SSL (UC Berkeley): Prospective Codes to Transfer to the CCMC

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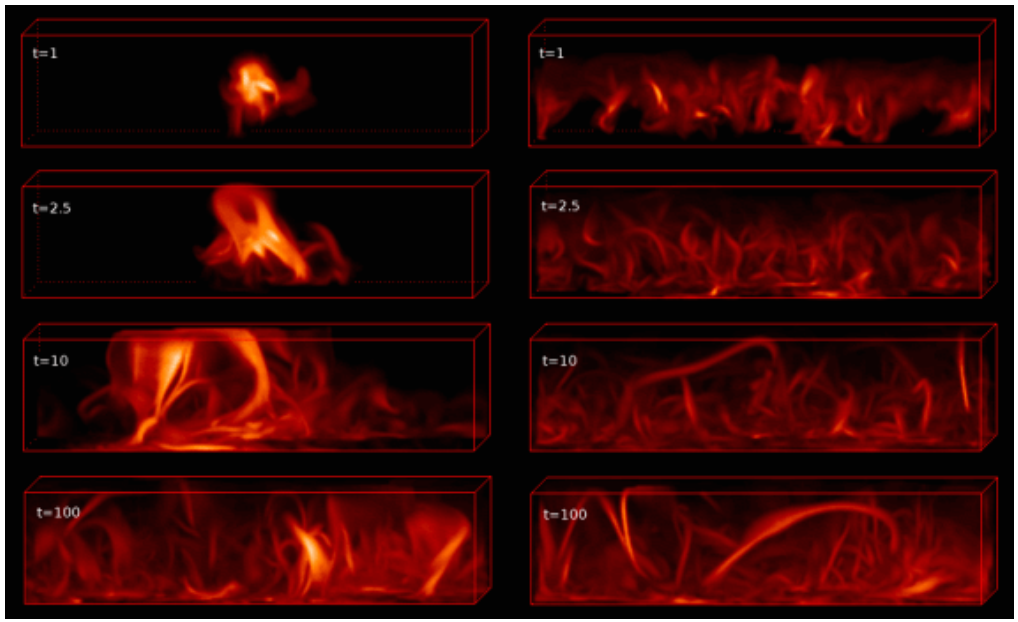
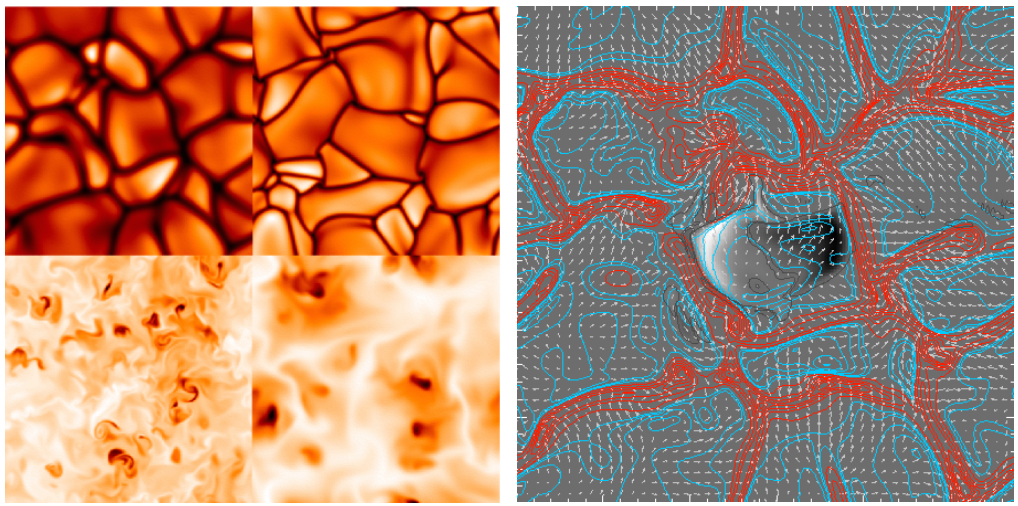
ANMHD solves the 3D MHD equations in the anelastic approximation on a Cartesian grid.

- The anelastic approximation filters out fast acoustic waves in the solar interior. This allows efficient simulation of sub-surface convection.
- The serial version of the code has been in production mode since 1998 --- the code is well tested and very robust.
- ANMHD has been used to study:
  - The sub-surface evolution of active region magnetic fields
  - The convective dynamo
  - The properties of magneto-convection
  - The formation process of active regions at the base of the convection zone

MOVIE of a convective dynamo!

Upper panel shows the evolution of a magnetized tube (left) or slab (right) interacting with with convective turbulence

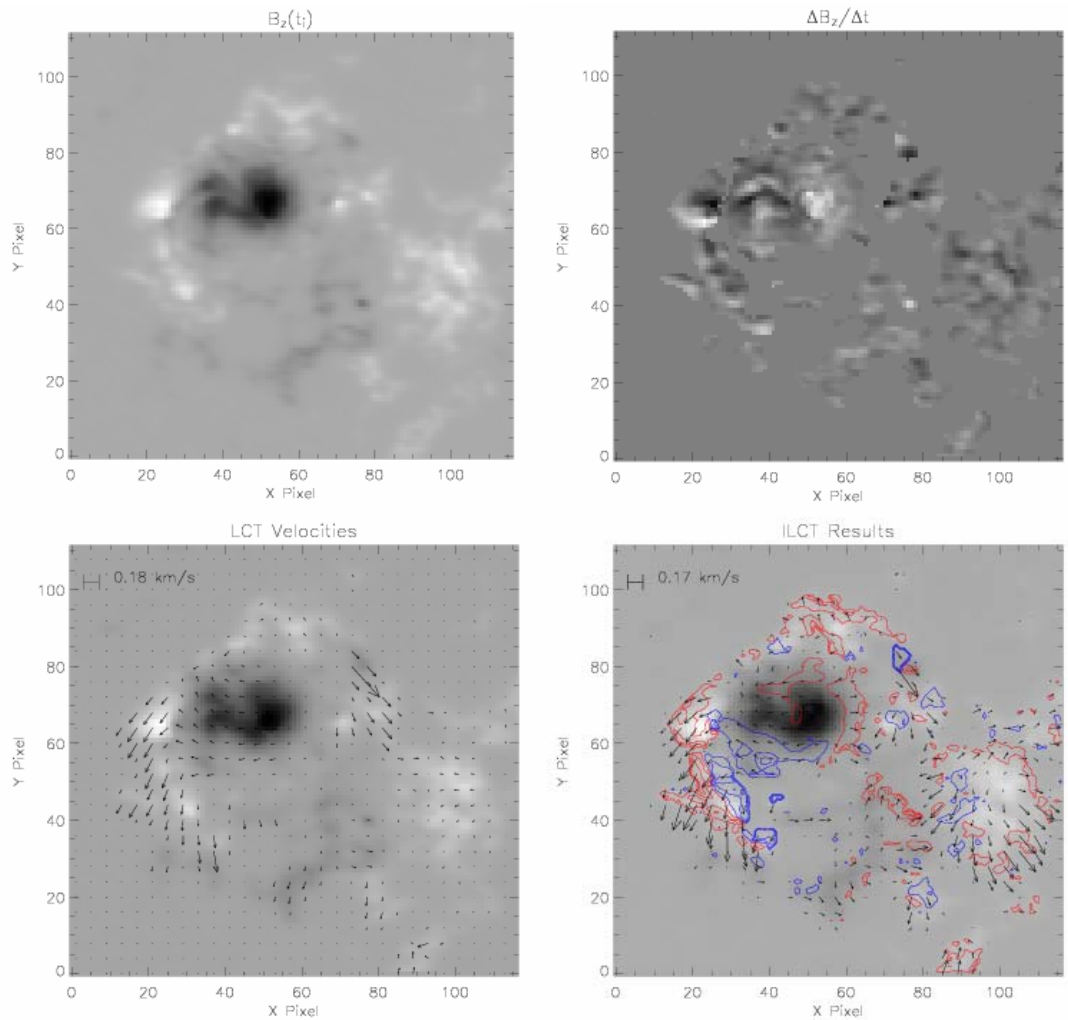




Left panel shows entropy fluctuations in the convective interior and surface; right panel shows An active region emerging (grey-scale) and velocity (arrows, plus red/blue color map) near the surface

FLCT uses local correlation tracking to determine spatial displacements of image structure between two successive images.

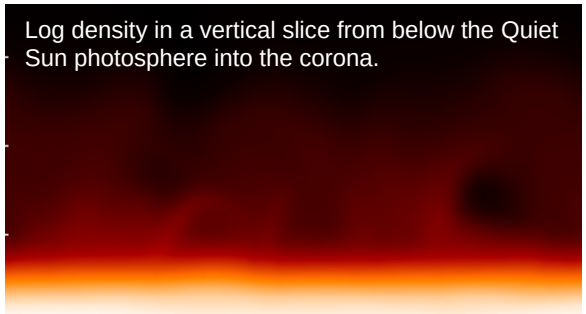
- Local correlation tracking (LCT) can be applied to a pair of 2D images to infer horizontal flows that evolve one image to the next.
- IDL and C versions (tested on Linux, Solaris, and Windows) of the code are currently publicly available.*
- FLCT has been applied to:
  - Magnetograms
  - H-α images
- Inductive LCT (ILCT), an auxiliary routine, combines LCT results with vector magnetograms to derive three components of velocity. A version is being prepared for release.

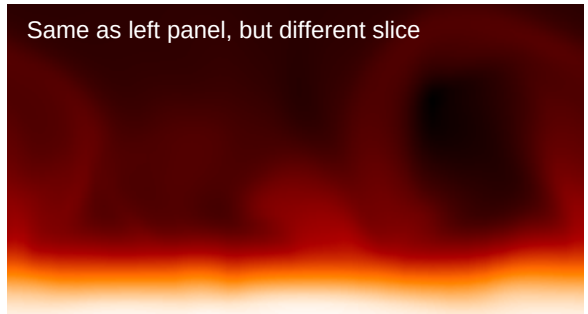


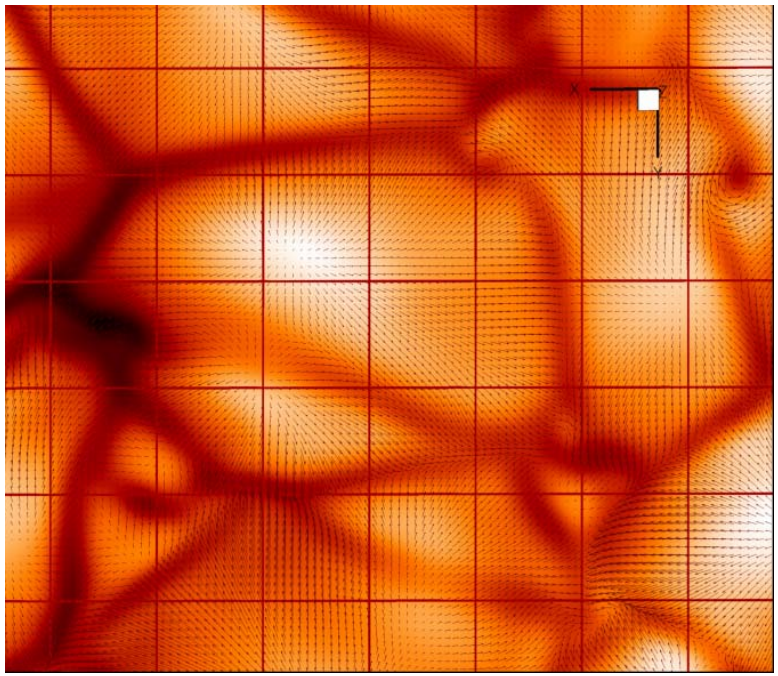
(* http://solarmuri.ssl.berkeley.edu/overview/publicdownloads/software.html)

AMPS (the adaptive MHD parallel solver) solves the 3D MHD equations with a sophisticated treatment of the energy equation

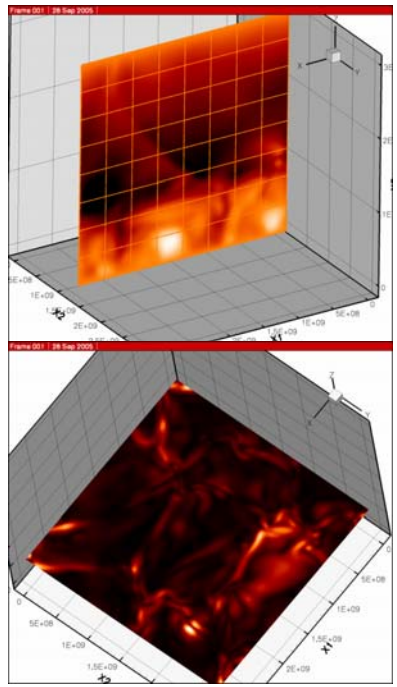
- AMPS is designed to study the evolution of magnetic fields from the solar convection zone to the Sun's upper atmosphere
- The semi-implicit algorithms allow for a simulation domain to include both the convectively unstable layers below the photosphere, and the solar corona
- The serial and MPI AMR (adaptive mesh refinement) versions are currently beta-testing
- AMPS is being used to study
  - Quiet Sun magnetic fields from the convection zone to the corona (e.g., pics to the right)
  - The emergence and decay of active region magnetic structures and the CME initiation process.







Flow field along a horizontal slice in the portion of the domain representing the convection zone. MPI block boundaries are shown.



Top: Vertical flows along a horizontal slice Bottom: |B| along a horizontal slice below the photosphere in the convection zone.

Under development: SANMHD --- solves the 3D MHD equations in the anelastic approximation in global, spherical geometry

- Funded by LWS and promised to CCMC
- The code has been in development since 2003 --- routines are being tested.
- Features:
  - Non-uniform radial grid
  - Spherical harmonic decomposition
  - Inclusion of a convective overshoot region at the base of the convection zone
- SANMHD will be used to study:
  - 3D global flux transport models
  - The large scale dynamo in the solar interior
  - The global interaction of active region scale magnetic fields below the solar surface
  - The properties of global magnetoconvection
  - The formation process of active regions at the base of the convection zone
  - Fully convective stars, and stellar dynamos