Effects of solar generated ionosphere disturbances on imminent earthquake strike zones during passage of the solar terminator

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(Please note: this is the text of the presentation which I made at the IWSE 2005 in Chofu during the Thursday afternoon session. I have made only slight modifications to make this more suitable for written, rather than oral presentation. If you wish a more detailed summary of my work and findings, please e-mail me at theraproject@hotmail.com and I will be happy to e-mail you a copy.)

The Thera Project was initiated in 1999. Our primary focus is on seismic studies and forecast. We examine not only certain precursor phenomena associated with earthquakes, but how they fit into the overall cycle of seismogenic zones as a whole. We do not look at precursors simply as reactive symptomatic phenomena, but as active phenomena which can affect the rate at which fault zones reach the critical failure point.

My primary area of investigation has had to do with external phenomena, notably solar generated phenomena. It may seem a very odd approach, but bear in mind that solar activity can influence events at ground-level on the Earth in a number of ways: for example, causing surface charging in pipelines and power grids. I will get back to this specific example a bit later, because it ties in to some of the satellite data on the ionosphere I've gathered, and plays a very important role in one scenario for pre-seismic activity. But I first want to say that I in no way disagree with the concept of plate tectonics as the basic mechanism behind earthquakes. I am merely saying that because fault zones that are about to rupture are under tremendous stress, it is not unreasonable to believe that they are very susceptible, and can potentially be pushed to the brink a little sooner by outside influences. Perhaps a better way to say it is that outside influences might accelerate some of the internal processes of fault zones, and SLIGHTLY speed up the time frame for an earthquake.

I initially started the research by taking specific earthquakes, and for each one, looking at the solar activity for the days leading up to the quake. The catalogs of the U.S based Space Environment Center were the source of my information. They provide precise data as to the timing of solar events.

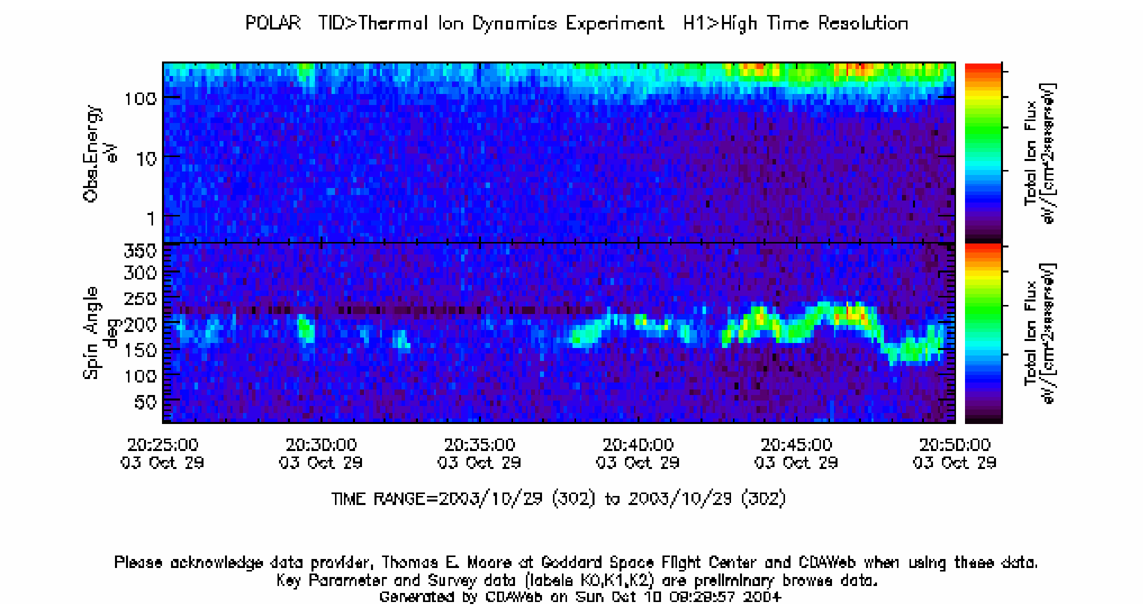
Upon closely looking at the solar event reports, I found there was a recurrent pattern. In a large number of earthquakes, I found that at least one sweep frequency radio burst., or at least one X-ray surge had occurred shortly after sunrise, or shortly before sunset, 24 to 48 hours before the earthquake: in other words, shortly after or shortly before the solar terminator passed over the subsequent earthquake strike zone. I have averaged out the time frames for the events, and it works out to within about 40 minutes after sunrise, or 40 minutes before sunset. However, because phenomena need time to travel to the earth, I have accepted events which might occur shortly "before" sunrise as well.

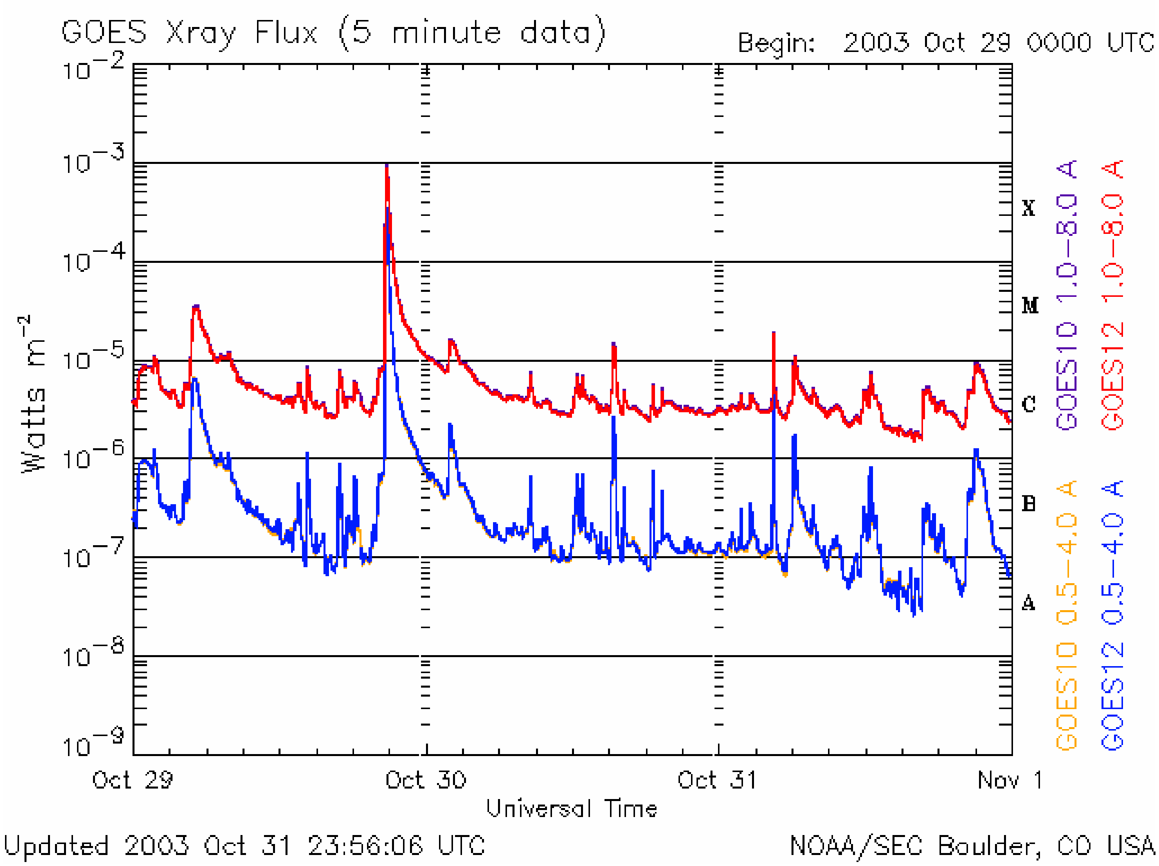
The two solar events, by the way, are connected. Teams working with the YOKOH satellite in the 1990s determined that Type III sweep frequency bursts propagate in soft X-ray jets; other types of sweep frequency burst are associated with X-ray surges that accompany coronal mass ejections.

Since last year, I have been looking at whether there were any indications of anomalous reactions in the ionosphere following these solar events, when the terminator was close to an earthquake strike zone. I have come up with some good correspondences.

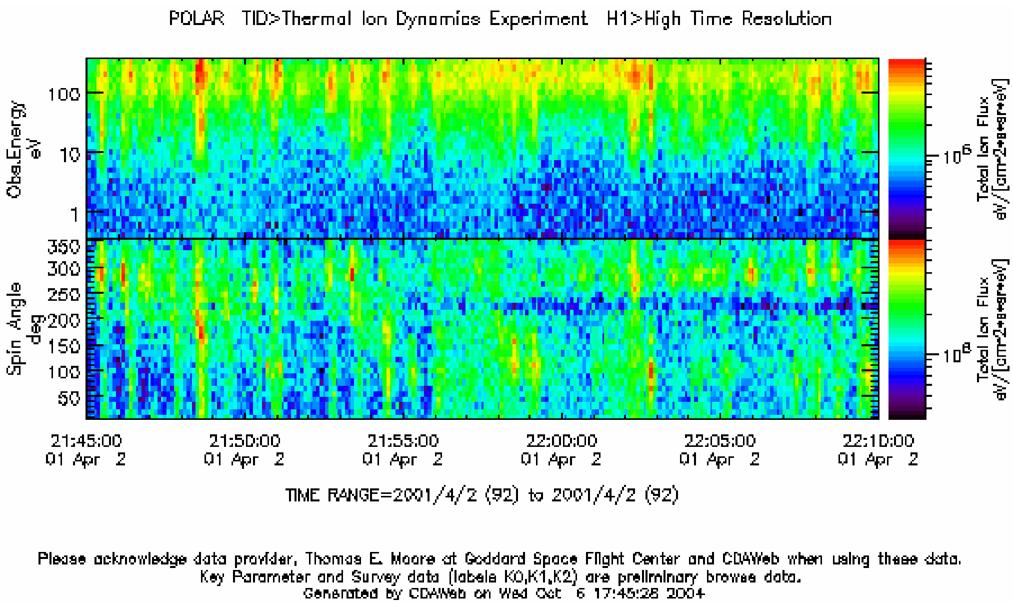
First, I want to show you a couple of examples of ionosphere data taken within 25 minutes after very strong solar events, so you can compare them to the others which I have associated with earthquakes. These data are from the TIDE instrument on the Polar spacecraft, which was launched in 1996. The TIDE instrument takes measure of ions which are of a type that are known to originate in our own ionosphere, and which have gained enough energy to escape that region and travel much farther out from Earth. This of course would be expected to occur during periods of geo-storming caused by strong solar events, or during the impact of a strong sudden impulse event. We will be looking at spectrograms showing the relative ion energies observed by the instrument, as well as their spin angle.

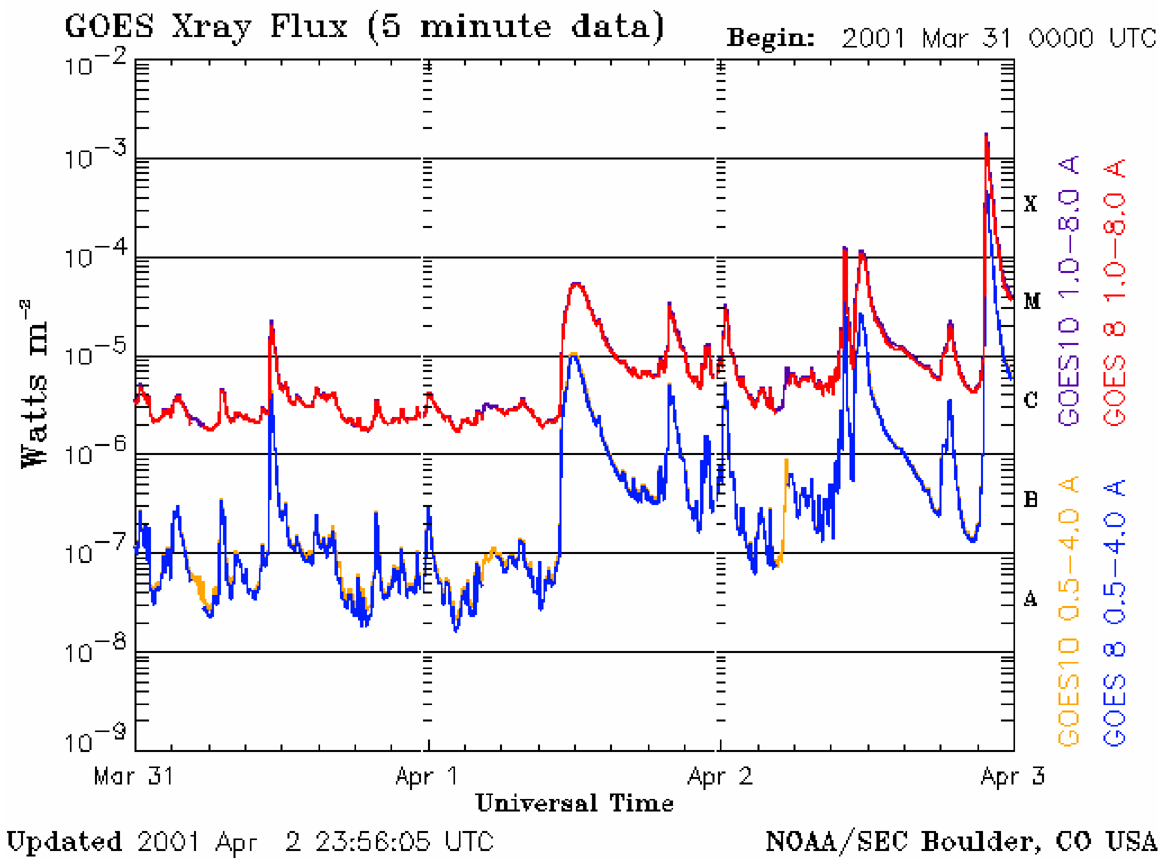
<u>The TIDE data, by the way, is provided through NASA's Coordinated Data Analysis web, courtesy of Dr. Thomas Moore at the Goddard Space Flight Center.</u>



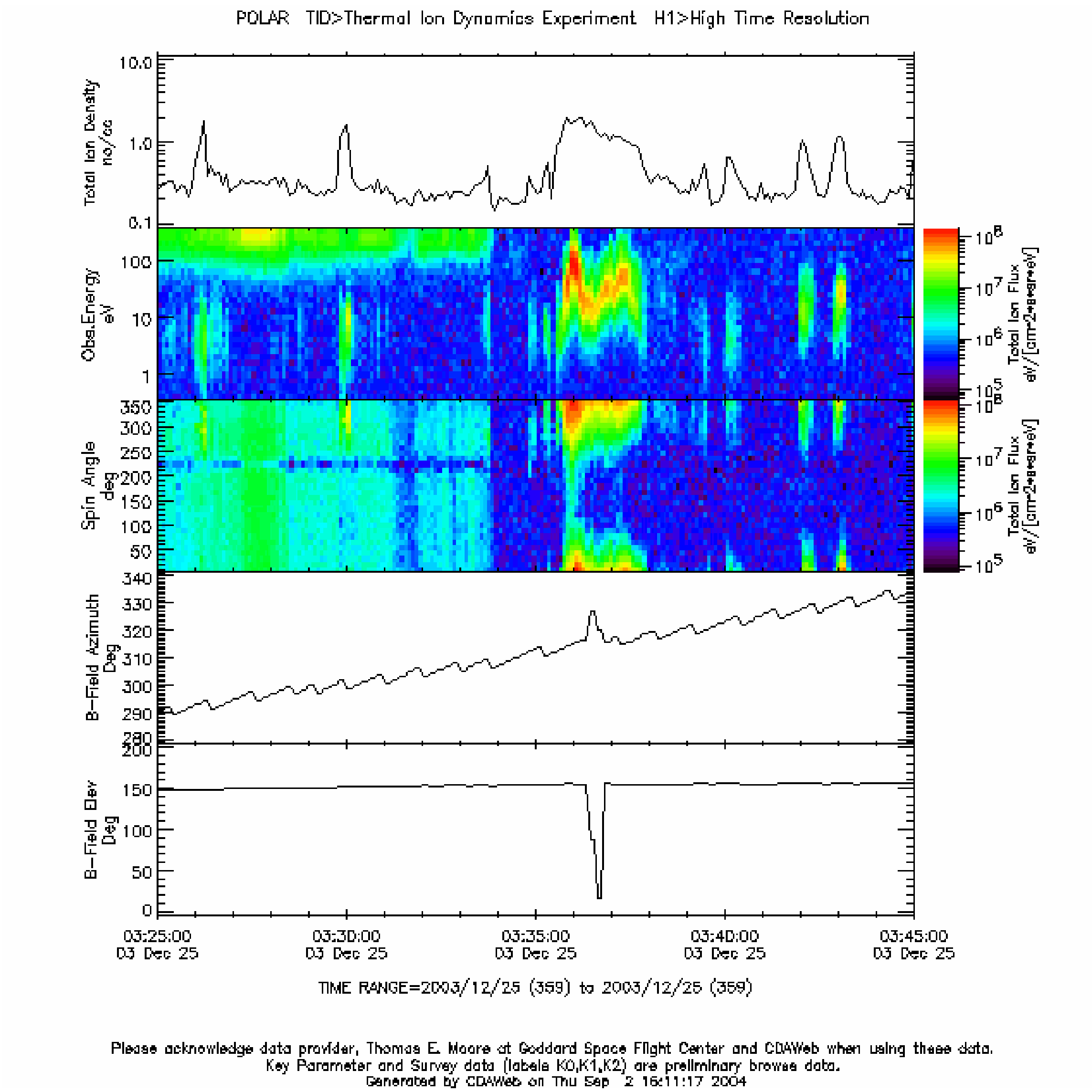


This first spectrogram set shown above covers the 25 minute period after an X-10 level event in October 2003. Beneath the spectrogram I have included the GOES X-ray plot for that day so you can see how sharp the X-ray surge was. Yet these spectrograms do not show much activity at all. The 25 minute time period is important, because it is within this period, following either a sweep-frequency burst or X-ray surge that I have noted reactions in the spectrograms associated with subsequent earthquakes, which I will show you in a few moments.



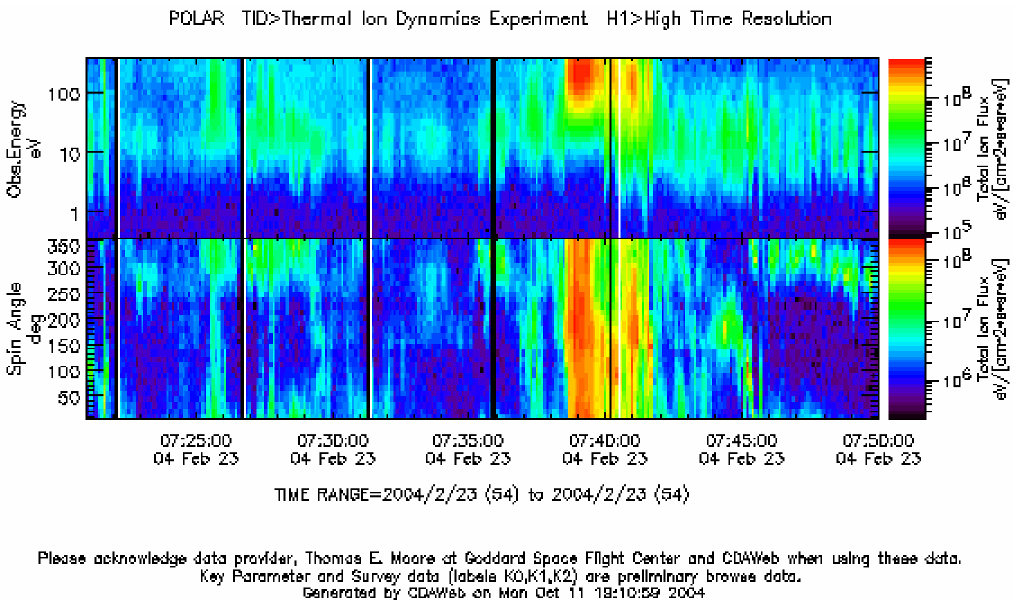


The next spectrogram set, shown just above this paragraph, covers the 25 minute period after an amazingly strong X-ray surge, which also had two sweep frequency bursts associated with it. This is one of the most powerful solar events on record. But, even though the spectrograms show some heightened levels of activity immediately after it, we do not see the concentrated reactions found in the spectrograms taken before earthquakes. The first of these examples is directly below.



This spectrogram was taken the day before the earthquake which hit Bam, Iran in 2003. (GFX 4) A sweep frequency burst had occurred at 3:26 Universal Time, which was about half an hour after sunrise. Within 10 minutes of that event, we see a sudden small, but very concentrated reaction. This spectrogram has additional data, which we will not see in most of the others I will be showing you. I excluded the non-spectrogram data from them simply because the spectrograms were the most unique readings in each case; in this chart, we also see a jump in total ion density registered by TIDE that coincides with this increased spectrogram activity, among other data.

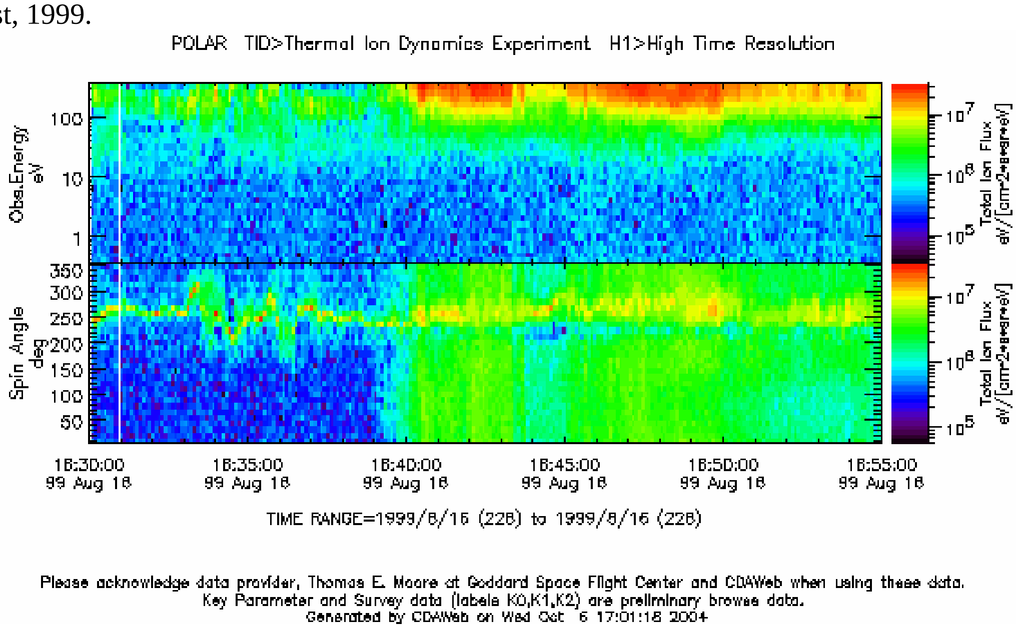
Moving along to a more vivid spectrogram:



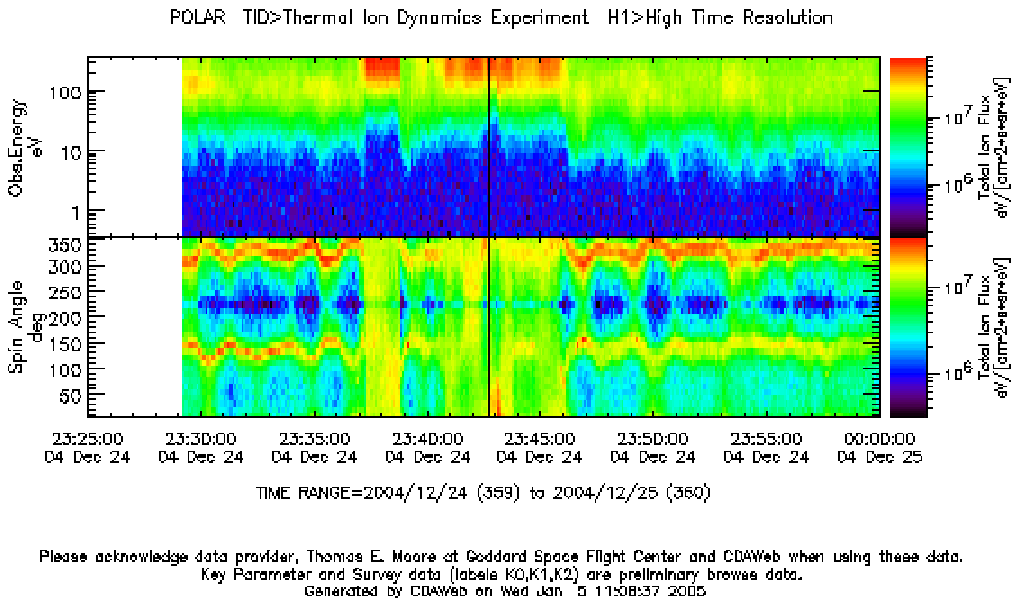
This was taken the day before a strong earthquake struck off the coast of Morocco early last year. About 26 minutes after sunrise at the epicenter, a sweep frequency burst occurred. 18 minutes later, the TIDE instrument picked up a definite surge with its spectrographic equipment.

There were no strong solar events prior to this sweep frequency radio burst, or the one which I showed you for Bam, which could account for the reactions; nor were there any periods of geo-storming. We must ask why there was a concentrated reaction after these two relatively mild radio events.

Another spectrogram now, this one associated with the strong earthquake which hit Turkey in August, 1999.

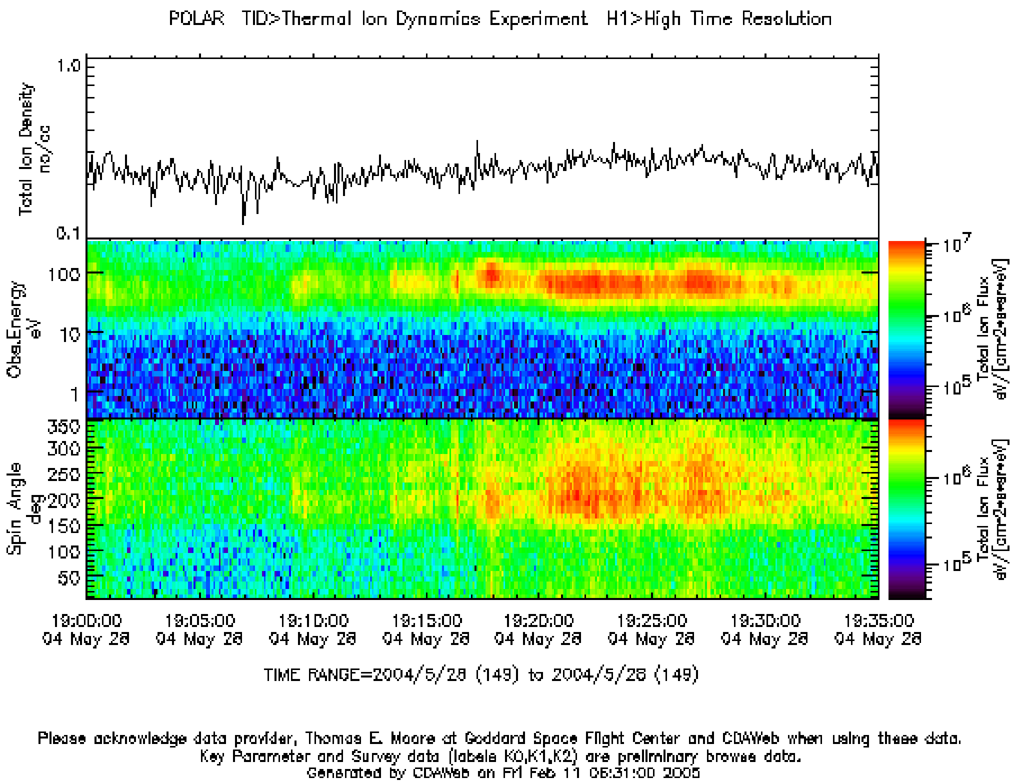


This spectrogram shown above was taken after a relatively mild X-ray surge the day before the earthquake. The X-ray event occurred at about 16:37 UTC, shortly before sunset. What is unusual about this spectrogram is that you will note an apparent reaction begins just about three minutes after, at 16:40. Now this is far too fast for any phenomena, even traveling at relativistic speeds, to reach the Earth, much less the TIDE instrument. It appears to die somewhat, and a few minutes later, actually about ten minutes after the X-ray event, we see it pick up again. This has bearing on something I will discuss in one minute, but first, I think there is a question some of you may have, and the answer is, yes, I have a correlative spectrogram for this past December's earthquake off of Sumatra.



A sweep frequency burst occurred at 23:22 UTC, 15 minutes before sunrise at the epicenter the day before the earthquake. As I mentioned earlier, since solar-generated phenomena cannot arrive instantly at the earth, we must allow some travel time before we can expect a reaction. And this spectrogram does indeed show a reaction, occurring right at sunrise. Again, there were no strong solar events before this one radio event, and the KP index was quite low for this period as well, ruling out geo-magnetic disturbances.

Another example of reactions associated with a pre-sunrise solar event: is found below.



This is a spectrogram taken after a very low-level, B class X-ray surge occurring about 15 minutes before sunrise at the epicenter of the May 30th earthquake, with a magnitude of 6.6, off the coast of Honshu. This event occurred the day before the quake, and the concentrated reaction begins right at the point of sunrise. Note there is a very slight jump in ion density at about 19:17 UTC, corresponding with the increased activity in both the total ion energy and ion spin angle spectrograms.

So what is happening in these spectrograms, and why are we seeing reactions to very low level events that ought not to be producing any significant change in readings? I think the answer has to do with conditions within the ionosphere itself prior to the earthquake. One condition that would explain these unusual reactions is the penetration into the ionosphere of an electro-static field from the fault zone. This conference is not the first time we have heard these discussions; in fact the theory was put forth, I believe, at this previous IWSE.

We know electro-static fields can work in a couple of different ways. In one case, an object can have an electric charge greater than its surroundings. So perhaps a fault zone, at a high level of tectonic strain and quite possibly a much higher level of geo-conductivity, could be sustaining an electrostatic field that can penetrate the ionosphere. This was modeled by Dr Grimalsky and his associates in a 2003 paper. But now let us suppose that a solar disturbance occurs at a critical time; right after passage of the terminator at sunrise, or right before it passes at sunset. Ionosphere turbulence is stronger at these times; if we factor in additional disturbance from a solar event, it could have significant consequences for the electro-static field. We might, in fact, see it discharge and collapse. This could account for the increased energy needed to send a stream of ions out of the ionosphere, to the point where they could be detected by TIDE.

But I want to take it a step further; and to explore the possibility that these solar events may actually be intensifying these fields or perhaps even initiating them.

Let us take a closer look at the spectrogram above, taken the day before the May 30th earthquake off of Honshu last year. The solar event itself occurred at 19:06 UTC. Just a few minutes after this solar event, we see a reaction at TIDE; it then appears to die down, but then strengthens again. The question: could this first part indicate penetration of the electro-static field.. and is this latter part of the reaction indicative of something more complex going on? The re-strengthening, if I may call it such, occurs about eight minutes after the X-ray event, which is within the time frame we would expect phenomena traveling at relativistic speeds to reach the earth. We cannot overlook the possibility that the solar phenomenon could in fact be causing the electro-static field to strengthen.

Solar phenomena can cause surface charging of pipelines and transformer grids at ground level; they do this by generating alternating currents high up in the atmosphere, which in turn cause localized charging on the ground. So at ground level, a solar event could possibly add a little bit more energy to the fault zone-- which, being under high tectonic strain is also more electro-conductive-- thereby causing the electro-static field to strengthen. Perhaps, in some cases, it actually provides the impetus for the field to be generated in the first place. In the case of a pre-existing field, there is also the possibility that the solar phenomena are generating some effect within the ionosphere, which is then overloading the penetrating portion of the electro-static field.

This could have serious consequences for a fault zone, because if an electro-static field becomes too intense, it then becomes a current, rather than a stasis field. This could cause catastrophic damage in a solid dielectric medium; in other words, whatever portion of the fault zone was capable of supporting the field in the first place. If there is some strong electric current suddenly erupting in the ionosphere, of course it would be capable of briefly exciting some of the plasma material there enough to jettison matter out of the region, to a point in space where it would then be detected by TIDE.

One of the key components of my theory is the presence of the terminator. In the case of sunrise events, as the terminator approaches, a foreshock precedes it. This has the effect of compressing not only portions of the ionosphere in its way, but also portions of the atmosphere immediately below it….portions where dry gasses that could be very good dielectric media are found. Compression, or the way in which a dielectric medium can concentrate an electro-static field, is one basis for judging how high its dielectric constant is. If we have a medium which becomes temporarily more efficient because of transitory compression, it could sustain a stronger field. Adding the influence of the solar phenomena, as I've already discussed, could indeed strengthen that field. But what happens when the compression effect wears off? The field has become too strong and, as I have already mentioned, it could then become a current conductor, causing disastrous effects in the fault zone.

In the case of sunset, let us suppose an electro-static field has already been generated and penetrated the ionosphere; perhaps it is generated in response to the solar event, or strengthened by it, but not to the point of conducting current. Then, the terminator passes, the lower region of the ionosphere disappears. The decreased density has the effect of decreasing compression, and again, the field's strength could exceed the dielectric capabilities of the medium. It may strengthen to the point that it becomes a current, and causes catastrophic disruption in a very stressed and susceptible portion of the fault.

I feel the best way to study these interactions, will be to put up several satellites working in conjunction, each monitoring the ionosphere from a specific vantage point with spectrographic and other equipment; having several devices will allow us to triangulate the source of ionosphere disturbances more readily, and pinpoint the corresponding areas of the Earth which may be generating them, and therefore at higher risk of imminent earthquakes. The varying levels of intensity should eventually help us discern patterns that will allow us to determine how strong subsequent earthquakes will be. That is of paramount importance, since we cannot have a valid warning system without determining the level of risk.

A Note on TIDE and Polar: It has come to my attention that my references to ionosphere reactions detected by TIDE might be confusing to those familiar with the Polar spacecraft. I am therefore including a brief explanation of how the data tie in.

Polar is designed to monitor the magnetized plasmas surrounding the Earth at various energy levels; several instruments are on the satellite, including TIDE. TIDE's main function is to observe the activity of core plasmas within the magnetosphere, including the activity of ions originating from the ionosphere and upper atmosphere. (A major breakthrough in the understanding of solar-terrestrial interactions came in 1998, when TIDE observed the ionosphere's reactions to a strong solar CME event; the levels of ions flowing from the ionosphere significantly increased after the shock wave arrived at Earth.)

What TIDE is detecting, then, are ions which have become extremely energized, to the point that they are capable of escaping the ionosphere; references to "ionosphere reactions" in the above sections should be taken in this context; to be more specific, TIDE is detecting the *byproduct* of such reactions. Nonetheless, the TIDE readings are evidence that a reaction is taking place after certain sweep-frequency bursts or X-ray surges. The question becomes, *why* is there an apparent reaction after some of these events, and not others? It seems either the answer does lie not with the solar event, but with the Earth's reaction to it, or that perhaps another sort of solar generated phenomena is occurring.

While the TIDE reactions found in the appendixes below may seem slight or minor, it should be noted that *any* detected reaction after sweep frequency bursts and relatively weak X-ray bursts is significant. If the TIDE apparatus was directly above an imminent quake strike zone that experienced a reaction to solar-generated events, there is a good chance the readings would be far stronger.

As an illustration, consider a night-time thunderstorm as seen from two different points; directly under the storm front, and many miles away. We would see lightning bolts from the first vantage point, but perhaps only faint flashes from the second point. But even these faint flashes are evidence that lightning bolts are, indeed, hitting somewhere, and we know that wherever they are striking there's going to be a lot of light and noise!

So, if TIDE is detecting even a small amount of extra ions from its vantage point, we can be sure that at the point of the ions' origin, there's a far greater outflow. We also can be sure that something must be occurring to excite the ions enough to cause them to escape the ionosphere and make it to the point where TIDE can detect them.

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