
# Evaluation of experiments regarding solar radiation on radiosonde temperature sensors

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# Motivation



- Sensor heating by solar radiation major issue for radiosonde measurements
- Effect dominant in stratosphere; ~1 K
- → Correction for $T$ essential
- Uncertainty of correction includes:
  - model approaches for albedo, sensor orientation, effective ventilation (pendulum motion),
  - sensor heating due to solar radiation

# Effective heating by radiation ($\Delta T$)



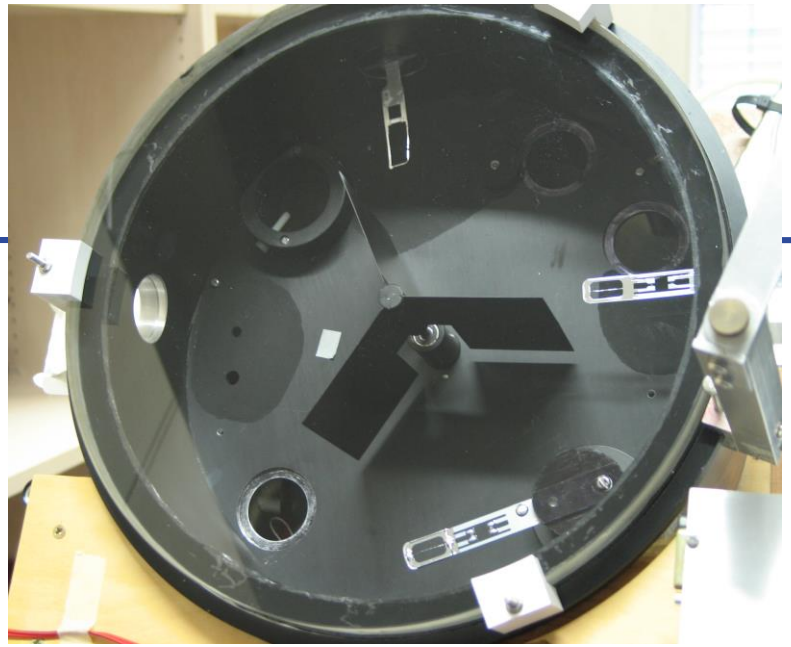
- $\Delta T$: effective heating of $T$-sensor above ambient air temperature (as net effect of solar irradiation and cooling by ventilation)
- Experimental approach:
  Ground based (and laboratory) measurements of $\Delta T$ as a function of irradiation $I_a$, pressure $p$, and air ventilation $v$ as the (considered) dimensions affecting the sensor temperature
- Parameterization included in GRUAN correction model:

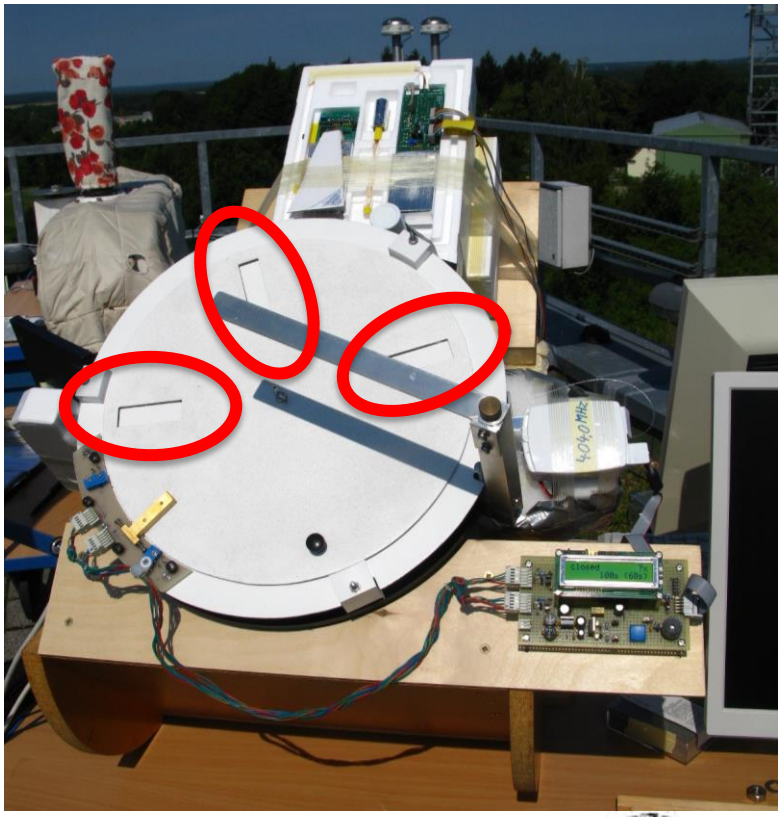
$$\Delta T = a\left(\frac{I_a}{p \cdot v}\right)^b$$ (Dirksen et al., 2014)

# Measurements

- MOL radiation chamber:
  up to 3 RS simultaneously, $p$ = 3 hPa to ambient,
  sun is radiation source
- $p$ and background $T$ inside chamber recorded by RS92 (shadow)
- Sensors exposed to sun for preselected time periods by aperture system
- Irradiance controlled by sun and grey filters;
  measured outside the chamber by pyrheliometer (CHP 1, Kipp & Zonen);
  setup orientation perpendicular to sun;
  → **maximum $\Delta T$**
- Ventilation ($v$) assumed as rotational speed of fan

→ Evaluation of MOL data (2012-2015) for Vaisala RS92 & RS41, Modem M10, and Graw DFM-09

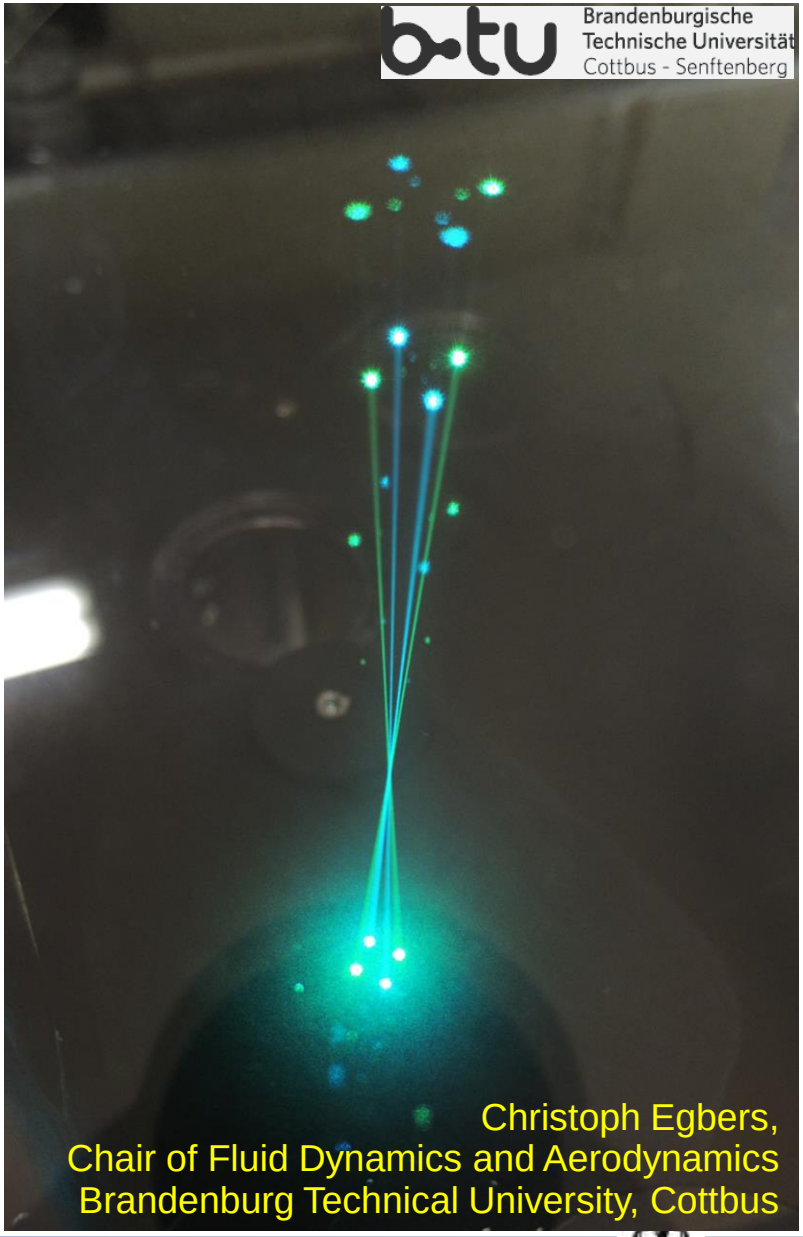




# Measurements: $v$



- Measurement of air flow field within chamber using LDA (Laser Doppler Anemometry) at different $p$

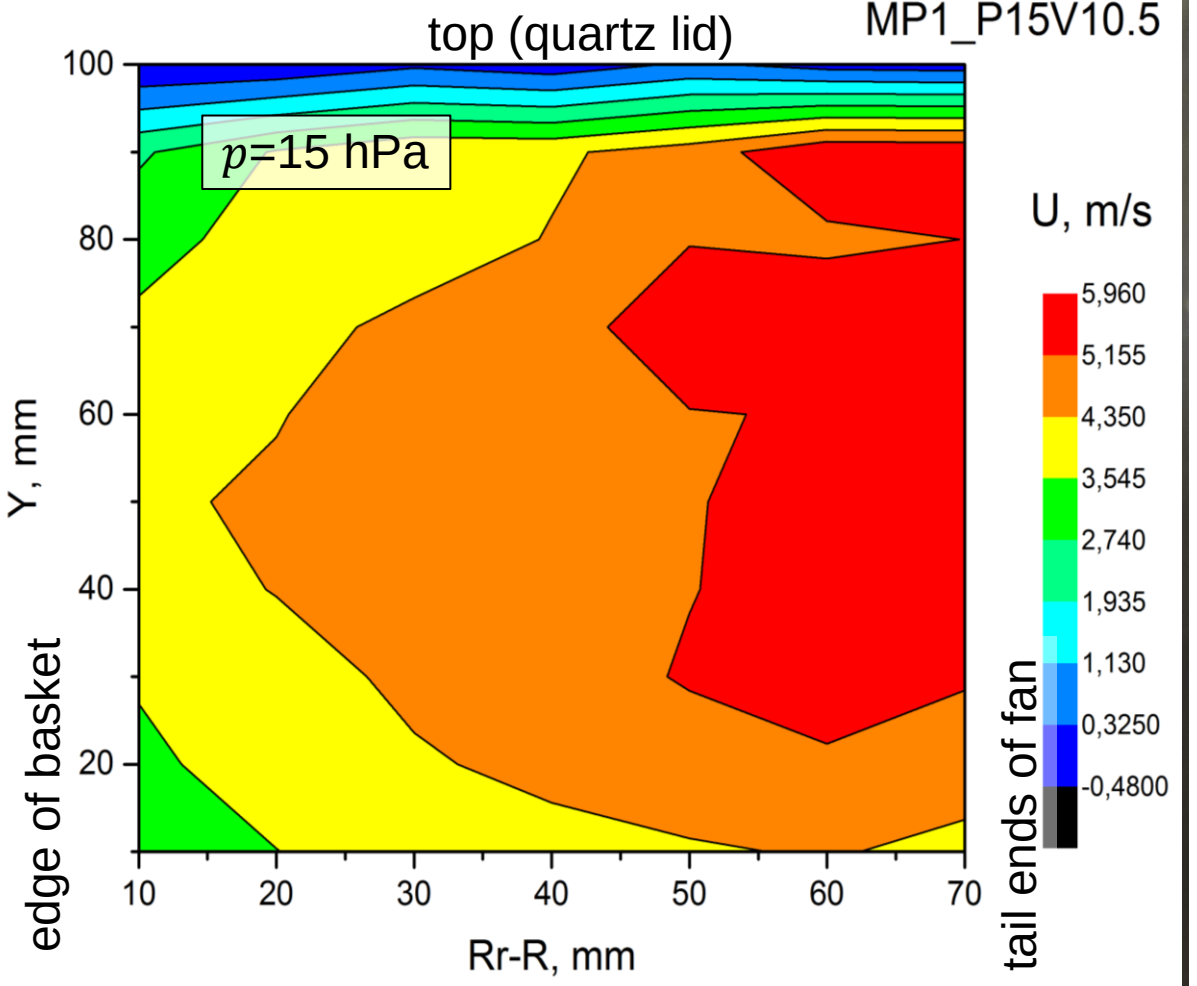


# Measurements: $v$



- Measurement of air flow field within chamber using LDA (Laser Doppler Anemometry) at different $p$

→ Results indicate correctness of assumptions about $v$ within less than $\pm 1$ m·s$^{-1}$

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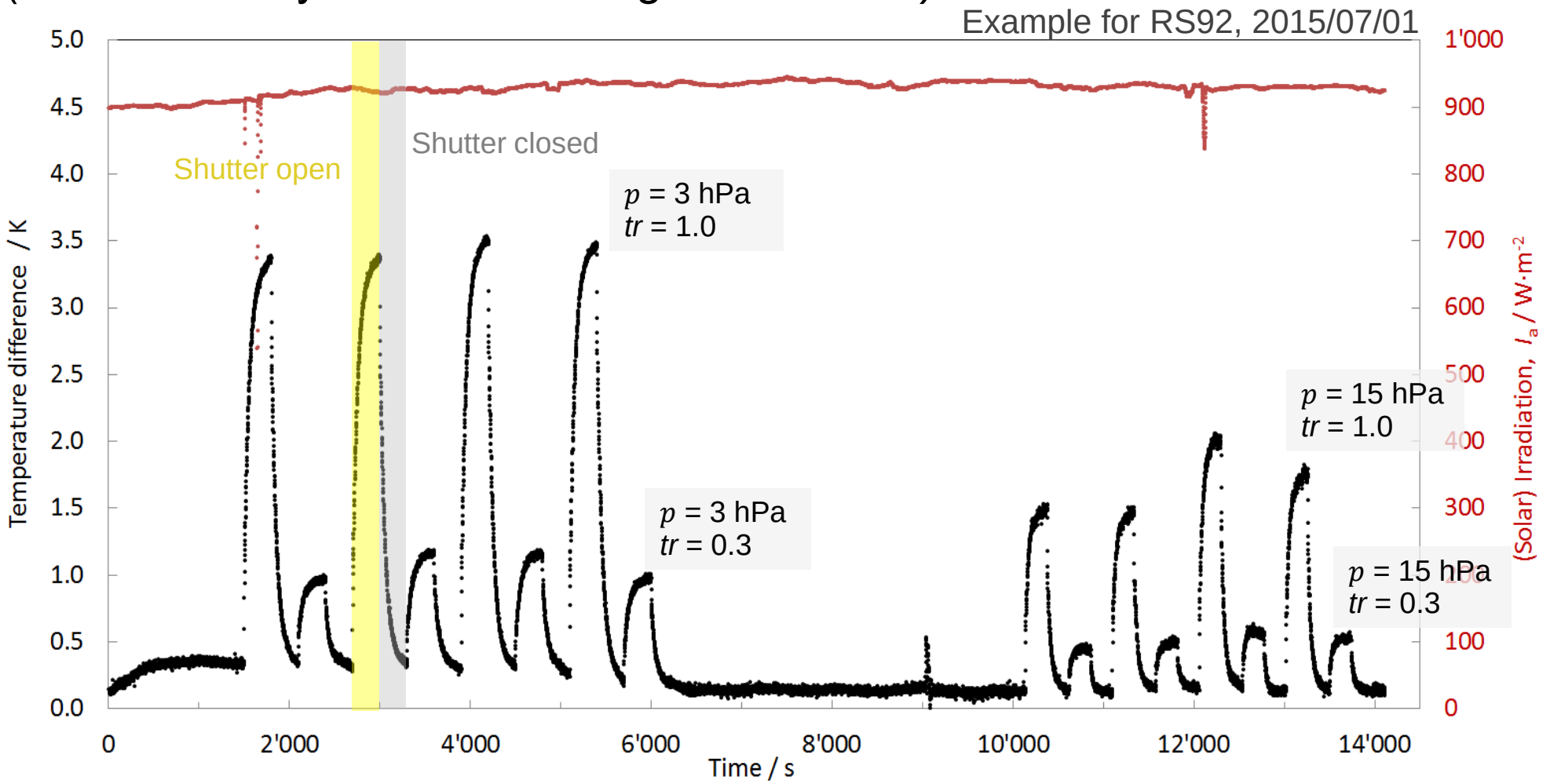
Brandenburg Technical University, Cottbus

# Measurements

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Record from test sonde for *T* – effect by irradiation, $v$ = 5 m·s$^{-1}$,
("detrended" by data from background sonde)



# Data evaluation

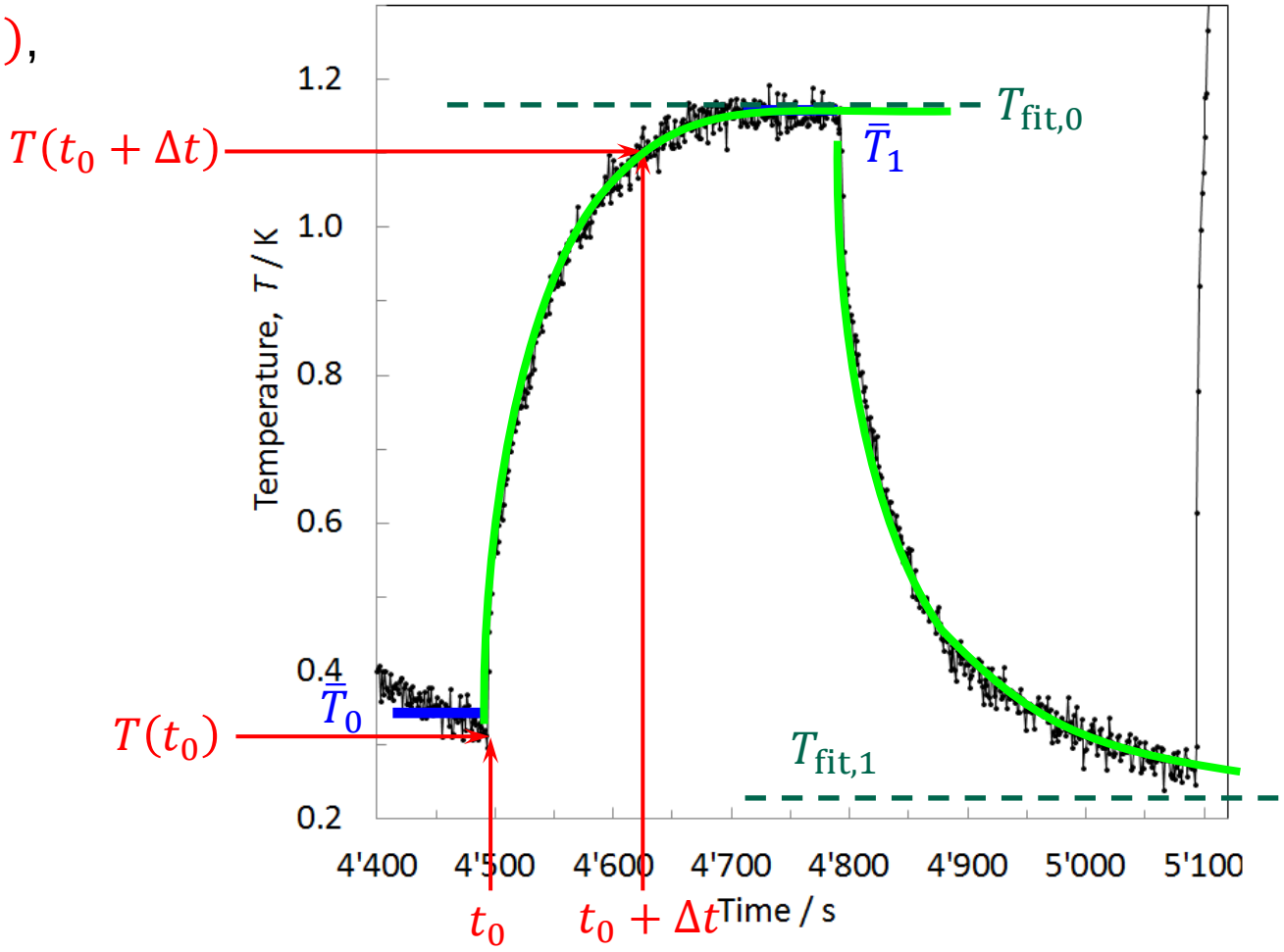


$\Delta T$ estimated by 3 methods:

1) Difference $T(t_0 + \Delta t) - T(t_0)$, with a fixed $\Delta t$

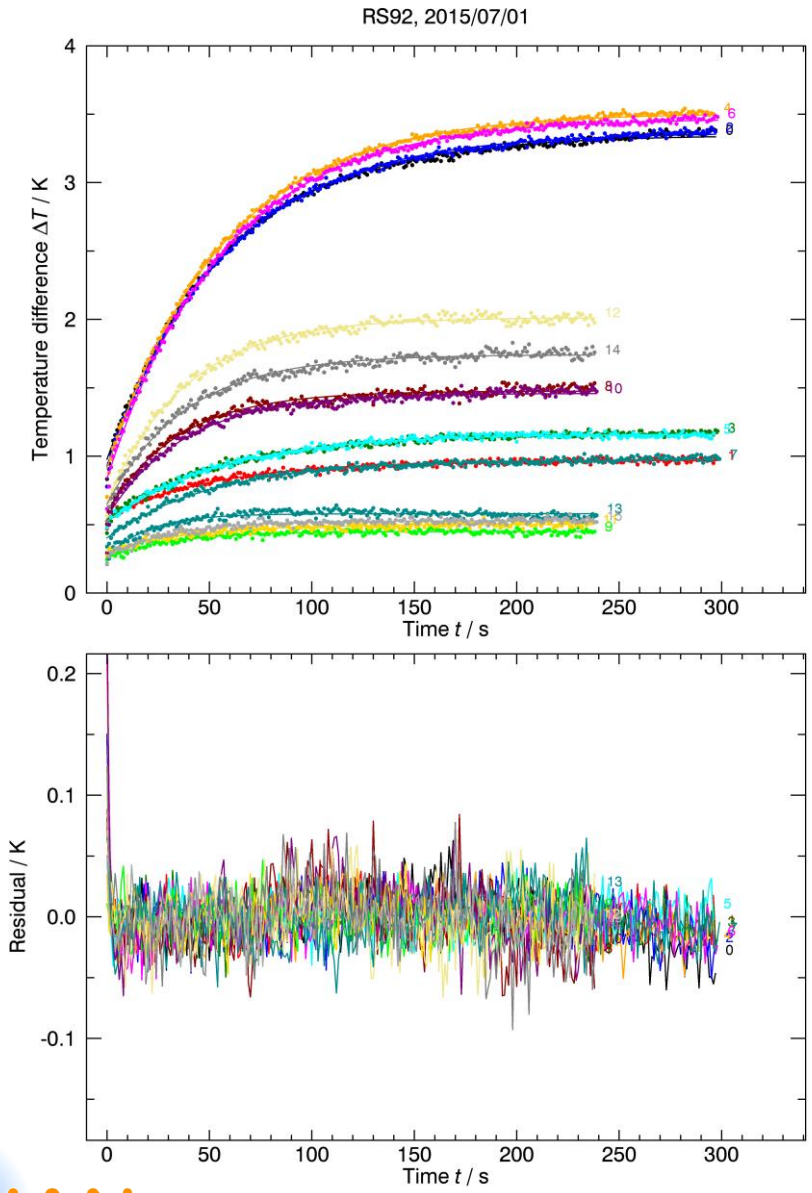
2) Difference of averages immediately before rising edge ($\overline{T}_0$), and at the end of the plateau ($\overline{T}_1$): $\overline{T}_1 - \overline{T}_0$; similar for descending edge

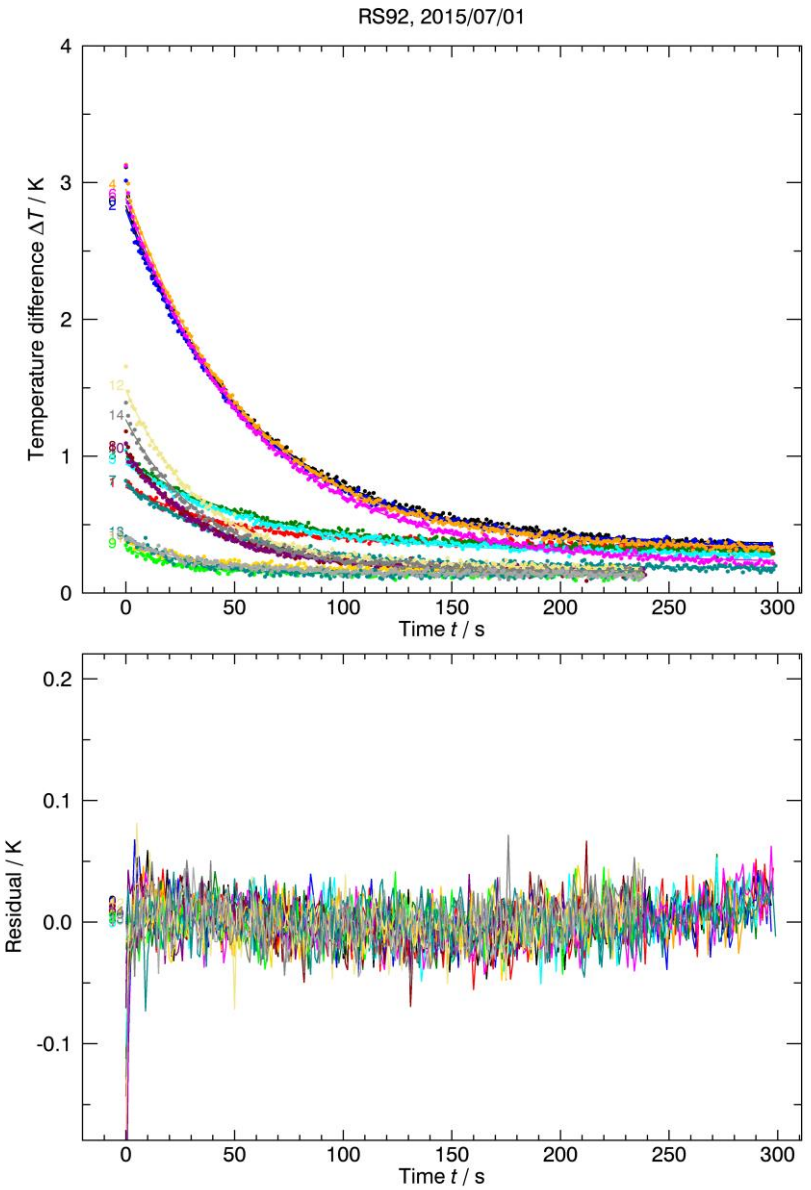
3) Fitting exponential functions $T_{\text{fit}} + T_1 \cdot e^{-(\lambda \cdot t)}$ to rising and falling edges, $T_{\text{fit},0} - T_{\text{fit},1}$;
→ independent of ‚integrity' of jumps



# Data evaluation



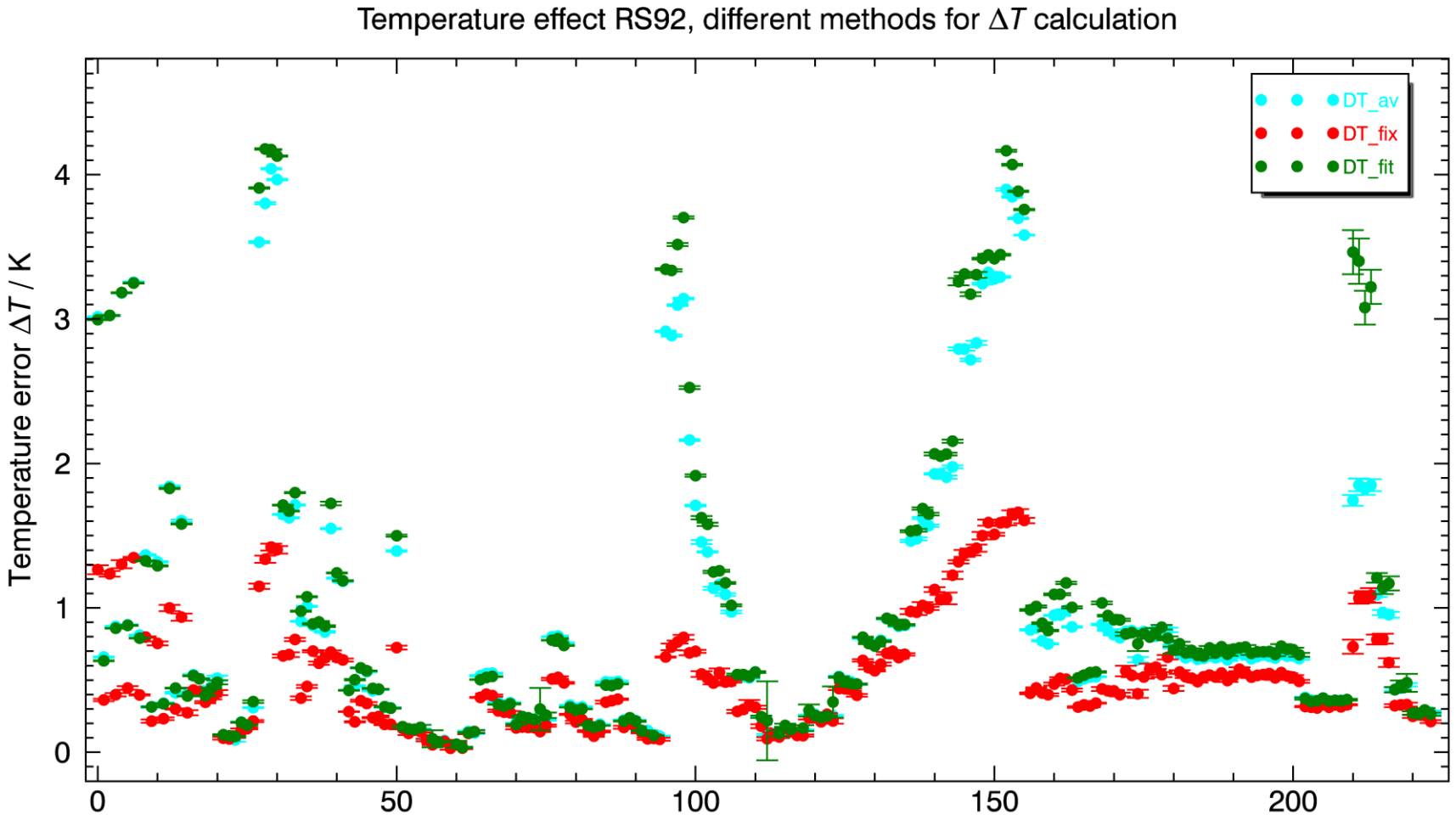


# Data evaluation



$\Delta T$ evaluated as T-difference for fixed time interval, T-averages, exponential fits



# Parameterization $\Delta T = a\left(\frac{I_a}{p \cdot v}\right)^b$

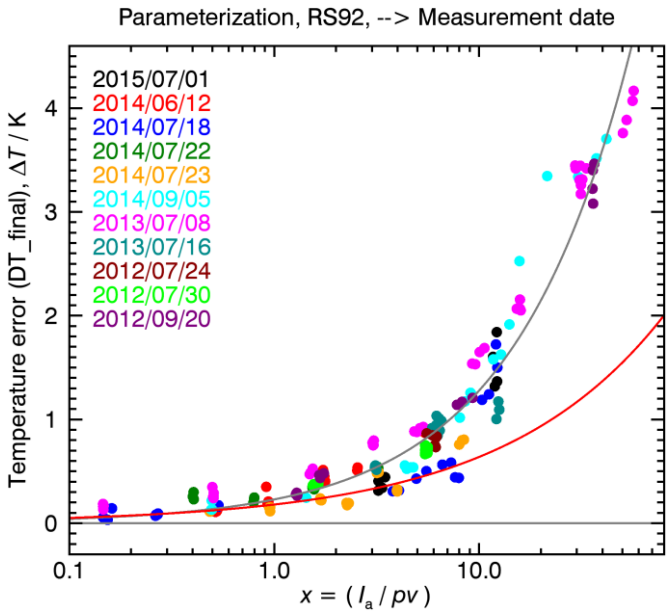


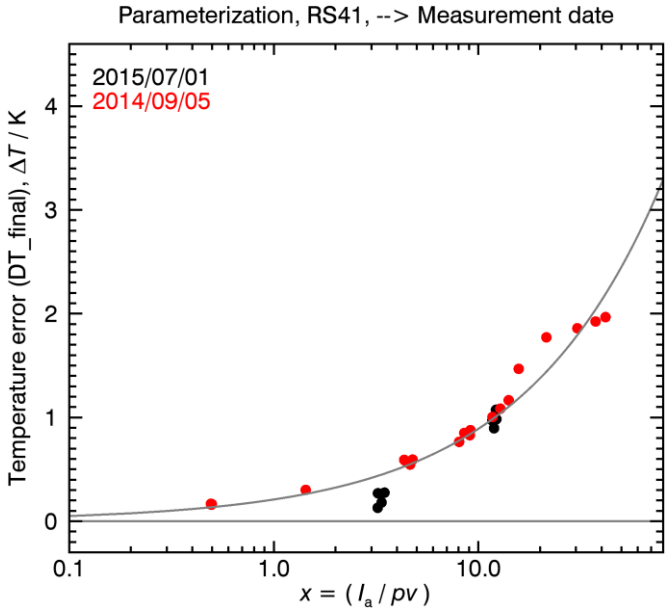
RS92:

$a = 0.23 \pm 0.01$
$b = 0.75 \pm 0.01$

RS92:

(Dirksen, 2014)
$a = 0.18 \pm 0.03$
$b = 0.55 \pm 0.06$



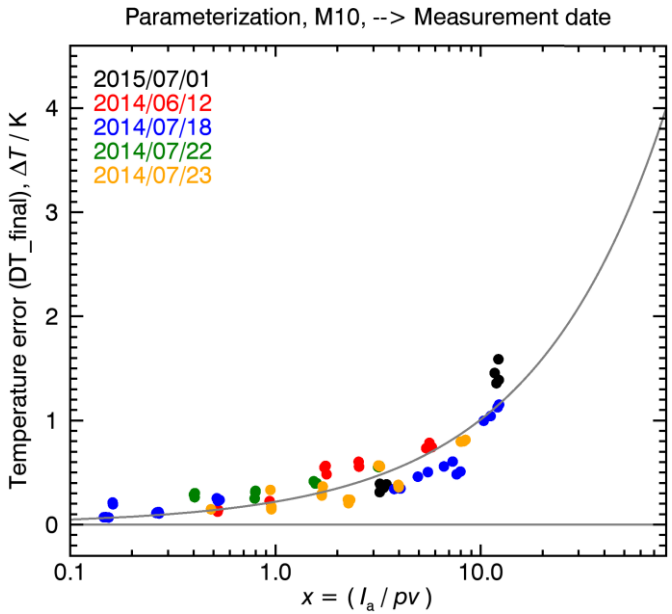



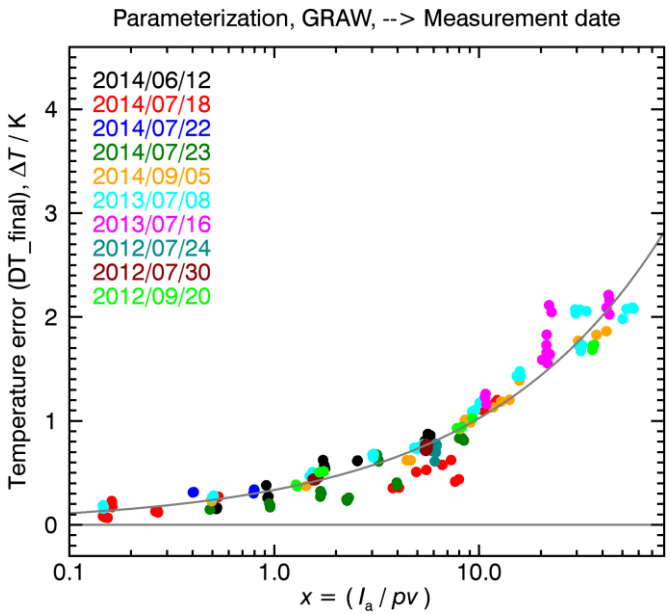

RS41:

$a = 0.21 \pm 0.02$
$b = 0.63 \pm 0.03$

M10:

$a = 0.22 \pm 0.02$
$b = 0.66 \pm 0.04$




DFM-09:

$a = 0.34 \pm 0.01$
$b = 0.49 \pm 0.01$

# Conclusions



- (Re-)evaluation of existing and new data for the effect of solar radiation on temperature measurements with radiosondes

- Improved methods for $\Delta T$ estimation, more data

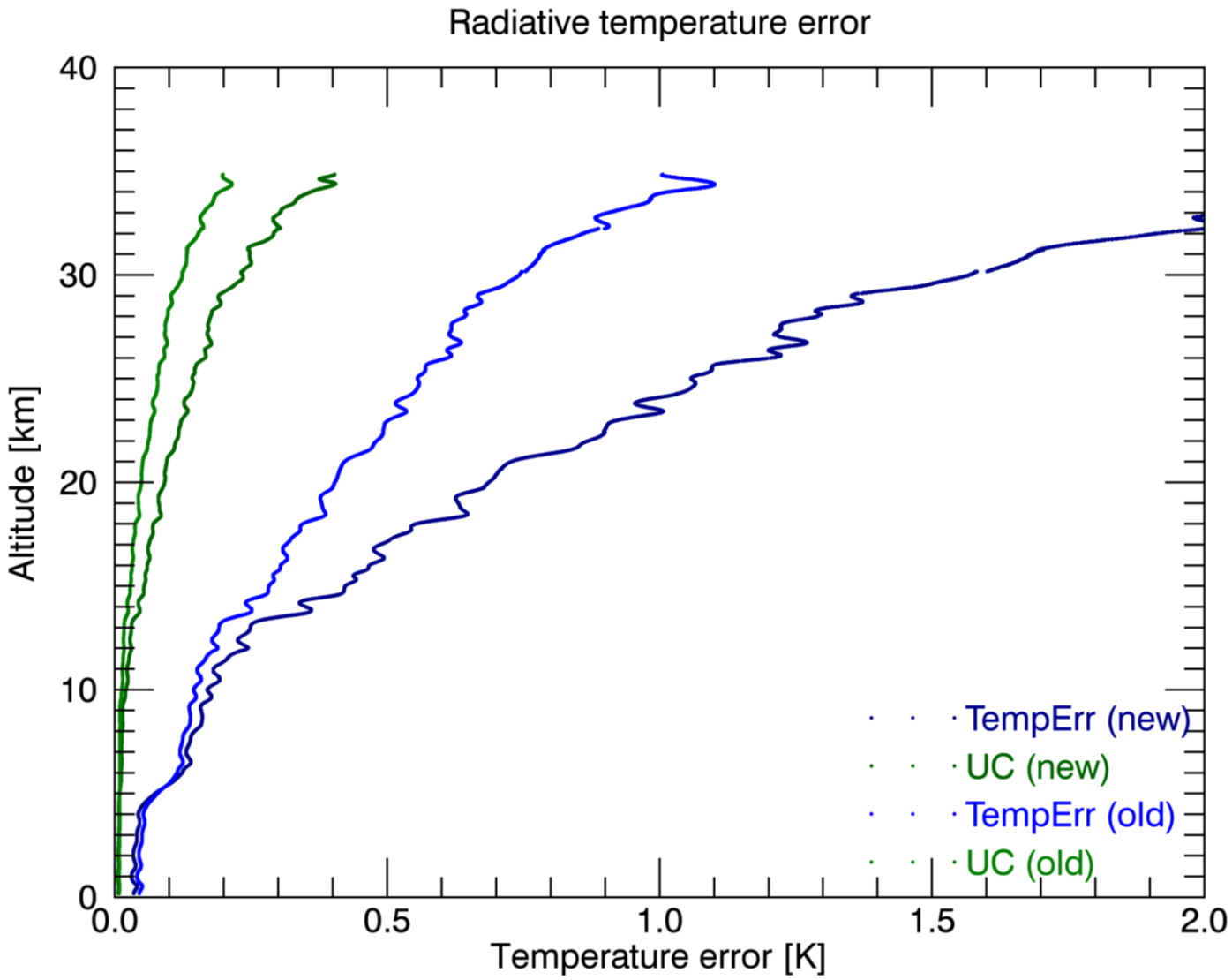
- Outcome: parameterization based on empirical approach
  $\Delta T = a\left(\frac{I_a}{p \cdot v}\right)^b$ more reliable

- Consequences (RS92): significant increase of $\Delta T$–effect, about a factor of 2 at low $p$

→ overestimating $\Delta T$ ?

# Conclusions






Correction of $T$-error due to solar radiation in GDP v.2 for RS92

„new“ vs. „old“ coefficients:

$a = 0.18 \rightarrow 0.23$
$b = 0.55 \rightarrow 0.75$

# Conclusions – open questions



To what extent does the MOL radiation setup represent real conditions?

→ thermal radiation (*not considered in $\Delta T$ parameterization*):

difference chamber <-> stratosphere (chamber surfaces, …), *how much*?

→ role of effective time response in conjunction with orientation changes (pendulum motion)?

*Thank you!*