

Climatological Analysis in Channels of High Densities of Atmospheric Discharges Located in Paraguayan Territory in Order to Optimize Electrical Continuity Service Due to The Downfall of High Tension Towers

Análisis Climatológico en Canales de Altas Densidades de Descargas Atmosféricas Ubicadas en Territorio Paraguayo a Fin de Optimizar la Continuidad del Servicio Eléctrico Debido a Caídas de Torres de Alta Tensión

Hugo Cesar Acosta Escobar¹

ABSTRACT

Paraguay is one of the countries with the most falls of atmospheric discharges per year but even the random and unpredictability of their fall there are regions with intense and frequent atmospheric discharges more than other regions within its territory. There are an average of 20 or more annual severe thunderstorms in the spring summer season where they can generate winds of 180-200 km/h, hail and strong atmospheric discharges what they can result collapses of power lines in rural and urban areas by falling of electrical structures. The objective of this work is to correlate and demonstrate using a satellite Statistics database of Lightning (NASA), also geomagnetic map (NOAA) and geological maps about the existence of five longitudinal channels with high densities of atmospheric discharges which crosses the country. To achieve decipher their exact locations and the cause that produces it was not an easy job but hereinafter electrical utility state can plan preventive strategies to optimize the restoration of the electricity service with a shortest possible time or decrease the frequency of their occurrence.

Keywords: thunderstorms,, collapses, atmospheric discharges, electrical structures, NASA, NOAA, service continuity

RESUMEN

Paraguay es uno de los países del mundo con más caídas de descargas atmosféricas por año, pero a pesar de la aleatoriedad e imprevisibilidad de su caída, hay regiones con intensas y frecuentes descargas atmosféricas más que de otras regiones dentro de su territorio. Existe un promedio de 20 o más tormentas severas anual en la temporada de primavera verano, en donde se pueden generar vientos de 180-200 km/h, granizos y fuertes descargas atmosféricas lo que pueden ocasionar colapsos del tendido eléctrico en áreas rurales y urbana por las caídas de las estructuras eléctricas. El objetivo del trabajo es correlacionar y demostrar mediante una base de datos satelital del relámpago, mapas geomagnéticos y geológicos sobre la existencia de cinco canales o franjas longitudinales con altas densidades de descargas atmosféricas que atraviesan al país Lograr descifrar su exacta ubicación y la causa que lo produce no fue una tarea fácil; pero en lo sucesivo se podrán planificar desde la empresa estatal de servicio eléctrico, estrategias preventivas para optimizar la reposición del servicio eléctrico con un menor tiempo posible o disminuir la frecuencia de su ocurrencia.

Palabras clave: Tormentas, colapsos, descargas atmosféricas, estructuras eléctricas, NASA, NOAA, continuidad de servicio

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Introduction

From the year 1982 up to date the National Electric Company (A.N.D.E) has undergone collapses in their airlines in 11 chances in lines of 220 kV 5 additional opportunities in lines of 66 kV and in lines of 23kV 32 times. The average transmission towers collapses were 3-22 structures and 10 to 30 structures in distribu-

tion lines. The average repair cost per kilometer for 220 kV lines ranging from 130,000 to 160,000 U\$ in 66 kV lines ranges from 85,000 to 100,000 U\$ and 23 kV lines 15,000 U\$ but we must add the energy not supplied it costs between 250,000 to 600,000 U\$/day (neither included the costs of industrial production). The reset time is between 36-72 hours depending on the severity of storms with atmospheric discharges and affected zone.

Cause and origin of 5 channels with higher rates of lightning discharges

The Earth's magnetic field is predominantly produced by electric currents occurring in the outer core of the earth composed of cast iron highly conductive. Physically, the magnetic field is generated to form a current line in a closed winding (Ampere's Law) a variable magnetic field generates an electric field (Faraday's

¹ Author Description: Electromechanical Engineer - Chief of Special studies of National Electricity Administration - Paraguay - Master in Management and Environmental Legislation - Professor of the Faculty of Electromechanical Engineering at the National University of Asuncion- Member of the Scientific Society of Paraguay - E-mail: hugo_acosta@ande.gov.py hugoc.acosta@gmail.com

Law) and the electric and magnetic fields exert a force on the loads that flowing in the current (the Lorentz force) which they may be represented at any point by a three-dimensional vector. On the surface of earth the magnetic field is a composite of the main magnetic field originated by an internal and external source but between of them with a temporary dependence. Geomagnetism is dominated by an axial dipole in the center of the earth very near to the rotational axis. This magnetic field changes in time in direction and amplitude due to internal and external physical processes of the earth therefore it has to be measured in regular intervals of time from the magnetic monitoring centers where they have documented historical records about these variations. The magnetic field of the terrestrial crust depends for the magnetization of the iron contained into the subsoil materials. In the field of internal origin, found in these rocks they have a "memory" of the magnetic field that cross known as magnetization by two components: a) the field of crust b) Field of the core.

Magnetic field models of reference

The Earth's magnetic field is described by seven parameters. These are declination (D), inclination (I), horizontal intensity (H), vertical intensity (Z), total intensity (F) and the north (X) and east (Y) components of the horizontal intensity. By convention, declination is considered positive when measured east of north, inclination and vertical intensity positive down, X positive north, and Y positive east. The magnetic field observed on Earth is constantly changing.

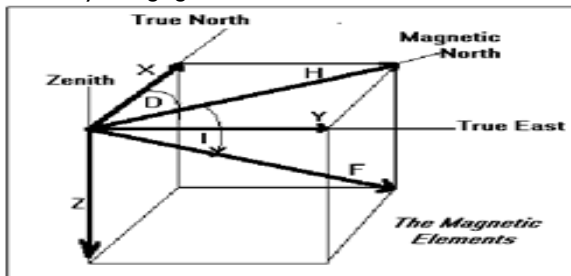


Figure1. The earth's magnetic field described by seven parameters

Magnetic field models of reference provide an easy way to calculate magnetic declination and other components. A reference field model it is a mathematical algorithm whose parameters are based on a analysis satellite magnetic surveillance whether over the world or part of the world.

Spherical harmonic analysis is the most common method used to produce global models. The World Magnetic Model (WMM) is the standard model used by the Department of Defense United States, the Ministry of Defence of the United Kingdom, the Organization of North Atlantic Treaty (NATO) and the International Hydrographic Organization (IHO), which widely used in civil navigation and is produced at intervals of five years, the present model will expire December 31st 2019 being able be found at NOAA.

website <http://www.ngdc.noaa.gov/geomag/WMM/DoDWMM.shtm>

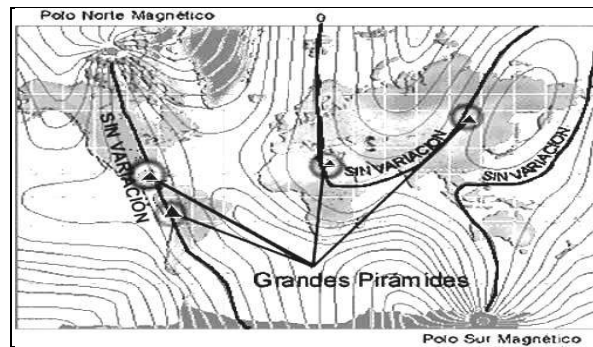


Figure2. Black lines are lines magnetic fields unchanged in the word

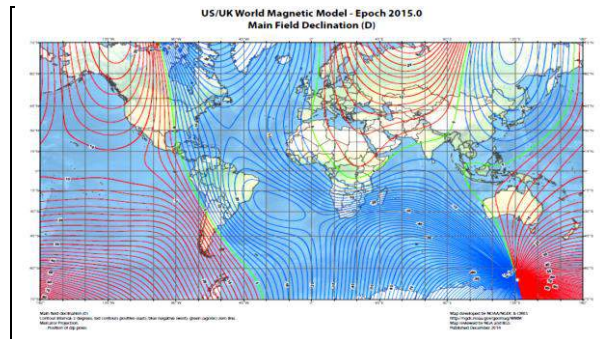


Figure3. The World Magnetic Model (WMM)

Ground magnetic anomalies

The main magnetic field is originated by the convection currents and swirls of fused materials in the core of earth while magnetized rocks of the crust are producing localized fields; these are known as magnetic anomalies. They are deviations of the main magnetic field who experiencing variations the average values in the elements of terrestrial magnetism about a particular location. Flux magnetic anomalies cover huge areas that are called regionalists, unlike local areas occupying from several square meters to thousands of square kilometers.

High atmospheric discharges events on the longitudinal sample spaces

During the development and deployment of a thunderstorm clouds they are electrostatically charged with positive and negative ions where can be generated thunderbolts and lightning of different intensities. Atmospheric discharges statistically it can be considered as a random and temporary phenomenon but however to know a little more about their activities and details in Paraguayan territory they were lowered temporary lightning samples taken from the website of the NASA (<http://thunder.msfc.nasa.gov/>) emitted by the LIS (Lightning Imaging Sensor) used in the satellite to detect distribution and variability of each event (lightening or rays) generated in several countries among them Paraguay. This activity is done on board the meteorological satellite TRMM (Tropical Rainfall Measuring Mission) <http://thunder.nsstc.nasa.gov/primer/index> by generating a atmospheric discharge in the earth this events are picked up through its optical sensor by means of glint and emission of an electromagnetic radiation. This events are referenced Cartographically with his latitude and longitude in almost all South American countries stored in a database of lightning with a period of 19 times per day. At the first opportunity these samples were lowered from 1998 to 2013 in annual, quarterly, and

monthly periods categorized by night and day events for relating average in Kilo-Amper of atmospheric discharges from every region of our country to utilize this information for dimensioning and design of high voltage electrical structures. The longitudinal areas of higher atmospheric discharges per square kilometer were not in our interest of this research but within the samples were detected certain areas or atmospheric discharges channels with higher intensities and frequencies that caught our attention at the LIS database but in a random manner in different times. The presumption of the existence of a longitudinal area of atmospheric discharges of greater intensity and frequency was because the phenomenon was observed repeatedly in other random samples but incompletely formed in the same places. Therefore we was assumed that there could be more than one area or several longitudinal channels of atmospheric discharges per square kilometer with similar characteristics in Paraguayan territory for this we proceeded in the LIS database to give variability in the time of random samples obtained through the mapping of atmospheric discharges in the satellite.

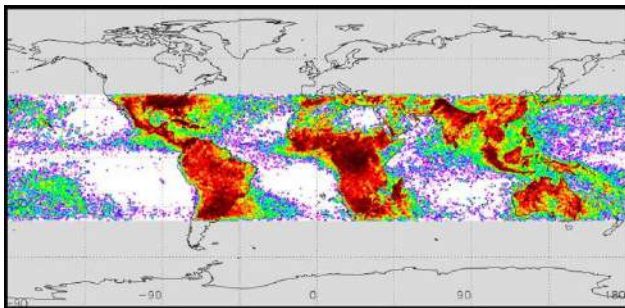


Figure4. Global lightning strikes from January 1998 to present day from the NASA/MSFC Lightning Imaging Sensor

Longitudinal areas of atmospheric discharges in Paraguayan territory

It is possible to explain the existence of areas or longitudinal channels characterized by high atmospheric discharges activities than other areas that cross the country in northwest southeast direction spaced each one in a parallel manner. These longitudinal channels or areas of high atmospheric discharges per square kilometer are not stable over time so in position and training, as it was observed in several random samples displaced by a few kilometers left and right of the longitudinal axis. It is known and reported in the magnetic monitoring centers around the world that the deviation of the main magnetic field is variable and represents 6% of the total intensity of the Earth magnetic field it produced by the movement of electrically charged particles in the atmosphere and is superimposed on the permanent magnetic field.

For explanation let's hypothetically consider a stable climate without thunderstorms and in the surface of the earth two mountains formed by igneous and metamorphic spaced from each other a few kilometers (may be 100 Km) irregularly distributed through some outcrops in the field of sparse vegetation. In this configuration we insert an imaginary cylinder containing lines anomalous magnetic fluxes that appeared thousands of years ago by induced or remnant magnetization in the rocks that were activated secondarily by the main magnetic field of the earth. In order to theoretically explain the existence of areas or longitudinal channels of high atmospheric discharges the Maxwell's equa-

tions tell us over the production and interrelationship of electric and magnetic fields.



Figure5. Location of Paraguay in South America

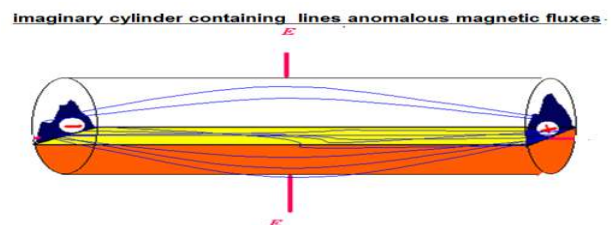


Figure6. Magnetized rocks generating anomalous magnetic fields

Let's consider this hypothetical approach spatial of a thunderstorm when crossing a magnetic anomalous flux lines moving at a certain speed within in an imaginary cylinder. The Gauss theorem relates the field divergence about this closed volume with magnetic flux lines across the surface around the volume. If nothing is lost or created within the volume, there will not be flux through its surface. The Stokes theorem relates the cross product of a vector field integrated on the surface to the line integral of the magnetic field along the curve surrounding the surface. We know that the magnetic field lines begin and end in the magnetic dipole, however, magnetic "charges" or "mono poles" do not exist.

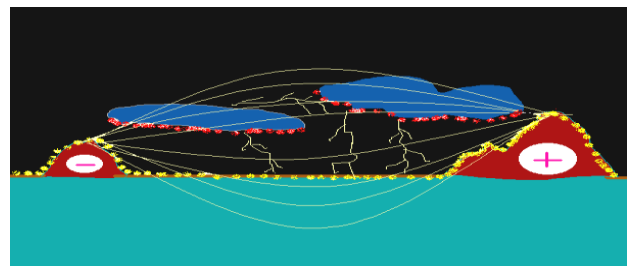


Fig7. Thunderstorm moving electric charges in anomalous magnetic fluxes

Now the flow of the secondary magnetic field is contained within the imaginary cylinder belonging to the closed surface which encloses the anomalous dipole that are generated by the two mountains magnetized secondarily by the flow of the main magnetic field of the earth. Is why all the field lines leave the surface enclosing the anomalous dipole inside the imaginary cylinder that they will return to reenter the same surface. With good condition weather there are no electric charge ions in displacement inside and outside the imaginary cylinder and there are not magnetic fluxes acting on it generated by the anomalous dipole of the two mountains but in a thunderstorm with moving electric

charges there exists a time dependence of the appearance the anomalous magnetic fluxes inducing strong electric fields when crossing the imaginary cylinder in the space formed by the two mountains. The reverse is also true: a time-dependent electric flux induces a magnetic field. Moving an electric current is also responsible for generating a magnetic field. For a surface enclosing a charge distribution (thunderstorm clouds), the flow through that surface would be related to the electric charge density contained in the volume this is a manifestation of the natural potential of the electric field. Moreover conducting a current in an electromagnetic field has been verified that a force (Lorentz). It is exerted on a load moving in an electric and magnetic field which is obeyed by all materials for which the current depends linearly on the applied potential difference. In the Magnetic anomalies the magnetic intensity has magnitude and direction that depends on the magnetic susceptibility and the remanent magnetization of the rock. The magnetic force can attract or repulse something. The magnetic effects may be caused by components little or abundance of magnetic substances in a rock. The temporal change of the magnetic field is due to the flow of material, which induces a new field, plus the temporal variation of the field when it changes by the ohmic decay. Generally the anomalous geomagnetic field, its magnitude and direction is determined by the magnetization of the magnetic rocks at superimposed on the magnitude and direction set by main geomagnetic field. As the geomagnetic field varies with time the magnitude and direction of the geomagnetic field also vary from place. Rocks can keep a remnant magnetization related to the existing geomagnetic field when these rocks were formed thousands of years ago. Structures causing magnetic anomalies are often parallel to each other as a system of parallel dikes with a high content magnetite.

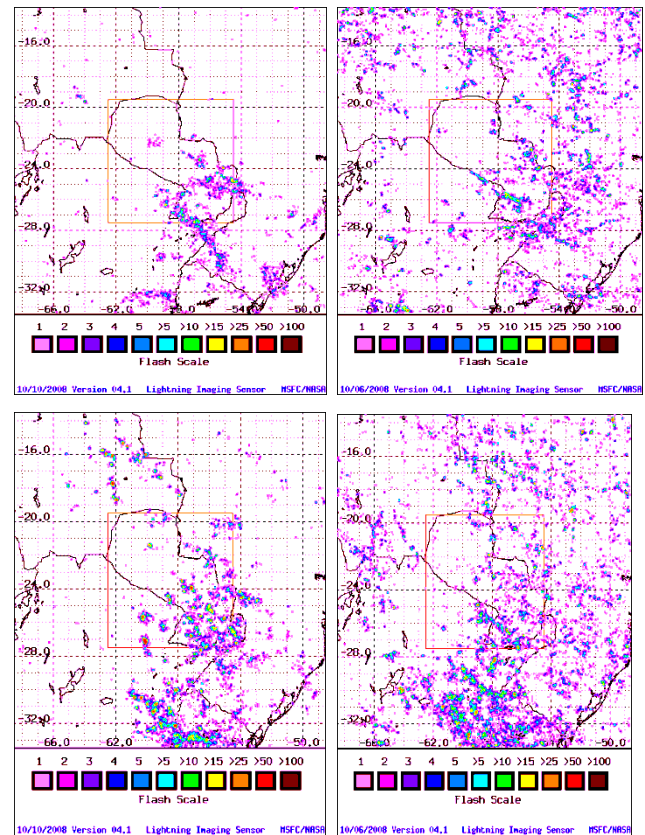
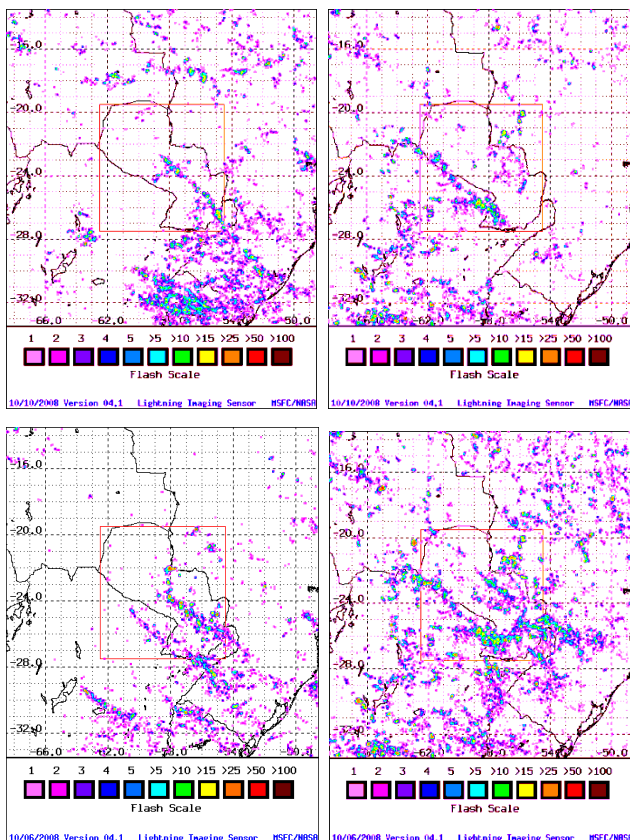


Figure8. Samples of longitudinal atmospheric discharges in Paraguay

We check later that the channels of high densities of lightning are activated longitudinally and perfectly within the magnetic anomaly profiles obtained from the World Magnetic Model (WMM) which converge with geological formations in Paraguayan territory.

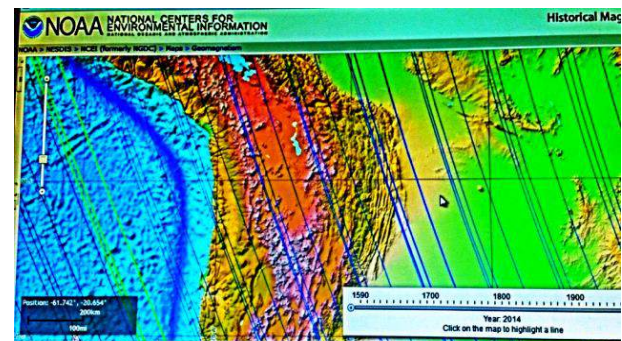


Figure9. Orografico system and Magnetic Declination 2014

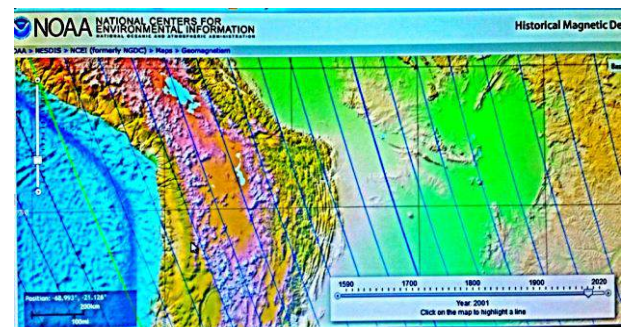


Figure10. Orografico system and Magnetic Declination 2001

We can see from the above figures that the secondary field lines are not stable like measurements (NOAA) obtained in 2014 and 2001 and more. We provide some samples of high rates of lightning by longitudinal square kilometers called PY-S1; PY-S2; PY-S3; PY-S4 investigated from the database issued by the LIS (Lightning Imaging Sensor).

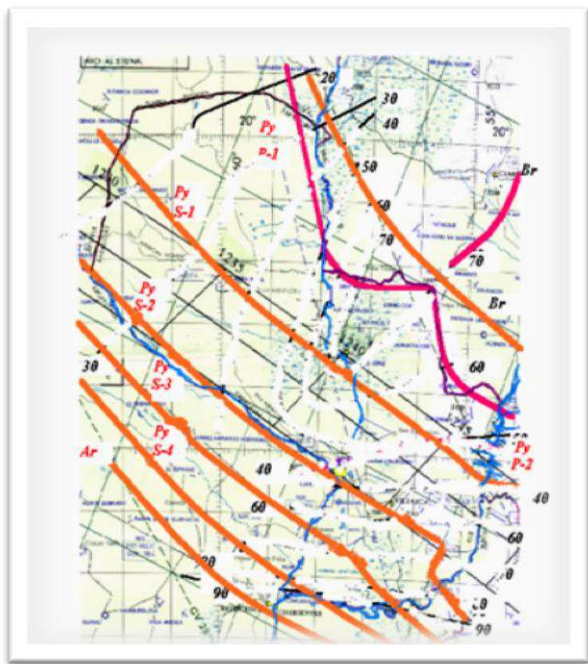


Figure 11. Physical location of 5 lightning channels in Paraguay

Table I. Channel sites of falls downs of high tension towers and transformers burned situated within the longitudinal magnetic anomalies

Year	Voltage	Place	Towers falls down and transformer burned	Longitudinal channel lightning
1982	220 kV	San Jose	22 towers	Py -S1
1994	66 kV	Caapucu	1 transformer	Py-S2
1998	220 kV	San Pedro	4 towers	Py-S1
1999	220 kV	Vaqueria	3 towers	Py-S1
2003	220 kV	San Jose	8 towers	Py-S1
2004	66 kV	Paraguari	12 towers	Py-S2
2008	220 kV	CampoDos	1 transformer	Py-S1
2008	220 kV	C.A Lopez	1 transformer	Py -S1
2010	66 kV	Pilar	7 towers	Py-S4
2014	220kV	Horqueta	3 towers	Py-S2

Data from National Electricity Administration state electricity utility in Paraguay (A.N.D.E) website www.ande.gov.py

Conclusion

The strategic value of the mapping of the five channels of high densities of lightning discharges and how that form in Paraguayan territory they will improve interrupt times by collapses of electrical structures this represents a management tool for making decisions both insulation and the earthing systems because may only be made below the high densities channels. Such modifications it could result in improved reliability and continuity of the electricity service due to the greater structural supportability to hazards of severe storms and may reduce the frequency of their occurrence and thereby historical collapses rates of State electric company. It can be concluded that through the interaction of satellite Lightning maps (NASA), the Orographic map of Paraguay together with the map of the World Magnetic Model (NOAA) have shown that the five channels of high densities of lightning discharges coincide with lineups in accordance with magnetized rocks occurred millions of years ago. Each channel is aligned southeast to northwest at 45° distancing themselves approximately 100-150 km from each other with a width between 5 to 8 km and they are not stable and oscillate about its own longitudinal axis approximately 5 to 10 km. In that way, using UTM coordinates the sites were located several structures collapses occurred at the State Electric Company coinciding perpendicular crosses always under the channels of high densities of lightning. We can say in this document that there are five lightning discharges channel in Paraguayan territory. For the country, these channels represent a serious threat for the population so they can mapping the locations of major risks and warn of this fact a desire to provide efficient and effective replies by relevant agencies directed the stricken population.

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Universidad de Atacama
SusanneGriem-Klee / sgriem@plata.uda.cl