Achieving FAIR water quality data exchange thanks to international OGC water standards

Sylvain Grellet – BRGM

09/05/2024 - ESIP - Information Technology and Interoperability Deep Dives

With support from
Hylke van der Schaaf - Fraunhofer IOSB
Katharina Schleidt - DataCove

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What is OGC?

A hub for thought leadership, innovation, and standards for all things related to location

Our Vision

Building the future of location with community and technology for the good of society

Our Mission

Make location information Findable, Accessible, Interoperable, and Reusable (FAIR)

Our Approach

A proven collaborative and agile process combining consensus-based standards, innovation project, and partnership building

Who Are Our Members?

Commercial

- Business Development
- Competitive Technical Advantage
- Global: Brand Exposure
- Funding for Innovation

Government

- Innovation & Market Support
- Trusted Advice
- Support & Certification
- International Partnerships
- Operational Policy

Research & Academia

- Applied Research Partners
- Funding for Innovation
- International Collaboration
- Citations

OGC Hydro Domain Working Group ?

- Joint OGC – World Meteorological Organization (OMM / WMO) group
  - Memorandum of Understanding between OGC - WMO

- Target: water data standards => WaterML 2.0 suite : https://www.ogc.org/standard/waterml/
- Organizing Interoperability Experiments - (IEs) focused on the water sub-domains

- Entry point

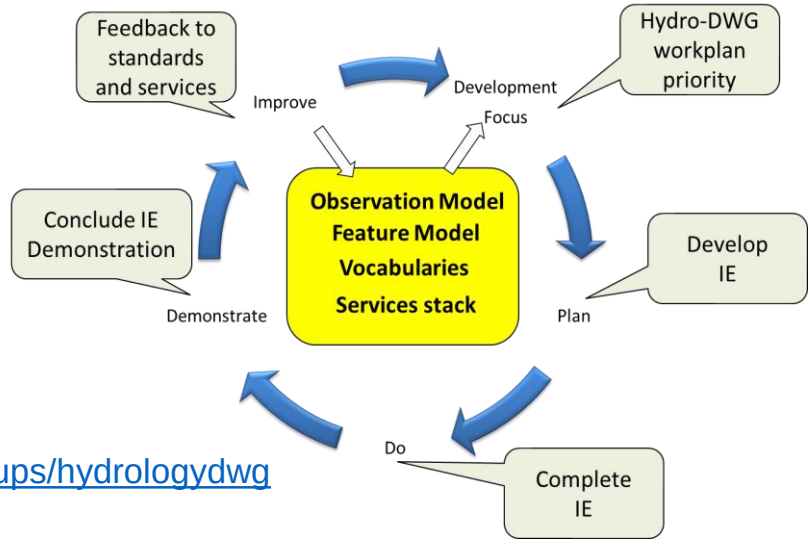
https://external.ogc.org/twiki_public/HydrologyDWG/WebHome

- Has a Research Data Alliance ‘sister group’

=> ‘Global Water Information Interest Group’

- Chairs
  - Tony Boston (Australia)
  - Silvano Pecora (Italy) – WMO Liaison
  - David Blodgett (USA)

Iterative Development



http://www.opengeospatial.org/projects/groups/hydrologydwg

Group dynamics

- A long history of joint activities
  - 2003 - Earth Systems Science Domain Working Group (DWG)
  - 2009 - Hydrology DWG
  - 2011 - Groundwater Interoperability Experiment (IE)
  - 2011 - Water Information Services Concept Development Study
  - 2011 - Surface Water Interoperability IE
  - 2012 - Hydrology Forecasting IE
  - 2013 - Climate-Hydrology Information Sharing Pilot
  - 2013 - GroundWater IE2
  - 2014 - Water ML 2.0 Standards Working Group (SWG)
  - 2015 - Hydrographic Features SWG
  - 2015 - Research Data Alliance Global Water Information IG (Hydro DWG sister group)
  - 2016 - Groundwater SWG
  - 2017 - Geoscience DWG
  - 2018 - Environmental Linked Features IE (ELFIE)
  - 2019 - Borehole IE
  - 2021 - Second ELFIE (SELFIE)
  - 2022 - Water Quality IE => on going

Group dynamics

- Un long history of meetings

First 5 years: Meetings 2008 - 2013

- OGC TC Meeting - Atlanta - 17 September 2008
- OGC TC Meeting - Valencia - 4 December 2008
- OGC TC Meeting - Athens - 30 March 2009
- OGC TC Meeting - Boston - 22 June 2009
- OGC TC Meeting - Darmstadt - 29 September 2009
- OGC TC Meeting - Mountain View - 8 December 2009
- 1st Hydrology DWG Workshop - Ispra - 15-18 March 2010
- OGC TC Meeting - Silver Spring - 15 June 2010
- OGC TC Meeting - Toulouse - 22 September 2010
- Hydrology DWG Workshop - Toulouse - 21-22 September 2010
- OGC TC Meeting - Sydney - 1 December 2010
- OGC TC Meeting - Bonn - 2 March 2011
- 2nd Hydrology DWG Workshop - Delft - 11-14 April 2011
- OGC TC Meeting - Taichung - 15 June 2011
- OGC TC Meeting - Boulder - 19-20 September 2011
- OGC Oceans/Met/Hydro Water Cycle Summit - 21 September 2011
- OGC TC Meeting - Brussels - 29 November 2011
- OGC TC Meeting - Austin - 19 & 21 March 2012
- 3rd Hydrology DWG Workshop 2012 - Reading - 25-28 June 2012
- OGC TC Meeting - Redlands - 16 January 2013
- 4th Hydrology DWG Workshop 2013 - Quebec City - 17-21 June 2013
- OGC TC Meeting - Frascati - 23 September 2013

Meetings 2014 and later

- OGC TC Meeting - Arlington - 24-28 March 2014
- OGC TC Meeting - Geneva - 10-14 June 2014
- 5th Hydrology DWG Workshop 2014 - New York - 11-15 August 2014
- Training workshop at 11th International Hydroinformatics Conference - Standardization of Water Data Exchange: WaterML 2.0 and Beyond - New York - 16 August 2014
- OGC TC Meeting - Boulder - 3 June 2015
- OGC Water Data Summit - Boulder TC - 3 June 2015
- OGC TC Meeting - Nottingham - 17 September 2015
- 6th Hydrology DWG Workshop 2015 - Orleans - 21-25 September 2015
- OGC TC Meeting - Sydney - 2 December 2015
- OGC TC Meeting - Washington - March 2016
- 7th Hydrology DWG Workshop 2016 - Koblenz - 13-17 June 2016
- OGC TC Meeting - Dublin - June 2016
- OGC TC Meeting - Delft - March 2017
- 8th Hydrology DWG Workshop 2017 - Tuscaloosa - 20-23 June 2017
- OGC TC Meeting - St John's - June 2017
- OGC TC Meeting - Palmerston North - December 2017
- OGC TC Meeting - Orleans - March 2018
- OGC TC Meeting - Stuttgart - September 2018
- 9th Hydrology DWG Workshop 2018 - Geneva - 17-20 September 2018
- OGC TC Meeting - Charlotte - December 2018
- OGC TC Meeting - Leuven - June 2019
- Session on HDWG during the ISDE11 - Florence - September 2019 - conference paper
- HydroDWG Seminar January 2021
- HydroDWG Seminar March 2021 - WQ Data
- HydroDWG Seminar August 2021 - Mainstems
- HydroDWG OGC Member Meeting - December 2021
- HydroDWG OGC Member Meeting - March 2022
- GWML2 Workshop March 2022
- Water Quality Workshop March 2022
- HydroDWG OGC Member Meeting - June 2022
- HydroDWG OGC Member Meeting - October 2022
- HydroDWG OGC Member Meeting - February 2023
- HydroDWG Spring 2023 - May 2023

Group dynamics

- Community
  - Members all across the world
  - Members from different organization types
    - Public administrations
    - Public research organizations
    - International organization
    - Private companies

- Some examples
  - NR-Can, GSC, USGS, US EPA, CUASHI, SDSC, BRGM, UK CEH, DELTARES, GRDC, BaFG, Univ Tartu, Fraunhofer IOSB, DataCove, NIWA/LAWA (NZ), Federation University (Australia), BoM Australia, CSIRO, …
  - WMO, UNESCO, …
  - Kisters, 52°N, Aquatic Informatics, …

A suite of standards

- WaterML2.0
  - Open and documented
  - implemented in WMO Information System and in many organizations : UNESCO, USGS, US EPA, NrCan, NIWA, BRGM, etc…
  - And in opensource tools : CUASHI Hydro-Server, Kisters, 52°N etc…
  - Updated with a regular contribution from projects involving Hydro DWG partners





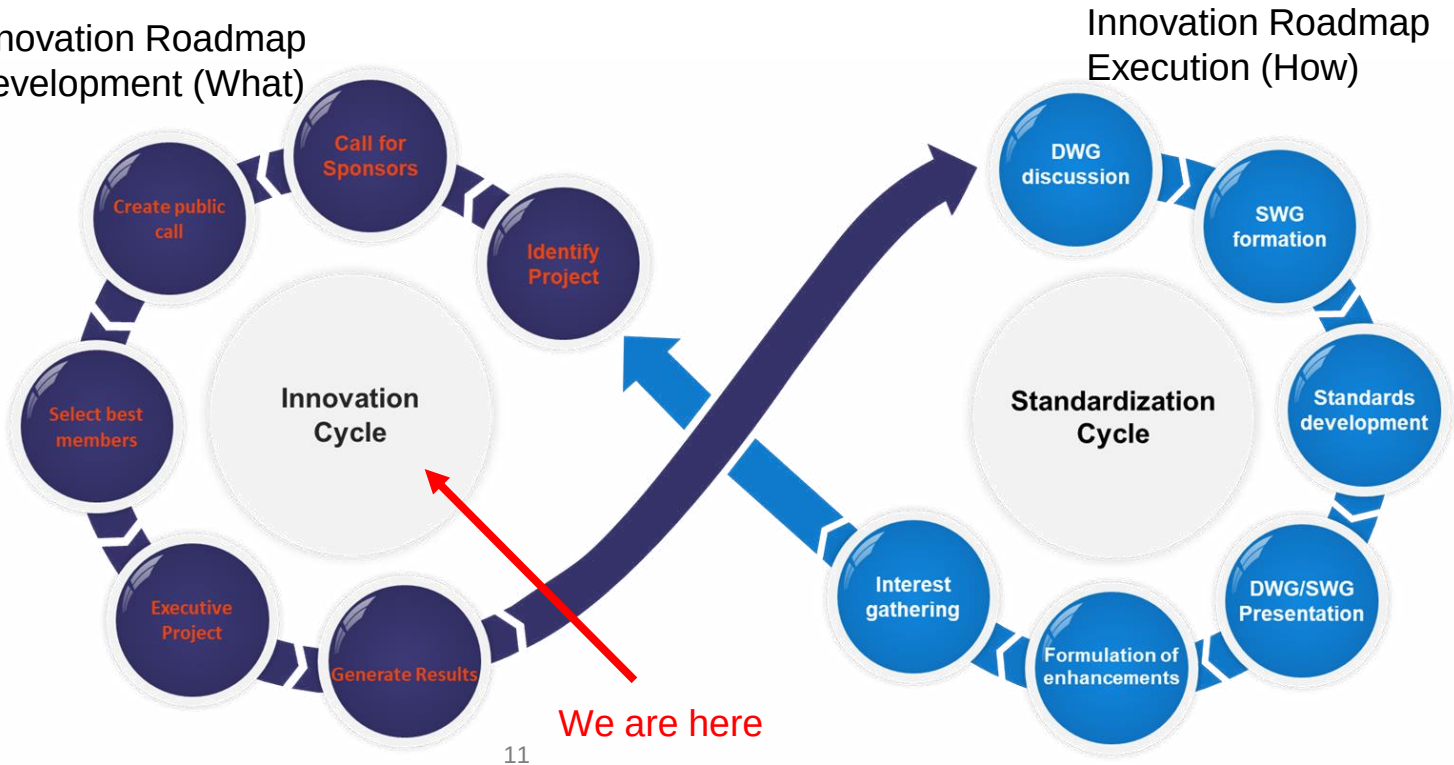
Part 1 - Timeseries	Part 2 – Ratings, Gaugings and Sections	Part 3 – Surface water features	Part 4 – Groundwater	Part 5 – Water quality (best practice) Soon to be updated by the Water Quality IE

Achieving FAIR water quality data exchange thanks to international OGC water standards

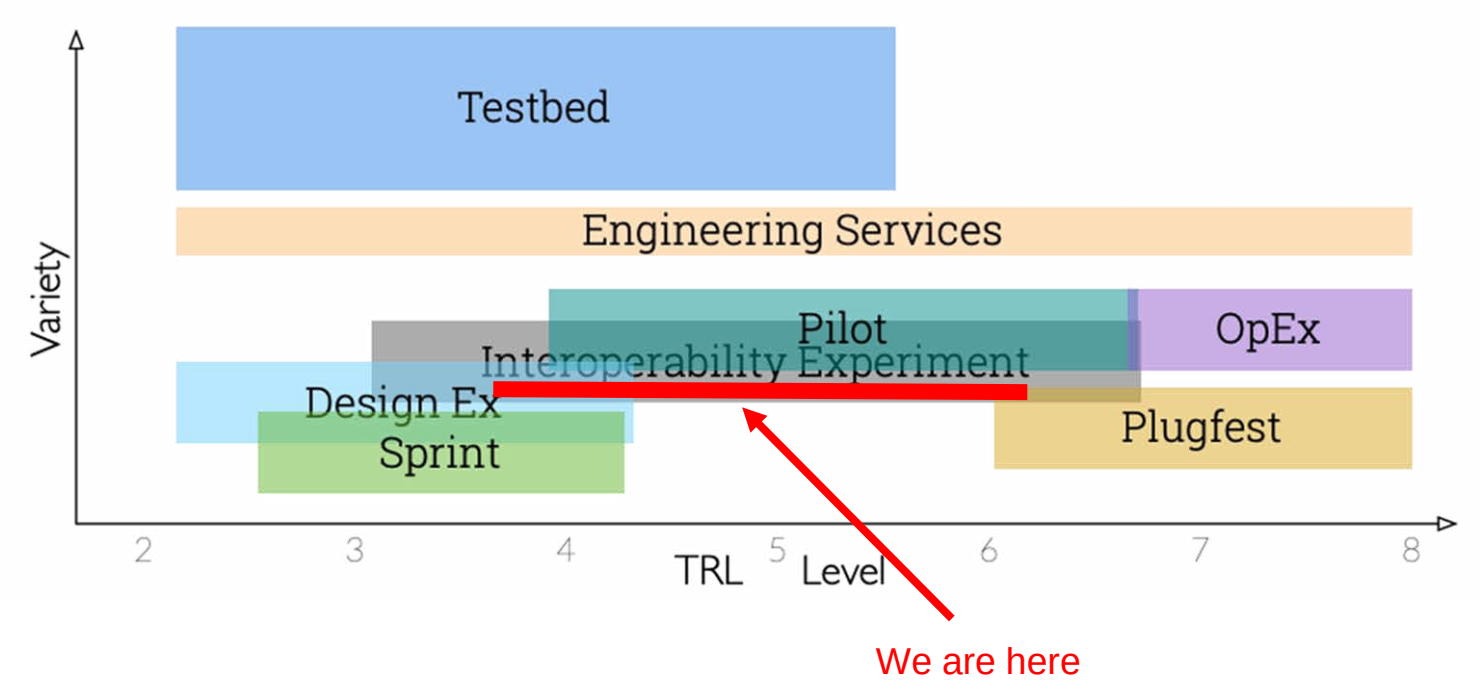
=> The OGC Water Quality Interoperability Experiment

OGC Interoperability Experiment (IE) ?

- OGC Innovation Continuum



OGC Interoperability Experiment (IE) ?



OGC Interoperability Experiment (IE) ?

- Applied research initiative led by OGC members and supported by OGC staff

⇒ Most of the time building on the current standards and best practices : the ‘OGC Baseline’ (pushing them to their limits / applying them to a new domain)

- Non-OGC member participation is allowed (usually as observers)

⇒ In several IEs: GitHub + mailing list + meetings are open

⇒ so the ‘observers’ can be really active

- Results documented in Engineering Report(s) or other OGC documents and generally used to define new Standardization work.

⇒ Some lead to Change Request to the ‘OGC Baseline’

⇒ Some to Best Practices in applying it

⇒ Some fill in gaps in the ‘OGC Baseline’ proposing document ready for the standardization process: exactly what happened to all the WaterML2.0 series of standards

It’s during the IE that the group decides what the output will be : through experimentation

OGC Water Quality IE set up

- Third time the topic is proposed within the OGC Hydro Domain Working Group

- Enough momentum and interest from parties

=> WMO-UNEP-WHO-UNESCO Water Quality workshop in March 2022 (29-31)

https://external.ogc.org/twiki_public/HydrologyDWG/WaterQualityWorkshopSprint2022

=> confirmation of the necessity and organizations interest. Identification of interested parties and IT challenges

Discussion on the best approach => an OGC Interoperability Experiment

- Water Quality IE inception

⇒ Charter, call for participation, kick-off (20/09/2022)

Co-chairs : Sylvain Grellet (BRGM), Kyle Onda (Lincoln Institute)

Since then :

- Starting point : https://github.com/opengeospatial/WaterQualityIE
- Weekly meetings
- Shared material
  - Rolling meeting minutes document,
  - One focal point for UML models
  - Shared deployment documentation initiated
- Note : shared images in that presentation represent **Work In Progress** currently being tested

The Engineering Report will summarize the group conclusions

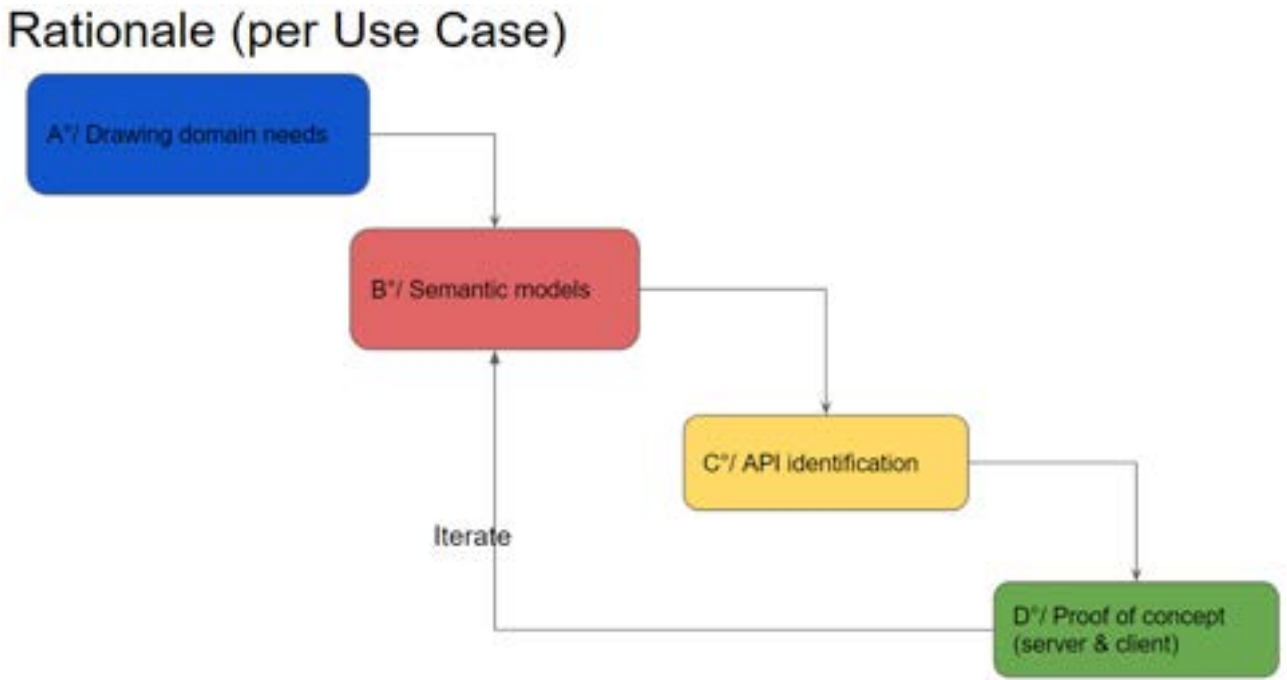
Use Cases identification and work methodology

	Org	FoI Type: Water (Surface and Ground together at this stage)			
Method	*Observed Property group*	Quantity	Physical properties	Chemistry	Biology
	Samples	Here as a support to WQ	1	2	3
	Sensors				
	Hydro Models				
	Remote Sensing				

FoI = Feature Of Interest = the real world feature on which observation is made

- Water Quality Use Case prioritisation
  - Physical Properties (ex : Temperature, Conductivity), Chemistry
  - + Water Quantity as a support to Water Quality
  - *Out of scope this IE : Biology (taxa observation), Hydro Models, Remote Sensing*

Use Cases identification and work methodology



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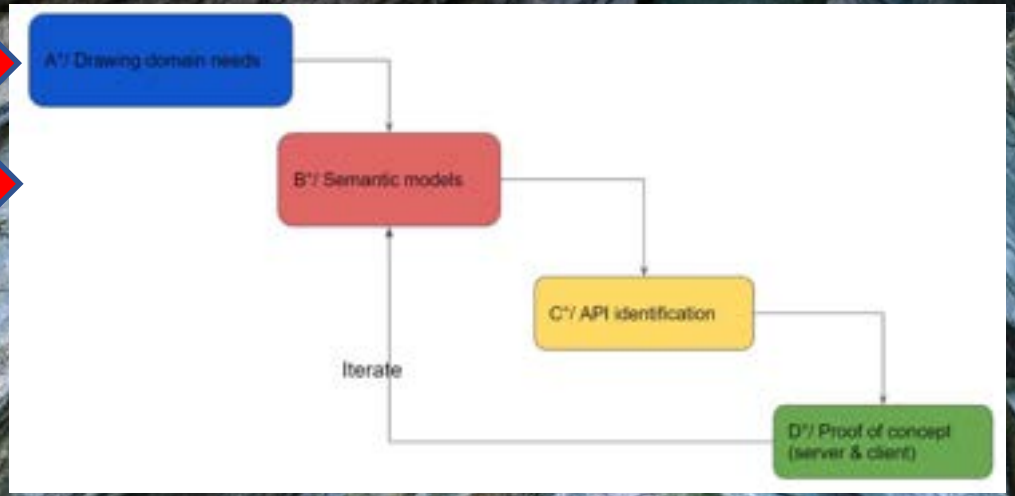
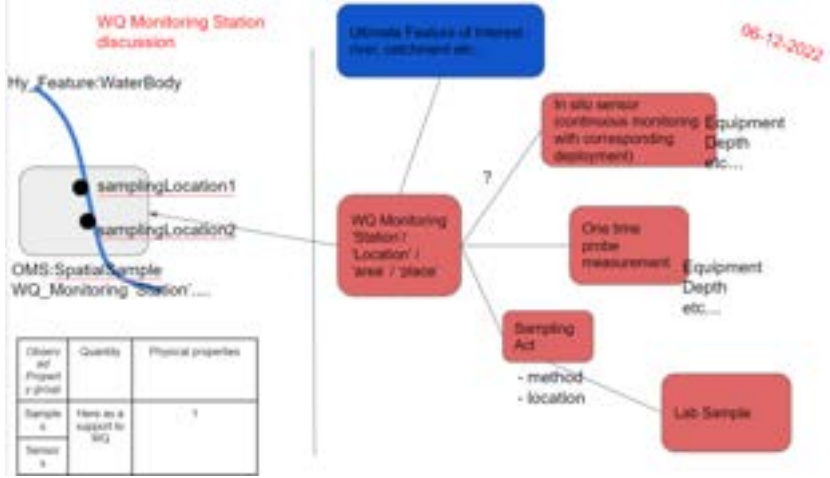


Conceptual Modelling

- Step 1°/ Express the domain need stemming from the UseCases



Conceptual Modelling

- Step 2°/ Identify the standards in the OGC standard baseline to build on
  - 2 OGC-WMO water standards : GroundWaterML2.0 & HY_Features
  - THE OGC-ISO standard for Observations & Samples : ISO 19156:2023 : Observations, measurements and samples

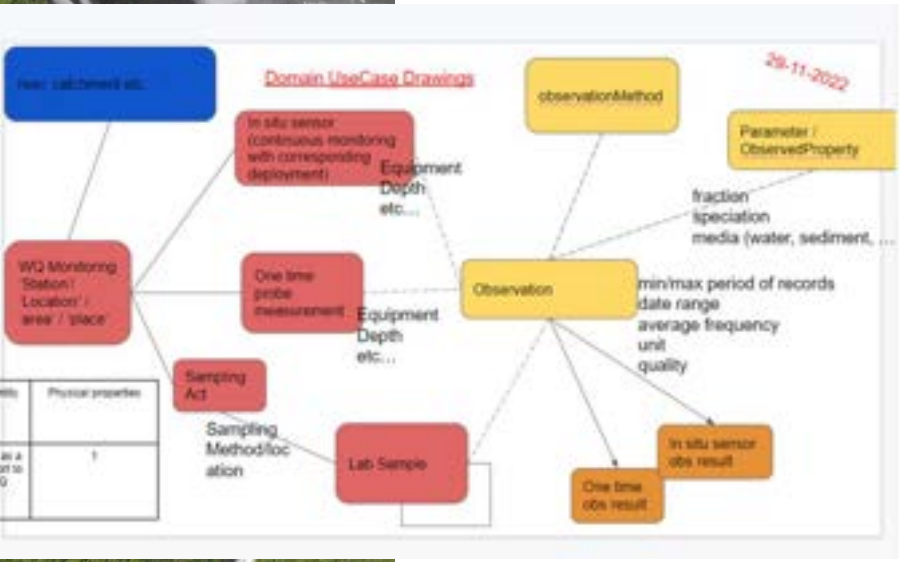
Conceptual Modelling

- Step 3°/ Express domain needs according to the OGC standard baseline

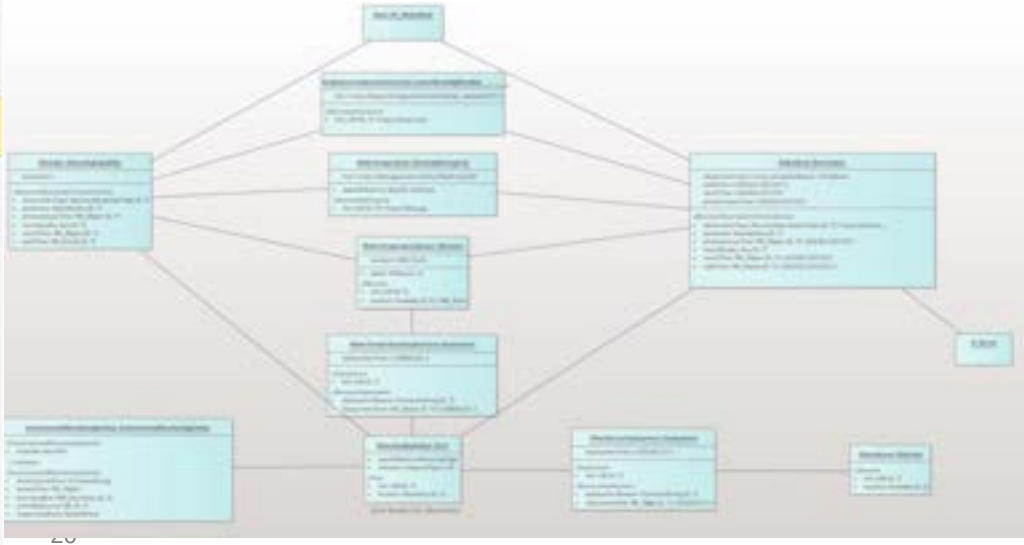
<u>=> Almost everything is in, just need to agree on how to use it</u>

=> mainly UML “Object diagrams exercise” to document the use of the standards

FROM

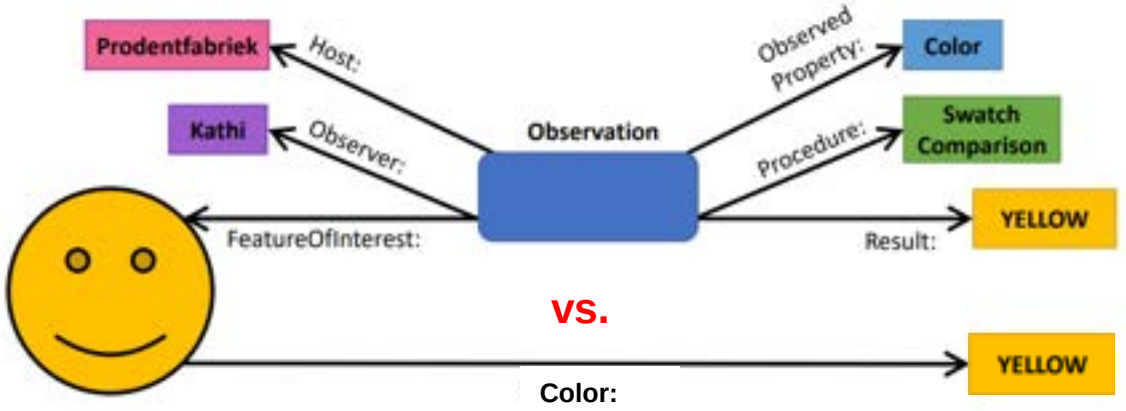


TO



Conceptual Modelling

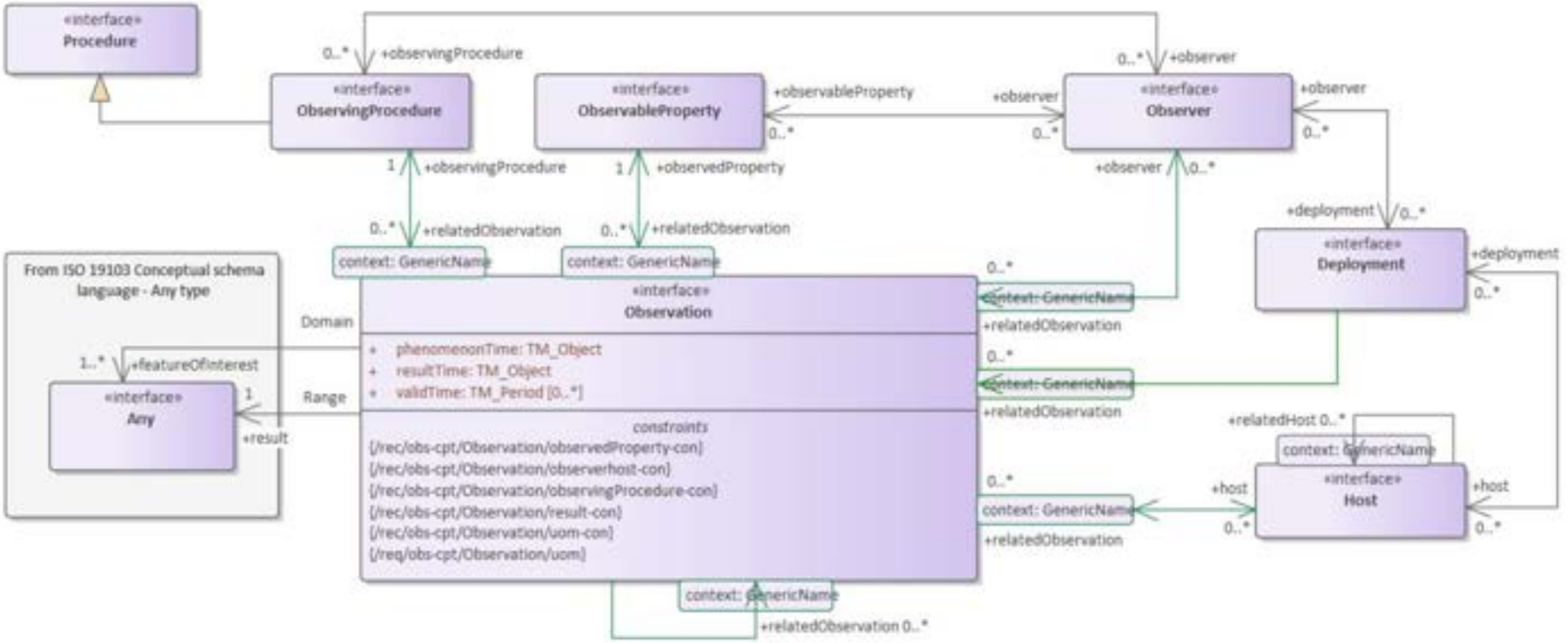
- Backbone to build on: OGC/ISO 19156 (2023) : Observations, measurements and samples (a.k.a OMS)



Credits: Kathi Schleidt, DataCove
https://www.youtube.com/watch?v=bYDSgs2fKLk

Conceptual Modelling

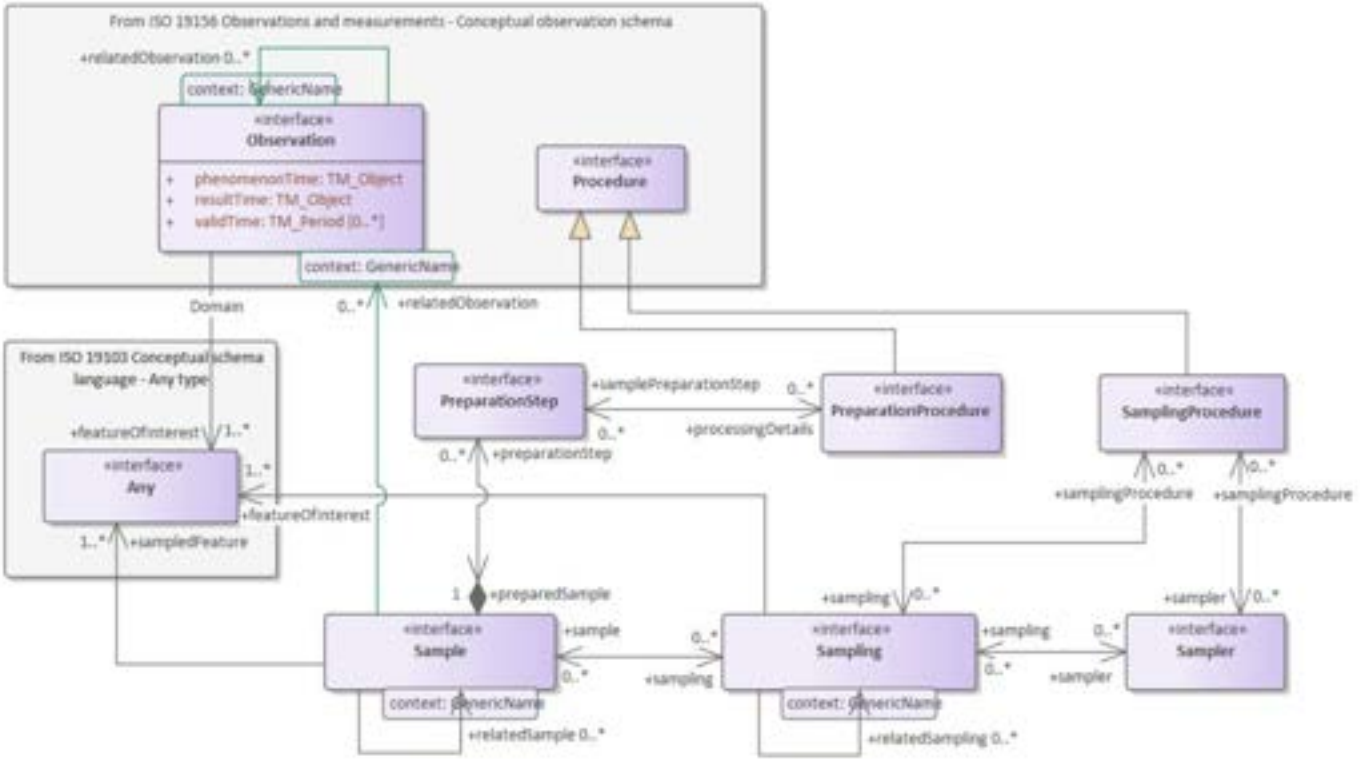
- Backbone to build on: Observations, measurements and samples



Conceptual Observation schema

Conceptual Modelling

- Backbone to build on: Observations, measurements and samples



Conceptual Sample schema

Conceptual Modelling

- Work organised around the identified UseCases

- Everything available online : https://umltool.ogc.org/login.php
  - Follow this path /OGC IEs/ WaterQuality_IE/ WaterQuality_Instance

- Ground Water (GW)
  - GW_InSitu_QuantityObservation
  - GW_InSitu_QualityObservation
  - GW_ExSitu_QualityObservation

- Surface Water (SW)
  - SW_InSitu_QuantityObservation
  - SW_InSitu_QualityObservation
  - SW_ExSitu_QualityObservation

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Conceptual Modelling

- 2 modelling patterns
- GW_InSitu_QuantityObservation < > SW_InSitu_QuantityObservation

  GW_InSitu_QualityObservation < > SW_InSitu_QualityObservation

In situ sensor

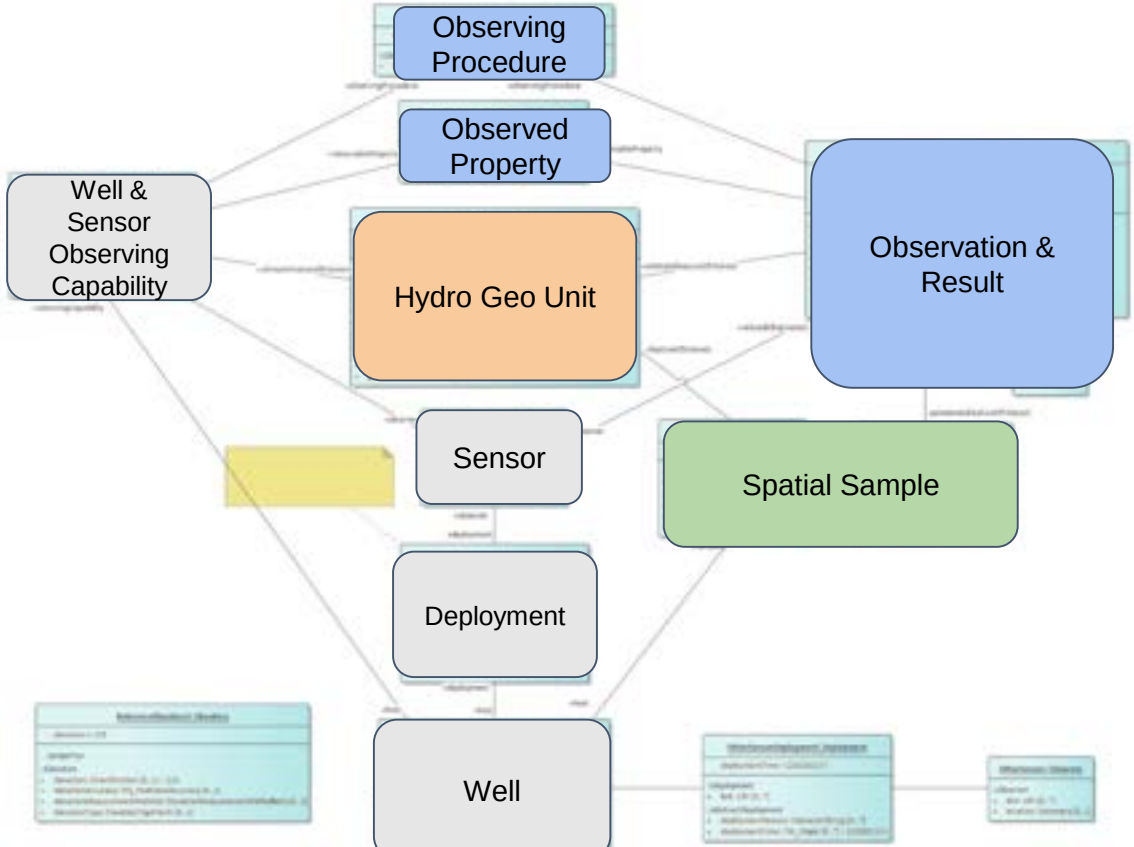
- GW_ExSitu_QualityObservation <> SW_ExSitu_QualityObservation

Ex situ = Laboratory

Conceptual Modelling

In situ sensor

- **GW**_InSitu_**Quantity**Observation (water level)



Conceptual Modelling

In situ sensor

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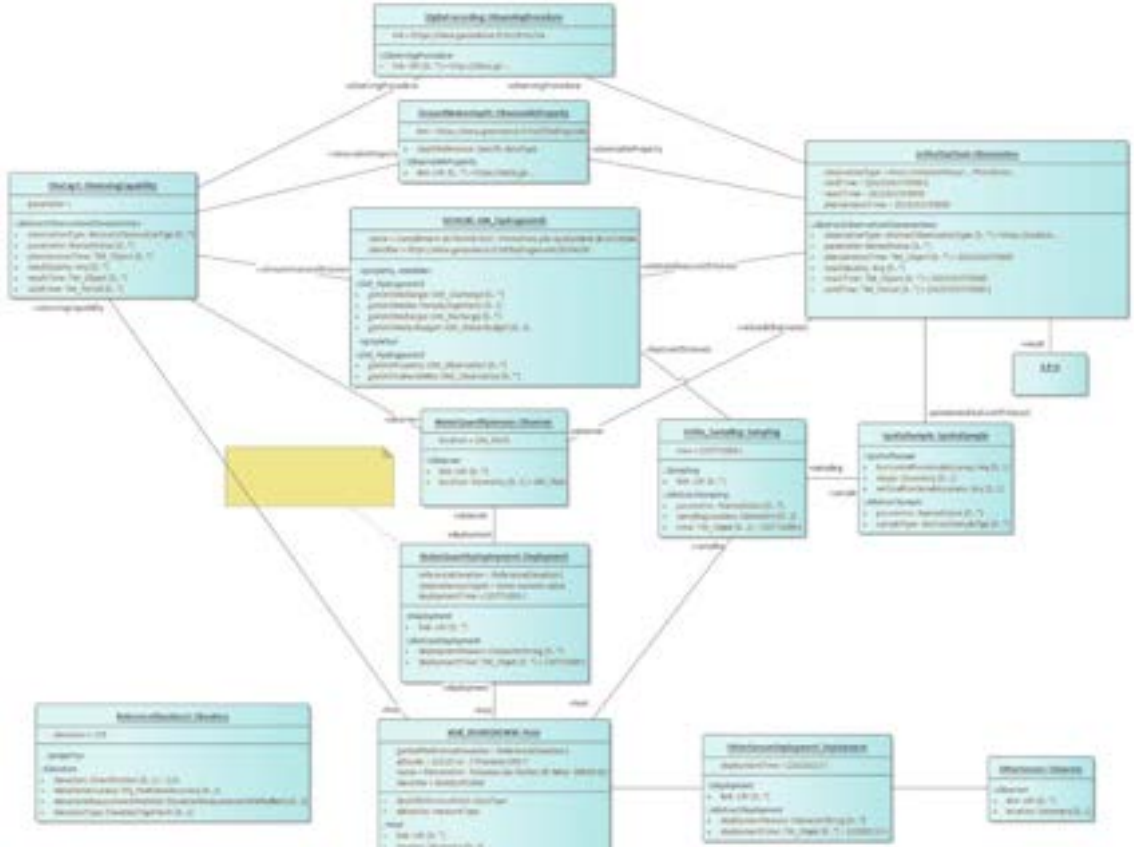

Conceptual Modelling

In situ sensor

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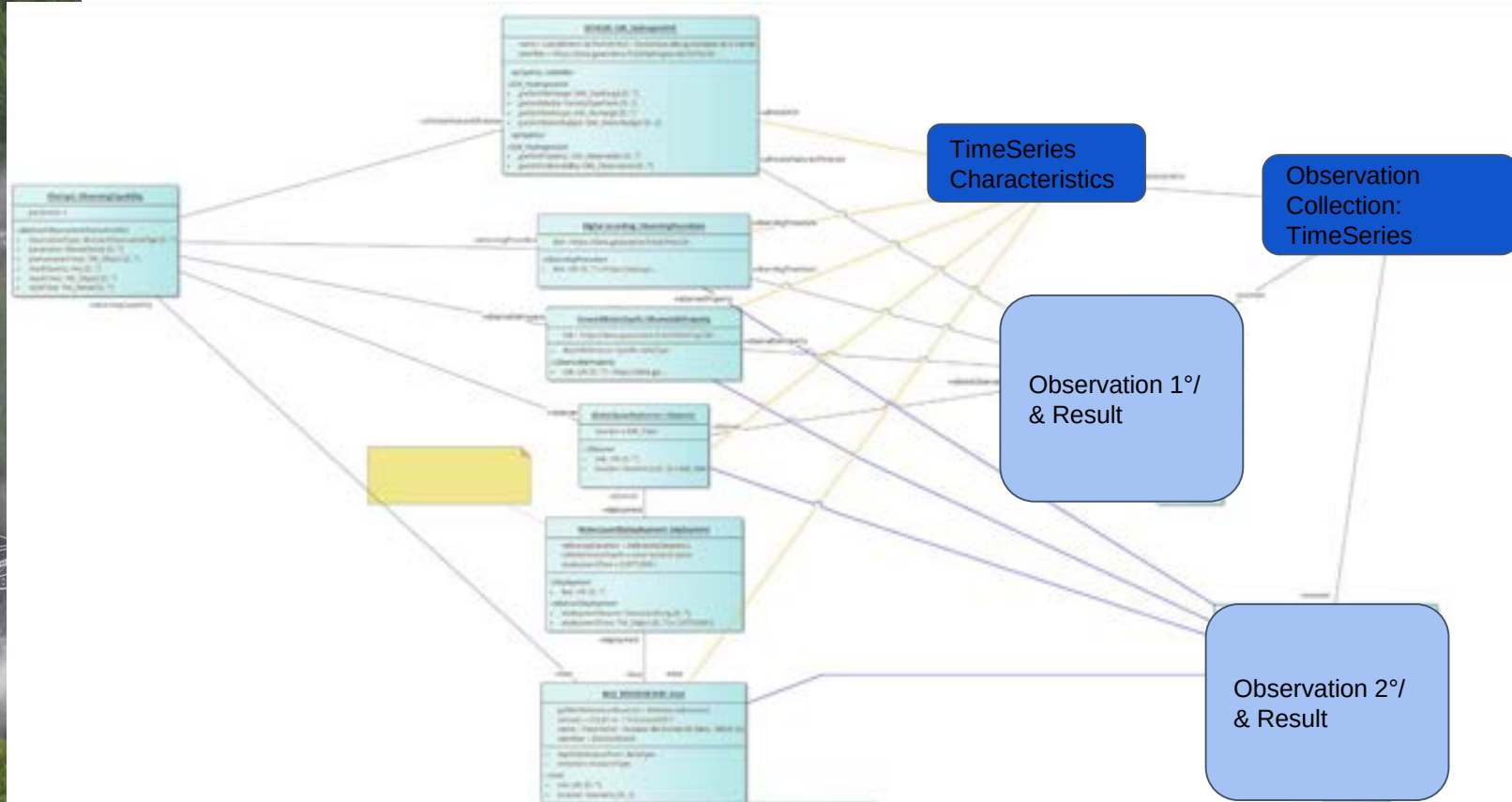

Conceptual Modelling

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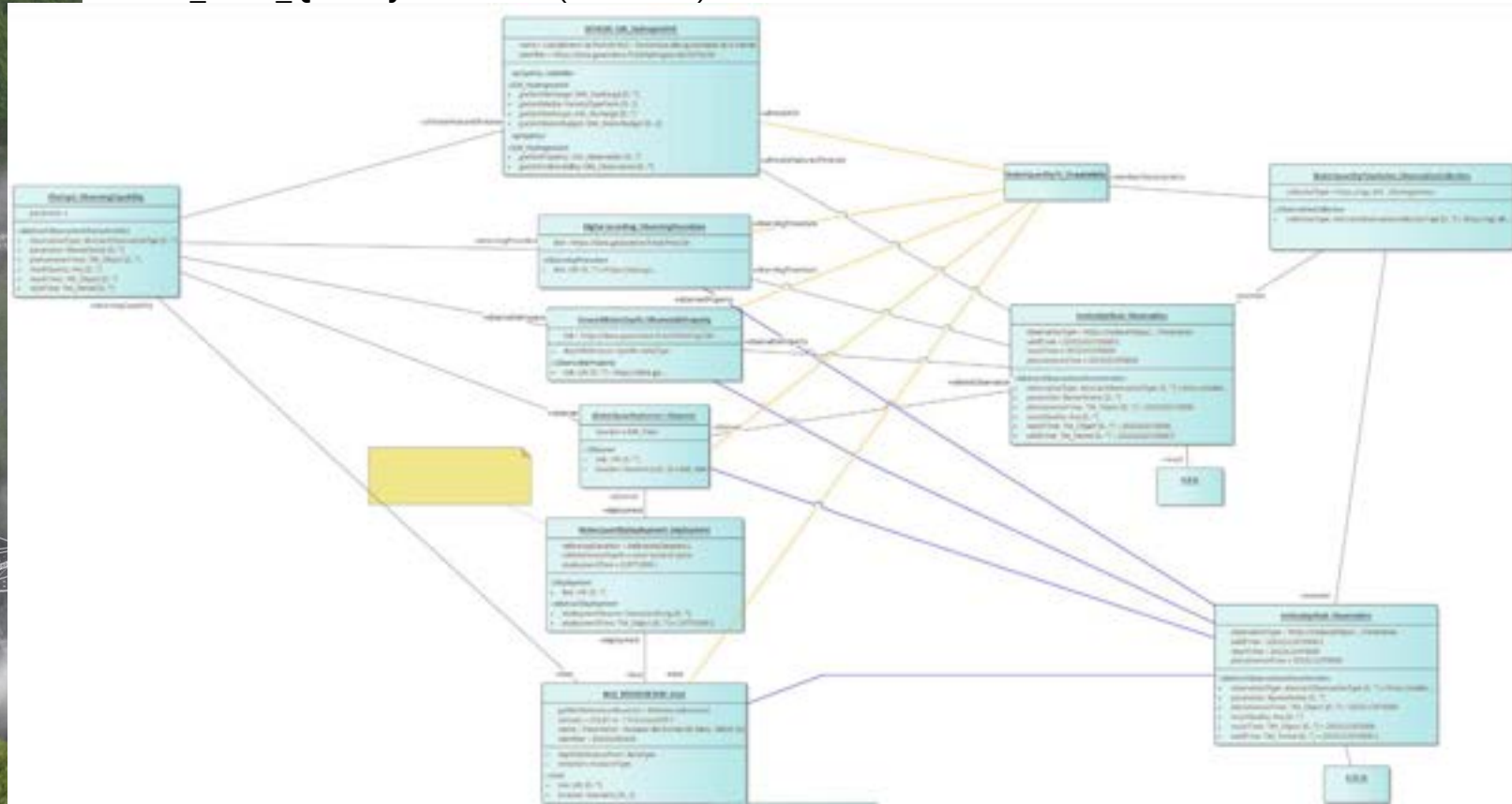
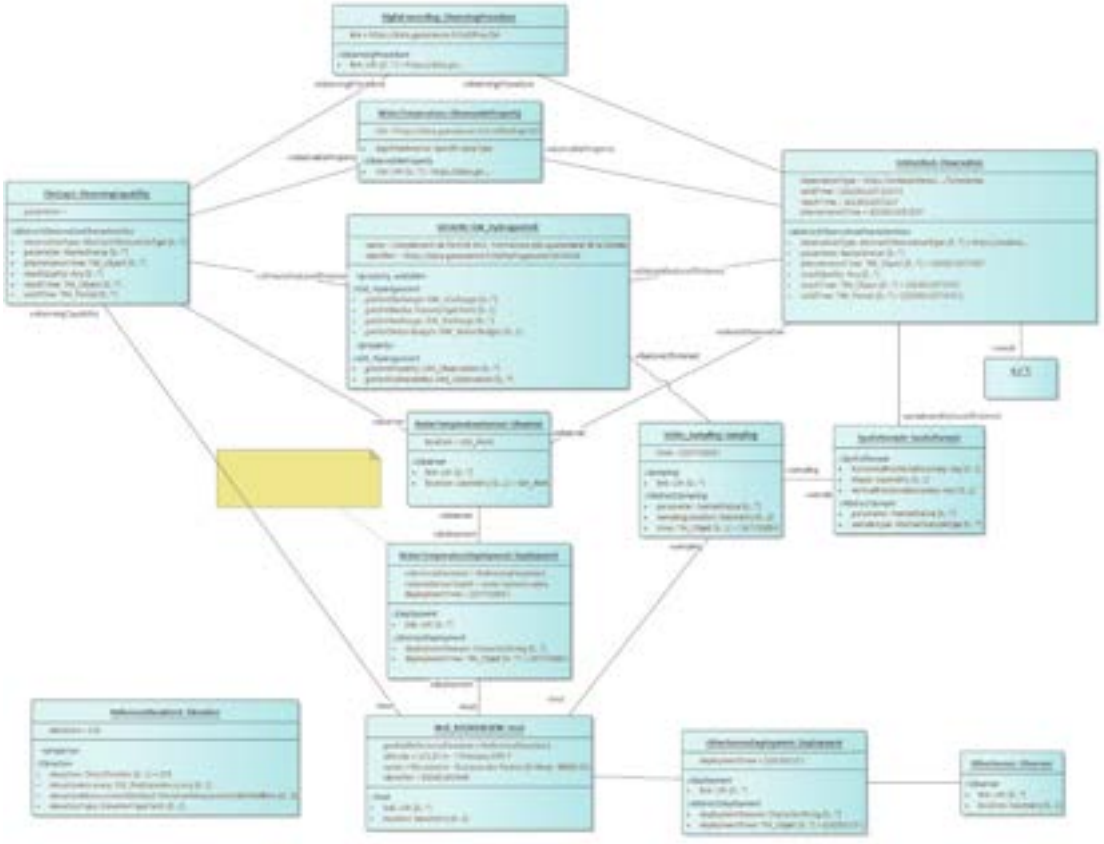


Conceptual Modelling

In situ sensor

- **GW**_InSitu_**Quality**Observation (temperature) => same pattern



Conceptual Modelling

In situ sensor

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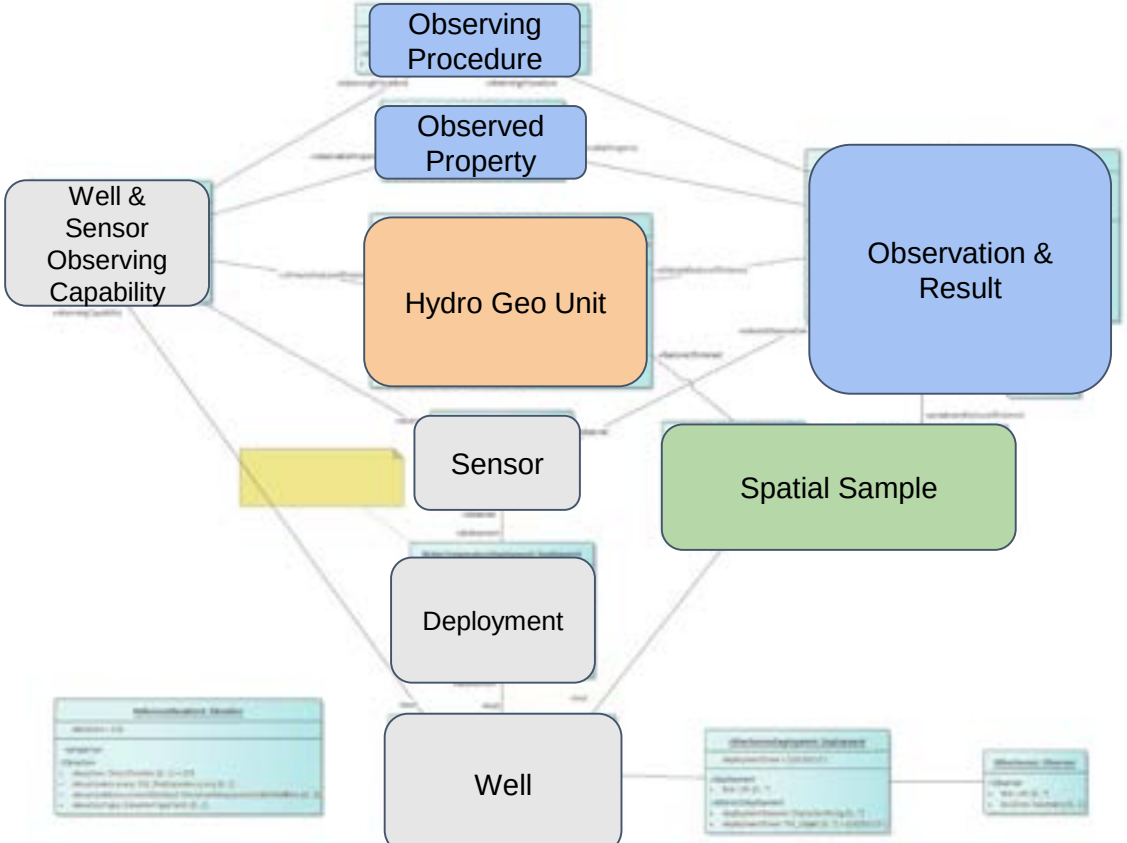

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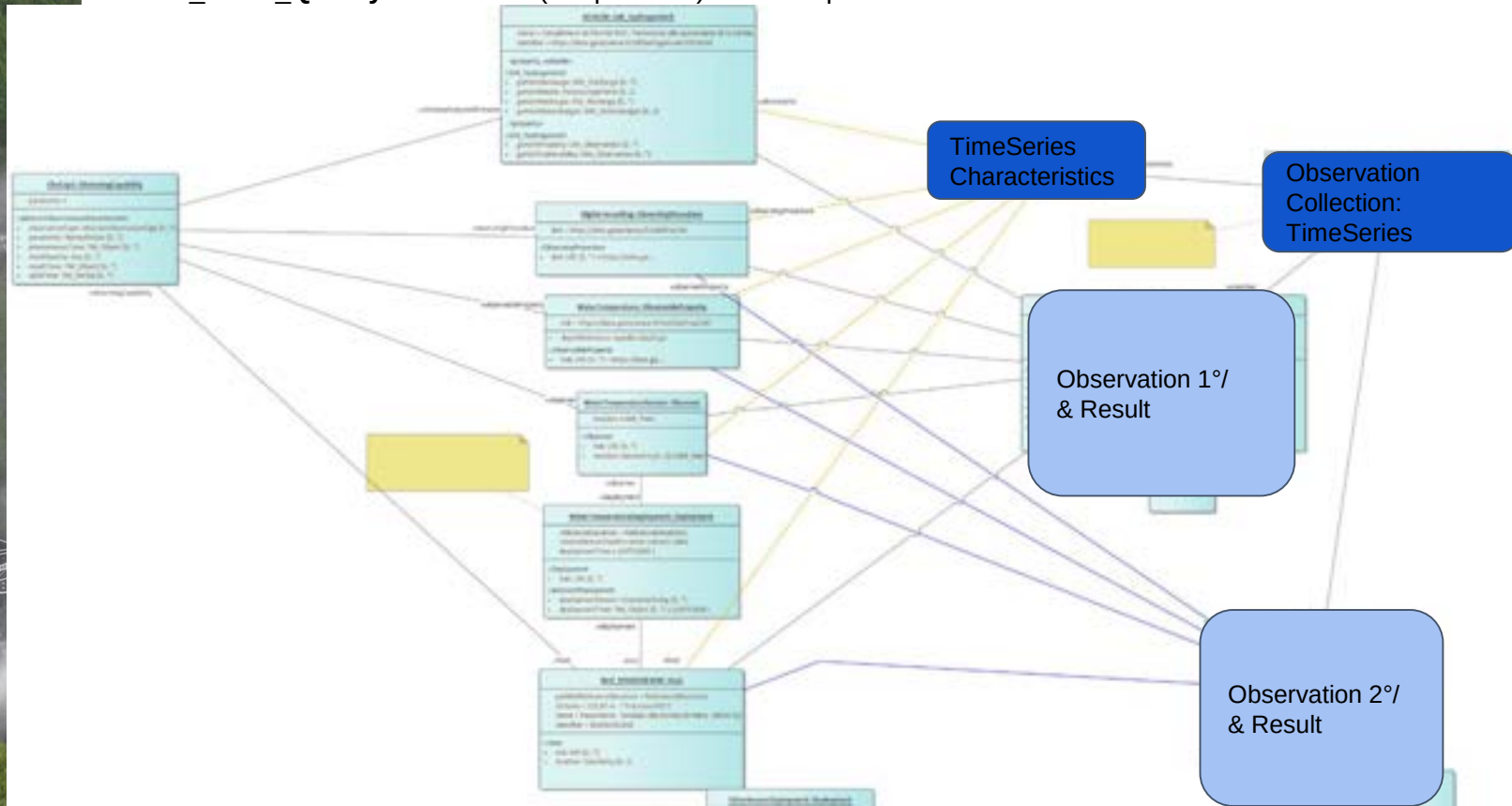
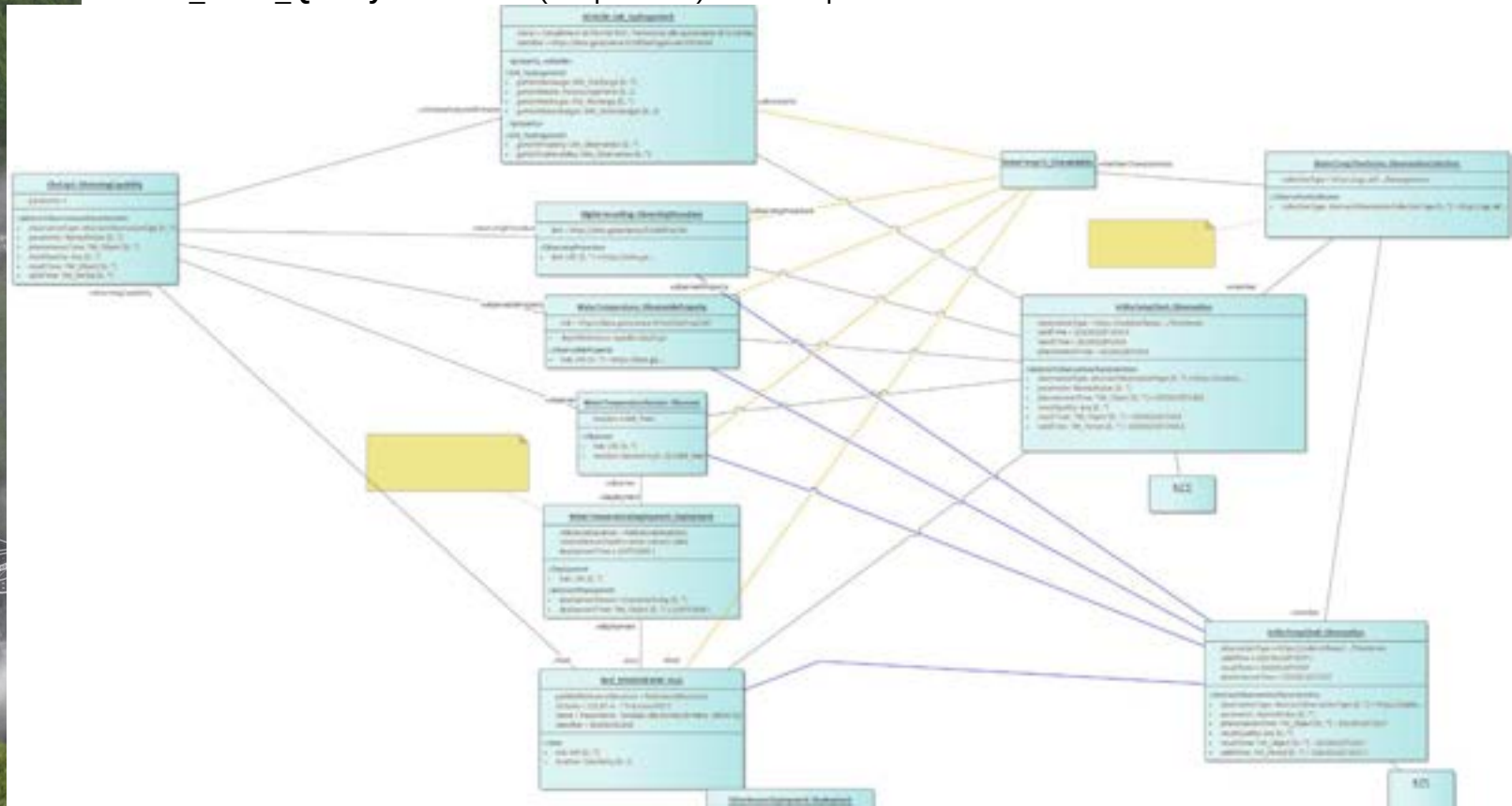


Conceptual Modelling

In situ sensor

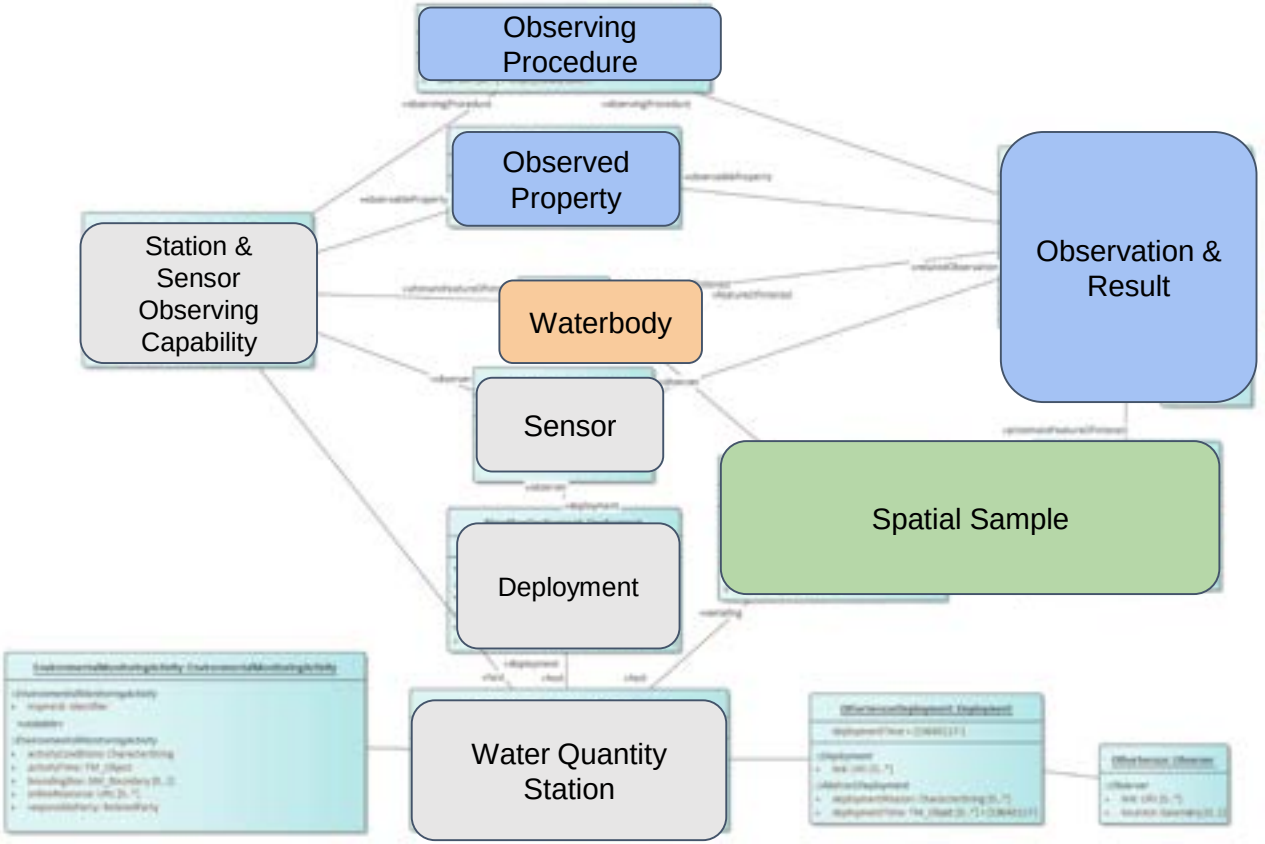
- **GW**_InSitu_**Quality**Observation (temperature) => same pattern



Conceptual Modelling

In situ sensor

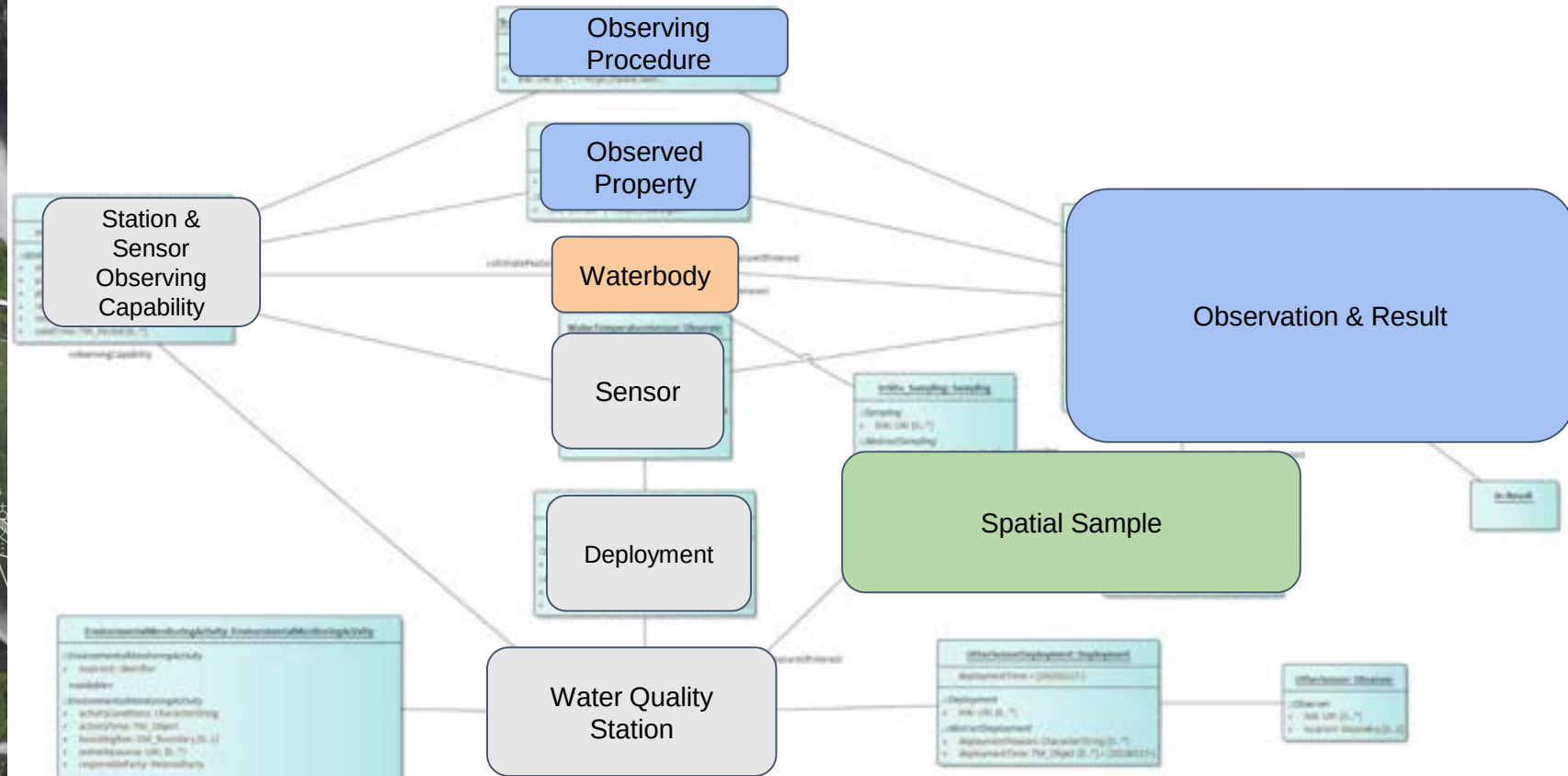
- **SW**_InSitu_**Quantity**Observation (river flow) => same pattern



Conceptual Modelling

In situ sensor

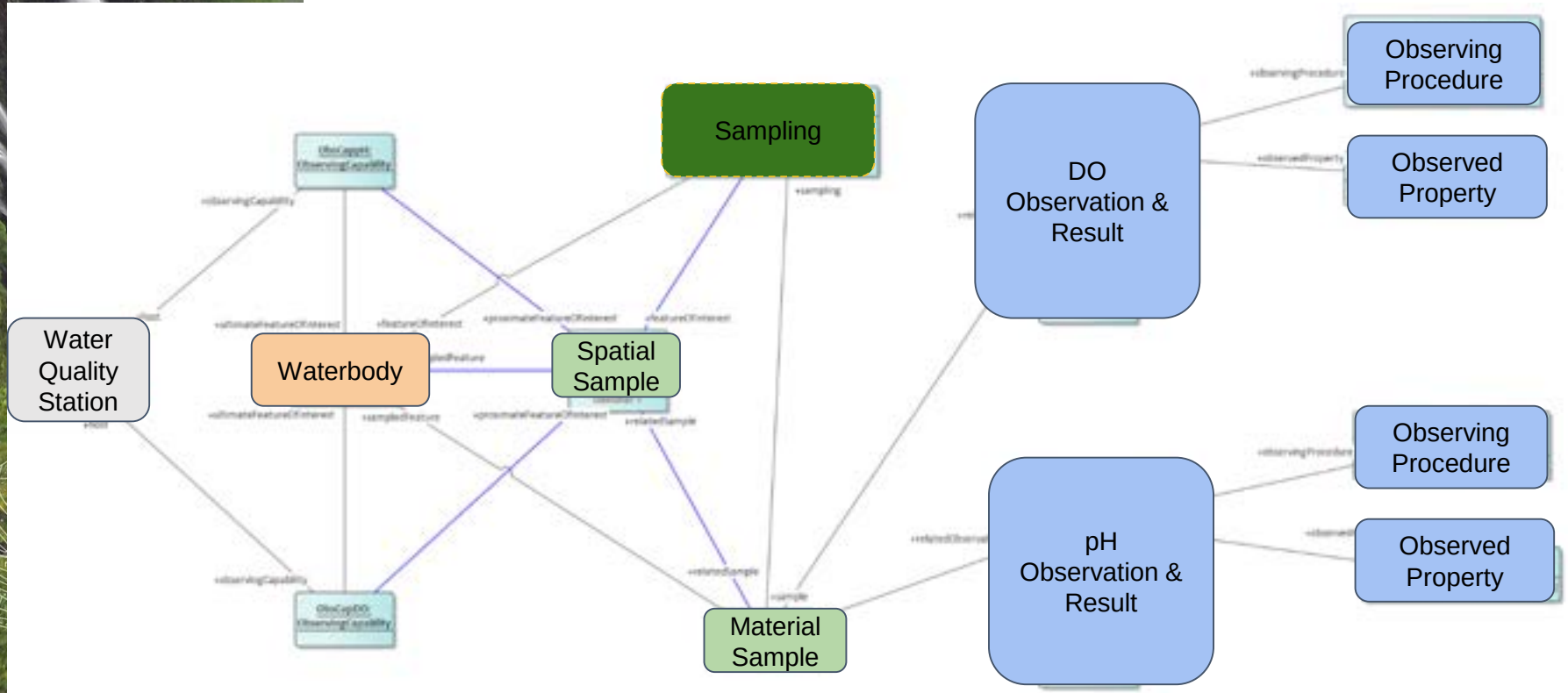
- **SW**_InSitu_**Quality**Observation (temperature, pH) => same pattern



Conceptual Modelling

Ex situ = Lab

- **SW**_ExSitu_**Quality**Observation (ex : Dissolved Oxygen, pH)



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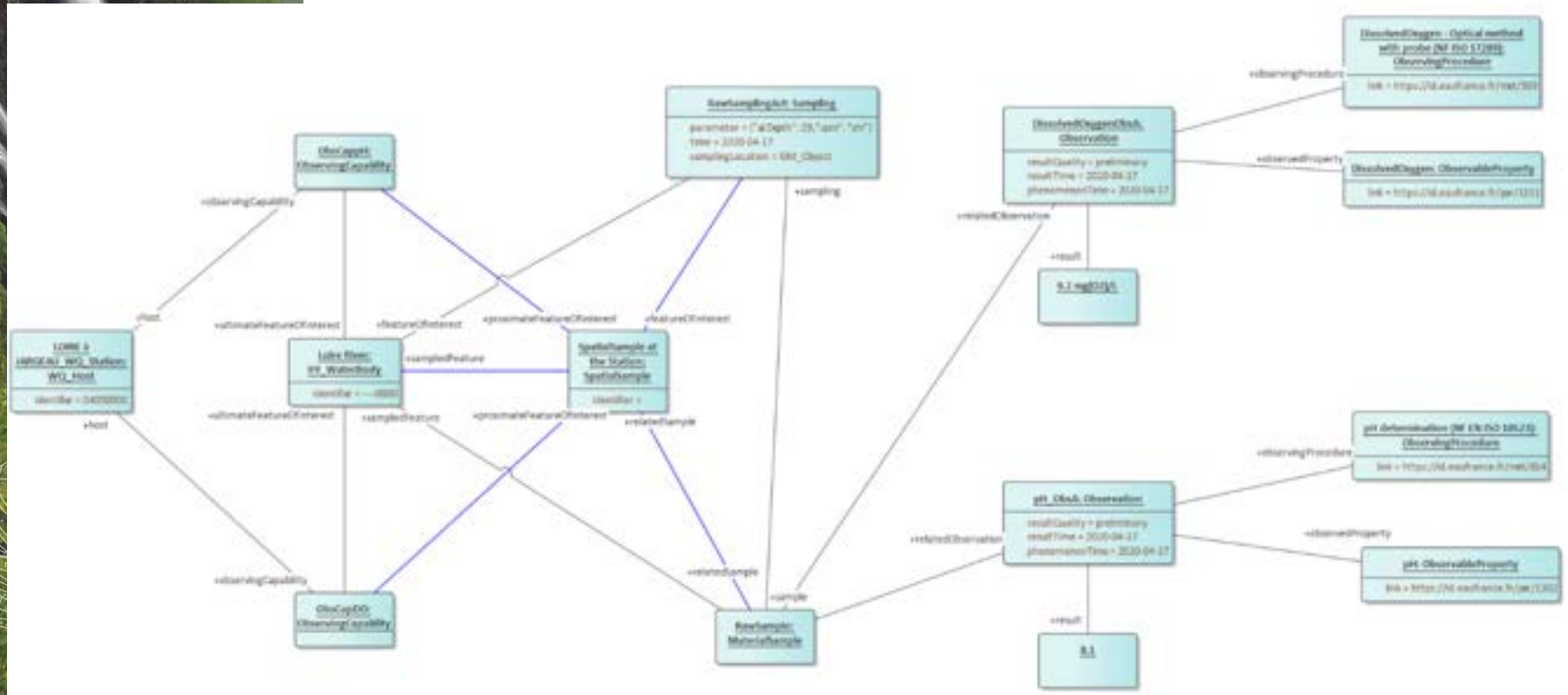
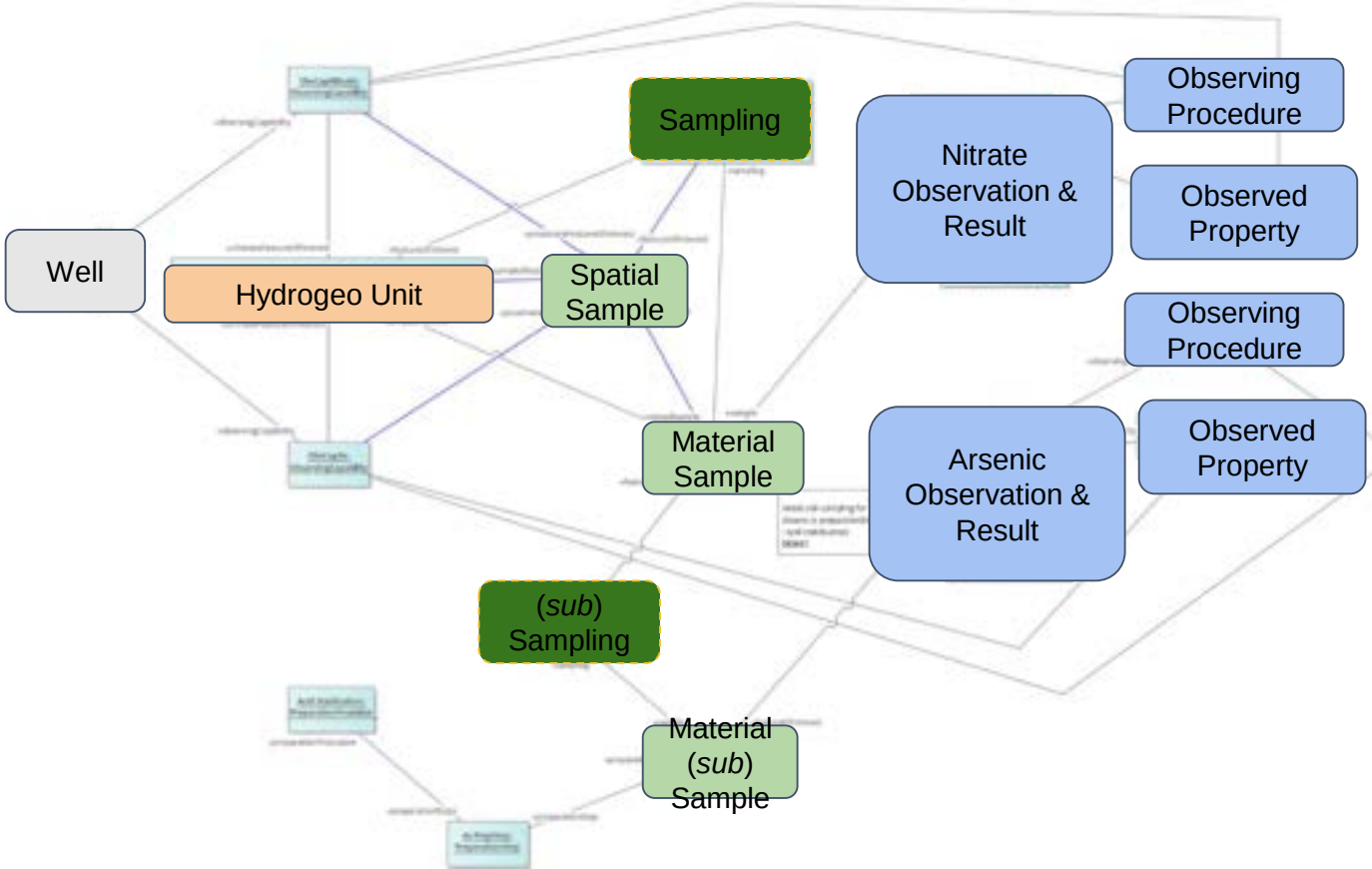


Conceptual Modelling

Ex situ = Lab

- **GW**_ExSitu_**Quality**Observation (ex : Nitrate, Arsenic) => same pattern



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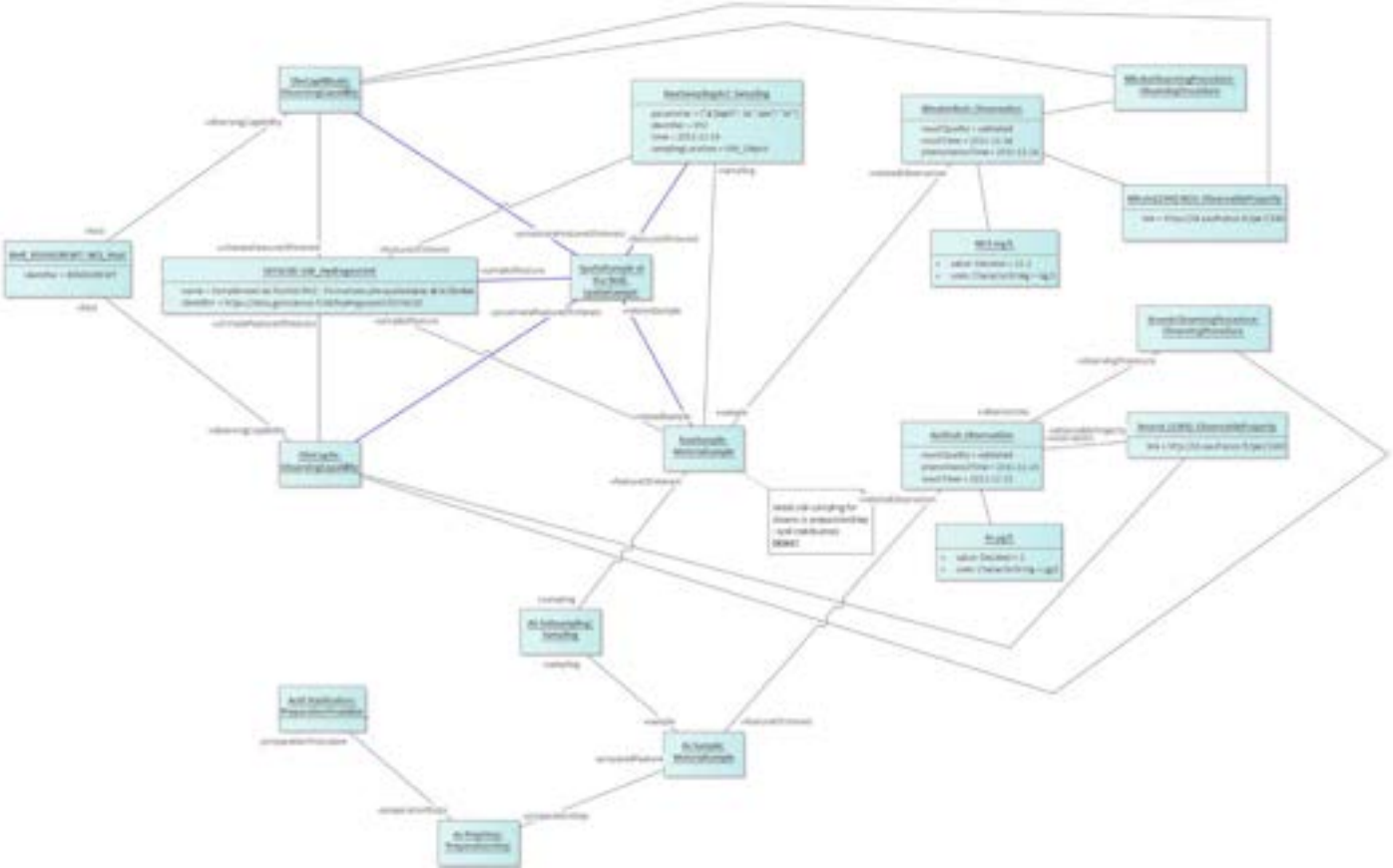
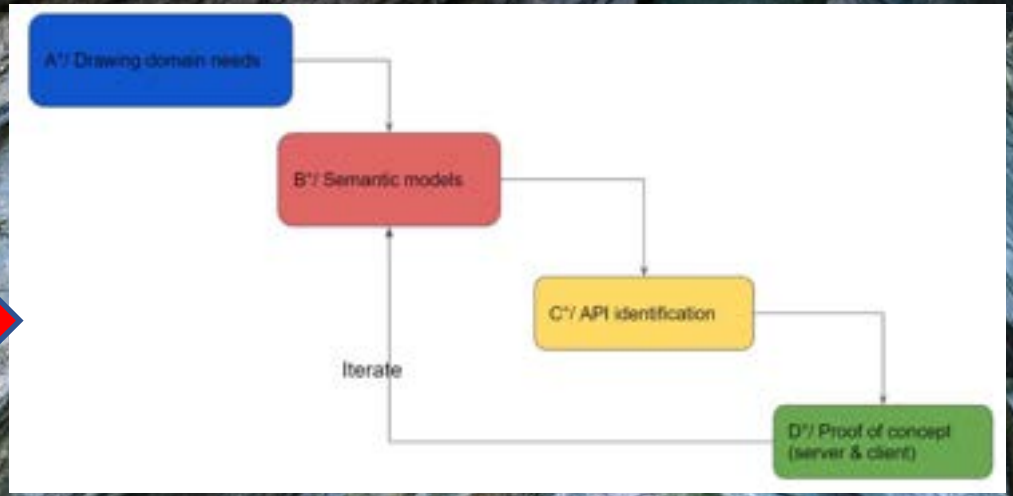


FAIR water quality data exchange thanks to international OGC water standards



Which interoperable / FAIR API ?

Available options

1. OGC WFS/API Features :

- All the identified concepts are Features => could work
- Not tied to a specific semantic/model and quite limited query mechanism on Observation topics

2. OGC SensorThings API

- Semantics : Already Observations & Measurements compliant
- Powerful query mechanism based on OASIS oData

Decision

1. Use OGC SensorThings API for Observation, Samples sharing and also a bit of River, Aquifer, Well information => core of the implementation, work presented here

2. Use OGC WFS / API – Features for pure geospatial features description / Use Cases : River, Aquifer, Well etc…

OGC SensorThings API?

- An OGC standard for exchanging sensor data and metadata
  - Historic data & current data
  - JSON Encoded
  - RESTful
  - Adapting OASIS OData URL patterns and query options
  - Supporting ISO MQTT messaging

- Easy to use & understandable
  - Discoverable with only a web browser

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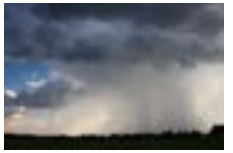
OGC SensorThings API?

Layman's terms

Observation method

Sensor type
= Rain gauge

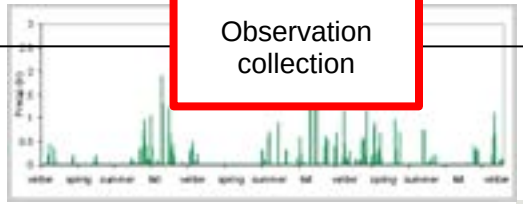
Observed property



= rainfall amount

"2021-05-07T09:50:00.000Z":"16

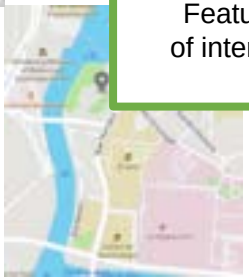
Observation collection



= rainfall time series

Observation

Feature of interest



= Representative zone around the station

Observer / Sensor / Station

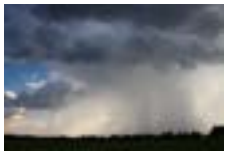
Sensor intance = The Strasbourg meteo station

OGC SensorThings API?

Terms from the standard

Sensor

Observed property



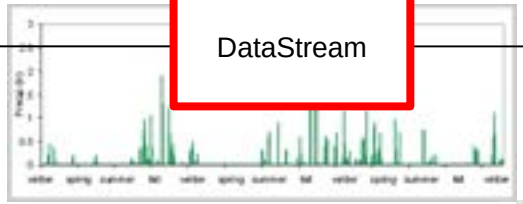
= rainfall amount

Sensor type
= Rain gauge

"2021-05-07T09:50:00.000Z":"16

DataStream

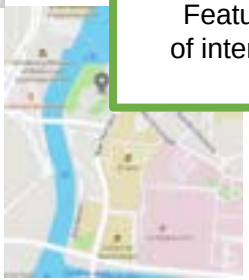
Observation



= rainfall time series

Thing

Feature of interest



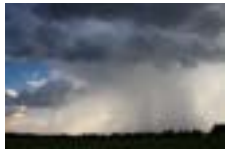
Sensor intance = The Strasbourg meteo station

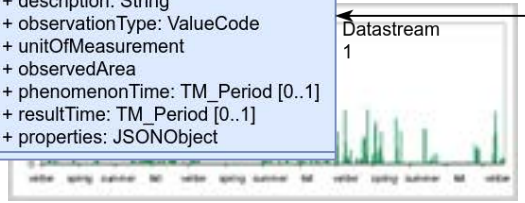
Historical location

Location

= Representative zone around the station

SensorThings API 1.1 – Data Model





Sensor
+ id: <<idType>>
+ name: String
+ description: String
+ properties: JSONObject
+ encodingType: String
+ metadata: <<any>>

ObservedProperty
+ id: <<idType>>
+ name: String
+ definition: URI
+ description: String
+ properties: JSONObject

ObservedProperty 1
Datastreams 0..*
Sensor 1

Datastream
+ id: <<idType>>
+ name: String
+ description: String
+ observationType: ValueCode
+ unitOfMeasurement
+ observedArea
+ phenomenonTime: TM_Period [0..1]
+ resultTime: TM_Period [0..1]
+ properties: JSONObject

Datastreams 0..*
Observations 0..*
Datastream 1

Observation
+ id: <<idType>>
+ result: <<any>>
+ phenomenonTime: TM_Object
+ resultTime: TM_Instant [0..1]
+ validTime: TM_Period [0..1]
+ resultQuality: DQ_Element [0..1]
+ parameters: JSONObject

Thing 1
Datastreams 0..*
Observations 0..*
FeatureOfInterest 1

Thing
+ id: <<idType>>
+ name: String
+ description: String
+ properties: JSONObject

Thing 1
HistoricalLocations 0..*
0..* Things
Locations 0..*

HistoricalLocation
+ id: <<idType>>
+ time: TM_Instant

HistoricalLocations 0..*
Locations 1..*

Location
+ id: <<idType>>
+ name: String
+ description: String
+ properties: JSONObject
+ encodingType: String
+ location: <<any>>

FeatureOfInterest
+ id: <<idType>>
+ name: String
+ description: String
+ properties: JSONObject
+ encodingType: String
+ feature: <<any>>

SensorThings live demo

- https://airquality-frost.k8s.ilt-dmz.iosb.fraunhofer.de/v1.1
  ~760 000 000 Observations
  ~21 000 Datastreams
  ~5 000 Stations

- Docker Quick-Start:
  https://fraunhoferiosb.github.io/FROST-Server/deployment/docker.html

- Full SensorThings API Tutorial
  https://fraunhoferiosb.github.io/FROST-Server/sensorthingsapi/1_Home.html

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SensorThings API 1.1 – API

HTTP:

	GET	POST	PATCH	DELETE
v1.1	Get index			
v1.1/Type	Get all of type	Create		
v1.1/Type(id)	Get one of type		Update	Delete
v1.1/Type(id)/Entity	Get linked entity			
v1.1/Type(id)/EntitySet	Get all linked	Create Linked		

MQTT:

1. Subscribe
   - v1.1/Things
   - v1.1/Datastreams(x)
   - v1.1/Datastreams(x)/Observations
   - etc.
2. Get Notified

- Fully Explorable with just a browser
- Composable Responses
- Powerful filtering

https://datacoveeu.github.io/API4INSPIRE/sensorthingsapi/1_Home.html

Fancy Queries

All data for a map:

```
v1.1/Things?
    $select=id,name,description,properties&
    $top=10&
    $filter=properties/countryCode eq 'HR'&
    $expand=
          Locations($select=location),
          Datastreams(
          $select=id,name,unitOfMeasurement;
          $expand=
          ObservedProperty($select=name),
          Observations(
                  $select=result,phenomenonTime;
                  $orderby=phenomenonTime desc;
                  $top=1)
          )
```

Link

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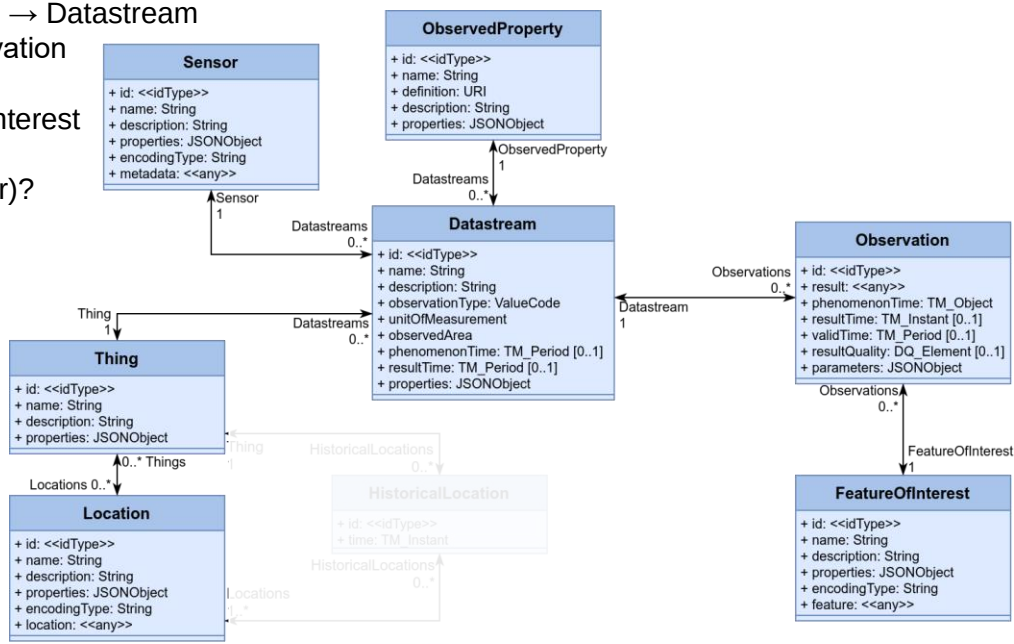
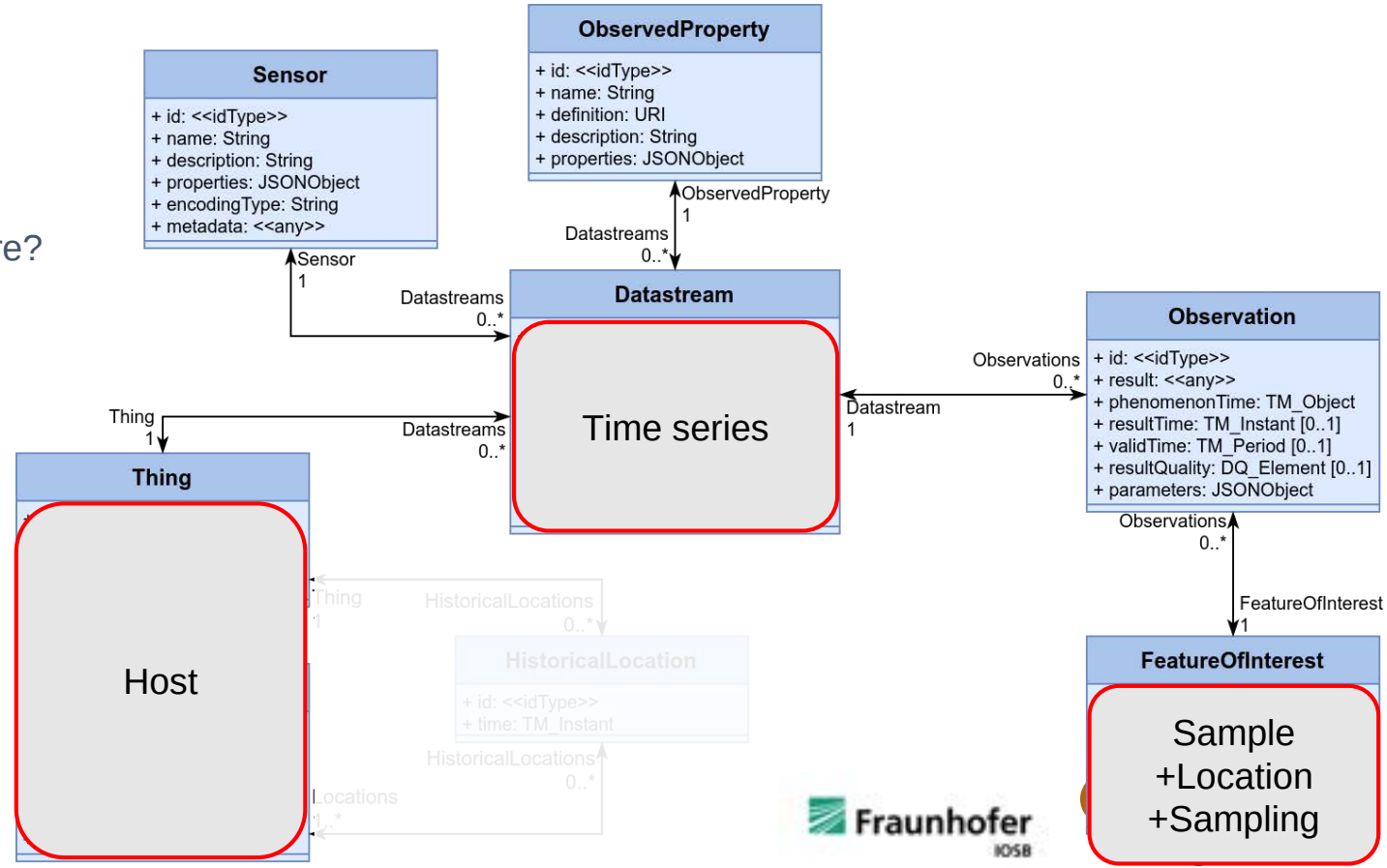
Physical model -> Mapping to OGC SensorThings API

1. Map matching concepts
   - Monitoring Facility → Thing + Location
   - Observed Property → ObservedProperty
   - Observation Collection → Datastream
   - Observation → Observation
   - Observer → Sensor
   - Sample → FeatureOfInterest
2. Add missing Classes
   - SampledFeature (River)?
   - Deployment?
   - Sampler?
   - ObservingProcedure?



SensorThings API 1.1 – Water Quality

- River? (SampledFeature)
- Deployment?
- Sampler?
- ObservingProcedure?



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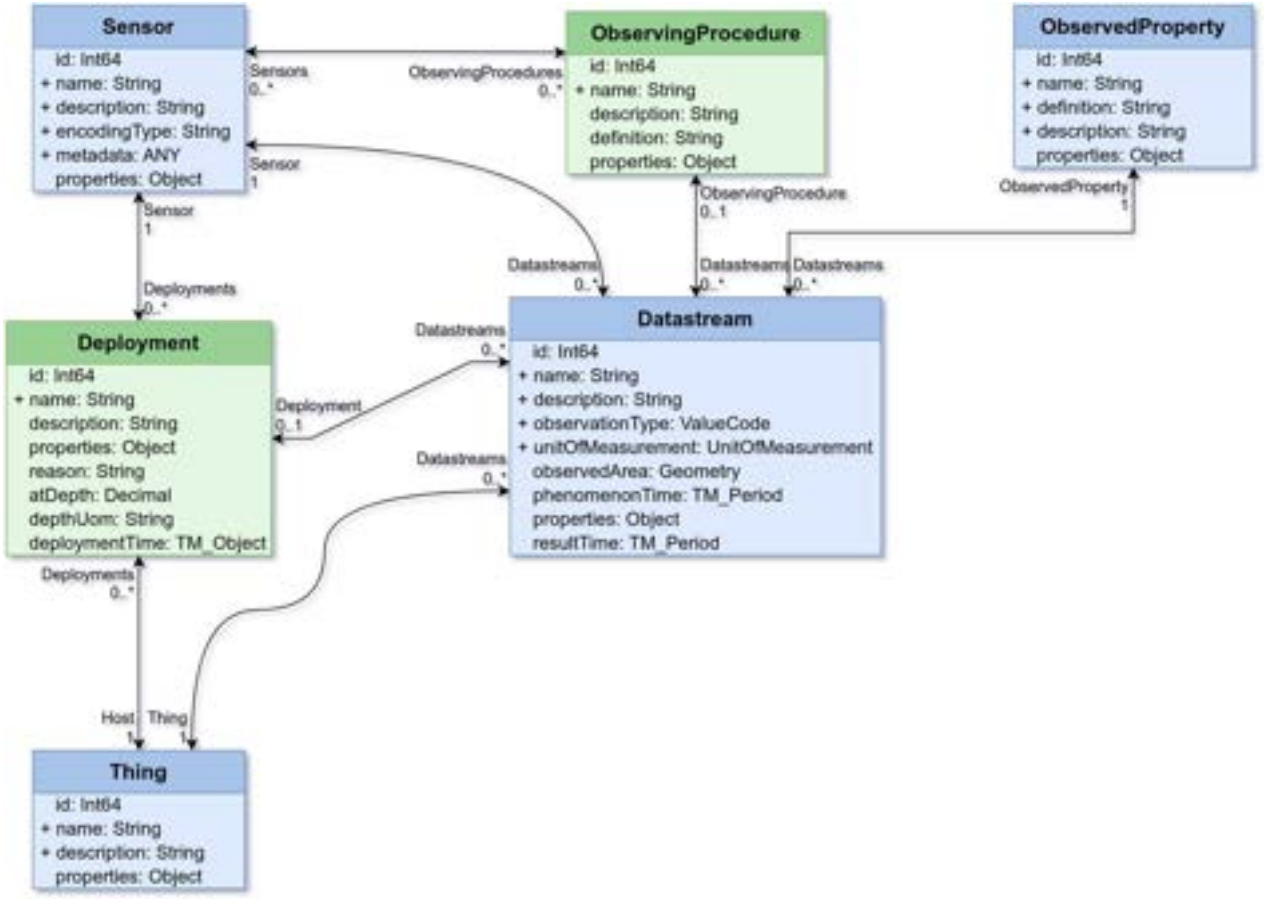
STA 1.1 WQ-IE – Sensor Extensions

Extending the Sensor

- \+ Deployment
- \+ ObservingProcedure

OMS addition

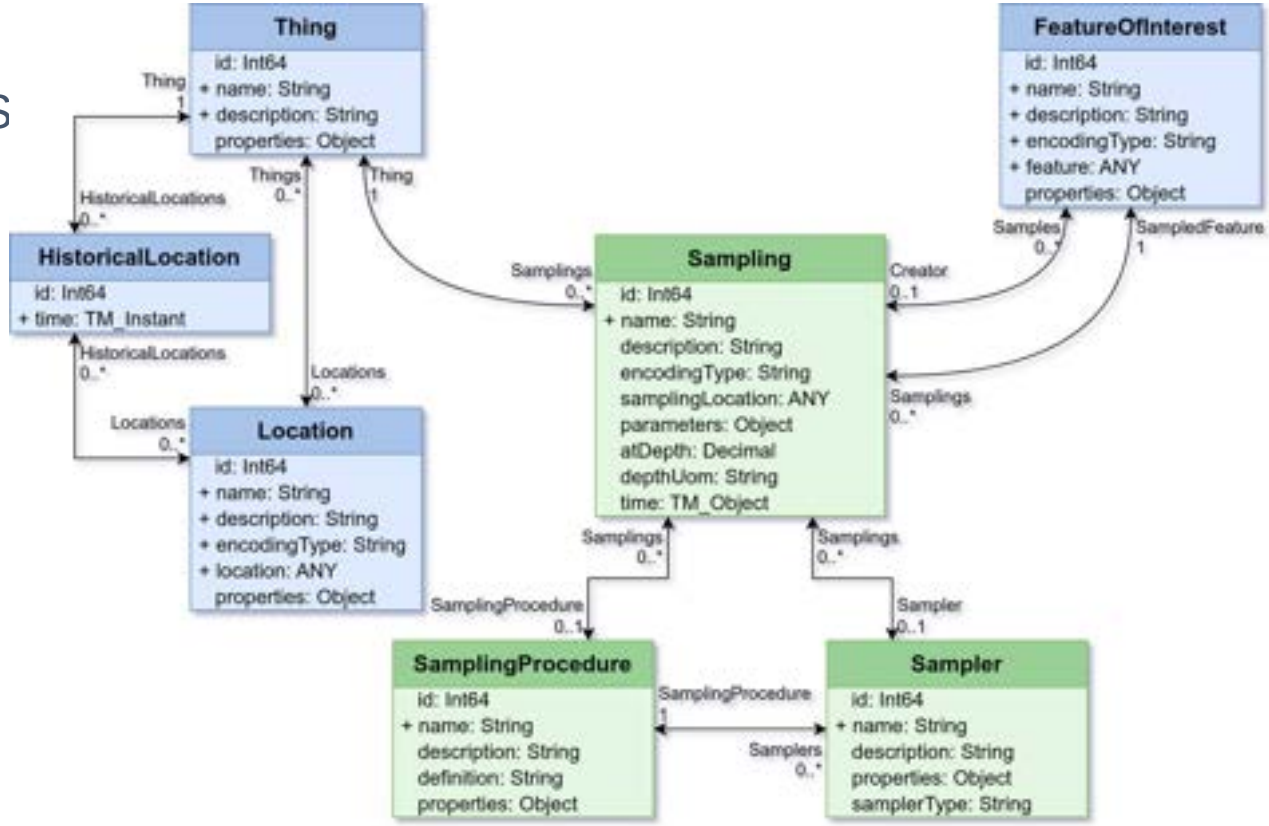


STA 1.1 WQ-IE – Sampling

Adding Sampling from OMS

- \+ Sampling
- \+ Sampler
- \+ SamplingProcedure

OMS addition



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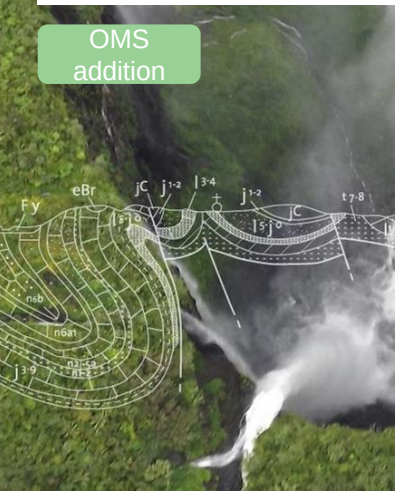
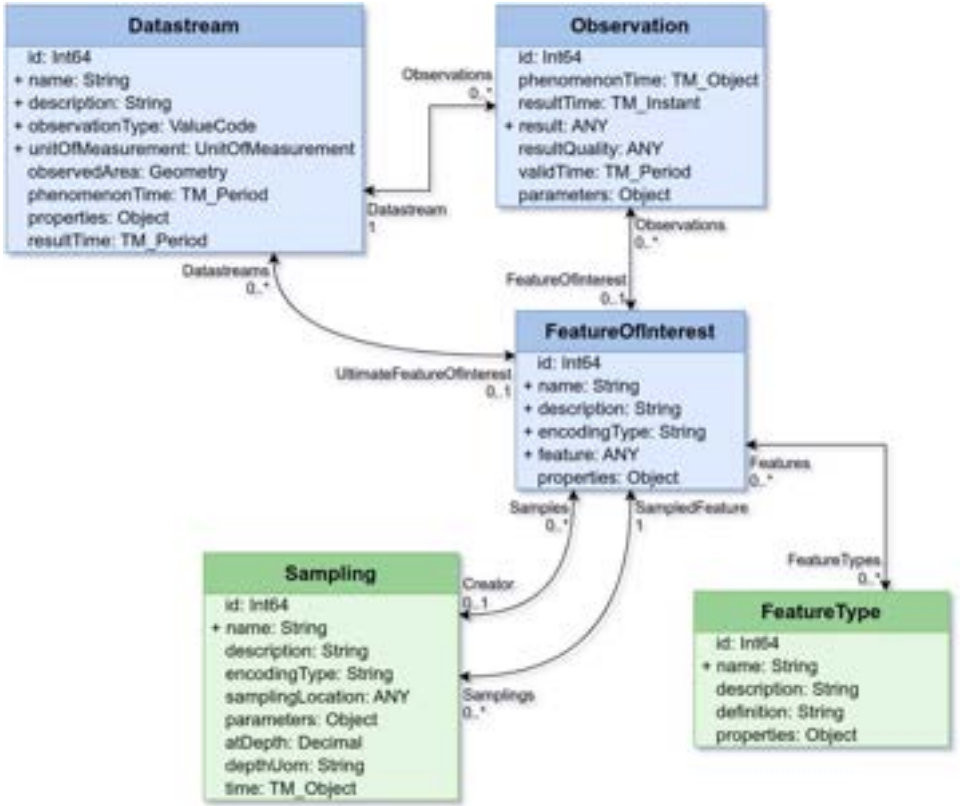
STA 1.1 WQ-IE – Features

Adding the River as Feature and linking a time series

- \+ FeatureType
- \+ Datastream → UltimateFeatureOfInterest

OMS addition





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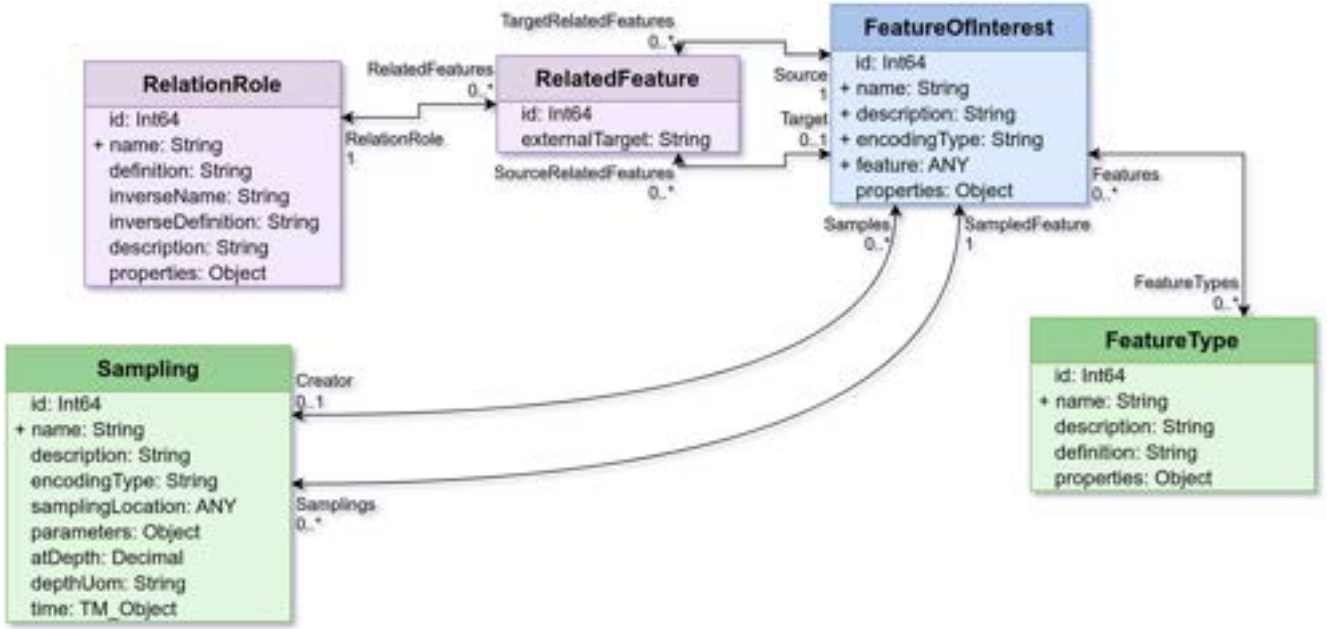
STA 1.1 WQ-IE – Relations

Relating Features to other Features

+ RelatedFeature
+ RelationRole

The same for:

+ RelatedThing
+ RelatedDatastream
+ RelatedObservation



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STA 1.1 WQ-IE

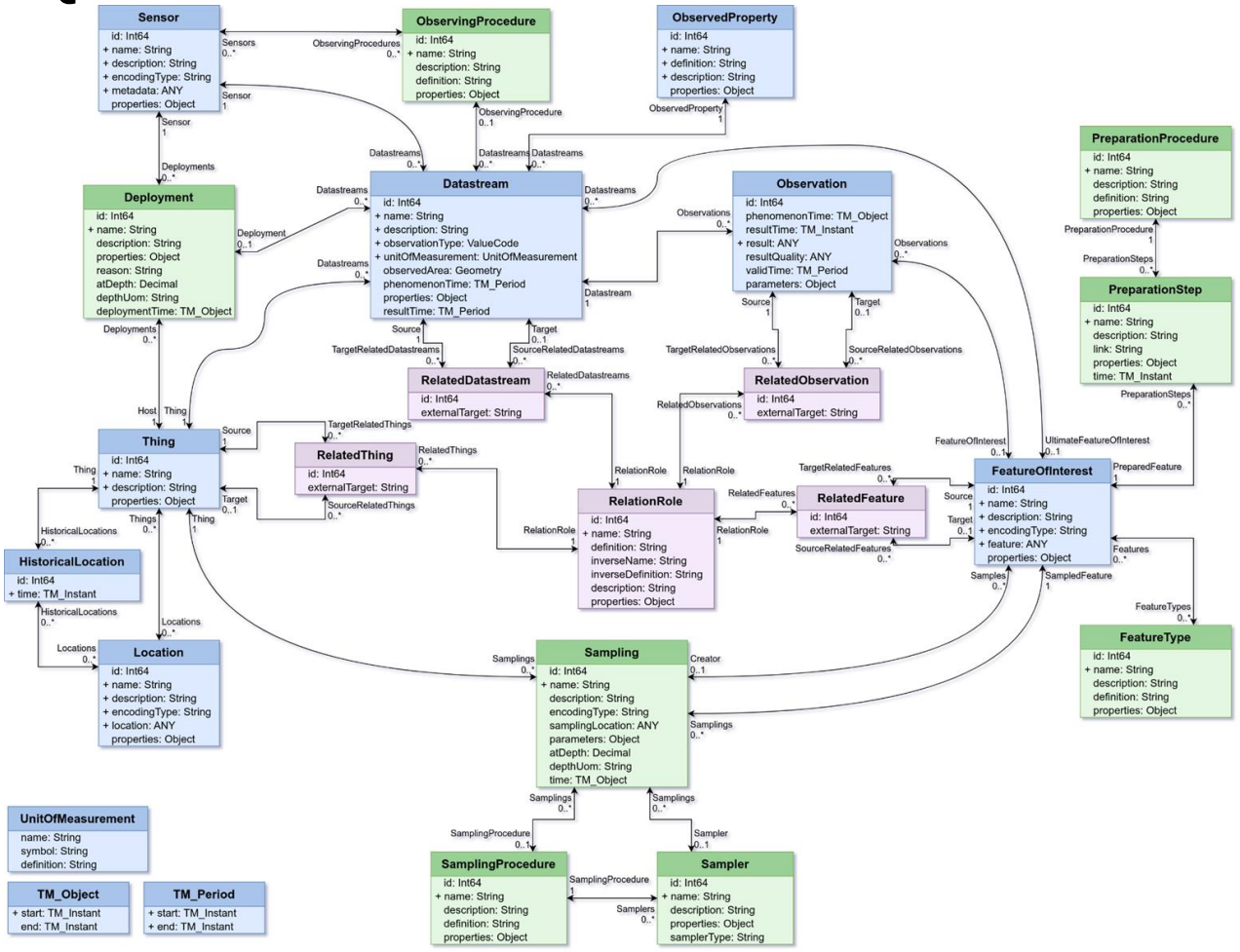
Full data model

- Still v1.1 compatible
- Paving the way to STA 2.0

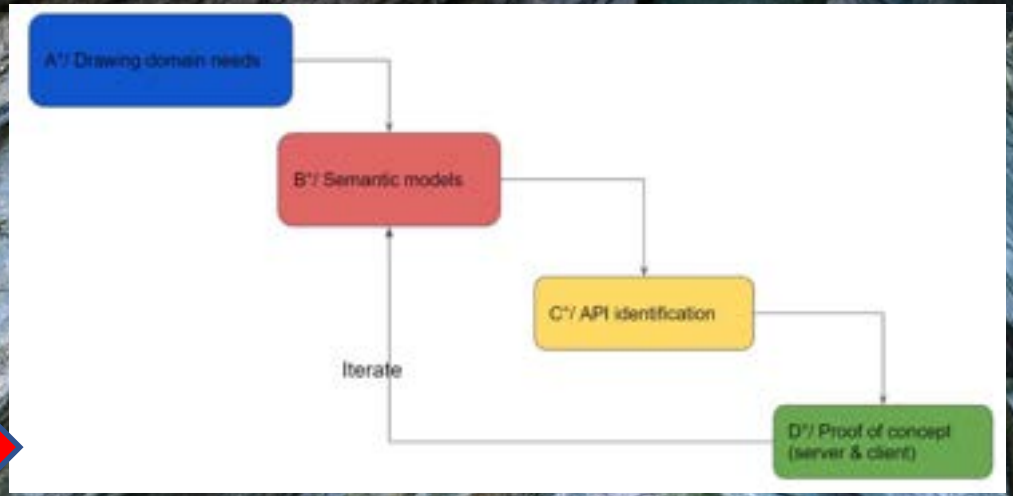
STA 1.1

OMS addition

Relation extension



FAIR water quality data exchange thanks to international OGC water standards



Implementation

- Who
  - Water Quality IE members USGS, USEPA, DataStream (Canada), BRGM, BaFG (Unesco Gems water), Fraunhofer
  - EU Water4All project partners
    - Ex : Danish DEP, ISPRA, Fraunhofer, VITO etc…
  - EU GSEU project partners
    - Many EU geological surveys

- What
  - FROST Data Model Plugin https://github.com/hylkevds/FROST-Server.Plugin.WaterQualityIE
  - Docker Image https://hub.docker.com/r/hylkevds/frost-http-waterquality

Implementation

- How
  - Documentation being written
    Google doc for now, will be moved to the GitHub when more mature
    https://docs.google.com/document/d/1Oqjxrz8uY_Q9OKBwEM2ZufrCEnlYvA4vWIIJSiMyGT4/edit

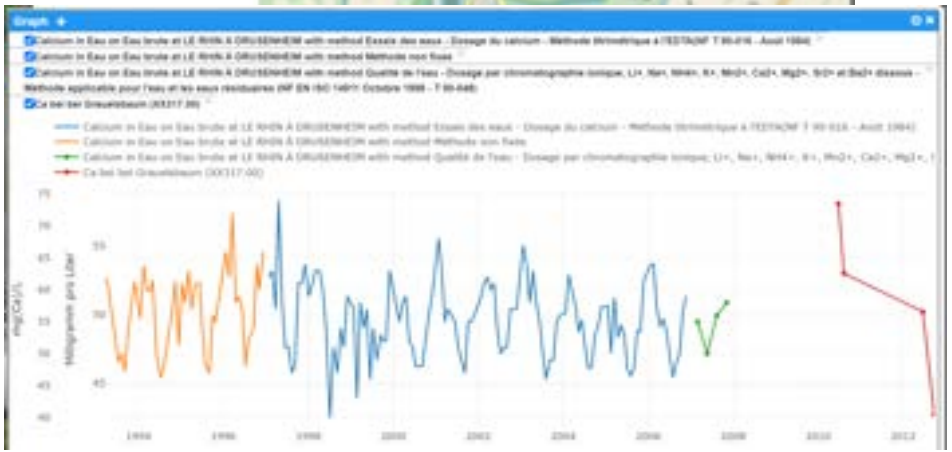
- Demo endpoints
  - Open Free-For-All Service (no data yet)
    https://ogc-demo.k8s.ilt-dmz.iosb.fraunhofer.de/FROST-WaterQuality/v1.1/
  - USGS endpoint (work in progress)
    Data: https://wqp.wqie.internetofwater.app/FROST-Server/v1.1
    Map: https://wqp.wqie.internetofwater.app/
    Map: https://wg-brgm.k8s.ilt-dmz.iosb.fraunhofer.de/servlet/is/211/

    Also tested in QGIS SensorThings API Plugin

Implementation

- It works !

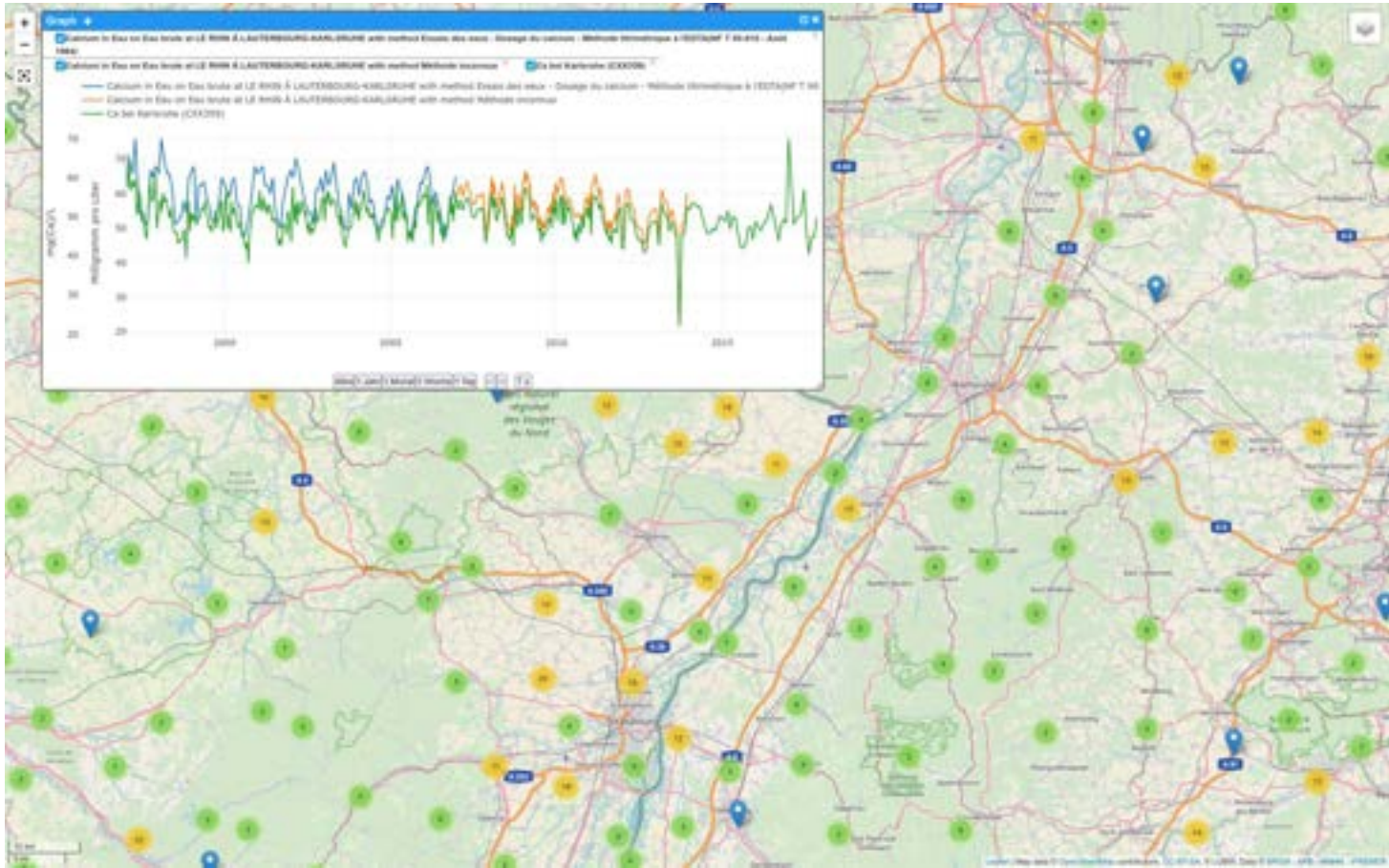
Surface water quality
USGS – Internet of Water US



Surface water quality
France - Germany

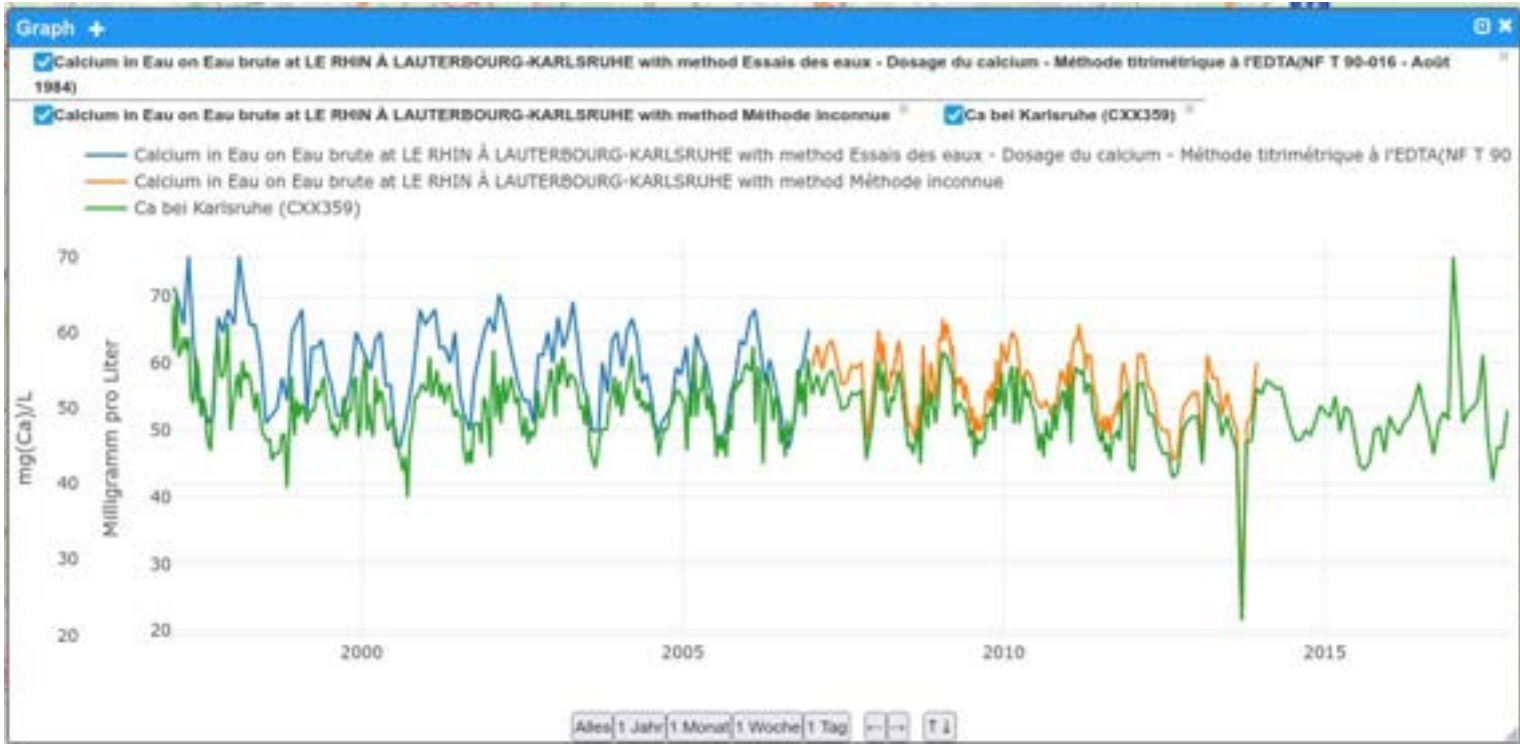
Implementation

- French & German Data
- 1 Map



Implementation

- French & German Data
- 1 Map



FAIR water quality data exchange thanks to international OGC water standards

Conclusion

Landing the Interoperability Experiment

- When
  - Current target => OGC Member Meeting in June 2024 (OGC Hydro DWG session)

- What
  - Demo based on the implementation feedback

  - + draft Engineering Report
    - summarizing the findings from the IE
    - and proposing next steps. Ex : adoption of a Best Practice for Water Quality data exchange Water ML2.0 Part 5 and (potentially) a revision of WaterML2.0 Part 1 : TimeSeries

Steps after the Interoperability Experiment

- Finalize a Best Practice for Water Quality data exchange Water ML2.0 Part 5 and start a draft revision of WaterML2.0 Part 1 : TimeSeries (to align with OMS and ST API)

- Work on shared ‘controlled’ vocabularies
  - Observed Property (? using I-ADOPT ?), Observing Procedure, …

- Current UseCases
  - More implementations : La Plata basin countries (through WMO), more Water4All and GSEU project partners

- Address the other UseCases
  - Out of scope this IE : Biology (taxa observation), Hydro Models, Remote Sensing

  ⇒ Enough material for a WQ IE 2 ☺

Some hindsight on the effort

- ***How the new "Observations, measurements and samples (OMS) " is meaningful to the Interoperability Experiment ?***

  - Most of what is needed semantically is already within the OGC semantic baseline : OMS + OGC WaterML2.0 part 3 (HydroFeatures) and part 4 (GroundWaterML 2.0)

  - OGC SensorThings API 1.1 being already Observations & Measurements compliant we just needed to add the missing elements to make it OMS compliant (ex : MaterialSample and some others)

    This is now embedded in SensorThings 2.0 working draft (revision ongoing)

Some hindsight on the effort

- ***How the new "Observations, measurements and samples (OMS) " is meaningful to the Interoperability Experiment ?***

=> No need to reinvent the wheel, just use the available standards and document it

Some context supporting this work

- Some supporting national /EU projects from our end (both running now)

OneWater Eau Bien Commun / PROGRAMME NATIONAL DE RECHERCHE SUR L'EAU

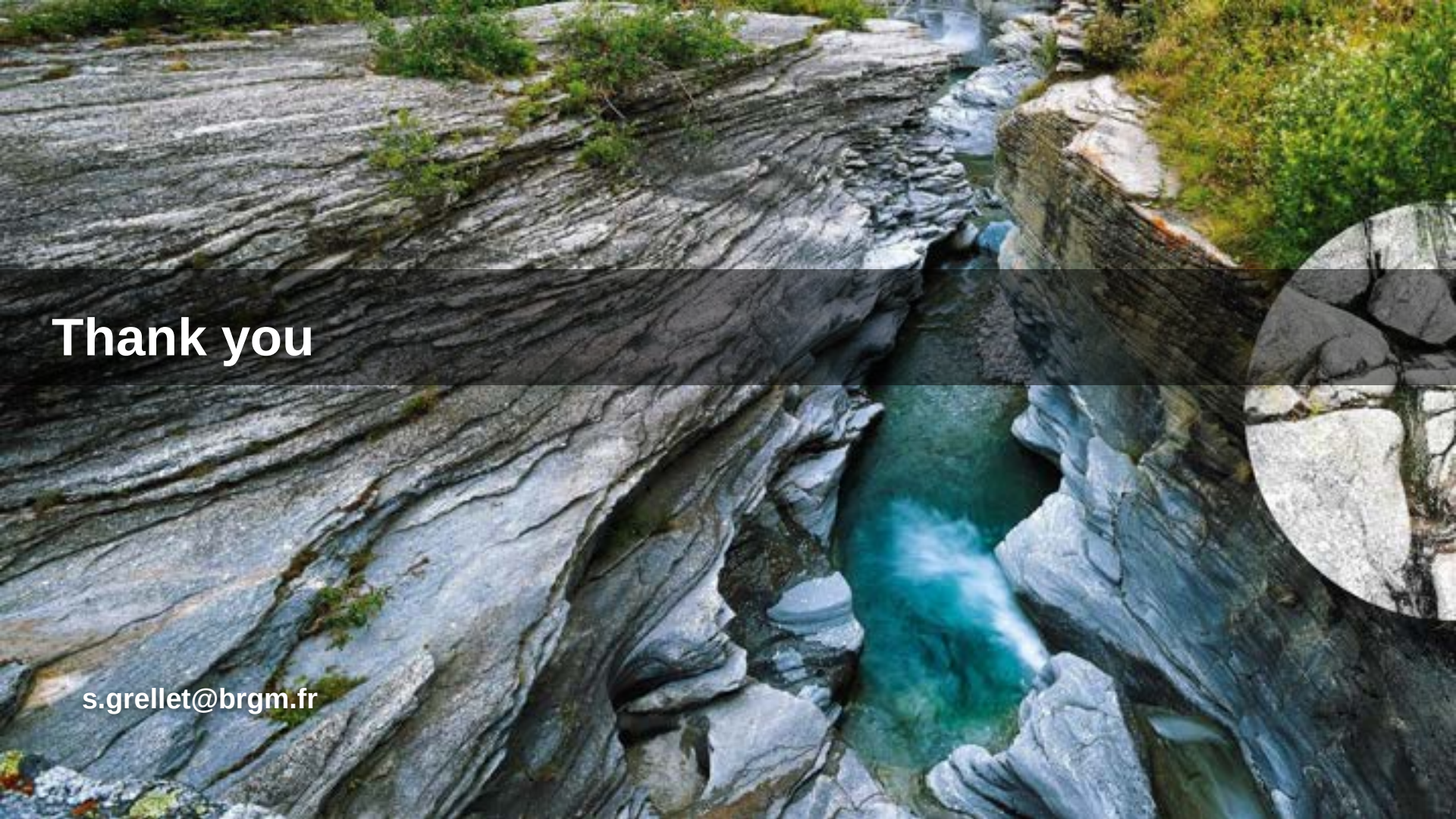
  - French Research project, 53 Million €, 10 years
  - https://www.onewater.fr/en (ANR project : 22-PEXO-0009)
  - Many domain objectives including FAIR (interoperable) Water Data Exchange

Water4All
Water security for the planet

  - EU joint research partnserhip
  - https://www.water4all-partnership.eu/
  - 31 countries, 7 years, 81 Million € for the 2 years.
  - Many domain objectives including FAIR (interoperable) Water Data Exchange

- Your project could join the effort

⇒ join the OGC Hydro DWG discussions



Thank you

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Thank to

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