European Lightning Detection Workshop 2016

Meeting of the EUCLID members

Météorage CATS operators Workshop

Centre International de Conférences
Météo-France - Toulouse – France
4th - 7th October 2016

VAISALA Météorage METEO FRANCE

ELDW 2016 Agenda

Tuesday 4th October - Vaisala network owners/operators meeting (on invitation)	
09:00	Registration
09:30	Welcome, Introduction of attendance, by Bernard Urban, Météo-France, deputy head of radar and lightning department.
10:00	Update presentations
11:00	Coffee break
11:15	Presentations
14:00	Presentations
15:00	Visit of the Meteopole
17:00	End of day

Wednesday 5th October - ELDW	
08:30	Registration
09:15	Welcome to ELDW 2016, by Emmanuel Legrand, Technical Director of Météo-France
Session 1 : operational applications	
9:30	1.1 Use of lightning data at Meteo-France, an overview, Météo-France (Philippe Héreil)
9:50	1.2 Mention of the convective activity in METAR AUTO, Météo-France (Olivier Laurantin)
Session 2 : field experiments and impact studies	
10:10	2.1 An overview of the HyMeX Lightning Science Team activities, LA-CNRS (Eric Defer)
10:30	2.2 SAETTA: high resolution 3D mapping of the lightning activity around Corsica, LA - CNRS (Sylvain Coquillat)
10:50	Coffee break - ELDW participants photo
Session 2 (continued)	
11:20	2.3 Lightning climatology in the Congo Basin, LA (Serge Soula)
11:40	2.4 Impact study of the "Millau Bridge" on the local lightning occurrence, Météorage (Stéphane Pedeboy)
Session 3 : Nowcasting and severe weather	
12:00	3.1 Lightning Jump" algorithm for the nowcast of severe weather: Preliminary evaluation at "meteo.cat" of an operational tool using VAISALA-LS8000 total lightning data, Meteorological Service of Catalonia (Nicolau Pineda)
12:20	Lunch
Session 3 (continued)	
13:30	3.2 Use of lighning data in Météo-France nowcasting convection products, Météo-France (Jean-Marc Moisselin)
13:50	3.3 Source Classification and Thunderstorm Warning with the GLD360 Dataset, Vaisala Inc (Ryan SAID)
Session 4 : space-based detection	
14:10	4.1 Meteosat Third Generation Lightning Imager (MTG-LI): Flash and Accumulated products and test data for user readiness activities, EUMETSAT (Heikki Pohjola)
14:30	4.2 TARANIS a space mission dedicated to the observation of the physical phenomena over the thunderstorms, CNES (Christophe Bastien-Thiry)
14:50	4.3 The SOLID (Space-based Optical LIghtning Detection) project, LA-CNRS (Eric Defer)
15:10	Coffee break
Session 5 : numerical modelling and assimilation	
15:40	5.1 Cloud electrification and lightning flashes in Meso-NH, LACy-CNRS (Christelle Barthe)
16:00	5.2 Lightning data assimilation in kilometre-scale NWP systems: Review and perspectives in the framework of the EXAEDRE project, CNRM (Olivier Caumont)
	Session 6 : lightning detection networks
16:20	6.1 ATDnet-LIS comparison, UKMO (Sven-Erik Enno)
16:40	6.2 Determining lightning outliers using weather radar to evaluate the performance of EUCLID, RMI Belgium (Dieter Poelman)
17:00	6.3 Latest EUCLID performance improvements/analyses, OVE Service GmbH - ALDIS

	(Wolfgang Schulz)
17:20	End of day
19:30	Dinner in Toulouse (Les caves de la Maréchale)

Thursday 6th October : EUCLID (on invitation)	
09:30	EUCLID members meeting
17:00	End of day

Friday 7th October : CATS users meeting (on invitation)	
09:30	CATS users meeting
17:00	End of day

Session 1: Operational Application

1.1 Use of lightning data at Météo-France : an overview

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Lighnting data is used at Meteo France for applications such as forecasting, nowcasting or automated warnings for aeronautical users. Depending on the region of interest, lightning data is provided by specific networks. Data from Météorage and partners network is used to cover Western Europe while overseas, Vaisala GLD360 data is employed since 2016 on Caribbean islands and La-Reunion areas. New Caledonia is managing its own lightning network, installed by Météorage in 2013. ATDnet and WWLLN global networks provide complementary data on other areas of interest.

1.2 Mention of the convective activity in METAR AUTO

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Météo-France has developed more than 10 years ago a software called MACMA which provides the convective cloud and present weather information required by automatic METAR (meteorological aerodrome report).
This software combines weather radar and lightning detection networks data to assess the convective activity in the vicinity of airports.
First deployed in Metropolitan France in 2006, it has been implemented overseas during the last 4 years, period when lightning data from different networks has been progressively integrated.

Session 2: Field Experiments and Impact Studies

2.1: An overview of the HyMeX Lightning Science Team activities

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The HyMeX (Hydrological cycle in Mediterranean EXperiment) program is dedicated to the study of the hydrological water cycle in the Mediterraean Sea. Several Academic groups, Weather Services, and lightning data providers are contributing to HyMeX Working Group 3 (heavy precipitation events, flash floods and floods) investigations via a series of lightning-based studies. The objectives of the HyMeX Lightning Science Team are:
i) Study the relationships between kinematics, microphysics, electrification, aerosols, and lightning occurrence and characteristics;
ii) Document the electrification processes and charge structures inside clouds over sea and land, and during sea-to-land and land-to-sea transitions;
iii) Promote the use of lightning records for data assimilation, nowcasting and very short-range forecasting applications;
iv) Cross-evaluate lightning observations from different operational lightning locating systems;
v) Establish climatology of lightning activity over the Mediterranean basin.

We will present an overview of the observational- and modelling-based HyMeX Lightning Science Team activities with an emphasis on the observations collected during the HyMeX Special Observation Period (SOP1) (September-November 2012).
The activities of the HyMeX Science Team are supported by MISTRALS/HyMeX and ANR-11-BS56-0005 IODA-MED.

2.2 SAETTA: high resolution 3D mapping of the lightning activity around Corsica

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In the frame of the French atmospheric observatory CORSiCA (http://www.obs-mip.fr/corsica), a total lightning activity detection system adapted to storm tracking at regional scale is operated by Laboratoire d'Aérologie. The SAETTA (Suivi de l'Activité Electrique Tridimensionnelle Totale de l'Atmosphère) network is composed of 12 standalone LMA stations (Lightning Mapping Array, New Mexico Tech). SAETTA maps lightning flashes in 3D and in real time, at high temporal (80 µs) and spatial resolutions in the 60-66 MHz band, within a radius of about 350 km from the centre of the network.
Many high quality observations have been recorded so far that provide an accurate location in space and time of the convective events, delivering unprecedented dynamical and microphysical features of the Corsican convective storms. Specific lightning events have also been detected such as bolts-from-the-blue, high altitude discharges in convective but also in stratiform regions, inverted polarity thunderstorms.
The SAETTA network will first be presented. Examples of usual and atypical lightning flashes and of lightning activity at the storm scale will be discussed. We will also discuss on the lightning climatology over Corsica deduced from the 2014 and 2015 SAETTA records.
Acknowledgements: Collectivité Territoriale de Corse through the Fonds Européen de Développement Régional of the European Operational Program 2007-2013 and the Contrat de Plan Etat Région; HyMeX/MISTRALS; Observatoire Midi-Pyrénées; Laboratoire d'Aérologie; and many individuals and regional institutions in Corsica that are hosting the 12 stations of the network or helped us to find sites. We thank Mathilde Chabasset for the graphs she produced during her research internship.

2.3 Titre: Lightning climatology in the Congo Basin

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The lightning climatology in a large region of Central Africa (2750 km × 2750 km) including the Congo Basin and several countries is analyzed in detail at a resolution of 0.1°. The study is based on World Wide Lightning Location Network (WWLLN) data for the period from 2005 to 2013. A comparison of this dataset with the Lightning Imaging Sensor (LIS) observation over the same period shows the average detection efficiency (DE) of WWLLN relative to LIS data, increases from about 1.70 % in 2005 to 5.90 % in 2013. However it does not increase uniformly over the whole area. Both the annual flash density and the annual number of stormy days show maximum values located in eastern Democratic Republic of Congo (DRC), west of Kivu Lake, regardless of the reference year and the period of the year. These maxima reach 12.86 flashes per square km and 189 days, respectively, in 2013. They correspond to a

very active region located along the Virunga mountain range characterized by summits that reach 3000 m. The presence of this range plays a role in the thunderstorm development during the whole year. The estimation of the local maximum of the lightning density by taking into account the value of DE, leads to a value consistent with that of the global climatology by Christian et al. (2003) and other authors. Thus, a mean maximum value of about 200 flashes per square km and per year is found for the annual lightning density. The average monthly flash rate describes an annual cycle with a strong activity from October to March and a low one from June to August, associated with the ITCZ migration but not exactly symmetrical on both sides of the equator. The zonal distribution of the lightning flashes exhibits a maximum between 1°S and 2°S and about 56 % of the flashes located below the equator in the 10°S – 10°N interval. The zonal distribution of the lightning flashes exhibits a maximum between 1°S and 2°S and about 56 % of the flashes are located south of the equator in the 10°S – 10°N interval. The diurnal evolution of the flash rate has a maximum between 1400 and 1700 UTC, according to the reference year. The diurnal cycle is more pronounced in the region of the maximum.

2.4 Impact study of the "Millau Bridge" on the local lightning occurence

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It is well known that lightning flashes preferably strike tall objects because they considerably enhance the local electric field favoring the attraction and the connection of downward leaders leading to return strokes. Depending on its total height, a given structure may not only attract but also trigger upward lightning. Based on lightning data collected by Météorage, the French national operator, a study was made on a 20-year period in the vicinity of one of the tallest structure ever built in France, the "Millau Bridge", to analyze its effective impact on the local lightning activity. The result clearly showed a local enhancement of lightning occurrence since 2005 after the bridge has been terminated, mainly due to the 90m masts supporting the road deck but not directly due to the height of the piers themselves. Interestingly, because of the high lightning location accuracy of the French Lightning Detection System, it was possible to demonstrate that the most central masts are concerned by the lightning occurrence enhancement possibly because they are free from the natural protection offered by the surrounding elevated terrain. Finally, a detailed review of individual flashes striking the bridge showed that 45% to 60% of the total flashes are upward lightning flashes, as expected because of the height of the bridge, with no particular seasonal effect.

Session 3: Nowcasting and Severe Weather

3.1 "Lightning Jump" algorithm for the nowcast of severe weather: Preliminary evaluation at "meteo.cat" of an operational tool using VAISALA-LS8000 total lightning data

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Several studies reported sudden increases in the total lightning flash rate (intra-cloud + cloud-to-ground) preceding the occurrence of severe weather (large hail, wind gusts associated to thunderstorms and/or tornadoes). This pattern, known as "Lightning Jump" (Williams et al., 1999), has demonstrated to be of operational use in the forecasting of severe weather phenomena Schultz et al. (2009), Gatlin and Goodman (2010) and Schultz et al. (2011).

The present study introduces the application of a lightning jump algorithm using VAISALA-LS8000 total lightning data. The identification of thunderstorm cells bearing severe weather is based solely on total lightning data, revealing that there is no need of radar data to trigger severe weather warnings. The algorithm was validated by means of a dataset severe weather events occurred in Catalonia in the period 2009–2014. Results obtained revealed very promising (see Farnell et al., 2016 for details).
After a period of validation, the Lightning Jump algorithm has become an operational tool for weather surveillance at the Meteorological Service of Catalonia. The tool has been introduced during the 2016 summer campaign, with a good acceptance among the forecasters as it has shown a good performance.

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3.2 Titre: Use of lighning data in Météo-France nowcasting convection products

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The Nowcasting Department of Météo-France makes a wide use of lightning data. Depending on the type of the products or their lo type or location, different network are used: French meteorage network, Euclid, WWLLN; GLD360, ATD, Nouvelle Calédonie Local network.
In the radar-based products like ASPOC3D, lightning data are used for metropolitan and oversea territories version. The lightning data are visualized directly through web visualisation interface. Additionally for each convective cells identified by the meteorological radars, the lightning activity is described.
In the satellite based convection product RDT (Rapidly Developing Thunderstorm), lightning data are used to describe convection, to tune and to validate the product. Additionally when a cloud cell is not discriminated as convective, the lightning activity can be used to change the diagnosis and thus to avoid non detection cases.
For future, there is a high expectation of lightning imager on-board of geostationary satellites (GOES-R, MTG).

3.3 Source Classification and Thunderstorm Warning with the GLD360 Dataset

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The Vaisala GLD360 global lightning dataset is generated by a long-range network that employs both Time of Arrival (TOA) and Magnetic Direction Finding (MDF) technologies at each

sensor to geo-locate individual lightning flashes. The sensors, sensitive to the Very Low Frequency range (VLF; ~500 Hz -- ~50 kHz), use a waveform recognition algorithm to identify specific features in radio atmospherics generated by individual lightning discharges. A propagation correction is applied to the time delay of each feature in order to recover a more consistent arrival time across a wide range of distances and propagation conditions. An attenuation model is also applied to the amplitude of the waveform, which is used to recover an estimate of peak current.
On August 18th, 2015, Vaisala released a major update to the location algorithm that generates the GLD360 dataset. This update includes several enhancements that are targeted at improving the performance of the network. The primary changes include a more refined propagation model, improved sensor correlation heuristics, and a more robust backend infrastructure. This paper reviews the technical relevance of these improvements in the context of the methodology behind this long-range lightning detection network, with an emphasis on the improved performance afforded by the updated long-range propagation model. Using reprocessed and production data, a brief analysis of the network performance before and after the upgrade is given.
Reprocessed GLD360 solution data from the new algorithm are used with two applications. Traditionally, only precision networks have provided classification information for individual events, labeling each as either a cloud pulse or a cloud-to-ground (CG) return stroke. These networks use a combination of waveform information, peak current and polarity, and source altitude measurements. This paper estimates the classification performance using just peak current magnitude and polarity as a classifier metric, and evaluates the resulting classification performance of reprocessed GLD360 using this approach.
The second application is a follow-up to a previous study that analyzed GLD360's skill as a lightning warning system, using practical figures of merit such as probability of detection and total duration in a warning state. This updated analysis of GLD360's utility as a lightning warning system is contrasted against the warning performance using lightning data from a regional precision network or a standalone single-point lightning detection sensor.

Session 4: Space-based detection

4.1 Meteosat Third Generation Lightning Imager (MTG-LI): Flash and Accumulated products and test data for user readiness activities

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EUMETSAT is currently developing with ESA the geostationary Meteosat Third Generation (MTG) satellite system to continue and enhance the service currently provided by Meteosat Second Generation (MSG), from 2020 onwards. One of the new missions of MTG is the Lightning Imager (LI) mission, which is intended to provide a real time lightning detection and location capability in support to nowcasting of high impact weather. The LI measures the total lightning, i.e. the combined cloud-to-ground and intracloud/cloud-to-cloud lightning.
Observation of optical pulses caused by lightning at cloud top is based on detecting the short transient pulse, which is characteristic to lightning, and which is also in contrast to a slowly changing background. The main challenges of the LI mission are the handling of the potentially high data load in peak periods and a successful filtering of false events, i.e. instrument triggered events not caused by lightning.
One of the major tasks in the MTG program is to provide the Level 2 product processor. The initial L2 products are based on the detection of the optical pulses on top of clouds following a false event filtering and clustering of the detected triggered lightning events in time and space. These are composed to the initial L2 products, i.e. groups and flashes representing geophysical flashes and strokes. A further L2 product category is the Accumulated Products, which integrate the Flash products into a fixed 2 km grid (same as for the MTG Flexible Combined Imager IR channels) with a 30 sec accumulation period. These 30-sec periods can be further

stacked by users. The products are disseminated as short duration chunks in order to meet the timeliness requirements.
The LI mission does not have a space heritage in a geostationary orbit. However, GOES-R GLM will be launched in November 2016. A lot of emphasis has been placed on familiarising the users to the products and test data well in advance of launch. Test data for Flashes and Accumulated products have been created and processed into the specified L2 format. Various user readiness activities are also in place, and planned for the coming years, to provide a mechanism for interaction with the user community.

4.2 TARANIS a space mission dedicated to the observation of the physical phenomena over the thunderstorms

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TARANIS (Tool for the Analysis of Radiations from lightning and Sprites) is a CNES scientific mission based on a microsatellite belonging to CNES Myriade series and dedicated to the study of impulsive transfers of energy between the Earth's atmosphere and the space environment. Objectives more precisely focus on the determination of the mechanisms at the origin of Transient Luminous Events (TLEs), Terrestrial Gamma-ray Flashes (TGFs) and on their effects on the Earth environment. TLEs are large light emissions generally observed obliquely in the upper atmosphere above thunderstorms at altitudes from 20 to 100 km. TARANIS will be the first space mission fully dedicated to the detection and observations from space with a complete range of scientific captors (optical, radiation, electro magnetism) of the TLE and TGF phenomena. The system is planned to be ready for launch by end of 2018.

4.3 The SOLID (Space-based Optical LIghtning Detection) project

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In preparation to the up-coming space-based optical lightning detection missions, several European groups have gathered through the SOLID (Space-based Optical Lightning Detection) project supported by the French space agency CNES. The SOLID project aims at preparing and consolidating the calibration and validation plans of the ISS-LIS (International Space Station Lightning Imaging Sensor), TARANIS (Tool for the Analysis of RAdiation from lightNIng and Sprites) and MTG-LI (Meteosat Third Generation Lightning Imager) missions, but also at preparing the use of observations of those new space-based missions through several studies exploring existing observations of the TRMM-LIS (Tropical Rainfall Measuring Mission Lightning Imaging Sensor) mission.
We will present an overview of the SOLID project by describing first its objectives and its different activities with an emphasis on current concurrent observations performed in Corsica with SAETTA (Suivi de l'Activité Electrique Tridimensionnelle Totale de l'Atmosphère) Lightning Mapping Array, Météorage, BLESKA (Broadband Lightning Electromagnetic Signal Keeper Analyzer) and SDA-2 (Short Dipole Antenna) instruments, on some comparison between LIS (Lightning Imaging Sensor) and LMA observations and on simulation of optical signal with the French cloud model MesoNH, its electrification/lightning CELLS scheme and its new optical lightning radiation module LiSim3M.
The SOLID project is supported by CNES-TOSCA.

Session 5 : Numerical Modelling and Assimilation

5.1 Cloud electrification and lightning flashes in Meso-NH

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A full explicit electrical scheme is implemented in the French atmospheric research model Meso-NH. It allows to simulate the whole lifecycle of electric charges, from their separation at the local scale to their partial neutralization by the lightning flashes. Several current applications (HyMeX cases, tropical cyclones...) and future activities will be presented.

5.2 Lightning data assimilation in kilometre-scale NWP systems: Review and perspectives in the framework of the EXAEDRE project

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Although lightning is related to deep convection, lightning observations are hardly assimilated by any numerical weather prediction (NWP) system. There are some reasons for that, among which the most crucial one is the difficulty to establish and exploit a reliable relationship between the model prognostic variables and the observations.
A step change in lightning observing systems is envisaged with the upcoming geostationary satellite missions MTG and GOES-R that will comprise lightning imagers detecting total lightning over hemispheres. The assimilation of such data could improve severe weather forecasts, especially over coastal areas prone to heavy precipitation such as around the Mediterranean basin. In those areas, convective systems often first grow over the sea, out of reach of ground-based instruments such as weather surveillance radars, and are then advected towards the coasts where they cause flash flooding.
In the framework of the EXploiting new Atmospheric Electricity Data for Research and the Environment (EXAEDRE) project, which just started, it is planned to use data from European-based Lightning Mapping Arrays (LMAs) to investigate the potential of the assimilation of total lightning data in kilometre-scale NWP systems so as to better anticipate heavy-precipitation events.
The presentation will review related past work and set out the rationale proposed in framework of the EXAEDRE to address this topic.

Session 6 : Lightning Detection Networks

6.1 ATDnet-LIS comparison, UKMO (Sven-Erik Enno)

6.2 Determining lightning outliers using weather radar to evaluate the performance of EUCLID

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Quantitative precipitation estimations (QPE) derived from the Belgian weather radar at Wideumont are overlayed with EUCLID CG and CC stroke observations in order to extract the percentage of lightning outliers. Applying this to a large dataset from 2006-2015 it is possible

to analyze the behavior of the outliers obtained over time with respect to the performance of EUCLID.

6.3 : Latest EUCLID performance improvements/analyses

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