

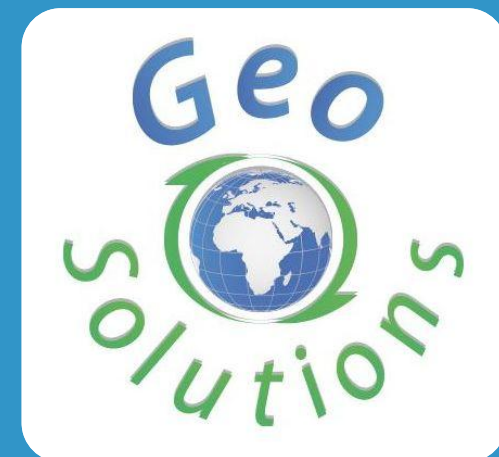
GeoServer for Spatio-temporal Data Handling With Examples For MetOc And Remote Sensing

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GeoSolutions

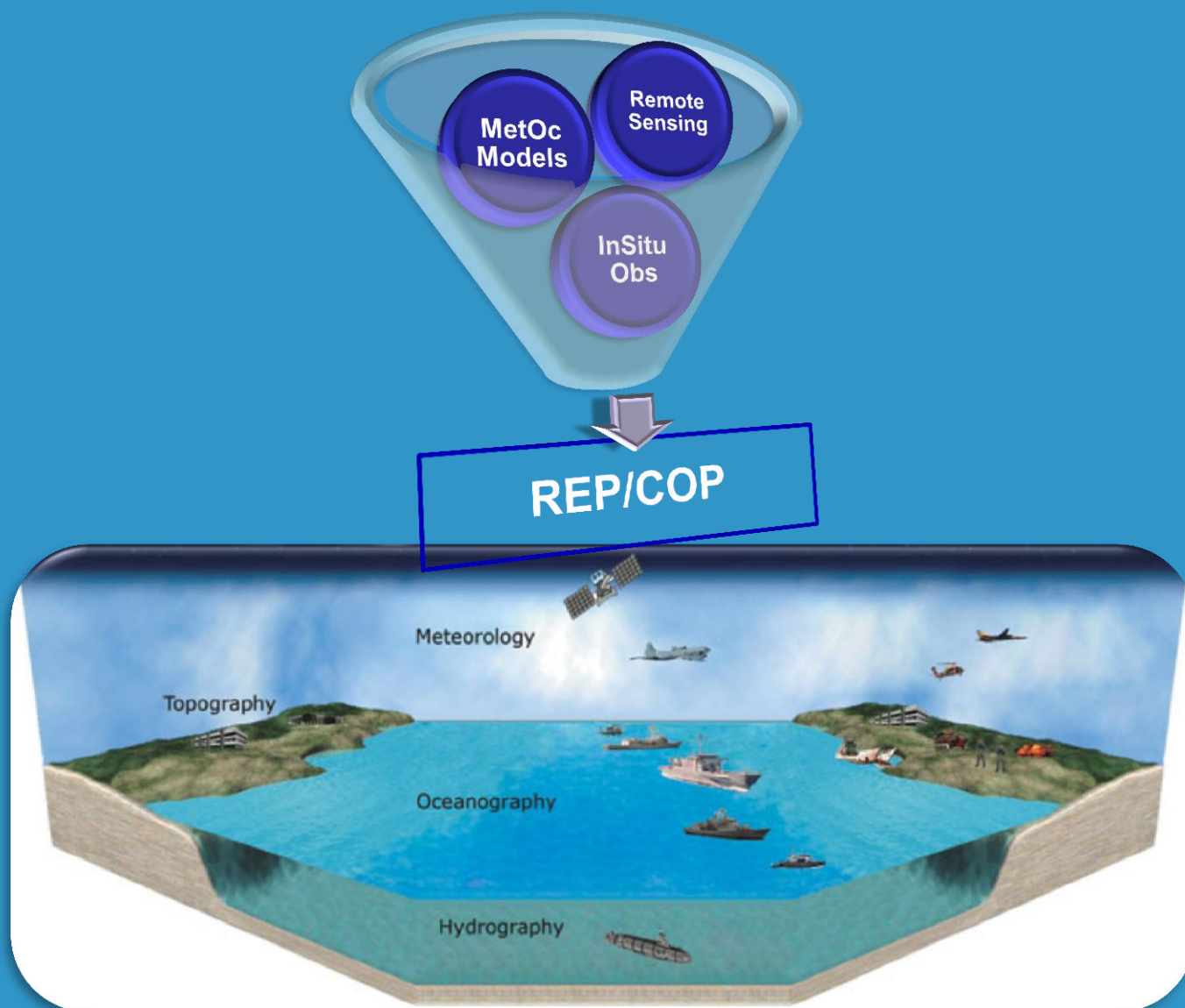


GeoSolutions

- **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**
 - GeoServer, MapStore
 - GeoNetwork, GeoNode, Ckan
- **Clients**
 - Public Agencies
 - Private Companies
- **<http://www.geo-solutions.it>**



Reference scenario



ImageMosaic – the basics



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	0103000020E610000001000000050000000000	NatColours_20130118T100000000Z.tif	2013-01-18 10:00:00
2	0103000020E610000001000000050000000000	NatColours_20130118T101500000Z.tif	2013-01-18 10:15:00
3	0103000020E610000001000000050000000000	NatColours_20130118T103000000Z.tif	2013-01-18 10:30:00
4	0103000020E610000001000000050000000000	NatColours_20130118T104500000Z.tif	2013-01-18 10:45:00

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



GraNules Assumptions

- Granules must share the same Coordinate Reference System
- ~~Granules must share the same ColorModel and SampleModel~~ → not anymore in GeoServer 2.8.0, assuming you enable JAI-EXT
- Granules can overlap as they please, can have different resolutions
- Granules can be in different file formats (faster if the format is uniform)

The mosaic index

- Always present
- Drives the collection of granules for mosaicking
- Implemented by default using GeoTools Vector Sources
- Currently supported/tested sources
 - PostGIS (JNDI)
 - Oracle (JNDI) *it's been a nightmare because of naming!*
 - H2
 - Shapefile
- Can be customized to support custom granule indexes (e.g. legacy catalog)

The dimensions

- 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

fid [PK] integer	the_geom geometry	location character varying	ingestion timestamp without time zon
1	0103000020E610000001000000050000000000	NatColours_20130118T100000000Z.tif	2013-01-18 10:00:00
2	0103000020E610000001000000050000000000	NatColours_20130118T101500000Z.tif	2013-01-18 10:15:00
3	0103000020E610000001000000050000000000	NatColours_20130118T103000000Z.tif	2013-01-18 10:30:00
4	0103000020E610000001000000050000000000	NatColours_20130118T104500000Z.tif	2013-01-18 10:45:00

Parsing dimensions from file names

- indexer.properties file

TimeAttribute=ingestion

ElevationAttribute=elevation

Schema=*the_geom:Polygon,location:String,ingestion:java.util.Date,elevation:Double

PropertyCollectors=TimestampFileNameExtractorSPI[timeregex](ingestion),DoubleFileNameExtractorSPI[elevationregex](elevation)

- elevationregex.properties file

regex=(?<=_) (\\d{3}) (?=_)



NCOM_wattemp_020_20081031T0000000_12.tiff



- elevationregex.properties file

regex=[0-9]{8}T[0-9]{9}Z(\\?!\\.*[0-9]{8}T[0-9]{9}Z\\.*)



Publishing dimensions


Custom dimension: FILEDATE

☒ Enabled

Units

Unit Symbol

Presentation

List 


Custom dimension: UPDATED

☒ Enabled

Units

Unit Symbol

Presentation

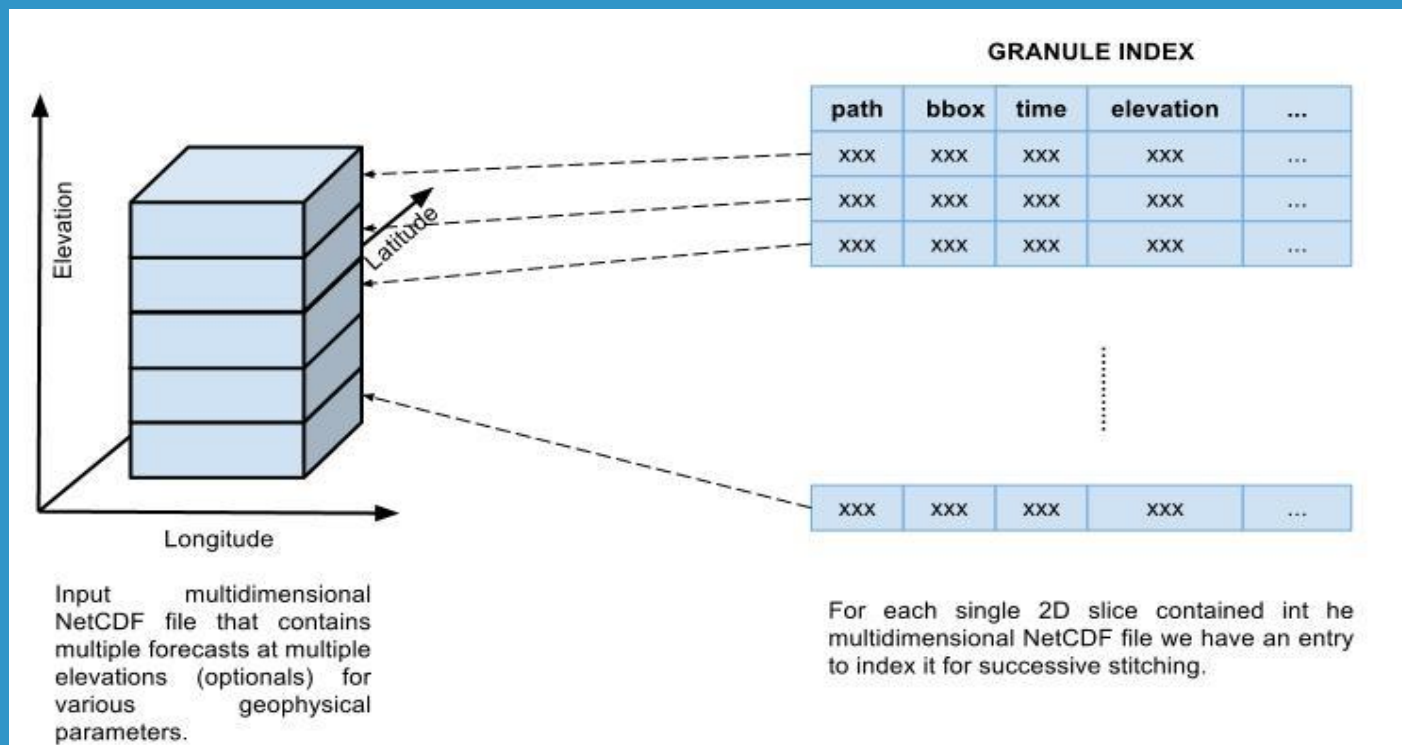
List 

```
<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,2013-03-01T  
    04:00:00.000Z,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:  
    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:  
    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:  
    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,2013-04-08T08:18:4  
  <Dimension name="FILEDATE" default="2013-03-01T00:00:00.000Z" units="">2013-03-01T00:00:00.000Z,2013-03-02T00:00:
```

NetCDF

NetCDF format support

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



NetCDF index support files

- **NetCDF Internal Index**
- **Speeds up 2D slice extraction**
- **H2/PostgreSQL + 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**

One or more variables

- Polyphemus Sample Dataset
- 1 File → Multiple Coverages!

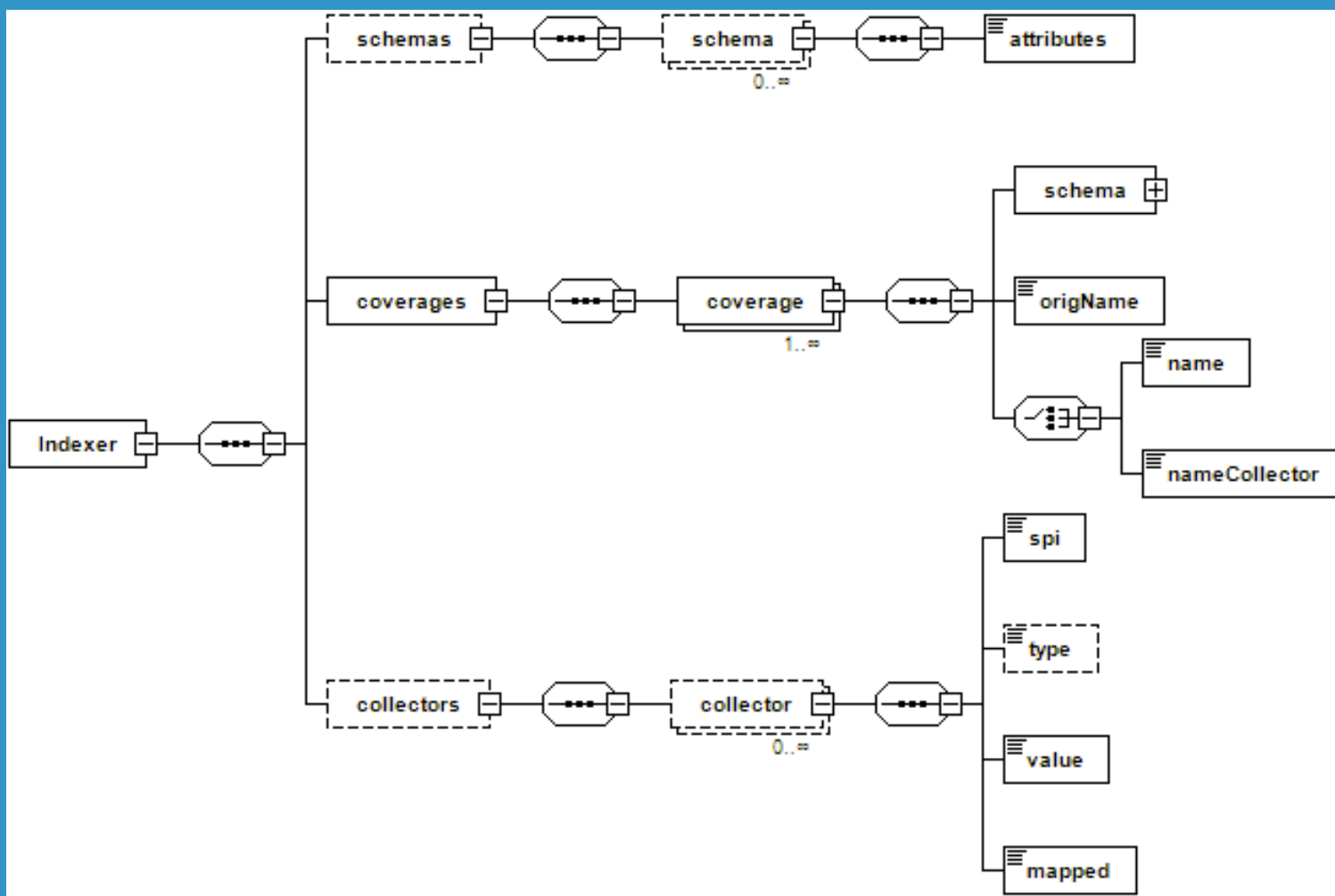
The screenshot shows the NetCDF (4.3) Tools application window. The 'Viewer' tab is active, displaying the dataset structure for 'C:/data/MD-WORKSHOP/data/polyphemus_20130301.nc'. The interface includes a file tree on the left and a table of variables on the right.

data...	description	dimensions	gr...	name	shape	units
time	Ozone conce...	time,z,lat,lon		O3	24,14,96...	
z	NO2 concent...	time,z,lat,lon		NO2	24,14,96...	
lat	Meridional w...	time,z,lat,lon		V	24,14,96...	
lon		time		time	24	hours since 2013-03-01 0:00:00
	height	z		z	14	meters
	latitudes	lat		lat	96	degrees_north
	longitudes	lon		lon	80	degrees_east

The file tree on the left shows the following structure:

- time
- z
- lat
- lon
- O3
- NO2
- V
- time
- z
- lat
- lon

NetCDF indexing configuration



NetCDF indexing configuration

- NetCDF Indexer → drive the indexing
- Automatically created, can be hand edited to expose some coverages only or parametrize 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>
```



NetCDF GridMapping to EPSG codes

Variable Info

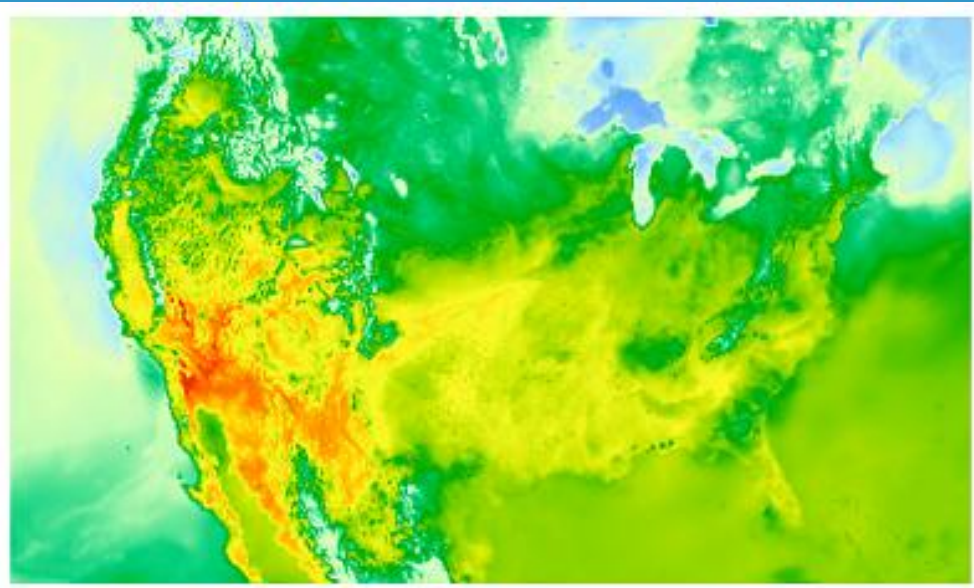
```
float Temperature_height_above_ground(time=1, height_above_ground=1, y=1059, x=1799);
:long_name = "Temperature @ Specified height level above ground";
:units = "K";
:abbreviation = "TMP";
:missing_value = NaNf; // float
:grid_mapping = "LambertConformal_Projection";
```

Variable Info

```
int LambertConformal_Projection;
:grid_mapping_name = "lambert_conformal_conic";
:latitude_of_projection_origin = 38.5; // double
:longitude_of_central_meridian = 262.5; // double
:standard_parallel = 38.5; // double
:earth_radius = 6371229.0; // double
```

EPSG:lambert_conformal_conic_1SP

```
PROJCS["lambert_conformal_conic_1SP",
  GEOGCS["unknown",
    DATUM["unknown",
      SPHEROID["unknown", 6371229.0, 0.0]],
    PRIMEM["Greenwich", 0.0],
    UNIT["degree", 0.017453292519943295],
    AXIS["Geodetic longitude", EAST],
    AXIS["Geodetic latitude", NORTH]],
  PROJECTION["Lambert_Conformal_Conic_1SP"],
  PARAMETER["central_meridian", -97.5],
  PARAMETER["latitude_of_origin", 38.5],
  PARAMETER["scale_factor", 1.0],
  PARAMETER["false_easting", 0.0],
  PARAMETER["false_northing", 0.0],
  UNIT["m", 1.0],
  AXIS["Easting", EAST],
  AXIS["Northing", NORTH],
  AUTHORITY["EPSG","971804"]]
```



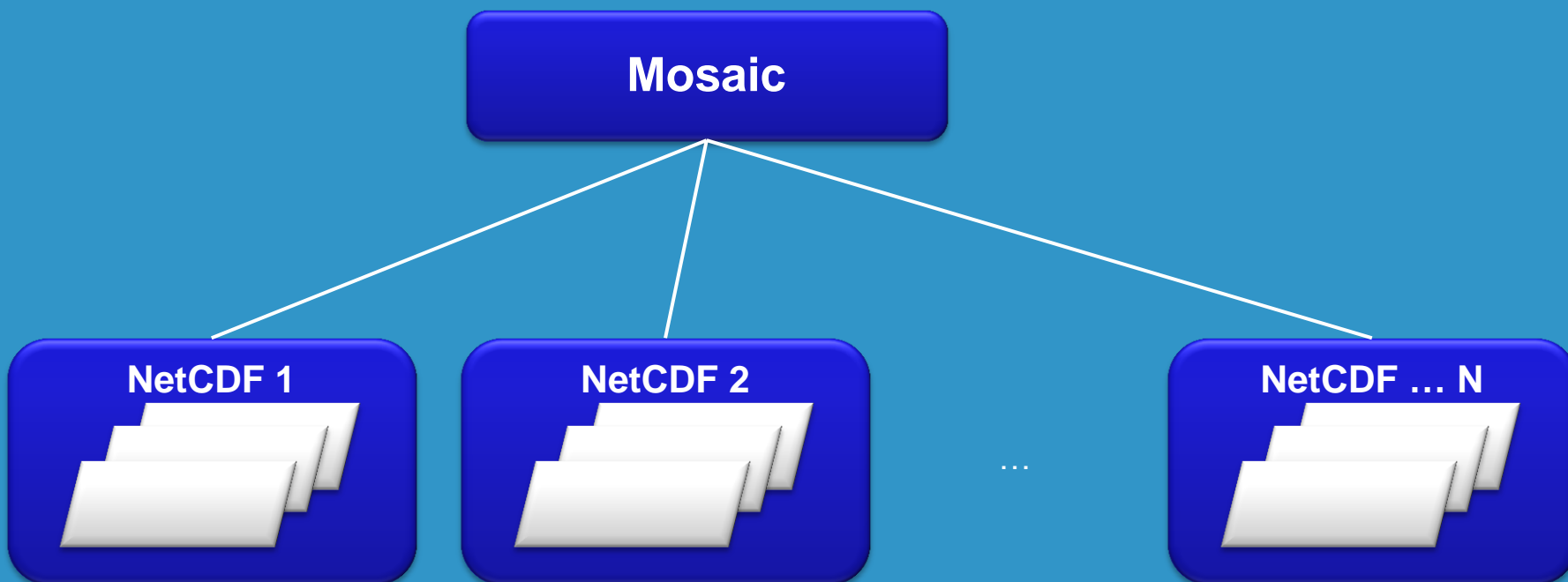
Assumptions/Limitations

- ~~Only WGS84 is supported~~ → in GeoServer 2.8.x also custom CRS are supported (GridMapping to EPSG properties)
- *Only NetCDF following COARDS/CF convention are supported*
- NetCDF WCS output is only available for multidimensional data sources (ImageMosaic and NetCDF)

ImageMosaic – NetCDF integration

NetCDF/Mosaic integration

- **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



XML based indexer 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

XML indexer: domains/dimensions

```
<?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>
```

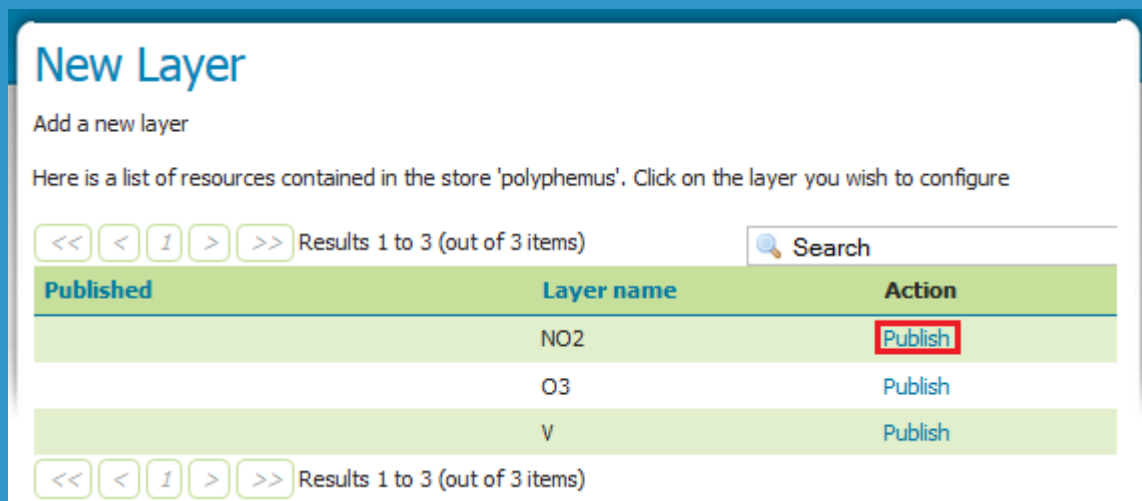
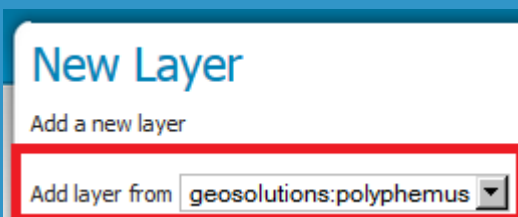
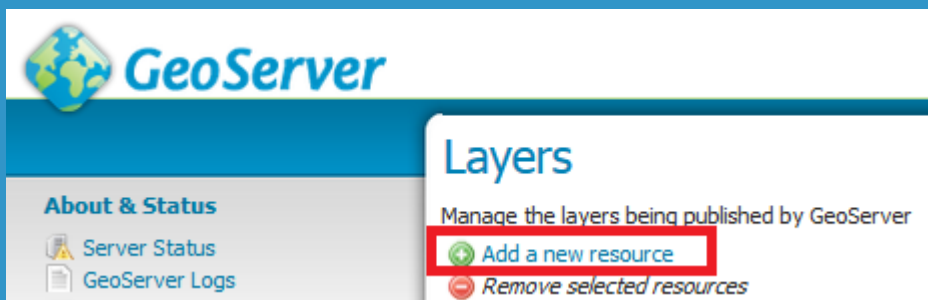
XML indexer : schemas and coverages

```
<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>
```


XML indexer : collectors and params

```
<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



REST configuration of mosaic contents

- 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/geosolu  
tions/coveragestores/temperature/file.imagemosaic
```

- READ index schema

```
curl -v -u admin:Geos -XGET  
http://localhost:8080/geoserver/rest/workspaces/geosolut  
ions/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/geosolu  
tions/coveragestores/polyphemus/coverages/NO2/index/gran  
ules.xml?limit=1&filter=time='2013-03-03T00:00:00Z"
```

REST configuration of mosaic contents

- READ (Retrieve specific granule by ID)

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

- UPDATE (harvest)

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



GRIB/GRIB2 Format Support

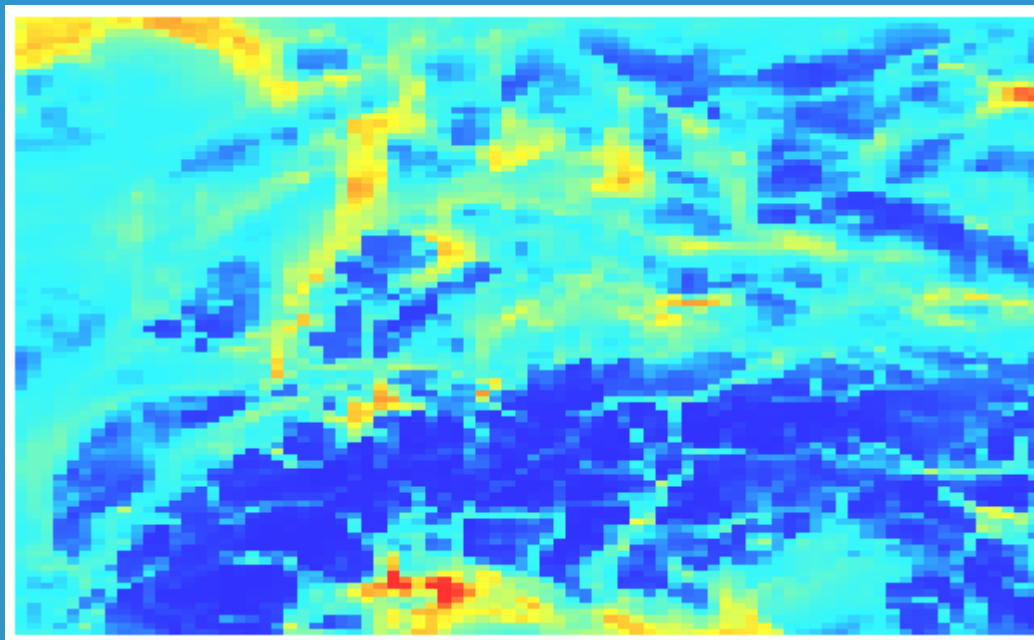
- Based on same UCAR NetCDF Java libs used by NetCDF Format
 - Same capabilities of NetCDF Format
 - Same indexing logic
 - Same ImageMosaic support

The services - visualize

WMS

TIME, ELEVATION & Custom dimensions

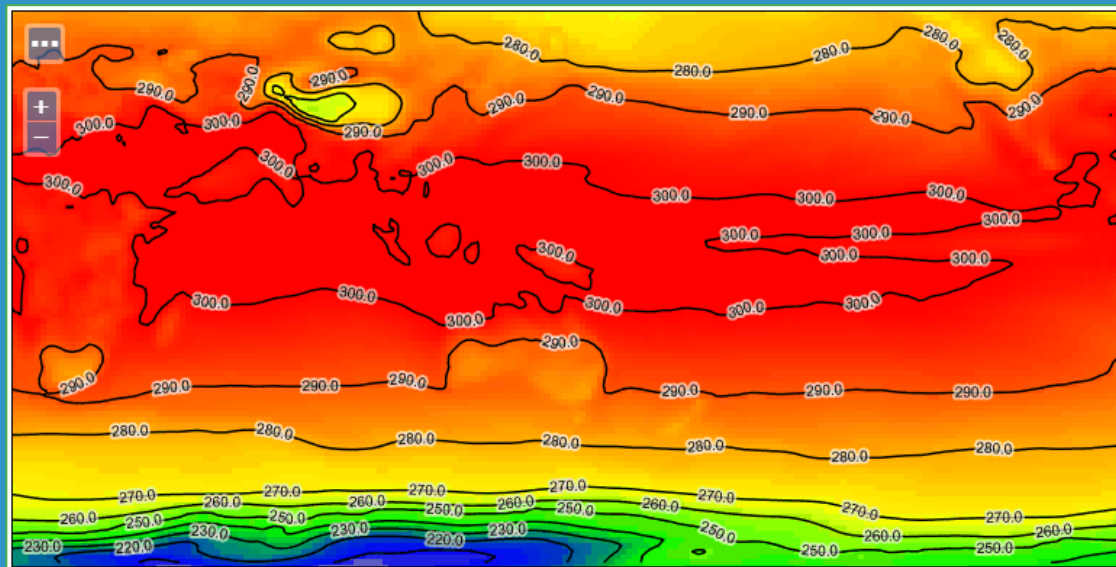
[http://localhost:8080/geoserver/geosolutions/wms?...
&time=2013-03-1T00:00:00.000Z
&elevation=35.0
&DIM_FILEDATE=2013-03-01T00:00:00.000Z
&DIM_UPDATED=2013-04-08T08:18:41.597Z](http://localhost:8080/geoserver/geosolutions/wms?...&time=2013-03-1T00:00:00.000Z&elevation=35.0&DIM_FILEDATE=2013-03-01T00:00:00.000Z&DIM_UPDATED=2013-04-08T08:18:41.597Z)



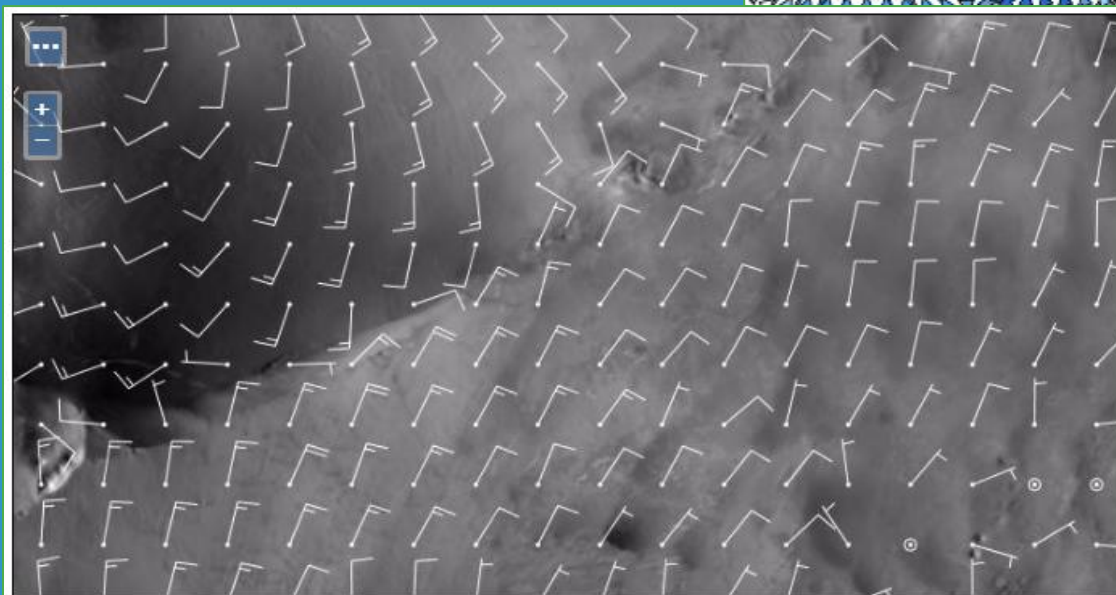
Rendering transformations

- SLD Based transformations
- On-the-fly contouring
- On-the-fly polygonalization
- Current arrows
- Wind Barbs
- Pluggable: add your own

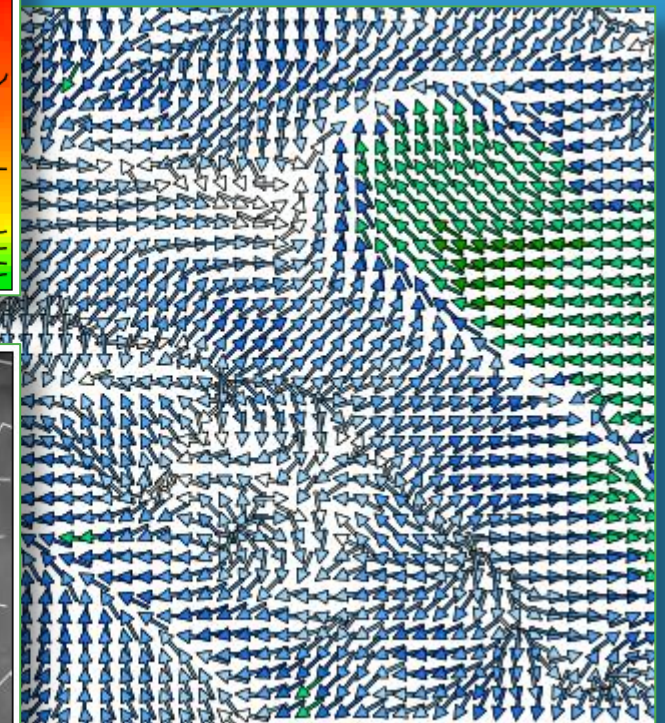
Rendering transformations



contouring



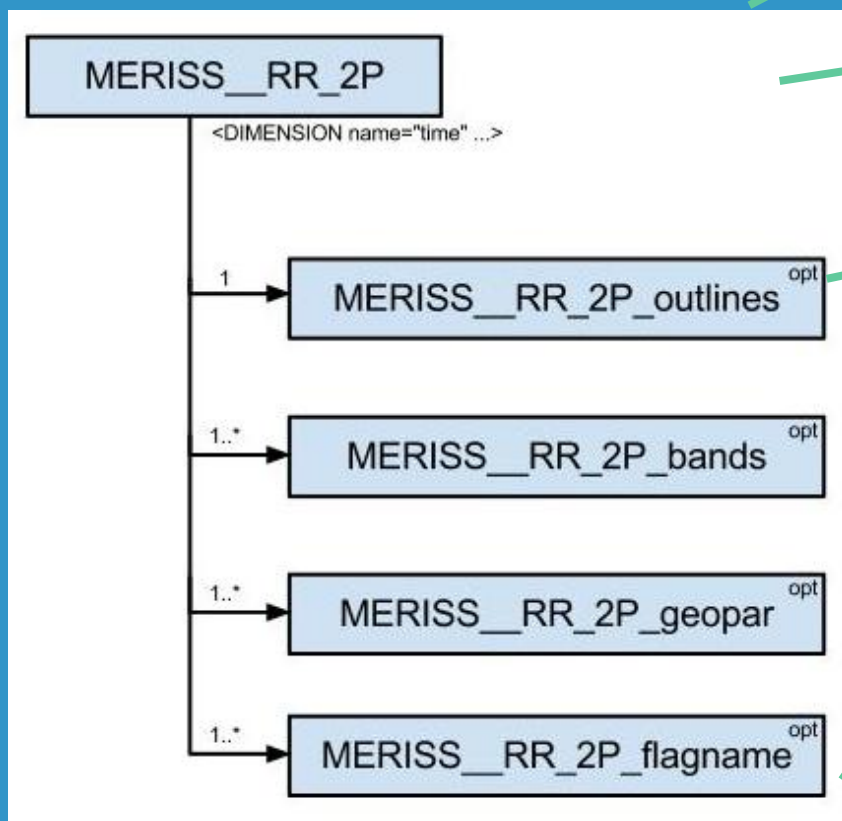
windbarbs



currents

WMS-EO

- Product layer tree
- Mix of vector and raster info
- Raw data, flags (clouds, snow), browse



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

WMS-EO



About & Status

- Server Status
- GeoServer Logs
- Contact Information
- About GeoServer

Data

- Layer Preview
- Workspaces
- Stores
- Layers
- Layer Groups
- EO Layer Groups
- Styles

EO Layer Groups

Define and manage Earth Observation layer groupings

- Add new EO layer group
- Remove selected EO layer group(s)

<< < > >> Results 0 to 0 (out of 0 items)

EO Layer Group

<< < > >> Results 0 to 0 (out of 0 items)

Add coverages into EO layer group

Select time based coverages from an existing store, and have GeoServer create the layers and add them to the layer group for

Select source store

Coverages to be added to layer group

<< < > >> Results 0 to 0 (out of 0 items)

Coverage	Layer type
MSG2_Channels	Geophysical parameter
	Ignore layer
	Browse image
	Bands
	Geophysical parameter
	Bitmask

<< < > >> Results 0 to 0 (out of 0 items)

Add to Group Cancel



About & Status

- Server Status
- GeoServer Logs
- Contact Information
- About GeoServer

Data

- Layer Preview
- Workspaces
- Stores
- Layers
- Layer Groups
- EO Layer Groups
- Styles

Services

- WCS
- WFS
- WMS
- WPS

Settings

- Global
- JAI
- Coverage Access

Tile Caching

- Tile Layers
- Caching Defaults
- Gridsets
- Disk Quota

Security

- Settings
- Authentication
- Passwords
- Users, Groups, Roles
- Data
- Services

New EO Layer Group

Add a new EO Layer Group

Name
msg2

Title
msg2

Abstract

Workspace

geosolutions

Bounds

Min X Min Y Max X Max Y

Coordinate Reference System

Find... ..

Generate Bounds

Layers

- Add layers from a new image mosaic
- Add layers from an existing coverage store

- Helper UI to build the tree

WMS-EO

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 Scegliere uno ▼

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

Position	Source layer	Layer name in group	Type	Style	Remove
↓	geosolutions:MSG2_MSG2_Channels	MSG2_Channels	Geophysical parameter	raster	⊖
↑ ↓	geosolutions:MSG2_MSG2_Airmass	MSG2_Airmass	Geophysical 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

■	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		OpenLayers KML	Select one ▼

<< < 1 > >> Results 1 to 13 (out of 13 items)



127M
map to get feature info

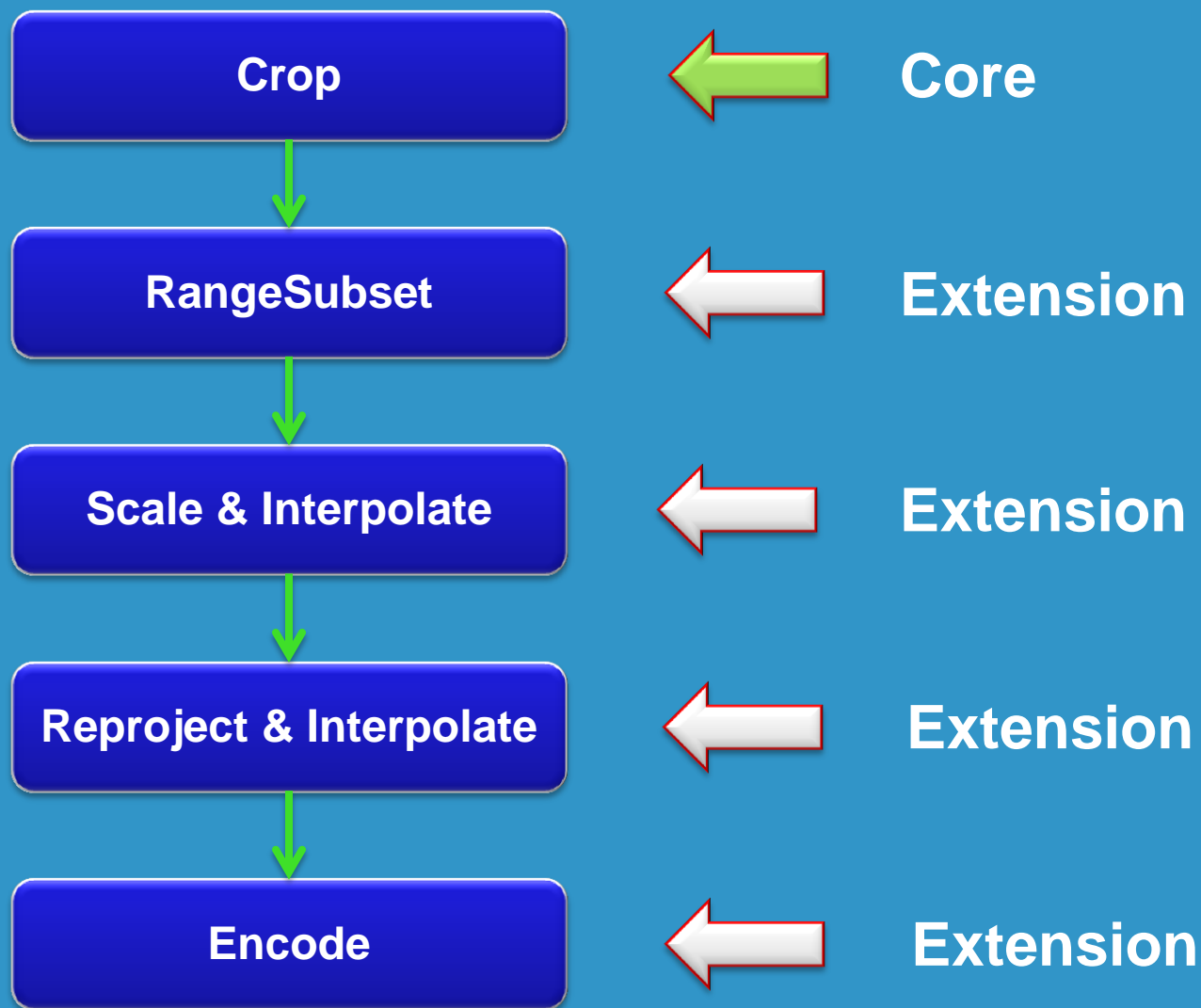
50.39063, 38.57422

The services - download

WCS 2.0

- **Basics**
 - Core service
 - KVP binding
 - XML binding
- **Common extensions**
 - CRS
 - Scaling
 - Interpolation
 - Range subsetting
 - GeoTiff
 - GML
 - NetCDF
- **Add the output format extensions**
 - GeoTIFF
 - GML Grid
 - NetCDF

WCS 2.0 processing chain



WCS 2.0 DescribeCoverage

```
<gml:boundedBy>
  <gml:EnvelopeWithTimePeriod srsName="http://www.opengis.net/def/crs/EPSSG
    <gml:lowerCorner>44.96875 4.9375 10.0</gml:lowerCorner>
    <gml:upperCorner>50.96875 14.9375 2500.0</gml:upperCorner>
    <gml:beginPosition>2013-03-01T00:00:00.000Z</gml:beginPosition>
    <gml:endPosition>2013-03-02T23:00:00.000Z</gml:endPosition>
  </gml:EnvelopeWithTimePeriod>
</gml:boundedBy>

<wcsgs:TimeDomain default="2013-03-02T23:00:00.000Z">
  <gml:TimeInstant gml:id="geosolutions__NO2_td_0">
    <gml:timePosition>2013-03-01T00:00:00.000Z</gml:timePosition>
  </gml:TimeInstant>
  <gml:TimeInstant gml:id="geosolutions__NO2_td_1">
    <gml:timePosition>2013-03-01T01:00:00.000Z</gml:timePosition>
  </gml:TimeInstant>
  <gml:TimeInstant gml:id="geosolutions__NO2_td_2">
    <gml:timePosition>2013-03-01T02:00:00.000Z</gml:timePosition>
  </gml:TimeInstant>
  ....
</wcsgs:TimeDomain>

<wcsgs:ElevationDomain uom="m" default="10.0">
  <wcsgs:SingleValue>10.0</wcsgs:SingleValue>
  <wcsgs:SingleValue>35.0</wcsgs:SingleValue>
  <wcsgs:SingleValue>75.0</wcsgs:SingleValue>
  <wcsgs:SingleValue>125.0</wcsgs:SingleValue>
  <wcsgs:SingleValue>175.0</wcsgs:SingleValue>
  <wcsgs:SingleValue>250.0</wcsgs:SingleValue>
  <wcsgs:SingleValue>350.0</wcsgs:SingleValue>
  ....
  <wcsgs:SingleValue>2500.0</wcsgs:SingleValue>
</wcsgs:ElevationDomain>

<wcsgs:DimensionDomain name="UPDATED" default="2013-04-08T07:40:29.061Z">
  <gml:TimeInstant gml:id="geosolutions__NO2_dd_0">
    <gml:timePosition>2013-04-08T07:40:29.061Z</gml:timePosition>
  </gml:TimeInstant>
  <gml:TimeInstant gml:id="geosolutions__NO2_dd_0">
    <gml:timePosition>2013-04-08T07:41.597Z</gml:timePosition>
  </gml:TimeInstant>
</wcsgs:DimensionDomain>
```

BBOX

TIME

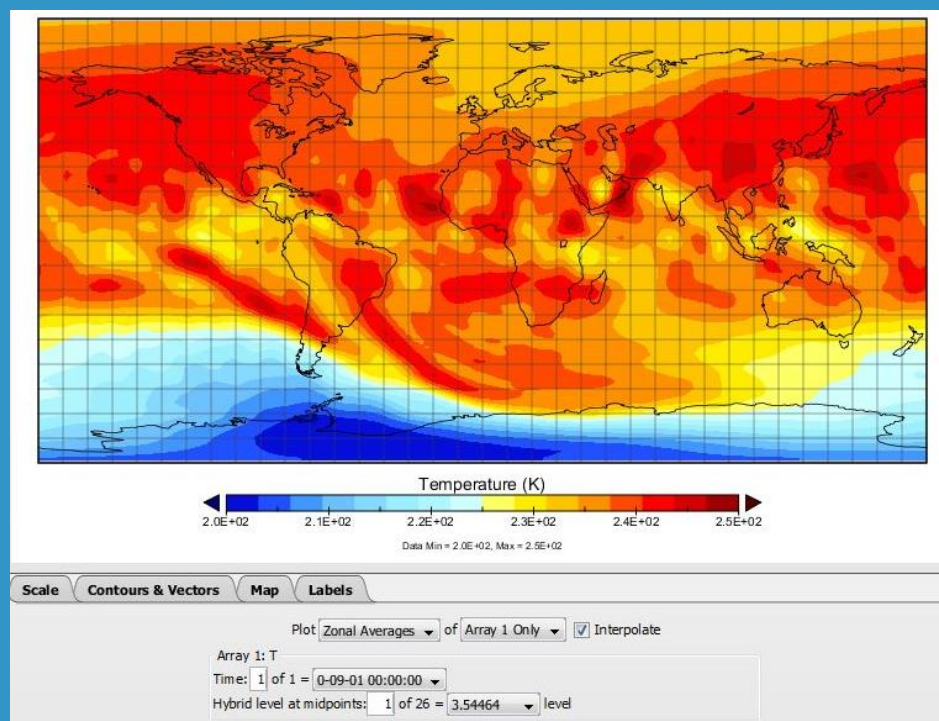
ELEVATION

CUSTOM

Download ND NetCDF

```
http://localhost:8080/geoserver/wcs?request=GetCoverage&service=WCS&
version=2.0.1&coverageId=geosolutions__NO2
&Format=application/x-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")
```

- Can also handle custom dimensions
- Described in DescribeCoverage in a vendor metadata section



WCS EO

- **Add support for WCS EO metadata in readers**
 - Associate each file with EO metadata
 - Include such information in DescribeCoverage/DescribeEODataset
- **EODataset: multidimensional mosaic or NetCDF file**
- **Describe the inner structure (granules listing) in DescribeEODataset**

That's all folks!



Questions?

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