SWOL2023 SPACE WEATHER OBSERVATIONS THROUGHOUT LATINOAMERICA	**Session** Ionosphere and Upper Atmosphere **Presentation type**: Oral

Quiet day curve for riometer: Analysis and comparison of methods

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Abstract:
The RIOMETER is a passive instrument that measures the intensity of the cosmic signal that reaches the Earth's surface. With the adequate analysis of this signal, it is possible to determine the attenuation suffered by them, when traveling through the ionosphere, particularly at the altitudes of the D region.

Both in the most basic zenithal beam instruments and in the more sophisticated multi-beam (or image RIOMETER), multifrequency, or mesospheric radar instruments, it is extremely important to obtain a correct reference curve corresponding to a calm day (Quiet Day Curve - QDC) in order to carry out this analysis. That "Quiet Day" is, in its most basic form, the attenuation suffered by the signal on those days when the ionosphere is undisturbed.

Since the beginning of the use of this technique, various methods have been developed and proposed to obtain this QDC, with varying degrees of implementation complexity and advantages. In general, the selection of one of these methods is based on the type of analysis we are interested in performing with the RIOMETER data, levels and nature of the interference at the site, noise, etc.

In this work, we analyze and apply several methods to take the QDC, according to Tanaka-Moro, of Percentile, of the point of inflection and based on Fourier Analysis, with data from RIOMETERs based on the Trelew Geophysical Observatory (National University of La Plata), Chubut, Argentina, and discuss the results to compare the methods.

Scientific Session: Ionosphere and Upper Atmosphere

Presenting author: Guillermo D. Rodriguez

Link:

http://swol2023.fcaglp.unlp.edu.ar/docs/abstracts/Ionosphere_and_Uppper_Atmoshpher e/Abstract_Rodriguez_Guillermo.pdf

Quiet Day Curves for RIOMETERs: Analysis and comparison of methods.

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What's a RIOMETER?

Relative **I**onospheric **O**pacity **M**eter for **E**xtra **T**errestrial **E**missions of **R**adio

Signal

Noise

Noise

Noise

Ionosphere

So … we need a Quiet Day Curve (QDC)

Here, We define this QDC as the curve representing the minimum absorption of the Ionosphere, which we can expect.

To analyze all the other results for any day, month, or year, the data must be compared with a QDC.

For this analysis, we used data from a RIOMETER placed at the Observatorio Geofísico de Trelew. Years from 2009 to 2015, and 2020.

Methods under test (I)

Percentil

1) Allocate the data in time bins (1 minute for us)
2) Take as the QDC value for each bin, the values that separate the highest 10%, from the other 90%.

R. J. Armstrong, F. T. Berkey, and T. Melbye, “The day to night absorption ratio in auroral zone riometer measurements,” *Planetary and Space Science*, vol. 25, no. 11, pp. 1031–1036, Nov. 1977, doi: 10.1016/0032-0633(77)90150-7.

Inflection point

1) Allocate the data in time bins (1 minute for us)
2) Calculate the voltage distribution
3) Take as the QDC value, the high side inflection point of distribution for each bin.

S. Krishnaswamy, D. L. Detrick, and T. J. Rosenberg, “The inflection point method of determining riometer quiet day curves,” *Radio Sci.*, vol. 20, no. 1, pp. 123–136, Jan. 1985, doi: 10.1029/RS020i001p00123.

Methods under test (II)

Moro - Tanaka

1) Eliminate days with Kp>3
2) Median + 0.75 % of the maximum reliable level measured restriction (10' bins)

1) Recursive Iteration $\mu \pm 3\,\sigma$ (1' bins)
2) QDC' as (80% μ) + 3 σ
3) Averaged over 30 points

J. Moro, C. M. Denardini, E. Correia, M. A. Abdu, N. J. Schuch, and K. Makita, "A comparison of two different techniques for deriving the quiet day curve from SARINET riometer data," *Ann. Geophys.*, vol. 30, no. 8, pp. 1159–1168, Aug. 2012, doi: 10.5194/angeo-30-1159-2012.

FFT

1) QDC' as peaks of the signal intensities distribution
2) Calculate FFT of this QDC'
3) High order coefs. = 0 (i>3 or 5)
4) IFFT over this result

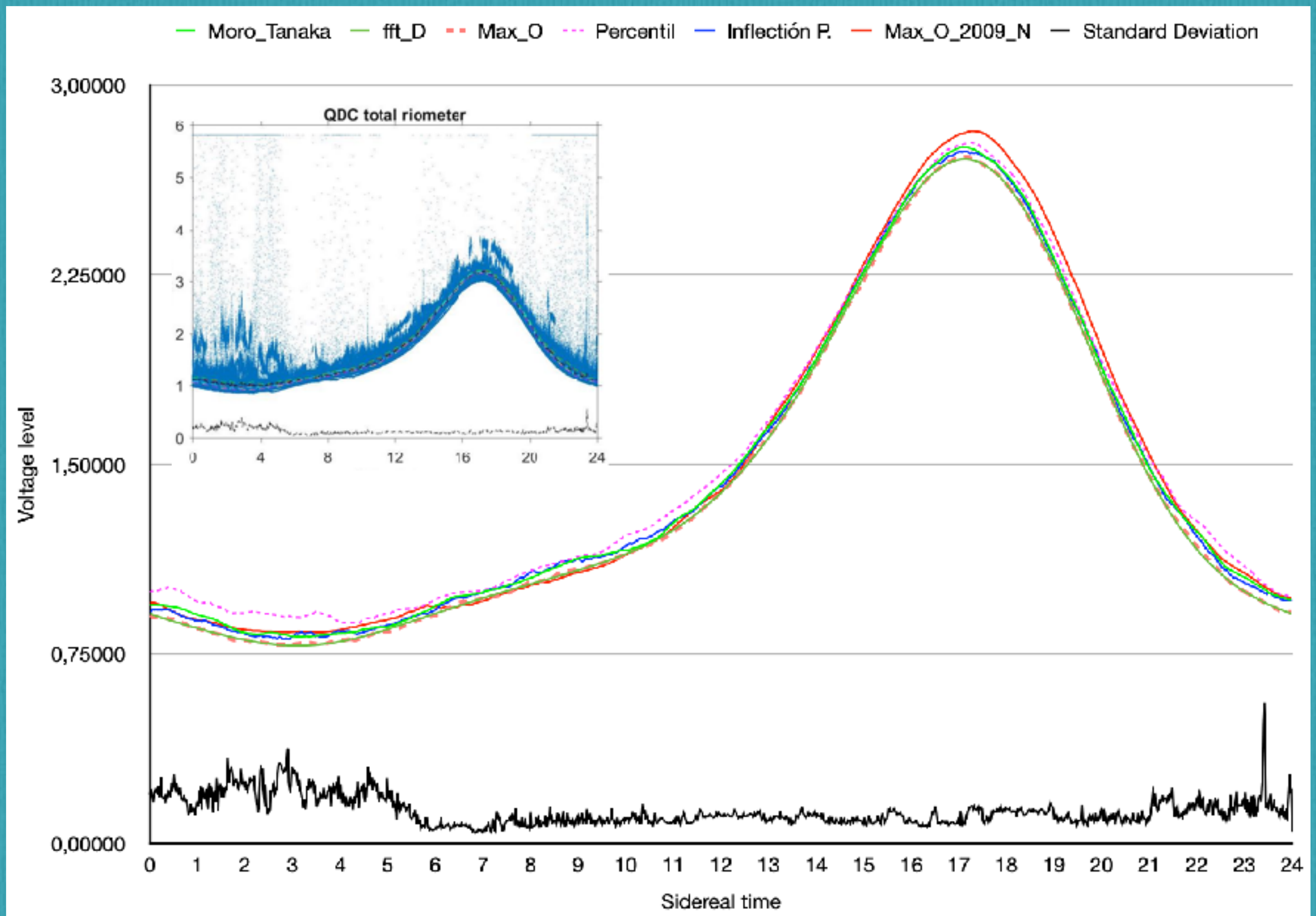
Drevin, G. R., and P. H. Stoker, Determining riometer quiet day curves, 2, Derivation of filter cutoff frequencies, Radio Sci., 38, doi:10.1029/2001RS002538,, 2003.

Methods under test (III)

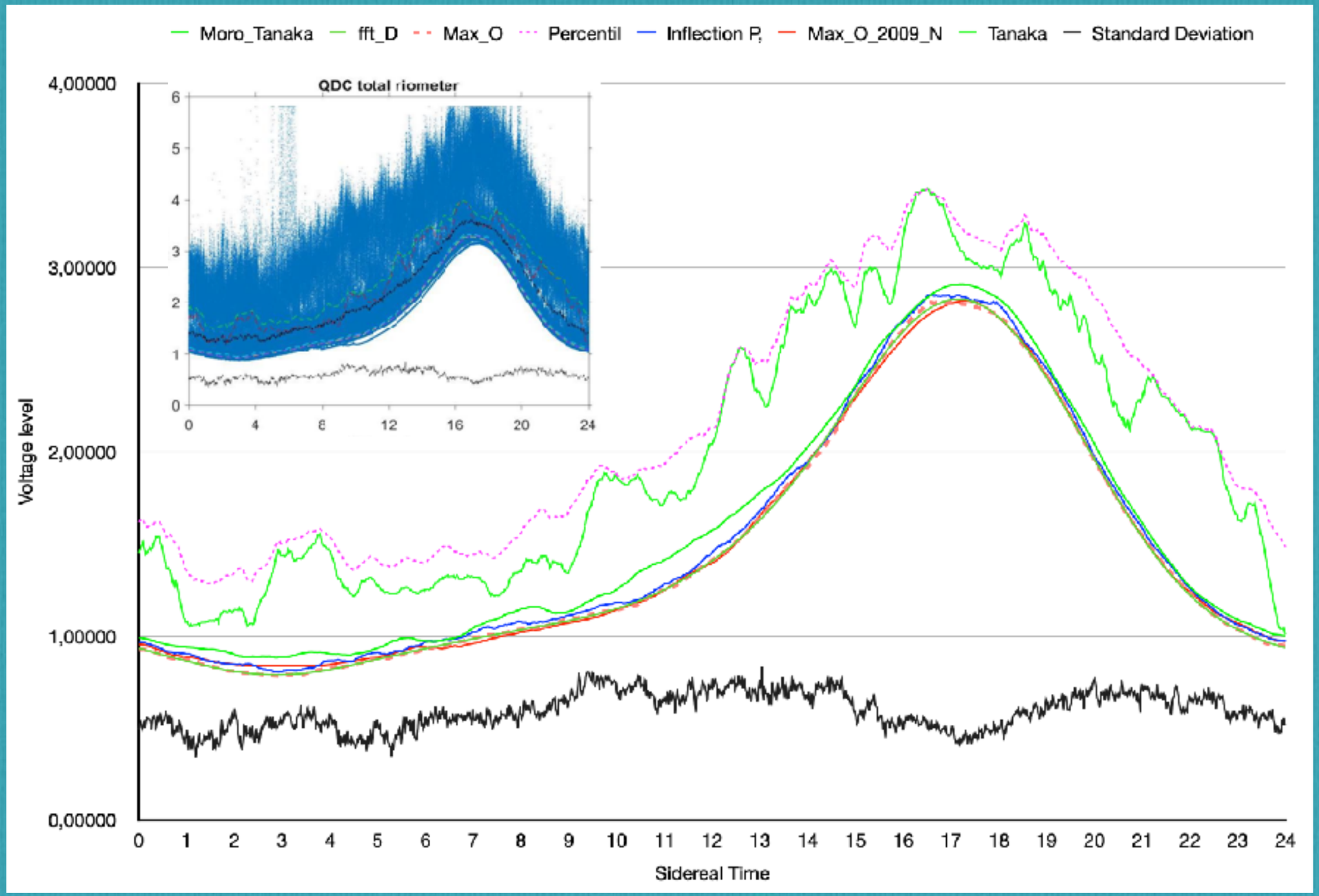
Maximun Occurrence - New proposal

1) Take data for the 0:00 to 4:00 AM period of each day of the year
2) Create an histogram for this data (1' bins)
3) Take like QDC, values with higher occurrence.
4) Here, we can do this procedure, just for a IQSY or each year.
5) Indeed, we compute this method using data for all the day to obtain monthly QDC.

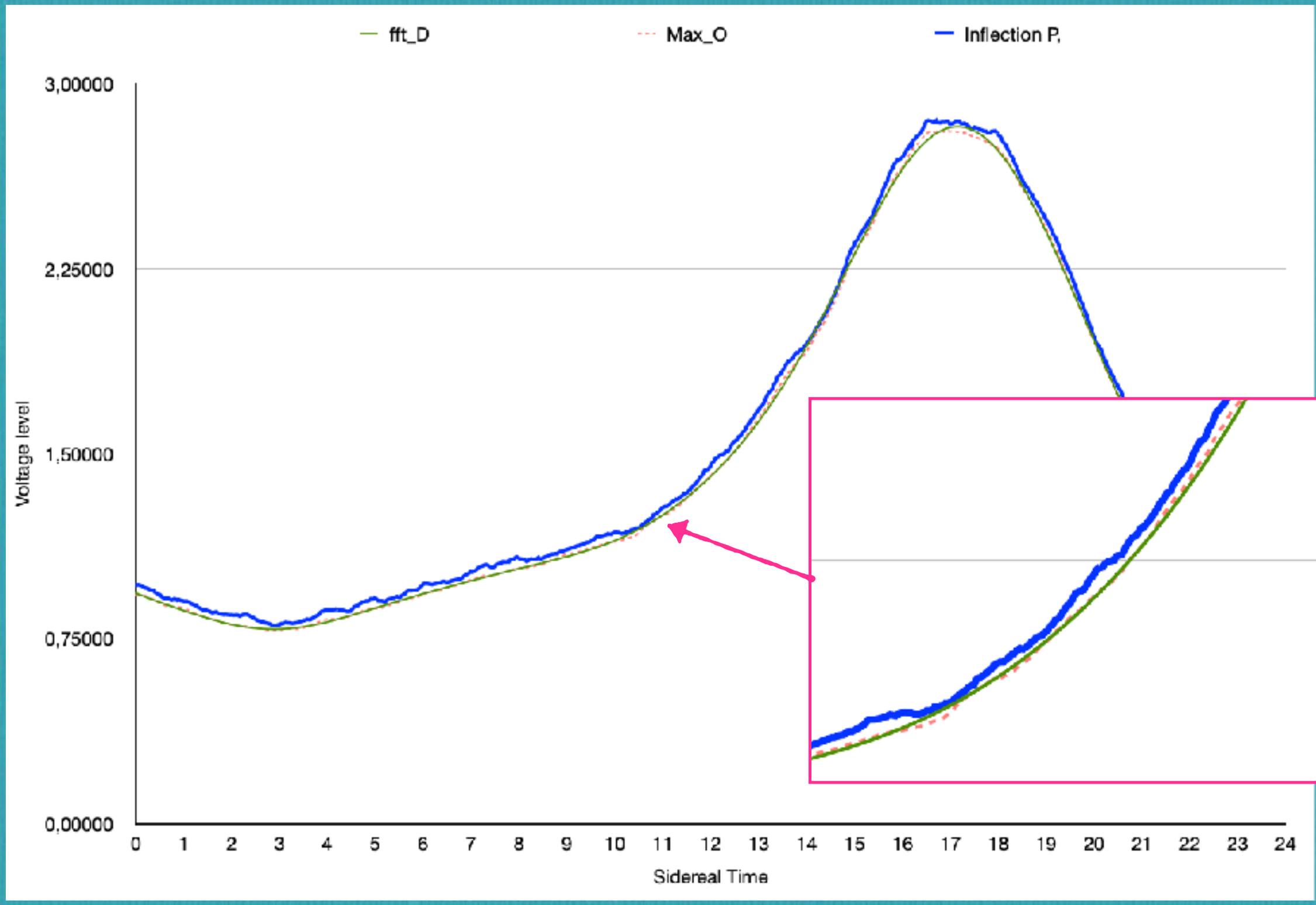
Results: February 2009 (quiet month)



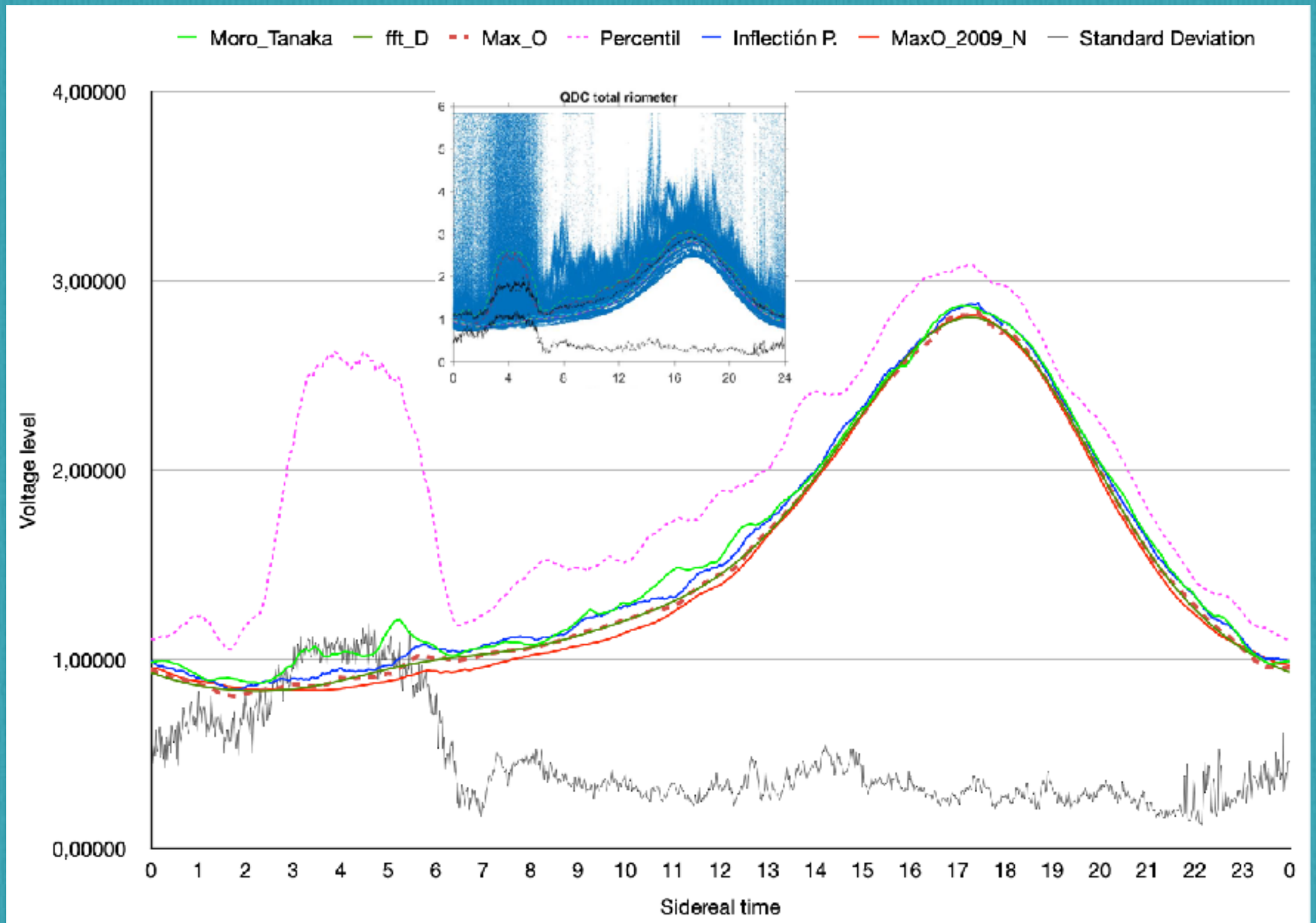
Results: April 2009 (noisy month)



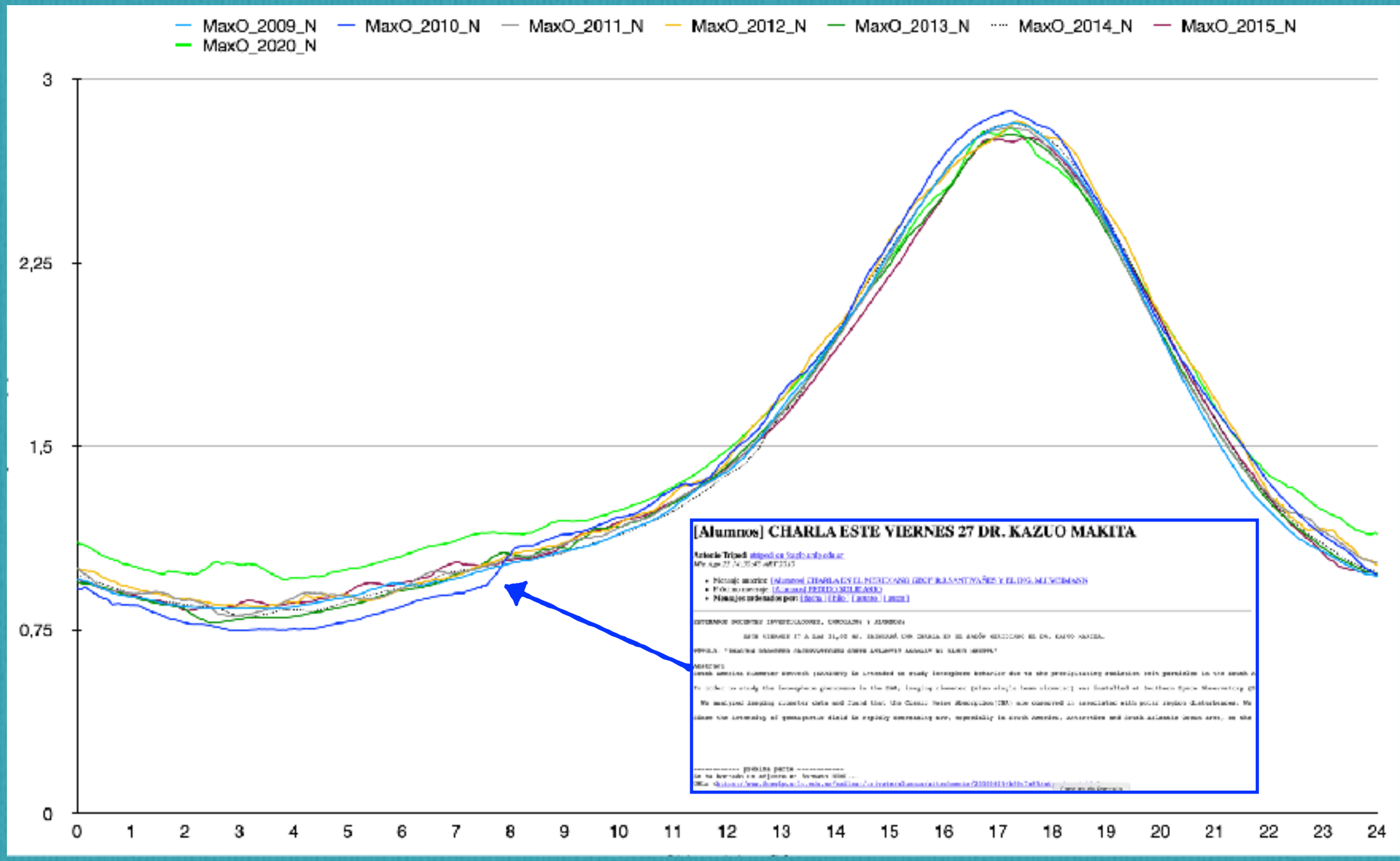
Results: April 2009



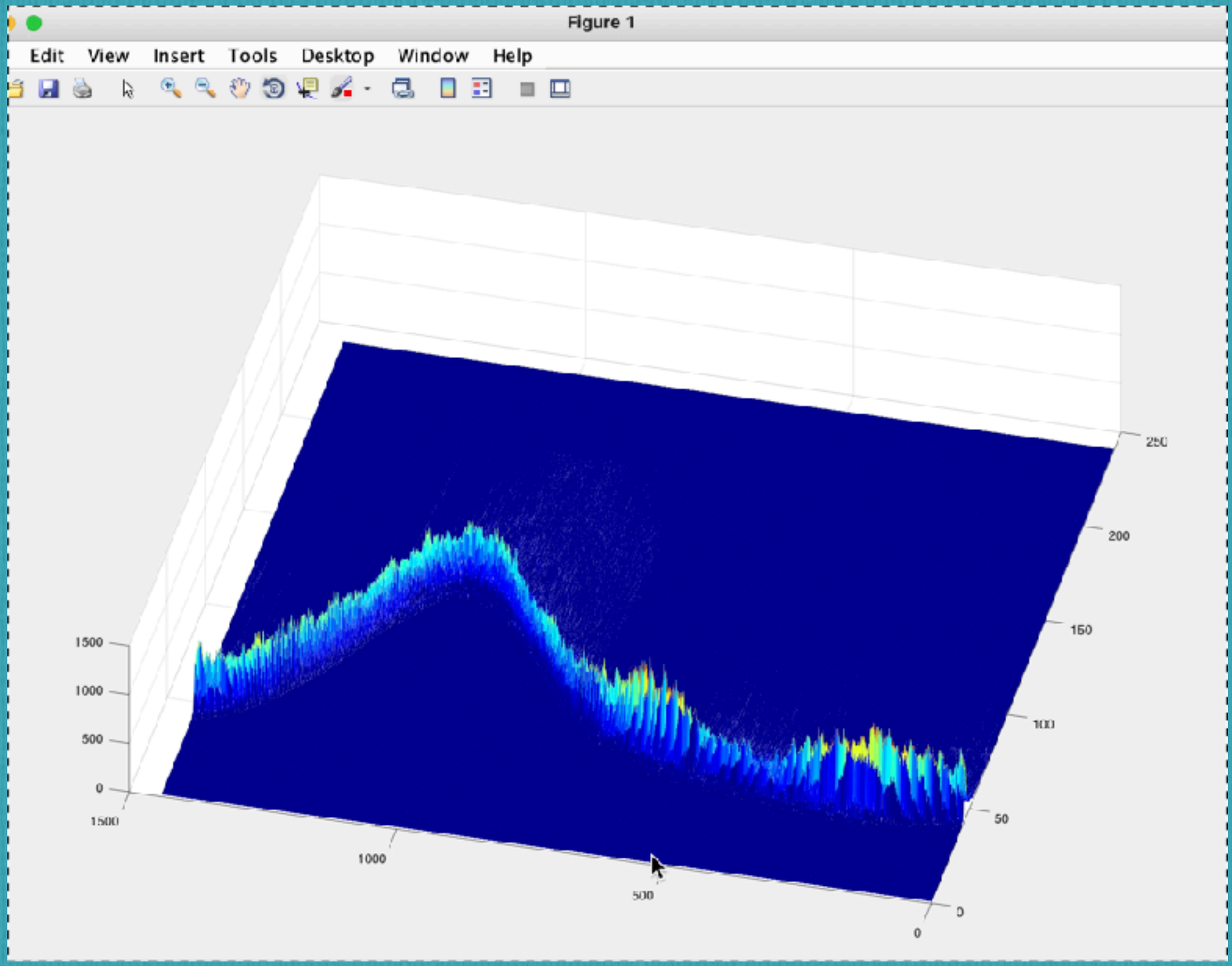
Results: April 2014 (noisy month)



Results: QDC Maximum Occurrence Night - Years comparison

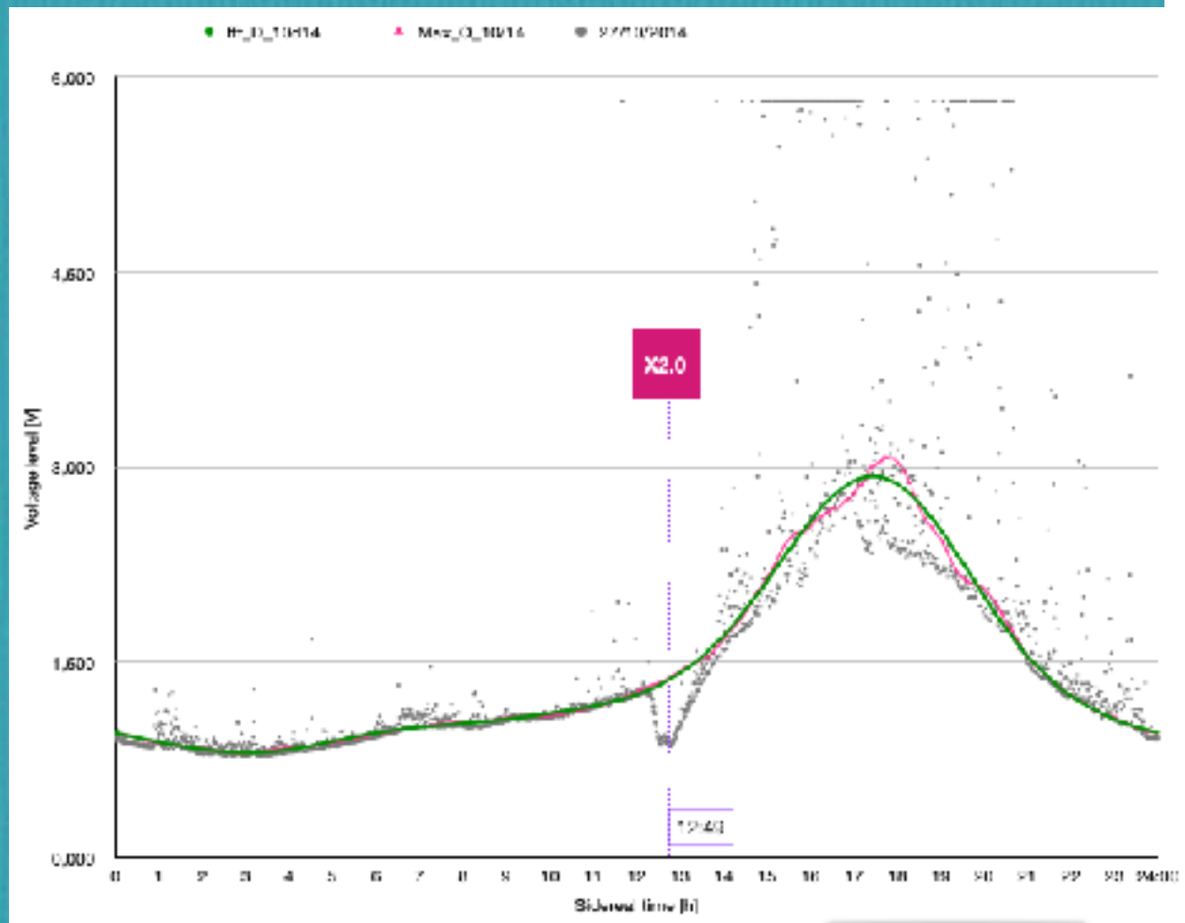


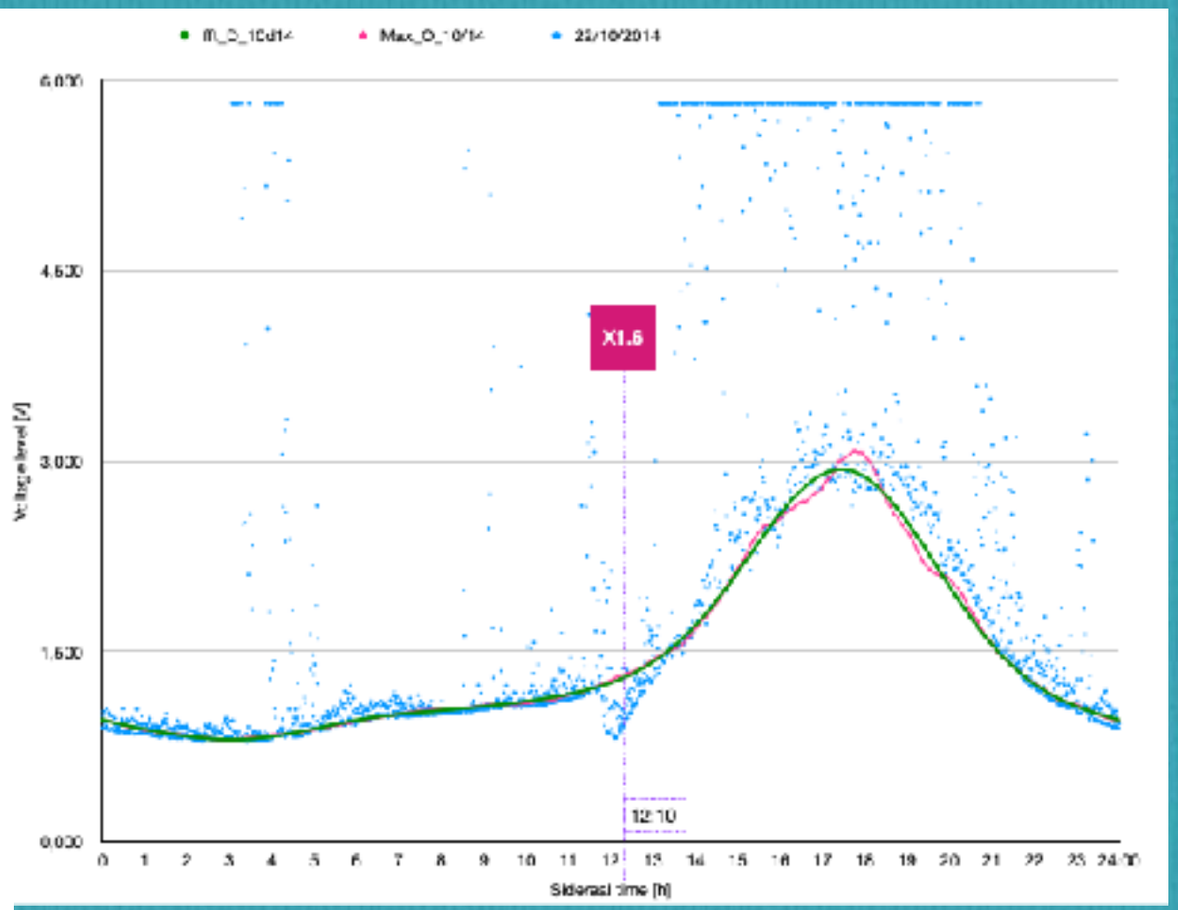
Results: QDC Maximum Occurrence



QDC used to analyze Solar Flares

October 2014 (22 and 27)





Conclusions

- For Maximum Occurrence method, we obtain similar results working with all day data or just with night data only (medium lattitud's).
- The use of anual data is complex related with the stability of the instrument. Changes on it, change the response.
- FFT and Maximun Occurrence methods are more sturdy against noise. Considering that the first one is a mathematical representation and the second is more confident with the data, we prefer Max_O.