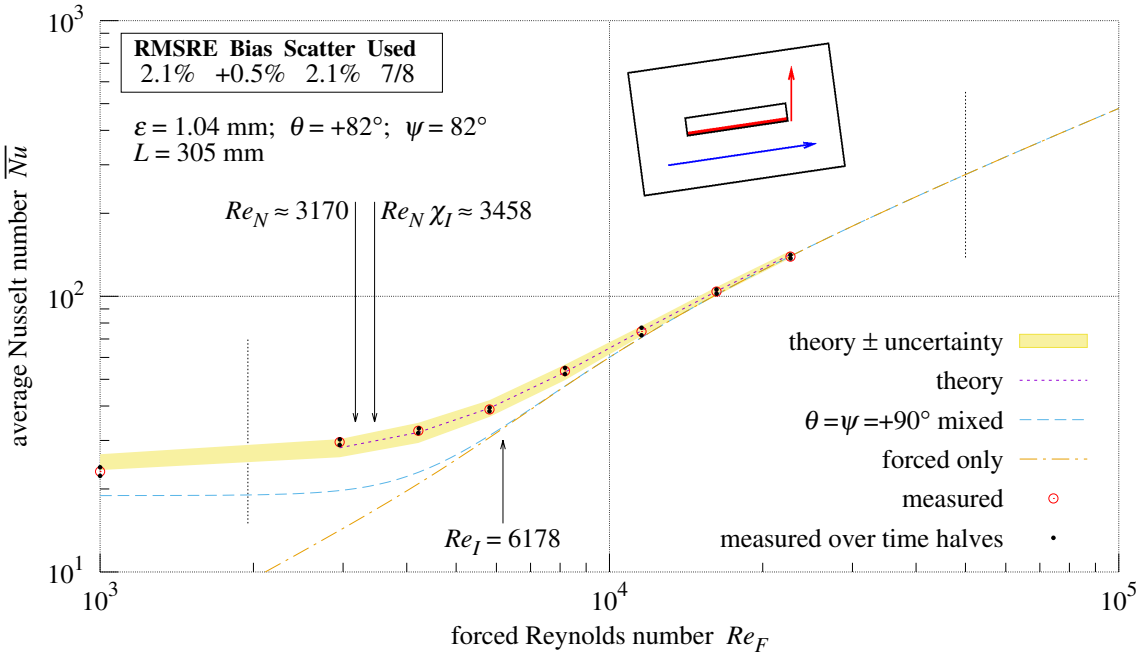
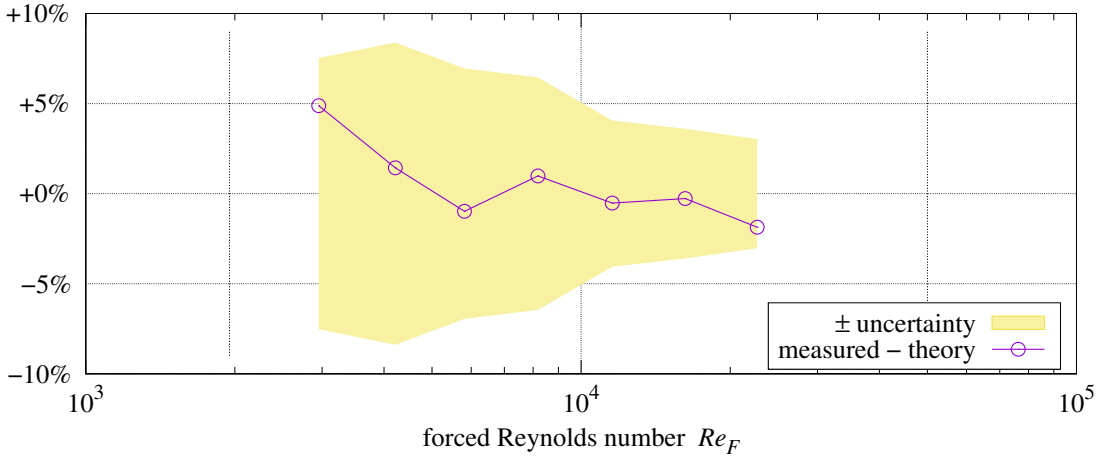
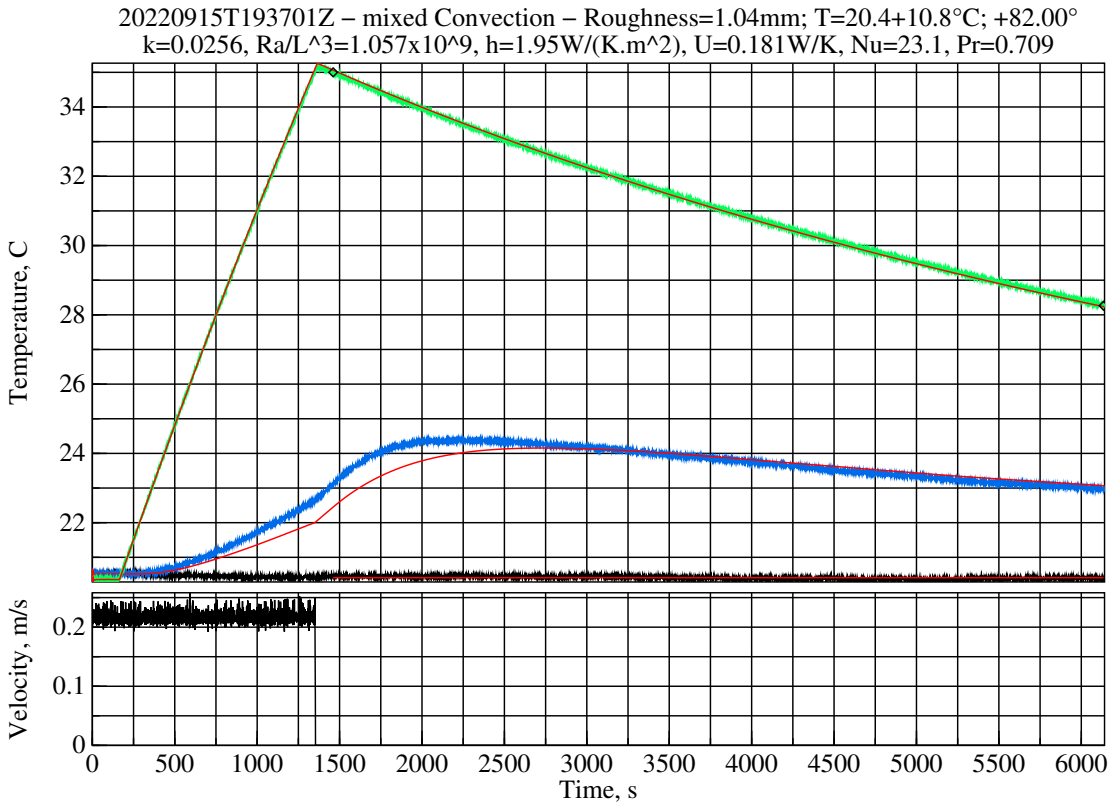


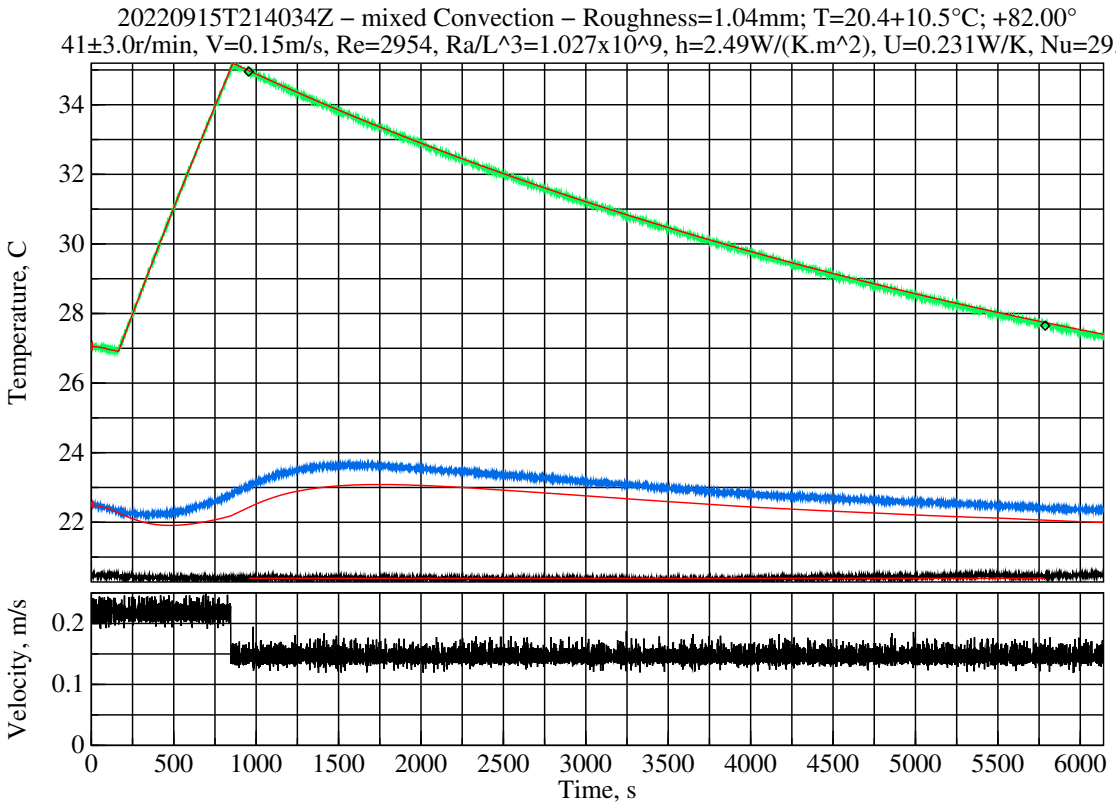
aiding inclined plate





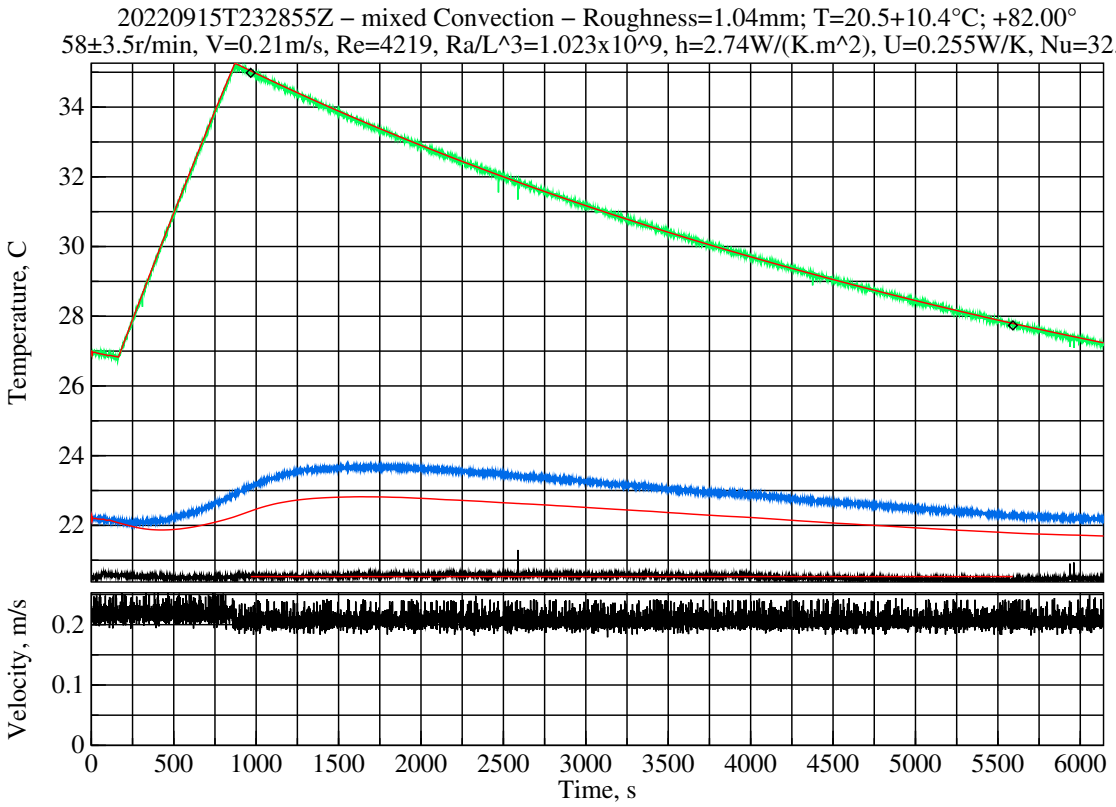
Estimated measurement uncertainties of natural convection at $\theta = 82.0$.

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
ΔT	10.8K	+31.3%/K	0.10K	3.13%	LM35C differential
T_{bb}	294K	+0.550%/K	0.50K	0.28%	radiative temperature
P	101kPa	+0.0008%/Pa	1.5kPa	1.26%	MPXH6115A6U air pressure
C_{pt}	4.24kJ/K	+0.070%/(J/K)	42J/K	2.96%	plate thermal capacity
L_c	0.305m	+907%/m	500um	0.45%	characteristic length
D_{PIR}	25.4mm	−705%/m	1.0mm	0.70%	insulation thickness
D_g	1.00mm	−715%/m	500um	0.36%	air gap
L_m	3.57mm	+1989%/m	500um	0.99%	side metal strip width
k_{PIR}	$22.2\frac{\mathrm{mW}}{\mathrm{K\cdot m}}$	$+0.681\%/\frac{\mathrm{mW}}{\mathrm{K\cdot m}}$	$1.1\frac{\mathrm{mW}}{\mathrm{K\cdot m}}$	0.76%	PIR thermal conductivity
ϵ_{XPS}	0.515	+61.2%	0.010	0.61%	XPS emissivity
ϵ_{tp}	0.890	+73.9%	0.015	1.11%	tape emissivity
Ω_{tp}	0.540	+49.9%	0.020	1.00%	tape coverage
ϵ_{rs}	0.040	+264%	0.010	2.64%	test-surface emissivity
ϵ_b	0.190	+16.7%	0.020	0.33%	back emissivity
ϵ_{wt}	0.900	+123%	0.025	3.08%	wind-tunnel emissivity
θ	82.0°	−2.51%/°	0.50°	1.25%	plate angle
				6.59%	combined bias uncertainty



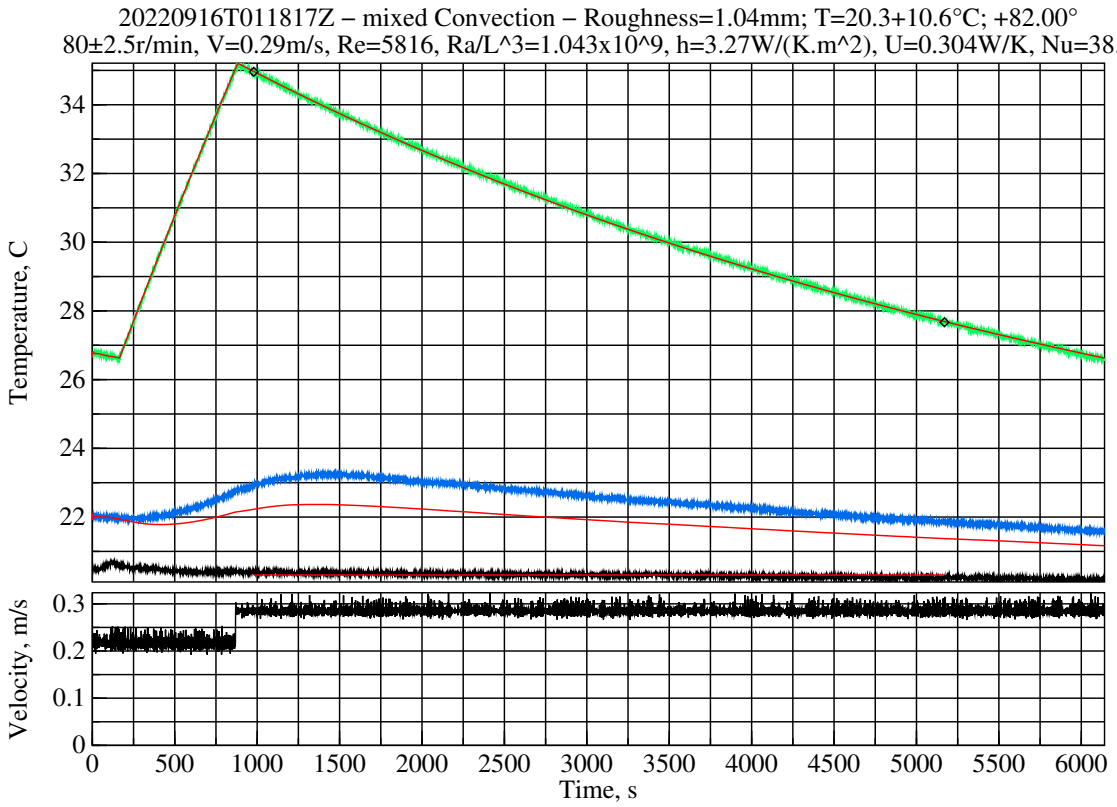
Estimated measurement uncertainties, bi-level 1mm roughness at $Re = 2953$.

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
ΔT	10.5K	+29.5%/K	0.10K	2.95%	LM35C differential
T_{bb}	294K	+0.471%/K	0.50K	0.24%	radiative temperature
P	101kPa	+0.0009%/Pa	1.5kPa	1.42%	MPXH6115A6U air pressure
C_{pt}	4.24kJ/K	+0.065%/(J/K)	42J/K	2.75%	plate thermal capacity
η	0.402	+76.4%	0.004	0.31%	anemometer calibration
L_c	0.305m	+805%/m	500um	0.40%	characteristic length
ς	2.00mm	+2651%/m	100um	0.27%	post height
D_{PIR}	25.4mm	−769%/m	1.0mm	0.77%	insulation thickness
D_g	1.00mm	−779%/m	500um	0.39%	air gap
L_m	3.57mm	+1870%/m	500um	0.94%	side metal strip width
k_{PIR}	$22.2\frac{\mathrm{mW}}{\mathrm{K\cdot m}}$	$+0.756\%/\frac{\mathrm{mW}}{\mathrm{K\cdot m}}$	$1.1\frac{\mathrm{mW}}{\mathrm{K\cdot m}}$	0.84%	PIR thermal conductivity
ϵ_{XPS}	0.515	+53.2%	0.010	0.53%	XPS emissivity
ϵ_{tp}	0.890	+64.2%	0.015	0.96%	tape emissivity
Ω_{tp}	0.540	+43.4%	0.020	0.87%	tape coverage
ϵ_{rs}	0.040	+230%	0.010	2.30%	test-surface emissivity
ϵ_{wt}	0.900	+105%	0.025	2.64%	wind-tunnel emissivity
θ	82.0°	−1.78%/°	0.50°	0.89%	plate angle
				6.01%	combined bias uncertainty
Symbol	**Nominal**	**Sensitivity**	**Variability**	**Uncertainty**	**Component**
ω	40.9r/min	+0.750%/(r/min)	3.0r/min	2.27%	fan rotation rate
				7.52%	RSS combined uncertainty



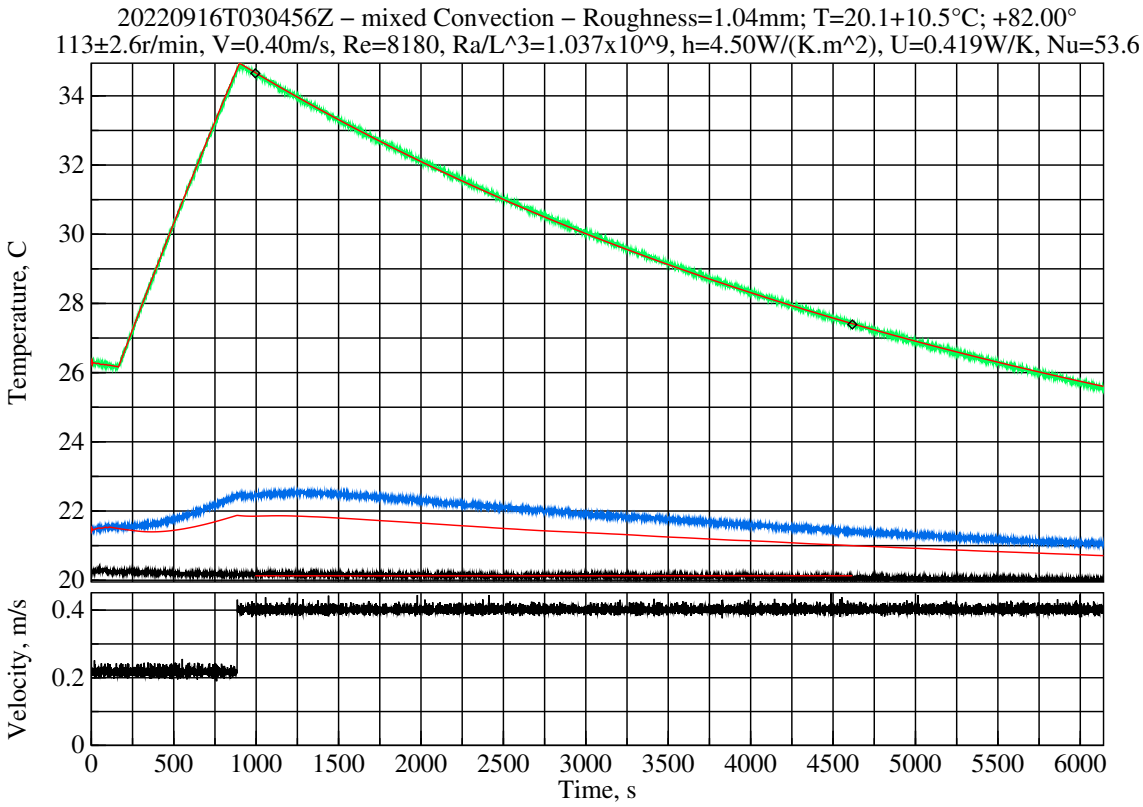
Estimated measurement uncertainties, bi-level 1mm roughness at $Re = 4216$.

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
ΔT	10.4K	+27.2%/K	0.10K	2.72%	LM35C differential
T_{bb}	294K	+0.412%/K	0.50K	0.21%	radiative temperature
P	101kPa	+0.0010%/Pa	1.5kPa	1.55%	MPXH6115A6U air pressure
C_{pt}	4.24kJ/K	+0.060%/(J/K)	42J/K	2.55%	plate thermal capacity
η	0.402	+130%	0.004	0.52%	anemometer calibration
L_c	0.305m	+757%/m	500um	0.38%	characteristic length
D_{PIR}	25.4mm	−736%/m	1.0mm	0.74%	insulation thickness
D_g	1.00mm	−746%/m	500um	0.37%	air gap
L_m	3.57mm	+1711%/m	500um	0.86%	side metal strip width
k_{PIR}	$22.2\frac{\mathrm{mW}}{\mathrm{K\cdot m}}$	$+0.727\%/\frac{\mathrm{mW}}{\mathrm{K\cdot m}}$	$1.1\frac{\mathrm{mW}}{\mathrm{K\cdot m}}$	0.81%	PIR thermal conductivity
ϵ_{XPS}	0.515	+46.8%	0.010	0.47%	XPS emissivity
ϵ_{tp}	0.890	+56.4%	0.015	0.85%	tape emissivity
Ω_{tp}	0.540	+38.1%	0.020	0.76%	tape coverage
ϵ_{rs}	0.040	+202%	0.010	2.02%	test-surface emissivity
ϵ_{wt}	0.900	+92.3%	0.025	2.31%	wind-tunnel emissivity
θ	82.0°	−1.27%/°	0.50°	0.64%	plate angle
				5.50%	combined bias uncertainty
Symbol	**Nominal**	**Sensitivity**	**Variability**	**Uncertainty**	**Component**
ω	58.4r/min	+0.894%/(r/min)	3.5r/min	3.17%	fan rotation rate
				8.39%	RSS combined uncertainty



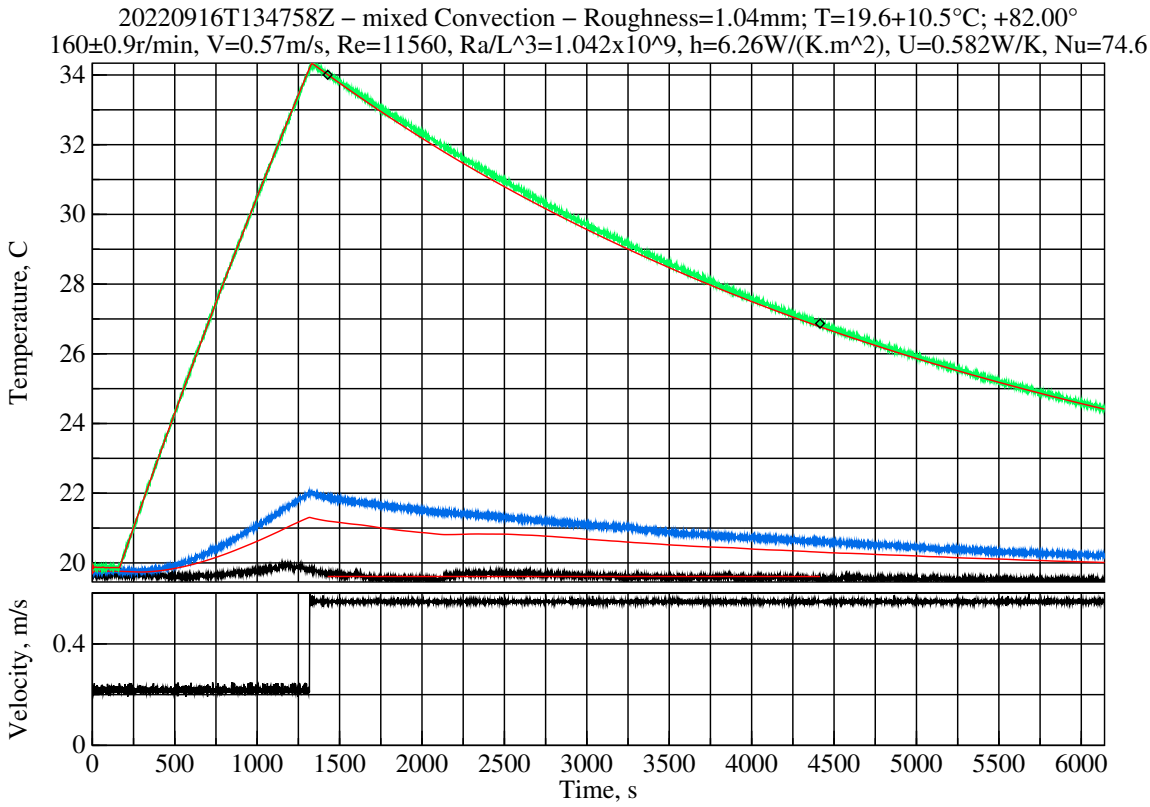
Estimated measurement uncertainties, bi-level 1mm roughness at $Re = 5815$.

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
ΔT	10.6K	+23.5%/K	0.10K	2.35%	LM35C differential
P	101kPa	+0.0012%/Pa	1.5kPa	1.75%	MPXH6115A6U air pressure
C_{pt}	4.24kJ/K	+0.054%/(J/K)	42J/K	2.28%	plate thermal capacity
η	0.402	+199%	0.004	0.80%	anemometer calibration
L_c	0.305m	+719%/m	500um	0.36%	characteristic length
L_T	8.34mm	+3402%/m	100um	0.34%	post length
ς	2.00mm	−8066%/m	100um	0.81%	post height
D_{PIR}	25.4mm	−642%/m	1.0mm	0.64%	insulation thickness
D_g	1.00mm	−651%/m	500um	0.33%	air gap
L_m	3.57mm	+1466%/m	500um	0.73%	side metal strip width
k_{PIR}	$22.2\frac{\mathrm{mW}}{\mathrm{K\cdot m}}$	$+0.637\%/\frac{\mathrm{mW}}{\mathrm{K\cdot m}}$	$1.1\frac{\mathrm{mW}}{\mathrm{K\cdot m}}$	0.71%	PIR thermal conductivity
ϵ_{XPS}	0.515	+38.1%	0.010	0.38%	XPS emissivity
ϵ_{tp}	0.890	+46.0%	0.015	0.69%	tape emissivity
Ω_{tp}	0.540	+31.0%	0.020	0.62%	tape coverage
ϵ_{rs}	0.040	+165%	0.010	1.65%	test-surface emissivity
ϵ_{wt}	0.900	+74.9%	0.025	1.87%	wind-tunnel emissivity
θ	82.0°	−0.724%/°	0.50°	0.36%	plate angle
				4.93%	combined bias uncertainty
Symbol	**Nominal**	**Sensitivity**	**Variability**	**Uncertainty**	**Component**
ω	80.5r/min	+0.994%/(r/min)	2.5r/min	2.45%	fan rotation rate
				6.95%	RSS combined uncertainty



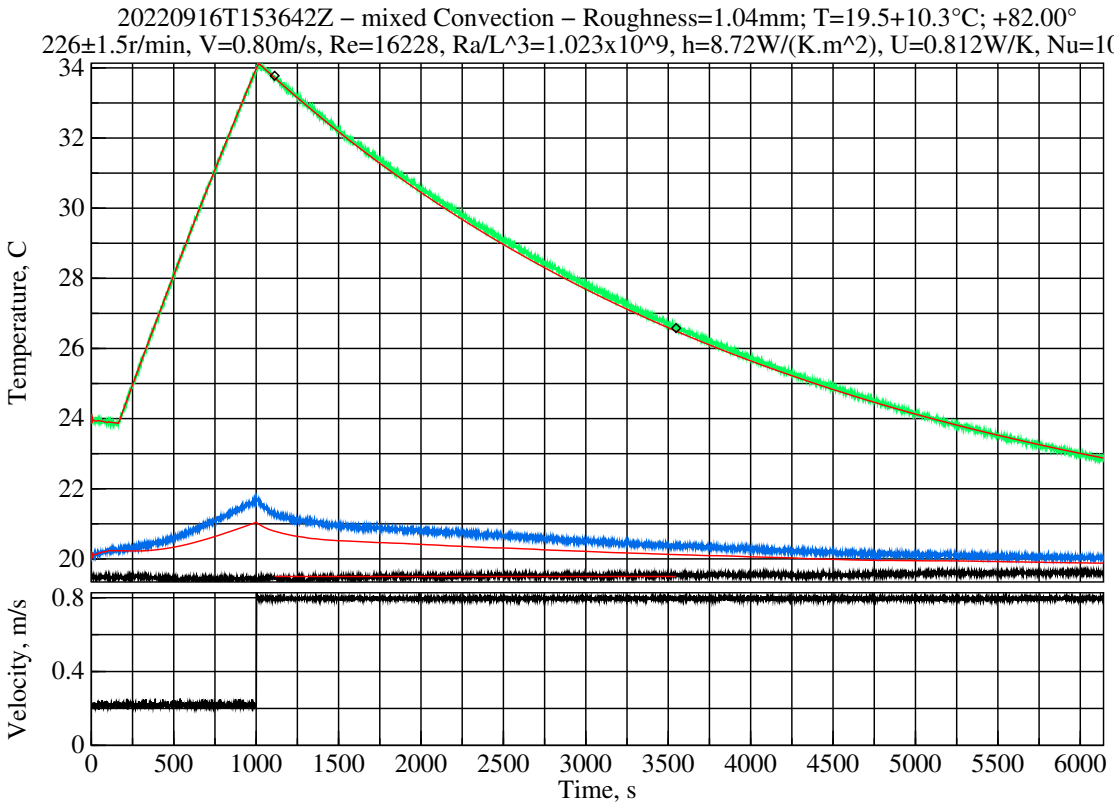
Estimated measurement uncertainties, bi-level 1mm roughness at $Re = 8180$.

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
ΔT	10.5K	+19.8%/K	0.10K	1.98%	LM35C differential
P	101kPa	+0.0012%/Pa	1.5kPa	1.86%	MPXH6115A6U air pressure
C_{pt}	4.24kJ/K	+0.046%/(J/K)	42J/K	1.94%	plate thermal capacity
η	0.402	+255%	0.004	1.02%	anemometer calibration
L_c	0.305m	+625%/m	500um	0.31%	characteristic length
L_T	8.34mm	+6417%/m	100um	0.64%	post length
ς	2.00mm	−16228%/m	100um	1.62%	post height
D_{PIR}	25.4mm	−500%/m	1.0mm	0.50%	insulation thickness
D_g	1.00mm	−507%/m	500um	0.25%	air gap
L_m	3.57mm	+1151%/m	500um	0.58%	side metal strip width
k_{PIR}	$22.2\frac{\mathrm{mW}}{\mathrm{K\cdot m}}$	$+0.498\%/\frac{\mathrm{mW}}{\mathrm{K\cdot m}}$	$1.1\frac{\mathrm{mW}}{\mathrm{K\cdot m}}$	0.55%	PIR thermal conductivity
ϵ_{XPS}	0.515	+27.8%	0.010	0.28%	XPS emissivity
ϵ_{tp}	0.890	+33.6%	0.015	0.50%	tape emissivity
Ω_{tp}	0.540	+22.7%	0.020	0.45%	tape coverage
ϵ_{rs}	0.040	+121%	0.010	1.21%	test-surface emissivity
ϵ_{wt}	0.900	+54.7%	0.025	1.37%	wind-tunnel emissivity
				4.50%	combined bias uncertainty
Symbol	**Nominal**	**Sensitivity**	**Variability**	**Uncertainty**	**Component**
ω	113r/min	+0.905%/(r/min)	2.6r/min	2.31%	fan rotation rate
				6.45%	RSS combined uncertainty



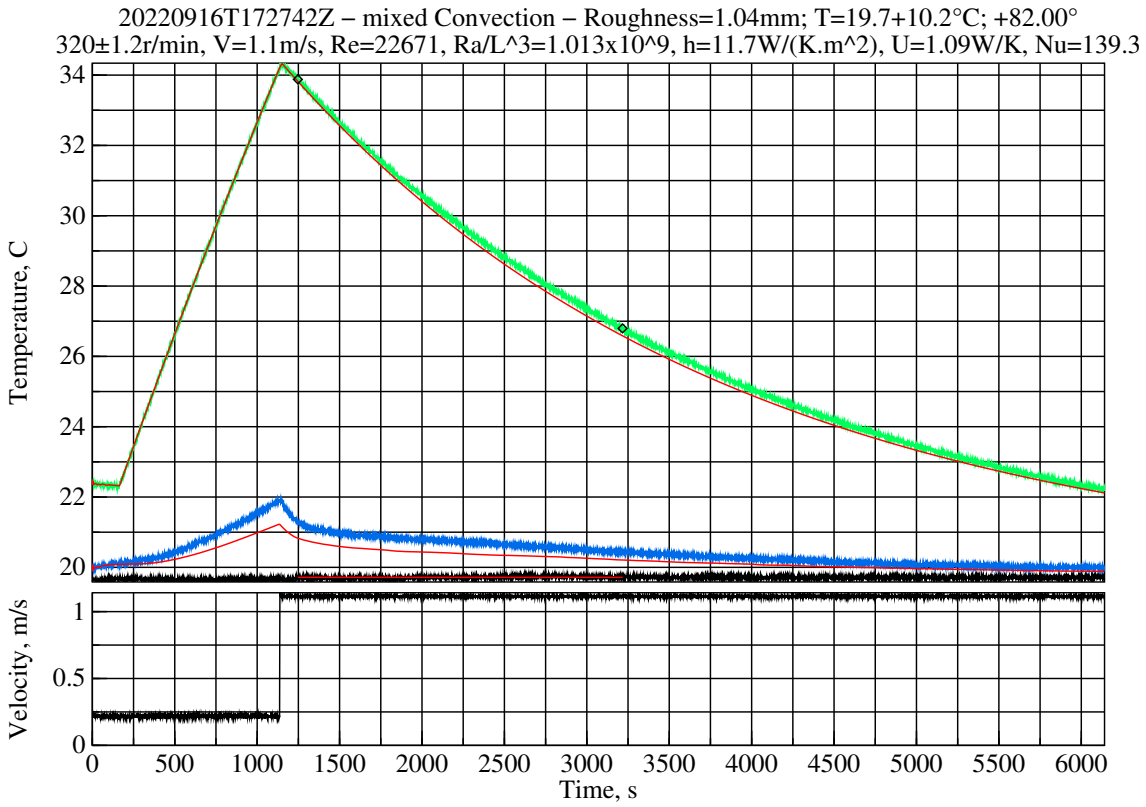
Estimated measurement uncertainties, bi-level 1mm roughness at $Re = 11559$.

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
ΔT	10.5K	+16.7%/K	0.10K	1.67%	LM35C differential
P	101kPa	+0.0012%/Pa	1.5kPa	1.74%	MPXH6115A6U air pressure
C_{pt}	4.24kJ/K	+0.039%/(J/K)	42J/K	1.66%	plate thermal capacity
η	0.402	+258%	0.004	1.04%	anemometer calibration
L_c	0.305m	+464%/m	500um	0.23%	characteristic length
L_T	8.34mm	+8160%/m	100um	0.82%	post length
ς	2.00mm	−15533%/m	100um	1.55%	post height
D_{PIR}	25.4mm	−367%/m	1.0mm	0.37%	insulation thickness
L_m	3.57mm	+879%/m	500um	0.44%	side metal strip width
k_{PIR}	$22.2\frac{\mathrm{mW}}{\mathrm{K\cdot m}}$	$+0.368\%/\frac{\mathrm{mW}}{\mathrm{K\cdot m}}$	$1.1\frac{\mathrm{mW}}{\mathrm{K\cdot m}}$	0.41%	PIR thermal conductivity
ϵ_{tp}	0.890	+23.3%	0.015	0.35%	tape emissivity
Ω_{tp}	0.540	+15.8%	0.020	0.32%	tape coverage
ϵ_{rs}	0.040	+84.1%	0.010	0.84%	test-surface emissivity
ϵ_{wt}	0.900	+38.0%	0.025	0.95%	wind-tunnel emissivity
				3.91%	combined bias uncertainty
Symbol	**Nominal**	**Sensitivity**	**Variability**	**Uncertainty**	**Component**
ω	160r/min	+0.648%/(r/min)	0.86r/min	0.55%	fan rotation rate
				4.06%	RSS combined uncertainty



Estimated measurement uncertainties, bi-level 1mm roughness at $Re = 16225$.

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
ΔT	10.3K	+14.9%/K	0.10K	1.49%	LM35C differential
P	101kPa	+0.0010%/Pa	1.5kPa	1.57%	MPXH6115A6U air pressure
C_{pt}	4.24kJ/K	+0.035%/(J/K)	42J/K	1.48%	plate thermal capacity
η	0.402	+239%	0.004	0.96%	anemometer calibration
L_T	8.34mm	+8819%/m	100um	0.88%	post length
ς	2.00mm	−11418%/m	100um	1.14%	post height
D_{PIR}	25.4mm	−272%/m	1.0mm	0.27%	insulation thickness
L_m	3.57mm	+699%/m	500um	0.35%	side metal strip width
k_{PIR}	$22.2\frac{\mathrm{mW}}{\mathrm{K\cdot m}}$	$+0.274\%/\frac{\mathrm{mW}}{\mathrm{K\cdot m}}$	$1.1\frac{\mathrm{mW}}{\mathrm{K\cdot m}}$	0.30%	PIR thermal conductivity
ϵ_{tp}	0.890	+16.5%	0.015	0.25%	tape emissivity
Ω_{tp}	0.540	+11.2%	0.020	0.22%	tape coverage
ϵ_{rs}	0.040	+59.7%	0.010	0.60%	test-surface emissivity
ϵ_{wt}	0.900	+26.9%	0.025	0.67%	wind-tunnel emissivity
				3.35%	combined bias uncertainty
Symbol	**Nominal**	**Sensitivity**	**Variability**	**Uncertainty**	**Component**
ω	226r/min	+0.425%/(r/min)	1.5r/min	0.66%	fan rotation rate
				3.60%	RSS combined uncertainty



Estimated measurement uncertainties, bi-level 1mm roughness at $Re = 22670$.

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
ΔT	10.2K	+13.7%/K	0.10K	1.37%	LM35C differential
P	101kPa	+0.0010%/Pa	1.5kPa	1.44%	MPXH6115A6U air pressure
C_{pt}	4.24kJ/K	+0.032%/(J/K)	42J/K	1.35%	plate thermal capacity
η	0.402	+218%	0.004	0.88%	anemometer calibration
L_T	8.34mm	+9087%/m	100um	0.91%	post length
ς	2.00mm	−7741%/m	100um	0.77%	post height
D_{PIR}	25.4mm	−205%/m	1.0mm	0.21%	insulation thickness
L_m	3.57mm	+587%/m	500um	0.29%	side metal strip width
k_{PIR}	$22.2\frac{\mathrm{mW}}{\mathrm{K\cdot m}}$	$+0.208\%/\frac{\mathrm{mW}}{\mathrm{K\cdot m}}$	$1.1\frac{\mathrm{mW}}{\mathrm{K\cdot m}}$	0.23%	PIR thermal conductivity
ϵ_{rs}	0.040	+43.7%	0.010	0.44%	test-surface emissivity
ϵ_{wt}	0.900	+19.6%	0.025	0.49%	wind-tunnel emissivity
				2.95%	combined bias uncertainty
Symbol	**Nominal**	**Sensitivity**	**Variability**	**Uncertainty**	**Component**
ω	320r/min	+0.274%/(r/min)	1.2r/min	0.34%	fan rotation rate
				3.03%	RSS combined uncertainty