



July 28-31, 2008

Travel-Time Measurements with the HMI Pipeline

**HMI time-distance pipeline
team**

Who is doing what for the time-distance pipeline (1)?

- John Beck: works on the quality check of datacubes obtained by fastrack
- Rick Bogart: produces the tracking code (fastrack) that will be used to produce the datacubes.
- Sébastien Couvidat: produces the codes to compute the travel times with the Gizon & Birch (2002) and (2004) definitions. Works on the azimuthal averaging of kernels. Works on the comparison of the different time-distance and inversion codes.
- Tom Duvall: works on comparison of codes dealing with geometry correction. Works on the travel-time error estimate in sunspots. Works on the comparison of the different time-distance codes.

Who is doing what for the time-distance pipeline (2)?

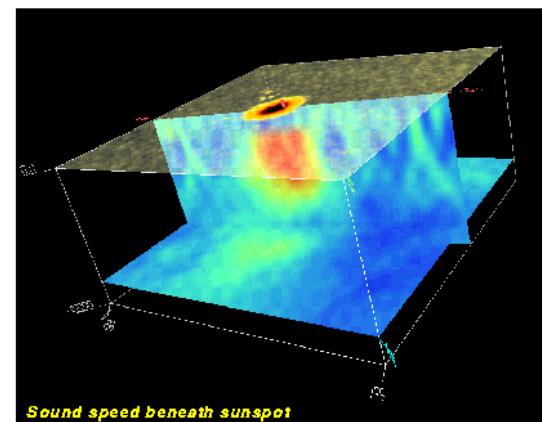
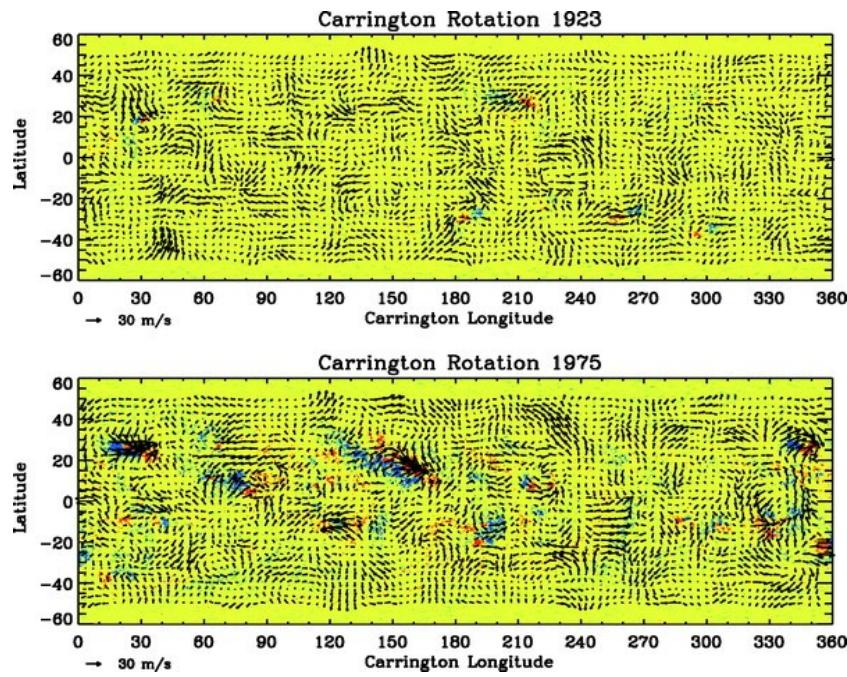
- Sasha Kosovichev: works on the comparison between the different inversion codes
- Konstantin Parchevsky: works on the production of ray-path kernels. Works on the production of Born kernels using Aaron's code.
- Junwei Zhao: produces the main code in fortran (data filtering, cross-covariance computation, and travel-time fit with the Gabor wavelet). Works on the travel-time error estimate in sunspots. Works on the comparison of the different time-distance codes. Works on the integration of the fortran codes in the DRMS

Standard products of the travel-time measurement part of the pipeline

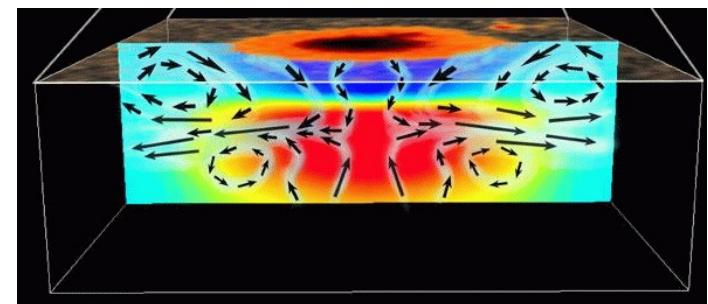
Travel-time maps (with error bars ?): mean -travel time, difference travel-time, East-West and North-South travel-time differences. To produce:

- ✓ Synoptic maps: every 8 hours and a half, we produce synoptic maps of the subsurface flows (depth 0-30 Mm) (with error bars ?)
- ✓ Subsurface flow fields of active regions (depth 0-30 Mm) (with error bars ?)
- ✓ Subsurface structure of active regions (depth 0-30 Mm) (with error bars ?)
- ✓ All these products will be saved as fits files in the DRMS

From Junwei's Napa Meeting presentation:



Sunspot data from MDI High Resolution, 18 June 1998

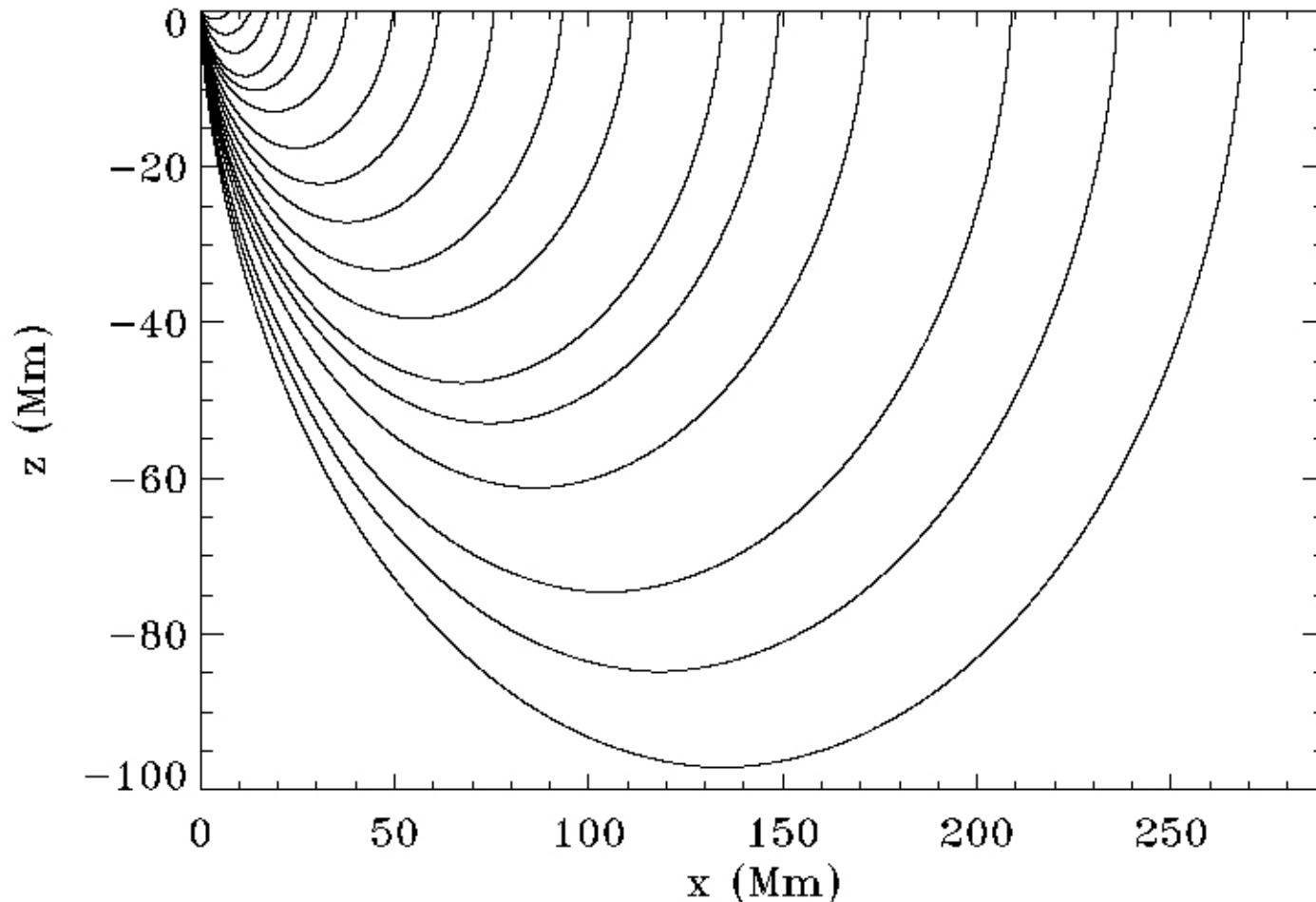


Tracking

- ✓ We start from HMI Dopplergrams and produce tracked datacubes
- ✓ Tracking with a code similar to fastrack
- ✓ 2 different configurations: one for synoptic maps, and another for individual active regions
- ✓ Synoptic maps: 9 overlapping tiles on solar surface. Tiles will be tracked at a different rotation rate. Which rate (Snodgrass? Supergranulation?). Inconsistencies might appear between tiles.

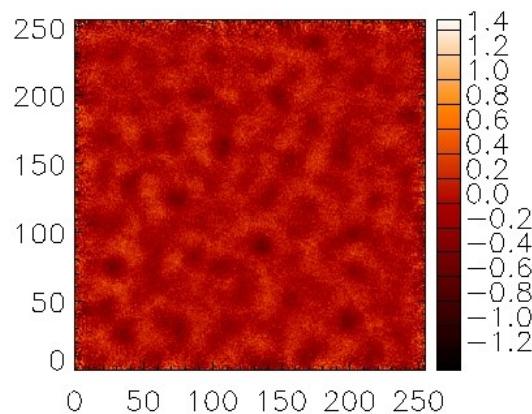
Distances Source-Receiver

- We selected 17 distances
- Ranging from 9.5 Mm to 270 Mm
- To reach layers deeper than 30 Mm

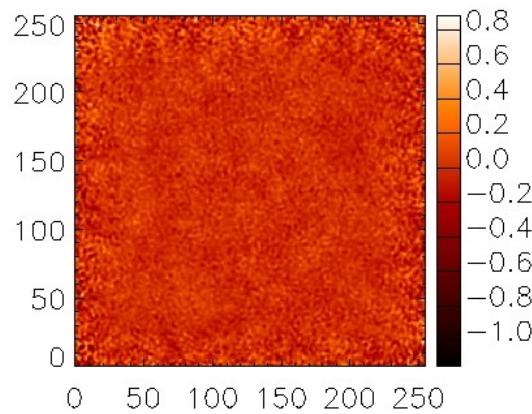


Datacube filtering and Cross-Covariance Calculations

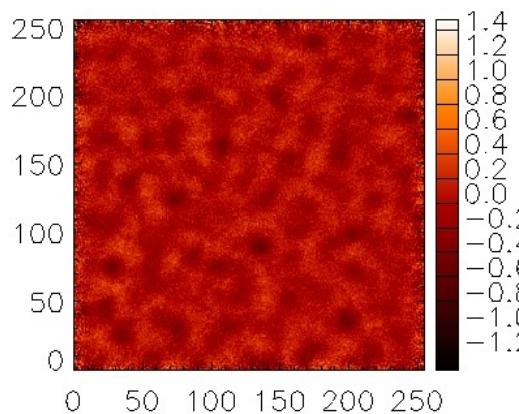
14.6 Mm



32.1 Mm



My code



Junwei's code

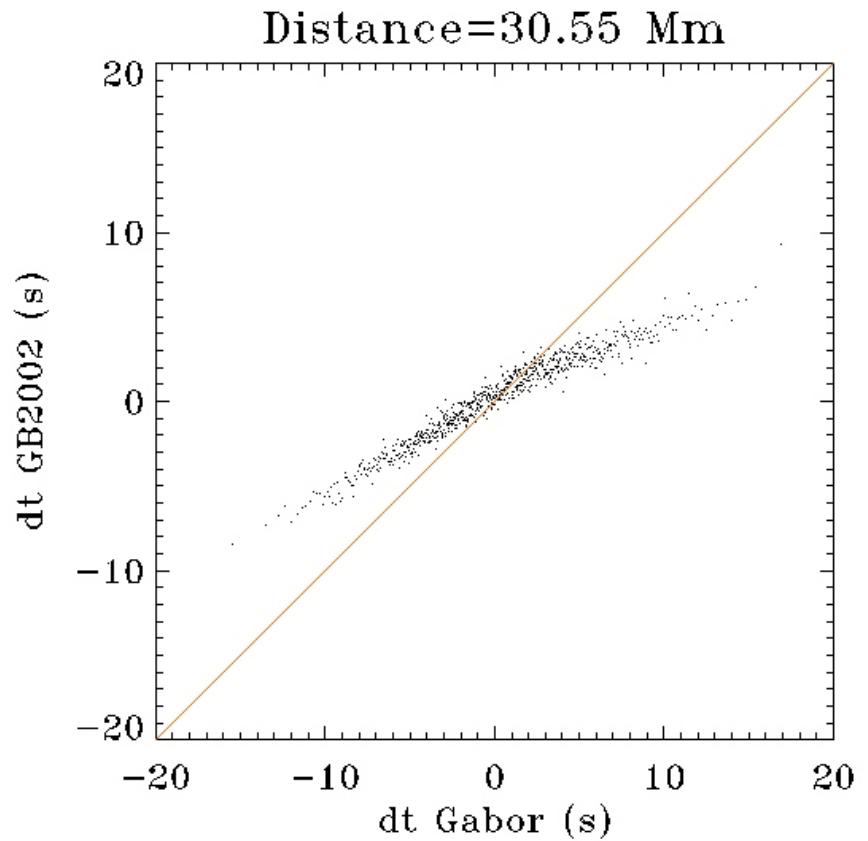
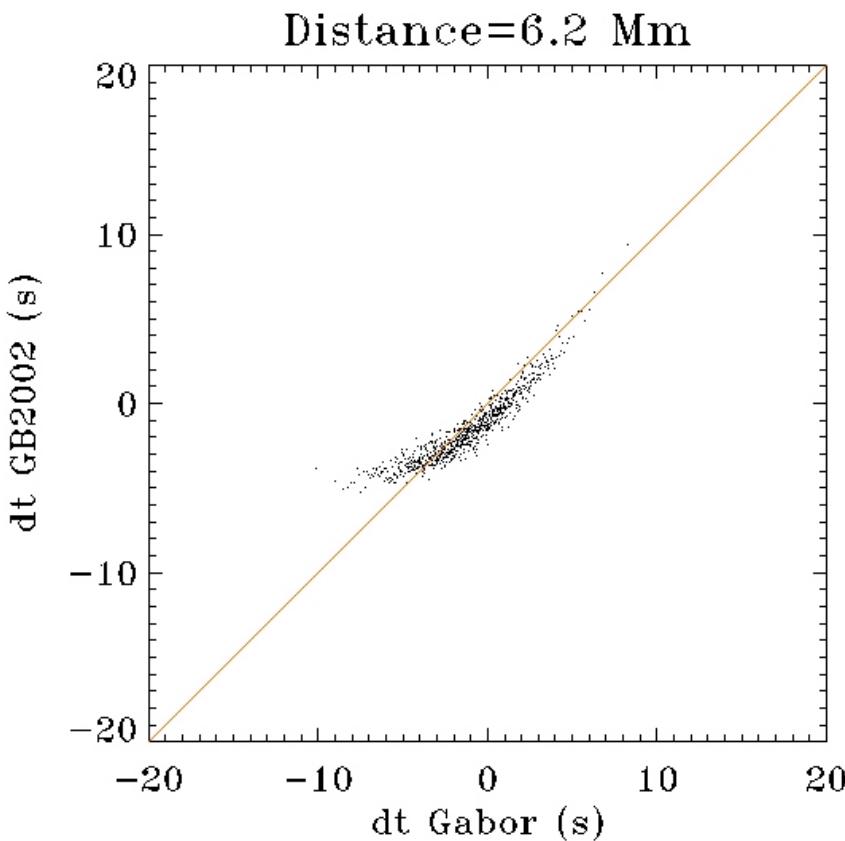
- We'll use Gaussian phase-speed filtering
- We'll apply the usual annulus and quadrant geometries
- Geometry corrections taken into account when computing cross-covariances
- Comparison between Junwei's, Tom's, and my code have already been made for the filtering and the cross-covariances

Travel-Time Calculations

- ✓3 subroutines available
- ✓Gabor wavelet fit
- ✓Gizon & Birch (2002) definition (translation into fortran from the Matlab code of Aaron)
- ✓Gizon & Birch (2004) definition
- ✓Gabor wavelet fits used with ray-path kernels ?
- ✓Gizon & Birch definition used with Born kernels (?) in quiet Sun only (?)

The definition(s) of Gizon & Birch and the Gabor wavelet fit give different results, even in the quiet Sun

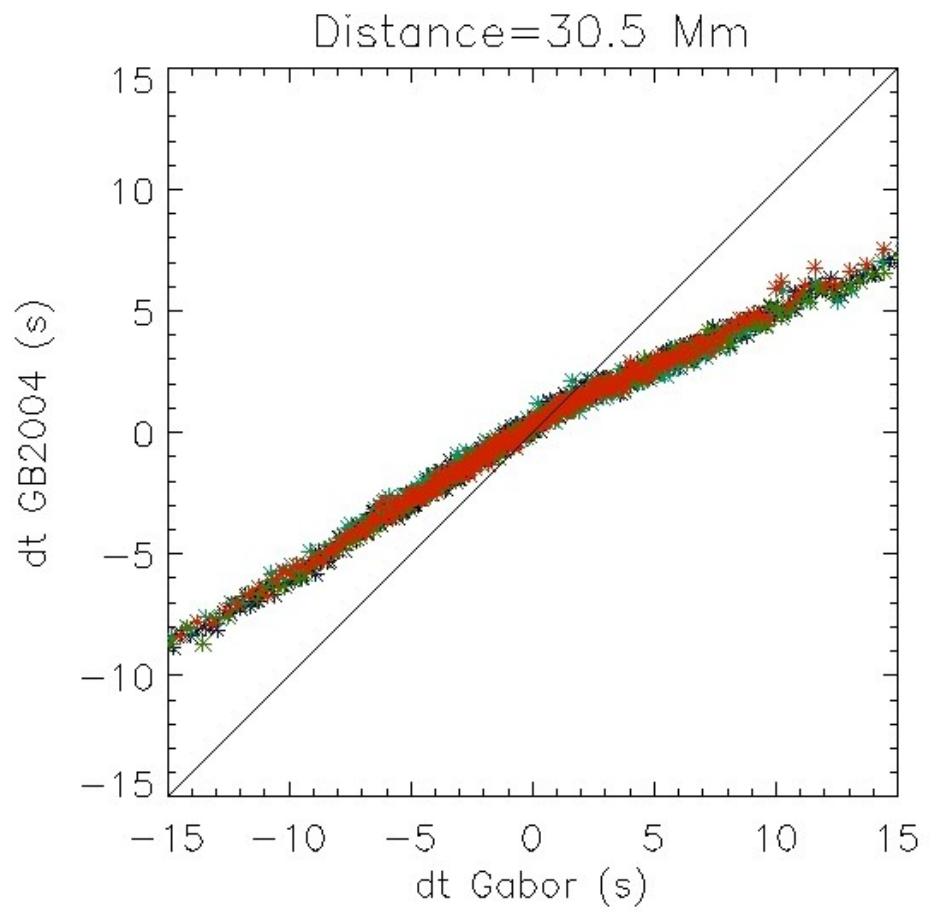
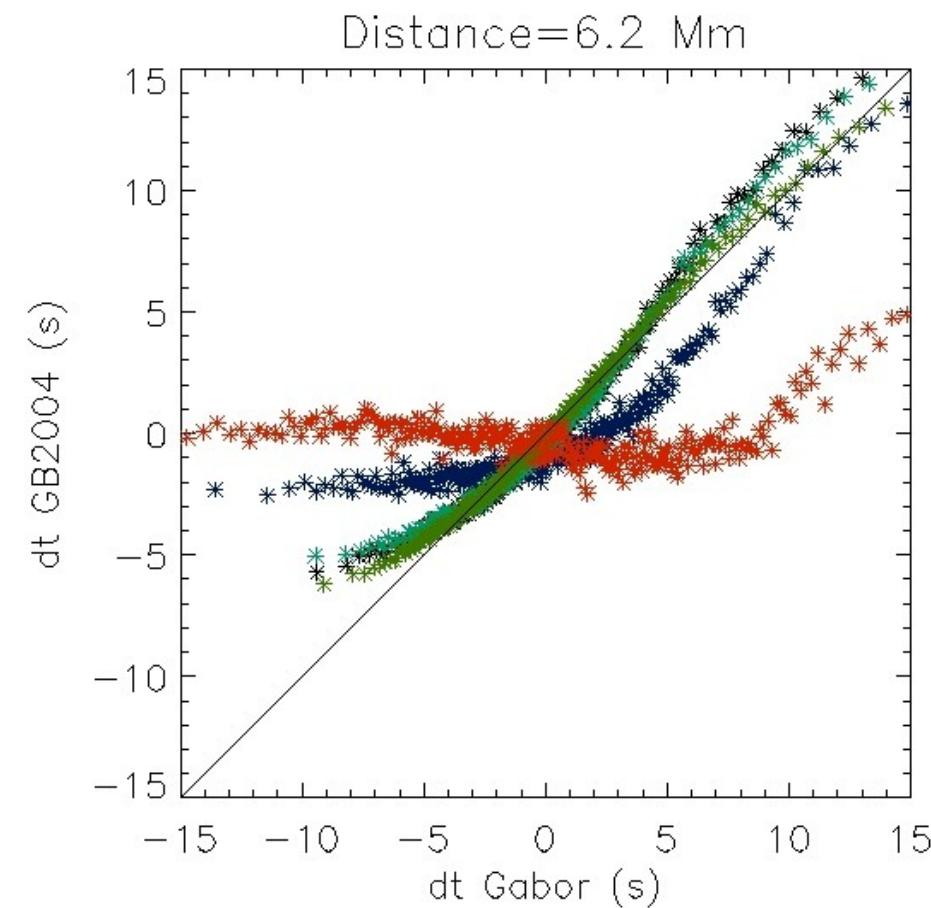
Differences between definitions of travel times



Comparison mean travel-time perturbations for quiet Sun: Gabor wavelet vs.
Gizon & Birch (2004)

Differences between definitions of travel times (2)

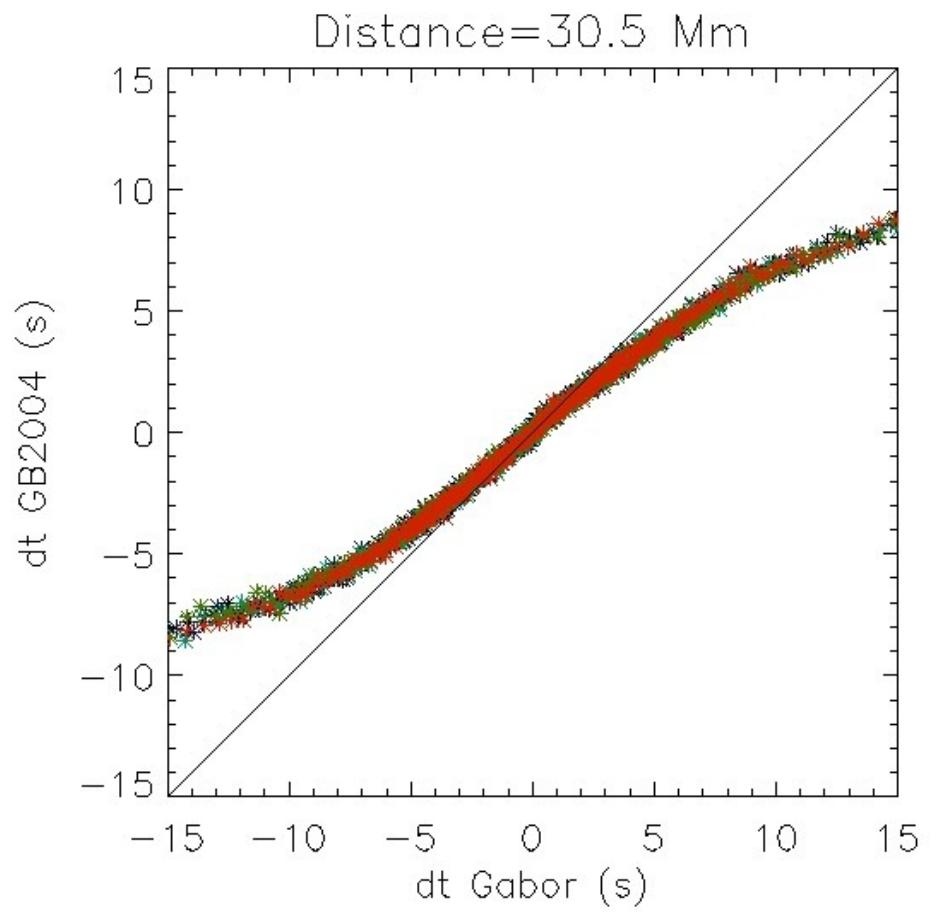
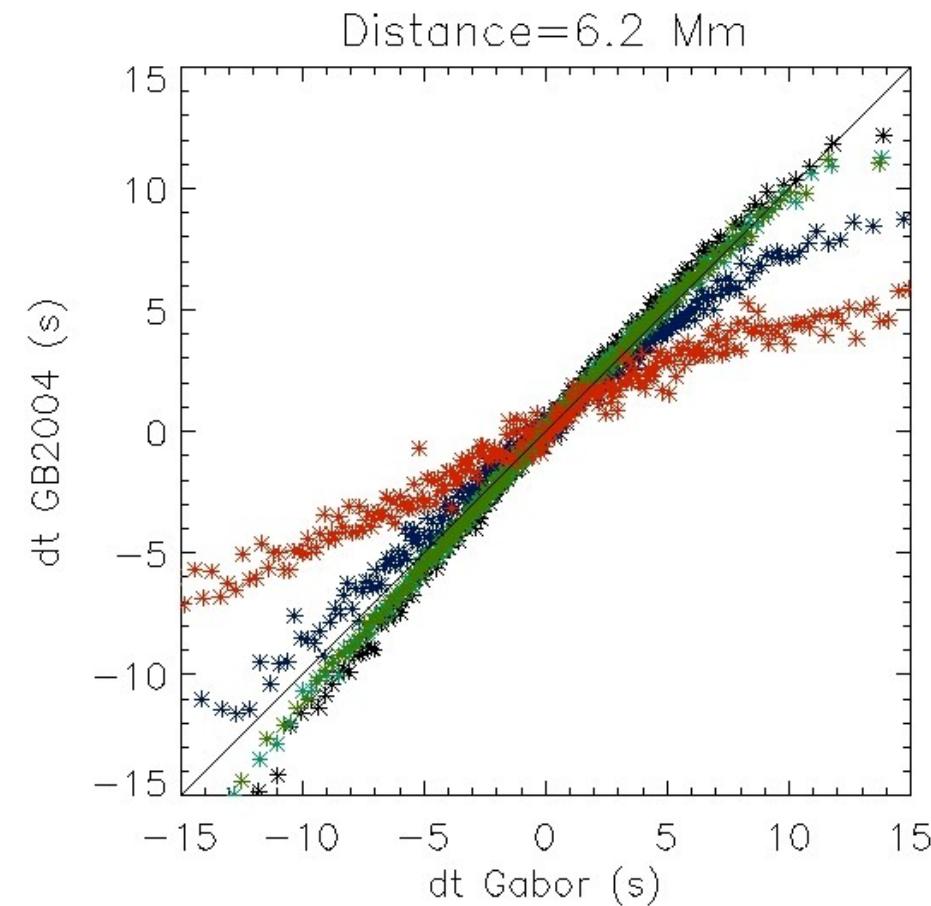
For mean travel-time perturbations



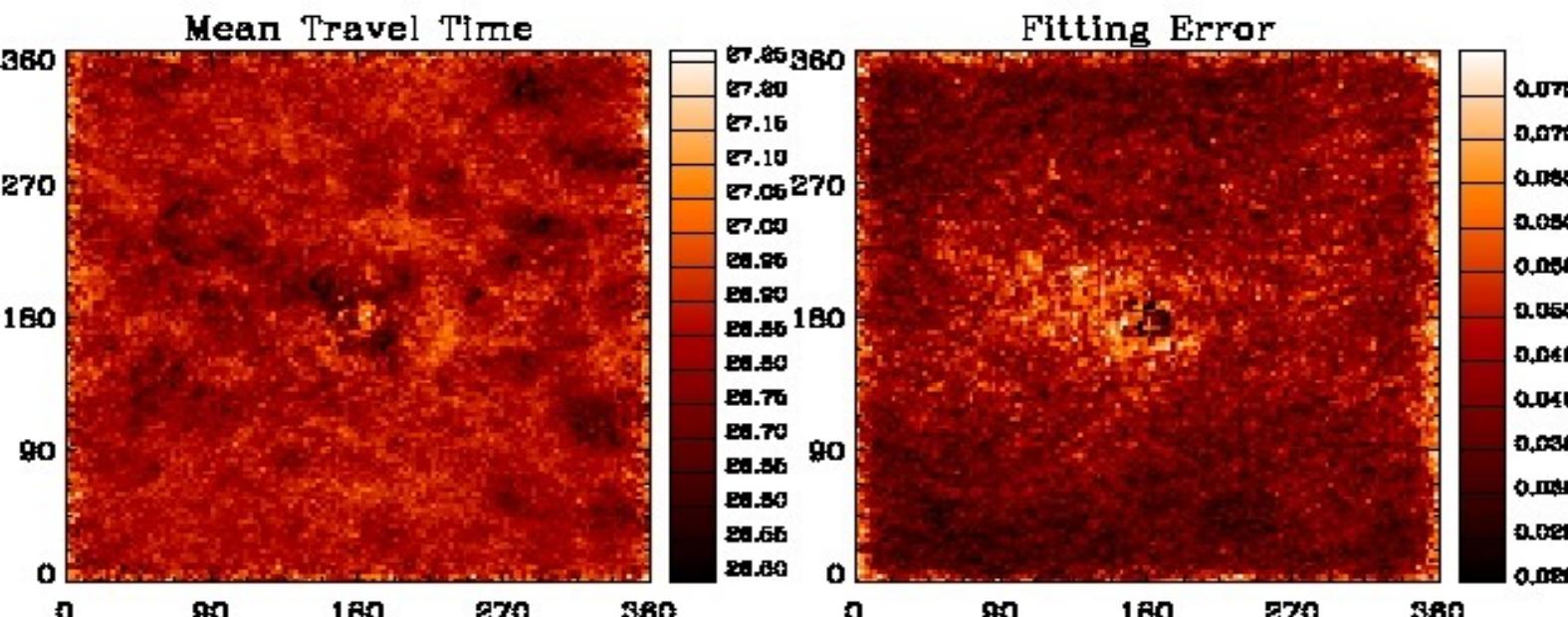
The difference depends on time window center and width at small distances

Differences between definitions of travel times (3)

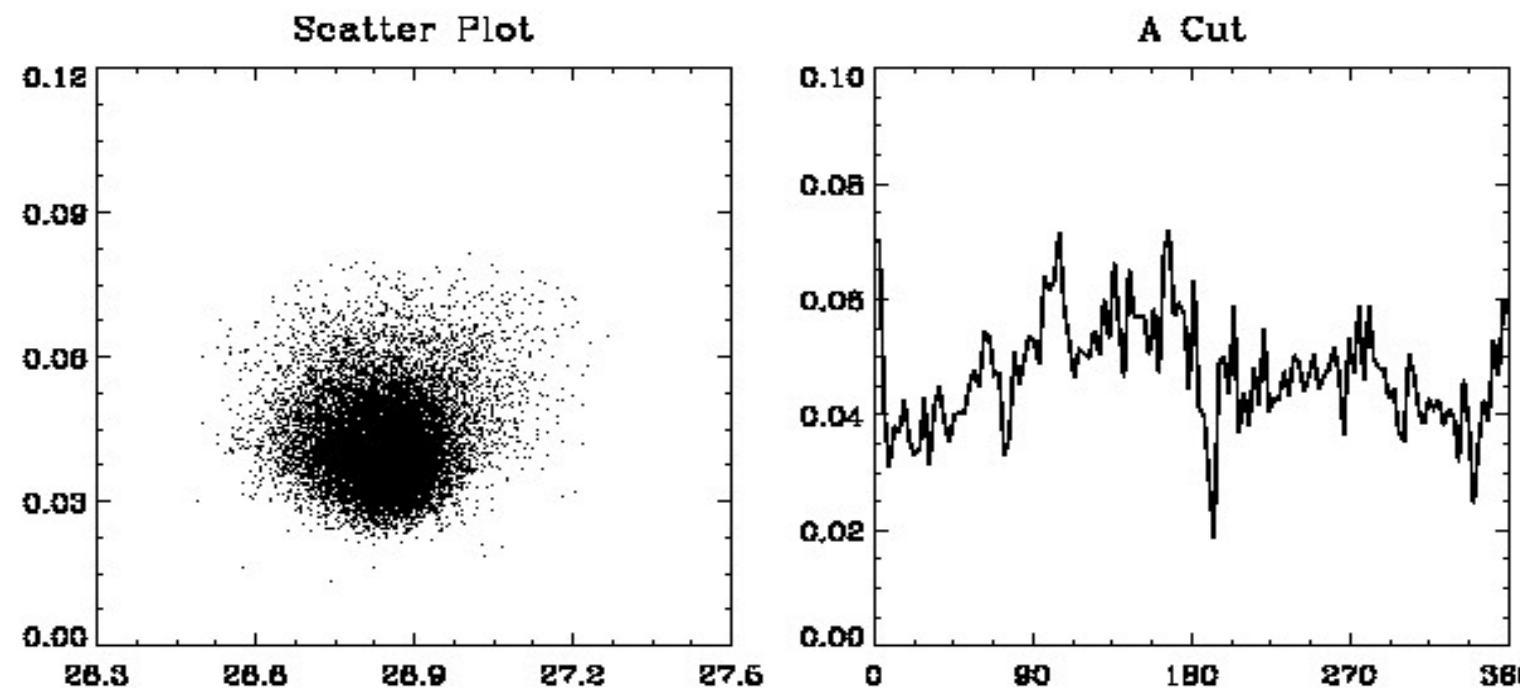
For difference travel-time perturbations



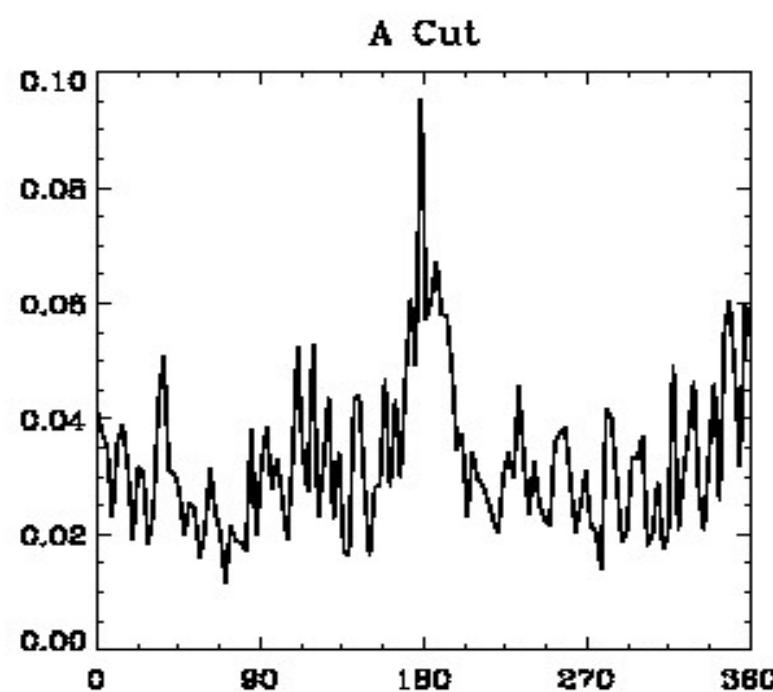
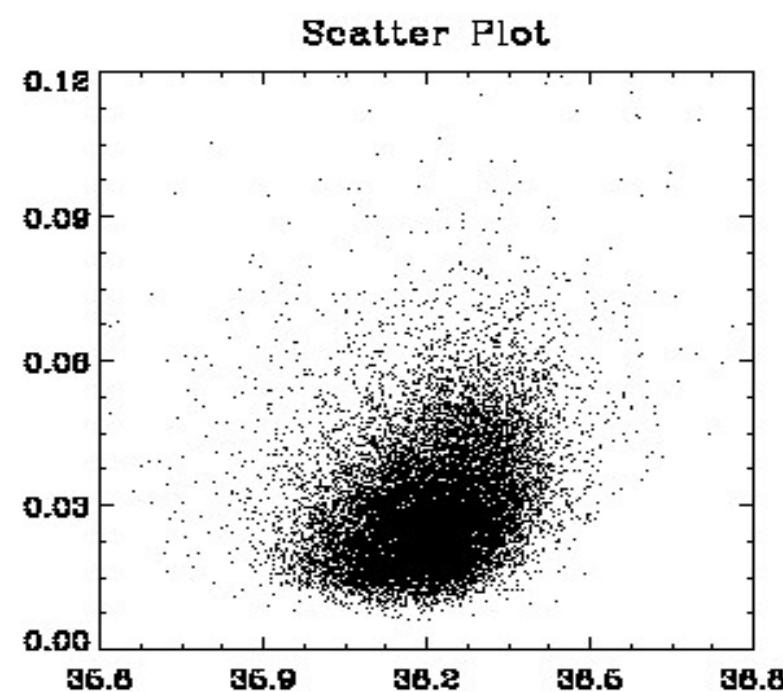
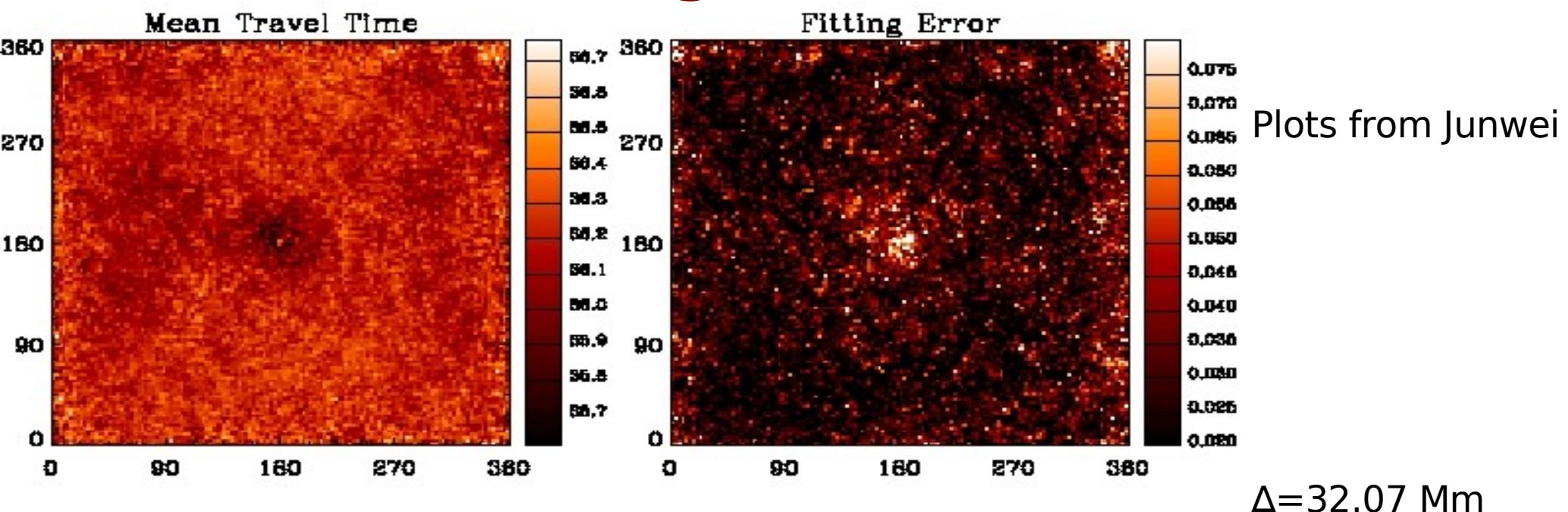
Fitting Errors



$\Delta=14.58 \text{ Mm}$



Fitting Errors (II)



Conclusion

- Travel-time measurement codes well developed (codes exist in fortran, but need to be included in DRMS)
- Main problem is in sunspots: we cannot use current Gizon & Birch definitions without correction
- Should we develop new definition that takes into account the change in cross-covariance amplitude in sunspots, or do a basic power correction?
- New definition would not be compatible with existing Born kernels
- Need to give error bars on the travel time estimates (?)