day using CCDOPs again, using New Mexico Skies' facilities. Some post processing was also done there using Photoshop CS4. I finished the processing at home once we'd returned to the UK using Photoshop CS3.

CONTENTS

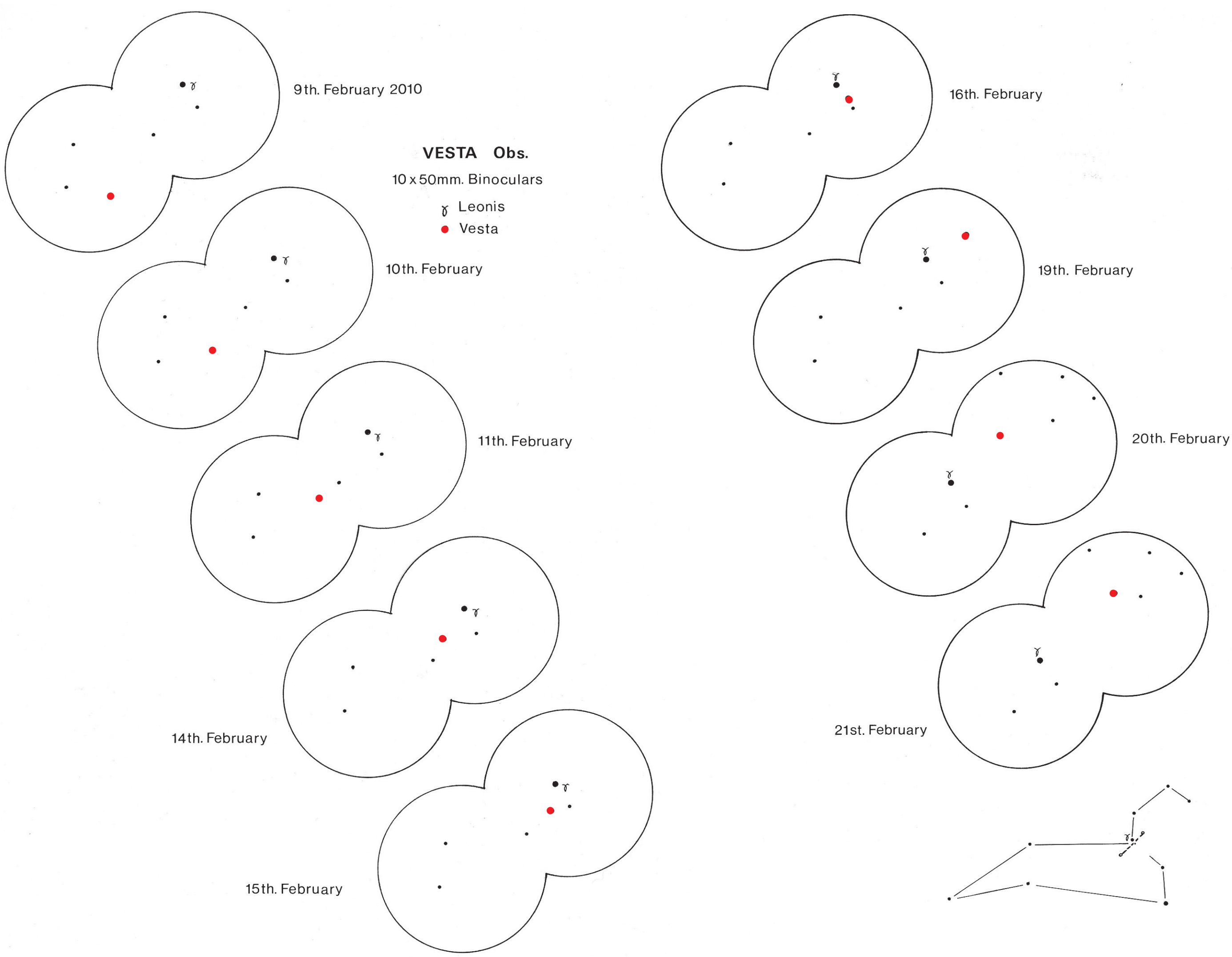
Observations of minor planet (4) *Vesta*

by Vaughan Cooper

A brief but fortuitous opportunity to follow almost on successive nights the movement of the minor planet (4) Vesta, whilst at its brightest and without the intrusion of the Moon, against the starry background of Leo.

During the time of observation, Vesta appears as a 6.1 mag star — bright enough to see without optical aid, but I required 10x50 bins and I found the movements of Vesta whilst very obvious and east to identify from my second observation artwork as it slowly moved approximately 4° to the north west close to γ Leonis (Algeiba) as illustrated by the dashed line on the Leo constellation diagram.

Although nothing of any scientific value was achieved, nevertheless I found satisfaction to follow a distance 336 mile diameter celestial body lying between the orbits of Mars and Jupiter.



The daily movements of (4) Vesta from the 9th February 2010, to the 21st. It reached opposition on the 18th shining at magnitude 6.1, so it should have been visible to the naked eye from a dark site.

Modelling the Ionosphere

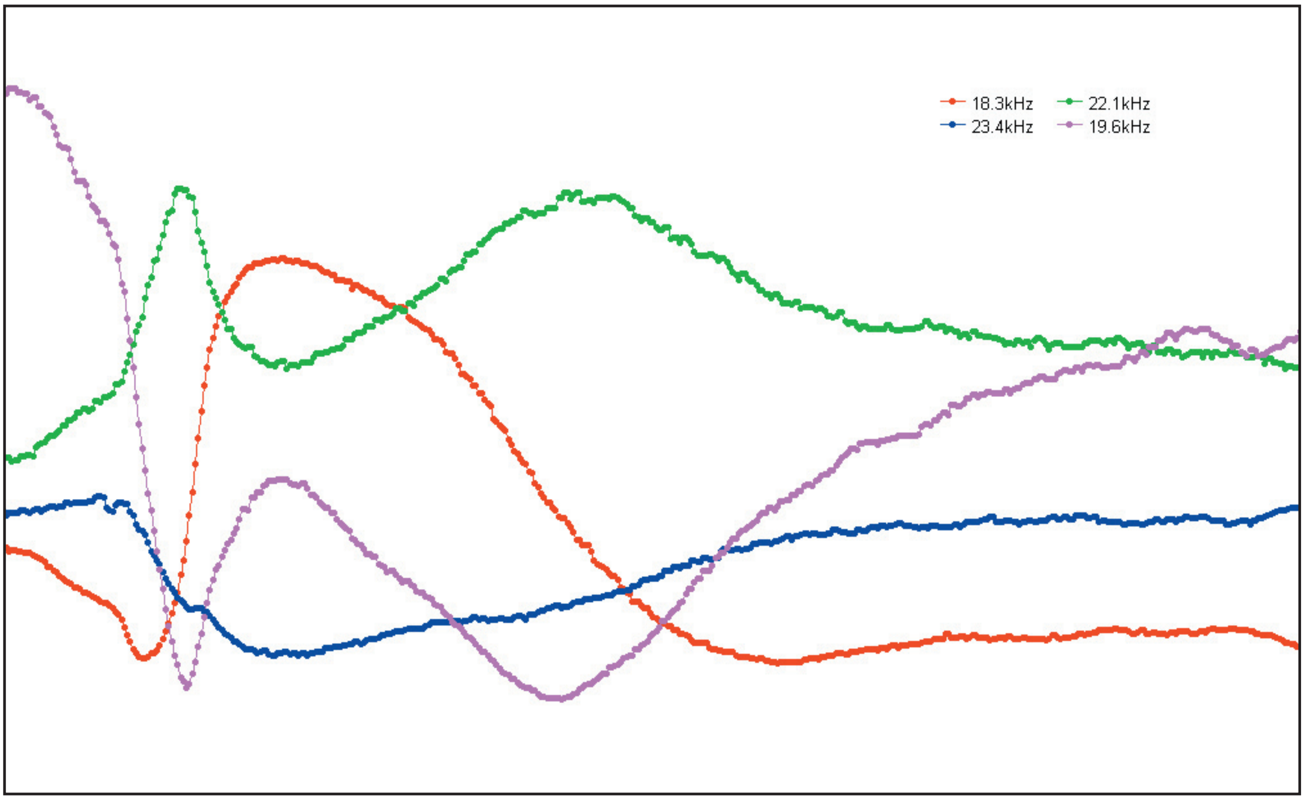
by

Mark Edwards

Our long period of solar inactivity was spectacularly terminated by a series of X-ray flares during January 2010. One of these, an M-class, produced an intense Sudden Ionospheric Disturbance (SID) at 11:22UT on 20th January 2010.

1 A SID observation

The picture below shows the effect it had, at my location near Coventry, on the received signal strength from four Very Low Frequency (VLF) transmitters scattered around Europe.



One thing was immediately obvious, the SID produced remarkably different effects at each of the four frequencies. Of particular note were the totally opposite effects at 19.6 and 22.1kHz, which were also notable for having two prominent peaks (or troughs).

This caused a problem as a SID report to the BAA is supposed to include not only the start and end times of the SID but also the time of maximum effect. However, where was the maximum when there were two peaks or troughs? It would seem, by comparison with the effects on the other two frequencies, that the maximum should be between the two, but was there any justification for that assumption?

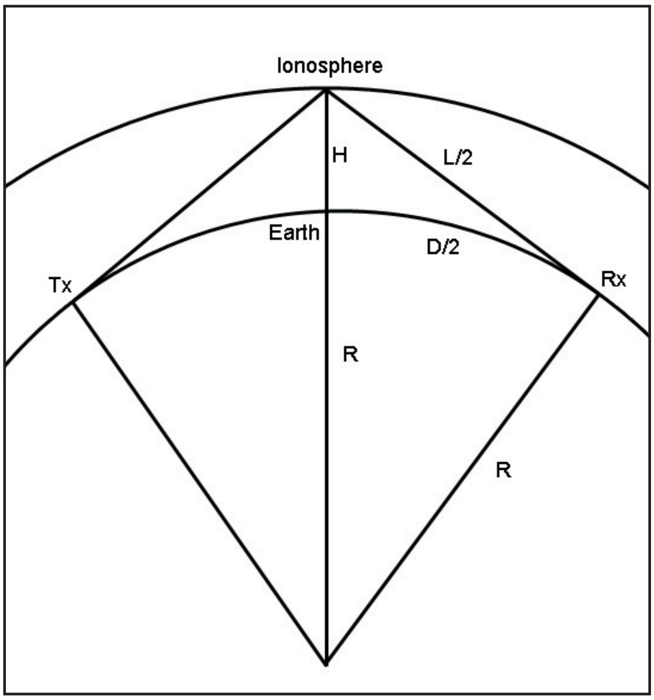
To try to answer these problems I decided to see if a simple empirical model of the changes in the ionosphere during a SID would give the type of effects that had been observed and in particular whether it would produce the mirror image traces.

2 VLF propagation

The simplest model for VLF propagation in the Earth-ionosphere waveguide consists of the addition of two waves – a ground wave that follows the curvature of the Earth and a sky wave which undergoes a specula reflection from the D-layer of the ionosphere. The effective height of the D-layer is then governed by its ionisation level, which in turn is determined by the amount of solar X-rays impinging on it.

During a solar flare the ionisation of the layer increases dramatically and its height rapidly reduces. After the flare,

through recombination, its ionisation gradually returns to normal and the layer gradually rises to its original level.
The geometry of the situation is shown in the diagram below:-



Where:-
Tx is the position of the transmitter
Rx is the position of the receiver
D = distance between the transmitter and receiver
R = radius of the Earth
H = height of the ionosphere above the Earth
L = length of the path taken by the sky wave between transmitter and receiver

From which:-
$L = 2\sqrt{[R^2 + (H+R)^2 - 2R(H+R)\cos(D/2R)]}$ --- (1)

The difference in the path lengths between the sky and ground waves is just (L – D) which translates into a phase difference (in radians) of:-

$P = (L-D)2\pi\nu/c$

Where:-
ν = frequency of transmission
c = speed of light

As there is an inversion of the electric field on reflection from the ionosphere this can be represented by the insertion of an extra half cycle (π) of phase:-

$P = (L-D)2\pi\nu /c + \pi$ --- (2)

The received amplitude is then the vector sum of the ground wave of amplitude G and phase 0, with the sky wave of amplitude S and phase P. Giving the amplitude of the resulting vector as:-

$A = \sqrt{(G^2 + S^2 + 2GS \cos P)}$ --- (3)

We now have three equations (1) – (3) that relate the received amplitude (A) of a transmitter (frequency ν) at a distance (D) to the height of the ionosphere (H).
These show that as the height of the ionosphere changes so the received amplitude varies between a minimum of (G – S) and a maximum of (G + S) as the phase difference between the sky and ground waves varies between an odd and even number of half cycles, respectively.
The equations can of course be run in reverse to obtain the height of the ionosphere corresponding to any given minima and maxima.

In this way and using distances of 305.98km for the 19.6kHz transmitter (located at Anthorn) and 277.67km for the 22.1kHz transmitter (located at Skelton) allows a comparison to be made between the height of the ionosphere required to receive a minimum amplitude at one frequency at my location and a maximum at the other:-

19.6kHz Amplitude	19.6kHz Height (km)	22.1kHz Height (km)	22.1kHz Amplitude
		29.4	Max
Max	32.6	42.5	Min
Min	47.2	52.6	Max
Max	58.6	61.4	Min
Min	68.3	69.2	Max
Max	77.1	76.4	Min
Min	85.1	83.1	Max
Max	92.6	89.5	Min

This is encouraging as it shows a close match at 68.3 and 69.2km (min at 19.6kHz and max at 22.1kHz) and 76.4 and 77.1km (max at 19.6kHz and min at 22.1kHz) which are also consistent with the generally accepted height of the D-layer (60 to 90km).

3 The effect of a SID

To model the change of height of the D-layer during a SID requires a function that matches the effect of X-rays on the ionisation of the D-layer during a flare. For this I chose a function that rises rapidly and has a gradual fall:-

$$F_{SID}(e^{(-t/T_F)} - e^{(-t/T_R)})$$

Where:-
t = time T_F = fall time constant T_R = rise time constant
F_{SID} = factor dependant upon the strength of the SID, the stronger the SID the larger the value.

Subtracting this function from 1 (to get the opposite effect) and treating it as a modulation of the normal height (H_{NOR}) of the ionosphere gives:-

$$H = H_{NOR}(1 - F_{SID}(e^{(-t/T_F)} - e^{(-t/T_R)}))$$ for the height of the ionosphere at time t.

4 Diurnal effects

The normal height of the ionosphere also varies slowly throughout the day as the altitude of the Sun changes. This diurnal change in height is given by[1]:-

$$H_{NOR} = H_0 + H_S \log_e(\sec \chi)$$

Where:-
H_0 = height of the ionosphere when $\chi = 0$, ie. the Sun is overhead
H_S = scale height (which varies from day to day) χ = Sun zenith angle

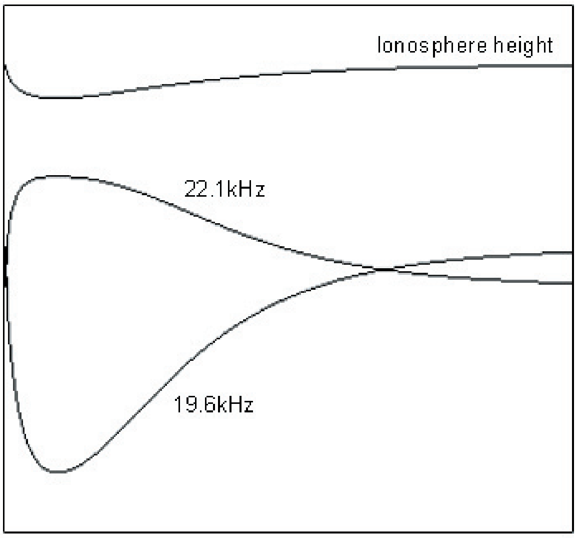
Combining this effect with that of the SID gives:-

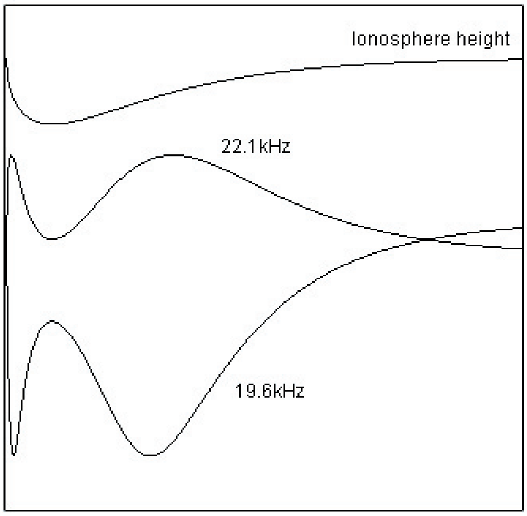
$$H = (H_0 + H_S \log_e(\sec \chi)) (1 - F_{SID}(e^{(-t/T_F)} - e^{(-t/T_R)})) \quad \text{--- (4)}$$

Equations (1) to (4) then form the basis of the SID model.

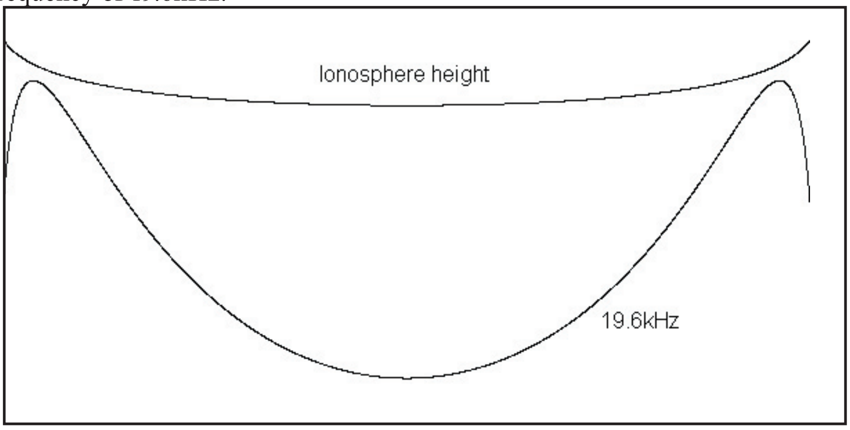
5 Output of the SID model

Running the model over the time of a simulated SID, ie. $F_{SID} > 0$, but without any diurnal variation, ie. $H_S = 0$, produces the following:-

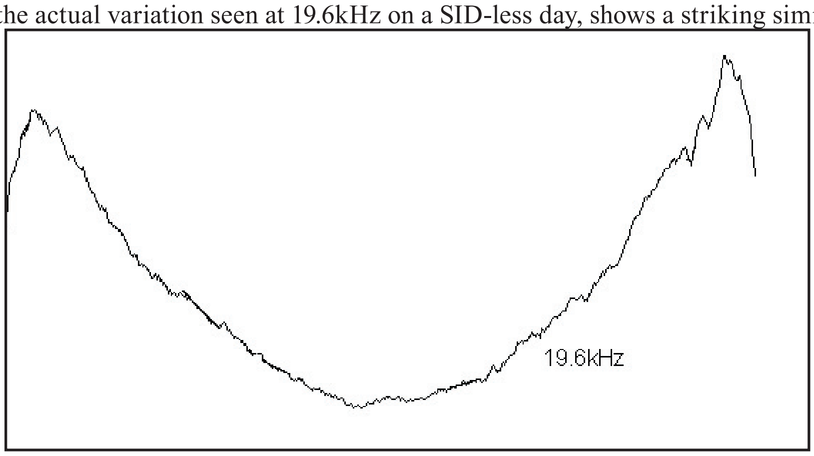




In the left-hand diagram the ionosphere starts at height just above 70km and drops by a small amount that takes it towards the height (69.2km) at which there is a maximum for 22.1kHz, but crucially not through it. This produces the characteristic single peak of a SID.
In the right-hand diagram, the drop in the height of the ionosphere is larger and sufficient to take it through the critical region of peak amplitude and towards the height of the next minimum (61.4km).
As the SID declines and the ionosphere returns to its undisturbed height, the critical height is passed through again but more slowly, so producing a broader amplitude peak than the first.
As the critical height for the minimum amplitude at 19.6kHz is only 0.9km lower than that for the maximum at 22.1kHz, the same changes are experienced at nearly the same time but in the reverse direction.
On the other hand, running the model in the absence of a SID, ie. $F_{SID} = 0$ and $Hs > 0$ produces curves of the type shown below for a frequency of 19.6kHz:-



This shows the diurnal variation in the strength of the received signal as the height of the ionosphere drops from 78km during the morning to 71km at local noon and rises again to its original height during the afternoon.
Comparing this with the actual variation seen at 19.6kHz on a SID-less day, shows a striking similarity:-



Finding that the model produced remarkably similar results to the actual observations encouraged me to write a model fitting program that would, given the SID observations as input, produce the values of the variables used in the four equations as output. What is more, if the program could fit more than frequency at once that would help to constrain the model.

6 Model fitting

The model fitting program is based on an old function minimisation routine[2]. It uses the method of gradient descent and so requires a function to minimise as input. The function to minimise is obviously a measure of the difference between the output of the model and the real data:-

$$F = \Sigma(A' - A)^2$$

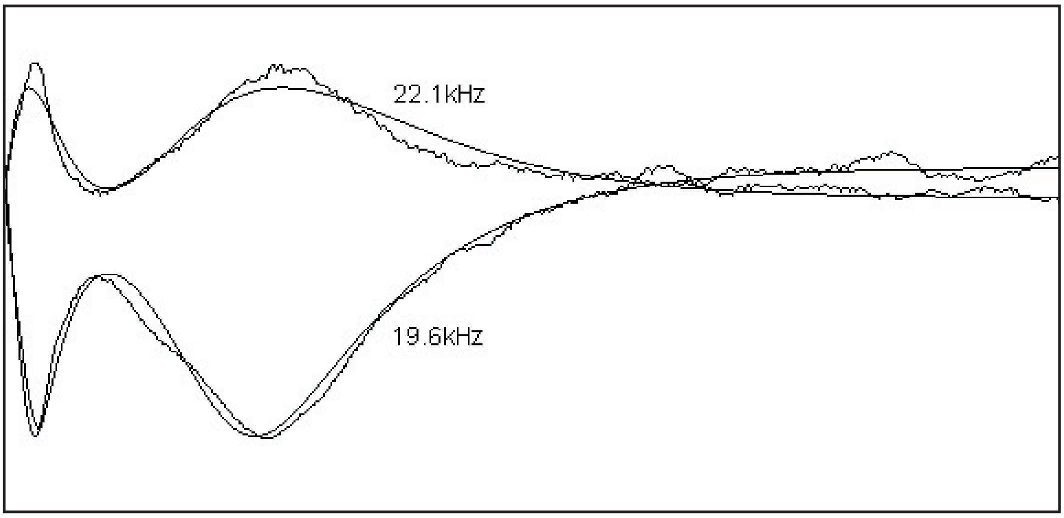
Where:-

A' = amplitude from observation A = amplitude from model

The sum is taken over all time and all frequencies of observation and will have a value of zero if the model matches the real data precisely.

7 Fitting a SID

Running the program produces a remarkably good match with the actual 19.6kHz and 22.1kHz SID observations:-



Where the smooth lines are the output of the model and the jagged lines are the observations.
As output, the model gives:-

Height of ionosphere before SID = 72km
Height drop produced by SID = 7km

Although very successful at fitting one or two frequencies at a time, the program is unable to fit all four frequencies affected by the SID at once. A glance at the minimum/maximum table for 18.3kHz shows why:-

18.3kHz Amplitude	18.3kHz Height (km)
Max	44.5
Min	66.1
Max	82.9
Min	97.2

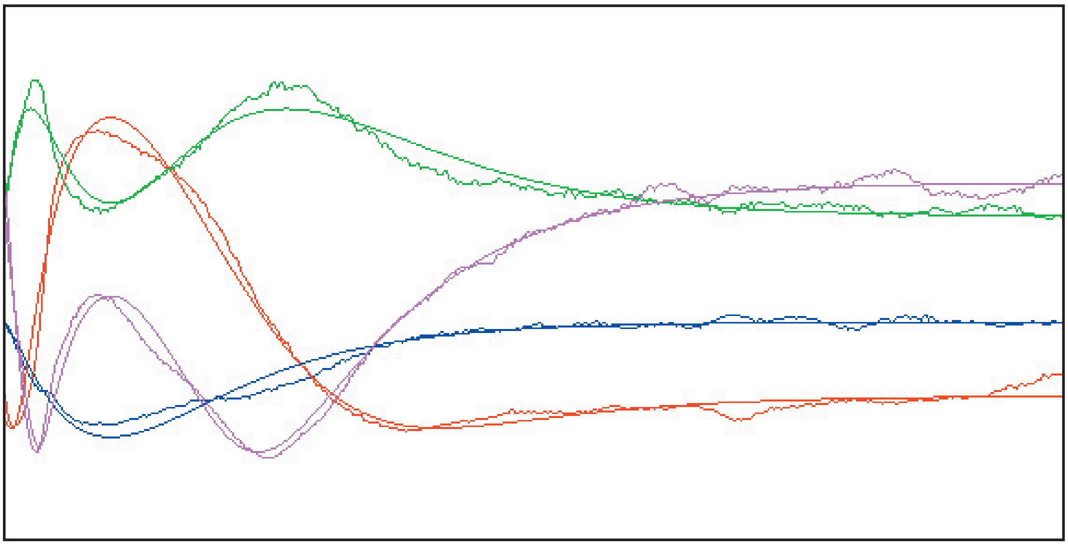
Falling from a height of 72km to 65km the amplitude of the 18.3kHz transmitter should go through its minimum at 66.1km after the 19.6kHz one goes through its minimum at 68.3km, but plainly it actually goes through its minimum before. Running the model with 18.3kHz alone indeed gives a good fit with a starting height just above 67km. Although at first sight this might appear to be a frequency affect, with the lower frequency penetrating less into the D-layer, it cannot be the case as there is no such effect evident between 19.6 and 22.1kHz. What does appear to be happening though, is a change of effective reflection height with distance. At 659.42km away from my location, the 18.3kHz transmitter is over twice the distance of the other two.

What has to be remembered is that the path of radio waves through the ionosphere is more complicated than the assumption of specula reflection and in fact takes the form of a curve. As the angle of incidence on the ionosphere of the radio waves from a local transmitter is less than that of a remote transmitter they have to penetrate further to be bent back to Earth, so their apparent reflection height is greater.
To take account of this, more rigorous models resort to ray tracing methods, but in my simplified model adding another linear term to equation (4) is sufficient to give it the required flexibility:-

$$H = (H_0 + H_S \log_e(\sec \chi))\,(1 - F_{SID}(e^{(-t/T_F)} - e^{(-t/T_R)}))\,(1 - F_{DIST}(D - D_L)) \quad \text{--- (5)}$$

Where:-
F_{DIST} = distance factor D_L = distance to the local transmitter

With this modification the model fits all four frequencies reasonably well:-



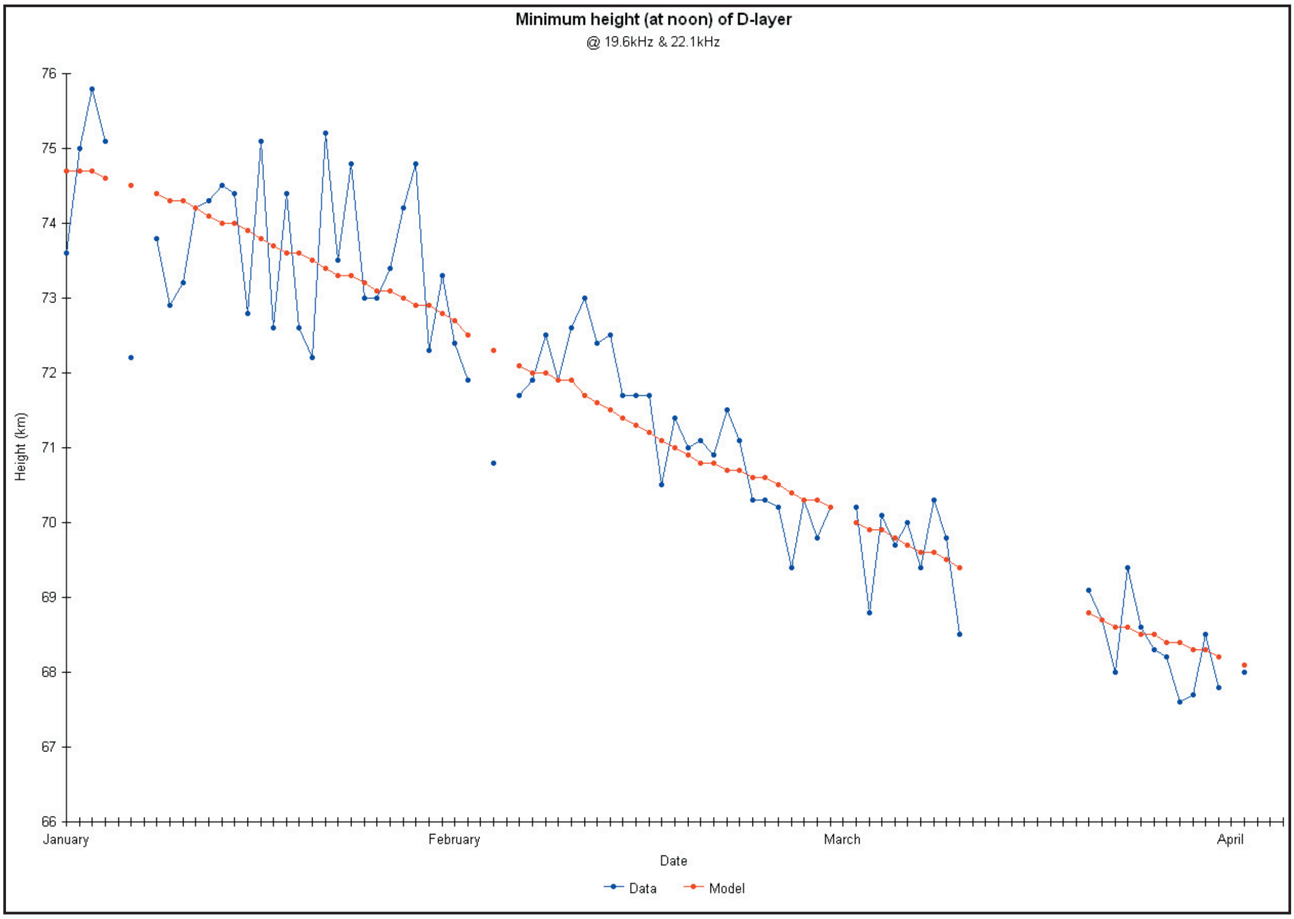
As output, the model gives:-

Transmitter frequency	18.3kHz	19.6kHz	22.1kHz	23.4kHz
Ionosphere height (km)	67.2	72.0	72.4	67.8
Drop during SID (km)	5.7	6.1	6.2	5.8

8 Fitting Diurnal Variation

Even more information about the ionosphere can be obtained by fitting the diurnal variation over a period of time. For not only does the height of the ionosphere vary throughout any given day due to the Sun's changing zenith angle, but also throughout the year as the Sun's declination varies.
The data below (jagged curve) was obtained by model fitting each day's variation at 19.6kHz and 22.1kHz for the first three months of 2010 and taking the resultant minimum height at noon:-

As can be seen, the height of the ionosphere shows a gradual decline as the Sun's declination rises from its winter minimum to the Vernal Equinox.



That decline follows the same equation as for the diurnal variation:-

$H = (H_0 + H_S \log_e(\sec \chi))$

Now, H_S (the scale height) = kT/mg

Where:-

k = Boltzmann's constant

m = mass of a gas molecule in the ionosphere

T = Temperature of the gas in the ionosphere

g = acceleration due to gravity

and can again be model fitted to the data, giving the smooth curve in the figure. That curve shows a good fit with H_0 = 65.4km and H_S = 6.4km.
Using this scale height of 6.4km and a typical temperature at 70km of 230 ^{o}K gives m = 30.7 u
Which is consistent with the known composition of the D-layer being a mixture of NO^+ (30 u) and O_2^+ (32 u) ions.

9 Conclusion

In conclusion, I have shown how a simple model can give a useful insight into the causes of seemingly random changes during a SID and also provide information about the ionosphere itself.

10 References

1 *Contributions to the 3D ionospheric sounding with GPS data*. PhD Thesis Universitat Politecnica de Catalunya. Miquel Garcia-Fernandez. January 22nd. 2004.

2 *Collected Algorithms from CACM. Algorithm 251.* M. Wells 13th July 1965 and 5th October 1964. Based on the method of Fletcher and Powell Computer Journal 6, 163-168 1963.

NASA Mission AS-506, Apollo 11 Owners' Workshop Manual

By Ivor Clarke

Those of us who are old enough, will remember in days gone by, when we bought a second hand car and they came, if you were lucky, with a Haynes workshop manual. You could tell straight away what had gone wrong with the car by the oily finger prints on the section in question. Even if it didn't come with a Haynes manual you soon got one to service and fix them. Those were the good old days when with a half decent tool box you could take a car to pieces. And with a Haynes to hand, put it back together. Haynes still publish workshop manuals for cars and motorbikes. But have also branched out nowadays with numerous books on other subjects including aircraft; like the Spitfire and Lancaster bomber. And also the one I received for my birthday this year off my son and his wife.

The Haynes manual on the *Apollo 11, NASA Mission AS-506* in 1969 is one of the best books I have seen on the equipment and rockets used in the Moon landings. Mind you to call this book a *"Owners' Workshop Manual"* is a bit misleading, as only the 12 foot section of the Command Module is left of Apollo 11. Out of the total height of the complete rocket stack of 365ft, only the CM came back to earth safely and is on view in The National Air and Space Museum, Washington, USA. So it will be a bit difficult to fix it all up again. For instance the first and second stages of the Saturn V rocket lie on the bed of the Atlantic ocean at 357 and 2,371 miles downrange from the Cape. They are still there having never been recovered. While the third stage following the TransLuna Injection is in a heliocentric orbit around the sun! And the LEM lunar lander half is still on the plains of Tranquillity while the Ascent stage was crashed back onto the Moon after rendezvous back with the orbiting CSM! The Service Module was detached from the Command Module just before re-entry into the Earth's atmosphere and burnt up.

The book follows the early history of space flight and development of all the major components of the Saturn V rocket and the Command and Service Modules and the Lunar Landing Craft. The book contains 9 chapters covering in detail the design and construction of most of the equipment needed for the journey. It gives a good insight into the work of the 400,000 designers, engineers and craftsmen who worked on the Apollo project.

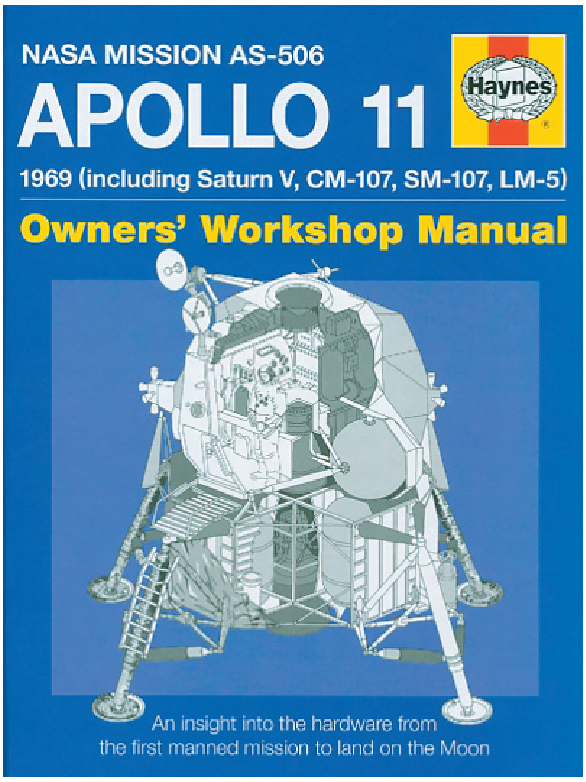
The opening chapter gives a good introduction to the early years of rockets and space flight and covers the reasons for the development of the lunar rendezvous method of achieving Kennedy's wish to put *"a Man on the Moon and bring him safely back to Earth"* that he made in May 1961. At this time no one had any idea how to do a moon trip apart from the direct Earth to Moon and return approach. This was just a month after Gagarin's orbital flight!

Chapter 2 covers the Saturn V rocket. It is still the biggest and most powerful rocket ever built and it never misfired or exploded. The complete Saturn V Apollo system contained over 5,600,000 parts which all had to work perfectly. Lots of the illustrations and colour photographs in this book have never been published before and form an interesting set showing the stages being assembled. Cut-a-way working drawings of layouts of pipe work with electronic and hydraulic systems give a good indication of the complexity of the task. All of the equipment had to be designed and tested to an arduous schedule to meet Kennedy's *"this decade"* deadline. The third chapter covers the Command and Service Modules and details how the crews have to live in space. One amusing item is the toilet system which everyone wants to know about. How *do* you go to the loo in space???? The next chapter covers the Guidance, Navigation and Control Systems and tells how NASA made one of the first computers. This was in the days before digital watches remember and the challenge was to make a programmable computer which had to fit into a one cubic foot space. The memory core was made by threading fine wire through tiny circular magnets to make a total of 36KB of memory. NASA had to develop from scratch a new integrated guidance system to work in space, this was called the Inertial Measuring Unit which was a 3 axis gyroscope which was backed up by a sextant system which proved its worth when it had to be used by the Apollo 13 crew to navigate their path in space back to Earth from the Moon in their crippled spacecraft.

The Lunar Module is covered in its own chapter with drawings showing the controls and layout of the equipment. The Descent and Ascent Stages were developed over a period of several years with each design getting bigger and heavier until a halt was called at 13 tons and many re-designs had to be made before the familiar LEM appeared, indeed it was only in 1965 that the final configuration was born with a single rocket motor in each section burning hypergolic propellant stored in four eggshell thin tanks. The newly developed engine could develop almost 5 tons of thrust and yet be throttled back to just a few pounds of thrust. So that the astronauts could walk safely on the moon, space suits were developed from the early pressure suits worn by high flying aircraft and the X-15 rocket plane. Each of the backpacks of the spacesuit had to keep the astronauts alive for several hours so this was a smaller version of the system installed in the LEM and CM capsules. There is a chapter on the Communication Systems and even tells why they had a beep in the voice transmissions!

The final chapters covers the J-Class Missions 15 to 17 and the cancelled ones. The book ends with pages of appendices covering timelines and acronyms and abbreviations.

Anyone interested in space and the history of NASA and the Apollo era will love this book. I thoroughly enjoyed reading it and learned a lot about the development and processes involved in the missions. Highly recommended.



NASA Mission AS-506, Apollo 11.
Owners' Workshop Manual.
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NOTES ON THE OBSERVATION OF RARE NIGHT CLOUDS

by JAMES PATON, M.A., B.Sc., F.R.S.E.
(Director of the B.A.A. Aurora and Zodiacal Light Section)

This article was first published July 1959. In **ALTAIR**, Vol.1, No.7, Journal of the Croydon Group of the Junior Astronomical Society, and is one of the first mentions of Noctilucent Clouds.

Noctilucent Clouds

These striking clouds are occasionally seen in the long twilight between mid-May and mid-August in latitudes 45° - 6.5° N. Noctilucent or luminous night clouds become slowly visible in the darkening twilight sky from half an hour to one hour after sunset. Usually they appear along the northern horizon in parallel streaks or waves, resembling clouds of cirriform type. They light up progressively from west to east, following the movement of the Sun, which at this time of year does not sink far below the horizon in these latitudes. They then slowly vanish in the brightening sky about an hour before dawn.

The clouds are pearly white or bluish in colour but may become tinged with red near the horizon. Measurement reveals that they are always situated at a height close to 80 Km. and that their light is scattered sunlight.

They must therefore be composed of material that forms or collects in a layer at this very great height, where it remains sunlit for all or for parts of the night in summer in middle or high latitudes. The constitution of the clouds is uncertain though the evidence so far available suggests that they consist of meteoric dust.

In the highest latitudes, close to the Arctic Circle, the clouds can be seen only at the beginning and end of summer, because the sky remains too bright in midsummer for them to show up. In the lowest latitudes the clouds are seen only for short periods after sunset and before sunrise because the Sun sinks too far below the horizon in the middle of the night to illuminate them. At a particular station the area of the sky within which the clouds are visible changes continuously during the night as the Sun moves eastwards below the horizon.

Since the clouds appear at a time when few people are about, they may often pass unnoticed and unrecorded. For this reason too it has never been possible to examine the geographical distribution of places from which a particular display is visible. The organisation for observers in connection with other phenomena such as aurora during the International Geophysical Year provides an excellent opportunity to secure this information for the first time. Observers between latitudes 45° and 65° are therefore asked to keep watch for these clouds during clear and cloudless nights in the summer. Of course, most observers will not often be in a position to watch during the "small hours" when these clouds appear; but meteorologists and astronomers whose duties require then to be up during the night and who make the effort to keep regular watch may be rewarded by witnessing a sight which they will never forget. A good display of these clouds is quite magnificent.

Observers should record the following things: -

(i) The night of occurrence, defined by two dates, i.e. July 2 - 3.
(ii) The period(s) of time during which the clouds remain visible.
(iii) The horizontal and vertical extent (expressed in degrees of azimuth and elevation) of the clouds at different times, say every quarter or half hour during the night.
(iv) The distribution of colour in the clouds at different times.

So far as we know, there is no recorded case of observation of these clouds in the southern hemisphere, which is not surprising since the region between 45° - 65° consists, apart from southern parts of New Zealand and South America, entirely of ocean. Observers in ships that ply in southern seas are, therefore, in a position to record for the first time an observation of southern noctilucent clouds.

Mothor-of-Pearl Clouds

These clouds are seen much less frequently than noctilucent clouds - probably for the reason that their occurrence is not nearly so widespread, their study has almost entirely been confined to Southern Norway, but they have been seen in various other parts of the globe, including Great Britain.

They appear usually as a bank of clouds showing iridescence (mother-of-pearl) colours. They are most spectacular just after sunset and just before sunrise and when they are close to the Sun. Situated at heights of between 20 and 30 Km., they remain visible for some time after the Sun has set and then grow dark quite suddenly (in a few minutes) as the Sun sinks below the horizon.

The iridescence shows that the clouds almost certainly consist of water drop-lets and it has been suggested that they are formed when condensation occurs by ascent of air in mountain waves generated at these heights in some conditions. They have seldom been seen in Norway or Scotland outside the period from December to February.

Observers are asked to watch in winter for these clouds in the western sky at and after sunset and in the eastern sky near sunrise, and to record an observation as follows:-

(i) The night of occurrence, defined by two dates.
(ii) The time, including the time at which they become dark (in the evening observation).
(iii) The shape and area of the clouds.
(iv) The angular distance from the Sun.
(v) The nature of the colouration.

I hope that if any of you see these rare night clouds you will record your observations and send then to us at the following address:

The Balfour Auroral Laboratory,
The University Natural Philosophy Department,
Drummond Street, Edinburgh 8.

(Don't forget this is 50+ years old!) Ed