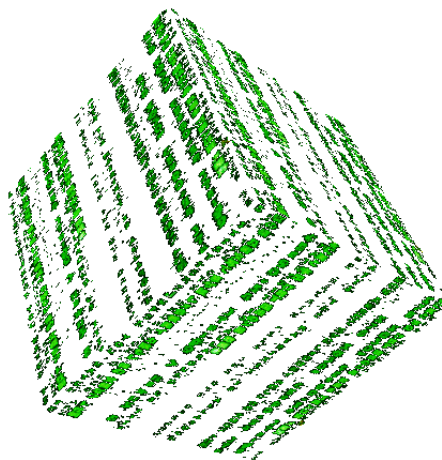




# Coverage & Datacube Standards: Introduction, Status, and a Question

EGU, 2020-may-05

P. Baumann

Jacobs University | rasdaman GmbH

# **BIG EARTH DATA**

**The Digitized Planet**

```

rwx--x--- 1 rasdata users 1485 Oct 13 2004 4251NW.ASC
rwx--x--- 1 rasdata users 216 Oct 13 2004 4251NWGR.tfw
rwx--x--- 1 rasdata users 640432 Oct 13 2004 4251NWGR.tif
rwx--x--- 1 rasdata users 216 Oct 13 2004 4251NWGW.tfw
rwx--x--- 1 rasdata users 779368 Oct 13 2004 4251NWGW.tif
rwx--x--- 1 rasdata users 216 Oct 13 2004 4251NWRL.tfw
rwx--x--- 1 rasdata users 712492 Oct 13 2004 4251NWRL.tif
rwx--x--- 1 rasdata users 216 Oct 13 2004 4251NWML.tfw
rwx--x--- 1 rasdata users 62830 Oct 13 2004 4251NWML.tif
rwx--x--- 1 rasdata users 1498 Oct 13 2004 4251S0.ASC
rwx--x--- 1 rasdata users 216 Oct 13 2004 4251S0GR.tfw
rwx--x--- 1 rasdata users 1076750 Oct 13 2004 4251S0GR.tif
rwx--x--- 1 rasdata users 216 Oct 13 2004 4251S0GW.tfw
rwx--x--- 1 rasdata users 197142 Oct 13 2004 4251S0GW.tif
rwx--x--- 1 rasdata users 216 Oct 13 2004 4251S0RL.tfw
rwx--x--- 1 rasdata users 936348 Oct 13 2004 4251S0RL.tif
rwx--x--- 1 rasdata users 216 Oct 13 2004 4251S0WL.tfw
rwx--x--- 1 rasdata users 119990 Oct 13 2004 4251S0WL.tif
rwx--x--- 1 rasdata users 1485 Oct 13 2004 4251SW.ASC
rwx--x--- 1 rasdata users 216 Oct 13 2004 4251SWGR.tfw
rwx--x--- 1 rasdata users 577868 Oct 13 2004 4251SWGR.tif
rwx--x--- 1 rasdata users 216 Oct 13 2004 4251SWGW.tfw
rwx--x--- 1 rasdata users 352188 Oct 13 2004 4251SWGW.tif
rwx--x--- 1 rasdata users 216 Oct 13 2004 4251SWRL.tfw
rwx--x--- 1 rasdata users 913032 Oct 13 2004 4251SWRL.tif
rwx--x--- 1 rasdata users 216 Oct 13 2004 4251SWML.tfw
rwx--x--- 1 rasdata users 74152 Oct 13 2004 4251SWML.tif
rwx--x--- 1 rasdata users 1485 Oct 13 2004 4252N0.ASC
rwx--x--- 1 rasdata users 216 Oct 13 2004 4252N0GR.tfw
rwx--x--- 1 rasdata users 355774 Oct 13 2004 4252N0GR.tif
rwx--x--- 1 rasdata users 216 Oct 13 2004 4252N0GW.tfw
rwx--x--- 1 rasdata users 49046 Oct 13 2004 4252N0GW.tif
rwx--x--- 1 rasdata users 216 Oct 13 2004 4252N0RL.tfw
rwx--x--- 1 rasdata users 600964 Oct 13 2004 4252N0RL.tif
rwx--x--- 1 rasdata users 216 Oct 13 2004 4252N0WL.tfw
rwx--x--- 1 rasdata users 46714 Oct 13 2004 4252N0WL.tif
rwx--x--- 1 rasdata users 1485 Oct 13 2004 4252NW.ASC
rwx--x--- 1 rasdata users 216 Oct 13 2004 4252NWGR.tfw
rwx--x--- 1 rasdata users 1445064 Oct 13 2004 4252NWGR.tif
rwx--x--- 1 rasdata users 216 Oct 13 2004 4252NWGW.tfw
rwx--x--- 1 rasdata users 410426 Oct 13 2004 4252NWGW.tif
rwx--x--- 1 rasdata users 216 Oct 13 2004 4252NWRL.tfw
rwx--x--- 1 rasdata users 655374 Oct 13 2004 4252NWRL.tif
rwx--x--- 1 rasdata users 216 Oct 13 2004 4252NWML.tfw
rwx--x--- 1 rasdata users 108612 Oct 13 2004 4252NWML.tif
rwx--x--- 1 rasdata users 1485 Oct 13 2004 4252S0.ASC
rwx--x--- 1 rasdata users 216 Oct 13 2004 4252S0GR.tfw
rwx--x--- 1 rasdata users 607646 Oct 13 2004 4252S0GR.tif
rwx--x--- 1 rasdata users 216 Oct 13 2004 4252S0GW.tfw
rwx--x--- 1 rasdata users 685092 Oct 13 2004 4252S0GW.tif
rwx--x--- 1 rasdata users 216 Oct 13 2004 4252S0RL.tfw
rwx--x--- 1 rasdata users 632172 Oct 13 2004 4252S0RL.tif
rwx--x--- 1 rasdata users 216 Oct 13 2004 4252S0WL.tfw

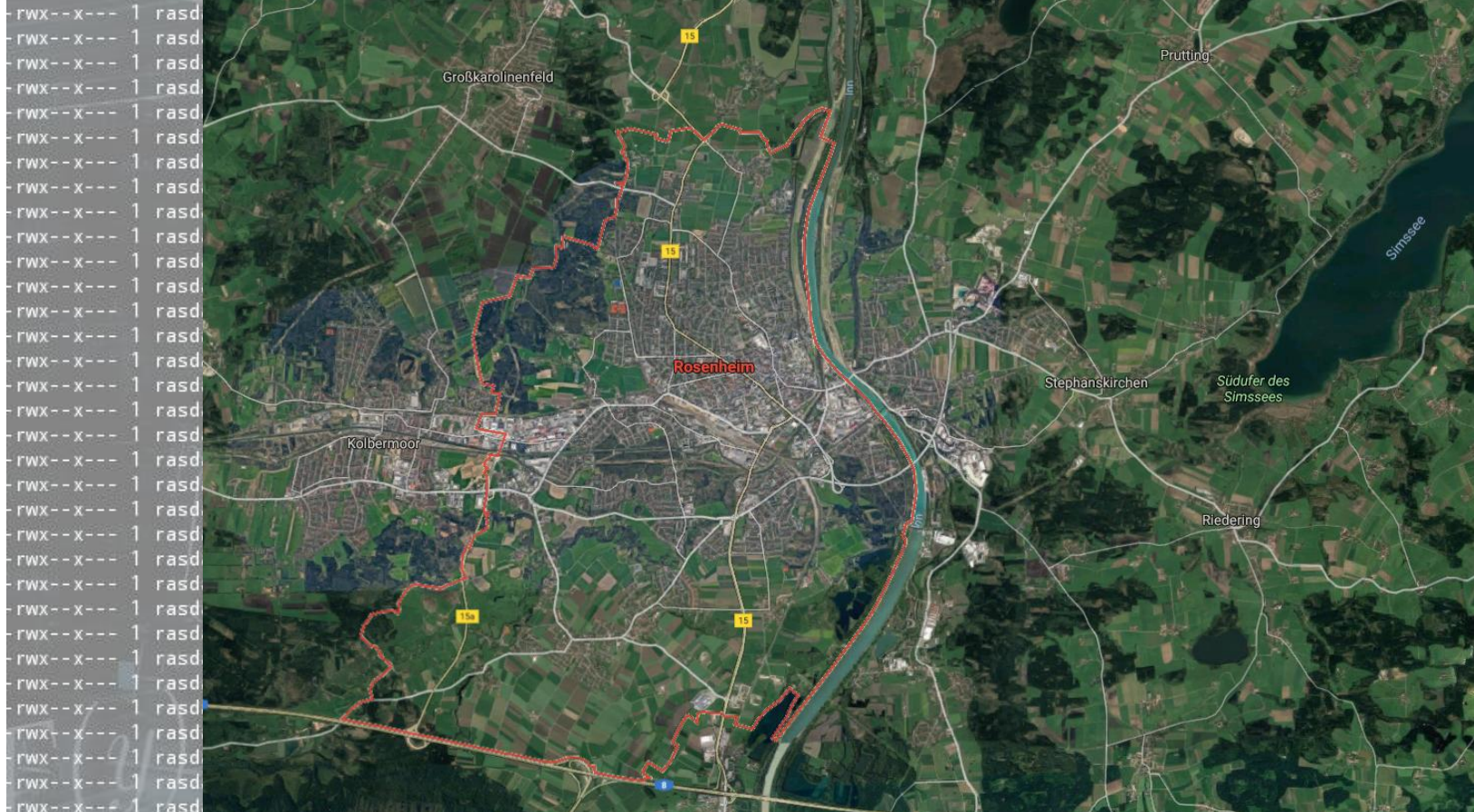
```



```

-rwx--x--- 1 rasdata users      1485 Oct 13 2004 4251NW.ASC
-rwx--x--- 1 rasdata users      216 Oct 13 2004 4251NWGR.tfw
-rwx--x--- 1 rasdata users    640432 Oct 13 2004 4251NWGR.tif
-rwx--x--- 1 rasdata users      216 Oct 13 2004 4251NWGW.tfw
-rwx--x--- 1 rasdata users    779368 Oct 13 2004 4251NWGW.tif
-rwx--x--- 1 rasdata users      216 Oct 13 2004 4251NWRL.tfw
-rwx--x--- 1 rasdata users    712492 Oct 13 2004 4251NWRL.tif
-rwx--x--- 1 rasdata users      216 Oct 13 2004 4251NWWL.tfw
-rwx--x--- 1 rasdata users     62830 Oct 13 2004 4251NWWL.tif
-rwx--x--- 1 rasdata users      1498 Oct 13 2004 4251S0.ASC

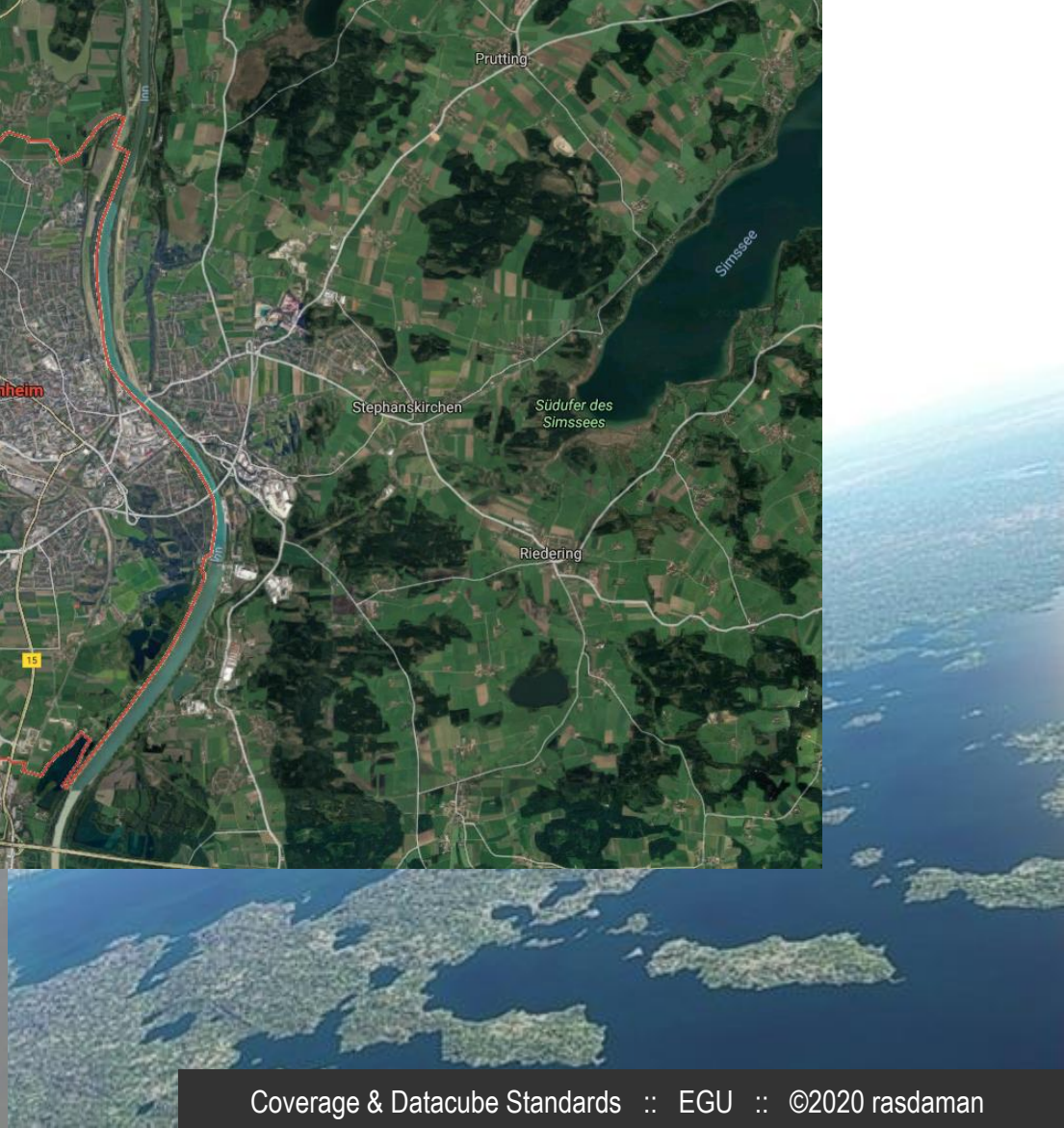
```



```

-rwx--x--- 1 rasdata users      216 Oct 13 2004 4252NWWL.tfw
-rwx--x--- 1 rasdata users    108612 Oct 13 2004 4252NWWL.tif
-rwx--x--- 1 rasdata users      1485 Oct 13 2004 4252S0.ASC
-rwx--x--- 1 rasdata users      216 Oct 13 2004 4252S0GR.tfw
-rwx--x--- 1 rasdata users    607646 Oct 13 2004 4252S0GR.tif
-rwx--x--- 1 rasdata users      216 Oct 13 2004 4252S0GW.tfw
-rwx--x--- 1 rasdata users    685092 Oct 13 2004 4252S0GW.tif
-rwx--x--- 1 rasdata users      216 Oct 13 2004 4252S0RL.tfw
-rwx--x--- 1 rasdata users    632172 Oct 13 2004 4252S0RL.tif
-rwx--x--- 1 rasdata users      216 Oct 13 2004 4252S0WL.tfw

```

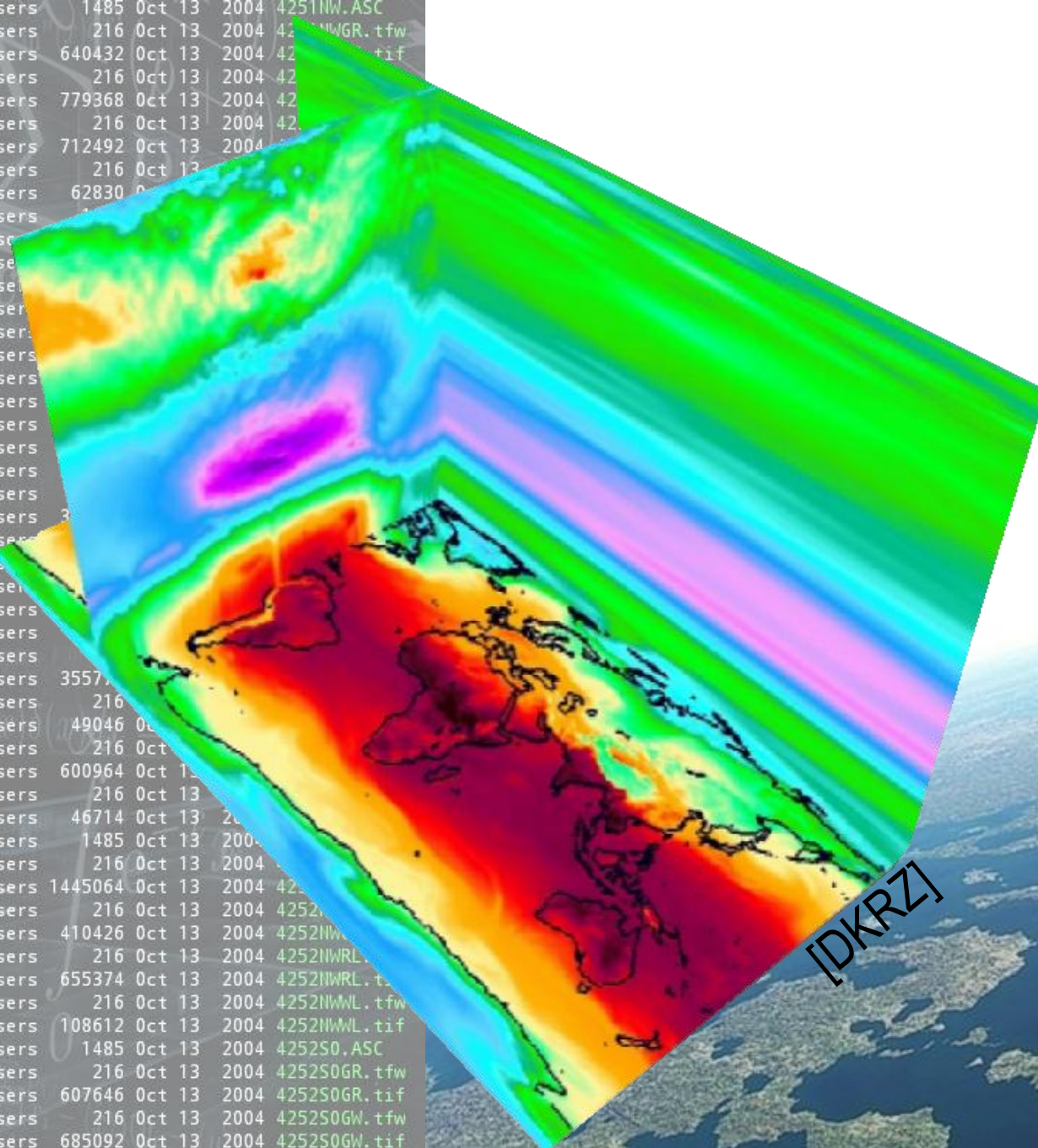




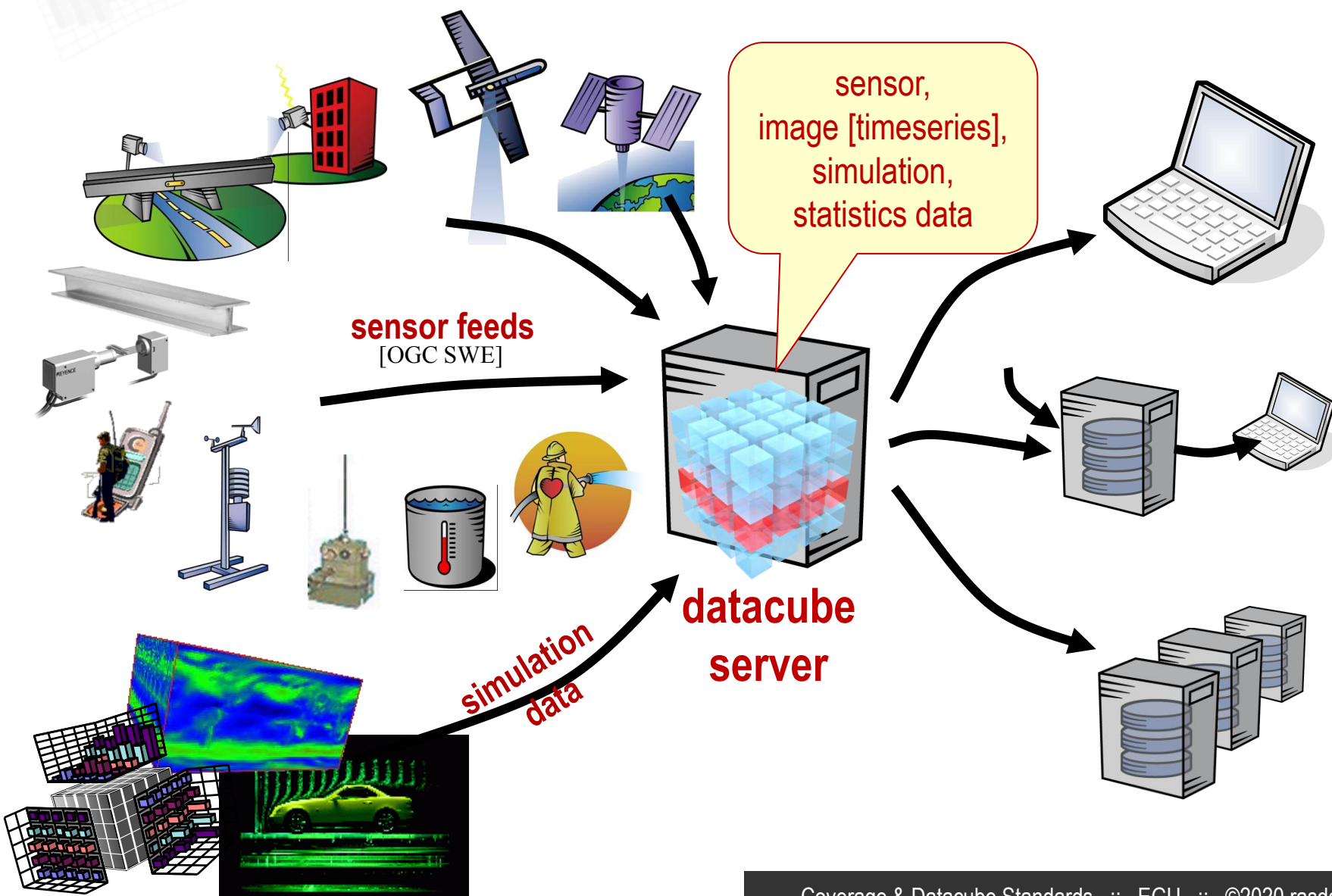
```

-rwx--x--- 1 rasdata users 1485 Oct 13 2004 4251NW.ASC
-rwx--x--- 1 rasdata users 216 Oct 13 2004 4251NWGR.tfw
-rwx--x--- 1 rasdata users 640432 Oct 13 2004 4251NW.tif
-rwx--x--- 1 rasdata users 216 Oct 13 2004 4252NW.ASC
-rwx--x--- 1 rasdata users 779368 Oct 13 2004 4252NWGR.tfw
-rwx--x--- 1 rasdata users 216 Oct 13 2004 4252NW.tif
-rwx--x--- 1 rasdata users 712492 Oct 13 2004 4252NWGR.tfw
-rwx--x--- 1 rasdata users 216 Oct 13 2004 4252NW.tif
-rwx--x--- 1 rasdata users 62830 Oct 13 2004 4252S0.ASC
-rwx--x--- 1 rasdata users 216 Oct 13 2004 4252S0GR.tfw
-rwx--x--- 1 rasdata users 607646 Oct 13 2004 4252S0GR.tif
-rwx--x--- 1 rasdata users 216 Oct 13 2004 4252S0GW.tfw
-rwx--x--- 1 rasdata users 685092 Oct 13 2004 4252S0GW.tif
-rwx--x--- 1 rasdata users 216 Oct 13 2004 4252S0RL.tfw
-rwx--x--- 1 rasdata users 632172 Oct 13 2004 4252S0RL.tif
-rwx--x--- 1 rasdata users 216 Oct 13 2004 4252S0WL.tfw
-rwx--x--- 1 rasdata users 3557 Oct 13 2004 4252S0WL.tif
-rwx--x--- 1 rasdata users 216 Oct 13 2004 4252S0WLGR.tfw
-rwx--x--- 1 rasdata users 49046 Oct 13 2004 4252S0WL.tif
-rwx--x--- 1 rasdata users 216 Oct 13 2004 4252S0WLGR.tfw
-rwx--x--- 1 rasdata users 600964 Oct 13 2004 4252S0WL.tif
-rwx--x--- 1 rasdata users 216 Oct 13 2004 4252S0WLGR.tfw
-rwx--x--- 1 rasdata users 46714 Oct 13 2004 4252S0WL.tif
-rwx--x--- 1 rasdata users 1485 Oct 13 2004 4252S0WLGR.tfw
-rwx--x--- 1 rasdata users 216 Oct 13 2004 4252S0WL.tif
-rwx--x--- 1 rasdata users 1445064 Oct 13 2004 4252S0WLGR.tfw
-rwx--x--- 1 rasdata users 216 Oct 13 2004 4252S0WL.tif
-rwx--x--- 1 rasdata users 410426 Oct 13 2004 4252S0WLGR.tfw
-rwx--x--- 1 rasdata users 216 Oct 13 2004 4252S0WL.tif
-rwx--x--- 1 rasdata users 655374 Oct 13 2004 4252S0WLGR.tfw
-rwx--x--- 1 rasdata users 216 Oct 13 2004 4252S0WL.tif
-rwx--x--- 1 rasdata users 108612 Oct 13 2004 4252S0WLGR.tfw
-rwx--x--- 1 rasdata users 1485 Oct 13 2004 4252S0WL.tif
-rwx--x--- 1 rasdata users 216 Oct 13 2004 4252S0WLGR.tfw
-rwx--x--- 1 rasdata users 607646 Oct 13 2004 4252S0WL.tif
-rwx--x--- 1 rasdata users 216 Oct 13 2004 4252S0WLGR.tfw
-rwx--x--- 1 rasdata users 685092 Oct 13 2004 4252S0WL.tif
-rwx--x--- 1 rasdata users 216 Oct 13 2004 4252S0WLGR.tfw
-rwx--x--- 1 rasdata users 632172 Oct 13 2004 4252S0WL.tif
-rwx--x--- 1 rasdata users 216 Oct 13 2004 4252S0WLGR.tfw

```



# Datacubes for Homogenizing Access



# 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)

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)

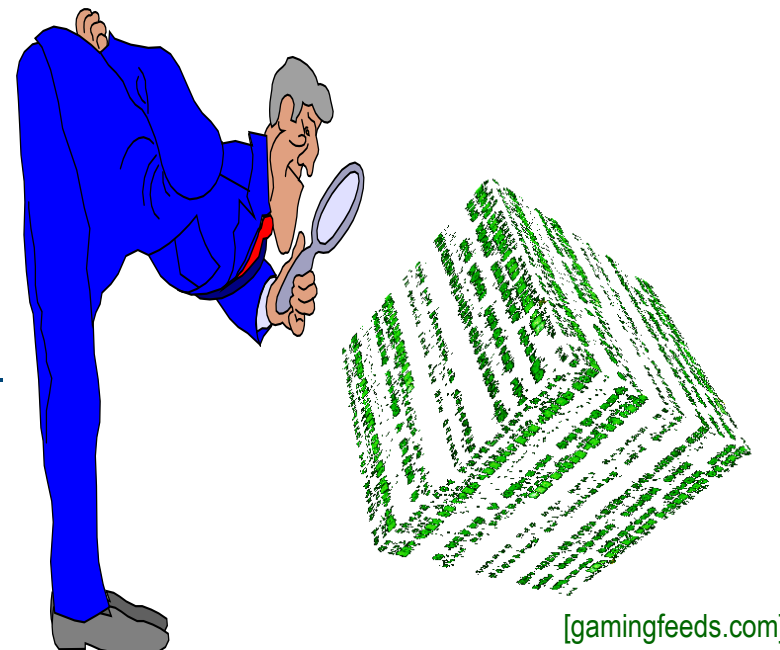


# OGC/ISO Coverage Implementation Schema (CIS)

**the rasdaman team**

Jacobs University | rasdaman GmbH

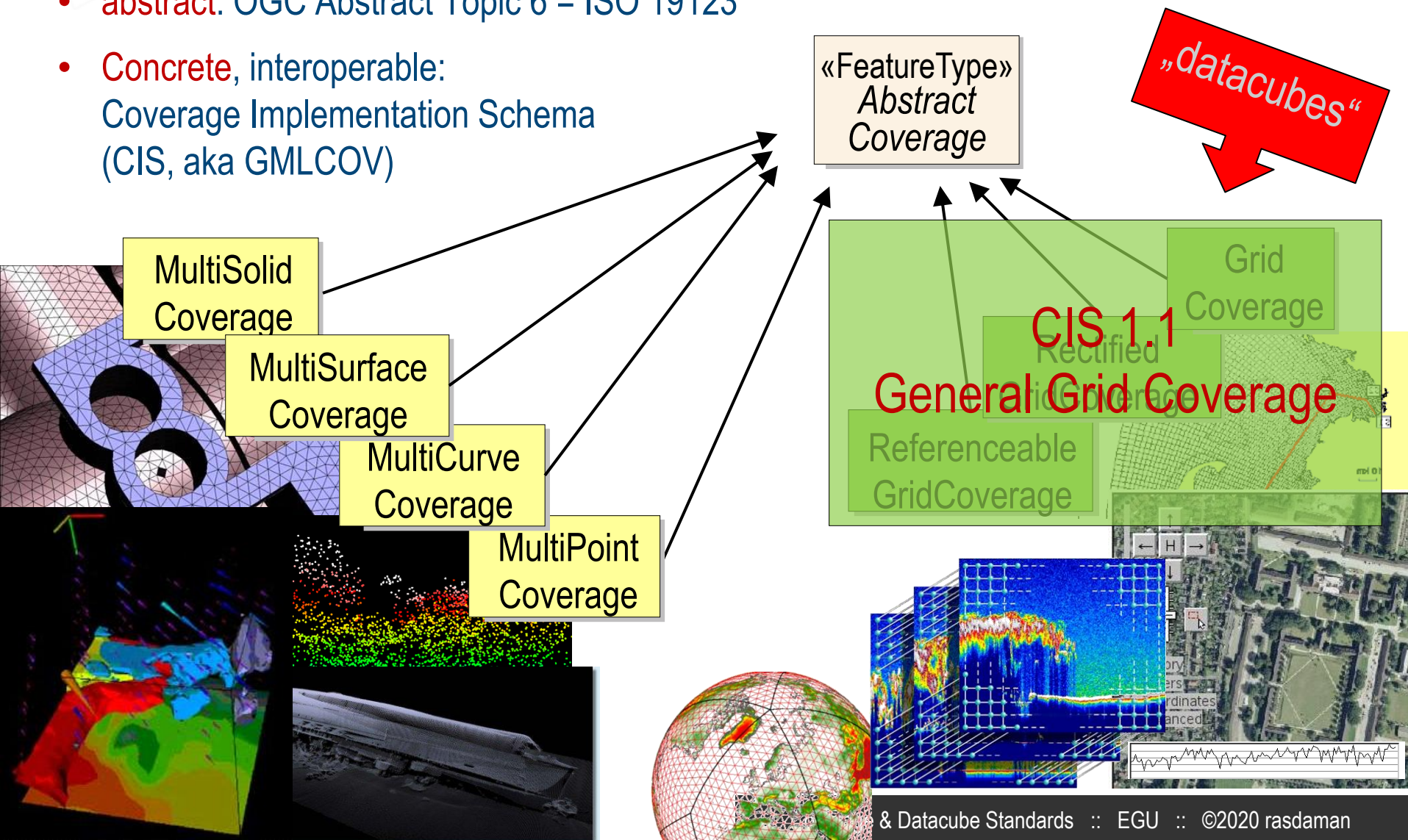
[www.jacobs-university.de/isis](http://www.jacobs-university.de/isis) | [www.rasdaman.com](http://www.rasdaman.com)



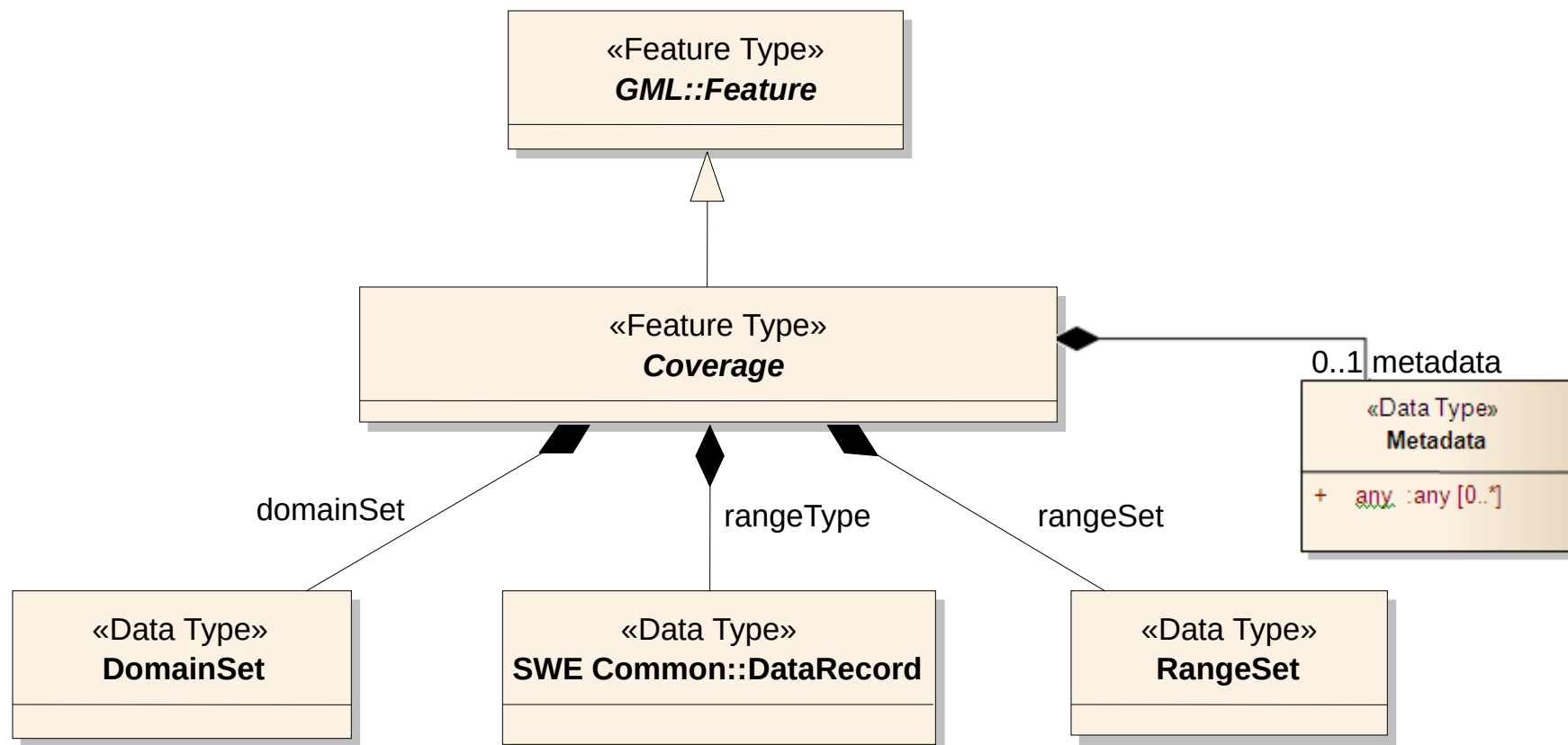


# Coverages= Grids, Point Clouds, Meshes

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



# Coverage Definition





# 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
      &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

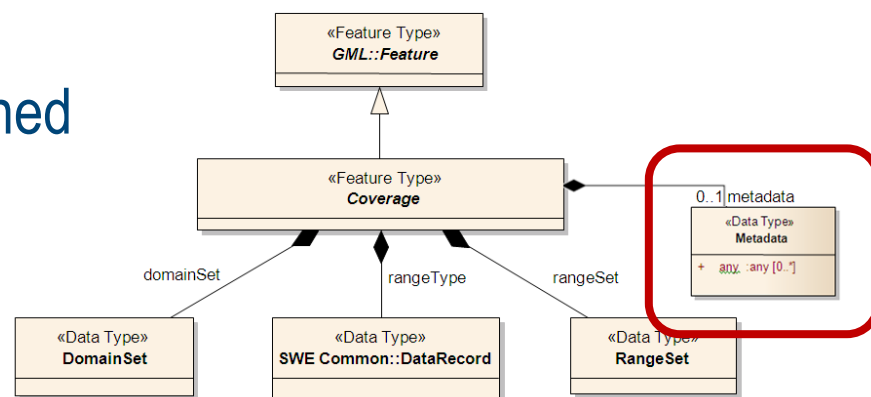
```
<http://www.opengis.net/cis/1.1/examples/CIS_05_2D>
<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>
<http://www.opengis.net/cis/1.1/CoverageByDomainAndRangeType> .
```

```
<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/axisLabels1> .
<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-syntax-ns#first> "k" .
```



# Metadata

- Technical metadata (required for understanding) in coverage:
  - Domain set: where are the data?
  - Range type: what do these data mean?
- Any arbitrary metadata can be attached
- Ex: INSPIRE metadata
  - Cf. <https://inspire.rasdaman.org>
- Options:
  - Add own metadata record, any number possible
  - Add reference to metadata record stored elsewhere



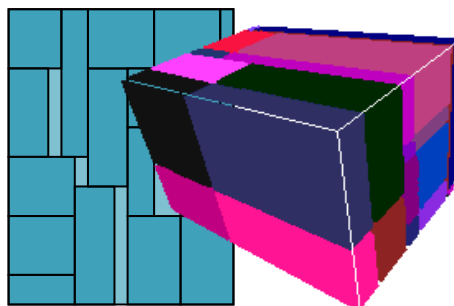
# Encoding Coverages

## ■ Single file encoding:

- Informationally complete: GML, JSON, RDF, ...
  - *Caveat: GeoJSON, CovJSON, W3C does **not** work*
- Further formats: GeoTIFF, NetCDF, JPEG2000, GRIB, ...

## ■ Multipart: container( "header" + file1 + file2 + ... )

- Multipart/MIME, zip, GMLJP2, SAFE, GeoPackage, ...
- Built-in collections / tiling



### Coverage

Domain set

Range type

Range set

App Metadata

### Coverage

Domain set

Range type

xlink

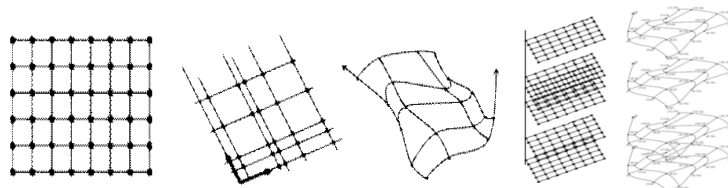
App Metadata

NetCDF

# Coverages: Summary

datacubes

- Coverage = regular & irregular grids, point clouds, meshes
- Coverage Implementation Schema 1.1  
= backwards-compatible evolution of CIS (GMLCOV) 1.0



- See <http://schemas.opengis.net/cis/1.1/> for schemas + examples
- OGC CIS = ISO 19123-2

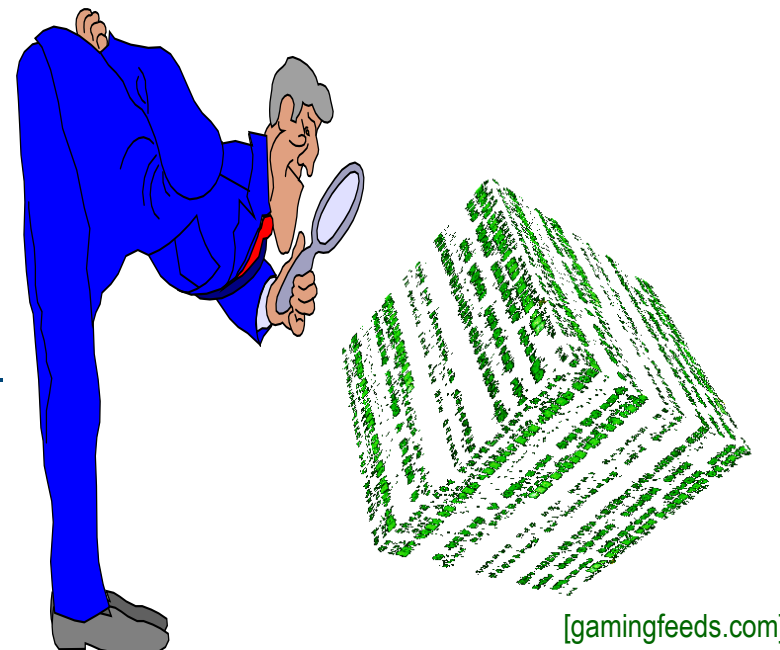


# OGC Web Coverage Service (WCS)

**the rasdaman team**

Jacobs University | rasdaman GmbH

[www.jacobs-university.de/isis](http://www.jacobs-university.de/isis) | [www.rasdaman.com](http://www.rasdaman.com)



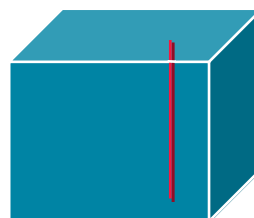
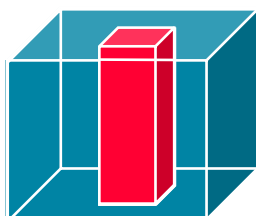
[gamingfeeds.com]

# 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*

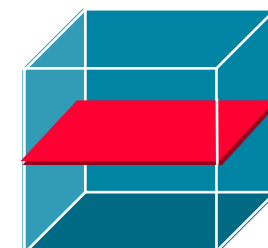
- Download a coverage (or a subset thereof), values **guaranteed unchanged**

- Ex: „*download coverage c001*“

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

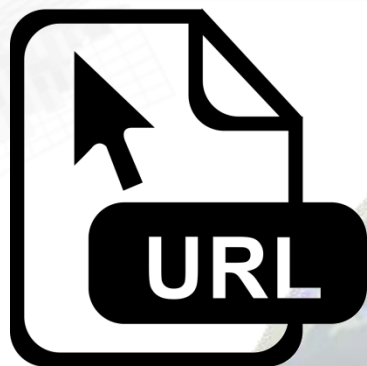
- Ex: „*coverage c001, lat/long cutout, time slice t=2009-11-06T23:20:52*“

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*”

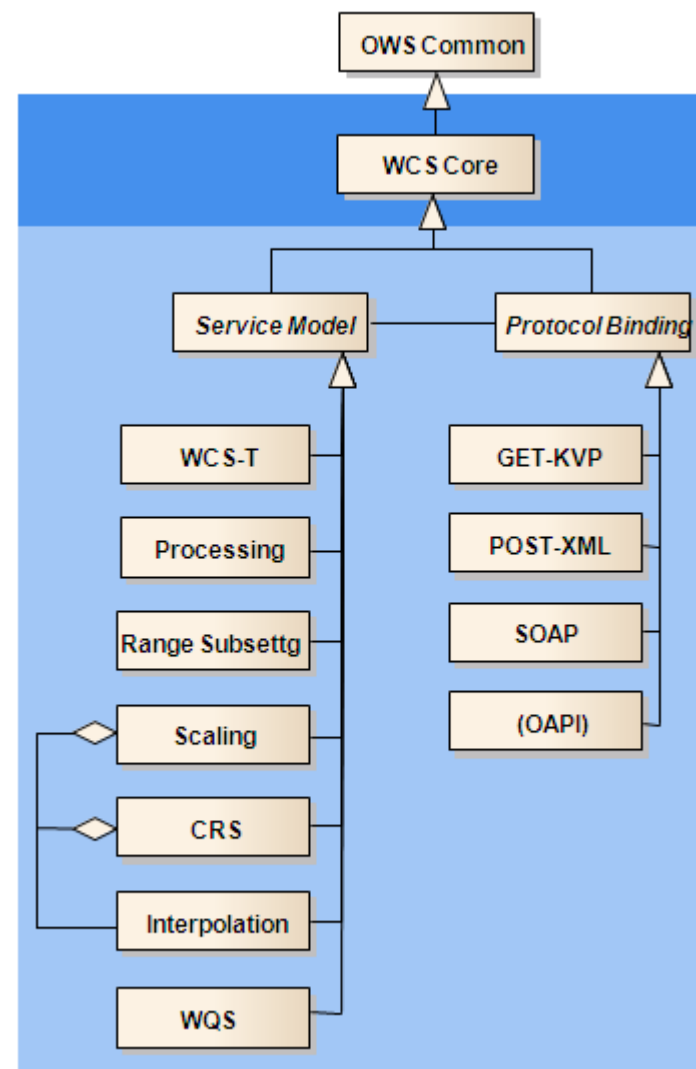
http://www.acme.com/wcs ? SERVICE=WCS & VERSION=2.0  
& REQUEST=GetCoverage & COVERAGEID=c001 & **FORMAT="image/tiff"**



**[standards.rasdaman.com](https://standards.rasdaman.com)**



# WCS Extensions (selected)



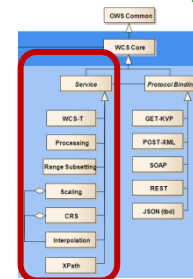
# WCS Range Subsetting

- Extract range components

- „bands“, „variables“

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

- *or:* `...& RANGESUBSET=nir,red,green &...`
- *or:* `...& RANGESUBSET=green,red,blue &...`
- *or:* `...& RANGESUBSET=nir:green &...`
- *or:* `...& RANGESUBSET=band01,band03:band05,band19:band21 &...`



# WCS CRS

- Express coordinates in CRSs different from Native CRS

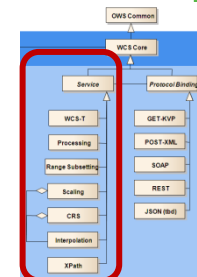
- Result coverage
- Subsetting coordinates

- Request: `http://www.acme.com/wcs ? SERVICE=WCS & VERSION=2.0  
& REQUEST=GetCoverage & COVERAGEID=c001  
& SUBSETTINGCRS=http://www.opengis.net/def/crs/EPSG/0/4326  
& OUTPUTCRS=http://www.opengis.net/def/crs/EPSG/0/4326`

- CRS definitions as URLs → OGC resolver

- EPSG + many more CRSs

- CRSs supported → Capabilities document



# WCS Transaction

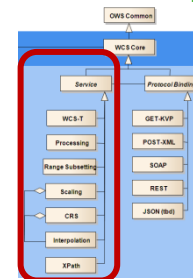
= **WCS-T**: Modify coverage offerings on a server via Web

- New request types:

*InsertCoverage* + *DeleteCoverage* + *UpdateCoverage* (incl. partial replacement)

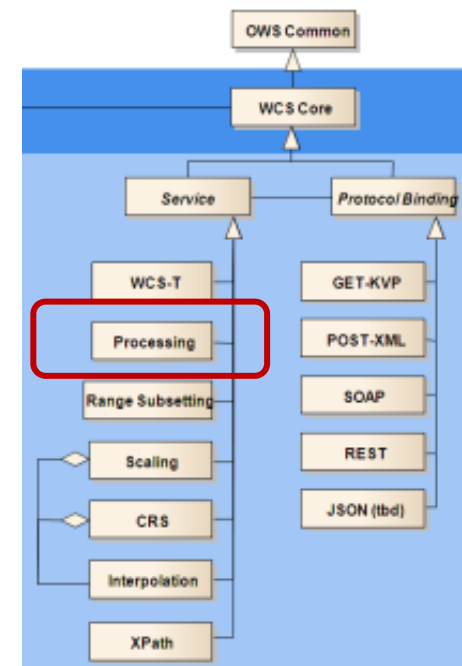
■ Core design goal: *GetCoverage* → *InsertCoverage*

■ Ex: <http://www.acme.com/wcs>  
 ? SERVICE=WCS & VERSION = 2.0  
 & **REQUEST=InsertCoverage**  
 & **COVERAGEREF=http://bcme.com/archive/hurricane.nc**  
 & **USEID=new**





# Web Coverage Processing Service (WCPS)



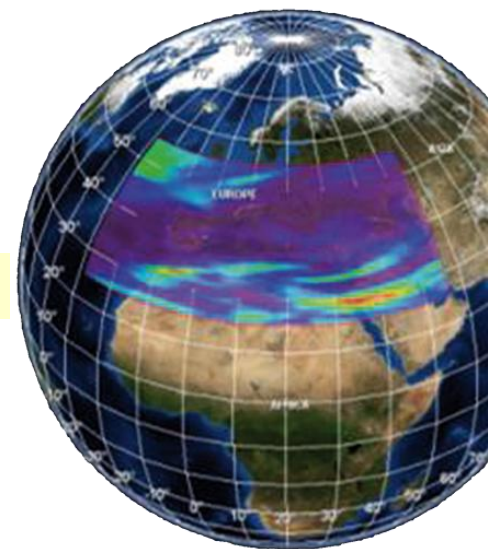
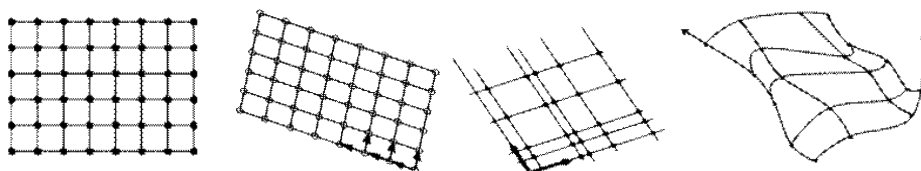
# OGC WCPS: Space/Time Datacubes

## ■ Web Coverage Processing Service (WCPS)

- spatio-temporal datacube analytics language

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

- space & time, regular & irregular grids

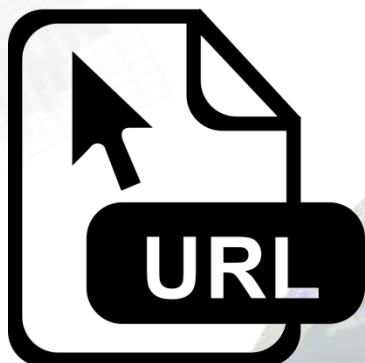


- "From MODIS scenes M1, M2, M3: difference red & nir, as TIFF"

- "...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]



**standards.rasdaman.com**  
**inspire.rasdaman.com**

# „Ship Code to Data“ -- *What Code to Ship?*

- ISO SQL & OGC WCPS are **safe in evaluation**
- programming languages (like python) are **not**



# COMMON SENSE

Just because you can, doesn't mean you should.



# Semantic Interoperability: WCPS vs WPS

- WCPS: semantics in query

```
for $c in ( M1, M2, M3 )
return encode abs( $c.red - $c.nir ), "hdf" )
```

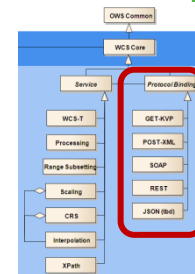
- WPS: semantics in human-readable text

```
<ProcessDescriptions ...>
  <ProcessDescription processVersion="2" storeSupported="true" statusSupported="false">
    <ows:Identifier>Buffer</ows:Identifier>
    <ows:Title>Create a buffer around a polygon.</ows:Title>
    <ows:Abstract>Create a buffer around a single polygon. Accepts the polygon as GML and
provides GML output for the buffered feature. </ows:Abstract>
    <ows:Metadata xlink:title="spatial" />
    <ows:Metadata xlink:title="geometry" />
    <ows:Metadata xlink:title="buffer" />
    <ows:Metadata xlink:title="GML" />
    <DataInputs>
      <Input>
        <ows:Identifier>InputPolygon</ows:Identifier>
        <ows:Title>Polygon to be buffered</ows:Title>
        <ows:Abstract>URI to a set of GML that describes the polygon.</ows:Abstract>
        <ComplexData defaultFormat="text/XML" defaultEncoding="base64" defaultSchema="http
://foo.bar/gml/3.1.0/polygon.xsd">
          <SupportedComplexData>
```



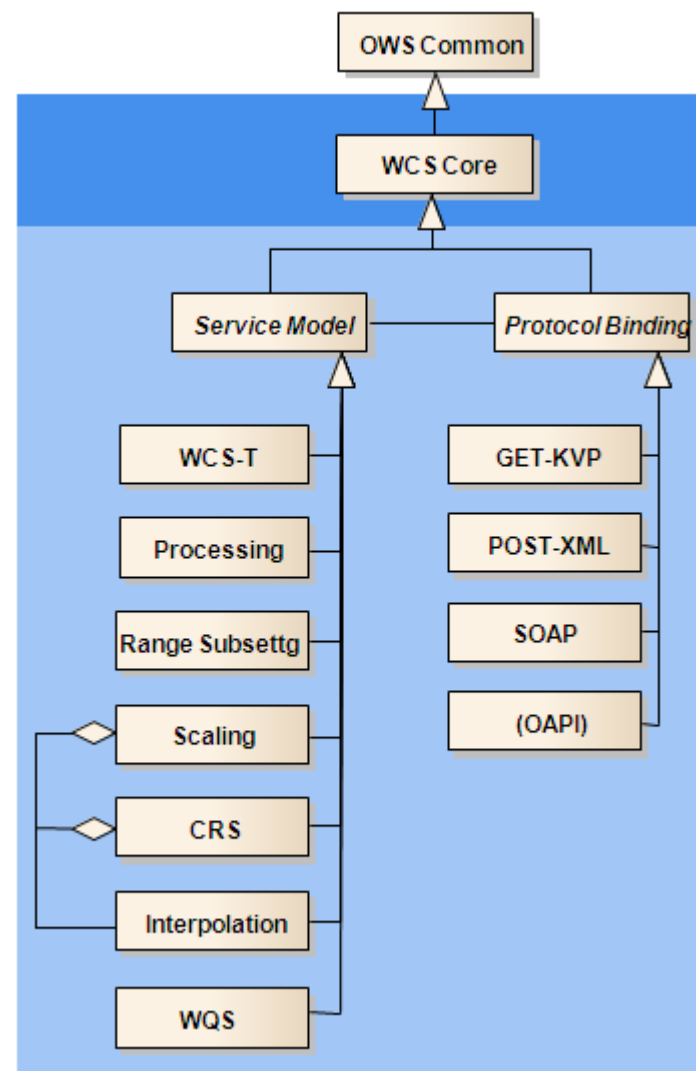
# WCS Protocol Bindings

- Up to now: GET/KVP in examples
- Same WCS functionality across various protocols:
  - GET/KVP [OGC 09-147r2]
  - XML-POST [OGC 09-148r1]
  - SOAP [OGC 09-149r1] + WSDL
  - OAPI
    - In progress: [https://github.com/opengeospatial/ogc\\_api\\_coverages](https://github.com/opengeospatial/ogc_api_coverages)



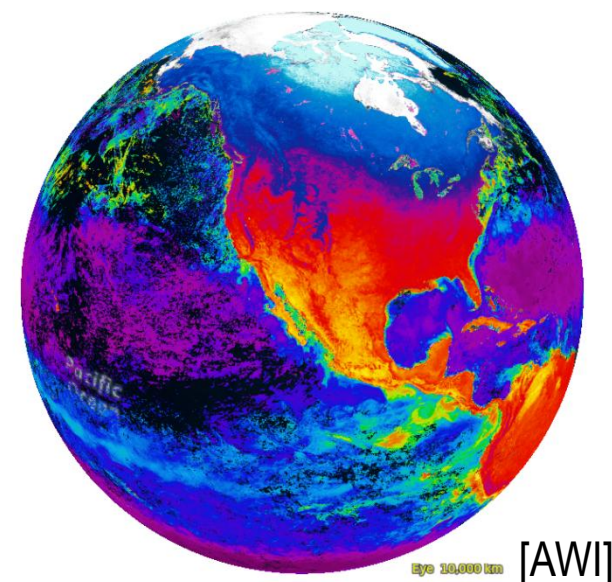
# In Progress: OAPI - Coverages

- Recent OGC activity towards unified W\*S interfaces
  - Catalog, WFS, WCS, WMS, WMTS, WPS
- OAPI-Coverages:
  - based on CIS 1.1
  - Workspace: [https://github.com/opengeospatial/ogc\\_api\\_coverages](https://github.com/opengeospatial/ogc_api_coverages)
- Basically quite similar functionality, new syntax & conventions
- Under active discussion in OGC
  - several open issues, work in progress



# WCS & WCPS: Summary

- OGC WCS **Core**
  - Coverage subsetting, formatting
- OGC WCS **Extensions**
  - Various bespoke functionality
- OGC **WCPS**
  - Spatio-temporal datacube analytics language
- pixel-level conformance tests for interoperability
- robust, scalable, mature
  - proven on multi-Petabytes in EarthServer



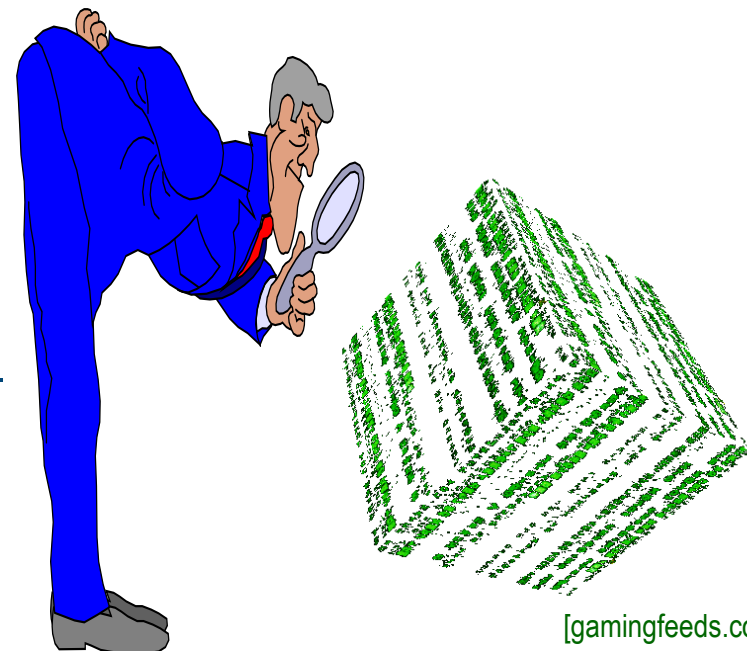


# INSPIRE WCS / WCPS

**the rasdaman team**

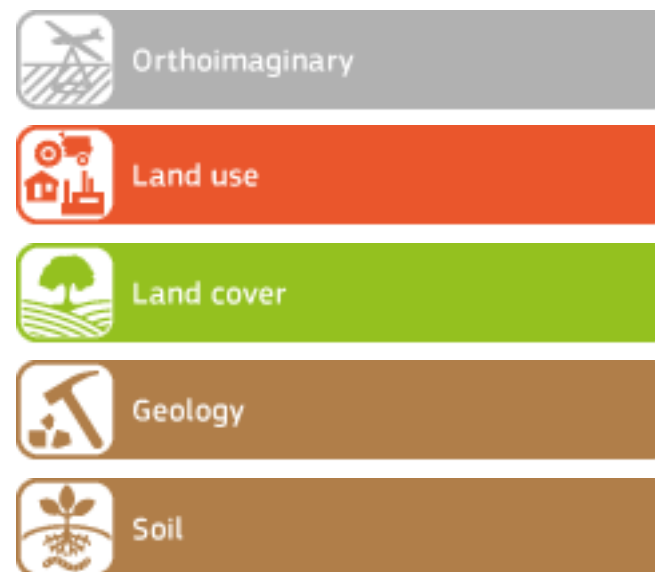
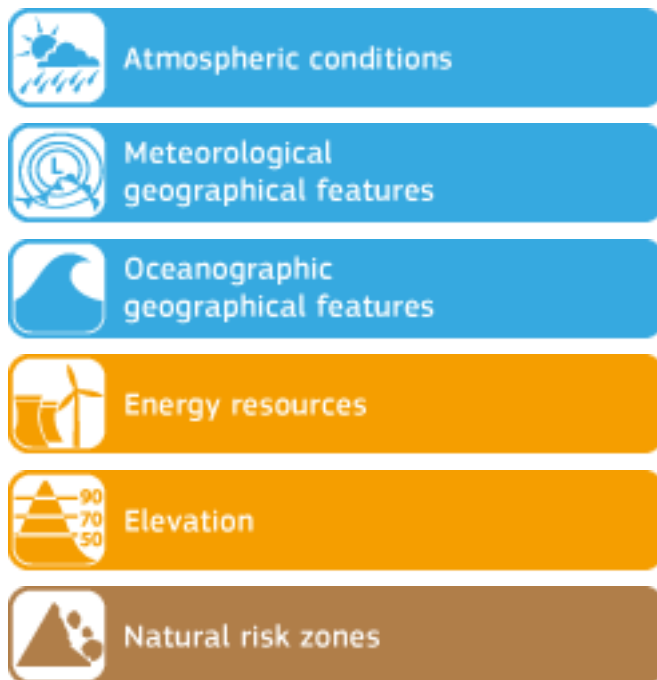
Jacobs University | rasdaman GmbH

[www.jacobs-university.de/isis](http://www.jacobs-university.de/isis) | [www.rasdaman.com](http://www.rasdaman.com)



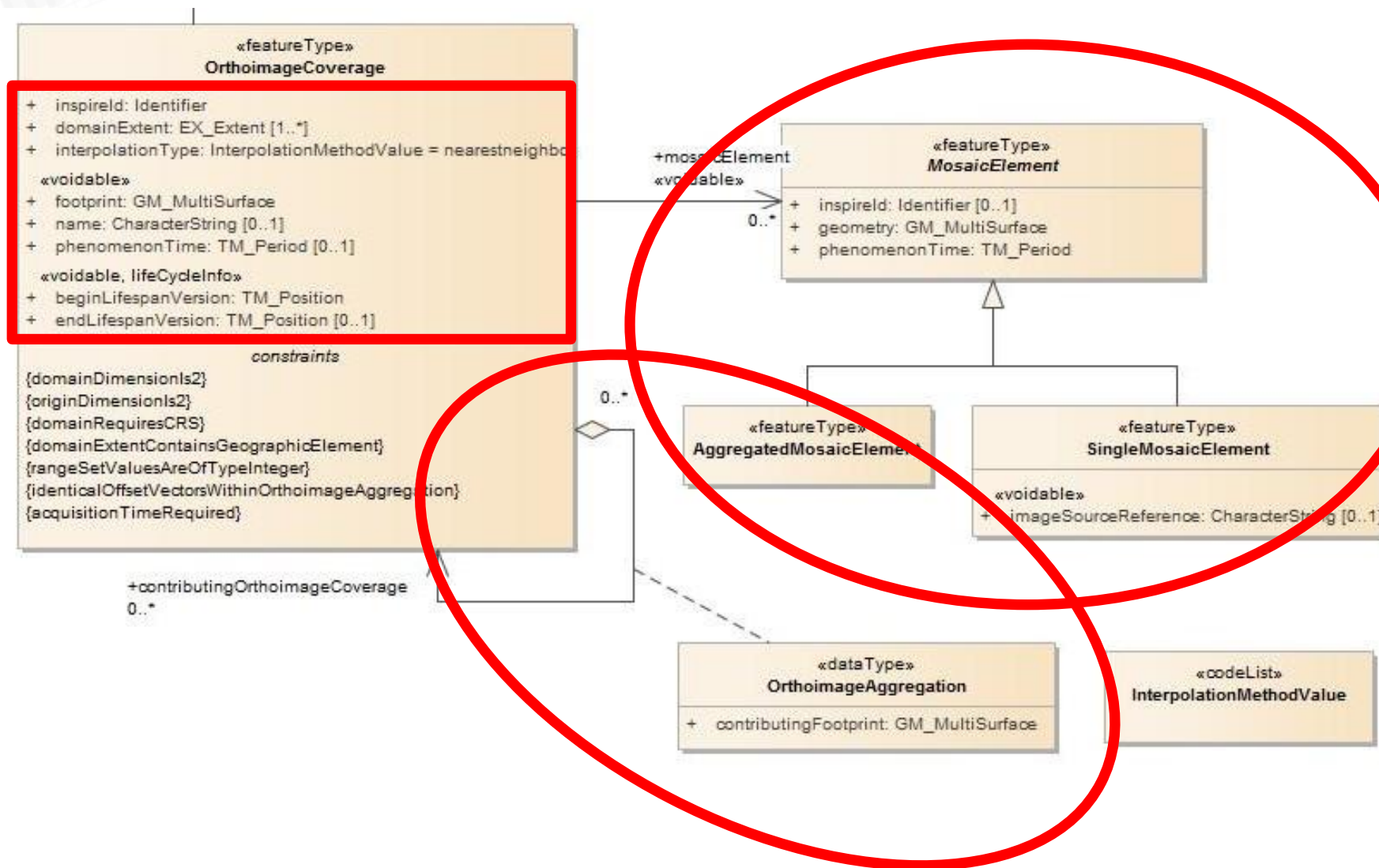
[gamingfeeds.com]

# Coverages in INSPIRE





# INSPIRE Coverage Data



# INSPIRE Coverage Services

- INSPIRE WCS  
for „Download Services“

- Alternatives: SOS, Atom

- At core only basic functionality

- Get data, get metadata, describe object, ...

- Recommended implementation: based on

- OGC WCS Core – mandatory
- OGC WCPS – optional



INSPIRE

Infrastructure for Spatial Information in Europe

**Technical Guidance for the implementation  
of INSPIRE Download Services using Web  
Coverage Services (WCS)**

# INSPIRE vs OGC Coverages

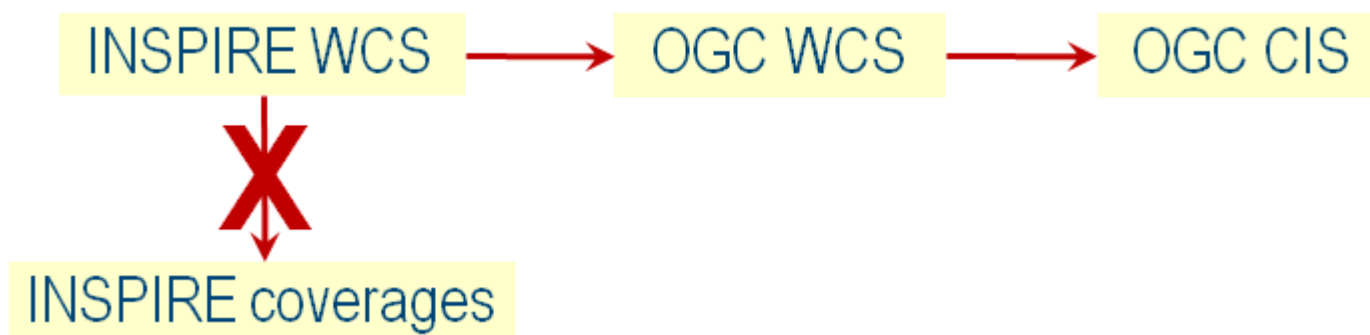
- INSPIRE WCS = OGC WCS
- OGC WCS normatively references OGC CIS

**Requirement 34/req/core/getCoverage-response-structure:**

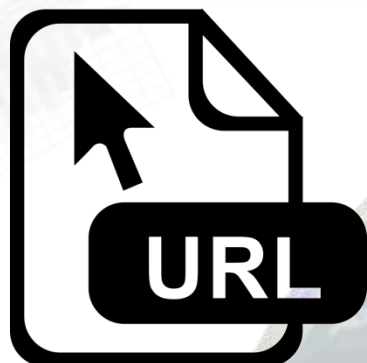
The contents of the response to a successful *GetCoverage* request **shall** be a concrete subtype of *AbstractCoverage*.

**Dependency:** <http://www.opengis.net/spec/GMLCOV/1.0/conf/gml-coverage>

- ...so INSPIRE WCS does **not** use INSPIRE coverages



- OGC CIS extensibility mechanism allows INSPIRE metadata



[inspire.rasdaman.org](https://inspire.rasdaman.org)



# Summary

- INSPIRE = active, ongoing process
  - Expert team → workable definitions
  - only rasdaman worked out → chosen as platform
- “Elevation & Orthoimagery data shall be provided using mainly the raster data spatial representation type – Coverages. WCS is the natural way to serve coverages.”
  - Jordi Escriu, INSPIRE Facilitator
- Via OGC WCS: **INSPIRE + Copernicus** harmonization



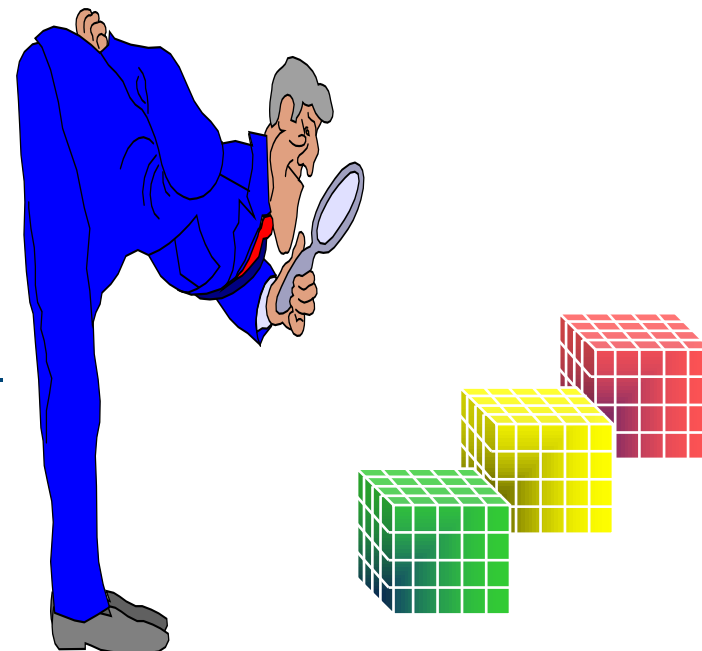


# rasdaman

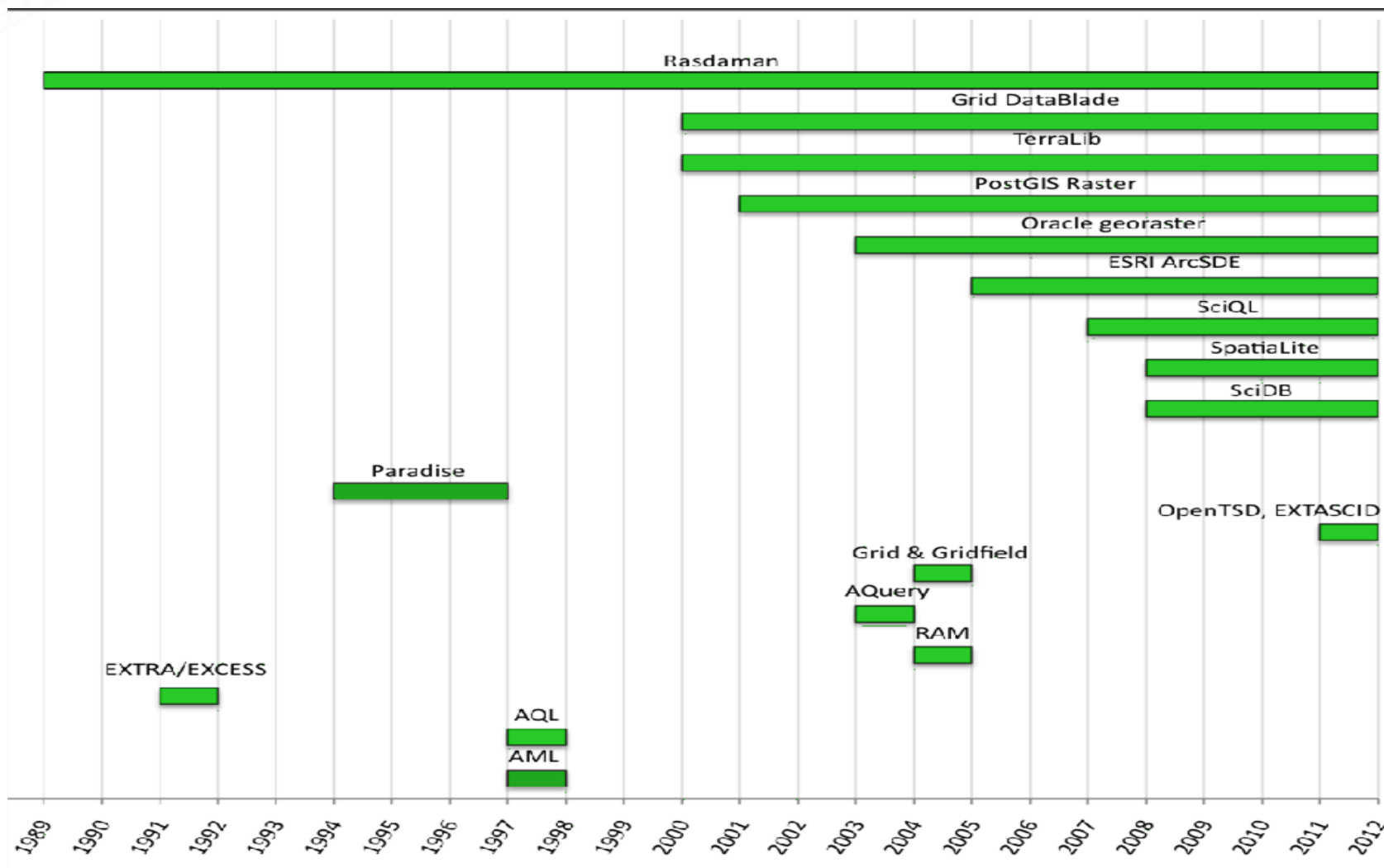
## the rasdaman team

Jacobs University | rasdaman GmbH

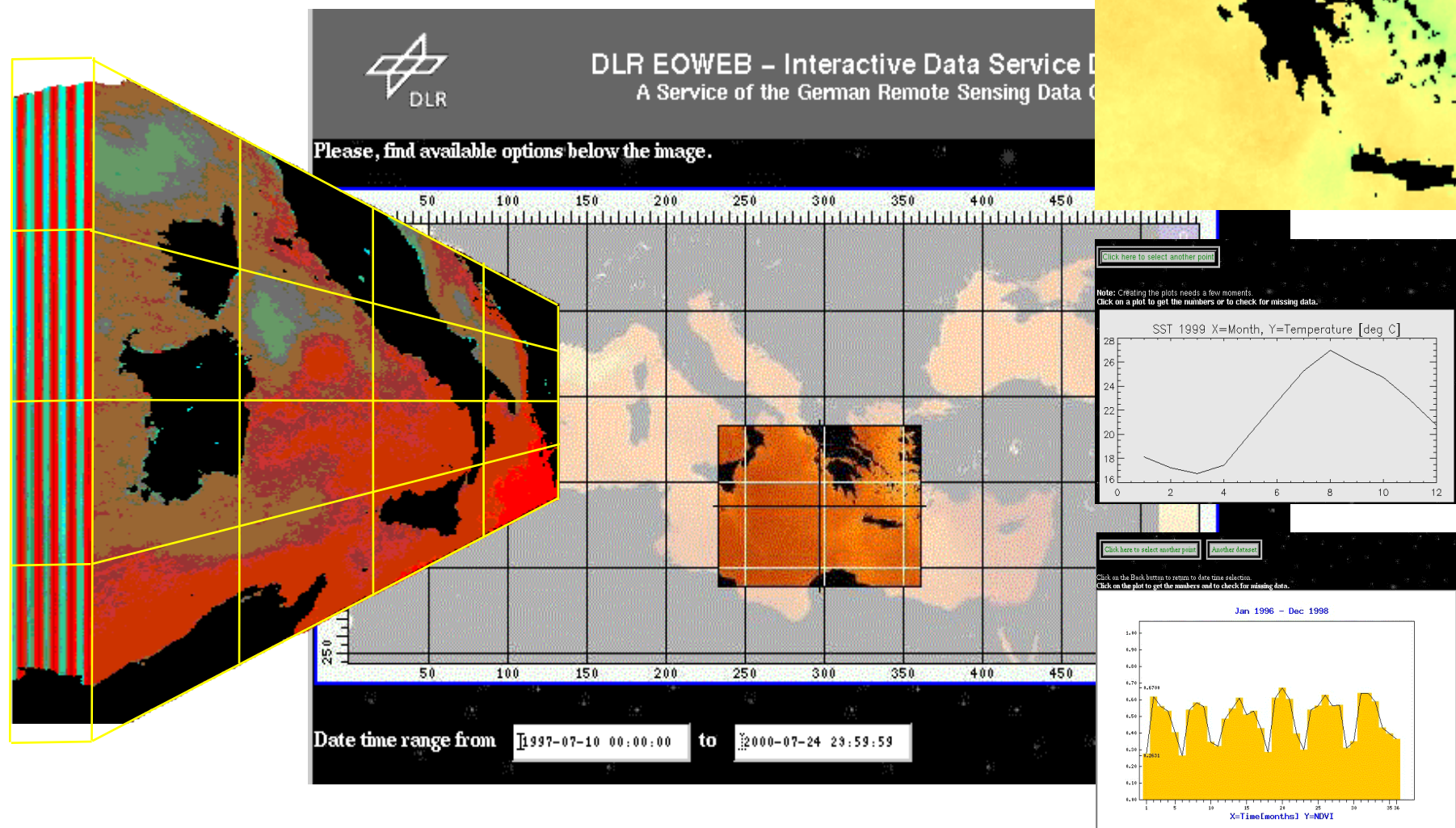
[www.jacobs-university.de/isis](http://www.jacobs-university.de/isis) | [www.rasdaman.com](http://www.rasdaman.com)



# A Brief History of Datacube Engines



# Ortho Image Timeseries



[Diedrich et al 2002, using rasdaman]

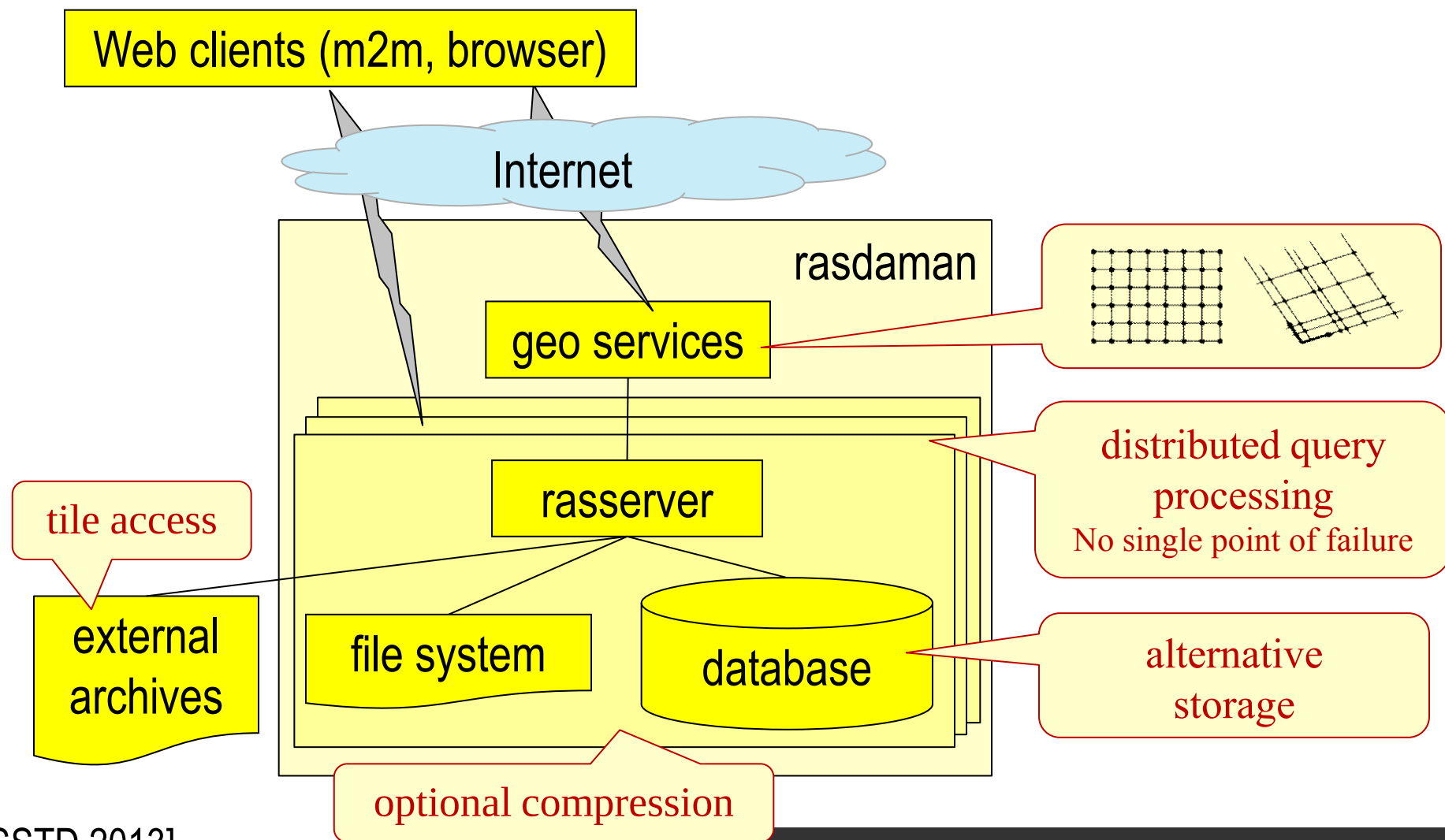
# rasdaman

= „raster data manager“: actionable n-D datacubes

- pioneered field (patents, publications)
- Full-stack scalable Big Datacube Analytics engine
  - multi-PB, planetary-scale federation
- reference implementation, series of innovation awards



# Architecture

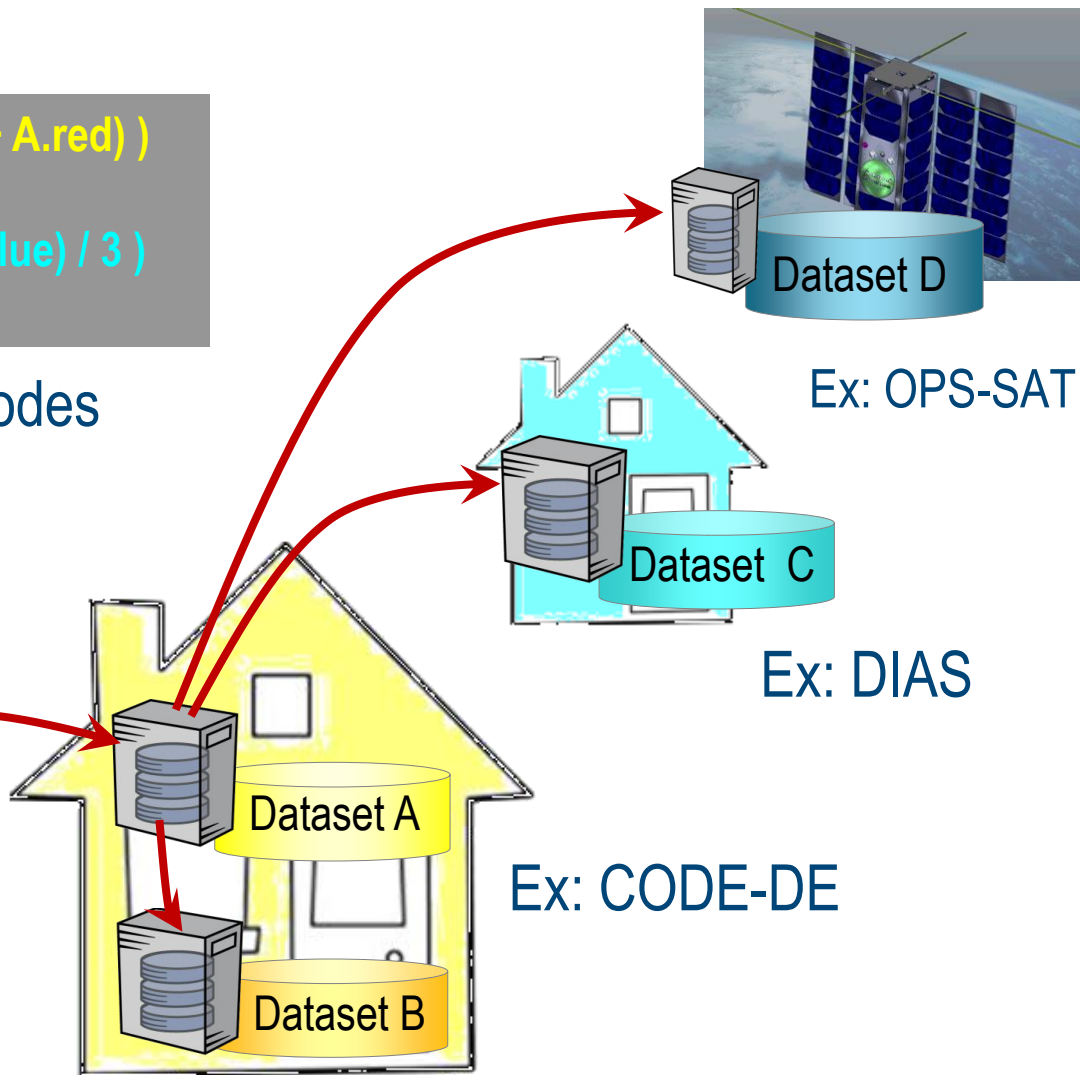




# Parallel, Distributed Processing

```
max( (A.nir - A.red) / (A.nir + A.red) )
+ avg(B.green)
+ max( (C.red + C.green + C.blue) / 3 )
+ max( (D.nir + D.red) / 2 )
```

1 query → 1,000+ cloud nodes



# Access Control

- Challenge: Datacubes too large for yes/no decision

- Ex: ECMWF climate timeseries



- Role-based access control + triggers

- Any user/role, any operation
- Full admin control

```
CREATE TRIGGER ForbiddenArea
WHEN some_cells( accessed( MyCov, [50:100,*:] ) )
BEGIN exception "Nope." END
```

- Authentication & authorization

- External identity provider (OGC Testbed-15)

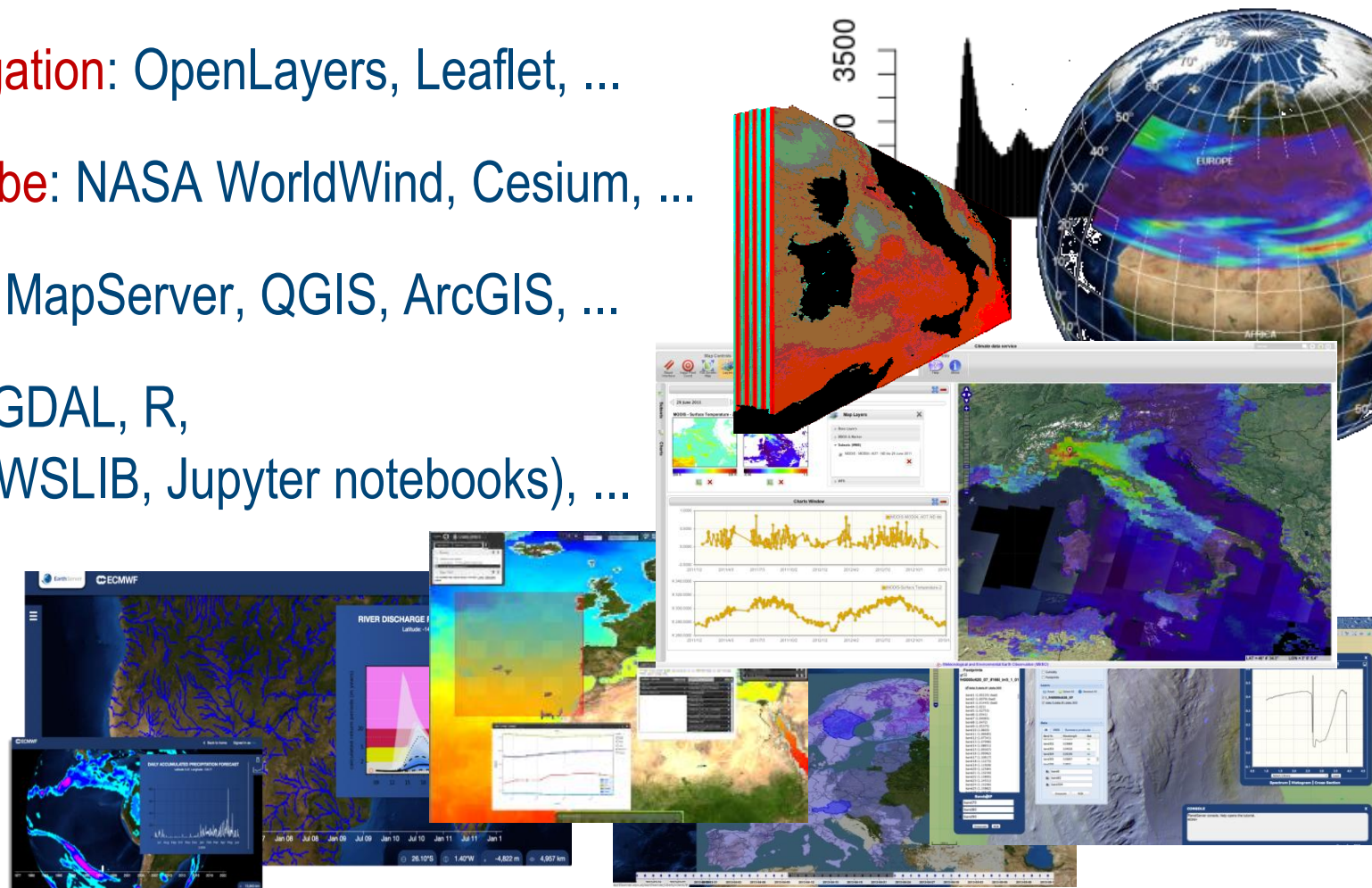
```
CREATE TRIGGER ForbiddenArea
WHEN context.resultsize > 1000000000
BEGIN exception "Not over 1 GB." END
```

- Quota: access, download, processing

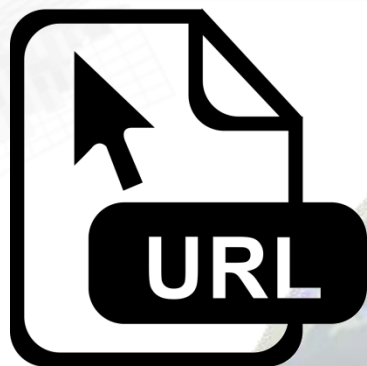
- Billing records

# Bring Your Favourite Client

- Open standards → users remain in comfort zone of well-known tools
- **Map navigation:** OpenLayers, Leaflet, ...
- **Virtual globe:** NASA WorldWind, Cesium, ...
- **Web GIS:** MapServer, QGIS, ArcGIS, ...
- **Analysis:** GDAL, R, python (OWSLIB, Jupyter notebooks), ...



[screenshots: rasdaman-based portals]

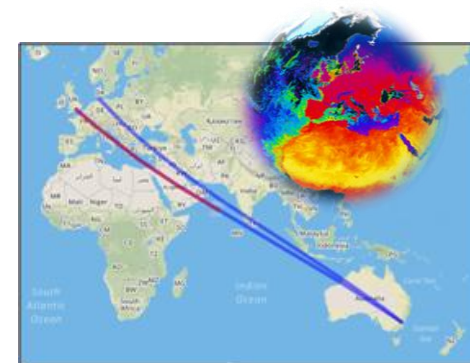
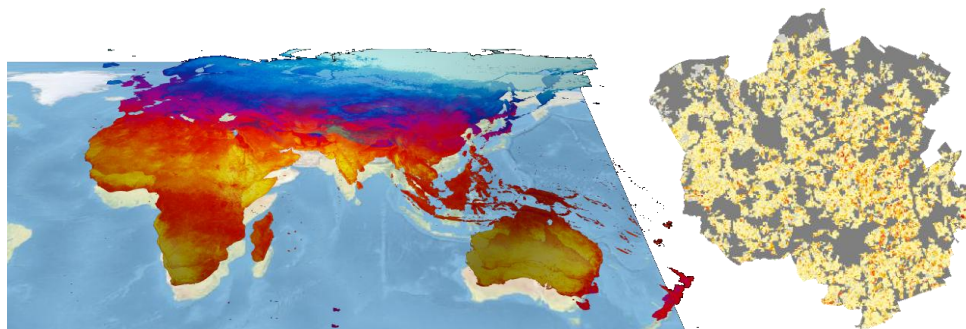
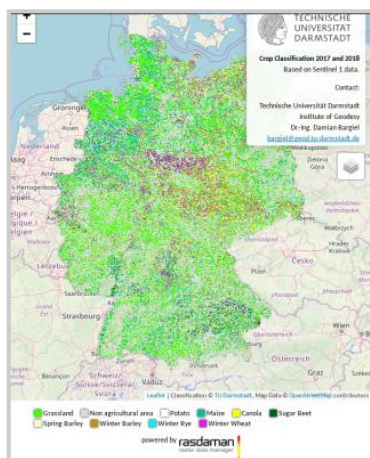


**[standards.rasdaman.com](https://standards.rasdaman.com)**



# Summary

- rasdaman = declarative, high-level datacube queries
  - + scalable architecture
  - + location-transparent federation
  - + security
- full-stack distributed datacube engine
- blueprint for ISO SQL/MDA, OGC WCPS
- [www.rasdaman.org](http://www.rasdaman.org), [www.rasdaman.com](http://www.rasdaman.com)



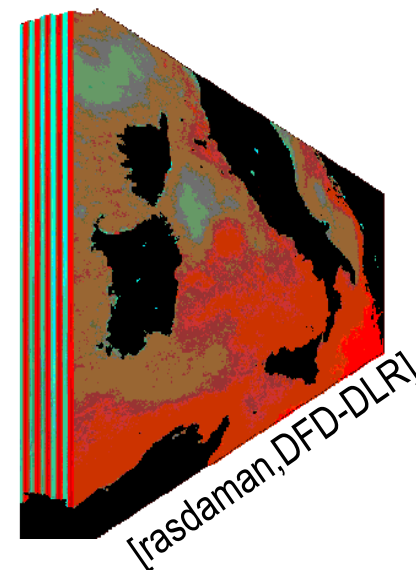


# Why Standards?



# 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: std bodies, major tools & vendors
- rasdaman: actionable raster coverages & datacubes
  - 20+ PB, 1000x parallelization, federations, security, clients; reference implementation



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

# Resources

- EarthServer federation portal (under development): [www.earthserver.eu](http://www.earthserver.eu)
- OGC authoritative standards page
  - [schemas.opengis.net/cis](http://schemas.opengis.net/cis), [schemas.opengis.net/wcs](http://schemas.opengis.net/wcs)
  - [www.opengeospatial.org/standards/wcs](http://www.opengeospatial.org/standards/wcs), [www.opengeospatial.org/standards/wcps](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](http://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/>
- rasdaman Reference Implementation: [www.rasdaman.org](http://www.rasdaman.org)



***Your opinions, please:***  
**what will future services look like?**