Our science goal is to develop a new software to support data-driven, time-dependent models of the solar atmosphere and heliosphere suitable for near real-time predictions of the SW properties at Earth's orbit and in the interplanetary space.

1. A new Open surface Flux Transport (OFT) model which evolves information to the back side of the Sun and its poles and update the model flux with new observations using data assimilation methods.

2. A new potential field solver (POT3D) combined with the output from the traditional WSA model, and with remote coronal and in situ solar wind observations. WSA and the new potential field solver (PFSS and PFCS) are both be validated using the maps from the OFT.

3. A highly parallel, adaptive mesh refinement (AMR) code (HelioCubed) for the Reynolds-averaged, ideal MHD equations describing the solar wind flow in the region between $R = 10-20$, and $1-3$ au. These equations will be accompanied by the equations describing the transport of turbulence. We are building on the Multi-Scale Fluid-Kinetic Simulation Suite (MS-FLUKSS) collaboratively developed at UAH using the Chombo AMR framework (Capl et al., 2007). The new version of our software is built on Chombo 4 and allow us to perform simulations with the fourth order of accuracy in time and space, and use cubed spheres to generate meshes around the Sun.

4. The developed software will run on both GPUs and CPUs and will be made publicly available.

**Abstract**

Our science goal is to develop a new software to support data-driven, time-dependent models of the solar atmosphere and heliosphere suitable for near real-time predictions of the SW properties at Earth’s orbit and in the interplanetary space. We are building on the Multi-Scale Fluid-Kinetic Simulation Suite (MS-FLUKSS) collaboratively developed at UAH using the Chombo AMR framework (Caplan et al., 2007). The new version of our software is built on Chombo 4 and allow us to perform simulations with the fourth order of accuracy in time and space, and use cubed spheres to generate meshes around the Sun.

**Data Acquisition and Processing: OFTpy**

We have developed OFTpy, a python codebase that facilitates acquisition and processing of data products to a computation-ready format for HipFT. The current code supports full processing of JSOC HMI M720s line-of-sight (LOS) magnetograms to a radial-flux Carrington Rotation (CR) Map. This extensible software will also serve as a prototype/example for future users to incorporate magnetograms from alternative observatories. For data acquisition of HMI LOS magnetograms, OFTpy acts as a Python wrapper for product query and download from the Stanford JSOC. Figure at the bottom shows an example. We are presently comparing this mapping to a mapping product developed by the Stanford team for use by ADAPT.

**Software Architecture: Chombo for GPUs**

Our software approach is based on Chombo, a C++ library developed at LBNL for implementing structured grid algorithms on distributed-memory multiprocessors. The design of Chombo is based on the following:

- Simulation data is defined on unions of rectangular patches in one of a nested hierarchy of uniform grid index spaces. The union of rectangles induces a domain decomposition onto a distributed memory set of processes.
- The fundamental unit of performance-critical computation is to apply discrete operators to data on a single patch. On CPU-based systems, this has been done using Fortran, or a low-level C-subset of C++, in order to obtain high performance.

While this has been a successful strategy for CPU-based distributed-memory systems, the extension to GPU-based systems introduces two new features that are not present in the CPU-based model:

1. Heterogeneous processors and memory on a node: there are both CPU and GPU systems on a single node, each with their own memory.

2. High-performance for floating point intensive operations is to be obtained using SIMT parallelism on the GPUs.

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