Detecting Seismic Anomalies within NOAA OLR data and DEMETER EM data Using Wavelet Transformation and Holder Exponents

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The Second DEMETER Workshop, Paris, France
10th – 12th October 2011

Overview

- Project background
- Methodology
- An application in detecting anomalies associated with the Wenchan and Puer earthquakes
  - OLR data observed by NOAA-8
  - Electromagnetic (EM) data recorded by DEMETER
- Summary

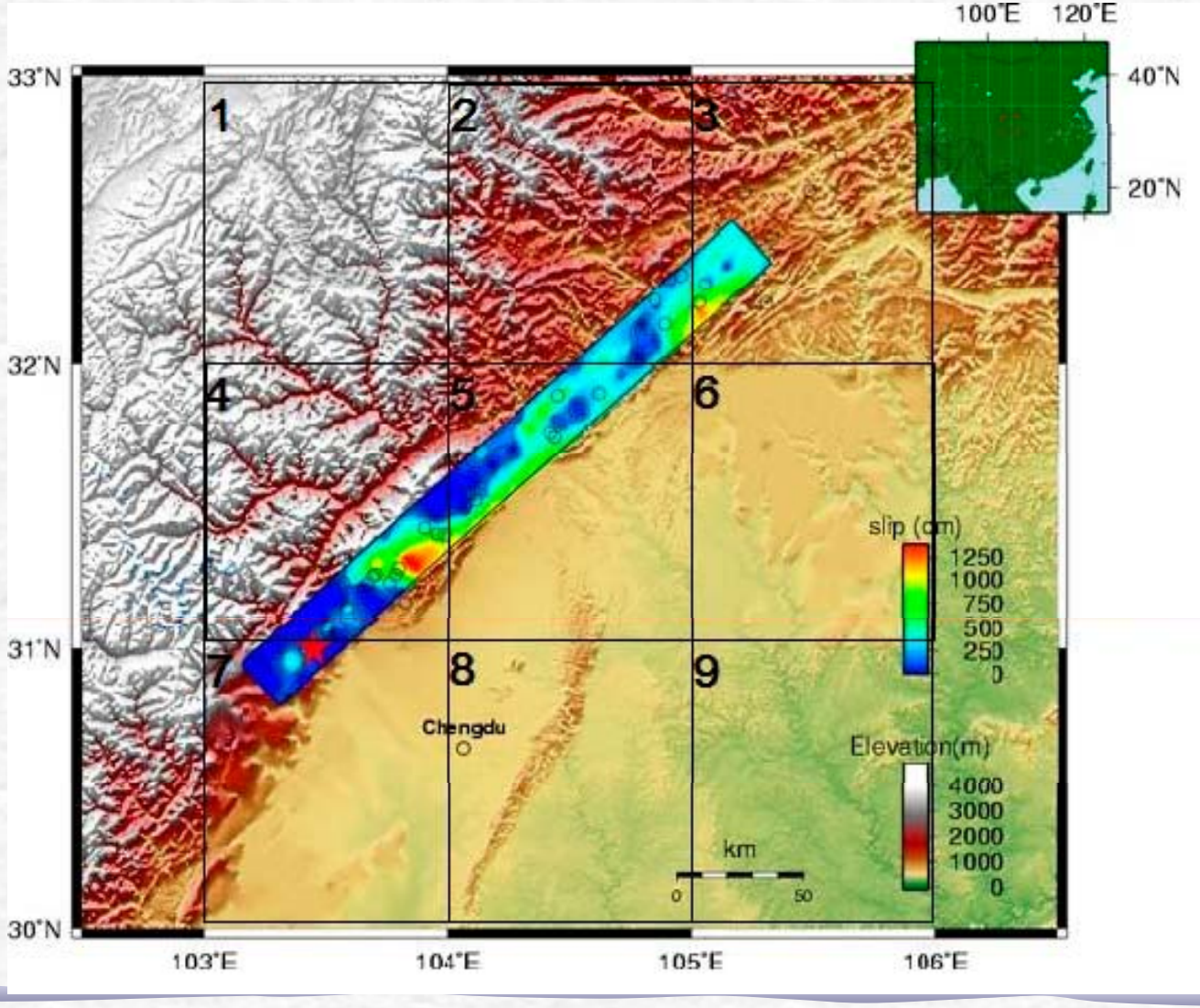
Research background

- A collaborative project of “data mining with multiple parameters constraints for earthquake study” between the University of Ulster, U.K and Institute of Earthquake Science, China Earthquake Administration (CEA)
- The aim of the project was to investigate associations between precursors identified from OLR and EM data with earthquake cases by using a range of data analysis methods, such as wavelet transforms, Holder exponent, and so forth

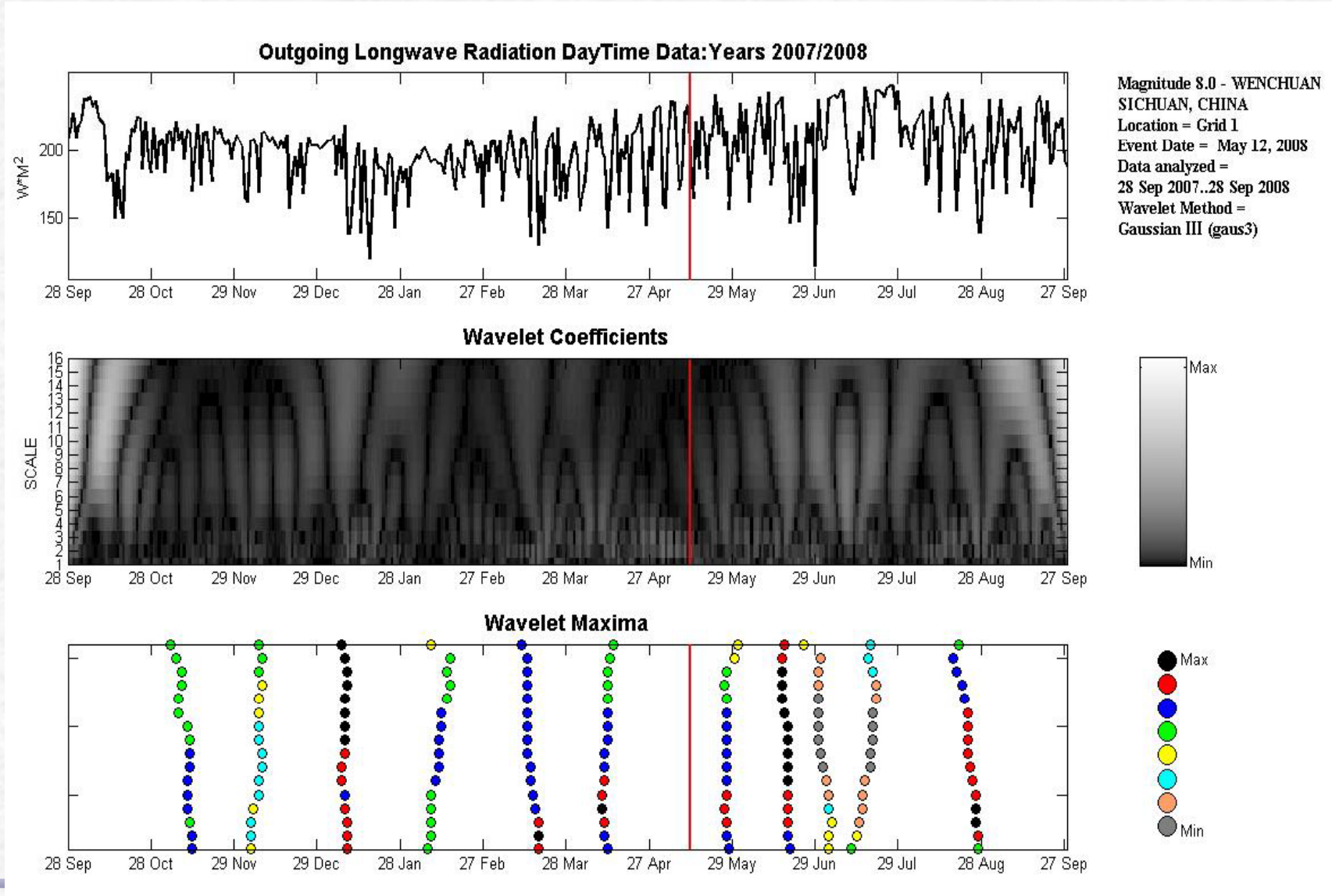
Identify seismic anomalies by wavelet and Holder Exponents

- Analyzing data sequences of grids and orbits using db1 (Daubechies) and (Gaussian) gaus3 wavelet methods.
- Identifying wavelet maxima for each of the scales predefined
- Generating a line of wavelet maxima along the scales over the grids.
- Measuring the space and time continuity of the lines of wavelet maxima in terms of singularity
- Decomposing data sequences into multi-signals based on the different scales
- Identifying seismic anomalies.

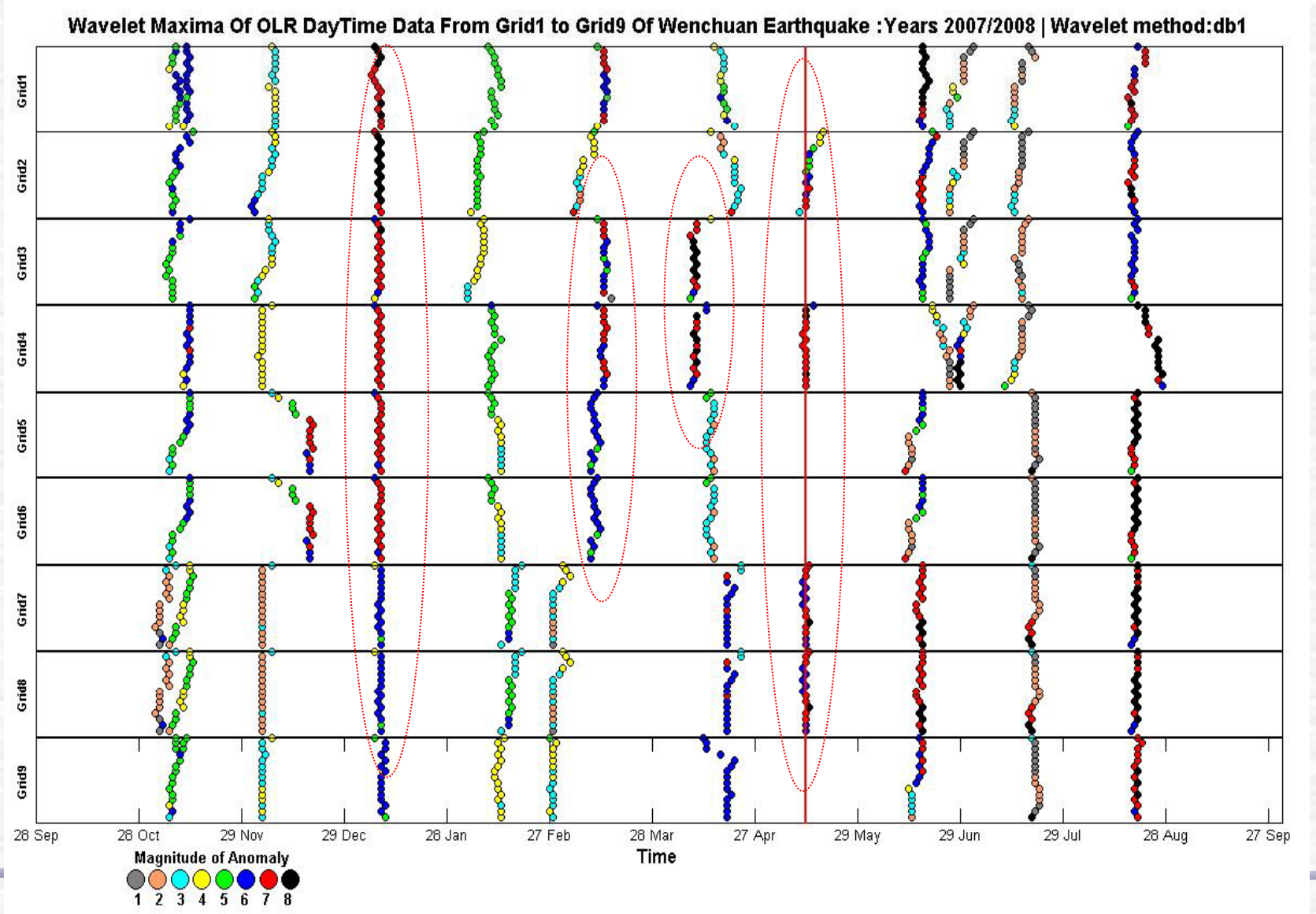
Gridding the study area



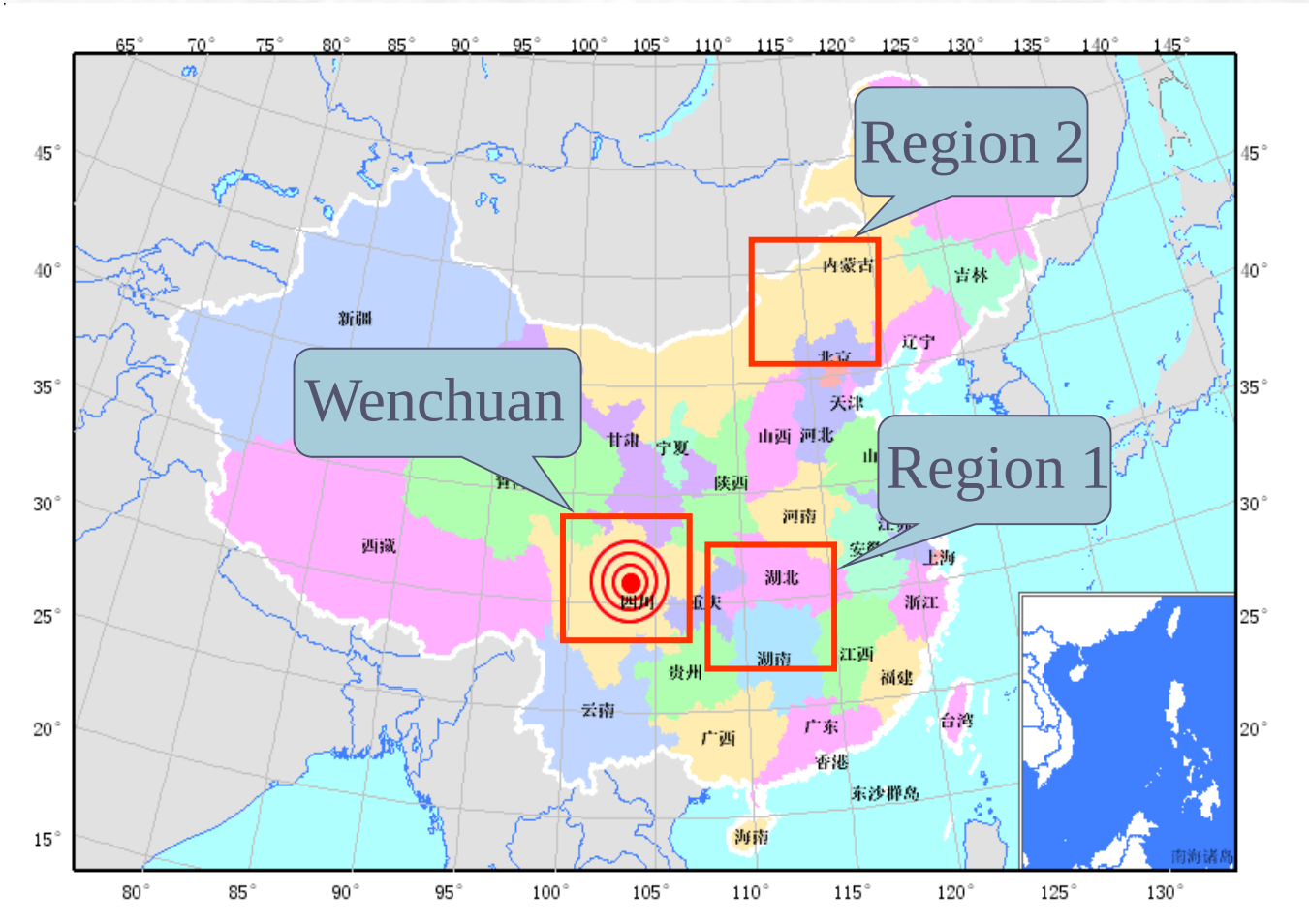
Plot of coefficients over time



The curves of wavelet maxima



Magnitude 8.0 - Wenchuan Earthquake



Date-Time

May 12, 2008 at 02:28:01 PM

Epicenter Location

30.986° N, 103.364° E

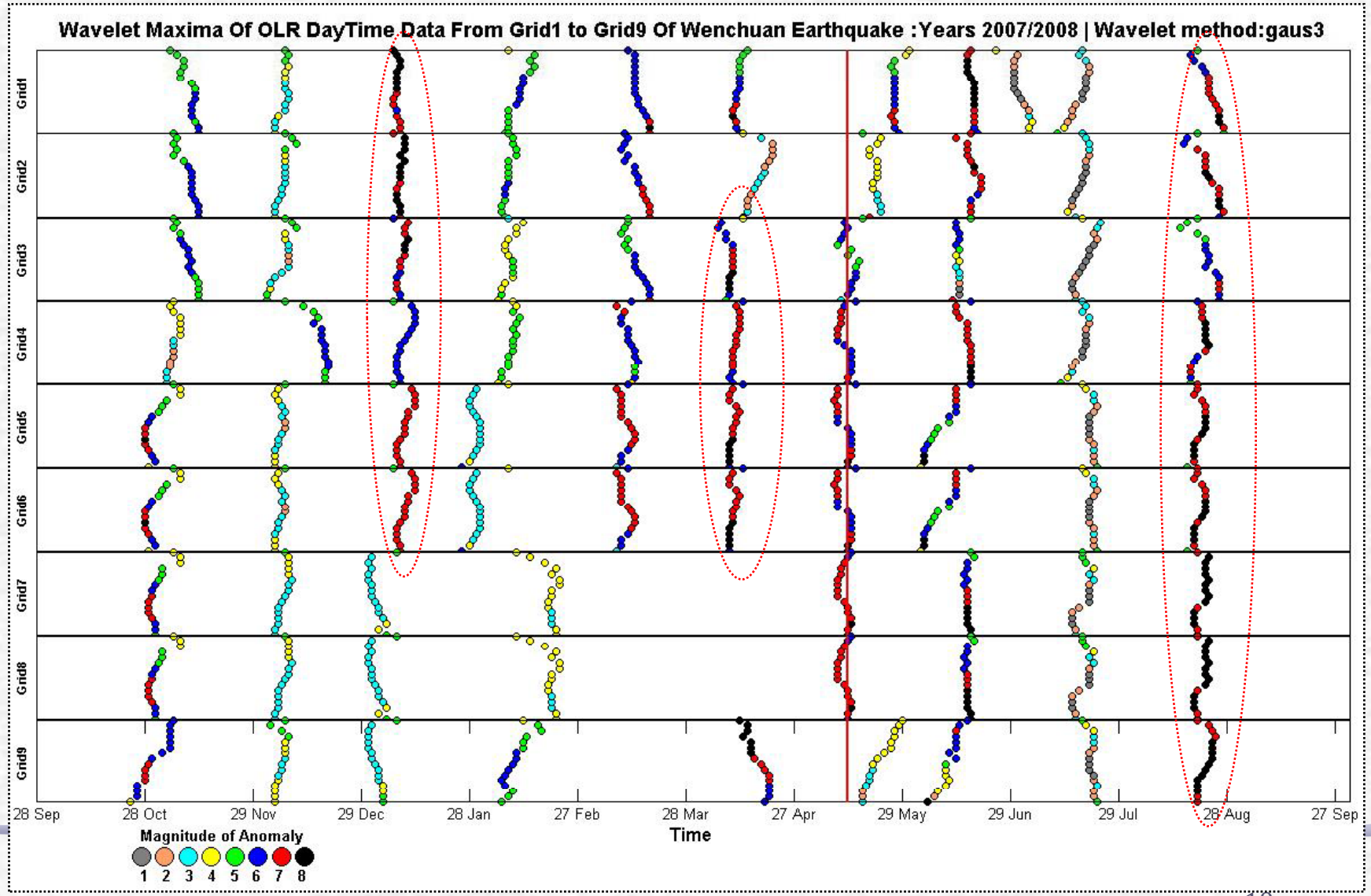
Region

WENCHUAN SICHUAN, CHINA

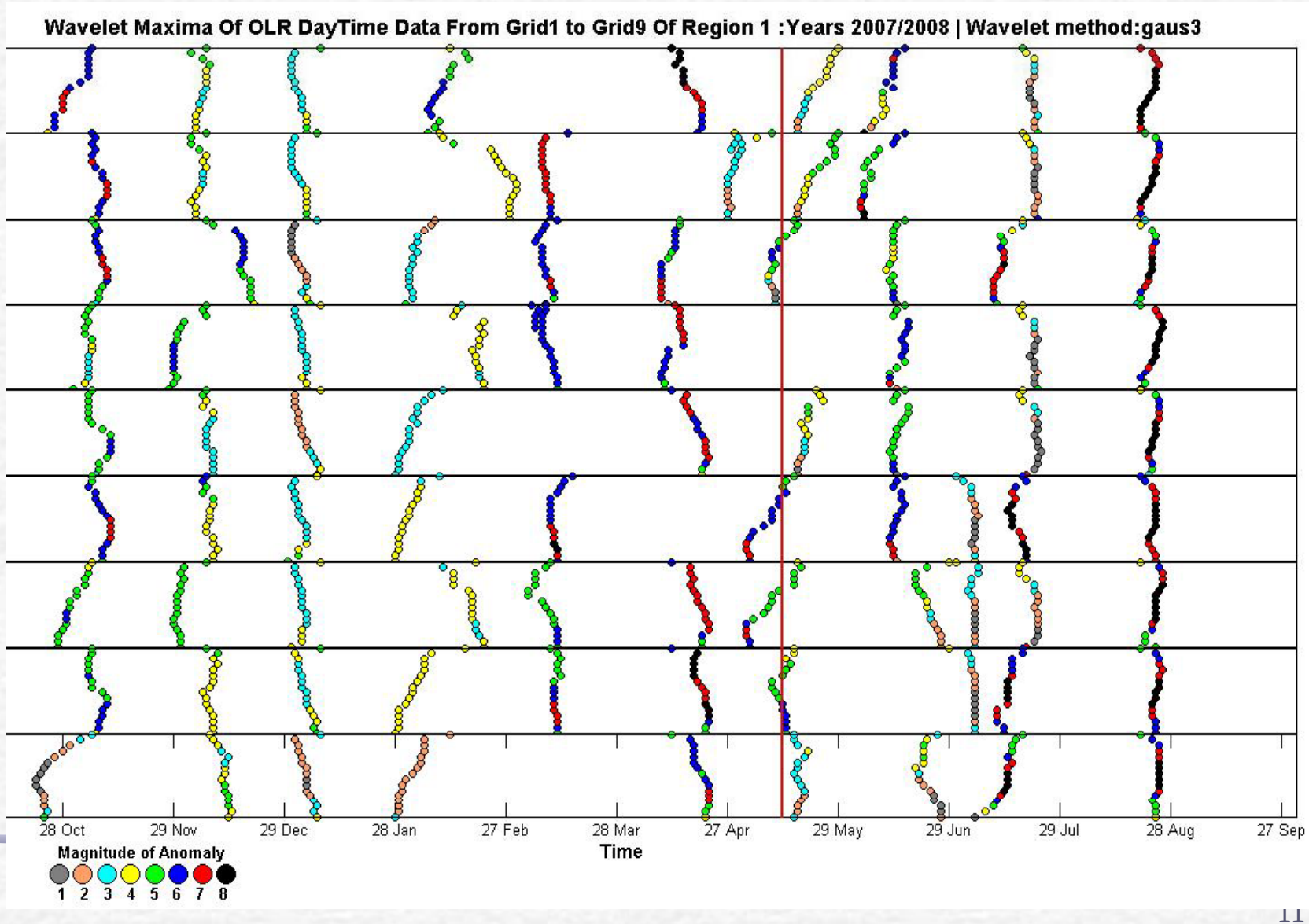
ORL Data

- Daily means of Outgoing Longwave Radiation (OLR) data from NOAA-18 (National Oceanic and Atmospheric Administration)
- Spatial coverage is 1 degree latitude by 1 degree longitude global grid and 30°N - 33°N, 103°E - 106°E.
- From 28th September 2007 to 27th September 2008

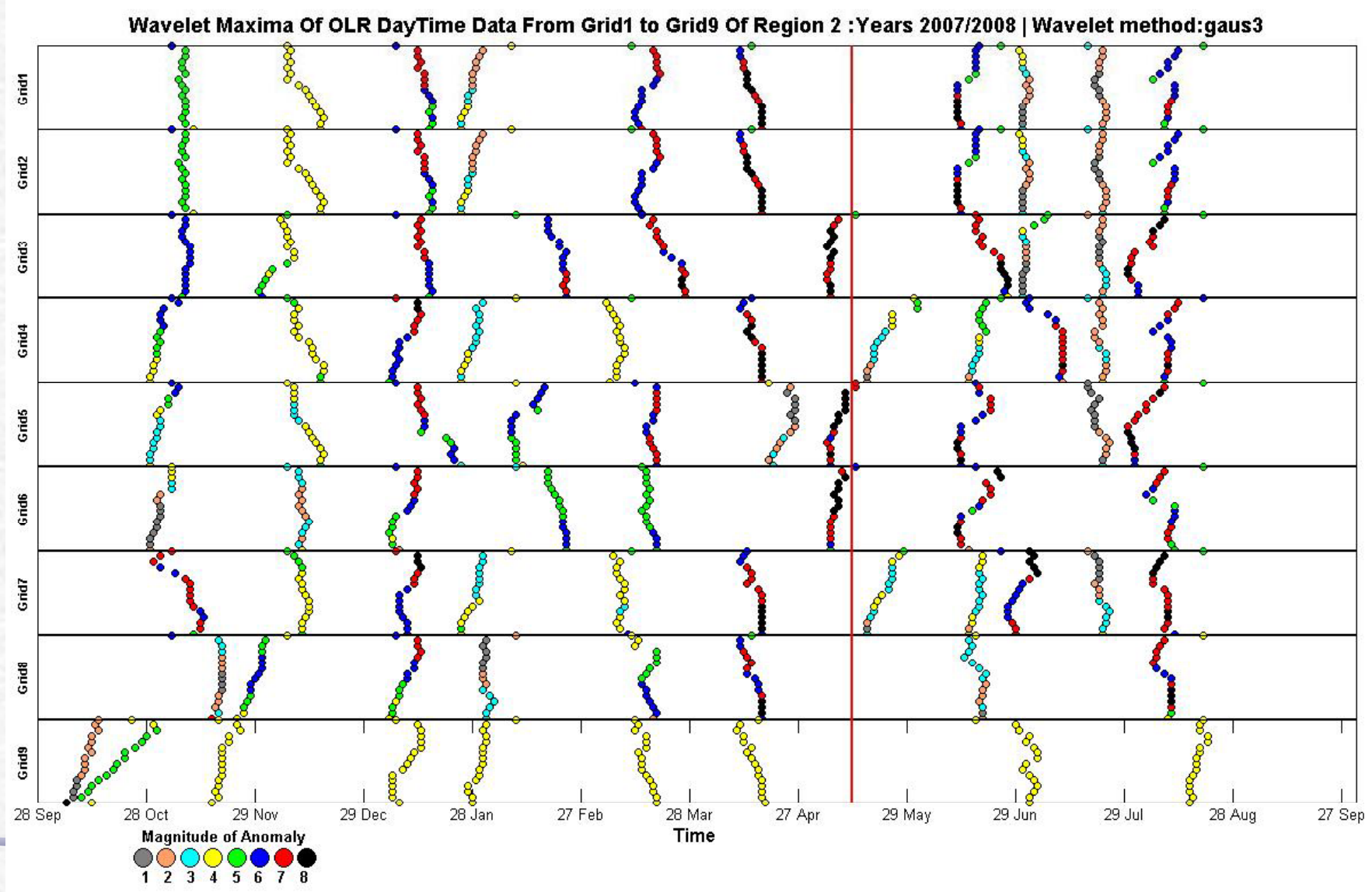
Maxima curves of the Wenchuan region



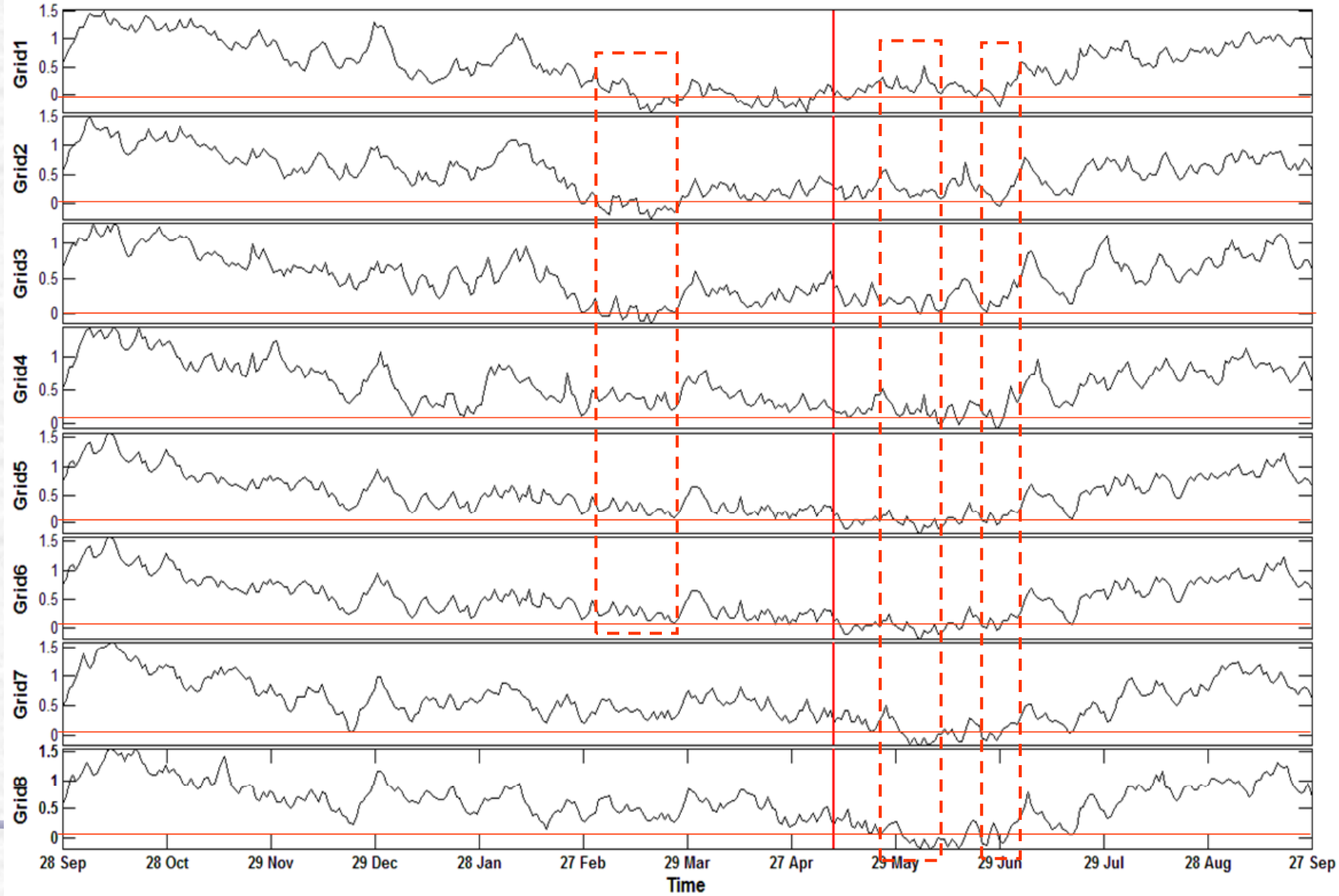
Maxima curves of the Region 1



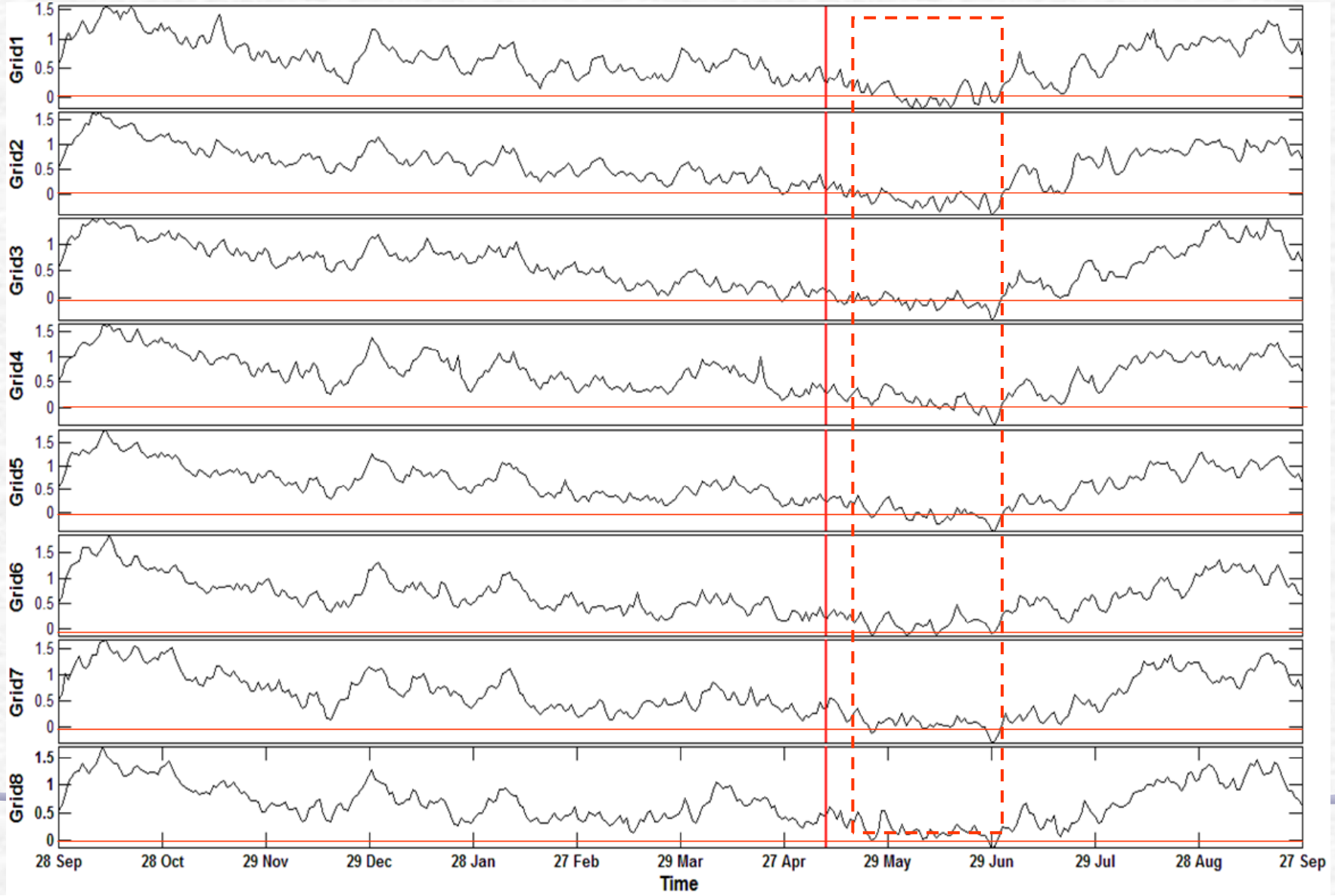
Wavelet maxima analysis curves of the Region 2



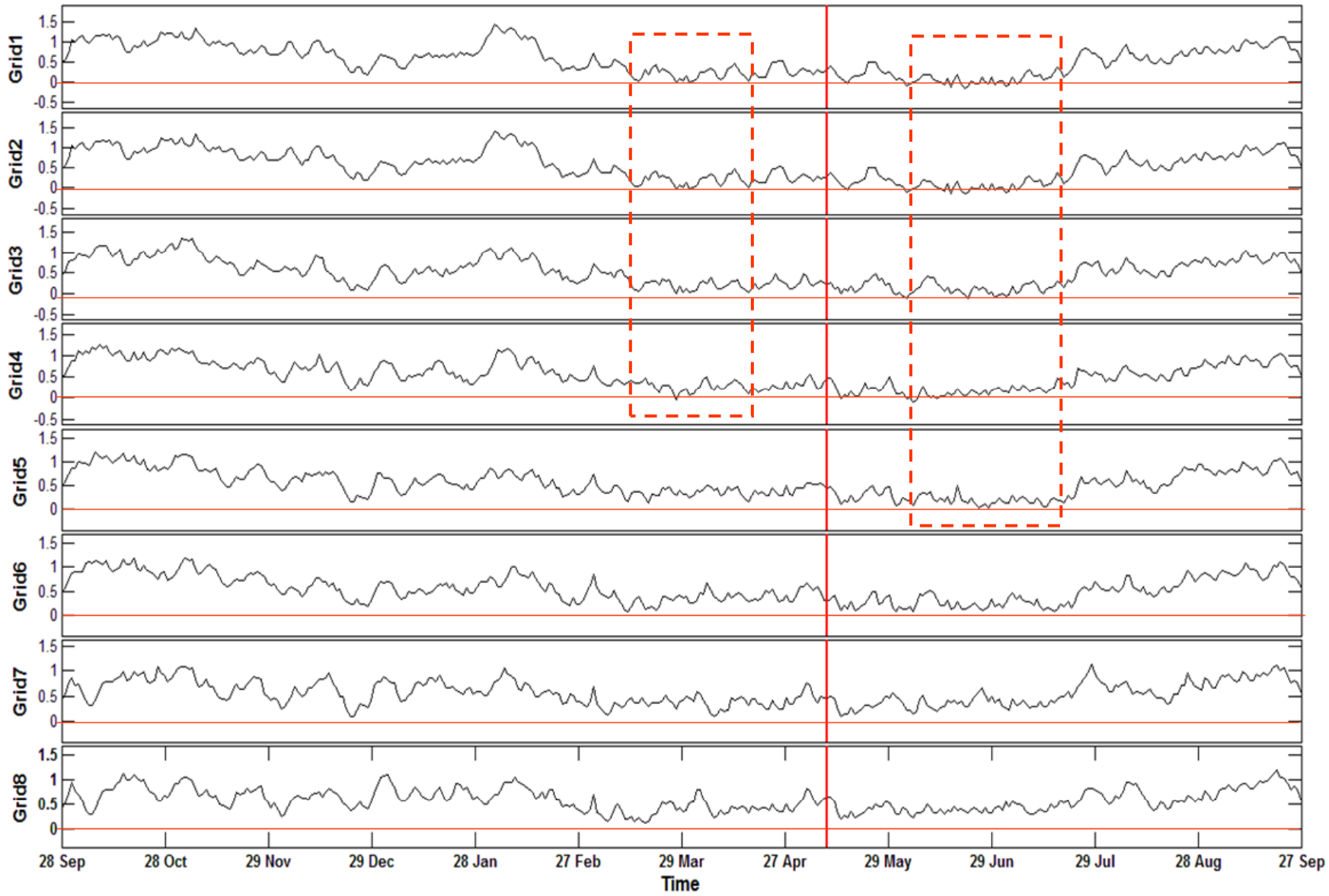
Holder exponent of the Wenchuan region



Holder exponent associated with Region 1



Holder exponent associated with Region 2



Data selected from DEMETER

- The abnormal events are identified on the basis of obvious synchronous perturbations on the physical parameters of interest at the same time interval in the same orbit from level 2 data provided by DEMETER
- 11 days data are selected (10 days prior to earthquakes and one day post earthquake occurrence).
- Epicenter as a central point of a studying area and 1888km a diameter, to select all the orbits within in 11 days.

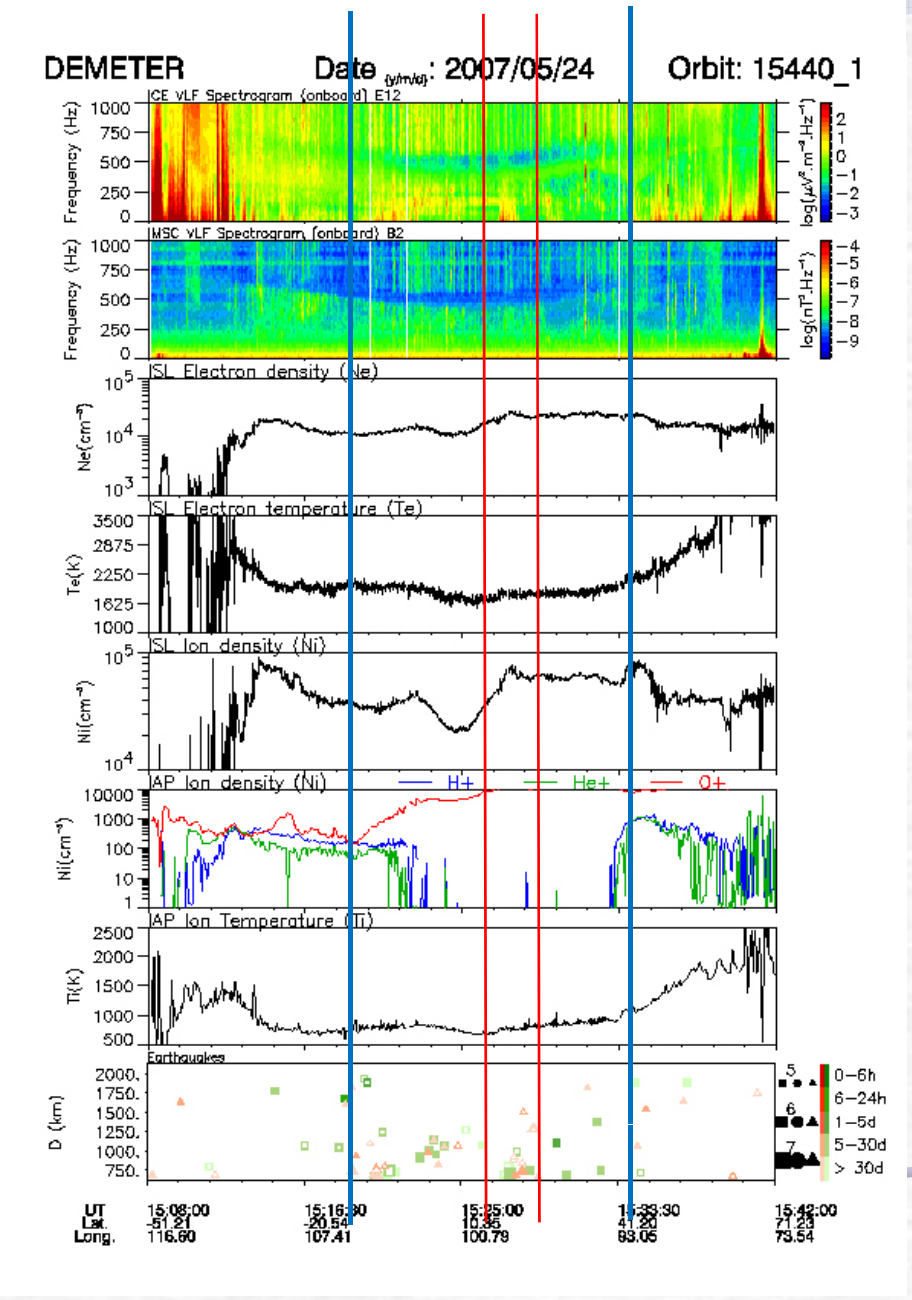
Data selected from DEMETER (cont'd)

- The studied physical parameters include below
  - electron density (Ne) measured by ISL
  - electron temperature (Te) measured by ISL
  - ion density (Ni) measured by ISL
  - ion Temperature (Ti) measured by IAP

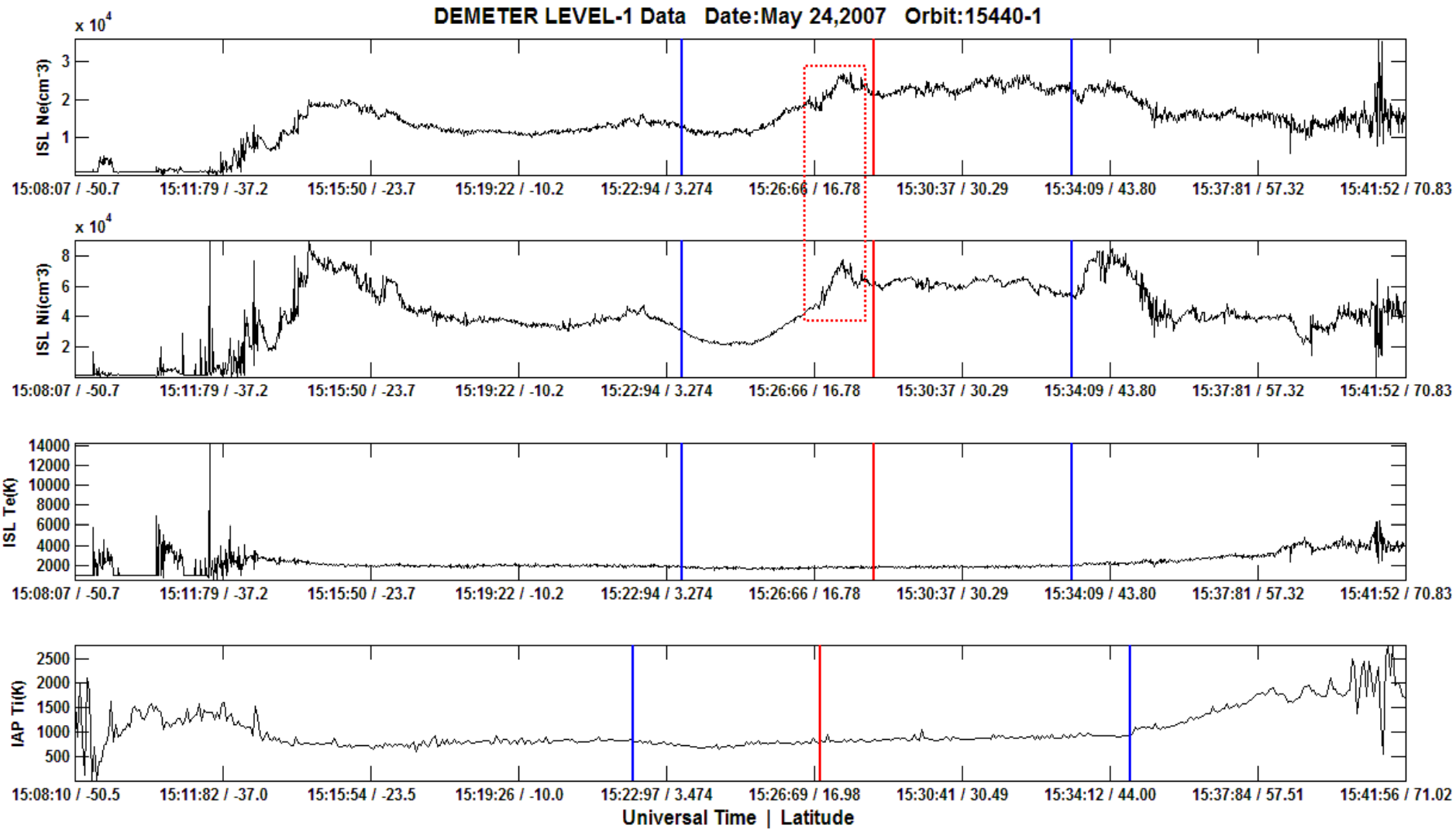
Data selection (cont'd)

- Earthquakes
  - Puer earthquake: orbits 5440_1, 15454_1, 15542_1, 15572_1 and 15558_1
  - Gaize earthquake: orbits 18716_1 and 18804_1
  - Wenchuan earthquake: orbits 20565_1 and 20595_1
  - Jiujiang earthquake: Orbit 07380_1
- Experimental results below are only orbit 15440_1

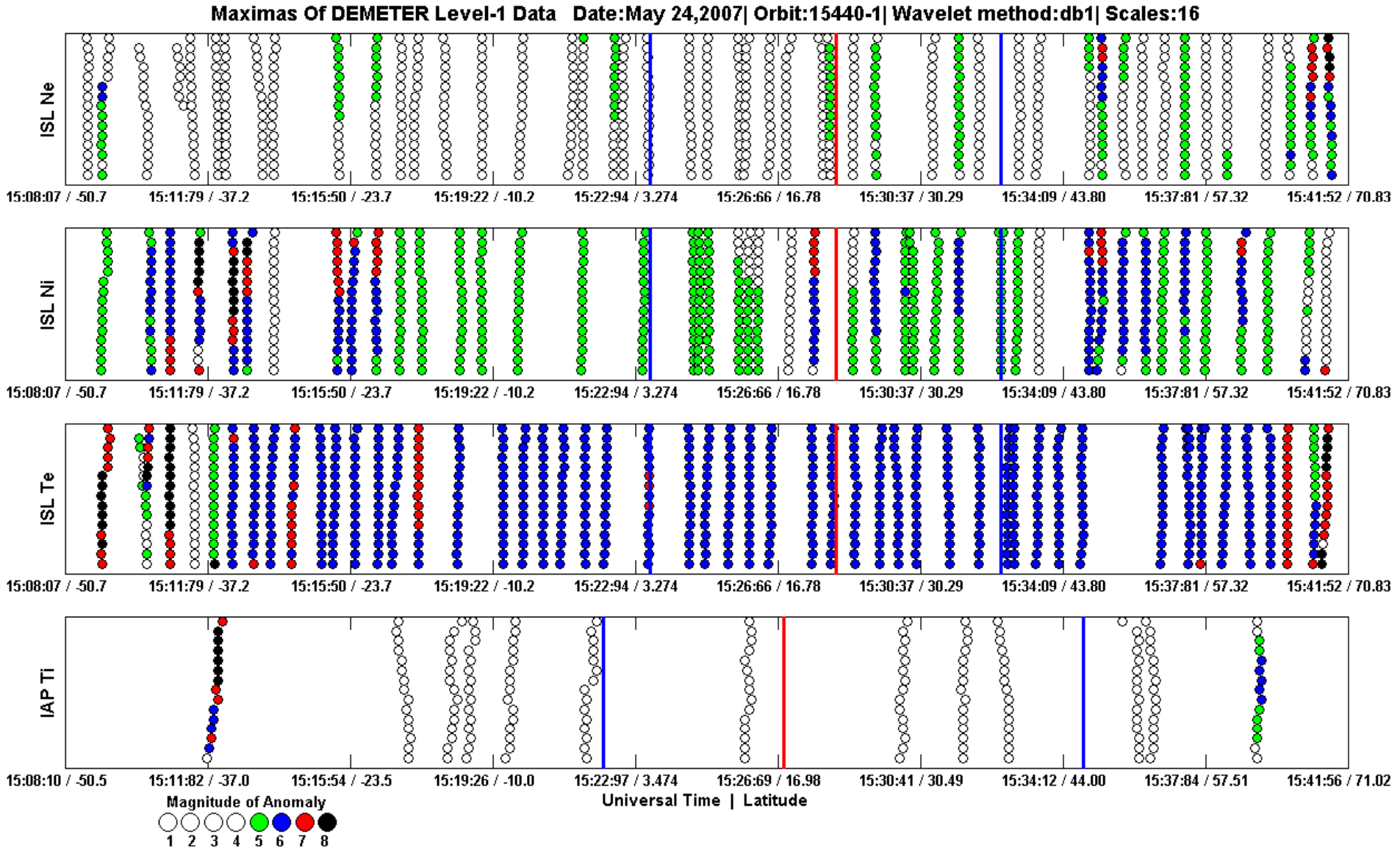
Orbit 15440_1 in Level 2



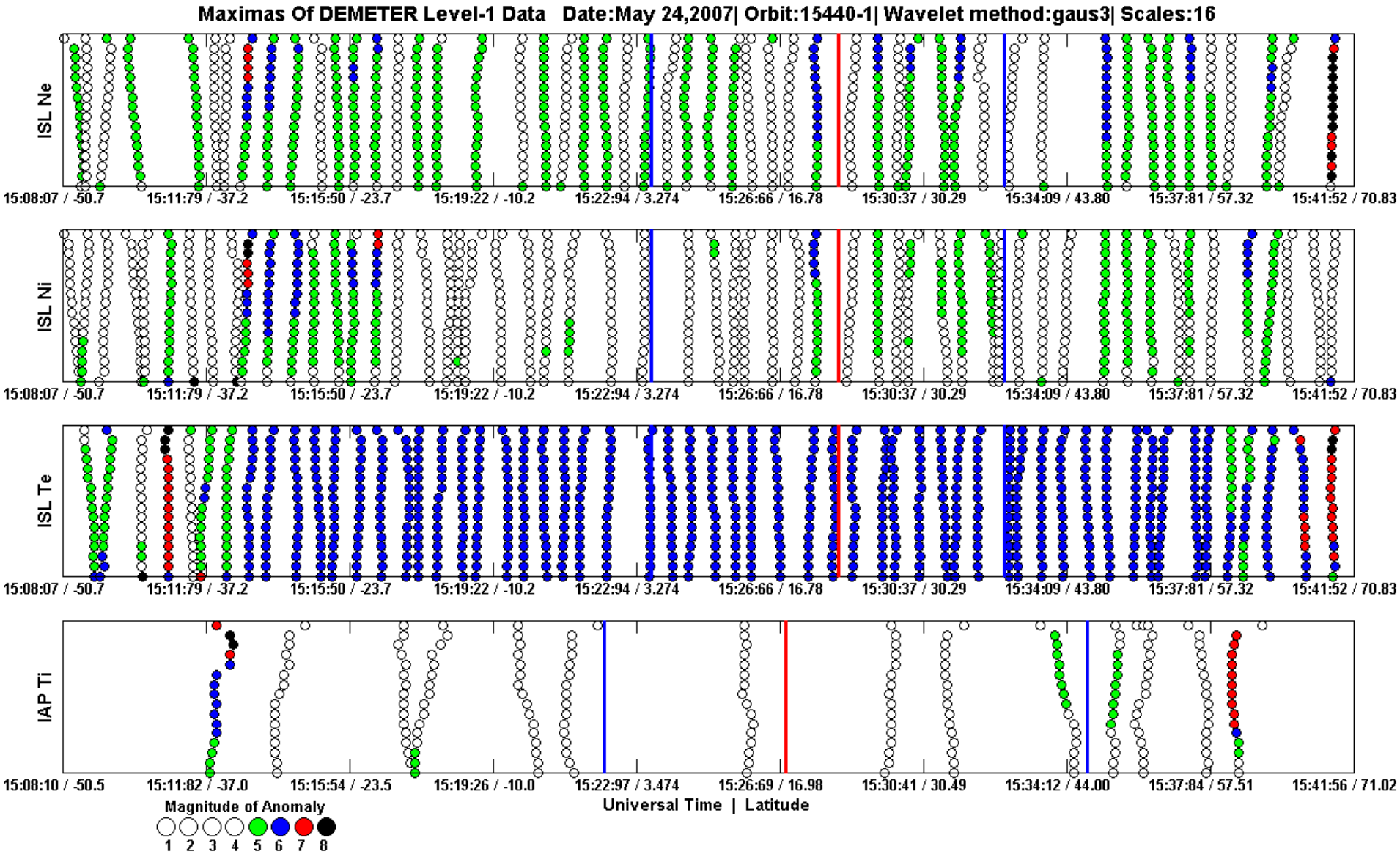
Plot of parameters of Ne, Te, Ni and Ti



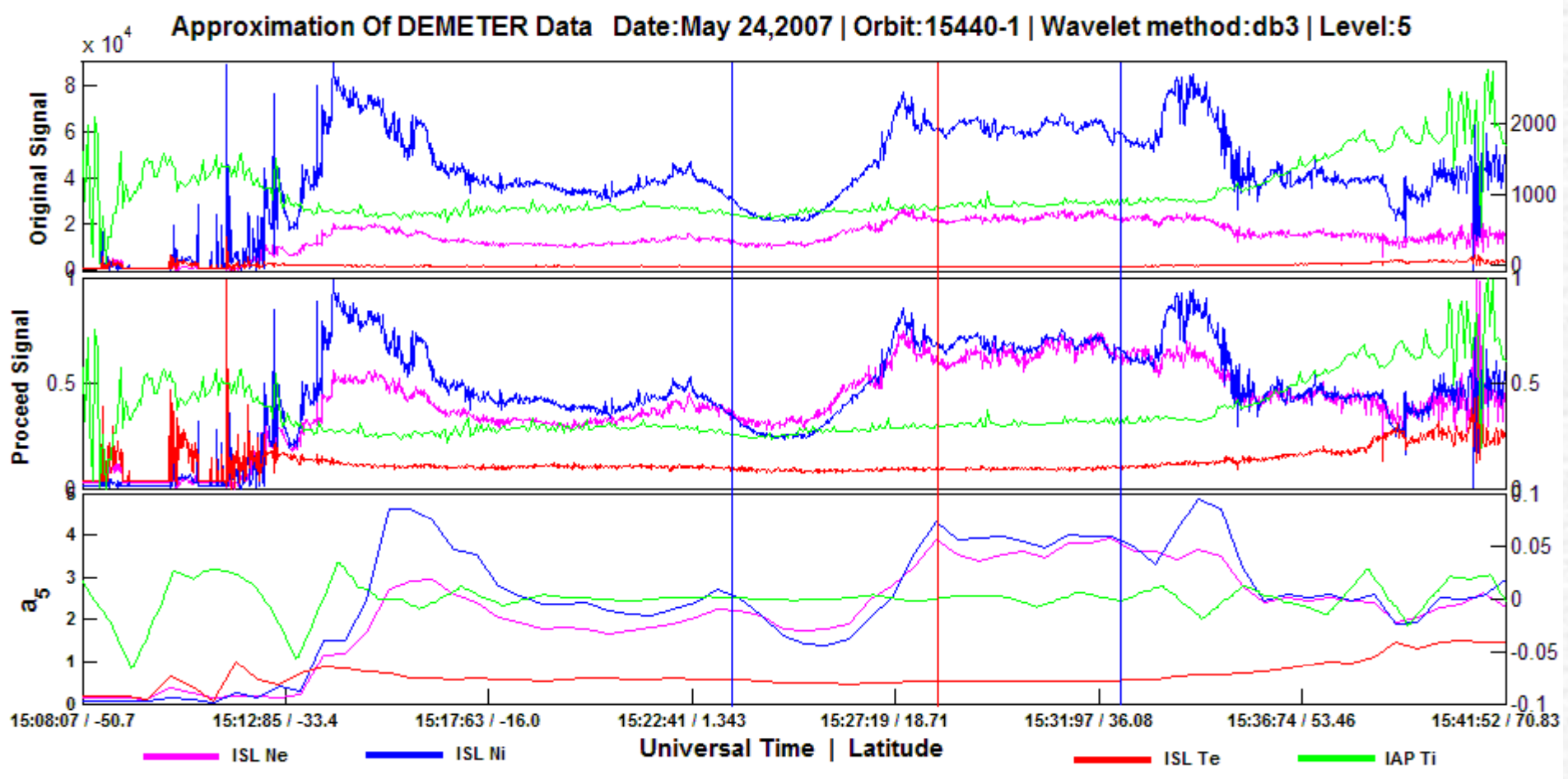
Wavelet maxima of the parameters of 5-8 magnitudes by db1



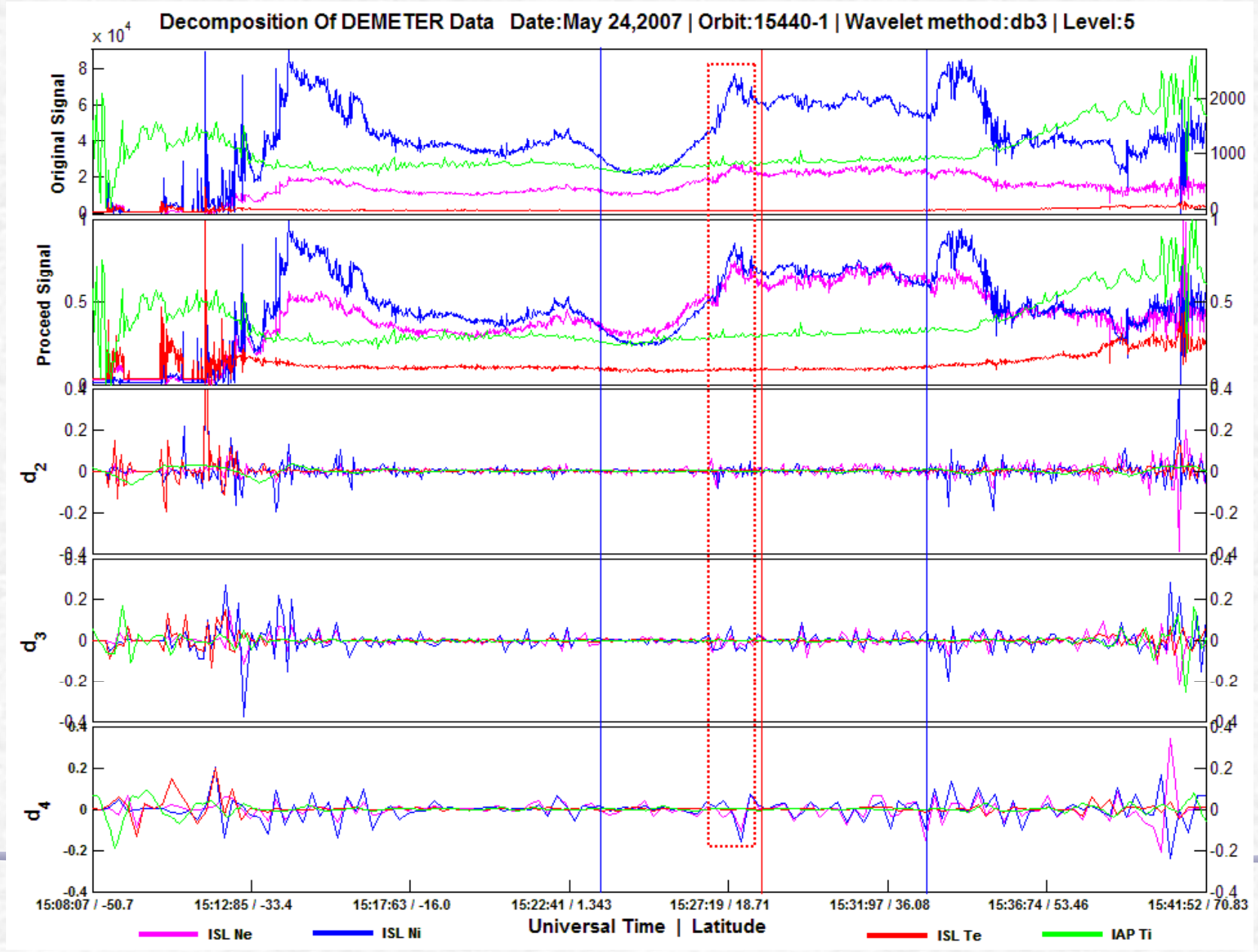
Wavelet maxima of the parameters of 5-8 magnitudes by gaus3



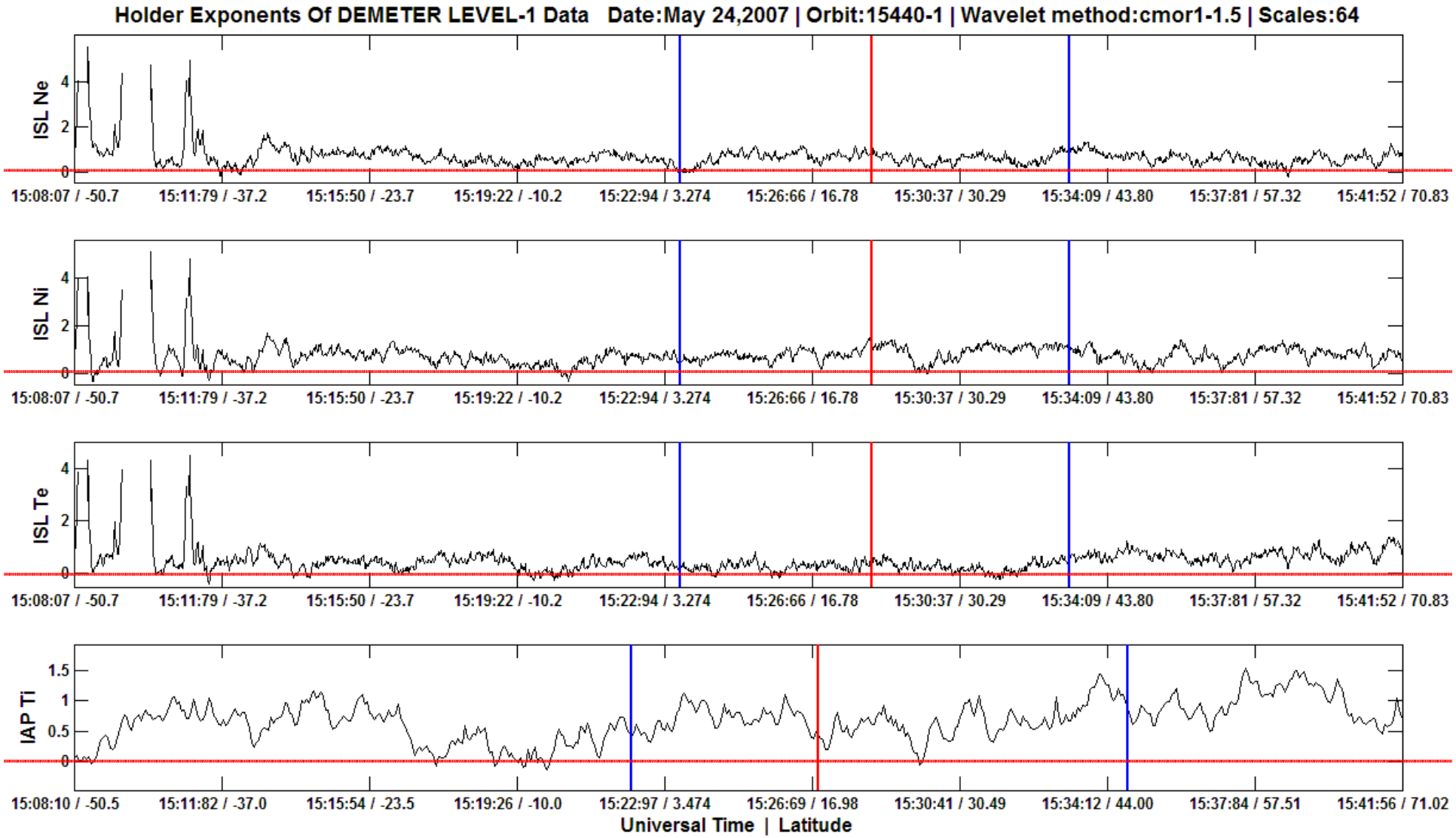
Wavelet approximation of studied physical parameters



Wavelet details of studied parameters



Holder exponents of studied parameters



Summary

- The wavelet modulus maxima and Holder exponent can be used as effective techniques to detect concept drifting or changes within data sequences
- The case studies show the method proposed appears to be more effective on Outgoing Longwave Radiation and Electromagnetic data
- The rest results are similar to these obtained for Puer earthquake, which pose a challenge to us for deep studies on our methods
- Cross-validation could be a promising approach for detecting seismic anomalies

Thank you ! and questions?