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All contributions that do not fall in the other sessions on Earth's magnetic field studies can be submitted/presented in this session. In particular, we solicit contributions on theory and simulations, instrumentation, laboratory experiments and field measurements, data analysis and interpretation, as well as inversion and modelling techniques.

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Relationship between major geophysical events and the planetary magnetic Ap index, from 1844 to the present

Michele Casati (1) and Valentino Straser (2)

(1)Altopascio (Lucca), Italy (michelecasati1974@alice.it), (2) International Earthquake and Volcano Prediction Center,Orlando -Florida (USA)

Abstract

In this study, for the first time, we compared the annual magnetic Ap index, taken from original sources, from 1844 to the present day *[Svalgaard,2014]*, with:

i) sixteen large volcanic eruptions of index VEI5 + recorded by, Smithsonian Institute (Global Volcanism Program),
ii) three sets of the volcanic aerosols data *[Ammann et.al, 2003][Gao;Chaochao;Alan Robock;Caspar Ammann,2008][Traufetter et.al,2004]* and
iii) eight major earthquakes of a magnitude between 8.7<M<9.5, which occurred from 1900 to the present.

We observe that the twenty four major geophysical events which occurred were in proximity to two specific thresholds, or limits, of the annual planetary Ap index. Specifically, in the downward phase of the planetary Ap index, under the annual value of 7 or, in the phase when the annual value exceeded 22. We identified a total of 14 transitions (eight in the solar minimum and six in the solar maxima) each with a period of about two and a half years making a total of almost 35 years of activity during the 169 years under review. During the 14 transitions 18 of the 24 major historical geophysical events occurred from 1844 to the present. Analysis of data shows a clear link between the electromagnetic (EM) dynamics recorded in large historical solar minima (Maunder, Dalton or solar minimum 1880-1920), the large solar maxima (solar cycles 19, 21 & 22) and the energy released during large geophysical events *[Casati,2014]*. The physical process of solar-terrestrial interaction, also reveal a deep and intrinsic relationship between the EM dynamics of the inner solar system and the temporal occurrence of major geophysical events. The references in scientific literature, in support of this work, are numerous:
from empirical evidence, that we find in the late nineteenth century - early twentieth century, to more recent references. Some of which are:*[Casey,2010][Charvátová,2010][Choi,2010][Duma and Vilardo, 1998][Khachikyan et al,2014][Kolvankar,2008][Kovalyov,2014][Mazzarella and Palumbo,1989][Stothers,1989][Streštik,2003][Sytinsky,1987,1989,1998]*.

Results and Discussion

The fourteen transitions identified in this study (each with a period of approximately two and half years), cover a total period of 35 years, of the 169 years studied. The fourteen transitions occurred during the minimum /maximum of the solar cycle, or very close to the ascent or descent phase (chart A).

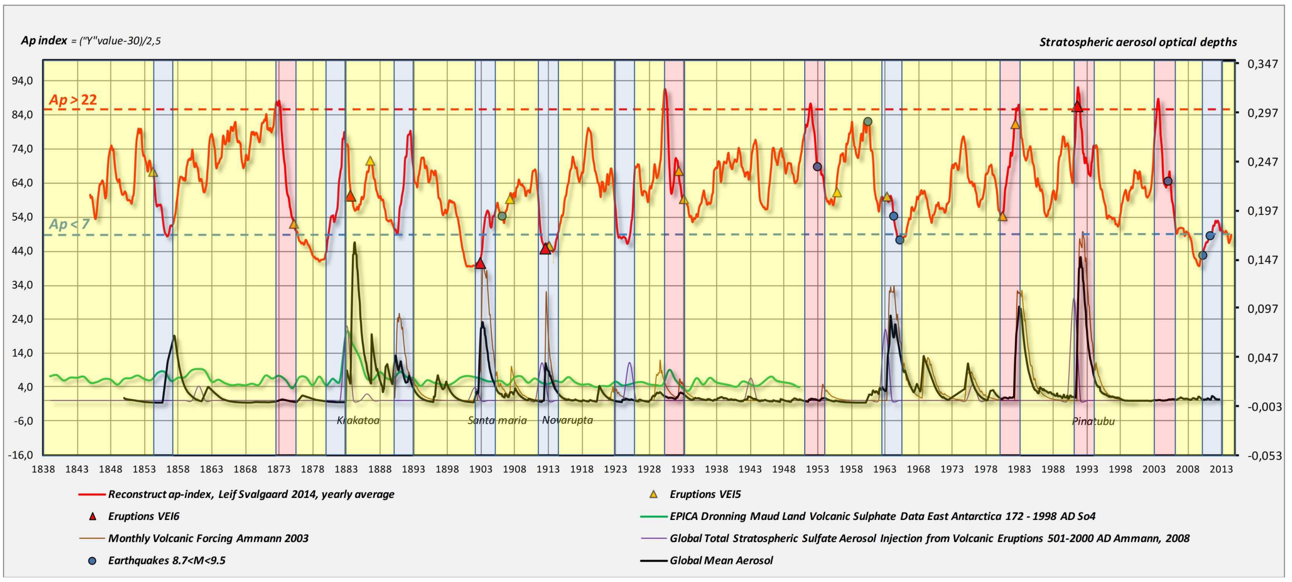

Chart "A"*1844-2014 - The 14 transitions (eight in the solar minimum and six in the solar maxima) each with a period of about two and a half years making a total of almost 35 years of activity during the 169 years under review.*

The solar cycles involved are :

Solar minimums and solar maximums (chart B):

i. four solar minima: SC9-SC10; SC15-SC16; SC19-SC20; SC23-SC24
ii. four solar maxima: SC11; SC16; SC18; SC23

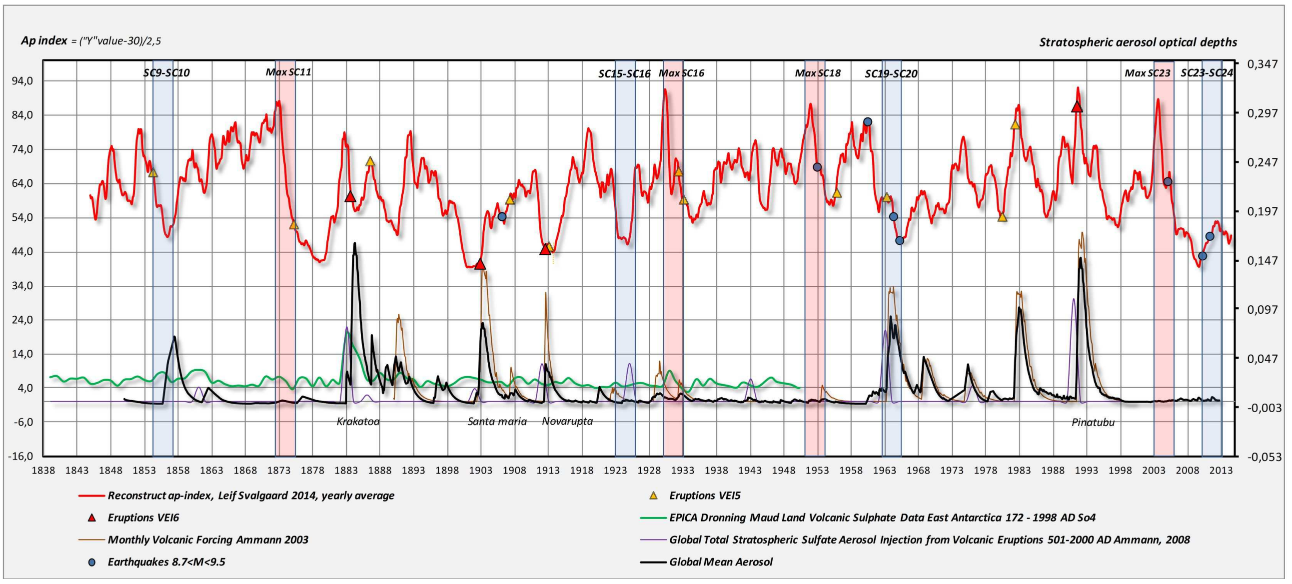

Chart "B" *Four solar minimums and four solar maximums*

Deep solar minimum and large solar maximum (chart C):

i. four historical deep solar minima occurred between 1880 and 1920. Solar cycles from SC12 to SC15
ii. two major solar cycles (bicentennial), SC21 (1976-1986) & SC22 (1986-1996)

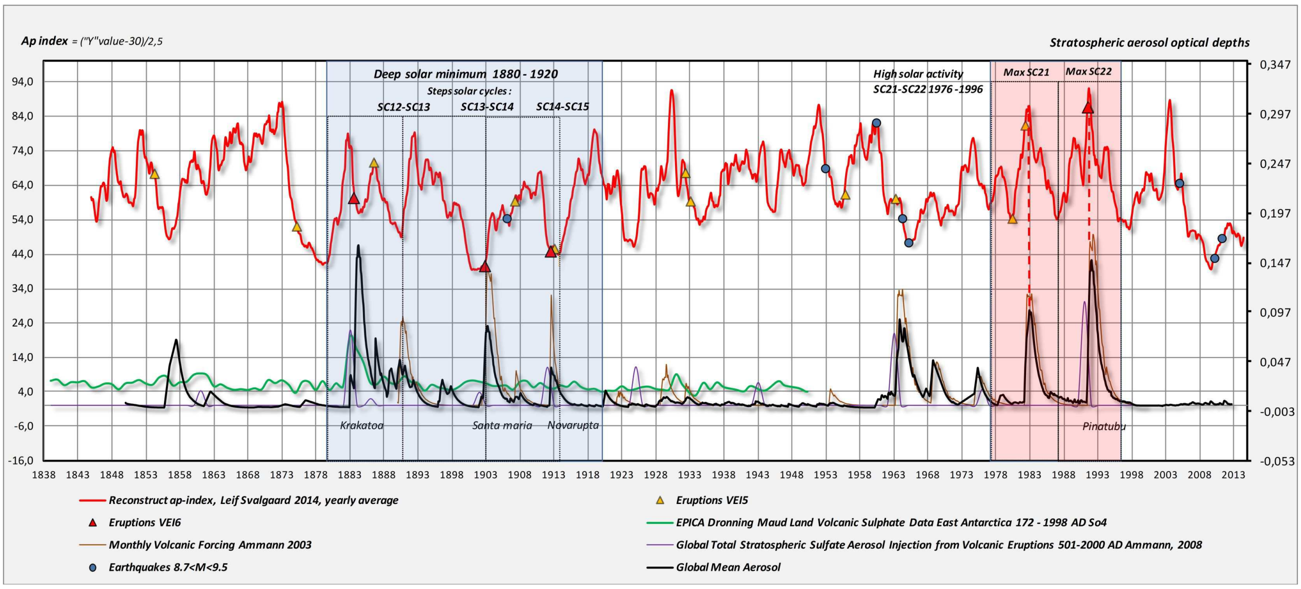

Chart "C" *Deep solar minimum and large solar maximum*

During the other 134 years (yellow areas – chart A), with the annual Ap index between 7<Ap<22, we find the remaining six geophysical events (in blue, table A) that occurred during the moderate solar activity oscillations. Phases characterized by moderate fluctuations of the planetary index Ap (weak EM variations of the interplanetary magnetic field, in intensity and speed of the transient). Four of the six major geophysical events, including the great eruption of Krakatoa in August of 1883 and three other major geophysical events, are outside of the fourteen transitions of about two and half years (chart A). However the four events, are found within the well-known historical period, 1880-1920, called the Gleissberg minimum, when there was extreme low solar activity. The forty years of weak and irregular EM activities are shown for example, in the register of the count of the sunspot cycle SC14, 1902-1913 (chart D).

Major geophysical event	Date (*tge*)	VEI or Magnitude	Solar cycle phase	Lower or upper thresholds "Index Ap"	Date (*tap*)	(*tge*)-(*tap*) [Years]
Honshu, Japan	2011,21	M9.0	Rising SC24	3,8	2009,71	1,50
Chile	2010,13	M8.8	Transition SC23 - SC24	3,8	2009,71	0,42
Sumatra	2004,96	M9.1	Declining SC23	23,4	2003,62	1,34
Hudson Cerro	1991,63	VEI5+	Maximum SC22	24,8	1991,70	-0,08
Pinatubu	1991,46	VEI6	Maximum SC22	24,8	1991,70	-0,24
El chichon	1982,29	VEI5	Declining SC21	22,3	1982,54	-0,25
St.helen	1980,38	VEI5	Maximum SC21	22,3	1982,54	-2,16
Rat Islands, Alaska	1965,13	M8.7	Transition SC19 - SC20	6,8	1965,38	-0,25
Alaska	1964,21	M9.2	Transition SC19 - SC20	6,8	1965,38	-1,17
Agung	1963,21	VEI5	Declining SC19	6,8	1965,38	-2,17
Chile	1960,38	M9.5	Declining SC19	6,8	1965,38	-5,00
Benzymianny	1955,80	VEI5	Rising SC19	22,9	1951,96	3,84
Kamchatka	1952,88	M9.0	Declining SC18	22,9	1951,96	0,92
Kharimkotan	1933,04	VEI5	Transition SC16 - SC17	24,6	1930,29	2,75
Cerro azul	1932,29	VEI5+	Declining SC16	24,6	1930,29	2,00
Colima	1913,04	VEI5	Transition SC13 - SC14	5,5	1913,71	-0,67
Novarupta	1912,46	VEI6	Transition SC13 - SC14	5,5	1913,71	-1,25
Ksudach	1907,21	VEI5	Maximum SC14	3,8	1900,88	6,33
Off the Coast of Ecuador	1906,04	M8.8	Maximum SC14	3,8	1900,88	5,17
Santa maria	1902,79	VEI6	Transition SC12 - SC13	3,8	1900,88	1,92
Mount tarawera	1886,46	VEI5	Declining SC12	4,4	1879,29	7,17
Krakatoa	1883,63	VEI6	Maximum SC12	4,4	1879,29	4,34
Askja	1875,21	VEI5	Declining SC11	23,2	1873,04	2,17
Shiveluch	1854,13	VEI5	Declining SC9	7,3	1856,38	-2,25

__Table “A”__ From left to right, list of twenty four major geophysical events that occurred from 1844 to the present, geophysical event date "tge", volcanic explosivity index or magnitude, the phase of the solar cycle (rising, declining, maximum, minimum), maximum (ap> 22) or minimum (ap <7) thresholds of the Ap index, annual Ap planatery index date "tap" used for comparison with geophysical events date, and time lag (number of years late or early) (tge) - (tap).

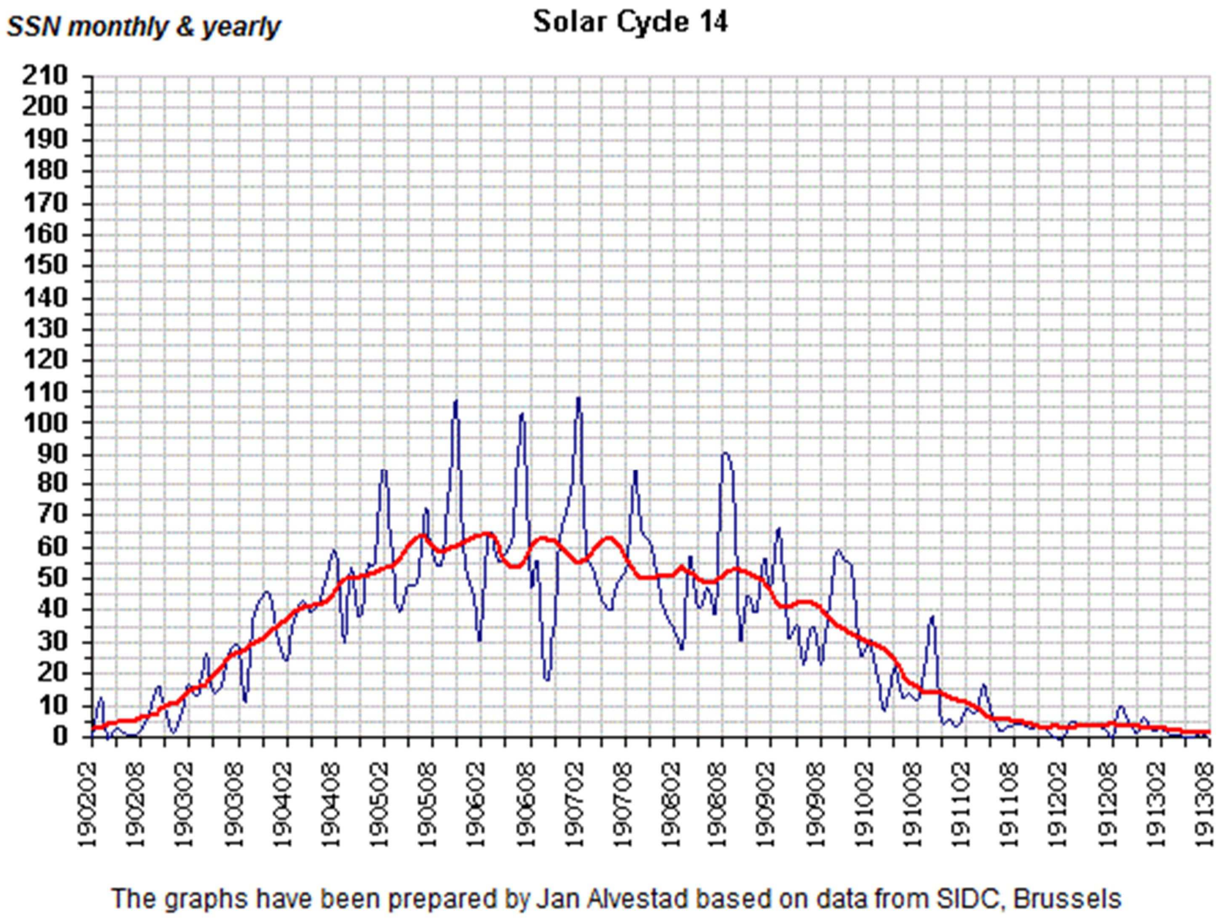

Chart “D” Solar cycle SC14 *Cycle 14 began in February 1902 with a smoothed sunspot number of 2.7 and ended in August 1913*

We hypothesize that :

i. atypical electrical impulsive phenomena (EM solar-terrestrial interactions) occurred during the solar minimum, with an enormous amount of energy released during the geophysical event. Phenomena not yet fully understood from a physical point of view (hypothesis of the global electrical circuit, GEC),

ii. the change in the genesis of the major geophysical events (occurring between 1970 and 1995, solar cycles 21 and 22, with the annual Ap index > 22), is to be linked to the major solar activity. Solar activity that did not have such high EM characteristics during the previous 200 years *[Steinhilber;Abreu;Beer and McCracken,2010]* or possibly even the last 3000 years *[Usoskin,2014]*.

The significant trace, of the three main sets of the volcanic aerosols data (see the black line in all graphs), further validates the observations described above.

Conclusions

So, given :

i. that solar activity has returned to low levels of late 18th century - early 19th century, in terms of magnetic activity (annual Ap index),
ii. the probable entry in a long deep solar minimum, during the transition to the next solar cycle SC25. Assertion made by many solar physicists : *[Ahluwalia,2013][Goelzer;Smith;Schwadron and McCracken,2013][Livingston;Penn and Svalgaard,2012][Steinhilber and Beer,2013],*
iii. the European Space Agency has recently confirmed the general trend of the weakening of the Earth's magnetic field. *[European Space Agency, Third Swarm Science Meeting 'in Copenhagen, Denmark., 2014],*
iv. the hypothesis of a possible and imminent geomagnetic reversal or excursion in the near future (2034 ± 3 years) *[De Santis,2013],*
v. the possible relationship between the major volcanic eruptions, the general increase of volcanism, the weakening of Earth’s magnetic field, the geomagnetic excursions or magnetic reversals.*[Kennett and Watkins,1970][Schnepp and Hradetzky,1994][Cassidy,2006][Nowaczyk,2012],*

we consider it is possible that an intense heliosphere EM oscillation (destabilization of the Earth's magnetosphere during the years of minimum solar or early ascent of the solar cycle), may trigger a major geophysical event (for a example a large volcanic eruption with index VEI5+) during the transition to the next solar cycle SC25 and/or successive SC26. Major geophysical events that would not be completely unexpected, as we concluded in our earlier study *[Casati and Straser,2013]*.

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My personal website : *http://michelecasati.altervista.org/index.html*

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