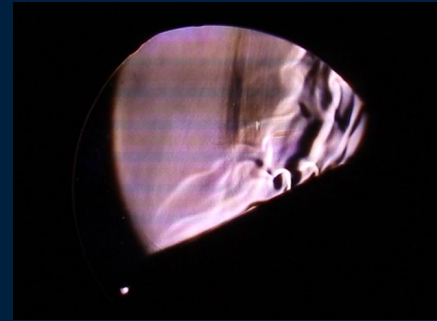


Schlieren Image Velocimetry: Illustration of Quantitative Results

Experiment: Fluid Visualization
Siddharth Sharma

Case: Horizontally Oriented Flat Plate Low Temperature



Post Processing and Velocity Extraction – Background



Objective: Enhance Schlieren video data to extract accurate, quantitative velocity fields from subtle refractive index gradients in low-temperature convection.

Post-Processing Workflow:

- Developed a series of custom scripts (PS1–PS5) to evaluate different filtering strategies.
- Applied methods including wavelet denoising, Fourier-domain streak filtering, Gaussian smoothing, and frame blending.
- Background subtraction was standardized using a 50-frame median to isolate dynamic features from static optical noise.
- Velocities were extracted by tracking the motion of thermal plumes across frames using centroid-based detection and displacement analysis.

Scripts with minimal filtering (e.g., PS1, PS5) were more sensitive to noise but preserved fine-scale features, while those with stronger filtering (e.g., PS4) offered smoother fields and more robust centroid detection at the cost of temporal sharpness. Optimizing these parameters was key to accurately resolving unsteady natural convection structures in the Schlieren dataset.

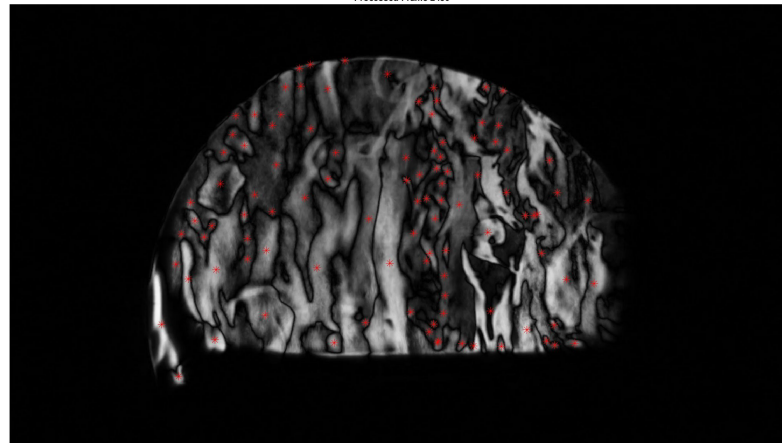
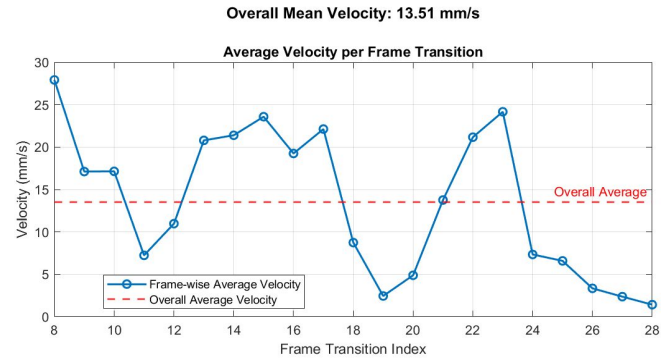
Filtering:

Feature	PS1	PS2	PS3	PS4	PS5
Filtering Method	Optional Wavelet denoising	Fourier-domain Streak Filtering	Fourier-domain Streak Filtering	Fourier-domain Streak Filtering	Fourier-domain Streak Filtering
Blending of Processed Frames	None	Balanced (50-50)	Balanced (50-50)	Weighted (60-40)	None
Gaussian Smoothing	None	0.2	0.2	0.8	2.0
Background Estimation (Tare)	Median (50 frames)	Median (50 frames)	Median (50 frames)	Median (50 frames)	Median (50 frames)
Tare Sensitivity	High (minimal filtering)	Improved (through balanced blending)	Moderate (same as PS2)	Reduced (due to blending)	Higher (no blending)
Tracking Initialization	First detected frame	First detected frame	First detected frame	First detected frame (initial)	Always frame 1



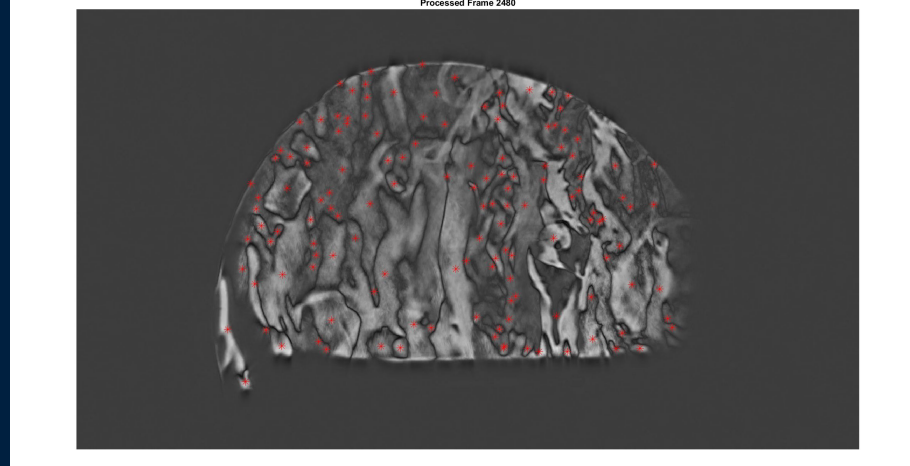
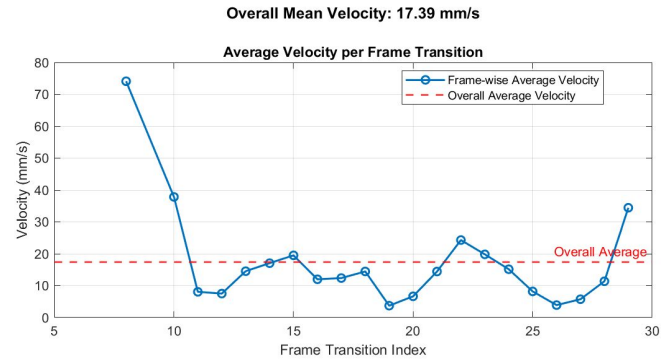
PS1

	FrameTransitionIndex	Velocity_mm_s
1	8	27.9138
2	9	17.1180
3	10	17.1396
4	11	7.2367
5	12	10.9752
6	13	20.7912
7	14	21.3911
8	15	23.5810
9	16	19.2474
10	17	22.1235
11	18	8.7416
12	19	2.4485
13	20	4.8851
14	21	13.7584



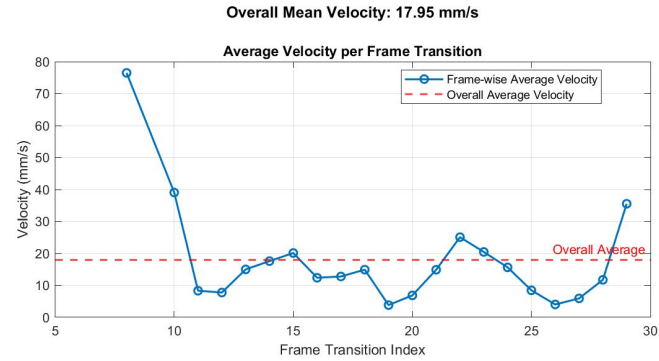
PS2

	FrameTransitionIndex	Velocity_mm_s
1	8	74.1022
2	10	37.8333
3	11	8.0724
4	12	7.5188
5	13	14.5335
6	14	17.0484
7	15	19.5051
8	16	12.0017
9	17	12.3833
10	18	14.4556
11	19	3.7206
12	20	6.6554
13	21	14.4332
14	22	24.3026

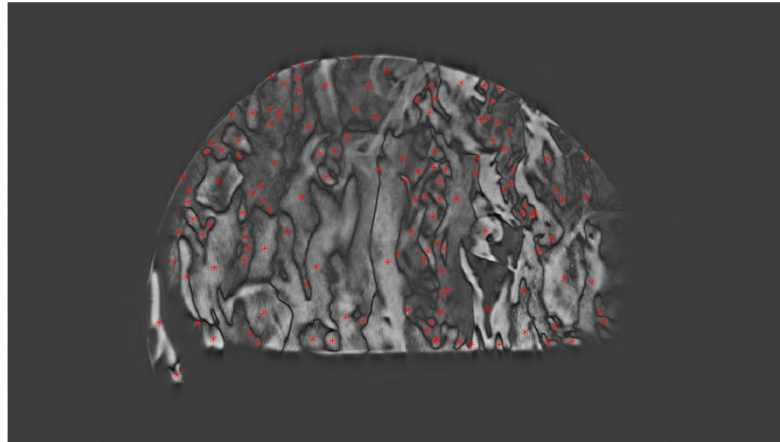


PS3

	FrameTransitionIndex	Velocity_mm_s
1	8	76.4778
2	10	39.0462
3	11	8.3311
4	12	7.7599
5	13	14.9994
6	14	17.5945
7	15	20.1304
8	16	12.3864
9	17	12.7803
10	18	14.9190
11	19	3.8399
12	20	6.8687
13	21	14.8956
14	22	25.0817

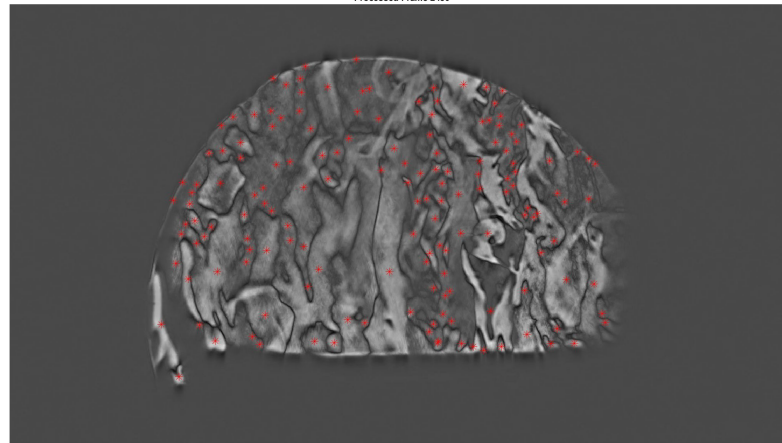
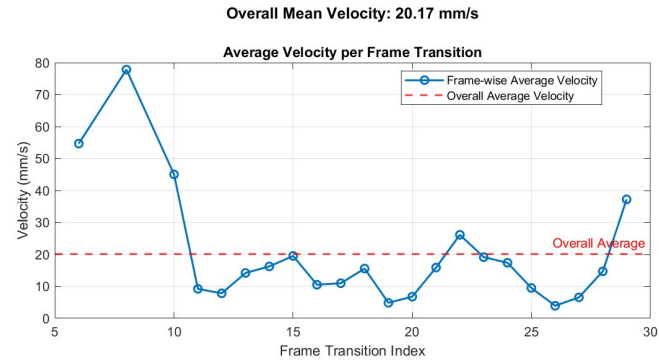


Processed Frame 2480



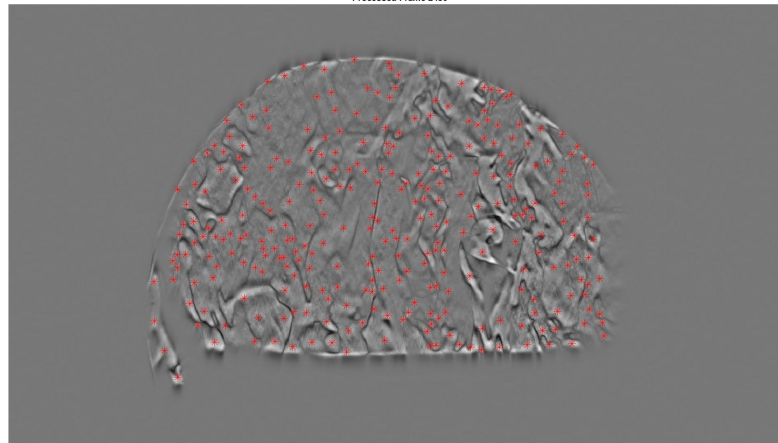
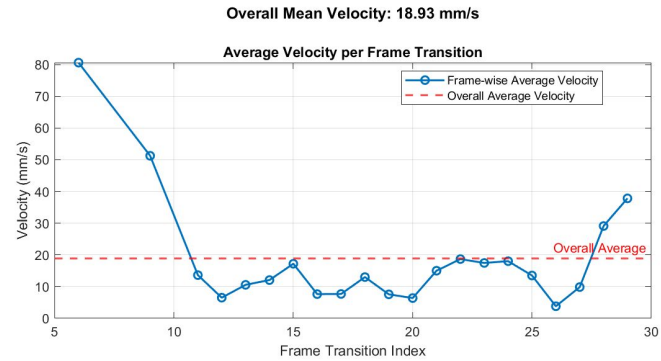
PS4

	FrameTransitionIndex	Velocity_mm_s
1	6	54.6825
2	8	77.8246
3	10	45.0407
4	11	9.2213
5	12	7.8312
6	13	14.1988
7	14	16.2481
8	15	19.5242
9	16	10.5211
10	17	10.9918
11	18	15.5776
12	19	4.8637
13	20	6.7853
14	21	15.8986



PS5

	FrameTransitionIndex	Velocity_mm_s
1	6	80.6237
2	9	51.2563
3	11	13.6296
4	12	6.5148
5	13	10.5661
6	14	12.0735
7	15	17.2192
8	16	7.6438
9	17	7.6832
10	18	13.0097
11	19	7.5666
12	20	6.4011
13	21	15.0197
14	22	18.6808



Discussion:

Quantitative Insights:

- Average plume velocity was successfully extracted using cross-correlation tracking between filtered frames.
- Gaussian smoothing significantly improved centroid continuity but slightly dampened peak velocity magnitudes.
- Script PS3 provided the best balance of noise reduction and temporal accuracy for this specific case.



Filtering Impact:

- Blending and streak filtering reduced false motion artifacts, enhancing tracking precision.
- Over-smoothing (e.g., PS5) led to centroid lag, underestimating peak velocities.
- Monte Carlo simulations validated turbulence intensity measurements, showing robustness against noise-induced variability.

Key Takeaway:

Careful tuning of filtering parameters is critical for extracting accurate velocity data from Schlieren imaging. The selected script enabled reliable quantification of unsteady convective motion, supporting the viability of SIV for low-speed thermal flow analysis.