



Norwegian
Meteorological
Institute

Data Management Handbook template for MET and partners in S-ENDA written in asciidoc

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Abstract

This document describes general data management practices in line with the FAIR principles, and focuses on the management and sharing of dynamical geodata (i.e., geolocated data about processes in nature). The practices aim at a metadata-driven data management regime. Data management principles are described and summarised. Details of the practical implementation of the principles are described along 4 pillars: structuring and documenting data; data services; user portals and documentation; and data governance. Practical guidance for data producers is also provided.

The present handbook is a general text that can be applied by anyone. We have prepared templates for organisation specific information that can be updated and merged into the general handbook by the user organisations.

Table of Contents

| | |
|---|----|
| 1. Introduction | 7 |
| 1.1. The principles of data management for dynamic geodata | 8 |
| 1.1.1. External data management requirements and forcing mechanisms | 8 |
| 1.1.2. The data value chain | 9 |
| 1.1.3. Dataset | 9 |
| 1.1.4. Metadata | 9 |
| 1.1.5. A data management model based on the FAIR principles | 11 |
| 1.2. Human roles in data management | 12 |
| 1.2.1. Context | 12 |
| 1.2.2. User definitions | 13 |
| 1.2.2.1. Data consumers | 13 |
| 1.2.2.1.1. Advanced consumers | 13 |
| 1.2.2.1.2. Intermediate consumers | 13 |
| 1.2.2.1.3. Simple consumers | 14 |
| 1.2.2.2. Data producers | 14 |
| 1.2.2.3. Data Management Roles | 15 |
| 1.3. Introduction to the data management at [insert organisation name here] | 15 |
| 1.3.1. Background at [insert organisation name here] | 15 |
| 1.3.2. External data management requirements and forcing mechanisms specific to [insert organisation name here] | 15 |
| 1.3.3. Data Management Roles at [insert organisation name here] | 15 |
| 1.4. Summary of data management requirements | 15 |
| 2. Structuring and Documenting Data for Efficient Discovery and Use | 19 |
| 2.1. Structuring and documenting data at [insert organisation here] | 19 |
| 2.1.1. Current practice in structuring and documenting data | 19 |
| 2.1.2. Planned developments in the near-term (< 2 years) | 19 |
| 2.1.3. Expected evolution in the longer term (> 2 years) | 19 |
| 3. Data Services | 21 |
| 3.1. Implementation of data services at [institution] | 21 |
| 3.1.1. Legacy | 21 |
| 3.1.2. Planned developments in near-term (< 2 years) | 21 |
| 3.1.3. Expected evolution in the longer term (> 2 years) | 21 |
| 4. User Portals and Documentation | 23 |
| 4.1. Implementation of user portals at [institution] | 23 |
| 4.1.1. Current implementation | 23 |
| 4.1.2. Planned developments in near-term (< 2 years) | 23 |
| 4.1.3. Expected evolution in the longer term (> 2 years) | 23 |
| 5. Data Governance | 25 |

| | |
|--|----|
| 5.1. Data life cycle management | 25 |
| 5.1.1. Data Management Plan | 25 |
| 5.2. Data governance data at [insert organisation here] | 26 |
| 5.2.1. Current implementation | 26 |
| 5.2.1.1. Organisational Roles | 26 |
| 5.2.1.2. Status DMH | 26 |
| 5.2.1.3. Status Discovery metadata | 26 |
| 5.2.1.4. Status DMP | 26 |
| 5.2.2. Planned developments in the near-term (< 2 years) | 26 |
| 5.2.3. Expected evolution in the longer term (> 2 years) | 26 |
| 6. Practical Guidance to producers of NetCDF-CF datasets | 27 |
| 6.1. Workflow | 27 |
| 6.2. Register context | 27 |
| 6.2.1. Submitting data as NetCDF/CF | 27 |
| 6.2.2. How to add NetCDF-CF data to thredds | 28 |
| 6.2.3. How to test MMD records and register datasets | 28 |
| 6.2.4. Local test environment | 29 |
| 6.2.5. S-ENDA Metadata Service gives feedback | 30 |
| 6.3. Search context | 31 |
| 6.3.1. User searches the catalog with OpenSearch | 31 |
| 6.3.2. Online catalog | 31 |
| 6.3.3. User searches web portals | 32 |
| 6.3.4. User searches from QGIS | 32 |
| 6.4. Practical Guidance to data producers at [INSTITUTION] | 32 |
| Acknowledgements | 33 |
| Glossary of Terms and Names | 35 |
| List of Acronyms | 41 |
| Appendix A: List of Referenced Software or Services | 49 |
| Appendix B: Users of [insert institution]’s data | 51 |
| Global attributes | 51 |
| Notes | 51 |
| List of Attributes | 52 |

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1. Introduction

The purpose of the Data Management Handbook (DMH) is threefold:

1. to provide an overview of the principles for [data management](#) to be employed.
2. to help personnel identify their roles and responsibilities for good [data management](#).
3. to provide personnel with practical guidelines for carrying out good [data management](#).

Data management is the term used to describe the handling of data in a systematic and cost-effective manner. The data management regime should be continuously evolving, to reflect the evolving nature of data collection. Therefore this [DMH](#) is a living document that will be revised and updated from time to time in order to maintain its relevance.

The [DMH](#) is a strategic governing document and should be used as part of the quality framework the organisation is using.

The primary focus of this [DMH](#) is on the management of [dynamic geodata](#). [Dynamic geodata](#) is weather, environment and climate-related data that changes in space and time and is thus descriptive of processes in nature. Examples are weather observations, weather forecasts, pollution (environmental toxins) in water, air and sea, information on the drift of cod eggs and salmon lice, water flow in rivers, driving conditions on the roads and the distribution of sea ice. [Dynamic geodata](#) provides important constraints for many decision-making processes and activities in society.

This introduction ([Chapter 1](#)) lays forth the background and principles for the data management regime. Chapters 2-5 describe the implementation of the main building blocks: structuring and documenting data ([Chapter 2](#)), data services ([Chapter 3](#)), portals and documentation aimed at users ([Chapter 4](#)), and governance issues ([\[glossary-data-governance\]](#)). Each chapter starts with a brief statement of its purpose, followed by a description of what is implemented at present, as well as the planned developments for the short-term (<2 years) and expected developments for the longer term (2-5 years).

Practical guidelines for carrying out good [data management](#) are addressed in Chapter 6.

The intended audience for this DMH is any personell involved in the process of making data available for the end user. This process can be viewed as a value chain that moves from the producer of the data to the data consumer (i.e., the end user). The process is further described in the section [Section 1.1.2](#) ([Figure 1](#)).

The handbook can be used in three ways:

1. Read the Introduction (Chapter 1) to find out the background and principles of [data management](#);
 2. Read Chapters 2-5 to learn about how [data management](#) is currently implemented and how it is expected to evolve in the next few years;
 3. Read chapter 6 to find how-to's and practical guidelines.
-

1.1. The principles of data management for dynamic geodata

Principles of standardised data documentation, publication, sharing and preservation have been formalised in the [FAIR](#) Guiding Principles for scientific data management and stewardship [RD3 [https://www.nature.com/articles/sdata201618]] through a process facilitated by [FORCE11](#). FAIR stands for findability, accessibility, [interoperability](#) and reusability.

By following the [FAIR](#) principles it is easier to obtain a common approach to [data management](#), or a [unified data management](#) model. One of the main motivations for implementing a [unified data management](#) is to better serve the users of the data. Primarily, this can be approached by making user needs and requirements the guide for determining what data we provide and how. For example, it will be described below how the specification of [datasets](#) should be determined. By implementing the data management practices described here, it is expected that users will experience:

- Ease of discovering, viewing and accessing [datasets](#);
- Standardised ways of accessing data, including downloading or streaming data, with reduced need for special solutions on the user side;
- Reduced storage needs;
- Simple and standard access to remote [datasets](#) and catalogues, with own data visualisationl and analysis tools;
- Ability to compare and combine data from internal and external sources;
- Ability to apply common data transformations, like spatial, temporal and variables subsetting and reprojection, before downloading anything;
- Possibility to build specialized metadata catalogues and data portals targeting a specific user community;

1.1.1. External data management requirements and forcing mechanisms

Any organisation that strives to implement [FAIR](#) data management model has to relate to external forcing mechanisms concerning [data management](#) at several levels. At the national level, the organisation must comply with national regulations as decided by the government. Some of these are indications of expected behaviour (e.g. [OECD](#) regulations) and some are implemented through a legal framework. The Norwegian government has over time promoted free and open sharing of public data. Mechanisms for how to do this are governed by the [Geodataloven](#) (implemented as [Geonorge](#)), which is a national implementation of the European [INSPIRE directive](#) (to be amended in 2019). [INSPIRE](#) defines a federated multinational [Spatial Data Infrastructure](#) (SDI) for the European Union, similar to [NSDI](#) in the USA or [UNSDI](#) under the United Nations. The goal is to provide a standardised access to data and provide the necessary tools to be able to work with the data in a unified manner. In short, these legal frameworks require standardised documentation (at discovery and use level; these concepts are described later) and access (through specified protocols) to the data identified.

Other external requirements and forcing mechanisms that are organisation-specific are listed under section X.X.X

1.1.2. The data value chain

The process of getting the data from the data producer to the consumer can be viewed as a value chain. An example of a data value chain is presented in Figure 1. Typically, data from a wide variety of providers are used in the value chain. Traditionally, the data used have been transmitted on request from one [data centre](#) to another, and used in the specific processing chains that requested the data. The focus on reuse of data in various contexts has been missing.



Figure 1. Value chain for data

Datasets and metadata are what travels through the value chain, and at the end of the [data management](#) value chain are the data consumers.

1.1.3. Dataset

A [dataset](#) is a collection of data. In the context of the [data management](#) model, the storage mode of the [dataset](#) is irrelevant, since access mechanisms can be decoupled from the storage layer as experienced by a data consumer. Typically, a [dataset](#) represents a number of variables in time and space. A more detailed definition is provided in the [Glossary of Terms](#). In order to best serve the data through [web services](#), the following principles are useful for guiding the [dataset](#) definition:

1. A [dataset](#) can be a collection of variables stored in, for example, a relational database or as flat files;
2. A [dataset](#) is defined as a number of spatial and/or temporal variables; and
3. A [dataset](#) should be defined by the information content and not the production method.
4. A good [dataset](#) does not mix [feature types](#), i.e., trajectories and gridded data should not be present in the same [dataset](#).

Point 3 implies that the output of, e.g., a numerical model may be divided into several [datasets](#) that are related. This is also important in order to efficiently serve the data through [web services](#). For instance, model variables defined on different vertical coordinates should be separated as [linked datasets](#), since some [OGC](#) services (e.g., [WMS](#)) are unable to handle mixed coordinates in the same [dataset](#).

Most importantly, a [dataset](#) should be defined to meet the consumer needs. This means that the specification of a [dataset](#) should follow not only the content guidelines just listed, but also address the consumer needs for data delivery, security and preservation.

1.1.4. Metadata

Metadata is a broad concept. In our [data management](#) model the term "metadata" is used in several contexts, specifically the five categories that are briefly described in [Table 1](#).

Table 1. Brief introduction to different types of metadata.

| Type | Purpose | Description | Examples |
|--------------------|-------------------------------|--|--|
| Discovery metadata | Used to find relevant data | Discovery metadata are also called index metadata and are a digital version of the library index card. They describe who did what, where and when, how to access data and potential constraints on the data. They shall also link to further information on the data, such as site metadata . | ISO 19115 GCMD DIF |
| Use metadata | Used to understand data found | Use metadata describes the actual content of a dataset and how it is encoded. The purpose is to enable the user to understand the data without any further communication. They describe the content of variables using standardised vocabularies, units of variables, encoding of missing values, map projections, etc. | Climate and Forecast (CF) Convention BUFR GRIB |
| Site metadata | Used to understand data found | Site metadata are used to describe the context of observational data. They describe the location of an observation, the instrumentation, procedures, etc. To a certain extent they overlap with discovery metadata , but also extend discovery metadata . Site metadata can be used for observation network design. Site metadata can be considered a type of use metadata . | WIGOS OGC O&M StInfoSys |

| Type | Purpose | Description | Examples |
|------------------------|--|--|----------|
| Configuration metadata | Used to tune portal services for datasets intended for data consumers (e.g., WMS) | Configuration metadata are used to improve the services offered through a portal to the user community. This can, e.g., be how to best visualise a product . | |
| System metadata | Used to understand the technical structure of the data management system and track changes in it | System metadata covers, e.g., technical details of the storage system, web services , their purpose and how they interact with other components of the data management system, available and consumed storage, number of users and other KPI elements etc. | SysDok |

The tools and facilities used to manage the information contained in the metadata are further described in Chapter 2.

1.1.5. A data management model based on the FAIR principles

The [data management](#) model is built upon the following principles:

- **Standardisation** – compliance with established international standards;
- **Interoperability** – enabling machine-to-machine interfaces including standardised documentation and encoding of data;
- **Integrity** – ensuring that data and data access can be maintained over time, and ensuring that the consumer receives the same data at any time of request;
- **Traceability** – documentation of the [provenance](#) of a [dataset](#), i.e., all actions taken to produce and maintain the [dataset](#) and the usage of the data in downstream systems;
- **Modularisation** – enabling replacement of one component of the system without necessitating other changes.

The model's basic functions fall into three main categories:

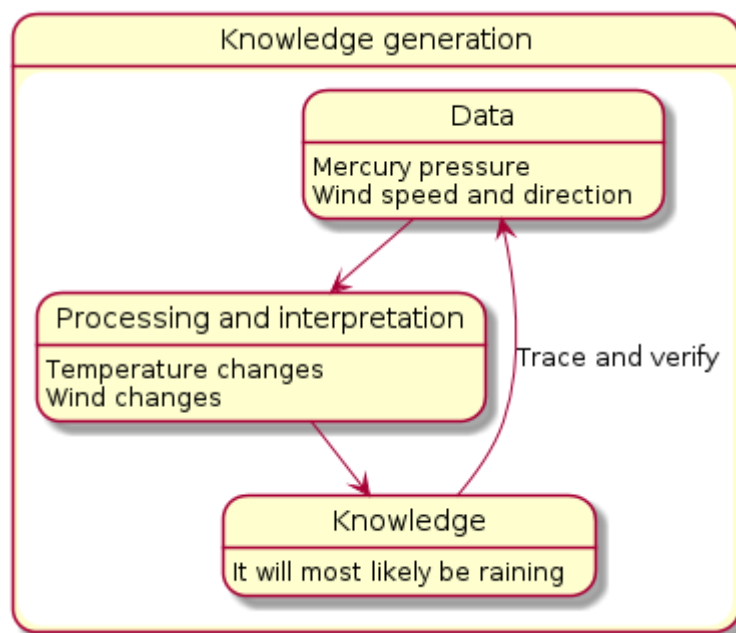
1. **Documentation of data** using [discovery](#) and [use metadata](#). The documentation identifies who, what, when, where, and how, and shall make it easy for consumers to find and understand data. This requires application of information containers and utilisation of [controlled vocabularies](#) and [ontologies](#) where textual representation is required. It also covers the topic of [data provenance](#) which is used to describe the origin and all actions done on a [dataset](#). [Data provenance](#) is closely linked with [workflow management](#). Furthermore, it covers the relationship between [datasets](#). Application of [ontologies](#) in data documentation is closely linked to the concept of [linked data](#).

2. **Publication and sharing of data** focuses on making data accessible to consumers internally and externally. Application of standardised approaches is vital, along with cost effective solutions that are sustainable. Direct integration of data in applications for analysis through data streaming minimises the complexity and overhead in dissemination solutions. This category also covers persistent identifiers for data.
3. **Preservation of data** includes short and long term management of data, which secures access and availability throughout the lifespan of the data. Good solutions in this area depend on expected and actual usage of the data. Preservation of data includes the concept of data life cycle, i.e., the documented flow of data from initial storage through to obsolescence and permanent archiving (or deletion) and preserving the metadata for the same data (even after deleting).

1.2. Human roles in data management

1.2.1. Context

Data is processed and interpreted to generate knowledge (e.g., about the weather) for end users. The knowledge can be presented as information in the form of actual data, illustrations, text or other forms of communication. In this context, an illustration is a representation of data, whereas data means the numerical values needed to analyse and interpret a natural process (i.e., calibrated or with calibration information; it must be possible to understand the meaning of the numerical value from the available and machine-readable information).



Data here means the numerical values needed to analyse and interpret a natural process (i.e., calibrated or with calibration information, provenance, etc.; it must be possible to understand the meaning of the numerical value from the available and machine-readable information).

Advanced users typically consume some type of data in order to process and interpret it, and produce new knowledge, e.g., in the form of a new dataset or other information. The datasets can be organised in different levels, such as the [WMO WIGOS definition for levels of data](http://codes.wmo.int/wmdr/) [http://codes.wmo.int/wmdr/

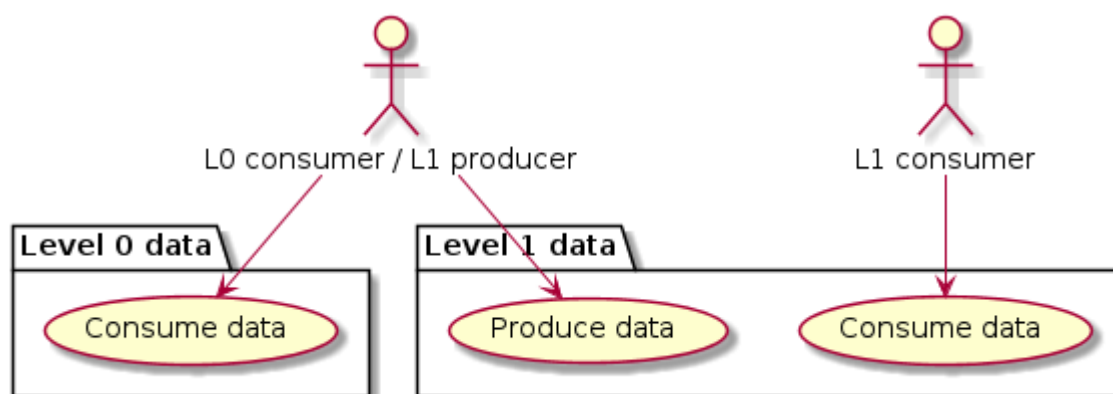
_SourceOfObservation]. Less advanced users apply information based on data (e.g., an illustration without) to make decisions (e.g., clothes adapted to the forecast weather).

1.2.2. User definitions

We define two types of users:

1. Producers: Those that create / produce data
2. Consumers: Those that consume data

A consumer of one level of data is typically a producer of data at the next level. A user can both consume data and produce data, or just have one of these roles (i.e., at the start/end of the production chain).



1.2.2.1. Data consumers

We split between three types of data consumers: (1) advanced, (2) intermediate, and (3) simple. These are defined below.

1.2.2.1.1. Advanced consumers

Advanced consumers require information in the form of data and metadata (including provenance) to gain a full understanding of what data exists and how to use it (discovery and use metadata), and to automatize the generation of derived data (new knowledge generation), verification (of information), and validation of data products.

Example questions:

- Need all historical weather data, that can be used to model / predict the weather in the future

Specific consumers:

- Researcher (e.g., for climate projections within the "Klima i Norge 2100" research project)

1.2.2.1.2. Intermediate consumers

Intermediate consumers need enough information to find data and understand if it can answer their question(s) (discovery and use metadata). Also, they often want to cross reference a dataset with another dataset or metadata for inter-comparative verification of information.

Example questions:

- Is this observation a record / weather extreme (coldest, warmest, wettest)?
- What was the amount of rain in last month in a certain watershed?

Specific consumers:

- Klimavakt (MET)
- Developer (app, website, control systems, machine learning, etc.)
- Energy sector (hydro, energy prices)
- External partners

1.2.2.1.3. Simple consumers

Simple consumers do not have any prior knowledge about the data. Information in the form of text or illustrations is sufficient for their decision making. They do not need to understand either data or metadata, and they are most likely looking for answers to simple questions.

Example questions:

- Will it be raining today?
- Can the event take place, or will the weather impeded it?
- When should I harvest my crops?

Specific consumers:

- Event organizer
- Journalist
- Farmer, or other people who work with the land like tree planters

NOTE

An advanced consumer may discover information pertaining a role as a simple consumer. Such a user may, for some reason, be interested in tracking the data in order to use it together with other data (interoperability) or to verify the information. Therefore, it is important to have provenance metadata pointing to the basic data source(s) also at the simplest information level.

1.2.2.2. Data producers

A producer is an advanced consumer at one level of data that generate new information at a higher level. This new information could be in the form of actual data or simple information, such as an illustration or a text summary. It is essential that any information can be traced back to the source(s).

1.2.2.3. Data Management Roles

Between the data providers and data consumers are the processes that manage and deliver the datasets (cf. [\[img-value-chain\]](#)). A number of human roles may be defined with responsibilities that, together, ensure that these processes are carried out in accordance with the data management requirements of the organisation. The definition and filling of these roles depend heavily on the particular organisation, and each organisation must devise its own best solution.

1.3. Introduction to the data management at [insert organisation name here]

1.3.1. Background at [insert organisation name here]

1.3.2. External data management requirements and forcing mechanisms specific to [insert organisation name here]

1.3.3. Data Management Roles at [insert organisation name here]

| Role | Description | Responsibility |
|------|-------------|----------------|
| | | |

1.4. Summary of data management requirements

The data management regime described in this DMH follows the Arctic Data centre model and shall ensure that:

1. There are relevant metadata for all datasets, and both data and metadata are available in a form and in such a way that they can be utilised by both humans and machines.

| | Link to relevant section | Example |
|--|--------------------------|---------|
| There are sufficient metadata for each dataset for both discovery and use purposes. | | |
| Discovery metadata are indexed and can be retrieved from available services in a standard way and with standard protocols. | | |

| | Link to relevant section | Example |
|--|--------------------------|---------|
| There are interfaces for discovery, visualisation and download, as well as portals for human access, that operate seamlessly across institutions. | | |
| The data are described in a relevant, standardised and managed vocabulary that supports machine-machine interfaces. | | |
| Datasets have attached a unique and permanent identifier that enables traceability. | | |
| Datasets have licensing that ensures free use and reuse wherever possible. | | |
| Datasets are available for download in a standard form according to the FAIR guiding principles and through standard protocols that are accepted and utilised in the user environment. | | |

2. There is an organisation that provides for the management of each dataset throughout its lifetime (life cycle management).

| | Link to relevant section | Example |
|---|--------------------------|---------|
| There is documentation that describes physical storage, lifetime of each dataset, degree of storage redundancy, metadata consistency methods, how dataset versioning is implemented and unique IDs to ensure traceability. The organisation provides seamless access to data from distributed data centres through various portals. | | |
| The above and a business model at dataset level are described in a Data Management Plan (DMP) | | |

3. There are services or tools that provide the following functionalities on the datasets:

| | Link to relevant section | Example |
|--|--------------------------|---------|
| Transformations, including: subsetting; slicing of gridded data sets to points, sections, profiles; reprojection; resampling; reformatting | | |
| Visualisation (time series, mapping services, etc.) | | |
| Aggregation | | |
| Upload of new datasets (including enabling and configuring data access services) | | |

2. Structuring and Documenting Data for Efficient Discovery and Use

In order to properly find, understand and use [dynamic geodata](#), standardised encoding and documentation are required, i.e., [metadata](#). Both [discovery metadata](#) and [use metadata](#) can be embedded in the files produced for a [dataset](#) through utilisation of self-explaining file formats. If properly done by the [data provider](#), publication and preservation of data through services is simplified and can be automated.

An essential prerequisite for structuring and documenting data is the specification of the [dataset\(s\)](#). The [dataset](#) is the basic building block of our [data management model](#); all the documentation and services described in this [DMH](#) are built on [datasets](#). The dataset specification is the first step in structuring one's data for efficient management, and it is mandatory.

2.1. Structuring and documenting data at [insert organisation here]

2.1.1. Current practice in structuring and documenting data

Table 2. Data types available at [insert institution here], with the fileformats supported. The primary fileformat is marked in **bold**

| Supported file formats/structures | Datatype | Available metadata | Examples |
|-----------------------------------|----------|--------------------|----------|
| Comments | | | |
| | | | |

2.1.2. Planned developments in the near-term (< 2 years)

2.1.3. Expected evolution in the longer term (> 2 years)

3. Data Services

The purpose of this chapter is to describe services that benefit from the standardisation performed in the previous step. The information structures described in the previous chapter pave the way for efficient data discovery and use through tools and automated services. Implementation of the services must be in line with the institute's delivery architecture.

Data services include:

1. Data ingestion, storing the data in the proper locations for long term preservation and sharing;
2. Data cataloging, extracting the relevant information for proper discovery of the data;
3. Configuration of visualisation and data publication services (e.g., OGC WMS and OpeNDAP).

When planning and implementing data services, there are a number of external requirements that constrain choices, especially if reuse of solutions nationally and internationally is intended and wanted for the data in question. At the national level, important constraints are imposed by the national implementation of the [INSPIRE](#) directive through Norge digitalt.

3.1. Implementation of data services at [institution]

3.1.1. Legacy

3.1.2. Planned developments in near-term (< 2 years)

3.1.3. Expected evolution in the longer term (> 2 years)

4. User Portals and Documentation

The purpose of this chapter is to describe the human interfaces which data consumers would use to navigate data and the related services. A portal is an entry point for data consumers, enabling them to discover and search for datasets and services, and providing sufficient documentation and guidance to ensure that they are able to serve themselves using the interactive and machine interfaces offered.

Here, we can distinguish between a general portal for all publishable datasets from the institution and targeted portals that offer a focused selection of data, which may include external datasets. Targeted portals cater to specific user groups and may have a limited lifetime, but also can be long-term commitments.

4.1. Implementation of user portals at [institution]

Table 3. User portals in use at [institution]

| User portal | Description | General or targeted portal | Data consumer |
|-------------------------|-------------|----------------------------|---------------|
| Example | | | |

4.1.1. Current implementation

4.1.2. Planned developments in near-term (< 2 years)

4.1.3. Expected evolution in the longer term (> 2 years)

5. Data Governance

This chapter describes how we organise and steer data management activities in order to ensure that:

1. The guidelines described above are implemented throughout the organisation;
2. Our data management practices are in line with and contribute to the institute's strategic aims;
3. Our data management regime is subject to review, analysis and revision in a timely manner.

These higher level aspects of data management are often referred to as [data governance](#). A useful definition is:

"Data governance ... is the overall management of the availability, usability, integrity and security of data used in an enterprise. A sound data governance program includes a governing body or council, a defined set of procedures and a plan to execute those procedures."

In this chapter we address many aspects of this definition, but a full description of data governance touches on management structures that are beyond the scope of this handbook.

5.1. Data life cycle management

[Data life cycle management](#) is steered by documentation describing how data generated or used in an activity will be handled throughout the lifetime of the activity and after the activity has been completed. This is living documentation that follows the activity and specifies what kind of data will be generated or acquired, how the data will be described, where the data will be stored, whether and how the data can be shared, and how the data will be retired (archived or deleted). The purpose of life cycle management is to safeguard the data, not just during their "active" period but also for future reuse of the data, and to facilitate cost-effective data handling.

This DMH recommends the following two concepts of [life cycle management](#) to be implemented for the institution:

- Extended [discovery metadata](#) for data in internal production chains. These are metadata elements that provide the necessary information for life cycle management just described.
- A [Data Management Plan](#) (DMP) document. A DMP is expected for datasets produced in external projects, but may also be useful for internal datasets, as a supplement to the extended discovery metadata.

The goal is that life cycle management information shall be readily available for every dataset managed by the institute. How these concepts are implemented are described in the institution specific subsection below.

5.1.1. Data Management Plan

A Data Management Plan ([DMP](#)) is a document that describes textually how the [data life cycle management](#) will be carried out for [datasets](#) used and produced in specific projects. Generally, these are externally financed projects for which such documentation is required by funding agencies. However,

larger internal projects covering many datasets may also find it beneficial to create a specific document of this type.

Currently, agencies funding R&D (such as [NFR](#) and the EU) do not strictly require a DMP from the start of any project. However, for projects in the geosciences, data management is an issue that must be addressed, and the agencies strongly recommend a DMP solution. For example, NFR publishes [guidelines](https://www.forskningradet.no/en/Adviser-research-policy/open-science/open-access-to-research-data/) [https://www.forskningradet.no/en/Adviser-research-policy/open-science/open-access-to-research-data/] for the contents of a DMP, including links to tools (templates and online services); these guidelines are recommended for any data management project or activity and will in time become a requirement according to [NFR](#).

5.2. Data governance data at [insert organisation here]

5.2.1. Current implementation

5.2.1.1. Organisational Roles

5.2.1.2. Status [DMH](#)

5.2.1.3. Status [Discovery metadata](#)

5.2.1.4. Status [DMP](#)

5.2.2. Planned developments in the near-term (< 2 years)

Revise DMH annually or when needed.

5.2.3. Expected evolution in the longer term (> 2 years)

Revise DMH annually or when needed.

6. Practical Guidance to producers of NetCDF-CF datasets

This chapter includes how-to's and other practical guidance for producers of NetCDF-CF datasets.

6.1. Workflow

1. Define your dataset (see [Dataset](#))
2. Create a netCDF-CF file (see, e.g., [netCDF4-python docs](https://unidata.github.io/netcdf4-python/) [https://unidata.github.io/netcdf4-python/])
3. Add discovery metadata as global attributes (see [section about global netCDF attributes](#))
4. Add variables and use metadata following the [CF conventions](https://cfconventions.org/) [https://cfconventions.org/]
5. Test that your dataset contains the necessary discovery metadata (see ...)
6. Store the file in a suitable location, and distribute it via thredds or another dap server (see, e.g., [Section 6.2.2](#))
7. Index your data in a searchable metadata catalog under a development environment
8. Verify that the development CSW service works as expected (e.g., that it provides correct metadata)
9. Index your data in a staging/production environment

The data producer should be able to handle points 1-5, whereas the last four points (6-9) should be done with help from a system expert.

6.2. Register context

6.2.1. Submitting data as NetCDF/CF

By documenting and formatting your data using [NetCDF](#) following the [CF conventions](https://cfconventions.org/) [https://cfconventions.org/] and the [Attribute Convention for Data Discovery \(ACDD\)](https://wiki.esipfed.org/Attribute_Convention_for_Data_Discovery_1-3) [https://wiki.esipfed.org/Attribute_Convention_for_Data_Discovery_1-3], [MMD](#) files can be automatically generated from the [NetCDF](#) files. The [CF conventions](#) is a controlled vocabulary providing a definitive description of what the data in each variable represents, and the spatial and temporal properties of the data. The [ACDD](#) vocabulary describes attributes recommended for describing a [NetCDF](#) dataset to data discovery systems.

Information about how to format the NetCDF files is available at link:<https://adc.met.no/node/4> and in [Global attributes](#). The latter contains an updated overview of the global NetCDF attributes required to generate an MMD file.

NOTE

The NASA GCMD/DIF keywords can be used for many of the [ACDD](#) attributes. You can use [py-thesaurus-interface](https://github.com/nansencenter/py-thesaurus-interface) [https://github.com/nansencenter/py-thesaurus-interface] to get them (helps to avoid typos etc.). [py-thesaurus-interface](https://github.com/nansencenter/py-thesaurus-interface) [https://github.com/nansencenter/py-thesaurus-interface] is also synchronized with the [MMD thesauri](https://github.com/metno/mmd/tree/master/thesauri) [https://github.com/metno/mmd/tree/master/thesauri] (although not yet merged) and the [CF variables](http://mmisw.org/ont/cf/parameter) [http://mmisw.org/ont/cf/parameter].

6.2.2. How to add NetCDF-CF data to thredds

How should you proceed to add your [NetCDF-CF](#) data to [thredds](#)? Follow these steps and your data will be discoverable by [thredds](#) (this is valid for the existing thredds server at MET NORWAY), and then harvestable by the [py-mmd-tools](https://github.com/metno/py-mmd-tools) [https://github.com/metno/py-mmd-tools]

1. You need to make your NetCDF-CF data available on our lustre filesystem.
 1. If you need help to transfer data, please contact service desk.
 2. Please also make sure you have sufficient quota on lustre for your data.
 3. You can either use your userspace or some other area you have access to within a project.
 4. Make sure you add the same data to both the A and B side if you need redundancy. Extra steps need to be taken for this to work.
2. Then, thredds needs to be able to discover your data.
 1. Take contact with service desk which will put you in contact the responsible person for adding data to thredds. He or she will need the full path to your data or base directory of your data structure. All data files ending with `.nc` (or `.ncml`) below this basedir will be displayed on thredds.
 2. You can have a look here for some user data link:https://thredds.met.no/thredds/catalog/metusers/catalog.html. All users can add [NetCDF-CF](#) data under their user area, mainly for testing.
3. Your [NetCDF-CF](#) data will now become visible on thredds. You can look here in the base catalog link:https://thredds.met.no/thredds/catalog.html to discover your data.

If your files are correctly formatted and following the conventions, it is now also straightforward to add them to the discovery metadata catalog.

6.2.3. How to test MMD records and register datasets

In order to make a dataset findable, a dataset must be registered in a searchable catalog with appropriate metadata. The (meta)data catalog is indexed and exposed through [CSW](#) [https://en.wikipedia.org/wiki/Catalogue_Service_for_the_Web].

The procedure to register a dataset in the catalog is as follows:

1. Create [MMD](#) [https://github.com/metno/mmd/blob/master/doc/mmd-specification.html] XML record of metadata
2. Translate from MMD to ISO19115
3. Index in CSW
4. Expose ISO19115 metadata via CSW to the internet

We have prepared Virtual Machine (VM) configurations and Docker containers to handle points 2-4 above.

| | |
|-------------|---|
| NOTE | Note to reviewers: Please consider if this makes sense, and can be done now |
|-------------|---|

The workflow which a MET data provider should follow in order to add new datasets to the common

metadata catalog service is then as follows:

1. Create [MMD](https://github.com/metno/mmd/blob/master/doc/mmd-specification.html) [https://github.com/metno/mmd/blob/master/doc/mmd-specification.html] XML record of metadata
2. Clone the [S-ENDA-csw-catalog](https://github.com/metno/S-ENDA-csw-catalog-service) [https://github.com/metno/S-ENDA-csw-catalog-service] repository
3. Test your MMD XML file(s) using the localtest vm ([Section 6.2.4](#))
4. Add an issue to the [S-ENDA-mmd-xml](https://gitlab.met.no/mmd/s-enda-mmd-xml) [https://gitlab.met.no/mmd/s-enda-mmd-xml] repository (e.g., "New foo model dataset" [the issue is numbered, e.g., 131]; note that this is only available inside the network of MET Norway)
5. Clone the [S-ENDA-mmd-xml](https://gitlab.met.no/mmd/s-enda-mmd-xml) [https://gitlab.met.no/mmd/s-enda-mmd-xml] repository
6. Create an issue branch: `git branch issue131_foo_dataset`
7. Add your MMD file in the new branch, then commit, push, and create a pull request
8. A reviewer will evaluate the new dataset, and provide feedback or directly accept and merge

NOTE

Note to reviewers: I now interpret <http://senda1.lab-a.met.no> as a staging server. How do we go from that to production, and what needs to be done? Please review and/or add issues in <https://github.com/metno/S-ENDA-project-plan..>

When the new MMD file is added to the metadata repository, it will be translated to a [PyCSW](https://github.com/geopython/pycsw) [https://github.com/geopython/pycsw] ISO19139 profile, indexed in a postgres database, and exposed to the public via the [\(meta\)data catalog](http://senda1.lab-a.met.no/) [http://senda1.lab-a.met.no/] in the same way as demonstrated in the localtest vm ([Section 6.2.4](#)).

6.2.4. Local test environment

This vm is used to test your MMD XML-files locally before pushing them to the main discovery metadata repository.

1. Put your test files in the folder `lib/input_mmd_file` (you may have to create this folder)
2. Start VM:

```
vagrant up localtest
```

1. If you want to test other MMD files after `vagrant up localtest`:

```
vagrant ssh localtest
cd /vagrant
sudo MMD_IN=/vagrant/lib/input_mmd_files ./deploy-metadata.sh
```

1. Or, if you want to translate and index MMD files from the main gitlab repository (requires vpn connection to MET):

```
sudo MMD_IN=/vagrant/lib/s-enda-mmd-xml ./deploy-metadata.sh
```

1. Check that the postgis db is added

```
vagrant ssh localtest
cd /vagrant/
sudo docker-compose exec postgis bash
psql -U postgis csw_db
\dt
select * from records;
```

The csw-catalog-service is now started, and the catalog can be accessed on `<http://10.20.30.10>`_`. Note that there is no point in debugging or changing code used in this environment. It is only meant to test the MMD files. If you want to modify code used in the catalog service, please refer to [\[local-developmen-env\]](#)

Search the metadata catalog using [QGIS](https://qgis.org/en/site/) [https://qgis.org/en/site/] (v3.14 or higher):

- [Download and install QGIS](https://qgis.org/en/site/forusers/download.html) [https://qgis.org/en/site/forusers/download.html]
- Run `qgis`
- Select **Web > MetaSearch > MetaSearch** menu item
- Select **Services > New**
- Type, e.g., `localtest` for the name
- Type `http://10.20.30.10` for the URL
- Under the **Search** tab, you can then add search parameters, click **Search**, and get a list of available datasets.
- Select a dataset
- Click **Add Data** and select a WMS channel - the data will then be displayed in QGIS

If you get an error about unexpected keyword argument 'auth' when searching for data, it is most likely due to a bug in QGIS: [link:https://github.com/qgis/QGIS/issues/38074](https://github.com/qgis/QGIS/issues/38074)

6.2.5. S-ENDA Metadata Service gives feedback

S-ENDA Metadata Service has two main types of feedback for the data provider:

1. Questions/praise/bug reports etc. from users.
2. Operational metrics about downloads and production runs for each dataset.

Feedback from users would come as either e-mails into a ticketing system, or as messages in a forum.

Operational metrics will be harvested from metrics server (e.g Prometheus), giving the data provider information such as number of downloads pr. day for each type of service(WMS, DAP etc.) and delays in producing the datasets.

6.3. Search context

6.3.1. User searches the catalog with OpenSearch

- Local testing *

The `localtest` and `localdev` virtual machines provide OpenSearch support through [PyCSW](https://github.com/geopython/pycsw) [https://github.com/geopython/pycsw]. To test OpenSearch via the browser, start the `localtest` vm (`vagrant up localtest`) and go to the following address:

1. link:`http://10.20.30.10/pycsw/csw.py?mode=opensearch&service=CSW&version=2.0.2&request=GetCapabilities`

This will return a description document of the catalog service. The `URL` field in the description document is a template format that can be used to represent a parameterized form of the search. The search client will process the URL template and attempt to replace each instance of a template parameter, generally represented in the form `{name}`, with a value determined at query time ([OpenSearch URL template syntax](https://github.com/dewitt/opensearch/blob/master/opensearch-1-1-draft-6.md#opensearch-url-template-syntax) [https://github.com/dewitt/opensearch/blob/master/opensearch-1-1-draft-6.md#opensearch-url-template-syntax]). The question mark following any search parameter means that the parameter is optional.

We can now find all datasets in the catalog:

1. link:`http://10.20.30.10/?mode=opensearch&service=CSW&version=2.0.2&request=GetRecords&elementsetname=full&typenames=csw:Record&resulttype=results`

Or datasets within a given time span:

1. link:`http://10.20.30.10/?mode=opensearch&service=CSW&version=2.0.2&request=GetRecords&elementsetname=full&typenames=csw:Record&resulttype=results&time=2000-01-01/2020-09-01`

pyCSW opensearch time queries do not relate to the "expected" `start_date` and `end_date` MMD fields, or the associated `beginPosition` and `endPosition`, in the pyCSW ISO19139 profile. We are working to understand and handle this...

Or, datasets from any of the Sentinel satellites:

1. link:`http://10.20.30.10/?mode=opensearch&service=CSW&version=2.0.2&request=GetRecords&elementsetname=full&typenames=csw:Record&resulttype=results&q=sentinel>`_`

6.3.2. Online catalog

For searching the online metadata catalog, please refer to `link:http://senda1.lab-a.met.no/` instead of `link:http://10.20.30.10/`:

- [Service description document](http://senda1.lab-a.met.no/pycsw/csw.py?mode=opensearch&service=CSW&version=2.0.2&request=GetCapabilities) [http://senda1.lab-a.met.no/pycsw/csw.py?mode=opensearch&service=CSW&version=2.0.2&request=GetCapabilities]
- [All available datasets](http://senda1.lab-a.met.no/?mode=opensearch&service=CSW&version=2.0.2&request=GetRecords&elementsetname=full&typenames=csw:Record&resulttype=results) [http://senda1.lab-a.met.no/?mode=opensearch&service=CSW&version=2.0.2&request=GetRecords&elementsetname=full&typenames=csw:Record&resulttype=results]

6.3.3. User searches web portals

GeoNorge.no

TODO: describe how to search in geonorge, possibly with screenshots

6.3.4. User searches from QGIS

A staging server for the CSW catalog service is available at link: <http://senda1.lab-a.met.no:8000/>. This can be used from QGIS, as follows:

1. Select **Web > MetaSearch > MetaSearch** menu item
2. Select **Services > New**
3. Type, e.g., **senda1-lab-a** for the name
4. Type <http://senda1.lab-a.met.no> for the URL

Under the **Search** tab, you can then add search parameters, click **Search**, and get a list of available datasets.

6.4. Practical Guidance to data producers at [INSTITUTION]

This chapter includes how-to's and other practical guidance for...

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Glossary of Terms and Names

| Term | Description |
|----------------------------|---|
| Application service | TBC |
| CDM dataset | A dataset that “may be a NetCDF, HDF5, GRIB, etc. file, an OPeNDAP dataset, a collection of files, or anything else which can be accessed through the NetCDF API.” Unidata Common Data Model [https://www.unidata.ucar.edu/software/netcdf-java/v4.6/CDM/index.html] |
| Configuration metadata | See Configuration metadata definition in Table 2 |
| Controlled vocabulary | A carefully selected list of terms (words and phrases) controlled by some authority. They are used to tag information elements (such as datasets) so that they are easier to search for. (see Wikipedia article [https://en.wikipedia.org/wiki/Controlled_vocabulary]) A basic element in the implementation of the Semantic web . |
| Data Governance | Tech Target (https://searchdatamanagement.techtarget.com/definition/data-governance). An alternative definition by George Firican: “Data Governance is the discipline which provides all data management practices with the necessary foundation, strategy, and structure needed to ensure that data is managed as an asset and transformed into meaningful information.” (http://www.lightsondata.com/what-is-data-governance/ which also contains several more definitions.) |
| Data life cycle management | “Data life cycle management (DLM) is a policy-based approach to managing the flow of an information system’s data throughout its life cycle: from creation and initial storage to the time when it becomes obsolete and is deleted.” Excerpt from TechTarget [https://searchstorage.techtarget.com/definition/data-life-cycle-management] article. Alias: life cycle management |

| Term | Description |
|----------------------|---|
| Data Management Plan | “A data management plan (DMP) is a written document that describes the data you expect to acquire or generate during the course of a research project, how you will manage, describe, analyse, and store those data, and what mechanisms you will use at the end of your project to share and preserve your data.” Stanford Libraries [https://library.stanford.edu/research/data-management-services/data-management-plans] |
| Data centre | A combination of a (distributed) data repository and the data availability services and information about them (e.g., a metadata catalog). A data centre may include contributions from several other data centres. |
| Data management | How data sets are handled by the organisation through the entire value chain - include receiving, storing, metadata management and data retrieval. |
| Data provenance | “The term ‘data provenance’ refers to a record trail that accounts for the origin of a piece of data (in a database, document or repository) together with an explanation of how and why it got to the present place.” (Gupta, 2009). See also Boohers (2015) [https://www.theboohers.org/2015/03/03/provenance/] |
| Data repository | A set of distributed components that will hold the data and ensure they can be queried and accessed according to agreed protocols. This component is also known as a Data Node. |

| Term | Description |
|--------------------|--|
| Dataset | <p>A dataset is a pre-defined grouping or collection of related data for an intended use. Datasets may be categorised by:</p> <p><i>Source</i>, such as observations (in situ, remotely sensed) and numerical model projections and analyses;</p> <p><i>Processing level</i>, such as “raw data” (values measured by an instrument), calibrated data, quality-controlled data, derived parameters (preferably with error estimates), temporally and/or spatially aggregated variables;</p> <p><i>Data type</i>, including point data, sections and profiles, lines and polylines, polygons, gridded data, volume data, and time series (of points, grids, etc.).</p> <p>Data having all of the same characteristics in each category, but different independent variable ranges and/or responding to a specific need, are normally considered part of a single dataset. In the context of data preservation a dataset consists of the data records and their associated knowledge (information, tools). In practice, our datasets should conform to the Unidata CDM dataset definition, as much as possible.</p> |
| Discovery metadata | See Discovery metadata definition in Table 2 |
| Dynamic geodata | <p>Data describing geophysical processes which are continuously evolving over time. Typically these data are used for monitoring and prediction of the weather, sea, climate and environment. Dynamic geodata is weather, environment and climate-related data that changes in space and time and is thus descriptive of processes in nature. Examples are weather observations, weather forecasts, pollution (environmental toxins) in water, air and sea, information on the drift of cod eggs and salmon lice, water flow in rivers, driving conditions on the roads and the distribution of sea ice. Dynamic geodata provides important constraints for many decision-making processes and activities in society.</p> |

| Term | Description |
|-------------------------------|--|
| FAIR principles | The four foundational principles of good data management and stewardship: *F*indability, *A*ccessibility, *I*nteroperability and *R*eusability. Nature article [RD3 [https://www.nature.com/articles/sdata201618]], FAIR Data Principles [https://www.go-fair.org/fair-principles/], FAIR metrics proposal [https://github.com/FAIRMetrics/Metrics], EU H2020 Guidelines [https://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/hi/oa_pilot/h2020-hi-oa-data-mgt_en.pdf] |
| Feature type | A categorisation of data according to how they are stored, for example, grid, time series, profile, etc. It has been formalised in the NetCDF/CF feature type table [https://www.nodc.noaa.gov/data/formats/netcdf/v2.0/#templatesexamples], which currently defines eight feature types. |
| Geodataloven | "Norwegian regulation toward good and efficient access to public geographic information for public and private purposes." See Deling av geodata – Geodataloven [https://www.regjeringen.no/no/tema/planbygg-og-eiendom/plan-og-bygningsloven/kart/geodataloven/id749728/]. |
| Geonorge | "Geonorge is the national website for map data and other location information in Norway. Users of map data can search for any such information available and access it here." See Geonorge [https://www.geonorge.no/en/]. |
| Geographic Information System | A geographic information system (GIS) is a system designed to capture, store, manipulate, analyze, manage and present spatial or geographic data. (Clarke, K. C., 1986) GIS systems have lately evolved in distributed Spatial Data Infrastructures (SDI) |
| Glossary | Terms and their definitions, possibly with synonyms. |
| Interoperability | The ability of data or tools from non-cooperating resources to integrate or work together with minimal effort. |
| Linked data | A method of publishing structured data so that they can be interlinked and become more useful through semantic queries [https://en.wikipedia.org/wiki/Semantic_query], i.e., through machine-machine interactions. (see Wikipedia article [https://en.wikipedia.org/wiki/Linked_data]) |

| Term | Description |
|-----------------------------|---|
| Ontology | A set of concepts with attributes and relationships that define a domain of knowledge. |
| OpenSearch | A collection of simple formats for the sharing of search results (OpenSearch [https://github.com/dewitt/opensearch]) |
| Product | "Product" is not a uniquely defined term among the various providers of dynamical geodata, either nationally or internationally. It is often used synonymously with "dataset." For the sake of clarity, "product" is not used in this handbook. The term "dataset" is adequate for our purpose. |
| Semantic web | "The Semantic Web provides a common framework that allows data to be shared and reused across application, enterprise, and community boundaries". W3C [https://www.w3.org/2001/sw/] (see Wikipedia article [https://en.wikipedia.org/wiki/Semantic_Web]) |
| Site metadata | See Site metadata definition in Table 2 |
| Spatial Data Infrastructure | "Spatial Data Infrastructure (SDI) is defined as a framework of policies, institutional arrangements, technologies, data, and people that enables the sharing and effective usage of geographic information by standardising formats and protocols for access and interoperability." (Tonchovska et al, 2012). SDI has evolved from GIS . Among the largest implementations are: NSDI in the USA, INSPIRE in Europe and UNSDI as an effort by the United Nations. For areas in the Arctic, there is arctic-sdi.org [https://arctic-sdi.org/]. |
| Unified data management | A common approach to data management in a grouping of separate data management enterprises. |
| Use metadata | See Use metadata definition in Table 2 |
| Web portal | A central website where all users can search, browse, access, transform, display and download datasets irrespective of the data repository in which the data are held. |

| Term | Description |
|--|--|
| Web service | Web services are used to communicate metadata, data and to offer processing services. Much effort has been put on standardisation of web services to ensure they are reusable in different contexts. In contrast to web applications, web services communicate with other programs, instead of interactively with users. (See TechTerms article [https://techterms.com/definition/web_service]) |
| Workflow management | Workflow management is the process of tracking data, software and other actions on data into a new form of the data. It is related to data provenance, but is usually used in the context of workflow management systems . |
| (Scientific) Workflow management systems | A scientific workflow system is a specialised form of a workflow management system designed specifically to compose and execute a series of computational or data manipulation steps, or workflow, in a scientific application. (Wikipedia [https://en.wikipedia.org/wiki/Scientific_workflow_system]) As of today, many different frameworks exist with their own proprietary languages, these might eventually get connected by using a common workflow definition language [https://www.commonwl.org/]. |

List of Acronyms

This list contains acronyms used throughout the DMH. The column "General/Specific" indicates if the acronyms are used in the general part of the DMH (from the template) or if they are organisation specific.

| Acronym | Meaning | General/specific |
|---------|--|------------------|
| ACDD | Attribute Convention for Dataset Discovery RD5 [https://wiki.esipfed.org/Attribute_Convention_for_Data_Discovery_1-3] | |
| ADC | Arctic Data Centre (ADC [https://pm.met.no/home]) | |
| AeN | Arven etter Nansen (English: Nansen Legacy) | |
| BUFR | Binary Universal Form for the Representation of meteorological data. WMO standard format for binary data, particularly for non-gridded data (BUFR [https://www.wmo.int/pages/prog/www/WDM/Guides/Guide-binary-1A.html]) | |
| CDM | Unidata Common Data Model (CDM [https://docs.unidata.ucar.edu/netcdf-java/current/userguide/common_data_model_overview.html]) | |
| CF | Climate and Forecast Metadata Conventions (CF [http://cfconventions.org/]) | |
| CMS | Content Management System | |
| CSW | Catalog Service for the Web (CSW [https://www.ogc.org/standards/cat]) | |
| DAP | Data access protocol (DAP [https://earthdata.nasa.gov/esdis/eso/standards-and-references/data-access-protocol-2]) | |
| DBMS | DataBase Management System (DBMS [https://en.wikipedia.org/wiki/Database#Database_management_system]) | |

| Acronym | Meaning | General/specific |
|------------|---|------------------|
| DIANA | Digital Analysis tool for visualisation of geodata, open source from MET Norway (DIANA [https://github.com/metno/diana]) | |
| diana-WMS | WMS implementation in DIANA | |
| DIAS | Copernicus Data and Information Access Services (DIAS [https://www.copernicus.eu/en/access-data/dias]) | |
| DIF | Directory Interchange Format of GCMD (DIF [https://earthdata.nasa.gov/esdis/eso/standards-and-references/directory-interchange-format-dif-standard]) | |
| DLM | Data life cycle management (DLM [https://searchstorage.techtarget.com/definition/data-life-cycle-management]) | |
| DM | Data Manager | |
| DMH | Data Management Handbook (this document) | |
| DMCG | Data Management Coordination Group | |
| DMP | Data Management Plan (DMP definition [https://en.wikipedia.org/wiki/Data_management_plan], easyDMP tool [https://www.sigma2.no/data-planning]) | |
| DOI | Digital Object Identifier (DOI [https://www.doi.org/index.html]) | |
| eduGAIN | The Global Academic Interfederation Service (eduGAIN [https://edugain.org/]) | |
| ENVRI | European Environmental Research Infrastructures (ENVRI [https://envri.eu/]) | |
| ENVRI FAIR | "Making the ENV RIs data services FAIR." A proposal to the EU's Horizon 2020 call INFRAEOSC-04 | |

| Acronym | Meaning | General/specific |
|-------------|--|------------------|
| EOSC | European Open Science Cloud (EOSC [https://eosc-portal.eu/]) | |
| ERDDAP | NOAA Environmental Research Division Data Access Protocol (ERDDAP [https://coastwatch.pfeg.noaa.gov/erddap/index.html]) | |
| ESA | European Space Agency (ESA [http://www.esa.int/]) | |
| ESGF | Earth System Grid Federation (ESGF [https://esgf.llnl.gov/]) | |
| EWC | European Weather Cloud () | |
| FAIR | Findability, Accessibility, Interoperability and Reusability RD3 [https://www.nature.com/articles/sdata201618] | |
| FEIDE | Identity Federation of the Norwegian National Research and Education Network (UNINETT) (FEIDE [https://www.feide.no/]) | |
| FFI | Norwegian Defence Research Establishment (FFI [https://www.ffi.no/en]) | |
| FORCE11 | Future of Research Communication and e-Scholarship (FORCE11 [https://www.force11.org/]) | |
| GCMD | Global Change Master Directory (GCMD [https://idn.ceos.org/]) | |
| GCW | Global Cryosphere Watch (GCW [https://globalcryospherewatch.org/]) | |
| GeoAccessNO | An NFR-funded infrastructure project, 2015- (GeoAccessNO [https://www.geoaccessno.no/]) | |
| GIS | Geographic Information System | |

| Acronym | Meaning | General/specific |
|-----------|---|-----------------------|
| GRIB | GRIdded Binary or General Regularly-distributed Information in Binary form. WMO standard file format for gridded data (GRIB [https://www.wmo.int/pages/prog/www/WDM/Guides/Guide-binary-2.html]) | |
| HDF, HDF5 | Hierarchical Data Format (HDF [https://en.wikipedia.org/wiki/Hierarchical_Data_Format]) | |
| Hyrax | OPeNDAP 4 Data Server (Hyrax [https://www.opendap.org/software/hyrax-data-server]) | |
| IMR | Institute of Marine Research (IMR [https://www.hi.no/en]) | |
| INSPIRE | Infrastructure for Spatial Information in Europe (INSPIRE [https://inspire.ec.europa.eu/]) | |
| ISO 19115 | ISO standard for geospatial metadata (ISO 19115-1:2014 [https://www.iso.org/standard/53798.html]). | |
| IPY | International Polar Year (IPY [https://public.wmo.int/en/bulletin/international-polar-year-2007-2008]) | |
| JRCC | Joint Rescue Coordination centre (Hovedredningssentralen [https://www.hovedredningssentralen.no/english/]) | |
| KDVH | KlimaDataVareHus | Specific to METNorway |
| KPI | Key Performance Indicator (KPI [https://en.wikipedia.org/wiki/Performance_indicator]) | |
| METCIM | MET Norway Crisis and Incident Management (METCIM [https://metcim.no/]) | Specific to METNorway |
| METSIS | MET Norway Scientific Information System | Specific to METNorway |
| MMD | Met.no Metadata Format MMD [https://github.com/metno/mmd] | |

| Acronym | Meaning | General/specific |
|----------------|--|------------------|
| MOAI | Meta Open Archives Initiative server (MOAI [https://github.com/infrae/moai]) | |
| ncWMS | WMS implementation for NetCDF files (ncWMS [https://reading-escience-centre.github.io/ncwms/]) | |
| NERSC | Nansen Environmental and Remote Sensing Center (NERSC [https://www.nersc.no/]) | |
| NetCDF | Network Common Data Format (NetCDF [https://www.unidata.ucar.edu/software/netcdf/]) | |
| NetCDF/CF | A common combination of NetCDF file format with CF -compliant attributes. | |
| NFR | The Research Council of Norway (NFR [https://www.forskningradet.no/en/]) | |
| NILU | Norwegian Institute for Air Research (NILU [https://www.nilu.no/Forsiden/tabid/41/language/en-GB/Default.aspx]) | |
| NIVA | Norwegian Institute for Water Research (NIVA [https://www.niva.no/en]) | |
| NMDC | Norwegian Marine Data Centre, NFR-supported infrastructure project 2013-2017 (NMDC [https://nmhc.no/]) | |
| NorDataNet | Norwegian Scientific Data Network, an NFR-funded project 2015-2020 (NorDataNet [https://www.nordatanet.no/]) | |
| Norway Digital | Norwegian national spatial data infrastructure organisation (Norway Digital [https://www.geonorge.no/en/infrastructure/norway-digital/]). Norwegian: Norge digitalt [https://www.geonorge.no/Geodataarbeid/Norge-digital/] | |

| Acronym | Meaning | General/specific |
|------------|--|------------------|
| NORMAP | Norwegian Satellite Earth Observation Database for Marine and Polar Research, an NFR-funded project 2010-2016 (NORMAP [https://normap.nersc.no/]) | |
| NRPA | Norwegian Radiation Protection Authority (NRPA [https://dsa.no/en/]) | |
| NSDI | National Spatial Data Infrastructure, USA (NSDI [https://www.fgdc.gov/nsdi/nsdi.html]) | |
| NVE | Norwegian Water Resources and Energy Directorate (NVE [https://www.nve.no/english/]) | |
| NWP | Numerical Weather Prediction | |
| OAI-PMH | Open Archives Initiative - Protocol for Metadata Harvesting (OAI-PMH [https://www.openarchives.org/pmh/]) | |
| OAIS | Open Archival Information System (OAIS [https://en.wikipedia.org/wiki/Open_Archival_Information_System]) | |
| OCEANOTRON | Web server dedicated to the dissemination of ocean in situ observation data collections (OCEANOTRON [https://forge.ifremer.fr/plugins/mediawiki/wiki/oceanotron/index.php/Oceanotron_description]) | |
| OECD | The organisation for Economic Co-operation and Development. OECD [https://www.oecd.org/] | |
| OGC | Open Geospatial Consortium (OGC [https://www.ogc.org/]) | |
| OGC O&M | OGC Observations and Measurements standard (OGC O&M [https://www.ogc.org/standards/om]) | |
| OLA | Operational-level Agreement (OLA [https://en.wikipedia.org/wiki/Operational-level_agreement]) | |

| Acronym | Meaning | General/specific |
|---------|---|------------------|
| OPeNDAP | Open-source Project for a Network Data Access Protocol (OPeNDAP [https://www.opendap.org/]) - reference server implementation | |
| PID | Persistent Identifier (PID [https://en.wikipedia.org/wiki/Persistent_identifier]) | |
| RM-ODP | Reference Model of Open Distributed Processing (RM-ODP [https://en.wikipedia.org/wiki/RM-ODP]) | |
| PROV | A W3C Working Group on provenance and a Family of Documents (PROV [https://www.w3.org/TR/prov-overview/]) | |
| SAON | Sustaining Arctic Observing Networks (SAON/IASC [https://iasc.info/data-observations/saon/]) | |
| SDI | Spatial Data Infrastructure | |
| SDN | SeaDataNet [https://www.seadatanet.org/], Pan-European infrastructure for ocean & marine data management | |
| SIOS | Svalbard Integrated Arctic Earth Observing System | |
| SIOS-KC | SIOS Knowledge Centre, an NFR-supported project 2015-2018 (SIOS-KC [https://www.sios-svalbard.org/KnowledgeCentre/]) | |
| SKOS | Simple Knowledge Organization System (SKOS [https://www.w3.org/2004/02/skos/]) | |
| SLA | Service-level Agreement (SLA [https://en.wikipedia.org/wiki/Service-level_agreement]) | |
| SolR | Apache Enterprise search server with a REST-like API (SolR [https://lucene.apache.org/solr/]) | |

| Acronym | Meaning | General/specific |
|-----------|---|-----------------------|
| StInfoSys | MET Norway's Station Information System | Specific to METnorway |
| TDS | THREDDS Data Server (TDS [https://www.unidata.ucar.edu/software/tds/current/]) | |
| THREDDS | Thematic Real-time Environmental Distributed Data Services | |
| UNSDI | United Nations Spatial Data Infrastructure (UNSDI [https://en.wikipedia.org/wiki/United_Nations_Spatial_Data_Infrastructure]) | |
| UUID | Universally Unique Identifier (UUID [https://en.wikipedia.org/wiki/Universally_unique_identifier]) | |
| W3C | World Wide Web Consortium (W3C [https://www.w3.org/]) | |
| WCS | OGC Web Coverage Service (WCS [https://www.ogc.org/standards/wcs]) | |
| WFS | OGC Web Feature Service (WFS [https://www.ogc.org/standards/wfs]) | |
| WIGOS | WMO Integrated Global Observing System (WIGOS [https://community.wmo.int/activity-areas/wigos]) | |
| WIS | WMO Information System (WIS [https://community.wmo.int/activity-areas/wis]) | |
| WMO | World Meteorological Organisation (WMO [https://public.wmo.int/en]) | |
| WMS | OGC Web Map Service (WMS [https://www.ogc.org/standards/wms]) | |
| WPS | OGC Web Processing Service (WPS [https://www.ogc.org/standards/wps]) | |
| YOPP | Year of Polar Prediction (YOPP Data Portal [https://yopp.met.no/metadata_search]) | |

Appendix A: List of Referenced Software or Services

| Name | Description | Reference |
|----------------------------------|--|--|
| Fimex package including fimex | File Interpolation, Manipulation and EXtraction library for gridded geospatial data | wiki.met.no documentation [https://wiki.met.no/fimex/start] github repository [https://github.com/metno/fimex] |
| frost2nc | Dump observational time series from KDVH to NetCDF files | github repository [https://github.com/metno/frost2nc] |
| met_moai | OAI-PMH implementation based on MOAI | github repository [https://github.com/metno/met_moai] |
| mdharvest | Perl and Python code to harvest discovery metadata using OAI-PMH, OpenSearch and OGC CSW | github repository [https://github.com/steingod/mdharvest] |
| METSIS-data -ingestion | A generic utility to index MMD dataset, thumbnails to SolR . | github repository: metsis-metadata [https://github.com/metno/metsis-metadata] |
| METSIS-data -drupal | A module linking the METSIS back-end services to the Drupal CMS | github repository: metsis-metadata [https://github.com/metno/metsis-metadata] |
| METSIS-station-handling | TBC | TBC |
| METSIS-ts | WPS or HTTP interface to graphical diagrams. | Not yet openly available, but beta-version is in use in ADC, SIOS, GCW, NorDataNet, YOPP and APPLICATE portals. |
| MMD XSD | XML Schema document for MMD | github repository: mmd [https://github.com/metno/mmd] |
| nc_to_mmd.py | Builds MMD metadata from ACDD -compliant NetCDF file attributes. | github repository: py-mmd-tools [https://github.com/metno/py-mmd-tools/tree/master/py_mmd_tools] |
| NorDataNet validator | Validates NetCDF files for CF and ACDD compliance. | Access URL [https://nordatanet.metsis.met.no/user/login?destination=dataset_validation/form] |
| threddsIso | Extracting discovery metadata from NetCDF/CF files with ACDD to ISO 19115 | github repository [https://github.com/Unidata/threddsIso] |

Appendix B: Users of [insert institution]'s data

Users are divided into categories by type of collaboration with [insert institution], not by type of service they consume.

| User category | Description | Examples |
|---------------|-------------|----------|
| | | |

Global attributes

In order to add netCDF-CF datasets to the discovery metadata catalog, the data producer should populate the file with certain global attributes mainly described in the Attribute Convention for Data Discovery (ACDD). For a complete description of the ACDD elements, please refer to http://wiki.esipfed.org/index.php/Attribute_Convention_for_Data_Discovery.

The ACDD recommendations should always be followed in order to properly document your netCDF-CF files. However, the below tables summarize the ACDD and some additional attributes that are needed to properly populate a discovery metadata catalog which fulfills the requirements of international standards (e.g., GCMD/DIF, the WMO profile of ISO19115, etc.).

Notes

Keywords describe the content of your dataset following a given vocabulary. It should be provided as a comma separated list with a short name defining the vocabulary used followed by the actual keyword, i.e., `short_name:keyword`. Example:

```
:keywords = "GCMDSK:Earth Science > Atmosphere > Atmospheric radiation, NORTHEMES:Weather and climate" ;
```

In addition, `keywords_vocabulary` provides information about the vocabulary defining the keywords. Example:

```
:keywords_vocabulary = "GCMDSK:GCMD Science
Keywords:https://gcmd.earthdata.nasa.gov/kms/concepts/concept_scheme/sciencekeywords,
GCMDPROV:GCMD
Providers:https://gcmd.earthdata.nasa.gov/kms/concepts/concept_scheme/providers,
GCMDLOC:GCMD
Locations:https://gcmd.earthdata.nasa.gov/kms/concepts/concept_scheme/locations" ;
```

See <https://adc.met.no/node/96> for more information about how to define the ACDD keywords.

A data **license** provides information about any restrictions on the use of the dataset. To support a linked data approach, the `license` element should be supported by a `license_resource` element, providing a link to the license definition. Example:

```
:license = "CC-BY-4.0" ;
:license_resource = "http://spdx.org/licenses/CC-BY-4.0" ;
```

List of Attributes

This section provides lists of ACDD elements that are required and recommended, as well as some extra elements that are needed to fully support our data management needs. The right columns of these tables provide the [MET Norway Metadata Specification \(MMD\)](https://htmlpreview.github.io/?https://github.com/metno/mmd/blob/master/doc/mmd-specification.html) [https://htmlpreview.github.io/?https://github.com/metno/mmd/blob/master/doc/mmd-specification.html] fields that map to the ACDD (and our extension to ACDD) elements. Please refer to [MMD](https://htmlpreview.github.io/?https://github.com/metno/mmd/blob/master/doc/mmd-specification.html) [https://htmlpreview.github.io/?https://github.com/metno/mmd/blob/master/doc/mmd-specification.html] for definitions of these elements, as well as controlled vocabularies that should be used. Note that the below tables are automatically generated - check https://github.com/metno/py-mmd-tools/blob/master/py_mmd_tools/mmd_elements.yaml if anything is unclear.

The following ACDD elements are required:

| ACDD Attribute | Repetition | MMD equivalent |
|------------------------|--|---------------------------------------|
| id | No repetition allowed | metadata_identifier |
| date_created | Use date_metadata_modified with comma separation | last_metadata_update>update>date_time |
| date_metadata_modified | Use date_metadata_modified with comma separation | last_metadata_update>update>date_time |
| title | Use ACDD extension for translations | title>title |
| summary | Use ACDD extension for translations | abstract>abstract |
| geospatial_lat_max | No repetition allowed | geographic_extent>rectangle>north |
| geospatial_lat_min | No repetition allowed | geographic_extent>rectangle>south |
| geospatial_lon_max | No repetition allowed | geographic_extent>rectangle>east |
| geospatial_lon_min | No repetition allowed | geographic_extent>rectangle>west |
| keywords | Comma separated list | keywords>keyword |
| keywords_vocabulary | Comma separated list | keywords>vocabulary |

The following ACDD elements are recommended:

| ACDD Attribute | Repetition | Default | MMD equivalent |
|---------------------|----------------------|---------|----------------------------|
| time_coverage_start | Comma separated list | | temporal_extent>start_date |

| | | | |
|---|--------------------------|---------------|---|
| time_coverage_end | Comma separated list | | temporal_extent>end_date |
| geospatial_bounds | No repetition allowed | | geographic_extent>polygon |
| processing_level | No repetition allowed | | operational_status |
| license | No repetition allowed | | use_constraint>identifier |
| ['creator_role', 'contributor_role'] | Comma separated list | Investigator | personnel>role |
| ['creator_name', 'contributor_name'] | Comma separated list | Not available | personnel>name |
| creator_email | Comma separated list | Not available | personnel>email |
| creator_institution | Comma separated list | Not available | personnel>organisation |
| institution | Comma separated list | | data_center>data_center_name>short_name |
| institution | Comma separated list | | data_center>data_center_name>long_name |
| publisher_url | Comma separated list | | data_center>data_center_url |
| project | Semicolon separated list | | project>short_name |
| project | Semicolon separated list | | project>long_name |
| platform | Comma separated list | | platform>short_name |
| platform | Comma separated list | | platform>long_name |
| platform_vocabulary | Comma separated list | | platform>resource |
| instrument | Comma separated list | | platform>instrument>short_name |
| instrument | Comma separated list | | platform>instrument>long_name |
| instrument_vocabulary | Comma separated list | | platform>instrument>resource |
| source | Semicolon separated list | | activity_type |
| creator_name | Comma separated list | | dataset_citation>author |
| date_created | Comma separated list | | dataset_citation>publication_date |
| title | | | dataset_citation>title |
| publisher_name | Comma separated list | | dataset_citation>publisher |
| metadata_link | Comma separated list | | dataset_citation>url |
| references | Comma separated list | | dataset_citation>other |

The following elements are ACDD extensions that are needed to improve (meta)data interoperability. Please refer to the documentation of [MMD](https://htmlpreview.github.io/?https://github.com/metno/mmd/blob/master/doc/mmd-specification.html) [https://htmlpreview.github.io/?https://github.com/metno/mmd/blob/master/doc/mmd-specification.html] for more details:

| Extra Attribute | Repetition | Default | MMD equivalent |
|---|-------------------------------------|---------------|----------------------------------|
| date_created_type | Comma separated list | Created | last_metadata_update>update>type |
| collection | Comma separated list | | collection |
| ['title_no'] | Use ACDD extension for translations | | title>title |
| title_lang | No repetition allowed | en | title>lang |
| ['summary_no'] | Use ACDD extension for translations | | abstract>abstract |
| summary_lang | No repetition allowed | en | abstract>lang |
| dataset_production_statuses | No repetition allowed | | dataset_production_statuses |
| access_constraint | No repetition allowed | | access_constraint |
| license_resource | No repetition allowed | | use_constraint>resource |
| contributor_email | Comma separated list | Not available | personnel>email |
| ['contributor_institution', 'contributor_organisation'] | Comma separated list | Not available | personnel>organisation |
| related_dataset_id | Comma separated list | | related_dataset>id |
| related_dataset_relation_type | Comma separated list | | related_dataset>relation_type |
| iso_topic_category | Comma separated list | | iso_topic_category |
| spatial_representation | No repetition allowed | | spatial_representation |