WCS2.1 Met-Ocean

16th Workshop on Operational Systems

A Revolutionary Approach to Multi-Dimensional Data Access of Gridded Datasets Using Current and Proposed OGC Web Coverage Standards

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Background: Coverages

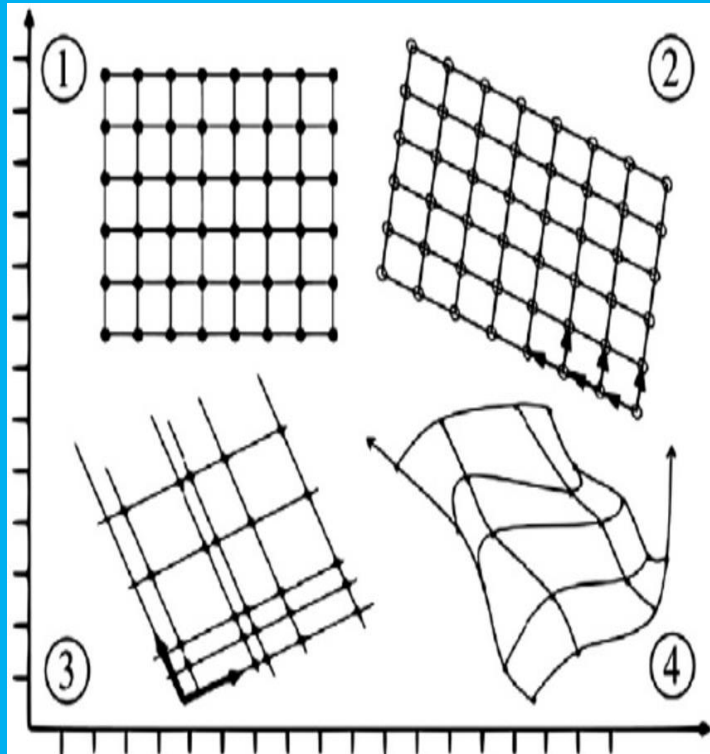*Phenomena that vary over geospatial domains*

→ Defined by ***Domain*** and ***Range***

- *Radar*
- *Vertical Profiles*
- *Time Series*
- *Wind Profiles*
- *Radiosondes*
- *Satellite Data*
- *NWP model output*

Background: OGC Web Coverage Service (WCS)

Met Office

Gridded Data

with OGC Standards

WCS

Request & Response API's

- **GetCapabilities**
- **DescribeCoverage**
- **GetCoverage**

Returns
- Service Properties/Offered Data
- Info on Specific Coverage
- Queried Data (or Subset)

GRIB2, NetCDF, etc

So What's the problems?

- ## Data Size, Volume, Resolution

  - ➢ *insufficient* storage, computer resources, bandwidth
  - ➔ ***Transfer*** of MetOcean data sets harder to push thru web services

- ## Subsetting

  - ➢ Returns only data *necessary* to consumer
  - ➢ WCS Core Functionality: Trimming, Slicing, but ***lacking***…
  - ➔ *Not **tailored*** to specific MetOcean community's needs.

- ## Interoperability

  - ➢ *Improvement* between disparate web services. Needed for global cooperation
  - ➔ Can we ***describe*** MetOcean WCS data in a ***community-based controlled vocabulary** ?*
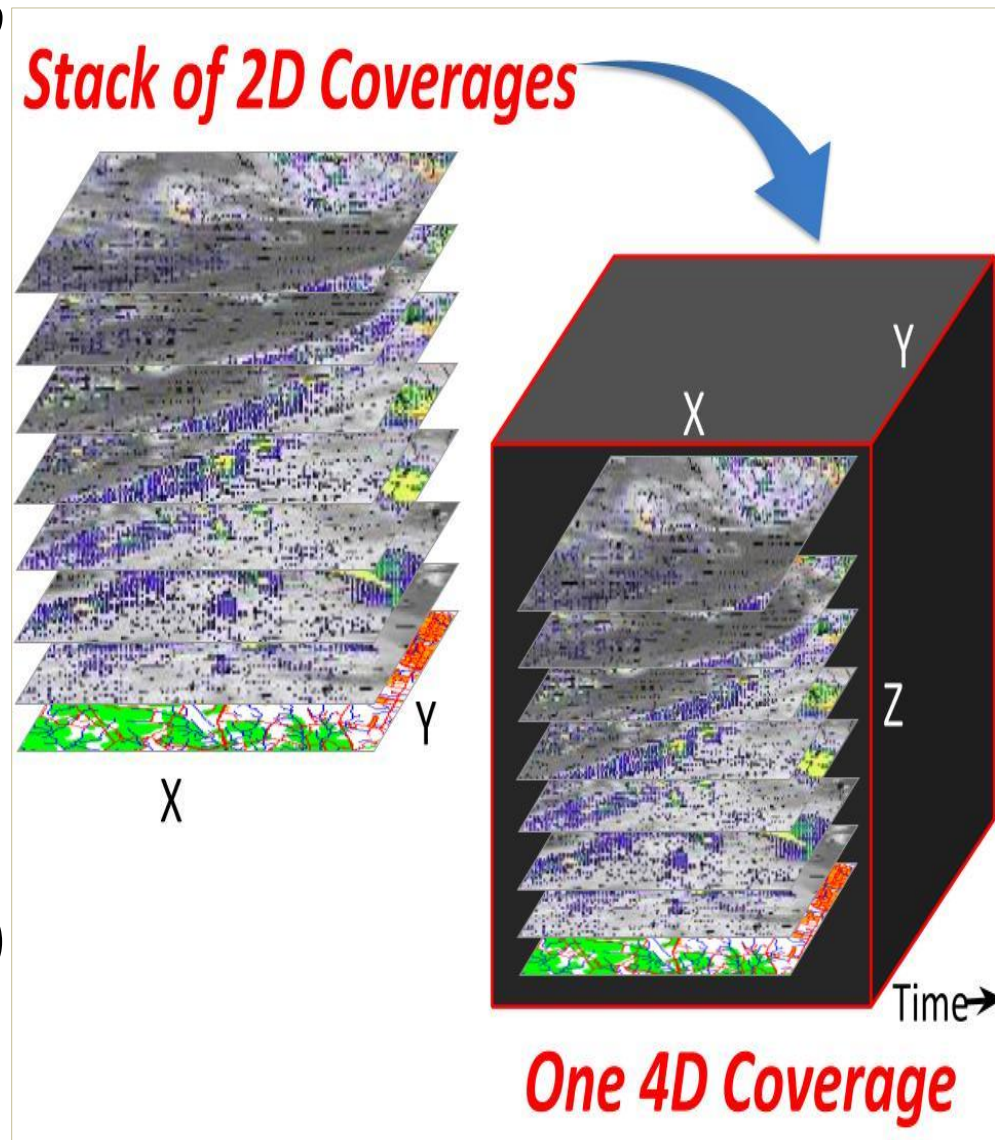
- ## MultiDimensionality

  - ➢ MetOcean data inherently ***4D*** (x/y/z/t)
  - ➢ WCS Coverages often ***2D*** (x/y)
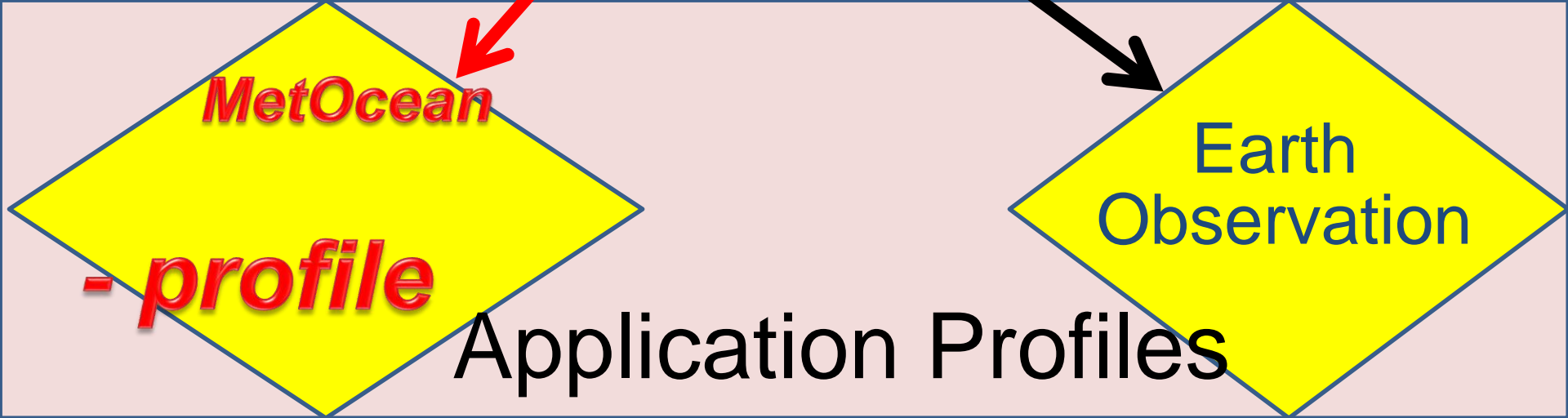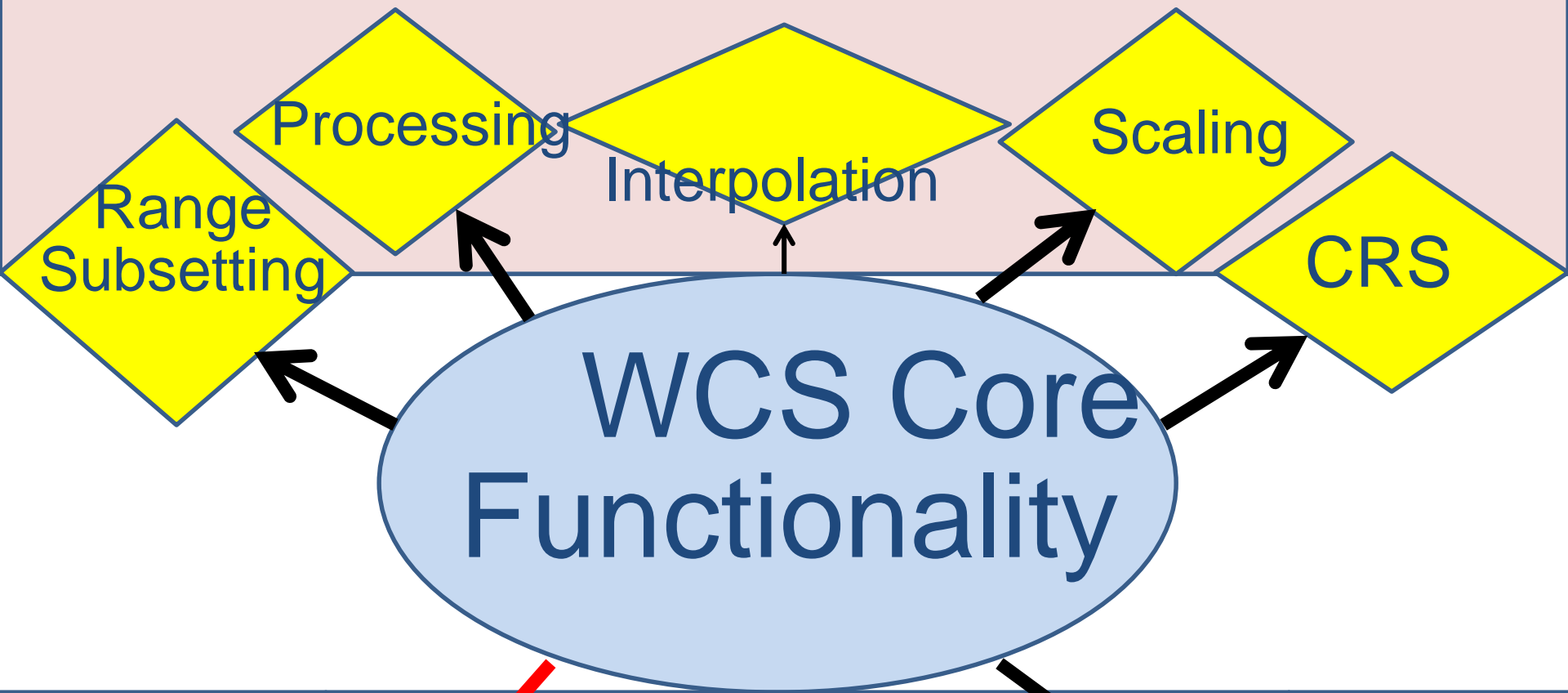 - ➢ Size, # WCS Requests & Responses w/ 2D Coverages ***unwieldy***

➔ ***Need new way of thinking about MetOcean coverages!***

Paradigm Shift in thinking about Coverages

- *Coverages: Stack 2D ➡ One 4D*

- *WCS2.1 Core allows 2D ➡ 4D*

- *Reduces # of Cov's ➡ Reduces # of WCS Transactions!*

- **Depict *whole atmosphere* as a multidimensional simulation**
  - Coverages *!=* Temp, Wspd, etc
  - Sample atmosphere as 1 4D object

- **Access Higher Dimensions (5D +)**

- *Allows consumers ability to singularly extract 4D/5D/+ data over geography, time, altitude, & ensembles, +*

Stack of 2D Coverages

One 4D Coverage

Service Extensions

Range Subsetting

Processing

Interpolation

Scaling

CRS

WCS Core Functionality

MetOcean - profile

Earth Observation

Application Profiles

- The main problem with the description of geospatial data is that is product based
- For example the names of layers are usually as follows:- Height_200hPa_T+24_GFS_2015-05-15T03:30:00Z
- Need to be "data centric"
- This is not geospatial and each layer is explicitly requested by name/
- Think of the atmosphere as a multi-dimensional cube. The number of dimensions is not limited, but normally x,y,z,t with the addition of ensemble.
- This hyper cube has properties e.g. temperature, wind, humidity, max wind level etc.
- The requests are then truly geo-spatial and only refer to the converge identifier, not a product name!
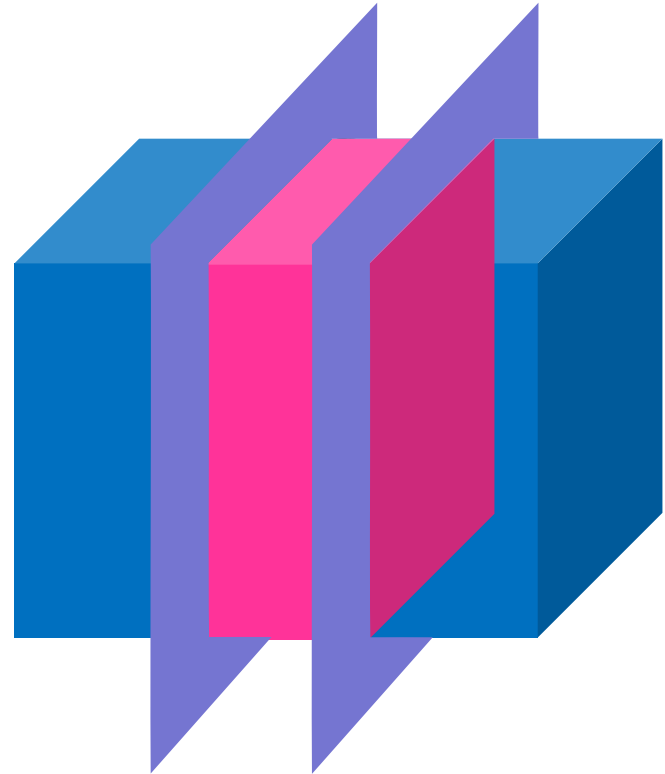
WCS 2.0 Core GetCoverage Operation

Slice Operation
(Dimension Reduction)
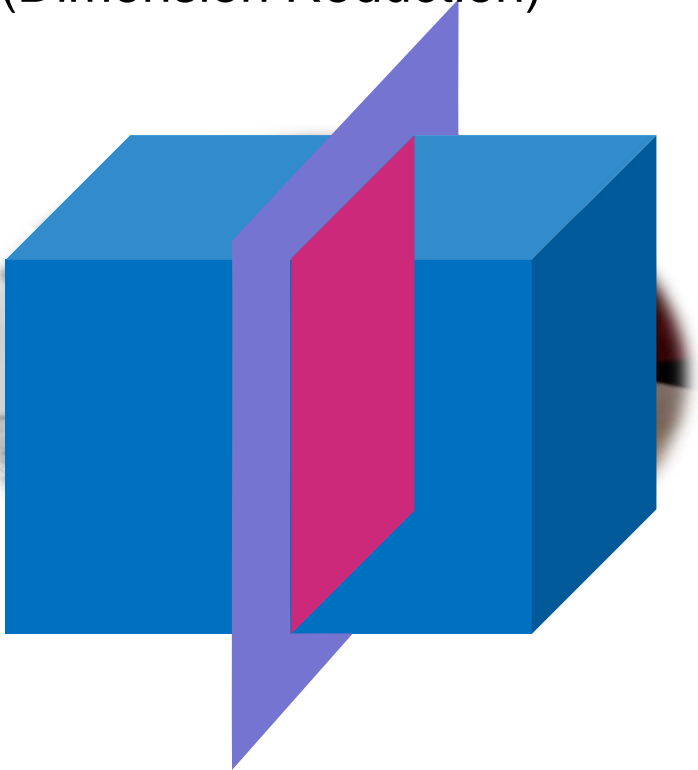
Trim Operation
(Extent Reduction)

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

Imagine 3D data cube without time

N

X

Y

Courtesy Jozef Matula IBL

Meteorological Data Extraction Patterns
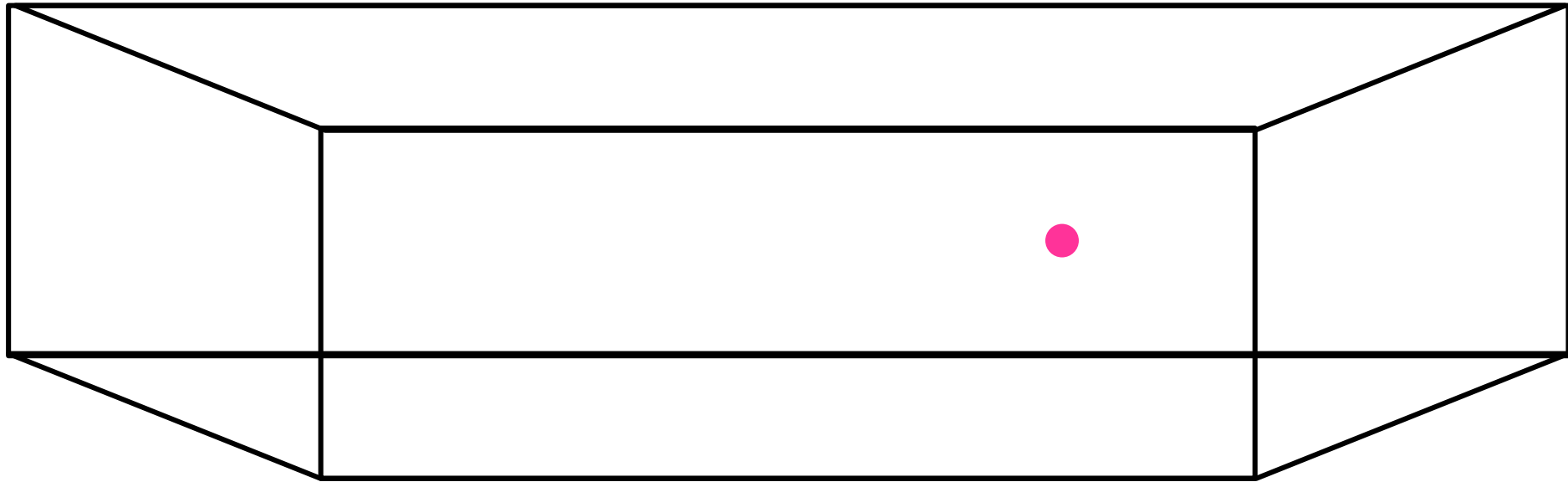
- Extracting data for a point = Slice X, Slice Y, Slice Z

Courtesy Jozef Matula IBL

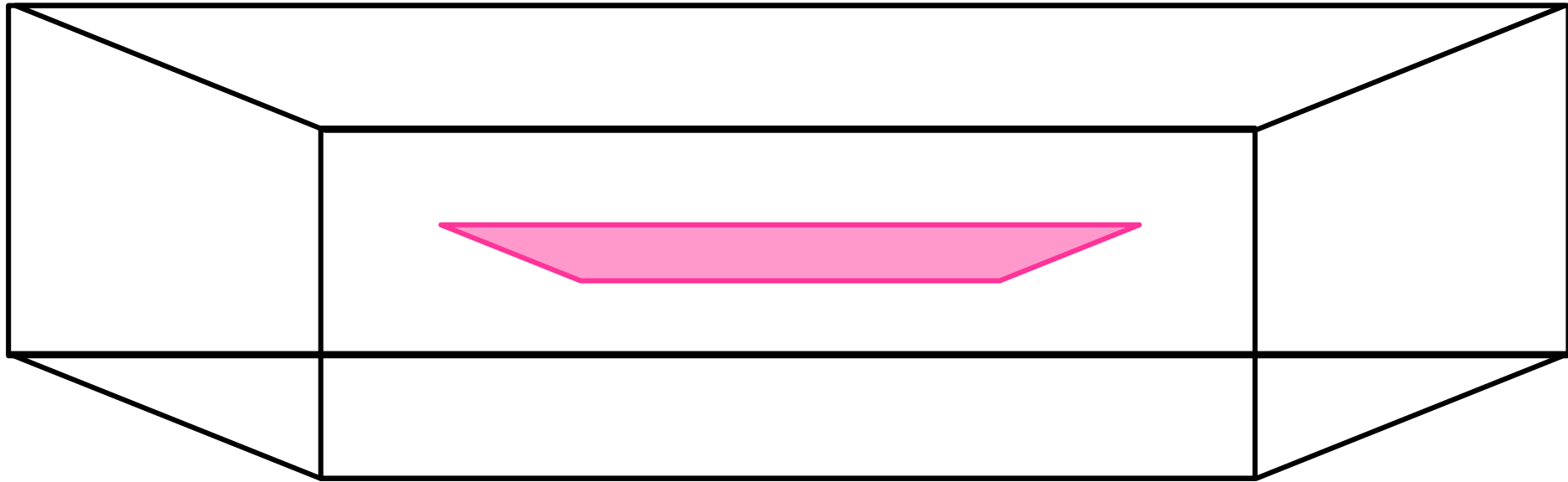# Meteorological Data Extraction Patterns
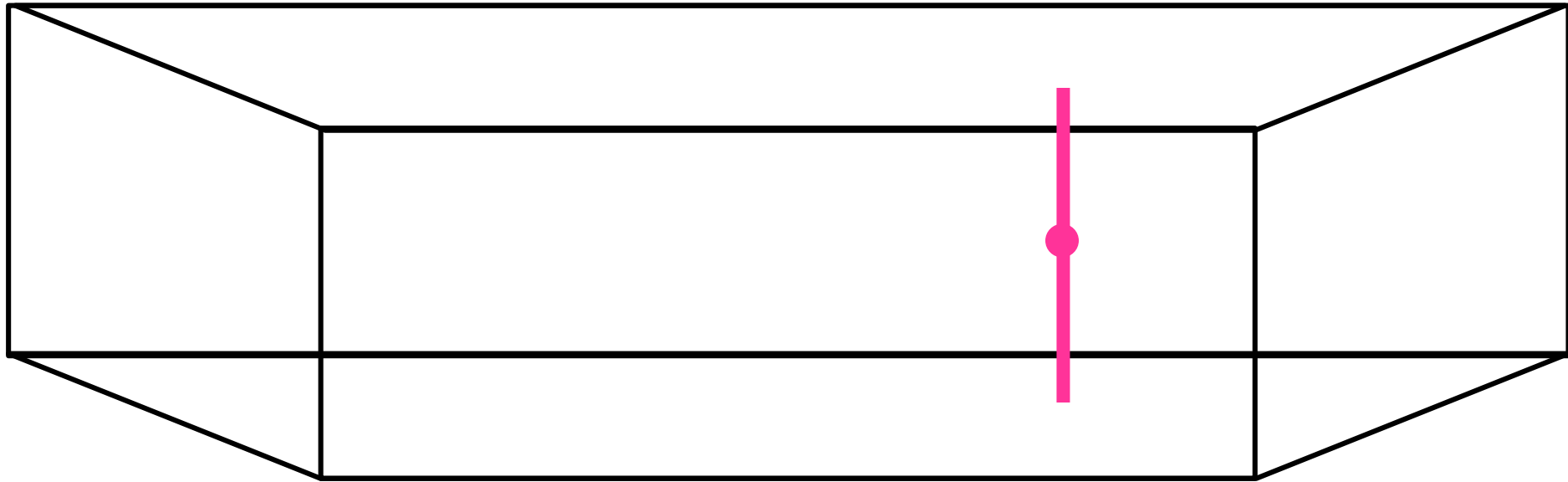
- Extracting vertical profile data for a point = Slice X, Slice Y

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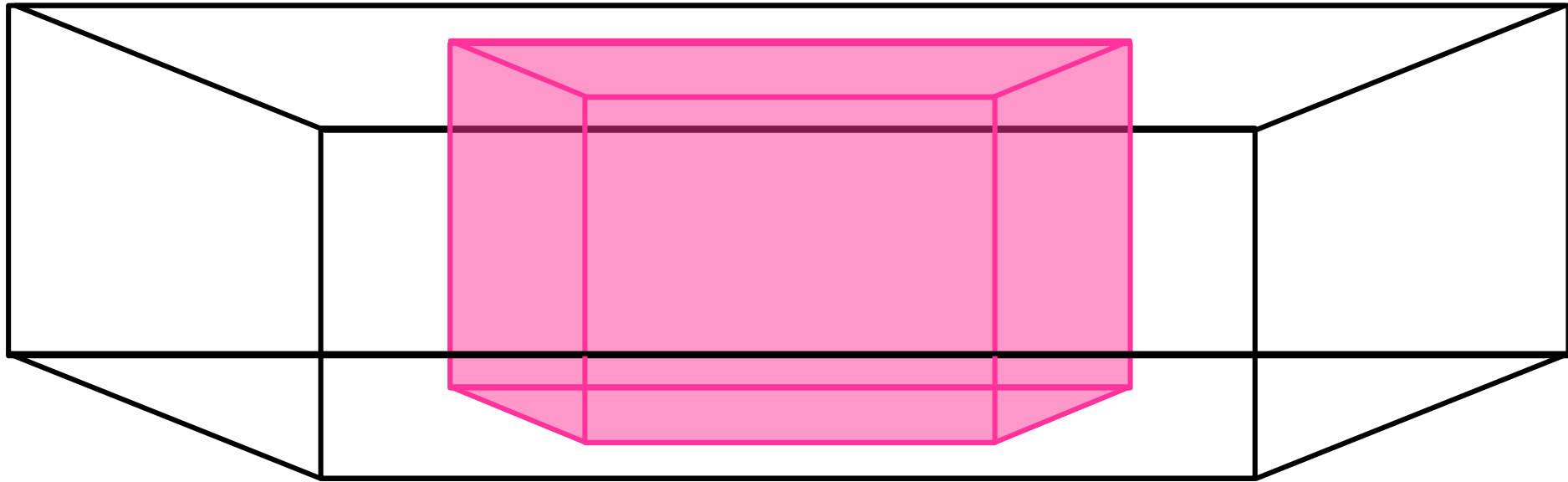
- Extracting vertical profile data for 2D geospatial domain = Trim X, Trim Y, Trim Z

Courtesy Jozef Matula IBL

Meteorological Data Extraction Patterns

T(0)　　　T(0.3)　　　T(0.6)　　　T(1)
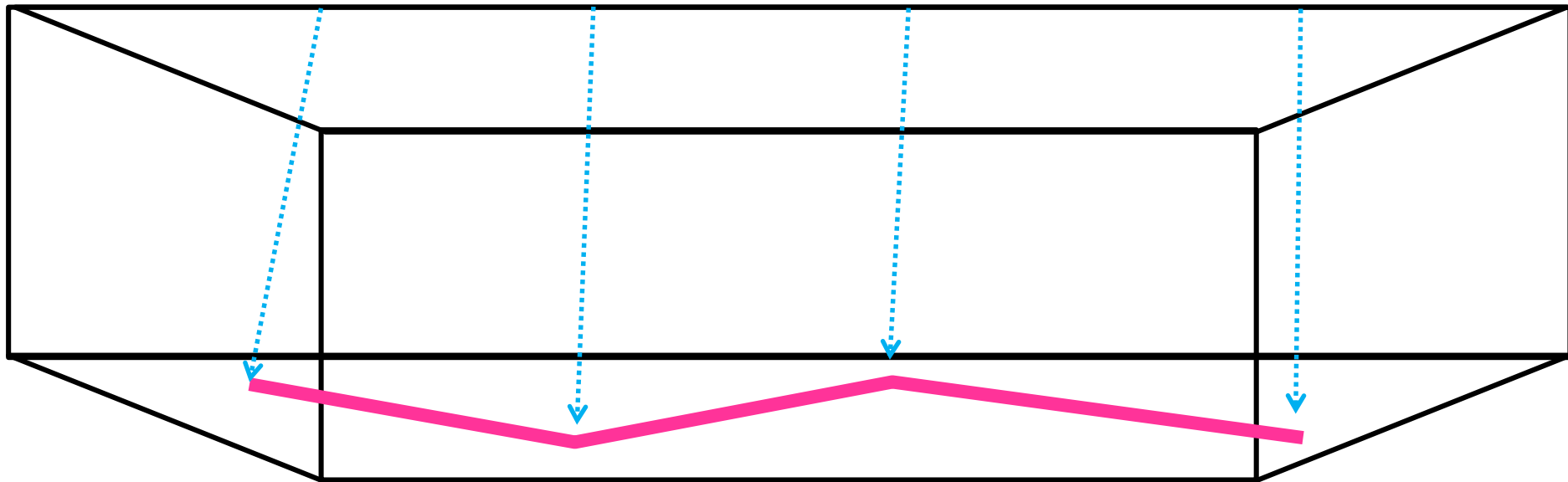
- Extracting data for a trajectory (for example road) = Trim in Trajectory CRS + Slice in Z.

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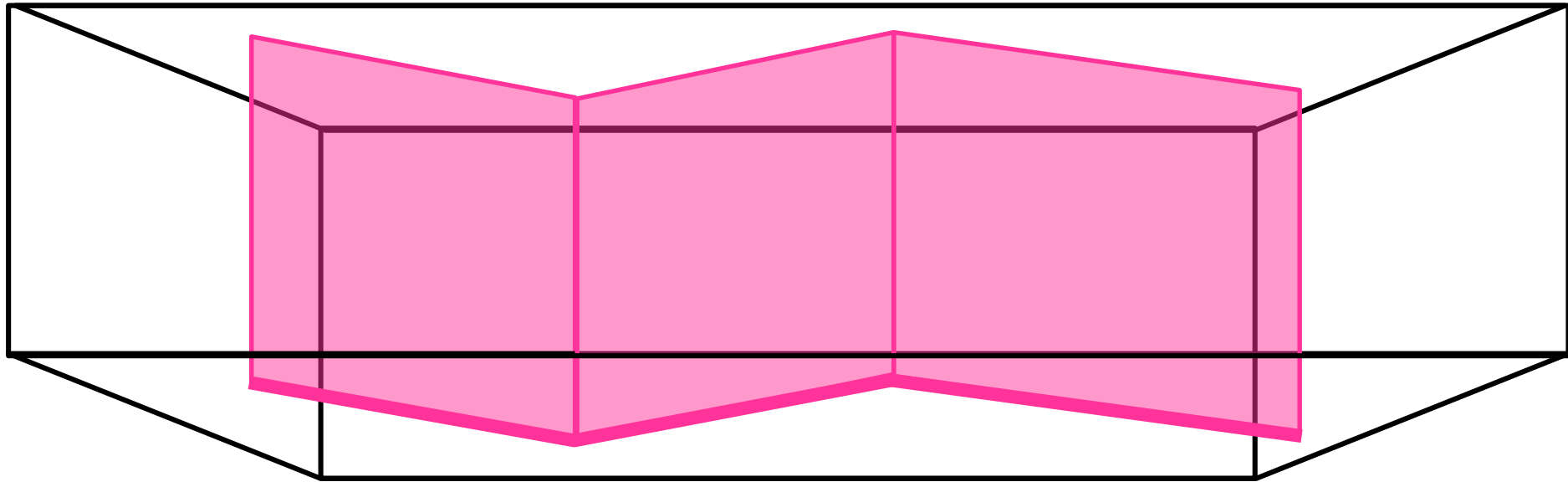
- Extracting vertical profile data for a trajectory = Trim in Trajectory CRS

Meteorological Data Extraction Patterns
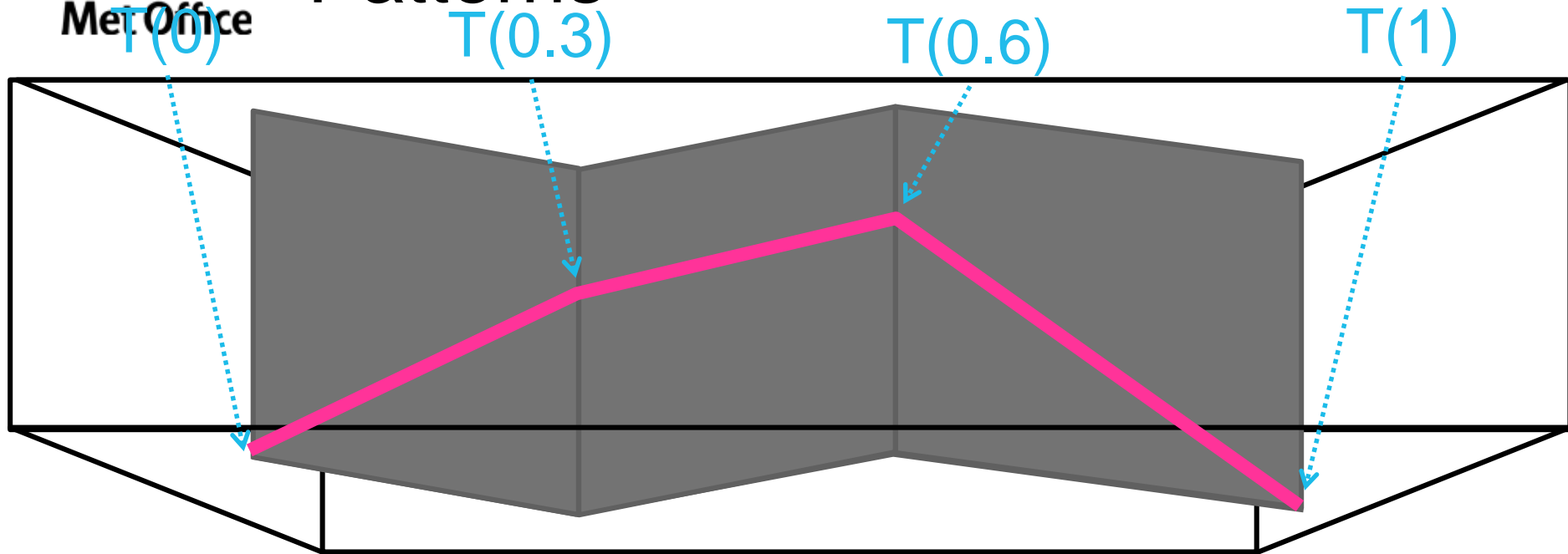
- Extracting data for a 3D trajectory (airplane) flight) = Trim in 3D Trajectory CRS

- 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

MetOcean Profile's Benefits to the WCS Core to Address new MetOcean Coverages

Coverage Collection

❑ Provide a very ***powerful way of grouping*** MetOcean Coverages. A NWP model run is in fact a coverage collection

  ➢ *NWP Model Simulations*   *Radar Mosaics*
  ➢ *Climate Observations*

❑ A ***single, uniquely identified resource*** consisting of member coverages related by common geospatial properties.

  ➢ *Treated as a single geospatial object*

❑ Address multidimensionality by further **REDUCING** the number of individual coverages, relevant to the GetCapbilites response.

❑ Attribute Common Metadata to entire collection, not each member coverage.

❑ New MetOcean operation ***DescribeCoverageCollection***

  ➢ *Returns member coverages with a simple API*

New Data Structural Patterns
(GetCapabilities Response document)

"Groups"

➢ Provides a hierarchical way of nesting "services".

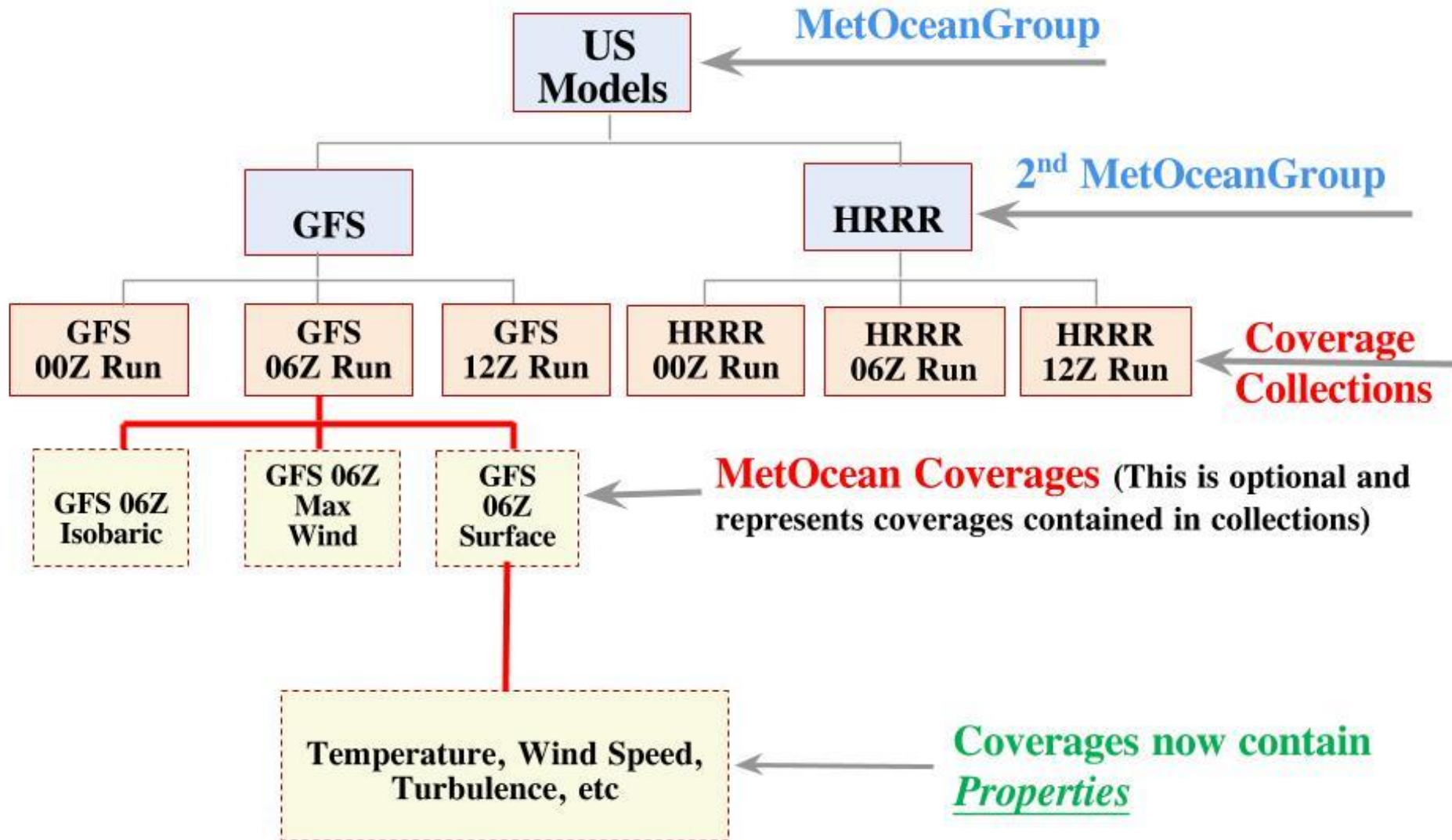➢ Supports **Service End Points**, allowing for a **Fully Distributed System**

"Collections"

➢ Return Info on Collections only, not individual member Coverages

Organizes & reduces amt of service metadata returned in GetCapabilities Response

!! Increases Efficiency of Web Services !!

A New Hierarchical Grouping Pattern (cont)

Describing a MetOcean Coverage as an Observational Type

➢ Current Obs -> Models -> Wx, Ocean, Climate Forecast Simulations
   ▪ *Simulations have properties describing characteristics of models*
➢ Define coverage metadata as a specialized **_O&M type_** (ISO 19156).

Benefits of using O&M

❑ Uses common Weather/Oceanic **_Vertical Reference Systems._**
❑ Supports **_Links for references_**. *Initial release supports WMO GRIB2 tables and concepts, but may be expanded. The metadata is not tied to a specific data format i.e. GRIB2.*
❑ By linking to WMO registers (e.g. http://codes.wmo.int/grib2/codeflag/4.5), there is support for a **_controlled vocabulary_** , facilitating interoperability and extensibility.
❑ A mechanism for **_Quality Control using a Data Mask_** (*See Backup Slide #25*)

   ➢ *Denotes at which forecast projection data is valid for.*
❑ A method to **_enumerate non-regular axes to support time and vertical dimensions_**. Key in 2D ➔ 4D .   *(See Backup Slide #24)*

Organizes metadata in a more common sense manner in a
DescribeCoverage Response !!

Effect of 4D coverages versus 2D coverages on web services: the GFS model, a case study

❑ User to extract GFS Model (one run time, e.g 06Z)

  ➢ 2D: ~ 10,000 individual coverages

  ➢ 4D: ~ 6 individual coverages

❑ Effect on ***GetCapabilities*** Response Doc (that lists the coverages)

  ➢ 2D: ~ ***30,000*** lines of XML!

  ➢ 4D: ~ ***200*** lines of XML!

→ *Massive Reduction in Amt of data Returned!*

❑ Effect on ***GetCoverage*** Request Number

  ➢ 2D: User makes ***10,000 Requests***

  ➢ 4D: User makes only ***6 Requests***

→ *Massive Reduction in Amt of data Requests!*

❑ Bottom line is MetOcean supports WCS operations that support ***multidimensionality with 4D Coverages (x,y,z,t).***

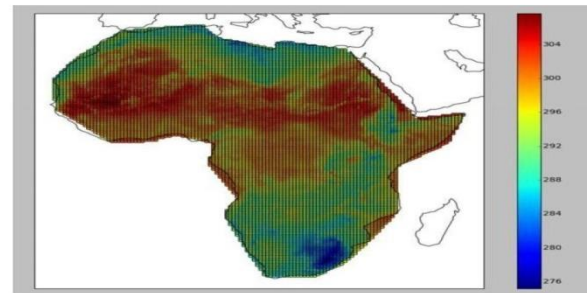# *New Operations to Query MetOcean Data*

❑ Complex Data Extraction

➢ Derived/Developed from Multi Dimensionality and 4D Coverage

❑ Tailored to common MetOcean Data Shapes

➢ More Explicit than WCS GetCoverage operation

❑ GetPolygon

➢ Area or Volume

❑ GetCorridor

T(0) T(0.3) T(0.6) T(1)
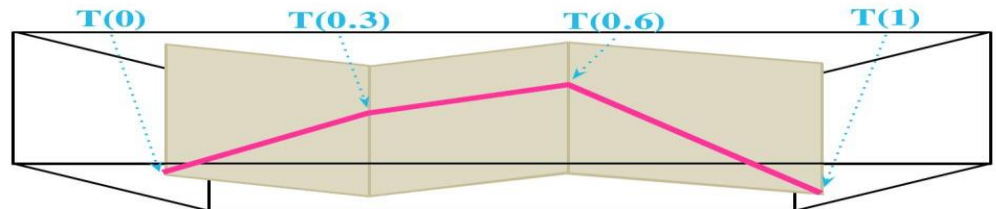
Current Status And Results: A Demo

➢ A web service <u>implementation</u> featuring the full MetOcean Profile has been <u>built</u> & <u>tested</u> *using UK Met & US NWS data*!

➢ The MetOcean Application Profile is <u>still</u> in need of comment!

➢ Links to the MetOcean Profile on the OGC website:

https://portal.opengeospatial.org/files/?artifact_id=70345&version=1

https://portal.opengeospatial.org/files/?artifact_id=70347&version=1

MetOcean Demonstration

Met Office

➢ To highlight the key MetOcean features the profile has extended over WCS 2.1 Core, a *transcontinental flight demo* will be shown that can request/receive info from a single proxy service.

➢ This *proxy setup* shows how multiple WCS servers can be accessed as separate component requests.

- Over UK airspace, proxy retrieves info from UK server
- Over US airspace, proxy retrieves info from US server
- *May be beneficial as an aviation/marine DST (NextGen/SESAR*

MetOcean Demonstration (cont)

➢ Show extraction of **WAFS data** along the flight

➢ Show a single user request to the proxy service
  - ✓ *Using single identifier*
  - ✓ *Access data from a 4D hyper cube (lat, lon, time, and vertical coord)*

➢ Proxy Service requests data from **2** disparate WCS servers
  - ✓ *Each WCS request accesses a **"hemisphere"** cut out of global data*
  - ✓ *The Flight Planning Client retrieves from the proxy server a "stitched" grid (merged product)*
  - ✓ Proxy server has a virtual copy of the ***"re-constituted"*** data

Met Office

- **GetCapabilites** (http://ws-sandbox.iblsoft.com/wafc/kwbc?SERVICE=WCS&VERSION=2.1.0&REQUEST=GetCapabilities)

- **DescribeCoverageCollection** (http://ws-sandbox.iblsoft.com/wafc/kwbc?SERVICE=WCS&VERSION=2.1.0&REQUEST=DescribeCoverageCollection&COVERAGECOLLECTIONID=KWBC_2017-03-01T06.00.00Z)

- **DescribeCoverage** (http://ws-sandbox-ie.iblsoft.com/wafc/kwbc?SERVICE=WCS&VERSION=2.1.0&REQUEST=DescribeCoverage&COVERAGEID=KWBC_2017-03-01T06.00.00Z_ISBL)

Demo Link:

http://ws-sandbox.iblsoft.com/demo2/

Future Plans

- Multi slicing and trimming with a single "GetCoverage" operation. Allows extraction of Multi pts/cross sections from one GetCoverage operation.

- Standardize MetOcean CRS, vertical levels, etc. Based on the WMO standards.

- Add formal extension for GetCorridor & GetPolygon

- Investigate adding a pub/sub model for offering subscription service.

- Explore adding data formats with metadata.

- Explore encoding coverages in JSON (CovJSON) in addition to XML.

- Add support for 5D ensemble members.

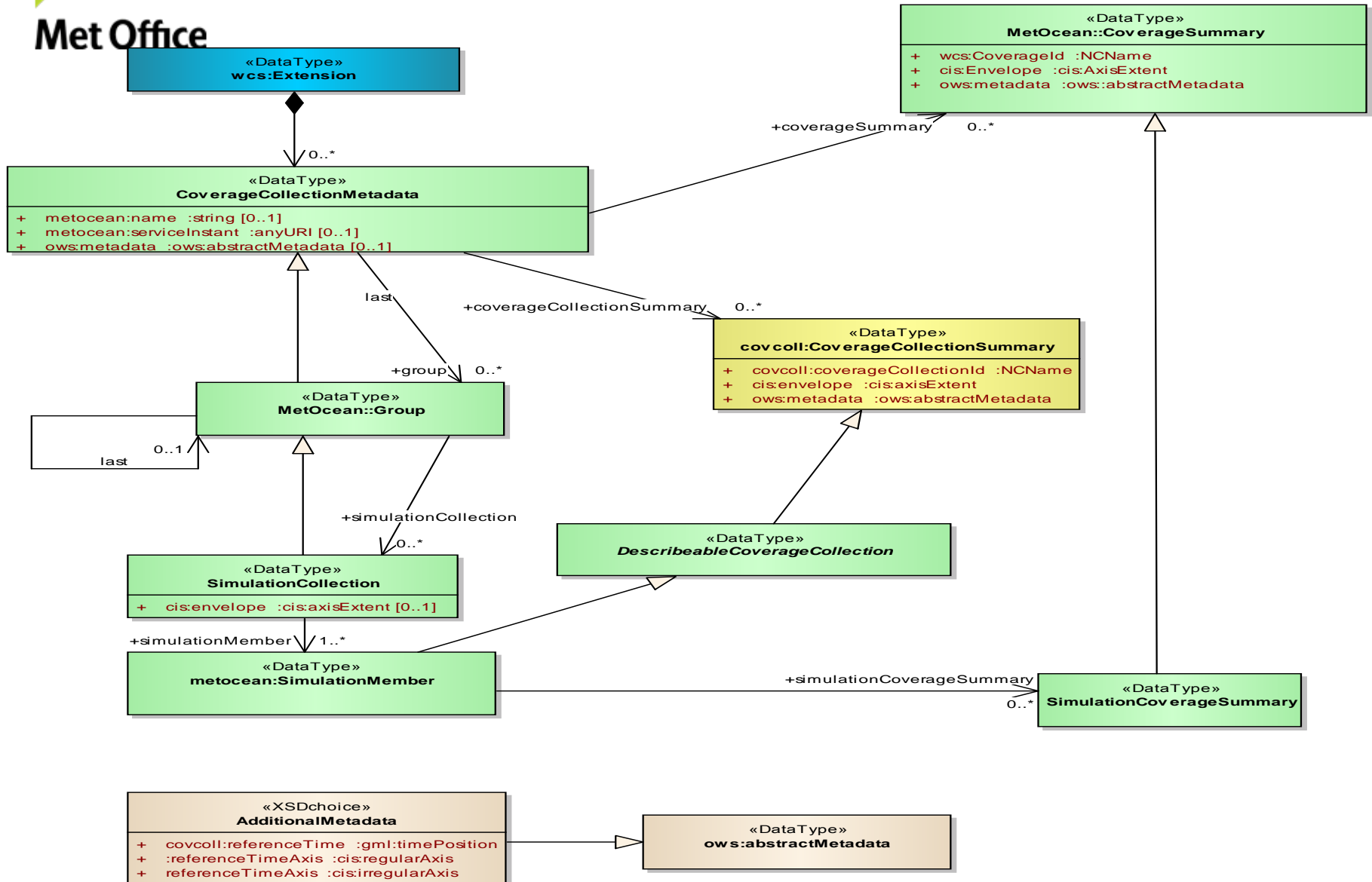- Incorporate MetOcean DWG requests/comments.

Questions ?

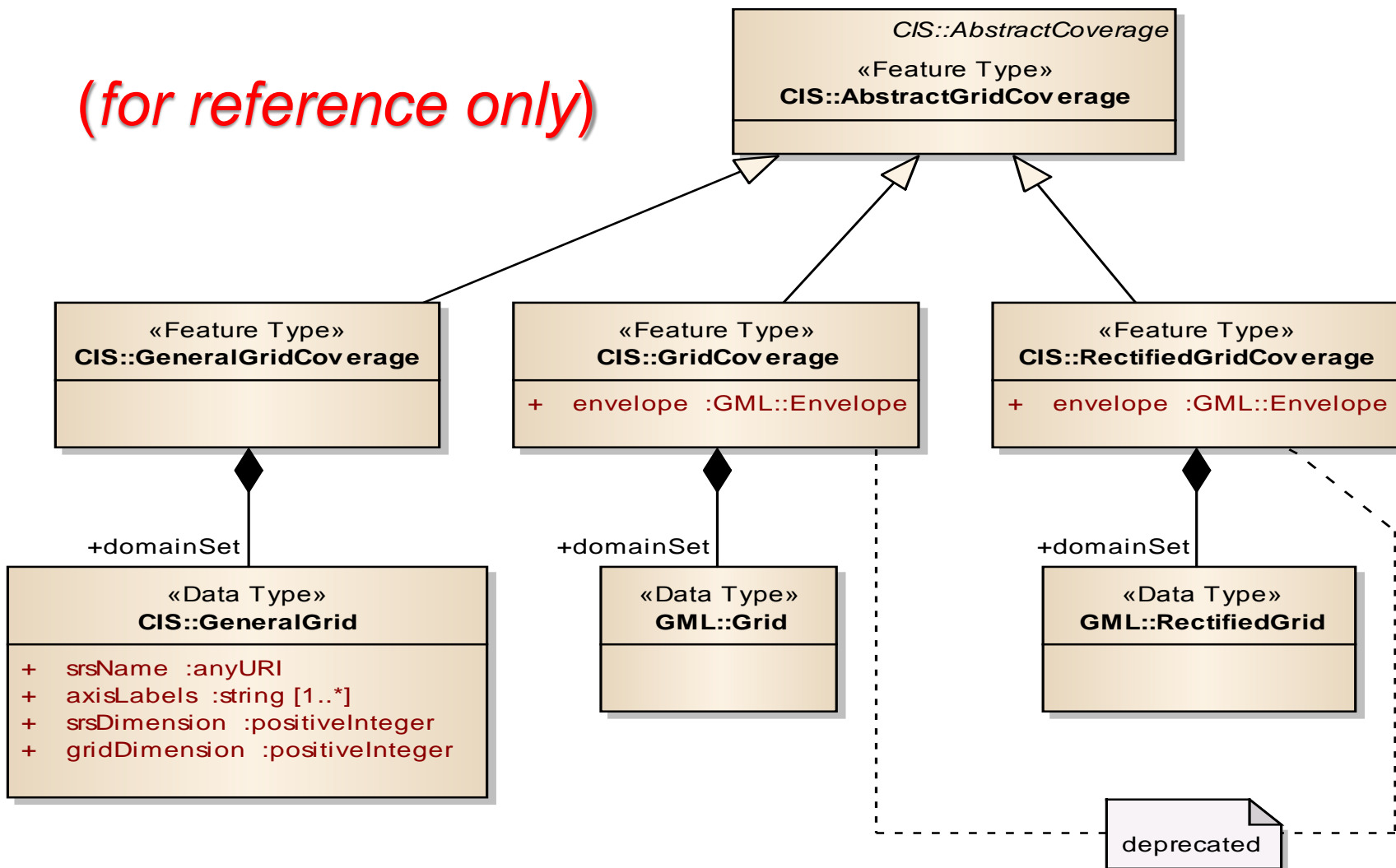# Backup Slides:

GetCapabilities

UML Model for CIS 1.1
(allows Derivation of one 4D coverage -> many 2D coverages)

class CIS::AbstractGridCoverage (as per grid-regular)

(for reference only)

CIS::AbstractCoverage
«Feature Type»
CIS::AbstractGridCoverage

«Feature Type»
CIS::GeneralGridCoverage

«Feature Type»
CIS::GridCoverage

+ envelope :GML::Envelope

«Feature Type»
CIS::RectifiedGridCoverage

+ envelope :GML::Envelope

+domainSet

«Data Type»
CIS::GeneralGrid

+ srsName :anyURI
+ axisLabels :string [1..*]
+ srsDimension :positiveInteger
+ gridDimension :positiveInteger

+domainSet

«Data Type»
GML::Grid

+domainSet

«Data Type»
GML::RectifiedGrid

deprecated

Quality Control using a Data Mask

2D Coverages, a Case Study
(Note: choose "Presentation mode" for scroll bar availability

Met Office

```xml
<?xml version="1.0" encoding="UTF-8"?>
<wcs:Capabilities updateSequence="20120504T160000Z" version="2.0.0"
 xmlns:xlink="http://www.w3.org/1999/xlink" xmlns:gml="http://www.opengis.net/gml/3.2"
 xmlns:gco="http://www.isotc211.org/2005/gco" xmlns:gmd="http://www.isotc211.org/2005/gmd"
 xmlns:gts="http://www.isotc211.org/2005/gts" xmlns:gsr="http://www.isotc211.org/2005/gsr"
 xmlns:gss="http://www.isotc211.org/2005/gss"
xmlns:metocean="http://www.opengis.net/wcs/metoceanProfile/1.0"
 xmlns:wcs="http://www.opengis.net/wcs/2.1" xmlns:ows="http://www.opengis.net/ows/2.0"
 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
 xmlns:covcoll="http://www.opengis.net/wcs/covcoll/1.0"
 xmlns:cis="http://www.opengis.net/cis/1.1"
 xmlns:crs="http://www.opengis.net/wcs/service-extension/crs/1.0"
 xsi:schemaLocation="http://www.opengis.net/wcs/metoceanProfile/1.0
file:/C:/Users/PTrevelyan/WCS/MetOceanWCS/MetOCeanProfile/Schemas/wcsMetOceanProfileAL
L.xsd">
 <ows:ServiceIdentification>
  <ows:Title>Test configuration of Met data server</ows:Title>
  <ows:Abstract> Copyright (C) The Met Office - UK </ows:Abstract>
  <ows:Keywords>
   <ows:Keyword>MO-WCS</ows:Keyword>
   <ows:Keyword>WCS MO-AP</ows:Keyword>
   <ows:Keyword>WCS 2.1</ows:Keyword>
   <ows:Keyword>WCS</ows:Keyword>
   <ows:Keyword>Meteorological Products</ows:Keyword>
   <ows:Keyword>Hydrological Products</ows:Keyword>
```

4D Coverages, a Case Study
(Note: choose "Presentation mode" for scroll bar availability

```xml
<?xml version="1.0" encoding="UTF-8"?>
<wcs:Capabilities updateSequence="20120504T160000Z" version="2.0.0"
 xmlns:xlink="http://www.w3.org/1999/xlink" xmlns:gml="http://www.opengis.net/gml/3.2"
 xmlns:gco="http://www.isotc211.org/2005/gco" xmlns:gmd="http://www.isotc211.org/2005/gmd"
 xmlns:gts="http://www.isotc211.org/2005/gts" xmlns:gsr="http://www.isotc211.org/2005/gsr"
 xmlns:gss="http://www.isotc211.org/2005/gss"
xmlns:metocean="http://www.opengis.net/wcs/metoceanProfile/1.0"
 xmlns:wcs="http://www.opengis.net/wcs/2.1" xmlns:ows="http://www.opengis.net/ows/2.0"
 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
 xmlns:covcoll="http://www.opengis.net/wcs/covcoll/1.0"
 xmlns:cis="http://www.opengis.net/cis/1.1"
 xmlns:crs="http://www.opengis.net/wcs/service-extension/crs/1.0"
 xsi:schemaLocation="http://www.opengis.net/wcs/metoceanProfile/1.0
file:/C:/Users/PTrevelyan/WCS/MetOceanWCS/MetOCeanProfile/Schemas/wcsMetOceanProfile
ALL.xsd">
 <ows:ServiceIdentification>
  <ows:Title>Test configuration of Met data server</ows:Title>
  <ows:Abstract> Copyright (C) The Met Office - UK </ows:Abstract>
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   <ows:Keyword>MO-WCS</ows:Keyword>
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```