PAN-EUROPEAN INFRASTRUCTURE FOR OCEAN & MARINE DATA MANAGEMENT

SeaDataNet

DATAFILE FORMATS

ODV, MEDATLAS, NETCDF
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Long title	
Description of data file formats for SeaDataNet	
Short description	
This document specify the data file format in used for data exchange in SeaDataNet. ODV (Ocean Data View) and NetCDF format are mandatory, whereas MEDATLAS is optional. This document describes the following versions of the SeaDataNet formats **SeaDataNet ODV import format 0.4** **SeaDataNet MEDATLAS format2.0** **SeaDataNet CFPOINT (CF NetCDF)1.0**	
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History

Version	Authors	Date	Comments
0.1	R. Lowry	2008-01-24	Initial ODV format description
0.3	R. Lowry M. Fichaut R. Schlitzer	2008-05-19	MEDATLAS section added (M. Fichaut) Minor changes to ODV section to re-order metadata parameters (R. Schlitzer) CF NetCDF section added (R. Lowry)
0.5	R. Schlitzer	2009-02-12	Update to rules for assigning value to data row type column
0.6	R. Lowry	2009-02-12	ISO8601 time strings allowed as an alternative to Chronological Julian Day and default option for 'type' incorporated.
0.7	R. Lowry	2009-08-05	Section on spatio-temporal co-ordinate conventions added
0.8	R. Schlitzer	2010-01-12	Guidance on ISO8601 precision representation changed and specific mention of Latin-1 character set restriction included.
1.0	R. Lowry	2012-08-31	Complete NetCDF format specifications added
1.0.1	R. Lowry	2012-10-18	NetCDF: Corrections for inconsistent labelling of attributes and PRESSURE variable name changed to PRES for OceanSITES compatibility.
1.0.2	R. Lowry	2012-11-01	Inconsistencies in naming rules for z co-ordinate NetCDF variables.
1.0.3	R. Lowry	2012-12-13	NetCDF: Versioning removed from SeaDataNet flag controlled vocabulary reference.
1.0.4	R. Lowry	2013-01-08	NetCDF: SDN_BOT_DEPTH:longname value in section 3.5.2 corrected. All references to 'crs_' replaced by 'crs:'.

1.0.5	R. Lowry	2013-01-15	NetCDF: Attributes linking LATITUDE and LONGITUDE variables to their co-ordinate reference system definition added
1.0.6	R. Lowry	2013-02-06	NetCDF: Units attribute switched to American spelling - meters, not metres. Section on usage of NVS V2 URNs in NetCDF added
1.0.7	M. Fichaut	2013-02-07	Change of http address of ODV and Medatlas examples
1.1	R. Lowry	2013-02-20	New Standard name used for pressure. ODV and MEDATLAS vocabulary references converted from NDG V1 to NDG V2. Initial public version with NetCDF.
1.1.1	R. Lowry	2013-04-04	<SDN_REFERENCES> header comments added to ODV format. Minor syntax correction (timeSeries_id replaced by timeseries_id) in NetCDF time series example.
1.2	M. Fichaut, G. Maudire	2014-03-14	Addition of NetCDF format for underway ADCP data
1.3	R. Lowry	2014-04-09	Addition of timeSeriesProfile feature type and rewriting underway ADCP to be an example of trajectoryProfile feature type. Restoration of emboldening for mandatory content in CDL examples. Instrument references from L22 vocabulary added to ODV and NetCDF formats. Linkage to WMO C3 vocabulary for XBT data added to ODV format. Typed SDN_REFERNCES linkage, plus the option of multiple linkages in a single file, added to ODV and NetCDF specifications.
1.4	M. Fichaut	2014-04-16	Changes on table of §3.2 Add depth as possible primary variable for MEDATLAS files DATE (mmdd) MEDATLAS parameter not available anymore in time series
1.5	R. Lowry	2014-05-07	External resource linkages more fully described and xlink mechanism proposed by Thomas Loubrieu implemented in both ODV and NetCDF formats.
1.6	M. Fichaut	2014-05-14	MEDATLAS format : Precision on the LOCAL_CDI_ID and addition of the external resources linkages
1.7	R. Lowry	2014-05-28	sdn_reference element extended to cover multiple station files. Minor change to CF conventions attribute (CF-1.6 to CF 1.6) to conform to CF checker. Additional note on data typing.
1.8	R. Lowry	2014-05-28	Colon replaces underscore as the delimiter in the value for the sdn:scope attribute.
1.9	M.Fichaut	2014-07-07	Add L33 for fall rate element.
1.10	S. Brégent	2014-08-04	§4.5.1.4 fixed SDN_XLINK attribute declaration: SDN_XLINK:long_name instead of SDN_XLINK_TYPE:long_name §3.3 fixed sdn_reference examples: added quotes

1.11	R. Lowry	2014-09-03	Explanatory note on handling character data in SeaDataNet NetCDF.
1.12	M.Fichaut	2014-11-17	Unique definition of EDMO-Code = the organisation hosting the Download Manager (CDI_partner)
1.13	R. Lowry	2014-12-11	Updated to allow variable precision dates/times in the metadata section of the ODV file.
1.14	S. Bregent	2015-03-13	§2.3.2: Move ODV/CFPoint SDN references equivalence into CFPoint chapter (§4.4.9). §4.4.1: Add link to §4.4.7 for STRINGx dimensions explanations
1.15	S. Bregent	2015-03-18	§4: fix variable name in CDL examples, for instrument linkages examples lines
1.16	M. Fichaut	2015-05-18	Delete all reference to fixed string length to 80 bytes §4.3 and replace STRING8x by STRINGx in § 4.4.1
1.17	M. Fichaut	2015-06-18	Change http links for ODV and MEDATLAS examples §2.5 and §3.4 Add links for netCDF examples §4.6
1.18	M. Fichaut	2017-07-19	Correct time ISO format replace 'mi' by 'mm' in §2.2 and 'yyyy-mm-dd' by 'YYYY-MM-DD' in §2.3.4 and §2.3.5
1.19	M. Fichaut	2018-02-21	Checks of all Http links and correction of the broken ones Correction of incoherencies concerning SDN_BOT_DEPTH • Change last sentence of §4.3 • Add SDN_BOT_DEPTH in CDL examples of §4.5.3.4 and §4.5.5.4

Content

1. Vocabulary URN Versioning

This document has been written since the introduction of Version 2 of the NERC Vocabulary server, which has a closely related, but nevertheless slightly different, syntax for URNs used to reference concepts and vocabularies than the one used in the previous version. For example, the V1 URN SDN:P011:53:TEMPPR01 is replaced in V2 by SDN:P01::TEMPPR01. It is important to realise that V2 URNs may be derived from V1 by a fixed string-slicing algorithm and that V2 URNs are also valid V1 URNs. The string slicing algorithm (PL/SQL) is:

```
V2_URN = SUBSTR (V1_URN,1,7)||'::'||SUBSTR(V1_URN,INSTR(V1_URN,':',1,3)+1))
```

The reason for this change is that an unforeseen consequence of the way labels were constructed in NVS V1 was that every concept ended up with a plethora of possible URNs. Having just one unique reference to each concept is an obvious rule that should not have been broken and needed to be repaired. The corrective solution adopted was to choose one of the possible V1 URNs for V2. Unfortunately the back office architecture forced a change from the syntax that had been adopted by SeaDataNet.

The SeaDataNet Technical Task Team have agreed a 'mixed-economy' approach for the migration in which tools that read pre-existing SeaDataNet files will work equally well with V1 and V2 URNs. Tools that generate SeaDataNet files will be updated so that only V2 URNs are produced. Whilst tools that do a V1 to V2 conversion will be made available, conversion of existing file stock from V1 to V2 will not be obligatory. Note that as no SeaDataNet NetCDF with V1 URNs has ever been produced, there is no requirement for tools that read SeaDataNet NetCDF to offer 'mixed- economy' support.

2. SeaDataNet ODV import format

2.1. Introduction

The SeaDataNet ODV import format is a version of the ODV version 4 generic spreadsheet format modified with some of the flexibility removed and to carry additional information required by SeaDataNet. Within the SeaDataNet Version 1 transaction process each CDI record maps to a single physical file in this format. The entity for the Version 1 CDI data model is defined as discrete profiles or instrument time series records. Consequently each physical file will contain data of a single 'type' (bottle, CTD, etc.) from a single station at the time of the transaction.

This will inevitably result in large numbers of small files from some requests. Whilst the transport inefficiencies of this may be addressed by rolling the data files in some type of zip file, this fails to address the logistical problem of loading large numbers of files into an ODV collection. Consequently, the file format has been designed to be able to hold multiple SeaDataNet data objects within a single physical file providing they conform to the same logical structure (i.e. providing they contain the same data columns). It is anticipated that tooling will be developed centrally to aggregate collections of transaction files and to split aggregated files into individual data objects.

2.2. The ODV Format Data Model

The fundamental data model underlying the format is the spreadsheet: i.e. a collection of rows each having the same fixed number of columns. There are three different types of column:

- Metadata columns

- Primary variable data columns (one column for the value plus one for the qualifying flag)
- Data columns

The metadata columns are stored at the left hand end of the row, followed by the primary variable columns and then the data columns.

There are three different types of row:

- Comment rows
- Column header row
- Data row

Data rows with exactly the same metadata parameters are grouped together and termed 'stations' in ODV. This is highly confusing in the SeaDataNet context because the term 'station' is also used for a SeaDataNet data object (the CDI record entity). Whilst ODV 'stations' and SeaDataNet 'stations' map one-to-one for most types of data, this is not always the case. Consequently, for the sake of clarity in this document ODV 'stations' will be called 'row_groups' and SeaDataNet 'stations' will be called 'data objects'.

Data of different 'shapes' (profiles, time series and trajectories) are mapped onto this data model thus:

- Profile data, such as CTD or bottle data, have row_groups made up of measurements at different depths. The metadata date and time are set to the time when the profile measurement started. The primary variable is the 'z co-ordinate', which for SeaDataNet is either depth in metres or pressure in decibars. Rows within the row_group are ordered by increasing depth.

- Point time series, such as current meter or sea level data, have row_groups made up of measurements from a given instrument at different times. The metadata date and time are set to the time when the first measurement was made. The primary variable is time (UT) encoded either as:

  - A real number representing the Chronological Julian Date, which is defined as the time elapsed in days from 00:00 on January 1st 4713 BC. If this option is chosen then the column must have the heading 'Chronological Julian Date [days]'.

    Note: The associated storage unit from the SeaDataNet P06 vocabulary (http://vocab.nerc.ac.uk/collection/P06/current) is SDN:P06::UTAA .

  - A string containing the UT date and time to sub-second precision corresponding to ISO8601 syntax (YYYY-MM-DDThh:mm:ss.sss) for example 2009-02-12T11:21:10.325. If this option is chosen, the column must have the heading 'time_ISO8601'.

  If the time is not known to sub-second precision then use the ISO8601 form appropriate to the known precision. For example, a timestamp to the precision of one hour would be represented by 2009-02-12T11:00 and a time stamp to a precision of a day by 2009-02-12.

  Note: The associated storage unit from the SeaDataNet P06 vocabulary (http://vocab.nerc.ac.uk/collection/P06/current/) is SDN:P06::TISO

Rows within the row_group are ordered by increasing time. Note that the z co-ordinate (e.g. instrument depth), essential for many types of time series data, needs to be stored as a data variable and could have the same value throughout the row_group.

- Trajectories, such as underway data, have row_groups made up of a single measurement making the metadata time and positions the spatio-temporal co-ordinate channels. The primary variable is the 'z co-ordinate', which for SeaDataNet is standardised as depth in metres. Rows within the row_group are ordered by increasing time.

2.3. Encoding

Character encoding: ASCII restricted to the ISO/IEC 8859-1 (commonly referred to as Latin 1) character set (http://en.wikipedia.org/wiki/ISO/IEC_8859-1).
Column separator: Tab (ASCII code 09 hex)
Comment lines: Identified by // characters at the beginning
File extension: .txt

Each file is made up of five parts:

- User comments
- External References
- SeaDataNet semantic header
- Column header row
- Data rows

2.3.1. User Comments

These are prefixed by the characters // and may appear anywhere in the data file other than within the SeaDataNet semantic header.

It is strongly recommended that user comment records be used to enrich the data files with additional usage metadata. This may be included as plain language documents, URLs to relevant on-line documentation or more structured content such as XML 'snippets'.

2.3.2. Linkages to External Resources

These are optional standard comment records that provide links to web resources related to the data in the file. If present, they must be placed before the semantic header comment records. The syntax for these records is:

//<SDN_REFERENCES>URI

The URI may be either a URN, such as a Digital Object Identifier (DOI), an http URL or a null string. If it is a URN then the namespace must be included. For example, DOIs must be prefixed by 'doi:'. The URI must resolve to a 'landing page' - i.e. an XHTML document - containing additional information such as usage metadata or further links to such information. Only one SDN_REFERENCES comment is allowed in an ODV file. If the ODV file contains multiple 'stations' then the SDN_REFERENCES link is considered to be equally applicable to all stations in the file.

Examples of valid external resource linkage records using the SDN_REFERENCES mechanism are:

//<SDN_REFERENCES>
//<SDN_REFERENCES>doi:10.5285/41479c42-4dfb-4da9-be97-4c532ce13922
//<SDN_REFERENCES>https://www.bodc.ac.uk/data/documents/series/436972/

The SDN_REFERENCES mechanism was considered insufficient as there was no information in the data files to inform software agents what to expect at the end of the URI and insufficient control over landing page content to guarantee that it would be provided elsewhere. Consequently, a second mechanism based on the xlink syntax has been introduced. This allows any number of resources to be linked to an ODV data file. Unlike SDN_REFERENCES, which can point indirectly to a suite of resources, each comment record only points to a single resource. Consequently, it has been given the singular name 'sdn_reference'.

Each <sdn_reference> element is formatted according to the following model:

//<sdn_reference xlink:type=URN xlink:role=text xlink:href=URI
sdn:scope=EDMO_code||':'||LOCAL_CDI_ID/>

The xlink:href is mandatory, whilst xlink:type and xlink:role are optional. It is either a URL or a URN including namespace.

The xlink:type attribute specifies the XML document type using the URN of that document type in the L23 vocabulary. For example, SDN:L23::CDI specifies a Common Data Index document and SDN:L23::CSR specifies a Cruise Summary Report document. If xlink:type is omitted then the document type to which the URI resolves is assumed to be XHTML.

The xlink:role indicates the purpose of the document. The following roles are allowed:

isDescribedBy CDI document or controlled vocabulary concept document
isObservedBy CSR document or EDIOS series document

The sdn:scope attribute indicates the 'station' - i.e. the data described by a CDI - for which the sdn_reference is relevant. The attribute value is constructed by concatenating the EDMO_code and LOCAL_CDI_ID for the series, separated by a colon (e.g. 43:955698 for BODC CDI 955698). If the sdn:scope attribute is missing then the sdn_reference is considered to be applicable to all stations in the file.

Example <sdn_reference> elements are:

//<sdn_reference xlink:type="SDN:L23::CDI" xlink:role="isDescribedBy"
xlink:href="http://seadatanet.maris2.nl/v_cdi_v3/print_xml.asp?edmo=486&identifier=8575"
sdn:scope="486:8575"/>

//<sdn_reference xlink:href="doi:10.5285/41479c42-4dfb-4da9-be97-4c532ce13922"/>

Note that this provides exactly the same functionality as:

//<SDN_REFERENCES>doi:10.5285/41479c42-4dfb-4da9-be97-4c532ce13922

This duplication was necessary to provide backward compatibility.

The equivalent to the SDN_REFERENCES and sdn_reference in the NetCDF format are the SDN_REFERENCES and SDN_XLINK arrays. See 4.4.9.

2.3.3. SeaDataNet Semantic Header

This is a set of 'special' mandatory comment lines that must appear before the column header row. Their function is to map the text strings used to label the metadata and data columns to standardized SeaDataNet concepts, which is necessary if data files from different sources are to be combined in a meaningful way.

The header begins with the line:

//SDN_parameter_mapping

This is followed by a line for each DATA column, including the primary variable, made up from three parts, each tagged to look like an XML element:

subject element	This contains the text used to label the column EXACTLY as it appears in the column row header WITHOUT the units declaration prefixed by the text 'SDN:LOCAL:' to encode it as a SeaDataNet URN. Don't worry if you don't know what this is, just include the text prefix and all will be well.
object element	This contains the URN to a concept from the SeaDataNet P01 vocabulary (http://vocab.nerc.ac.uk/collection/P01/current/accepted– warning contains over 25000 terms). Again, if you don't understand what this all means, just prefix the appropriate code from P01 with the text 'SDN:P01::' and all will be well.
units element	This contains a URN for the storage units used IN THE FILE for the data column in the SeaDataNet P06 vocabulary (http://vocab.nerc.ac.uk/collection/P06/current/). It is NOT the code for units linked in past versions of the P01 vocabulary to the parameter code (these are the units BODC uses, which is not an obligation for SeaDataNet). Again, if you don't understand what this all means, just prefix the appropriate code from P06 with the text 'SDN:P06::' and all will be well.
instrument element	This contains the URN for the device used to measure the parameter taken from the SeaVoX L22 vocabulary (http://vocab.nerc.ac.uk/collection/L22/current/. Again, if you don't understand what this all means, just prefix the appropriate code from L22 with the text 'SDN:L22::' and all will be well.
fall_rate element	This element is specifically designed for XBT data and it contains the URN for the XBT probe type and the fall rate equation applied to obtain the z co-ordinate values for the data from the Seavox L33 vocabulary (http://vocab.nerc.ac.uk/collection/L33/current/). L33 is done from WMO C3 vocabulary of XBT data types.

The 'subject', 'object' and 'units' elements are mandatory. The 'instrument' and 'fall_rate' elements are optional.

The following are examples of valid data column semantic descriptions:

```
//<subject>SDN:LOCAL:Depth</subject><object>SDN:P01::ADEPZZ01</object><units>SDN:P06::ULAA</units>
//<subject>SDN:LOCAL:Temperature</subject><object>SDN:P01::TEMPS901</object><units>SDN:P06::UPAA</units><instr
ument>SDN:L22::TOOL0002</instrument>
//<subject>SDN:LOCAL:Depth</subject><object>SDN:P01::ADEPZZ01</object><units>SDN:P06::ULAA</units>><instrument
>SDN:L22::TOOL0262</instrument><fall_rate>SDN:L33::011</fall_rate>
//<subject>SDN:LOCAL:Salinity</subject><object>SDN:P01::PSALST01</object><units>SDN:P06::UUUU</units>
//<subject>SDN:LOCAL:Oxygen</subject><object>SDN:P01::DOXYCZ01</object><units>SDN:P06::KGUM</units>
//<subject>SDN:LOCAL:Phosphate</subject><object>SDN:P01::PHOSZZXX</object><units>SDN:P06::KGUM</units>
//<subject>SDN:LOCAL:Silicate</subject><object>SDN:P01::SLCAZZXX</object><units>SDN:P06::KGUM</units>
//<subject>SDN:LOCAL:Nitrate</subject><object>SDN:P01::NTRAZZXX</object><units>SDN:P06::KGUM</units>
```

The semantic descriptions are terminated by an empty comment record (i.e. a record containing the // characters and nothing else)

2.3.4. Column Header Row

This contains a label for each column of the file. The leftmost columns are the metadata columns, followed by the data column pairs (a data column plus a qualifying flag column). The following metadata column header labels are mandatory and must be included EXACTLY as written or (in the case of time) specified.

Cruise
Station
Type
The ISO8601 format mask appropriate for the precision to which the date and time is quoted e.g. 'YYYY-MM-DDThh:mm:ss.sss' or 'YYYY-MM-DD', etc.
Longitude [degrees_east]
Latitude [degrees_north]
LOCAL_CDI_ID
EDMO_code
Bot. Depth [m]

These standardized metadata column headings are followed by pairs of column headings, with one pair for the primary variable followed by one pair for each data parameter. The first heading in each pair is the description for the data parameter plus its storage units enclosed in brackets, such as ‘Salinity [psu]’. The second heading in each pair is always ‘QV:SEADATANET’.

2.3.5. Data Row

The metadata columns are populated as follows:

Cruise — A text string identifying the grouping label for the data object to which the data row belongs. This will obviously be the cruise name for data types such as CTD and bottle data, but could be something like a mooring name for current meter data.

Station — A text string identifying the data object to which the data row belongs. This will be the station name for some types of data, but could also be an instrument deployment identifier.

Type — The type of data. Set to 'C' for CTD and XBT profile data and 'B' for bottle profile data. For other data types (e.g., time series, trajectories, etc.) set to ‘B’ for small (<250 rows) row_groups or ‘C’ for larger row_groups. Alternatively it can be set to a default value of '*'.

ISO8601 format mask — Date and time (UT time zone) when the sample was collected or measurement was made in ISO8601 format corresponding to the mask in the header row such as 2008-04-23T15:15:00.000for ''YYYY-MM-DDThh:mm:ss.sss ' or 2008-04-23 for ''YYYY-MM-DD''.

Longitude [degrees_east] — Longitude as decimal degrees where the sample was collected or measurement was made.

Latitude [degrees_north] — Latitude as decimal degrees where the sample was collected or measurement was made.

LOCAL_CDI_ID — The local identifier of the Common Data Index record associated with the data row. The maximum size allowed for this parameter is 80 bytes.

EDMO_code — The key identifying the organisation hosting the Download Manager (CDI_partner) given in the European Directory of Marine Organisations (EDMO).

Bot. Depth [m] — Bathymetric water depth in metres where the sample was collected or measurement was made. Set to zero if unknown or inapplicable.

As metadata values are constant throughout a row_group it is usual practice just to populate the first row.

The metadata values are followed by the primary variable value, its flag and then the data value plus qualifying flag pairs for each parameter. Flag values are taken from the SeaDataNet vocabulary for qualifying flags
(L20 at http://vocab.nerc.ac.uk/collection/L20/current).

If there is no data value then the data value column is left blank with the flag field set to ‘9’.

2.4. Spatio-temporal Co-ordinate Conventions

There are many different ways to express time and position. For times there is the issue of time zone and for positions there is a bewildering array of possible co-ordinate reference systems (CRS). There are two possible strategies for addressing this. The first is to have a fully descriptive format that includes explicit statements of time zone and CRS. The second is to specify the time zone and CRS that must be used.

For pragmatic reasons SeaDataNet has adopted the latter approach. Whilst the full ISO8601 syntax addresses time zone, we are also allowing CJD data format which does not. In the case of position, whilst it is possible to build CRS conversions into data tooling, this is a major task considered beyond SeaDataNet's current resources.

Consequently, all times in SeaDataNet data files are presented as universal time (UT) and all positions are presented such that tools may assume the WGS84 CRS. This means that positions with known CRS must be transformed to WGS84 prior to output to the file. Data for which the CRS is unknown are of insufficient accuracy for the assumption of WGS84 to be significant and are therefore output unmodified.

2.5. Example Files

Example data files for profiles, time series and trajectories are available on SeaDataNet web site at:
https://www.seadatanet.org/content/download/635/3328/file/SDN_D85_WP8_ODV_files_examples.zip

3. SeaDataNet MEDATLAS Format

3.1. Introduction

The MEDATLAS format - vertical profiles is an auto-descriptive ASCII format. It has been designed in 1994, in conformity with the international ICES/IOC GETADE recommendations, to fulfil the following requirements:

- To facilitate the reading of the data, (and not to optimize the data archiving on the magnetic medium, neither to speed up the data processing).
- To be independent of the computer.
- To keep track of the history of the data including the data collection and the processing. Therefore metadata on cruise must be documented.
- To allow the processing of profile independently. Therefore the date, time and geographical co-ordinate must be reported on each profile header.
- To be flexible and accept (almost) any number of different parameters.
- The real numbers (floating numbers must remain in the same way as they have been transmitted, not re-formatted into integer numbers). The number of decimals must implicitly indicate the accuracy of the measurements.

These requirements have been taken into account in the MEDATLAS exchange format which has been designed by the MEDATLAS and MODB consortia, in the frame of the European MAST II program. The format has been reviewed and extended for processing time series in the following MTPII/MATER project and for other international projects.

The general format description is available at:
http://en.data.ifremer.fr/All-about-data/Gestion-des-donnees/Formats/MEDATLAS-Format

3.2. The MEDATLAS Format Data Model

MEDATLAS format can support files with 1 to n stations. A MEDATLAS "station" can be a vertical profile, a time-series or a trajectory. The "Data Type" of the station header, which is aC77 code corresponding to an instrument, makes the difference. This station "Data Type" can take the following values:

C77 code	C77 name	Type
B73	Sediment traps	Time-series
D01	Current meters	Time-series
D05	Surface drifters/drifting buoys	Trajectory
D06	Neutrally buoyant floats	Trajectory
D09	Sea level (incl. bottom p. IES)	Time-series
D71	Current profiler (eg ADCP)	Vertical profile or Trajectory
D72	Instrumented wave measurements	Time-series
H09	Water bottle stations	Vertical profile
H10	CTD stations	Vertical profile
H11	Subsurface temperature and salinity measurements	Trajectory or Time series
H13	Bathythermograph	Vertical profile
H71	Surface measurements underway (T,S)	Trajectory
H72	Subsurface temperature measurements	Trajectory or Time-series
M90	Other meteorological measurements	Trajectories or Time series

Within one MEDATLAS file containing several stations, the station Data Type is unique per station and must be the same for all the stations in the file.

The data model underlying the format is an ASCII file divided into 3 parts:

- Cruise header : only one cruise header per MEDATLAS file
- Station header : 1 to n station headers per MEDATLAS file depending on the number of stations in the file
- Measured parameters in columns: 1 to n measured parameters part per MEDATLAS file depending on the number of stations in the file.

Part 2 and 3 are linked and are repeated for each station if they are several stations in one file.

MEDATLAS format is able to handle:

- Profile data, such as CTD or bottle data, the first parameter in the list measured of parameters has to be either pressure in decibars or depth in metres (primary variable). The data rows are ordered by increasing primary variable.

- Time series, such as current meter or sea level data, the first parameter in the list of measured of parameters have to be related to UT time primary variable) which is :
    - Year (format YYYY), Month (format MM) day (format DD) time (format hhmmss)

The data rows are ordered by increasing date

- Trajectories, such as underway data, are managed as time-series data, the following parameters are mandatory after the parameters list related to UT time (primary variable) :
  - Latitude in decimal degrees
  - Longitude in decimal degrees

  The data rows are ordered by increasing date

3.3. Encoding - SeaDataNet Semantic lines

Character encoding: ASCII
Column separator: Blank
File extension: free

As for ODV there is a set of 'special' mandatory comment lines that must appear in the station header comments. Their function is to map the text strings used to label the data columns to standardized SeaDataNet concepts, which is necessary if data files from different sources are to be combined in a meaningful way.

The comment must contains the following lines:

*SDN_parameter_mapping

This is followed by a line for each parameter column, including the primary variable, made up from three parts, each tagged to look like an XML element:

subject element: This contains the text used to label the column EXACTLY as it appears in the column row header WITHOUT the units declaration prefixed by the text 'SDN:LOCAL:' to encode it as a SeaDataNet URN. Don't worry if you don't know what this is, just include the text prefix and all will be well.

object element This contains the URN to a concept from the SeaDataNet P01 vocabulary (http://vocab.nerc.ac.uk/collection/P01/current/ – warning contains over 25000 terms). Again, if you don't understand what this all means, just prefix the appropriate code from P01 with the text 'SDN:P01::' and all will be well.

units element This contains a URN for the storage units used IN THE FILE for the data column in the SeaDataNet P06 vocabulary (http://vocab.nerc.ac.uk/collection/P06/current/). It is NOT the code for units linked in past versions of the P01 vocabulary to the parameter code (these are the units BODC uses, which is not an obligation for SeaDataNet). Again, if you don't understand what this all means, just prefix the appropriate code from P06 with the text 'SDN:P06::' and all will be well.

instrument element This contains the URN for the device used to measure the parameter taken from the SeaVoX L22 vocabulary (http://vocab.nerc.ac.uk/collection/L22/current/). Again, if you don't understand what this all means, just prefix the appropriate code from L22 with the text 'SDN:L22::' and all will be well.

fall_rate element	This element is specifically designed for XBT data and it contains the URN for the XBT probe type and the fall rate equation applied to obtain the z co-ordinate values for the data from the Seavox L33 vocabulary (http://vocab.nerc.ac.uk/collection/L33/current/). L33 is done from WMO C3 vocabulary of XBT data types.

The 'subject', 'object' and 'units' elements are mandatory. The 'instrument' and 'fall_rate' elements are optional.

The following are examples of valid data column semantic descriptions:

*<subject>SDN:LOCAL:Depth</subject><object>SDN:P01::ADEPZZ01</object><units>SDN:P06::ULAA</units>
*<subject>SDN:LOCAL:Temperature</subject><object>SDN:P01::TEMPS901</object><units>SDN:P06::UPAA</units><instrument>SDN:L22::TOOL0002</instrument>
*<subject>SDN:LOCAL:Depth</subject><object>SDN:P01::ADEPZZ01</object><units>SDN:P06::ULAA</units>><instrument>SDN:L22::TOOL0262</instrument><fall_rate>SDN:L33::011</fall_rate>
*<subject>SDN:LOCAL:Salinity</subject><object>SDN:P01::PSALST01</object><units>SDN:P06::UUUU</units>
*<subject>SDN:LOCAL:Oxygen</subject><object>SDN:P01::DOXYCZ01</object><units>SDN:P06::KGUM</units>
*<subject>SDN:LOCAL:Phosphate</subject><object>SDN:P01::PHOSZZXX</object><units>SDN:P06::KGUM</units>
*<subject>SDN:LOCAL:Silicate</subject><object>SDN:P01::SLCAZZXX</object><units>SDN:P06::KGUM</units>

*EDMO_CODE = EDMO identifier of the organisation hosting the Download Manager (CDI_partner)

* LOCAL_CDI_ID = local identifier of the station

To guarantee the iniquity of the LOCAL_CDI_ID, the local identifier of the station could be a concatenation of the MEDATLAS station code, EDMO_CODE and station data type. Note that the EDMO_CODE is not mandatory in the LOCAL_CDI_ID itself because it is already provided in the EDMO_CODE field, and the iniquity of LOCAL_CDI_ID has to be managed per data centre.

Example of a valid LOCAL_CDI_ID lines :
*LOCAL_CDI_ID = FI3520020012100001_486_H10 (including the EDMO_CODE)
*LOCAL_CDI_ID = FI35200500301_00042_H09 (not including the EDMO_CODE)

Optional linkage to external resources are may also be added after the LOCAL_CDI_ID line, as described in §2.3.2.

Example of linkage to external resources in MEDATLAS format:

*<sdn_reference xlink:href="doi:10.5285/41479c42-4dfb-4da9-be97-4c532ce13922"/>
*<sdn_reference xlink:type="SDN:L23::CDI" xlink:role="isDescribedBy" xlink:href="http://seadatanet.maris2.nl/v_cdi_v3/print_xml.asp?edmo=540&identifier=14795548"/>
*<sdn_reference xlink:href="https://www.bodc.ac.uk/data/documents/series/436972/"/>

3.4. Example Files

MEDATLAS example files are available for vertical profiles, time-series and trajectory. They are the same examples than the ODV ones to allow easy comparison. They may be downloaded from the SeaDataNet web site at:
https://www.seadatanet.org/content/download/634/3323/file/SDN_D85_WP8_MEDATLAS_files_examples.zip

4. Climate and Forecast (CF) Convention NetCDF Format

4.1. Introduction

The CF metadata conventions (https://cf-trac.llnl.gov/trac) are designed to promote the processing and sharing of files created with the NetCDF API. The conventions define metadata that provide a definitive description of what the data in each variable represents, and the spatial and temporal properties of the data. This enables users of data from different sources to decide which quantities are comparable, and facilitates building applications with powerful extraction, regridding, and display capabilities.

The standard is both mature and well-supported by formal governance for its further development. The standard is fully documented by a PDF manual accessible from a link from the CF metadata homepage (https://cf-trac.llnl.gov/trac). Note that CF is a developing standard and consequently access via the homepage rather than through a direct URL to the document is recommended to ensure that the latest version is obtained. The current version of this document was prepared using version 1.6 of the conventions dated 5 December 2011.

The approach taken with the development of the SeaDataNet profile based on CF 1.6 was to classify data on the basis of feature types and produce a SeaDataNet specification for storage of each of the following:

- Profile (x, y, t fixed; z variable). The specification given is for storage of a single profile such as a CTD cast or bottle profile. However, the design is such that very little change is required to facilitate the storage of multiple profiles in a single netCDF file.
- TimeSeries (x, y, z fixed; t variable). The specification given is for storage of a single time series, such as a current meter record. However, the design is such that very little change is required to facilitate the storage of multiple time series in a single netCDF file.
- Trajectory (x, y, z, t all variable). The specification given is for storage of a single trajectory, but this may be easily modified to store several trajectories in a single file.

The specification was then developed through discussions on a collaborative e-mail list involving participants in SeaDataNet, MyOcean, USNODC, NCAR and AODN. The working objective focussed on producing profiles with the following properties:

- CF 1.6 conformant
- Have maximum interoperability with CF 1.6 implementations in use by MyOcean (OceanSITES conventions), USNODC (USNODC NetCDF templates) and two contributors to AODN (IMOS and METOC)
- Include storage for all labels, metadata and standardised semantic mark-up that were included in the SeaDataNet ODV format files for the equivalent feature type.

Significant list discussion focussed on the version of NetCDF that should be used for SeaDataNet. The conclusion was that NetCDF 4 should be used wherever possible, but that NetCDF 3, although strongly discouraged, should not be totally forbidden.

4.2. SeaDataNet CF Profiling and Beyond

The CF conventions include guidance on data encoding into NetCDF, a small number of mandatory attributes plus a large number of optional attributes. This results in a great deal of flexibility, which unfortunately tends to compromise interoperability. The objective of the profiling process is to enhance interoperability by reducing the number of degrees of freedom. Profiling therefore generally focuses on making optional elements in the base specification mandatory, specification of mandatory data streams and the introduction of additional attributes or data streams from other conventions.

The $64,000 question when profiling is “How far should one go?” In terms of the optional elements in CF should be made mandatory for SeaDataNet it was decided to adopt a ‘light touch’ approach. For this mandatory attributes that assure any CF-aware application has usable labels for all variables and their units of measure (long_name and units mandatory) and is able to make full use of the spatial data.

The mandatory data streams specified are either data quality flags or variables to hold information included in the ODV data specification. An optional data stream has also been included under the SeaDataNet namespace to provide linkage URLs to additional usage metadata resources.

The CF profiling by OceanSITES, USNODC and METOC has included the specification of attributes (some mandatory), particularly global attributes, to store additional discovery metadata. This approach has not been followed for SeaDataNet to avoid issues resulting from the management of information duplicated in the CDI records. The SeaDataNet extensions, clearly labelled with the SDN namespace, have been restricted to what is needed to ensure that SeaDataNet ODV data files may be converted to NetCDF with no loss of information.

It is extremely important to realise that the SeaDataNet CF profile is a specification for the MINIMUM information content in a SeaDataNet NetCDF file. There is absolutely no reason why additional attributes or ancillary variables from CF (or even other conventions) should not be included. The example format for the profile feature type includes guidance on how a NetCDF file could be created that is fully compliant with both the SeaDataNet and OceanSITES conventions.

Indeed, theSeaDataNet profile could even itself be profiled to produce specifications for the storage of specific data types for use in projects based on SeaDataNet technology such as EMODNET and Geo-Seas. Such additional profiles would need to be developed by communities with expertise in the data types to be stored.

4.3. SeaDataNet Extensions to CF

The SeaDataNet extensions to CF are concerned with providing storage for the standardised semantics and metadata included in the SeaDataNet ODV format. The standardised semantics are included as four MANDATORY parameter attributes for each data or co-ordinate variable, which are:

- sdn_parameter_urn – this is the URN for the parameter description taken from the P01 vocabulary, for example SDN:P01::TEMPST01.

- sdn_parameter_name – this is the plain language label (Entryterm) for the parameter taken from the P01 vocabulary at the time of data file creation. Note that whilst the URN is fixed in both syntax and meaning, there is a possibility that the text of the label might be updated subsequently (e.g. to clarify misleading wording) in the master vocabulary.

- sdn_uom_urn – this is the URN for the parameter units of measure taken from the P06 vocabulary, for example SDN:P06::ULAA.

- sdn_uom_name - this is the plain language label (Entryterm) for the parameter taken from the P06 vocabulary at the time of data file creation. Note that whilst the URN is fixed in both syntax and meaning, there is a possibility that the text of the label might be updated subsequently (e.g. to clarify misleading wording) in the master vocabulary.

Note that the local name (SDN:LOCAL) used for the column headings in the ODV format becomes the variable name in the NetCDF file. For example, the equivalent of an ODV column named 'Salinity' related to the semantic header entry

```
//<subject>SDN:LOCAL:Salinity</subject><object>SDN:P01::PSALZZ01</object><units>SDN:P06::UUUU</units>
```

would be represented in NetCDF CDL as

```
float Salinity(INSTANCE, MAXZ) ;

--
-- CF attributes not included in this example
--
      PSAL:sdn_parameter_urn = "SDN:P01::PSLTZZ01" ;
      PSAL:sdn_parameter_name = "Practical salinity of the water body" ;
      PSAL:sdn_uom_urn = "SDN:P06::UUUU" ;
      PSAL:sdn_uom_name = "Dimensionless"
```

In addition to attributes there are a number of variables that form part of the SeaDataNet extension:

- SDN_CRUISE – this is an array (which can have a dimension of 1 for single object storage) containing text strings identifying a grouping label for the data object to which the array element belongs. This will obviously be the cruise name for data types such as CTD and bottle data, but could be something like a mooring name for current meter data.

- SDN_STATION – this is an array of text strings identifying the data object to which the array element belongs. This will be the station name for some types of data, but could also be an instrument deployment identifier.

- SDN_LOCAL_CDI_ID - this is an array of text strings containing the local identifier of the Common Data Index record associated with the data object to which the array element belongs. The maximum size allowed for this parameter is 80 bytes.

- SDN_EDMO_CODE – this is an integer array containing keys identifying the organisation hosting the Download Manager (CDI_partner) given in the European Directory of Marine Organisations (EDMO). This provides the namespace for the label.

- SDN_BOT_DEPTH – this is a floating point array holding bathymetric water depth in metres where the sample was collected or measurement was made. Set to the fill value (-999) if unknown or inapplicable.

- SDN_REFERENCES – this is an array of text strings containing a URI (URN or URL) pointing to a web resource such as a usage metadata document for the data object to which the array element belongs. If URNs such as DOIs are used then the namespace (e.g. 'doi:' for DOI) must be included.

With the exception of SDN_REFERENCES and SDN_BOT_DEPTH, these variables are mandatory for all SeaDataNet profile, time series and trajectory (but not grid) data.

4.4. General Features of the SeaDataNet NetCDF Profiles

Whilst the SeaDataNet NetCDF profiles differ in certain details, such as the dimensioning of co-ordinate variables, there is much that they have in common and these common features are documented in this section.

4.4.1. Dimensions

There are many ways in which a given type of data may be stored in NetCDF, each of which is associated with a particular pattern of dimension assignments.

The pattern followed by SeaDataNet for profiles, time series and trajectories is to have an ‘INSTANCE’ unlimited dimension plus a maximum repetition within instance dimension. This is the maximum number of z co-ordinate levels (MAXZ) for profiles and the maximum number of time steps (MAXT) for time series and trajectories.

Grids again have an unlimited ‘UNLIMITED’ dimension plus two maximum repetition instances, one each for the x and y axes. Generally, these will be associated with longitude and latitude in SeaDataNet usage.

One or more string size dimension(s) (STRINGx) is also included for text arrays. See 4.4.7.

4.4.2. Co-ordinate Variables

CF subdivides variables into three categories, namely geophysical variables (the things that are actually measured), co-ordinate variables that provide the spatio-temporal information for the geophysical variables and ancillary variables that provide supporting information for them.

The co-ordinate variables in the SeaDataNet profiles have inherited co-ordinate variable names from the OceanSITES convention, which are ‘LONGITUDE’ for x, ‘LATITUDE’ for y, ‘TIME’ for t and ‘DEPTH’, ‘PRES’ or ‘HEIGHT’ for z.

Each SeaDataNet co-ordinate variable has the following mandatory attributes:

- long_name – free text label

- standard_name – CF variable label that may be found in the P07 vocabulary (http://vocab.nerc.ac.uk/collection/P07/current/accepted)

- units – plain text label taken from the UDUNITS-2 database (http://www.unidata.ucar.edu/software/udunits)

- ancillary_variables – name of the flag channel for the co-ordinate variable. Note that the OceanSITES practice of having a single flag channel to cover both latitude and longitude has been adopted for profile, time series and trajectory data.

- axis – the Cartesian axis (X, Y, Z, T) that maps to the co-ordinate.

- calendar – set to 'julian' for SeaDataNet (TIME co-ordinate only)

- SeaDataNet mandatory semantic attributes (sdn_parameter_urn, sdn_parameter_name, sdn_uom_urn, sdn_uom_name as described in section 4.3) and optional instrument attributes:
    - sdn_instrument_urn:This contains the URN for the device used to measure the parameter taken from the SeaVoX L22 vocabulary (http://vocab.nerc.ac.uk/collection/L22/current/. Again, if you don't understand what this all means, just prefix the appropriate code from L22 with the text 'SDN:L22::' and all will be well.
    - sdn_instrument_name:preferred label of L22 code given in sdn_instrument_urn
    - sdn_fall_rate_urn:This element is specifically designed for XBT data and it contains theURN for the XBT probe type and the fall rate equation applied to obtain the z co-ordinate values for the data from the Seavox L33 vocabulary (http://vocab.nerc.ac.uk/collection/L33/current/). L33 is done from WMO C3 vocabulary of XBT data types.
    - sdn_fall_rate_name:preferred label of L33 code given in sdn_instrument_urn

SeaDataNet practice is to specify that x and y spatial co-ordinates should be LATITUDE and LONGITUDE within the 2D WGS-84 co-ordinate reference system or so inaccurate that WGS-84 may be assumed. This is stated explicitly by the inclusion of the crs container variable taken from the USNODC NetCDF template with linkages to LATITUDE and LONGITUDE through the grid_mapping attribute.

It should be noted that some of these co-ordinate variable names are ambiguous, particularly for the z co-ordinate. For example, 'HEIGHT' could be the height above the seabed or the height above the sea surface. Likewise 'DEPTH' could be depth below sea surface for water column data or depth below the seabed for sediment profiles. This ambiguity is eliminated using the standard_name, sdm_parameter_urn and sdn_parameter_name attributes.

4.4.3. Ancillary Variables

SeaDataNet has its origins in the designs of the IODE Group of Experts in the Technical Aspects of Data Exchange (GETADE) in which a fundamental requirement for interoperability was a clear understanding of data quality on a point by point basis. This was achieved by tagging every measurement with a single-byte encoded label, often referred to as a 'flag'. This practice is carried through to the SeaDataNet NetCDF formats as follows:

- A flag variable is mandatory for all geophysical and co-ordinate variables in all feature types except gridded data.

- The OceanSITES practice of combining the flag variables for latitude and longitude into a single flag for 'position' has been adopted.

- Flag channels are encoded using the SeaDataNet L20 vocabulary (http://vocab.nerc.ac.uk/collection/L20).

The flag channels have been incorporated as CF ancillary variables. The ancillary variables are linked to the geophysical or co-ordinate variable to which they relate through an 'ancillary_variables' attribute in the parent variable set to the name of the ancillary variable.

Each SeaDataNet flag ancillary variable has the following mandatory attributes:

- long_name – plaintext indicating the function of the ancillary variable, such as 'Quality flag'
- Conventions – reference to the encoding convention used for the flag ('SeaDataNet measurand qualifier flags' in the case of SeaDataNet.
- _FillValue – the value associated with missing data – set to 57b (ASCII '9')
- sdn_conventions_urn – a SeaDataNet extension set to 'SDN:L20::'
- flag_values – a list of all the flag values used in the encoding scheme
- flag_meanings – a list of the meanings associated with the codes in flag_values as space-delimited strings with internal spaces replaced by underscores.

The flag variables are encoded as type 'byte' to circumvent some technical concerns raised during the design discussions. However, the flag values used are the ASCII encodings resulting in data identical to variables typed 'char'.

One feature of the design is that it overcomes interoperability issues with data that use different flag conventions by allowing for the storage of multiple flag channels for every variable. For this approach to have any value, it is essential that any application software is able to easily recognise the flag channels in which it is interested. Consequently, the naming of the flag channels has been standardised through the L27 controlled vocabulary (http://vocab.nerc.ac.uk/collection/L27). The flag channel name is given by concatenating an underscore and the concept key to the corresponding geophysical variable name, co-ordinate variable name or 'POSITION' for combined latitude/longitude flags.

For example, the SeaDataNet L27 entry at URL http://vocab.nerc.ac.uk/collection/L27/current/SEADATANET_QC is:


```
  <skos:Concept rdf:about="http://vocab.nerc.ac.uk/collection/L27/current/SEADATANET_QC/">
  <skos:prefLabel xml:lang="en">SeaDataNet measurand qualifier flags</skos:prefLabel>
  <skos:altLabel/>
  <skos:definition xml:lang="en">SeaDataNet measurand qualifier flags</skos:definition>
  <dc:identifier>SDN:L27::SEADATANET_QC</dc:identifier>
  <skos:notation>SDN:L27::SEADATANET_QC</skos:notation>
  <owlxml:versionInfo>2</owlxml:versionInfo>
  <dc:date>2012-07-24 13:48:47.0</dc:date>
  <skos:note xml:lang="en">accepted</skos:note>
  <owlxml:deprecated>false</owlxml:deprecated>
</skos:Concept>
```

The concept key to be included in the flag variable name is the text after 'SDN:L27::' in the dc:identifier element and the text to be included in the Conventions attribute is the content of the skos:prefLabel element.

Flags are not the only type of ancillary variable specified by the CF conventions. For, example it is possible to include quantitative descriptions of quality such as standard errors. The CF documentation contains a clear description with examples of how this should be done. Additional ancillary variables may be included as required, or specified as part of more restrictive profiles built on the SeaDataNet profiles.

4.4.4. Geophysical Variables

The 'geophysical variables' are the measured variables in the data file, such as temperature and salinity for a CTD profile. Their name indicates the origins of the CF conventions, but has absolutely no relevance. 'Geophysical variables' may contain chemical, biological or geological parameters in addition to physical ones.

The geophysical variables have the following mandatory attributes:

- long_name – free text label
- units – plain text label taken from the UDUNITS-2 database (http://www.unidata.ucar.edu/software/udunits)
- coordinates – lists the co-ordinate variables for the measurement value as a space-delimited list. For example this could be "TIME DEPTH LATITUDE LONGITUDE" for a CTD or "TIME HEIGHT LATITUDE LONGITUDE" for a radiosonde.
- SeaDataNet mandatory semantic attributes (sdn_parameter_urn, sdn_parameter_name, sdn_uom_urn, sdn_uom_name as described in section4.3) and optional instrument attributes (sdn_instrument_urn, sdn_instrument_name, sdn_fall_rate_urn, sdn_fall_rate_nameas described insection 4.4.2)..

A _FillValue attribute may be included if the data object includes absent data. Note that the CF standard_name attribute is not mandatory. This is to simplify the inclusion of parameters for which there are no standard names into SeaDataNet NetCDF. However, the CF Standard Names have become widely used and so significantly enhance interoperability. Consequently, their inclusion is STRONGLY recommended to the extent that SeaDataNet partners should engage with the CF community to extend the Standard Name list where required.

4.4.5. Global Attributes

The following global attributes are mandatory for SeaDataNet NetCDF. The first two are taken from CF; the remaining two are from OceanSITES:

- Conventions – this informs application software of the encoding conventions to which the data conform. If the file conforms to multiple conventions then they are all listed as space-delimited or comma-delimited (if one or more convention labels include embedded spaces) list. The usual value for SeaDataNet will be 'SeaDataNet_1.0 CF1.6'. Should the file also conform to OceanSITES conventions then this becomes 'SeaDataNet_1.0, OceanSITES Manual 1.1, CF1.6'

- featureType – this is a description of the spatio-temporal shape of the data held in the NetCDF using a vocabulary specified in CF 1.6. The value to be used is given in the relevant feature-specific profile description

- title – this is a plain language label for the file contents, such as 'CTD data for station CS from North Sea Project cruise RRS Challenger CH33'. It is designed to be used for labelling visualisations of the data held in the file.

- date_update – a timestamp (UT to 1-second precision as an ISO8601 string) specifying when the contents (i.e. its attributes and/or values) of the file were last changed. This provides both a publication date and a version label for the dataset contained in the file. It may be earlier (but obviously not later) than the last modification date of the physical file.

Other conventions, such as OceanSITES, have specified significant numbers of additional global attributes primarily for the storage of discovery metadata. This hasn't been done for SeaDataNet, but this doesn't mean that additional attributes are prohibited. If additional attributes are included it is strongly preferred that their names and usage are taken from an existing convention. Local attributes are allowed if no such suitable attribute can be located.

In an ideal world, attributes added by conventions other than CF should be labelled with a namespace to indicate their origin. Unfortunately, this practice hasn't been universally followed in existing profiles of CF. For SeaDataNet, if local attributes are introduced then labelling them with a namespace is mandatory to ensure identification of their source.

The 'profile' feature-specific profile includes a large number of example attributes from the OceanSITES convention (data_type, format_version, platform_code, institution, wmo_platform_code, platform_name, history, etc.) for purposes of illustration.

4.4.6. Extension to Multiple Object Storage

The SeaDataNet operational model is based on very fine-grained data objects, such as individual CTD casts. Consequently, the primary SeaDataNet use case is to provide NetCDF containers for single profiles, time series or trajectories. However, it is not difficult to envisage the need for an aggregation layer between the user and SeaDataNet data holdings that requires a container for multiple profiles, time series, etc. Consequently, the SeaDataNet profiles have been designed to switch from single to multiple object storage with a minimum of change. The changes required are documented in each feature-specific profile specification.

4.4.7. Character Storage and Encoding

Character handling is not one of the strengths of the NetCDF data model. There is no string data type and so characters need to be stored in fixed length arrays with each array element storing a single byte, very much like FORTRAN66 holleriths. For example, to store 50 strings up to 80 bytes in length we need:

```
NSTRING = 50;
STRING80 = 80;
CHARACTER STRING (NSTRING, STRING80);
```

The SeaDataNet profile of CF point data needs to store a significant amount of character information as data. The convention adopted in the examples is to use a single dimension named STRING80 set to a value of 80. **This is just an example and does not imply any restriction on the nature of character data stored.** If the strings to be stored are longer then this dimension needs to be increased to the length of the longest string in the dataset. However, if the dimension is set excessively large then wastage of storage will become significant.

It is also unnecessary to have all string arrays in a file set to the same length. For example, it is possible to have:

NSTRING = 50;
STRING20 = 20;
STRING80 = 80;
STRING200 = 200;
CHARACTER SHORTSTRING (NSTRING, STRING20);
CHARACTER MEDSTRING (NSTRING, STRING80);
CHARACTER LONGSTRING (NSTRING, STRING200);

It is strongly recommended that the convention of naming the string length dimensions STRINGx where x is the value be maintained.

All character data should be encoded in ASCII and restricted to the ISO/IEC 8859-1 (commonly referred to as the Latin alphabet number 1 Latin-1) character set (http://en.wikipedia.org/wiki/ISO/IEC_8859-1).

4.4.8. Data Typing

Geophysical variables can hold any valid NetCDF data type. Note that there are performance implications if double precision is used where single precision will suffice. However, because tools cannot be aware of the required precision for a given parameter, they will default to double precision.

Variables that contain textual data are stored as data type ‘char’. They will depend on an additional dimension that holds the length of the longest string in the data stream. The dimension should follow the naming convention of STRING80 to start with ‘STRING’ and end on its length (e.g STRING20).

4.4.9. Linkages to External Resources

One of the founding principles of CF is that all data files should be totally self-contained. One of the most controversial aspects of the SeaDataNet profiling of CF is to break this principle. The reasoning behind this move is that the SeaDataNet design is modular with numerous types of metadata document. If the data files are to be self-contained then the content of all these documents - CDI, CSR, EDMED, EDIOS, EDMERP, EDMO and vocabulary server RDF XML - would need to be included in the data file. This is unwise for two reasons. First, whenever a single item of information is stored in two locations there is the risk of the content in one location being changed and not in the other. Secondly, a lot of this information is hierarchically related text. NetCDF is very bad at handling text (on a par with FORTRAN-66 with fixed-length 1-byte arrays, not strings) and even worse at handling hierarchies. There is also the matter that the world has moved on since 2003. Not only has internet availability increased dramatically, but there has also been the emergence of Linked Data and the Semantic Web.

The SeaDataNet approach is to keep duplication of information to a minimum through the provision of external linkages to additional information. Initially, the intention was to follow the DOI model and provide a mechanism to link the SeaDataNet data file to a single 'landing page' - an XHTML document providing additional information. The intention was that this page could include additional links to other XML documents, such as the CDI and CSR. The SDN_REFERENCES variable was introduced for this purpose. This is a character array for each INSTANCE (i.e. normally one per file for SeaDataNet) in which a URI is stored. This is either the landing page URL or a URN including namespace such as a DOI.

However, this was considered insufficient as there was no information in the data files to inform software agents what to expect at the end of the URI and insufficient control over landing page content to guarantee that it would be provided elsewhere. Consequently, the SDN_XLINK character array was introduced. This allows any number (the REFMAX dimension) of strings to be associated with each INSTANCE. Each string is formatted according to the following model:

<sdn_reference xlink:type="URN" xlink:role="text" xlink:href="URI"/>

The xlink:href is mandatory, whilst xlink:type and xlink:role are optional. It is either a URL or a URN including namespace.

The xlink:type attribute specifies the XML document type using the URN of that document type in the L23 vocabulary. For example, SDN:L23::CDI specifies a Common Data Index document and SDN:L23::CSR specifies a Cruise Summary Report document. If xlink:type is omitted then the document type is assumed to be XHTML.

The xlink:role indicates the purpose of the document. The following roles are allowed:

isDescribedBy	CDI document or controlled vocabulary concept document
isObservedBy	CSR document or EDIOS series document

The mapping between the ODV and NetCDF linkages is as follows. Consider a case where an ODV file includes 5 stations and has the following SDN_REFERENCES entry:

//<SDN_REFERENCES>https://www.bodc.ac.uk/data/documents/series/436972/

In this case, the NetCDF INSTANCE dimension will be equal to 5, so SDN_REFERENCES will be a 5-element string array. All five elements should be set to 'https://www.bodc.ac.uk/data/documents/series/436972/'. Likewise if there is an sdn_reference entry with no sdn:scope attribute, the XLINK string is copied into five SDN_XLINK elements having the same REFMAX index. However, if sdn:scope is specified then the XLINK string is only stored in one SDN_XLINK element.

For example, an ODV file carries two stations having the local CDI IDs '8575' and '8576'. In NetCDF, '8575' is stored in INSTANCE=1 and '8576' is stored in INSTANCE=2. If the ODV file has two sdn_reference entries thus:

//<sdn_reference xlink:type="SDN:L23::CDI" xlink:role="isDescribedBy" xlink:href="http://seadatanet.maris2.nl/v_cdi_v3/print_xml.asp?edmo=486&identifier=8575" sdn:scope="486:8575/>
//<sdn_reference xlink:type="SDN:L23::CDI" xlink:role="isDescribedBy" xlink:href="http://seadatanet.maris2.nl/v_cdi_v3/print_xml.asp?edmo=486&identifier=8576" sdn:scope="486:8576/>
//<sdn_reference xlink:href="doi:10.5285/41479c42-4dfb-4da9-be97-4c532ce13922"/>

Then the SDN_XLINK array will be:

SDN_XLINK (1,1) = <sdn_reference xlink:type="SDN:L23::CDI" xlink:role="isDescribedBy" xlink:href="http://seadatanet.maris2.nl/v_cdi_v3/print_xml.asp?edmo=486&identifier=8575" sdn:scope="486:8575/>

SDN_XLINK (2,1) = <sdn_reference xlink:type="SDN:L23::CDI" xlink:role="isDescribedBy" xlink:href="http://seadatanet.maris2.nl/v_cdi_v3/print_xml.asp?edmo=486&identifier=8576" sdn:scope="486:8576/>

SDN_XLINK (1,2) =<sdn_reference xlink:href="doi:10.5285/41479c42-4dfb-4da9-be97-4c532ce13922"/>

SDN_XLINK (2,2) =<sdn_reference xlink:href="doi:10.5285/41479c42-4dfb-4da9-be97-4c532ce13922"/>

4.5. Feature-specific SeaDataNet Profiles

4.5.1. SeaDataNet NetCDF Profile for Profile Data

This is the SeaDataNet NetCDF profile to be used for the storage of data that have been mapped onto the profile feature types, which is defined as having a single x co-ordinate (e.g. longitude), a single y co-ordinate (e.g. latitude), a single time co-ordinate and a monotonic set of z co-ordinates (e.g. depth or pressure). It covers many common oceanographic types such as processed (e.g. binned) CTD data, water bottle data and XBT data.

4.5.1.1. Co-ordinate variables

The co-ordinate variables are of two types. Time, latitude and longitude are 1-D vectors, which for single profile storage have a length of 1. These have been used in preference to scalars to provide a foundation for multi-profile storage. The SeaDataNet practice of using Chronological Julian Day (CJD) as the numeric representation of time has been followed.

The z co-ordinate is either depth, pressure (although depth is preferred), or a height above sea level. The values are stored in a 2D array, with one dimension set to one for single-profile storage. Note that CF required that co-ordinate variables be monotonic. Consequently, this means that CTD data that include both the upcast and the downcast in a single file cannot be stored as logged. Further, some discrete downcasts may require processing such as pressure sorting or binning before they become CF compliant.

4.5.1.2. Geophysical variables

The geophysical variables, like the z co-ordinates, are stored as 2D arrays with the INSTANCE dimension set to 1. Each geophysical variable has at least one ancillary variable named using the conventions described in section 3.4.3 containing the SeaDataNet qualifier flags for that variable.

4.5.1.3. Attributes

The Featuretype attribute is set to 'profile'.

4.5.1.4. CDL example

There now follows an example NetCDF file structure for the storage of a single profile (e.g. a CTD cast) in annotated network Common Data form Language (CDL). The annotations are contained in lines prefixed by two hyphens ('- - ').

The example is quite verbose because it is designed to illustrate how a SeaDataNet file could be created that is also compliant with another extension – in this case the OceanSITES convention used by MyOcean. Interoperability is established through repetition, such as including both SeaDataNet and OceanSITES flags. OceanSITES tools will ignore the SeaDataNet elements and SeaDataNet tools will ignore the OceanSITES elements, but the one file serves both communities.

Please note that this example is only an illustration and includes a lot of attributes and variables that are not required for SeaDataNet. The 'extras' required for OceanSITES have been coloured red. Anything that is mandatory for SeaDataNet is in bold black text. Other optional elements suggested for SeaDataNet files that are not part of OceanSITES are in normal black text.

```
--
-- This file specifies the SeaDataNet NetCDF encoding for a single profile
-- (e.g. a CTD cast) in annotated CDL
--
dimensions:
--
-- The 'unlimited' dimension is the number of profiles stored in the file,
-- which in this case is fixed at 1
-- The MAXZ dimension is set to the maximum number of z co-ordinate values
-- in a stored profile (other profiles are padded to this length)
-- The STRING80 dimension is specifies the length of fixed size strings for
-- profile label variables
-- The optional REFMAX dimension specifies the maximum number of external URIs that
-- may be linked to a profile instance. For backward compatibility 2-D SDN_REFERENCES
-- (INSTANCE, STRING80) is also allowed.
--
        INSTANCE = 1 ;
        MAXZ = 501 ;
        STRING80 = 80;
        REFMAX = 5;
variables:
--
-- The name for this variable, including upper case, is fixed for
-- SeaDataNet
--
        double TIME(INSTANCE) ;
--
```

```
-- CF attributes mandatory for SeaDataNet - include verbatim except for
-- ancillary variables
--
                TIME:long_name = "Chronological Julian Date" ;
                TIME:standard_name = "time" ;
                TIME:units = "days since -4713-01-01T00:00:00Z" ;
--
-- If no OceanSITES flag channel is included then TIME:ancillary_variables is set to
"TIME_SEADATANET_QC"
--
                TIME:ancillary_variables = "TIME_OCEANSITES_QC
TIME_SEADATANET_QC" ;
                TIME:axis = "T" ;
                 TIME:calendar = "julian" ;
--
-- CF attributes optional for SeaDataNet
--
                TIME:valid_min = 0. ;
                TIME:valid_max = 2500000. ;
--
-- OceanSITES attributes optional for SeaDataNet
-- QC_indicator is an OceanSITES extension to CF categorising the quality
-- for the entire data channel.
-- QC_procedure is an OceanSITES extension describing how QC was done
-- The coding conventions for these attributes is documented in the
-- OceanSITES manual.
-- Note each attribute has its own convention and these conventions are not
-- identical to the OceanSITES QC flag convention. These are documented in
-- the OceanSITES manual.
--
                TIME:QC_indicator = 1 ;
                TIME:QC_procedure = 1 ;
--
-- The values in the following optional attributes are hypothetical
-- examples and should not be copied verbatim
--
          TIME:uncertainty = "5 minutes"
          TIME:comment = "Timestamp refers to the start of the downcast"
--
-- SeaDataNet semantic extensions - mandatory for SeaDataNet
--
-- sdn_parameter_urn should specify the correct concept from the P01
-- vocabulary for the parameter.
-- sdn_parameter_name is the preferred label for the concept from the P01
-- vocabulary.
-- sdn_uom_urn should specify the correct concept from the P06 vocabulary
-- for the unit of measure
-- sdn_uom_name is the preferred label for the concept from the P06
-- vocabulary
--
                TIME:sdn_parameter_urn = "SDN:P01::CJDY1101" ;
                TIME:sdn_parameter_name = "Julian Date (chronological)" ;
                TIME:sdn_uom_urn = "SDN:P06::UTAA" ;
                TIME:sdn_uom_name = "Days"
```

```
--
-- This is the OceanSITES QC flag convention and is optional for SeaDataNet
-- but essential for full MyOcean interoperability
--
        byte TIME_OCEANSITES_QC(INSTANCE) ;
                TIME_OCEANSITES_QC:long_name = "OceanSites quality flag" ;
                TIME_OCEANSITES_QC:Conventions = "OceanSites reference table 2" ;
                TIME_OCEANSITES_QC:_FillValue = -128b ;
                TIME_OCEANSITES_QC:valid_min = 0b ;
                TIME_OCEANSITES_QC:valid_max = 9b ;
                TIME_OCEANSITES_QC:flag_values = 0b, 1b, 2b, 3b, 4b, 5b, 6b, 7b, 8b, 9b
;
                TIME_OCEANSITES_QC:flag_meanings = "no_qc_performed good_data
probably_good_data bad_data_that_are_potentially_correctable bad_data value_changed
not_used nominal_value interpolated_value missing_value" ;
--
-- This is the SeaDataNet flag convention and is mandatory (all attributes)
-- for SeaDataNet
-- The name for this variable, including upper case, is fixed for
-- SeaDataNet. Include verbatim.
--
        byte TIME_SEADATANET_QC(INSTANCE) ;
                TIME_SEADATANET_QC:long_name = "SeaDataNet quality flag" ;
                TIME_SEADATANET_QC:Conventions = "SeaDataNet measurand
                qualifier flags" ;
                TIME_SEADATANET_QC:_FillValue = 57b;
                TIME_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";
                TIME_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b, 52b, 53b,
                54b, 55b, 56b, 57b, 65b ;
                TIME_SEADATANET_QC:flag_meanings = "no_quality_control
                good_value probably_good_value probably_bad_value bad_value
                changed_value value_below_detection value_in_excess
                interpolated_value missing_value value_phenomenon_uncertain" ;
--
-- The name for this variable, including upper case, is fixed for
-- SeaDataNet
--
-- Note the rule in SeaDataNet is that position is assumed to be WGS-84 on
-- the basis that this is either the correct CRS or the accuracy
-- is so poor that CRS is irrelevant.
-- This rule is reported by the inclusion below of a crs variable with
-- attributes appropriate to WGS84
--
        double LATITUDE(INSTANCE) ;
--
-- CF attributes mandatory for SeaDataNet
--
                LATITUDE:long_name = "Latitude" ;
                LATITUDE:standard_name = "latitude" ;
                LATITUDE:units = "degrees_north" ;
                LATITUDE:ancillary_variables = "POSITION_OCEANSITES_QC
POSITION_SEADATANET_QC" ;
                LATITUDE:axis = "Y" ;
--
```

```
-- CF attributes optional for SeaDataNet
--
                LATITUDE:valid_min = -90. ;
                LATITUDE:valid_max = 90. ;
--
-- SeaDataNet semantic extensions - mandatory for SeaDataNet
--
                LATITUDE:sdn_parameter_urn = "SDN:P01::ALATZZ01" ;
                LATITUDE:sdn_parameter_name = "Latitude north" ;
                LATITUDE:sdn_uom_urn = "SDN:P06::DEGN" ;
                LATITUDE:sdn_uom_name = "Degrees north" ;

-- CRS Linkage - mandatory for SeaDataNet
                LATITUDE:grid_mapping = "crs";
--
-- OceanSITES attributes optional for SeaDataNet
-- See 'TIME' for more details
--
                LATITUDE:QC_indicator = 1 ;
                LATITUDE:QC_procedure = 1 ;
                LATITUDE:uncertainty = "0.00001 degree" ;
                LATITUDE:comment = "Averaged value over profile measurement" ;
--
-- The name for this variable, including upper case, is fixed for
-- SeaDataNet
--
        double LONGITUDE(INSTANCE);
--
-- CF attributes mandatory for SeaDataNet
--
                LONGITUDE:long_name = "Longitude" ;
                LONGITUDE:standard_name = "longitude" ;
                LONGITUDE:units = "degrees_east" ;
                LONGITUDE:ancillary_variables      =      "POSITION_OCEANSITES_QC
POSITION_SEADATANET_QC" ;
                LONGITUDE:axis = "X" ;
--
-- CF attributes optional for SeaDataNet
--
                LONGITUDE:valid_min = -180. ;
                LONGITUDE:valid_max = 180. ;
--
-- SeaDataNet semantic extensions - mandatory for SeaDataNet
--
                LONGITUDE:sdn_parameter_urn = "SDN:P01::ALONZZ01" ;
                LONGITUDE:sdn_parameter_name = "Longitude east" ;
                LONGITUDE:sdn_uom_urn = "SDN:P06::DEGE" ;
                LONGITUDE:sdn_uom_name = "Degrees east" ;
-- CRS Linkage - mandatory for SeaDataNet
                LONGITUDE:grid_mapping = "crs";
--
-- OceanSITES attributes optional for SeaDataNet
-- See 'TIME' for more details
--
```

```
                LONGITUDE:QC_indicator = 1 ;
                LONGITUDE:QC_procedure = 1 ;
                LONGITUDE:uncertainty = " 0,00001 degree " ;
                LONGITUDE:comment = "Averaged value over profile measurement" ;
--
-- The OceanSITES convention of merging latitude and longitude QC into a
-- position QC has been followed.
-- Again we have flags in OceanSITES (optional) and SeaDataNet (mandatory)
-- conventions.
--
-- OceanSITES
--
        byte POSITION_OCEANSITES_QC(INSTANCE) ;
                POSITION_OCEANSITES_QC:long_name = "OceanSites quality flag" ;
                POSITION_OCEANSITES_QC:Conventions = "OceanSites reference table 2"
;
                POSITION_OCEANSITES_QC:_FillValue = -128b ;
                POSITION_OCEANSITES_QC:valid_min = 0b ;
                POSITION_OCEANSITES_QC:valid_max = 9b ;
                POSITION_OCEANSITES_QC:flag_values = 0b, 1b, 2b, 3b, 4b, 5b, 6b, 7b,
8b, 9b ;
                POSITION_OCEANSITES_QC:flag_meanings = "no_qc_performed
good_data probably_good_data bad_data_that_are_potentially_correctable bad_data
value_changed not_used nominal_value interpolated_value missing_value" ;
--
-- SeaDataNet
-- The name for this variable, including upper case, is fixed for
-- SeaDataNet.
--
        byte POSITION_SEADATANET_QC(INSTANCE) ;
                POSITION_SEADATANET_QC:long_name = "SeaDataNet quality
                flag" ;
                POSITION_SEADATANET_QC:Conventions = "SeaDataNet
                measurand qualifier flags" ;
                POSITION_SEADATANET_QC:_FillValue = 57b;
                POSITION_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";
                POSITION_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b, 52b,
                53b, 54b, 55b, 56b, 57b, 65b ;
                POSITION_SEADATANET_QC:flag_meanings = "no_quality_control
                good_value probably_good_value probably_bad_value bad_value
                changed_value value_below_detection value_in_excess
                interpolated_value missing_value value_phenomenon_uncertain" ;
--
-- OceanSITES profile description variables.
-- Optional for SeaDataNet.
--
        char DATA_MODE(INSTANCE) ;
                DATA_MODE:long_name = "Delayed mode or real time data" ;
                DATA_MODE:Conventions = "R: real time; D:delayed mode; A:real time with
adjustment" ;
                DATA_MODE:_FillValue = " " ;
        char DIRECTION(INSTANCE) ;
                DIRECTION:long_name = "Direction of the profiles" ;
                DIRECTION:Conventions = "A: Ascending profile, D: descending profile" ;
```

```
                DIRECTION:_FillValue = " " ;
--
-- SeaDatanet CRS reporting - include verbatim
--
        int crs ;
                crs:grid_mapping_name = "latitude_longitude"
                crs:epsg_code = "EPSG:4326"
                crs:semi_major_axis = 6378137.0 ;
                crs:inverse_flattening = 298.257223563 ;
--
-- SeaDataNet attribute and metadata variables such as profile identifiers
-- and water depths at the measurement site
--
-- Mandatory for SeaDataNet
-- Note this could be included as delimited lists in global attributes, but
-- this is encoding is preferred.
-- The names for these variables, including case, are fixed for SeaDataNet.
--
        char SDN_CRUISE(INSTANCE,STRING80) ;
                SDN_CRUISE:long_name = "Profile group label" ;
        char SDN_STATION(INSTANCE,STRING80) ;
                SDN_STATION:long_name = "Profile label" ;
        char SDN_LOCAL_CDI_ID (INSTANCE,STRING80) ;
                SDN_LOCAL_CDI_ID:long_name = "SeaDataNet CDI identifier" ;
                SDN_LOCAL_CDI_ID:cf_role = "profile_id" ;
--
-- EDMO code provides the namespace for CDI local identifier
-- (SeaDataNet convention).
-- Name including case id fixed for SeaDataNet.
--
        int SDN_EDMO_CODE (INSTANCE) ;
                SDN_EDMO_CODE:long_name = "European Directory of Marine
                Organisations code for the CDI partner"
--
-- Bathymetric depth required to support seafloor masking of section plot
-- visualisations
--
        float SDN_BOT_DEPTH (INSTANCE) ;
                SDN_BOT_DEPTH:standard_name =
                "sea_floor_depth_below_sea_surface" ;
                SDN_BOT_DEPTH:long_name = "Bathymetric depth at profile
                measurement site" ;
                 SDN_BOT_DEPTH:units = "meters" ;
                SDN_BOT_DEPTH:sdn_parameter_urn = "SDN:P01::MBANZZZZ" ;
                SDN_BOT_DEPTH:sdn_parameter_name = "Sea-floor depth (below
                instantaneous sea level) {bathymetric depth} in the water body" ;
                SDN_BOT_DEPTH:sdn_uom_urn = "SDN:P06::ULAA" ;
                SDN_BOT_DEPTH:sdn_uom_name = "Metres" ;
                SDN_BOT_DEPTH:_FillValue = -999.0
--
-- SeaDataNet optional attribute variables
--
-- Linkages to external resources (see Section 4.4.8)
--
```

```
-- SDN_REFERENCES - single linkage to a URI which resolves to an XHTML page
-- carrying additional information such as usage metadata or DOI landing page
--
-- SDN_XLINK - multiple (in this example 5) linkages to external resource URNs
-- following a strictly defined syntax that resolve into either XML documents of known
-- schema or XHTML.
--
        char SDN_REFERENCES(INSTANCE, STRING80) ;
                SDN_REFERENCES:long_name = "Usage metadata reference";
        char SDN_XLINK (INSTANCE, REFMAX, STRING80) ;
                SDN_XLINK:long_name = "External resource linkages";


-- This is the profile z co-ordinate of dimension MAXZ.
-- Acceptable parameters for the z co-ordinate are DEPTH, PRES and
-- HEIGHT. These names do not imply an origin (e.g. sea surface) – that must be
-- specified through attributes.
-- Depth is preferred to pressure.
-- Height is used for atmospheric profiles such as radiosondes.
-- A rule for SeaDataNet profiles is that the z co-ordinate increases or decreases
-- monotonically but not necessarily in regular increments.
--
-- The netCDF name for this variable, including upper case, is fixed for
-- SeaDataNet at DEPTH, PRES or HEIGHT as appropriate.
--
        float DEPTH(INSTANCE, MAXZ) ;
--
-- CF attributes mandatory for SeaDataNet.
--
                DEPTH:long_name = "Depth" ;
--
-- Example standard names to use are 'depth', 'sea_water_pressure_due_to_sea_water'
or 'height'
--
                DEPTH:standard_name = "depth" ;
                DEPTH:units = "meters" ;
                DEPTH:ancillary_variables= "DEPTH_OCEANSITES_QC
                DEPTH_SEADATANET_QC";
                DEPTH:axis = "Z" ;
                DEPTH:positive = "down" ;
--
-- SeaDataNet semantic extensions - mandatory for SeaDataNet
--
                DEPTH:sdn_parameter_urn = "SDN:P01::ADEPZZ01" ;
                DEPTH:sdn_parameter_name = "Depth below surface of the water
                body" ;
                DEPTH:sdn_uom_urn = "SDN:P06::ULAA" ;
                DEPTH:sdn_uom_name = "Metres"

-- Optional SeaDataNet linkage to the instrument used to measure the parameter
-- and the fall rate equation applied for XBT and XCTD data.
--

              DEPTH::sdn_instrument_urn = "SDN:L22:: TOOL0714"
```

```
        DEPTH::sdn_instrument_name =" Lockheed Martin Sippican AXCTD "

        DEPTH::sdn_fall_rate_urn = "SDN:L33::720"
        DEPTH::sdn_fall_rate_name = " Sippican AXCTD"

--
-- Again we have flags in OceanSITES (optional) and SeaDataNet
-- (mandatory) conventions.
--
-- OceanSITES
--
    byte DEPTH_OCEANSITES_QC(INSTANCE, MAXZ) ;
        DEPTH_OCEANSITES_QC:long_name = "OceanSites quality flag" ;
        DEPTH_OCEANSITES_QC:Conventions = "OceanSites reference table 2" ;
        DEPTH_OCEANSITES_QC:_FillValue = -128b ;
        DEPTH_OCEANSITES_QC:valid_min = 0b ;
        DEPTH_OCEANSITES_QC:valid_max = 9b ;
        DEPTH_OCEANSITES_QC:flag_values = 0b, 1b, 2b, 3b, 4b, 5b, 6b, 7b, 8b,
        9b ;
        DEPTH_OCEANSITES_QC:flag_meanings = "no_qc_performed good_data
        probably_good_data bad_data_that_are_potentially_correctable bad_data
        value_changed not_used nominal_value interpolated_value missing_value";
--
-- SeaDataNet
-- The name for this variable, including upper case, is fixed for
-- SeaDataNet at DEPTH_SEADATANET_QC, PRES_SEADATANET_QC
-- or HEIGHT_SEADATANET_QC as appropriate.
--
    byte DEPTH_SEADATANET_QC(INSTANCE, MAXZ) ;
        DEPTH_SEADATANET_QC:long_name = "SeaDataNet quality flag" ;
        DEPTH_SEADATANET_QC:Conventions = "SeaDataNet measurand
        qualifier flags" ;
        DEPTH_SEADATANET_QC:_FillValue = 57b;
        DEPTH_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";
        DEPTH_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b, 52b,
        53b, 54b, 55b, 56b, 57b, 65b ;
        DEPTH_SEADATANET_QC:flag_meanings = "no_quality_control
        good_value probably_good_value probably_bad_value bad_value
        changed_value value_below_detection value_in_excess
        interpolated_value missing_value value_phenomenon_uncertain" ;
--
-- Salinity is included here as an example data variable: there will almost
-- certainly be others!
-- Repeat the same set of attributes for each data parameter.
-- The variable names and long names of these variables are not
-- standardised - the standardised naming is achieved through
-- the sdn_parameter_urn and sdn_parameter_name attributes.
--
    float PSAL(INSTANCE, MAXZ) ;
--
-- CF attributes mandatory for SeaDataNet.
--
        PSAL:long_name = "Practical salinity" ;
        PSAL:units = "1e-3" ;
```

```
--
-- It is possible that other ancillary variables such as standard
-- deviations might be required.
-- These should be included following the examples in the CF1.6 Metadata
-- Convention, but should also include the four SeaDataNet semantic
-- parameter attributes (sdn_parameter_urn, sdn_parameter_name,
-- sdn_uom_urn, sdn_uom_name).
--
        PSAL:ancillary_variables= "PSAL_OCEANSITES_QC"
        PSAL_SEADATANET_QC" ;
--
-- Note this will be different if the z co-ordinate is PRES or HEIGHT
--
        PSAL:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;
--
-- CF attributes optional for SeaDataNet
-- Inclusion of the Standard Name here is intentional because the
-- SeaDataNet vocabulary is more extensive and it fulfils the function
-- of uniquely identifying the variable within the file.
-- However, inclusion of a Standard Name if at all possible is very
-- strongly recommended.
--
        PSAL:standard_name = "sea_water_practical_salinity" ;
        PSAL:_FillValue = -1.0f ;
--
-- SeaDataNet semantic extensions - mandatory for SeaDataNet.
--
        PSAL:sdn_parameter_urn = "SDN:P01::PSLTZZ01" ;
        PSAL:sdn_parameter_name = "Practical salinity of the water body";
        PSAL:sdn_uom_urn = "SDN:P06::UUUU" ;
        PSAL:sdn_uom_name = "Dimensionless"
--
-- Optional SeaDataNet linkage to the instrument used to measure the parameter
--
        PSAL::sdn_instrument_urn = "SDN:L22::TOOL0002"
        PSAL::sdn_instrument_name ="Neil Brown MK3 CTD"


-- Again we have flags in OceanSITES (optional) and SeaDataNet
-- (mandatory) conventions.
--
-- OceanSITES
--
    byte PSAL_OCEANSITES_QC(INSTANCE, MAXZ) ;
        PSAL_OCEANSITES_QC:long_name = "OceanSites quality flag" ;
        PSAL_OCEANSITES_QC:Conventions = "OceanSites reference table 2" ;
        PSAL_OCEANSITES_QC:_FillValue = -128b ;
        PSAL_OCEANSITES_QC:valid_min = 0b ;
        PSAL_OCEANSITES_QC:valid_max = 9b ;
        PSAL_OCEANSITES_QC:flag_values = 0b, 1b, 2b, 3b, 4b, 5b, 6b, 7b, 8b, 9b
;
        PSAL_OCEANSITES_QC:flag_meanings = "no_qc_performed good_data
probably_good_data bad_data_that_are_potentially_correctable bad_data value_changed
not_used nominal_value interpolated_value missing_value" ;
```

```
--
-- SeaDataNet flag
--
        byte PSAL_SEADATANET_QC(INSTANCE, MAXZ) ;
                PSAL_SEADATANET_QC:long_name = "SeaDataNet quality flag" ;
                PSAL_SEADATANET_QC:Conventions = "SeaDataNet measurand
                qualifier flags" ;
                PSAL_SEADATANET_QC:_FillValue = 57b;
                PSAL_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";
                PSAL_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b, 52b, 53b,
                54b, 55b, 56b, 57b, 65b ;
                PSAL_SEADATANET_QC:flag_meanings = "no_quality_control
                good_value probably_good_value probably_bad_value bad_value
                changed_value value_below_detection value_in_excess
                interpolated_value missing_value value_phenomenon_uncertain" ;

// global attributes:
--
-- CF attributes mandatory for SeaDataNet
-- If the file is SeaDataNet compliant, but not MyOcean compliant then the
-- Conventions attribute would be "SeaDataNet_1.0 CF1.6" (no comma: they
-- are only included if a convention label included embedded spaces
-- - see CF Trac ticket 76).
--
        :Conventions = "SeaDataNet_1.0,OceanSITES Manual 1.1,CF1.6" ;
        :featureType = "profile" ;
        :title = "RRS Challenger Cruise CH33 CTD Station 35" ;
        :date_update = "2012-05-22T19:28:30Z" ;
--
-- CF attributes recommended for SeaDataNet where appropriate
--
        :comment = "Published version of the profile."
--
-- OceanSITES attributes
-- Optional for SeaDataNet. Note that "references" has been moved from an
-- attribute to a variable to allow a reference to be assigned to each
-- profile in the collection.
--
                :references = "http://www.myocean.eu.org,http://www.coriolis.eu.org" ;
                :source = "GLIDER : observation" ;
--
-- OceanSITES extensions
-- Optional for SeaDataNet
-- From a SeaDataNet perspective, there is no problem with the
-- inclusion of additional global attributes to enhance interoperability
-- with MyOcean or other conventions such as USNODC NetCDF templates.
-- However, be aware that some attributes might place constraints on the
-- composition of the collection (e.g. inclusion of "platform_name"
-- restricts the collection to profiles from a given platform) that are
-- contrary to SeaDataNet business objectives such as EMODNET product
-- aggregations.
-- Note that each profile in SeaDataNet has an accompanying ISO19115
-- (soon to be ISO19139) metadata document so a "metadata light"
-- approach has been taken to avoid the inevitable maintenance
```

```
-- issues with information duplication
--
                :data_type = "OceanSITES vertical profile" ;
                :format_version = "1.1" ;
                :platform_code = "EGO-Pheidippides" ;
                :institution = "Oceanography Center Cyprus" ;
                :wmo_platform_code = "68450" ;
                :platform_name = "EGO-Pheidippides" ;
                :history = "2012-05-22T19:28:30Z : Creation" ;
                :data_mode = "R" ;
                :quality_control_indicator = "6" ;
                :quality_index = "A" ;
                :netcdf_version = "3.5" ;
                :summary = "The Pheidippides glider was deployed in December 2011, equiped with salinity and oxygen sensors" ;
                :naming_authority = "OceanSITES" ;
                :id = "68450_20120521" ;
                :cdm_data_type = "vertical profile" ;
                :area = "Global Ocean" ;
                :geospatial_lat_min = "33.7655" ;
                :geospatial_lat_max = "33.796" ;
                :geospatial_lon_min = "33.2675" ;
                :geospatial_lon_max = "33.305" ;
                :geospatial_vertical_min = "2" ;
                :geospatial_vertical_max = "1002" ;
                :geospatial_vertical_positive = "down" ;
                :time_coverage_start = "2012-05-21T03:43:00Z" ;
                :time_coverage_end = "2012-05-21T17:34:00Z" ;
                :institution_references = "http://www.coriolis.eu.org" ;
                :contact = "codac@ifremer.fr" ;
                :author = "Coriolis and MyOcean data provider" ;
                :data_assembly_center = "Coriolis" ;
                :pi_name = "Dan Hayes" ;
                :distribution_statement = "These data follow MyOcean standards; they are public and free of charge. User assumes all risk for use of data. User must display citation in any publication or product using data. User must contact PI prior to any commercial use of data. More on: http://www.myocean.eu/data_policy" ;
                :citation = "These data were collected and made freely available by the MyOcean project and the programs that contribute to it" ;
                :update_interval = "daily" ;
                :qc_manual = "OceanSITES User\'s Manual v1.1" ;
--
-- Additional attributes from other conventions may be included here.
-- The SeaDataNet specification describes the minimum amount of information
-- required by SeaDataNet.
--
-- There is no upper limit.
--
data:
```

Follows on from here.......

4.5.1.5. Extension to multiple profile storage

Extending the single-profile design to multiple profile storage is simple, requiring two changes. First, the INSTANCE dimension value needs to be changed from 1 to UNLIMITED. Secondly, a _FillValue attribute, to be used when padding profiles to an even length, needs to be added to the z co-ordinate variable.

4.5.2. SeaDataNet NetCDF Profile for Time Series Data

This is the SeaDataNet NetCDF profile to be used for the storage of data that have been mapped onto the time series feature types, which is defined as having a single x co-ordinate (e.g. longitude), a single y co-ordinate (e.g. latitude), a single z co-ordinate (e.g. depth) and a monotonic set of time co-ordinates. It covers many common oceanographic types such as most moored instrument data (except ADCPs) and sea level data from tide gauges.

4.5.2.1. Co-ordinate variables

The co-ordinate variables are of two types. The z co-ordinate, latitude and longitude are 1-D vectors, which for single profile storage have a length of 1. These have been used in preference to scalars to provide a foundation for multi-profile storage. The preferred z co-ordinate parameter is either depth below sea level for measurements in water bodies or height above sea level for measurements in the atmosphere such as meteorological measurements. Height above the seafloor is also allowed (but depth is STRONGLY preferred) to cover legacy data where depth cannot be calculated because no bathymetric depth data are available. Pressure as a z co-ordinate is not allowed for time series.

Time values are stored in a 2D array, with one dimension set to one for single-profile storage. The SeaDataNet practice of using Chronological Julian Day (CJD) as the numeric representation of time has been followed. Note that CF requires that co-ordinate variables be monotonic, so the data need to be time sorted.

4.5.2.2. Geophysical variables

The geophysical variables, like the time co-ordinates, are stored as 2D arrays with the INSTANCE dimension set to 1. Each geophysical variable has at least one ancillary variable named using the conventions described in section 3.4.3 containing the SeaDataNet qualifier flags for that variable.

4.5.2.3. Attributes

The Featuretype attribute is set to ‘timeSeries’.

4.5.2.4. CDL example

There now follows an example NetCDF file structure for the storage of a single time series (e.g. a current meter record) in annotated network Common Data form Language (CDL). The annotations are contained in lines prefixed by two hyphens (‘- - ‘). Mandatory (for SeaDataNet) variables and attributes are shown in bold type.

```
--
-- This file specifies the SeaDataNet NetCDF encoding for a single time series
-- in annotated CDL
--
dimensions:
--
-- The INSTANCE dimension is the number of profiles stored in the file
```

```
-- The MAXT dimension is set to the number of time steps in the stored series
-- The STRING80 dimension is specifies the length of fixed size strings for time
--  series label variables
--
        INSTANCE = 1 ; //MAXT = 1000 ;
        STRING80 = 80;
        REFMAX = 5;
variables:
--
-- The name for this variable, including upper case, is fixed for SeaDataNet
--
        double TIME(INSTANCE, MAXT) ;
--
-- CF attributes mandatory for SeaDataNet - include verbatim
--
                TIME:long_name = "Chronological Julian Date" ;
                TIME:standard_name = "time" ;
                TIME:units = "days since -4713-01-01T00:00:00Z" ;
                TIME:ancillary_variables = "TIME_SEADATANET_QC" ;
                TIME:axis = "T" ;
                TIME:calendar = "julian" ;
--
-- SeaDataNet semantic extensions - mandatory for SeaDataNet
--
-- sdn_parameter_urn should specify the correct concept from the
-- P01 vocabulary for the parameter.
-- sdn_parameter_name is the preferred label for the concept from the P01
-- vocabulary.
-- sdn_uom_urn should specify the correct concept from the P06 vocabulary
-- for the unit of measure.
-- sdn_uom_name is the preferred label for the concept from
-- the P06 vocabulary.
--
                TIME:sdn_parameter_urn = "SDN:P01::CJDY1101" ;
                TIME:sdn_parameter_name = "Julian Date (chronological)" ;
                TIME:sdn_uom_urn = "SDN:P06::UTAA" ;
                TIME:sdn_uom_name = "Days"
--
-- This is the SeaDataNet flag and is mandatory (all attributes) for SeaDataNet
-- The name for this variable, including upper case, is fixed
-- for SeaDataNet. Include verbatim.
--
        byte TIME_SEADATANET_QC(INSTANCE, MAXT) ;
                TIME_SEADATANET_QC:long_name = "SeaDataNet quality flag" ;
                TIME_SEADATANET_QC:Conventions = "SeaDataNet measurand
                qualifier flags" ;
                TIME_SEADATANET_QC:_FillValue = 57b;
                TIME_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";
                TIME_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b, 52b,
                53b, 54b, 55b, 56b, 57b, 65b ;
                TIME_SEADATANET_QC:flag_meanings = "no_quality_control
                good_value probably_good_value probably_bad_value bad_value
                changed_value value_below_detection value_in_excess
                interpolated_value missing_value value_phenomenon_uncertain" ;
```

```
--
-- The name for this variable, including upper case, is fixed for SeaDataNet
--
-- Note the rule in SeaDataNet is that position is assumed to be
-- WGS-84 on the basis that this is either the correct CRS
-- or the accuracy is so poor that CRS is irrelevant
-- This is reported by the inclusion below of a crs variable with attributes
-- appropriate to WGS84
--
        double LATITUDE(INSTANCE) ;
--
-- CF attributes mandatory for SeaDataNet
--
                LATITUDE:long_name = "Latitude" ;
                LATITUDE:standard_name = "latitude" ;
                LATITUDE:units = "degrees_north" ;
                LATITUDE:ancillary_variables = "POSITION_SEADATANET_QC" ;
                LATITUDE:axis = "Y" ;
                LATITUDE:grid_mapping = "crs";

--
-- SeaDataNet semantic extensions - mandatory for SeaDataNet
--
                LATITUDE:sdn_parameter_urn = "SDN:P01::ALATZZ01" ;
                LATITUDE:sdn_parameter_name = "Latitude north" ;
                LATITUDE:sdn_uom_urn = "SDN:P06::DEGN" ;
                LATITUDE:sdn_uom_name = "Degrees north" ;
--
-- The name for this variable, including upper case, is fixed for SeaDataNet
--
        double LONGITUDE(INSTANCE) ;
--
-- CF attributes mandatory for SeaDataNet
--
                LONGITUDE:long_name = "Longitude" ;
                LONGITUDE:standard_name = "longitude" ;
                LONGITUDE:units = "degrees_east" ;
                LONGITUDE:ancillary_variables = "POSITION_SEADATANET_QC" ;
                LONGITUDE:axis = "X" ;
                LONGITUDE:grid_mapping = "crs";
--
-- SeaDataNet semantic extensions - mandatory for SeaDataNet
--
                LONGITUDE:sdn_parameter_urn = "SDN:P01::ALONZZ01" ;
                LONGITUDE:sdn_parameter_name = "Longitude east" ;
                LONGITUDE:sdn_uom_urn = "SDN:P06::DEGE" ;
                LONGITUDE:sdn_uom_name = "Degrees east" ;
--
-- The OceanSITES convention of merging latitude and longitude QC into
-- a position QC has been followed
-- The name for this variable, including upper case, is fixed for SeaDataNet
--
        byte POSITION_SEADATANET_QC(INSTANCE) ;
```

```
        POSITION_SEADATANET_QC:long_name = "SeaDataNet quality
        flag" ;
        POSITION_SEADATANET_QC:Conventions = "SeaDataNet
        measurand qualifier flags" ;
        POSITION_SEADATANET_QC:_FillValue = 57b;
        POSITION_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";
        POSITION_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b,
        52b, 53b, 54b, 55b, 56b, 57b, 65b ;
        POSITION_SEADATANET_QC:flag_meanings = "no_quality_control
        good_value probably_good_value probably_bad_value bad_value
        changed_value value_below_detection value_in_excess
        interpolated_value missing_value value_phenomenon_uncertain" ;
--
-- SeaDatanet CRS reporting - include verbatim
--
    int crs ;
        crs:grid_mapping_name = "latitude_longitude"
        crs:epsg_code = "EPSG:4326"
        crs:semi_major_axis = 6378137.0 ;
        crs:inverse_flattening = 298.257223563 ;
--
-- SeaDataNet attribute and metadata variables such as identifiers
-- and water depths at the measurement site.
--
-- Mandatory for SeaDataNet.
-- Note this could be included as delimited lists in global attributes, but this
-- encoding is preferred.
-- The names for these variables, including case, are fixed for SeaDataNet.
--
    char SDN_CRUISE(INSTANCE,STRING80) ;
        SDN_CRUISE:long_name = "Time series grouping label" ;
     char SDN_STATION(INSTANCE,STRING80) ;
        SDN_STATION:long_name = "Time series label" ;
    char SDN_LOCAL_CDI_ID (INSTANCE,STRING80) ;
        SDN_LOCAL_CDI_ID:long_name = "SeaDataNet CDI identifier" ;
        SDN_LOCAL_CDI_ID:cf_role = "timeseries_id" ;
--
-- EDMO code provides the namespace for CDI local identifier.
-- Name including case id fixed for SeaDataNet.
--
    int SDN_EDMO_CODE (INSTANCE) ;
    SDN_EDMO_CODE:long_name = "European Directory of Marine
    Organisations code for the CDI partner"
--
-- SeaDataNet optional attribute variables.
-- Bathymetric depth required is considered less important for time series than profiles
-- and so is optional rather than mandatory.
--
    float SDN_BOT_DEPTH (INSTANCE) ;
        SDN_BOT_DEPTH:standard_name =
        "sea_floor_depth_below_sea_surface";
        SDN_BOT_DEPTH:long_name = "Bathymetric depth at time series
        measurement site" ;
        SDN_BOT_DEPTH:units = "meters" ;
```

```
                SDN_BOT_DEPTH:sdn_parameter_urn = "SDN:P01::MBANZZZZ" ;
                SDN_BOT_DEPTH:sdn_parameter_name = "Sea-floor depth (below
                instantaneous sea level) {bathymetric depth} in the water body" ;
                SDN_BOT_DEPTH:sdn_uom_urn = "SDN:P06::ULAA" ;
                SDN_BOT_DEPTH:sdn_uom_name = "Metres" ;
                SDN_BOT_DEPTH:_FillValue = -999.0
--
-- Linkages to external resources (see Section 4.4.8)
--
-- SDN_REFERENCES - single linkage to a URI which resolves to an XHTML page
-- carrying additional information such as usage metadata or DOI landing page
--
-- SDN_XLINK - multiple (in this example 5) linkages to external resource URNs
-- following a strictly defined syntax that resolve into either XML documents of known
-- schema or XHTML.
--
        char SDN_REFERENCES(INSTANCE, STRING80) ;
                SDN_REFERENCES:long_name = "Usage metadata reference";
        char SDN_XLINK (INSTANCE, REFMAX, STRING80) ;
                SDN_XLINK_TYPE:long_name = "External resource linkages";
--
-- In the CF1.6 specification time series do not have a z co-ordinate.
-- However in observational oceanography, the depth of a measurement is as
-- important as latitude and longitude and so a z co-ordinate array with
-- one value per time series stored has been included.
--
-- Acceptable netCDF variable names are DEPTH and HEIGHT.
-- These names do not imply an origin (e.g. sea surface) – that must be
-- specified through attributes.
-- HEIGHT may be used for atmospheric profiles such as radiosondes
-- or to specify locations in the water column relative to the seabed.
-- The latter should be regarded as a last resort.  Depth below sea surface
-- should be used instead if at all possible.
--
        float DEPTH(INSTANCE) ;
--
-- CF attributes mandatory for SeaDataNet.
--
                DEPTH:long_name = "Nominal depth over time series" ;
--
-- Standard names to use are 'depth', 'height' or 'height_above_sea_floor'
--
                DEPTH:standard_name = "depth" ;
                DEPTH:units = "meters" ;
                DEPTH:ancillary_variables = "DEPTH_SEADATANET_QC" ;
                DEPTH:axis = "Z" ;
                DEPTH:positive = "down" ;
                DEPTH:_FillValue -999.0f;
--
-- SeaDataNet semantic extensions - mandatory for SeaDataNet.
--
                DEPTH:sdn_parameter_urn = "SDN:P01::ADEPZZ01" ;
                DEPTH:sdn_parameter_name = "Depth below surface of the water
                body" ;
```

```
                DEPTH:sdn_uom_urn = "SDN:P06::ULAA" ;
                DEPTH:sdn_uom_name = "Metres"
--
-- The name for the flag variable, including upper case, is fixed for SeaDataNet
-- at DEPTH_SEADATANET_QC, HEIGHT_SEADATANET_QC or
-- HEIGHT_ABOVE_SEAFLOOR_SEADATANET_QC as appropriate.
--
        byte DEPTH_SEADATANET_QC(INSTANCE) ;
                DEPTH_SEADATANET_QC:long_name = "SeaDataNet quality flag" ;
                DEPTH_SEADATANET_QC:Conventions = "SeaDataNet measurand
                qualifier flags" ;
                DEPTH_SEADATANET_QC:_FillValue = 57b;
                DEPTH_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";
                DEPTH_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b, 52b,
                53b, 54b, 55b, 56b, 57b, 65b ;
                DEPTH_SEADATANET_QC:flag_meanings = "no_quality_control
                good_value probably_good_value probably_bad_value bad_value
                changed_value value_below_detection value_in_excess
                interpolated_value missing_value value_phenomenon_uncertain" ;
--
-- Salinity is included here as an example data variable:
-- there will almost certainly be others!
-- Repeat the same set of attributes for each data parameter.
-- The variable names and long names of these variables are not standardised.
-- The standardised naming is achieved through the sdn_parameter_urn
-- and sdn_parameter_name attributes.
--
        float PSAL(INSTANCE, MAXT) ;
--
-- CF attributes mandatory for SeaDataNet
--
                PSAL:long_name = "Practical salinity" ;
                PSAL:units = "1e-3" ;
--
-- It is possible that other ancillary variables such as standard
-- deviations might be required.
-- These should be included following the examples in the
-- CF1.6 Metadata Convention, but should also include the four SeaDataNet
-- semantic parameter attributes  (sdn_parameter_urn, sdn_parameter_name,
-- sdn_uom_urn, sdn_uom_name).
--
                PSAL:ancillary_variables = "PSAL_SEADATANET_QC" ;
--
-- Note this will be different if the z co-ordinate is HEIGHT_ABOVE_SEAFLOOR
-- or HEIGHT.
--
                PSAL:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;
--
-- CF attributes optional for SeaDataNet.
-- Inclusion of the Standard Name here is intentional because the SeaDataNet vocabulary
-- is more extensive and it fulfils the function of uniquely identifying the variable within
-- the file.
-- However, inclusion of a Standard Name if at all possible is very strongly
-- recommended.
```

```
--
                PSAL:standard_name = "sea_water_practical_salinity" ;
                PSAL:_FillValue = -1.0f ;
--
-- SeaDataNet semantic extensions - mandatory for SeaDataNet.
--
                PSAL:sdn_parameter_urn = "SDN:P01::PSLTZZ01" ;
                PSAL:sdn_parameter_name = "Practical salinity of the water
                body";
                PSAL:sdn_uom_urn = "SDN:P06::UUUU" ;
                PSAL:sdn_uom_name = "Dimensionless"
--
-- Optional SeaDataNet linkage to the instrument used to measure the parameter
--
                PSAL::sdn_instrument_urn = "SDN:L22::TOOL0211"
                PSAL::sdn_instrument_name ="Aanderaa RCM 4/5 Recording Current
                Meter"
--
-- SeaDataNet flag channel.
--
        byte PSAL_SEADATANET_QC(INSTANCE, MAXT) ;
                PSAL_SEADATANET_QC:long_name = "SeaDataNet quality flag" ;
                PSAL_SEADATANET_QC:Conventions = "SeaDataNet measurand
                qualifier flags" ;
                PSAL_SEADATANET_QC:_FillValue = 57b;
                PSAL_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";
                PSAL_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b, 52b,
                53b, 54b, 55b, 56b, 57b, 65b ;
                PSAL_SEADATANET_QC:flag_meanings = "no_quality_control
                good_value probably_good_value probably_bad_value bad_value
                changed_value value_below_detection value_in_excess
                interpolated_value missing_value value_phenomenon_uncertain" ;

// global attributes:
--
-- CF attributes mandatory for SeaDataNet.
--
        :Conventions = "SeaDataNet_1.0 CF1.6" ;
        :featureType = "timeSeries" ;
        :title = "North Sea Project current meter data" ;
        :date_update = "2012-05-22T19:28:30Z" ;
--
-- CF attributes recommended for SeaDataNet where appropriate.
--
        :comment = "Published dataset"
--
-- Additional attributes from other conventions may be included here.
-- The SeaDataNet specification describes the minimum amount of information
-- required by SeaDataNet.
--
-- There is no upper limit.
--
data:
```

Follows on from here.......

4.5.2.5. Extension to multiple time series storage

Extending the single time series design to multiple time series storage is simple, requiring two changes. First, the INSTANCE dimension value needs to be changed from 1 to UNLIMITED. Secondly, a _FillValue attribute, to be used when padding time series to an equal number of time steps, needs to be added to the TIME variable.

4.5.3. SeaDataNet NetCDF Profile for Trajectory Data

This is the SeaDataNet NetCDF profile to be used for the storage of data that have been mapped onto the trajectory feature types, which is defined as having an equal number of x co-ordinates (e.g. longitude), y co-ordinates (e.g. latitude), z co-ordinates (e.g. depth) and time co-ordinates. It is generally used for continuously sampled shipboard measurements, such as thermosalinograph data (but not vessel-mounted ADCP data) and some AUV data, such as unbinned glider data.

CF feature types do not distinguish between two-dimensional and three-dimensional trajectories. Consequently, the approach taken has been to use the same NetCDF profile for both, with a mandatory z co-ordinate variable. In the case of two-dimensional trajectories all values in the z co-ordinate array are set to the same value.

Should full (downcast plus upcast) CTD profiles need to be stored in SeaDataNet compliant NetCDF then they may be modelled as trajectories. Note that this will require inclusion of date/time, latitude and longitude values for every data point.

4.5.3.1. Co-ordinate variables

All four co-ordinate variables are stored in 2D arrays, with the INSTANCE dimension set to one for single-trajectory storage. The TIME array should be monotonic. The SeaDataNet practice of using Chronological Julian Day (CJD) as the numeric representation for time has been followed.

The x and y co-ordinates are LONGITUDE and LATITUDE. SeaDataNet convention is to use the 2D WGS-84 CRS (EPSG 4326). The two co-ordinates share a common qualifier flag variable (POSITION_SEADATANET_QC).

The permitted z co-ordinate variables are the same as for profile data, namely DEPTH, HEIGHT or PRES. DEPTH is preferred to PRES.

4.5.3.2. Geophysical variables

The geophysical variables, like the co-ordinate variables, are stored as 2D arrays with the INSTANCE dimension set to 1. Each geophysical variable has at least one ancillary variable named using the conventions described in section 3.4.3 containing the SeaDataNet qualifier flags for that variable.

4.5.3.3. Attributes

The Featuretype attribute is set to 'trajectory'.

4.5.3.4. CDL example

There now follows an example NetCDF file structure for the storage of a single trajectory (e.g. a thermosalinograph record for a cruise) in annotated network Common Data form Language (CDL). The annotations are contained in lines prefixed by two hyphens ('- -'). Mandatory (for SeaDataNet) variables and attributes are shown in bold type.

```
-- This file specifies the SeaDataNet NetCDF encoding for a single trajectory
-- in annotated CDL.
--
dimensions:
--
-- The 'INSTANCE dimension is set to 1.
-- This example was based on storage a trajectory containing 1000 time steps.
-- The STRING80 dimension is specifies the length of fixed size strings for time
-- series label variables.
--
        INSTANCE = 1 ;
        MAXT = 1000 ;
        STRING80 = 80;
        REFMAX = 5;
variables:
--
-- The name for this variable, including upper case, is fixed for SeaDataNet.
--
        double TIME(INSTANCE, MAXT) ;
--
-- CF attributes mandatory for SeaDataNet - include verbatim except for
-- ancillary variables.
--
                TIME:long_name = "Chronological Julian Date" ;
                TIME:standard_name = "time" ;
                TIME:units = "days since -4713-01-01T00:00:00Z" ;
                TIME:ancillary_variables = "TIME_SEADATANET_QC" ;
                TIME:axis = "T" ;
                TIME:calendar = "julian" ;
--
-- SeaDataNet semantic extensions - mandatory for SeaDataNet
--
-- sdn_parameter_urn should specify the correct concept
-- from the P01 vocabulary for the parameter.
-- sdn_parameter_name is the preferred label for the concept from the
-- P01 vocabulary.
-- sdn_uom_urn should specify the correct concept from the P06
-- vocabulary for the unit of measure.
-- sdn_uom_name is the preferred label for the concept from the
-- P06 vocabulary.
--
                TIME:sdn_parameter_urn = "SDN:P01::CJDY1101" ;
                TIME:sdn_parameter_name = "Julian Date (chronological)" ;
                TIME:sdn_uom_urn = "SDN:P06::UTAA" ;
                TIME:sdn_uom_name = "Days"
--
-- This is the SeaDataNet flag and is mandatory (all attributes) for SeaDataNet.
-- The name for this variable, including upper case, is fixed for SeaDataNet.
-- Include verbatim.
--
        byte TIME_SEADATANET_QC(INSTANCE, MAXT) ;
```

```
                TIME_SEADATANET_QC:long_name = "SeaDataNet quality flag" ;
                TIME_SEADATANET_QC:Conventions = "SeaDataNet measurand
                qualifier flags" ;
                TIME_SEADATANET_QC:_FillValue = 57b;
                TIME_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";
                TIME_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b, 52b, 53b,
                54b, 55b, 56b, 57b, 65b ;
                TIME_SEADATANET_QC:flag_meanings = "no_quality_control
                good_value probably_good_value probably_bad_value bad_value
                changed_value value_below_detection value_in_excess
                interpolated_value missing_value value_phenomenon_uncertain" ;
--
-- The name for this variable, including upper case, is fixed for SeaDataNet.
--
-- Note the rule in SeaDataNet is that position is assumed to be WGS-84
-- on the basis that this is either the correct CRS or the accuracy is so poor
-- that CRS is irrelevant.
-- This is reported by the inclusion below of a crs variable with attributes
-- appropriate to WGS84.
--
        double LATITUDE(INSTANCE, MAXT) ;
--
-- CF attributes mandatory for SeaDataNet
--
                LATITUDE:long_name = "Latitude" ;
                LATITUDE:standard_name = "latitude" ;
                LATITUDE:units = "degrees_north" ;
                LATITUDE:ancillary_variables = "POSITION_SEADATANET_QC" ;
                LATITUDE:axis = "Y" ;
                LATITUDE:grid_mapping = "crs";
--
-- SeaDataNet semantic extensions - mandatory for SeaDataNet.
--
                LATITUDE:sdn_parameter_urn = "SDN:P01::ALATZZ01" ;
                LATITUDE:sdn_parameter_name = "Latitude north" ;
                LATITUDE:sdn_uom_urn = "SDN:P06::DEGN" ;
                LATITUDE:sdn_uom_name = "Degrees north" ;
--
-- The name for this variable, including upper case, is fixed for SeaDataNet.
--
        double LONGITUDE(INSTANCE, MAXT);
--
-- CF attributes mandatory for SeaDataNet.
--
                LONGITUDE:long_name = "Longitude" ;
                LONGITUDE:standard_name = "longitude" ;
                LONGITUDE:units = "degrees_east" ;
                LONGITUDE:ancillary_variables = "POSITION_SEADATANET_QC" ;
                LONGITUDE:axis = "X" ;
                LONGITUDE:grid_mapping = "crs";
--
-- SeaDataNet semantic extensions - mandatory for SeaDataNet.
--
                LONGITUDE:sdn_parameter_urn = "SDN:P01::ALONZZ01" ;
```

```
                LONGITUDE:sdn_parameter_name = "Longitude east" ;
                LONGITUDE:sdn_uom_urn = "SDN:P06::DEGE" ;
                LONGITUDE:sdn_uom_name = "Degrees east" ;
--
-- The OceanSITES convention of merging latitude and longitude QC into a
-- position QC has been followed.
-- The name for this variable, including upper case, is fixed for SeaDataNet.
--
        byte POSITION_SEADATANET_QC(INSTANCE, MAXT) ;
                POSITION_SEADATANET_QC:long_name = "SeaDataNet quality
                flag" ;
                POSITION_SEADATANET_QC:Conventions = "SeaDataNet
                measurand qualifier flags" ;
                POSITION_SEADATANET_QC:_FillValue = 57b;
                POSITION_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";
                POSITION_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b, 52b,
                53b, 54b, 55b, 56b, 57b, 65b ;
                POSITION_SEADATANET_QC:flag_meanings = "no_quality_control
                good_value probably_good_value probably_bad_value bad_value
                changed_value value_below_detection value_in_excess
                interpolated_value missing_value value_phenomenon_uncertain" ;
--
-- SeaDatanet CRS reporting - include verbatim
--
        int crs ;
                crs:grid_mapping_name = "latitude_longitude"
                csr:epsg_code = "EPSG:4326"
                crs:semi_major_axis = 6378137.0 ;
                crs:inverse_flattening = 298.257223563 ;
--
-- SeaDataNet attribute and metadata variables such as identifiers.
-- Note that bathymetric depth is considered as a geophysical variable for
-- trajectory series as it constitutes a measured parameter within the dataset.
--
-- Mandatory for SeaDataNet.
-- Note this could be included as delimited lists in global attributes
-- but this is encoding is preferred.
-- The names for these variables, including case, are fixed for SeaDataNet.
--
        char SDN_CRUISE(INSTANCE,STRING80) ;
                SDN_CRUISE:long_name = "Trajectory grouping label" ;
        char SDN_STATION(INSTANCE,STRING80) ;
                SDN_STATION:long_name = "Trajectory label" ;
        char SDN_LOCAL_CDI_ID (INSTANCE,STRING80) ;
                SDN_LOCAL_CDI_ID:long_name = "SeaDataNet CDI identifier" ;
                SDN_LOCAL_CDI_ID:cf_role = "trajectory_id";
--
-- EDMO code provides the namespace for CDI local identifier
-- (SeaDataNet convention).
-- Name including case id fixed for SeaDataNet.
--
        int SDN_EDMO_CODE (INSTANCE) ;
                SDN_EDMO_CODE:long_name = "European Directory of Marine
                Organisations code for the CDI partner"
```

```
--
-- SeaDataNet optional attribute variables.
-- Bathymetric depth is optional rather than mandatory.
--
        float SDN_BOT_DEPTH (INSTANCE) ;
                SDN_BOT_DEPTH:standard_name =
                "sea_floor_depth_below_sea_surface";
                SDN_BOT_DEPTH:long_name = "Bathymetric depth along trajectory
                measurement site";
                SDN_BOT_DEPTH:units = "meters" ;
                SDN_BOT_DEPTH:sdn_parameter_urn = "SDN:P01::MBANZZZZ" ;
                SDN_BOT_DEPTH:sdn_parameter_name = "Sea-floor depth (below
                instantaneous sea level) {bathymetric depth} in the water body" ;
                SDN_BOT_DEPTH:sdn_uom_urn = "SDN:P06::ULAA" ;
                SDN_BOT_DEPTH:sdn_uom_name = "Metres" ;
                SDN_BOT_DEPTH:_FillValue = -999.0
--
-- Linkages to external resources (see Section 4.4.8)
--
-- SDN_REFERENCES - single linkage to a URI which resolves to an XHTML page
-- carrying additional information such as usage metadata or DOI landing page
--
-- SDN_XLINK - multiple (in this example 5) linkages to external resource URNs
-- following a strictly defined syntax that resolve into either XML documents of known
-- schema or XHTML.
--
        char SDN_REFERENCES(INSTANCE, STRING80) ;
                SDN_REFERENCES:long_name = "Usage metadata reference";
        char SDN_XLINK (INSTANCE, REFMAX, STRING80) ;
                SDN_XLINK_TYPE:long_name = "External resource linkages";
--
-- In the CF1.6 specification trajectories do not have a z co-ordinate.
-- However in observational oceanography, the depth of a measurement is as
-- important as latitude and longitude. Also, there are an increasing number
-- of 3D trajectory datasets in oceanography with the growth in the
-- use of AUVs.
-- Consequently, a z co-ordinate has been included.
-- This will have a constant value for 2D trajectory data such
-- as thermosalinograph data.
--
-- The name for this variable, including upper case, is fixed for SeaDataNet
-- to DEPTH, HEIGHT or PRES as appropriate. DEPTH is preferred over PRES.
-- These names do not imply an origin (e.g. sea surface) – that must be
-- specified through attributes.

        float DEPTH(INSTANCE, MAXT) ;
--
-- CF attributes mandatory for SeaDataNet
--
                DEPTH:long_name = "Depth" ;
--
-- Standard names to use are 'depth', 'height' or
--'sea_water_pressure_due_to_sea_water'
--
```

```
                DEPTH:standard_name = "depth" ;
                DEPTH:units = "meters" ;
                DEPTH:ancillary_variables = "DEPTH_SEADATANET_QC" ;
                DEPTH:axis = "Z" ;
                DEPTH:positive = "down" ;
                DEPTH:_FillValue -999.0f;
--
-- SeaDataNet semantic extensions - mandatory for SeaDataNet
--
                DEPTH:sdn_parameter_urn = "SDN:P01::ADEPZZ01" ;
                DEPTH:sdn_parameter_name = "Depth below surface of the water
                body" ;
                DEPTH:sdn_uom_urn = "SDN:P06::ULAA" ;
                DEPTH:sdn_uom_name = "Metres"
--
-- The name for the flag variable, including upper case, is fixed for SeaDataNet
-- at DEPTH_SEADATANET_QC, HEIGHT_SEADATANET_QC or
-- PRES_SEADATANET_QC as appropriate.
--
        byte DEPTH_SEADATANET_QC(INSTANCE, MAXT) ;
                DEPTH_SEADATANET_QC:long_name = "SeaDataNet quality flag" ;
                DEPTH_SEADATANET_QC:Conventions = "SeaDataNet measurand
                qualifier flags" ;
                DEPTH_SEADATANET_QC:_FillValue = 57b;
                DEPTH_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";
                DEPTH_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b, 52b,
                53b, 54b, 55b, 56b, 57b, 65b ;
                DEPTH_SEADATANET_QC:flag_meanings = "no_quality_control
                good_value probably_good_value probably_bad_value bad_value
                changed_value value_below_detection value_in_excess
                interpolated_value missing_value value_phenomenon_uncertain" ;
--
-- Salinity is included here as an example data variable:
-- there will almost certainly be others!
-- Repeat the same set of attributes for each data parameter.
-- The variable names and long names of these variables are not standardised.
-- The standardised naming is achieved through the sdn_parameter_urn
-- and sdn_parameter_name attributes.
--
        float PSAL(INSTANCE, MAXT) ;
--
-- CF attributes mandatory for SeaDataNet
--
                PSAL:long_name = "Practical salinity" ;
                PSAL:units = "1e-3" ;
--
-- It is possible that other ancillary variables such as standard
-- deviations might be required.
-- These should be included following the examples in the CF1.6 Metadata
-- Conventions,  but should also include the four SeaDataNet semantic
-- parameter attributes  (sdn_parameter_urn, sdn_parameter_name,
-- sdn_uom_urn, sdn_uom_name).
--
                PSAL:ancillary_variables = "PSAL_SEADATANET_QC" ;
```

```
--
-- Note this will be different if the z co-ordinate is PRES or HEIGHT.
--
                PSAL:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;
--
-- CF attributes optional for SeaDataNet.
-- Inclusion of the Standard Name here is intentional because the SeaDataNet vocabulary
-- is more extensive and it fulfils the function of uniquely identifying the variable within
-- the file.  However, inclusion of a Standard Name if at all possible is very strongly
-- recommended.
--
                PSAL:standard_name = "sea_water_practical_salinity" ;
                PSAL:_FillValue = -1.0f ;
--
-- SeaDataNet semantic extensions - mandatory for SeaDataNet.
--
                PSAL:sdn_parameter_urn = "SDN:P01::PSLTZZ01" ;
                PSAL:sdn_parameter_name = "Practical salinity of the water body";
                PSAL:sdn_uom_urn = "SDN:P06::UUUU" ;
                PSAL:sdn_uom_name = "Dimensionless"
--
-- Optional SeaDataNet linkage to the instrument used to measure the parameter
--
                PSAL::sdn_instrument_urn = "SDN:L22::TOOL0276"
                PSAL::sdn_instrument_name ="OceanData TSG103 thermosalinograph"
--
-- SeaDataNet flag channel.
--
        byte PSAL_SEADATANET_QC(INSTANCE, MAXT) ;
                PSAL_SEADATANET_QC:long_name = "SeaDataNet quality flag" ;
                PSAL_SEADATANET_QC:Conventions = "SeaDataNet measurand
                qualifier flags" ;
                PSAL_SEADATANET_QC:_FillValue = 57b;
                PSAL_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";
                PSAL_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b, 52b, 53b,
                54b, 55b, 56b, 57b, 65b ;
                PSAL_SEADATANET_QC:flag_meanings = "no_quality_control
                good_value probably_good_value probably_bad_value bad_value
                changed_value value_below_detection value_in_excess
                interpolated_value missing_value value_phenomenon_uncertain" ;

// global attributes:
--
-- CF attributes mandatory for SeaDataNet.
--
        :Conventions = "SeaDataNet_1.0 CF1.6" ;
        :featureType = "trajectory" ;
        :title = "North Sea Project thermosalinograph data" ;
        :date_update = "2012-05-22T19:28:30Z" ;
--
-- CF attributes recommended for SeaDataNet where appropriate.
--
        :comment = "Published dataset"
--
```

```
-- Additional attributes from other conventions may be included here.
-- The SeaDataNet specification describes the minimum amount of information
-- required by SeaDataNet.
--
-- There is no upper limit.
--
data:

 Follows on from here.......
```

4.5.3.5. Extension to multiple trajectory storage

Extending the single trajectory design to multiple trajectory storage is simple, requiring two changes. First, the INSTANCE dimension value needs to be changed from 1 to UNLIMITED. Secondly, a _FillValue attribute, to be used when padding trajectories to an equal number of time steps, needs to be added to all four co-ordinate variables (TIME, LATITUDE, LONGITUDE and DEPTH).

4.5.4. SeaDataNet NetCDF for timeSeriesProfile Data

The data model for the CF1.6 timeSeries feature time includes one or more geophysical variables along the TIME dimension plus co-ordinate variables (latitude, longitude and depth/height) along the INSTANCE dimension. The timeSeriesProfile feature type adds the possibility of one or more geophysical variables for each instance that have another dimension in addition to the time dimension.

It is tempting when considering some types of oceanographic data such as moored ADCPs or thermistor chains to jump in and label this additional dimension as 'depth'. However, this approach is both limiting and potentially very confusing. It is limiting because there are data types, such as the grain-size distribution of suspended particulate material where this additional dimension could be non-spatial. It is potentially confusing because there is the possibility for 'DEPTH' to provide the z co-ordinate for one or more 2-D (INSTANCE and TIME) geophysical variables. Consider a moored ADCP mounted mid-water (e.g. on the leg of an oil rig) with a temperature sensor as part of the instrument. The water temperatures need to be associated with a depth that is different from the depths of any of the current measurements. Consequently, a different, neutral variable name - PROFZ - has been chosen for the additional dimension of the 3-D geophysical variables.

4.5.4.1. Co-ordinate variables

The co-ordinate variables are of three types. The depth/height, latitude and longitude are 1-D vectors, which for single profile storage have a length of 1. These have been used in preference to scalars to provide a foundation for multi-profile storage. The SeaDataNet practice where latitude and longitude are either given in 2-D WGS-84 (EPSG 4326) CRS or are of such low accuracy that WGS-84 can be assumed has been followed.

The preferred z co-ordinate parameter is either depth below sea level for measurements in water bodies or height above sea level for measurements in the atmosphere such as meteorological measurements. Height above the seafloor is also allowed for seabed packages especially those measuring sea level or to cover legacy data where depth cannot be calculated because no bathymetric depth data are available. If feasible then depth is strongly preferred. Pressure as a z co-ordinate is not allowed for time series.

Time values are stored in a 2-D array, with one dimension set to one for single-profile storage. The SeaDataNet practice of using Chronological Julian Day (CJD) as the numeric representation of time has been followed. Note that CF requires that co-ordinate variables be monotonic, so the data need to be time sorted.

The profile z co-ordinates are stored in a 3-D array, with one dimension set to one for single-profile storage. In order to maximise the flexibility of the format, there are minimal restrictions in the SeaDataNet profile on the variables that may be mapped onto this co-ordinate. It could be an absolute depth below sea surface, an absolute height above the seabed, the distance between the instrument and the measurement, a grain size or even the identifier of a biological taxon.

4.5.4.2. Geophysical variables

The geophysical variables are of two types. First, there are the variables measured at each level in the profile, such as current velocities for an ADCP., Like the profile z co-ordinates, these are stored as 3-D arrays with the INSTANCE dimension set to 1.

The second type are only measured at a single level for each time step, such as water temperature measured by a temperature sensor fixed to an ADCP instrument. These are stored in 2-D arrays of dimension (INSTANCE, MAXT)

Each geophysical variable has at least one ancillary variable named using the conventions described in section 3.4.3 containing the SeaDataNet qualifier flags for that variable.

4.5.4.3. Attributes

The Featuretype attribute is set to ‘timeSeriesProfile'.

4.5.4.4. CDL example

There now follows an example NetCDF file that will hold a single series from a moored ADCP with 24 current bins and both pressure and temperature sensors fitted to the base instrument in annotated networkCommonDataform Language (CDL). The annotations are contained in lines prefixed by two hyphens (‘- - ‘). Mandatory (for SeaDataNet) variables and attributes are shown in bold type.

This example has been designed for the primary SeaDataNet use case, which is to deliver data to a user who is primarily interested in applying the geophysical variables, such as the builder of an aggregated data product like a climatology. Consequently, the number of geophysical variables carried is kept to a minimum. Should the format be required to fulfil use cases such as delivery to an expert for re-analysis then additional geophysical variables may be added, such as individual beam returns and performance criteria.

```
--
-- This file specifies the SeaDataNet NetCDF encoding for a moored ADCP with
-- pressure and temperature sensors mounted on the instrument in annotated CDL
-- Compared to the profile, timeSeries and trajectory examples above the level
-- of annotation has been drastically reduced. If further clarification is required
-- consult the timeSeries example above.
--
dimensions:
--
-- The INSTANCE dimension is the number of profiles stored in the file
-- The MAXZ dimension is the size of the second dimension of the geophysical variables
```

```
-- The MAXT dimension is set to the number of time steps in the stored series
-- The STRING80 dimension is specifies the length of fixed size strings for labels
--
        INSTANCE = 1 ; // MAXT = 1000 ;
        STRING80 = 80; MAXZ = 24 ; REFMAX = 5;
variables:
--
-- Co-ordinates
--
        double TIME(INSTANCE, MAXT) ;
                TIME:long_name = "Chronological Julian Date" ;
                TIME:standard_name = "time" ;
                TIME:units = "days since -4713-01-01T00:00:00Z" ;
                TIME:ancillary_variables = "TIME_SEADATANET_QC" ;
                TIME:axis = "T" ;
                TIME:calendar = "julian" ;
                TIME:sdn_parameter_urn = "SDN:P01::CJDY1101" ;
                TIME:sdn_parameter_name = "Julian Date (chronological)" ;
                TIME:sdn_uom_urn = "SDN:P06::UTAA" ;
                TIME:sdn_uom_name = "Days";

        byte TIME_SEADATANET_QC(INSTANCE, MAXT) ;
                TIME_SEADATANET_QC:long_name = "SeaDataNet quality flag" ;
                TIME_SEADATANET_QC:Conventions = "SeaDataNet measurand
                qualifier flags" ;
                TIME_SEADATANET_QC:_FillValue = 57b;
                TIME_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";
                TIME_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b, 52b,
                53b, 54b, 55b, 56b, 57b, 65b ;
                TIME_SEADATANET_QC:flag_meanings = "no_quality_control
                good_value probably_good_value probably_bad_value bad_value
                changed_value value_below_detection value_in_excess
                interpolated_value missing_value value_phenomenon_uncertain" ;

        double LATITUDE(INSTANCE) ;
                LATITUDE:long_name = "Latitude" ;
                LATITUDE:standard_name = "latitude" ;
                LATITUDE:units = "degrees_north" ;
                LATITUDE:ancillary_variables = "POSITION_SEADATANET_QC" ;
                LATITUDE:axis = "Y" ;
                LATITUDE:grid_mapping = "crs";
                LATITUDE:sdn_parameter_urn = "SDN:P01::ALATZZ01" ;
                LATITUDE:sdn_parameter_name = "Latitude north" ;
                LATITUDE:sdn_uom_urn = "SDN:P06::DEGN" ;
                LATITUDE:sdn_uom_name = "Degrees north" ;
        double LONGITUDE(INSTANCE) ;
                LONGITUDE:long_name = "Longitude" ;
                LONGITUDE:standard_name = "longitude" ;
                LONGITUDE:units = "degrees_east" ;
                LONGITUDE:ancillary_variables = "POSITION_SEADATANET_QC" ;
                LONGITUDE:axis = "X" ;
                LONGITUDE:grid_mapping = "crs";
                LONGITUDE:sdn_parameter_urn = "SDN:P01::ALONZZ01" ;
                LONGITUDE:sdn_parameter_name = "Longitude east" ;
```

```
                LONGITUDE:sdn_uom_urn = "SDN:P06::DEGE" ;
                LONGITUDE:sdn_uom_name = "Degrees east" ;
--
-- The OceanSITES convention of merging latitude and longitude QC into
-- a single position QC has been followed
--
        byte POSITION_SEADATANET_QC(INSTANCE) ;
                POSITION_SEADATANET_QC:long_name = "SeaDataNet quality
                flag" ;
                POSITION_SEADATANET_QC:Conventions = "SeaDataNet
                measurand qualifier flags" ;
                POSITION_SEADATANET_QC:_FillValue = 57b;
                POSITION_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";
                POSITION_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b,
                52b, 53b, 54b, 55b, 56b, 57b, 65b ;
                POSITION_SEADATANET_QC:flag_meanings = "no_quality_control
                good_value probably_good_value probably_bad_value bad_value
                changed_value value_below_detection value_in_excess
                interpolated_value missing_value value_phenomenon_uncertain" ;

        float HEIGHT(INSTANCE) ;
                HEIGHT:long_name = "Nominal height above bed for time series" ;
                HEIGHT:standard_name = "'height_above_sea_floor " ;
                HEIGHT:units = "meters" ;
                HEIGHT:ancillary_variables = "HEIGHT_SEADATANET_QC" ;
                HEIGHT:axis = "Z" ;
                HEIGHT:positive = "up" ;
                HEIGHT:_FillValue -999.0f;
                HEIGHT:sdn_parameter_urn = "SDN:P01::AHSFZZ01" ;
                HEIGHT:sdn_parameter_name = "Height above bed in the water
                body " ;
                HEIGHT:sdn_uom_urn = "SDN:P06::ULAA" ;
                HEIGHT:sdn_uom_name = "Metres"
        byte HEIGHT_SEADATANET_QC(INSTANCE) ;
                HEIGHT_SEADATANET_QC:long_name = "SeaDataNet quality flag" ;
                HEIGHT_SEADATANET_QC:Conventions ="SeaDataNet measurand
                qualifier flags";
                HEIGHT_SEADATANET_QC:_FillValue = 57b;
                 HEIGHT_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";
                HEIGHT_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b, 52b,
                53b, 54b, 55b, 56b, 57b, 65b ;
                HEIGHT_SEADATANET_QC:flag_meanings = "no_quality_control
                good_value probably_good_value probably_bad_value bad_value
                changed_value value_below_detection value_in_excess
                interpolated_value missing_value value_phenomenon_uncertain" ;

--
-- Note that following CF 1.6 each time step carries a set of PROFZ co-ordinates
--so these do not have to be constant throughout the time series
--
        float PROFZ(INSTANCE,MAXT,MAXZ) ;
                PROFZ:long_name = "Bin depth below mean sea level" ;
                PROFZ:standard_name = "depth_below_geoid" ;
                PROFZ:units = "meters" ;
```

```
                PROFZ:ancillary_variables = "PROFZ_SEADATANET_QC" ;
                PROFZ:axis = "Z" ;
                PROFZ:positive = "down" ;
                PROFZ:_FillValue -999.0f;
--
-- SeaDataNet semantic extensions - mandatory for SeaDataNet.
--
                PROFZ:sdn_parameter_urn = "SDN:P01::DBINAA01" ;
                PROFZ:sdn_parameter_name = "Depth below sea surface (ADCP
                bin)" ;
                PROFZ:sdn_uom_urn = "SDN:P06::ULAA" ;
                PROFZ:sdn_uom_name = "Metres"
        byte PROFZ_SEADATANET_QC(INSTANCE) ;
                PROFZ_SEADATANET_QC:long_name = "SeaDataNet quality flag" ;
                PROFZ_SEADATANET_QC:Conventions ="SeaDataNet measurand
                qualifier flags";
                PROFZ_SEADATANET_QC:_FillValue = 57b;
                PROFZ_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";
                PROFZ_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b, 52b,
                53b, 54b, 55b, 56b, 57b, 65b ;
                PROFZ_SEADATANET_QC:flag_meanings = "no_quality_control
                good_value probably_good_value probably_bad_value bad_value
                changed_value value_below_detection value_in_excess
                interpolated_value missing_value value_phenomenon_uncertain" ;
--
-- SeaDatanet CRS reporting - include verbatim
--
        int crs ;
        crs:grid_mapping_name = "latitude_longitude"
        crs:epsg_code = "EPSG:4326"
        crs:semi_major_axis = 6378137.0 ;
        crs:inverse_flattening = 298.257223563 ;
--
-- SeaDataNet identifiers and site water depth
--
-- 'CRUISE' is a grouping label that could be the deploying cruise
-- or mooring name. If in doubt set the same as 'STATION'
--
        char SDN_CRUISE(INSTANCE,STRING80) ;
                SDN_CRUISE:long_name = "Time series profile grouping label" ;
        char SDN_STATION(INSTANCE,STRING80) ;
                SDN_STATION:long_name = "Time series label" ;
        char SDN_LOCAL_CDI_ID (INSTANCE,STRING80) ;
                SDN_LOCAL_CDI_ID:long_name = "SeaDataNet CDI identifier" ;
                SDN_LOCAL_CDI_ID:cf_role = "timeSeriesProfile_id" ;
--
-- EDMO code provides the namespace for CDI local identifier.
--
        int SDN_EDMO_CODE (INSTANCE) ;
                SDN_EDMO_CODE:long_name = "European Directory of Marine
                Organisations code for the CDI partner"
--
-- Bathymetric depth is considered less important for time series than profiles
-- and so is optional rather than mandatory.
```

```
--
        float SDN_BOT_DEPTH (INSTANCE) ;
                SDN_BOT_DEPTH:standard_name ="sea_floor_depth_below_geoid";
                SDN_BOT_DEPTH:long_name = "Mean bathymetric depth at time series
                profile measurement site":
                SDN_BOT_DEPTH:units = "meters" ;
                SDN_BOT_DEPTH:sdn_parameter_urn = "SDN:P01::BATHDPTH" ;
                SDN_BOT_DEPTH:sdn_parameter_name = "Sea-floor depth (below mean
                sea level) {bathymetric depth}" ;
                SDN_BOT_DEPTH:sdn_uom_urn = "SDN:P06::ULAA" ;
                SDN_BOT_DEPTH:sdn_uom_name = "Metres" ;
                SDN_BOT_DEPTH:_FillValue = -999.0
--
-- Optional SeaDataNet linkage to the instrument used to measure the parameter
--
                SDN_BOT_DEPTH::sdn_instrument_urn = "SDN:L22::TOOL0130"
                SDN_BOT_DEPTH::sdn_instrument_name ="Simrad EA500 echosounder"


--
-- SeaDataNet optional attribute variables
--
-- Linkages to external resources (see Section 4.4.8)
--
-- SDN_REFERENCES - single linkage to a URI which resolves to an XHTML page
-- carrying additional information such as usage metadata or DOI landing page
--
-- SDN_XLINK - multiple (in this example 5) linkages to external resource URNs
-- following a strictly defined syntax that resolve into either XML documents of known
-- schema or XHTML.
--
        char SDN_REFERENCES(INSTANCE, STRING80) ;
                SDN_REFERENCES:long_name = "Usage metadata reference";
        char SDN_XLINK (INSTANCE, REFMAX, STRING80) ;
                SDN_XLINK_TYPE:long_name = "External resource linkages";

-- The geophysical variables included in this example are:
--Sea temperature (2-D)
-- Sea level - i.e. SFPG pressure  (2-D)
-- Eastward current component (3-D)
-- Northward current component (3-D)
-- There could well be others!
--
        float TEMP (INSTANCE, MAXT) ;
                TEMP:long_name = "Water temperature" ;
                TEMP:units = "degC" ;
                TEMP:ancillary_variables = "TEMP_SEADATANET_QC" ;
                TEMP:coordinates = "TIME HEIGHT LATITUDE LONGITUDE" ;
                TEMP:standard_name = "sea_water_temperature" ;
                TEMP:_FillValue = -99.0f ;
                TEMP:sdn_parameter_urn = "SDN:P01::TEMPPR01" ;
                TEMP:sdn_parameter_name = "Temperature of the water body" ;
                TEMP:sdn_uom_urn = "SDN:P06::UPAA" ;
                TEMP:sdn_uom_name = "Degrees Celsius"
--
```

-- Optional SeaDataNet linkage to the instrument used to measure the parameter
--

TEMP::sdn_instrument_urn = "SDN:L22::TOOL0294"
TEMP::sdn_instrument_name ="Teledyne RDI Workhorse Sentinel-600 ADCP"

byte TEMP_SEADATANET_QC(INSTANCE, MAXT) ;
TEMP_SEADATANET_QC:long_name = "SeaDataNet quality flag" ;
TEMP_SEADATANET_QC:Conventions = "SeaDataNet measurand qualifier flags" ;
TEMP_SEADATANET_QC:_FillValue = 57b;
TEMP_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";
TEMP_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b, 52b, 53b, 54b, 55b, 56b, 57b, 65b ;
TEMP_SEADATANET_QC:flag_meanings = "no_quality_control good_value probably_good_value probably_bad_value bad_value changed_value value_below_detection value_in_excess interpolated_value missing_value value_phenomenon_uncertain" ;

float WATERDEP (INSTANCE, MAXT) ;
WATERDEP:long_name = "Pressure due to sea water" ;
WATERDEP:units = "meters" ;
WATERDEP:ancillary_variables = "WATERDEP_SEADATANET_QC" ;
WATERDEP:coordinates = "TIME HEIGHT LATITUDE LONGITUDE" ;
WATERDEP:standard_name = "sea_water_pressure_due_to_sea_water" ;
WATERDEP:_FillValue = -99.0f ;
WATERDEP:sdn_parameter_urn = "SDN:P01::PRESPS02" ;
WATERDEP:sdn_parameter_name = "Pressure (measured variable) exerted by the water body by fixed in-situ pressure sensor and corrected to read zero at sea level" ;
WATERDEP:sdn_uom_urn = "SDN:P06::UPDB" ;
WATERDEP:sdn_uom_name = "Decibars"
--
-- Optional SeaDataNet linkage to the instrument used to measure the parameter
--

WATERDEP::sdn_instrument_urn = "SDN:L22::TOOL0294"
WATERDEP::sdn_instrument_name ="Teledyne RDI Workhorse Sentinel-600 ADCP"
byte WATERDEP_SEADATANET_QC(INSTANCE, MAXT) ;
WATERDEP_SEADATANET_QC:long_name = "SeaDataNet quality flag" ;
WATERDEP_SEADATANET_QC:Conventions = "SeaDataNet measurand qualifier flags" ;
WATERDEP_SEADATANET_QC:_FillValue = 57b;
WATERDEP_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";
WATERDEP_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b, 52b, 53b, 54b, 55b, 56b, 57b, 65b ;
WATERDEP_SEADATANET_QC:flag_meanings = "no_quality_control good_value probably_good_value probably_bad_value bad_value changed_value value_below_detection value_in_excess interpolated_value

float EWCT (INSTANCE, MAXT, MAXZ) ;
EWCT:long_name = "Eastward current velocity" ;

EWCT:units = "meter/second" ;
EWCT:ancillary_variables = "EWCT_SEADATANET_QC" ;
EWCT:coordinates = "TIME PROFZ LATITUDE LONGITUDE" ;
EWCT:standard_name = "eastward_sea_water_velocity" ;
EWCT:_FillValue = -99.0f ;
EWCT:sdn_parameter_urn = "SDN:P01::LCEWAP01" ;
EWCT:sdn_parameter_name = Eastward current velocity (Eulerian) in the water body by moored acoustic doppler current profiler (ADCP)" ;
EWCT:sdn_uom_urn = "SDN:P06::UVAA" ;
EWCT:sdn_uom_name = "Metres per second"
--
-- Optional SeaDataNet linkage to the instrument used to measure the parameter
--
EWCT::sdn_instrument_urn = "SDN:L22::TOOL0294"
EWCT::sdn_instrument_name ="Teledyne RDI Workhorse Sentinel-600 ADCP"
byte EWCT_SEADATANET_QC(INSTANCE, MAXT, MAXZ) ;
EWCT_EADATANET_QC:long_name = "SeaDataNet quality flag" ;
EWCT_SEADATANET_QC:Conventions = "SeaDataNet measurand qualifier flags" ;
EWCT_SEADATANET_QC:_FillValue = 57b;
EWCT_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";
EWCT_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b, 52b, 53b, 54b, 55b, 56b, 57b, 65b ;
EWCT_SEADATANET_QC:flag_meanings = "no_quality_control good_value probably_good_value probably_bad_value bad_value changed_value value_below_detection value_in_excess interpolated_value missing_value value_phenomenon_uncertain" ;

float NWCT (INSTANCE, MAXT, MAXZ) ;
NWCT:long_name = "Northward current velocity" ;
NWCT:units = " meter/second " ;
NWCT:ancillary_variables = "NWCT_SEADATANET_QC" ;
NWCT:coordinates = "TIME PROFZ LATITUDE LONGITUDE" ;
NWCT:standard_name = "northward_sea_water_velocity" ;
NWCT:_FillValue = -99.0f ;
NWCT:sdn_parameter_urn = "SDN:P01::LCNSAP01" ;
NWCT:sdn_parameter_name = "Northward current velocity (Eulerian) in the water body by moored acoustic doppler current profiler (ADCP)" ;
NWCT:sdn_uom_urn = "SDN:P06::UVAA" ;
NWCT:sdn_uom_name = "Metres per second"
--
-- Optional SeaDataNet linkage to the instrument used to measure the parameter
--
NWCT::sdn_instrument_urn = "SDN:L22::TOOL0294"
NWCT::sdn_instrument_name ="Teledyne RDI Workhorse Sentinel-600 ADCP"
byte NWCT_SEADATANET_QC(INSTANCE, MAXT, MAXZ) ;
NWCT_EADATANET_QC:long_name = "SeaDataNet quality flag" ;
NWCT_SEADATANET_QC:Conventions = "SeaDataNet measurand qualifier flags" ;
NWCT_SEADATANET_QC:_FillValue = 57b;
NWCT_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";

```
NWCT_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b, 52b, 53b, 54b, 55b, 56b, 57b, 65b ;
NWCT_SEADATANET_QC:flag_meanings = "no_quality_control good_value probably_good_value probably_bad_value bad_value changed_value value_below_detection value_in_excess interpolated_value missing_value value_phenomenon_uncertain" ;

// global attributes:

        :Conventions = "SeaDataNet_1.0 CF1.6" ;
        :featureType = "timeSeriesProfile" ;
        :title = "North Sea Project current meter data" ;
        :date_update = "2012-05-22T19:28:30Z" ;
--
-- CF attributes recommended for SeaDataNet where appropriate.
--
                :comment = "Published dataset"
--
-- Additional attributes from other conventions may be included here.
-- The SeaDataNet specification describes the minimum amount of information
-- required by SeaDataNet. There is no upper limit on what may be included.
--
data:

 Follows on from here.......
```

4.5.4.5. Extension to multiple time series storage

Extending the single time series profile design to multiple time series profile storage is simple, requiring two changes. First, the INSTANCE dimension value needs to be changed from 1 to UNLIMITED. Secondly, a _FillValue attribute, to be used when padding time series to an equal number of time steps, needs to be added to the TIME and PROFZ variables.

4.5.5. SeaDataNet NetCDF for trajectoryProfile Data

The data model for the CF1.6 trajectory feature time includes one or more geophysical variables along the TIME dimension plus co-ordinate variables (latitude, longitude and depth/height) that are also along the TIME dimension. The trajectoryProfile feature type adds the possibility of one or more geophysical variables for each instance that have another dimension in addition to the time dimension.

It is tempting when considering some types of oceanographic data such as ship-borne ADCP data to label this additional dimension as 'depth'. However, this approach is both limiting and potentially very confusing. It is limiting because there are data types, such as towed optical plankton counters or ship-borne spectral radiometers where this additional dimension could be non-spatial. It is potentially confusing because there is the possibility for 'DEPTH' to provide the z co-ordinate for one or more 2-D (INSTANCE and TIME) geophysical variables. Consider a submarine-mounted ADCP with a temperature sensor mounted on the platform or bottom currents determined by a ship-borne ADCP using bottom-tracking. These need to be associated with a depth that is different from the depths of any of the binned current measurements. Consequently, a different, neutral variable name - PROFZ - has been chosen for the additional dimension of the 3-D geophysical variables.

Note that CF 1.6 specifies that the z co-ordinate for the 3-D geophysical variables has dimensions (INSTANCE, MAXT, MAXZ). This means that the PROFZ values can vary as a function of time. In the case of ship-borne ADCP data, where the PROFZ values are fixed, this will result in identical values being repeated for each time step. The resulting inefficiency in storage is a small price to pay for interoperability through the adoption of standards.

4.5.5.1. Co-ordinate variables

The co-ordinate variables are of two types. Time, depth/height, latitude and longitude are 2-D vectors of dimension (INSTANCE, MAXT). For single profile storage INSTANCE is set to 1. The SeaDataNet practices are followed in which time is expressed as Chronological Julian Day and latitude/longitude are either given in 2-D WGS-84 (EPSG 4326) CRS or are of such low accuracy that WGS-84 can be assumed. Time should be monotonic.. Latitude and longitude share a common qualifier flag variable (POSITION_SEADATANET_QC).

The parameter mapping to 'DEPTH' for SeaDataNet trajectoryProfiles requires some explanation. The purpose of 'DEPTH' (or 'HEIGHT') is to provide the z co-ordinate for the 2-D geophysical variables. If we had an AUV carrying a temperature sensor then DEPTH would carry the depth below the surface of the AUV and would be linked through the 'coordinates' attribute to the temperature geophysical variable. In the case of bottom-tracking seabed currents, 'DEPTH' needs to be mapped to the water depth, because that is the depth at which the bottom tracked current is measured.

The preferred depth parameter is either depth below sea level for measurements in water bodies or height above sea level for measurements in the atmosphere such as meteorological measurements. Height above the seafloor is also allowed to cover cases where depth cannot be calculated because no bathymetric depth data are available. It should only be used as a last resort for trajectories. Pressure as a platform z co-ordinate is not allowed for time series.

The profile z co-ordinates are stored in a 3-D array of dimension (INSTANCE, MAXT, MAXZ). Instance is set to one for single-profile storage. In order to maximise the flexibility of the format, there are minimal restrictions in the SeaDataNet profile on the variables that may be mapped onto this co-ordinate. It could be an absolute depth below sea surface, the distance between the instrument and the measurement, a particle size class, a wavelength or even the identifier of a biological taxon.

4.5.5.2. Geophysical variables

The geophysical variables are of two types. First, there are the variables measured at each level in the profile, such as current velocities for an ADCP., Like the profile z co-ordinates, these are stored as 3-D arrays with the INSTANCE dimension set to 1.

The second type are only measured at a single level for each time step, such as bottom currents measured in shallow water by ADCP bottom tracking. These are stored in 2-D arrays of dimension (INSTANCE, MAXT)

Each geophysical variable has at least one ancillary variable named using the conventions described in section 3.4.3 containing the SeaDataNet qualifier flags for that variable.

4.5.5.3. Attributes

The Featuretype attribute is set to 'trajectoryProfile'.

4.5.5.4. CDL example

There now follows an example NetCDF file that will hold a single series from aship-borne ADCP with 24 current bins and seabed currents measured by bottom tracking. The annotations are contained in lines prefixed by two hyphens ('--'). Mandatory (for SeaDataNet) variables and attributes are shown in bold type.

This example has been designed for the primary SeaDataNet use case, which is to deliver data to a user who is primarily interested in applying the geophysical variables, such as the builder of an aggregated data product like a climatology. Consequently, the number of geophysical variables carried is kept to a minimum. Should the format be required to fulfil use cases such as delivery to an expert for re-analysis then additional geophysical variables may be added, such as individual beam returns, performance criteria and platform velocity parameters.

```
--
-- This file specifies the SeaDataNet NetCDF encoding for a ship-borne ADCP with
-- bottom-tracking currents in annotated CDL
-- Compared to the profile, timeSeries and trajectory examples above the level
-- of annotation has been drastically reduced. If further clarification is required
-- consult the trajectory example above.
dimensions:
--
-- The 'INSTANCE dimension is set to 1.
-- This example was based on storage a trajectory Profile containing 24 depth levels
-- (i.e. bins) on the vertical and 1000 time steps.
-- The STRING80 dimension is specifies the length of fixed size strings for label variables.
--
        INSTANCE = 1 ;
        MAXZ = 24;
        MAXT = 1000 ;
        STRING80 = 80;
        REFMAX = 5;

variables:

        double TIME(INSTANCE, MAXT) ;
                TIME:long_name = "Chronological Julian Date" ;
                TIME:standard_name = "time" ;
                TIME:units = "days since -4713-01-01T00:00:00Z" ;
                TIME:ancillary_variables = "TIME_SEADATANET_QC" ;
                TIME:axis = "T" ;
                TIME:calendar = "julian" ;
                TIME:sdn_parameter_urn = "SDN:P01::CJDY1101" ;
                TIME:sdn_parameter_name = "Julian Date (chronological)" ;
                TIME:sdn_uom_urn = "SDN:P06::UTAA" ;
                TIME:sdn_uom_name = "Days"
        byte TIME_SEADATANET_QC(INSTANCE, MAXT) ;
                TIME_SEADATANET_QC:long_name = "SeaDataNet quality flag" ;
                TIME_SEADATANET_QC:Conventions = "SeaDataNet measurand
                qualifier flags" ;
                TIME_SEADATANET_QC:_FillValue = 57b;
                TIME_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";
                TIME_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b, 52b, 53b,
                54b, 55b, 56b, 57b, 65b ;
```

```
            TIME_SEADATANET_QC:flag_meanings = "no_quality_control good_value probably_good_value probably_bad_value bad_value changed_value value_below_detection value_in_excess interpolated_value missing_value value_phenomenon_uncertain" ;

      double LATITUDE(INSTANCE, MAXT) ;
            LATITUDE:long_name = "Latitude" ;
            LATITUDE:standard_name = "latitude" ;
            LATITUDE:units = "degrees_north" ;
            LATITUDE:ancillary_variables = "POSITION_SEADATANET_QC" ;
            LATITUDE:axis = "Y" ;
            LATITUDE:grid_mapping = "crs";
            LATITUDE:sdn_parameter_urn = "SDN:P01::ALATZZ01" ;
            LATITUDE:sdn_parameter_name = "Latitude north" ;
            LATITUDE:sdn_uom_urn = "SDN:P06::DEGN" ;
            LATITUDE:sdn_uom_name = "Degrees north" ;

      double LONGITUDE(INSTANCE, MAXT) ;
            LONGITUDE:long_name = "Longitude" ;
            LONGITUDE:standard_name = "longitude" ;
            LONGITUDE:units = "degrees_east" ;
            LONGITUDE:ancillary_variables = "POSITION_SEADATANET_QC" ;
            LONGITUDE:axis = "X" ;
            LONGITUDE:grid_mapping = "crs";
            LONGITUDE:sdn_parameter_urn = "SDN:P01::ALONZZ01" ;
            LONGITUDE:sdn_parameter_name = "Longitude east" ;
            LONGITUDE:sdn_uom_urn = "SDN:P06::DEGE" ;
            LONGITUDE:sdn_uom_name = "Degrees east" ;
--
-- The OceanSITES convention of merging latitude and longitude QC into a
-- position QC has been followed.
--
      byte POSITION_SEADATANET_QC(INSTANCE, MAXT) ;
            POSITION_SEADATANET_QC:long_name = "SeaDataNet quality flag" ;
            POSITION_SEADATANET_QC:Conventions = "SeaDataNet measurand qualifier flags" ;
            POSITION_SEADATANET_QC:_FillValue = 57b;
            POSITION_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";
            POSITION_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b, 52b, 53b, 54b, 55b, 56b, 57b, 65b ;
            POSITION_SEADATANET_QC:flag_meanings = "no_quality_control good_value probably_good_value probably_bad_value bad_value changed_value value_below_detection value_in_excess interpolated_value missing_value value_phenomenon_uncertain" ;

      float DEPTH(INSTANCE) ;
            DEPTH:long_name = "Instantaneous water depth" ;
            DEPTH:standard_name = "sea_floor_depth_below_sea_surface" ;
            DEPTH:units = "meters" ;
            DEPTH:ancillary_variables = "DEPTH_SEADATANET_QC" ;
            DEPTH:axis = "Z" ;
            DEPTH:positive = "down" ;
            DEPTH:_FillValue -999.0f;
```

```
                DEPTH:sdn_parameter_urn = "SDN:P01::ADEPZZ01" ;
                DEPTH:sdn_parameter_name = Depth below surface of the water
                body" ;
                DEPTH:sdn_uom_urn = "SDN:P06::ULAA" ;
                DEPTH:sdn_uom_name = "Metres"
        byte DEPTH_SEADATANET_QC(INSTANCE) ;
                DEPTH_SEADATANET_QC:long_name = "SeaDataNet quality flag" ;
                DEPTH_SEADATANET_QC:Conventions ="SeaDataNet measurand
                qualifier flags";
                DEPTH_SEADATANET_QC:_FillValue = 57b;
                DEPTH_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";
                DEPTH_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b, 52b,
                53b, 54b, 55b, 56b, 57b, 65b ;
                DEPTH_SEADATANET_QC:flag_meanings = "no_quality_control
                good_value probably_good_value probably_bad_value bad_value
                changed_value value_below_detection value_in_excess
                interpolated_value missing_value value_phenomenon_uncertain" ;

--
-- Note that following CF 1.6 each time step carries a set of PROFZ co-ordinates
-- which do not have to be constant throughout the time series
--
        float PROFZ(INSTANCE,MAXT,MAXZ) ;
                PROFZ:long_name = "Bin depth below mean sea level" ;
                PROFZ:standard_name = "depth_below_geoid" ;
                PROFZ:units = "meters" ;
                PROFZ:ancillary_variables = "PROFZ_SEADATANET_QC" ;
                PROFZ:axis = "Z" ;
                PROFZ:positive = "down" ;
                PROFZ:_FillValue -999.0f;
--
-- SeaDataNet semantic extensions - mandatory for SeaDataNet.
--
                PROFZ:sdn_parameter_urn = "SDN:P01::DBINAA01" ;
                PROFZ:sdn_parameter_name = "Depth below sea surface (ADCP
                bin)" ;
                PROFZ:sdn_uom_urn = "SDN:P06::ULAA" ;
                PROFZ:sdn_uom_name = "Metres"
        byte PROFZ_SEADATANET_QC(INSTANCE) ;
                PROFZ_SEADATANET_QC:long_name = "SeaDataNet quality flag" ;
                PROFZ_SEADATANET_QC:Conventions ="SeaDataNet measurand
                qualifier flags";
                PROFZ_SEADATANET_QC:_FillValue = 57b;
                PROFZ_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";
                PROFZ_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b, 52b,
                53b, 54b, 55b, 56b, 57b, 65b ;
                PROFZ_SEADATANET_QC:flag_meanings = "no_quality_control
                good_value probably_good_value probably_bad_value bad_value
                changed_value value_below_detection value_in_excess
                interpolated_value missing_value value_phenomenon_uncertain" ;
--
-- SeaDataNet CRS reporting - include verbatim
--
        int crs ;
```

```
                crs:grid_mapping_name = "latitude_longitude"
                csr:epsg_code = "EPSG:4326"
                crs:semi_major_axis = 6378137.0 ;
                crs:inverse_flattening = 298.257223563 ;
--
-- SeaDataNet identifiers.
--
        char SDN_CRUISE(INSTANCE,STRING80) ;
                SDN_CRUISE:long_name = "Trajectory grouping label" ;
        char SDN_STATION(INSTANCE,STRING80) ;
                SDN_STATION:long_name = "Trajectory label" ;
        char SDN_LOCAL_CDI_ID (INSTANCE,STRING80) ;
                SDN_LOCAL_CDI_ID:long_name = "SeaDataNet CDI identifier" ;
                SDN_LOCAL_CDI_ID:cf_role = "trajectoryProfile_id";
--
-- EDMO code provides the namespace for CDI local identifier
-- (SeaDataNet convention).
--
        int SDN_EDMO_CODE (INSTANCE) ;
        SDN_EDMO_CODE:long_name = "European Directory of Marine
        Organisations code for the CDI partner"
--
-- SeaDataNet optional attribute variables
-- Bathymetric depth is optional rather than mandatory.
--
        float SDN_BOT_DEPTH (INSTANCE) ;
                SDN_BOT_DEPTH:standard_name =
                "sea_floor_depth_below_sea_surface";
                SDN_BOT_DEPTH:long_name = "Bathymetric depth along trajectoryProfile
                measurement site";
                SDN_BOT_DEPTH:units = "meters" ;
                SDN_BOT_DEPTH:sdn_parameter_urn = "SDN:P01::MBANZZZZ" ;
                SDN_BOT_DEPTH:sdn_parameter_name = "Sea-floor depth (below
                instantaneous sea level) {bathymetric depth} in the water body" ;
                SDN_BOT_DEPTH:sdn_uom_urn = "SDN:P06::ULAA" ;
                SDN_BOT_DEPTH:sdn_uom_name = "Metres" ;
                SDN_BOT_DEPTH:_FillValue = -999.0
--
-- Linkages to external resources (see Section 4.4.8)
--
-- SDN_REFERENCES - single linkage to a URI which resolves to an XHTML page
-- carrying additional information such as usage metadata or DOI landing page
--
-- SDN_XLINK - multiple (in this example 5) linkages to external resource URNs
-- following a strictly defined syntax that resolve into either XML documents of known
-- schema or XHTML.
--
        char SDN_REFERENCES(INSTANCE, STRING80) ;
                SDN_REFERENCES:long_name = "Usage metadata reference";
        char SDN_XLINK (INSTANCE, REFMAX, STRING80) ;
                SDN_XLINK_TYPE:long_name = "External resource linkages";
--

--  Geophysical variables
```

```
--
-- Bottom-track Eastward current velocity
-- Bottom-tracked Northward current velocity
-- Eastward current velocity in ADCP bins
-- Northward current velocity in ADCP bins
--There may well need to be others (e.g. upward current velocity)
--
        float EWBV (INSTANCE, MAXT) ;
                EWBV:long_name = "Bottom track eastward current velocity" ;
                EWBV:units = "meters/second" ;
                EWBV:ancillary_variables = " EWBV_SEADATANET_QC" ;
                EWBV:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;
                EWBV:standard_name = "eastward_sea_water_velocity" ;
                EWBV:_FillValue = -99.0f ;
                EWBV:sdn_parameter_urn = "SDN:P01::LCEWBT01" ;
                EWBV:sdn_parameter_name = "Eastward current velocity (Eulerian) in the water
                body by ADCP bottom tracking;
                EWBV:sdn_uom_urn = "SDN:P06::UVAA" ;
--
-- Optional SeaDataNet linkage to the instrument used to measure the parameter
--
                EWBV::sdn_instrument_urn = "SDN:L22::TOOL0062"
                EWBV::sdn_instrument_name ="Teledyne RDI 150kHz Narrowband Vessel-
                Mounted ADCP"
                EWBV:sdn_uom_name = "Metres per second"
        byte EWBV_SEADATANET_QC(INSTANCE, MAXT) ;
                EWBV_EADATANET_QC:long_name = "SeaDataNet quality flag" ;
                EWBV_SEADATANET_QC:Conventions = "SeaDataNet measurand
                qualifier flags" ;
                EWBV_SEADATANET_QC:_FillValue = 57b;
                EWBV_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";
                EWBV_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b, 52b, 53b,
                54b, 55b, 56b, 57b, 65b ;
                EWBV_SEADATANET_QC:flag_meanings = "no_quality_control
                good_value probably_good_value probably_bad_value bad_value
                changed_value value_below_detection value_in_excess
                interpolated_value missing_value value_phenomenon_uncertain" ;

        float NSBV (INSTANCE, MAXT) ;
                NSBV:long_name = "Bottom track northward current velocity" ;
                NSBV:units = "meters/second" ;
                NSBV:ancillary_variables = " NSBV_SEADATANET_QC" ;
                NSBV:coordinates = "TIME DEPTH LATITUDE LONGITUDE" ;
                NSBV:standard_name = "northward_sea_water_velocity" ;
                NSBV:_FillValue = -99.0f ;
                NSBV:sdn_parameter_urn = "SDN:P01::LCNSBT01" ;
                NSBV:sdn_parameter_name = "Northward current velocity
                (Eulerian) in the water body by ADCP bottom tracking)" ;
                NSBV:sdn_uom_urn = "SDN:P06::UVAA" ;
                NSBV:sdn_uom_name = "Metres per second"
--
-- Optional SeaDataNet linkage to the instrument used to measure the parameter
--
                NSBV::sdn_instrument_urn = "SDN:L22::TOOL0062"
```

```
                NSBV::sdn_instrument_name ="Teledyne RDI 150kHz Narrowband Vessel-
                Mounted ADCP"
        byte NSBV_SEADATANET_QC(INSTANCE, MAXT) ;
                NSBV_EADATANET_QC:long_name = "SeaDataNet quality flag" ;
                NSBV_SEADATANET_QC:Conventions = "SeaDataNet measurand
                qualifier flags" ;
                NSBV_SEADATANET_QC:_FillValue = 57b;
                NSBV_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";
                NSBV_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b, 52b, 53b,
                54b, 55b, 56b, 57b, 65b ;
                NSBV_SEADATANET_QC:flag_meanings = "no_quality_control
                good_value probably_good_value probably_bad_value bad_value
                changed_value value_below_detection value_in_excess
                interpolated_value missing_value value_phenomenon_uncertain";

        float EWCT (INSTANCE, MAXT, MAXZ) ;
                EWCT:long_name = "Eastward current velocity" ;
                EWCT:units = "meter/second" ;
                EWCT:ancillary_variables = "EWCT_SEADATANET_QC" ;
                EWCT:coordinates = "TIME PROFZ LATITUDE LONGITUDE" ;
                EWCT:standard_name = "eastward_sea_water_velocity" ;
                EWCT:_FillValue = -99.0f ;
                EWCT:sdn_parameter_urn = "SDN:P01::LCEWAS01" ;
                EWCT:sdn_parameter_name = Eastward current velocity (Eulerian) in the
                water body by shipborne acoustic doppler current profiler (ADCP)" ;
                EWCT:sdn_uom_urn = "SDN:P06::UVAA" ;
                EWCT:sdn_uom_name = "Metres per second"
--
-- Optional SeaDataNet linkage to the instrument used to measure the parameter
--
                EWCT::sdn_instrument_urn = "SDN:L22::TOOL0062"
                EWCT::sdn_instrument_name ="Teledyne RDI 150kHz Narrowband Vessel-
                Mounted ADCP"
        byte EWCT_SEADATANET_QC(INSTANCE, MAXT, MAXZ) ;
                EWCT_EADATANET_QC:long_name = "SeaDataNet quality flag" ;
                EWCT_SEADATANET_QC:Conventions = "SeaDataNet measurand
                qualifier flags" ;
                EWCT_SEADATANET_QC:_FillValue = 57b;
                EWCT_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";
                EWCT_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b, 52b, 53b,
                54b, 55b, 56b, 57b, 65b ;
                EWCT_SEADATANET_QC:flag_meanings = "no_quality_control
                good_value probably_good_value probably_bad_value bad_value
                changed_value value_below_detection value_in_excess
                interpolated_value missing_value value_phenomenon_uncertain" ;

        float NWCT (INSTANCE, MAXT, MAXZ) ;
                NWCT:long_name = "Northward current velocity" ;
                NWCT:units = " meter/second " ;
                NWCT:ancillary_variables = "NWCT_SEADATANET_QC" ;
                NWCT:coordinates = "TIME PROFZ LATITUDE LONGITUDE" ;
                NWCT:standard_name = "northward_sea_water_velocity" ;
                NWCT:_FillValue = -99.0f ;
                NWCT:sdn_parameter_urn = "SDN:P01::LCNSAS01" ;
```

```
                    NWCT:sdn_parameter_name = "Northward current velocity (Eulerian) in
                    the water body by shipborne acoustic doppler current profiler (ADCP)"  ;
                    NWCT:sdn_uom_urn = "SDN:P06::UVAA" ;
                    NWCT:sdn_uom_name = "Metres per second"
--
-- Optional SeaDataNet linkage to the instrument used to measure the parameter
--
                    NWCT::sdn_instrument_urn = "SDN:L22::TOOL0062"
                    NWCT::sdn_instrument_name ="Teledyne RDI 150kHz Narrowband Vessel-
                    Mounted ADCP"
          byte NWCT_SEADATANET_QC(INSTANCE, MAXT, MAXZ) ;
                    NWCT_EADATANET_QC:long_name = "SeaDataNet quality flag" ;
                    NWCT_SEADATANET_QC:Conventions = "SeaDataNet measurand
                    qualifier flags" ;
                    NWCT_SEADATANET_QC:_FillValue = 57b;
                    NWCT_SEADATANET_QC:sdn_conventions_urn = "SDN:L20::";
                    NWCT_SEADATANET_QC:flag_values = 48b, 49b, 50b, 51b, 52b, 53b,
                    54b, 55b, 56b, 57b, 65b ;
                    NWCT_SEADATANET_QC:flag_meanings = "no_quality_control
                    good_value probably_good_value probably_bad_value bad_value
                    changed_value value_below_detection value_in_excess
                    interpolated_value missing_value value_phenomenon_uncertain" ;
// global attributes:
          :Conventions = "SeaDataNet_1.0 CF1.6" ;
          :featureType = "trajectoryProfile" ;
          :title = "Shipborne ADCP data example" ;
          :date_update = "2014-03-14T09:28:30Z" ;
          :comment = "Published dataset"
--
-- Additional attributes from other conventions may be included here.
-- The SeaDataNet specification describes the minimum amount of information
-- required by SeaDataNet. More may be added with no upper limit.

data:

          Follows on from here.......
```

4.6. Example Files

NetCDF example files (netCDF files and corresponding text files using ncdump) are available for vertical profiles, time-series and trajectory. They are the same examples than the ODV and MEDATLAS ones to allow easy comparison. They may be downloaded from the SeaDataNet web site at:
https://www.seadatanet.org/content/download/637/3338/file/SDN_D85_WP8_netCDF_files_examples.zip