

Research Using LITOS

(Leibniz-Institute Turbulence Observations in the Stratosphere)

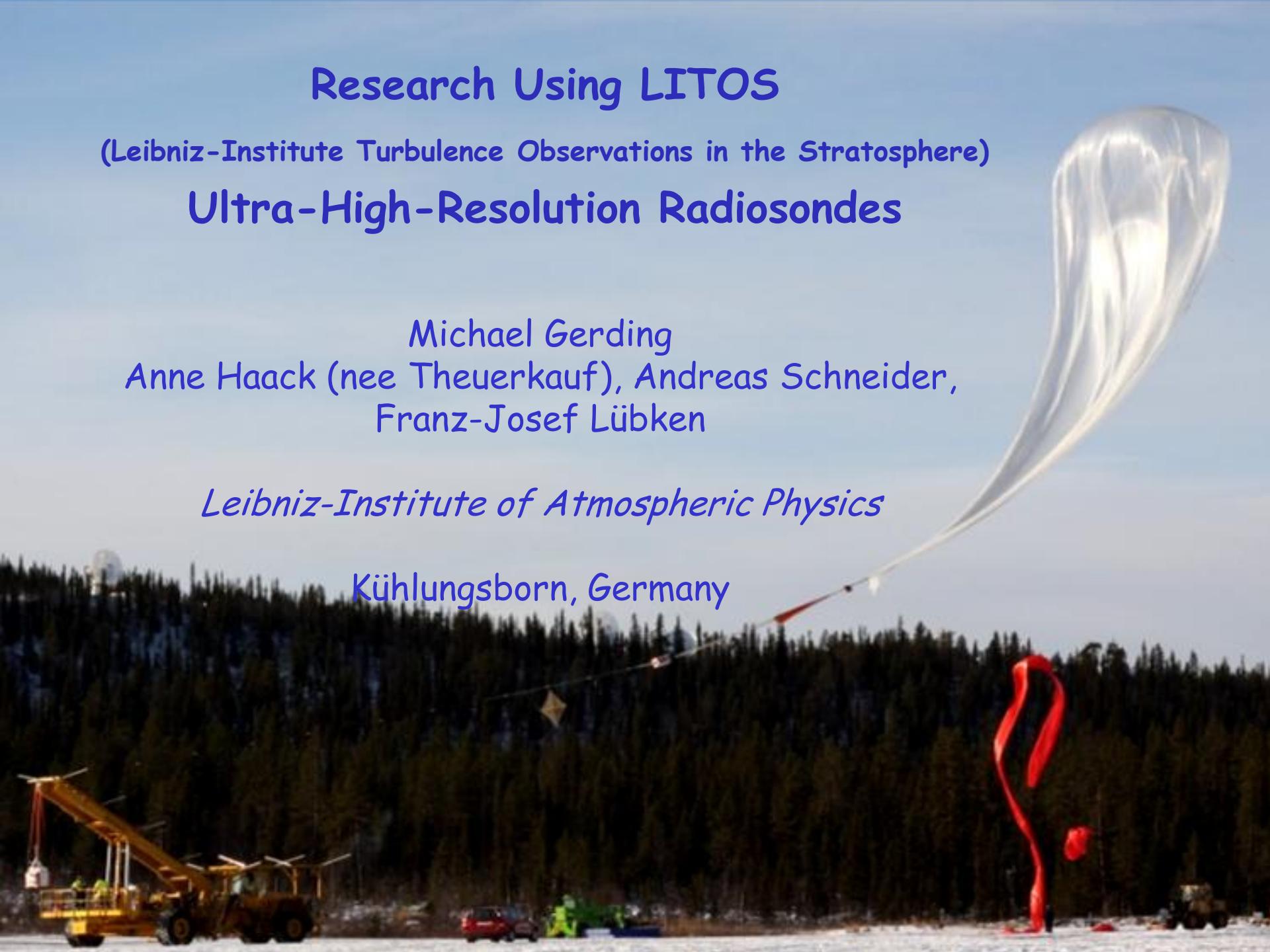
Ultra-High-Resolution Radiosondes

Michael Gerding

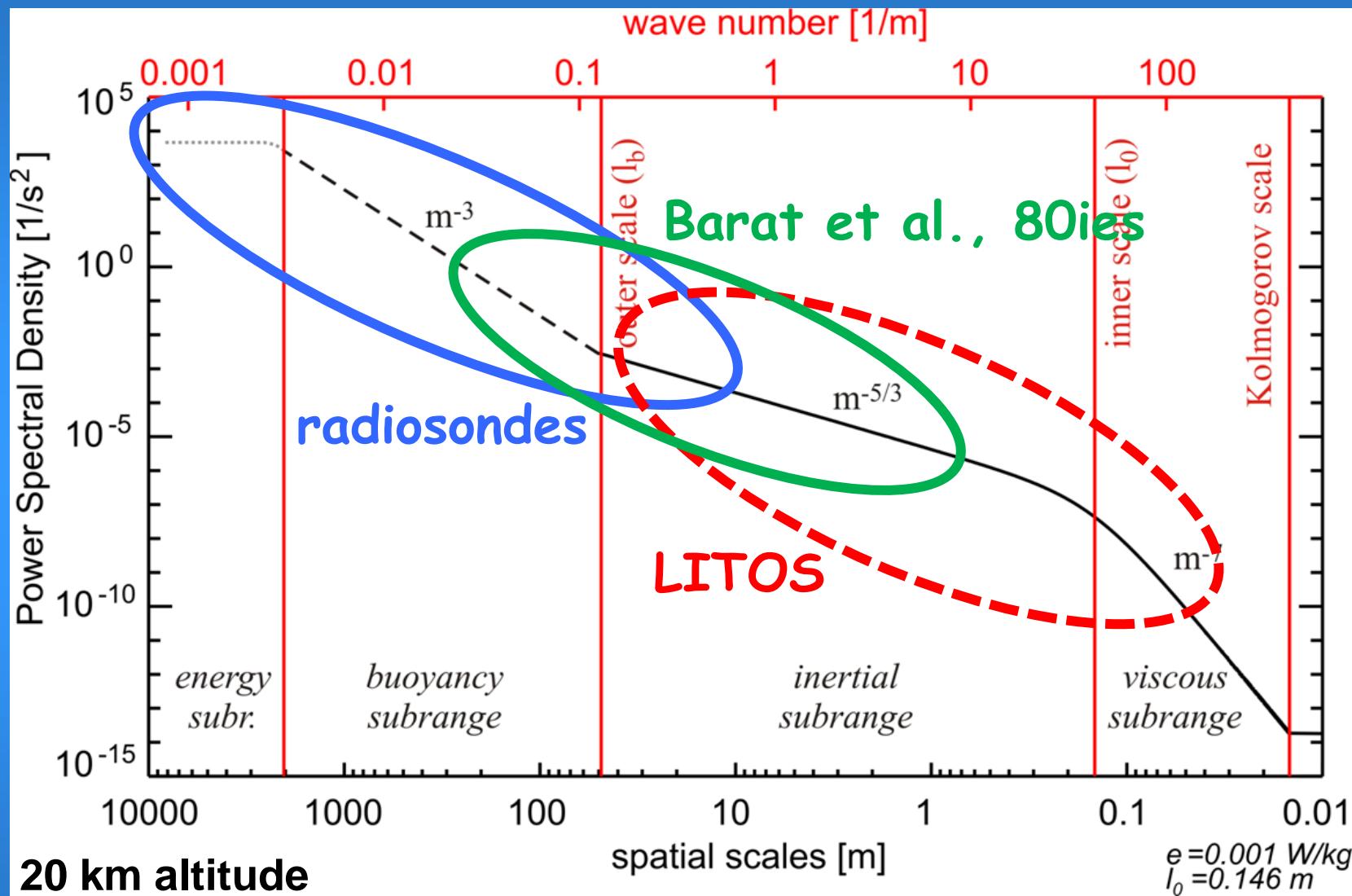
Anne Haack (nee Theuerkauf), Andreas Schneider,
Franz-Josef Lübken

Leibniz-Institute of Atmospheric Physics

Kühlungsborn, Germany

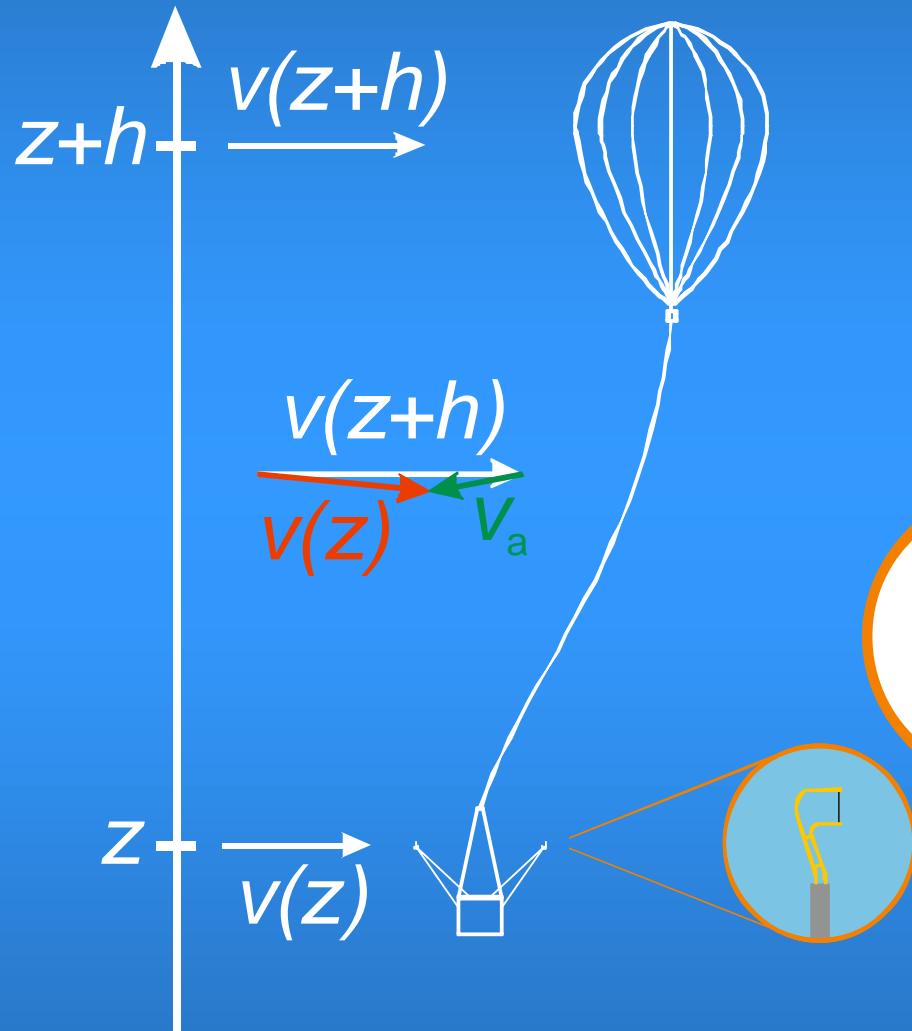


Turbulence in the stratosphere - Scales



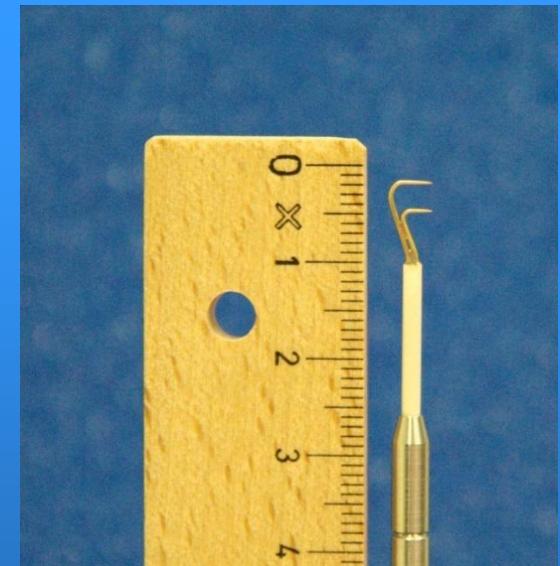
LITOS measurement principle: wind (CTA)

altitude

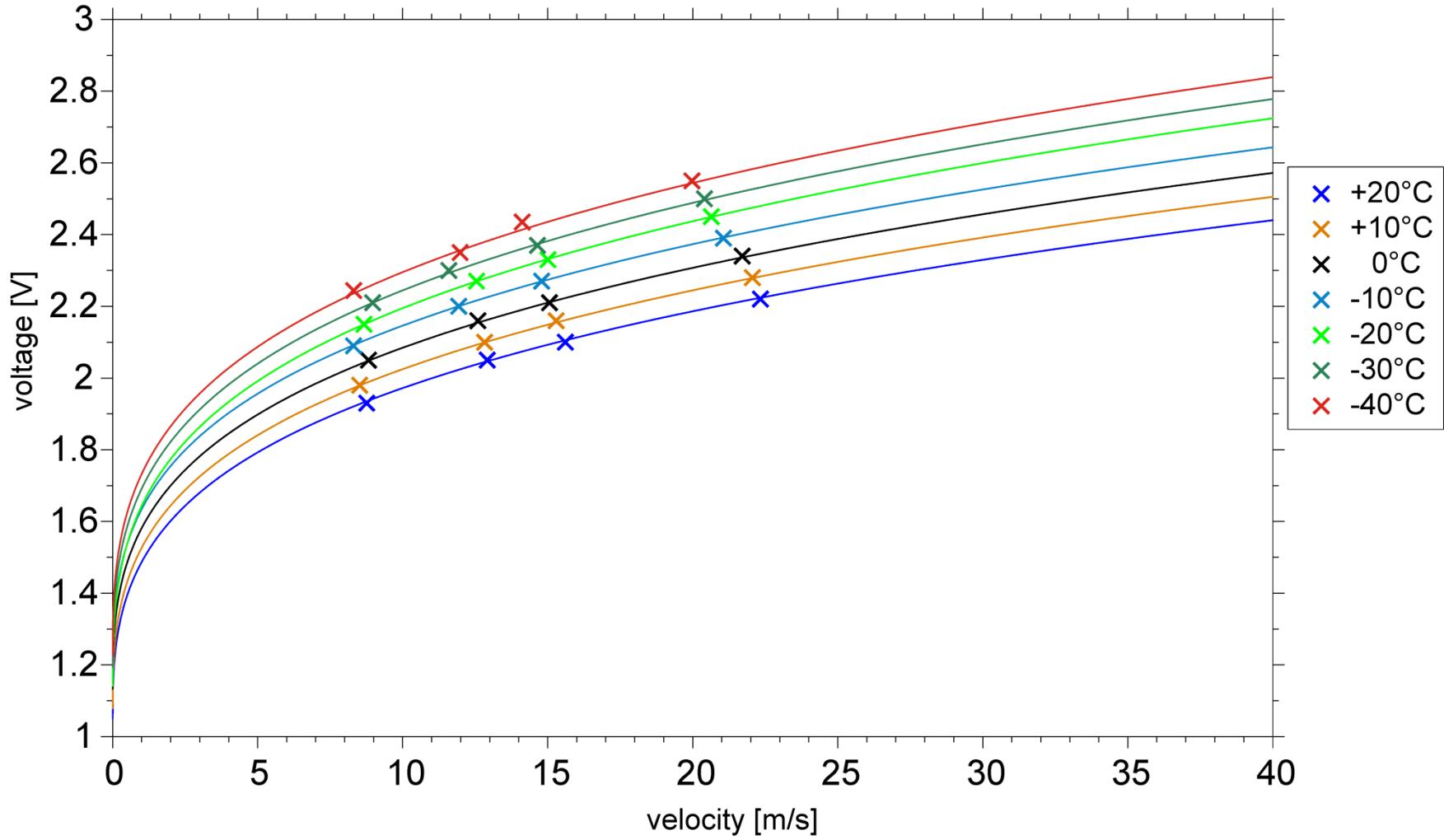


- Constant Temperature Anemometer
 - tungsten wire of 5 μm diameter, 1.25 mm length
 - resistance is kept constant
 - Sampling rate 2-8 kHz

→ *U measure of cooling = wind*



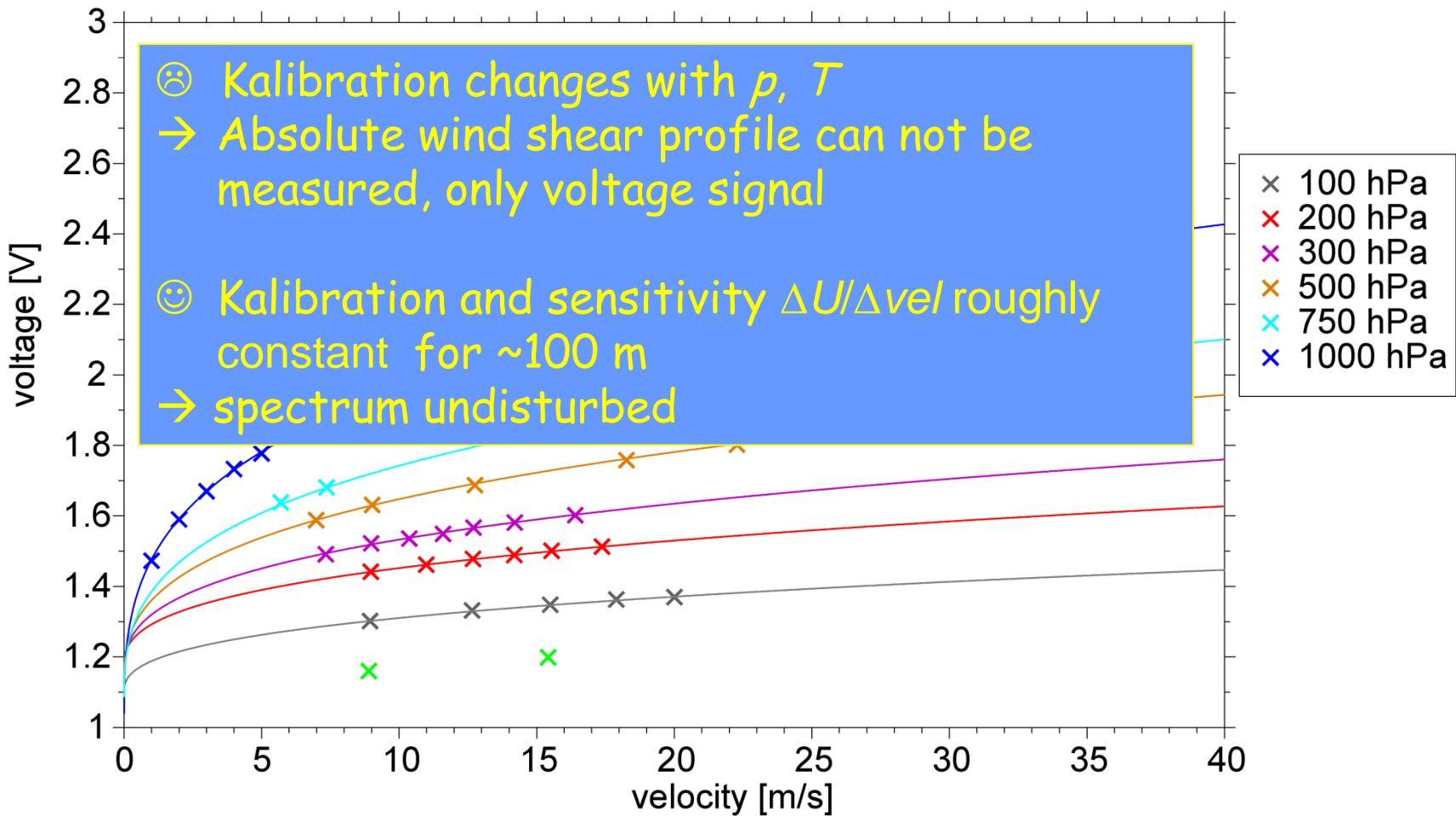
Calibration in climate chamber - King's law



Theuerkauf et al., AMT, 2011

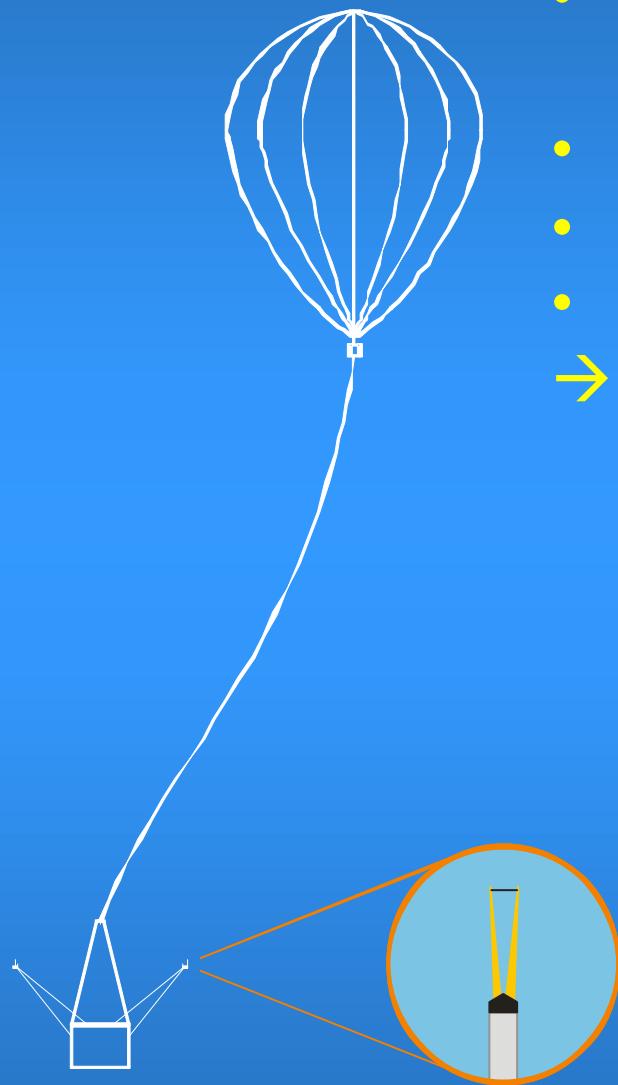
Gerding et al.: LITOS ultra-high resolution sondes

Calibration in vacuum chamber - King's law

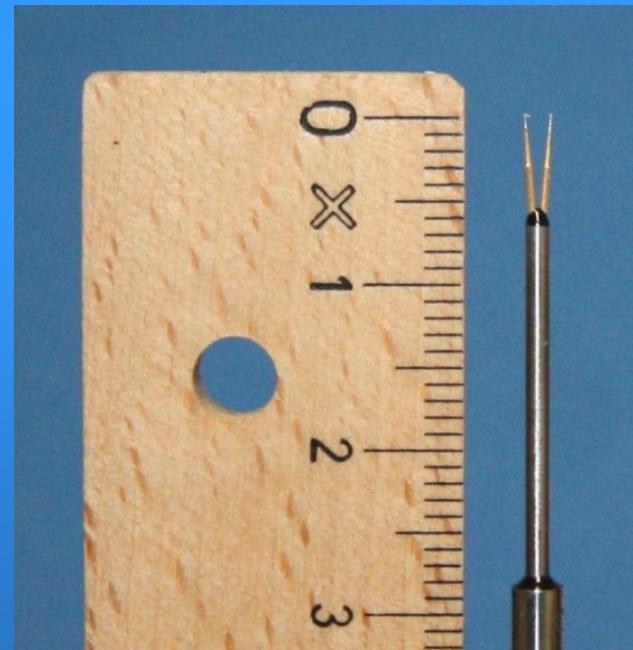


Theuerkauf et al., AMT, 2011

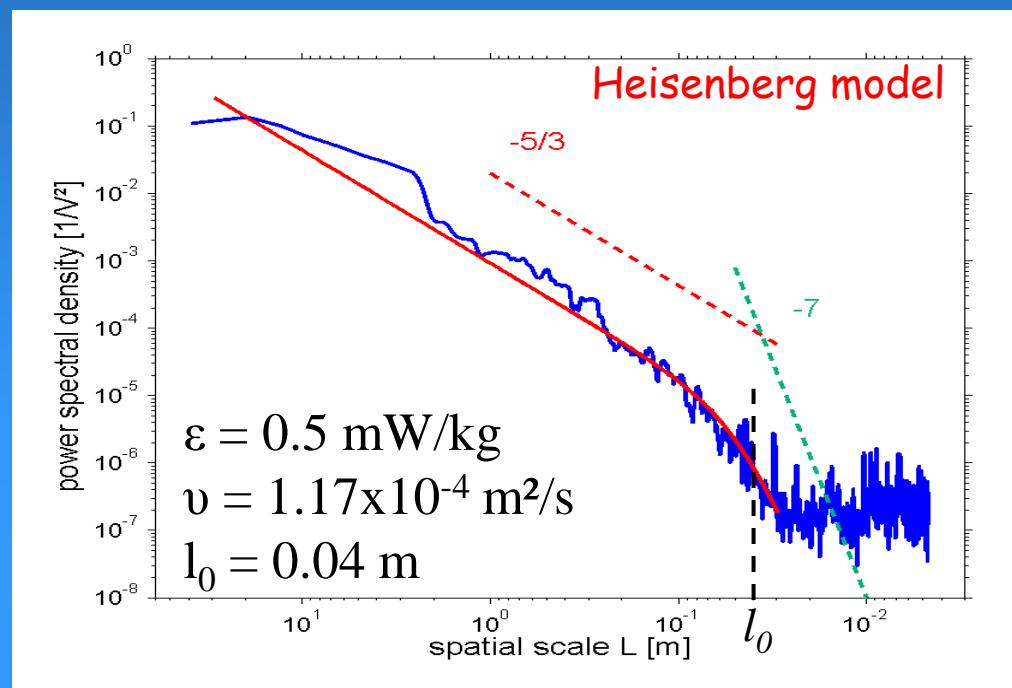
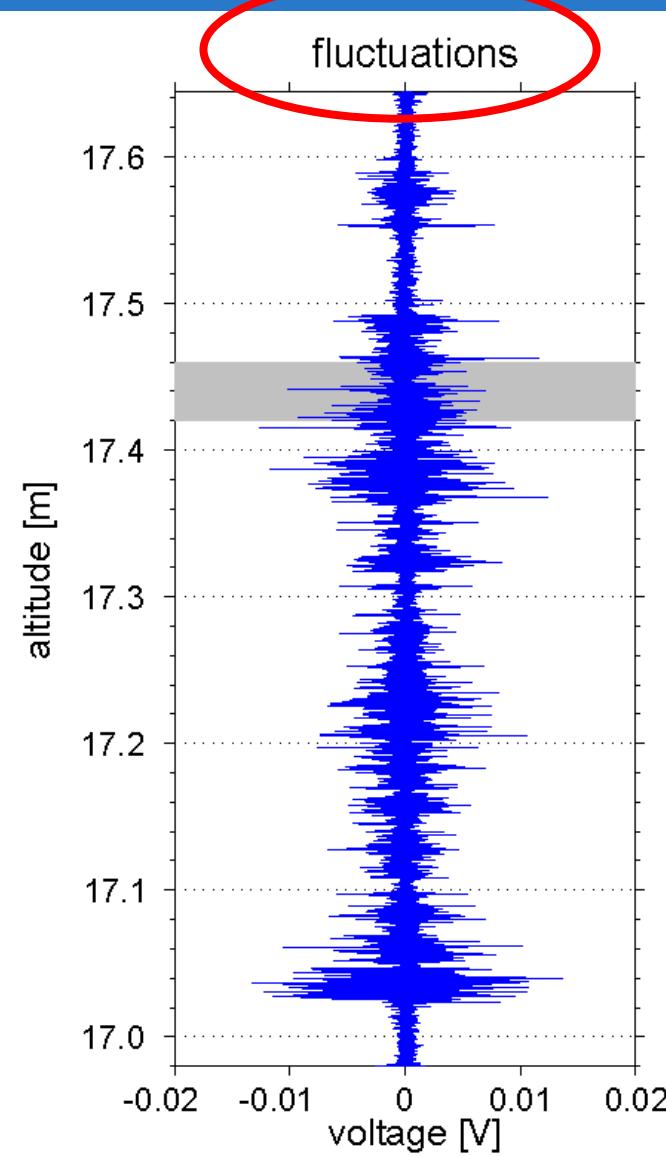
LITOS measurement principle: temperature (CCA)



- Resistance thermometer
(Constant-Current-Anemometer)
 - Wire diameter $3.8 \mu\text{m}$
 - Current kept constant
 - 2-8 kHz sampling rate
- \rightarrow Measure of resistance = temperature



Determination of energy dissipation rate

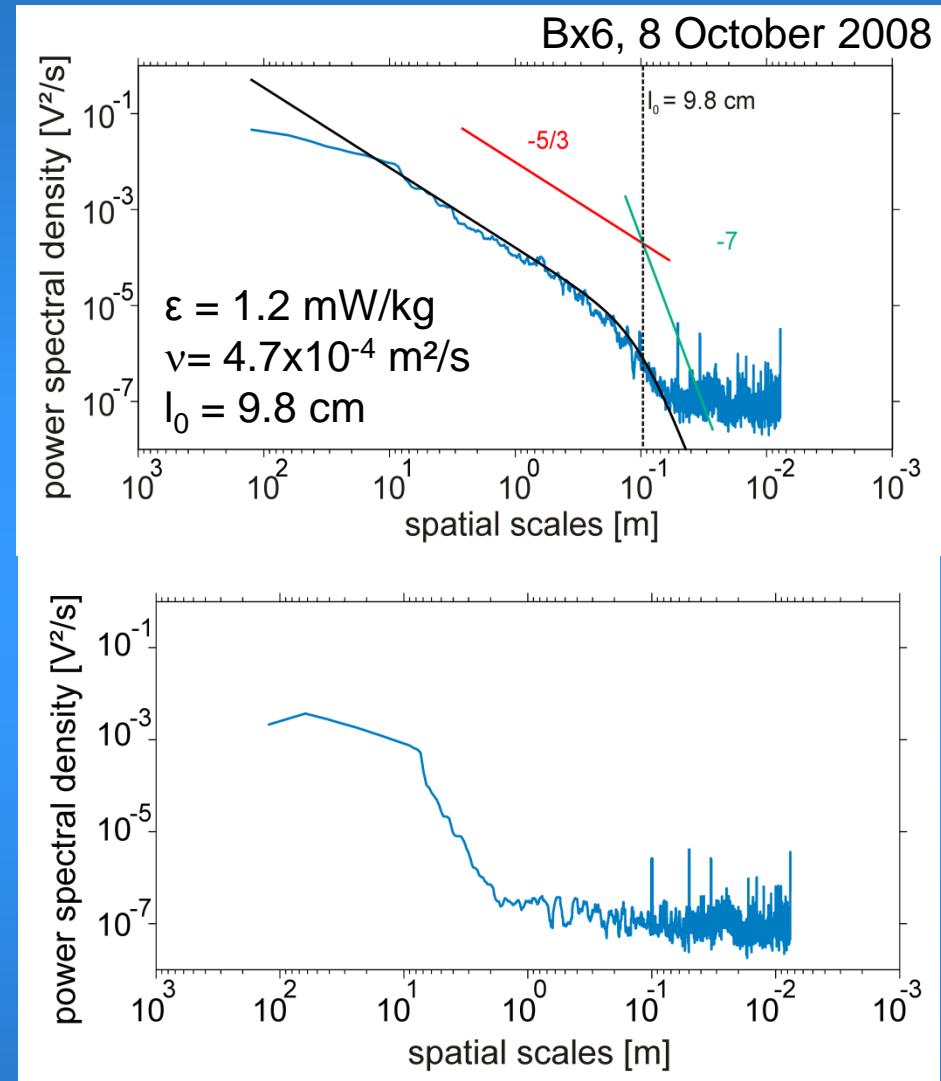
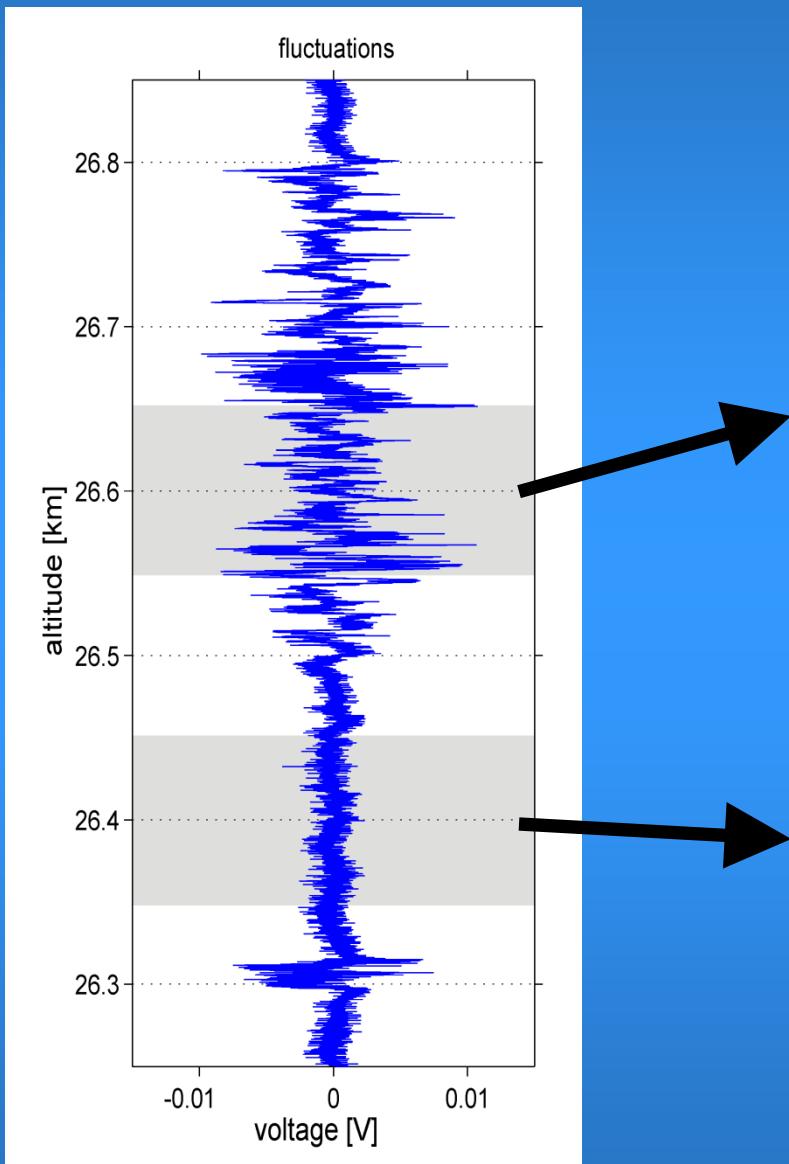


$$l_o = c \cdot \left(\frac{\nu^3}{\epsilon} \right)^{\frac{1}{4}}$$

ϵ : energy dissipation rate
 ν : kinematic viscosity
 l_o : inner scale
 c : 10.9 (temperature)
5.7 (wind)

(Lübken, JGR, 1992 , Theuerkauf et al., AMT, 2011 (upd.))

Turbulent and non-turbulent spectra

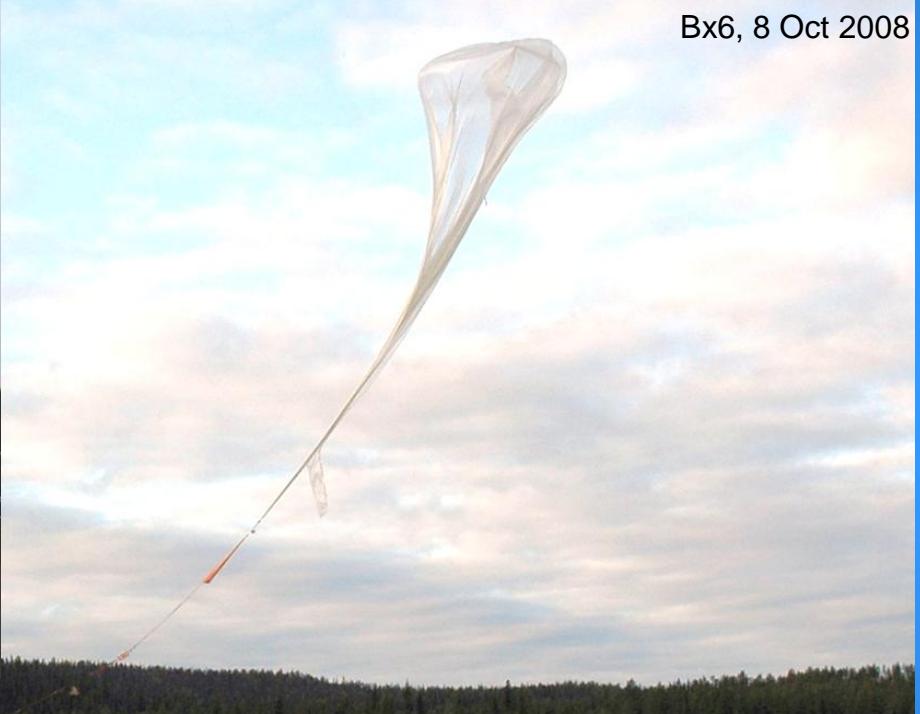


BEXUS launches



SSC/DLR

Bx6, 8 Oct 2008



Payload size: 60*70*60 cm

Payload mass: 121 kg

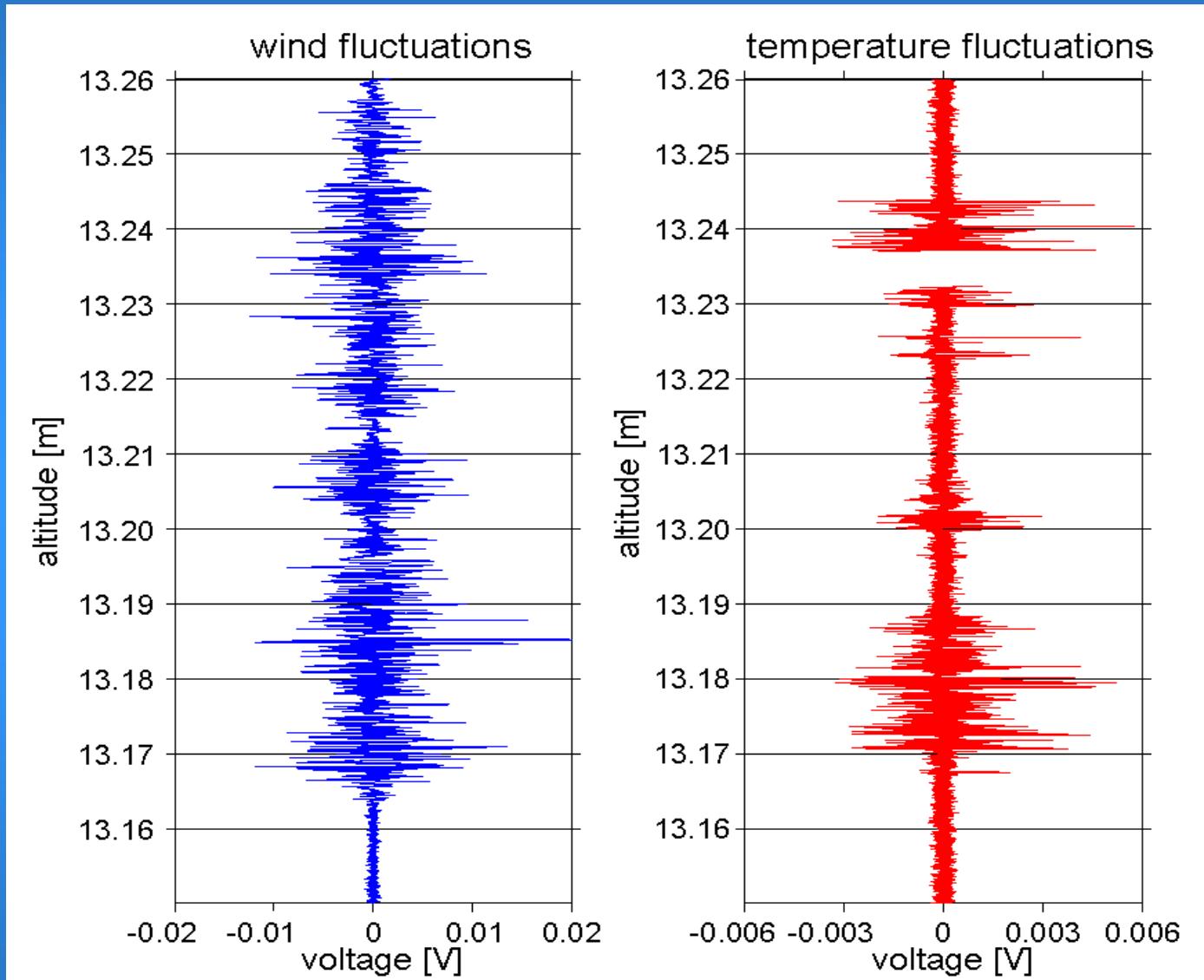
Balloon size: 10 000 m³



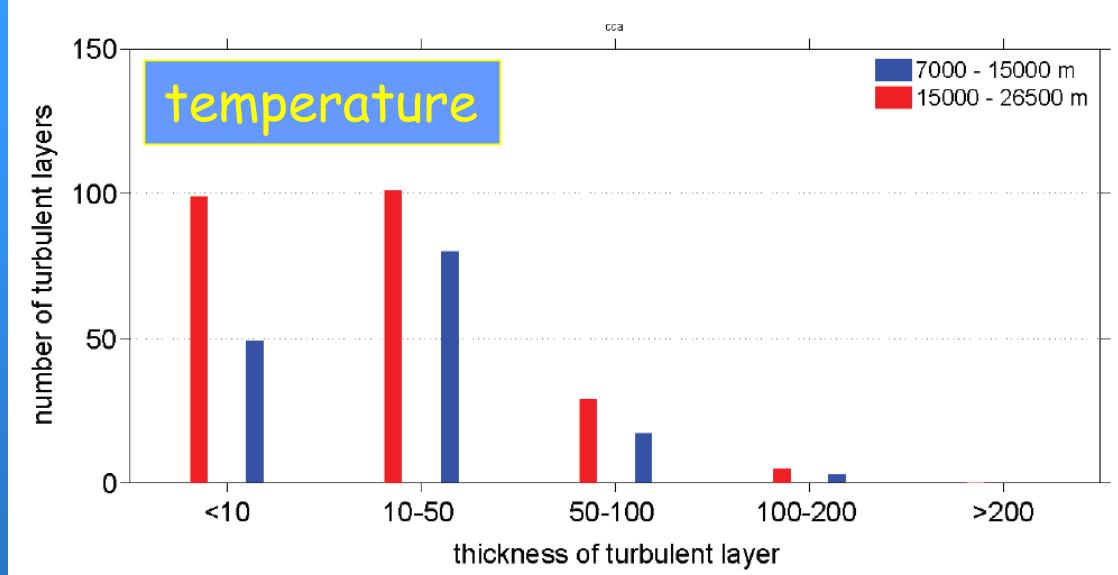
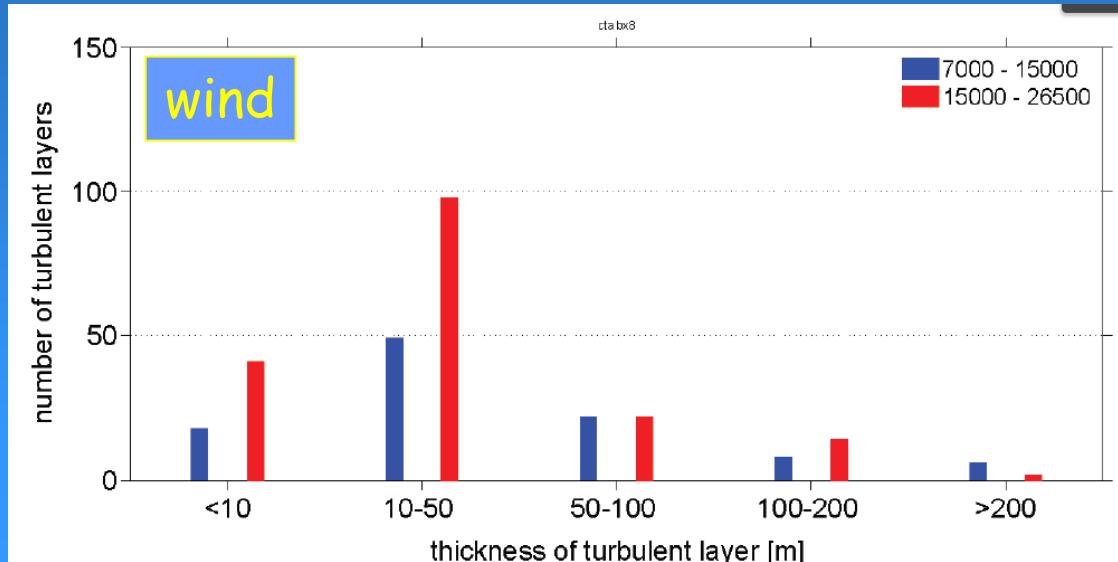
3 soundings at Kiruna:

- 8 October 2008 (BEXUS 6)
- 10 October 2009 (BEXUS 8)
- 27 September 2011 (BEXUS 12)

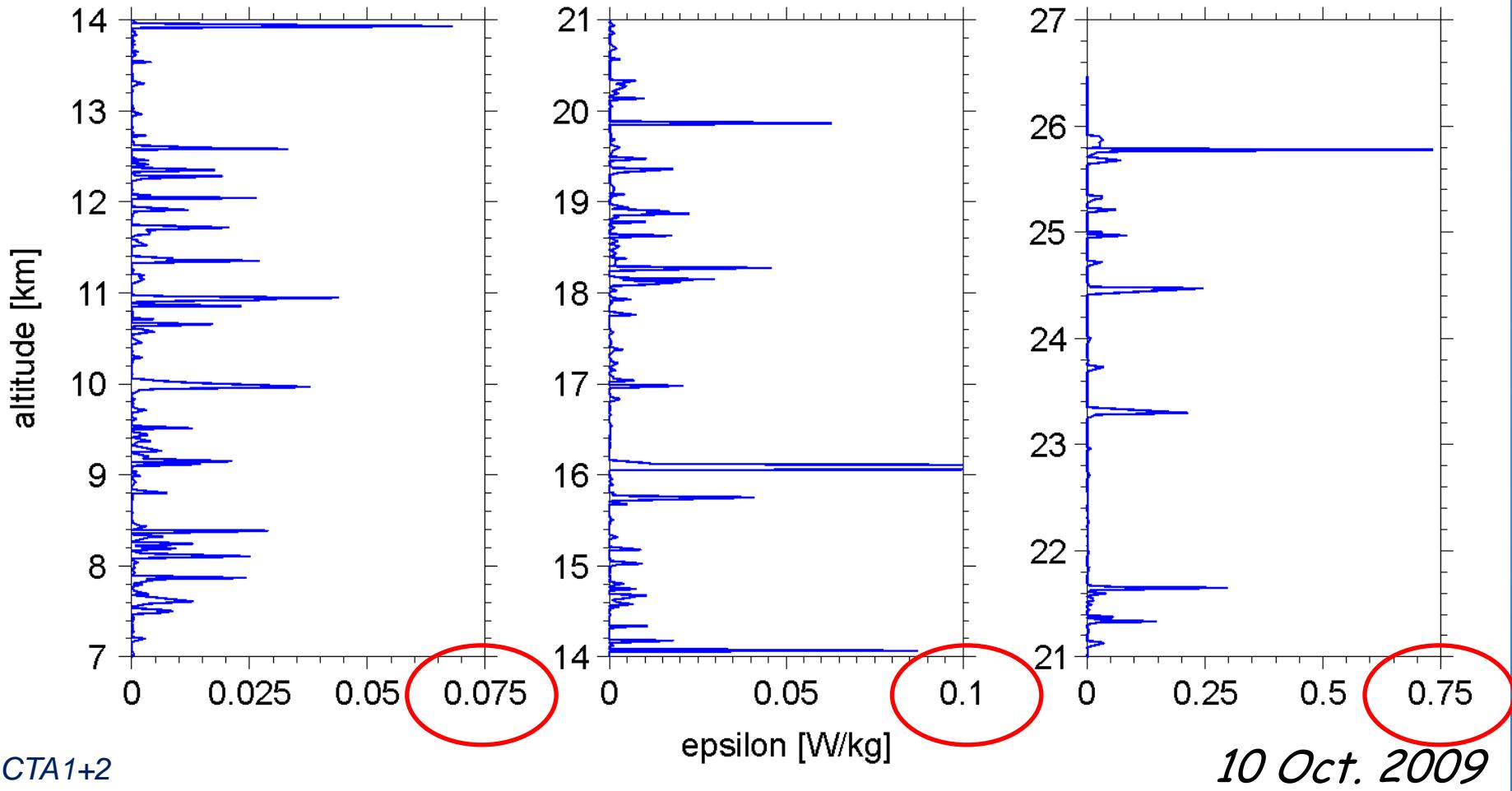
LITOS - turbulence measurements



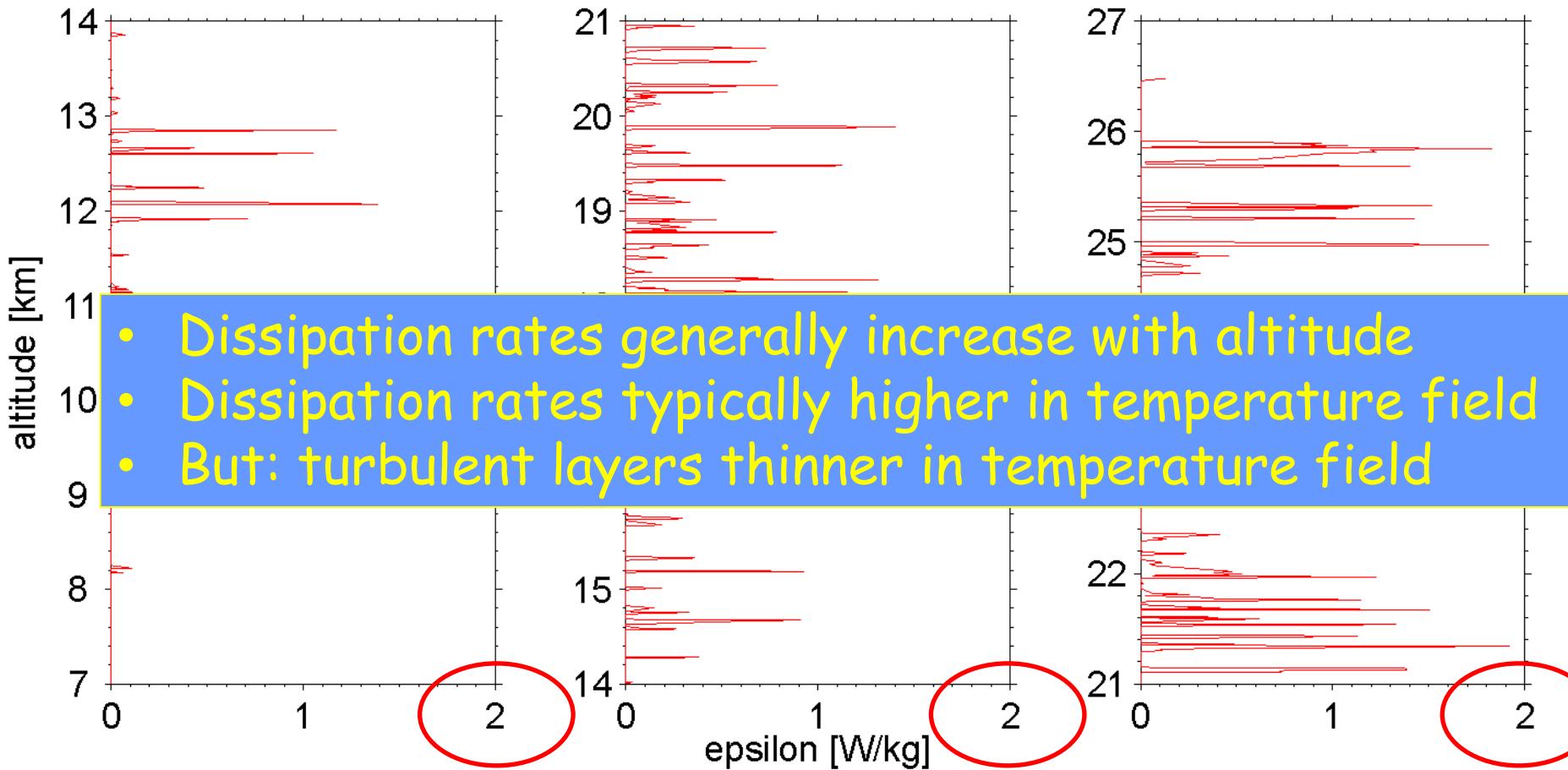
Thickness of turbulent layers (BEXUS 8)



BEXUS 8: Energy dissipation rates (wind)

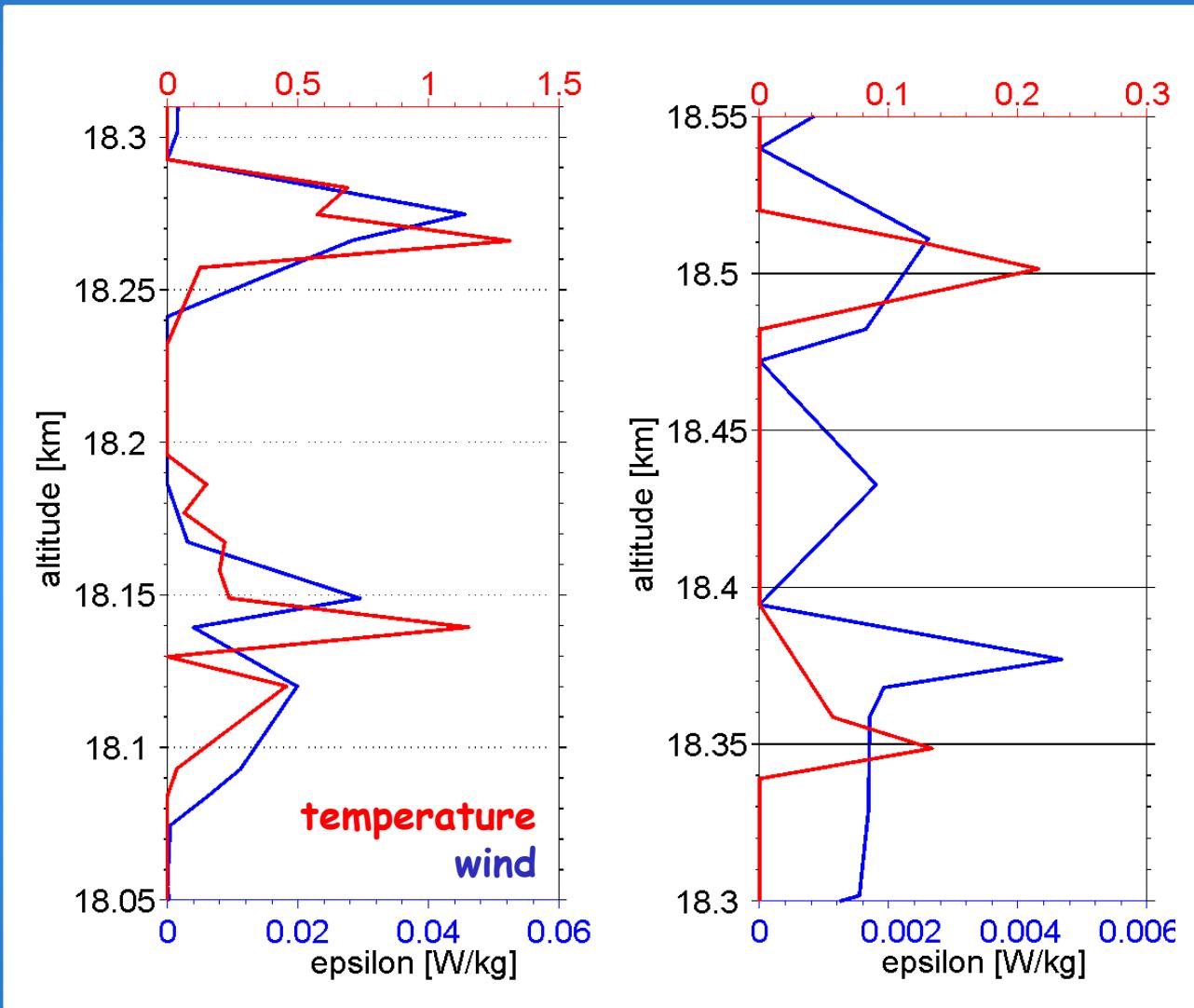


BEXUS 8: Energy dissipation rates (temperature)

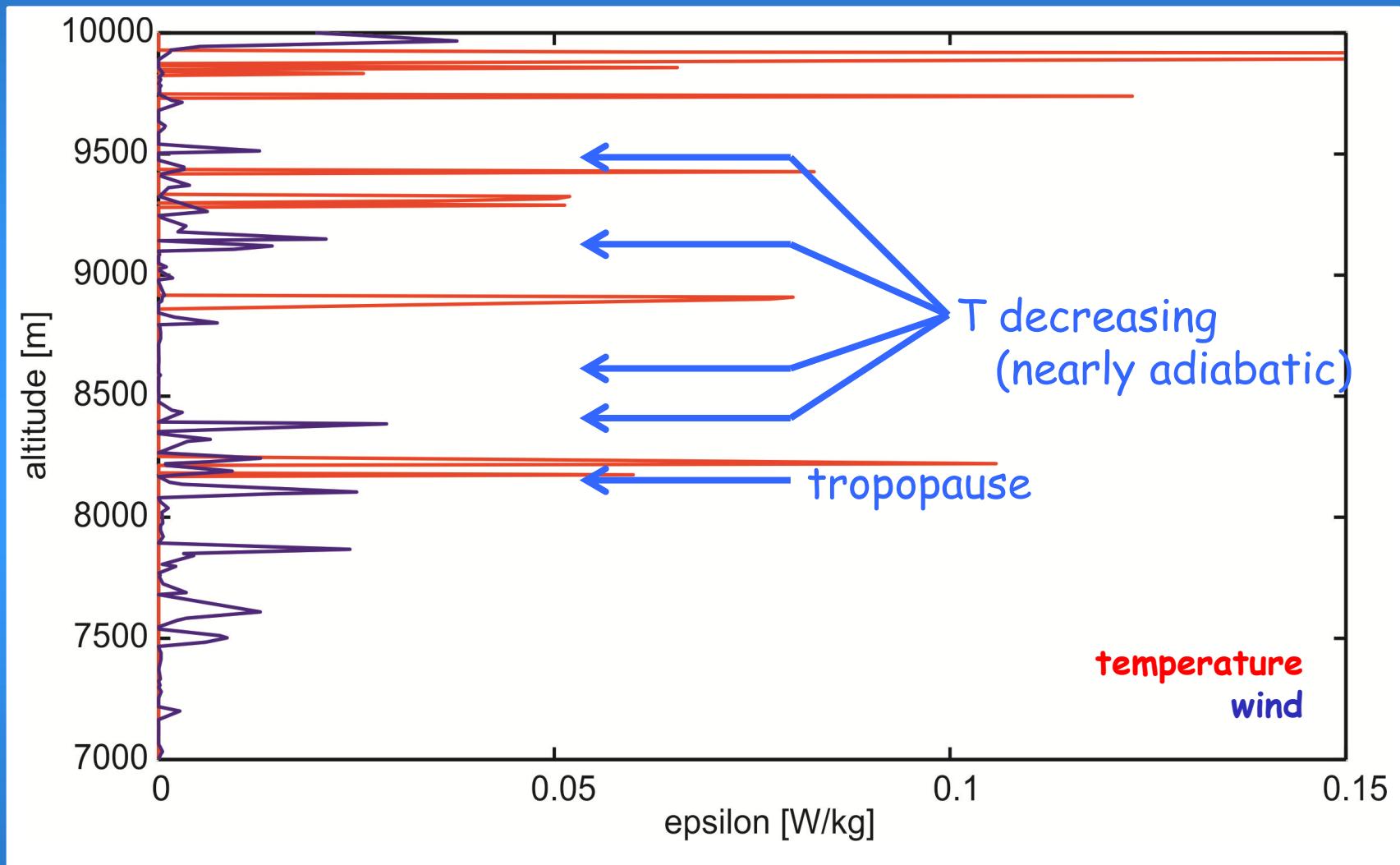


10 Oct. 2009

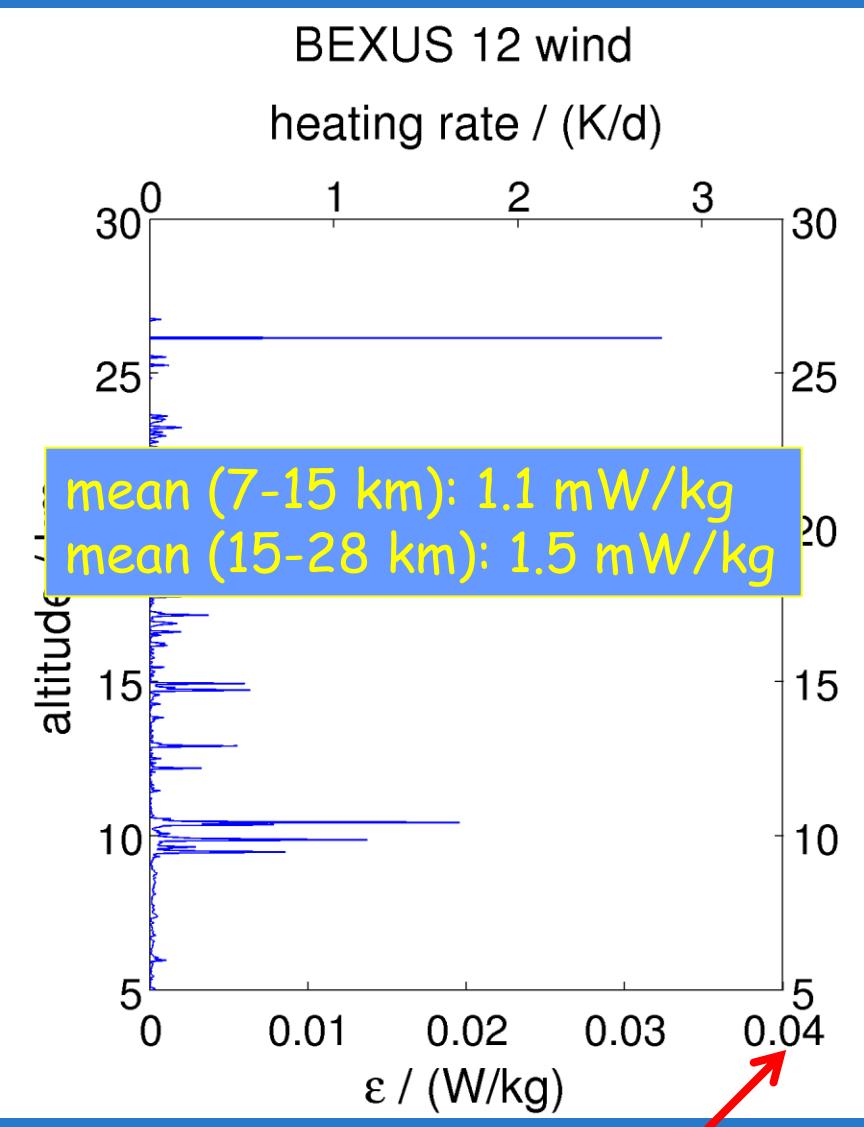
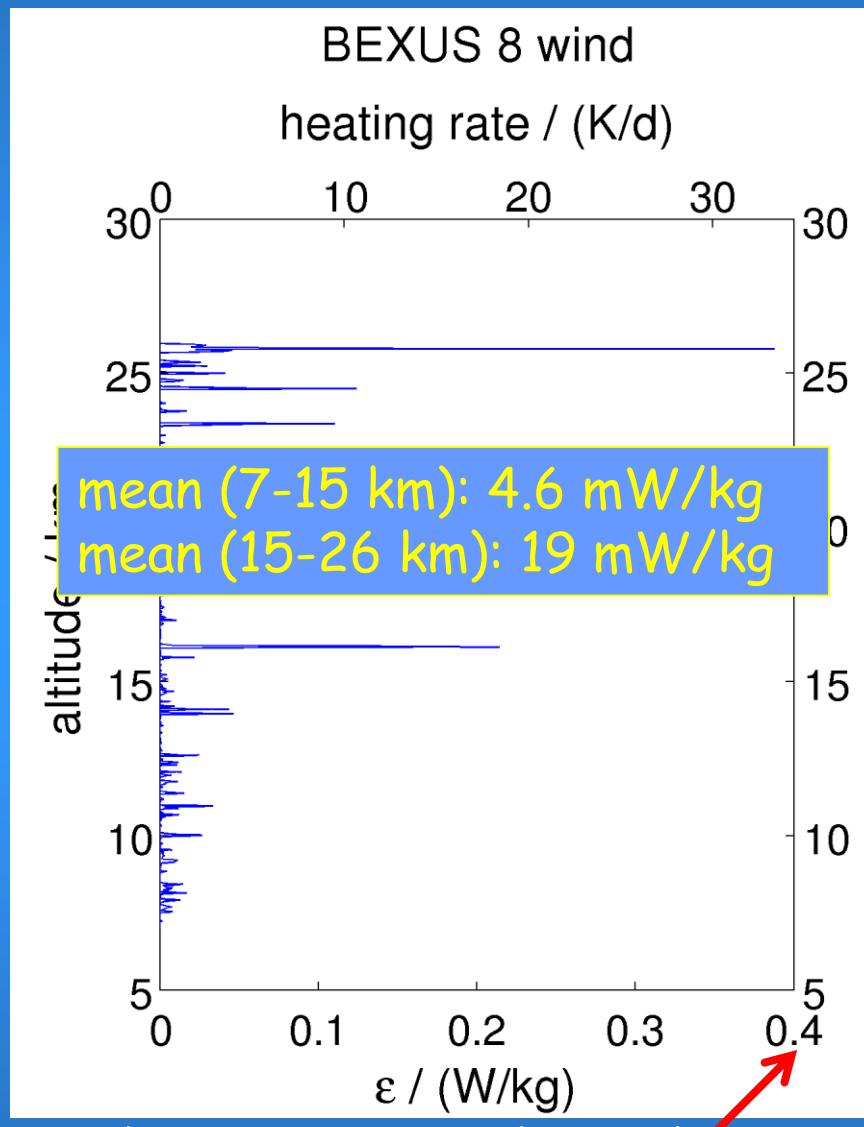
BEXUS 8, 10 October 2009



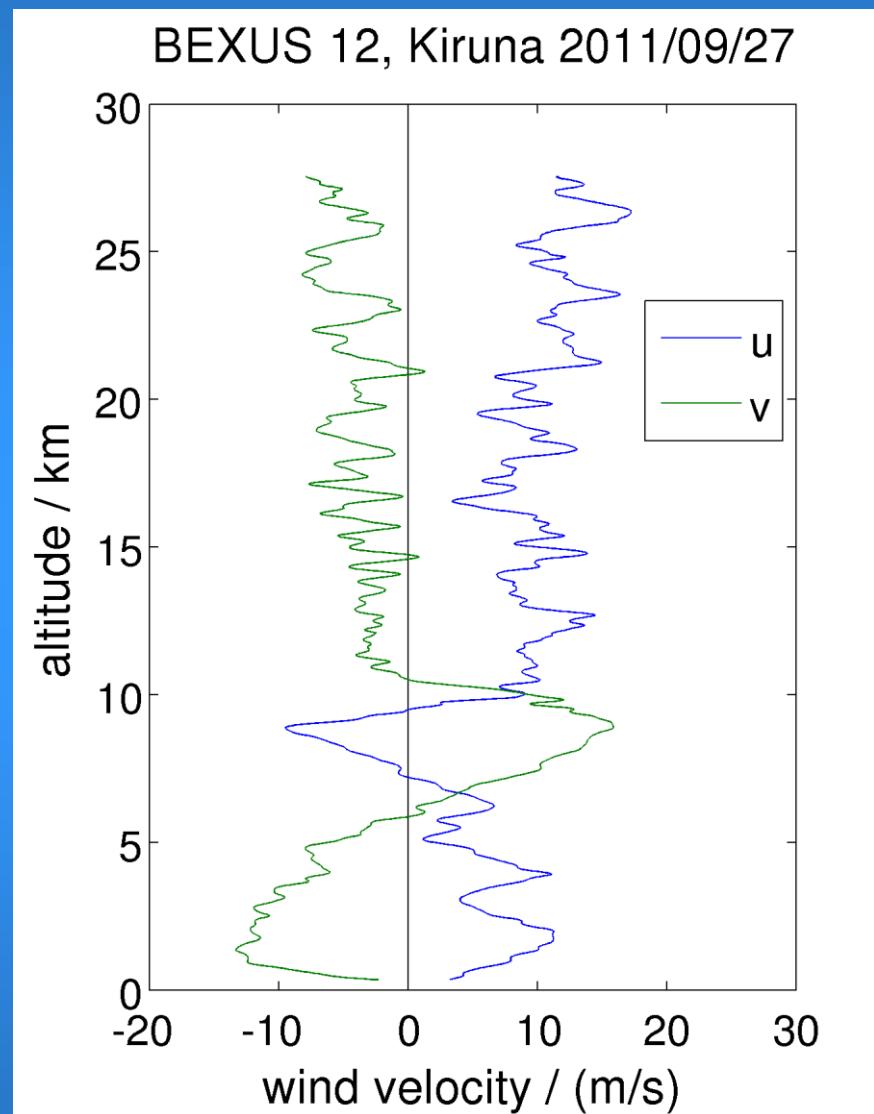
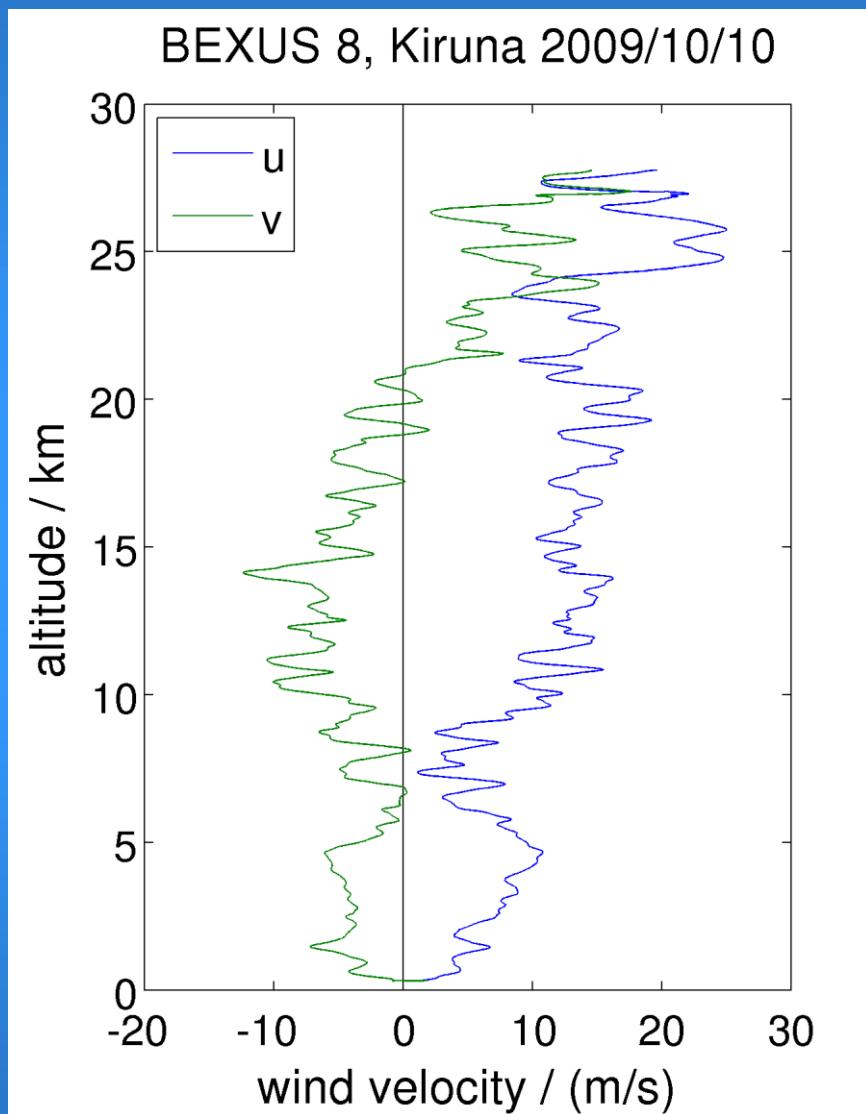
BEXUS 8, turbulence in wind and temperature



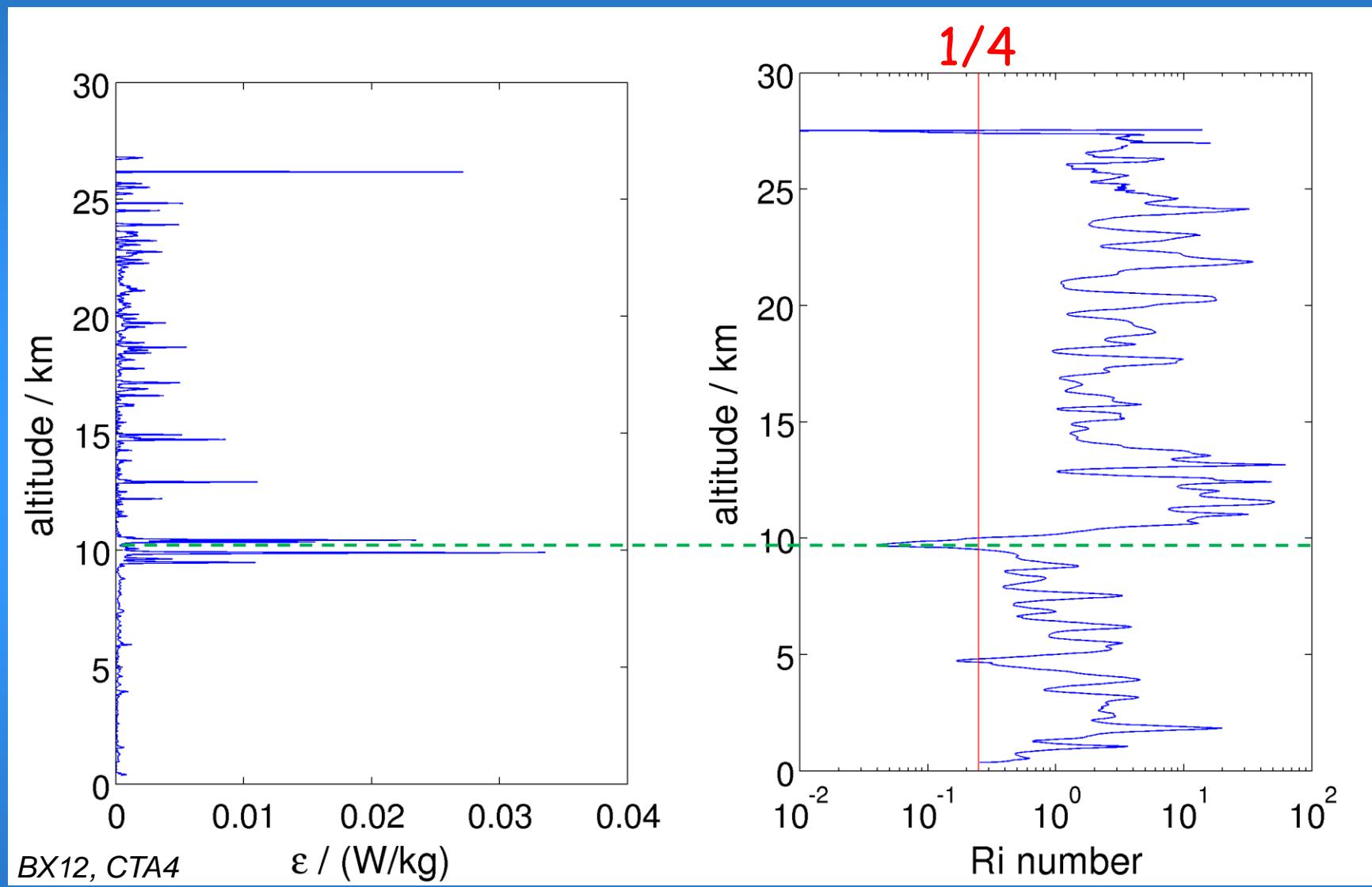
BEXUS-8 vs. BEXUS-12: Energy dissipation



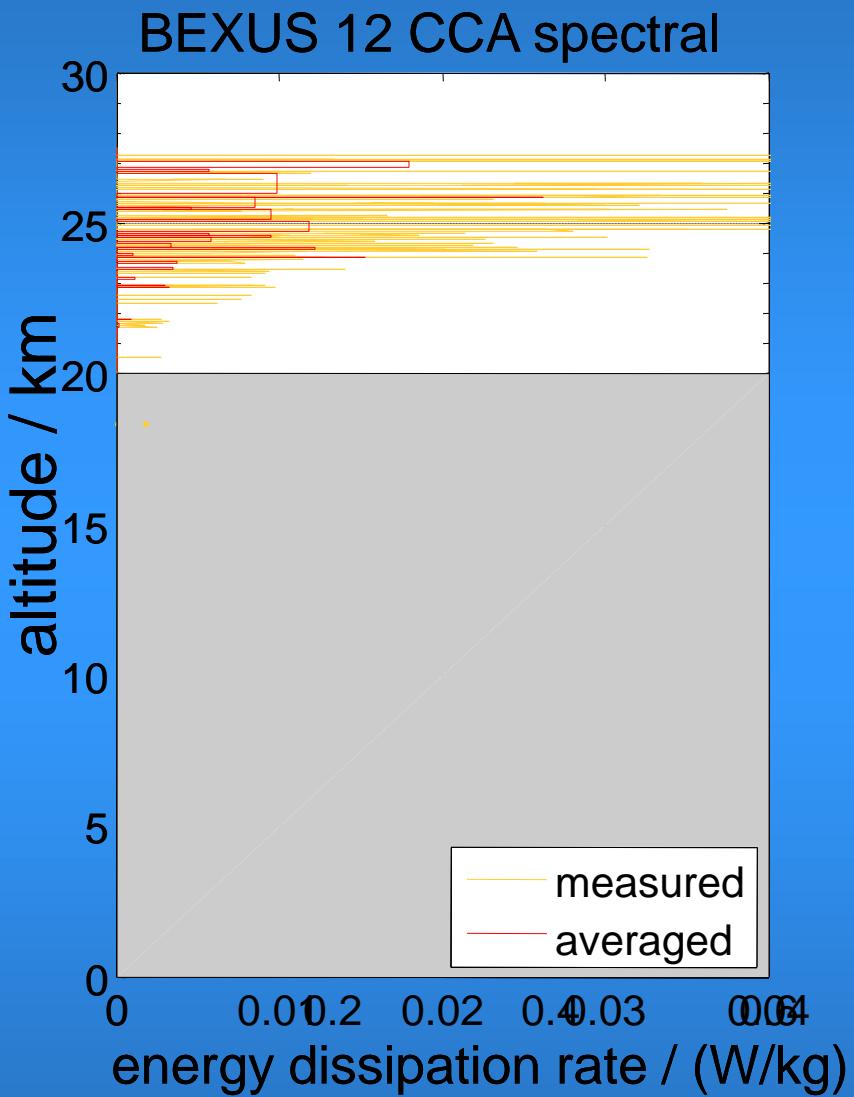
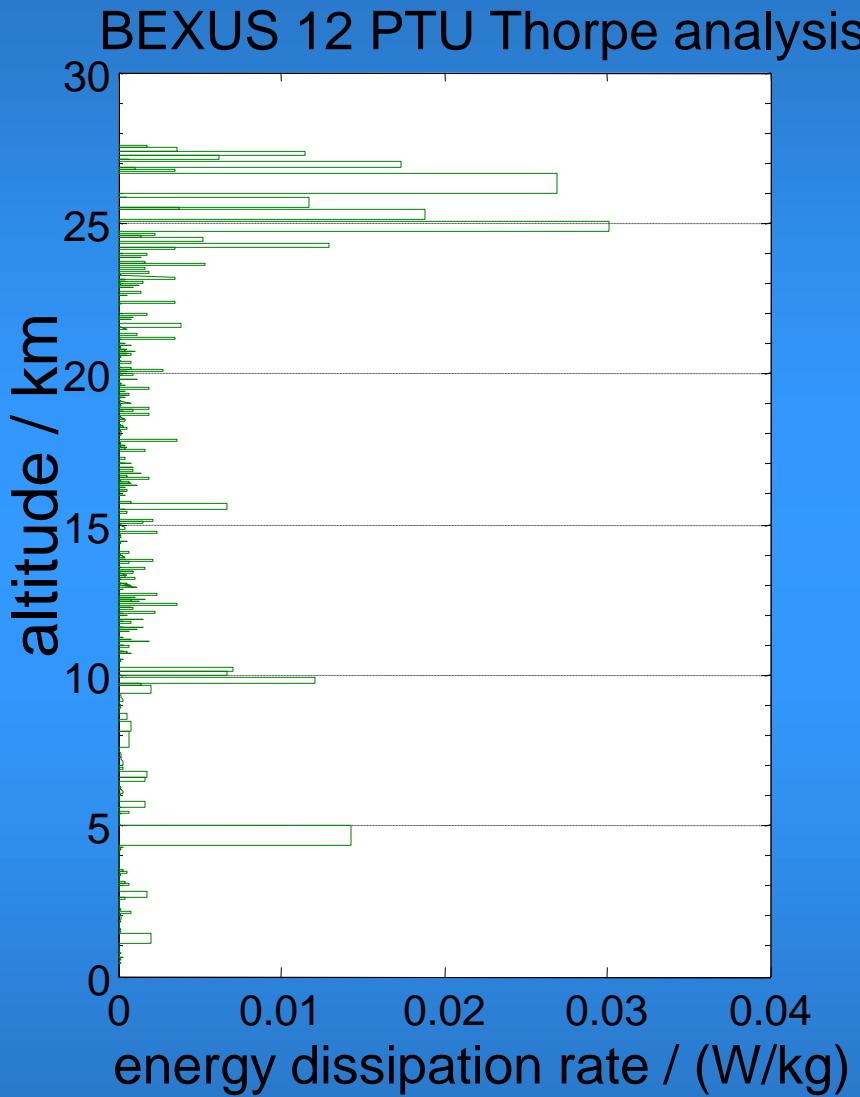
BEXUS-8 vs. BEXUS-12: Background wind



BEXUS 12: Energy dissipation and Ri number

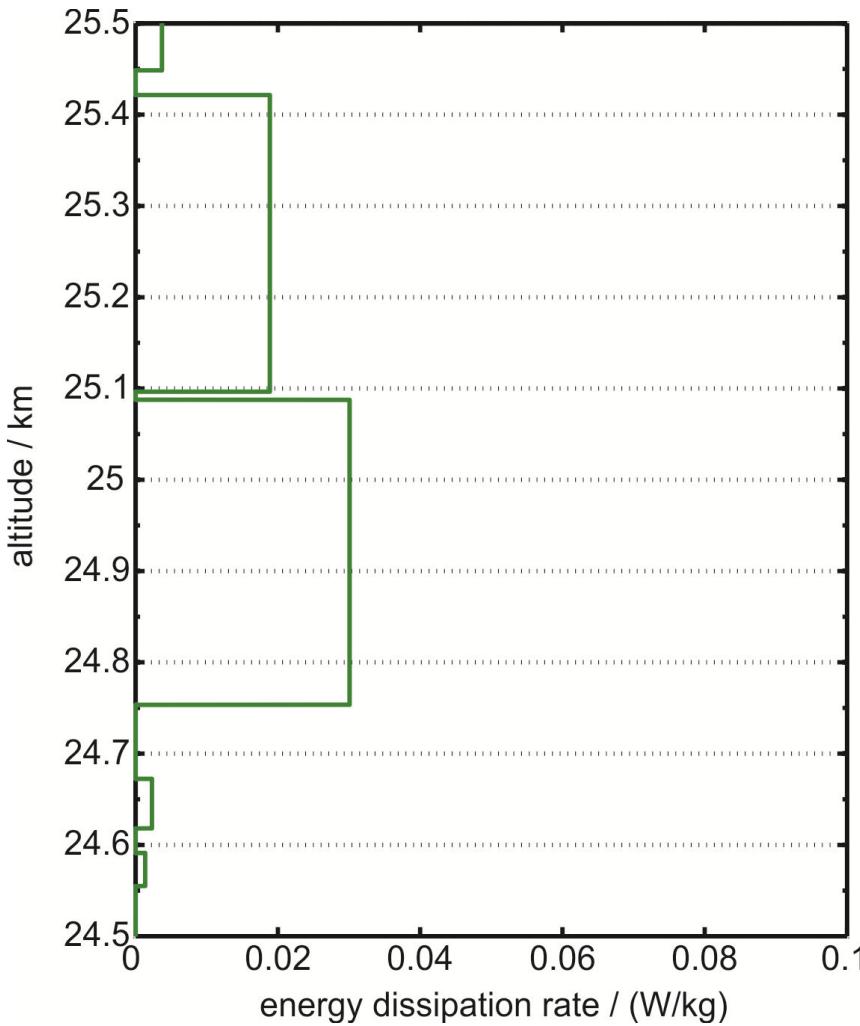


BEXUS 12 Thorpe analysis

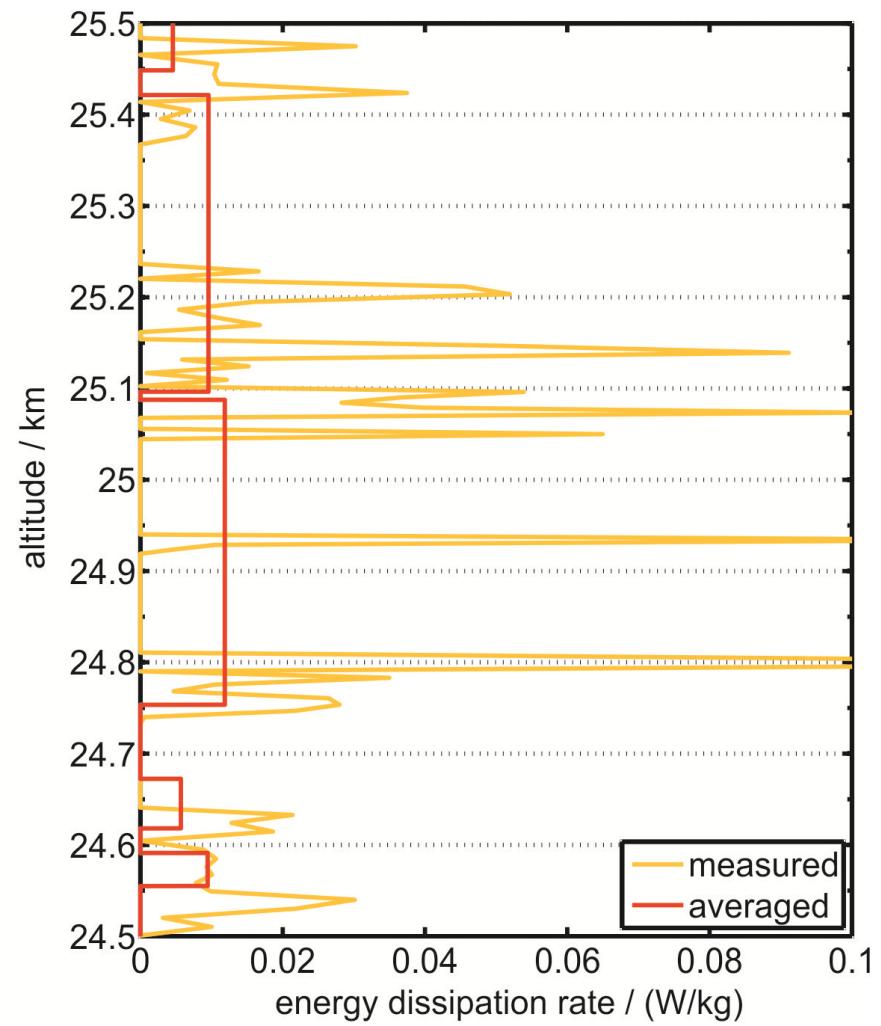


BEXUS 12: Fine scale of turbulent layers

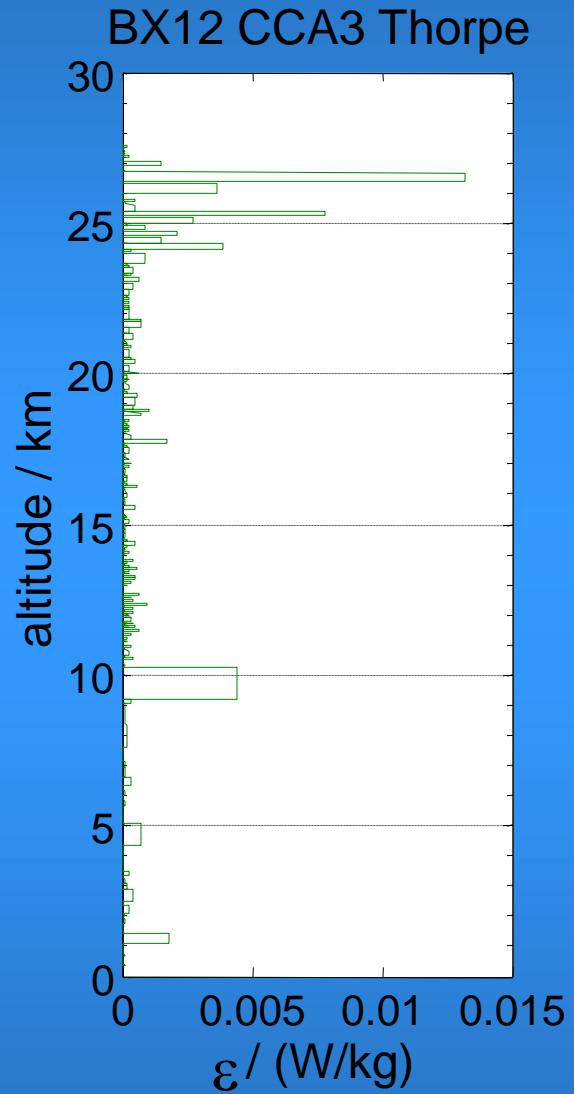
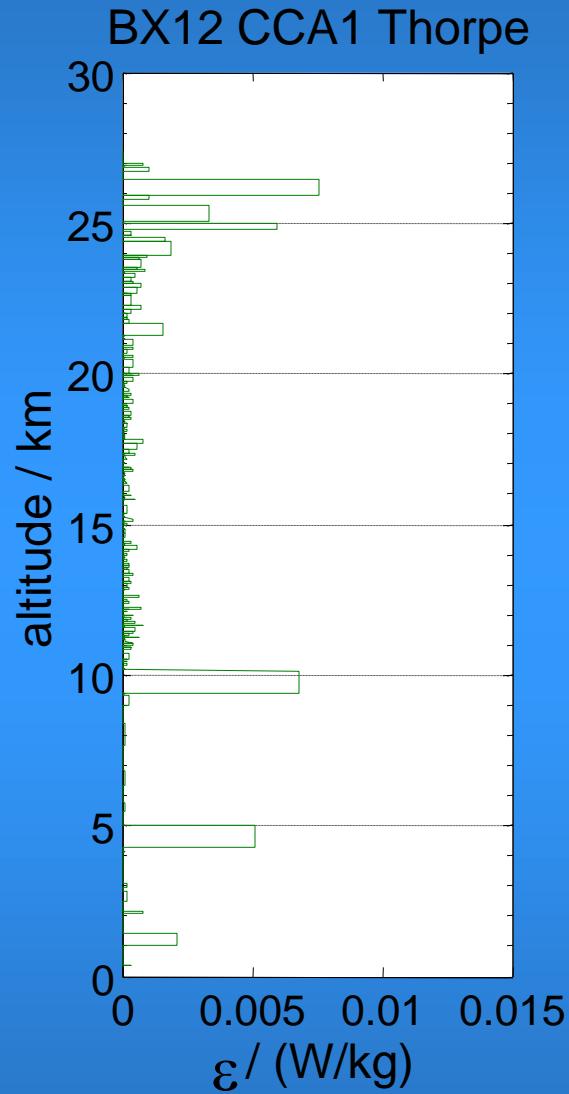
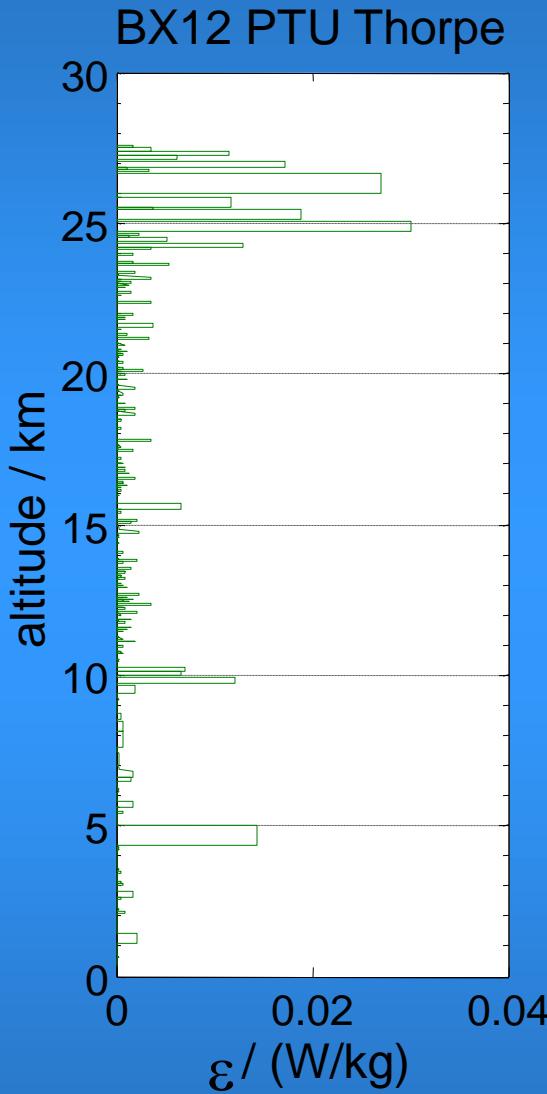
BEXUS 12 PTU Thorpe analysis



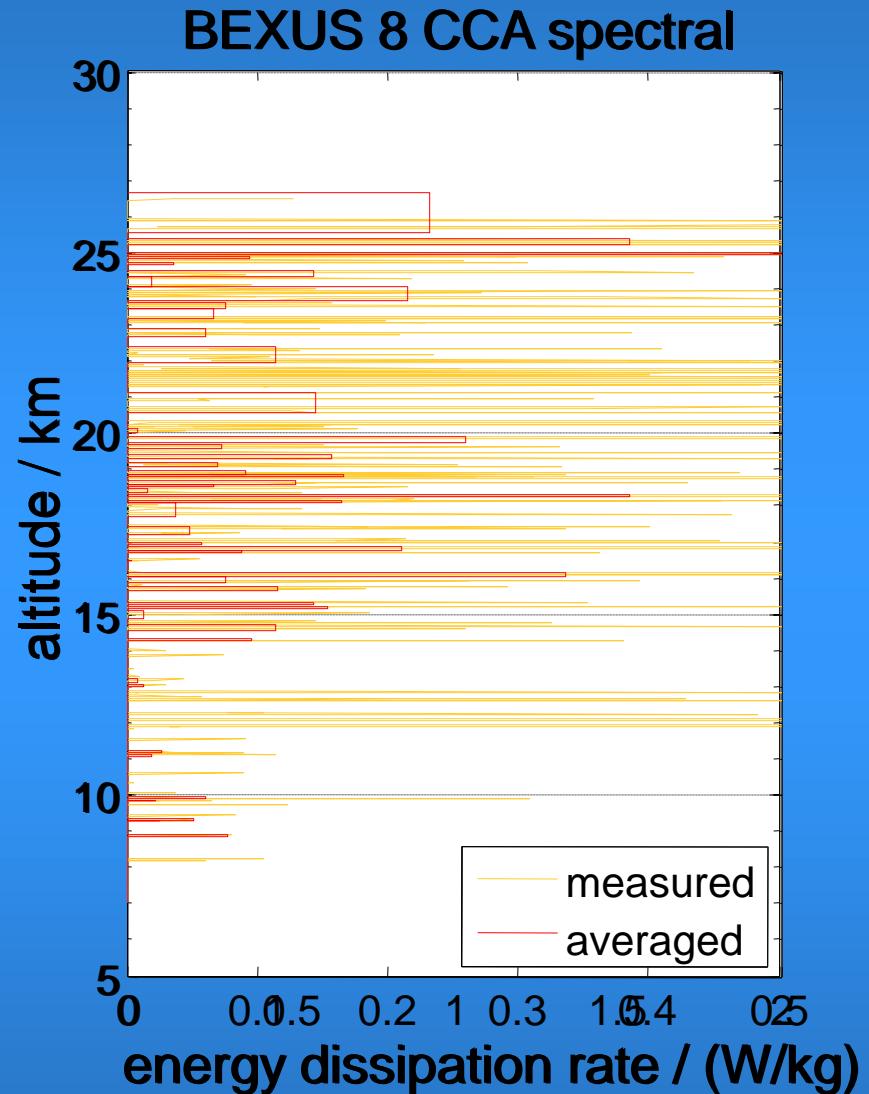
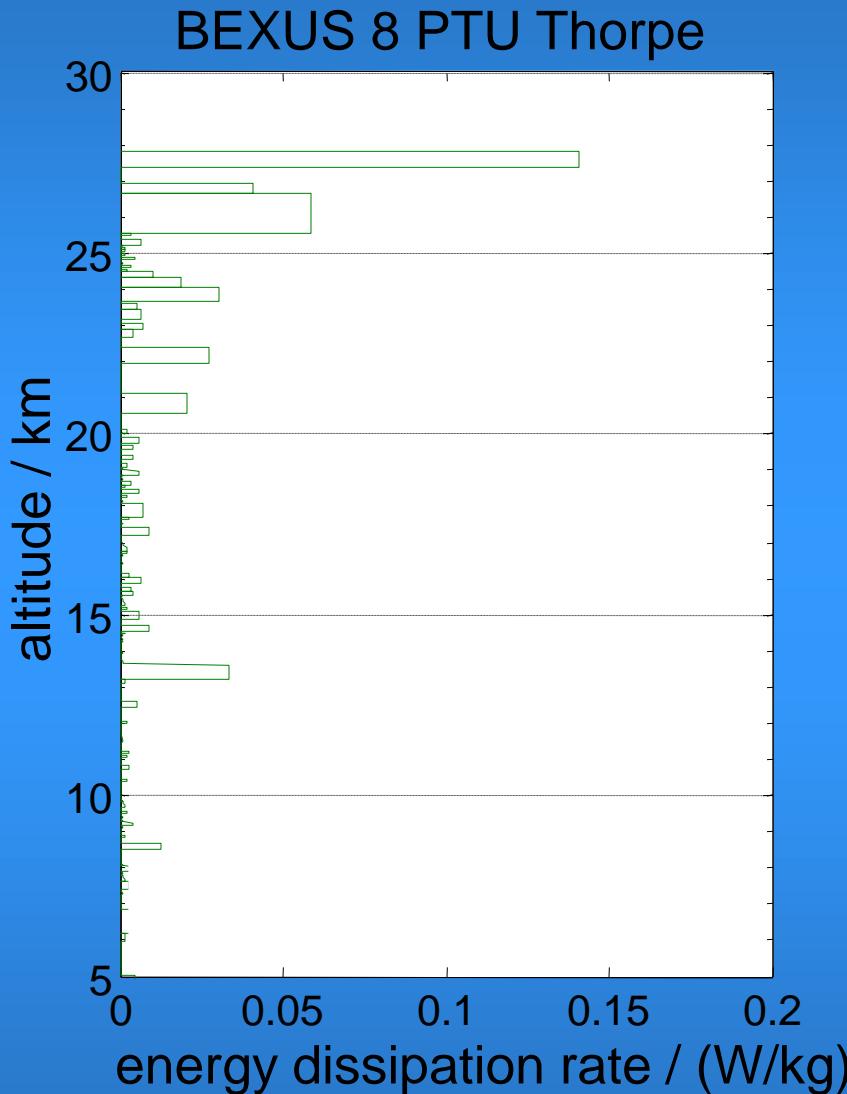
BEXUS 12 CCA spectral



BEXUS 12: Thorpe from RS and CCA



BEXUS 8 Thorpe analysis



Summary and Conclusions

- LITOS: simultaneous in-situ measurements of wind and temperature fluctuations in the stratosphere
- Transition to viscous subrange \rightarrow dissipation rate computed directly from spectrum
- Turbulent layers typically only 30 - 50 m thick (temperature thinner than wind)
- BX8/BX12: Great variability in ϵ \rightarrow to be further investigated (e.g. source of turbulence)
- Partly turbulent wind layers not visible in temperature
- ϵ from Thorpe analysis compares within factor ~ 3
- *new lightweight payload under development*