



# OGC API - DISCRETE GLOBAL GRID SYSTEMS - PART 1: CORE

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**STANDARD**  
Implementation

**CANDIDATE SWG DRAFT**

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## ABSTRACT

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This specification defines building blocks which can be used as part of a Web API to retrieve geospatial data for a specific area, time and resolution of interest, based on a specific Discrete Global Grid System (DGGS) and indexing scheme, as defined in [OGC Abstract Topic 21](#), as well to query the list of DGGS zones from which data is available and/or matching a specify query (in combination with other building blocks defining queries, such as a filter defined using the [OGC Common Query Language \(CQL2\)](#)).



## KEYWORDS

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The following are keywords to be used by search engines and document catalogues.

ogcdoc, OGC document, API, openapi, html, ogcapi



## PREFACE

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**NOTE:** OGC API standards define modular API building blocks to spatially enable Web APIs in a consistent way. The OpenAPI specification is used to define the API building blocks.

*OGC API – Discrete Global Grid Systems* provides API building blocks to retrieve data and query zones based on Discrete Global Grid Systems (DGGS) concepts defined in [OGC Abstract Topic 21](#). Additional parts for *OGC API – Discrete Global Grid Systems* may be defined in the future to provide additional capabilities.

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## SECURITY CONSIDERATIONS

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No security considerations have been made for this document.





# SUBMITTING ORGANIZATIONS

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The following organizations submitted this Document to the Open Geospatial Consortium (OGC):

- Pangaea Innovations Pty. Ltd.
- Ecere Corporation



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Jérôme Jacovella-St-Louis (editor)	Ecere Corporation



1

# SCOPE

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**NOTE:** Insert Scope text here. Give the subject of the document and the aspects of that scope covered by the document.



2

# CONFORMANCE

---

The one Standardization Target for this standard is Web APIs.

*OGC API – Common* provides a common foundation for OGC API standards. Some conformance classes of this standard have a dependency on, or are designed to be easily integrated with, conformance classes defined in *OGC API – Common Part 1* and/or *Part 2*, as well as within a Web API conforming to additional OGC API standards.

This standard identifies twenty-two Conformance Classes. Each Conformance Class has an associated Requirements Class. The Requirements Classes define the functional requirements which will be tested through the associated Conformance Class. Only the Core requirements class is mandatory, all others are optional.

The Requirements Classes for *OGC API – Discrete Global Grid Systems* are:

## 2.1. Requirements classes defining resources

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- Core
- Zone Data Retrieval
- Zone Query

## 2.2. Requirements classes defining origins

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- Root DGGS
- Collection DGGS

## 2.3. Requirements classes defining parameters

---

- Zone data subsetting
- Zone data custom depths

## 2.4. Requirements classes defining resource representations

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- HTML Data
- GeoJSON Data
- GeoTIFF Data
- netCDF Data
- CoverageJSON Data
- JPG Data
- PNG Data
- JPEG XL Data
- (Geo)Zarr Data
- HTML Zone List
- JSON Zone List
- 64-bit Binary Zone List
- GeoJSON Zone List
- GeoTIFF Zone List
- **OpenAPI 3.0**

The Data Encoding Requirements Classes address support for formats commonly used for encoding geospatial data.

The Zone List Encoding Requirements Classes address support for formats efficiently and/or intuitively encoding a list of DGGS zone identifiers.

The *OpenAPI 3.0* Requirements Class defines additional requirements in addition to those defined in *OGC API – Common – Part 1: Core* to facilitate identifying DGGS resources from an OpenAPI 3.0 API Definition.

Conformance with this standard shall be checked using all the relevant tests specified in Annex A (normative) of this document. The framework, concepts, and methodology for testing, and the criteria to be achieved to claim conformance are specified in the OGC Compliance Testing Policies and Procedures and the OGC Compliance Testing web site.

In order to conform to this OGC® interface standard, a software implementation shall implement at minimum the “Core” requirements class defined in Annex A (normative).

All requirements-classes and conformance-classes described in this document are owned by the standard(s) identified.

## 2.5. Summary of conformance URIs

**Table 1** — Conformance class URIs

CORRESPONDING REQUIREMENTS CLASS	CONFORMANCE CLASS URI
Core	<a href="http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/core">http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/core</a>
Zone Data Retrieval	<a href="http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/data-retrieval">http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/data-retrieval</a>
Zone Query	<a href="http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/zone-query">http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/zone-query</a>
Root DGGS	<a href="http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/root-dggs">http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/root-dggs</a>
Collection DGGS	<a href="http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/collection-dggs">http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/collection-dggs</a>
Data subsetting	<a href="http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/data-subsetting">http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/data-subsetting</a>
Data custom depths	<a href="http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/data-custom-depths">http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/data-custom-depths</a>
HTML Data	<a href="http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/data-html">http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/data-html</a>
GeoJSON Data	<a href="http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/data-geojson">http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/data-geojson</a>
GeoTIFF Data	<a href="http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/data-tiff">http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/data-tiff</a>
netCDF Data	<a href="http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/data-netcdf">http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/data-netcdf</a>
CoverageJSON Data	<a href="http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/data-jpeg">http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/data-jpeg</a>
JPEG Data	<a href="http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/data-png">http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/data-png</a>
PNG Data	<a href="http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/data-jpegxl">http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/data-jpegxl</a>
JPEG XL Data	<a href="http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/data-png">http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/data-png</a>
(Geo)Zarr Data	<a href="http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/data-zarr">http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/data-zarr</a>

CORRESPONDING REQUIREMENTS CLASS	CONFORMANCE CLASS URI
HTML Zone List	<a href="http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/zone-html">http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/zone-html</a>
JSON Zone List	<a href="http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/zone-json">http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/zone-json</a>
64-bit Binary Zone List	<a href="http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/zone-uint64">http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/zone-uint64</a>
GeoJSON Zone List	<a href="http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/zone-geojson">http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/zone-geojson</a>
GeoTIFF Zone List	<a href="http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/zone-tiff">http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/zone-tiff</a>
OpenAPI Specification 3.0	<a href="http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/oas30">http://www.opengis.net/spec/ogcapi-dggs-1/1.0/conf/oas30</a>





3

# NORMATIVE REFERENCES

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The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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ISO: ISO 19115-1:2014, *Geographic information – Metadata – Part 1: Fundamentals.* International Organization for Standardization, Geneva (2014). <https://www.iso.org/standard/53798.html>.

ISO: ISO 19157:2013, *Geographic information – Data quality.* International Organization for Standardization, Geneva (2013). <https://www.iso.org/standard/32575.html>.

ISO: ISO 19139:2007, *Geographic information – Metadata – XML schema implementation.* ISO (2007).

ISO: ISO 19115-3, *Geographic information – Metadata – Part 3: XML schema implementation for fundamental concepts.* International Organization for Standardization, Geneva <https://www.iso.org/standard/80874.html>.

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4

# TERMS AND DEFINITIONS

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This document uses the terms defined in OGC Policy Directive 49, which is based on the ISO/IEC Directives, Part 2, Rules for the structure and drafting of International Standards. In particular, the word “shall” (not “must”) is the verb form used to indicate a requirement to be strictly followed to conform to this document and OGC documents do not use the equivalent phrases in the ISO/IEC Directives, Part 2.

This document also uses terms defined in the OGC Standard for Modular specifications (OGC 08-131r3), also known as the ‘ModSpec’. The definitions of terms such as standard, specification, requirement, and conformance test are provided in the ModSpec.

For the purposes of this document, the following additional terms and definitions apply.

This document uses the terms defined in Sub-clause 5.3 of OGC06-121r9, which is based on the ISO/IEC Directives, Part 2, Rules for the structure and drafting of International Standards. In particular, the word “shall” (not “must”) is the verb form used to indicate a requirement to be strictly followed to conform to this standard.

For the purposes of this document, the following additional terms and definitions apply.

### 4.1. example term

---

term used for exemplary purposes

**Note 1 to entry:** An example note.

Example      Here’s an example of an example term.

[SOURCE: ISO 19101-1:2014]



5

# CONVENTIONS

---

This section provides details and examples for any conventions used in the document. Examples of conventions are symbols, abbreviations, use of XML schema, or special notes regarding how to read the document.

### 5.1. Identifiers

---

The normative provisions in this standard are denoted by the URI

<http://www.opengis.net/spec/{standard}/{m.n}>

All requirements and conformance tests that appear in this document are denoted by partial URIs which are relative to this base.



6

# REQUIREMENT CLASS “CORE”

---



## 6.1. Overview

The “Core” Requirement Class allows a client to list available DGGS for a given resource, retrieve additional information about a particular DGGS, and retrieve information about a particular DGGS zone.

The “Core” Requirement Class is the only mandatory Requirements Class, but an implementation with practical use is expected to additionally implement either the “Zone Data Retrieval” Requirement Class, the “Zone Query” Requirement Class, or both.

### REQUIREMENTS CLASS 1

**TARGET TYPE** Web API

**LABEL** <http://www.opengis.net/spec/ogcapi-dggs-1/1.0/req/core>

## 6.2. Requirements

### 6.2.1. Listing available DGGS (.../dggs)

#### REQUIREMENT 1

**LABEL** /req/core/dggs-list

**STATEMENT** For retrieving the list of available discrete global grid reference systems:

- A** The Implementation SHALL support an HTTP GET operation at a resource path ending with .../dggs.
- B** The Implementation SHALL support a JSON representation of this .../dggs resource.
- C** The .../dggs resource SHALL include a dggs array property listing all discrete global grid reference systems supported by the Implementation.

## REQUIREMENT 1

D	Each element of the dggs array SHALL include a subset of the information available in the individual DGGs information described below, including at minimum the id, title, uri (if applicable), and links.
E	The links property SHALL include at minimum a link to the discrete global grid reference system using the self link relation type, as well as a link to the discrete global grid reference system using the [ogc-rel:dggs-definition] relation type.

### 6.2.2. Discrete global grid reference system information (.../dggs/{dggsId})

## REQUIREMENT 2

**LABEL** /req/core/dggs-info

**STATEMENT** For retrieving information for a particular available discrete global grid reference system:

A	The Implementation SHALL support an HTTP GET operation at a resource path ending with .../dggs/{dggsId}.
B	The Implementation SHALL support a JSON representation of this .../dggs/{dggsId} resource.
C	The .../dggs/{dggsId} resource SHALL include an id property consistent with the {dggsId} resource path parameter.
D	The .../dggs/{dggsId} resource SHALL include a link to the resource itself using the self link relation type.
E	The .../dggs/{dggsId} resource SHALL include a link to a definition of the discrete global grid reference system (describing both the discrete global grid as well as the particular indexing scheme to identify zones by identifiers), using the link relation type [ogc-rel:dggs-definition]. The schema for that definition is likely to evolve in order to support describing a growing number of classes of DGGs. A first draft of this schema is available <a href="#">here</a> .
F	The .../dggs/{dggsId} resource SHALL include a templated link to request information for a particular zone using the link relation type [ogc-rel:dggs-zone-info].
G	If the discrete global grid reference system (the combination of the discrete global grid and indexing system) is registered with an authority, the resource SHALL include uri property corresponding to that registered discrete global grid reference system.
H	If the discrete global grid reference system is based on a particular coordinate reference system, the resource shall specify that CRS in a crs property, preferably as a URI (if one is available).
I	The Implementation SHALL include a short title property identifying the discrete global grid reference system intended for display to a human.
J	The Implementation SHALL include a description property providing a summary description of the discrete global grid reference system used by this particular DGGs instance.

### 6.2.3. Retrieving zone information (.../dggs/{dggsId}/zones/{zoneId})

#### REQUIREMENT 3

**LABEL** /req/core/zone-info

**STATEMENT** For retrieving information for a particular DGGS zone:

- |          |   |
|----------|---|
| <b>A</b> | The Implementation SHALL support an HTTP GET operation at a resource path ending with .../dggs/{dggsId}/zones/{zoneId} providing information for a valid individual zones of the discrete global grid reference system. |
| <b>B</b> | The zone information resource SHALL support a JSON representation.  |
| <b>C</b> | The zone information resource SHALL include an id property corresponding to the {zoneId} resource path parameter.   |
| <b>D</b> | The zone information resource SHALL include a link back to the corresponding DGGS resource (.../dggs) using the [ ogc-rel : dggs ] link relation type.  |

#### RECOMMENDATION 1

**LABEL** /rec/core/zone-info

- |          |   |
|----------|---|
| <b>A</b> | The zone information resource SHOULD include an areaMetersSquare property indicating the surface area of the zone in square meters.   |
| <b>B</b> | For a DGGS with three spatial dimension, the zone information resource SHOULD include a volumeMetersCube property indicating the volume of the zone in cubic meters.  |
| <b>C</b> | For a temporal DGGS, the zone information resource SHOULD include a temporalDurationSeconds property indicating the amount of time covered by the zone in seconds.  |
| <b>D</b> | The zone information resource SHOULD include a geometry property indicating the 2D and/or 3D spatial geometry of the zone, using GeoJSON or OGC Features & Geometry JSON for the JSON encoding.   |
| <b>E</b> | For a temporal DGGS, the zone information resource SHOULD include a temporalInterval property indicating the start and end time of the zone.  |
| <b>F</b> | The implementation SHOULD support a GeoJSON and/or OGC Features & Geometry JSON representation of the zone information resource where the top-level object is a feature representing the zone geometry, the feature ID corresponds to the {zoneId}, and the other properties described in this recommendation are properties of that feature. |
| <b>G</b> | For a zone associated with a particular collection, the implementation SHOULD provide summary statistics (minimum, maximum, average, stdDev) pertaining to this zone for each field (fields of the range of a coverage, or relevant numeric properties of a feature collection) of the data. In the JSON                                      |

## RECOMMENDATION 1

encoding, this SHOULD be implemented as a JSON dictionary mapping field names to an object with each statistic.

H

For a zone associated with a particular collection, the implementation SHOULD provide `areaMetersSquareWithData`, `volumeMetersCubeWithData`, `temporalDurationSecondsWithData` properties corresponding to the respective properties defined above for the overall zones, but considering only the portions of the zone where there is data (e.g., regions of the zone excluding NODATA values for a gridded coverage, or within geometry for a feature collection).



7

# REQUIREMENT CLASS “DATA RETRIEVAL”

---

## 7.1. Overview

The Data Retrieval conformance class allows to retrieve data from a specific Discrete Global Grid System (DGGS) in a particular indexing scheme from an individual zone. It describes an HTTP GET operation, as well as its response. The selected DGGS is listed as available and described in the Core conformance class, and conforms to OGC Topic 21.

The data for a particular zone is retrieved based on a URI template including a variable representing a Zone ID.

The resource from which data is retrieved can either be for a particular collection of geospatial data, for a dataset as a whole, or in connection with *OGC API – Processes – Part 3: Workflows & Chaining*, the output of a processing workflow.

### REQUIREMENTS CLASS 2

TARGET TYPE      Web API

PREREQUISITE      <http://www.opengis.net/spec/ogcapi-common-1/1.0/req/core>

LABEL                <http://www.opengis.net/spec/ogcapi-dggs-1/0.0/req/data-retrieval>

## 7.2. Requirements

### 7.2.1. Retrieving data from a zone (`.../dggs/{dggsId}/zones/{zoneId}/data`)

The following requirements describe how a client can retrieve data from a single DGGS zone at the resource path `.../dggs/{dggsId}/zones/{zoneId}/data`.

### REQUIREMENT 4

LABEL                `/req/data-retrieval/zone-data`

## REQUIREMENT 4

**STATEMENT** For retrieving data for a single DGGS zone:

- |          |  |
|----------|--|
| <b>A</b> | The operation SHALL support an HTTP GET operation at a resource path ending with <code>.../dggs/{dggsId}/zones/{zoneId}/data</code> .  |
| <b>B</b> | The operation SHALL include a templated link to this resource path in the “Core” <code>.../dggs/{dggsId}</code> resource links, and regular link in the <code>.../dggs/{dggsId}/zones/{zoneId}</code> resource links using the link relation type <code>[ogc-rel:dggs-zone-data]</code> .  |
| <b>C</b> | The response of the HTTP GET operation SHALL have a status code of 200.  |
| <b>D</b> | The content of the response SHALL be a data packet corresponding precisely to the area covered by the DGGS zone.   |
| <b>E</b> | The selection of an encoding for the response SHALL be consistent with HTTP content negotiation.   |
| <b>F</b> | The <code>.../dggs/{dggsId}</code> resource SHALL include a <code>defaultDepth</code> property indicating the implementation’s default depth for when the <code>zone-depth</code> parameter is omitted. This default value could be any valid value and/or form as defined in the <code>/req/data-custom-depths/zone-depth-parameter</code> requirement (single depth, range of depths, or list of depths, relative to the <code>{zoneId}</code> hierarchy level). |
| <b>G</b> | Unless a <code>zone-depth</code> parameter is specified, the response SHALL return a data packet consistent with this <code>defaultDepth</code> property, in accordance with the capabilities of the negotiated data packet encoding.  |



8

# REQUIREMENT CLASS “DATA SUBSETTING”

---



## 8.1. Overview

The Data Subsetting requirements class extends the zone data retrieval requirements with the ability to subset data on additional dimensions beyond those defined by the discrete global grid reference systems (DGGRS), for example along time or vertical dimension if those axes are not part the DGGRS definition, or along additional dimensions such as atmospheric pressure levels. Two parameters are defined for this purpose: `datetime` (specifically for time) and `subset` (for any dimension, including time).

### REQUIREMENTS CLASS 3

TARGET TYPE	Web API
PREREQUISITE	<a href="http://www.opengis.net/spec/ogcapi-dggs-1/0.0/req/data-retrieval">http://www.opengis.net/spec/ogcapi-dggs-1/0.0/req/data-retrieval</a>
LABEL	<a href="http://www.opengis.net/spec/ogcapi-dggs-1/0.0/req/data-subsetting">http://www.opengis.net/spec/ogcapi-dggs-1/0.0/req/data-subsetting</a>

## 8.2. Requirements

### 8.2.1. Parameter `subset`

#### REQUIREMENT 5

LABEL	/req/data-subsetting/subset
STATEMENT	For specifying a multi-dimensional subset for the zone data being retrieved (excluding dimensions of the discrete global grid reference system):
A	<p>The Implementation SHALL support a <code>subset</code> query parameter for the zone data retrieval operation (resource path ending with <code>.../dggs/{dggsId}/zones/{zoneId}/data</code>) conforming to the following Augmented Backus Naur Form (ABNF) fragment:</p> <pre> SubsetSpec:      "subset"=axisName(intervalOrPoint) axisName:        {text} intervalOrPoint: interval \  point interval:        low : high           </pre>

## REQUIREMENT 5

```

low:           point \ | *
high:          point \ | *
point:         {number} \| "{text}"

```

Where:  
 \" = double quote = ASCII code 0x42,  
 {number} is an integer or floating-point number, and  
 {text} is some general ASCII text (such as a time and date notation in ISO 8601).

<b>B</b>	The implementation SHALL support as axis names time for a temporal dataset, unless this temporal axis is an axis of the discrete global grid reference system.
<b>C</b>	If a third vertical spatial dimension is supported (if the resource's spatial extent bounding box is three dimensional) and that dimension is not part of the discrete global grid system definition, the implementation SHALL also support a h dimension (elevation above the ellipsoid in EPSG:4979 or CRS84h) for geographic CRS and z for projected CRS, which are to be interpreted as the vertical axis in the CRS definition.
<b>D</b>	The implementation SHALL support as axis names any additional dimension (beyond spatial and temporal) as described in the extent property of the collection or dataset description.
<b>E</b>	The implementation SHALL return a 400 error status code if an axis name does not correspond to one of the axes of the Coordinate Reference System (CRS) of the data or an axis defined in the relevant extent property.
<b>F</b>	If a subset parameter including any of the dimensions corresponding to the axes of the discrete global grid reference system is used, the server SHALL return a 400 client error.
<b>G</b>	The implementation SHALL interpret multiple subset parameters, as if all dimension subsetting values were provided in a single subset parameter (comma separated). Example: subset=time("2018-02-12T16:00:0Z":"2018-02-12T20:00:00Z")&subset=atm_pressure_hpa(500:750) is equivalent to subset=time("2018-02-12T16:00:0Z":"2018-02-12T20:00:00Z"),atm_pressure_hpa(500:750)

**NOTE:** When the *interval* values fall partially outside of the range of valid values defined by the CRS for the identified axis, the service is expected to return the non-empty portion of the data resulting from the subset.

### 8.2.2. Parameter *datetime*

## REQUIREMENT 6

**LABEL** /req/data-subsetting/datetime

**STATEMENT** For specifying a time instant or interval for which to retrieve data from a zone for a non-temporal DGGs:

**A** The implementation SHALL support a *datetime* parameter expressed corresponding to either a date-time instant or a time interval, conforming to the following syntax (using [ABNF](#)):  
 interval-closed = date-time "/" date-time

## REQUIREMENT 6

```
interval-open-start = [".."] "/" date-time
interval-open-end   = date-time "/" [".."]
interval            = interval-closed / interval-open-start / interval-open-end
datetime            = date-time / interval
```

**B** The syntax of date-time is specified by [RFC 3339, 5.6](#).

**C** Only the portions of the data within the specified interval SHALL be part of the zone data response, performing a trim operation for an interval or a slicing operation for an instant (in the case of a gridded coverage), or a filtering operation for feature data.

**D** The implementation SHALL support a double-dot (..) or an empty string for the start/end as indicating an unbounded or half-bounded interval (only having a start or end).

**E** If a datetime parameter is specified requesting zone data where no temporal dimension applies, the implementation SHALL either ignore the parameter or return a 4xx client error.

Note: ISO 8601-2 distinguishes unbounded start/end timestamps (double-dot) and unknown start/end timestamps (empty string). For queries, an unspecified start/end has the same effect as an unbounded start/end.

### Examples:

**Example 1 — A date-time:** February 12, 2018, 23:20:52 GMT:

```
datetime=2018-02-12T23:20:52Z
```

**Example 2 — Intervals:** February 12, 2018, 00:00:00 GMT to March 18, 2018, 12:31:12 GMT:

```
datetime=2018-02-12T00:00:00Z/2018-03-18T12:31:12Z
```

February 12, 2018, 00:00:00 UTC or later:

```
datetime=2018-02-12T00:00:00Z/..
```

March 18, 2018, 12:31:12 UTC or earlier:

```
datetime=../2018-03-18T12:31:12Z
```



9

# REQUIREMENT CLASS “DATA CUSTOM DEPTHS”

---

# REQUIREMENT CLASS “DATA CUSTOM DEPTHS”

## 9.1. Overview

The Data Custom Depths requirements class extends the zone data retrieval requirements class allowing a client to customize which depths to include as part of a zone data response relative to the requested hierarchy level for which data is being requested. This can be either a single depth, a range of depths, or a list of depths. The depths to include in the response are specified using the zone-depth query parameter. This depth customization ability can be restricted by the capability of the particular zone data response encoding negotiated.

### REQUIREMENTS CLASS 4

TARGET TYPE	Web API
PREREQUISITE	<a href="http://www.opengis.net/spec/ogcapi-dggs-1/0.0/req/data-retrieval">http://www.opengis.net/spec/ogcapi-dggs-1/0.0/req/data-retrieval</a>
LABEL	<a href="http://www.opengis.net/spec/ogcapi-dggs-1/0.0/req/data-custom-depths">http://www.opengis.net/spec/ogcapi-dggs-1/0.0/req/data-custom-depths</a>

## 9.2. Requirements

### 9.2.1. Parameter zone-depth

#### REQUIREMENT 7

LABEL	/req/data-custom-depths/zone-depth-parameter
STATEMENT	Parameter to specify the DGGS resolution levels beyond the specified DGGS zone's hierarchy level to include in the response, when retrieving data for that zone
A	The implementation SHALL support a zone-depth parameter for the HTTP GET operation on a resource path ending with <code>.../dggs/{dggsId}/zones/{zoneId}/data</code> .

## REQUIREMENT 7

<b>B</b>	<p>The implementation SHALL accept the following types of values for the zone-depth parameter:</p> <ul style="list-style-type: none"> <li>• A single positive integer value — representing a specific zone depth to return (e.g., zone-depth=5);</li> <li>• A range of positive integer values in the form "{low}-{high}" — representing a continuous range of zone depths to return (e.g., zone-depth=1-8); or,</li> <li>• A comma separated list of at least two (2) positive integer values — representing a set of specific zone depths to return (e.g., zone-depth=1,3,7). Some or all of these forms of the zone-depth parameter may not be supported with particular data packet encodings (the data encoding may support a fixed depth, a range of depths, and/or an arbitrary selection of depths).</li> </ul>
<b>C</b>	<p>For each zone depth to be included in the response, the interpretation of a selected depth (whether requesting a single depth, a range of depths, or a list of depths) SHALL be:</p> <ul style="list-style-type: none"> <li>• 0 corresponding to a single set of range (properties / field) value(s) for the requested zone,</li> <li>• 1 corresponding to all zones of the next deeper hierarchy level associated with the requested zone by the indexing scheme,</li> <li>• ..</li> <li>• <i>n</i> corresponding to all zones for the <i>n</i>'th deeper level in the hierarchy level associated with the requested zone by the indexing scheme.</li> </ul>
<b>D</b>	<p>The association of zones of deeper hierarchy levels with the requested zone SHALL be based on the DGGS reference system, which takes into consideration both the grid definition as well as the indexing system in use for the DGGS resource.</p>
<b>E</b>	<p>If a zone-depth is specified, the operation SHALL return the data at the resolution(s) / scale(s) specified.</p>

**NOTE 1:** A use case for a zone-depth of 0 would be to query the single set of values for a specific DGGS zone.

**NOTE 2:** For use cases such as visualization and performing analysis over a certain area, a non-zero zone-depth would normally be used to avoid an overwhelming number of server round-trips. In this case, more than a single value would be returned for each zone request, with values returned for descendent zones at zone-depth levels deeper than the requested zone's level. For example, requesting data for a level 10 zone with a zone-depth of 8 would return individual values for each level 18 zones contained within that level 10 zone being requested.



10

# REQUIREMENT CLASS “ZONE QUERY”

---

## 10.1. Overview

The Zone Query conformance class allows to request the list of DGGS zones from a specific Discrete Global Grid System (DGGS) in a particular indexing scheme for which there is data available, or matching a particular query (e.g., using a filtering parameter). It describes an HTTP GET operation, as well as its response. The selected DGGS is listed as available and described in the Core conformance class, and conforms to OGC Topic 21. The list of zones from a Web API using this conformance class can either be for a particular collection of geospatial data, for a dataset as a whole, or in connection with *OGC API – Processes – Part 3: Workflows & Chaining*, the output of a processing workflow.

### REQUIREMENTS CLASS 5

TARGET TYPE	Web API
PREREQUISITE	<a href="http://www.opengis.net/spec/ogcapi-dggs-1/1.0/req/core">http://www.opengis.net/spec/ogcapi-dggs-1/1.0/req/core</a>
LABEL	<a href="http://www.opengis.net/spec/ogcapi-dggs-1/1.0/req/zone-query">http://www.opengis.net/spec/ogcapi-dggs-1/1.0/req/zone-query</a>

## 10.2. Requirements

### 10.2.1. Listing zones (.../dggs/{dggsId}/zones)

The following requirements describe how a client can retrieve the list of zones from which data is available at the resource path .../dggs/{dggsId}/zones.

### REQUIREMENT 8

LABEL	/req/zone-query/zones-list
STATEMENT	For retrieving a list of DGGS zones:



## REQUIREMENT 8

A	The Implementation SHALL support an HTTP GET operation at a resource path ending with <code>.../dggs/{dggsId}/zones</code> .
B	The Implementation SHALL include a link to this resource path in the "Core" <code>.../dggs/{dggsId}</code> resource links using the link relation type <a href="http://www.opengis.net/def/rel/ogc/1.0/dggs-zone-query">http://www.opengis.net/def/rel/ogc/1.0/dggs-zone-query</a> .
C	The response of the HTTP GET operation SHALL have a status code of 200.
D	The content of the response SHALL be a list of zones fully covering where data is available (in the case where the resource is associated with a particular dataset), and matching any additional query parameters specified by the client (e.g., a filtering query parameter), without any redundancy.
E	Unless the zones is a compact list of zones (see <code>compact-zones</code> parameter), the zones returned SHALL all be of the same DGGs hierarchy level.
F	The selection of an encoding for the returned list of zones SHALL be consistent with HTTP content negotiation.
G	The implementation SHALL support at minimum a JSON encoding (media type <code>application/json</code> ) where each zone ID is specified as a string within an array of zones assigned to a <code>zones</code> property within a JSON object (e.g., <code>{ "zones": [ "1-E-14"s, "1-E-15", "1-F-14", "1-F-15", "1-F-16" ] }</code> ).

### 10.2.2. Parameter `zone-level`

The following requirements describe how a client can specify the DGGs hierarchy level at which to retrieve the list of zones.

## REQUIREMENT 9

LABEL	<code>/req/zone-query/zone-level</code>
STATEMENT	For specifying a level at which to return a list of DGGs zones using a <code>zone-level</code> query parameter:
A	The Implementation SHALL support a <code>zone-level</code> query parameter for the zone query operation (resource path ending with <code>.../dggs/{dggsId}/zones</code> ).
B	If a compact zones list is used (the default), the zones returned in the response SHALL be of the DGGs hierarchy level specified by the <code>zone-level</code> query parameter, or of a lower hierarchy level standing in for a compact representation of multiple zones at the requested hierarchy level.
C	If a compact zones list is not used, the zones returned in the response SHALL be of the DGGs hierarchy level specified by the <code>zone-level</code> query parameter.

### 10.2.3. Parameter `compact-zones`

By default, implementations return a compact list of zones where children zones fully covering a parent are recursively replaced by the parent zones, allowing to express large areas in a much more compact list of zones. The following requirements describe how a client can disable returning a compact list of zones.

#### REQUIREMENT 10

**LABEL** `/req/zone-query/compact-zones`

**STATEMENT** For specifying whether to retrieve a list of DGGS zones using a `compact-zones` parameter:

- |          |  |
|----------|--|
| <b>A</b> | The Implementation SHALL support a boolean <code>compact-zones</code> query parameter for the zone query operation (resource path ending with <code>.../dggs/{dggsId}/zones</code> ), where a value of <code>true</code> corresponds to the default behavior when the parameter is not specified, and a value of <code>false</code> disables the use of compact-zones in the response. |
| <b>B</b> | When the <code>compact-zones</code> parameter is to <code>false</code> , the zones list response SHALL NOT be a compact list, and SHALL explicitly list every individual zone at the requested or default DGGS hierarchy level.  |
| <b>C</b> | When the <code>compact-zones</code> parameter is to <code>true</code> (or unspecified), the zones list response SHALL be a compact list, where children zones completely covering the area of a parent zone SHALL be replaced by that parent zone, in a recursive manner all the way to the lowest DGGS hierarchy level.   |

### 10.2.4. Parameter `limit` for paging

The following requirements describe how a client can specify a limit to the number of zones to be returned and page through large list of zones as multiple requests and responses.

#### REQUIREMENT 11

**LABEL** `/req/zone-query/limit`

**STATEMENT** For specifying a paging limit for the list of zones using a `limit` query parameter:

- |          |  |
|----------|--|
| <b>A</b> | The Implementation SHALL support a parameter <code>limit</code> integer query parameter, with a minimum value of 1.                                      |
| <b>B</b> | The response SHALL not contain more zones than specified by the optional <code>limit</code> parameter (if specified).                                    |
| <b>C</b> | If the API definition specifies a maximum value for the <code>limit</code> parameter, the response SHALL not contain more zones than this maximum value. |

## REQUIREMENT 11

D	If the value of the <code>limit</code> parameter is larger than the maximum value, this SHALL NOT result in an error (but instead be replaced by the maximum as the parameter value).
E	If using compact zones, the parent zones SHALL count as a single zone, rather than the number of children zones they stand in for.
F	If an implementation does not return the full list of zones for the request, a link with relation type <code>next</code> SHALL be included in a <code>links</code> array property of the response, which a client can request to resume listing the zones.

### 10.2.5. Parameter `bbox`

## REQUIREMENT 12

**LABEL** `/req/zone-query/bbox`

**STATEMENT** For specifying a spatial bounding box for which to return a list of DGGS zones:

The Implementation SHALL support a `bbox` query parameter for the zone query operation (resource path ending with `.../dggs/{dggsId}/zones`) with the characteristics defined in the OpenAPI Specification 3.0 fragment:

`bbox:`

`name: bbox`

`in: query`

`description:`

Bounding box of the rendered map. The bounding box is provided as four or six coordinates

- \* Lower left corner, coordinate axis 1
- \* Lower left corner, coordinate axis 2
- \* Minimum value, coordinate axis 3 (optional)
- \* Upper right corner, coordinate axis 1
- \* Upper right corner, coordinate axis 2
- \* Maximum value, coordinate axis 3 (optional)

**A**

The coordinate reference system and axis order of the values are indicated in the ``bbox-crs`` parameter or if the parameter is missing in <http://www.opengis.net/def/crs/OGC/1.3/CRS84>

`required: false`

`schema:`

`type: array`

`oneOf:`

`- minItems: 4`

`maxItems: 4`

`- minItems: 6`

`maxItems: 6`

`items:`

`type: number`

`format: double`

`style: form`

`explode: false`

**B**

`bbox` SHALL be a comma separated list of four or six floating point numbers. If the bounding box consists of six numbers, the first three numbers are the coordinates of the lower bound corner of a

## REQUIREMENT 12

three-dimensional bounding box and the last three are the coordinates of the upper bound corner. The axis order is determined by the `bbox-crs` parameter value or longitude and latitude if the parameter is missing (<http://www.opengis.net/def/crs/OGC/1.3/CRS84> axis order for a 2D bounding box, <http://www.opengis.net/def/crs/OGC/1.3/CRS84h> for a 3D bounding box). For example in <http://www.opengis.net/def/crs/OGC/1.3/CRS84> the order is `left_lon`, `lower_lat`, `right_lon`, `upper_lat`.

C

The returned list of zone IDs SHALL only contain zones inside or intersecting with the spatial extent of the geographical area of bounding box.

### 10.2.6. Parameter `bbox-crs`

## REQUIREMENT 13

**LABEL** `/req/zone-query/bbox-crs`

**STATEMENT** For specifying the CRS in used for the `bbox` parameter using the `bbox-crs` parameter

A

The list of zones resource SHALL support a `bbox-crs` parameter specifying the CRS used for the `bbox` parameter.

B

For Earth centric data, the implementation SHALL support <http://www.opengis.net/def/crs/OGC/1.3/CRS84> as a value.

C

If the `bbox-crs` is not indicated <http://www.opengis.net/def/crs/OGC/1.3/CRS84> SHALL be assumed.

D

The native CRS (`storageCRS`) SHALL be supported as a value. Other conformance classes may allow additional values (see `crs` parameter definition).

E

The CRS expressed as URIs or as safe CURIEs SHALL be supported.

F

If the `bbox` parameter is not used, the `bbox-crs` SHALL be ignored.

### 10.2.7. Parameter `subset`

## REQUIREMENT 14

**LABEL** `/req/zone-query/subset`

**STATEMENT** For specifying a multi-dimensional subset for which to return a list of DGGS zones:

## REQUIREMENT 14

A	<p>The Implementation SHALL support a subset query parameter for the zone query operation (resource path ending with .../dggs/{dggsId}/zones) conforming to the following Augmented Backus Naur Form (ABNF) fragment:</p> <pre> SubsetSpec:      "subset"=axisName(intervalOrPoint) axisName:        {text} intervalOrPoint: interval \  point interval:         low : high low:             point \  * high:            point \  * point:           {number} \  "{text}" </pre> <p>Where:          \" = double quote = ASCII code 0x42,          {number} is an integer or floating-point number, and          {text} is some general ASCII text (such as a time and date notation in ISO 8601).</p>
B	<p>The implementation SHALL support as axis names Lat and Lon for geographic CRS and x and y for projected CRS, which are to be interpreted as the best matching spatial axis in the CRS definition.</p>
C	<p>If a third spatial dimension is supported (if the resource's spatial extent bounding box is three dimensional), the implementation SHALL also support a h dimension (elevation above the ellipsoid in EPSG:4979 or CRS84h) for geographic CRS and z for projected CRS, which are to be interpreted as the vertical axis in the CRS definition.</p>
D	<p>The implementation SHALL support as axis names time for a temporal dataset.</p>
E	<p>The implementation SHALL support as axis names any additional dimension (beyond spatial and temporal) as described in the extent property of the collection or dataset description.</p>
F	<p>The implementation SHALL return a 400 error status code if an axis name does not correspond to one of the axes of the Coordinate Reference System (CRS) of the data or an axis defined in the relevant extent property.</p>
G	<p>For a CRS where an axis can wrap around, such as subsetting across the dateline (anti-meridian) in a geographic CRS, a <i>low</i> value greater than <i>high</i> SHALL be supported to indicate an extent crossing that wrapping point.</p>
H	<p>The implementation SHALL interpret the coordinates as values for the named axis of the CRS specified in the subset-crs parameter value or in <a href="http://www.opengis.net/def/crs/OGC/1.3/CRS84">http://www.opengis.net/def/crs/OGC/1.3/CRS84</a> (<a href="http://www.opengis.net/def/crs/OGC/1.3/CRS84h">http://www.opengis.net/def/crs/OGC/1.3/CRS84h</a> for vertical dimension) if the subset-crs parameter is missing.</p>
I	<p>If the subset parameter including any of the dimensions corresponding to those of the map bounding box is used with a bbox, the server SHALL return a 400 client error.</p>
J	<p>The implementation SHALL interpret multiple subset parameters, as if all dimension subsetting values were provided in a single subset parameter (comma separated). Example: subset=Lat(-90:90)&amp;subset=Lon(-180:180) is equivalent to subset=Lat(-90:90),Lon(-180:180)</p>

**NOTE 1:** A subset parameter for <http://www.opengis.net/def/crs/OGC/1.3/CRS84> will read as subset=Lon(left\_lon:right\_lon),Lat(lower\_lat:upper\_lat).

**NOTE 2:** When the *interval* values fall partially outside of the range of valid values defined by the CRS for the identified axis, the service is expected to return the non-empty portion of the resource resulting from the subset.

**NOTE 3:** For the operation of returning a list of zone IDs, there normally is no value in preserving dimensionality, therefore a *slicing* operation (using the *point* notation) is usually equivalent to a *trimming* operation (using the *interval* notation) when the low and high bounds of an interval are the same. Therefore, use of the point notation is encouraged in these cases.

### 10.2.8. Parameter `subset-crs`

REQUIREMENT 15	
<b>LABEL</b>	<code>/req/zone-query/subset-crs</code>
<b>STATEMENT</b>	For specifying the CRS in used for the <code>subset</code> parameter using the <code>subset-crs</code> parameter
<b>A</b>	The zone listing operation SHALL support a parameter <code>subset-crs</code> with the characteristics identifying the CRS in which the <code>subset</code> parameter is specified with a URI or safe CURIE.
<b>B</b>	For Earth centric data, <a href="http://www.opengis.net/def/crs/OGC/1.3/CRS84">http://www.opengis.net/def/crs/OGC/1.3/CRS84</a> as a value SHALL be supported.
<b>C</b>	If the <code>subset-crs</code> is not indicated, <a href="http://www.opengis.net/def/crs/OGC/1.3/CRS84">http://www.opengis.net/def/crs/OGC/1.3/CRS84</a> SHALL be assumed.
<b>D</b>	The native CRS ( <code>storageCRS</code> ) SHALL be supported as a value. Other requirements classes may allow additional values (see <code>crs</code> parameter definition).
<b>E</b>	CRSs expressed as URIs or as safe CURIEs SHALL be supported.
<b>F</b>	If no <code>subset</code> parameter referring to an axis of the CRS is used, the <code>subset-crs</code> SHALL be ignored.

### 10.2.9. Parameter `datetime`

REQUIREMENT 16	
<b>LABEL</b>	<code>/req/zone-query/datetime</code>
<b>STATEMENT</b>	For specifying a multi-dimensional subset for which to return a list of DGGS zones:
<b>A</b>	The implementation SHALL support a <code>datetime</code> parameter expressed corresponding to either a date-time instant or a time interval, conforming to the following syntax (using <a href="#">ABNF</a> ): <code>interval-closed</code> = <code>date-time "/" date-time</code> <code>interval-open-start</code> = <code>[".."] "/" date-time</code>

## REQUIREMENT 16

interval-open-end = date-time "/" [".."]  
interval = interval-closed / interval-open-start / interval-open-end  
datetime = date-time / interval

- B** The syntax of date-time is specified by [RFC 3339, 5.6](#).
- C** Only the zones with data whose geometry intersect with the specified temporal interval SHALL be part of the zone list response.
- D** The implementation SHALL support a double-dot (..) or an empty string for the start/end as indicating an unbounded or half-bounded interval (only having a start or end).
- E** If a datetime parameter is specified requesting zone data where no temporal dimension applies, the implementation SHALL either ignore the parameter or return a 4xx client error.



11

# REQUIREMENT CLASS “ROOT DGGS”

---



## 11.1. Overview

The “Root DGGS” Requirement Class defines the availability of DGGS resources applying to a whole dataset or API, as defined by *OGC API – Common – Part 1: Core*.

### REQUIREMENTS CLASS 6

TARGET TYPE	Web API
PREREQUISITE	<a href="http://www.opengis.net/spec/ogcapi-common-1/1.0/req/core">http://www.opengis.net/spec/ogcapi-common-1/1.0/req/core</a>
LABEL	<a href="http://www.opengis.net/spec/ogcapi-dggs-1/1.0/req/root-dggs">http://www.opengis.net/spec/ogcapi-dggs-1/1.0/req/root-dggs</a>

## 11.2. Requirements

### 11.2.1. Root DGGS (/dggs)

#### REQUIREMENT 17

LABEL	/req/root-dggs/dggs
STATEMENT	For API/dataset-wide DGGS resources:
A	The Implementation SHALL support DGGS resources for the dataset as a whole, for the “Core” requirement class, as well as any resources defined in additional supported requirements classes.



12

# REQUIREMENT CLASS “COLLECTION DGGs”

---

## 12.1. Overview

The “Collection DGGS” Requirement Class defines the availability of DGGS resources applying to one or more collections of geospatial data, as defined by *OGC API – Common – Part 2: Geospatial data*.

### REQUIREMENTS CLASS 7

TARGET TYPE	Web API
PREREQUISITE	<a href="http://www.opengis.net/spec/ogcapi-common-2/1.0/req/collections">http://www.opengis.net/spec/ogcapi-common-2/1.0/req/collections</a>
LABEL	<a href="http://www.opengis.net/spec/ogcapi-dggs-1/1.0/req/collection-dggs">http://www.opengis.net/spec/ogcapi-dggs-1/1.0/req/collection-dggs</a>

## 12.2. Requirements

### 12.2.1. Collection DGGS (/collections/{collectionId}/dggs)

#### REQUIREMENT 18

**LABEL** /req/collection-dggs/dggs

**STATEMENT** For collection DGGS resources:

- A** The Implementation SHALL support DGGS resources for at least one collection, for the “Core” requirement class, as well as any resources defined in additional supported requirements classes.
- B** The /collections/{collectionId}/dggs and /collections/{collectionId}/dggs/{dggsId} resources SHALL include a link to the collection using the link relation type [ogc-rel:geodata].



13

# MEDIA TYPES FOR ANY DATA ENCODING(S)

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A section describing the MIME-types to be used is mandatory for any standard involving data encodings. If no suitable MIME type exists in <http://www.iana.org/assignments/media-types/index.html> then this section may be used to define a new MIME type for registration with IANA.



A

# ANNEX A (INFORMATIVE) CONFORMANCE CLASS ABSTRACT TEST SUITE (NORMATIVE)

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# ANNEX A

## (INFORMATIVE)

### CONFORMANCE CLASS ABSTRACT TEST SUITE (NORMATIVE)

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**NOTE:** Ensure that there is a conformance class for each requirements class and a test for each requirement (identified by requirement name and number)

#### A.1. Conformance Class A

---

##### A.1.1. Requirement 1

REQUIREMENT A.1	
TEST PURPOSE	Verify that...
TEST METHOD	Inspect...

##### A.1.2. Requirement 2



B

# ANNEX B (INFORMATIVE)

## TITLE

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## ANNEX B (INFORMATIVE) TITLE

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**NOTE:** Place other Annex material in sequential annexes beginning with “B” and leave final two annexes for the Revision History and Bibliography



# ANNEX C (INFORMATIVE) REVISION HISTORY

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## ANNEX C (INFORMATIVE) REVISION HISTORY

Table C.1

DATE	RELEASE	EDITOR	PRIMARY CLAUSES MODIFIED	DESCRIPTION
2021-05-17	0.1	Matthew Purss	all	initial version
2022-07-22	0.2	Jerome St Louis	all	Renamed Part 1 to core – <a href="#">github commit – 316d37f</a>
2022-07-22	0.3	Jerome St Louis	all	Initial set up of conformance classes clauses – <a href="#">github commit – b76073c</a>
2022-07-26	0.4	Gobe Hobona	all	Fixes problem that was breaking auto-build – <a href="#">github commit – a13c2a8</a>
2022-10-04	0.5	Jerome St Louis	7-Data Retrieval	Initial take at Data Retrieval Conformance Class – <a href="#">github commit – b67f290</a>
2022-11-11	0.6	Jerome St Louis	7-Data Retrieval	Split multi-done retrieval into separate conformance class – <a href="#">github commit – 06a4260</a>
2022-11-11	0.7	Jerome St Louis	8-zone query	Initial progress on Zone Query conformance class – <a href="#">github commit – a208502</a>
2022-11-11	0.8	Jerome St Louis	21-038; 0-front material	Added preface, abstract, Jerome added as editor – <a href="#">github commit – 71e76c6</a>
2022-11-11	0.9	Jerome St Louis	7-Data Retrieval	Clarification regarding resolution – <a href="#">github commit – c43bfad</a>
2022-11-11	0.10	Jerome St Louis	8-zone query	Clarifications – <a href="#">github commit – cee3685</a>
2023-02-17	0.11	Jerome St Louis	7-Data Retrieval	Added zone-depth parameter – <a href="#">github commit – 2b8fa58</a>



# BIBLIOGRAPHY





## BIBLIOGRAPHY

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- [1] OGC: *OGC Web Service Common Implementation Specification*, [OGC 06-121r9](#)
- [2] OGC: *OGC Testbed 12 Annex B: Architecture* (2015).