Who we are

Natasha   Quentin   Norman   Ben
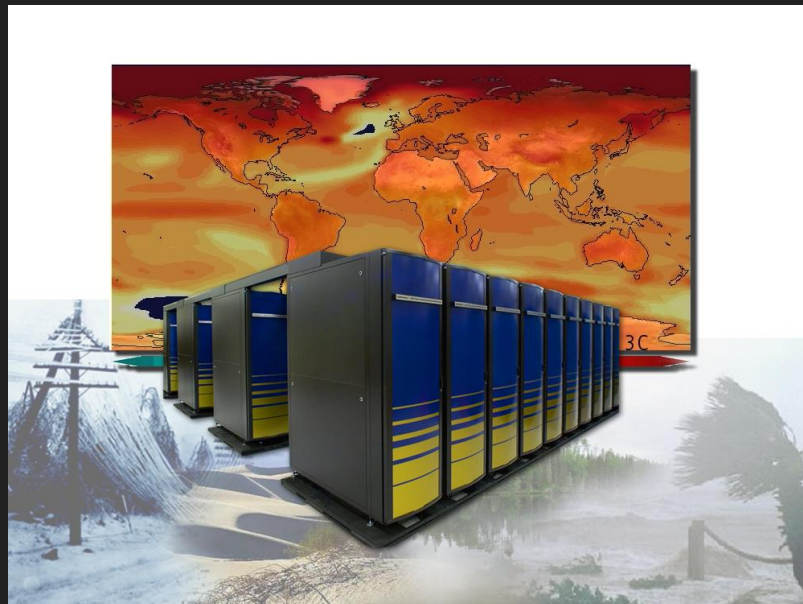
Climate Simulation Models
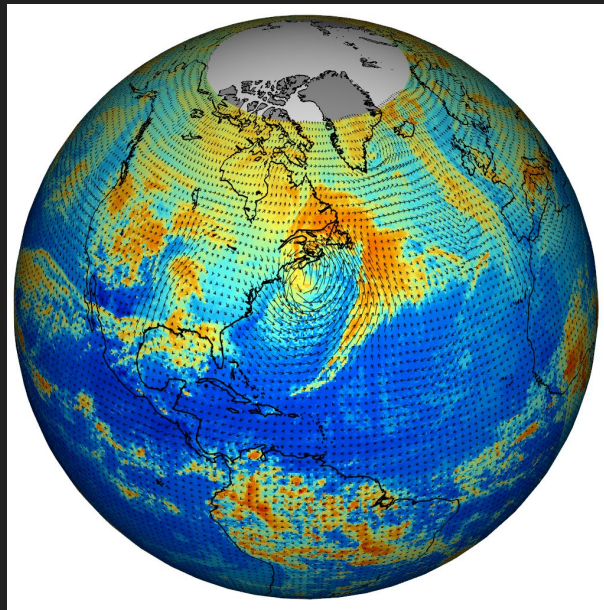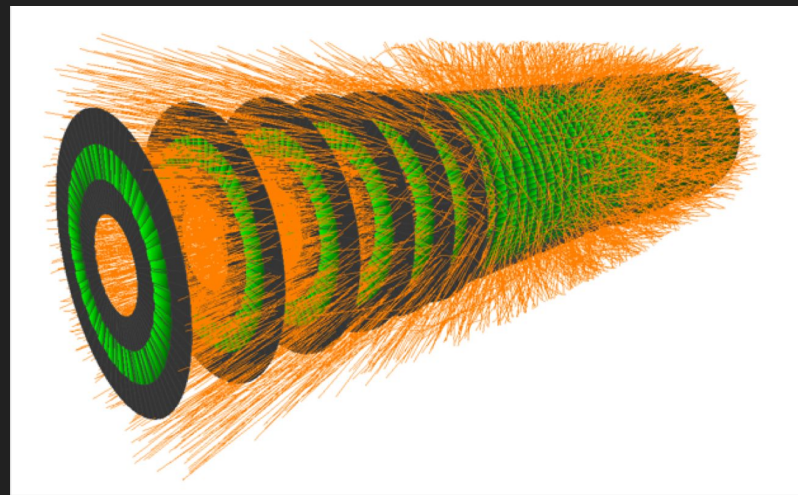

TrackML Challenge

A distributed training framework for TensorFlow

Image Super-Resolution

Parallelism

- **Hardware**
  - Multi-threading
  - GPUs
- **Software**
  - OpenMP
  - CUDA
  - Vector Processing
    - AVX extensions

Optimization

- **Hardware (kind of)**
  - Pipelining
  - Cache Coherency
- **Through Software**
  - Compiler
    - code motion
    - return values
  - Profiling

An API for shared memory parallel applications

aka

The quick-start to parallelizing your c++ code in 5 mins

for-loop parallelization using an OpenMP pragma

```
for (int i=0; i<3600; i++) {
    c[i] = a[i] + b[i];          // takes 1 sec
}
```

Runtime : 1 hour

for-loop parallelization using an OpenMP pragma
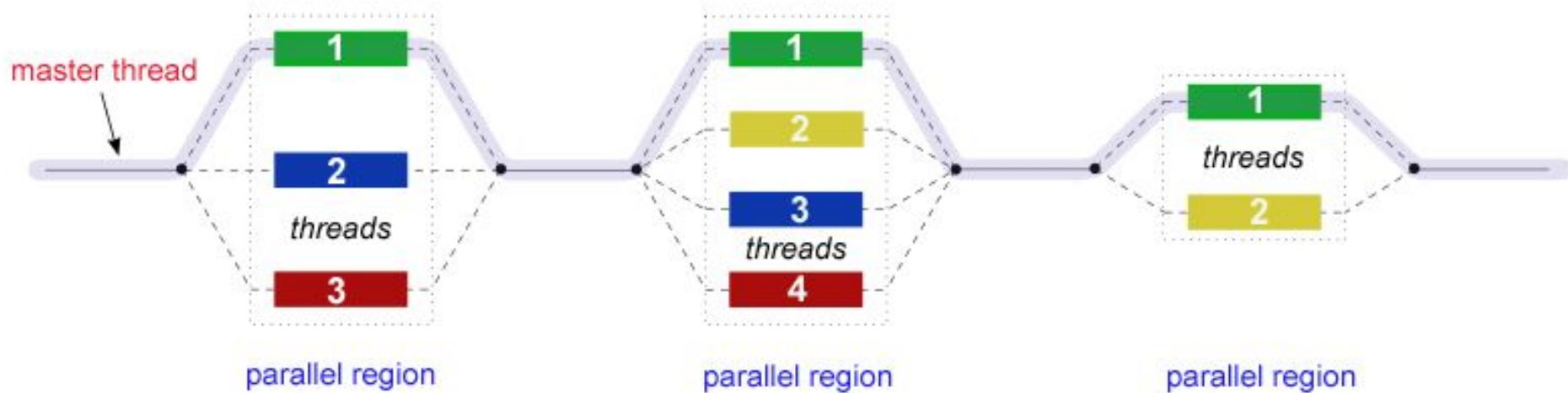
```
# pragma omp parallel for
for (int i=0; i<3600; i++) {
    c[i] = a[i] + b[i];          // takes 1 sec
}
```

Runtime : ~ 1 sec

Simple Parallel Execution

Thread 0	Thread 1	Thread 2	Thread 3	Thread 4
a[i]	a[i]	a[i]	a[i]	a[i]
+	+	+	+	+
b[i]	b[i]	b[i]	b[i]	b[i]
=	=	=	=	=
c[i]	c[i]	c[i]	c[i]	c[i]

The Fork-Join Model

More examples

```
#pragma omp parallel
#pragma omp sections
{
        X_calculation();
#pragma omp section
        y_calculation();
#pragma omp section
        z_calculation();
}
```

```
#pragma omp parallel
sections private(val)
reduction(+:sum)
{
    #pragma omp section
    {
        bla bla code
        sum += val;
    }
    #pragma omp section
    {
        bla bla code
        sum += val;
    }
}
```

An API for shared memory parallel applications consisting of:

- Compiler directives (#pragma omp parallel for)

- Library routines (Reduce, get_thread_num())

- Environment variables (setenv OMP_NUM_THREADS 8)

Let's try it!

** you must have gcc installed on your computer **

git clone https://github.com/buhpc/buhpc-workshops/

cd buhpc-workshops/openmp

make all run

OpenMP Resources

https://www.nersc.gov/assets/Uploads/IntroToOpenMP.pdf

https://computing.llnl.gov/tutorials/openMP/