

Characterizing mixing properties in large rivers based on UAV measured Lagrangian surface flow data

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Motivation

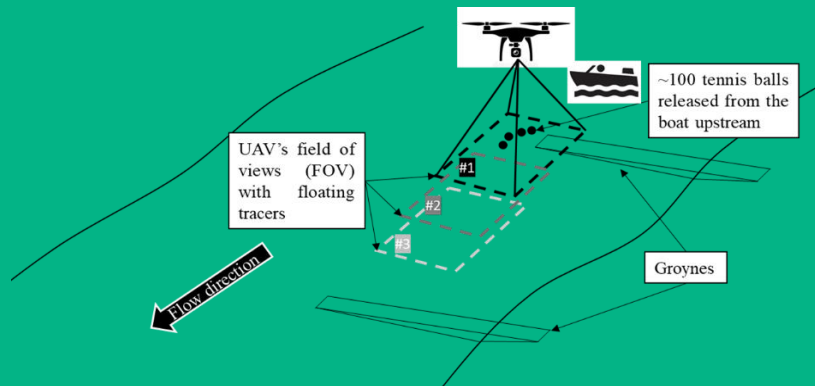
- UAV videos became very popular also in the engineering applications
 - Reasons:
 - Indirect measurements
 - Large spatial coverage possible
 - Low cost
 - Easy to learn
 - Fast technical development
- Tracer velocimetry offers an inherently Lagrangian view of the mixing instead of the traditional Eulerian description
- Previous study with floating buoys

Measurement site and equipments

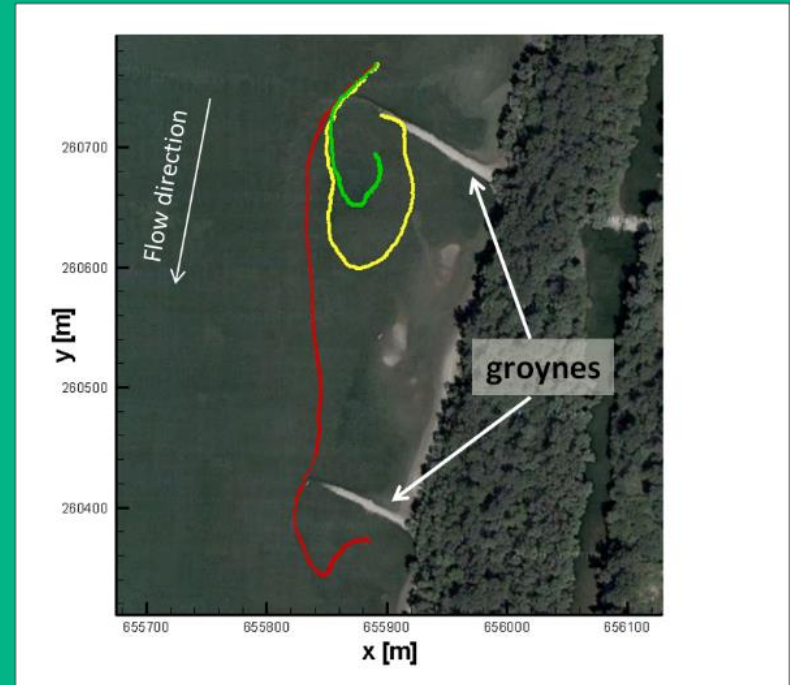
UAV: DJI Phantom 3 Standard



Measurement method:

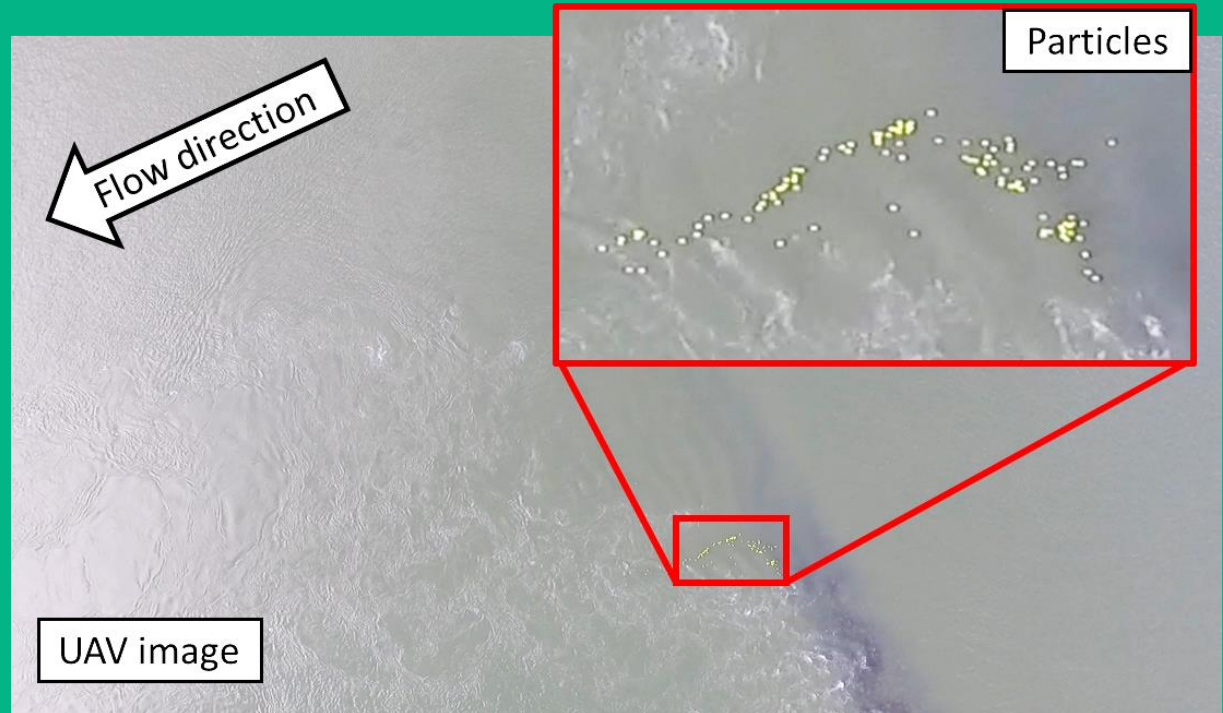
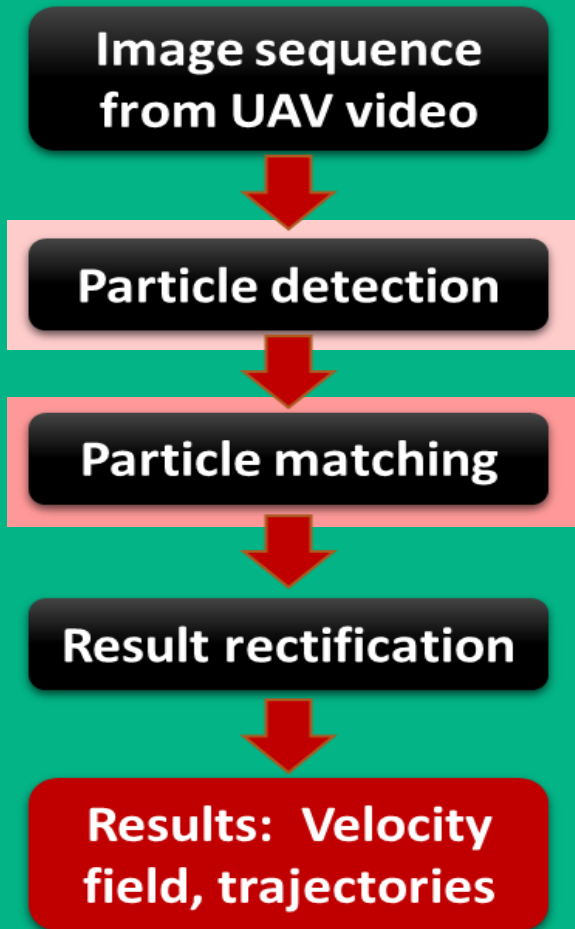


Measurement site: a groyne field
in the River Danube

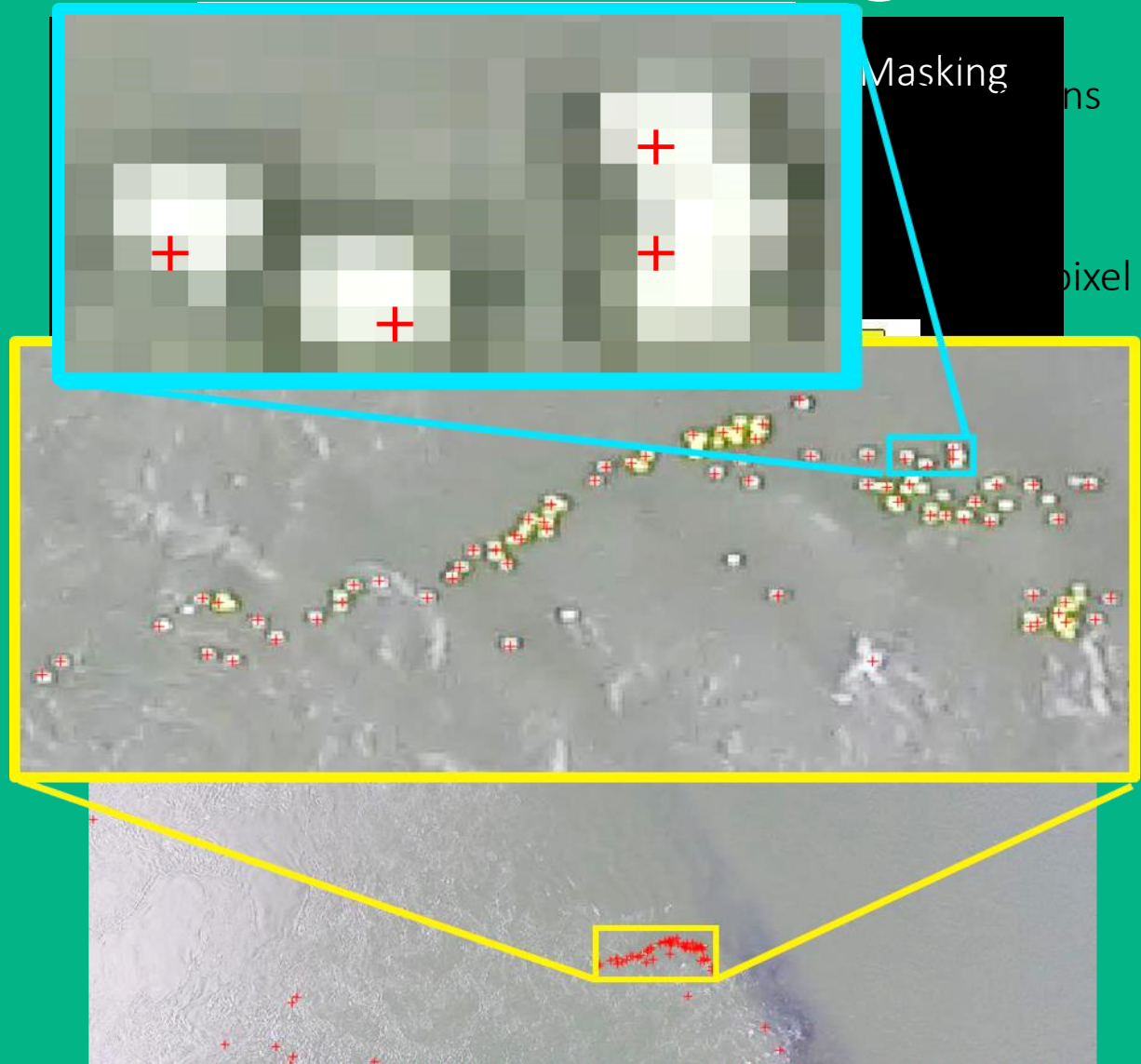
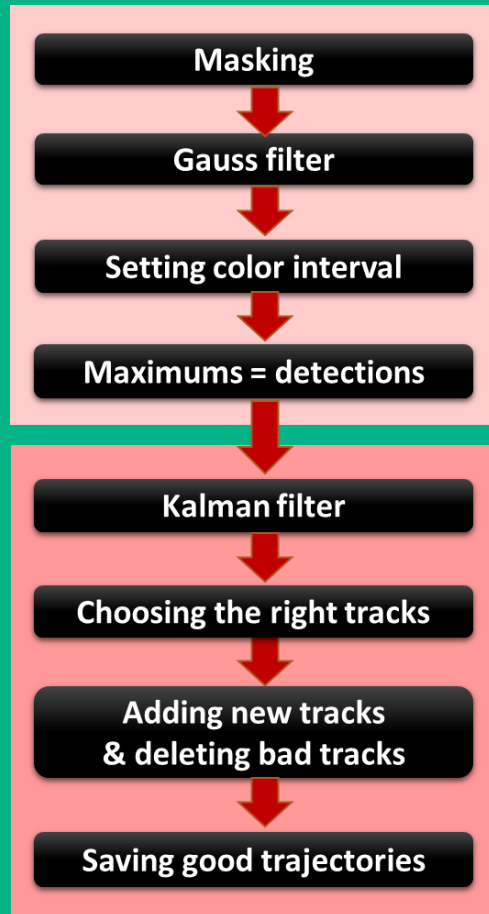


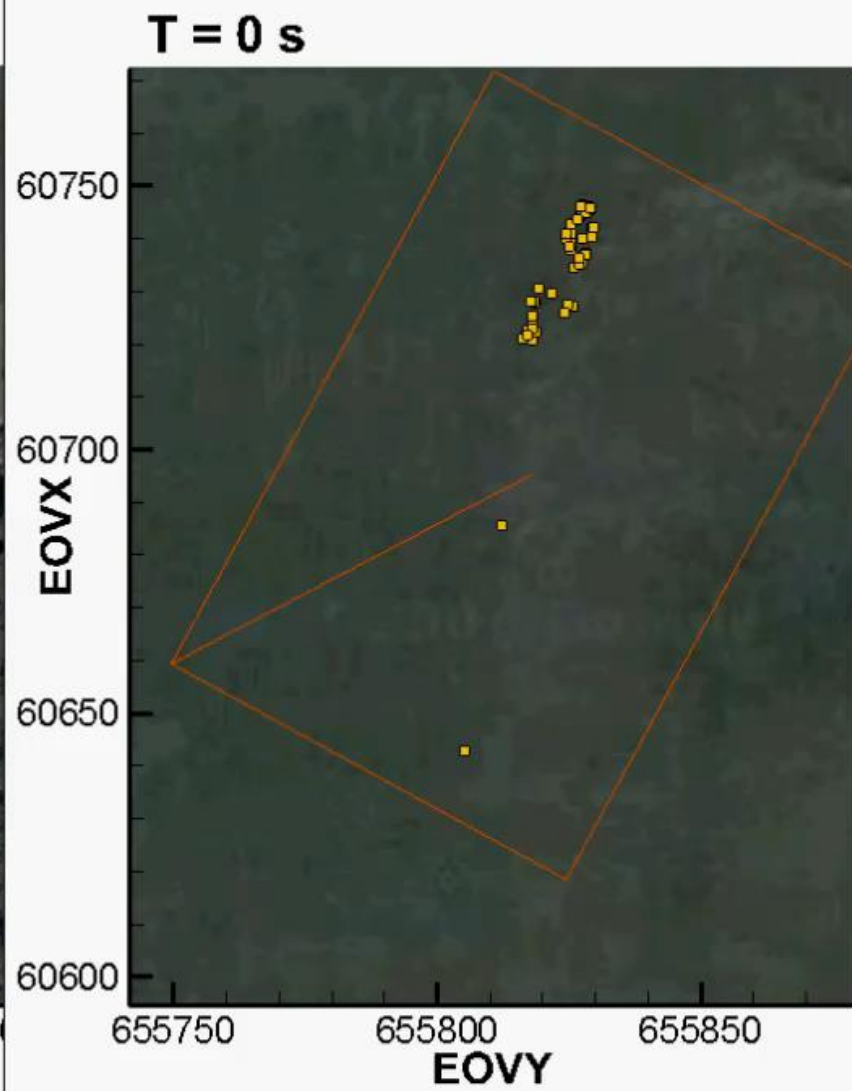
+ Complementary ADCP measurements

Particle Tracking Velocimetry (PTV)



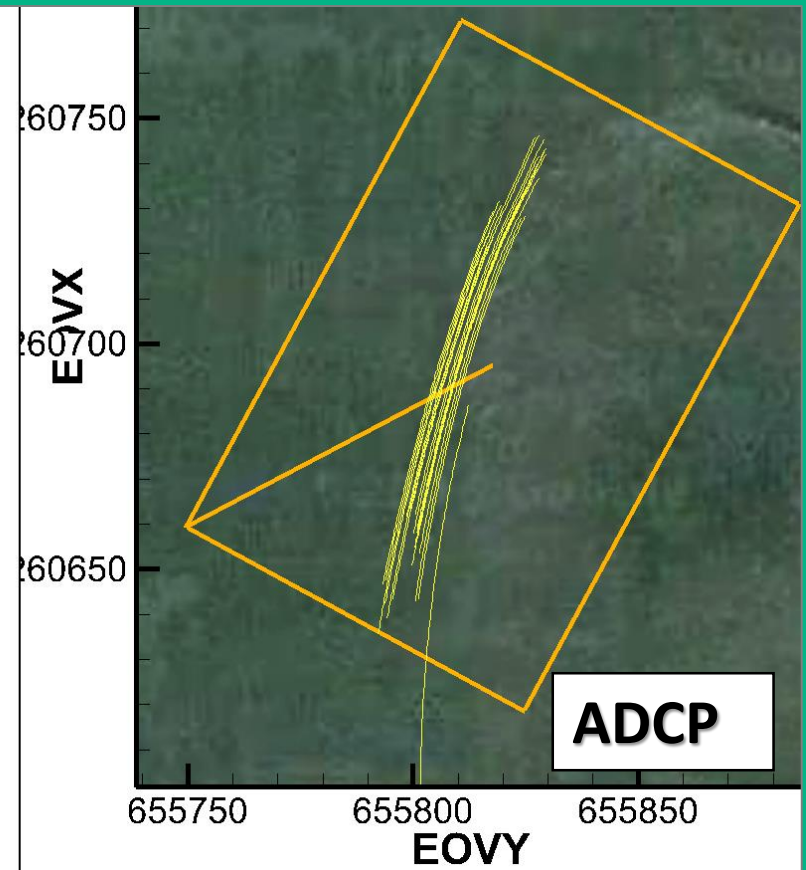
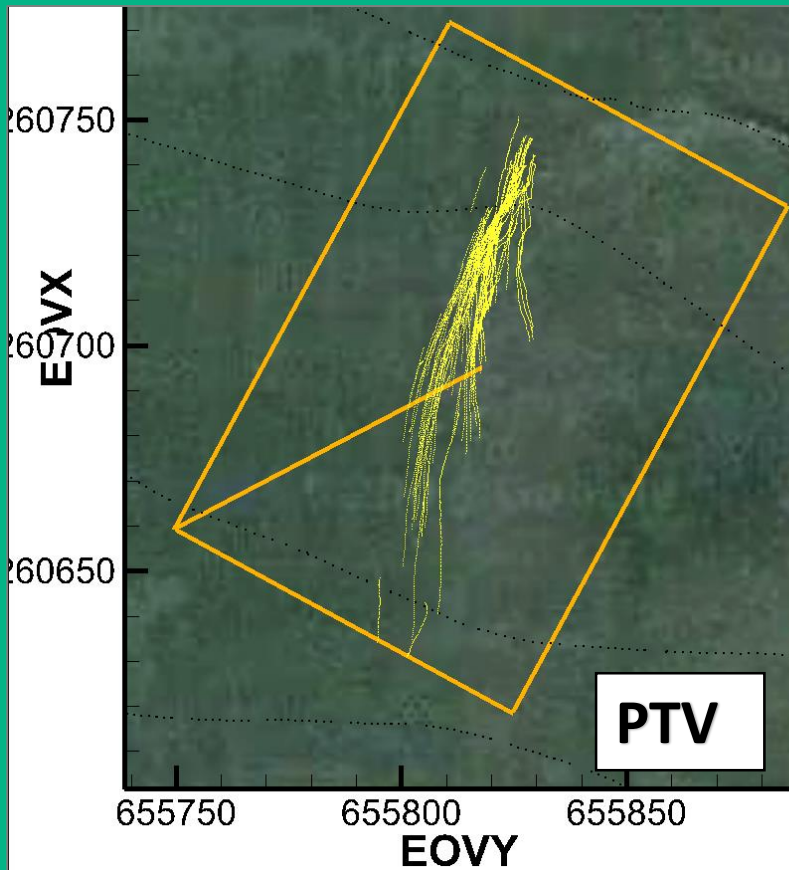
Particle detection and matching



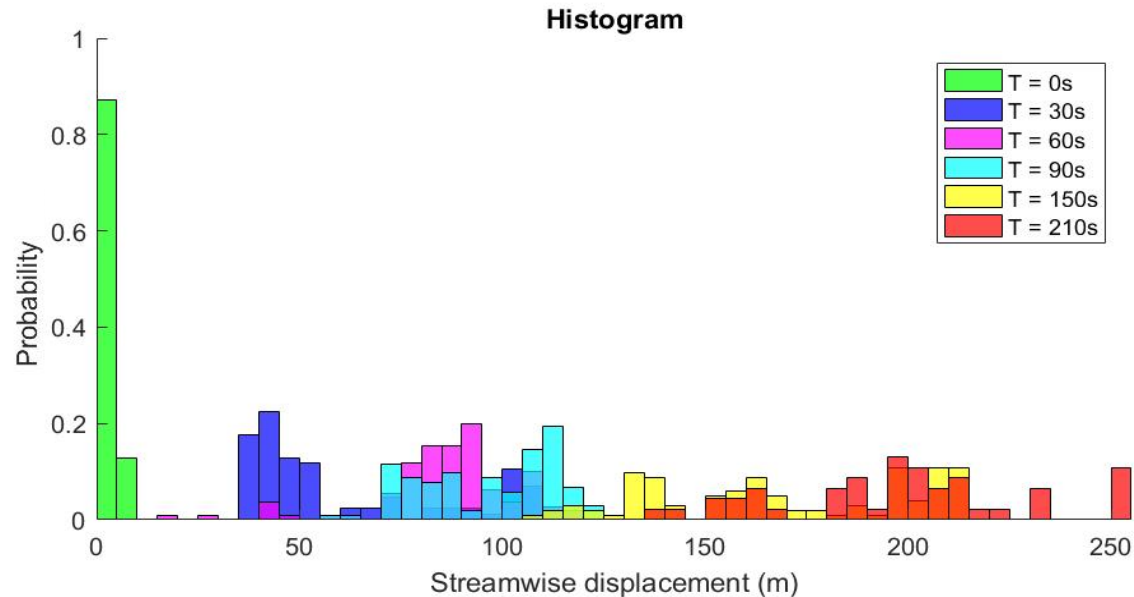
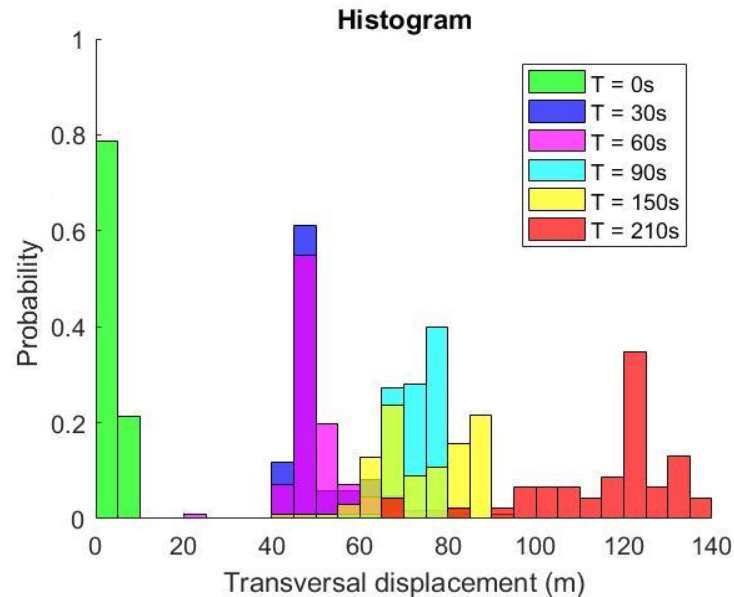


Results – trajectories

- Fine structures visible
- Effects of eddies, crossing trajectories, trapping
- Smooth, permanent behaviour
- Streamlines are nearly parallel



Tracer patch size evolution



Time (T)	0 s	30 s	60 s	90 s	150 s	210 s
Transversal	<10 m	30 m	45 m	50 m	60 m	75 m
Streamwise	<10 m	50 m	75 m	80 m	110 m	>130 m

Local Lyapunov exponents (λ)

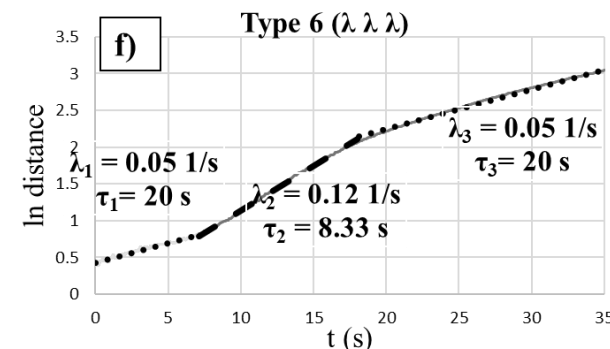
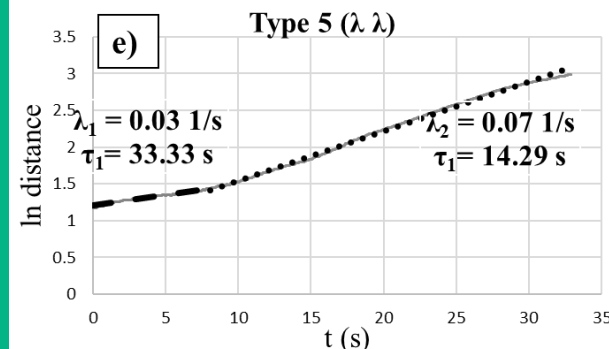
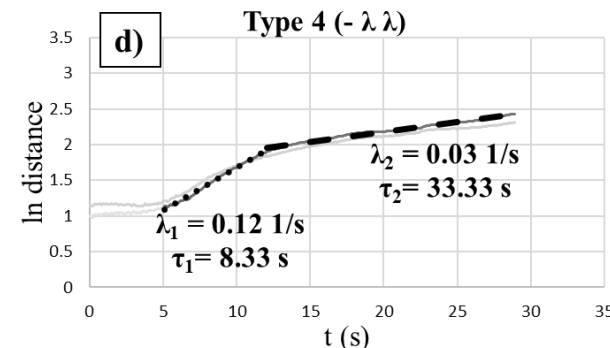
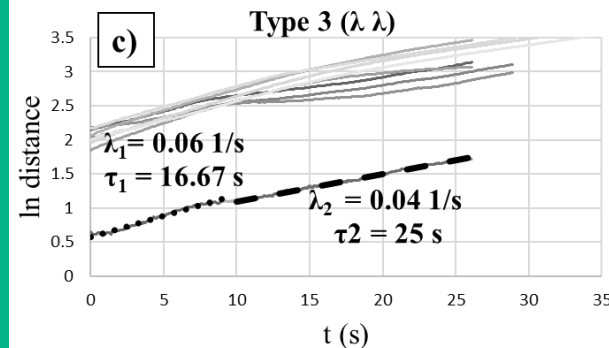
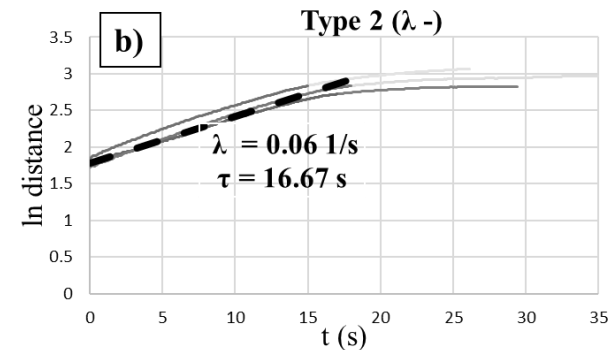
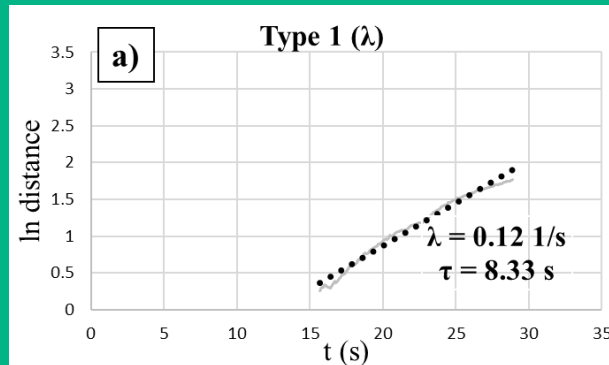
- Measure the rate of the distance evolution between particle pairs

$$\Delta r = \Delta r_0 \cdot e^{\lambda t}$$

- Forecast time: „how long the particles remember to the initial conditions”

$$\tau = \frac{1}{\lambda}$$

- Results are comparable to previous measurements
- More details due to more available pairs



Future plans

The introduced results are just the beginning of this kind of research

- Improved measurements
 - Seeding
 - More spatial coverage
 - Colored balls may enhance the effectiveness of the detection
 - New methods
 - Trajectory network approach
 - Clustering mixing regions