Comparison of subsurface flows obtained with acoustic holography and ring analysis

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Introduction

We compare synoptic maps of subsurface flows obtained with acoustic holography and ring analysis. We measure the horizontal flows of Carrington rotation 1988 by analyzing Doppler images from the Michelson Doppler Imager instrument onboard the Solar and Heliospheric Observatory.

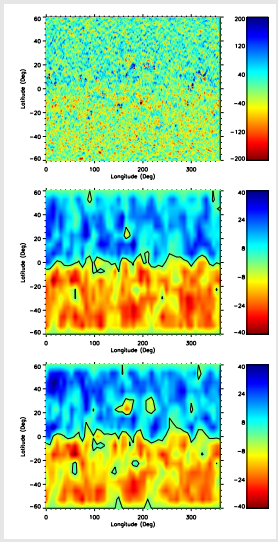
For the comparison, we bin the holography maps to a spatial resolution similar to the one of the ring analysis. The holography maps represent averages over layers from the surface to a depth of about 3 Mm, while the ring-diagram maps are derived at different depths to about 16 Mm.

Meridional Flow

Acoustic Holography Map — focal depth: 0.0043

Binned Acoustic Holography Map

Ring-Diagram Map — depth: 0.6 Mm

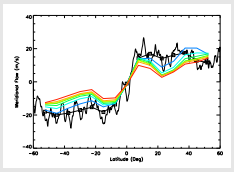


The binned holography map of the meridional flow is very similar to a corresponding ring-diagram map. (Blue/red colors indicate flows to the North/South.)

solid: holography

squares: binned holography

ring-diagram: 0.6 Mm, 0.9 Mm, 1.2 Mm, 1.5 Mm, 1.7 Mm, 2.0 Mm, 3.1 Mm

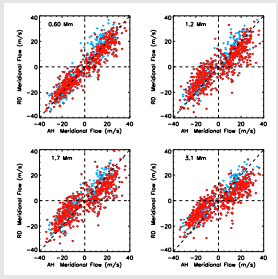


Meridional flow averaged in longitude, as a function of latitude.

dashed lines: slope of one

Latitude ≤ 37.5 Deg

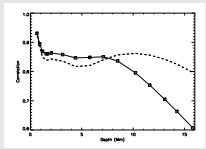
Latitude > 37.5 Deg



Binned acoustic-holography meridional flow values vs. ring-diagram flow values at four depths. The slopes are close to one; both methods lead to similar flows.

solid line: all latitudes

dashed line ≤ 37.5 Deg



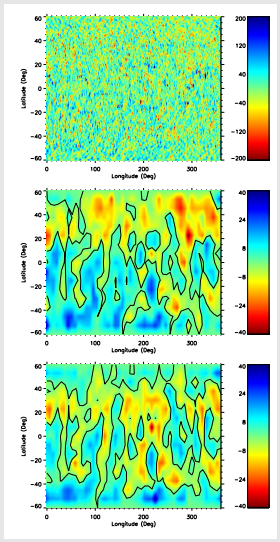
Correlation of the meridional flows of the binned holography map with the ones of ring-diagram maps at different depths. The largest correlation occurs for ring maps at 0.6 Mm.

Zonal Flow

Acoustic Holography Map — focal depth: 0.0043

Binned Acoustic Holography Map

Ring-Diagram Map — depth: 3.1 Mm

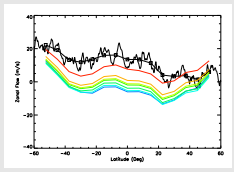


The binned holography map of the zonal flow is very similar to a corresponding ring-diagram map.

solid: holography

squares: binned holography

ring-diagram: 0.6 Mm, 0.9 Mm, 1.2 Mm, 1.5 Mm, 1.7 Mm, 2.0 Mm, 3.1 Mm

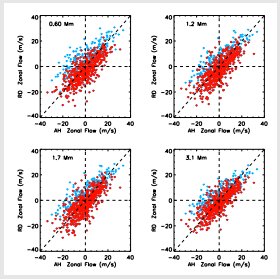


Zonal flow averaged in longitude, as a function of latitude.

dashed lines: slope of one

Latitude ≤ 37.5 Deg

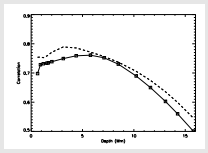
Latitude > 37.5 Deg



Binned acoustic-holography zonal flow values vs. ring-diagram flow values at four depths. The slopes are close to one; both methods lead to similar flows.

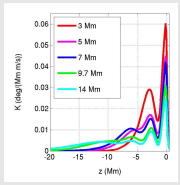
solid line: all latitudes

dashed line ≤ 37.5 Deg



Correlation of the zonal flows of the binned holography map with the ones of ring-diagram maps at different depths. The largest correlation occurs for ring maps near 3 Mm (or 5 Mm).

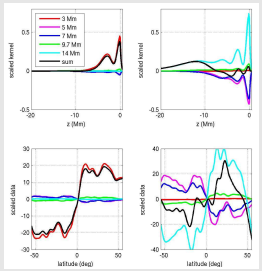
Longitudinal-Averaged Holography Inversions



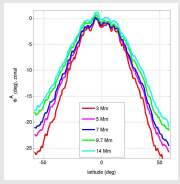
Kernels for holography measurements of horizontally uniform horizontal flows for five different focus depths. The kernels reflect the kinetic energy density of the modes which contribute to the measurements at each focus depth.

black: averaging kernel and fbw at target depth

color: constituent kernels and fbws



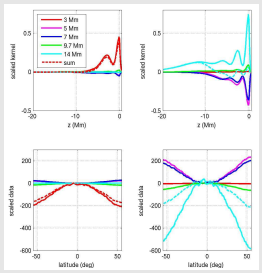
Averaging kernels (top panels) and inversion results (bottom panels) for meridional flows (in m/s). At a depth of 3 Mm (left column), the measurement is dominated by the contribution at a focus depth of 3 Mm, while at a depth of 14 Mm (right column), the measurements at several focus depths contribute. A second cell in the northern hemisphere is seen at a depth of 14 Mm.



Zonal anti-symmetric phase, Φ^A, measured as a function of latitude for five focus depths.

Dashed lines: averaging kernel and fbw at target depth

color: constituent kernels and fbws



Averaging kernels (top panels) and inversion results (bottom panels) for zonal flow (in m/s) at a depth of 3 Mm (left column) and at 14 Mm (right column).

Conclusions

Binned acoustic-holography maps of zonal and meridional flows are very similar to corresponding ring-diagram maps. The longitudinal averages agree quite well.

This similarity is apparent in a quantitative comparison leading to regression slopes and correlation coefficients close to one (for ring maps at shallow depths).

At great depth, measurements from several depths contribute to holography inversions, while near the surface, only the target depth contributes.

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