# REAL-TIME SMOKE SIMULATION WITH ARTSS

## Data Assimilation

03.12.2020 | 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

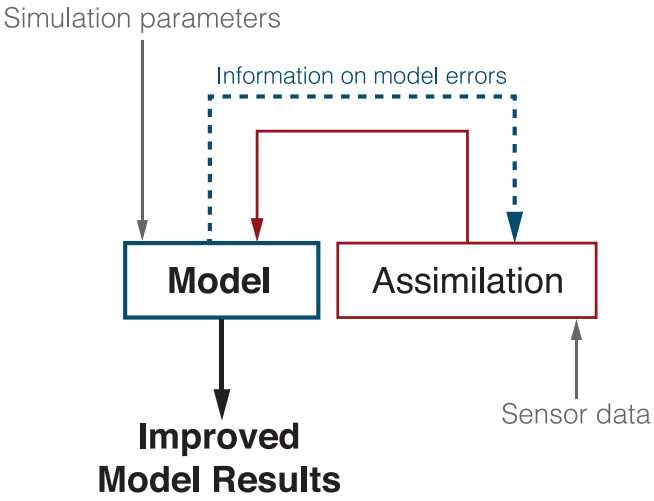
- former name: JuROr (PhD thesis of Anne Küsters)
- open-source software
- release on GitHub (`github.com/FireDynamics/ARTSS`)

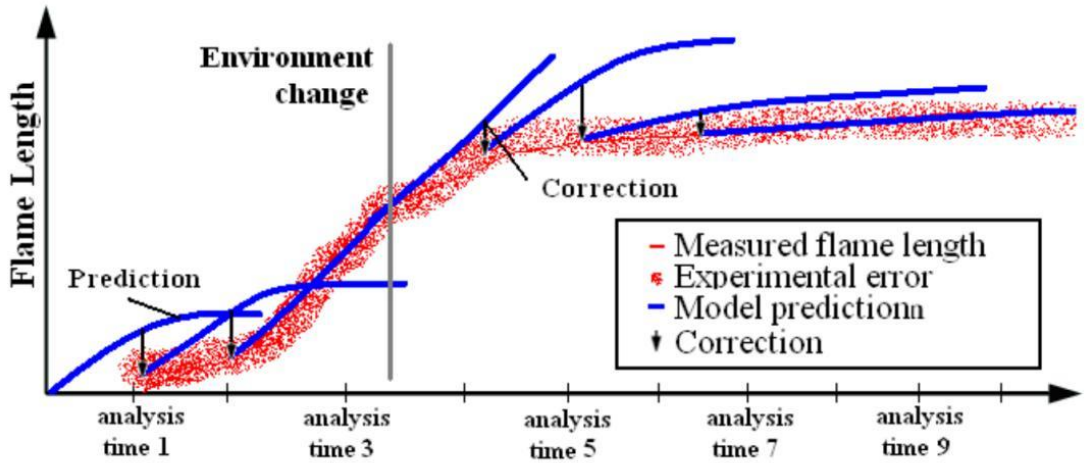
## Features

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

# Data Assimilation

## Using data to improve simulation results

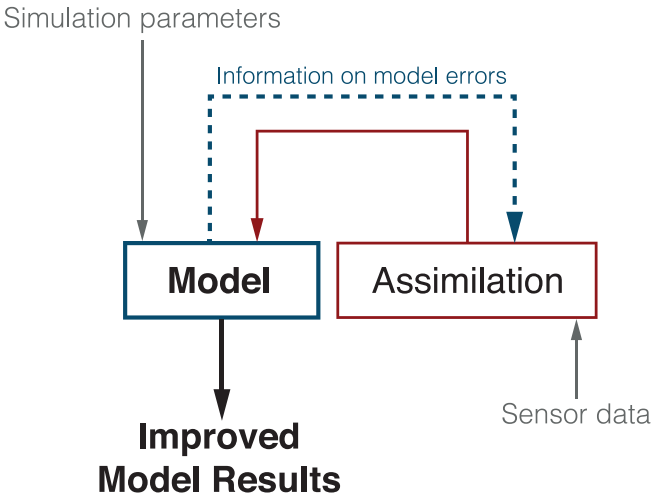


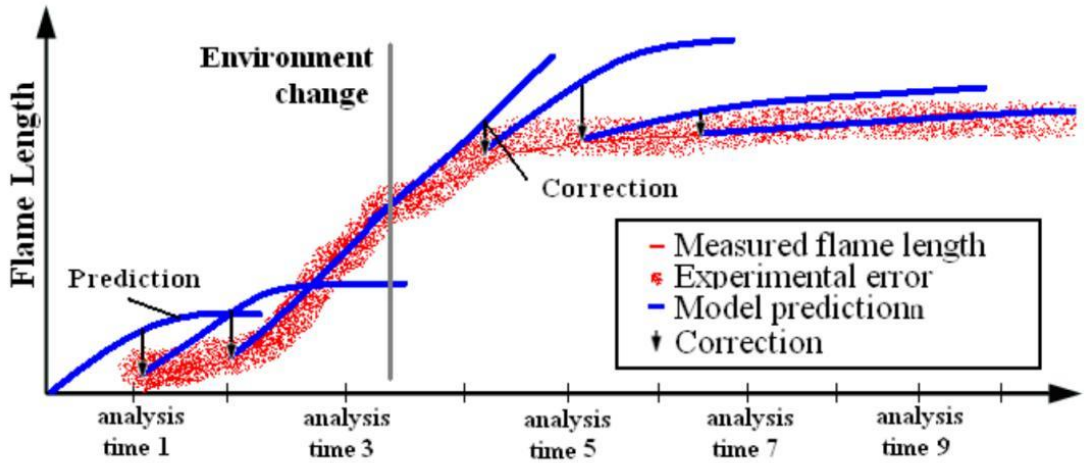




Jahn, Wolfram & Rein, Guillermo & Torero, Jose. (2009).
Data assimilation in enclosure fire dynamics - towards adjoint modelling

# Data Assimilation

## Using data to improve simulation results




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

Real case scenario:

- incomplete informations

# 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)
  - the fire protection measurements (eg. sprinkler)

# 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)
  - the fire protection measurements (eg. sprinkler)
- data assimilation can show us
  - if there is a sudden increase/decrease in smoke
  - if there is an underlying stream

# Data Assimilation

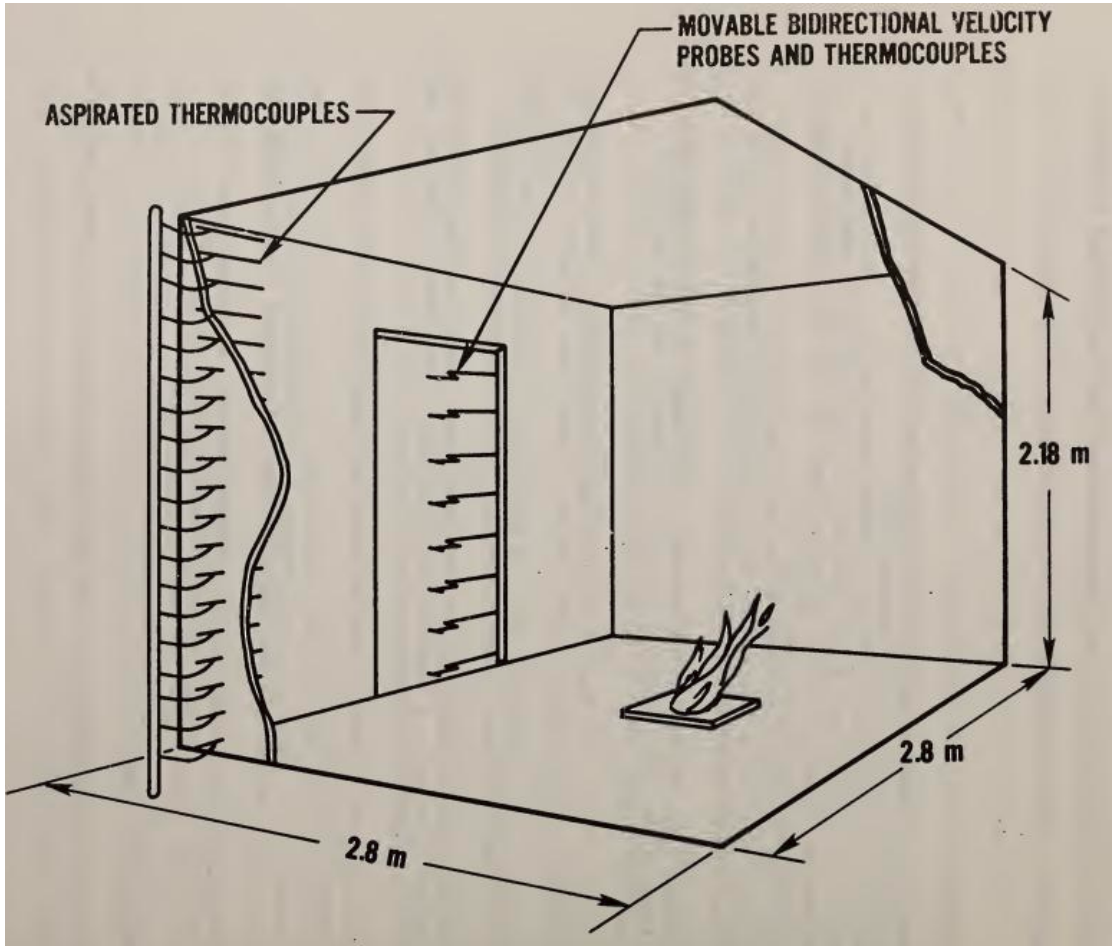
## First Concept

comparison with a well documented experiment (Steckler)

1. simple attempt
   - reconstruct experimental setting
   - implement interface to integrate data during the running simulation (not time-delayed yet)
   - change model based on a simple attempt (proof of concept)
2. time-delayed attempt
   - safe state of simulation
   - reload simulation at time step of sensor data
   - change model [...]
3. model-based attempt
   - gradient-based
   - new boundary conditions

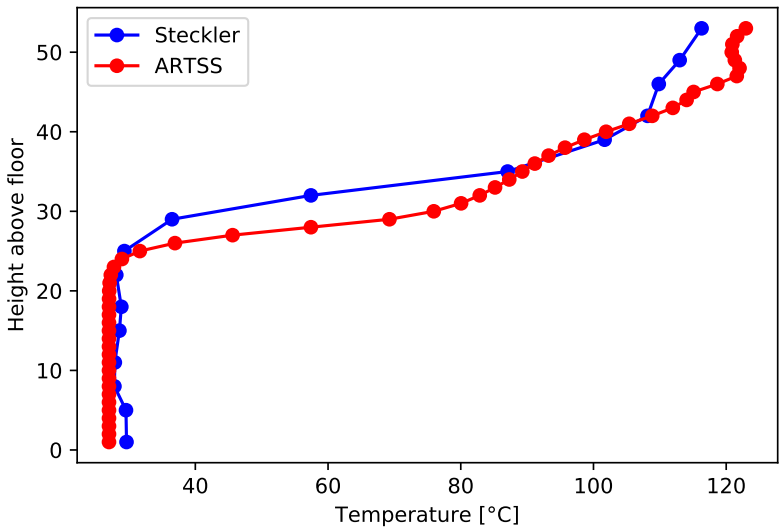
# Current work

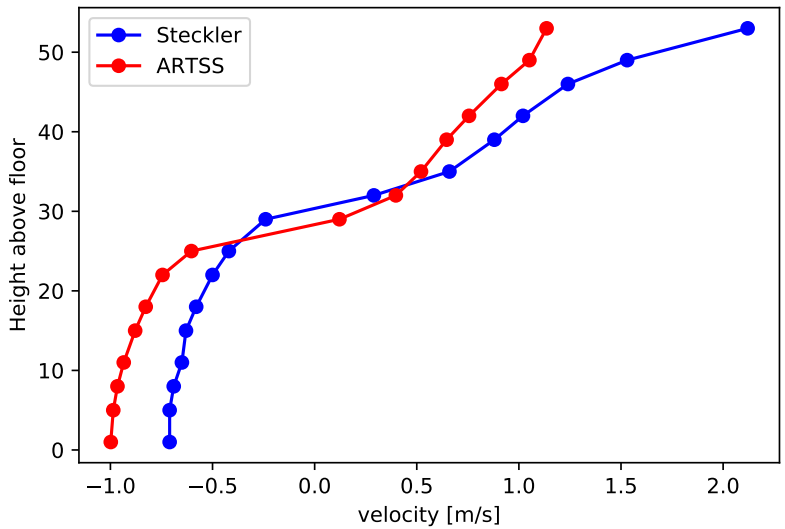
## Steckler case in ARTSS



# Current work

## Steckler case in ARTSS






JÜLICH Forschungszentrum

# Contact Information


## My Linh Würzburger

Phone: +49 2461 61-8823
email: m.wuerzburger@fz-juelich.de


https://www.fz-juelich.de/ias/ias-7/


Forschungszentrum Jülich GmbH
Institute for Advanced Simulation
Civil Safety Research (IAS-7)
Wilhelm-Johnen-Straße
52425 Jülich

# ARTSS

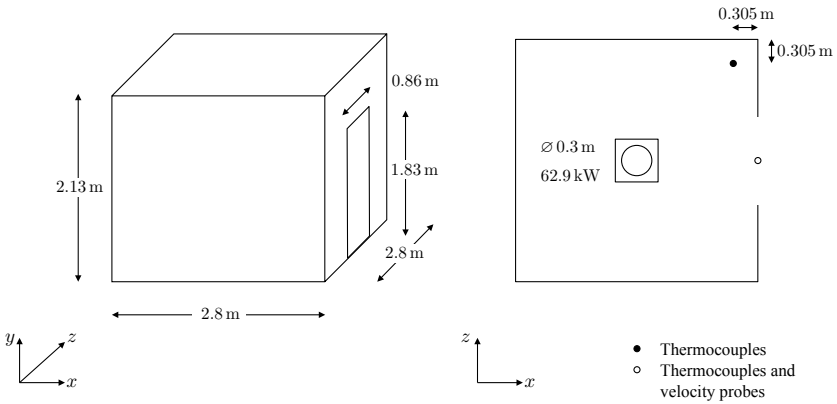
## Difference to FDS

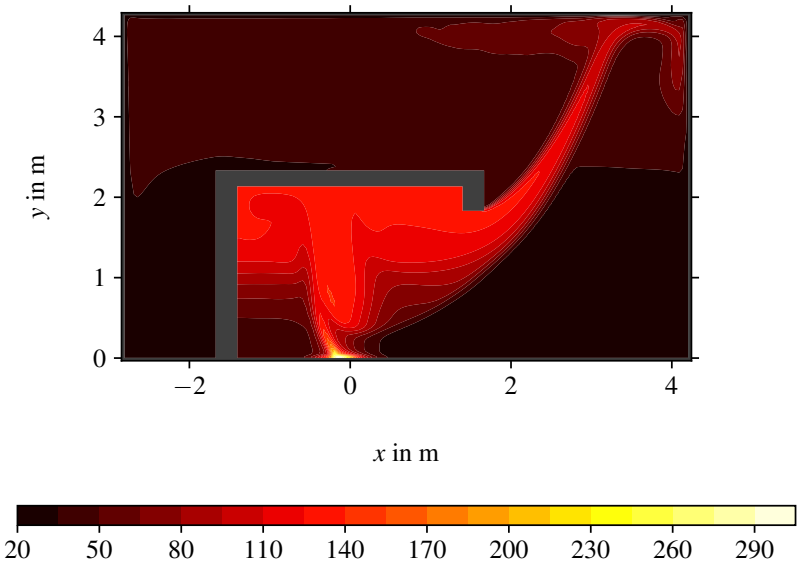
| FDS | ARTSS |
|---|---|
| CFD/LES model | |
| turbulent, incompressible fluid dynamics | |
| smoke spread, pyrolysis, radiation, etc. | smoke spread |
| cartesian grids, rectangular objects (FDM) | |
| CPU | CPU + GPU |
| Fortran/MPI/OpenMP | C++/OpenACC |
| smokeview | VisIt, Paraview |
| ∼115 000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



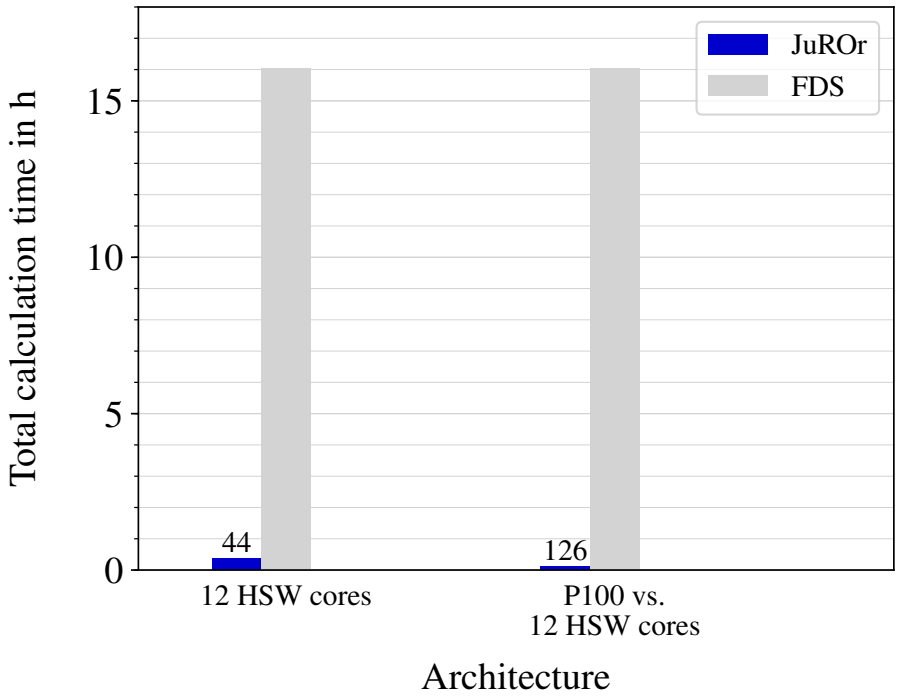






JÜLICH Forschungszentrum

# ARTSS - Difference to FDS

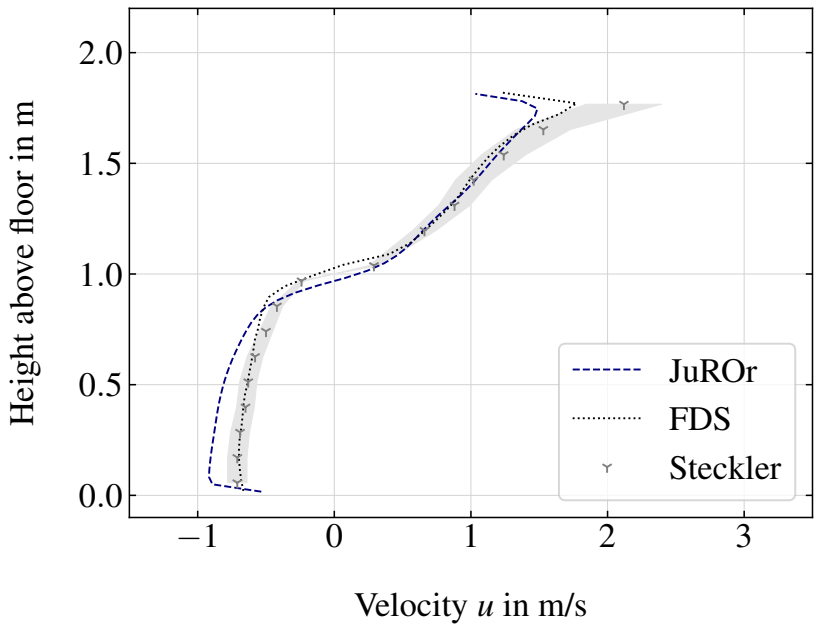
## Steckler Experiment - Benchmarking



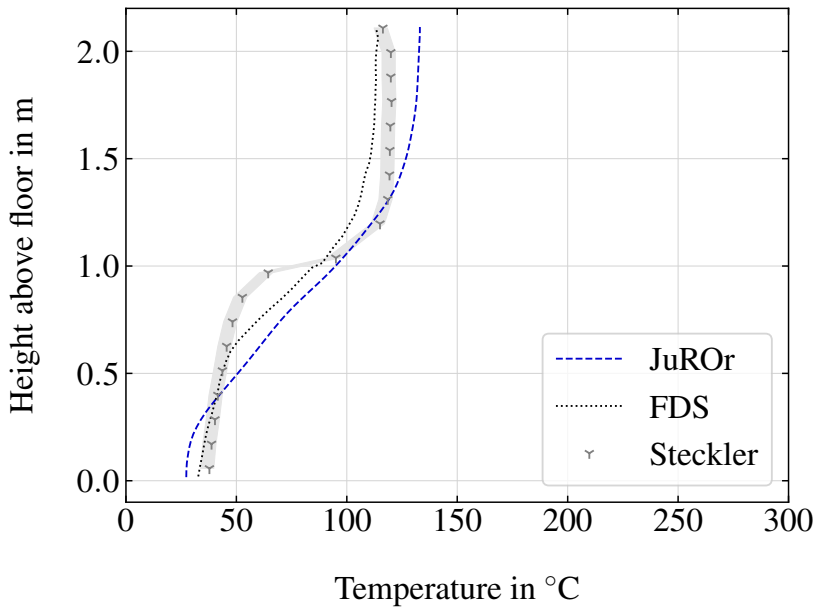

- 2-socket Intel Xeon Haswell E5-2680 v3 @ 2.5 GHz and 2 x 12 cores
- NVIDIA Pascal P100 (PCIe) GPU with 1328 MHz, 12 GB, 56 SMs and a 2-socket Intel Xeon Broadwell E5-2623 v4 @ 2.6 GHz

# 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



JÜLICH Forschungszentrum