

# Turbulence parameters from HVRRD

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*Workshop on Research Applications of High-Resolution Radiosonde Data*

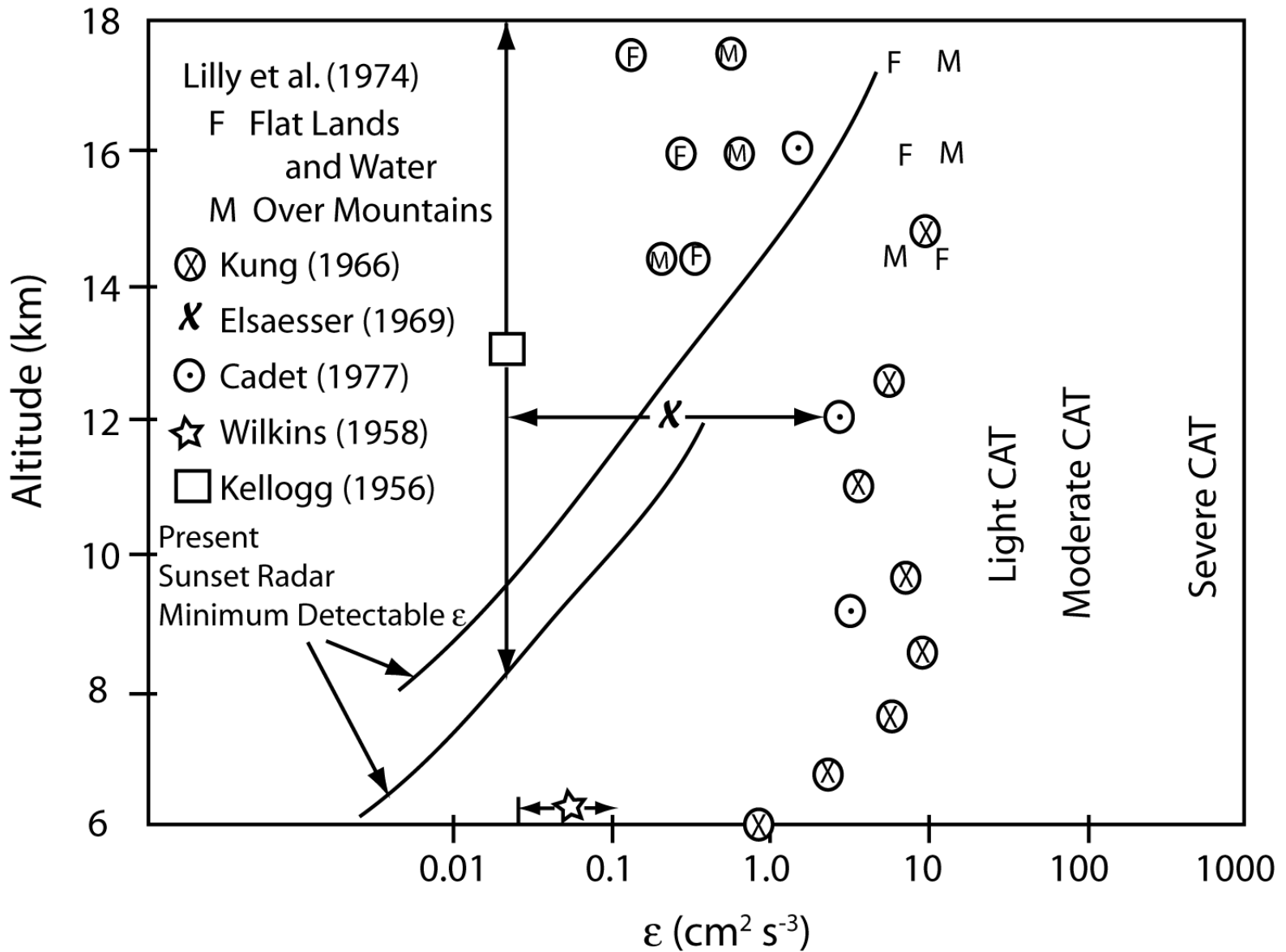
*Stony Brook, NY*

*27 May 2013*

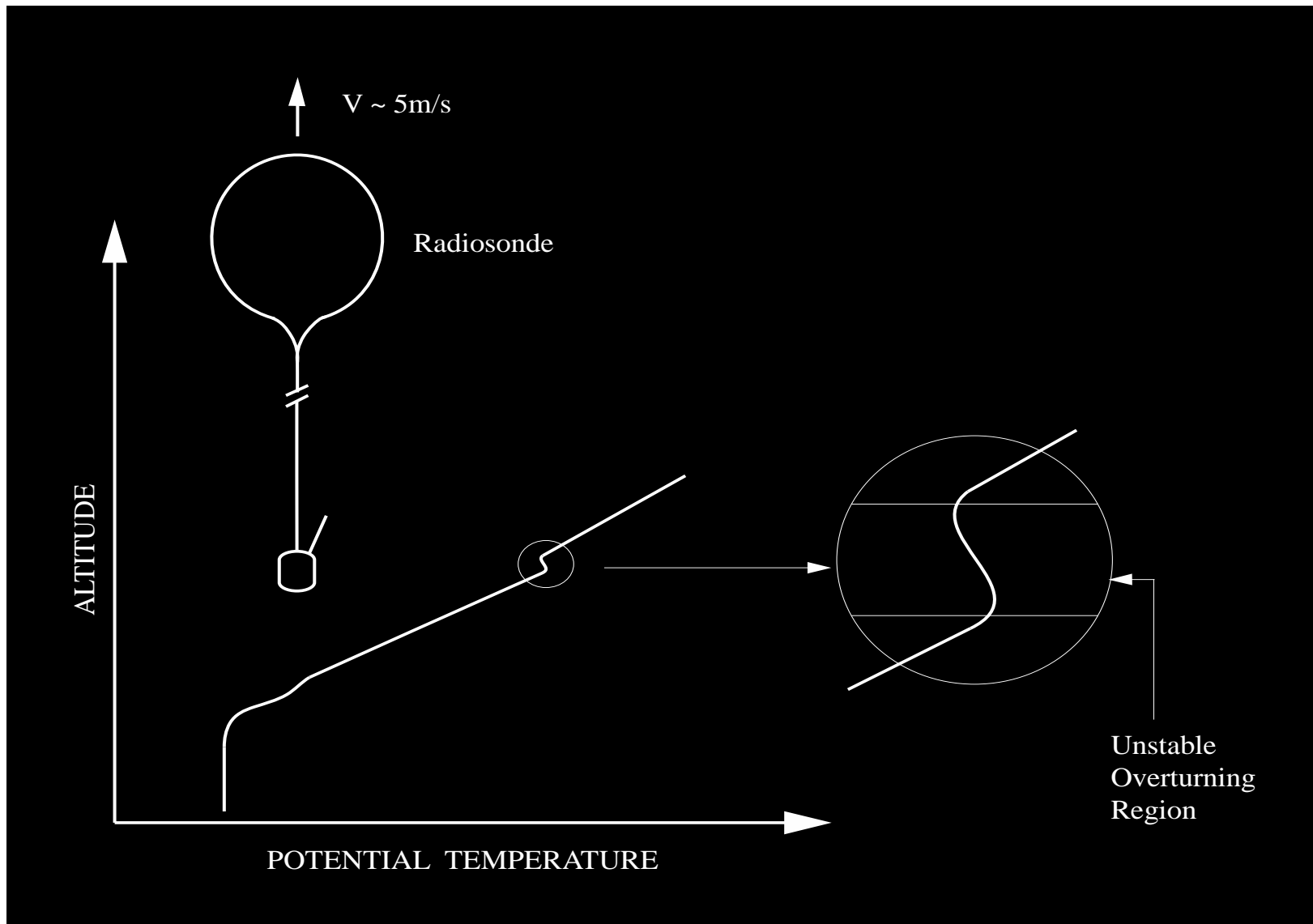


# Turbulence in the Free Atmosphere

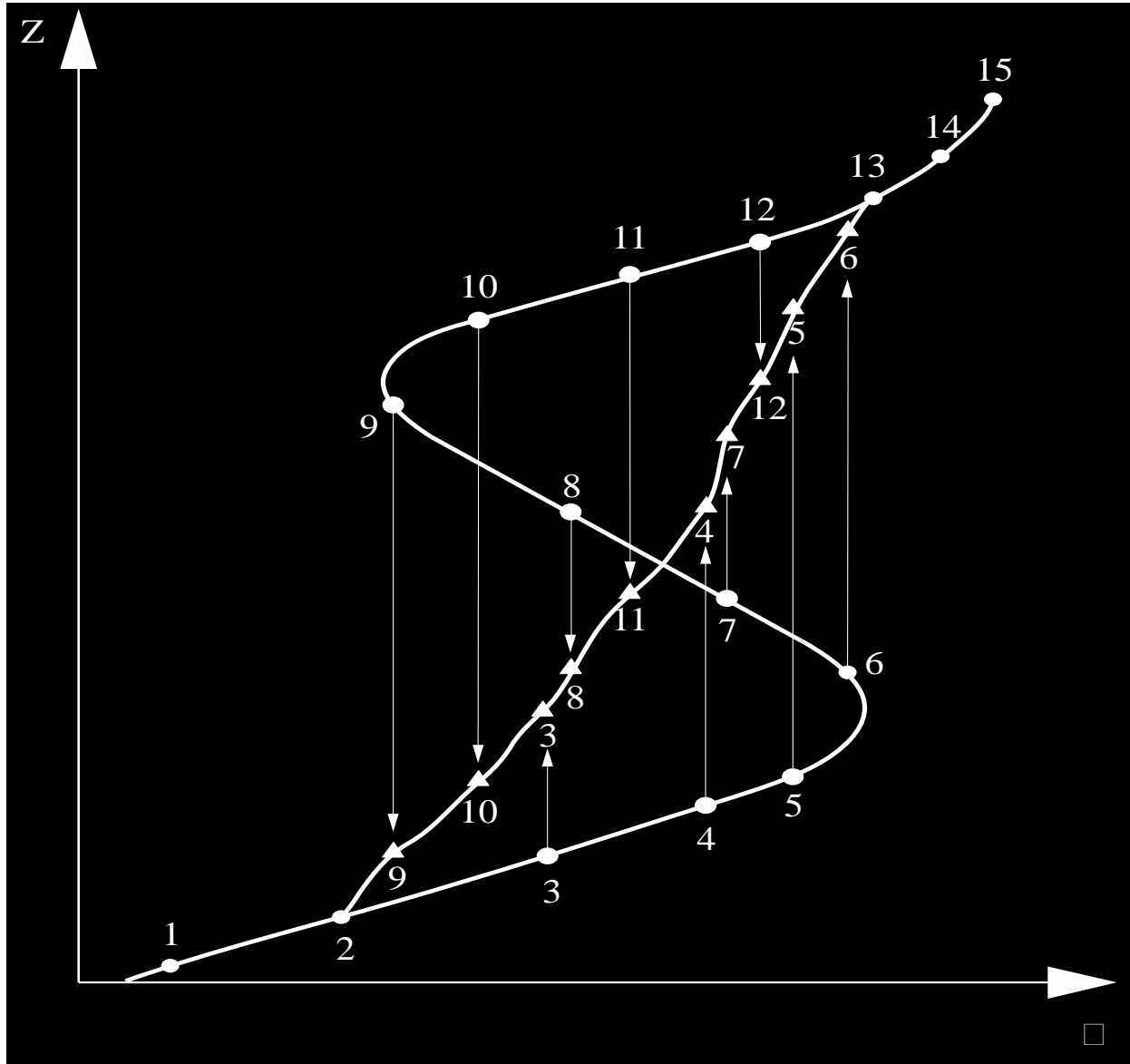
## Gage et al. (1980)



# Unstable Overturning Regions



# Thorpe's Sorting Algorithm



Displacement

$$d = |Dz|$$

Thorpe scale

$$L_T = rms(d_1 \cdots d_n)$$

Ozmidov scale

$$L_O = \sqrt{e / N^3}$$

$$L_O \sim L_T \rightarrow e = C_K L_T^2 N^3$$

$$C_K \sim O(1)$$

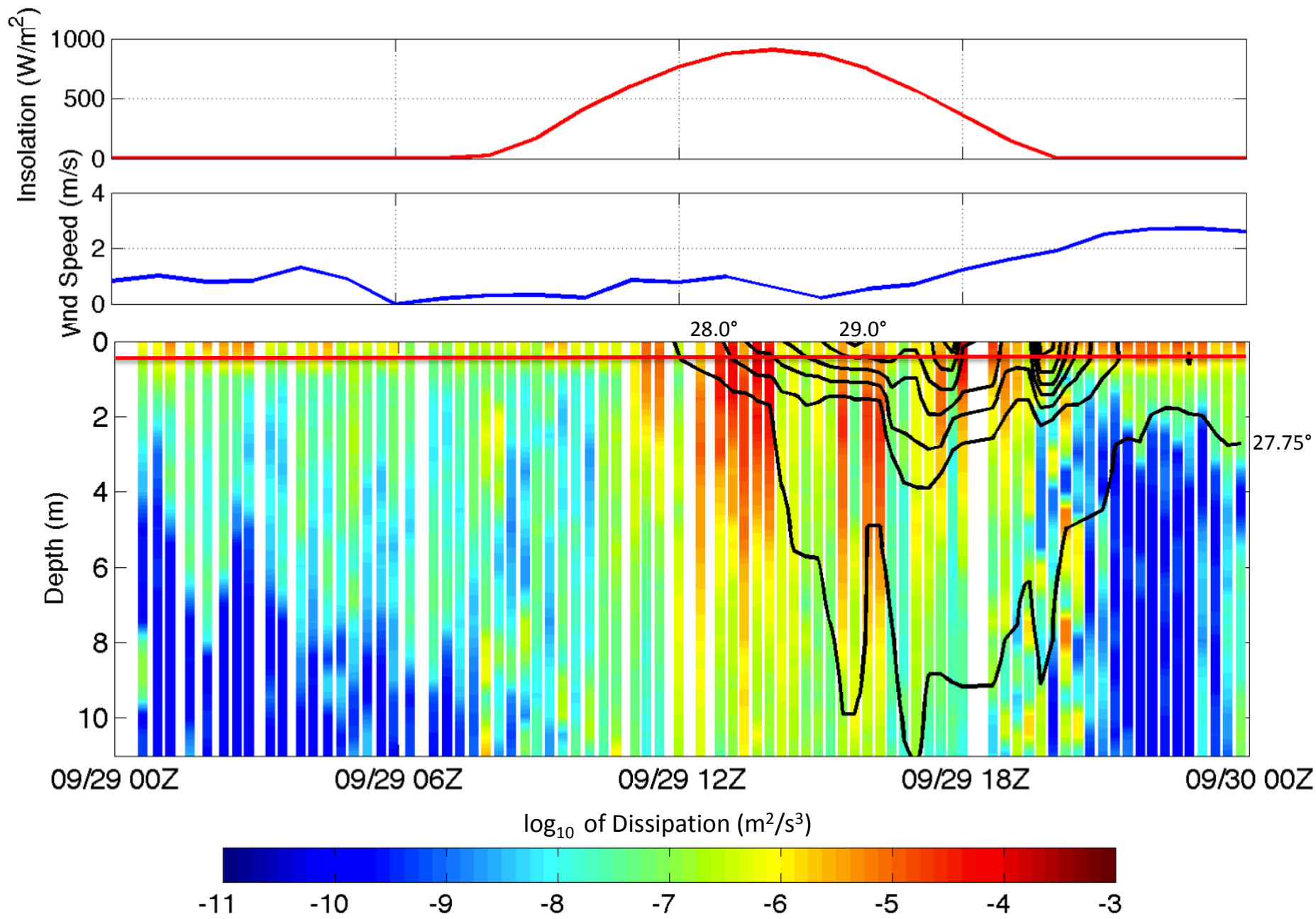
Mixing coefficient

$$K = g e N^{-2}$$

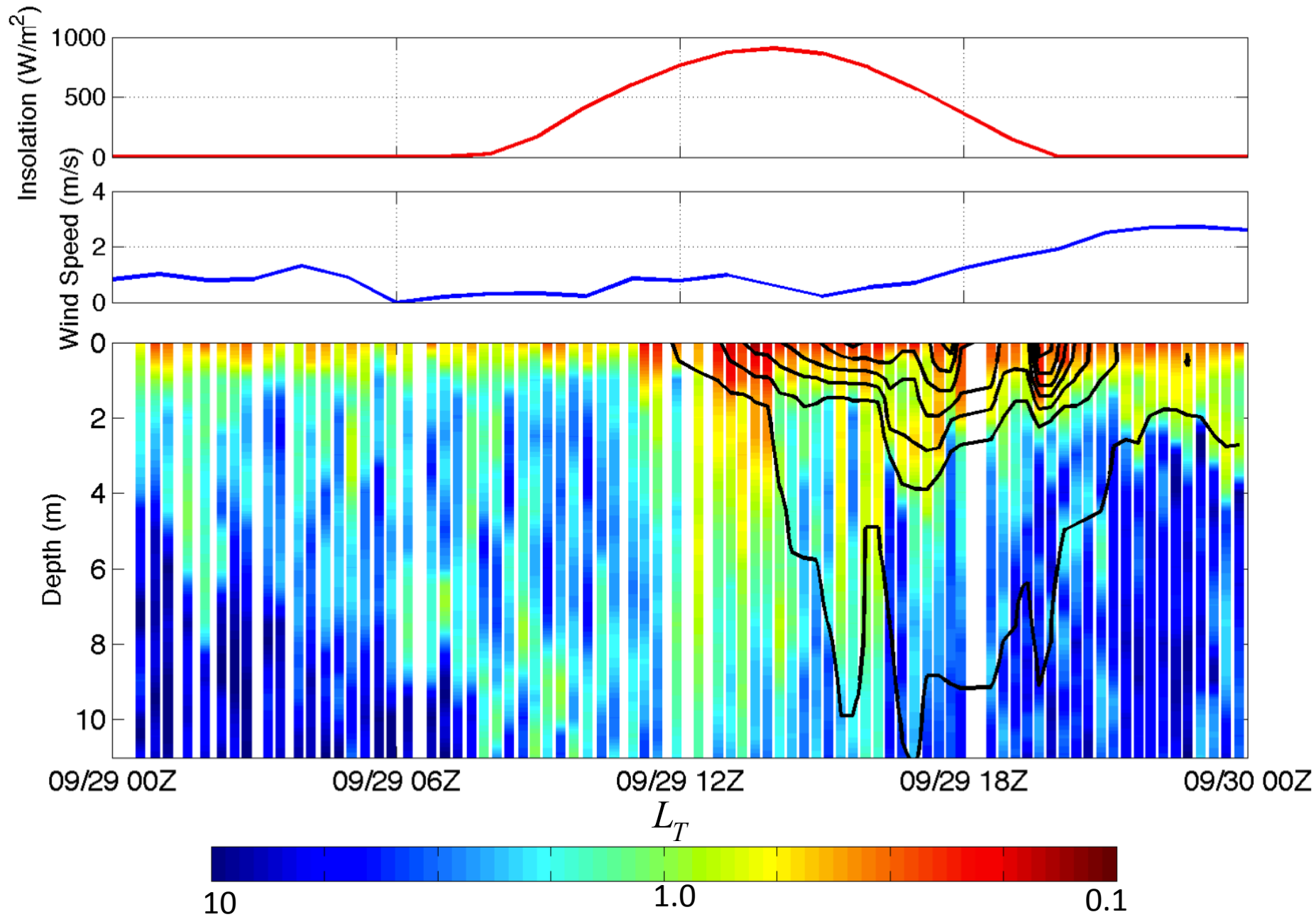
Mixing efficiency

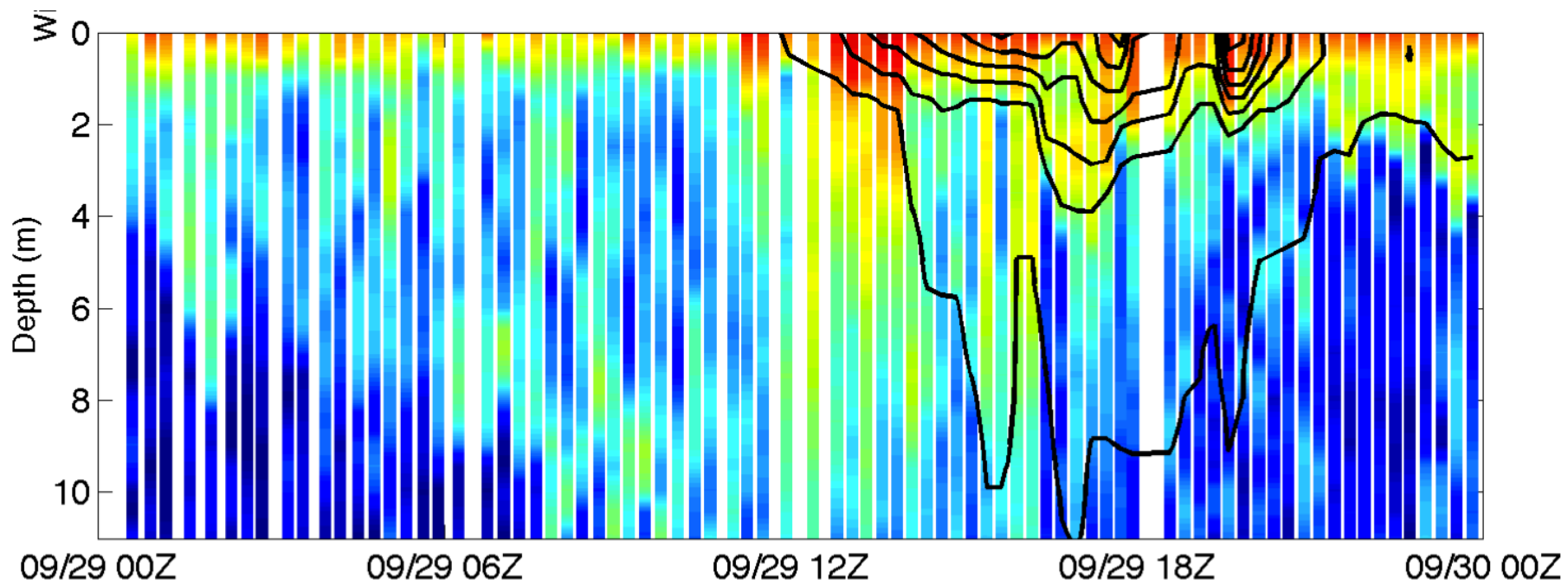
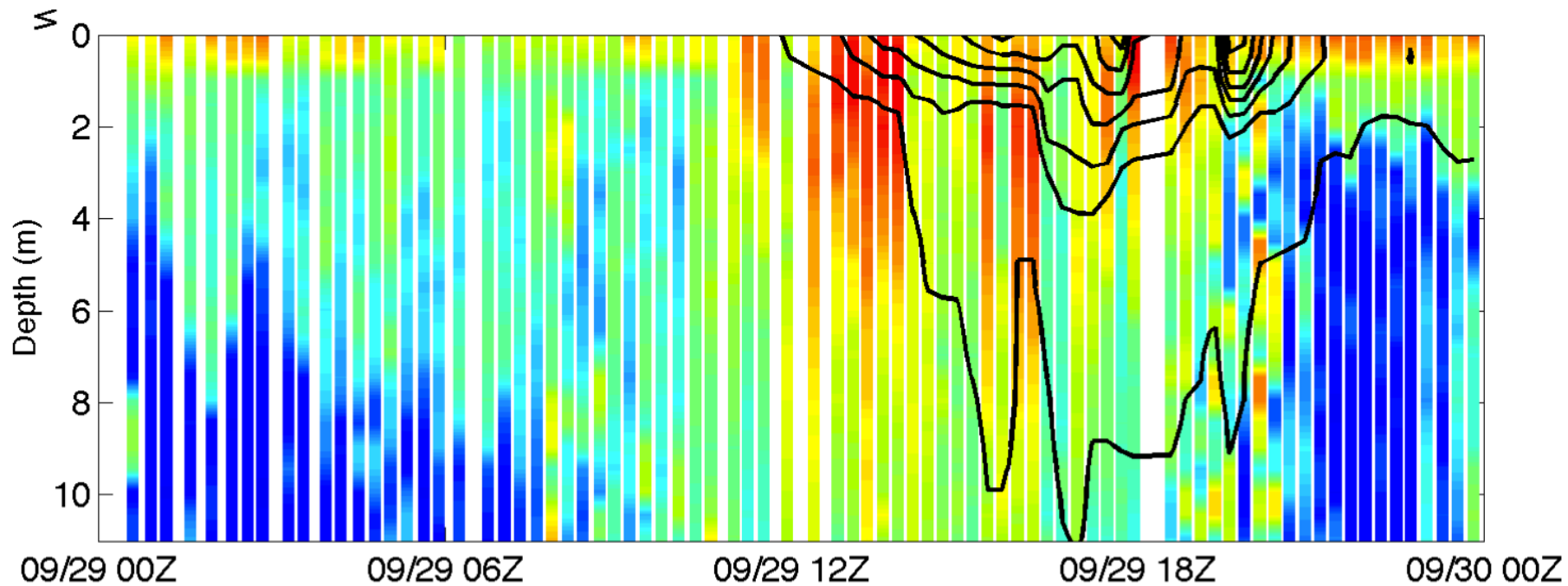
$$g \sim 0.25$$

# September 29, 2012 – TKE Dissipation ( $\epsilon$ ) w/ Temperature



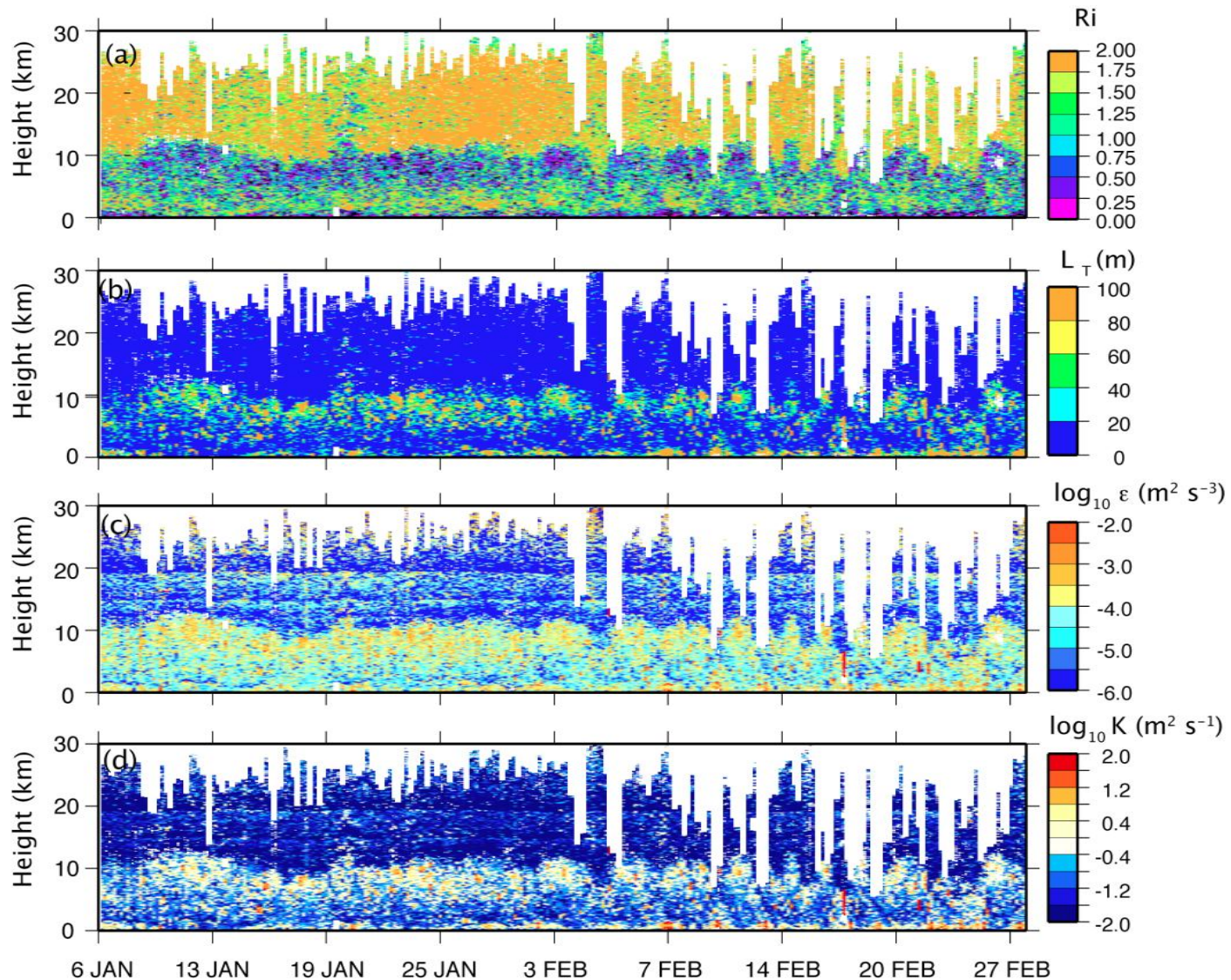
# September 29, 2012 – Thorpe Scale w/ Temperature





# 2 sec (~ 10 m) FASTEX Radiosonde Soundings in 1997

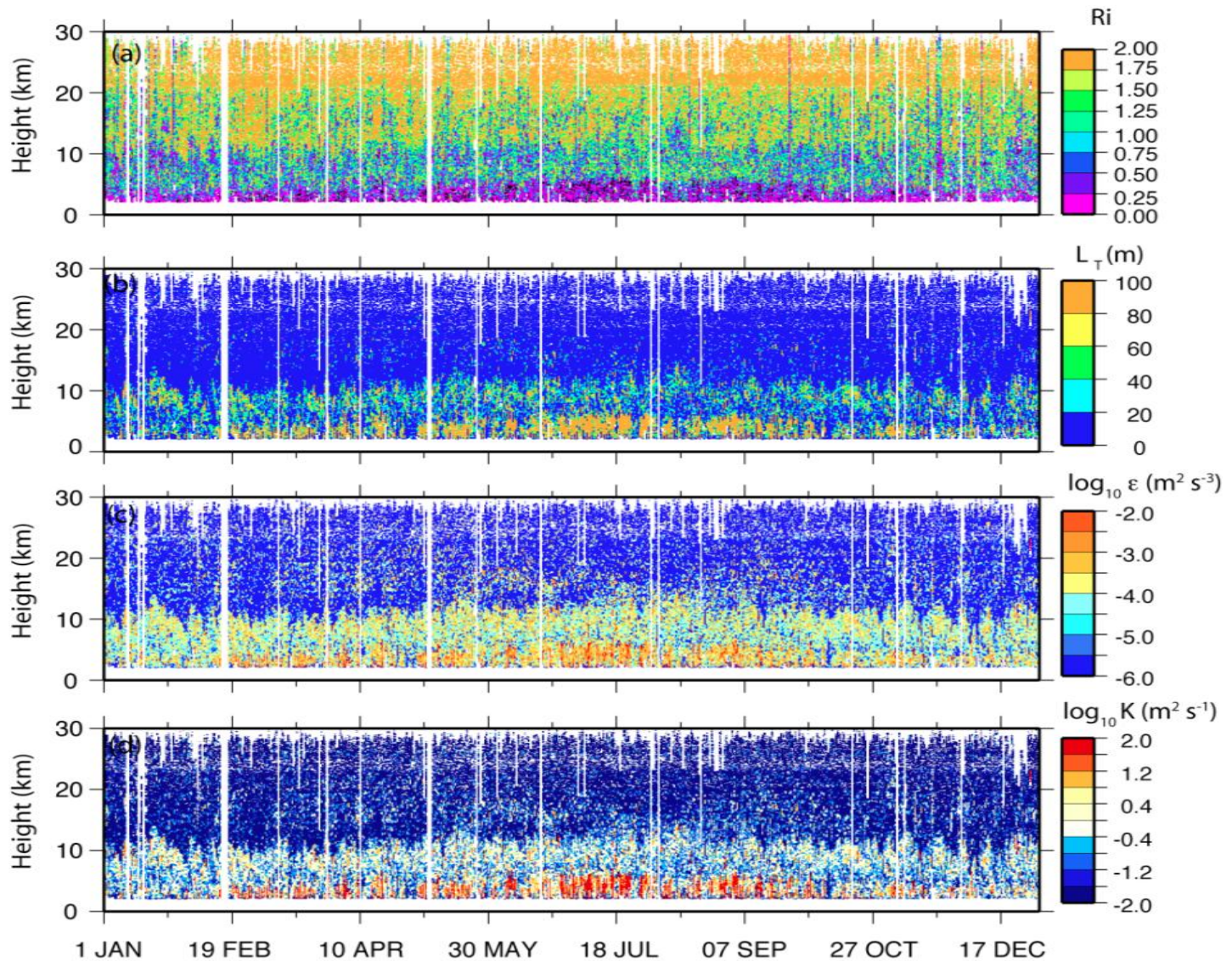
## Clayson and Kantha (2008)





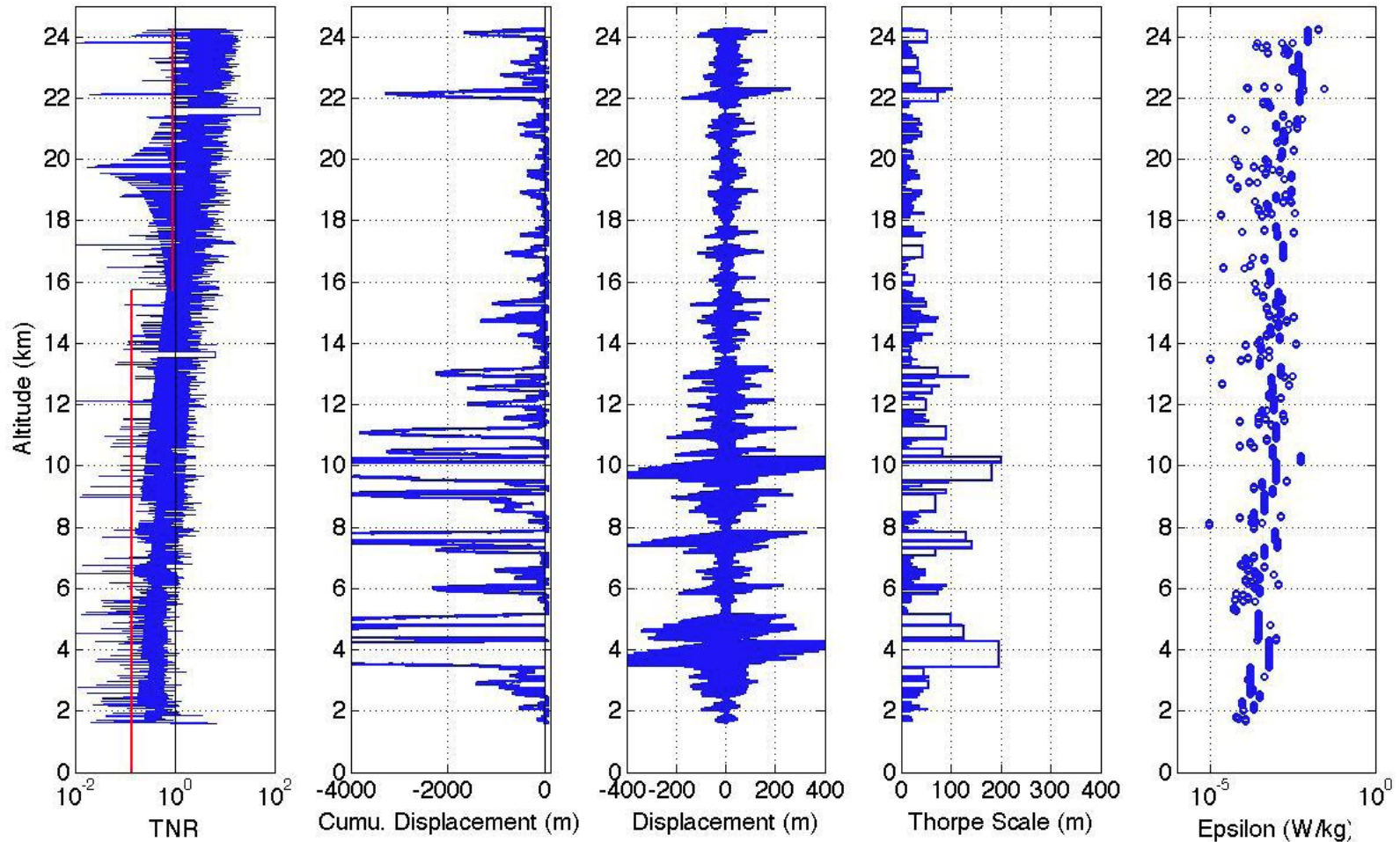
# 6 sec (~ 30 m) Operational Soundings at Denver in 2005

Clayson and Kantha (2008)



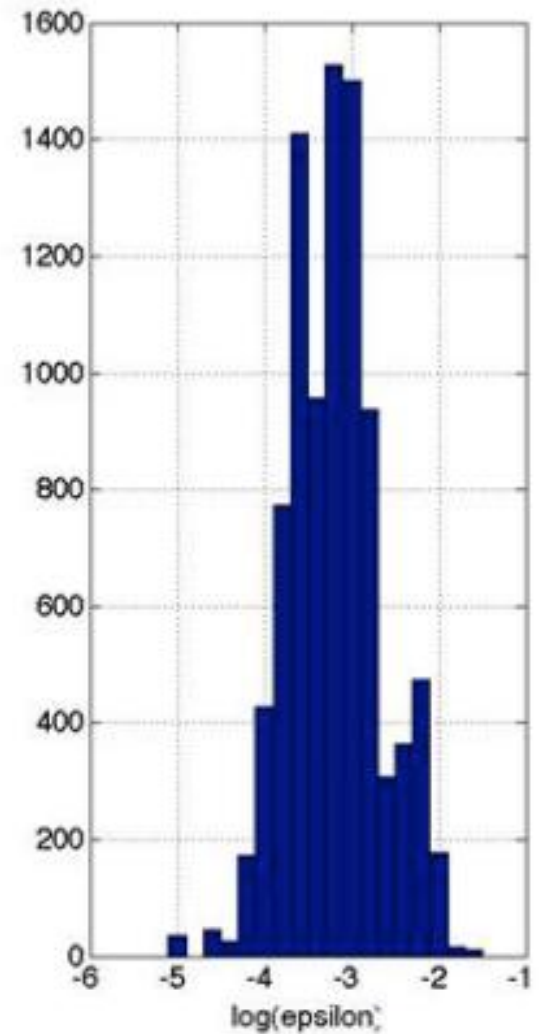
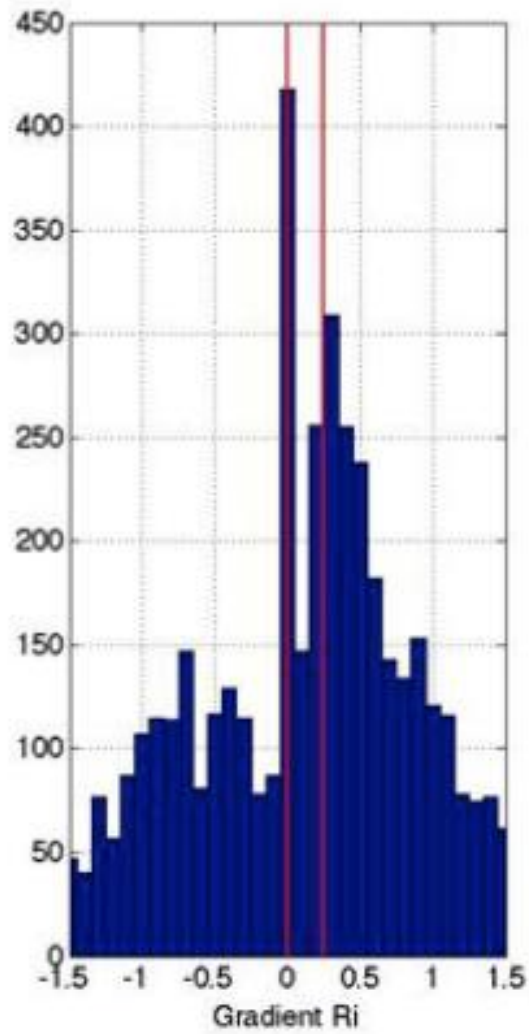
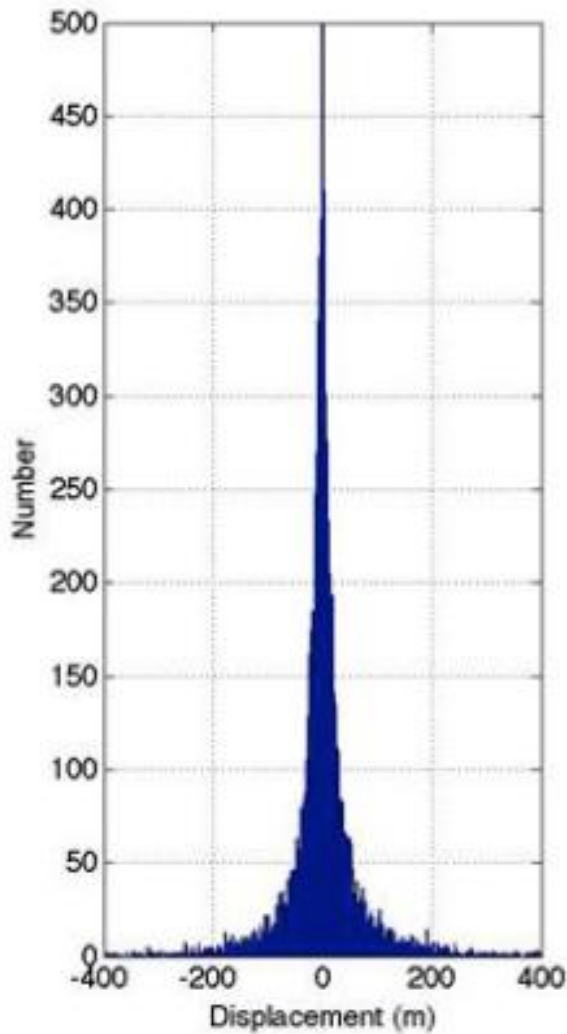
Resolution, Resolution, Resolution

# 1 sec (~ 2 m) SAMS (Balsley et al. 2010) Soundings Kantha (2012)

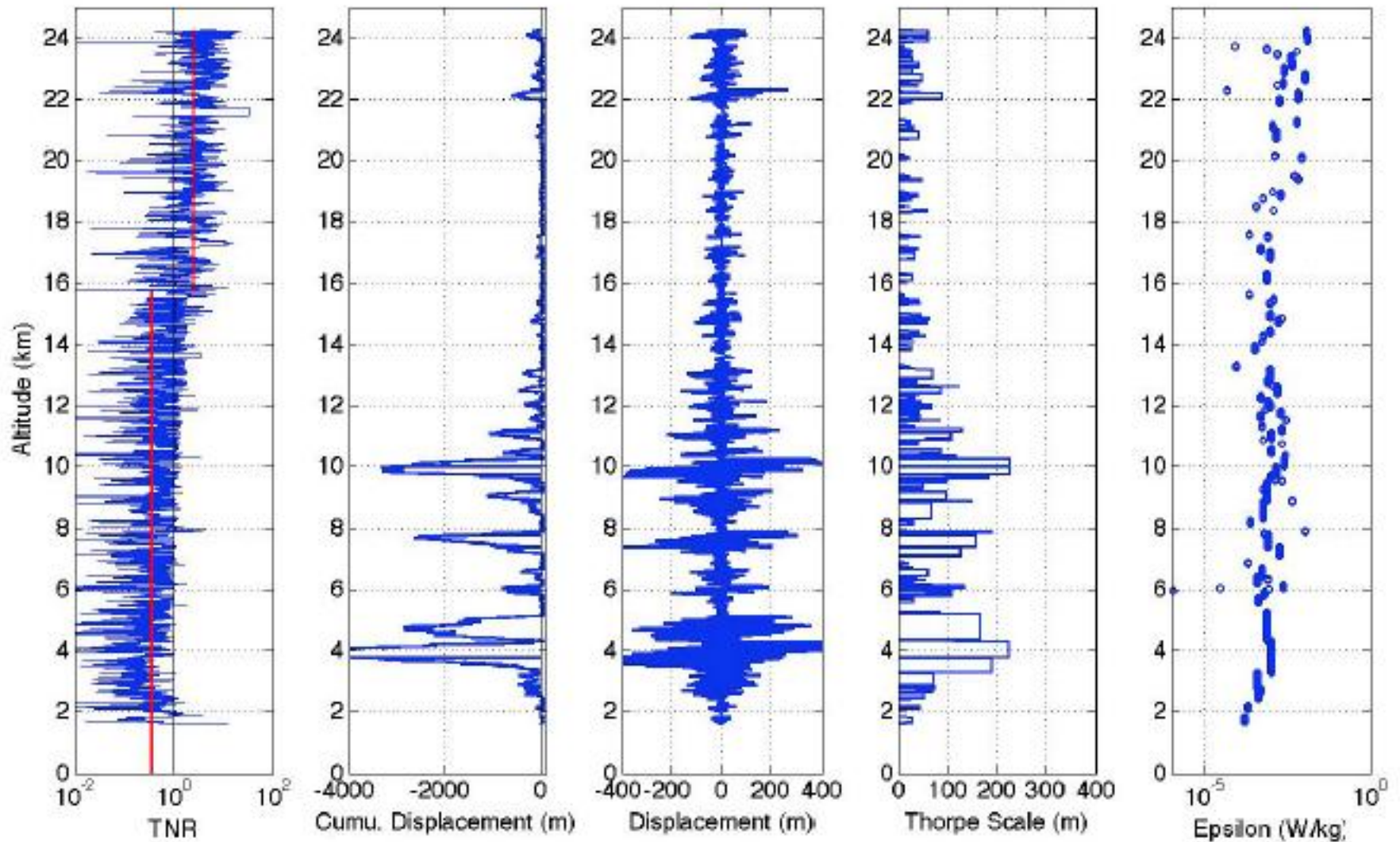




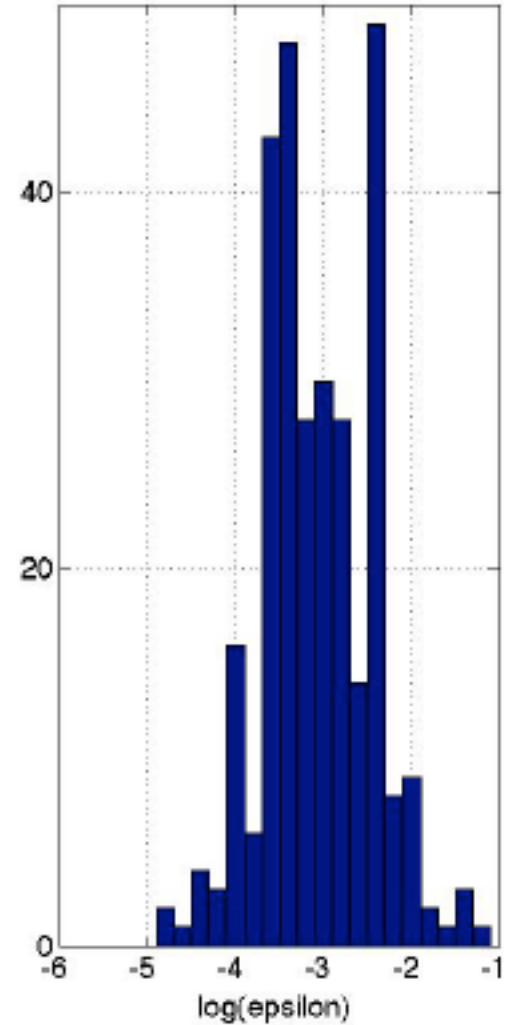
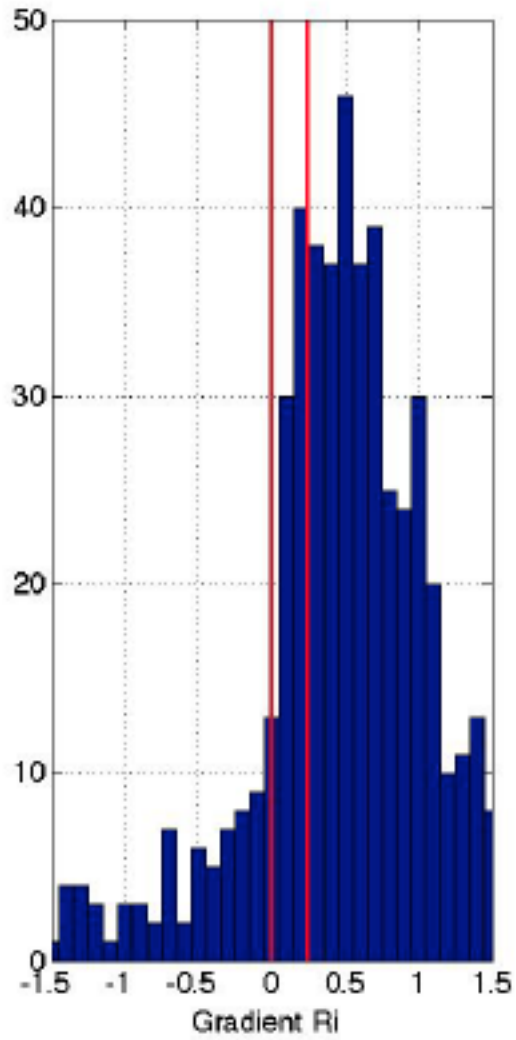
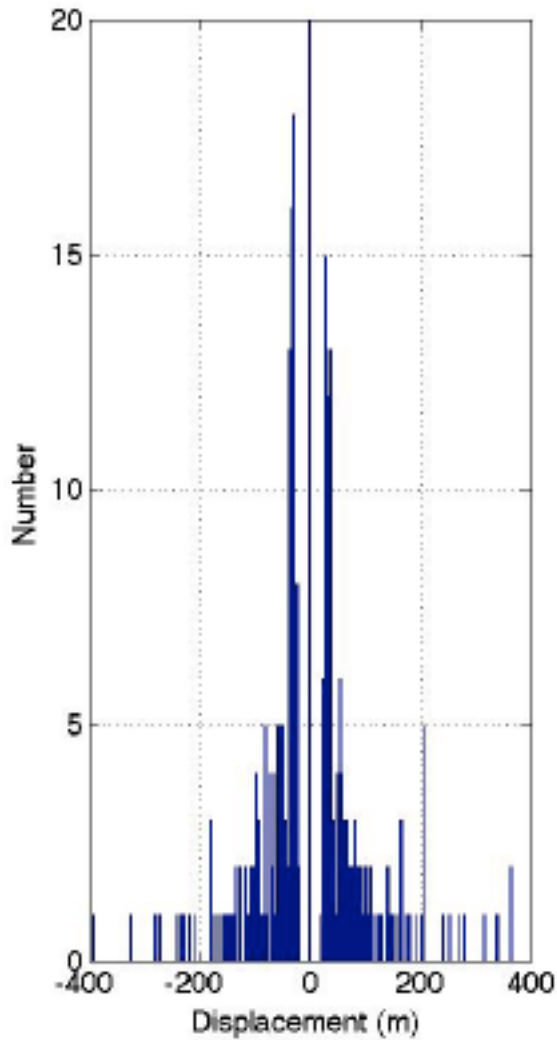
# 1 sec (~ 2 m) SAMS (Balsley et al. 2010) Soundings Kantha (2012)



# Subsampled data to 10 m resolution

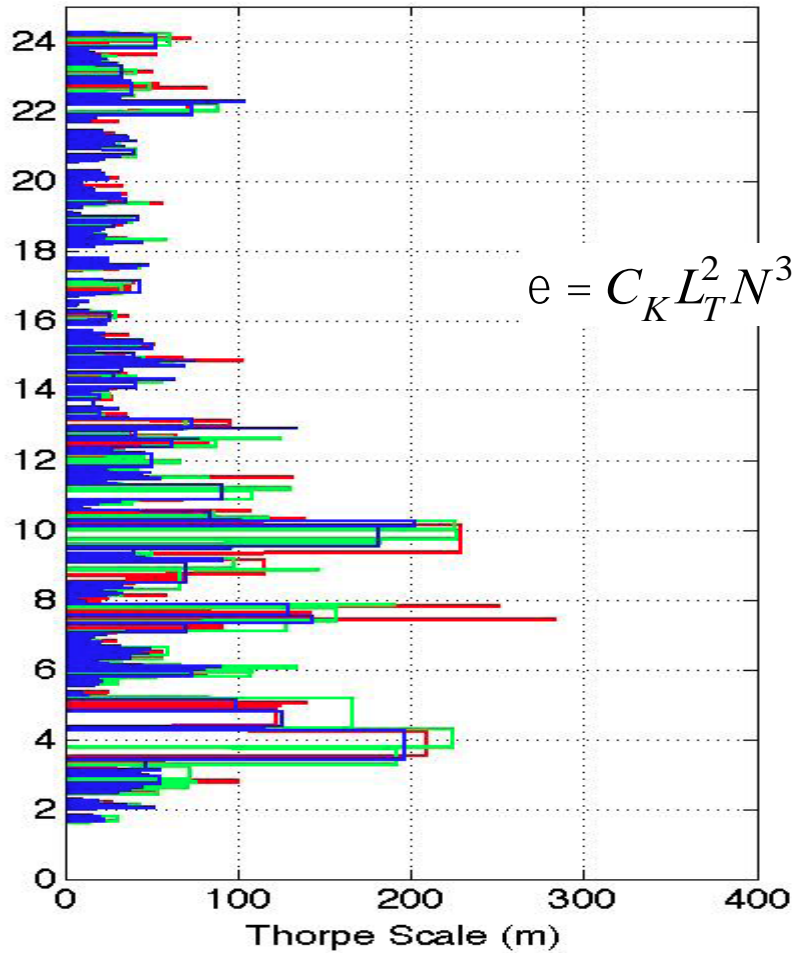


# Subsampled data to 10 m resolution

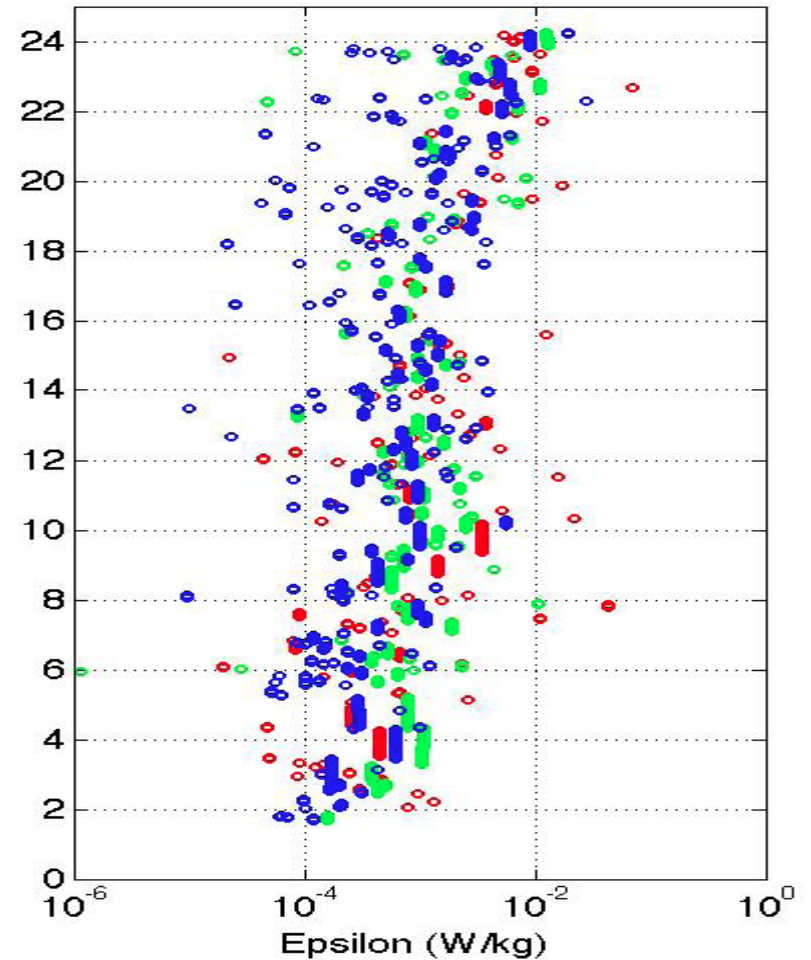


# Effect of Vertical Resolution on

# extractions (Kantha 2012)



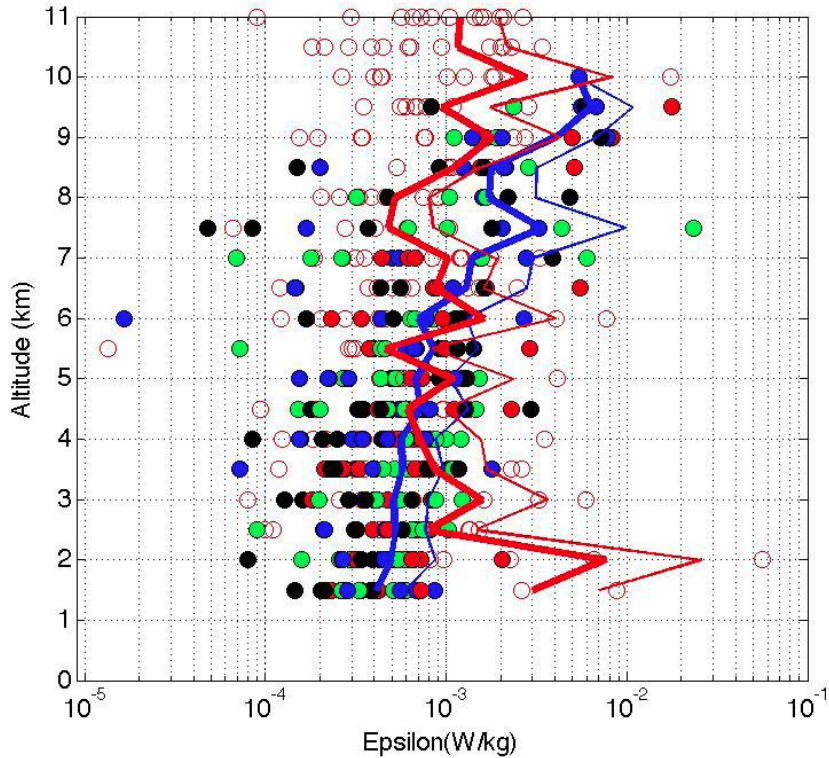
$$e = C_K L_T^2 N^3 \rightarrow$$



Blue - 2 m, Green - 10 m, Red - 30 m



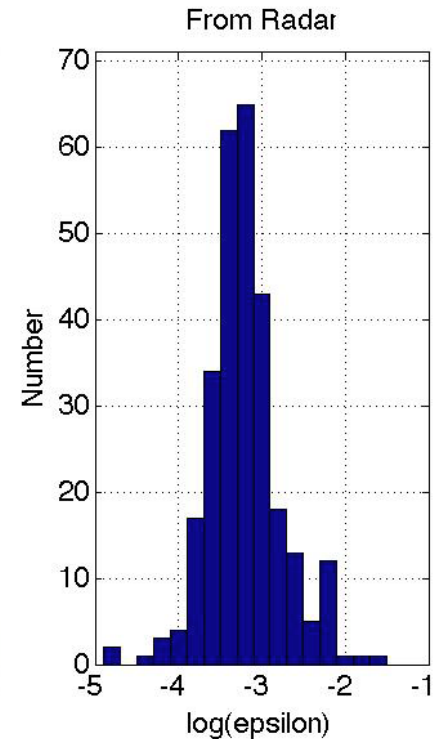
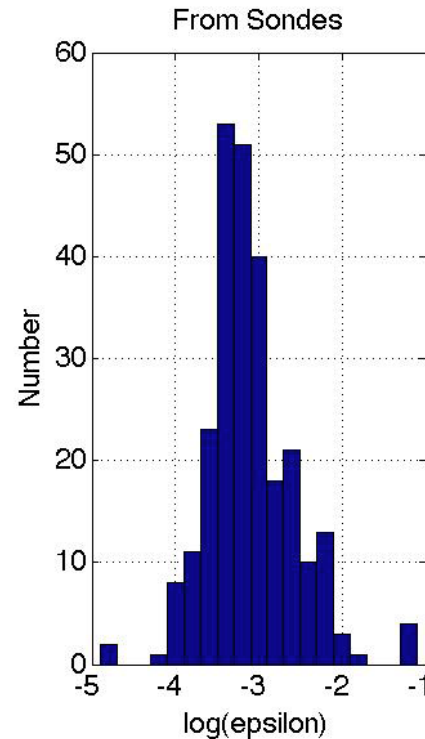
# Harrow (Canada) ST Radar (Kantha & Hocking 2011)



$$e = 0.6d^2 N$$

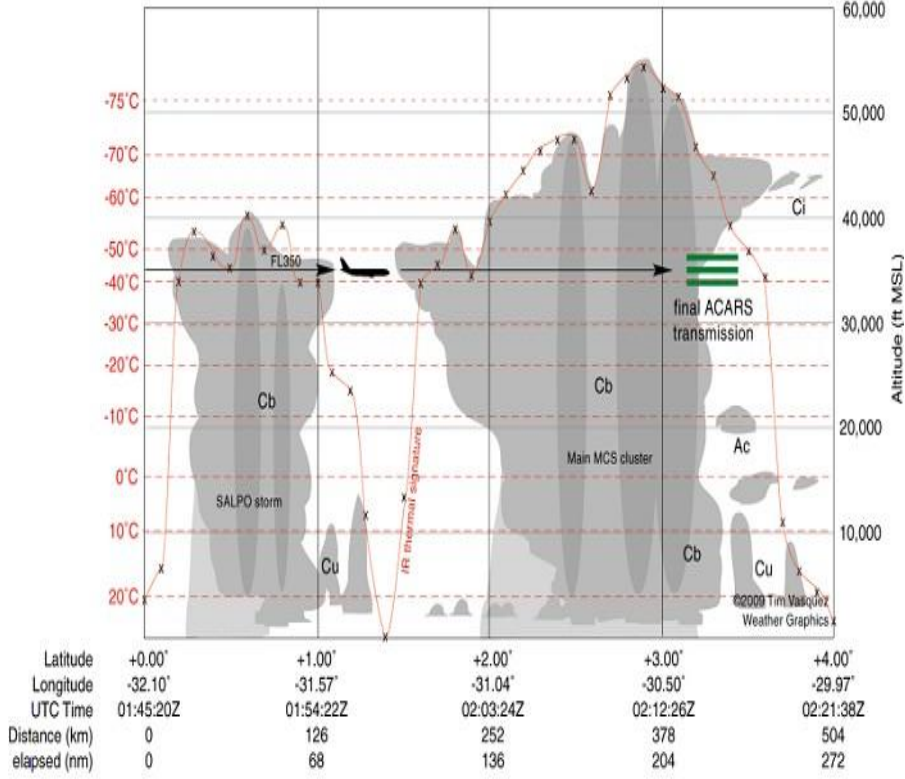
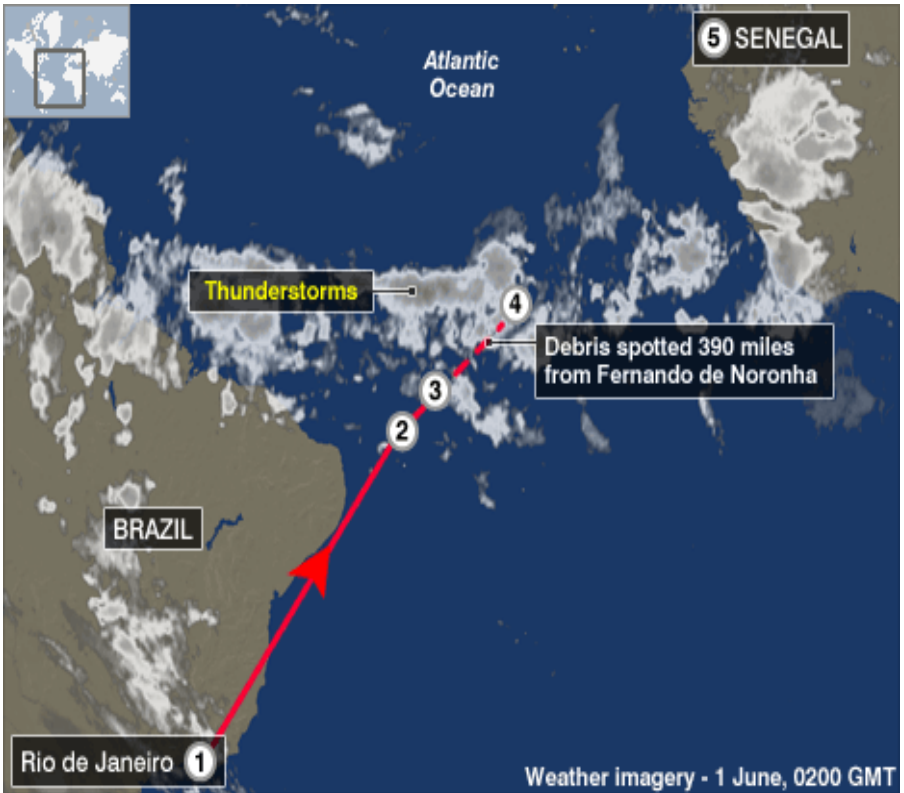
d - Corrected Spectral Width

Sondes – Red open circles  
Red lines  
Radar – Filled circles, Blue lines



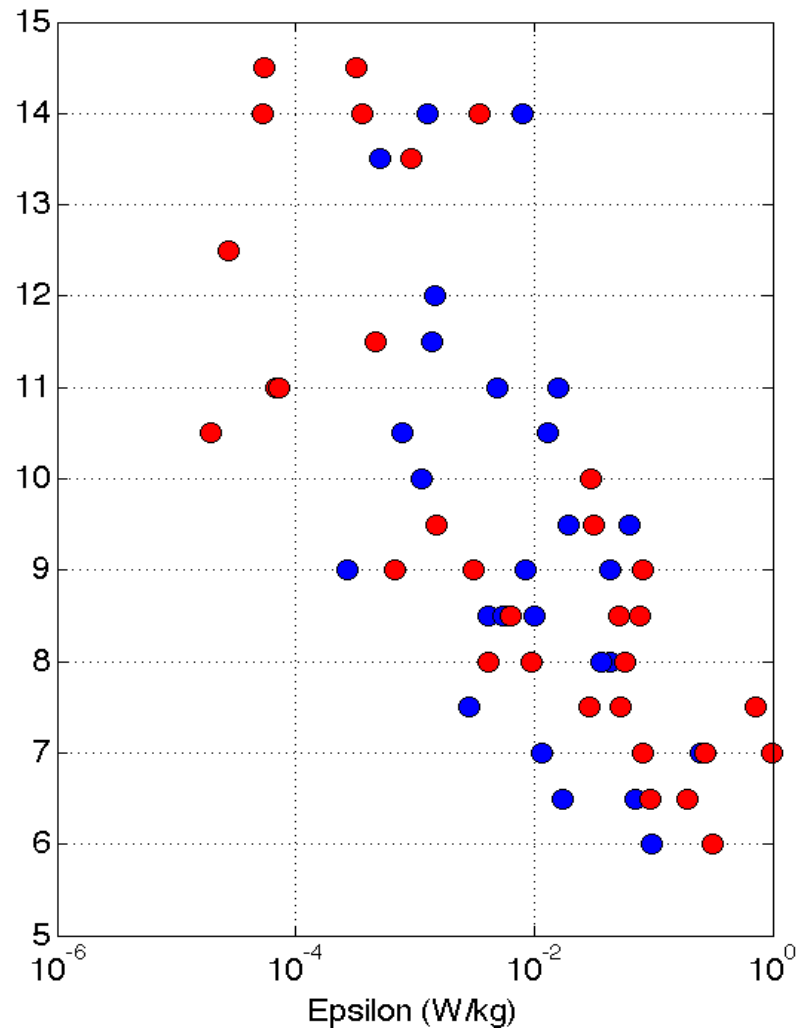
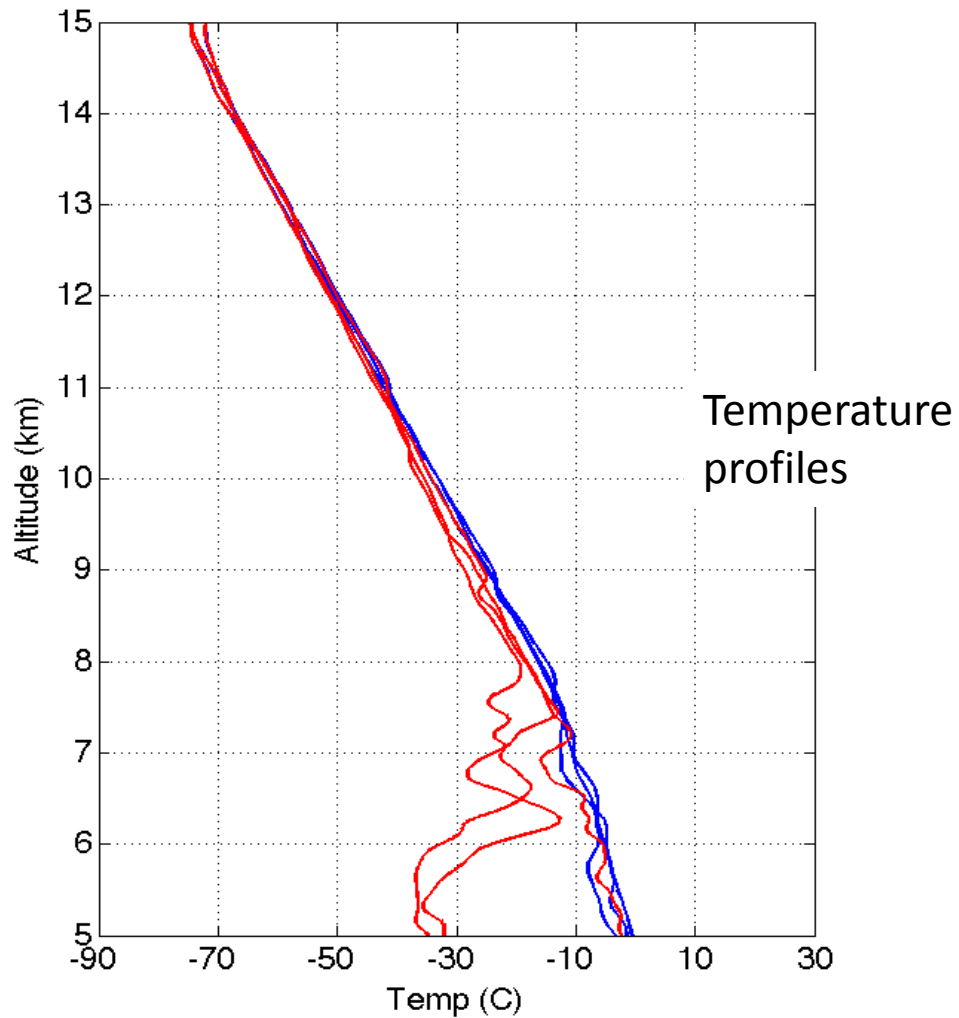


# Flight Track of AF447 Through Convective Storm Cluster in the ITCZ



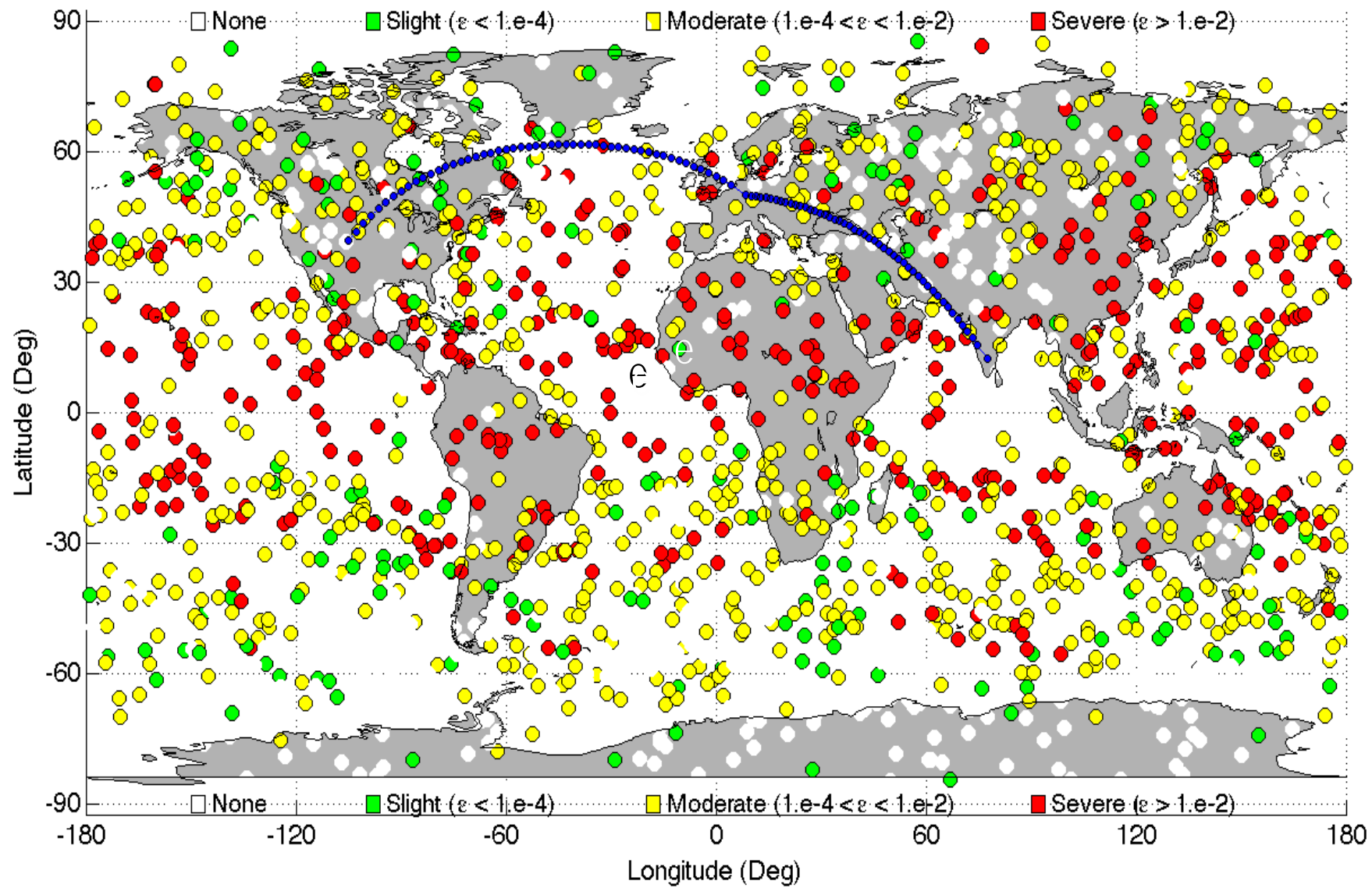
\* From Final report

# AF 447 Crash Site Temperature profiles and TKE Dissipation Rates (COSMIC data)



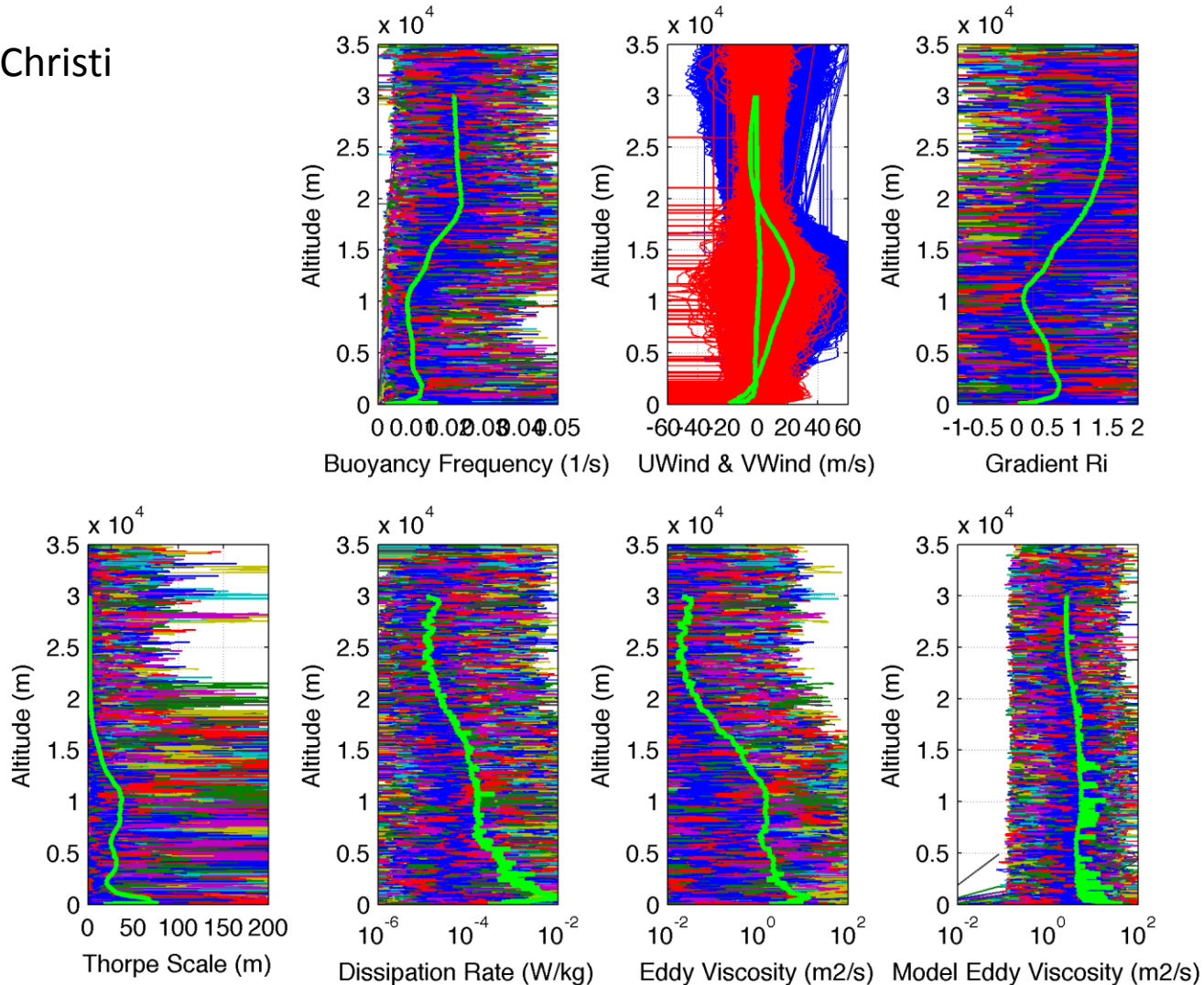
Red – Dry temperature, Blue – Temperature corrected for water vapor

# Average COSMIC between Flight Levels 8 and 12 km on July 1, 2010



# Some looks at the HVRRD data

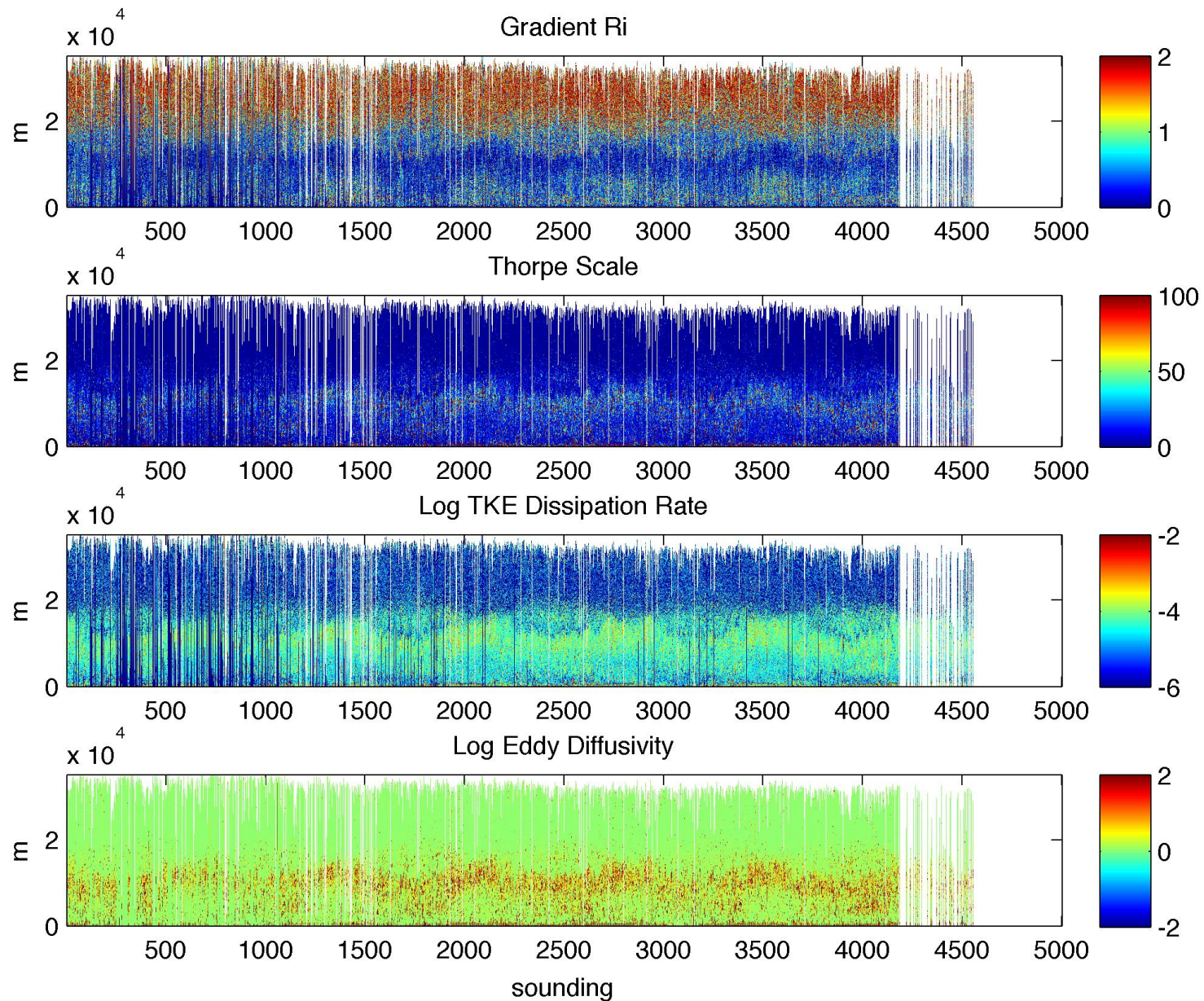
Corpus Christi



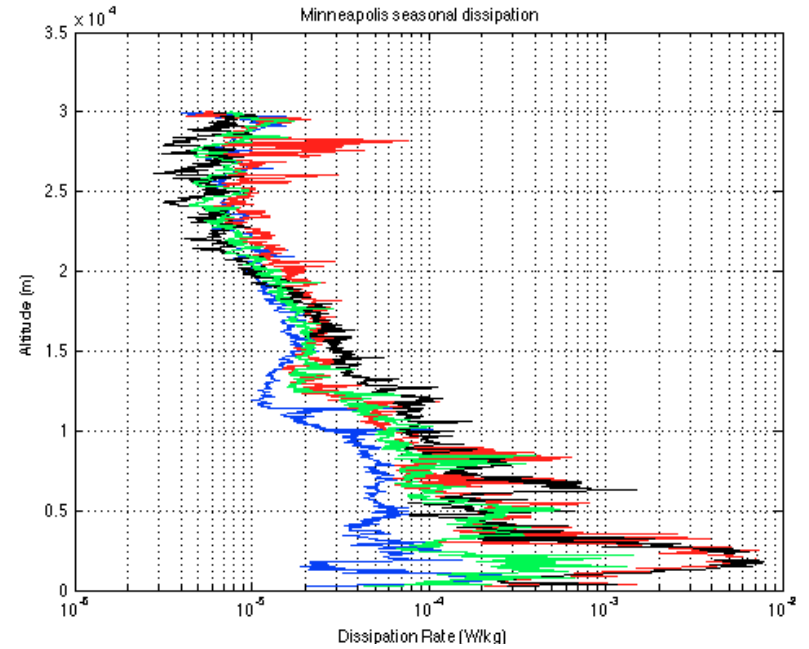
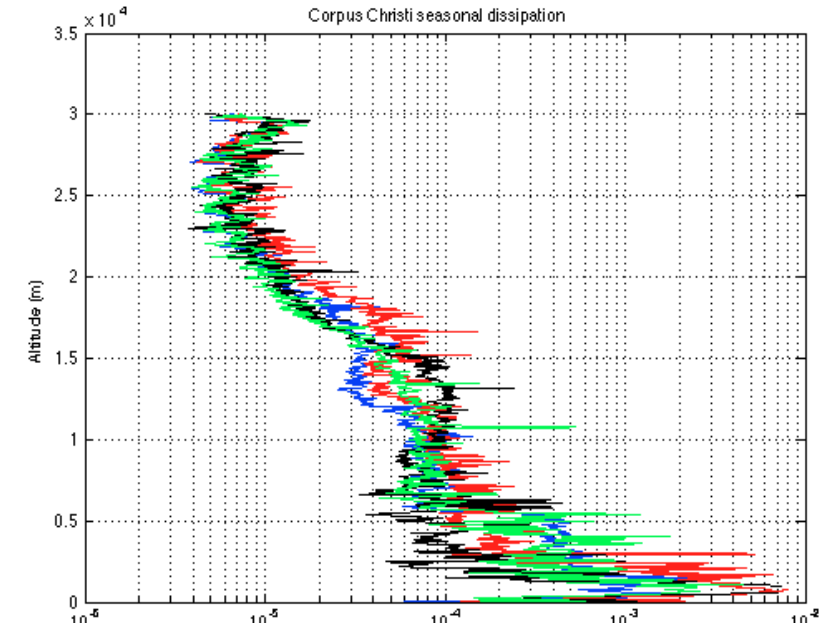
At last, enough data that putting all on a plot is too much information



# Corpus Christi, 5+ years



# Seasonal averages

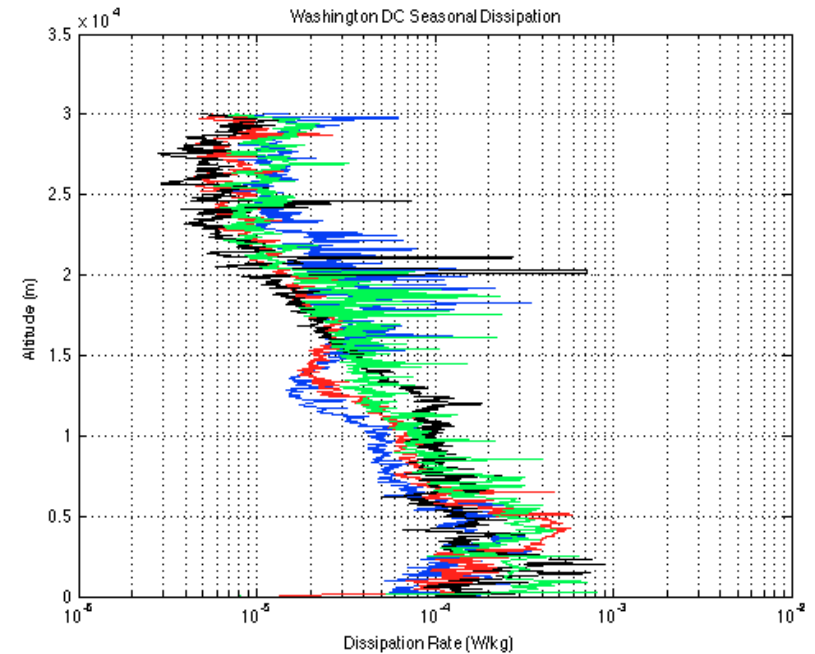
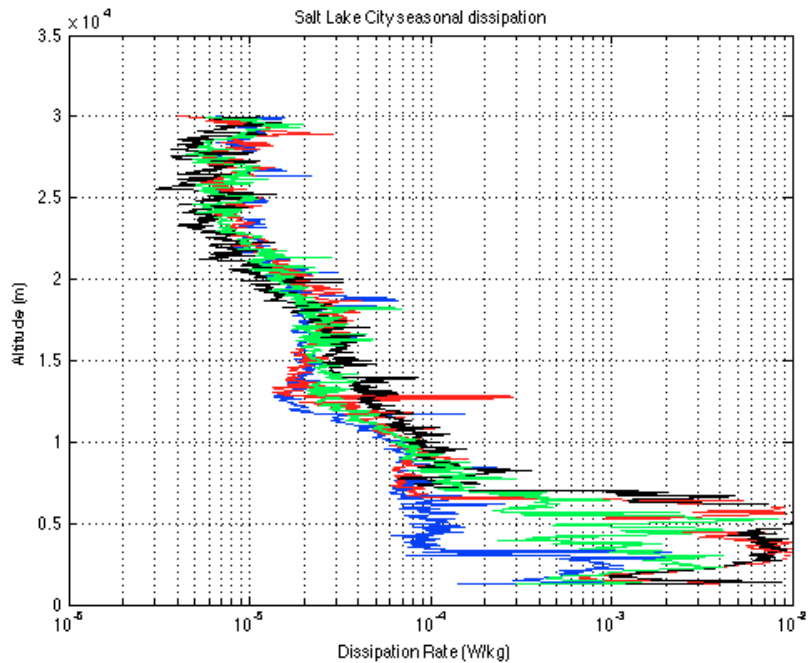


DJF

MAM

JJA

SON



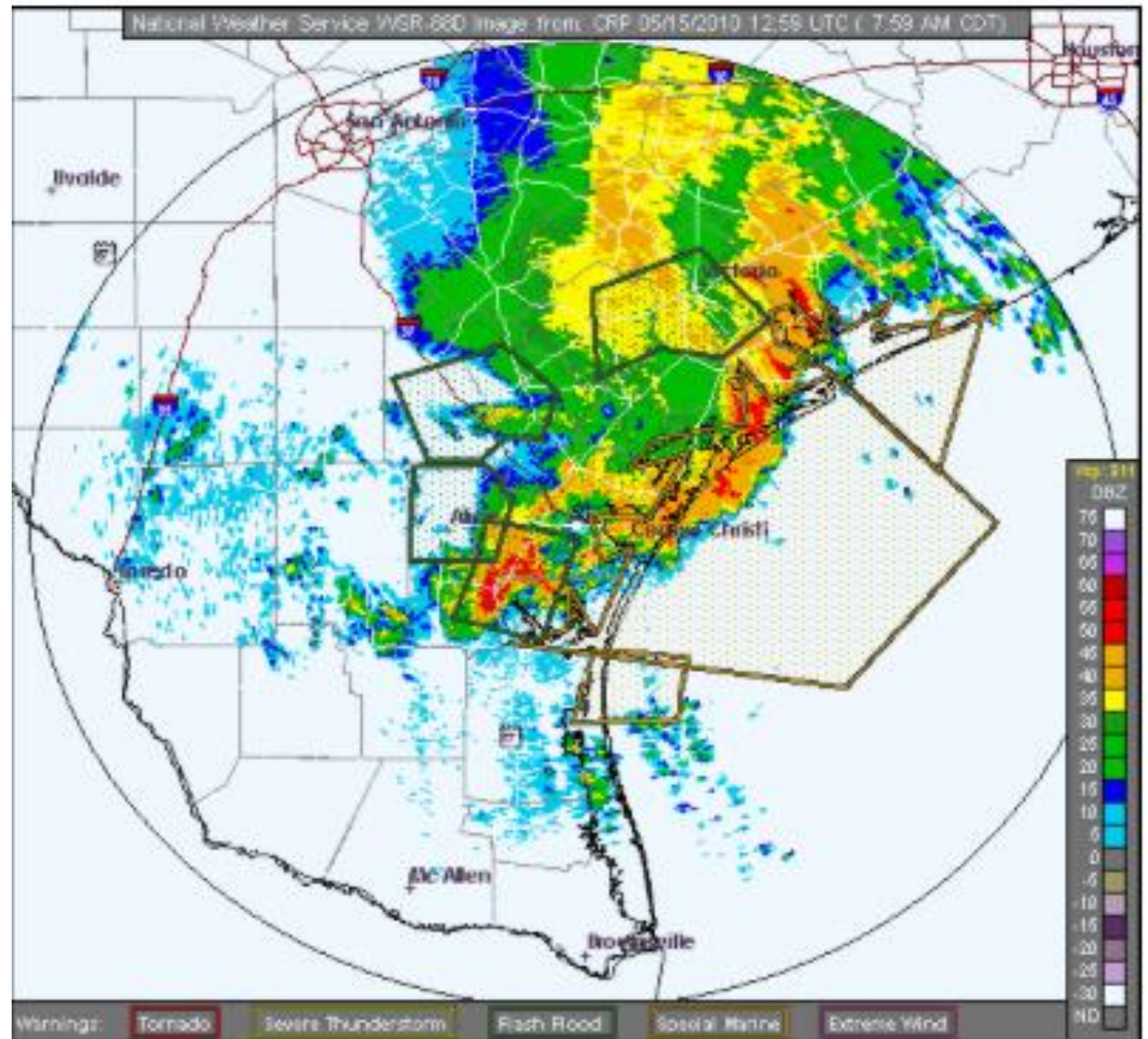


# Can we see individual events?

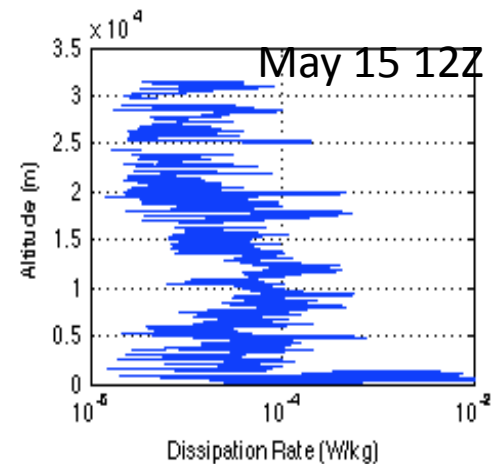
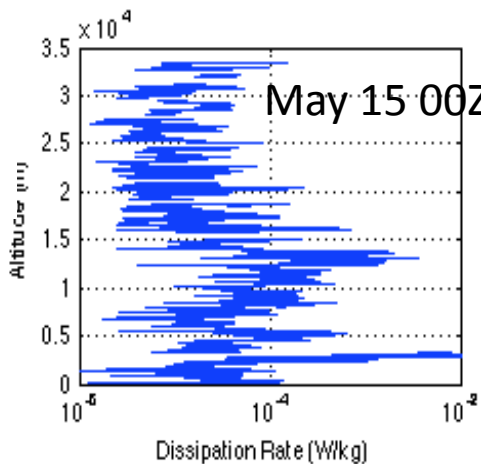
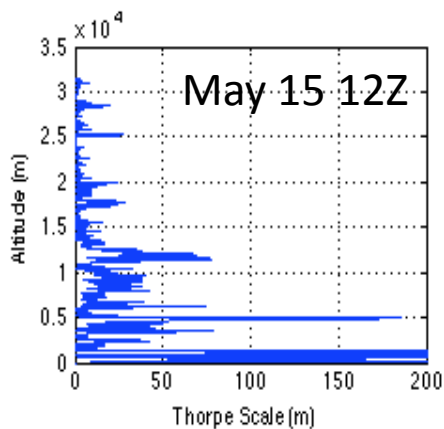
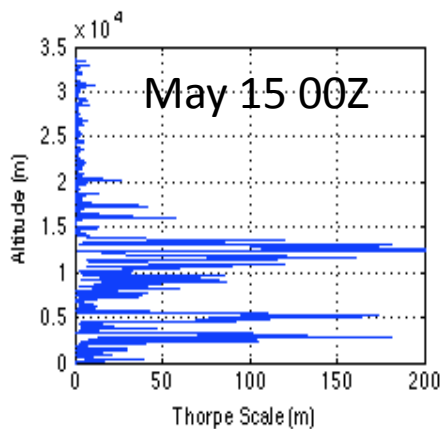
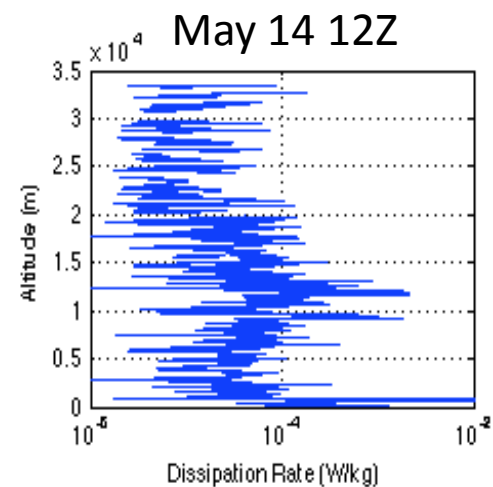
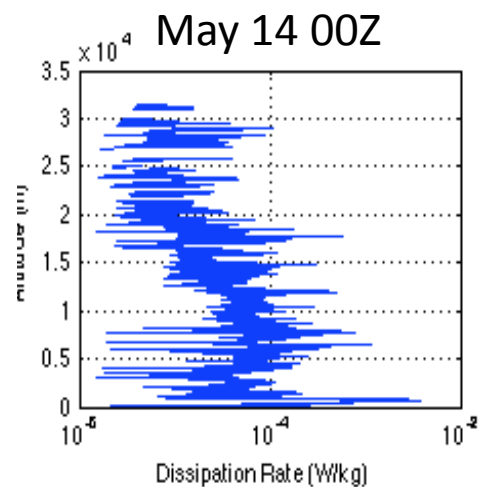
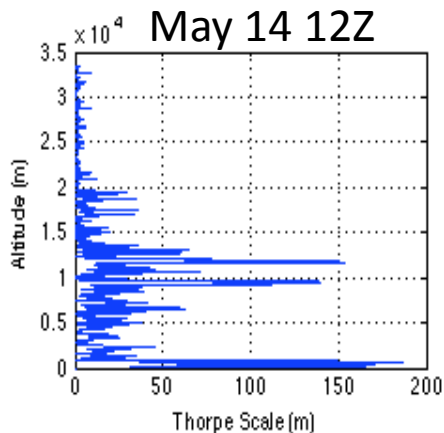
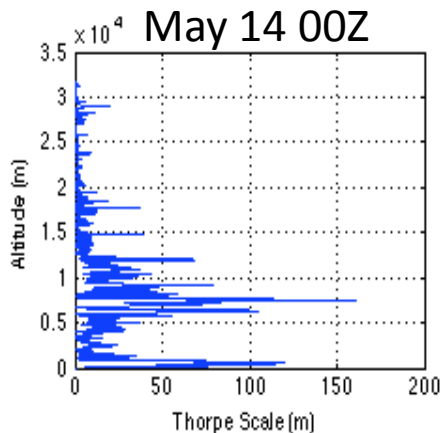
May 14<sup>th</sup> – 15<sup>th</sup>, 2010: significant squall line event

Strong winds (up to 65 mph)

Up to 7 inches of rain fell



# May 14<sup>th</sup> and 15<sup>th</sup> profiles

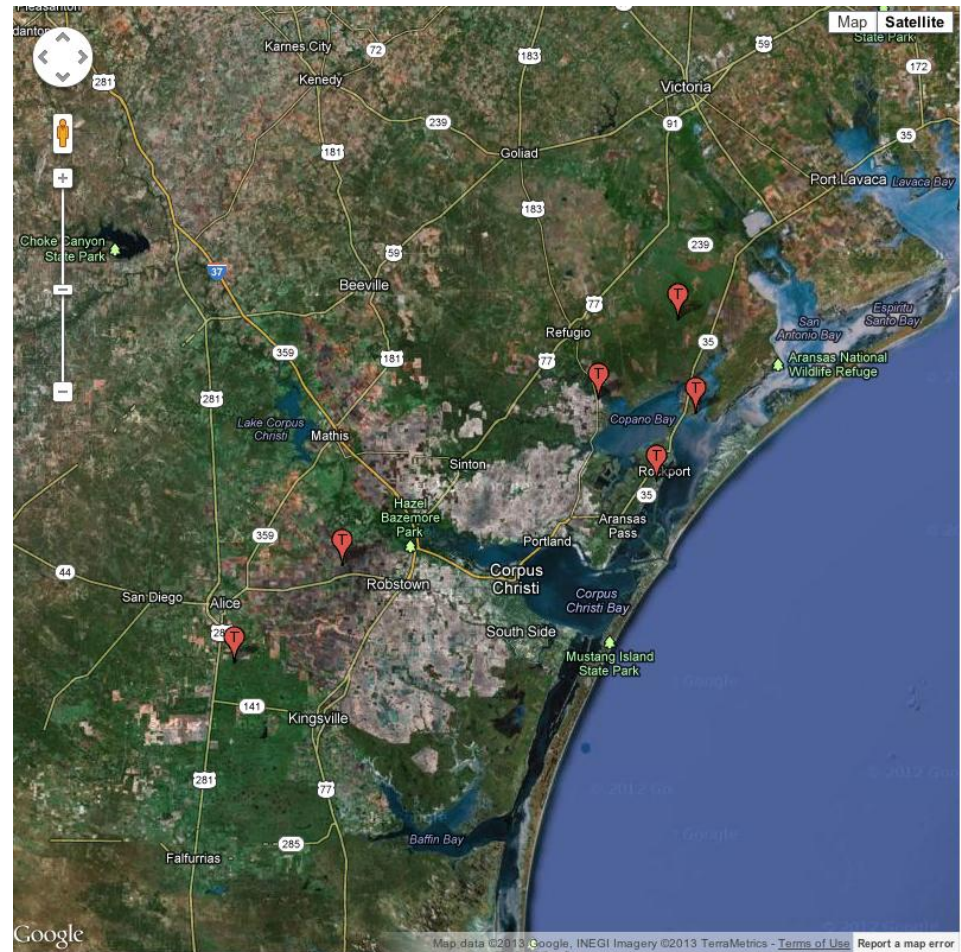




# Hurricane Alex– 30 June 2010

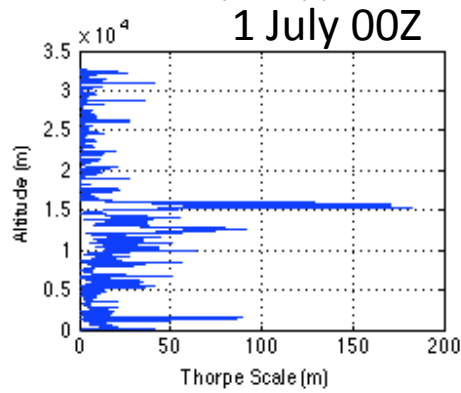
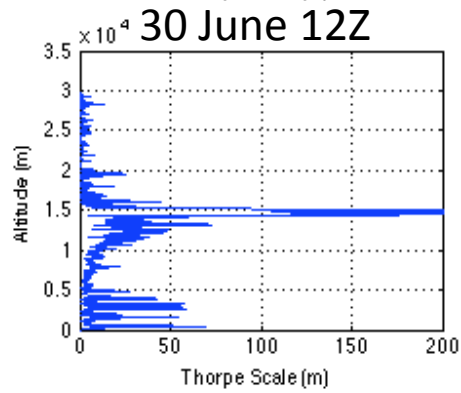
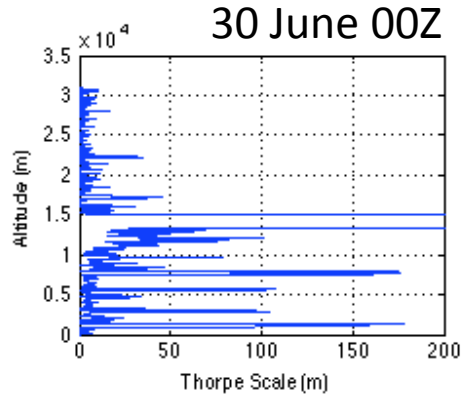
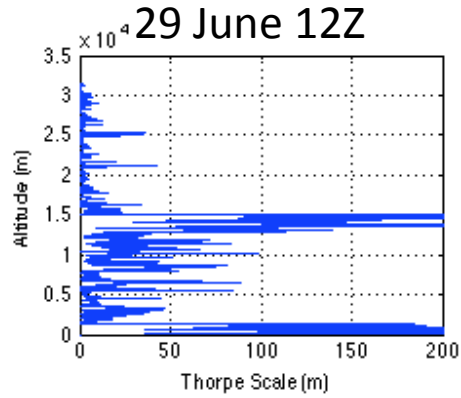
- Very large storm (tropical storm force winds extending over 200 miles from the center)
- Outer rain bands produced 6 tornadoes in the area
- Rainfall totals of 3 to 6 inches (some locations near 10 inches)

Locations of associated tornadoes

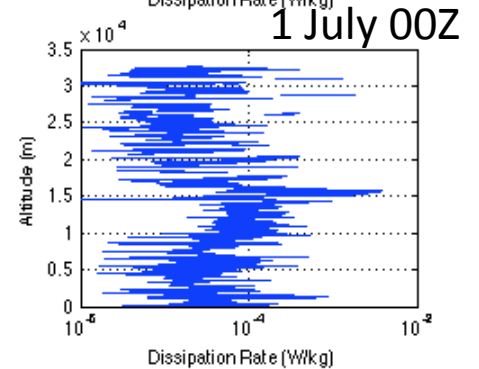
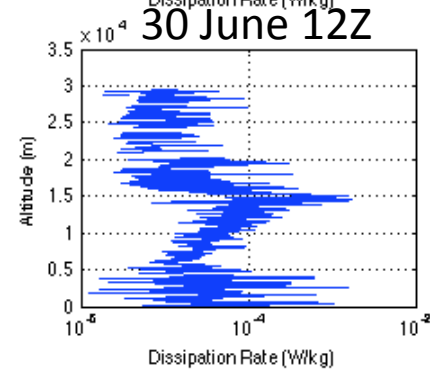
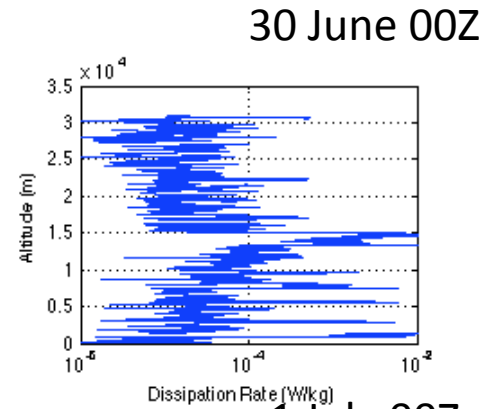
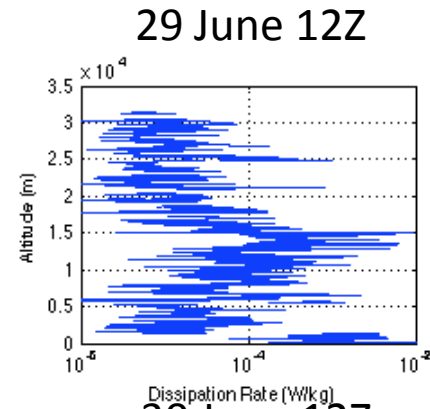




# Corpus Christi Thorpe Scales

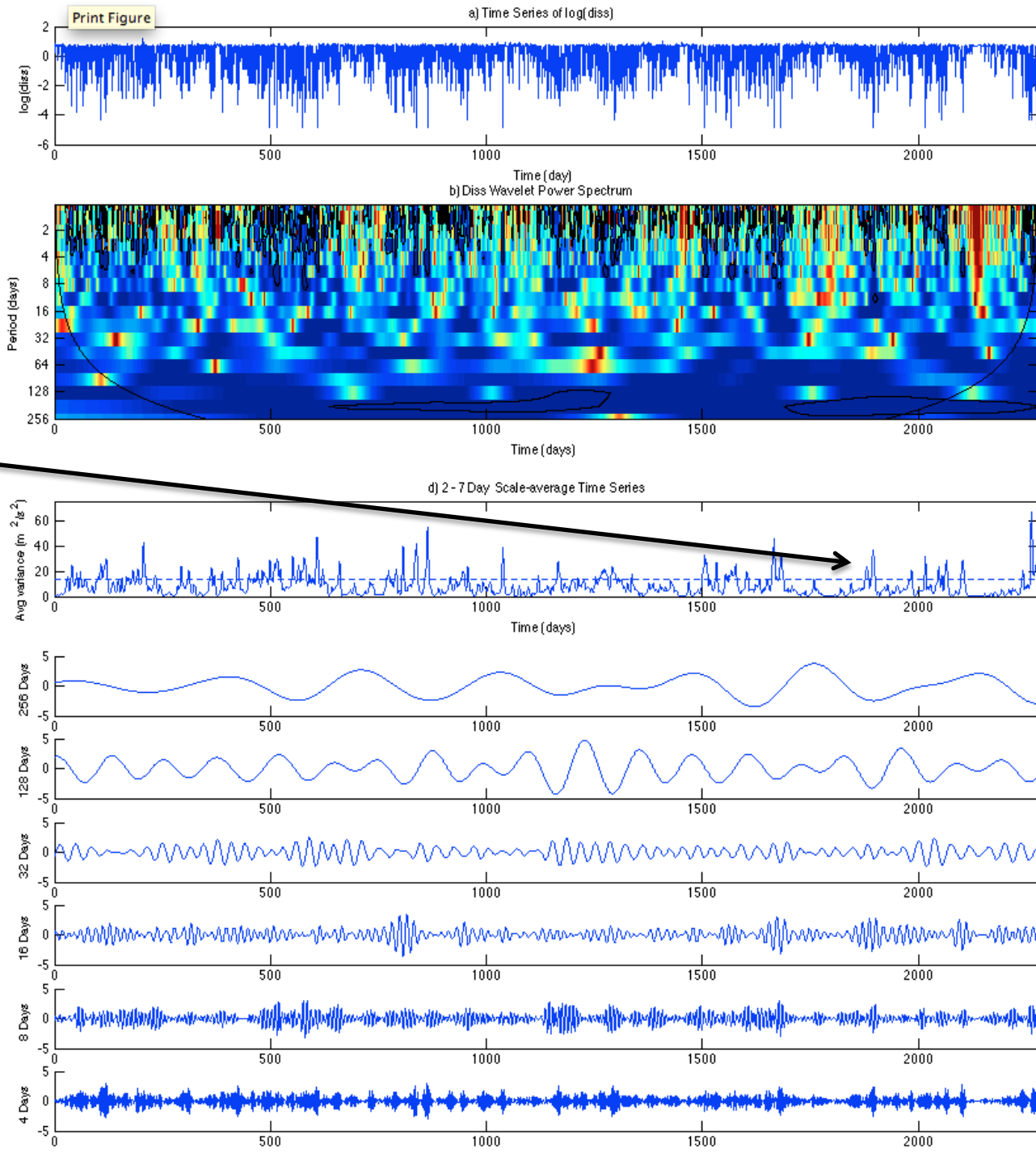


# Corpus Christi Dissipation

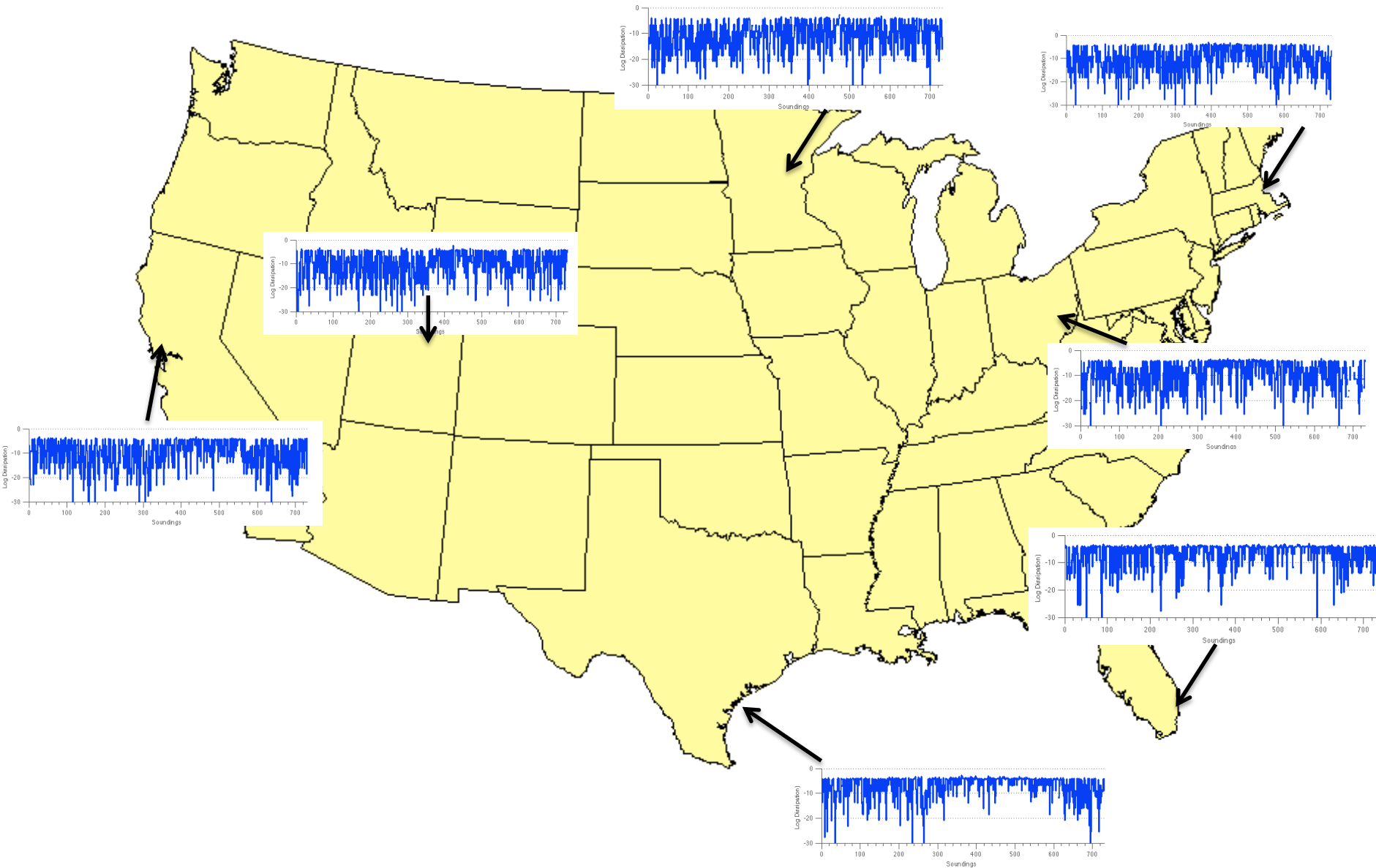


# Variability at 15 km

Alex, squall line events



# 2010 15-km layers



# Concluding Remarks

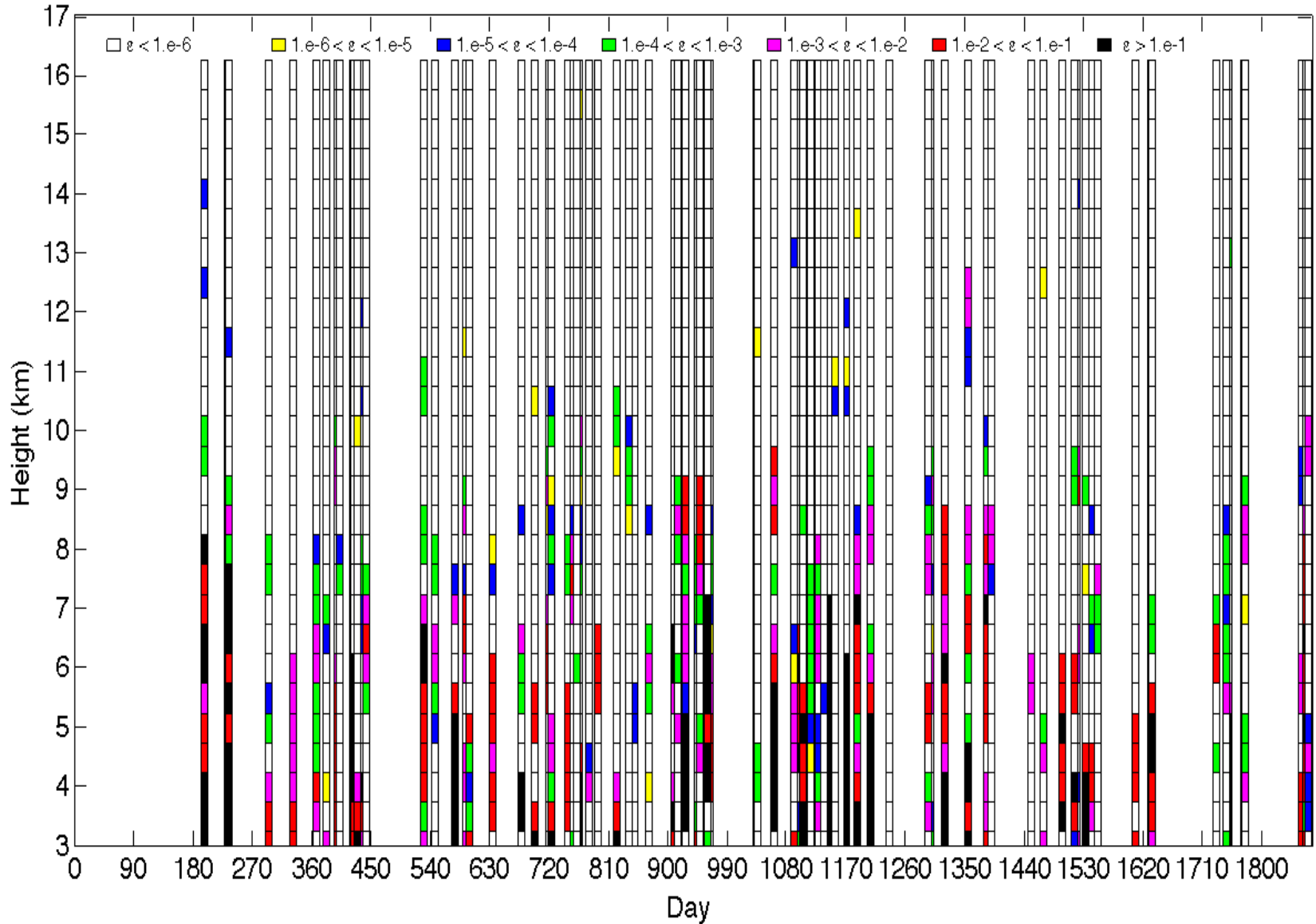
- Extraction of turbulence locations and intensities feasible from HVRRD
- More cal/val is needed – ST/MST radars can help here, PIREPS too
  - $C_K$  still needs to be refined (function? Constant? What value?)
  - Resolution impacts on  $C_K$ , technique
  - Signal to noise ratio needs to be checked carefully
- This technique can help us understand the spatio-temporal variability of mixing in the global free atmosphere
  - Possibilities now of looking at seasonal variability as well as shorter time scales
  - Effects of this use on modeling?



# Aberystwyth (Wales) 50 MHz MST Radar



# TKE Dissipation Rates in 1° x 1° box around Wales MST Radar

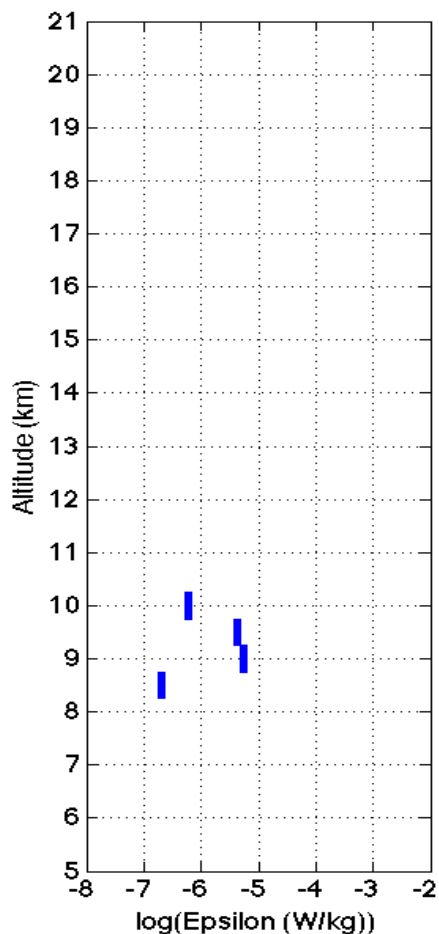
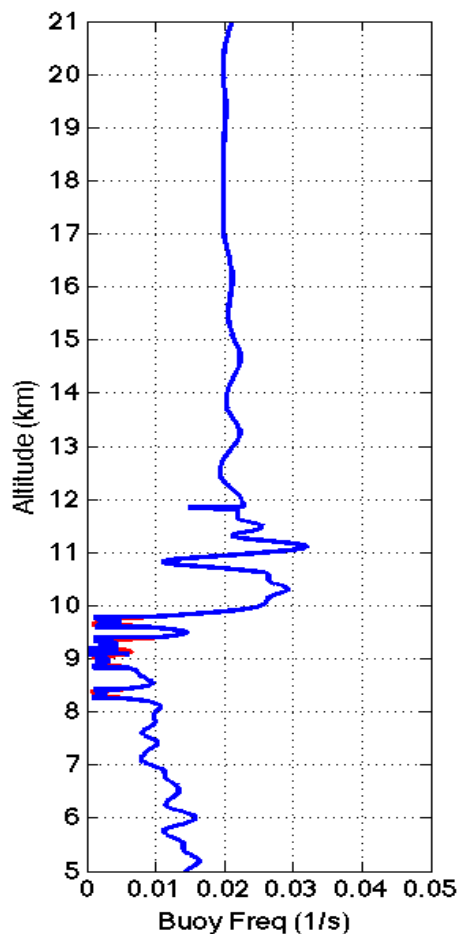




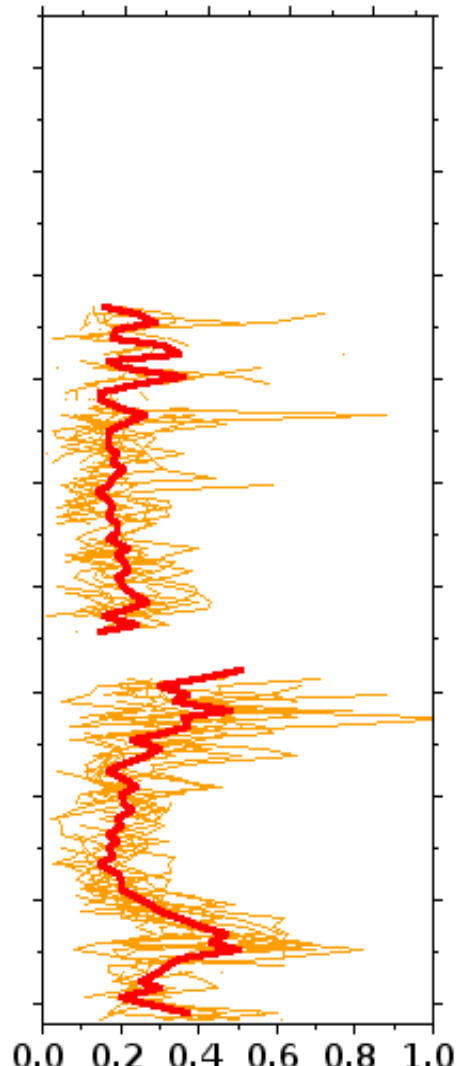
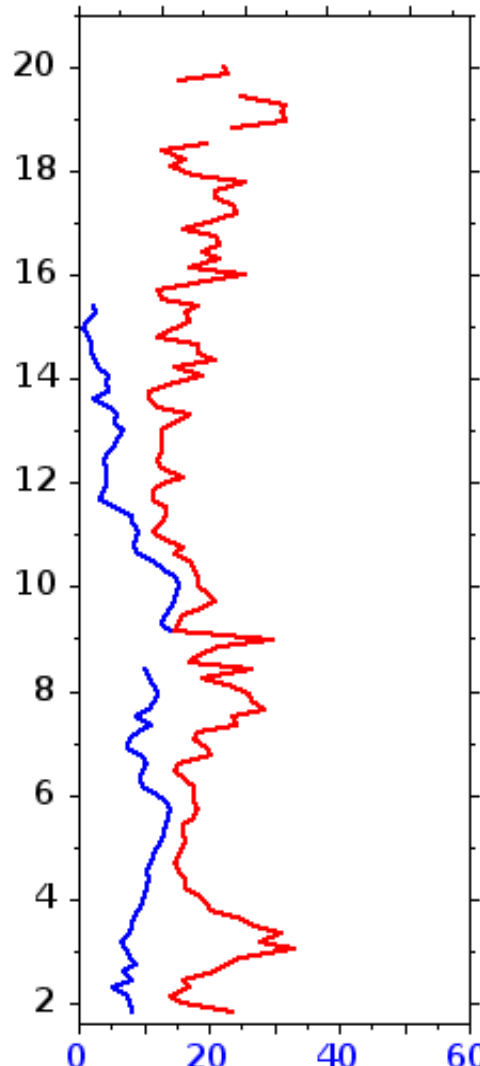
# Comparison with Wales ST Radar

<http://mst.nerc.ac.uk>

NERC MST Radar d



Uncorrected Spectral Width ( $\text{m s}^{-1}$ )  
0.0 0.2 0.4 0.6 0.8

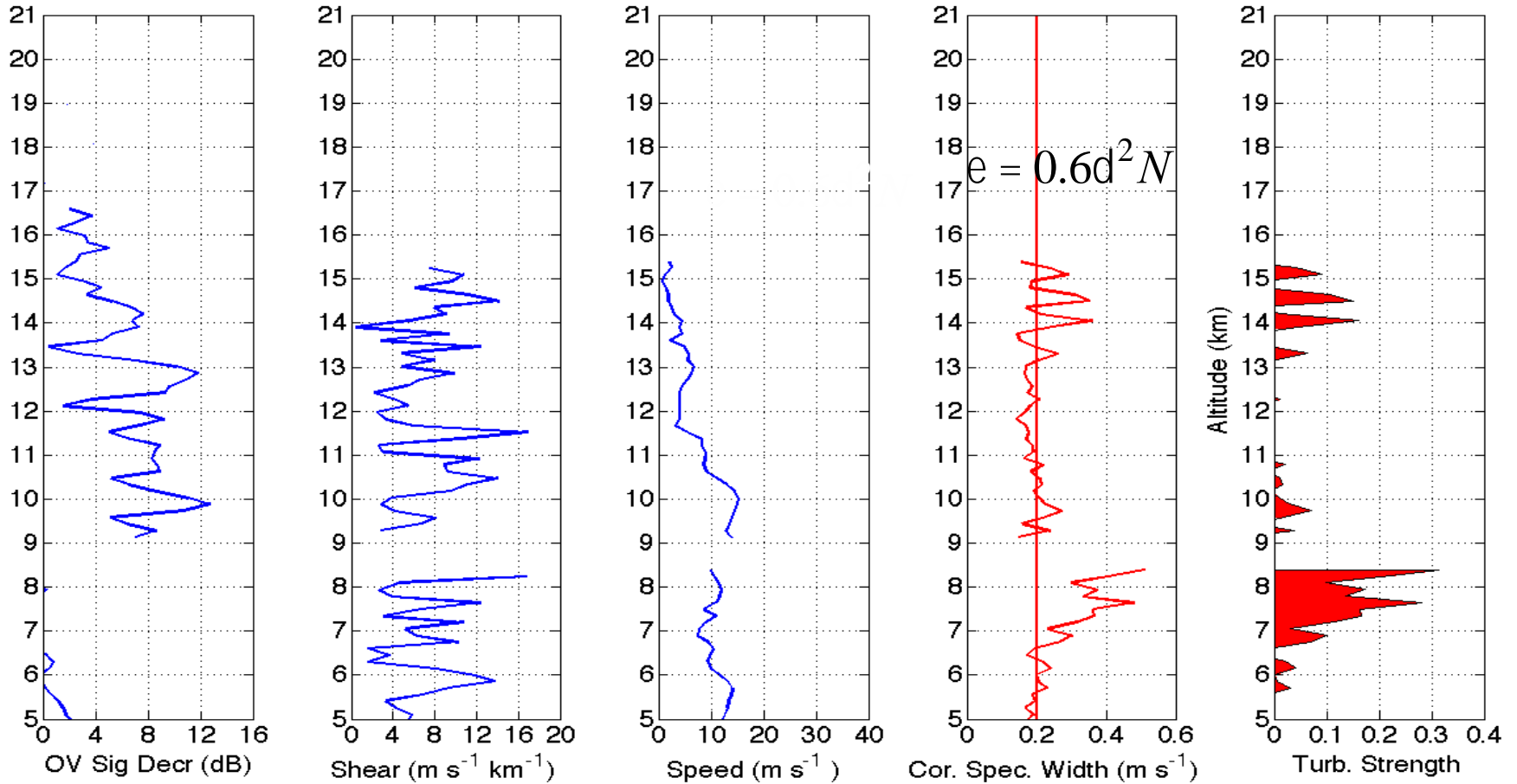


UTC 11:52 on April 19, 2008

NERC radar data from Dr. David Hooper

# Comparison with Wales ST Radar

2008-04-19-1152



UTC 11:52 on April 19, 2008