

Joint Laboratory
for Petascale Computing



Inria



Towards Smart Visualization Framework for Climate Simulations

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University of Illinois at Urbana Champaign

Argonne National Laboratory



école
normale
supérieure



Outline

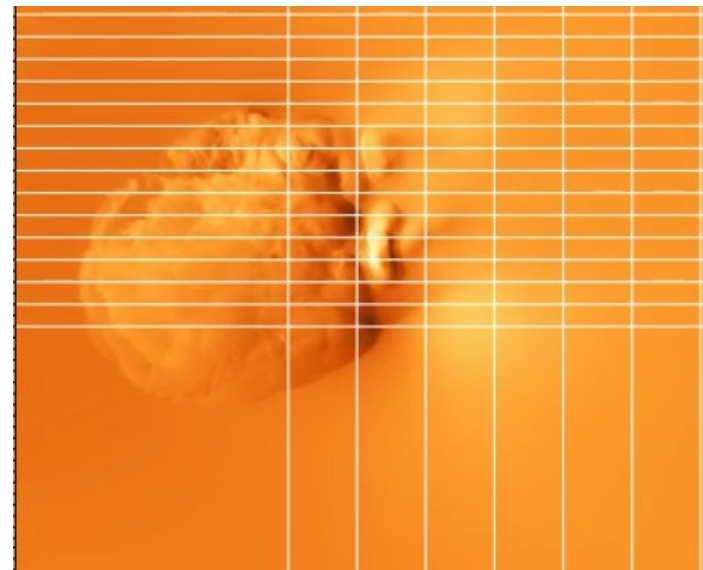
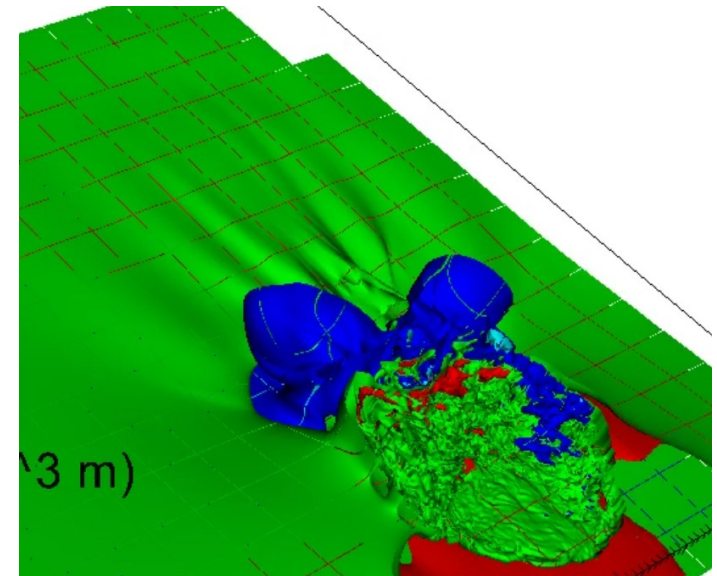
1. HPC Climate Simulations & In Situ Visualization
2. Smart In Situ Visualization
3. Experimental Results
4. Conclusion

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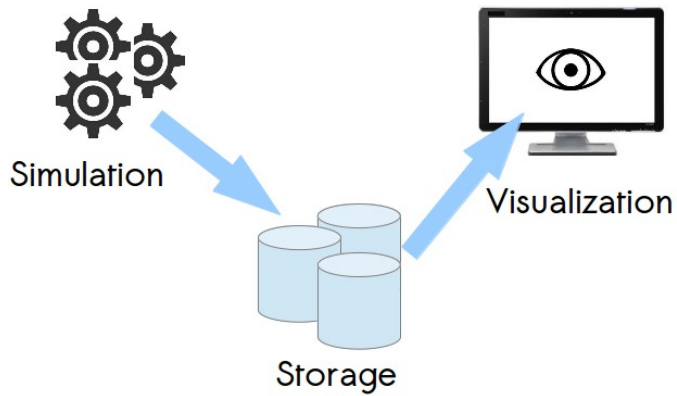
CM1 : Atmospheric Phenomena Simulation

- CM1 on Kraken
 - Simulated space : 48 x 44 x 200 per process
 - 9216 cores
 - 14.2 GBytes/Iteration (~1.69 MBytes for each compute process)
- CM1 on BlueWaters
 - Simulated space : 3840 x 3840 x 400
 - 6400 cores
 - 23.6 GBytes/Iteration (~3.7 MBytes for each process)

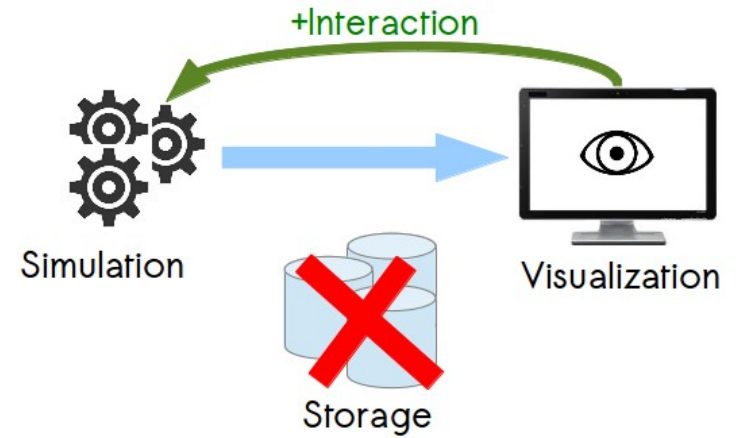


In Situ Visualization

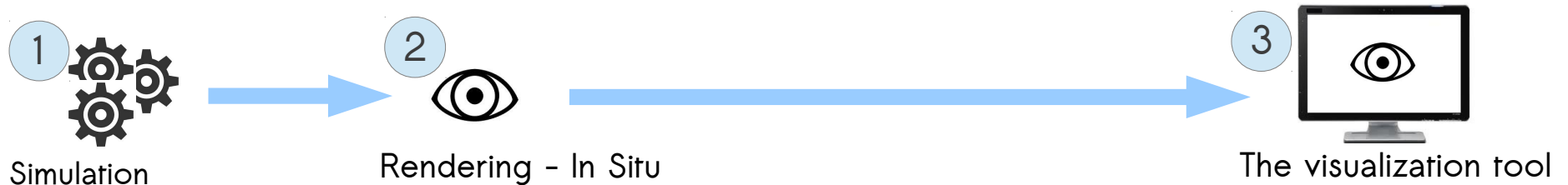
Off-line



In Situ

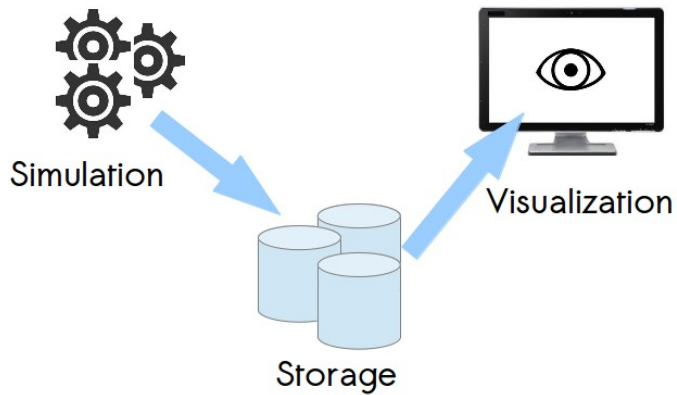


In Situ Visualization Workflow

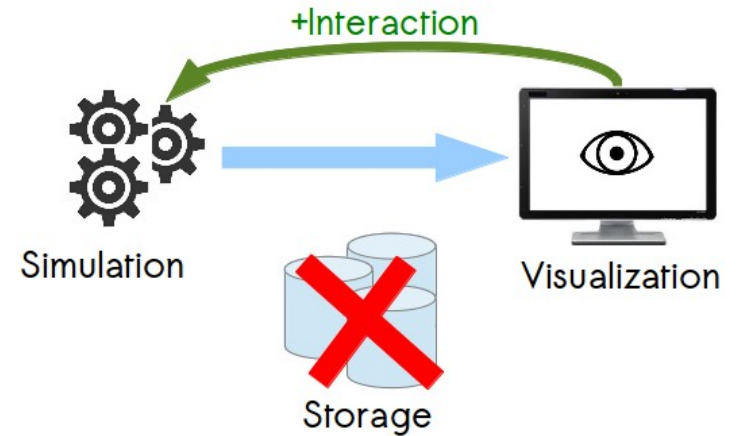


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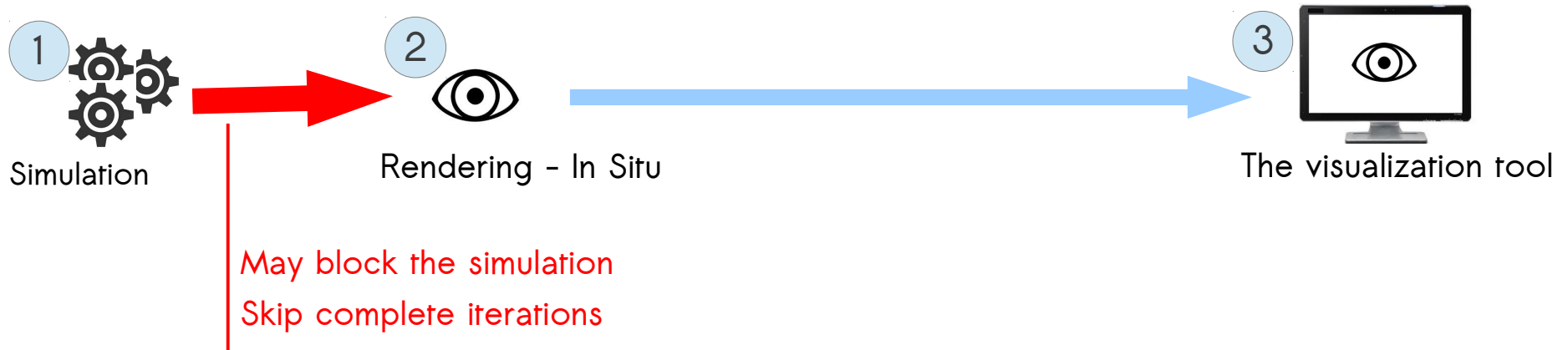
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In Situ

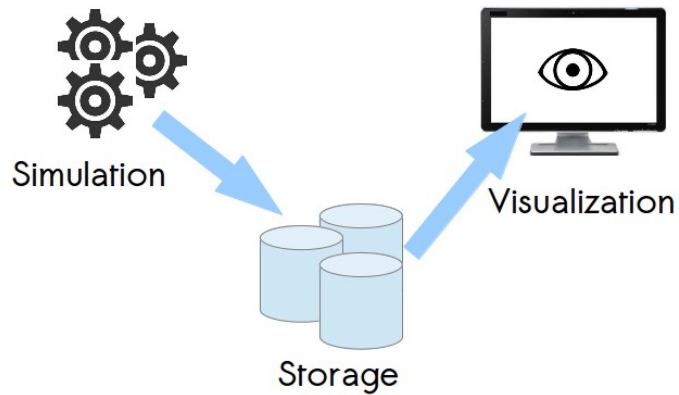


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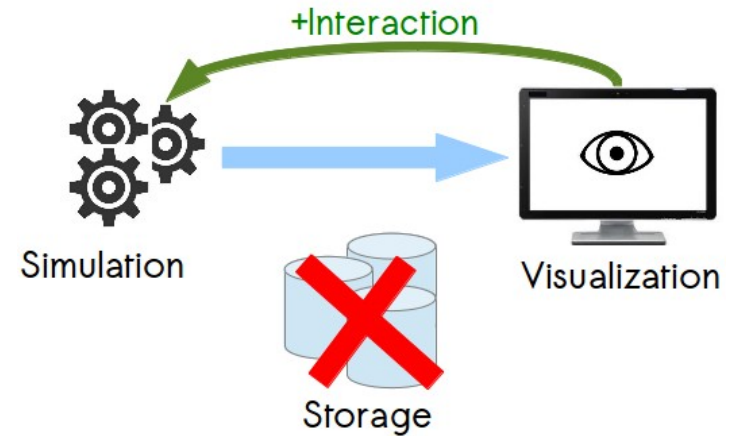


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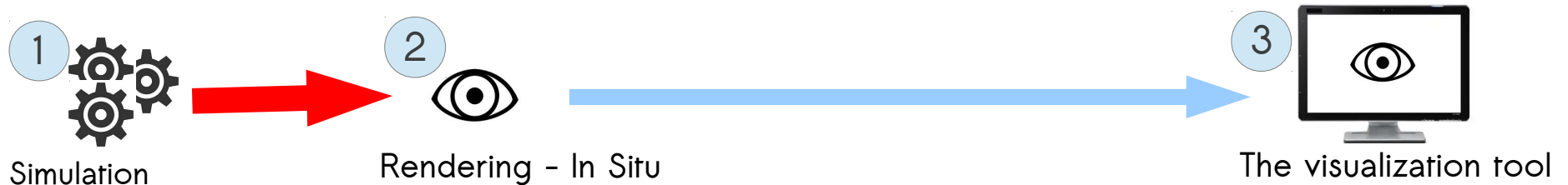
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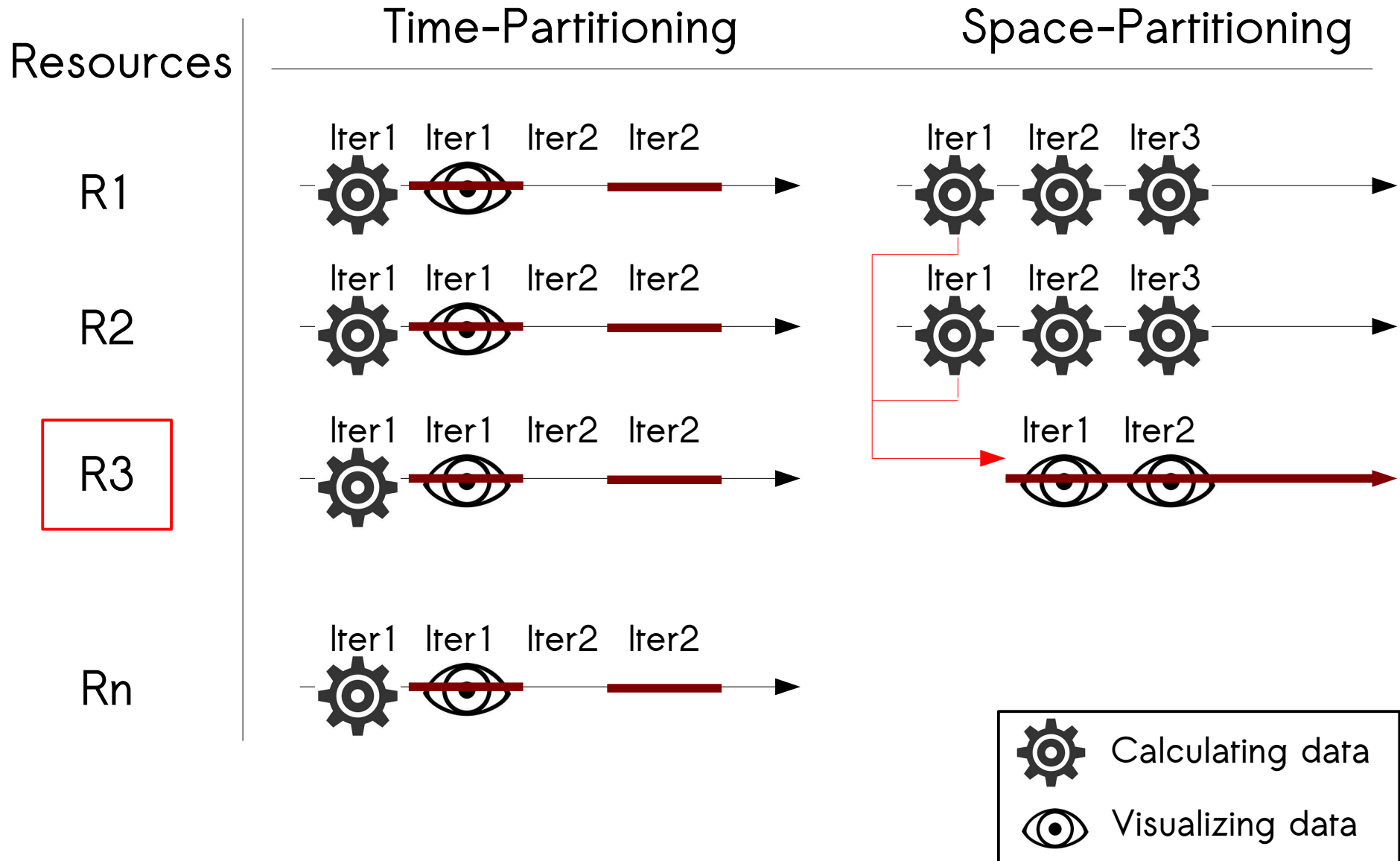


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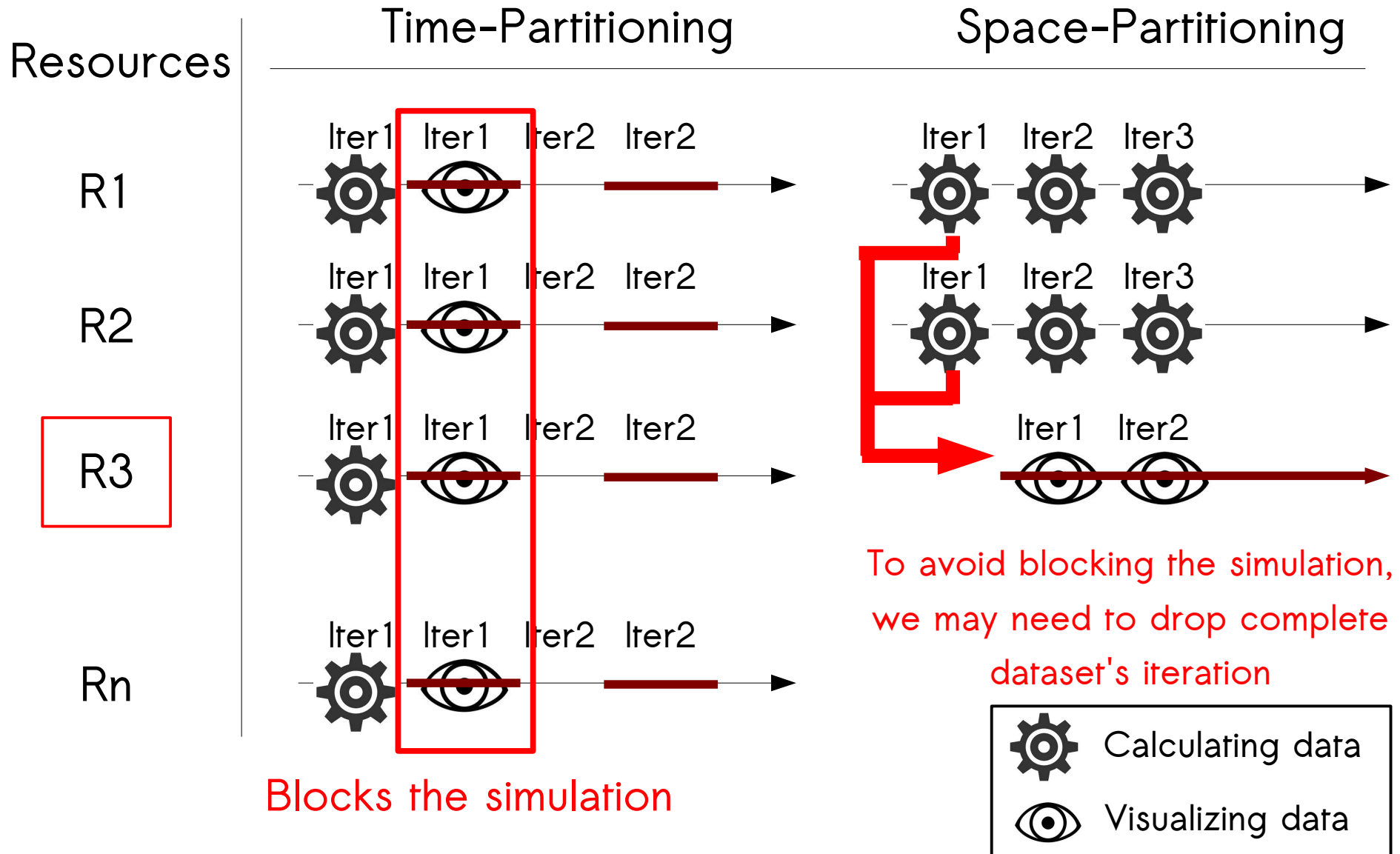


Avoid blind drop of data

In Situ Visualization Implementation



In Situ Visualization Implementation

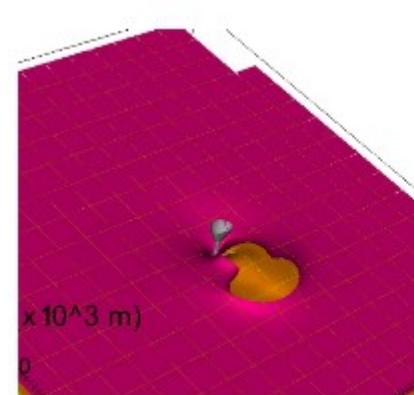
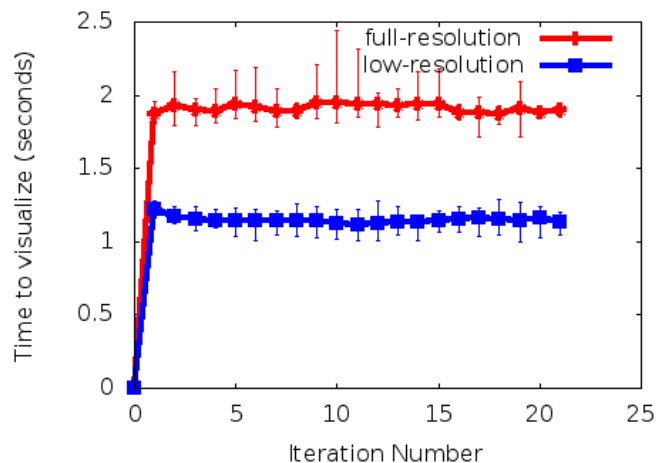


Be Smart, Visualize only relevant data

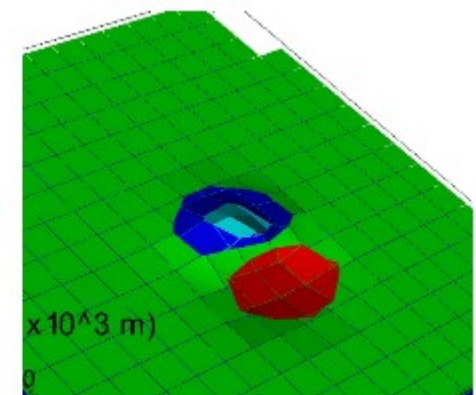
- Avoid blind drop of data
 - Keep all iterations
 - Reduce the amount of data on each iteration
- On each iteration, visualize only relevant data considering the physical phenomena being simulated
 - Interesting data will be visualized in full resolution
 - The rest will be visualized in low resolution

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(a) Full resolution



(b) Low resolution

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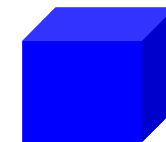
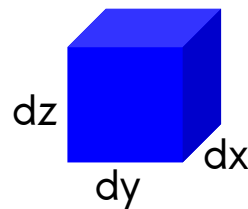
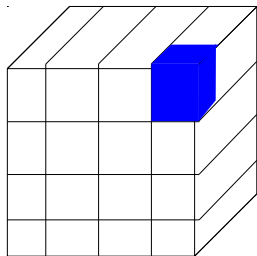
What is 'relevant' data?
and
how to detect it?

Outline

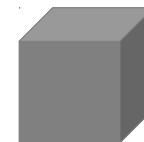
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What is Relevant in a Dataset?

- The solution needs to be:
 - Generic: application-independent
 - Automatic: user-transparent
 - Efficient
- Defined semantic : Variation of the data



full resolution:
 $dx \times dy \times dz$



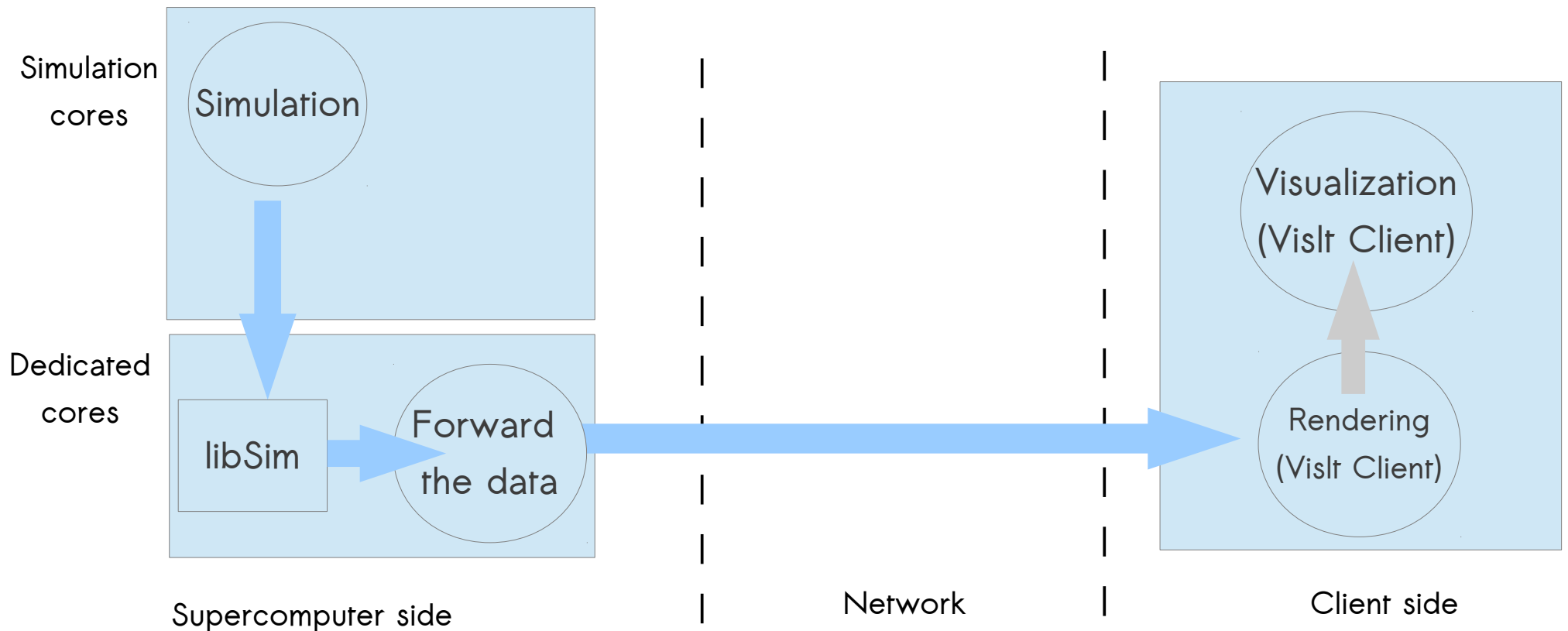
low resolution:
 $2 \times 2 \times 2$

How to Automatically Detect Relevant Data?

- Metrics used to do filtering should :
 - Provide different levels of variation measurement
 - Can be 'normalized'
- To detect variation in \mathcal{X} , a set of values $\{x_1, x_2, \dots, x_n\}$
 - Entropy (Information Theory) : of a random variable \mathbf{X}
 - Coefficient of Variation (Statistics) $C_v = \frac{\sigma}{\mu}$
 - Independent from the unit of measurement
 - Hard to normalize
 - Gradient (Image Processing)
 - Calculate the derivate over each axis
 - Is not a complete metric

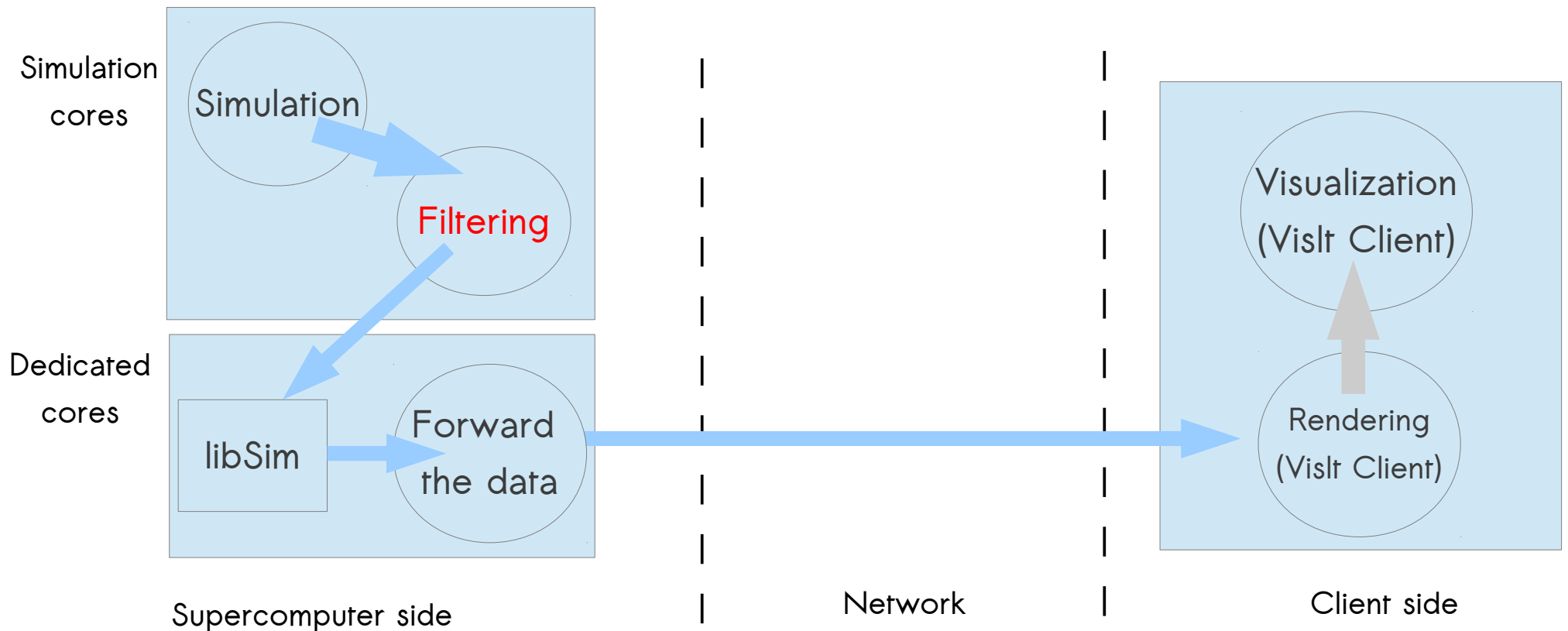
Integration int Existing ISV Frameworks

- Damaris/Viz ISV framework:
 - Damaris : I/O framework
 - VisIt : Client-Server visualization tool



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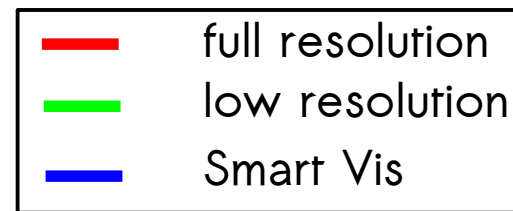
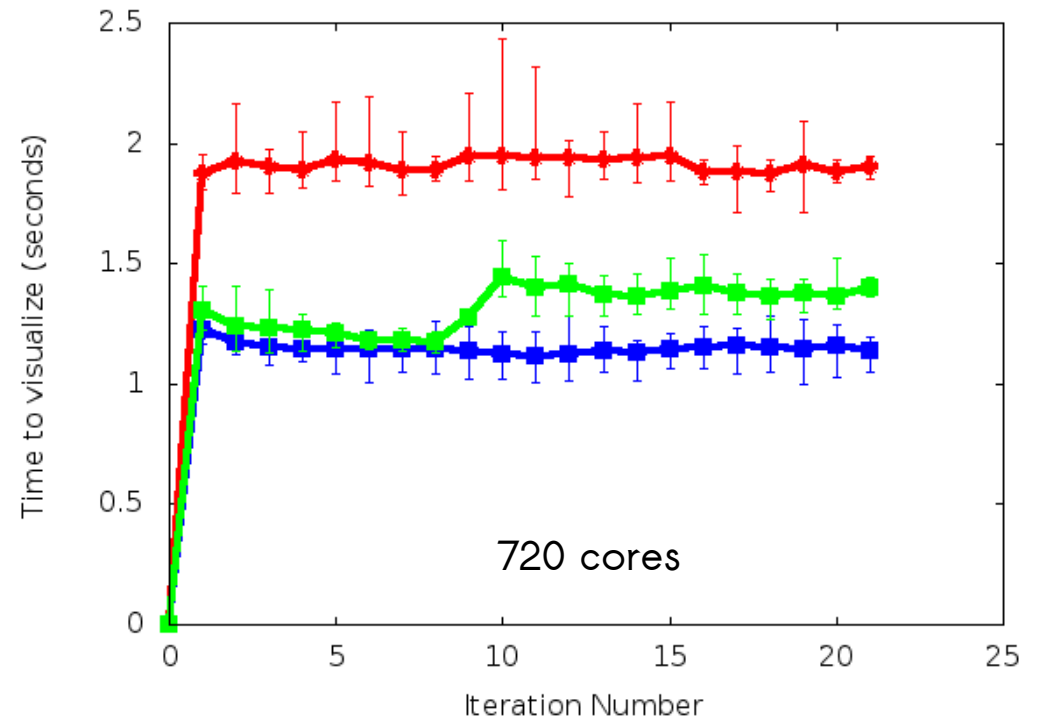


Outline

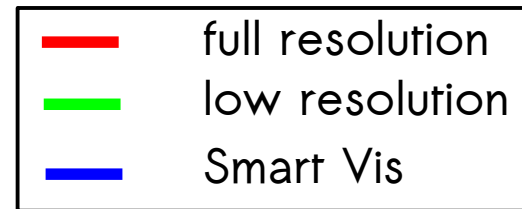
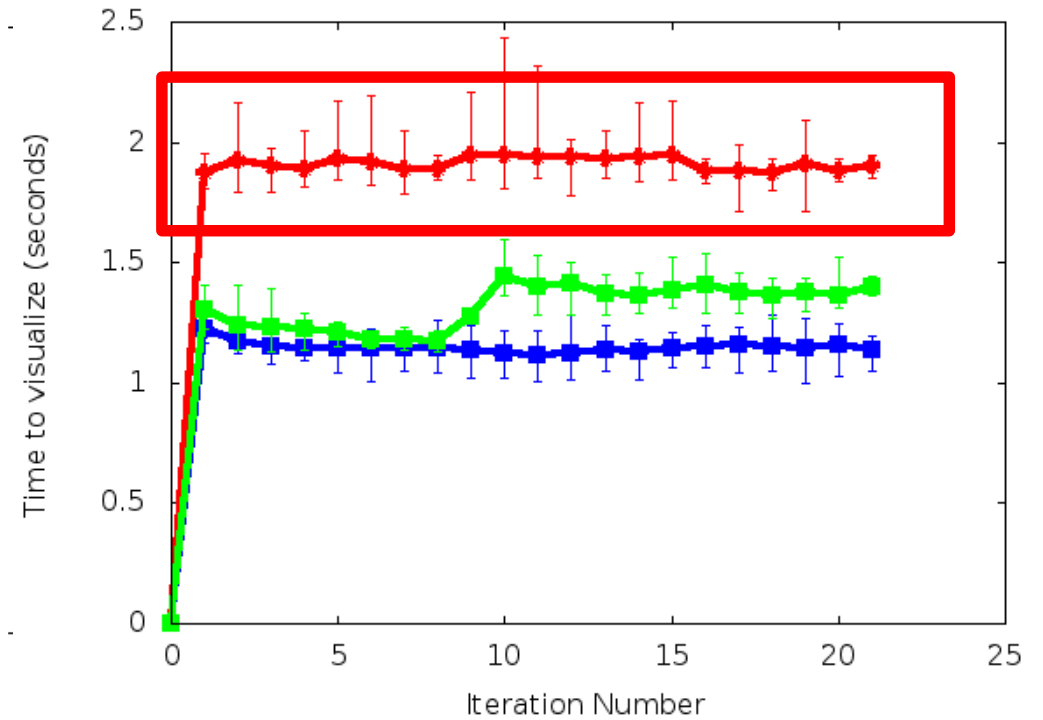
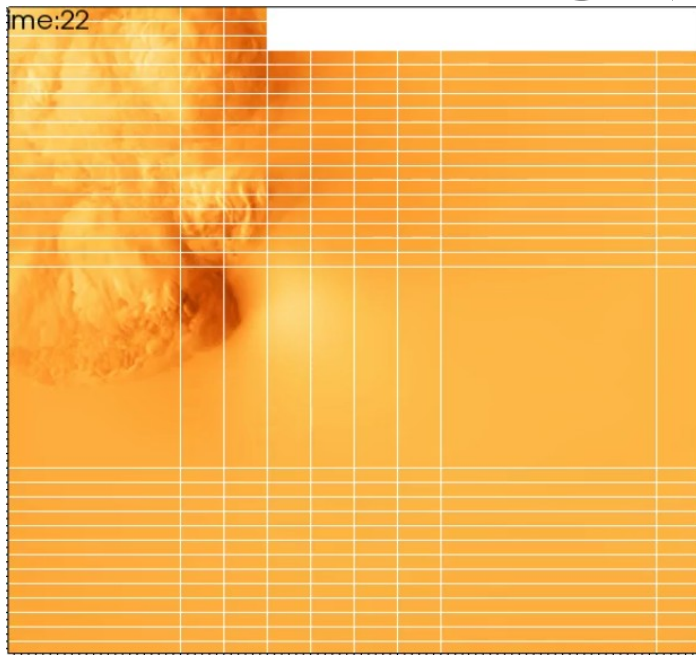
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CM1 on Grid5000

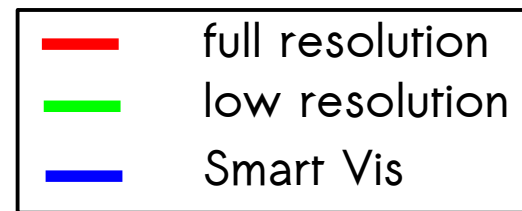
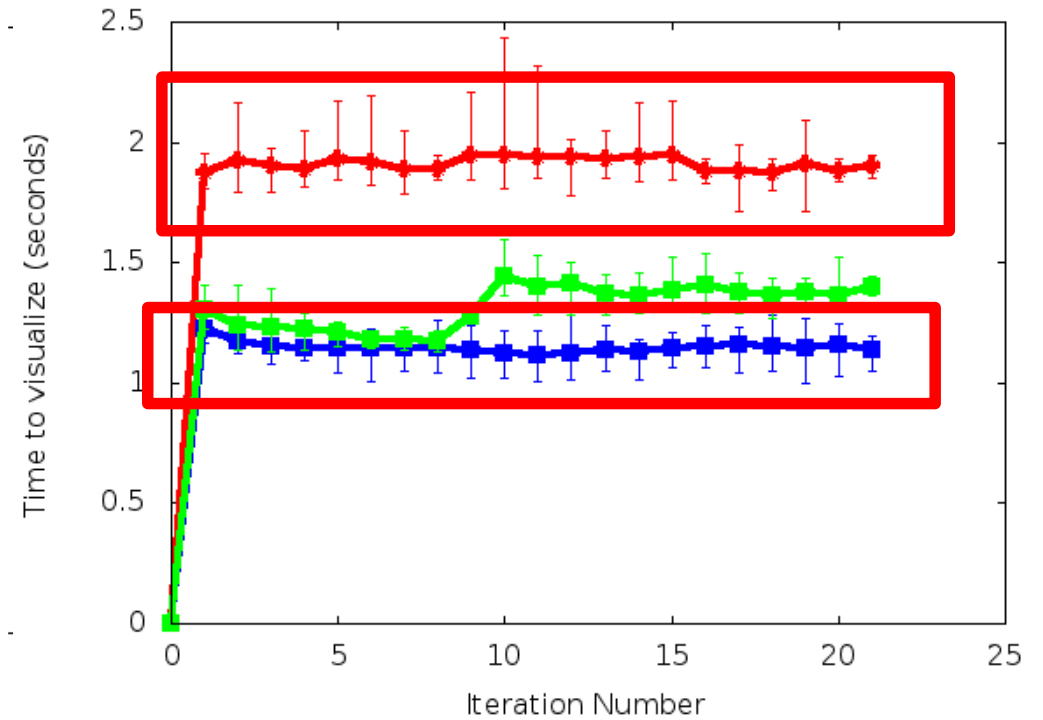
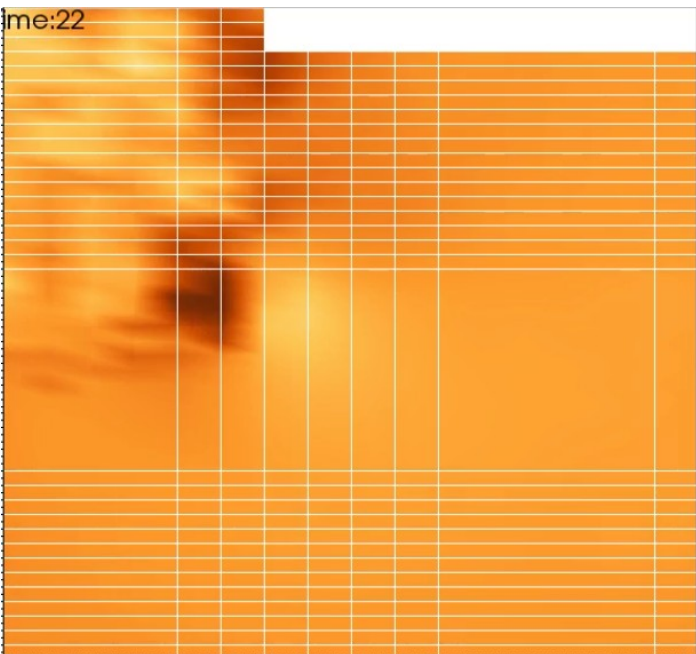
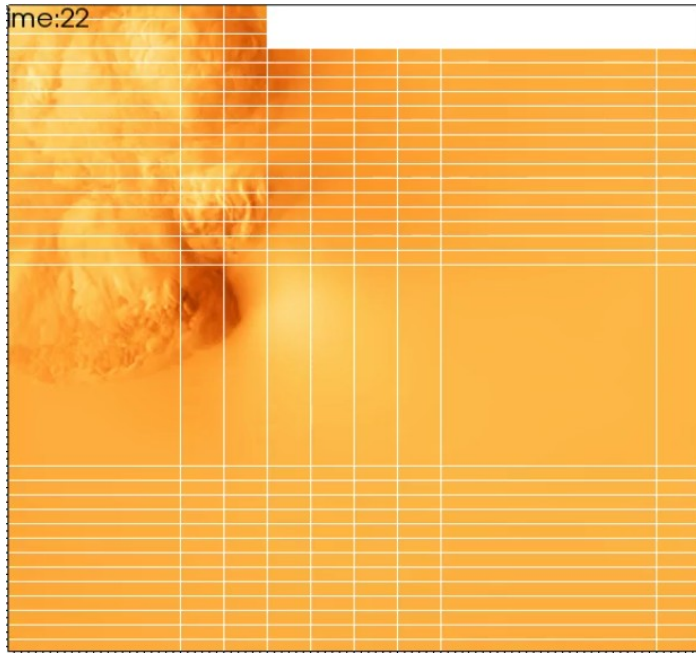
- CM1 on Reims cluster:
 - 30 nodes, 24 cores each
 - 1Gbits/s Ethernet



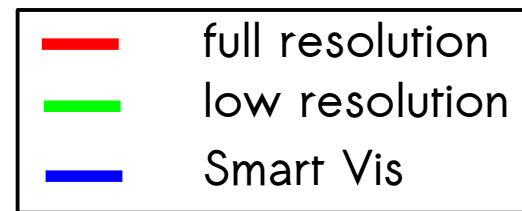
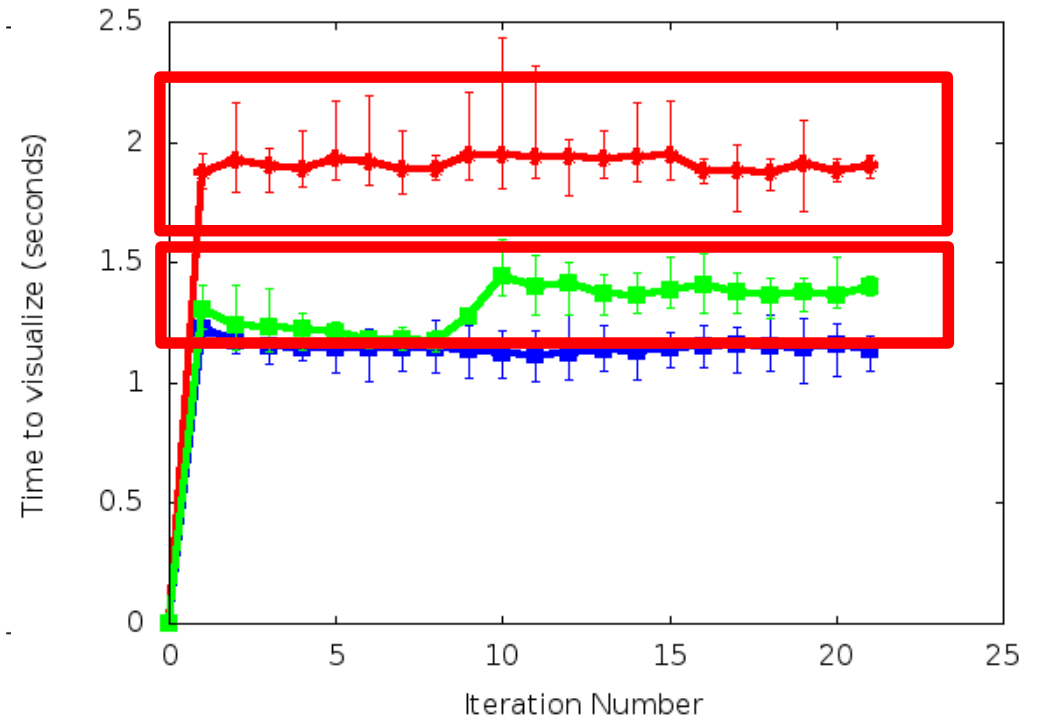
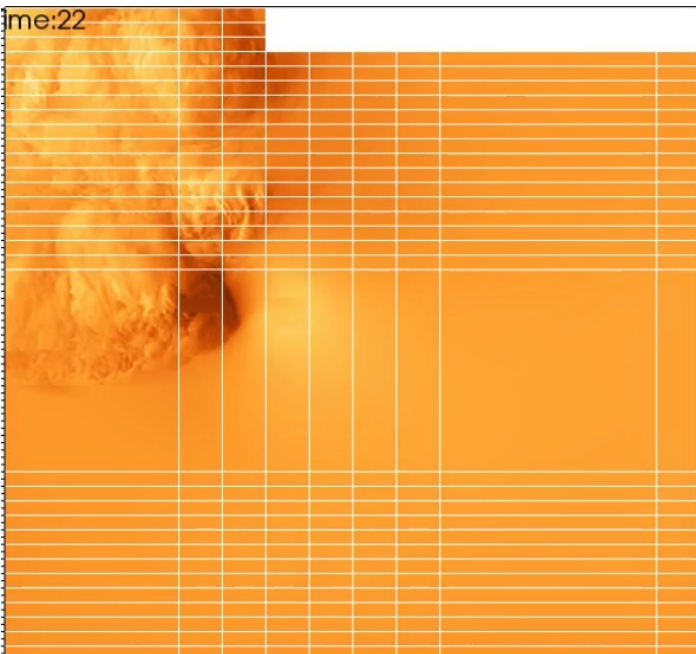
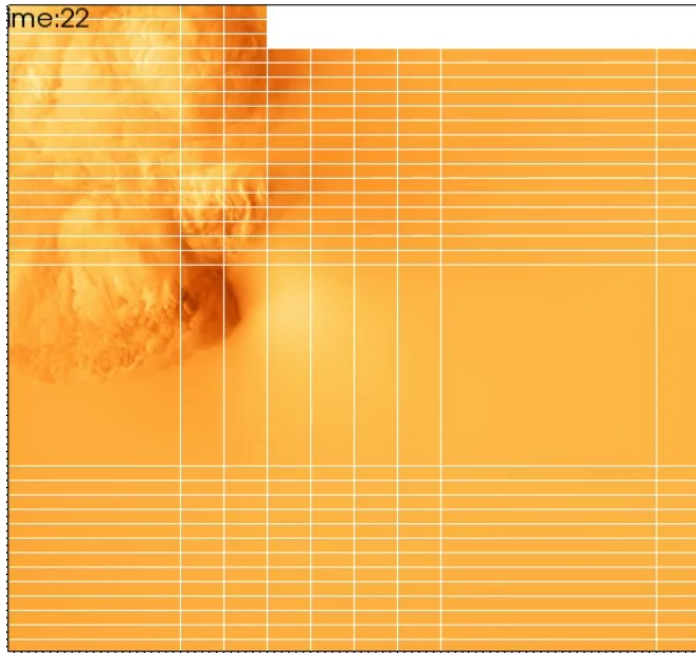
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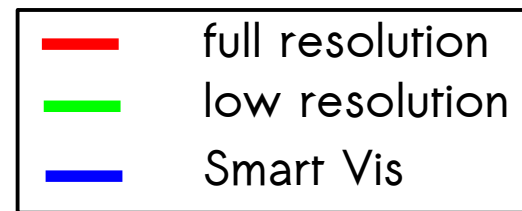
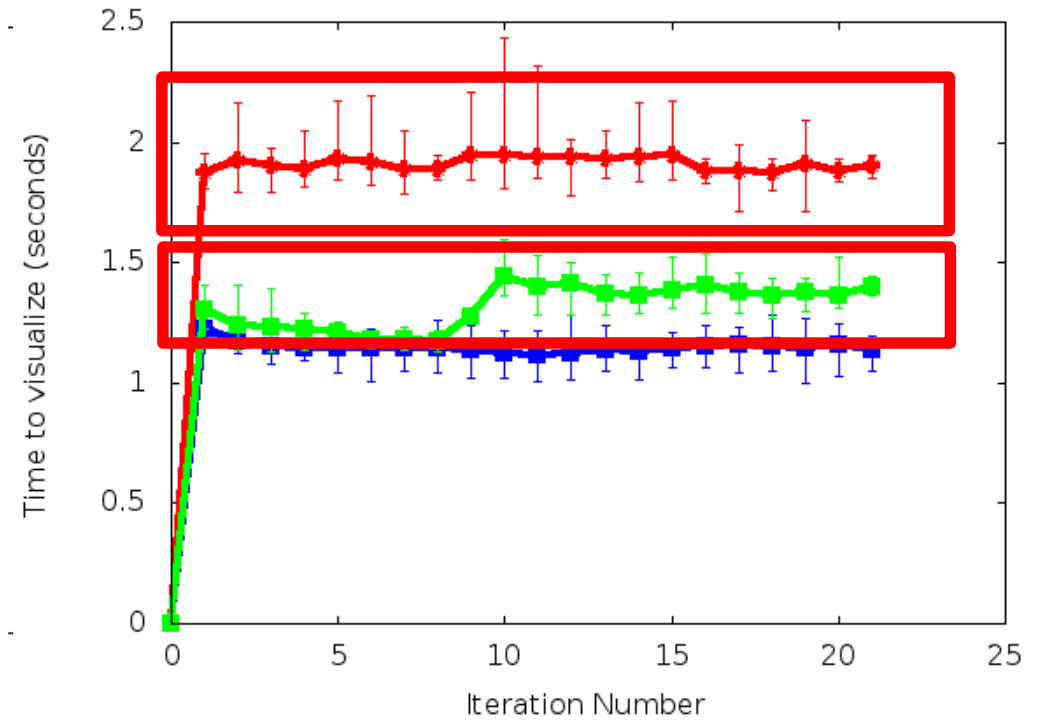
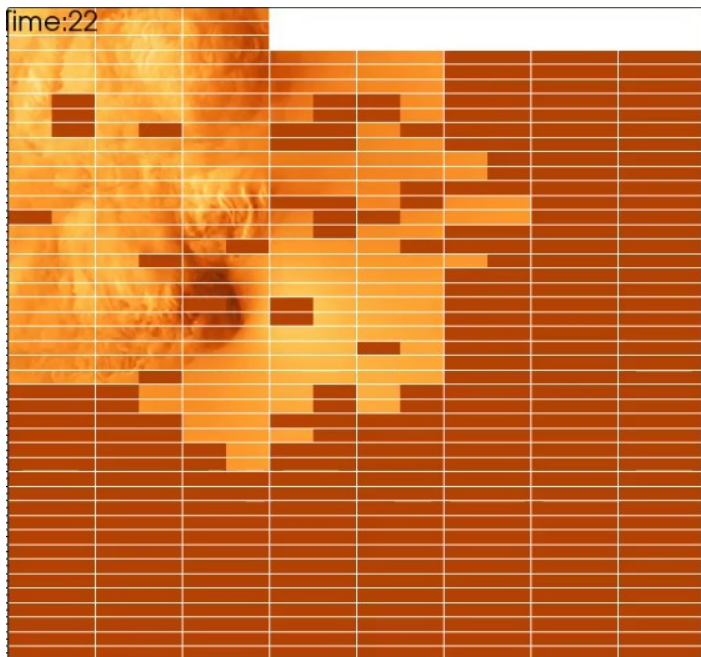
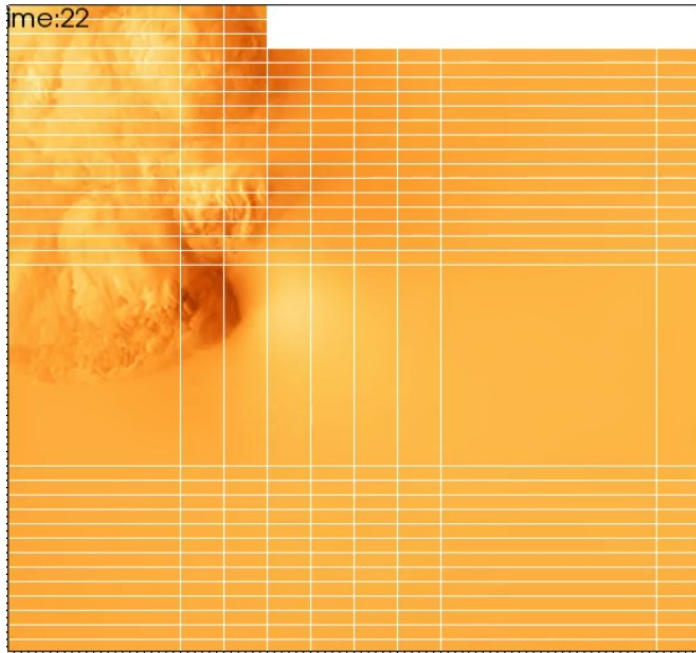
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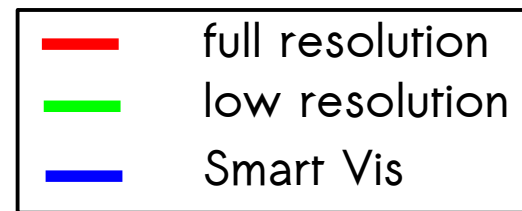
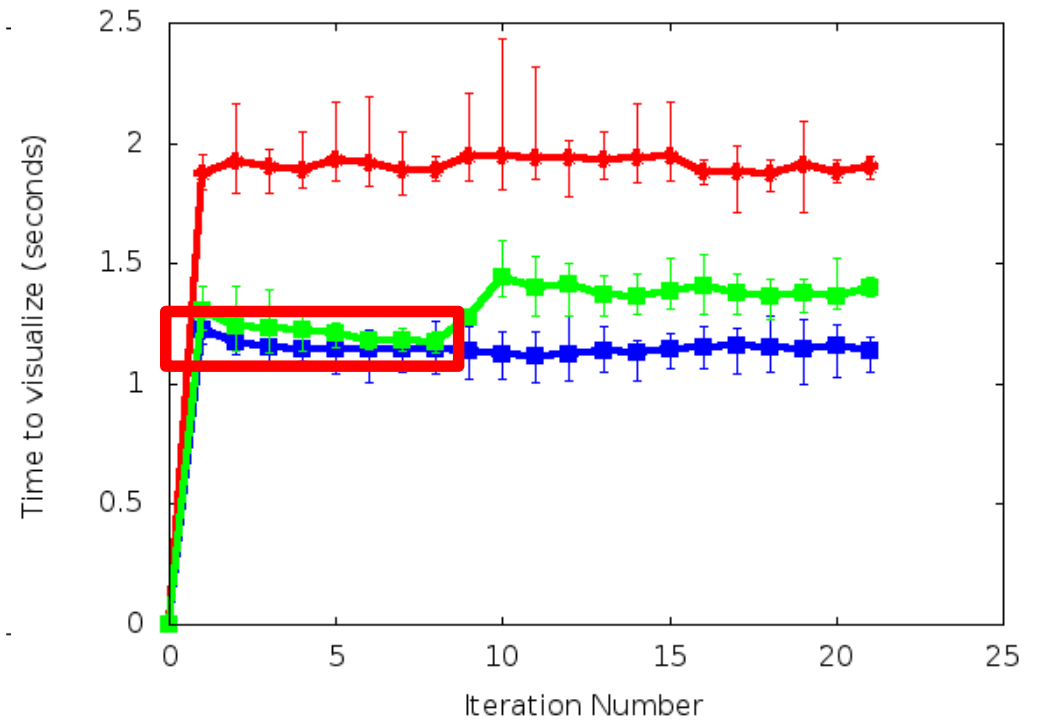
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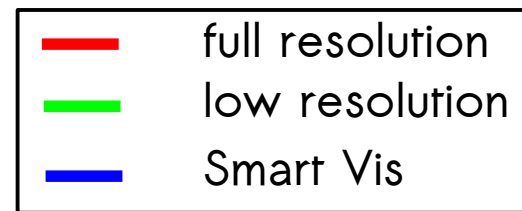
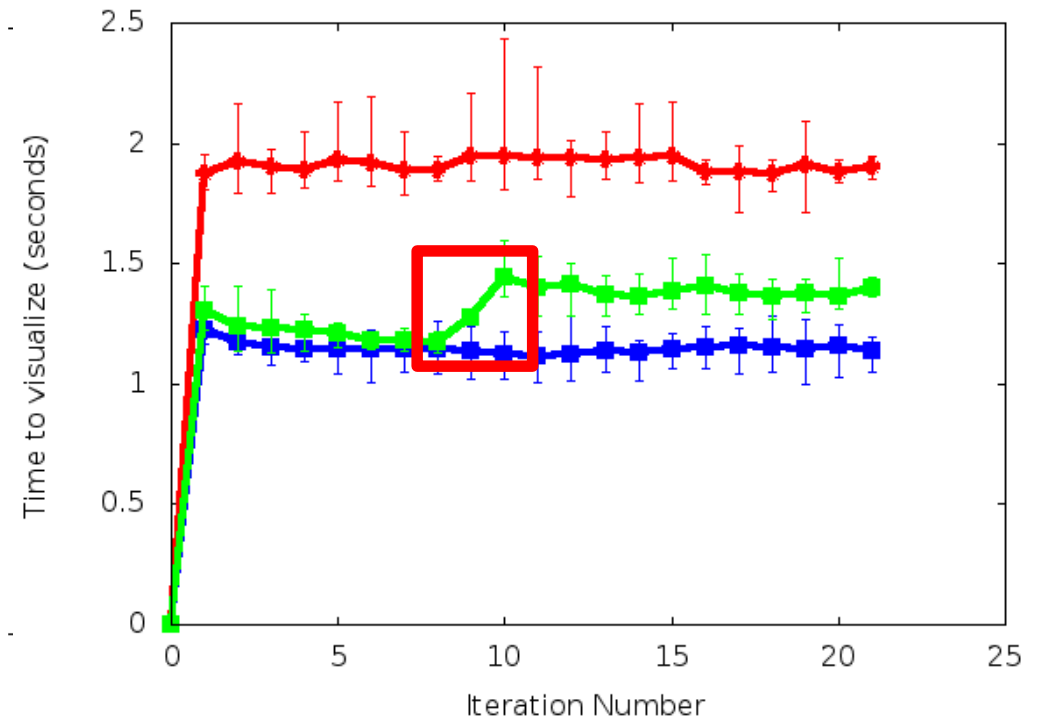
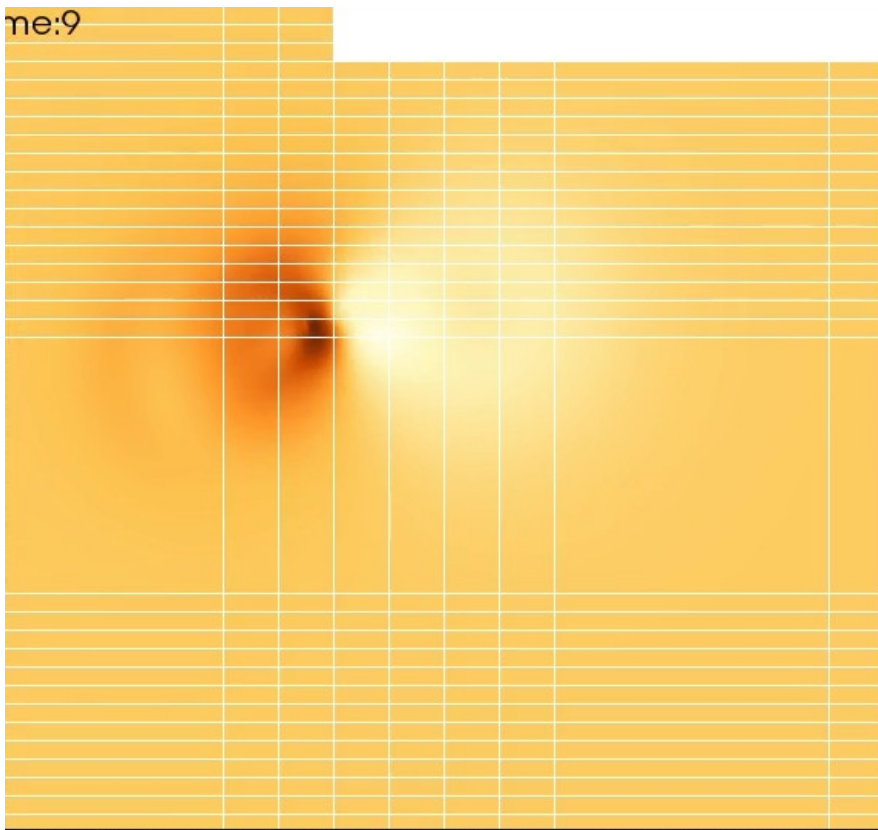
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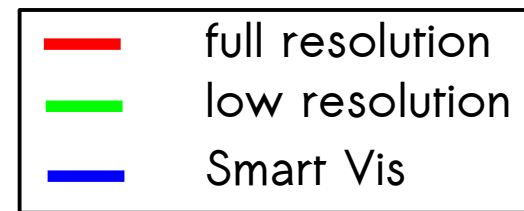
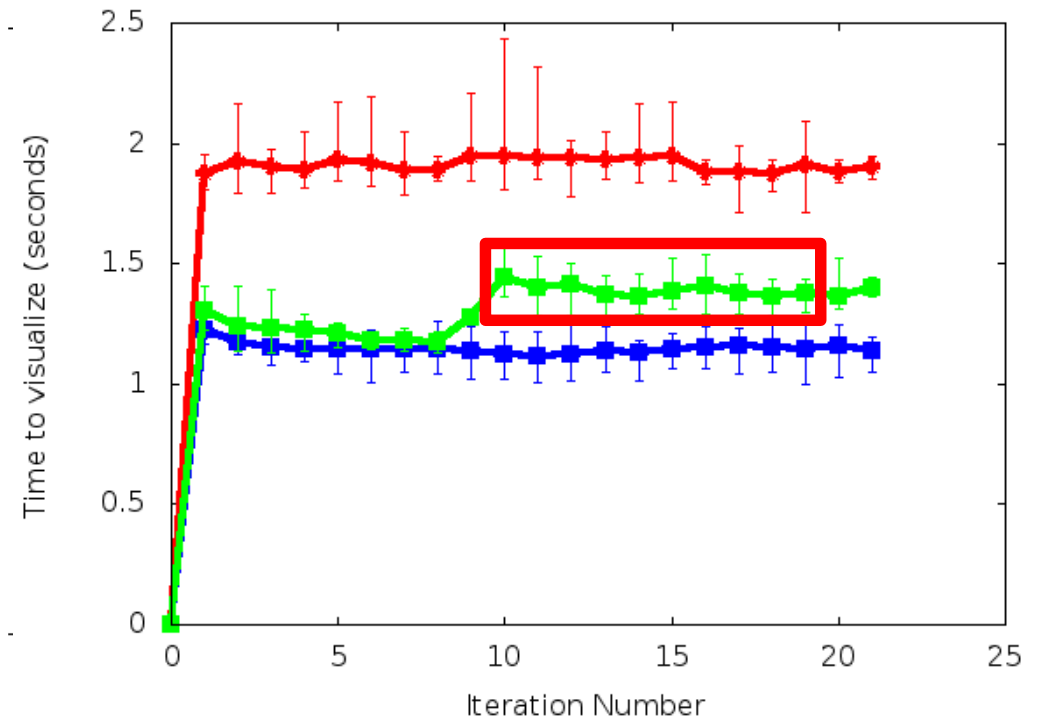
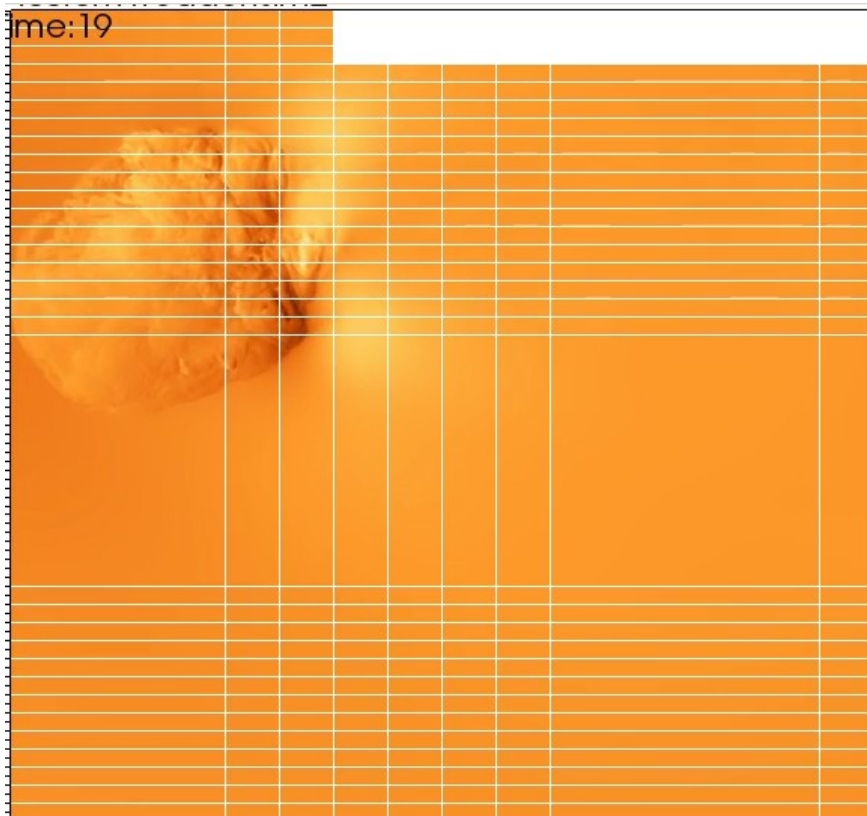
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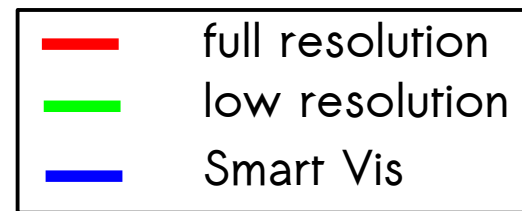
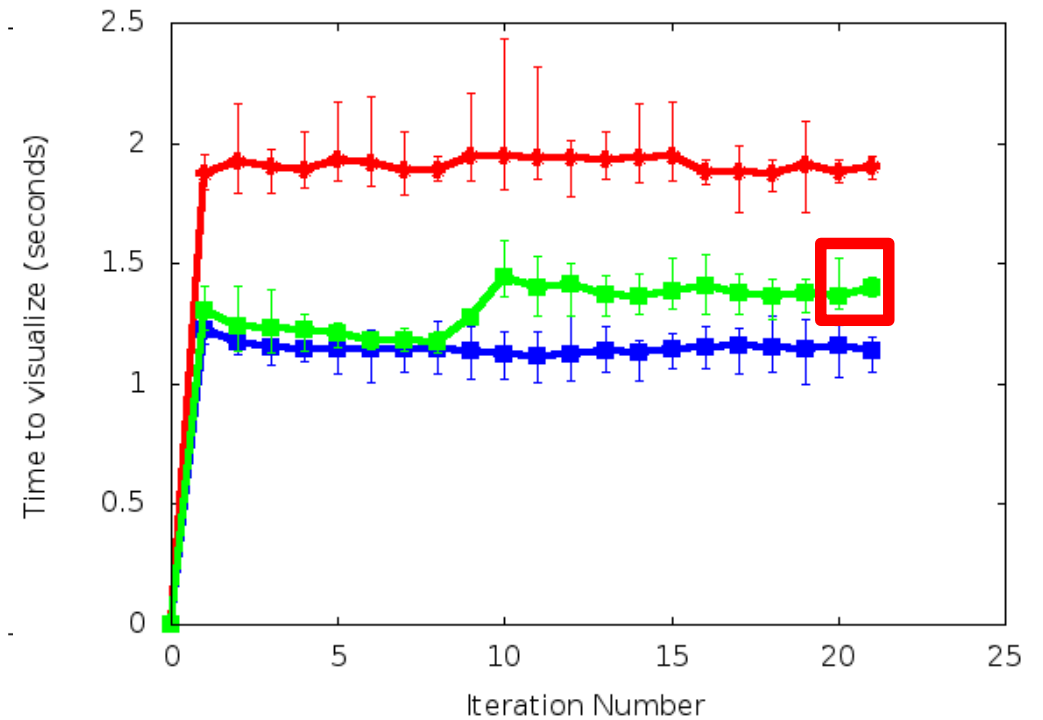
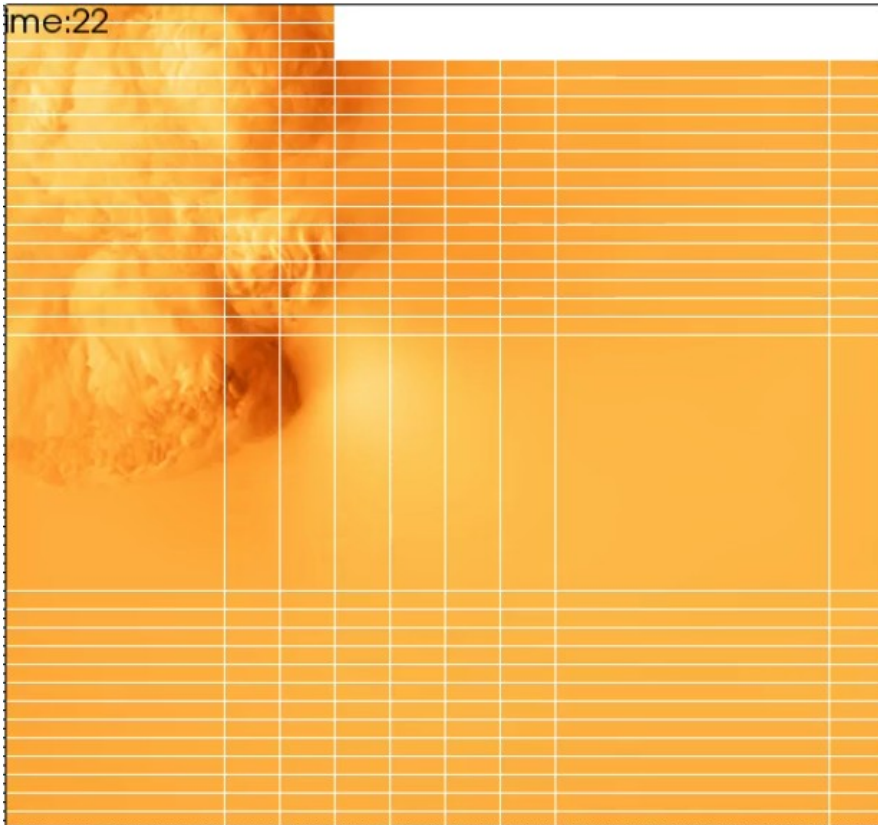
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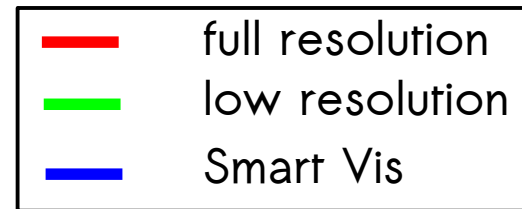
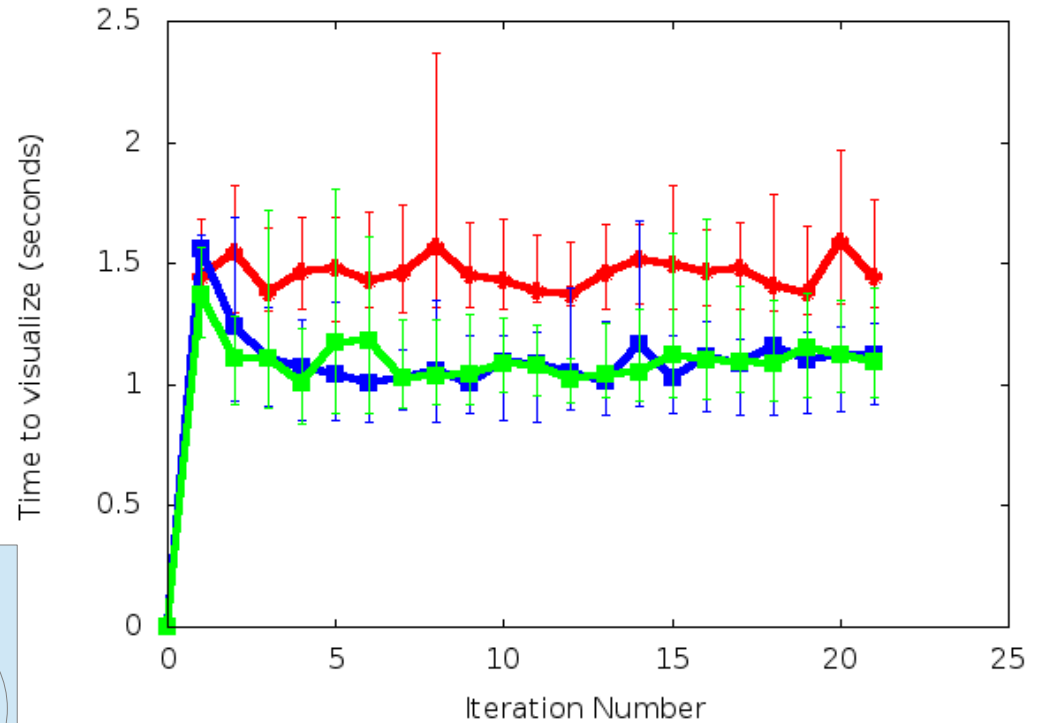
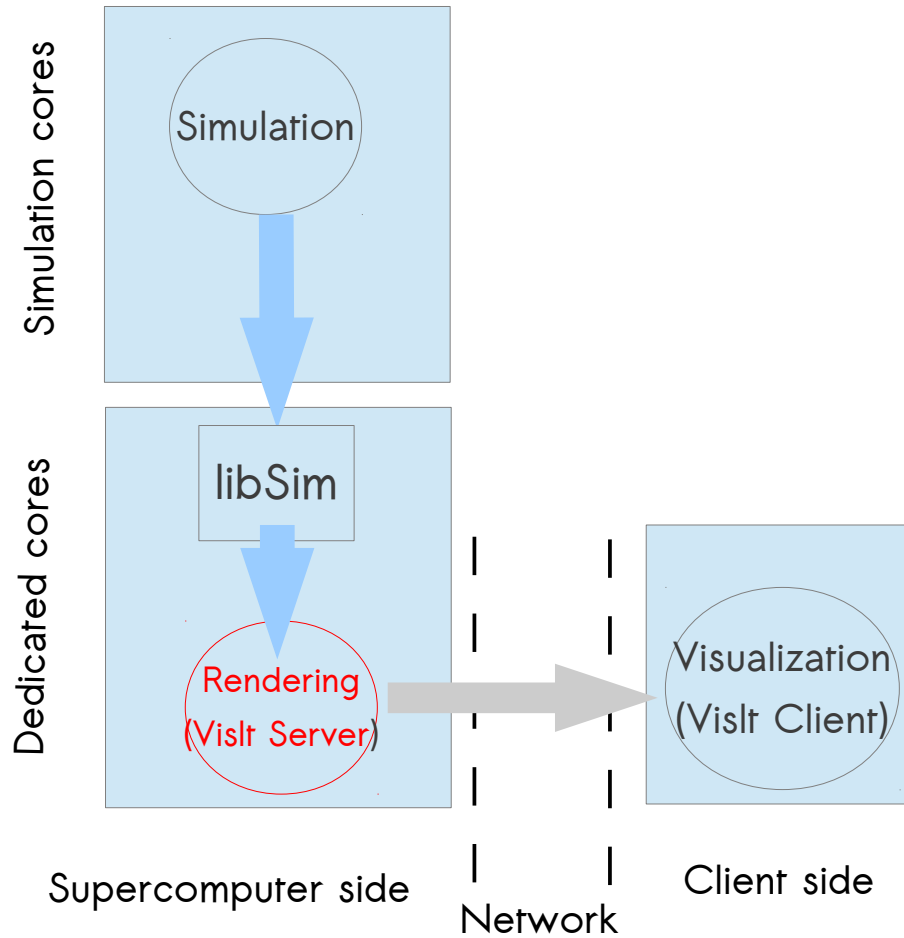
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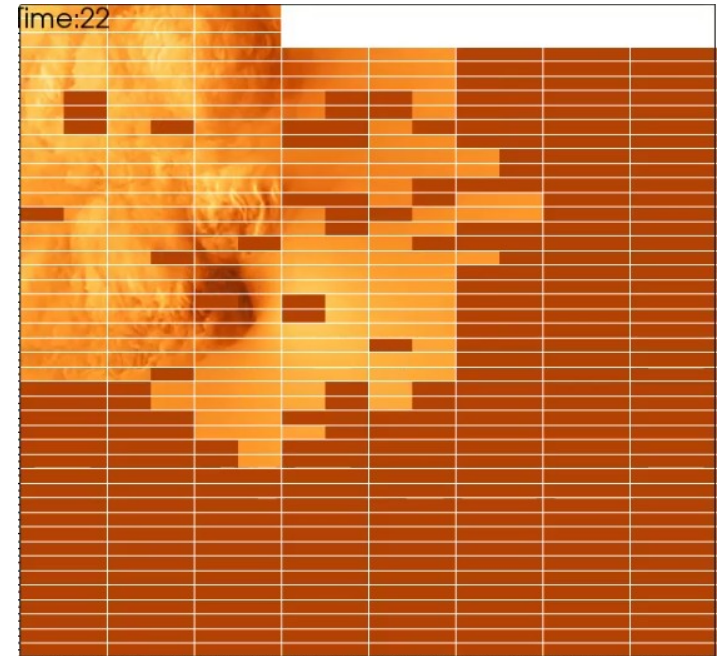
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Visit Scalable Rendering

Gaining the Trust of Scientists

- Provide a window to show filtered areas
- Implement a VisIt plug-in with :
 - A slider to control the metrics
 - A list of available metrics
- Provide a metric to calculate the QoV
 - Objective metrics (ex MSRE, MSR) : bad metrics
 - Working with image processing researchers on a best metric



Entropy

Coefficient of

Other

Use gradient

Precision

0 100%

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Conclusion

- Defined a semantic based on variation in the data
- Propose different metrics to automatically detect relevant data
- Integrate it in existing ISV framework in a complete transparent way
- Provide a gain up to 40% with no considerable loss in quality of visualization

On going work

- Implement a slider to control the metrics as a plug-in in VisIt
- Propose a metric to calculate the quality of visualization QoV => Hard to use an objective metric
- Validation tests at larger scale on BlueWaters are being conducted