The Accuracy of Altimetric Surface Geostrophic Velocities

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Summary

Coordinated orbit phasing of multiple altimetric satellites is expected to lead to significant improvements in resolution and accuracy of sea surface height (SSH) and surface geostrophic velocity fields [1]. This investigation evaluates three methods of velocity estimation which are currently in use, or which have recently been proposed with tandem missions in mind, for several single and two-satellite configurations, in the Gulf Stream (GS) region. Sea surface height measurements are simulated using the output of the 1/10° resolution Los Alamos model of the North Atlantic [2]. Velocities are then evaluated from perfect measurements, as well as from measurements to which realistic instrument noise and orbit errors have been added, and compared with the original model velocities. These two cases identify velocity uncertainties associated with sampling and data errors respectively.

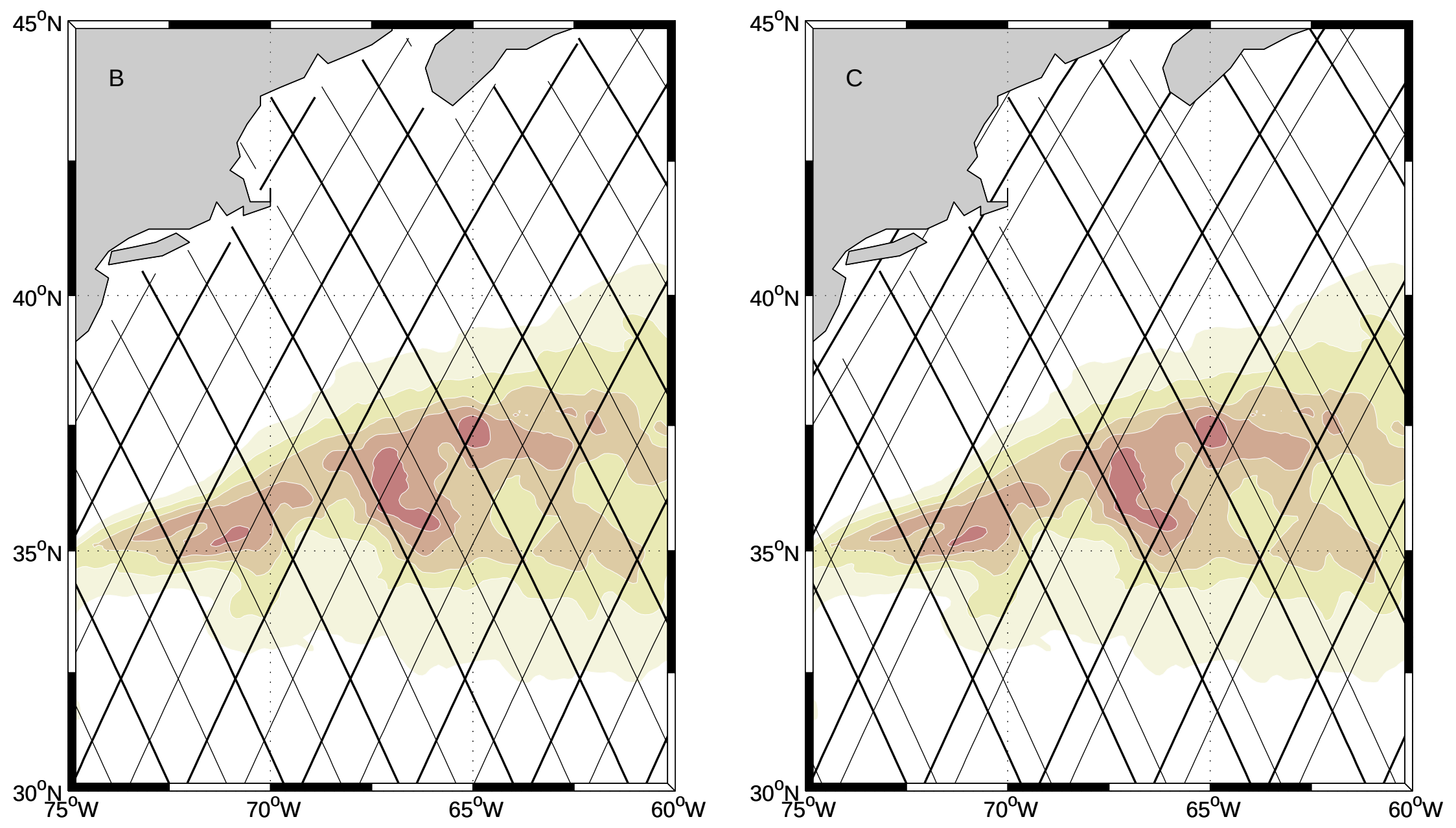

Figure 1: Ground track patterns for (B) T/P and JASON tandem mission with interleaved tracks (configuration proposed by the science working team), and (C) T/P and JASON tandem mission with orbit planes offset by 0.75° (proposed for velocity determination along ground tracks [3]), overlayed on a map of kinetic energy in the GS region.

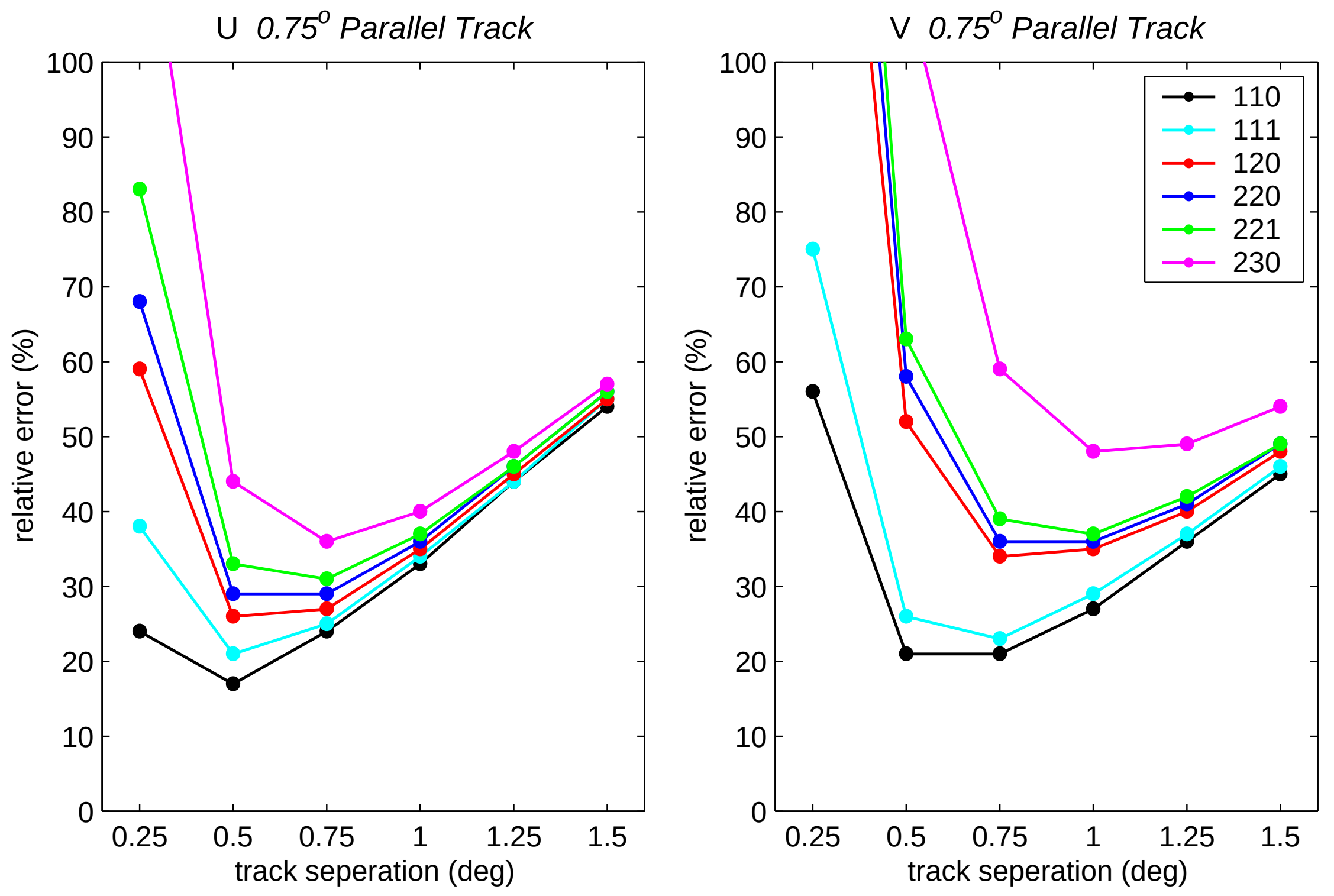

Figure 2: Accuracy of geostrophic velocities resulting from application of the 'parallel-track method' [3] to configuration (C) in the GS region (30° -50° N, 80° -40° W), as a function of track separation and for different data error budgets. Velocity error variances are expressed as a percentage of the local signal variance. The error budgets consist of three contributions, denoted in the figure by its magnitude in cm. The first number represents the random instrument noise which was reduced here by along-track smoothing (100 km cutoff); the second number represents the amplitude of a once-per-rev orbit error, which introduces a bias between two separate tracks; the third number represents a parameterization of additional errors such as due to track displacements in the presence of a cross-track mean sea surface slope. Figure 2 suggests that: (1) Orbit errors have a considerable impact on velocity errors; (2) Very small track separations are undesirable since the effect of data errors is amplified; (3) Even for orbit errors of 3 cm useful velocity estimates can still be obtained; (4) Velocity errors are insensitive to data error for larger track separations and become dominated by sampling errors.

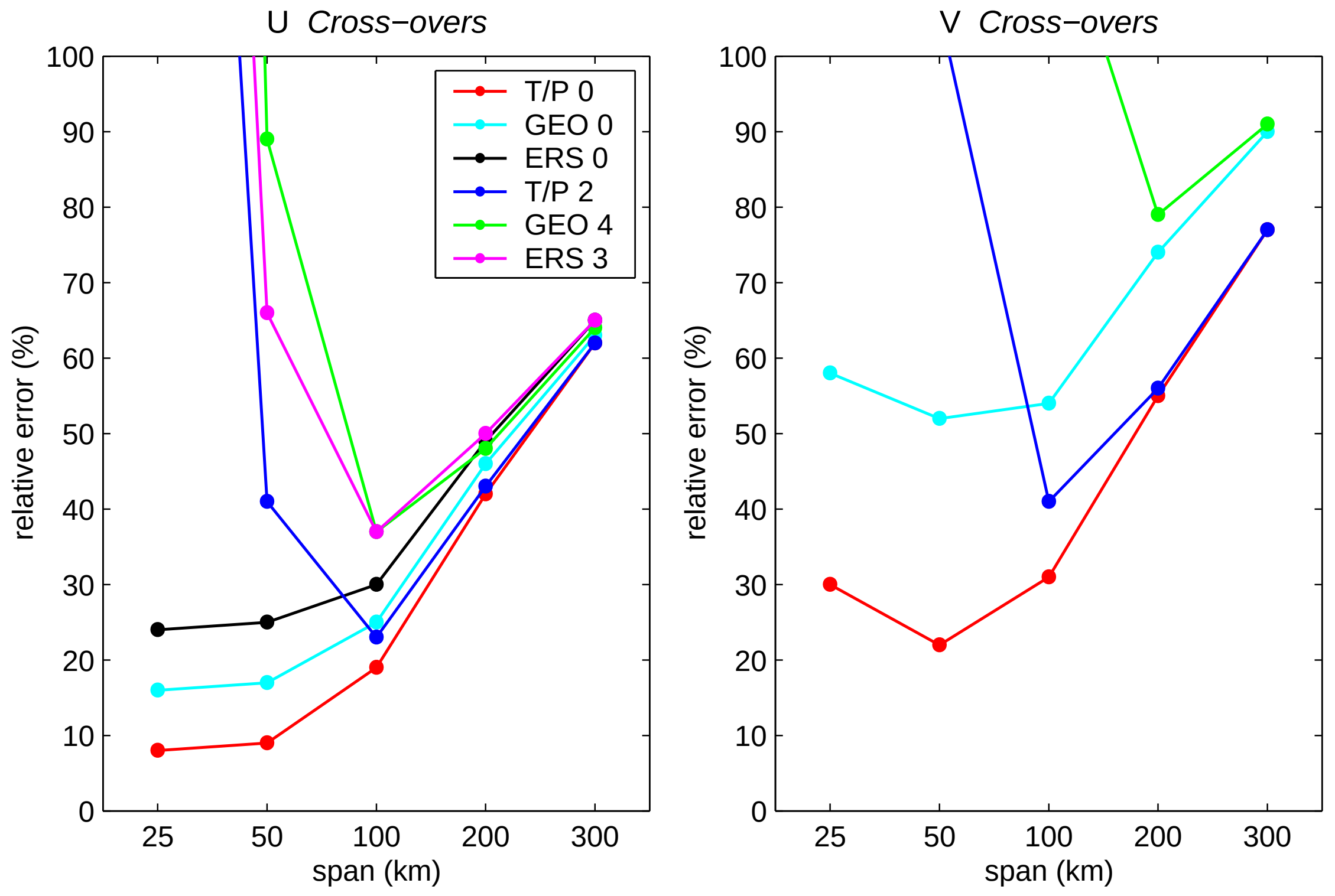

Figure 3: Accuracy of velocities estimated at crossovers in the GS region as a function of smoothing span for the T/P, ERS and GEOSAT missions. The 'smoothing span' is the distance over which the along-track SSH slope is estimated. Estimates are given for both noise-free measurements and for measurements incorporating realistic noise estimates for the three missions (2, 3 and 4 cm respectively). Conclusions from Figure 3: (1) Even in the absence of data errors, velocity accuracies are limited by sampling errors resulting from the nonsynchronicity of the over flights, introducing a temporal interpolation error; (2) Both orbit inclination and repeat period affect this error contribution, leading to relatively lower accuracies for GEOSAT and ERS; (3) At the GS latitude, the V component is more poorly determined than the U component;

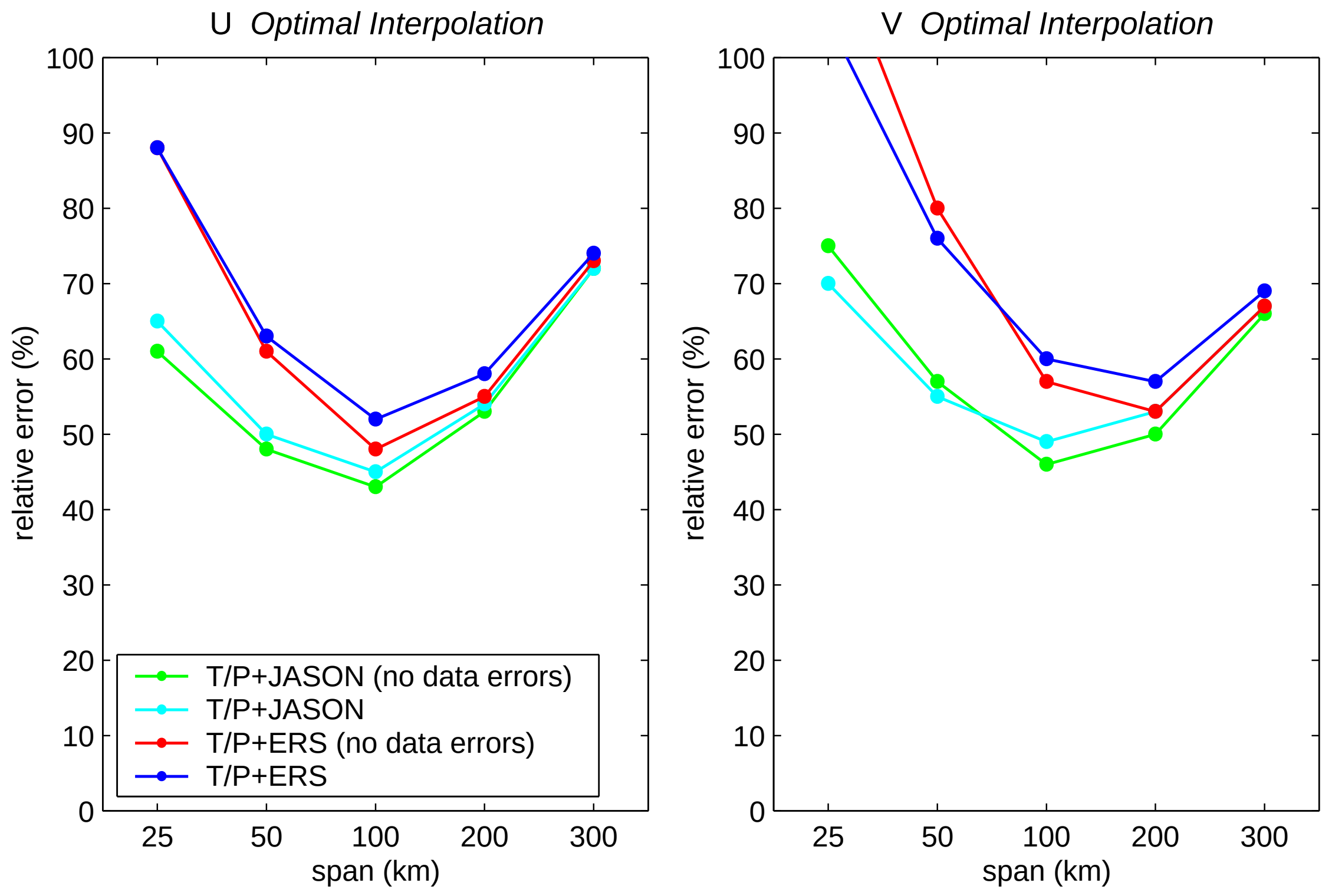

Figure 4: Accuracy of velocity estimates determined from optimally interpolated SSH maps as a function of the smoothing span for both a T/P+JASON interleaving tandem mission, and a T/P+ERS combination, with and without data errors. Orbit errors for T/P, JASON and ERS were 2, 2 and 4 cm respectively. In conclusion: (1) Velocity accuracies in the GS region are not severely impacted by data errors; (2) Accuracies obtained from the T/P-ERS combination are only slightly lower than for the T/P-JASON combination; (3) Accuracies in both components are comparable; (4) Velocity accuracies are slightly lower than those obtained from parallel track and crossover methods for identical error budgets when averaged over the GS region.

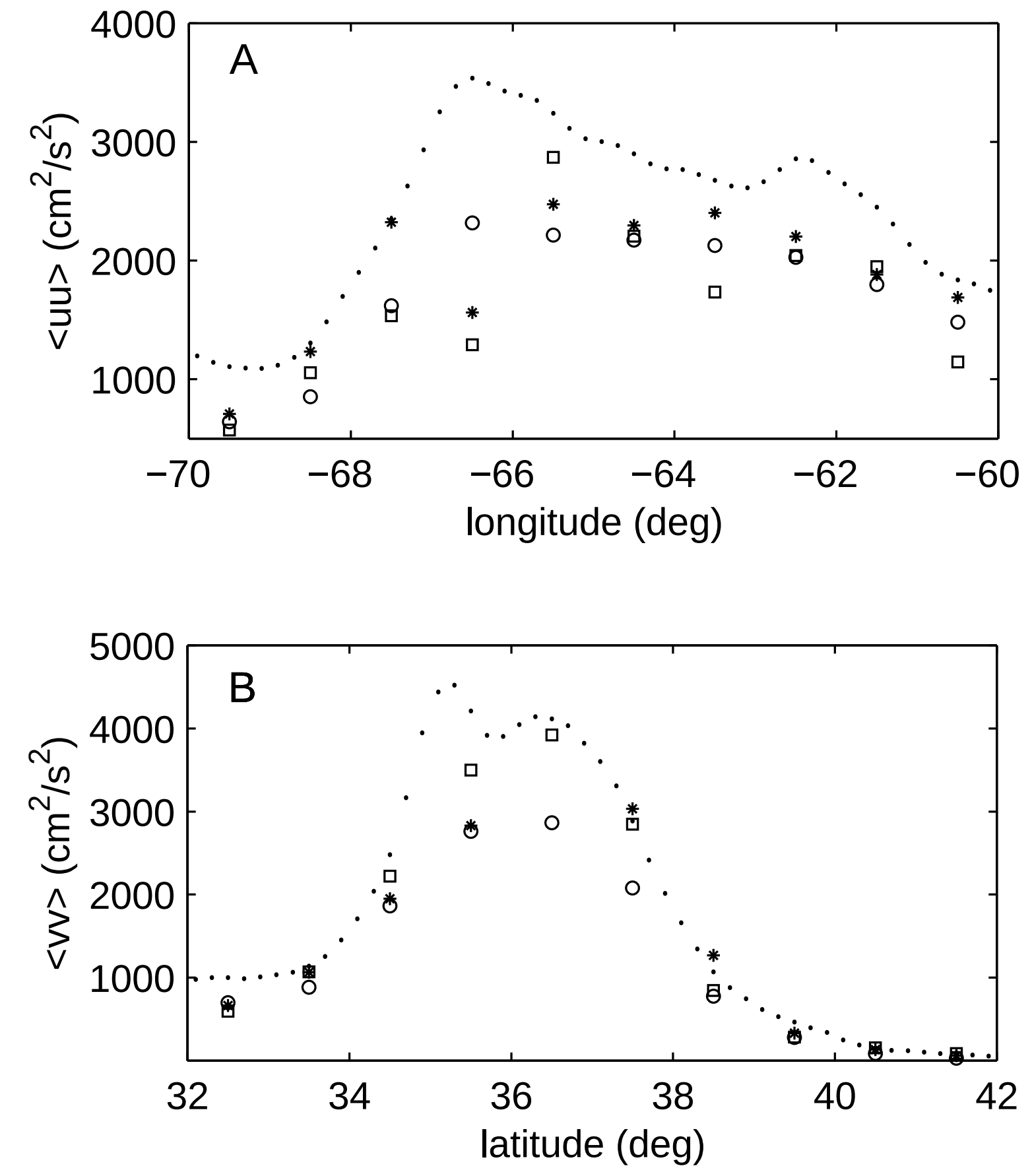

Figure 5: A comparison of the $< u'u' >$ and $< v'v' >$ terms of the Reynolds stress tensor, along and across the Gulf Stream core respectively, obtained from parallel-track (squares) and interleaving configurations, in the latter case obtained with both the crossover (stars) and optimal interpolation (circles) methods. The dotted line represents the model truth.

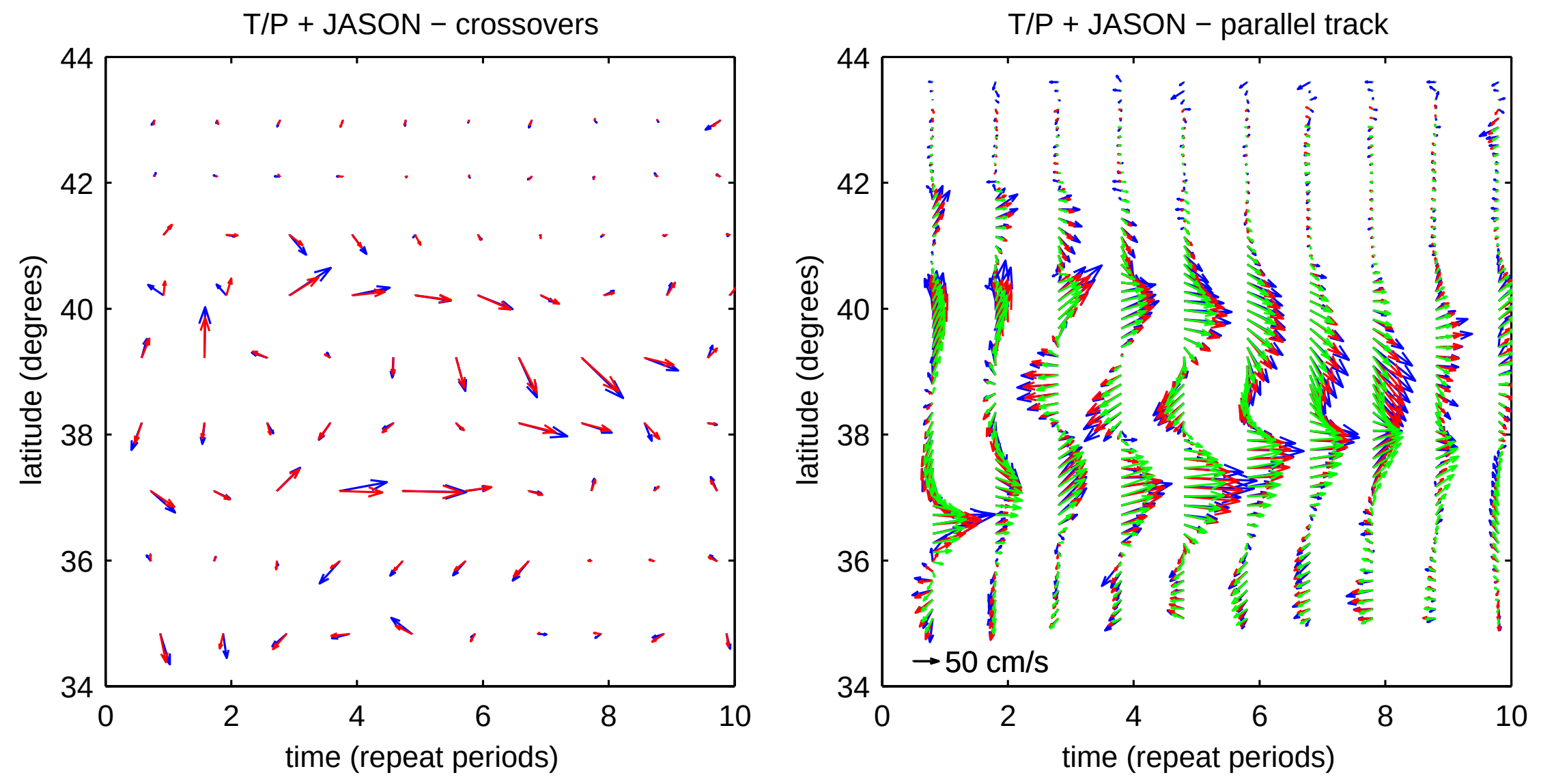

Figure 6: Velocity vectors obtained from crossover and parallel-track procedures along a ground track crossing the Gulf Stream. The model velocity is shown in blue, and estimates from simulated data with errors are shown in red. The green velocities were obtained by applying the parallel-track method to an interleaved configuration.

Table 1 (next column): Velocity error variances in the region (34° - 39° N, 70° - 60° W) for several mission combinations and methods. The OI and XO methods are applied on the interleaving T/P+JASON configuration. The PT method was applied on tracks separated by 0.75° .

missions	method	U (%)	V (%)
T/P+Jason	PT	13	11
T/P+Jason	XO	8	16
Geosat	XO	10	33
ERS	XO	34	127
T/P+Jason	OI	22	26
T/P+ERS	OI	27	36

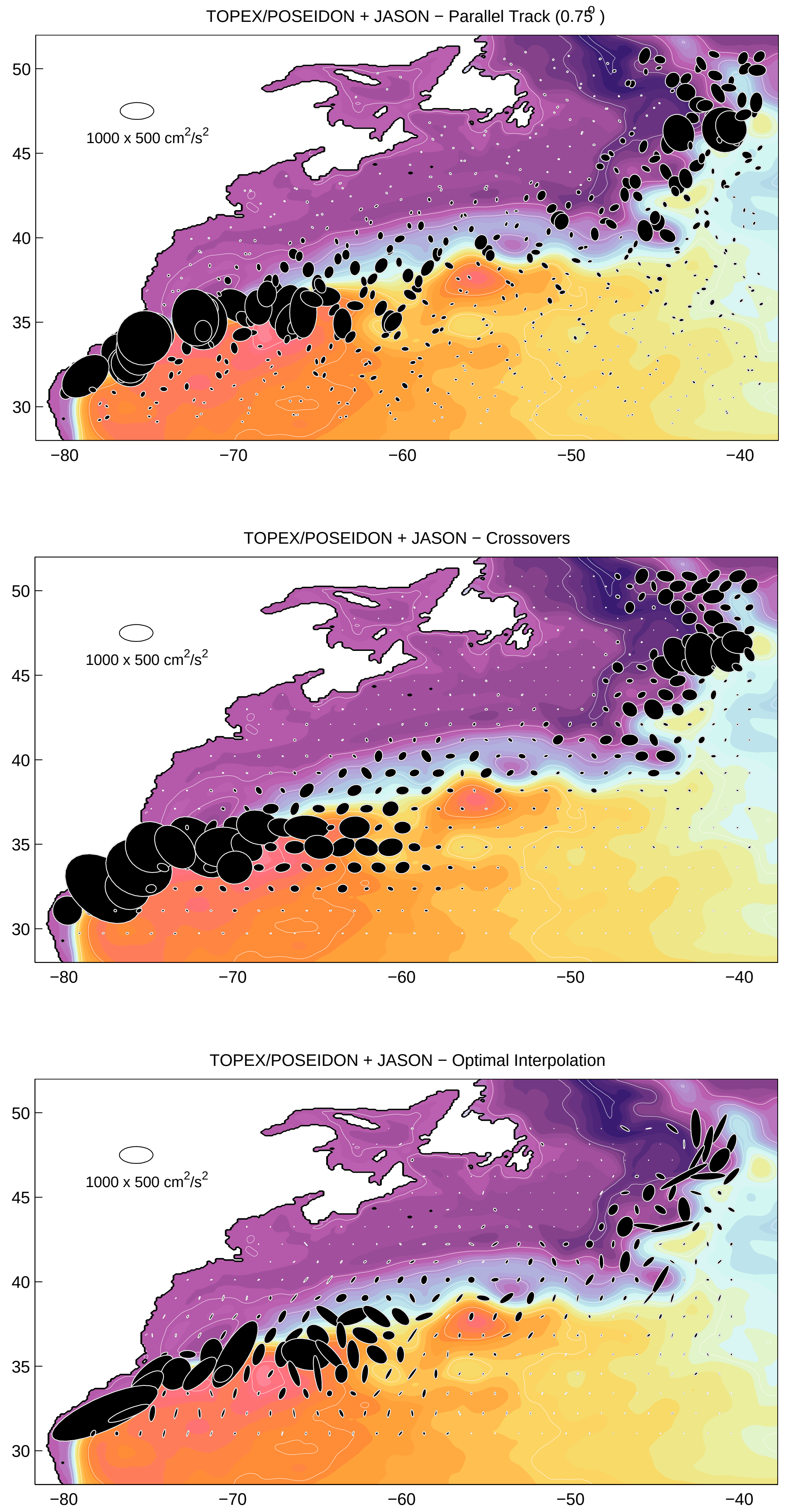

Figure 7: Velocity error variance ellipses resulting from application of the PT, XO and OI methods to parallel-track and interleaving T/P - JASON tandem configurations respectively for measurements including data errors, overlayed on the mean sea surface height, identifying the mean location of the Gulf Stream.

References

[1] **Greenslade, D. J. et al.**, 1997: *J. Atmos. Oceanic. Technol.*, 14, 849-870. [2] **Smith, R. D. et al.**, 2000: *J. Phys. Oceanogr.*, 30, 1532–1561. [3] **Stammer, D., and C. Dieterich**, 1999: *J. Atmos. Oceanic Technol.*, 16, 1198–1207. [4] **Leeuwenburgh and Stammer**, 2002: to appear in *J. Geophys. Res.*