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## OGC API-Coverages Users Guide

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# Table of Contents

1. Scope .....	5
2. References .....	6
3. Terms and Definitions .....	8
3.1. Coverage .....	8
3.2. Regular grid .....	8
3.3. Irregular grid .....	8
3.4. Displaced grid .....	8
3.5. Mesh .....	8
3.6. Partition [of a coverage] .....	8
3.7. Sensor model .....	8
3.8. Transformation grid .....	8
4. Conventions .....	9
4.1. Identifiers .....	9
5. Users Guide .....	10
5.1. Get Data From Point .....	10
5.1.1. Discussion .....	10
5.1.2. Return Type .....	11
5.2. Using API-Common .....	11
5.3. Using Metadata .....	12
5.4. Selecting Pixels .....	12
5.5. Range Types .....	16
5.6. Slicing and Subsetting .....	18
Annex A: Revision History .....	19
Annex B: Glossary .....	20
Annex C: Bibliography .....	22

## **i. Abstract**

<Insert Abstract Text here>

## **ii. Keywords**

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

ogcdoc, OGC document, <tags separated by commas>

## **iii. Preface**

### **NOTE**

Insert Preface Text here. Give OGC specific commentary: describe the technical content, reason for document, history of the document and precursors, and plans for future work. > Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. The Open Geospatial Consortium shall not be held responsible for identifying any or all such patent rights.

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# Chapter 1. Scope

## NOTE

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

# Chapter 2. References

The following normative documents contain provisions that, through reference in this text, constitute provisions of this document. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the normative document referred to applies.

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- Open API Initiative: **OpenAPI Specification 3.0.2**, [OpenAPI](#)
- **Schema.org**: [Schema.org](#)
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# Chapter 3. Terms and Definitions

This document uses the terms defined in Sub-clause 5 of [OGC API - Common - Part 1: Core](#) (OGC 19-072), 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.

## 3.1. Coverage

feature that acts as a function to return values from its range for any direct position within its spatiotemporal domain, as defined in OGC Abstract Topic 6

## 3.2. Regular grid

grid whose grid lines have a constant distance along each grid axis

## 3.3. Irregular grid

Grid whose grid lines have individual distances along each grid axis

## 3.4. Displaced grid

grid whose direct positions are topologically aligned to a grid, but whose geometric positions can vary arbitrarily

## 3.5. Mesh

coverage consisting of a collection of curves, surfaces, or solids, respectively

## 3.6. Partition [of a coverage]

separately stored coverage acting, by being referenced in the coverage on hand, as one of its components

## 3.7. Sensor model

mathematical model for estimating geolocations from recorded sensor data such as digital imagery

## 3.8. Transformation grid

grid whose direct positions are given by some transformation algorithm not further specified in this standard



# Chapter 4. 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.

## 4.1. Identifiers

The normative provisions in this document 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.

# Chapter 5. Users Guide

Everything up to now has been information about this document and how to use it. Topics related to the implementation of Coverages APIs are included in this section.

## 5.1. Get Data From Point

### 5.1.1. Discussion

Users might want to query a coverage for getting a data value from a single point. Typical use case is to check the height at given location from DEM but probably queries with more dimensions "temperature at location x,y,z at time ..." make sense as well.

WCS 2.0 defines two possibilities for getting a coverage from a single point.

1. Use subsets with lower limit = upper limit (trim to a point)

```
``&SUBSET=Lat(20,20)&SUBSET=Long(30,30)``
```

2. Use subsets with slice points (slice to a point)

```
``&SUBSET=Lat(20)&SUBSET=Long(30)``
```

The difference between the trimming and slicing is that trimming does not alter the dimensionality but slicing removes dimensions. If the coverage is 2D raster DEM in case 1) the result can be 1 by 1 pixel sized GeoTIFF. In case 2) the result must use format like GML because rasters have always 2 dimensions but the result must have zero.

Behavior in existing WCS 2.0 implementations vary. GeoServer sends 1x1 sized GeoTIFF with slice type of query but trim to point yields an error "Empty intersection after subsetting"

<https://osgeo-org.atlassian.net/browse/GEOS-9553>. MapServer sends 1x1 sized GeoTIFF with trim to point query but it does not accept slicing query. Because MapServer is limited to send coverages only as rasters it cannot use for example GML for 0-dimensional coverages.

To my knowledge it is much more common to use WMS GetFeatureInfo for pixel value queries than WCS. However, GetFeatureInfo does not suit well for other than 8 bit rasters, and if raster is styled for visualisation, some servers send the pixel value of the native data but others the pixel value after styling is applied. Thus GFI is a poor workaround and users deserve better.

I would like to see a recommendation about how to support point queries in OACov. From the client application side I believe that slicing together with some very simple format for rangeset would be convenient.

Unfortunately point queries are not as trivial as they may feel. In the next image query by point 1 that hits a data point should not give any troubles. Point 2 is also easy and those who think that

coverages are pixels can select the intersected pixel, and folks who prefer points can take the nearest point. The result is the same.

Queries by points 3 and 4 are not as easy. Should the result be an average of 2 or 4 nearest points, respectively (requires interpolation), or simply the value of some nearest neighbor? Which nearest? How to guarantee that different servers give uniform results? There are also coverages which are certainly not continuous and only query by point 1 is reasonable.



### 5.1.2. Return Type

0D support (slice to point) could return single value range set, which in `application/json` media-type could be either a number for a single band e.g.

```
403.51
```

or an object for multiple bands:

```
{ "red" : 0.434, "green" : 0.123, "blue" : 0.53 }
```

Trim to point could return 1x1 image.

## 5.2. Using API-Common

Provides a description of how API-Common Parts 1 and 2 should be used in a Coverage API. Key issues:

1) Collections vs. Coverages 2) Use of bbox and datetime - what is their purpose, what elements are they applied against, what are their limitations.

## 5.3. Using Metadata

API-Common provides sets of common metadata along with JSON schema for that metadata. Resource-specific APIs are expected to extend that metadata with information specific to their resource type.

In the case of coverages, we should distinguish between discovery metadata and exploitation metadata. Coverage metadata is that metadata used to identify and select a coverage. Exploitation metadata is metadata required to use the coverage. Note that there is some overlap between these categories. The API implementor should have the freedom to draw the line based on how they expect their API to be used.

Foot Stomp - metadata has to come from somewhere. If it is not in the coverage, then it cannot be populated in the API.

## 5.4. Selecting Pixels

Imagine to have some raster data with pixel size 10 by 10 units and bbox starting at 0,0. Let's put the anchor point at the centre of the pixel. Now user requests a subset as

`&SUBSET=E(572,612)&SUBSET=N(477,518)`



Which pixels should be selected?

A) All pixels that intersect with the subset



B) Only pixels which all totally contained by the subset



C) Only pixels whose anchor points are within the subset



With plain GetCoverage no resampling nor scaling should happen and if I understand right, in all three cases the envelope of the result is different from the envelope of the subsetting request. Also, if user sends a new request with subset envelope that is adjacent to the previous one, interpretation A would give duplicate pixels, interpretation B) would lead to rows of missing pixels, and only alternative C) would give a resultset that is adjacent to the first resultset.

These sections in the WCS 2.0 Core deal somehow with the case but I feel that they do not answer my question.

The WCS Core standard defines

the domain subsetting operation which delivers all data from a coverage inside a specified

request envelope (“bounding box”), relative to the coverage’s envelope – more precisely, the

intersection of the request envelope with the coverage envelope.

Requirement 32 /req/core/getCoverage-request-trim-within-extent:

Let the extent of the coverage’s gml:Envelope along the dimension specified in the trim

request range from L to H. Then, for the trim bounds trimLow and trimHigh the following

shall hold:  $L \leq \text{trimLow} \leq \text{trimHigh} \leq H$ .

Let further

$c$  be the OfferedCoverage of the server addressed;

$low = tLow$  if specified in the request, otherwise  $low$  is set to the coverage's lower

bound in dimension  $dname$ ;

$high = tHigh$  if specified in the request, otherwise  $high$  is set to the coverage's upper

bound in dimension  $dname$ ;

$B$  be an envelope equal to the domain of  $c$ , except that in dimension  $dname$  the extent

is given by the closed interval  $[low, high]$ ;

Then, the following requirement holds:

Requirement 38 /req/core/getCoverage-response-trimming:

The response to a successful GetCoverage request on coverage identifier  $id$  of admissible

type containing no slicing and exactly one trimming operation with dimension name  $dname$ ,

lower bound parameter evaluating to  $low$ , and upper bound parameter evaluating to  $high$

shall be a coverage identical to  $c$ , but containing all points of  $c$  with location inside  $B$ , and

no other points.

NOTE This requirement does not specify the actual extent of the coverage returned. Possible options include: the minimal bounding box of the coverage returned, or the request bounding box. Servers are strongly encouraged to deliver the minimal bounding box.

I believe the correct answer is C. At least that's the way CubeWerx has implemented it. The way I see it, coverages typically deal with points, not pixels. When a coverage is returned in a pixel-based representation such as GeoTIFF, it represents each sample point by a pixel, where the sample point

is at the centre of each pixel. If a sample point intersects the requested subset, it should be returned in the GeoTIFF response as a pixel; otherwise it shouldn't.

CubeWerx's implementation of the various OGC web services distinguishes between what we call a "cell-based" extent (used, for example, by WMS) and a "grid-based" extent (used, for example, by WCS). A grid-based extent is always one pixel smaller in each dimension (0.5 pixels per side) than its corresponding cell-based extent.

So if there's a sample point at each integral unit and a coverage subset of E(572,612) N(477,518) is requested, the resulting GeoTIFF will contain 41x42 pixels (representing 41x42 sample points). Its grid-based extent is exactly what was requested (572,477 to 612,518) but its cell-based extent (that is, corner to corner) is 571.5,476.5 to 612.5,518.5. If you wanted to make a map request of this coverage subset, that'd be the extent you'd specify.

If a coverage subset of E(571.9,612.1) N(476.9,518.1) is requested, you'd get exactly the same response.

However, if a coverage subset of E(572.1,611.9) N(477.1,517.9) is requested, you'd get a response that's only 39x40 pixels in size, representing the subset E(573,611) N(478,517). It would have a grid-based extent of 573,478 to 611,517 and a cell-based extent of 572.5,478.5 to 610.5,517.5.

Reference This existing OGC document may have material you can reuse:  
<http://docs.opengeospatial.org/is/10-140r2/10-140r2.html> <<http://docs.opengeospatial.org/is/10-140r2/10-140r2.html>>

## 5.5. Range Types

In our implementation, we currently support coverages encoded in 16-bit PNG, with the 16-bit range mapped linearly to the range of values for the coverage, similar to how it is done in the [GeoPackage tile gridded coverage extension](#).

Two main points:

- How could it be possible to describe in the `.../{collectionId}` resource the range of the values that occur in the coverage? e.g. -11000..9000, or 1 to 27?

As far as I understand the RangeType does not specify this, it only says a 32-bit float or an unsigned 8 bit integer is used.

\* How could a linear mapping be established from encoded values to units like meters, to use a format like PNG and maximize precision while minimizing storage size?

GeoServer WCS 2 example:



```

<swe:Quantity>
<swe:description>RED_BAND</swe:description>
<swe:nilValues>
<swe:nilValues>
<swe:nilValue reason="http://www.opengis.net/def/nil/OGC/0/unknown">0.0</swe:nilValue>
</swe:nilValues>
</swe:nilValues>
<swe:uom code="W.m-2.Sr-1"/>
<swe:constraint>
<swe:AllowedValues>
<swe:interval>100.0 150.0</swe:interval>
</swe:AllowedValues>
</swe:constraint>
</swe:Quantity>
</swe:field>

```

Here is an example using ISO 19115-2. I believe the Range Type in CIS is similar. The coverage is a SAR collection. Each pixel is an imaginary number (real and imaginary components) represented as 2s complement integers. "Count" is the SWE Common equivalent of integer. There is a lot of additional information you can add, but this was sufficient for my immediate needs.

I'm sure there is a range type you cannot represent using SWE Common, but I haven't found one yet.

```

<gco:Record>  <DataRecord xmlns="http://www.opengis.net/swe/2.0">
    <field name="RE16I">
        <Count axisID="Real">
            <description>Each component is stored in a 16-bit signed integer in
2s complement format.</description>
            <constraint>
                <AllowedValues> 0 65535 </AllowedValues>
            </constraint>
        </Count>
    </field>
    <field name="IM16I">
        <Count axisID="Imaginary">
            <description>Each component is stored in a 16-bit signed integer in
2s complement format.</description>
            <constraint>
                <AllowedValues> 0 65535 </AllowedValues>
            </constraint>
        </Count>
    </field>
</DataRecord>
</gco:Record>

```

## 5.6. Slicing and Subsetting

First we need to define two concepts:

subsetting - this appears to be the case where you select a subset of the range set that is at full resolution. To perform a selection you identify the range of values along each axis that should be included in the result.

thinning - appears to be the case where you reduce the resolution of the range set. This is done by removing elements from the range set and performing any smoothing or interpolation functions needed to maintain the integrity of the data.

Once we have agreed on these definitions, we can talk about the implications of these techniques for both regular and irregular grids.

Also consider edge cases: 1) non-terrestrial data 2) swath or curtain data (collection across a vertical column) 3) RF data - phase, frequency, doppler, etc.

# Annex A: Revision History

Date	Release	Editor	Primary clauses modified	Description
2016-04-28	0.1	G. Editor	all	initial version

# Annex B: Glossary

- **Conformance Test Module**

set of related tests, all within a single conformance test class ([OGC 08-131r3](#))

<b>NOTE:</b>	When no ambiguity is possible, the word <b>test</b> may be omitted. i.e. <a href="#">conformance test module</a> is the same as <a href="#">conformance module</a> . Conformance modules may be nested in a hierarchical way. This term and those associated to it are included here for consistency with ISO 19105.
--------------	---

- **Conformance Test Class; Conformance Test Level**

set of [conformance test modules](#) that must be applied to receive a single **certificate of conformance**. ([OGC 08-131r3](#))

<b>NOTE:</b>	When no ambiguity is possible, the word <b>test</b> may be left out, so <a href="#">conformance test class</a> may be called a <a href="#">conformance class</a> .
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- **Executable Test Suite (ETS)**

A set of code (e.g. Java and CTL) that provides runtime tests for the assertions defined by the ATS. Test data required to do the tests are part of the ETS ([OGC 08-134](#))

- **Recommendation**

expression in the content of a document conveying that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required, or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited ([OGC 08-131r3](#))

<b>NOTE:</b>	"Although using normative language, a <a href="#">recommendation</a> is not a <a href="#">requirement</a> . The usual form replaces the <b>shall</b> (imperative or command) of a <a href="#">requirement</a> with a <b>should</b> (suggestive or conditional)." (ISO Directives Part 2)
--------------	--

- **Requirement**

expression in the content of a document conveying criteria to be fulfilled if compliance with the document is to be claimed and from which no deviation is permitted ([OGC 08-131r3](#))

- **Requirements Class**

aggregate of all requirement modules that must all be satisfied to satisfy a conformance test class ([OGC 08-131r3](#))

- **Requirements Module**

aggregate of [requirements](#) and [recommendations](#) of a specification against a single [standardization target](#) type ([OGC 08-131r3](#))

- **Standardization Target**

entity to which some requirements of a standard apply ([OGC 08-131r3](#))

<b>NOTE:</b>	The standardization target is the entity which may receive a certificate of conformance for a requirements class.
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# Annex C: Bibliography

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