Towards a semantic approach for environmental timeseries data reusability

FAIR Data Science for Green Life Sciences
Session B: Intelligent data infrastructures in agrifood

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Motivation

- Semantic heterogeneity
- Environmental timeseries
- Re-usability
- E-scientists

Assumptions - What is a dataset?

- A collection of observations
- with arbitrary:
  - format/syntax
  - vocabulary

A specific problem: DSSAT to APSIM

dssat.txt — inputs

```
! SRAD     daily Insolation Incident On A Horizontal Surface (MJ/m^2/day)
! T2M      Average Air Temperature At 2 m Above The Surface Of The Earth (degrees C)
! TMIN     Minimum Air Temperature At 2 m Above The Surface Of The Earth (degrees C)
! TMAX     Maximum Air Temperature At 2 m Above The Surface Of The Earth (degrees C)
! RH2M     Relative Humidity At 2 m (%)
! TDEW     Dew/Frost Point Temperature At 2 m (degrees C)
! RAIN     Average Precipitation (mm/day)
! WIND     Wind Speed At 10 m Above The Surface Of The Earth (m/s)
*WEATHER DATA: NASA

@ INSI   WTHLAT   WTHLONG  WELEV   TAV   AMP  REFHT  WNDHT
  NASA   33.500   -80.750     39                      10

@ WEYR WEDAY  SRAD   TMAX   TMIN   RAIN   WIND   TDEW    T2M   RH2M
  2000    1   8.0   16.8    6.5    0.4    0.8   10.1   11.2   92.9
  2000    2  10.7   19.6    9.2    0.0    1.6   12.7   13.7   93.8
  2000    3  12.2   21.7   12.3    0.0    3.0   14.6   16.4   89.6
  2000    4   4.6   21.8   13.9    0.0    5.1   15.9   17.9   88.4
  2000    5  13.6   10.1    4.0    0.0    4.5    1.0    7.2   64.9
  2000    6   9.8    9.8    1.3    0.0    2.5    3.5    6.2   82.8
  2000    7  12.0   15.4    6.7    0.0    3.0    7.7   10.8   80.7
  2000    8   9.3   14.8    1.7    0.0    2.8    2.4    8.4   65.6
  2000    9   4.8   18.6    6.0    0.0    1.9   11.3   12.9   90.0
  2000   10   9.8   20.9   10.9    0.8    4.8   13.3   17.2   77.6
  2000   11  13.9   18.1    6.4    0.0    4.1    4.7   11.2   63.7
  2000   12  13.7   19.4    3.0    0.0    2.4    1.3   10.5   53.2
  2000   13   9.0   21.1    9.5    0.0    5.3    6.8   14.3   60.5
  2000   14  14.3    7.3   -0.3    0.0    5.4   -9.9    3.8   36.4
  2000   15  12.9    8.0   -4.2    0.0    1.6  -11.2    1.1   39.6
  2000   16   8.4   15.9    0.2    0.0    4.2   -0.9    8.2   52.6
  2000   17  13.3   10.6    3.0    0.0    3.7   -1.1    7.5   54.1
  2000   18   2.7    9.8    4.2    6.1    2.8    2.5    6.0   78.2
  2000   19   9.7    6.7    1.6    1.0    2.6   -0.0    3.8   76.1
  2000   20  12.5   11.7    2.4    0.4    6.1    3.9    7.9   75.5
  2000   21  15.6    4.4   -3.5    0.0    3.7   -9.2   -0.5   52.2
  2000   22   6.6    3.0   -5.1    0.9    2.3   -8.2   -0.8   57.1
  2000   23   1.9    6.2    1.9   53.3    2.3    3.2    3.2  100.0
  2000   24   2.2    2.0   -0.2   39.0    5.3   -0.4    0.8   92.2
```

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Yucheng.met — inputs

```
[weather.met.weather]

Latitude    =    36.68
longitude    =    116.98
tav    =    14.6    (oC) !    annual    average    ambient    temperature
amp    =    28.2    (oC) !    annual    amplitude mean    monthly    temperature
!!!!    1/01/1961    to    31/12/2005
day    year    radn    maxt    mint    rain    wind    RH
273    2002    17.5    27.2    14.6    0    3.5    54
274    2002    13.6    23.1    14.7    0    5.3    40
275    2002    15.8    27.1    11.1    0    5.5    29
276    2002    15.5    25.8    16.5    0    3.8    39
277    2002    14.9    25.5    14.6    0    2.5    63
278    2002    15.2    23.1    15.2    0    3      47
279    2002    13.4    19.9    10.9    0    3      38
280    2002    15.7    19.3    8.2     0    2.5    47
281    2002    15.3    22.9    8.6     0    3.8    41
282    2002    15.4    26      14.3    0    5.8    30
283    2002    10.9    24.1    16.1    0    4.3    47
284    2002    14.1    26.2    17.6    0    3.3    54
285    2002    9.5     24.1    19.4    0    4.8    50
286    2002    14.7    24.2    13.5    0    3.8    22
287    2002    11.7    25.8    19      0    6.3    43
288    2002    15.7    27.3    12.8    0    2.8    42
289    2002    15.2    30.7    22      0    7.3    34
290    2002    12.2    30.2    21.3    0    5.5    58
291    2002    4.2     23.4    9.5     4.9  5.5    89
292    2002    4.2     10.8    6.4     0.7  5.3    79
293    2002    9.1     13.8    6.4     0.3  3.5    60
294    2002    15.8    10.3    5.2     0    4.3    51
295    2002    8.1     11.6    3.5     0    2.8    52
296    2002    14.6    15.9    5.6     0    5.5    46
```

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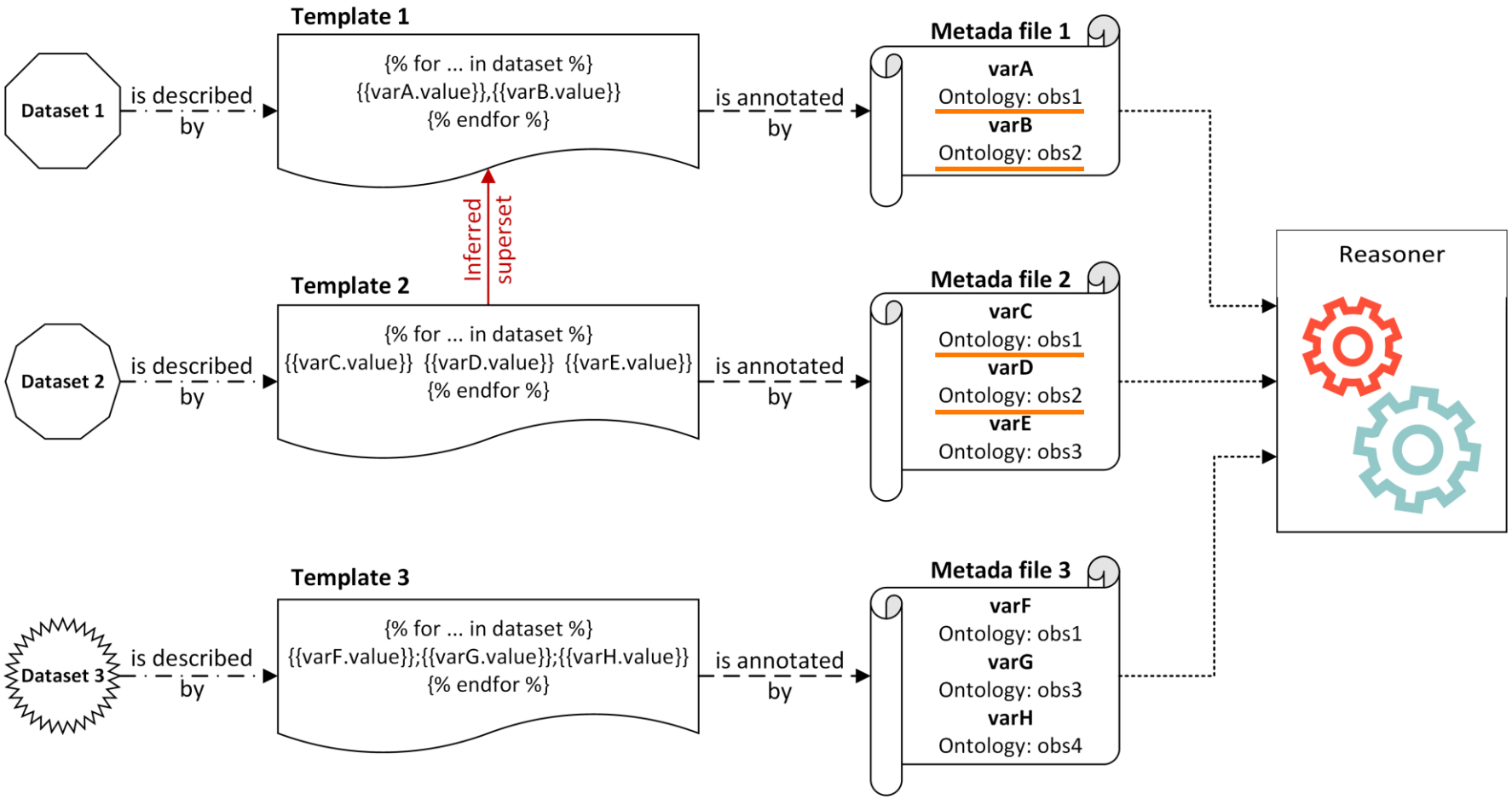
Abstract architectural design



Workflow

The user:

- Drafts template
  - One template per syntax
- Annotates observables with terms from an ontology
- Defines the corresponding units of measurement
  - *Metadata file* is bound to a template

The reasoner:

- Parses *metadata files*
- Creates dataset axioms
- Infers compatibility

APSIM example: Input template

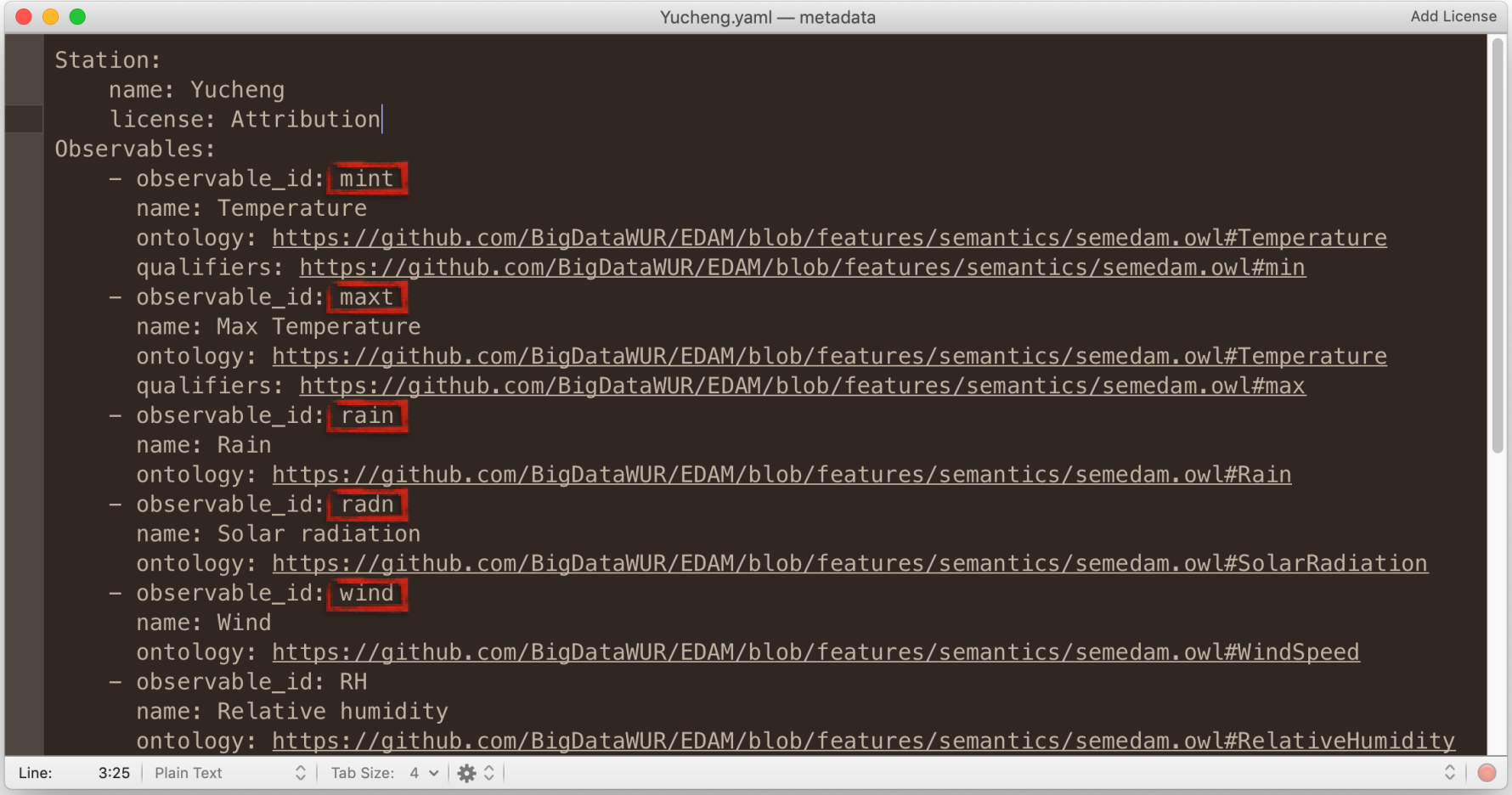
APSIM.MET — inputs

```
[weather.met.weather]

Latitude   =   36.68
longitude   =   116.98
tav   =   14.6   (oC)   !   annual   average   ambient   temperature
amp   =   28.2   (oC)   !   annual   amplitude   in   mean   monthly   temperature
!!!!   1/01/1961   to   31/12/2005
day   year   radn   maxt   mint   rain   wind   RH
273   2002   17.5   27.2   14.6   0   3.5   54
274   2002   13.6   23.1   14.7   0   5.3   40
275   2002   15.8   27.1   11.1   0   5.5   29
276   2002   15.5   25.8   16.5   0   3.8   39
277   2002   14.9   25.5   14.6   0   2.5   63
```

APSIM.tmpl — templates

```
[weather.met.weather]

Latitude   =   {{station.latitude}}
longitude   =   {{station.longitude}}
tav   =   {{station.tags.tav}}
amp   =   {{station.tags.amp}}
!!!!   1/01/1961   to   31/12/2005
   day   year   radn   maxt   mint   rain   wind   RH
{%for timestamp, radn,maxt,mint,rain,wind,RH in chunk%}
{{timestamp.dayofyear}}  {{timestamp.year}}  {{radn.value}}  {{maxt.value}}  {{mint.value}}  {{rain.value}}  {{wind.value}}  {{RH.value}}
{%endfor%}
```

APSIM example: Metadata file (Observables)



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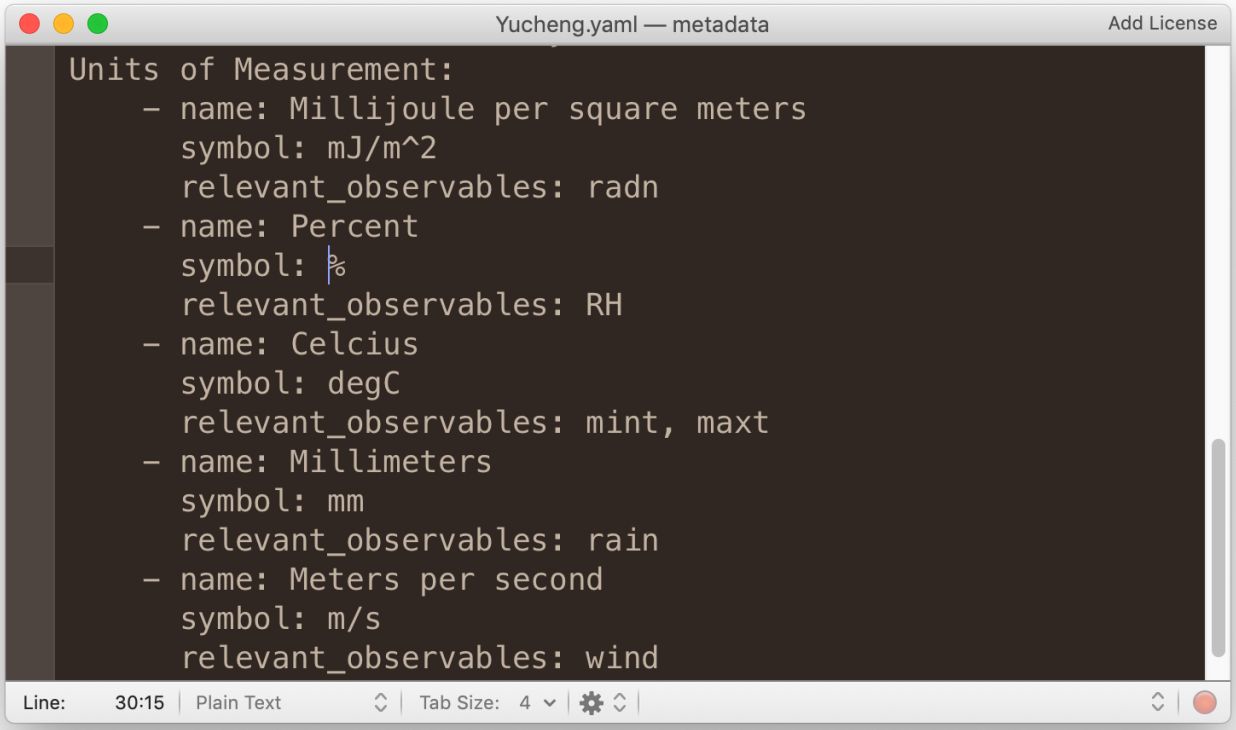
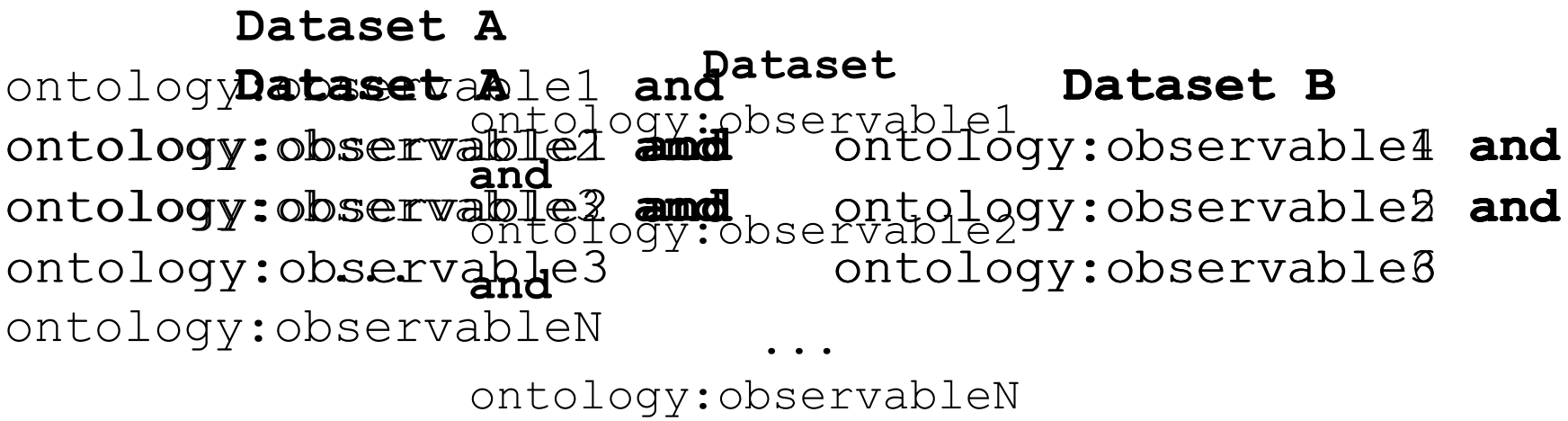
APSIM example: Metadata file (UOMs)



Reasoner - Axioms and compatibility



- A is **equal** to B,
- A is a **superset** of B,
- A is **not compatible** to B

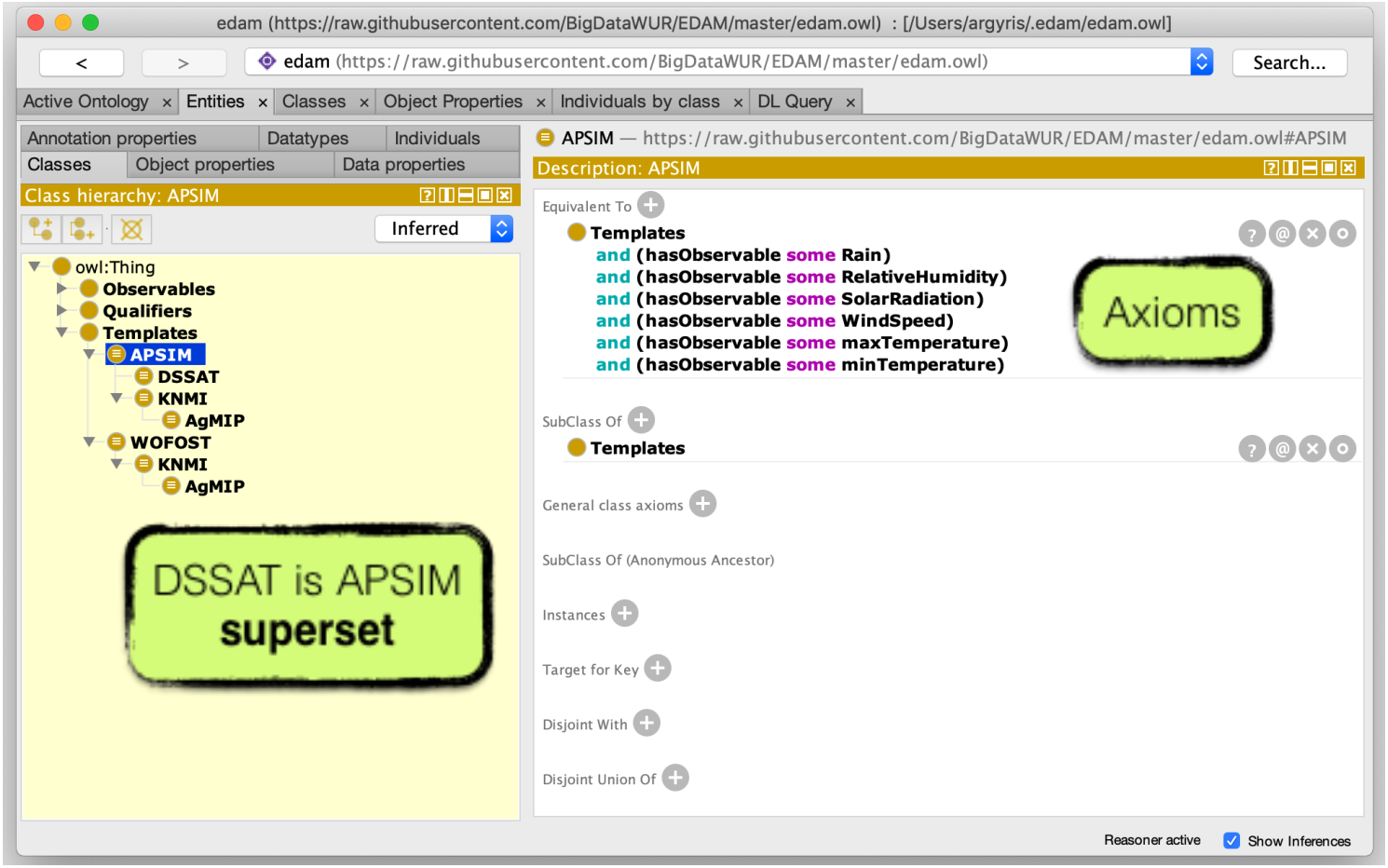
Implementation

- EDAM (`pip install edam`)
- Owlready2
  - Reasoner
- Pint
  - Units of measurement transformation

Demonstration

Observables	**Datasets**				
	APSIM	AgMiP	DSSAT	WOFOST	KNMI
Solar Radiation	radn (mJ/m^2)	SRAD ($MJ/m2$)	SRAD (MJ/m^2)	irradiation (kJ/m^2)	Q (J/cm^2)
Avg Temperature	-	-	T2M (^oC)	-	TG (d^oC)
Max Temperature	maxt (^oC)	TMAX (^oC)	TMAX (^oC)	maxt (^oC)	TX (d^oC)
Min Temperature	mint (^oC)	TMIN (^oC)	TMIN (^oC)	mint (^oC)	TN (d^oC)
Precipitation	rain (mm)	RAIN (mm)	RAIN (mm)	precip (mm)	RH (dmm)
Wind speed	wind (m/s)	WIND (km/h)	WIND (m/s)	mwind (m/s)	FG (dm/s)
Relative Humidity	RH (%)	RHUM (%)	RH2M (%)	-	UG (%)
Dew Point Temperature	-	DEWP (^oC)	TDEW (^oC)	-	-
Vapor Pressure	-	vprs (hPa)	-	emvp (kPa)	PG ($dhPa$)

Reasoner in action - DSSAT and APSIM



Demonstration

Observables	Datasets				
	APSIM	AgMiP	DSSAT	WOFOST	KNMI
Solar Radiation	radn (mJ/m^2)	SRAD ($MJ/m2$)	SRAD (MJ/m^2)	irradiation (kJ/m^2)	Q (J/cm^2)
Avg Temperature	-	-	T2M (^oC)	-	TG (d^oC)
Max Temperature	maxt (^oC)	TMAX (^oC)	TMAX (^oC)	maxt (^oC)	TX (d^oC)
Min Temperature	mint (^oC)	TMIN (^oC)	TMIN (^oC)	mint (^oC)	TN (d^oC)
Precipitation	rain (mm)	RAIN (mm)	RAIN (mm)	precip (mm)	RH (dmm)
Wind speed	wind (m/s)	WIND (km/h)	WIND (m/s)	mwind (m/s)	FG (dm/s)
Relative Humidity	RH (%)	RHUM (%)	RH2M (%)	-	UG (%)
Dew Point Temperature	-	DEWP (^oC)	TDEW (^oC)	-	-
Vapor Pressure	-	vprs (hPa)	-	emvp (kPa)	PG ($dhPa$)

Demo

Findings

- Integrating semantic heterogeneous timeseries is a manual and custom process
- Related modelling solutions use different vocabularies
- Declarative approaches can address semantic heterogeneity
- In EDAM, we took first steps towards:
  - Compatibility inference,
  - Unit transformation,
  - Automatic transformation

Available on pip
`pip3 install edam`

Questions?

Thank you!

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