Statistical analysis of automatically detected density variations recorded by DEMETER in relation with seismic activity

M. Parrot

LPC2E/CNRS, Univ. Orléans

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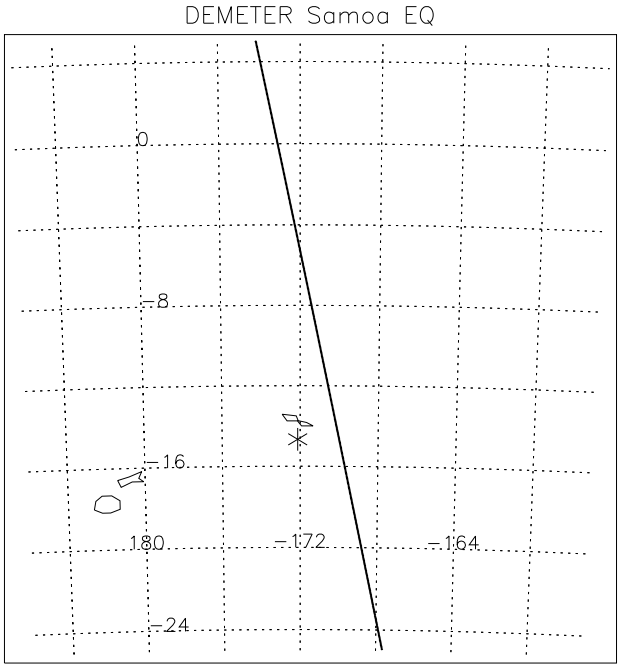
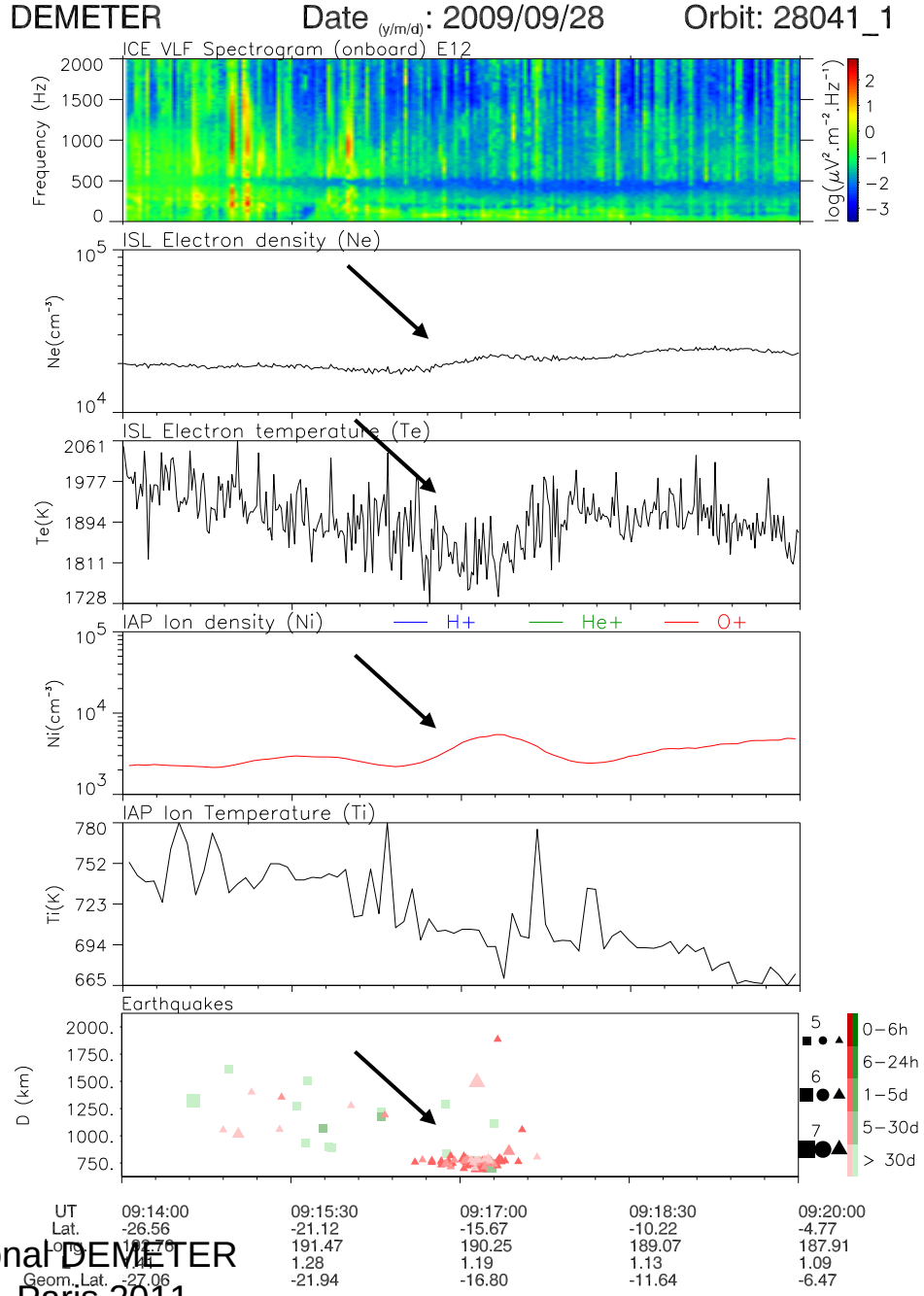
Conclusions

SAMOA EQ
September 29, 2009
17:48:11 UT
15.51°S 172.03°W
M=8.1 d=18km





1 day before

Important points:

There are numerous ionospheric perturbations coming from other sources (solar activity, AGW, TID, plasma dynamics, large meteorological phenomena…)

We can say that there are EQs with no ionospheric perturbation. (Perhaps due to the crust composition and configuration)

But the other possibility is: there are EQs where the satellite does not see any perturbation for the following reasons:

We do not expect to have continuous ionospheric perturbations

With a single satellite we are ‘above’ a given future epicenter only during 3 minutes per day.

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Statistic on the ion density measured by IAP

Software for automatic search of increases/decreases in the IAP data base until 15 days before the EQs during night time when the satellite is at less than 1500 km from the epicenters.
(we assume that there is at least one orbit per day enough close to the epicenter of each EQ)

August 2004 – October 2009

EQ data base: 17366 EQs with M > 4.8

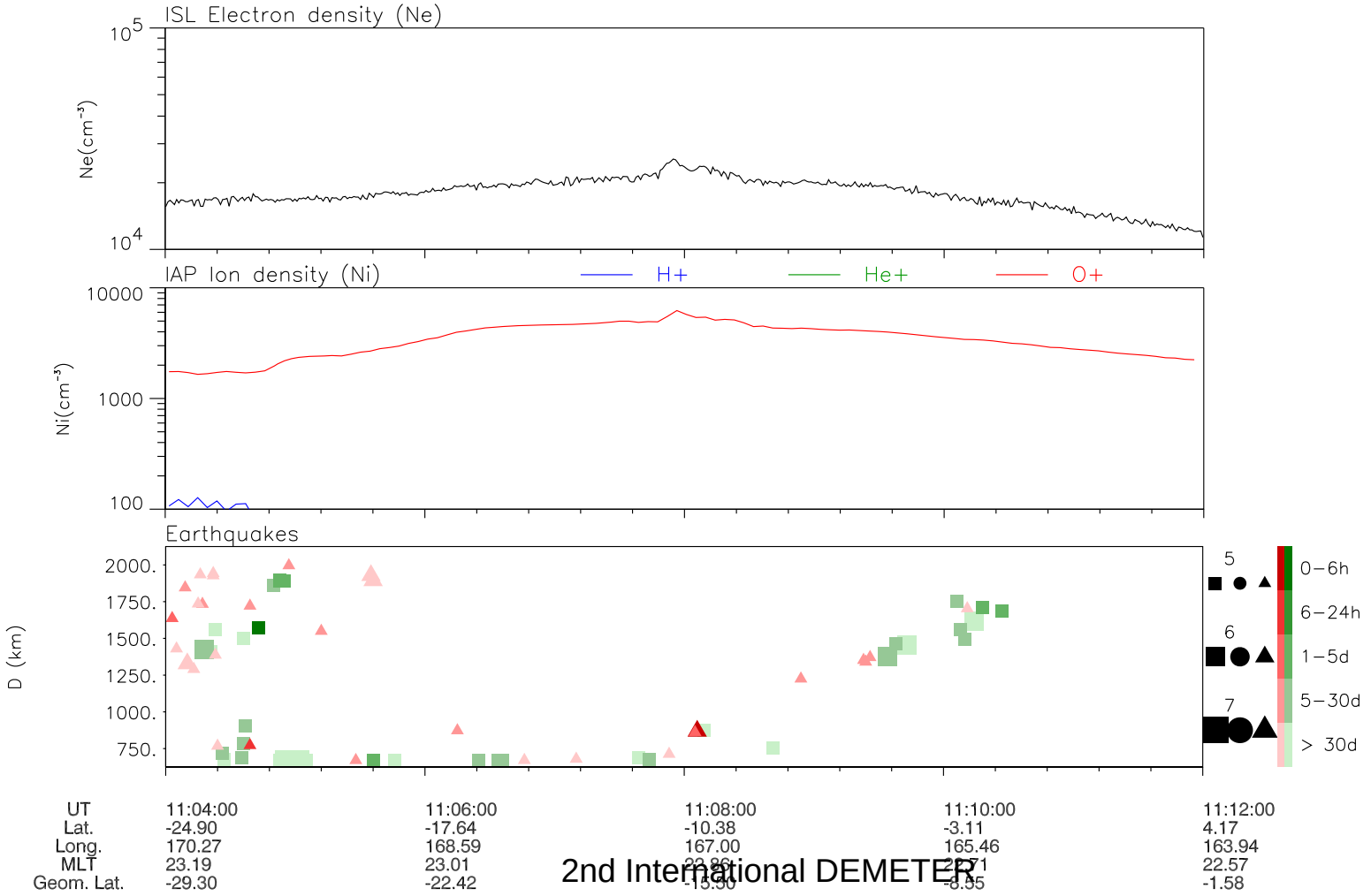
Results: number of perturbations and percentage of variation relative to a background every 15 days before each EQ

Nov. 11, 2007
17:49:58 UT
10.95°S 162.15°E
M=6.6 d=42km

DEMETER

Date (y/m/d): 2007/11/27

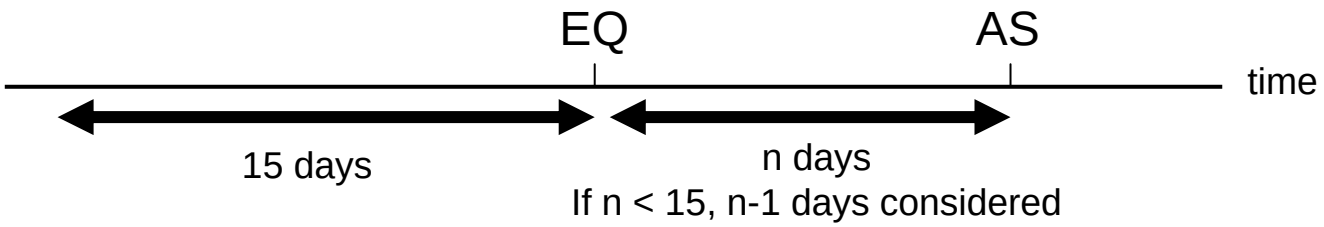
Orbit: 18184_1



Parameters of the statistic

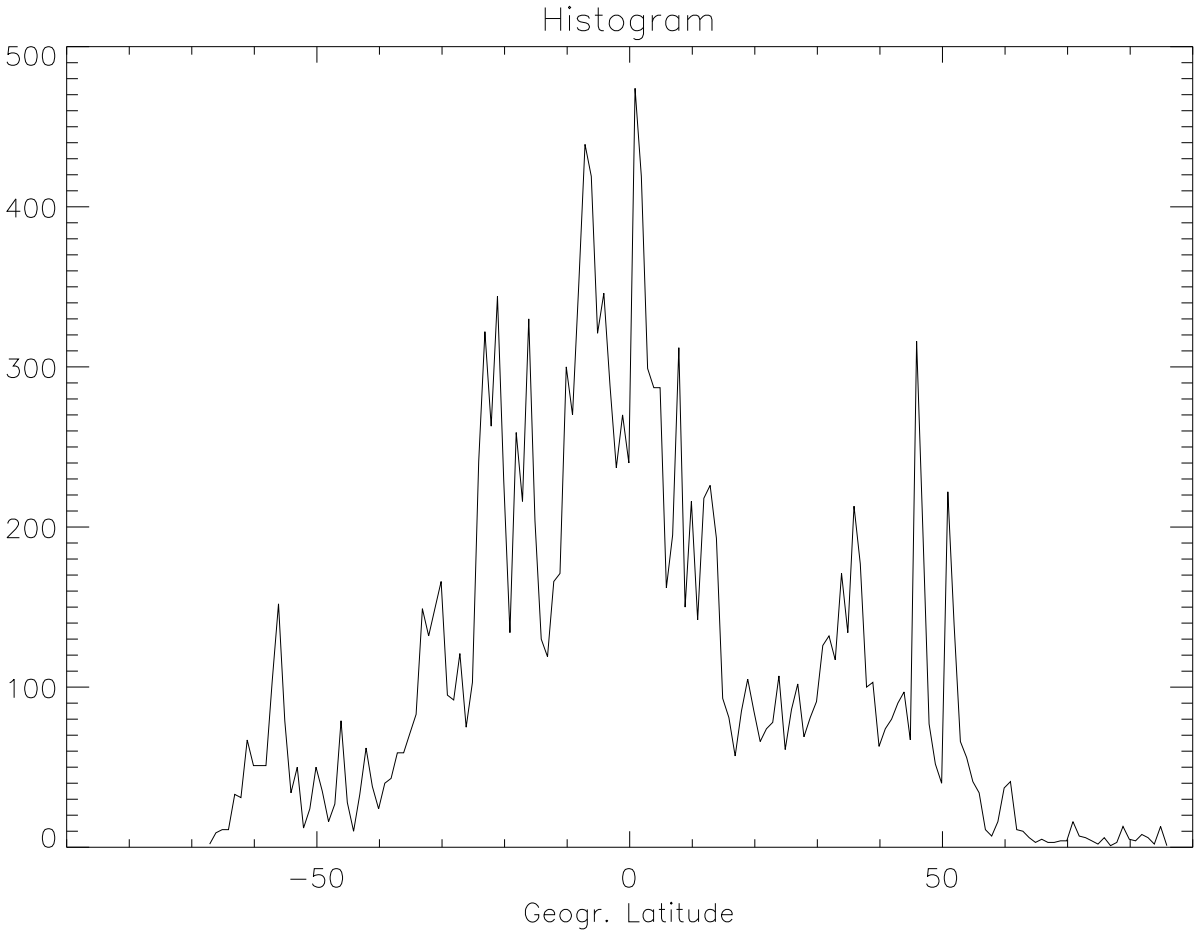
Location of EQs
Magnitude
Depth
Magnetic activity (Kp)

Aftershocks removed



Other data base with random data has been used:

RAND1 same time but random positions
RAND2 shift EQ longitudes 25° to the west



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Threshold % = 2.

Ratio between the number of perturbations with T > 2 and the total number of cases for the 15 days before an EQ

M	Rand1	Rand2	> 4.8	> 5.	> 5.5	> 6.
All	21.3 (15498)	23.8 (5954)	24.2 (6026)	24.7 (3502)	25.2 (943)	25.7 (279)
Sea	23.9 (4114)	25.4 (2666)	30.5 (1797)	30.4 (1097)	30.9 (301)	31.4 (76)
Land	18.7 (4956)	21.5 (2551)	20.0 (2001)	20.5 (1157)	21.6 (314)	22.7 (98)

Statistical analysis

Parameter A: Maximum of percentage on 15 days for each EQ
(percentage = the peak amplitude / the background)

The characteristics of the statistical distributions of A
have been evaluated using the kurtosis and the skewness parameters.
It appears that the kurtosis is always much less than 3 and the skewness
not close to 0. This means that the distribution of these data does
not follow a normal law and that it is better to use a median value
than an average value of the parameter A.

Parameter A: Maximum of percentage on 15 days for each EQ
(percentage = the peak amplitude / the background)

Comparison of A values between RAND1 and RAND2

Magnitude	[4.8, 5.0]	]5.0, 5.5]	]5.5, 6.0]	]6.0, 9.0]
Event number	7576	4347	1259	570
Median	**7.49**	**7.52**	**7.89**	**7.12**
Kurtosis	1.548	1.565	1.669	2.456
Skewness	1.145	1.160	1.124	1.373

RAND1

Magnitude	[4.8, 5.0]	]5.0, 5.5]	]5.5, 6.0]	]6.0, 9.0]
Event number	6218	3460	987	415
Median	**7.68**	**7.77**	**8.03**	**7.19**
Kurtosis	0.719	0.843	0.805	0.346
Skewness	0.931	0.966	0.897	0.878

RAND2

RAND2 is used as reference

- We have selected 20 random sets of data in the RAND2 data base using false magnitude and depth.

- For each set we have calculated its median value.

- We have calculated the mean value and the variance of the median for the 20 sets.

- This gives the normal variation for the median values of the parameter A:

Everywhere	7.82 ± 0.61	(max 8.43)
above the sea	8.21 ± 1.23	(max 9.44)
Inland	7.46 ± 0.34	(max 7.80)

EQ data base – Median values of A

Magnitude	[4.8, 5.0]	]5.0, 5.5]	]5.5, 6.0]	]6.0, 9.0]
EQ number (all)	6332	3506	1032	420
Median (all)	**8.16**	**8.23**	**8.47**	**9.27**
Kurtosis (all)	0.437	0.598	0.003	-0.032
Skewness (all)	0.812	0.809	0.686	0.696
EQ number (sea)	1734	1084	328	98
Median (sea)	**8.66**	**8.69**	**8.33**	**10.48**
Kurtosis (sea)	0.628	0.457	0.021	-0.582
Skewness (sea)	0.830	0.777	0.650	0.474
EQ number (inland)	4598	2422	704	322
Median (inland)	**7.94**	**7.93**	**8.53**	**8.96**
Kurtosis (inland)	0.373	0.656	-0.086	0.201
Skewness (inland)	0.812	0.809	0.687	0.774

Averaged median values + standard deviation

8.43

9.44

7.80

Influence of the depth

M =]6.0, 9.0]

Depth	≤ 40 km	> 40 km
EQ number (all)	313	107
Median (all)	**9.35**	**8.64**
EQ number (sea)	75	23
Median (sea)	**10.84**	**8.64**
EQ number (inland)	238	84
Median (inland)	**8.96**	**8.84**

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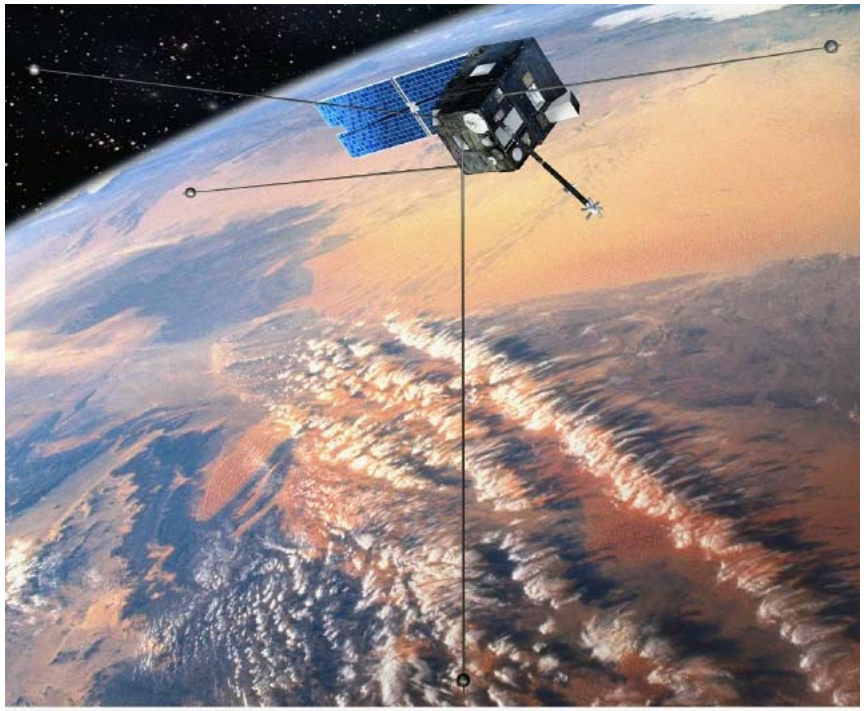

Conclusions

- We have statistically shown that we detect more ionospheric perturbations before EQ occurrences than without seismic activity.

- Surprisingly, the effect seems larger for EQs occurring below the sea. But the statistic shows that only large EQs below the sea are efficient. Otherwise the inland EQs always give a perturbation whatever is the magnitude (> 4.8).