Electric field anomalies in the mid latitude ionosphere: Possible connection with earthquakes?

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United Nations/Austria Symposium on Data Analysis and Image Processing for Space Applications and Sustainable Development: Space Weather ***18 - 21 September 2012, Graz, Austria***

Introduction

An anomalous increase of 3–7 mV/m in the vertical component of the quasi-static electric field has been first observed on board IC-BULGARIA-1300 satellite in the near-equatorial ionosphere over the earthquake region approximately 15 min before an earthquake with M = 4.8 by *Chmyrev et al.* (1989).

An electrodynamic model of atmosphere–ionosphere coupling has been formulated by *Sorokin et al.* (2001) and improved *Sorokin et al.* (2006). According to this model, the external current arises as a result of emanation of charged aerosols transported into the atmosphere by soil gases and the subsequent processes of upward transfer, gravitational sedimentation and charge relaxation.

We found observational evidence in the IC-BULGARIA-1300 satellite data for increases in vertical components of the quasi-static electric field up to 10–30 mV/m. We have reviewed almost all available sets of measurements aboard satellite IC-BULGARIA-1300. We searched for effects caused by earthquakes with magnitudes greater than 4.9. In many from measurements the effect of earthquakes, occurred in the period of measurement, is simply absent.

Introduction - continued

When should we doubt results ?

Disturbance in the electric field can be of magnetosphere-ionospheric source. This is the reason to exclude measurements made in:

a/ polar regions or

b/ disturbed geomagnetic conditions.

The satellite

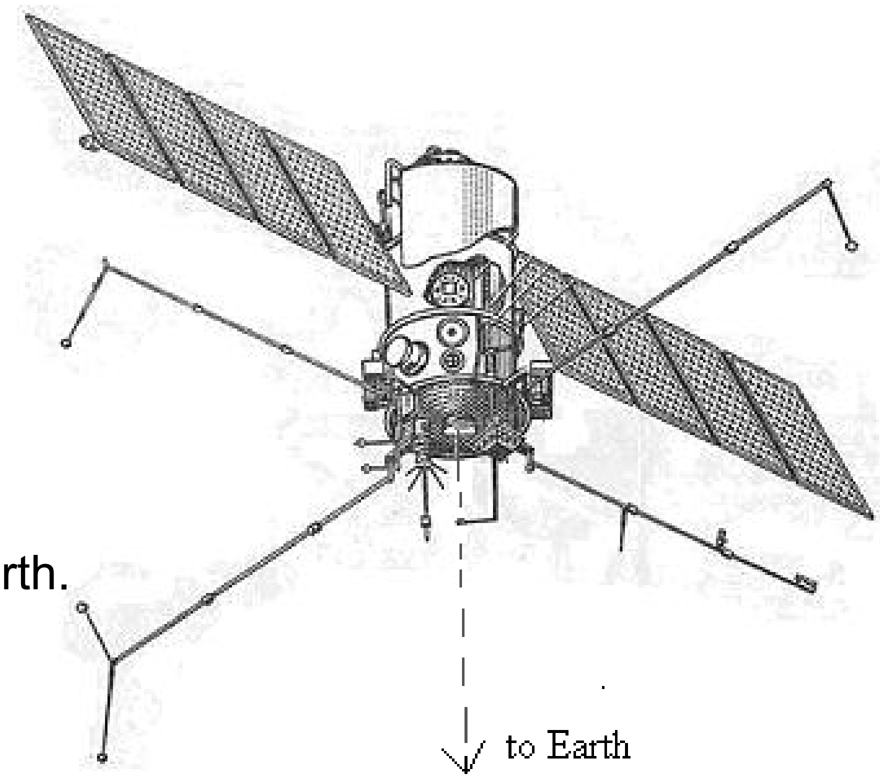
The IC-BULGARIA-1300 satellite was launched on 7th August 1981.

The satellite has a nearly circular orbit with the following parameters:

- **Perigee of 825 km;**
- **Apogee of 906 km;**
- **Orbit Inclination of 81.2^{0};**
- **Period of 101,9** min

Axes of the satellite are stabilized with a precision of 1^{0} deviation from the orbital reference system.

Oz is parallel to the Radius-vector of the Earth.



The instrument

DC electric field measurement

For measuring the quasi-static (DC) electric field (0-0.2Hz) the IESP-1 instrument was used.

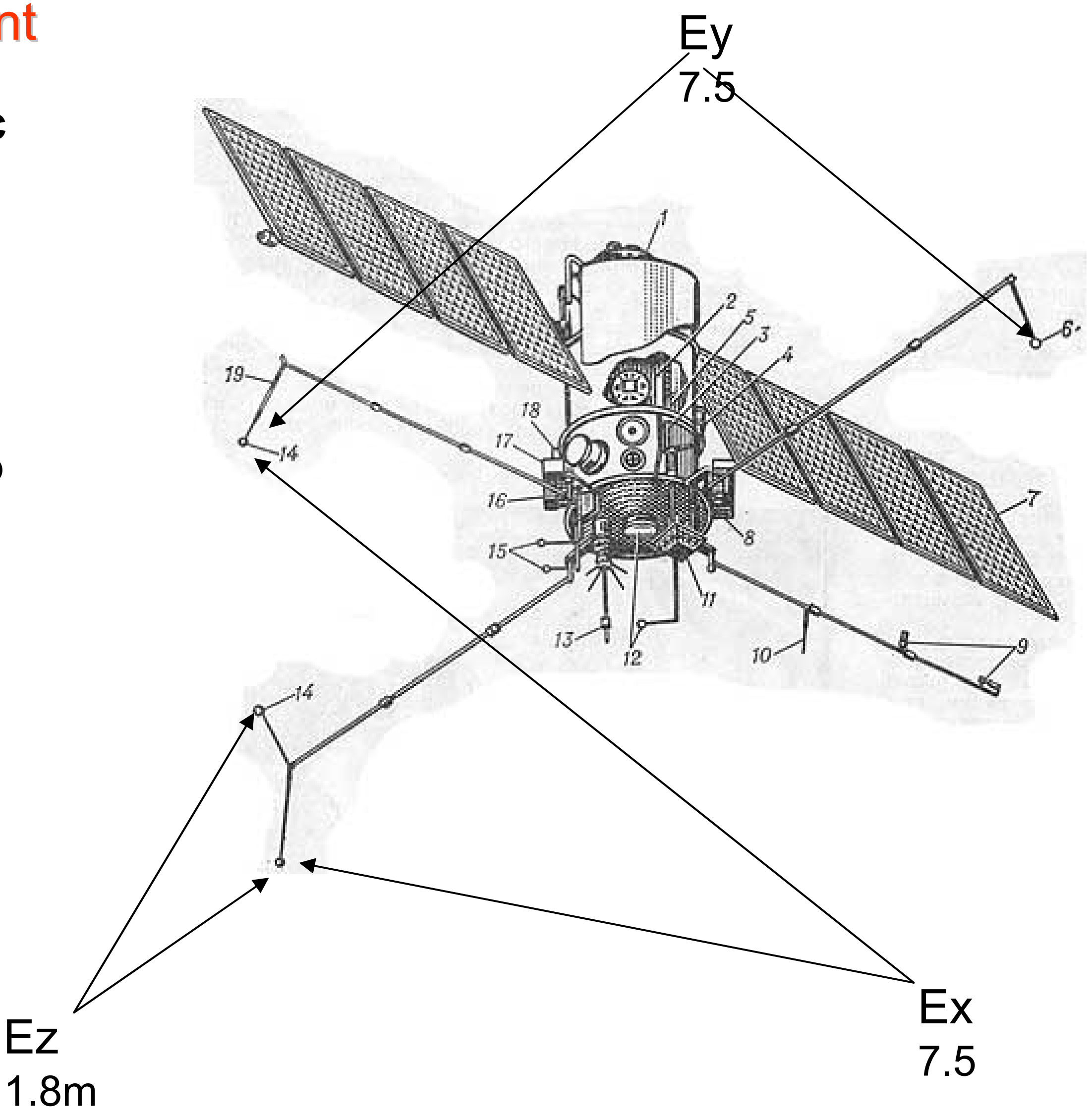
The method is "double probe" ie "floating potential method".

To obtain one component, two sensors were needed.

Projected Dynamic Range:
Ex - **±300 mV/m**
Ey - **±600 mV/m**
Ez - ±200 mV/m

The sensitivity for all was 1 mV/m

The bases were:
For Ex and Ey - 7.5 m
For Ez - **1.8 m**



Database and observational methodology

Data Processing

Ex is the horizontal component along the vector of the velocity;
Ez is the vertical component (from the Earth) ;
Ey make up to the right coordinate system**.**

Dedicated software calculates the induced field and then subtract that from the measurements (in the computations the IGRF85 model of the magnetic field was used).

In the absence of interference, all the components (Ex, Ey, Ez) should be zero.

The systematic error

Small errors in determining the position and velocity of satellite (arising from not accurate orbital parameters) lead to deviations from zero.
These deviations are slowly changing in one orbit, so that they can not be an obstacle to our study.

Database and observational methodology

To minimize false events we chose the following rules:

To remove instrumentation effects

❖ ignore measurements made during the crossing of the terminator

❖ ignore two minutes at the start and one minute before the end of each set of measurements (seance). In these intervals there are effects caused by the on / off device

❖ carefully review the data about possible discontinuation of telemetry, shading of the sensor, etc...

To reduce the likelihood that the disturbance have another origin

- **measurement must be on quiet days (Kp < 5+)**
- **to exclude all measurements taken at high latitudes**
- **the angular distance $\Delta\lambda$ between the earthquake epicentre and the closest point of the satellite orbit to be $\Delta\lambda < 15^0$;**

Observational methodology

The search process

A. For each earthquake, we look for orbits - close to it. (**$\Delta\lambda < 15^0$**)

B. Draw the electric field as a function of time.

C. Draw trend (error due to inaccurate determination of the speed and position of satellite)

The computer processing ends with this.

Follows labor intensive visual estimation of the disturbance in the **Ez** component

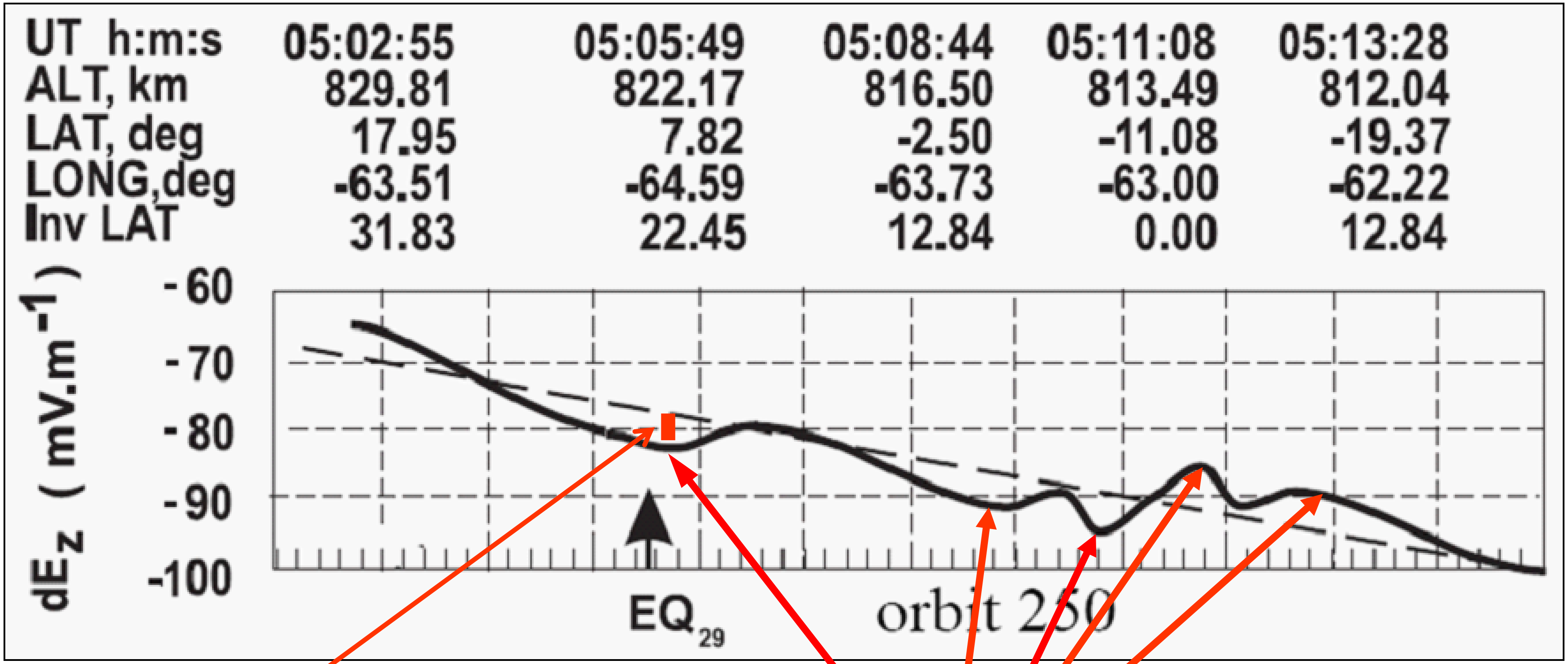
On the next slide, we show how we find ‘anomalies in the electric field’

Observational methodology

How to find ‘anomalies in the electric field’

Observational methodology

How to find 'anomalies in the electric field' continued



We select only that which is a closest to the earthquake

all this are anomalies in the electric field Ez

Observational methodology

What we have processed

A. For all 73 earthquakes of magnitude M> 5 occurred in August and September 1981, we found closer to each earthquake orbit.

Note: Overflight must be no earlier than 3 days before and not later than 3 days after the earthquake.

It turns out that:

- for each earthquake orbits are more than one
- there are no measurements made at some of selected orbits
- there are measurements that are close to more than one earthquake

B. Search for corresponding disturbance in the measured electric field

Results

- For 25 earthquakes (35 datasets of measurements) we can not find any disturbance.
- In 4 cases, we can not precisely determine which is the source.
- 17 earthquakes are so close together, they can not be distinguished

Earthquake selected from USGS website							set of measurements		time lag	netic activity	Pertur-bation	distance from epicenter	distance from epicenter
EQ No	DATE	Time HHMMSS	Lat deg	Long deg	Dept km	M	Orbit	DATE	Δt H:M	Kp	ΔE, mV/m	Δd km	Δλ deg
EQ18	1981.08.23	015950	-22.06	170.95	100	5.8	170	19.08.1981	-84:21	3	12	879	02.30
EQ41	1981.09.01	092931	-14.96	-173.08	25	7.9	170	19.08.1981	-180	3	18	822	00.28
EQ23	1981.08.24	112033	61.22	-59.01	10	4.8	193	21.08.1981	-79:19	2	10	946	02.84
EQ16	1981.08.21	225240	-26.50	-114.76	10	5.1	196	21.08.1981	-13:20	2	8	909	03.40
EQ17	1981.08.22	234741	-35.83	-103.30	10	5.2	196	21.08.1981	-14:12	2	10	1509	10.32
EQ10	1981.08.19	122533	-49.79	164.23	33	4.8	213	22.08.1981	+50:05	3	5	1102	06.20
EQ11	1981.08.20	021948	-11.48	166.16	70	5.0	213	22.08.1981	+53:56	3	8	933	01.03
EQ18	1981.08.23	015950	-22.06	170.95	100	5.8	213	22.08.1981	-14:35	3	10	1022	05.10
EQ26	1981.08.25	052021	-34.61	-179.46	68	5.4	213	22.08.1981	-59:52	3	4	1724	12.90
EQ21	1981.08.23	195632	-17.07	120.52	33	4.8	215	22.08.1981	-26:10	3	8	1110	06.39
EQ2[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	06.09
EQ2[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12.00
EQ29	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	13.00
EQ37	1981.08.29	074151	-2.20	100.85	57	4.9	258	25.08.1981	-84:56	3	3	1386	09.50
EQ19	1981.08.23	120026	48.71	157.39	40	6.0	283	27.08.1981	+91:57	5	10	1160	09.03
Eq46	1981.09.01	155557	-58.71	-25.36	115	4.8	347	01.09.1981	-12:47	0	10	1123	06.46
EQ60	1981.09.04	082306	-15.69	-13.10	10	5.1	347	01.09.1981	-78:02	0	2	1847	14.13
EQ46	1981.09.01	155557	-58.71	-25.36	115	4.8	348	01.09.1981	-11:50	4	8	1896	14.43
EQ46	1981.09.01	155557	-58.71	-25.36	115	4.8	403	05.09.1981	+81:19	4	8	1597	11.57
EQ60	1981.09.04	082306	-15.69	-13.10	10	5.1	403	05.09.1981	+19:40	4	2	1295	08.00
EQ61	1981.09.06	164319	-36.17	-100.70	10	5.4	483	10.09.1981	+96:49	3	2	1320	08.15
EQ65	1981.09.12	022916	27.85	56.97	33	4.8	505	12.09.1981	+04:43	3	5	959	03.00
EQ67	1981.09.16	022348	-8.85	-109.13	10	4.9	505	12.09.1981	*-101:10*	3	5	1068	05.96
EQ72	1981.09.19	114056	-39.08	-74.80	30	5.6	546	15.09.1981	-76:20	2	10	1280	07.50
EQ67	1981.09.16	022348	-8.85	-109.13	10	4.9	547	15.09.1981	*-22:47*	2	10	833	01.81
EQ70	1981.09.18	141732	-35.24	-110.34	10	5.0	547	15.09.1981	-80:57	2	10	871	02.35
EQ67	1981.09.16	022348	-8.85	-109.13	10	4.9	581	17.09.1981	+40:34	1	3	1596	11.00
EQ70	1981.09.18	141732	-35.24	-110.34	10	5.0	581	17.09.1981	-22:18	1	5	1596	11.00
EQ72	1981.09.19	114056	-39.08	-74.80	30	5.6	602	19.09.1981	-08:32	5	10	852	01.30
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

The results are implemented in a table like this.

Results

Our results show that disturbances in electric field Ez may occur before as well and after an earthquake .

One earthquake can cause disturbances for long period.

EQ29 cause disturbances for 1 hour

EQ67 ….. for 62 hours.

EQ70 ------------ for 58 hours

EQ72 ------------ for 66 hours

Earthquake selected from USGS website							set of measurements		time lag	Pertur-bation
EQ No	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	M	Orbit	DATE	Δt H:M	ΔE_z mV/m
EQ29	1[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.2	250	25.08.1981	-11:05	5
EQ29	1981.08.25	165438	6.93	-76.59	33	5.2	251	25.08.1981	-10:06	4
EQ72	1981.09.19	114056	-39.08	-74.80	30	5.6	546	15.09.1981	-76:20	10
EQ67	1981.09.16	022348	-8.85	-109.13	10	4.9	[illegible]	[illegible]	-22:47	10
EQ70	1981.09.18	141732	-35.24	-110.34	10	5.0	547	15.09.1981	-80:57	10
EQ67	1981.09.16	022348	-8.85	-109.13	10	4.9	[illegible]	[illegible]	+40:34	3
EQ70	1981.09.18	141732	-35.24	-110.34	10	5.0	581	17.09.1981	-22:18	5
EQ72	1981.09.19	114056	-39.08	-74.80	30	5.6	602	19.09.1981	-08:32	10

EQ67 before

EQ67 after

Discussion

Our **suggestion**, which we can not prove:

disturbances, in question, have short life time and are periodical

We will give argument in favor of it:

We have over 35 cases when the satellite is at a suitable distance from the epicenter and disturbance in the vertical component is not monitored. This case we observe for EQ67

Conclusions

A. Relationship between disturbances in the vertical component of the electric field, at altitudes to 900km, and earthquakes is possible but is not yet a proven fact.

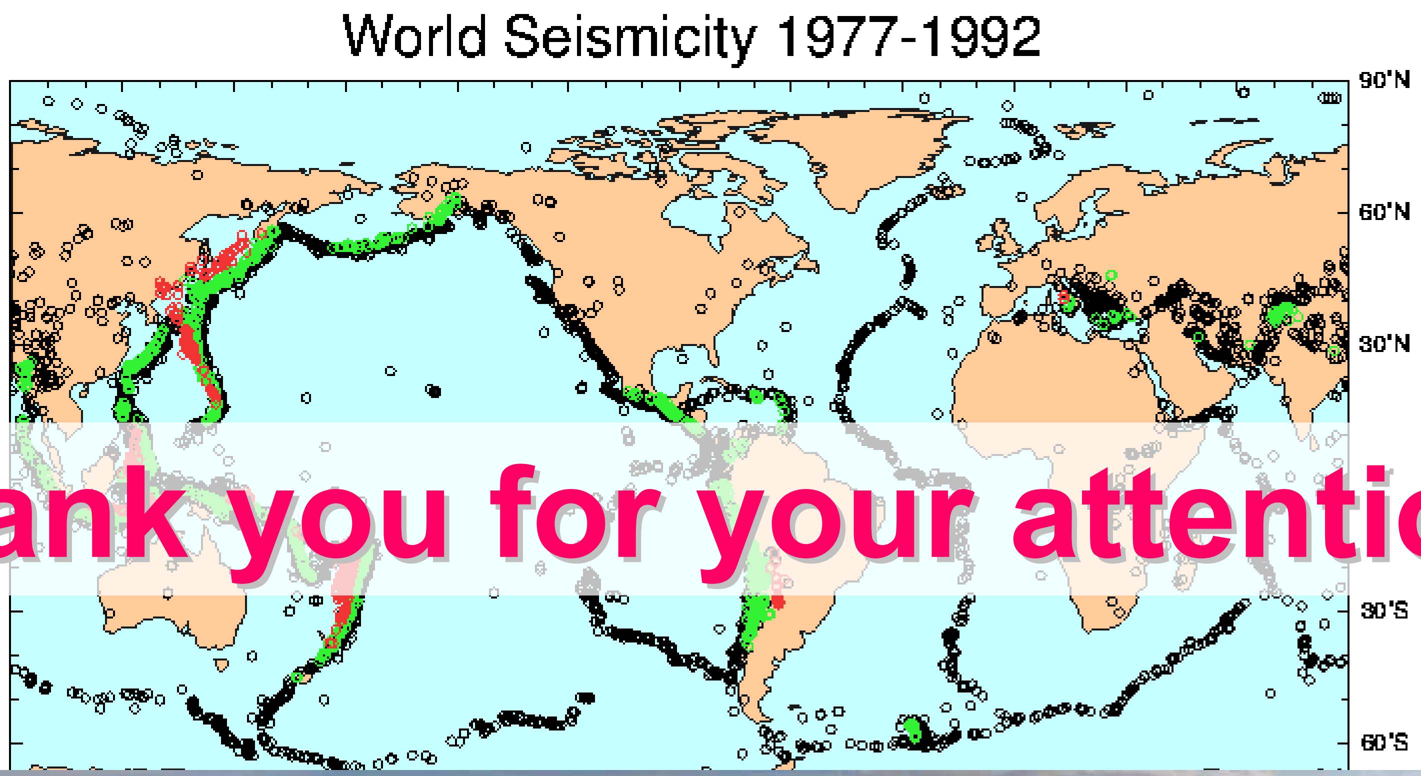
B. The use of satellites to examination the relationship above is hampered for several reasons:

1/ Possible noise coming from the ionosphere and / or magnetosphere.

2/ Special requirements to orbital parameters (low apogee satellites are better because they have smaller period and distance from the ground).

Author is grateful to UN OOSA and the co-sponsors for the chance to attend

the Symposium.



Thank you for your attention