Objective 1: CZ dynamics & solar dynamo

- A. Structure and dynamics of tachocline
- B. Variations in differential rotation
- C. Evolution in meridional circulation
- D. Dynamics in near-surface shear layer

Objective 2: Evolution of active complexes
**Themes of Session**

- What are primary targets, most critical issues for local helioseismology?
- How to get deeper within CZ with local probing (+ examine meridional circulation)?
- How to adequately image tachocline and evolving flow or magnetic structures there?
- How to achieve high-resolution probing of 3-D flows in near-surface shear layer?
- How to make analysis of flows in presence of (strong) magnetic fields reliable?
Evaluate properties of GIANT CELLS

- **Large-scale convection must be dominant player** in defining solar differential rotation
- **Persistent downflows** could pummel tachocline, yield active longitudes or nests

- **Can we clearly detect GCs, assess their evolution and Reynolds stresses?**
- **Can we resolve 3 vector components of GC flows in near-surface shear layer?**

![Evolution in Radial Velocity (0.96 R)](image)
Giant cells: complex evolving structures

But why so difficult to detect GCs?
Big Questions: Global-Scale Convection

- **Why no clear or direct detection** of giant convection cells?
- **Does intense near-surface turbulence** of granulation and supergranulation yield transport barrier to deflect such flows?
- **May simply be very tough to detect** since narrow downflows but wide cell scales, and they both evolve and propagate
- But fast horiz flows of **supergranulation** (~500 m/s) *may hide GC flows* (~20 m/s)

Assess Meridional Circulations

- **Theory suggests:** Likely **multi-celled in latitude and radius, with N-S asymmetries, temporal variability**
- Crucial for assessing flux transport dynamo approaches
- How to **probe deeply and reliably, and be available to calibrate / challenge theory**
### Flows Near Magnetism

- **Examine large-scale flows and their coupling to magnetic complexes**
- **Who pushes whom around?**
- **Are flow assessments reliable, given complex mode conversion issues?**
- **How can we provide soon-(real)-time continuous subsurface flow mappings in upper 20+ Mm -- fast analysis pipes**

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**Changing Meridional Circulations**

- **SOUTH: SINGLE CELL**
- **NORTH: DOUBLE CELL**
- **POLEWARD FLOW NEAR SURFACE**
- **REVERSED FLOW AT DEPTH**

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*Haber et al (2002)*
Probing Flows Near Filaments

High-Resolution Ring Analysis
Time-Distance: Flows Within Active Region

[Image of a flow map with color coding and annotations]

NOAA 9393, 2001.04.26 20:00, d=6.4 Mm

Theory: Global Views of Flows and Fields

[Image of flow and magnetic field maps with annotations]

Miesch, Brun & Toomre (2004)
Close-up View of Evolution

Toroidal B