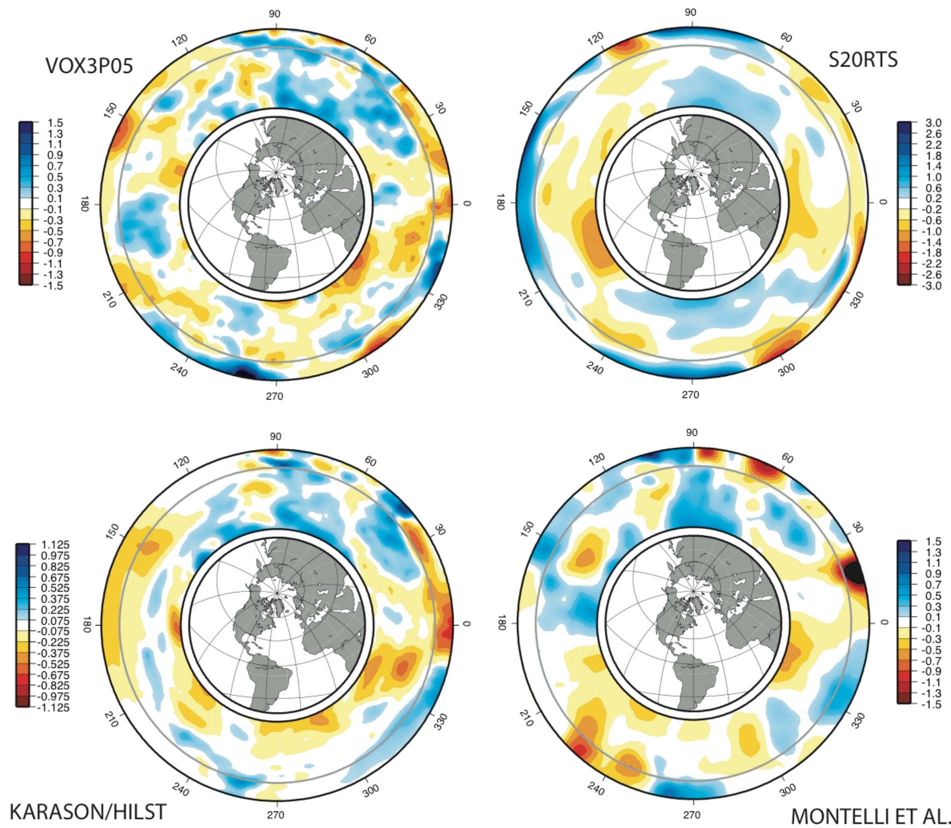
“Global seismic tomography: limitations and the future”

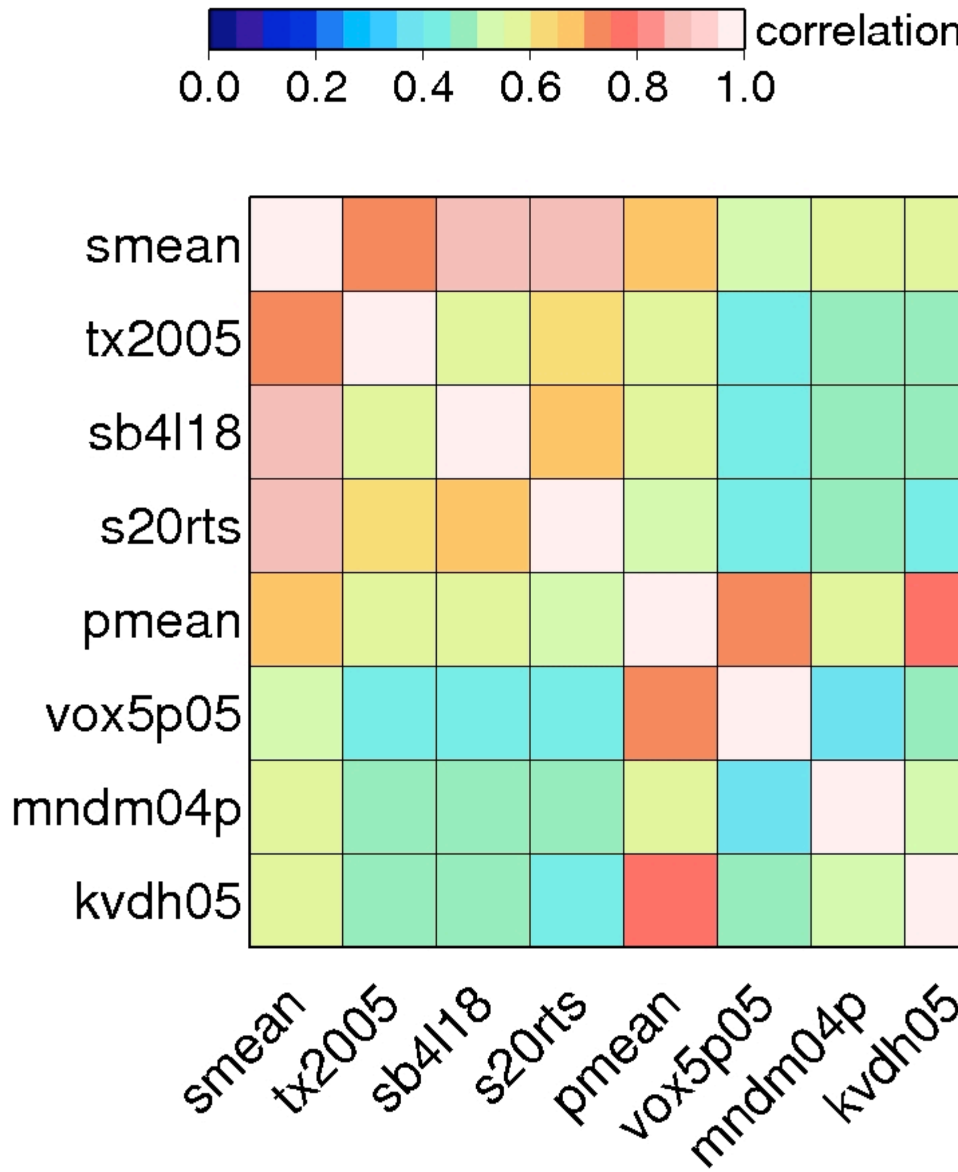


Lapo Boschi with: Mike Antolik, Thorsten Becker, Adam Dziewonski, Göran Ekström, Bill Fry, Domenico Giardini, Daniel Peter, Gaia Soldati, Carl Tape, John Woodhouse

Long-wavelength agreement (up to l=8)

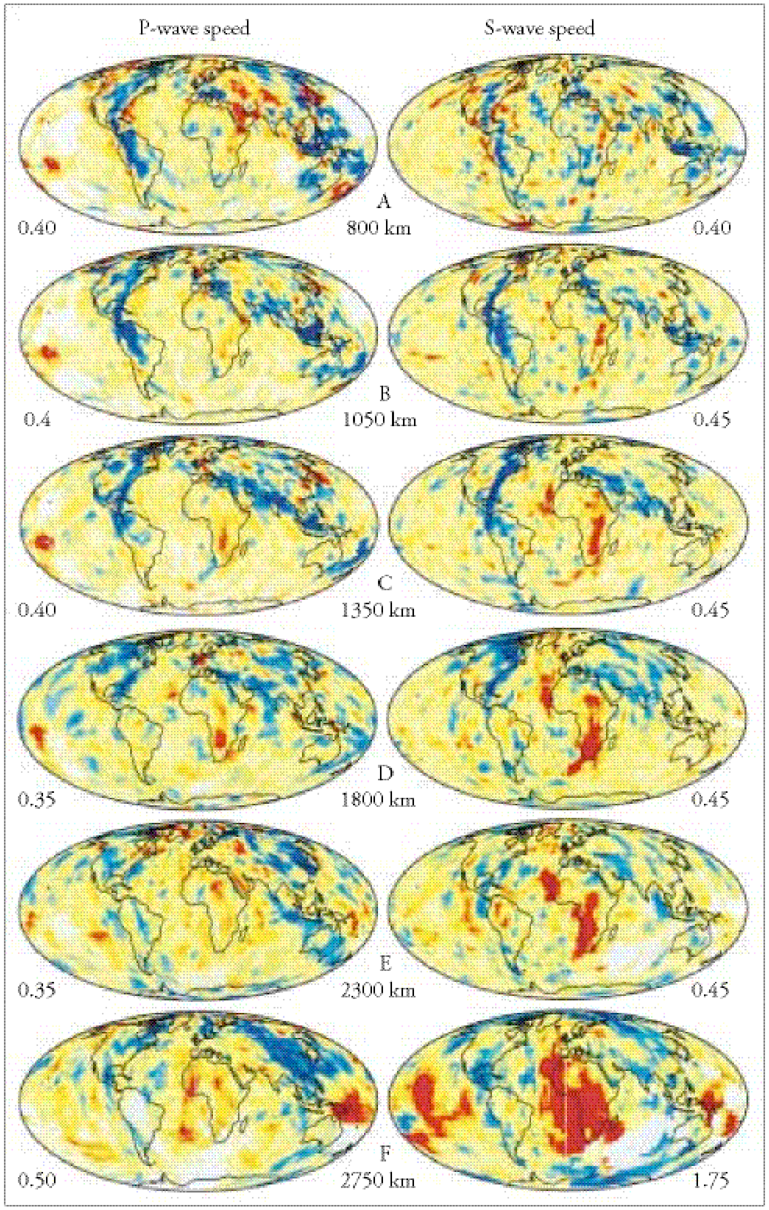
From T. Becker

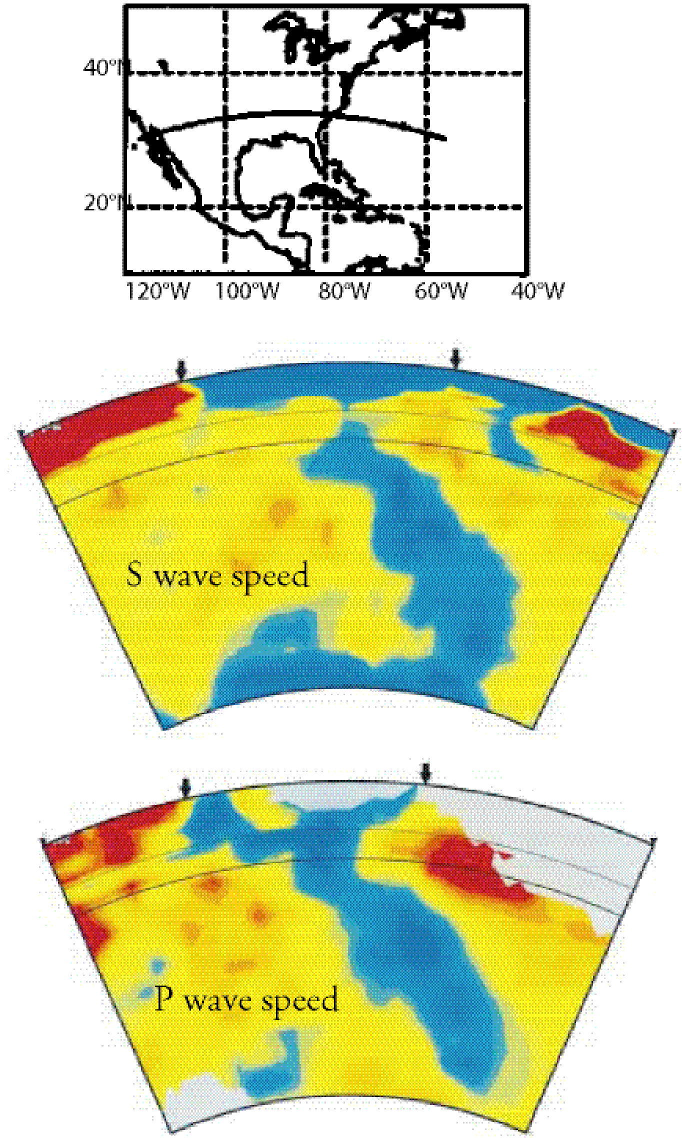
Long-wavelength agreement (up to l=20)



From T. Becker

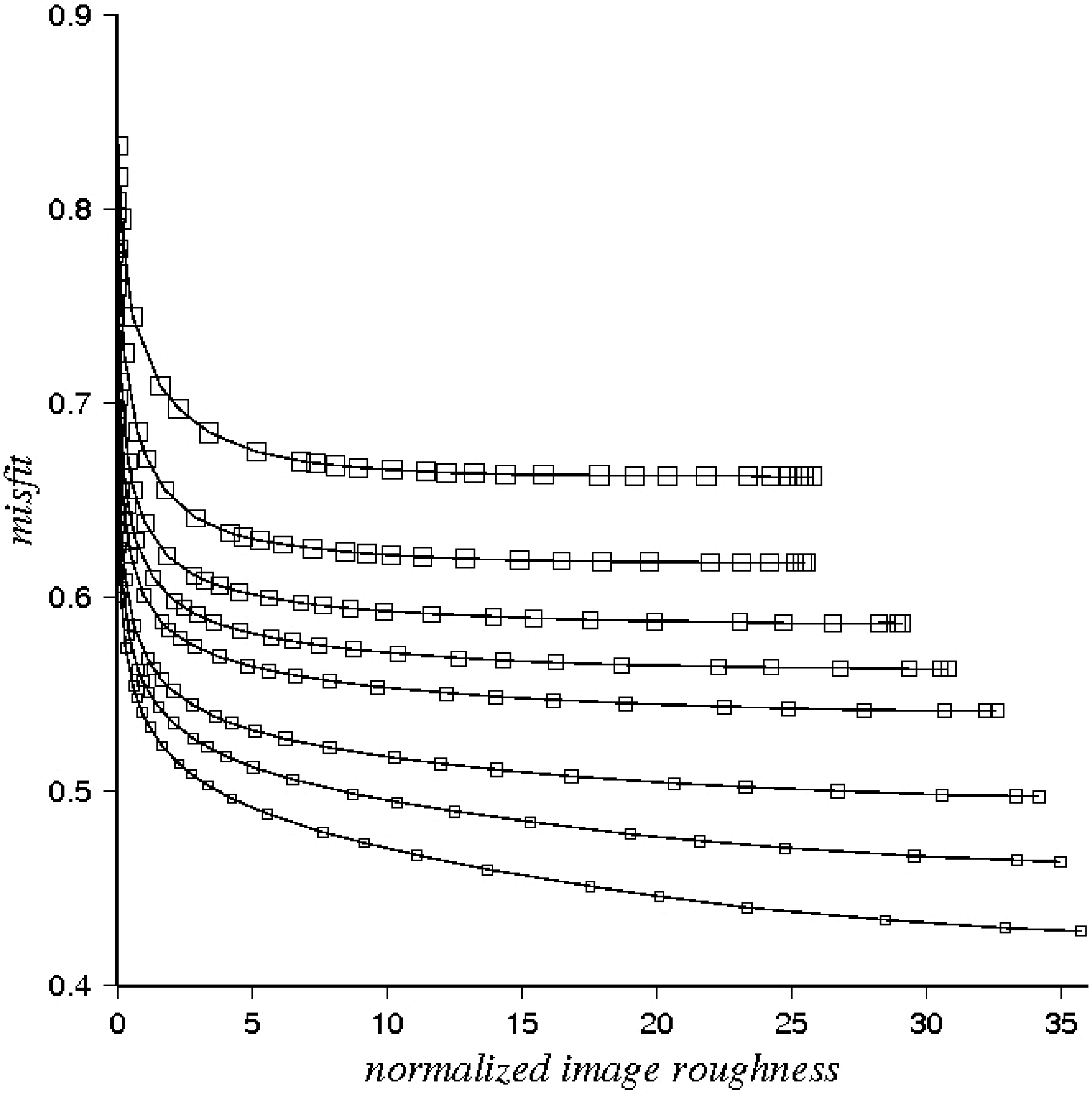
High resolution tomography? Refining parameterization and data coverage





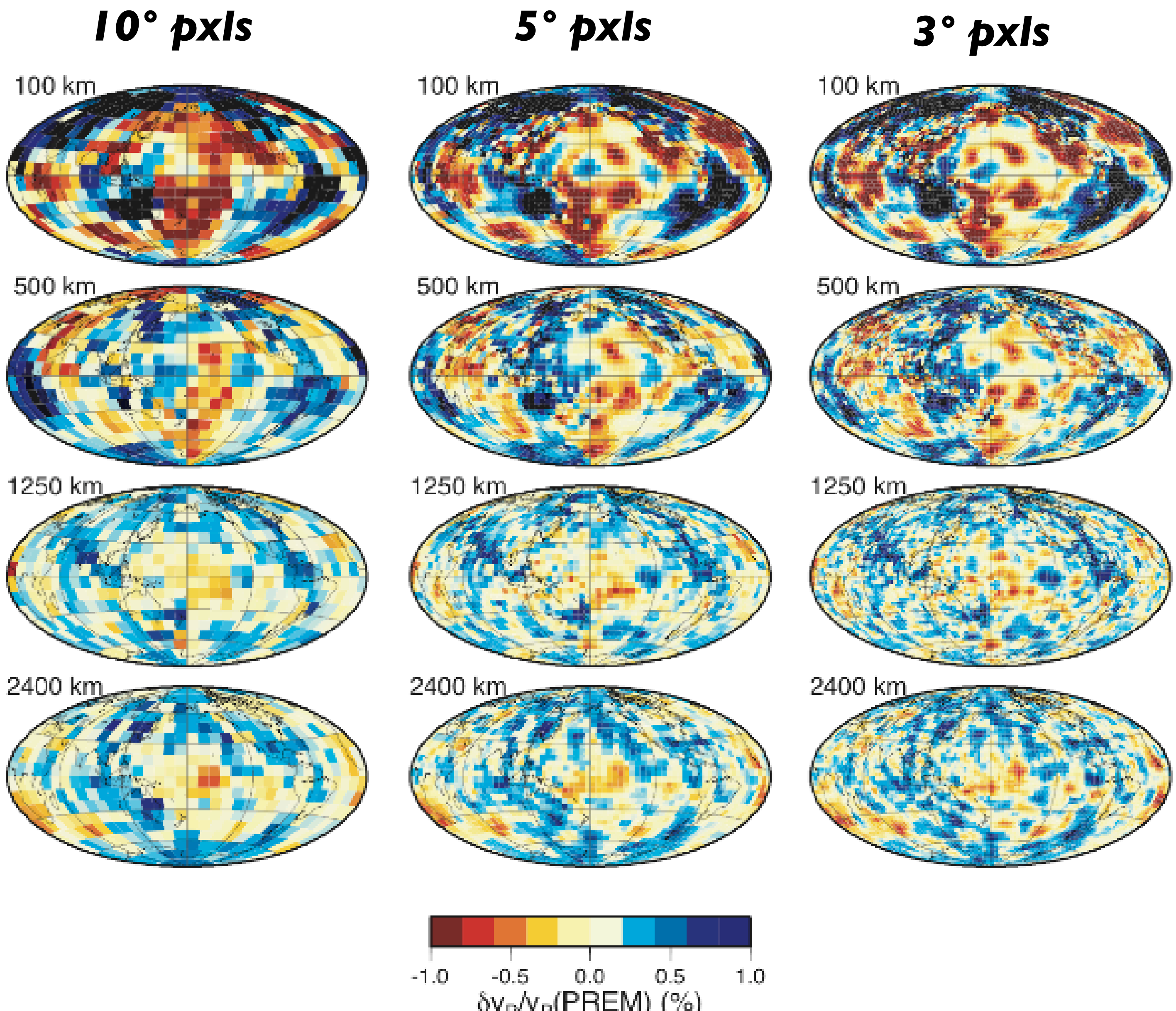
From Grand & van der Hilst, 1997

L-curve analysis, P wave inversions on different grid sizes



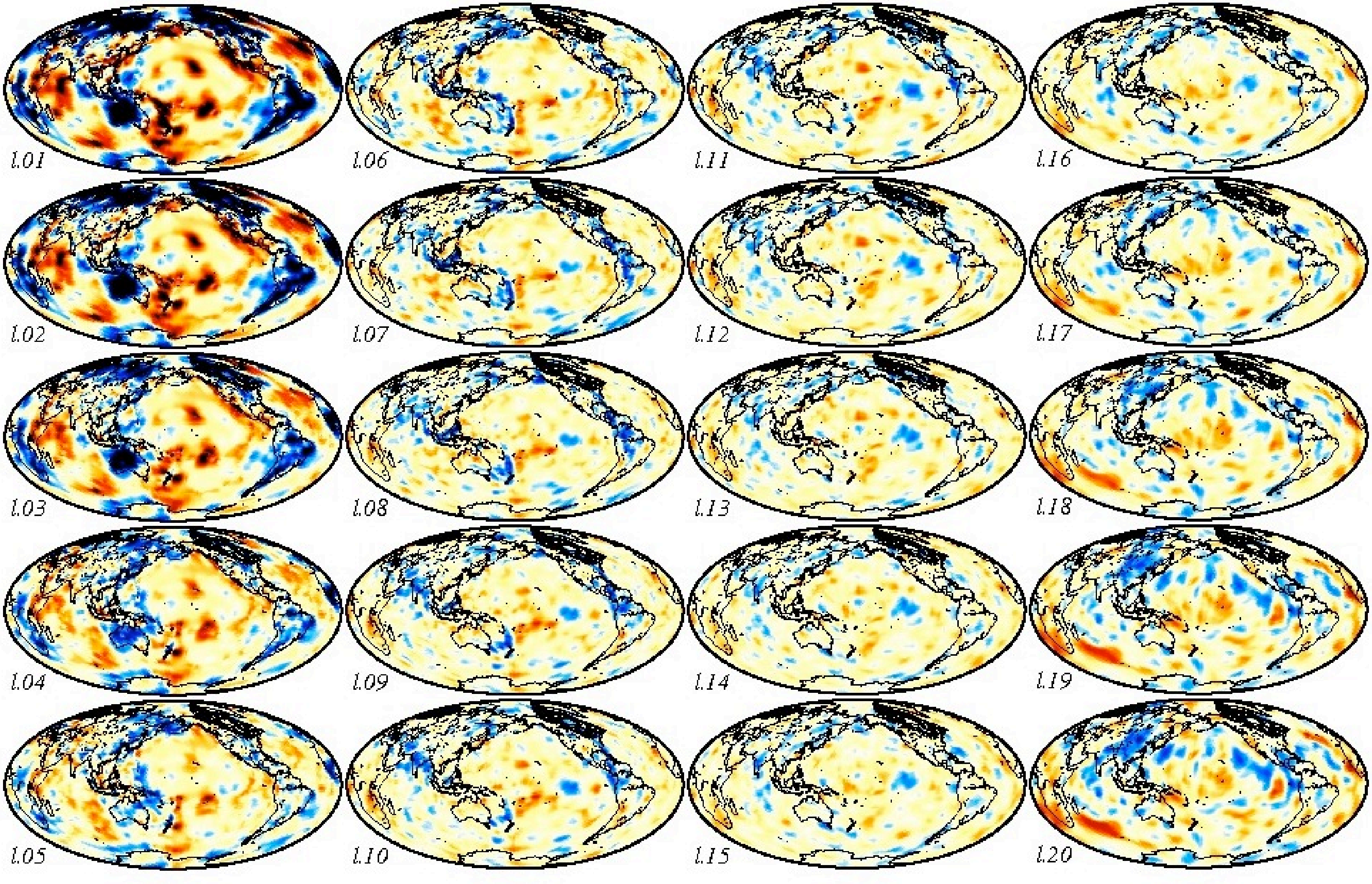
From G. Soldati

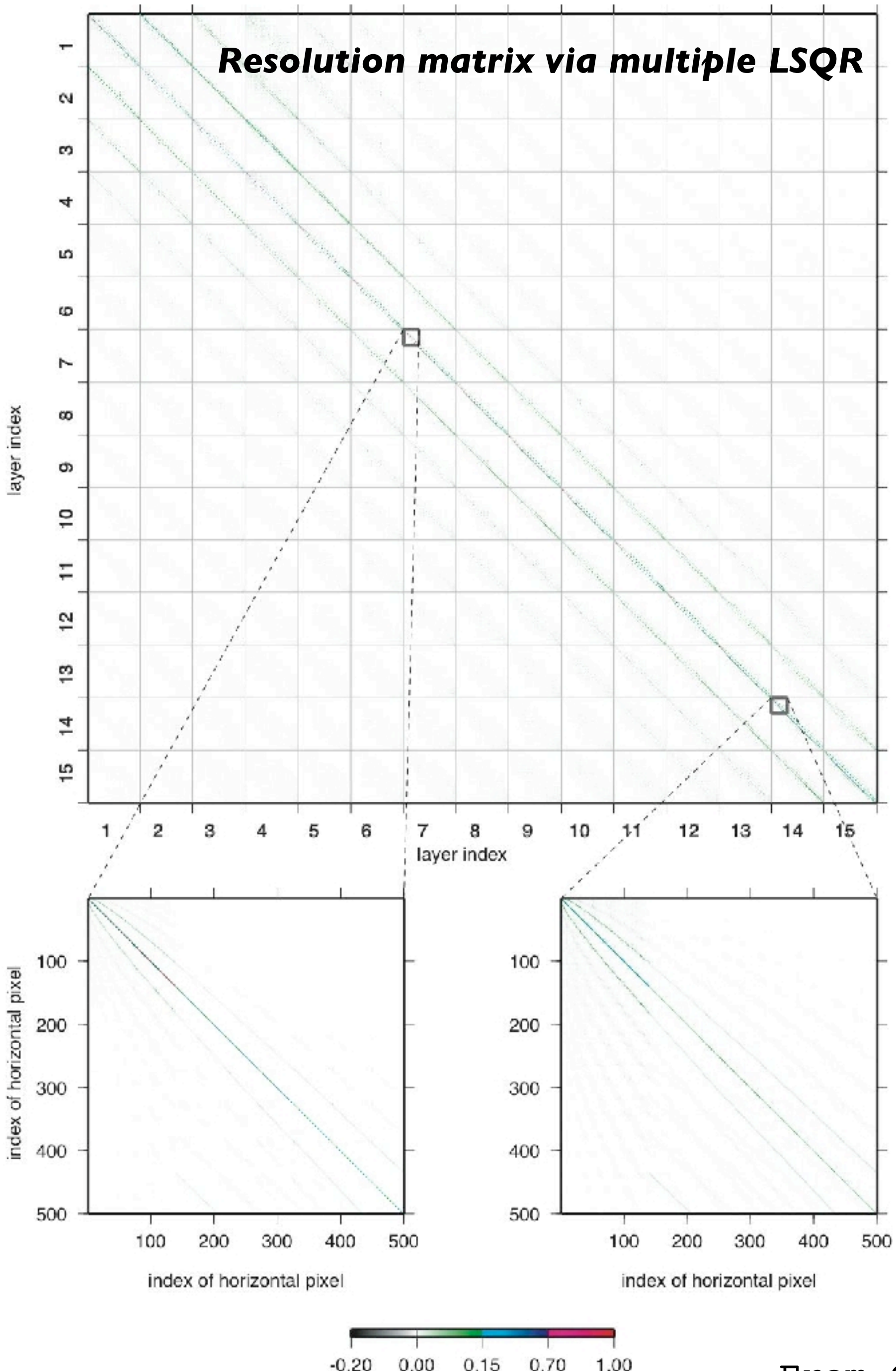
New P models by Soldati and Boschi, ISC data, corrections by Antolik.



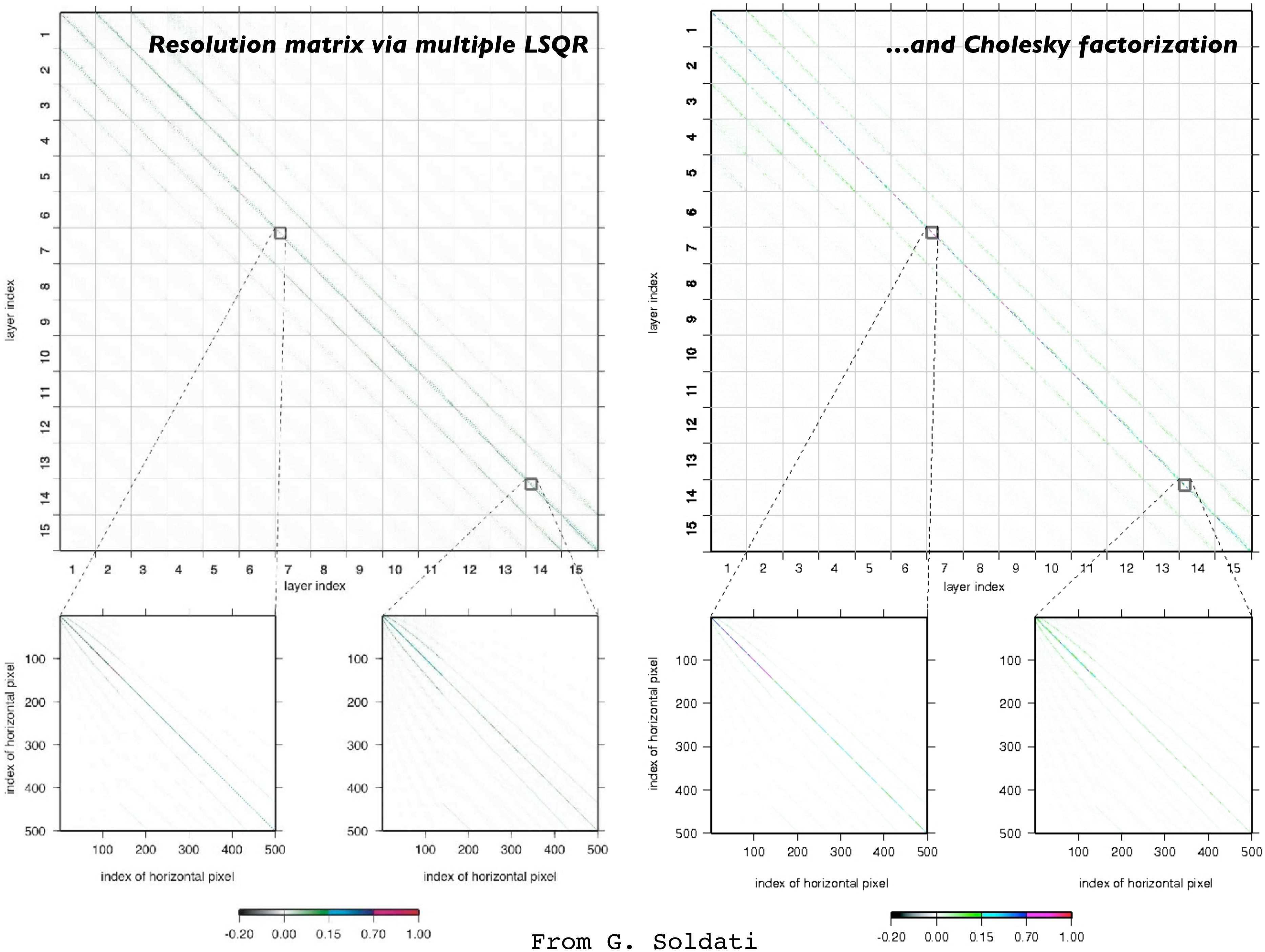
From G. Soldati

P-velocity from ISC, 1.5° nominal resolution



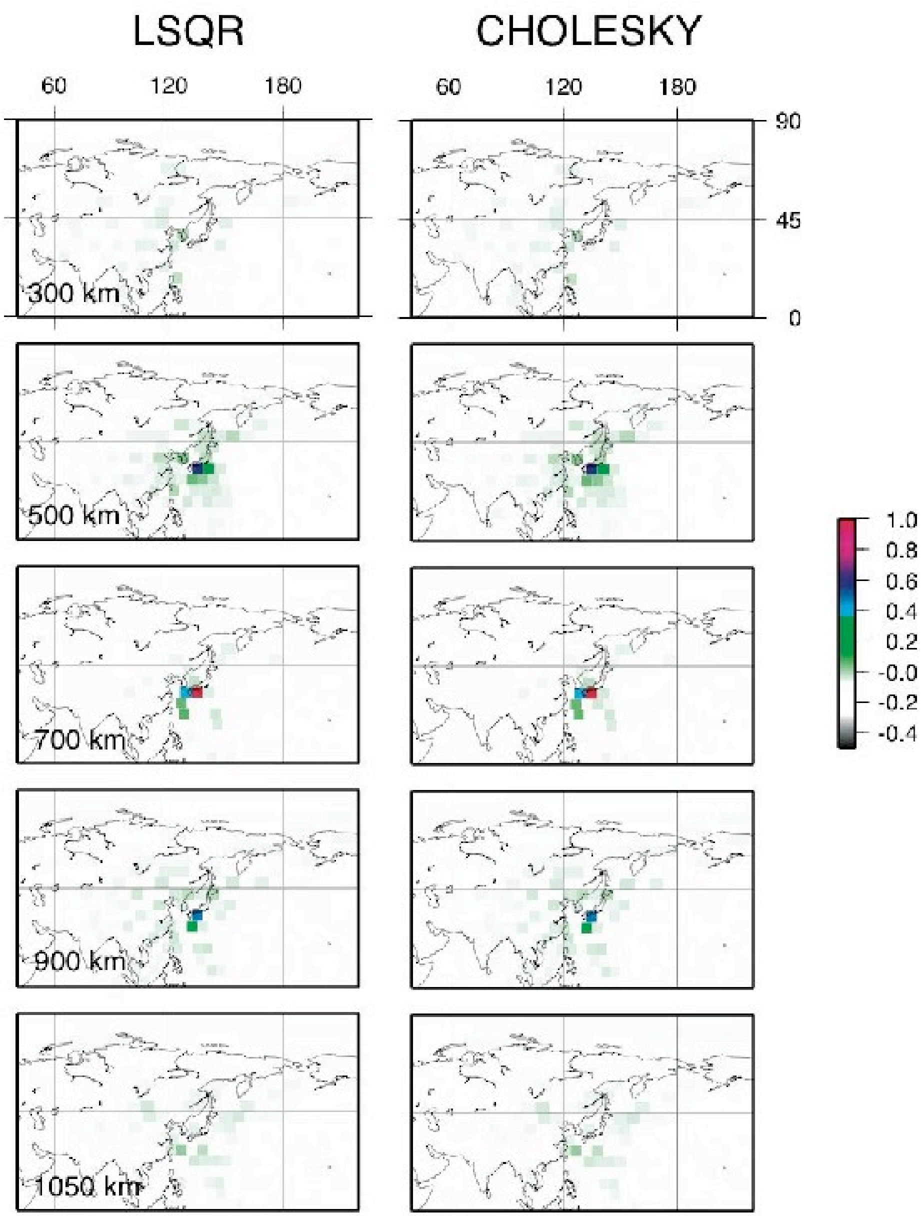


From G. Soldati



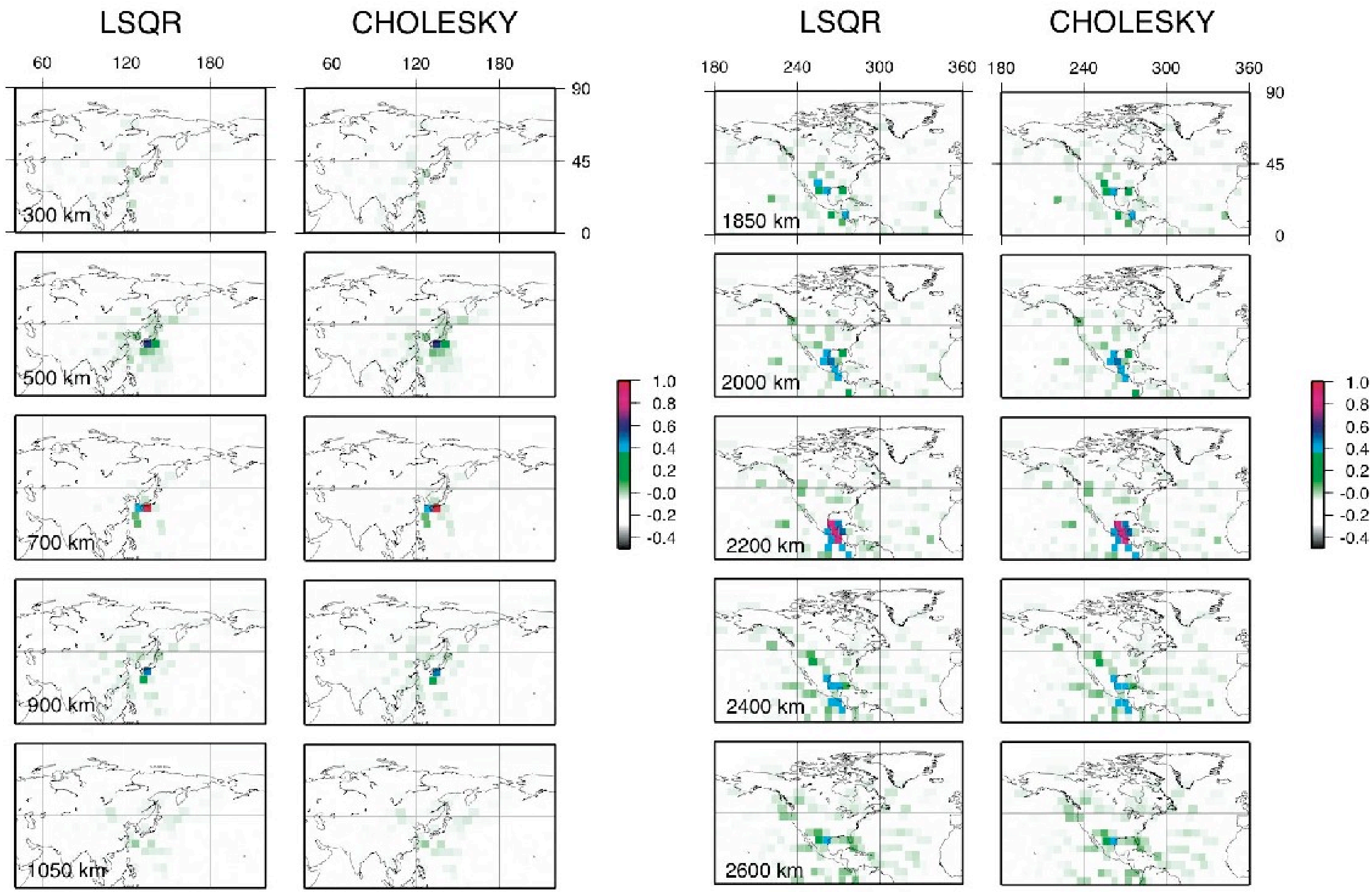
From G. Soldati

Looking at one row of the resolution matrix at a time…



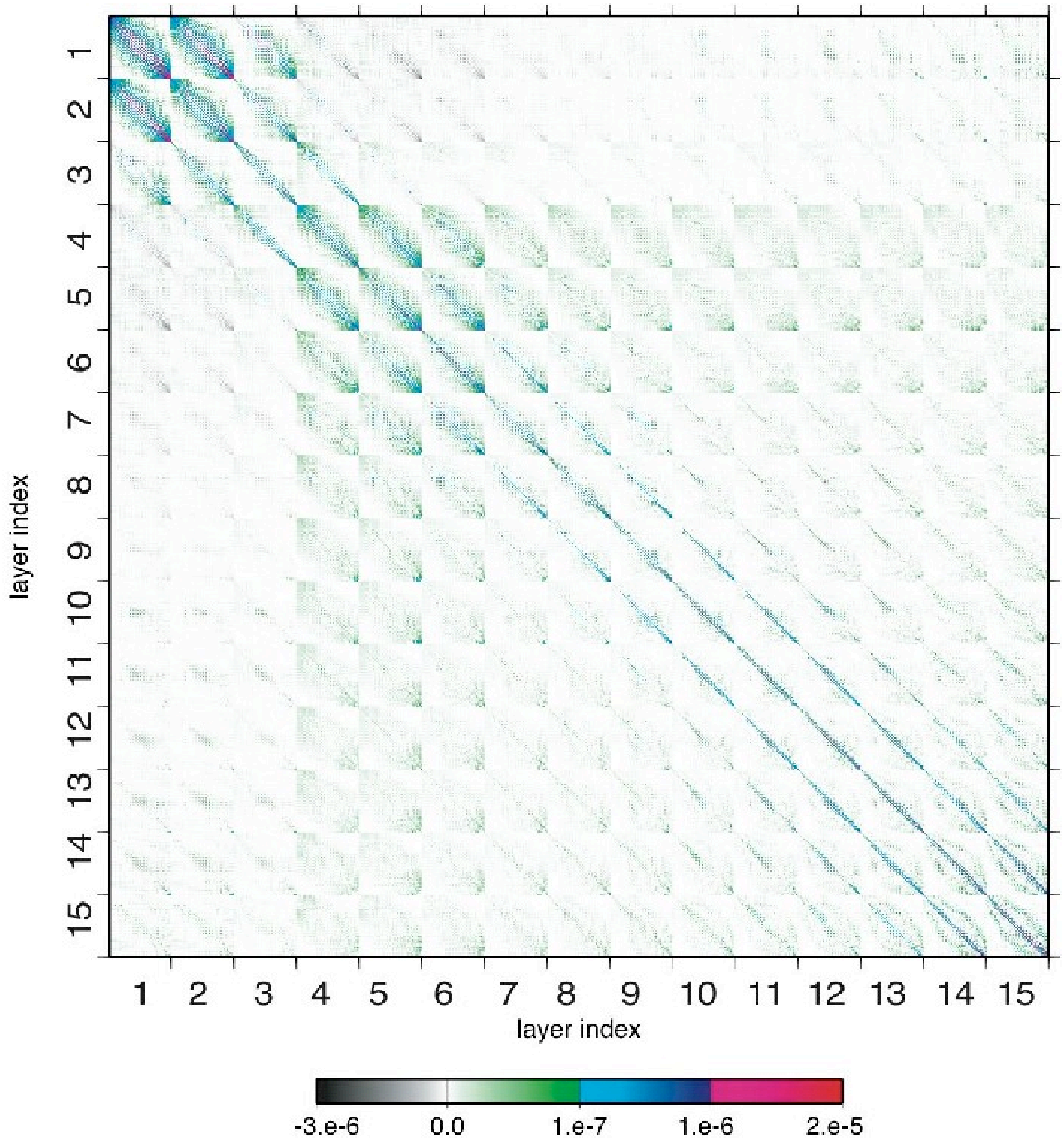
From G. Soldati

Looking at one row of the resolution matrix at a time...

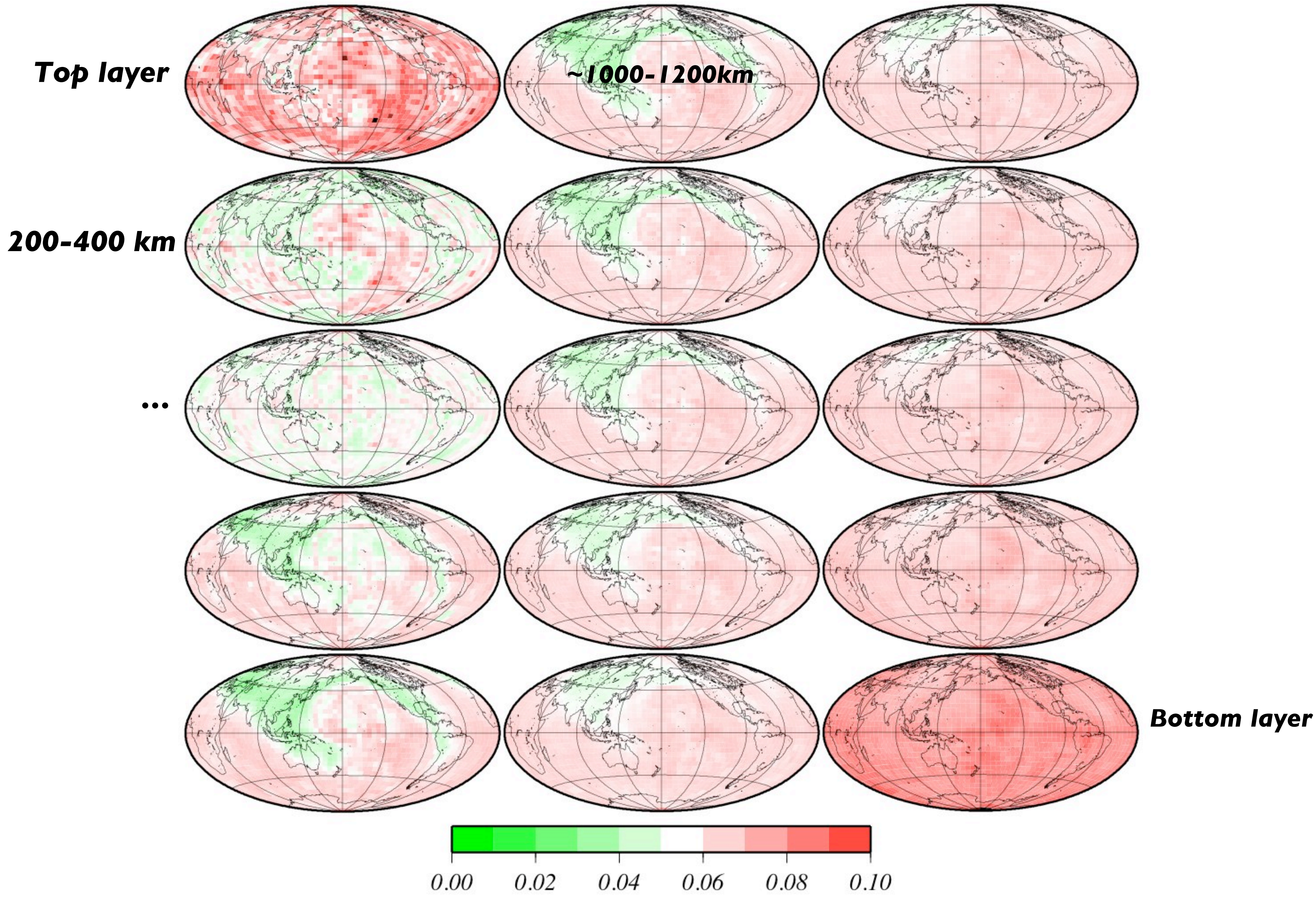


From G. Soldati

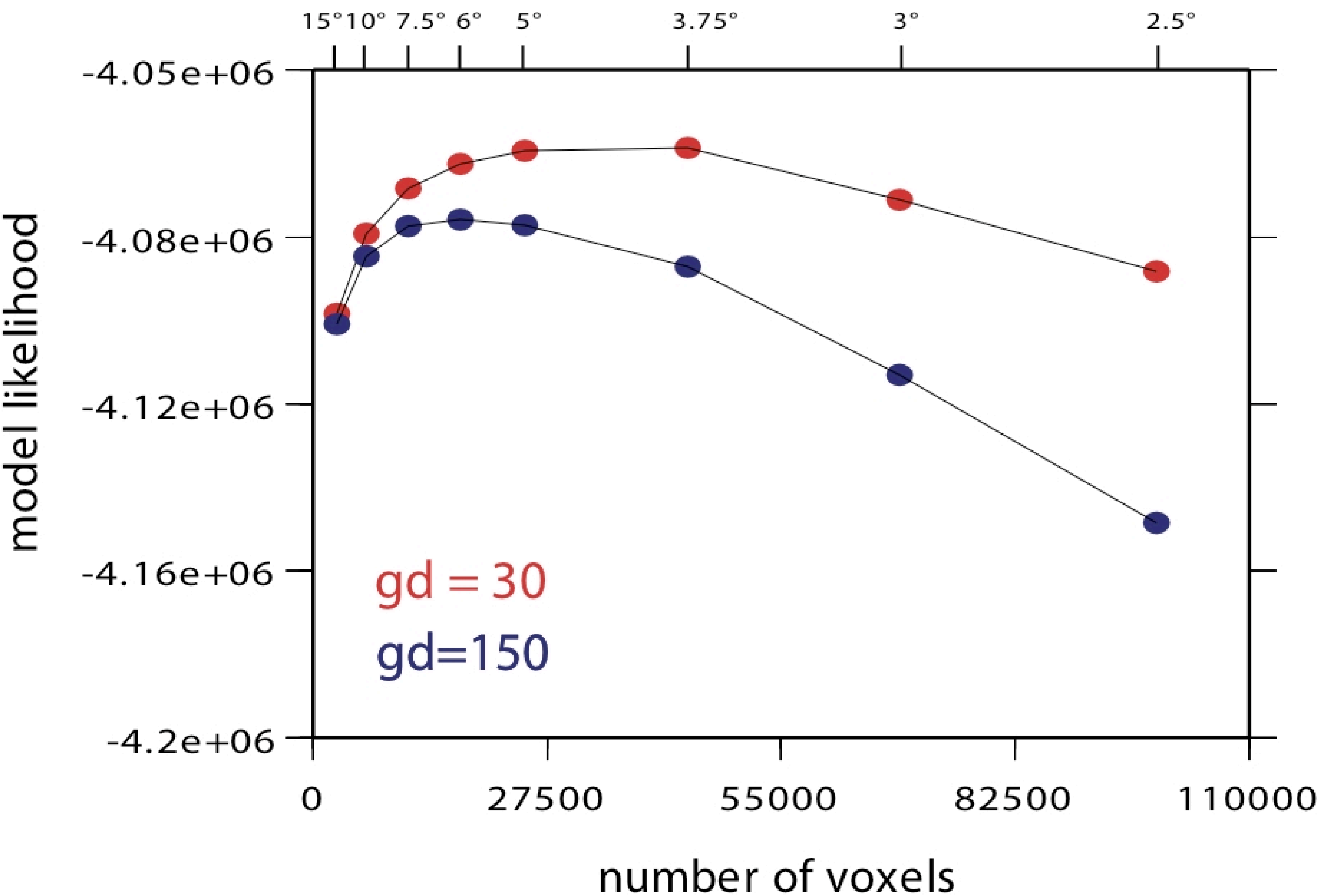
Covariance matrix



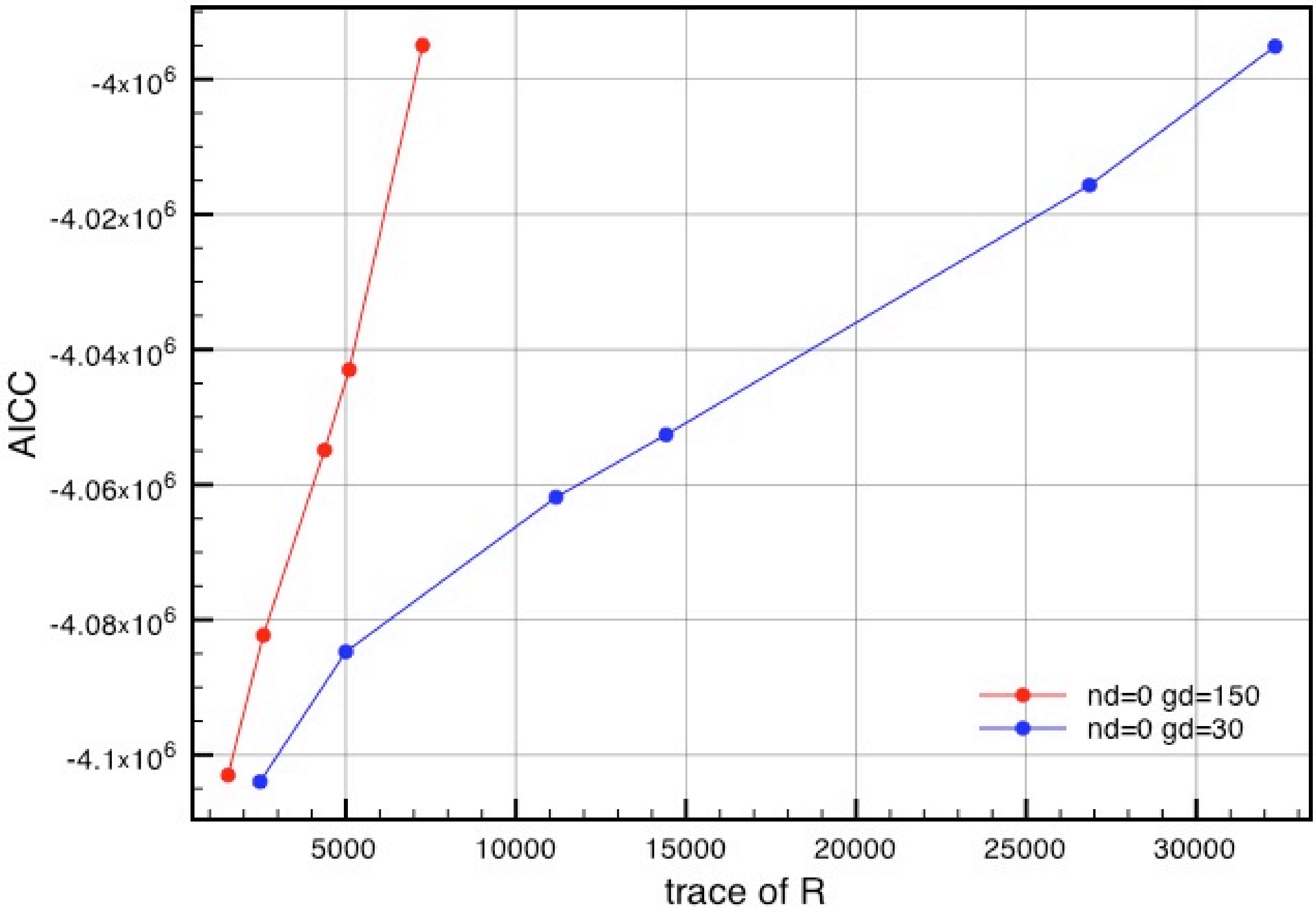
Estimate of absolute error on percent δv_P from covariance matrix



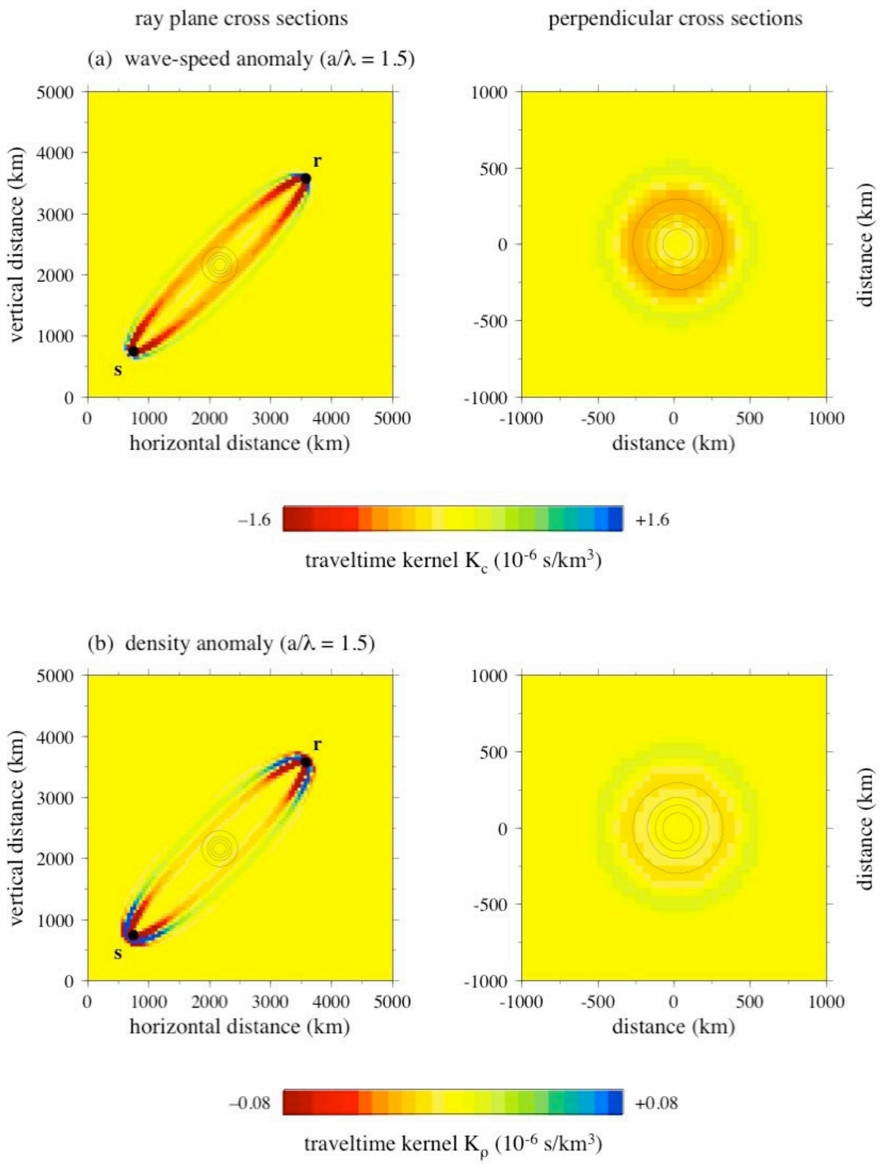
Corrected Akaike information-content criterion for model selection

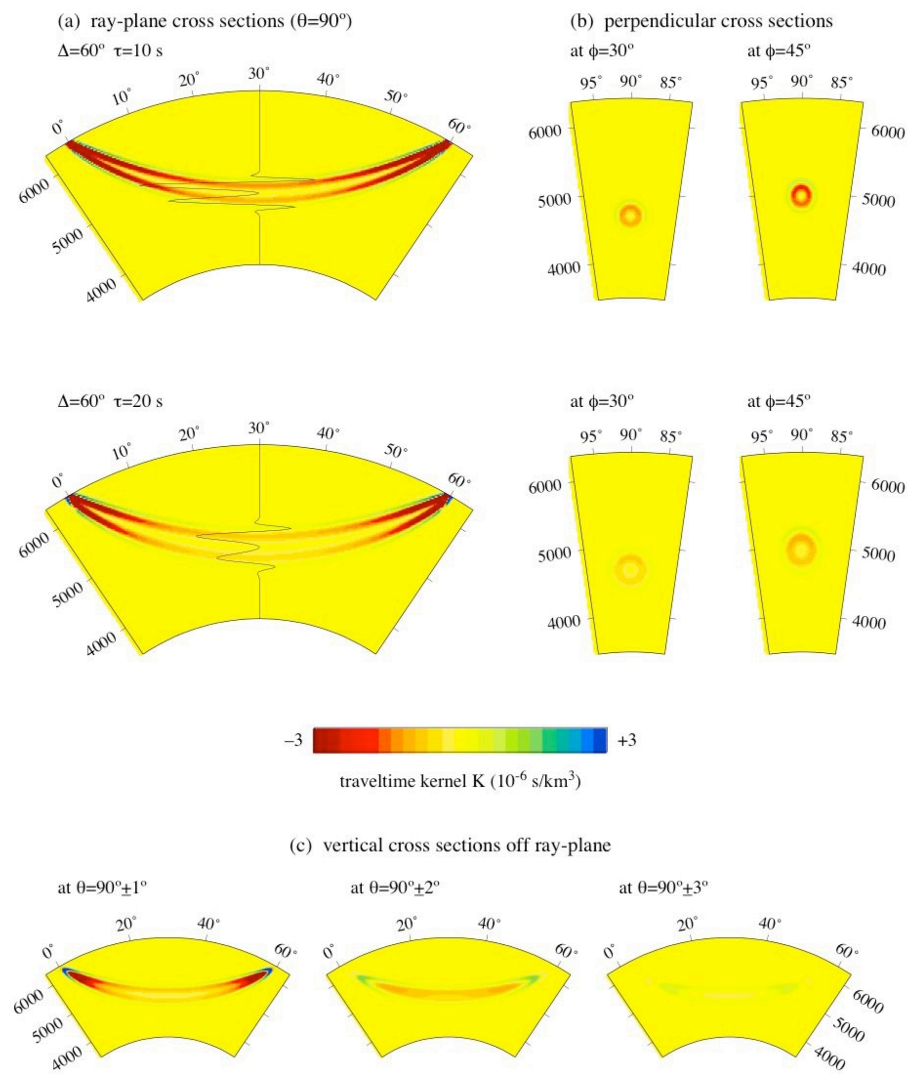


AICC using trace of res. matrix as estimate of number of degrees of freedom



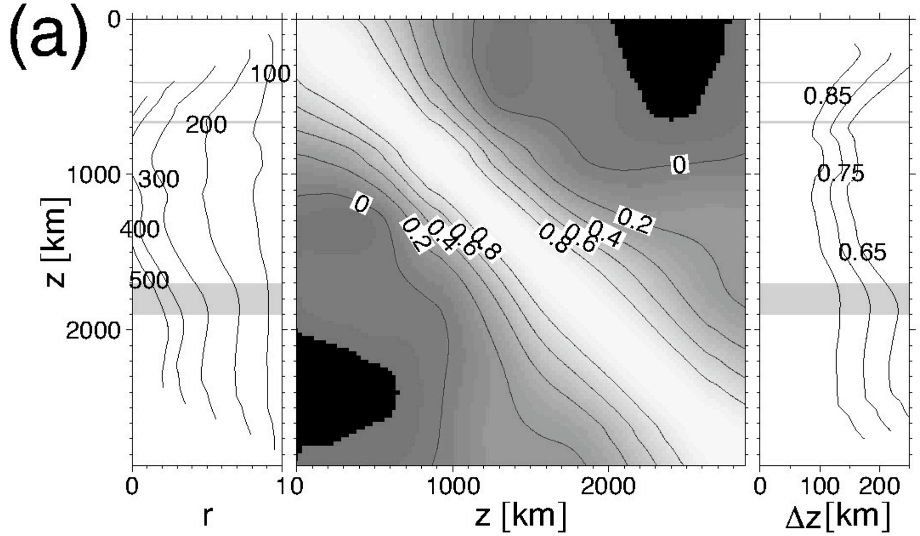
High resolution tomography? More accurate theory



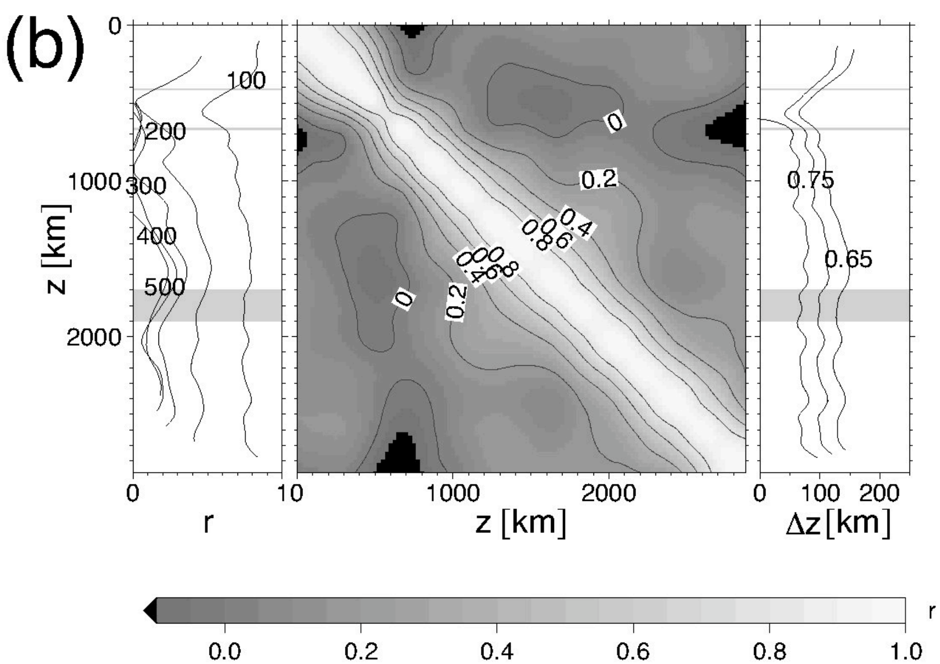


From Dahlen and others (2000)

Why finite-frequency tomography is questioned, I



Radial coherence: Princeton Born-theory P model



Radial coherence: ETH-INGV ray-theory P model

From T. Becker

Why finite-frequency tomography is questioned, 2

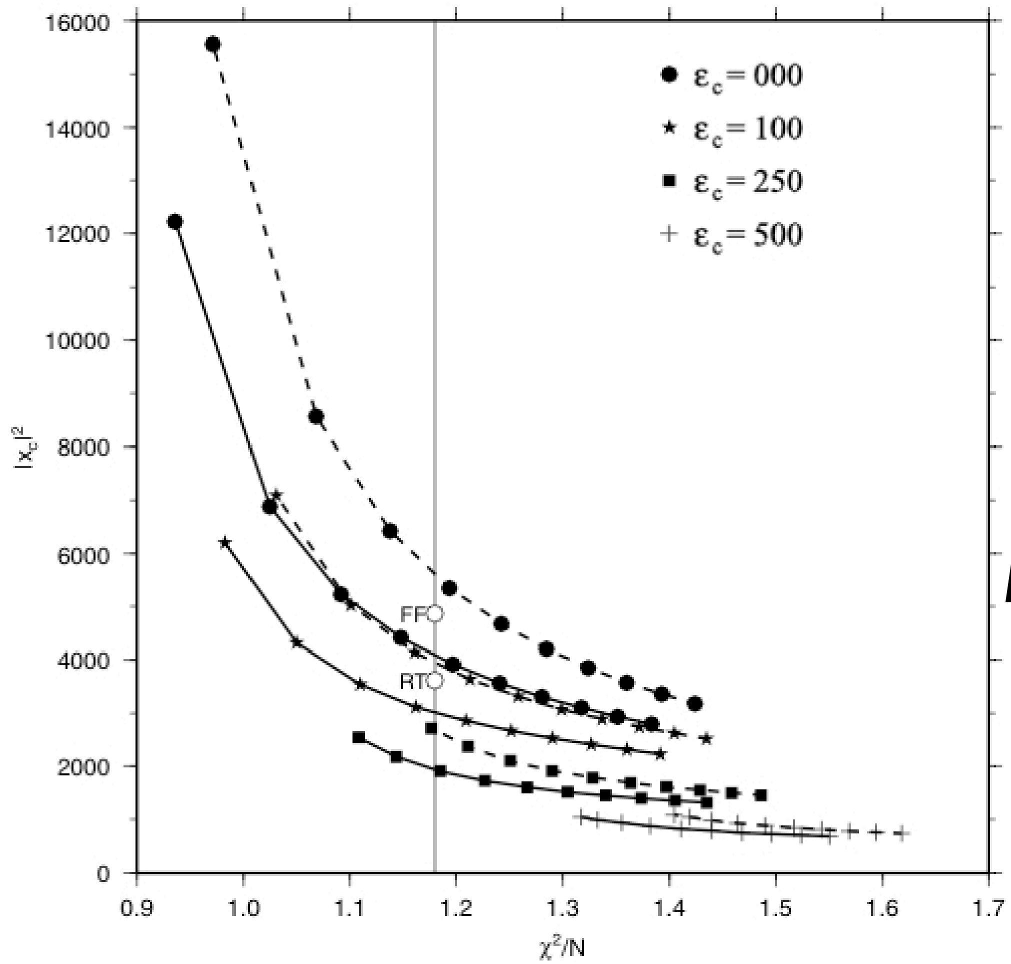
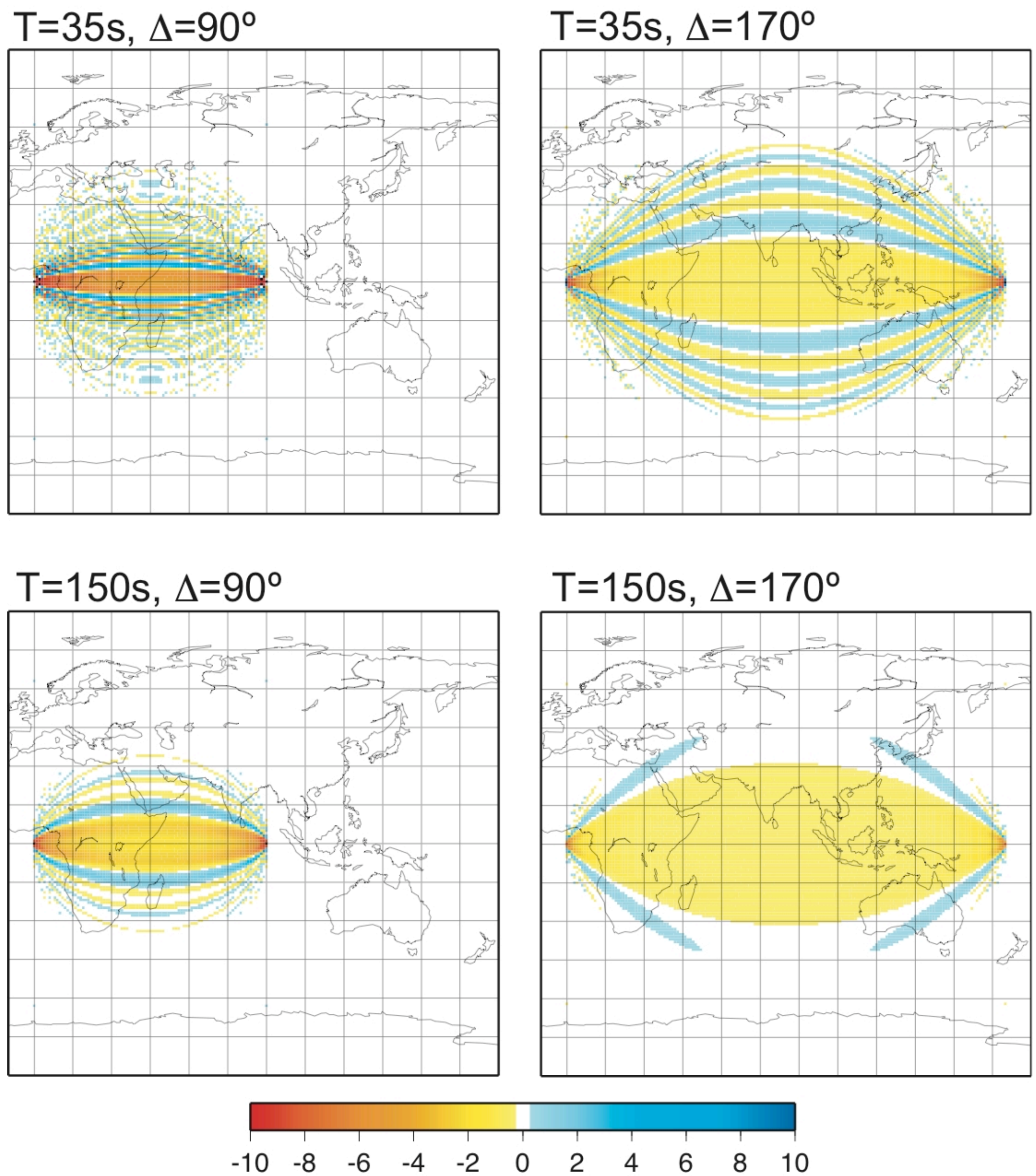


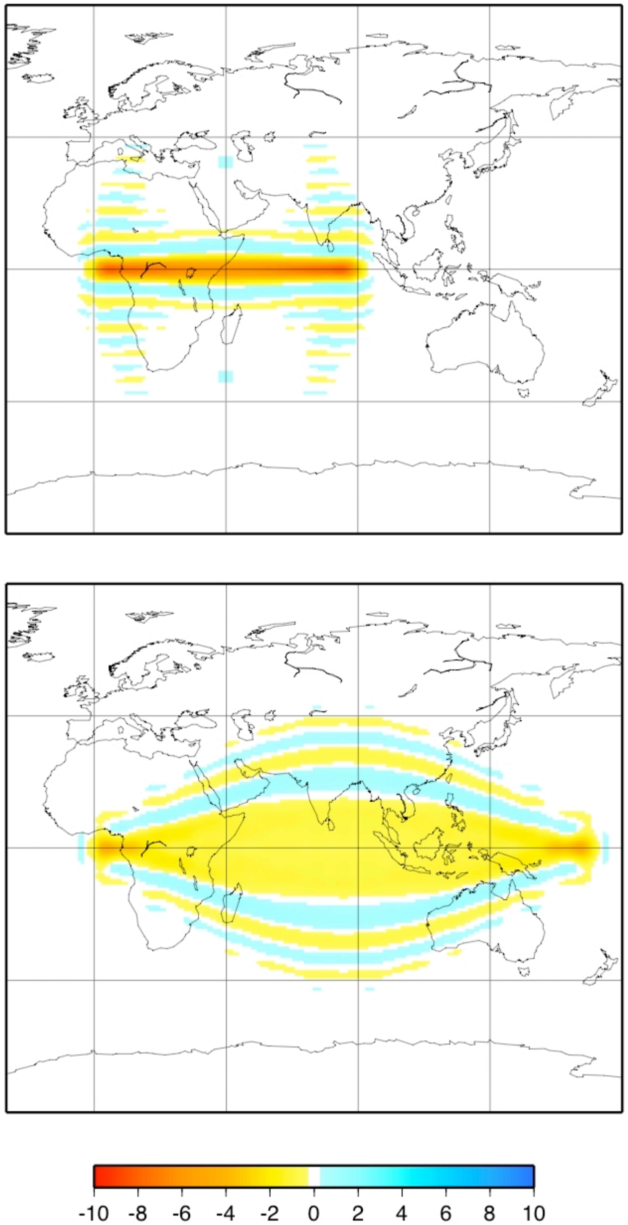
Figure 7. Model norm versus χ^2/N for a combination of values of norm damping ϵ_c and smoothing ϵ_s. Solutions for ray-theory (solid line) and finite-frequency (dotted line) tomographies are compared. Symbols—listed in the legend—correspond to different norm damping parameters. Smoothing increases from upper right to lower left along the curves. The two white dots indicate the FF and RT solutions, respectively, which are discussed in the text and in Figs 9–11.

From Montelli et al.GJI 2004

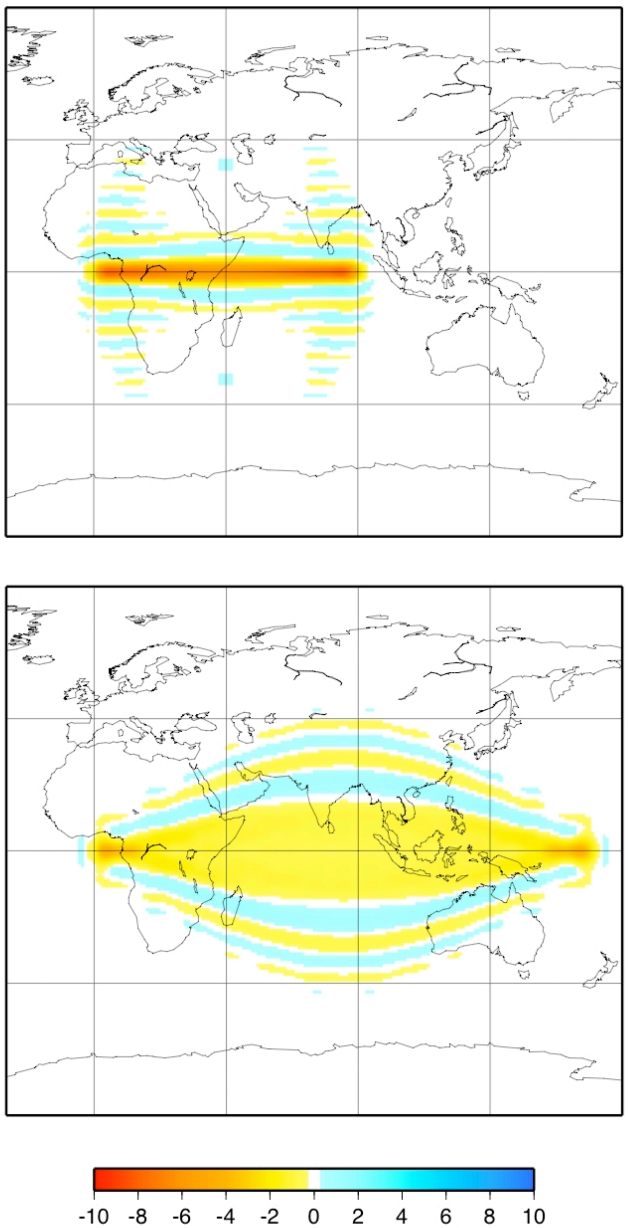
Smaller, 2-d problem: surface wave phase velocity maps from ray- and Born-theory inversions. Dispersion database by Ekström and others.



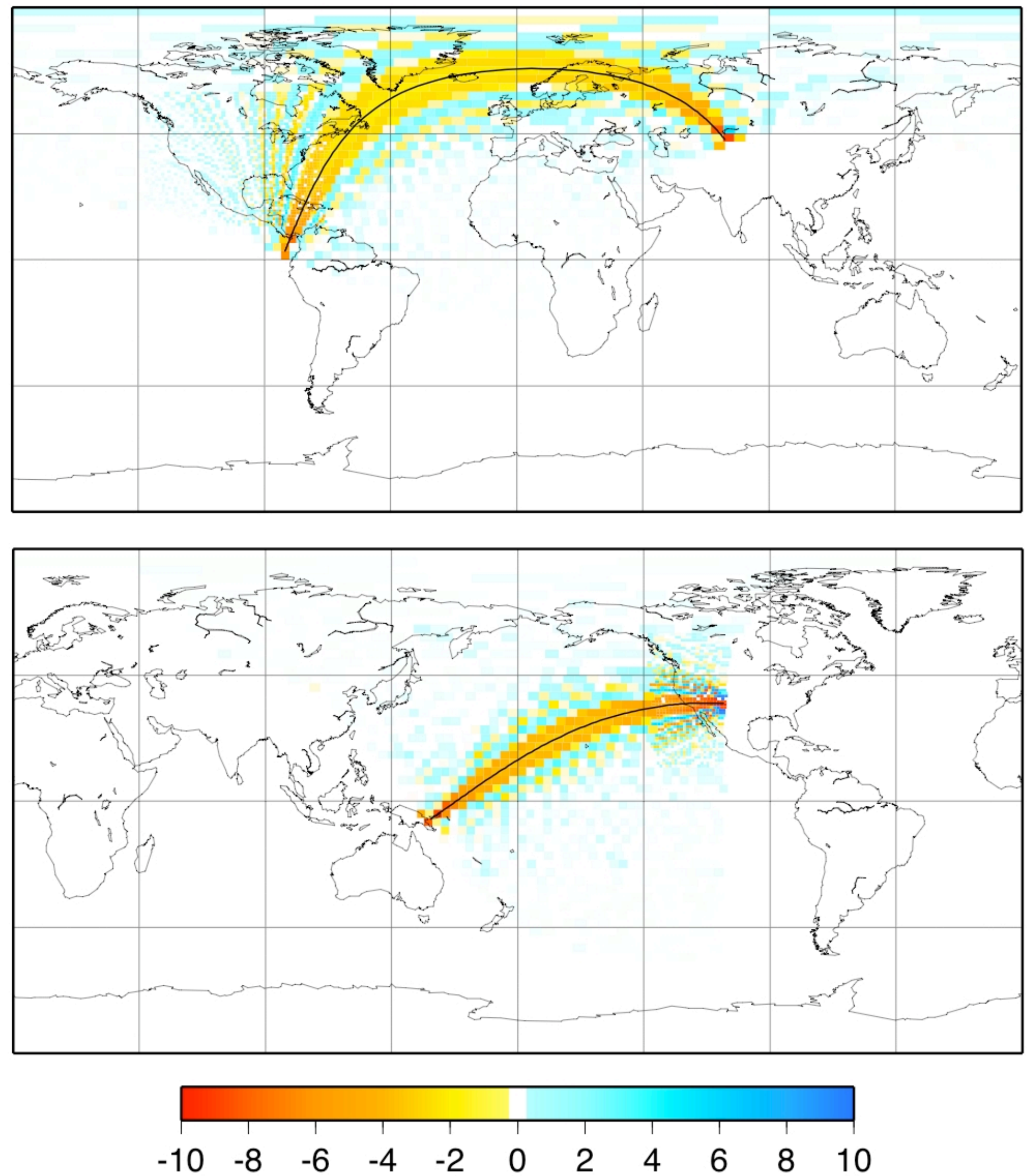
harmonics up to L=40



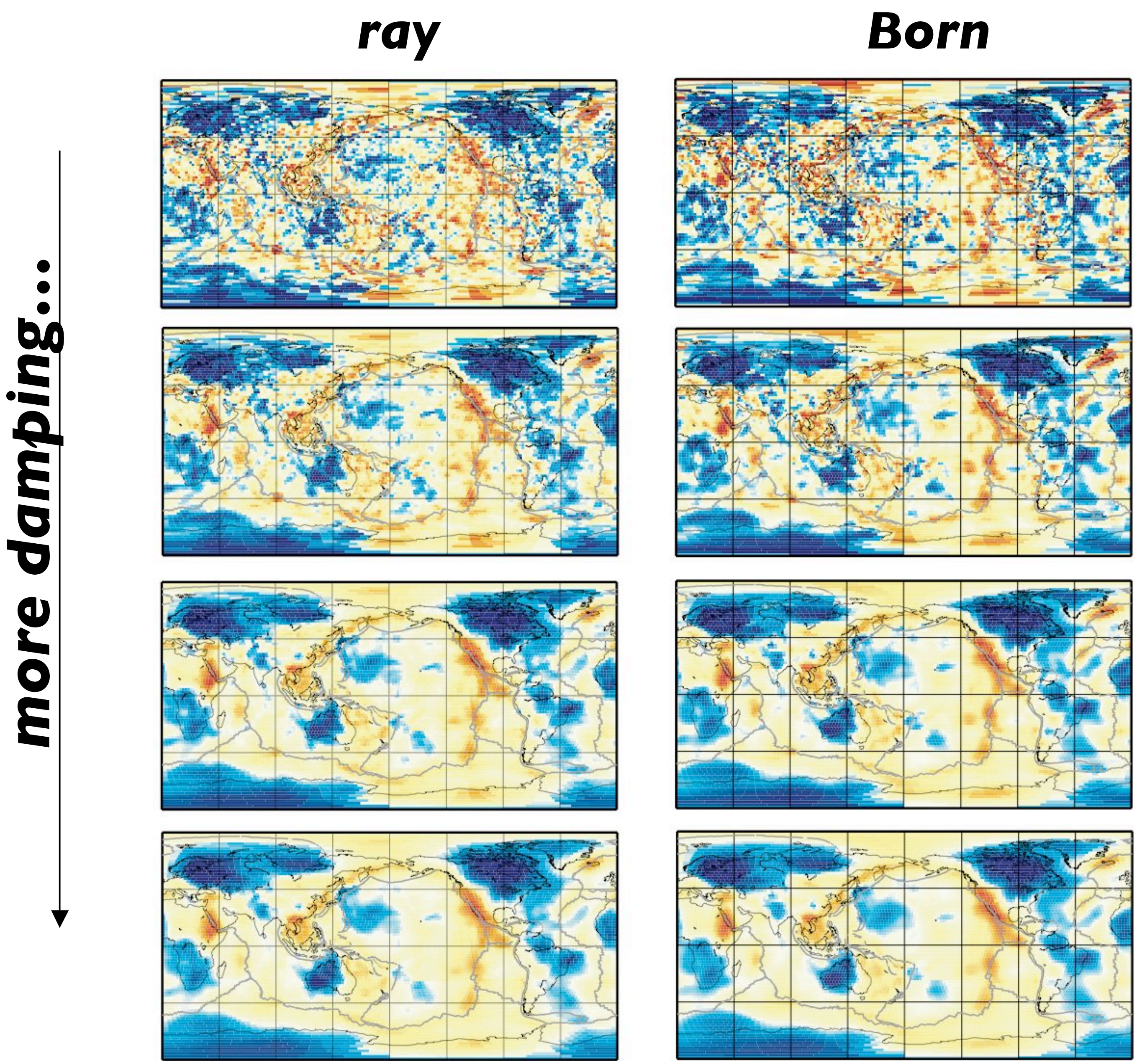
harmonics up to L=40



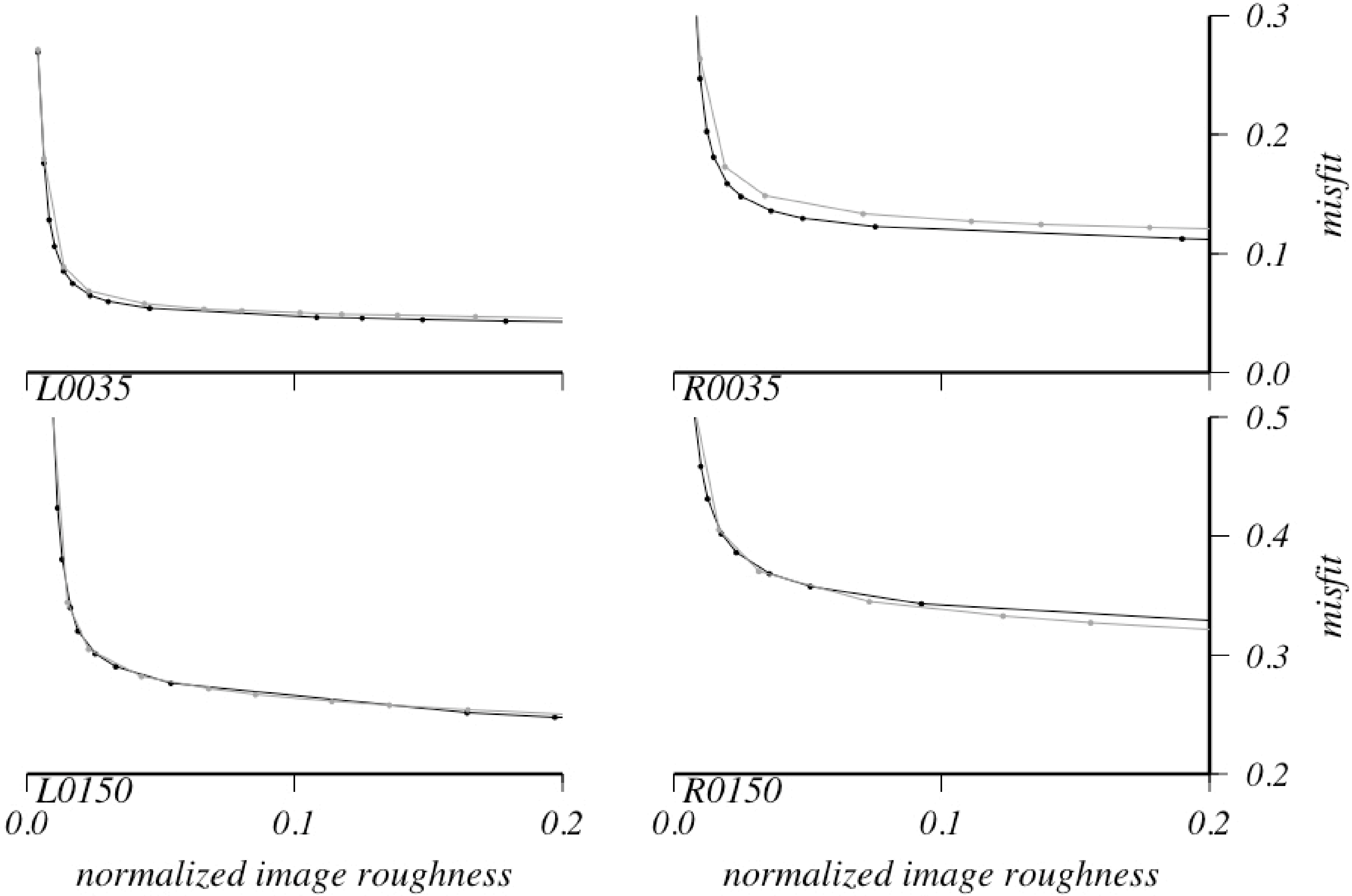
pixels, multiple resolution



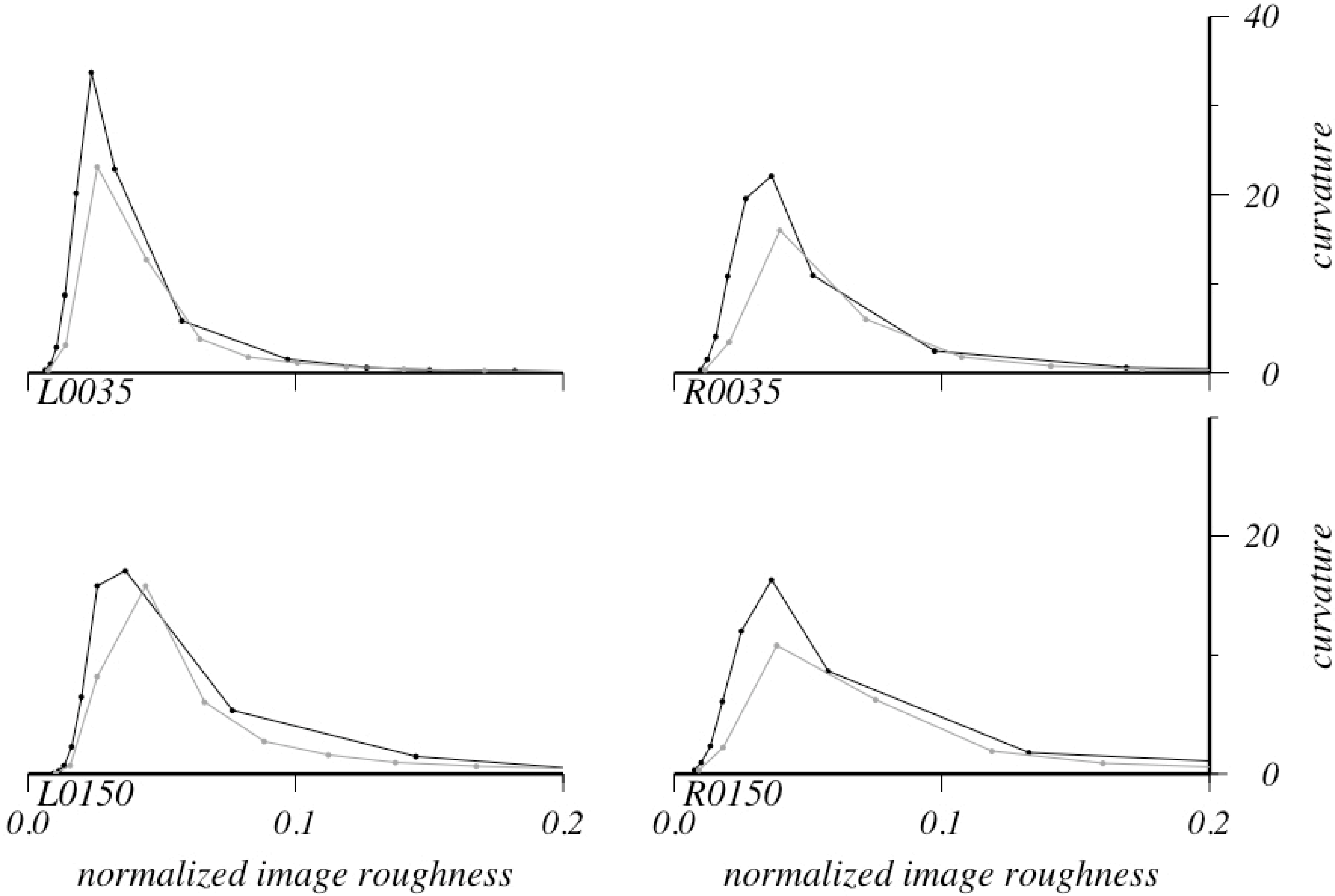
All acceptable solutions:



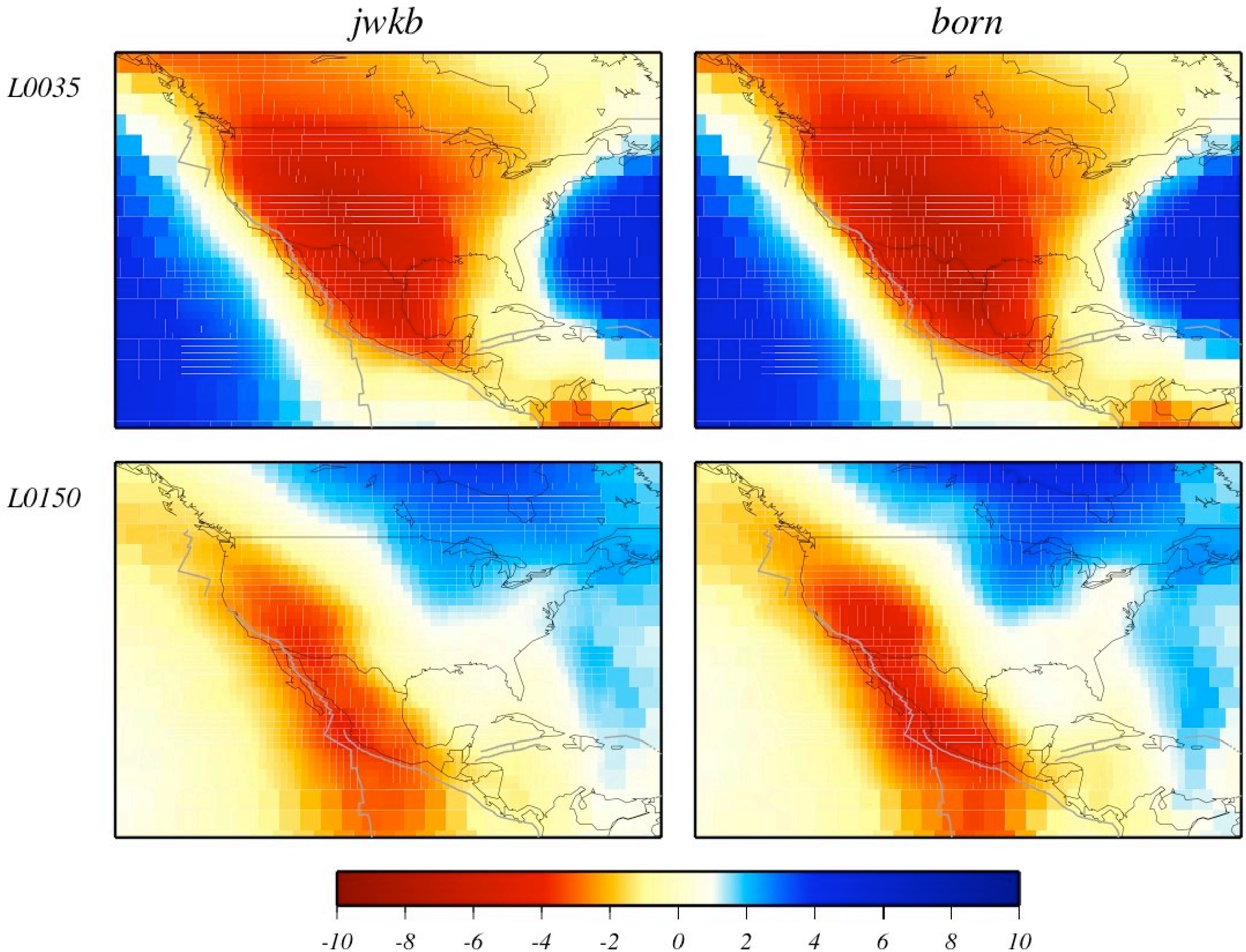
L-curve analysis



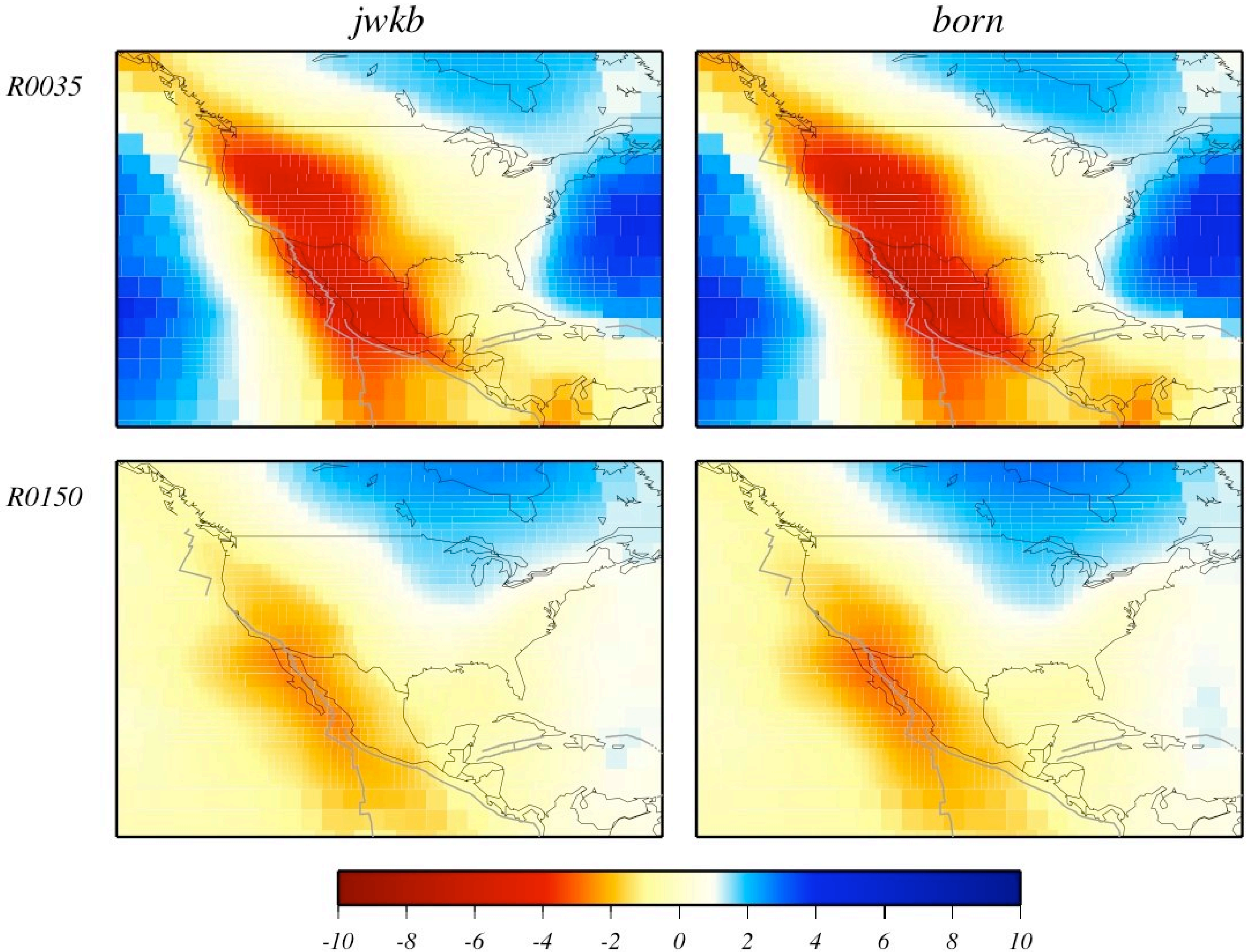
L-curve analysis--curvature



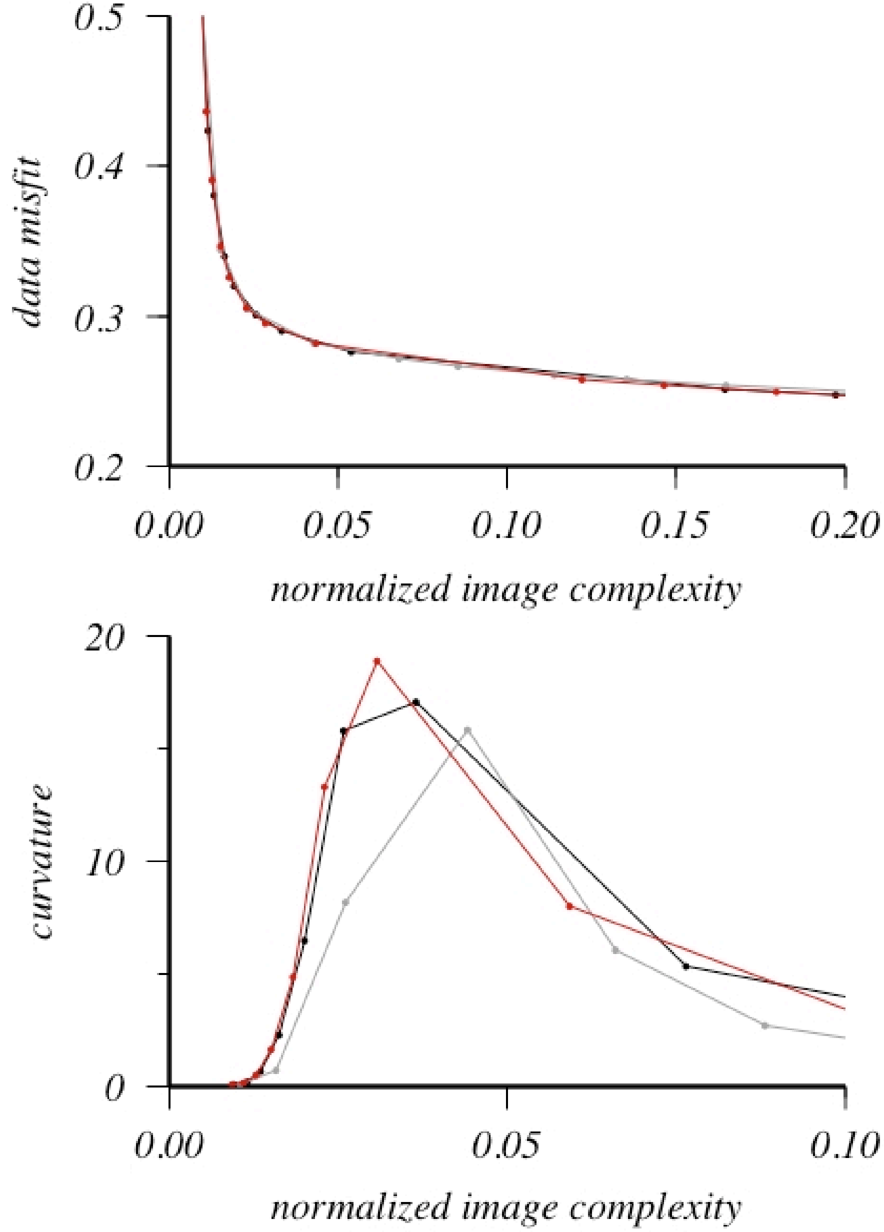
Love wave phase velocity, corner of L-curve

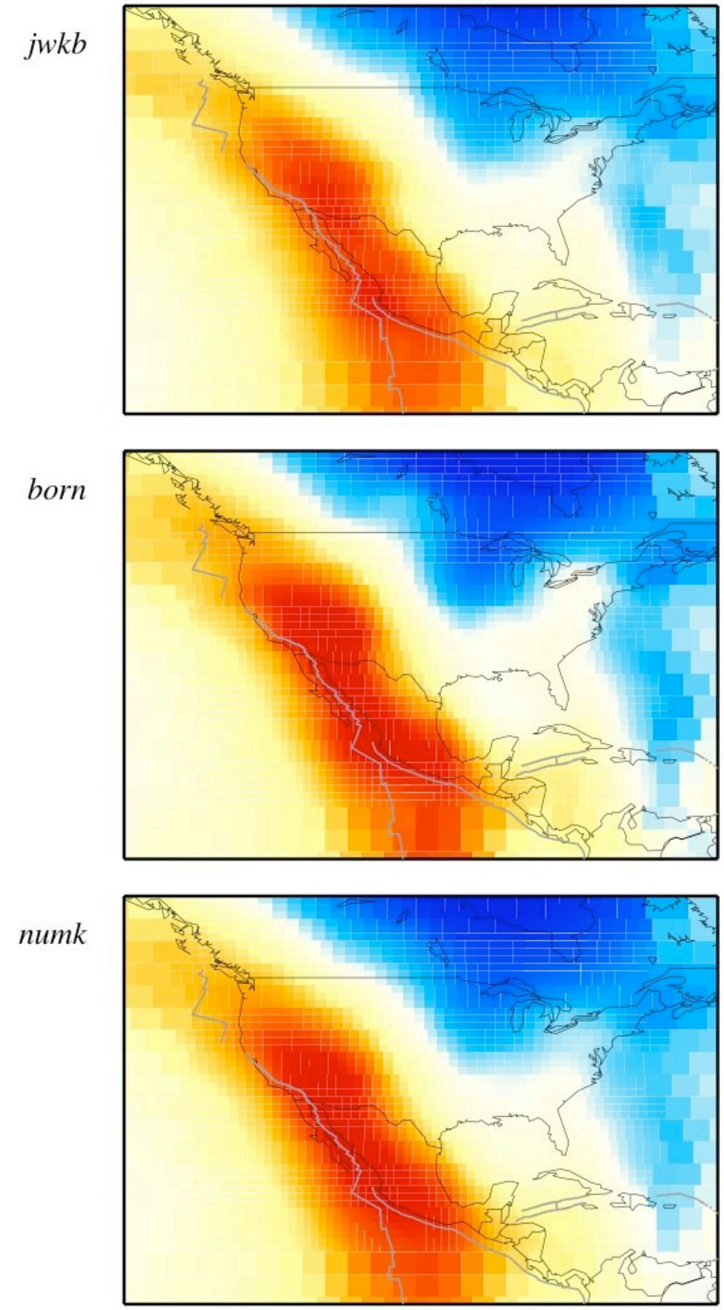


Rayleigh wave phase velocity, corner of L-curve



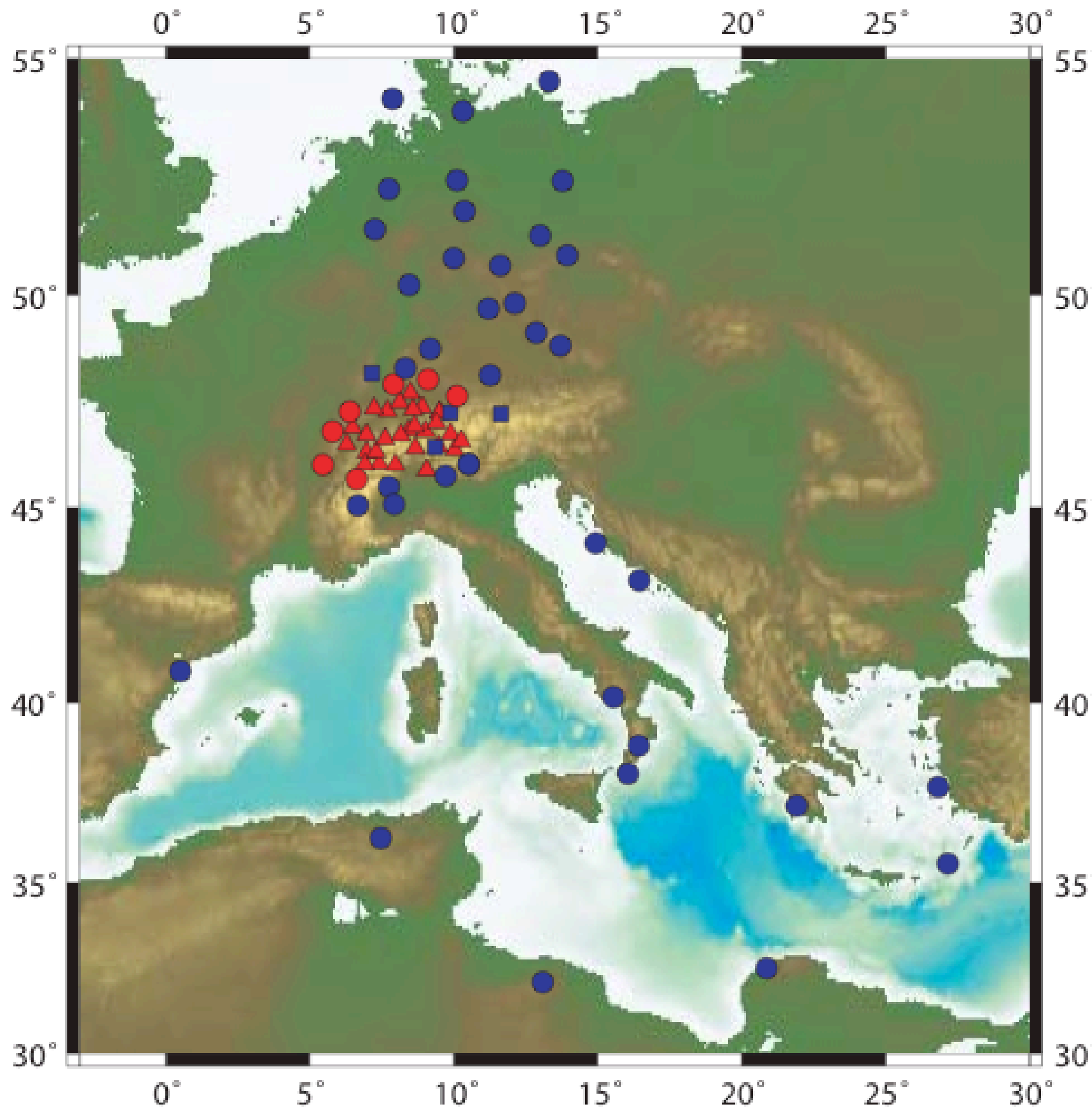
Comparison with "numerical" kernels (Love waves 150 s)





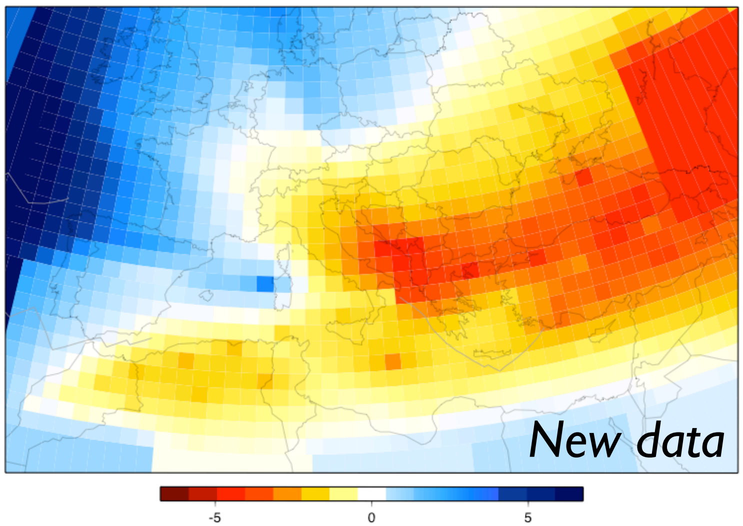
From D. Peter

Evaluate significance of theoretical improvement, get better models: denser station coverage.

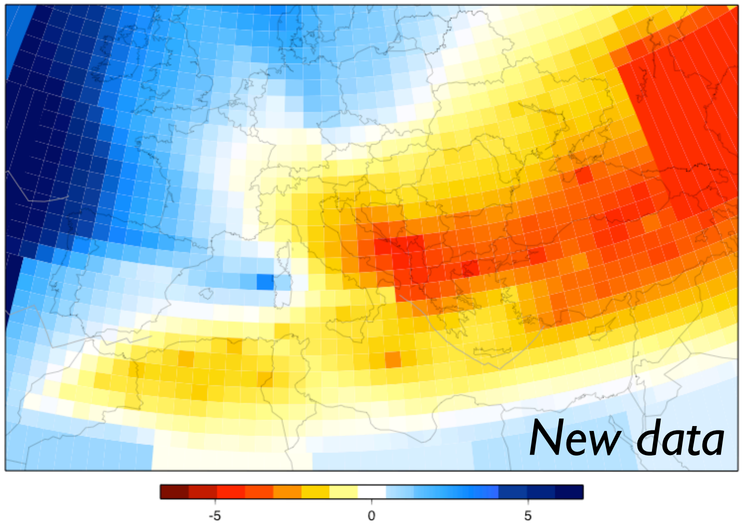


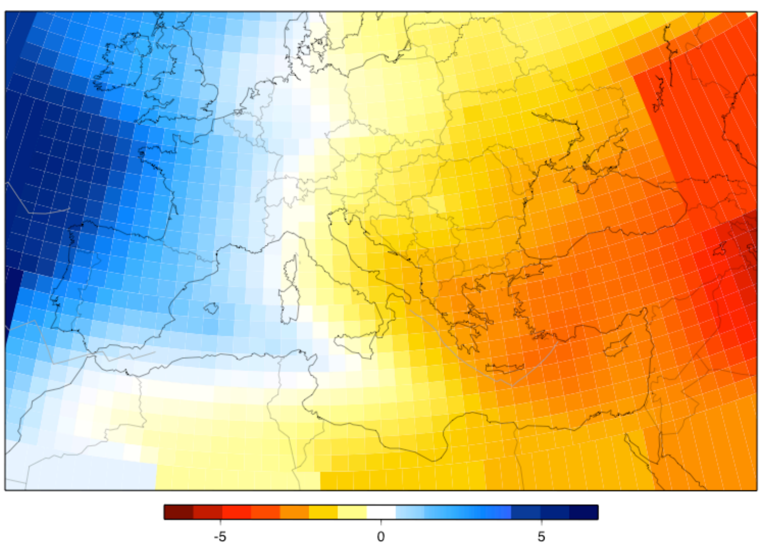
From B. Fry

35 s Love waves, new vs. old data

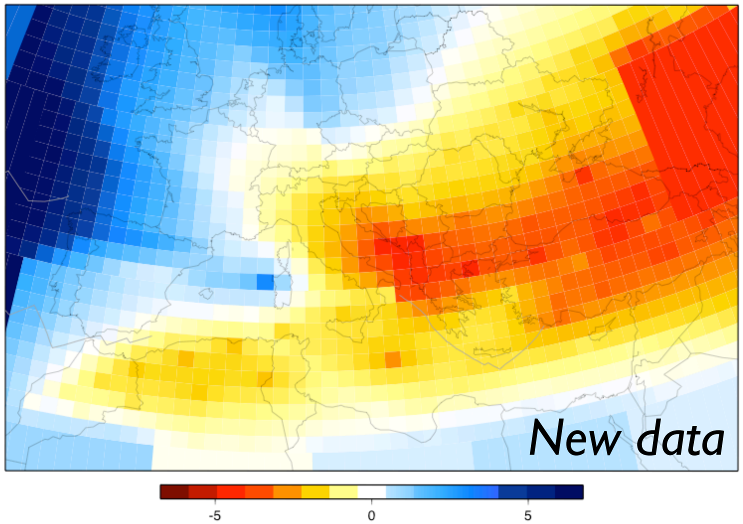


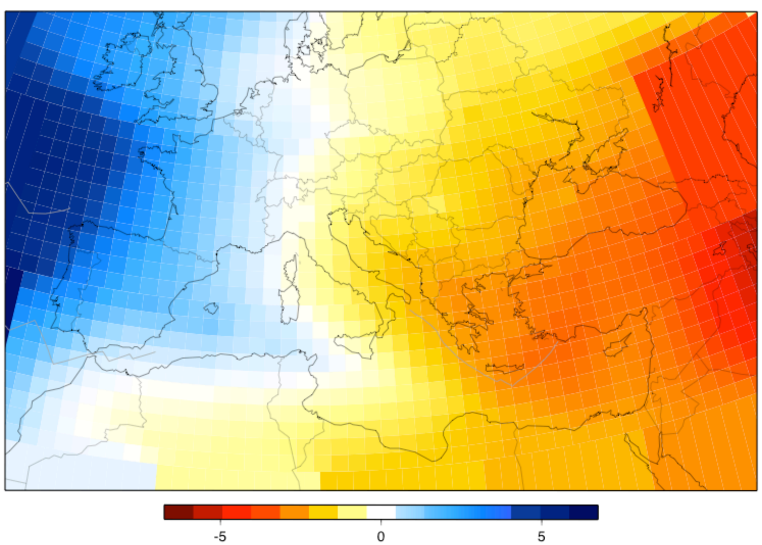
35 s Love waves, new vs. old data

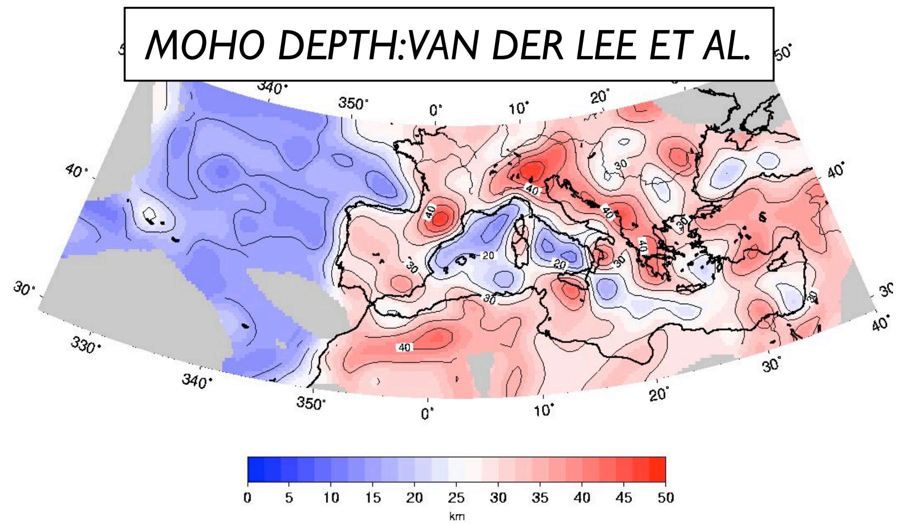




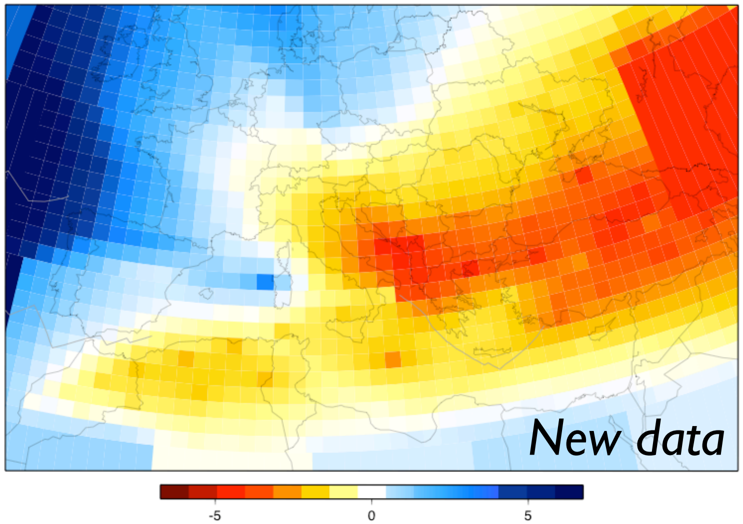
35 s Love waves, new vs. old data

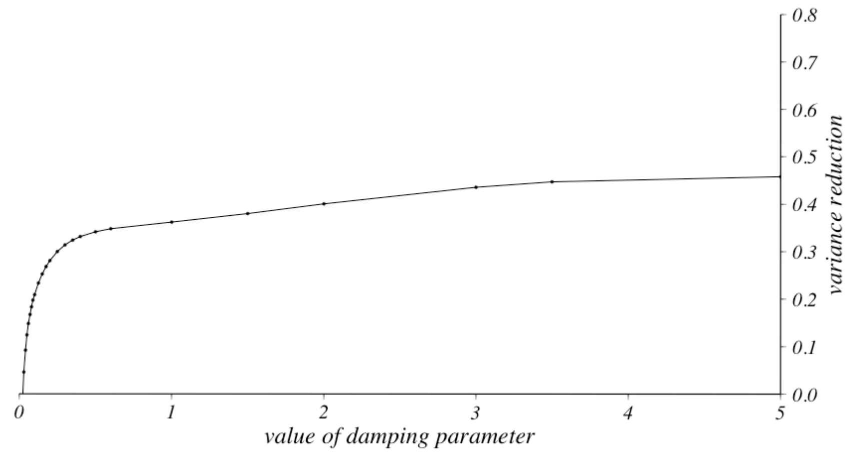


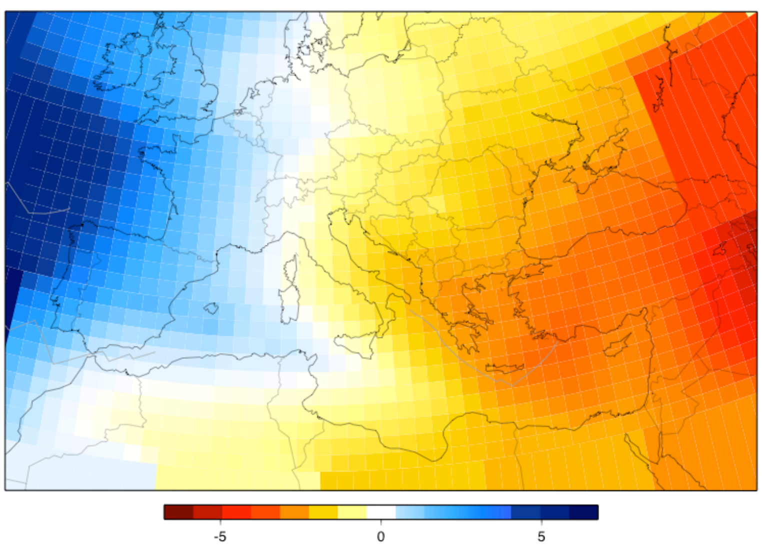


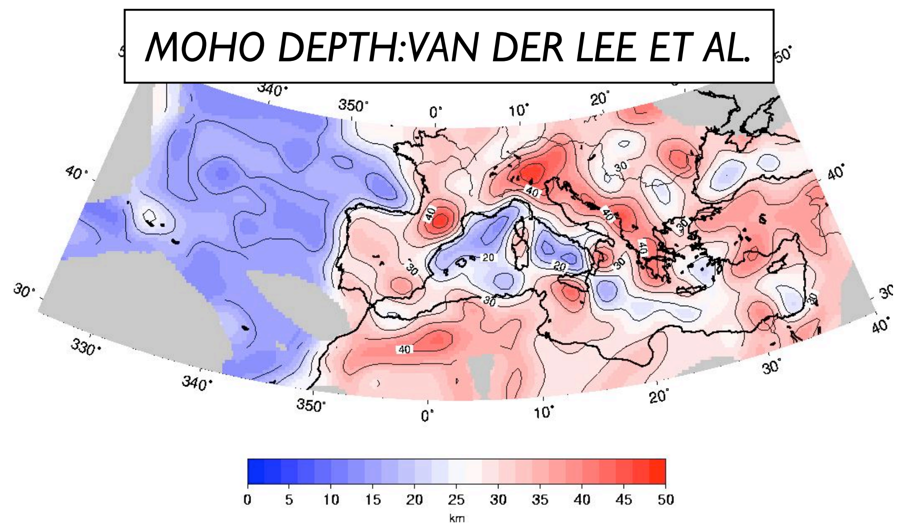


35 s Love waves, new vs. old data









Summary

- ***Global tomographic models are in good agreement at long wavelengths.***
- ***Fast, large-memory computers help us evaluate model resolution and quality: I propose global resolution of ~5° and error one order of magnitude smaller than size of largest anomalies.***
- ***At the current level of data coverage and quality, finite-frequency theory is probably not improving significantly our current knowledge of the Earth's mantle.***
- ***Near future: determine if finite-frequency theory important at regional scale, using improved data-coverage of Mediterranean Basin.***

In practice:

- ***ISC database (not yet updated) can resolve P-velocity heterogeneities of 4°-6°.***
- ***Absolute error on P-velocity less than 0.1% (with anomalies less than 1%-2% in most P models)***

study by Spetzler et al. (GJI 2002)

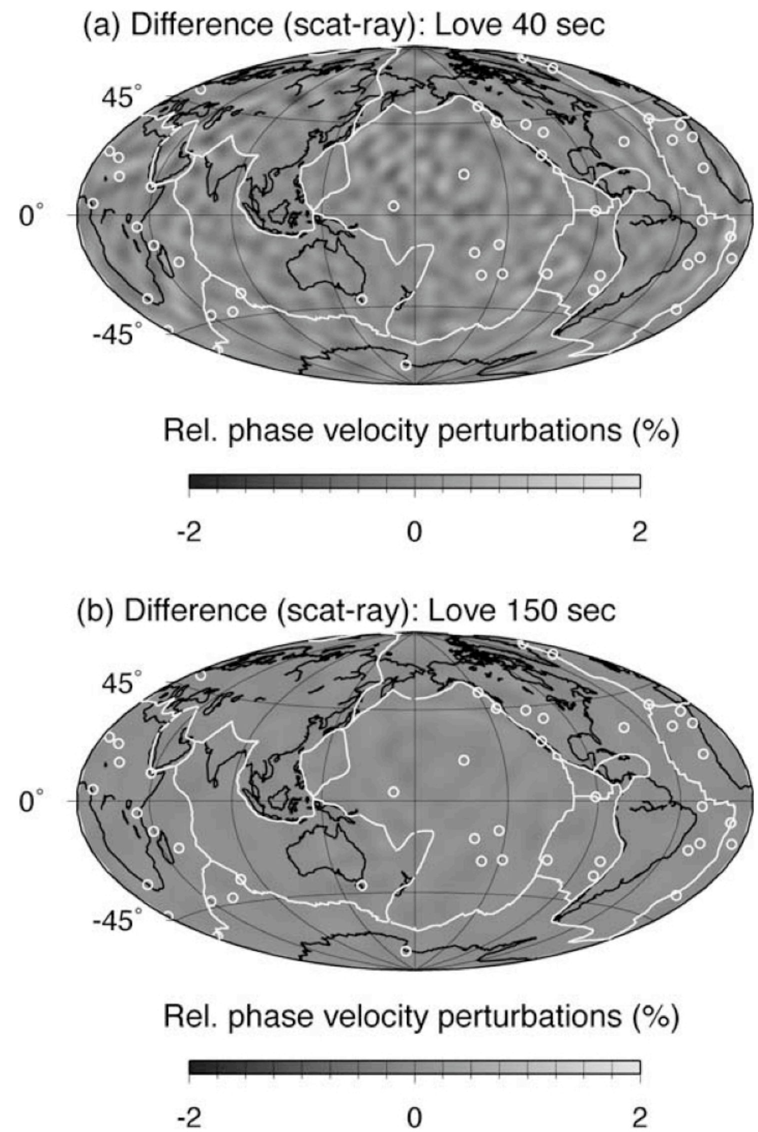
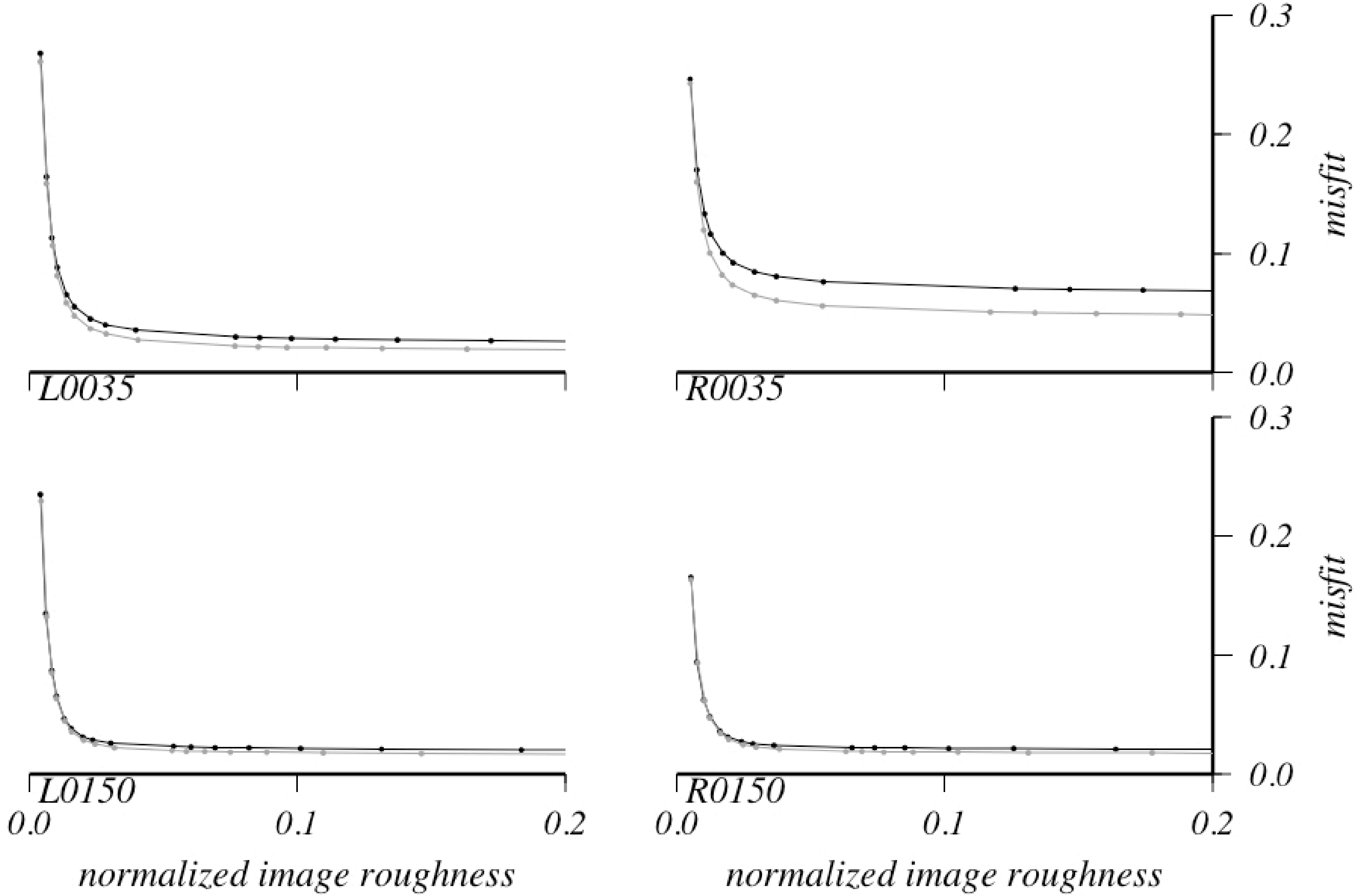
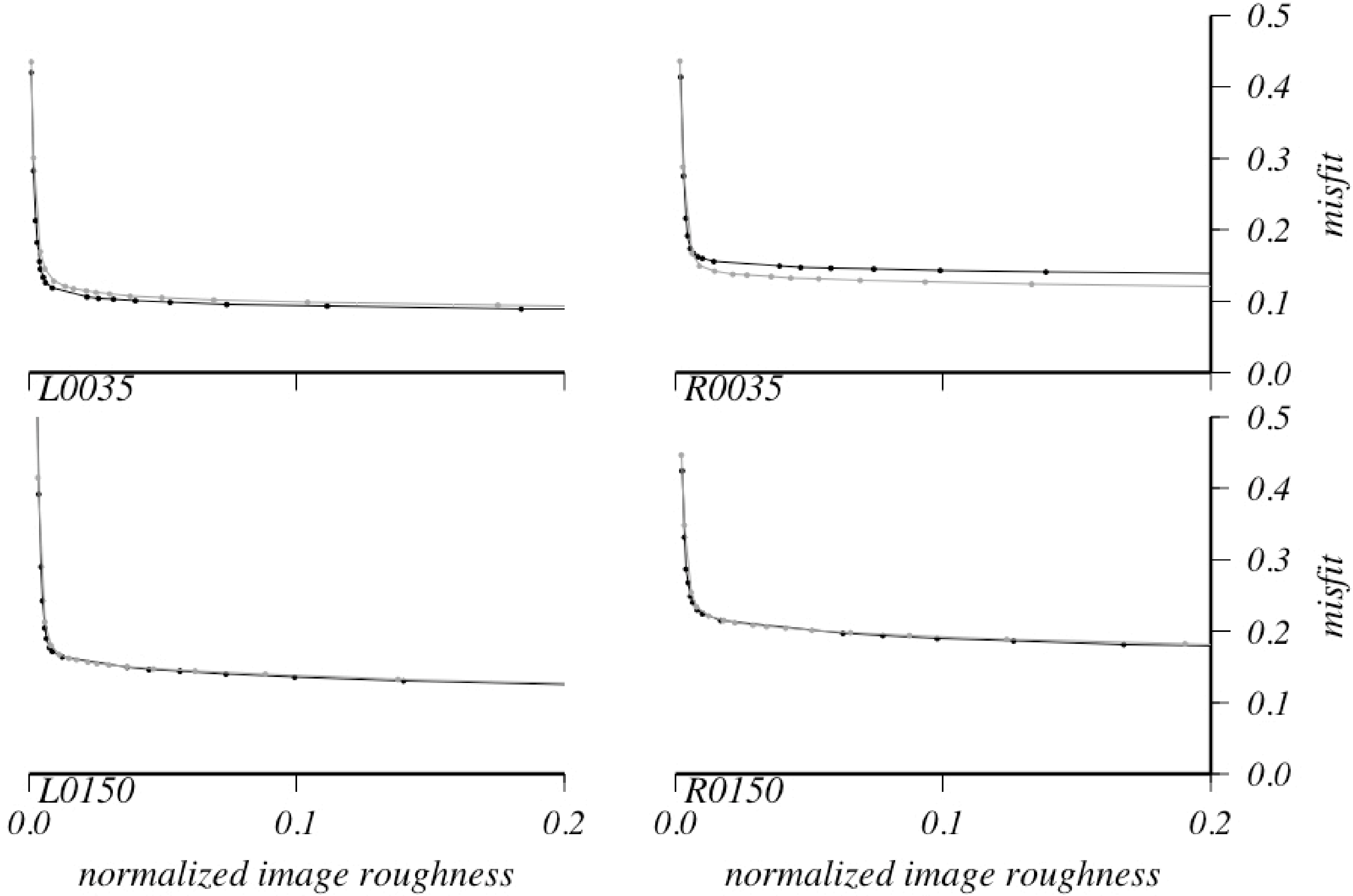


Figure 3. The difference between the phase velocity maps obtained using scattering theory and ray theory for Love wave at 40 and 150 s. The difference in relative phase velocity are given in per cent on a scale between ±2 per cent. Plate boundaries and hotspots are drawn with white lines and circles, respectively. The coastlines are marked with black lines on the difference between the phase velocity maps compiled using scattering theory and ray theory. (A) Love wave at 40 s. The smoothness factor $\gamma = 1 \times 10^{-4}$. (B) Love waves at 150 s. The smoothness factor $\gamma = 1 \times 10^{-2}$.

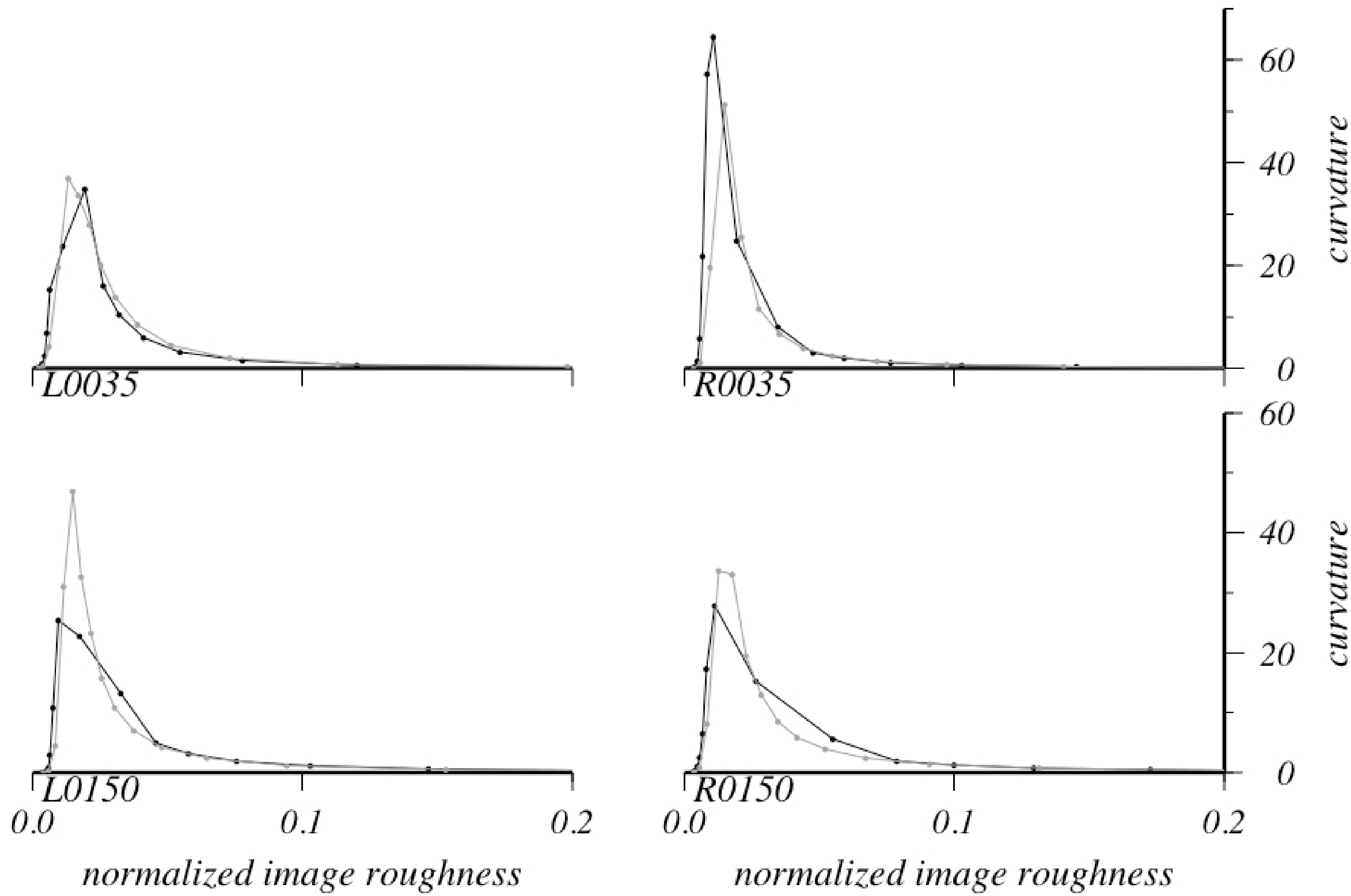
L-curves from synthetic test



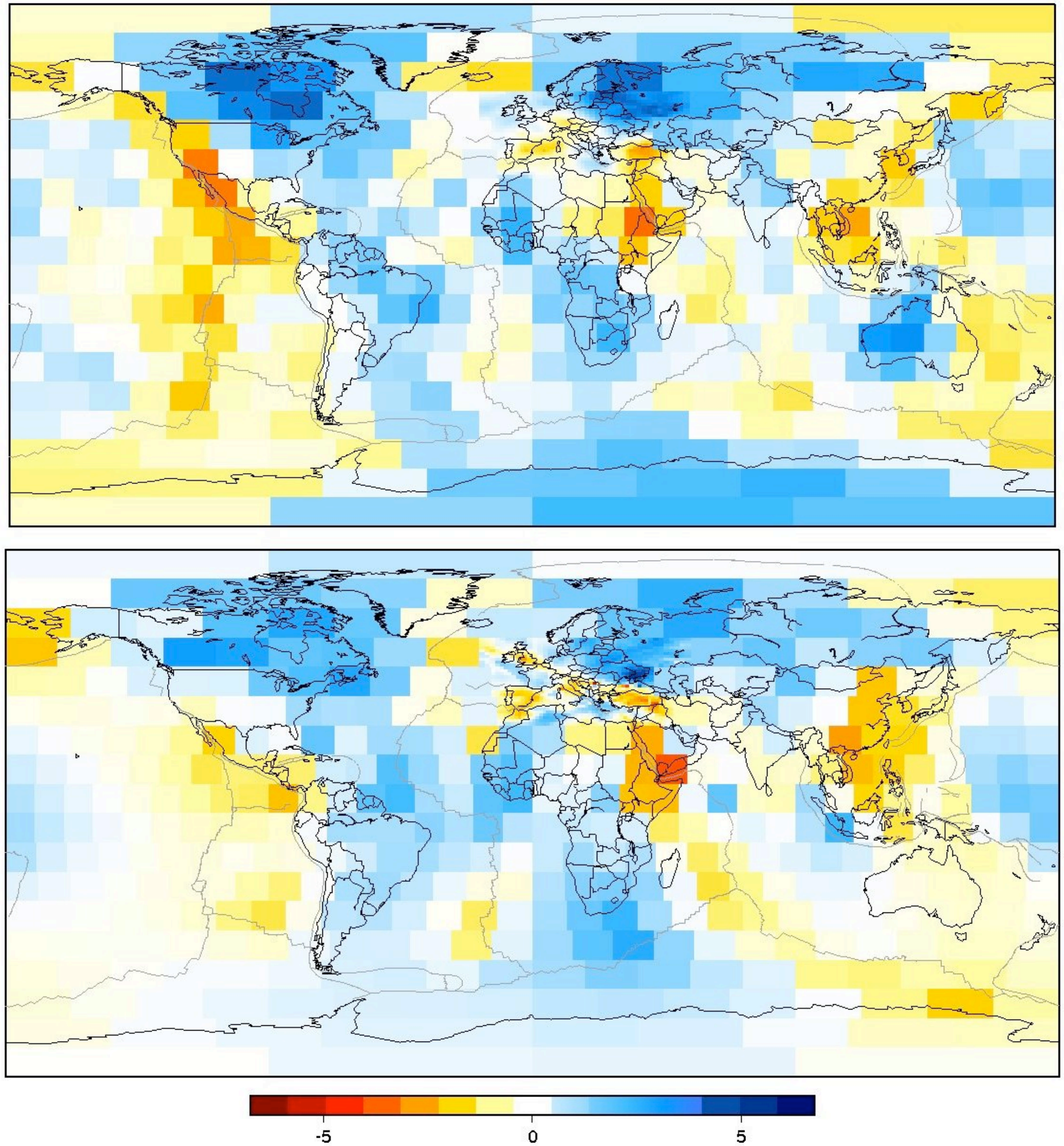
L-curve analysis: data that sample North America



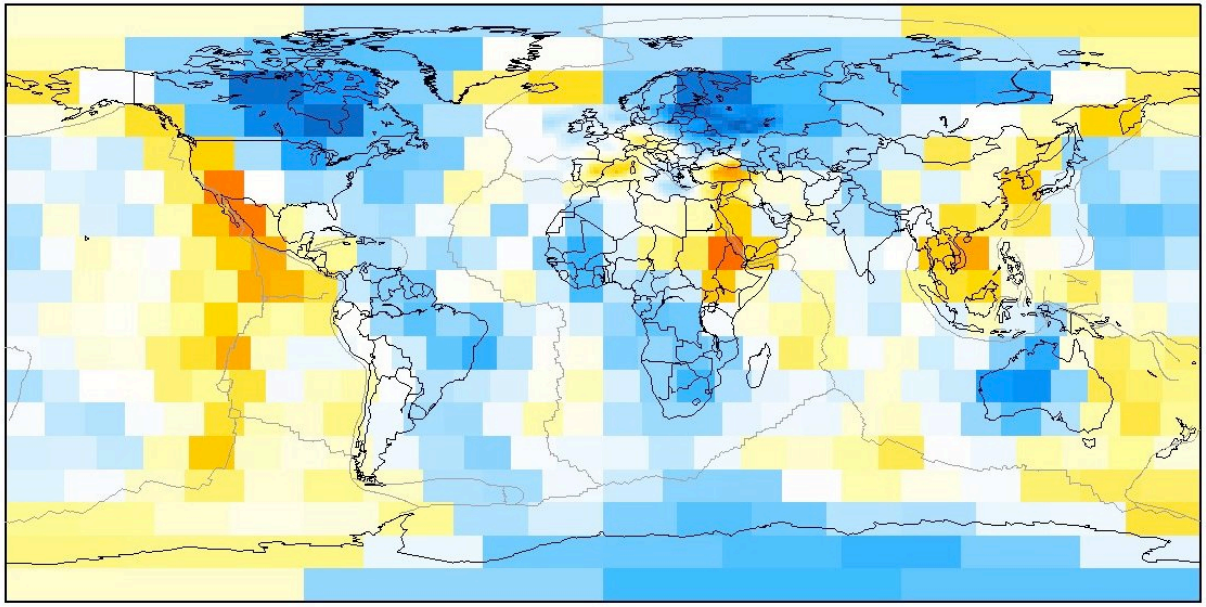
L-curve curvature: data that sample North America



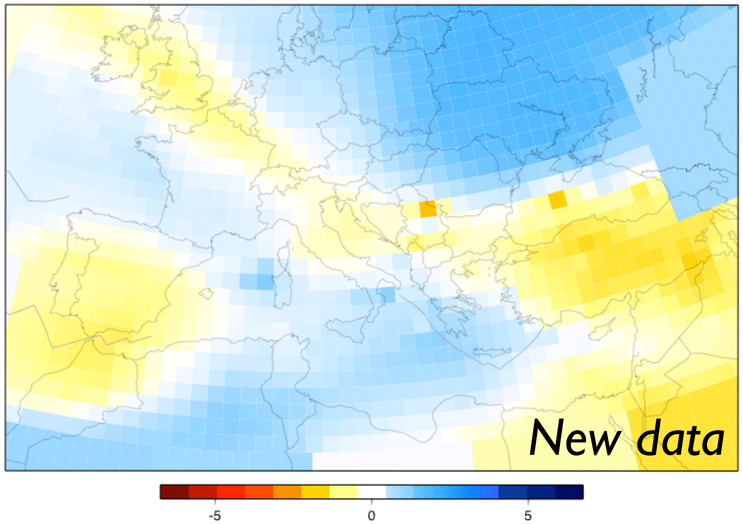
Old vs. new data: global agreement (100 s Rayleigh waves)

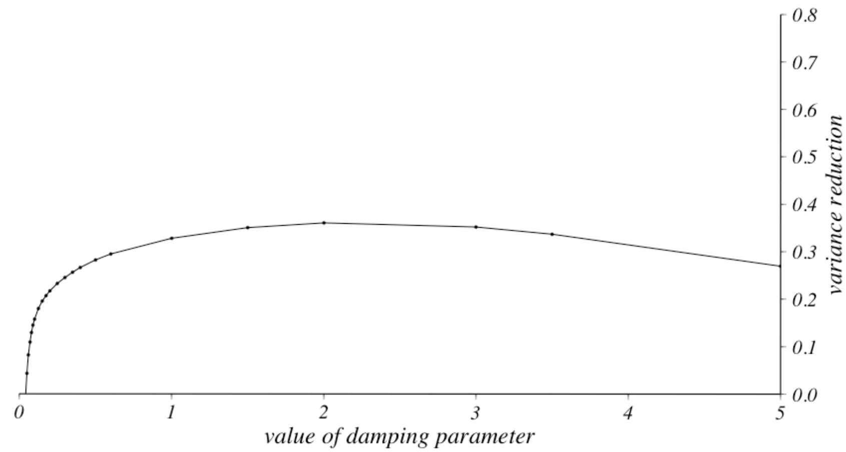


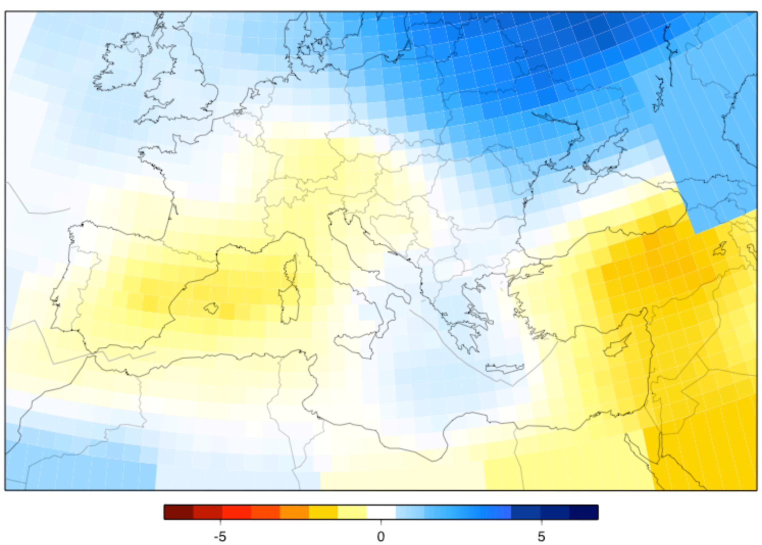
Old vs. new data: global agreement (100 s Rayleigh waves)



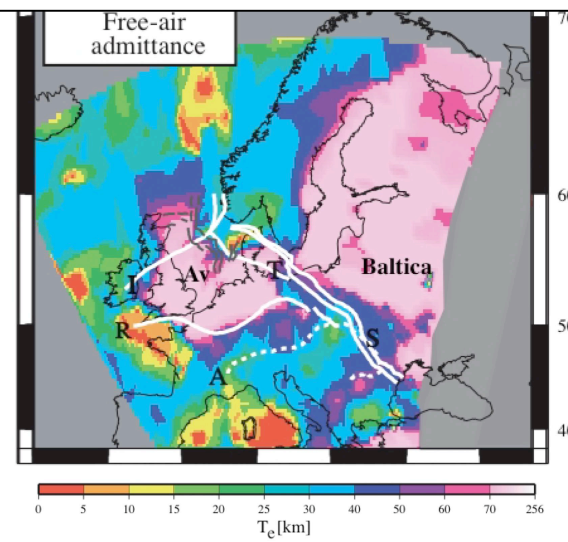
100 s Rayleigh waves







Te: PEREZ-GUSSINYE AND WATTS 2005



Estimate of absolute error on percent δv_P from boot-strap calculation