

Quality Information

Use Case: I need to provide information about the quality of my data and how it was measured.

Overview

A principle goal of metadata is to ensure that the data they describe can be independently understood and used effectively. Data quality measures and reports play a critical role in achieving this goal. Connecting these to the metadata record is clearly important.

The approach to including quality information in ISO 19115 metadata records is similar to the approach used in ECHO and improves on it considerably. It includes the capability to describe quality measures that are used and the techniques used to apply them. Understanding how to take advantage of this flexibility and implementing systems that maximize the value that this capability provides will certainly be a challenge for the environmental data community.

The Data Quality Section of the ISO standard supports flexibility at several levels. The DQ_DataQuality object (see Figure) includes two sections: scope, and element. A metadata record can have any number of associated DQ_DataQuality objects.

Presentations available that [describe](#) the ISO data quality standard and [compare](#) it with the DIF and ECHO approaches.

Recommendations

An important initial goal is to connect users to existing literature that includes quality information. This should be done at the collection level using standaloneQualityReports. A complete report includes a description of the scope of the quality information with spatial and temporal extent information, an abstract, and a complete citation.

Conceptual Model

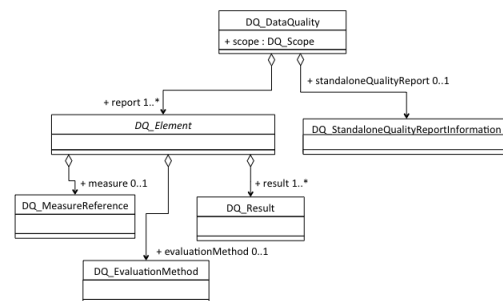
This Figure shows an overview of the data quality information included in the ISO 19157 standard. The elements are:

Scope: quality information can be provided at many different level of detail from an entire series down to specific attributes in particular regions or time periods. The scope attribute lets users know what the current information pertains to.

StandaloneQualityReport: quality information exists in papers and reports that are already part of the scientific literature. Users can find this information using citations included in the metadata record.

Report: quality reports hold the bulk of the structured quality information in the metadata record. They describe the quality measure, how it was applied, and the result of the application.

An overview of the complete data quality standard is also [available](#).



Scope:

The DQ_Scope object enables a complete description of the scope of a data quality report whether it pertains to a complete data series or to a particular temporal and spatial extent for a particular parameter in a dataset.

level:

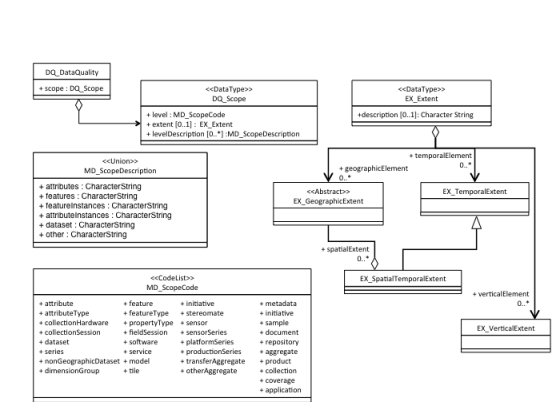
The level element of the scope provides a general description of the scope using a codelist of standard terms. The level can be used in an initial search of the quality information to answer questions like "what kinds of quality information are available for this collection or granule".

attribute	dimensionGroup	model	aggregate
attributeType	feature	tile	product
collectionHardware	featureType	metadata	collection

collectionSession	propertyType	initiative	coverage
dataset	fieldSession	sample	application
series	software	document	
nonGeographicDataset	service	repository	

levelDescription:

In some cases, the general description provided by the codelist is not enough. In those cases the levelDescription can be used to provide more detail. For example, the scope code might be "attribute", indicating that the report concerns an attribute of the dataset, and the levelDescription would provide the name(s) of the specific attributes covered, i.e. precipitation rate.



extent:

In some cases, the quality information may apply to a particular spatial and temporal extent of the dataset. This [extent](#) can be described at several different levels of detail using the EX_Extent object. The extent should be described quantitatively, if possible, or with a text description if quantitative information is not possible.

StandAlone Report

ISO 19157 recognizes that important data quality information can exist outside of the conceptual framework of the model and that it may be helpful to provide that information as a supplement to the metadata. The standaloneQualityReport was added to enable connections between the metadata and these reports. It includes an abstract (CharacterString) that provides a brief description of the quality report in the metadata record and a the [citation](#) (CI_Citation) that provides the reference that a user needs for the complete report.

In many cases quality information is provided on the Web pages. Those can also be referenced as StandAloneReports.

Report

Quality reports are encapsulated in the 19115 DQ_Element class that includes three kinds of information, the measure, the evaluationMethod and the result. It is expected that an organization uses a standard set of quality measures that are managed centrally and have unique names, descriptions, and identifiers. The nameOfMeasure and measureDescription are included in the metadata record and should help users understand the nature of the measure. The measureIdentification is an identifier that can be used to find a more detailed description of the measure.

The evaluation method provides information on how the quality measure was applied for this report. These methods can also be standardized across an organization. Citations are available to describe the specific procedure and more complete references.

Finally, the result reports the results of the application of the measure in this specific case. Several types of reports are included in the standard (see below).

As an example, consider this data quality description from a GCMD metadata record:

Abstract: The fire training-set may also have been biased against savanna and savanna woodland fires since their detection is more difficult than in humid, forest environments with cool background temperatures [Malingreau, 1990]. There may, therefore, be an under-sampling of fires in these warmer background environments.

Citation: Malingreau J.P, 1990, The contribution of remote sensing to the global monitoring of fires in tropical and subtropical ecosystems. In: Fire in Tropical Biota, (J.G. Goldammer , editor), Springer Verlag , Berlin: 337-370.

```

DQ_MeasureReference [0..1]
+ measureIdentification: MD_Identifier [0..1]
+ nameOfMeasure: CharacterString [0..*]
+ measureDescription: CharacterString [0..1]
  
```

```

DQ_EvaluationMethod [0..1]
+ dateTime: DateTime [0..*]
+ evaluationMethodDescription: CharacterString [0..1]
+ evaluationProceedure: CI_Citation [0..1]
+ referenceDoc: CI_Citation [0..*]
+ evaluationMethodType: DQ_EvaluationMethodTypeCode [0..1]
  
```

```

DQ_Result [1..*]
+ dateTime: DateTime [0..*]
+ resultScope: DQ_ScopeCode [0..1]
  
```

Result Types

The ISO Standard include four types of data quality results in the DQ_Element object.

The first, the DQ_ConformanceResult, describes how the dataset was tested for conformance to a published standard and whether the dataset passed the test.

The second, the DQ_QuantitativeResult, provides a mechanism for describing the results of a quantitative quality evaluation.

Finally, the QE_CoverageResult (from ISO 19115-2), allows a quality result to be expressed as a spatial object. For example, if a gridded dataset has an associated grid of quality flags, that quality grid could be described here. Note also that the coverage results have an associated file and format.

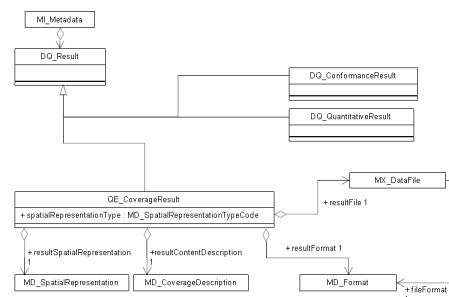
The quality of many datasets varies spatially within the dataset. For example, gridded satellite datasets include grids that provide quality flag values for every pixel. Radiosondes in the atmosphere and profiles in the ocean also can have quality that varies along their paths. In situations like these, the quality information can be described using a spatial feature like a grid or a line. In ISO quality information in spatial features is described using a coverageResult. The

coverageResult includes MD_SpatialRepresentation and MD_CoverageDescriptions that describe the quality coverage. In this case, the MD_CoverageDescription can serve a role that is similar to the role of the measure and evaluationMethod elements in the report. The MD_CoverageDescription includes a contentType that can currently be image, thematicRepresentation, or physicalMeasurement. The revision of 19115 may add qualityInformation to this codelist and allow multiple contentType values.

Finally, the DQ_Descriptive result was introduced in ISO 19157 in order to include simple textual descriptions of data quality in the standard. It is a simple CharacterString.

DQ_ConformanceResult
+ specification : CI_Citation
+ explanation : CharacterString
+ pass : Boolean
Or
DQ_QuantitativeResult
+ valueType [0..1] : RecordType
+ valueUnit : UnitOfMeasure
+ errorStatistic [0..1] : CharacterString
+ value [1..*] : Record
Or
QE_CoverageResult (added in ISO 19115-2, see UML below)
+ spatialRepresentationType: MD_SpatialRepresentationTypeCode, one of vector, grid, textTable, tin, stereoModel, video
+ resultFile: MX_DataFile
+ resultFormat: MD_Format
+ resultSpatialRepresentation: MD_SpatialRepresentation
+ resultContentDescription: MD_CoverageDescription
Or
DQ_DescriptiveResult
+ statement: CharacterString

DQ_CoverageResult



Implementation (ISO)

ISO 19115-2

The general structure of a data quality report in ISO 19115-2 is:

```
<gmd:DQ_DataQuality xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="http://www.isotc211.org/2005/gmd http://www.isotc211.org/2005/gmd/gmd.xsd http://www.isotc211.org/2005/gmi http://www.isotc211.org/2005/gmi/gmi.xsd"
  xmlns:gmi="http://www.isotc211.org/2005/gmi" xmlns:gco="http://www.isotc211.org/2005/gco" xmlns:gmd="http://www.isotc211.org/2005/gmd" xmlns:xlink="http://www.w3.org/1999/xlink"
  xmlns:srv="http://www.isotc211.org/2005/srv" xmlns:gml="http://www.opengis.net/gml/3.2">
```

```
  <gmd:scope>
    <!--
      The DQ_Scope object can include an id attribute that allows the same quality scope to be referenced from several different sections of the metadata record.
```

```
      For example, if all of the quality reports in the record pertain to the entire granule, they could all reference the same scope object with a value of "dataset".
```

```
      In this case, the id is set to datasetScope.
```

```
    -->
```

```
    <gmd:DQ_Scope id="datasetScope">
```

```
      <gmd:level>
```

```
        <!--
```

```
          The MD_ScopeCode is a codelist that includes two standard attributes: a URL that gives the location of the codeList,
```

```
          and a value from the codelist. The location can be set to the standard location if the standard codelist is sufficient
```

for the data provider needs or, if necessary, it can be set to a codelist that has been extended to include dataset specific values.

```
-->
<gmd:MD_ScopeCode codeList="http:CodeListLocation//#MD_ScopeCode" codeListValue="dataset"
>dataset</gmd:MD_ScopeCode>
</gmd:level>
<!--
```

The extent of the quality report can include specific information, if appropriate, or it can reference an extent defined in another part of the metadata record. In this case, the extent of the quality report is the same as that of the dataset, so the identifier boundingExtent is used. If necessary, the qualityReport can contain more than one extent. See extent examples.

```
-->
<gmd:extent xlink:href="#boundingExtent"/>
<gmd:levelDescription>
<!--
```

The levelDescription is used to provide more detail about the scope of the quality report. It can include name(s) of attributes or features or a text description of the scope. The properties also include dataset and other which are both character strings. If necessary, the quality report can contain more than one levelDescription.

```
-->
<gmd:MD_ScopeDescription>
  <gmd:dataset>
    <gco:CharacterString>levelDescription</gco:CharacterString>
  </gmd:dataset>
</gmd:MD_ScopeDescription>
</gmd:levelDescription>
</gmd:DQ_Scope>
</gmd:scope>
<gmd:report>
<!--
```

The report holds the meat of the DQ_DataQuality section of the metadata. It includes four major sections: the measure, the method, the date, and the result. There are a number of different types of reports that reflect general areas of data quality, e.g. DQ_Completeness, DQ_LogicalConsistency, DQ_PositionalAccuracy, DQ_ThematicAccuracy, DQ_TemporalAccuracy, DQ_QuantitativeAttributeAccuracy, and DQ_Usability. These are very general descriptors that should be used if clearly appropriate. At the same time, some of these names were created with collections of geographic features in mind and so may not make sense in the context of other data types. In those cases, the very general type DQ_QuantitativeAttributeAccuracy serves as a generally applicable catch-all.

```
-->
<gmd:DQ_QuantitativeAttributeAccuracy>
<!--
```

Information about the quality measure: To facilitate data set comparisons, it is helpful if the results in the data quality reports are expressed in a comparable way and that there is a common understanding of the data quality measures that have been used. ISO 19157 provides a set of standard measures to facilitate comparisons, but these are very general, e.g. "number of missing items" or "relative horizontal error". The standard also describes how user defined quality measures can be cataloged for sharing across a community.

A number of types of data quality reports are available. The DQ_QuantitativeAttributeAccuracy is the most general and most broadly applicable of these.

ISO 19115 quality reports include three elements that are used to describe the quality measure. The nameOfMeasure and measureDescription are used to provide enough information for a user to understand the measure being used if they are familiar with the measures used in a community. The measureIdentifier is used to support a search for more information.

-->

<!--

ESDIS Data Quality Information:

The ECHO metadata model includes several kinds of quality information: QASTats and QAFlags.

These measures have standard names. The QASTats are QAPercentMissingData, QAPercentOutOfBoundsData, QAPercentInterpolatedData, QAPercentCloudCover and the QAFlags are AutomaticQualityFlag, OperationalQualityFlag, ScienceQualityFlag. In the ISO implementation these are measure names.

Currently the measure names serve as globally unique identifiers for the ESDIS quality measures so nameOfMeasure = identifier.

The QASTats have self-explanatory names so they do not require a description. The QAFlags are more general and have mission or product specific explanations. In ECHO these are called AutomaticQualityFlagExplanation, OperationalQualityFlagExplanation, ScienceQualityFlagExplanation. In the ISO implementation, these explanations are measureDescriptions.

Other quality information:

Many ESDIS products include quality indicators that are specific to a particular product and not in the general ECHO model. In some cases this quality information is in product specific attributes (or additional attributes) with names that include "PERCENT" or start with "QA", e.g. PERCENTSHAPEFIXEDBRDFS, PERCENTLOWSUN, QAPERCENTPOOROUTPUT250MBAND1, QAPERCENTPOOROUTPUT250MBAND2. In the ISO implementation these are measure names.

In some cases these names are self-explanatory, but in many cases, more detailed description of how they are calculated would benefit users. Those descriptions could be measure descriptions or references to how they were calculated could be provided as evaluation procedure citations.

-->

```
<gmd:nameOfMeasure>
  <gco:CharacterString>nameOfMeasure</gco:CharacterString>
</gmd:nameOfMeasure>
<gmd:measureIdentification>
  <gmd:MD_Identifier>
    <gmd:code>
      <gco:CharacterString>measureIdentifier</gco:CharacterString>
    </gmd:code>
  </gmd:MD_Identifier>
</gmd:measureIdentification>
<gmd:measureDescription>
  <gco:CharacterString>measureDescription</gco:CharacterString>
</gmd:measureDescription>
<!--
```

The evaluation method provides a description of how the measure was used in the context of a particular dataset

in order to generate the quality report. ISO 19115 includes three elements that are relevant to the evaluationMethod:

the type is a codelist with values of directInternal, directExternal, or indirect; the evaluationMethodDescription is a text description that is available to a user along with the metadata record; the evaluationProcedure provides a citation to more detailed information.

-->

```
<gmd:evaluationMethodType>
  <gmd:DQ_EvaluationMethodTypeCode codeList="URI to codelist location" codeListValue="
direct_external">direct_external</gmd:DQ_EvaluationMethodTypeCode>
</gmd:evaluationMethodType>
<gmd:evaluationMethodDescription>
  <gco:CharacterString>evaluationMethodDescription</gco:CharacterString>
</gmd:evaluationMethodDescription>
```

```

    <gmd:evaluationProcedure>
      <gmd:CI_Citation>
        <gmd:title>
          <gco:CharacterString>title of reference material</gco:CharacterString>
        </gmd:title>
        <gmd:date gco:nilReason="missing"/>
      </gmd:CI_Citation>
    </gmd:evaluationProcedure>
  <!--
    The dateTime gives the date and time of the quality test in ISO8601 compliant text format
  -->
  <gmd:dateTime>
    <gco:DateTime>2012-10-02T15:44:00</gco:DateTime>
  </gmd:dateTime>
  <!--
    The result is the actual result of the quality test. There are four types of results:
    DQ_QuantitativeResult,
    DQ_ConformanceResult, QE_CoverageResult (from ISO 19115-2), and DQ_DescriptiveResult (from
    ISO 19157). A single
    report can contain one or two results.
  -->
  <gmd:result>
    <gmd:DQ_QuantitativeResult>
      <!--
        gmd:DQ_QuantitativeResult:

        Results of many quality reports are single simple numbers (%'s or counts). In
        those cases a
        DQ_QuantitativeResult can be used to hold the result.

        Unit definitions generally come from an accepted source that can be referenced
        for an authoritative
        definition. In Earth Science the UDUNITS package is commonly used (http://www.unidata.ucar.edu/software/udunits/).
        A more general source for unit definitions is "The Unified Code for Units of
        Measure" (http://unitsofmeasure.org).
        See https://coastwatch.pfeg.noaa.gov/erddap/convert/units.html for a comparison
        of the two approaches.

        The xlink included in the valueUnit is designed to provide an unambiguous
        identifier for the definition of the
        unit. Neither UCUM not UDUNITS support such URIs. UCUM does have a table of unit
        abbreviations and definitions
        at http://unitsofmeasure.org/ucum.html#section-Alphabetic-Index. These can be
        referenced as
        degrees Celsius = xlink:href="http://unitsofmeasure.org/ucum.
        html#Cel"
      -->
      <gmd:valueUnit xlink:href="AnyValidURI"/>
      <gmd:value>
        <!--
          A Record is a string of value(s) with a given type. In most quantitative
          quality reports the type is a simple
          primitive type (gco:Real_PropertyType, gco:Integer_PropertyType). In other
          cases, it could be a string
          (gco:CharacterString_PropertyType) that includes multiple
          numbers.
        -->
        <gco:Record xsi:type="gco:Integer_PropertyType">
          <gco:Integer>999</gco:Integer>
        </gco:Record>
      </gmd:value>
    </gmd:DQ_QuantitativeResult>
  </gmd:result>
  <gmd:result>
    <gmi:QE_CoverageResult>
      <!--
        gmi:QE_CoverageResult:

        The gmi:QE_CoverageResult is used to provide a quality report that is in the
        form of a coverage (e.g. a

```

timeseries or grid). It therefore shares a number of elements with coverage descriptions. In cases where these elements are repeated in a single metadata record, these can be references to elements that are completely described elsewhere in the record (e.g. `xlink:href="#datasetspatialRepresentation"`).

The `resultFile` and `resultFormat` can be used to describe a coverage result that is in a different file.

```
-->
  <gmi:spatialRepresentationType/>
  <gmi:resultSpatialRepresentation/>
  <gmi:resultContentDescription/>
  <gmi:resultFormat/>
  <gmi:resultFile/>
</gmi:QE_CoverageResult>
</gmd:result>
<gmd:result>
  <gmd:DQ_ConformanceResult>
    <!--
```

`gmd:DQ_ConformanceResult:`

The `gmd:DQ_ConformanceResult` is used to provide a quality report on conformance of a dataset to a particular standard, e.g. an OGC Web Service or OPeNDAP.

The result in this case is a Boolean, i.e. True or False.

```
-->
  <gmd:specification/>
  <gmd:explanation/>
  <gmd:pass/>
</gmd:DQ_ConformanceResult>
</gmd:result>
</gmd:DQ_QuantitativeAttributeAccuracy>
</gmd:report>
</gmd:DQ_DataQuality>
```

ISO 19115-1 / ISO 19157

The current version of the ISO metadata standards (ISO 19157 and ISO 19115-1) improved the structure of the metadata by modularizing the measure and evaluation information. This makes it easier to re-use measure and evaluation information across multiple collections or granules. The namespaces also changed as another step towards increased modularity.

```
<mdq:DQ_DataQuality xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="
http://standards.iso.org/iso/19115/-3/mdb/1.0 http://standards.iso.org/iso/19115/-3/mdt/1.0/mdt.xsd"
  xmlns:mdq="http://standards.iso.org/iso/19157/-2/mdq/1.0" xmlns:mdb="http://standards.iso.org/iso/19115/-3
/mdb/1.0" xmlns:gco="http://standards.iso.org/iso/19115/-3/gco/1.0"
  xmlns:mcc="http://standards.iso.org/iso/19115/-3/mcc/1.0" xmlns:xlink="http://www.w3.org/1999/xlink"
  xmlns:cit="http://standards.iso.org/iso/19115/-3/cit/1.0">
```

```
  <mdq:scope>
```

```
    <!--
```

The `DQ_Scope` object can include an `id` attribute that allows the same quality scope to be referenced from several different sections of the metadata record.

For example, if all of the quality reports in the record pertain to the entire granule, they could all reference the same scope object with a value of "dataset".

In this case, the `id` is set to `datasetScope`.

```
    -->
```

```
  <mcc:MD_Scope>
```

```
    <mcc:level>
```

```
    <!--
```

The `MD_ScopeCode` is a codelist that includes two standard attributes: a URL that gives the location of the codelist,

and a value from the codelist. The location can be set to the standard location if the standard codelist is sufficient

for the data provider needs or, if necessary, it can be set to a codelist that has been extended to include dataset

specific values.

```

-->
<mcc:MD_ScopeCode codeList="http:CodeListLocation//#MD_ScopeCode" codeListValue="dataset"
>dataset</mcc:MD_ScopeCode>
</mcc:level>
<!--
    The extent of the quality report can include specific information, if appropriate, or it can
    reference an extent defined
    in another part of the metadata record. In this case, the extent of the quality report is the
    same as that of the dataset,
    so the identifier boundingExtent is used. If necessary, the qualityReport can contain more than
    one extent. See extent examples.
-->
<mcc:extent xlink:href="#boundingExtent"/>
<mcc:levelDescription>
<!--
    The levelDescription is used to provide more detail about the scope of the quality report.
    It can include name(s) of
    attributes or features or a text description of the scope. The properties also include
    dataset and other which are
    both character strings. If necessary, the quality report can contain more than one
    levelDescription.
-->
<mcc:MD_ScopeDescription>
<mcc:dataset>
<gco:CharacterString>levelDescription</gco:CharacterString>
</mcc:dataset>
</mcc:MD_ScopeDescription>
</mcc:levelDescription>
</mcc:MD_Scope>
</mdq:scope>
<mdq:standaloneQualityReport>
<mdq:DQ_StandaloneQualityReportInformation>
<!--
    DQ_StandaloneQualityReportInformation
    Many important data quality reports are described in scientific papers or reports that can be
    referenced as
    standalone quality reports that include citations to the report and an abstract that provides a
    brief
    description of the result. This is a new capability introduced in ISO 19157. The report includes
    a citation
-->
<mdq:reportReference>
<cit:CI_Citation/>
</mdq:reportReference>
<mdq:abstract>
<gco:CharacterString/>
</mdq:abstract>
</mdq:DQ_StandaloneQualityReportInformation>
</mdq:standaloneQualityReport>
<mdq:report>
<!--
    The report holds the meat of the DQ_DataQuality section of the metadata. It includes four major
    sections: the measure,
    the method, the date, and the result. There are a number of different types of reports that reflect
    general areas of
    data quality, e.g. DQ_Completeness, DQ_LogicalConsistency, DQ_PositionalAccuracy,
    DQ_ThematicAccuracy, DQ_TemporalAccuracy,
    DQ_QuantitativeAttributeAccuracy, and DQ_Usability. These are very general descriptors that should
    be used if clearly
    appropriate. At the same time, some of these names were created with collections of geographic
    features in mind and so
    may not make sense in the context of other data types. In those cases, the very general type
    DQ_QuantitativeAttributeAccuracy
    serves as a generally applicable catch-all.
-->
<mdq:DQ_QuantitativeAttributeAccuracy>
<!--
    Information about the quality measure: To facilitate data set comparisons, it is helpful if the
    results in the data quality
    reports are expressed in a comparable way and that there is a common understanding of the data
    quality measures that have

```

been used. ISO 19157 provides a set of standard measures to facilitate comparisons, but these are very general, e.g.

"number of missing items" or "relative horizontal error". The standard also describes how user defined quality measures can be cataloged for sharing across a community.

A number of types of data quality reports are available. The DQ_QuantitativeAttributeAccuracy is the most general and most broadly applicable of these.

ISO 19115 quality reports include three elements that are used to describe the quality measure. The nameOfMeasure and measureDescription are used to provide enough information for a user to understand the measure being used if they are familiar with the measures used in a community. The measureIdentifier is used to support a search for more information.

-->

<!--

ESDIS Data Quality Information:

The ECHO metadata model includes several kinds of quality information: QASTats and QAFlags. These measures have standard names. The QASTats are QAPercentMissingData, QAPercentOutOfBoundsData, QAPercentInterpolatedData, QAPercentCloudCover and the QAFlags are AutomaticQualityFlag, OperationalQualityFlag, ScienceQualityFlag. In the ISO implementation these are measure names.

Currently the measure names serve as globally unique identifiers for the ESDIS quality measures so nameOfMeasure = identifier.

The QASTats have self-explanatory names so they do not require a description. The QAFlags are more general and have mission or product specific explanations. In ECHO these are called AutomaticQualityFlagExplanation, OperationalQualityFlagExplanation, ScienceQualityFlagExplanation. In the ISO implementation, these explanations are measureDescriptions.

Other quality information:

Many ESDIS products include quality indicators that are specific to a particular product and not in the general ECHO model. In some cases this quality information is in product specific attributes (or additional attributes) with names that include "PERCENT" or start with "QA", e.g. PERCENTSHAPEFIXEDBRDFS, PERCENTLOWSUN, QAPERCENTPOOROUTPUT250MBAND1, QAPERCENTPOOROUTPUT250MBAND2. In the ISO implementation these are measure names.

In some cases these names are self-explanatory, but in many cases, more detailed description of how they are calculated would benefit users. Those descriptions could be measure descriptions or references to how they were calculated could be provided as evaluation procedure citations.

-->

<mdq:measure>

<mdq:DQ_MeasureReference>

<mdq:measureIdentification>

<mcc:MD_Identifier>

<mcc:code>

<gco:CharacterString>measureIdentifier</gco:CharacterString>

</mcc:code>

</mcc:MD_Identifier>

</mdq:measureIdentification>

<mdq:nameOfMeasure>

<gco:CharacterString>nameOfMeasure</gco:CharacterString>

</mdq:nameOfMeasure>

<mdq:measureDescription>

<gco:CharacterString>measureDescription</gco:CharacterString>

</mdq:measureDescription>

</mdq:DQ_MeasureReference>

```

</mdq:measure>
<!--
    The evaluation method provides a description of how the measure was used in the context of a
    particular dataset
    in order to generate the quality report. ISO 19157 includes a new abstract DQ_DataEvaluation
    class that can be implemented
    as DQ_FullInspection, DQ_SampleBasedInspection, or DQ_IndirectEvaluation. It includes three
    elements that are relevant to the evaluationMethod:
    the type is a codelist with values of directInternal, directExternal, or indirect; the
    evaluationMethodDescription
    is a text description that is available to a user along with the metadata record; the
    evaluationProcedure provides
    a citation to more detailed information.
-->
<mdq:evaluationMethod>
  <mdq:DQ_FullInspection>
    <!--
      The dateTime gives the date and time of the quality test in ISO1601 compliant text
format
    -->
    <mdq:dateTime>
      <gco:DateTime>2012-10-02T15:44:00</gco:DateTime>
    </mdq:dateTime>
    <mdq:evaluationMethodDescription>
      <gco:CharacterString>evaluationMethodDescription</gco:CharacterString>
    </mdq:evaluationMethodDescription>
    <mdq:evaluationProcedure>
      <cit:CI_Citation>
        <cit:title>
          <gco:CharacterString>title of reference material</gco:CharacterString>
        </cit:title>
        <cit:date gco:nilReason="missing"/>
      </cit:CI_Citation>
    </mdq:evaluationProcedure>
    <mdq:evaluationMethodType>
      <mdq:DQ_EvaluationMethodTypeCode codeList="codeListLocation#DQ_EvaluationMethodTypeCode"
codeListValue="direct_external">direct_external</mdq:DQ_EvaluationMethodTypeCode>
    </mdq:evaluationMethodType>
  </mdq:DQ_FullInspection>
</mdq:evaluationMethod>
<!--
    The result is the actual result of the quality test. There are four types of results:
DQ_QuantitativeResult,
    DQ_ConformanceResult, QE_CoverageResult (from ISO 19115-2), and DQ_DescriptiveResult (from
ISO 19157). A single
    report can contain one or two results.
-->
<mdq:result>
  <mdq:DQ_QuantitativeResult>
    <!--
      gmd:DQ_QuantitativeResult:

      Results of many quality reports are single simple numbers (%'s or counts). In
those cases a
      DQ_QuantitativeResult can be used to hold the result.

      Unit definitions generally come from an accepted source that can be referenced
for an authoritative
      definition. In Earth Science the UDUNITS package is commonly used (http://www.unidata.ucar.edu/software/udunits/).
      A more general source for unit definitions is "The Unified Code for Units of
Measure" (http://unitsofmeasure.org).
      See https://coastwatch.pfeg.noaa.gov/erddap/convert/units.html for a comparison
of the two approaches.

      The xlink included in the valueUnit is designed to provide an unambiguous
identifier for the definition of the
      unit. Neither UCUM not UDUNITS support such URIs. UCUM does have a table of unit
abbreviations and definitions
      at http://unitsofmeasure.org/ucum.html#section-Alphabetic-Index. These can be
referenced as

```

```

degrees Celsius = xlink:href="http://unitsofmeasure.org/ucum.
html#Cel"
-->
<mdq:value>
<!--
    A Record is a string of value(s) with a given type. In most quantitative
quality reports the type is a simple
    primitive type (gco:Real_PropertyType, gco:Integer_PropertyType). In other
cases, it could be a string
    (gco:CharacterString_PropertyType) that includes multiple
numbers.
-->
    <gco:Record xsi:type="gco:Integer_PropertyType">
    <gco:Integer>999</gco:Integer>
    </gco:Record>
</mdq:value>
<mdq:valueUnit xlink:href="AnyValidURI"/>
</mdq:DQ_QuantitativeResult>
</mdq:result>
<mdq:result>
    <mdq:QE_CoverageResult>
    <!--
        gmi:QE_CoverageResult:

        The gmi:QE_CoverageResult is used to provide a quality report that is in the
form of a coverage (e.g. a
        timeseries or grid). It therefore shares a number of elements with coverage
descriptions. In cases where
        these elements are repeated in a single metadata record, these can be references
to elements that are
        completely described elsewhere in the record (e.g. xlink:href="
#datasetspatialRepresentation").

        The resultFile and resultFormat can be used to describe a coverage result that
is in a different file.
-->
    <mdq:spatialRepresentationType/>
    <mdq:resultSpatialRepresentation/>
    <mdq:resultContentDescription/>
    <mdq:resultFormat/>
    <mdq:resultFile/>
    </mdq:QE_CoverageResult>
</mdq:result>
<mdq:result>
    <mdq:DQ_ConformanceResult>
    <!--
        gmd:DQ_ConformanceResult:

        The gmd:DQ_ConformanceResult is used to provide a quality report on conformance
of a dataset to a
        particular standard, e.g. an OGC Web Service or OPeNDAP.

        The result in this case is a Boolean, i.e. True or False.
-->
    <mdq:specification/>
    <mdq:explanation/>
    <mdq:pass/>
    </mdq:DQ_ConformanceResult>
</mdq:result>
<mdq:result>
    <mdq:DQ_DescriptiveResult>
    <!--
        DQ_DescriptiveResult
        The DQ_DescriptiveResult provides an opportunity to include a character string describing
the quality test.
        These are similar to the dataQuality element in the DIF metadata standard.
-->
    <mdq:statement/>
    </mdq:DQ_DescriptiveResult>
</mdq:result>
</mdq:DQ_QuantitativeAttributeAccuracy>

```

```
</mdq:report>
</mdq:DQ_DataQuality>
```

ECHO Reports in ISO

Details and examples of how ECHO data quality content can be [represented in ISO](#).

Implementation (NcML)

The XML implementations shown above work well in systems designed to manage metadata in internationally accepted XML dialects. Typically these systems manage metadata for collections and, in many cases, they are separate from the actual data files (or granules). Historically, the metadata in files has been generated and used by analysis and visualization tools. It is written and read by tools that understand the specifics of the data format and the organization and naming of the metadata elements. The ISO standards shown above provide an organization and a set of names. Can we take advantage of those in the granules?

We have recently explored this idea with a [standard transform between ISO metadata and NcML](#), a simple XML dialect originally developed as part of the netCDF ecosystem that includes groups and attributes and translated easily to the structure of an HDF file. The NcML version of the ISO 19115 quality information is shown below. This representation includes all of the ISO content and can be transformed back into ISO when it is appropriate.

```
<nc:netcdf xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns="http://www.unidata.ucar.edu/namespaces/netcdf/ncml-2.2"
  xmlns:nc="http://www.unidata.ucar.edu/namespaces/netcdf/ncml-2.2">
  <nc:group name="gmd:DQ_DataQuality">
    <nc:attribute name="__role" value="metadataRoot"/>
    <nc:attribute name="__type" value="gmd:DQ_DataQuality"/>
    <nc:attribute name="@xsi:schemaLocation"
      value="http://www.isotc211.org/2005/gmd http://www.isotc211.org/2005/gmd/gmd.xsd
http://www.isotc211.org/2005/gmi http://www.isotc211.org/2005/gmi/gmi.xsd"/>
    <!--
      The DQ_Scope object can include an id attribute that allows the same quality scope to be referenced
      from several different sections of the metadata record.
      For example, if all of the quality reports in the record pertain to the entire granule, they could
      all reference the same scope object with a value of "dataset".
      In this case, the id is set to datasetScope.
    -->
    <nc:group name="gmd:scope">
      <nc:attribute name="__role" value="gmd:scope"/>
      <nc:attribute name="__type" value="gmd:DQ_Scope"/>
      <nc:attribute name="@id" value="datasetScope"/>
    <!--
      The MD_ScopeCode is a codelist that includes two standard attributes: a URL that gives the
      location of the codeList,
      and a value from the codelist. The location can be set to the standard location if the
      standard codelist is sufficient
      for the data provider needs or, if necessary, it can be set to a codelist that has been
      extended to include dataset
      specific values.
    -->
    <nc:group name="gmd:level">
      <nc:attribute name="__role" value="gmd:level"/>
      <nc:attribute name="__type" value="gmd:MD_ScopeCode"/>
      <nc:attribute name="@codeList" value="http:CodeListLocation//#MD_ScopeCode"/>
      <nc:attribute name="@codeListValue" value="dataset"/>
      <nc:attribute name="value" value="dataset"/>
    </nc:group>
    <!--
      The extent of the quality report can include specific information, if appropriate, or it can
      reference an extent defined
      in another part of the metadata record. In this case, the extent of the quality report is the
      same as that of the dataset,
      so the identifier boundingExtent is used. If necessary, the qualityReport can contain more than
      one extent. See extent examples.
    -->
    <nc:group name="gmd:extent">
      <nc:attribute name="@xlink:href" value="#boundingExtent"/>
    </nc:group>
    <!--
      The levelDescription is used to provide more detail about the scope of the quality report.
      It can include name(s) of
```

attributes or features or a text description of the scope. The properties also include dataset and other which are

both character strings. If necessary, the quality report can contain more than one levelDescription.

```
-->
<nc:group name="gmd:levelDescription">
  <nc:attribute name="__role" value="gmd:levelDescription"/>
  <nc:attribute name="__type" value="gmd:MD_ScopeDescription"/>
  <nc:attribute name="gmd:dataset"
    value="levelDescription"
    __isoType="gco:CharacterString"/>
</nc:group>
</nc:group>
<!--
```

The report holds the meat of the DQ_DataQuality section of the metadata. It includes four major sections: the measure, the method, the date, and the result. There are a number of different types of reports that reflect general areas of data quality, e.g. DQ_Completeness, DQ_LogicalConsistency, DQ_PositionalAccuracy, DQ_ThematicAccuracy, DQ_TemporalAccuracy, DQ_QuantitativeAttributeAccuracy, and DQ_Usability. These are very general descriptors that should be used if clearly appropriate. At the same time, some of these names were created with collections of geographic features in mind and so may not make sense in the context of other data types. In those cases, the very general type DQ_QuantitativeAttributeAccuracy serves as a generally applicable catch-all.

```
-->
<nc:group name="gmd:report">
  <nc:attribute name="__role" value="gmd:report"/>
  <nc:attribute name="__type" value="gmd:DQ_QuantitativeAttributeAccuracy"/>
<!--
```

Information about the quality measure: To facilitate data set comparisons, it is helpful if the results in the data quality reports are expressed in a comparable way and that there is a common understanding of the data quality measures that have been used. ISO 19157 provides a set of standard measures to facilitate comparisons, but these are very general, e.g. "number of missing items" or "relative horizontal error". The standard also describes how user defined quality measures can be cataloged for sharing across a community.

A number of types of data quality reports are available. The DQ_QuantitativeAttributeAccuracy is the most general and most broadly applicable of these.

ISO 19115 quality reports include three elements that are used to describe the quality measure. The nameOfMeasure and measureDescription are used to provide enough information for a user to understand the measure being used if they are familiar with the measures used in a community. The measureIdentifier is used to support a search for more information.

```
-->
<!--
  ESDIS Data Quality Information:
```

The ECHO metadata model includes several kinds of quality information: QASStats and QAFlags. These measures have standard names. The QASStats are QAPercentMissingData, QAPercentOutOfBoundsData, QAPercentInterpolatedData, QAPercentCloudCover and the QAFlags are AutomaticQualityFlag, OperationalQualityFlag, ScienceQualityFlag. In the ISO implementation these are measure names.

Currently the measure names serve as globally unique identifiers for the ESDIS quality measures so nameOfMeasure = identifier.

The QASStats have self-explanatory names so they do not require a description. The QAFlags are more general and have mission or product specific explanations. In ECHO these are called AutomaticQualityFlagExplanation, OperationalQualityFlagExplanation,

ScienceQualityFlagExplanation. In the ISO implementation, these explanations are measureDescriptions.

Other quality information:

Many ESDIS products include quality indicators that are specific to a particular product and not in the general ECHO

model. In some cases this quality information is in product specific attributes (or additional attributes)

with names that include "PERCENT" or start with "QA", e.g. PERCENTSHAPEFIXEDBRDFS, PERCENTLOWSUN,

QAPERCENTPOOROUTPUT250MBAND1, QAPERCENTPOOROUTPUT250MBAND2. In the ISO implementation these are measure names.

In some cases these names are self-explanatory, but in many cases, more detailed description of how they are

calculated would benefit users. Those descriptions could be measure descriptions or references to how they

were calculated could be provided as evaluation procedure citations.

-->

```
<nc:attribute name="gmd:nameOfMeasure"
              value="nameOfMeasure"
              __isoType="gco:CharacterString"/>
<nc:group name="gmd:measureIdentification">
  <nc:attribute name="__role" value="gmd:measureIdentification"/>
  <nc:attribute name="__type" value="gmd:MD_Identifier"/>
  <nc:attribute name="gmd:code"
                value="measureIdentifier"
                __isoType="gco:CharacterString"/>
</nc:group>
<nc:attribute name="gmd:measureDescription"
              value="measureDescription"
              __isoType="gco:CharacterString"/>
<!--
```

The evaluation method provides a description of how the measure was used in the context of a particular dataset

in order to generate the quality report. ISO 19115 includes three elements that are relevant to the evaluationMethod:

the type is a codelist with values of directInternal, directExternal, or indirect; the evaluationMethodDescription

is a text description that is available to a user along with the metadata record; the evaluationProcedure provides

a citation to more detailed information.

-->

```
<nc:group name="gmd:evaluationMethodType">
  <nc:attribute name="__role" value="gmd:evaluationMethodType"/>
  <nc:attribute name="__type" value="gmd:DQ_EvaluationMethodTypeCode"/>
  <nc:attribute name="@codeList" value="URI to codelist location"/>
  <nc:attribute name="@codeListValue" value="direct_external"/>
  <nc:attribute name="value" value="direct_external"/>
</nc:group>
<nc:attribute name="gmd:evaluationMethodDescription"
              value="evaluationMethodDescription"
              __isoType="gco:CharacterString"/>
<nc:group name="gmd:evaluationProcedure">
  <nc:attribute name="__role" value="gmd:evaluationProcedure"/>
  <nc:attribute name="__type" value="gmd:CI_Citation"/>
  <nc:attribute name="gmd:title"
                value="title of reference material"
                __isoType="gco:CharacterString"/>
  <nc:group name="gmd:date">
    <nc:attribute name="@gco:nilReason" value="missing"/>
  </nc:group>
</nc:group>
<!--
```

The dateTime gives the date and time of the quality test in ISO8601 compliant text format

-->

```
<nc:attribute name="gmd:dateTime"
              value="2012-10-02T15:44:00"
              __isoType="gco:DateTime"/>
<!--
```

The result is the actual result of the quality test. There are four types of results: DQ_QuantitativeResult, DQ_ConformanceResult, QE_CoverageResult (from ISO 19115-2), and DQ_DescriptiveResult (from ISO 19157). A single report can contain one or two results.

```
-->
<nc:group name="gmd:result">
  <nc:attribute name="__role" value="gmd:result"/>
  <nc:attribute name="__type" value="gmd:DQ_QuantitativeResult"/>
<!--
```

gmd:DQ_QuantitativeResult:

Results of many quality reports are single simple numbers (%'s or counts). In those cases a DQ_QuantitativeResult can be used to hold the result.

Unit definitions generally come from an accepted source that can be referenced for an authoritative definition. In Earth Science the UDUNITS package is commonly used (<http://www.unidata.ucar.edu/software/udunits/>). A more general source for unit definitions is "The Unified Code for Units of Measure" (<http://unitsofmeasure.org>). See <https://coastwatch.pfeg.noaa.gov/erddap/convert/units.html> for a comparison of the two approaches.

The xlink included in the valueUnit is designed to provide an unambiguous identifier for the definition of the unit. Neither UCUM nor UDUNITS support such URIs. UCUM does have a table of unit abbreviations and definitions at <http://unitsofmeasure.org/ucum.html#section-Alphabetic-Index>. These can be referenced as degrees Celsius = xlink:href="http://unitsofmeasure.org/ucum.html#Cel"

```
-->
<nc:group name="gmd:valueUnit">
  <nc:attribute name="@xlink:href" value="AnyValidURI"/>
</nc:group>
<!--
```

A Record is a string of value(s) with a given type. In most quantitative quality reports the type is a simple primitive type (gco:Real_PropertyType, gco:Integer_PropertyType). In other cases, it could be a string (gco:CharacterString_PropertyType) that includes multiple numbers.

```
-->
<nc:group name="gmd:value">
  <nc:attribute name="__role" value="gmd:value"/>
  <nc:attribute name="__type" value="gco:Record"/>
  <nc:attribute name="@xsi:type" value="gco:Integer_PropertyType"/>
  <nc:attribute name="gco:Record" value="999" __isoType="gco:Integer"/>
</nc:group>
</nc:group>
<nc:group name="gmd:result_d1e62">
  <nc:attribute name="__role" value="gmd:result"/>
  <nc:attribute name="__type" value="gmi:QE_CoverageResult"/>
<!--
```

gmi:QE_CoverageResult:

The gmi:QE_CoverageResult is used to provide a quality report that is in the form of a coverage (e.g. a timeseries or grid). It therefore shares a number of elements with coverage descriptions. In cases where these elements are repeated in a single metadata record, these can be references to elements that are completely described elsewhere in the record (e.g. xlink:href="#datasetspatialRepresentation").

The resultFile and resultFormat can be used to describe a coverage result that is in a different file.

```
-->
<nc:group name="gmi:spatialRepresentationType">
```

```

        <nc:attribute name="gco:nilReason" value="unknown"/>
    </nc:group>
    <nc:group name="gmi:resultSpatialRepresentation">
        <nc:attribute name="gco:nilReason" value="unknown"/>
    </nc:group>
    <nc:group name="gmi:resultContentDescription">
        <nc:attribute name="gco:nilReason" value="unknown"/>
    </nc:group>
    <nc:group name="gmi:resultFormat">
        <nc:attribute name="gco:nilReason" value="unknown"/>
    </nc:group>
    <nc:group name="gmi:resultFile">
        <nc:attribute name="gco:nilReason" value="unknown"/>
    </nc:group>
</nc:group>
<nc:group name="gmd:result_d1e70">
    <nc:attribute name="__role" value="gmd:result"/>
    <nc:attribute name="__type" value="gmd:DQ_ConformanceResult"/>
<!--

```

gmd:DQ_ConformanceResult:

of a dataset to a

The gmd:DQ_ConformanceResult is used to provide a quality report on conformance particular standard, e.g. an OGC Web Service or OPeNDAP.

The result in this case is a Boolean, i.e. True or False.

-->

```

    <nc:group name="gmd:specification">
        <nc:attribute name="gco:nilReason" value="unknown"/>
    </nc:group>
    <nc:group name="gmd:explanation">
        <nc:attribute name="gco:nilReason" value="unknown"/>
    </nc:group>
    <nc:group name="gmd:pass">
        <nc:attribute name="gco:nilReason" value="unknown"/>
    </nc:group>
</nc:group>
</nc:group>
<nc:group name="namespace_1">
    <nc:attribute name="prefix" value="xml"/>
    <nc:attribute name="uri" value="http://www.w3.org/XML/1998/namespace"/>
</nc:group>
<nc:group name="namespace_2">
    <nc:attribute name="prefix" value="xsi"/>
    <nc:attribute name="uri" value="http://www.w3.org/2001/XMLSchema-instance"/>
</nc:group>
<nc:group name="namespace_3">
    <nc:attribute name="prefix" value="gmi"/>
    <nc:attribute name="uri" value="http://www.isotc211.org/2005/gmi"/>
</nc:group>
<nc:group name="namespace_4">
    <nc:attribute name="prefix" value="gco"/>
    <nc:attribute name="uri" value="http://www.isotc211.org/2005/gco"/>
</nc:group>
<nc:group name="namespace_5">
    <nc:attribute name="prefix" value="gmd"/>
    <nc:attribute name="uri" value="http://www.isotc211.org/2005/gmd"/>
</nc:group>
<nc:group name="namespace_6">
    <nc:attribute name="prefix" value="xlink"/>
    <nc:attribute name="uri" value="http://www.w3.org/1999/xlink"/>
</nc:group>
<nc:group name="namespace_7">
    <nc:attribute name="prefix" value="srv"/>
    <nc:attribute name="uri" value="http://www.isotc211.org/2005/srv"/>
</nc:group>
<nc:group name="namespace_8">
    <nc:attribute name="prefix" value="gml"/>
    <nc:attribute name="uri" value="http://www.opengis.net/gml/3.2"/>
</nc:group>

```

```

    </nc:group>
</nc:netcdf>

```

ISO 19115-1 / ISO 19157

The same transform can be used to create NcML from the ISO 19115-1 / ISO 19157 representation.

```

<nc:netcdf xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns="http://www.unidata.ucar.edu/namespaces/netcdf/ncml-2.2"
  xmlns:nc="http://www.unidata.ucar.edu/namespaces/netcdf/ncml-2.2">
  <nc:group name="mdq:DQ_DataQuality">
    <nc:attribute name="__role" value="metadataRoot"/>
    <nc:attribute name="__type" value="mdq:DQ_DataQuality"/>
    <nc:attribute name="@xsi:schemaLocation"
      value="http://standards.iso.org/iso/19115/-3/mdb/1.0 http://standards.iso.org/iso/19115/-
3/mdt/1.0/mdt.xsd"/>
    <!--
      The DQ_Scope object can include an id attribute that allows the same quality scope to be referenced
      from several different sections of the metadata record.
      For example, if all of the quality reports in the record pertain to the entire granule, they could
      all reference the same scope object with a value of "dataset".
      In this case, the id is set to datasetScope.
    -->
    <nc:group name="mdq:scope">
      <nc:attribute name="__role" value="mdq:scope"/>
      <nc:attribute name="__type" value="mcc:MD_Scope"/>
      <!--
        The MD_ScopeCode is aodelist that includes two standard attributes: a URL that gives the
        location of the codeList,
        and a value from the codeList. The location can be set to the standard location if the
        standard codeList is sufficient
        for the data provider needs or, if necessary, it can be set to a codeList that has been
        extended to include dataset
        specific values.
      -->
      <nc:group name="mcc:level">
        <nc:attribute name="__role" value="mcc:level"/>
        <nc:attribute name="__type" value="mcc:MD_ScopeCode"/>
        <nc:attribute name="@codeList" value="http:CodeListLocation/#MD_ScopeCode"/>
        <nc:attribute name="@codeListValue" value="dataset"/>
        <nc:attribute name="value" value="dataset"/>
      </nc:group>
      <!--
        The extent of the quality report can include specific information, if appropriate, or it can
        reference an extent defined
        in another part of the metadata record. In this case, the extent of the quality report is the
        same as that of the dataset,
        so the identifier boundingExtent is used. If necessary, the qualityReport can contain more than
        one extent. See extent examples.
      -->
      <nc:group name="mcc:extent">
        <nc:attribute name="@xlink:href" value="#boundingExtent"/>
      </nc:group>
      <!--
        The levelDescription is used to provide more detail about the scope of the quality report.
        It can include name(s) of
        attributes or features or a text description of the scope. The properties also include
        dataset and other which are
        both character strings. If necessary, the quality report can contain more than one
        levelDescription.
      -->
      <nc:group name="mcc:levelDescription">
        <nc:attribute name="__role" value="mcc:levelDescription"/>
        <nc:attribute name="__type" value="mcc:MD_ScopeDescription"/>
        <nc:attribute name="mcc:dataset"
          value="levelDescription"
          __isoType="gco:CharacterString"/>
      </nc:group>
    </nc:group>
  </nc:netcdf>

```

```

<nc:group name="mdq:standaloneQualityReport">
  <nc:attribute name="__role" value="mdq:standaloneQualityReport"/>
  <nc:attribute name="__type" value="mdq:DQ_StandaloneQualityReportInformation"/>
  <!--
    DQ_StandaloneQualityReportInformation
    Many important data quality reports are described in scientific papers or reports that can be
referenced as
    standalone quality reports that include citations to the report and an abstract that provides a
brief
    description of the result. This is a new capability introduced in ISO 19157. The report includes
a citation
  -->
  <nc:group name="mdq:reportReference">
    <nc:attribute name="__role" value="mdq:reportReference"/>
    <nc:attribute name="__type" value="cit:CI_Citation"/>
  </nc:group>
  <nc:group name="gco:CharacterString">
    <nc:attribute name="gco:nilReason" value="unknown"/>
  </nc:group>
</nc:group>
<!--
  The report holds the meat of the DQ_DataQuality section og the metadata. It includes four major
sections: the measure,
  the method, the date, and the result. There are a number of different types of reports that reflect
general areas of
  data quality, e.g. DQ_Completeness, DQ_LogicalConsistency, DQ_PositionalAccuracy,
DQ_ThematicAccuracy, DQ_TemporalAccuracy,
  DQ_QuantitativeAttributeAccuracy, and DQ_Usability. These are very general descriptors that should
be used if clearly
  appropriate. At the same time, some of these names were created with collections of geographic
features in mind and so
  may not make sense in the context of other data types. In those cases, the very general type
DQ_QuantitativeAttributeAccuracy
  serves as a generally applicable catch-all.
  -->
  <nc:group name="mdq:report">
    <nc:attribute name="__role" value="mdq:report"/>
    <nc:attribute name="__type" value="mdq:DQ_QuantitativeAttributeAccuracy"/>
  <!--
    Information about the quality measure: To facilitate data set comparisons, it is helpful if the
results in the data quality
    reports are expressed in a comparable way and that there is a common understanding of the data
quality measures that have
    been used. ISO 19157 provides a set of standard measures to facilitate comparisons, but these
are very general, e.g.
    "number of missing items" or "relative horizontal error". The standard also describes how user
defined quality
    measures can be cataloged for sharing across a community.

    A number of types of data quality reports are available. The DQ_QuantitativeAttributeAccuracy is
the most general and
    most broadly applicable of these.

    ISO 19115 quality reports include three elements that are used to describe the quality measure.
The nameOfMeasure and
    measureDescription are used to provide enough information for a user to understand the measure
being used if they are
    familiar with the measures used in a community. The measureIdentifier is used to support a
search for more information.
  -->
  <!--
    ESDIS Data Quality Information:

    The ECHO metadata model includes several kinds of quality information: QASStats and QAFlags.
These measures have standard names. The QASStats are QAPercentMissingData,
QAPercentOutOfBoundsData, QAPercentInterpolatedData,
    QAPercentCloudCover and the QAFlags are AutomaticQualityFlag, OperationalQualityFlag,
ScienceQualityFlag. In the ISO
    implementation these are measure names.

    Currently the measure names serve as globally unique identifiers for the ESDIS quality measures

```

so nameOfMeasure = identifier.

The QAStats have self-explanatory names so they do not require a description. The QAFlags are more general and have mission or product specific explanations. In ECHO these are called AutomaticQualityFlagExplanation, OperationalQualityFlagExplanation, ScienceQualityFlagExplanation. In the ISO implementation, these explanations are measureDescriptions.

Other quality information:

Many ESDIS products include quality indicators that are specific to a particular product and not in the general ECHO model. In some cases this quality information is in product specific attributes (or additional attributes) with names that include "PERCENT" or start with "QA", e.g. PERCENTSHAPEFIXEDBRDFS, PERCENTLOWSUN, QAPERCENTPOOROUTPUT250MBAND1, QAPERCENTPOOROUTPUT250MBAND2. In the ISO implementation these are measure names.

In some cases these names are self-explanatory, but in many cases, more detailed description of how they are calculated would benefit users. Those descriptions could be measure descriptions or references to how they were calculated could be provided as evaluation procedure citations.

```
-->
<nc:group name="mdq:measure">
  <nc:attribute name="__role" value="mdq:measure"/>
  <nc:attribute name="__type" value="mdq:DQ_MeasureReference"/>
  <nc:group name="mdq:measureIdentification">
    <nc:attribute name="__role" value="mdq:measureIdentification"/>
    <nc:attribute name="__type" value="mcc:MD_Identifier"/>
    <nc:attribute name="mcc:code"
      value="measureIdentifier"
      __isoType="gco:CharacterString"/>
  </nc:group>
  <nc:attribute name="mdq:nameOfMeasure"
    value="nameOfMeasure"
    __isoType="gco:CharacterString"/>
  <nc:attribute name="mdq:measureDescription"
    value="measureDescription"
    __isoType="gco:CharacterString"/>
</nc:group>
<!--
```

The evaluation method provides a description of how the measure was used in the context of a particular dataset in order to generate the quality report. ISO 19157 includes a new abstract DQ_DataEvaluation class that can be implemented as DQ_FullInspection, DQ_SampleBasedInspection, or DQ_IndirectEvaluation. It includes three elements that are relevant to the evaluationMethod: the type is a codelist with values of directInternal, directExternal, or indirect; the evaluationMethodDescription is a text description that is available to a user along with the metadata record; the evaluationProcedure provides a citation to more detailed information.

```
-->
<nc:group name="mdq:evaluationMethod">
  <nc:attribute name="__role" value="mdq:evaluationMethod"/>
  <nc:attribute name="__type" value="mdq:DQ_FullInspection"/>
<!--
```

The dateTime gives the date and time of the quality test in ISO1601 compliant text format

```
-->
<nc:attribute name="mdq:dateTime"
  value="2012-10-02T15:44:00"
  __isoType="gco:DateTime"/>
<nc:attribute name="mdq:evaluationMethodDescription"
  value="evaluationMethodDescription"
  __isoType="gco:CharacterString"/>
<nc:group name="mdq:evaluationProcedure">
  <nc:attribute name="__role" value="mdq:evaluationProcedure"/>
```

```

        <nc:attribute name="__type" value="cit:CI_Citation"/>
        <nc:attribute name="cit:title"
            value="title of reference material"
            __isoType="gco:CharacterString"/>
        <nc:group name="cit:date">
            <nc:attribute name="@gco:nilReason" value="missing"/>
        </nc:group>
    </nc:group>
    <nc:group name="mdq:evaluationMethodType">
        <nc:attribute name="__role" value="mdq:evaluationMethodType"/>
        <nc:attribute name="__type" value="mdq:DQ_EvaluationMethodTypeCode"/>
        <nc:attribute name="@codeList" value="codeListLocation#DQ_EvaluationMethodTypeCode"/>
        <nc:attribute name="@codeListValue" value="direct_external"/>
        <nc:attribute name="value" value="direct_external"/>
    </nc:group>
</nc:group>
<!--
    The result is the actual result of the quality test. There are four types of results:
    DQ_QuantitativeResult,
    DQ_ConformanceResult, QE_CoverageResult (from ISO 19115-2), and DQ_DescriptiveResult (from
    ISO 19157). A single
    report can contain one or two results.
-->
<nc:group name="mdq:result">
    <nc:attribute name="__role" value="mdq:result"/>
    <nc:attribute name="__type" value="mdq:DQ_QuantitativeResult"/>
<!--
    gmd:DQ_QuantitativeResult:

    Results of many quality reports are single simple numbers (%'s or counts). In
those cases a
    DQ_QuantitativeResult can be used to hold the result.

    Unit definitions generally come from an accepted source that can be referenced
for an authoritative
    definition. In Earth Science the UDUNITS package is commonly used (http://www.unidata.ucar.edu/software/udunits/).
    A more general source for unit definitions is "The Unified Code for Units of
Measure" (http://unitsofmeasure.org).
    See https://coastwatch.pfeg.noaa.gov/erddap/convert/units.html for a comparison
of the two approaches.

    The xlink included in the valueUnit is designed to provide an unambiguous
identifier for the definition of the
    unit. Neither UCUM not UDUNITS support such URIs. UCUM does have a table of unit
abbreviations and definitions
    at http://unitsofmeasure.org/ucum.html#section-Alphabetic-Index. These can be
referenced as
    degrees Celsius = xlink:href="http://unitsofmeasure.org/ucum.
html#Cel"
-->
<!--
    A Record is a string of value(s) with a given type. In most quantitative
quality reports the type is a simple
    primitive type (gco:Real_PropertyType, gco:Integer_PropertyType). In other
cases, it could be a string
    (gco:CharacterString_PropertyType) that includes multiple
numbers.
-->
    <nc:group name="mdq:value">
        <nc:attribute name="__role" value="mdq:value"/>
        <nc:attribute name="__type" value="gco:Record"/>
        <nc:attribute name="@xsi:type" value="gco:Integer_PropertyType"/>
        <nc:attribute name="gco:Record" value="999" __isoType="gco:Integer"/>
    </nc:group>
    <nc:group name="mdq:valueUnit">
        <nc:attribute name="@xlink:href" value="AnyValidURI"/>
    </nc:group>
</nc:group>
<nc:group name="mdq:result_d1e72">
    <nc:attribute name="__role" value="mdq:result"/>

```

```
<nc:attribute name="__type" value="mdq:QE_CoverageResult"/>
<!--
```

```
gmi:QE_CoverageResult:
```

The gmi:QE_CoverageResult is used to provide a quality report that is in the form of a coverage (e.g. a timeseries or grid). It therefore shares a number of elements with coverage descriptions. In cases where these elements are repeated in a single metadata record, these can be references to elements that are completely described elsewhere in the record (e.g. xlink:href="#datasetSpatialRepresentation").

The resultFile and resultFormat can be used to describe a coverage result that is in a different file.

```
-->
<nc:group name="mdq:spatialRepresentationType">
  <nc:attribute name="gco:nilReason" value="unknown"/>
</nc:group>
<nc:group name="mdq:resultSpatialRepresentation">
  <nc:attribute name="gco:nilReason" value="unknown"/>
</nc:group>
<nc:group name="mdq:resultContentDescription">
  <nc:attribute name="gco:nilReason" value="unknown"/>
</nc:group>
<nc:group name="mdq:resultFormat">
  <nc:attribute name="gco:nilReason" value="unknown"/>
</nc:group>
<nc:group name="mdq:resultFile">
  <nc:attribute name="gco:nilReason" value="unknown"/>
</nc:group>
</nc:group>
<nc:group name="mdq:result_d1e80">
  <nc:attribute name="__role" value="mdq:result"/>
  <nc:attribute name="__type" value="mdq:DQ_ConformanceResult"/>
<!--
```

```
gmd:DQ_ConformanceResult:
```

The gmd:DQ_ConformanceResult is used to provide a quality report on conformance of a dataset to a particular standard, e.g. an OGC Web Service or OPeNDAP.

The result in this case is a Boolean, i.e. True or False.

```
-->
<nc:group name="mdq:specification">
  <nc:attribute name="gco:nilReason" value="unknown"/>
</nc:group>
<nc:group name="mdq:explanation">
  <nc:attribute name="gco:nilReason" value="unknown"/>
</nc:group>
<nc:group name="mdq:pass">
  <nc:attribute name="gco:nilReason" value="unknown"/>
</nc:group>
</nc:group>
<nc:group name="mdq:result_d1e86">
  <nc:attribute name="__role" value="mdq:result"/>
  <nc:attribute name="__type" value="mdq:DQ_DescriptiveResult"/>
<!--
```

```
DQ_DescriptiveResult
```

The DQ_DescriptiveResult provides an opportunity to include a character string describing the quality test.

These are similar to the dataQuality element in the DIF metadata standard.

```
-->
<nc:group name="mdq:statement">
  <nc:attribute name="gco:nilReason" value="unknown"/>
</nc:group>
</nc:group>
</nc:group>
<nc:group name="namespace_1">
  <nc:attribute name="prefix" value="xml"/>
  <nc:attribute name="uri" value="http://www.w3.org/XML/1998/namespace"/>
```

```

</nc:group>
<nc:group name="namespace_2">
  <nc:attribute name="prefix" value="xsi"/>
  <nc:attribute name="uri" value="http://www.w3.org/2001/XMLSchema-instance"/>
</nc:group>
<nc:group name="namespace_3">
  <nc:attribute name="prefix" value="mdq"/>
  <nc:attribute name="uri" value="http://standards.iso.org/iso/19157/-2/mdq/1.0"/>
</nc:group>
<nc:group name="namespace_4">
  <nc:attribute name="prefix" value="mdb"/>
  <nc:attribute name="uri" value="http://standards.iso.org/iso/19115/-3/mdb/1.0"/>
</nc:group>
<nc:group name="namespace_5">
  <nc:attribute name="prefix" value="gco"/>
  <nc:attribute name="uri" value="http://standards.iso.org/iso/19115/-3/gco/1.0"/>
</nc:group>
<nc:group name="namespace_6">
  <nc:attribute name="prefix" value="mcc"/>
  <nc:attribute name="uri" value="http://standards.iso.org/iso/19115/-3/mcc/1.0"/>
</nc:group>
<nc:group name="namespace_7">
  <nc:attribute name="prefix" value="xlink"/>
  <nc:attribute name="uri" value="http://www.w3.org/1999/xlink"/>
</nc:group>
<nc:group name="namespace_8">
  <nc:attribute name="prefix" value="cit"/>
  <nc:attribute name="uri" value="http://standards.iso.org/iso/19115/-3/cit/1.0"/>
</nc:group>
</nc:group>
</nc:netcdf>

```

Notes

Tracking Compliance With Standards

The importance of standards in data integration is well known and broadly acknowledged. It is also well known that compliance tests will be required so that developers can systematically measure compliance with standards that evolve with time. Of course, these tests can only be useful to users if the results are available and understandable.

There are two ISO Standard objects that apply to compliance reports. The first is the DQ_DataQuality object. This object associates a DQ_Element with a service, a dataset, or some subset of a dataset described by the DQ_Scope. The DQ_Element references a test and an evaluation procedure that produces a DQ_Result at a particular time. There are three types of DQ_Results, but the DQ_ConformanceResult is the type that is relevant here. It references the specification being tested, explains the meaning of conformance, and gives a Boolean result.

How might these new types of reports be used? The environmental data community is using more and more standard formats for data files. The conformance test might indicate how well the dataset conforms to those file formats or associated conventions like the Climate Forecast conventions for netCDF.

Tracking Problems Identified by Users

The second ISO object that could be related to conformance testing is the MD_Usage object. This provides a mechanism for incorporating user problems into the metadata for a dataset or service. The object includes a description of the specific usage, the problem encountered (the limitation), the date and the user contact information. In the case of standards compliance, the usage would be attempting to access the dataset or service in a way that is consistent with an advertised standard and the limitation would be finding the dataset to be non-compliant with the advertisement. These problem reports would be available from the archive and, hopefully, would motivate data providers to be careful about advertising services that they could not support.

```

MD_Usage
+ specificUsage : CharacterString
+ usageDateTime [0..1] : DateTime
+ userDeterminedLimitations [0..1] : CharacterString
+ userContactInfo [1..*] : CI_ResponsibleParty

```