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OPERATIONAL USE OF LIGHTNING DETECTION METHODS
Report on the Operational use of Lightning Detection Methods in Brazil

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Summary and purpose of document

This document contains information on the operational use of lightning detection methods in Brazil, the compatibility of lightning detection remote sensing and conventional in-situ observations, the evaluation methods for operational lightning detection systems and lightning detection projects and networks.

Action proposed

The meeting is invited to take information provided in the document in discussing operational use of lightning detection methods.

Report on Operational use of Lightning Detection Methods

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5. Operational use of lightning detection methods

Lightning discharges range from low current intra-cloud (IC), in VHF, events that can range up to a kilometer to large cloud-to-ground (CG), in LF, return strokes, with several hundred kA and lengths greater than 10 km. As these events cannot be detected by using just one single technique, there are currently several lightning detection systems (LDS) in operation around the world. The main technologies in use, operating in LF, VLF and VHF, are:

1. Methods of Direction Finding (MDF), using VLF and LF, determine the stroke position by means of a triangulation using at least two sensors, and the peak current can be estimated from the measurement of peak field. Though the methods can have a good estimated of the cloud-ground lightning, there are certain conditions where the geometrical relationship between the sensors and the discharges produce poor results.
2. TOA, using VLF and is based on the measurements of the time-of-arrival of a radio pulse at several stations that are precisely synchronized. This technique may fail on detect the correct position of the stroke source if less than four sensors are used. However if the antennas are properly sited, it can provide accurate locations at long ranges and the systematic errors are minimal.

3. LPATS (Lightning Position and Tracking System), which is a wideband TOA receiver that is suitable for locating lightning sources at medium and long ranges, through a hyperbolic method.
4. IMPACT (Improved Accuracy Using Combined Technology), which can take information from combination of MDF, TOA and LPATS. The methodology can provide information about both intra-cloud and cloud-ground discharges, using the same instrumentation and with reliable propagation through mountainous terrains.
5. SAFIR, which is consists of a network of detection stations combining a VHF interferometric array and a LF sensor for the localization and characterization of total lightning activity. The SAFIR interferometric array uses differential phase measurement on electromagnetic lightning waves for long-range direction finding of lightning activity. The SAFIR LF discrimination sensor is a wide-band electric antenna capable of identifying cloud-ground lightning characteristic. The data is all GPS synchronized and reported to a central station, which computes the location by the triangulation technique.

Based on information gathered from the literature and consultancy to HMEI members, LDS networks can cover global or regional areas from 400 to about 2000 km. Currently they include the following ones.

1. EUCLID, European LF-systems, with about 77 antennas.
2. NALDN, USA and Canada
3. SAFIR, BENELUX
4. CELDN, Central Europe
5. RINDAT, BLDN, WWLL, SIDDEM, Brazil
6. UKMO ATD

Basically, these networks can be split on two classes:

- LF systems, with MDF, LPTAS, IMPACT sensors, mostly used for detecting CG discharges.
- VHF systems with SAFIR sensors, which can detect CG and IC discharges.

Most of such LDS networks operate on national basis by either private or government ownership, using different sensor types and generations. Moreover, the spacing distribution can vary from sparse location to very heterogeneous. Figure 1 shows the distribution of main LDS networks over the world.

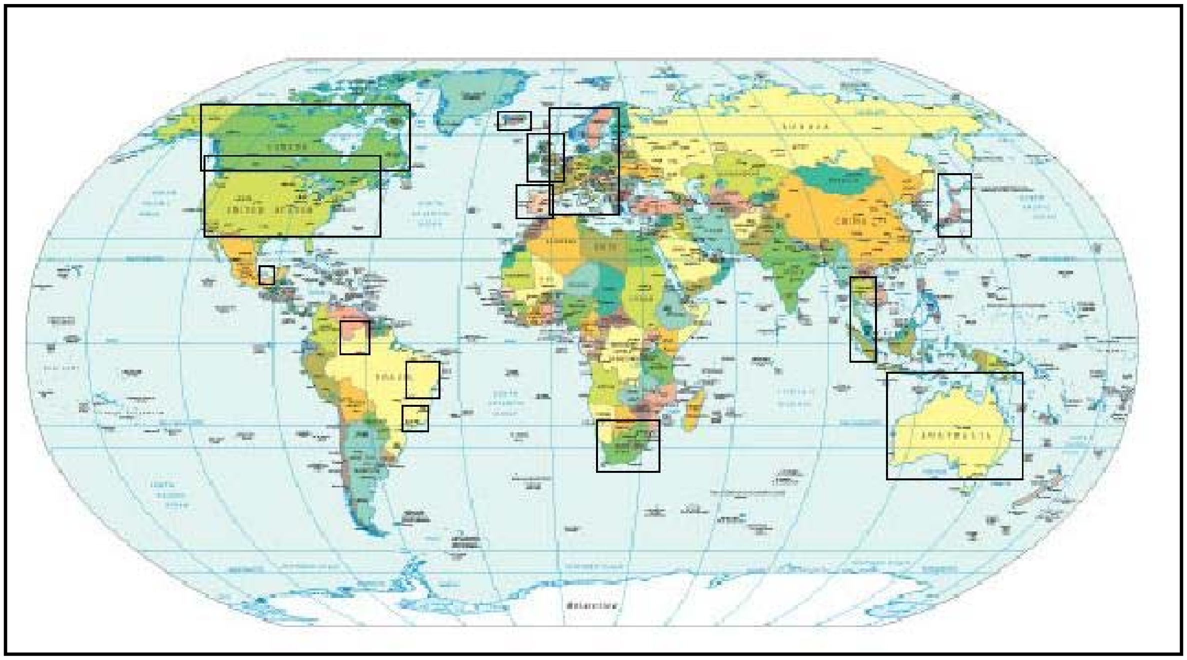

Figure 1: Global distribution of main lightning detection networks.

As example, Brazil has four networks that differs according to their frequency and are results from integration of sensors operated by either private or govern sectors:

- RINDAT, which covers about 50 to 60% of Brazil and operates at LF/VLF, with a range of 400 km. It is a consortium among Brazilian Electric Companies and Research Institutes.
- BLDN, which covers the Rondonia state, and operates at LF/VLF. NASA, INMET and INPE operate it.
- World Wide Lightning Location Network (WWLL), which operates at VLF and is a consortium between INPE and University of Washington. Cover the whole Brazil, but with low efficiency and precision.
- SIDDEM, covering South of Brazil and operates at VHF, with the range of 100 km.

The RINDAT and BLDN use the LPATS and IMPACT technologies. The WWLL uses a TOA technology and SIDDEM the SAFIR technology.

Figure 2 illustrates the Integrated Lightning Detection Network – RINDAT and figure 3 shows the distribution of the sensors over Central and South of Brazil.

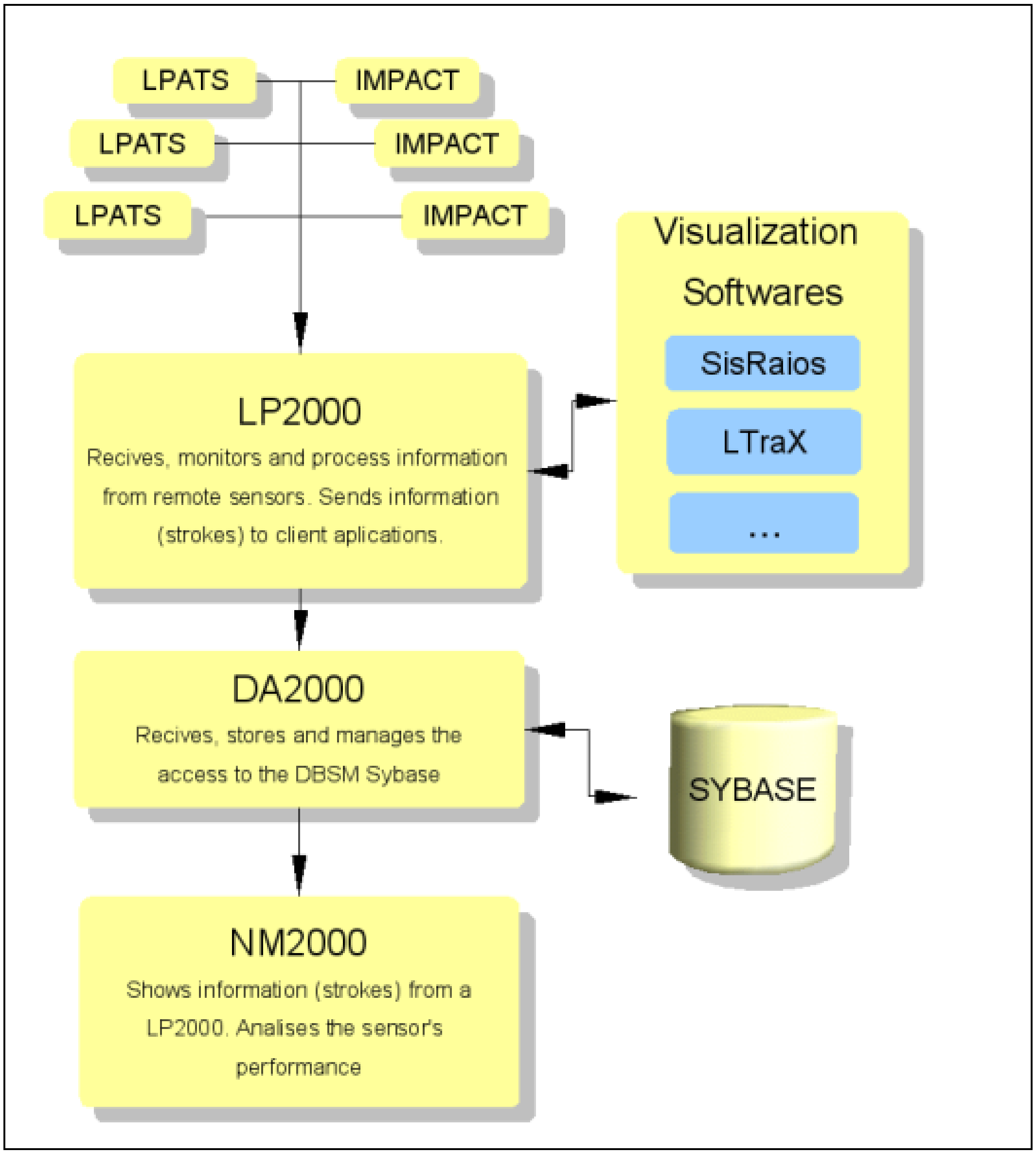

Figure2: RINDAT network control structure. Source:http://www.rindat.com.br.

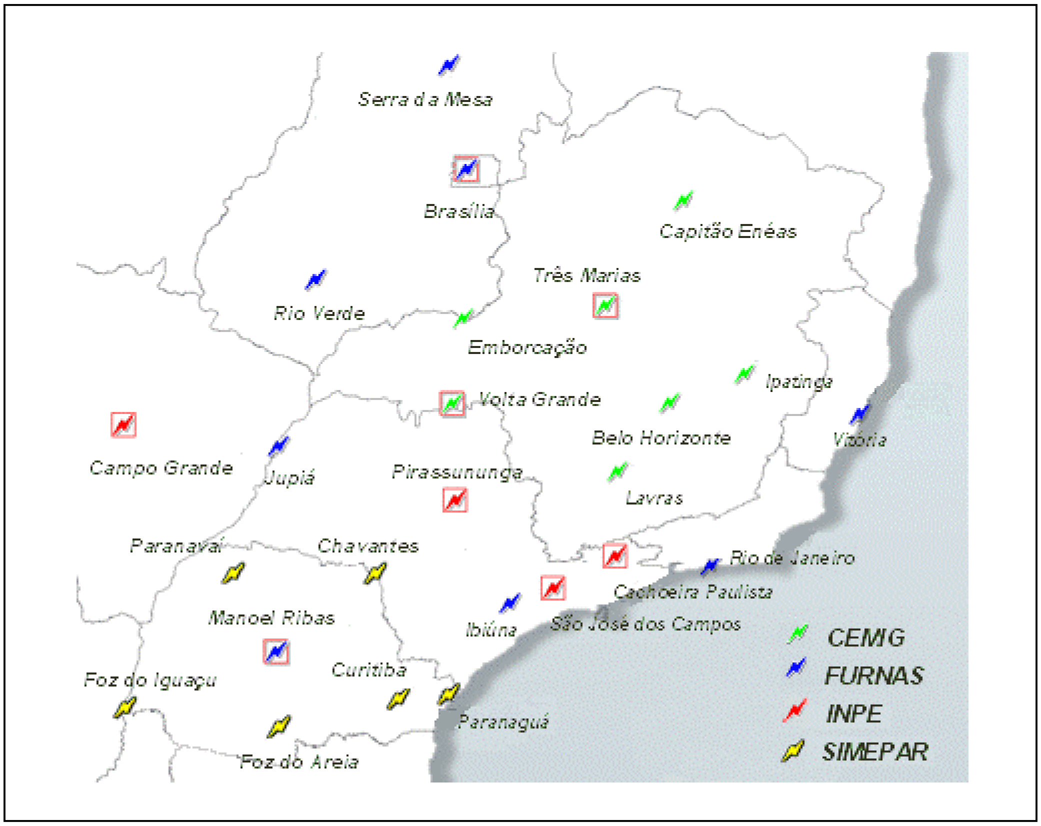

Figure 3: RINDAT sensor distribution. Source:http://www.rindat.com.br.

5.1 Compatibility of lightning detection remote sensing and conventional in-situ observations

The detection efficiency has been reported to between 70 to 90 % at most of the networks and the location accuracy less than 1 km.

The location accuracy of RINDAT, BLDN and SIDDEM is around 2 km within Brazil. The accuracy of WWLL network is around 20 km. Scientific analyses performed by Brazilian groups showed that the cloud-to-ground detection efficiency of RINDAT is in between 80-90% inside the network, and WWLL is under 2%. SIDDEM is expected to have above 90% of detection efficiency for total lightning (cloud-to-ground and intra-cloud), and no analyses were performed for BLDN.

5.2 Evaluation methods for operational lightning detection systems

Most of the evaluations are performed in the basis of comparisons with independent systems, such as instrumented towers, induced lightning, videos, photography and theoretical modeling.

Vaisala reported that there are ongoing activities using GPS synchronized speed video experiments being performed by universities and research institutions, evaluating detection efficiency, location accuracy and lightning type. They also reported that they are undertaking comparisons versus rocket triggered lightning and inter-comparisons of new equipments versus existing versions.

5.3 Lightning detection projects and networks

Extension of long range detection capabilities, such as over oceans, integration of sensors LF and VHF, aiming total lightning detection, homogenization of sensor distribution as well as integration with independent data are expect future goals of LDS. Whereas some countries and regions are expecting medium to long term development, these projects are willing to solve current problems as coverage, heterogeneity and problems related to the effects in the measurements, such as propagation and ground clutter. Balance between CG systems and IC systems will be also addressed.

As illustration, in Brazil there is plan to integrate the network which cover Rondonia to RINDAT and to improve the WWLL using new VLF sensors. RINDAT is looking for more partners with the goal to extend its coverage over other regions in Brazil. Additionally, there is a collaborating project between the University of Connecticut and University of São Paulo to expand the ZEUS Long Range Lightning Monitoring Network (**http://sferics2.engr.uconn.edu**) in Brazil by adding 2 more VLF receivers (this system applies the TOA technique). Figure

4 shows a perspective status of future stage of the Brazilian Lightning Detection Network.

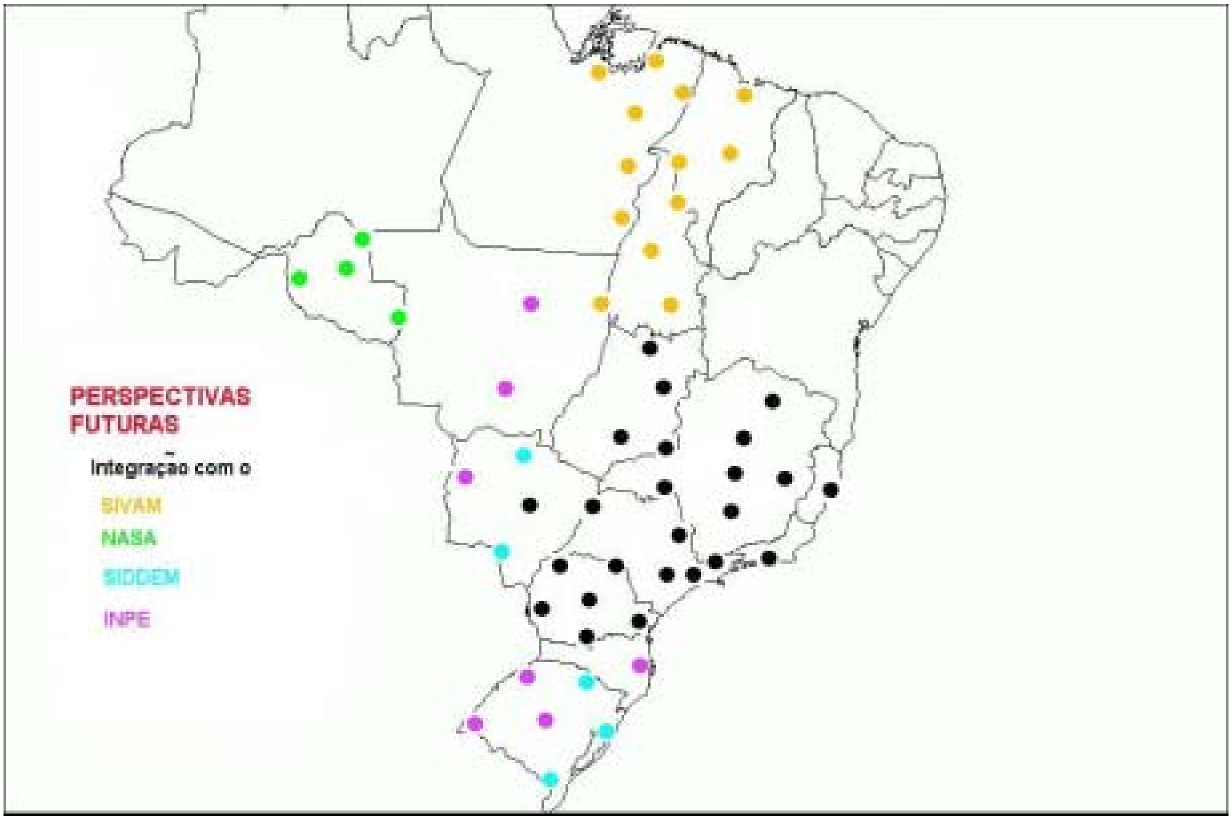

Figure 4: Future situation of the Brazilian Network Lightning Detection Network. Source: Saba, M.M.F., Pinto, O. Jr., Ballarotti, M.G., Naccarato, K.P, ILDC,2004.

5.4 Acknowledgements

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