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OGC Network Common Data Form **(NetCDF)
Core Encoding Standard version 1.0**

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1. Preface

This document specifies the core of the OGC netCDF encoding standard.

Suggested additions, changes, and comments on this draft report are welcome and encouraged. Such suggestions may be submitted by email message or by making suggested changes in an edited copy of this document.

1. Terms and definitions

This document uses the specification terms defined in Subclause 5.3 of [OGC 06-121r8], which is based on the ISO/IEC Directives, Part 2, Rules for the structure and drafting of International Standards. In particular, the word “shall” (not “must”) is the verb form used to indicate a requirement to be strictly followed to conform to this standard.

1. Submitting organizations

The following organizations submitted this Candidate Implementation Specification to the Open Geospatial Consortium Inc.

* IMAA-CNR Italy
* METEO-FRANCE
* Natural Environment Research Council (NERC)
* Northrop Grumman Corporation
* University Corporation for Atmospheric Research (UCAR)
* US National Oceanic and Atmospheric Administration (NOAA)
1. Submission contact points

|  |  |
| --- | --- |
| **Name** | **Organization**  |
| Ben Domenico | UCAR Unidata |
| Stefano Nativi | University of Florence, CNR/IMAA |
|  |  |

1. Revision history

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Date | Release | Author | Paragraph modified | Description |
| 2010-08-27 | 1.0.0 | Ben Domenico,Stefano Nativi | All | Created |

1. Changes to the OpenGIS Abstract Specification

The OpenGIS® Abstract Specification does not require any changes to accommodate the technical contents of this (part of this) document.

1. Future work

Based on this netCDF core standard, several extensions are foreseen. An outline of how these extensions can happen is provided in the CF-netCDF Primer, OGC-10-091r1.

Foreword

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. The Open Geospatial Consortium shall not be held responsible for identifying any or all such patent rights.

Recipients of this document are requested to submit, with their comments, notification of any relevant patent claims or other intellectual property rights of which they may be aware that might be infringed by any implementation of the standard set forth in this document, and to provide supporting documentation.

Introduction

The OGC netCDF encoding supports electronic encoding of geospatial data, specifically digital geospatial information representing space and time-varying phenomena.

This document specifies the netCDF core; every netCDF encoding shall adhere to the mandatory elements as specified in this standard.

NetCDF (network Common Data Form) is a data model for array-oriented scientific data. A freely distributed collection of access libraries implementing support for that data model, and a machine-independent format are available. Together, the interfaces, libraries, and format support the creation, access, and sharing of multi-dimensional scientific data.

NetCDF data is intended to make possible the creation of collections of data that are:

* Self-Describing: A netCDF dataset may include descriptive information about the data they contain. Hence a netCDF dataset may constitute a complete and independent unit with no need for external metadata.
* Portable: Computers with different ways of storing integers, characters, and floating point numbers can access netCDF data.
* Direct-access: A small subset of a large data set may be accessed efficiently, without first reading through all the preceding data.
* Appendable: Data may be appended to a properly structured netCDF file without copying the data set or redefining its structure.
* Sharable: One writer and multiple readers may simultaneously access the same netCDF file. Using parallel netCDF interfaces, multiple writers may write a file concurrently.
* Archivable: Access to current and earlier forms of netCDF data will be supported by current and future versions of the software.

The purpose of netCDF is to provide a data model, software libraries, and machine-independent data format for geoscience data. Together, the netCDF interfaces, libraries, and format support the creation, access, and sharing of scientific data. With suitable community conventions, netCDF can help improve interoperability among data providers, data users, and data services.

OGC Abstract Specification: NetCDF Core

# Scope

This document is an abstract specification defining the netCDF data model that defines the core set of requirements to which every netCDF encoding must adhere. NetCDF extension specifications can add further functionality to the core requirements. In particular, netCDF extension specifications are required for specific encodings. This document indicates which extensions, at minimum, need to be considered in addition to this core for achieving useful implementation specifications.

# Conformance

Standardization targets are netCDF implementations (currently: encodings).

This document establishes a single requirements class, *core*, of <http://www.opengis.net/spec/netCDF/1.0/req/core> with a single pertaining conformance class, *core*, with URI [http://www.opengis.net/spec/netCDF/1.0/conf /core](http://www.opengis.net/spec/netCDF/1.0/conf%20/core). Requirements and conformance test URIs defined in this document are relative to <http://www.opengis.net/spec/netCDF/1.0/>.

Annex A (normative) specifies conformance tests which shall be exercised by any encoded dataset claiming to implement an OGC netCDF encoding.

# Normative references

The OGC NetCDF Core standard consists solely of this document.

The complete standard is identified by OGC URI <http://www.opengis.net/spec/netcdf/1.0>.

The document has OGC URI <http://www.opengis.net/doc/AS/netcdf/1.0>.

# Terms and definitions

For the purposes of this document, the terms and definitions given in the above references apply. In addition, the following terms and definitions apply.

## attribute

Attributes hold metadata. An attribute contains information about properties of a variable or an entire dataset. The usage of this term in the context of netCDF is given in Chapter 6.

## data

The ISO definition of data is the reinterpretable representation of information in a formalized manner suitable for communication, interpretation, or processing [ISO/IEC 2382-1].

## data model

A data model is an abstract model that describes how data are represented. [ISO ?????]

## data type

According to ISO, the definition of a data type is the specification of a value domain with operations allowed on values in this domain [ISO 19103]. The usage of this term in the context of netCDF is given in Chapter 6.

## data value

According to OGC Observations and Measurements, data value results from an observation which is a specialized act of observing a property or phenomenon, with the goal of producing an estimate of the value of the property [OGC 07-022r1].

## dataset

According to ISO, a dataset is an identifiable collection of data [ISO 19101].

## dimension

Dimensions are used to specify variable shapes, common grids, and coordinate systems. The usage of this term in the context of netCDF is given in Chapter 6.

Note that certain specifications of common grids and coordinate systems are done in netCDF conventions which are beyond the scope of this netCDF core specification and are part of extension specifications.

## domain

A domain is a well-defined set [ISO 19103].

## encoding

An encoding is a conversion of data into a series of codes [ISO 19118].

## global attribute (dataset attribute)

Global attributes apply to a whole data set and may be used to record properties of all the data in a file, such as processing history or conventions used.

## grid

A grid is a network composed of two or more sets of curves in which the members of each set intersect the members of the other sets in a regular way [ISO 19123].

Note that certain specifications of common grids and coordinate systems are done in netCDF conventions which are beyond the scope of this netCDF core specification and are part of extension specifications.

## metadata

Metadata is data about data [ISO 19115].

## model

A model is an abstraction of some aspects of a universe of discourse [ISO 19109]

## netCDF

NetCDF (network Common Data Form) is a data model for array-oriented scientific data, a freely distributed collection of access libraries implementing support for that data model, and a machine-independent format. Together, the interfaces, libraries, and format support the creation, access, and sharing of scientific data.

The classic model represents information in a netCDF data set using dimensions, variables, and attributes, to capture the meaning of array-oriented scientific data.

Note that this document is the specification of the netCDF classic data model. The formal requirements are given in Chapter 6.

## netCDF conventions

The mere use of netCDF is not sufficient to make data "self-describing" and meaningful to both humans and machines. The names of variables and dimensions should be meaningful and conform to any relevant conventions. Dimensions should have corresponding coordinate variables where sensible.

Conventions provide a mechanism whereby a community can specify standard ways to represent quantities and coordinate systems within the simple framework provided by netCDF, using only dimensions, variables, attributes, and a limited set of six primitive types.

Note that the specification of conventions is not covered in the core netCDF specification, but is left to be done in extension specifications.

## record

A record is a finite, named collection of related items (objects or values).

The usage of this term in the context of netCDF is given in Chapter 6.

## record dimension (unlimited length dimension)

In the netCDF classic model, at most one dimension can have the unlimited length, which means variables can grow along that dimension. Record dimension is another term for an unlimited dimension.

The usage of this term in the context of netCDF is given in Chapter 6.

## shape

The shape of a variable is specified with a list of zero or more dimensions.

The usage of this term in the context of netCDF is given in Chapter 6.

## variable

A variable has a name, type, shape, attributes, and values. In face, much of the netCDF specification consists of defining the specific characteristics of variables. Variables hold data values. In the netCDF model, a variable can hold a multidimensional array of values of the same type.

The usage of this term in the context of netCDF is given in Chapter 6.

## variable attribute

Variable attributes record the properties of one variable.

The usage of this term in the context of netCDF is given in Chapter 6.

## NetCDF-specific definitions

The following table lists the definitions specific to the context of this specification.

Table 1 -- NetCDF-specific Definitions

|  |  |  |
| --- | --- | --- |
| Definition Type | Token for URI | Source Clause in this document: OGC 10-090r1 |
| attribute | attribute | 4.1in OGC 10-090r1 |
| dimension | dimension | 4.7 in OGC 10-090r1 |
| global attribute | globalAttribute | 4.10 in OGC 10-090r1 |
| netCDF | netcdf | 4.14 in OGC 10-090r1 |
| netCDF conventions | netcdfConventions | 4.15 in OGC 10-090r1 |
| record | record | 4.16 in OGC 10-090r1 |
| record dimension | recordDimension | 4.17 in OGC 10-090r1 |
| shape | shape | 4.18 in OGC 10-090r1 |
| variable | variable | 4.19 in OGC 10-090r1 |
| variable attribute | variableAttribute | 4.20 in OGC 10-090r1 |

# Document Conventions

## UML notation

All the diagrams that appear in this specification are presented using the Unified Modeling Language (UML) static structure diagram, as described in Subclause 5.2 of OGC Web Services Common [OGC 06-121r8].

## Data dictionary tables

The UML model data dictionary is specified herein in a series of tables. The contents of the columns in these tables are described in Subclause 5.5 of [OGC 06-121r8]. The contents of these data dictionary tables are normative, including any table footnotes.

## Namespace prefix conventions

The following namespaces are used in this document. The prefix abbreviations used constitute conventions used here, but are **not** normative. The namespaces to which the prefixes refer are normative, however.

Table 2 -- Namespace Mappings

|  |  |  |
| --- | --- | --- |
| **Prefix** | **Namespace URI** | **Description** |
| netcdf | http://www.opengis.net/netcdf/ | netCDF – the network Common Data Form  |

# NetCDF classic data model

This Clause specifies the underlying data model for a netCDF classic dataset used in the further Clauses of this standard.

## NetCDF classic model overview

The classic model represents information in a netCDF data set using dimensions, variables, and attributes, to capture the meaning of array-oriented scientific data. Figure 1 presents a UML diagram of the classic data model.

## NetCDF classic data model UML notation



Figure 1: netCDF classic data model

For a more comprehensive explanation of the netCDF data model, see the NetCDF User's Guide[1] or the online NetCDF Workshop for Developers and Data Providers [3].

**Requirement 1 /req/core/data-model-elements:**

NetCDF classic datasets shall represent information using dimensions, variables and attributes using the primitive data types as shown in the UML diagram in Figure 1.

## Primitive data types

**Requirement 2 /req/core/primitive-data-types**:

Variables and attributes shall have one of six primitive data types: char, byte, short, int, float, double.

## Variables

Variables hold data values. In the classic model, a variable can hold a multidimensional array of values of the same type. A variable has a name, type, shape, attributes, and values. The shape of a variable is specified with a list of zero or more dimensions:

* 0 dimensions: a scalar variable with only one value.
* 1 dimension: a 1-D (vector) variable.
* 2 dimensions: a 2-D (matrix or grid) variable.
* ...
* N dimensions: a N-D (matrix or grid) variable.

**Requirement 3 /req/core/variables-data-values:**

Variables shall contain data values.

**Requirement 4 /req/core/variable-name-type-value:**

A variable shall have a name, type, and values.

**Requirement 5 /req/core/variable-attributes:**

A variable shall have zero or more variable attributes.

**Requirement 6 /req/core/variable-shape:**

The shape of a variable shall be specified with a list of zero or more dimensions.

## Dimensions

Dimensions are used to specify variable shapes, common grids, and coordinate systems A dimension has a name and a length. Dimensions may be shared among variables, indicating a common grid. Dimensions may be associated with coordinate variables to identify coordinate axes. In the classic model, at most one dimension can have the unlimited length, which means variables can grow along that dimension. Record dimension is another term for an unlimited dimension. (In the enhanced model, multiple dimensions can have the unlimited length.)

Note that certain specifications of common grids and coordinate systems are done in netCDF conventions which are beyond the scope of this netCDF core specification and are part of extension specifications. Likewise this core specification is confined to the netCDF classic data model so the specification of the enhanced model is left to an extension specification.

**Requirement 7 /req/core/dimension-shapes:**

Dimensions shall specify variable shapes which may be shared as common grids.

**Requirement 8 /req/core/dimension-name-length:**

A dimension shall have a name and a length.

**Requirement 09 /req/core/record-dimension:**

At most one dimension (the record dimension) shall have unlimited length

### Attribute

Attributes hold metadata. An attribute contains information about properties of a variable or an entire data set. Variable attributes may be used to specify properties such as units. Attributes that apply to a whole data set, also called global attributes, may be used to record properties of all the data in a file, such as processing history or conventions used. An attribute may have zero, one, or multiple values (1-D), but attributes cannot be multidimensional.

NetCDF conventions are defined primarily in terms of attributes. Thus the names of attributes are typically standardized in conventions rather than the names of variables. NetCDF conventions are specified in extensions to this core specification.

**Requirement 10 /req/core/global-attributes:**

A netCDF dataset shall have zero or more global attributes.

**Requirement 11 /req/core/global-attribute-metadata:**

Global attributes shall hold metadata about the entire dataset.

**Requirement 12 /req/core/variable-attribute**:

A variable attribute shall hold metadata about one variable.

**Requirement 13 /req/core/attribute-values:**

An attribute shall have zero, one, or multiple values (one dimensional).

**Requirement 14** **/req/core/attribute-dimension:**

An attribute shall have at most one dimension.

Bibliography

IETF RFC 2396, *Uniform Resource Identifiers (URI): Generic Syntax*. IETF, 1998

[ISO 19101, *Geographic information -- Reference model*. ISO, 2002] (Dataset)

[ISO 19103, *Geographic information -- Conceptual schema language*, 2005 ] (Domain)

[ISO 19115, *Geographic information – Metadata*, 2003] (Metadata)

[ISO 19118, *Geographic information – Encoding*, 2005] (Encoding)

[ISO 19123, *Geographic information -- Schema for coverage geometry and functions*, 2005] (Grid)

[ISO/IEC 2382-1, *Information technology -- Vocabulary -- Part 1: Fundamental terms*, 1993] (Data and data type.)

[OGC 07-022r1], *Observations and Measurments – Part1 – Observation Schema*. (Data value)

NASA ESDS-RFC-011v2.00 R. Rew, E. Hartnett, D. Heimbigner, E. Davis, J. Caron: *NetCDF Classic and 64-bit Offset File Formats*

CF-netCDF Primer [OGC 10-091r1]

[*http://www.esdswg.org/spg/rfc/esds-rfc-011/ESDS-RFC-011v2.00.pdf*](http://www.esdswg.org/spg/rfc/esds-rfc-011/ESDS-RFC-011v2.00.pdf)

Unidata UCAR, NetCDF Reference Document, 2009
[http://www.unidata.ucar.edu/netcdf/docs/](http://www.unidata.ucar.edu/software/netcdf/docs/)

Unidata UCAR, NetCDF User Guide
[http://www.unidata.ucar.edu/netcdf/docs/netcdf.html](http://www.unidata.ucar.edu/software/netcdf/docs/netcdf.html)

Unidata UCAR, NetCDF Reference Implementations
ftp://ftp.unidata.ucar.edu/pub/netcdf/netcdf.tar.gz

Annex A: Conformance Class Abstract Test Suite (Normative)A netCDF encoding must satisfy the following characteristics to be conformant with this specification. Note, however, that an encoding extension is needed in order to actually implement executable tests corresponding to these abstract tests.

* 1. Conformance Test Class: netCDF Core
		1. [Requirement 1](#Req01)

|  |  |
| --- | --- |
| **Test ID** | **Requirement 1 /conf/core/data-model-elements:** |
| **Test purpose** | NetCDF classic datasets shall represent information using dimensions, variables and attributes using the primitive data types as shown in the UML diagram in Figure 1. |
| **Test method** | Open the dataset and check that it represents information using dimensions, variables and attributes using the primitive data types as shown in the UML diagram in Figure 1. |

* + 1. [Requirement 2](#Req02)

|  |  |
| --- | --- |
| **Test ID** | **Requirement 2 /conf/core/primitive-data-types** |
| **Test purpose** | Variables and attributes shall have one of six primitive data types: char, byte, short, int, float, double. |
| **Test method** | Open the dataset and check that all variables and attributes have one of six primitive data types: char, byte, short, int, float, double. |

.

* + 1. [Requirement 3](#Req03)

|  |  |
| --- | --- |
| **Test ID** | **Requirement 3 /conf/core/variables-data-values** |
| **Test purpose** | Variables shall contain data values. |
| **Test method** | Open the dataset and check that all variables contain data values. |

* + 1. [Requirement 4](#Req04)

|  |  |
| --- | --- |
| **Test ID** | **Requirement 4 /conf/core/variable-name-type-value** |
| **Test purpose** | A variable shall have a name, type, and values. |
| **Test method** | Open the dataset and check that all variables have a name, type, and values. |

* + 1. [Requirement 5](#Req05)

|  |  |
| --- | --- |
| **Test ID** | **Requirement 5 /conf/core/variable-attributes** |
| **Test purpose** | A variable shall have zero or more variable attributes. |
| **Test method** | Open the dataset and check that each variable has zero or more variable attributes. |

* + 1. [Requirement 6](#Req06)

|  |  |
| --- | --- |
| **Test ID** | **Requirement 6 /conf/core/variable-shape** |
| **Test purpose** | The shape of a variable shall be specified with a list of zero or more dimensions |
| **Test method** | Open the dataset and check that, for any variable for which there is a shape, the shape is specified with a list of zero or more dimensions. |

* + 1. [Requirement 7](#Req07)

|  |  |
| --- | --- |
| **Test ID** | **Requirement 7 /conf/core/dimension-shapes** |
| **Test purpose** | Dimensions shall specify variable shapes which may be shared as common grids. |
| **Test method** | Open the dataset and check that, for any variable for which there is a shape dimensions specify the variable shape. |

* + 1. [Requirement 8](#Req08)

|  |  |
| --- | --- |
| **Test ID** | **Requirement 8 /conf/core/dimension-name-length** |
| **Test purpose** | A dimension shall have a name and a length. |
| **Test method** | Open the dataset and check that all dimensions have a name and a length. |

* + 1. [Requirement 9](#Req09)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|

|  |  |
| --- | --- |
| **Test ID** | **Requirement 09 /conf/core/record-dimension** |
| **Test purpose** | At most one dimension (the record dimension) shall have unlimited length |
| **Test method** | Open the dataset and check that at most one dimension (the record dimension) has unlimited length. |

 |  |

* + 1. [Requirement 10](#Req10)

|  |  |
| --- | --- |
| **Test ID** | **Requirement 10 /conf/core/global-attributes** |
| **Test purpose** | A netCDF dataset shall have zero or more global attributes. |
| **Test method** | This requirement is optional so there is no abstract test. |

* + 1. [Requirement 11](#Req11)

|  |  |
| --- | --- |
| **Test ID** | **Requirement 11 /conf/core/global-attribute-metadata** |
| **Test purpose** | Global attributes shall hold metadata about the entire dataset |
| **Test method** | Open the dataset and check that any global attributespresent hold metadata about the entire dataset.. |

* + 1. [Requirement 12](#Req12)

|  |  |
| --- | --- |
| **Test ID** | **Requirement 12 /conf/core/variable-attribute** |
| **Test purpose** | A variable attribute shall hold metadata about one variable |
| **Test method** | Open the dataset and check that each variable attribute holds metadata about one variable |

* + 1. [Requirement 13](#Req13)

|  |  |
| --- | --- |
| **Test ID** | **Requirement 13 /conf/core/attribute-values** |
| **Test purpose** | An attribute shall have zero, one, or multiple values (one dimensional). |
| **Test method** | Open the dataset and check that each attribute has zero, one, or multiple values (one dimensional). |

* + 1. [Requirement 14](#Req14)

|  |  |
| --- | --- |
| **Test ID** | **Requirement 14** **/conf/core/attribute-dimension** |
| **Test purpose** | An attribute shall have at most one dimension. |
| **Test method** | Open the dataset and check that each attribute has at most one dimension. |

-- end of ATS --