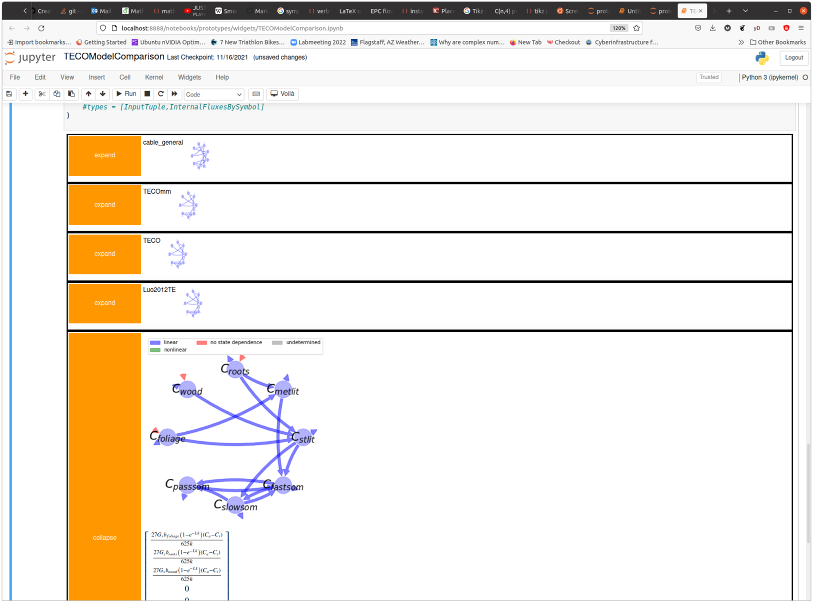
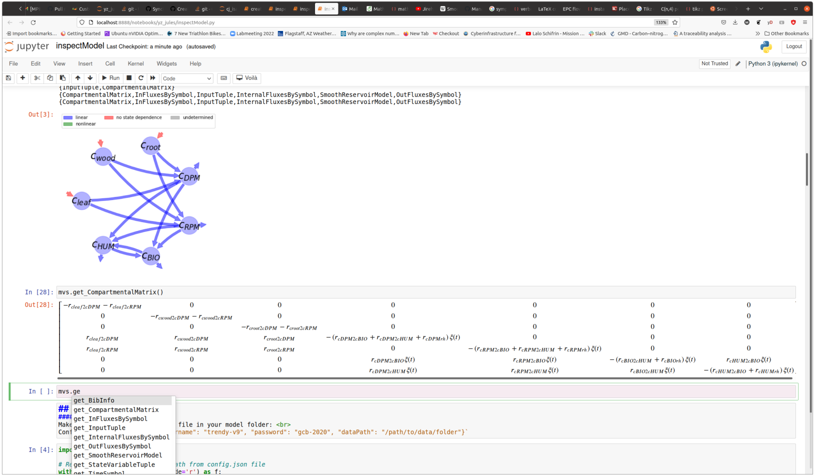
Overview

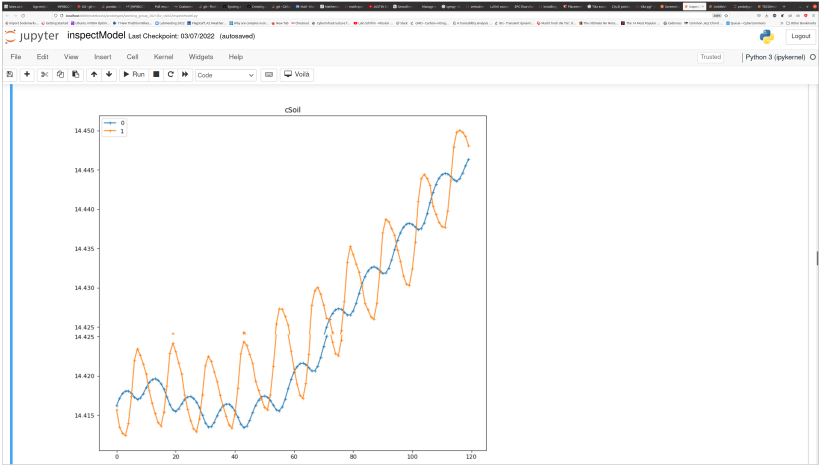
The Biogeochemical Model Database bgc_md2



Analysis with symbolic tools . . .



. . . or numerically



Diagnostic Variables implemented once, available for all models

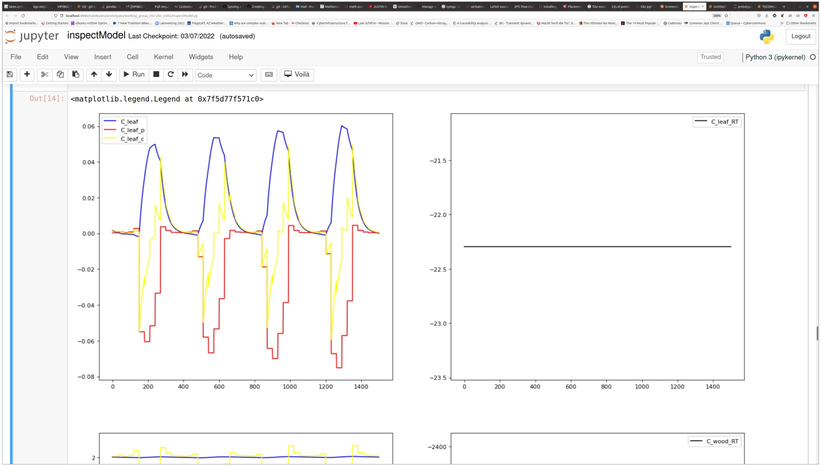


Figure: pool content + Tracebility Analysis: carbon storage potential , carbon storage capacity and residence time

Userinterface using computability graphs

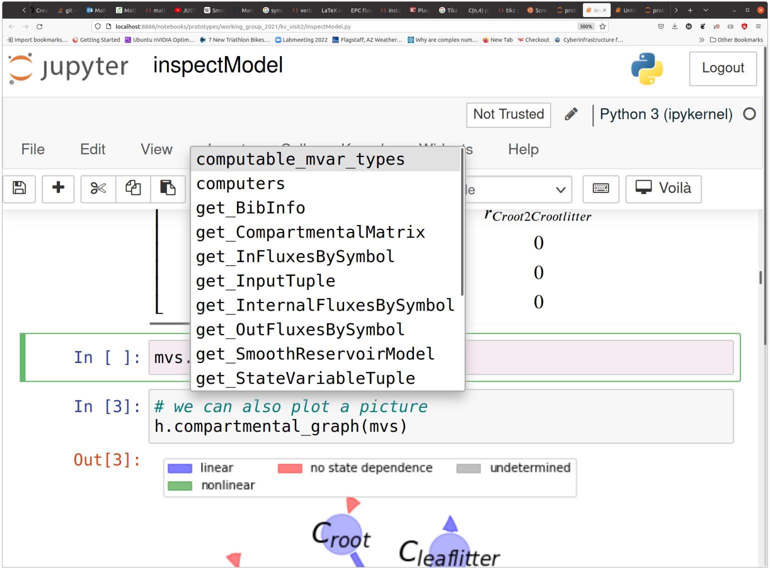
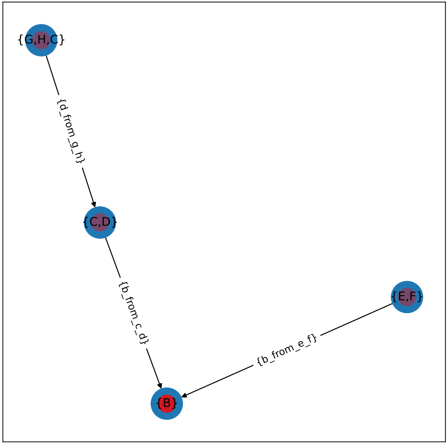


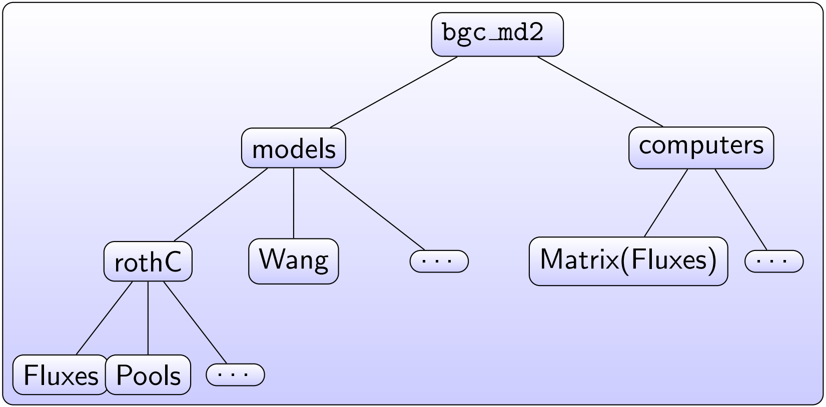
Figure: Suggested methods automatically created by a graph library

Finding what's missing

given a set of functions:
a(i), b(c,d), b(e,f), c(b), d(b), d(g,h), e(b), f(b) and the target variable B
e.g. `CompartmentalMatrix`,
The algorithm computes all possible combinations and paths from which B can be computed.



Internal Structure of bgc_md2



Database records are python modules

mm@Georgia: ~/bgc_md2/talks/bgc_md2_intro

```python
from sympy import  Symbol, Function
from ComputabilityGraphs.CMTVS import CMTVS
from bgc_md2.helper import module_computers
from bgc_md2.models.BibInfo import BibInfo
from bgc_md2.resolve.mvars import (
    InFluxesBySymbol,
    OutFluxesBySymbol,
    InternalFluxesBySymbol,
    TimeSymbol,
    StateVariableTuple,
)
import bgc_md2.resolve.computers as bgc_c

# Make a small dictionary for the variables we will use
sym_dict={
    "r_vl_2_vw": "internal flux rate from leaf to wood",
    "r_vw_2_vl": "internal flux rate from wood to leaf",
    'C_soil_fast': '',
    'C_soil_slow': '',
    'C_soil_passive': '',
    'C_leaf': '',
    'C_root': '',
    'C_wood': '',
    'C_leaf_litter': '',
    'C_root_litter': '',
    'C_wood_litter': '',
    'r_C_leaf_2_C_leaf_litter': '',
    'r_C_root_2_C_root_litter': '',
    'r_C_wood_2_C_wood_litter': '',
    'r_C_leaf_litter_rh': '',
    'r_C_root_litter_rh': '',
    'r_C_wood_litter_rh': '',
    'r_C_soil_fast_rh': '',
    'r_C_soil_slow_rh': '',
    'r_C_soil_passive_rh': '',
    'r_C_leaf_litter_2_C_soil_fast': '',
    'r_C_leaf_litter_2_C_soil_slow': '',
    'r_C_leaf_litter_2_C_soil_passive': '',
    'r_C_wood_litter_2_C_soil_fast': '',
    'r_C_wood_litter_2_C_soil_slow': '',
    'r_C_wood_litter_2_C_soil_passive': '',
    'r_C_root_litter_2_C_soil_fast': '',
    'r_C_root_litter_2_C_soil_slow': '',
    'r_C_root_litter_2_C_soil_passive': '',
    'tas': 'air temperature',
    'mrso': '',
    'T_0': '',
    'E': '',
    'KM': '',
    'beta_leaf': '',
    'beta_wood': '',
}
for k in sym_dict.keys():
    code=k+" = Symbol('{0}')".format(k)
    exec(code)

# some we will also use some symbols for functions (which appear with an argument)
func_dict={
    'xi': 'a scalar function of temperature and moisture and thereby ultimately of time',
    'NPP': '',
}
for k in func_dict.keys():
    code=k+" = Function('{0}')".format(k)
    exec(code)

t=TimeSymbol("t")
beta_root = 1.0- (beta_leaf+beta_wood)
mvs = CMTVS(
```

~/bgc_md2/prototypes/working_group_2021/kv_visit2/source.py 20,25 Top


```python
    exec(code)

# some we will also use some symbols for functions (which appear with an argument)
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    'xi': 'a scalar function of temperature and moisture and thereby ultimately of time',
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for k in func_dict.keys():
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    exec(code)

t=TimeSymbol("t")
beta_root = 1.0- (beta_leaf+beta_wood)
mvs = CMTVS(
```


```python
    {
        t,
        StateVariableTuple((
            C_leaf,
                C_wood,
                C_root,
                C_leaf_litter,
                C_wood_litter,
                C_root_litter,
                C_soil_fast,
                C_soil_slow,
                C_soil_passive,
        )),
        InFluxesBySymbol(
            {
                C_leaf: NPP(t) * beta_leaf,
                C_root: NPP(t) * beta_root,
                C_wood: NPP(t) * beta_wood
            }
        ),
        OutFluxesBySymbol(
            {
                C_leaf_litter: r_C_leaf_litter_rh*C_leaf_litter*xi(t),
                C_wood_litter: r_C_wood_litter_rh*C_wood_litter*xi(t),
                C_root_litter: r_C_root_litter_rh*C_root_litter*xi(t),
                C_soil_fast: r_C_soil_fast_rh*C_soil_fast*xi(t),
                C_soil_slow: r_C_soil_slow_rh*C_soil_slow*xi(t),
                C_soil_passive: r_C_soil_passive_rh*C_soil_passive*xi(t),
            }
        ),
        InternalFluxesBySymbol(
            {
                (C_leaf, C_leaf_litter): r_C_leaf_2_C_leaf_litter*C_leaf,
                (C_wood, C_wood_litter): r_C_wood_2_C_wood_litter*C_wood,
                (C_root, C_root_litter): r_C_root_2_C_root_litter*C_root,
                (C_leaf_litter, C_soil_fast)    : r_C_leaf_litter_2_C_soil_fast * C_leaf_litter*xi(t),
                (C_leaf_litter, C_soil_slow)    : r_C_leaf_litter_2_C_soil_slow * C_leaf_litter*xi(t),
                (C_leaf_litter, C_soil_passive) : r_C_leaf_litter_2_C_soil_passive * C_leaf_litter*xi(t),
                (C_wood_litter, C_soil_fast)    : r_C_wood_litter_2_C_soil_fast * C_wood_litter*xi(t),
                (C_wood_litter, C_soil_slow)    : r_C_wood_litter_2_C_soil_slow * C_wood_litter*xi(t),
                (C_wood_litter, C_soil_passive) : r_C_wood_litter_2_C_soil_passive * C_wood_litter*xi(t),
                (C_root_litter, C_soil_fast)    : r_C_root_litter_2_C_soil_fast * C_root_litter*xi(t),
                (C_root_litter, C_soil_slow)    : r_C_root_litter_2_C_soil_slow * C_root_litter*xi(t),
                (C_root_litter, C_soil_passive) : r_C_root_litter_2_C_soil_passive * C_root_litter*xi(t),
            }
        ),
        BibInfo(# Bibliographical Information
            name="Visit",
            longName="",
            version="1",
            entryAuthor="Konstiantyn Viatkin",
            entryAuthorOrcid="",
            entryCreationDate="",
            doi="",
```

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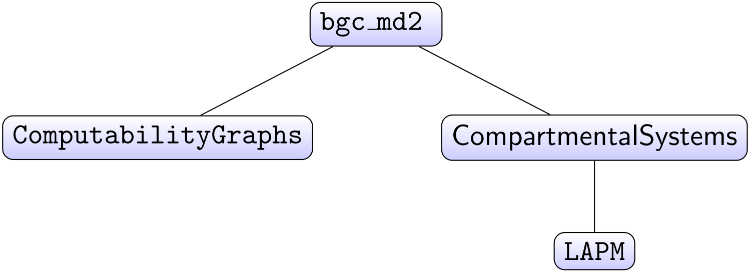
Relation to other Python Packages



Applications

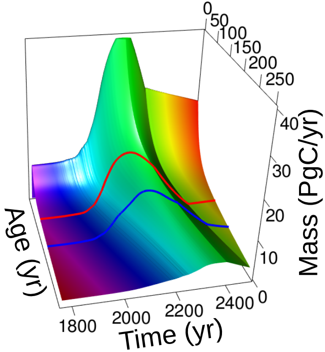


Figure: age distribuition of a pool as function of time

Metzler, H., Müller, M., and Sierra, C. (2018). Transit-time and age distributions for nonlinear time-dependent compartmental systems. *Proceedings of the National Academy of Sciences*, 115:201705296.

Summary: Give me what you have and I"ll show you what I can do with it

bgc_md is a library providing:

1. Datatypes defining building blocks of models e.g. `CompartmentalMatrix`, `InternalFluxesBySymbol`, ...
2. Functions operating on those properties (forming the edges of the graph where the Datatypes are nodes)
3. A user interface based on graph algorithms to
   3.1 compute the set of computable properties (e.g. the comparable criteria for a set of models, database queries)
   3.2 actually compute the desired properties by recursively connecting several function applications.
   3.3 show what is missing to compute a desired property.
4. 30+ vegetation, soil or ecosystem models for carbon and nitrogen cycling as reusable python modules using the building blocks in a flexible way.
5. An interface to *many algorithms* in `CompartmentalSystems` to compute diagnostic variables for *many models* in `bgc_md2`.

Links

- The README of the package on github (wiht installation instructions): https://github.com/MPIBGC-TEE/bgc_md2
- Work in progress using and extending the package: https://github.com/MPIBGC-TEE/bgc_md2/tree/master/prototypes/working_group_2021
- An incomplete tutorial (jupyter notebook) for the creation of a new model. The package has to be installed. https://github.com/MPIBGC-TEE/bgc_md2/blob/master/prototypes/working_group_2021/kv_visit2/createModel.py