The Journal of Open Source Software

FlowSieve: A Coarse-Graining Utility for Geophysical Flows on the Sphere

Benjamin A. Storer[1] **and Hussein Aluie**[1¶]

1 University of Rochester, USA ¶ Corresponding author

DOI: 10.xxxxxx/draft

Software

- Review
- Repository
- Archive

Editor: Kristen Thyng

Reviewers:

- @noraloose
- @kris-rowe

Submitted: 11 March 2022
Published: unpublished

Summary

Ocean and atmosphere dynamics span an incredibly wide range of spatial and temporal scales, with spatial scales ranging from the sub-millimetre viscous scales all the way up to planetary scales at tens of thousands of kilometres. Because of the strong non-linear nature of oceanic and atmospheric flows, not only do the behaviour and characteristics change significantly with scale, but important energetic interactions exist between different scales. As a result, an important step in understanding and predicting the behaviour of such complex flow systems is being able to disentangle the complex interactions across this wide range of scales. Coarse-graining is a physically-motivated and mathematically-rigorous technique for partitioning spatial flows as a function of a specified partitioning scale, allowing for a consistent and comprehensive scale-by-scale analysis.

Statement of need

Aluie et al. (2018) demonstrated how, when applied appropriately, coarse-graining can not only be applied in a data-processing sense, but also to the governing equations. This provides a physically meaningful and mathematically coherent way to quantify not only how much energy is contained in different length scales, but also how much energy is being transferred to different scales.

`FlowSieve` is a heavily-parallelized coarse-graining codebase that provides tools for spatially filtering both scalar fields and vector fields in Cartesian and spherical geometries. Specifically, filtering velocity vector fields on a sphere provides a high-powered tool for scale-decomposing oceanic and atmospheric flows following the mathematical results in Aluie (2019).

`FlowSieve` is designed to work in high-performance computing (HPC) environments in order to efficiently analyse large oceanic and atmospheric datasets, and extract scientifically meaningful diagnostics, including scale-wise energy content and energy transfer.

Acknowledgements

We would like to thank Mahmoud Sadek, Shikhar Rai, Michele Buzzicotti, Hemant Khatri, Stephen Griffies, for valuable feedback in developing FlowSieve.

Development of FlowSieve was financially supported by US NASA grant 80NSSC18K0772 and NSF grant OCE-2123496.

References

Aluie, H. (2019). Convolutions on the sphere: commutation with differential operators.

GEM - International Journal on Geomathematics, *10*(1), 9. https://doi.org/10.1007/s13137-019-0123-9

Aluie, H., Hecht, M., & Vallis, G. K. (2018). Mapping the Energy Cascade in the North Atlantic Ocean: The Coarse-graining Approach. *Journal of Physical Oceanography*, *48*, 225–244. https://doi.org/10.1175/JPO-D-17-0100.1