A Look at Vertical Motions in Arctic Mixed-phase Clouds

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With contributions from
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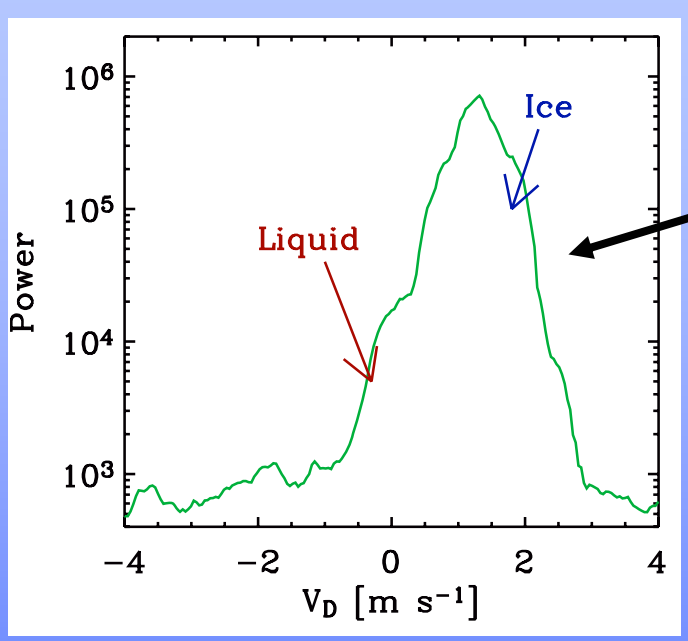
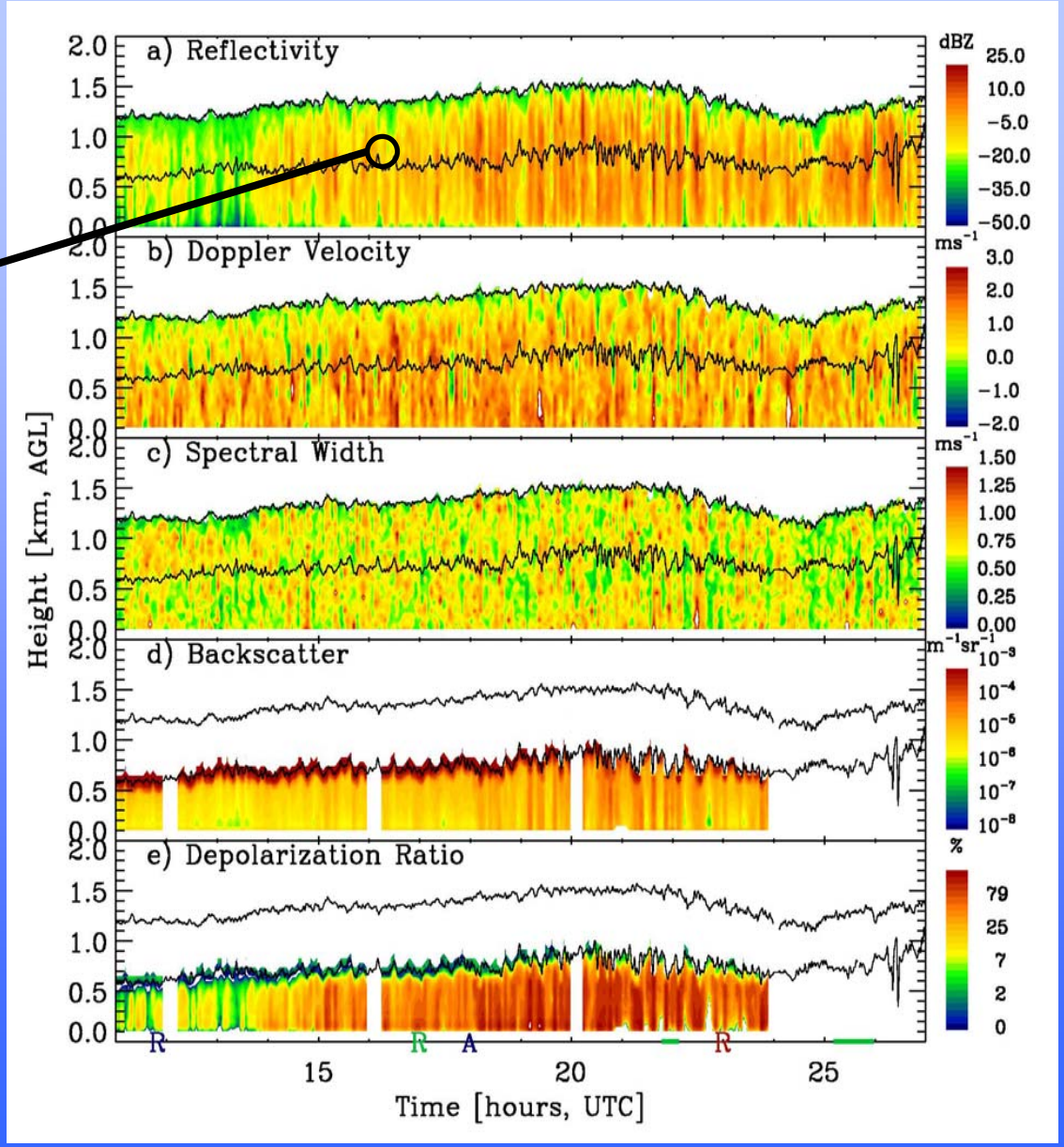
The General Idea



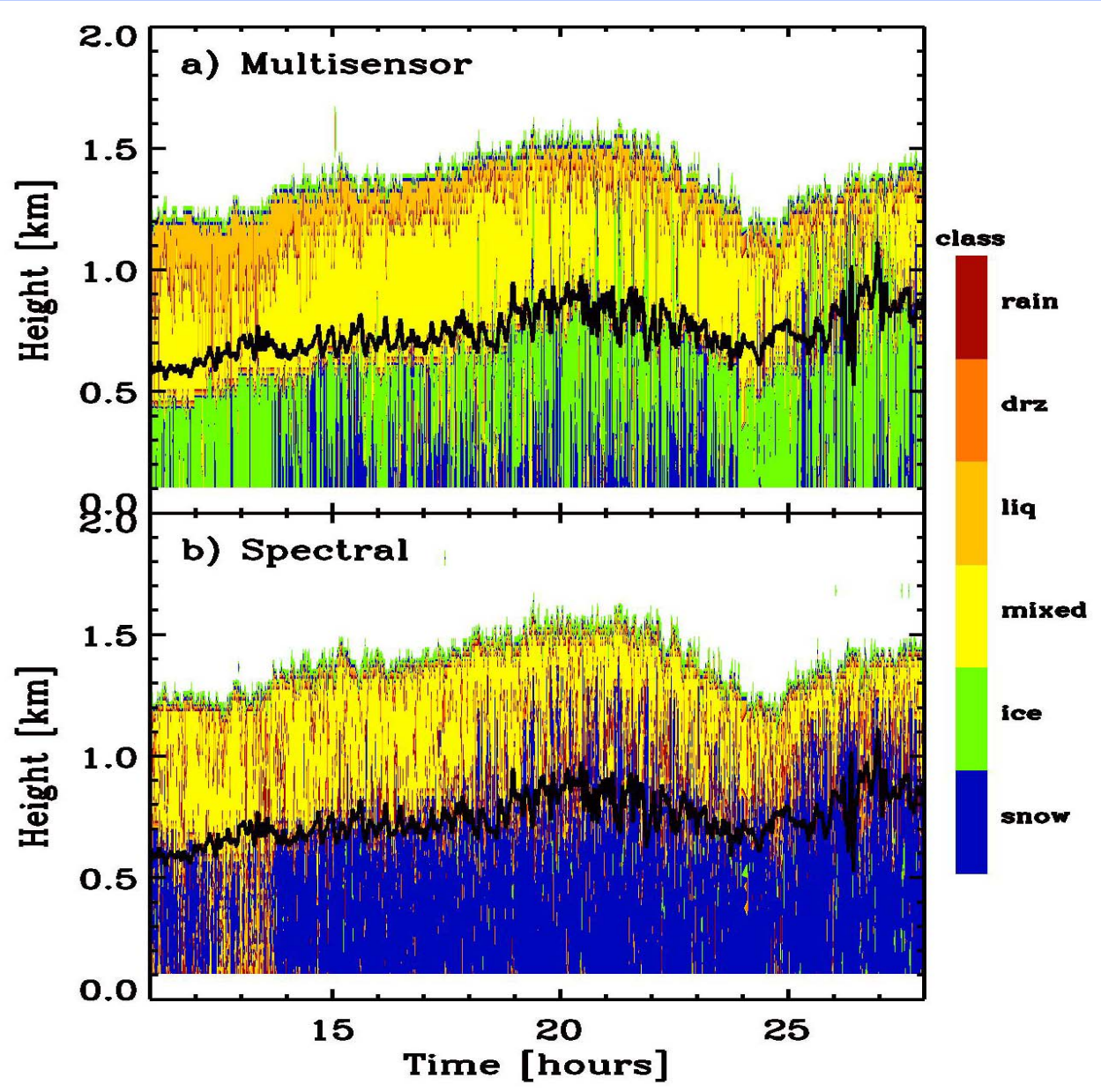


- Liquid droplets are tracers for air motions (due to size)
- Must identify where liquid exists

Cloud Type Classification

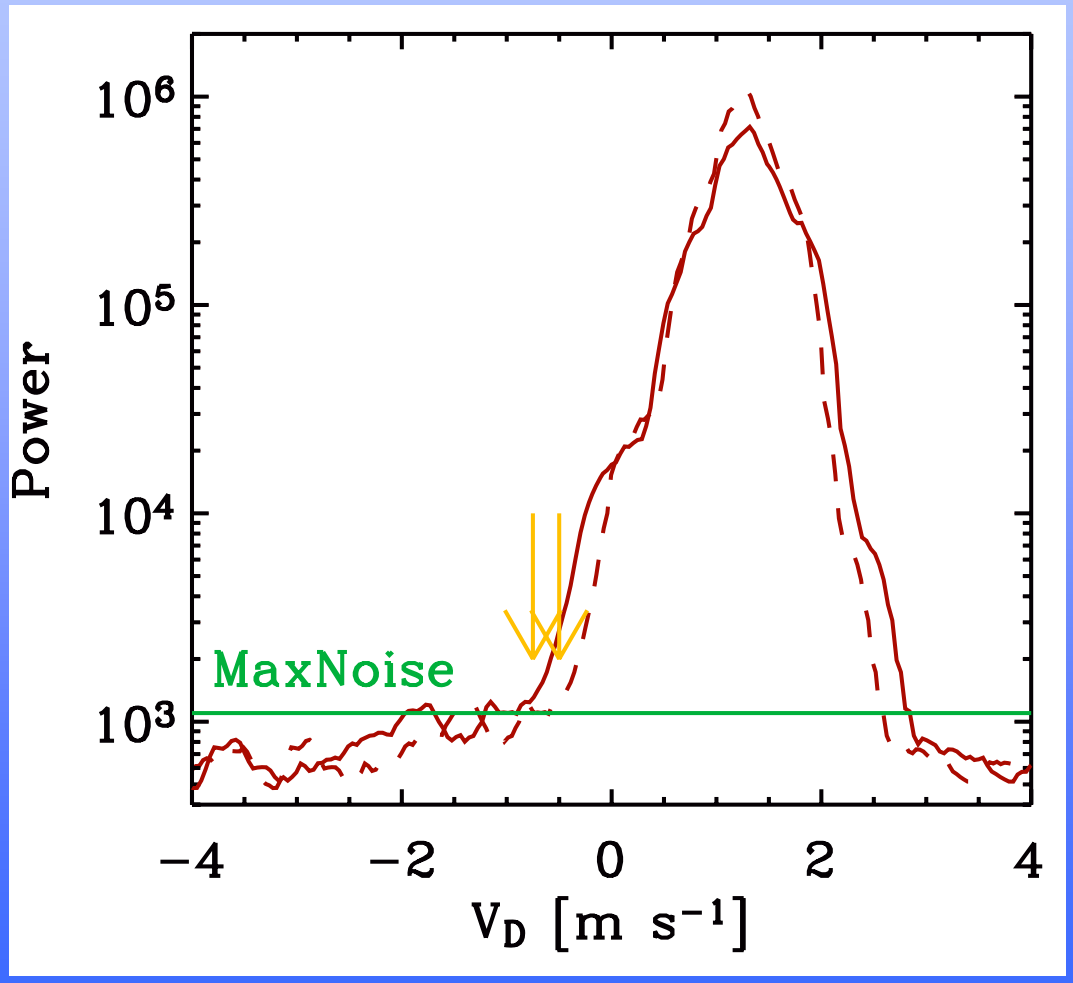
The Critical Step!

- **MMCR** – moments and cloud boundaries
- **Lidar** – backscatter and depolarization ratio
- **Radiosonde** – temperature
- **MWR** – Liquid water path
- (**Ceilometer** – cloud base height)



Methodology

$$\sigma_D^2 = \sigma_{DSD}^2 + \sigma_T^2 + \sigma_S^2 + \sigma_B^2$$



- Terms are used to correct the vertical velocity estimate
- Bi-product of σ_T^2 retrieval is the turbulent dissipation rate.

- All broadening terms together typically total about 4 cm s^{-1}.

- Largest terms are shear (55%) and turbulent (37%).

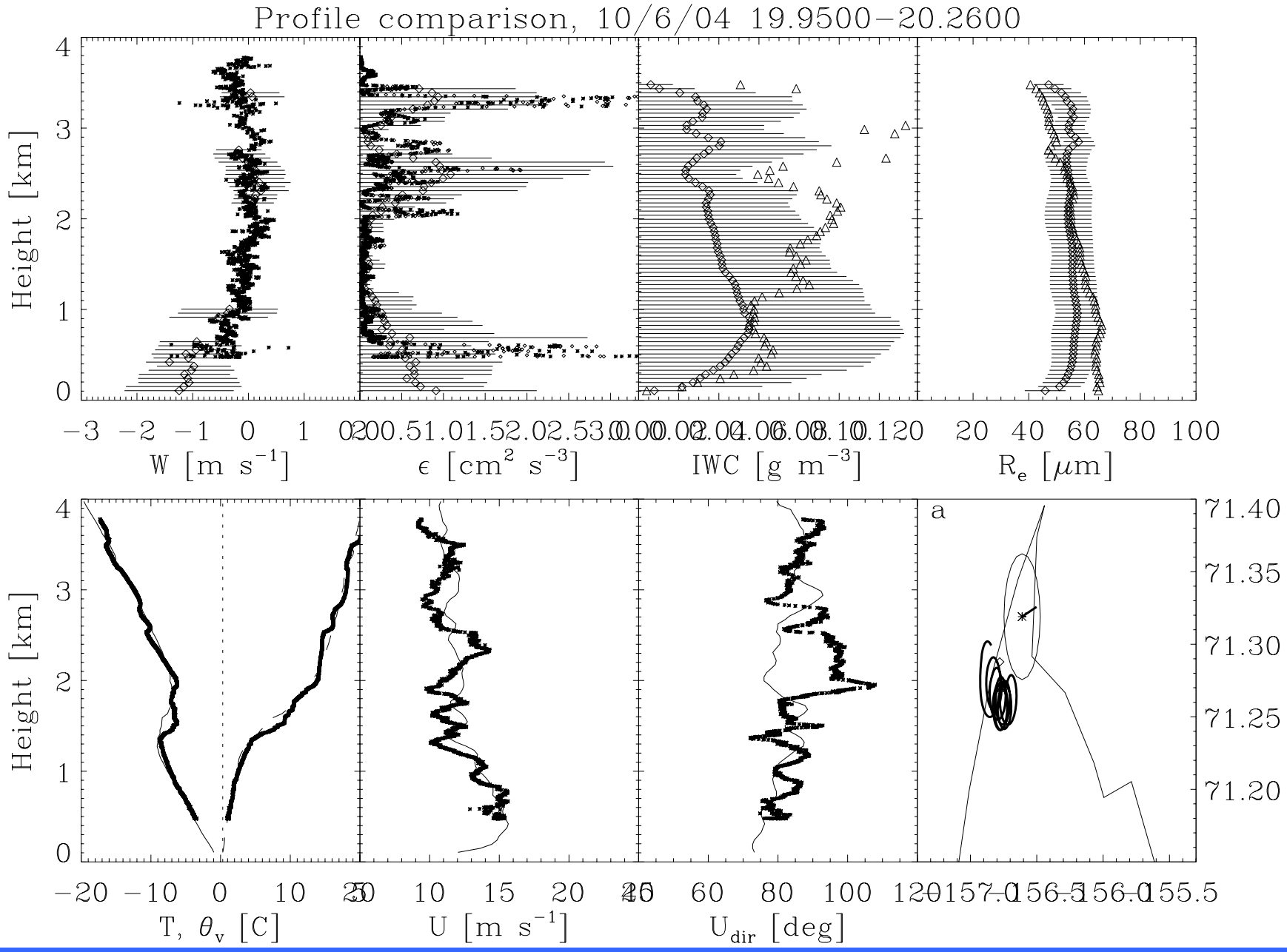
Other Cloud Retrievals

LWP - Multiple microwave radiometer methods [standard, Liljegren/Turner statistical, physical]

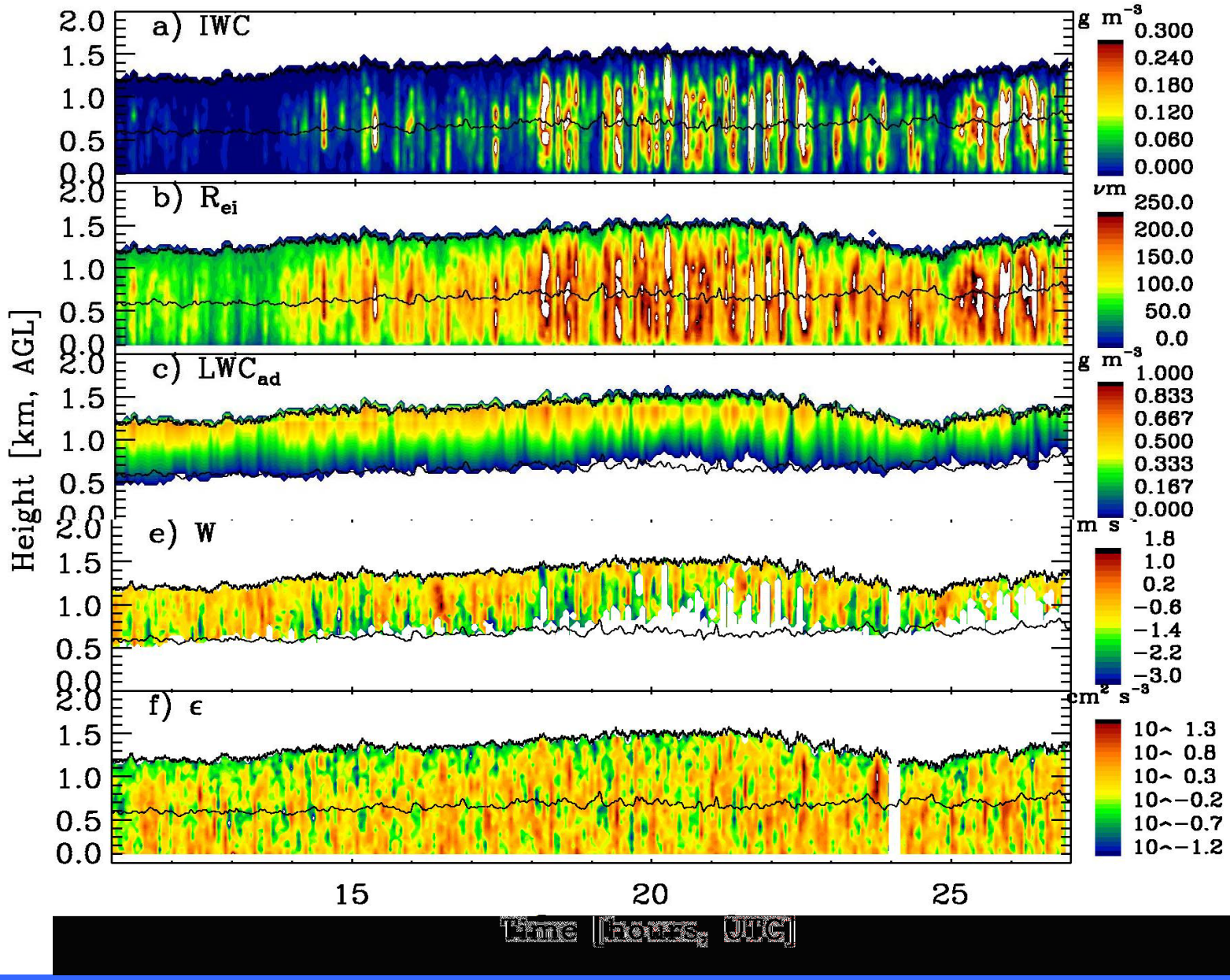
LWC - Adiabatic based on cloud boundaries from active sensors and radiosonde thermodynamic profiles. (At this point the Doppler spectra have not been used to derive liquid properties).

IWC and R_{e_ice} - Ice microphysics from empirical radar retrievals or Doppler moments method (Matrosov et al. 2002)

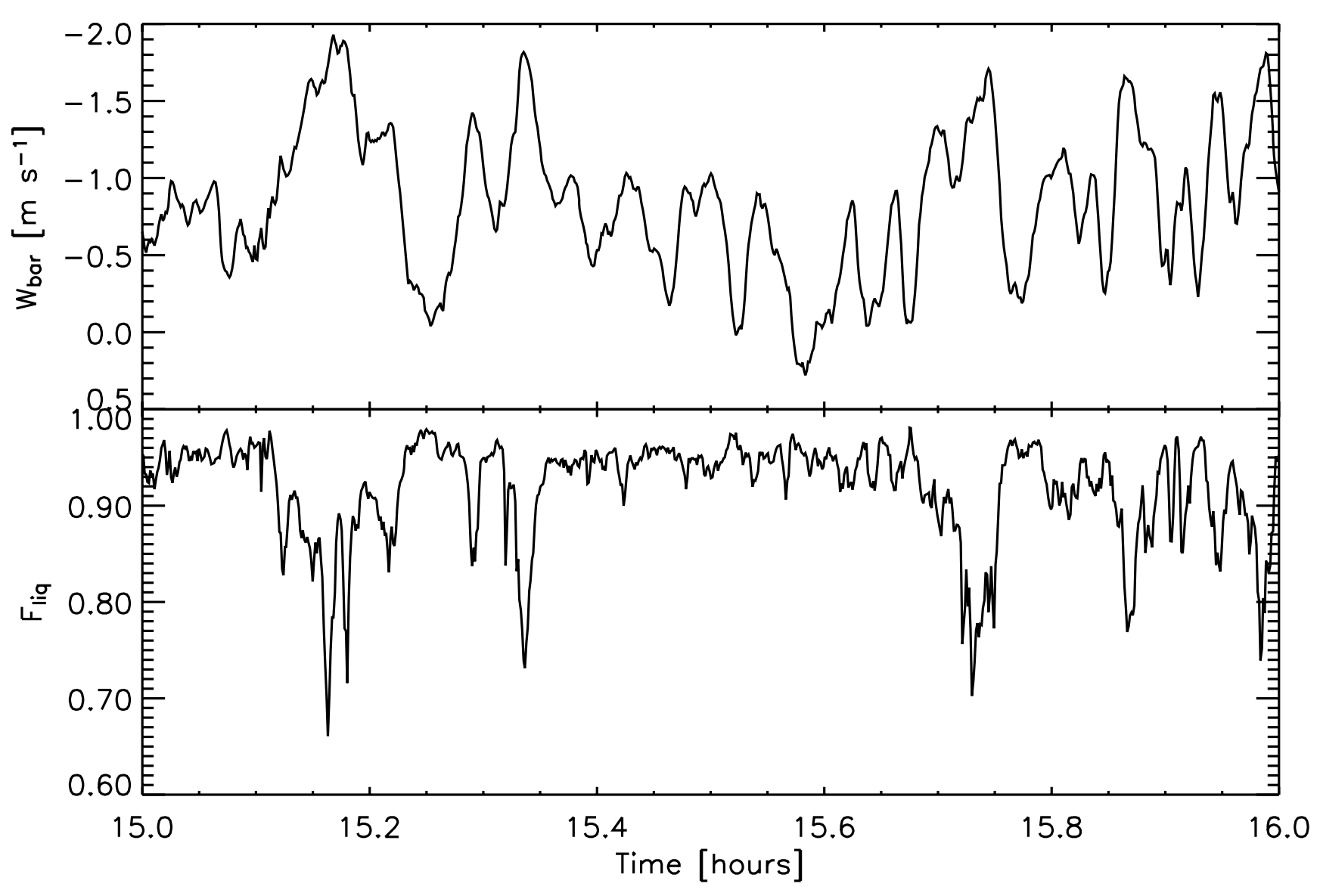
Aircraft Comparisons



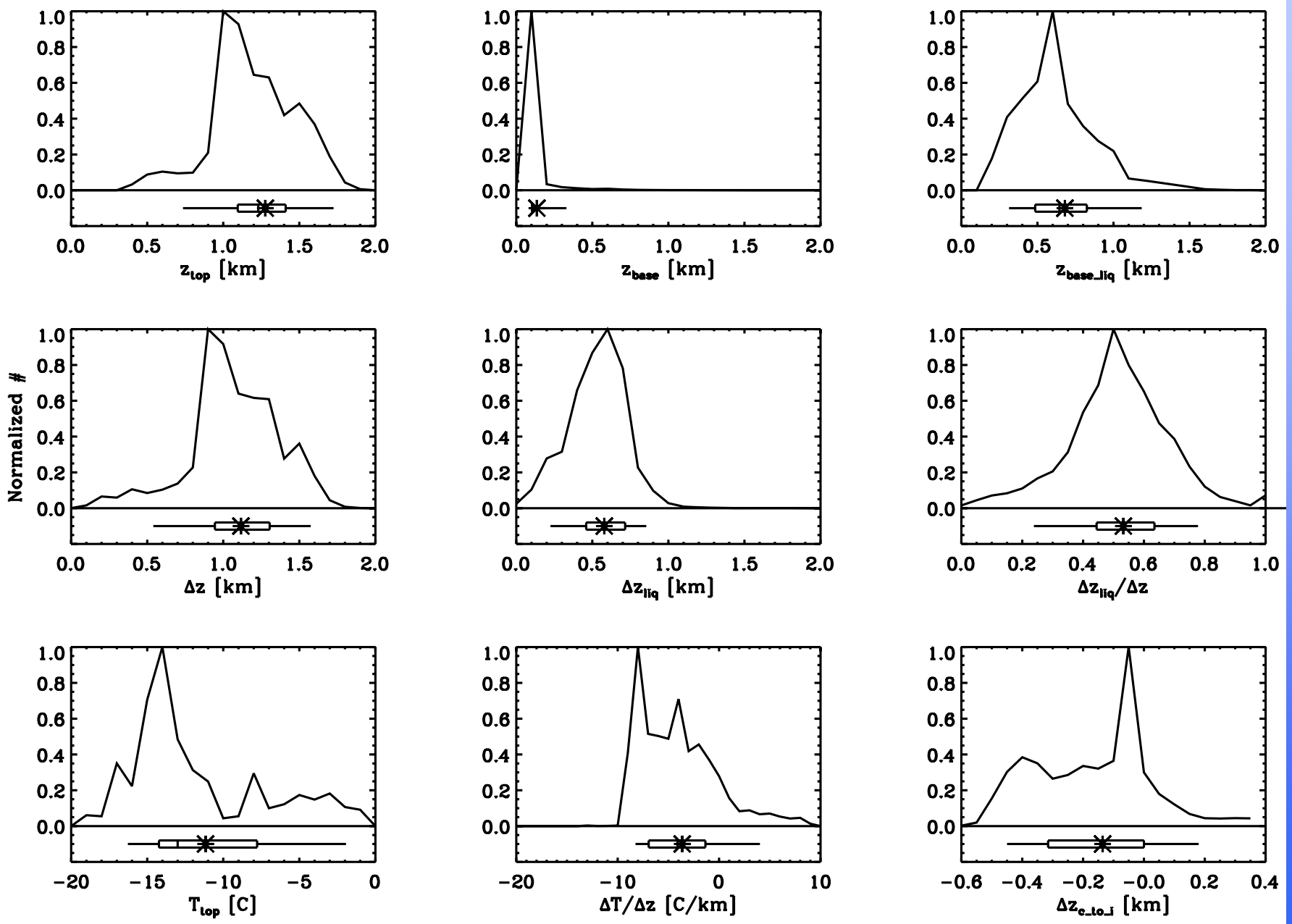
Example Retrievals



Timeseries


−2.0
−1.5
−1.0
−0.5
0.0
0.5
W_{bar} [m s^{-1}]
1.00
0.90
0.80
0.70
0.60
F_{liq}
15.0
15.2
15.4
15.6
15.8
16.0
Time [hours]

MPACE Mixed-Phase Cloud Results



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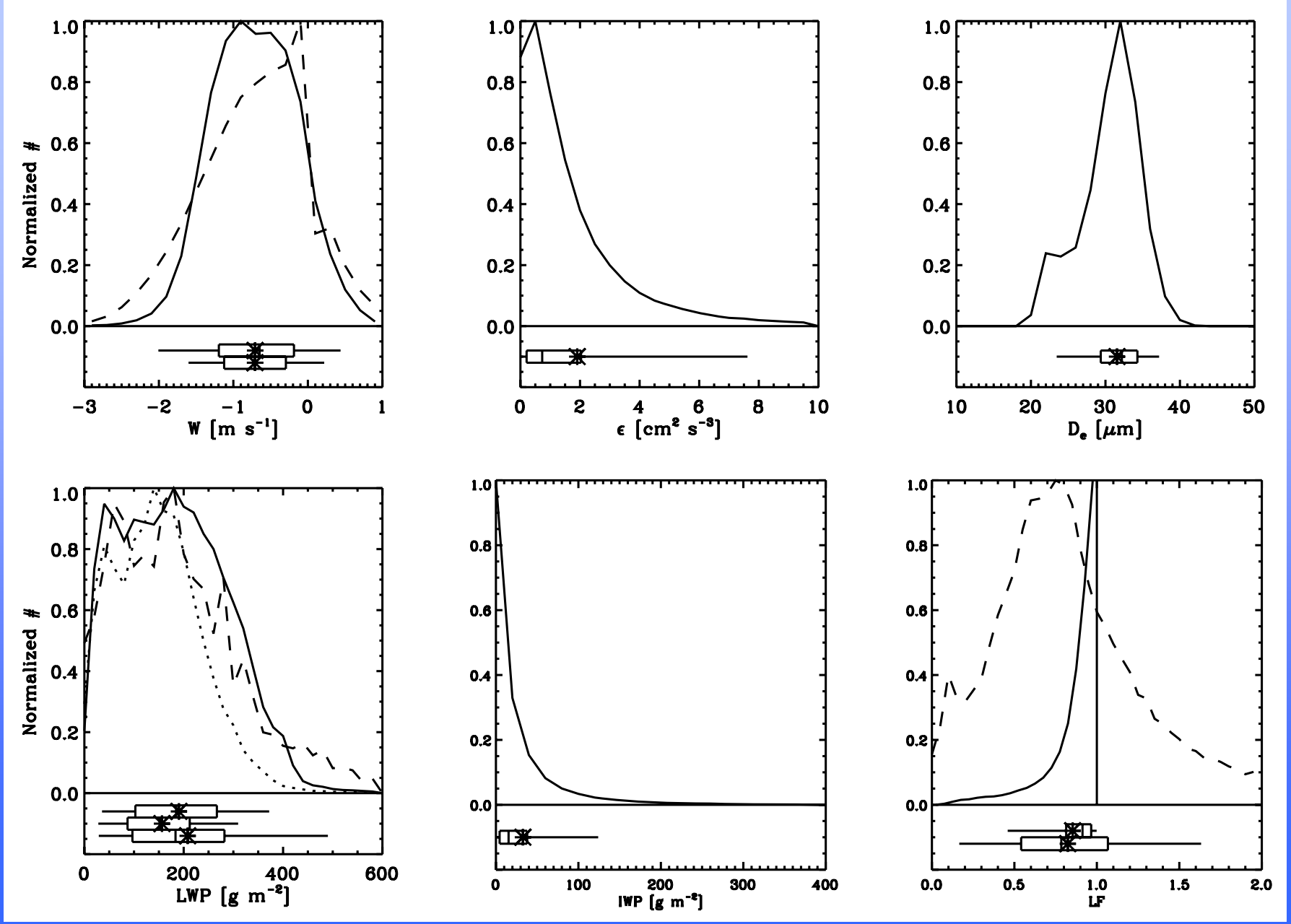
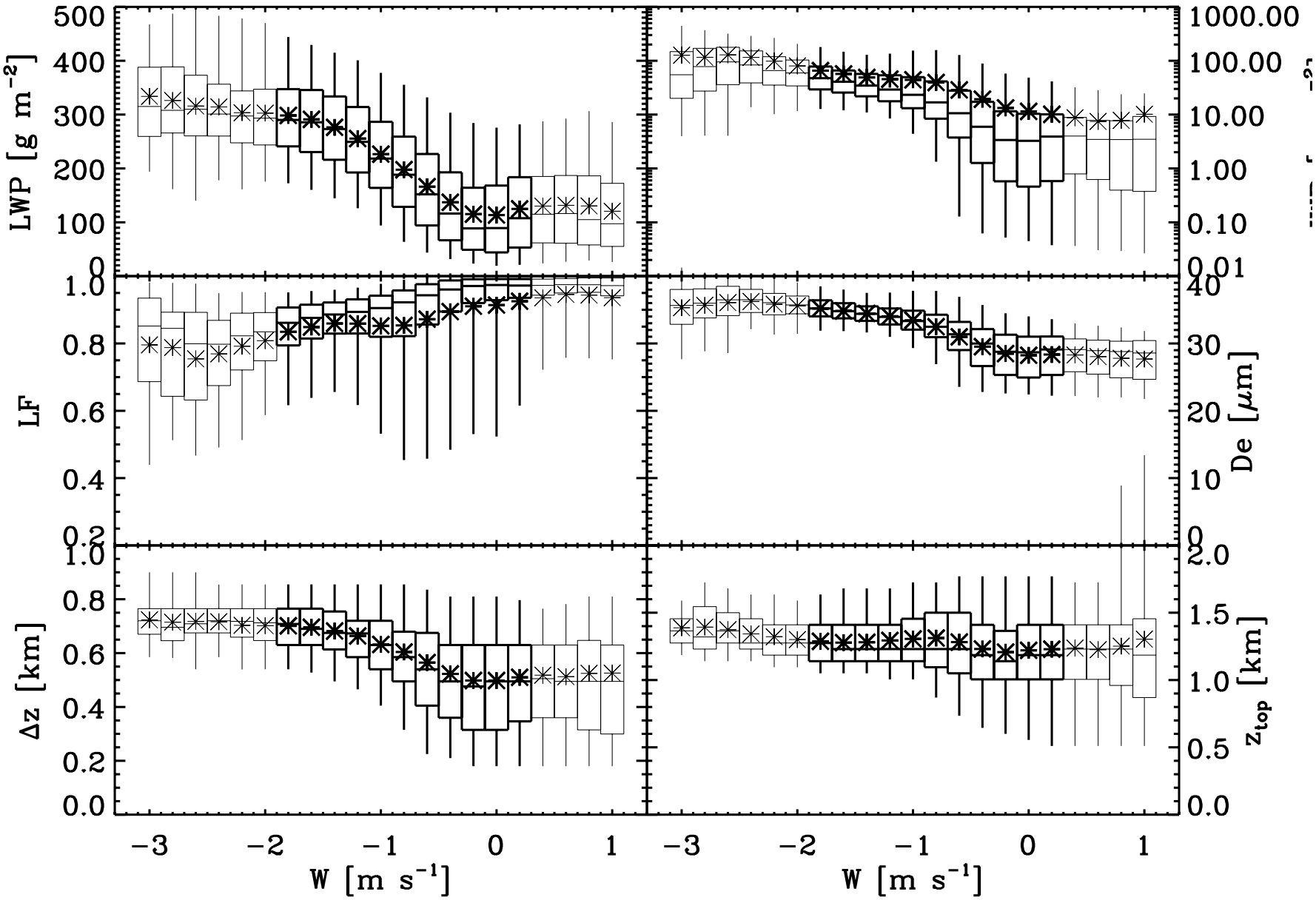
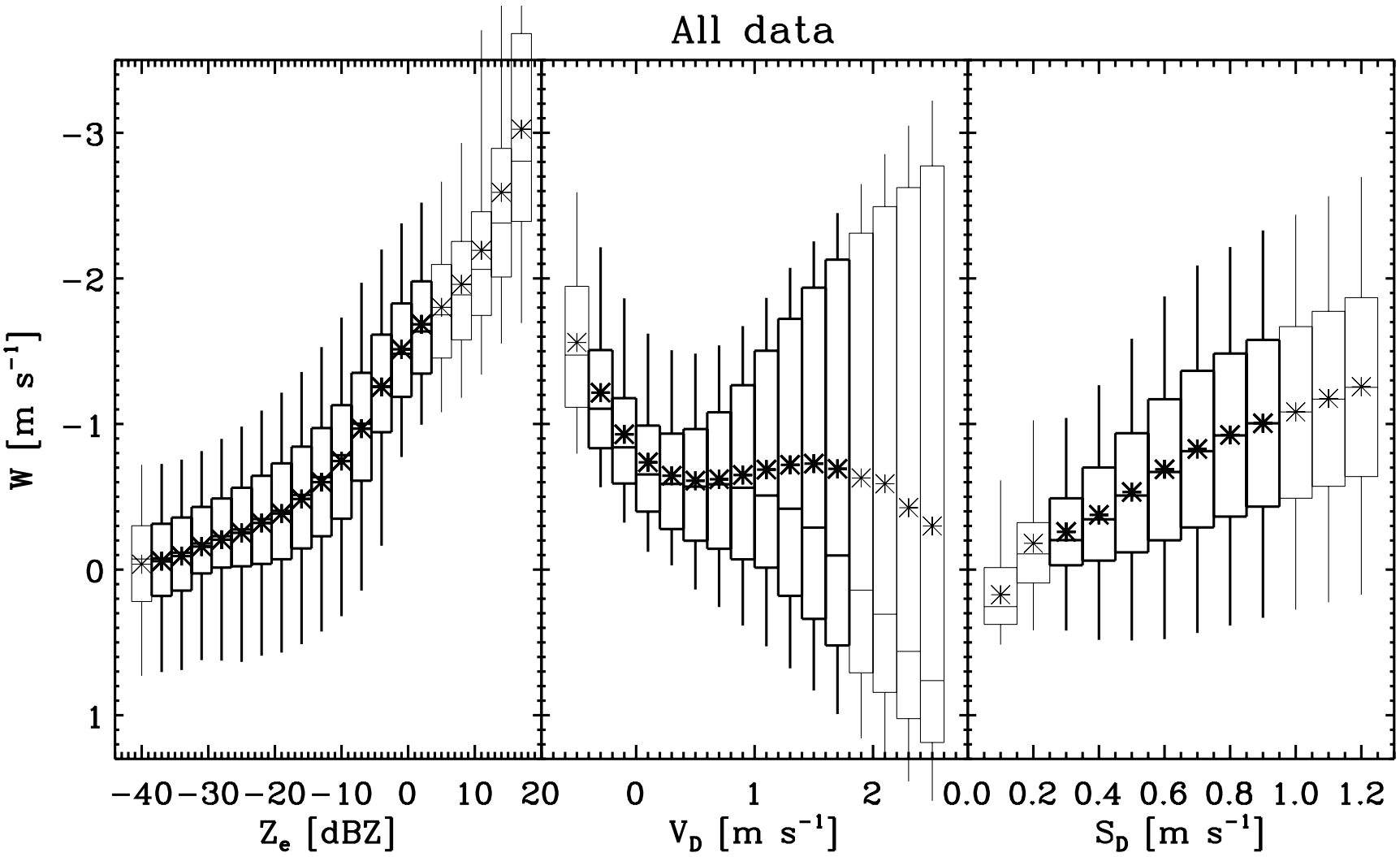


Vertical Motion Relations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