A Ubiquitous Urgent Computing Framework for Ensembles of Flash Flood Forecasts

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16 March 2016

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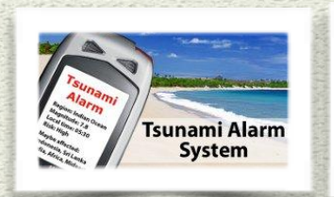
Urgent Computing

I have a really important paper with an impending deadline. I need urgent computing!

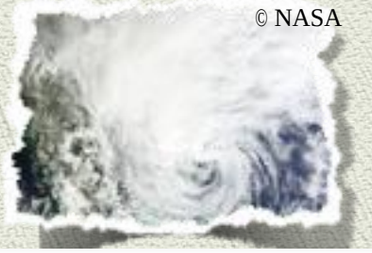
- Requires computations (**disasters**)
  - ✓ Commence in short order

  - ✓ Complete before a stipulated **deadline**

  - ✗ Support mitigation activities



  - ✗ From events that requires immediate attention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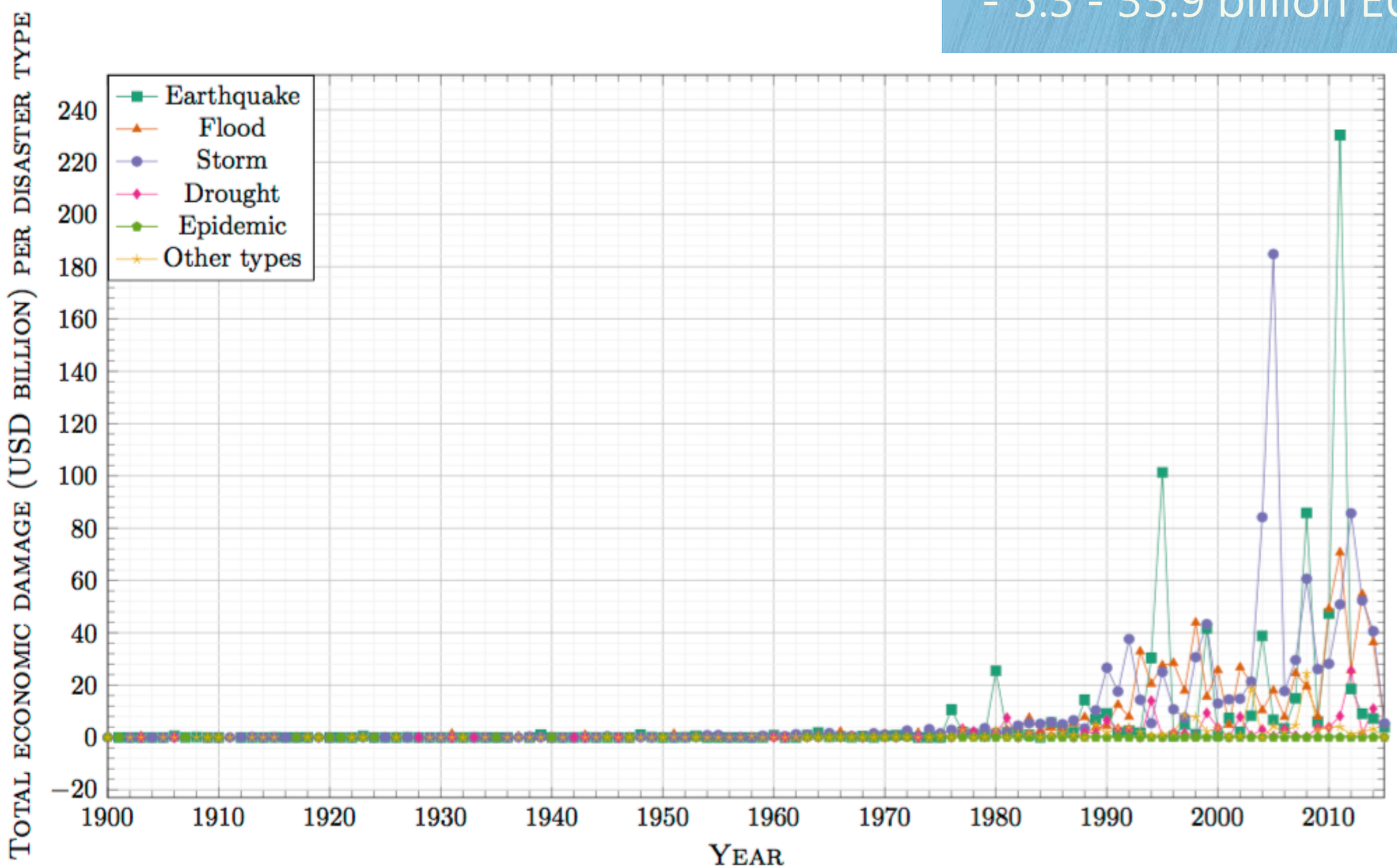
[8] S. H. Leong and D. Kranzlmüller. Towards a General Definition of Urgent Computing. In *ICCS Proceedings*, volume 51 of *Procedia Computer Science*, pages 2337 – 2346. Elsevier, 2015.

Motivation

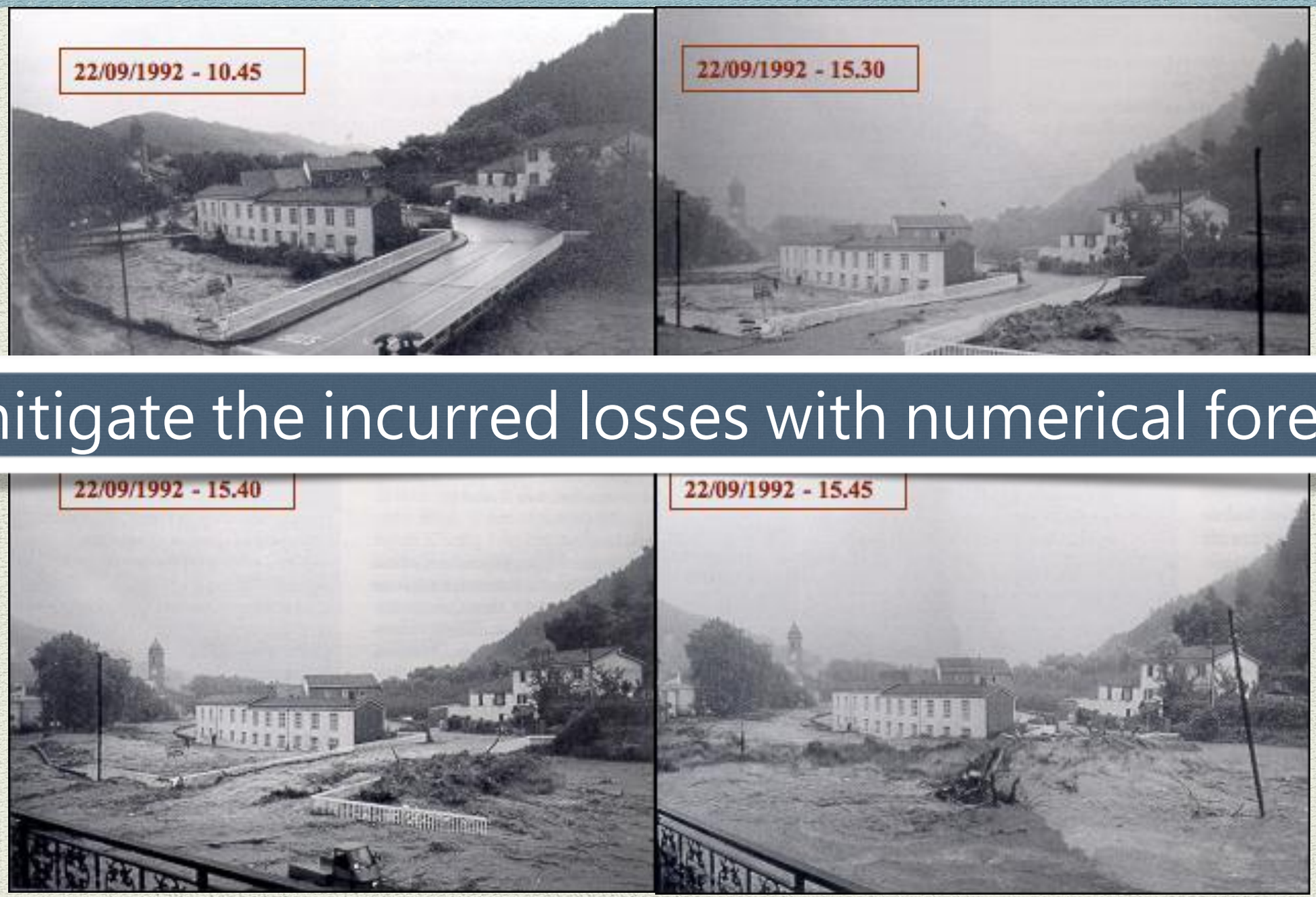
EC Joint Research Centre

- Germany' s flooding in 2080
  - 170,000 - 323,700 affected population
  - 5.3 - 33.9 billion EUR



(b) Total Economic Damage caused by Reported Natural Disasters (EM-DAT)

Motivation



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To mitigate the incurred losses with numerical forecasts

Sudden Flash Flood in a small catchment (Mediterranean area)

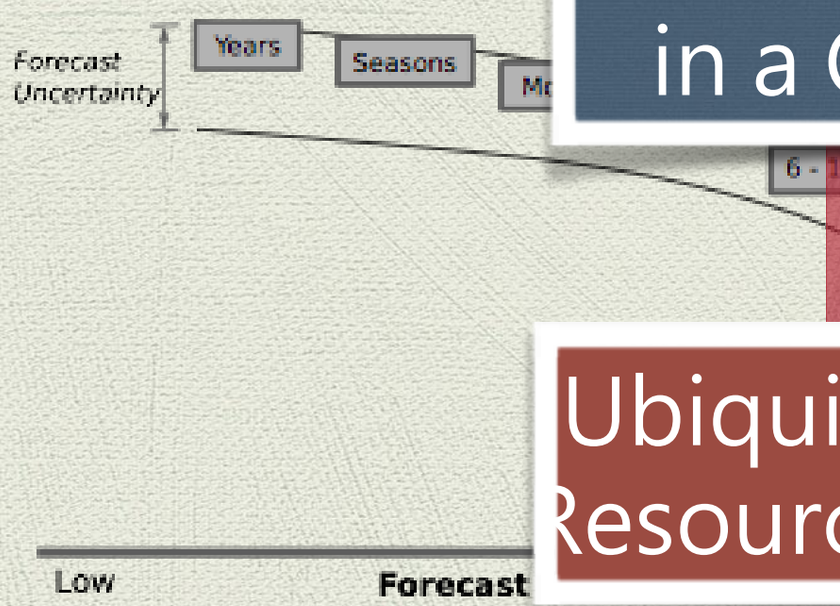
Problems & Proposed Solutions

Inaccuracy in observational dat

Limitations of forecast models

Coordinate Multiple Forecasts under Timing Constraints in a Chaotic Environment

Redrawn from NWS



Chaotic environment

Ubiquitous Framework with Resource Allocation Heuristic

Leverage on zero hour data

Stochastic forecast methods

Task-based Ubiquitous (TbU) Approach

Swiftly

Reliably

UC Requirements

Event Requirements

Anytime

Anywhere

Ubiquitous Process Orchestrator

Activity & Task Manager

Information Manager | Resource & Environment Manager | Schedule Manager | Fault Manager

Subtask Coordinator

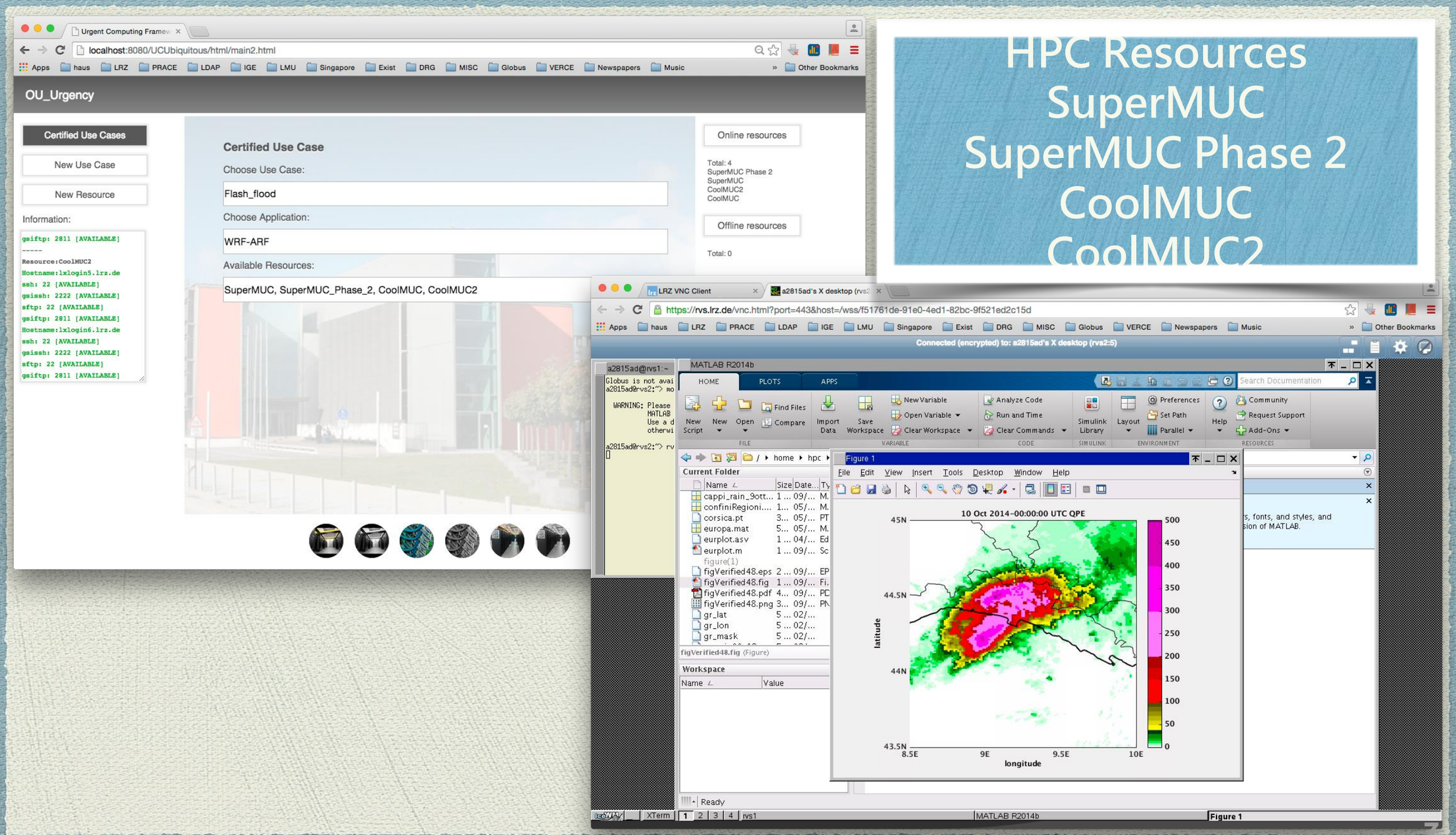
PRACE

HPCs

HTCs

egi

TbU Approach



Resource Allocation Heuristic Objectives

Meeting the stipulated deadline

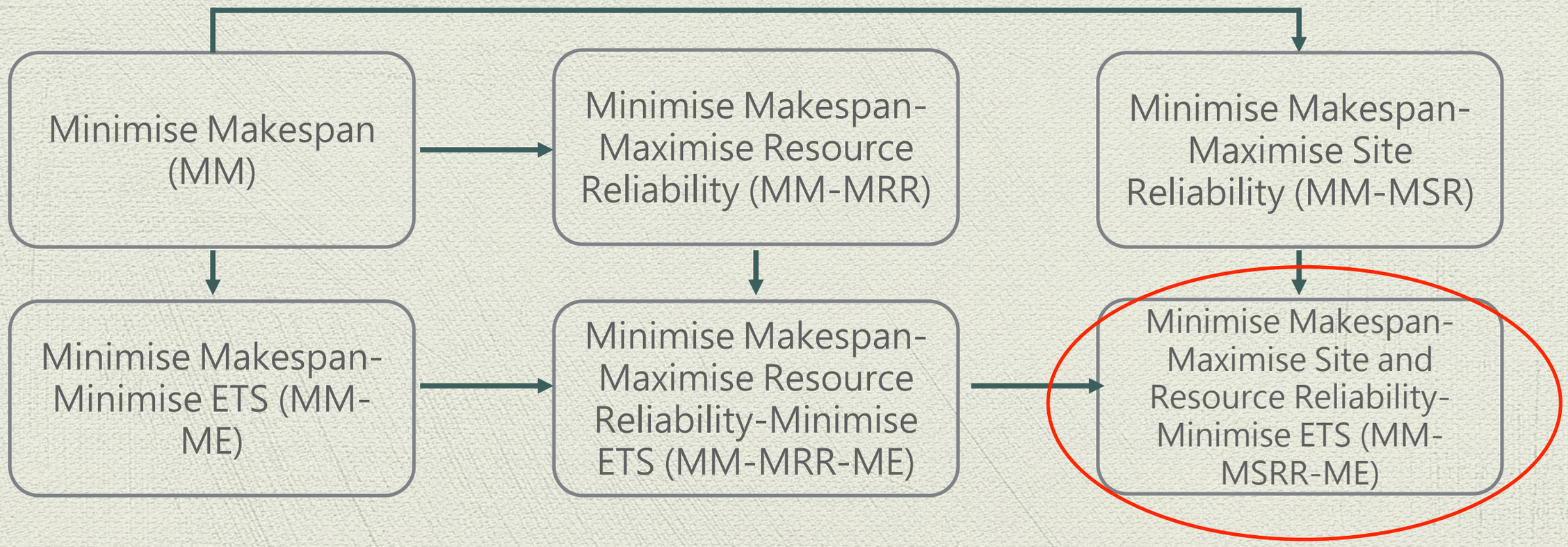
(i) Maximise Makespan Robustness
(ii) Minimise Energy Usage
(iii) Maximise Reliability across Sites and/or Resources

Reliability across resources and/or sites

Maximise Reliability

Resource Allocation Heuristics

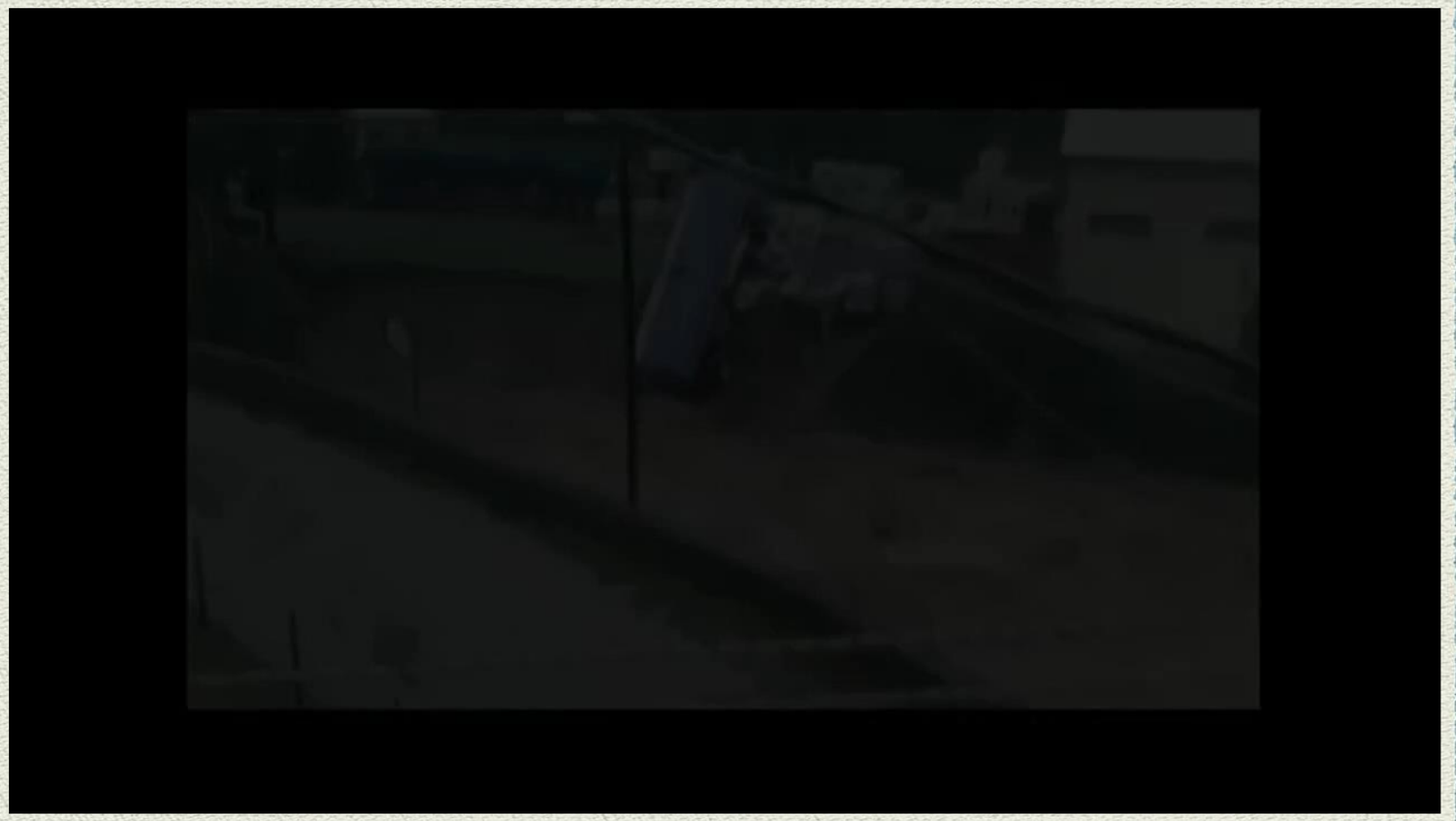
Priority 1:	Maximise Makespan Robustness /Minimise Makespan
Priority 2:	Maximise Site and/or Resource Reliability
Priority 3:	Minimise Energy-To-Solution



Genoa flash flood October 2014

Flash flood: one of the the most dangerous type of floods as it can form swiftly with little or no prior warning.

- Forecast heavy rain and storm
- No warning about flood
- Two rivers overflow the banks
- More than one metre of water and mud
- Electricity cut, school closed, train derailed



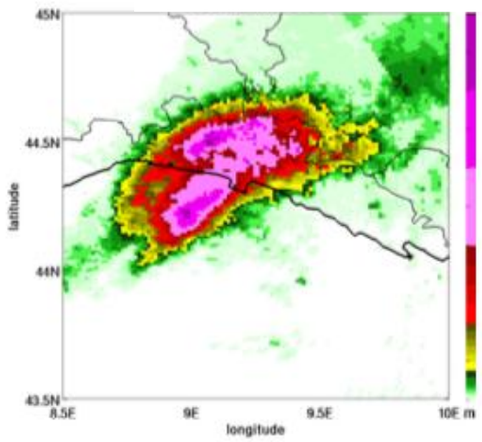
Test & Results

- Case Study
  - Forecast Genoa flash Flood (9 Oct. 2014)
  - Loss: ~303 million USD and one death (EM-DAT)
  - Deadline: 3 hours

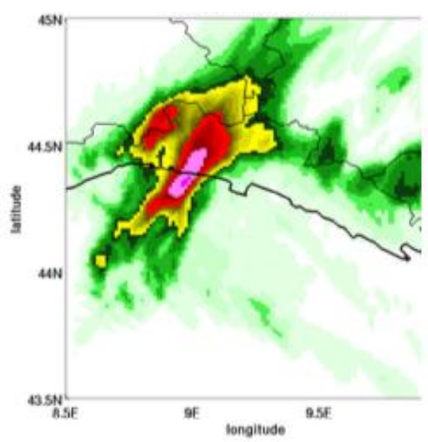
- WRF-ARF Model
  - Eight ensemble forecasts with different microphysics options
  - Each forecast: 640 cores to generate a 24 hours forecast with 2 domains (5km and 1 km)

Resource	Available cores	Default Freq (GHz)	Freq Scaling	Site	Availability	Performance	ETS
SuperMUC	131,072	2.3	yes	LRZ	0.85	High	Medium
SuperMUC Phase 2	71,680	2.2	yes	LRZ	0.85	High	Low

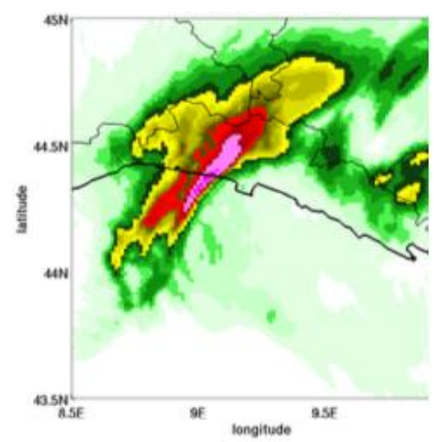
Test & Results



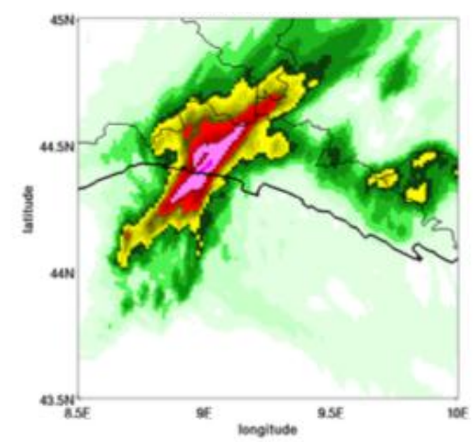
(a) Radar Verification



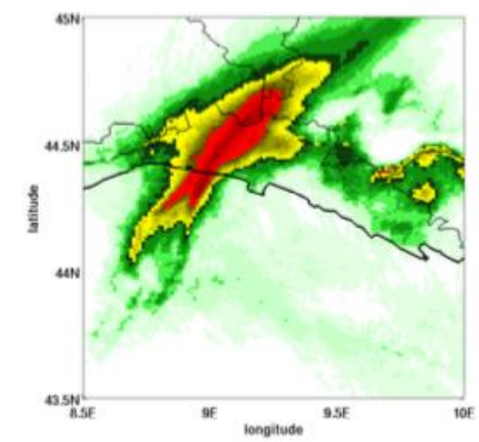
(b) Kessler



(c) WSM3

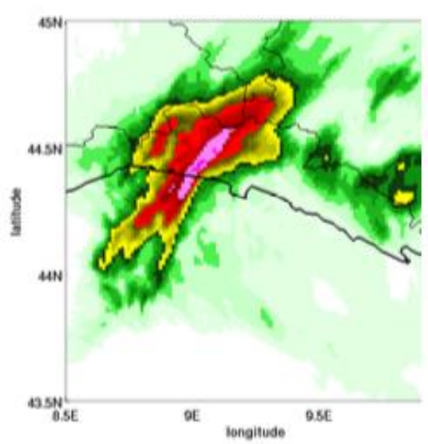


(d) WSM5

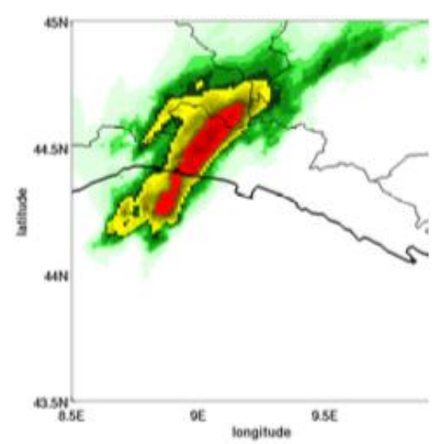


(e) Ferrier

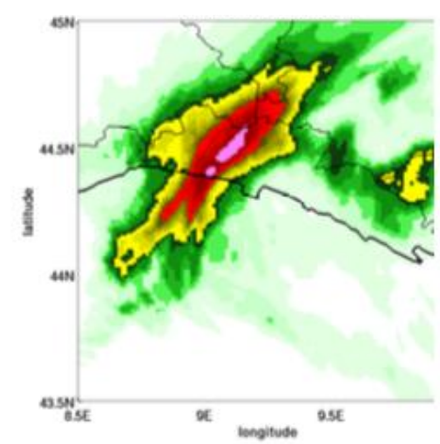
At the 24th hour



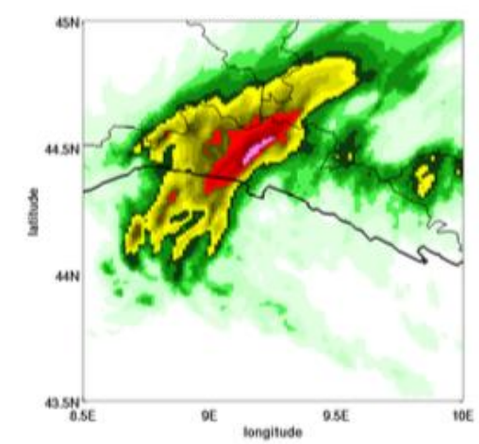
(f) WSM6



(g) WSM6D



(h) Thompson



(i) Morrison

Conclusion

- TbU approach
  - 3-layer architecture
  - Ubiquitous access from anywhere and at anytime
  - Realise urgent computing and event requirements
- Resource Allocation Heuristic
  - Manage resource allocation swiftly
  - Fulfil three objectives
    - Minimise Makespan-Maximise Site and Resource Reliability-Minimise ETS

Future Work

- Cost of Urgent Computing
  - Preemption
- Prediction Models
- Advanced Visualisation

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