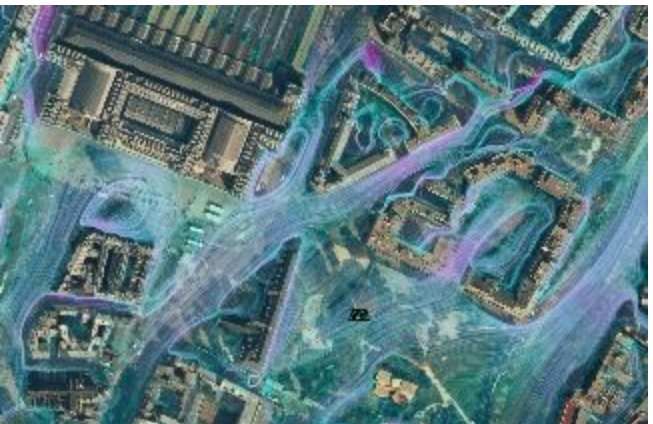
Web visualization of atmospheric modelling applied to very large (or just any) calculations



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Visualize small but also very large simulation data for operational use

- In highly parallel simulation projects, we ended up with large amount of simulation data that are hard to visualize:
  - Not because of numerous time frames,
  - But due to very large horizontal extensions of the calculation domain.

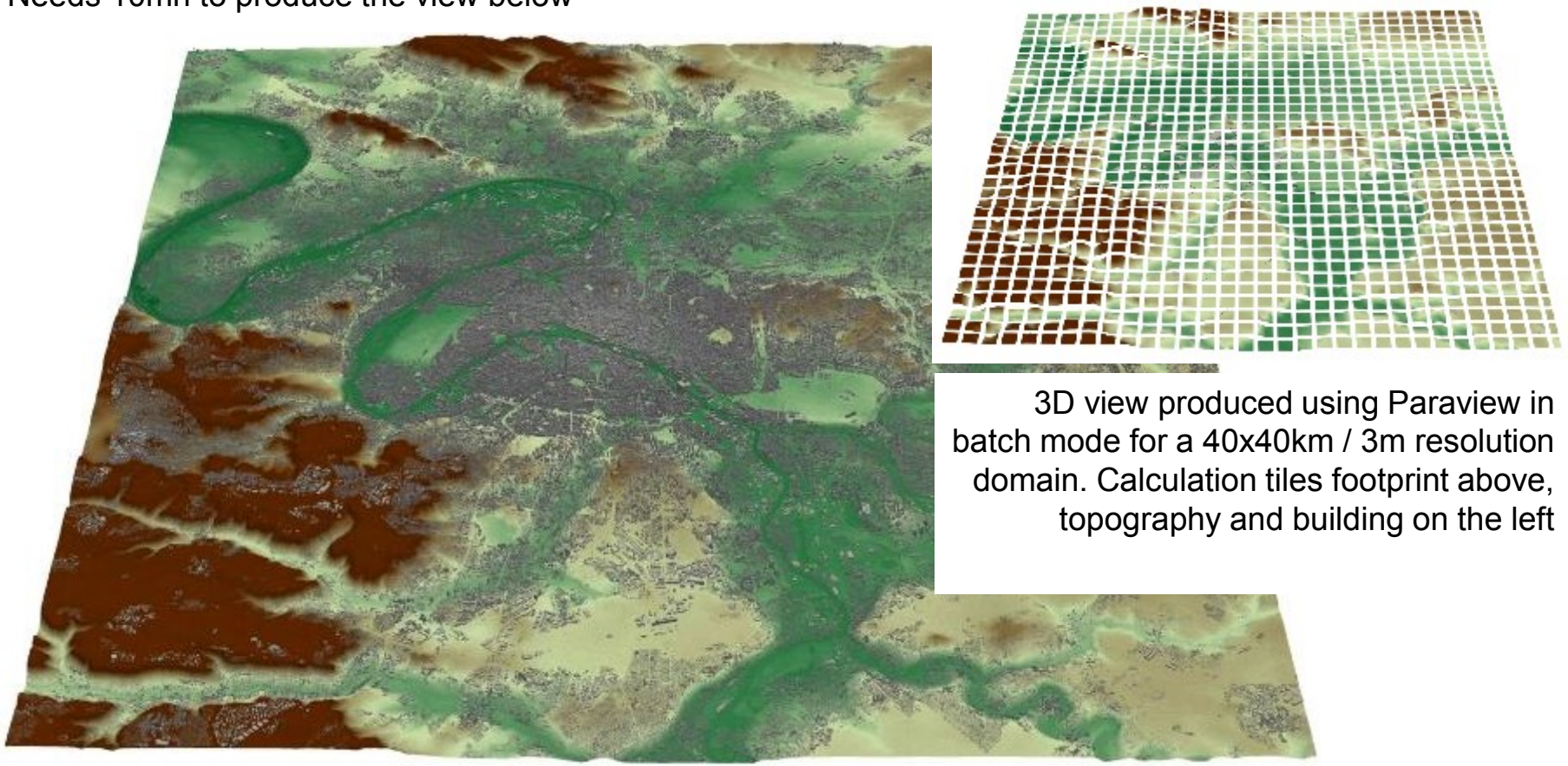
See Emergencies Mediterranean - A prospective high-resolution modelling and decision-support system in case of adverse atmospheric releases (P. Armand, H18-013 this Monday)

- Visualization is useful:
  - (obviously) for us, modellers, to verify our modelling,
  - but also to communicate with decision makers.

- Traditional 3D scientific viewers are difficult to use in operational situations, especially to browse large outputs

We did use Paraview parallel 3D viewer

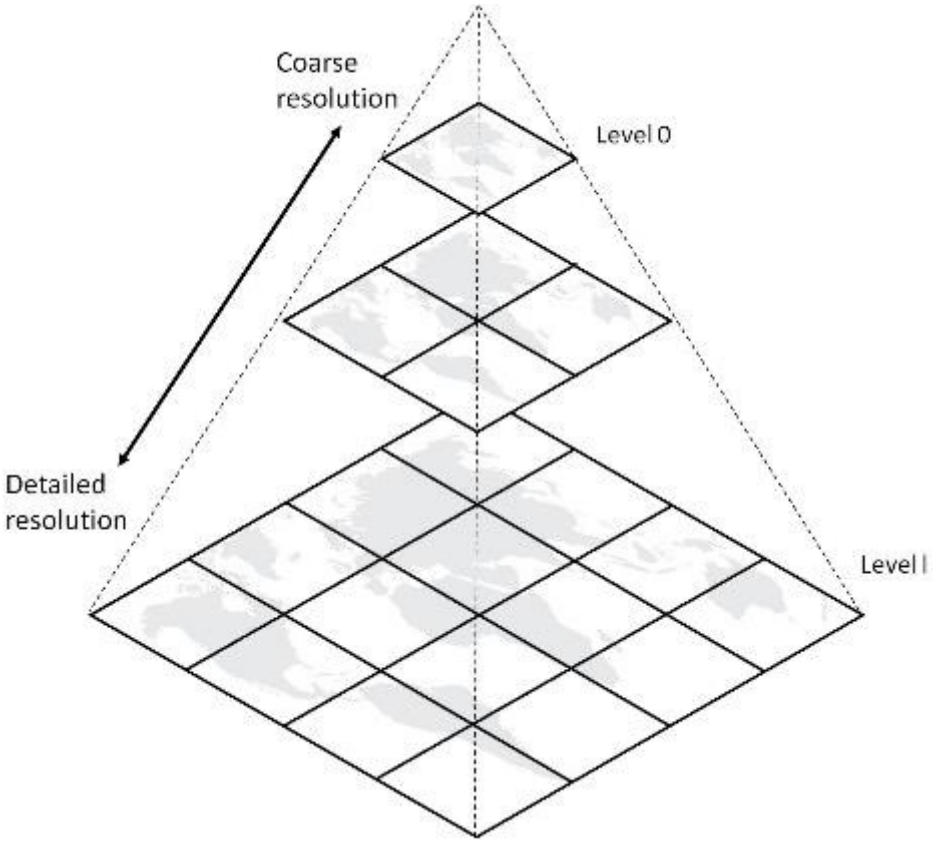
- Example: large computational domain decomposed in 1000 calculation tiles
- Custom Paraview parallel plugin applied in batch mode using 1000 cores (1 core / tile)
- Needs 10mn to produce the view below



3D view produced using Paraview in batch mode for a 40x40km / 3m resolution domain. Calculation tiles footprint above, topography and building on the left

Reduce the workload during visualization thanks to data streaming

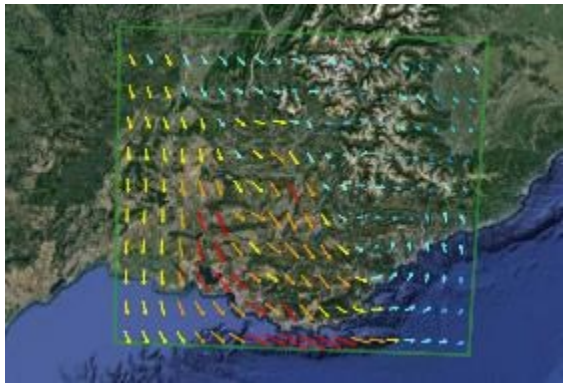
- Limit data access to:
  - The geographical area being displayed
  - The correct level of details according to the zoom level being chosen
- Multilevel tiled images are generated and stored in a SQLite database file (MBtiles) during post processing
- Viewing is handled by a Javascript web client using Leaflet cartographic library



Tiled image example with 3 levels of zoom and 4x4 images at the more detailed zoom level

Custom display of data is handled by Javascript built on top of Leaflet library

Wind speed display using streamlines (see above) or vectors (see right hand side)



- Leaflet Javascript is used to handle the cartographic layers,
- Custom Javascript is used to handle specific needs, such as time varying aspects,
- Scalar or vectors can be displayed.

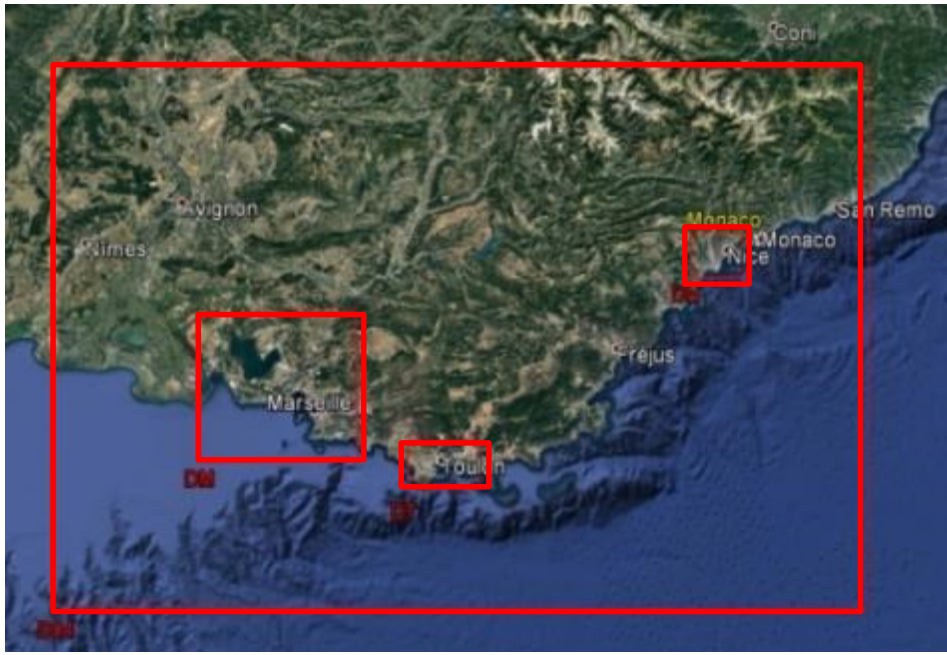
Parallelisation has been introduced to speedup the post processing

- Post processing to generate the multilevel tiles is done only once after the calculation,
- Parallel algorithm is encoded using Message Passing Interface (MPI) library,
- The workload is distributed among calculation cores on a tile basis:
  - If the domain is small, not so many tiles, but very limited post processing at the same time,
  - If the domain is very large or the number of time frame is important, many tiles (typical tile size is 256x256 points).

How to visualize high resolution calculations on very large domains?

- EMED project (Emergencies for MEDiterranean coastline) was presented by P. Armand (H18-013). Calculations on 3 high resolution (3m) nested domains :
  - Nice : 20x16km^2 / ~ 6 000 x 5 000 x 39 mesh points
  - Toulon : 26x16km^2 / ~ 8 000 x 5 000 x 39 mesh points
  - Marseille : 58x50km^2 / ~ 19 000 x 16 000 x 39 mesh points
- Output size (Nice / Toulon / Marseille) :
  - Wind (per time frame): 70 / 100 / 700 Go
  - Concentration (total): 500 / 300 / 800 Go
- Visualization for operational use is a challenge

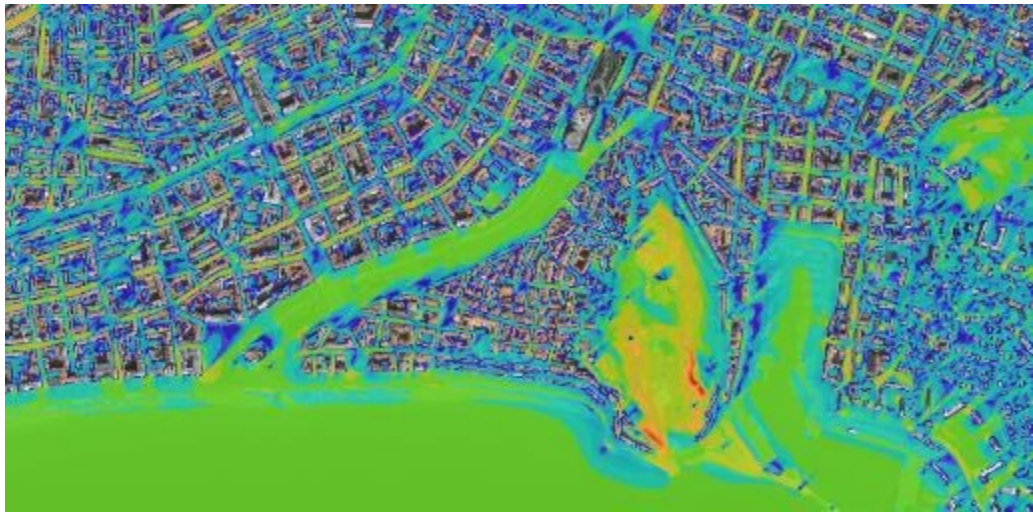
(plain visualization is also a challenge)



Large scale domain and high resolution nested domains for EMED project (from West to East: Marseille, Toulon and Nice)

The approach allowed us to explore and show simulation results despite the very large amount of data produced

- Wind post processing (100 cores), per time frame:
  - 10mn for Marseille
  - 30s for Nice or Toulon
- Concentration post processing (20 cores), per time frame:
  - 30s for Marseille
  - 20s for Nice or Toulon



View of wind speed in Nice city centre for a particular time frame (zoom level 16)

Comments

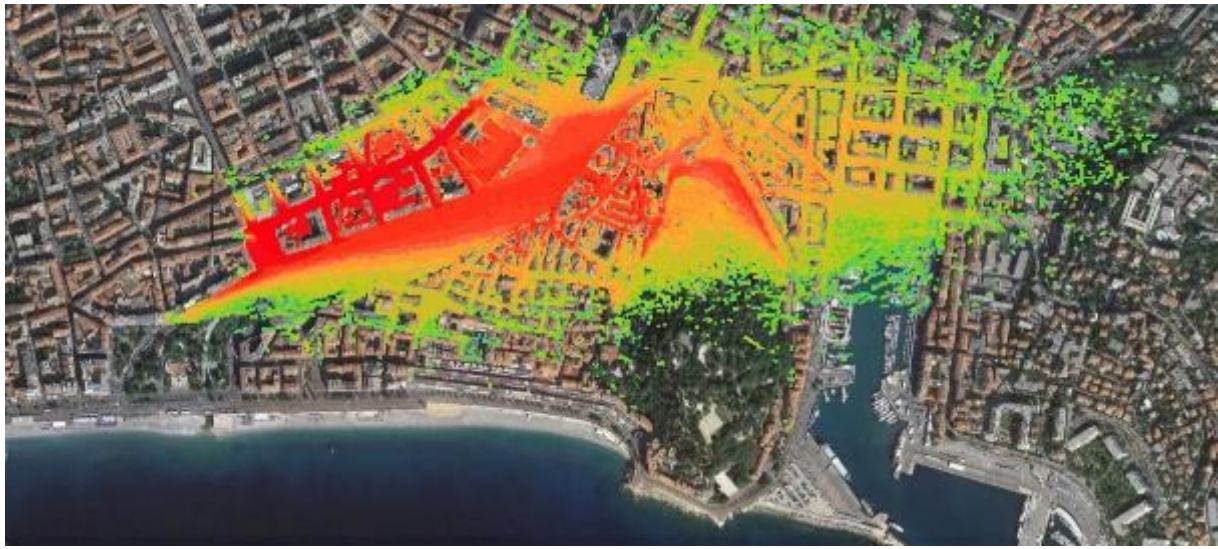
- No parametric study was performed for post processing
- Number of cores used for post processing was small compared to number of cores used for calculation
- Post processing can be done on the fly as soon as results are available.

Explore and share simulation results, including very large calculations

- Web visualization trough multilevel tiles makes it possible for us to:
  - Explore simulation results with the same level of interactivity in case of very large calculation or small test cases,
  - Share easily simulation visualization between modellers through web access.
- Post processing:
  - Is performed once and can be done on the fly during calculation as soon as outputs are available,
  - Specific parallel algorithms were introduced to speedup the processing of very large calculations.

- On-going work: benchmark the post processing parallel efficiency

Concentration near ground in Nice 15mn after release time (zoom level 17)



Simulation service for Air Quality

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