Performance of the EUCLID network in cloud lightning detection in the South-East France

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1 – Background

EUCLID is capable to detect both Cloud-to-Ground (CG) and a fraction of Intra-Cloud (IC).

Detection Efficiency (DE) is an important parameter that must be known to assess the quality of a lightning dataset. EUCLID's DE_{CG} is well-know and documented (about 98% $DE_{CG\text{-}flash}$ and 89% $DE_{CG\text{-}stroke}$) but DE_{IC} cannot be studied with high speed camera records, rocket triggered lightning or Instrument towers.

LMA system that maps in 3D all flashes in a thundercloud with a 100% detection efficiency can provide ground truth datasets to study DE_{IC}

2 – Objectives

#1: To determine the DE_{IC} on a bigger LMA dataset to get more relevant statistical results on a larger dataset.

#2: To develop a LMA flash grouping algorithm to automatize the correlation of big LMA datasets and LF data.

#3: To better understand the physical process in IC discharges being detected in the LF range.

3 – Intra-cloud flash types

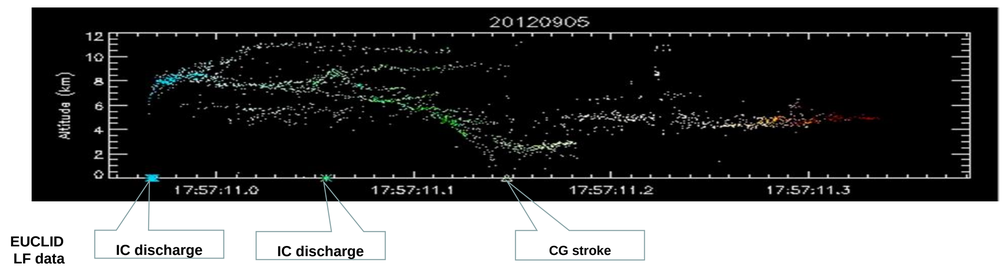

Fig-3.1. Hybrid flash 05/09/12 17:57:11 UTC.[HyLMA & EUCLID]

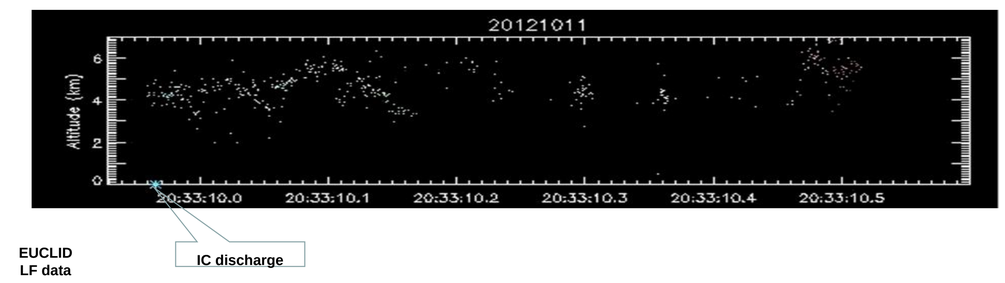

Fig-3.2. Isolated flash 11/10/12 20:33:10 UTC.[HyLMA & EUCLID]

4 – Main results

Variability of DE_{IC} as a function of thunderstorms

	05/09/12	25/09/12	26/09/12	29/09/12	30/09/12	11/10/12	22/10/12
Begin date	**16:35**	**09:10**	**04:45**	**12:00**	**00:00**	**16:50**	**19:30**
End date	**18:20**	**15:00**	**16:15**	**17:45**	**01:15**	**20:40**	**23:59**
Total LF Flashs	143	803	518	242	75	400	95
CG	*47*	*260*	*217*	*110*	*46*	*207*	*50*
IC	*96*	*543*	*301*	*132*	*29*	*193*	*45*
Total LMA Flashes	105	1617	1132	110	15	186	40
Hybrid flashes	*39*	*226*	*126*	*53*	*12*	*75*	*18*
Flashs IC isolés	*66*	*1391*	*1006*	*57*	*3*	*111*	*22*
Correlation between LMA and EUCLID LF data							
Nb IC_{LF} in Hybrid flash	*22*	*50*	*26*	*24*	*5*	*22*	*7*
DE IC hybrid	**56%**	**22%**	**21%**	**45%**	**42%**	**29%**	**39%**
Nb IC_{LF} in Isolated flash	*30*	*136*	*114*	*16*	*2*	*24*	*10*
DE IC isolated	**45%**	**10%**	**11%**	**28%**	**67%**	**22%**	**45%**
Total IC-LF	52	186	140	40	7	46	17
DE IC total	**50%**	**12%**	**12%**	**36%**	**47%**	**25%**	**43%**

Fig-4.1 Result of the correlation between LMA and EUCLID flashes.
LMA flashes are identified with the grouping algorithm which parameters are:
Δt_{src} < 150 ms, Δd_{src} < 3km, alt_{src} < 12 km, X^2 < 3, Nb stations > 6

- Correlation between LMA flashes and EUCLID data (IC/CG) determines the type of the flash: Hybrid or $IC_{Isolated}$
- LMA flashes with no correlated EUCLID data are considered as $IC_{Isolated}$.

Fig-4.2. Area of concern for with LMA station locations

DE_{IC} is globally highly variable from a thunderstorm to another !

Variability of DE_{IC} as a function of flash rates

	05/09/12	25/09/12	26/09/12	29/09/12	30/09/12	11/10/12	22/10/12
Global DE_{IC}	50%	12%	12%	36%	47%	25%	43%
Avg. flash rate (flash/min)	*0,8*	**4,7**	**2,8**	*0,5*	*0,3*	*0,9*	*0,3*
Max. flash rate (flash/min)	*3,2*	**16,7**	**10,9**	*1,5*	*0,6*	*2,3*	*1*

Fig-4.3.
Relation between DE_{IC} and lightning flash rates in number of flash per minute

- The global DE_{IC} is compared with the mean total lightning flash rate per thunderstorm.

High flash rates tend to lead to low DE_{IC} and vice-versa !

- However, the trend 'low flash rate/high DE_{IC}' is not respected on the 29/09/12 and 11/10/12

Variability of DE_{IC} as a function of flash minimum altitude and vertical extent

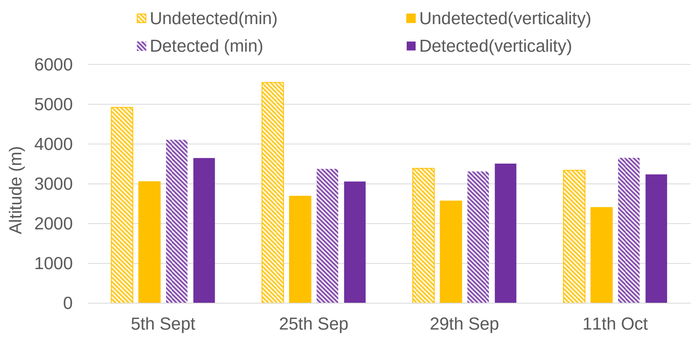

Fig-4.4
Comparison of the vertical extent and minimum altitude of detected and undetected IC flashes

- The **vertical extent**[1] and the **minimum altitude**[2] are compared for the detected and undetected IC flashes (fig 4.4).
- The vertical extent of a flash can give an idea about the vertical length of the IC discharge resulting from the initial-breakdown process which radiates in the LF range.

The undetected IC flashes <u>always</u> exhibit a smaller vertical extent (680m in average). The undetected IC flashes <u>mostly</u> exhibit a higher minimum altitude (not on 11/10/12).

*(1) The **minimum altitude** is the 5th percentile of all the source altitudes.*
*(2) The **vertical extent** of flashes is the difference between the 95th and the 5th percentile of all the source altitudes*

Variability of DE_{IC} as a function of cell lifecycles

- The average on 10 minutes period of several parameters are distributed as a function of time:
  a) $DE_{Isolated}$ and $DE_{Isolated+Hybrid}$
  b) Minimum altitude
  c) Vertical extent
- Panels in fig 4.5 show the result for a high DE (top) and a low DE (bottom)

DE_{IC} is highly variable during the lifecycle of a cell regardless the type of thunderstorm

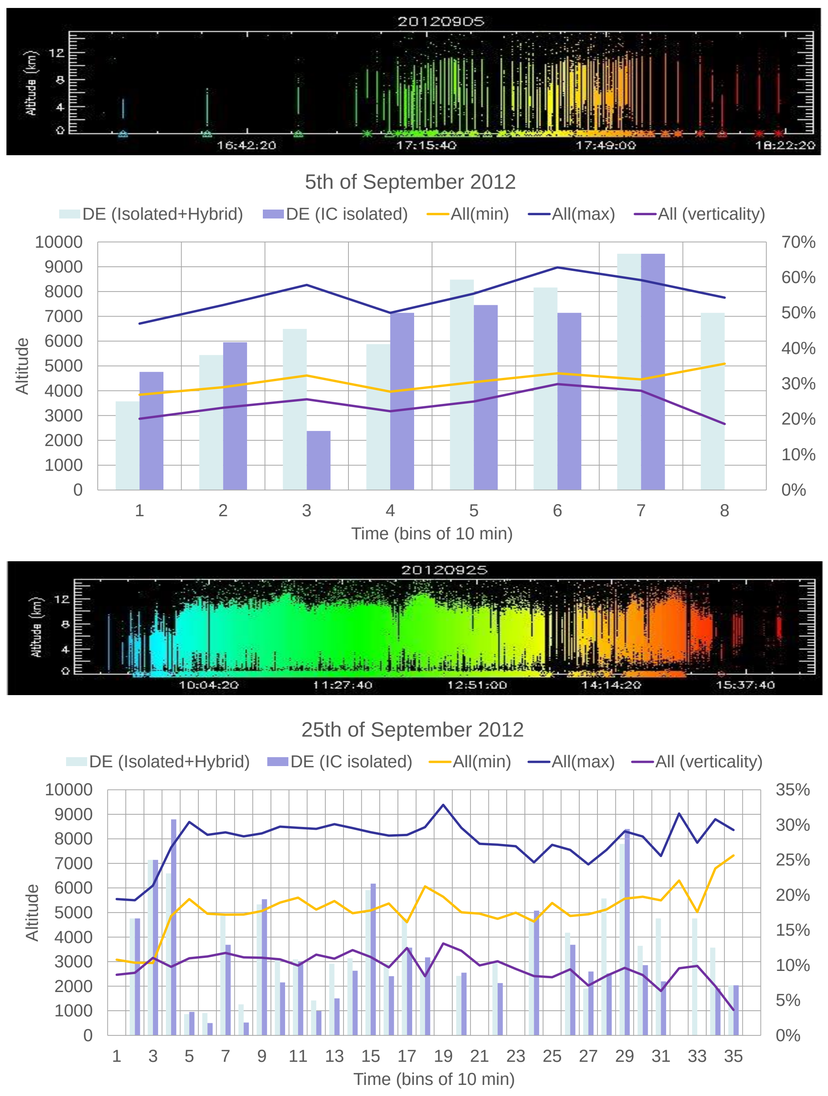

Fig-4.5 Lifecycle variations in term of $IC_{Isolated}$/Hybrid flashes ratio, DE_{IC}, minimum altitude and vertical extent

5 – Preliminary conclusion

DE_{IC} for both IC in hybrid or IC isolated flashes, is globally highly variable not only **from a thunderstorm to another** but also during the **lifecycle** of the storm cell because of:

- The **flash rate** which varies according to the stage of the storm
- The **vertical extent** likely to represent the length of the vertical discharge
- In a lesser extend the **minimum altitude** of the flash.

When the length of the vertical channel in IC discharges is smaller, the electromagnetic signal produced in the LF range is less intense and propagates on shorter distances.

As a result, the LF lightning locating system may either do not detected at all the discharge (effect on the DE_{IC}) or detect the discharge with few sensors (effect on the location accuracy)

6 – Future work

Analyze further cases in details to validate the effect of the vertical extent and possibly the minimum altitude.

Investigate other parameters to better understand their effect on the DE_{IC} like:

a) Performances of the sensors under high flash rates.

b) The different stages (early/final) of cloud discharges being detected or not.
- Does LF systems detect preferably initial-breakdown or J,K processes ?
- Speed of propagation of the channel ?

c) Polarity and power of LMA sources at the initial stage of the discharge.

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