APPENDIX 2

ETNA1

RESULTS OF THE RUNS 1 AND 2

Comparison between EDF ETNA test-cell models
developed with

AxBU, APACHE, CA-SIS, CLIM 2000,
DOE-2 and SERI-RES.

Empirical validation
2ⁿᵈ RUN

SHORT VERSION

review of the previous
results (extracts of October 1997 report)

<div style="border:1px solid black; text-align:center;">

Table of contents

</div>

I. DATA ANALYSIS AND COMPARISONS FOR MEASURE AND REFERENCE CELLS

I.1. Solar radiation flux (south facing and vertical)

Graphical comparison

Apart from the DOE calculation, all programs present simulations in good agreement with measurements.

For DOE, some problems occur for the days 65, 66 and 77. The calculation for solar radiation gives negative results for the days 65 and 66, and inconsistent values for theses days and day 77.

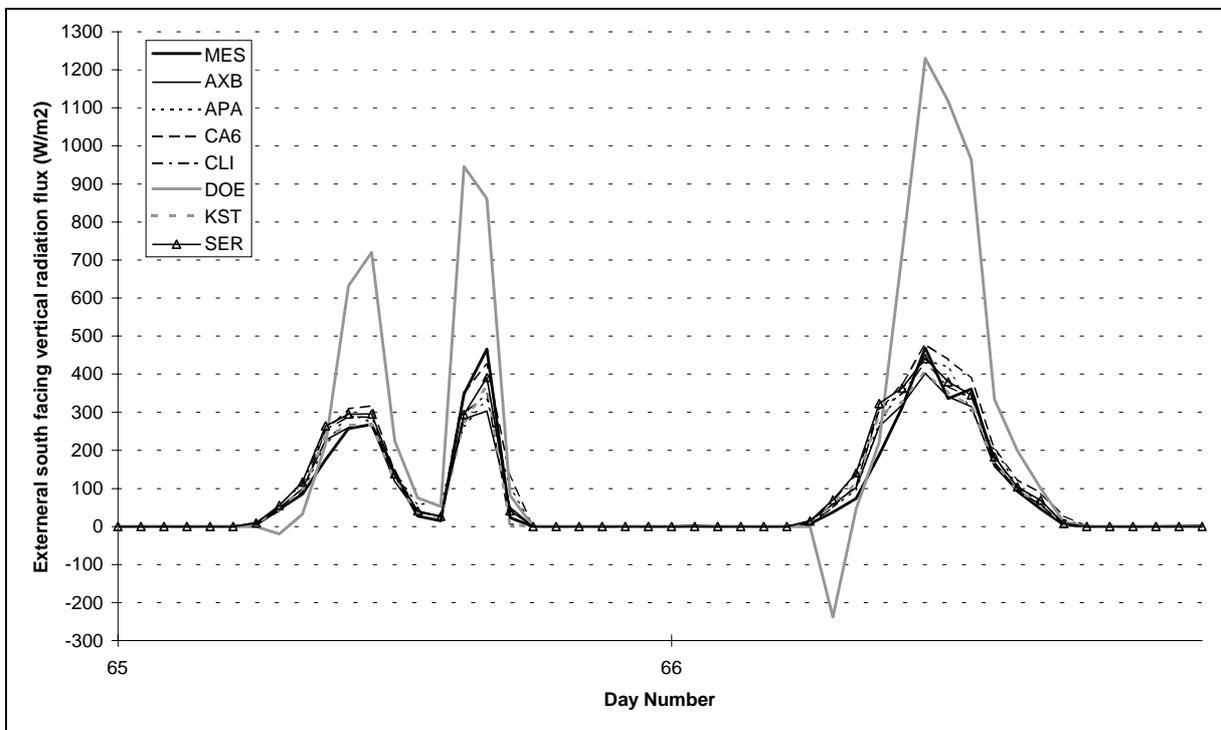The calculation of the vertical radiation flux for DOE should be verified and corrected.

figure 1 Vertical radiation flux for days 65 and 66.

The differences between measurements and simulations demonstrate that in general the programs overestimate the radiation in the morning, and underestimate it in the evening.

Statistical comparison of the models

Vertical radiation flux							
	AXB	**APA**	**CA6**	**CLI**	**DOE**	**KST**	**SER**
DTMIN	-171.99	-192.66	-111.08	-131.91	-275.30	-156.04	-130.94
DTMAX	94.25	245.28	190.58	130.45	781.41	108.25	138.78
MEANDT	-4.71	4.17	10.91	2.91	7.18	-2.50	6.45
MIN	0.00	0.00	0.00	0.00	-238.03	0.00	0.00
MAX	840.53	862.00	942.80	880.75	1230.24	856.29	908.90
MEAN	91.92	100.80	107.54	99.53	103.81	94.13	103.08
AB MEAN DT	16.34	17.60	14.96	15.65	31.95	14.27	15.77
SQ MEAN DT	36.77	37.58	32.02	31.76	94.09	31.43	31.77
STDERR	36.51	37.39	30.13	31.66	93.92	31.36	31.14
SUM	41913.50	45965.00	49039.44	45387.61	47337.84	42922.78	47002.56

Table 1 : statistical comparison for the vertical radiation flux calculation.

For all the programs, the precision between measurements and simulation are equivalent, excepted for the results of DOE, which gives the higher differences, due to the problems presented above.

Note that the measured vertical radiation energy is 44062 $W.h.m^{-2}$. In terms of total energy received by solar radiation, the more correct predictions are given by AXB (-4%), and the less accurate predictions are given by CA-SIS (+11%).

I.2. Flux inside test cell

Statistical comparison of the models

Total energy inside test cell							
	AXB	**APA**	**CA6**	**CLI**	**DOE**	**KST**	**SER**
SUM	27458.44	27388.00	25703.53	28433.72	21360.40	18835.89	28239.87
Relative error in %	8.34	8.06	1.41	12.19	-15.72	-25.68	11.42

Table 2 : statistical comparison for the vertical radiation flux calculation.

The relative error presented in the Table 2 is calculated by comparing specific software results with the mean value of all the predicted value. Table 2 presents the sum of the energy behind glazing for all the programs (in $W.h.m^{-2}$). We can see very large differences of the total energy behind glazing.

The mean value for the 7 simulation is 25345 $W.h.m^{-2}$, the lowest difference are given by CA-SIS (+2%) and the higher difference are for DOE (-15%) and KST (-25%).

These differences for the estimated fluxes inside cells are surprising, and we could think that this will have large influences on the temperatures in the cells.

The transient differences encountered with the DOE program for the calculation of the vertical solar radiation flux are detected for the calculation of the flux behind glazing, as shown below.
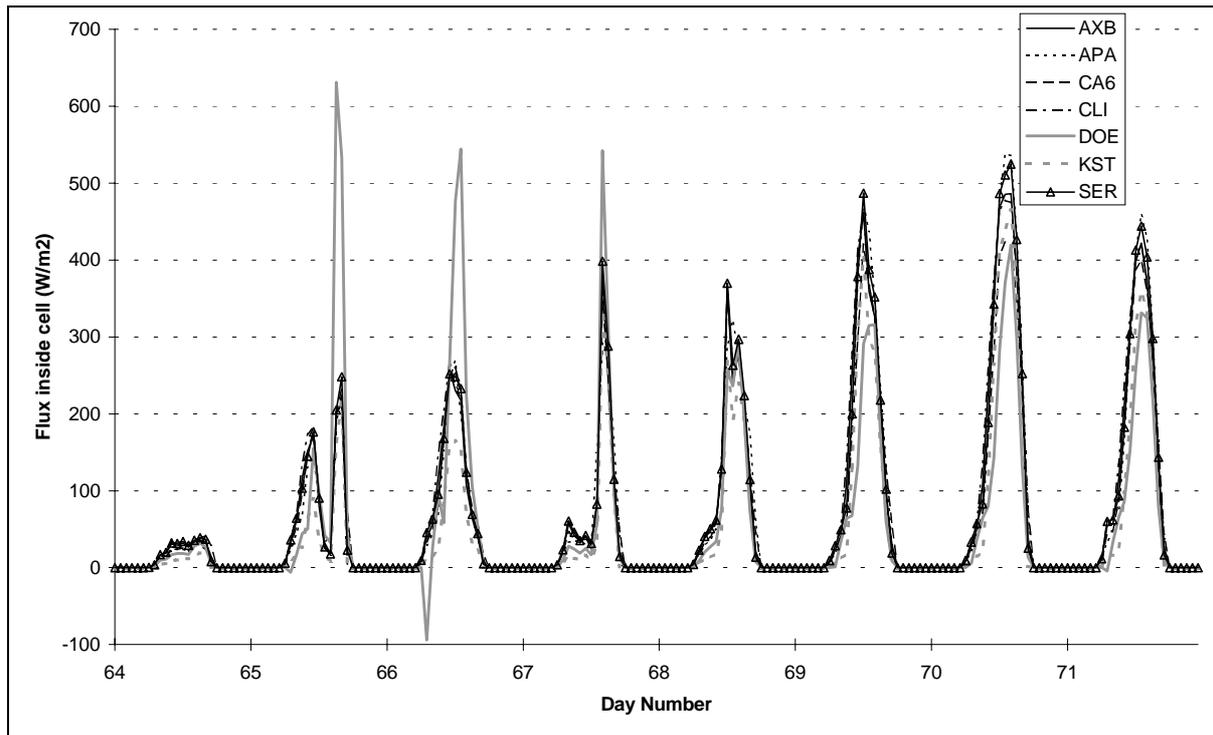
figure 2 Flux behind glazing (W.m^{-2}). Day 64 to 71.

I.3.   Heating power

	AXB	APA	CA6	CLI	DOE	KST	SER
DTMIN	-124.90	-4.90	0.00	-0.58	-0.50	0.00	-0.01
DTMAX	127.76	5.00	0.00	-0.17	0.50	0.00	0.01
MEANDT	-0.23	-0.88	0.00	-0.39	-0.02	0.00	0.00
MIN	2.20	0.00	2.10	1.75	2.00	2.10	2.11
MAX	519.91	520.00	520.60	520.25	521.00	520.60	520.61
MEAN	240.10	239.45	240.33	239.94	240.31	240.33	240.33
AB MEAN DT	60.25	2.65	0.00	0.39	0.27	0.00	0.01
SQ MEAN DT	81.94	2.90	0.00	0.40	0.30	0.00	0.01
STDERR	82.03	2.77	0.00	0.06	0.30	0.00	0.01
SUM	109485.52	109190.00	109591.90	109413.40	109581.00	109591.90	109591.80

Table 3 : statistical comparison for the heating power in MEASURE test cell

	AXB	APA	CA6	CLI	DOE	KST	SER
DTMIN	-136.73	-4.90	0.00	-0.62	-0.50	0.00	-0.01
DTMAX	140.64	5.00	0.00	-0.22	0.50	0.00	0.01
MEANDT	-0.25	-0.25	0.00	-0.36	-0.01	0.00	0.00
MIN	1.85	0.00	1.80	1.50	2.00	1.80	1.81
MAX	572.82	580.00	578.10	577.58	578.00	578.10	578.11
MEAN	261.42	261.43	261.68	261.32	261.67	261.68	261.68
AB MEAN DT	65.67	2.43	0.00	0.36	0.20	0.00	0.01
SQ MEAN DT	89.57	2.74	0.00	0.37	0.25	0.00	0.01
STDERR	89.67	2.73	0.00	0.06	0.25	0.00	0.01
SUM	119208.16	119210.00	119324.30	119159.66	119321.00	119324.30	119323.82

Table 4 : statistical comparison for the heating power in MEASURE test cell

Excepted for the AXB results, all simulation programs reproduce this entry with a very good agreement. This is expected, because the heating power in a input of the simulations.

The problem for AXB results are discussed in (V.4.2 Validity of the data). The total energy in test cell, and the mean values are exactly the same as for the other programs.

Assuming that this point is only a problem in time convention or data restitution, we included the AXB results in this analysis.

I.4. Air temperatures analysis

I.4.1. MEASURE Cell

Apart from the transient period of 4 days, the established simulations demonstrate :

- in most cases, simulations overestimate the air temperature ;

- the greatest disagreement with empirical data in the response of the air temperature for fast dynamics (excessive variations of temperature, see STDERR) for SERI-RES ;

- large disagreement with the slow dynamics of the building with DOE program, but DOE accurately describes fast dynamics

- a good agreement of the slow responses for all other programs ;

- a good agreement for static and dynamic response for air temperature for CA-SIS.

I.4.2. REFERENCE Cell

The simulations show :

- for DOE program, a very poor reproduction of the dynamic of the building. The variations of air temperature simulated by DOE program are very overestimated.

- for the other programs, the same conclusion can be stated for REFERENCE cell as for MEASURE cell.

In addition to previous results, we conclude to a large disagreement with calculation for all programs ; the response for air temperature is more accurate in the case of the MEASURE cell (real heat source) than for REFERENCE cell (including an ideal heat source).

### I.4.3. Comparison between MEASURE and REFERENCE cells

Table 5 presents the statistical comparison to the measurements for each MEASURE and REFERENCE cells.

	MEA	REF	MEA	REF	MEA	REF	MEA	REF	MEA	REF	MEA	REF
	AXB		APA		CA6		DOE		KST		SER	
DTMIN	0.17	0.37	0.47	0.62	-1.41	-0.97	-0.25	-0.56	-0.15	0.02	-1.00	-1.14
DTMAX	2.80	3.15	4.17	5.00	1.46	2.12	4.29	4.43	3.12	4.17	4.29	5.23
MEANDT	1.42	1.70	1.93	2.27	0.17	0.54	1.64	1.77	1.61	2.12	1.42	1.65
MIN	13.79	14.23	13.80	14.10	12.67	13.15	13.90	15.50	13.50	13.95	12.50	12.88
MAX	24.25	25.42	26.00	27.50	22.85	24.26	24.50	24.00	24.93	26.81	24.92	26.25
MEAN	18.72	19.56	19.22	20.13	17.46	18.40	18.94	19.63	18.90	19.97	18.71	19.51
ABMEANDT	1.42	1.70	1.93	2.27	0.48	0.66	1.64	1.80	1.61	2.12	1.48	1.71
SQMEANDT	1.50	1.81	2.08	2.45	0.61	0.83	1.82	2.07	1.79	2.34	1.76	2.04
STDERR	0.49	0.61	0.78	0.94	0.58	0.63	0.79	1.08	0.79	1.01	1.05	1.21

Table 5 : statistical comparison of air temperature to measurements for MEASURE and REFERENCE cells.
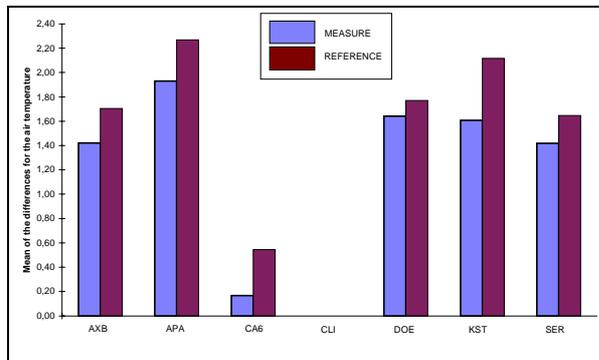
Mean of the differences (simulations-measurements) for the air temperature (°C).
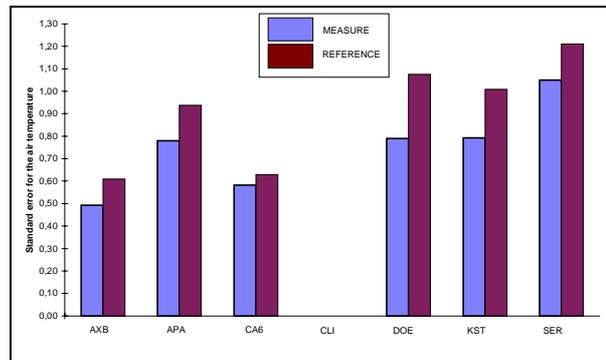
Standard error of the differences (simulations-measurements) for the air temperature (°C).

This shows that for all programs, the air temperature for MEASURE test cell is in better agreement with empirical data than for the REFERENCE test cell. The mean of the differences and the standard error are lower for MEASURE cell.

For all the programs, the overestimation of the air temperature in MEASURE cell is less than for the REFERENCE test cell.

The statistical comparison to measurements shows that :

– the lower mean differences versus empirical data are given by CA-SIS ;

– for the other programs the mean difference values indicates a disagreement with empirical data regarding static heat losses;

– SERI-RES is subject to the higher standard error, showing a problem for describing fast dynamics (too high variations of air temperature in heating periods). This is not the case for CA-SIS, which standard error is one of the best after AXB.

Table 6 presents a statistical comparison of the difference (REFERENCE-MEASURE) for the measured values and the predicted values of each program.

REFERENCE-MEASURE : air temperature							
	MES	**AXB**	**APA**	**CA6**	**DOE**	**KST**	**SER**
DTMIN	-0.25	0.28	0.30	0.39	-1.40	0.37	0.31
DTMAX	1.01	1.46	1.70	1.61	2.40	1.95	1.48
MEANDT	0.56	0.85	0.90	0.94	0.69	1.07	0.79
AB MEAN DT	0.57	0.85	0.90	0.94	0.83	1.07	0.79
SQ MEAN DT	0.60	0.89	0.96	0.98	0.99	1.14	0.83
STDERR	0.20	0.26	0.32	0.27	0.71	0.38	0.23

Table 6 : statistical comparison for air temperature between REFERENCE - MEASURE.

A higher air temperature in REFERENCE test cell is measured, and predicted by all programs. Nevertheless, this difference of the air temperature between REFERENCE and MEASURE cells are too high for the KST and CA-SIS programs.

I.5. Mean radiant temperatures analysis

I.5.1. MEASURE Cell

The established simulations demonstrate :

– a better agreement with empirical data for mean radiant temperature for all comparable simulations than for air temperature ; differences are about 1°C lower than for air temperature errors of prediction.

I.5.2. REFERENCE Cell

As for MEASURE cell, the results for REFERENCE cell show a good agreement between simulations and measurements for all the program (less good for APACHE), and a low static difference for KST (compared to the high difference for the 1st run).

I.5.3. Comparison between MEASURE and REFERENCE cells

Table 7 presents the statistical comparison to the measurements for each MEASURE and REFERENCE cells.

	MEA	**REF**	**MEA**	**REF**	**MEA**	**REF**	**MEA**	**REF**
	AXB		**APA**		**KST**		**SER**	
DTMIN	-1.68	-0.80	-0.93	0.10	-1.71	-0.75	-1.42	-0.64
DTMAX	2.35	2.63	2.19	2.23	1.50	1.78	2.42	2.98
MEANDT	0.50	0.81	1.00	1.27	0.42	0.88	0.52	0.93
MIN	13.88	14.32	13.70	14.10	13.49	13.94	13.12	13.53
MAX	22.86	23.50	23.80	24.50	22.59	23.57	22.99	23.93
MEAN	17.82	18.40	18.32	18.87	17.73	18.47	17.83	18.53
ABMEANDT	0.80	0.88	1.02	1.27	0.59	0.90	0.68	0.97
SQMEANDT	0.97	1.06	1.13	1.34	0.73	0.98	0.84	1.15
STDERR	0.83	0.69	0.52	0.41	0.60	0.44	0.67	0.68

Table 7 : statistical comparison of radiant temperature to measurements for MEASURE and REFERENCE cells.
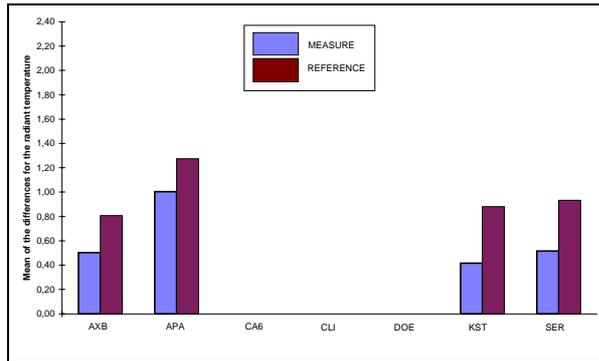
Mean of the differences (simulations-measurements) for the radiant temperature (°C).
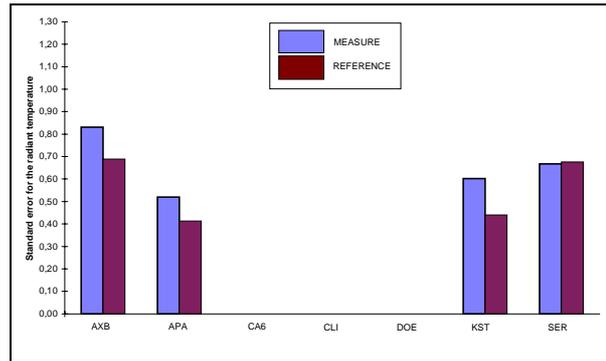
Standard error of the differences (simulations-measurements) for the radiant temperature (°C).

This shows that for all programs, the radiant temperature for MEASURE test cell has better agreement with empirical data than for the REFERENCE test cell. The mean of the differences are lower for MEASURE cell, but standard deviations are often lower for MEASURE test cell (excepted for SERI-RES program).

For all the programs, the overestimation of the radiant temperature in MEASURE cell is less than for the REFERENCE test cell.

The statistical comparison of the differences to mean radiant temperature measurements underlines that :

- the best agreement with empirical data are given by KST ;

- for the other programs the mean difference values indicate disagreement with empirical data regarding static heat losses ;

- AXB is subject to the higher standard error, showing a problem in describing fast dynamics (too high variations of radiant temperature in heating periods).

Table 8 presents a statistical comparison of the difference (REFERENCE-MEASURE) for the measured values and the predicted values of each program.

REFERENCE-MEASURE : radiant temperature					
	MES	AXB	APA	KST	SER
DTMIN	-0.67	0.30	0.20	0.37	0.34
DTMAX	0.67	0.85	0.90	1.19	1.16
MEANDT	0.28	0.58	0.55	0.74	0.70
AB MEAN DT	0.30	0.58	0.55	0.74	0.70
SQ MEAN DT	0.35	0.59	0.57	0.76	0.71
STDERR	0.21	0.12	0.15	0.16	0.16

Table 8 : statistical comparison between REFERENCE - MEASURE : 2nd run.

A higher radiant temperature in REFERENCE test cell is measured, and predicted by all programs, but in all cases this difference of temperature is underestimated.

I.6.   Enclosure temperatures analysis

<u>Note</u>

In the 1st run, the calculation of the enclosure temperature was assumed to be the mean of the radiant and air temperature for all the programs. That is :

$$T_{enclosure} = \frac{T_{air} + T_{radiant}}{2}$$

In this second RUN, the SERI-RES enclosure temperature has been calculated by :

$$T_{enclosure} = \frac{h_c \cdot T_{air} + h_r \cdot T_{radiant}}{h_c + h_r}$$

With h_c = 2.7 W.m^{-2}.K^{-1} and h_r = 5.2 W.m^{-2}.K^{-1}, the enclosure temperature is given by :

$$T_{enclosure} \approx 0.34 \cdot T_{air} + 0.66 \cdot T_{radiant}$$

I.6.1. MEASURE Cell

The established simulations show :

- a agreement with empirical data for enclosure temperature for CLIM2000 ;

- a best agreement for dynamics for CLIM2000, in terms of standard deviation ;

- for the APACHE program, the mean difference values show probably a wrong prediction of static heat losses ;

- the standard deviation for all the programs are close together ;

- a less accurate response for fast dynamics for CLIM2000 ; this phenomena is particularly demonstrated in the case of high heat power sequences ;

The best agreement with empirical are given by CLIM2000 for enclosure temperature.

I.6.2. REFERENCE Cell

As for MEASURE cell, the results for REFERENCE cell show for CLIM2000 the best agreement with empirical data between simulations and measurements.

### I.6.3. Comparison between MEASURE and REFERENCE cells

Table 9 presents the statistical comparison with the measurements for each MEASURE and REFERENCE cells.

	MEA	REF	MEA	REF	MEA	REF	MEA	REF	MEA	REF
	AXB		APA		CLI		KST		SER	
DTMIN	-0.67	-0.16	0.11	0.60	-1.53	-1.32	-0.89	-0.24	-0.74	-0.54
DTMAX	2.49	2.86	2.78	3.48	1.43	1.82	2.17	2.68	2.85	3.54
MEANDT	0.96	1.26	1.47	1.77	0.56	0.91	1.01	1.50	0.83	1.14
MIN	13.84	14.28	13.75	14.10	13.03	13.55	13.50	13.95	12.90	13.30
MAX	23.45	24.39	24.90	26.00	23.42	24.59	23.70	25.19	23.38	24.54
MEAN	18.27	18.98	18.77	19.50	17.86	18.64	18.32	19.22	18.14	18.86
ABMEANDT	0.99	1.26	1.47	1.77	0.67	0.94	1.03	1.50	0.88	1.16
SQMEANDT	1.13	1.37	1.57	1.87	0.75	1.01	1.14	1.61	1.06	1.36
STDERR	0.60	0.55	0.57	0.61	0.50	0.45	0.53	0.59	0.65	0.75

Table 9 : statistical comparison of enclosure temperature with measurements for MEASURE and REFERENCE cells.
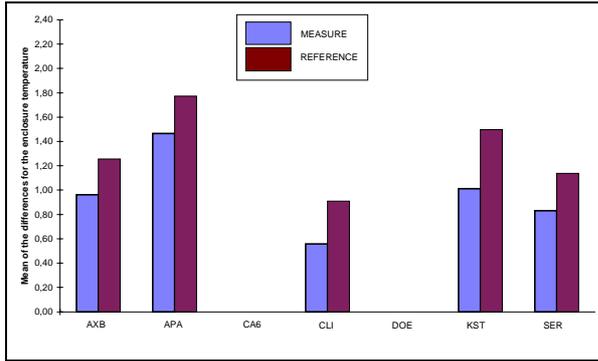
Mean of the differences (simulations-measurements) for the enclosure temperature (°C).
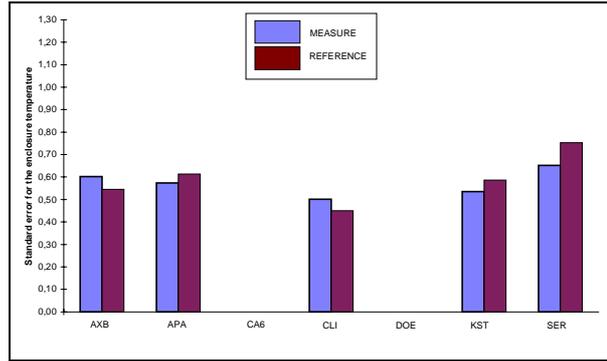
Standard error of the differences (simulations-measurements) for the enclosure temperature (°C).

This shows that for all programs, the enclosure temperature for MEASURE test cell is better predicted than for the REFERENCE test cell. The mean of the differences and the standard error are lower for MEASURE cell.

For all the programs, the overestimation of the air temperature in MEASURE cell is less than for the REFERENCE test cell.

The statistical comparison of the differences with measurements shows that :

- − the best agreement with empirical data are given by CLIM2000 ;
- − SERI-RES is subject to the higher standard error.

Table 10 presents a statistical comparison of the difference (REFERENCE-MEASURE) for the measured values and the predicted values of each program.

REF-MEA : enclosure temperature						
	MES	**AXB**	**APA**	**CLI**	**KST**	**SER**
DTMIN	-0.42	0.30	0.30	0.40	0.37	0.33
DTMAX	0.84	1.15	1.30	1.19	1.57	1.27
MEANDT	0.42	0.71	0.73	0.77	0.91	0.73
AB MEAN DT	0.43	0.71	0.73	0.77	0.91	0.73
SQ MEAN DT	0.46	0.74	0.76	0.79	0.94	0.75
STDERR	0.19	0.18	0.21	0.16	0.27	0.18

Table 10 : statistical comparison between REFERENCE - MEASURE.

A higher enclosure temperature in REFERENCE test cell is measured, and predicted by all programs.

Nevertheless, this difference of the air temperature between REFERENCE and MEASURE cells are too high for all the programs.

I.7. Surface temperatures

I.7.1. South wall temperature

	AXB	APA	CA6	CLI	SER
DTMIN	-1.86	-1.39	-3.24	-1.83	-3.61
DTMAX	2.77	4.35	1.82	1.50	1.81
MEANDT	0.43	0.87	-0.68	-0.06	-1.01
MIN	13.56	13.32	12.39	12.52	10.73
MAX	23.29	24.85	21.65	22.86	23.26
MEAN	17.79	18.23	16.68	17.31	16.35
AB MEAN DT	1.14	1.09	1.03	0.70	1.18
SQ MEAN DT	1.30	1.35	1.27	0.80	1.42
STDERR	1.23	1.04	1.08	0.80	1.00

Table 11 : comparison with measurement for the south wall temperature. MEASURE cell.

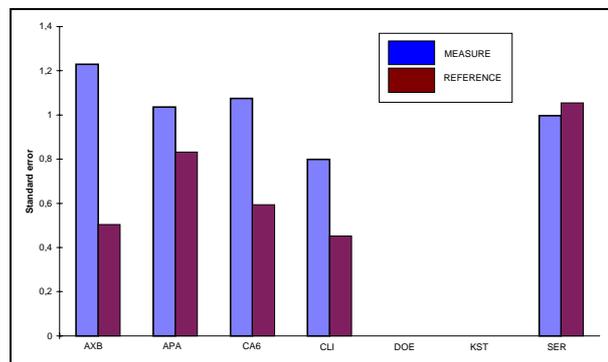|	AXB	APA	CA6	CLI	SER
DTMIN	0.66	0.70	-0.84	0.30	-2.20
DTMAX	3.38	5.55	2.75	2.72	3.77
MEANDT	1.97	2.46	1.00	1.63	0.56
MIN	13.99	13.67	12.86	13.02	11.06
MAX	23.95	25.78	22.60	23.97	24.12
MEAN	18.39	18.87	17.41	18.04	16.97
AB MEAN DT	1.97	2.46	1.02	1.63	0.96
SQ MEAN DT	2.04	2.60	1.16	1.69	1.19
STDERR	0.50	0.83	0.59	0.45	1.06

Table 12 : comparison with measurement for the south wall temperature. REFERENCE cell.

Table 11 and Table 12 show that the south wall temperature is often underestimated for MEASURE test cell (excepted for CLIM2000). but is often highly overestimated for REFERENCE test cell.

The position of the electrical convector in the MEASURE cell (on the south wall) makes the simulation less accurate than in the case of a purely convective source located in the centre of the room (REFERENCE cell). This results in a very large standard error for the temperature of this surface. for the MEASURE test cell.
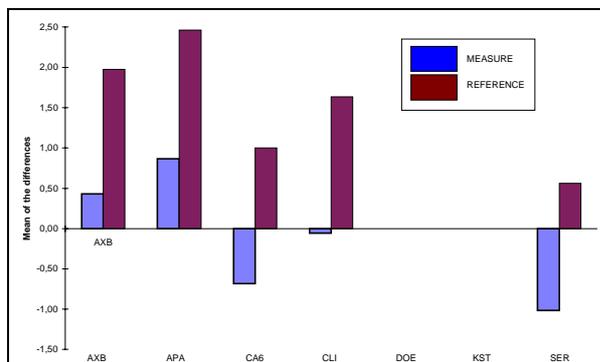
Mean of the differences (simulations-measurements) for the south wall temperature (°C).

Standard error of the differences (simulations-measurements) for the south wall temperature (°C).

I.7.2. North wall and ceiling surface temperatures

	AXB	APA	CA6	CLI	SER
DTMIN	0.43	0.19	-0.94	-0.28	-1.15
DTMAX	2.87	5.23	1.52	1.84	2.59
MEANDT	1.47	1.88	0.23	1.04	0.61
MIN	13.92	13.64	12.64	13.03	12.39
MAX	23.09	24.87	21.38	22.65	21.70
MEAN	17.92	18.34	16.68	17.49	17.06
AB MEAN DT	1.47	1.88	0.43	1.04	0.77
SQ MEAN DT	1.53	2.07	0.54	1.10	0.95
STDERR	0.44	0.86	0.49	0.38	0.73

Table 13 : comparison with measurement for the north wall temperature. MEASURE cell.

	AXB	APA	CA6	CLI	SER
DTMIN	0.36	0.33	-0.69	-0.26	-1.24
DTMAX	3.07	5.48	1.89	2.34	3.15
MEANDT	1.56	2.03	0.45	1.28	0.75
MIN	14.33	14.00	13.11	13.54	12.74
MAX	23.74	25.80	22.30	23.73	22.85
MEAN	18.51	18.98	17.40	18.23	17.70
AB MEAN DT	1.56	2.03	0.54	1.28	0.92
SQ MEAN DT	1.63	2.22	0.68	1.36	1.13
STDERR	0.47	0.92	0.51	0.45	0.85

Table 14 : comparison with measurement for the north wall temperature. REFERENCE cell.

	AXB	APA	CA6	CLI	SER
DTMIN	-0.10	0.20	-1.22	-0.65	-0.72
DTMAX	2.42	4.38	1.41	1.43	4.06
MEANDT	1.16	1.62	0.05	0.77	1.42
MIN	13.92	13.75	12.71	13.02	12.59
MAX	23.45	25.28	22.04	23.15	24.23
MEAN	18.11	18.58	17.00	17.73	18.38
AB MEAN DT	1.16	1.62	0.39	0.79	1.45
SQ MEAN DT	1.27	1.77	0.48	0.85	1.68
STDERR	0.53	0.71	0.48	0.34	0.88

Table 15 : comparison with measurement for the ceiling surface temperature. MEASURE.

|	AXB	APA	CA6	CLI	SER
DTMIN	0.57	0.69	-0.34	-0.25	-0.77
DTMAX	3.00	5.29	2.32	2.71	5.68
MEANDT	1.75	2.25	0.79	1.50	2.15
MIN	14.36	14.11	13.19	13.54	12.97
MAX	24.13	26.24	23.06	24.29	25.40
MEAN	18.74	19.24	17.77	18.49	19.13
AB MEAN DT	1.75	2.25	0.81	1.50	2.17
SQ MEAN DT	1.81	2.40	0.95	1.59	2.46
STDERR	0.46	0.84	0.54	0.52	1.21

Table 16 : comparison with measurement for the ceiling surface temperature. REFERENCE.

Table 13 to Table 16 show that the differences with the measurements for the two test cell are close together. for the north and ceiling surface temperatures.

We have shown that in most cases. the temperatures (air. mean radiant and enclosure) in test cell were more accurately predicted for the MEASURE cell. than for the REFERENCE cell.

For the south surface temperatures. the REFERENCE cell is more accurately simulated. and the simulations for the other surface temperatures are equivalent for the two test cells.
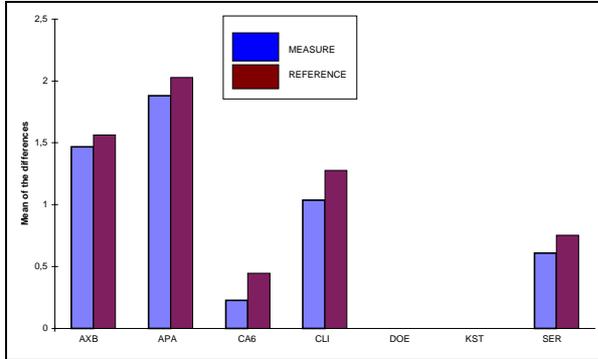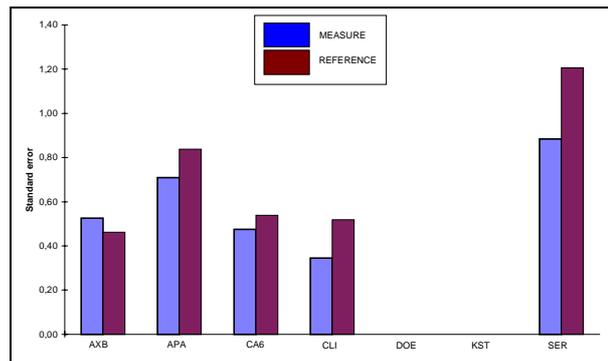

Mean of the differences (simulations-measurements) for the north wall temperature (°C).
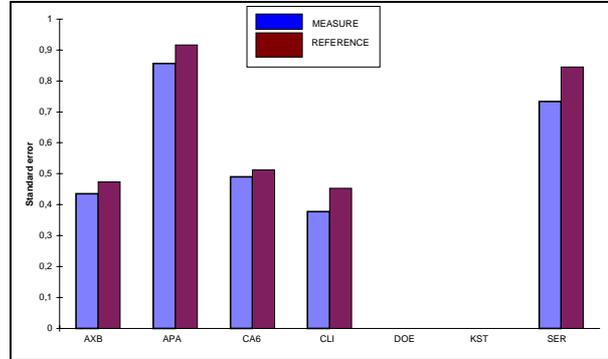
Standard error of the differences (simulations-measurements) for the north wall temperature (°C).
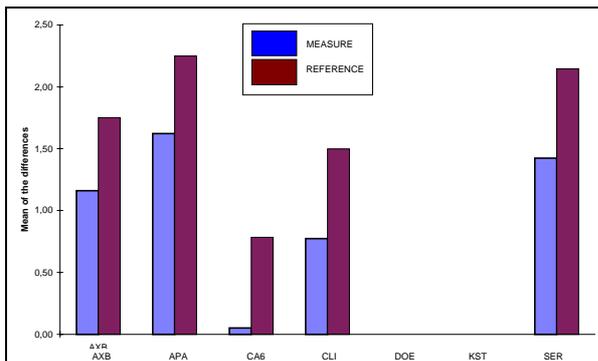
Mean of the differences (simulations-measurements) for the ceiling surface temperature (°C).

Standard error of the differences (simulations-measurements) for the ceiling surface temperature (°C).

I.8.   Surface fluxes

Note : The sums of surface fluxes (hourly integrated values) are given in $kWh.m^{-2}$.

I.8.1.   South surface

	AXB	APA	CA6	CLI	SER
DTMIN	-6.91	-2.10	-59.82	-1.85	1.01
DTMAX	2.56	3.33	44.16	3.51	11.55
MEANDT	-0.07	0.92	1.17	1.35	6.82
MIN	-1.80	1.10	-54.42	0.72	1.92
MAX	7.05	8.20	45.45	9.41	17.89
MEAN	3.64	4.63	4.88	5.06	10.53
AB MEAN DT	1.13	1.16	18.24	1.37	6.82
SQ MEAN DT	1.55	1.39	22.21	1.57	7.11
STDERR	1.55	1.05	22.21	0.79	2.03
SUM	1659.34	2111.50	2225.87	2307.49	4800.33

Table 17 : comparison with measurement for the south wall fluxes. MEASURE cell.

	AXB	APA	CA6	CLI	SER
DTMIN	-5.75	-1.40	-60.16	-0.19	1.66
DTMAX	3.91	3.64	44.94	3.63	13.37
MEANDT	0.72	1.25	1.53	1.72	7.56
MIN	-1.71	1.30	-54.10	0.87	2.30
MAX	8.55	8.60	45.83	9.97	18.75
MEAN	4.39	4.91	5.20	5.38	11.22
AB MEAN DT	1.46	1.41	18.26	1.72	7.56
SQ MEAN DT	1.79	1.67	22.18	1.78	7.91
STDERR	1.64	1.11	22.15	0.47	2.31
SUM	1999.80	2239.60	2370.06	2453.60	5118.25

Table 18 : comparison with measurement for the south wall fluxes. REFERENCE cell.
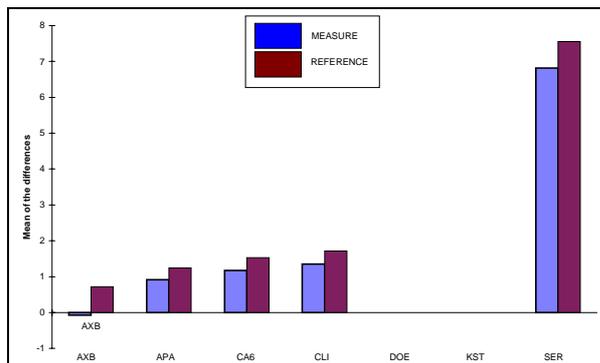
Mean of the differences (simulations-measurements) for the south wall flux.
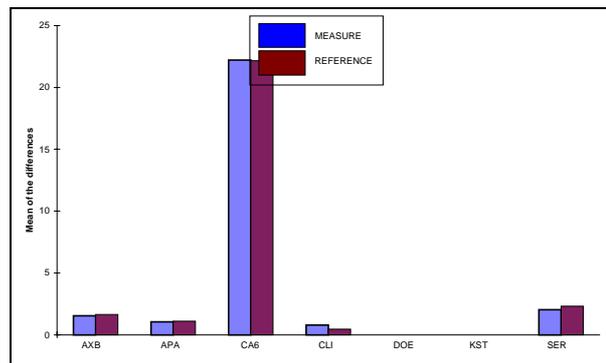
Standard error of the differences (simulations-measurements) for the south wall flux.

SERI-RES predictions for the south wall flux are very inaccurate. with a large mean deviation. For CA-SIS. it could exist a problem about the data given. In fact. the mean error is good for CA-SIS. but it presents a very high standard error. It should be verified if these data are really a flux through the south wall.

I.8.2. North surface

	AXB	APA	CA6	CLI	SER
DTMIN	-7.42	-3.85	-3.53	-2.86	-0.11
DTMAX	2.40	5.34	7.37	4.29	5.86
MEANDT	0.01	1.45	2.09	1.11	3.25
MIN	-1.54	1.60	1.80	-2.49	-0.47
MAX	6.13	6.80	7.41	11.87	15.21
MEAN	2.28	3.72	4.36	3.38	5.52
AB MEAN DT	1.10	1.94	2.51	1.30	3.25
SQ MEAN DT	1.56	2.31	3.00	1.61	3.46
STDERR	1.56	1.80	2.16	1.16	1.19
SUM	1039.11	1696.40	1986.47	1541.80	2515.47

Table 19 : comparison with measurement for the north wall fluxes. MEASURE cell.

	AXB	APA	CA6	CLI	SER
DTMIN	-5.44	-2.95	-3.57	-2.15	0.69
DTMAX	3.66	5.34	7.64	4.66	6.97
MEANDT	0.65	1.63	2.43	1.33	3.62
MIN	-1.61	1.80	1.98	-2.71	-0.37
MAX	7.89	7.30	8.03	12.86	16.35
MEAN	3.02	4.01	4.80	3.70	5.99
AB MEAN DT	1.35	1.92	2.69	1.52	3.62
SQ MEAN DT	1.69	2.28	3.17	1.84	3.92
STDERR	1.57	1.60	2.04	1.27	1.50
SUM	1375.99	1826.60	2190.02	1687.34	2732.66

Table 20 : comparison with measurement for the north wall fluxes. REFERENCE cell.
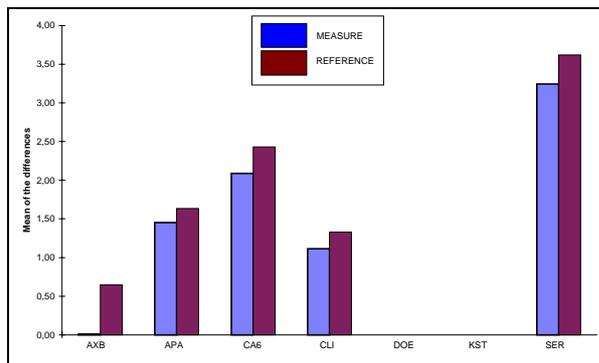
Mean of the differences (simulations-measurements) for the north wall flux.
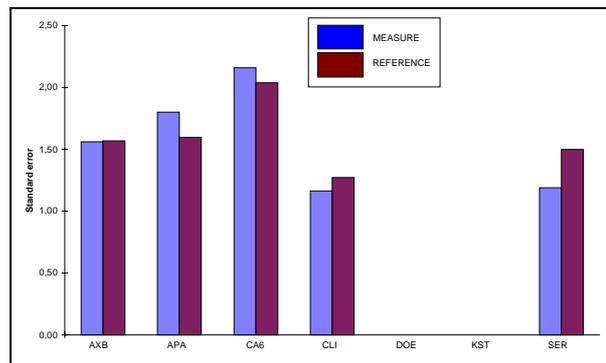
Standard error of the differences (simulations-measurements) for the north wall flux.

Excepted for AXB simulation which give the best mean error. the other programs give less accurate but equivalent results.
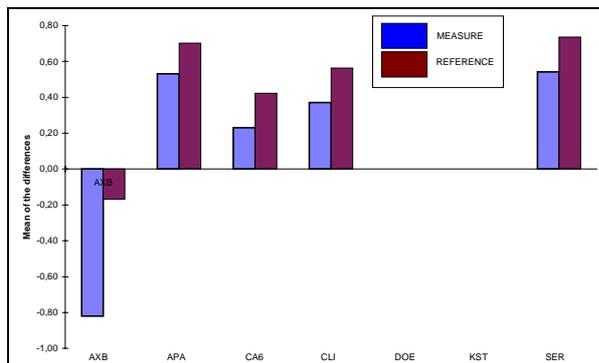
I.8.3. Ceiling surface

	AXB	APA	CA6	CLI	SER
DTMIN	-9.99	-6.37	-7.65	-3.37	-1.16
DTMAX	2.98	5.58	6.18	3.20	2.01
MEANDT	-0.82	0.53	0.23	0.37	0.54
MIN	-5.09	0.60	0.56	-2.06	-4.39
MAX	3.18	3.33	2.56	6.63	10.52
MEAN	0.32	1.67	1.37	1.51	1.68
AB MEAN DT	2.06	2.20	2.45	0.91	0.66
SQ MEAN DT	2.60	2.57	2.86	1.10	0.82
STDERR	2.47	2.51	2.86	1.04	0.62
SUM	145.15	762.02	624.31	688.83	766.23

Table 21 : comparison with measurement for the ceiling surface fluxes. MEASURE cell.

	AXB	APA	CA6	CLI	SER
DTMIN	-7.27	-3.68	-5.27	-2.93	-2.58
DTMAX	2.44	4.09	4.64	3.38	4.19
MEANDT	-0.17	0.70	0.42	0.56	0.74
MIN	-4.97	0.69	0.48	-2.34	-4.80
MAX	4.42	3.62	2.60	7.33	11.38
MEAN	0.93	1.80	1.52	1.66	1.83
AB MEAN DT	1.18	1.42	1.64	0.81	1.26
SQ MEAN DT	1.70	1.70	1.96	1.00	1.57
STDERR	1.70	1.55	1.91	0.83	1.38
SUM	423.03	820.56	692.72	756.83	835.47

Table 22 : comparison with measurement for the ceiling surface fluxes. REFERENCE cell.

Mean of the differences (simulations-measurements) for the ceiling surface flux.
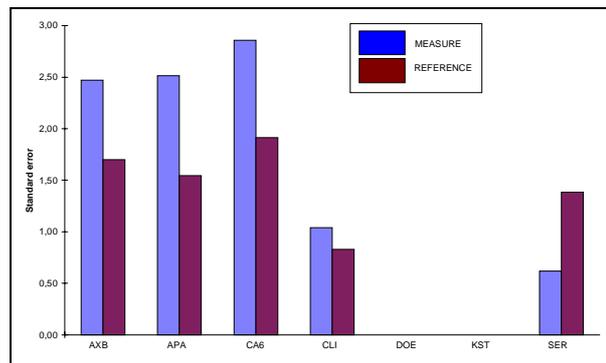
Standard error of the differences (simulations-measurements) for the ceiling surface flux.

The best agreement with empirical data for the ceiling temperature are given by CLIM2000.

Note that the STDERR, for the ceiling surface flux, are in most cases more important for the MEASURE test cell than for the REFERENCE test cell. This result does not appear for the other surface fluxes and temperatures (excepted for the South wall temperature).

I.9.   Summary of the measurements

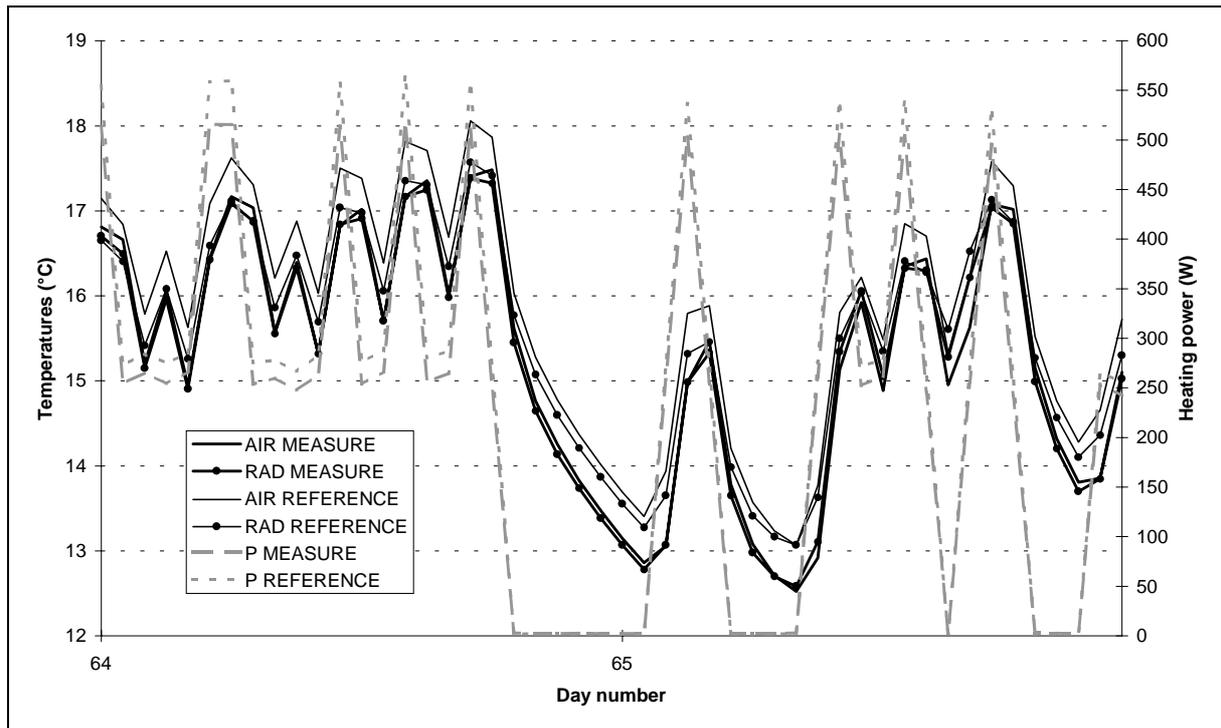To summarise the measurements. we add few plots as wished by some participant.

figure 3 Air and radiant temperature measurements and heating powers for MEASURE and REFERENCE cells.
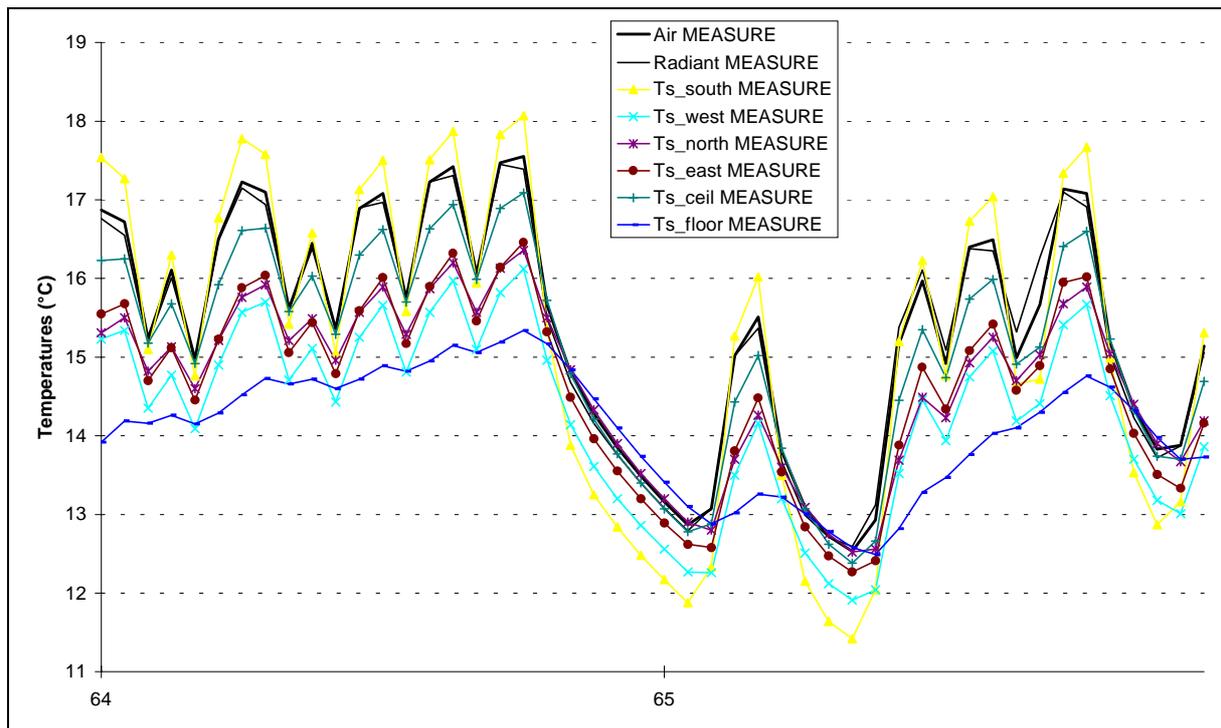

figure 4 Air and radiant temperature measurements and surface temperatures for MEASURE cell.
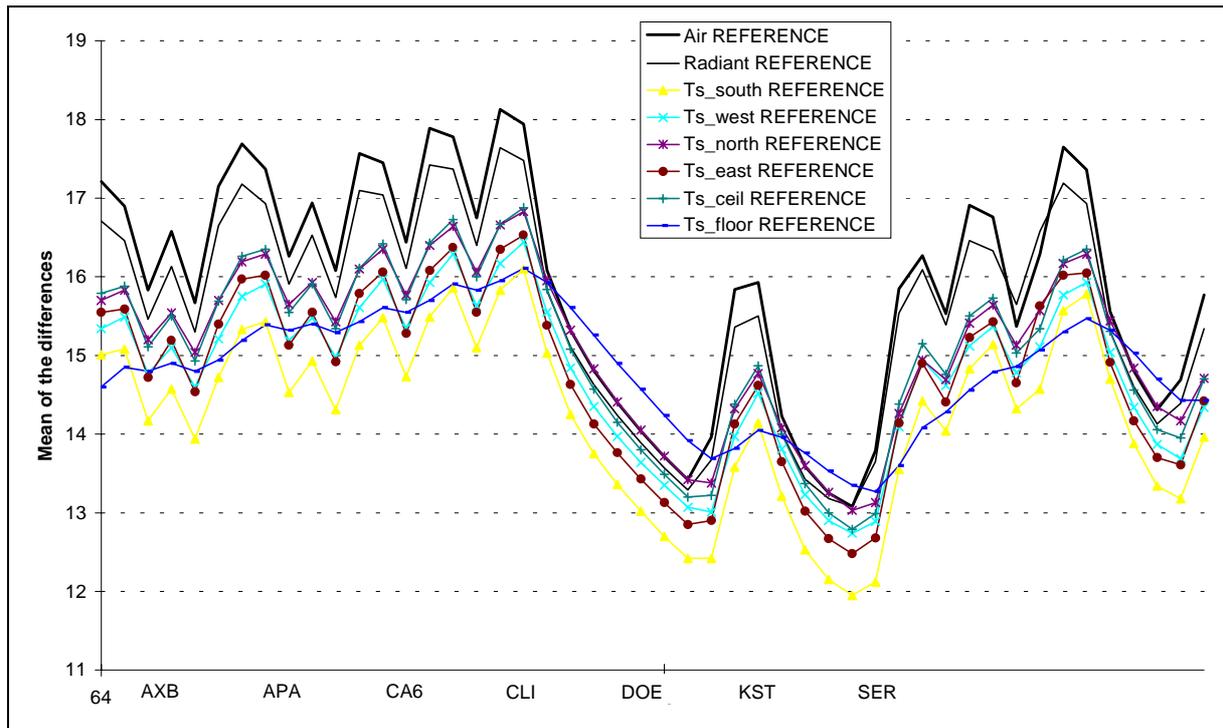
figure 5 Air and radiant temperature measurements and surface temperatures for REFERENCE cell.