Data-assimilation with COSTA

An Introduction

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Outline

- Data assimilation and calibration
- Current implementation issues
- COSTA
- Applications
- Conclusions
Models vs Observations

- Models produce values for any time-instance and any location, but:
  Predictions are not perfect!

- Observations represent the ‘truth’ but:
  Only at specific times and locations
Data assimilation and calibration

Make model perform better using the available observations:

- Calibration: change model parameters in order to reduce the difference between the model predictions and observations
- Data assimilation: combine the model forecast and observations into a mixed forecast
For example...

- No assimilation
- Assimilation of land based observations
- Assimilation of land based and satellite observations
- Assimilation of satellite observations
So, why not use it right away?

- Simulation software is complex
- More complex when combined with Data assimilation and/or Calibration methods
- Expensive to develop and maintain
- Difficult to know which method is best
Why not use a generic library?

- Why people think they have to develop a custom implementation of a DA method:
  - Computationally efficient
  - Need to handle model specific issues

- But if you would have a generic library then:
  - You could play around with methods to see which one is best
  - The implementation costs would be reduced dramatically
  - You could use methods and tools developed by others
  - The software is probably more reliable because it is used by many
COSTA

- A platform for data assimilation and calibration
  - Can be coupled to every (?) model
  - Offers various data assimilation methods
  - Platform for exchanging methods
- A generic environment where user can easily try out different DA-methods for their models
- A generic environment where method developers can easily implement their method to different models
The COSTA software

- Free software (LGPL)
- Developed by Delft University of Technology, VORtech, Deltares, TNO
- Major release as OpenDA 1.0 mid-2010, including tools from Deltares
- Supported by the OpenDA Association
The COSTA software

- Language bindings
  - Fortran77/90
  - C/C++
  - Java
  - Matlab (under construction)

- Special features
  - Optimized for High Performance Computing
  - Coupling to various data-formats (NetCDF, CSV, SQL)

- Parameter estimation
  - Simplex method
  - Conjugate gradient
  - LBFGS
  - DUD, DUD-Sparse

- Data-assimilation methods
  - Ensemble method
  - Reduced Rank Square Root
  - COFFEE method
How to use COSTA

- For closed-source models: the **black box model builder**
- Models available as dll: **COSTA workbench**
- Or tightly integrated for highest performance
COSTA components

Model, observations and DA-method
Applications: IMPOSE

- Operational monitoring of air quality over open sea for maintaining a shipping emissions treaty
- Based on the Open Source Chimere model for atmospheric chemistry
- Assimilate satellite and land-based air quality observations
Applications: WAQUA

- Replaced dedicated RRSQRT filter with COSTA
- Capable of handling all model-specific issues in a generic way
- Runtime some 6% longer than the dedicated version
- Experiments also with EnKF, also with Domain Decomp.
Applications: Calibriv

- Efficient because of direct coupling observation and calibration parameter
- Need for high/low water bottom roughness
- Using OpenDA with (variation of) DUD
- Black box coupling
Conclusion

- COSTA/OpenDA is a freely available platform for
  - Data-assimilation
  - Calibration

- Generic: can be used with any model:
  - Arbitrary application field
  - Closed source, dll or open (available) source code

- Used and supported by major institutes
  - Delft University of Technology
  - Deltares
  - TNO