OpenDA-OpenMI framework for Hydrological data assimilation

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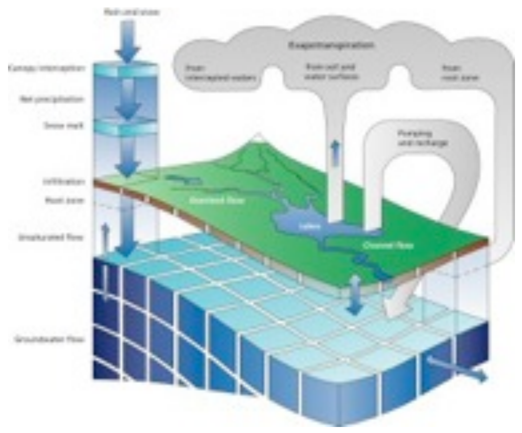
Monday, May 13, 13

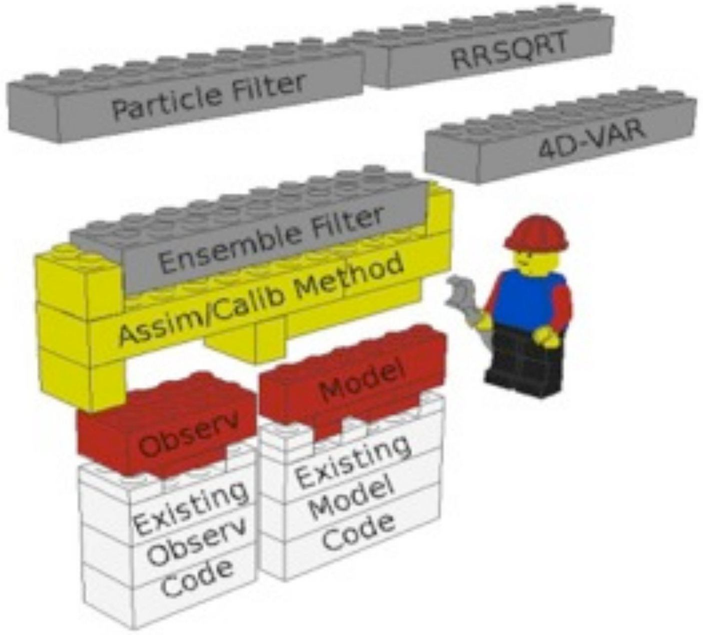
Overview

- Goal
- Black box coupling in OpenDA
- OpenMI
- OpenDA-OpenMI framework
- Problems
- Medium size example
- Next Steps

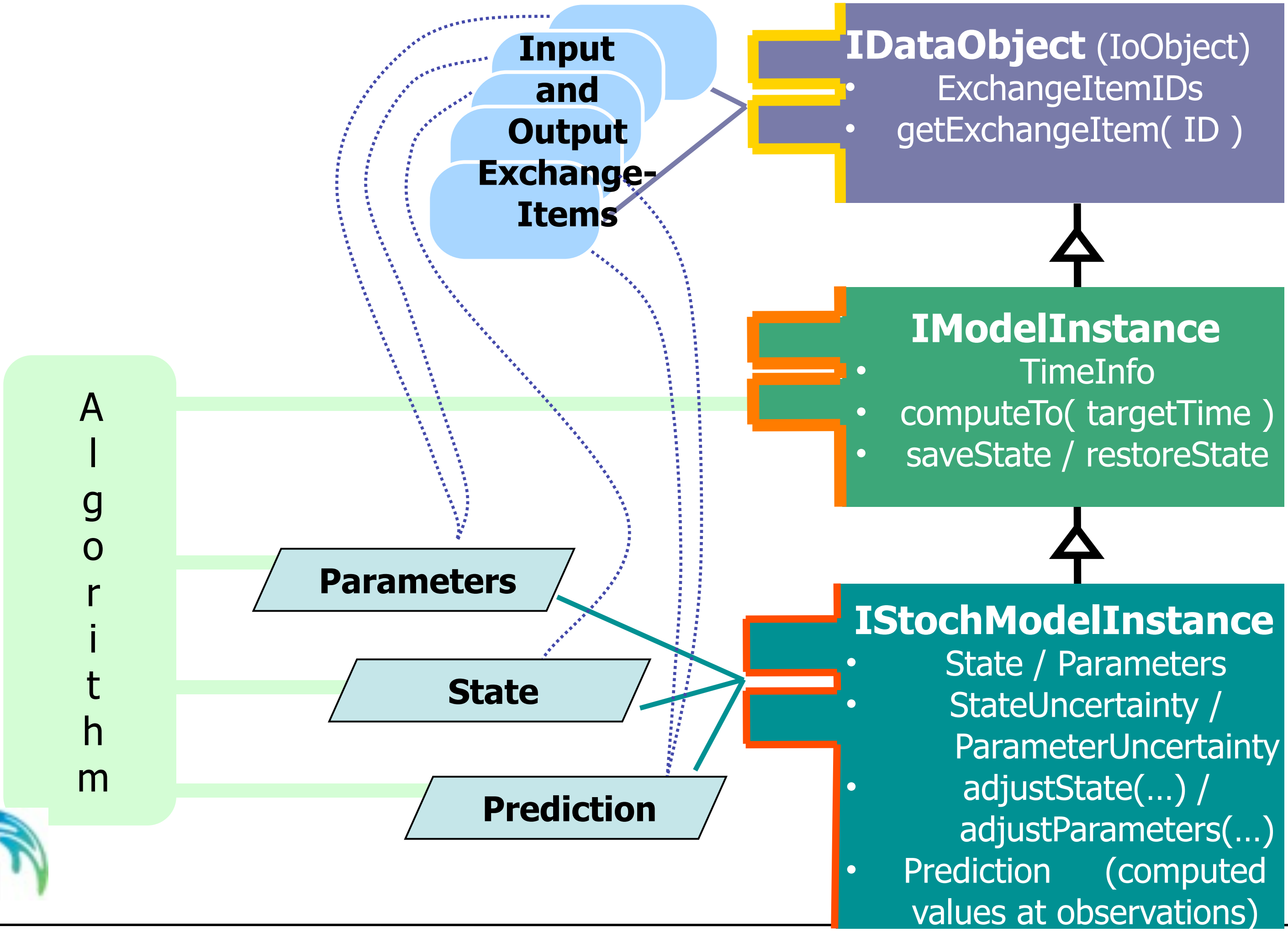
Goal

- OpenDA: framework for Data Assimiation
- MIKE-SHE: Integrated catchment modelling
- Data assimiltion with MIKE-SHE





Black box coupling in OpenDA


Input and Output Exchange-Items
IDataObject (IoObject)
• ExchangeItemIDs
• getExchangeItem(ID)
IModelInstance
• TimeInfo
• computeTo(targetTime)
• saveState / restoreState
IStochModelInstance
• State / Parameters
• StateUncertainty / ParameterUncertainty
• adjustState(…) / adjustParameters(…)
• Prediction (computed values at observations)
Algorithm
Parameters
State
Prediction

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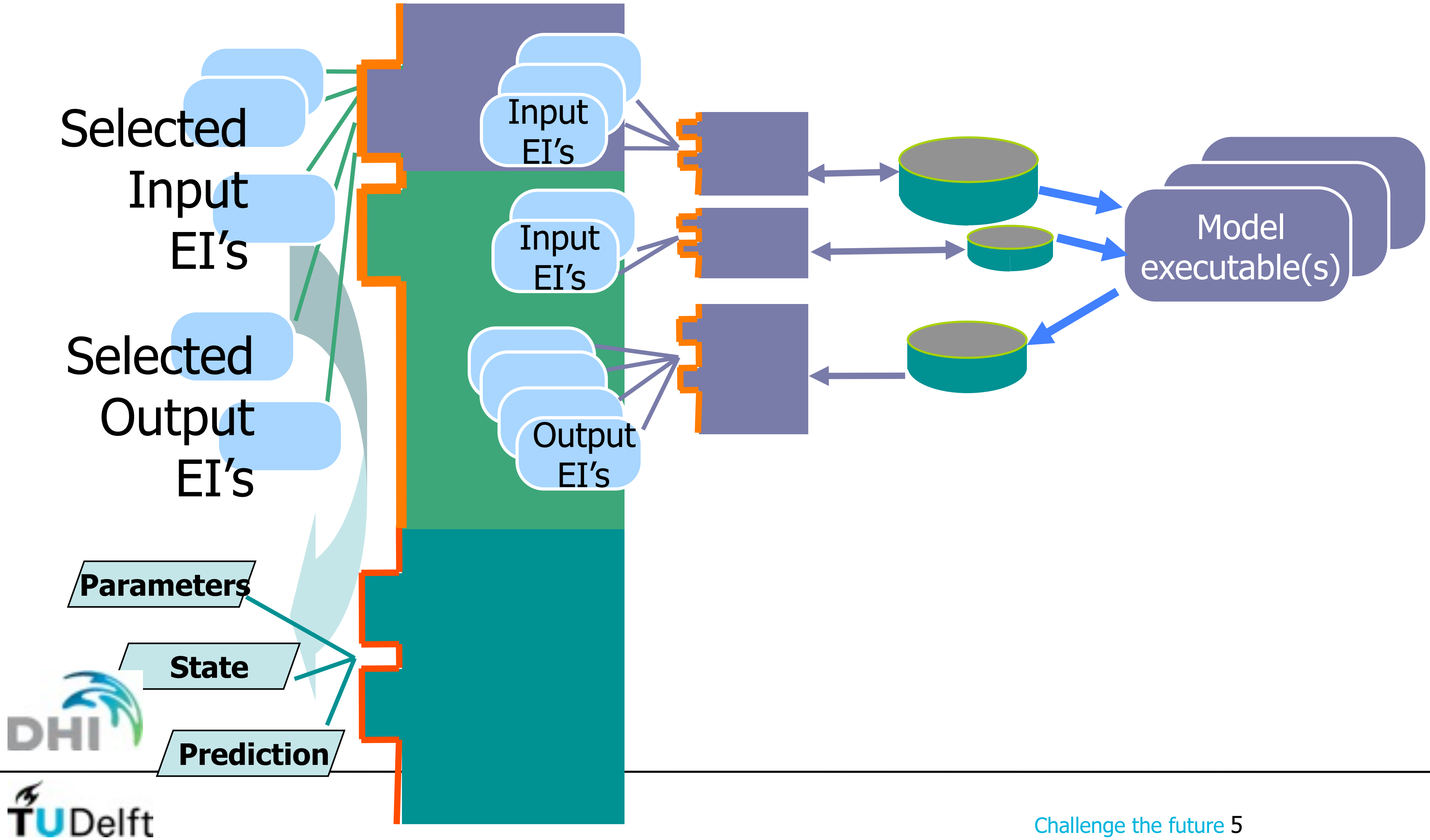
Black box coupling in OpenDA



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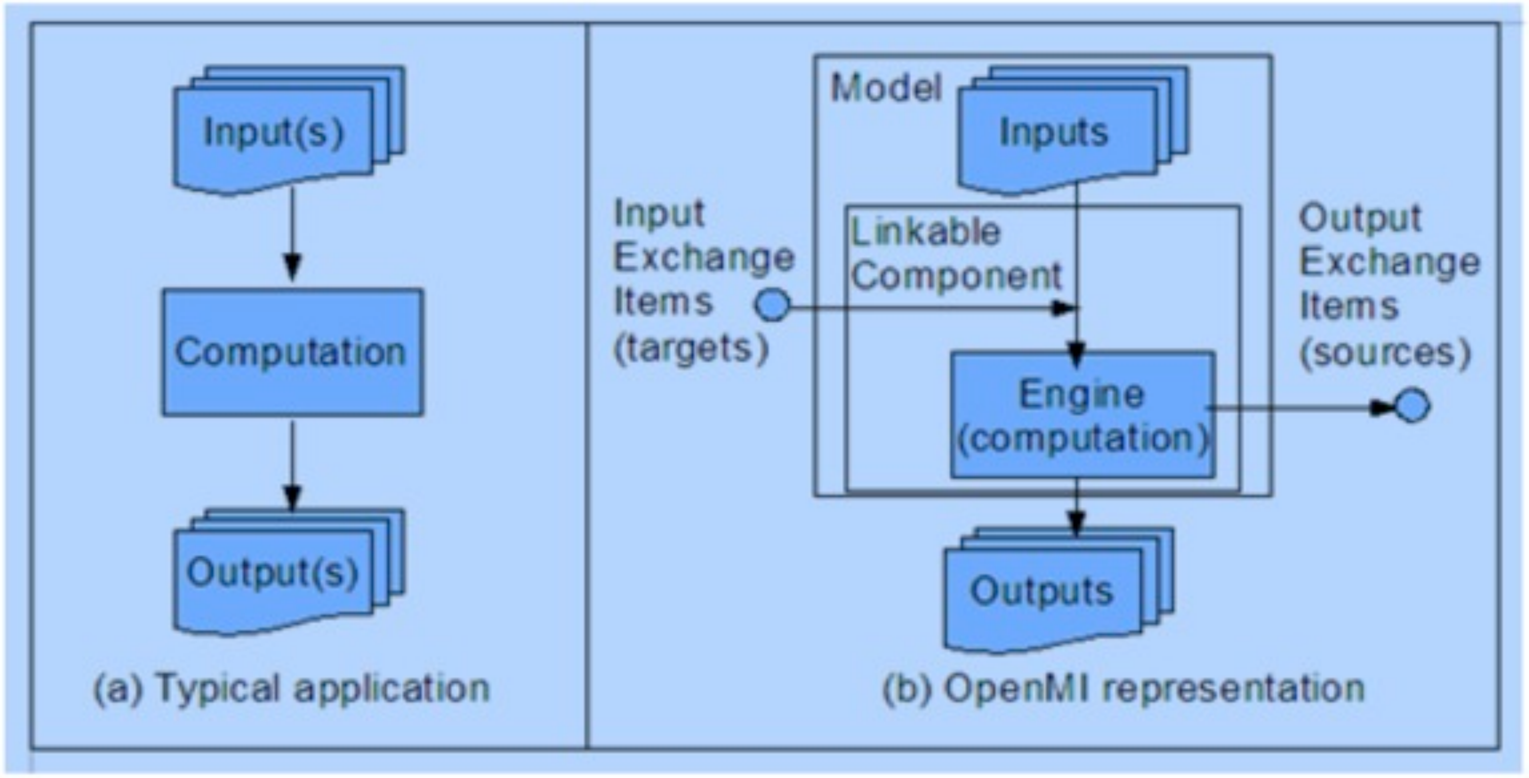
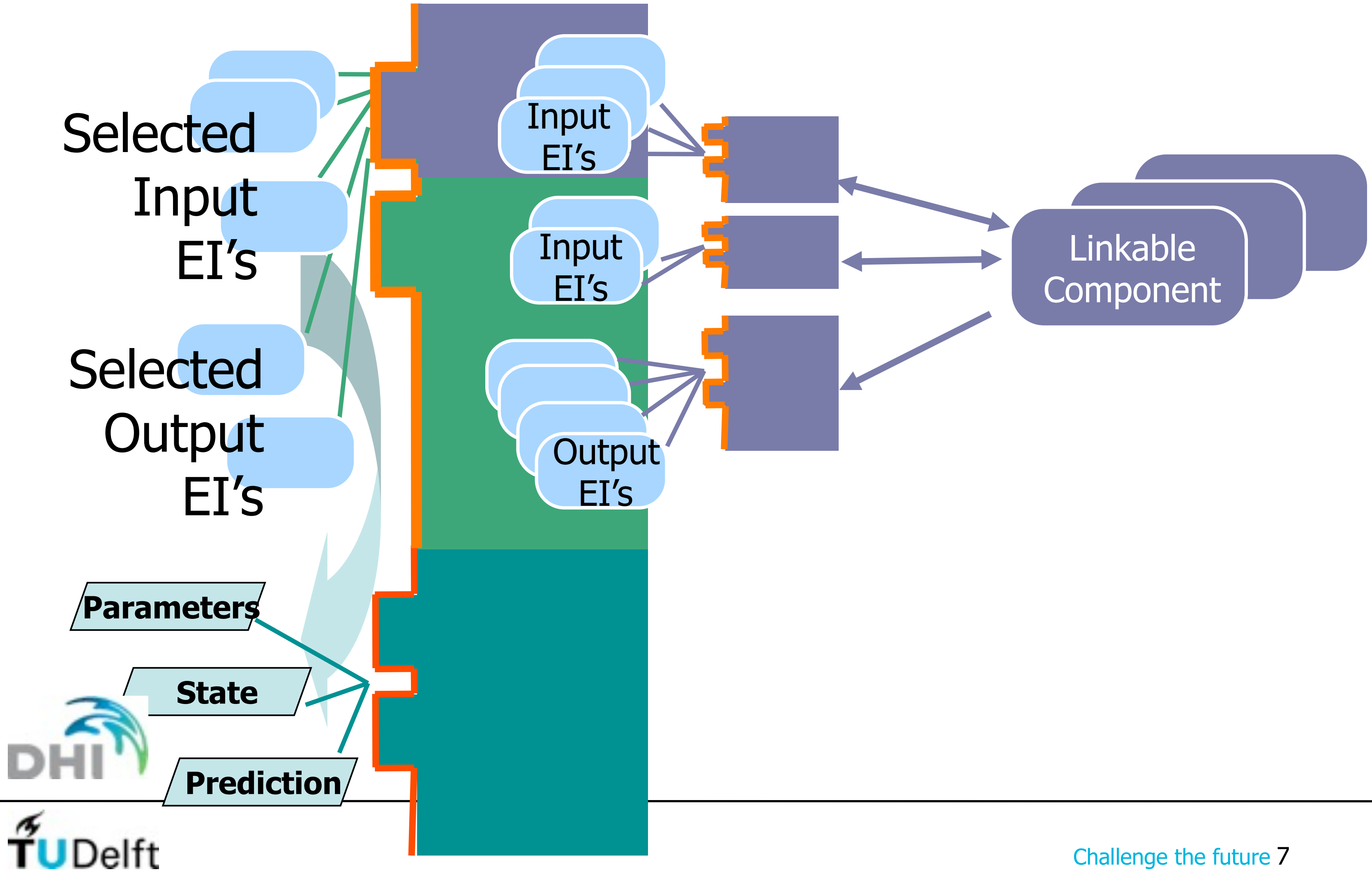
OpenMI

- MIKE-SHE has an OpenMI interface

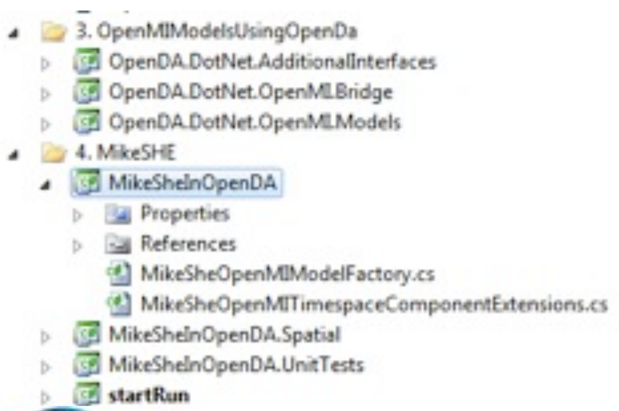


OpenDA-OpenMI framework

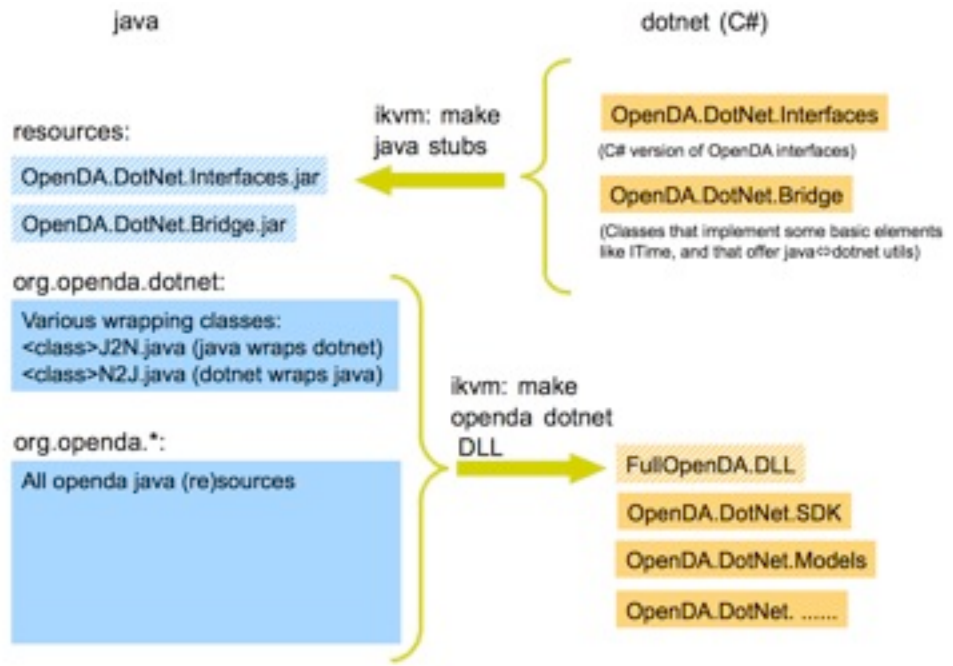


OpenDA-OpenMI framework

- Programming language :OpenDA (Java) OpenMI (C#)
- IKVM automatic translation of OpenDA to C# libraries
- Generic Layer
- MIKE-SHE specific Layer
- Debugging?



- 3. OpenMIModelsUsingOpenDa
  - OpenDA.DotNet.AdditionalInterfaces
  - OpenDA.DotNet.OpenMI.Bridge
  - OpenDA.DotNet.OpenMI.Models
- 4. MikeSHE
  - MikeSheInOpenDA
    - Properties
    - References
    - MikeSheOpenMIModelFactory.cs
    - MikeSheOpenMITimespaceComponentExtensions.cs
  - MikeSheInOpenDA.Spatial
  - MikeSheInOpenDA.UnitTests
  - startRun


java
dotnet (C#)
resources:
OpenDA.DotNet.Interfaces.jar
OpenDA.DotNet.Bridge.jar
ikvm: make java stubs
OpenDA.DotNet.Interfaces
(C# version of OpenDA interfaces)
OpenDA.DotNet.Bridge
(Classes that implement some basic elements like ITime, and that offer java<>dotnet utils)
org.openda.dotnet:
Various wrapping classes:
<class>J2N.java (java wraps dotnet)
<class>N2J.java (dotnet wraps java)
org.openda.*:
All openda java (re)sources
ikvm: make openda dotnet DLL
FullOpenDA.DLL
OpenDA.DotNet.SDK
OpenDA.DotNet.Models
OpenDA.DotNet. ......

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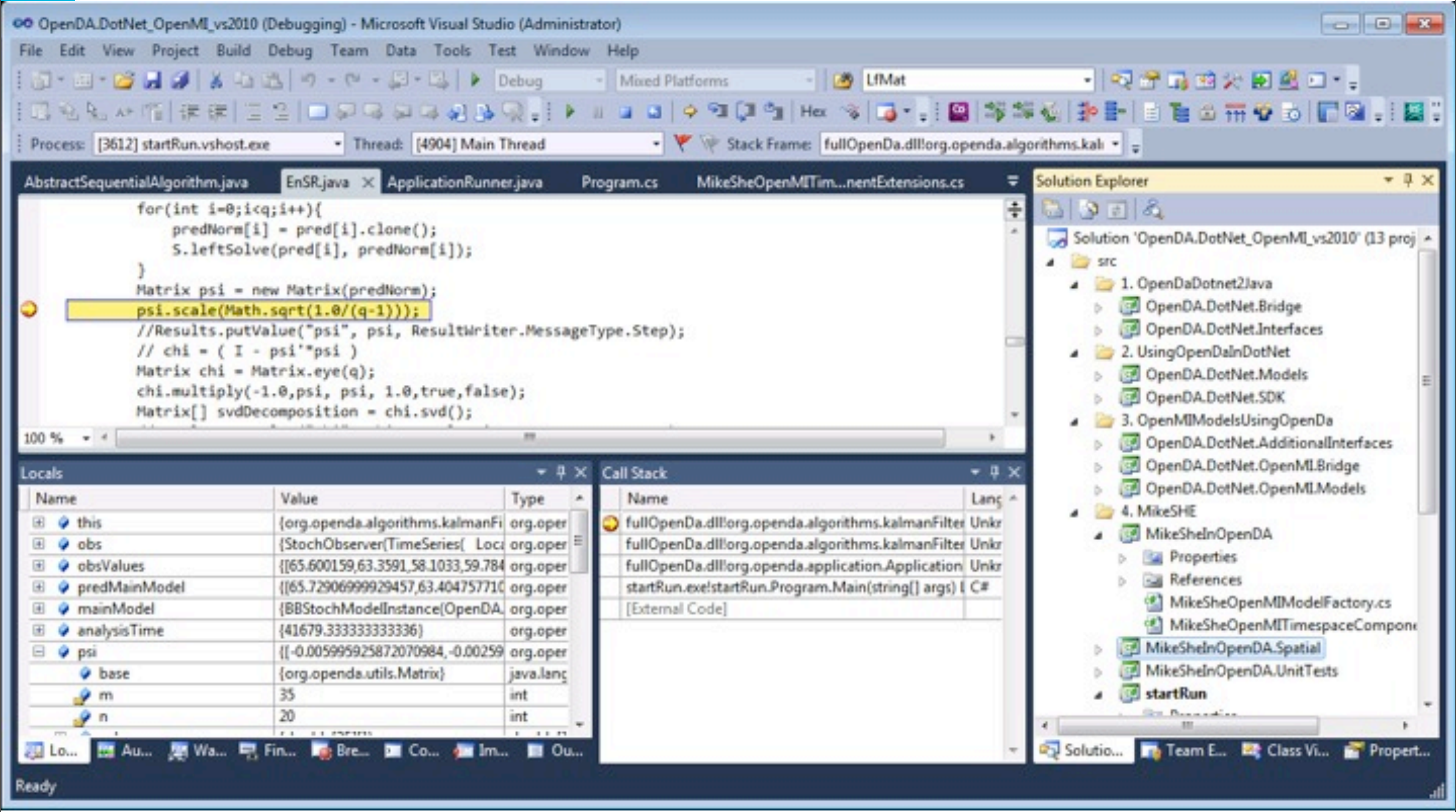
OpenDA-OpenMI framework



OpenDA.DotNet_OpenMI_vs2010 (Debugging) - Microsoft Visual Studio (Administrator)

Process: [3612] startRun.vshost.exe   Thread: [4904] Main Thread   Stack Frame: fullOpenDa.dll!org.openda.algorithms.kal

AbstractSequentialAlgorithm.java   EnSR.java   ApplicationRunner.java   Program.cs   MikeSheOpenMITim...nentExtensions.cs

```
for(int i=0;i<q;i++){
    predNorm[i] = pred[i].clone();
    S.leftSolve(pred[i], predNorm[i]);
}
Matrix psi = new Matrix(predNorm);
psi.scale(Math.sqrt(1.0/(q-1)));
//Results.putValue("psi", psi, ResultWriter.MessageType.Step);
// chi = ( I - psi'*psi )
Matrix chi = Matrix.eye(q);
chi.multiply(-1.0,psi, psi, 1.0,true,false);
Matrix[] svdDecomposition = chi.svd();
```

Locals

Name	Value	Type
this	{org.openda.algorithms.kalmanFi	org.oper
obs	{StochObserver(TimeSeries(Loca	org.oper
obsValues	{[65.600159,63.3591,58.1033,59.784	org.oper
predMainModel	{[65.72906999929457,63.404757710	org.oper
mainModel	{BBStochModelInstance(OpenDA.	org.oper
analysisTime	{41679.333333333336}	org.oper
psi	{[-0.005995925872070984,-0.00259	org.oper
base	{org.openda.utils.Matrix}	java.lang
m	35	int
n	20	int

Call Stack

Name	Lang
fullOpenDa.dll!org.openda.algorithms.kalmanFilter	Unkr
fullOpenDa.dll!org.openda.algorithms.kalmanFilter	Unkr
fullOpenDa.dll!org.openda.application.Application	Unkr
startRun.exe!startRun.Program.Main(string[] args) L	C#
[External Code]	

Solution Explorer

- Solution 'OpenDA.DotNet_OpenMI_vs2010' (13 proj
  - src
    - 1. OpenDaDotnet2Java
      - OpenDA.DotNet.Bridge
      - OpenDA.DotNet.Interfaces
    - 2. UsingOpenDaInDotNet
      - OpenDA.DotNet.Models
      - OpenDA.DotNet.SDK
    - 3. OpenMIModelsUsingOpenDa
      - OpenDA.DotNet.AdditionalInterfaces
      - OpenDA.DotNet.OpenMI.Bridge
      - OpenDA.DotNet.OpenMI.Models
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      - MikeSheInOpenDA.Spatial
      - MikeSheInOpenDA.UnitTests
      - startRun

Ready

TUDelft

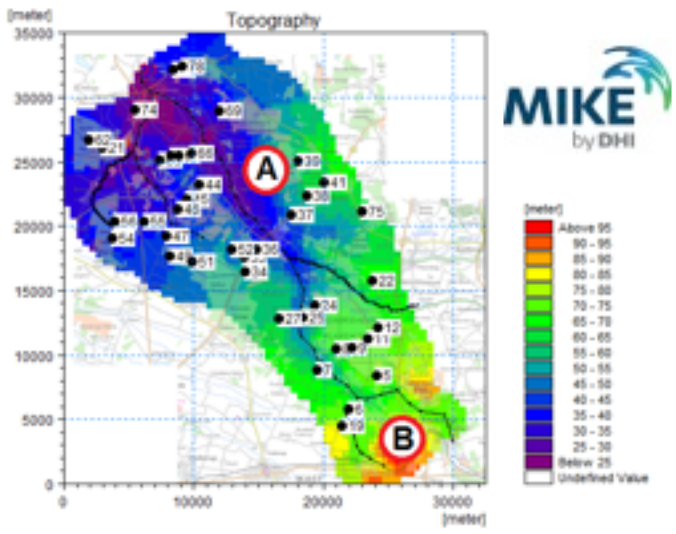
OpenDA-OpenMI framework

- One week behind a single desk in Delft
- Email/Skype
- Repository

Problems (found and fixed)

- SetExchangeItem (MIKE-SHE) not correctly implemented
  - Work around in OpenMI wrapper code
- Performance when all OpenMI exchangeItems are available
  - Configure MIKE-SHE to only export relevant/used ones
- Localization support in OpenDA Black Box is not optimal
  - Added optional interfaces for easy connection
- Observation matching in OpenDA Black Box only on exchangeItem ID
  - Added optional interfaces for full control

Medium size example



Karup Catchment

•Uncertainty based on GLUE (generalised likelihood uncertainty estimation)

•Perturbed

•Rainfall & Potential ET.

•Parameters (UZ, SZ, OL)

Ensemble Kalman filter

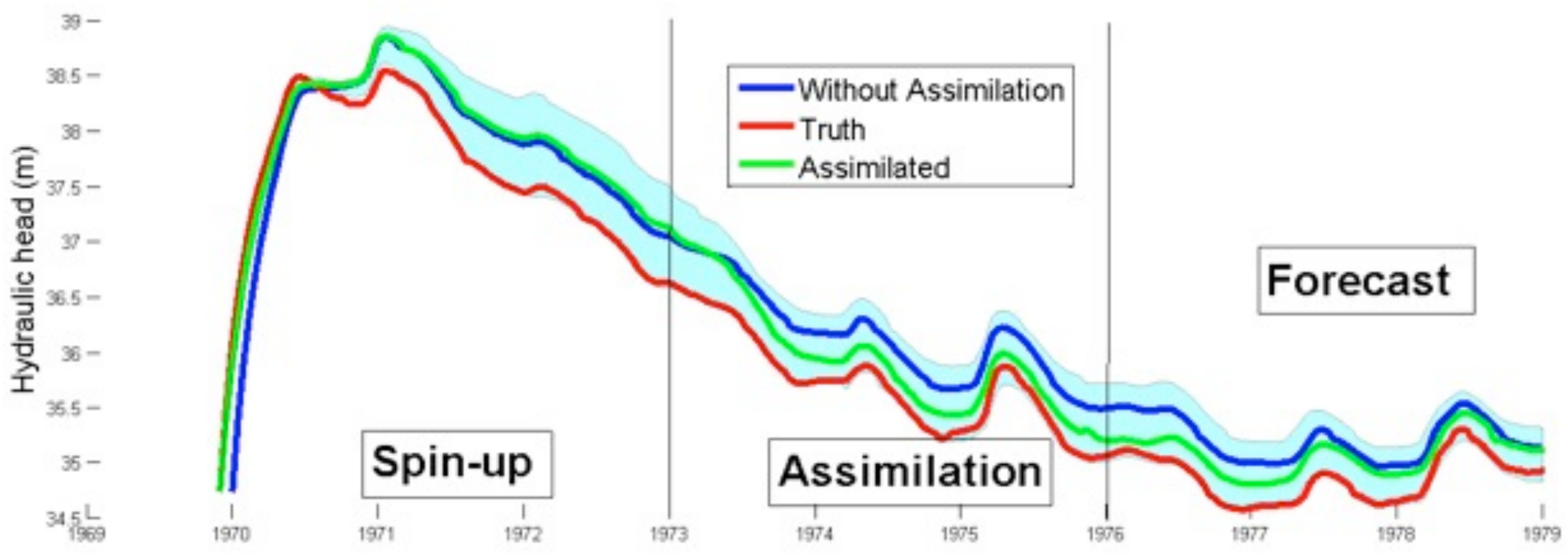
•30 Ensemble members

•Daily hydraulic head observations (m = 35). Synthetic

•State updating (n = 522)

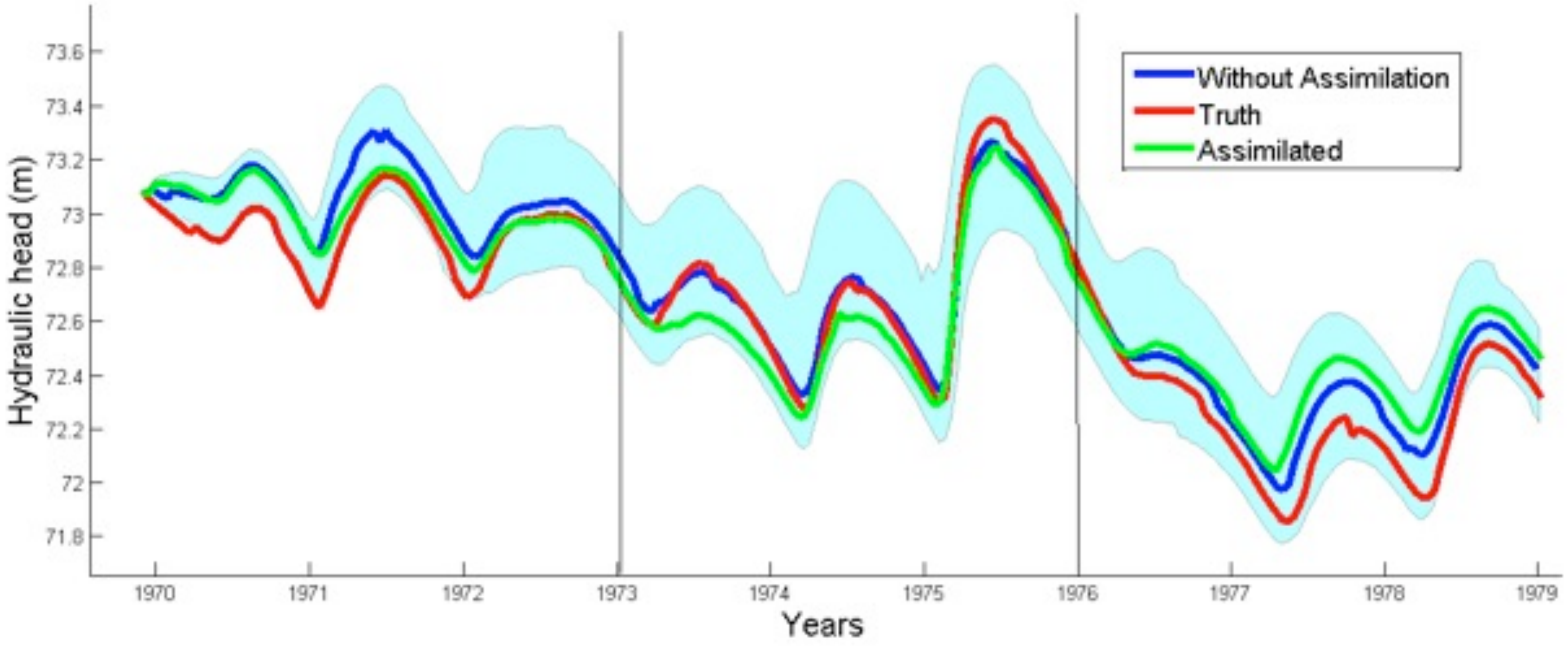
•Localization

At Point A



Hydraulic head (m)
39
38.5
38
37.5
37
36.5
36
35.5
35
34.5
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
Without Assimilation
Truth
Assimilated
Spin-up
Assimilation
Forecast

At Point B


Hydraulic head (m)
73.6
73.4
73.2
73
72.8
72.6
72.4
72.2
72
71.8
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
Years
Without Assimilation
Truth
Assimilated

Next steps

- Doing all kinds of experiments
  - EnKF
  - EnSR
  - Localization
  - Various fields in model state
- DHI C# observation code
- ...