MULTIFLUX THEORY

Variational Consistency Test of Multiflux Theory v2.0

Eulerian–Lagrangian Integration via Effective Action Analysis
Numerical Results for $N = 256^3$

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Abstract

This report presents a numerical consistency test of Multiflux Theory v2.0 at spatial resolution $N = 256^3$. The analysis evaluates whether the subflux decomposition exhibits statistical alignment with a local effective-action principle, defined as $L = \mathrm{KE} - \mathcal{D}$, where $\mathcal{D}$ denotes viscous dissipation. The results show that dominant subfluxes systematically display lower relative dissipation and higher effective action. The effective number of subfluxes remains stable at $N_{\text{eff}} = 12$, confirming robustness across clustering regularizations. These findings support the internal consistency of the v2.0 variational formulation, without claiming a full variational derivation of the Navier–Stokes equations.

Key Numerical Findings

- Stable decomposition with $N_{\text{eff}} = 12$ (volume cutoff $> 0.5\%$).
- Negative correlation between subflux volume and dissipation.
- Positive correlation between subflux volume and effective action.

- Results remain consistent under Voronoi spatial regularization and Bayesian assignment smoothing.

Methodological Notes

The velocity field corresponds to a homogeneous isotropic turbulent realization. Subflux identification is performed using invariant-based features, followed by:

- Voronoi spatial regularization to enforce geometric coherence.
- Bayesian post-processing to stabilize cluster assignments.

These steps act purely as statistical regularization tools and do not introduce additional physical modeling or closure assumptions.

Figures

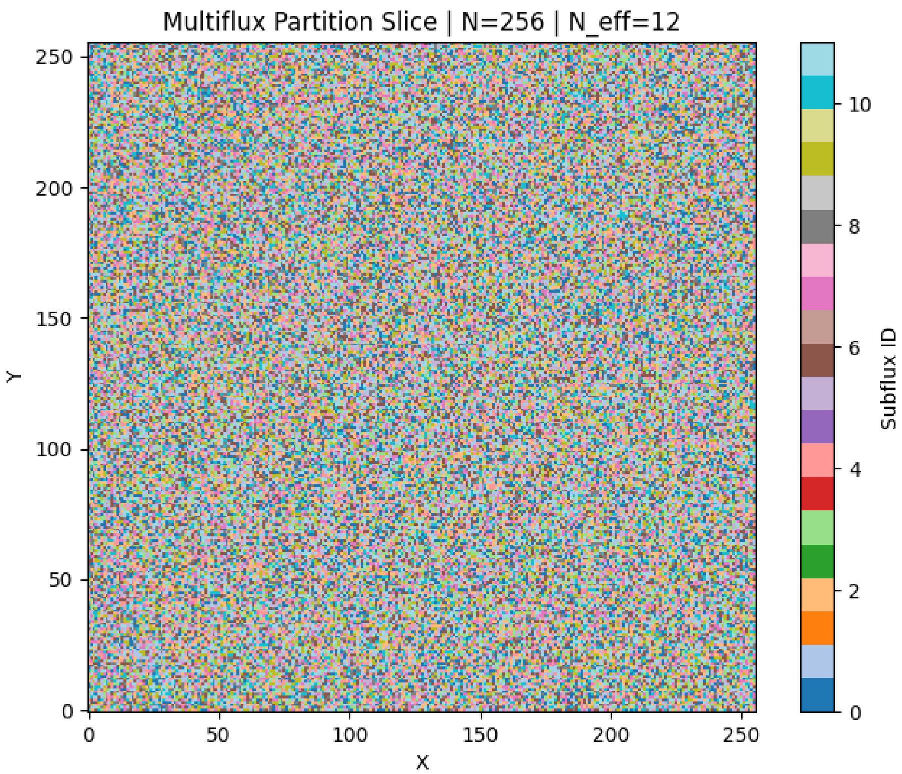

Figure 1: Multiflux partition slice at z = const for $N = 256$. Twelve coherent subflux regions are observed, with smooth spatial interfaces after Voronoi–Bayes regularization.

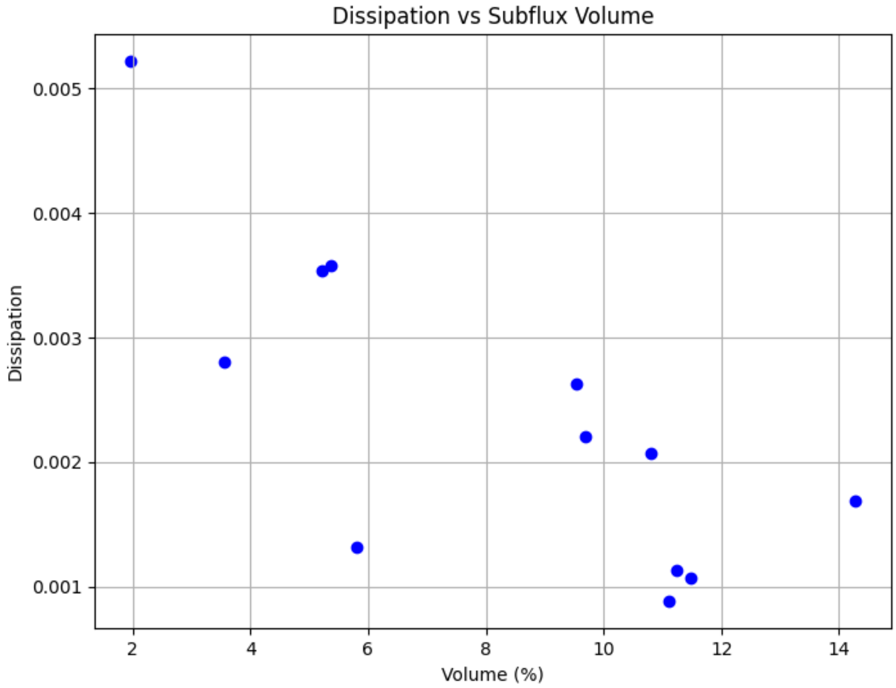

Figure 2: Average dissipation versus subflux volume fraction. A clear negative correlation is observed, indicating that larger subfluxes exhibit lower dissipation rates.

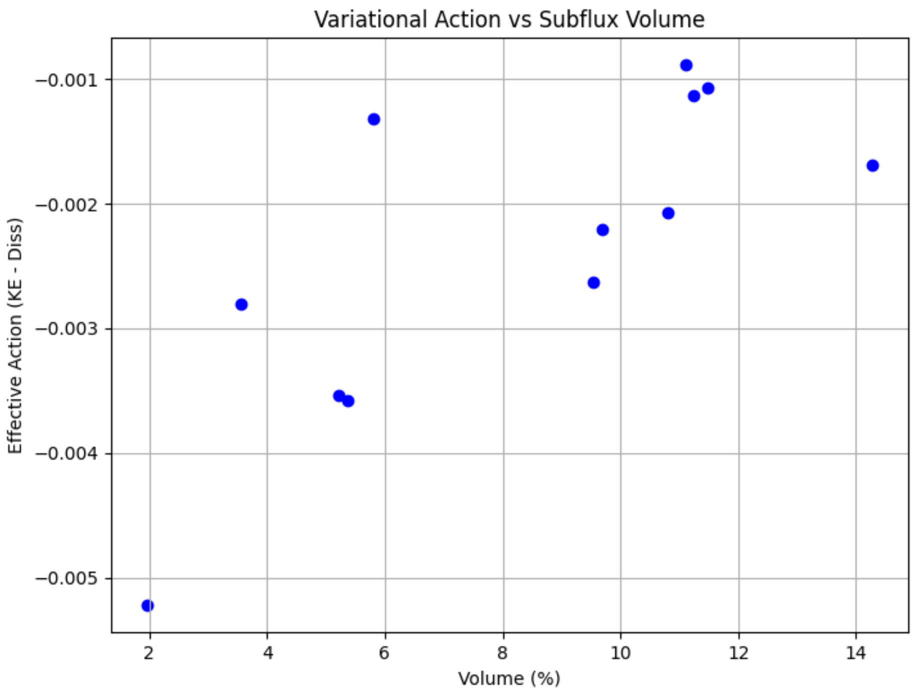

Figure 3: Effective action $L = \mathrm{KE} - \mathcal{D}$ versus subflux volume fraction. Dominant subfluxes show systematically higher (less negative) effective action values.

Effective Action per Subflux ($N = 256^3$, Top 12)

Subflux ID	Volume Fraction	KE	Dissipation	L_{eff}	Volume (%)
10	0.1427	4.13e-08	0.001693	-0.001693	14.27
0	0.1147	8.78e-08	0.001065	-0.001065	11.47
6	0.1123	1.32e-08	0.001128	-0.001128	11.23
2	0.1110	4.15e-08	0.000883	-0.000883	11.10
8	0.1080	8.95e-08	0.002075	-0.002075	10.80
7	0.0969	1.34e-08	0.002203	-0.002203	9.69
1	0.0954	4.40e-08	0.002625	-0.002625	9.54
3	0.0580	1.72e-07	0.001313	-0.001313	5.80
11	0.0536	2.06e-08	0.003575	-0.003575	5.36
5	0.0521	8.25e-08	0.003534	-0.003534	5.21
9	0.0356	1.67e-07	0.002800	-0.002800	3.56
4	0.0197	5.52e-08	0.005220	-0.005220	1.97

Interpretation

The numerical results indicate a consistent tendency for dominant subfluxes to minimize dissipation relative to their volume, resulting in higher effective action. This behavior is statistically robust under changes in clustering regularization and supports the internal coherence of the Multiflux v2.0 framework. The findings should be interpreted as numerical consistency evidence, not as a formal variational derivation.

Repository and Reproducibility

All scripts, notebooks, figures, and tables are publicly available at: https://github.com/meshwave65/Multiflow-Turbulence

Conclusion

The $N = 256^3$ simulation confirms that the Multiflux v2.0 decomposition exhibits stable, reproducible correlations between subflux volume, dissipation, and effective action. These results justify further investigation at higher resolutions and with external DNS datasets.