REAL-TIME SMOKE SIMULATION WITH ARTSS

Data Assimilation

28.11.2019 | My Linh Würzburger | Civil Safety Research

Introduction

Research Center Jülich

- Institute: Civil Safety Research
- Division: Fire Dynamics

My Linh Würzburger

- studies: mathematics and software development
- start as PhD student: September 2019
- PhD Project: Data Assimilation in ARTSS

ARTSS

Accelerator-based Real-Time Smoke Simulator

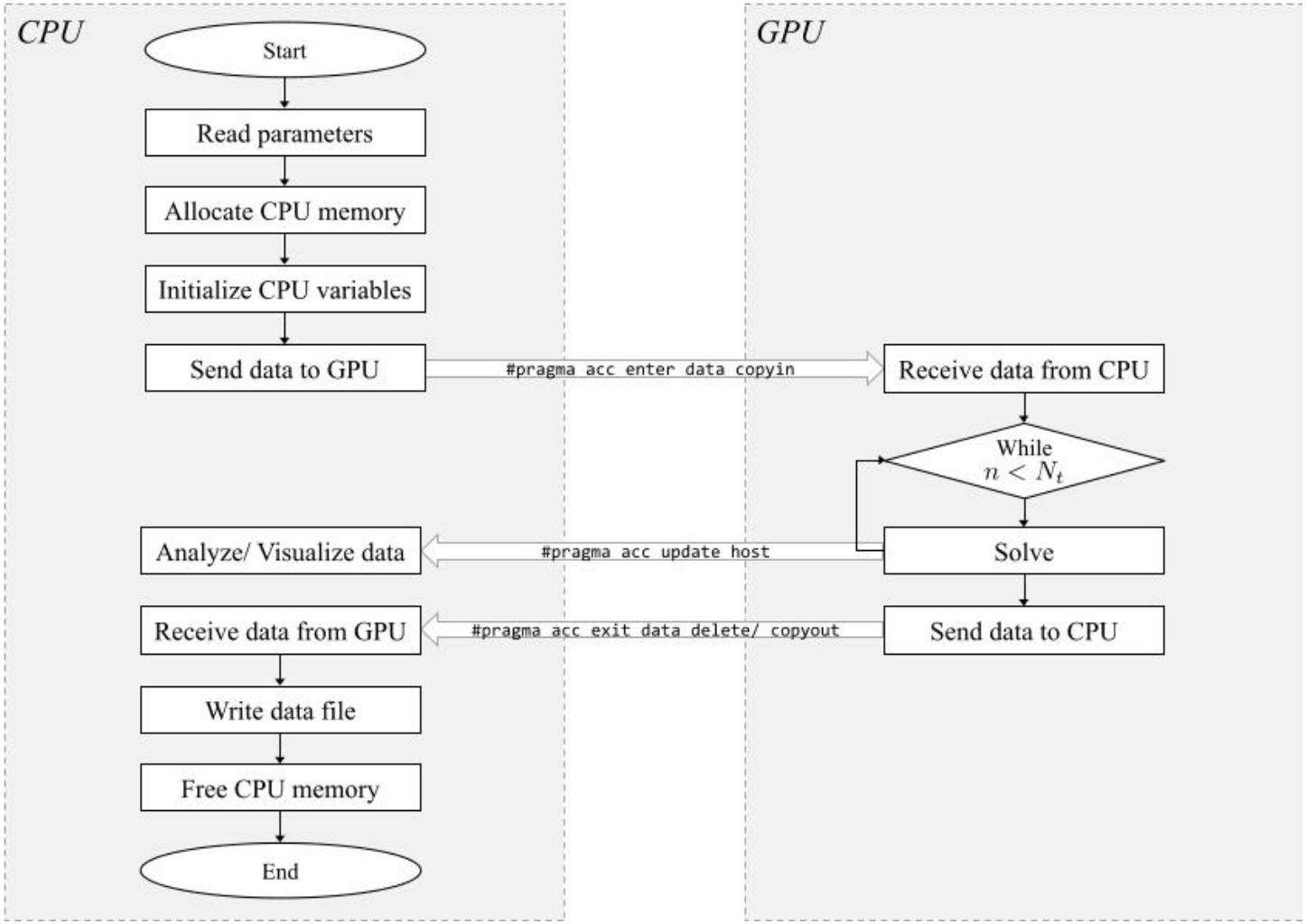
- former name: JuROr (PhD thesis of Anne Küsters)
- open-source software
- release on GitHub at the end of the year/beginning of the 2020

Features

- aim for real-time
- use of graphics board (GPU)
- just smoke, no combustion (yet), radiation or pyrolysis
- „simple“ approach

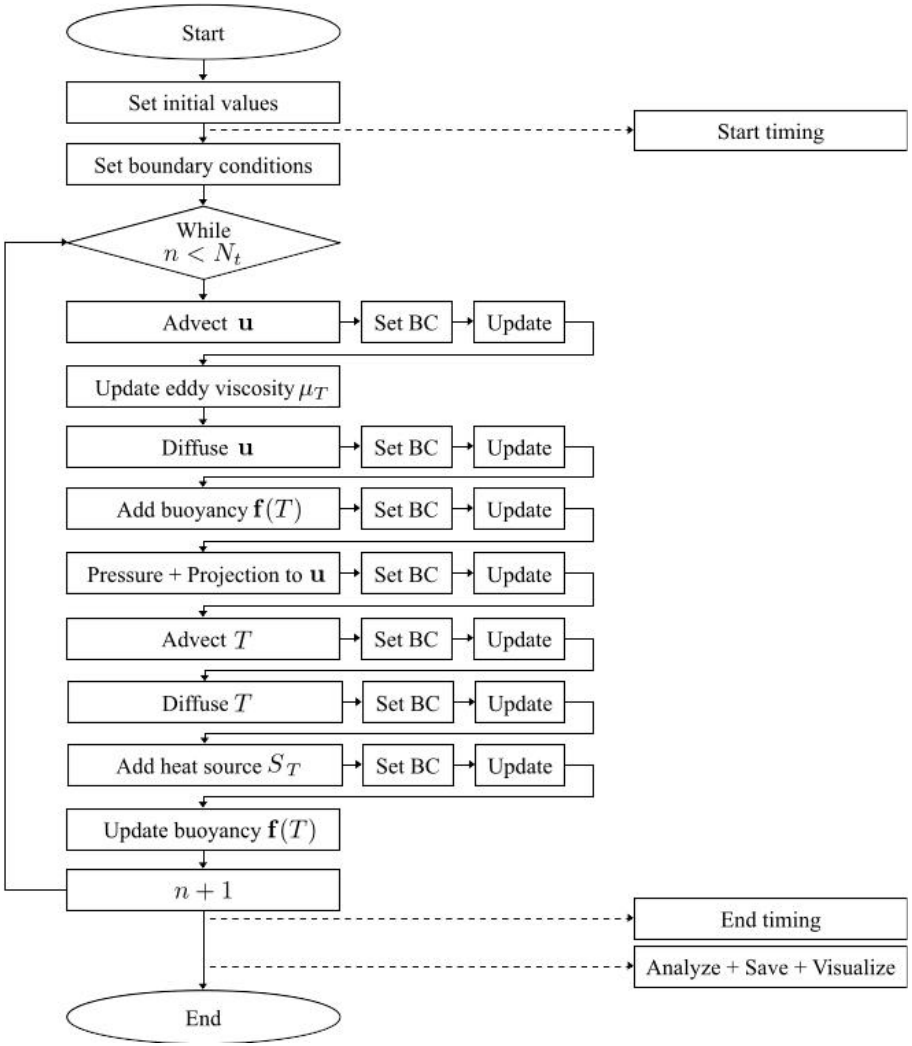
ARTSS

Working with the graphics board



ARTSS

Solution process



- read parameters from XML
- set initial conditions
- start time measuring
- set boundary conditions
- start time integration
  - velocity
    - advection, turbulence
    - diffusion, buoyancy as source
    - pressure
  - temperature
    - advection, diffusion
    - heat source
    - update buoyancy
- stop time measuring
- analysis (error, output, visualisation)

ARTSS

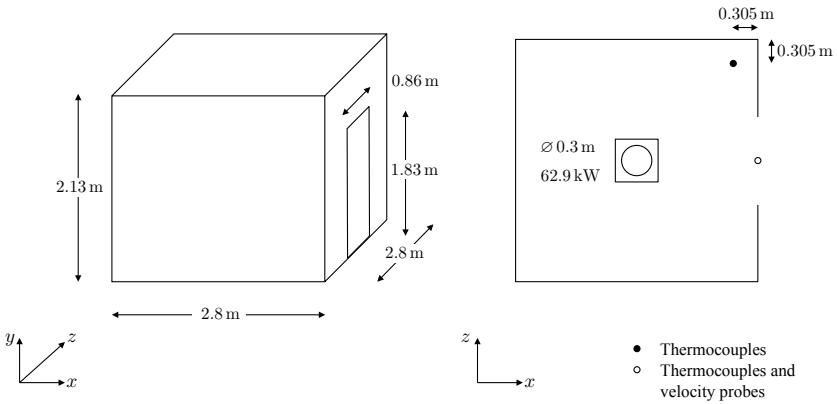
Difference to FDS

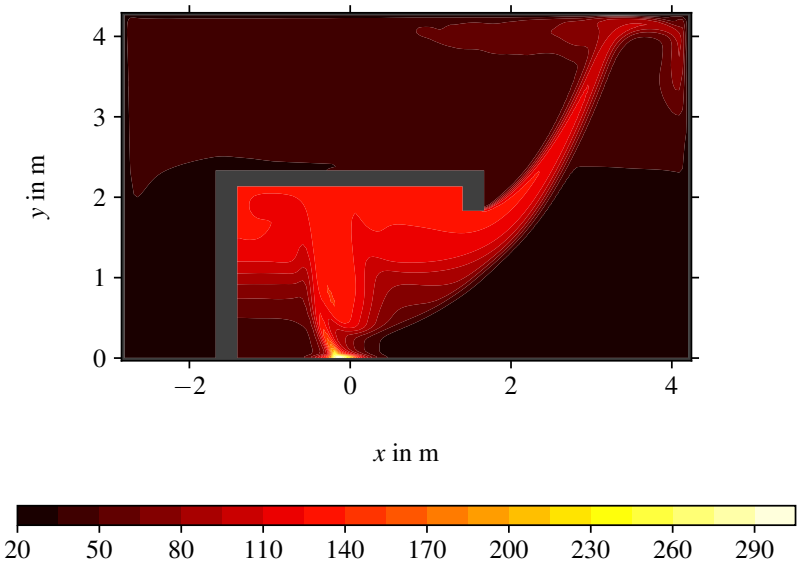
FDS	ARTSS
CFD/LES model	
turbulent, incompressible fluid dynamics	
smoke spread, pyrolysis, radiation, etc.	smoke spread
cartesian grids, rectangular objects (FDM)	
CPU	CPU + GPU
Fortran/MPI/OpenMP	C++/OpenACC
smokeview	VisIt, Paraview
∼115 000 lines of code, open source	∼18 000 lines of code, open source

ARTSS - Difference to FDS

Steckler Experiment

Fire induced flow experiment in a compartment





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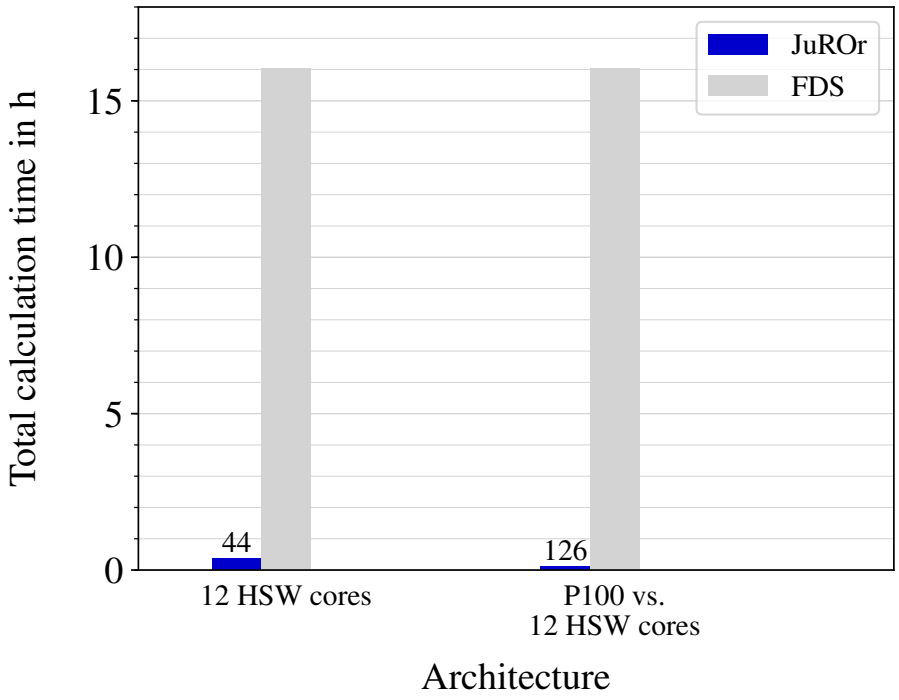
ARTSS - Difference to FDS

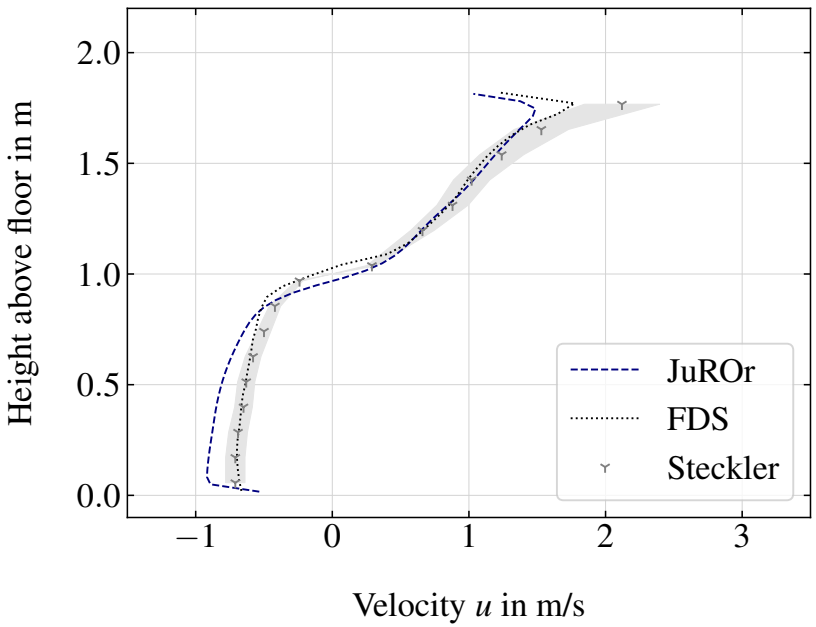
Steckler Experiment - Benchmarking



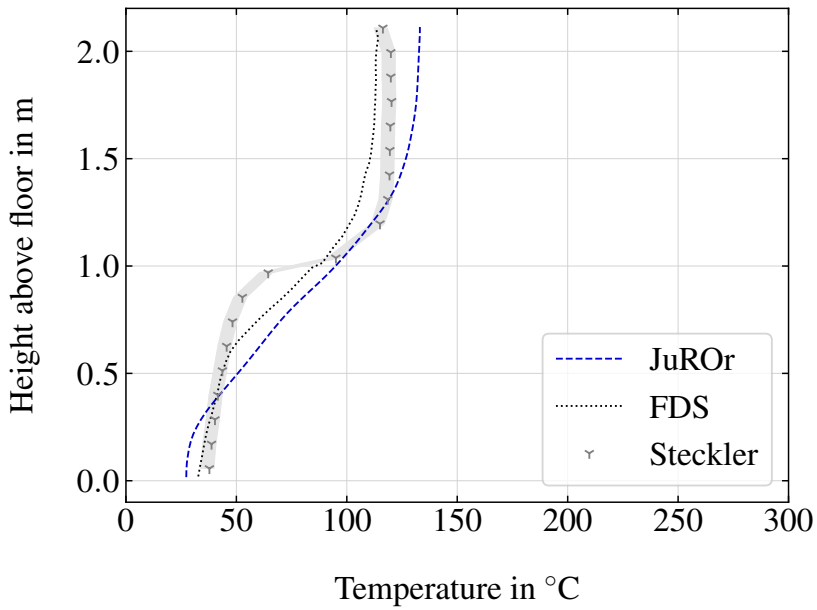
- 2-socket Intel Xeon Haswell E5-2680 v3 @ 2.5 GHz and 2 x 12 cores
- NVIDIA Pascal P100 (PCIe) GPU with 1328 MHz, 12 GB, 56 SMs and a 2-socket Intel Xeon Broadwell E5-2623 v4 @ 2.6 GHz

ARTSS - Difference to FDS

Steckler Experiment - Accuracy



Vertical velocity (at the top) at the center of the doorway



Temperature profile (at the bottom) at the center of the doorway

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Data Assimilation

Definition data assimilation

Data assimilation is a mathematical discipline that seeks to optimally combine theory (usually in the form of a numerical model) with observations. (taken from wikipedia)

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- already used in prediction for wildfires

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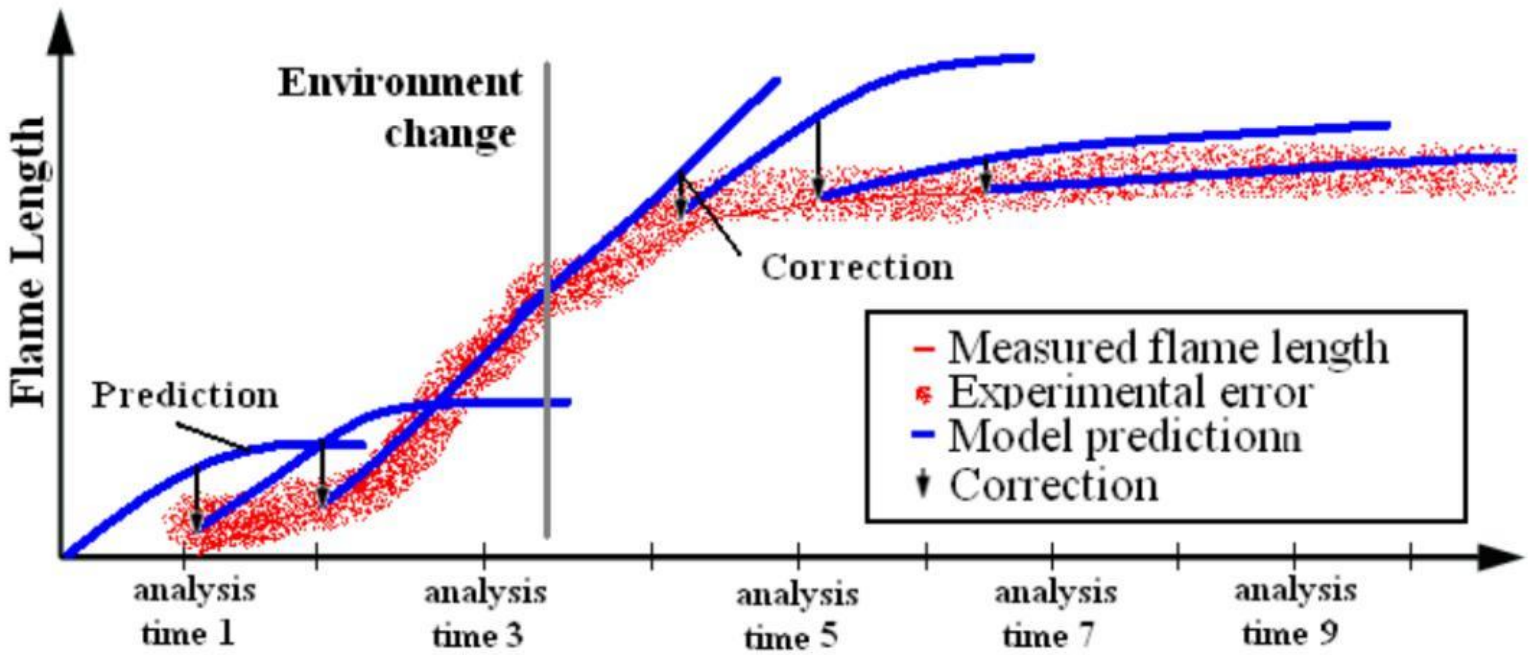
$\rightarrow$ improvement of accuracy through data assimilation

Data Assimilation

Wolfram Jahn

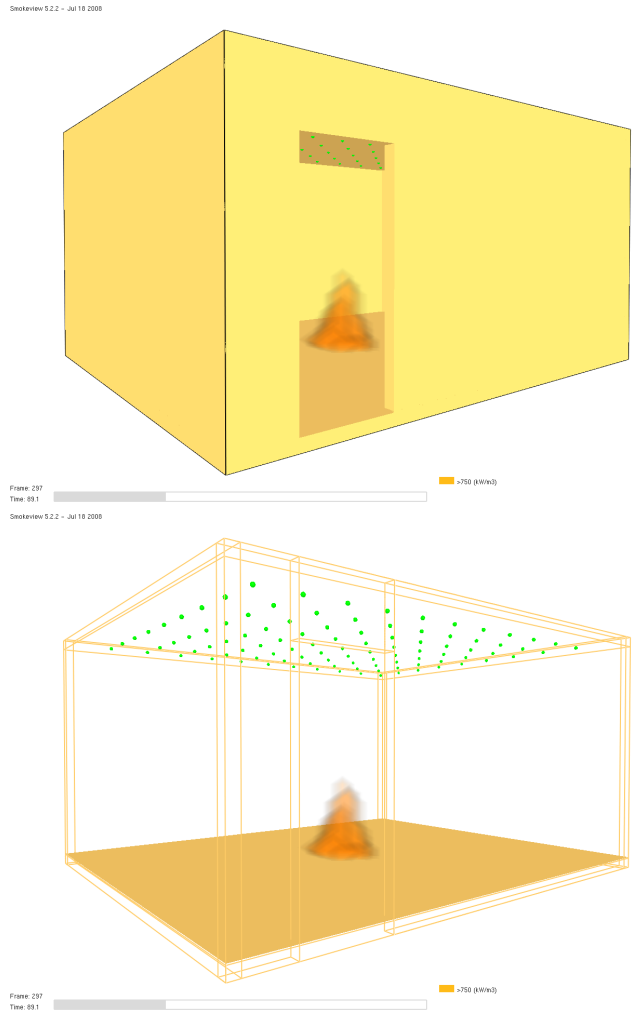
Jahn, Wolfram & Rein, Guillermo & Torero, Jose. (2009).
Data assimilation in enclosure fire dynamics - towards adjoint modelling



Data Assimilation

Wolfram Jahn - Approach

- comparison parameter
  - temperatures (at walls)
  - heat fluxes
- two stages of fire
  - fuel controlled fire
  - ventilation controlled fire



Data Assimilation in ARTSS

Importance

- fundamental (unknown) parameter
  - how strong does it burn? (heat release rate)
  - where does it burn? (location)
- smoke spread depends on
  - the fuel (eg. furniture)
  - the room structure (eg. door open/closed)
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$\rightarrow$ it may be possible to extend the room-based approach to the whole building