Catch a Wave

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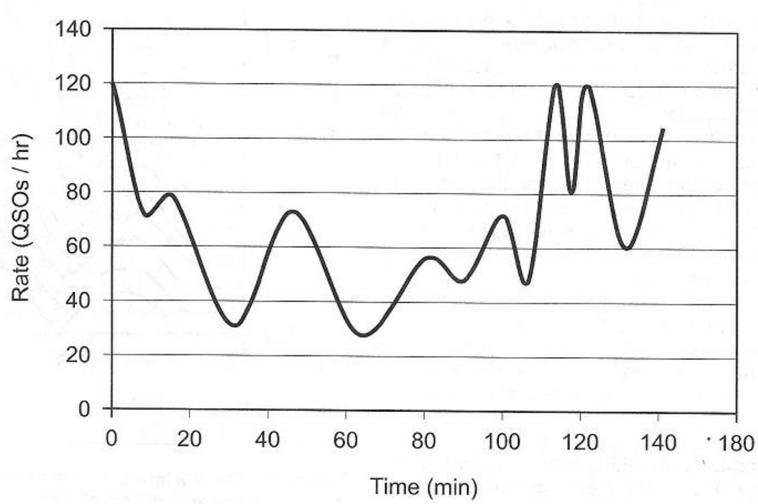
No, no, no – I'm not going to talk about Jan and Dean's old song (see image on the right) that said "grab a board and go sidewalk surfing with me." By the way, the Beach Boys had their version of this song, too.

What I'm talking about is a wave-like structure of the F2 region of the ionosphere – more commonly known as a traveling ionospheric disturbance (TID).

I first talked about TIDs in my Propagation column in the December 1999 **WorldRadio** magazine. Bob NM7M (SK) and I looked at data from the Boulder ionosonde – the height of the F2 region maximum electron density in December 1980 and the 3000 km F2 region MUF (maximum usable frequency) in February 1981. Both showed a cyclic pattern.

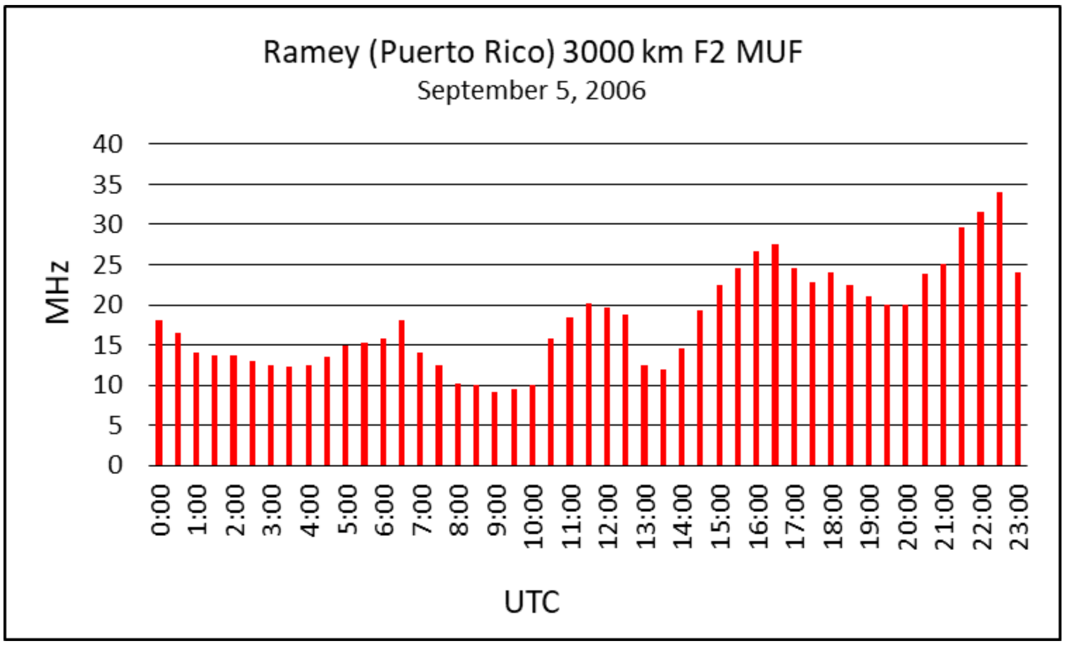
My next encounter with TIDs was during our DXpedition to YK9A (Damascus, Syria) in February 2001. I'm pretty sure I experienced TIDs on 10-Meter SSB one afternoon. I could work North America for several minutes, but then they'd go away. Several minutes later, they'd appear again and I worked as many as possible until they disappeared again. Several minutes later they would be back. This repeated for quite a while, and suggested that the F2 region MUF was cyclic in nature – in other words, a TID.

In my Propagation column in the July/August 2001 issue of NCJ (the **National Contest Journal**), TIDs again were discussed as an answer to a cyclic run rate seen by NC7W in his CQ WPX CW effort in 2000. Here's part of his log plotted in terms of the run rate as calculated in intervals of 12 QSOs (a short-term look as opposed to the more usual long-term 1-hour look).



The cyclic nature of the run rate is obvious, and I attributed this to TIDs. I backed up this assumption with more ionosonde data – from a 1989 **Radio Science** paper showing F2 region TIDs.

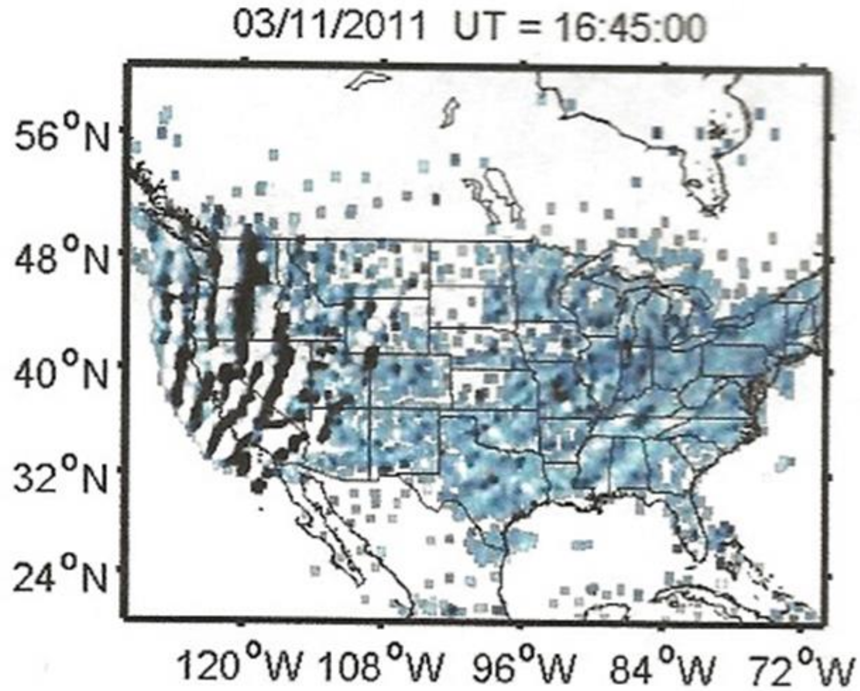
Now let's fast-forward to my Propagation column in the June 2008 issue of **WorldRadio**. I was analyzing early morning QSOs in September between a station in Florida to the area of southern Africa and the Indian Ocean on 15-Meters and 12-Meters during the solar minimum period between Cycles 23 and 24. The fact that these were equatorial paths certainly helped, but when I downloaded ionosonde data from the Ramey (Puerto Rico) ionosonde, I saw the following.



The cyclic nature of the ionosphere (TIDs) is obvious. Unfortunately Ramey is south of the paths from Florida to southern Africa and the Indian Ocean, so all the above data shows is the general characteristics of the low latitude ionosphere during that period. But it shows that TIDs could have been happening along the paths I was analyzing [note 1].

Let's again fast-forward – this time to March 11, 2011. That's when a magnitude 9.0 earthquake occurred near Tohoku, Japan at 0546 UTC. This event is discussed by Irfan Azeem, Sharon Vadas, Geoff Crowley and Jonathan Makela in their paper titled "*Traveling ionospheric disturbances over the United States induced by gravity waves from the 2011 Tohoku tsunami and comparison with gravity wave dissipative theory*", **JGR: Space Physics**, 122, 3430-3447, 2017.

The ensuing tsunami with 9-meter waves traveled across the Pacific Ocean and arrived at the US West Coast about 11 hours later. TEC (total electron count) data over the western US showed the following perturbations around 11 hours after the earthquake occurred – when the tsunami arrived on the West Coast.



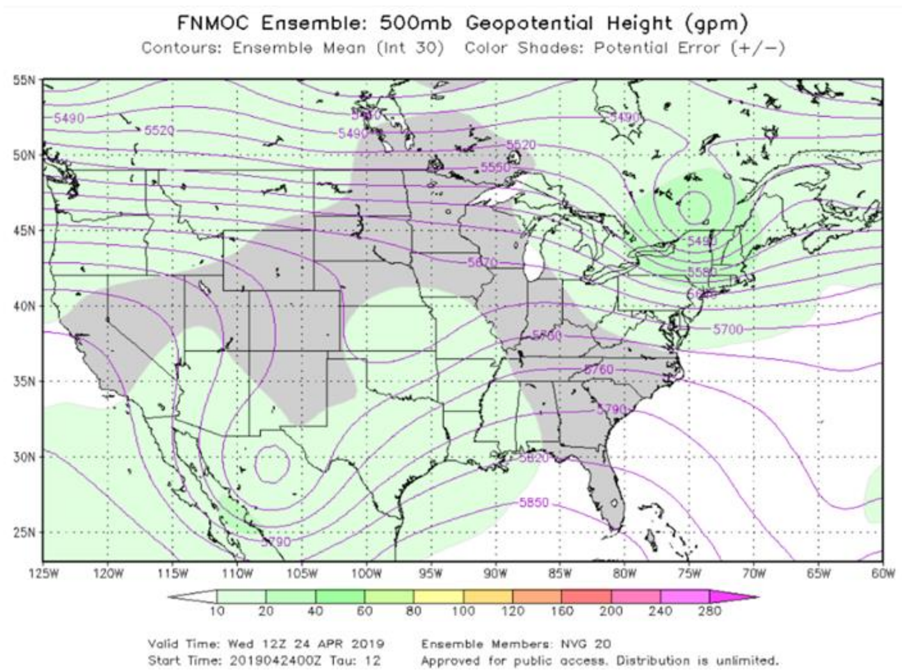
The wave-like structure of a TID in the ionosphere is very obvious here, too. The light blue data are positive perturbations in TEC (up to +0.03 TECU), while the dark blue/black data are negative perturbations in TEC (up to -0.03 TECU). TECU is TEC units – one TECU is 1E16 electrons/square meter.

That's enough of old examples of TIDs. What causes TIDs? They are caused by atmospheric gravity waves (AGWs) that may be generated in the lower atmosphere by events in the lower atmosphere (or even at ground level as is the case of the Kohotu earthquake). These AGWs may then couple up to the ionosphere to cause TIDs.

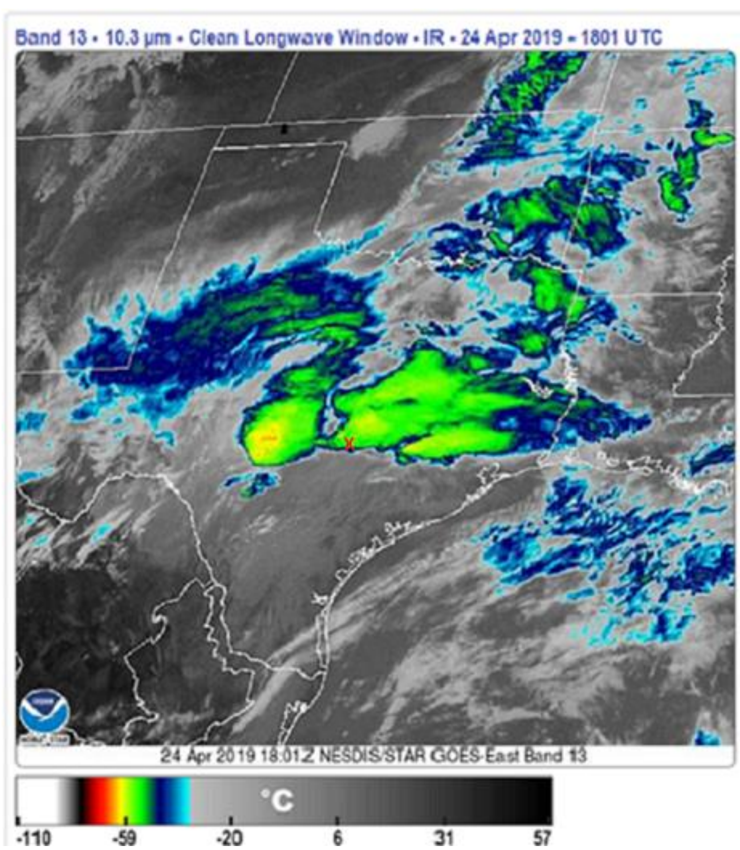
All of these examples of TIDs have sent Larry N6NC, C. Gabriel (Scripps Institution of Oceanography, University of California San Diego) and me on a mission – to try to catch a lower atmospheric event that generates an AGW and then results in a TID as seen in ionosonde data.

This has turned into a daunting task. One issue is how big does an event have be to generate an AGW and then a TID? A second issue is something I've experienced many times over the years – there's usually not an ionosonde where you need one [note 2]. And even if there is an ionosonde located nearby, the cadence may not be sufficiently fast to catch the cyclic nature of a TID. For example, many ionosondes take data only every 15 minutes.

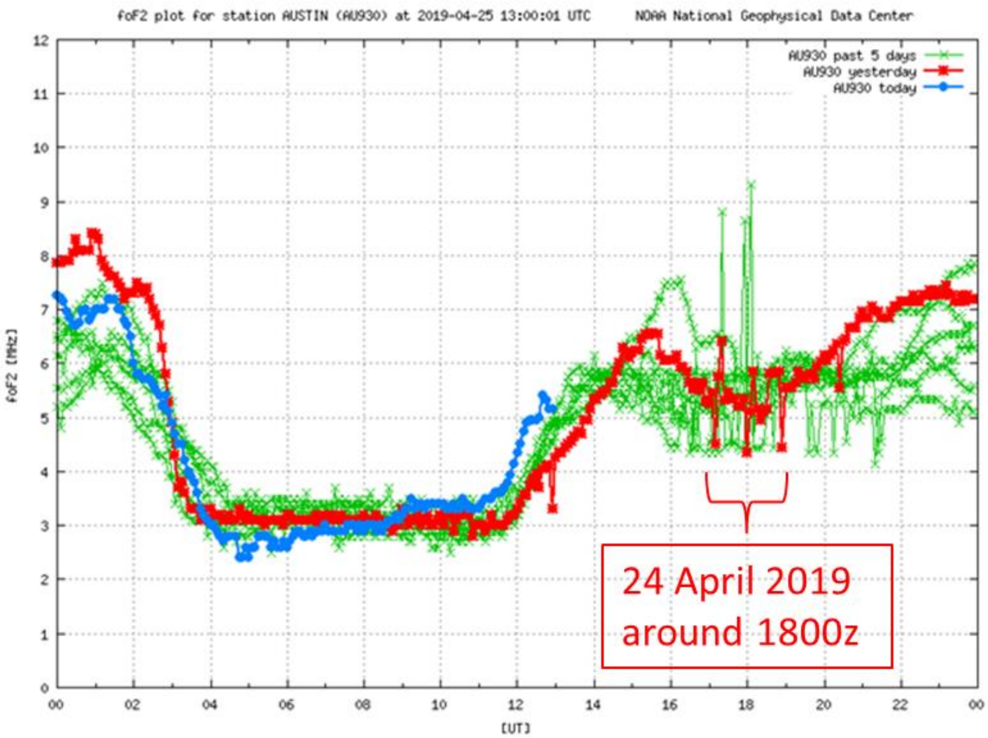
Our best "catch" to date is the thunderstorm activity over Texas in late April (2019). Here's the 500 mb weather map on April 24, 2019 at 1200 UTC. Strong thunderstorm activity is predicted in the Texas area due to the low pressure area southwest of Texas.



Here's the atmosphere at infrared wavelengths (10.3 µm) on April 24 at 1801 UTC, with the Austin, Texas ionosonde location indicated with a red x. The thunderstorm tops appear to be at 33,000 feet or so.



And here’s the Austin ionosonde data for April 24 (the red curve). Possible TIDs are highlighted from 1700-1900 UTC (noon to 2PM local time).



We have much more work to do. We realize that we may have to look at more intense weather events than thunderstorms. So stay tuned. Maybe we’ll capture our goal one of these days.

Notes

1. What could have caused the Ramey TID? I have no proof, but Hurricane Ernesto (Aug 24 to Sep 1) and Hurricane Florence (Sep 3 to Sep 13) could certainly have been a factor in generating the TIDs seen in the Ramey data.

2. This is where TEC data can come in handy – as long as you’re looking over land areas where there are numerous GPS receivers.