



National Centre for Atmospheric Science

NATURAL ENVIRONMENT RESEARCH COUNCIL

The National Centre for Atmospheric Science Image Metadata Standard (NCAS-IMAGE) version 1.0

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Abstract

This document specifies version 1.0 of the National Centre for Atmospheric Science Image Metadata Standard (NCAS-IMAGE). The standard relies on the capacity of digital image files to have metadata fields embedded within them. It has been designed to be analogous to the NCAS-GENERAL standard for netCDF data files, i.e. to ensure that all of the information required to interpret a data plot or a photograph is available within the file. The details covered by the standard include a description of what the image shows, the time and location for which it is applicable, who was responsible for creating it, when it was created, from where it is available, and the licence covering its use. This makes the image files compliant with FAIR data principles. Where possible, the NCAS-IMAGE standard has made use of metadata fields covered by existing standards, i.e. the Dublin Core Metadata Element Set (DCMES) and the International Press Telecommunications Council (IPTC) Photo Metadata Standard.

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1 Introduction

Digital image files have the capacity to have metadata fields embedded within them. This is exploited by digital cameras to record details such as the date and time of image capture and the various camera settings. This capacity is not restricted to photographs, but is shared by a wide range of image file types, including:

- Joint Photographic Experts Group (JPEG) File Interchange Format (JFIF), which will be referred to as JPEG image files in this document
- Portable Network Graphics (PNG)
- Graphics Interchange Format (GIF)
- Portable Document Format (PDF)

The [National Centre for Atmospheric Science \(NCAS\)](#) image metadata standard (NCAS-IMAGE) described in this document has been designed to make use this capacity. It is intended to be analogous to the [NCAS-GENERAL metadata standard](#) for netCDF data files, i.e. to ensure that all of the information required to interpret a data plot or a photo is available within the file. The details covered by the standard include:

- a description of what the image shows
- the time(s) and location for which it is applicable
- the provenance of the file, e.g. who was responsible for creating it, when it was created, and from where it is available
- permitted use of the image, i.e. details of the licence and of whom to credit for use of the image

This will also mean that NCAS's image files are compliant with [FAIR data principles](#), i.e. by ensuring they are:

- Findable
- Accessible
- Interoperable
- Reusable

The availability of harvestable metadata that conform to recognised standards will also be of use to long-term data repositories, such as the [Centre for Environmental Data Analysis \(CEDA\)](#), which curate the images. The metadata can be catalogued in order to aid discoverability.

All of the metadata fields covered by the NCAS-IMAGE standard are of the [Extensible Metadata Platform \(XMP\)](#) type.

The only freely-available software that can both embed and extract the metadata fields covered by the NCAS-IMAGE standard is [ExifTool](#). Consequently, some of the nomenclature used in this document is specific to [ExifTool](#).

[NCAS has made available a python-based handler for ExifTool](#), which allows metadata to be embedded from a template.

1.1 Scope of the standard

The NCAS-IMAGE standard is primarily intended to be used for image files that fulfil both of the following criteria:

- they belong to an NCAS dataset, e.g.:
 - photos taken by an automatic camera, which constitute primary data products
 - plots of data from an instrument or model, which typically constitute secondary data products
- they are intended to be made openly-accessible (typically using the [the UK Open Government Licence](#))

Use of the standard for in-scope material requires that all of the specified fields must be used as stated within this document. Additional fields may optionally be used, although they are outside of the scope of the standard.

The standard does not have to be used for:

- image files that are not intended to be made publicly-visible, e.g.
 - photos taken by members of NCAS staff using their own cameras
 - plots of data produced by members of NCAS staff as part of research/development projects or for monitoring purposes
- images that are made publicly-visible for illustrative rather than curation purposes, e.g. for use on the [NCAS website](#)

Nevertheless, since the use of embedded metadata fields provides a convenient way of adding value to any image file, adopting parts of the standard could still be useful for material that is out of scope.

Video files support only a small number of metadata fields and so the NCAS-IMAGE standard cannot be applied to them.

1.2 Limitations of embedded metadata fields

The main limitations of embedded metadata fields are cultural rather than technical:

- most people are unaware of their existence and so will not think to look for them. Where possible, it is useful to include text along the lines of *“Refer to embedded XMP metadata for more details”* somewhere on the image.
- many image viewing applications are only capable, at best, of showing a limited number of them
- even the image viewing applications that are capable of showing all of them do not do so by default. [Eye of GNOME](#) is recommended for Linux platforms. It can be used

within the the KDE environment as well as the GNOME one.

- different image viewing applications can use different names for the same field, which can be confusing. The names used in this document are specific to the [ExifTool](#) software.
- it is difficult to find examples of images that make use of metadata fields in a way that is relevant to the needs of the NCAS-IMAGE standard. Consequently, it has not been possible to find examples of good practice.

Nevertheless, there is a gradual move towards mainstream applications and web services making the existence of embedded metadata more visible. For example, since 2018, [Google image searches are able to show the contents of a limited number of embedded metadata fields](#).

1.3 Basis for the NCAS-IMAGE standard

The NCAS-IMAGE standard is modelled on the [NCAS-GENERAL standard](#). However, unlike netCDF data files, image files cannot have arbitrarily-named metadata fields embedded within them (at least not without access to proprietary software). Nevertheless, there are a large number of pre-defined fields available. The NCAS-IMAGE standard makes use of fields that are covered by existing standards, where the interpretation of the value is intended to be similar.

- the [Dublin Core Metadata Element Set \(DCMES\)](#). This comprises of 15 fields, which are intended to be of general use for a wide range of digital objects rather than just image files.
- the [International Press Telecommunications Council \(IPTC\) Photo Metadata Standard](#). This is much more extensive. Although it is only intended to be applied to photos, there is not technical reason preventing it from being applied to data plots.

1.4 Special nomenclature and concepts used in this document

[ExifTool](#) is the only freely-available software that can be used to embed the metadata fields covered by the NCAS-IMAGE standard. Consequently, some of its nomenclature has been adopted for this document.

Note that the following terms are local to this document rather than being in common usage: inherent metadata field, optional metadata field, short tag name, and full tag name.

All digital image files contain **inherent metadata fields**, e.g. for recording the image encoding system used and the size of the image in terms of number of pixels. Although the values of these fields can be extracted, they cannot be changed after the file has been created.

The NCAS-IMAGE standard relies on **optional metadata fields**. These may be embedded within the files at the time of file creation, as is typically the case for photos taken by digital cameras, or at any subsequent time. It is possible to remove optional metadata fields and to change their values.

Tag names are the handles used by [ExifTool](#) to access the **(tag) values** of metadata fields. Some of the **short tag names** given in the [ExifTool](#) documentation are ambiguous, since they can be associated with more than one **metadata group**. Consequently, this document makes use of **full tag names**, which are colon-delimited concatenations of the family 1 group name (which will be referred to as the **group name** in this document) and the short tag name.

In general, tag values may be of Boolean, floating point, integer, or string type. All of the metadata fields covered by the NCAS-IMAGE standard are of the [Extensible Metadata](#)

Platform (XMP) type, whose values are stored as character strings. These strings may include **Unicode characters**, which is useful since it permits the use of symbols such as for degrees (°). The NCAS-IMAGE standard mandates that only **UTF-8** encoding may be used under such circumstances.

Some of the tag values for fields covered by the NCAS-IMAGE standard are **controlled**. This means that they must conform to a specific format. In most cases, this is because the values are intended to be interpreted automatically by computer systems, e.g for fields containing:

- **date-time information**
- **Global Positioning System (GPS) coordinates**

Further details will be given in the relevant sections of this document. In some cases, the controlled nature of the value is specific to the NCAS-IMAGE standard. If the value of a field is not controlled, it is permissible to enter free text, which may be as short or as long as is necessary. The NCAS-IMAGE standard recommends that “\n” end-of-line characters be inserted into the text so that no line is more than 80 characters in length. This will aid readability for the end-users.

List tags are metadata fields that may contain multiple values. The order of these values is preserved when they are extracted from the file. It is permissible for them to contain only a single value.

Structured tags are metadata fields that are intended to contain multiple, closely-related elements as key/value pairs. This makes them analogous to dictionaries in the python programming language. In practice, **ExifTool** allows each element to be accessed using a **flattened tag name**, which makes it look like any other metadata field. However, the field names displayed by image viewing applications will probably look different. Moreover, some image viewing applications that are capable of displaying the values of a wide range of metadata fields will simply ignore structured tags.

2 Fields covered by the NCAS-IMAGE standard

In order to aid readability, the following fonts will be used to highlight:

- **tag names**
- **tag values**
- the names of global attributes used by the NCAS-GENERAL standard
- **internal and external hyperlinks**
- **computer code** (this is only used in section 3)

2.1 A full example of embedded metadata

Before looking into the detail of each metadata field covered by the NCAS-IMAGE standard, it is useful to consider the fields as an ensemble.

- There are a few differences to the way in which the NCAS-IMAGE standard is applied to a photo and to a data plot. The example below is for a data plot.
- The tag names are sufficiently descriptive that, in most cases, their intended interpretation will be clear to someone who is not familiar with embedded metadata fields
- Line breaks have been added to the values of **XMP-photoshop:Headline**, **XMP-iptcExt:LocationShownLocationName**, and **XMP-dc:Relation** for the purposes of this document. Otherwise the tag values are show exactly as they occur within files.
- Embedded metadata fields do not have an inherent order. In the examples below, they have been arranged in the order in which their details are subsequently examined.

XMP-photoshop:Instructions:

Metadata follow the National Centre for Atmospheric Science Image Metadata Standard v1.0: <https://doi.org/10.5281/zenodo.6368295>

XMP-photoshop:Headline:

Wind data from st300 mode observations made by the MST Radar at the NCAS Capel Dewi Atmospheric Observatory

XMP-dc:Description:

This plot shows wind data from st300 mode observations made by the Mesosphere-Stratosphere-Troposphere (MST) Radar (52.424500°N, -4.005467°E) at the National Centre for Atmospheric Science (NCAS) Capel Dewi Atmospheric Observatory (CDAO). The CDAO is located near Aberystwyth in west Wales (UK) and was previously known as the Natural Environment Research Council (NERC) Mesosphere-Stratosphere-Troposphere (MST) Radar Facility.

The plot is derived from a daily v3.2 Cartesian data file. The horizontal wind components have been averaged over a nominal period of 33.0 minutes in order to improve their representativeness. These values have been used to derive the horizontal wind speed, magnitude of vertical shear of horizontal wind vector, and beam-broadening-corrected vertical beam spectral width. All other values represent unaveraged data. Vertical beam secondary signals are only shown to belong to a radial chain where the same condition exists for adjacent cycles. This improves the clarity of the plot. The underlying data files are openly-accessible through the Centre for Environmental Data Analysis (CEDA). Further details are available through the Atmospheric Measurement and Observation Facility (AMOF) website: <https://amof.ac.uk/observatory/capel-dewi-atmospheric-observatory-cdao/>

XMP-iptcExt:LocationShownLocationName:

Capel Dewi Atmospheric Observatory, Capel Dewi, Aberystwyth, Ceredigion, UK

XMP-iptcExt:LocationShownGPSAltitude:

48 m

XMP-iptcExt:LocationShownGPSLatitude:

+52.424500

XMP-iptcExt:LocationShownGPSLongitude:

-4.005467

XMP-xmp:CreateDate:

2022:04:28 06:37:14

XMP-xmp:MetadataDate:

2022:04:28 06:37:16

XMP-iptcExt:TemporalCoverageFrom:

2022:04:27 00:01:22

XMP-iptcExt:TemporalCoverageTo:

2022:04:27 23:59:51

XMP-dc:Rights:

Use of this image is covered by the (UK) Open Government Licence, <http://www.nationalarchives.gov.uk/doc/open-government-licence/>

XMP-xmpRights:WebStatement:

<http://www.nationalarchives.gov.uk/doc/open-government-licence/>

XMP-photoshop:Credit:

National Centre for Atmospheric Science (NCAS)

XMP-dc:Title:

nerc-mstrf-radar-mst_capel-dewi_20220427_st300_wind.png

XMP-dc:Relation:

IsBasedOn

<https://catalogue.ceda.ac.uk/uuid/6d9a74e917d04cde9f0f7fa5fb3a9dd4>

XMP-dc:Creator:

Hooper, David A.

XMP-iptcCore:CreatorWorkEmail:

david.hooper@ncas.ac.uk

XMP-iptcExt:CreatorIdentifier:

<https://orcid.org/0000-0003-0956-6732>

XMP-iptcExt:ContributorName

Hooper, David A.

XMP-iptcExt:ContributorIdentifier

<https://orcid.org/0000-0003-0956-6732>

XMP-iptcExt:ContributorRole

Project Principal Investigator

2.2 Version of the standard being followed

XMP-photoshop:Instructions

- This field is used to indicate the version of the NCAS-IMAGE metadata standard being followed.
- It serves a similar purpose to the `Conventions` global attribute in the [NCAS-GENERAL standard](#).
- It is covered by the [IPTC \(Core\) standard](#).
- The value is `controlled` within the NCAS-IMAGE standard and should be given exactly as shown below (although the position of the line break is arbitrary).
- Example value:
 - *Metadata follow the National Centre for Atmospheric Science Image Metadata Standard v1.0: <https://doi.org/10.5281/zenodo.6368295>*

2.3 Description of what is shown in the image

XMP-photoshop:Headline

- This field should be used to record a brief (i.e. no more than one sentence) description of what the image shows.
- It does not need to spell out the meaning of any abbreviations.
- It does not need to include a line break if it is greater than 80 characters in length.
- It is approximately the equivalent of the `title` global attribute in the [NCAS-GENERAL standard](#).
- It is covered by the [IPTC \(Core\) Standard](#)
- Example values:
 - *Photo taken by the Sky-Camera at the NCAS Capel Dewi Atmospheric Observatory*
 - *Data from the Campbell Scientific surface met sensors at the NCAS Capel Dewi Atmospheric Observatory*
 - *Turbulence data from st300 mode observations made by the MST Radar at the NCAS Capel Dewi Atmospheric Observatory*

XMP-dc:Description

- This field should be used to record a more-detailed description of what the image shows.
- It may contain the same value as **XMP-photoshop:Headline**, if such a low level of detail suffices.
- If a large volume of detail (i.e. more than about half a page's worth of text) is required for someone to fully understand/interpret what is being shown in an image, this information should be put into a document, which is referenced from this field. The document should be openly-accessible through a long term repository. [Zenodo](#) is recommended for this purpose. It will provide a [Digital Object Identifier \(DOI\)](#) for each submission. An article published in an academic journal may alternatively be used, as long as it is openly-accessible. However, a regular web page should not be used, since the address cannot be relied upon to remain valid over the longer term.
- In the case of a **data plot**, the image is a secondary data product. If the underlying data files contain comprehensive metadata, the level of detail appropriate for this field is probably not so high. Nevertheless, the types of information that might be important include:
 - any processing applied to the data in order to create the plot
 - which version of a dataset was used, if more than one is available
- In the case of a **photograph**, the image is the primary data product and so a higher level of detail will probably be appropriate. The types of information that might be important include:
 - the pointing direction of the camera, in terms of both the azimuth and elevation angles
 - the angular size of the field of view
 - details of the observation strategy (which could be as simple as taking a photo at regular intervals)

- Example values:
 - For a photo taken by a static camera.

This photograph was taken by the sky-camera (52.424419°N, -4.004343°E) at the National Centre for Atmospheric Science (NCAS) Capel Dewi Atmospheric Observatory (CDAO). The CDAO is located near Aberystwyth in west Wales (UK) and was previously known as the Natural Environment Research Council (NERC) Mesosphere-Stratosphere-Troposphere (MST) Radar Facility. Photographs are taken at 60 s intervals on a continuous basis in order to capture general atmospheric conditions. The camera is mounted approximately 3 m above ground level on the north side of the CDAO bungalow. It is directed towards an azimuth angle of approximately 280° and an elevation angle of approximately 23°. The angular field of view is approximately 57° by 38°. The size is not known exactly since the camera has a zoom lens, which has been adjusted in order to optimise the view of the sky. It should be possible to determine both the pointing direction and the size of the field of view more accurately by analysing the locations of bright stars and planets as they pass through the images. The star Arcturus can often be seen in the images during the nights just after mid summer. The camera is an Axis M1113 webcam. It automatically adjusts its settings to cope with the amount of light available. No details of these settings are available. The photos are openly-accessible through the Centre for Environmental Data Analysis (CEDA). Further details are available through the Atmospheric Measurement and Observation Facility (AMOF) website: <https://amof.ac.uk/observatory/capel-dewi-atmospheric-observatory-cdao/>
 - For a plot of surface met data.

This plot shows data from the Campbell Scientific surface meteorological sensors (52.425068°N, -4.004717°E) at the National Centre for Atmospheric Science (NCAS) Capel Dewi Atmospheric Observatory (CDAO). The CDAO is located near Aberystwyth in west Wales (UK) and was previously known as the Natural Environment Research Council (NERC) Mesosphere-Stratosphere-Troposphere (MST) Radar Facility. The values of air temperature and relative humidity shown in this plot represent means over 10 minute intervals. The rainfall and downwelling shortwave radiation are shown as rates and fluxes, respectively, although the underlying measurements represent accumulations over the 10 minute intervals. The underlying data files are openly-accessible through the Centre for Environmental Data Analysis (CEDA). Further details are available through the Atmospheric Measurement and Observation Facility (AMOF) website: <https://amof.ac.uk/observatory/capel-dewi-atmospheric-observatory-cdao/>
 - For a plot of MST radar data.

This plot shows wind data from st300 mode observations made by the Mesosphere-Stratosphere-Troposphere (MST) Radar (52.424500°N, -4.005467°E) at the National Centre for Atmospheric Science (NCAS) Capel Dewi Atmospheric Observatory (CDAO). The CDAO is located near Aberystwyth in west Wales (UK) and was previously known as the Natural Environment Research Council (NERC) Mesosphere-Stratosphere-Troposphere (MST) Radar Facility. This plot is one of 3 (showing wind, turbulence, and diagnostic data products) derived from a daily v3.2 Cartesian data file. The horizontal wind components have been averaged over a nominal period of 33.0 minutes in order to improve their representativeness. These values have been used to derive the horizontal wind speed, magnitude of vertical shear of horizontal wind vector, and beam-broadening-corrected vertical beam spectral width. All other values represent unaveraged data. Vertical beam secondary signals are only shown to belong to a radial chain where the same

*condition exists for adjacent cycles. This improves the clarity of the plot. The underlying data files are openly-accessible through the Centre for Environmental Data Analysis (CEDA). Further details are available through the Atmospheric Measurement and Observation Facility (AMOF) website:
<https://amof.ac.uk/observatory/capel-dewi-atmospheric-observatory-cdao/>*

2.4 Location of a camera or an instrument

- Each image file should contain a single **LocationDetails** structured tag:
 - for field **XMP-iptcExt:LocationCreated**, in the case of a photo, to represent the location of a camera
 - for field **XMP-iptcExt:LocationShown**, in the case of a data plot, to represent the location of an instrument or model grid point
- The value of each element of a **LocationDetails** structured tag is controlled within the NCAS-IMAGE standard.
- Latitudes, longitudes, and altitudes should be given relative to **World Geodetic System 1984 (WGS84)**, which is the standard used for Global Positioning System (GPS) measurements. Note that the **coordinate system used for Ordnance Survey data products is somewhat different to that used for WGS84**. The altitudes can differ by several tens of metres. Consequently, Ordnance Survey data products should not be used to determine these values.
- Only one of the elements of the **LocationDetails** structured tag (**LocationName**) is covered by the **IPTC (Extension) standard**. None is covered by the Dublin Core Metadata Element Set.

XMP-iptcExt:LocationCreatedLocationName for a **photo**, or

XMP-iptcExt:LocationShownLocationName for a **data plot**

- This field is used to record the location of the camera/instrument in a style that is somewhat similar to a postal address.
- It is the equivalent of the `location_keywords` global attribute in the **NCAS-GENERAL standard**.
- The value is **controlled** within the NCAS-IMAGE standard. However, given that subsequent fields specify the location more precisely, some flexibility is permissible. It should contain some or all of the following elements in the order shown. Each element should be separated by a comma and a single blank space.
 - site name
 - nearest town/city
 - county/province/state
 - country
- Example values:
 - *Capel Dewi Atmospheric Observatory, Capel Dewi, Aberystwyth, Ceredigion, UK*
 - *Chilbolton Atmospheric Observatory, Chilbolton, Hampshire, UK*

XMP-iptcExt:LocationCreatedGPSAltitude for a **photo**, or

XMP-iptcExt:LocationShownGPSAltitude for a **data plot**

- This field is used to record the altitude (in metres) of the **ground level** where the camera/instrument is located with respect to the **World Geodetic System 1984 (WGS84)** coordinate system.
- It is the equivalent of the `platform_altitude` global attribute in the **NCAS-GENERAL standard**.
- If the altitude of the camera/instrument above ground level is significant, this information should be recorded in the **XMP-dc:Description** field. However, it should not be included in this field.
- The value is **controlled** within the NCAS-IMAGE standard in that it should be supplied in units of metres as an integer value. Note that this level of precision will exceed **the accuracy of GPS measurements from a smartphone**, which will be of the order to

several metres.

- The values of these fields are stored within files in a “rational” format, i.e. as two integers (separated by a “/” character) whose ratio represents the supplied value. For example, a supplied value of 50 will be stored as 50/1. Some image viewing applications will display the value in the rational format. ExifTool will display the value as 50 m, i.e. as an integer and including the symbol for metres.
- Example value:
 - 50

Values of latitude and longitude:

- may be supplied to ExifTool in a variety of formats (example values are shown in the table below), which include:
 - just decimal degrees (D)
 - integer degrees and decimal minutes (DM)
 - integer degrees and minutes, and decimal seconds (DMS)
- may be either
 - “signed” (indicated by a leading “+” sign in the format indicator), in which case positive/negative values are used to indicate latitudes to the north/south of the equator and longitudes to the east/west of the primary meridian
 - “unsigned”, in which case the letters N/S are used to indicate latitudes to the north/south of the equator and the letters E/W to indicate longitudes to the east/west of the primary meridian. These letters should be offset from the numerical part of the value by one space.
- should be supplied using the number of decimal places shown in the table below. These levels of precision are consistent with the standard of supplying values in DM format with 4 decimal places. They will exceed the accuracy of GPS measurements from a smartphone.
- should be supplied with **caution when making use of negative values in the “signed” +DM and +DMS formats**. Each element of the value, not just the first (degrees) one, must include a “-” sign. Otherwise, subsequent elements will be interpreted as positive perturbations from the negative degrees value, e.g. -4 0 19.68 will be interpreted as 3 59 40.32 W.
- will be converted into a preferred format by software that is capable of extracting and displaying them. This is commonly a variation on DM. ExifTool’s default format is a variation on DMS so that the example values of latitude and longitude will be given as 52 deg 25’ 28.20” N and 4 deg 0’ 19.68” W, respectively. The final column in the table below gives appropriate extraction formats to supply to ExifTool using the “-c” option.

Format Indicator	Decimal Places	Latitude example	Longitude example	Extraction format
+D	6	52.424500	-4.005467	%+.6f
D	6	52.424500 N	4.005467 W	%.6f
+DM	4	52 25.4700	-4 -0.3280	%+d %+.4f
DM	4	52 25.4700 N	4 0.3280 W	%d %.4f
+DMS	2	52 25 28.20	-4 0 -19.68	%+d %+d %+.2f
DMS	2	52 25 28.20 N	4 0 19.68 W	%+d %+d %+.2f

XMP-iptcExt:LocationCreatedGPSLatitude for a **photo**, or

XMP-iptcExt:LocationShownGPSLatitude for a **data plot**

- This field is used to record the GPS latitude of the camera/instrument/model grid location with respect to the **World Geodetic System 1984 (WGS84)** coordinate system.
- Its closest equivalent in the **NCAS-GENERAL standard** is the global attribute the **geospatial_bounds**, which records both latitude and longitude.
- Its value is controlled in that it must represent a valid latitude and be supplied to ExifTool using one of the permissible formats shown in the table above.
- Example values:
 - 52.424500

- 52 25.4700 N
- 52 25 28.20 N

XMP-iptcExt:LocationCreatedGPSLongitude for a **photo**, or

XMP-iptcExt:LocationShownGPSLongitude for a **data plot**

- This field is used to record the GPS longitude of the camera/instrument/model grid location with respect to the [World Geodetic System 1984 \(WGS84\)](#) coordinate system.
- Its closest equivalent in the [NCAS-GENERAL standard](#) is the global attribute the `geospatial_bounds`, which records both latitude and longitude.
- Its value is controlled in that it must represent a valid longitude and be supplied to [ExifTool](#) in one of the permissible formats shown in the table above.
- Example values:
 - -4.005467
 - 4 0.3280 W
 - 4 0 19.68 W

2.5 Date-time details

In general, metadata fields that are intended to contain date-time information will accept a subset of [ISO 8601 formats](#) in order to represent different levels of granularity. However, only the following two formats may be used within the NCAS-IMAGE standard. The second one should only be used if sub-second accuracy is significant, e.g. if photos are being captured at a rate of more than one per second.

- YYYY:MM:DD hh:mm:ss
- YYYY:MM:DD hh:mm:ss.s

where:

- **YYYY** is a 4 digit representation of the year
- **MM** is a 2 digit representation of the month (01 represents January and 12 represents December)
- **DD** is a 2 digit representation of the day of the month (01 - 31)
- **hh** is a 2 digit representation of the hour (00 - 23)
- **mm** is a 2 digit representation of the minute (00 - 59)
- **ss** is a 2 digit representation of the seconds (00 - 59)
- **s** is one or more digits representing a decimal fraction of a second. The number of digits should be chosen to match the level of precision required.

Note that:

- within the NCAS-IMAGE standard, date-time values are assumed to represent Coordinated Universal Time (UTC), although a trailing character **Z** is not included to indicate this.
- [ExifTool](#) will accept a wide variety of characters as delimiters between the elements of a date-time value, not just **:**. For example, the characters **-** or **/** may be used to separate the date elements and the character **T** may be used to separate the date and the time elements. However, by default, [ExifTool](#) will extract the values using only **:** as a delimiter (and a single space between the date elements and the time elements).
- **there are some differences to the way in which the fields covered by this section are used for photos and for data plots.**

XMP-xmp:CreateDate

- This field should be used to record the UTC date-time at which the image was originally created.
- **in the case of a photo**
 - this implies the date-time at which the image was originally captured rather than the date-time at which a particular instance of the photo is created.
 - If the duration of the image capture lasts for more than 1 s, this field may be used to represent either the start or the end date-time of the image capture. The appropriate interpretation should be recorded in the [XMP-dc:Description](#) field.

- **in the case of a data plot**
 - this implies the date-time at which the plot was created
- It is the equivalent of the `last_revised_date` global attribute in the [NCAS-GENERAL standard](#).
- Although this field is not covered by either the Dublin Core Metadata Element Set or the IPTC standard, it is one that is commonly checked by image viewing applications for the image capture date-time of a photo. Some will do this only the case of a JPEG image, but others will also do so for a PNG image.
- Example value:
 - `2022:04:08 09:15:27`

XMP-xmp:MetadataDate

- This field should be used to record the UTC date-time at which the NCAS-IMAGE metadata were embedded within the file
- If the metadata are embedded shortly after a photo was taken or a plot was created (i.e. within approximately one minute), it is acceptable to use the same value given by **XMP-xmp:CreateDate**.
- Example value:
 - `2022:04:08 09:15:27`

The following two fields

- **should only be used for a data plot**
- are elements of the **XMP-iptcExt:TemporalCoverage** structured tag

XMP-iptcExt:TemporalCoverageFrom

- This field should be used to record the UTC date-time of the first data shown in the **plot**
- It is the equivalent of the `time_coverage_start` global attribute in the [NCAS-GENERAL standard](#).
- Example value:
 - `2022:04:08 09:15:27`

XMP-iptcExt:TemporalCoverageTo

- This field should be used to record the UTC date-time of the final data shown in the **plot**.
- It is the equivalent of the `time_coverage_end` global attribute in the [NCAS-GENERAL standard](#).
- If the plot shows data for only a single time, the value of this field should be the same as that for **XMP-iptcExt:TemporalCoverageFrom**.
- Example value:
 - `2022:04:08 09:15:27`

2.6 Licensing and acknowledgement details

By default, images that fall within [the scope NCAS-IMAGE standard](#) are expected to be covered by the [\(UK\) Open Government Licence](#):

- This allows the images to be used by anyone and for any purpose, including a commercial one, as long as the source of the image is appropriately acknowledged.
- It is functionally similar to the more-widely-used [Creative Commons Attribution License \(CC BY\)](#)

In exceptional circumstances, it might be permissible to apply one of the more restrictive [Creative Commons licenses](#) to an image. However, there would need to be a very good reason for doing so.

XMP-dc:Rights

- This field should be used to record a human-readable statement of the licence that covers use of the image
- It is the equivalent of the `licence` global attribute in the [NCAS-GENERAL standard](#).
- It is covered by the [Dublin Core Metadata Element Set](#) and the [IPTC \(Core\) standard](#)
- The value of this field is **controlled** within the NCAS-IMAGE standard and must be given exactly as shown below (although the location of the line break is arbitrary).
- Example value:
 - *Use of this image is covered by the (UK) Open Government Licence,
<http://www.nationalarchives.gov.uk/doc/open-government-licence/>*

XMP-xmpRights:WebStatement

- This field is used to record the Uniform Resource Locator (URL), i.e. web address, for the licence covering use of the image.
- It is intended to be machine-interpretable, which is why it is included within the NCAS-IMAGE standard alongside the human-readable **XMP-dc:Rights** field, despite the fact that they essentially contain the same information.
- It is covered by the [IPTC \(Extension\) standard](#). Its value can also be revealed by a [Google Image search](#).
- The value of this field is **controlled** within the NCAS-IMAGE standard and must be given exactly as shown below.
- Example value:
 - *<http://www.nationalarchives.gov.uk/doc/open-government-licence/>*

XMP-photoshop:Credit

- This field is used to indicate that NCAS should be acknowledged wherever the image is used
- It is covered by the [IPTC \(Core\) standard](#). Its contents can also be revealed by a [Google Image search](#).
- It is the equivalent of the `acknowledgement` global attribute in the [NCAS-GENERAL standard](#).
- The value of this field is **controlled** within the NCAS-IMAGE standard and must be given exactly as shown below.
- Example value:
 - *National Centre for Atmospheric Science (NCAS)*

2.7 Source of the image

The two fields covered by this sub-section will allow end-users to trace an image back to its source.

XMP-dc:Title

- This field is used to give the official NCAS file name of the image, which provides a unique way to reference it within the context of NCAS datasets.
- It is covered by the [Dublin Core Metadata Element Set](#) and the [IPTC \(Core\) standard](#).
- Note that this field is not the equivalent of the `title` global attribute in the [NCAS-GENERAL standard](#), which is similar to the **XMP-photoshop:Headline** field.
- The value of this field is **controlled** within the NCAS-IMAGE standard
- Example values (note that the 2nd one does not make use of the latest NCAS file naming convention):
 - *[ncas-cam-4_capel-dewi_20210623215001.jpg](#)*
 - *[nerc-mstrf-radar-mst_capel-dewi_20220206_st300_wind.png](#)*

XMP-dc:Relation

- This field should be used to provide both the URL of the most relevant [Centre for Environmental Data Analysis \(CEDA\)](#) catalogue page for the image and the relation of the image to it.
- It may be omitted if no relevant CEDA catalogue page is available.

- It is covered by the [Dublin Core Metadata Element Set](#)
- The value of this field is [controlled](#) within the NCAS-IMAGE standard and should follow the format:
`<relation-type> <url-of-most-relevant-ceda-catalogue-page>`
- The most relevant CEDA catalogue page will be the first of the following that is available:
 - dataset - [follow this link for an example of a dataset page](#)
 - dataset collection - [follow this link for an example of a dataset collection page](#)
 - project - [follow this link for an example of a project page](#)
- The value of the `<relation-type>` element is [controlled](#) and must be one of the following, which are examples of [Dublin Core relation types](#):
 - `isPartOf` if the image belongs to the dataset. This will typically be the case for a photo.
 - `isBasedOn` if the image is derived from a dataset but does not belong to it. This will typically be the case for a data plot.
 - `isFormatOf` should only be used in the case of a version of an image that has been derived from an original, e.g. if a scaled-down version of a photo is released in addition to the full-sized original.
- This field is a [list tag](#) and so may contain multiple values. This is useful in the case of plots of data that are technically from separate, albeit connected, datasets. The order in which the values are given is arbitrary under such circumstances.
- Example values (note that line breaks have been included for the purposes of this document, in order to prevent the values for over-running the page width, but are not required otherwise):
 - For a photo:
`isPartOf`
<https://catalogue.ceda.ac.uk/uuid/5a18810018d9be419a0c37bd276d04fe>
 - For a data plot:
`IsBasedOn`
<https://catalogue.ceda.ac.uk/uuid/86d964d18ac242a58e13bb8d1c849b48>

2.8 Instrument Scientist's Details

The values of all three fields covered by this section should relate to the same person.

- That person should be the one who is most appropriate to contact for further details about the image or the underlying camera/instrument. Although this will typically be the NCAS instrument scientist, in principle it could be someone else.
- Note that these three fields are not explicitly related to each other outside of the NCAS-IMAGE standard. Nevertheless, the connection should be fairly obvious to a human reader.

XMP-dc:Creator

- This field should be used to record the name of the primary person responsible for the image
- It is the equivalent of the `creator_name` global attribute in the [NCAS-GENERAL standard](#).
- It is covered by the [Dublin Core Metadata Element Set](#) and the [IPTC \(Core\) standard](#) and its value can be displayed by a [Google Image search](#).
- Since this is a [list tag](#), it is technically possible to add the names of additional people who have played some role in the creation of the image or have some level of responsibility for the underlying camera/instrument. However, the other two fields covered by this section are only capable of storing the details for one person, which should be the first one covered by this field.
- The value of this field is [controlled](#) within the NCAS-IMAGE standard and must be given in one of the following formats:
 - `<last name>, <first name>`
 - `<last name>, <first name> <middle initials(s)>`
 - `<last name>, <first name> <middle name(s)>`

- If middle initials are used, each one should be followed by a “.”
- Irrespective of which name format is used, each element should be separated from the next one by a single space
- Example values:
 - *Hooper, David*
 - *Brooks, Barbara J.*
 - *Garland, Wendy Elizabeth*

XMP-iptcCore:CreatorWorkEmail

- This field should be used to record the NCAS e-mail address of the primary person responsible for the image.
- It is the equivalent of the `creator_email` global attribute in the [NCAS-GENERAL standard](#).
- It is covered by the [IPTC \(Core\) standard](#)
- It is a single element of a [ContactInfo structured tag](#) for field **XMP-iptcCore:CreatorContactInfo**.
- The value is [controlled](#) within the NCAS-IMAGE standard and should contain a valid NCAS e-mail address.
- Example values:
 - *david.hooper@ncas.ac.uk*
 - *barbara.brooks@ncas.ac.uk*
 - *wendy.garland@ncas.ac.uk*

XMP-iptcExt:CreatorIdentifier

- This field should be used to record the [ORCID iD](#) of the primary person responsible for the image
- It is the equivalent of the `creator_url` global attribute in the [NCAS-GENERAL standard](#).
- This is a single element of an [EntityWithRole structured tag](#) for field **XMP-iptcExt:Creator**.
- The value is [controlled](#) within the NCAS-IMAGE standard and should contain a valid [ORCID iD](#).
- Example values:
 - *<https://orcid.org/0000-0003-0956-6732>*
 - *<https://orcid.org/0000-0001-8932-9256>*
 - *<https://orcid.org/0000-0001-8108-8267>*

2.9 Principal Investigator's Details

The following 3 fields:

- should be used to record details of the Principal Investigator for the project that is responsible for operating the camera/instrument from which the image is derived
- are all elements of the [EntityWithRole structured tag](#) for field **XMP-iptcExt:Contributor**

XMP-iptcExt:ContributorName

- This field should be used to record the name of the Principal Investigator
- It is the equivalent of the `project_principal_investigator` global attribute in the [NCAS-GENERAL standard](#).
- The value of this field is [controlled](#) within the NCAS-IMAGE standard and must be given in one of the following formats, i.e. following the same rules as for [XMP-dc:Creator](#):
 - *<last name>, <first name>*
 - *<last name>, <first name> <middle initials(s)>*
 - *<last name>, <first name> <middle name(s)>*
- Example values:
 - *Hooper, David*
 - *Brooks, Barbara J.*
 - *Garland, Wendy Elizabeth*

XMP-iptcExt:ContributorIdentifier

- This field should be used to record the [ORCID iD](#) of the Principal Investigator
- It is the equivalent of the `project_principal_investigator_url` global attribute in the [NCAS-GENERAL standard](#).
- The value is [controlled](#) within the NCAS-IMAGE standard and should contain a valid [ORCID iD](#)
- Example values:
 - <https://orcid.org/0000-0003-0956-6732>
 - <https://orcid.org/0000-0001-8932-9256>
 - <https://orcid.org/0000-0001-8108-8267>

XMP-iptcExt:ContributorRole

- This field should be used to record the fact that the role of the “Contributor” is that of the Principal Investigator for the project responsible for photo/data collection
- The value of this field is [controlled](#) within the NCAS-IMAGE standard and should be given exactly as shown below.
- Example value:
 - *Project Principal Investigator*

3 An introduction to ExifTool

It is beyond the scope of this document to examine the capabilities of different software applications for interacting with embedded metadata. Nevertheless, since [ExifTool](#) is the only freely-available software capable of embedding the metadata fields covered by the NCAS-IMAGE standard, it merits special consideration. The following sub-sections give some basic usage details. Note that there is [a python-based ExifTool handler](#), which makes these tasks more straight forward.

Where the software is installed on a Linux/Unix system, the following commands will provide access to comprehensive documentation for [ExifTool](#) and for tag names, respectively:

```
man exiftool
man Image::ExifTool::TagNames
```

Since these man pages are rather long, the following commands (which are a subset of those available) can be used to navigate them. Most of the commands consist of a single key press, which is indicated by being enclosed between angled brackets, `<>`. Note that they are case sensitive.

Action	Command
Show full list of commands	<code><h></code>
Go forwards by 1 line	<code><Return></code> <code><↓></code>
Go backwards by 1 line	<code><↑></code>
Go forwards by 1 page	<code><Space></code> <code><Page Down></code>
Go backwards by 1 page	<code></code> <code><Page Up></code>
Search forwards for first instance of “pattern”	<code></>pattern<Return></code>
Search backwards for first instance of “pattern”	<code><?>pattern<Return></code>
Search forwards for next instance of last-used search “pattern”	<code><n></code>
Search backwards for next instance of last-used search “pattern”	<code><N></code>
Return to the first line of the man page	<code><g></code>

In each of the following subsections, `<image-file-path>` represents the path of an image file.

3.1 Displaying metadata

The following command will display the metadata embedded within an image file using the [full tag names](#) followed in this document:

```
exiftool -G1 -args -c %+.6f <image-file-path>
```

- if the `-G1` option is omitted, the [\(family 1\) group names](#) will not be shown and [short tag names](#) will be shown instead of [full tag names](#).
- if the `-args` option is omitted, tag descriptions will be shown instead of tag names
- if the `c %+.6f` option is omitted, [GPS latitudes and longitudes will be shown in ExifTool's preferred format](#) rather than as decimal degrees.

Not all of the fields displayed represent [optional metadata fields](#):

- **ExifTool:ExifToolVersion** records the version of [ExifTool](#) being used
- tags with [group name System](#) are derived from the operating system
- tags with [group names File](#) and **JFIF** (in the case of a JPEG image) or **PNG** (in the case of a PNG image) represent [inherent metadata fields](#):
- tags with group name **Composite** are derived by [ExifTool](#) from information already available in [inherent and optional metadata fields](#). They do not contain any additional information and are only provided for convenience. The number of such fields depends on how much information is contained within the other metadata fields.
- There is no inherent order to the metadata fields. [ExifTool](#) tends to show them in alphabetical order within a family 1 group, although the order of the groups is not alphabetical.

There are two oddities in the way that [ExifTool](#) displays tag values. These issues do not affect the values when they are [extracted](#) rather than being displayed and they do not affect the way in which the [python-based ExifTool handler](#) displays metadata fields.

- in the case of values that contain instances of `\n` to indicate line breaks, the lines are displayed concatenated using a full stop as a delimiter between each one. It is not necessarily possible to differentiate between a full stop that happens to be included in a tag value from one that is intended to represent a line break. This behaviour cannot be changed.
- in the case of a [list tag](#) that contains more than one value, the individual values are displayed concatenated using a comma followed by a single white space as a delimiter between each one. It is not necessarily possible to distinguish between a comma that happens to be included in a tag value from one that is intended to represent a list tag separator. It is possible to change the separator using the `-sep` option.

3.2 Extracting metadata

The following [ExifTool](#) command can be used to extract metadata in a format that is suitable to be handled by a computer programme:

```
exiftool -G1 -j -c %+.6f <image-file-path>
```

- The `-j` option forces [ExifTool's](#) output to be in [JavaScript Object Notation \(JSON\)](#) format. This requires that tag names rather than tag descriptions be used and so it is not necessary to include the `-args` option, which was recommended for [displaying metadata](#).
- all other arguments perform the same functions described for the case of [displaying metadata](#)

Suitable code will need to be written to handle the output from this command.

3.3 Embedding metadata

One call to [ExifTool](#) can be used to embed as many metadata fields within an image file as are required. The general syntax is as follows:

```
exiftool -overwrite_original \
  -<tag-name-1>=<tag-value-1> \
  -<tag-name-2>=<tag-value-2> \
  . . .
  -<tag-name-n>=<tag-value-n> \
  <image-file-path>
```

where:

- [<tag-name-*>](#) represents a tag name. In principle [short tag names](#) may be used, although it is safer to use [full tag names](#).
- [<tag-value-*>](#) represents the corresponding tag value
- the `-overwrite_original` option prevents [ExifTool](#) from creating a new file, which contains the required metadata, in addition to the original one (whose name is altered by having `_original` appended to it).

The following is a trivial example using metadata fields relevant to the NCAS-IMAGE standard, which will be referred to below:

```
exiftool -overwrite_original \
  -XMP-photoshop:Headline="This is a trivial example" \
  -XMP-dc:Creator="Hooper, David A." \
  -XMP-dc:Creator="Brooks, Barbara J." \
  <image-file-path>
```

Here are some points to note:

- all tag values must be supplied in string format. This means that a value must be enclosed within inverted commas if it contains any white spaces (see examples above)
- if it is necessary to embed multiple values within a [list tag](#), such as the example of **XMP-dc:Creator** above, multiple instances of the tag name should be supplied, but paired with a separate value each time. If this approach is used for a metadata field that is not a [list tag](#), [ExifTool](#) will not produce an error message but will simply embed the final supplied value within the file.
- if a supplied tag name relates to a metadata field that already exists within the file, the value will be overwritten with the new one. This also true in the case of a [list tag](#). The supplied value(s) will overwrite the existing one(s) rather than being appended.
- if [ExifTool](#) is supplied with an invalid tag name, a warning message will be given, but all valid fields supplied in the same call to [ExifTool](#) will be embedded.
- in addition to the supplied metadata fields an [optional metadata field](#) **XMP-x:XMPToolkit** will automatically be embedded within the file to indicate which version of [ExifTool](#) was used.