Using GeoServer for spatio-temporal data management with examples for MetOc and remote sensing

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19th November 2013
Outline

- Who we are
- The Building Blocks
- More on GeoServer
  - NetCDF
  - ImageMosaic PLugin
  - OGC Services
- Real World Use-Cases

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GeoSolutions

- Founded in Italy in late 2006
- Expertise
  - Image Processing, GeoSpatial Data Fusion
  - Java, Java Enterprise, C++, Python
  - JPEG2000, JPIP, Advanced 2D visualization
- Supporting/Developing FOSS4G projects
  - MapStore, GeoServer
  - GeoBatch, GeoNetwork
- [http://www.geo-solutions.it](http://www.geo-solutions.it)
GeoServer

- GeoSpatial enterprise gateway
  - Java Enterprise
  - Management and Dissemination of raster and vector data
- Standards compliant
  - OGC WCS 1.0, 1.1.1 (RI), 2.0.1
  - OGC WFS 1.0, 1.1 (RI), 2.0
  - OGC WMS 1.1.1, 1.3
  - OGC WPS 1.0.0
  - OGC CSW 2.0.2
- Google Earth/Maps support
  - KML, GeoSearch, etc..
Formats and Protocols

- **Shapefile**
- **PostGIS**
  - Oracle
  - H2
  - DB2
  - SQL Server
  - MySql
  - Spatialite
  - GeoCouch

**ArcSDE WFS**

**GeoTIFF**

**WMS**
- ArcGrid
- GTopo30
- Img+World
- Mosaic
- MrSID
- JPEG 2000
- ECW, Pyramid, Oracle GeoRaster, PostGis Raster

**GeoServer**

- **WMS**
  - 1.1.1
  - 1.3.0
- **WFS**
  - 1.0, 1.1, 2.0
- **CSW**
  - 2.0.2
- **WPS**
  - 1.0.0
- **WCS**
  - 1.0.1.1, 2.0.1
- **GWC**
  - (WMTS, TMS, WMS-C)

**Servers**

**DBMS**

**Vector files**

**Servers**

**GeoServer**

**Styled maps**

- PNG, GIF
- JPEG
- TIFF, GeoTIFF
- SVG, PDF
- KML/KMZ

**Raw vector data**

- Shapefile
- GML2
- GML3
- GeoRSS
- GeoJSON
- CSV/XLS

**Raw raster data**

- GeoTIFF
- ArcGrid
- GTopo30
- Img+World

**KML superoverlays**

- Google maps tiles
- OGC tiles
- OSGEO tiles

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MapStore

- Create and manage maps and mashups
- The Map is the key resource
  - Definition of data sources (e.g. WMS)
  - Definition and Layout of widgets
- Main features
  - Map Creation → you can create personal maps
  - Map Browsing → you can navigate existing maps
  - Map Sharing → you can share maps
  - Map Security → you can define access rights
- Open source
  - https://github.com/geosolutions-it/mapstore

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Standards Supported

- We believe in standards, whether internationally recognized
  - WMS: 1.1.1, 1.3.0
  - WFS: 1.0.0, 1.1.0
  - WPS: 1.0.0
  - WMTS: 1.0.0
  - TMS: 1.0.0
  - CSW: 2.0.2
  - KML: XXX
- Or de-facto
  - GeoJSON
  - GeoRSS

Thanks to OpenLayers 😊

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GeoBatch

- Geospatial batch ingestion/processing system
  - Event based processing
  - Time based processing (periodic, one-off, based on Quartz)
- Tools for automatic collection, processing and publication of data
- Open Source leverages on
  - GeoTools
  - Apache FTP
  - Spring
  - XStream
  - Hibernate
GeoBatch

- Code on GitHub
- Embedded FTP Server
- Automagically publish to
  - GeoServer
  - GeoWebCache (ongoing)
  - GeoNetwork
- User Interface
- REST Interface
- JMX Interface*
- JMS Connector*
Reference Scenario/Domain

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ImageMosaic – Part 1
**Terminology**

- **Granule/Tile**
  - The individual raster element composing the mosaic

- **(Granule) Index**
  - The collection of metadata records describing the location, spatial coverage and other attributes of each single granule

<table>
<thead>
<tr>
<th>fid</th>
<th>the_geom</th>
<th>location</th>
<th>ingestion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>01030000020E61000000 100000000500000000</td>
<td>NatColours_20130118T1000000002.tif</td>
<td>2013-01-18 10:00:00</td>
</tr>
<tr>
<td>2</td>
<td>01030000020E61000000 100000000500000000</td>
<td>NatColours_20130118T1015000002.tif</td>
<td>2013-01-18 10:15:00</td>
</tr>
<tr>
<td>3</td>
<td>01030000020E61000000 100000000500000000</td>
<td>NatColours_20130118T1030000002.tif</td>
<td>2013-01-18 10:30:00</td>
</tr>
<tr>
<td>4</td>
<td>01030000020E61000000 100000000500000000</td>
<td>NatColours_20130118T1045000002.tif</td>
<td>2013-01-18 10:45:00</td>
</tr>
</tbody>
</table>

**Dimensions/Domains**

- The dimensions besides the spatial ones used to distinguish individual granules
(Granule) Index

- Always present
- Drives the collection of granules for mosaicking
- Implemented by default using GeoTools Vector Sources
- Can be customized to support custom granule indexes (e.g. legacy catalog)
- Currently supported/tested DBMS
  - PostGis (JNDI)
  - Oracle (JNDI) *it’s been a nightmare because to make it work!*
  - H2
Dimensions/Domains
Maps to alphanumeric attributes in the index
TIME and ELEVATION receive special treatment for WMS and WCS
Custom/Additional dimensions
  - Everything besides TIME & ELEVATION
  - Map to DIM_XXX in WMS
  - They can be dynamically discovered
Custom/Additional dimensions
- **Dimensions/Domains parsing**
- `indexer.properties` file (*the old way*)

```plaintext
TimeAttribute=ingestion
ElevationAttribute=elevation
Schema=*the_geom:Polygon,location:String,ingestion:java.util.Date,elevation:Double
PropertyCollectors=TimestampFileNameExtractorSPI[timeregex](ingestion),DoubleFileNameExtractorSPI[elevationregex](elevation)
```
- Dimensions/Domains parsing
- elevationregex.properties file *(the old way)*
  
  ```
  regex=(?<=\_)(\d{4}\./\d{3})(?=\_)
  ```

- elevationregex.properties file *(the old way)*
  
  ```
  regex=[0-9]{8}T[0-9]{9}Z(\?!\.*[0-9]{8}T[0-9]{9}Z.\*)
  ```

- Regex turn name parts into index attribute values!
Limitations/assumptions

Granules must share the same Coordinate Reference System

Granules must share the same ColorModel and SampleModel

- We can still merge RGB with Paletted RGB via colormap expansion

1 row in the index maps to 1 physical file
NetCDF
NetCDF Format Support

- **NetCDF support**
  - Support COARDS* conventions loosely
  - Expose NetCDF internal data as a set of 2D slices
  - Fast 2D (time, elevation) slice extraction

---

**Granule Index**

| path | bbox | time | elevation | ...
|------|------|------|-----------|
| xxx  | xxx  | xxx  | xxx       | ...
| xxx  | xxx  | xxx  | xxx       | ...
| xxx  | xxx  | xxx  | xxx       | ...

For each single 2D slice contained in the multidimensional NetCDF file, we have an entry to index it for successive stitching.
NetCDF Format Support

- Polyphemus Sample Dataset
- 1 File → Multiple Coverages!
NetCDF Format Support

- NetCDF Indexer
NetCDF Format Support

- **NetCDF Indexer → drive the indexing**

```xml
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<Indexer>
  <schemas>
    <schema name="default">
      <attributes>
        the_geom:Polygon, imageindex:Integer, time:java.util.Date, elevation:Double
      </attributes>
    </schema>
  </schemas>
  <coverages>
    <coverage>
      <name>O3</name>
      <schema ref="default"></schema>
    </coverage>
    ...
  </coverages>
</Indexer>
```
NetCDF Format Support

- NetCDF Internal Index
- Speeds up 2D slice extraction
- H2 + binary file

Index location is configurable via – DNETCDF_DATA_DIR

- Data in a non-writable location
- Granule Index in a DBMS
- Individual NetCDF Indexes on a separate directory
NetCDF Format Support

- **Limitations/assumptions**
  - Only WGS84 is supported
  - *Only NetCDF following COARDS convention are supported*
  - ImageMosaic dimensions naming should be consistent with that of the underlying NetCDF reader
  - NetCDF output is available only for StructuredGridCoverage2DReader implementors (ImageMosaic and NetCDF)
ImageMosaic – Part 2
ImageMosaic – Part 2

- ImageMosaic NetCDF integration
  - Allow the ImageMosaic to handle multiple NetCDF files
  - Expose NetCDF internal structure (times, elevations)
  - Make ImageMosaic handle slices of the NetCDF file as granules
New Indexer File (XML file)
Definition of Dimensions/Domains
Definition of table schema
Definition of Coverage
Mapping of dimensions and table schema to Coverages
PropertyCollector definition
Additional Indexing Parameters:
  - Path Behaviour
  - Indexing Directories
  - Aux File
New Indexer File (XML file)

```xml
<?xml version="1.0" encoding="UTF-8" standalone="yes" ?>
<Indexer>
  <domains>
    <domain name="time">
      <attributes><attribute>time</attribute></attributes>
    </domain>
    <domain name="elevation">
      <attributes><attribute>elevation</attribute></attributes>
    </domain>
    <domain name="fileDate">
      <attributes><attribute ref="fileDateCollector">fileDate</attribute></attributes>
    </domain>
    <domain name="updated">
      <attributes><attribute ref="updatedCollector">updated</attribute></attributes>
    </domain>
  </domains>
</Indexer>
```
New Indexer File (XML file)

```xml
<schemas>
  <schema name="default">
    <attributes>
      the_geom:Polygon, location:String, imageindex:Integer, time:java.util.Date, elevation:Double, fileDate:java.util.Date, updated:java.util.Date
    </attributes>
  </schema>
</schemas>

<coverages>
  <coverage>
    <name>V</name>
    <schema ref="default"/>
    <domains>
      <domain ref="time"/>
      <domain ref="elevation"/>
      <domain ref="fileDate"/>
      <domain ref="updated"/>
    </domains>
  </coverage>
</coverages>
```
New Indexer File (XML file)

```xml
<collectors>
  <collector name="fileDateCollector">
    <value>[0-9]{8}</value>
    <spi>TimestampFileNameExtractorSPI</spi>
    <mapped>fileDate</mapped>
  </collector>
  <collector name="updatedCollector">
    <value>MODIFY_TIME</value>
    <spi>RuntimeExtractorSPI</spi>
    <mapped>updated</mapped>
  </collector>
</collectors>

<parameters>
  <parameter name="AbsolutePath" value="true" />
  <parameter name="AuxiliaryFile" value="polyphemus-test.xml" />
  <parameter name="IndexingDirectories" value="D:/Training_2.4_multidim_Win64/source_data/polyphemus" />
</parameters>
```
Multiple Coverages per Mosaic
Granule Index CRUD Operations via REST

CREATE


READ index schema


READ WFS like with CQL filtering and paging

curl -v -u admin:Geos -XGET "http://localhost:8080/geoserver/rest/workspaces/geosolutions/coveragestores/polyphemus/coverages/NO2/index/granules.xml?limit=1&filter=time='2013-03-03T00:00:00Z'"
Granule Index CRUD Operations via REST

**UPDATE**

curl -v -u admin:Geos -XPOST -H "Content-type: text/plain" -d
"/polyphemus_20130303.nc"
"http://localhost:8080/geoserver/rest/workspaces/geosolutions/coveragestores/polyphemus/external.imagemosaic"

**DELETE**  WFS like with CQL filtering and paging or by ID

curl -v -u admin:geoserver -XDELETE

curl -v -u admin:geoserver -XGET
"http://localhost:8080/geoserver/rest/workspaces/topp/coveragestores/polyphemus-v1/coverages/NO2/index/granules/NO2.2689.xml"
The Services
TIME, ELEVATION & More

http://localhost:8080/geoserver/geosolutions/wms?...&time=2013-03-01T00:00:00.000Z&elevation=35.0&DIM_FILEDATE=2013-03-01T00:00:00.000Z&DIM_UPDATED=2013-04-08T08:18:41.597Z
Rendering Transformations
- SLD Based transformations
- On-the-fly contouring
- On-the-fly polygonalization
- Wind Barbs
**WCS 2.0**

- **Build the basics**
  - Core service
  - KVP binding
  - XML binding

- **Implement the GetCoverage extensions**
  - CRS
  - Scaling
  - Interpolation
  - Range subsetting
  - GeoTiff
  - GML
  - NetCDF

- **Add the output format extensions**
  - GeoTIFF
  - GML Grid
  - NetCDF
WCS 2.0

- Processing Chain
  - Crop
  - RangeSubset
  - Scale & Interpolate
  - Reproject & Interpolate
  - Encode

Core

Extension

Extension

Extension

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WCS 2.0

- **NetCDF Output**

http://localhost:8080/geoserver/wcs?request=GetCoverage&service=WCS&version=2.0.1&coverageId=geosolutions__NO2&Format=NetCDF

subset=http://www.opengis.net/def/axis/OGC/0/Long(5,20)
subset=http://www.opengis.net/def/axis/OGC/0/Lat(40,50)
subset=http://www.opengis.net/def/axis/OGC/0/elevation(300,1250)
subset=http://www.opengis.net/def/axis/OGC/0/time("2013-03-01T10:00:00.000Z","2013-03-01T22:00:00.000Z")
WCS 2.0

- NetCDF Output

![Map of NO2 concentrations](image)

**Data**

- Arrays:
  - Array: NO2
  - File Date: 2013-03-01 00:00:00 +0000
  - Updated: 2013-04-08 08:18:41 +0000
  - Time: 12 of 13
  - Elevation: 500 m
Use Cases
LaMMa GeoPortal

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Ingestion and preprocessing of

- 3 Meteorological model 2 times a day (00 & 12 UTC)
  - WRF-ARW @ 12km over MED with ECMWF initdata
  - WRF-ARW @ 12km over MED with GFS initdata
  - WRF-ARW @ 3km over Italy with ECMWF initdata

- MeteoSat 2nd and 3rd generation data every 15 minutes
- Radar data every 5 minutes

Meteorological model

- Acquire via FTP after each run
- Transcode from Grib1 to a series of GeoTiff
- Mosaic with support for time
- Publish in GeoServer
- Prepare metadata and register in GeoNetwork
GeoBatch – LAMMA

- Operational Use
- Integrated Visualisation Tool for Obs and Models
- Data visual direct Query
- Everything in real-time!
GeoBatch – LAMMA
NATO STO CMRE employs Geoserver to store MetOc and Tactical Decision Aids layers. All layers are rendered with OpenLayers in the CMRE Web GIS Viewer. Layers have Time Dimension and an extra custom dimension to handle the model’s “forecast time”. Data ingestions and dimensions definitions are performed via Geoserver REST interface, scheduled on regular basis. Dynamic Colormap is used to dynamically render Coverage layers: for each image the color map is generated between image min and max.

(*) Environmental Knowledge and Operational Effectiveness (EKOE) - Decisions in Uncertain Ocean Environments (DUOE)
NATO STO CMRE
EKOE DUOE

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Internet

FTP/HTTP

Acquisition scripts

GeoServer

WCS

MetOc layers

Piracy Activity Group (PAG) Tactical Decision Aid

Geoserver

WCS

PAG layers

Optimal Assets Allocator

ODBC

PostGIS

Web GIS Viewer
- NOAA WW3 Wind Speed, global coverage
- Time dimension and custom “Run” dimension (DIM_RUN)
Use Case – NATO CMRE

- Gliders Observations (in-situ)
- ROMS Model (sea surface currents)
- NETTUNO Model (sea surface currents)
- Everything in real-time!
Use Case – FAO - GAEZ

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Use Case – FAO - GAEZ

- Multidimensional Mosaic
- 50 Years of data
  - Soil
  - Water
  - Land Cover
  - Protected Areas
- A few Mosaic Layer with dimensions rather than 100k layers
- Search Engine for on-the-fly filtering of Mosaic Layers
The End

Thank You

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WMS-EO

- How this fits in GeoServer’s world
- GSIP 84

Wizard to configure EO layer groups
Extending LayerGroup concept
Support same style on both raster and vector data
Support custom dimensions
Alter map on the fly to support band combination

MERISS__RR_2P

1
MERISS__RR_2P_outlines opt

1.*
MERISS__RR_2P_bands opt

1.*
MERISS__RR_2P_geopar opt

1.*
MERISS__RR_2P_flagname opt

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GeoSolutions

ECMWF
WMS-EO Quirks

- Root layer must respond with a specific layer rather than the composition of the children
  - Kind of a default visualization for a certain Dataset
  - E.g. when I send a GetMap for the root layer I could get back the browse image default layer

- Same styles for both Raster as well as Vector data
  - E.g. yellow can be use for both flags as well as outlines

- Peculiar behavior for Band layer (raw data)
  - E.g. multiple bands at different wavelengths
  - Can request either 1 (grayscale image) or 3 (RGB image)
  - Different combinations are prohibited

- Peculiar Behavior for GetFeatureInfo
- Extending the LayerGroup GeoServer concept
  - Show the nested layers in the capabilities document
  - Allow the root of the group to be represented by a separate layer (the overview one)
  - The above is a set of API, GUI and REST config changes, so a GeoServer proposal is needed

- Add the notion of custom dimensions in raster data
  - Needed to support the “eoproduct_bands” layer
  - Modify the GeoServer API to support custom dimensions (was almost ready in this respect)
  - Modify the grid coverage readers API to allow new dimensions to be exposed
  - Allow “dynamic” dimensions to be exposed (dimensions that are configured by the user)
  - Adapt the GUI to allow new dimensions to be configured
Build on top of a working WCS 2.0 with full extensions

- WCS 2.0
- CRS extension
- Range subsetting extension
- Interpolation extension
- Scaling extension
- GeoTiff extension
- NetCDF extension

Add support for the WCS-EO extras

- Listing coverage datasets in the capabilities documents (based on image mosaic contents, which will have to be marked as “exposed” so that we show their inner structure for EO)
- Support describe coverage dataset
- Support returning results for an entire dataset in GetCoverage
WCS-EO

- Add support for downloading the original file in case of no subsetting/reprojection/scaling/format change
  - Add support to GeoTools readers to signal they are returning us an original file
  - Use that information to download the original file directly
- Add support for WCS EO metadata in readers
  - Associate each file with EO metadata
  - Include such information in DescribeCoverage/DescribeEODataset