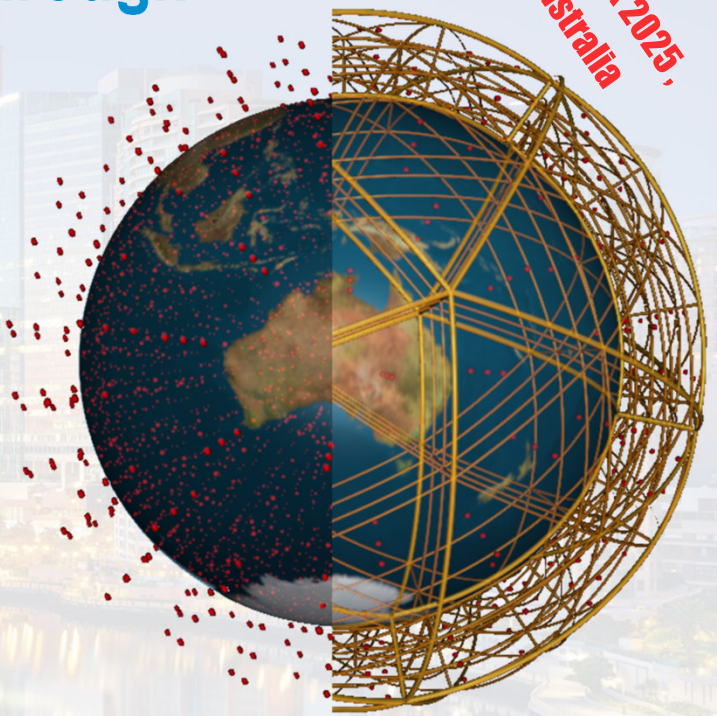
FIG WORKING WEEK 2025
AND Locate25 THE NATIONAL GEOSPATIAL CONFERENCE
Collaboration, Innovation and Resilience: Championing a Digital Generation
FIG Geospatial Council of Australia
Brisbane, Australia 6–10 April

Advancing Urban Digital Twin Implementation Through Discrete Global Grid Systems



Dr Matthew B.J. Purss

Co-Founder and CEO

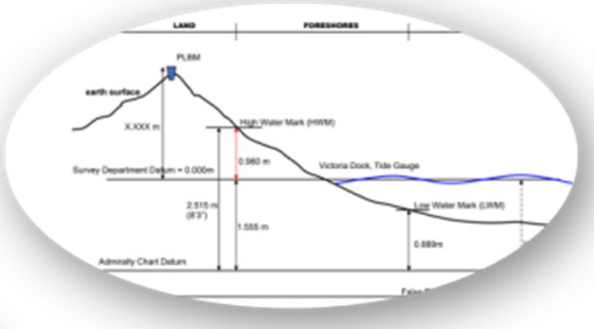
Pangaea Innovations Pty Ltd

ORGANISED BY FIG Geospatial Council of Australia
PLATINUM SPONSORS Australian Government CHCNAV esri THE SCIENCE OF WHERE Leica Geosystems HydroMeter Surveyors Australia

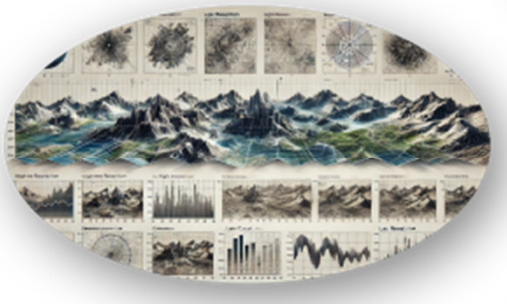
Overview

- The Challenge of Digital Twins
- Discrete Global Grid Systems - a new approach to data interoperability
- The Digital Nexus is already here

The Challenge of Digital Twins - Why are they hard to build?...



Multiple CRSs



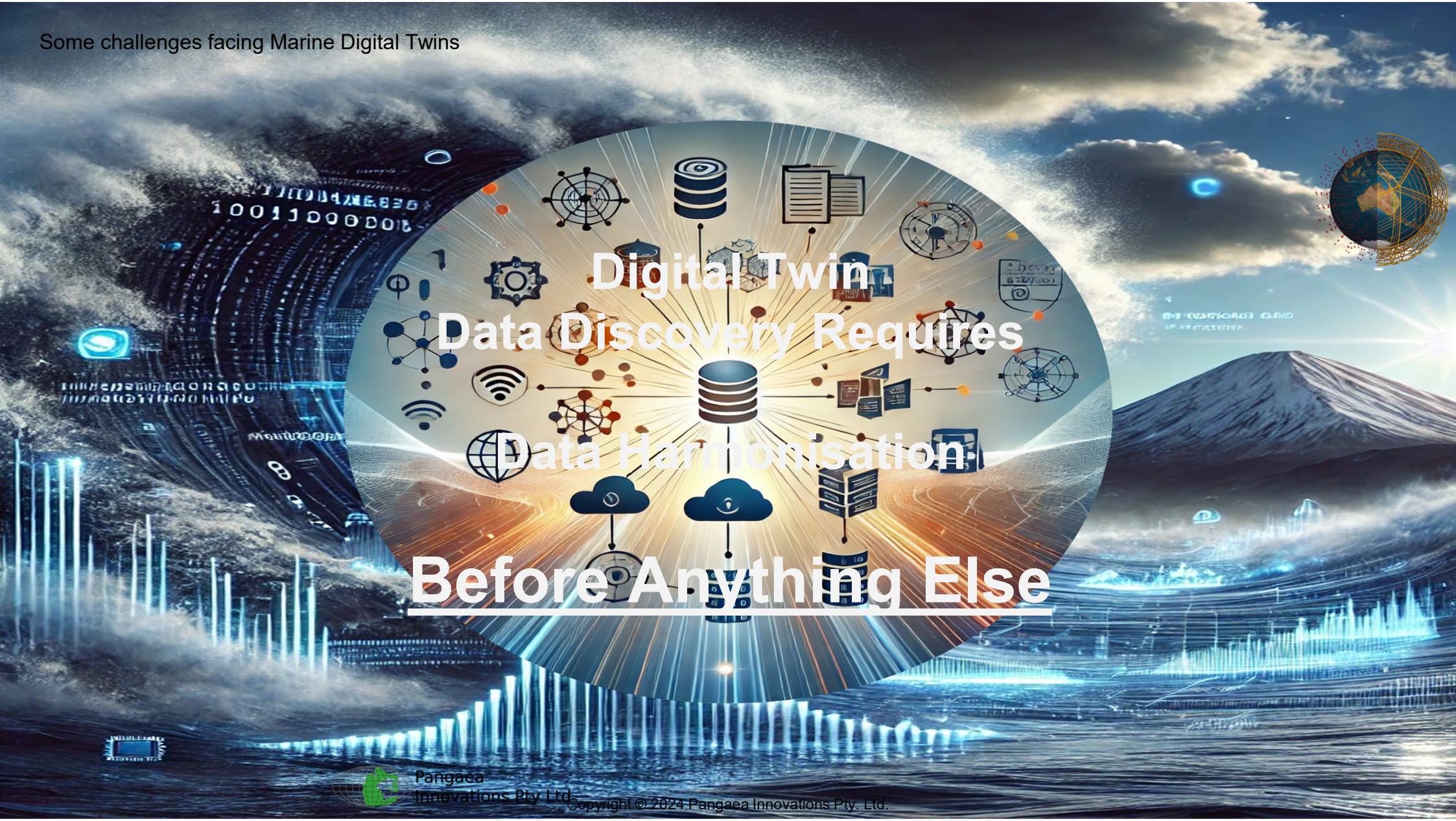
Multiple Sampling Resolutions

Multiple Jurisdictions

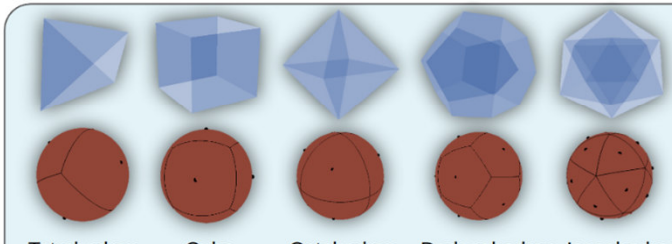
Multiple Data Formats


~40% of the world's population (~3.3Bn people) live ≤ 100km of the coast
~10% of the world's population (~800Mn people) live ≤ 10m above sea level
~40% of the world's largest cities (~200 cities) are on the coast
significant implications for climate change mitigation

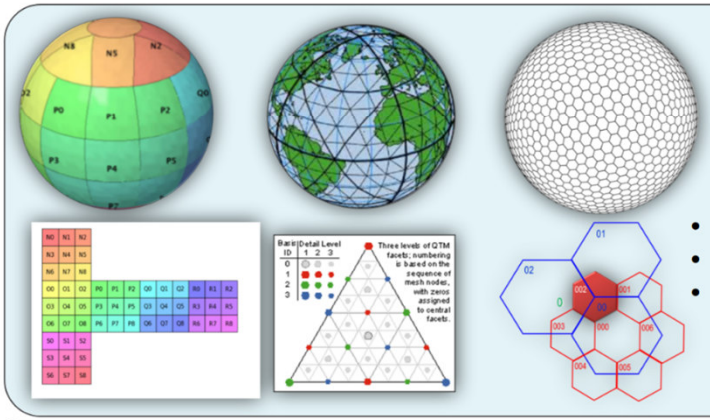
Some challenges facing Marine Digital Twins



Pangaea Innovations Pty Ltd



Equal Area Tessellations of the Earth's Surface Model

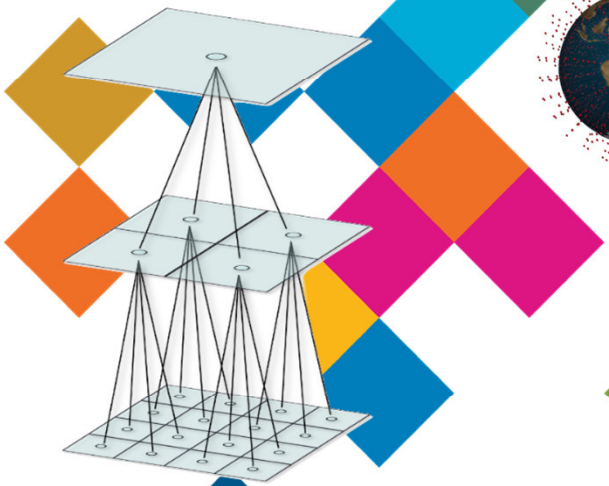


Simple cell Types:

- Rectangular
- Triangular
- Hexagonal

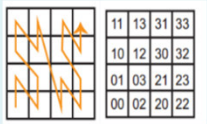
Spatial Data Analytics Without "Flattening"

Open Geospatial Consortium



Fixed Cell Hierarchy

Massively Scalable



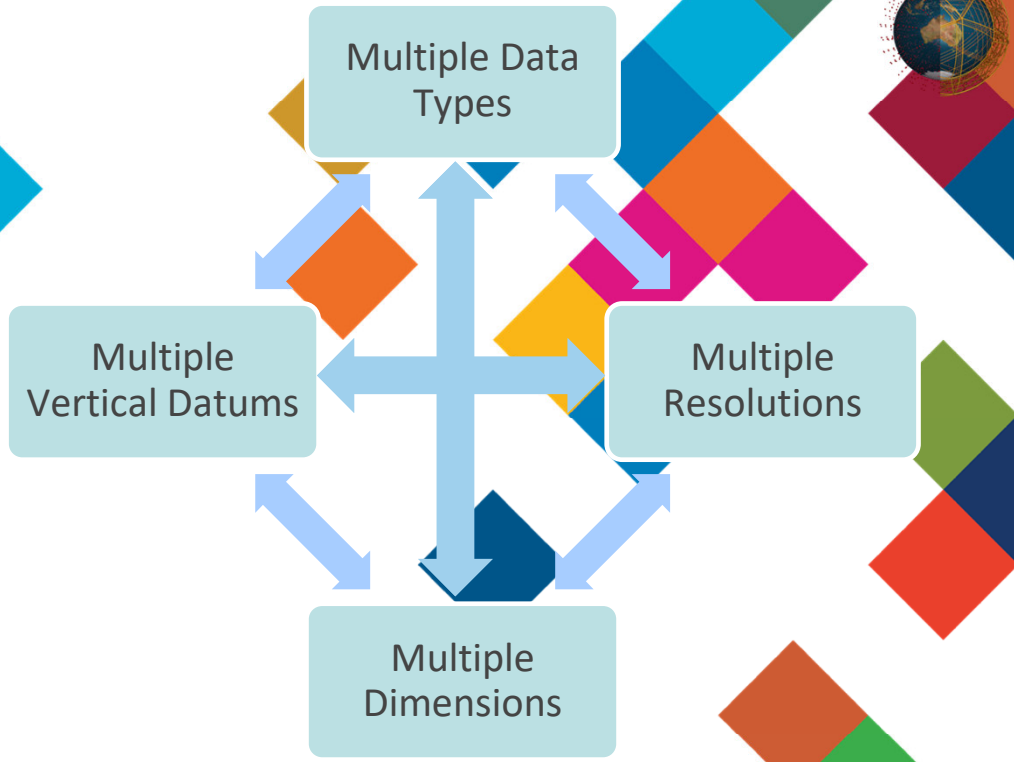
nD Spatial Analyses
↓
1D Array Processes

Globally Unique Cell Indices

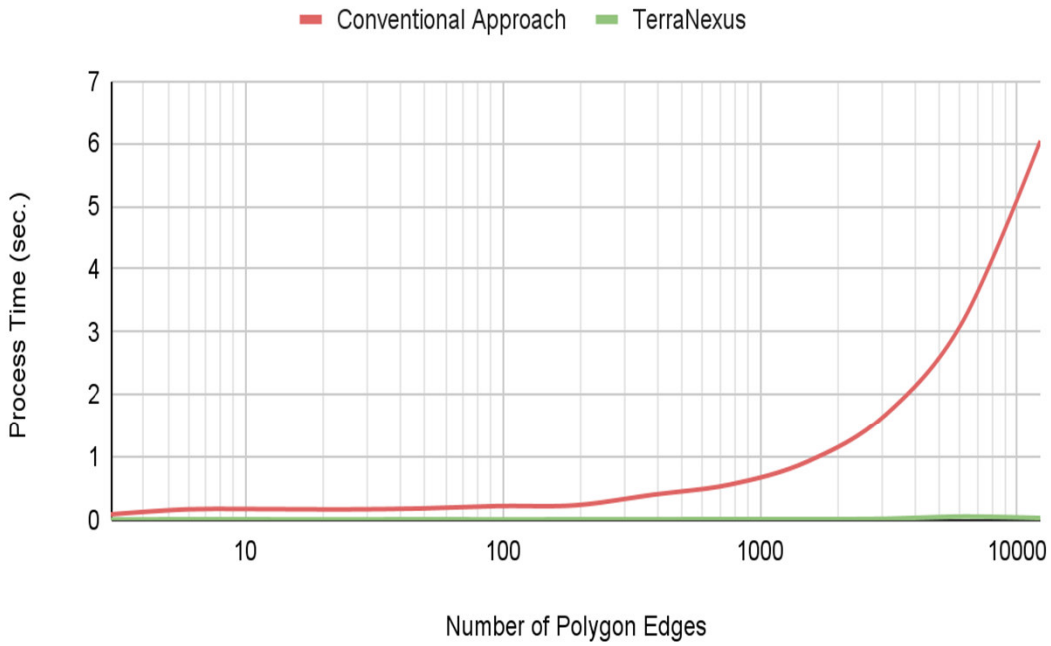
00	01	02	03	10	11	12	13	20	21	22	23	30	31	32	33

DGGS can bring massive value to Spatial Data Infrastructures in addressing the data interoperability Challenge.

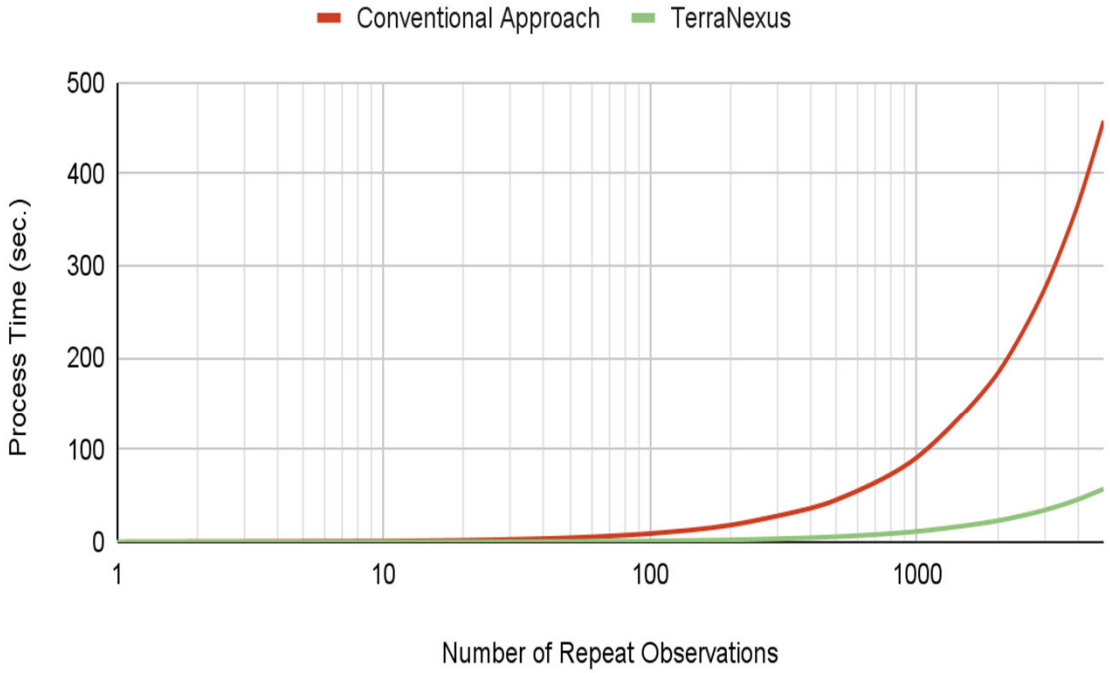
Removing the need to reformat, resample or perform multiple coordinate reference transformations of the data before it can be used in a Marine Digital Twin context.



Single Point in Polygon vs Polygon Complexity Test (Process Time)



Point in Polygon vs Repeat Operations Test (Process Time)

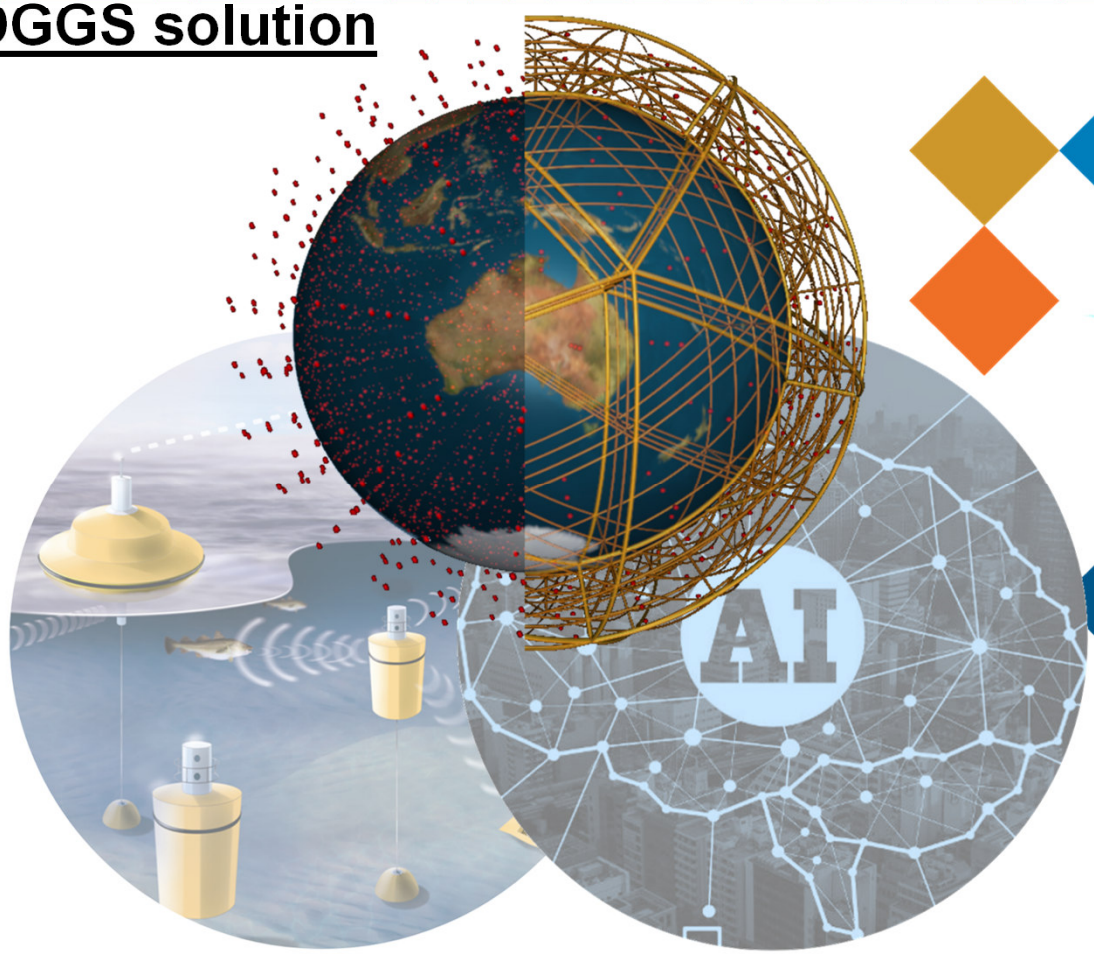


TerraNexus – A 4D DGGS solution

4D Indexing with real world context baked in

Equal Volume Zones

Solid Earth DGGS



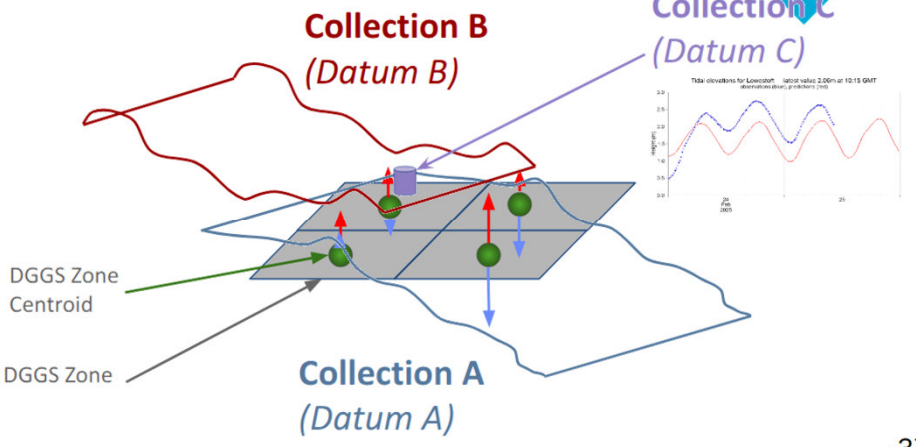
Leverages OGC and W3C Semantic Standards

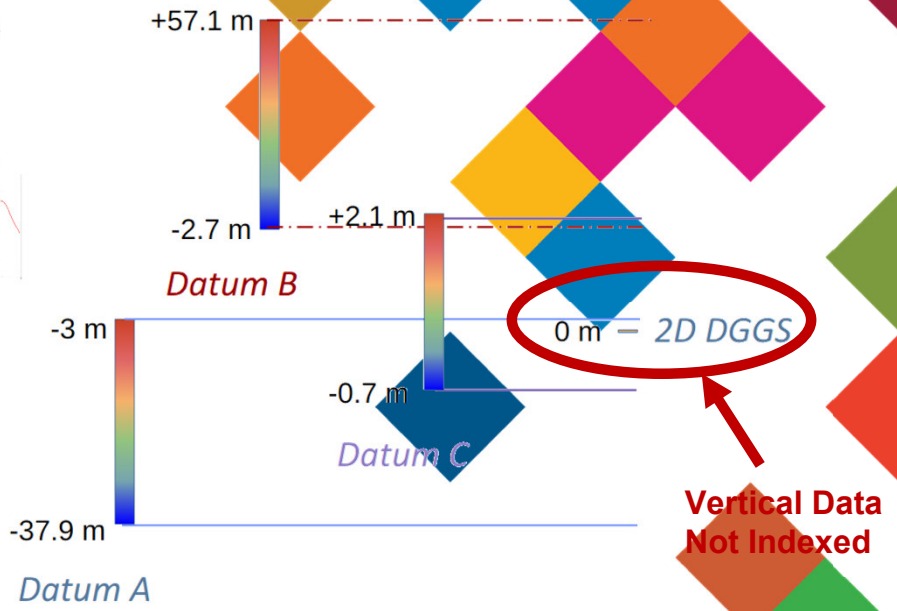
Builds Trust Through Provenance

Designed with Multi-Jurisdiction Interoperability in mind

2D DGGS

- Discovery and selection/subsetting of data across collections is a simple index lookup using a DGGS - not a series of complex mathematical operations
- **But… for 2D DGGS indexing only applies to the lateral (e.g. x,y) dimensions we still have the issue of height datum differences**

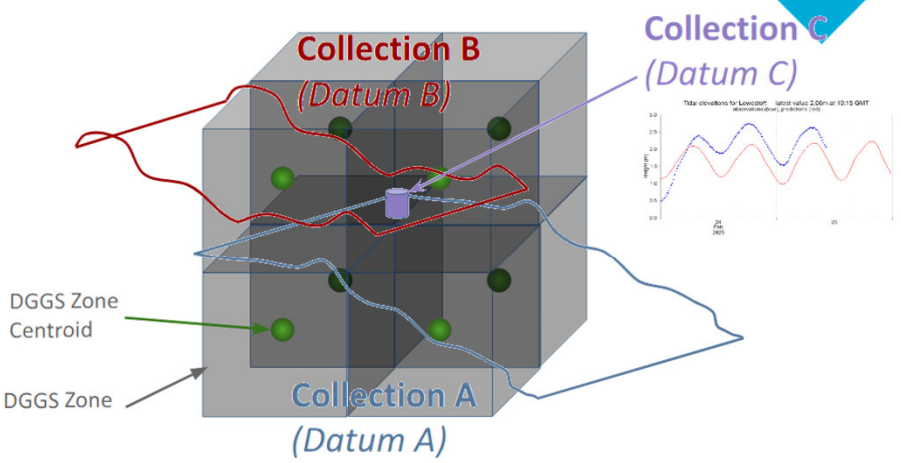


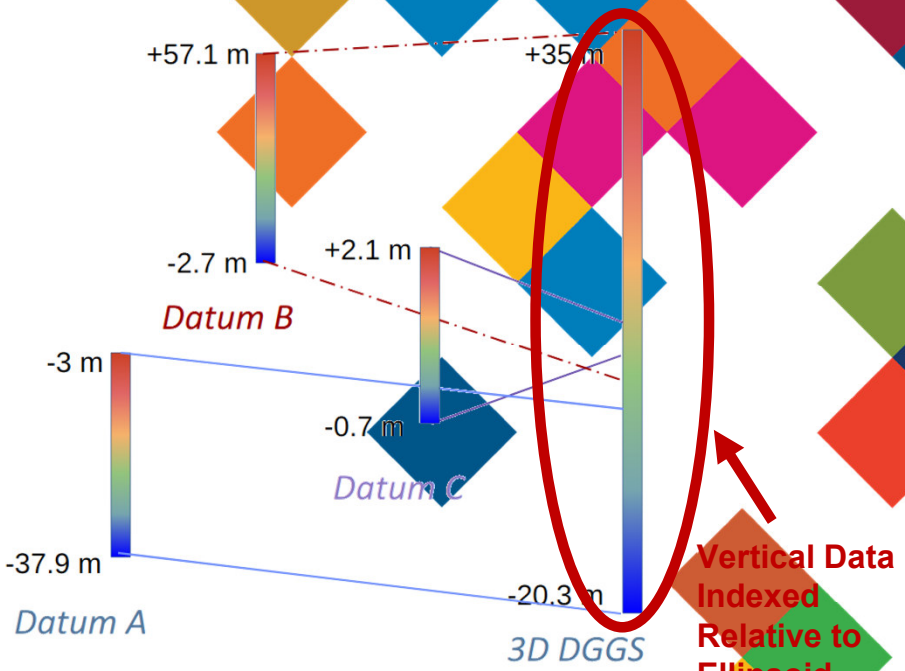


2D DGGS ZoneId's are fixed to the Earth Model (e.g. ellipsoidal 0m level)

3D DGGS

- Discovery and selection/subsetting of data across collections is a simple index lookup using a DGGS - not a series of complex mathematical operations
- **3D DGGS enable a common spatial index that enables data integration across collections and vertical datums but not time.**

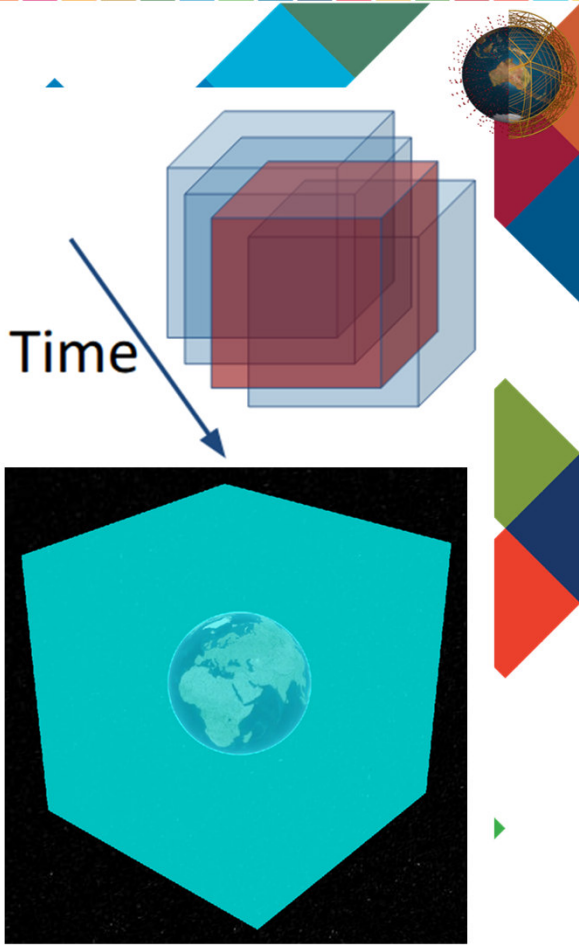




3D DGGS ZoneId's are fixed relative to the Earth Model (e.g. relative to the GRS80 Ellipsoid) - data is indexed relative to the DGGS spatial context but not resampled

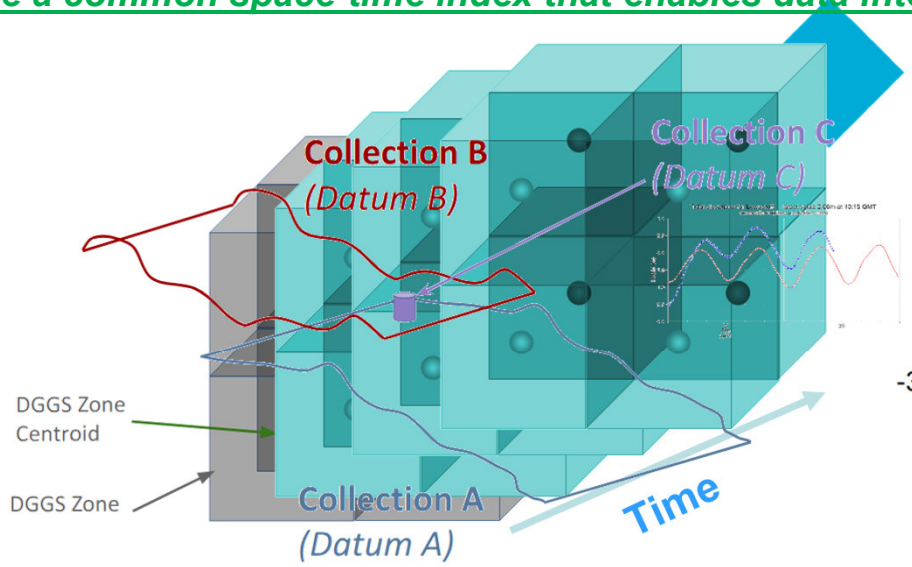
Demonstration

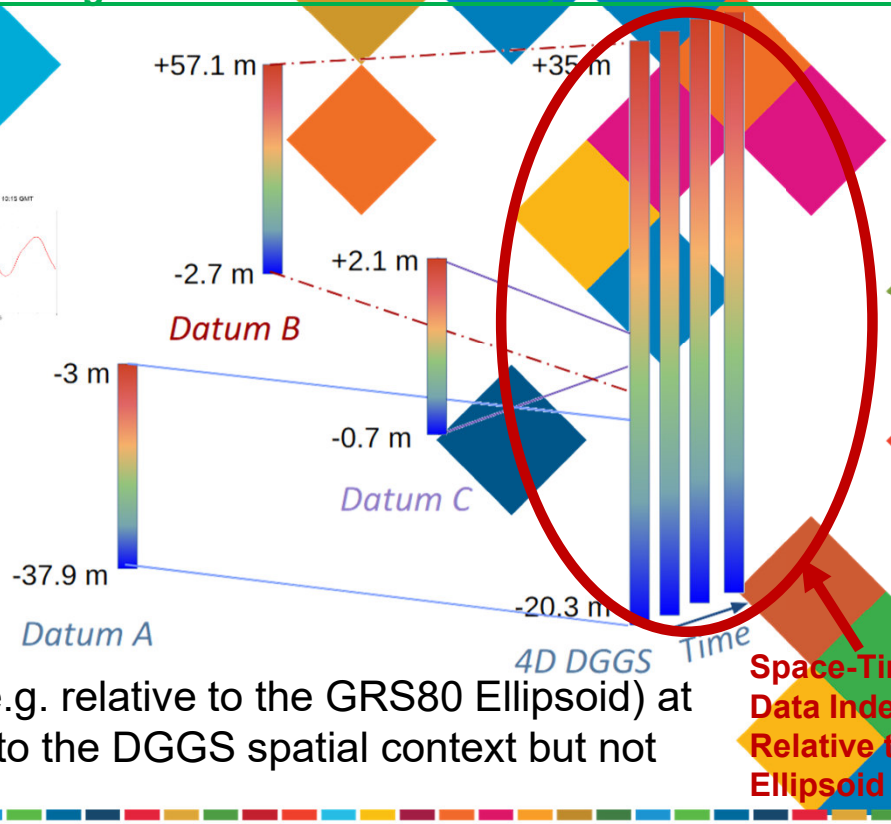
- **4D (Spatio-Temporal) DGGS** take the concept of 3D DGGS into the tessellated temporal dimension.
- TerraNexus does this using a **Tesseract (Hypercube)** centred on the Geodetic Earth Centred Earth Fixed (ECEF) coordinate space and scaled to enclose the entire Earth.
- Why do this?
  - The advantage of tiling and indexing spatial objects is well established (not just by the DGGS community)
  - We are extending this indexing capability to include time.



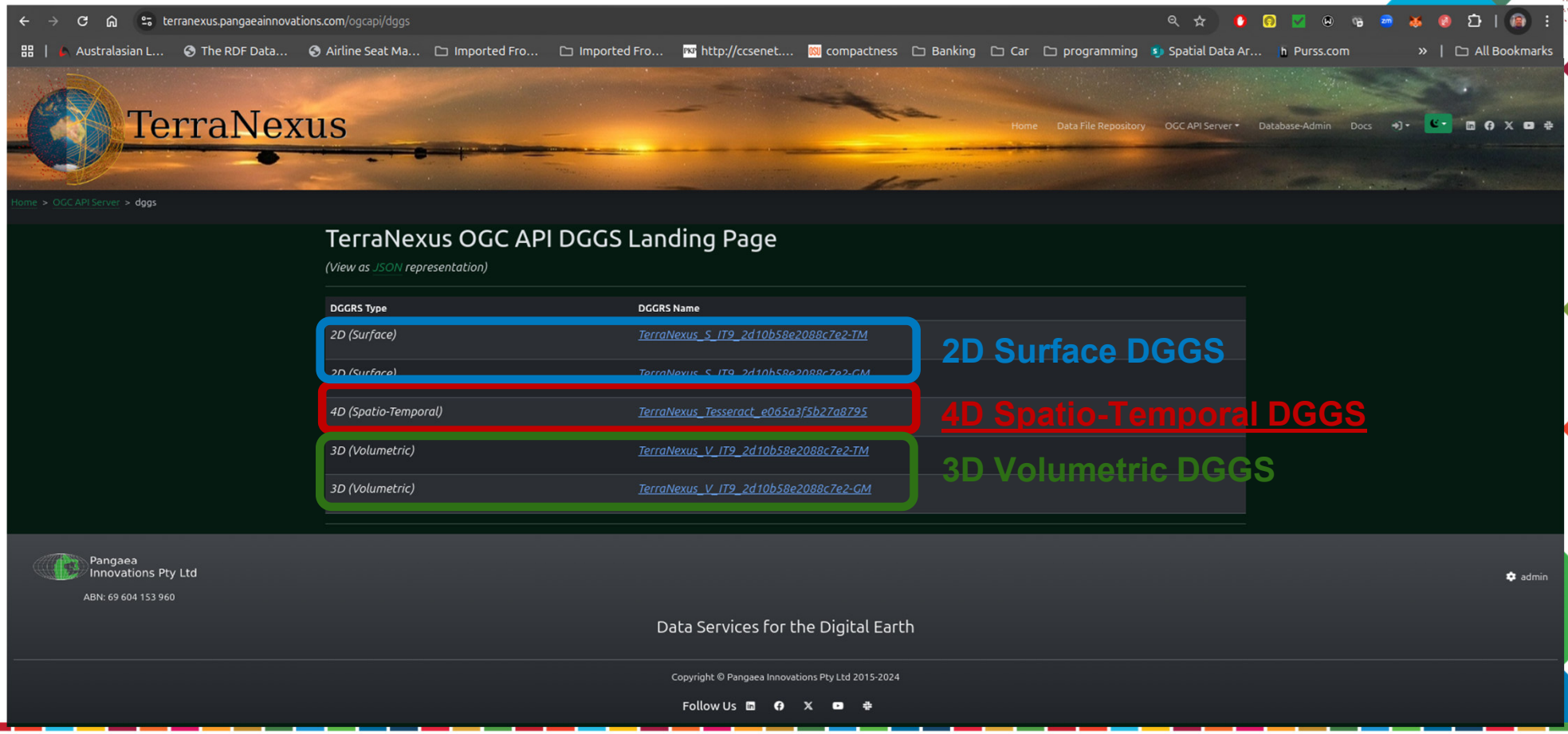
4D DGGS

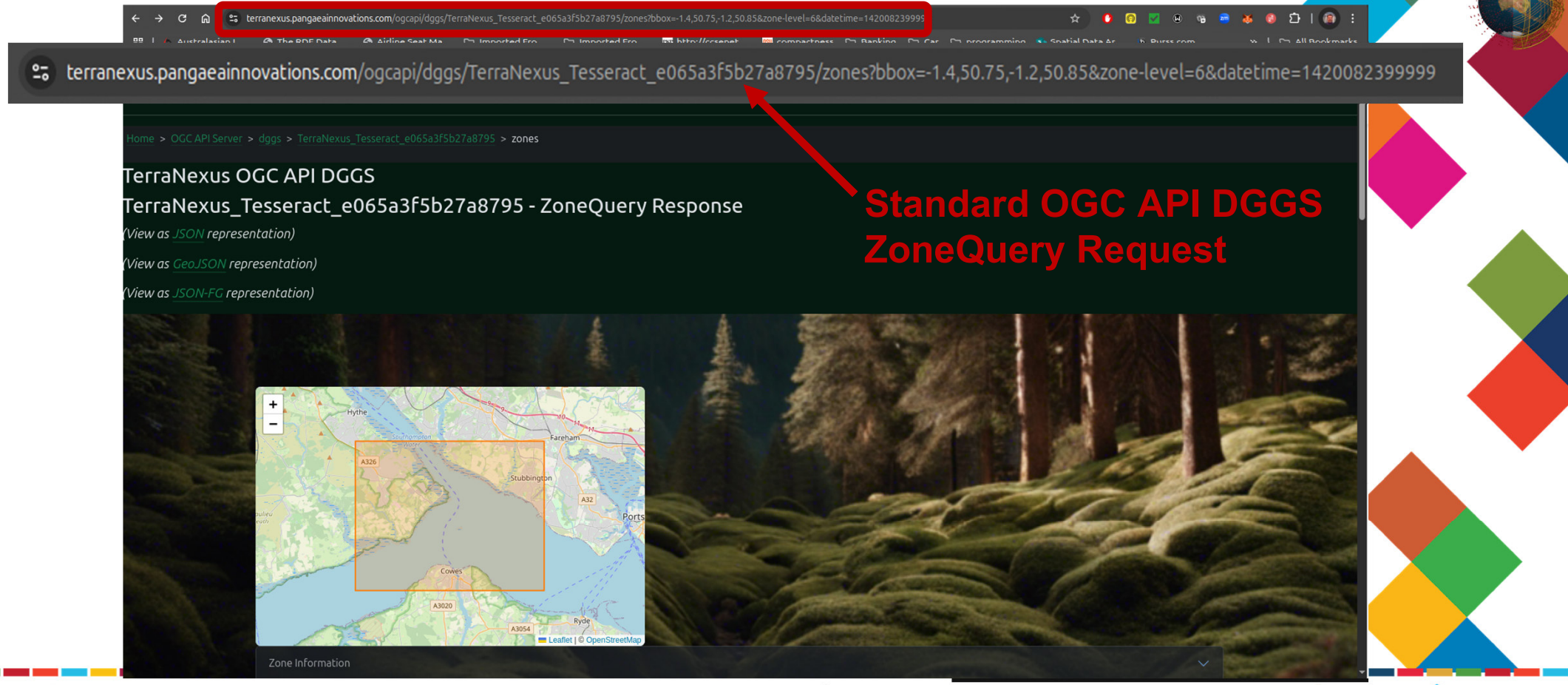
- Discovery and selection/subsetting of data across collections is a simple index lookup using a DGGS - not a series of complex mathematical operations
- ***4D DGGS enable a common space-time index that enables data integration across collections, vertical datums and time.***

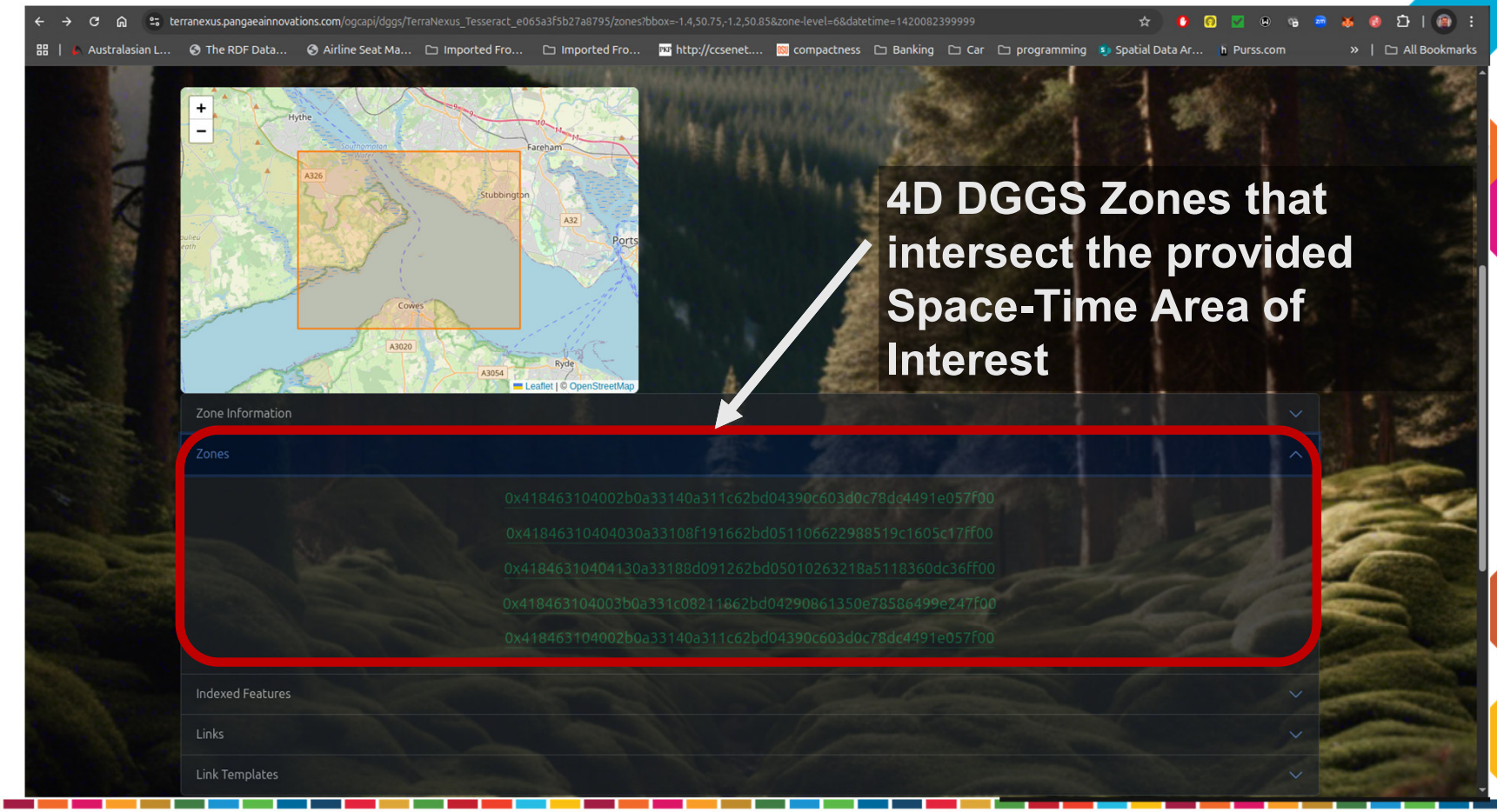


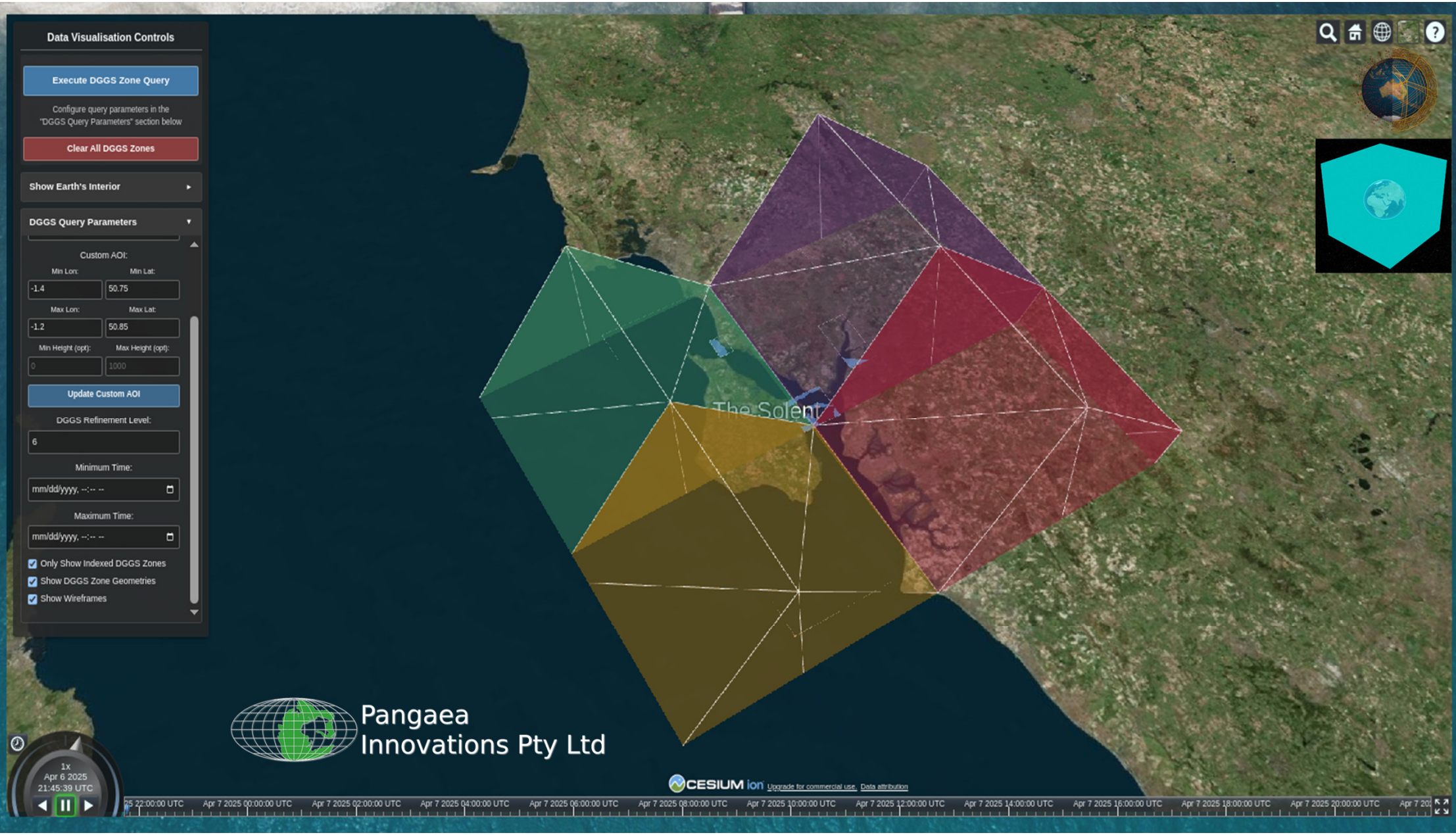


4D DGGS ZoneId's are fixed relative to the Earth Model (e.g. relative to the GRS80 Ellipsoid) at specific time intervals - data is spatially indexed relative to the DGGS spatial context but not resampled


terranexus.pangaeainnovations.com/ogcapi/dggs
TerraNexus
Home
Data File Repository
OGC API Server
Database-Admin
Docs
Home > OGC API Server > dggs
TerraNexus OGC API DGGS Landing Page
(View as JSON representation)
DGGRS Type
DGGRS Name
2D (Surface)
TerraNexus_S_IT9_2d10b58e2088c7e2-TM
4D (Spatio-Temporal)
TerraNexus_Tesseract_e065a3f5b27a8795
3D (Volumetric)
TerraNexus_V_IT9_2d10b58e2088c7e2-TM
3D (Volumetric)
TerraNexus_V_IT9_2d10b58e2088c7e2-GM
2D Surface DGGS
4D Spatio-Temporal DGGS
3D Volumetric DGGS
Pangaea Innovations Pty Ltd
ABN: 69 604 153 960
admin
Data Services for the Digital Earth
Copyright © Pangaea Innovations Pty Ltd 2015-2024
Follow Us

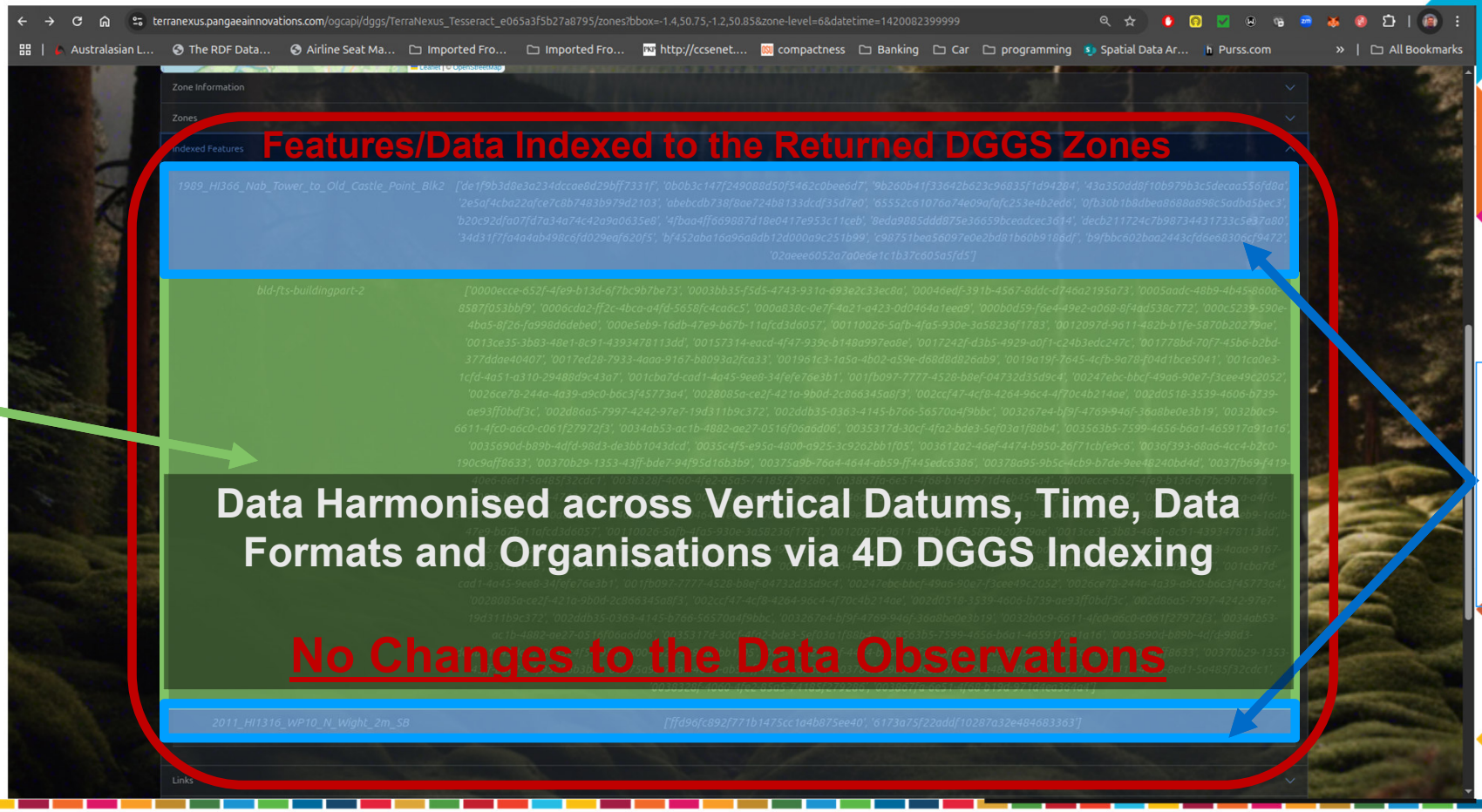

terranexus.pangaeainnovations.com/ogcapi/dggs/TerraNexus_Tesseract_e065a3f5b27a8795/zones?bbox=-1.4,50.75,-1.2,50.85&zone-level=6&datetime=1420082399999
Home > OGC API Server > dggs > TerraNexus_Tesseract_e065a3f5b27a8795 > zones
TerraNexus OGC API DGGS
TerraNexus_Tesseract_e065a3f5b27a8795 - ZoneQuery Response
(View as JSON representation)
(View as GeoJSON representation)
(View as JSON-FG representation)
Standard OGC API DGGS
ZoneQuery Request
Hythe
Fareham
Stubbington
Ports
Cowes
Ryde
A326
A32
A3020
A3054
Leaflet | © OpenStreetMap
Zone Information


terranexus.pangaeainnovations.com/ogcapi/dggs/TerraNexus_Tesseract_e065a3f5b27a8795/zones?bbox=-1.4,50.75,-1.2,50.85&zone-level=6&datetime=1420082399999
Australasian L...
The RDF Data...
Airline Seat Ma...
Imported Fro...
Imported Fro...
http://ccsenet....
compactness
Banking
Car
programming
Spatial Data Ar...
Purss.com
All Bookmarks
Hythe
Fareham
Stubbington
Ports
Cowes
Ryde
A326
A32
A3020
A3054
Leaflet | © OpenStreetMap
4D DGGS Zones that intersect the provided Space-Time Area of Interest
Zone Information
Zones
0x418463104002b0a33140a311c62bd04390c603d0c78dc4491e057f00
0x41846310404030a33108f191662bd051106622988519c1605c17ff00
0x41846310404130a33188d091262bd05010263218a5118360dc36ff00
0x418463104003b0a331c08211862bd04290861350e78586499e247f00
0x418463104002b0a33140a311c62bd04390c603d0c78dc4491e057f00
Indexed Features
Links
Link Templates


Data Visualisation Controls
Execute DGGS Zone Query
Configure query parameters in the "DGGS Query Parameters" section below
Clear All DGGS Zones
Show Earth's Interior
DGGS Query Parameters
Custom AOI:
Min Lon:
Min Lat:
-1.4
50.75
Max Lon:
Max Lat:
-1.2
50.85
Min Height (opt):
Max Height (opt):
0
1000
Update Custom AOI
DGGS Refinement Level:
6
Minimum Time:
mm/dd/yyyy, --:-- --
Maximum Time:
mm/dd/yyyy, --:-- --
Only Show Indexed DGGS Zones
Show DGGS Zone Geometries
Show Wireframes
The Solent
Pangaea
Innovations Pty Ltd
1x
Apr 6 2025
21:45:39 UTC
CESIUM ion
Upgrade for commercial use.
Data attribution
Apr 7 2025 00:00:00 UTC
Apr 7 2025 02:00:00 UTC
Apr 7 2025 04:00:00 UTC
Apr 7 2025 06:00:00 UTC
Apr 7 2025 08:00:00 UTC
Apr 7 2025 10:00:00 UTC
Apr 7 2025 12:00:00 UTC
Apr 7 2025 14:00:00 UTC
Apr 7 2025 16:00:00 UTC
Apr 7 2025 18:00:00 UTC
Apr 7 2025 20:00:00 UTC

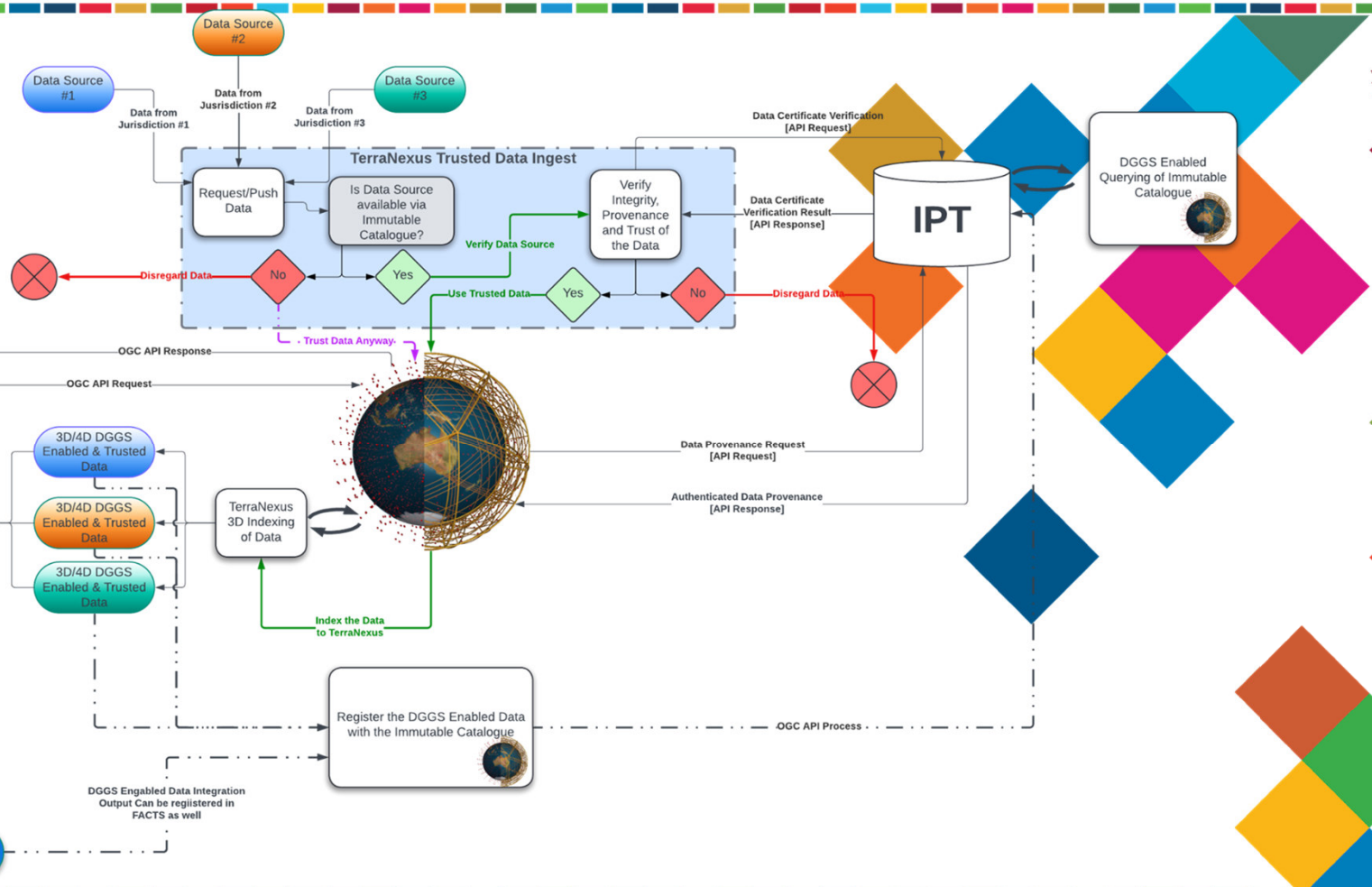
Terrestrial Building Feature Data

OS



Marine Bathymetry Point Cloud Data

UKHO


Data Source #2
Data Source #1
Data Source #3
Data from Jurisdiction #1
Data from Jusrisdiction #2
Data from Jurisdiction #3
TerraNexus Trusted Data Ingest
Request/Push Data
Is Data Source available via Immutable Catalogue?
Verify Integrity, Provenance and Trust of the Data
Verify Data Source
Disregard Data
No
Yes
Use Trusted Data
Yes
No
Disregard Data
Trust Data Anyway
Data Certificate Verification [API Request]
Data Certificate Verification Result [API Response]
IPT
DGGS Enabled Querying of Immutable Catalogue
OGC API Response
OGC API Request
3D/4D DGGS Enabled & Trusted Data
3D/4D DGGS Enabled & Trusted Data
3D/4D DGGS Enabled & Trusted Data
Data Integration Query
TerraNexus 3D Indexing of Data
Index the Data to TerraNexus
Data Provenance Request [API Request]
Authenticated Data Provenance [API Response]
Integrated Analyses of "Data of Interest"
Register the DGGS Enabled Data with the Immutable Catalogue
OGC API Process
DGGS Engabled Data Integration Output Can be regiistered in FACTS as well
Trusted & Integrated Data Output

Standards Enable Integrity, Provenance and Trust (IPT) in Data

OGC/ISO Standards

- ISO 19170 / OGC Topic 21 - DGGS
  - Part 1 (published) - Core Data Model and 2D Equal Area DGGS
  - Part 2 (draft) - 3D Equal Volume DGGS
  - Part 3 (draft) - Spatio-Temporal DGGS
  - Part 4 (draft) - Axis-Aligned DGGS
- OGC API DGGS
- OGC API Features
- OGC API Common
- OGC API Processes
- GeoJSON
- Features & Geometry JSON (JSON-FG)
- Linked Data JSON (JSON-LD)
- ISO 8601 - Date and time format

IHO Standards

- S100

The most relevant SDGs related to the presentation and theme of this session

1st relevant SDG

2nd relevant SDG

3rd relevant SDG

SUSTAINABLE DEVELOPMENT GOALS

International Federation of Surveyors supports the Sustainable Development Goals

Thank You

SCAN ME

https://pangaeainnovations.com/about_us