Transient Attracting Profiles in the Great Pacific Garbage Patch

Luca Kunz[a], Alexa Griesel[a], Carsten Eden[a], Rodrigo Duran[b], Bruno Sainte-Rose[c]
[a]Institute of Oceanography, University of Hamburg, Germany,
[b]Theiss Research, La Jolla CA, USA, [c]The Ocean Cleanup, Rotterdam, The Netherlands

contact: alucakunz@gmail.com

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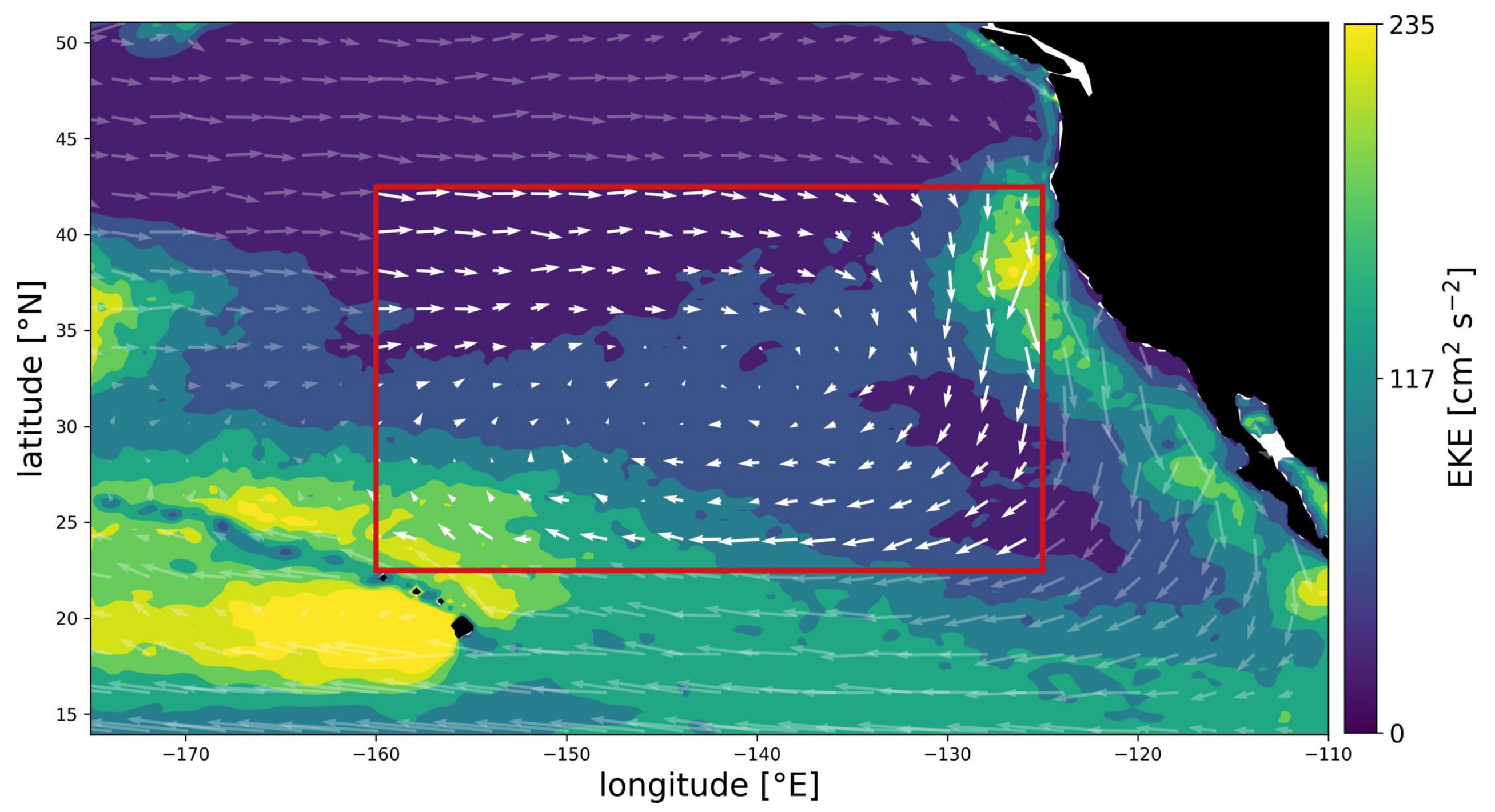
Introduction

TRansient Attracting Profiles[6] (TRAPs) are short-term attractors on the ocean surface and allow to predict pathways of material transport[3,5,6]. We apply this concept to the problem of marine debris and study the characteristics of such hyperbolic structures within the North Pacific subtropical gyre, a large-scale convergence zone that is known to entail the Great Pacific Garbage Patch (GPGP). Image: *Mean geostrophic + Ekman current velocities[1] in the Northeast Pacific, averaged over 2000-2019.* *The colourmap indicates the eddy kinetic energy (EKE) w.r.t. the same period. Study domain highlighted in red.*



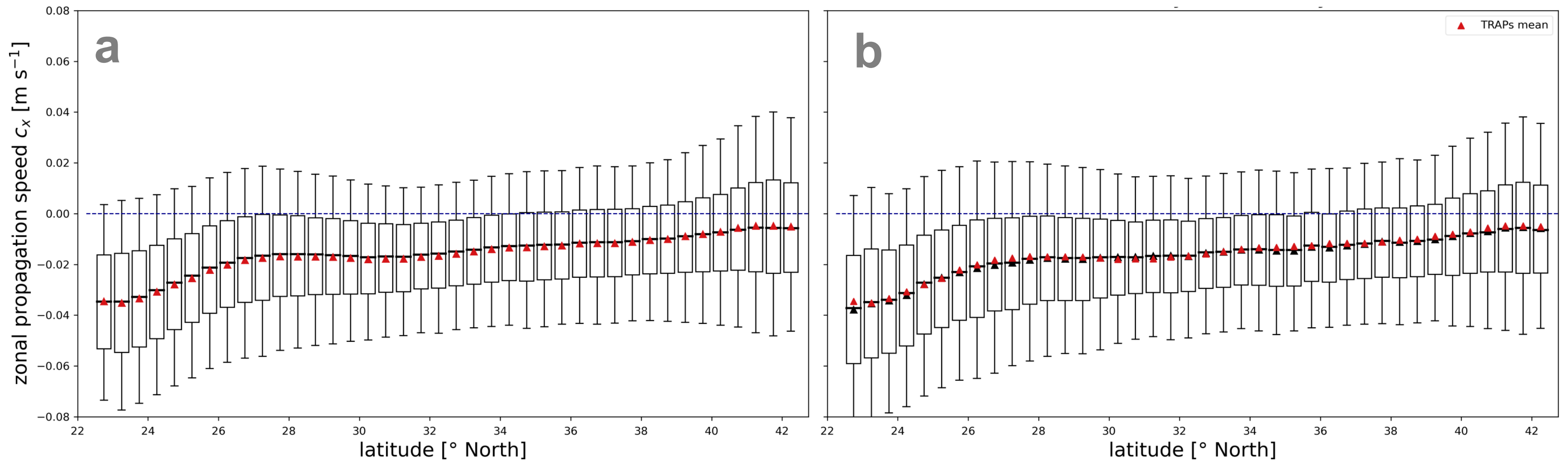
Methods

TRAPs are computed[4] from snapshots of near-surface geostrophic velocity[2]. They represent local minima of the smaller Eigenvalue field s_1 of the rate-of-strain tensor and are at every point tangent to the unit eigenvector field e_2, indicating directions of maximal stretching. We study TRAPs in the GPGP for the period 2000-2019 and find **4,537,424 TRAP objects** from which we identify **646,223 trajectories**. For every TRAP, we estimate the

- translation speed and compare it to the propagation of mesoscale eddies[7]
- lifetime Λ
- strongest attraction $\breve{s}_1$ along its trajectory
- duration λ of hyperbolic drifter[4] motion around the structure

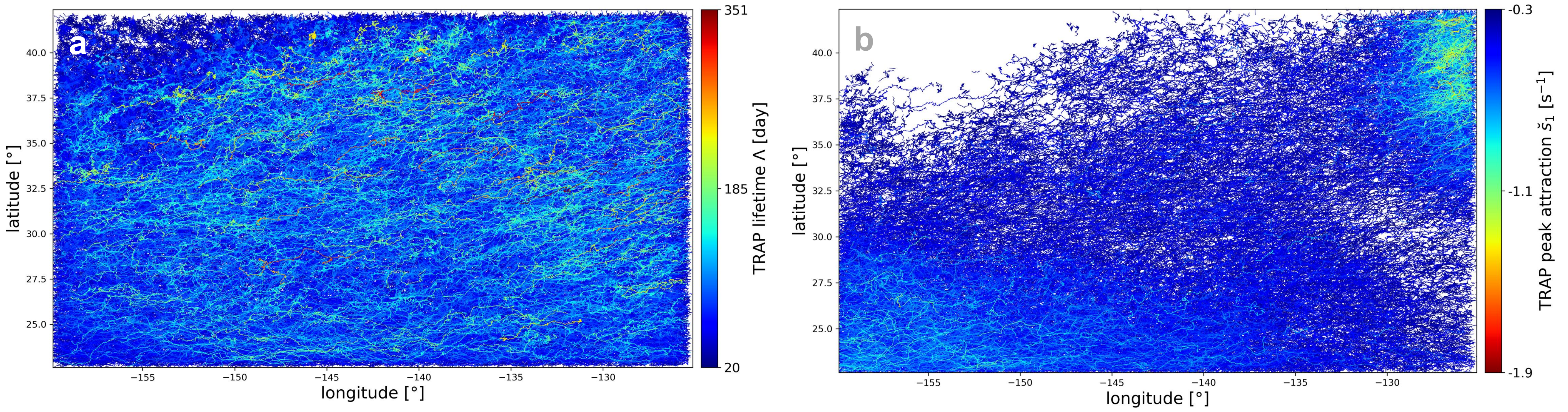
Propagation

The zonal propagation speeds of TRAPs and of mesoscale eddies coincide. Image: *Latitudinal distribution of zonal propagation speeds for a) 3,570,329 TRAP and b) 1,286,131 mesoscale eddy[7] instances in the domain. Values are allocated to 0.5° bins in form of box-whisker-plots.*



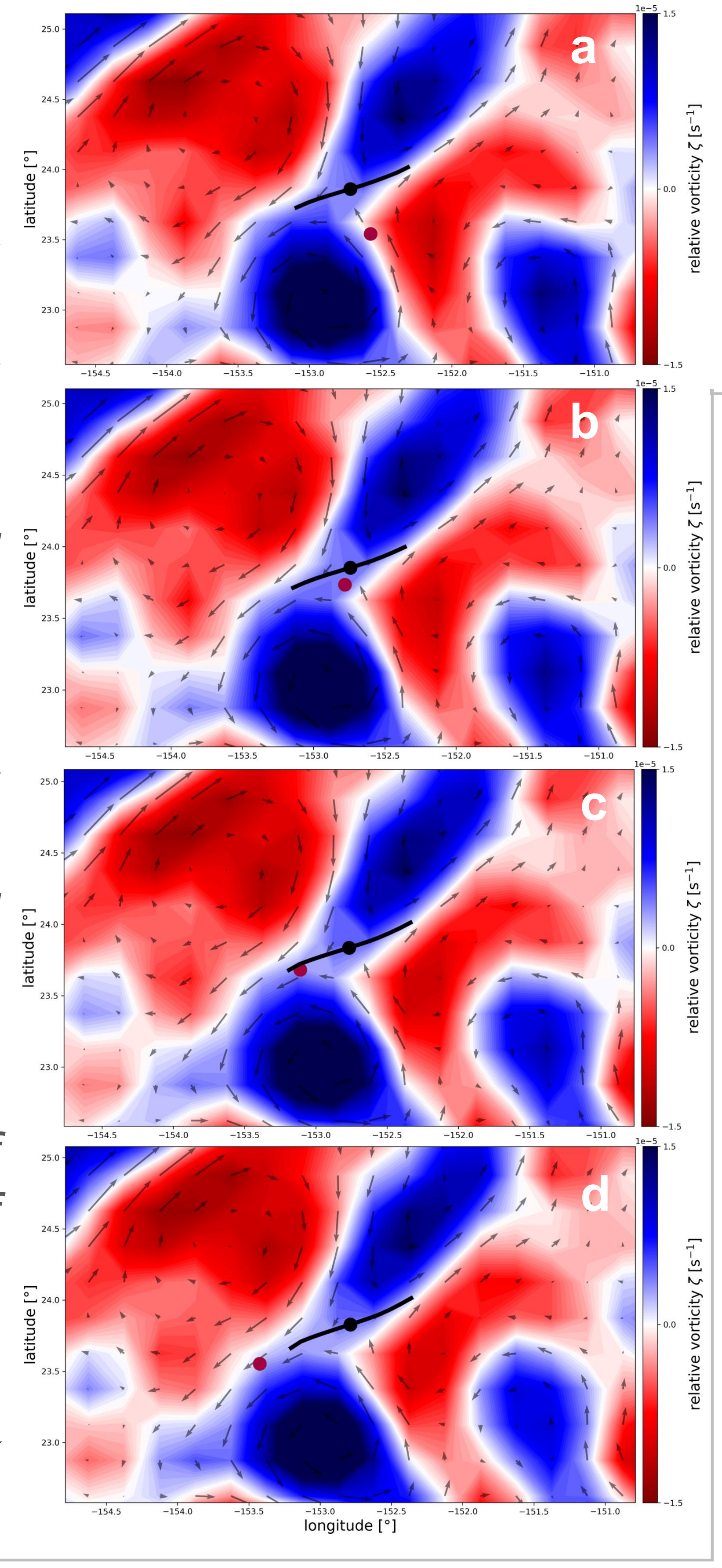
Trajectories

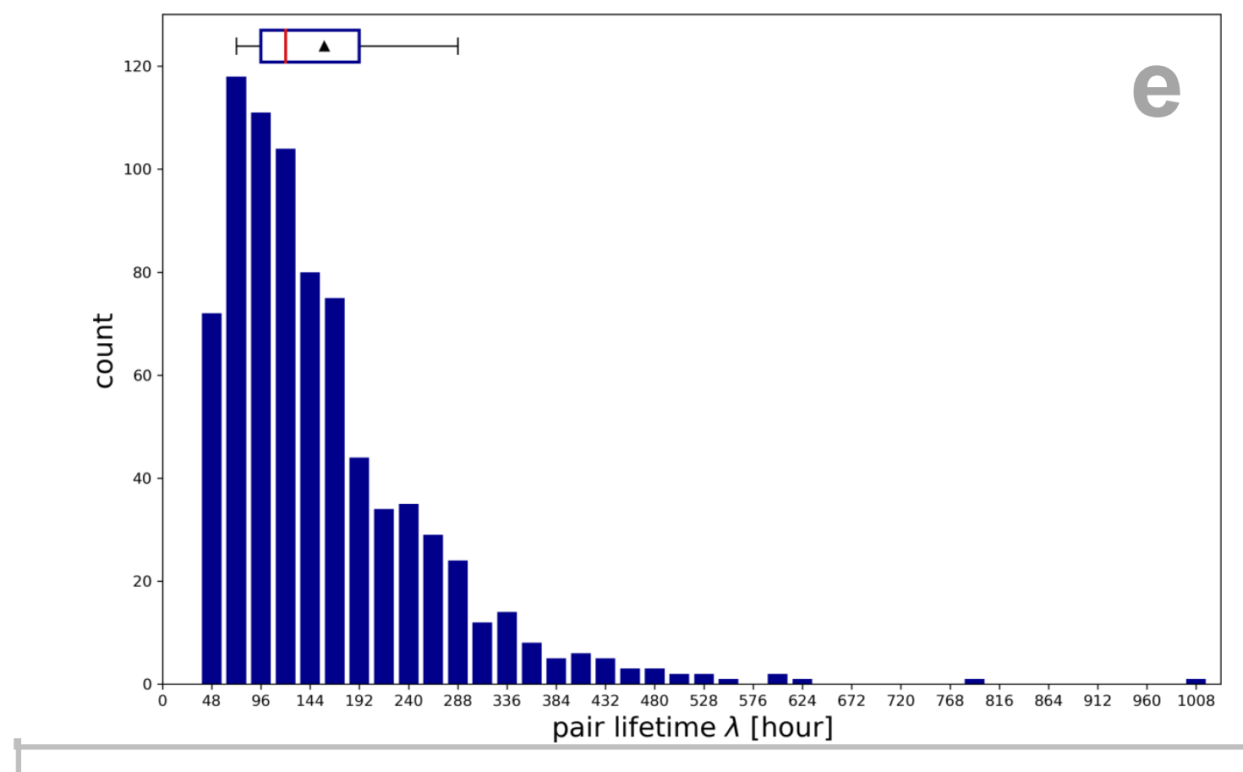
Strong TRAPs primarily form in regions of high EKE, weak and ephemeral ones in regions of low EKE. On average, TRAPs exist for 7 days with lifetimes reaching up to 351 days. Image: *Trajectories of the 65,000 a) most persistent and b) strongest TRAPs in the domain. Trajectories are coloured by the associated TRAP lifetime Λ and peak attraction $\breve{s}_1$.*



Impact on drifters

We find 792 (1,824) encounters for which a drogued (undrogued) drifter moves hyperbolically around a TRAP, the mean duration for this hyperbolic transport is around 7 days (5 days). Image: a) to d) *Observed hyperbolic transport around a TRAP. Panels show in chronological order how a drifter (purple dot) is attracted perpendicular towards a TRAP and then transported along it. Quivers indicate the geostrophic surface velocity, the colourmap the relative vorticity field. e) Distribution of the estimated duration λ of hyperbolic drifter motion around TRAPs for 792 drifter-TRAP pairs with drogue. The mean is indicated by a black triangle.*





Conclusion

TRAPs origin from strain between mesoscale vortices, show propagation characteristics similar to mesoscale eddies and organise hyperbolic transport of both drogued and undrogued drifters.

References: **[1]** CMEMS. Global total surface and 15m current (copernicus-globcurrent) from altimetric geostrophic current and modeled ekman current reprocessing. E.U. Copernicus Marine Environment Monitoring Service, 2022b. doi: 10.48670/moi-00050. **[2]** CMEMS. Global ocean gridded l 4 sea surface heights and derived variables reprocessed 1993 ongoing. E.U. Copernicus Marine Environment Monitoring Service, 2022c. doi: 10.48670/moi-00148. **[3]** R. Duran, T. Nordam, M. Serra, and C. Barker. Horizontal transport in oil-spill modeling, pages 59–96. Elsevier, 08 2021. ISBN 9780128193549. doi: 10.1016/B978-0-12-819354-9.00004-1. **[4]** NOAA. Global drifter program drifter data, 2022. URL https://www.aoml.noaa.gov/phod/gdp/data.php. Last visited 2022-12-15. **[1]** M. Serra. Compute transient attracting profiles (traps), 2020. URL https://github.com/MattiaSerra/TRAPs. Last visited 2022-12-15. **[5]** M. Serra and G. Haller. Objective eulerian coherent structures. Chaos: An Interdisciplinary Journal of Nonlinear Science, 26(5):053110, 2016. doi: 10.1063/1.4951720. **[6]** M. Serra, P. Sathe, I. Rypina, A. Kirincich, S. D. Ross, P. Lermusiaux, A. Allen, T. Peacock, and G. Haller. Search and rescue at sea aided by hidden flow structures. Nature Communications, 11(1), 2020. ISSN 20411723. doi: 10.1038/s41467-020-16281-x. **[7]** SSALTO/DUACS/AVISO+/CNES/IMEDEA. The altimetric Mesoscale Eddy Trajectories Atlas (META3.2 DT allsat version). doi: 10.24400/527896/a01-2022.005.220209.