WCS2.0 Met-Ocean

MetGis Frankfurt

Peter Trevelyan 28th October 2014

The Main Messages(1)

- To incorporate actionable advice within their applications, DST (Decision Support Tools) developers require functionality that can:
  - Convert ‘raw weather data’ (e.g., winds, rain, and clouds) into ‘actionable information’;
  - Retrieve, manage, analyze, and display weather data/rules;
  - Facilitate ***efficient*** machine to machine exchange.
- Such service by definition will need to be interoperable.

The Main Messages(2)

- The challenge is to move from a “data centric” approach to one that is “service centric”
  - To do this the data must be accessible to any function/service via commodity interface.
  - Bulk data transfer is no longer viable due to data volumes; therefore data must be tailored at source to fit the use of the use
  - Data may be in the form of images, features (e.g. lines/contours, or cut out grids.
- Services may be “chained” to increase functionality.

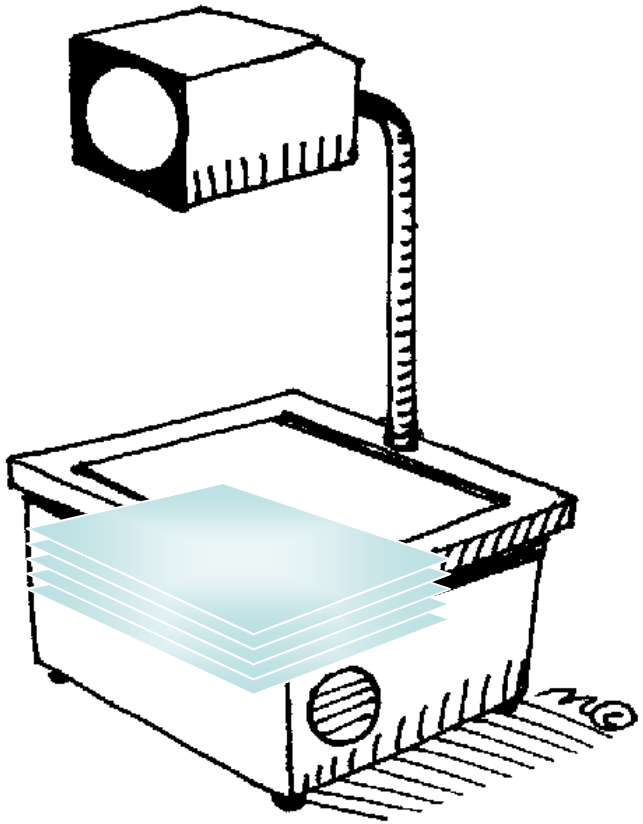
Opportunities:-

“Weather information must be designed to integrate with, and support, decision-oriented products with automation capabilities that enhance user safety and efficient operations. Many decisions are based on threshold conditions”.

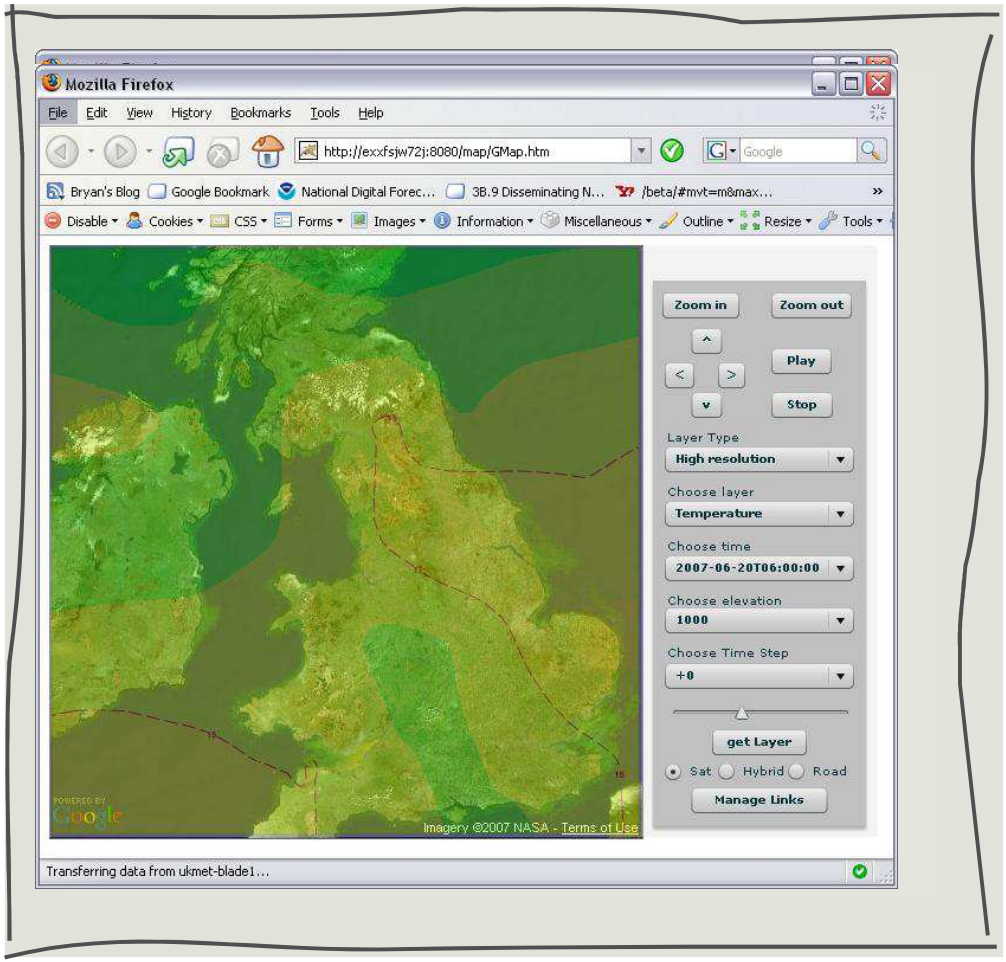
The Story so far:

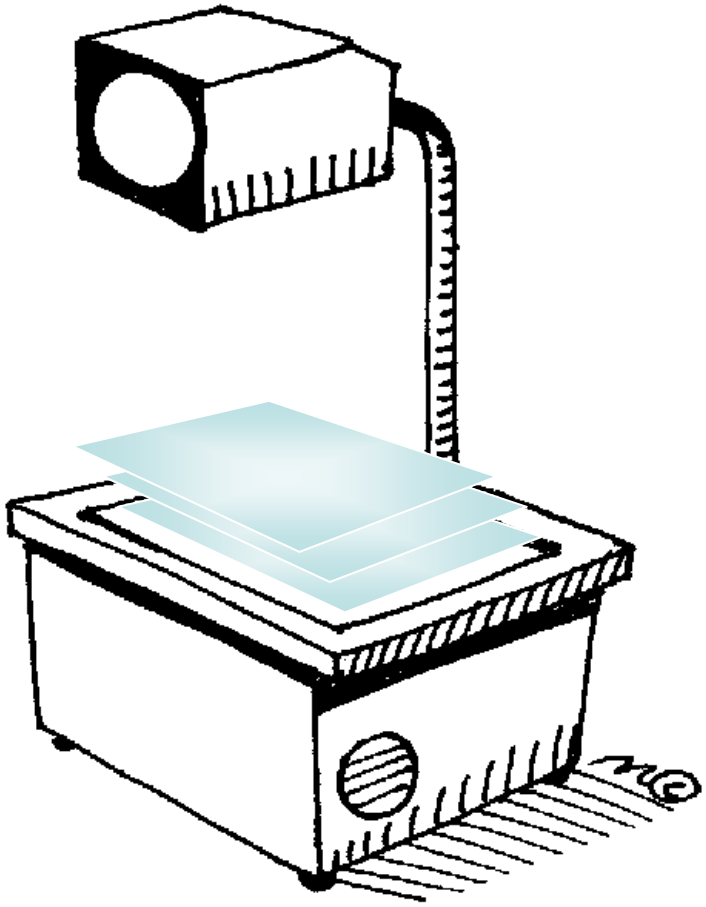
Overhead projector (metaphor for WMS) …

- Historically when developing visualisation systems we've developed a complete 'stove-pipe' … all the transparencies and a new overhead projector every time!
- Now we can develop the projector once (e.g. a web-client) and build up a catalogue of re-usable transparencies …
- We can sell 'off-catalogue' & build 'bespoke' layers to specification.



The Current Approach:





What has changed with the weather?

- NWP (Numerical Weather Prediction) has evolved such that:
  - High spatial resolution (2KM for limited area) is now common and will soon be down to 1KM;
  - The update frequency of weather information is now commensurate with the need to respond to rapidly changing circumstances;
  - Weather capabilities allow rapid notification (automation-to-automation) of changing weather situations to strategic and tactical decision makers; update rate now every 15 minutes, soon to be 5 minutes.
  - Probabilistic weather forecast elements are better suited for risk based decisions and greatly increase the amount of data needed to be processed.

The Paradigm shift:

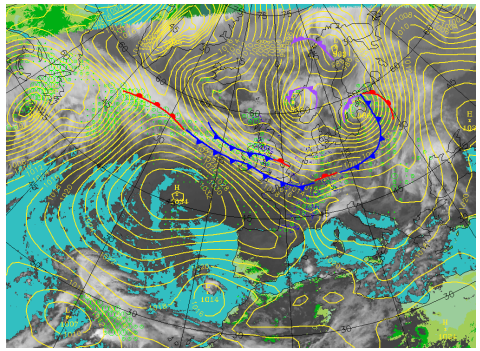
- The "weather forecast" paradigm shift in the next era is that, while stand-alone graphical displays of weather readily convey more information than text, they are no longer adequate.
- Required is the merging of more accurate probabilistic weather forecasts in gridded format with expected asset e.g. aircraft, ships, traffic positions etc enabling DST (Decision Support Tools) algorithms to determine optimal ‘throughput‘ in and around forecast weather.

What kind of hazards:-

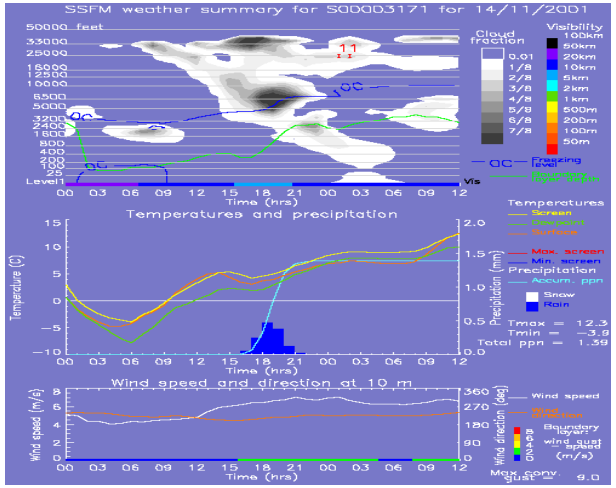
- Low-level wind shear and gusty surface winds:
- Large hail:
- Moderate or greater in-flight icing:
- Meso-cyclones, tornadoes, funnel clouds, and waterspouts:
- Lightning:
- Low visibility and ceiling due to heavy precipitation:

The Data Problem:

- Most of our data is structured to meet one requirement i.e. creating contoured charts and this causes real issues e.g.



The data to create this are stored in layers and created by sampling 604X481 grid points.



The data to create this are stored in layers and created by sampling 784,414,800 grid points! If the data had been optimally for this request the amount of data would have been: **2,700!**

The Shape of things to come:
(Welcome to the world of coverages)

- What is important is the impact of weather, not the weather itself.
- The execution of business rules on raw data should be done upstream and only data relevant to a business process passed to the consumer.
- The extraction of relevant information form large data holdings is key to solving the data overload experienced by many of todays decision support tools.

The “shape” of the data is critical to its use.

- For example; if you want to find out how many times the temperature will fall below zero for a site you do not need the complete 4D grid for the UK, only a time series of temperature for the selected site.
- Better still you may only want the hours, if any, for which the temperature is below zero.

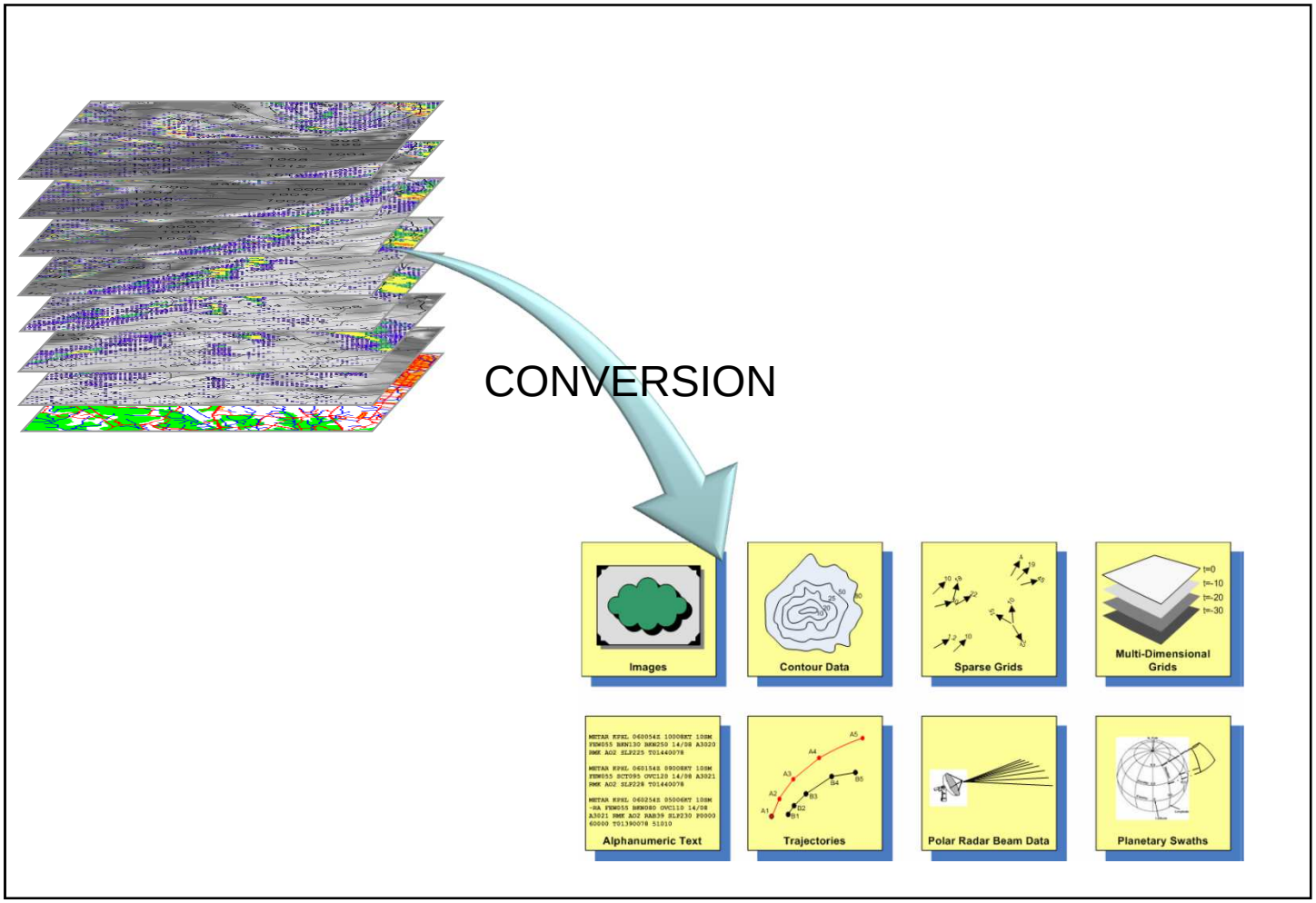
What kind of shapes:-

- A number of use cases have been examined and the following “data shapes” have been identified.
  - GRIDS:
  - Time Series:
  - Cross sections:
  - Point collections (e.g. observations):
  - Vertical profiles (e.g. ascents):
  - Trajectories:

Flexibility of Digital Data:

- Two main uses of digital data:
  - As input into DST (decision support tool)
  - Respond to interrogation e.g. give me a value at a certain point.
- We will look at each in turn starting with the DST and some case studies:-

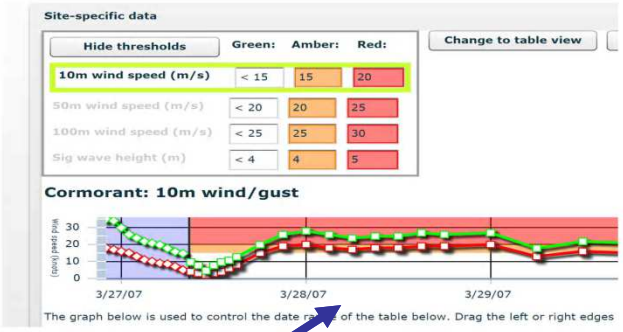
The Goal is to:



Welcome to the world of geospatial data and the OGC:

- The OGC (Open Geospatial Consortium) is a grouping of interested parties.
- The OGC sponsors interoperability through the use of geospatial standards.
- The term “Feature” and “Feature Type” are used to describe real world objects.
- Data shapes identified for use within meteorology map into the world of Features and Feature Type.
- We can therefore use OGC services and definitions.

An Integrated World



Applications

WMS

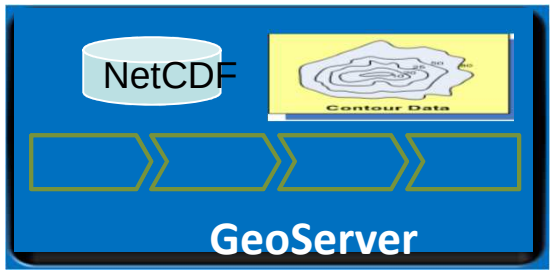
WCS

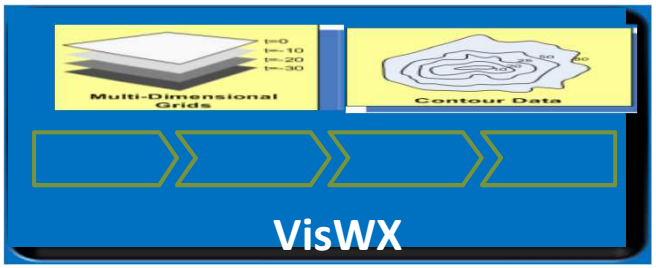
Non-met features

WFS

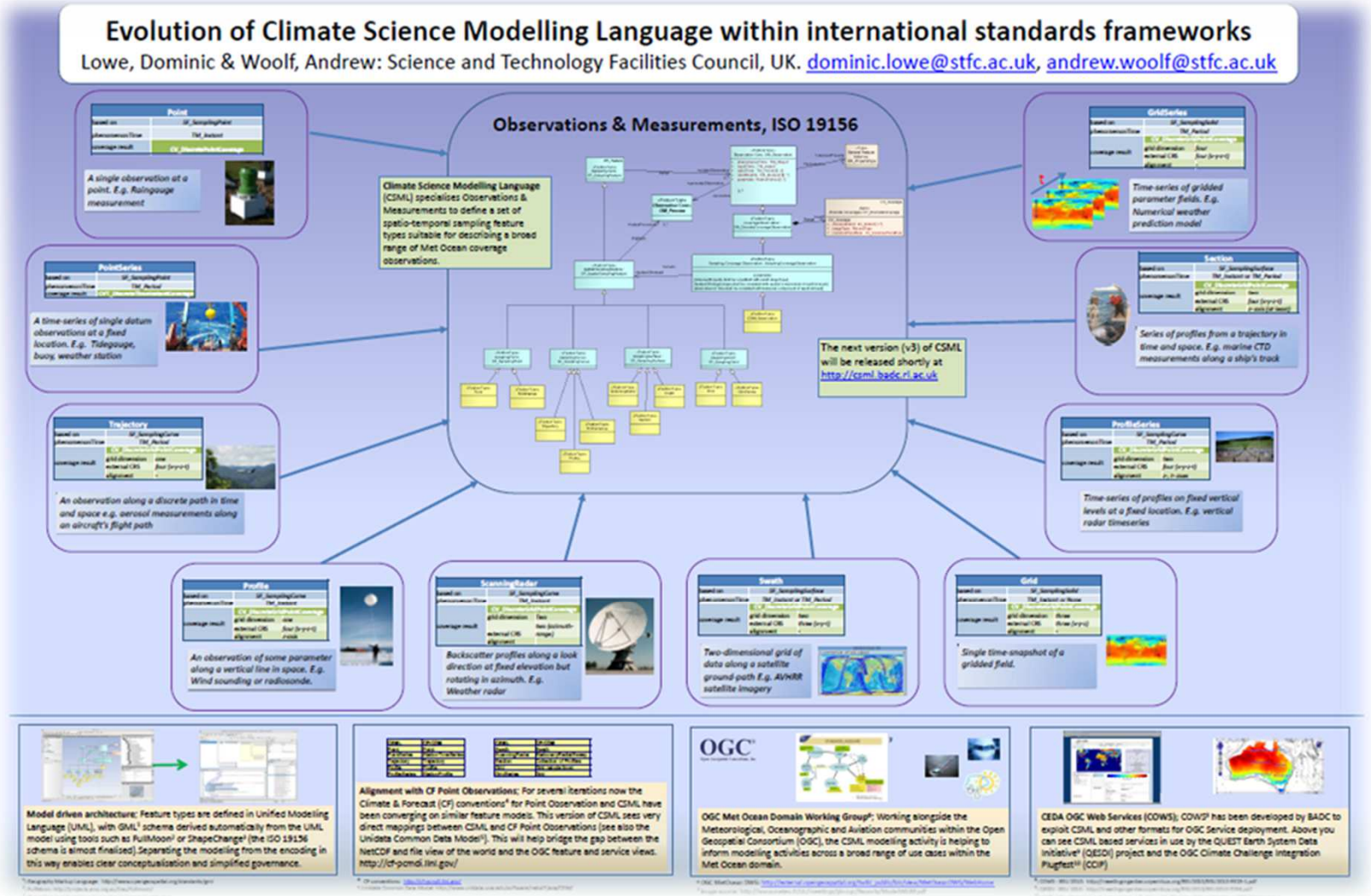
Arc Gis Server

Arc SDE



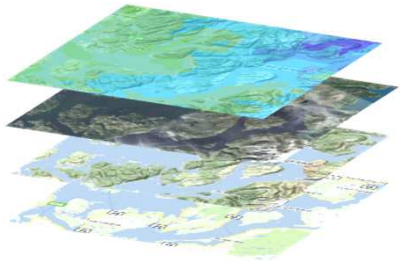


Coverages used in Met-Ocean



What kind of coverages?

1. Assess foundation data



MetOc imagery
DEM
topography/ bathymetry

2. UAV Mission Planning

deterministic & probablistic weather f/c with 'confidence' quality mask

3. Data capture (UAV & sensors) – integrate with predictive models

temp/pressure/ wind/precip time-series (deployed met-sensors)

temp soundings (deployed sono-bouys)

geo-rectified hi-res imagery / hi-res TIN coverage DEM

4. Assess overland trafficability for route plan

DEM
land-usage
terrain type
soil moisture
precipitation

5. Assess optimal coastal landing point and time

bathymetry
SCAT-winds
ocean-currents
sea-state
Tideline variation

So what are Coverages?

- A “coverage” is a special kind of geographic feature, with the distinguishing characteristics that whilst other features have one particular value associated a coverage typically conveys different values at different locations.
- A “coverage” is represented by its "domain" (the universe of extent) and a range of values representing the Coverage's value at each defined location.
- A “coverage” can be multi-dimensional, such as a 4-D x/y/z/t for climate, weather and ocean data.

Coverage = Field

Why WCS and Why OGC?:

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

- "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 sub-setting 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. "*

Core of the WCS 2.0 Core Standard

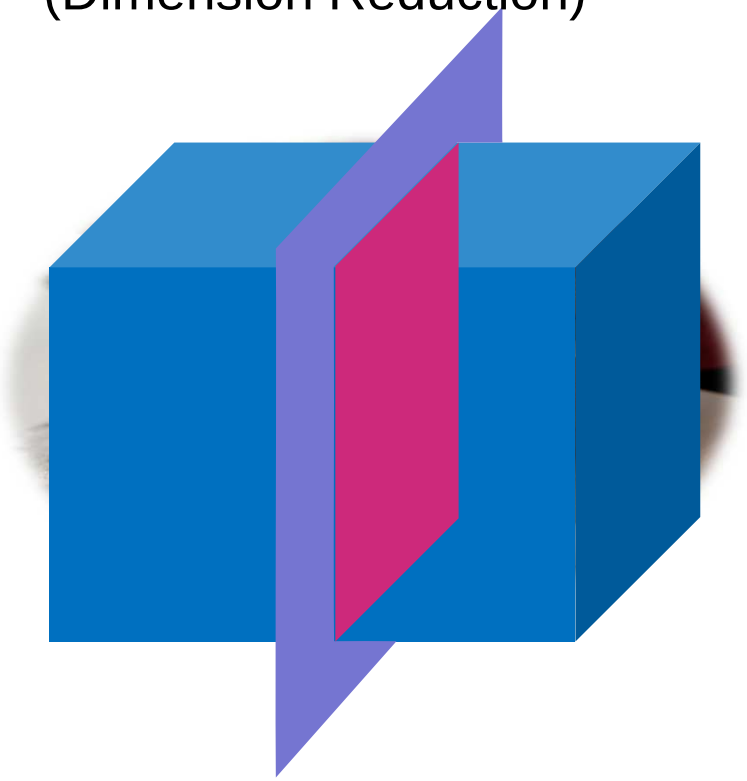
- Reasonably sized (?) 49 pages, closely coupled with GML.
  - 3 main types of requests (procedures):
  - GetCapabilities – lists all coverages.
  - DescribeCoverage – describes coverage metadata.
  - GetCoverage with “Slice” and “Trim” operations.
- Designed to be extensible:
- By default the WCS requests are passed via HTTP XML POST requests

Courtesy Jozef Matula IBL

WCS 2.0 Core GetCoverage Operation

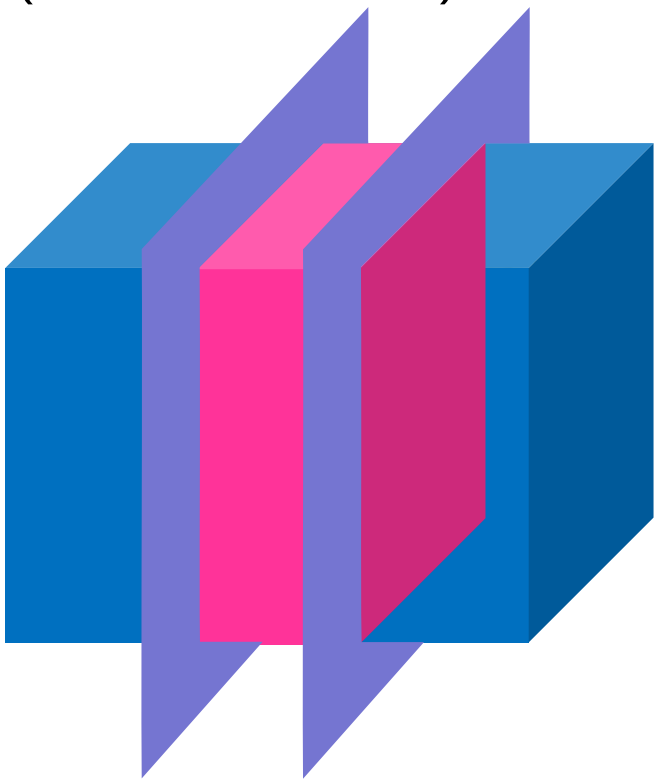
Slice Operation

(Dimension Reduction)



Trim Operation

(Extent Reduction)



Courtesy Jozef Matula IBL

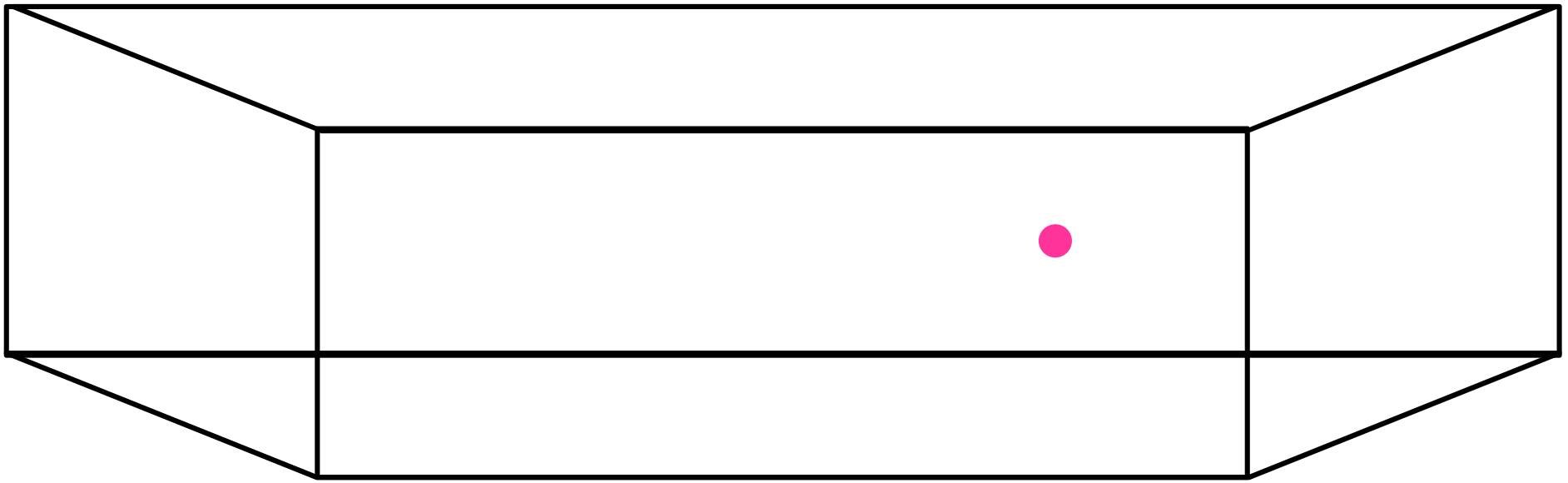
Start with an example:

- 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 to 2D.
  - Sounds promising for vertical profile extraction.
- “Trim” operation implements dimension range filtering, if typically applied to both X and Y.
  - Sounds promising for geospatial data “BBOX” extraction.
- “Slice” and “Trim” can be requested in other coordinate reference systems (CRS) than the CRS of the source data (re-projection)

Courtesy Jozef Matula IBL

Meteorological Data Extraction Patterns

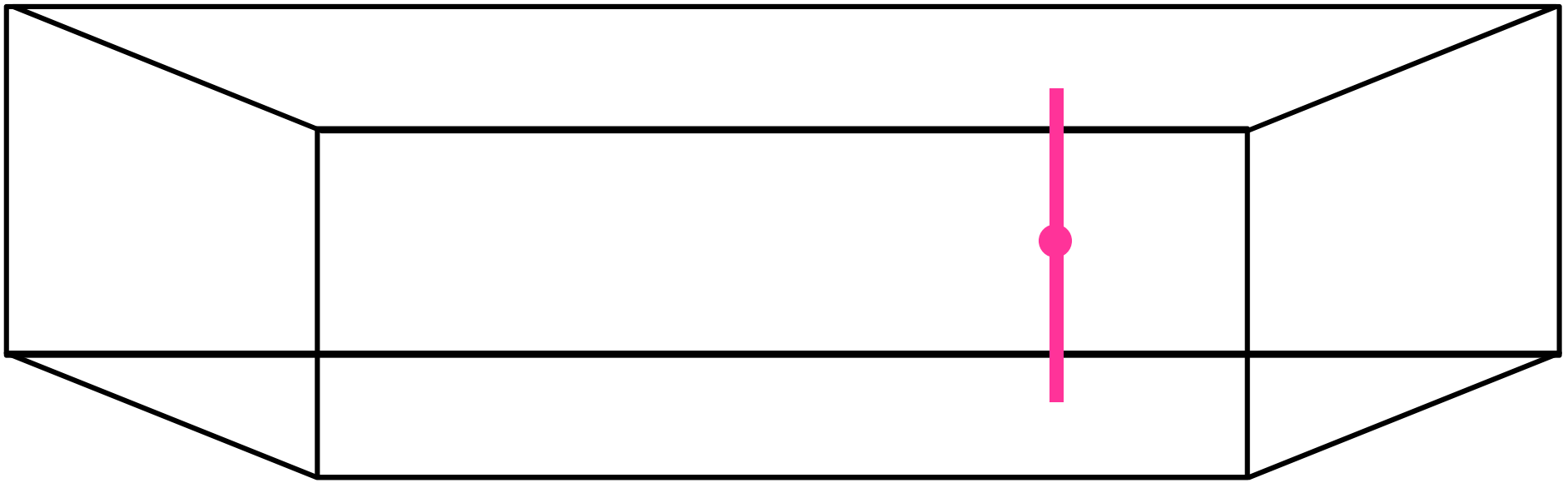
Meteorological Data Extraction Patterns



- Extracting data for a point = Slice X, Slice Y, Slice Z

Courtesy Jozef Matula IBL

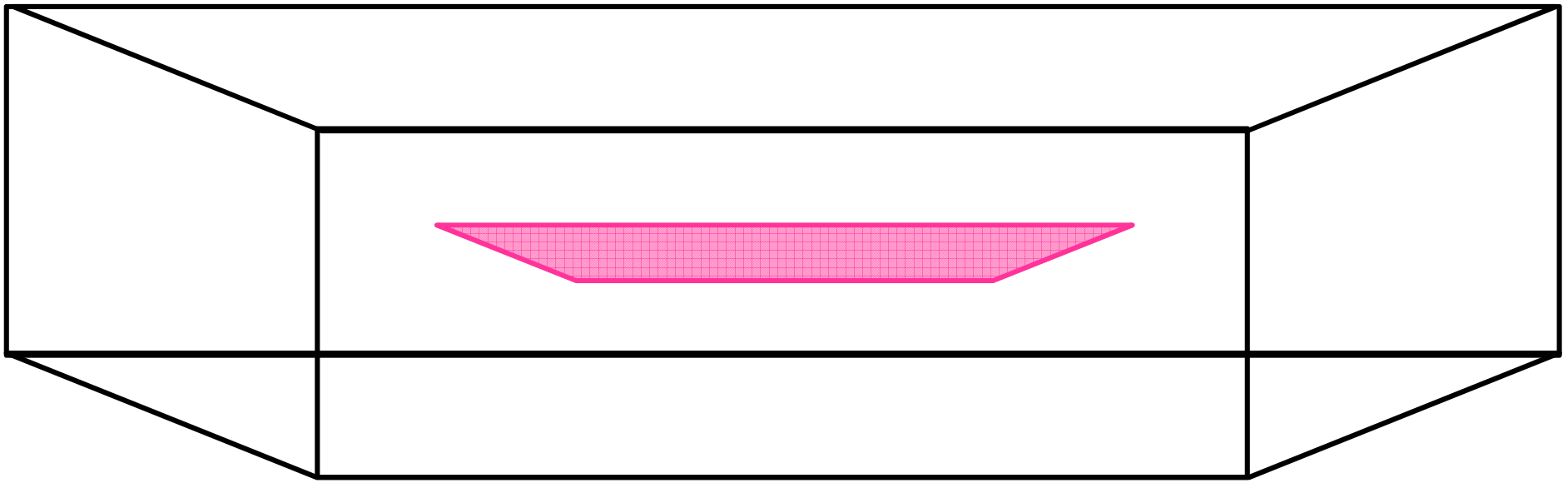
Meteorological Data Extraction Patterns



- Extracting vertical profile data for a point = Slice X, Slice Y
- With vertical range = Slice X, Slice Y, Trim Z

Courtesy Jozef Matula IBL

Meteorological Data Extraction Patterns



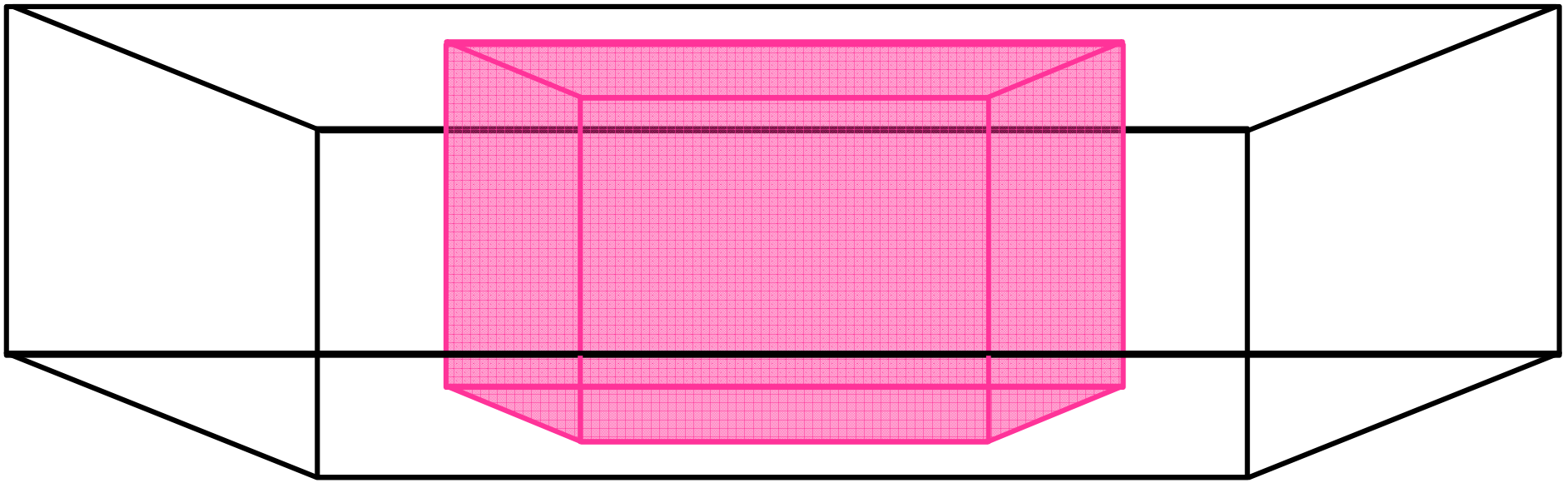
- Extracting data for 2D geospatial domain for a single vertical level = Trim X, Trim Y, Slice Z

Courtesy Jozef Matula IBL

Met-Ocean Data Extraction.

- All mentioned patterns were purely geospatial and height related.
- Is the time is 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.

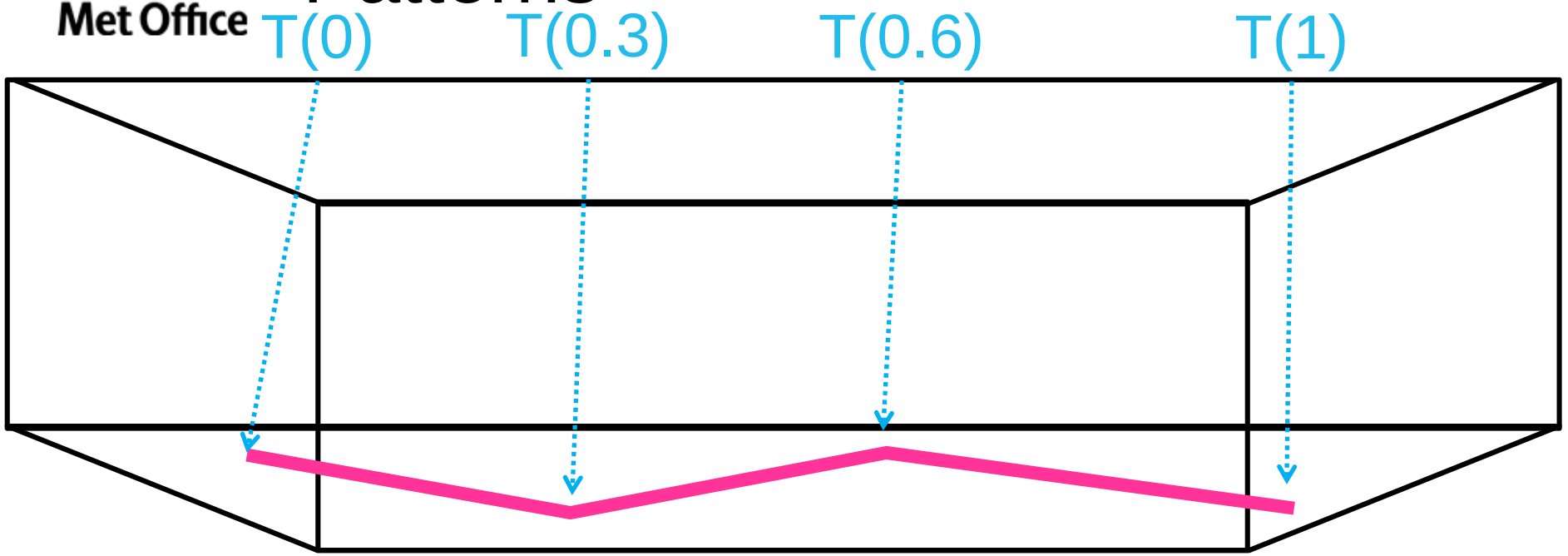
Meteorological Data Extraction Patterns



- Extracting vertical profile data for 2D geospatial domain = Trim X, Trim Y, Trim Z

Courtesy Jozef Matula IBL

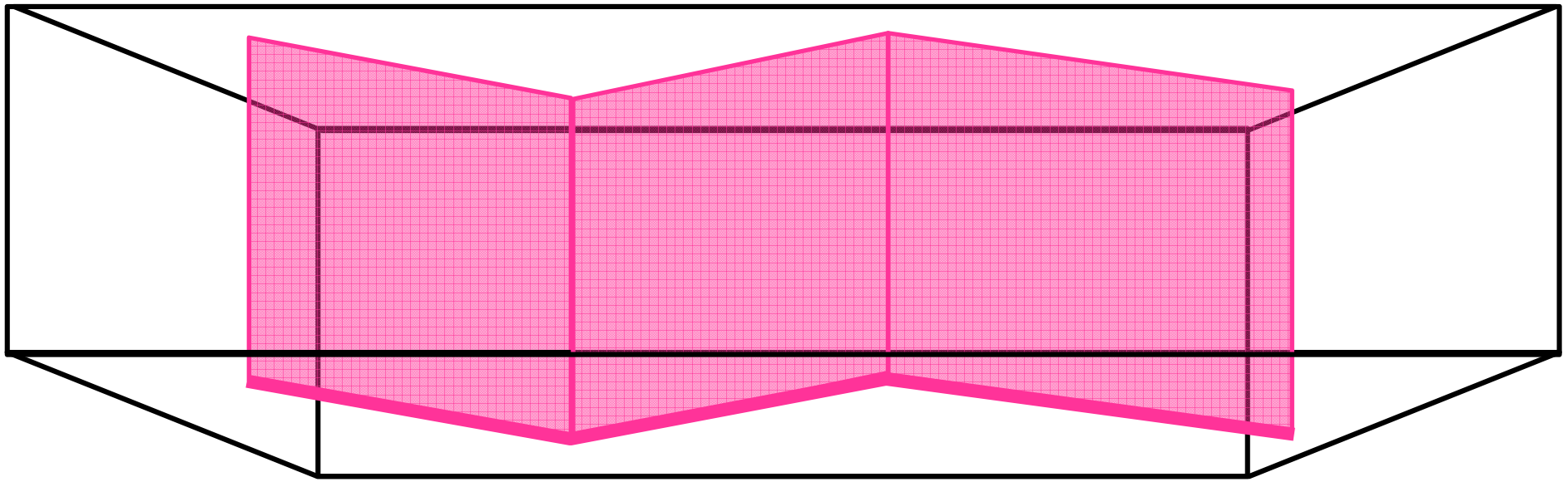
Meteorological Data Extraction Patterns



- Extracting data for a trajectory (for example road) = Trim in Trajectory CRS + Slice in Z.
- Trajectory CRS is 1 dimensional function *T*(*q*) for *q* in <0;1> mapping *q* to actual X, Y coordinates!

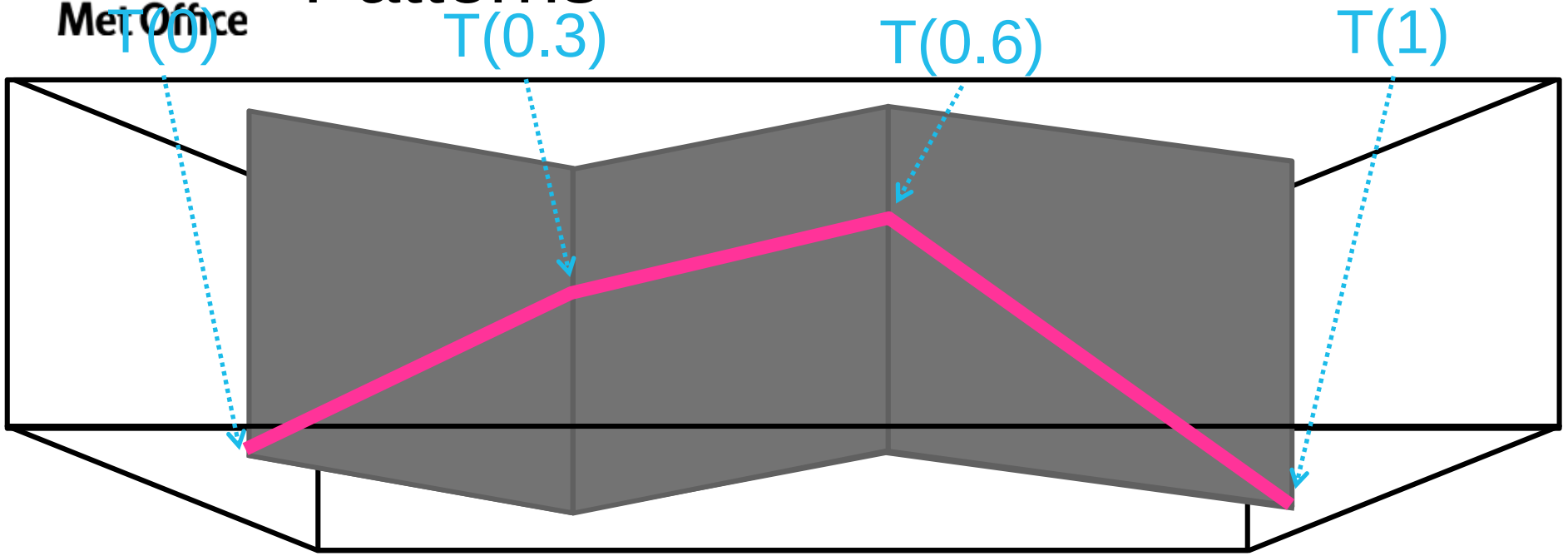
Courtesy Jozef Matula IBL

Meteorological Data Extraction Patterns



- Extracting vertical profile data for a trajectory = Trim in Trajectory CRS

Meteorological Data Extraction Patterns



- 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.

Courtesy Jozef Matula IBL

Extending the WCS2.0 Core:

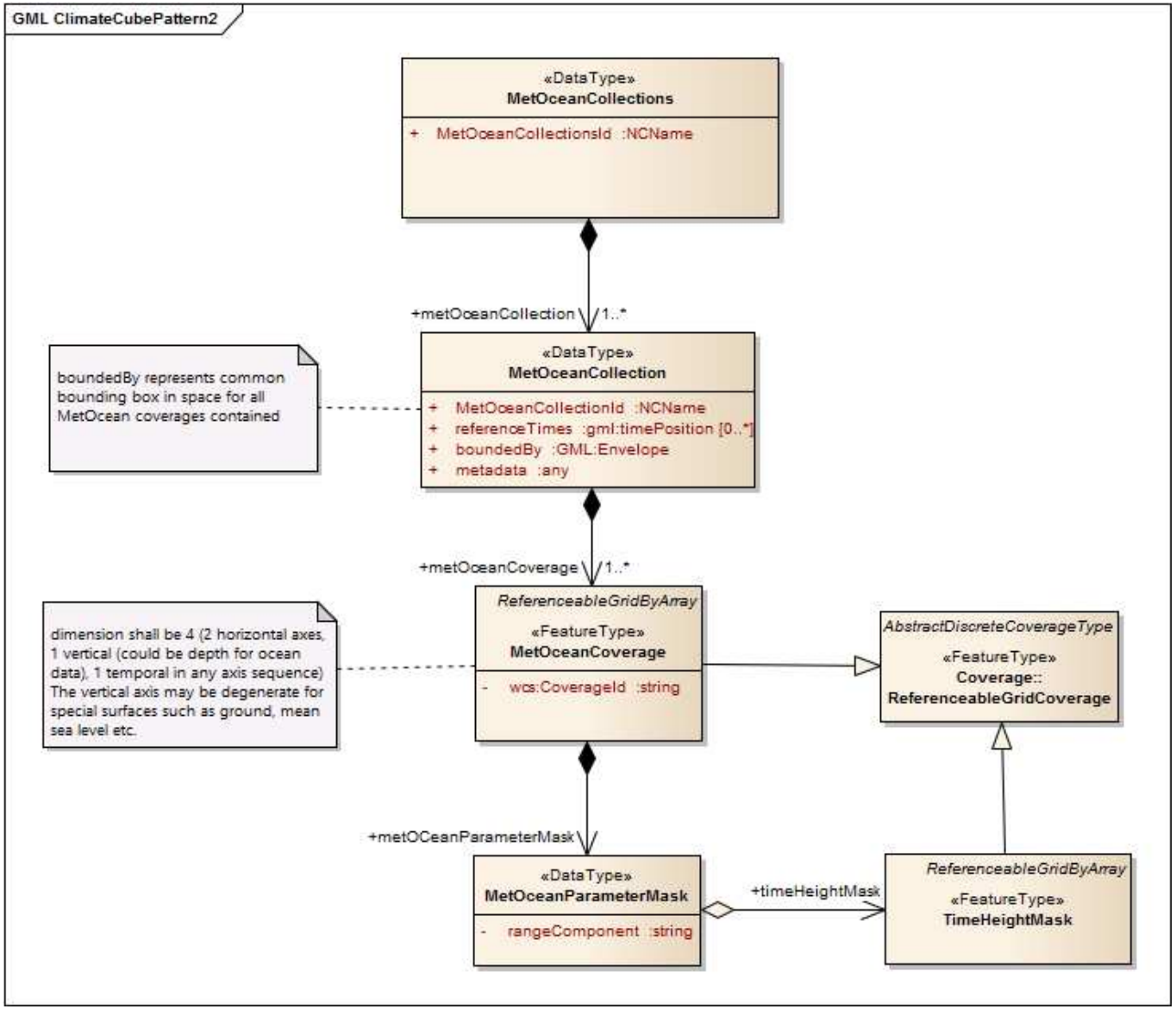
- WCS 2.0 Core Spec: “The specification contained in this WCS Core is not sufficient for a fully functioning WCS implementation.”
- No guidance on how to advertise validity times for which coverage data is available!
- Vertical level type of a coverage must be uniform (same as in WMS)
- Definition of “trajectory CRS” is strange quite hard to extend (time, corridor extents, interpolation types, etc.).
- How do you encode a “sparse coverage”?

Extending the WCS2.0 Core:

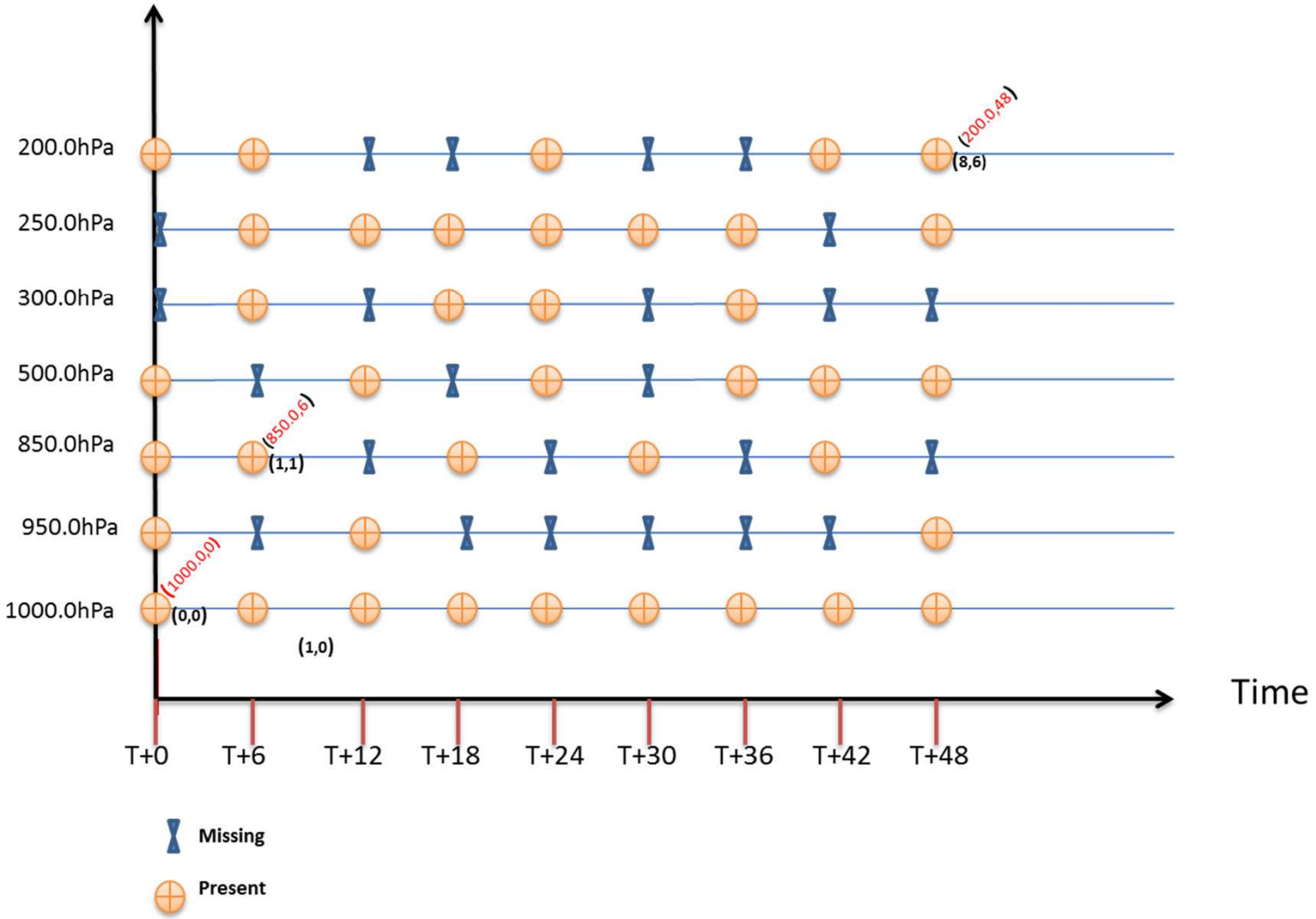
- Developed a prototype with IBL to test concepts:
- Working with Prof Baumann (the author of WCS2.0 core) to create a MetOcean interface standard.
- The document is currently out for discussion:
- Will be voted on using the 60 day rule.
- How do you encode a “sparse coverage”?

New Met-Ocean Patterns:-

- Create a true 4D coverage from a sparse coverage



The data mask for a sparse coverage.

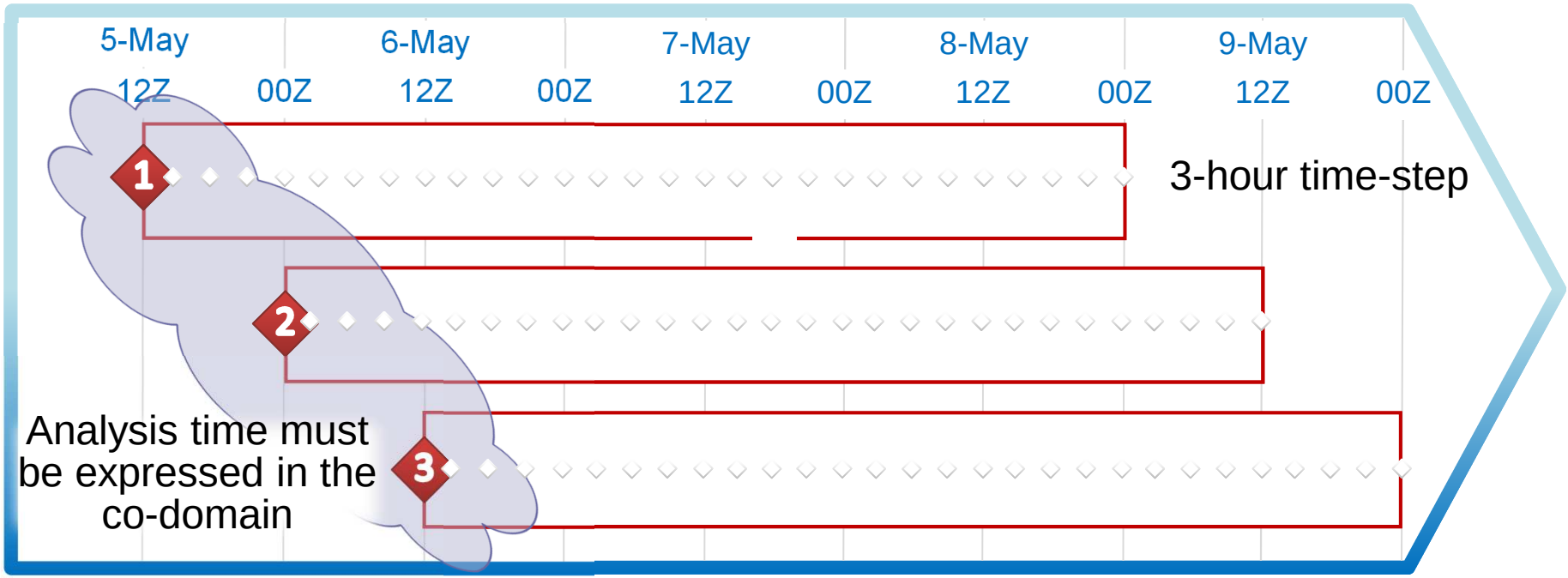


New Met-Ocean Patterns (2):-

- A “MetOcean Coverage” is a type of coverage, but extended by the use of a mask.
- This mask enables the sparse coverage (typical of normal NWP output) to be treated as true 4D coverage.
- The time and vertical axes are enumerated:
- The mask itself is a coverage:

Querying a Forecast Model Run Collection coverage

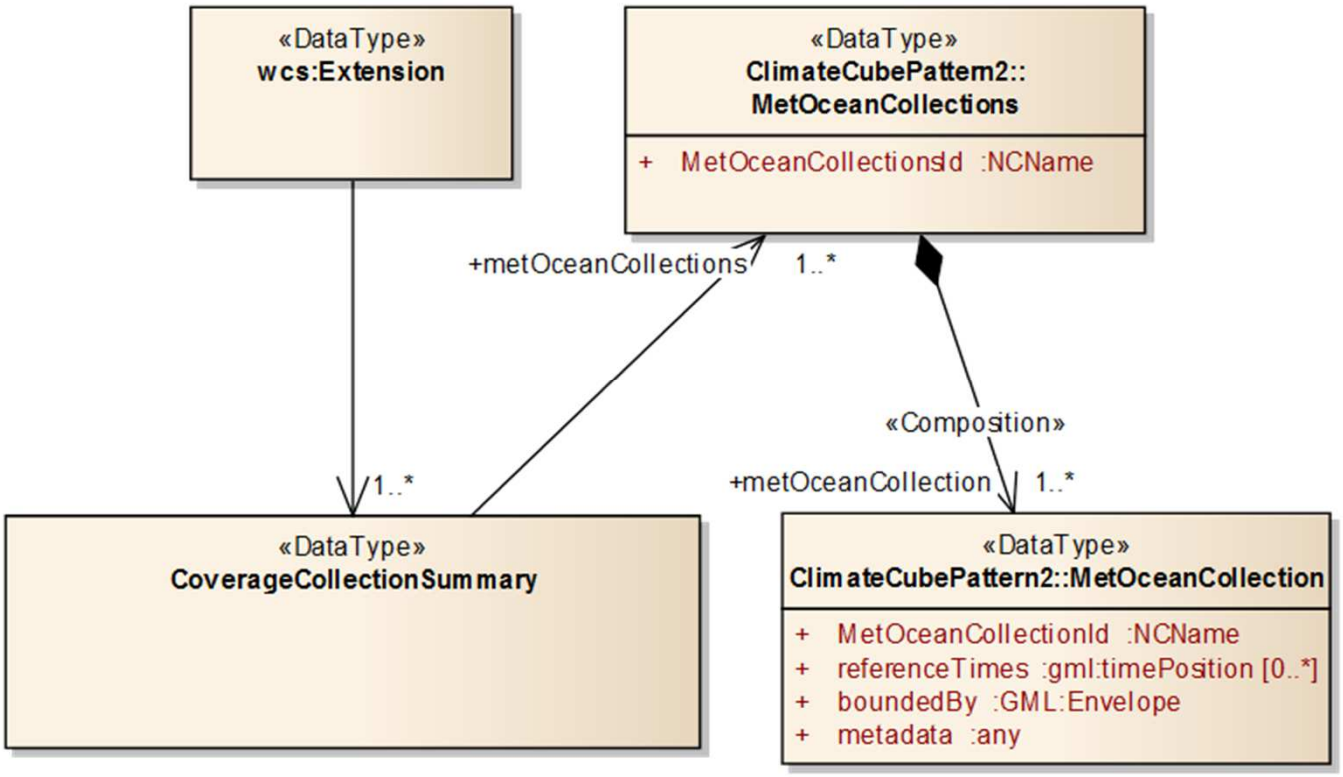
… there is often a requirement to compare values from different simulations. This slide shows an example Web Coverage Service (WCS) requests for a service exposing **forecast model run collection** as a single coverage offering …



full details of WCS requests omitted for brevity

MetOcean Collection:-

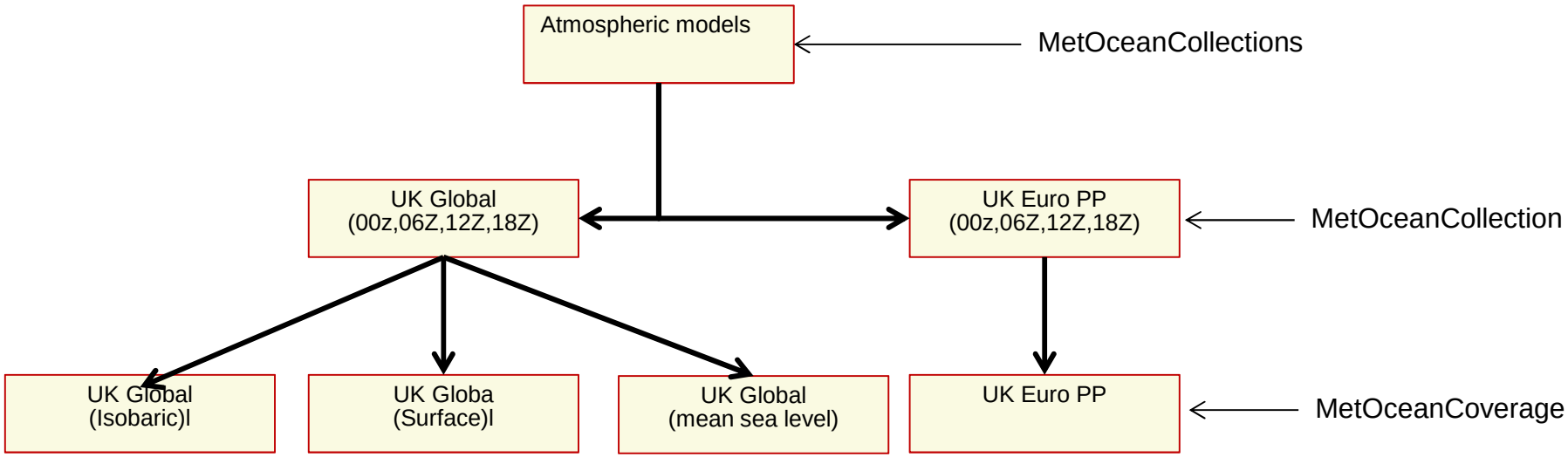
A MetOcean collection as advertised in the GetCapabilities response.



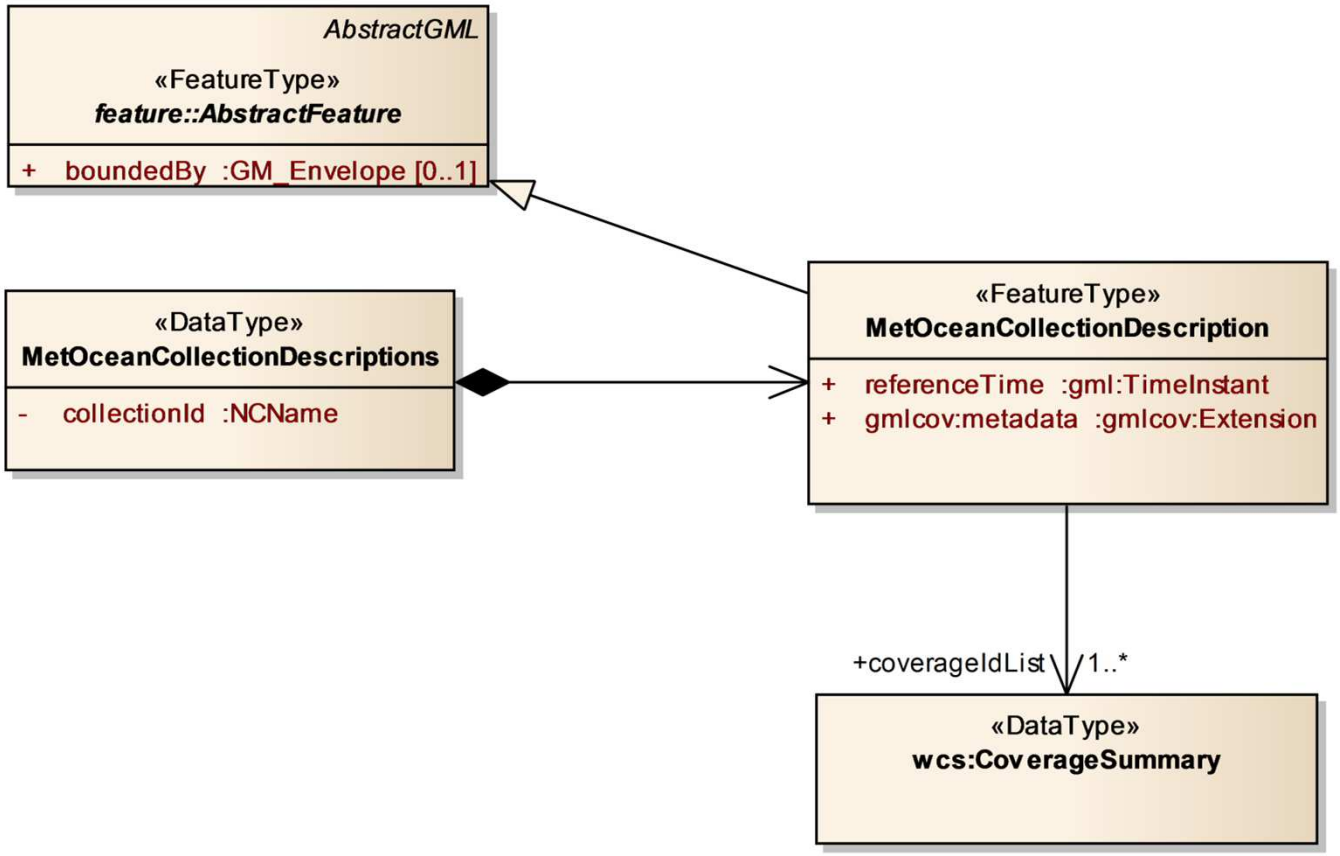
Collections:-

- The concept of collections is very powerful as it allows coverages to be grouped together.
- An individual model run is, in its own right, a collection of coverages, each with a different vertical coordinate reference system.
- There is often a requirement to compare values from different simulations. The “reference times” (aka model run times) are considered to be a property of the coverage collection.

MetOceanCollections



A MetOcean Collection:-



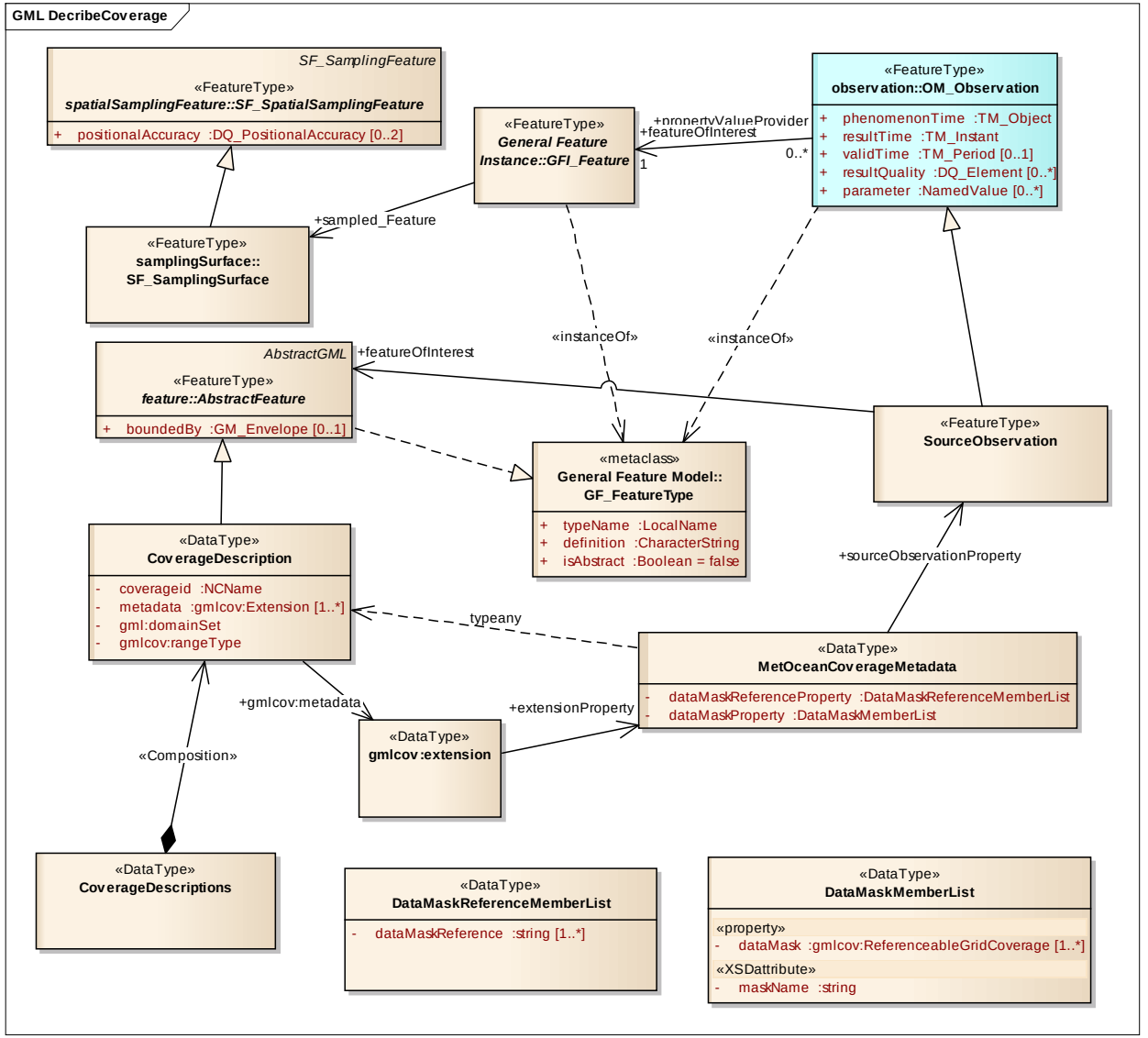
A MetOcean Coverage Summary

- Each coverage within the collection is listed with an identifier.
- The DescribeCoverage operation will further describe each coverage.
- The collection adds an extra level of description that may include a link the service serving the coverage.

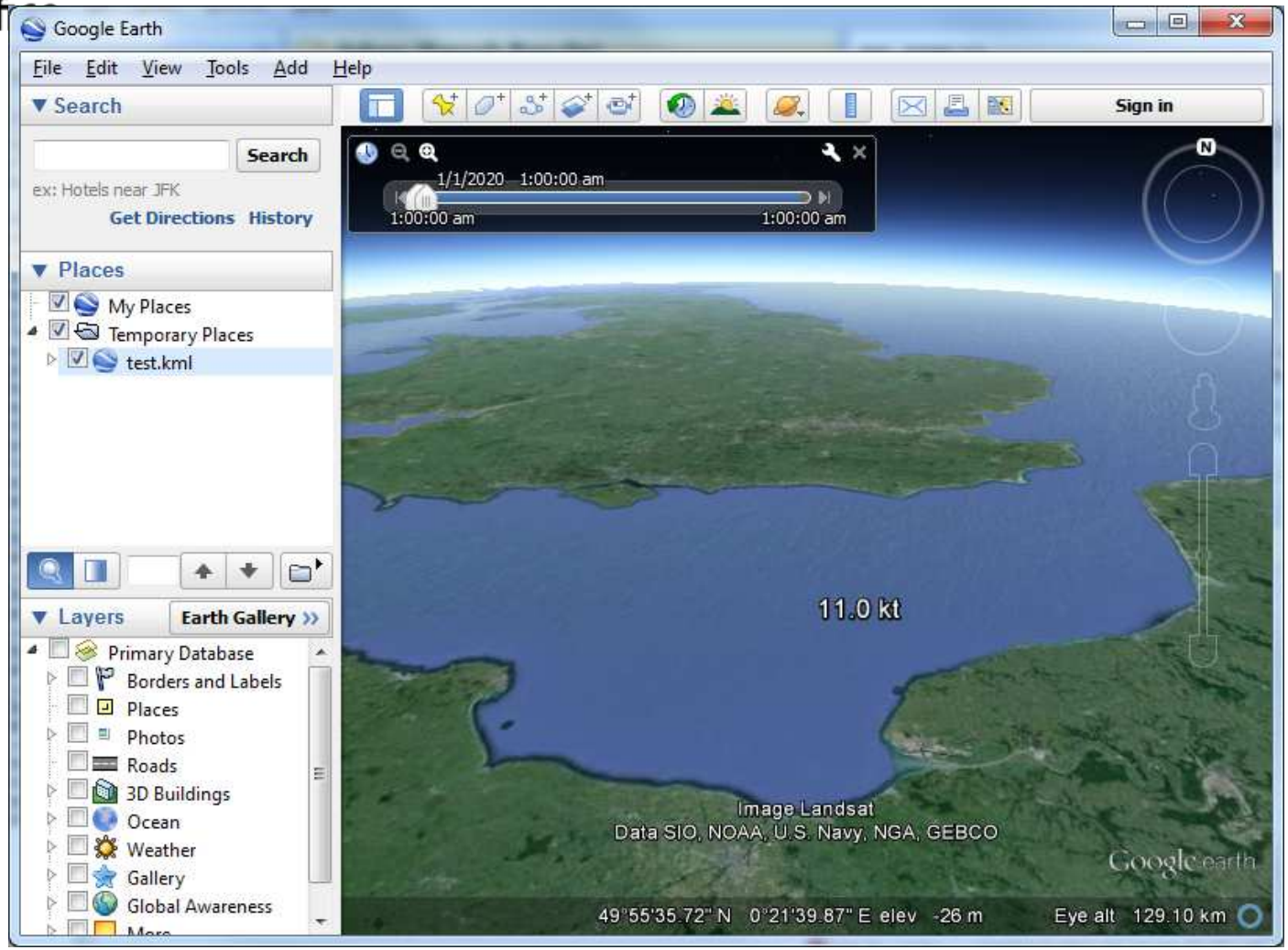
```
<wcs:CoverageSummary>
  <wcs:CoverageId>UK_GLOBAL_2012-05-15T12.00.00Z_Thickness</wcs:CoverageId>
  <wcs:CoverageSubtype>NamedRange</wcs:CoverageSubtype>
    <ows:Metadata xlink:href="www.codes.wmo.int/GRIB2/table4.5/Thickness"
        <metocean:coverageDescription coverageDescription="Thickness"
    </ows:Metadata>
</wcs:CoverageSummary>
```

Describe Coverage:-

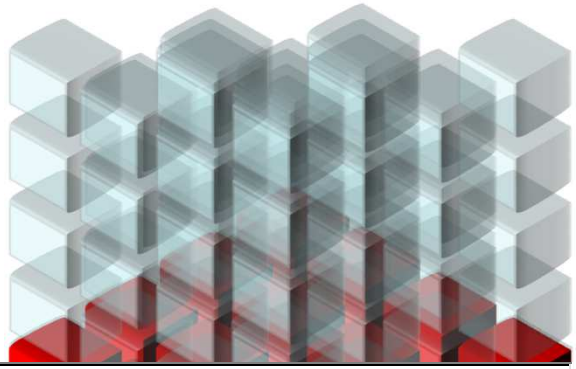
The Describe Coverage response is based on the O&M pattern for Metadata. Thus it will be compatible with MetCE



Visualisation

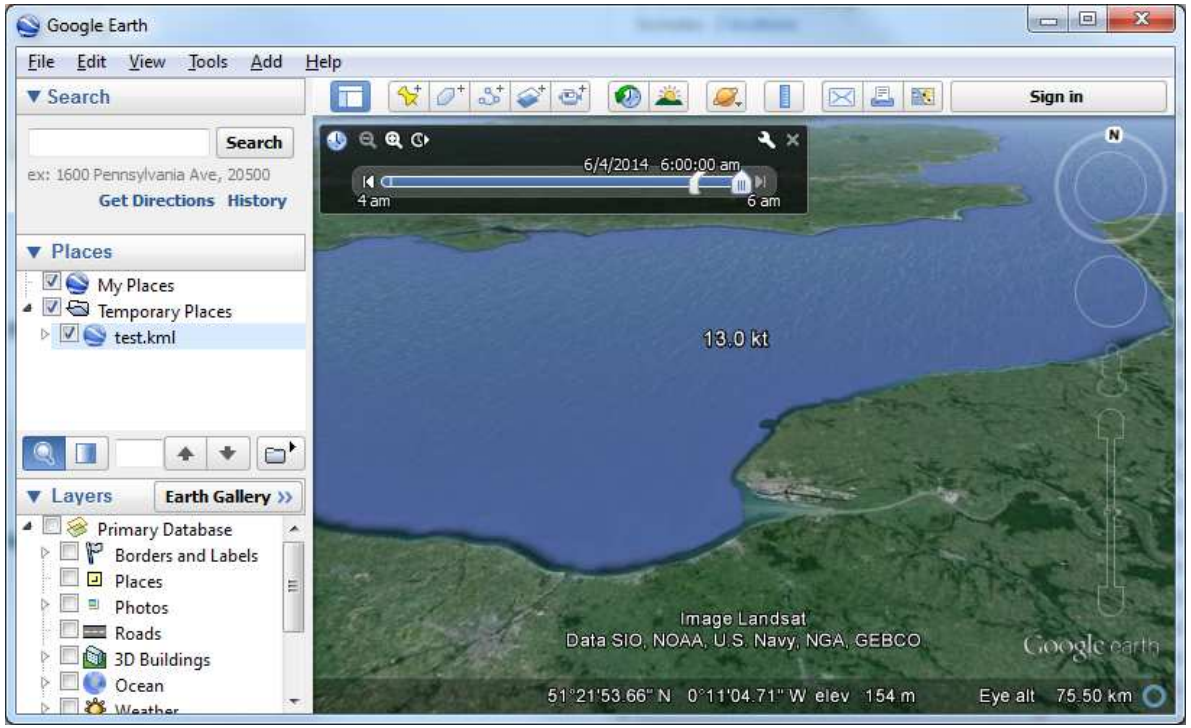


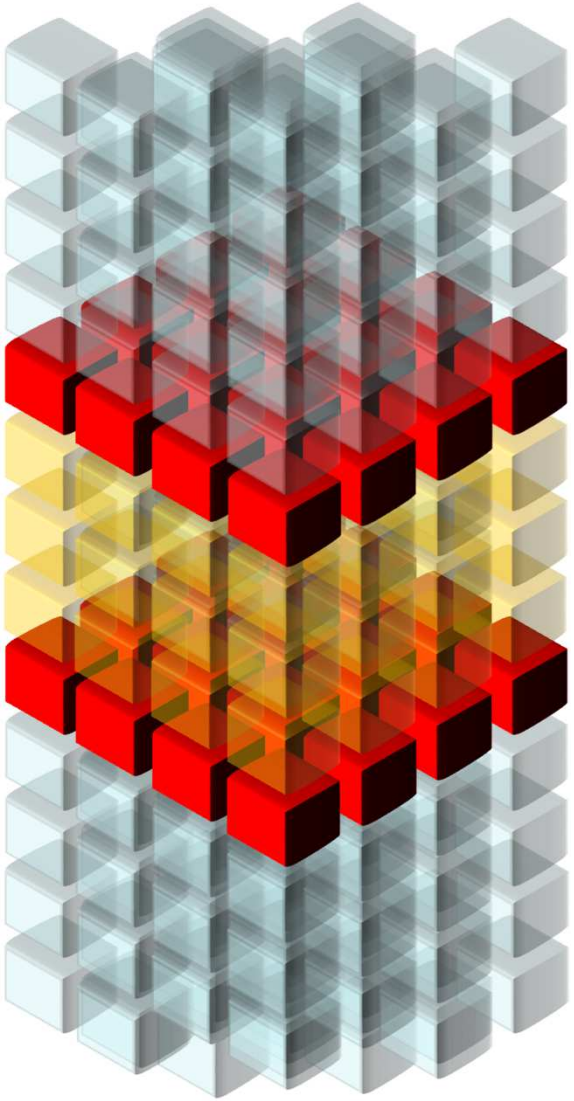
Trim Request



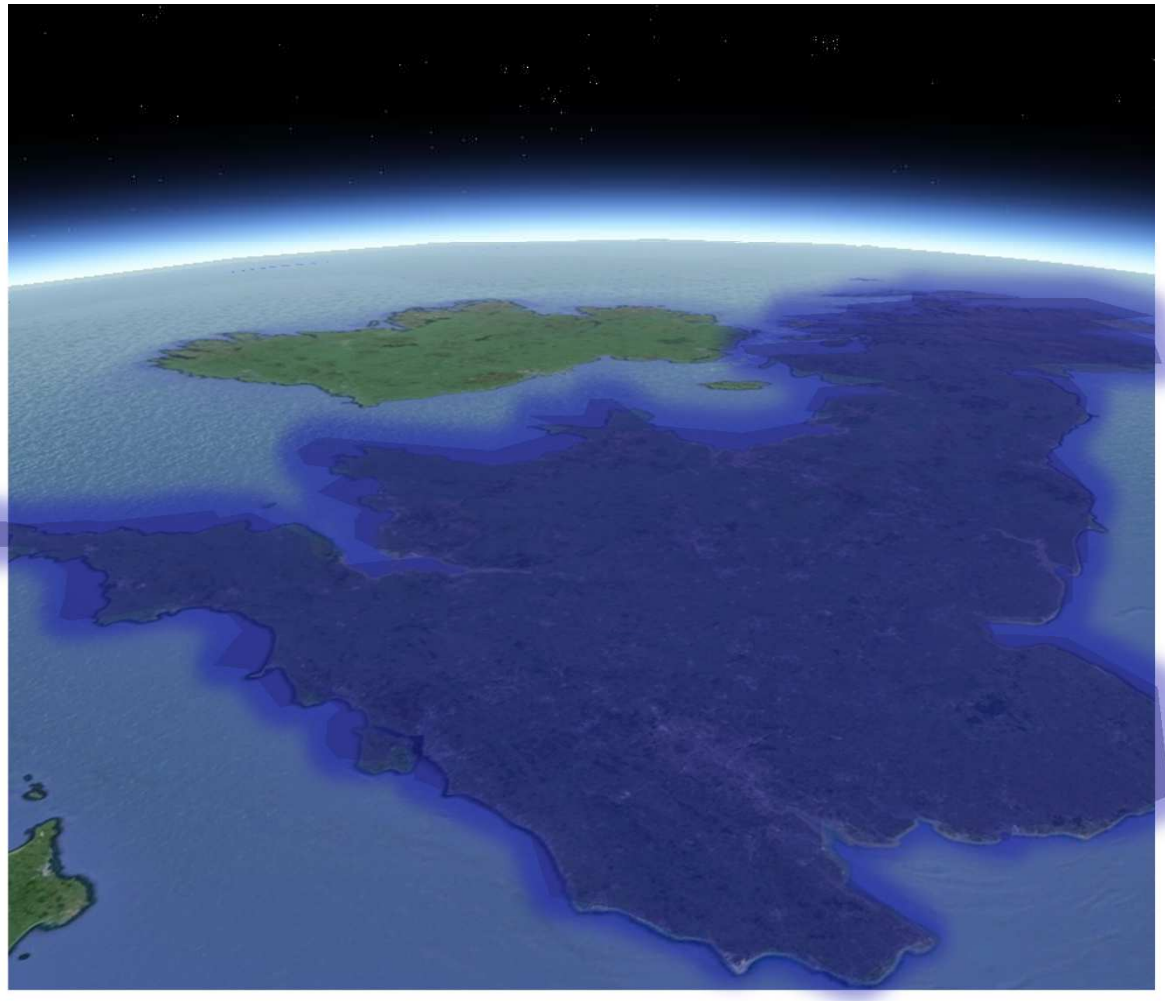
```
<?xml version="1.0" encoding="UTF-8"?>
<wcs:GetCoverage xmlns:xlink="http://www.w3.org/1999/xlink"
    xmlns:wcs="http://www.opengis.net/wcs/2.0"
    xmlns:wcsCRS="http://www.opengis.net/wcs_service-extension_crs/1.0"
    xmlns:int="http://www.opengis.net/WCS_service-extension_interpolation/1.0"
    xmlns:rsub="http://www.opengis.net/wcs/range-subsetting/1.0"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xmlns:metocean="http://def.wmo.int/metce/2013/metocean"
    service="WCS" version="2.0.0">
    <wcs:Extension>
        <rsub:rangeSubset>
                <rsub:rangeComponent>UKPPNOW_
10m_Max_Gust_Speed_KT</rsub:rangeComponent>
        </rsub:rangeSubset>
```

Visualisation





Polygon Use Case



Polygon Request

```
<?xml version="1.0" encoding="UTF-8"?>
<metocean:GetPolygonCoverage xmlns:xlink="http://www.w3.org/1999/xlink"
    xmlns:wcs="http://www.opengis.net/wcs/2.0"
    xmlns:metocean="http://def.wmo.int/metce/2013/metocean"
    xmlns:wcsCRS="http://www.opengis.net/wcs_service-extension_crs/1.0"
    xmlns:int="http://www.opengis.net/WCS_service-extension_interpolation/1.0"
    xmlns:gml="http://www.opengis.net/gml/3.2"
    xmlns:rsub="http://www.opengis.net/wcs/range-subsetting/1.0"
    xmlns:gmlrgrid="http://www.opengis.net/gml/3.3/rgrid"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    service="WCS" version="2.0.0"
    xsi:schemaLocation="http://www.opengis.net/wcs/2.0 http://schemas.opengis.ne
    http://www.opengis.net/wcs/crs/1.0 https://raw.github.com/EOxServer/schemas/
    http://www.opengis.net/WCS_service-extension_interpolation/1.0 file:/C:/Users/R
    http://def.wmo.int/metce/2013/metocean file:/C:/Users/Rocky/WCS/MOWCS3/sc
    http://www.opengis.net/wcs/range-subsetting/1.0 file:/C:/Users/Rocky/WCS/MO
    <wcs:Extension>
        <rsub:rangeSubset>
            <rsub:rangeComponent>UKMO_Global_Temperature</rsub:rangeCom
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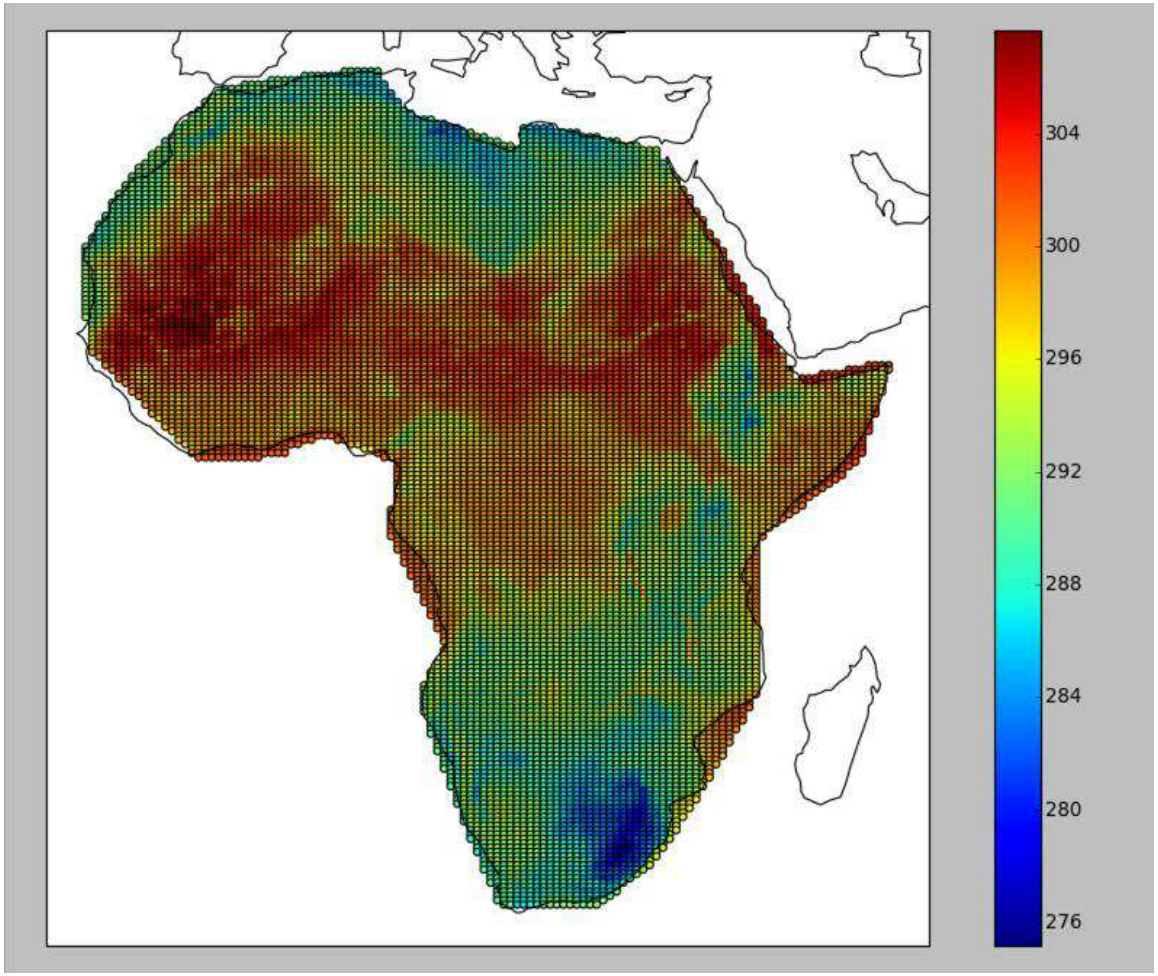
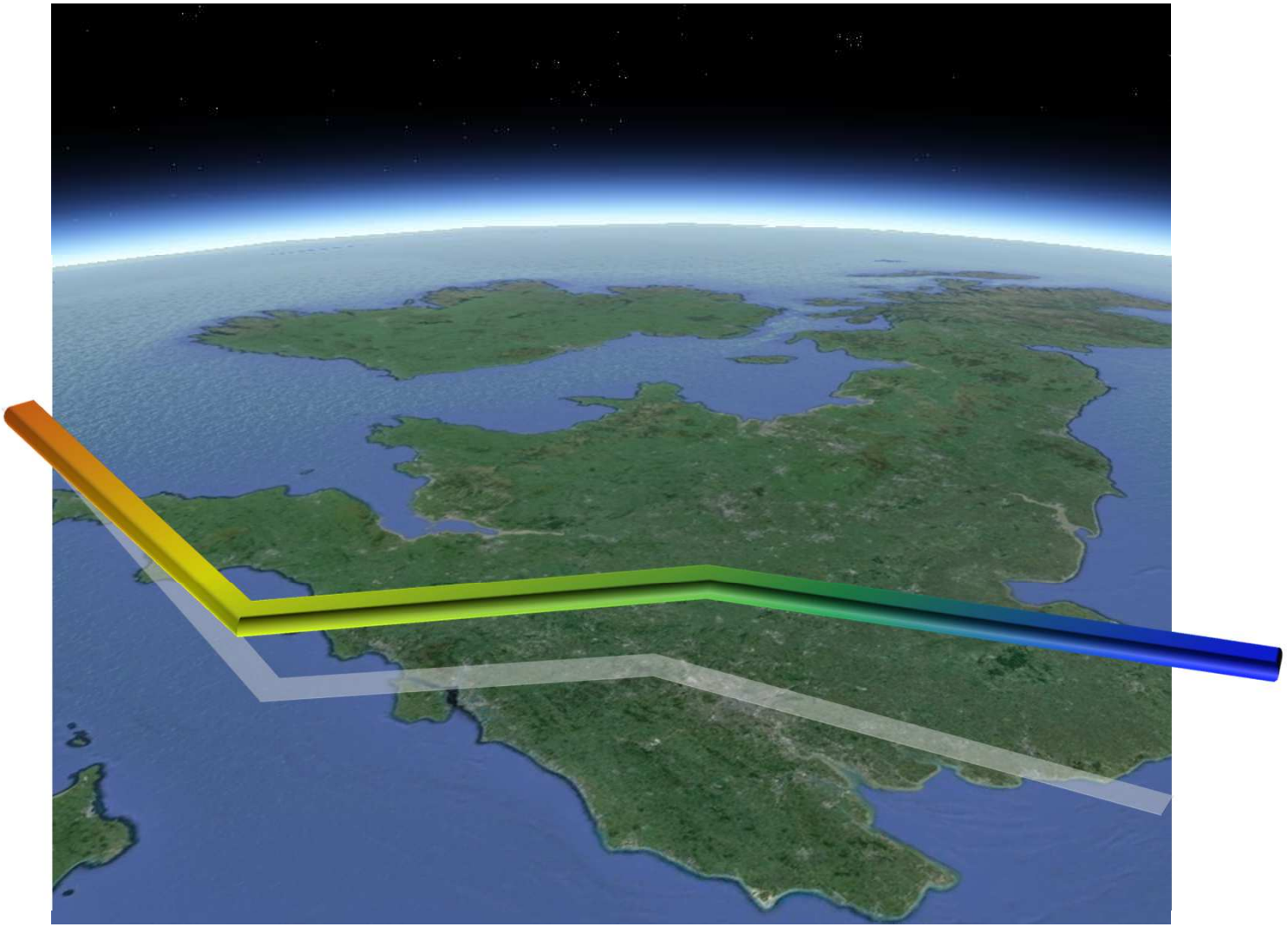
Visualisation (IRIS)

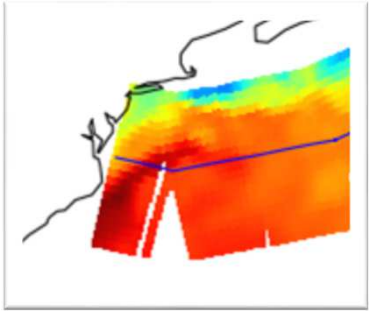


Corridor Use Cases



Planes, Trains and Automobiles

Ship Tracks Request



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<?xml version="1.0" encoding="UTF-8"?>
<metocean:GetCorridorCoverage xmlns:xlink="http://www.w3.org/1999/xlink"
    xmlns:wcs="http://www.opengis.net/wcs/2.0"
    xmlns:metocean="http://def.wmo.int/metce/2013/metocean"
    xmlns:wcsCRS="http://www.opengis.net/wcs_service-extension_crs/1.0"
    xmlns:int="http://www.opengis.net/WCS_service-extension_interpolation/1.0"
    xmlns:gml="http://www.opengis.net/gml/3.2"
    xmlns:rsub="http://www.opengis.net/wcs/range-subsetting/1.0"
    xmlns:gmlrgrid="http://www.opengis.net/gml/3.3/rgrid"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    service="WCS" version="2.0.0"
    xsi:schemaLocation="http://www.opengis.net/wcs/2.0 http://schemas.opengis
    http://def.wmo.int/metce/2013/metocean file:/C:/Users/Rocky/WCS/MOWCS3/
    http://www.opengis.net/wcs/crs/1.0 https://raw.github.com/EOxServer/schema
    http://www.opengis.net/WCS_service-extension_interpolation/1.0 file:/C:/User
    http://www.opengis.net/wcs/range-subsetting/1.0 https://raw.github.com/EOx
    <wcs:Extension>
```
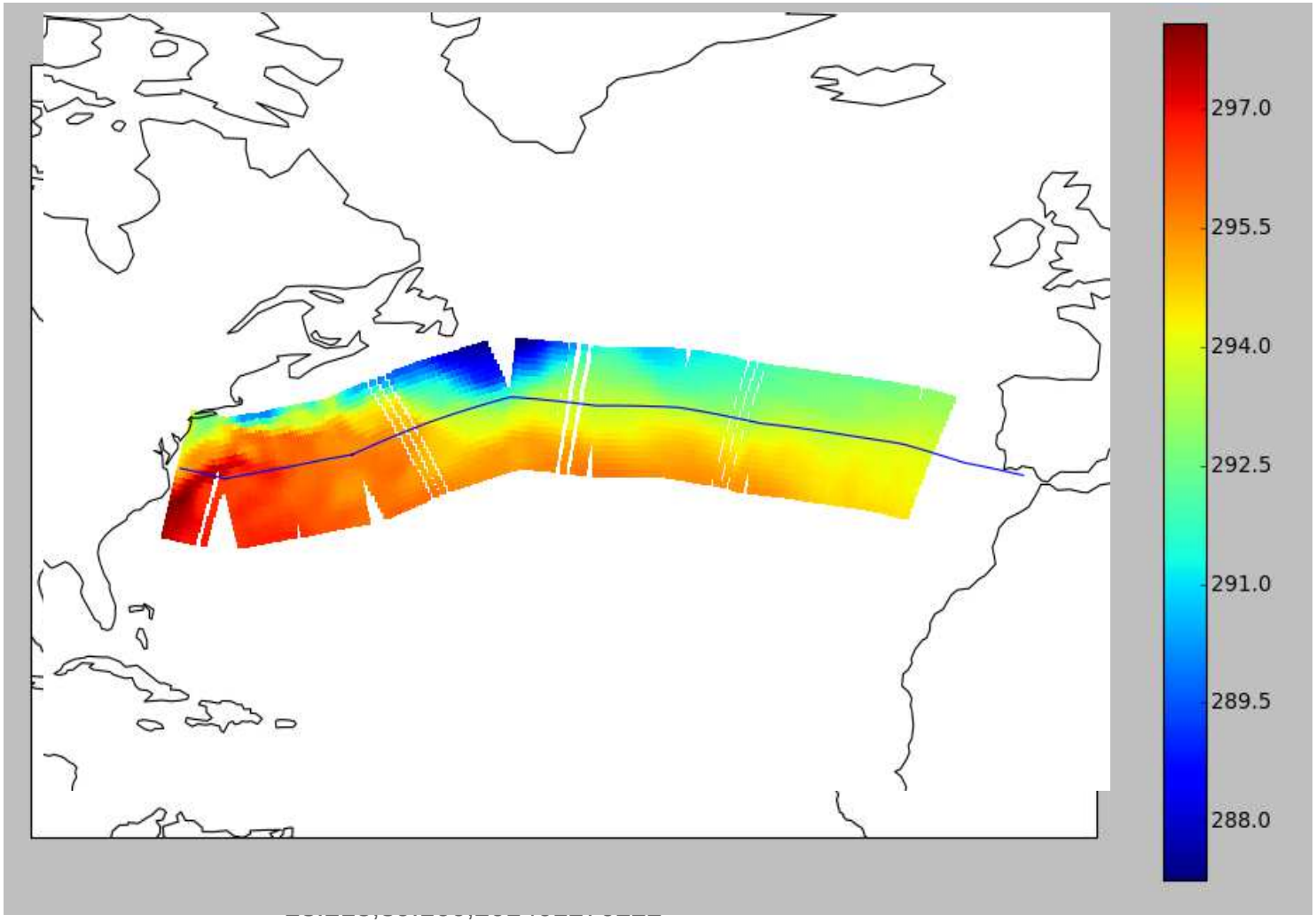

-28.563,39.799,201401261800
-26.160,39.543,201401270000
-23.215,39.160,201401270222
-22.139,39.000,201401270600
-20.325,38.765,201401271200
-17.480,38.336,201401271501

Ship Tracks Data

Visualisation (IRIS)



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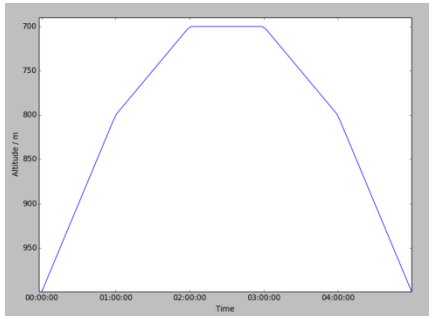
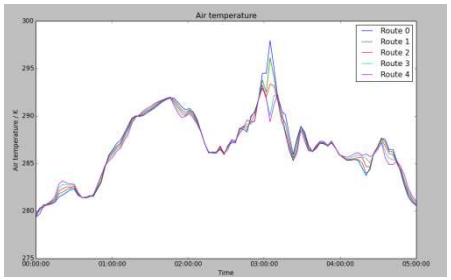
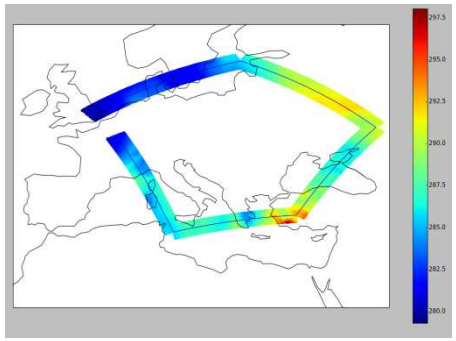
-20.325,38.765,201401271200
-17.480,38.336,201401271501

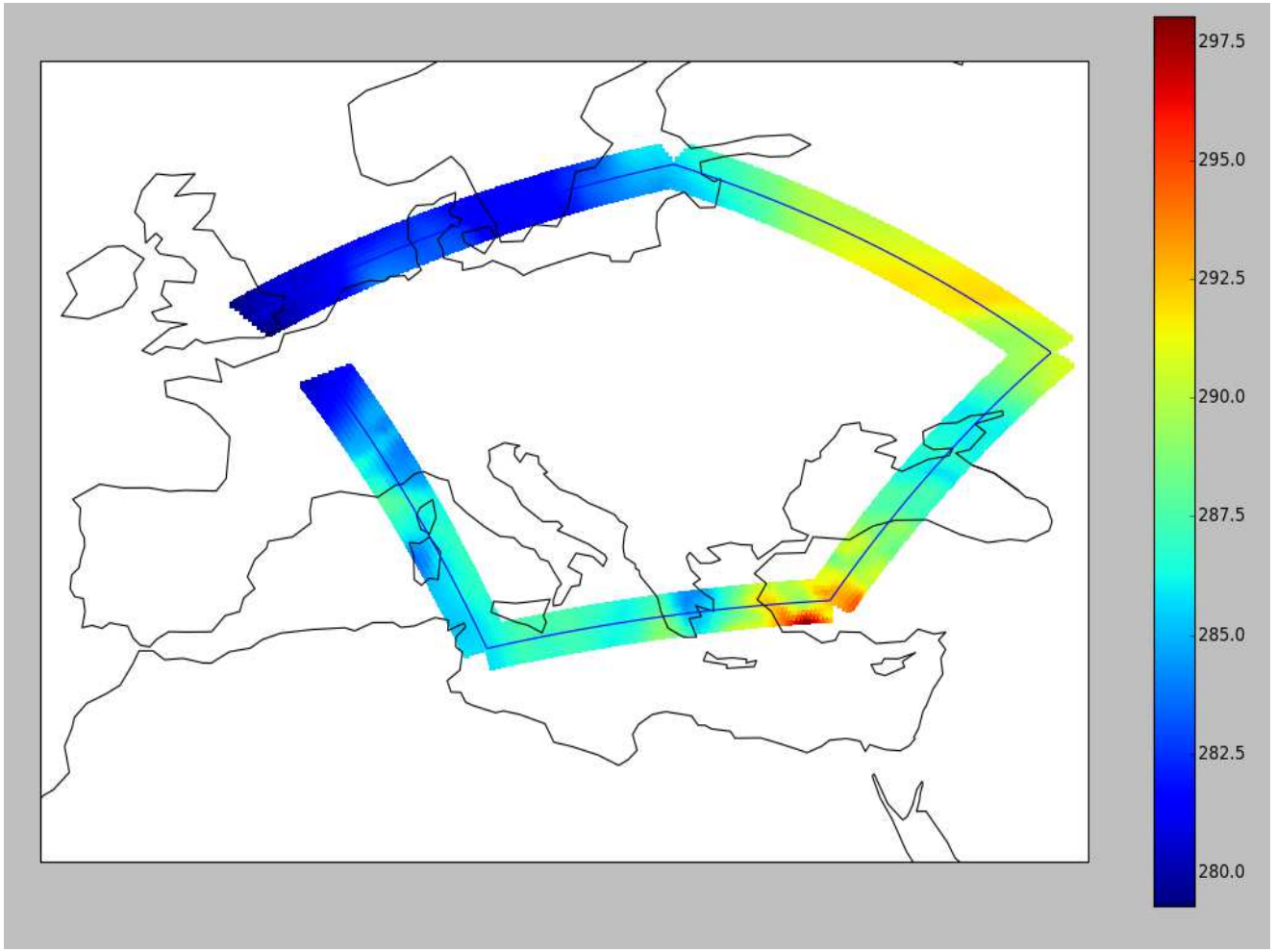
Aerial Trajectory

Visualisation (IRIS)

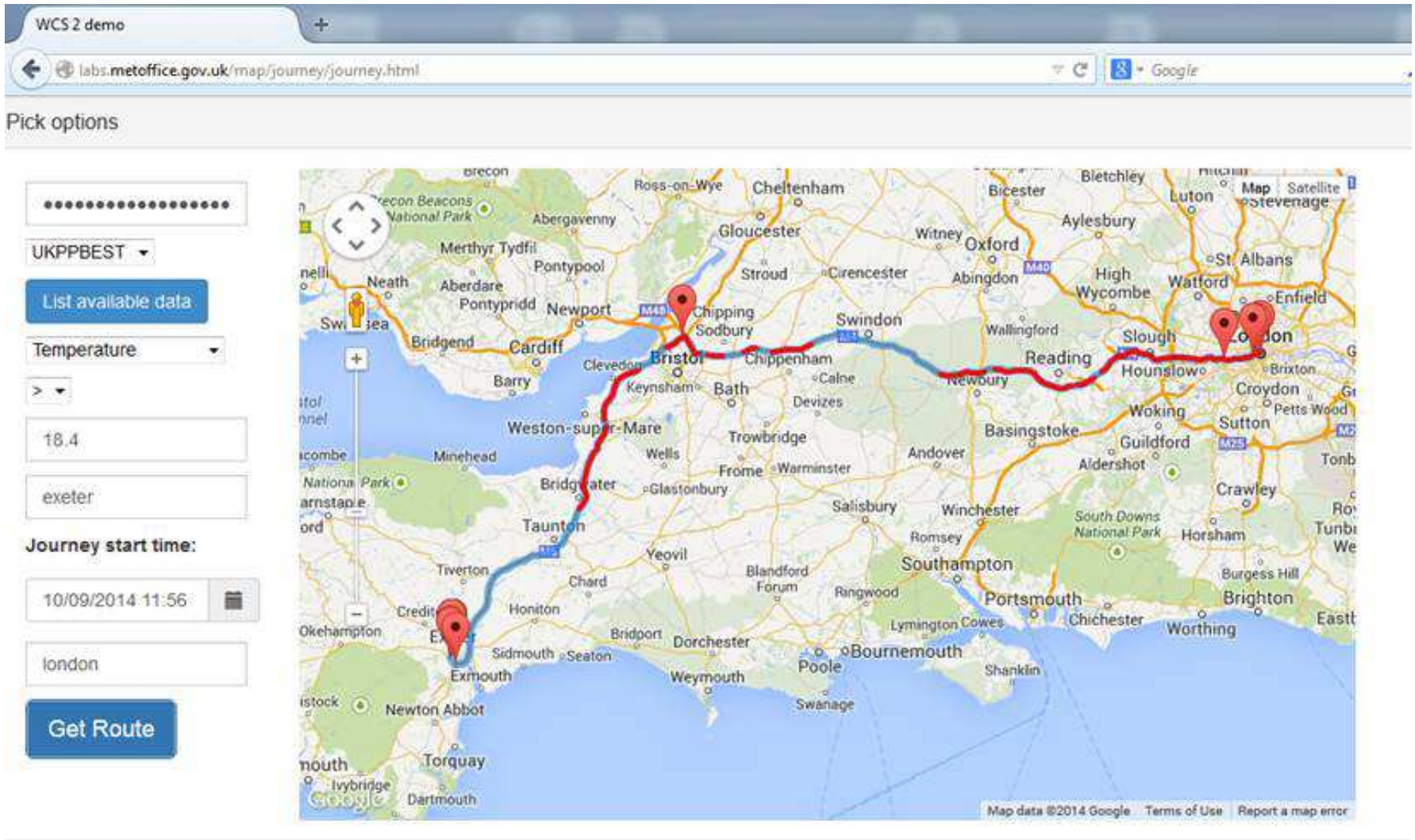




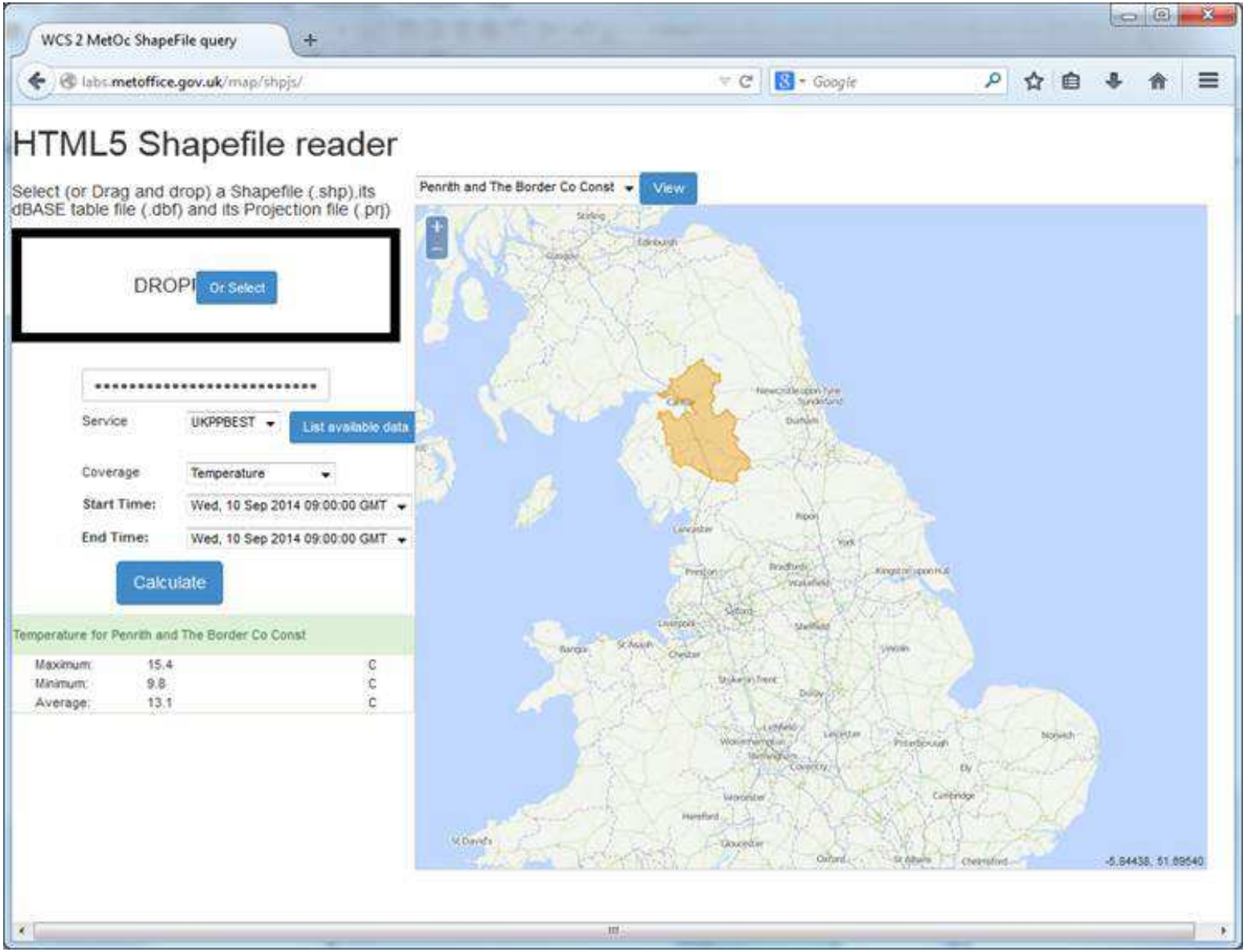




Route Planning

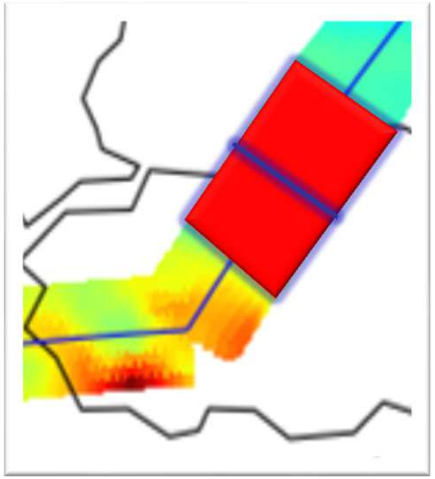


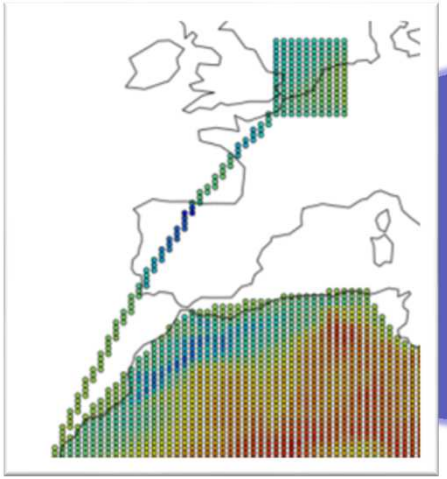
Drag and Drop Shapefiles

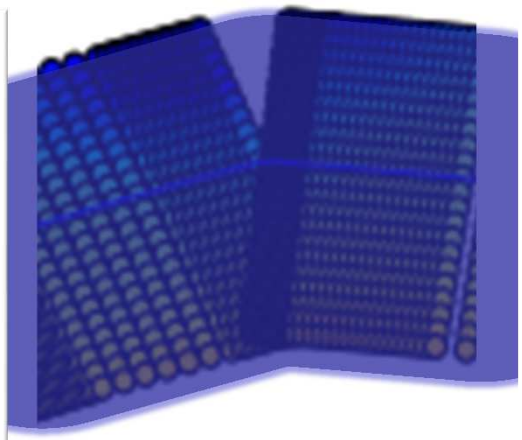


WCS2.0 MetOcean extensions – future changes

- Variable corridor height and width
- Time/segment length
- Multiple polygons in single request
- Perpendicular corridors - use locus instead







Questions & answers