3D FOLD GROWTH RATES

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SUMMARY

- Geological folds are inherently three-dimensional structures, which therefore also grow in three dimensions.
- Three-dimensional buckle folding is modeled using a finite-element code for simulating the deformation of Newtonian media.
- The higher-viscous layer exhibits an initial point perturbation.
- Compression in one direction leads to a mechanical folding instability that grows from the perturbation in all three dimensions.
- Fold growth rates in all three dimensions are calculated and compared.

DEFINITIONS

Fold amplification (growth in z-direction)

... describes the (vertical) growth from a fold shape with low limb-dip angle to a shape with higher limb-dip angle.

Fold elongation (growth in y-direction)

... is parallel to the fold axis and describes the growth from a dome-shaped (3D) structure to a more cylindrical fold (2D).

Sequential fold growth (growth in x-direction)

... is parallel to the shortening direction describing the growth of secondary (and further) folds adjacent to the initial isolated fold.

Fold elongation and sequential growth have both been referred to as lateral fold growth, which here serves as an umbrella term for both.

NUMERICAL RUNS

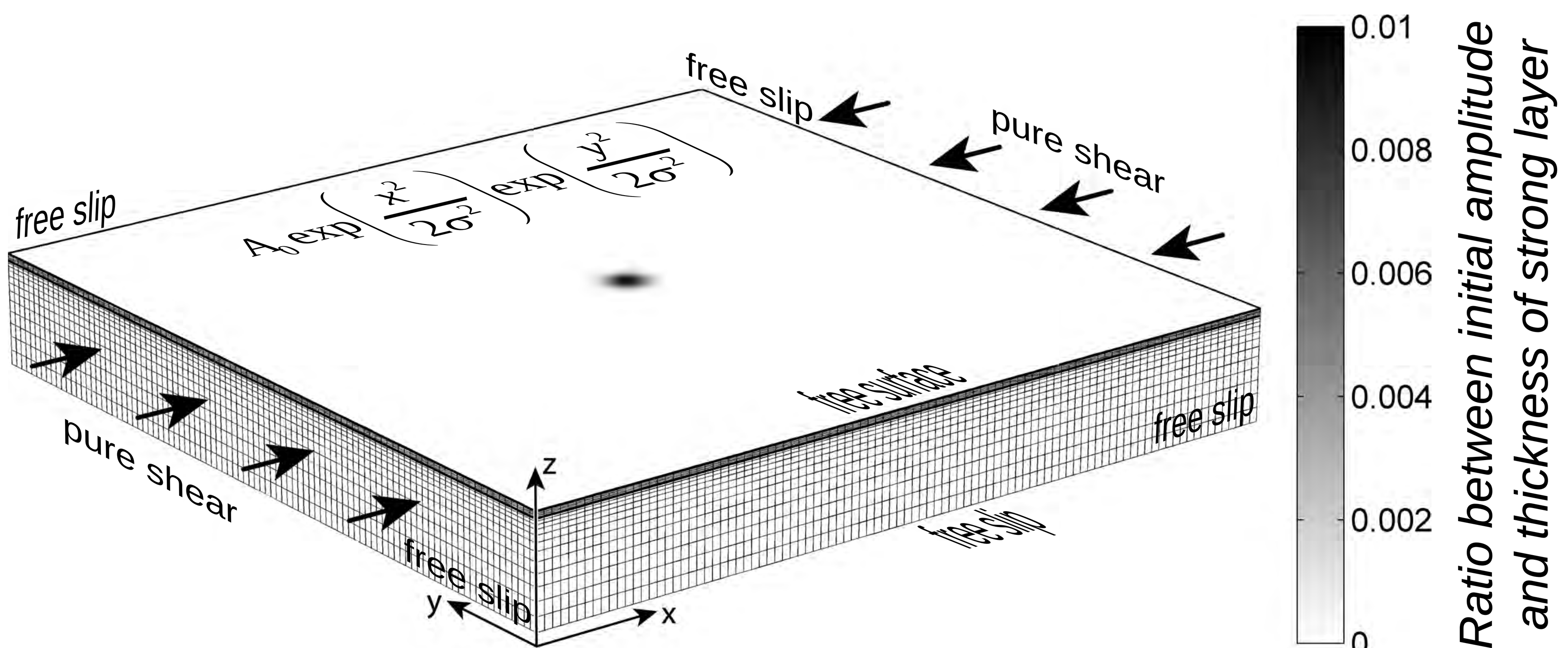


Figure 1: Model setup for finite-element simulations with Gaussian initial perturbation (A_0=0.01H_{layer}).

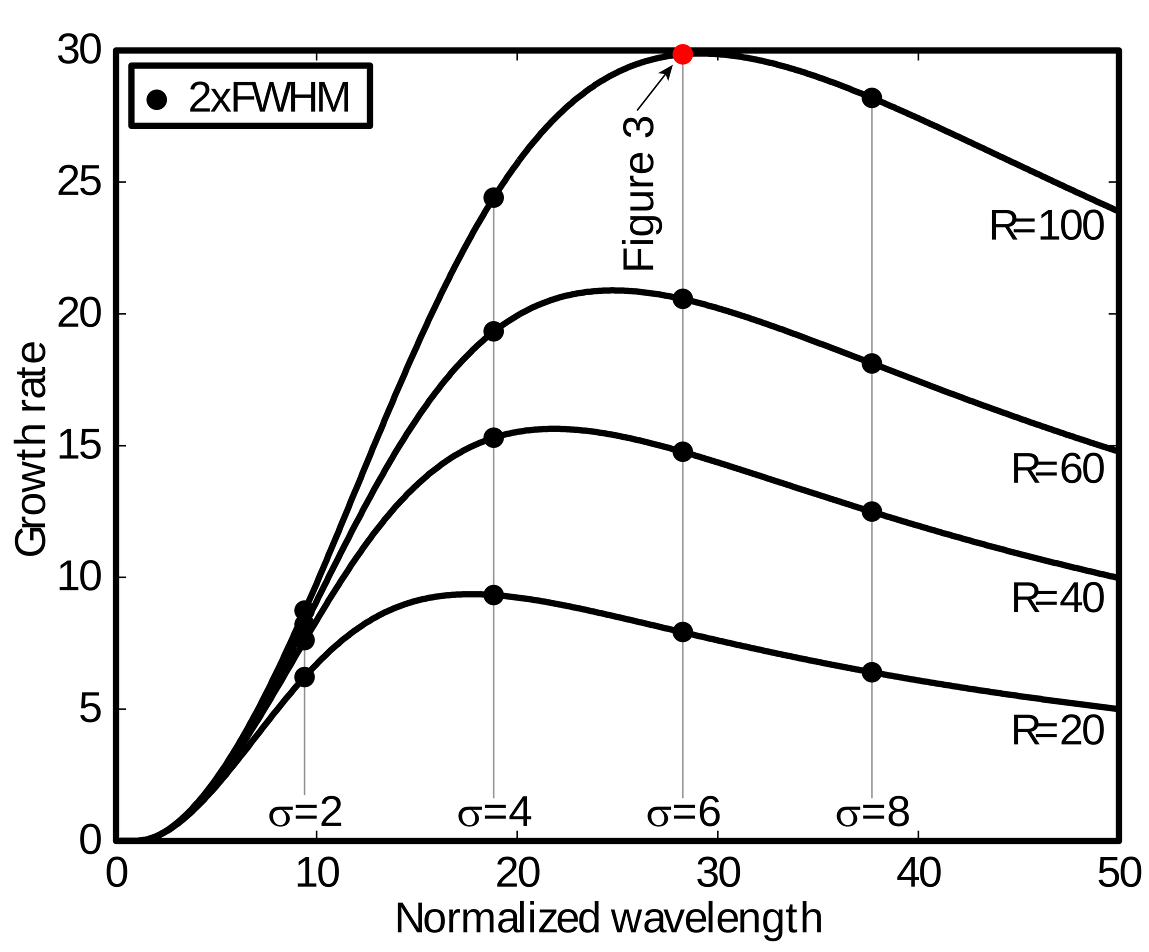
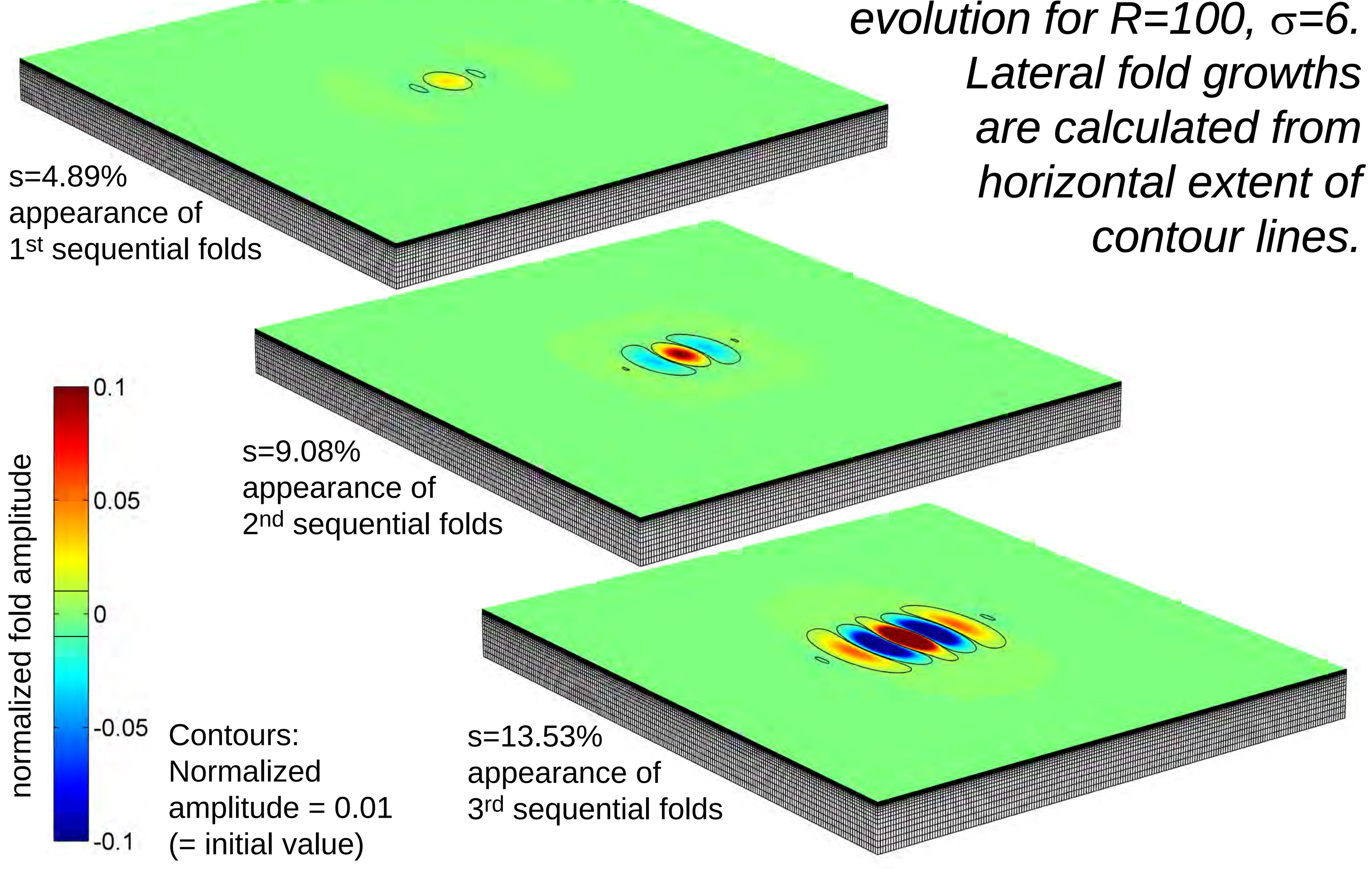


Figure 2: Analytical 3D growth rate curves for different viscosity ratios (R) between strong layer and matrix after Fletcher (1991). Four widths for the Gaussian initial perturbation (σ) were used. Wave length of Gaussian is defined as 2x full width of half maximum (FWHM).

SNAPSHOTS

Figure 3: Example of 3D fold evolution for R=100, σ=6. Lateral fold growths are calculated from horizontal extent of contour lines.



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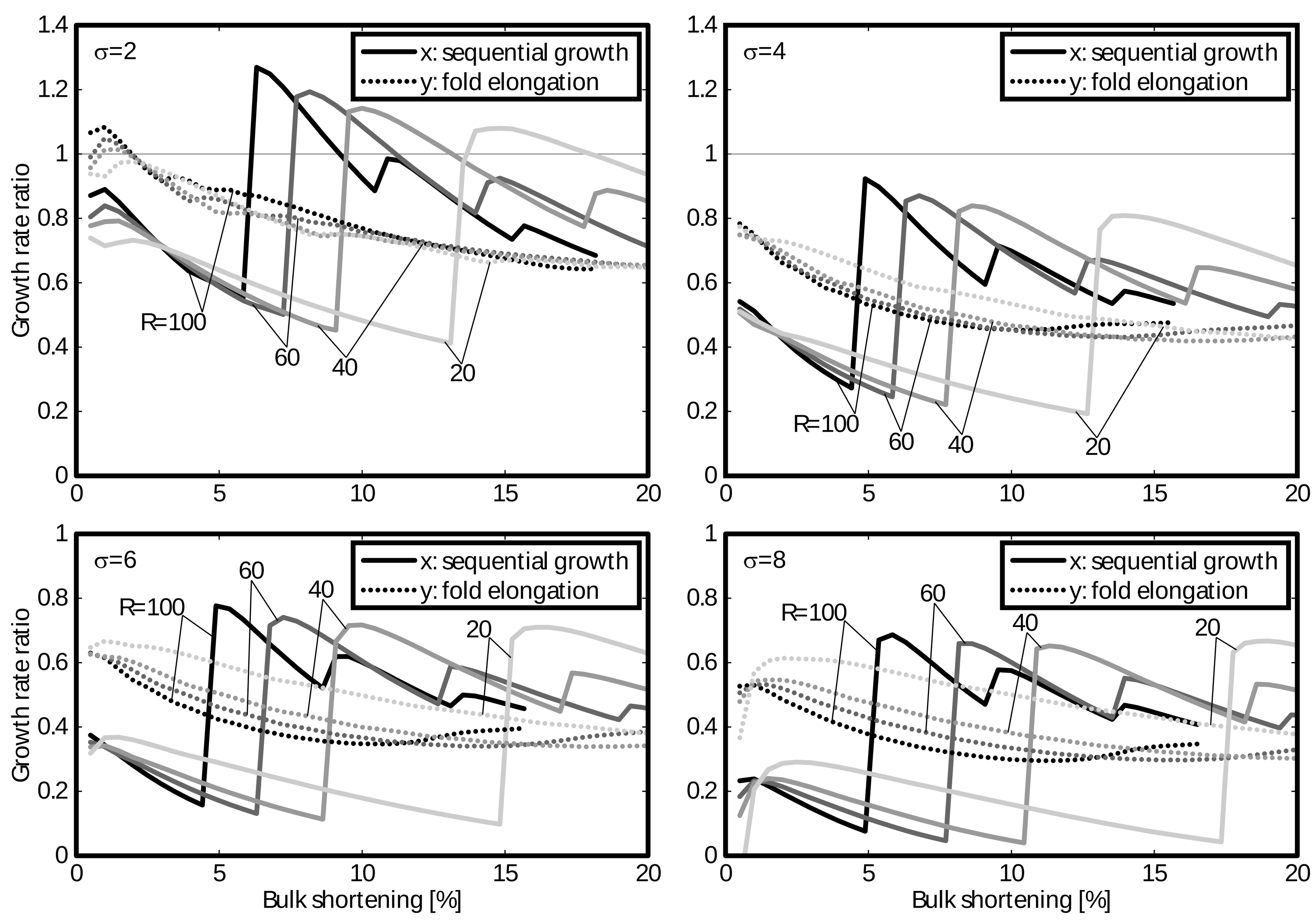

Figure 4: Fold growth rates in x- (solid) and y-direction (dotted) normalized by the fold growth rate in z-direction; negative: slower and positive: faster than fold growth in z-direction.

CONCLUSIONS

- Jumps in fold growth in x-direction (Fig. 4) occur when new sequential folds appear (Fig. 3).
- Until the first sequential folds appear, sequential fold growth is slower than fold elongation. After that, sequential growth is faster.
- Fold amplification is faster than the two lateral fold growths. Exceptions occur for exceptionally slow fold amplification (σ=2).
- Fold amplification rate decreases with shortening, but the two lateral fold growth rates decrease even faster.

These results can help better interpret fold-and-thrust belts elongating along strike (and linking of individual folds) and advancing towards the foreland (e.g., Zagros Mountains, Bretis et al., 2011; Grasemann & Schmalholz, 2012).

REFERENCES

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Fletcher R.C., 1991: Three-dimensional folding of an embedded viscous layer in pure shear, J. Struct. Geol. 13, 87-96
Grasemann B. & Schmalholz S.M., 2012: Lateral fold growth and fold linkage, Geology 40, 1039-1042

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