
Manaaki Whenua
Landcare Research
Our Land, Our Future
Tō tātou whenua, mō āpōpō

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Landcare Research

An Interoperable Low-Code Modelling Framework for Integrated Spatial Modelling

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Overview

- Smarter Targeting of Erosion Control Research Programme
- BMI – Basic Model Interface Interoperability Standard
- Model Integration Platform - LUMASS
  - Integration of LUMASS models into a BMI composite model
  - Integration of BMI-compliant models into LUMASS compsite models

Smarter Targeting of Erosion Control

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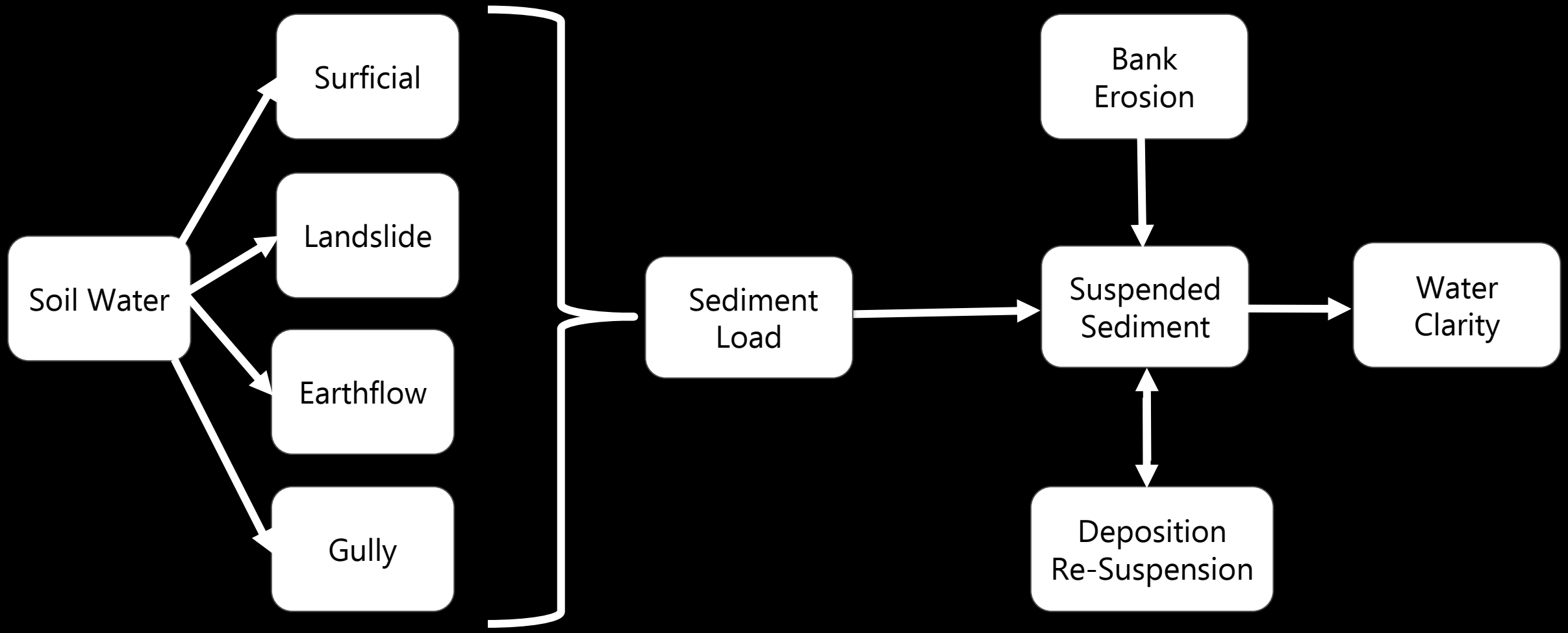
- **Event-Scale Soil Erosion Modelling**
  - High spatial detail so that erosion mitigation can be modelled
  - Temporal variation so that sediment and water quality can be modelled

- **In-Stream Sediment Transport**
  - Temporal (hourly) modelling of suspended sediment, deposition, and re-suspension so that water clarity can assessed

Smarter Targeting of Erosion Control



Smarter Targeting of Erosion Control

Benefits of adding BMI coupling capabilities to LUMASS

- Seamless integration of 'external' model components
- Reduced component development effort through
  - provision of data read/write and other processing components
  - provision of sequential processing
  - provision of multi-threadded processing (bmi-c++)
  - Provision of fine-grained data provenance tracking (PROV-N)
- Simplification of multi-scale model development through
  - provision of hierarchical (processing) workflow engine
  - visual development (coupling) environment

BMI – Basic Model Interface

- Introduced by Peckham et al. (2013)[1]
- Set of functions[2] for
  - Model control
  - Model information
  - Variable information, getter and setter
  - Time
  - Model grid functions

[1] https://doi.org/10.1016/j.cageo.2012.04.002

[2] https://bmi.readthedocs.io/en/latest/

Land Use Management Support System - LUMASS

LUMASS
modelling & optimisation

https://bitbucket.org/landcareresearch/lumass

How does the system work?

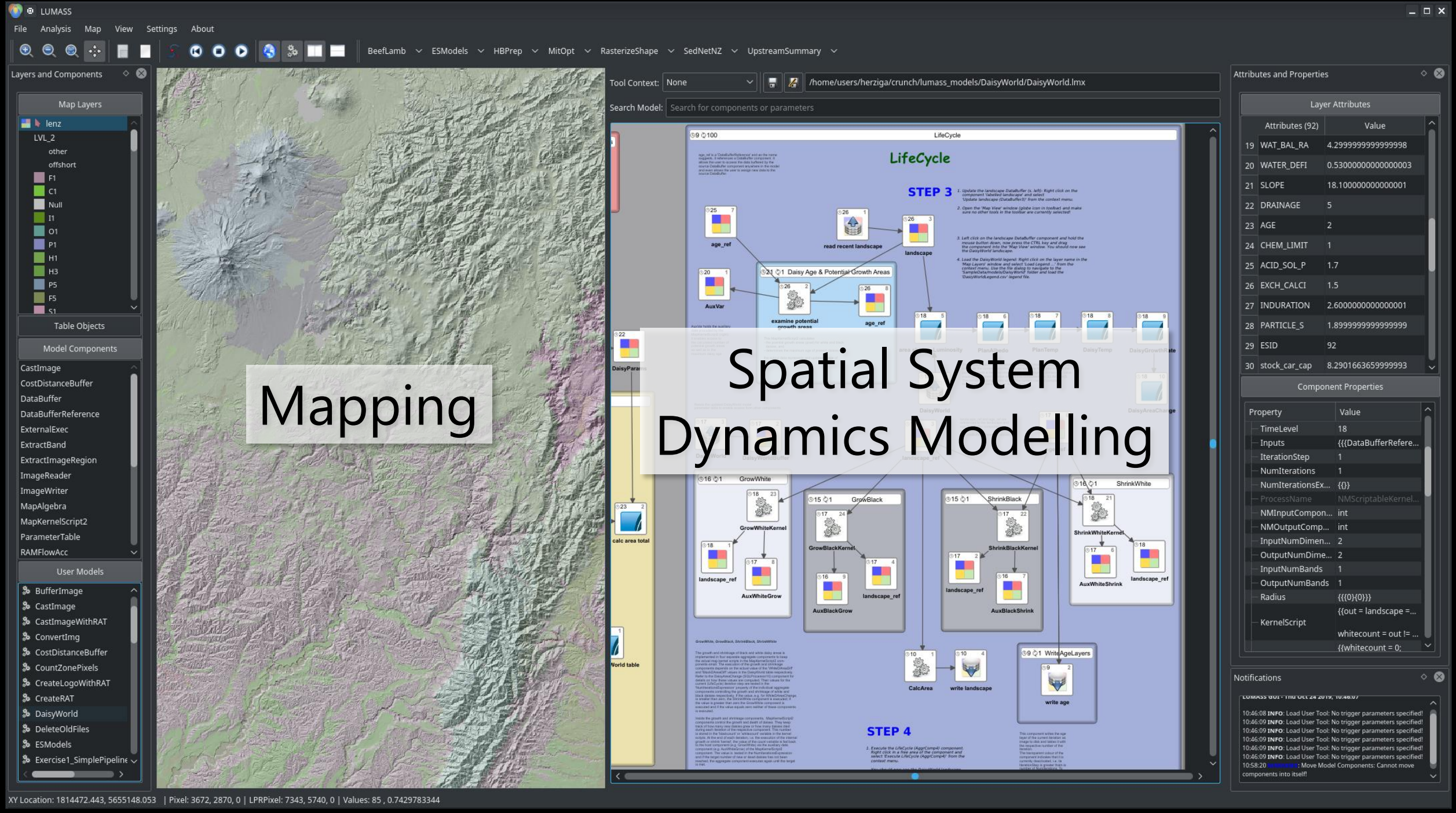
How does it react to management?

- Spatially explicit system dynamics modelling
- System understanding
- Impact assessment

What do we do?

Where do we do it?

- Optimal spatial resource/land-use allocation
- Land-use development scenarios
- Limits testing
- Resource-use efficiency

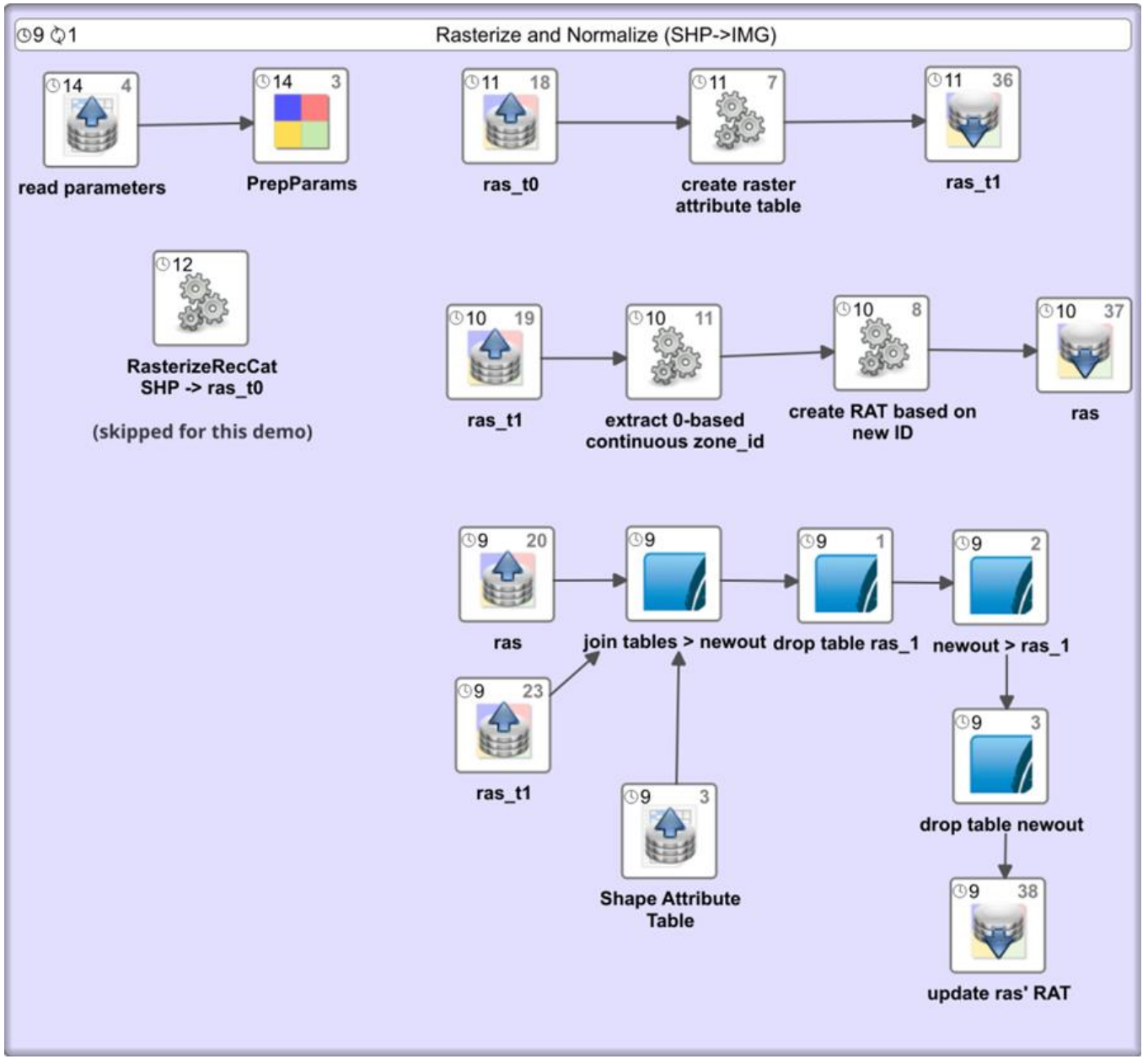

LUMASS
File
Analysis
Map
View
Settings
About
BeefLamb
ESModels
HBPrep
MitOpt
RasterizeShape
SedNetNZ
UpstreamSummary
Layers and Components
Map Layers
lenz
LVL_2
other
offshort
F1
C1
Null
I1
O1
P1
H1
H3
P5
F5
S1
Table Objects
Model Components
CastImage
CostDistanceBuffer
DataBuffer
DataBufferReference
ExternalExec
ExtractBand
ExtractImageRegion
ImageReader
ImageWriter
MapAlgebra
MapKernelScript2
ParameterTable
RAMFlowAcc
User Models
BufferImage
CastImage
CastImageWithRAT
ConvertImg
CostDistanceBuffer
CountZonePixels
CreateLogoWithRAT
CreateRAT
DaisyWorld
DeleteOldFiles
ESModels
Exercise1_SimplePipeline
Mapping
Tool Context:
None
/home/users/herziga/crunch/lumass_models/DaisyWorld/DaisyWorld.lmx
Search Model:
Search for components or parameters
LifeCycle
STEP 3
age_ref
read recent landscape
landscape
AuxVar
Daisy Age & Potential Growth Areas
examine potential growth areas
age_ref
GrowWhite
GrowWhiteKernel
calc area total
landscape_ref
AuxWhiteGrow
GrowBlack
GrowBlackKernel
AuxBlackGrow
landscape_ref
ShrinkBlack
ShrinkBlackKernel
landscape_ref
AuxBlackShrink
ShrinkWhite
ShrinkWhiteKernel
AuxWhiteShrink
landscape_ref
World table
CalcArea
write landscape
WriteAgeLayers
write age
STEP 4
Spatial System Dynamics Modelling
Attributes and Properties
Layer Attributes
Attributes (92)
Value
19 WAT_BAL_RA 4.2999999999999998
20 WATER_DEFI 0.53000000000000003
21 SLOPE 18.100000000000001
22 DRAINAGE 5
23 AGE 2
24 CHEM_LIMIT 1
25 ACID_SOL_P 1.7
26 EXCH_CALCI 1.5
27 INDURATION 2.6000000000000001
28 PARTICLE_S 1.8999999999999999
29 ESID 92
30 stock_car_cap 8.2901663659999993
Component Properties
Property
Value
TimeLevel 18
Inputs {{{DataBufferRefere...
IterationStep 1
NumIterations 1
NumIterationsEx... {{}}
ProcessName NMScriptableKernel...
NMInputCompon... int
NMOutputComp... int
InputNumDimen... 2
OutputNumDime... 2
InputNumBands 1
OutputNumBands 1
Radius {{{0}{0}}}
KernelScript {{out = landscape =...
whitecount = out != ...
{{whitecount = 0;
Notifications
10:46:08 INFO: Load User Tool: No trigger parameters specified!
10:46:09 INFO: Load User Tool: No trigger parameters specified!
10:46:09 INFO: Load User Tool: No trigger parameters specified!
10:46:09 INFO: Load User Tool: No trigger parameters specified!
10:46:09 INFO: Load User Tool: No trigger parameters specified!
10:46:09 INFO: Load User Tool: No trigger parameters specified!
10:58:20 : Move Model Components: Cannot move components into itself!
XY Location: 1814472.443, 5655148.053 | Pixel: 3672, 2870, 0 | LPRPixel: 7343, 5740, 0 | Values: 85 , 0.7429783344

LUMASS Processing Pipelines

support

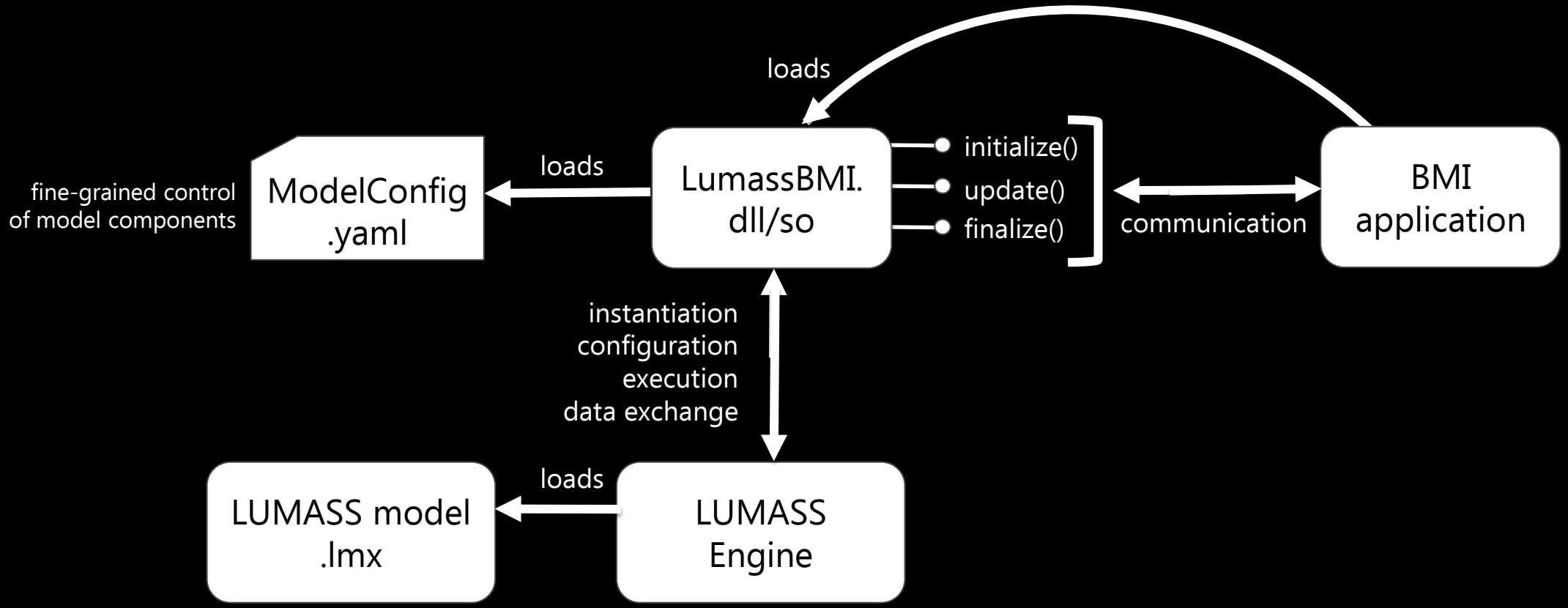
- hierarchical
- sequential
- parallel
- iterable
- multi-dimensional

array processing
and SQLite database
processing

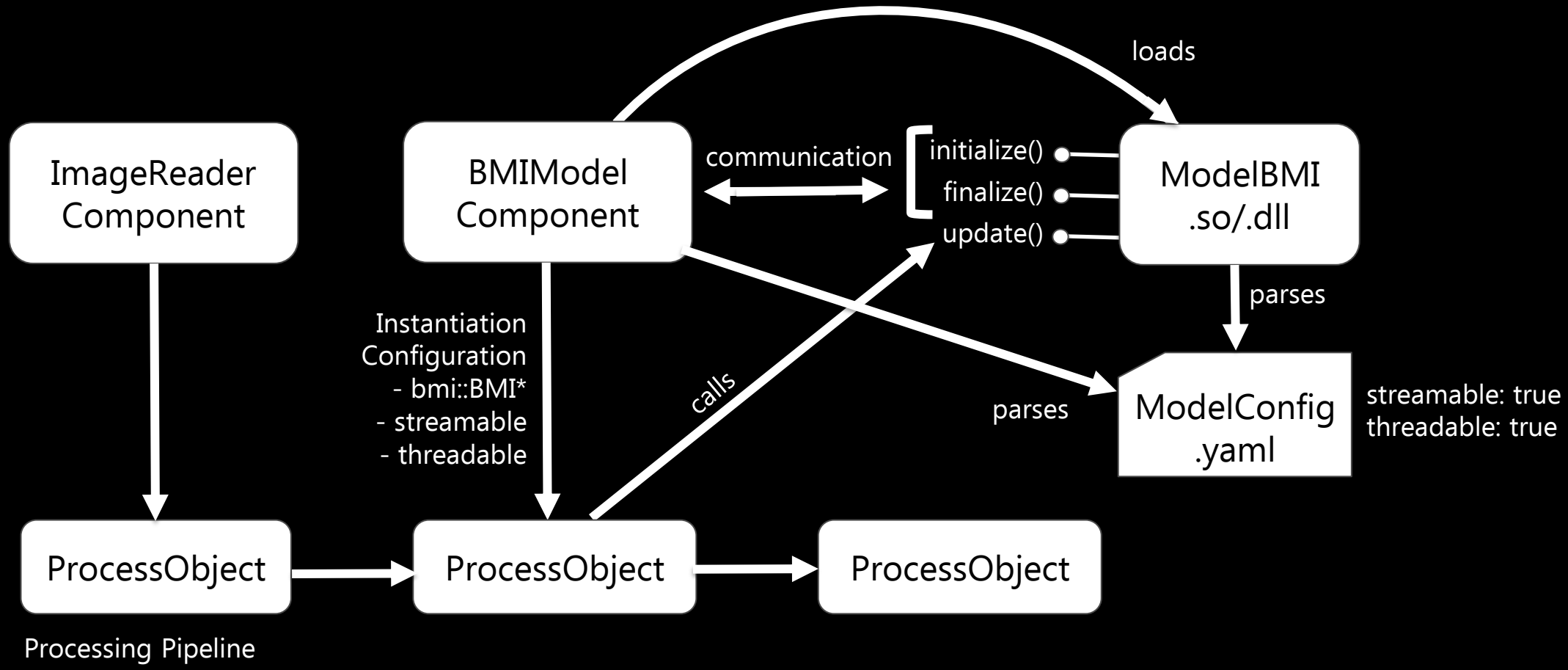


Basic model mechanics: https://www.youtube.com/watch?v=1DN9LcyT9ic
Spatial DaisyWorld: https://www.youtube.com/watch?v=aN2H-izUyCE

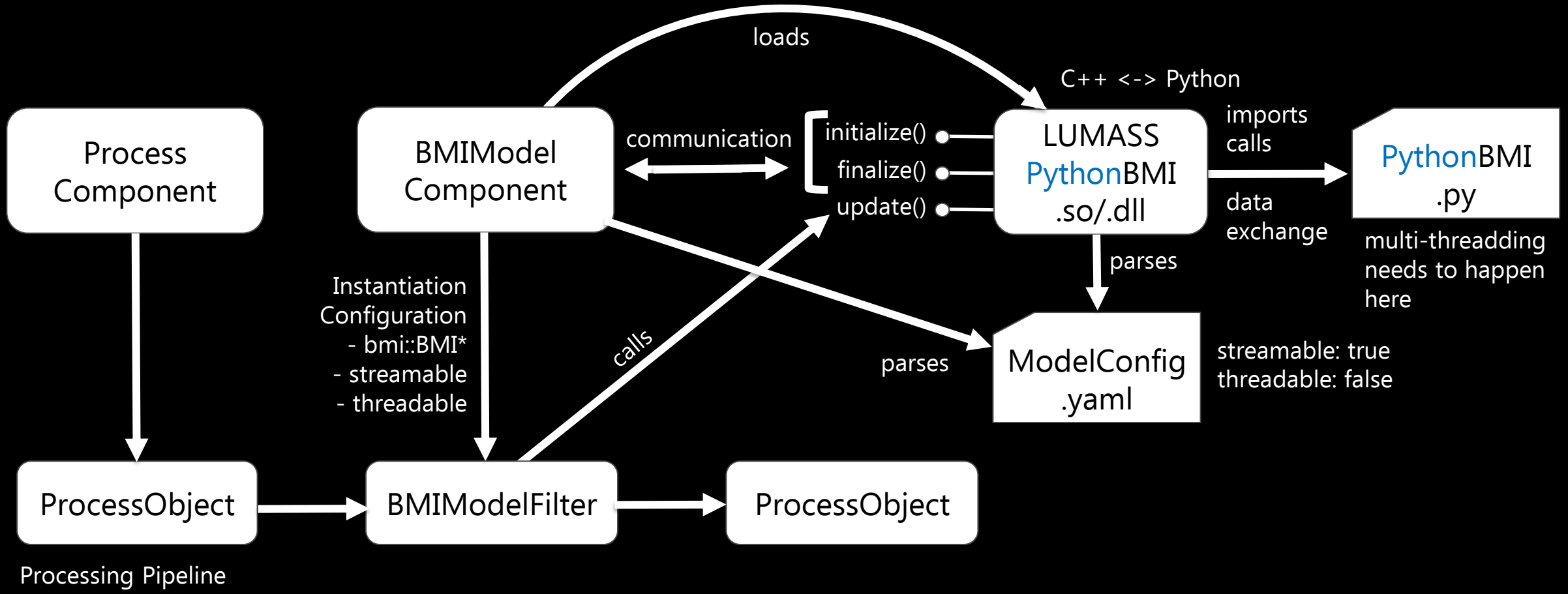
LUMASS to C-BMI



C++ BMI to LUMASS



Python BMI to LUMASS



LumassBMIConfig.yaml

```yaml
# configuration for LUMASS' BMIModel component
LumassBMIConfig:

    # bmi interface type <bmi-cxx | bmi-python>
    type: bmi-python
    # path to bmi library
    #       python: path to *.py module file
    #          e.g.: /home/python/watyieldbmi.py
    #
    #       native: path to  *.dll/*.so
    path: /home/alex/garage/python/watyield/bmi/watyieldbmi.py
    # name of class/module, implementing the BMI interface
    #    python: name of python module / class
    #       e.g.: WatYieldBMI
    #    native: name of bmi::Bmi subclass
    name: WatyieldBMI
    # whether or not the model component produces and output that can
    # be fetched by a downstream component, i.e. the component doesn't
    # write its output
    issink: false
    # whether the component's implemented algorhtim supports streaming,
    # i.e. the sequential processing of parts of the input array;
    # conceptually, algorithms working on a single pixel, local, or
    # focal neighbourhoods are streamable;
    # if issink == true, the component becomes executable and will be
    # called by the lumas model controller depending on the time level
    # of its host BMIModel component
    streamable: true
    # whether or not the component is threadable, i.e. can be called
    # safely from multiple threads of the processing pipeline;
    # note: for python-bmi we assue that any threading is done
    # within the component, e.g. using numba, since the python interpreter
    # cannot be called safely from multiple threads
    threadable: false
```

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