Assessing the impact of high-resolution wide-swath altimetry on the determination of the Lagrangian surface ocean circulation

F. J. Beron-Vera,† M. J. Olascoaga† and G. J. Goni‡

†RSMAS, University of Miami, Miami, Florida, USA

‡AOML, National Oceanic and Atmospheric Administration, Miami, Florida, USA

Abstract

We present preliminary results of an assessment of the potential improvement brought by high-resolution wide-swath altimetry measurements with respect to low-resolution measurements made by current nadir-looking altimeters in the representation of the surface ocean Lagrangian circulation. The starting point of our study is the daily output from a $1/12°$-resolution Hybrid-Coordinate Ocean Model (HYCOM) simulation. We seek to identify regions of the global surface ocean where turbulent mixing dominates over chaotic mixing, i.e., regions where Lagrangian calculations are sensitive to the resolution of the velocity field and thus have the potential of being most benefited by high-resolution wide-swath altimetry. This is done by evaluating how much of the Lagrangian coherent structure entanglement associated with the HYCOM surface ocean velocity field is distorted compared to those associated with surface geostrophic velocity fields inferred using: (1) full-resolution HYCOM sea surface height (SSH); and (2) a spatiotemporal truncation of the latter. These simulate the resolution provided by gridded fields obtained from wide-swath and along-track altimetry observations, respectively. The evaluation is complemented with the analysis of a variety of passive tracer evolution diagnostics, which include: kinetic energy and tracer variance spectra; probability distribution functions (PDFs) of finite-time Lyapunov exponents (FTLEs); and Eulerian and Lagrangian autocorrelation times of velocity gradient components.

Regions of study

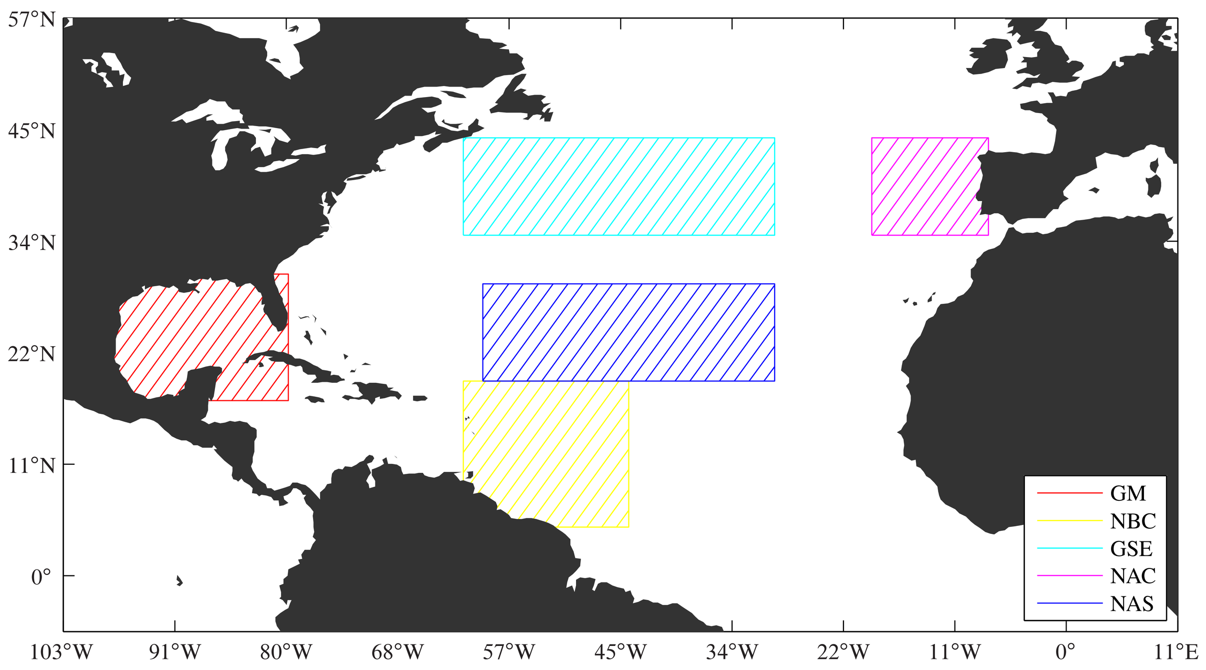

Figure 1. Map showing the regions where the various tracer evolution diagnostics were computed.

NAS

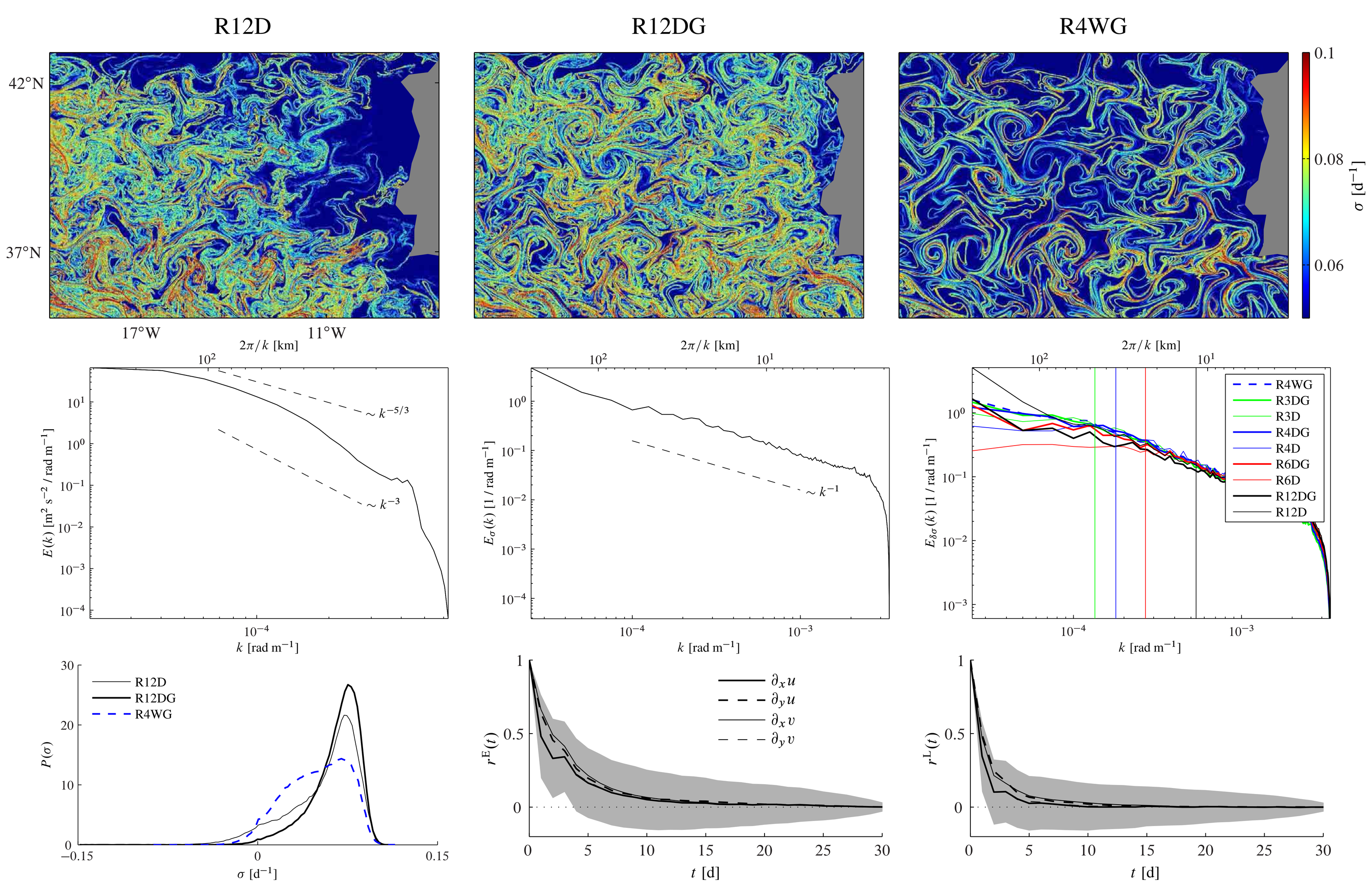

Figure 2. (top-left, -center, and -right) Snapshot of 60-d-backward FTLE field on 1 June 2006 in NAS based on: daily-archived $1/12°$-resolution HYCOM surface velocities (R12D); geostrophic velocities inferred from daily-archived $1/12°$-resolution HYCOM SSH (R12DG); and geostrophic velocities inferred from weekly-archived HYCOM SSH truncated at $1/4°$-resolution (R4G). (mid-left, -center, and -right) Kinetic energy spectrum; tracer (FTLE) variance spectrum; and spectra of the variance of tracer distribution difference with respect to R12D tracer distribution. (bottom-left, -center, and -right) PDF of FTLEs; and Eulerian and Lagrangian autocorrelations of velocity gradient components.

NAC

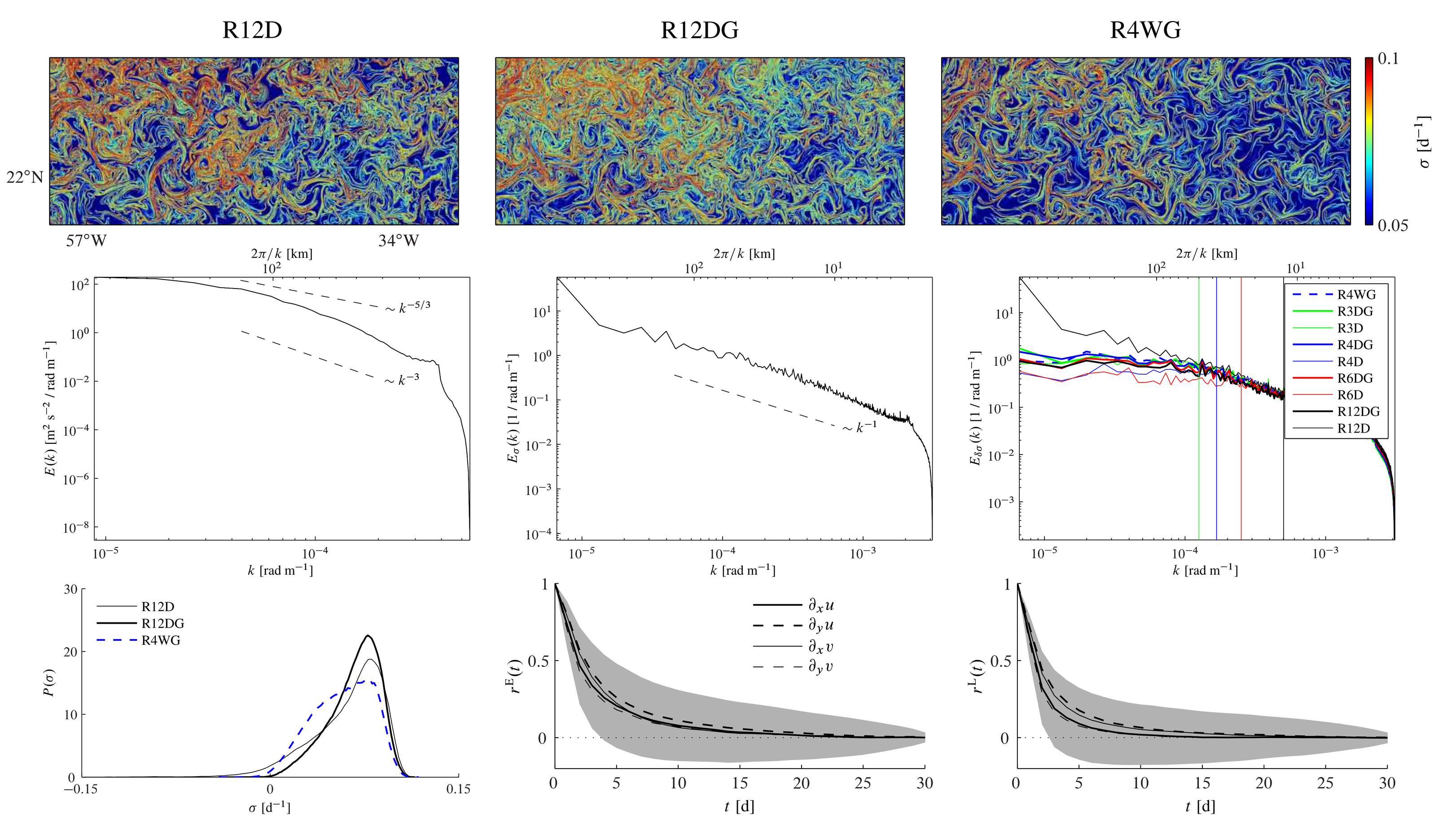

Figure 3. As in the previous figure, but for NAC.

NBC

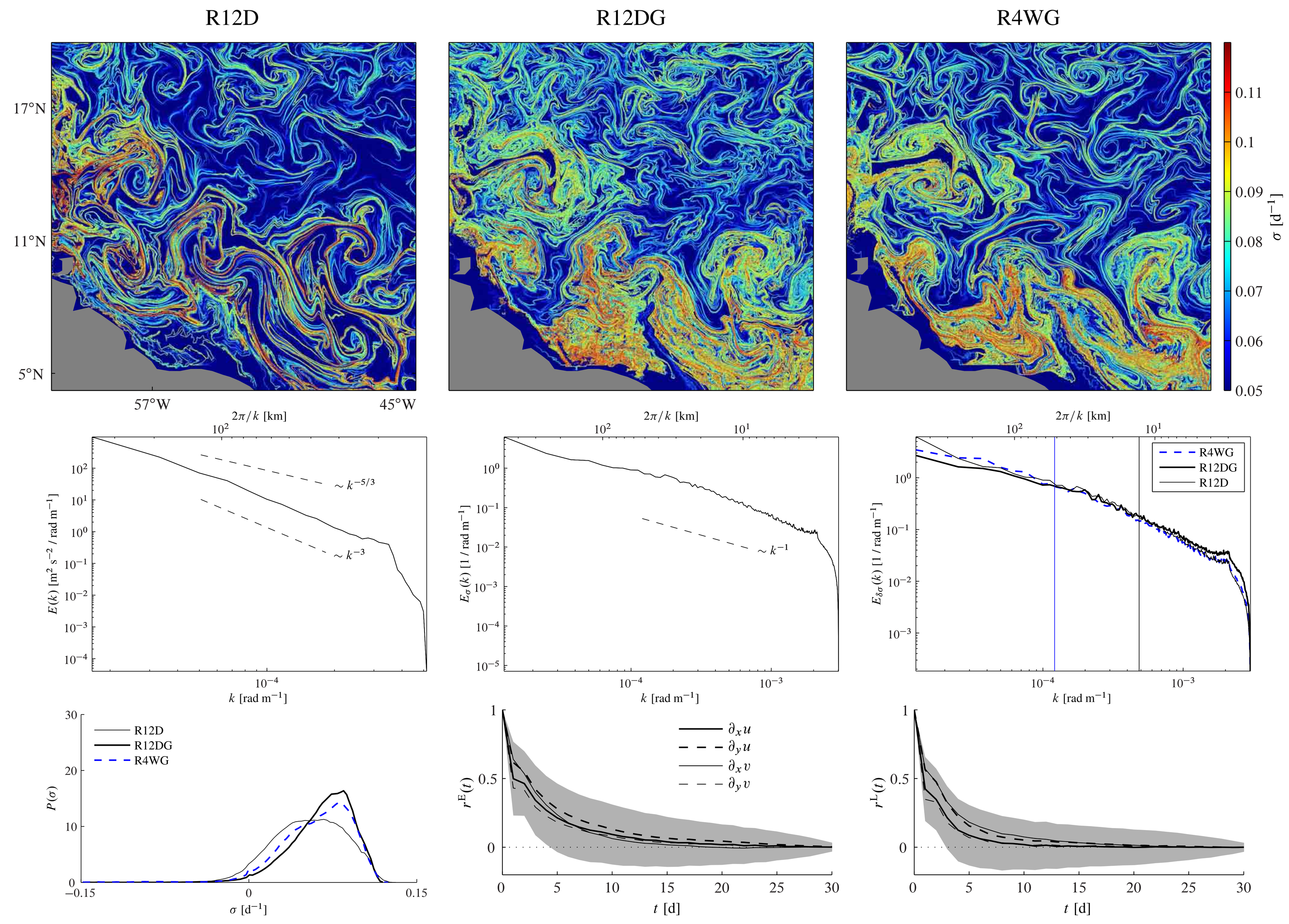

Figure 4. As in the previous figures, but for NBC.

GSE

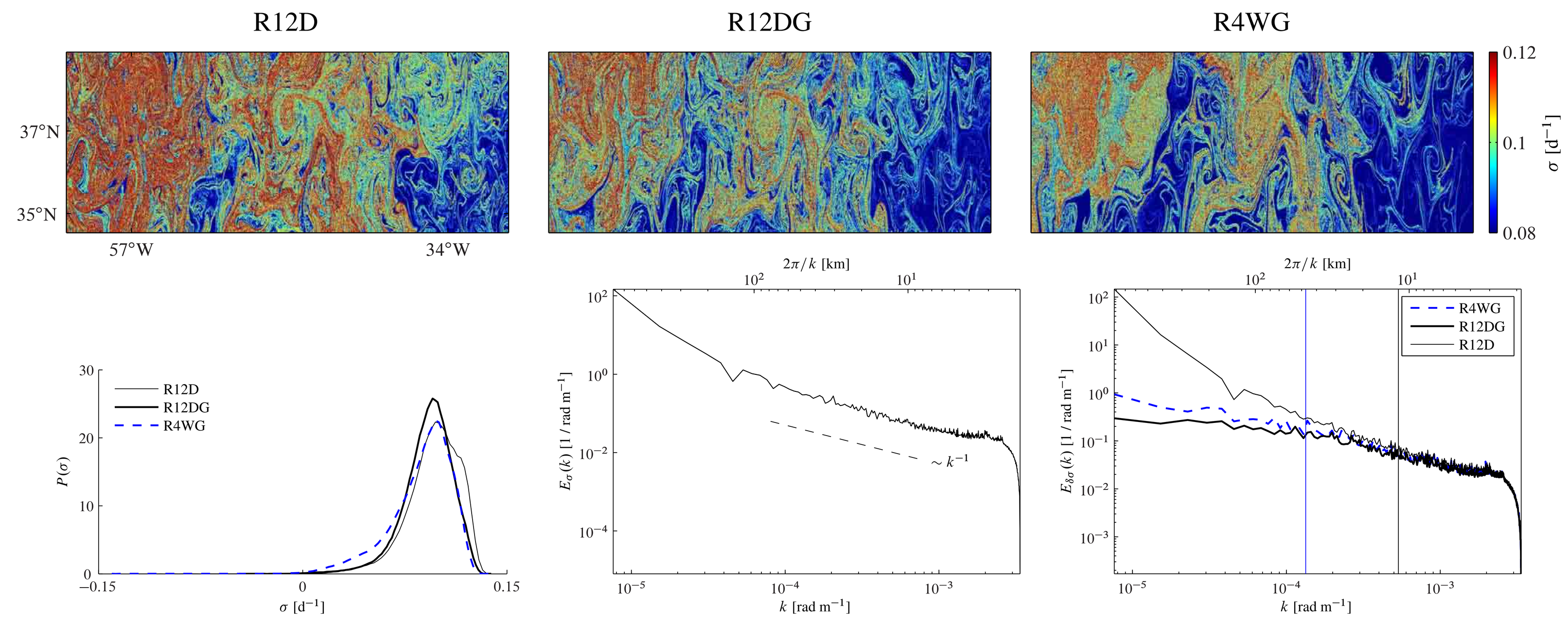

Figure 5. Similar to previous figures, but for GSE.

GM

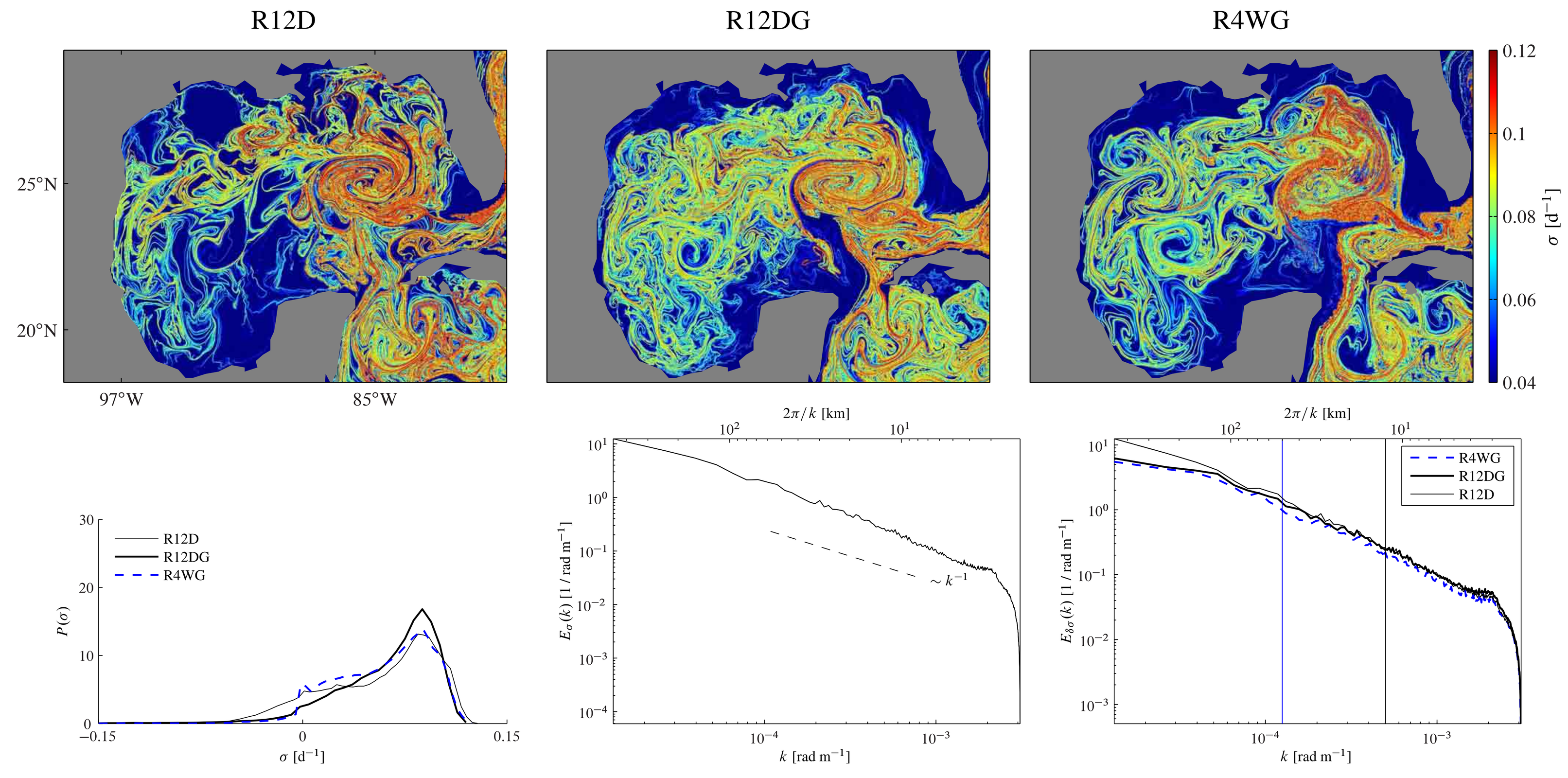

Figure 6. Similar to previous figures, but for GSE.

Preliminary conclusions

The Lagrangian surface ocean circulation within the regions so far analyzed appears to lie in the margin between spectrally local (or turbulent mixing) and spectrally nonlocal (or chaotic mixing) regimes. Tracer evolution on a given scale thus seems to be influenced to a nonneglible extent by velocity details at a comparable scale. As a result, high-resolution wide-swath altimetry has the potential of improving the reliability of tracer calculations below the resolution scale of gridded SSH fields provided by current nadir-looking altimeters. But it must be bear in mind that the degree of reliability of such calculations is hampered by the validity of the geostrophic model applied to the SSH field to estimate the advection field.

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References

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