An explicit OWL representation of ISO/OGC Observations and Measurements

Comparison with SSN ontology

Simon Cox | Research Scientist | Environmental Information Systems

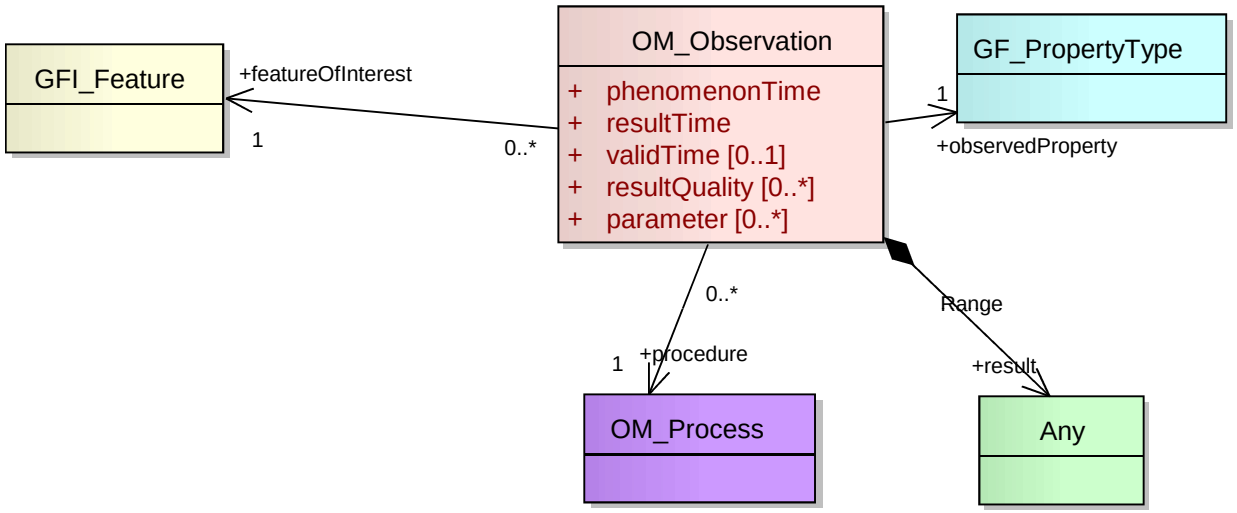
17 October 2013

Outline

- Methodology for O&M in OWL
- Challenges in converting from UML
- Expressivity
- Alignment

OBSERVATIONS AND MEASUREMENTS

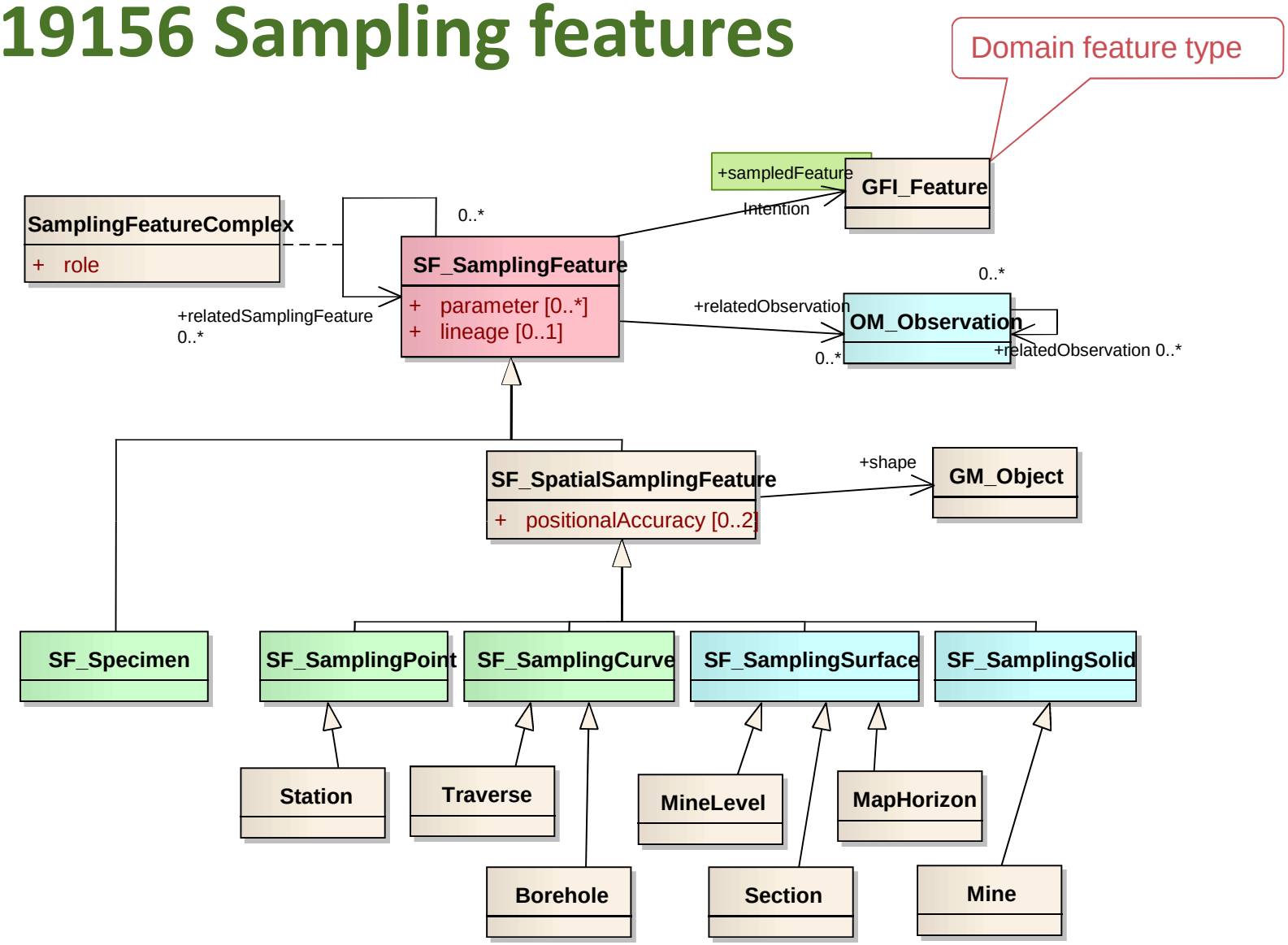
ISO 19156 Observations and Measurements



An Observation is an action whose result is an estimate of the value of some property of the feature-of-interest, obtained using a specified procedure

Cox, OGC Abstract Specification – Topic 20: Observations and Measurements 2.0
ISO 19156:2011 Geographic Information – Observations and measurements

ISO 19156 Sampling features



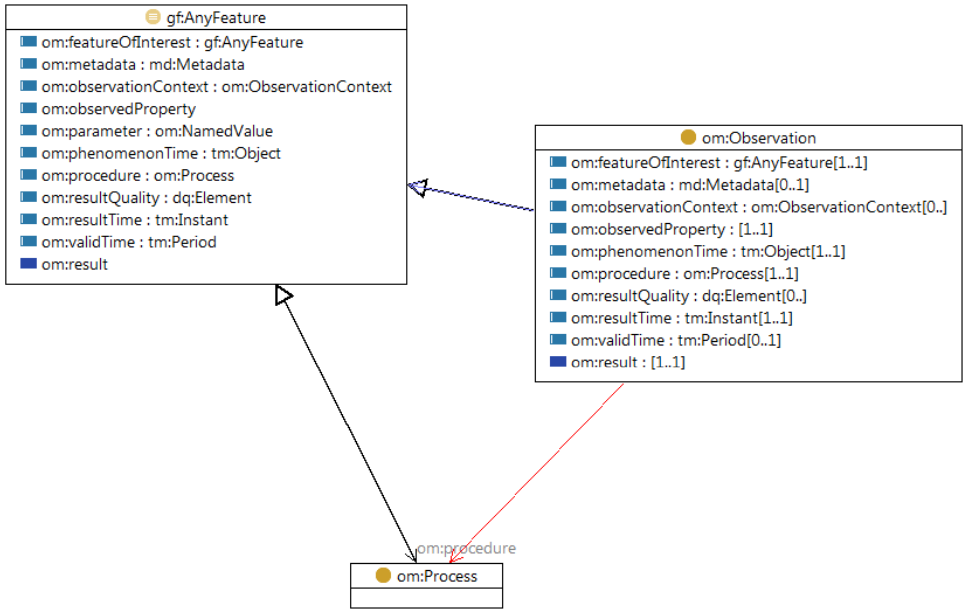
Cox, OGC Abstract Specification – Topic 20: Observations and Measurements 2.0
ISO 19156:2011 Geographic Information – Observations and measurements

UML → OWL CONVERSION RULES

ISO 19150-2 (2015?)

- UML Package → OWL Ontology
- UML Class → OWL Class
- UML Attribute/Association role → RDF Property
- UML Stereotype → OWL Class

om:Observation class



(TopBraid diagram view)

UML-OWL mismatches

UML is frame-based

- Attributes owned by classes
- Association-roles owned by classes
- property redefinition/refinement uncommon and complicated

RDF is open-world

- *Properties scoped to Ontology (namespace)*
- *Property re-use expected*
- *rdfs:subPropertyOf easy, commonly used*

Options for defining properties

Frame-based

- Name scoped to class
- Narrow rdfs:domain
- Narrow rdfs:range
- Strict cardinality constraints

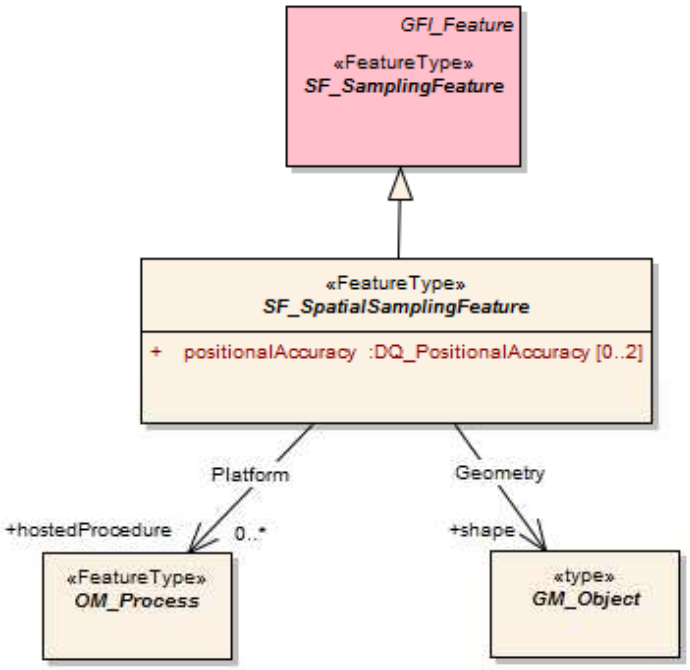
```
om:Observation.resultTime
      a        owl:ObjectProperty ;
      rdfs:label "Result time"@en ;
      rdfs:domain om:Observation ;
      rdfs:range tm:Instant .
```

Open-world

- Name scoped to namespace
- Generic rdfs:domain
- Narrow rdfs:range
- Loose cardinality constraints

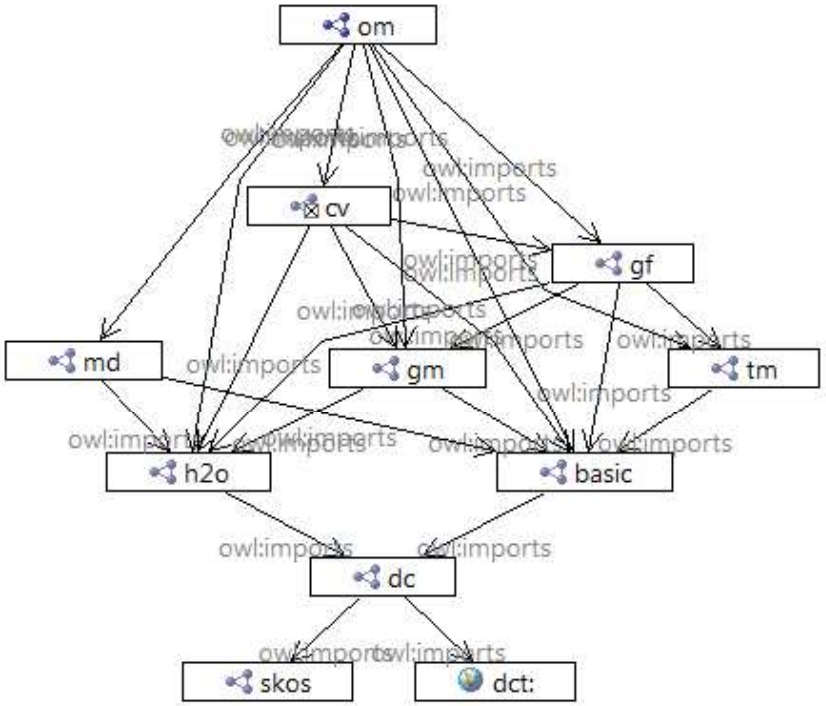
```
om:resultTime
      a        owl:ObjectProperty ;
      rdfs:label "Result time"@en ;
      rdfs:domain gf:AnyFeature ;
      rdfs:range tm:Instant .
```

Complete example – lax form




```
sam:SF_SpatialSamplingFeature
  a   owl:Class ;
  rdfs:label "Spatial sampling feature"@en ;
  rdfs:subClassOf gf:AnyFeature , sam:SF_SamplingFeature ;
  rdfs:subClassOf
  [ a   owl:Restriction ;
    owl:cardinality "1"^^xsd:nonNegativeInteger ;
    owl:onProperty sam:shape ] ;
  rdfs:subClassOf
  [ a   owl:Restriction ;
    owl:minCardinality "0"^^xsd:nonNegativeInteger ;
    owl:onProperty sam:positionalAccuracy ] ;
  rdfs:subClassOf
  [ a   owl:Restriction ;
    owl:maxCardinality "2"^^xsd:nonNegativeInteger ;
    owl:onProperty sam:positionalAccuracy ] ;
  rdfs:subClassOf
  [ a   owl:Restriction ;
    owl:minCardinality "0"^^xsd:nonNegativeInteger ;
    owl:onProperty sam:hostedProcedure ] ;
  skos:notation
   "SF_SpatialSamplingFeature"^^h2o:ISOClassName .
```

O&M integrated into ISO framework

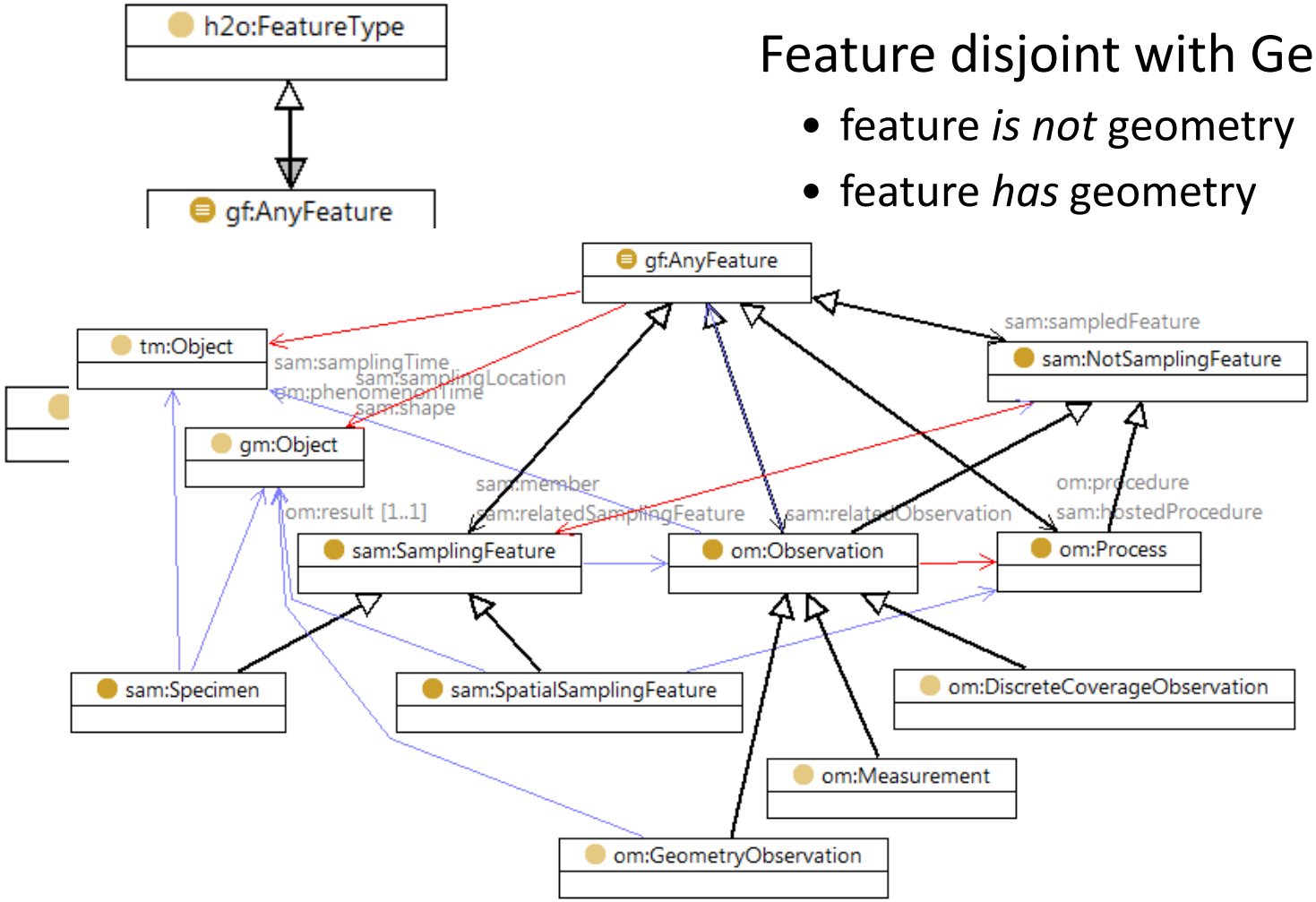


Direct dependencies

- Feature ISO 19109
- Geometry ISO 19107
- Temporal ISO 19108
- Coverage (fields) ISO 19123
- Metadata (!) ISO 19115
- Meta-model ISO 19150-2
- Basic datatypes ISO 19103

No other alignment attempted
at this time

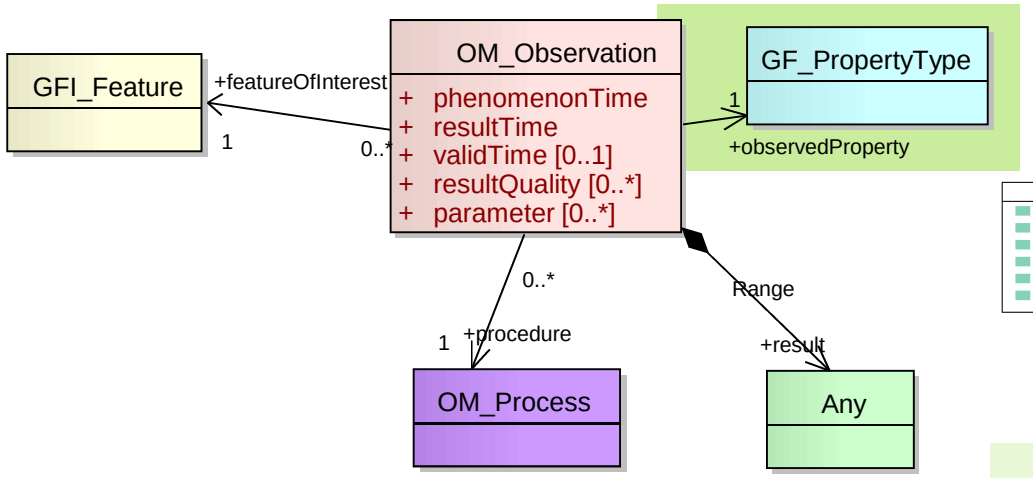
ISO/OGC Feature Model

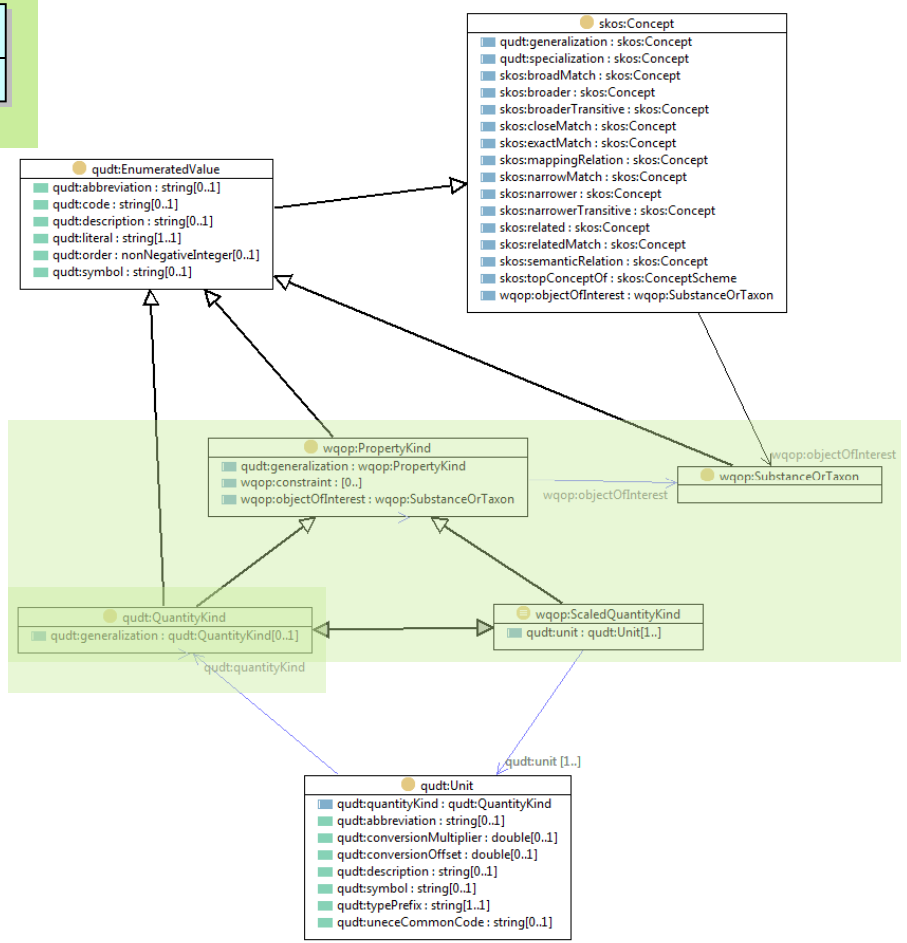


Feature disjoint with Geometry

- feature *is not* geometry
- feature *has* geometry

O&M linked to QUDT






```
om:observedProperty
      a       owl:ObjectProperty ;
      rdfs:domain gf:AnyFeature ;
      rdfs:label "Observed property"@en ;
      skos:definition """The association
  Phenomenon shall link the
  OM_Observation to the GF_PropertyType
  for which the OM_Observation:result
  provides an estimate of its
  value."""^^xsd:string .
```

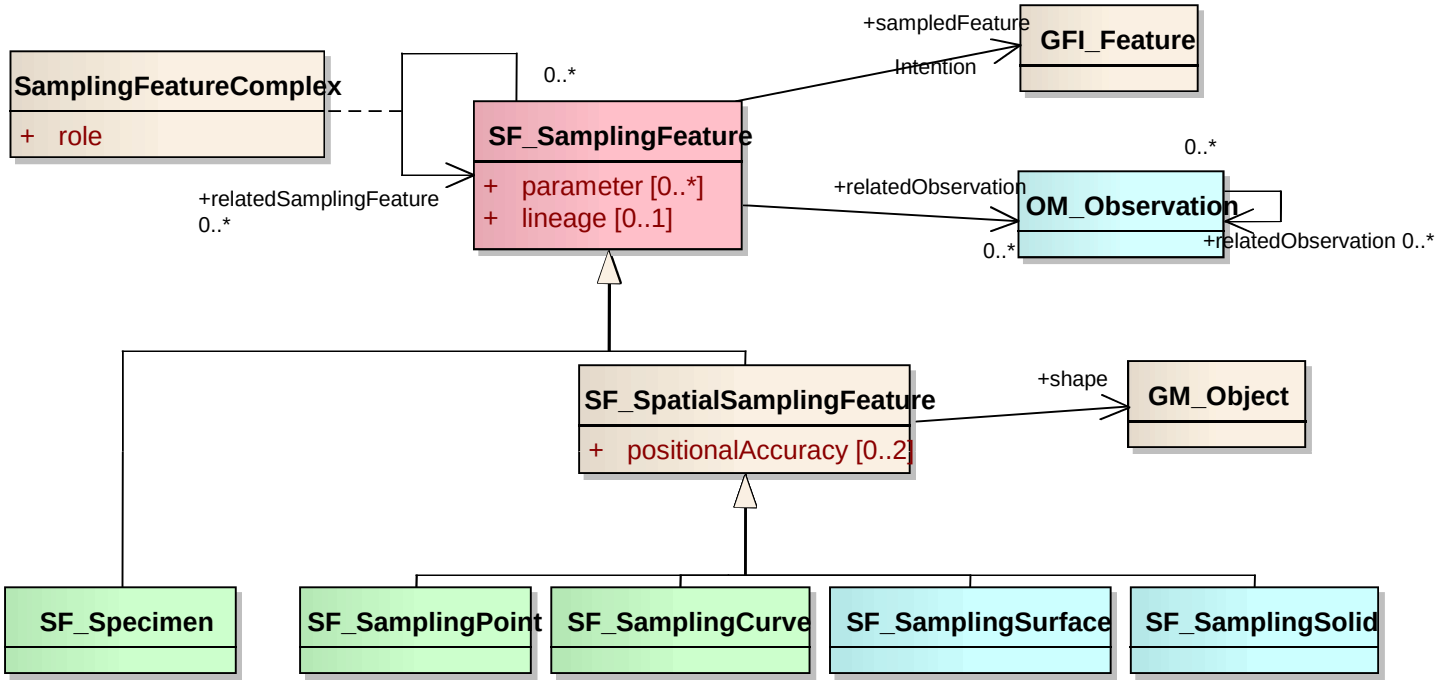
COMPARE WITH SSN

Side by side instances

```
p1:obsTest1
 rdf:type om:Measurement ;
 om:featureOfInterest    <http://wfs...&featureid=fruit37f> ;
 om:observedProperty
    <http://sweet.jpl.nasa.gov/2.0/phys.owl#Mass> ;
 om:phenomenonTime p1:ot1t ;
 om:procedure p1:Sscales1 ;
 om:result
 [ rdf:type basic:Measure ;
  basic:uom <http://www.opengis.net/def/uom/UCUM/0/kg> ;
  basic:value "0.28"^^basic:Number  ] ;
 om:resultTime p1:ot1t ;
 om:parameter
 [ rdf:type om:NamedValue ;
  om:name
    <http://sweet.jpl.nasa.gov/2.0/physThermo.owl#Temperature> ;
  om:value
  [ rdf:type basic:Measure ;
    basic:uom <http://www.opengis.net/def/uom/UCUM/0/Cel> ;
    basic:value "22.3"^^basic:Number   ]  ] .

p1:Sscales1
 rdf:type om:Process ;
 rdfs:label "Salter scales"^^xsd:string .

p1:ot1t
 rdf:type tm:Instant ;
 tm:dateTimePosition "2005-01-11T16:22:25.00"^^xsd:dateTime .
```

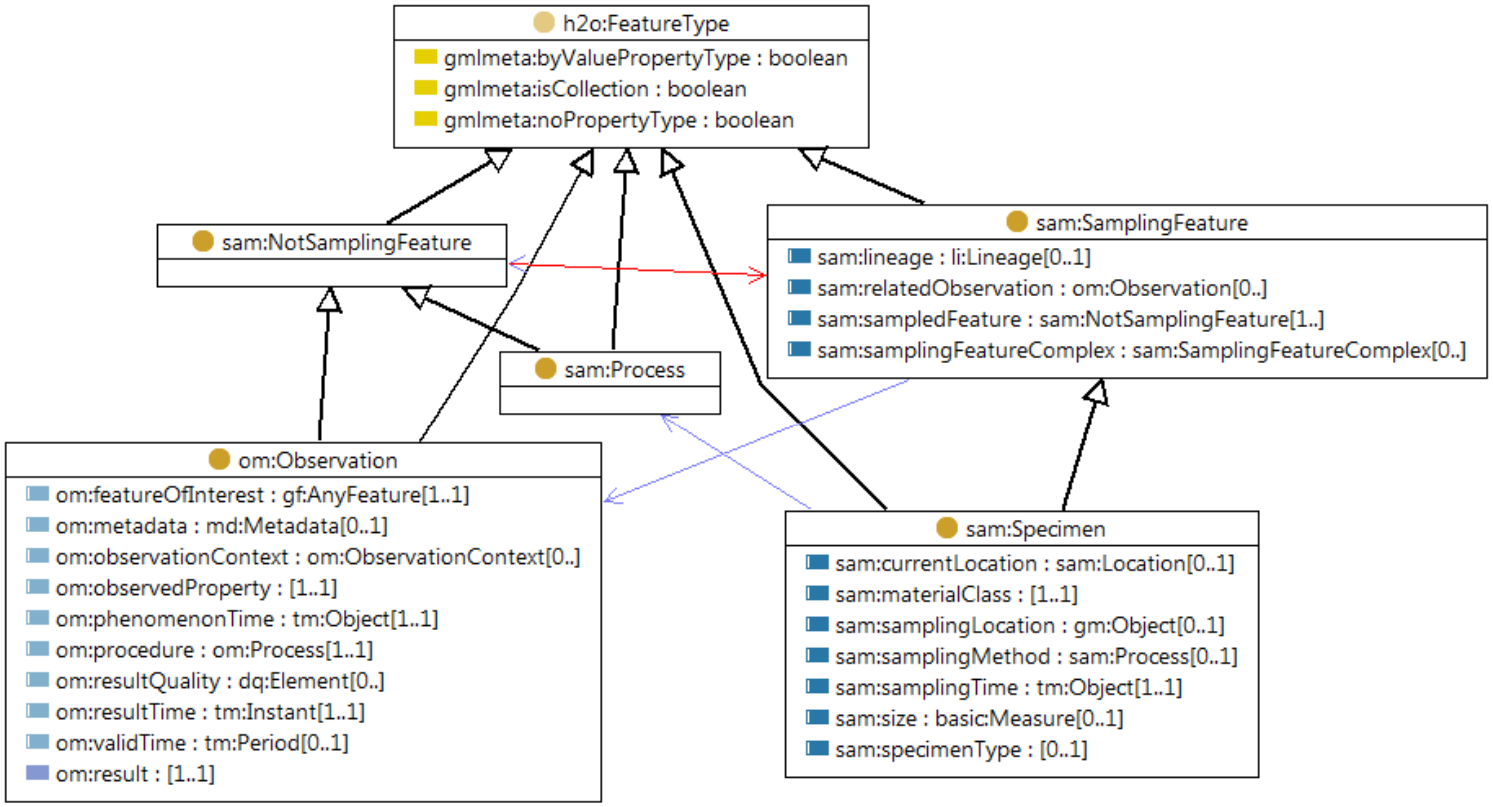
```
p1:obsTest1
 rdf:type ssn:Observation ;
 ssn:featureOfInterest    <http://wfs...&featureid=fruit37f> ;
 ssn:observedProperty <http://qudt.org/vocab/quantity#Mass> ;
 ssn:observationSamplingTime  p1:ot1t ;
 ssn:observedBy p1:Sscales1 ;
 ssn:observationResult
 [ rdf:type ssn:SensorOutput ;
  ssn:hasValue
  [ rdf:type DUL:Amount , ssn:ObservationValue ;
    DUL:hasDataValue "0.28"^^xsd:float ;
    DUL:isClassifiedBy <http://qudt.org/vocab/unit#Kilogram> ] ;
  ssn:isProducedBy p1:Sscales1 ] ;
 ssn:observationResultTime p1:ot1t ;
 DUL:hasSetting p1:tempObsTest1 .

p1:tempObsTest1
 a   ssn:Observation ;
 rdfs:comment "Observation of temperature context for
    measurement of fruit mass"^^xsd:string ;
 ...
 DUL:isSettingFor p1:obsTest1 .

p1:Sscales1
 rdf:type ssn:SensingDevice ;
 rdfs:label "Salter scales"^^xsd:string .

p1:ot1t
 rdf:type DUL:Amount ;
 DUL:hasDataValue "2005-01-11T16:22:25.00"^^xsd:dateTime .
```

ISO 19156 Sampling features

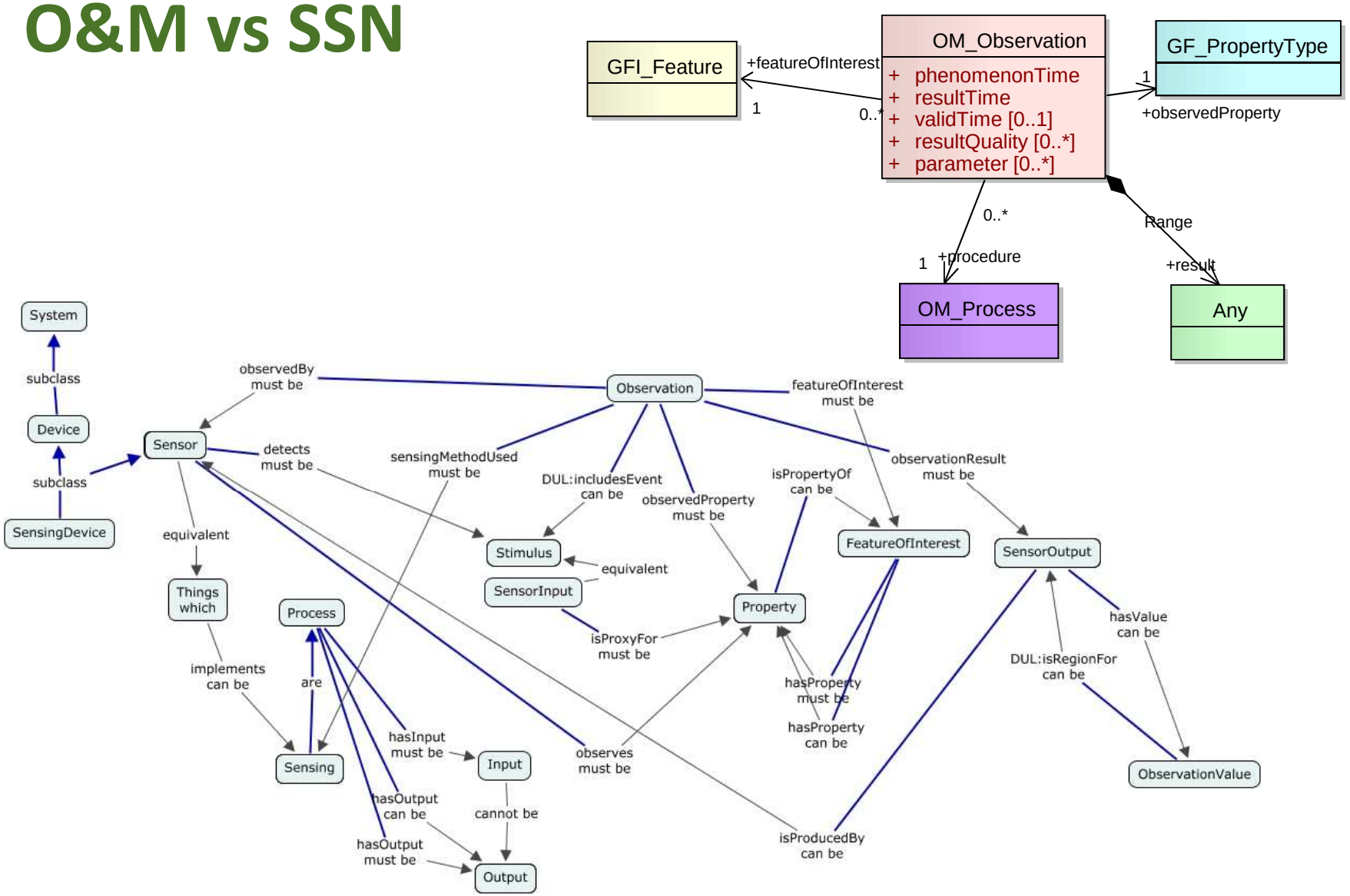


Cox, OGC Abstract Specification – Topic 20: Observations and Measurements 2.0
ISO 19156:2011 Geographic Information – Observations and measurements

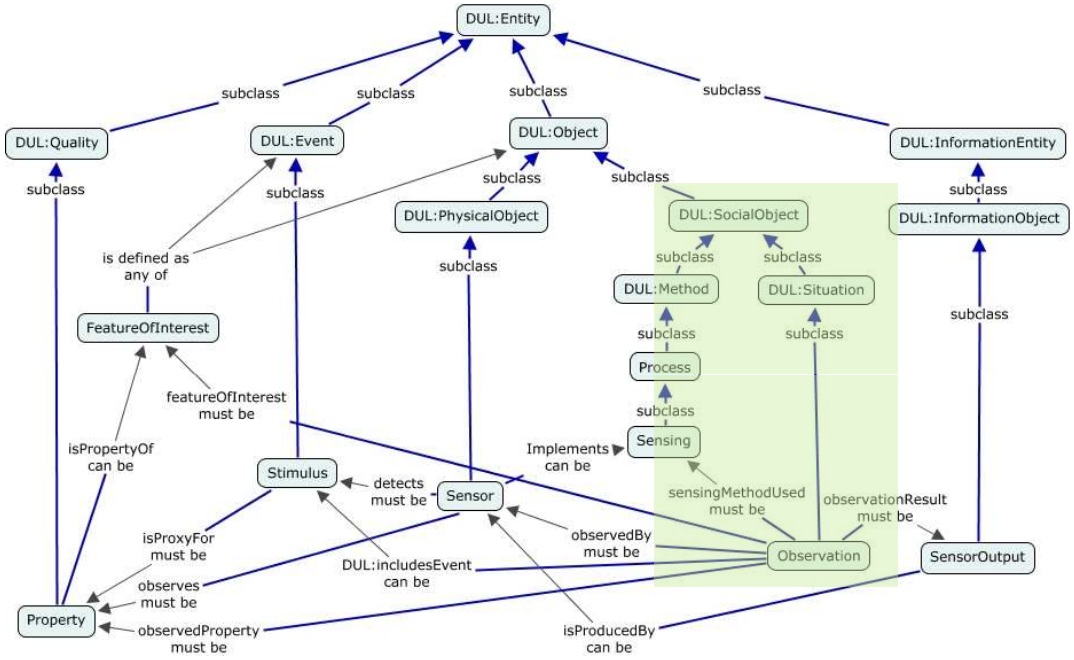
sam:Specimen

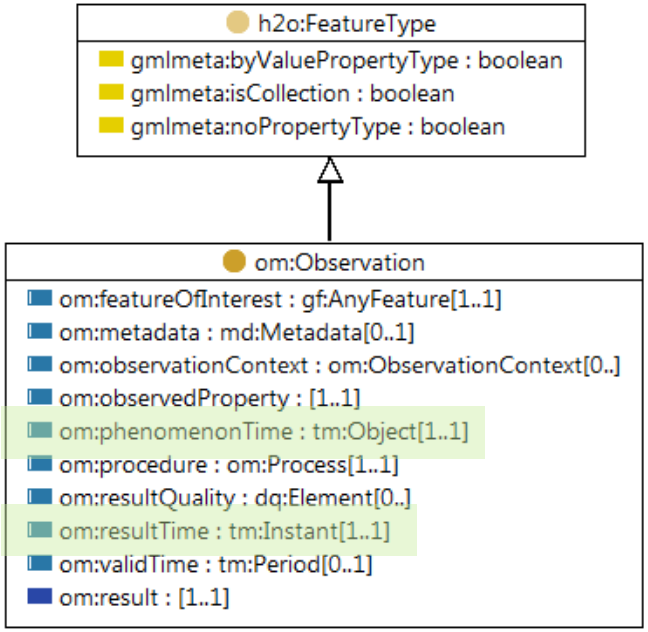


O&M vs SSN


GFI_Feature
+featureOfInterest
1
0..*
OM_Observation
+ phenomenonTime
+ resultTime
+ validTime [0..1]
+ resultQuality [0..*]
+ parameter [0..*]
GF_PropertyType
1
+observedProperty
0..*
1
+procedure
Range
+result
OM_Process
Any
System
subclass
Device
subclass
SensingDevice
Sensor
observedBy must be
Observation
featureOfInterest must be
detects must be
sensingMethodUsed must be
DUL:includesEvent can be
observedProperty must be
isPropertyOf can be
observationResult must be
equivalent
Things which
Stimulus
equivalent
SensorInput
FeatureOfInterest
SensorOutput
Process
Property
isProxyFor must be
implements can be
are
hasProperty must be
hasProperty can be
DUL:isRegionFor can be
hasValue can be
hasInput must be
Input
observes must be
Sensing
hasOutput can be
cannot be
hasOutput must be
Output
isProducedBy can be
ObservationValue

SSN alignment





Alignment strategy

SSN

- Syntactic/semantic alignment (UML→OWL/RDF+DUL) in one step
- Conflates concerns?

OM

- UML→OWL 'syntactic' alignment first
- Semantic alignment (various) in later steps, separate graphs

`rdfs:subClassOf`
`owl:equivalentClass`
`rdfs:subPropertyOf`

SUMMARY

Summary

- Model
  - Rule-based transformation from UML to OWL
  - Dependencies on other ISO 19100 models
- Expressivity
  - SSN & O&M comparable
- Alignment
  - O&M 2.0 Observation is an Event
  - SSN Observation is a DUL:SocialObject
  - Separate syntactic and semantic alignment?

Additional credits

O&M: Fowler & O'Dea, OGC, ISO/TC 211,
Rob Atkinson (CLW), Rob Woodcock(CESRE)

OM Ontology: David Ratcliffe, Michael Compton,
Laurent Lefort (CCI), Jonathan Yu (CLW)

Projects: XMML, pmd*CRC, AuScope, WIRADA, IPBA, eREEFS

Thank you

CSIRO Land and Water
Simon Cox
Research Scientist

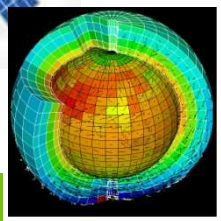
t +61 3 9252 6342
e simon.cox@csiro.au
w www.csiro.au/people/simon.cox

The need for standardisation

- Integrated modelling is becoming the norm
  - bioregional assessment
  - eReefs
- When using heterogeneous (data) sources, discovery & integration is a major challenge

- **Standards make this easier**

  Many private contracts
  →one public agreement



Remote sensing

Earth science

Metrology

Chemistry

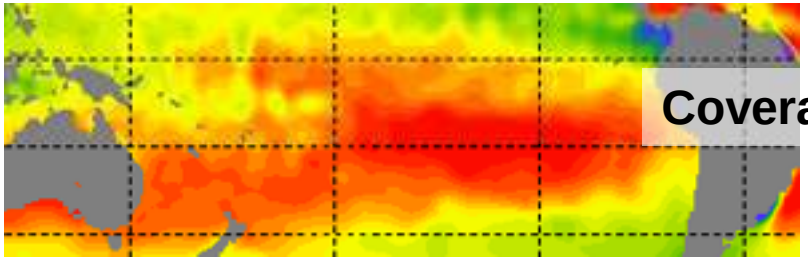
Environmental monitoring

Observations & Measurements	Environmental monitoring
procedure	Gauge, sensor
result	Value, time-series
observed property	Parameter
feature of interest	Station

Views of data

Features

Features exist, have attributes and can be spatially described – 'discrete' or 'vector'



Coverages

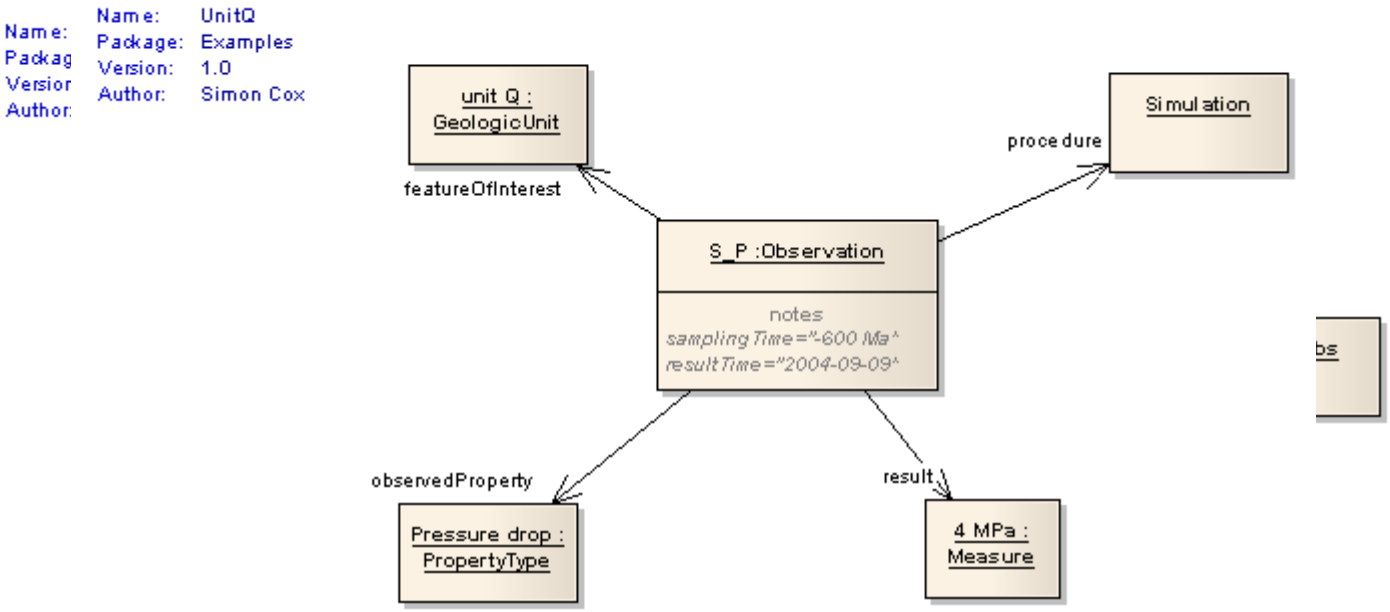
Continuous phenomena, varying in space and time – 'raster'.

A function: spatial, temporal or spatio-temporal domain to attribute range

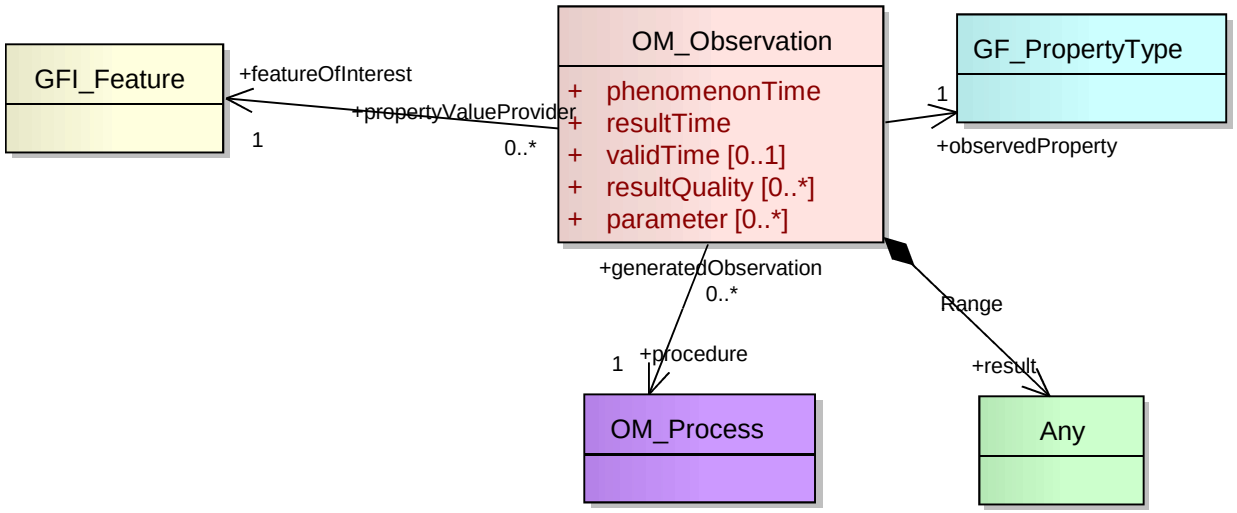
Observations

An act that results in the estimation of the value of a feature property, and involves application of a specified procedure, such as a sensor, instrument, algorithm or process chain

In “pictures”


Name:
Packag
Versior
Author:
Name: UnitQ
Package: Examples
Version: 1.0
Author: Simon Cox
unit Q : GeologicUnit
featureOfInterest
Simulation
procedure
S_P :Observation
notes
samplingTime="-600 Ma^
resultTime="2004-09-09^
observedProperty
Pressure drop : PropertyType
result
4 MPa : Measure

ISO 19156 Observations and Measurements



An Observation is an action whose result is an estimate of the value of some property of the feature-of-interest, obtained using a specified procedure

Cox, OGC Abstract Specification – Topic 20: Observations and Measurements 2.0
ISO 19156:2011 Geographic Information – Observations and measurements

Cross-domain model for observations

- Standard terminology for cross-domain/interdisciplinary use

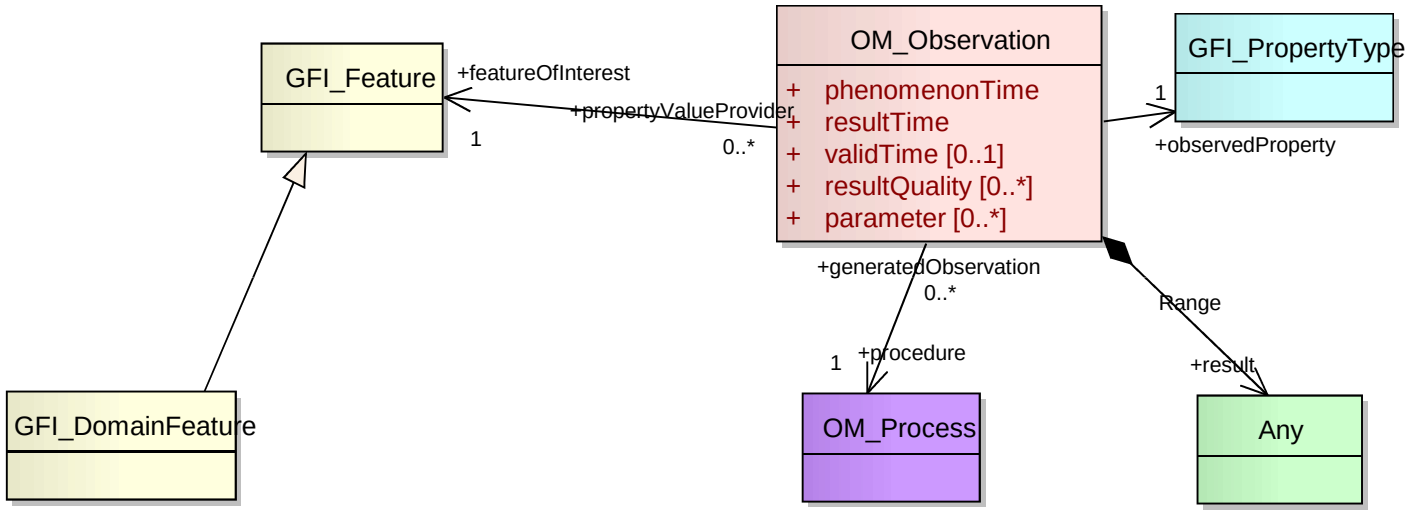
- Broadly applicable
  - In-situ observations, monitoring
  - Remote sensing
  - Sampling and ex-situ (lab) observations
  - Simulations and forecasts

- Adoption
  - GeoSciML, AIXM, INSPIRE, D&I
  - WMO, WaterML, ODIP, ANZSoilML,

Domain specific vocabularies required

observed property

Related to feature-of-interest



feature of interest

Feature-type

Feature instances

procedure

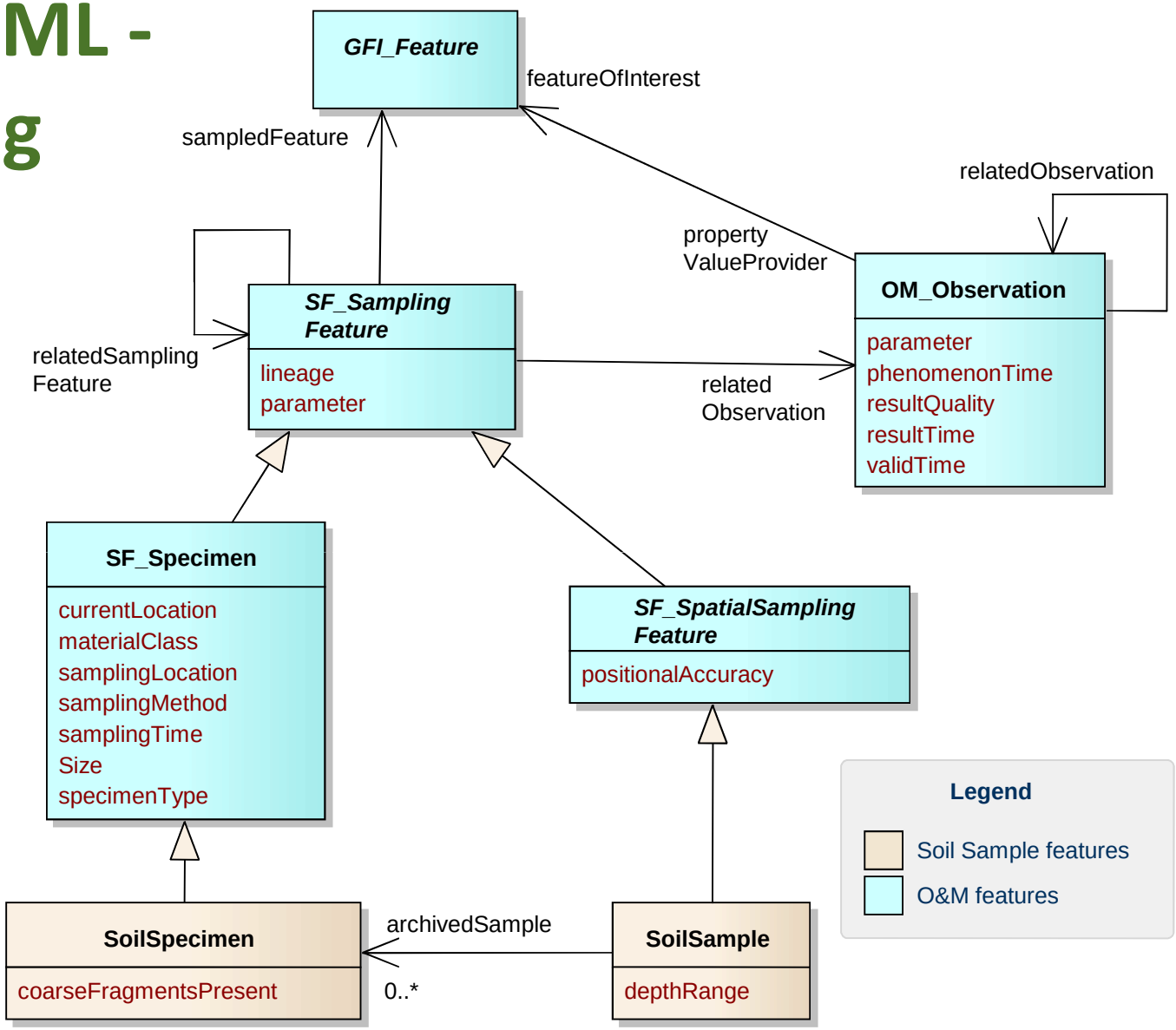
Standard procedures,

result

GML, SWE, netCDF

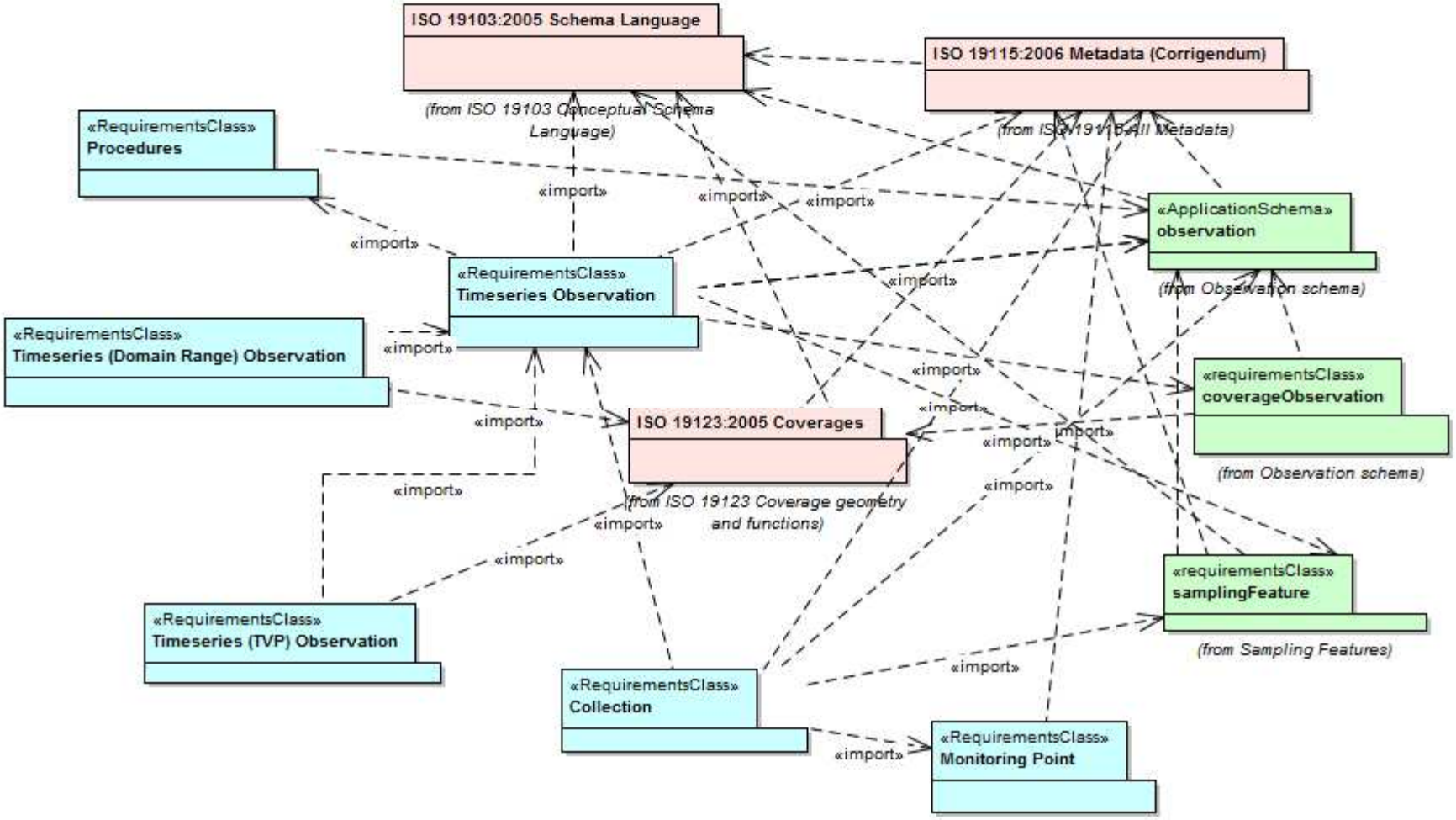
APPLICATIONS

ANZSoilML - sampling



Simons, Wilson, Ritchie, Cox – ANZ SoilML – EGU 2013
Simons, Wilson, Ritchie – OZ SoilML – ANZ Soils Conference 2013

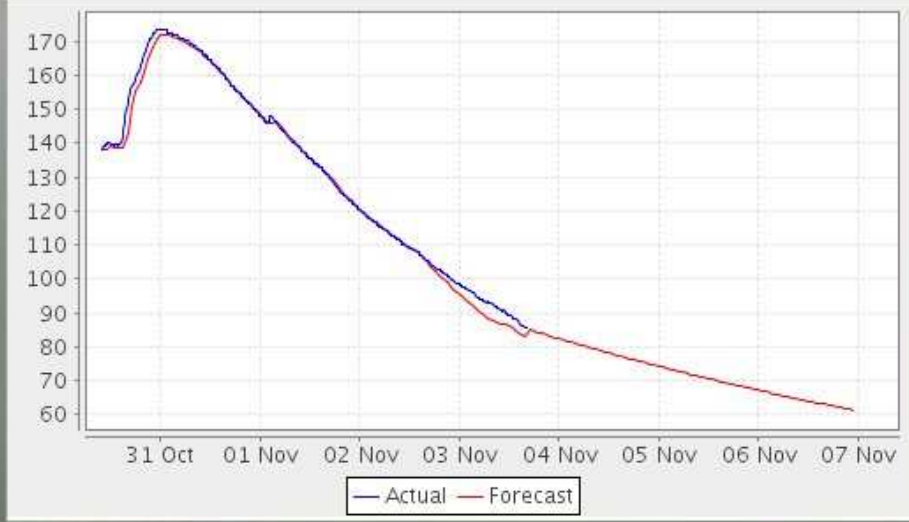
WaterML 2.0



Taylor, OGC Implementation Specification, WaterML 2.0 2012

Catchment | Weather Forecast | Graphing

Water Flow (ML/day) - Nile River at Deddington



Water Level (m) - Nile River at Deddington

General Graph

Environmental Data Discovery and Transformation - Beta Service Version

Forecasting Interoperability Experiment USGS Timeseries Observations

RED RIVER OF THE NORTH AT GRAND FORKS, ND : 05082500
Note: Data loading performs best in **Firefox, Chrome, Safari, or IE9**.

Navigation

- OGC Services
- Interactive Map
- Timeseries Plot

Provisional data subject to revision
Link to plot data: offering=00001&observedProperty=00010
Link to plot data: offering=00003&observedProperty=00060
Return home

Get New Station: 05082500

Begin Date: 2012-07-25
Plot Begins: 2012-07-25

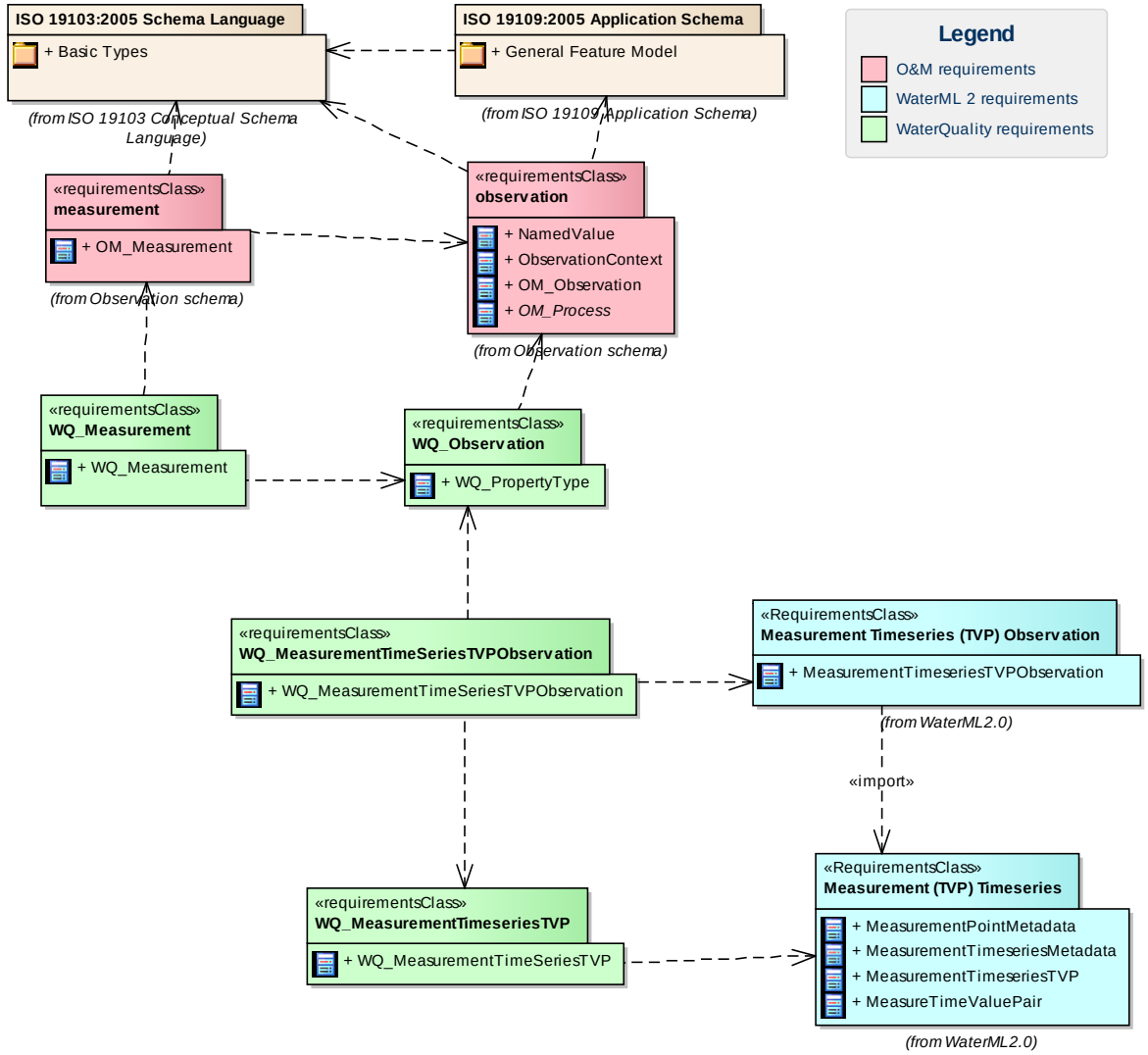
End Date: 2013-07-25
Plot Ends: 2013-07-25

Available Data (choose up to 3 properties to plot):

	Property	Begin date	End date
☐	Temperature, water (deg C) Continuous	2007-10-01	2013-07-25
☑	Temperature, water (deg C) Daily Maximum	1966-07-15	1966-09-30
☐	Temperature, water (deg C) Daily Minimum	1966-07-15	1966-09-30
☐	Temperature, water (deg C) Daily Mean	2007-03-31	2013-07-24
☐	Temperature, water (deg C) Daily Am	1956-10-02	1958-09-30
☐	Temperature, water (deg C) Daily Instantaneous	1958-10-01	1973-09-30
☐	Discharge (cfs) Continuous	2007-	2013-

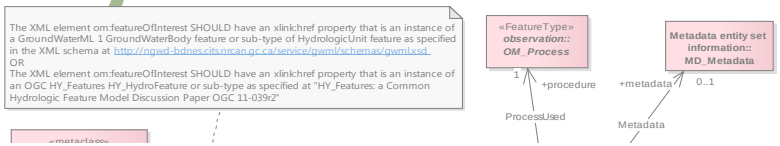
Submit

WQML

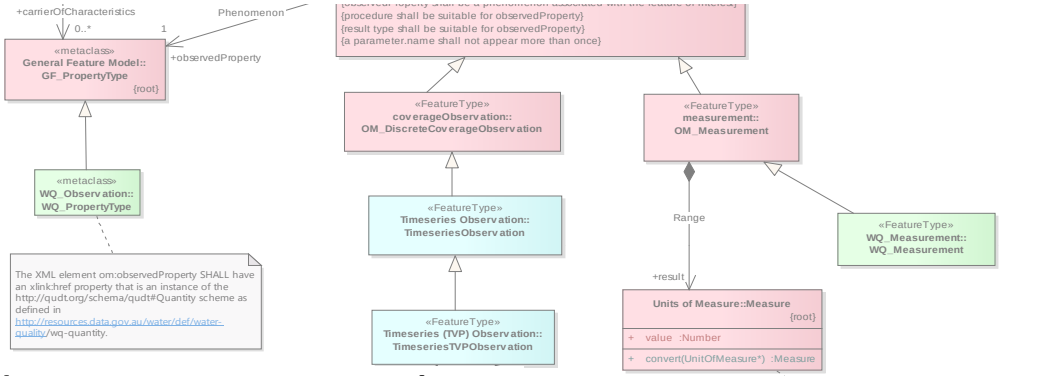


Simons, Cox – IPBA Report, 2013

Water quality observations model

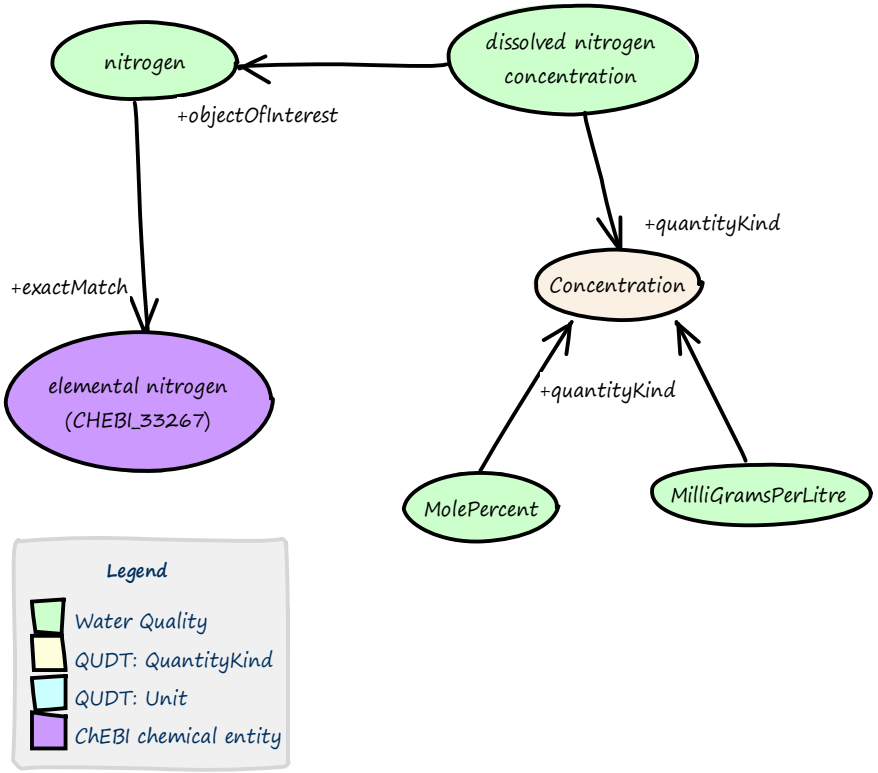


- The observation feature of interest must be either a groundwater or geofabric feature

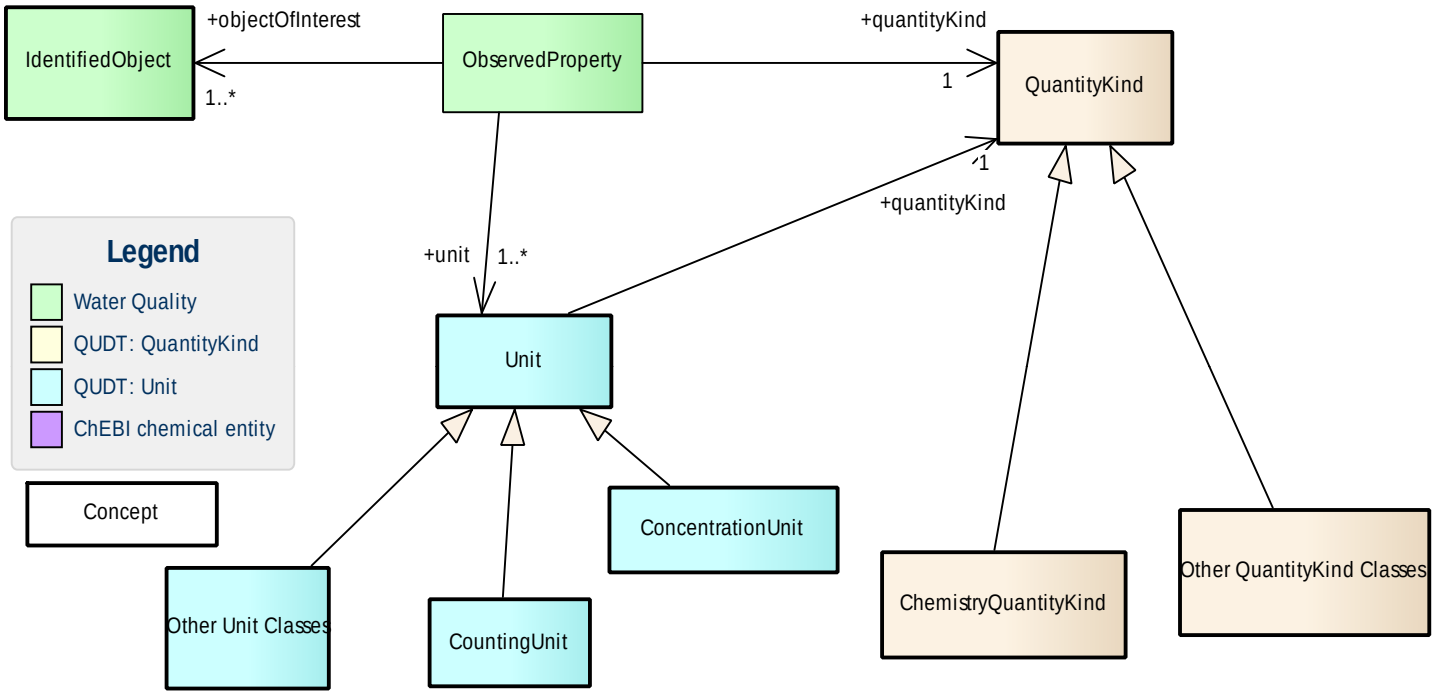


- The observed property must be a water-quality parameter
- The units of measure must match the water-quality parameter

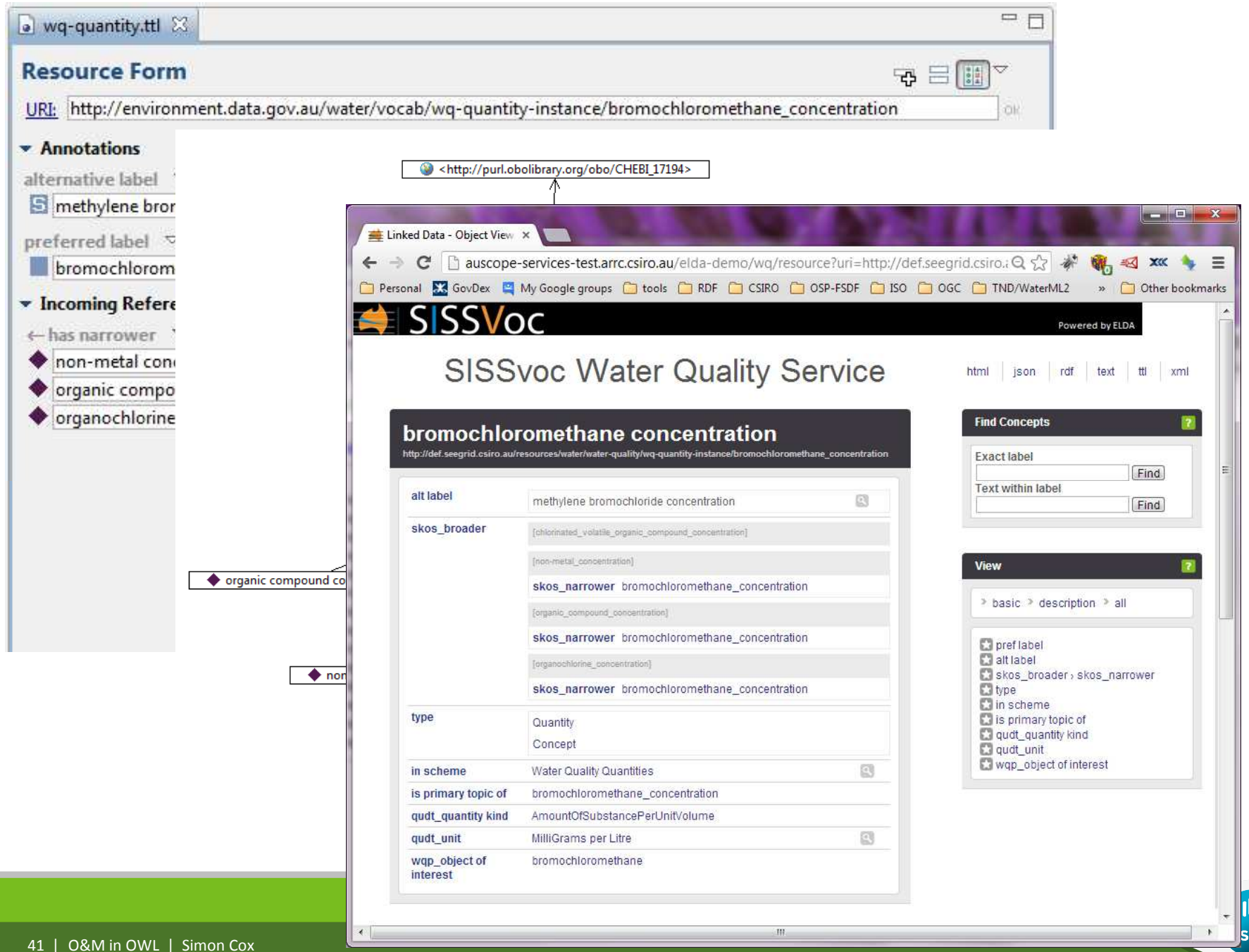
Observed properties – water quality



WQ Properties model



Simons, Yu, Cox – IPBA Report 2013
Cox, Simons Yu – AGU Fall Meeting 2013


wq-quantity.ttl
Resource Form
URI: http://environment.data.gov.au/water/vocab/wq-quantity-instance/bromochloromethane_concentration
Annotations
alternative label
methylene bror
preferred label
bromochlorom
Incoming Refere
has narrower
non-metal con
organic compo
organochlorine
<http://purl.obolibrary.org/obo/CHEBI_17194>
organic compound co
Linked Data - Object View
auscope-services-test.arrc.csiro.au/elda-demo/wq/resource?uri=http://def.seegrid.csiro.
Personal
GovDex
My Google groups
tools
RDF
CSIRO
OSP-FSDF
ISO
OGC
TND/WaterML2
Other bookmarks
SISSVoc
Powered by ELDA
SISSvoc Water Quality Service
html
json
rdf
text
ttl
xml
bromochloromethane concentration
http://def.seegrid.csiro.au/resources/water/water-quality/wq-quantity-instance/bromochloromethane_concentration
alt label
methylene bromochloride concentration
skos_broader
[chlorinated_volatile_organic_compound_concentration]
[non-metal_concentration]
skos_narrower bromochloromethane_concentration
[organic_compound_concentration]
skos_narrower bromochloromethane_concentration
[organochlorine_concentration]
skos_narrower bromochloromethane_concentration
type
Quantity
Concept
in scheme
Water Quality Quantities
is primary topic of
bromochloromethane_concentration
qudt_quantity kind
AmountOfSubstancePerUnitVolume
qudt_unit
MilliGrams per Litre
wqp_object of interest
bromochloromethane
Find Concepts
Exact label
Find
Text within label
Find
View
basic
description
all
pref label
alt label
skos_broader › skos_narrower
type
in scheme
is primary topic of
qudt_quantity kind
qudt_unit
wqp_object of interest

WQ Ontology

- Immediate requirements
  - IPBA, eReefs partners, BoM
- Harmonization and alignment
  - CUAHSI, EPA, USGS
  - ChEBI - Chemical Entities of Biological Interest
  - QUDT – NASA/TopBraid
- Formalization
  - Semantic Web technologies – RDF/OWL/SKOS
- Publication
  - SISSvoc