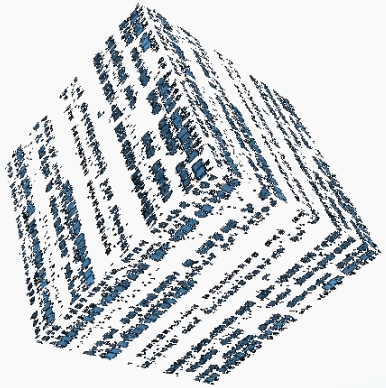


News from Datacube Land: rasdaman, Standards, and Federation

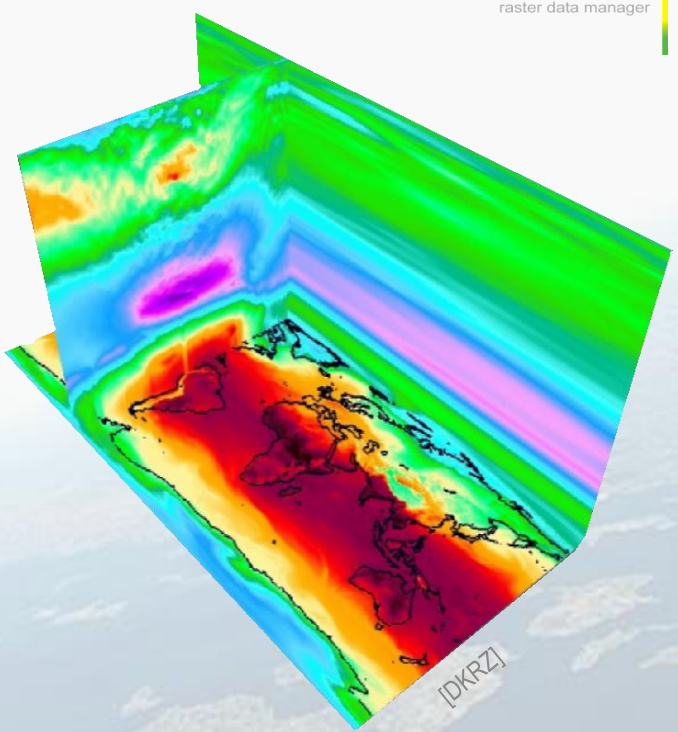
AWI Seminar, virtual, 2023-04-26

Peter Baumann

Constructor University | rasdaman GmbH

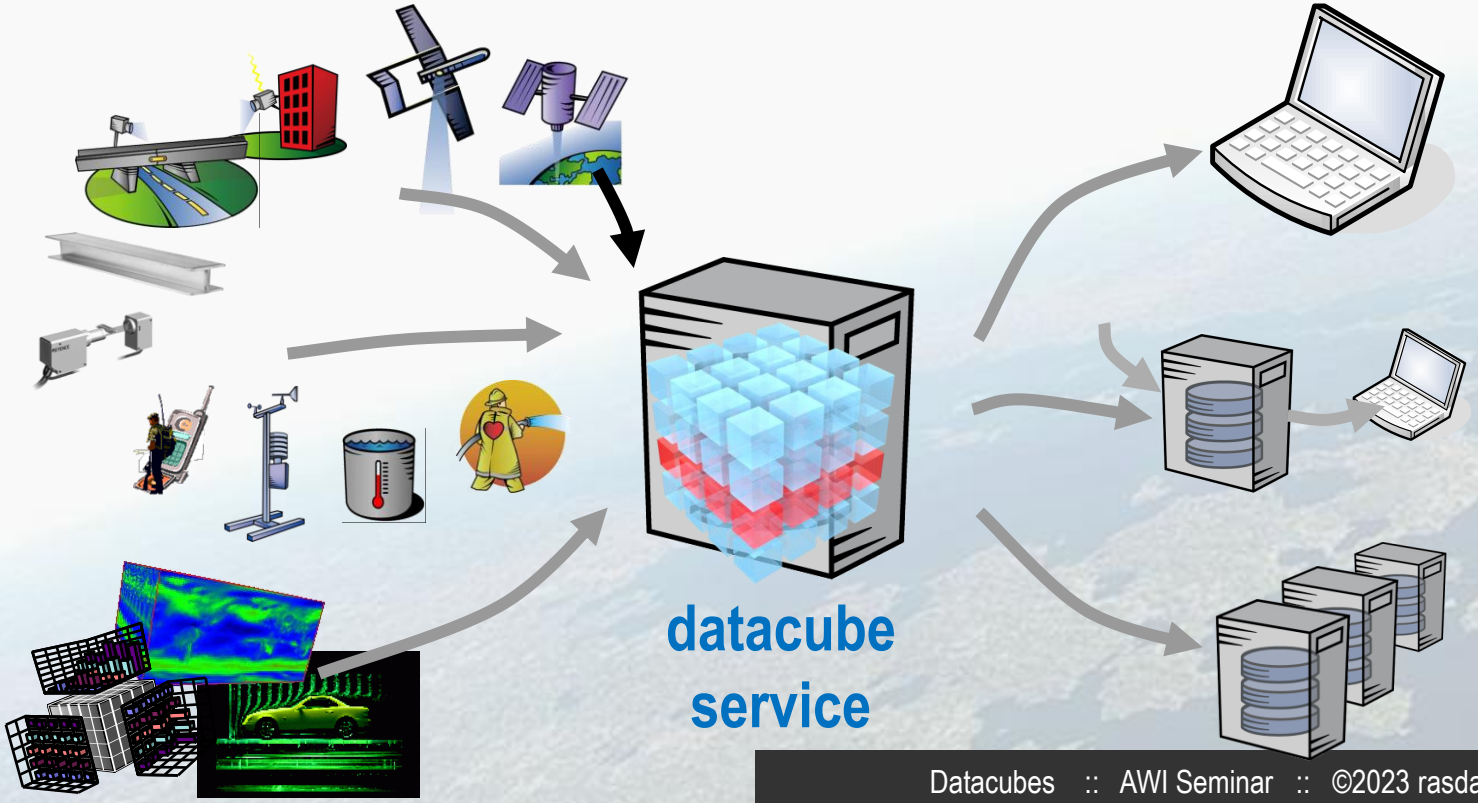
rasdaman
raster data manager

Why Datacubes?



- natural paradigm
  to interact with
  spatio-temporal, n-D data
- Accepted cornerstone for
  Analysis-Ready Data,
  Digital Twins

Homogenized, Analysis-Ready Datacubes



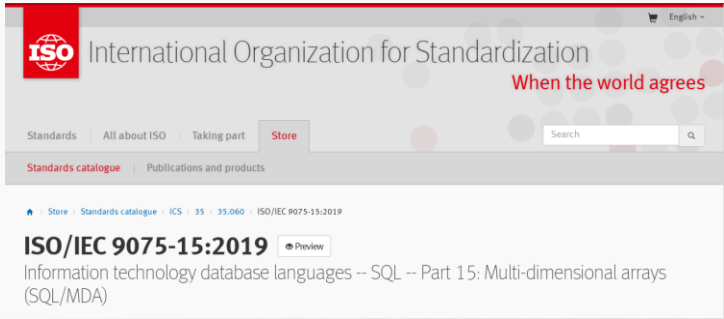
rasdaman

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

- pioneered, see 200+ publications & patents

- scalable Big Datacube Management & Analytics
  - Zero-coding, high performance & scalability, federation, security, clients
  - Mature full-stack implementation
  - Successfully from European research into international markets

- Official OGC Reference Implementation & INSPIRE Good Practice



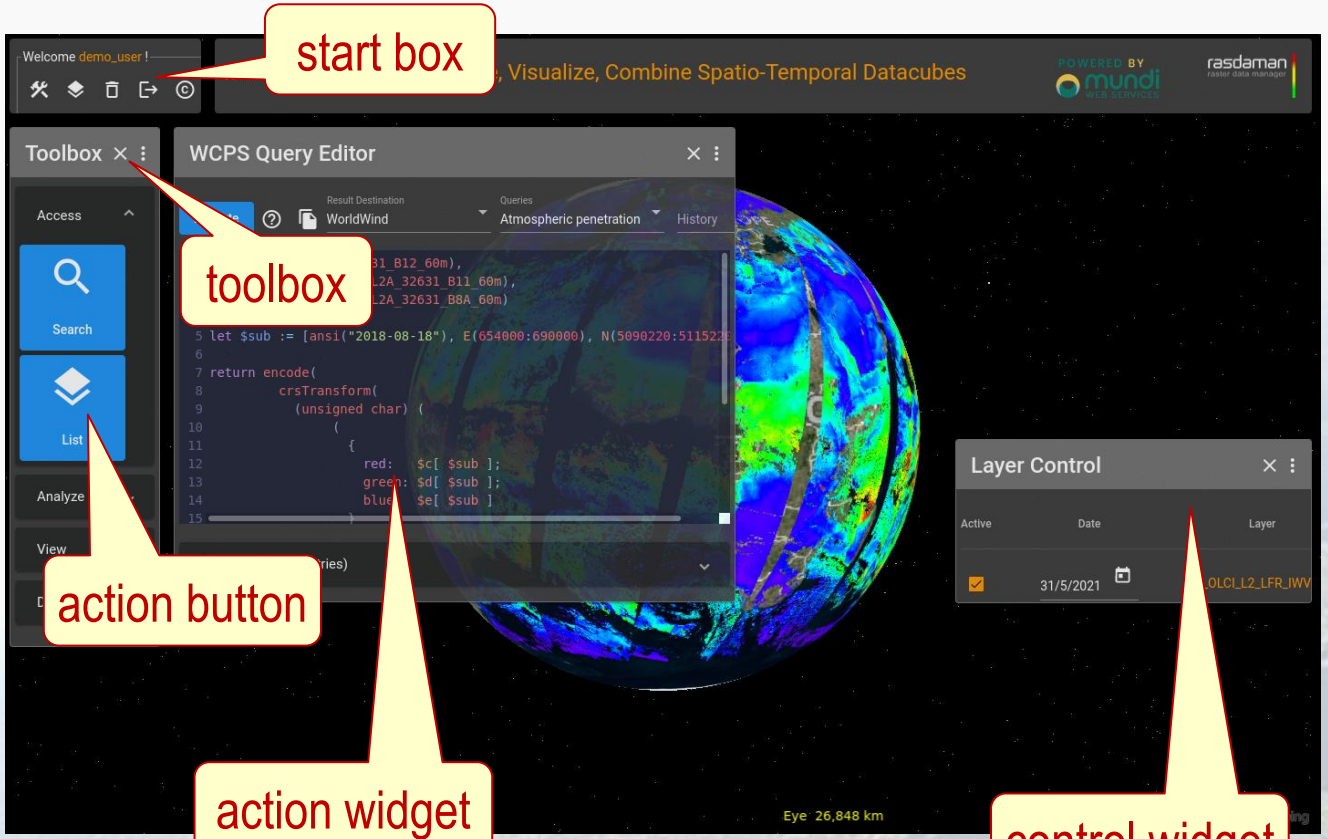
What's new in rasdaman

- Completely overhauled query engine: JIT
  - substantially increased performance, reduced memory usage
- New powerful query operators, such as sort
- Virtual coverages: integrated datacubes from heterogeneous coverages
- Innovative Web dashboard frontend
- Role-Based Access Control, fine-grain and across federations
- Billing & quota support
- Enhanced automated datacube management

Virtual Coverages

- DIAS archives offer Sentinel granules
  - Individual UTM zones
  - Archive too big to copy
- Step 1: homogenize within UTM zone
  - Coverage references granules through in-situ mechnism
  - Data access →extract pixel set from relevant granules
- Step 2: virtual coverage over UTM coverages
  - Super-coverage = virtual single homogeneous coverage
  - Data access in arbitrary CRS →extract from relevant UTM coverages, auto-reproject
  - Query optimization: only files relevant, omit reprojection if unnecessary, ...

rasdaman Dashboard

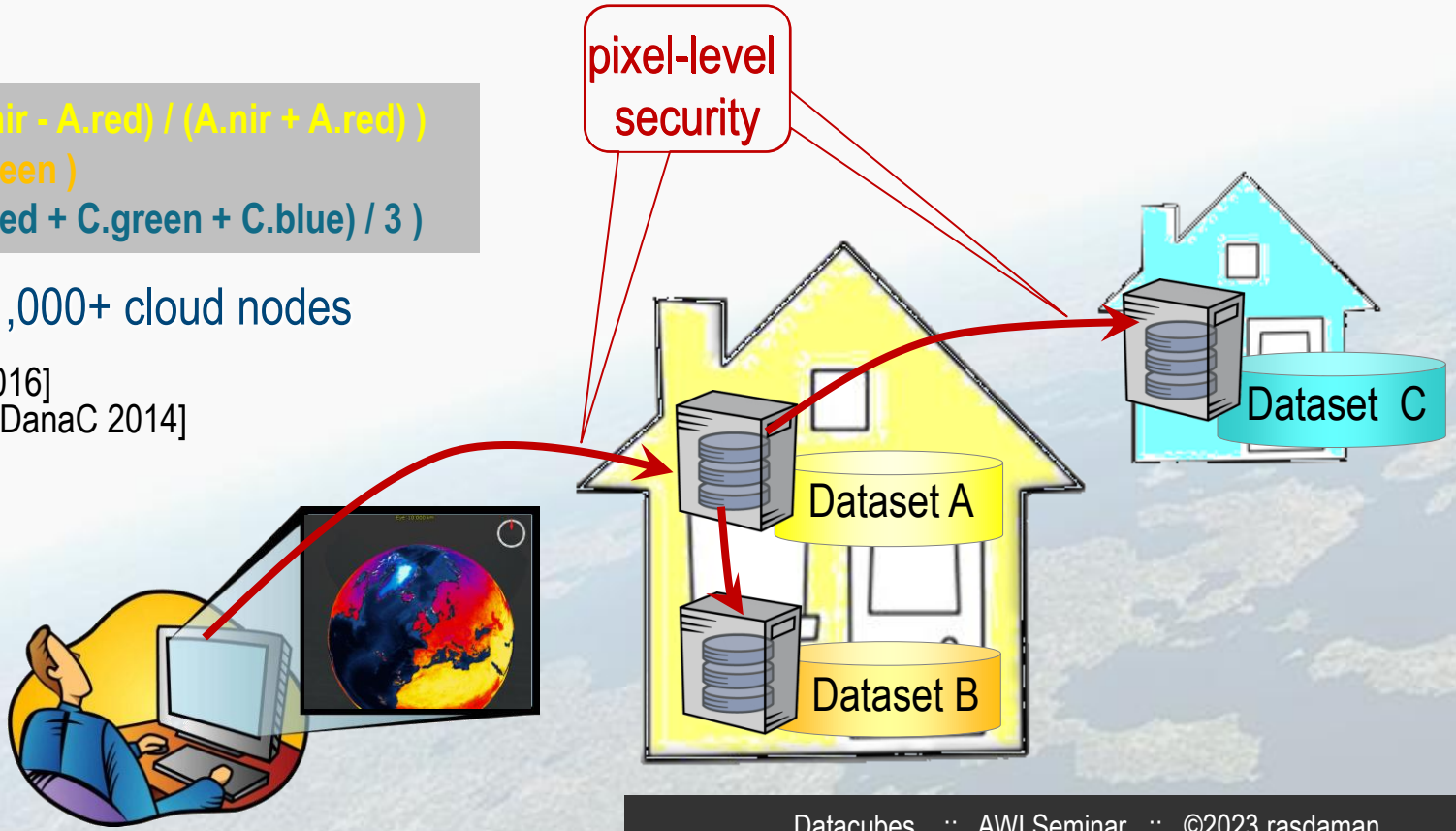


Parallel, Distributed Processing

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

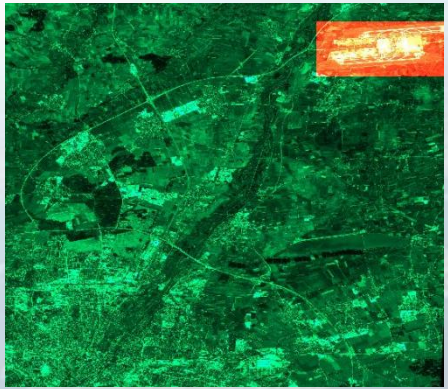
1 query → 1,000+ cloud nodes

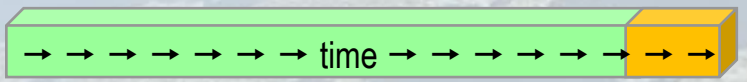
[VLDB BOSS 2016]
[ACM SIGMOD DanaC 2014]



Security

- Role-Based Access Control: users ← roles ← privileges
  - Full admin control, retained also in federation
  - Configurable policies
- Authorization down to single pixel
  - any region
- Quota & billing

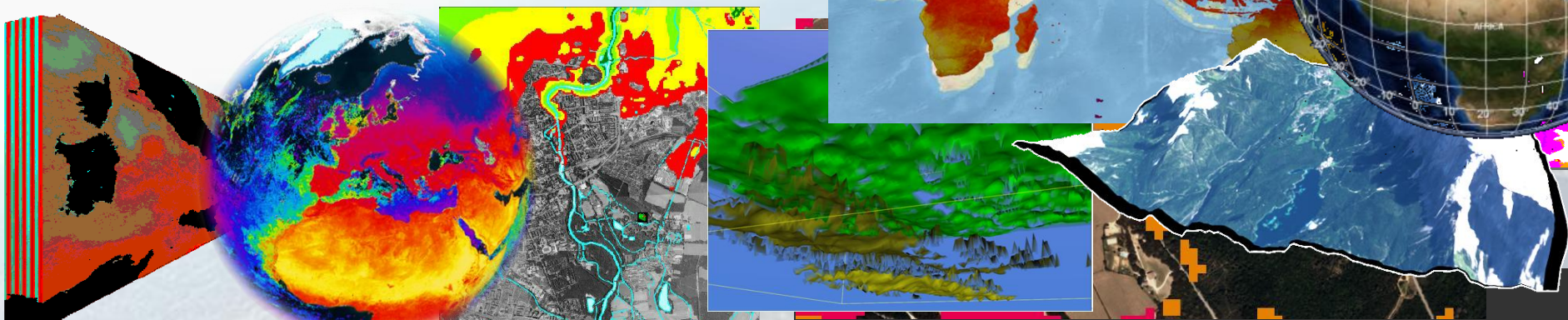


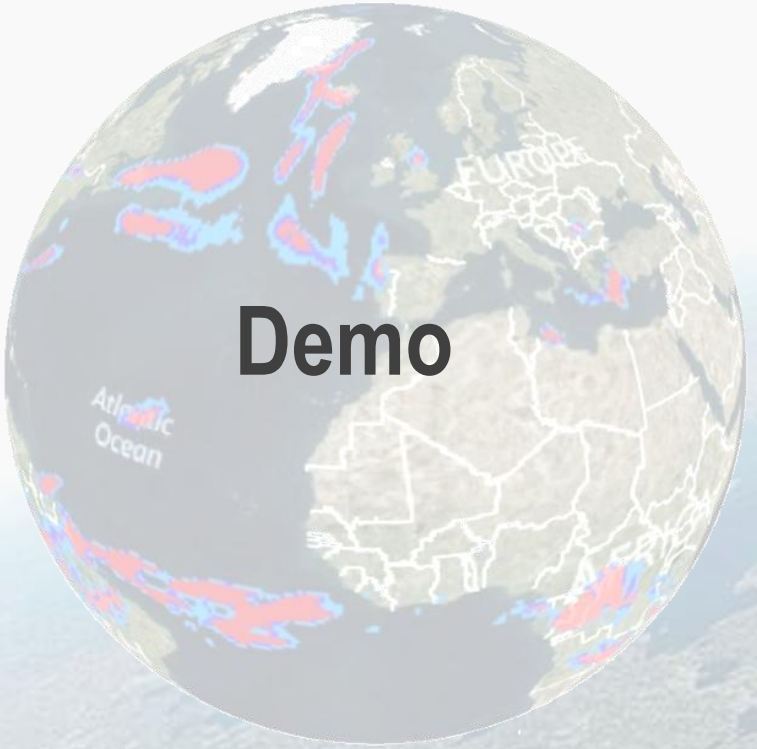


rasdaman
raster data manager

Comfort Zone of Well-known Clients

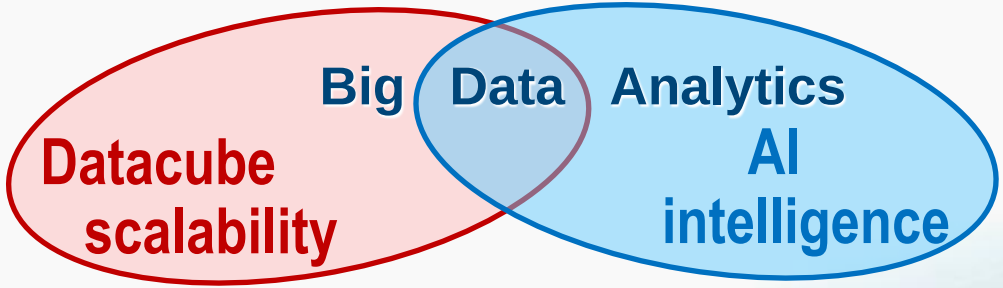
- Map navigation: OpenLayers, Leaflet, ...
- Virtual globe: NASA WorldWind, Cesium, ...
- Web GIS: QGIS, ArcGIS, ...
- Analytics: GDAL, R, python, ...
- Visualization: paraview, ...





Demo

AI-Cube



- federated EO datacubes + advanced EO AI + natural language processing
- BigEarthNet Large-Scale Benchmark Archive
  - 590,326 tagged Sentinel-1/2 pairs

- Jacobs University, TU Berlin, rasdaman GmbH; Sep 2021, 18 months

Bundesministerium für Ernährung und Landwirtschaft

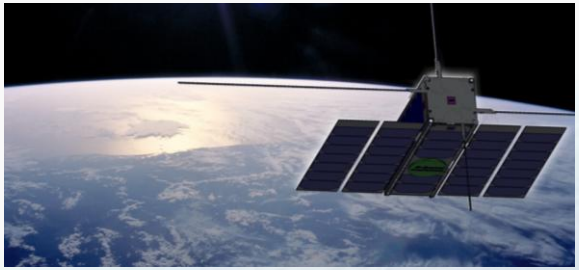
ai-cu.be

Real-time Moving Source Integration

- drone → 5G → rasdaman datacube → visual client
  - DLR MACSnano on Vector UAV, 1 image/sec
  - 2 seconds latency
- Live @ Sep 2022 NATO C-UAS tech show

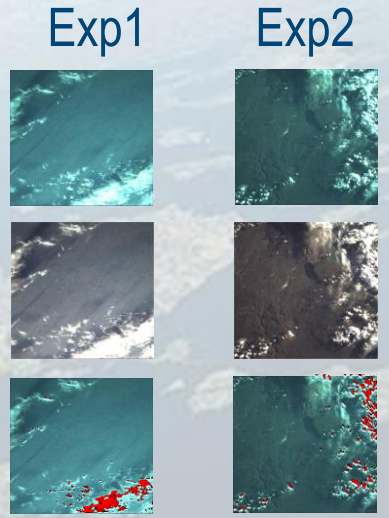
NATO OTAN
This project is supported by: The NATO Science for Peace and Security Programme

ORBiDANSe



= Orbital Big Data Analytics Service

- „Process close to source“ → datacube engine on nanosat
- Answer analytics questions = avoid full download
  - Save bandwidth
  - Deliver insight, not pixels



Ex 1: (naive) radiometry correction

Ex 2: (naive) cloud mask

Federal Ministry
for Economic Affairs
and Climate Action

Federation

Connecting Datacube Lakes into Spaces

- Increasing number of Datacube Lakes by individual institutions
- Connecting into Data Space through federation
- Many initiatives, like GAIA-X and EarthServer
- EarthServer: location-transparent datacubes

EarthServer

- datacube provider federation
  - 140+ PB location-transparent data space
  - Open standards, zero-coding
- Open, free, transparent, democratic
  - Open & private; free & commercial
- Latest: NCHC Taiwan

earthserver.xyz

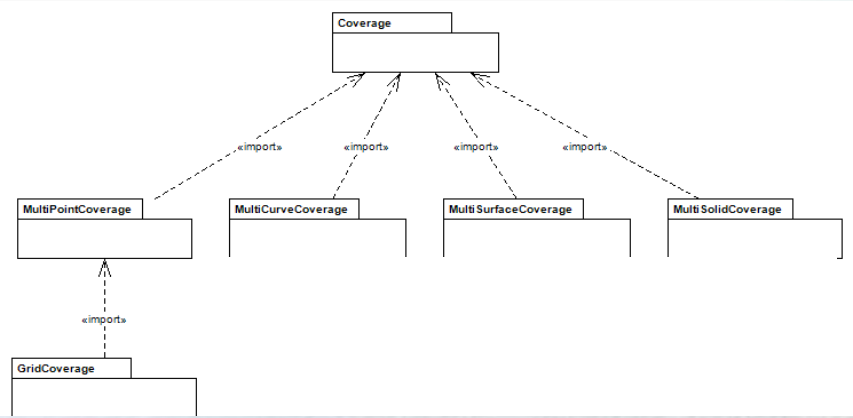
Standards

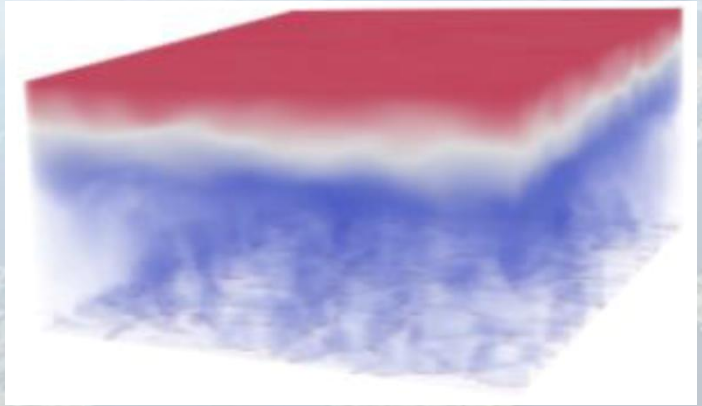
Why Standards?

[www.jhchoppers.com]

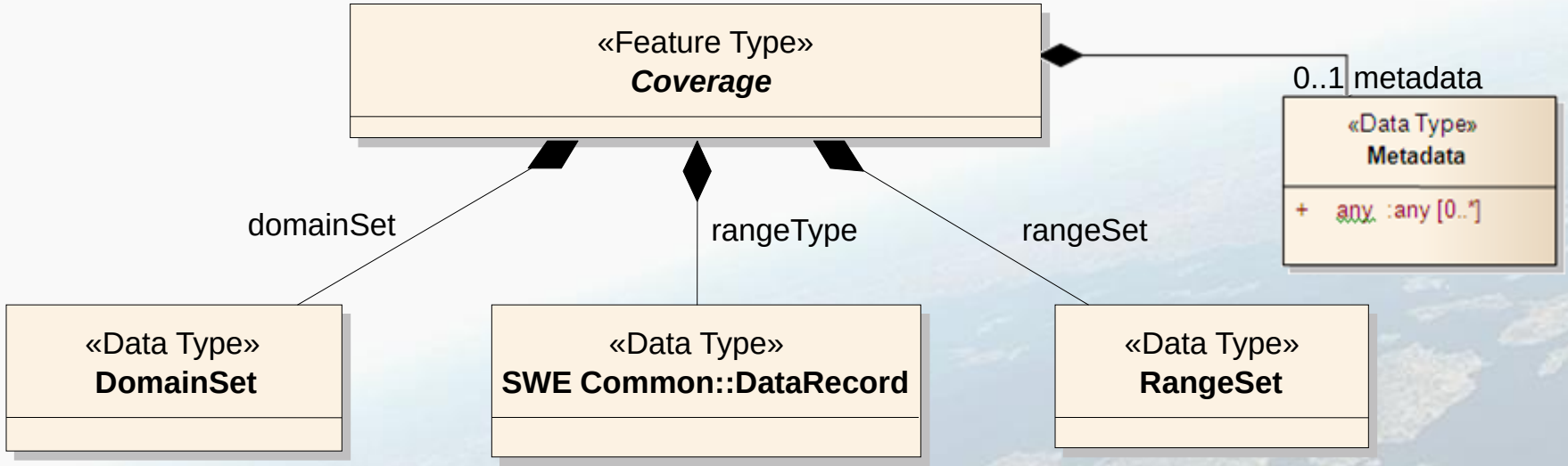
Datacubes & Coverages

- In standardization: coverage = digital representation of (physical) field
  - In practice: regular & irregular grids, point clouds, general meshes
- Space, time, other axes; discrete & continuous





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
                              &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" .
```

ISO Coverages

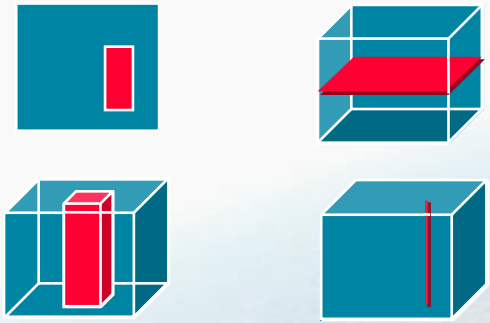
	Geometry/data model	Function/processing model
abstract	**19123-1** Coverage Fundamentals = *OGC AT6* adopted	**19123-3** Coverage Processing Fundamentals = *OGC WCPS* adopted
concrete	**19123-2** Coverage Implementation Schema = *OGC CIS* todo: CIS 1.0 → CIS 1.1	**19123-4** Coverage Services = *OGC WCS & OAPI-Coverages ?* Potential future

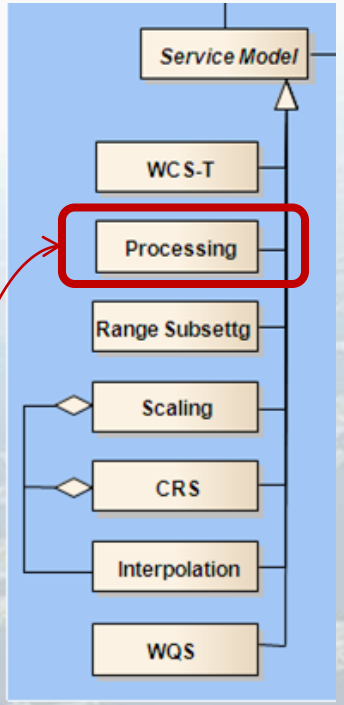
OGC Coverages

- Coverage data model: Coverage Implementation Schema (CIS)
  - = ISO 19123-2
  - CIS 1.1 adds General Grid Coverage aka datacubes
  - Open-ended encodings
- Coverage service models:
  - WCS suite (mature, proven)
  - OAPI-Coverages (under construction since 5+ years)
  - Environmental Data Retrieval (EDR): generic, little semantics
- *Note: WMS = pictures, WCS = data*

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, including WCPS
- *rasdaman implements WCS Core & all extensions, reference implementation*

Conclusion

- rasdaman v10: substantial enhancements, readily available to AWI
- EarthServer: location-transparent federation – aka Datacube Space
  - Copernicus, atmospheric, land governance, and many more – continuously growing
- ...all based on open coverage standards
- Questions? baumann@rasdaman.com