SPACE WEATHER CONDITIONS PRIOR TO THE M8.3 CHILE EARTHQUAKE

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Abstract: This paper reports significant space weather conditions in advance of the M8.3 Chile Earthquake on September 16, 2015. Early warning signs include the slope reversal in the Sunspot number trend and the large Sun's coronal hole area immediately prior to the event. Similar patterns are observed for the M9.1 earthquake in Northern Sumatra in 2004. Such evidences and correlations can potentially serve as indicators for future catastrophic earthquakes.

Keywords: *earthquake, coronal hole, space weather, sunspot number, solar wind.*

Introduction

Earthquake is one of the calamitous natural disasters that may significantly impact human lives. Researchers around the world have conducted relevant studies to determine causes and triggers of large earthquakes. Such findings would accelerate the development of earthquake warning systems and help with emergency readiness and response planning, thus mitigating the impact of earthquakes on a large number of people. Several recent studies (Davidson et al., 2015; U-yen, 2014; Straser and Cataldi, 2015) considered space weather as a trigger of large earthquakes. Davidson et al. (2015) revealed the relationship between the Sun's polar magnetic pole and large earthquakes, which were also found to be linked with solar wind streams, as discussed in U-yen (2014) and Straser and Cataldi (2014). In this paper, significant space weather events prior to the M8.3 Chile Earthquake (The European-Mediterranean Seismological Centre (EMSC), http://www.emsc-csem.org/Earthquake/world/M5/) are reported. The emphasis is placed on the trend of sunspot number and the size of Sun's coronal hole. The case of the M8.3 Chile Earthquake in 2015 is compared with that of the M9.1 Sumatra Earthquake in 2004 that has similar patterns.

Observations of sunspot number and Sun's coronal hole

Prior to the M8.3 Chile Earthquake, from May 13 to September 5, 2015, the Sun experienced the 116-day decline in its sunspot number trend based on the data from the Royal Observatory of Belgium (http://sidc.oma.be/silso/eisnplot). See **Fig. 1(a)**. At the end of this period, the sunspot number approached the end of its decline reaching the lowest number in eight weeks on September 5. Then, the trend began to reverse and the sunspot number increased at a rapid pace reaching its highest number in four weeks on September 12. Between September 11 and 15, 2015, the largest coronal hole area was observed. See **Fig. 1(b)**.

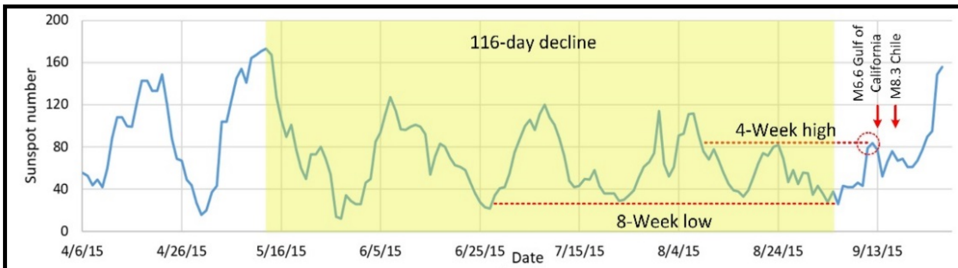

Fig. 1(a). Sunspot number from April 2015 to September 2015. Its trend indicates a 116-day decline prior to the M8.3 Chili Earthquake.

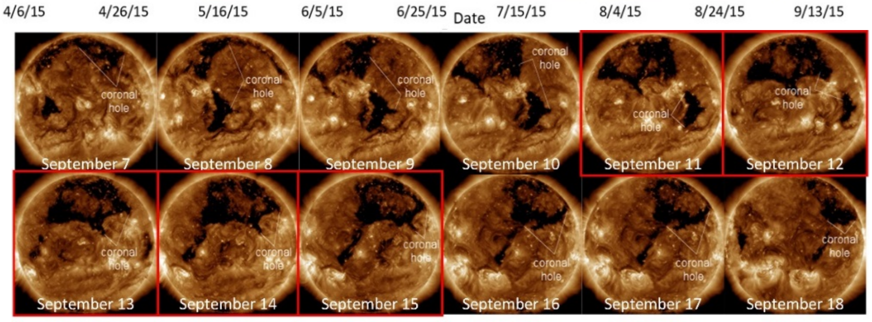

Fig. 1(b). Sun's coronal hole images between September 7 and 18, 2015 (www.spaceweather.com). Red squares indicate the dates with the largest area of Earth-facing coronal hole.

Afterward, the Earth had an uptick in earthquake activities and the M6.6 earthquake occurred in the Gulf of California on September 13, 2015. The M8.3 Chile Earthquake occurred four days after the 4-week peak sunspot number on September 12, 2015. This period is coincided with the approximate time required for the plasma wave to propagate from the Sun to the Earth.

For comparison, space weather patterns observed prior to the M9.1 earthquake on the west coast of northern Sumatra are shown in **Fig. 2(a)** for the sunspot number, and in **Fig. 2(b)** for the Sun's coronal hole images during the respective period in 2004. In this case, the sunspot number showed a 52-day continuous decline from October 24, 2004 to December 15, 2004. The largest coronal hole area was observed between December 26 and 27, 2004. Subsequently, the M7.8 earthquake occurred on December 23, 2004 and the M9.1 earthquake occurred three days after the 2-week peak Sunspot number on December 22, 2004.

Fig. 2(a). Sunspot number from September 2004 to January 2005, indicating a 52-day decline prior to the M9.1 Sumatra Earthquake

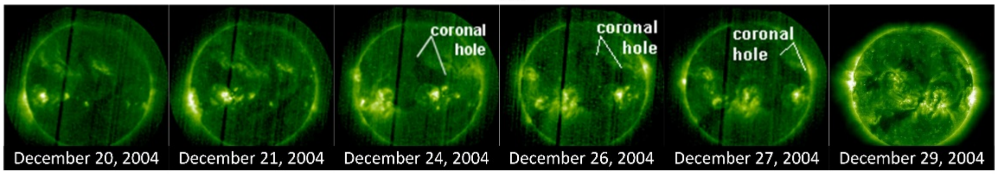

Fig. 2(b). Sun's coronal hole images between December 20 and 29, 2004 (www.spaceweather.com).

Note that the opposite direction of sunspot number trend change (i.e., slope reversal from positive slope to negative slope) can also be considered as an early warning sign for large earthquakes, such as the one occurred during M9.1 Japan Earthquake in 2011 (U-yen, 2015). This is not discussed here for brevity.

In addition to space weather factors, the global atmospheric water content may influence the occurrence of large earthquakes. This can be seen from the period between July 27 and September 5, 2015 when the Earth experienced the extended period of tropical storms. During this period, there was an absence of earthquakes with the magnitude of 6.6 or larger. This suggests that the global earthquake intensity has an inverse correlation with the global atmospheric water content.

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