Analysis of Climate Data over Fast Networks

&

Parallel Tetrahedral Mesh Refinement

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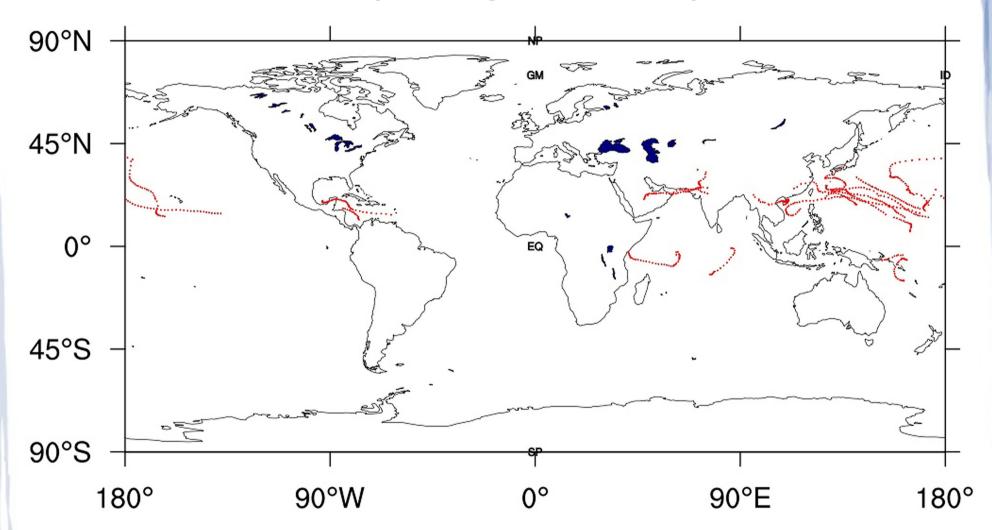
CScADS 2011

Climate Analysis

Applications:

- **Embarrassingly parallel**
- Detecting Tropical Storms (compute intensive)
- Atmospheric Rivers (data intensive)
- Earth System Grid Center For Enabling Technologies (ESG-CET)
 - NetCDF data files
 - Fortran / C
 - Python scripts (visualization, etc.)

Tropical Storms (from fvCAM2.2 simulation encompassing 1979-1993)

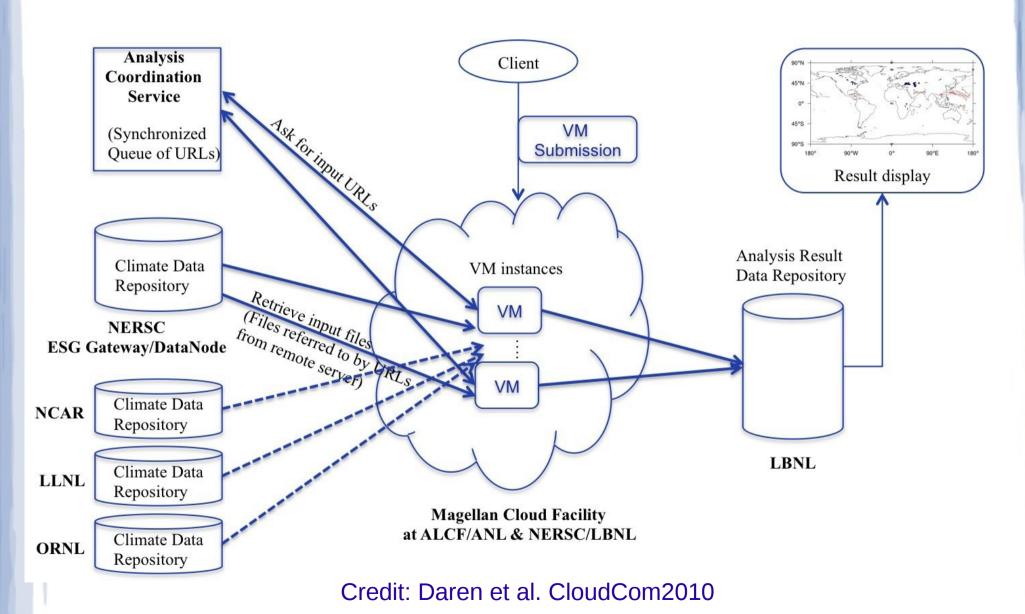


Credit: Daren et al. CloudCom2010

Data Access & I/O Pattern

- Distribution of input data files (file dispatcher)
 - Input files: ~2G, 0.5G each (total several TBs, will be PBs)
 - One file per process
 - Join results for further analysis
- Batch Processing (Linux Cluster, Grid)
 - Retrieve data files over the network
- Cloud (NERSC Magellan, Eucalyptus)
 - Retrieve data files over the network
- •MPI (for file coordination) (Franklin, Hopper)
 - Read files directly from the file system (GPFS)

Job Submission & Remote Data Access



Remote Data Repositories

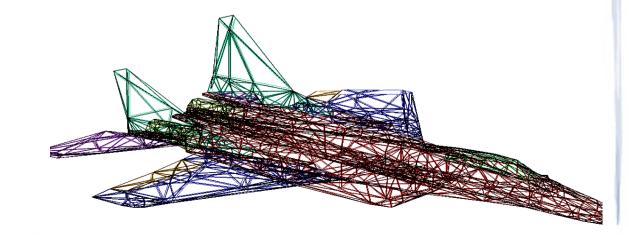
- Challenge:
 - Petabytes of data
 - Data is usually in a remote location
 - How can we access efficiently?
- •Data Gateways / Caching?
 - I/O performance?
 - Scalability (using many instances?)
 - Network Performance, Data Transfer protocols

Benefit from next generation high bandwidth networks

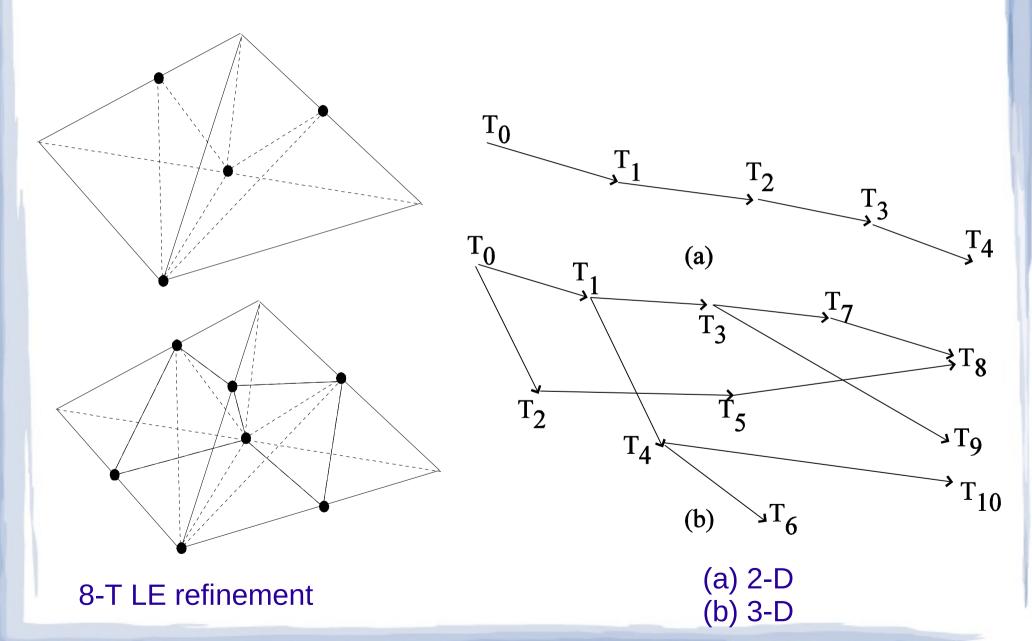
Adaptive Mesh Refinement

Parallel Tetrahedral Mesh Refinement (PTMR)

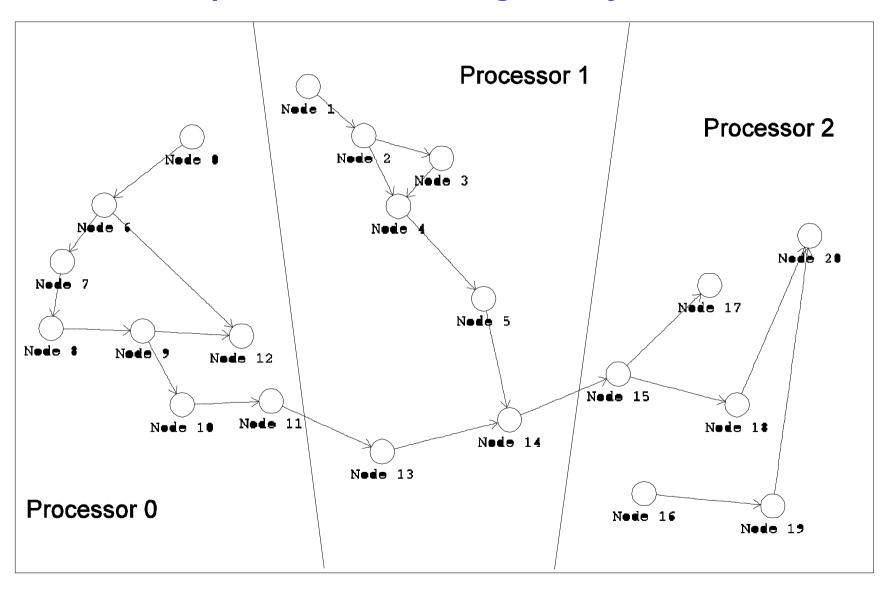
- Problem size and computational cost grow very rapidly in 3-dimensional refinement algorithms
 - Process very large data
 - Distribute load over multiple processors
- Longest-edge bisection
- Skeleton algorithms (8-Tetrahedra LE)



Propagation Path



LEPP-Graph Partitioning & Synchronization



PTMR

- Implemented using MPI
- •I/O: only processor 0 (head node) reads/writes (input file, output file)
- Mesh structure is distributed among processing nodes (load balancing)
- Each process handles its local mesh data
- Synchronize local propagation paths (data is distributed)
 - Each process informs other processing nodes whether a border element in the local partition is selected

PTMR performance

- Processor 0 (head node) acts as a gateway
 - Each message sent through the gateway
 - Gateway aggregates messages

Reduce the number of MPI messages (improves overall performance)

