High Performance Applied Geophysical Computing: A Mature Area at SDSU for an Industrial Consortium

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Idea

- In the past year the Computational Science Research Center and the Geophysics Department have been discussing the possibility of organizing an Industrial Consortium.
- I would like to continue Rob Mellors's talk with some thoughts on this important area of R&D in which SDSU has important unique strengths.
- An Industrial Consortium in an specific area is very much as what ACSESS is all about, but focused into a narrower application endeavor.
- The advantage of this setup is that instead of pursuing many small projects suggested by industry in different areas one has a central subject and a larger project that is of interest to the University and to the sponsors:

It is push R&D instead of pull R&D!

Large Scale Wave Propagation

- With the advance in computer technology and by using large computer clusters it has become possible to simulate earthquakes in great detail.
- In particular, the Terashake and Petashake efforts, with leading participation from SDSU's Ken Olsen and Steven Day among others, have produced unprecedented details of the effects of earthquakes in the LA Basin.

http://visservices.sdsc.edu/projects/scec/terashake/

- These calculations require very large computer resources and also produce large amounts of output.

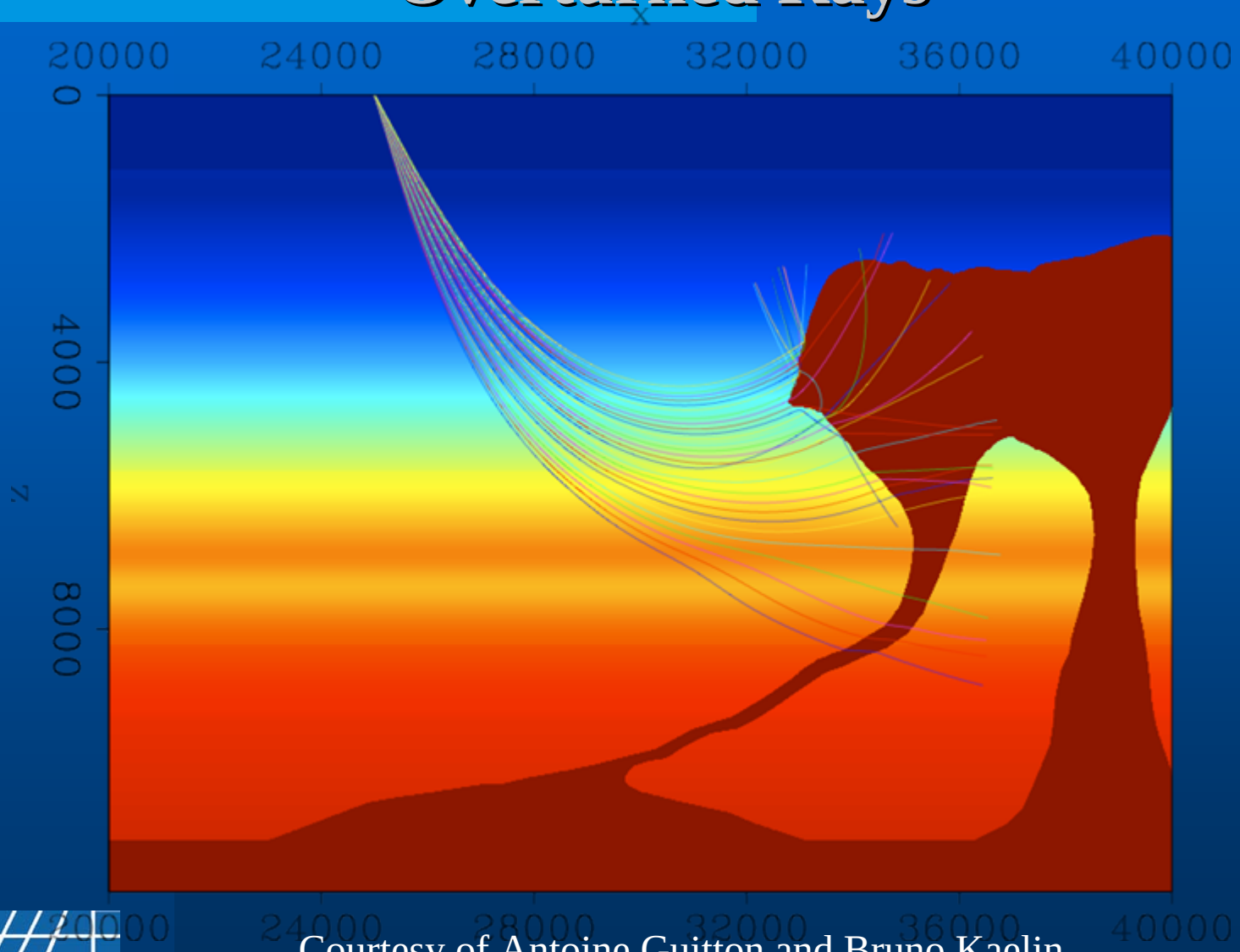
A Good Beginning, but …

- Of course, this is just the beginning, but there are far more demanding tasks ahead if one wants to obtain realistic shake maps for many of the possible locations of earthquakes in the LA and other seismically active areas that involve highly populated urban environments.
- Also, there is a tremendous potential for the application of these full wave simulations to imaging problems, both in earthquake seismology and in general, in energy resource exploration and exploitation.
- Seismic inversion and imaging has been the domain of ray tracing until very recently, that being the only feasible technique given the available computing resources.
- Current advanced techniques under development use full wave propagation techniques.

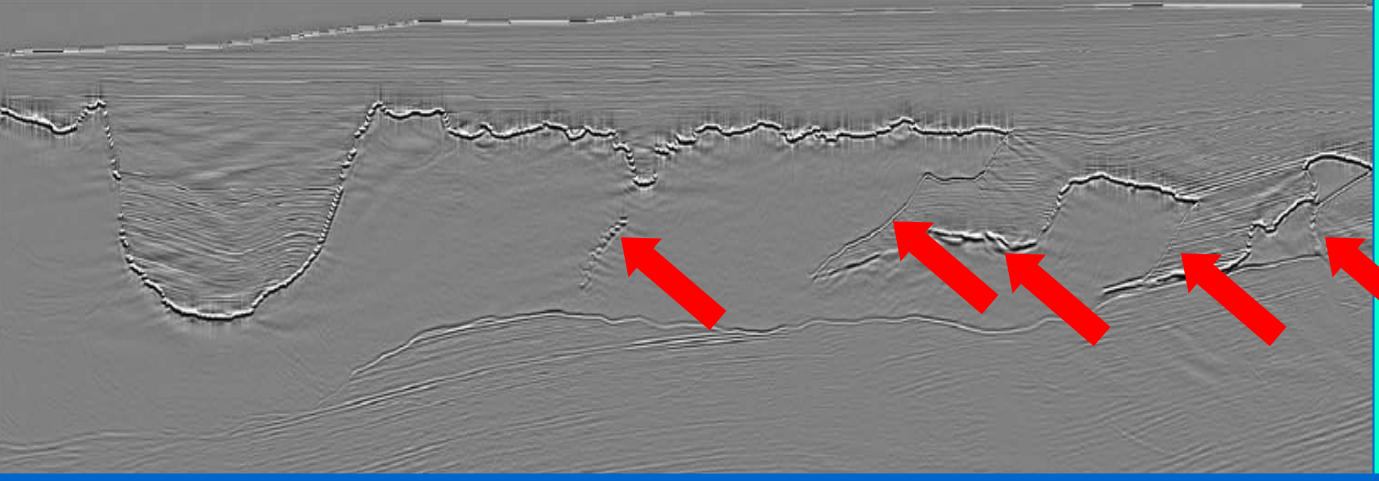
Seismic Oil Exploration

- Seismic oil exploration requires the processing of very large scale data sets. The data is collected in the time domain, but maps of the underground are required in the space domain.
- The most sophisticated processing is called Depth Migration and mostly approximate solutions to the wave equation are used, such as the one way or parabolic approximation. This has some limitations in complex areas.
- One of the currently more expensive processes uses full wave simulation from the sources and backward propagation of the seismic data from the receivers in order to create these depth migrated images.
- In 3D it is not unusual to manipulate many terabytes of data in large computer clusters.

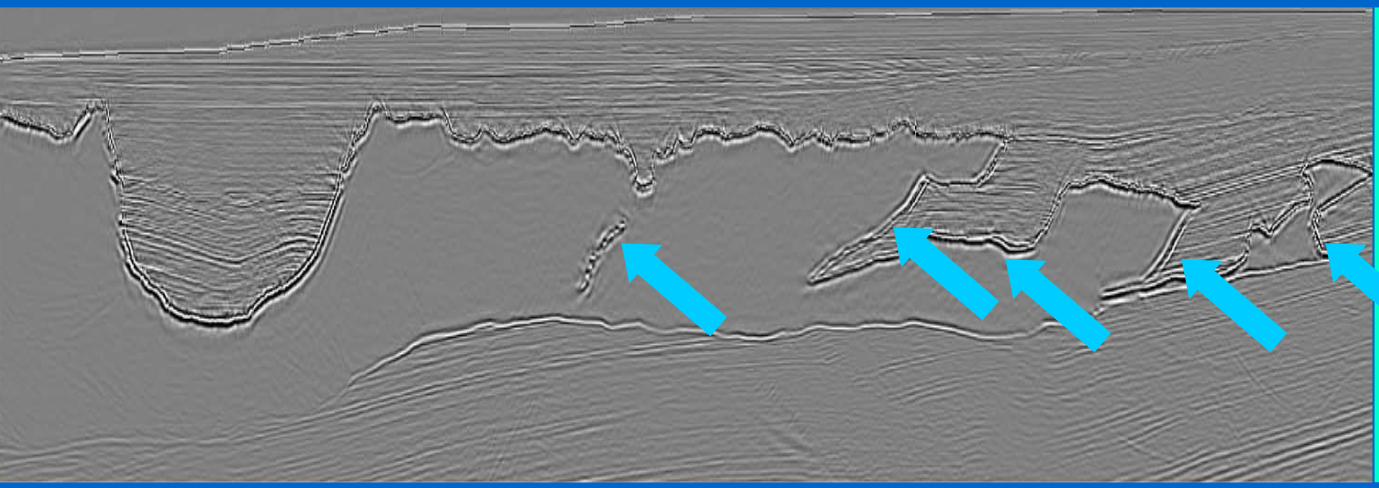
Reverse Time Migration (RTM)
Overturned Rays



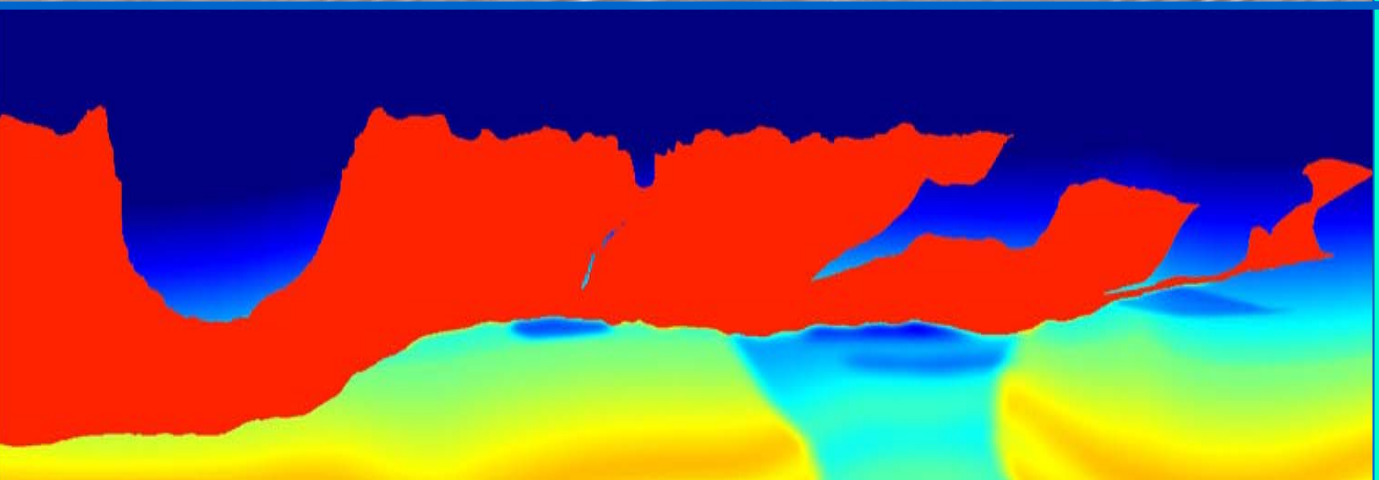
Courtesy of Antoine Guitton and Bruno Kaelin



Shot-Profile
Migration
One-way WE



Reverse-Time
Migration



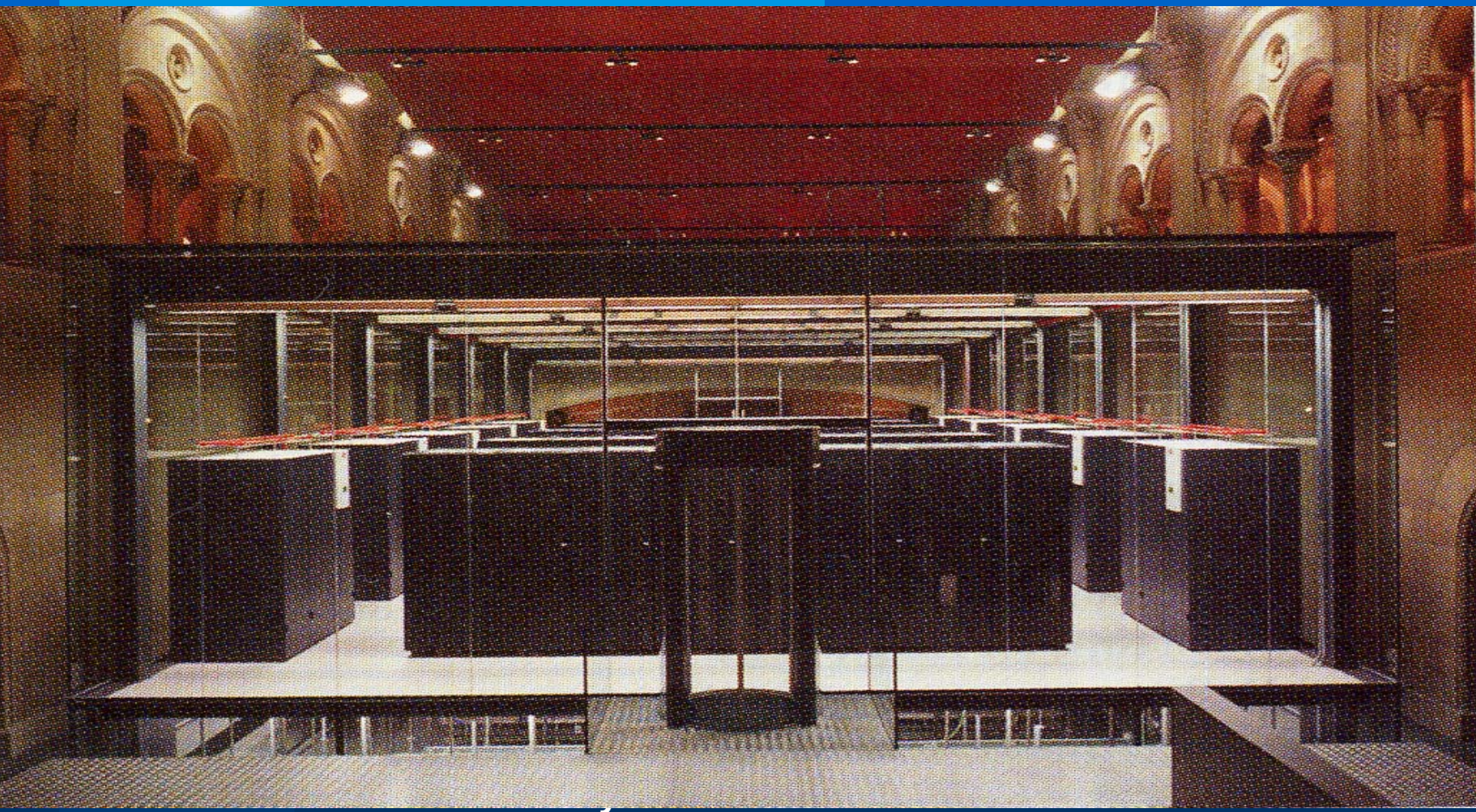
Velocity

Courtesy of Antoine Guitton

An Example of Industrial R&D where SDSU Expertise can be Valuable

- Repsol-YPF and 3DGeo Corp. (Santa Clara, CA) have a joint R&D program (Kaleydoscope) for developing large scale novel seismic imaging techniques such as the ones we just described.
- The calculations are run on MareNostrum, a 94 Teraflops machine, the third largest (10240 processors) cluster in Europe and 13th in the world.
- A major bottleneck is network traffic and access to secondary storage.
- See article on the January 2008 issue of IEEE Spectrum on "Winner & Losers 2008: The best and worst technology projects."
- Kaleydoscope, an 8 Million Euros project is the winner in Geophysics (pp. 32-36).

MareNostrum (Our Sea, the Mediterranean)



- Other possible applications are to acoustic and electromagnetic wave propagation for medical imaging, inverse problems, illumination …

Conclusions

- SDSU has an excellent computational geophysics group, good access to large scale computer resources, and experience in complex large scale simulations of wave propagation.
- Thus, it is well placed to start an Industrial Consortium similar to the ones that have been available for many years at Stanford, Rice, U. Utah, U. Houston, etc.
- It can focus on current strengths to provide cutting edge R&D to the Oil Industry.