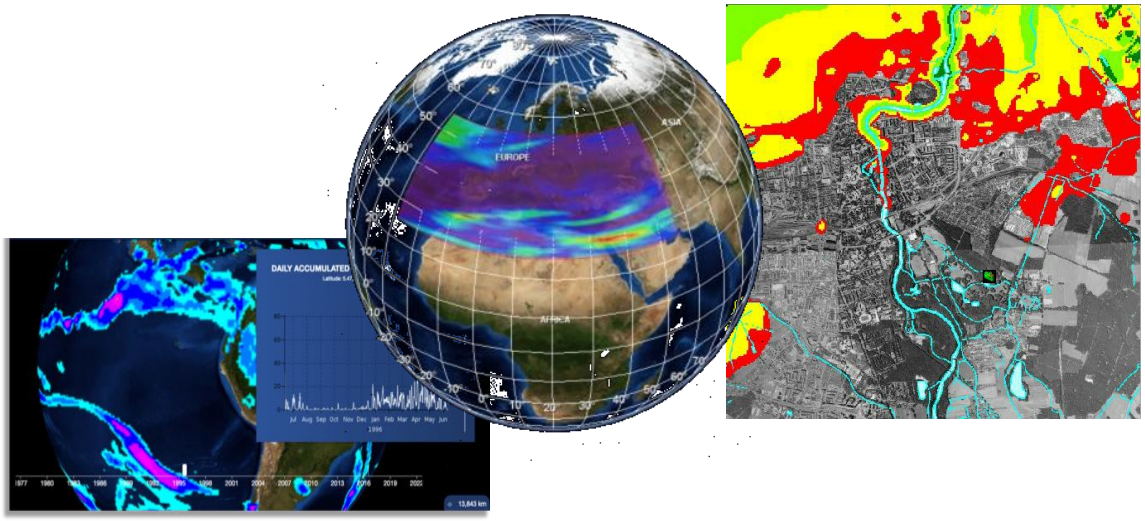

INSPIRE WCS / WCPS

INSPIRE Workshop, Helsinki, 2019-oct-16

the rasdaman team

rasdaman GmbH | Jacobs University

www.rasdaman.com | www.jacobs-university.de/lsis

Why Standards?

[www.jhchoppers.com]

Coverages in INSPIRE: Recent Work

- 2018: concerted coverage clarification effort started
  - Severe issues spotted: incompatibilities & technical infeasibilities
  - P. Baumann, J. Escriu: *INSPIRE Coverages: An Analysis and Some Suggestions*. Open Geospatial Data, Software and Standards, (2019) 4:1, DOI: https://doi.org/10.1186/s40965-019-0059-x
- Minimal changes proposed to JRC, waiting...
  - Re-harmonizing with OGC, aligning SOS + WCS (no-brainer)
- Coverage awareness campaign
  - INSPIRE Amsterdam 2018 workshop, K. Schleidt & P. Baumann & J. Escriu
  - INSPIRE Helsinki 2019, same team
  - National webinars, workshops

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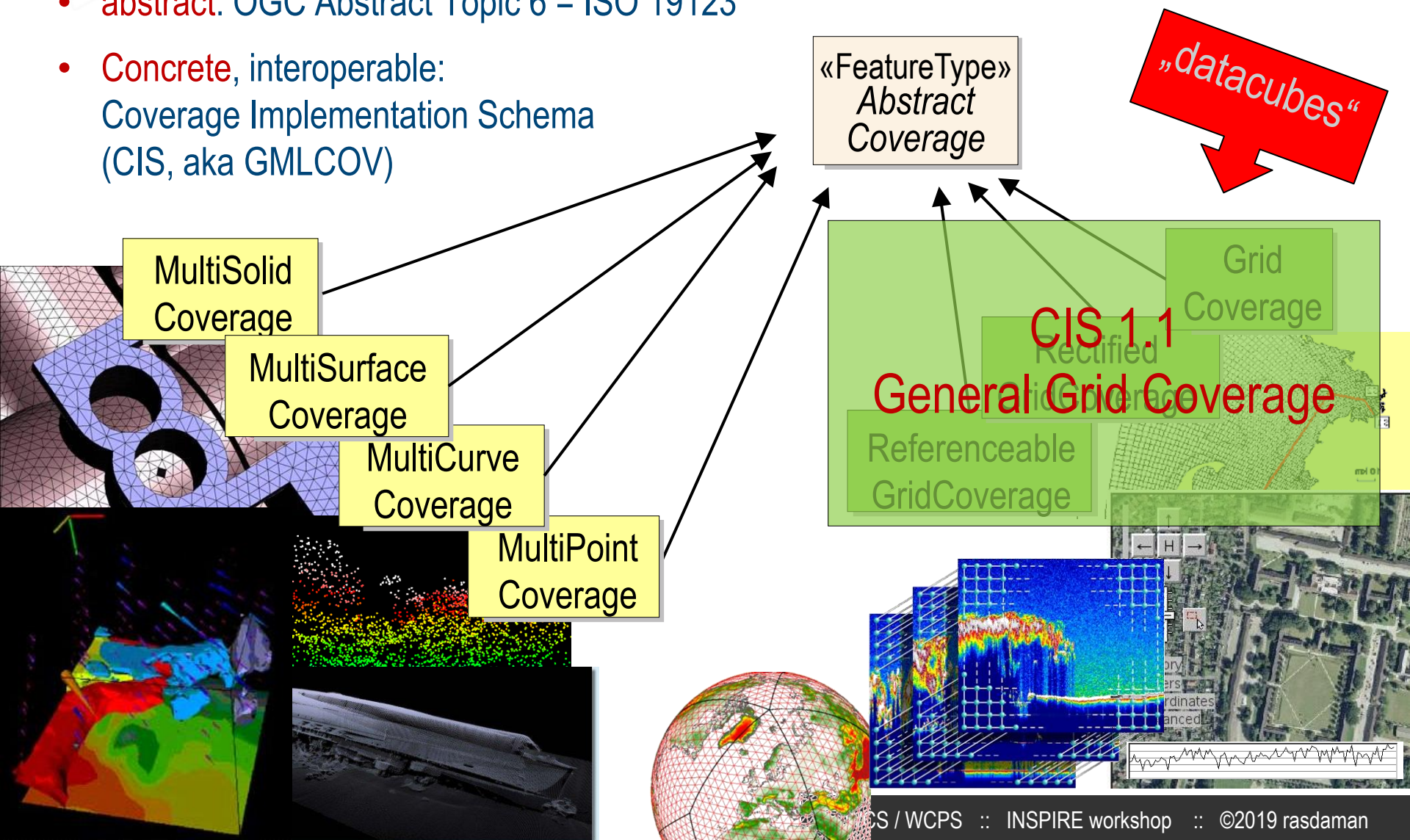
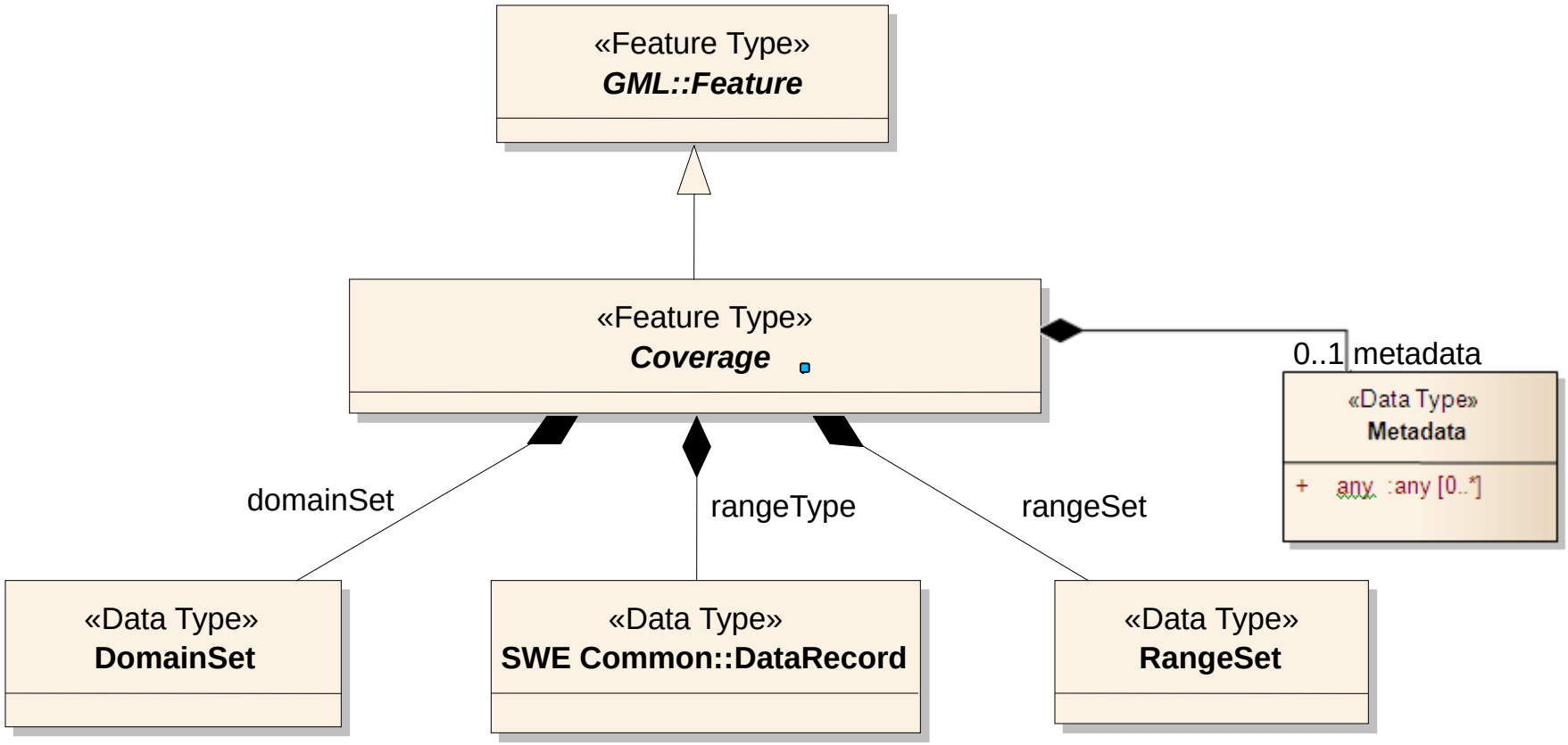
OGC Coverage Implementation Schema

Coverages= Grids, Point Clouds, Meshes

- abstract: OGC Abstract Topic 6 = ISO 19123
- Concrete, interoperable:
  Coverage Implementation Schema
  (CIS, aka GMLCOV)



Coverage Definition



[OGC 09-146r2]

A Simple Coverage, in GML

```
<generalGridCoverage ...  gml:id="CIS_001">

    <domainSet>
        <generalGrid srsName="http://www.opengis.net/def/crs-compound?
                              1=http://www.opengis.net/def/crs/EPSG/0/4979
                             &amp;2=http://www.opengis.net/def/crs/OGC/0/AnsiDate"
            axisLabels="Lat Long h date">
            <regularAxis   axisLabel="Lat"  uomLabel="deg" lowerBound="40"  upperBound="60" resolution="10"/>
            <regularAxis   axisLabel="Long" uomLabel="deg" lowerBound="-10" upperBound="10"  resolution="10"/>
            <irregularAxis axisLabel="h"    uomLabel="m">
                <c>  0</c>
                <c>100</c>
            </irregularAxis>
            <irregularAxis axisLabel="date" uomLabel="d">
                <c>2015-12-01</c>
                <c>2015-12-02</c>
            </irregularAxis>
            <gridLimits srsName="http://www.opengis.net/def/crs/OGC/0/Index4D" axisLabels="i j k l">
                <indexAxis axisLabel="i" lowerBound="0" upperBound="2"/>
                <indexAxis axisLabel="j" lowerBound="0" upperBound="2"/>
                <indexAxis axisLabel="k" lowerBound="0" upperBound="1"/>
                <indexAxis axisLabel="l" lowerBound="0" upperBound="1"/>
            </gridLimits>
        </generalGrid>
    </domainSet>

    <rangeSet>
        <dataBlock>
              <v>01</v> <v>02</v> <v>03</v> <v>04</v> <v>05</v> <v>06</v> <v>07</v> <v>08</v> <v>09</v>
              <v>01</v> <v>02</v> <v>03</v> <v>04</v> <v>05</v> <v>06</v> <v>07</v> <v>08</v> <v>09</v>
              <v>01</v> <v>02</v> <v>03</v> <v>04</v> <v>05</v> <v>06</v> <v>07</v> <v>08</v> <v>09</v>
              <v>01</v> <v>02</v> <v>03</v> <v>04</v> <v>05</v> <v>06</v> <v>07</v> <v>08</v> <v>09</v>
        </dataBlock>
    </rangeSet>

    <rangeType>
        <swe:DataRecord>
            <swe:field name="panchromatic">
                <swe:Quantity definition="http://opengis.net/def/property/OGC/0/Radiance">
                    <swe:uom code="W.m-2.sr-1.nm-1"/>
                </swe:Quantity>
            </swe:field>
        </swe:DataRecord>
    </rangeType>

</generalGridCoverage>
```

A Simple Coverage, in JSON

```
{   "type": "CoverageByDomainAndRangeType",
    "domainSet":{
        "type": "DomainSetType",
        "generalGrid":{
            "type":          "GeneralGridCoverageType",
            "srsName":    "http://www.opengis.net/def/crs/OGC/0/Index2D",
            "axisLabels": ["i", "j"],
            "axis": [{      "type": "IndexAxisType“, "axisLabel": "i", "lowerBound": 0, "upperBound": 2
            },{             "type": "IndexAxisType“, "axisLabel": "j", "lowerBound": 0, "upperBound": 2  }]
        }
    },
    "rangeSet": {     "type": "RangeSetType",
                      "dataBlock": { "type": "VDataBlockType",  "values": [1,2,3,4,5,6,7,8,9] }     },
    "rangeType": {   "type": "DataRecordType",
                      "field":[{     "type": "QuantityType",
                                     "definition": "ogcType:unsignedInt",
                                     "uom": { "type": "UnitReference", "code": "10^0“ }     }]
    }
}
```

A Simple Coverage, in RDF

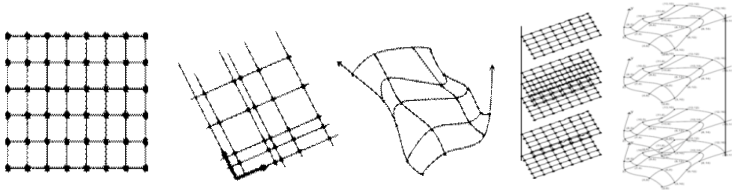
```
<http://www.opengis.net/cis/1.1/examples/CIS_05_2D>
 <http://www.w3.org/1999/02/22-rdf-syntax-ns#type>
 <http://www.opengis.net/cis/1.1/CoverageByDomainAndRangeType> .

<http://www.opengis.net/cis/1.1/examples/CIS_05_2D>
 <http://www.opengis.net/cis/1.1/domainSet>
 <http://www.opengis.net/cis/1.1/examples/CIS_DS_05_2D> .
<http://www.opengis.net/cis/1.1/examples/CIS_DS_05_2D>
 <http://www.opengis.net/cis/1.1/generalGrid>
 <http://www.opengis.net/cis/1.1/examples/CIS_DS_GG_05_2D> .
<http://www.opengis.net/cis/1.1/examples/CIS_DS_05_2D>
 <http://www.w3.org/1999/02/22-rdf-syntax-ns#type>
 <http://www.opengis.net/cis/1.1/DomainSetType> .
<http://www.opengis.net/cis/1.1/examples/CIS_DS_GG_05_2D>
 <http://www.opengis.net/cis/1.1/axis>
 <http://www.opengis.net/cis/1.1/examples/CIS_DS_GG_I_05_2D> .
<http://www.opengis.net/cis/1.1/examples/CIS_DS_GG_05_2D>
 <http://www.opengis.net/cis/1.1/axis>
 <http://www.opengis.net/cis/1.1/examples/CIS_DS_GG_J_05_2D> .
<http://www.opengis.net/cis/1.1/examples/CIS_DS_GG_05_2D>
 <http://www.opengis.net/cis/1.1/axisLabels>
 <http://www.opengis.net/cis/1.1/axisLabels0> .
<http://www.opengis.net/cis/1.1/axisLabels0> <http://www.w3.org/1999/02/22-rdf-syntax-ns#first> "i" .
<http://www.opengis.net/cis/1.1/axisLabels0> <http://www.w3.org/1999/02/22-rdf-syntax-ns#rest> <http://www.opengis.net/cis/1.1/axisLa
<http://www.opengis.net/cis/1.1/axisLabels1> <http://www.w3.org/1999/02/22-rdf-syntax-ns#first> "j" .
<http://www.opengis.net/cis/1.1/axisLabels1> <http://www.w3.org/1999/02/22-rdf-syntax-ns#rest> <http://www.w3.org/1999/02/22-rdf-sy
```

Summary

datacubes

- Coverage = regular and irregular grids, point clouds, meshes
- Coverage Implementation Schema 1.1
  = backwards-compatible evolution of CIS 1.0
  - Grids: Regular + irregular (generalizing CIS 1.0 & GML 3.3), SensorML



  - Interpolation, representations, practice-driven packaging, ...
- *OGC CIS = ISO 19123-2*

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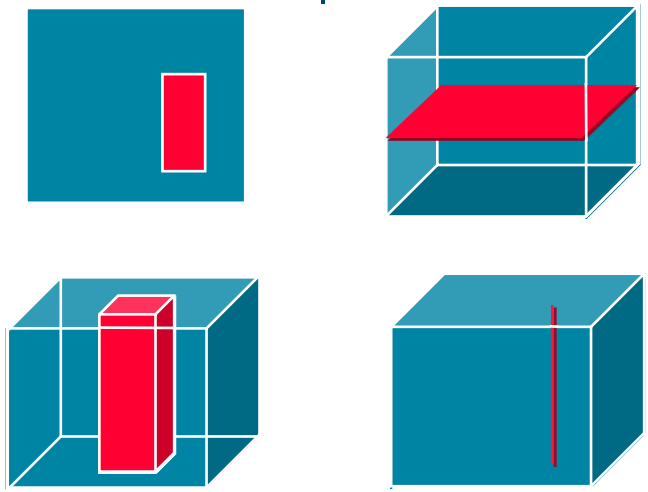
OGC Web Coverage Service
Core & Extensions

OGC Web Coverage Service (WCS)

- WCS Core: access to spatio-temporal coverages & subsets
  - Encoding on the fly
  - subset = trim | slice



- WCS Extensions: optional functionality facets
- *rasdaman implements WCS Core & all Extensions*
  - *reference implementation*

WCS Core *GetCoverage*

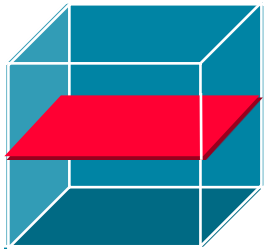
- Download a coverage (or a subset thereof), values guaranteed unchanged

- Ex: „*download coverage c001*“

```
http://www.acme.com/wcs ? SERVICE=WCS & VERSION=2.0
    & REQUEST=GetCoverage & COVERAGEID=c001
```

- Ex: „*coverage c001, lat/long cutout, time slice t=2009-11-06T23:20:52*”

```
http://www.acme.com/wcs ? SERVICE=WCS & VERSION=2.0
    & REQUEST=GetCoverage & COVERAGEID=c001
    & SUBSET=Long(100,120) & SUBSET=Lat(50,60)
    & SUBSET=time("2009-11-06T23:20:52")
```



- Ex: “*coverage c001, in GeoTIFF*”

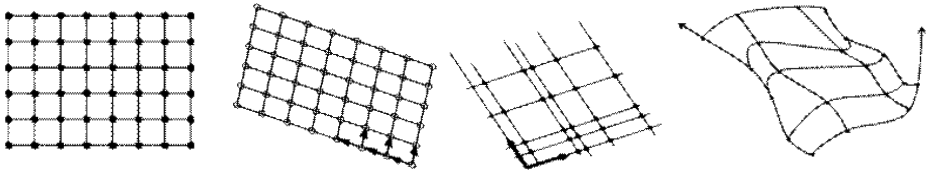
```
http://www.acme.com/wcs ? SERVICE=WCS & VERSION=2.0
    & REQUEST=GetCoverage & COVERAGEID=c001 & FORMAT=“image/tiff“
```

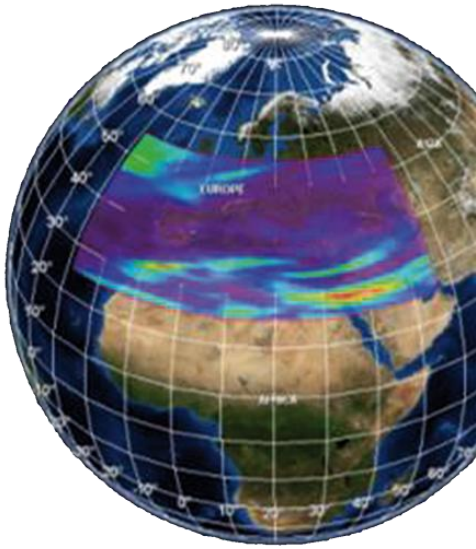
Coverage Processing

- Web Coverage Processing Service (WCPS)
  - WCS processing extension
  - spatio-temporal datacube analytics language

```
A[Lat(10.2),Long(8.4),date("2017-12-04")]
```

  - space & time, regular & irregular grids





- "From MODIS scenes M1, M2, M3: difference red & nir, as TIFF"
  - "…but only those where nir exceeds 127 somewhere"

```
for $c in ( M1, M2, M3 )
where some( $c.nir > 127 )
return encode( $c.red - $c.nir, "image/tiff" )
```

[SSDBM 2009, SSDBM 2010, Geoinformatica 2010]

WCS Protocol Bindings

- Protocol binding = „command language“
- Identical WCS functionality across various protocols
  - GET/KVP, XML-POST, XML-SOAP, OAPI-Coverages
- OAPI: OGC activity towards unified W*S protocol using OpenAPI
  - features, coverages, maps, tiles, processes, ... + OAPI Common
  - Challenge: bring together rather different worlds
    - *Heritage, conventions, implementations, ...*
  - Ex: bbox, collections, ...

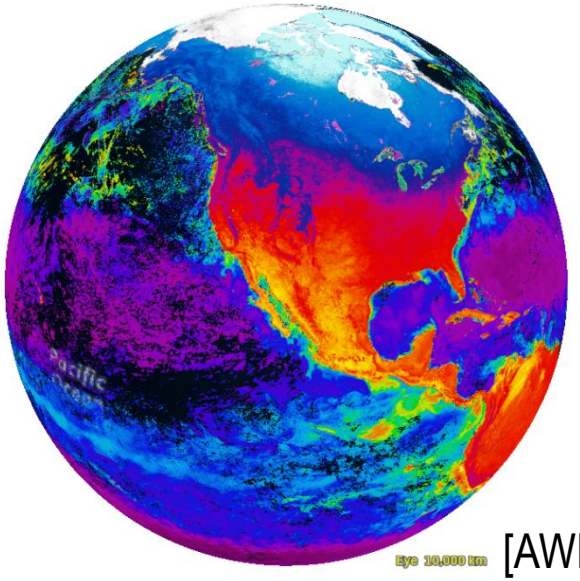
    GET /collections/{cid}/items?bbox=160.6,-55.95,-170,-25.89

    GET /collections/{cid}/coverages/{covid}?SUBSET=Lat(40,50)&SUBSET=Long(10,20)

  - *Caveat: work in progress*

Summary

- OGC WCS Core & Extensions
  - modular
  - pixel-level conformance tests for interoperability
  - OGC WCPS:
    spatio-temporal datacube analytics language
- robust, scalable, mature
  - proven on 2.5+ PB in EarthServer
- *The modern, accepted way of doing powerful, flexible raster services*
- ...and now let‘s get hands-on!



[AWI]

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Wrap-Up

Coverage Standards & Friends

- Earth Sciences:
  - Open Geospatial Consortium (OGC):
    - *Coverage data model: Coverage Implementation Schema (CIS)*
    - *Coverage service model: Web Coverage Service (WCS) suite*
  - ISO:
    - *OGC CIS → 19123-2*
    - *19123 revised → 19123-1*
  - INSPIRE:
    - *Coverages (contorted) & WCS (verbatim)*

Core implemented by leading tools

- General Data Analytics:
  - ISO: SQL/MDA („Multi-Dimensional Arrays“)
    - *= rasdaman array QL*

ICS › 35 › 35.060
ISO/IEC 9075-15:2019
Information technology database languages — SQL — Part 15: Multi-dimensional arrays (SQL/MDA)

INSPIRE WCS

- INSPIRE WCS Tech Guidance
  - https://inspire.ec.europa.eu/id/document/tg/download-wcs
  - TG Requirement 1
    The WCS download service instance shall conform to WCS 2.0 Conformance Class 'core WCS'
  - Recommended implementation Get Spatial Object:
    - *shall be requested […] through a WCS ProcessCoverages request*
- Bottom line:
  - INSPIRE WCS → OGC WCS → OGC Coverages ≠ INSPIRE Coverages
  - plus INSPIRE metadata!
    - *Following WCS extension mechanism*

Caveat: Free Riders

- „coverage“ recognized as enabling concept, trending
- Many independent uses of term, no compatibility demonstrated:
  - OGC GeoPackage Extension for Tiled Gridded Coverage Data
  - CoverageJSON
  - W3C Coverages
- Currently known implementations of OGC WCS Core:
  - http://myogc.org/go/coveragesDWG #Known_Implementations
  - Conformance testing

Projects Co-Funding INSPIRE Work

- BigDataCube: Public/Private datacube partnership
- EOSC-hub: Earth Observation datacubes
- DeepRain: Localized rain forecasts through AI + Array Databases
- BigPicture: Ground-truthed satellite analytics for agriculture
- LandSupport: Integrated geo analytics for land management
- ORBiDANSe: Orbital Big Data Analytics Service
- CopHub.AC: European Copernicus Knowledge Landscape
- *...plus several more*

Summary

- OGC Coverage open standards suite:
  the modern way to do raster data
  - easy-to-use, unified, powerful: from access to analytics
- Practice proven: mosaics, timeseries, datacubes, ...
  - pixel-level interoperability
  - consensus: OGC + ISO (~INSPIRE) std bodies, major tools & vendors
- rasdaman: actionable raster coverages & datacubes
  - 2.5+ PB, 1000x parallelization, operational federations; reference implementation


[rasdaman,DFD-DLR]

"Web developers who have not heard of OGC standards before immediately feel at home with these coverage standards"
-- Stephan Siemen, ECMWF

[baumann@rasdaman.com]

Resources

- OGC authoritative standards page
  - http://schemas.opengis.net/cis , http://schemas.opengis.net/wcs
  - http://www.opengeospatial.org/standards/wcs
  - http://www.opengeospatial.org/standards/wcps
- OGC Coverages.DWG wiki (background info, stds pre-releases)
  - http://myogc.org/go/coveragesDWG
- Training material
  - Wikipedia: coverages, WCS, WCPS
  - Webinars: www.earthserver.eu/webinars
  - Tutorials: http://tutorial.rasdaman.org/rasdaman-and-ogc-ws-tutorial/
  - Online interactive demos & sandbox: http://standards.rasdaman.com/
  - Jupyter notebooks: http://nbviewer.jupyter.org/github/earthserver-eu/