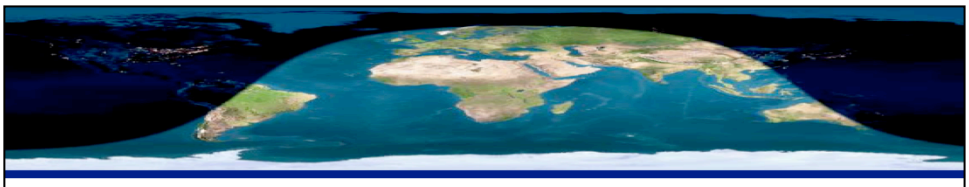
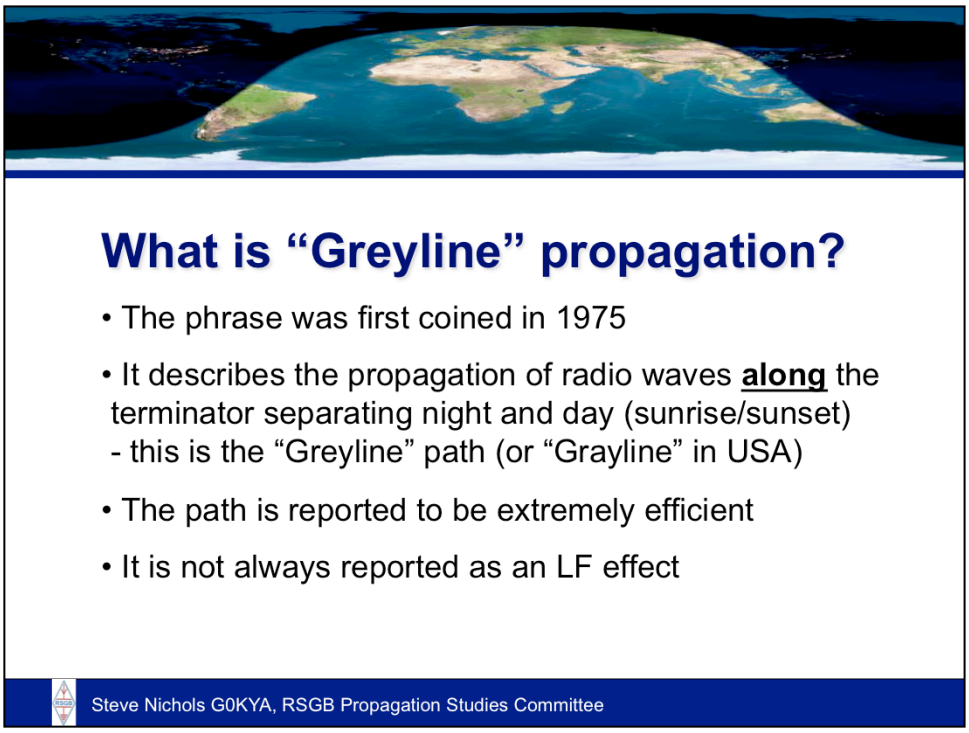


Greyline Propagation of LF/HF signals

- Fact and Fiction (or do observations fit the theory?)

Steve Nichols G0KYA, RSGB Propagation Studies Committee

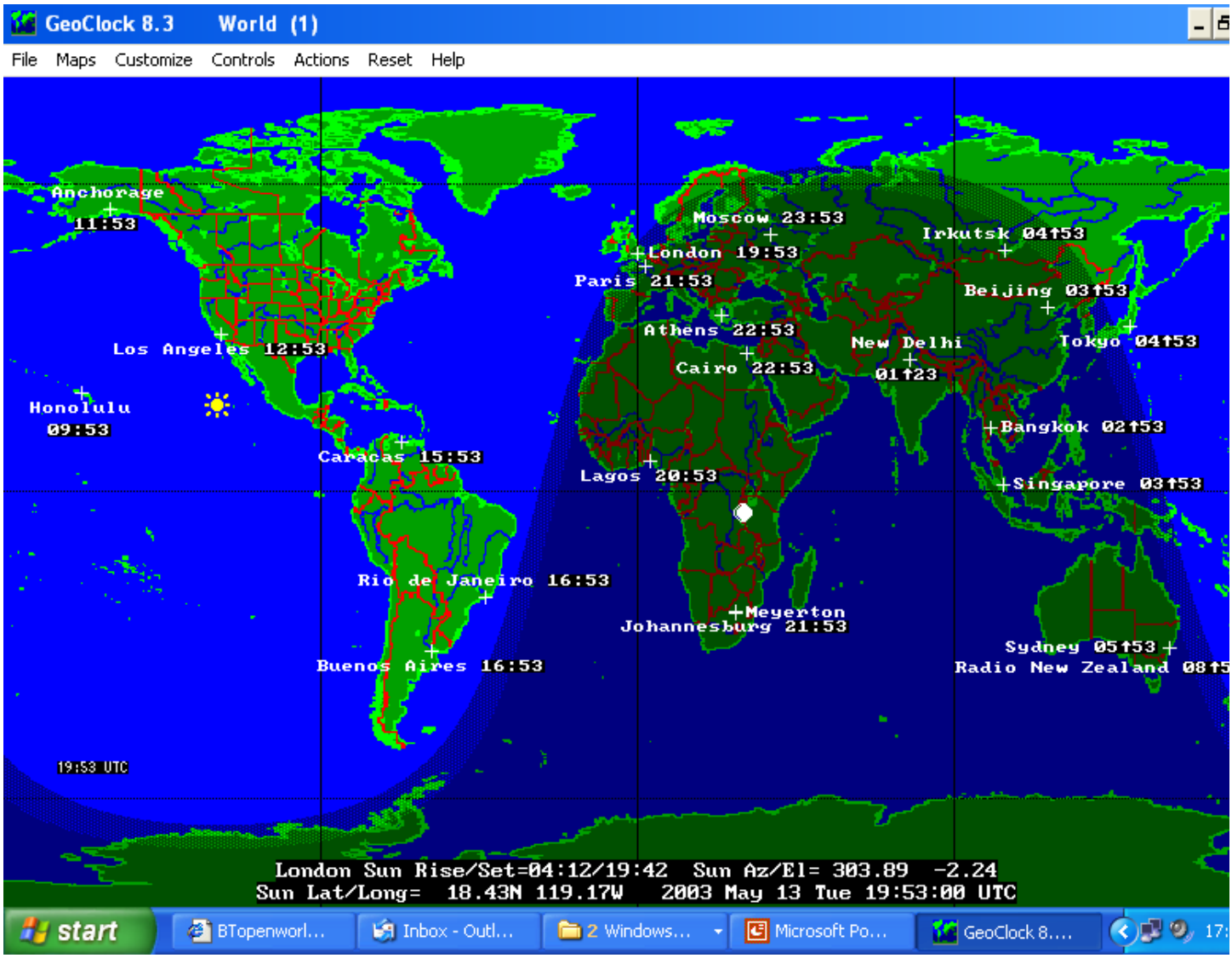
This was the title of a talk given to the RSGB HF Convention on Saturday 12th October 2002. For further, basic, information please refer to the article on Greyline Propagation written by Steve Nichols G0KYA and published in the RSGB's June 2002 issue of RadCom

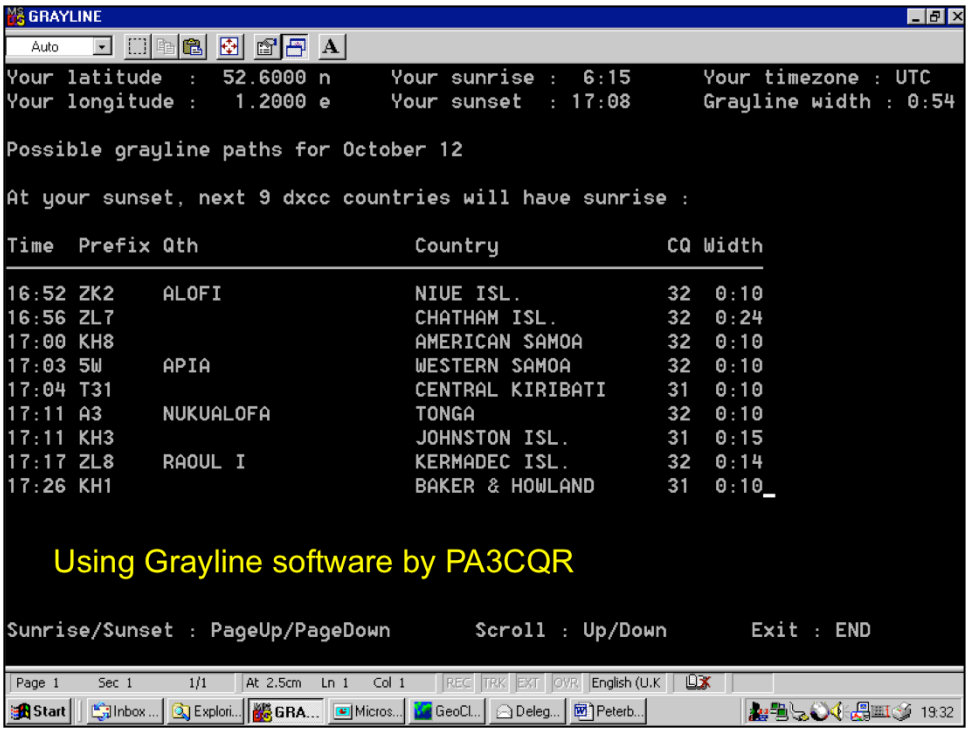


The main point was that all books on propagation refer to greyline without being too specific about the bands actually affected.

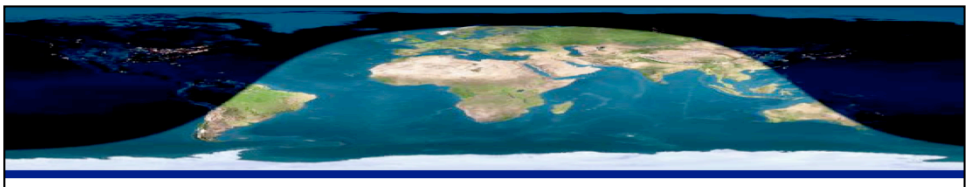
One article, in Practical Wireless discussed greyline propagation 28MHz. As greyline is basically described as being the zone where D layer absorption is at a minimum, while F later illumination is still very high, it is unlikely that 28Mhz would see any benefit.

However, 28MHz paths crossing the terminator may experience skip focusing effects - not to be confused with greyline which is along the terminator.


GeoClock 8.3 World (1)
File Maps Customize Controls Actions Reset Help
Anchorage 11:53
Los Angeles 12:53
Honolulu 09:53
Caracas 15:53
Rio de Janeiro 16:53
Buenos Aires 16:53
Moscow 23:53
London 19:53
Paris 21:53
Athens 22:53
Cairo 22:53
Lagos 20:53
Meyerton
Johannesburg 21:53
Irkutsk 04:53
Beijing 03:53
Tokyo 04:53
New Delhi 01:23
Bangkok 02:53
Singapore 03:53
Sydney 05:53
Radio New Zealand 08:5
19:53 UTC
London Sun Rise/Set=04:12/19:42 Sun Az/El= 303.89 -2.24
Sun Lat/Long= 18.43N 119.17W 2003 May 13 Tue 19:53:00 UTC
start
BTopenworl...
Inbox - Outl...
2 Windows...
Microsoft Po...
GeoClock 8....

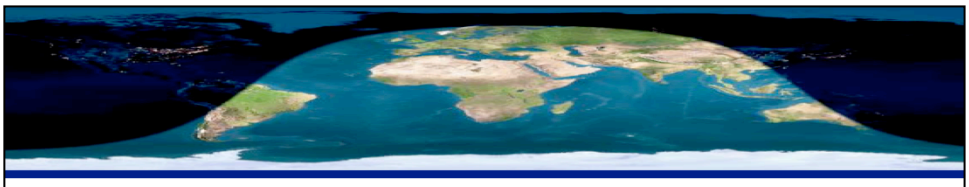


This software by PA3CQR can calculate supposed greyline openings by calculating simultaneous sunrise/sunset.



The D Layer:

- Is at an average height of about 60-90km
- It is mainly responsible for absorbing/attenuating signals on 160-20m. It can reflect signals at VLF
- This is why we don't hear "much" skip on the LF bands during daylight, especially in summer
- The actual level of absorption is dependent upon the frequency, time of day/year and solar/geomagnetic levels

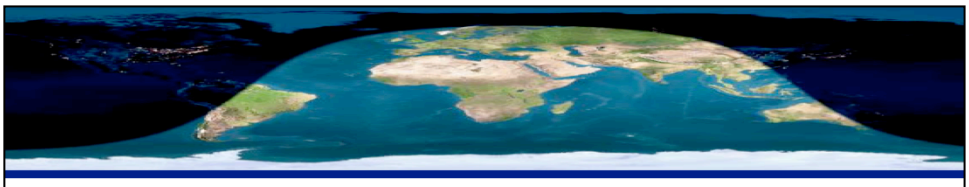


D Layer Absorption:

Absorption (db)= $(10 * log[\text{flux } (W\ m^{-2})] + 65)^{2}/f^{2}$

Steve Nichols G0KYA, RSGB Propagation Studies Committee

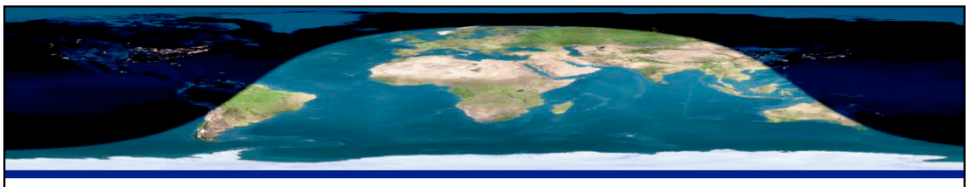
The main point is that absorption goes as the inverse square of the frequency



Relative D Layer Absorption:

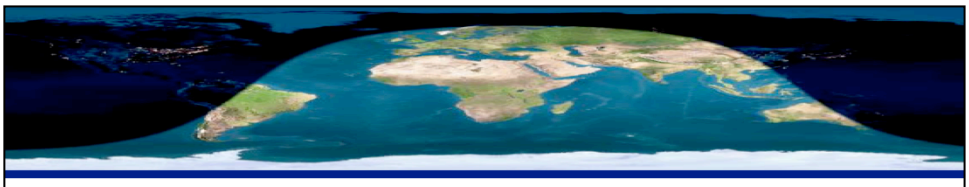
According to the RSGB "*Amateur Radio Operating Manual*", for a daytime path:

- 6db attenuation per hop on 21MHz
- 40db attenuation per hop on 7 MHz
- 100db attenuation per hop on 3.5MHz



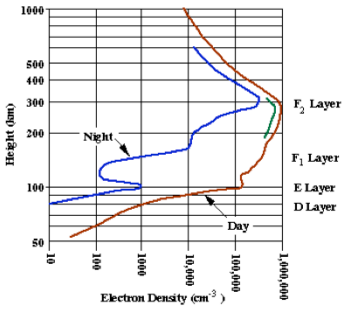
Thoughts from KN4LF (160m)

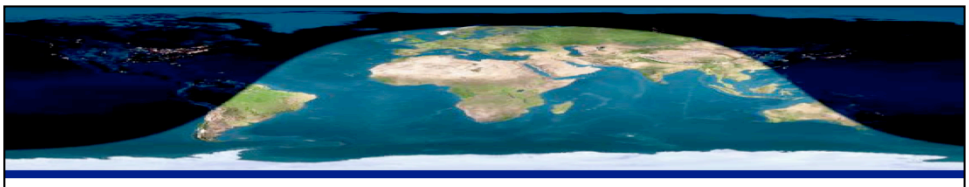
- The D layer does not always disappear at night
- It is affected by flares, CMEs, Sporadic-D, solar background X-ray level and energetic proton events
- The angle of the signal can have a profound effect (Magneto Ionic Power Coupling)
- Polar cap absorption can be severe for signals going near the poles. Also, consider electron gyro frequency absorption effects.



So why is the Greyline thought to be efficient?

- At sunset, the lower D layer is no longer illuminated, therefore absorption is reducing
- The higher F-layer(s) are still illuminated, so we still have ionisation to aid propagation
- At sunrise, the reverse occurs





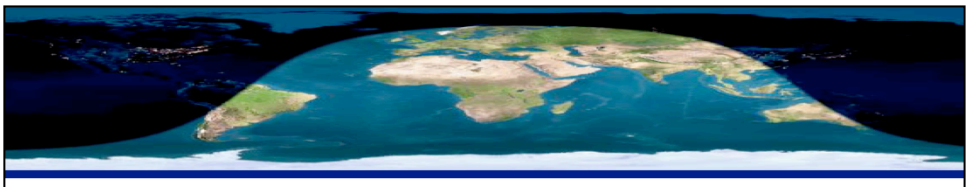
So what can we hear at sunrise?

Theoretically,

- ZS6 (South Africa) in August
- ZL (North Island, New Zealand) in December
- LU/PY/VP8 (Argentina, Brazil, Falklands) in December
- And others according to the season

Steve Nichols G0KYA, RSGB Propagation Studies Committee

These are theoretical



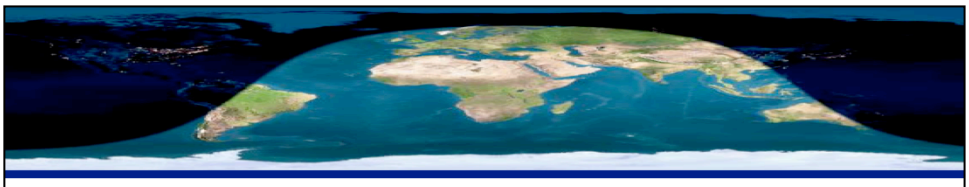
So what can we hear at sunset?

Theoretically,

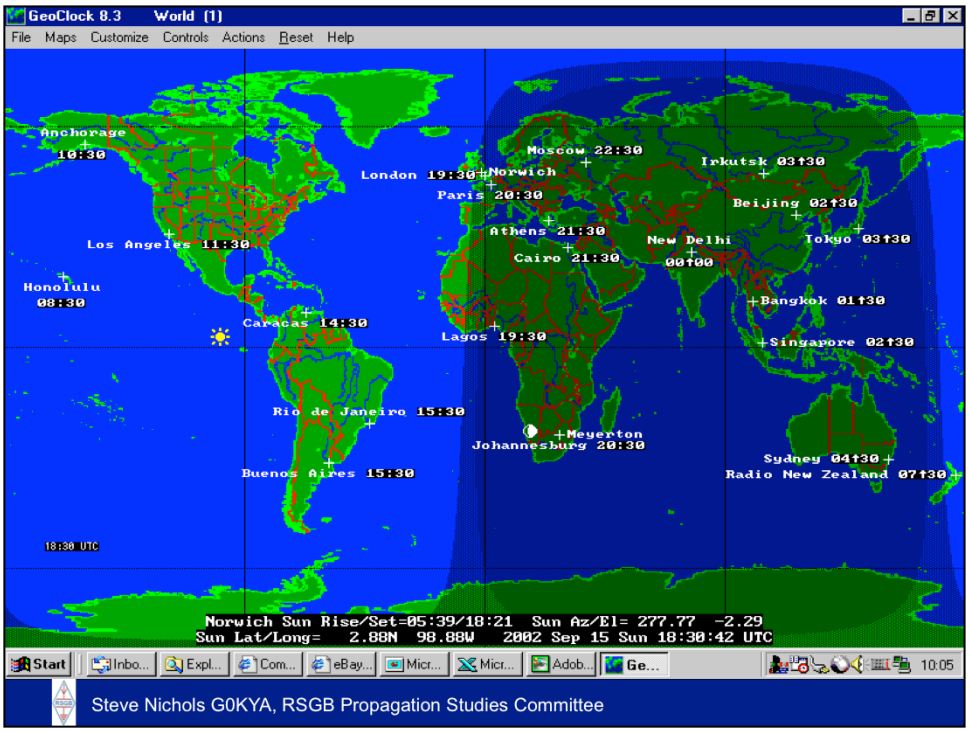
- JA (Japan) in August
- ZL (New Zealand) in September
- ZS6 (South Africa) in November
- LU/PY/VP8 (Argentina, Brazil, Falklands) in June
- And others according to the season

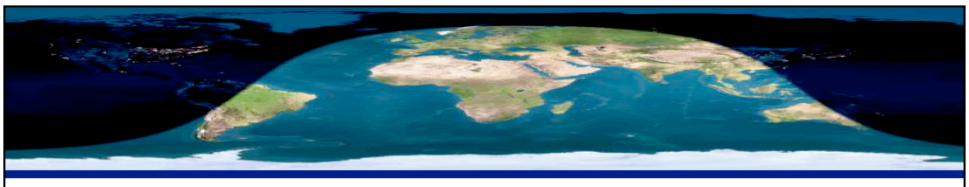
Steve Nichols G0KYA, RSGB Propagation Studies Committee

These are theoretical



So let's take a look!


GeoClock 8.3 World (1)
File Maps Customize Controls Actions Reset Help
Anchorage 10:30
Los Angeles 11:30
Honolulu 08:30
Caracas 14:30
Rio de Janeiro 15:30
Buenos Aires 15:30
London 19:30
Norwich
Paris 20:30
Moscow 22:30
Athens 21:30
Cairo 21:30
Lagos 19:30
Meyerton
Johannesburg 20:30
New Delhi 00:00
Irkutsk 03:30
Beijing 02:30
Tokyo 03:30
Bangkok 01:30
Singapore 02:30
Sydney 04:30
Radio New Zealand 07:30
18:30 UTC
Norwich Sun Rise/Set=05:39/18:21 Sun Az/El= 277.77 -2.29
Sun Lat/Long= 2.88N 98.88W 2002 Sep 15 Sun 18:30:42 UTC
Start
10:05
Steve Nichols G0KYA, RSGB Propagation Studies Committee



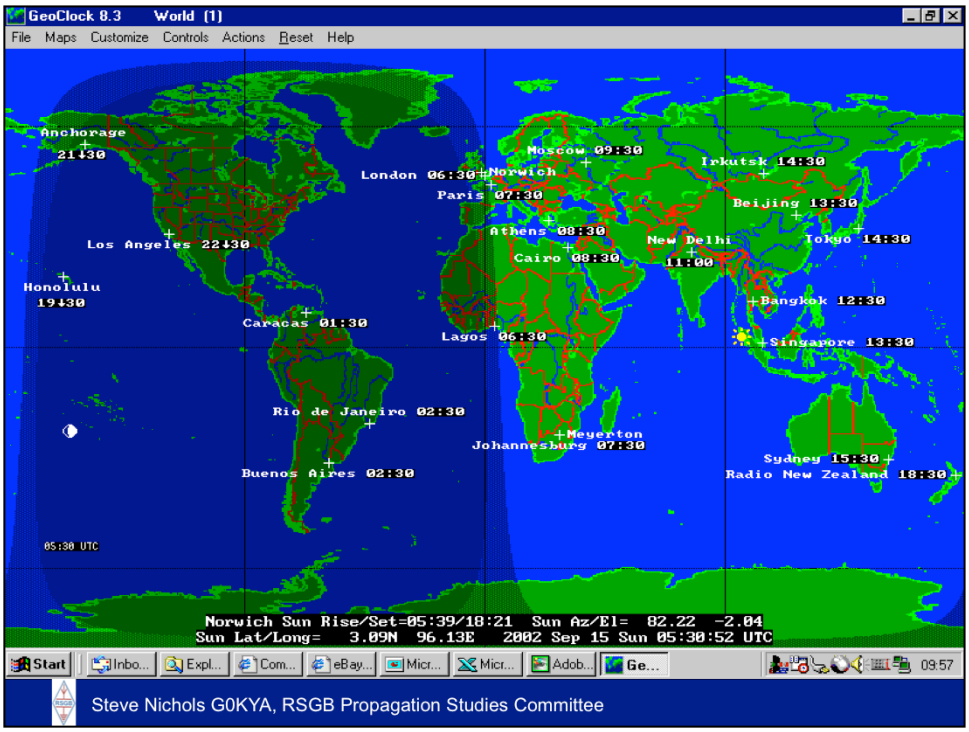
DXCluster list of contacts from Europe to ZL, 9/2001

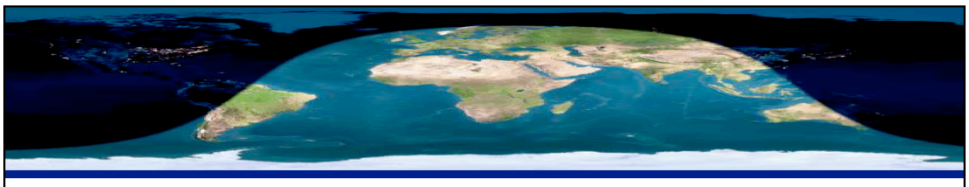
Time (UTC)	160m	80m	40m	30m	20m	17m	15m	10/12m
15:00				2				
15:30					1	1		
16:00				1		1		
16:30				1				
17:00			2	2		5		
17:30		3		1	1			
18:00		2	2			1		
18:30		1		1		1		1
19:00			1		3	2	1	5
19:30					1	2	1	4
20:00				1		1		5
20:30								
21:00								1
21:30								

Steve Nichols G0KYA, RSGB Propagation Studies Committee

This was an analysis of the DX cluster of all contacts into ZL from UK and surrounding countries for September 2001.

The yellow line shows the greyline - as you can see there were few contacts, showing that greyline openings are not as common as we are led to believe.


GeoClock 8.3 World (1)
File Maps Customize Controls Actions Reset Help
Anchorage 21:30
Los Angeles 22:30
Honolulu 19:30
Caracas 01:30
Rio de Janeiro 02:30
Buenos Aires 02:30
London 06:30
Norwich
Paris 07:30
Moscow 09:30
Athens 08:30
Cairo 08:30
Lagos 06:30
Meyerton
Johannesburg 07:30
New Delhi 11:00
Irkutsk 14:30
Beijing 13:30
Tokyo 14:30
Bangkok 12:30
Singapore 13:30
Sydney 15:30
Radio New Zealand 18:30
05:30 UTC
Norwich Sun Rise/Set=05:39/18:21 Sun Az/El= 82.22 -2.04
Sun Lat/Long= 3.09N 96.13E 2002 Sep 15 Sun 05:30:52 UTC
Start
09:57
Steve Nichols G0KYA, RSGB Propagation Studies Committee



DXCluster list of contacts from Europe to ZL, 9/2001

Time (UTC)	160m	80m	40m	30m	20m	17m	15m	10/12m
0:00								
0:30								
1:00								
1:30								
2:00						1		
2:30								
3:00						2		
3:30								
4:00						2		1
4:30					1	4		
5:00			2	3	5	2	1	
5:30		12	2	2	3	2		
6:00		5	7	6	2	3	2	2
6:30			2	4	3	2	2	1
7:00				4	8	9	2	1
7:30					2			1
8:00	1			1	5	2	2	1
8:30						3	4	2
9:00				2	1	2	4	2

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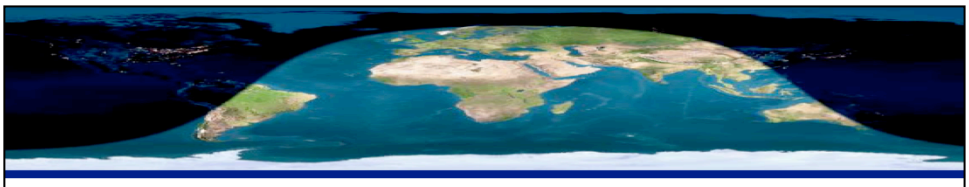
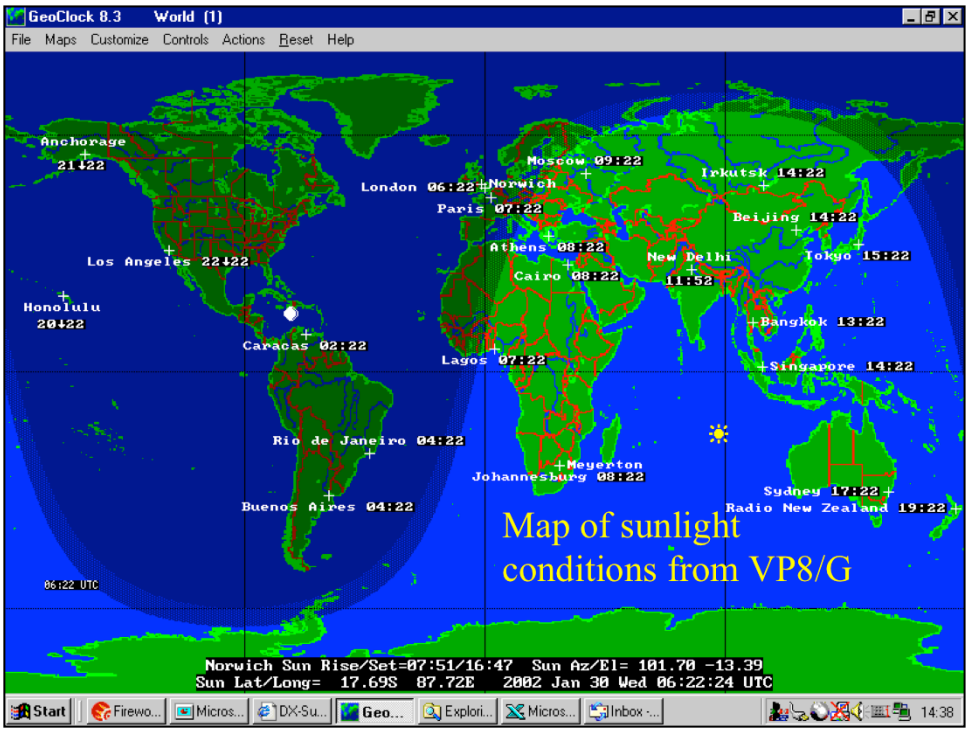
There are however many contacts at the sunset condition on 80m. The previous map does not however show a true greyline path.



So what about about G/VP8?

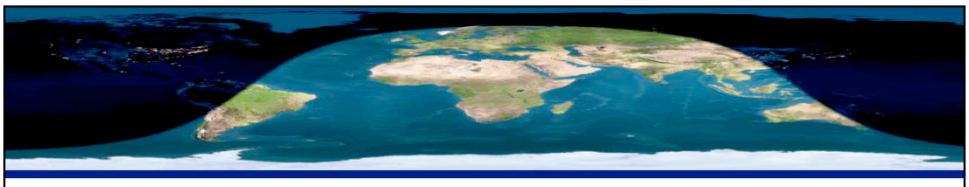
- On 40m/80m there were no logged contacts on the DXCluster in December and June 2001 at all
- All contacts that did take place were definitely outside the Greyline times
- But this one contact stands out:

  G3MLO 7077.0 VP8GEO ***PEAKING S9 IN UK***
  06:22 30 Jan 2002



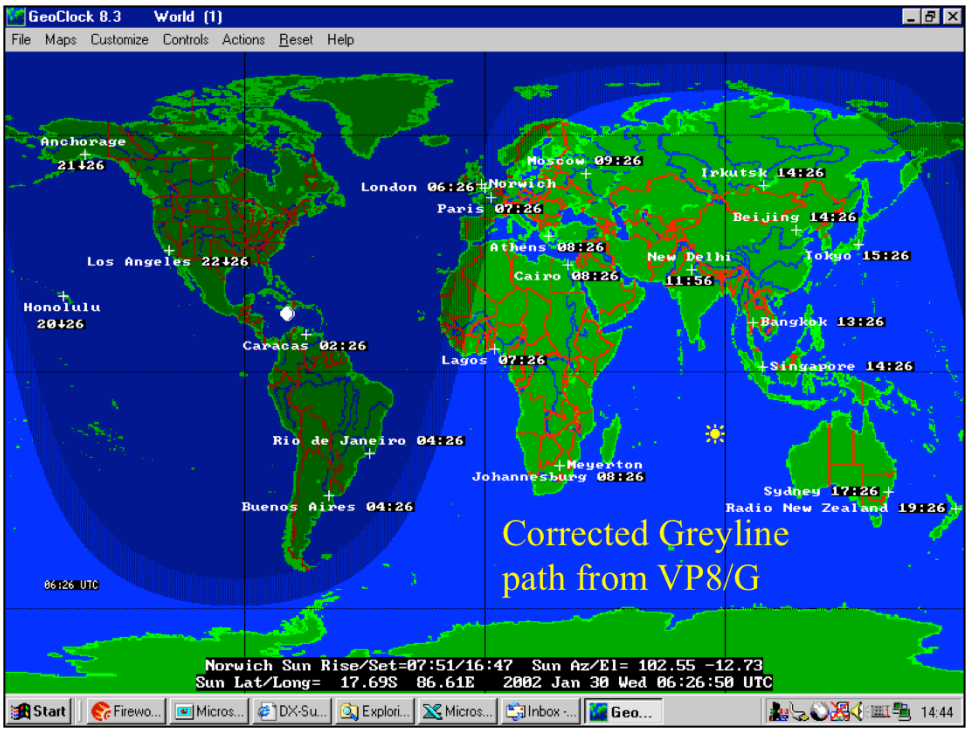
Map of sunlight conditions from VP8/G

The contact into VP8 South Sandwich Island was not a true greyline path using sunrise/sunset as our measure of the greyline. My argument is that what we are interested in is what is happening above our heads at 75km - not what is happening on the ground.

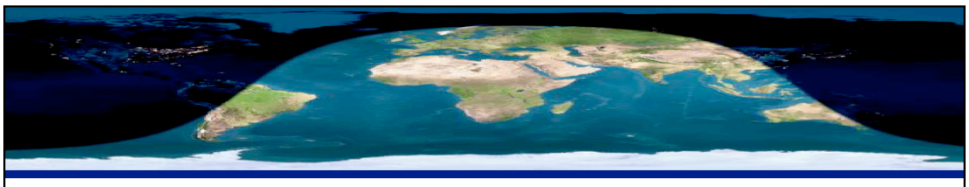


Is the Greyline where we think it is?

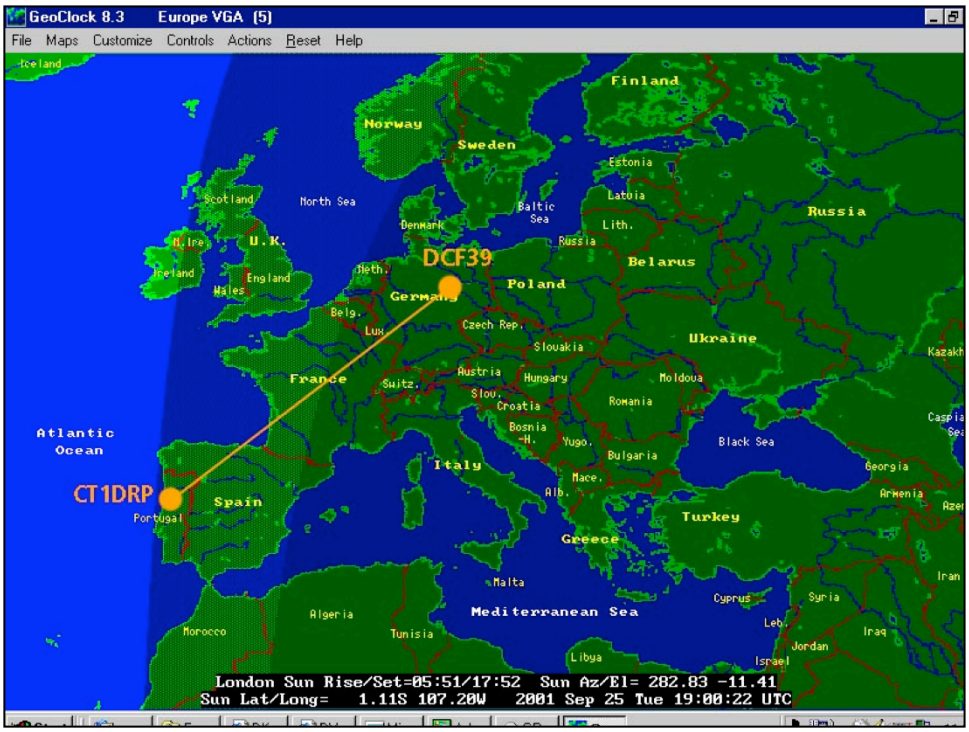
- The D layer is at a height of about 60-90km
- The F layer(s) are at a height of 150-300km
- So, sunrise/sunset tells us nothing about the illumination of the D/F layers, which is what we need to know
- By changing Geoclock to show the start/stop of illumination of the D/F layers we get ……



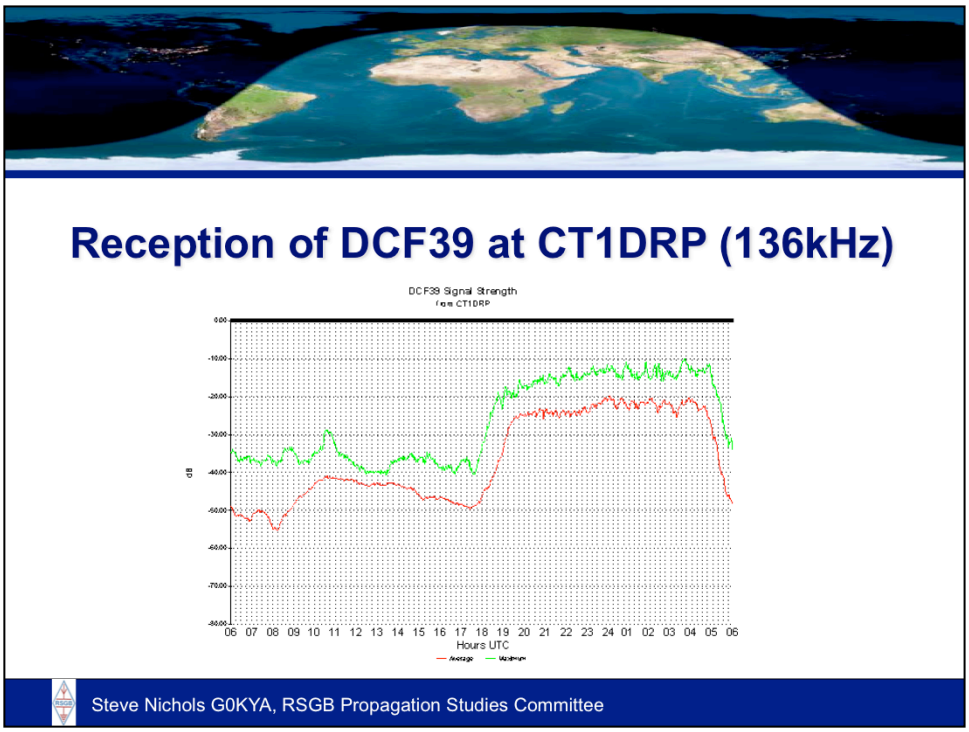
By showing the D/F layer illumination we get a better picture of where the greyline is.



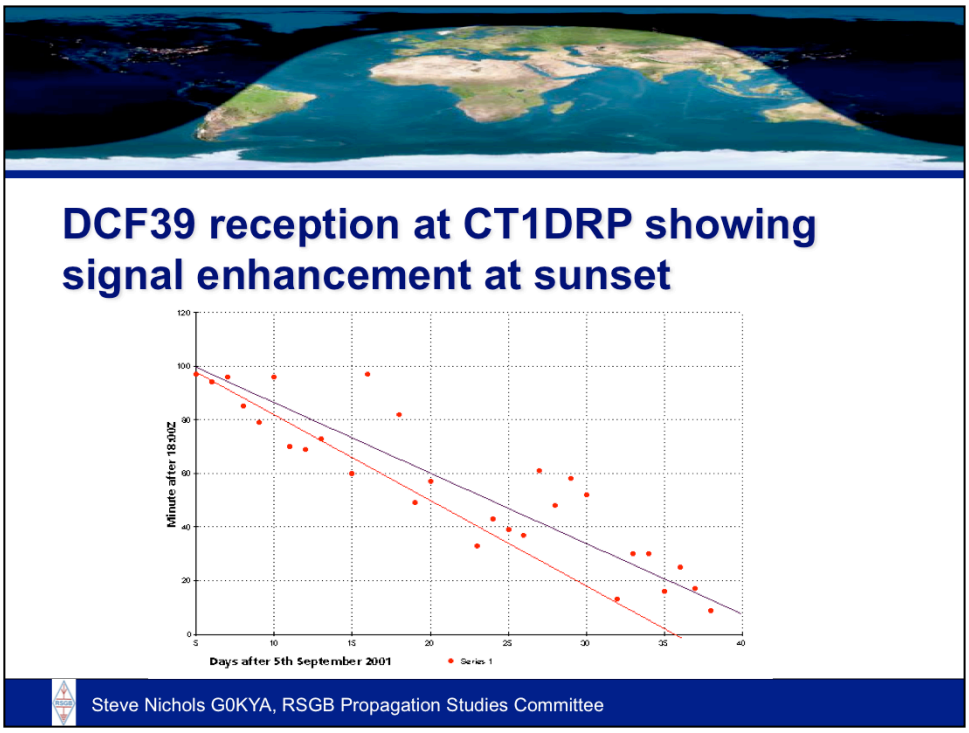
Is this model of the D layer illumination correct?



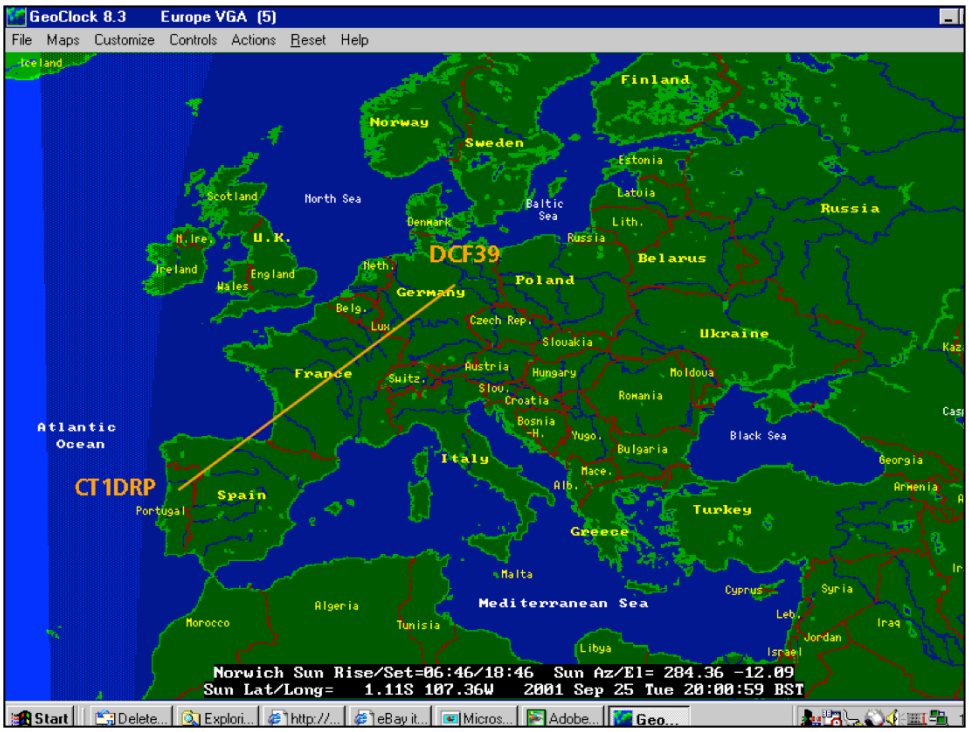
We have extensive data for the reception of the DCF39 into Portugal. The above shows the uncorrected sunset map for the path.



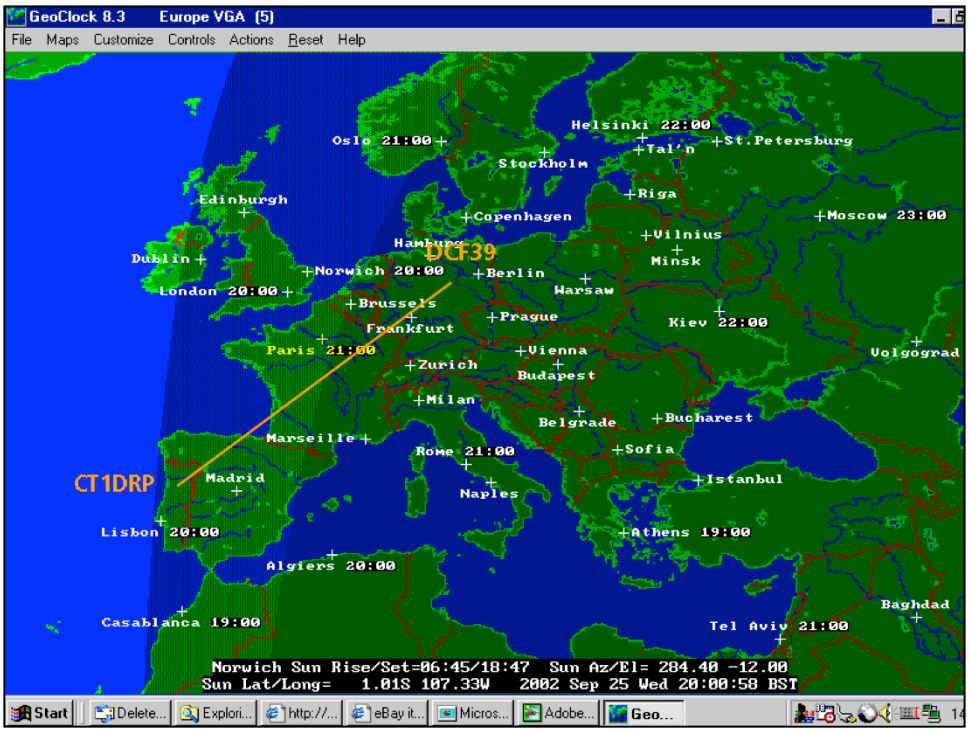
The upturn is due to the D layer illumination ending some time after sunset. Before that time the signal bounces off the bottom of the D layer. After that time is bounce off the bottom of the E layer. We can use this data to map where the D layer absorption ends.



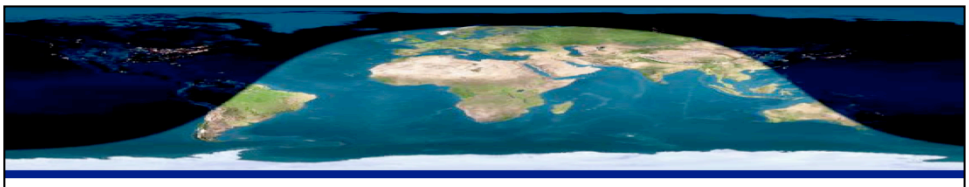
This graph shows that this is not that predictable - it varies from day to day even allowing for sunset occurring earlier. In other words, the data points don't lay on a straight line.



This shows the sunset condition - it doesn't explain the upturn in signal. There is little correlation.



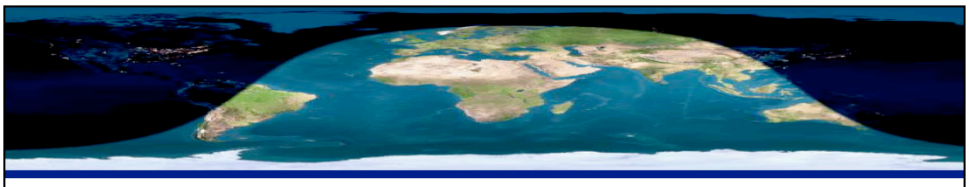
This shows the adjusted greyline. Now we can see that the signal increases some time after the D layer illumination ends and just before F layer illumination ends. We can now test this hypothesis by looking for greyline enhancement and checking any upturn with the time.



But the "corrected" path does not appear to work with all so-called greyline contacts, especially those from VK, ZL etc

Steve Nichols G0KYA, RSGB Propagation Studies Committee

This theory seems to hold for local paths, but not for long paths. More work needed!

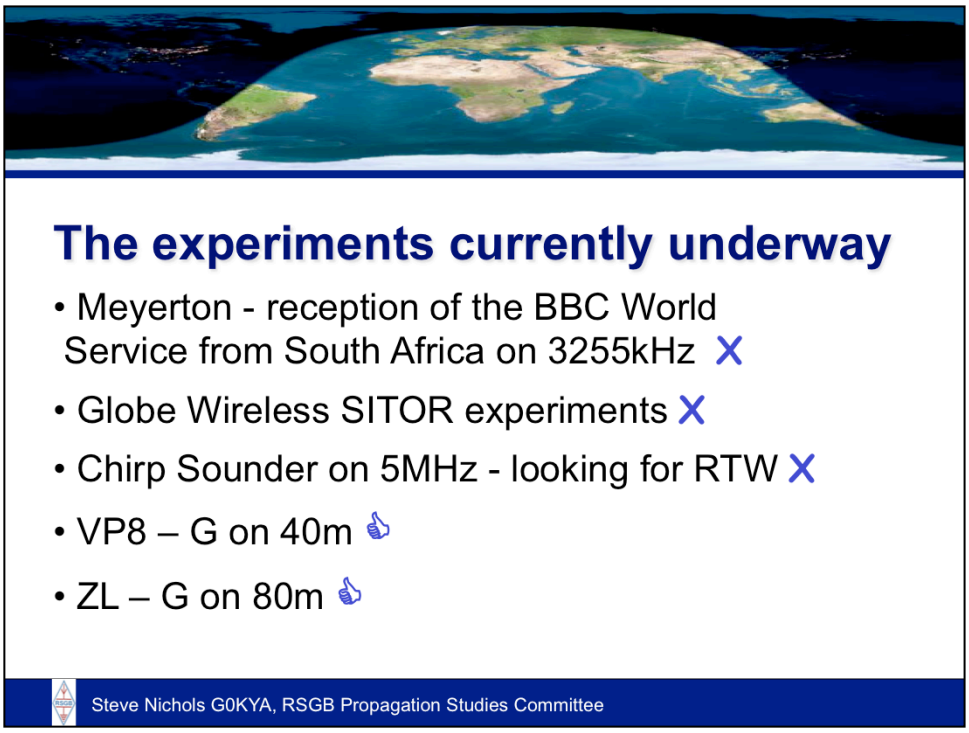


The purpose of Project Greyline

- To find better ways of modelling the greyline
- To find out if greyline paths actually exist in the way we currently model them
- To find out what frequencies are the most efficient over greyline paths if any.
- To look at trans-terminator paths (skip focusing)

Steve Nichols G0KYA, RSGB Propagation Studies Committee

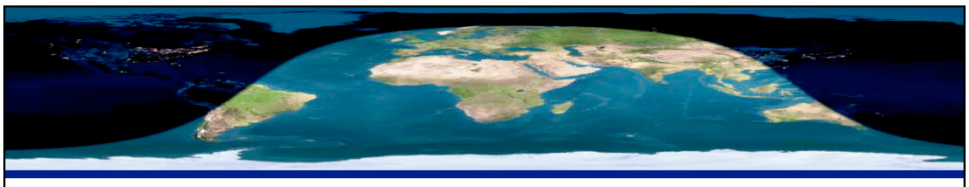
This is the new group that has been set up. The home page can be found at http://uk.groups.yahoo.com/group/greyline/



We are looking at the reception of signals from South Africa in early November to look for any greyline enhancement. Since the lecture a station in Lusaka has been added too on 4265KHz.

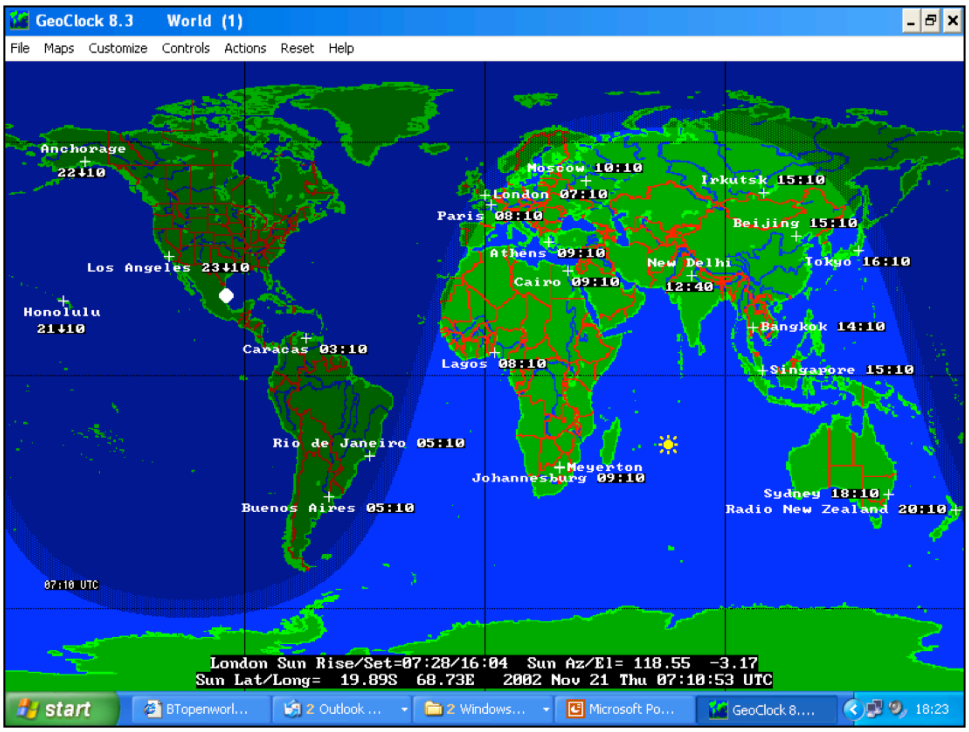
We also have a lost of frequencies and location for a worldwide network of SITOR stations

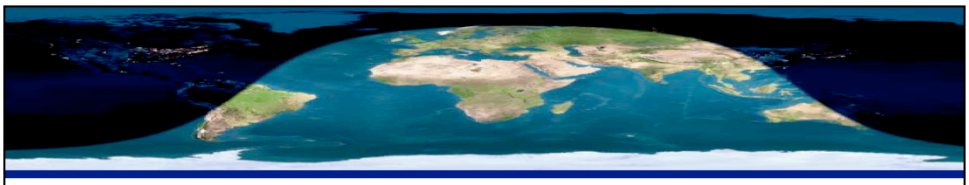
We are also looking for round the world greyline echoes on 5MHz using chirpsounder - none found so far.

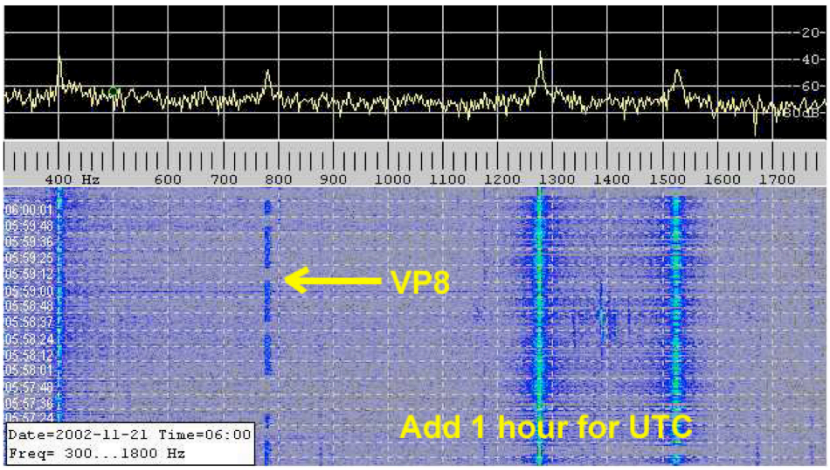


The G<>VP8 experiment 11/02

- Mike Harris VP8NO set up a 40m dipole and an Elecraft K2
- Using slow Morse (QRSS) he transmitted his call on 7039.41kHz
- Signals were received in the UK for three weeks using SpectrumLab software


GeoClock 8.3 World (1)
File Maps Customize Controls Actions Reset Help
Anchorage 22:10
Los Angeles 23:10
Honolulu 21:10
Caracas 03:10
Rio de Janeiro 05:10
Buenos Aires 05:10
Moscow 10:10
London 07:10
Paris 08:10
Athens 09:10
Cairo 09:10
Lagos 08:10
Irkutsk 15:10
Beijing 15:10
New Delhi 12:40
Tokyo 16:10
Bangkok 14:10
Singapore 15:10
Meyerton
Johannesburg 09:10
Sydney 18:10
Radio New Zealand 20:10
07:10 UTC
London Sun Rise/Set=07:28/16:04 Sun Az/El= 118.55 -3.17
Sun Lat/Long= 19.89S 68.73E 2002 Nov 21 Thu 07:10:53 UTC
start
BTopenworl...
2 Outlook ...
2 Windows...
Microsoft Po...
GeoClock 8....
18:23





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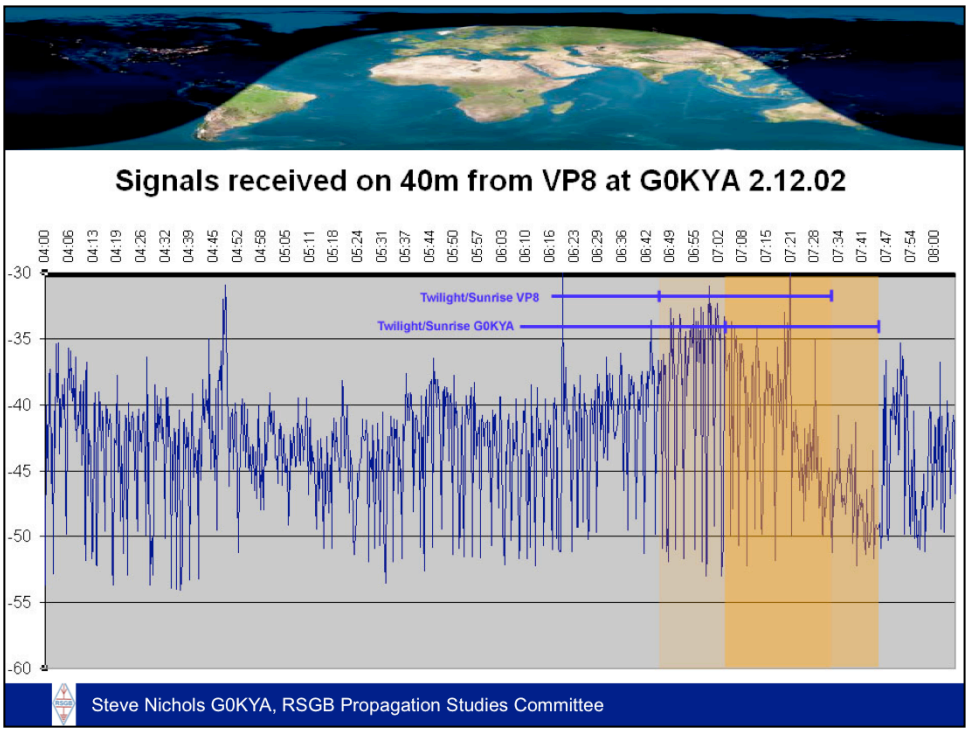
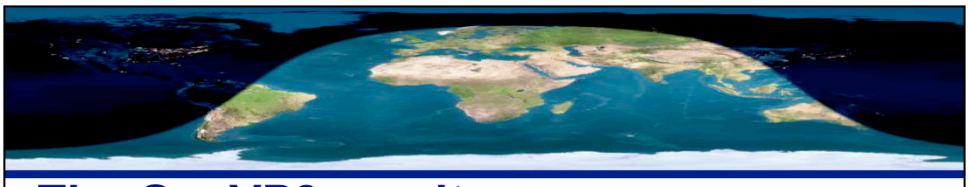
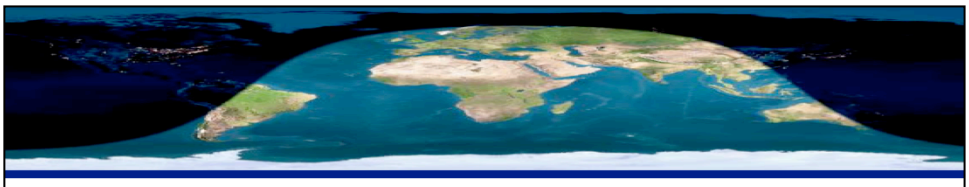

Signals received on 40m from VP8 at G0KYA 2.12.02
04:00
04:06
04:13
04:19
04:26
04:32
04:39
04:45
04:52
04:58
05:05
05:11
05:18
05:24
05:31
05:37
05:44
05:50
05:57
06:03
06:10
06:16
06:23
06:29
06:36
06:42
06:49
06:55
07:02
07:08
07:15
07:21
07:28
07:34
07:41
07:47
07:54
08:00
-30
-35
-40
-45
-50
-55
-60
Twilight/Sunrise VP8
Twilight/Sunrise G0KYA
Steve Nichols G0KYA, RSGB Propagation Studies Committee



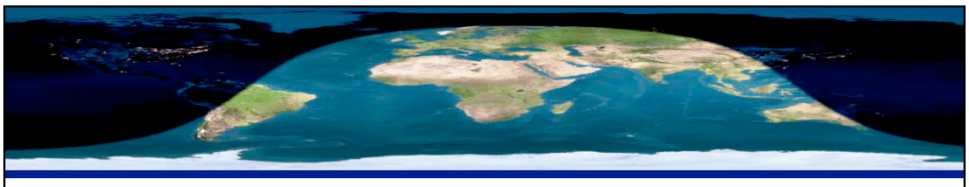
The G<>VP8 results

- Signals were received through the night
- A greyline enhancement of about 6-10db could be seen about 75% of the time.
- The enhancement occurred in the traditional twilight period - about 30-60 mins. before sunrise.
- This is probably due to a time lag on E/F layer build-up

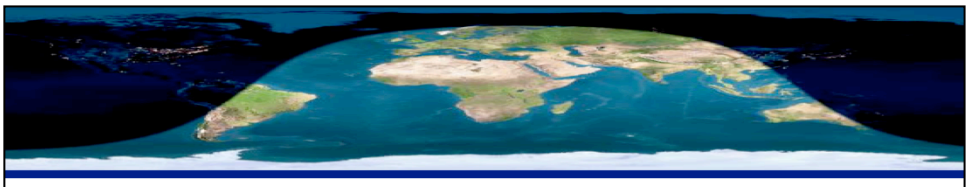


The G<>VP8 40m sunset experiment

- Took place throughout May 2003
- Signals were very poor, probably due to the season and high A/K indices.
- There was no confirmed greyline enhancement.

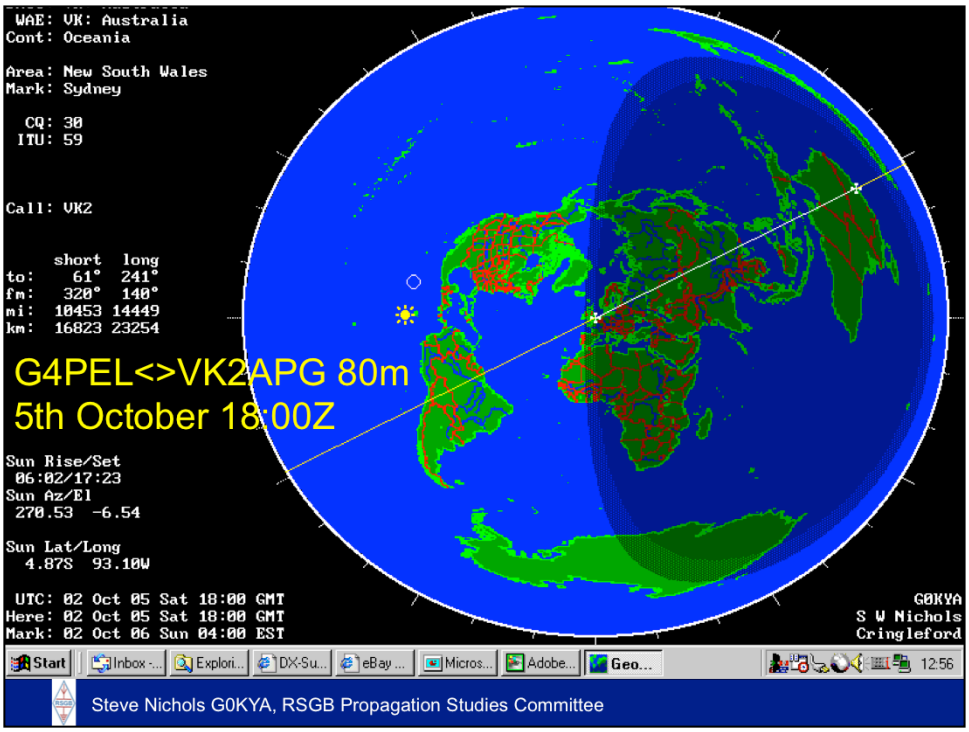


But is there an alternative explanation for contacts occurring at sunrise/sunset?

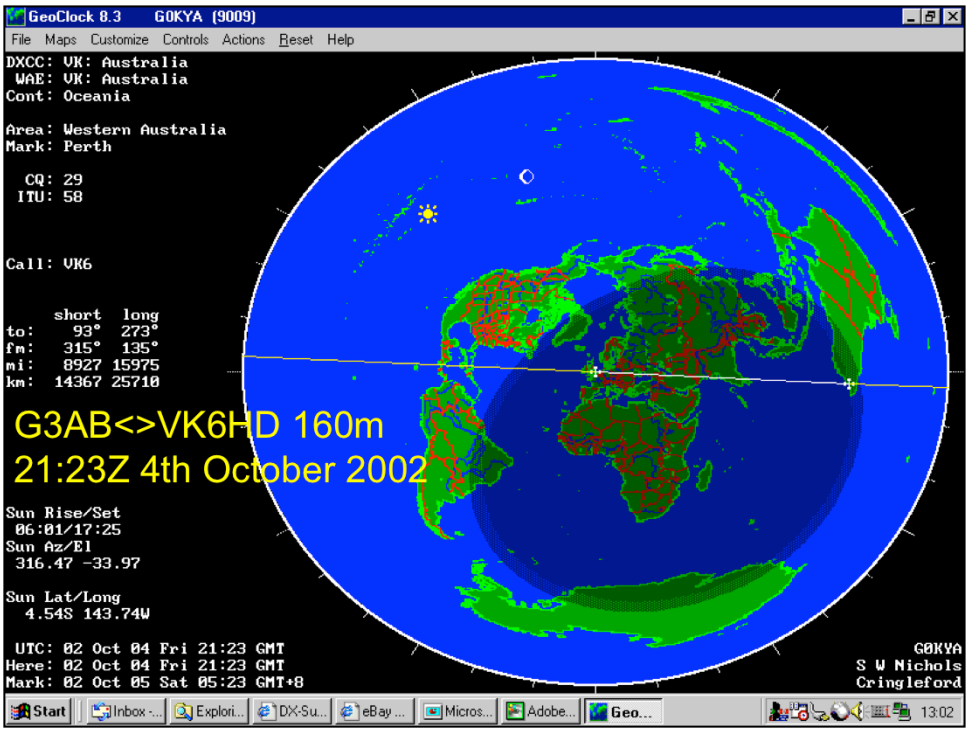


Trans-terminator paths or sunrise/ sunset enhancements

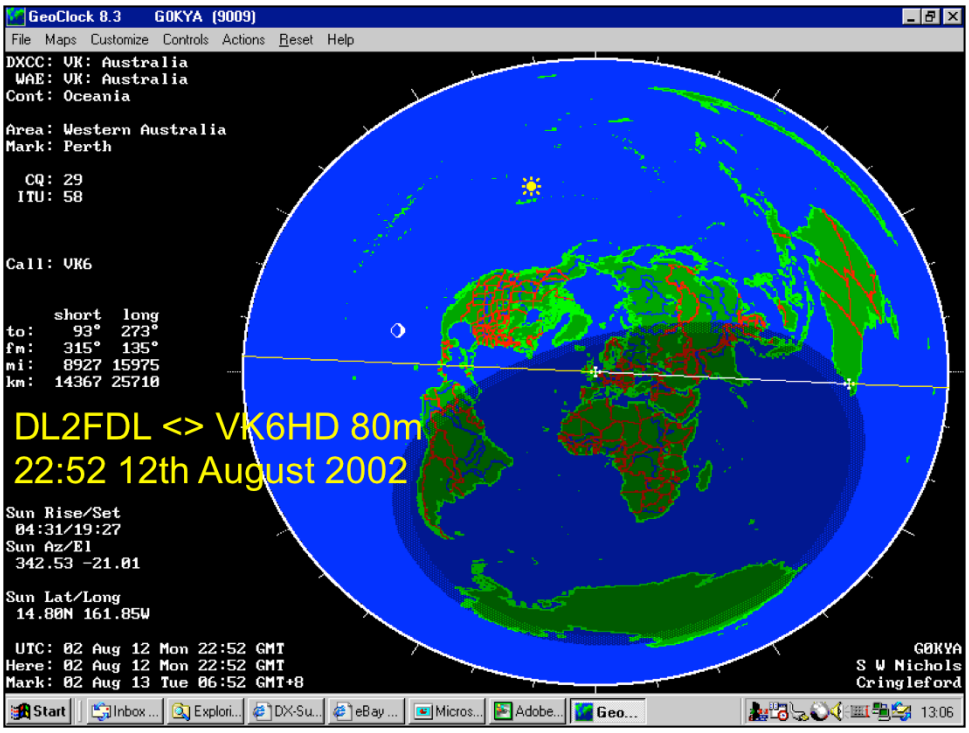
- ON4UN suggests that 160m/80m signals are best at ***right angles*** to the terminator. Only 40m signals tend to follow a greyline path.
- N4KG says on 80 and 40 meters, signals ALWAYS peak **AFTER SUNRISE** to the west and **BEFORE SUNSET** to the EAST. On 160m, signals can peak at sunrise and sunset and can also peak during darkness. 160m is the **LEAST** predictable band in the amateur spectrum.

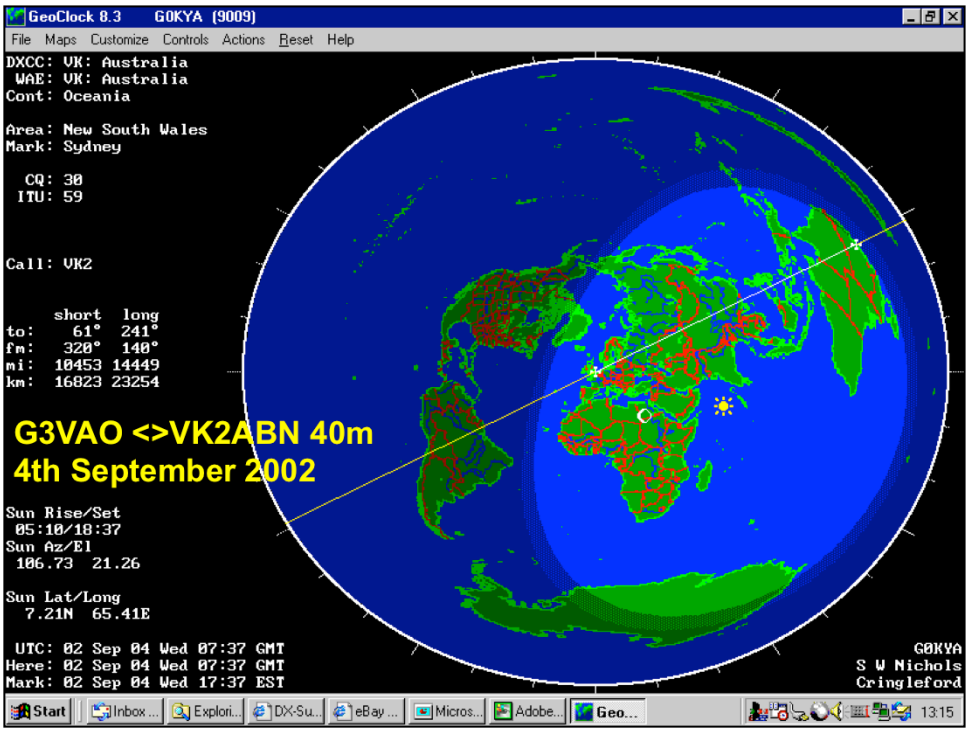


These graphs show that many so-called greyline contacts are anything but. However, they do follow the rule that signals can be strong at local sunrise/sunset from the dark portion of the earth.

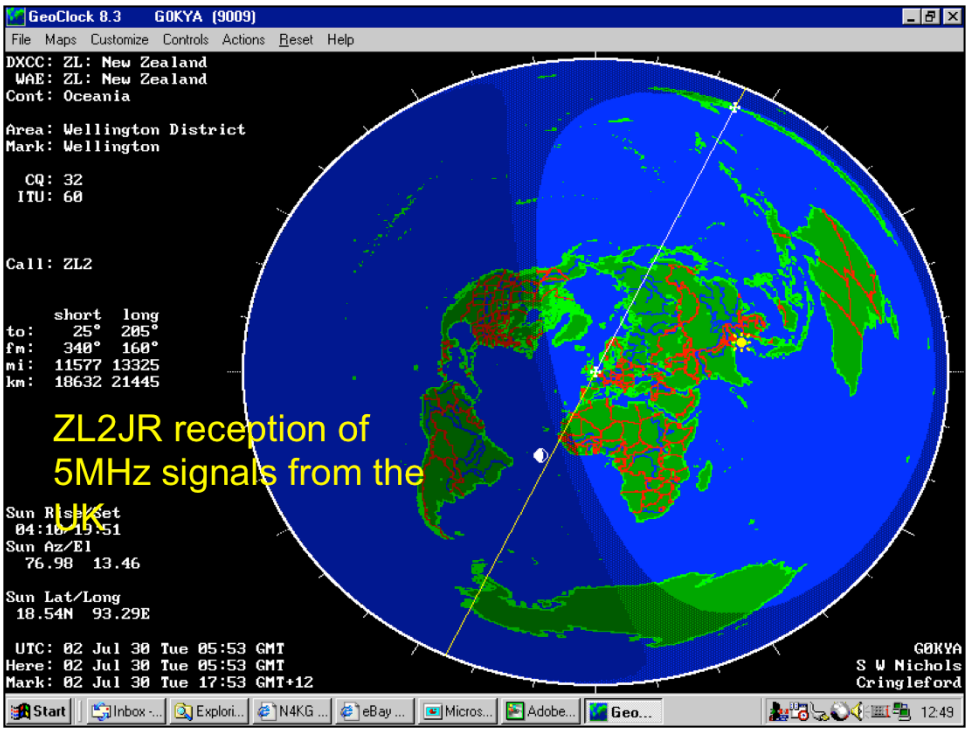


Or at DX sunrise/sunset into the dark portion of the earth.

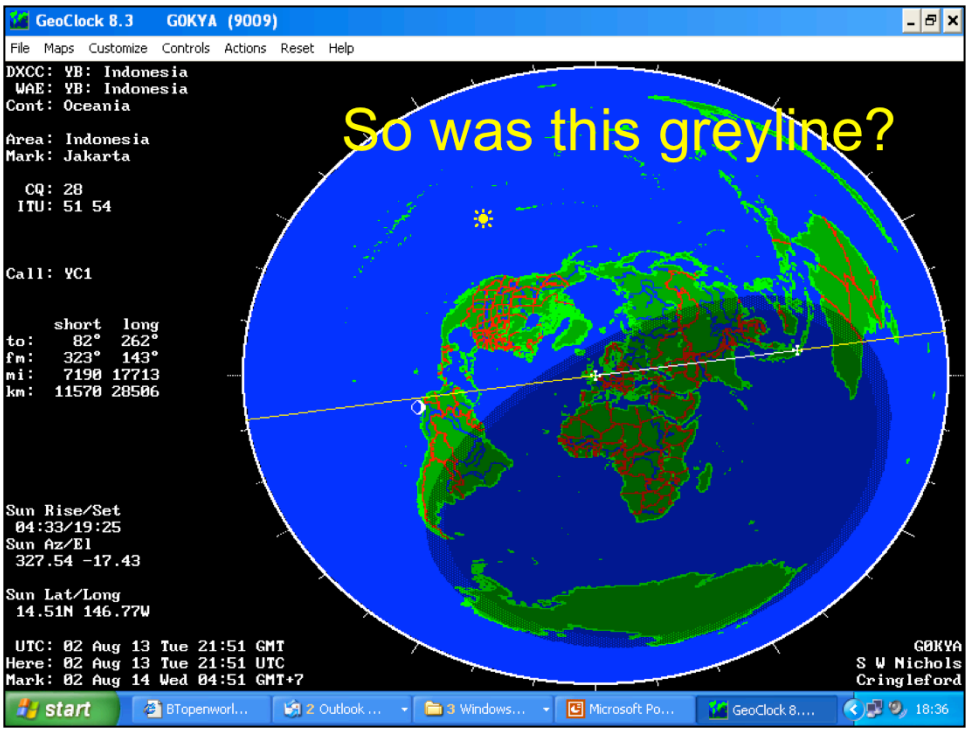

GeoClock 8.3 G0KYA (9009)
File Maps Customize Controls Actions Reset Help
DXCC: VK: Australia
WAE: VK: Australia
Cont: Oceania
Area: Western Australia
Mark: Perth
CQ: 29
ITU: 58
Call: VK6
short long
to: 93° 273°
fm: 315° 135°
mi: 8927 15975
km: 14367 25710
DL2FDL <> VK6HD 80m
22:52 12th August 2002
Sun Rise/Set
04:31/19:27
Sun Az/El
342.53 -21.01
Sun Lat/Long
14.80N 161.85W
UTC: 02 Aug 12 Mon 22:52 GMT
Here: 02 Aug 12 Mon 22:52 GMT
Mark: 02 Aug 13 Tue 06:52 GMT+8
G0KYA
S W Nichols
Cringleford
Start
13:06

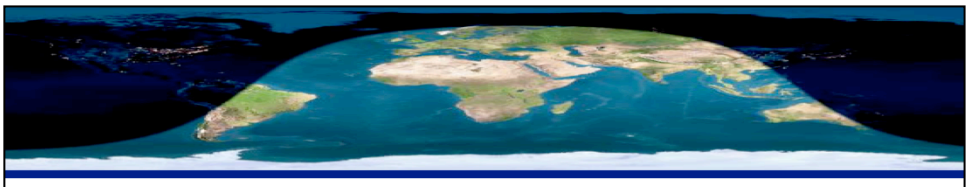


This is probably due to along path across South America. Note it is a sunset enhancement



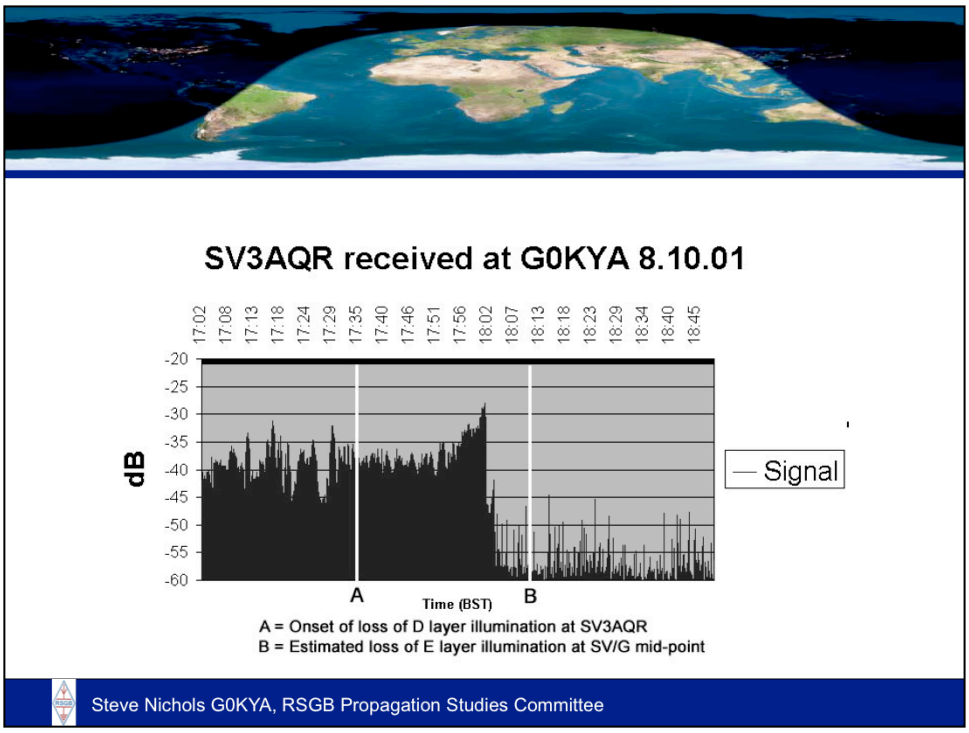
This was reported on GB2RS as being greyline. Once again, it is probably longpath. Only by analysing such contacts using GEOCLOCK can you really see what is happening.


GeoClock 8.3 G0KYA (9009)
File Maps Customize Controls Actions Reset Help
DXCC: YB: Indonesia
WAE: YB: Indonesia
Cont: Oceania
Area: Indonesia
Mark: Jakarta
CQ: 28
ITU: 51 54
Call: YC1
short long
to: 82° 262°
fm: 323° 143°
mi: 7190 17713
km: 11570 28506
Sun Rise/Set
04:33/19:25
Sun Az/El
327.54 -17.43
Sun Lat/Long
14.51N 146.77W
UTC: 02 Aug 13 Tue 21:51 GMT
Here: 02 Aug 13 Tue 21:51 UTC
Mark: 02 Aug 14 Wed 04:51 GMT+7
G0KYA
S W Nichols
Cringleford
So was this greyline?
start
BTopenworl...
2 Outlook ...
3 Windows...
Microsoft Po...
GeoClock 8....
18:36

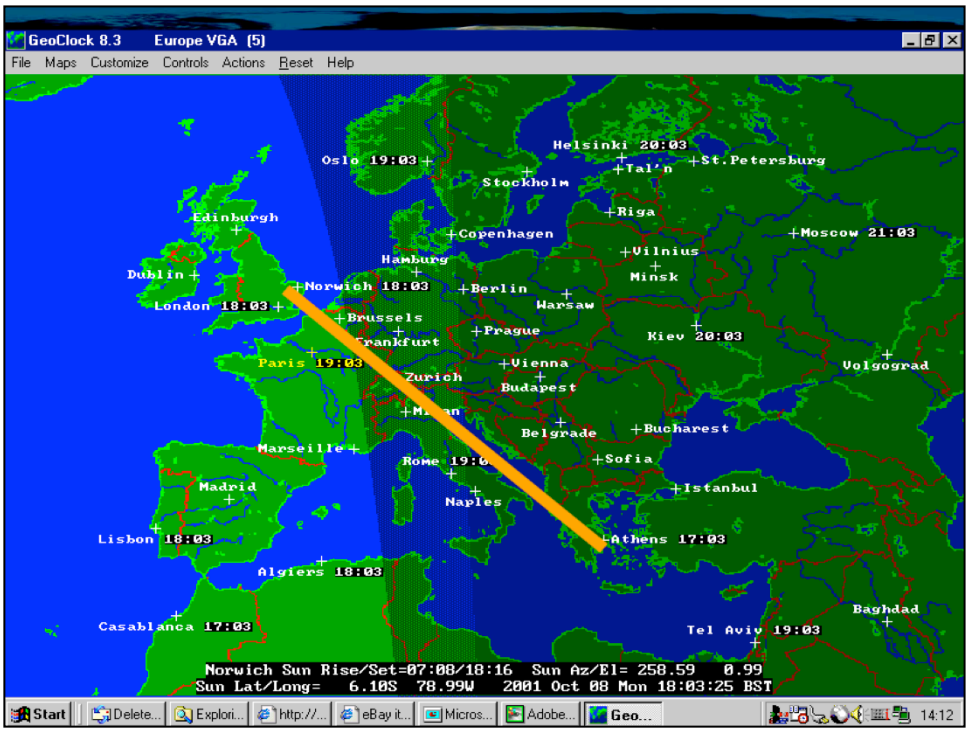


And what about skip focusing on HF - eg. 10m?

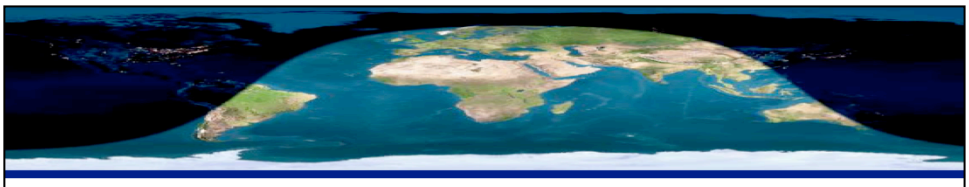
This occurs when operating near to the MUF



This shows how trans-terminator paths can being about signal enhancements near sunset. This effect is called skip-focusing.

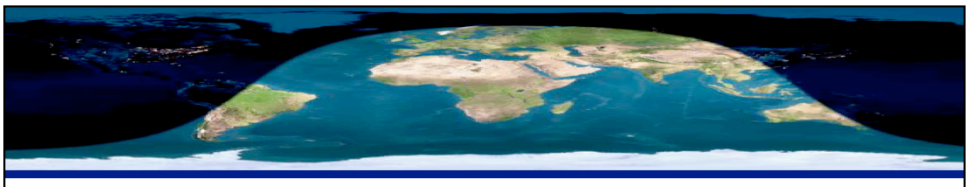


The path shown in the previous slide.



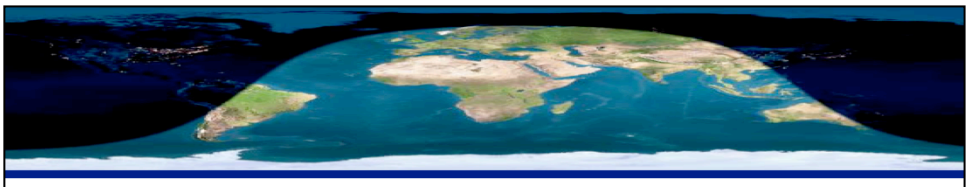
In conclusion - true greyline paths

- Greyline paths on 160m/80m are **not** that efficient
- Sunrise/Sunset gives enhancements on the LF bands, but the paths are NOT always “greyline” - they need modelling
- The “corrected” greyline method does not appear to work on all DX paths
- There may be true greyline effects on 40m eg VP8
- D layer absorption due to solar events must be taken into account, as must polar paths



In conclusion - trans-terminator paths

- On LF, Expect enhancements at your local sunrise and sunset towards the dark zone.
- Also look for enhancements from DX stations across the dark zone at **their** sunset/sunrise, especially perpendicular
- For the above to work you must be in darkness on LF
- Look for skip focusing enhancements on 28Mhz as the terminator crosses the DX path and you are in daylight



Web addresses for “greyline” information

- ***Geoclock*** - www.geoclock.com
- ***D-layer absorption predictions***
  www.sec.noaa.gov/rt_plots/dregion.html
- ***Critical frequency (fof2) predictions***
  www.spacew.com/www/fof2.html
- ***SpectrumLab* software** - www.qsl.net/dl4yhf/
- ***Beacon Time Wizard*** by Taborsoft
  www.taborsoft.com
- ***RSGB Greyline Research Group*** -
  http://uk.groups.yahoo.com/group/greyline/