Quantifying Turbulence for Tidal Power Applications

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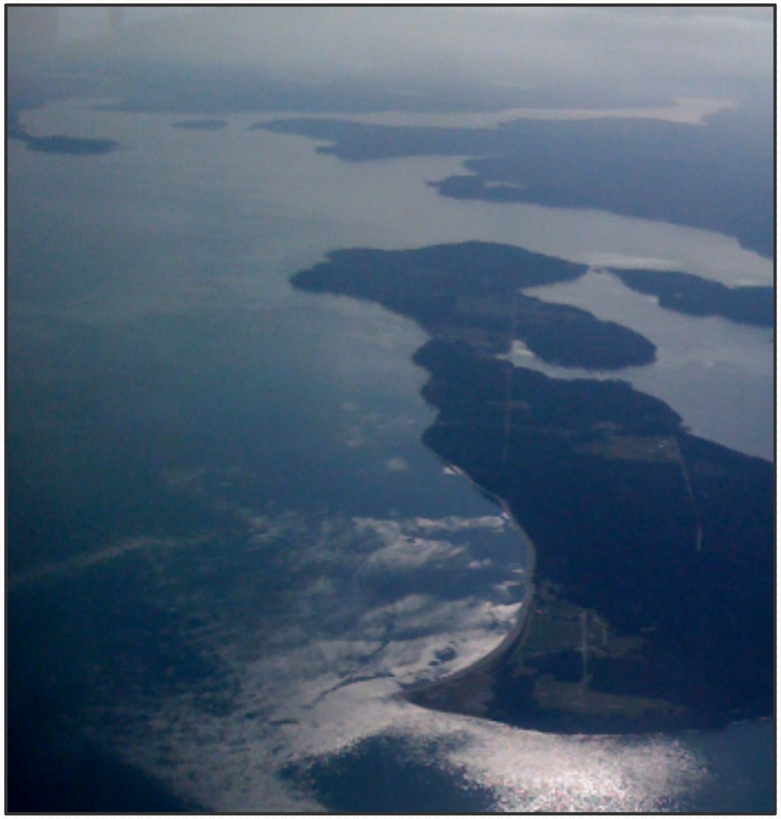
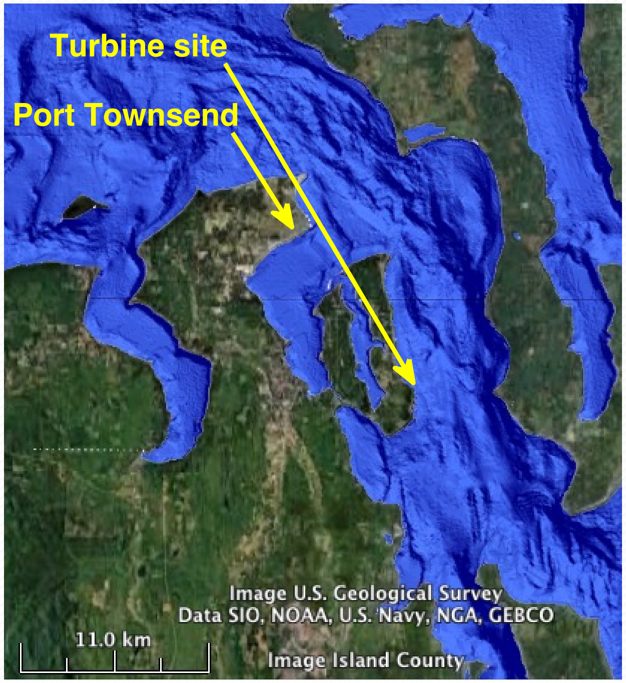
Motivation

- Turbine performance
- Turbine fatigue
- Environmental effects



Objectives

- Field measurements from an actual tidal power site
- Evaluation of metrics:
  - Turbulent intensity, $I = \sigma_v / \langle v \rangle$
  - Turbulent dissipation rate, ε
  - Coherence, $\langle v'_x v_y' \rangle$
- Best practices:
  - Sampling schemes
  - Rigorous treatment of errors



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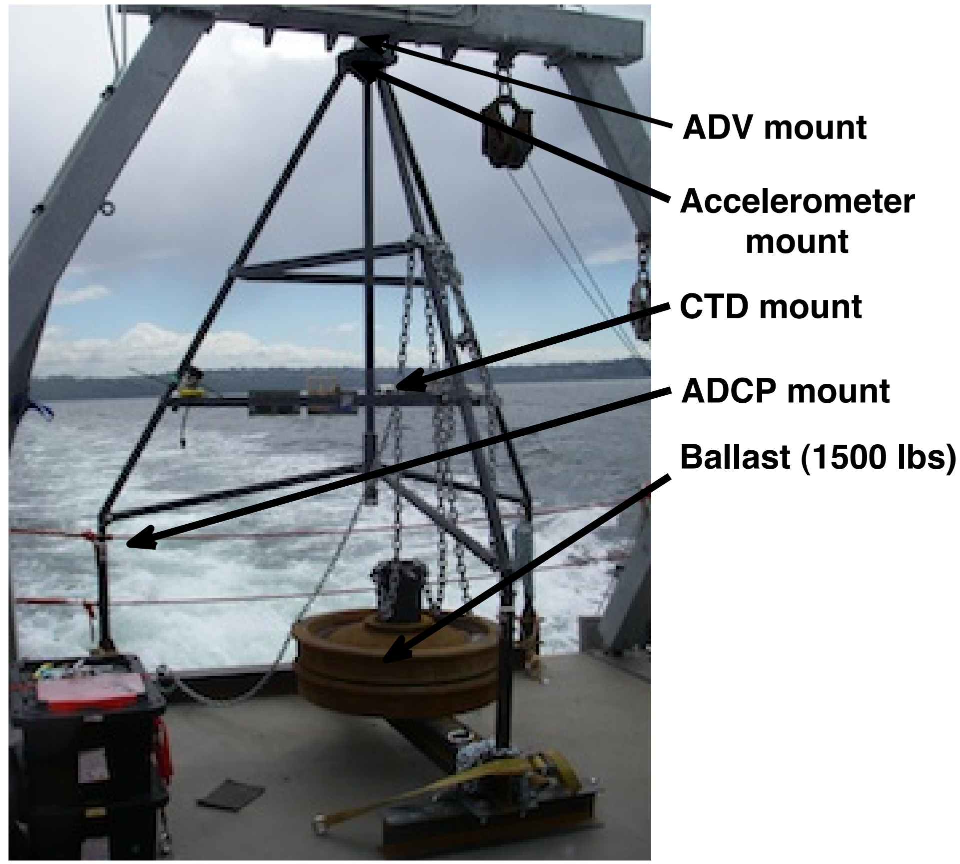
Instruments and sampling

- Acoustic Doppler Current Profiler (ADCP):
  - volume sampling
    ** beam coordinates**
  - 64 s @ 2 Hz= 128 points, every 30 min
- Acoustic Doppler Velocimeter (ADV):
  - point precision
  - 64 s @ 32 Hz = 2048 pts, every 10 min



5 m tripod deployed in 22 m water depth

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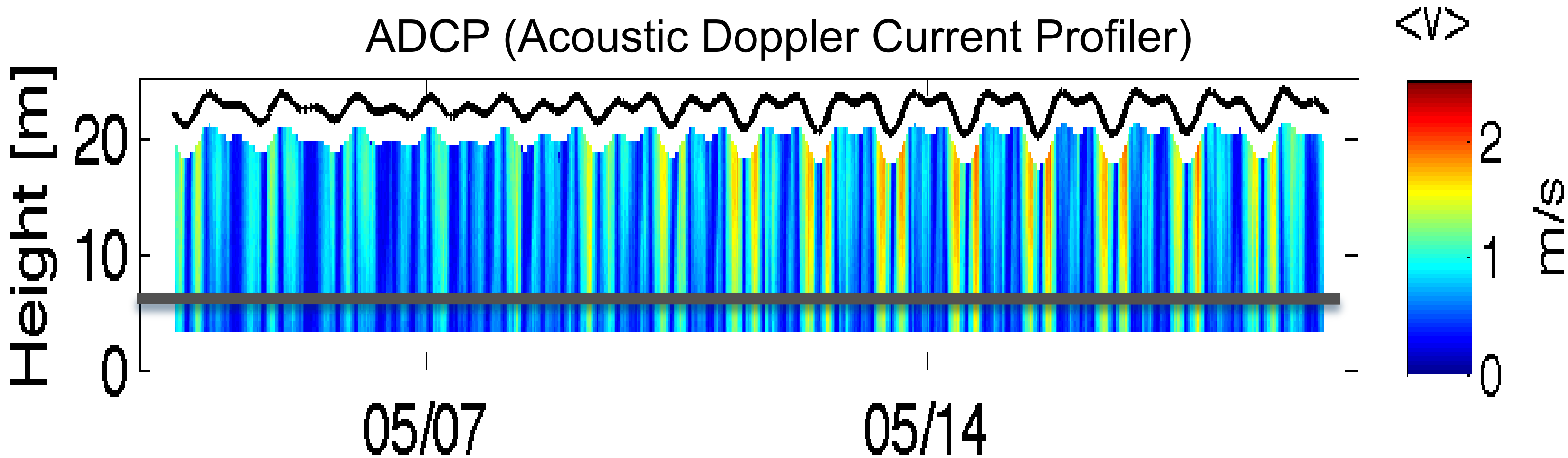
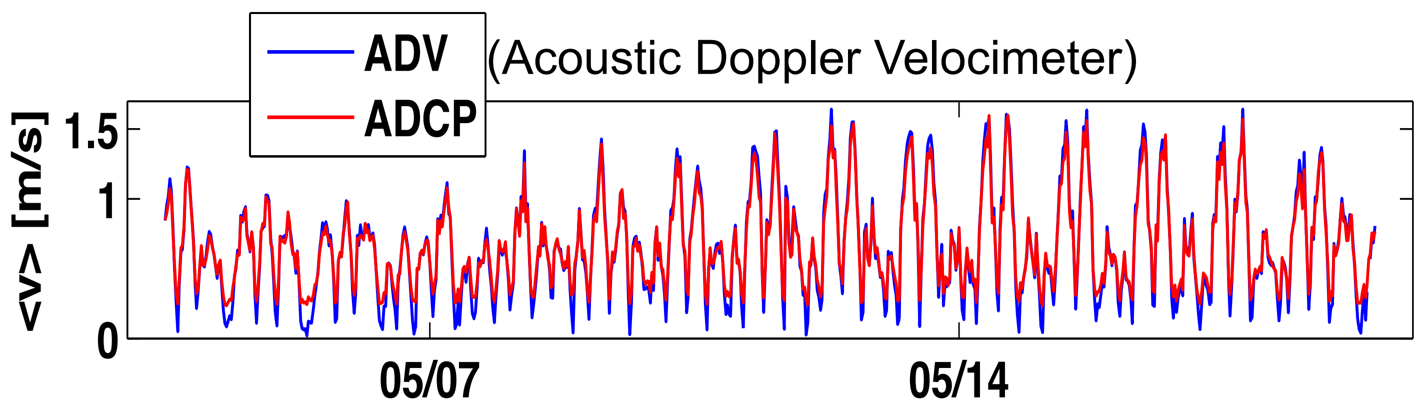
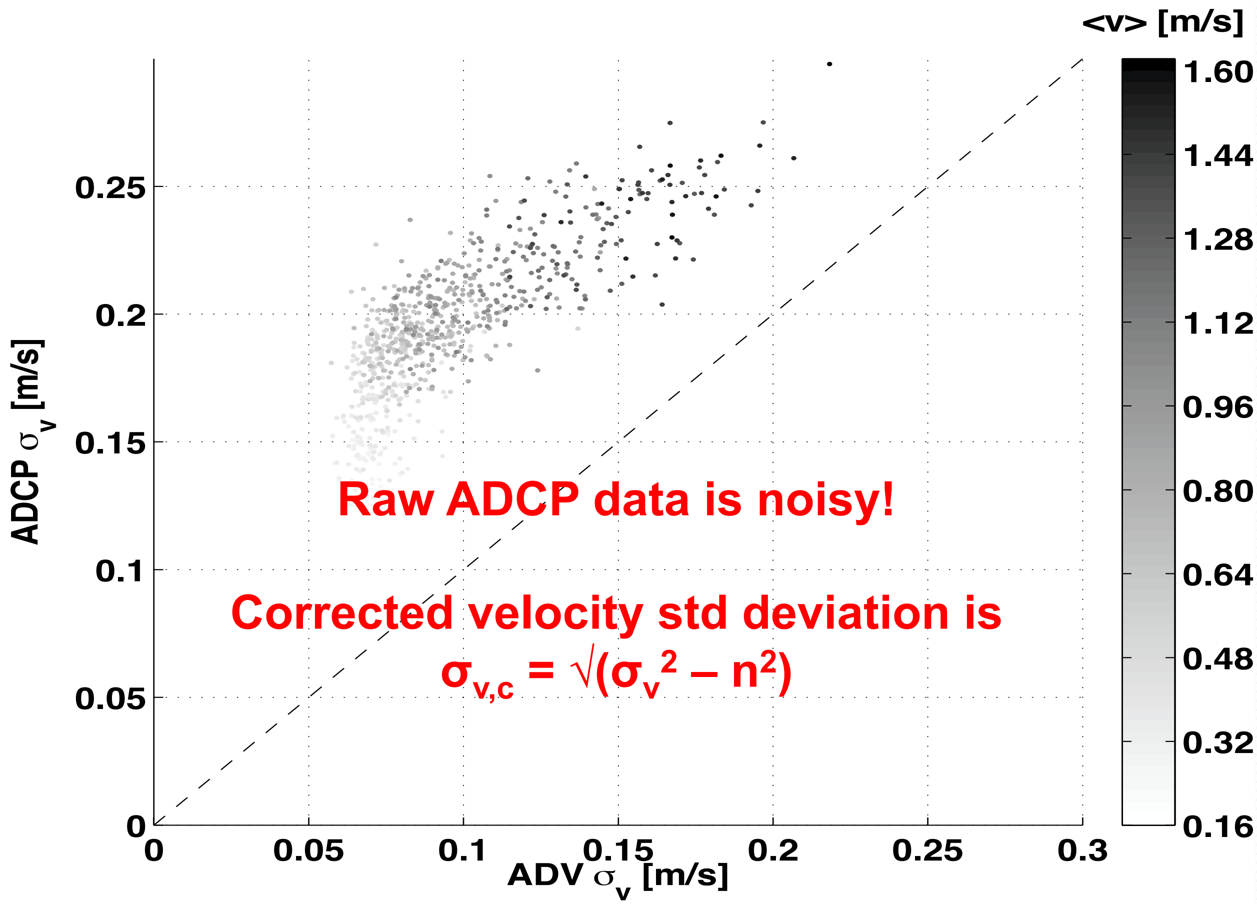
Mean velocities



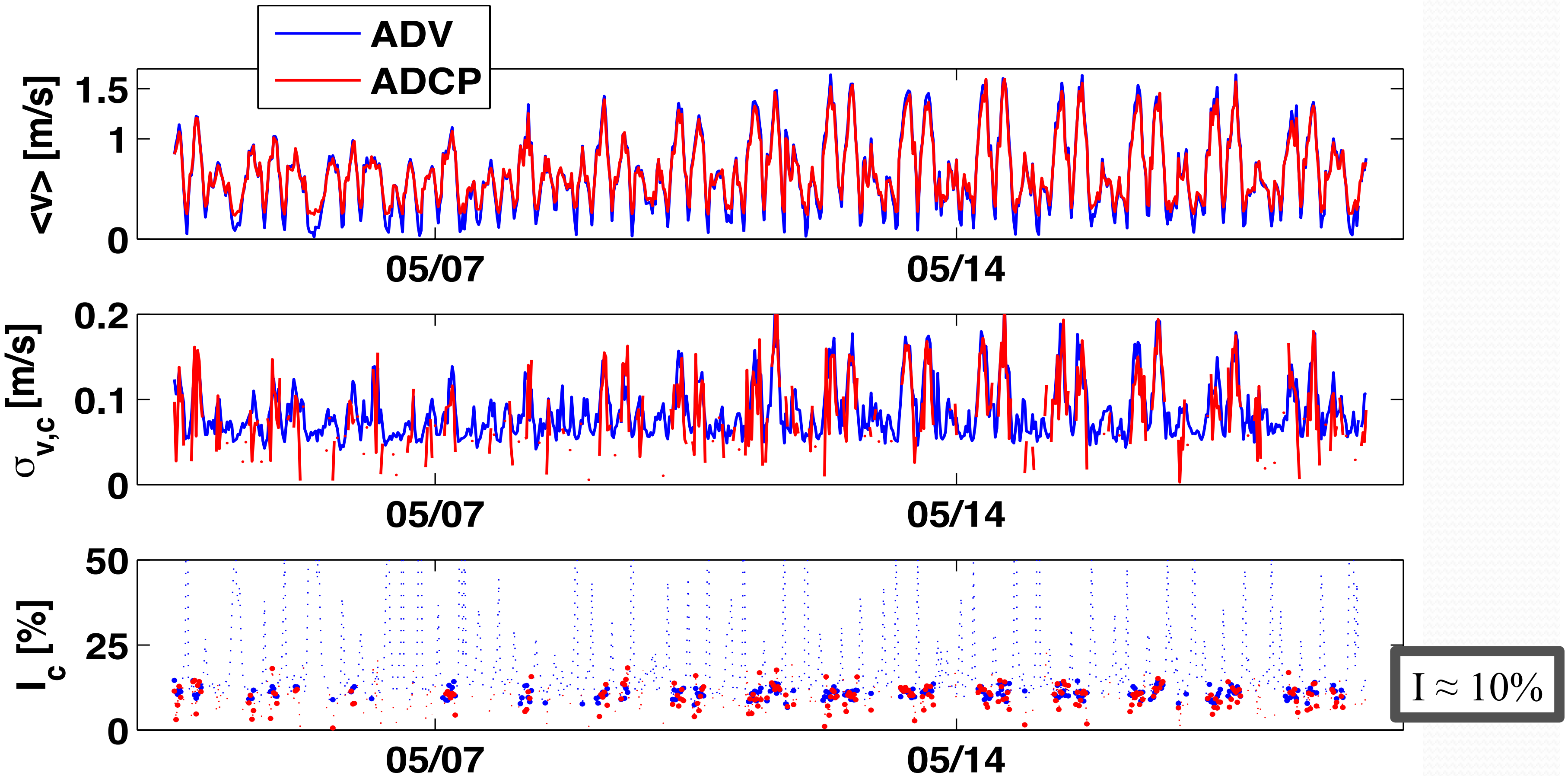


4.6 m
above seabed

Raw velocity fluctuations



Corrected results



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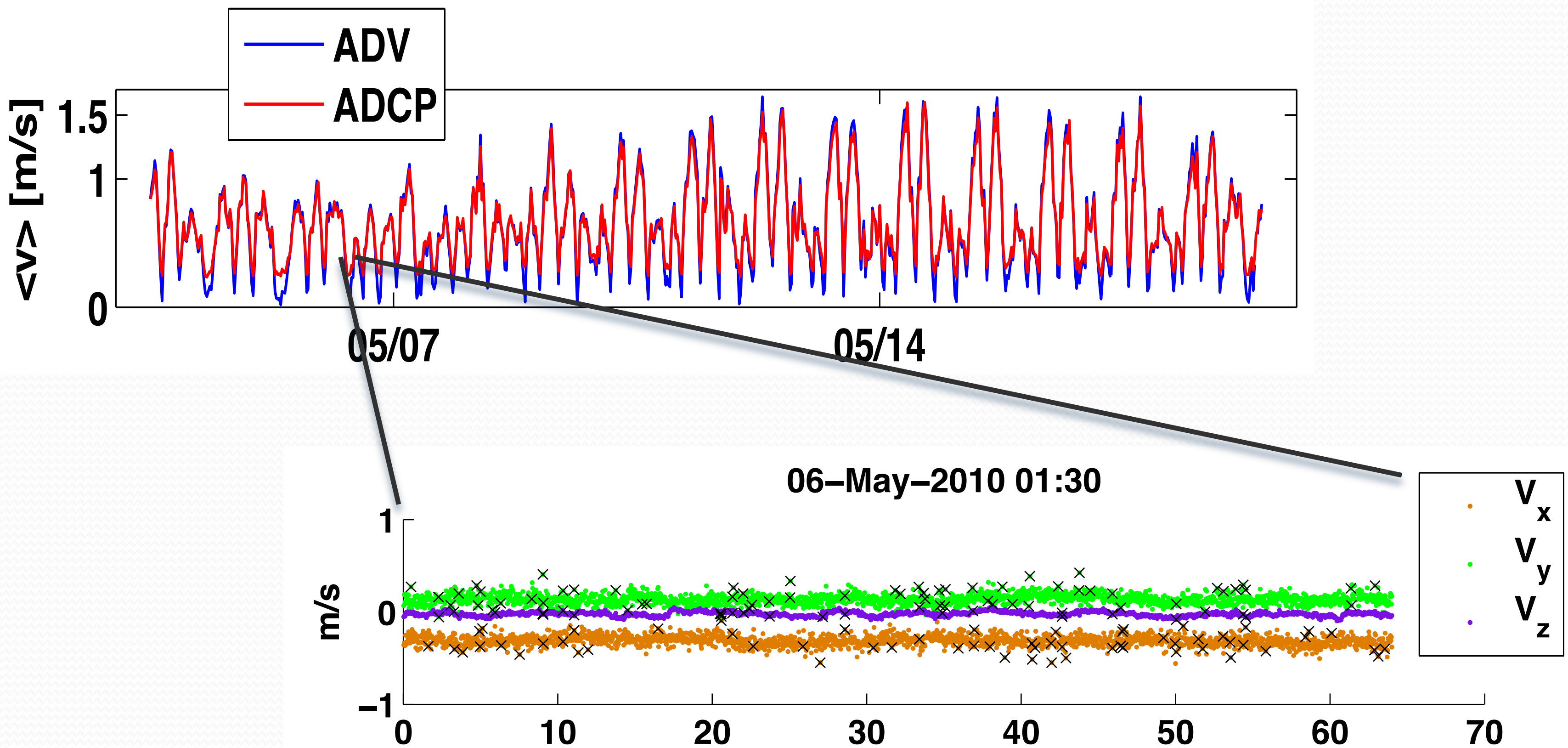
Stationarity (stable mean)

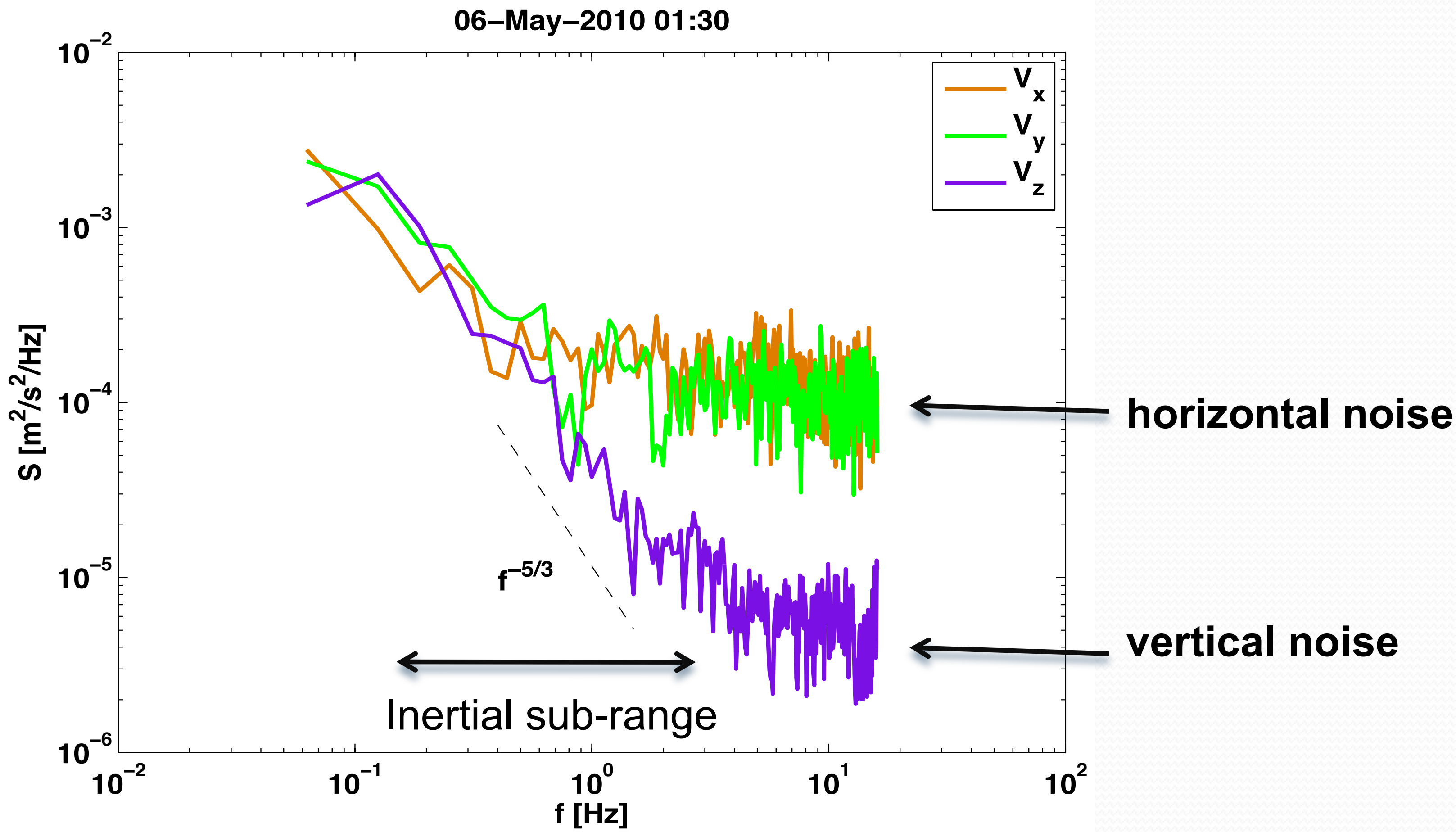


Short, but not too short, records ("bursts") are necessary for robust statistics…

…see Polagye et al (in prep)

Dissipation rate

- Frequency spectra from ADV
- Inertial sub-range shows cascade of energy to small scales,
- Slope is rate of energy loss



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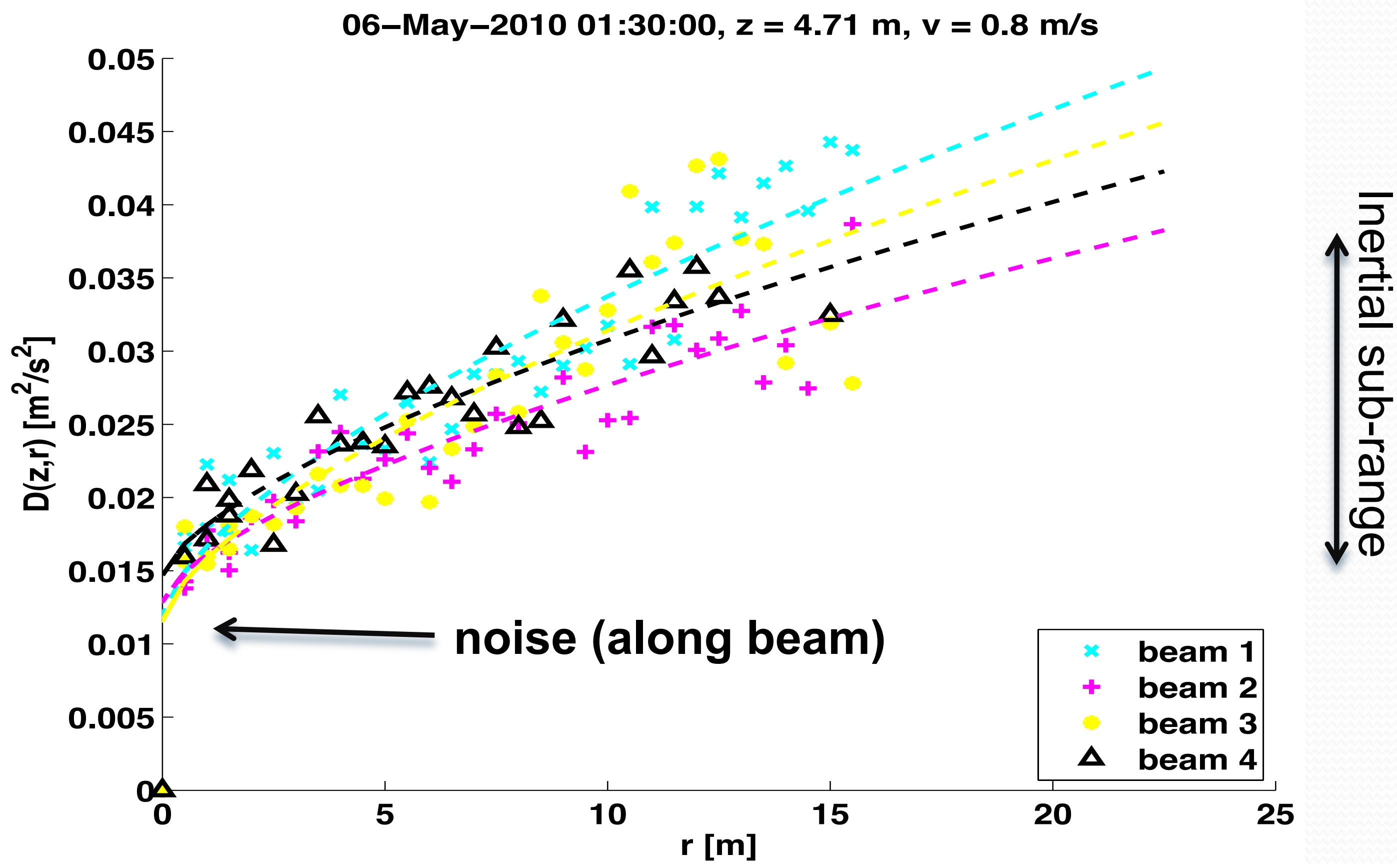
Dissipation rate

- Spatial structure from ADCP
- Inertial sub-range shows cascade of energy to small scales,
- Slope is rate of energy loss



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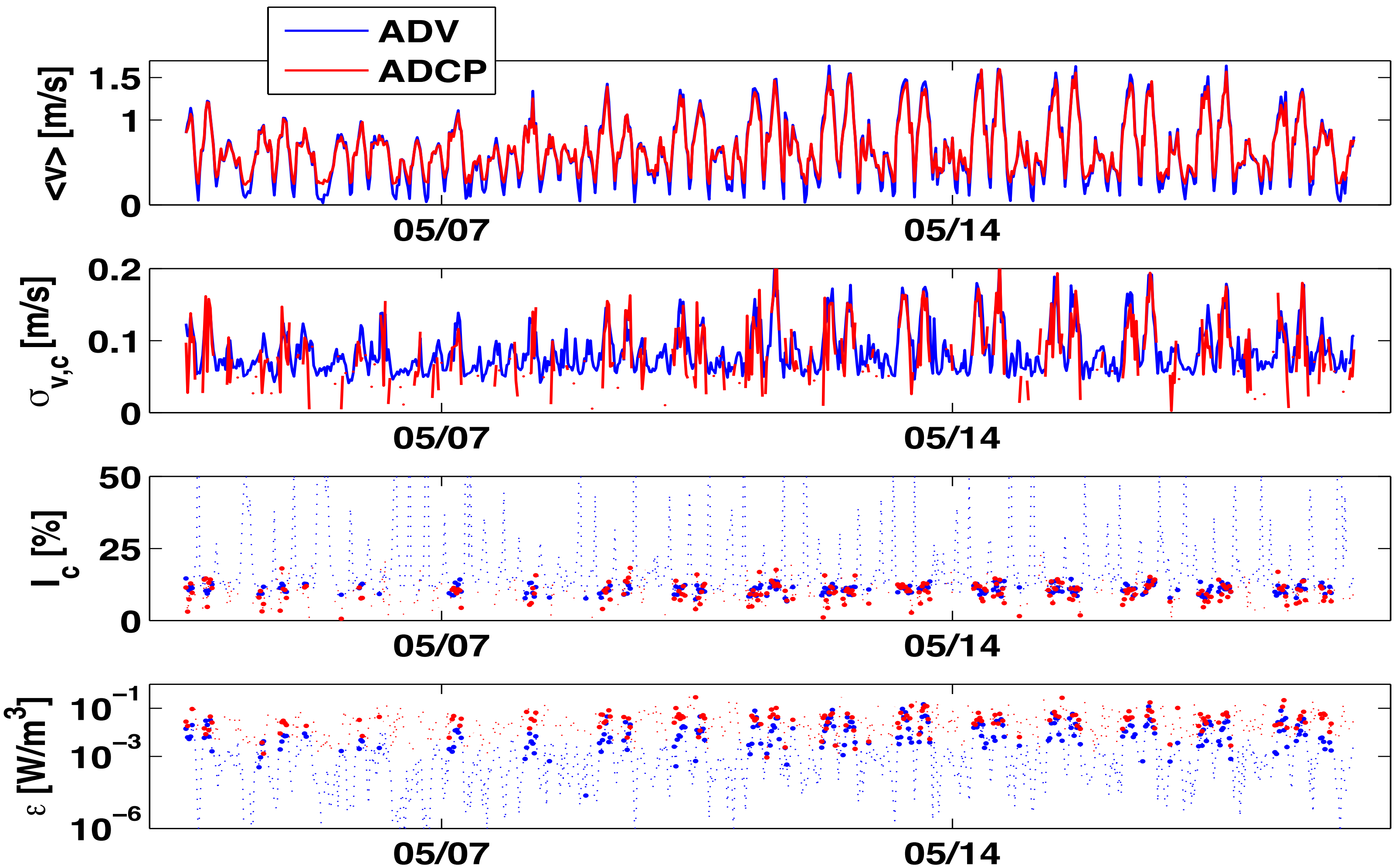
Combined results



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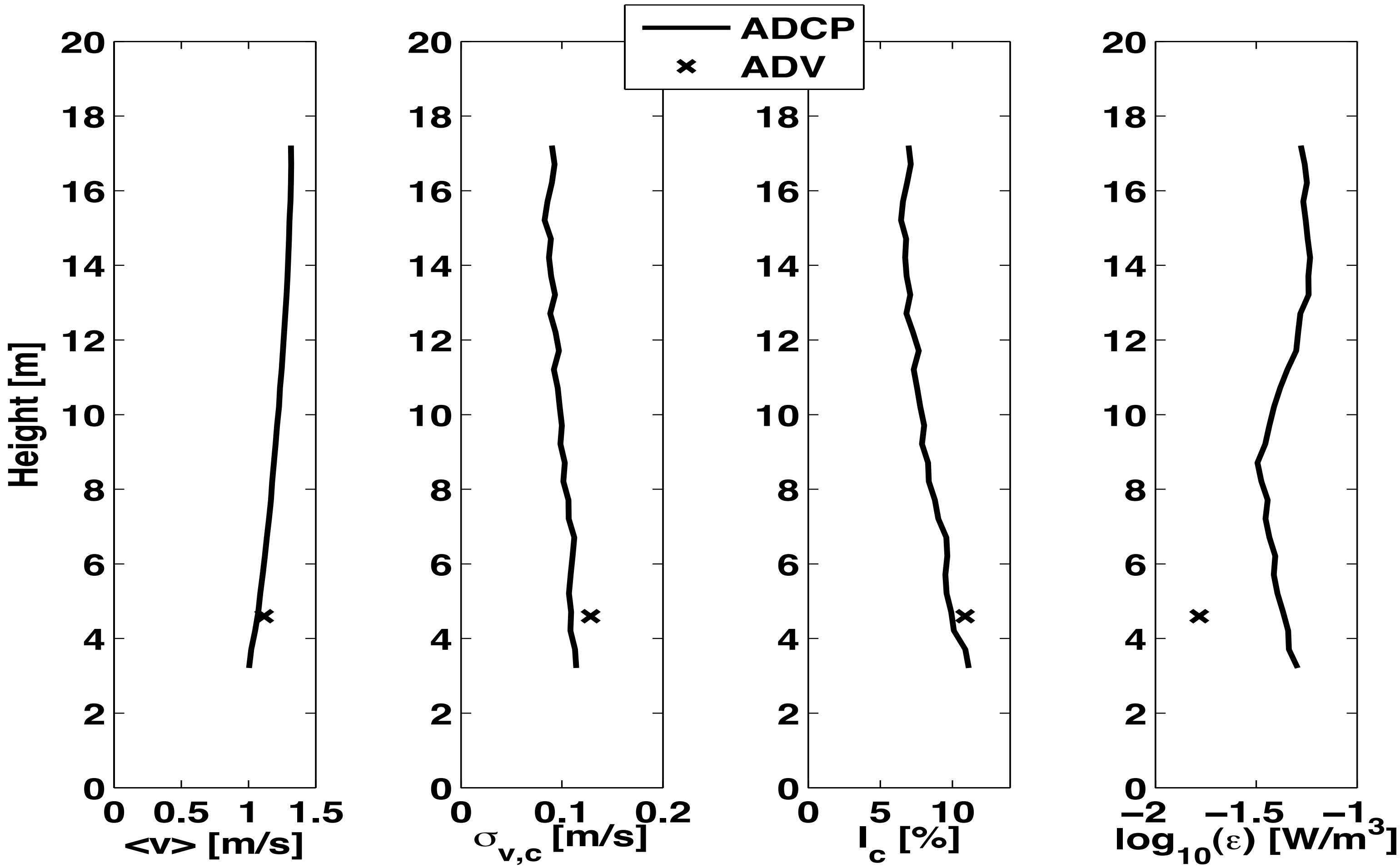
Vertical dependence



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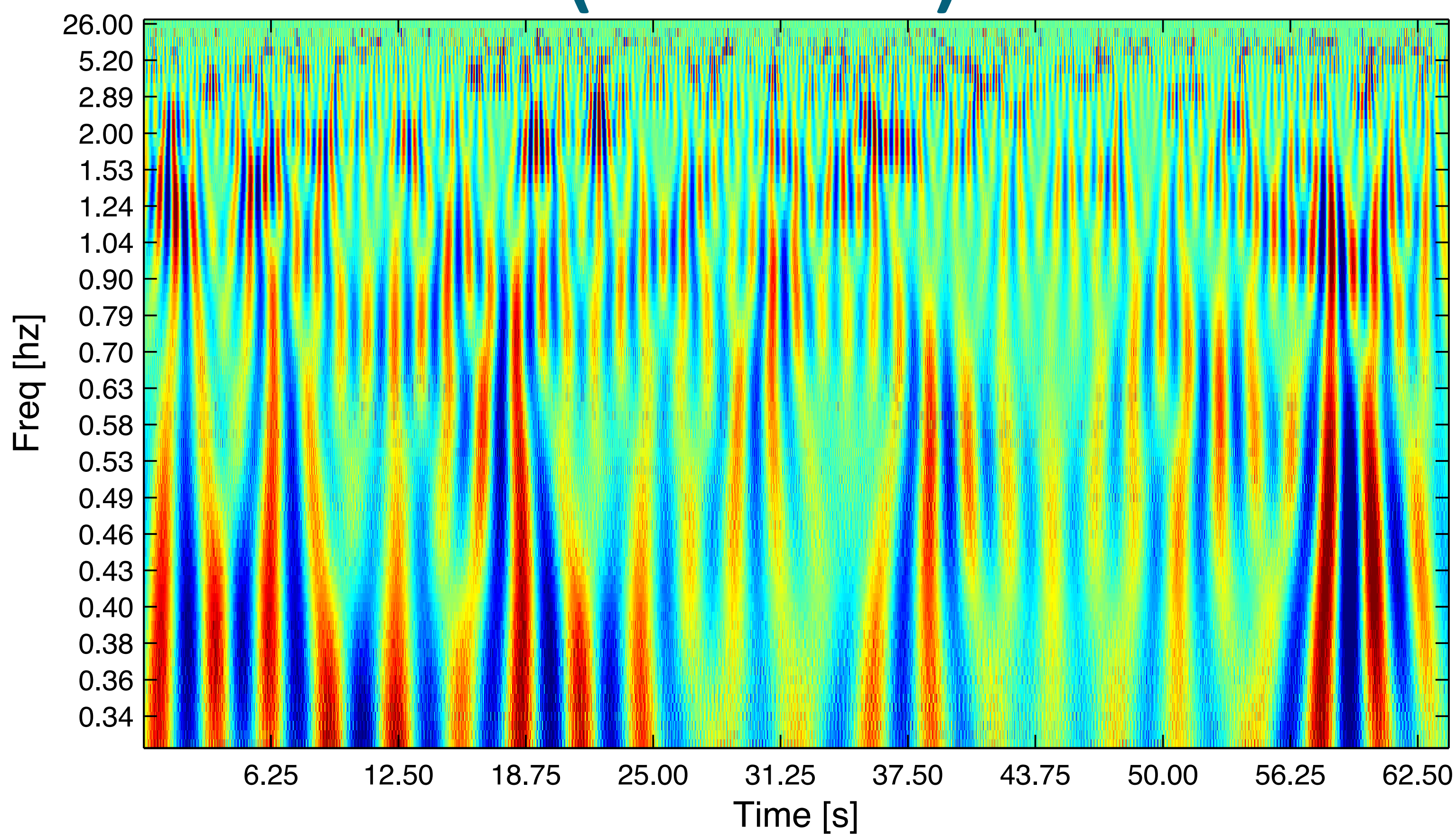
Coherent Turbulent Kinetic Energy (eddies)



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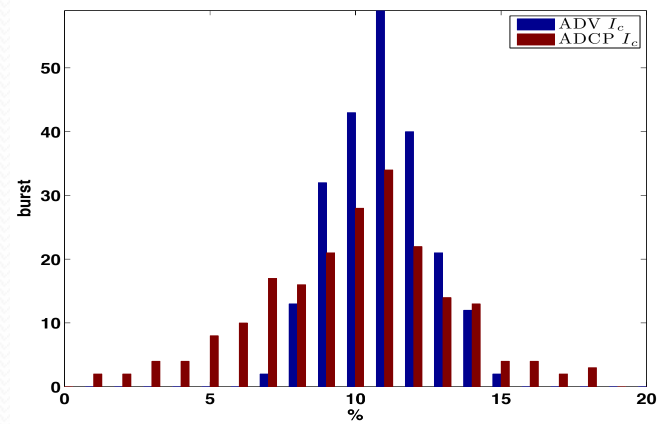
Conclusions



- Turbulent intensity ≈ 10%
- Doppler measurement error ("noise") can heavily bias observed velocity variance and **must be removed**.
- Dissipation rate has more dynamic range the turbulent intensity, but operational significance unknown
- Coherent TKE shows time-space scales of eddies

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Tripod motion?