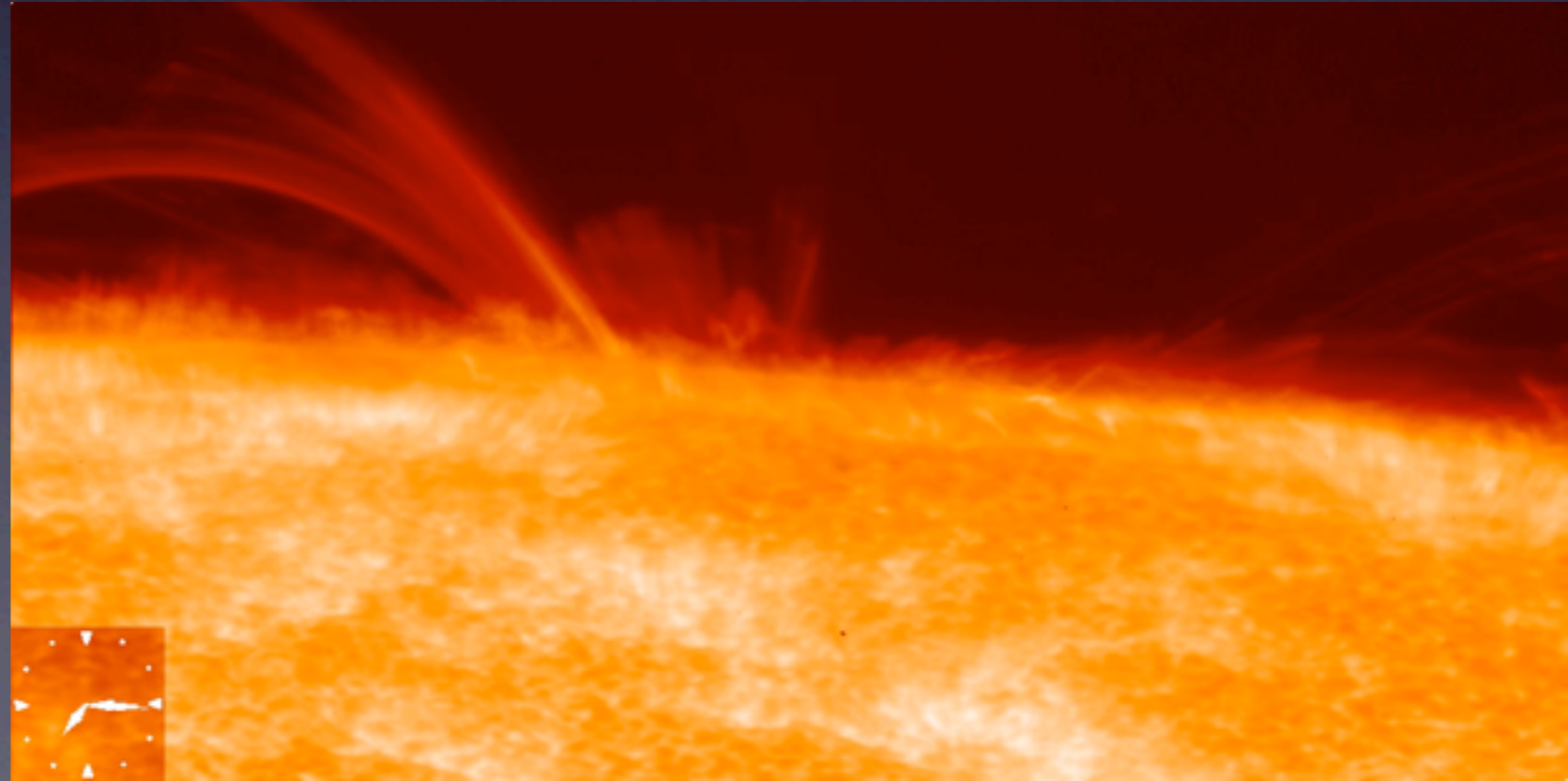
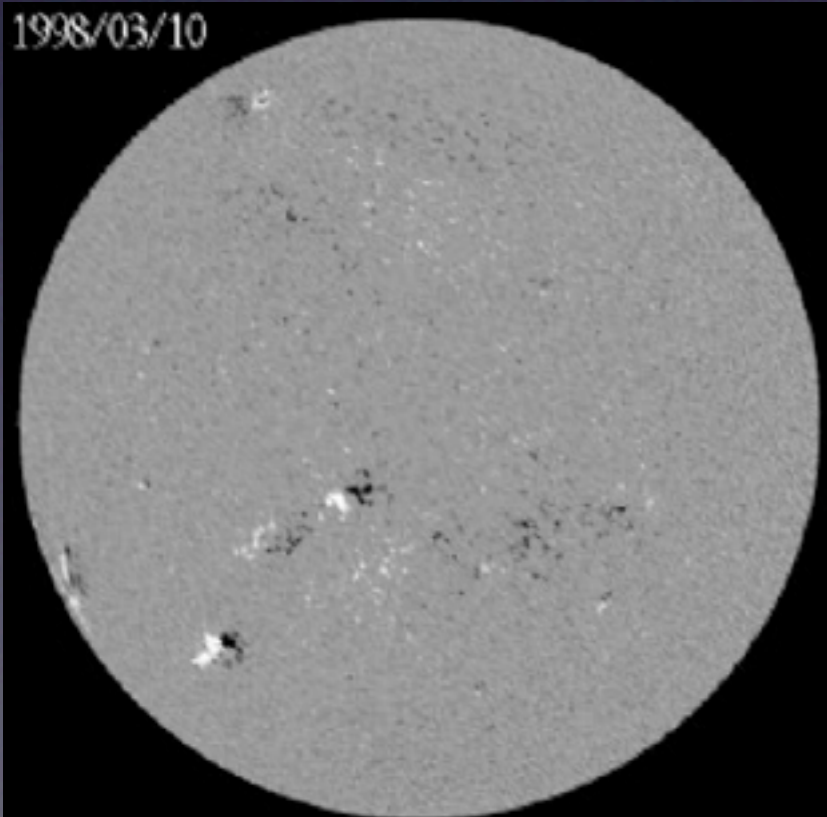
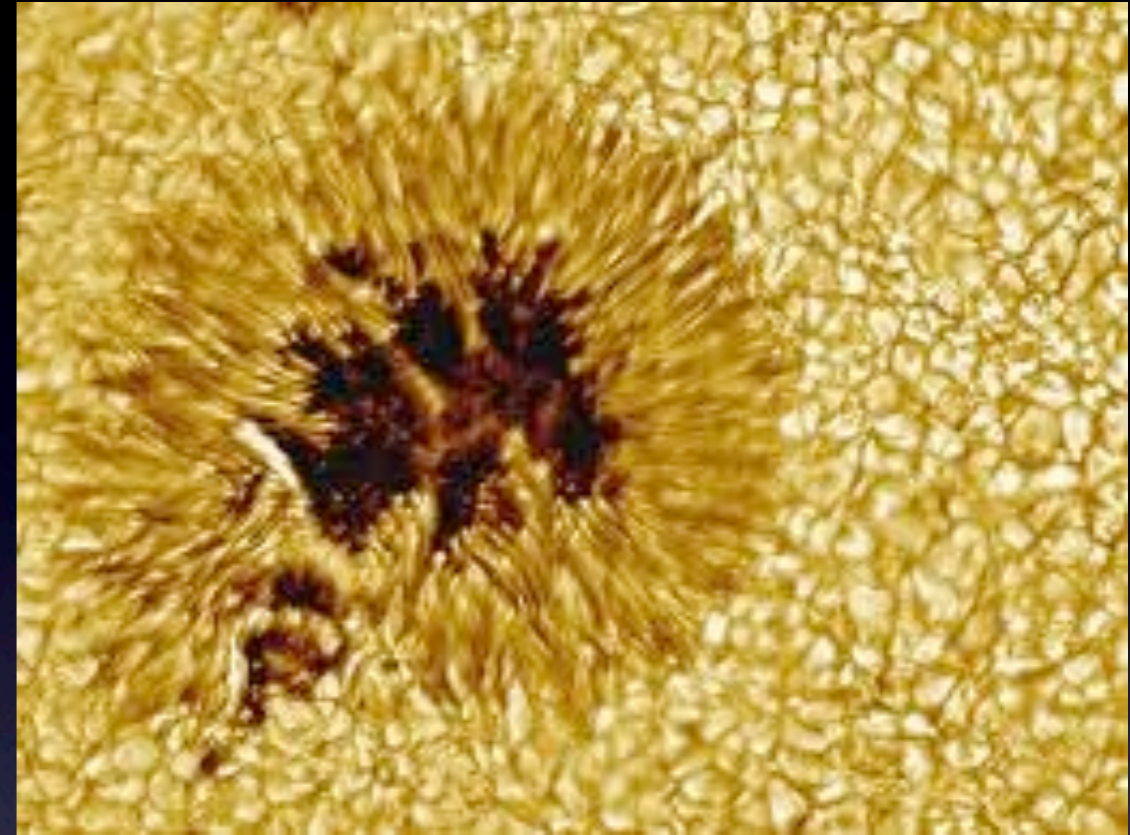


Imaging the sedimentary basins of the Sun

Shravan Hanasoge
Princeton University

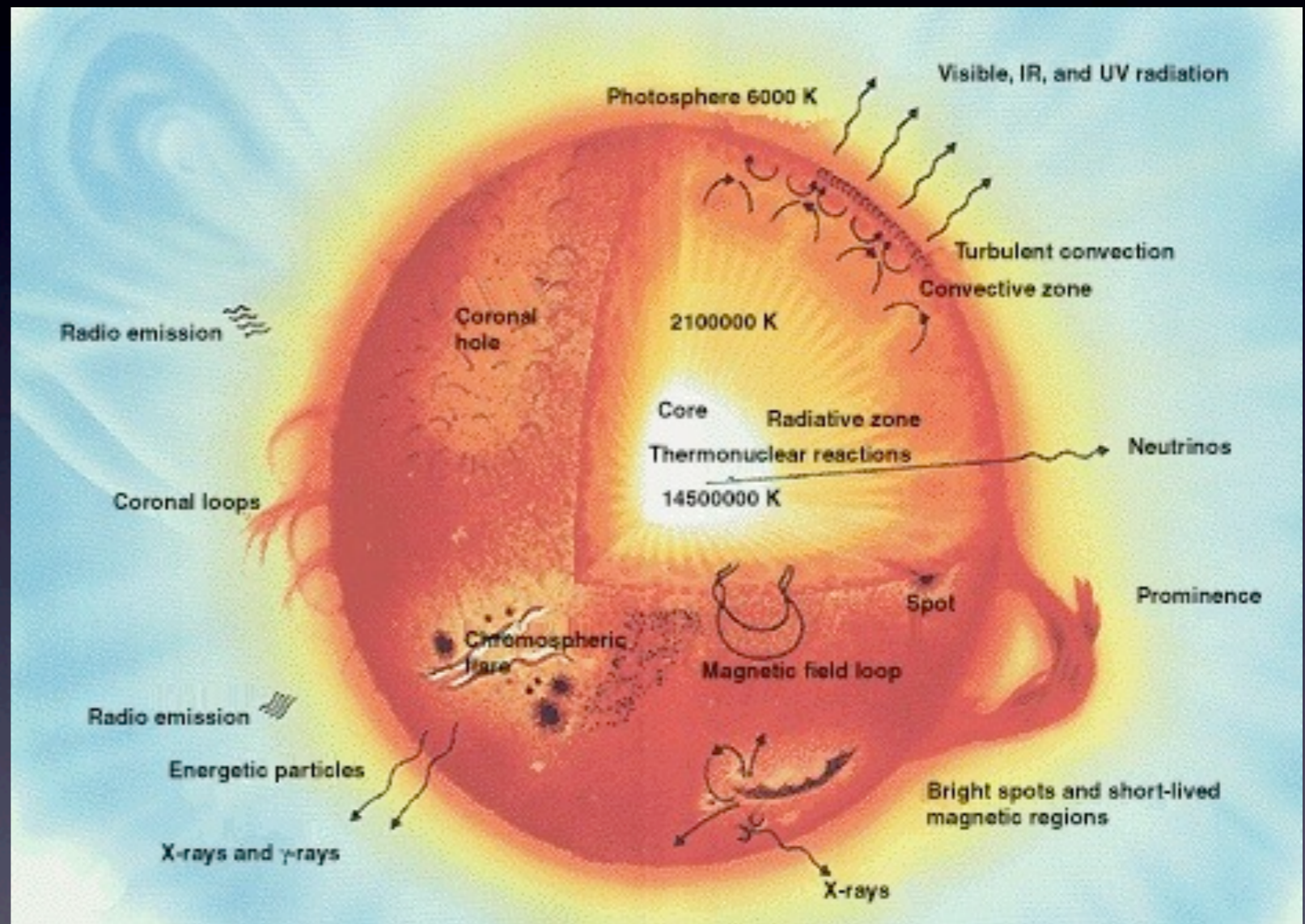
The Sun

- Directly impacts Earth climate
- Affects space weather
- Remarkable physics
- “Noisy” seismic system

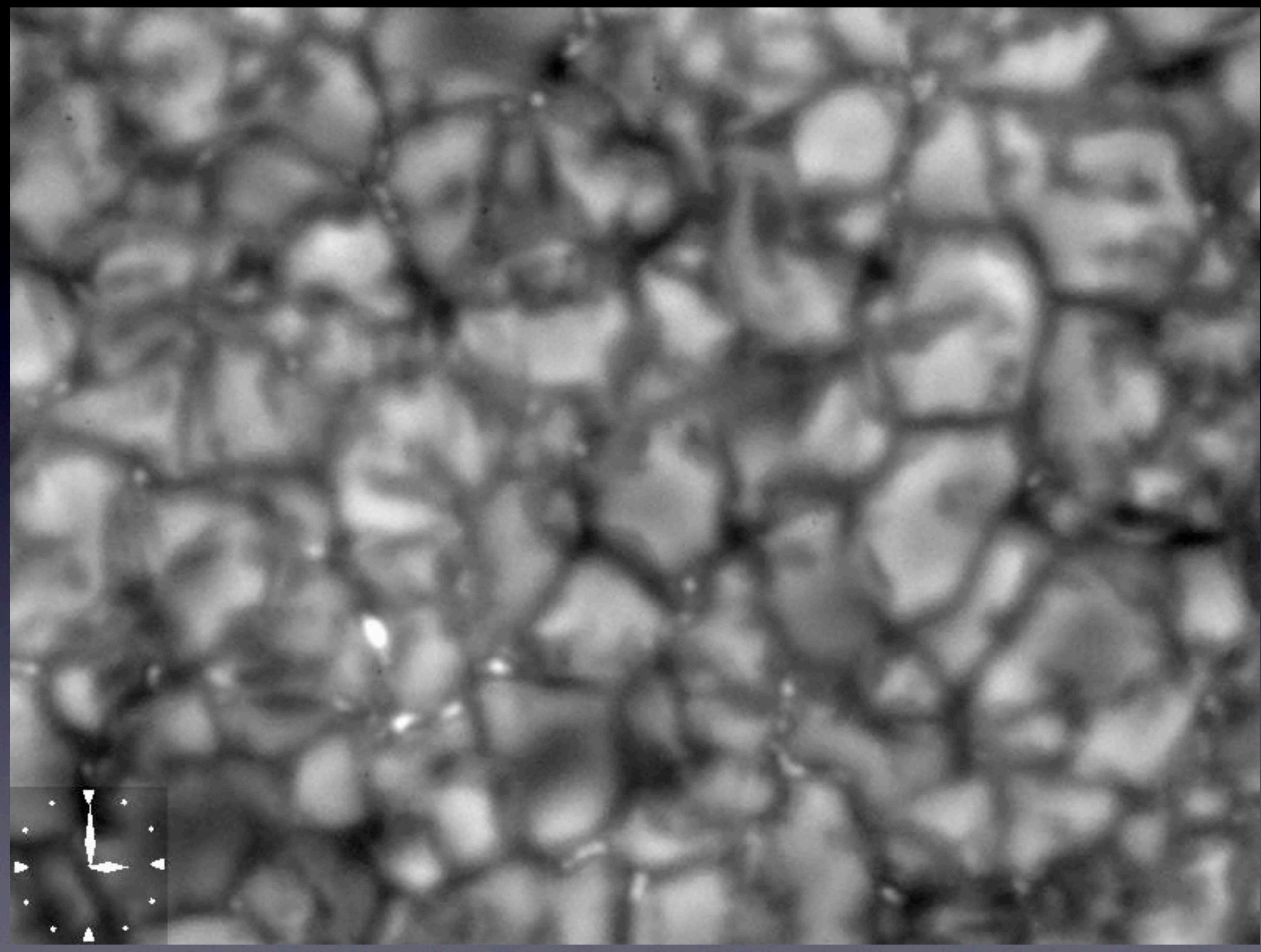


Internal structure

- Normal-mode global helioseismology + 1D stellar evolution
- Fluid body
- Opaque interior

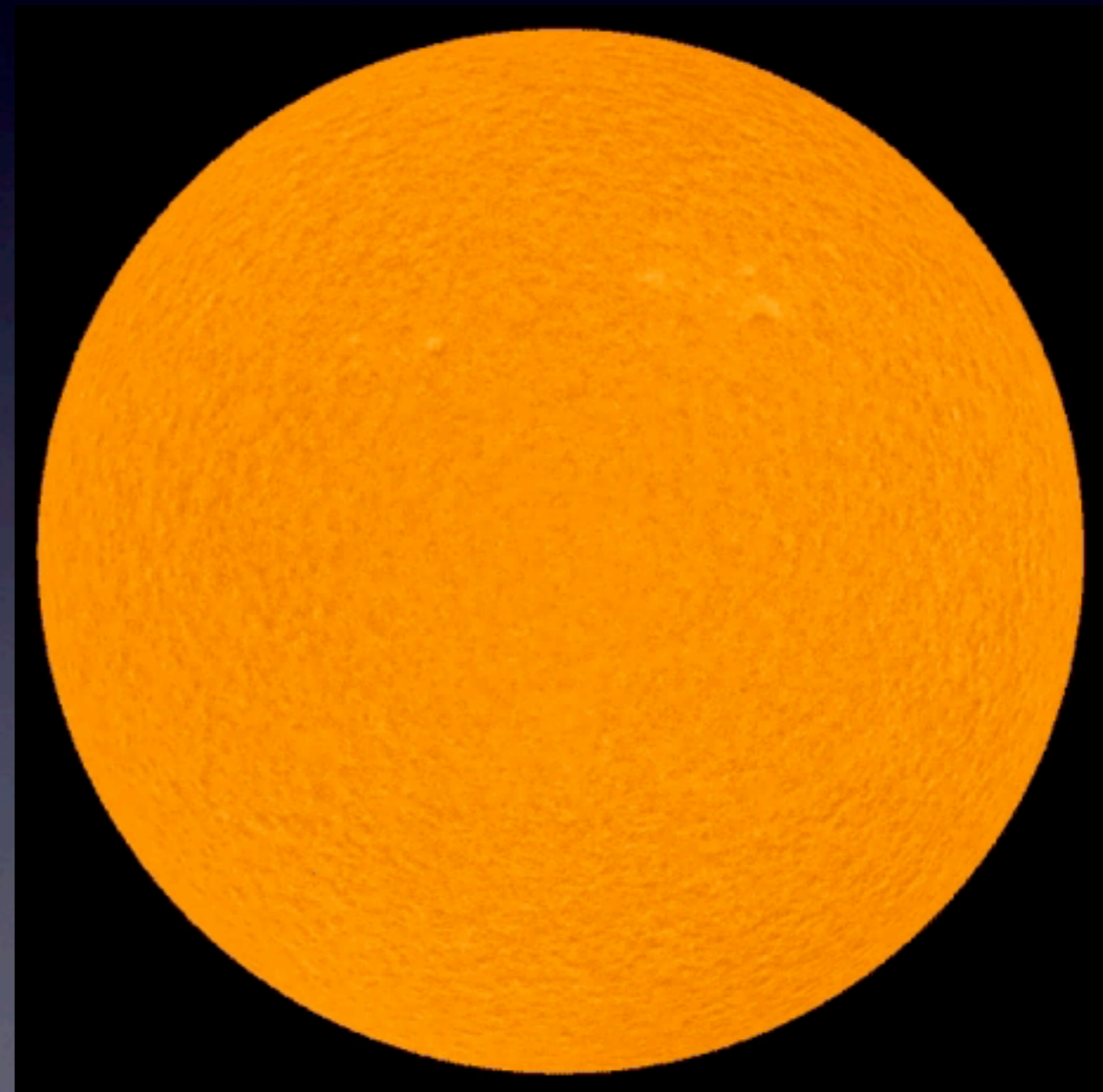


- Acoustic waves excited by surface turbulence
- Sources are homogeneous and uniform



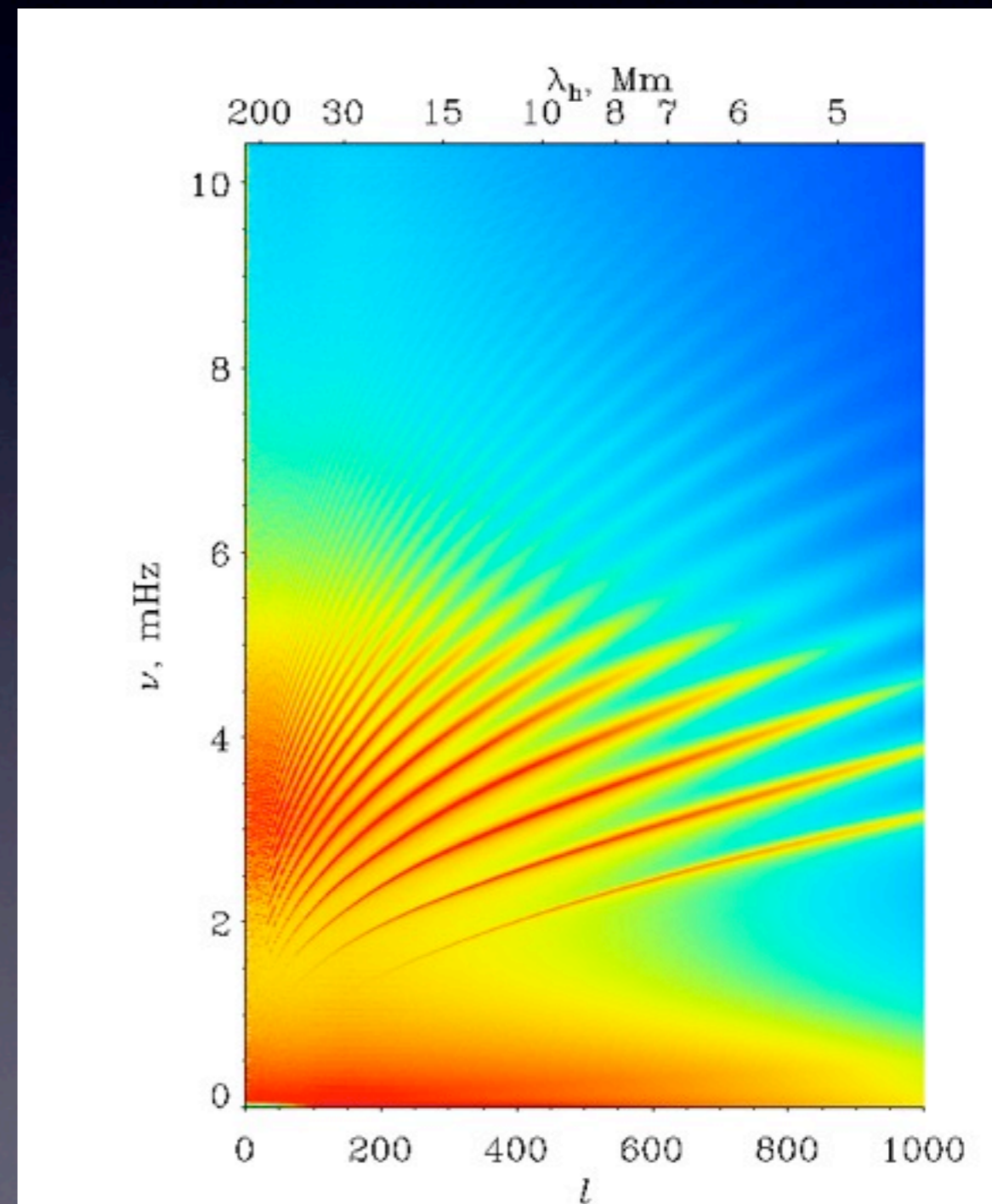
Noise tomography on the Sun

- Doppler shifts of absorption lines - line-of-sight projected wavefield velocity
- Measured at millions of “pixels” on the surface
- Cross correlations reveal statistically significant seismic information



Power spectrum of solar oscillations

- Ridges of high power well understood
- Background power remains mysterious
- Frequencies are measured with high precision



Seismic comparison

Differences

- No discontinuities
- Sources are everywhere, all the time
- High-resolution coverage
- Rapid evolution of the Sun
- Limited frequency band

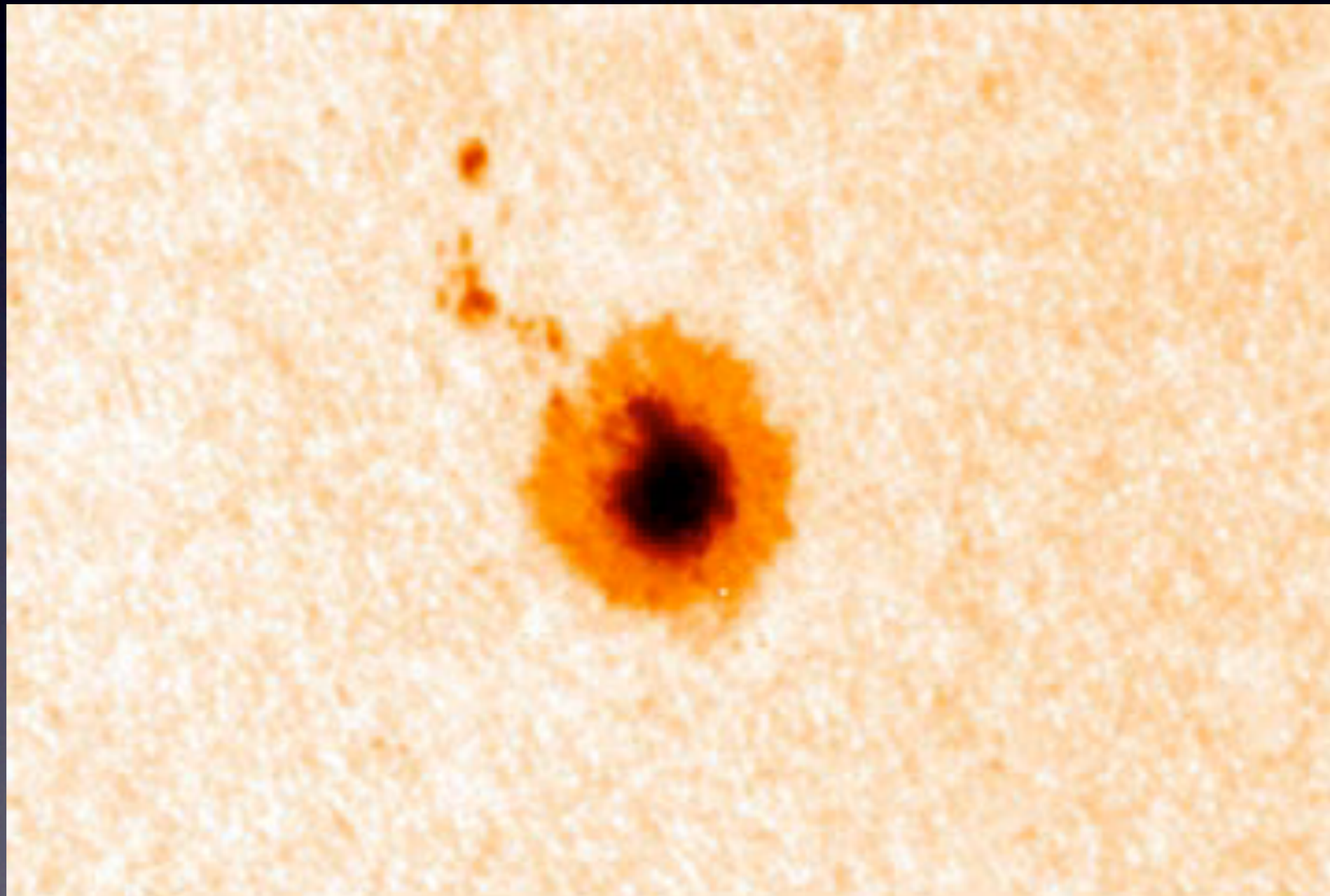
Similarities

- Linear wave equation
- Normal modes exist
- Cross-correlation travel-time tomography
- Surface layers (like earth's crust) make it difficult to image interior

Posing inverse problems

- Sub-surface structure driven by:
Data + Forward model + Inverse theory
- Data are incredible, high resolution and complete coverage
- Consequently the other two facets are sometimes not taken seriously

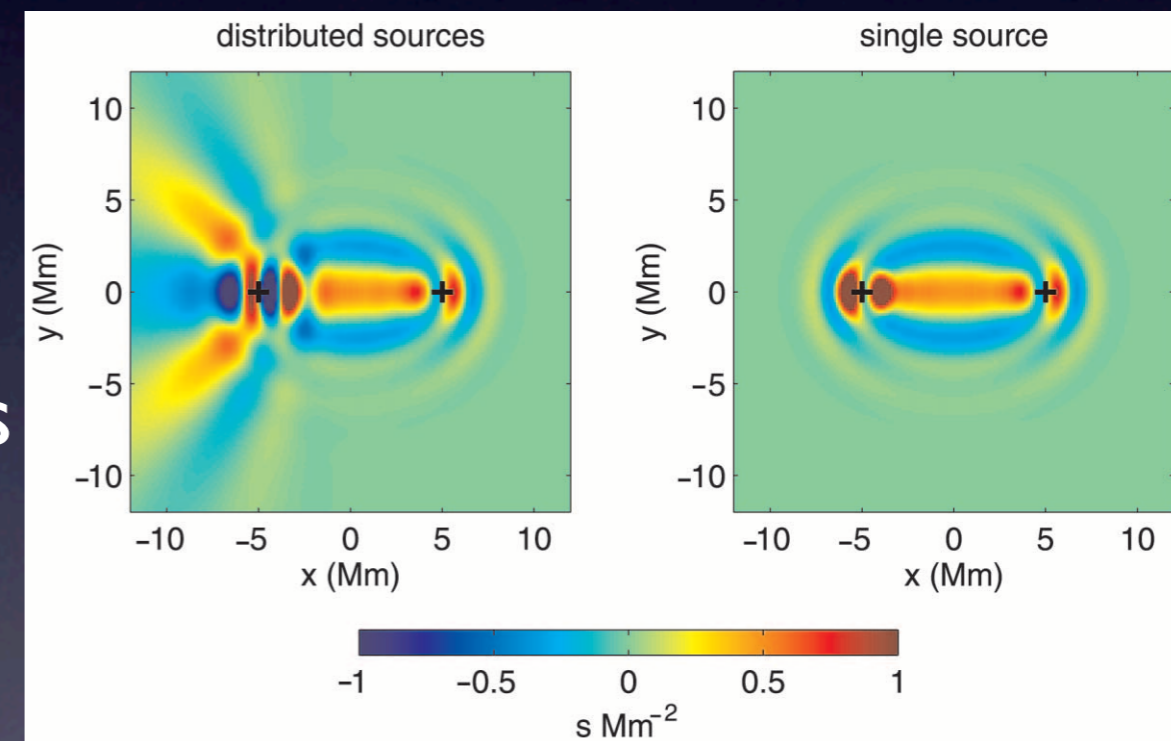
An example of an inversion



(Kosovichev; Stanford Solar Group). Likely inaccurate.

Adjoint tomography

- Recent developments make this feasible (Tromp et al. 2010; Hanasoge et al. 2011)
- Fundamental challenges remain
- Sensitivity of measurement to sources far away: kernels inherently different
- Unknown Scattering properties and poorly known source distribution may make it more complex for earth



e.g. Gizon & Birch 2002

What remains to be done?

- Structure of sunspots
- Dynamics of turbulent convection and rotation; meridional circulation belt
- What drives the solar dynamo? Predicting emergence of active regions.
- Normal-mode seismology of non-axisymmetric features in the solar interior (profound consequences)

Other stars

- Understanding exoplanets dependent on appreciating the host star
- COROT, KEPLER, PLATO etc. (Contact Laurent Gizon: gizon@mps.mpg.de)

The end

