

Scaling Ionograms

Phil Wilkinson

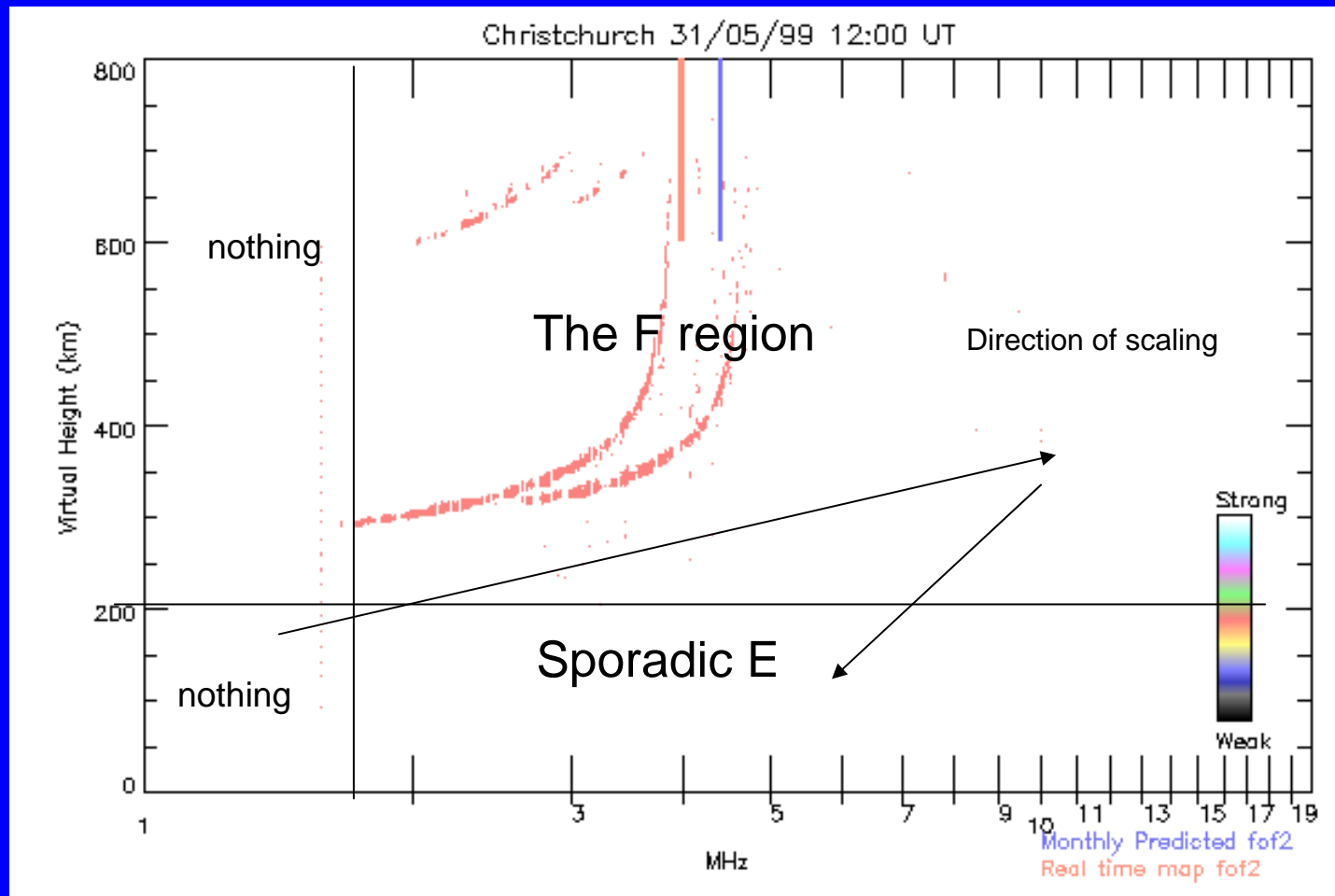
IPS

August 2005

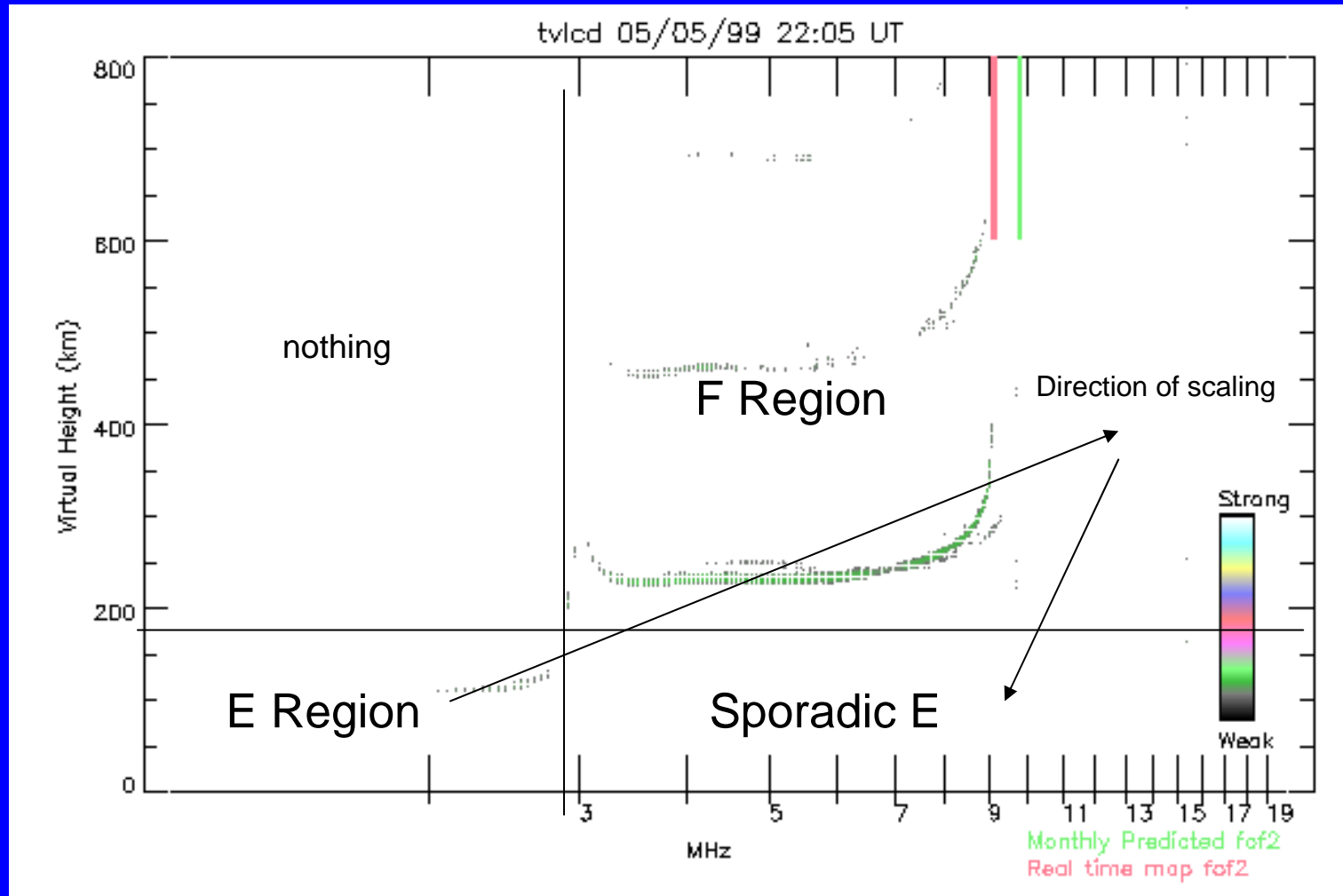
Basic Scaling

- Regions of the Ionosphere
 - Normal regions: E, F2, F2 & sporadic E
 - Less familiar: E2, F0.5, F1.5, meteors
 - Notable conditions: spread F, absorption
 - Notorious effects: interference, equipment failure

Nighttime



Daytime



Basic Scaling

- Geometry of reflections
 - think specular
 - know the difference between thick and thin layers; retardation and blanketing,
 - recognise examples of layers
 - develop concepts of oblique returns; recognise and eliminate them when scaling
 - recognise unusual things; particle E, spurs, travelling disturbances

Basic Scaling

- **Resources**
 - UAG-23A; the bible, by Rawer and Piggott
 - UAG-50; the High Latitude Supplement by Piggott
 - INAG; an outlet for frustration for some, a link with all the other scalers for others
 - Japanese scaling manual
 - Scaling aids
 - IPS scaling notes
 - ionograms and your own common sense
 - ***look at, and scale, lots of ionograms***

Nuts and Bolts of Scaling

- Accuracy of the scaling - qualifying letters
 - quantitative accuracy; E, D, U
 - unquantifiable errors; J, A, O, Z
 - unknown errors; I
- Reason for the loss of accuracy - descriptive letters
 - Gaps; A, B, C, G, L, R, S, W, Y
 - bumps; H, V
 - things; F, K, P, Q, X, Z
- Flags
 - which are more objective things.

Ionospheric Features

- **Once you recognise these you are understanding much of the ionogram.**
 - * Spread F: a well known night time phenomenon.
 - * sporadic E
 - * Travelling ionospheric disturbances (TID); medium scale features.
 - * Ionospheric storms - These are global events.
 - * Troughs: a sub auroral, large scale features.

Ionospheric Regions

- There are distinctive aspects to the different regions
 - Mid latitudes
 - sporadic E, travelling ionospheric disturbances, ionospheric storms
 - Low latitudes
 - absorption, thick ionosphere and variability, nighttime HF interference
 - High latitudes
 - particle effects (Es-K, B) and troughs and ridges of ionisation, much spreading in E and F region

Course Objectives

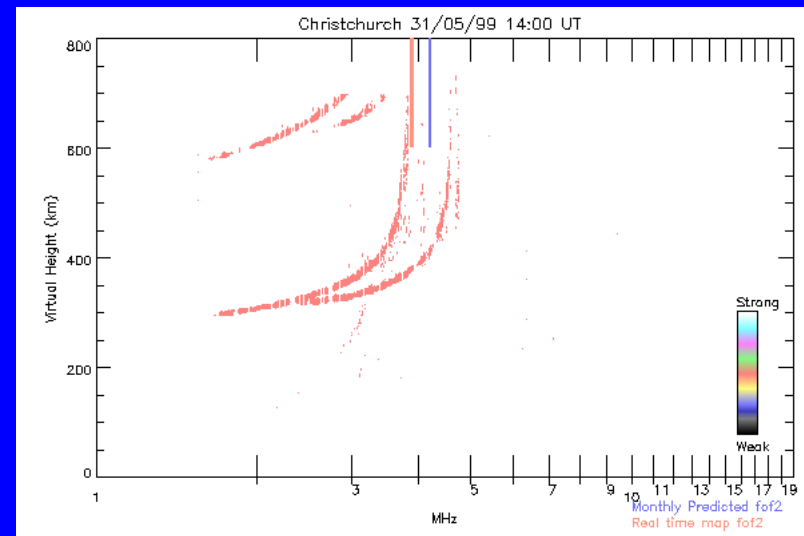
- recognise and scale all the conventional parameters,
- use scaling letters effectively,
- recognise good and bad ionograms,
- use simple principles to scale complex ionograms.
- appreciate the sources affecting ionograms,

In addition you may

- recognise large scale ionospheric processes,
- become more confident in assessing ionospheric effects on HF systems.

Sample Ionograms : nighttime

- Boring nighttime ionogram
- Clear foF2 and fxF2
- Multiples present
- No interference effects
- A few odd details worth noting:
 - around the time base echo
 - slight spreading



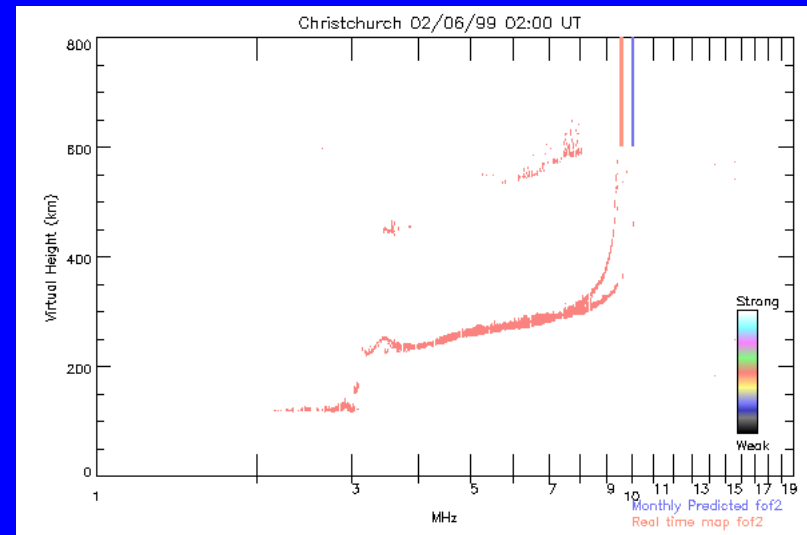
foF2, fmin, h'F, all Es are easy;
fxl is too.

Sample Ionograms : daytime

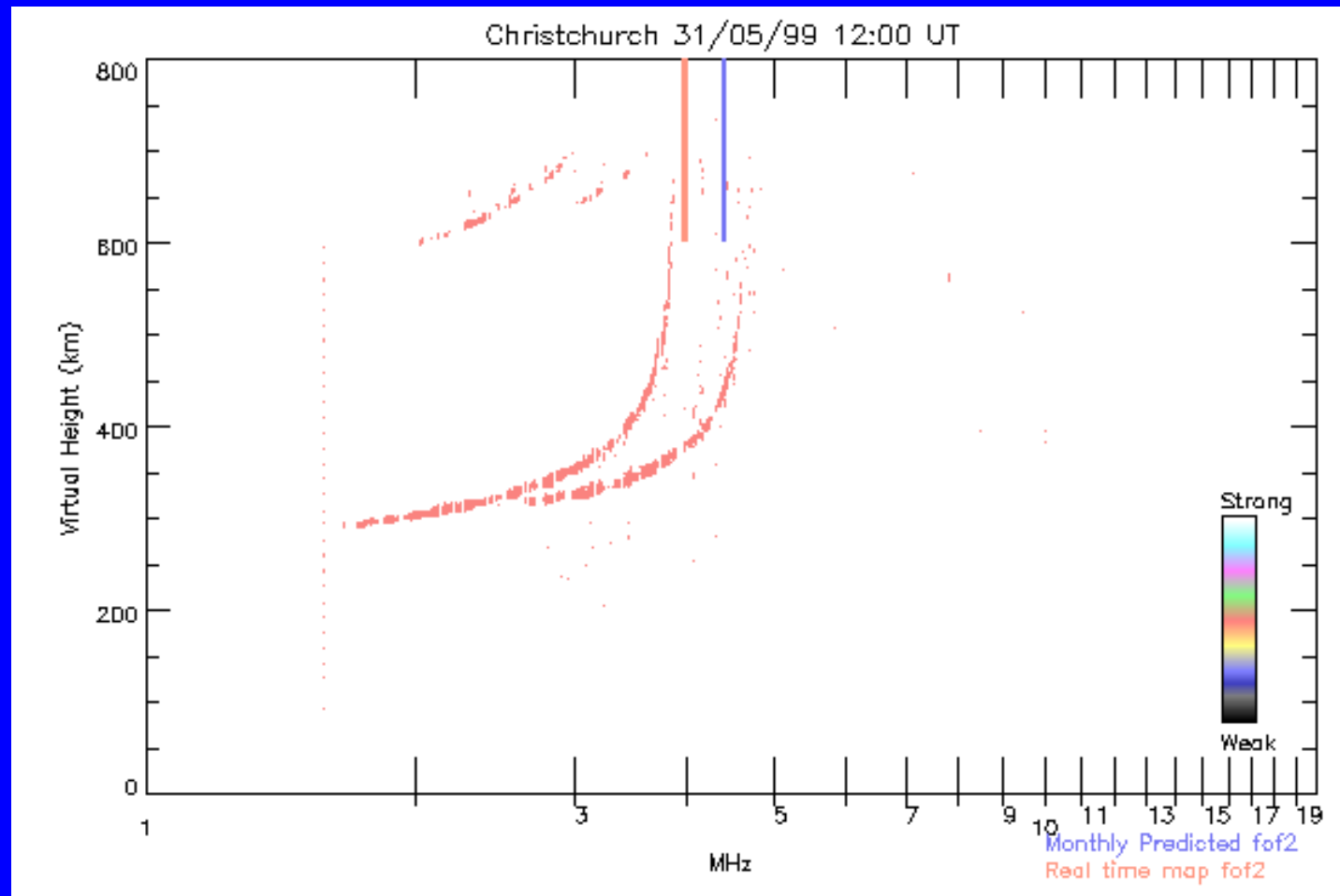
- Typical daytime ionogram
- E/F region layers
- multiples
- extraordinary weak
- sporadic E present
- easy to scale

Scaling problems:

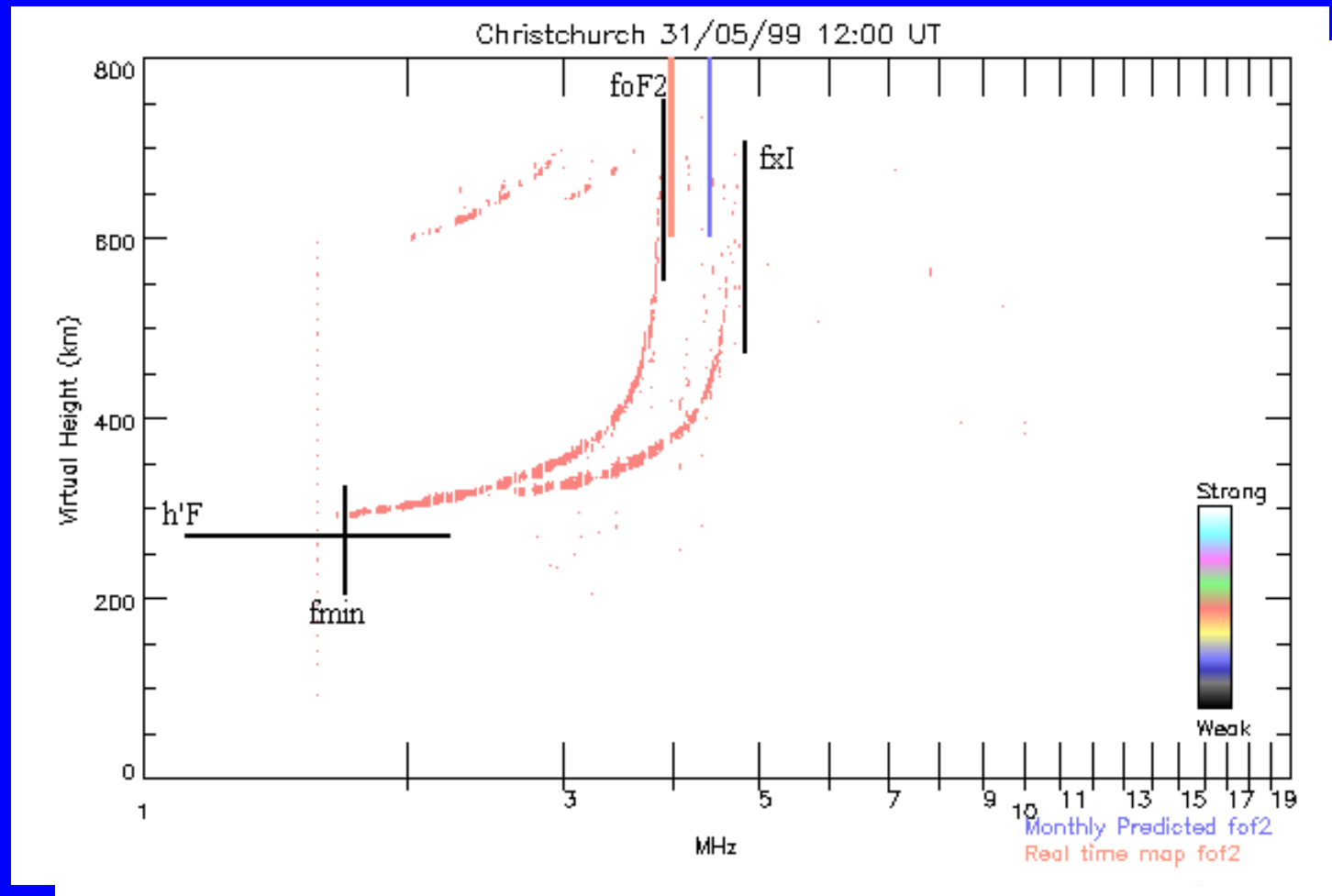
- foE - extrapolation
- Es - weak traces
- fxl - interference



Sample Ionograms : nighttime (Chch 31/05/99 12 UT)



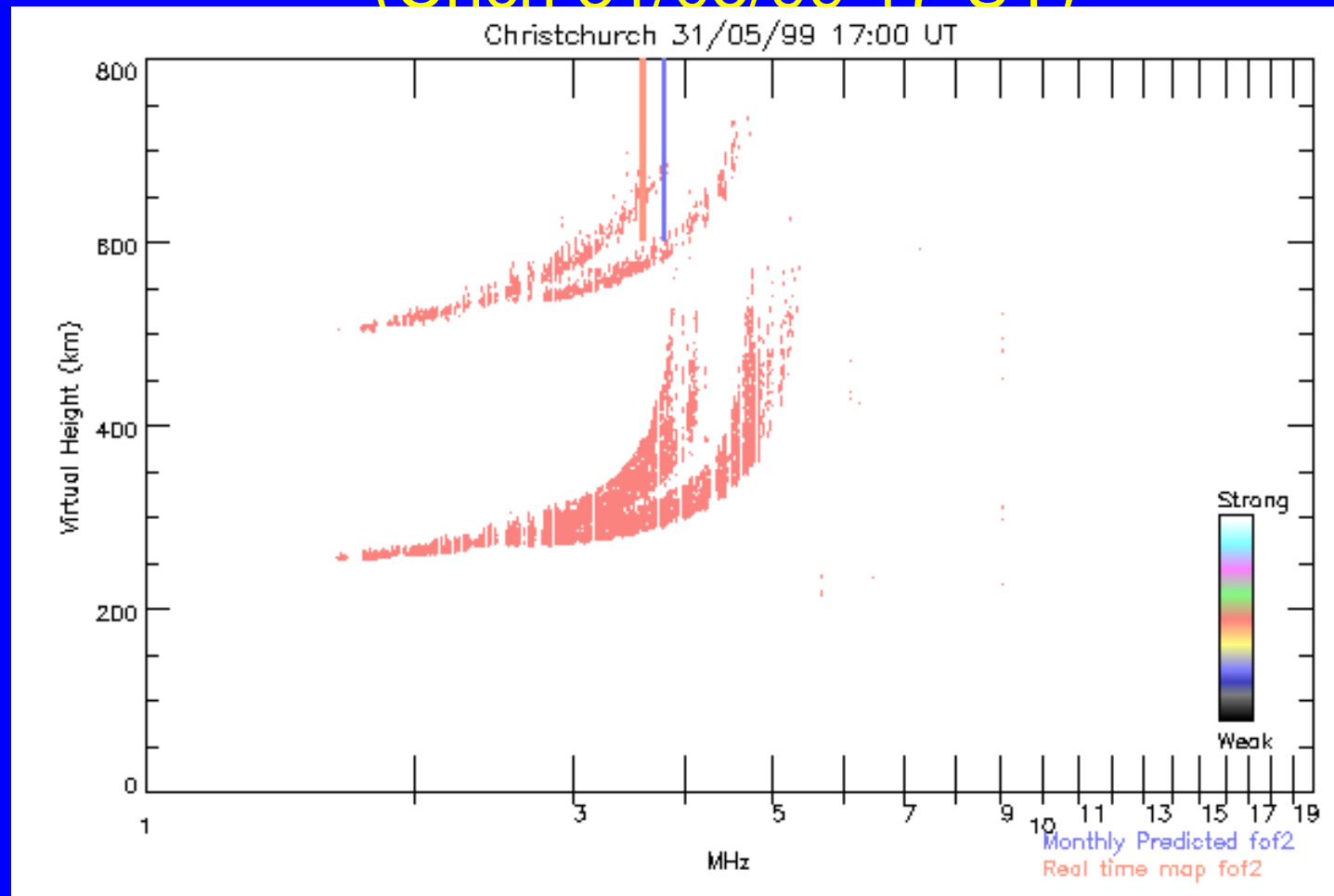
Sample Ionograms : nighttime (Chch 31/05/99 12 UT)



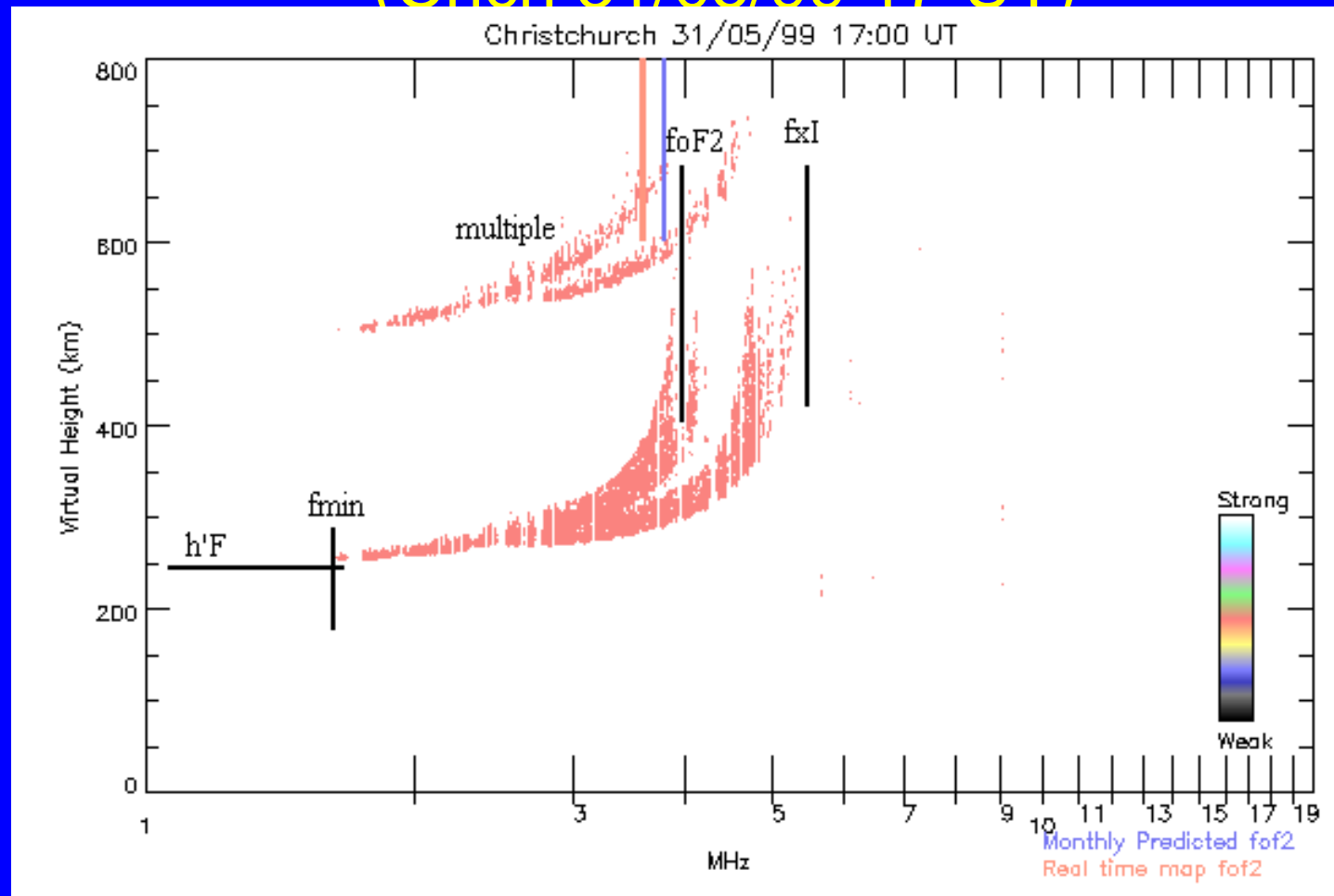
Sample Ionograms : nighttime (Chch 31/05/99 12 UT)

- What can we say?
 - Clear fmin (__ES)
 - no Es parameters
 - Clear foF2,
 - fxl = foF2+split
 - h'F, extrapolate down, *maybe* (__US)
This is the hardest decision you will make scaling ionograms like this.

Sample Ionograms : nighttime (Chch 31/05/99 17 UT)



Sample Ionograms : nighttime (Chch 31/05/99 17 UT)

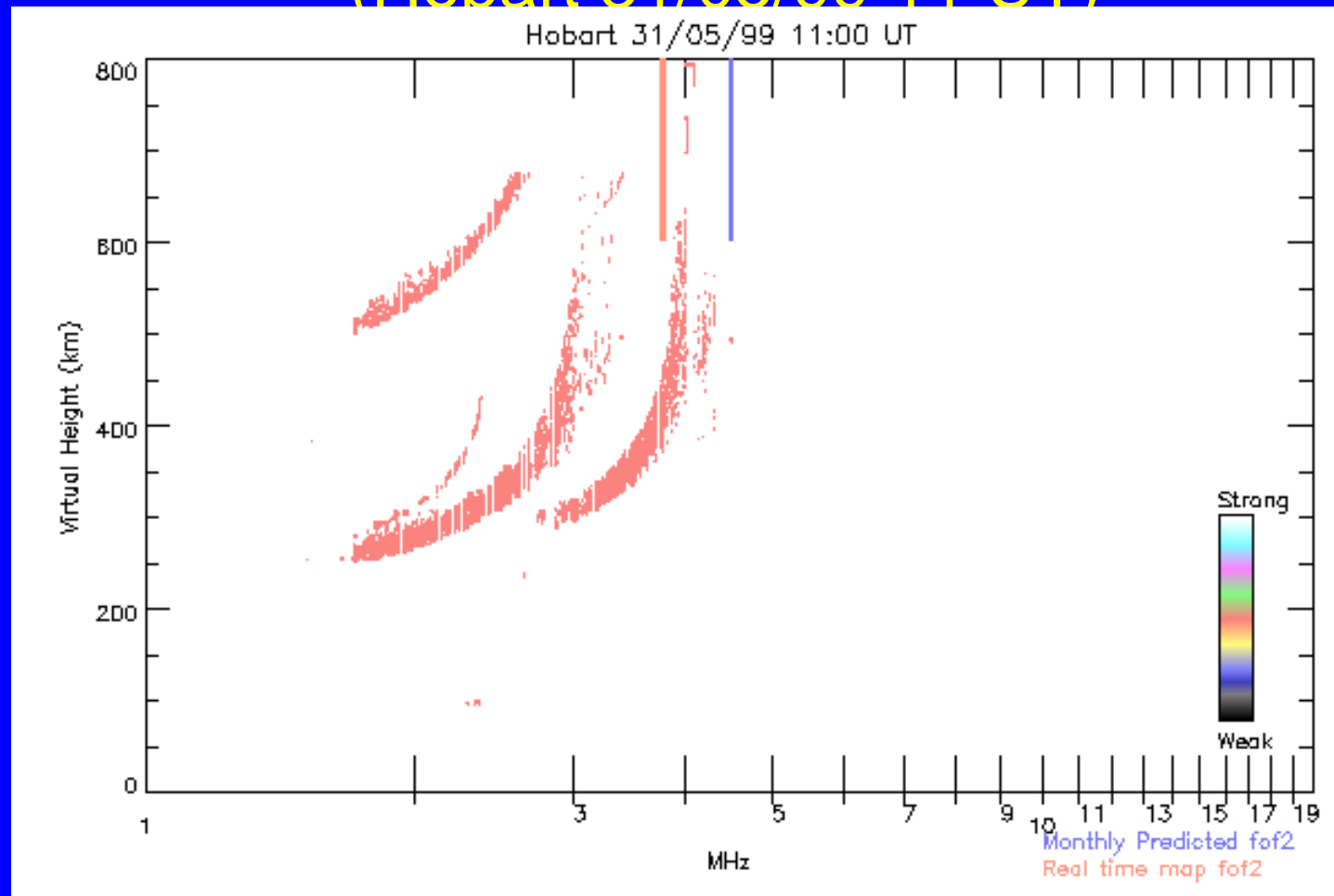


Sample Ionograms : nighttime (Chch 31/05/99 17 UT)

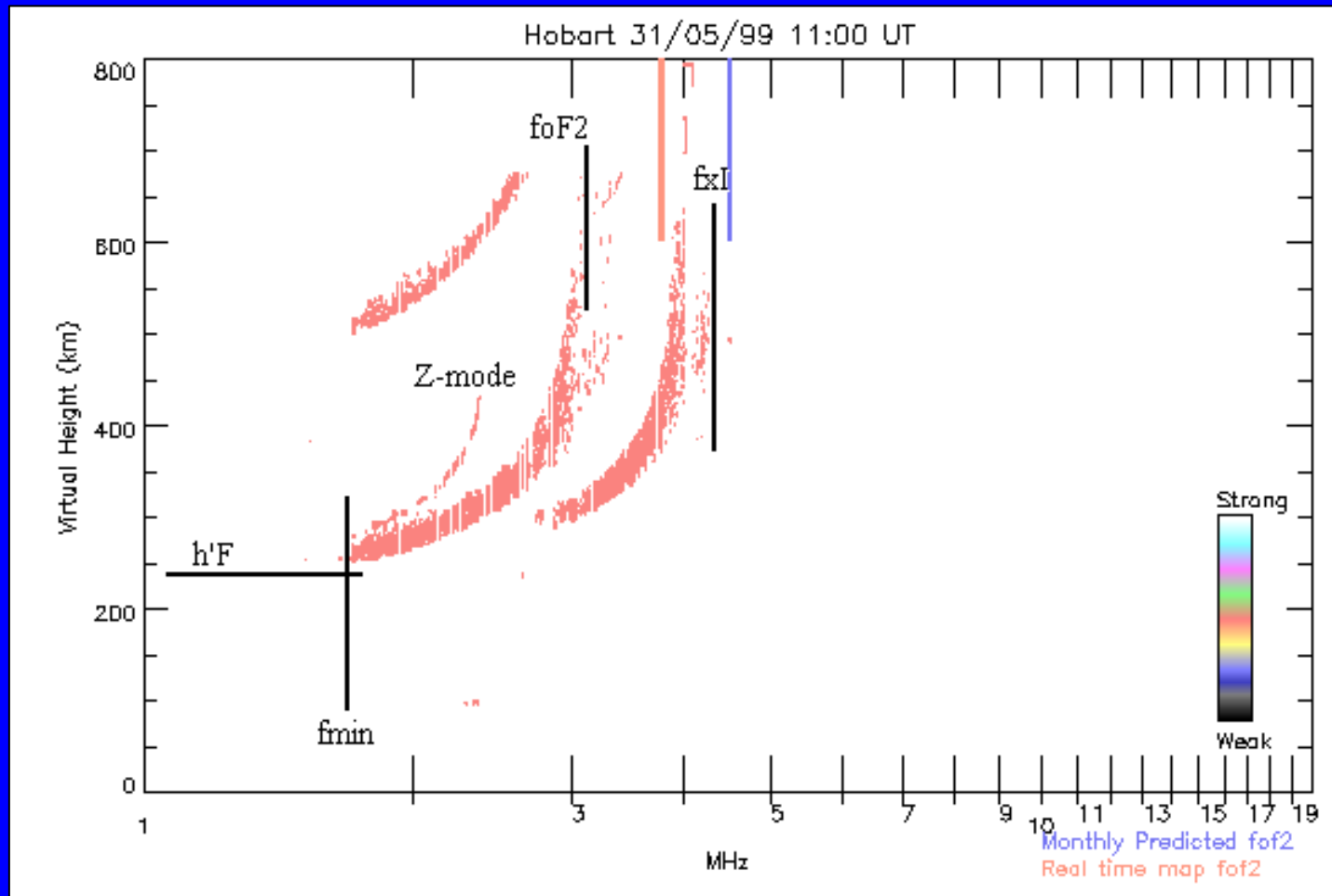
- What can we say?
 - Clear fmin (__ES)
 - no Es parameters
 - foF2
 - Clearly spread F is present, scale inside edge (__ UF)
 - fxl - scale outside edge of trace (could be slightly high here)
 - h'F, extrapolate down, *probably* (__. .)
- Note:
 - multiple is spread less
 - primary appears to be split.
 - Clear gaps in trace due to interference

You ought to be able to scale these better than autoscale did!

Sample Ionograms : nighttime (Hobart 31/05/99 11 UT)



Sample Ionograms : nighttime (Hobart 31/05/99 11:00 UT)

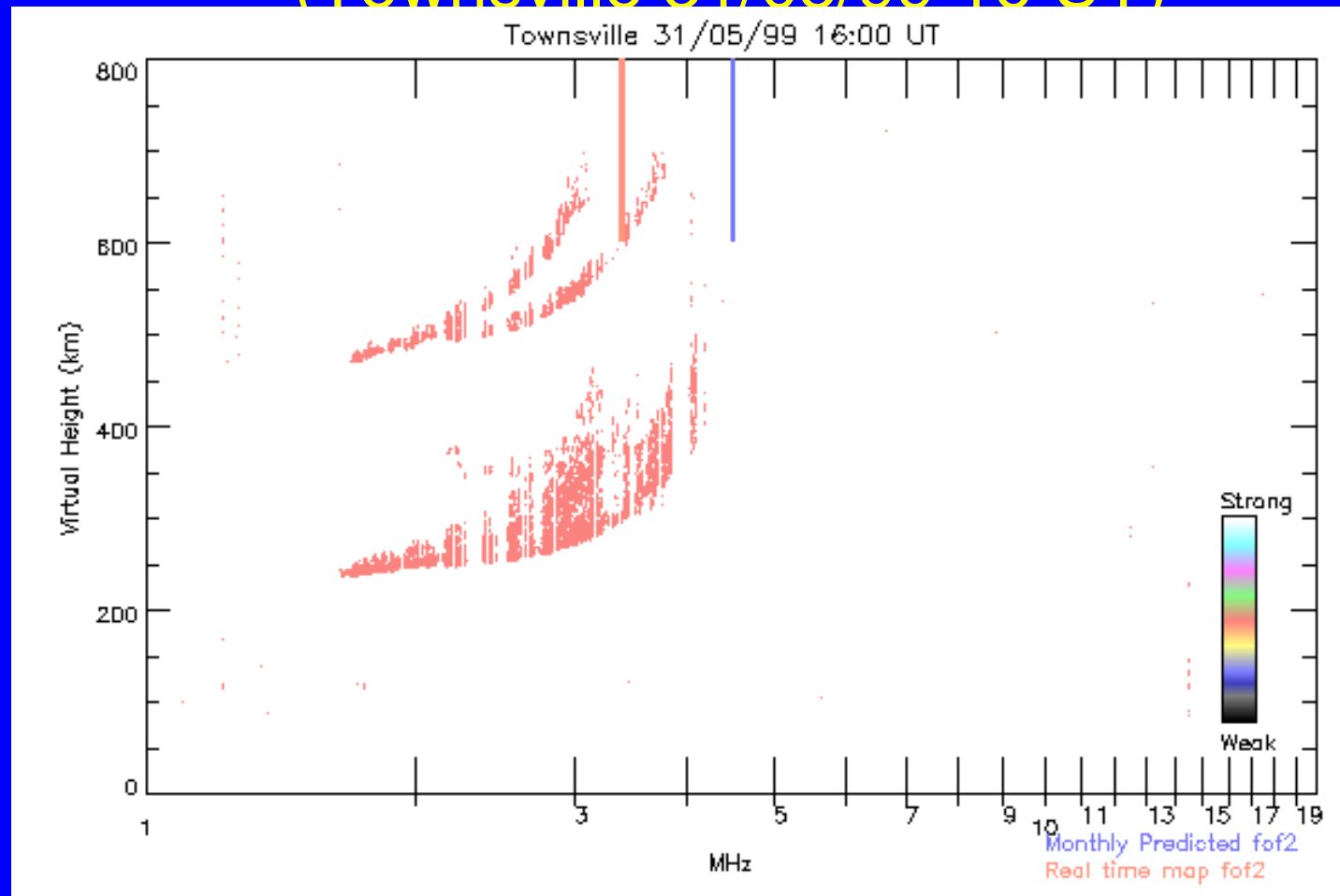


Sample Ionograms : nighttime (Hobart 31/05/99 11 UT)

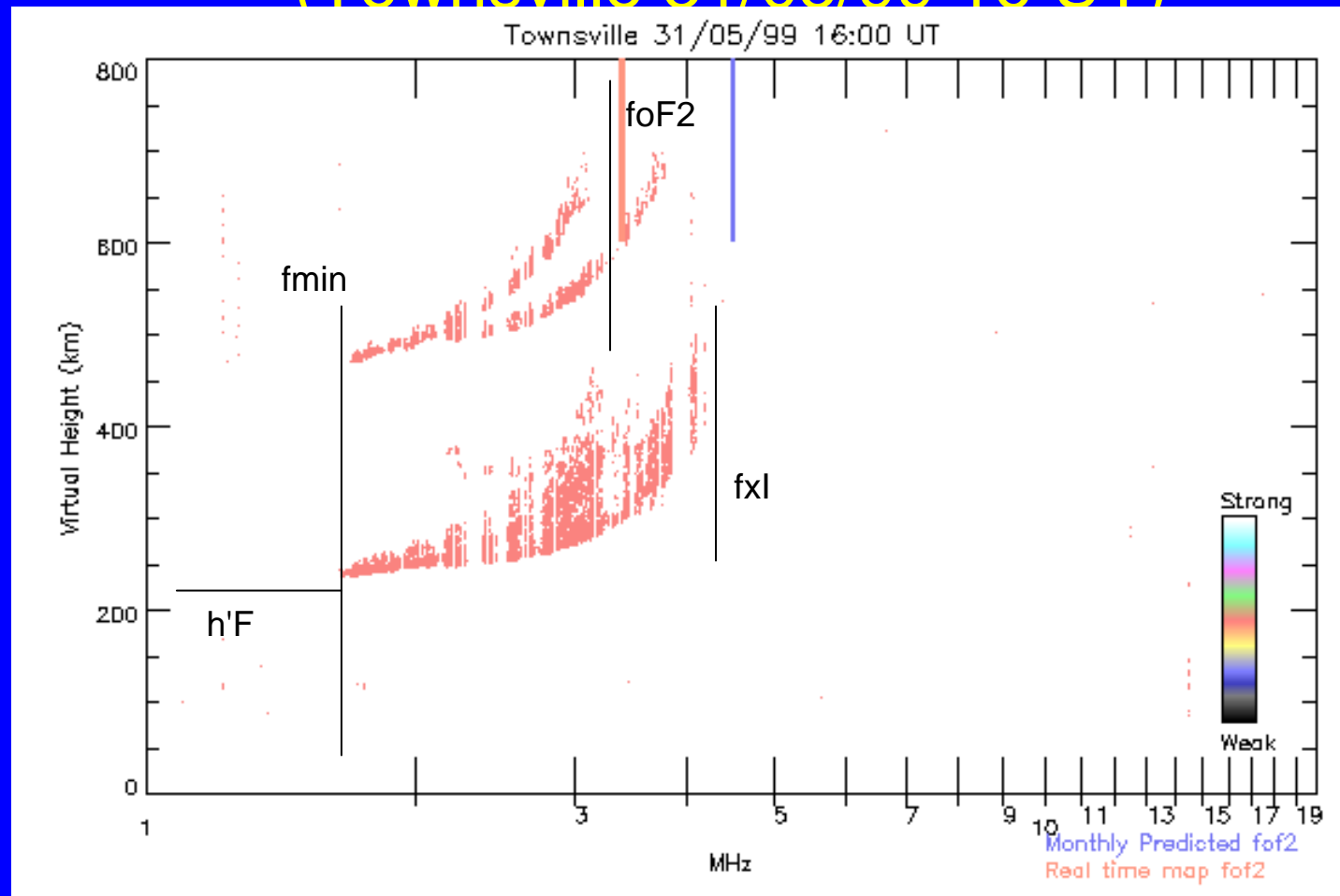
- What can we say?
 - Clear fmin (__ES) (You can get to like fmin)
 - no Es parameters (Phew)
 - foF2
 - Clearly spread F is present, scale inside edge (__ . F)
 - but did you recognise the Z-trace?
 - fxl - scale outside edge of the spread F.
 - h'F, extrapolate down, *maybe* (__US)
- Note:
 - multiple is spread less
 - You can get a good foF2 value from the Z-trace

You ought to be able to scale these better than autoscale did!

Sample Ionograms : nighttime (Townsville 31/05/99 16 UT)



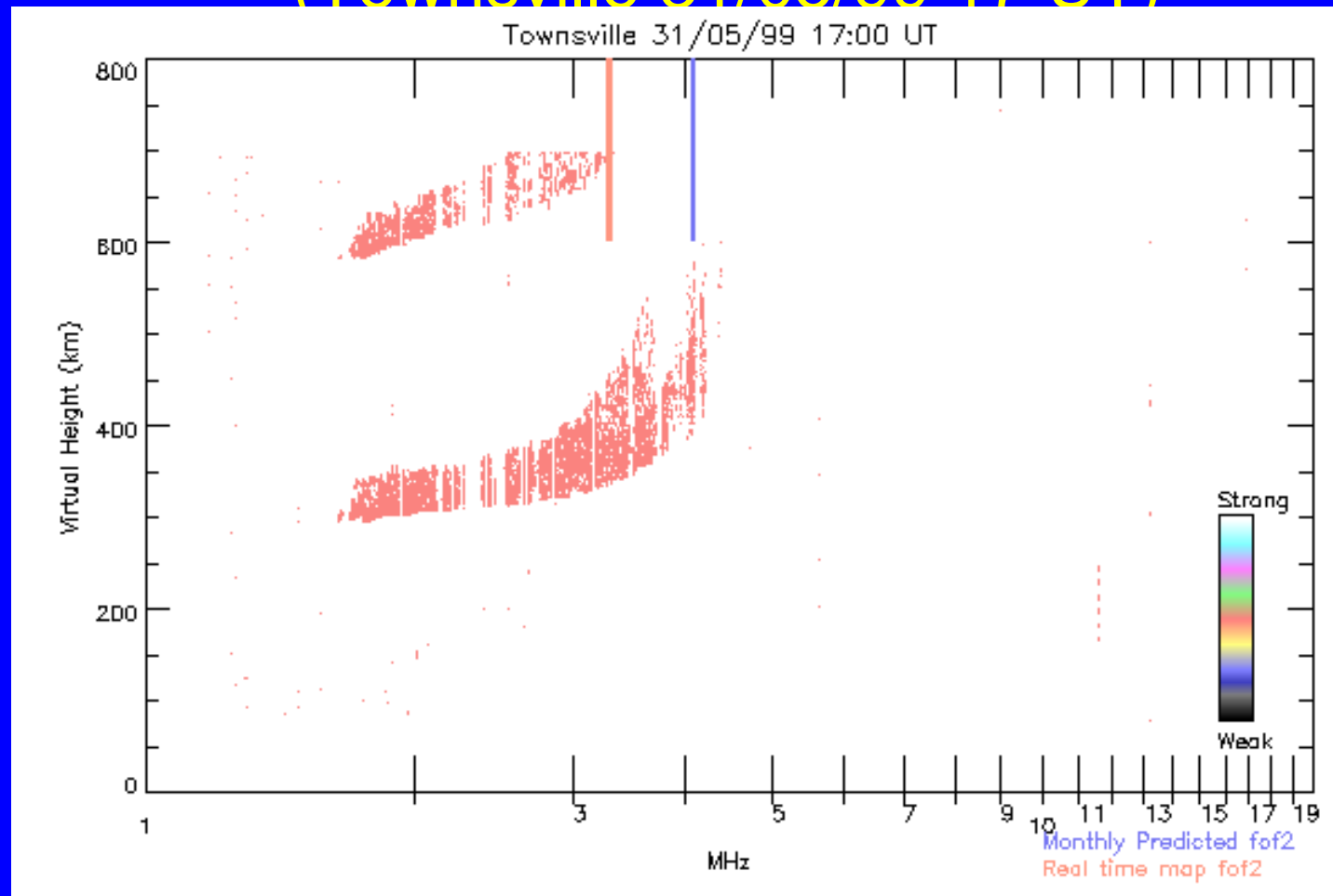
Sample Ionograms : nighttime (Townsville 31/05/99 16:00 UT)



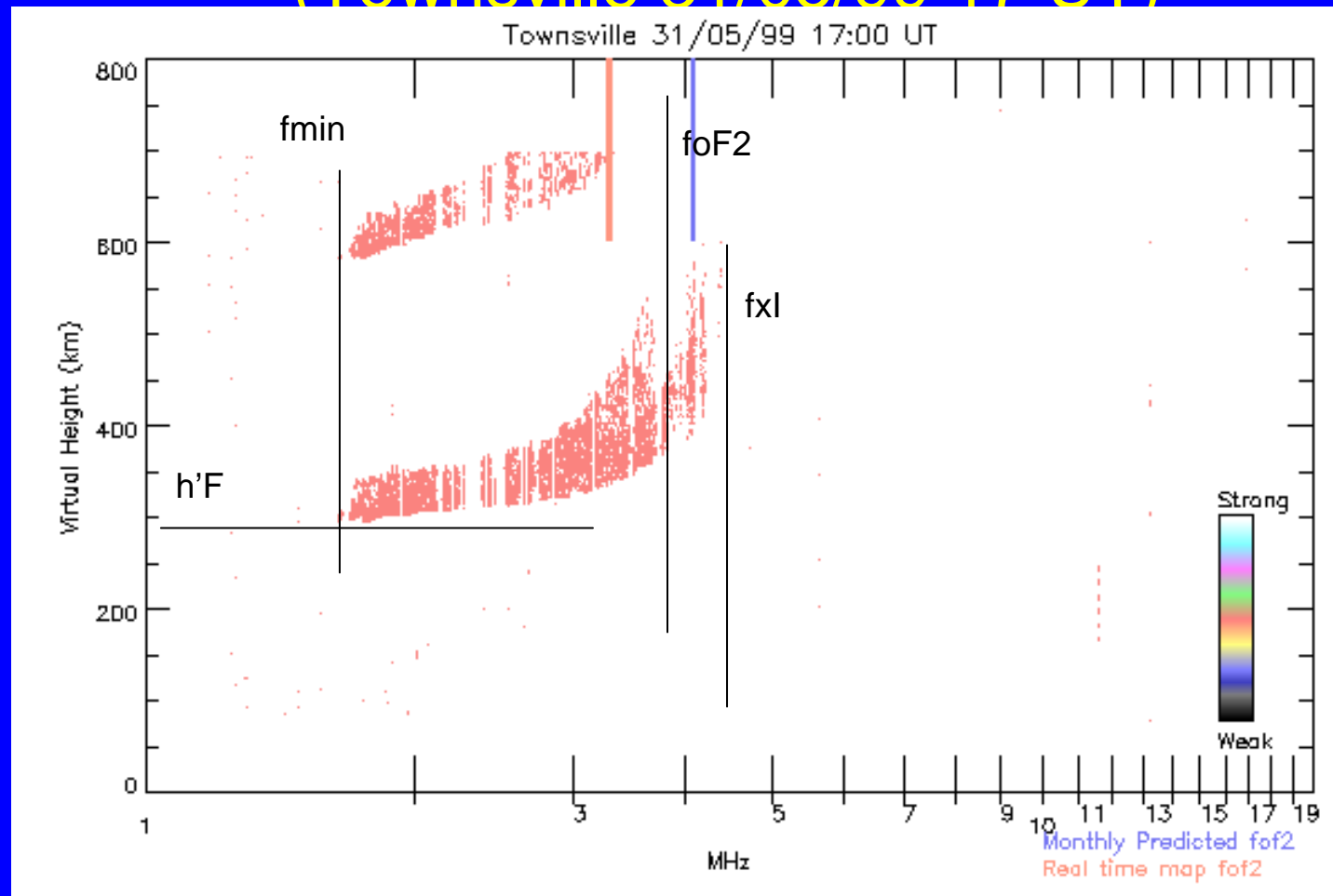
Sample Ionograms : nighttime (Townsville 31/05/99 16 UT)

- What can we say?
 - Clear fmin (__ES)
 - no Es parameters
 - foF2
 - Clearly spread F is present, scale inside edge (__ UF)
 - fxl - scale outside edge (may be __ S)
 - h'F, extrapolate down, *maybe* (__US)
- Note:
 - More spread
 - but multiple gives some guidance
 - multiple has *odd* shape

Sample Ionograms : nighttime (Townsville 31/05/99 17 UT)



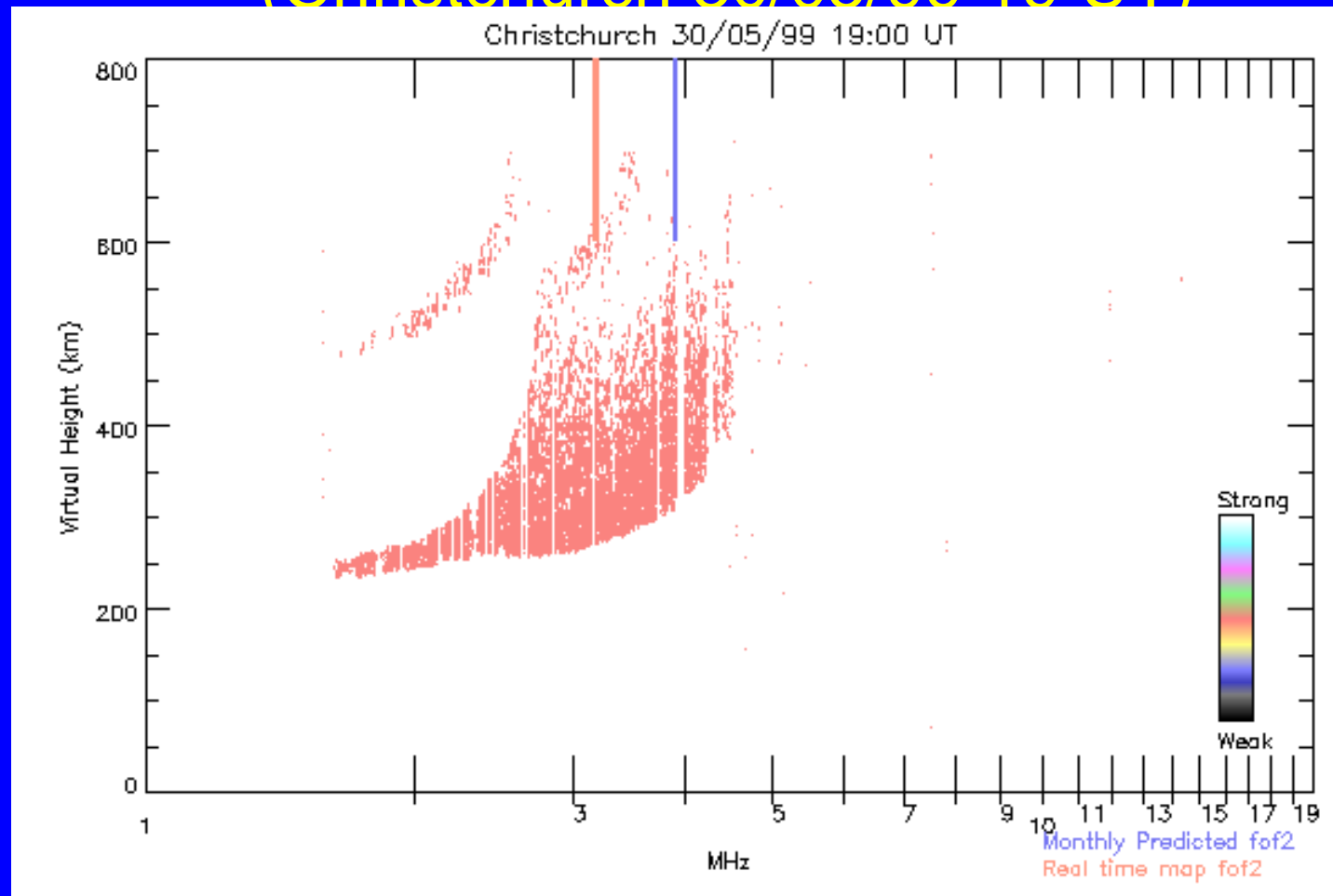
Sample Ionograms : nighttime (Townsville 31/05/99 17 UT)



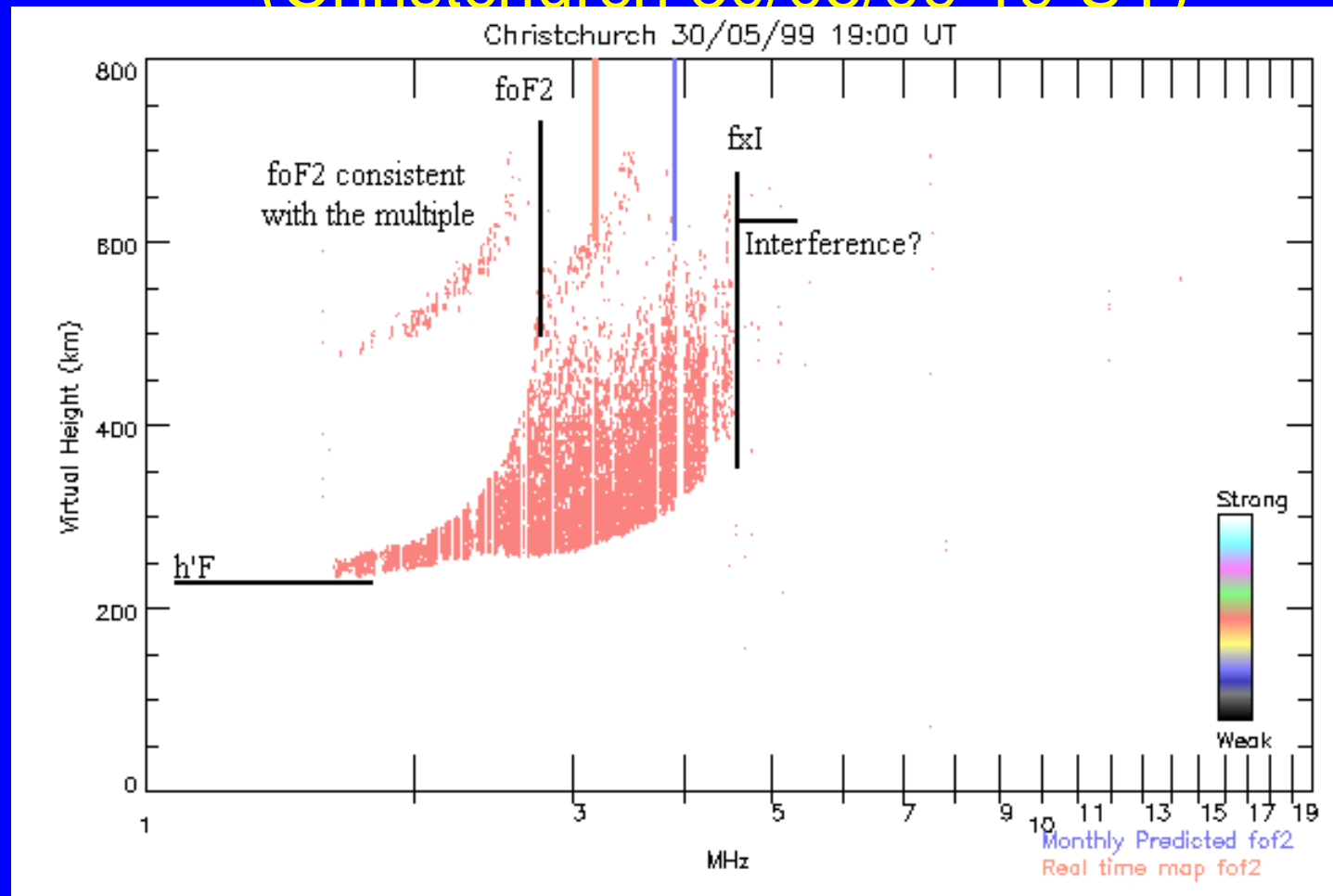
Sample Ionograms : nighttime (Townsville 31/05/99 17 UT)

- What can we say?
 - Clear fmin (__ES)
 - no Es parameters
 - foF2
 - Clearly spread F is present, scale inside edge (__ UF) or worse
 - fxl - scale outside edge
 - h'F, extrapolate down, *maybe* (__ . Q) (for range spread)
- Note:
 - multiple is not much help
 - traces are now rather broad
 - interference evident

Sample Ionograms : nighttime (Christchurch 30/05/99 19 UT)



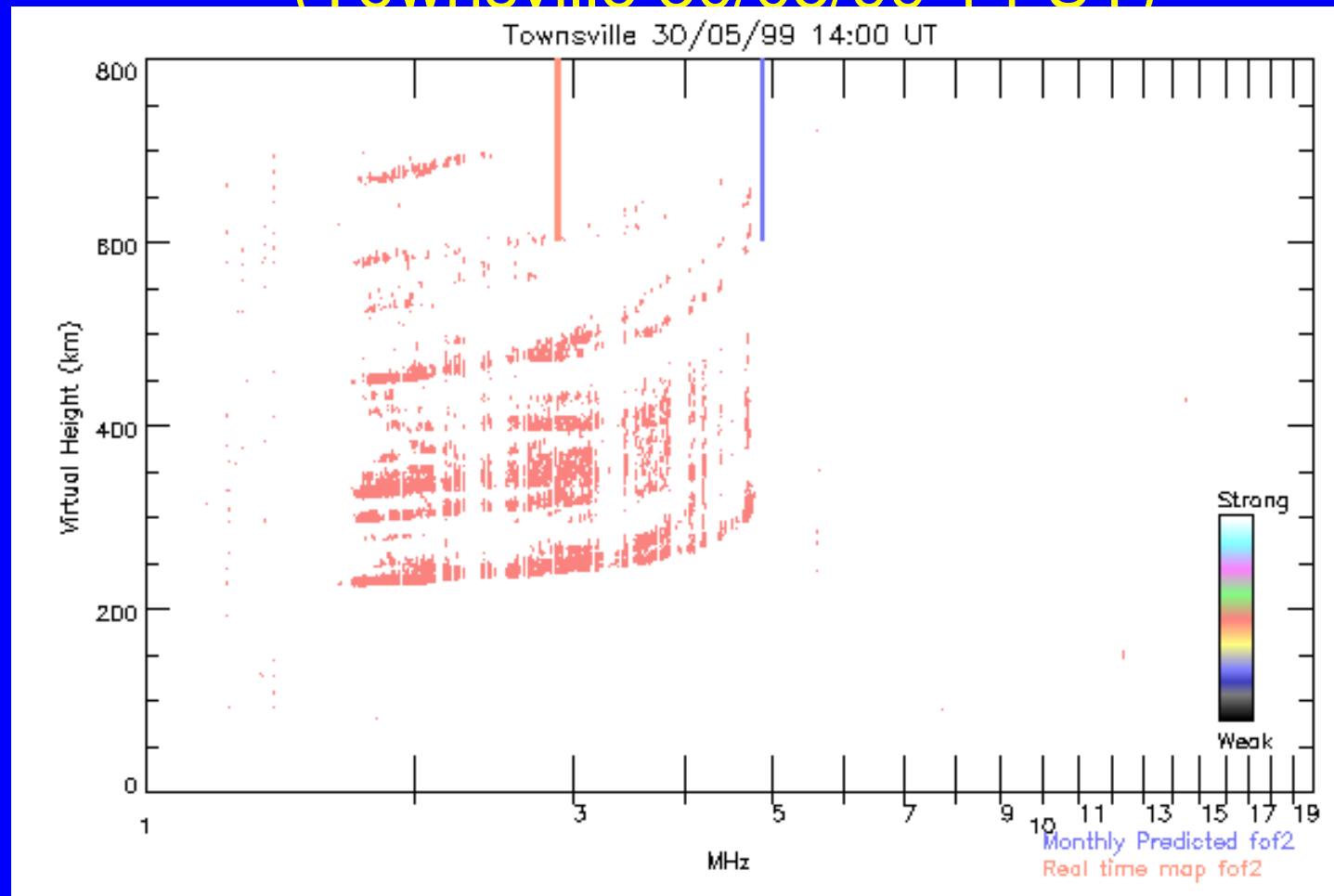
Sample Ionograms : nighttime (Christchurch 30/05/99 19 UT)



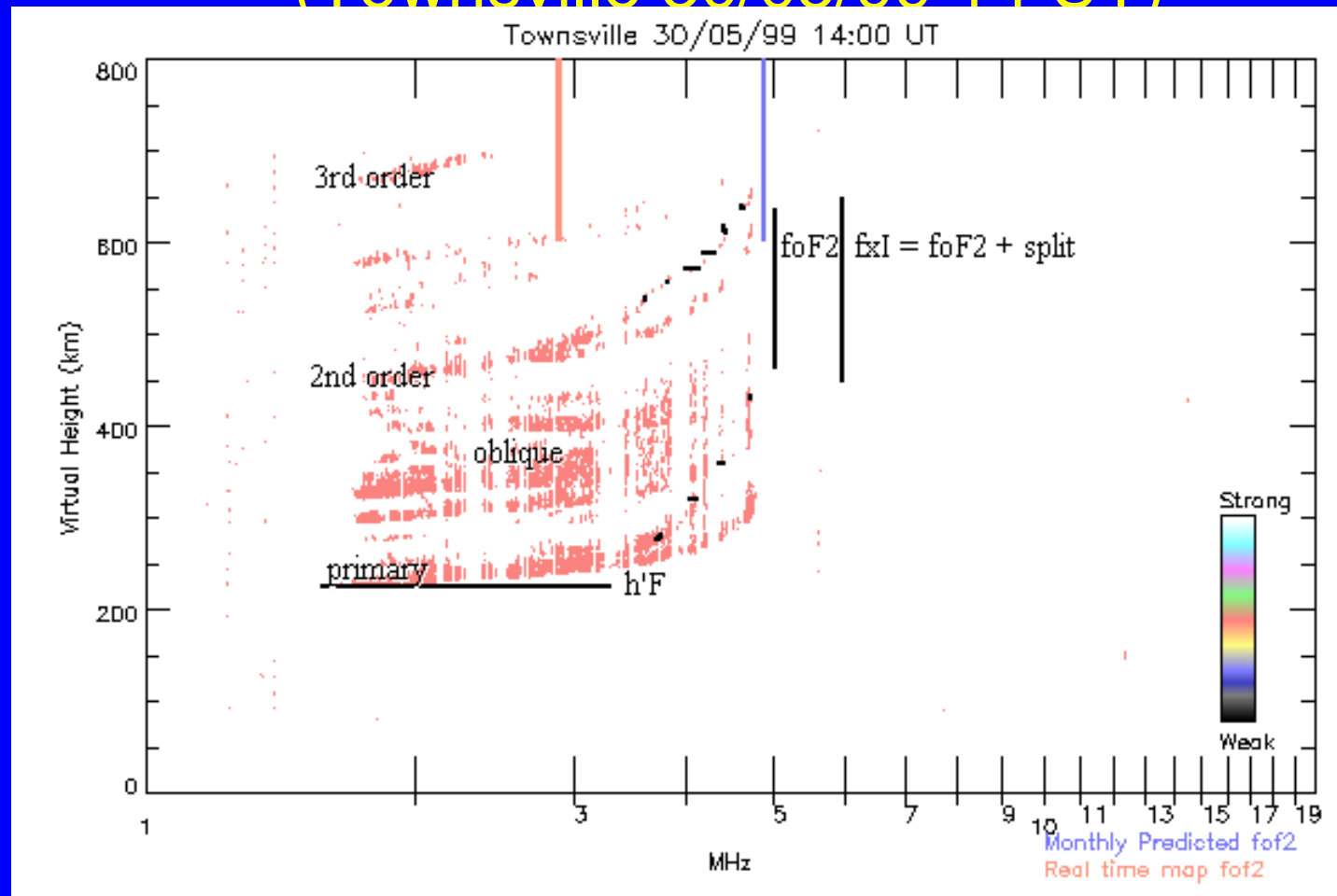
Sample Ionograms : nighttime (Christchurch 30/05/99 19 UT)

- Well developed mid latitude spread F
- What is f_{xl}
 - possibly interference obscures part of the trace, (___ US)
 - Note X-multiple

Sample Ionograms : nighttime (Townsville 30/05/99 14 UT)



Sample Ionograms : nighttime (Townsville 30/05/99 14:00 UT)



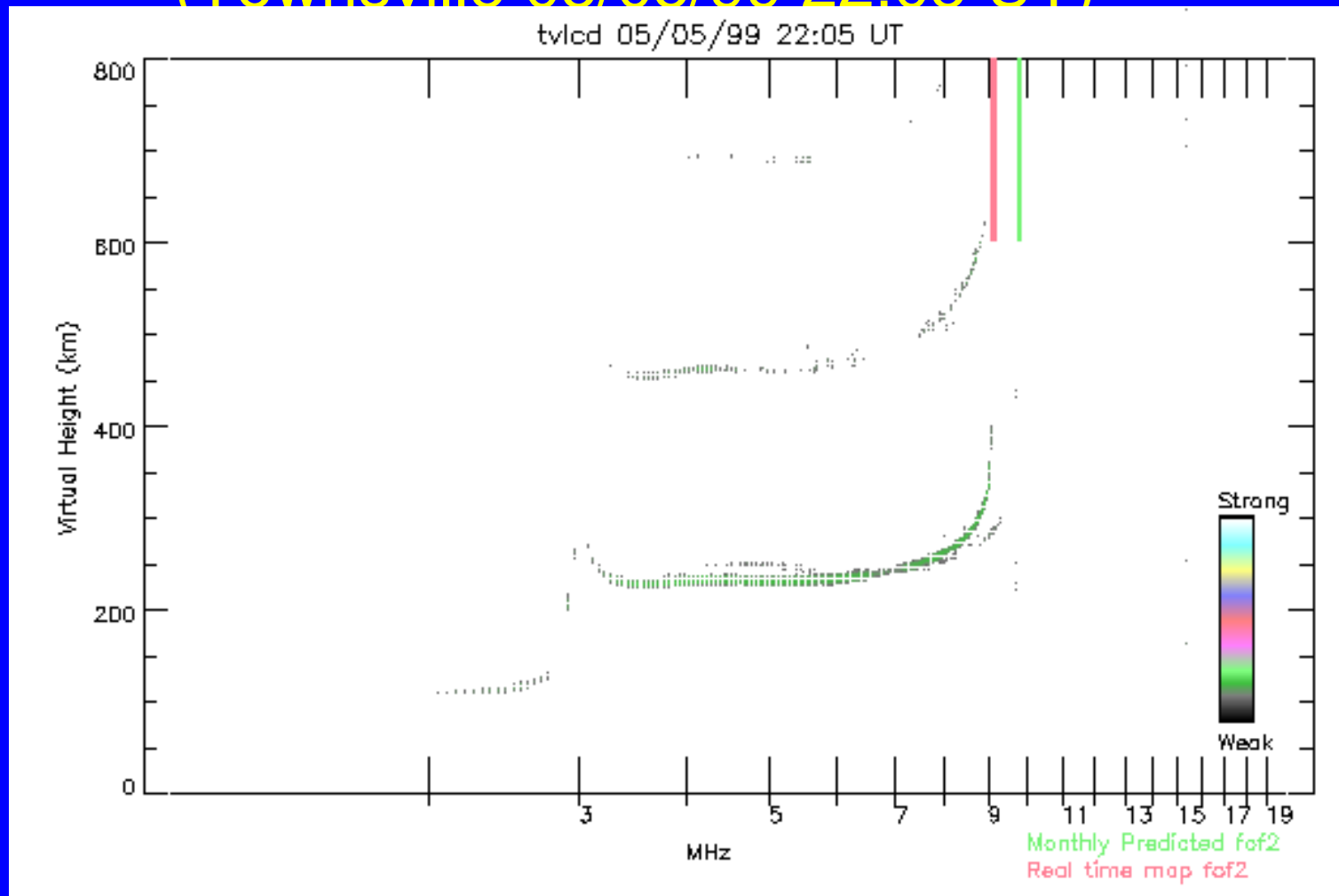
Sample Ionograms : nighttime (Townsville 30/05/99 14 UT)

- What can we say?
 - Clear fmin (__ES)
 - no Es parameters
 - foF2
 - Looks awful? Look at multiple, back to primary, and foF2 is clear, and probably not spread.
 - fxl - scale outside edge. Probably (__ U S).
 - h'F, extrapolate down, *probably* (__ . Q) (for range spread)
- Note:
 - (the black dash/dots were my attempt to identify the main trace)
 - multiple, once identified, is valuable
 - many traces are now present, confusing the ionogram
 - interference very evident (it can get worse)

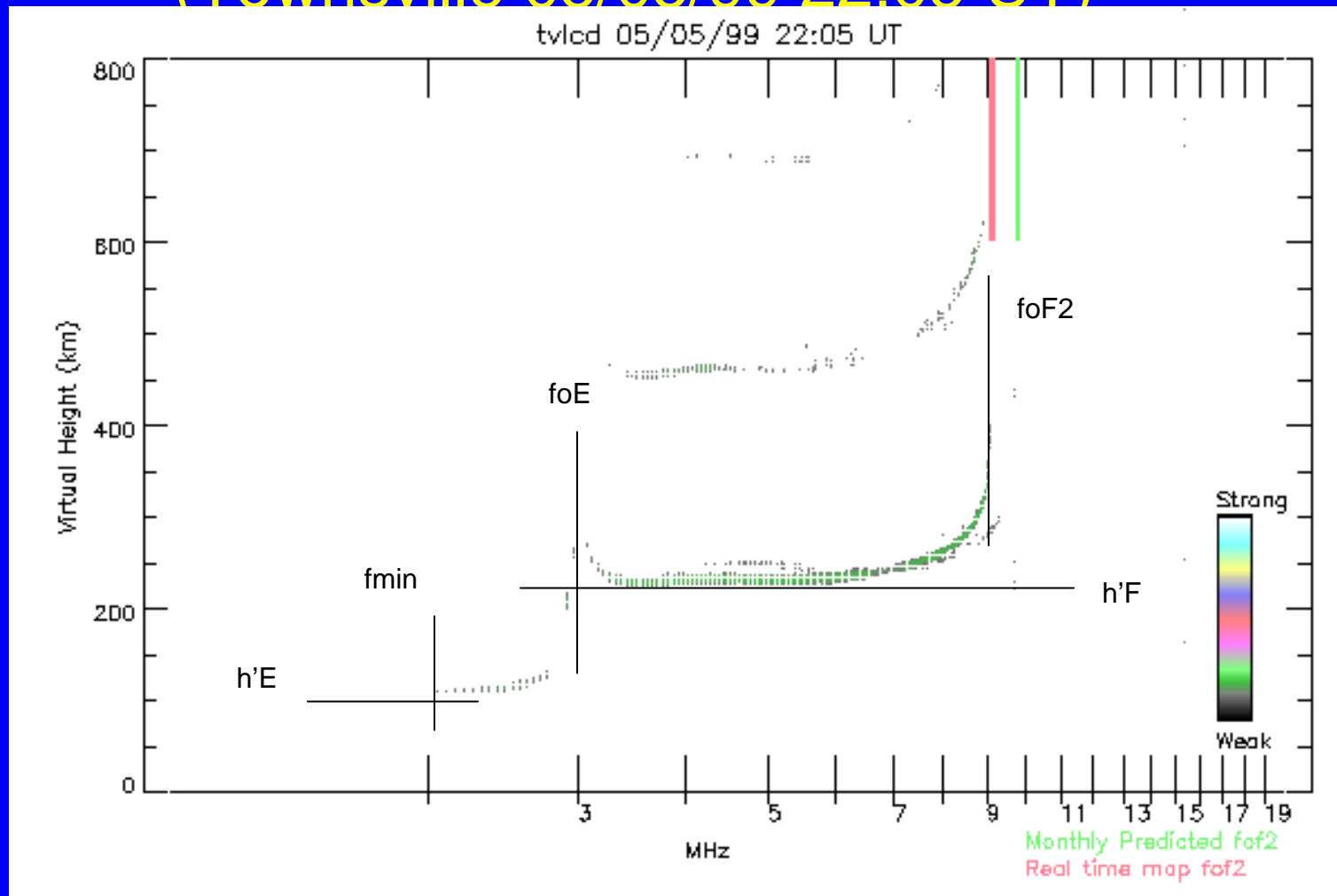
And now for something
completely different

Daytime

Sample Ionograms : daytime (Townsville 05/05/99 22:05 UT)



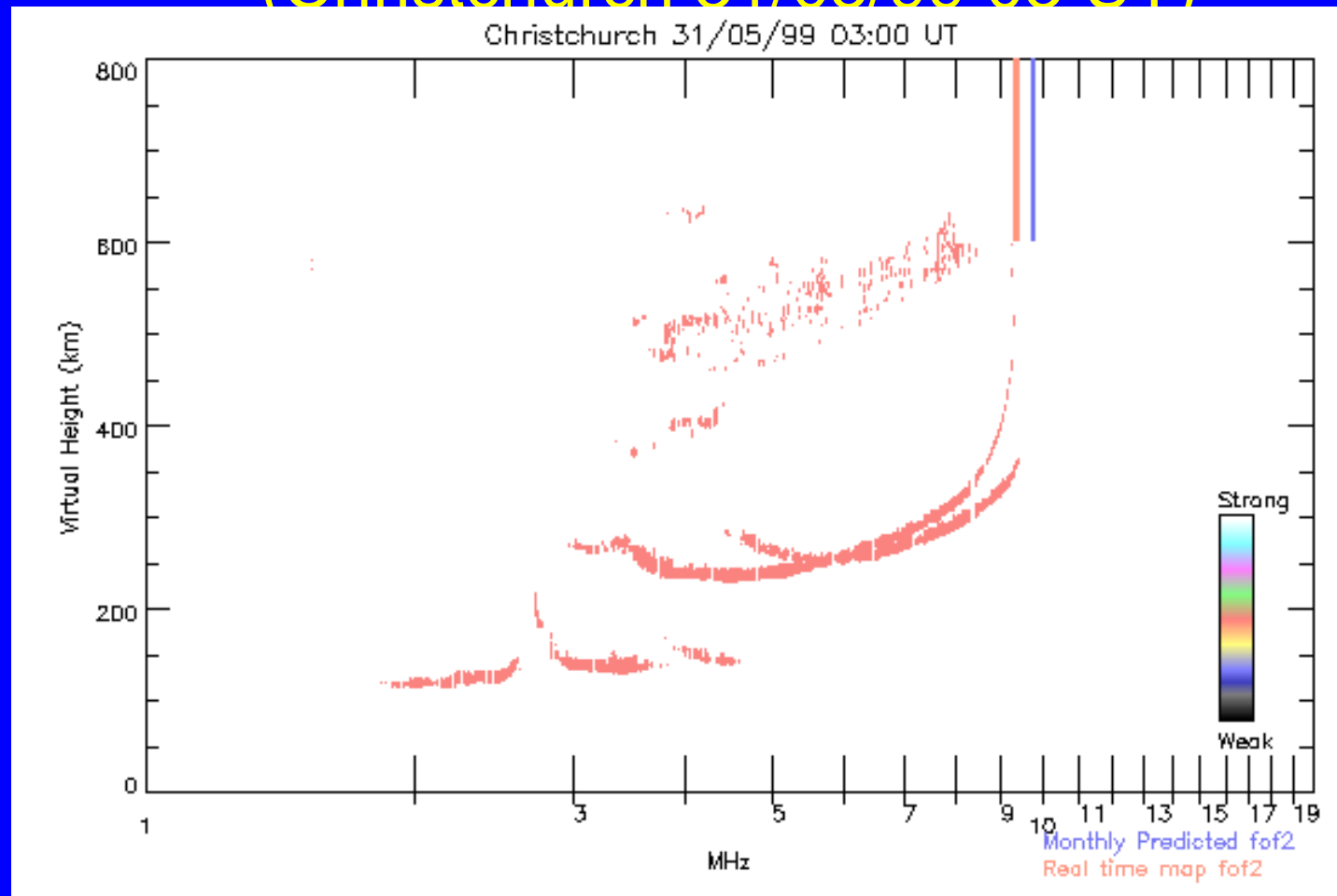
Sample Ionograms : daytime (Townsville 05/05/99 22:05 UT)



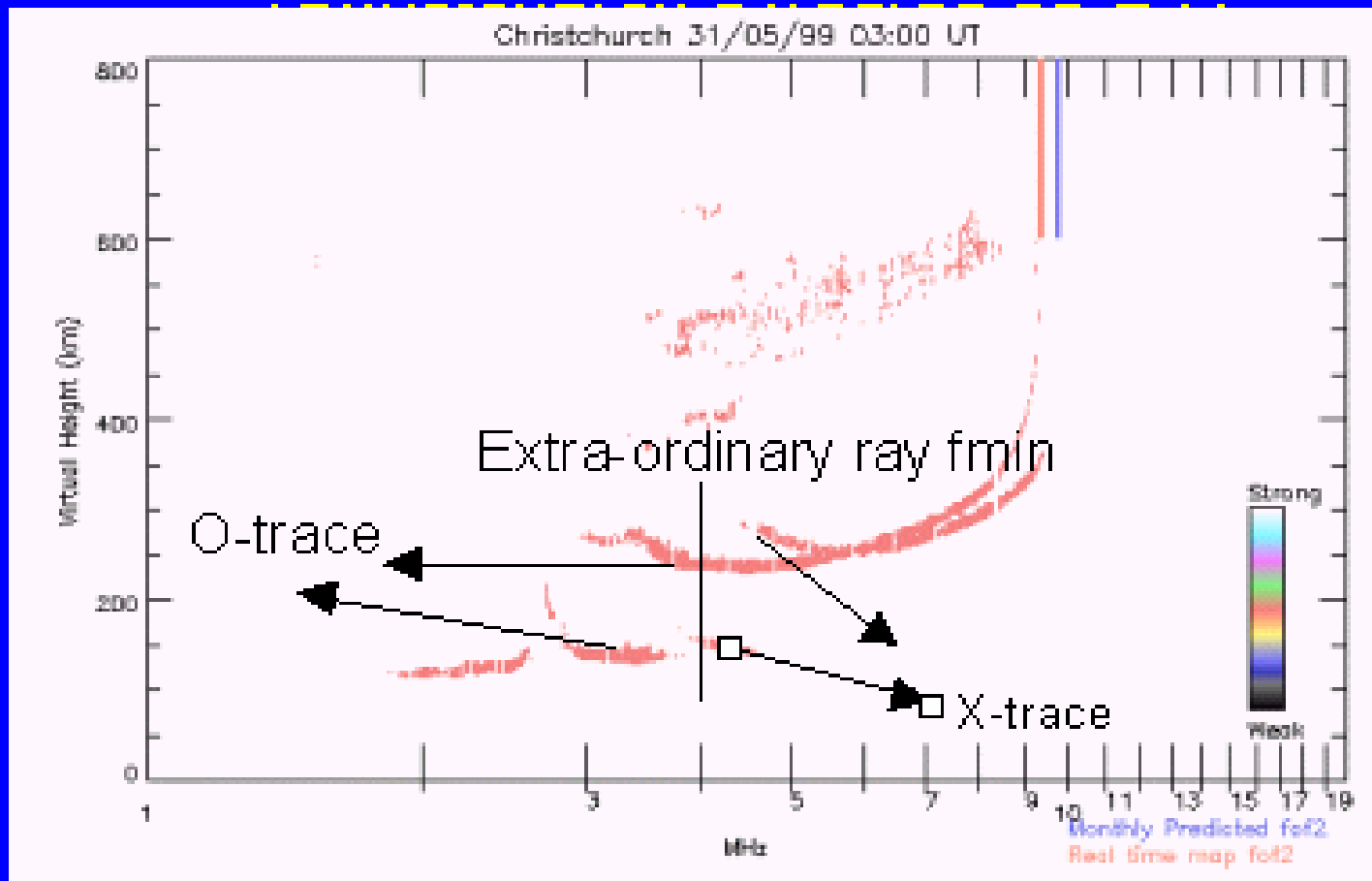
Sample Ionograms : daytime (Townsville 05/05/99 22:05 UT)

- What can we say?
 - Clear fmin (___) (with no scaling letters)
 - good foE value
 - foF2: good value
 - h'F okay
- Note:
 - This is a good daytime ionogram to scale
 - Traces “seem” thinner, less strongly defined. Partly, a different ionosonde.

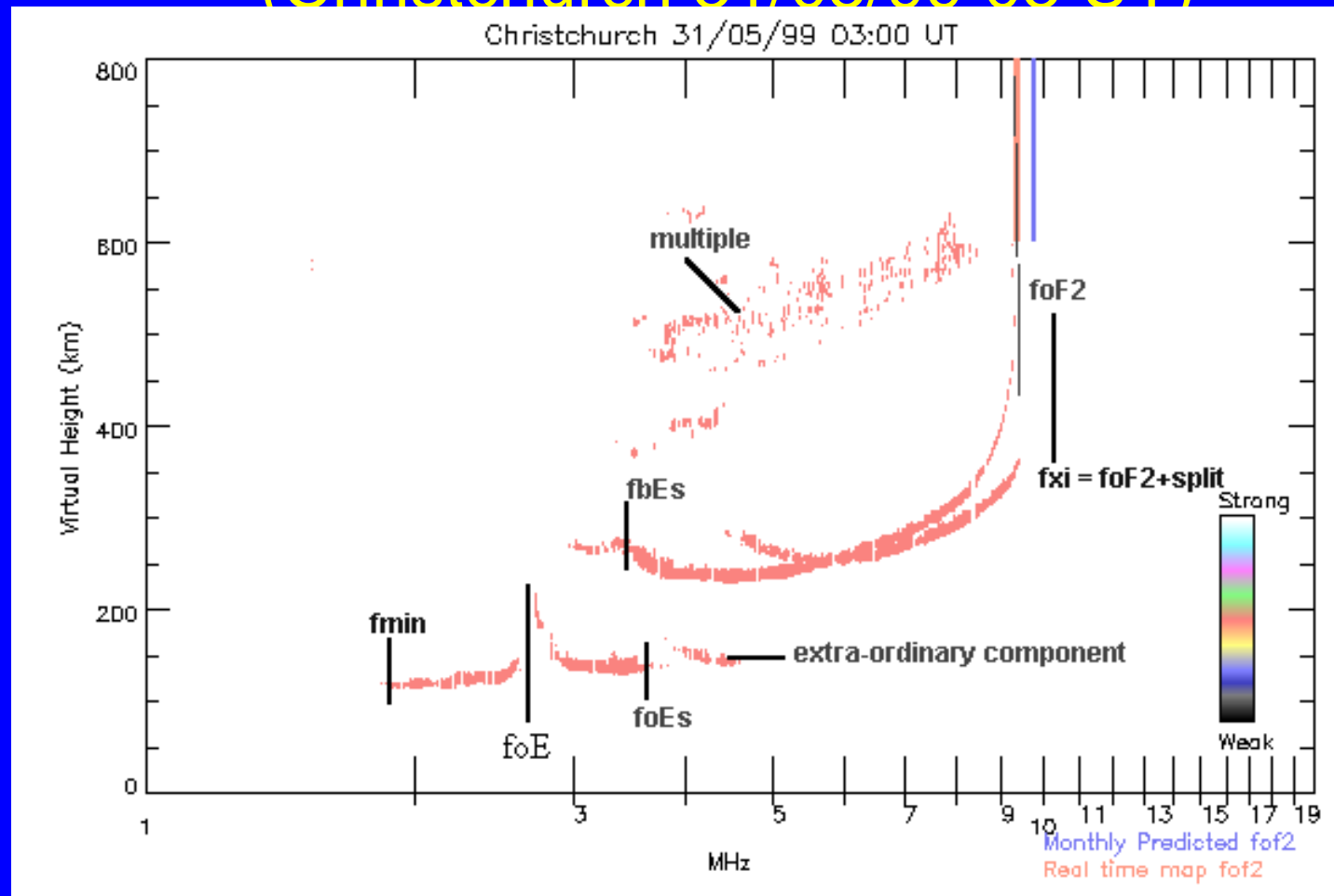
Sample Ionograms : daytime (Christchurch 31/05/99 03 UT)



Sample Ionograms : daytime (Christchurch 31/05/99 03 UT)



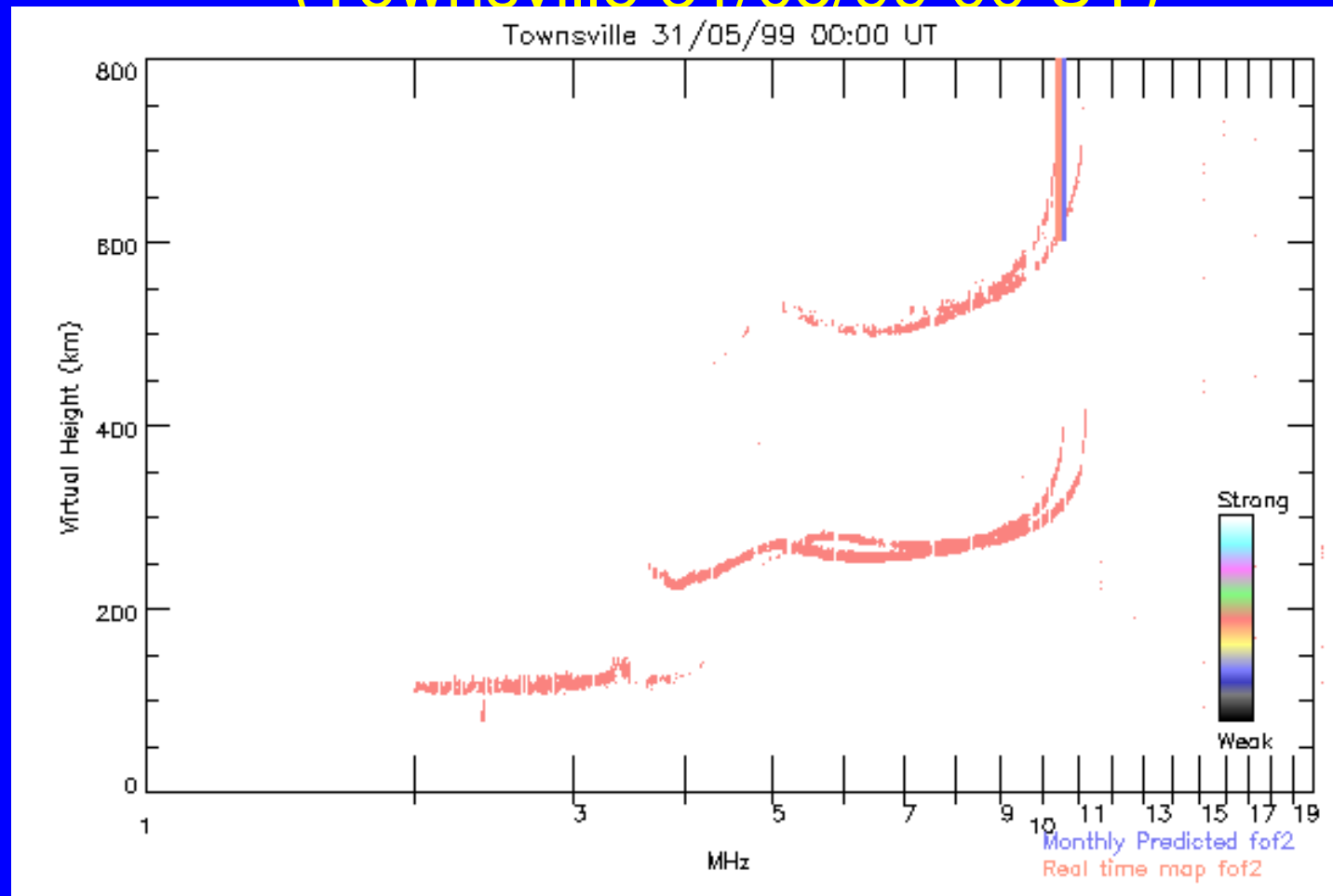
Sample Ionograms : daytime (Christchurch 31/05/99 03:00 UT)



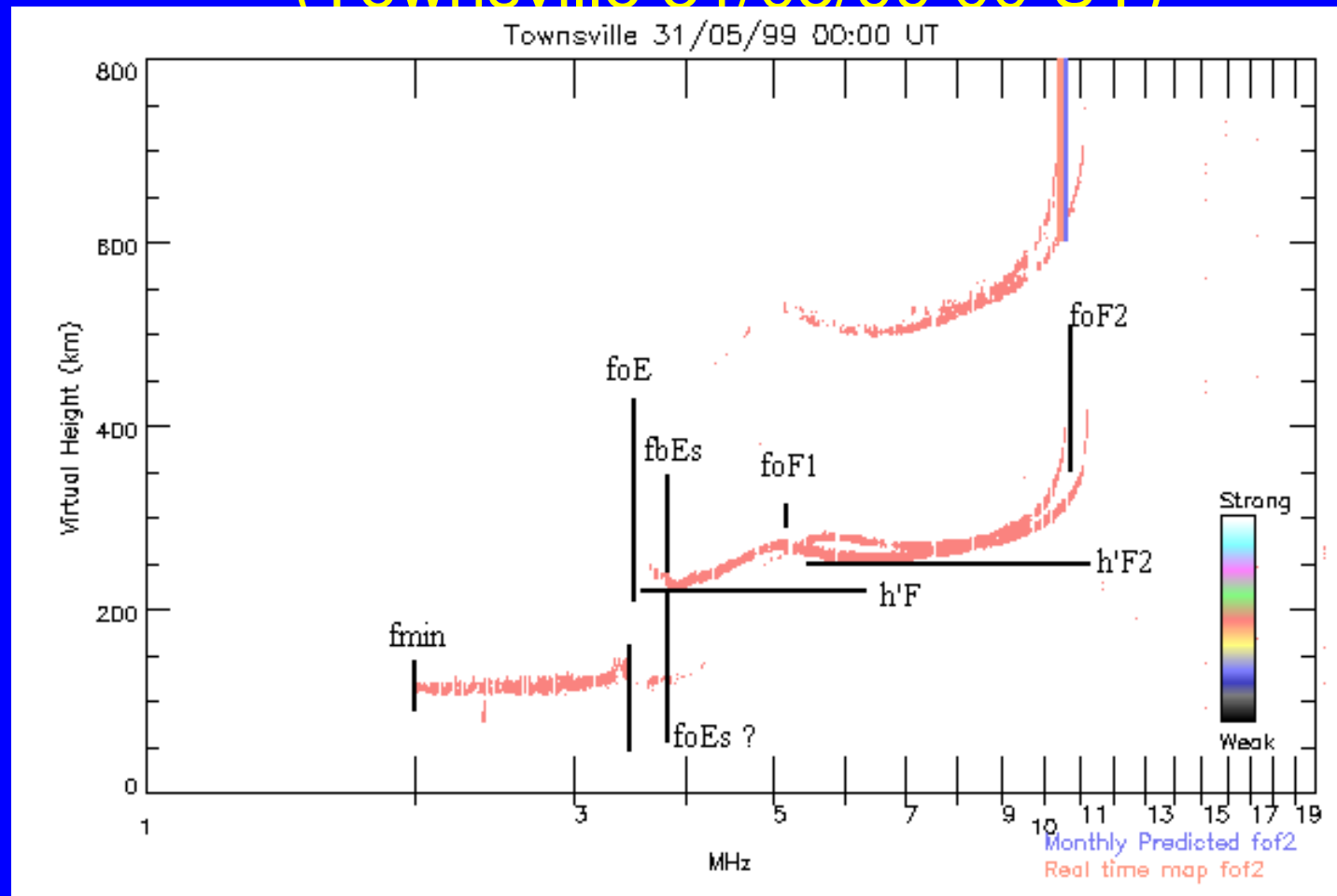
Sample Ionograms : daytime (Christchurch 31/05/99 03 UT)

- What can we say?
 - Clear fmin (___) (with no scaling letters) (bit high here)
 - Sporadic E is present
 - foEs: descending layer, multiple present, extra-ordinary present
 - fbEs: tip of F region present
 - foF2: good value
 - h'F or h'F2 (need to know where to expect foF1)
- Note:
 - This is a good daytime ionogram to scale
 - disturbed multiple
 - how many sporadic E layers are present?

Sample Ionograms : daytime (Townsville 31/05/99 00:00 UT)



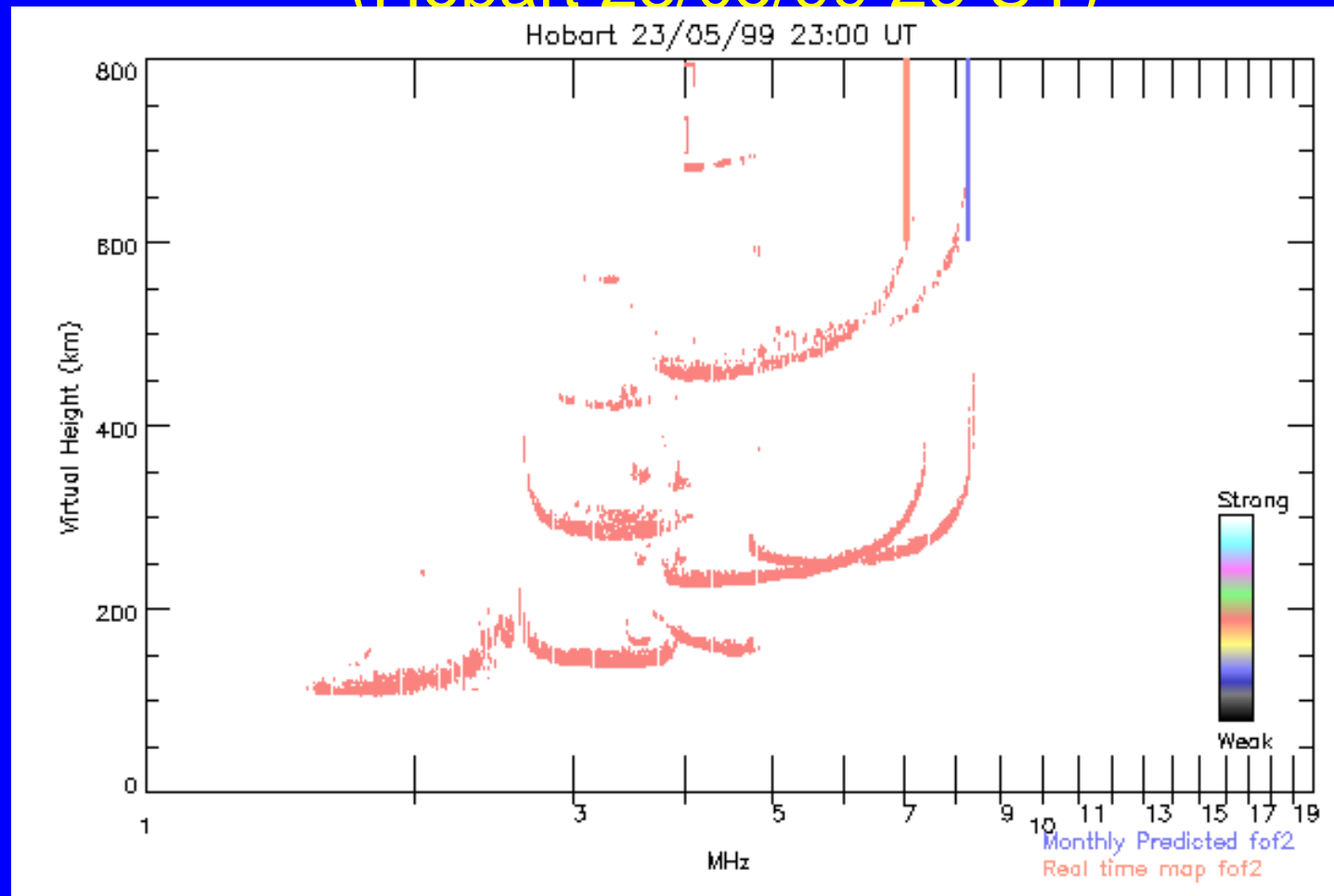
Sample Ionograms : daytime (Townsville 31/05/99 00 UT)



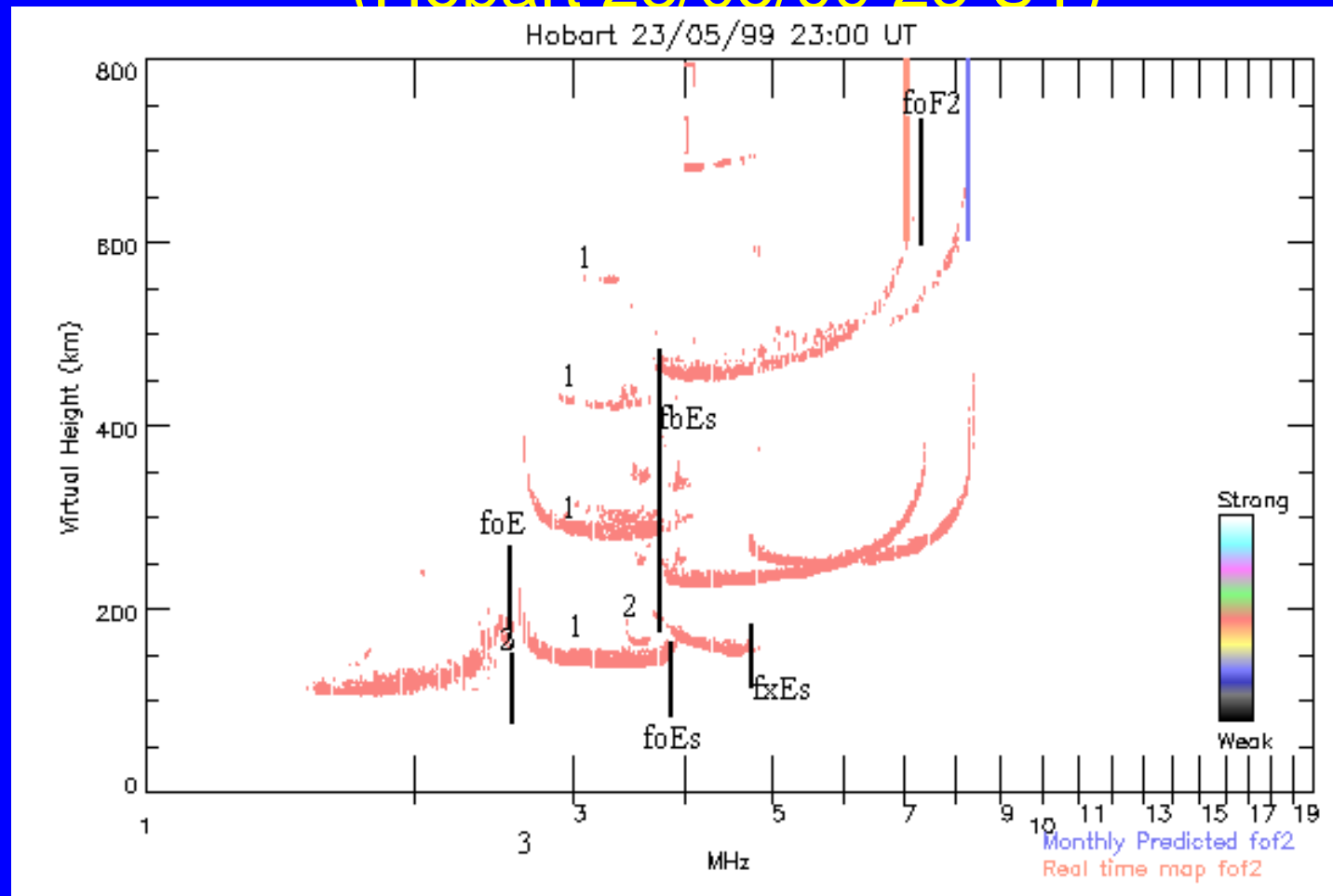
Sample Ionograms : daytime (Townsville 31/05/99 00 UT)

- What can we say?
 - Clear fmin (___) (with no scaling letters)
 - Sporadic E parameters are awkward
 - probably some X component present
 - a weak trace, and may depend on sequence
 - foF2: good value
 - h'F2 okay, h'F possibly disturbed
 - foE: scaled too low here.
- Note:
 - sporadic E gives problems
 - This is a typical daytime ionogram, just a little awkward

Sample Ionograms : daytime (Hobart 23/05/99 23:00 UT)



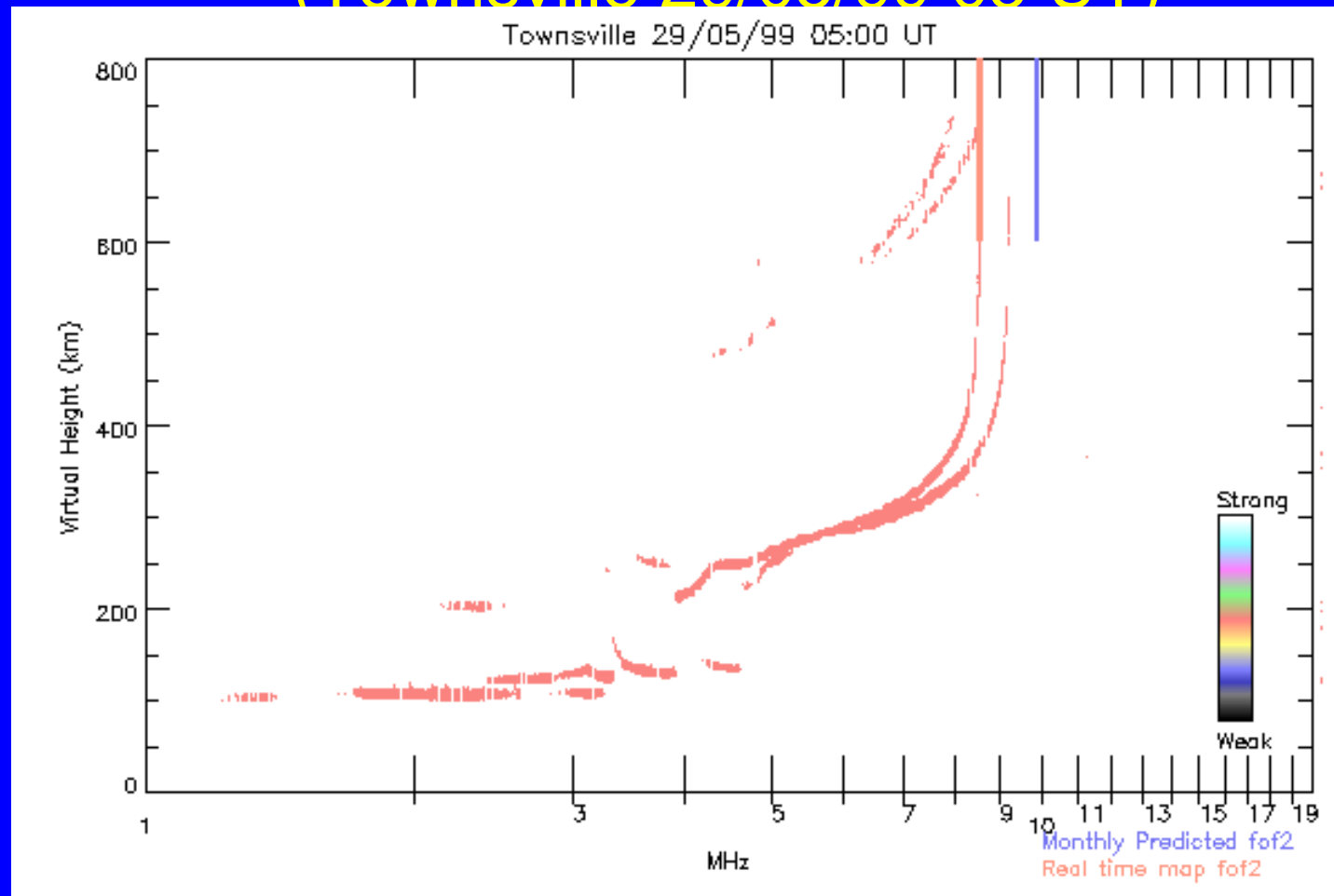
Sample Ionograms : daytime (Hobart 23/05/99 23 UT)



Sample Ionograms : daytime (Hobart 23/05/99 23 UT)

- Clear descending Es layer (but check sequence anyway)
- Another Es layers is also present
- This is a useful example of several multiples.
 - Decide which are multiples of which
 - scale the primary characteristics
- Note the possibly second Es layer
 - ordinary component is hard to detect
 - but extra ordinary is clear

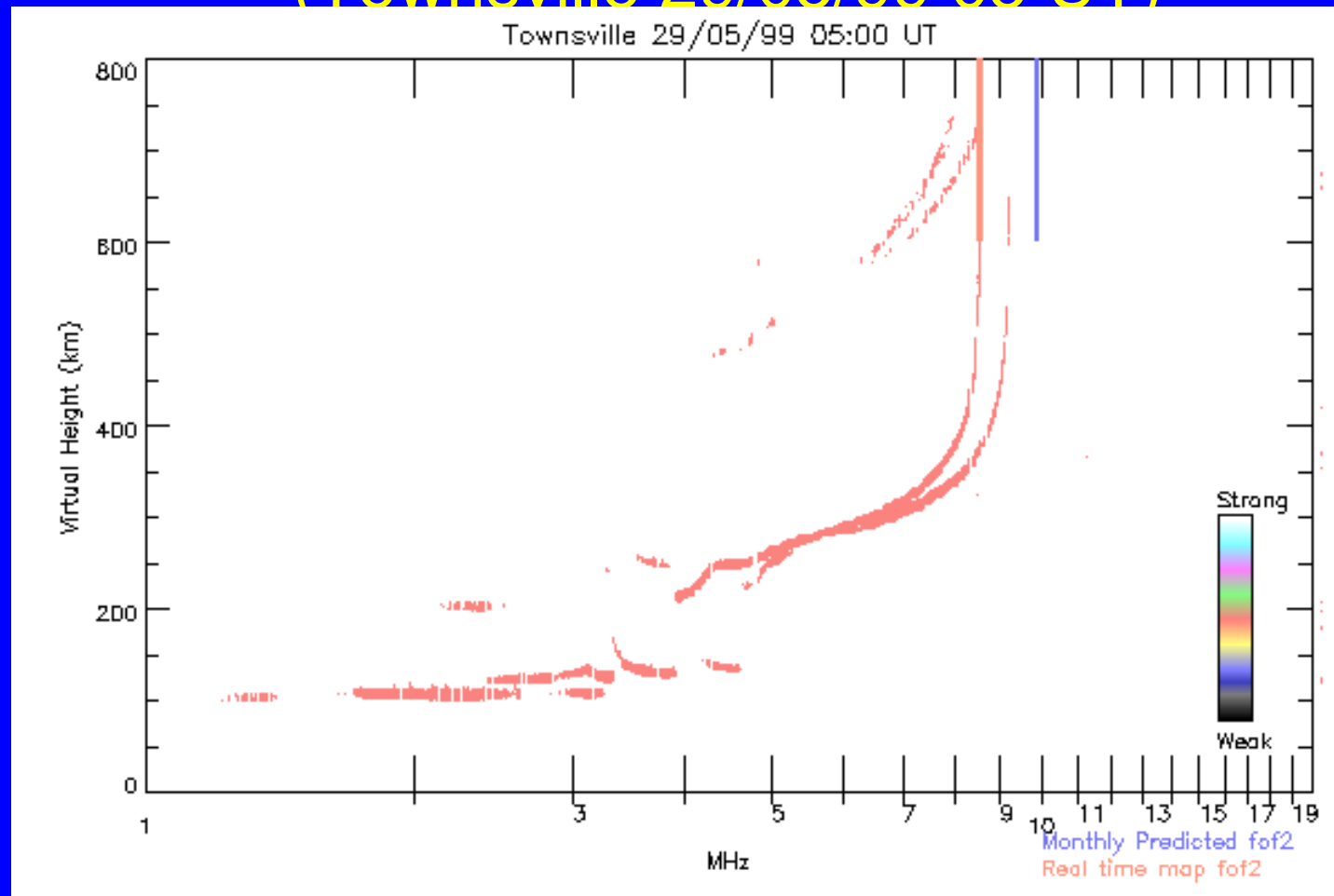
Sample Ionograms : daytime (Townsville 29/05/99 05:00 UT)



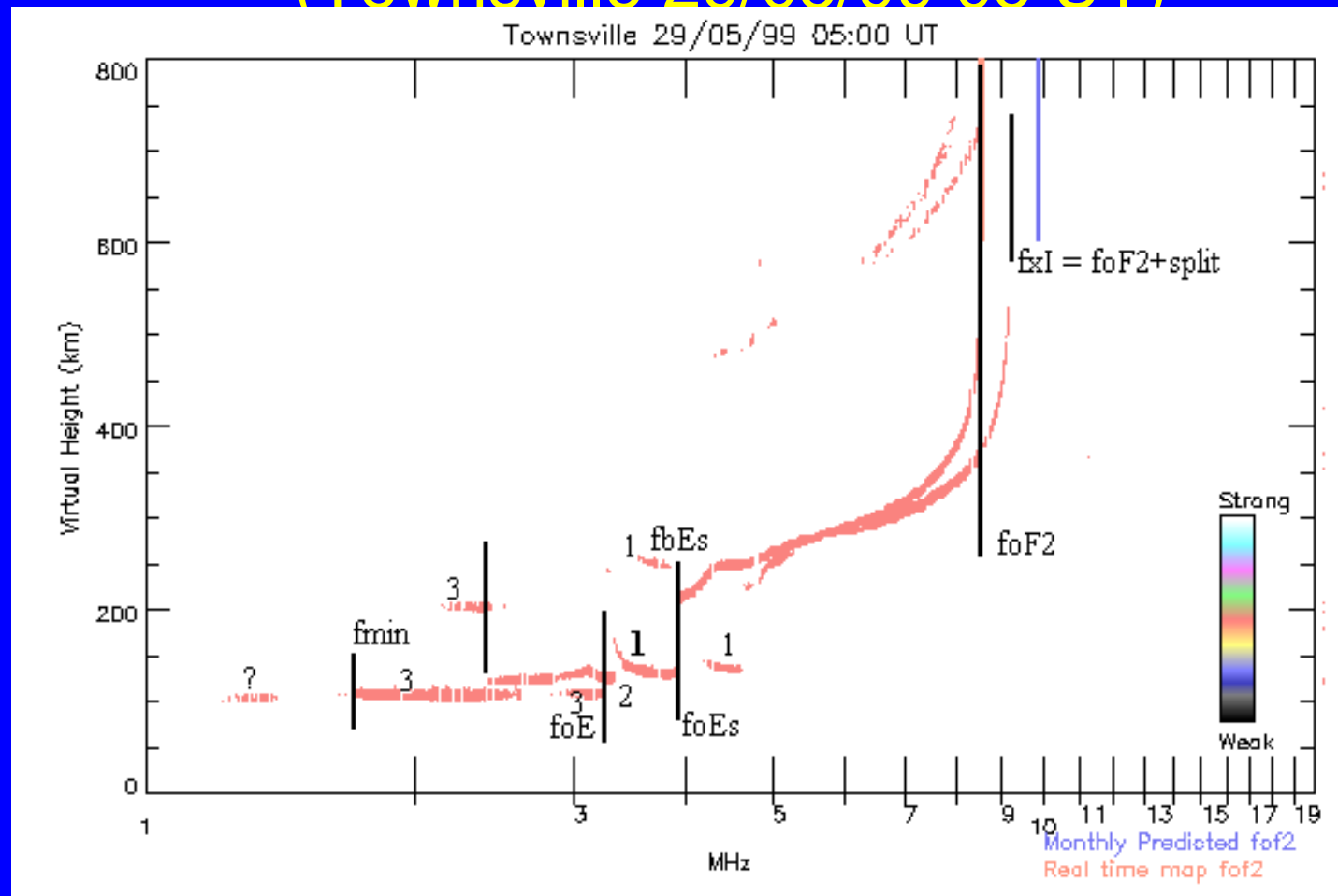
Sample Ionograms : daytime (Townsville 29/05/99 05 UT)

- Fmin? Weak trace rule
- foF2: easy, autoscale agrees
- h'F2: poorly formed F1, none there
- h'F: (___ U A) or (___ UH) or (___) ??
- foEs ? How many Es traces and which
- foE?

Sample Ionograms : daytime (Townsville 29/05/99 05:00 UT)



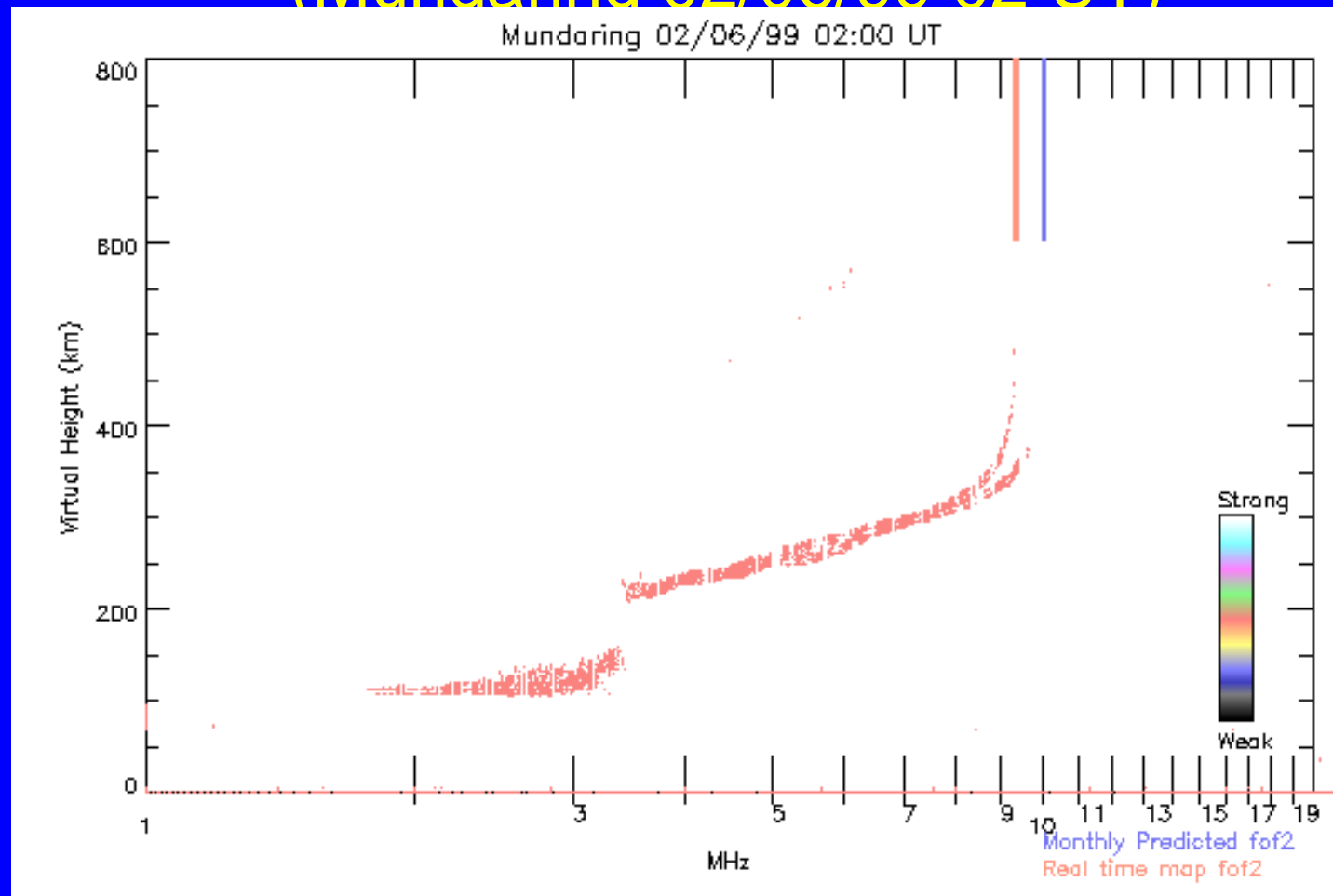
Sample Ionograms : daytime (Townsville 29/05/99 05:00 UT)



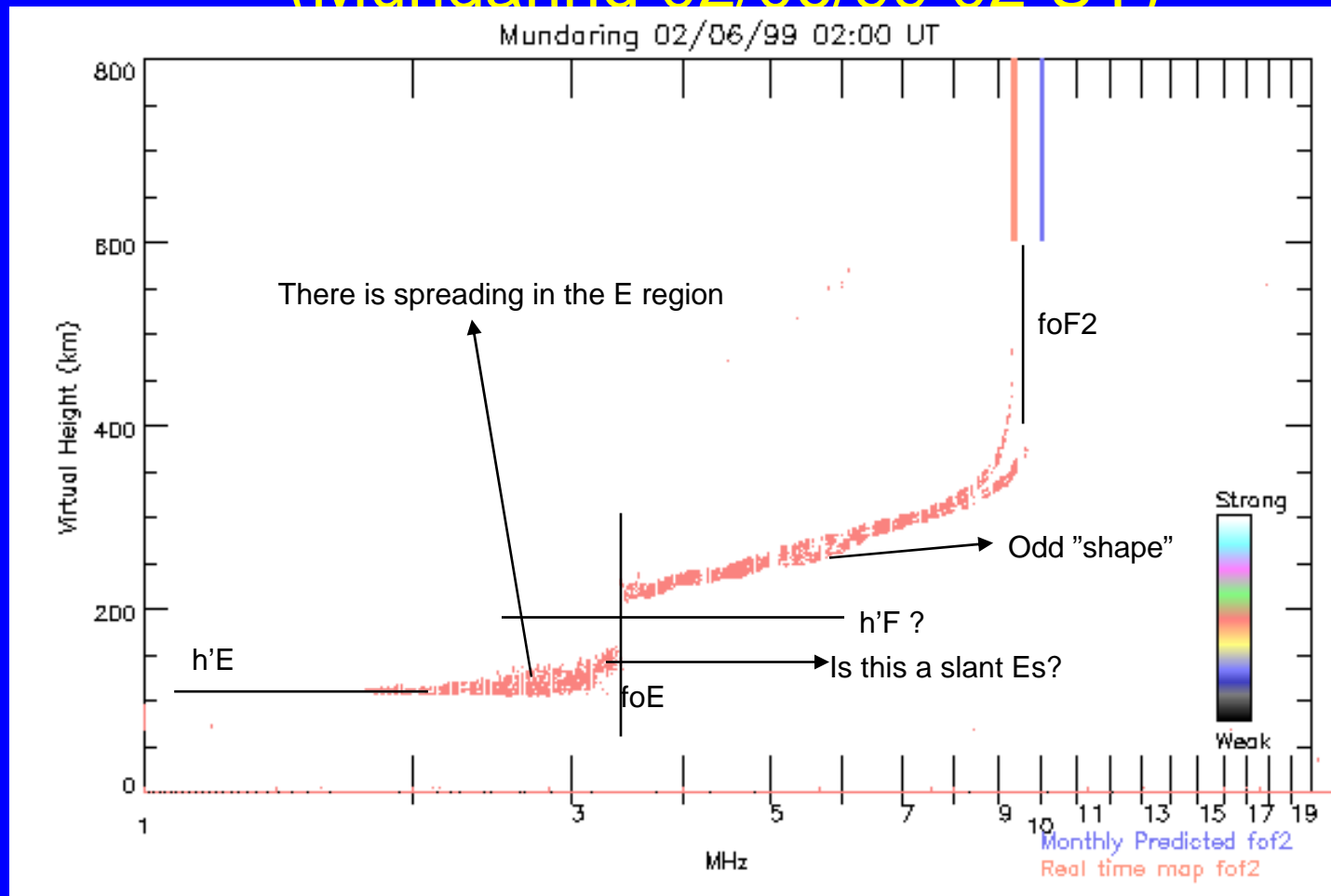
Sample Ionograms : daytime (Townsville 29/05/99 05 UT)

- Fmin Weak trace rule - ignore the low bit
 - but some discussion over this. See a sequence.
- foF2: agreed
- h'F / h'F2:
- h'F: (___ H) only h'F scaled
- foEs: scale the highest foEs. Note low type
- foE: using c, h Es layers, foe = good value

Sample Ionograms : daytime (Mundaring 02/06/99 02 UT)



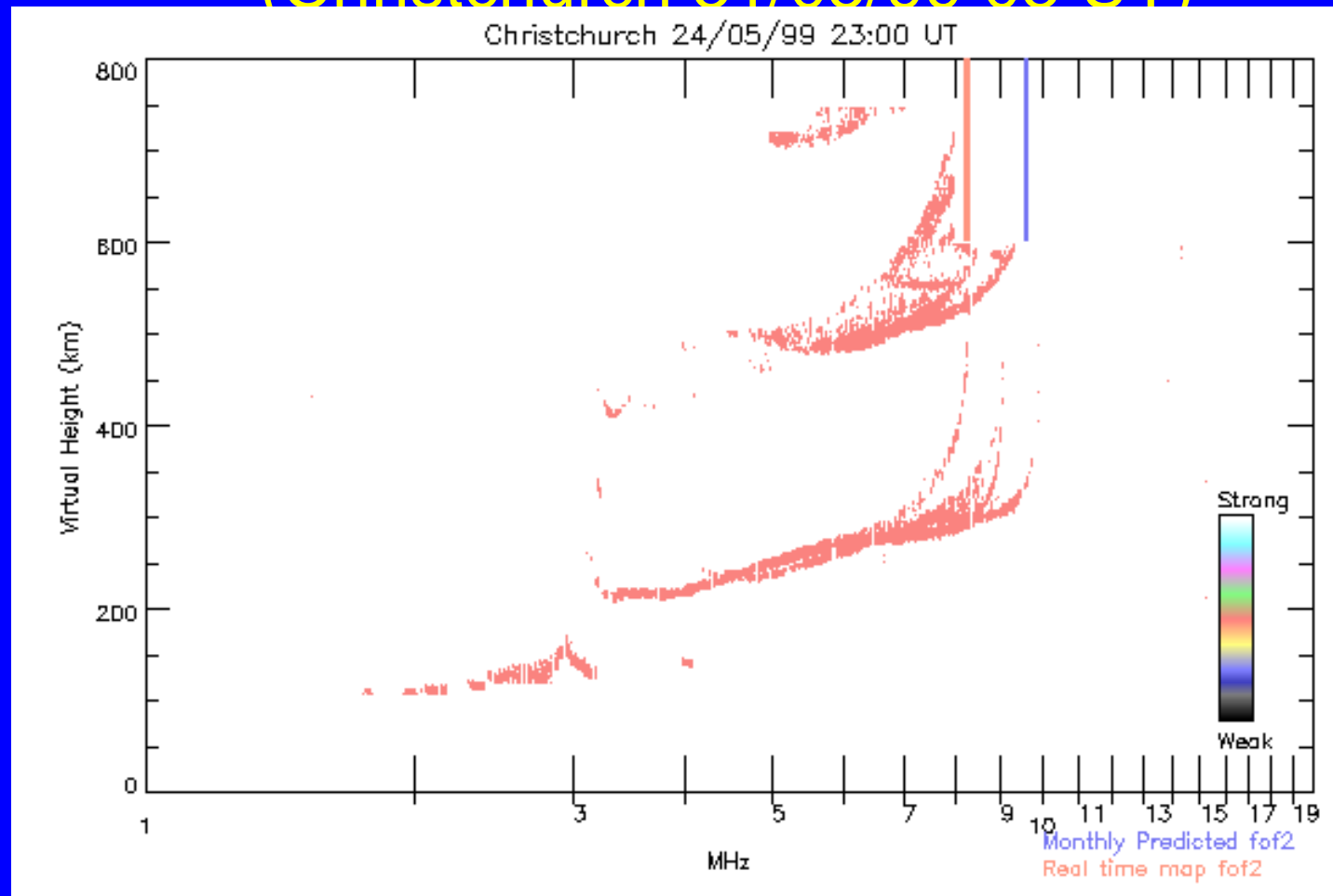
Sample Ionograms : daytime (Mundaring 02/06/99 02 UT)



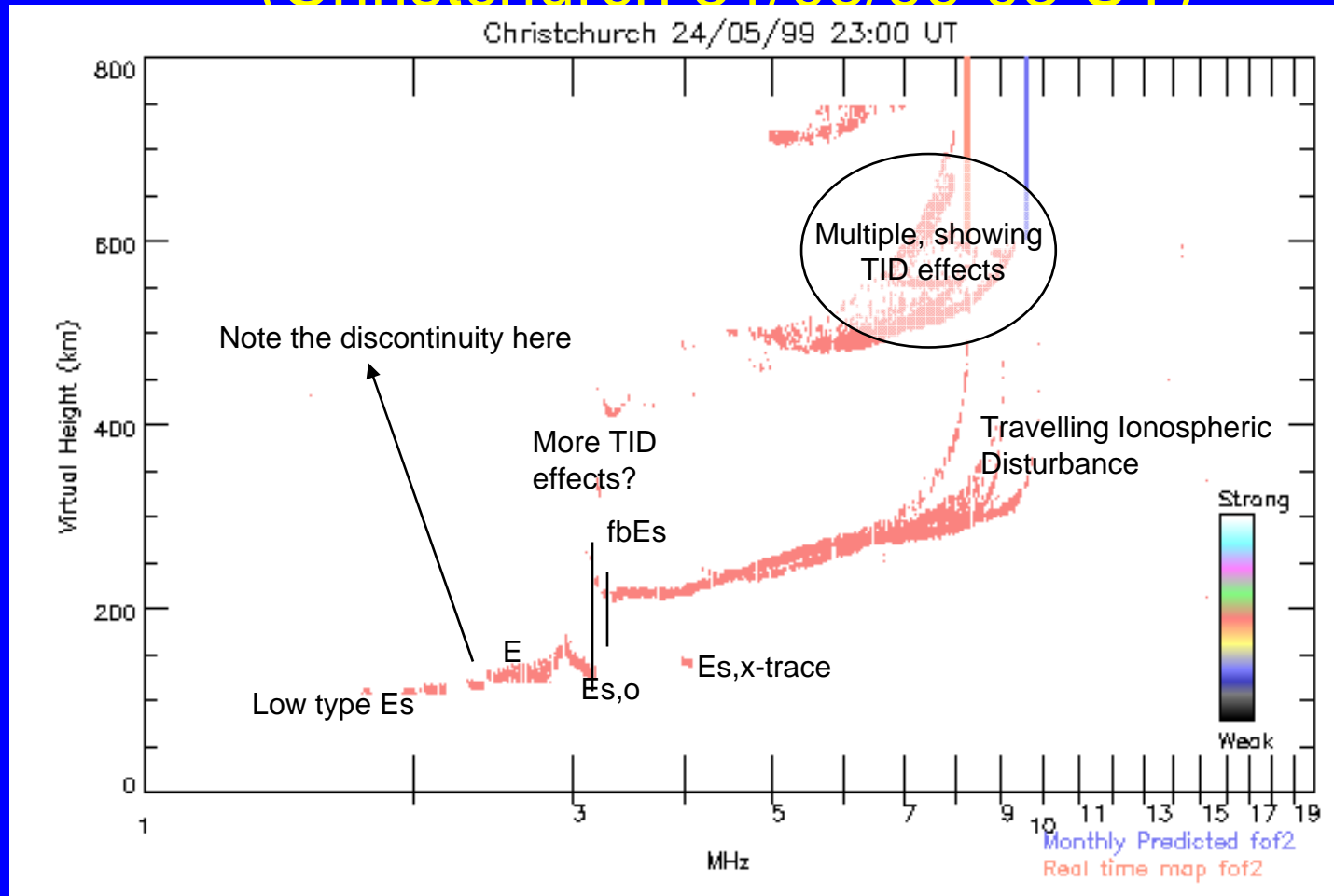
Sample Ionograms : daytime (Mundaring 02/06/99 02 UT)

- Spread Es example
- Spreading in the E region is an unusual condition we note by scaling a Q on h'Es
- There may also be a slant Es here
- Note weak F2 region criticals
- Also note the odd splitting on the Mundaring trace.
 - An example of an equipment problem you would need to recognise.

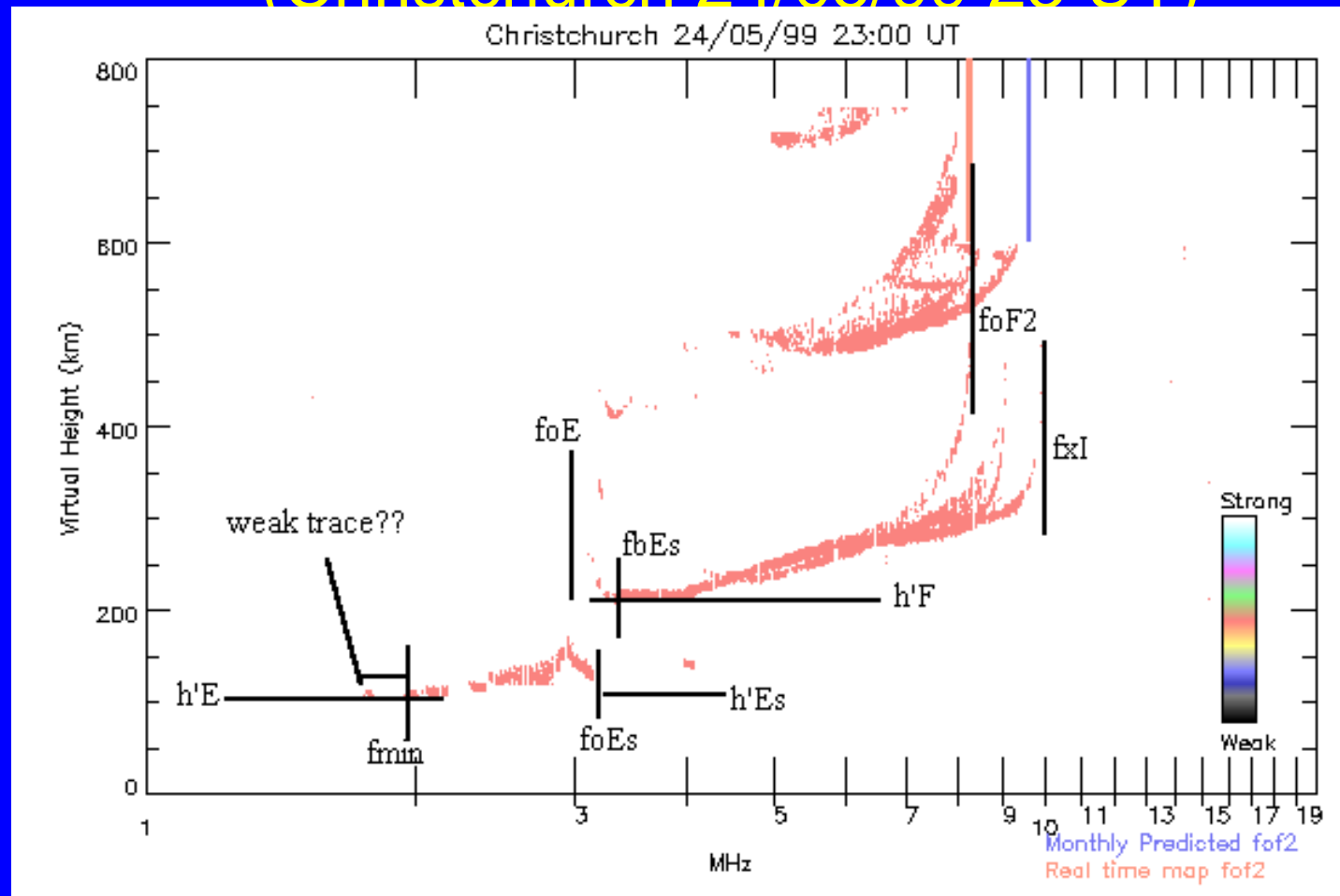
Sample Ionograms : daytime (Christchurch 31/05/99 03 UT)



Sample Ionograms : daytime (Christchurch 31/05/99 03 UT)



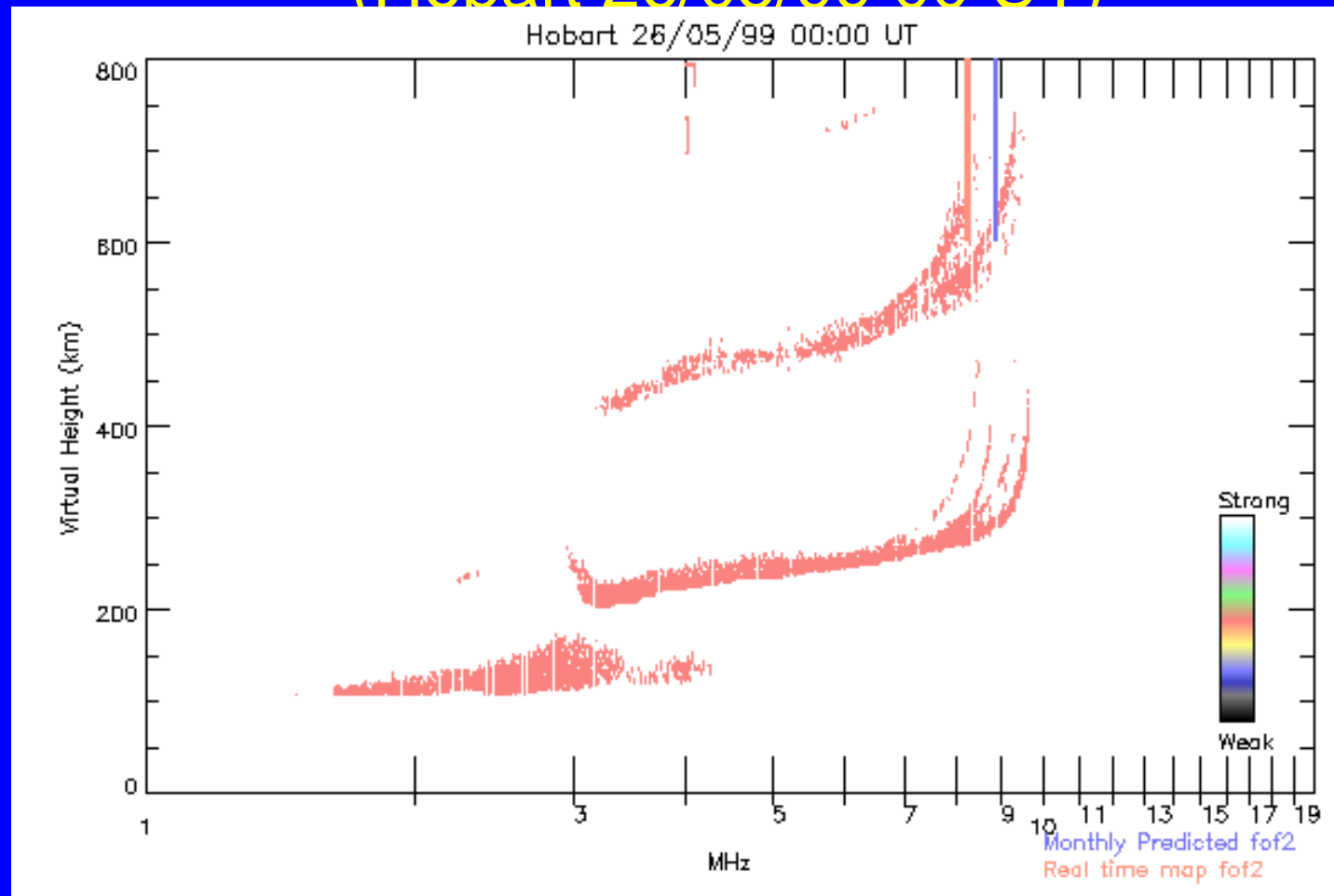
Sample Ionograms : daytime (Christchurch 24/05/99 23 UT)



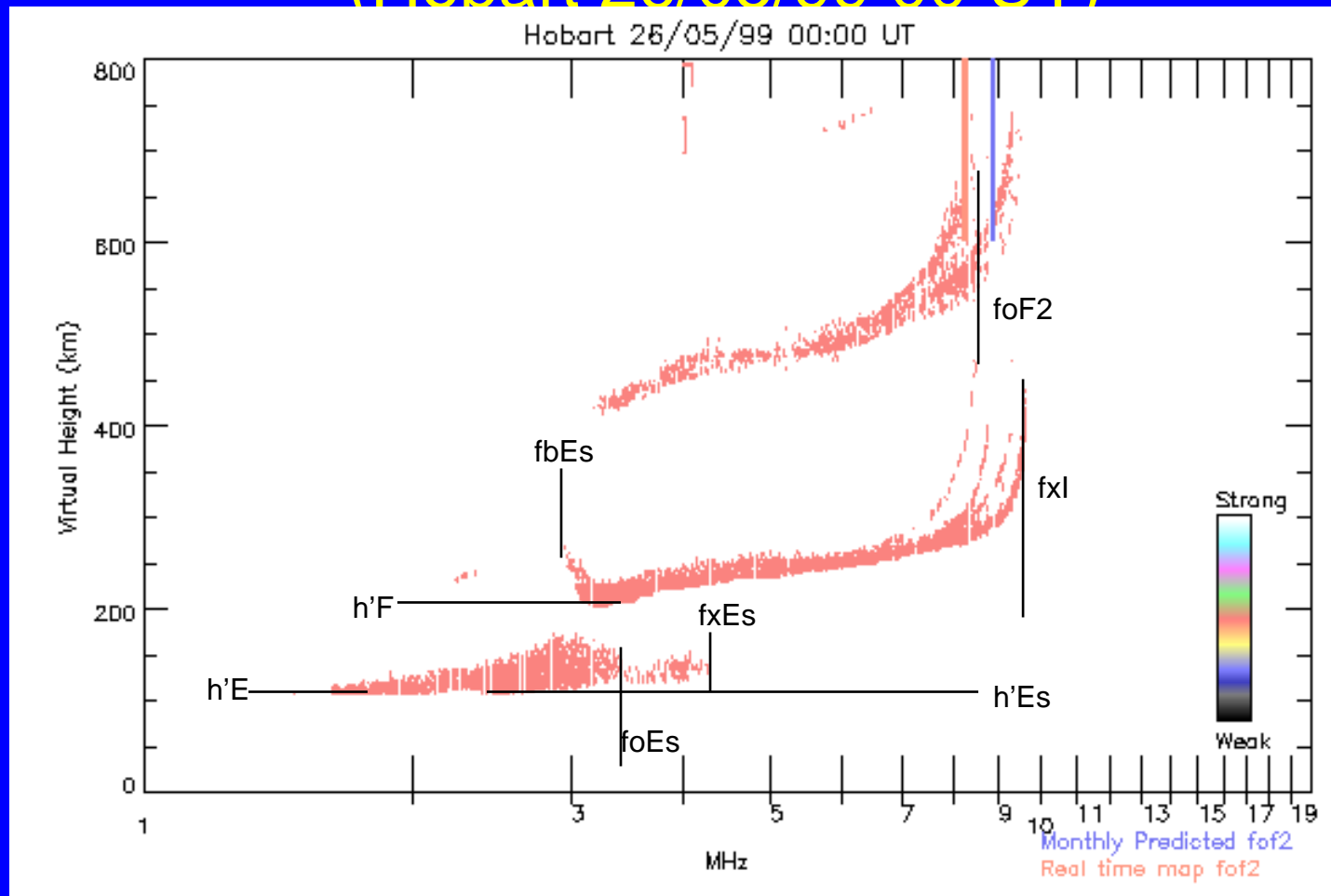
Sample Ionograms : daytime (Christchurch 24/05/99 23 UT)

- Travelling Ionospheric Disturbances (TIDs)
 - give some zest to scaling.
 - They affect both the E and F region,
 - but are most prominent in F2 region.
 - When present, scale H on characteristics *affected* by it.
- However, this ionogram has several other tricky bits
 - fmin - weak trace rule needed?
 - foE - extrapolation, probably (__ UA)
 - (and maybe scaled even higher than here)
 - h'Es - extrapolation (__ UG)
 - foF2 - clearly affected by a TID (__ H)

Sample Ionograms : daytime (Hobart 26/05/99 00 UT)



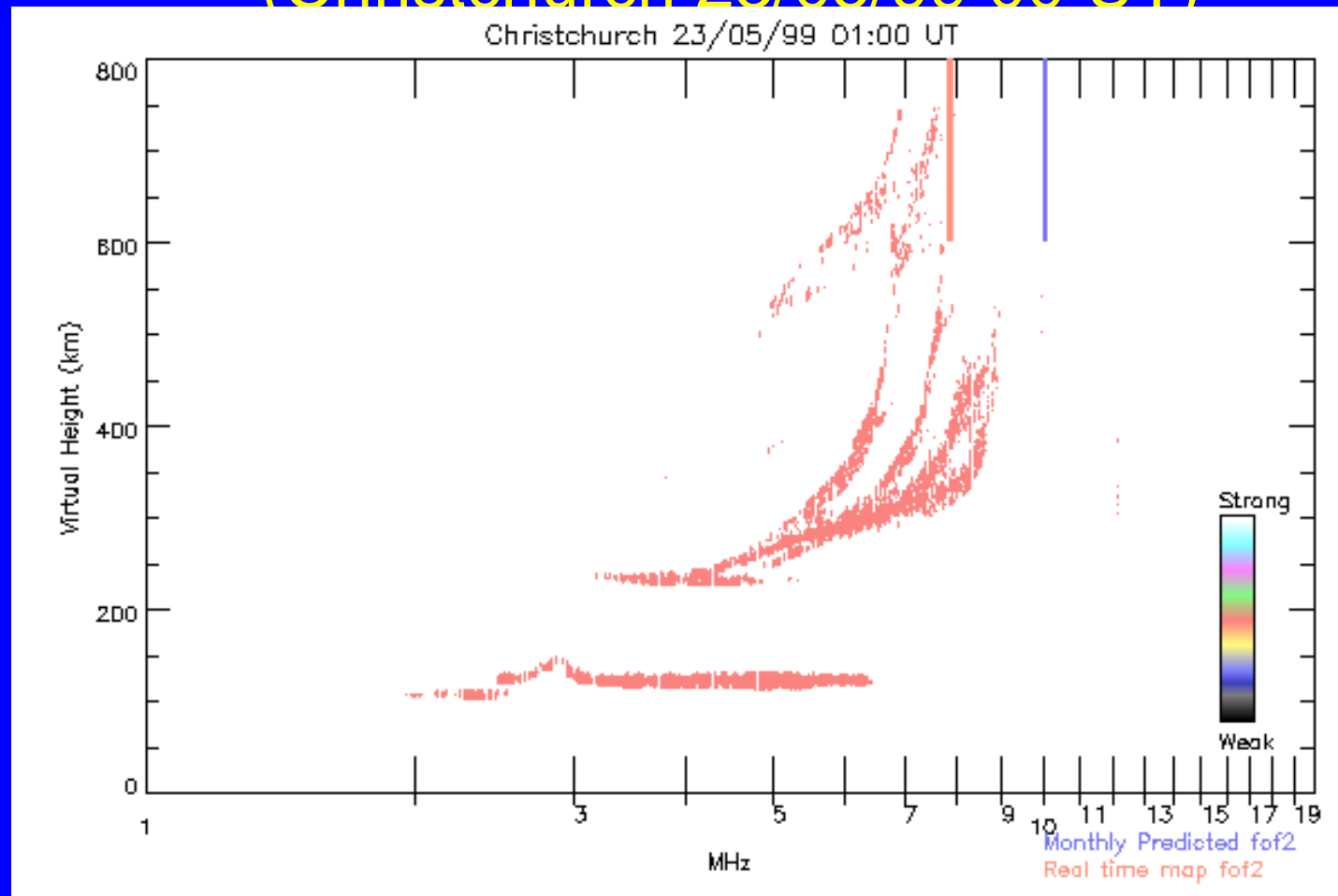
Sample Ionograms : daytime (Hobart 26/05/99 00 UT)



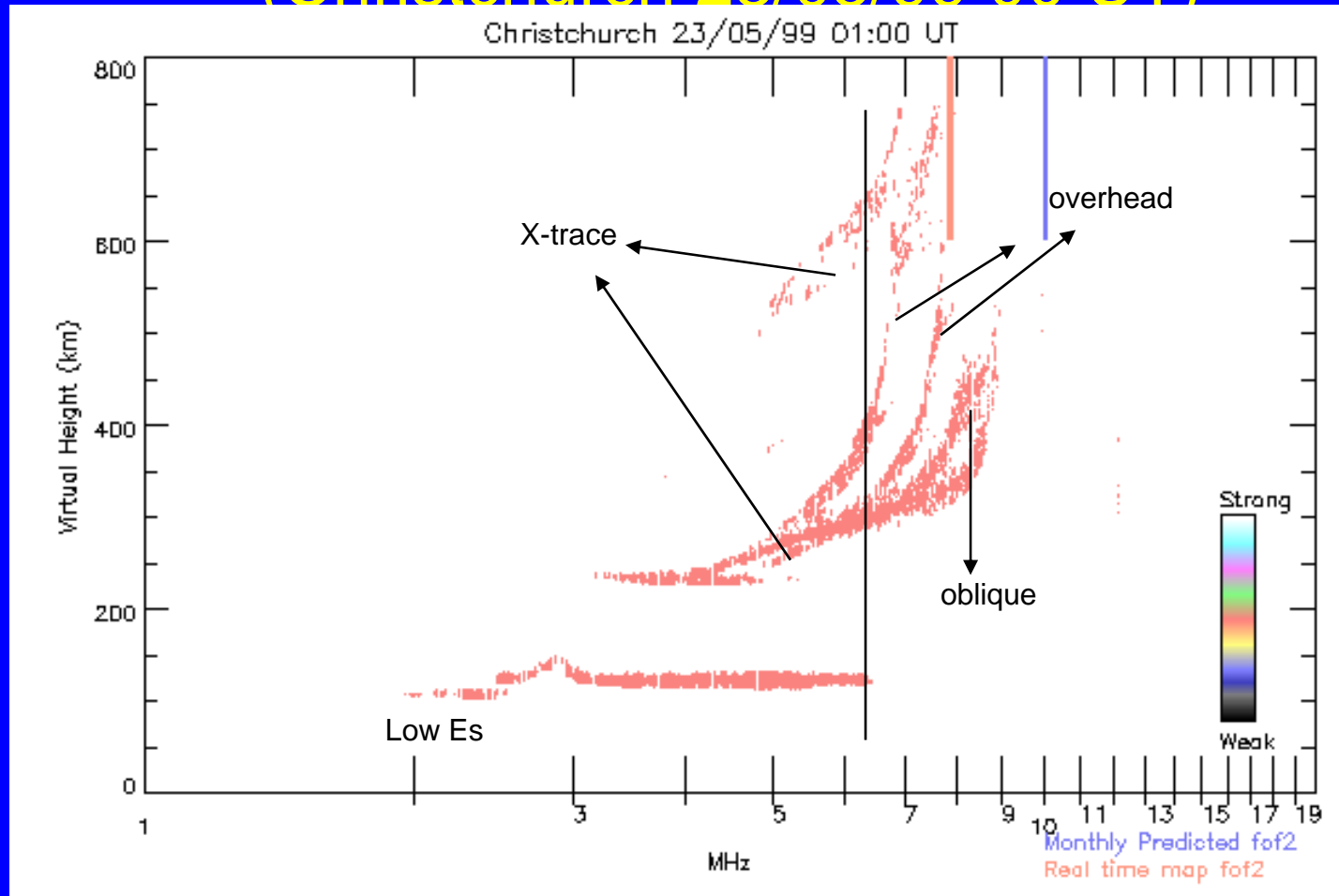
Sample Ionograms : daytime (Hobart 26/05/99 23 UT)

- E region
 - spread Es well developed
 - $f_x E_s \neq f_o E_s + \text{split}$ (spread Es is signal strength dependent)
 - $f_b E_s$ is possibly too low here.
- F2 region
 - A travelling ionospheric disturbance, the so-called V
 - the meaning of V is contested
 - the inner edge is inconsistent with the multiple
 - $f_o F_2$: (___ . V) although (___ . H) is just as good
 - $f_x I$ will have descriptive letter X; no spread.

Sample Ionograms : daytime (Christchurch 23/05/99 00 UT)



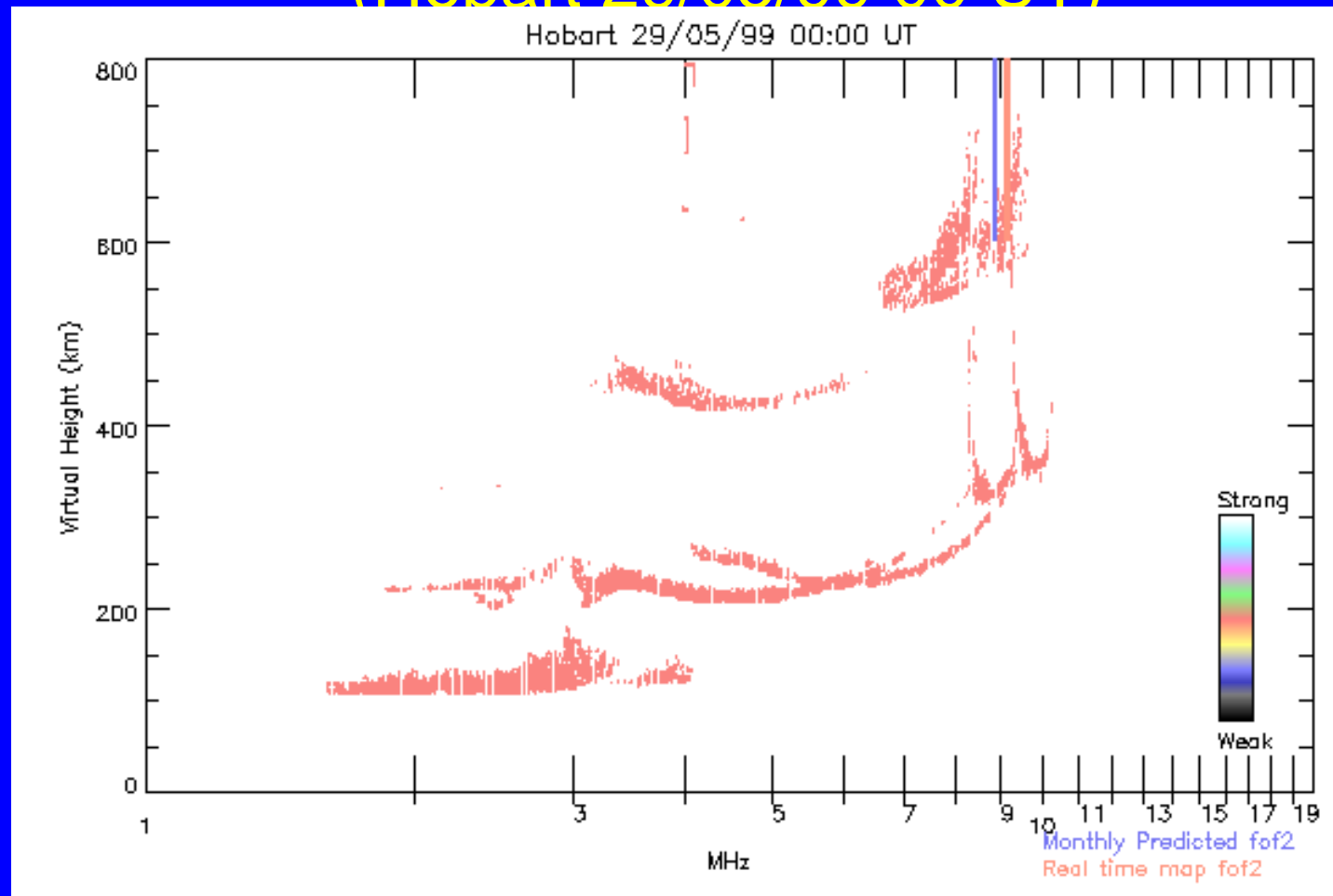
Sample Ionograms : daytime (Christchurch 23/05/99 00 UT)



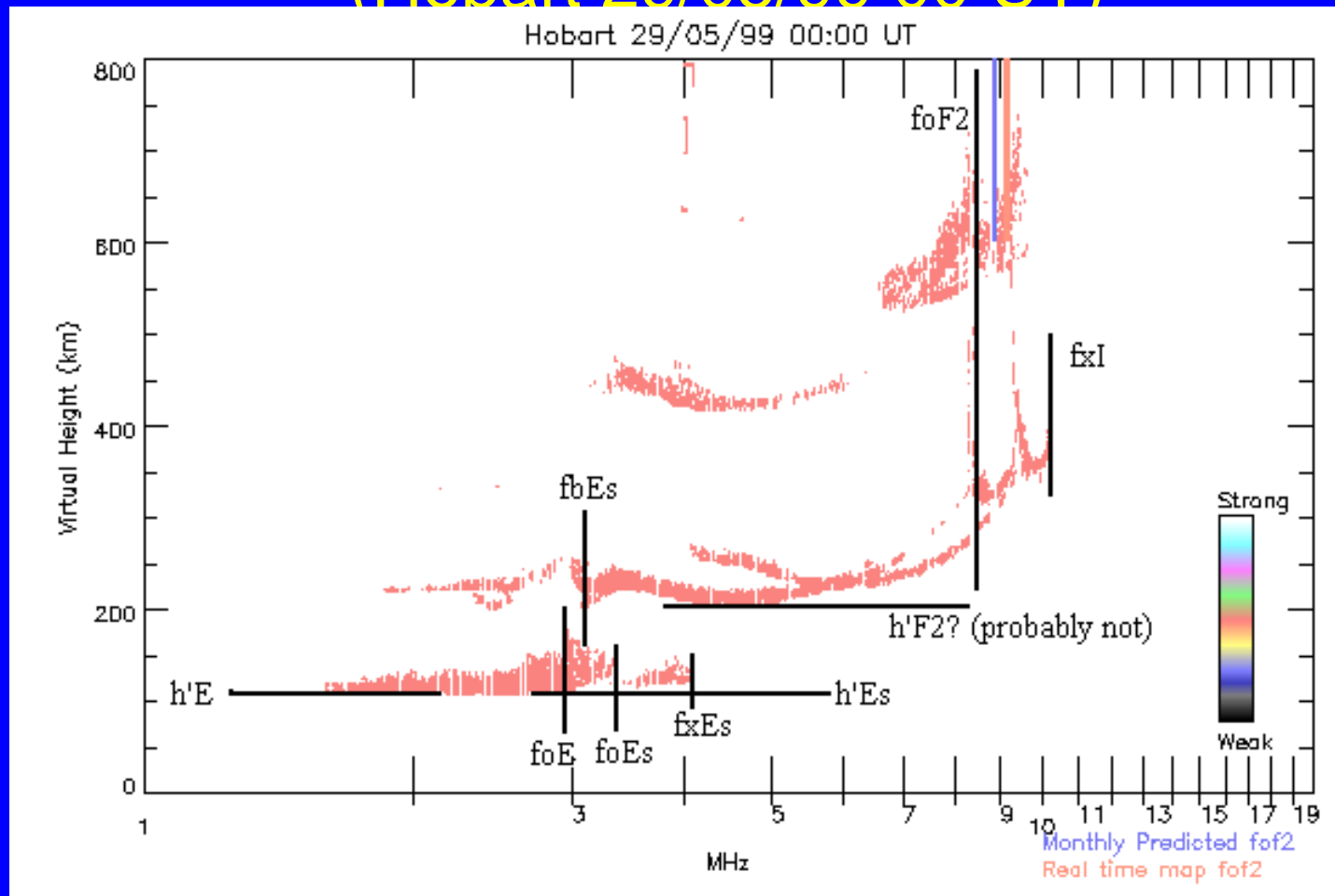
Sample Ionograms : daytime (Christchurch 23/05/99 23 UT)

- One day earlier
 - it isn't unusual to find similar cases clustering
- There are several tricky scaling issues
 - foEs = fxEs - split (note slight change in trace)
 - fmin - weak trace issues
 - foE - extrapolation (__ UA) probably
 - Note low type Es, record type, but don't scale it
 - h'F - probably (__ EA) or maybe (__ UA)
 - fxl - outside trace = (-- F)
 - foF2 (__ UH)

Sample Ionograms : daytime (Hobart 29/05/99 00:00 UT)



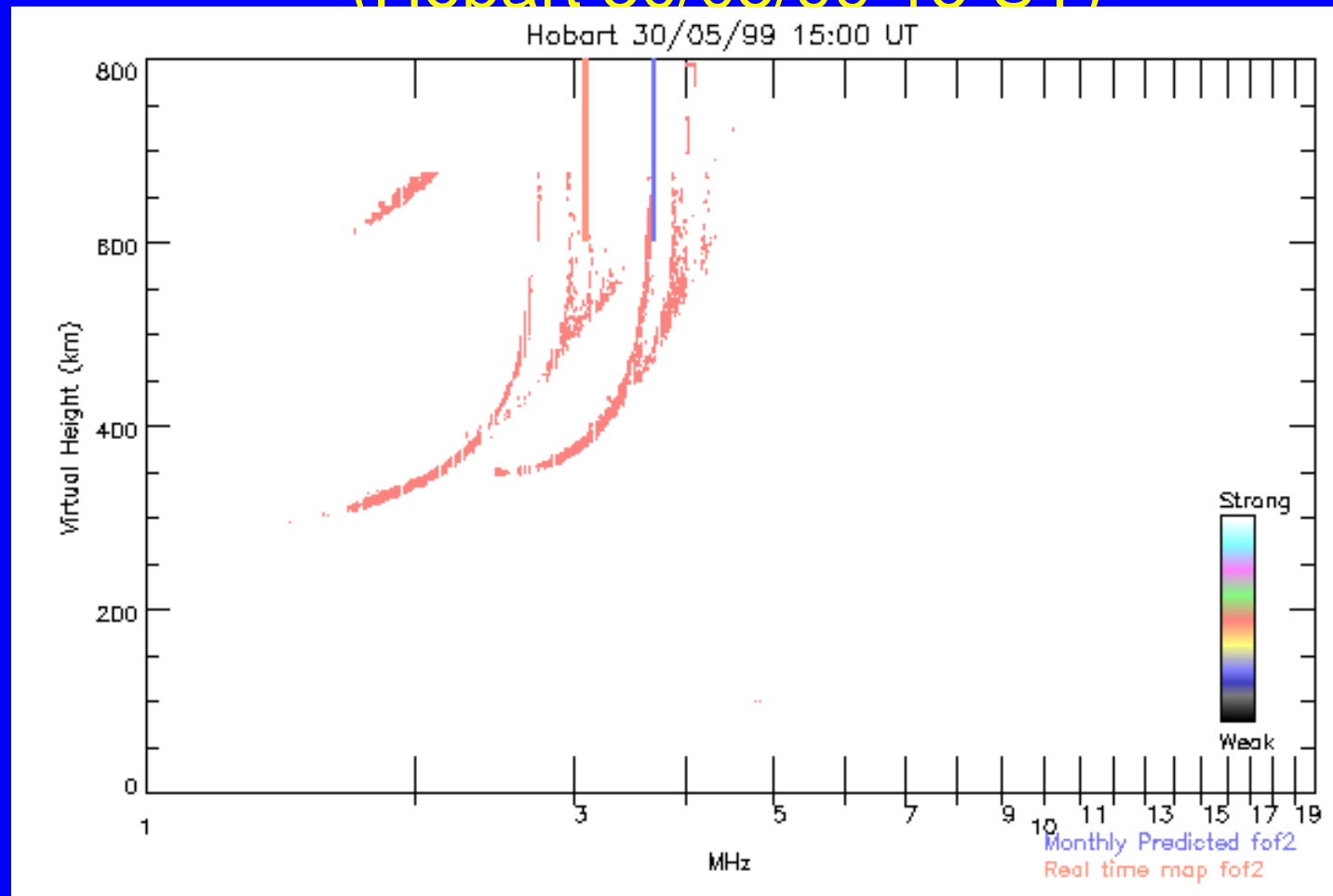
Sample Ionograms : daytime (Hobart 29/05/99 00 UT)



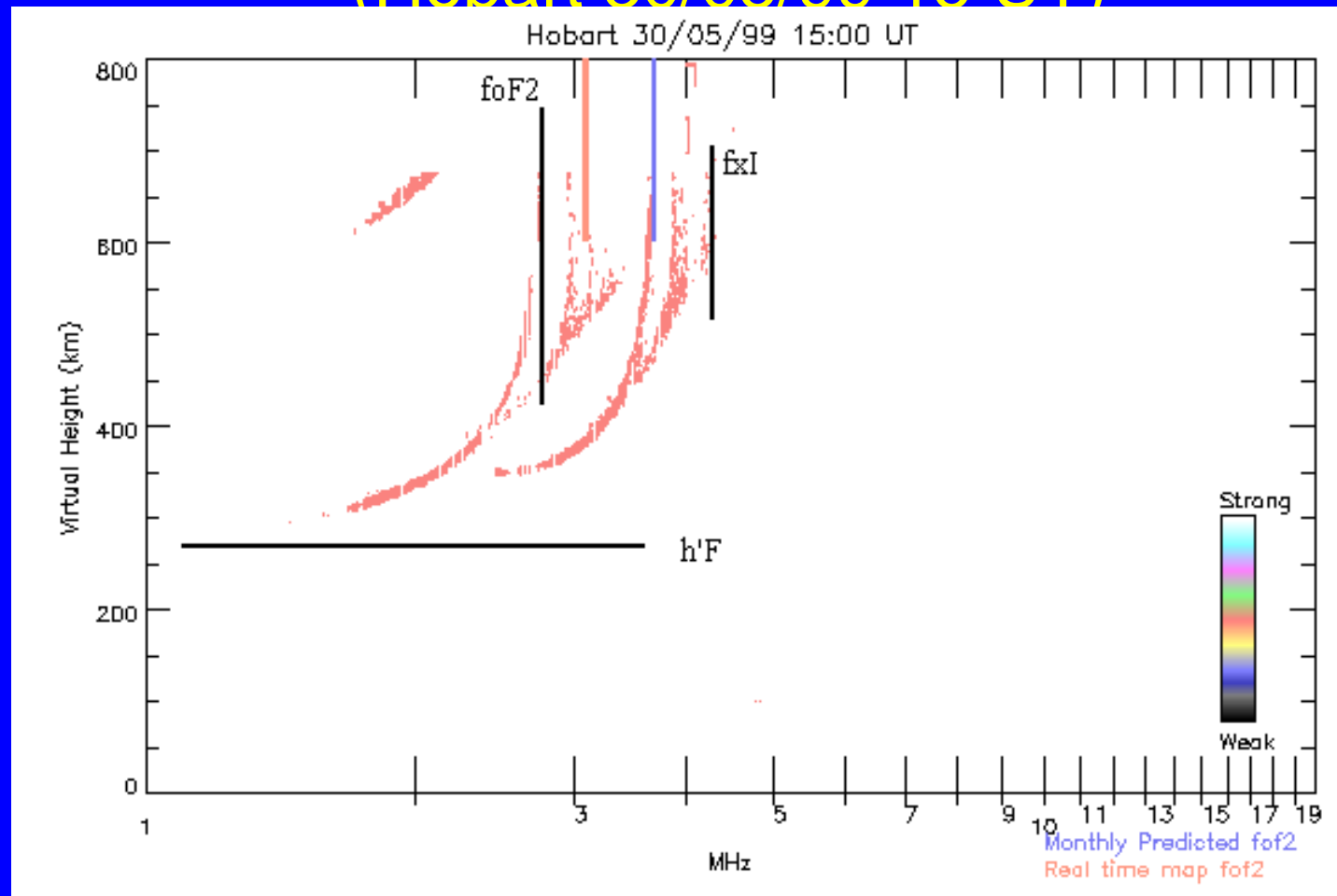
Sample Ionograms : daytime (Hobart 29/05/99 00 UT)

- Large TID & Spread Es - a disturbed ionogram
- E region
 - spread Es, but h'Es difficult to measure
 - foE: (00 . A) but sequence may give a value
- F1 present? Need a sequence
 - h'F (-- H)
- F2: major TID implies big gradients
 - normally scale the inside edge
 - the multiple offers some extra information (___ . H)

Sample Ionograms : nighttime (Hobart 30/05/99 15 UT)



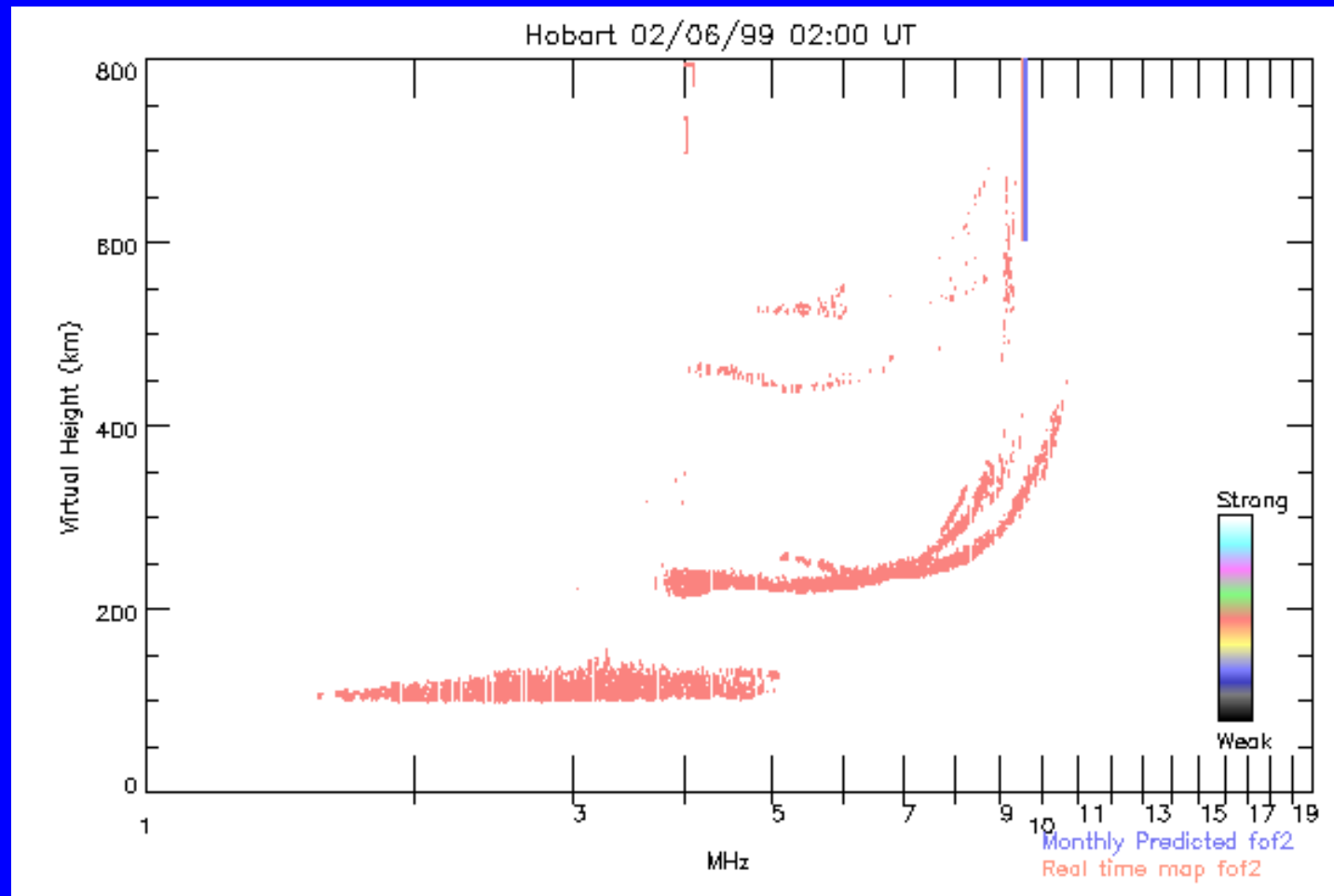
Sample Ionograms : nighttime (Hobart 30/05/99 15:00 UT)



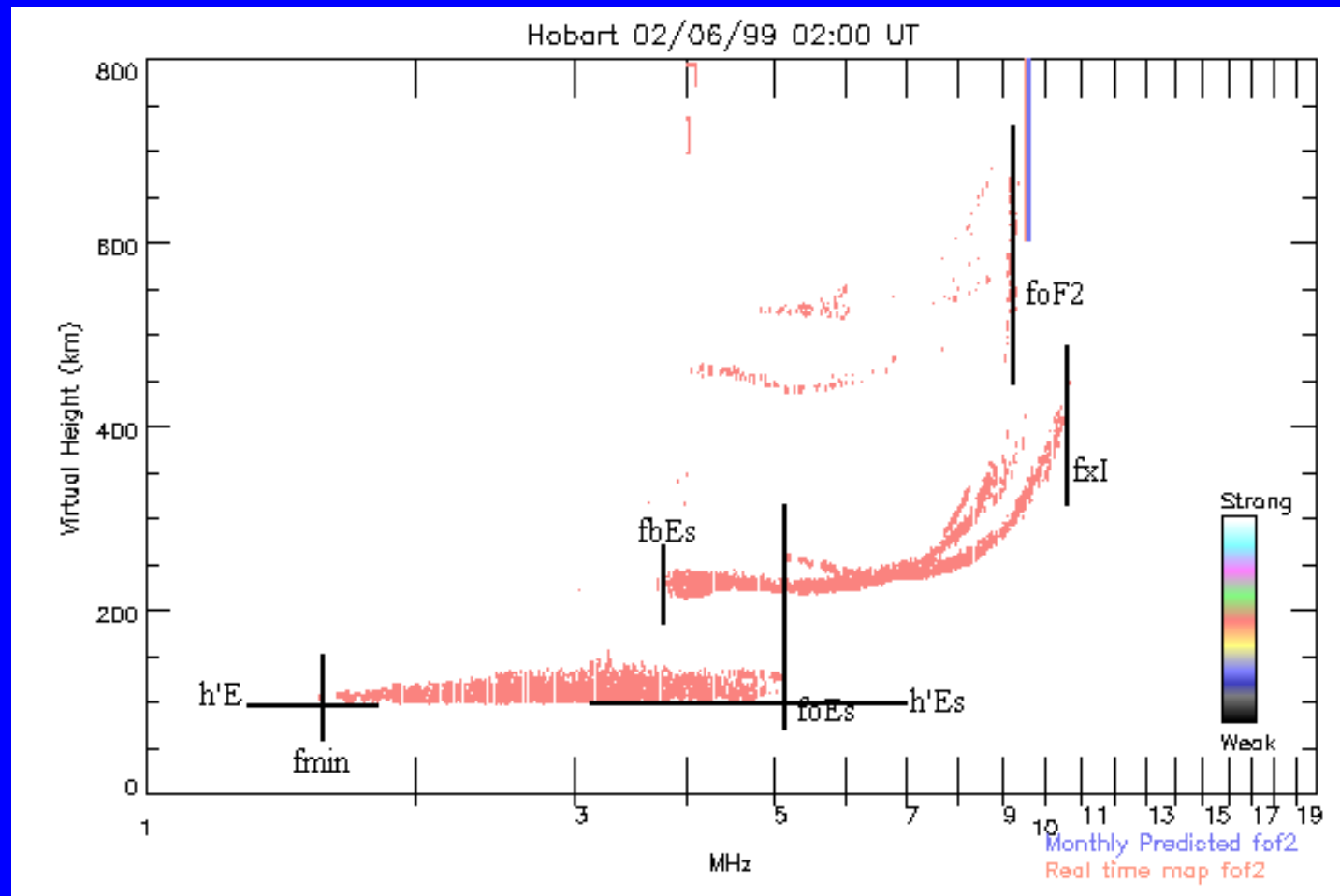
Sample Ionograms : nighttime (Hobart 30/05/99 15 UT)

- A nighttime travelling ionospheric disturbance (TID)
 - Note $f_{xI} \neq f_oF2 + \text{split}$
- Need to estimate overhead trace carefully, but not much information in one ionogram.
- $h'F$: this requires considerable extrapolation
 - (___ UF) or even (___ EF) if you are uncertain.

Sample Ionograms : daytime (Hobart 02/06/99 02 UT)



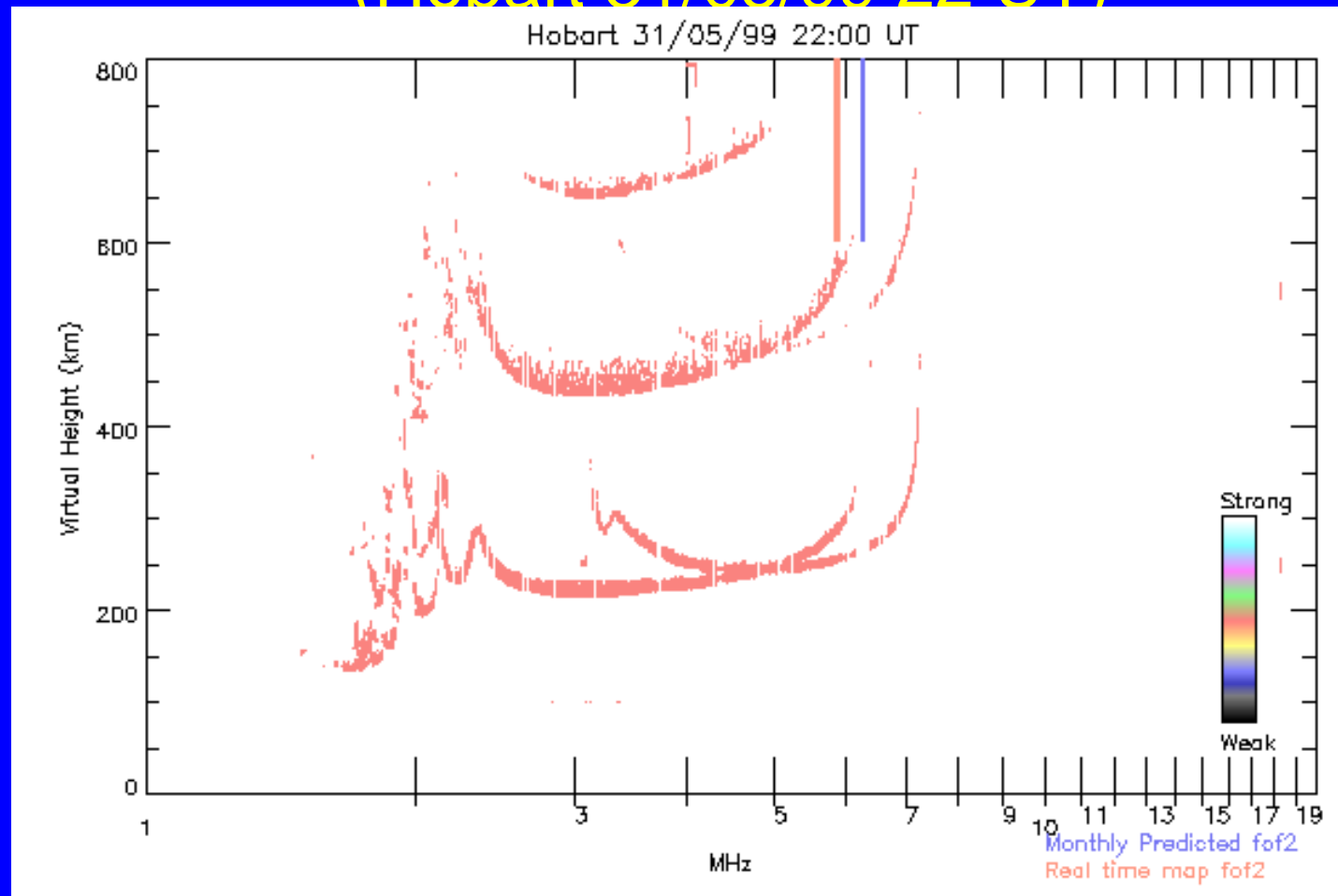
Sample Ionograms : daytime (Hobart 02/06/99 02 UT)



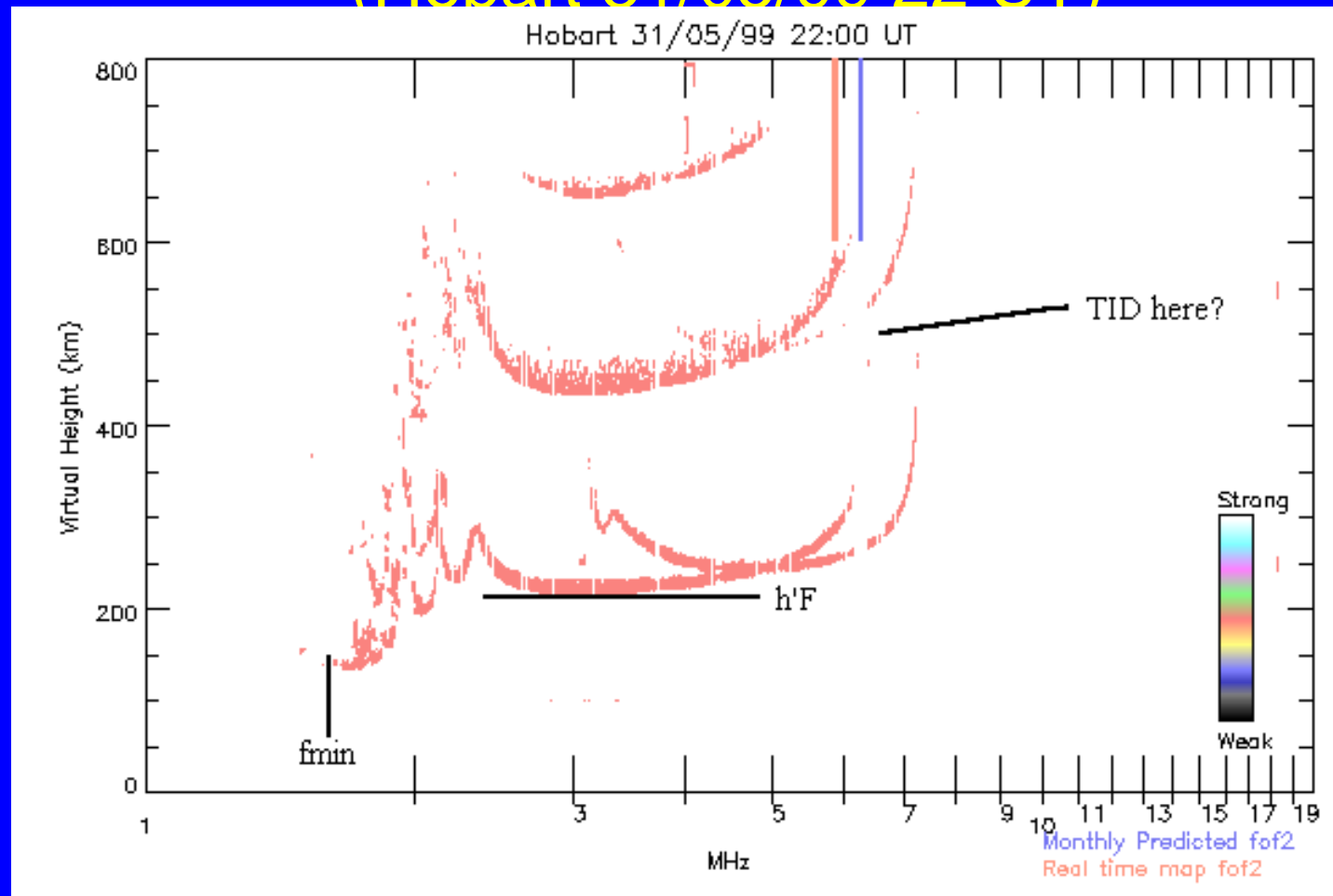
Sample Ionograms : daytime (Hobart 02/06/99 02 UT)

- foF2 - maybe wrong, multiple not consistent (___ .H)
 - or F if spreading is sufficient
- foE - can't be scaled from this ionogram,
 - maybe knowing foE would help
- Es is showing clear range spread
 - and fbEs may need a sequence to define it
- Probably no x-mode Es present,
 - although this is contentious, scale foEs (___ .F)
 - h'Es (___ . Q)
- fmin - accept weak trace; whole trace is weakening

Sample Ionograms : daytime (Hobart 31/05/99 22:00 UT)



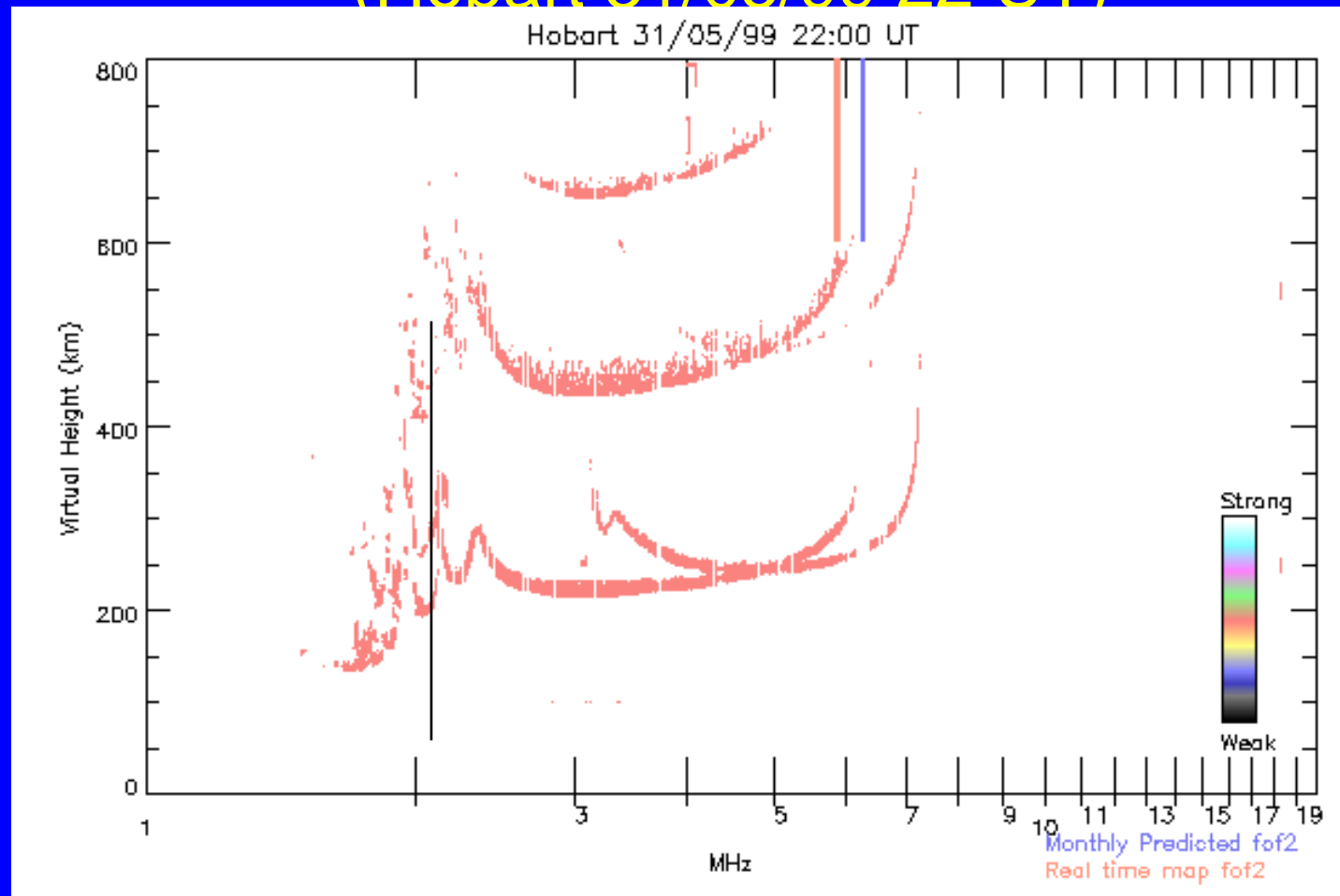
Sample Ionograms : daytime (Hobart 31/05/99 22:00 UT)



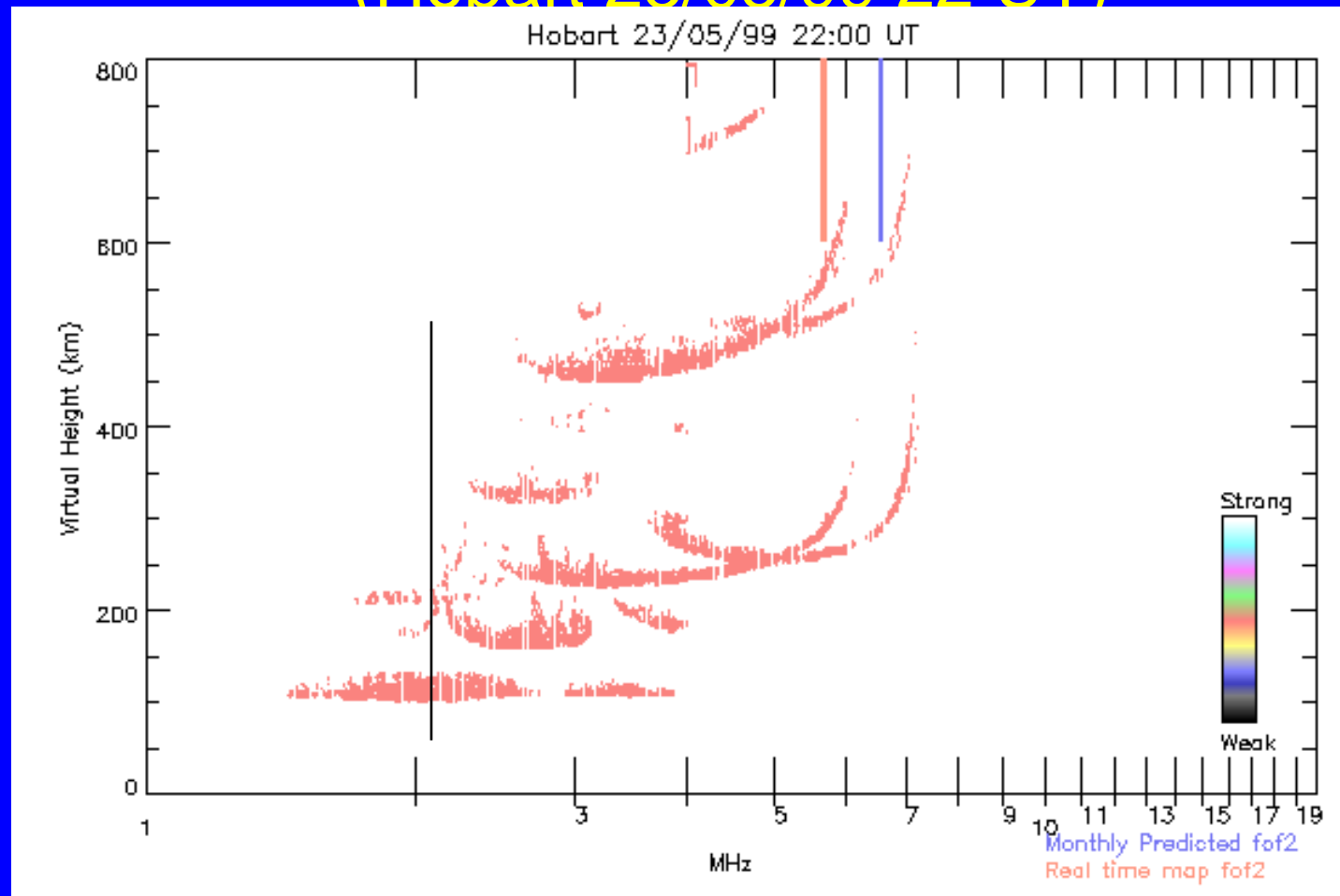
Sample Ionograms : daytime (Hobart 31/05/99 22 UT)

- Dawn: a time of awkward ionograms
- foF2 - small TID present; use H or not? Probably no.
- fmin - weak trace rule
- foE - you **NEED** a prediction for foE here
 - or a sequence
 - or experience from other similar days
 - foe = ... H (in the absence of better information)
- Sporadic E, possibly, but probably not

Sample Ionograms : daytime (Hobart 31/05/99 22:00 UT)



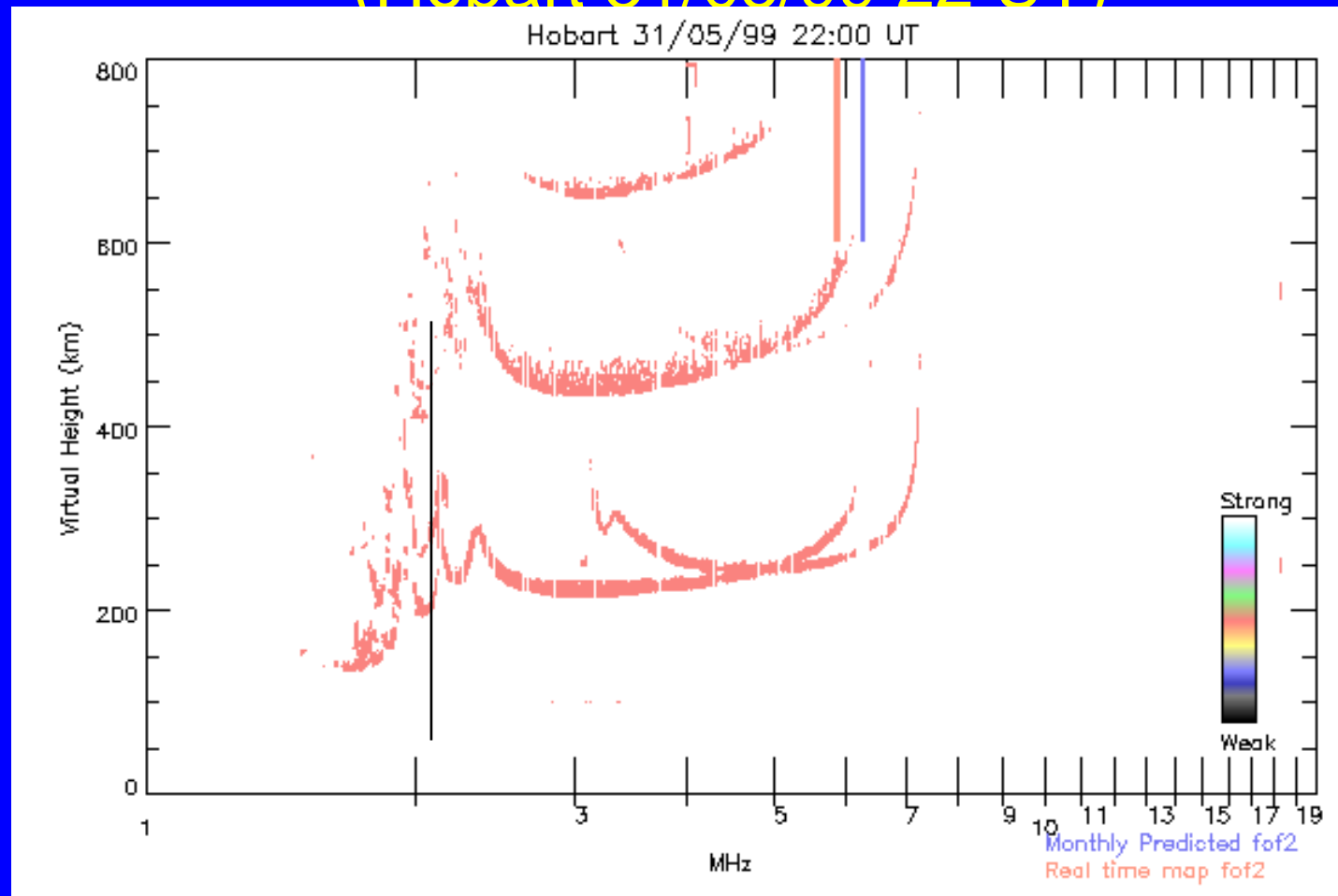
Sample Ionograms : daytime (Hobart 23/05/99 22:00 UT)



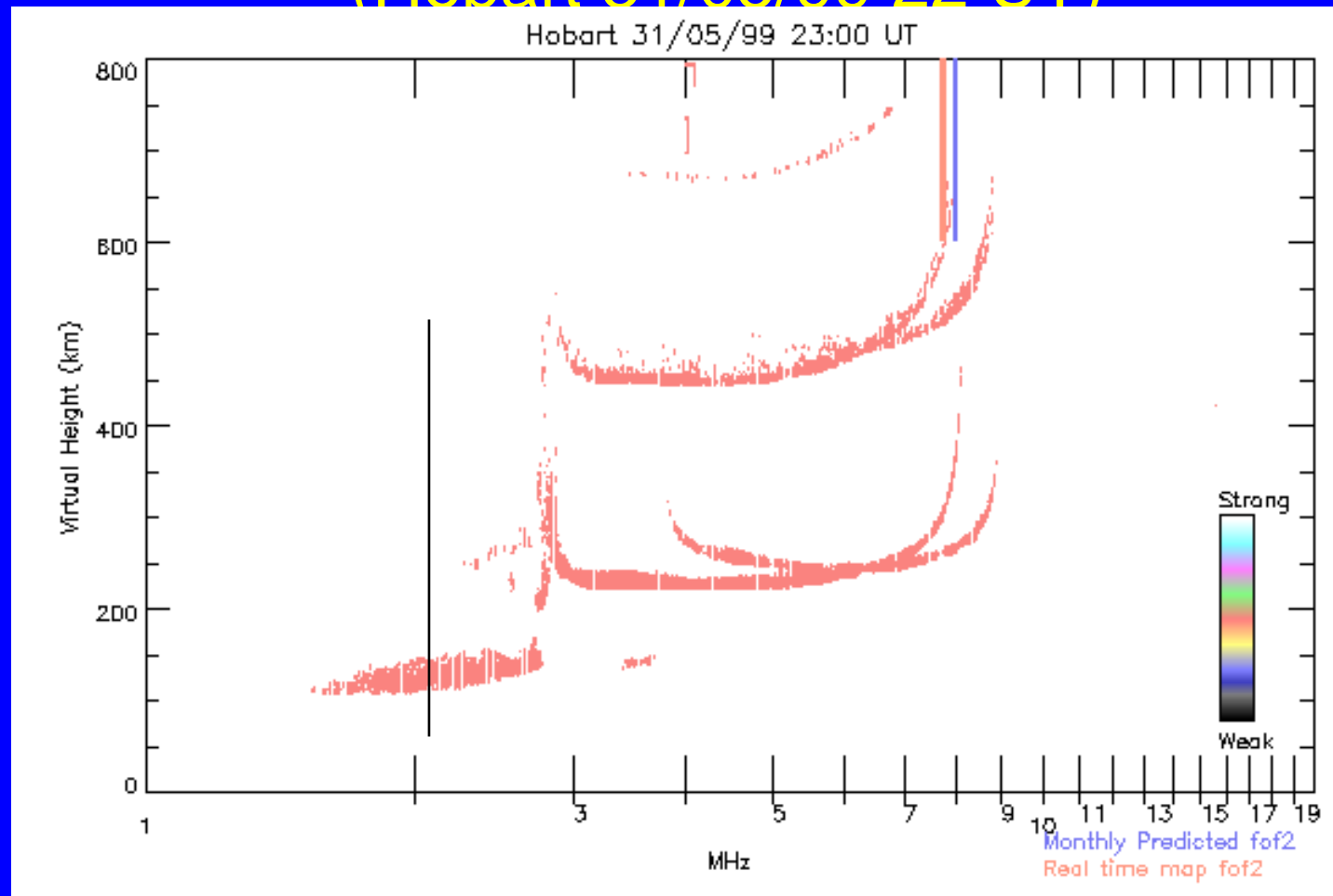
Sample Ionograms : daytime (Hobart 23/05/99 22 UT)

- Compare these two days
- Substantial development, but:
 - foE is clearer, isn't it? Still not easy.
 - foEs appears in second ionogram
 - layers look more like f0.5, or E2 in the former
 - Note multiples are disorganised; a dynamic change near dawn.

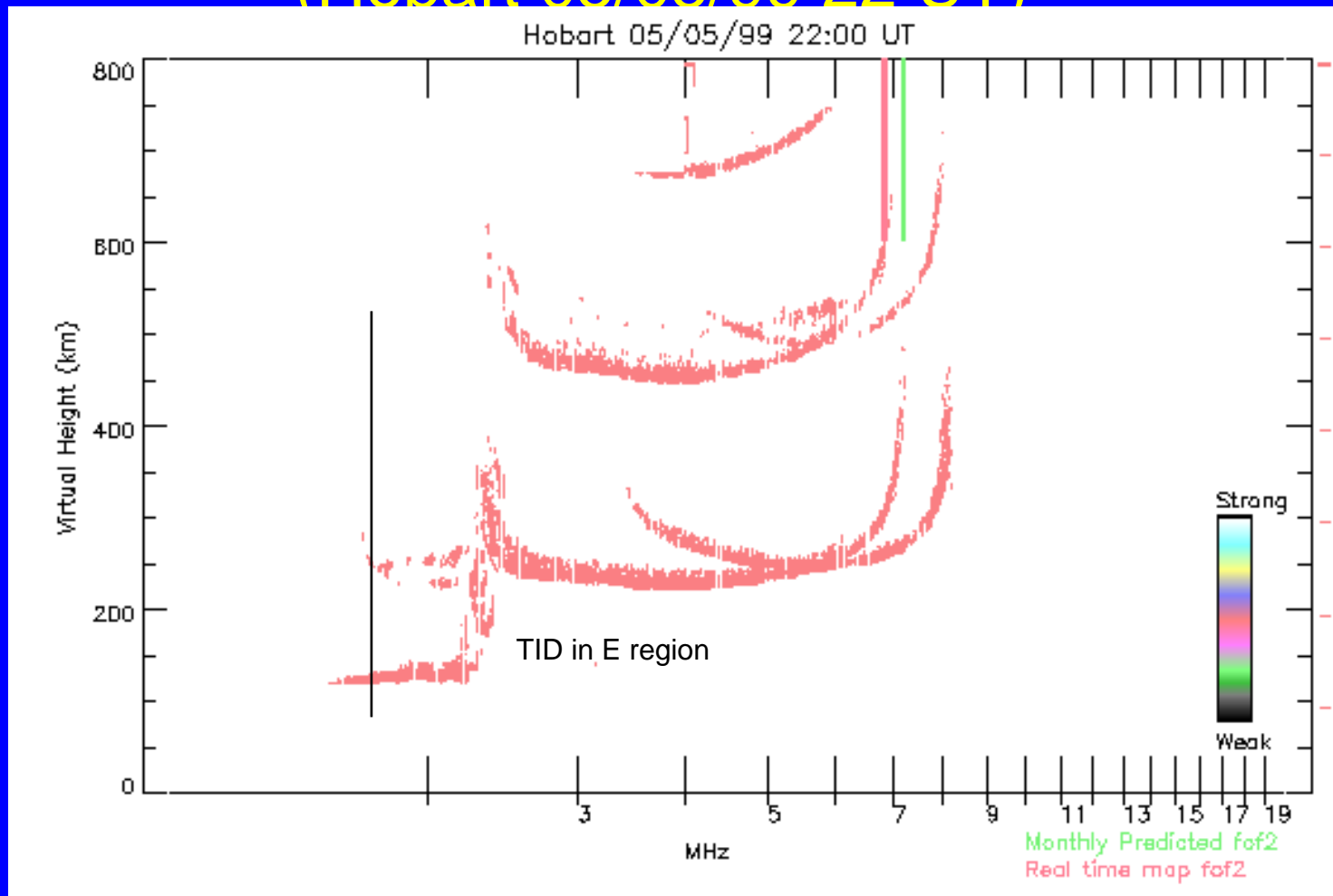
Sample Ionograms : daytime (Hobart 31/05/99 22:00 UT)



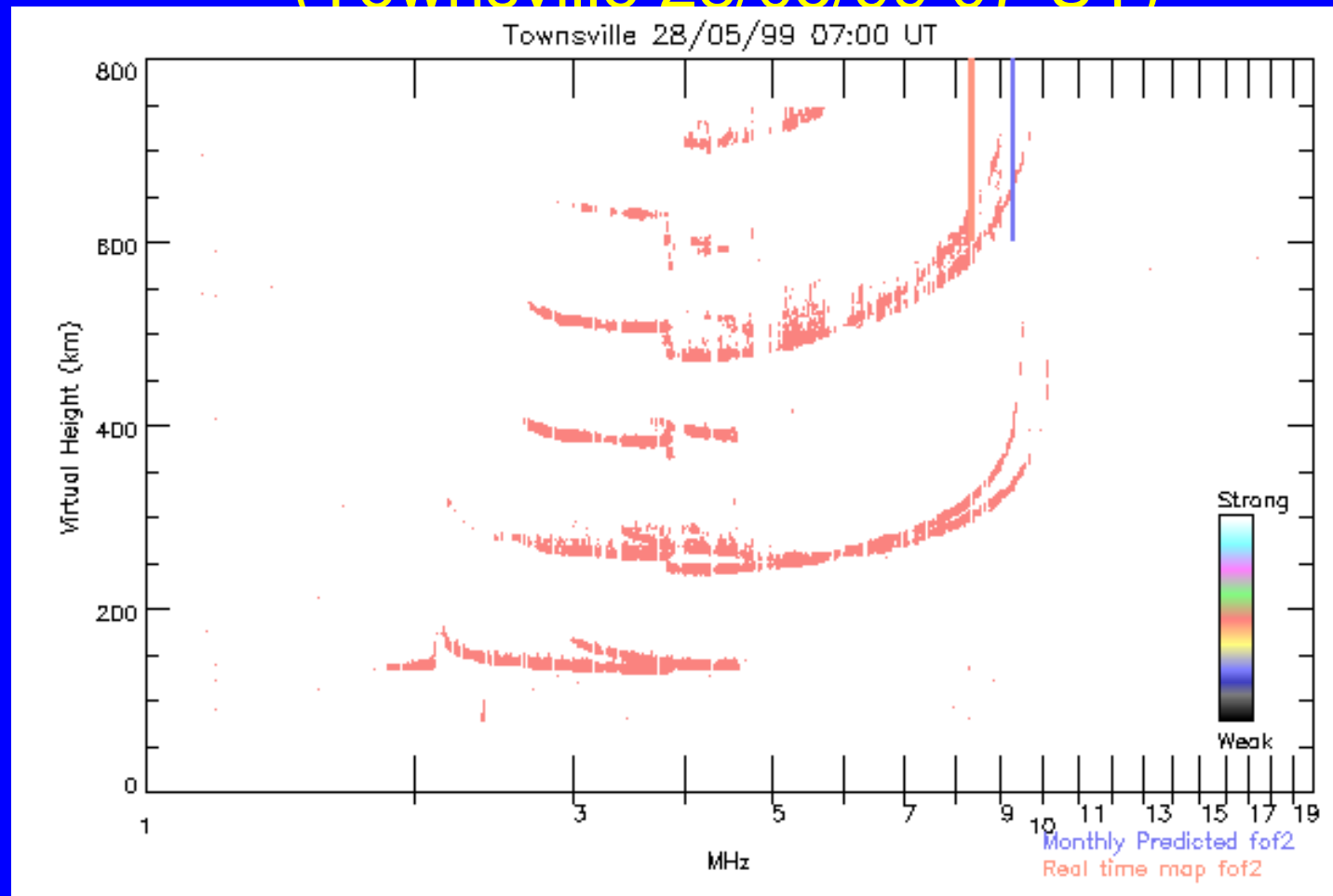
Sample Ionograms : daytime (Hobart 31/05/99 22 UT)



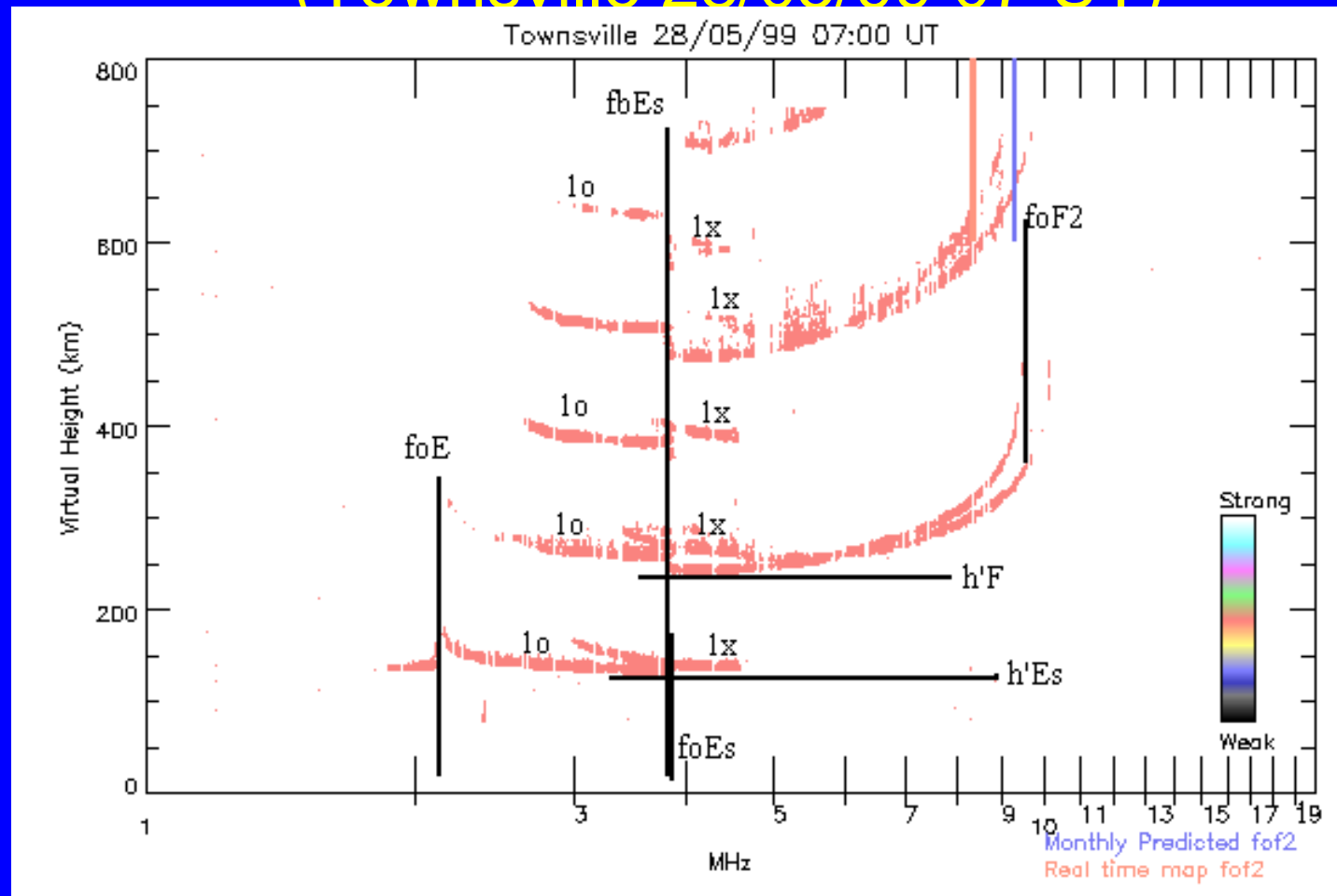
Sample Ionograms : daytime (Hobart 05/05/99 22:00 UT)



Sample Ionograms : daytime (Townsville 28/05/99 07:00 UT)



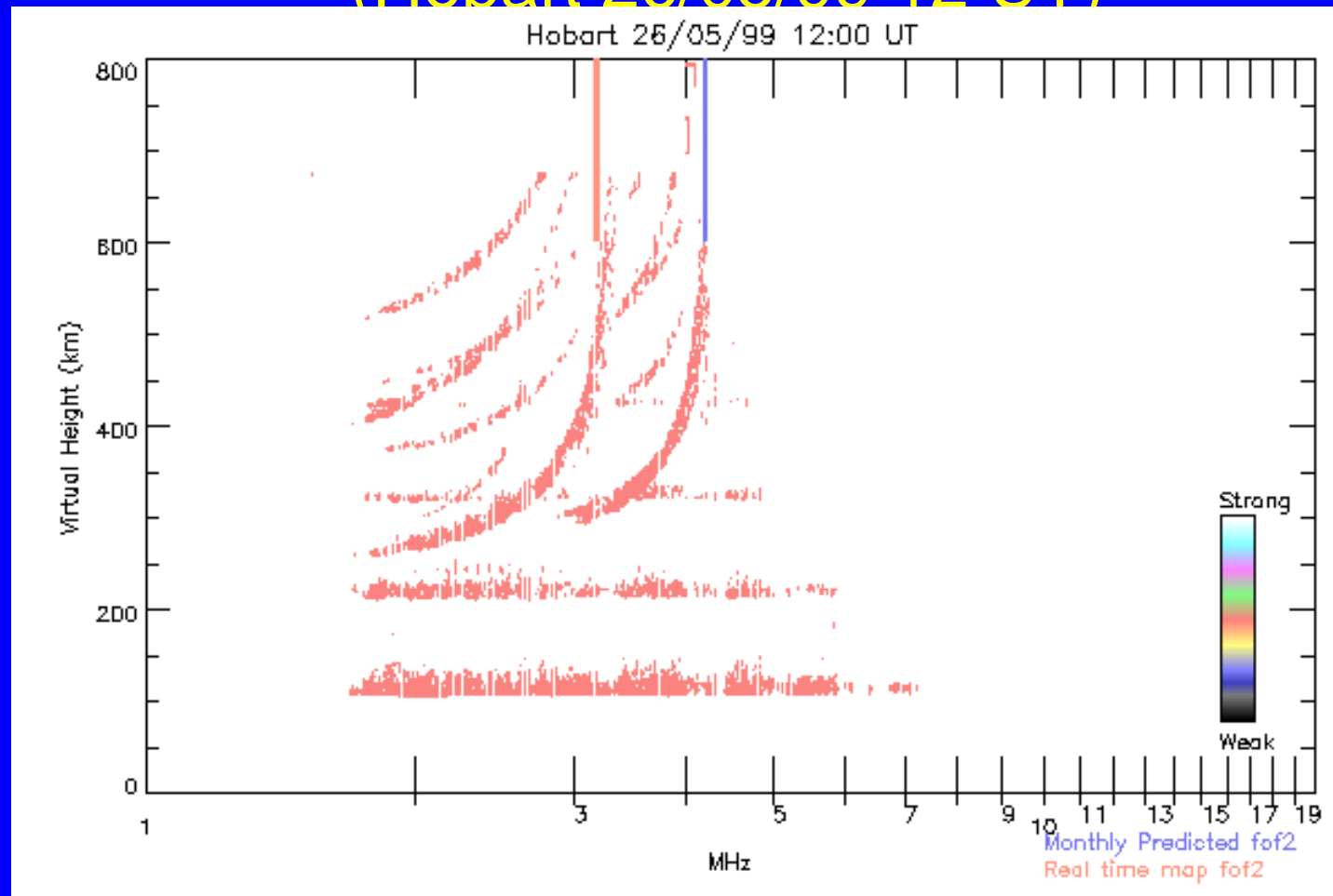
Sample Ionograms : daytime (Townsville 28/05/99 07:00 UT)



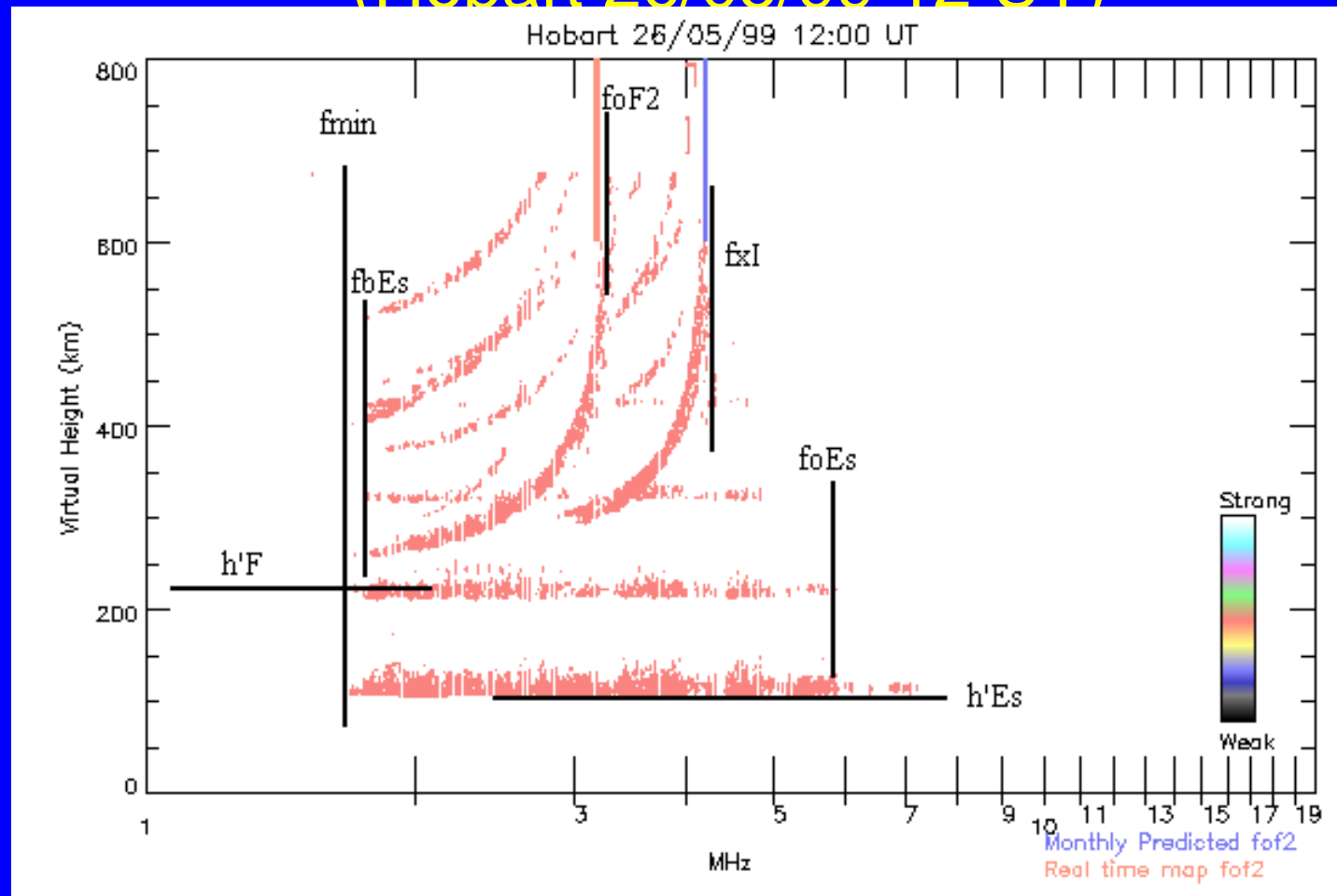
Sample Ionograms : daytime (Townsville 28/05/99 07 UT)

- Blanketing sporadic E can require much scaling skill
- Identify primary trace,
 - then O-mode and x-mode
 - then multiples of each
- Having disentangled all the extra information,
- scale foE
- Is it h'F? Use other days to know if foF1 is possible

Sample Ionograms : nighttime (Hobart 26/05/99 12 UT)



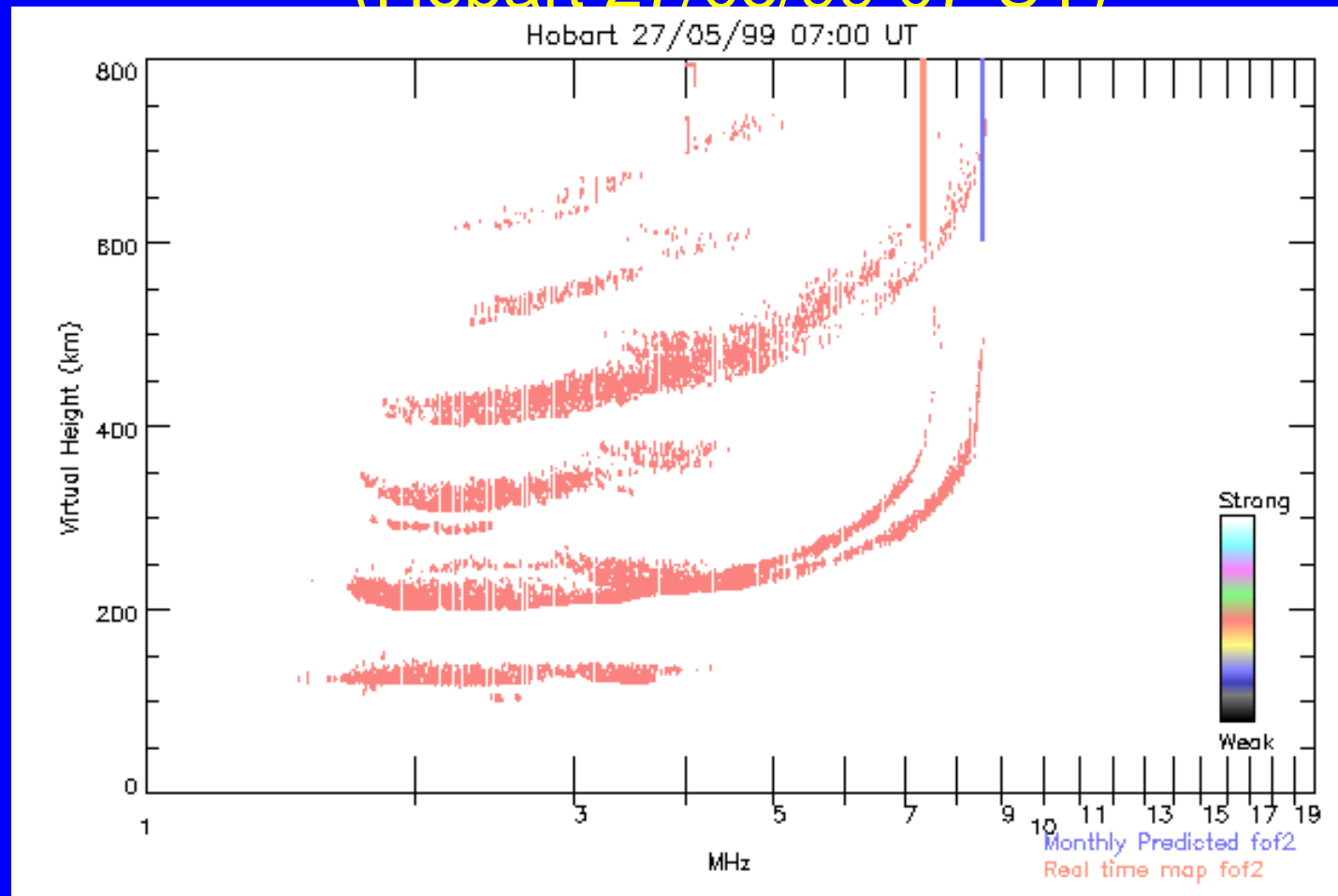
Sample Ionograms : nighttime (Hobart 26/05/99 12:00 UT)



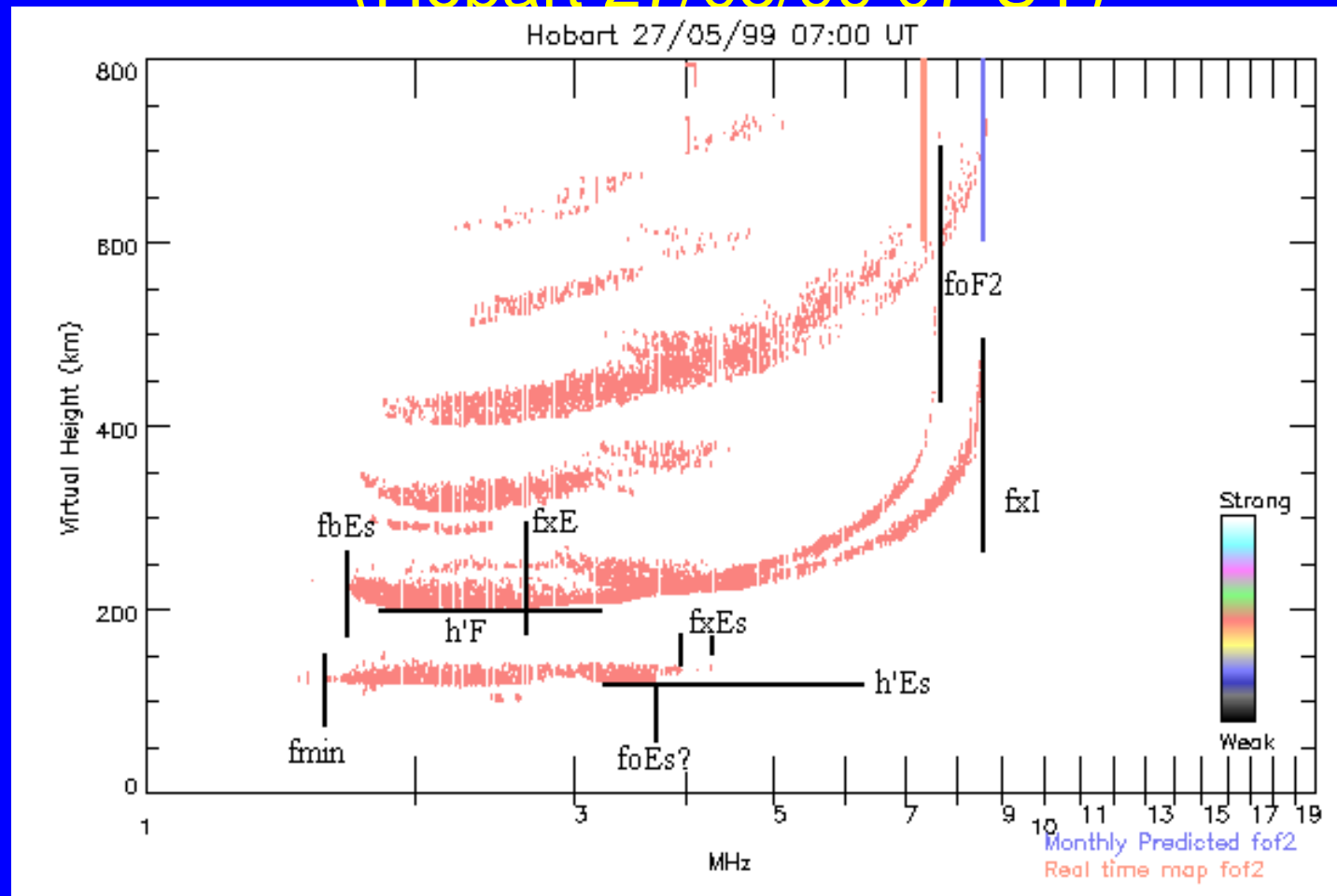
Sample Ionograms : nighttime (Hobart 26/05/99 12 UT)

- E region
 - figure out where the multiples are
 - fbEs slightly higher than fmin
 - foEs = fxEs - split (note: weakened trace)
- F region
 - Is foF2 (___ . F)?
 - Either way, fxl = (___ . .); no X

Sample Ionograms : nighttime (Hobart 27/05/99 07:00 UT)



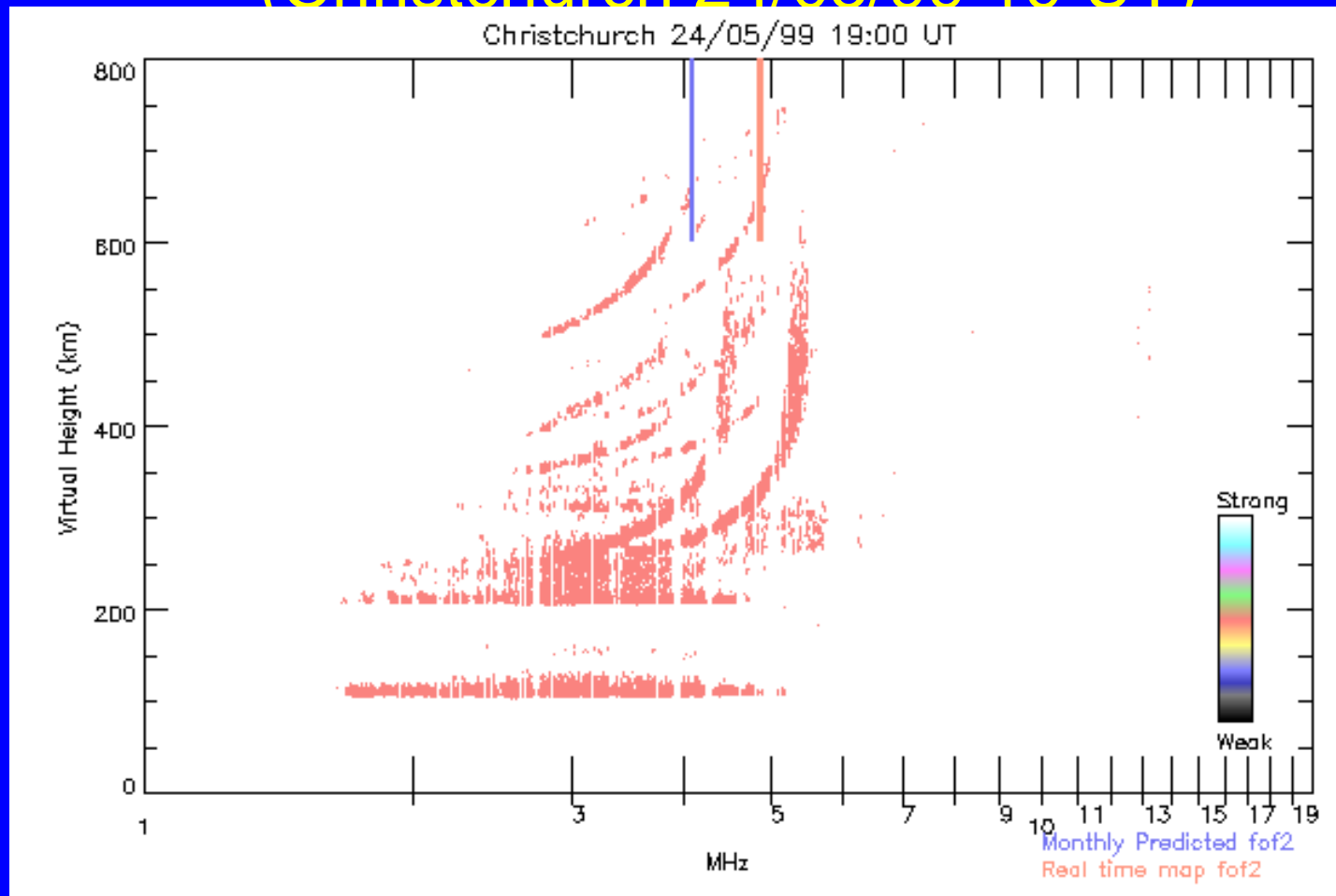
Sample Ionograms : nighttime (Hobart 27/05/99 07 UT)



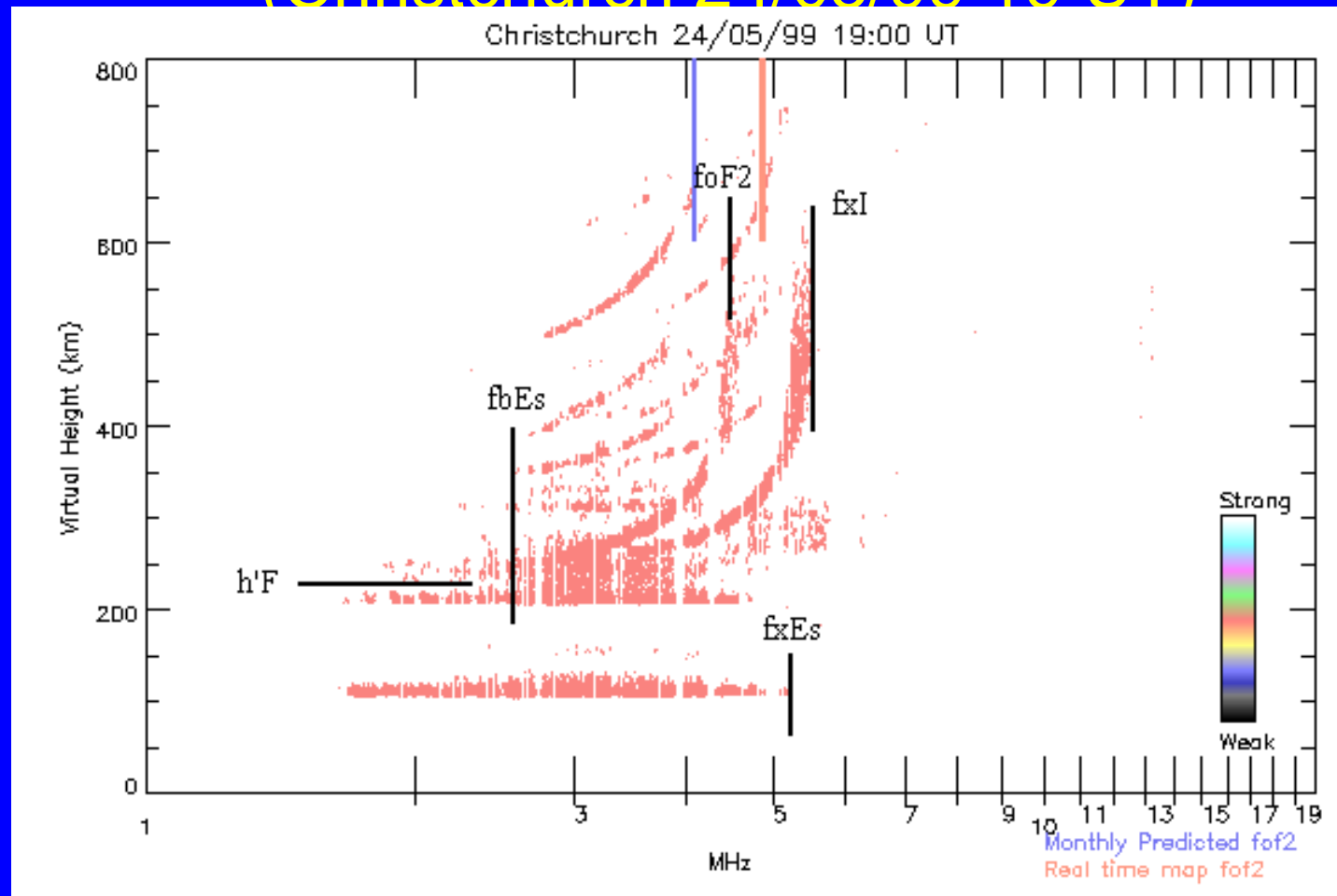
Sample Ionograms : nighttime (Hobart 27/05/99 07 UT)

- F region
 - straightforward
- E region
 - foEs: decide where fxEs is, and subtract split, or scale where the break in trace appears
 - fbEs is easier,
 - foE: (__ EB), since F trace shows retardation
 - h'E: (00 . S) replacement letter S
- fmin
 - follow the weak trace through here as no discontinuity

Sample Ionograms : daytime (Christchurch 24/05/99 19:00 UT)



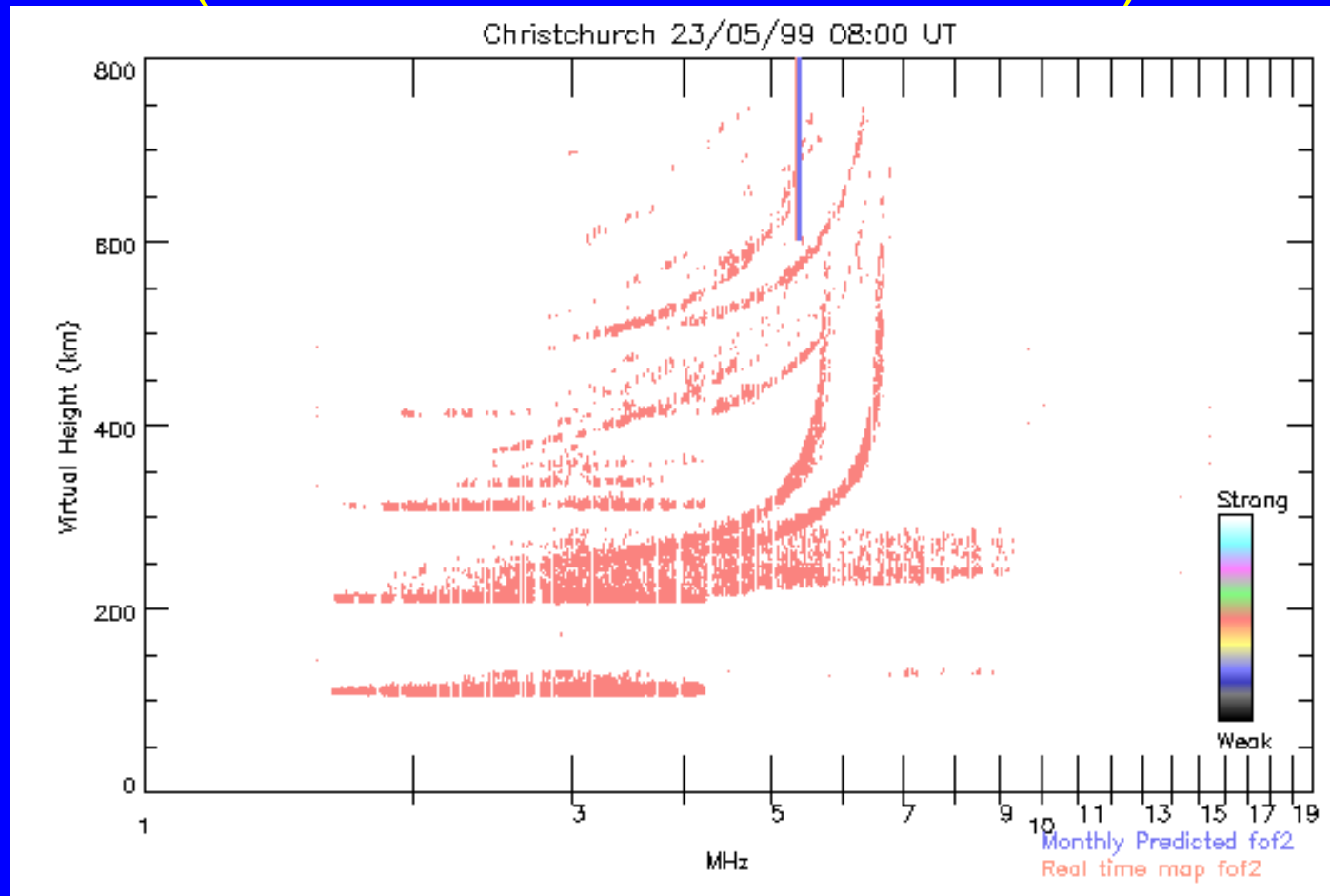
Sample Ionograms : daytime (Christchurch 24/05/99 19 UT)



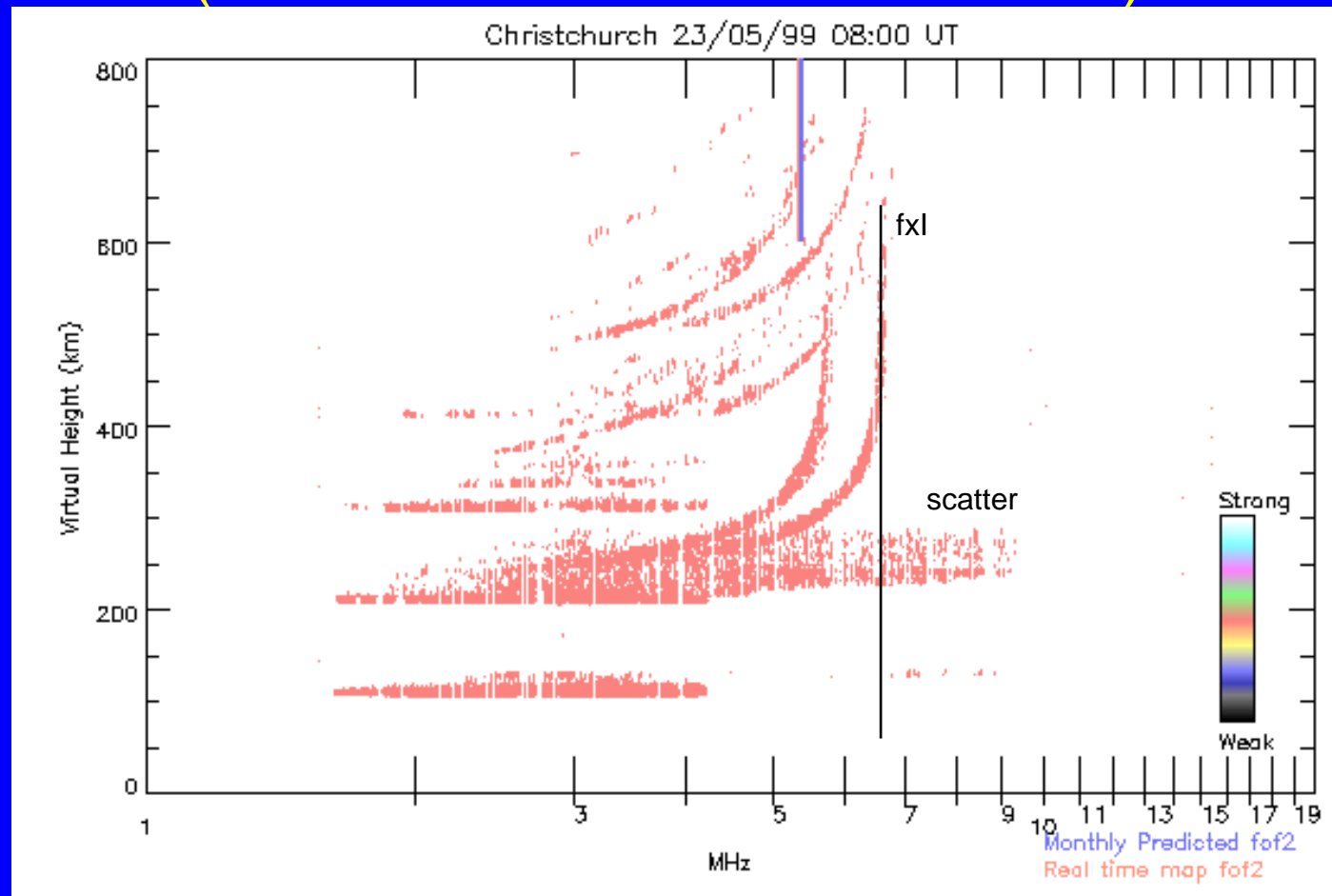
Sample Ionograms : daytime (Christchurch 24/05/99 19 UT)

- F region
 - foF2 (___ . F)
 - h'F: possibly (___ . .), maybe (___ UA)
It is reasonably clear where it tends to.
- E region
 - Identify, and ignore oblique traces
 - foE required? Know the time.
 - foEs = fxEs - split (___ JA) Let program do it

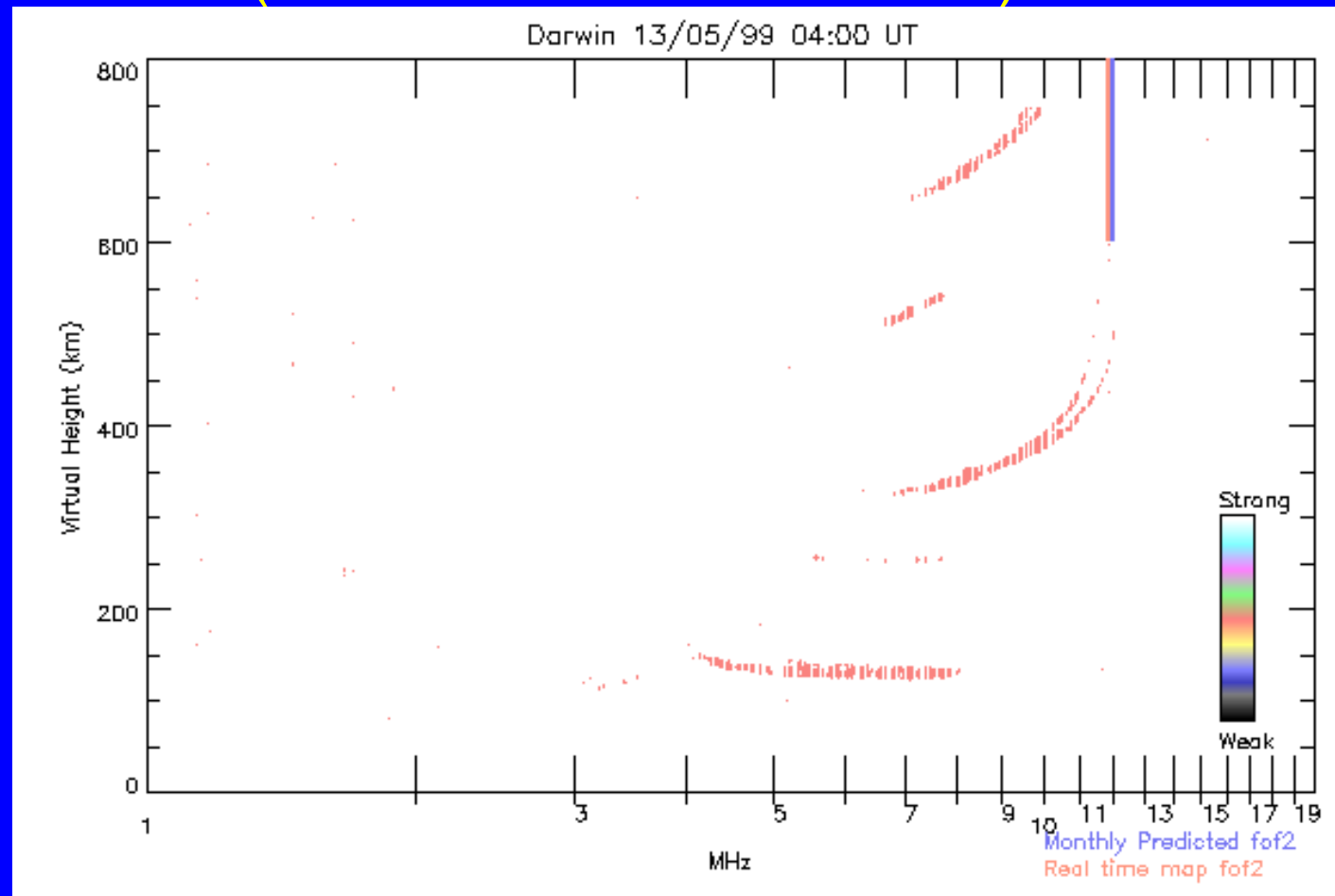
Sample Ionograms : daytime (Christchurch 23/05/99 08 UT)



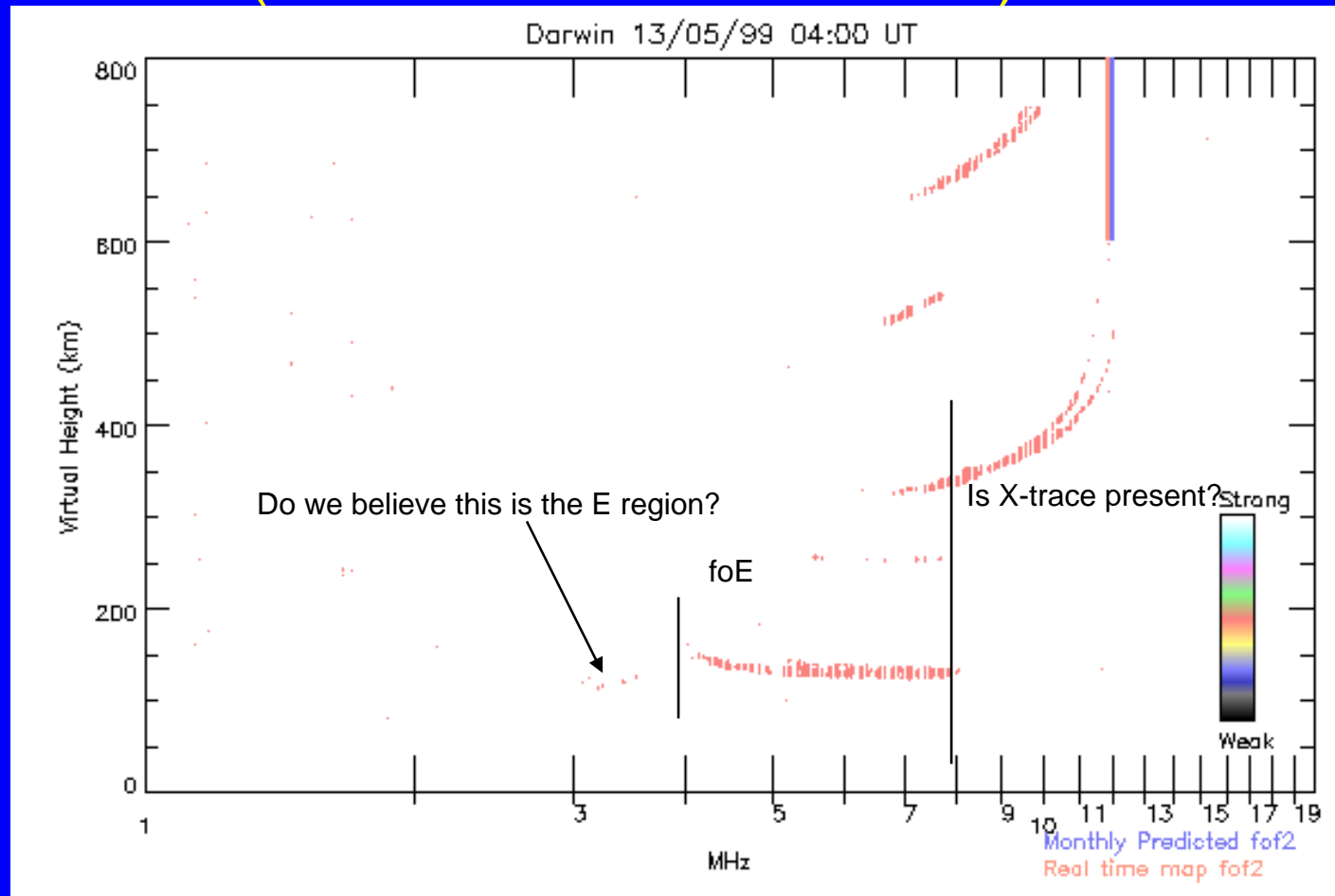
Sample Ionograms : daytime (Christchurch 23/05/99 08 UT)



Sample Ionograms : daytime (Darwin 13/05/99 04 UT)



Sample Ionograms : daytime (Darwin 13/05/99 04 UT)



Accuracy

- Feel confident about your interpretation
- Use accuracy rules to communicate your confidence
- Estimate of accuracy:
 - no scaling letters; within 5% (__ ..)
 - descriptive letter; possible errors (__ .#)
 - qualifying letter U; 4 to 10% accurate (__ U#)
 - qualifying letters E&D; within 20% (__ E/D #)
 - replacement letter; over 20% uncertainty (0 . #)
- As many values as possible should be scaled.

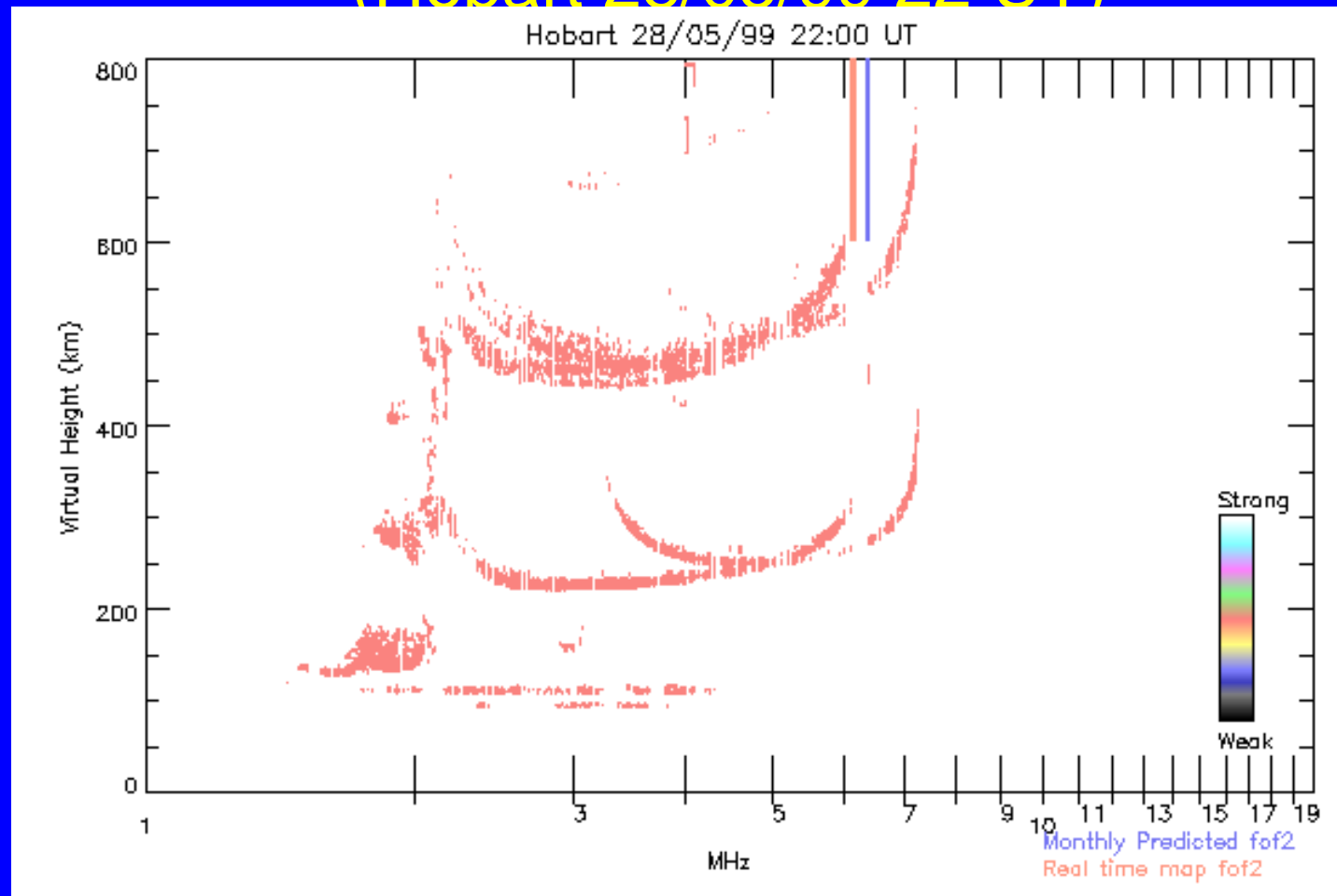
Estimating parameters

- Frequency
 - use x-mode to infer o-mode, (___ J #)
 - use o-mode to infer x-mode, (___ O #)
 - use z-mode to infer another mode (___ Z #)
 - All these imply an unknown, possible error
- Heights
 - $h'z < h'o < h'x$
 - with experience, you can estimate $h'o$

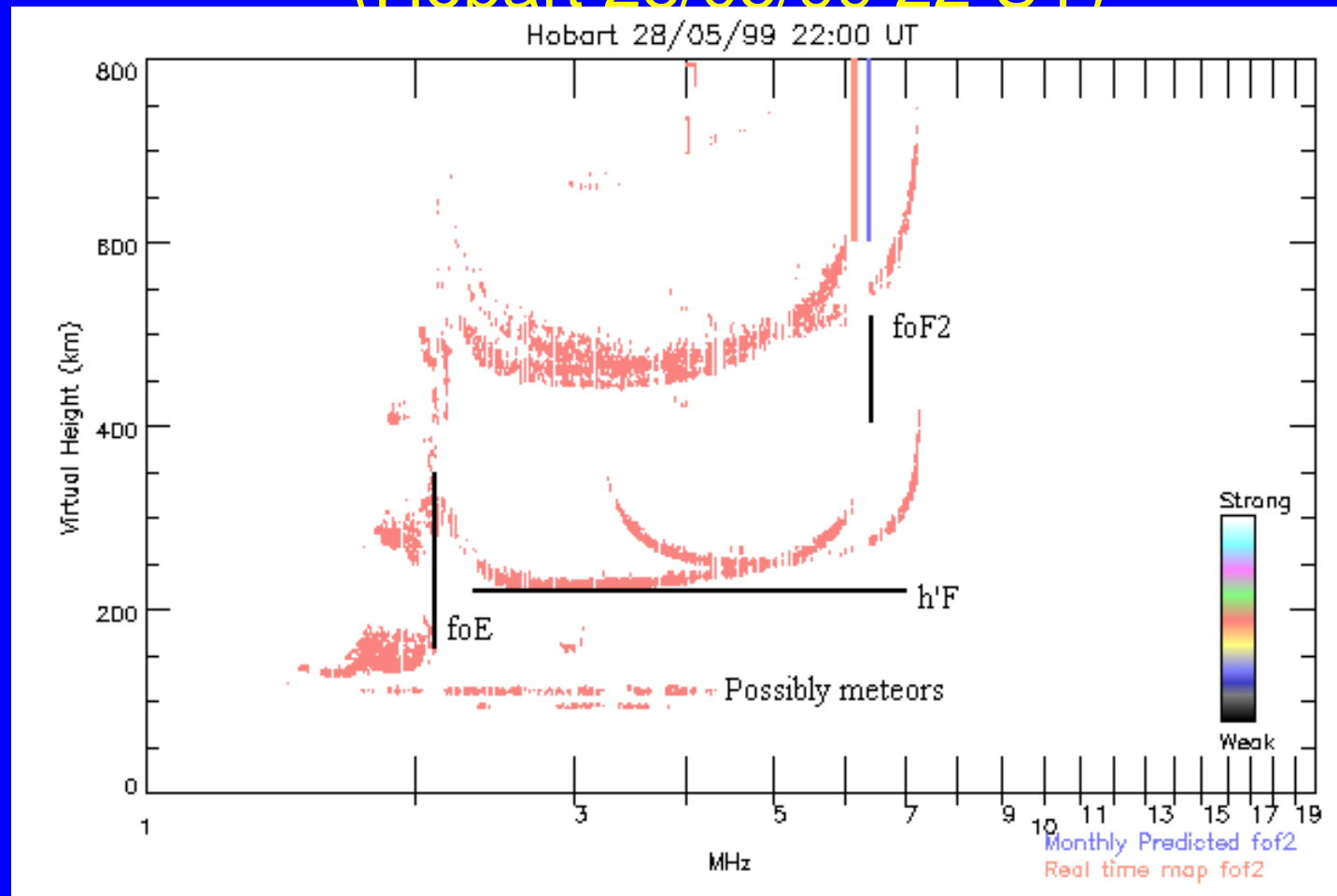
Flags

- F : spread F, spread exceeds 0.2 MHz
- k type Es : particle E present
- l type Es : fmin is scaled from low type Es layer
- L : mixed range and frequency spread (unusual)
- P : fxl measured from oblique, or unusual spur
- Q : range spread, spread exceeds 30 km
- X : no spread present in F region
- Z : Z-mode present in layer
- Disturbances : R, V, H, Y usually used on parameters

Sample Ionograms : daytime (Hobart 28/05/99 22:00 UT)



Sample Ionograms : daytime (Hobart 28/05/99 22:00 UT)



Sample Ionograms : daytime (Hobart 28/05/99 22 UT)

- F region
 - very easy
- E region
 - foE: looks spread, but fxE isn't? (___ . H)
 - foEs: possible meteor traces. Right characteristics. Check the sequence.

Oblique sporadic E or ?

