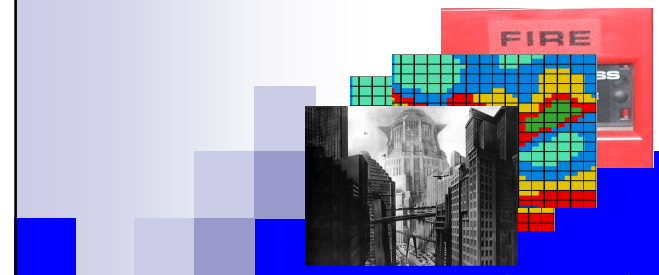
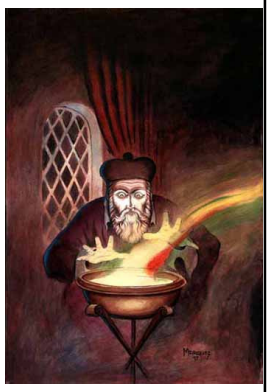


FireGrid:
Forecasting Fire Dynamics to lead the emergency response

Dr Guillermo Rein
BRE Centre for Fire Safety Engineering
The University of Edinburgh

IFE 2007 Rasbash Lecture, BRE Watford

Seeing the Future



of Fire Emergencies







FireGrid: Effective Emergency response

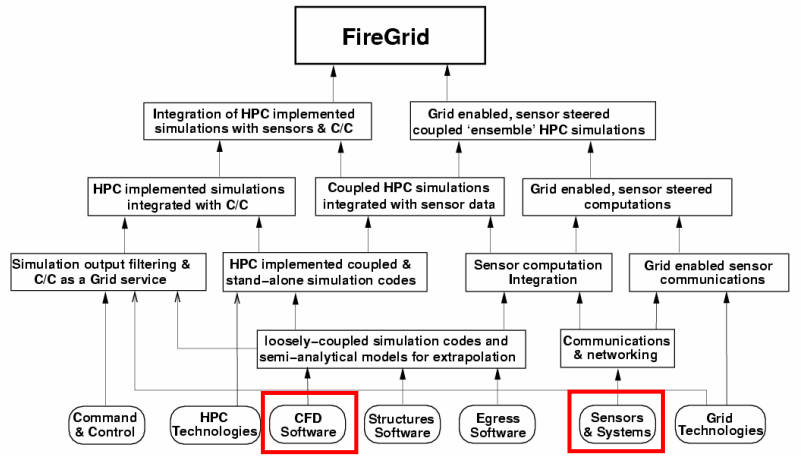
- Paradigm shift in emergency response?
- Premise '**Information is essential**'

FireGrid

- using the Present and the Past : sensor information
- to predict fire behaviour predictions in super real time

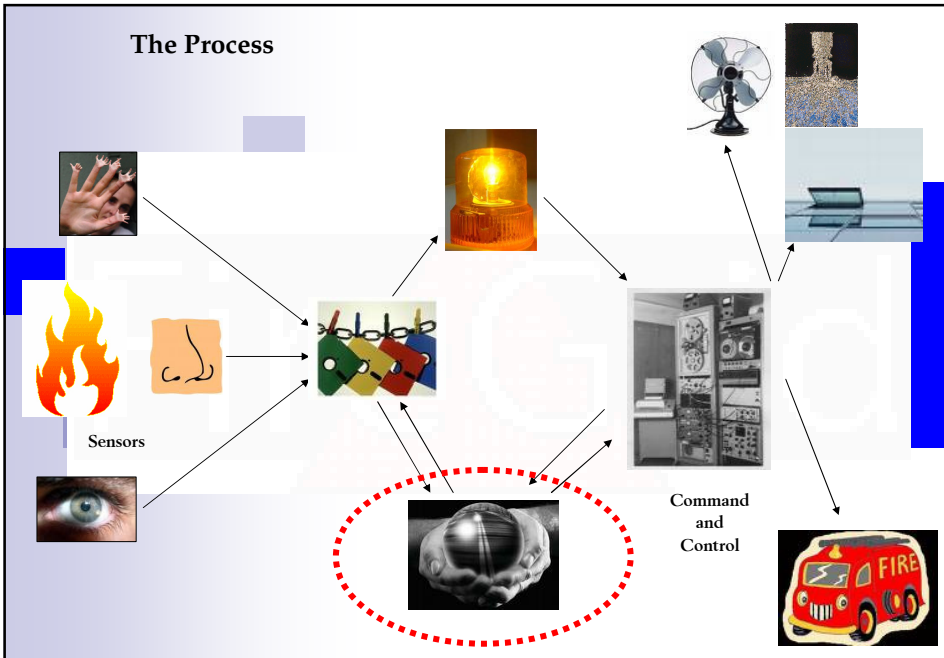
- Integration of Sensor Technology, High Performance Computing and The Grid
- Follow **Fire dynamics**, structure behaviour, evacuation process…

The FireGrid Architecture



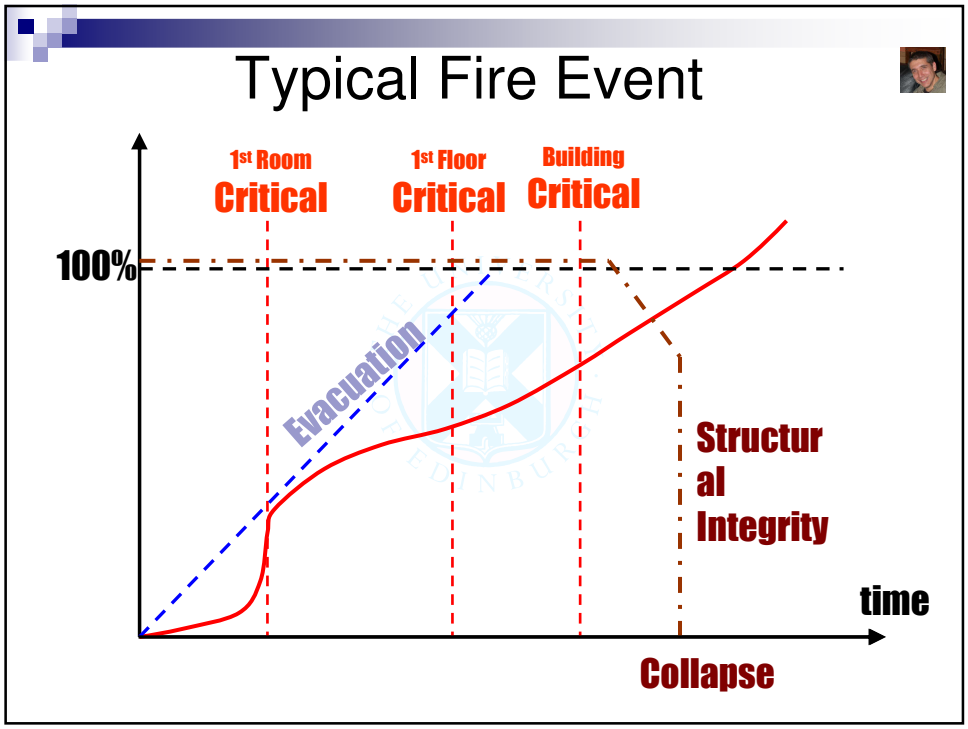
FireGrid

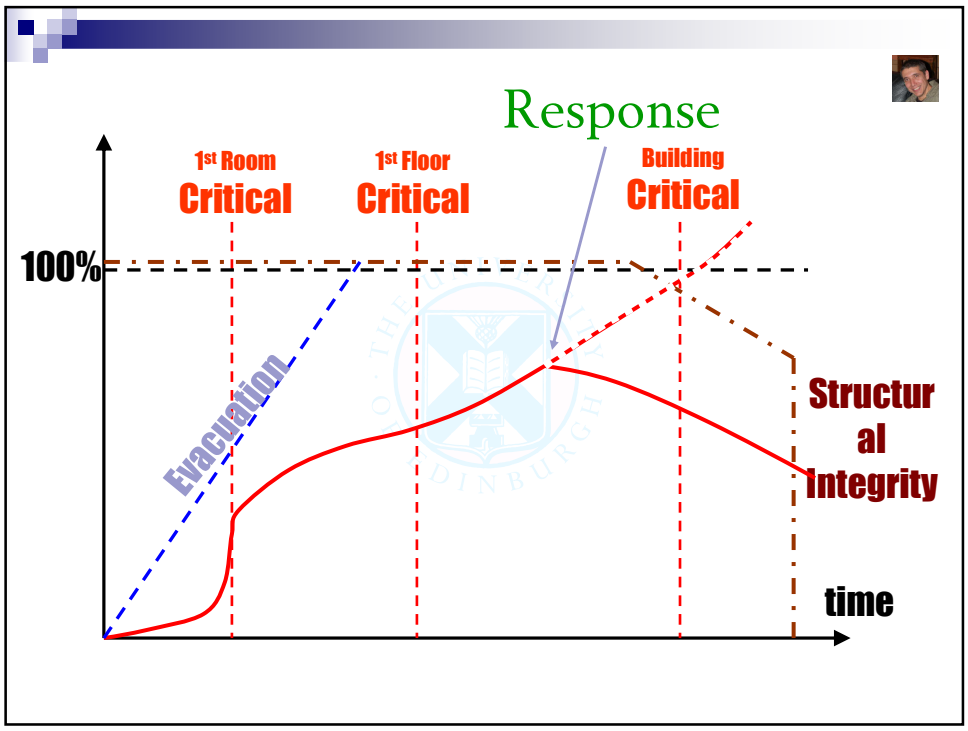
The Process



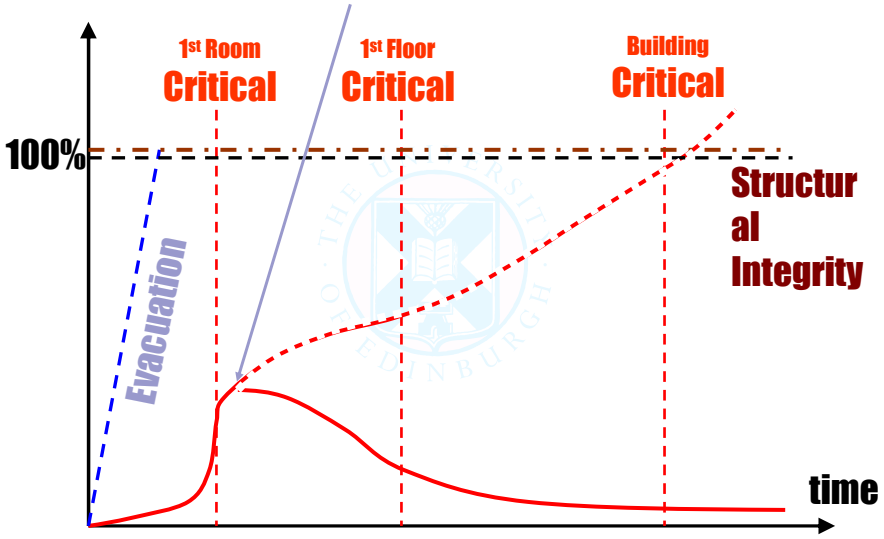
from A. Cowlard

FireGrid


Typical Fire Event
1st Room
Critical
1st Floor
Critical
Building
Critical
100%
Evacuation
Structur
al
Integrity
time
Collapse

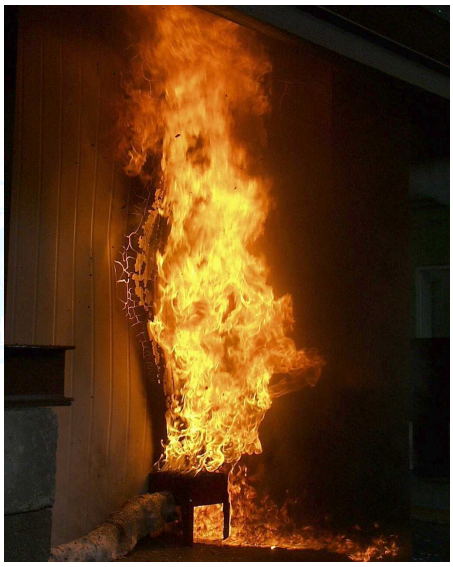

Response
1st Room
Critical
1st Floor
Critical
Building
Critical
100%
Evacuation
Structur
al
Integrity
time

Earlier Response



Questions

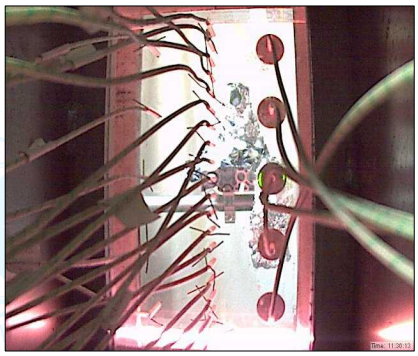
- Putting for one moment aside the availability of sensors…
- Is fire modelling state of the art good enough?
- Accurate enough?
- Fast enough?
- Simple enough?

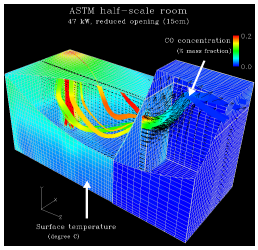


What would be the way forward?

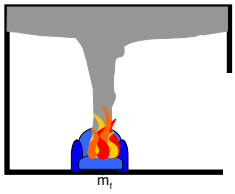
- *Brute Force*
- *Weak Force*
- *Tuned Force*

FireGrid





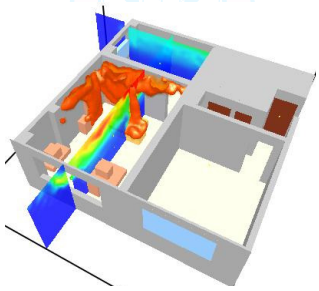
Modelling Limitations



- Analytical Model:
  - Only valid for simple scenarios
  - Large body of assumptions
- Zone Models: Baseline computations
  - Accuracy limited by the assumptions
  - Large part of physics is lost
- Field Models: High Resolution
  - Include most of necessary physics
  - Adequate accuracy
  - Very time intensive

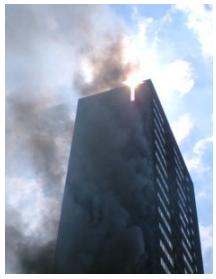
Round Robin of fire modelling

- How robust is the state of the art?
- International pool of experts provide **blind** predictions of a large-scale test (Dalmarnock)

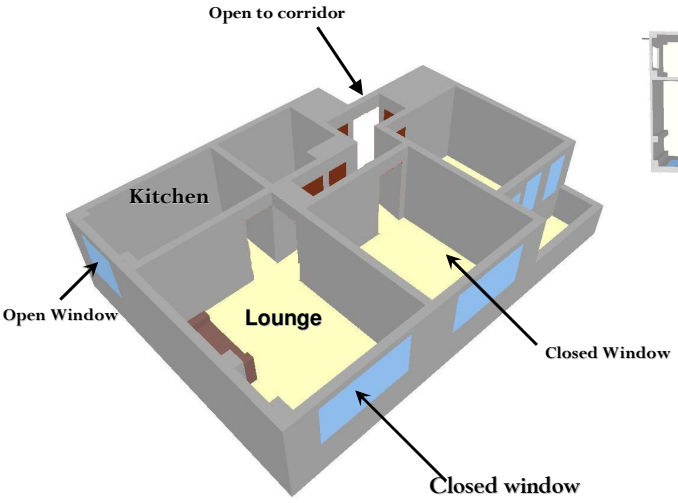


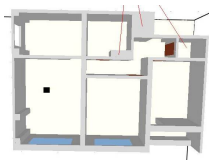
Concepts

- Lead time
- Data Assimilation
- Pre-run scenarios
- Sensors
- Grid

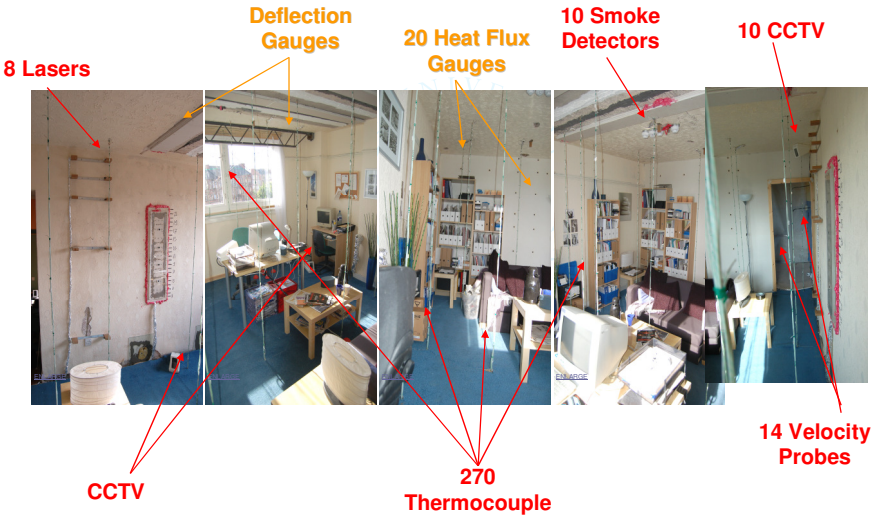


Flat Layout



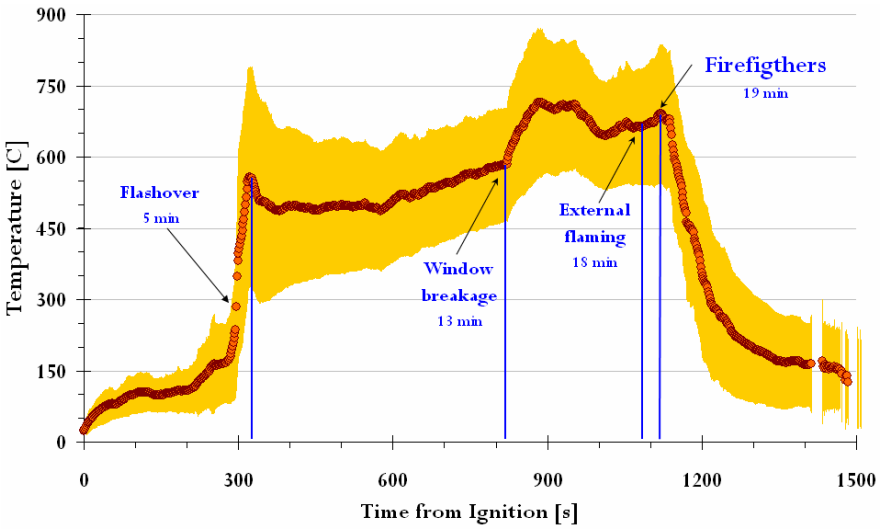


Heavily Instrumented

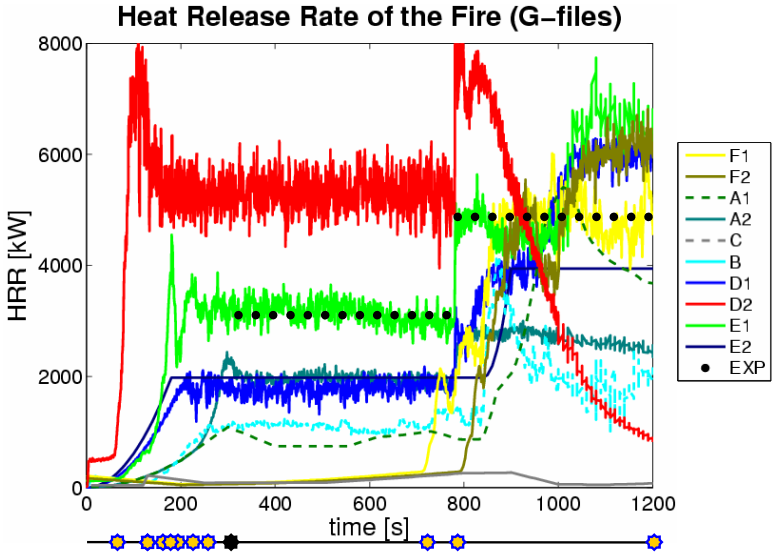


Aftermath

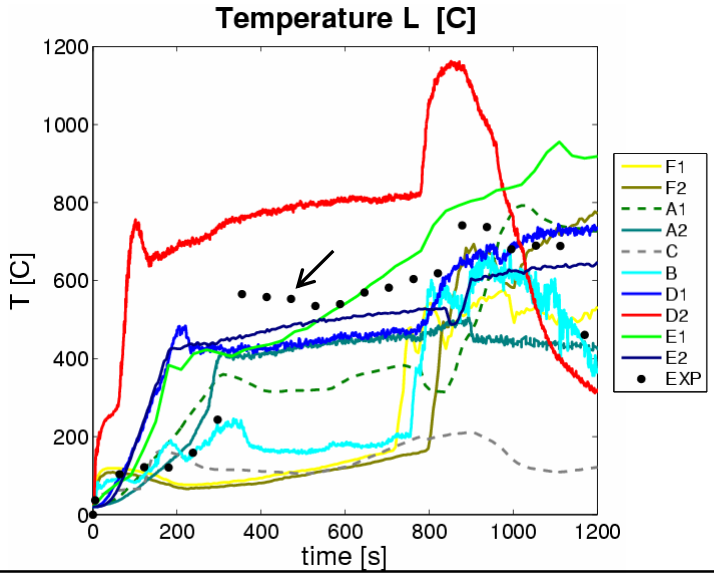
Average Compartment Temperature



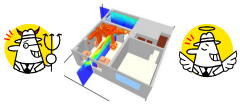
Results: HRR



Results: Hot Layer Temperature



RR Lessons



- *Brute Force* forecasting would provide big scatter at **small spatial-scales** and diverge at **long time-scales**

- Complex dynamics driven by critical events (items ignition, window breakage, flashover…)
- Need strong and continuous interactions with **sensor data**

Rein et al. 2007, 5th Fire and Explosions Hazards

Similar Problems

- **Weather** forecasting

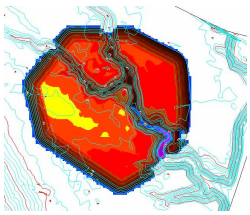
lead time is 4 days, weather scales are 10 km and 10 hr

- **Wildfire** forecasting:

lead time is ¿1 hr?, forest scales are 100 m and 1 hr

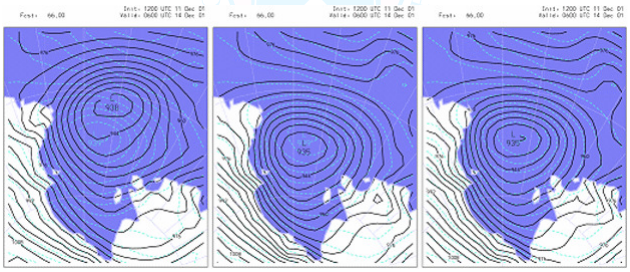
- **Enclosure fire** forecasting:

¿lead time? enclosure scales 1 m and 1 min



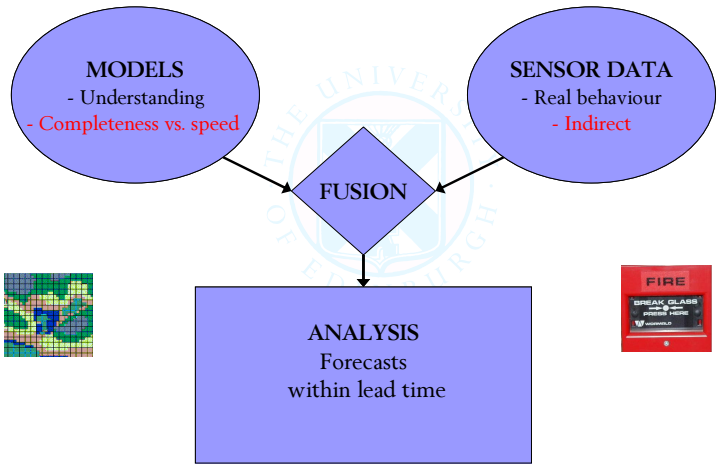
Data Assimilation *(Tuned Force)*

- To combine all sensor and model information to produce an estimate of future conditions
- The concept has been applied successfully to Weather forecast since 1970's
- Many methodologies currently in used

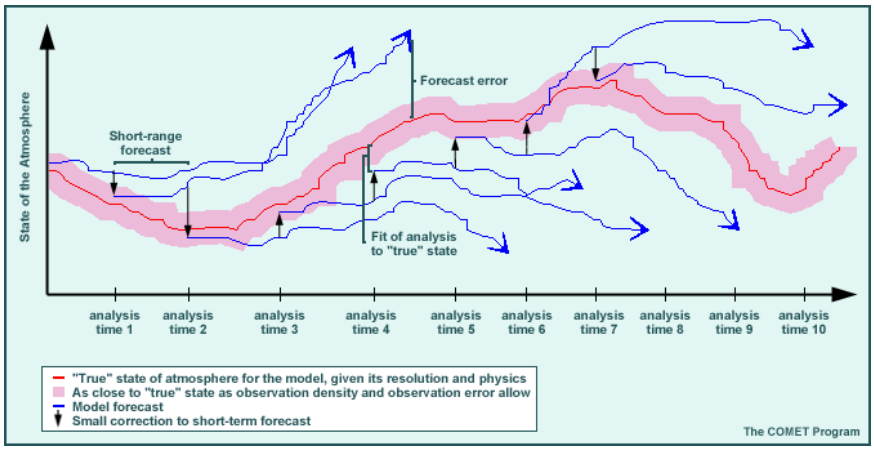


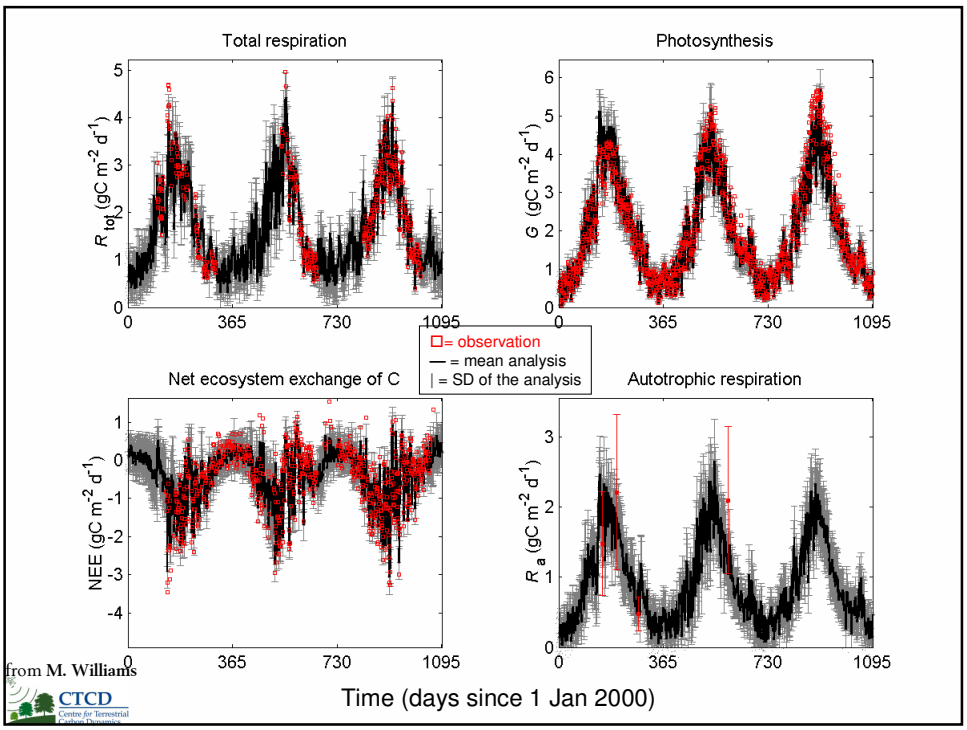
Data Assimilation is also called Dynamic Data Driven Modelling

Data Assimilation (smart force?)



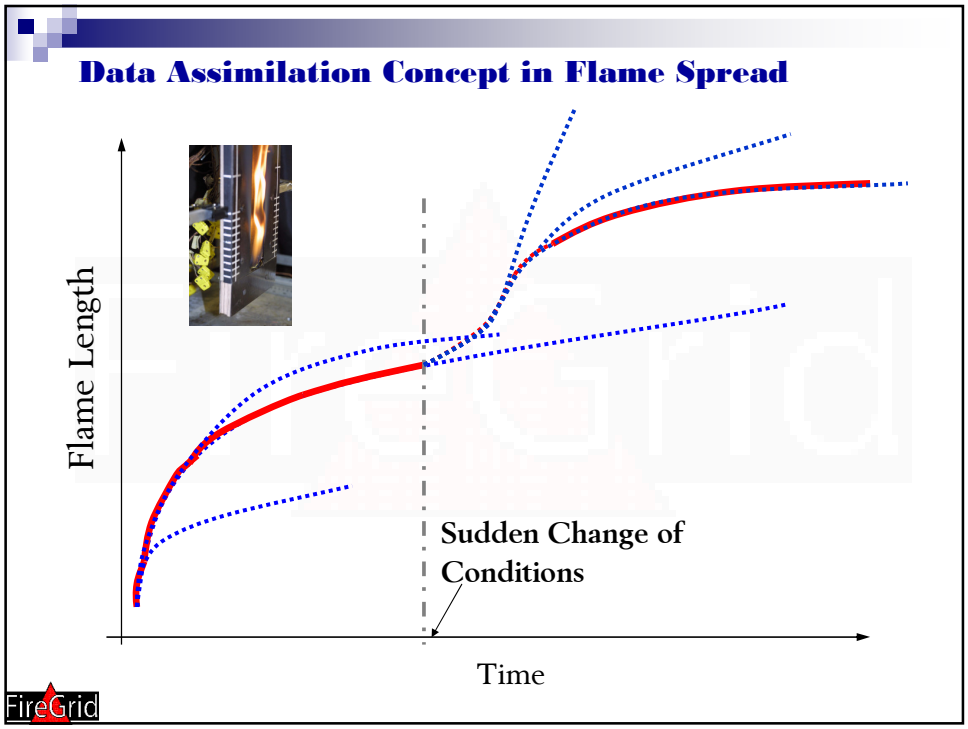
Data Assimilation Concept in Atmospheric Modelling





from M. Williams

CTCD Centre for Terrestrial Carbon Dynamics

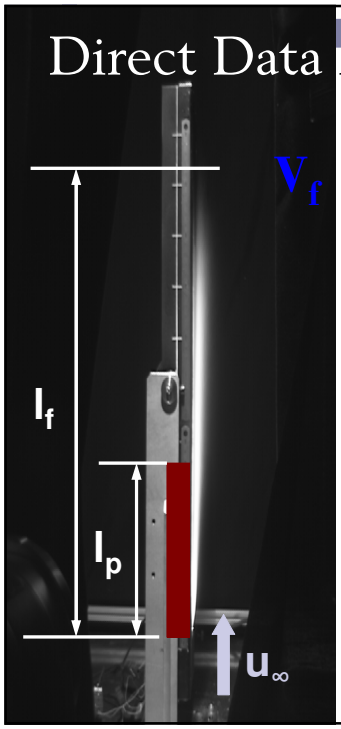


Some Results from FireGrid

- 'step by step'

- Direct Data Assimilation (~*Weak Force*)
- Preliminaries of Weather Forecast Methods

Direct Data Assimilation

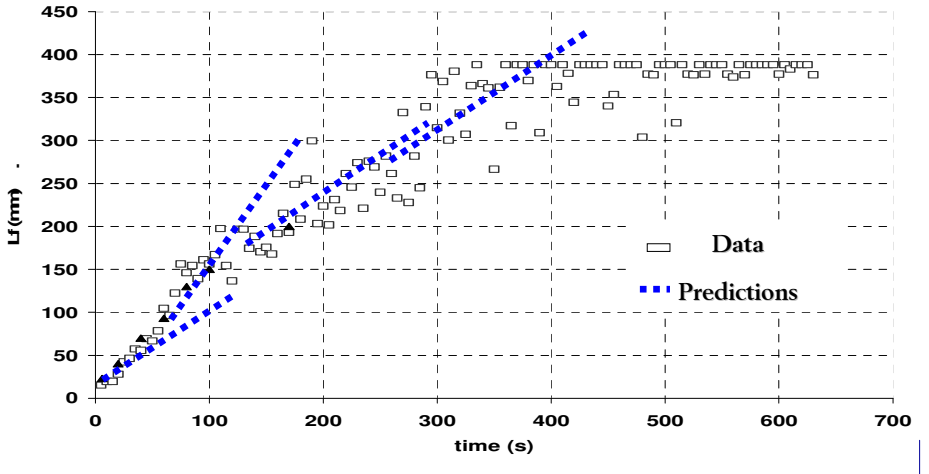


$$V_f = \frac{4c[(c_1 k_g \rho_g c_p u_\infty / l_p)^{1/2} (T_f - T_p) + q_s]^2 l_p}{\pi k_s \rho_s c_s (T_p - T_0)^2}$$

- k, ρ, c, k – Non variant constants
- u_∞, l_p, q_s, T_p, T_f – Parameters measured
- c and c_1 - non-dimensional constants particular to the experiment to be calibrated

FireGrid

Direct Data Assimilation Results

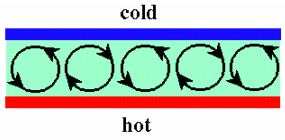


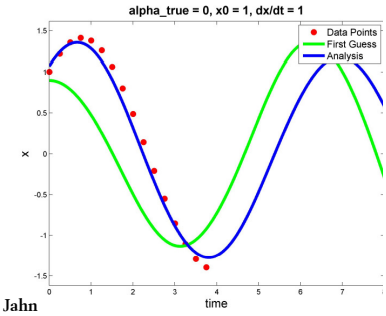
FireGrid

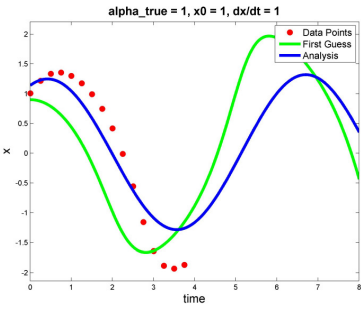
A Simple Weather Forecast Approach

- Natural convection between two layers (Van der Pol)

$$\frac{d^2x}{dt^2} - \mu(1-x^2)\frac{dx}{dt} + x = 0$$







from **W. Jahn**

FireGrid

A Simple Weather Approach

errors	Forecast	IC	Parameter
Linear	10%	8%	3%
Non-linear	100%	40%	60%

- Very fast and effective tool for linear or near-linear problems
- Very limited tool for non-linear problems

- Complex method, Large computer resources, Little transparency, relatively quality results for near linear problem….

from **W. Jahn**

FireGrid

Concluding Remarks

- Computations must be steered by sensors (DA)
- Balance between accuracy, complexity and resources
- State of the art is closer to very simple models

- Next level at hand: Zone models (within Firegrid)

- Technology and our **understanding** of fire dynamics is constantly improving
- Thus, Emergency response will only improve

FireGrid Project

funded by the Technology Programme of the Department Trade and Industry, UK

http://www.firegrid.org

BRE Center for Fire Safety Engineering

bre ARUP ABAQUS

ANSYS LFB LONDON FIRE BRIGADE making London a safer city

Vision Systems

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