Format for ".comcat" output files written by *mloc*

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v1.4.2

This document describes a variant of the the native data format used in the multiple event relocation program *mloc*. Data files with the native format have the filename suffix ".mnf" and the format will be referred to as MNF for "*mloc* native format".

Version 1.4 of MNF is a special-purpose variant of what would be considered the "standard" version, v1.3.1. It was created to address a specific problem, the creation of an output file for import into the Global Calibrated Earthquake Cluster (GCEC) catalog in the USGS COMCAT catalog server. This version of MNF should only be found in ".comcat" output files created by the "ccat" command in *mloc*. Version 1.4 of MNF contains several new record types and the formatting of some record types is different from that used in v1.3.1 of MNF.

Version 1.4.2 of MNF makes a significant change to the format of phase records, adding a field for a deployment/network code.

Changes from v1.41 to v1.4.2

- In **phase records**, an 8-character field for the deployment code is inserted after the station code. Under IASPEI's recommended ADSLC station-definition format the deployment code can be up to 8 characters in length. It is legitimate to use FDSN network codes (2 characters) as deployment codes. Agency codes are not supported.
- All seismograph stations used in the analysis are now listed. Formerly, only stations defined in supplemental station files (i.e., not the master station file, which is based on the ISC's International Registry) were listed.
- **Station records** now include fields for agency and deployment.

Changes from v1.4 to v1.41

- In **phase records**, the travel time residual is now carried with two decimal places of precision, instead of one.

Changes from v1.3.1 to v1.4

- A **station coordinates record**, identified by "C" in column 1, is now defined.
- A **layer velocity record**, identified by "L" in column 1, is now defined.
- **Depth records** are not supported in v1.4.
- Only one **hypocenter line** (the preferred one) is permitted, and the usage code is omitted.
- Usage codes are stripped out of **magnitude records**.
- A "+" usage code is defined in **phase records** for readings that were used.
- A special event ID is defined in **event records**.

- The format of **phase records** is substantially changed.

Background

See the documentation of MNF v1.3.1 for a full discussion. Version 1.4 of MNF is only supported in versions of *mloc* from 10.0.7, and only as an output format for "comcat" files, which is controlled by the "ccat" command. Version 1.41 is first supported in v10.2.6 of *mloc*, released on July 5, 2015.

Description and Features

MNF is a fixed format based on the common concept of a small set of distinct record types with different formats, identified by a character flag in the first column. Each record is a single line. Each type of information (e.g., event, hypocenter, magnitude, phase arrival) has a specific record type, and there are a few utility record types. The currently-defined record types and their flags are given in the following table:

Flag	Record Type
B	Bulletin
F	Format version
E	Event
H	Hypocenter
M	Magnitude
P	Phase reading
#	Comment
C	Station Coordinates
S	Stop event
L	Layer velocity
EOF	End of file

Unlike all other record types, which are distinguished by the flag in column 1, the **end-of-file record** ("EOF") uses columns 1-3; it has no other arguments. It should only be found once, at the end of the .comcat file.

An MNF v1.4 file (or "comcat" file) always starts with a **bulletin record** "B", and it will carry a descriptive comment if it was created by *mloc*. The **bulletin record** is always followed by a **format record** "F". If there is commentary describing the most important features of the earthquake cluster and its relocation, which is highly recommended, it will follow the **format record** "F" as a series of **comment records** "#". If a custom crustal velocity model has been used this section will be followed by a series of **layer velocity records** "L". Otherwise it should be assumed that the ak135 travel-time model was used for all phases. If any station coordinates have been taken from sources other than the NEIC metadata server or the ISC Station Registry, there will next be a series of **station coordinate records** "C". This constitutes the header block of a comcat file. This is followed by a set of event blocks. The comcat file is terminated by an **end of file record** "EOF".

Data for a single event is carried in a block of records that must start with an **event record** "E" and end with a **stop event record** "S". Within the block, data is carried in a combination of **hypocenter** "H", **magnitude** "M", and **phase reading** "P" records. Only one **hypocenter record** "H" is permitted. **Magnitude records** are optional and there is no limit to how many can be supplied.

Magnitudes

Magnitude estimates are carried in a **magnitude record**, one magnitude estimate per record. Multiple magnitude estimates can be carried. Magnitudes can be carried to two decimal places.

Optional Fields

All fields defined below will normally be present in a comcat file written by *mloc*. Under certain circumstances the following record types might be absent:

- Comment records, if no commentary text has been provided.
- Layer velocity records, if ak135 was used for all travel-time calculations.
- Magnitude records, if an event has no magnitude estimates.

Defined Record Types

Bulletin Record ("B" in column 1)

Column	Description
1:1	**Line format flag "B"**
5:121	**Bulletin description (a117)**

Format Version Record ("F" in column 1)

Column	Description
1:1	**Line format flag "F"**
5:9	**Format version (a5)**

Comment Record ("#" in column 1)

Column	Description
1:1	**Line format flag "#"**
2:121	**Comment, optional (a120)**

Layer Velocity Record ("L" in column 1)

Column	**Description**
1:1	**Line format flag "L"**
8:14	**Depth or layer thickness (f7.3)**
20:24	**Vp (f5.3)**
30:34	**Vs (f5.3)**

Note: *mloc* writes the crustal velocity model with two values for each layer, the depth of the upper and lower interface. Internal interface depths are therefore repeated, giving velocities above and below. This accommodates a model in which a layer can have a linear gradient in velocity. Alternatively, a flat-layered model could be defined by with one line per layer, in which the first parameter is interpreted as layer thickness. Depth/layer thickness is given in km. Velocities are given in km/s.

Station Coordinates Record ("C" in column 1)

Column	Description
1:1	**Line format flag "C"**
3:8	**Station (a6)**
10:14	**Agency (a5)**
16:23	**Deployment (a8)**
25:32	**Latitude (f8.4)**
34:42	**Longitude (f9.4)**
44:49	**Elevation (i6)**

Note: Station elevation is the elevation of the instrument, given in meters, relative to mean sea level (positive or negative).

Event Record ("E" in column 1)

Column	Description
1	**Line format flag "E"**
5:121	**Event ID (a116)**

Note: Event IDs are built up from the prefix "cec_" (Calibrated Earthquake Cluster), the cluster name, and the event number within the cluster.

Hypocenter Record ("H" in column 1)

Column	Description
1	**Line format flag "H"**
5-8	**Year (i4)**
10:11	**Month (i2)**
13:14	**Day (i2)**
16:17	**Hour (i2)**
19:20	**Minute (i2)**
22:26	**Seconds (f5.2)**
28:32	**OT uncertainty (f5.2)**
35:42	**Latitude (f8.4)**
44:52	**Longitude (f9.4)**
54:56	**S_{min} azimuth (i3)**
58:62	**Error ellipse S_{min}, (f5.2)**
64:68	**Error ellipse S_{maj} (f5.2)**
70:74	**Focal Depth (f5.1)**
76:76	**Depth code (a1)**
78:82	**Plus depth uncertainty (f5.1)**
84:88	**Minus depth uncertainty (f5.1)**
90:93	**GTCU (a4)**
95:102	**Author (a8)**
104:121	**Cluster ID (a18)**

Note: Both depth uncertainties are provided as positive numbers. "Plus" depth uncertainty is on the deeper side; "Minus" uncertainty is shallower, and therefore should not be greater than the focal depth in absolute value.

The "GTCU" field carries a four-character code relating to calibration status (I prefer this term to "ground truth" level). It could be the GTX formulation (e.g., Bondar et al., (2004)), but I have developed the GTCU nomenclature to provide much more detailed information on the subject of what hypocentral parameters are considered to be calibrated (i.e., thought to be bias-free). The GTCU nomenclature is documented fully elsewhere.

The “depth code” in column 76 defines the nature of the depth constraint. Standard values are:

Depth Code	Meaning
c	Cluster default depth
d	Teleseismic depth phases
e	Engineered (man-made explosion)
f	Fault model (InSAR, GPS, etc)
l	Local-distance readings
m	*mloc* solution with free depth
n	Near-source station readings
r	Relocation outside *mloc* with free depth
u	Unknown
w	Waveform analysis

Magnitude Record ("M" in column 1)

Column	Description
1	**Line format flag “M”**
5:8	**Magnitude (f4.2)**
10:14	**Magnitude scale (a5)**
16:110	**Author and comments (a95)**

Phase Reading Record ("P" in column 1)

Column	Description
1	**Line format flag “P”**
3	**Usage flag (a1)**
5:10	**Station code (a6)**
12:19	**Deployment code (a8)**
21:26	**Epicentral distance (f6.2)**
28:30	**Azimuth, event to station (i3)**
32:39	**Phase name (a8)**
41:44	**Arrival time year (i4)**
46:47	**Arrival time month (i2)**
49:50	**Arrival time day (i2)**
52:53	**Arrival time hour (i2)**
55:56	**Arrival time minute (i2)**
58:63	**Arrival time seconds (f6.3)**
65:66	**Reading precision (i2)**
68:73	**TT residual (f6.2)**
75:79	**Empirical reading error (f5.2)**

Note: The usage flag will be either “+”, meaning the reading was used for either the hypocentroid or cluster vectors or both, “-”, meaning the reading was not used in the relocation for some reason, or “x” meaning that the reading was flagged as an outlier and not used for relocation. It is important to note that the factors controlling how an individual phase reading was used (or not) in an *mloc* analysis are quite complex and there is no information in the v1.4 format concerning why a reading was not used, except for the special case when it has been identified as an outlier. Reference to other *mloc* input and output files is needed to answer that question.

The arrival time seconds field is written with the precision implied by the “reading precision” field.

Stop Event Record ("S" in column 1)

Column	Description
1:1	**Line format flag “S”**

Note: Only the “S” in column 1 is required, but for better readability it is useful to write “STOP” in columns 1:4.

End of File Record ("EOF" in columns 1-3)

Column	Description
1:3	**Line format flag “EOF”**