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

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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 Fu
  - Java, Java Enterprise, C++, Python
  - JPEG2000, JPIP, Advanced 2D visualiza
- Supporting/Developing FOSS4G projects
  - MapStore, GeoServer
  - GeoBatch, GeoNetwork
- http://www.geo-solutions.it

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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..

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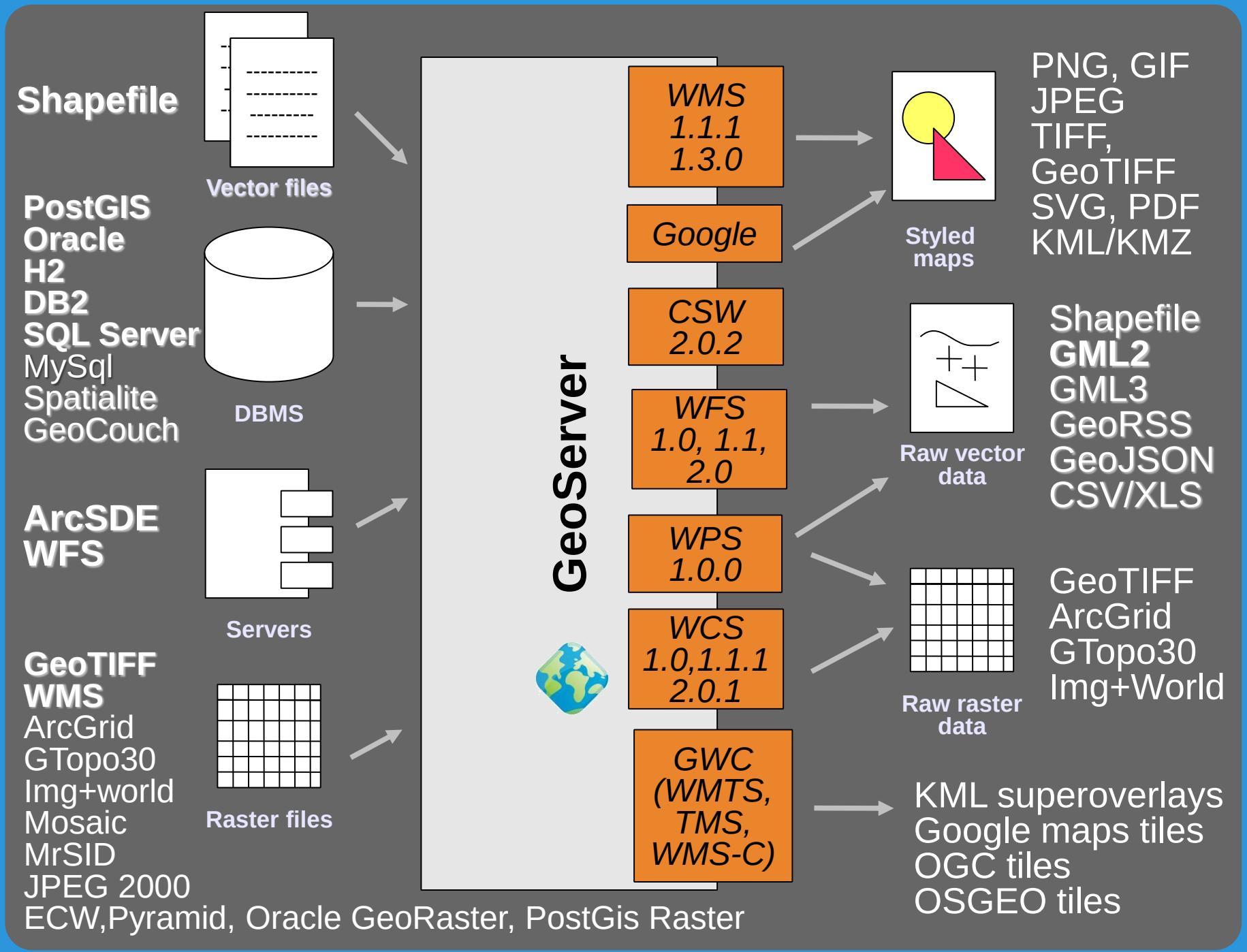
Formats and Protocols



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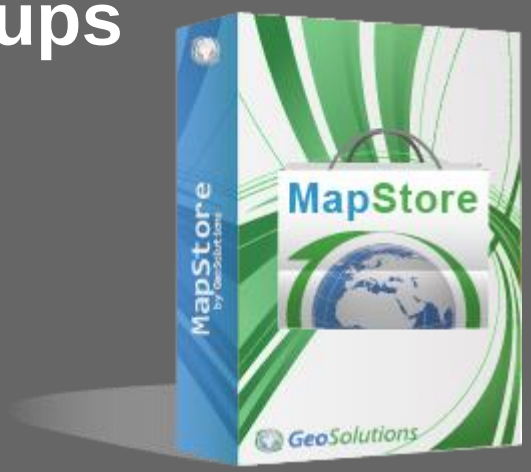
MapStore

- 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 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

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GeoBatch

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

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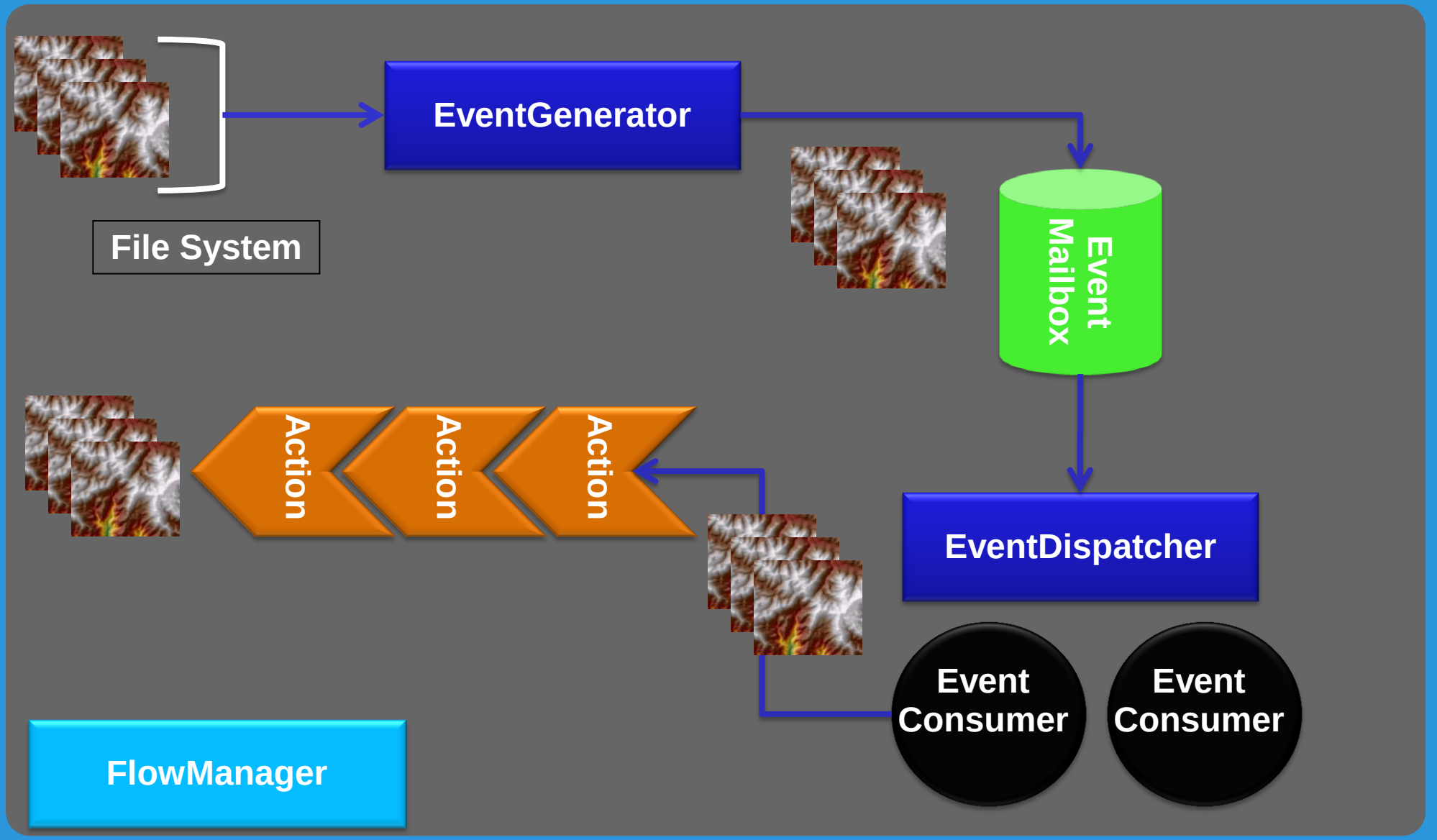
GeoBatch Architecture



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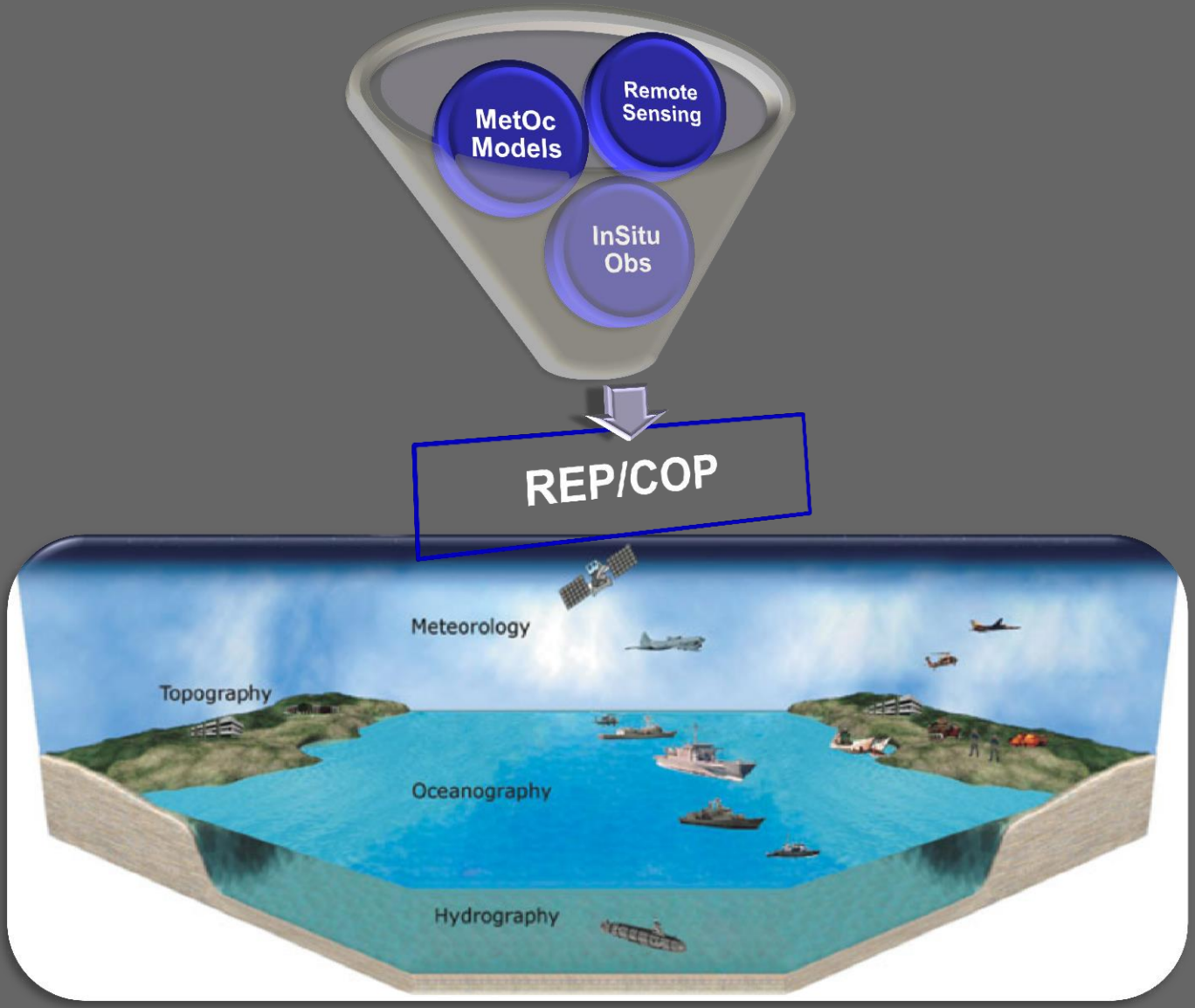
Reference Scenario/Domain



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ImageMosaic – Part 1

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ImageMosaic

- **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

fid [PK] integer	the_geom geometry	location character varying	ingestion timestamp without time zon
1	0103000020E61000000100000005000000000	NatColours_20130118T100000000Z.tif	2013-01-18 10:00:00
2	0103000020E61000000100000005000000000	NatColours_20130118T101500000Z.tif	2013-01-18 10:15:00
3	0103000020E61000000100000005000000000	NatColours_20130118T103000000Z.tif	2013-01-18 10:30:00
4	0103000020E61000000100000005000000000	NatColours_20130118T104500000Z.tif	2013-01-18 10:45:00

- Dimensions/Domains
  - The dimensions besides the spatial ones used to distinguish individual granules

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ImageMosaic

- (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

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ImageMosaic

- **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

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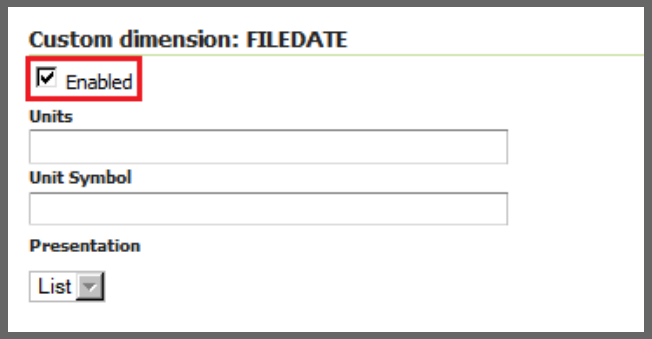
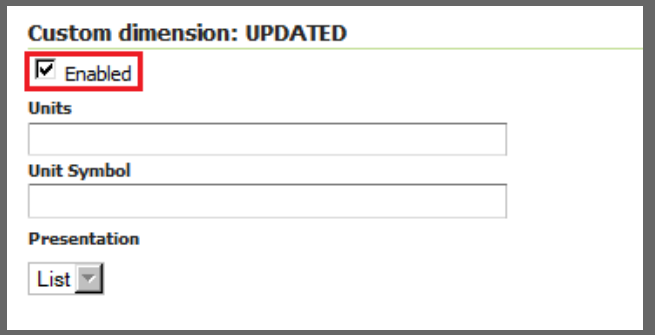
ImageMosaic

- ## Custom/Additional dimensions






```
▼<Layer queryable="1">
  <Name>geosolutions:NO2</Name>
  <Title>NO2</Title>
  <Abstract/>
 ▶<KeywordList>...</KeywordList>
  <CRS>EPSG:4326</CRS>
  <CRS>CRS:84</CRS>
 ▶<EX_GeographicBoundingBox>...</EX_GeographicBoundingBox>
  <BoundingBox CRS="CRS:84" minx="5.0" miny="45.0" maxx="14.875" maxy="50.9375"/>
  <BoundingBox CRS="EPSG:4326" minx="45.0" miny="5.0" maxx="50.9375" maxy="14.875"/>
 ▼<Dimension name="time" default="current" units="ISO8601">
    2013-03-01T00:00:00.000Z,2013-03-01T01:00:00.000Z,2013-03-01T02:00:00.000Z,2013-03-01T03:00:00.000Z,2013-03-01T04:00:00.000Z,2013-03-01T05:00:00.000Z,2013-03-
    01T06:00:00.000Z,2013-03-01T07:00:00.000Z,2013-03-01T08:00:00.000Z,2013-03-01T09:00:00.000Z,2013-03-01T10:00:00.000Z,2013-03-01T11:00:00.000Z,2013-03-01T12:00:00.000Z,2013-
    03-01T13:00:00.000Z,2013-03-01T14:00:00.000Z,2013-03-01T15:00:00.000Z,2013-03-01T16:00:00.000Z,2013-03-01T17:00:00.000Z,2013-03-01T18:00:00.000Z,2013-03-
    01T19:00:00.000Z,2013-03-01T20:00:00.000Z,2013-03-01T21:00:00.000Z,2013-03-01T22:00:00.000Z,2013-03-01T23:00:00.000Z,2013-03-02T00:00:00.000Z,2013-03-02T01:00:00.000Z,2013-
    03-02T02:00:00.000Z,2013-03-02T03:00:00.000Z,2013-03-02T04:00:00.000Z,2013-03-02T05:00:00.000Z,2013-03-02T06:00:00.000Z,2013-03-02T07:00:00.000Z,2013-03-
    02T08:00:00.000Z,2013-03-02T09:00:00.000Z,2013-03-02T10:00:00.000Z,2013-03-02T11:00:00.000Z,2013-03-02T12:00:00.000Z,2013-03-02T13:00:00.000Z,2013-03-02T14:00:00.000Z,2013-
    03-02T15:00:00.000Z,2013-03-02T16:00:00.000Z,2013-03-02T17:00:00.000Z,2013-03-02T18:00:00.000Z,2013-03-02T19:00:00.000Z,2013-03-02T20:00:00.000Z,2013-03-
    02T21:00:00.000Z,2013-03-02T22:00:00.000Z,2013-03-02T23:00:00.000Z
  </Dimension>
 ▼<Dimension name="elevation" default="10.0" units="EPSG:5030" unitSymbol="m">
    10.0,35.0,75.0,125.0,175.0,250.0,350.0,450.0,550.0,700.0,900.0,1250.0,1750.0,2500.0
  </Dimension>
  <Dimension name="UPDATED" default="2013-04-08T07:40:29.061Z" units="">2013-04-08T07:40:29.061Z,2013-04-08T08:18:41.597Z</Dimension>
  <Dimension name="FILEDATE" default="2013-03-01T00:00:00.000Z" units="">2013-03-01T00:00:00.000Z,2013-03-02T00:00:00.000Z</Dimension>
```

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ImageMosaic

- **Dimensions/Domains parsing**
- **indexer.properties file (*the old way*)**

```
TimeAttribute=ingestion
ElevationAttribute=elevation
Schema=*the_geom:Polygon,location:String,ingestion:java.util.Date,elevation:Double
PropertyCollectors=TimestampFileNameExtractorSPI[timeregex](ingestion),DoubleFileNameExtractorSPI[elevationregex](elevation)
```

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ImageMosaic

- **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!**

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ImageMosaic

- **Limitations/assumptions**
- **Granules must share the same Coordinate Reference System**
- **Granules must share the same ColorModel and SampleModel**
  - We can stil merge RGB with Paletted RGB via colormap expansion
- 1 row in the index maps to 1 physical file

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NetCDF

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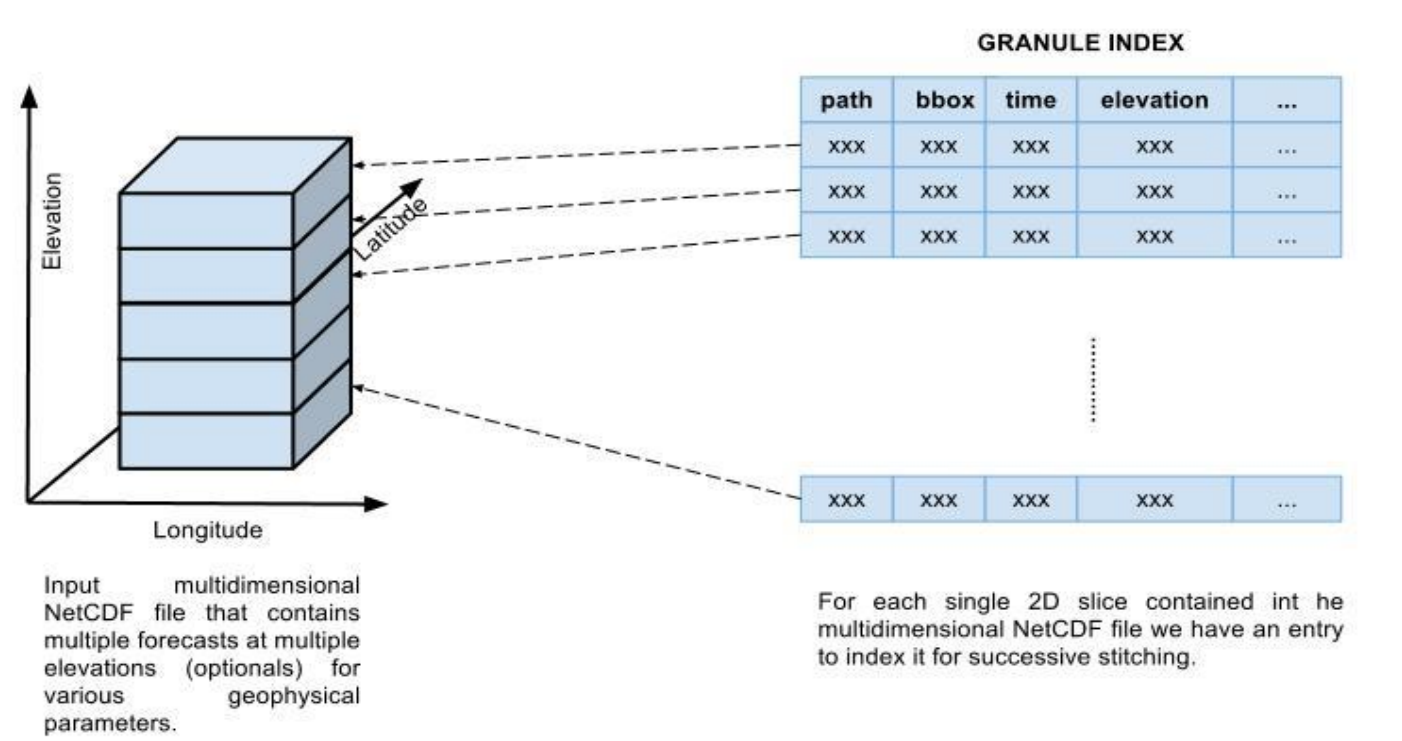
NetCDF Format Support

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



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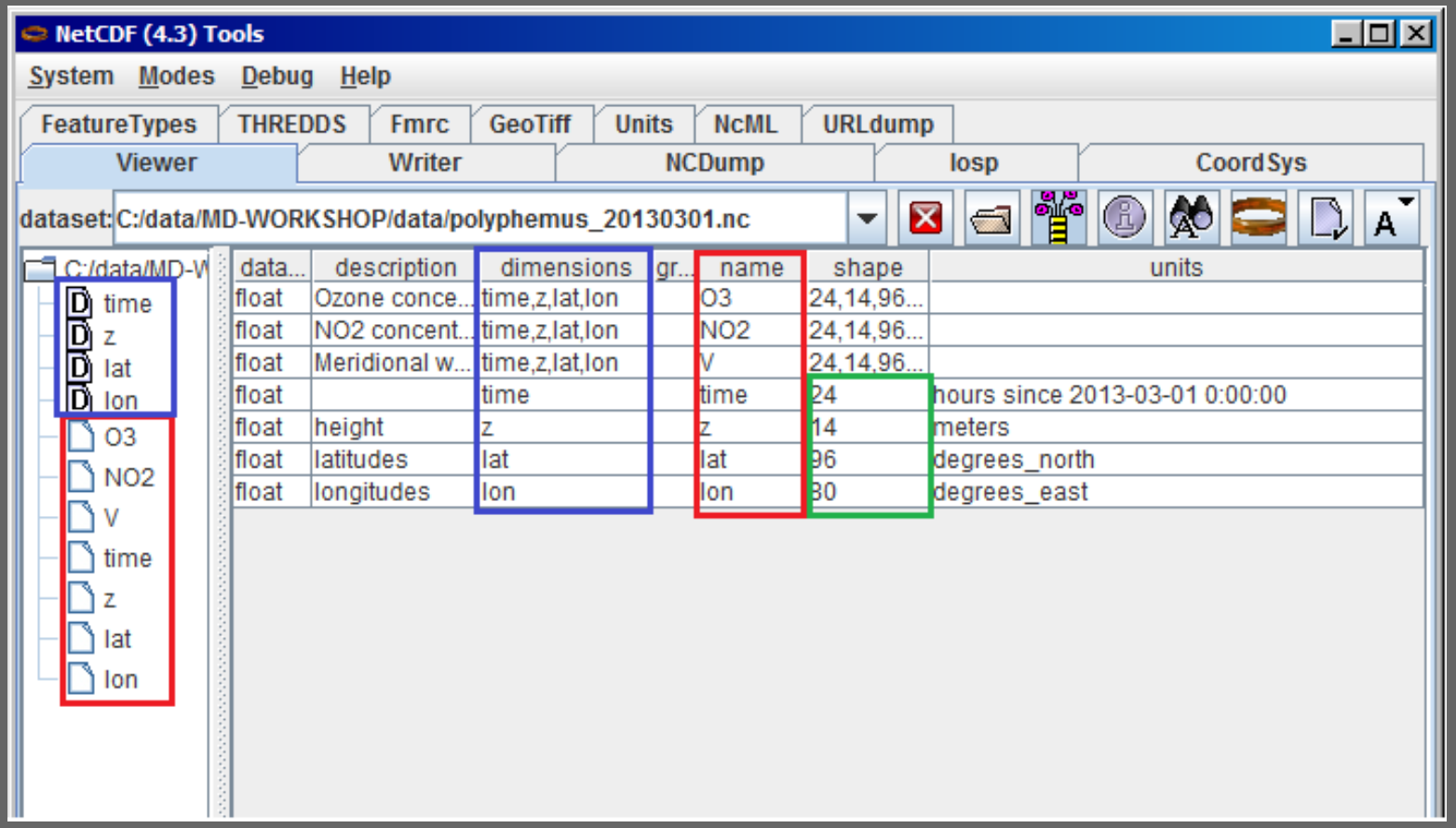
NetCDF Format Support

- **Polyphemus Sample Dataset**
- **1 File → Multiple Coverages!**



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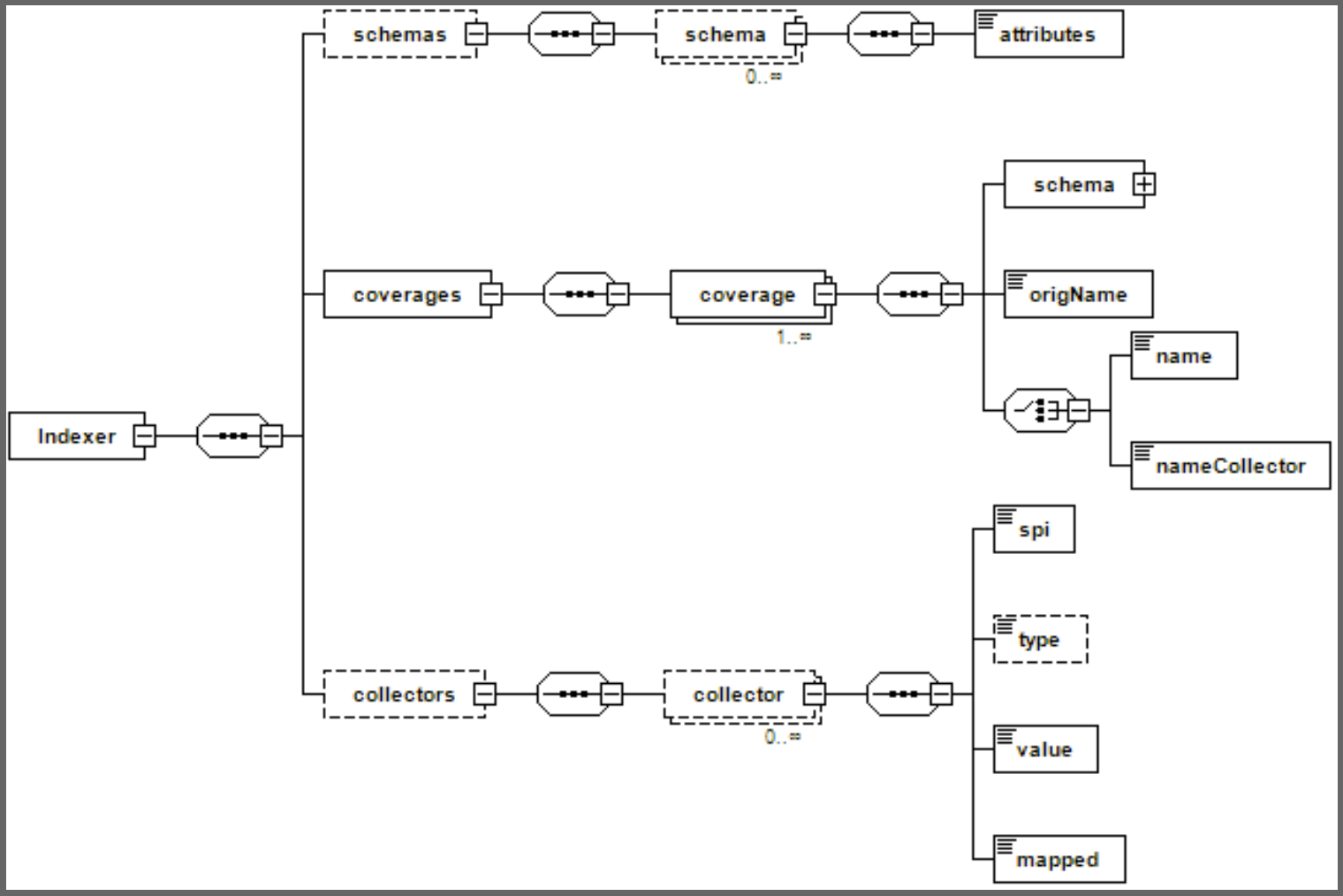
NetCDF Format Support

- NetCDF Indexer



NetCDF Format Support

- **NetCDF Indexer → drive the indexing**

```
<?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>
```

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NetCDF Format Support

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

```
20130103.METOPA.GOME2.O3.PGL.idx
20130103METOPAGOME2O3PGL.2.log.db
20130103METOPAGOME2O3PGL.data.db
20130103METOPAGOME2O3PGL.index.db
20130103METOPAGOME2O3PGL.trace.db
```

- 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

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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)**

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ImageMosaic – Part 2

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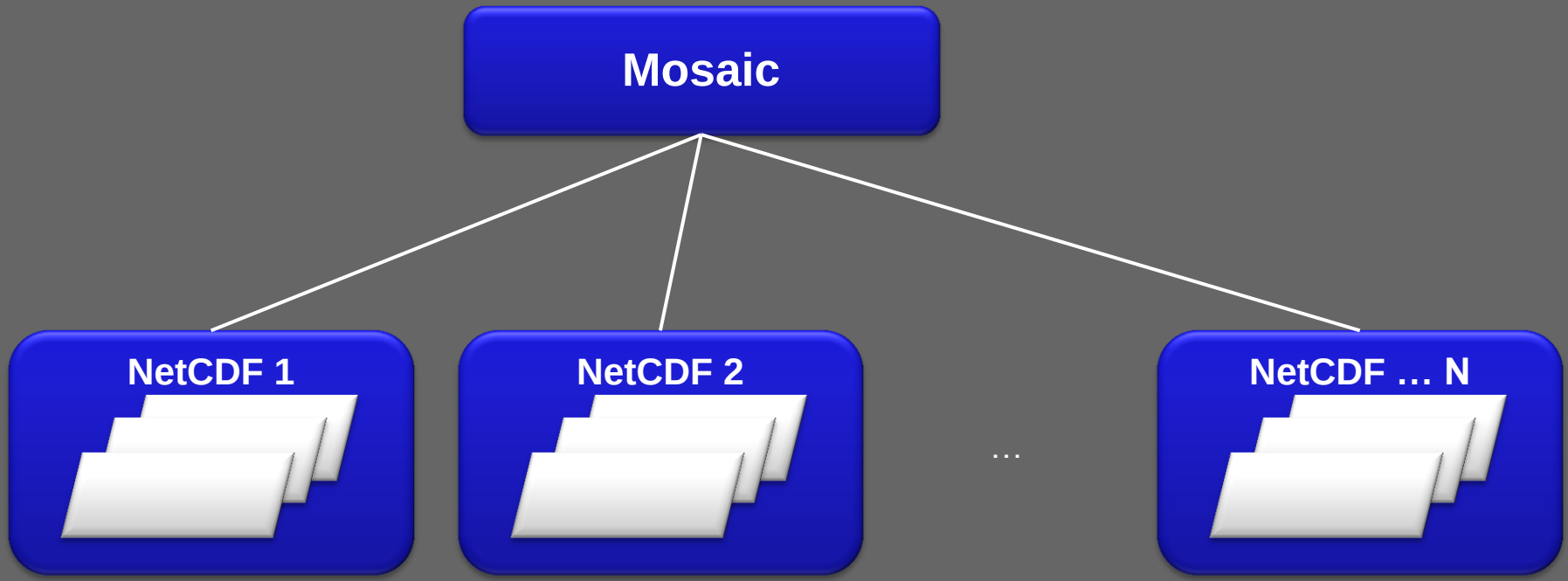
ImageMosaic – Part 2

- 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



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ImageMosaic – Part 2

- **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**

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ImageMosaic – Part 2

- **New Indexer File** (XML file)

```
<?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>
```

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ImageMosaic – Part 2

- **New Indexer File** (XML file)

```
<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"></schema>
      <domains>
        <domain ref="time" />
        <domain ref="elevation" />
        <domain ref="fileDate" />
        <domain ref="updated" />
      </domains>
    </coverage>
  </coverages>
```

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ImageMosaic – Part 2

- **New Indexer File** (XML file)

```
<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>
```

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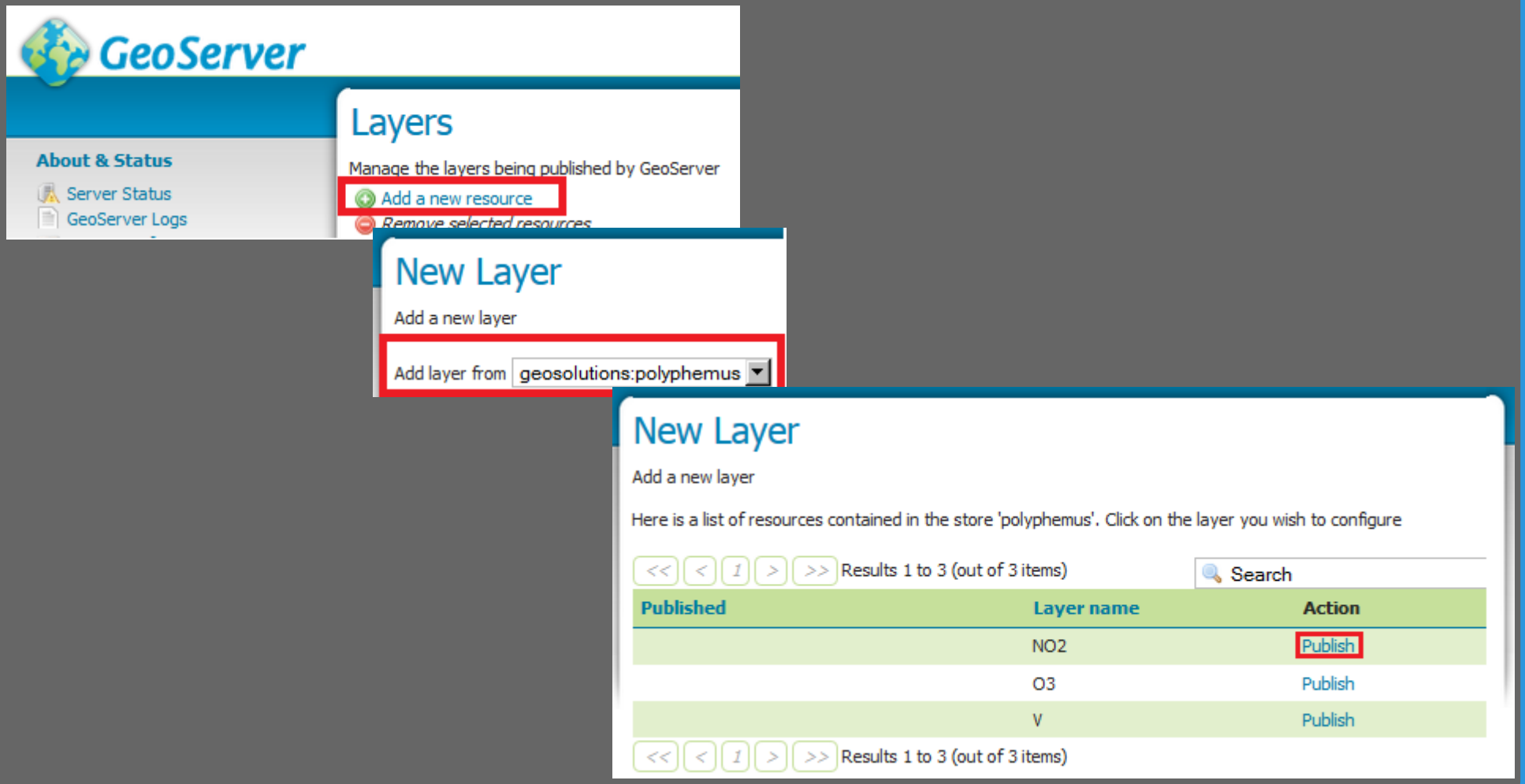
ImageMosaic – Part 2

- ## Multiple Coverages per Mosaic



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ImageMosaic – Part 2

- **Granule Index CRUD Operations via REST**
- **CREATE**

```
curl -u admin:Geos -XPUT -H "Content-type:application/zip" --data-binary
@http://localhost:8080/geoserver/rest/workspaces/geosolutions/coveragestores/temperature/file.imagemosaic
```

- **READ** index schema

```
curl -v -u admin:Geos -XGET
"http://localhost:8080/geoserver/rest/workspaces/geosolutions/coveragestores/polyphemus/coverages/NO2/index.xml"
```

- **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'"
```

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ImageMosaic – Part 2

- **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/pol
yphemus/external.imagemosaic"
```

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

```
curl -v -u admin:geoserver -XDELETE
"http://localhost:8080/geoserver/rest/workspaces/topp/coveragestores/polyphemus-
v1/coverages/NO2/index/granules.xml?filter=location='polyphemus_20130301.nc'"
```

```
curl -v -u admin:geoserver -XGET
"http://localhost:8080/geoserver/rest/workspaces/topp/coveragestores/polyphemus-
v1/coverages/NO2/index/granules/NO2.2689.xml"
```

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The Services

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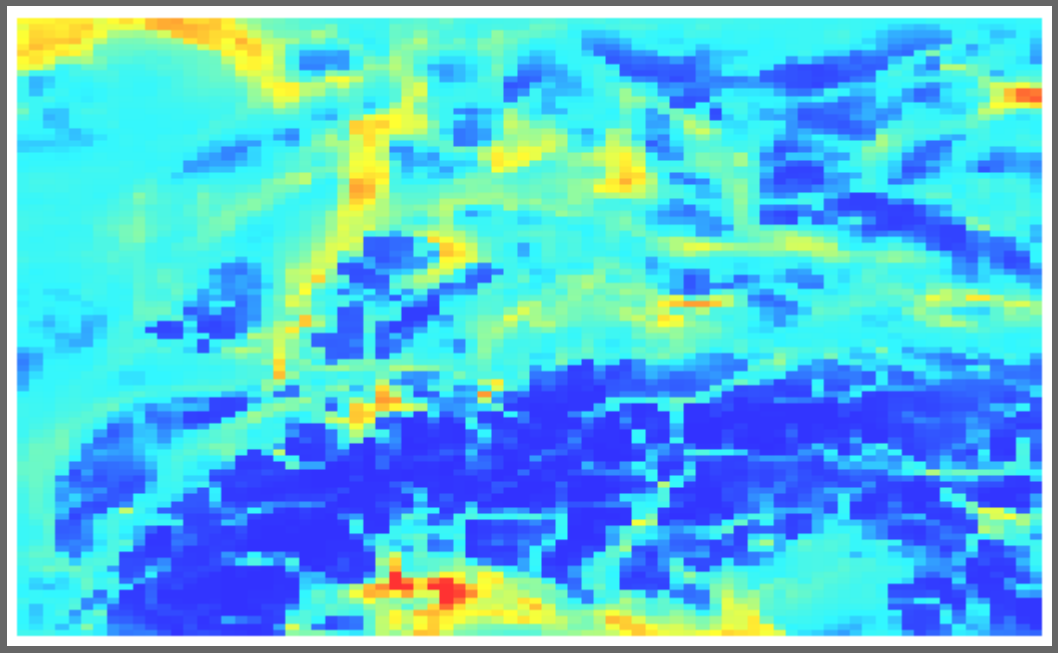
WMS

- ## 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



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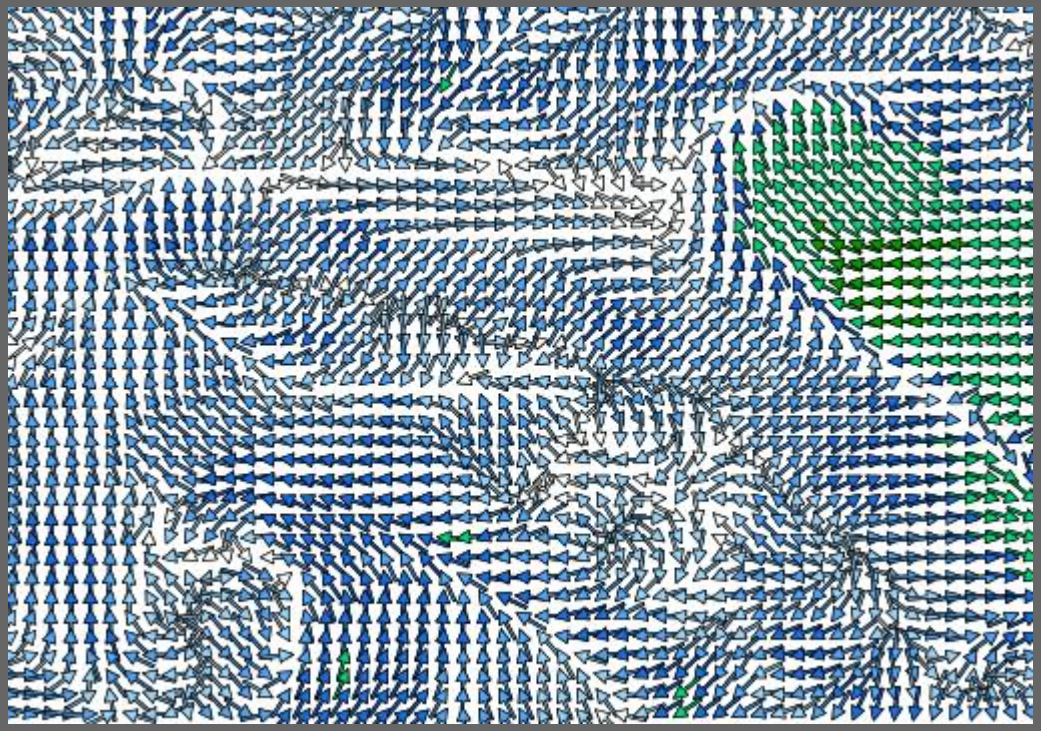
WMS + WPS

- **Rendering Transformations**
- SLD Based transformations
- On-the-fly contouring
- On-the-fly poligonalization
- Wind Barbs



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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

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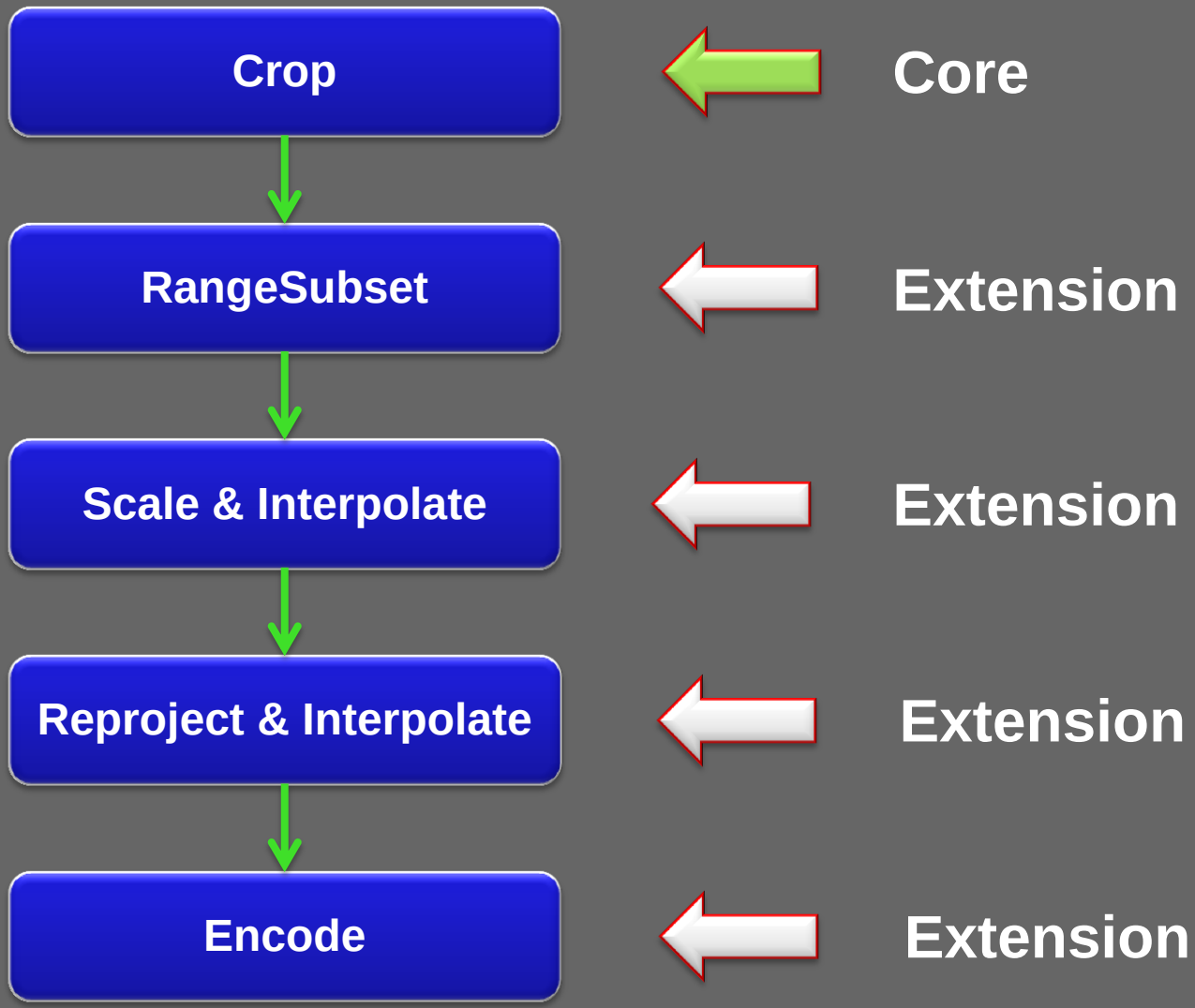
WCS 2.0

- Processing Chain



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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")

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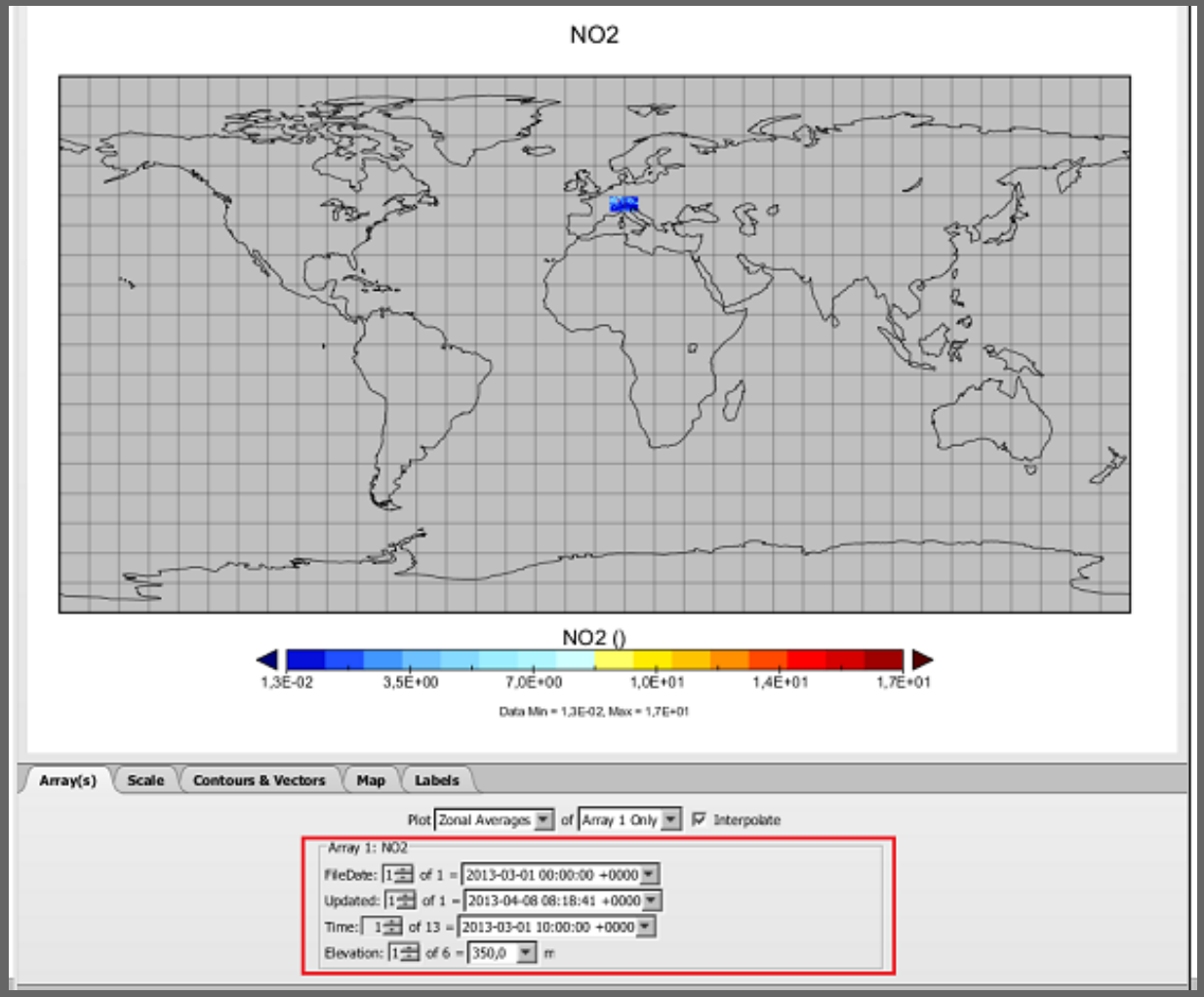
WCS 2.0

- **NetCDF Output**



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Use Cases

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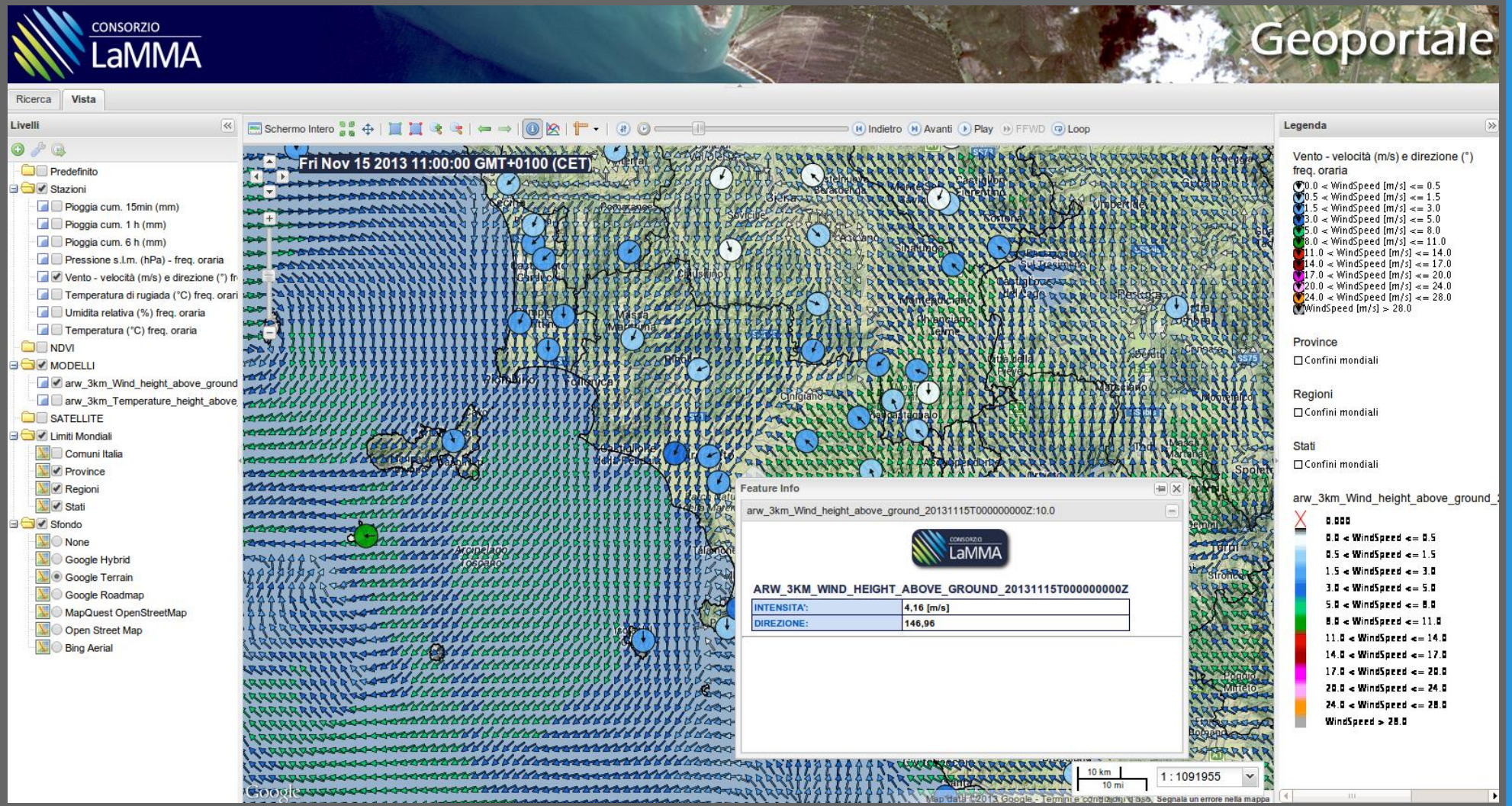
LaMMa GeoPortal



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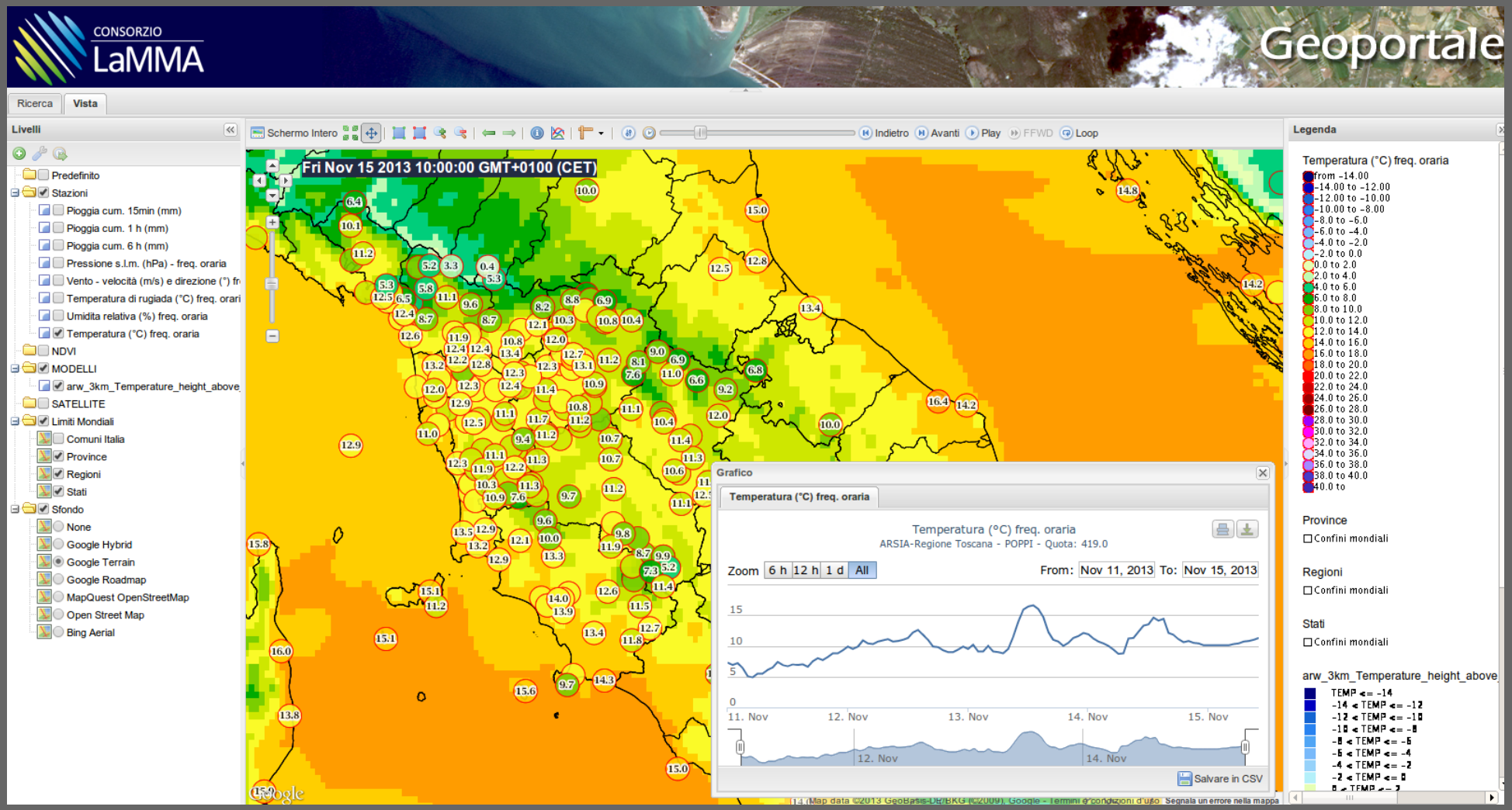
LaMMa GeoPortal



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19th November 2013

ECMWF

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GeoBatch – LAMMA

- 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

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GeoBatch – LAMMA

- Operational Use
- Integrated Visualisation Tool for Obs and Models
- Data visual direct Query
- Everything in real-time!

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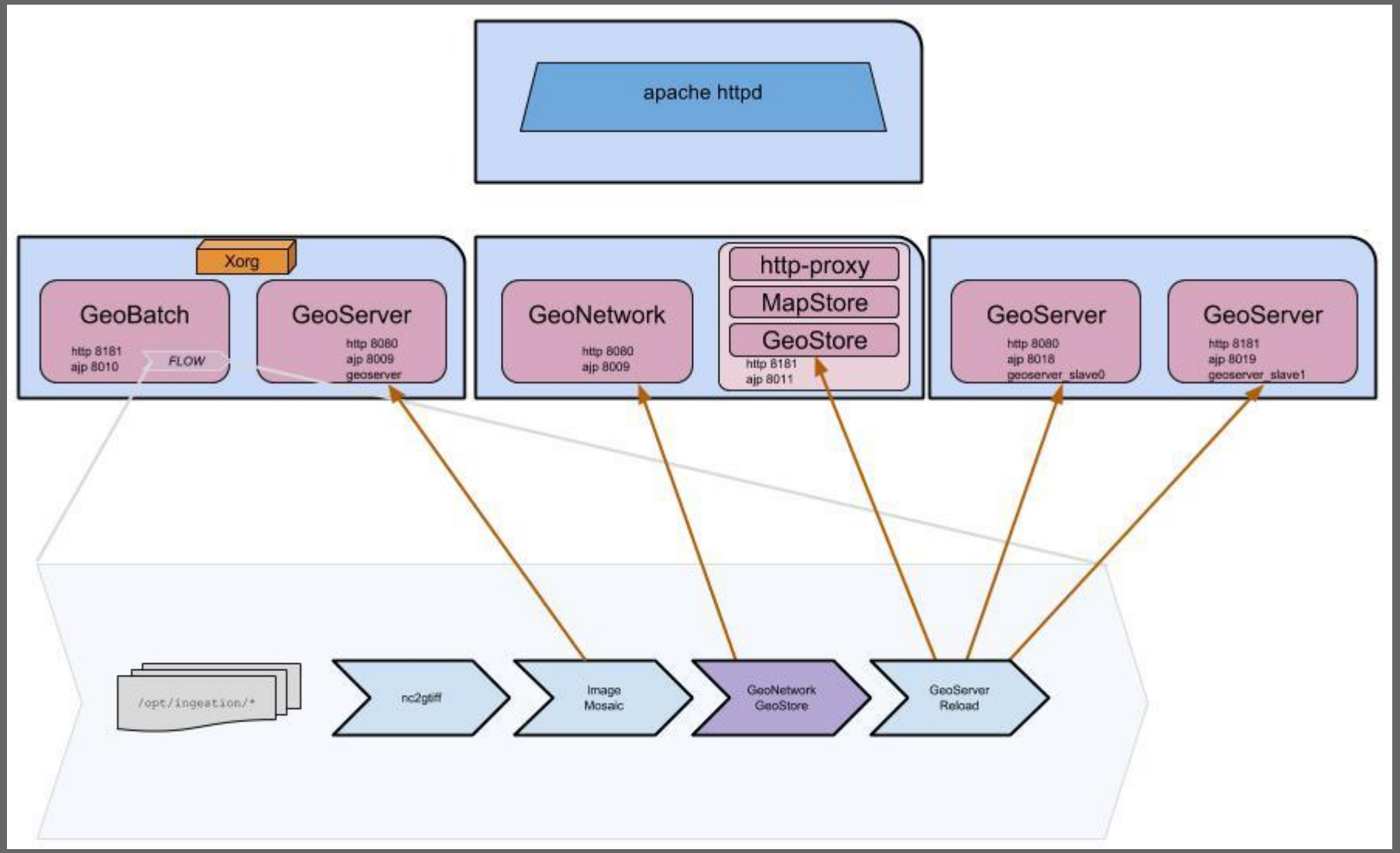
GeoBatch – LAMMA



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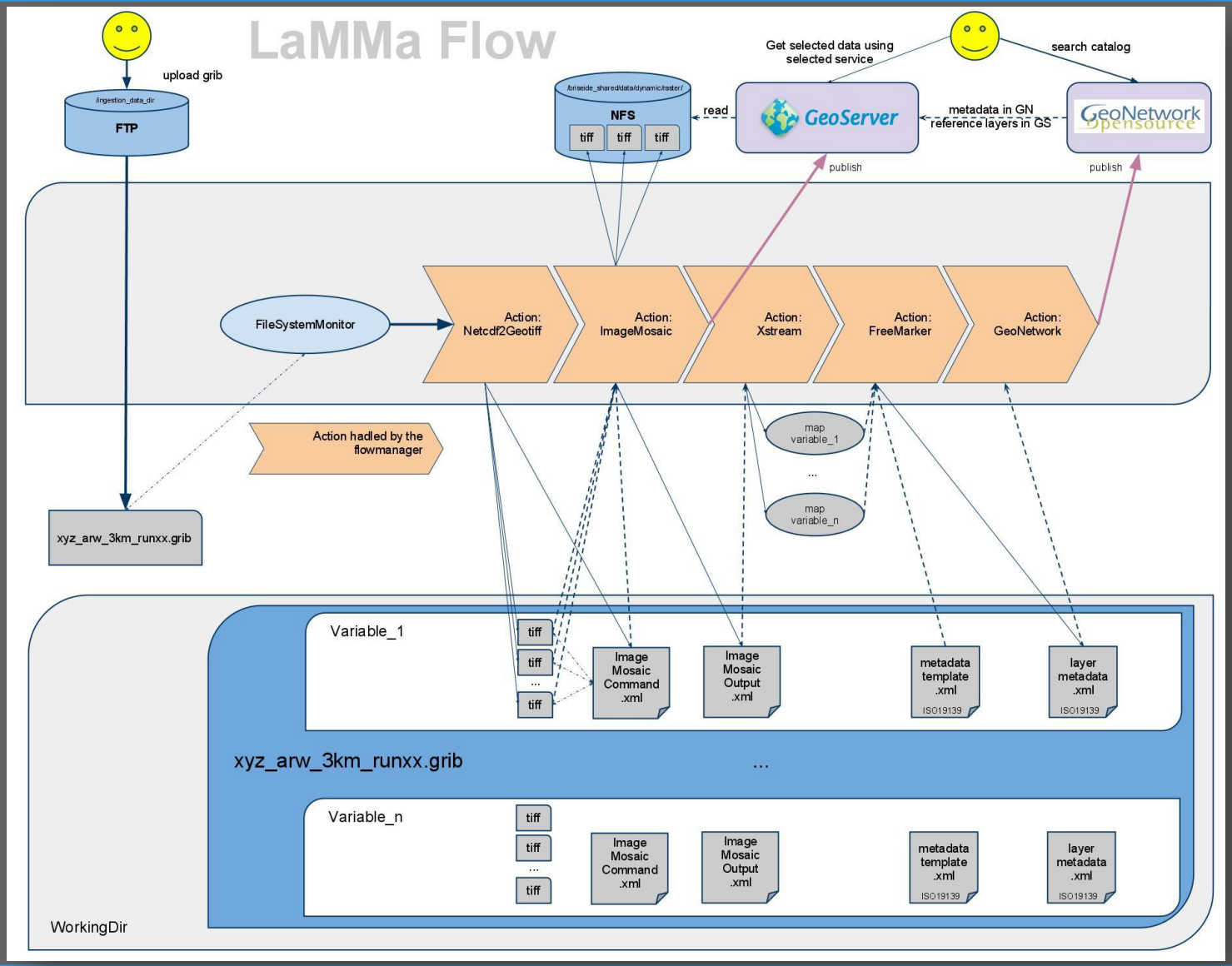
GeoBatch – LAMMA



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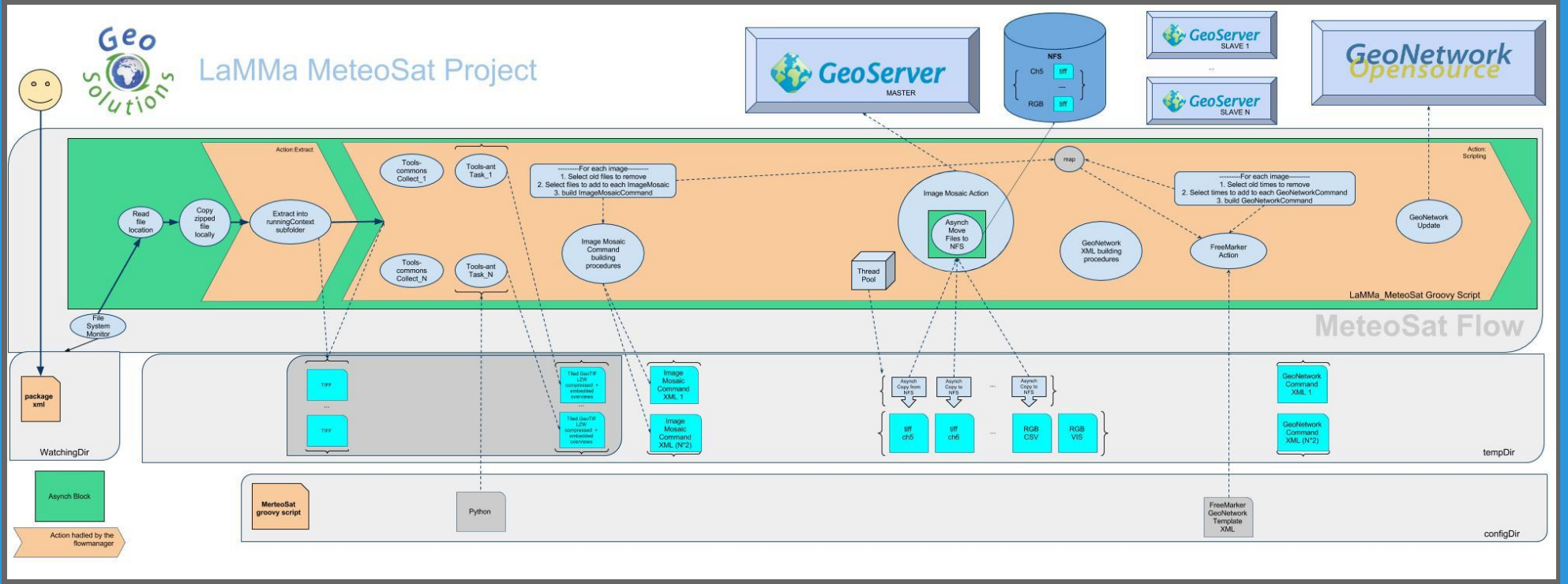
GeoBatch – LAMMA



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NATO STO CMRE
EKOE DUOE (*)

- 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
- Leyers 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)

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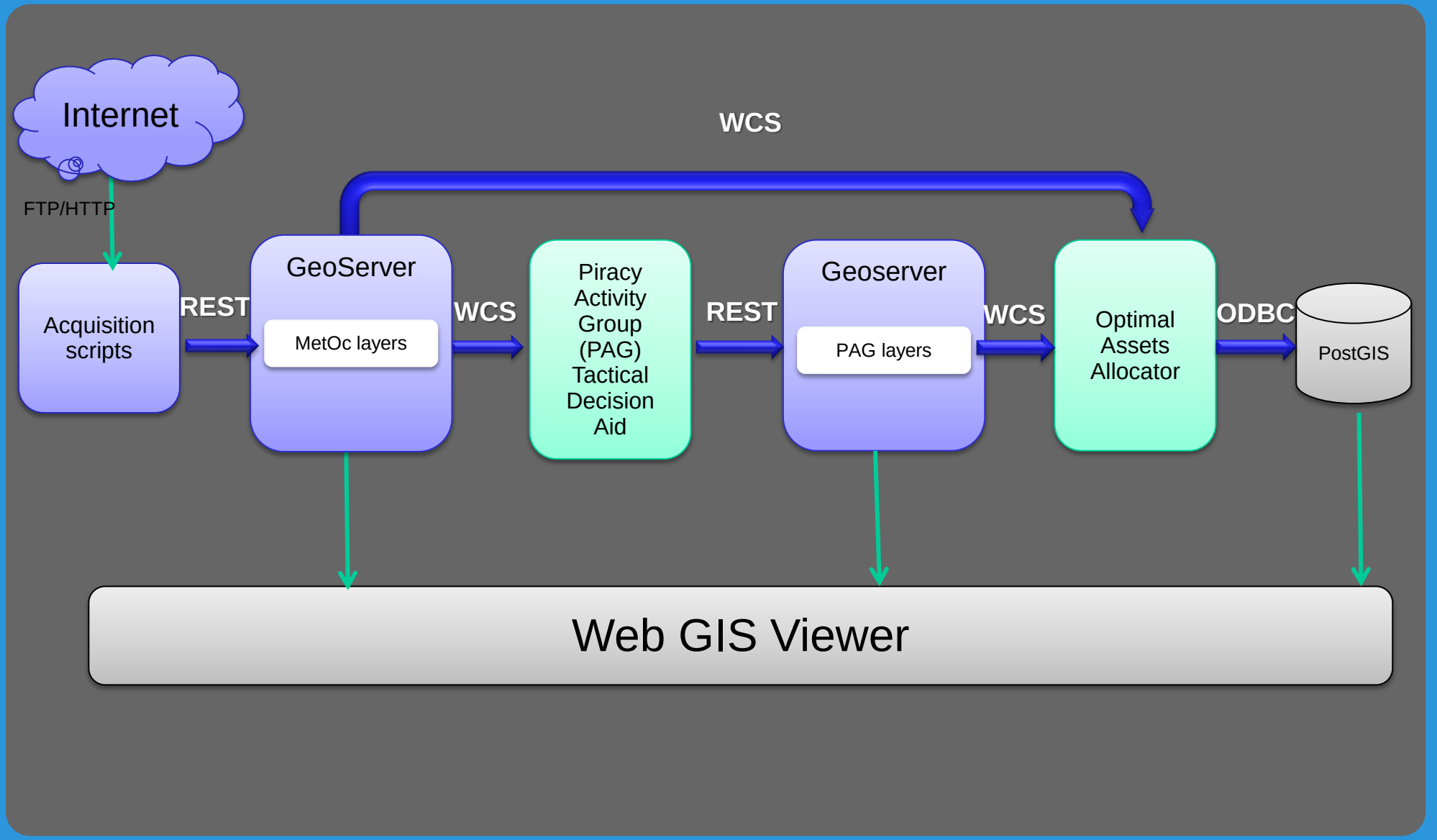
NATO STO CMRE
EKOE DUOE



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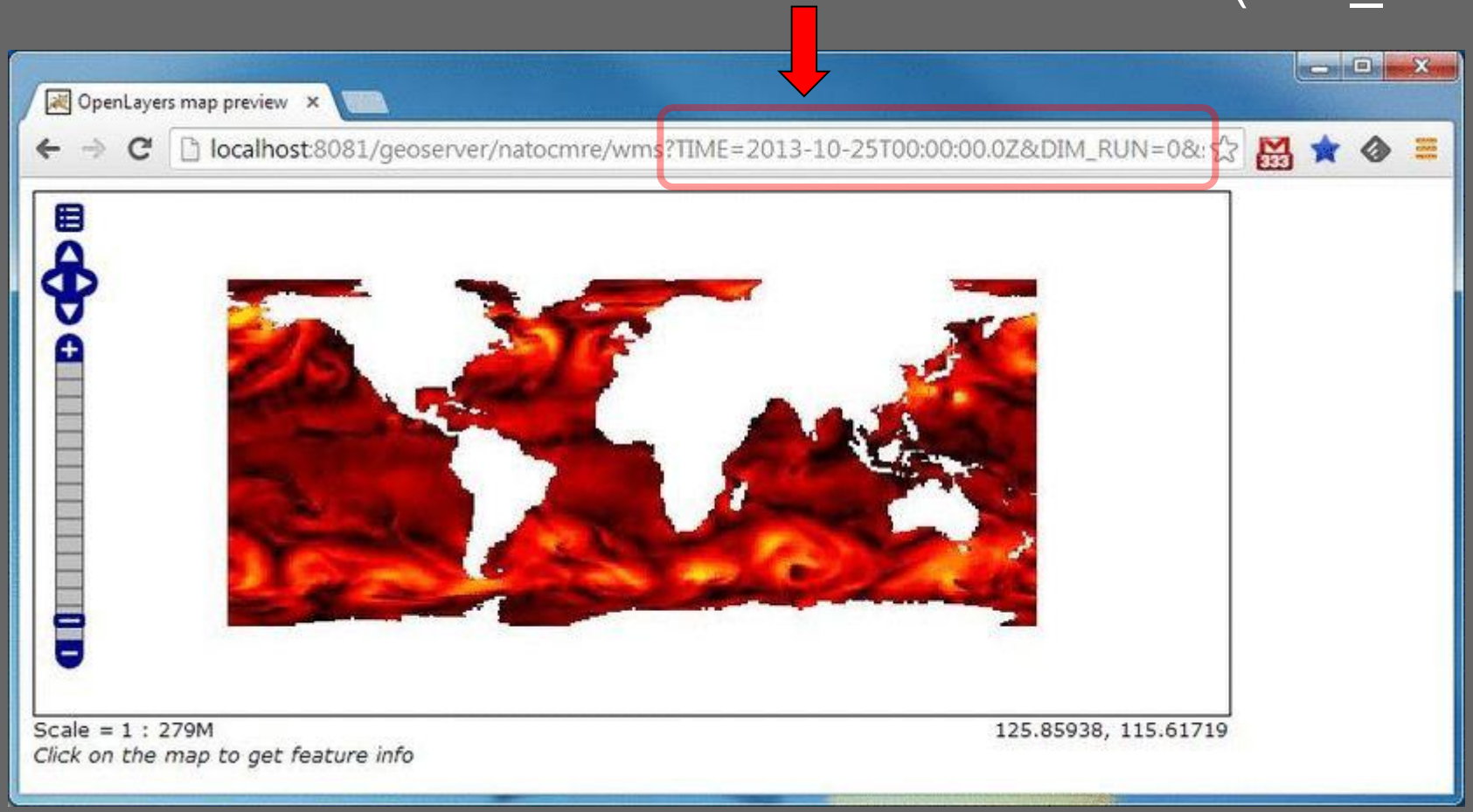
NATO STO CMRE
EKOE DUOE

- NOAA WW3 Wind Speed, global coverage
- Time dimension and custom “Run” dimension (DIM_RUN)



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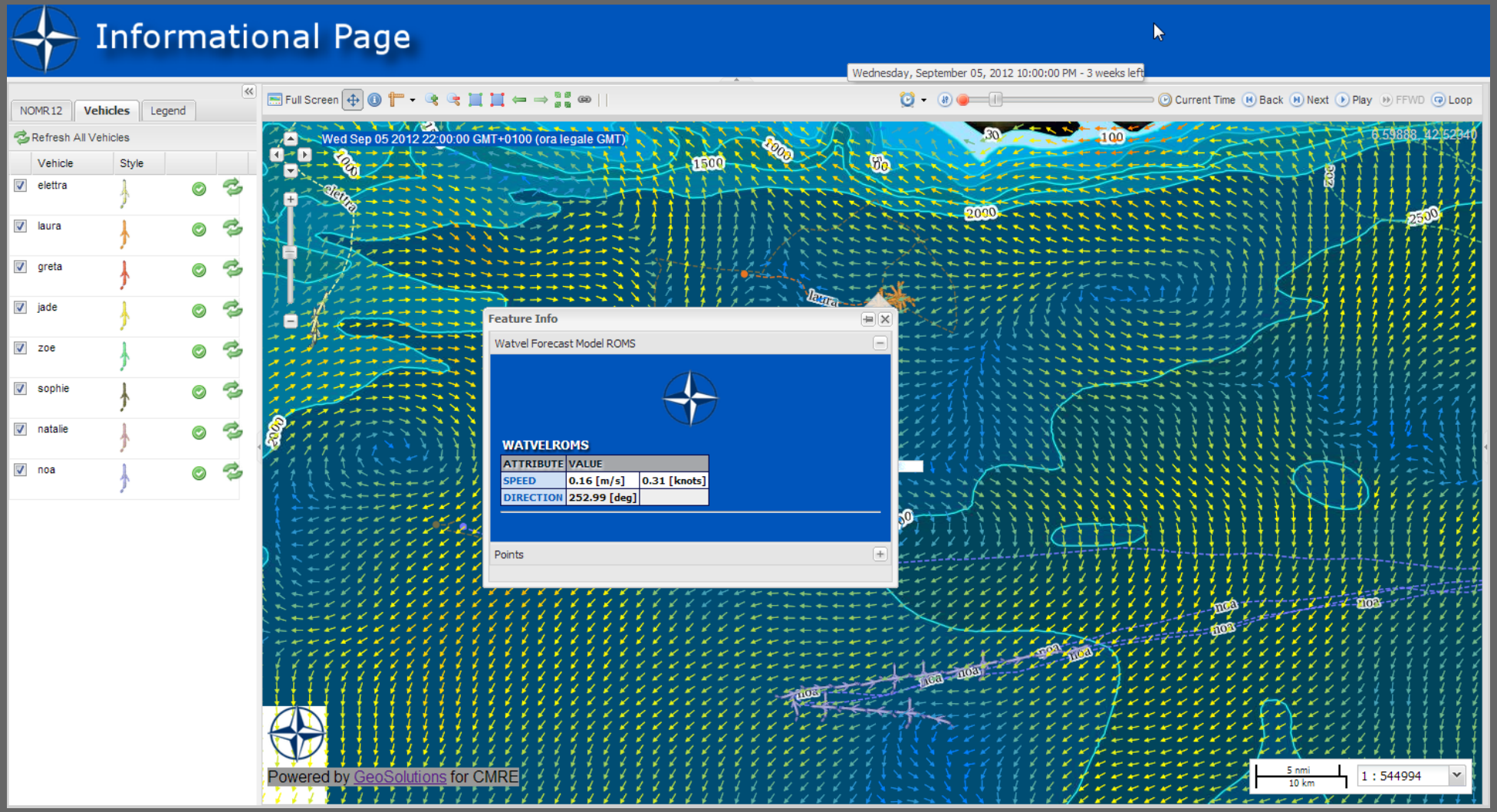
NATO CMRE Gliders Portal



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Use Case – NATO CMRE

- Gliders Observations (in-situ)
- ROMS Model *(sea surface currents)*
- NETTUNO Model *(sea surface currents)*
- *Everything in real-time!*

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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

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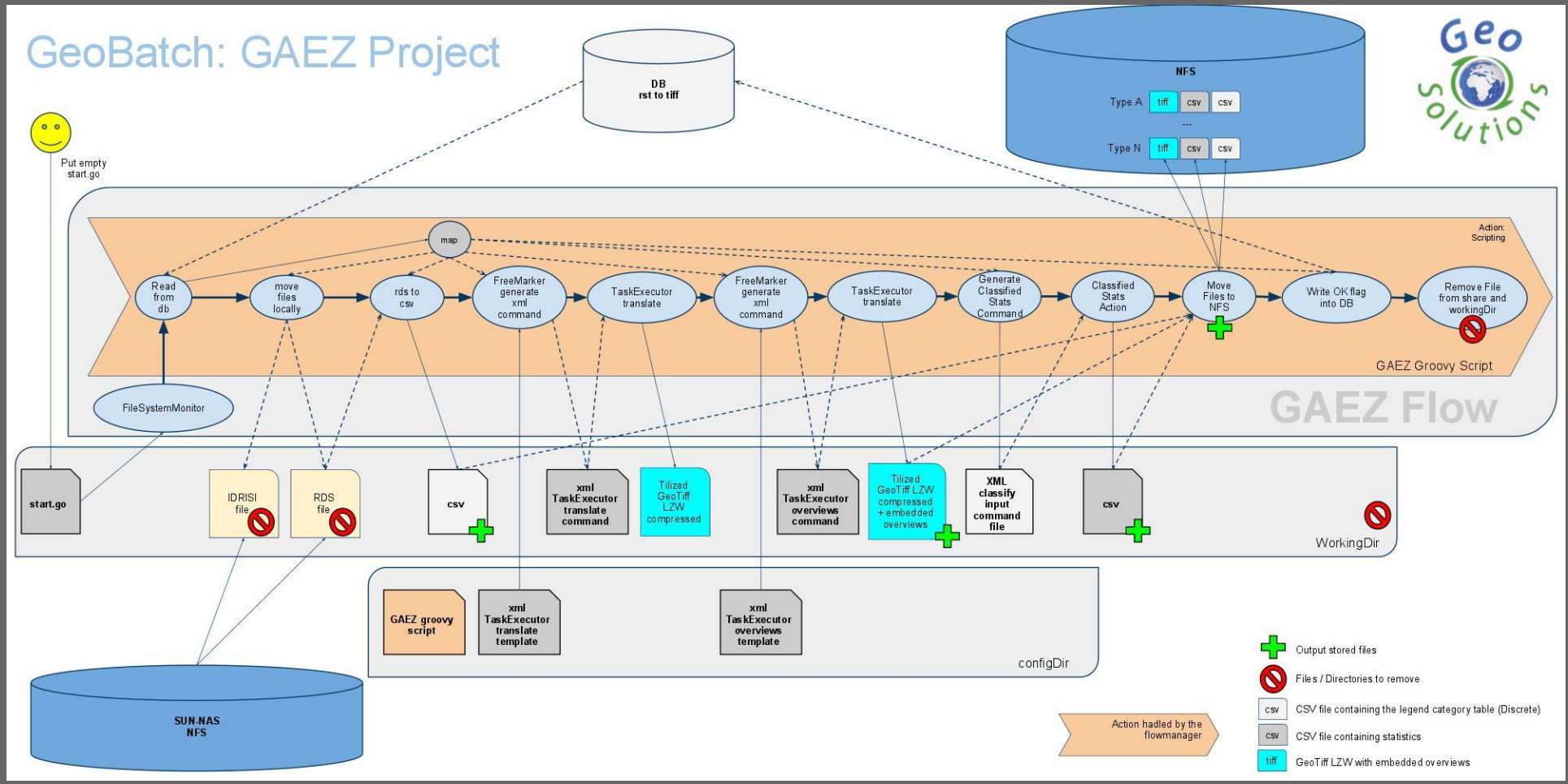
GeoBatch – FAO Gaez Project



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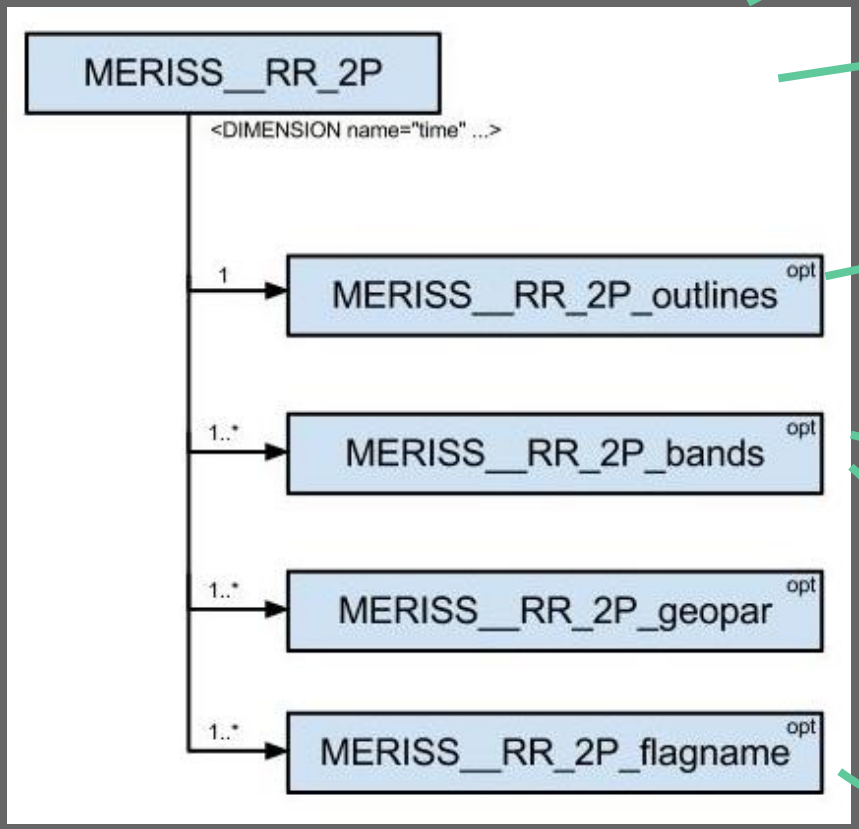
The End

Thank You

simone.giannecchini@geo-solutions.it

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

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WMS-EO

- **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**

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WMS-EO

- **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

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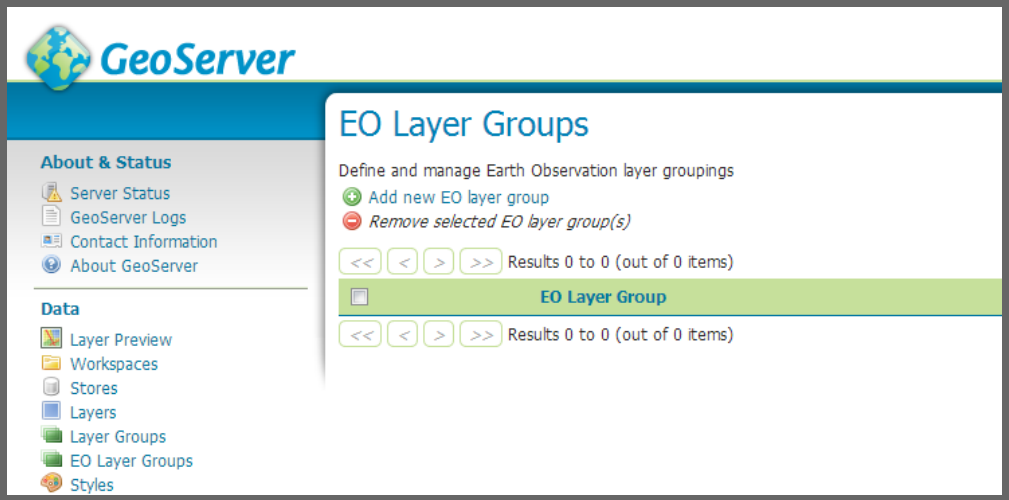
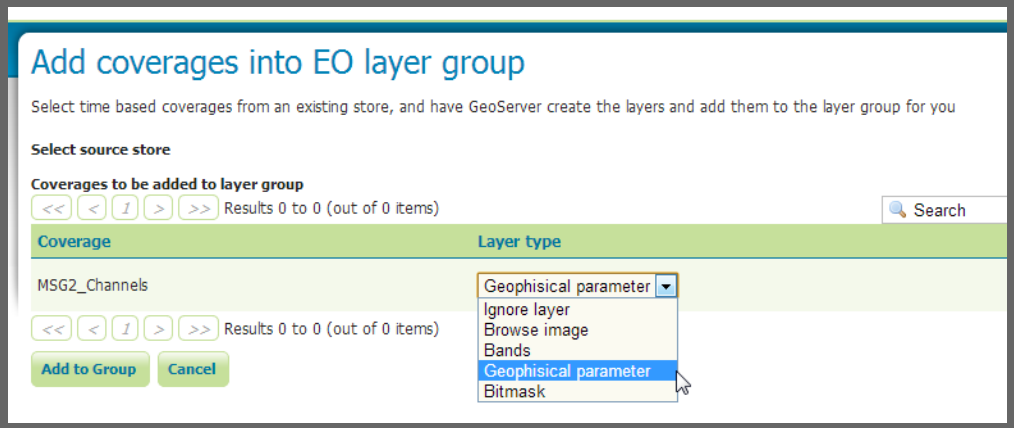
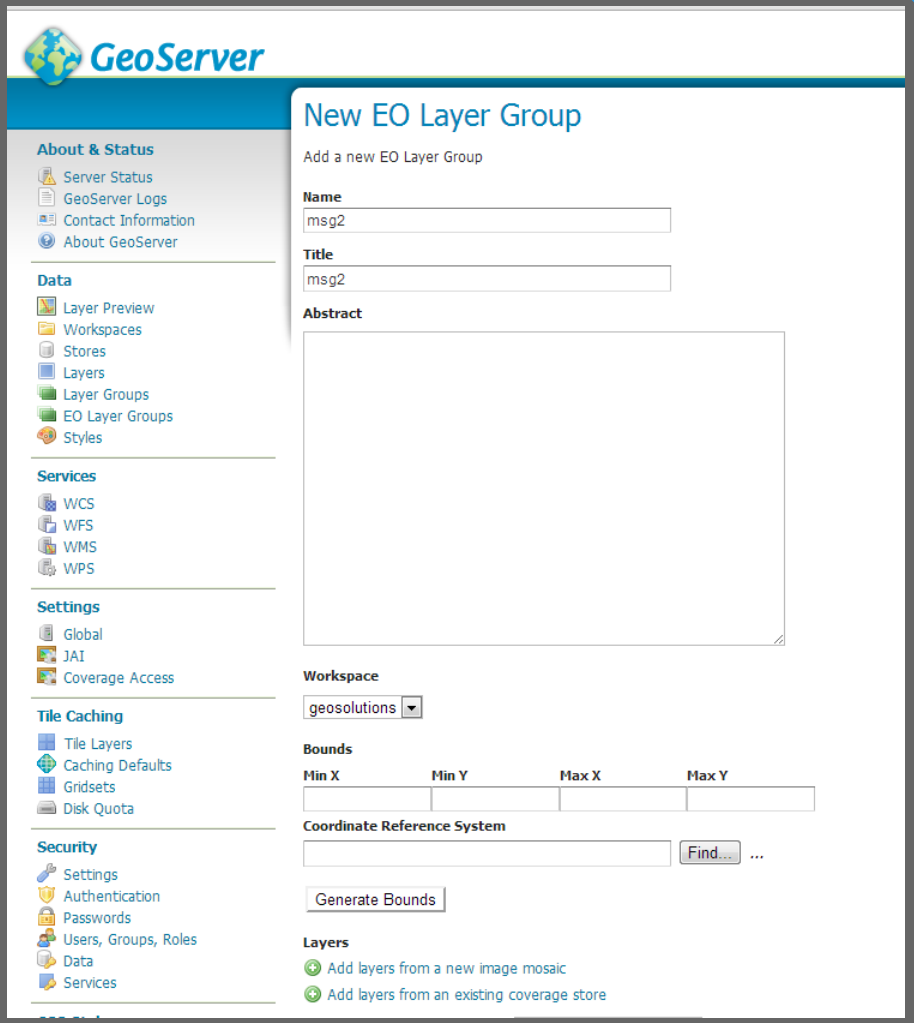
WMS-EO







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WMS-EO

geosolutions:MSG2_MSG2_Channels	MSG2_MSG2_Channels	OpenLayers KML	Select one
geosolutions:MSG2_MSG2_Airmass	MSG2_MSG2_Airmass	OpenLayers KML	Select one
geosolutions:MSG2_MSG2_FlagA	MSG2_MSG2_FlagA	OpenLayers KML	Select one
geosolutions:MSG2_browse	MSG2_MSG2_NatColours	OpenLayers KML	Select one
geosolutions:MSG2			

<< < 1 > >> Results 1 to 13 (out of 13 iter

Scale = 1 : 127M 50.39063, 38.57422

Click on the map to get feature info

Workspace

geosolutions

Bounds

Min X	Min Y	Max X	Max Y
-22	-2	60	65

Coordinate Reference System

EPSG:4326 Find... *EPSG:WGS 84...*

Generate Bounds

Layers

Add layers from a new image mosaic

Add layers from an existing coverage store

Select existing layer of type Sceglierne uno

Select a mosaic in the group and create a outlines layer from it: Sceglierne uno

Position	Source layer	Layer name in group	Type	Style	Remove
↓	geosolutions:MSG2_MSG2_Channels	MSG2_Channels	Geophisical parameter	raster	⊖
↑ ↓	geosolutions:MSG2_MSG2_Airmass	MSG2_Airmass	Geophisical parameter	raster	⊖
↑ ↓	geosolutions:MSG2_MSG2_FlagA	MSG2_FlagA	Bitmask	red	⊖
↑	geosolutions:MSG2_browse	browse	Browse image	raster	⊖

<< < 1 > >> Results 1 to 4 (out of 4 items)

Save Cancel

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WMS-EO

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  <Title>geosolutions:MSG2</Title>
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  <CRS>EPSG:4326</CRS>
  ▶<EX_GeographicBoundingBox>...</EX_GeographicBoundingBox>
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    ▶<Style>...</Style>
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    <CRS>CRS:84</CRS>
    ▶<EX_GeographicBoundingBox>...</EX_GeographicBoundingBox>
    <BoundingBox CRS="CRS:84" minx="-22.0" miny="-2.0" maxx="60.0" maxy="65.0"/>
    <BoundingBox CRS="EPSG:4326" minx="-2.0" miny="-22.0" maxx="65.0" maxy="60.0"/>
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    ▶<EX_GeographicBoundingBox>...</EX_GeographicBoundingBox>
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    ▶<Style>...</Style>
  </Layer>
```

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WCS-EO

- **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

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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