Measurements and Intercomparisons at the Payerne GRUAN Site and the Meteolabor Sonde Product

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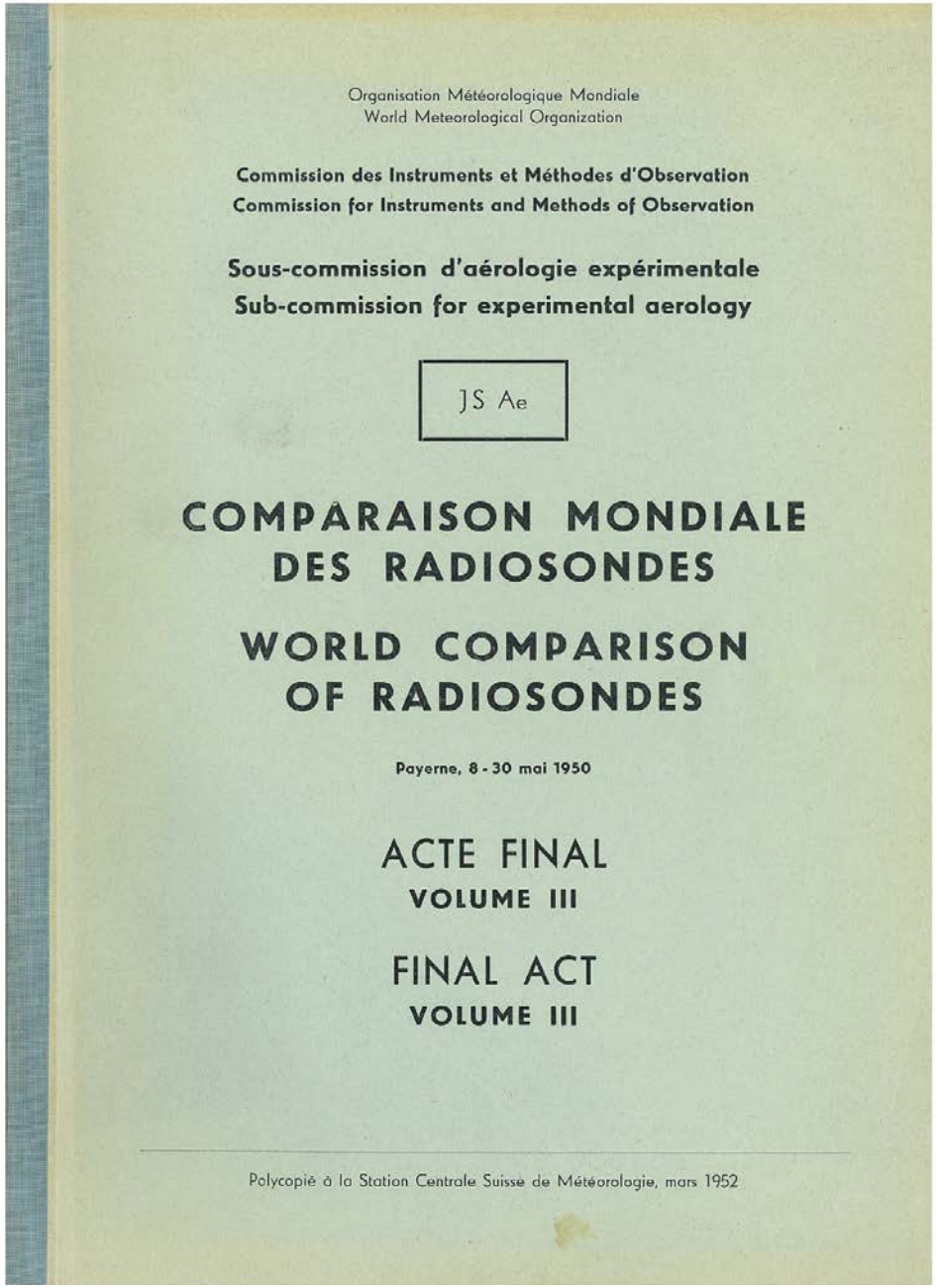
MeteoSwiss

World Comparison of Radiosondes Payerne 1950



Organisation Météorologique Mondiale
World Meteorological Organization

Commission des Instruments et Méthodes d'Observation
Commission for Instruments and Methods of Observation

Sous-commission d'aérologie expérimentale
Sub-commission for experimental aerology

JS Ae

COMPARAISON MONDIALE DES RADIOSONDES

WORLD COMPARISON OF RADIOSONDES

Payerne, 8 - 30 mai 1950

ACTE FINAL
VOLUME III

FINAL ACT
VOLUME III

Polycopié à la Station Centrale Suisse de Météorologie, mars 1952

History:

- **Studies in Sweden in 1942**
- **Comparisons of Vaisala and U.S. Radiosondes showed systematic and large differences**
- **At a P.I.C.A.O. meeting in London in 1946 the I.M.O. was charged to study the question**
- **First steps at I.M.O. meeting in Toronto 1947**
- **At the R.A. VI meeting in London 1949, the Swedish Institute suggested a new Committee**
- **Dr. Jean Lugeon, became president and in 1950 he invited all members to Payerne**
- **Six radiosondes were compared at Payerne: Finnish, French, Swiss, U.S., U.K., German**
- **Reports from: U.S., U.K, Switzerland, Belgium, Sweden, France**

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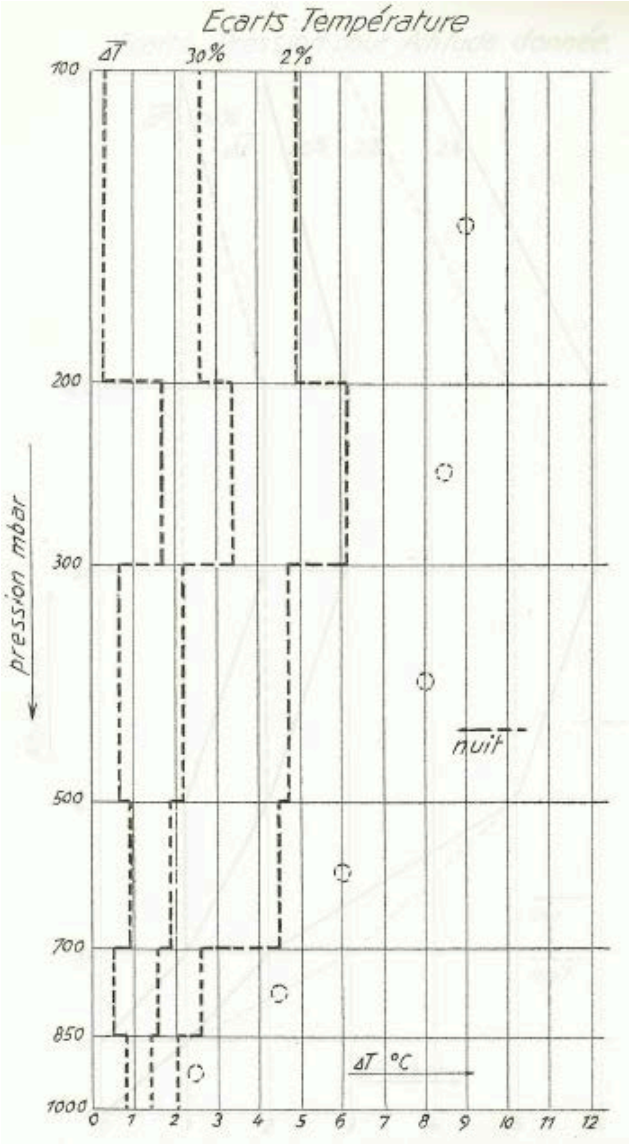
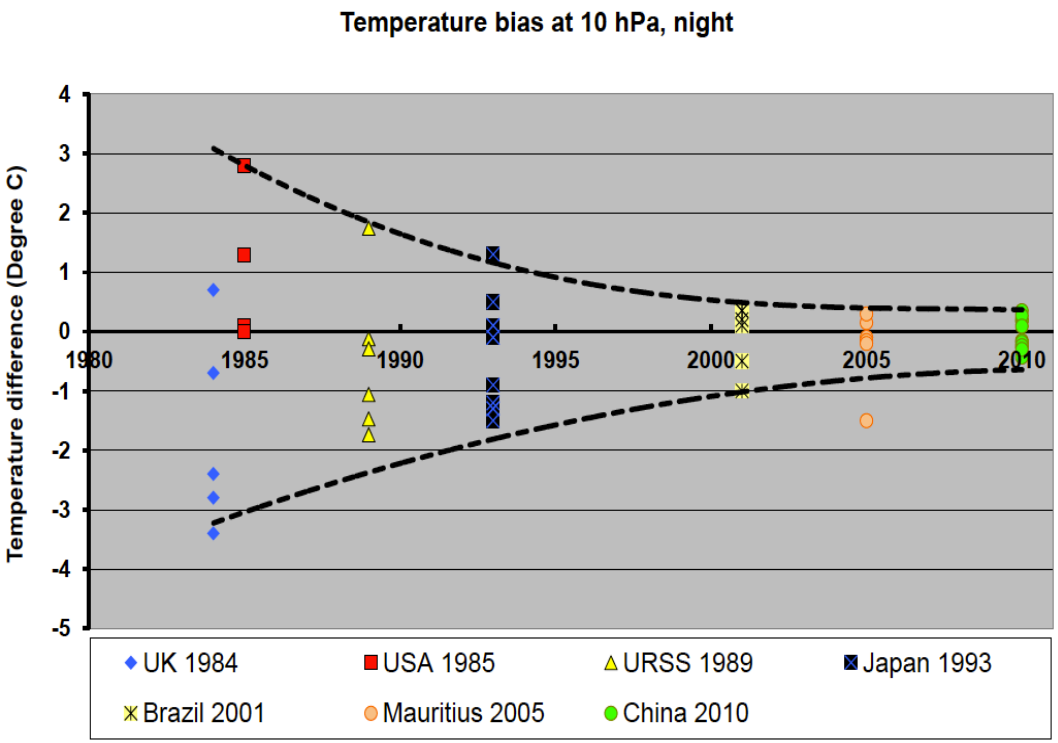
WMO Radiosonde Intercomparisons 1984 - 2010

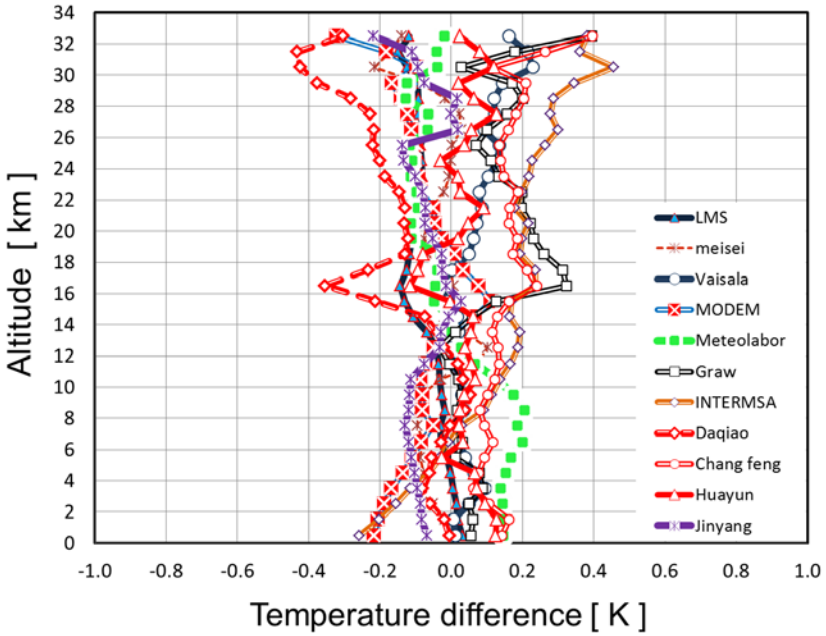


Payerne 1950

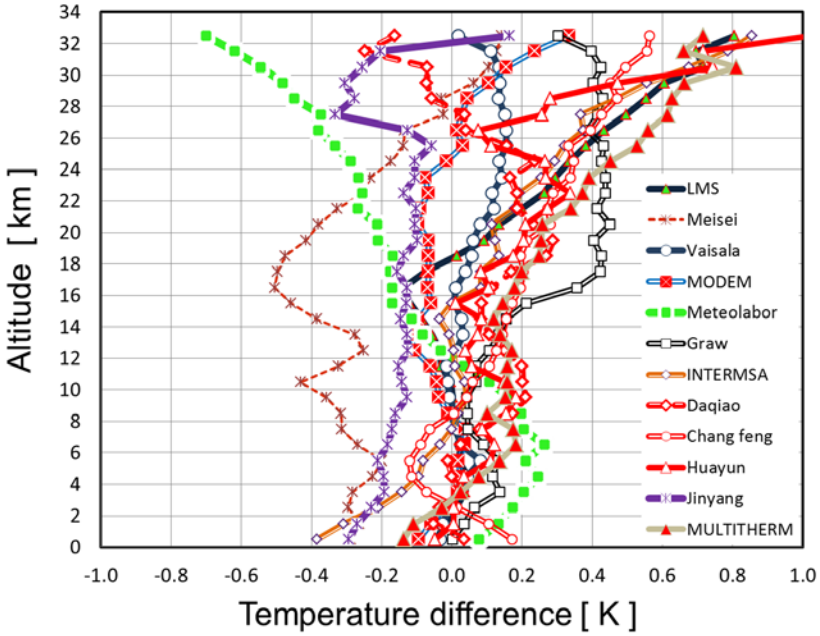


WMO Intercomparison of QRS in Yangjiang, China, 2010

Night



Day



J. Nash, T. Oakley, H. Vömel, LI Wei, WMO/TD-No. 1580, 2011

Results WMO Intercomparison 2010

Table 12.1:
Summary of operational performance of QRS as measured in Yangjiang

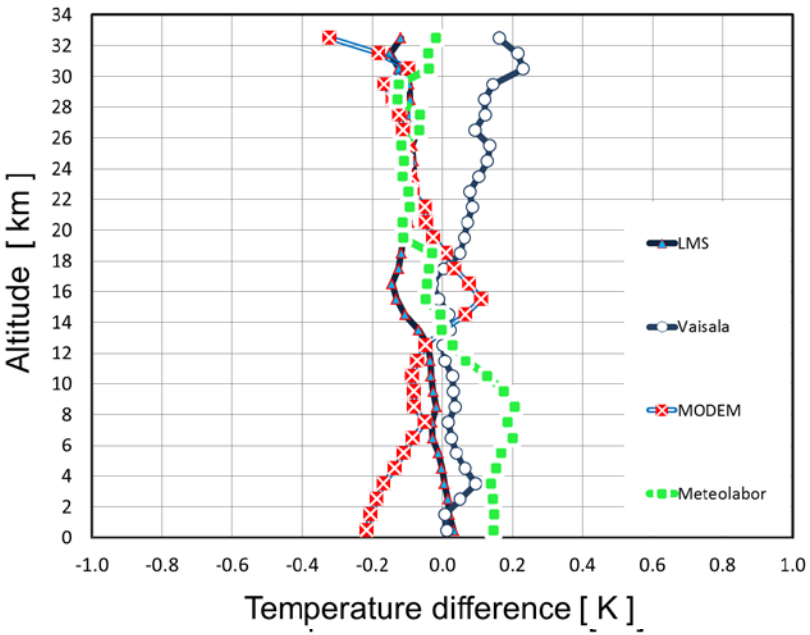
	InterMet	Modem	Graw	Meteo-labor	Daqiao	Jinyang	Meisei	Changfeng	Huayun	LMS	Vaisala	Snow-white	Multi-thermistor
2 years operations	Yes	Yes	No	No	Yes	No	No	No	No	Yes	Yes	Yes	Yes
Used in:-	global	global		Switz.	China	Korea				global	global	global	USA
Temperature, Night, height.<16 km	4.5	5	4.5	5	4.25	4.75	5	4.75	5	5	5	See Meteolabor	5
Temperature, Night, height > 16 km	3.25	5	4.5	5	3.25	3.75	5	4.75	5	5	5	See Meteolabor	5
Temperature, day, height <16 km	4.75	5	4.5	5	4.5	4.5	4	5	5	5	5	See Meteolabor	5
Temperature, day, Height >16 km	3.25	5	4.25	4.75	3.75	3.5	4.25	4.5	2.75	5	5	See Meteolabor	4.25
Protection for Evap. cooling errors	No	No	No	No	No	No	No	No	No	No	Yes	See Meteolabor	No
Humidity T>-40 deg C, night	4.5	3[1]	5	4.25	2.75	3.75	4.75	5	4	5	5	5	See LMS
Humidity T>-40 deg C, day	4.25	4.25[1]	4.75	3.25	4	4.75	5	4.25	3.75	5	5	5	See LMS
Humidity, Upper trop. T<-40 deg C, night	4.5	4.25	4.5	xx	xx	4	4	3.5	3.25	4.75	5	5	See LMS
Humidity, Upper trop. T<-40 deg C, day	2.5	3	4.25	xx	xx	4.25	3	3	2.75	4.5	4.5	xx	See LMS
Height P higher than 100 hPa	5	5	5[2]	5	4.75	4.25[5]	4[6]	5	5	5	5[7]	See Meteolabor	See LMS
Height P lower than 100 hPa	5	5	5[2]	5	3.25	5	5[6]	5	5	5	5	See Meteolabor	See LMS
Pressure Higher than100hPa	4	5	4.5[2]	4[3]	4.75	3.5[5]	4.5[6]	5	5	5	5[7]	See Meteolabor	See LMS
Pressure Lower than 100hPa	4.75	4.75	4.5[2]	4.75[3]	3.25	4.25	4.25[6]	5	4.75	5	5	See Meteolabor	See LMS
Wind, troposphere	5	5	5	3[4]	5	5	5	5	5	5	5	See Meteolabor	See LMS
Wind ,stratosphere	5	5	5	5	4.5	5	5	5	5	5	5	See Meteolabor	See LMS

Mark	Status
3	Just meets the operational requirements of the CIMO Guide
4	Better than operational requirements of CIMO Guide, but still needs some improvement to become ideal for GRUAN
5	As good as can be expected for GRUAN at the moment

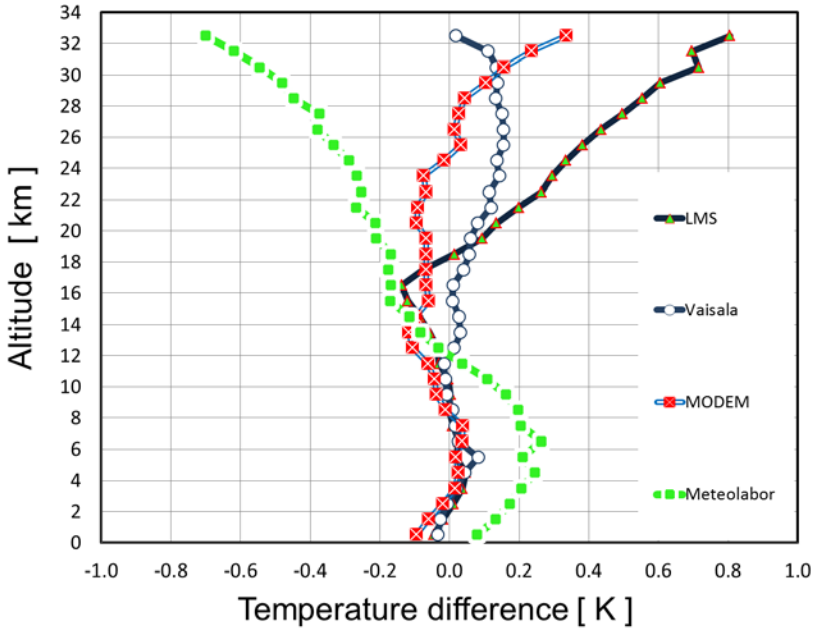
MeteoSwiss

WMO Intercomparison of QRS in Yangjiang, China, 2010

Night



Day



J. Nash, T. Oakley, H. Vömel, LI Wei, WMO/TD-No. 1580, 2011

Reinvestigation of Meteolabor radiation correction

Experiments: Atmosphere / Laboratory

1 **Measurements of the radiation error on unshaded and shaded temperature sensors in flight**

2 **Measurements of the radiation error on temperature sensors in a vacuum chamber in Lindenberg**

3 **Measurements of solar and thermal radiation flux profiles through the atmosphere**

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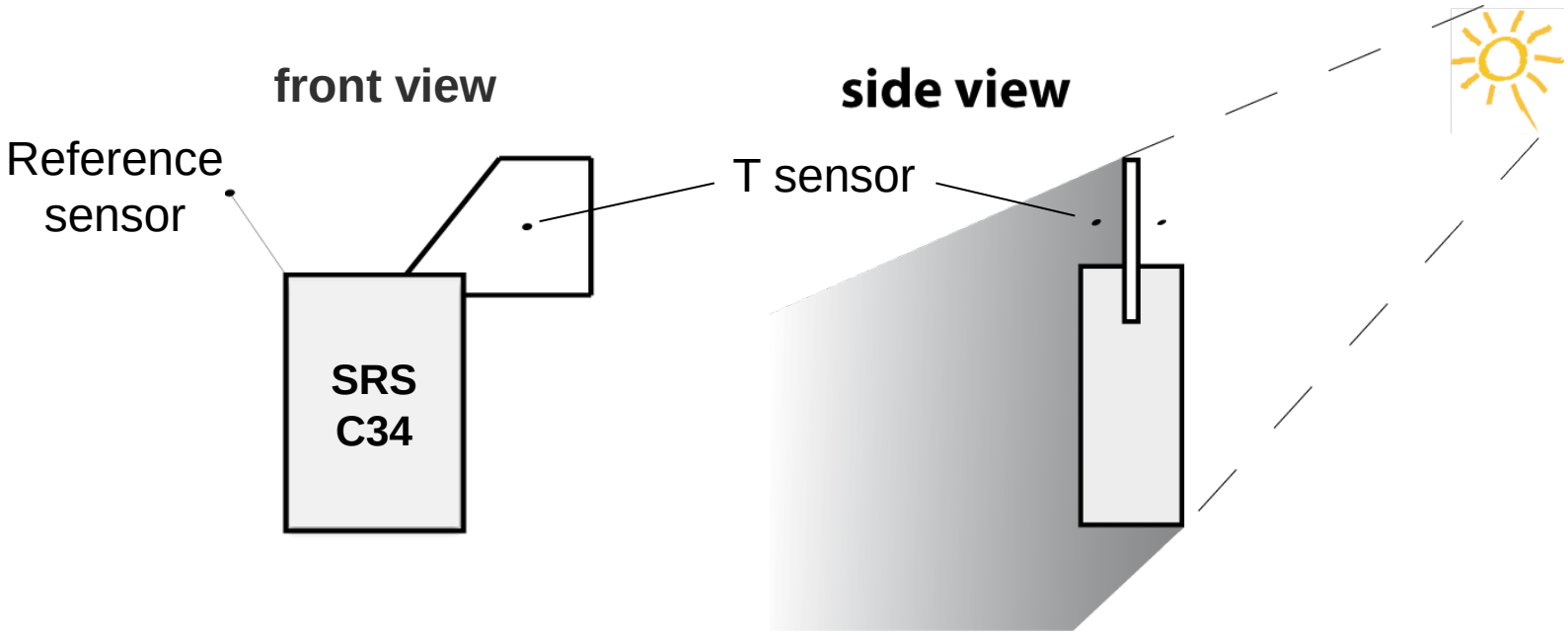
Shaded / Unshaded Temperature Measurement

- **Aluminium plate (brilliant / black) attached to Meteolabor sonde**
- **Temperature sensors on both sides (5cm distance)**
- **Alternately one sensor is exposed to the sun**



Shaded / Unshaded Temperature Measurement

50 micron thermocouple temperature sensors unshaded and shaded

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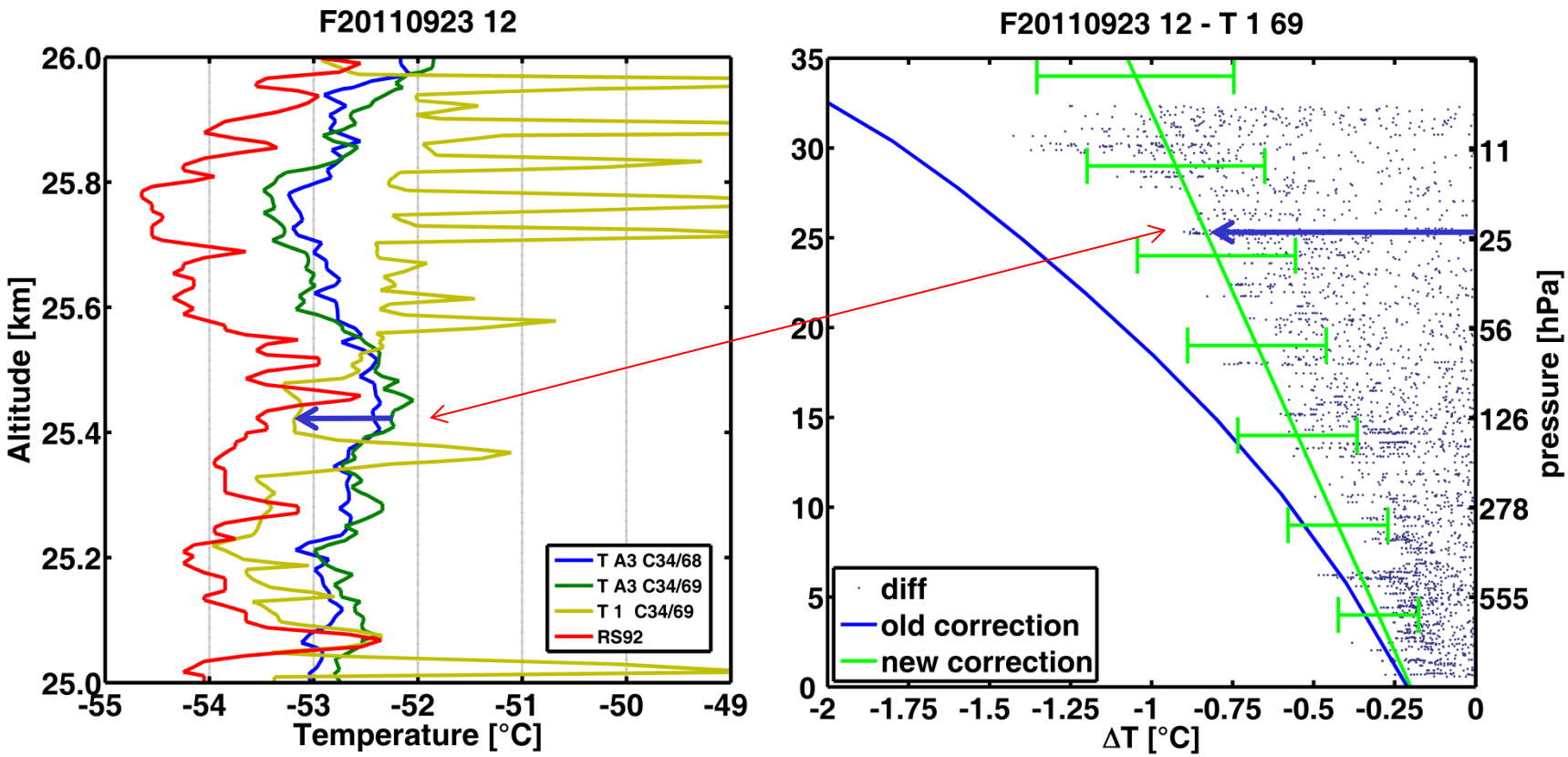
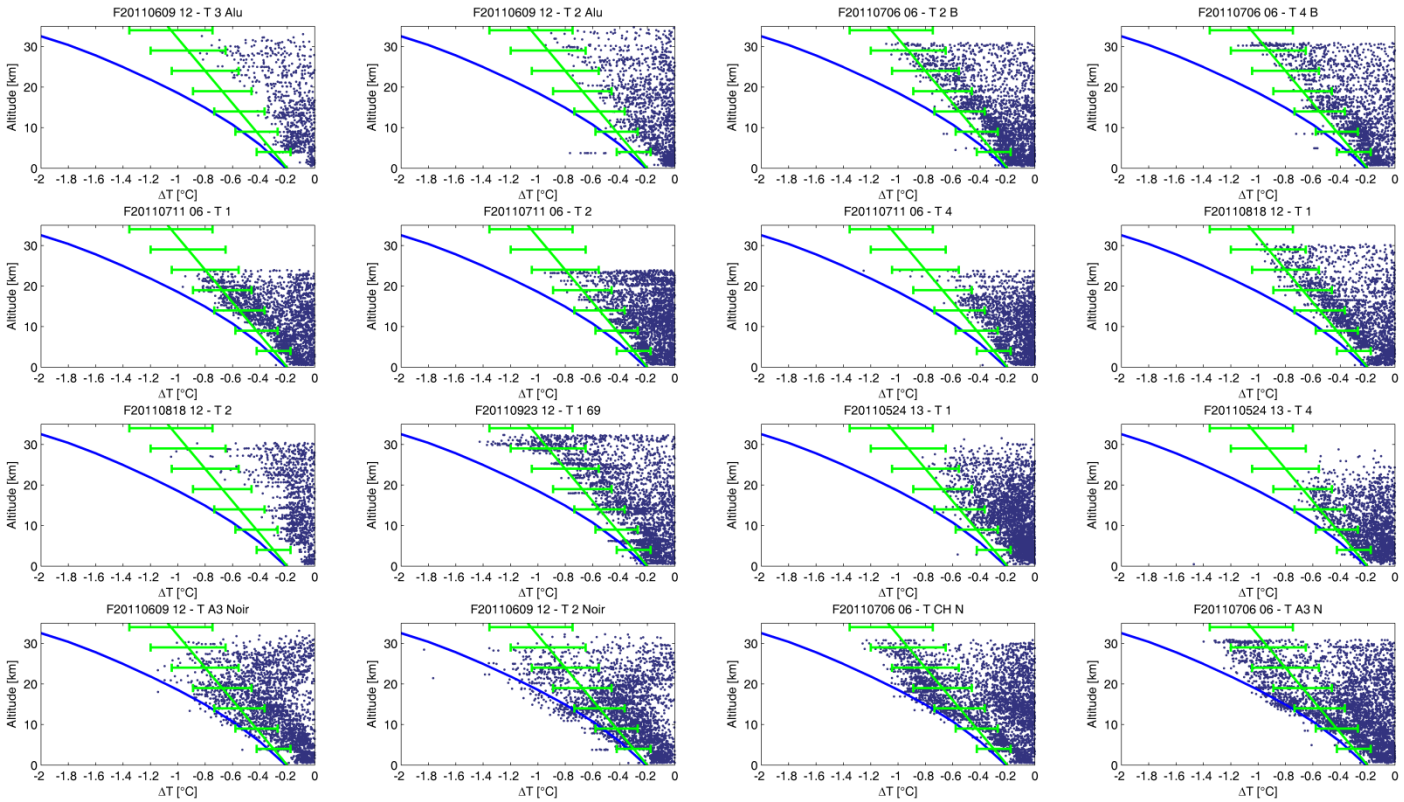
Radiation Error on Temperature Measurement



$$\Delta T_{year} = 0.2 + (0.8 * \frac{Alt_{geo}}{32'000})$$

New Radiation Error Correction Curve



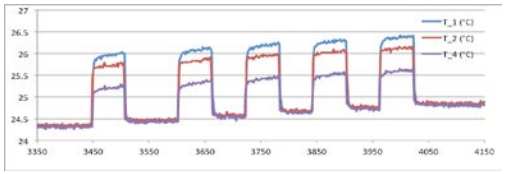
$$\Delta T_{year} = 0.2 + (0.8 * \frac{Alt_{geo}}{32'000})$$

Uncertainty on radiation error : u = ± [0.1 + (0.2* Alt geo/32’000)]

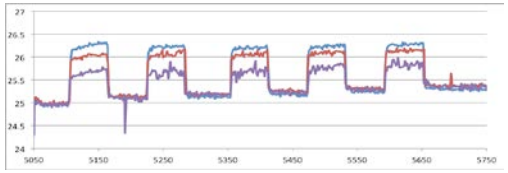
Radiation Error measured in Vacuum Chamber

Experiment with one Meteolabor sonde having three thermocouple sensors with wires of 20μ, 50μ, 100μ

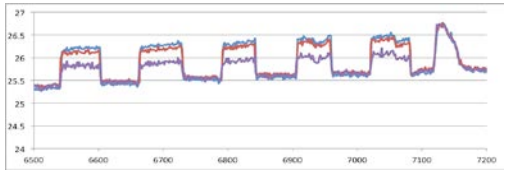
1 Minute on, 1 Minute off



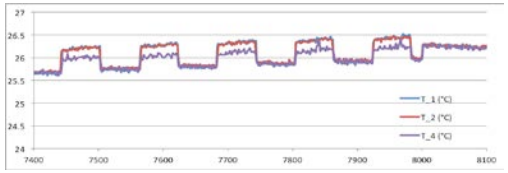
P = 5 hPa
v = 5 m/s



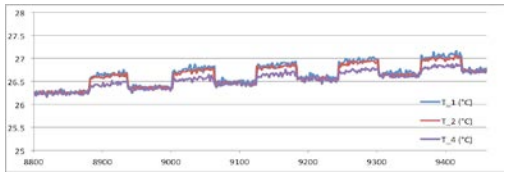
P = 10 hPa
v = 5 m/s



P = 30 hPa
v = 5 m/s

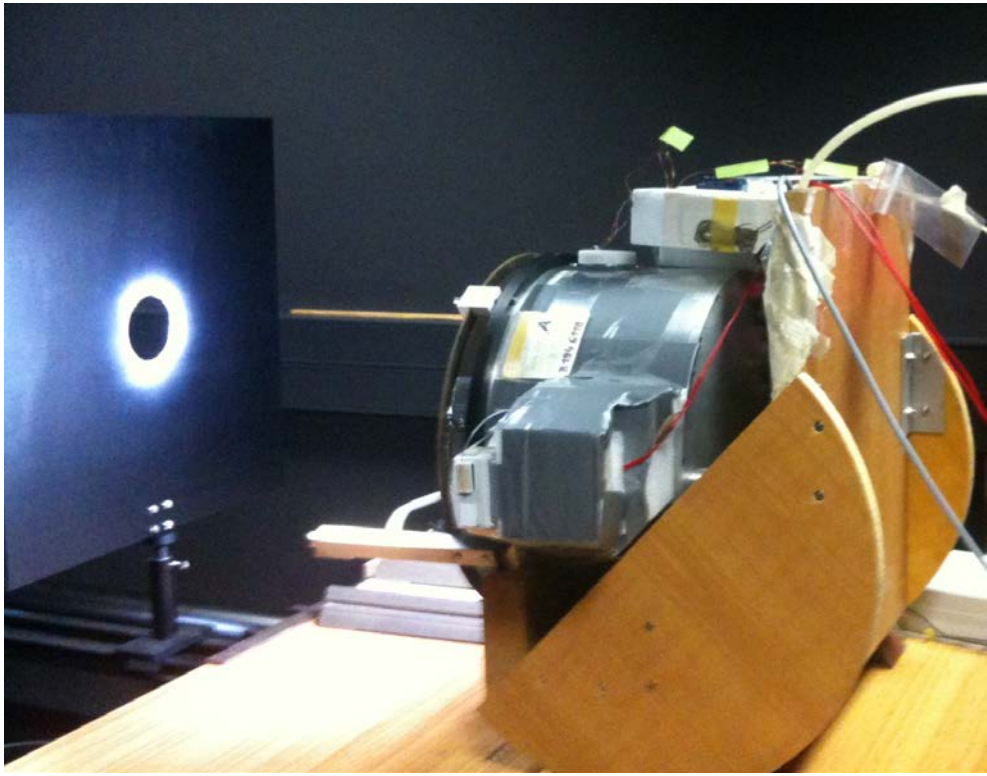


P = 100 hPa
v = 5 m/s



P = 300 hPa
v = 5 m/s

Observatory of Lindenberg Vacuum Chamber
Xenon Arc Lamp, Intensity: ~ **1650 Wm^{-2}**



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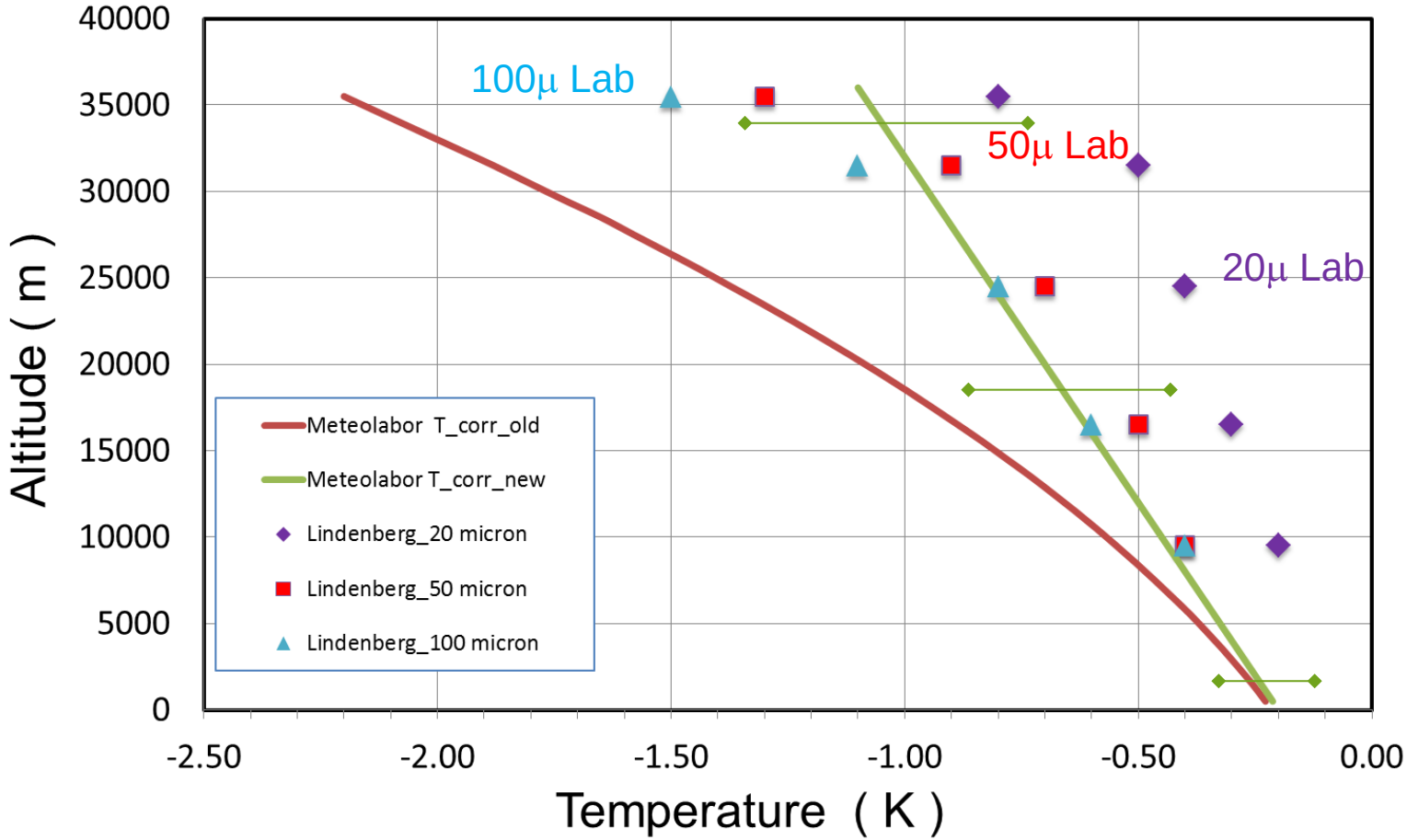
Radiation Error: Atmosphere / Laboratory

Old radiation error New radiation error and uncertainty

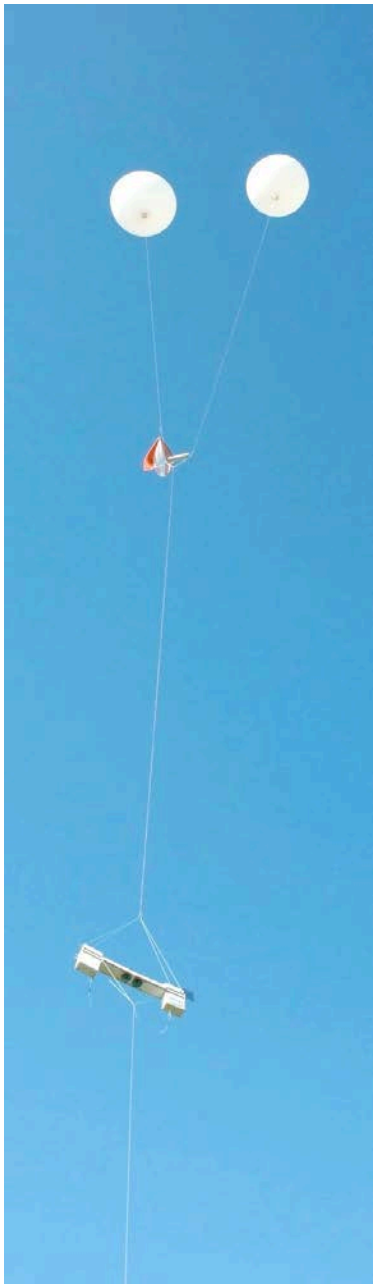


$$\Delta T_{year} = 0.2 + (0.8 * \frac{Alt_{geo}}{32'000})$$

Uncertainty on radiation error : u = ± [0.1 + (0.2* Alt geo/32'000)]

MeteoSwiss

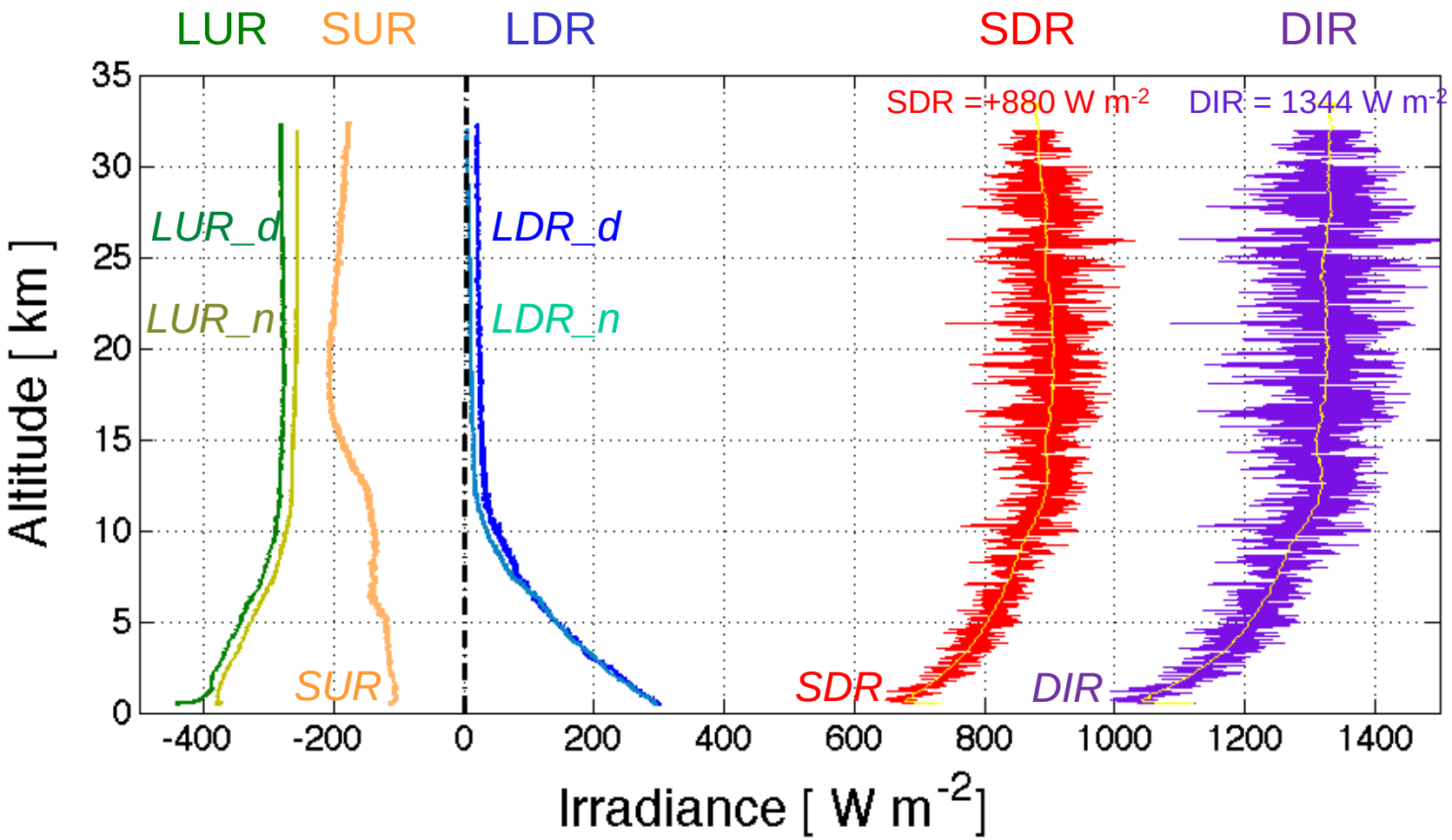
Radiation Measurements through the Atmosphere



SRS-C34 Radiosondes from Meteolabor and CNR 4 Net Radiometer from Kipp and Zonen

Shortwave and longwave Radiation Profiles

Night flight: 23 Sep 2011, UT21:20 **and** **Day flight: 23 Sep 2011, UT10:13**

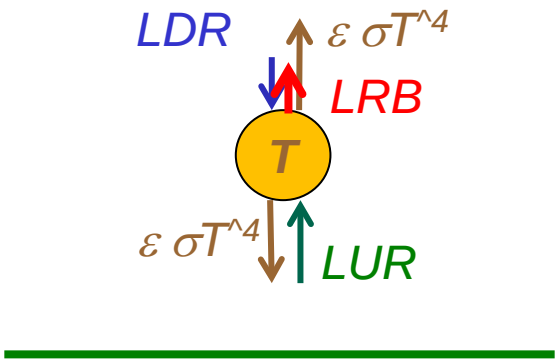


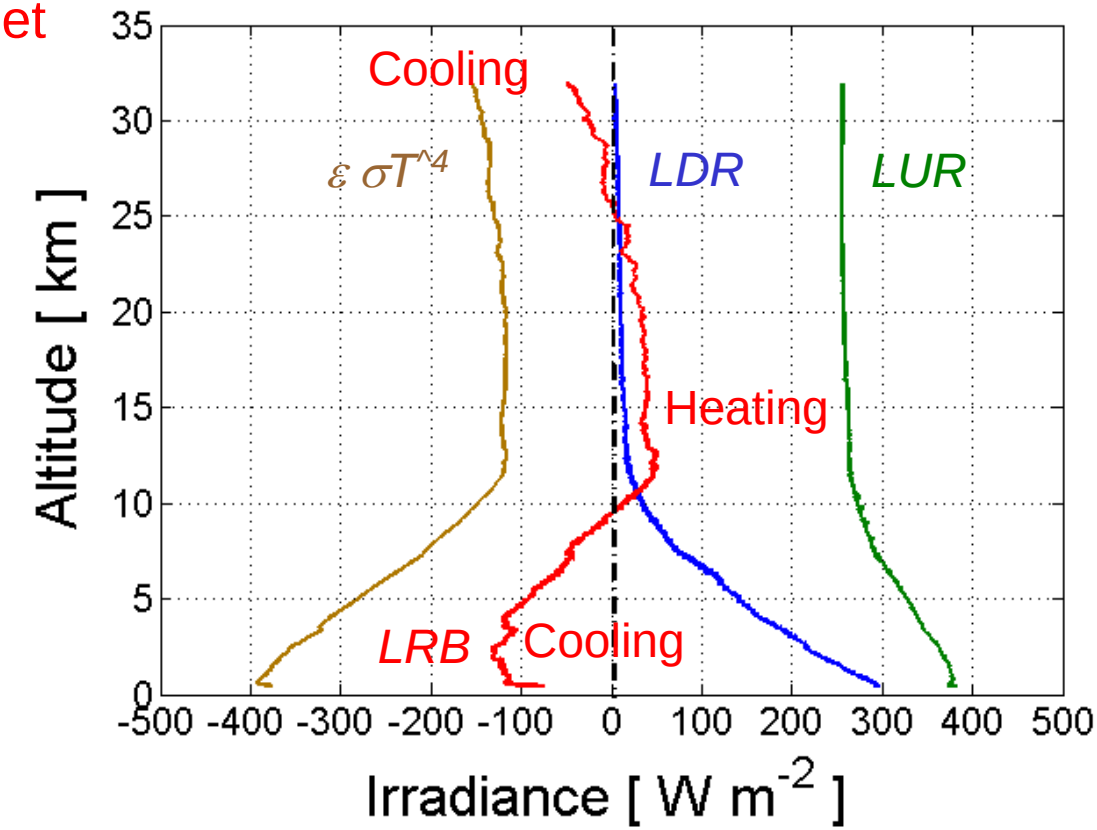
Philipona, Kräuchi, Brocard, GRL, 2012 doi:10.1029/2012GL052087

Longwave Radiation Error during the Night

Night flight: 23 Sep 2011, UT21:20

Longwave Radiation Budget on Temperature Sensor

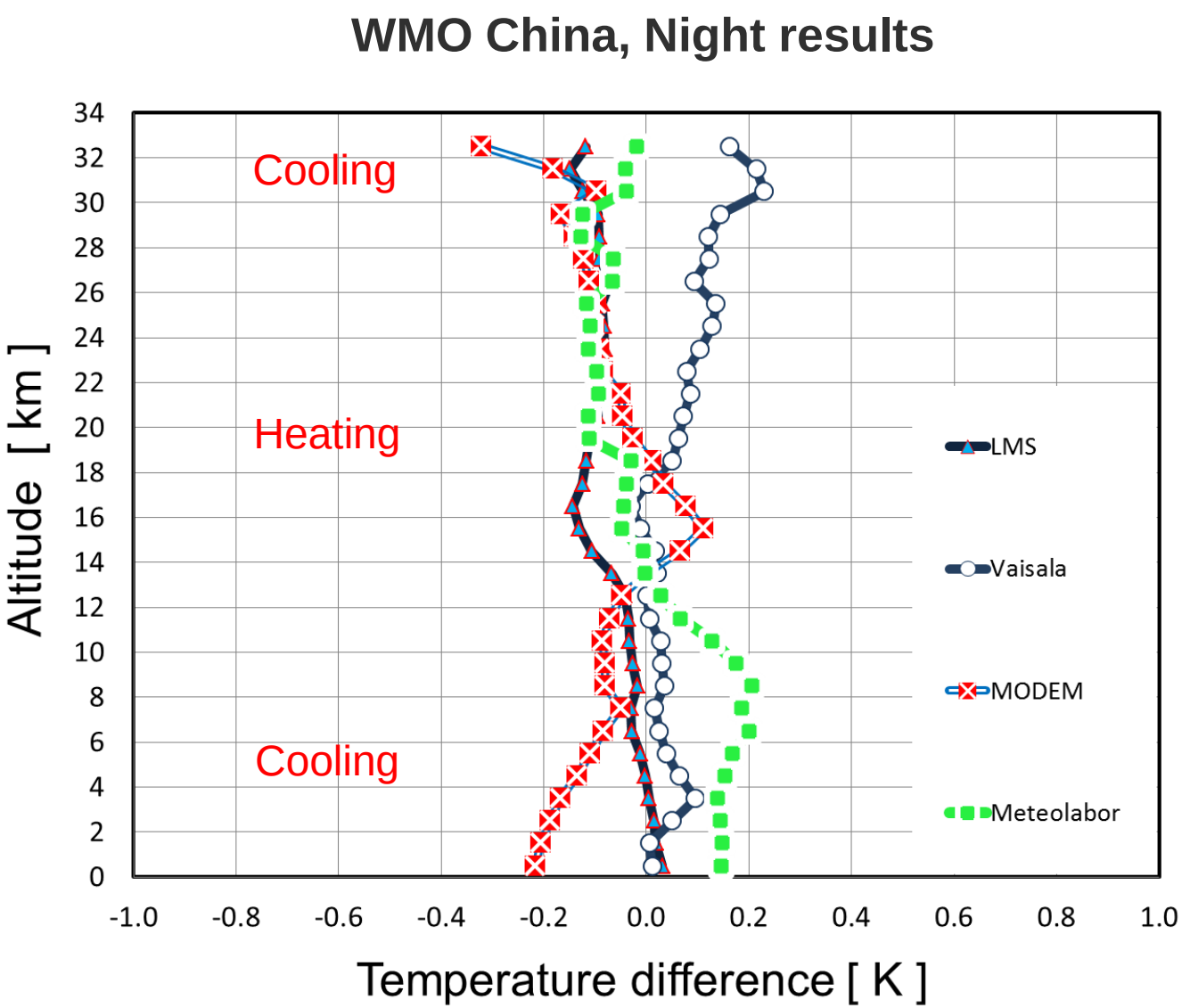




Glenn E. Daniels, JAM, 1968:

- Reduce sensor Size
- Reduce sensor Emissivity
- Increase sensor Speed

Longwave Radiation Error during the Night



Meteolabor

50µ
T sensor

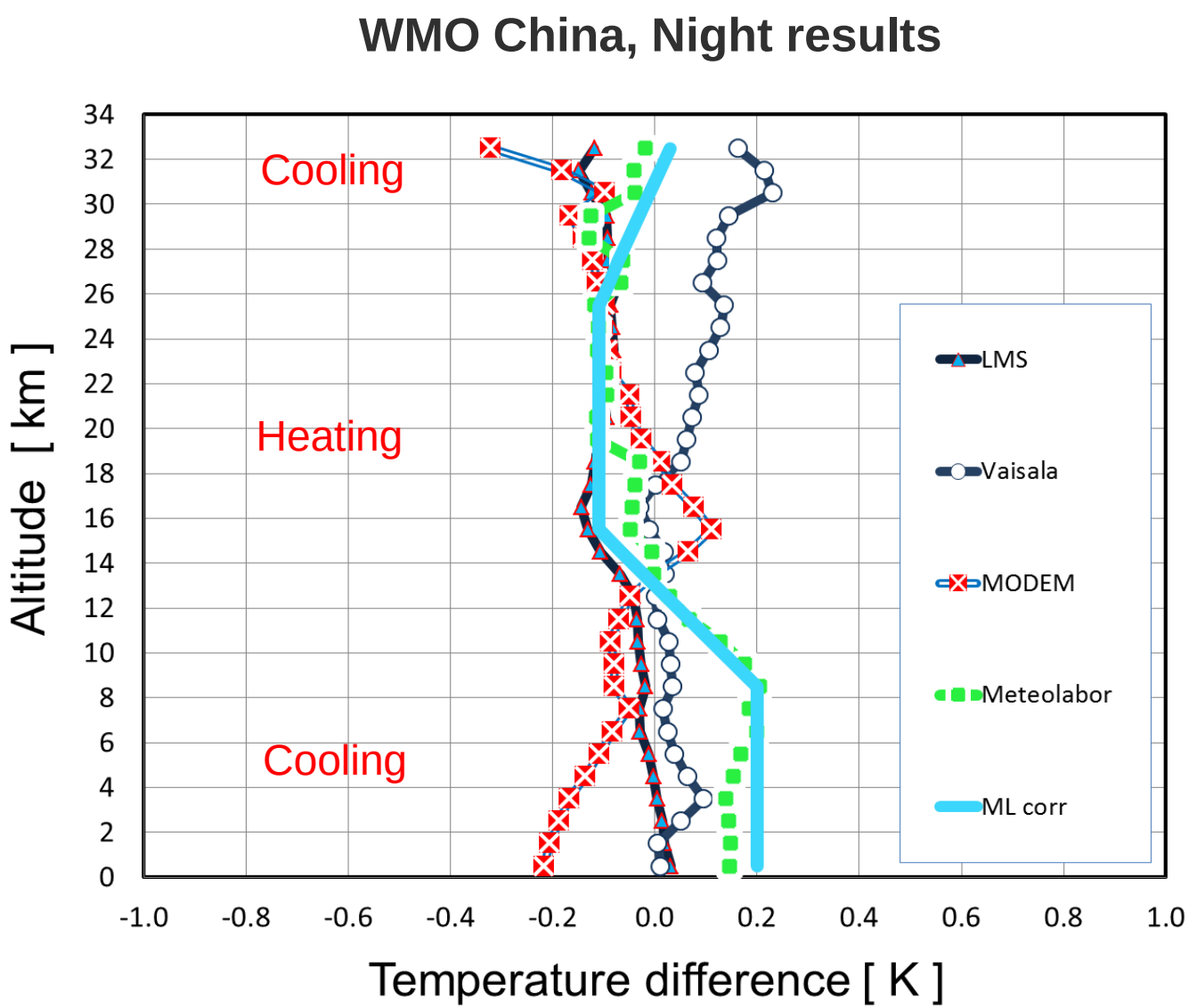
smallest Size

uncertain Emissivity

same Speed

MeteoSwiss

Longwave Radiation Error during the Night



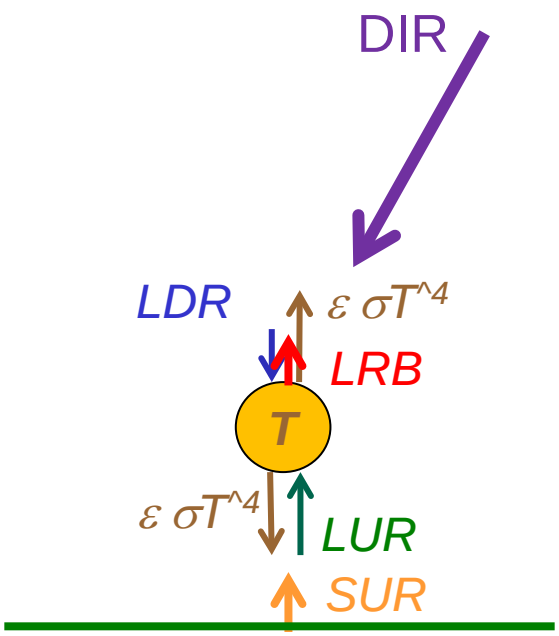
Sensors are too warm

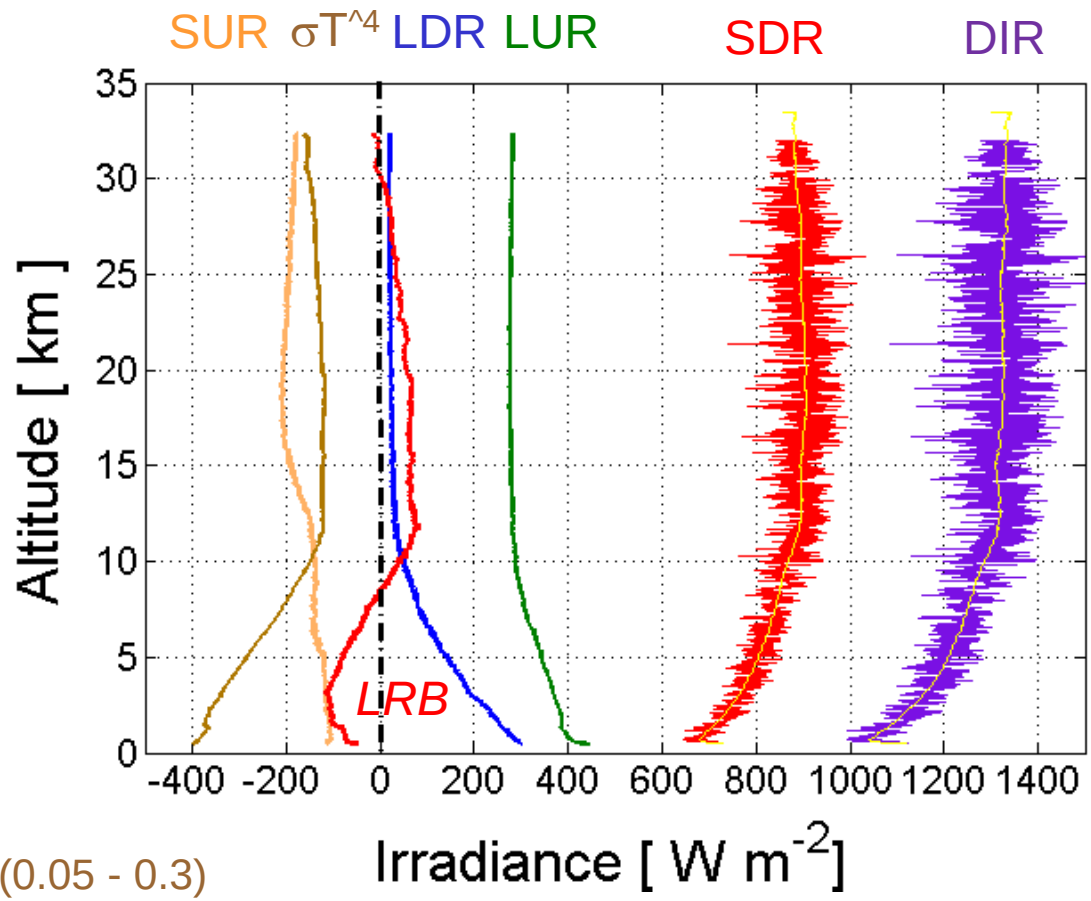
Sensors are too cold

LW and SW Radiation Error during the Day

Day flight: 23 Sep 2011, UT10:13

Longwave Radiation Budget
on Temperature Sensor



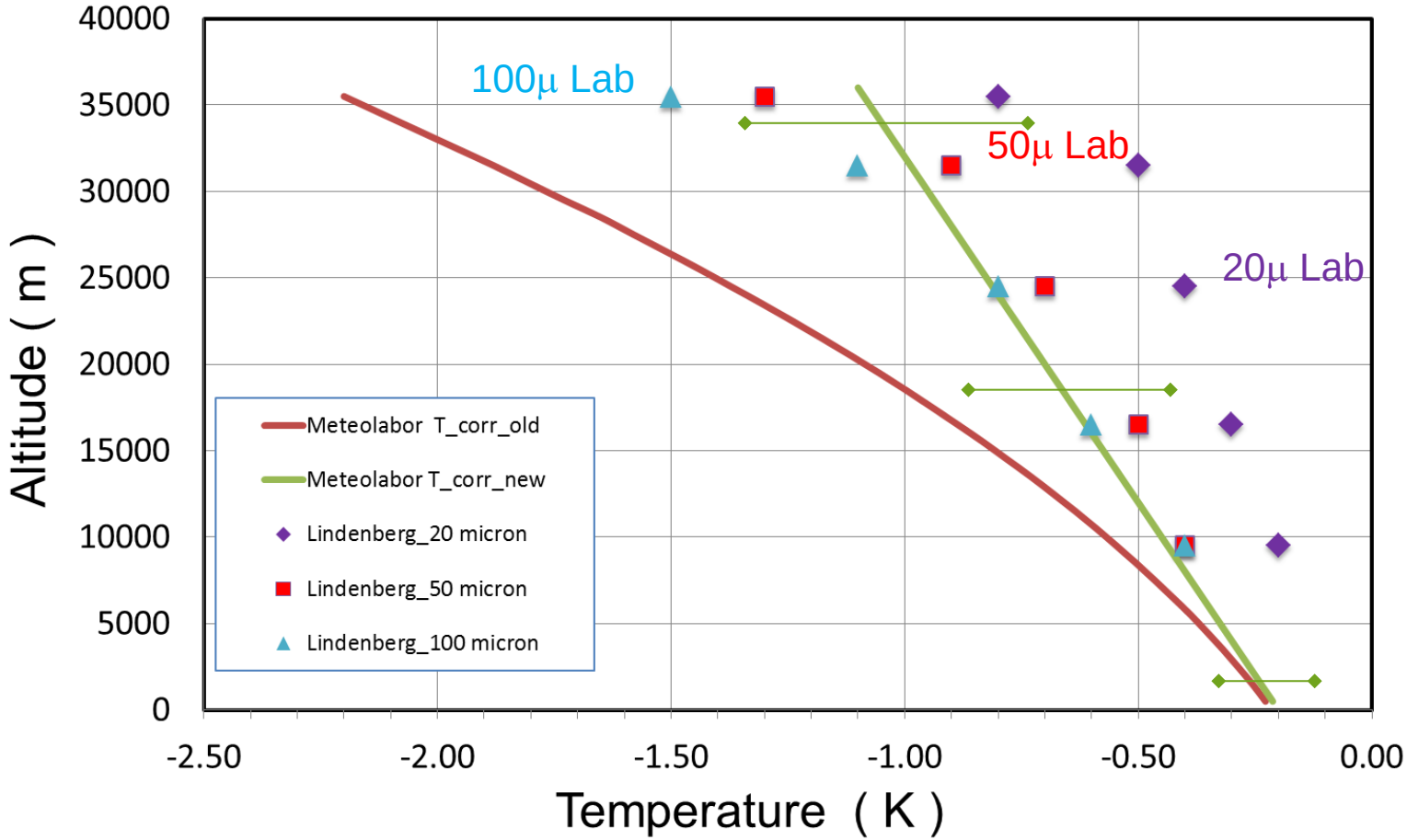


Longwave Emission ε: (0.05 - 0.3)

Shortwave Absorption α: (0.01 - 0.2)

SW Radiation Error: Atmosphere / Laboratory

Old radiation error New radiation error and uncertainty



$$\Delta T_{year} = 0.2 + (0.8 * \frac{Alt_{geo}}{32'000})$$

Uncertainty on radiation error : u = ± [0.1 + (0.2* Alt geo/32’000)]

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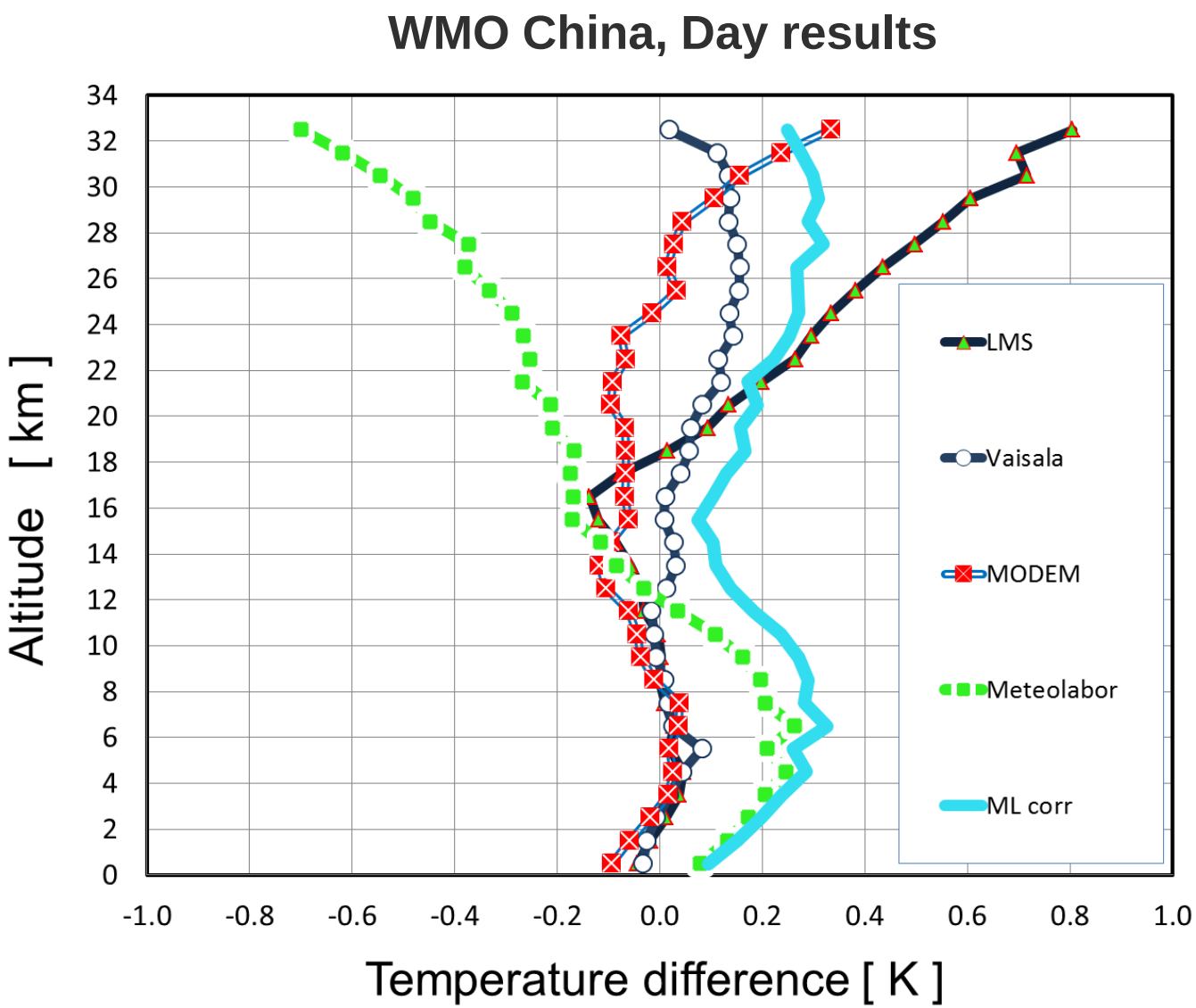
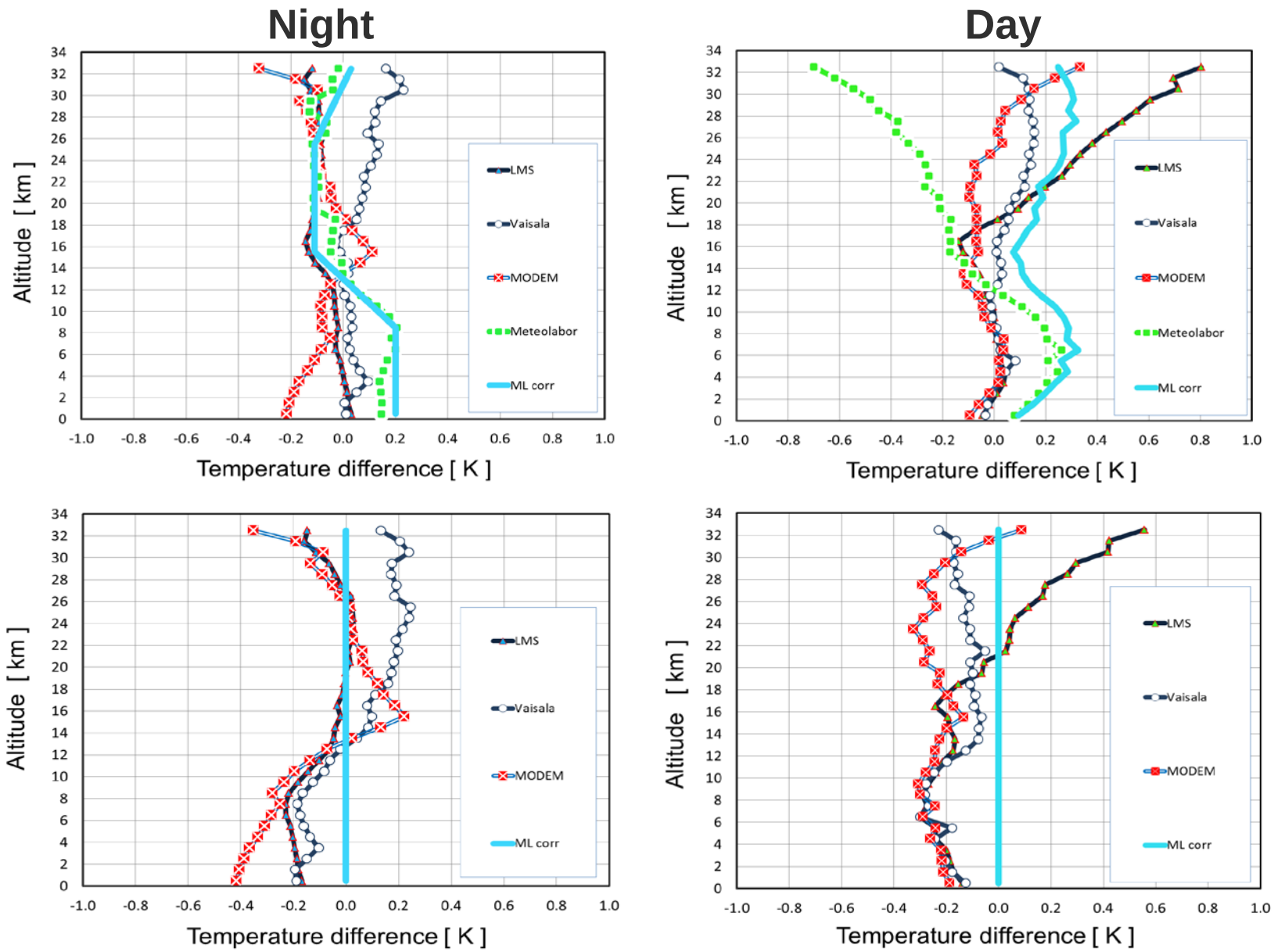
Radiation Error Correction during Day



Radiation Error Night and Day



Philipona et al., JTECH, 2013 doi:10.1175/JTECH-D-13-00047.1

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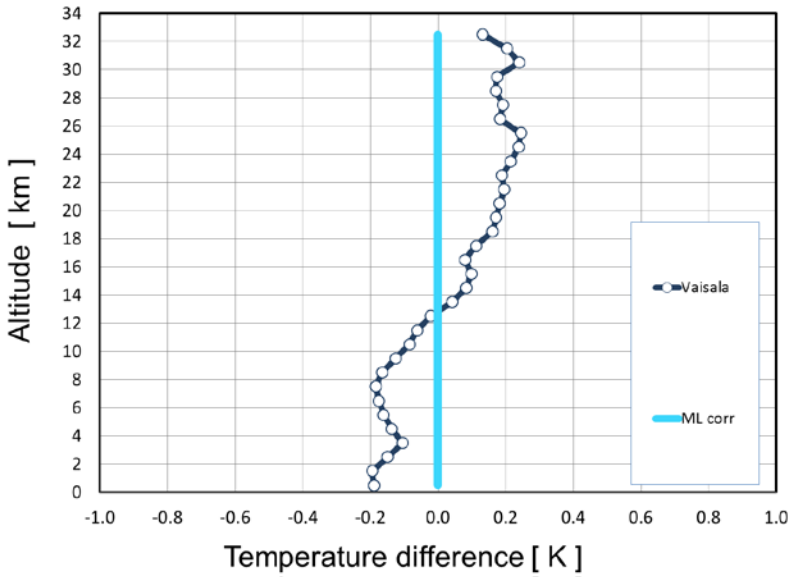
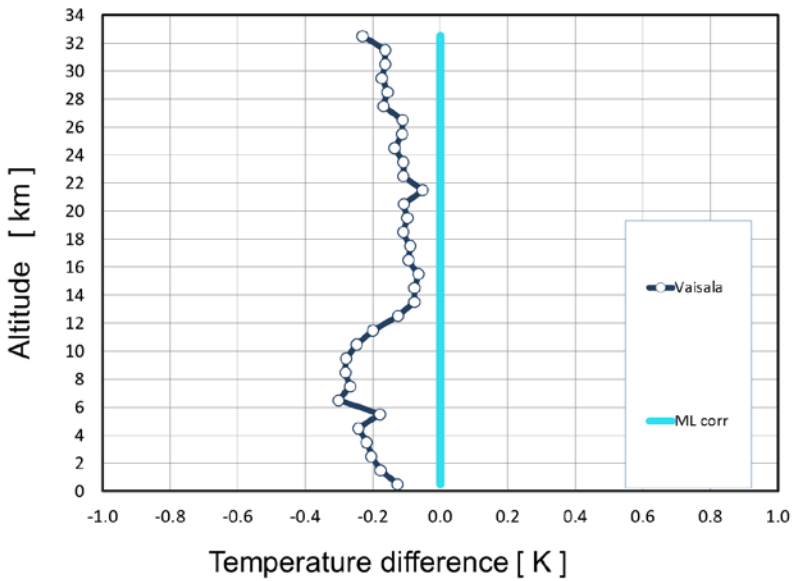
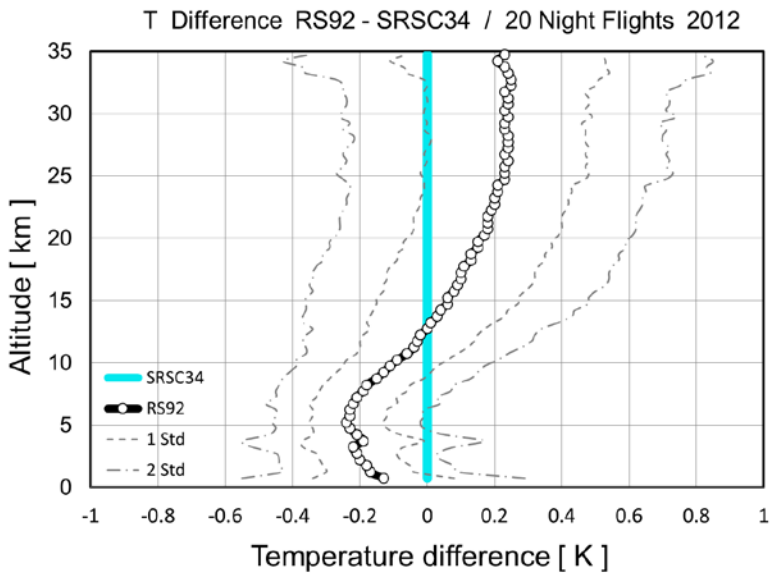
Vaisala versus Meteolabor 2010 and 2012

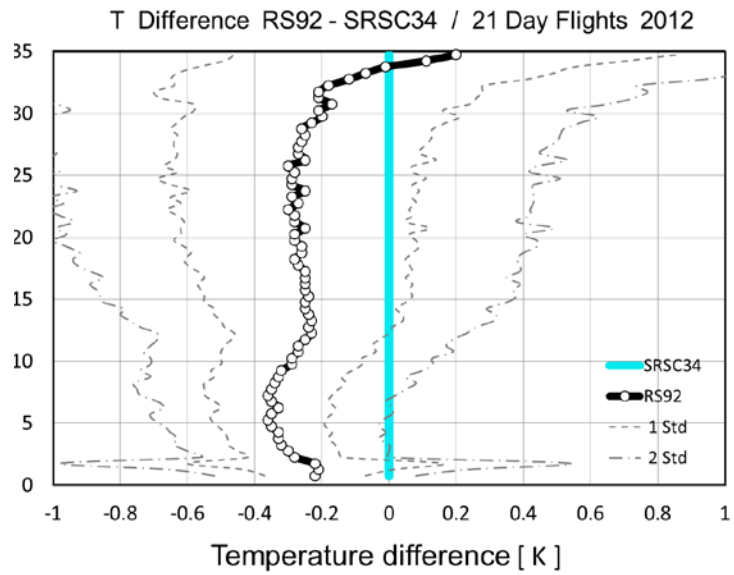
Night



Day



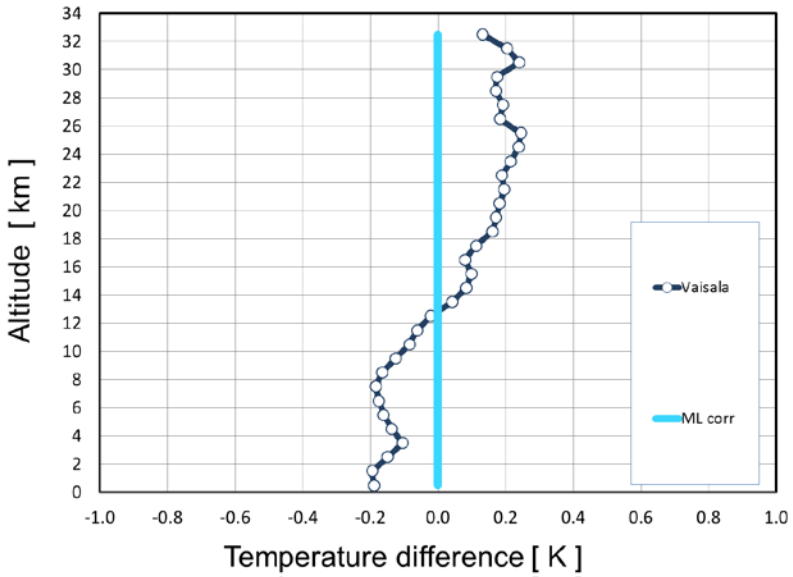




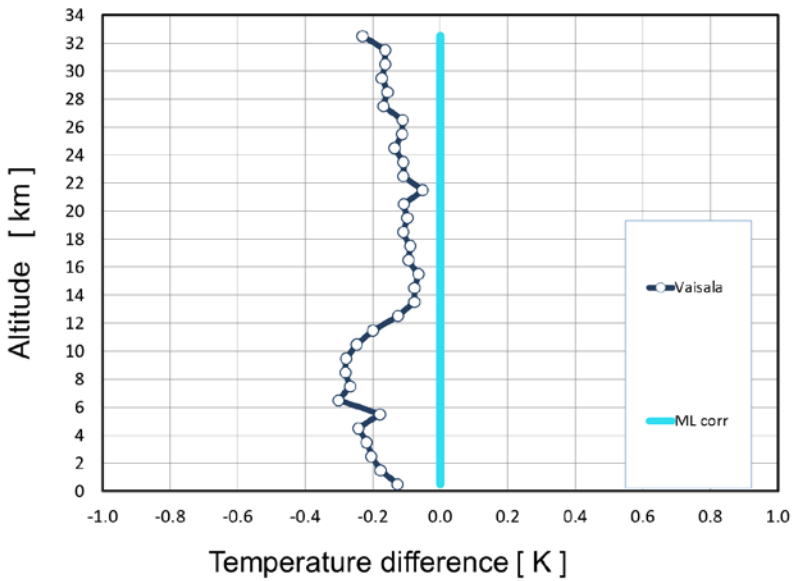
MeteoSwiss

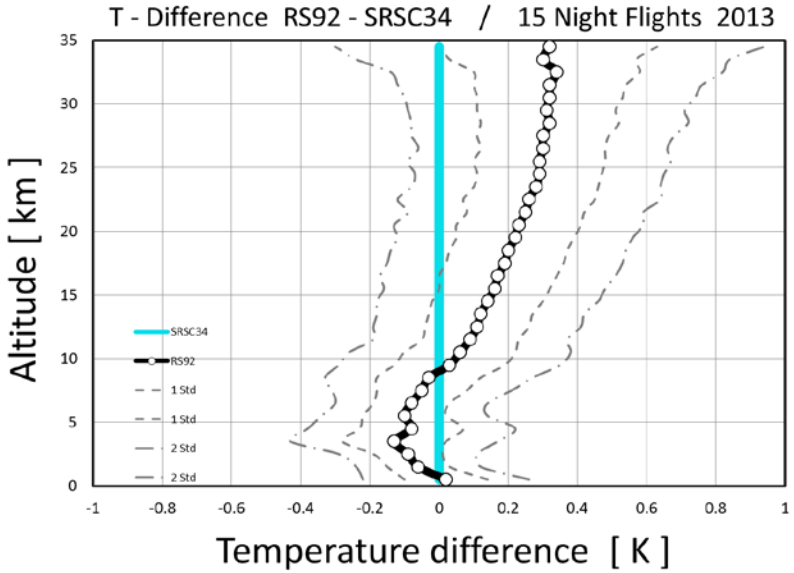
Vaisala versus Meteolabor 2010 and 2013

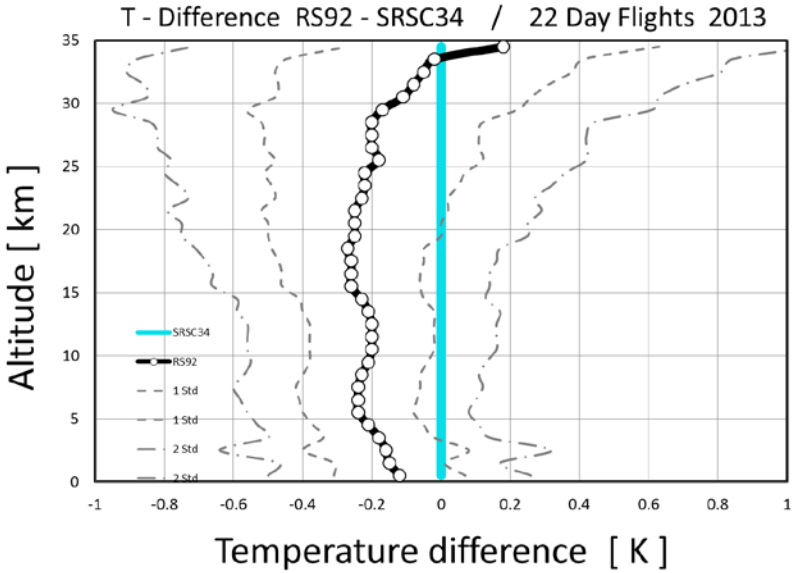
Night



Day



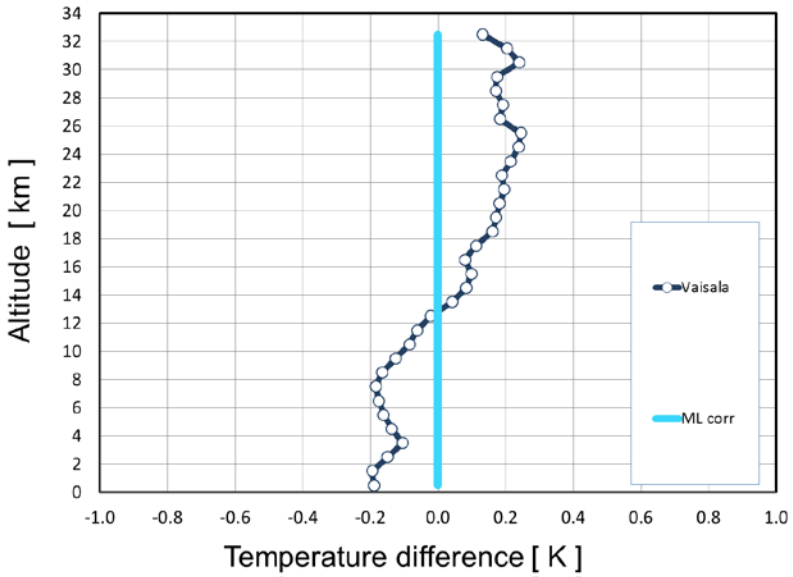




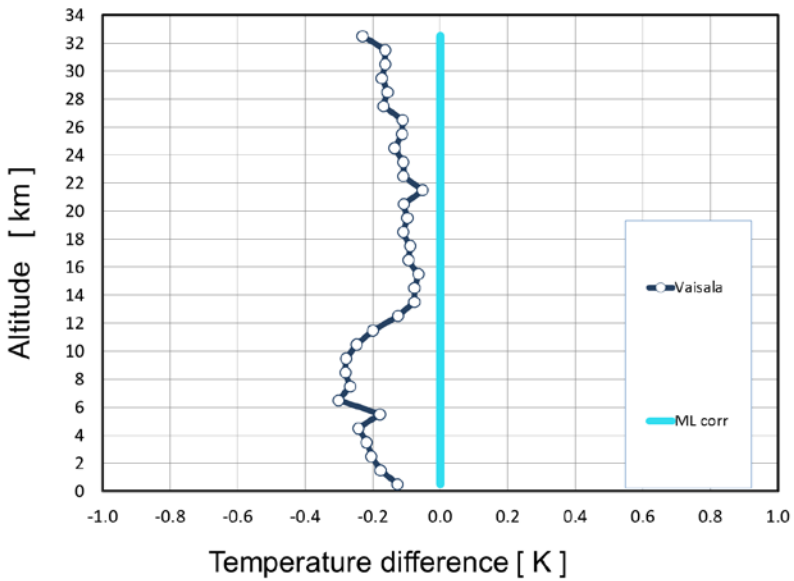
MeteoSwiss

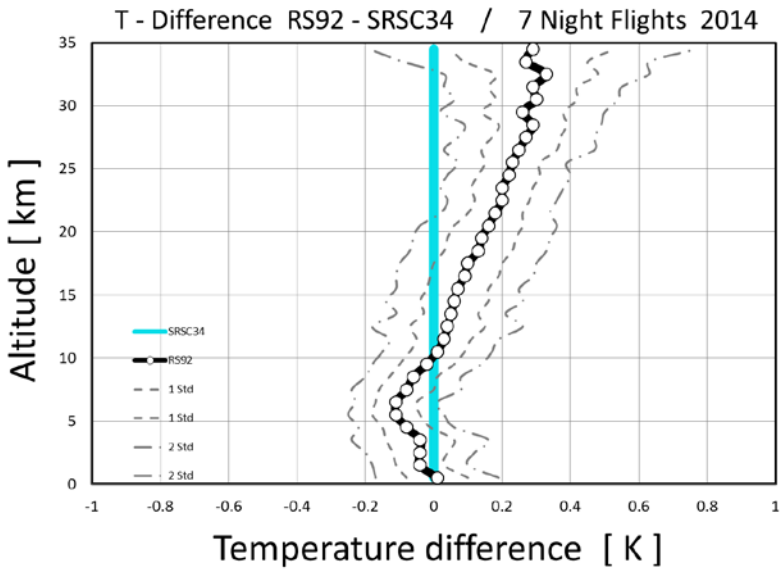
Vaisala versus Meteolabor 2010 and 2014

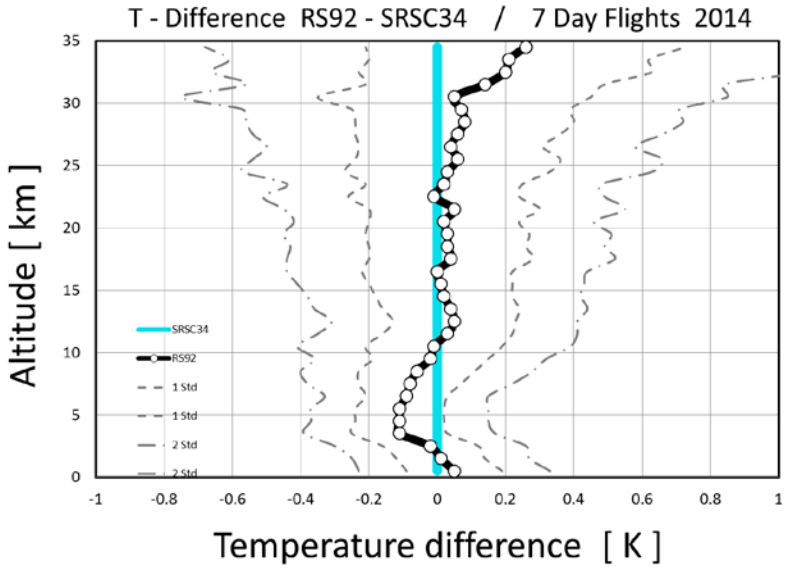
Night



Day



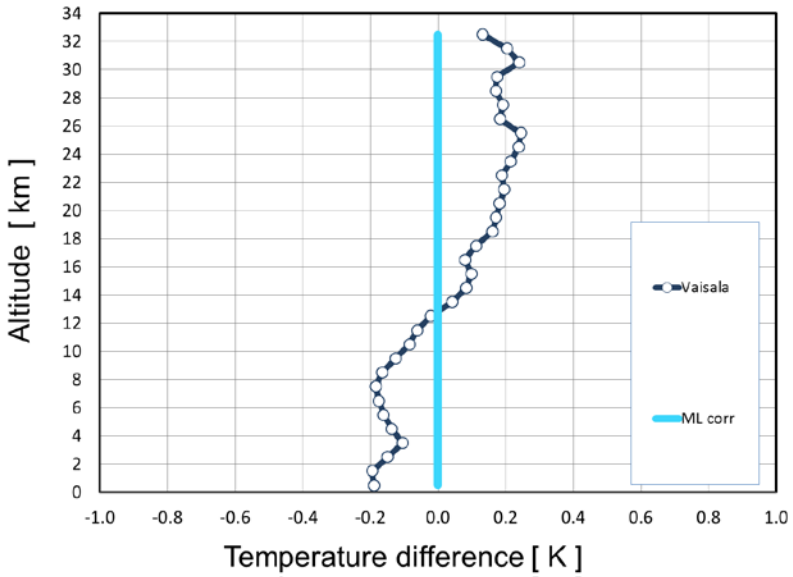




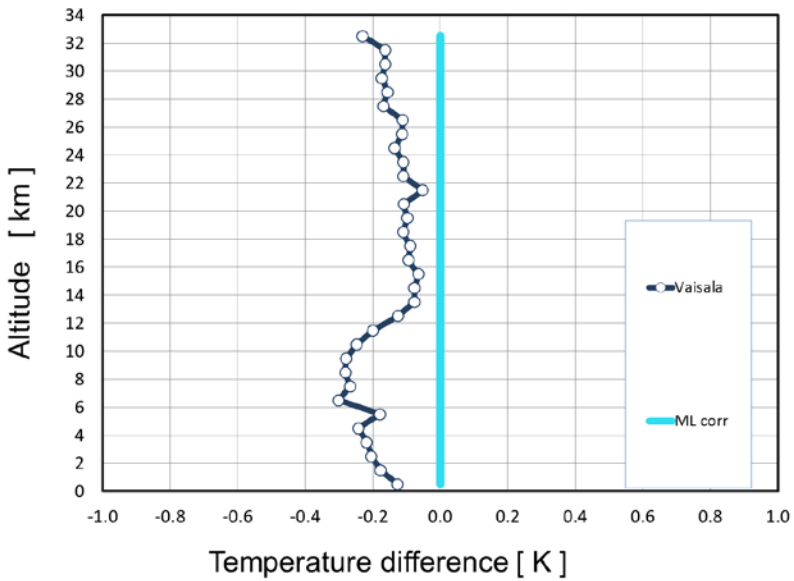
MeteoSwiss

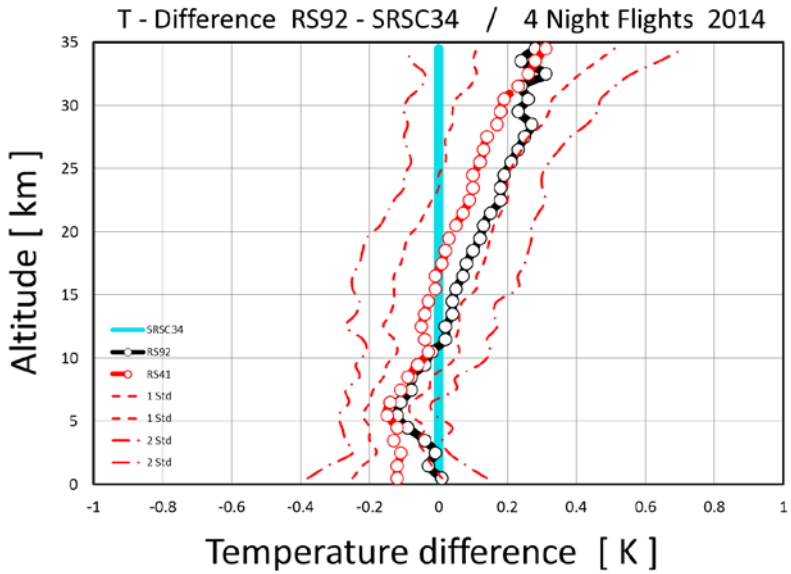
RS92 and RS41 versus Meteolabor 2014

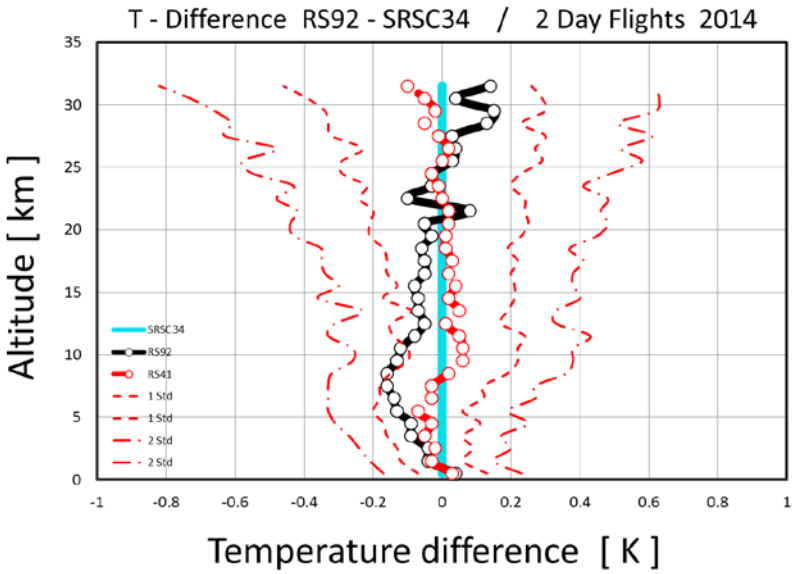
Night



Day







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Results WMO Intercomparison 2010

Table 12.1:
Summary of operational performance of QRS as measured in Yangjiang

	InterMet	Modem	Graw	Meteo-labor	Daqiao	Jinyang	Meisei	Changfeng	Huayun	LMS	Vaisala	Snow-white	Multi-thermistor
2 years operations	Yes	Yes	No	No	Yes	No	No	No	No	Yes	Yes	Yes	Yes
Used in:-	global	global		Switz.	China	Korea				global	global	global	USA
Temperature, Night, height.<16 km	4.5	5	4.5	5	4.25	4.75	5	4.75	5	5	5	See Meteolabor	5
Temperature, Night, height > 16 km	3.25	5	4.5	5	3.25	3.75	5	4.75	5	5	5	See Meteolabor	5
Temperature, day, height <16 km	4.75	5	4.5	5	4.5	4.5	4	5	5	5	5	See Meteolabor	5
Temperature, day, Height >16 km	3.25	5	4.25	4.75	3.75	3.5	4.25	4.5	2.75	5	5	See Meteolabor	4.25
Protection for Evap. cooling errors	No	No	No	No	No	No	No	No	No	No	Yes	See Meteolabor	No
Humidity T>-40 deg C, night	4.5	3[1]	5	4.25	2.75	3.75	4.75	5	4	5	5	5	See LMS
Humidity T>-40 deg C, day	4.25	4.25[1]	4.75	3.25	4	4.75	5	4.25	3.75	5	5	5	See LMS
Humidity, Upper trop. T<-40 deg C, night	4.5	4.25	4.5	xx	xx	4	4	3.5	3.25	4.75	5	5	See LMS
Humidity, Upper trop. T<-40 deg C, day	2.5	3	4.25	xx	xx	4.25	3	3	2.75	4.5	4.5	xx	See LMS
Height P higher than 100 hPa	5	5	5[2]	5	4.75	4.25[5]	4[6]	5	5	5	5[7]	See Meteolabor	See LMS
Height P lower than 100 hPa	5	5	5[2]	5	3.25	5	5[6]	5	5	5	5	See Meteolabor	See LMS
Pressure Higher than100hPa	4	5	4.5[2]	4[3]	4.75	3.5[5]	4.5[6]	5	5	5	5[7]	See Meteolabor	See LMS
Pressure Lower than 100hPa	4.75	4.75	4.5[2]	4.75[3]	3.25	4.25	4.25[6]	5	4.75	5	5	See Meteolabor	See LMS
Wind, troposphere	5	5	5	3[4]	5	5	5	5	5	5	5	See Meteolabor	See LMS
Wind ,stratosphere	5	5	5	5	4.5	5	5	5	5	5	5	See Meteolabor	See LMS

Mark	Status
3	Just meets the operational requirements of the CIMO Guide
4	Better than operational requirements of CIMO Guide, but still needs some improvement to become ideal for GRUAN
5	As good as can be expected for GRUAN at the moment

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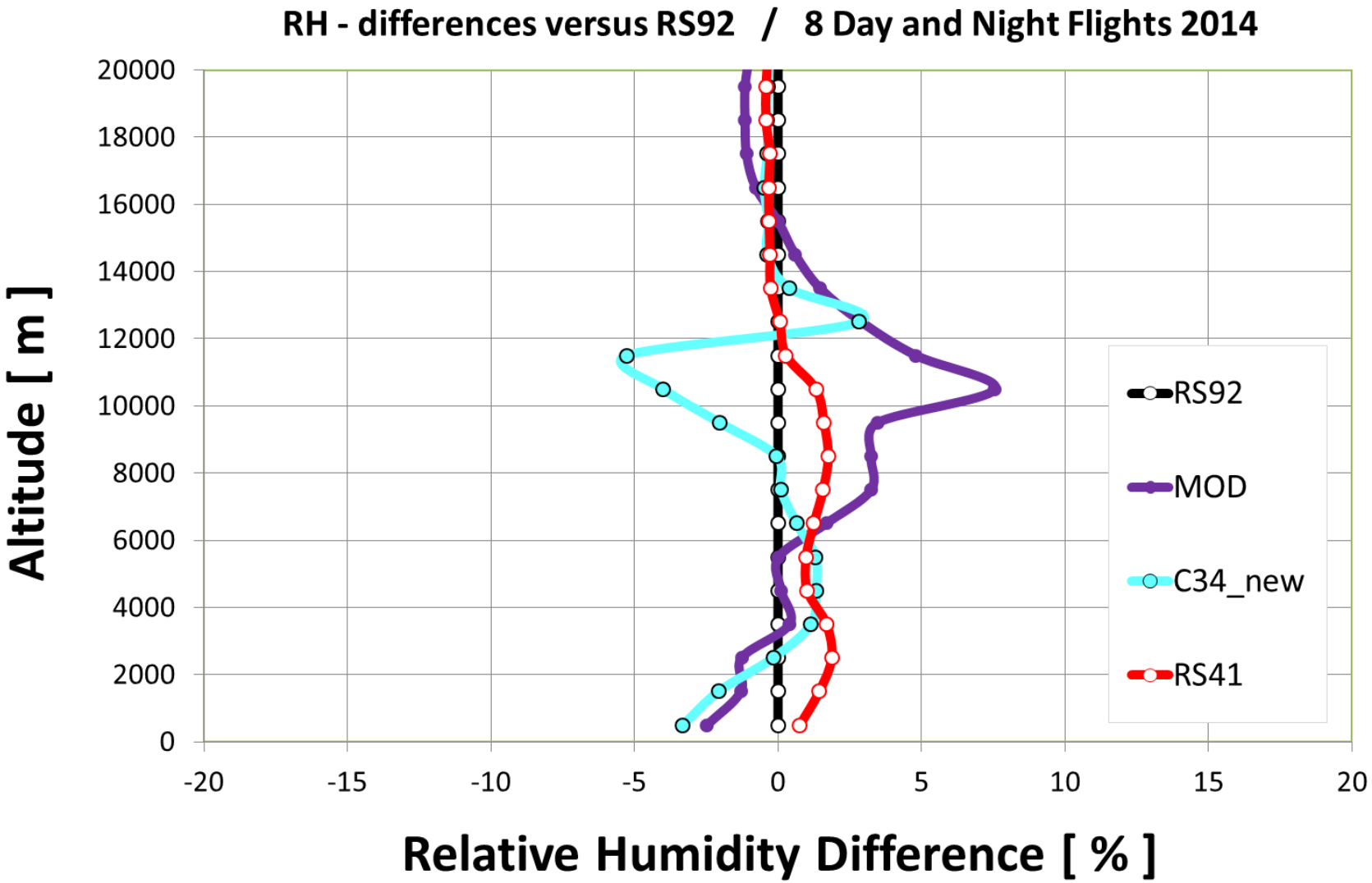
Differences versus RS92 on relative Humidity



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Double-Sounding to evaluate Reproducibility

CIMO-Testbed
Intercomparisons:

Fall 2013
Spring 2014

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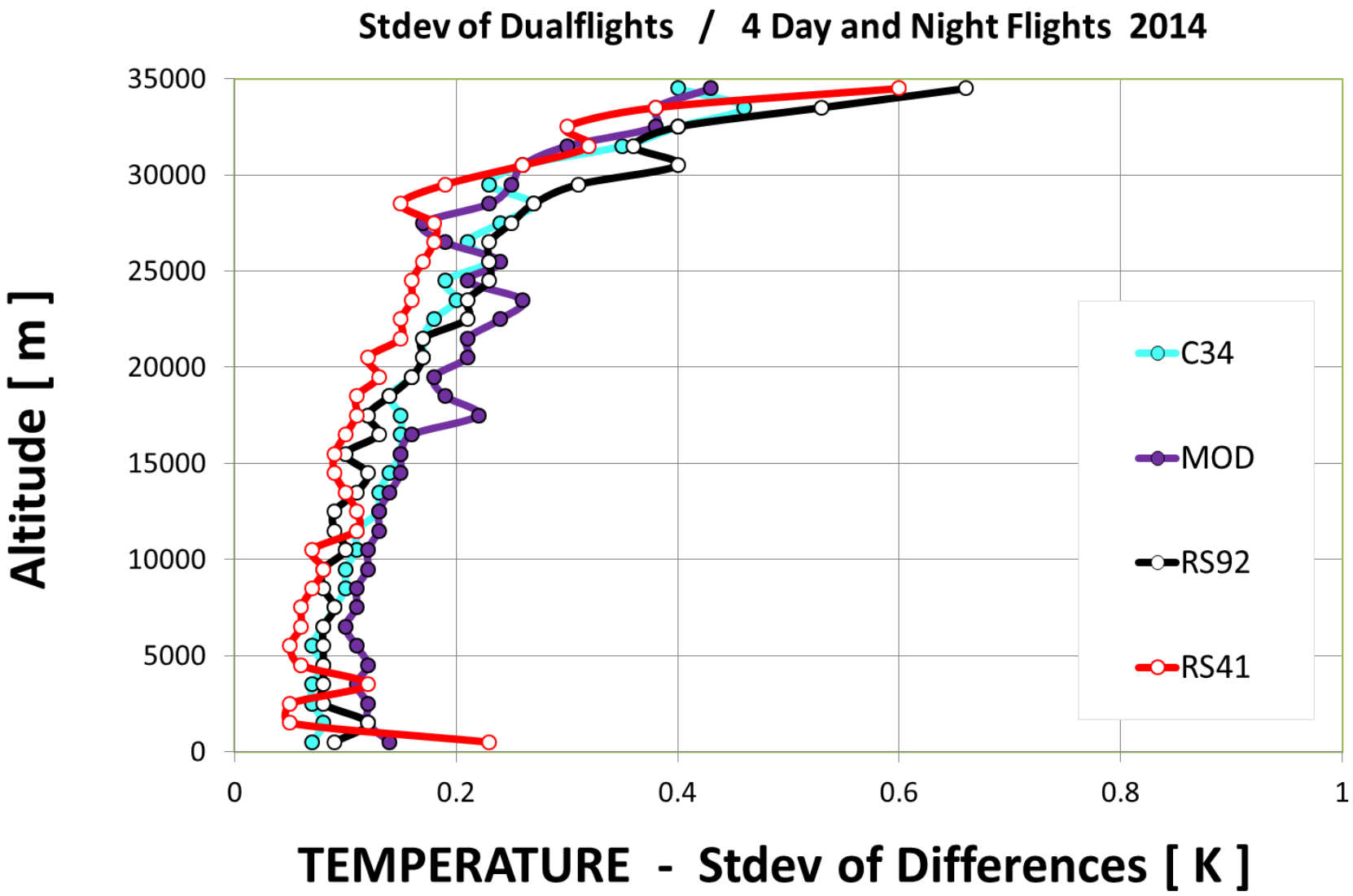
Uncertainty on Reproducibility in Temperature



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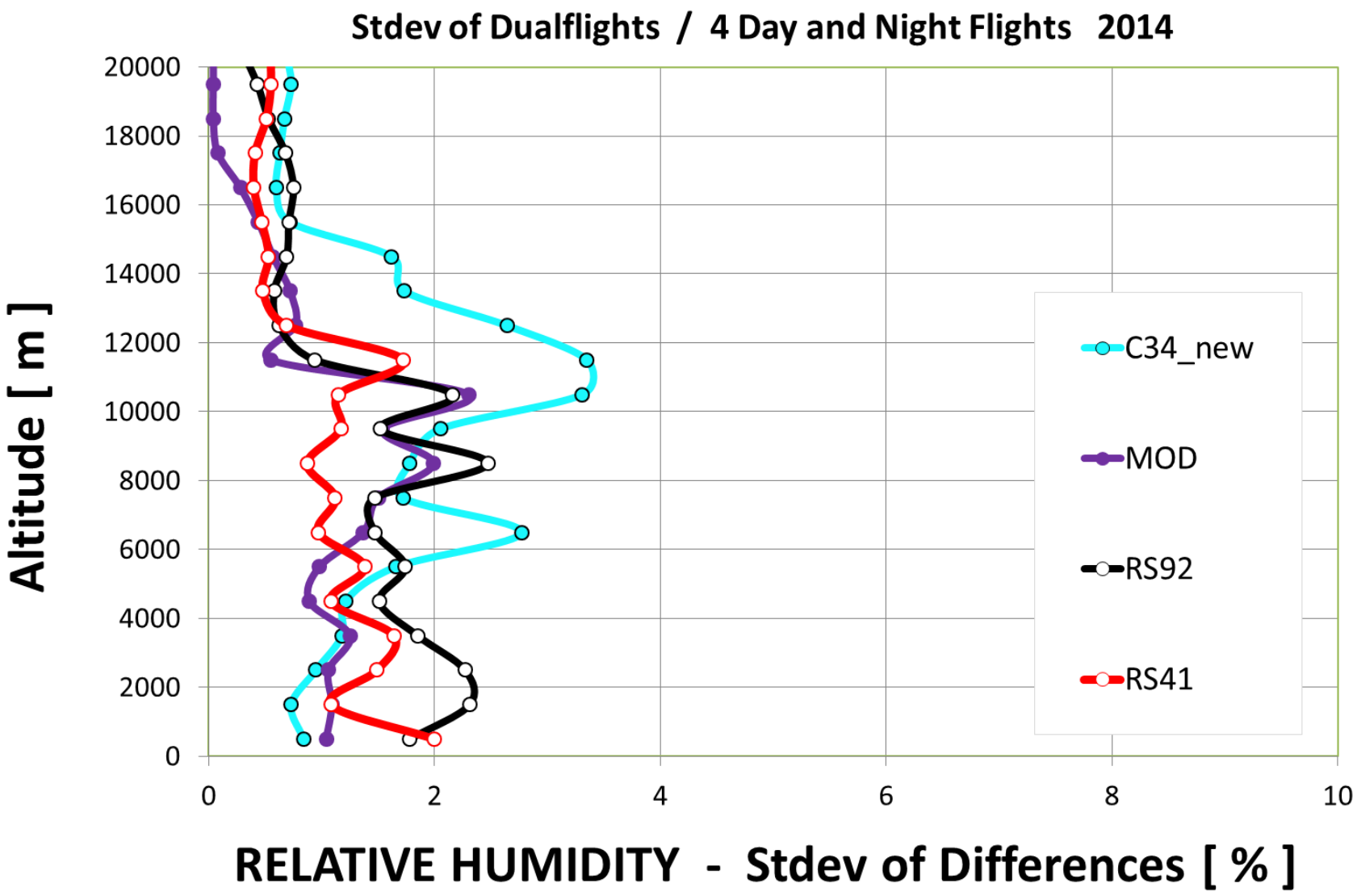
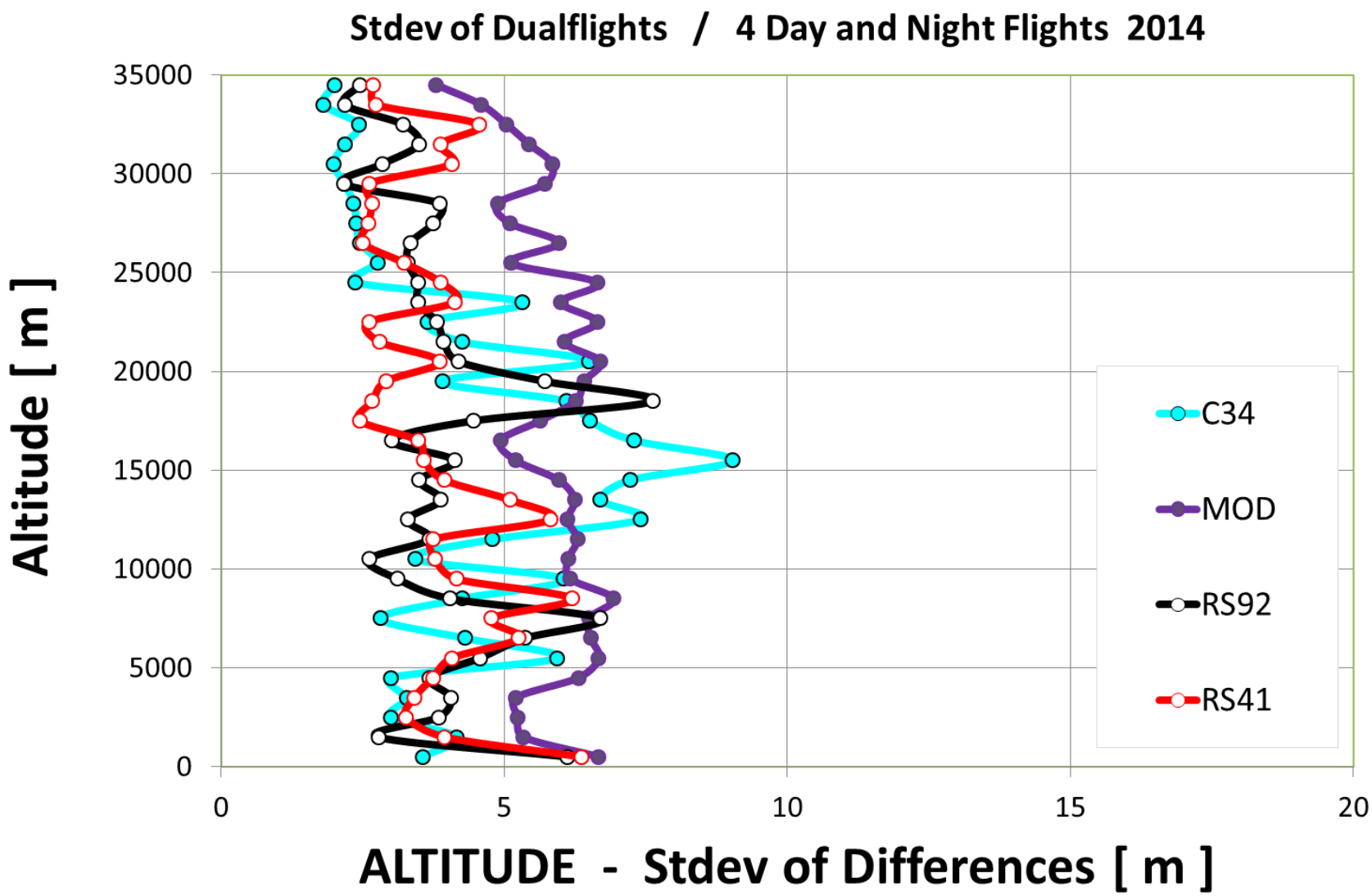
Uncertainty on Reproducibility in Relative Humidity

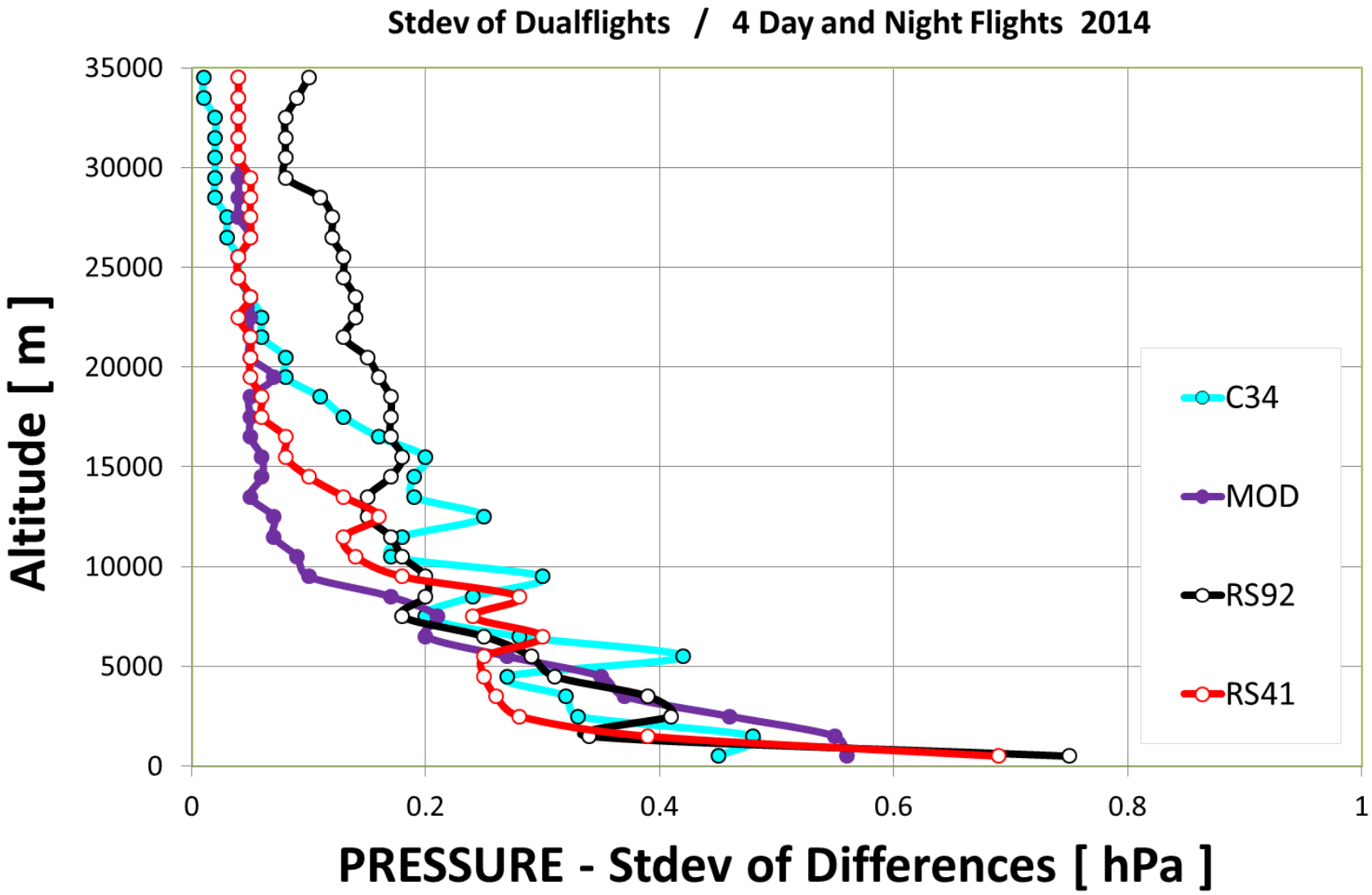


MeteoSwiss

Uncertainty on Reproducibility in Altitude

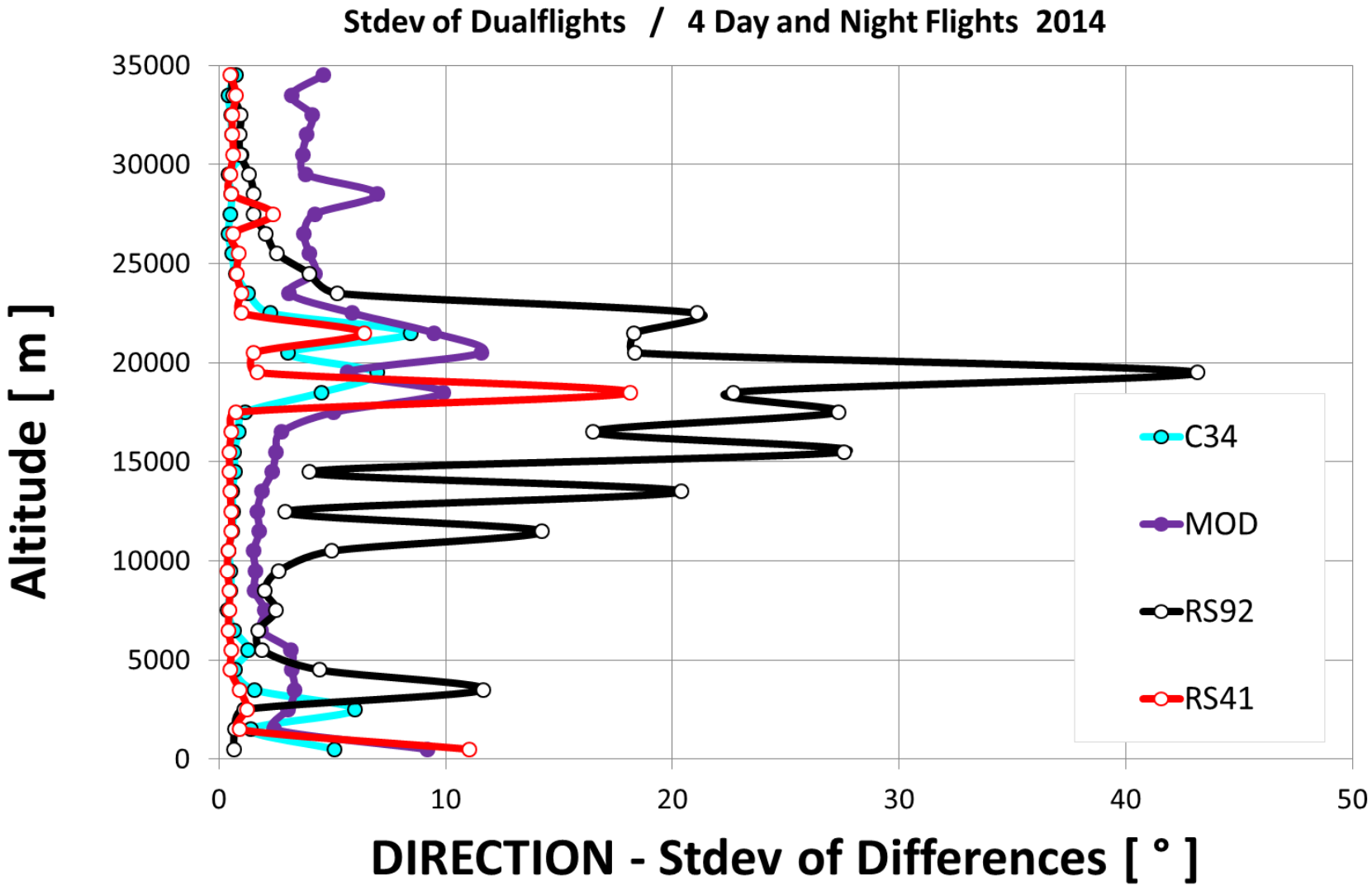


Uncertainty on Reproducibility in Pressure

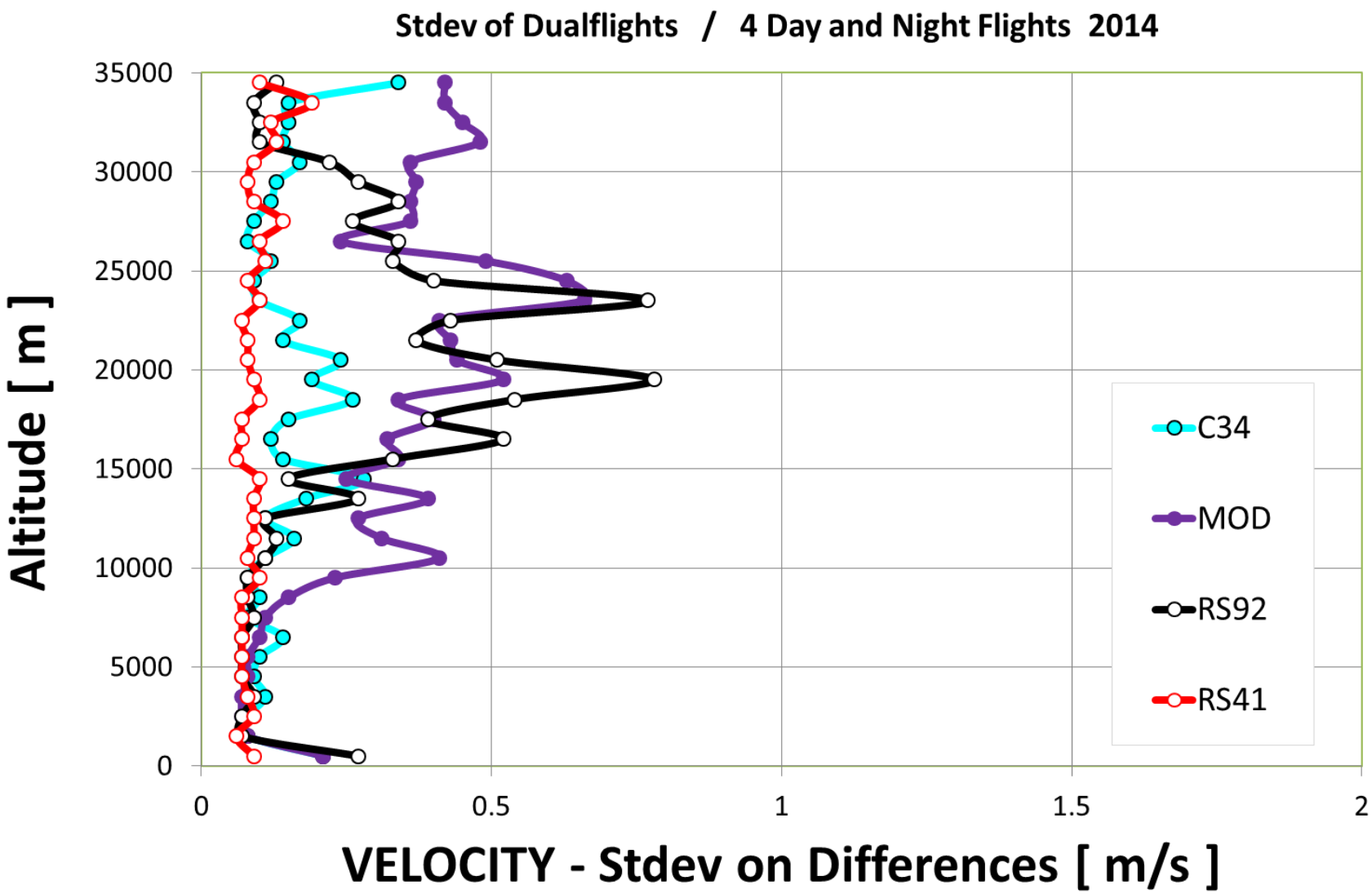


MeteoSwiss

Uncertainty on Reproducibility in Direction



Uncertainty on Reproducibility in Velocity



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Summary of Stdev on Reproducibility

	Troposphere	Stratosphere	
Altitude	7	5	[m]
Pressure	0.6	0.2	[hPa]
Temperature	0.2	0.5	[°C]
Rel. Humidity	3	3	[%]
Wind Dir.	5	5	[°]
Wind Vel.	0.5	0.5	[m/s]

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Summary Radiosonde Intercomparisons

- The radiation error on temperature was determined by simultaneous measurements of shaded and unshaded temperature sensors
- Laboratory experiments in a vacuum chamber and artificil light confirm the radiation error as measured in the atmosphere
- Radiation profiles measured through the atmosphere explain thermal nightime radiation errors measured on different sensor diameters
- Temperature differences between SRS-C34 and RS92 radiosondes observed during the China intercomparison are confirmed at Payerne
- Double soundings allow reproducibility tests of radiosondes which provide important information on instrument uncertainty

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Payerne GRUAN Data Product and Certification

Steps towards GRUAN certification:

- **Weekly GRUAN multi-soundings with RS92 + RS41 + SRS-C34**
- **GRUAN certification on Vaisala RS92 soundings during 2015**
- **Develop a GRUAN product data file for the SRS Radiosonde in collaboration with Lead Center**
- **New Meteolabor SRS-NEW radiosonde in operation early 2016**
- **GRUAN certification on Meteolabor sonde product end of 2016**

MeteoSwiss

GRUAN Multi-Soundings

Biweekly Daytime **UT 12:00 (Tuesday or Thursday)**

Multi-sounding:

- Meteolabor SRS-C34 (operational) submitted to GRUAN
- Vaisala RS92 (DigiCORA MW31) submitted to GRUAN
- Vaisala RS41

Biweekly Nighttime **UT 00:00 (Tuesday or Wednesday or Thursday)**

Multi-sounding:

- Meteolabor SRS-C34 (operational) submitted to GRUAN
- Vaisala RS92 (DigiCORA MW31) submitted to GRUAN
- Vaisala RS41
- Meteolabor SnowWhite dew/frost point hygrometer

Daily Operational SRS-C34 at UTC 00:00 and 12:00

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Payerne GRUAN Product Data File SRS-C34

PAY_GRUAN_001_20150213.12.csv

Station Name	Payerne
Station Longitude(°)	6.94368
Station Latitude(°)	46.813018
Station Altitude(m)	491
Sonde Start Date/Time	2015-02-13T11:00:19Z
Sonde Type	SRS_C34
Sonde Number	4231
Sonde Identifier	56
Sonde Transmission Freq (MHz)	403.5
Software Version	X-ASMS Brass V1.7.2
Software Config	SRS-C34-56, 14.08.2013
Software Product Version	1
Surface Pressure (hPa)	962
Surface Temperature (°C)	0.3
Surface Humidity (%)	90.9
Surface Dewpoint (°C)	-1
Surface Wind Vel (m/s)	0.9
Surface Wind Dir (°)	322
Surface Ozone (nbar)	11
Surface Cloud Observation	20936
Ground Check T Ref (°C)	24.44
Ground Check T Sonde (°C)	24.06
Ground Check RH Ref (%)	24.91
Ground Check RH Sonde (%)	23.93
SW Ice on Mirror (°C)	-99.99
ECC Serial Number	7808
ECC Background Current ib1 (uA)	0.01
ECC Background Current ib2 (uA)	0.03
ECC Pump Performance (s/100ml)	26.9
IWV (mm)	10.657
Isotherm Zero Degree (m)	1793
Tropopause Height (m)	10702.23
Tropopause Temperature (°C)	-61.71
Tropopause Pressure (hPa)	231.01
Remark	
Modified Date/Time	2015-02-16T19:31:58Z
Sounding Data	

Header with basic information

Location + Time

Radiosonde + Software

Weather Conditions

Ground Check

Ozone Sensor

Tropopause Information

Final calculated values **Uncertainties** **Raw data**

Rel_Time	ALT_geop (m)	P (hPa)	T (°C)	RH (%)	W_Dir (°)	W_Vel (m	O3 (nbar)	RH_SW (%	U_ALT_ge	U_P (hPa)	U_T (°C)	U_RH (%)	U_W_Dir (	U_W_Vel	U_O3 (nba	U_RH_SW	DP (°C)	DP_SW (°(	Level_flag	LAT (°)	LON (°)	ALT_gps (i	CR (m/s)
0	491.02	962	0.3	90.9	322	0.9	11		5.156	0.53	0.415	5.376	6.705	0.216	2.655		-1		1	46.81343	6.943978	497	2.51
1	500.22	961	-0.72	100	9.99	0.67	3.53		4.121	0.408	0.269	4.603	6.219	0.204	1.308		-0.71		0	46.81342	6.943978	500.2	3.06
2	503.82	960.57	-0.75	100	355.69	0.68	3.44		4.01	0.397	0.205	4.315	3.031	0.2	0.087		-0.75		0	46.81341	6.943977	503.8	3.6
3	509.02	959.94	-0.79	100	338.26	0.76	3.27		4	0.395	0.205	4.318	3.012	0.201	0.122		-0.79		0	46.8134	6.943972	509	4.1
4	514.42	959.29	-0.82	100	323.5	0.93	3.61		4	0.395	0.205	4.322	3.003	0.2	0.09		-0.82		0	46.81339	6.943965	514.4	4.5
5	519.92	958.63	-0.87	99.63	313.84	1.17	3.96		4	0.395	0.205	4.477	3	0.2	0.21		-0.92		6	46.81338	6.94396	519.9	4.72
6	525.52	957.96	-0.92	92.71	307.92	1.43	3.26		4	0.395	0.205	4.328	3	0.2	0.082		-1.98		0	46.81337	6.943958	525.5	4.78
7	530.82	957.33	-0.97	85.78	304	1.69	2.57		4	0.395	0.205	4.379	3.001	0.2	0.387		-3.04		0	46.81337	6.943968	530.8	4.92
8	535.92	956.71	-1.03	82.47	300.93	1.93	4.04		4.001	0.395	0.205	4.335	3.002	0.2	0.282		-3.64		0	46.81336	6.94399	535.9	4.85
9	540.42	956.18	-1.09	79.16	298.16	2.14	4.02		4.002	0.395	0.205	4.366	3.004	0.2	0.101		-4.23		0	46.81336	6.944023	540.4	4.76
10	544.22	955.72	-1.14	78.64	295.46	2.29	4.01		4	0.395	0.205	4.357	3.002	0.2	0.146		-4.36		2	46.81336	6.944067	544.2	4.61
11	548.02	955.26	-1.19	80.3	292.77	2.38	4.6		4.006	0.396	0.206	4.343	3.003	0.201	0.115		-4.09		0	46.81335	6.944115	548	4.5
12	553.02	954.67	-1.15	81.96	290.07	2.38	5.2		4.001	0.395	0.205	4.352	3.002	0.201	0.388		-3.83		0	46.81333	6.944162	553	4.43
13	557.52	954.13	-1.12	84.95	287.25	2.28	3.73		4	0.395	0.206	4.348	3	0.2	0.372		-3.38		0	46.81331	6.944203	557.5	4.43
14	562.02	953.59	-1.2	87.95	284.07	2.11	4.3		4.001	0.395	0.205	4.351	3	0.2	0.108		-2.93		0	46.81329	6.944242	562	4.5
15	566.02	953.11	-1.28	90.72	280.01	1.88	4.86		4.001	0.395	0.205	4.357	3	0.2	0.188		-2.6		0	46.81328	6.944277	566	4.68
16	570.52	952.57	-1.37	92.5	274.28	1.63	4.61		4	0.395	0.206	4.357	3	0.2	0.115		-2.39		4	46.81327	6.944308	570.5	4.88
17	575.12	952.02	-1.39	94.28	265.81	1.4	4.35		4.001	0.395	0.205	4.369	3	0.2	0.109		-2.18		0	46.81326	6.944338	575.1	4.92
18	580.21	951.42	-1.4	94.46	253.86	1.23	4.09		4	0.395	0.206	4.363	3	0.201	0.102		-2.18		0	46.81327	6.944362	580.2	4.99
19	585.41	950.8	-1.44	94.65	239.44	1.17	3.82		4.001	0.395	0.205	4.371	3.001	0.201	0.11		-2.18		0	46.81328	6.944373	585.4	5.04
20	591.01	950.13	-1.48	93.65	225.62	1.22	3.86		4	0.394	0.206	4.374	3.005	0.201	0.097		-2.37		2	46.8133	6.944372	591	5.09

MeteoSwiss

Payerne GRUAN Product SRS-C34

- **The GRUAN Product Data File for SRS-C34 was developed with the help of the GRUAN Lead Center (Michael Sommer)**
- **All GRUAN product data values and all uncertainties are calculated by MeteoSwiss**
- **GRUAN Data files and all metadata are submitted with the GRUAN RsLaunchClient to the Lead Center since Sep 2014**
- **Future corrections that need to be made to the Payerne GRUAN product data values will be made by MeteoSwiss**

Swiss Radiosonde Meteolabor SRS-C34

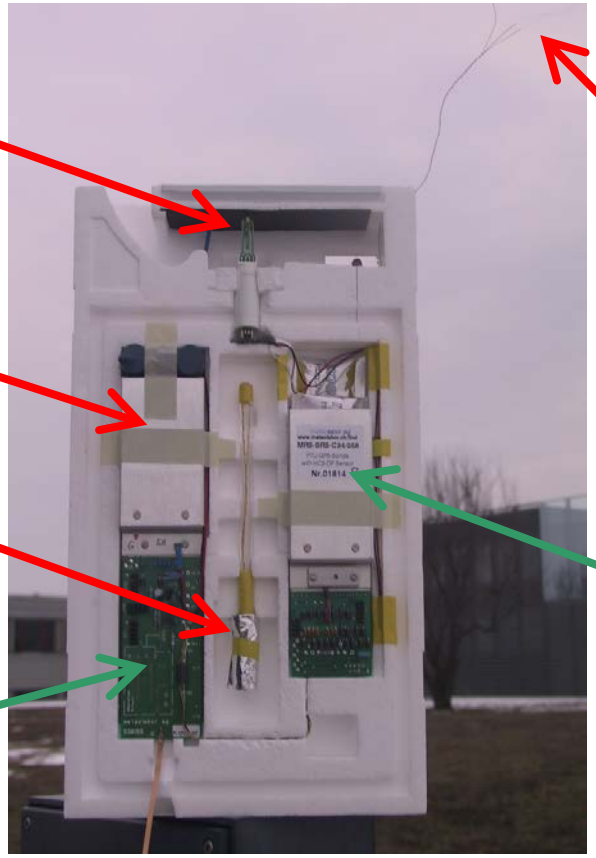
Temperature:	**Thermocouple**
Humidity:	**Rotronic HC2 capacitive**
Altitude/Pressure:	**GPS (Hypsometer)**
Wind Speed/Dir.:	**GPS**

Rotronic HC2 capacitive sensor

GPS

Water Hypsometer

Transmitter 400 Mhz



Thermocouple (Copper - Constantan) (wire ø 0.05 mm)

Electronique Interface

Telemetry

MeteoSwiss

Main goals:

- **The new Meteolabor radiosonde SRS-NEW will be smaller and lighter**
- **SRS-NEW will be compatible with the SRS-C34 ground station**
- **SRS-NEW will use the present Meteolabor software**
- **SRS-NEW will use the same sensors except for the humidity sensor**
- **SRS-NEW will be compatible with ECC-Ozone, SnowWhite, COBALD**

Conclusions Payerne GRUAN Data Product

- Daily operational SRS-C34 soundings at UTC 00:00 and 12:00 are submitted in NRT to the GTS and weekly as GRUAN products
- Weekly multi-soundings with RS92, RS41 and SRS-C34 sondes are made during 2015 and submitted to the Lead Center
- The Payerne GRUAN station will be certified during 2015 on the basis of the weekly Vaisala RS92 soundings
- A new Meteolabor SRS radiosonde will be operational in 2016 and submitted in NRT and weekly as improved GRUAN product
- Change managment between the old and the new Meteolabor sonde will be made during the weekly multi-soundings
- In 2016 Payerne should become GRUAN certified for their new Meteolabor GRUAN sonde data product.

Thank you for your attention !

MeteoSwiss