

## Correlation Between Time-Specific Solar Activity and Subsequent Earthquakes

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Since 1999, a research associate and I have been examining whether in certain circumstances external influences might prompt earthquakes to occur soon than they normally would have under regular tectonic processes. Specifically, we have been investigating whether it is possible to find a direct pattern of solar activity which precedes seismic events and may be useful as a tool of prediction. We do not in any way discount the accepted models of how earthquakes occur, in other words the plate tectonic schema of how faults and subduction zones work. But we do believe that these processes are not always self-contained, and can in fact be influenced by outside factors.

Specifically we have examined solar activity and subsequent seismic activity, with the aim of determining whether there was a specific event or events on the Sun which could be statistically linked to earthquakes.

After examining the patterns of solar activity ahead of several earthquakes, a pattern did emerge. In a large number of earthquakes, one to two days before the seismic event, the Sun had emitted either a sweep-frequency radio burst or an X-ray surge during a very narrow time frame: within 40 minutes before sunset, or from 15 minutes before to 30 minutes after sunrise. Overall, this is 95 minutes per day, or 190 minutes within the 48 hour period; this represents less than six-point-six percent of the overall time within that 48 hours.

This is an extremely narrow period in which to find a recurring pattern; nonetheless, three statistical analyses show the pattern is so consistent that coincidence must be ruled out.

The two solar events are related. Sweep-frequency bursts of the Type III and Type V variety propagate in soft X-ray jets, while Type II and Type IV are associated with disturbances that frequency are also accompanied by strong X-ray surges as well as coronal mass ejections.

We are performing statistical analyses to determine an average correspondence ration between solar events and subsequent earthquakes. Three are complete so far.

## Statistical Analysis A for Solar/Seismic Correspondence

- 360 consecutive earthquakes listed by the National Earthquake Information Center between May 2004 and June 2004
- 82 percent of the quakes had at least one X-ray surge or sweep-frequency radio burst during 40 minute post-sunrise, pre-sunset windows 24-48 hours before earthquake

*Figure 1: Correspondence solar activity and 360 earthquakes between May and June of 2004*

One of our statistical analyses looked at 360 consecutive earthquakes listed by the National Earthquake Information Center between May and June of 2004. In 82 percent of these earthquakes, the Sun emitted at least one X-ray surge or sweep frequency burst within time frame I have specified.

## Statistical Analysis B for Solar/Seismic Correspondence

- Earthquakes of magnitude 5 or higher in Xinjiang and Qinghai provinces in Western and Northwestern China between 1985 and 2005
- 84 percent of the earthquakes had at least one X-ray surge or sweep-frequency radio burst during 40 minute post-sunrise, pre-sunset windows 24-48 hours before earthquake

*Figure 2: Correspondence of solar activity and earthquakes in Western China from 1985-2005.*

A second analysis of earthquakes of magnitude five or higher in the Xinjiang province in Western and Northwestern China between 1985 and 2005 showed another high correspondence. Of the 45 earthquakes which occurred, 38 had at least one correlated solar event—an 84 percent correspondence rate. This is significant because the time frame involved is a 20-year period, not a period of a few months.

## Statistical Analysis C for Solar/Seismic Correspondence

- Earthquakes of magnitude 5 or higher in Tibet between 1985 and 2005
- 72 percent of the earthquakes had at least one X-ray surge or sweep-frequency radio burst during 40 minute post-sunrise, pre-sunset windows 24-48 hours before earthquake

*Figure 3: Correspondence of solar activity and earthquakes in Tibet from 1985-2005*

In a separate analysis of 53 earthquakes in Tibet, again of magnitude five or higher between 1985 and 2005, the correspondence rate was 72 percent. While not as high as the previous two correspondence ratios, still it is very high considering we are speaking of a 20 year period. It therefore cannot be explained away by saying the results are merely due to a high period of solar activity.

## Some significant earthquakes which match the parameters for pre-seismic solar activity

<b>Java, Indonesia May 2006</b>	<b>Pakistan, October 2005</b>
<b>Banda Aceh, Indonesia December 2004</b>	<b>Bam, Iran, December 2003</b>
<b>Kunlunshan/ Tibet-Qinghai border, November 2001</b>	<b>Chi-Chi Taiwan September 1999</b>
<b>Kobe, Japan December 1995</b>	<b>Loma Prieta, California October 1989</b>

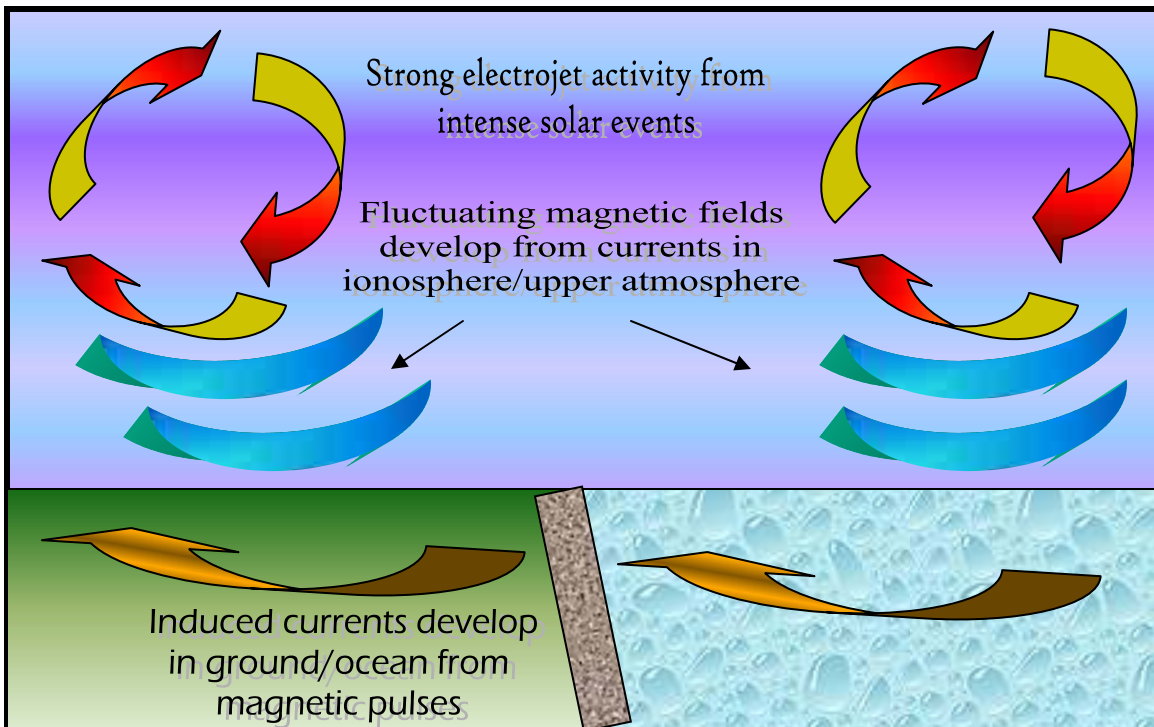
*Figure 4: List of some significant earthquakes which correspond to the precursor solar activity outlined above. A full table can be found at [www.theraproject.com](http://www.theraproject.com)*

Among the significant, well-known earthquakes which meet the parameters are the earthquake which hit Java, Indonesia in May; last October's earthquake in Pakistan; the Banda Aceh earthquake of 2004; the Tibet-Qinghai border earthquake of 2001; the Kobe, Japan event of 1995 and the Loma Prieta, California earthquake of 1989.

Several copies of all of these correspondence tables were distributed during the afternoon for this particular session. However, those who did not receive them may go to [www.theraproject.com](http://www.theraproject.com) and download a PDF version of them by clicking on the tab labeled WPGM tables. These tables detail the specific timing of the solar events correlated with each earthquake in the relative studies.

Because the Thera project places a very high value on the integrity of the data and total transparency as to our sources and methods, this compilation also contain links to websites such as the U.S. Naval Observatory and the Space Environment Center which will allow you to verify the raw data for yourselves.

The main question, of course, is how solar activity could affect the progression of events along a seismic zone.

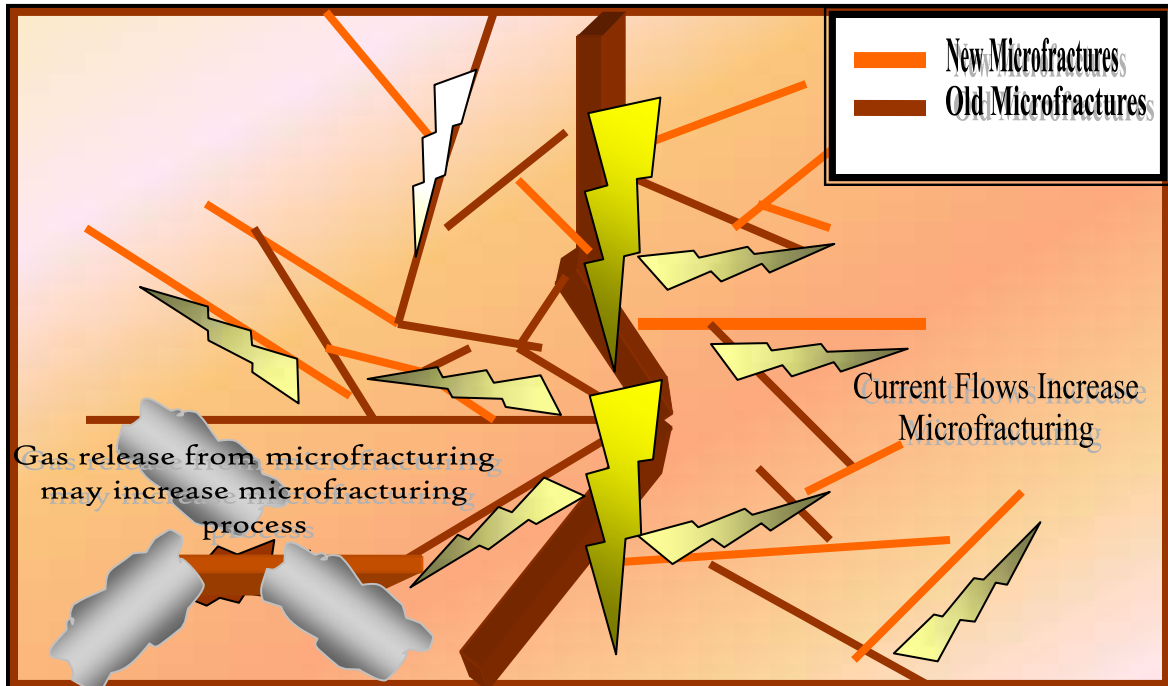


*Diagram A: Basic model showing how solar activity can generate reciprocal currents in both the ground and the ocean.*

We know that strong solar events can generate increased electro-jet activity high above the Earth, which in turn creates irregular magnetic pulses. These pulses induce currents to develop both within the Earth itself and the ocean. The ground currents can affect power grids as well as pipelines; one such event is blamed for the blackout of most of Quebec in 1989.

The possibility that fault zones are susceptible to currents has been explored by previous researchers, including Madden and Mackie who theorized that increased rates of micro-fracturing from tectonic stress would increase fluid distribution in fault zones, thereby making them more amenable to conducting electricity.

So what would happen if an induced current begins flowing in a fault zone under stress?



*Diagram B: Additional currents flowing through a fault zone could increase micro-fracturing rates, further weakening areas under stress. Trapped pockets of gas could also burst out.*

The currents could increase the rates of micro-fracturing, thereby further weakening the fault zone. They could also excite the release of trapped gas, possibly in an explosive manner, causing further instability within the fault by opening up larger cavities.

While direct ground-charging is possible during strong solar activity, there is also an explanation as to how enough ground-charging could take place during more ordinary solar events to affect a fault zone under high stress.

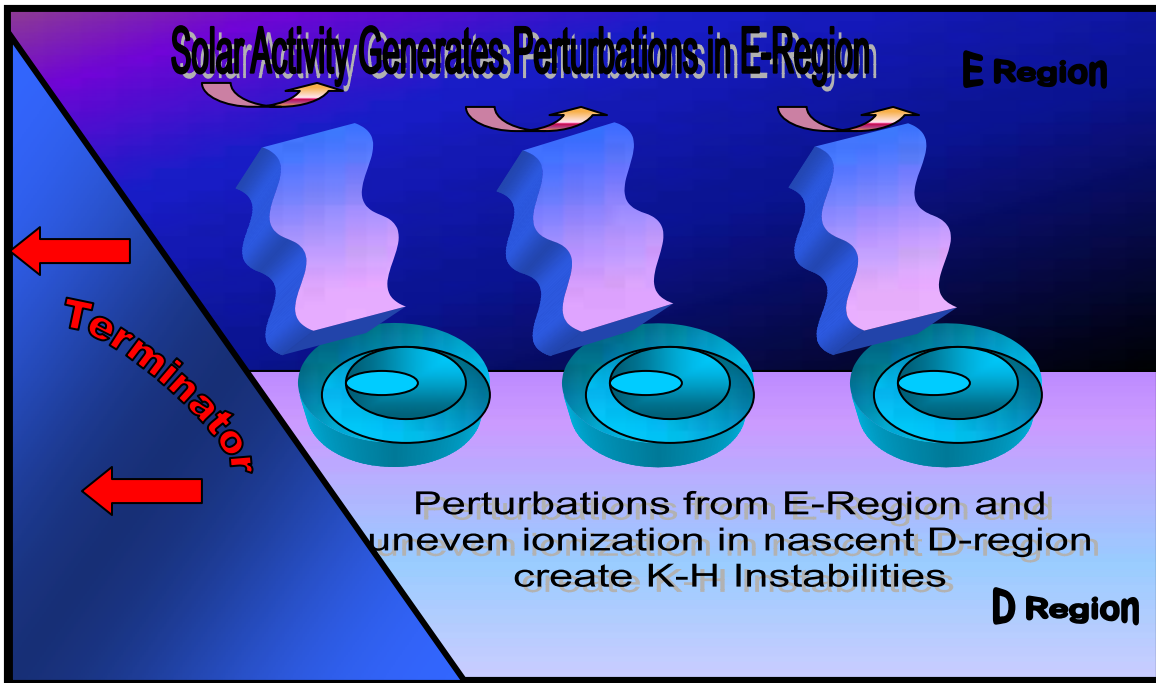
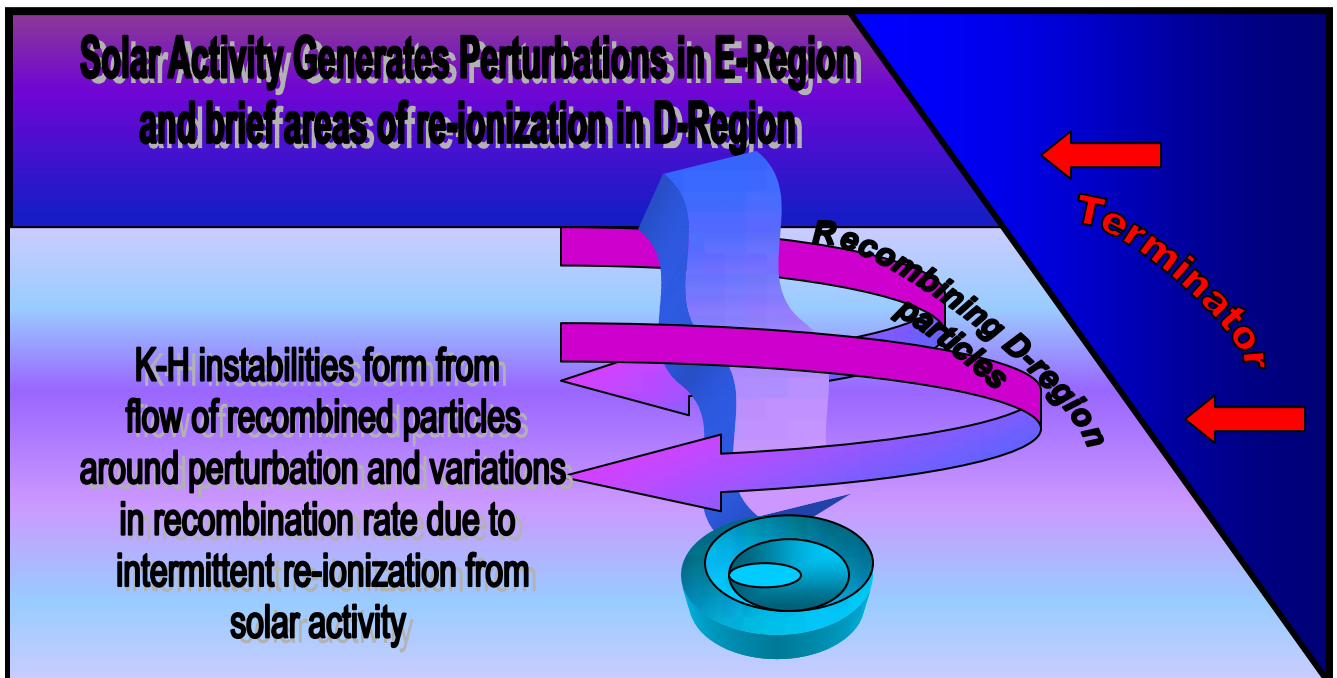


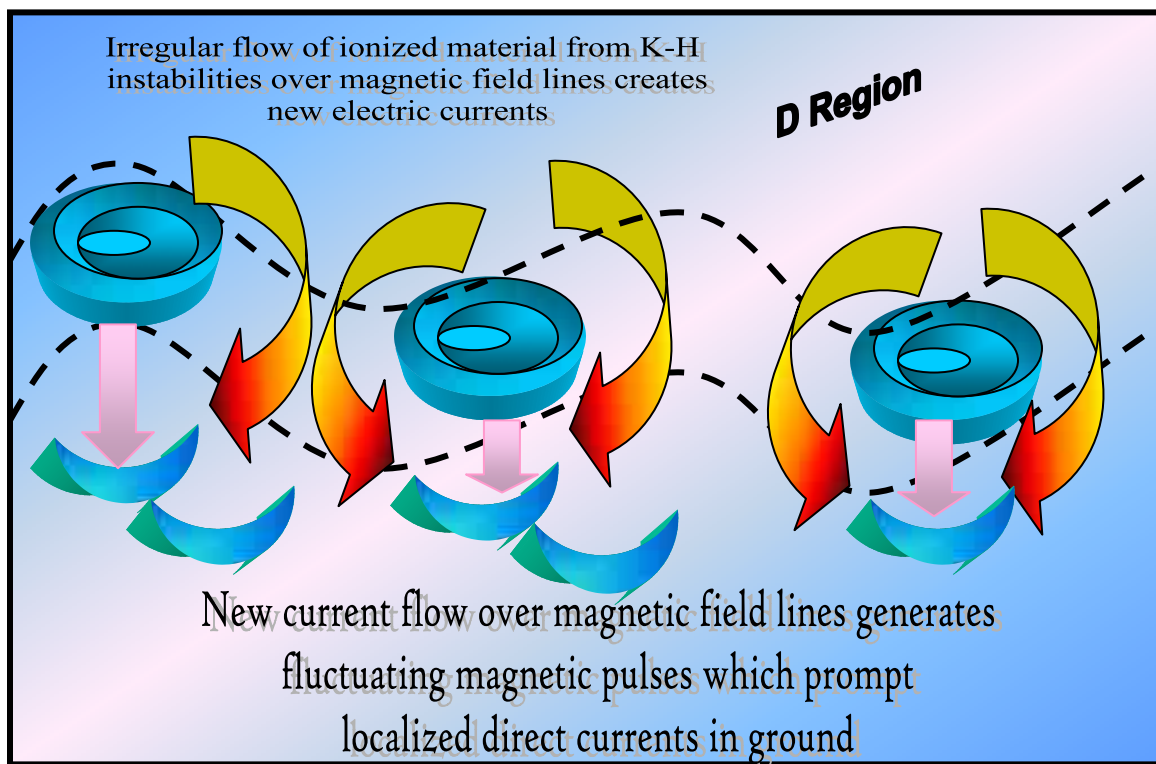
Diagram C: Model showing what may occur when low-level solar activity causes disruptions in the ionosphere at sunrise.

Solar activity occurring close to sunrise could give rise to perturbations within the E-region of the ionosphere, which in turn could cause disruptions in the nascent D-region. The D-region, because it is still ionizing, is already turbulent, and any impinging disruption from the E region would make it more so. Variances in plasma flow rates within the D-region could create Kelvin-Helmholtz instabilities, in other words vortices of plasma.



A somewhat different process will occur at sunset. As any region of the earth approaches the terminator again during this period, recombination rates in the D-region accelerate as the D-region begins to thin. The recombined particles, being heavier than ions, will tend to drift downward, possibly circulating around the perturbations.

X-ray surges especially may temporarily re-excite some of these particles, causing them to re-ionize. With or without fluctuating ionization rates, the downward flow of heavier recombined particles circulating around the perturbations will set up plasma flow variances, again providing the conditions for Kelvin-Helmholtz instabilities to develop.

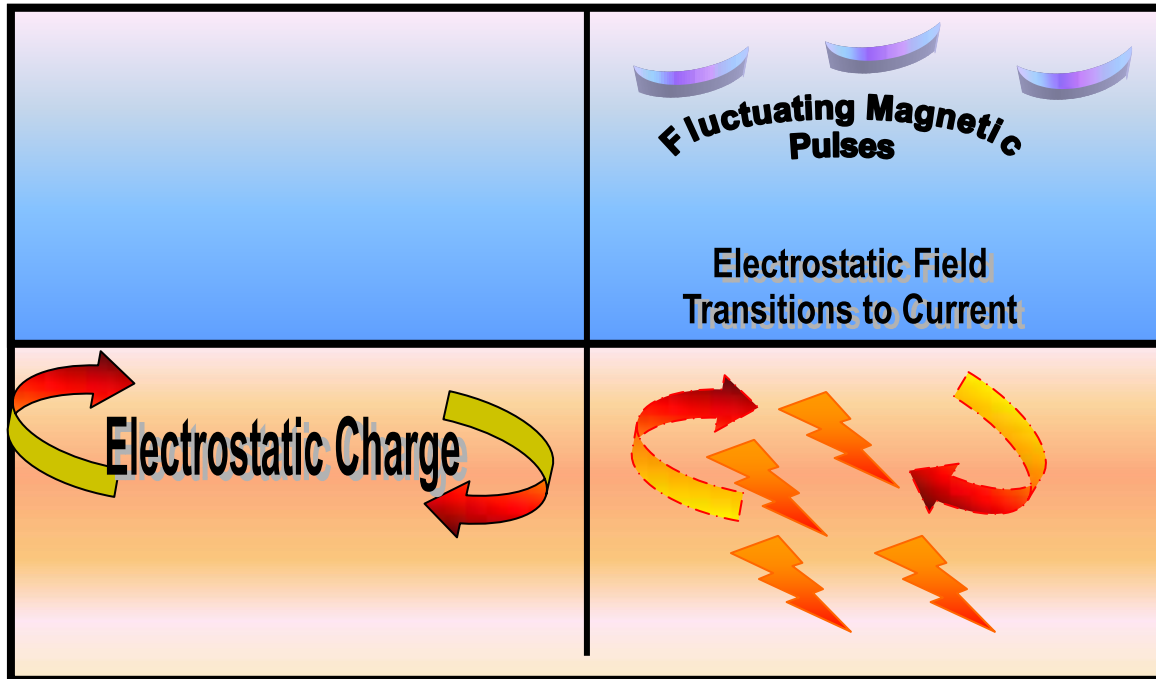


*Figure E: Kelvin-Helmholtz instabilities may interact with localized magnetic field lines, producing intermittent magnetic pulses.*

This circulation of plasma in the classic Kelvin-Helmholtz pattern over the magnetic field lines could theoretically generate new fluctuating currents. These currents in turn will produce fluctuating magnetic pulses similar to those caused by strong electro-jet activity. It is these magnetic pulses which then could induce ground currents within the most susceptible regions; in other words, the ones under highest tectonic stress.

Now let us briefly consider a second possibility: that a region under seismic stress is already supporting an electric charge in the form of an electrostatic field. This would be possible under several models by other researchers, who rely on various methods for overall charge

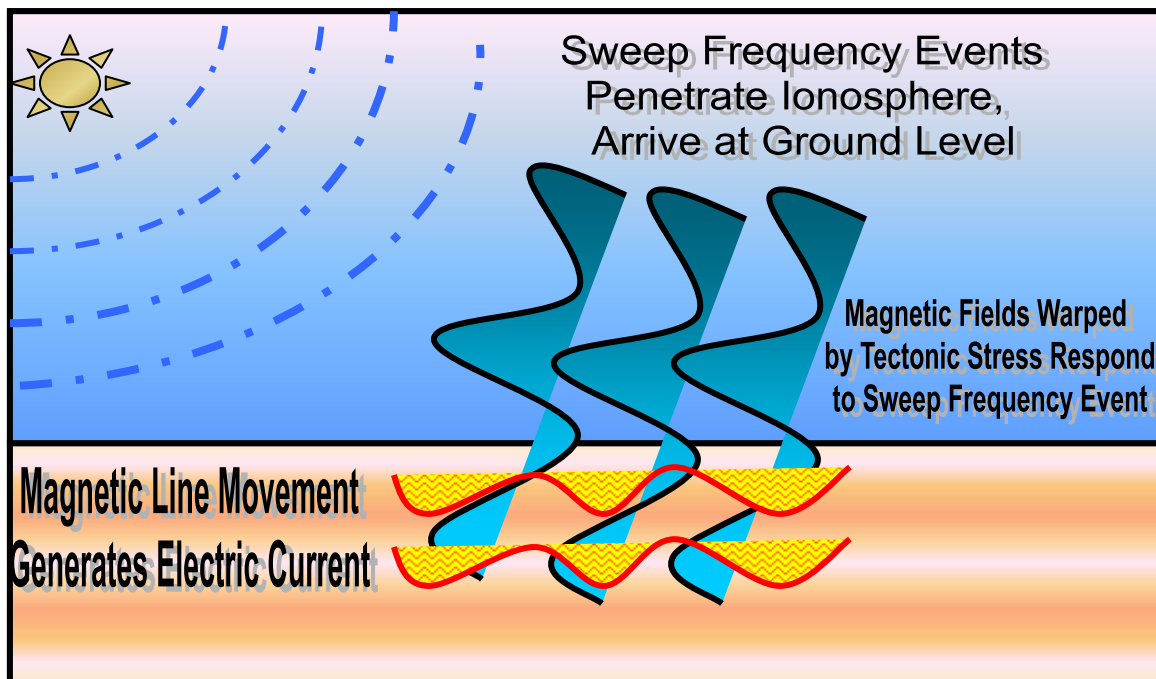
propagation. Whenever an area has a higher electric charge than its surroundings, it is essentially supporting an electro-static field.



*Figure F: If a region under tectonic stress is already supporting a localized electro-static field due to increased activity such as defect electron production (Freund) or higher piezoelectric activity from micro-fracturing (Madden and Mackie) the additional influence of alternating magnetic pulses in the atmosphere could cause it to transition into a flowing current.*

The fault zone then acts as a solid dielectric medium helping to support this field. In such a case, irregular magnetic pulses formed by the model described above could cause enough additional strengthening of the electrostatic field to allow it to transition into a flowing current. Solid dielectric media exposed to direct currents usually suffer irreparable damage; in this case, the processes of micro-fracturing could increase significantly, thereby weakening a fault zone to the point of rupture.

Finally, a third possibility to consider: that some sort of resonance effect generated by the Sun may be influencing the fault zone. Let us use an analogy of a harp and a piano sitting in the same room. If you strike a note upon the piano, the string tuned to the corresponding note on the harp will vibrate. No other strings will respond; only the string tuned to the very specific frequency of the note hit on the piano.



*Figure G: Tectonic stress may warp localized magnetic fields in the region under most pressures. These warped fields may respond to the frequency variations of solar radio events through reciprocal resonance, thus generating new electric fields.*

Similarly, magnetic fields around a seismic zone under stress may be said to be tuned to specific frequency; or more properly, to have a specific pitch. A sweep-frequency burst, ranging from high frequency to low-frequency, may be enough to excite these magnetic fields if the proper combination of pitches is involved. The movement of magnetic fields, of course, generates a reciprocal electrical field in the area; once again, an electrical field flowing in the fault zone could cause catastrophic damage in the form of high rates of micro-fracturing which destroy the integrity of the fault zone, leading to rupture. This would be particularly true if, as I mentioned a moment ago, there was already a pre-existing electrostatic field within the fault zone.

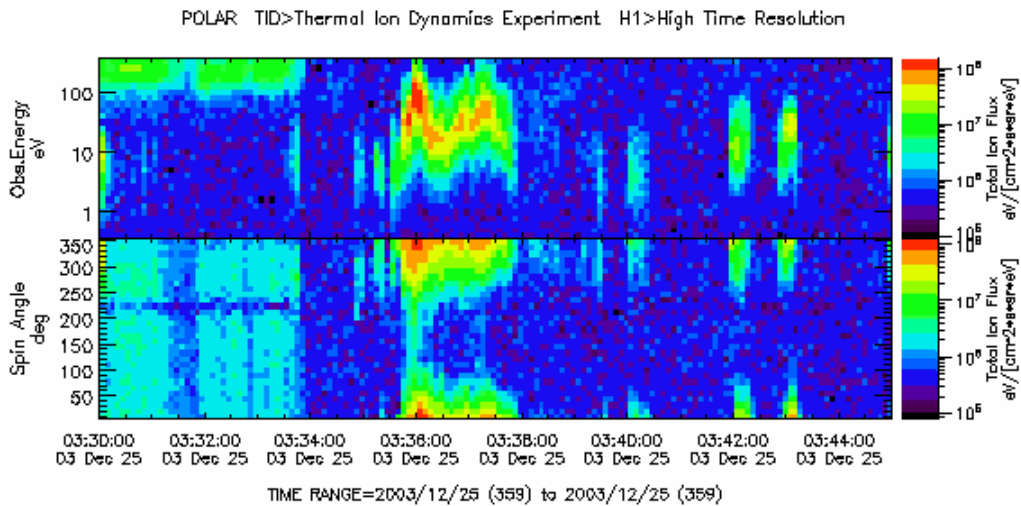
To close, let us look at some of the evidence we have gathered that there are indeed unusual reactions to solar events taking place in the ionosphere when an imminent earthquake strike zone is close to the terminator.

These will be spectrograms from the Thermal Ion Dynamics Experiment, or TIDE, which is one of the many experiments on the Polar spacecraft. Polar orbits at a distance of about eight earth radii. TIDE was designed to study core plasma reactions, and specifically to determine whether material from Earth's own ionosphere and upper atmosphere has been displaced by solar activity. In 1998, for example, TIDE data confirmed that the impact from a strong

coronal mass ejection event caused a significant increase in the ambient levels of ions flowing from the ionosphere.

Of course because TIDE is orbiting at such a great distance, the overall population of such ions is for the most part non-existent in its path; therefore, if there is even a small indication of energetic activity from the ions native to the ionosphere at that distance, we must understand that it means a far stronger reaction has taken place closer to the Earth.

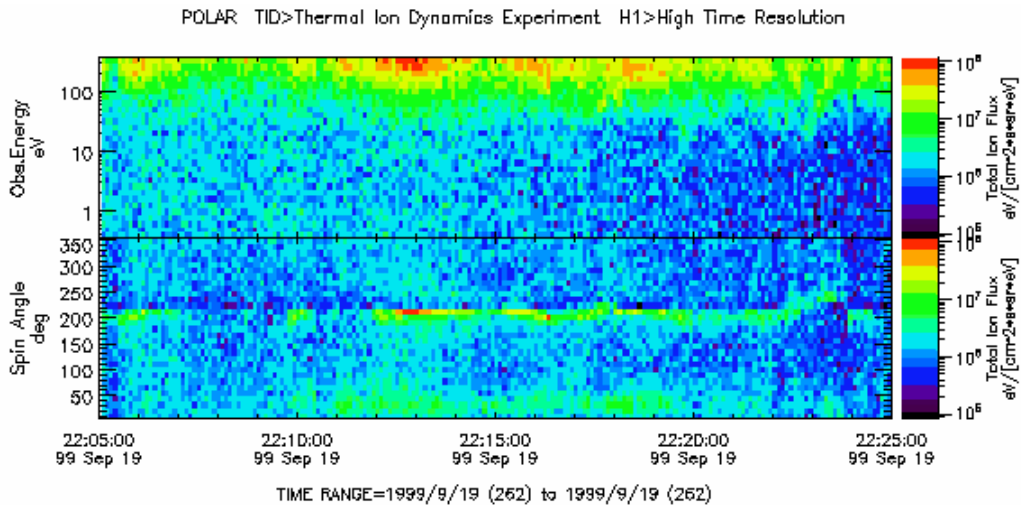
At this point I want to stress that the Thera Project is not part of the TIDE program. This data was all obtained through public access from NASA's CDA web, and the spectrograms are available for public access courtesy of Dr. Thomas Moore and the TIDE experiment team.



Please acknowledge data provider, Thomas E. Moore at Goddard Space Flight Center and CDAWeb when using these data.  
Key Parameter and Survey data (labels K0,K1,K2) are preliminary browse data.  
Generated by CDAWeb on Mon Jun 5 17:58:25 2006

*Figure H: TIDE spectrogram taken one day before the Bam earthquake of 2003.*

This spectrogram was taken one day before the December 26 2003 earthquake which hit Bam, Iran. A sweep-frequency burst occurred at 3:26 Universal time, about half an hour after sunrise at the epicenter. Within about ten minutes of that solar event, we see a small but definite surge in the spectrograms showing the observed energy of the ions as well as the ion spin angle.

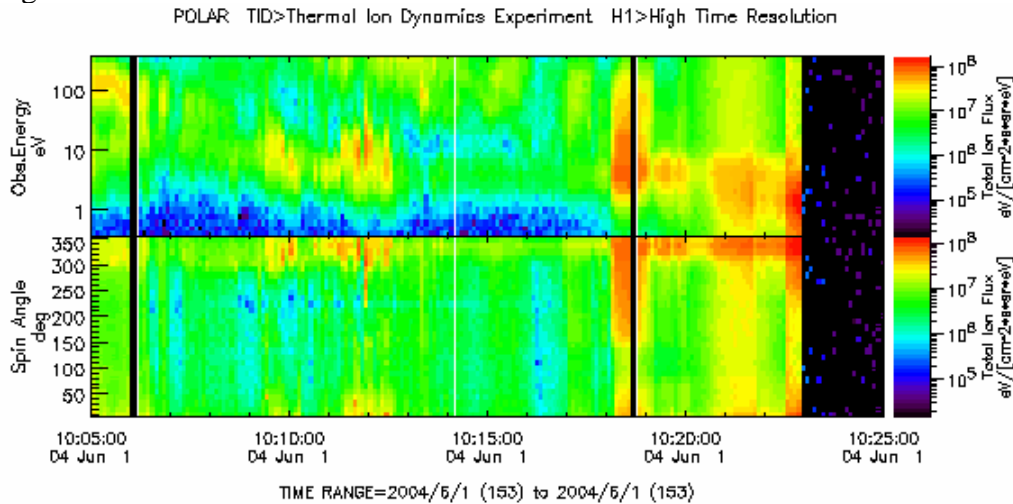


Please acknowledge data provider, Thomas E. Moore at Goddard Space Flight Center and CDAWeb when using these data.  
 Key Parameter and Survey data (labels K0,K1,K2) are preliminary browse data.  
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*Figure K: TIDE spectrogram taken before the Chi-Chi earthquake of 1999.*

This spectrogram was taken a day before the 1999 Chi-Chi earthquake. A sweep-frequency burst occurred at 22:07 UTC on September 19<sup>th</sup>. In Taiwan it was already September 20<sup>th</sup>, the day before the quake, and this event was about 24 minutes after sunrise. We see a slight but definite reaction indicating increased outflow of material from the ionosphere shortly afterwards.

Looking to another event on Taiwan:



Please acknowledge data provider, Thomas E. Moore at Goddard Space Flight Center and CDAWeb when using these data.  
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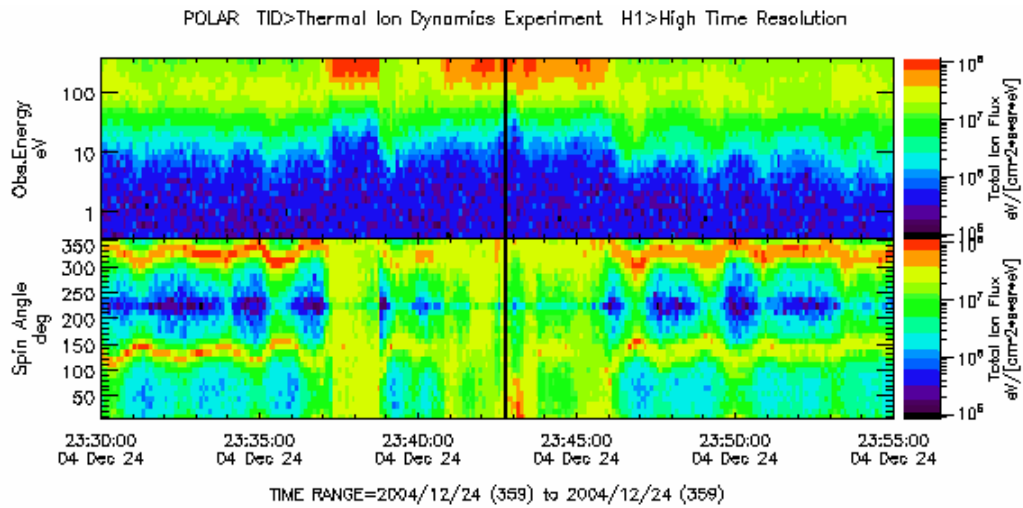
*Figure L: TIDE spectrogram taken before a 2004 earthquake in Taiwan.*

This spectrogram was taken two days before a magnitude 5.2 quake hit Taiwan on June second, 2004. A sweep-frequency burst occurred at 10:05 on June first, about half an hour

before sunset. As you can see from the spectrogram, there was a definite outflow of ionosphere material, which registered at TIDE about 15 minutes after the solar event.

This next spectrogram was taken the day before the December 26<sup>th</sup>, 2004 Banda Aceh earthquake in Sumatra.

As I noted earlier, in the Thera Project's research we do count events which have occurred up to 15 minutes before sunrise, simply because any sort of affective phenomena would need time to travel from the Sun to the Earth.

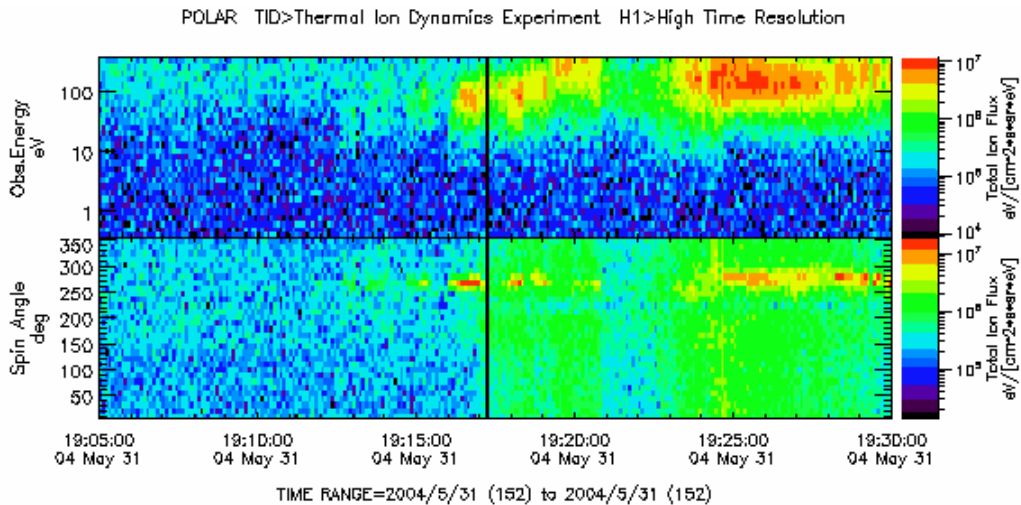


Please acknowledge data provider, Thomas E. Moore at Goddard Space Flight Center and CDAWeb when using these data.  
Key Parameter and Survey data (labels K0,K1,K2) are preliminary browse data.  
Generated by CDAWeb on Mon Jun 5 18:02:35 2006

*Figure M. TIDE spectrogram taken before the Banda Aceh earthquake of 2004.*

A sweep frequency burst occurred at 23:22 Universal Time, 15 minutes before sunrise at the epicenter. And at sunrise, 23:37 UTC on December 24<sup>th</sup>, which would have been December 25<sup>th</sup> local time, one day before the quake, we see a definite reaction..

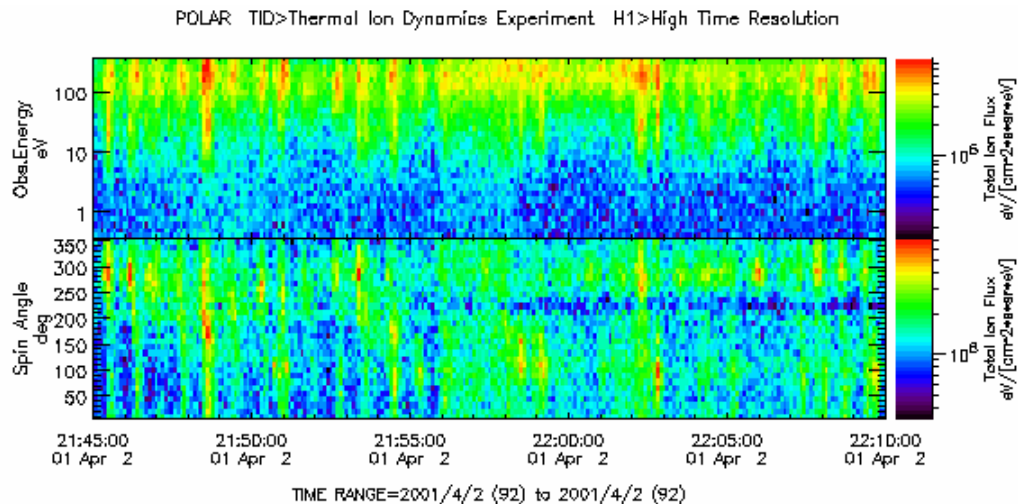
To give you an example of a spectrogram related to X-ray surges ahead of seismic events: This was taken one day before a 6.2 earthquake South of the Kermadec Islands on June second 2004. An X-ray surge occurred at 19:07 on 5/31, which would have been about 20 minutes after sunrise on June first local time. About nine minutes later we see the beginning of an ionosphere outflow register at TIDE, and then within a few minutes the reaction picks up noticeably. (see below)



Please acknowledge data provider, Thomas E. Moore at Goddard Space Flight Center and CDAWeb when using these data.  
Key Parameter and Survey data (labels K0,K1,K2) are preliminary browse data.  
Generated by CDAWeb on Mon Jun 5 18:23:21 2006

Figure N: TIDE spectrogram taken before an earthquake off the Kermadec Islands in 2004.

To show you why I consider these readings to be anomalous, I want to present spectrograms taken after two very powerful solar events.

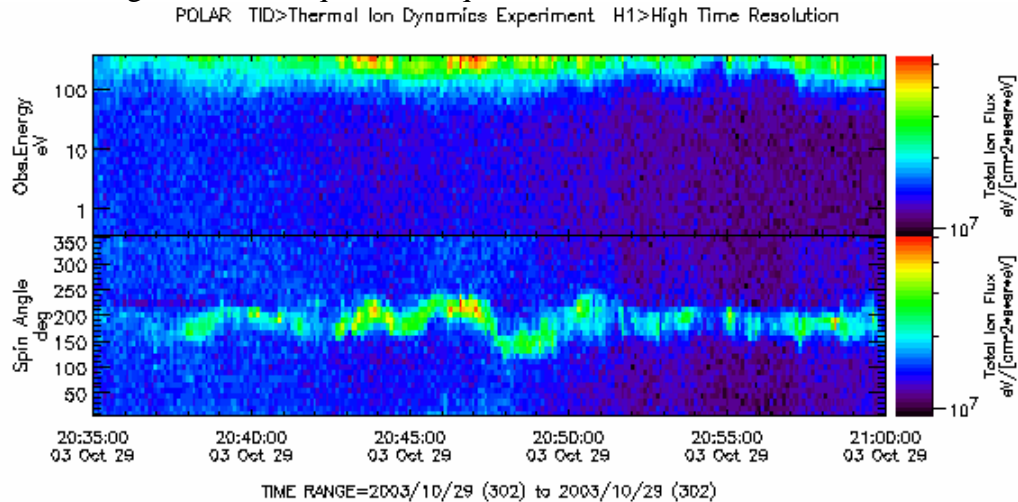


Please acknowledge data provider, Thomas E. Moore at Goddard Space Flight Center and CDAWeb when using these data.  
Key Parameter and Survey data (labels K0,K1,K2) are preliminary browse data.  
Generated by CDAWeb on Wed Oct 6 17:45:28 2004

Figure P: Spectrogram taken after an extremely powerful X-ray flare. While there is an elevated level of activity, the concentrated bursts seen in previous spectrograms associated with subsequent earthquakes is not seen.

The first spectrogram was taken after the extremely powerful X-20 level flare on April second, 2001. As you can see, while the spectrograms for this event do show some increased

activity, it is not as concentrated as the reactions from the spectrograms associated with solar events occurring before subsequent earthquakes.



Please acknowledge data provider, Thomas E. Moore at Goddard Space Flight Center and CDAWeb when using these data.  
Key Parameter and Survey data (labels K0,K1,K2) are preliminary browse data.  
Generated by CDAWeb on Wed Oct 6 18:01:54 2004

*Figure Q: Spectrogram taken after another strong solar event. This one shows no immediate level of ionosphere outflow, unlike spectrograms associated with subsequent earthquakes.*

The second spectrogram set was taken after an X-10 level X-ray event in October 2003. This event was much stronger than the events seen in the spectrograms associated with earthquakes, but the reaction is far weaker.

What is significant about the spectrograms in Figures P and Q is that in both of these cases, the terminator was NOT proximate to an imminent earthquake strike zone. That is, no place which had just undergone sunrise or was about to undergo sunset when these solar events occurred experienced a seismic event within the following 48 hours.

Of course there is much more to say about all of this data, and I realize I have gone through quite a lot in a short time frame. I will of course be happy to take questions in a moment.

I would like to close with a quote from a woman whose works I greatly admire. I think it holds special meaning for all of us who are trying to discover precursors that could help us devise an earthquake warning system, especially since we meet with frequent resistance from those who believe it can't be done.

The woman is Hildegard of Bingen, and the quote is this: Everything in the heavens, and on the earth, and under the earth, is penetrated with connectedness, penetrated with relatedness.

Again, those who would like copies of the detailed data tables which I distributed during the afternoon T44 session at the WPGM may download them free of charge by going to [www.theraproject.com](http://www.theraproject.com) and clicking on the WPGM tables tab.

