A generic approach for applying data assimilation on parallel models

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Introduction

COSTA is a generic toolbox that simplifies the application of data assimilation techniques. It provides interfaces between the assimilation algorithms, the model and observation handling code. It provides well-tested implementations of various data assimilation techniques as well. Concepts of object oriented programming are used to define building blocks for data assimilation systems that can be exchanged and reused.

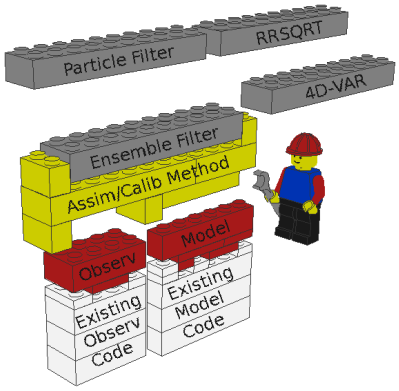

Figure 1. *The COSTA framework defines and provides building blocks for creating data assimilation systems*

Models and Parallel Computing

The computational demand of dynamic simulation models can be huge especially in combination with data assimilation techniques. Parallel computing is therefore needed to reduce the computational time.
A dynamic model in COSTA has the form:

$$\frac{d\mathbf{x}(t)}{dt} = \mathcal{M}\left(t, \mathbf{x}(t), \mathbf{p}, \mathbf{u}(t), \mathbf{w}(t)\right) \qquad (1)$$

The state of a COSTA model $(t, \mathbf{x}, \mathbf{p}, \mathbf{u}, \mathbf{w})$ can only be accessed and changed by a set of functions called the interface of the model.

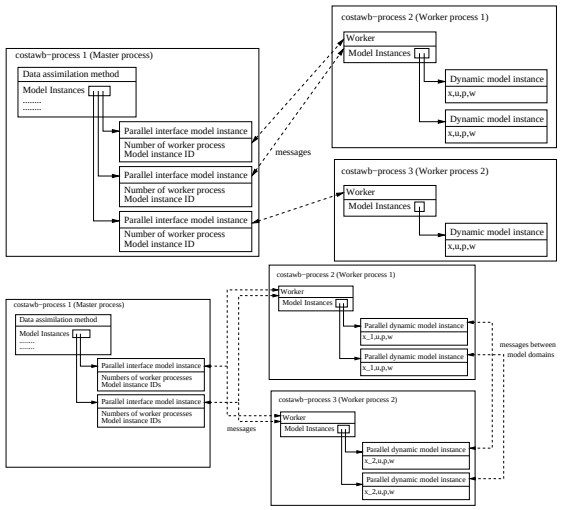

Figure 2. *Automatic parallelization in COSTA and coupling with parallel models*

Multiple instances of a model with their own state can be created like in object oriented programming. The object oriented approach make it possible to automatic parallelize model timesteps and couple to models that are parallel.

Results

Experiments have been performed with the sequential LOTOS-EUROS air quality model, the parallel (worker-worker) WAQUA/TRIWAQ model for 2D and 3D shallow water simulation and the parallel (master-worker) Chimere air quality model. The experiments show that large (parallel) operational models can be used in COSTA.

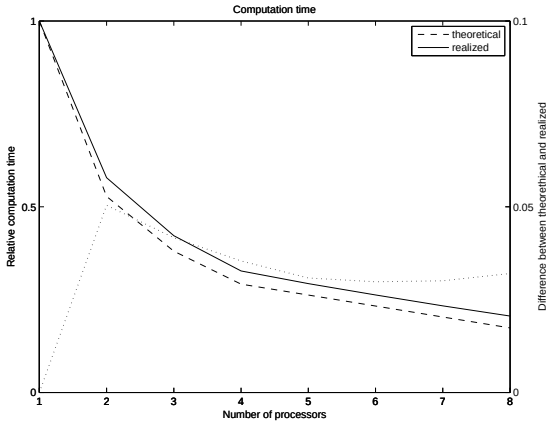

Figure 3. *Computational time using the automatic parallelization for LOTOS-EUROS*

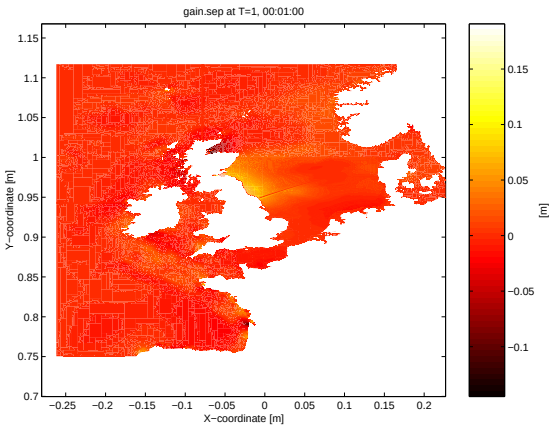

Figure 4. *Gain for station North Shields of the CZUNO model computed using COSTA. CZUNO is a large domain decomposition WAQUA/TRIWAQ model.*

More Information

* N. van Velzen, H.X. Lin, E. Vollebregt and E. Loots, 2009, Parallel computing and model coupling in the COSTA framework for data assimilation, submitted to Scientific Programming

* N. van Velzen and A. Segers, 2009, COSTA: a problem solving environment for data assimilation; applied for comparing the performance of various Kalman filtering techniques for the LOTOS-EUROS air quality model, submitted to Environmental Modelling & Software

* N. van Velzen and M. Verlaan, 2007, COSTA a problem solving environment for data assimilation applied for hydrodynamical modelling, Meteorologische Zeitschrift, Vol. 16, No. 6, 777-793 (December 2007)

* N. van Velzen, 2006, COSTA a Problem Solving Environment for Data Assimilation, CMWR-XVI proceedings

* http://www.costapse.org (COSTA project website)

* http://sourceforge.net/projects/costapse (COSTA software)

* http://www.openda.org (OpenDA Java interface definition)