Korea LMA Level 1 File Documentation

The Korean LMA was a NASA system that was deployed near Seoul during May-October 2023 for a field campaign called Korea Precipitation Observation Program (KPOP): International collaborative experiments for Mesoscale convective system (MCS) in Seoul metropolitan area (KPOP-MS). The NASA Marshall Space Flight Center contacts for this dataset are Timothy Lang (timothy.j.lang@nasa.gov) and Matthew Wingo (matthew.t.wingo@nasa.gov). The lead for KPOP-MS was GyuWon Lee (gyuwon@knu.ac.kr) of Kyungpook National University.

Level 1 data were created using the lma_analysis software package developed at New Mexico Tech and LMA Technologies. Useful contacts for LMA software and technology are Harald Edens (harald.edens@nmt.edu), Bill Rison (William.Rison@nmt.edu), and Dan Rodeheffer (rodeheffer@lmatechnologies.com).

A minimum of 6 detecting stations and a maximum chisqr goodness-of-fit value of 5 are required to locate a VHF source. Every station has an assumed GPS timing delay of 13 ns, based on GPS cable lengths (which are uniform across all Korean LMA stations).

Each Korean LMA Level 1 file is an ASCII architecture header information at the top, and then information about each detected source.

The header section of each file contains all information needed to understand how the data were processed and what stations were involved. This information is mostly self-descriptive.

The columns in the data portion of the file (below the '*** data ***' header line) are the following:

- Decimal second of day
- Decimal latitude
- Decimal longitude
- Altitude in m above the WGS84 ellipsoid
- Chi-squared goodness-of-fit
- VHF source power (dBW)
- Hexadecimal mask containing information on number of stations detecting source

In Python, you can use the lmatools package (https://github.com/deeplycloudy/lmatools) to ingest the data. The XLMA software, available from New Mexico Tech, is another option for reading these data.

Figure 1 shows approximately how many stations were up on a given day. Station availability ranged between 8 and 10 on a given day, with the latter half of the project subject to relatively more station outages.

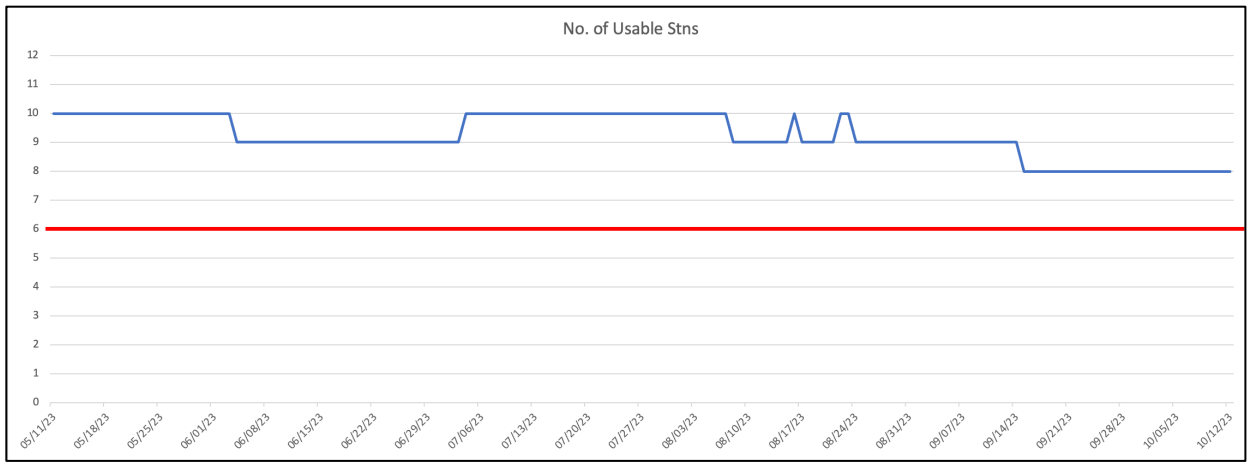

Figure 1. Estimated number of stations available and contributing to solutions on a given day (blue). The red line indicates the minimum number of stations needed for valid solutions.

In Fig. 2 a map of the network is shown. The network was centered around Seoul, on the NW coast of South Korea, near the border with North Korea. A list of stations and their locations is shown in Table 1. In Fig. 1, station A was out during a portion of June and early July, station H started to fail in August, and was joined by station C in September.

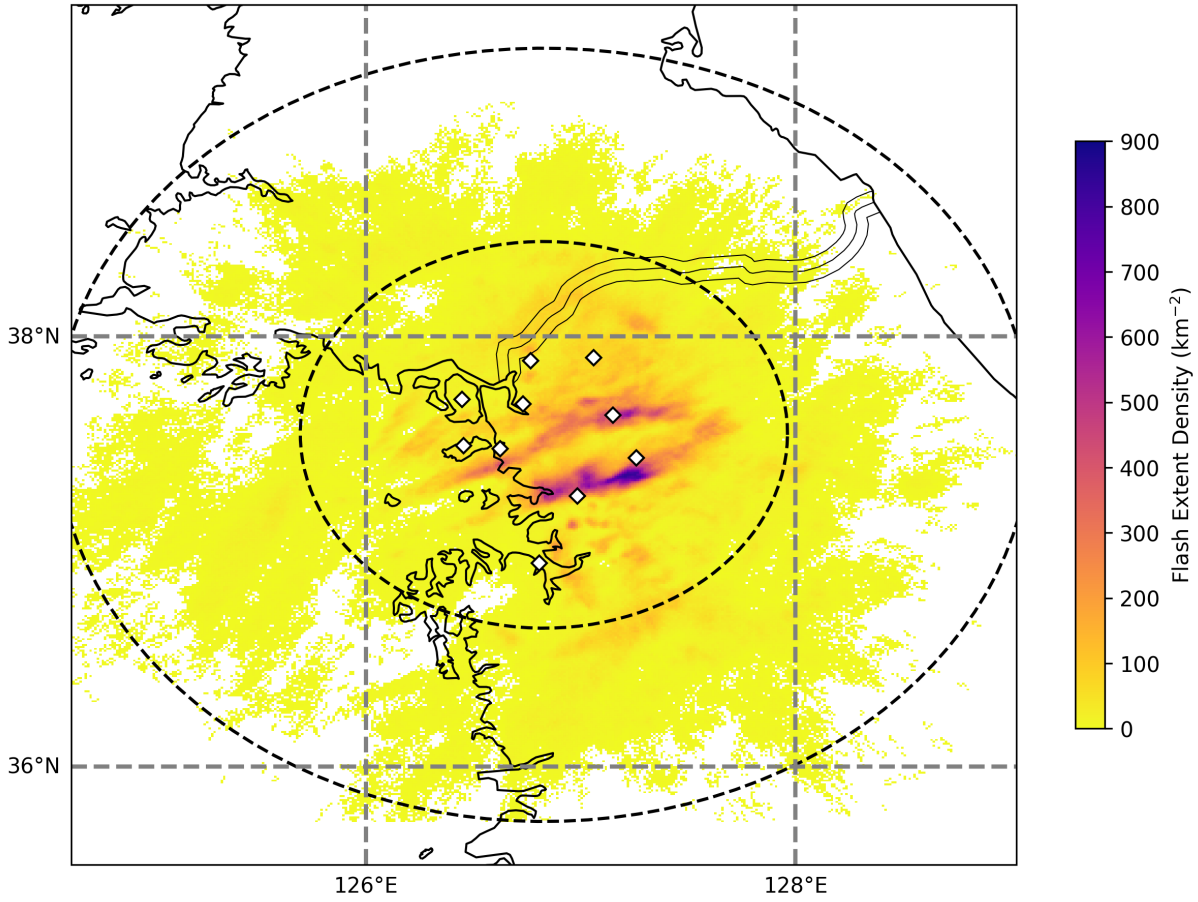

Figure 2. Map of the Korean LMA with stations as diamonds, dashed range rings every 100 km, and integrated flash extent density for the deployment.

Table 1. Korean station names and locations.

Unit	Num	Site name	Lat (deg)	Lon (deg)	Ele (m)
A	1	Paju	37.88596	126.766532	26
B	2	Dongducheon	37.901894	127.060868	115
C	3	Ganghwa	37.707264	126.446104	47
D	4	Cactus	37.6851172	126.730775	17
E	5	Incheon_Airport	37.492998	126.453192	61
F	6	Incheon_WxObs	37.477942	126.624559	68
G	7	Hangdam	36.945735	126.806461	12
H	8	Namyangju	37.634012	127.150594	28
I	9	Suwon	37.257502	126.983089	40
J	10	Gwangju	37.435253	127.259231	124

Miscellaneous Data Quality Notes

- There are missing L1, L2, and L3 data during the following times. The data did not fully process properly for an unknown reason, but the L1-L3 files exist. Unfortunately, these temporal gaps occurred during active thunderstorm cases.
    - ~2305-2310 UTC on 10 July 2023
    - ~0022-0030 UTC on 11 July 2023
- Here are missing L1 files (all 10-minute files missing, so no related L2 or L3 data either). Weak thunderstorms likely were in the area during these times.
    - KOREA_230722_103000_0600.dat.gz
- Here are additional missing L1 files (all 10-minute files missing, so no related L2 or L3 data either). All of these files were during lightning-quiet periods.
    - KOREA_230511_034000_0600.dat.gz
    - KOREA_230517_201000_0600.dat.gz
    - KOREA_230517_214000_0600.dat.gz
    - KOREA_230517_224000_0600.dat.gz
    - KOREA_230518_171000_0600.dat.gz
    - KOREA_230518_181000_0600.dat.gz
    - KOREA_230519_095000_0600.dat.gz
    - KOREA_230520_042000_0600.dat.gz
    - KOREA_230520_052000_0600.dat.gz
    - KOREA_230520_170000_0600.dat.gz
    - KOREA_230520_180000_0600.dat.gz
    - KOREA_230521_163000_0600.dat.gz
    - KOREA_230521_173000_0600.dat.gz
    - KOREA_230522_061000_0600.dat.gz
    - KOREA_230522_071000_0600.dat.gz
    - KOREA_230523_000000_0600.dat.gz
    - KOREA_230523_001000_0600.dat.gz
    - KOREA_230523_002000_0600.dat.gz

    - KOREA_230523_003000_0600.dat.gz
    - KOREA_230523_004000_0600.dat.gz
    - KOREA_230523_005000_0600.dat.gz
    - KOREA_230529_000000_0600.dat.gz
    - KOREA_230529_001000_0600.dat.gz
    - KOREA_230529_002000_0600.dat.gz
    - KOREA_230529_003000_0600.dat.gz
    - KOREA_230529_004000_0600.dat.gz
    - KOREA_230529_005000_0600.dat.gz
    - KOREA_230612_054000_0600.dat.gz
    - KOREA_230629_065000_0600.dat.gz
    - KOREA_230701_000000_0600.dat.gz
    - KOREA_230715_175000_0600.dat.gz
    - KOREA_231001_000000_0600.dat.gz
    - KOREA_231001_231000_0600.dat.gz
    - KOREA_231002_231000_0600.dat.gz
    - KOREA_231003_231000_0600.dat.gz
    - KOREA_231004_231000_0600.dat.gz
    - KOREA_231005_231000_0600.dat.gz
    - KOREA_231006_231000_0600.dat.gz
    - KOREA_231007_231000_0600.dat.gz
    - KOREA_231008_231000_0600.dat.gz
    - KOREA_231009_231000_0600.dat.gz
    - KOREA_231010_231000_0600.dat.gz
    - KOREA_231011_231000_0600.dat.gz
    - KOREA_231012_231000_0600.dat.gz
- Overall, this represents about 463 minutes of data lost over the 155-day data record (~0.2%).
- Enhanced noise sometimes occurred. This issue was transient and mainly affected L1 data. We recommend stricter chisqr requirements if this noise affects your analysis.