Web Coverage Service
Meeting with Reality

Jozef Matula
Visual Weather Team Leader

14th Workshop on Meteorological Operational Systems, 18th–20th Sep 2013
ECMWF, Reading, United Kingdom
Why should you be interested?
OGC Web Coverage Service
  - WCS Core 2.0
Meteorological Data Extraction Patterns
MetOcean DWG WCS 2.0 Profile (Proposal)
  - Mapping NWP Models
  - Vertical level types
  - Trajectories and corridors

By courtesy of Peter Trevelyan, UK Met Office and Pavol Novotný, IBL
• Meteorological services all around the world produce lots of gridded data. There is more and more data available.
• There is increasing demand from end-users for the raw data (understandable by their computers) rather than for the data visualisation (what only humans can read).

Is there a chance of rain within next 7 days?

If user’s computers want to take decision, we can:
- push all data to the user and let him evaluate the answer or,
- provide user with “subset” of the data.
• Data volumes grow faster than the network links.

Is there a chance of rain within next 7 days?
1M grid points x 24h x 7 days ≈ hundreds MB of data

• Wikipedia: “Big data is the term for a collection of data sets so large and complex that it becomes difficult to process using on-hand database management tools or traditional data processing applications. The challenges include capture, curation, storage, search, sharing, transfer, analysis, and visualization.”

• Sooner or later the data volumes needed for “some simple answers” will not be transferable over networks!
If you just start reading the specification it seems like a dream given a form and it has all what is needed:

- WCS 2.0 Spec: “The OGC Web Coverage Service (WCS) supports electronic retrieval of geospatial data as "coverages" – that is, digital geospatial information representing space/time-varying phenomena.”

- WCS 2.0 Spec: “A GetCoverage request prompts a WCS service to process a particular coverage selected from the service’s offering and return a derived coverage. The WCS Core standard defines the domain subsetting operation which delivers all data from a coverage inside a specified request envelope (“bounding box”), relative to the coverage’s envelope – more precisely, the intersection of the request envelope with the coverage envelope.”

WCS is a machine to machine protocol for gridded data extraction (subsetting).
Coverage ≈ Field(s)
Core of the WCS 2.0 Core Standard

- 49 pages, closely coupled with GML.
- 3 main types of requests (procedures):
  - GetCapabilities – lists all coverages.
  - DescribeCoverage – describes coverage metadata.
  - GetCoverage with “Slice” and “Trim” operations.
- Designed to be extensible:
  
  *WCS 2.0 Spec*: “OGC Profile and Application Profile standards establish domain-targeted specializations of interface standards.”

- By default the WCS requests are passed via HTTP XML POST requests with a complicated XML schema.
WCS 2.0 Core GetCoverage Operation

Potentially different geospatial domain

New Coverage

Potentially different data format
WCS 2.0 Core GetCoverage Operation

Slice Operation
(dimension reduction)

Trim Operation
(extent reduction)
• Source coverage data is potentially N dimensional – just like variables in NetCDF.
  – Can have X, Y, Z (vertical level), Time.
• “Slice” operation reduces dimensions e.g. from 3D → 2D or/then 2D → 1D.
• “Trim” operation implements dimension range subsetting e.g. if applied to both X and Y we create a BBOX subsetting.

• “Slice” and “Trim” can be requested in other coordinate reference systems (CRS) than the CRS of the source data (in this case reprojection is needed).
Imagine 3D data cube without time
• Extracting data for a point = Slice X, Slice Y, Slice Z
• Extracting vertical profile data for 2D geospatial domain = Trim X, Trim Y, Trim Z
• Extracting vertical profile data for a point = Slice X, Slice Y
• With vertical range = Slice X, Slice Y, Trim Z
• Extracting data for 2D geospatial domain for a single vertical level = Trim X, Trim Y, Slice Z
• Extracting **vertical profile** data “above” a trajectory = Trim in Trajectory CRS

• Trajectory CRS is 1 dimensional function $T(q)$ for $q$ in $<0;1>$ mapping $q$ to actual X, Y coordinates!
For road we need **Compound CRS** = Trajectory CRS + Z axis = Trim in Trajectory CRS + Slice in Z.
• Extracting data for a 3D trajectory (airplane flight) = Trim in 3D Trajectory CRS
• 3D Trajectory CRS is 1 dimensional function $T(q)$ for $q$ in $<0;1>$ mapping $q$ to real $X,Y,Z$ coordinates.
• All mentioned patterns were purely geospatial and height related.

• Is the time just yet another 4th dimension?

• We need to take into account:
  – Forecast validity time.
  – Model run reference time.
  – Ensemble member dimension.

• This potentially creates a 6D coverage?!

• Not to be forgotten too - “sampling” and “interpolation”.
WCS 2.0 Limitations

- **WCS 2.0 Spec:** “The specification contained in this **WCS Core is not sufficient for a fully functioning WCS implementation.**”

- No guidance on how to advertise validity times for which coverage data is available!

- Vertical level type of a coverage must be uniform (same as in WMS)

- Definition of “trajectory CRS” is strange quite hard to extend (time, corridor extents, interpolation types, etc).

- Unclear dimension name called “t” or “time”. Some CRSs use “lat”, “long”, some “x”, “y” coordinates.
Other WCS 2.0 Extension Profiles

- Protocol Extensions:
  - Key-Value Protocol Binding (using HTTP GET requests)
  - SOAP
- Format Extensions (GML, GeoTIFF, HDF-EOS, ...)
- Range Subsetting (extract only certain values)
- WCS Processing Extension (WCPS)

“EO-WCS” Earth Observation WCS 2.0 Profile:
- Defines metadata about times for which the coverage is available
- Targeted on satellite imagery (EO)
Met Ocean WCS 2.0 Profile

• Built over WCS 2.0 Core. Targeted on exposing NWP data.

• Coverage =
  – Set of NWP Model Parameters,
  – from certain model run reference time (e.g. run from today 00Z),
  – using certain vertical level type (e.g. only hPa or only meters).

• Coverage Collection =
  – Logical set of coverages, possibly with mixed vertical levels types, various model runs etc.
  – Set of parameters for certain use case e.g. “Aviation Parameters Coverage” including Wind, Temperature, Icing and Turbulence coverages.
  – Whole NWP model e.g. “ECMWF Deterministic Global Model Coverage”.
MO Profile – NWP Metadata Hierarchy

NWP Model

Model run 00Z
Model run 06Z
Model run 12Z
Model run 18Z
MO Profile – NWP Metadata Hierarchy

NWP Model

- Model run 00Z
  - Isobaric Levels
  - Meters Above Mean Sea
  - Meters Above Ground
  - Hybrid Levels

- Model run 06Z
  - Isobaric Levels
  - Meters Above Mean Sea
  - Meters Above Ground
  - Hybrid Levels

- Model run 12Z
  - Isobaric Levels
  - Meters Above Mean Sea
  - Meters Above Ground
  - Hybrid Levels

- Model run 18Z
  - Isobaric Levels
  - Meters Above Mean Sea
  - Meters Above Ground
  - Hybrid Levels
MO Profile – NWP Metadata Hierarchy

Metadata for one NWP model run assuming “only” 3 parameters, 3 forecast offset times.
Intentionally unreadable!
MO Profile – NWP Metadata Discovery

GetCapabilities()

DescribeCoverageCollection(NWP Model)

CoverageCollection Identifier

NWP Model

Model run 00Z
Model run 06Z
Model run 12Z
Model run 18Z
...

Isobaric Levels

Temperature
+0H
+6h
+12h

Wind
850hPa
500hPa
300hPa

Relative Humidity
+0H
+6h
+12h

Meters Above Mean Sea

Meters Above Ground

Hybrid Levels

GetCoverage(Wind, SliceZ(500hPa), SliceT(+6h)...)
• Backward compatible with standard WCS GetCapabilities.
• Declares 2 custom operations:
  – DescribeCoverageCollection
  – GetCorridorCoverage
• Includes metadata about available Coverage Collections.

• Typically one NWP model is exposed as a single Coverage Collection.

• User has to use the DescribeCoverageCollection operation to discover further details/metadata.
Request returns detailed metadata of Coverage Collection:

- Listing “actual coverages” - NWP model runs and vertical levels types used in this collection – for example GFS Coverage Collection with 3 different vertical level types (ISBL, AGL, AMSL) can list following coverages:
  
  GFS_2013-11-07T00.00.00Z_ISBL
  GFS_2013-11-07T00.00.00Z_AGL
  GFS_2013-11-07T00.00.00Z_AMSL
  GFS_2013-11-07T12.00.00Z_ISBL
  GFS_2013-11-07T12.00.00Z_AGL
  GFS_2013-11-07T12.00.00Z_AMSL

- User has to use the DescribeCoverageCollection operation to discover further details/metadata.
• Backward compatible DescribeCoverage.
• For actual coverage listing available forecast offsets and vertical levels using the “availability mask” (matrix).
• Native 2D+Time (fixed height) or 3D+Time trajectory concept.
• Trajectory depiction is part of request rather than part of CRS.
• Z extent is metric height in meters.
In Visual Weather 3.6 we implement WCS 2.0 interface for:
- accessing NWP data,
- reprojection,
- vertical interpolation,
- horizontal interpolation.

Support for trim and slice operations.

Exposing metadata conforming to:
- Earth Observation WCS Profile as well as
- Met Ocean WCS Profile.

Supported output formats are GRIB1, GRIB2, NetCDF and GeoTIFF, JSON, KML.
Well, the WCS 2.0 MetOcean Profile is a work in progress.

Future work and plans should/will address:

- Key-Value-Pair HTTP GET Binding Profile to simplify usage.
- GetPolygonCoverage (coverage over only polygonal geospatial area)
- GetCrossSectionCoverage (coverage over only polygonal geospatial area)
- Ensemble models.
- Merge with EO WCS 2.0 Profile.
- Evaluate oceanography and climatology applications.
Questions?