# JOSIE-2002

## Performance of 10 SPC-6A ECC Ozone Sondes

## for

## SAGE-III Validation

by

***Herman G.J. Smit and Wolfgang Straeter***

*World Calibration Centre for Ozone Sondes, Research Centre Juelich*
*Institute for Chemistry and Dynamics of the Geosphere: Troposphere (ICG-II)*
*P.O. Box 1913, 52425 Juelich, Germany,*
*(Email: h.smit@fz-juelich.de / Phone: +49-2461-613290 / Fax: +49-2461-615346)*

# Table of Contents

# 1 Introduction

Ozone sondes are small, lightweight and compact balloon borne instruments, developed for measuring the vertical distribution of atmospheric ozone up to an altitude of about 30-35 km (*Smit*, 2002). Each ozone sounding is made with a new instrument, which has therefore to be characterized well prior to flight. Consistency of instruments with regard to their quality and characteristics is a pre-requisite to assure consistent sonde measurements. (*SPARC-IOC-GAW Assessment of Trends in the Vertical Distribution of Ozone*, 1998, This can be achieved by intercalibration and intercomparison.. Therefore, the environmental simulation facility at the Research Centre Juelich [*Smit et al.*, 2000, http://www.fz-juelich.de/icg/icg-ii/esf/ ] is established as World Calibration Centre for Ozone Sondes (WCCOS) to assess the performance of the different types of ozone sondes that are commonly used within GAW (=Global Atmosphere Watch). The simulation chamber enables control of pressure, temperature and ozone concentration and can simulate flight conditions of ozone soundings up to an altitude of 35 km., whereby an accurate UV-photometer (OPM) serves as a reference (*Smit et al*, 2000).

Since 1996 several JOSIE (= Juelich Ozone Sonde Intercomparison Experiment; http://www.fz-juelich.de/icg/icg-ii/josie ) experiments to assess the performance of ozone sondes of ECC-type (*Komhyr*, 1969) from different manufactureres have been conducted at the calibration facility. JOSIE (*Smit and Kley*, 1998) have clearly shown that a regular quality check of the instrumental performance of the major sonde types (QA-Manufacturers) is essential. JOSIE-2002 is dedicated to the quality assurance of the instrumental performance of ECC (Electrochemical Concentration Cell) sonde used for the SAGE-III validation program . The primary goal is to do a quality check of the instrumental performance over a sample of 10 randomly selected ECC-sondes from a batch of 100 ECC sondes which will be used for the SAGE-III validation in the course of 2002. All tested ECC-sondes were SPC-6A type, manufactured by Science Pump Corporation, New Jersey, USA. The selected sondes were brand new, in the original packing of the manufacturer, while the manufacturing date was after June 2001. In this technical report a detailed overview of the JOSIE-2002 results of the sonde performance experiments are presented.

# 2 Experimental Design

In three simulation experiments at the WCCOS the 10 ECC ozone sondes, type SPC-6A of Science Pump Incorporation were tested between May 27. and June 3., 2002. (See Table 1)The strategy for the preparation and handling of the sondes has been briefly as follows:

(1) All 10 ECC-sondes have been operated according the guidelines documented in: “Provisional Standard Operating Procedures (SOPs) for ECC Ozonesondes up to 30 km (Two Manufacturers)” established unanimously by “Ozonesonde SOP Meeting of Experts” at Geneva, 30 April – 4 May 2001 (See Annex A)

(2) All 10 ECC-sondes have been prepared in the laboratory prior to their simulation runs using the same equipment

(3) All 10 ECC-sondes were using the same interfacing electronics to the data aquisition system of the facility.

(4) Preparation of the sondes, simulation runs, data processing, data validation, data analysis and data evaluation have been carried out by the staff of the facility

(5) Sensing solutions (CATHODE: 1% KI, full buffer and ANODE: Saturated KI) prepared according the receipt given in Komhyr handbook (1986). The solutions (in dark bottles) are stored at about 4-6 Celsius in a (dark) refrigerator. Before using the sensing solutions they were at room temperature.

(6) Preparation 3-7 days in advance, prior to simulation according the provisional SOPs (See Annex A)

(7) Storage of the prepared sonde(s) in a clean plastic bag at a dry, dark place at room temperature.

(8) Preparation at the day of the simulation according provisional SOPs for preparation on day of flight"(See Annex A). Condition was that the period between the end of the preparation and the start of the simulation is not longer than 4 hours.

(9) Interfacing electronics between ECC-sondes and data acquisition system used is the standard interface developed at the facility which had been deployed successfully during the various JOSIE campaigns. Recorded sonde parameters are cell current, pump temperature (internal), pump motor current and the temperature at the air inlet tube of the sonde.

(10) The simulation has started at a pressure of 1000±2hPa and a test room temperature 20±2$^o$C: the pump motors of the sonde had been turned on.

(11) Between pump activation and start of simulation run a time period of at least 5 minutes for-running time of the sondes (maximum of about 15 minutes)

(12) Simulation profile of pressure, temperature and ozone concentration at typical mid-latitude conditions according the profile also used during JOSIE-96 (*Smit and Kley*, 1998)

(13) Simulation of an ascent profile at a constant ascent velocity of 5 m/s started at a pressure of 1000 hPa down to 5 hPa.

(14) To investigate the response time and the background characteristics of the sondes during the simulation run ozone was set temporarily (period ≈ 150-200 sec) to zero level. This zero-step response has been performed two times during the simulation run: Once in the tropospheric part at a simulated altitude between 4 and 7 km (simulation time between 900 and 1300 second) and once in the stratosphere at an altitude between 16 and 19 km (simulation time between 3500 and 4000 second)

(15) High graded purified synthetic air has been used for the sonde preparation as well as for the ozone profile simulation

(16) During ground preparation the downward response time and conversion efficiency of the sonde has been determined.

(17) After the simulation the remaining sensing cathode solution, the background current, the downward response time and conversion efficiency of the sonde has been determined again.

***Table 1:*** *Overview simulation experiments of JOSIE 2002 as part of SAGE-III validation*

| Sim. Nr. | Sim Date | Sonde Nr | Sonde Code | Total Ozone Column ECC [DU] | Total Ozone Column OPM [DU] | Total Ozone Norm.Factor OPM/ECC |
|---|---|---|---|---|---|---|
| 112 | May 27., 2002 | 1 | 6A7606 | 370.3 | 356.2 | 0.96 |
| 112 | May 27., 2002 | 2 | 6A7607 | 380.0 | 356.2 | 0.94 |
| 112 | May 27., 2002 | 3 | 6A7608 | 374.1 | 356.2 | 0.95 |
| 112 | May 27., 2002 | 4 | 6A7609 | 375.4 | 356.2 | 0.95 |
| 113 | May 28., 2002 | 5 | 6A7610 | 392.8 | 388.2 | 0.99 |
| 113 | May 28., 2002 | 6 | 6A7611 | 395.4 | 388.2 | 0.98 |
| 113 | May 28., 2002 | 7 | 6A7612 | 414.5 | 388.2 | 0.94 |
| 113 | May 28., 2002 | 8 | 6A7613 | 412.5 | 388.2 | 0.94 |
| 114 | June 3., 2002 | 9 | 6A7614 | 379.2 | 351.2 | 0.93 |
| 114 | June 3., 2002 | 10 | 6A7615 | 358.3 | 351.2 | 0.98 |

# 3 Data Processing

## 3.1 Basic Operating Formulas

In the ECC-ozone sensor each molecule of ozone forced through the sensing solution in the electrochemical cell generates an electrical current of approximately two electron in the external circuit. In other words, the electrical current generated in the electrochemical cell is directly related to the uptake rate of ozone in the sensing solution and is determined by:

[E-1] $$\mathbf{P_{O3,\,Sonde} = 0.04307 * \frac{T_{Pump}}{\Phi_{V,\,Pump}} * I_{O3,\,Sonde}}$$

$P_{O3,Sonde}$ = Pressure of ozone, [mPa]
$T_{Pump}$ = Temperature of air sampling pump, [K]
$\Phi_{V,Pump}$ = Volumetric flow rate of air sampling pump, [ml/s]
$I_{O3,Sonde}$ = Electrical current due to sampled ozone, [μA]

The overall electrical current, $I_{M,SONDE}$ , measured by the sonde may be a superposition of the ozone current, $I_{O3,SONDE}$ and the background current, $I_{B,SONDE}$:

[E-2] $$I_{O_3,Sonde} = I_{M,Sonde} - I_{B,Sonde}$$

$I_{O3,Sonde}$ = Electrical current measured by ozone sensor due to ozone, [μA]
$I_{B,Sonde}$ = Electrical current measured by ozone sensor due to background, [μA]

## 3.2 Data Reduction and Correction Methods

All sonde data were processed and corrected according to the operating procedures specified by *Komhyr* (1986), summarized in Table 2.

***Table 2:*** *Corrections(BG2) used for the processing of the sounding profile data according Komhyr [1986]. (*) Exception is that the internal pump temperature instead of the external pump (=box) temperature has been used (see text below).*

| Background Correction | Temperature Pump | Pumpflow Corrections |
|---|---|---|
| Before exposure to ozone<br>Pressure dependent | Internal (*) | Pump Efficiency: Komhyr 1986 |

Exception from Komhyr 1986 is that instead of the external pump (i.e. box) temperature the internal pump temperature has been measured and applied in equation E1 to determine the ozone pressure. The difference between internal and external pump temperature can achieve values varying between 0 and 8 K in the course of the sounding as shown in Figure 1.

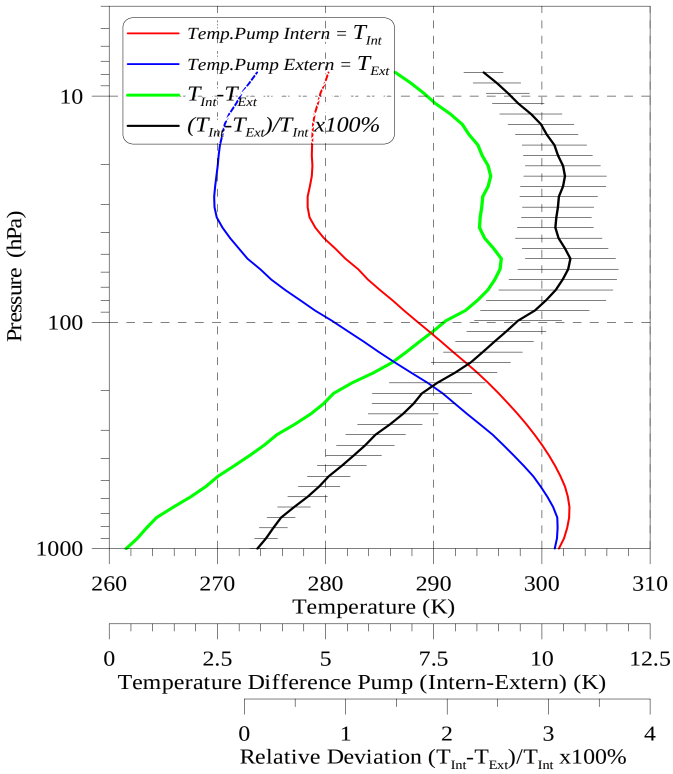



***Figure 1:*** *Internal (red solind line) and external (blue solind line) pump temperature as a function of pressure obtained from 6 simulation experiments made during JOSIE 2000 using SPC-6A type ECC-sondes. Difference internal and external pump temperature ( green line) and relative deviation (black line) with horizontal bars represents ± one standard deviation from the mean*

The background is treated as being pressure dependent which means that this offset gradually declines with decreasing pressure and is vanishing small in the upper troposphere and above [*Komhyr*, 1986].

The volumetric flow of the gas sampling pump of each sonde is individually measured before flight as part of the pre-flight preparation procedure. At ambient air pressures below about 200 hPa the efficiency of the gas sampling pump decreases which is corrected for by applying an average pump efficiency correction table as function of ambient pressure reported by *Komhyr* [1986] and listed in Table 3.

***Table 3:*** *Pumpflow corrections at low pressures according Komhyr 1986.*

| **Pressure (hPa)** | **Correction after Komhyr 1986 (Handbook) (2.5 cm3 cathode solution)** |
|---|---|
| 1000 | 1.000 |
| 150 | 1.008 |
| 100 | 1.010 |
| 70 | 1.012 |
| 50 | 1.015 |
| 30 | 1.024 |
| 20 | 1.033 |
| 15 | 1.041 |
| 10 | 1.054 |
| 7 | 1.070 |

# 4. Results and Discussion

## 4.1 Introduction

For the simulation runs a typical mid-latitude profile for 40 $^{o}$N-50$^{o}$N with a tropopause height of about 12 km (*Smit and Kley*, 1998, *Smit et al.*, 2000). Pressure and temperature in the simulation chamber were regulated to follow an ascent velocity of 5m/s up to an altitude corresponding to about 33 km. The pressure inside the test room of the simulation chamber has been measured with three different capacitive manometers: 1-1000 hPa, 0-100 hPa, and 0.1-12.5 hPa ( accuracy of each manometer better than +/-0.5 % of their reading). Spatial temperature variations of about 2-5 Kelvin inside the test room depending of the air pressure can be expected. Therefore, two different air temperatures, measured inside the Environmental Simulation Chamber, are recorded: temperature inside chamber measured with a Pt100 located at ozone manifold and the actual temperature measured (by Pt-100) at the individual air intake of each sonde, just exterior its styrofoam box. The dual beam UV-Photometer, developed by *Proffitt et al.* (1983) has a precision of ±0.025 mPa and relative accuracy of ±2% (Z=0-25km) and ±3.5% (Z=30-35 km) (*Smit et al.*, 2000).

As independent and common time scale the system time of the data acquisition system is used for the processing of the simulation data. Synchronously with the system time there is supported the simulation time which is set to zero at the start of the simulation experiment. The data were made equidistant in time (system time) with a time step of 2.5 seconds. The simulated altitude had been calculated step by step as the cumulative sum of the height difference between two successive pressure levels using the hydrostatic equation(1).

The individual results of the 10 tested ECC-sondes during the 3 simulation runs are presented in Appendix B of this report in the form of a panel of four diagrams. The upper left diagram displays the complete individual vertical profiles of measured ozone by sonde (K86-correction) & UV-Photometer, air temperature and internal pump temperature while the upper right diagram presents the tropospheric in more detail. The lower left and right diagrams show the corresponding vertical profiles of the absolute deviations and relative deviations of ozone measured by the sonde compared with the UV-Photometer as reference, respectively. Excluded are time response parts (one in troposphere) and (one in stratosphere) which are replaced by linear interpolation between begin and end values of the individual reported parameters. The time response parts are reported separately in section 4.3. The results of the individual profiles show that in general the tested sondes track the simulated ozone profiles very well and are in good agreement with the reference.

## 4.2 Total Ozone Normalization as Screening Test

The integrated column of ozone measured by the UV-photometer during the simulation of the ascent profile serves as a reference for the total ozone normalization. The total ozone normalization factor is defined as the ratio of the integrated columns of ozone obtained from the UV-photometer and the sonde respectively (See Table 1). Although the total ozone normalization factor is not used to correct the sonde profile, it provides an excellent screening test for unreliable soundings using the criterion, that in field operation the normalization factor should not deviate more than about 10-20 percent from unity. However, the normalization factor is not a guarantee that the profile is correct. Table 1 shows the total ozone column normalization factor for the BG2-corrected ozone sonde data, which is the ratio of the integrated ozone profile measured by the UV-photometer and sonde, for each sonde tested plus the average factor (incl. standard deviation) for each sonde type. All individual normalization factors for the standard corrected data range between 0.93 and 0.99. The average normalization factor obtained for the 10 tested SPC-6A sondes is 0.96±0.02.

## 4.3 In-Flight Time Response

To investigate the response time and background characteristics of the different ozone sondes in the troposphere as well as in the stratosphere during each simulation run, ozone was temporarily set to zero level. The individual time response profiles of the four simultaneously tested sondes are for each in-flight response test shown in Annex C. From the individual response curves the

---

[1] Hydrostatic equation is defined as $\Delta Z = \frac{R}{g} * \frac{T_{i+1} + T_i}{2} * Ln\left(\frac{P_i}{P_{i+1}}\right)$ , whereby R= gas constant, g= gravity constant, T= temperature, P= pressure and indices i and i+1 are representing the two succeeding pressure levels

response time(2) and the observed offset at zero ozone of each sonde has been estimated. For the sake of clarity the presented sonde data were already corrected for background according Table 2.

In general, the time response in upward as well as in downward direction is rather good for all tested sondes. The response time of both ECC-sonde types is within 20-30 seconds, which corresponds at an ascent velocity of 5m/s to an altitude resolution of about 100-150 m. During the periods (200-300 s) of zero ozone none of the tested sondes returned to zero. Typical offset values of 0.10 mPa in tropospheric part A and 0.30 mPa in stratospheric part B respectively were observed. Based on the relative short response time of 20-30 seconds the ozone sensor signal should give values far below the observed offset-values. In the stratospheric part the offsets of each sonde is for both sonde types even substantial larger than in the corresponding tropospheric part of the simulated ozone profile. This may indicate to an offset which depends on the ozone exposure of the ECC-ozone sensor. However, at present the origin of these offset signal is not understood (*Johnson et al.*, 2002)

## 4.4 Precision, Bias and Accuracy

To address precision and accuracy of the SPC6A-sonde the average plus/minus one standard deviation of the ozone pressure deviations and the relative deviations of the individual sonde readings from the UV-photometer obtained from the 10 tested ECC-sondes as a function of altitude are presented in Figure 2. The precision is determined by the standard deviation of the average of the sonde deviations (= bias) with the UV-Photometer, while the accuracy is determined as the sum of sonde precision and the absolute value of its bias with the UV-Photometer. A survey of the SPC6A-sonde bias, its precision and accuracy are listed in altitude bins of 5 km in Table 4 on ozone pressure scale and on relative scale with regard to UV-Photometer

The 10 tested SPC6A sondes show an excellent precision throughout the entire profile. In the troposphere the precision is better than ±2% and in the stratosphere below 30 km altitude the precison is about ±3% , while slightly increasing to ±(4-5)% at altitudes above 30 km. On a relative scale the SPC6A sondes show a positive bias which is varying between 4% and 7% in the tropopshere, between 2 and 5% in the stratosphere. The relative accuracy of the SPC6A sonde is about ±(6-8) % and majorly determined by the contribution of the positive bias. This bias is about (1-3)% higher compared with results obtained from SPC6A sondes tested during previous JOSIE campaigns in 1996 (Smit and Kley), 1998 and 2000 (*Smit*, private communication, 2003). However, in general the obtained results are in good agreement with results obtained for SPC6A sondes obtained during previous JOSIE campaigns.

All the individual results of the 10 ECC-sondes of SPC6A type tested in the scope of SAGE-III validation are in digitized form available on a CD-rom (JOSIE 2002). Description of the data files is given in Annex D.

---

[2] The response time $\tau_{Res}$ on a downward response is defined as the time required, that the signal S(t) decayed by a factor 1/e of its initial value S(0) , whereby $S(t) = S(0) * Exp[-t/\tau_{Res}]$

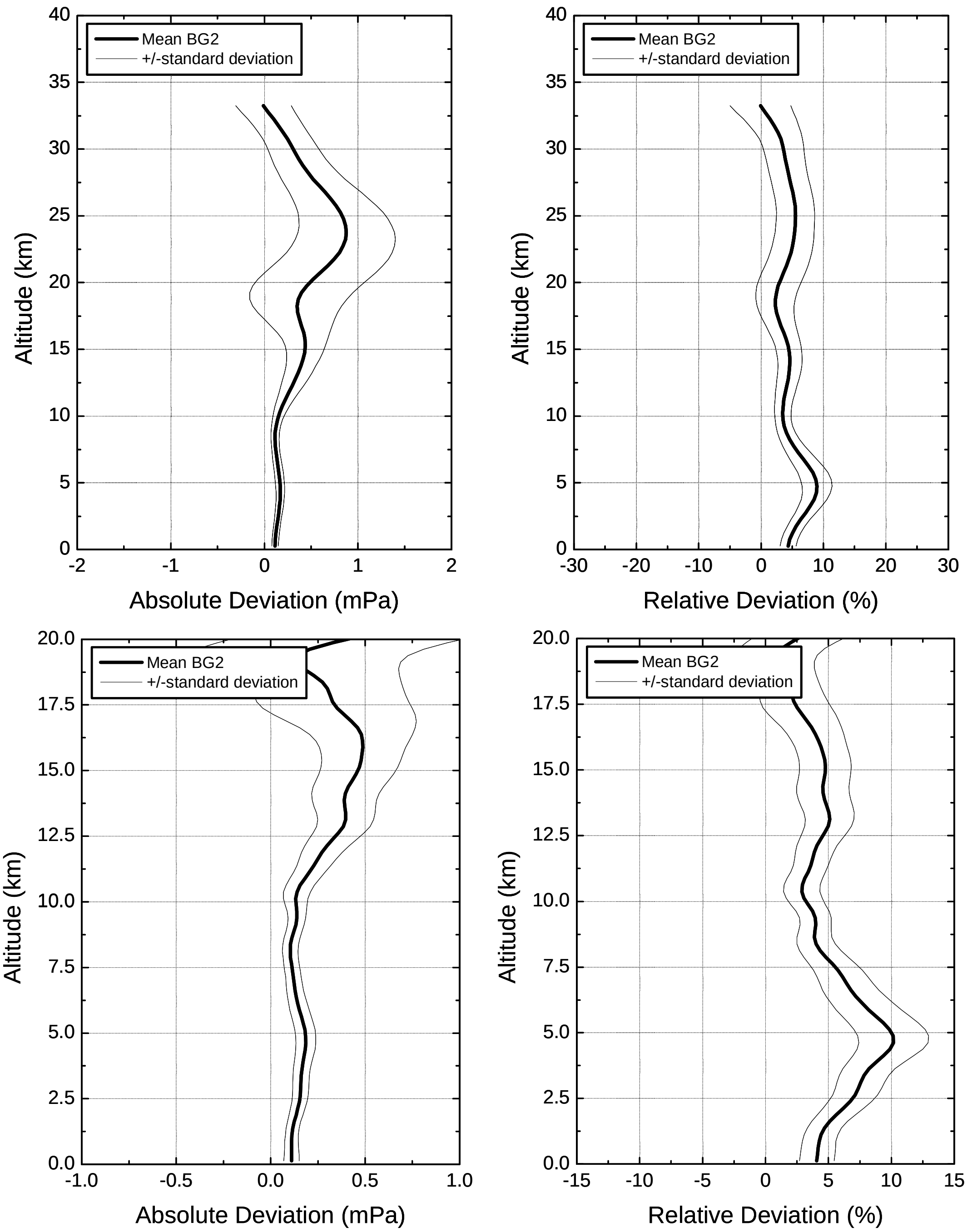



***Figure 2:*** *JOSIE-2002 overal comparison of tested SPC-6A ozone sondes. Absolute and relative deviations of ozone sonde from UV-photometer readings presented as averages (± one standard deviation) of the ozone pressure deviations (upper left and lower left diagram) and as relative deviations (upper right and lower right diagram). Upper diagrams given entire profile while lower diagrams given the tropospheric & lower stratospheric part of the profile. BG2 correction after Komhyr 1986 with exception of applying internal pump temperature instead of external pump (=box) temperature*

***Table 4:*** *JOSIE-2002 comparison SPC-6A ozone sondeswith UV-photometer(OPM): Absolute and relative deviations of ozone sonde from UV-photometer readings given as averages over 5 km atititude bins (± one standard deviation=precision) of the ozone pressure deviations and as relative deviations. The numbers between brackets is the estimated accuracy of the tested ECC-sondes of type SPC-6A.*

| *Altitude Range* [km] | *Difference Ozone Pressure* $P_{O3,ECC}-P_{O3,OPM}$ [mPa] | *Relative Difference Ozone Pressure* $[P_{O3,ECC}-P_{O3,OPM}]/P_{O3,OPM}$ x100 [%] |
|---|---|---|
| 30-33 | 0.17 ±0.27<br>(±0.44) | 2.2 ±4.0<br>(±6.2) |
| 25-30 | 0.57 ±0.36<br>(±0.93) | 4.7 ±3.1<br>(±7.8) |
| 20-25 | 0.76 ±0.50<br>(±1.26) | 4.7 ±3.3<br>(±8.0) |
| 15-20 | 0.40 ±0.40<br>(±0.80) | 3.0 ±2.7<br>(±5.7) |
| 10-15 | 0.31 ±0.13<br>(±0.44) | 4.1 ±1.7<br>(±5.8) |
| 5-10 | 0.13 ±0.05<br>(±0.18) | 5.9 ±1.9<br>(±7.8) |
| 0-5 | 0.14 ±0.04<br>(±0.18) | 6.7 ±1.7<br>(±8.4) |

# References

Johnson, B.J., S.J. Oltmans, H. Vömel, H.G.J. Smit, T. Deshler, and C. Kröger, ECC Ozonesonde pump efficiency measurements and tests on the sensitivity to ozone of buffered and unbuffered ECC sensor cathode solutions, J. Geophys. Res., 10. 1029/2001JD000557, **2002.**

Komhyr, W.D., Electrochemical concentration cells for gas analysis, Ann.Geoph., 25, 203-210, **1969**.

Komhyr, W.D., Operations handbook - Ozone measurements to 40 km altitude with model 4A-ECC-ozone sondes, NOAA Techn. Memorandum ERL-ARL-149, **1986**.

Proffitt, M.H., and R.J. McLaughlin, Fast response dual-beam UV-absorption photometer suitable for use on stratospheric balloons, Rev. Sci. Instrum., 54, 1719-1728, **1983.**

Smit, H.G.J., and D. Kley, Jülich Ozone Sonde Intercomparison Experiment (JOSIE), WMO Global Atmosphere Watch report series, No. 130 (Technical Document No. 926), World Meteorological Organization, Geneva, **1998**.

Smit, H.G.J., Ozone sondes, In: "Encyclopedia of Atmospheric Sciences", J. Holton, J. Pyle, and J. Curry (Eds.), Academic Press, London, **2002**.

SPARC-IOC-GAW Assessment of Trends in the Vertical Distribution of Ozone, SPARC report No.1, WMO Global Ozone Research and Monitoring Project Report No. 43, **1998**.

WMO (=World Meteorological Organization) , Scientific Assessment of Ozone Depletion: 1998, Global Ozone Research and Monitoring Project - Report No. 44, World Meteorological Organization, Geneva , **1999**.

# Annex-A

## Provisional Standard Operating Procedures (SOPs) for ECC Ozonesondes up to 30 km (Two Manufacturers)

Preparation and test procedures were established unanimously by
"Ozonesonde SOP Meeting of Experts"
Geneva, 30 April – 4 May 2001

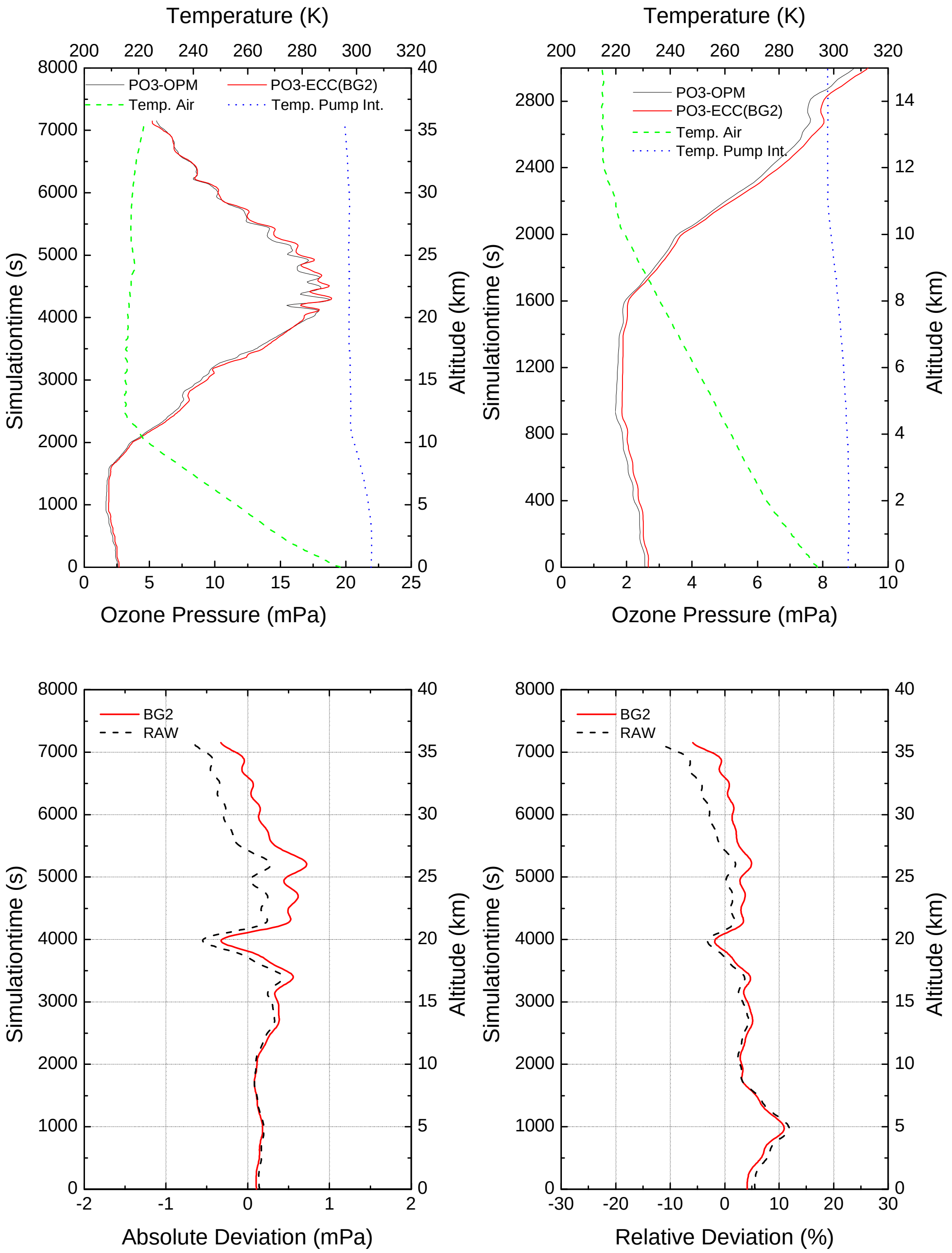
**Unfortunately at present still not released for public use**

# Annex B:

## Results of Individual Tested SPC6A-ECC Ozone Sondes

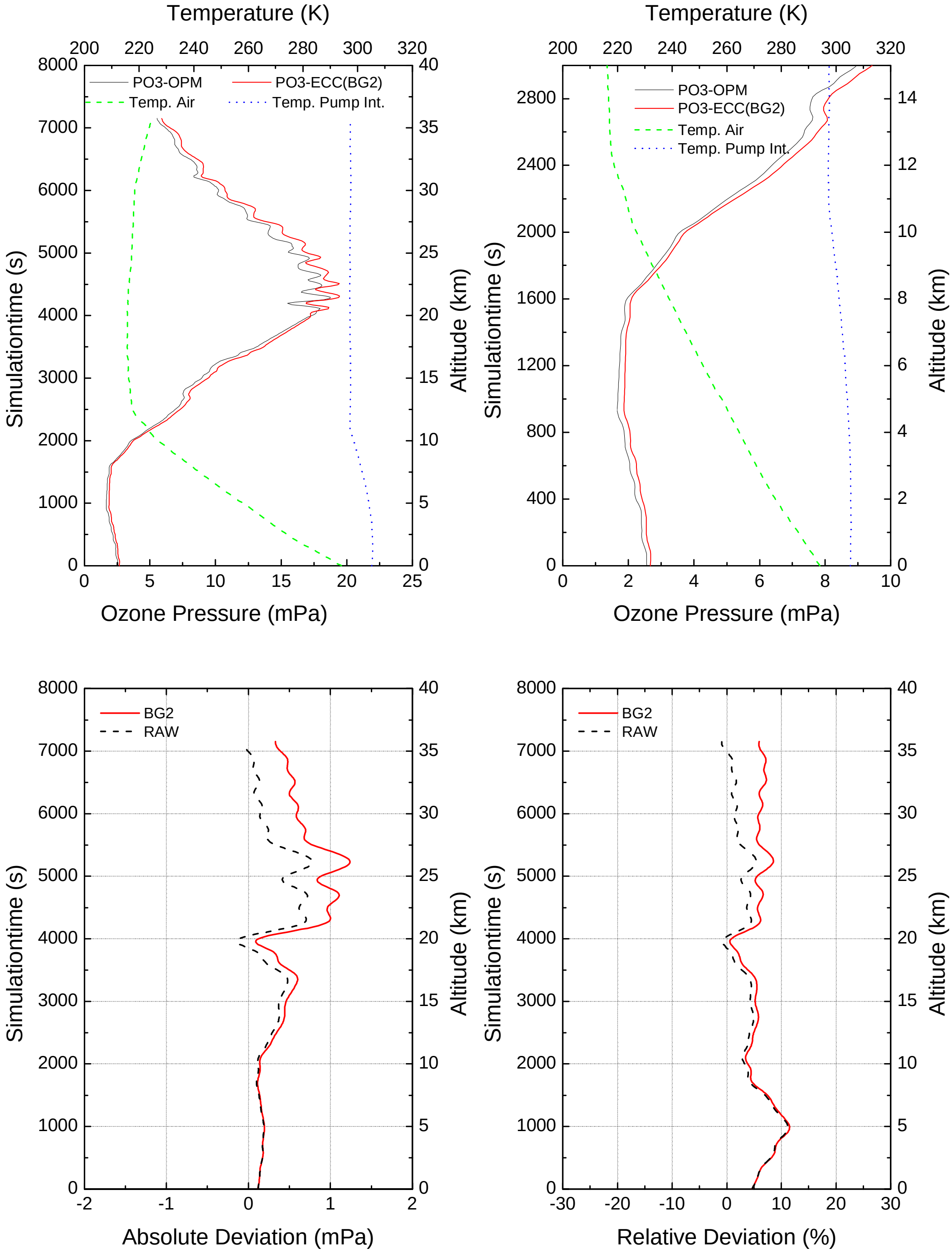
# JOSIE-2002

Sonde No.=01 Sonde Type=SPC-6A Sol. Type=1A Sim. No.=112



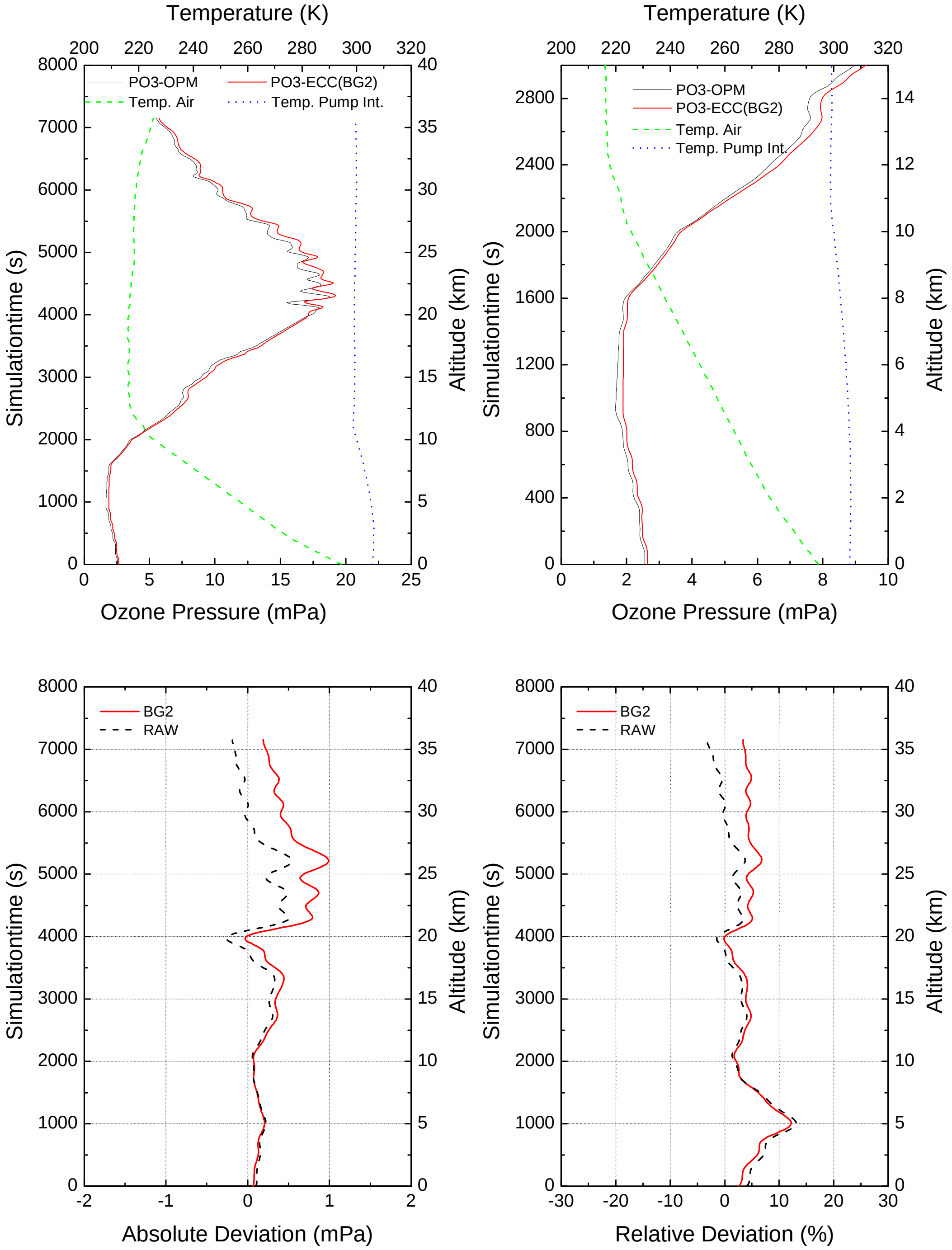
# JOSIE-2002

Sonde No.=02 Sonde Type=SPC-6A Sol. Type=1A Sim. No.=112



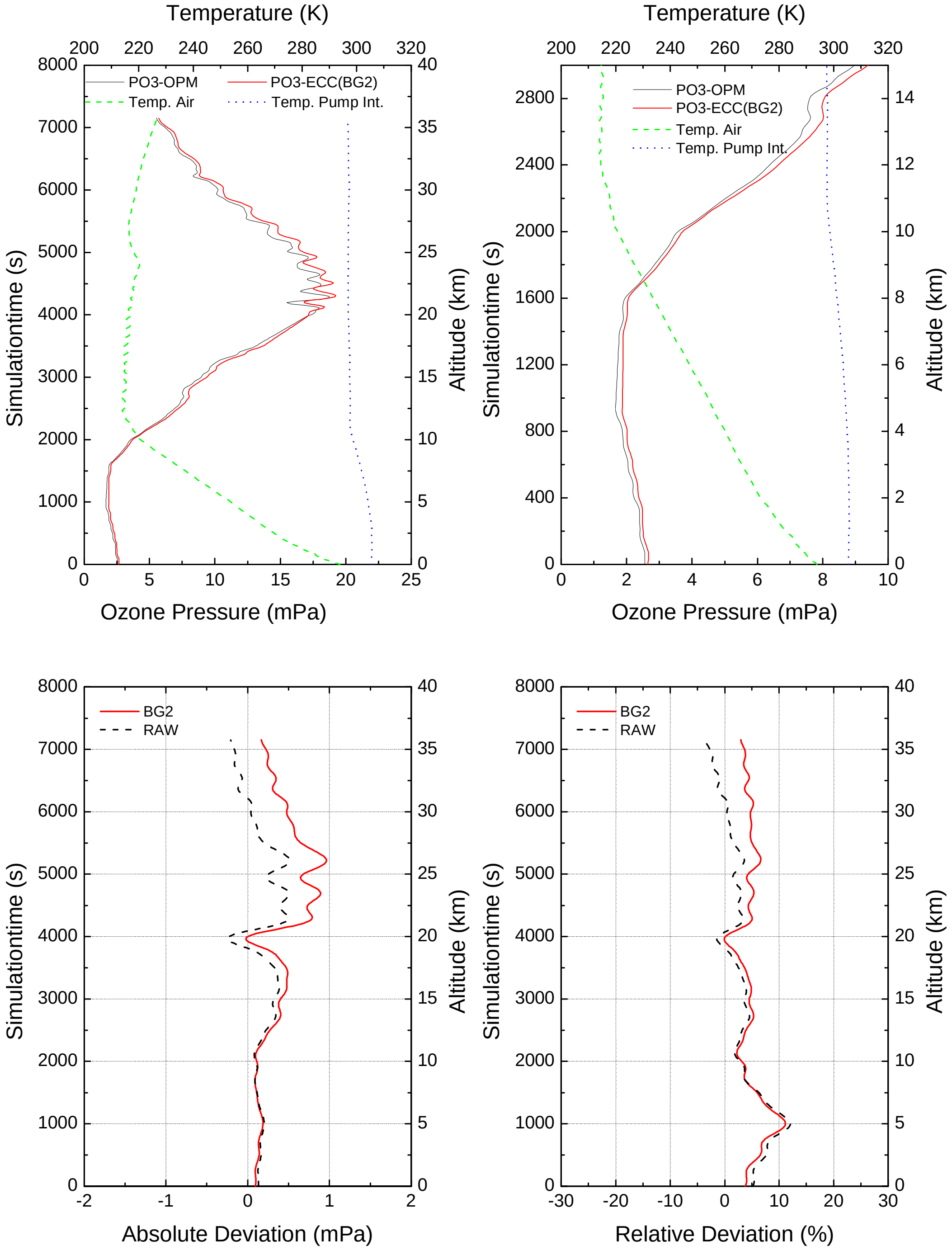
# JOSIE-2002

Sonde No.=03 Sonde Type=SPC-6A Sol. Type=1A Sim. No.=112



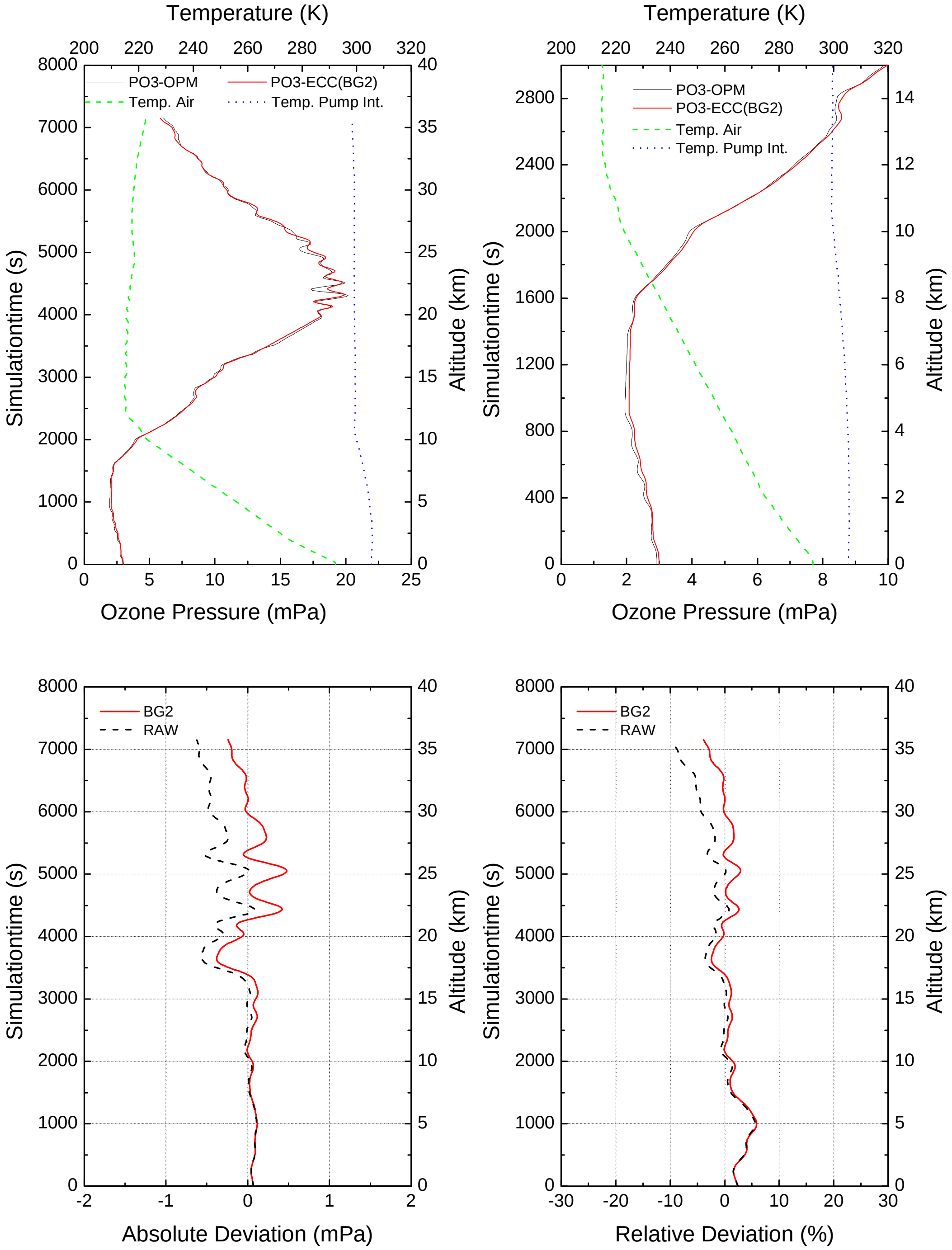
# JOSIE-2002

Sonde No.=04    Sonde Type=SPC-6A    Sol. Type=1A    Sim. No.=112



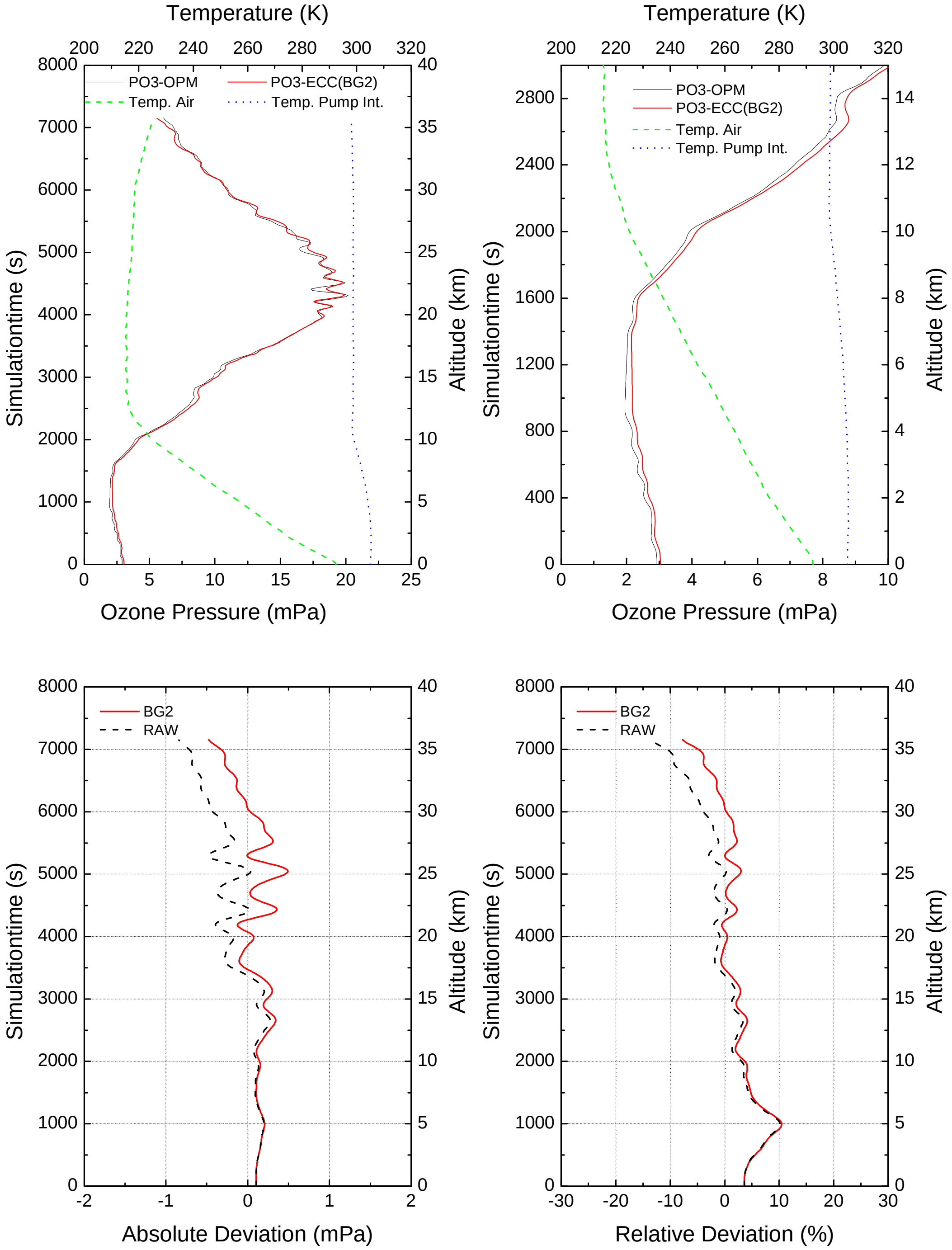
# JOSIE-2002

Sonde No.=05 Sonde Type=SPC-6A Sol. Type=1A Sim. No.=113



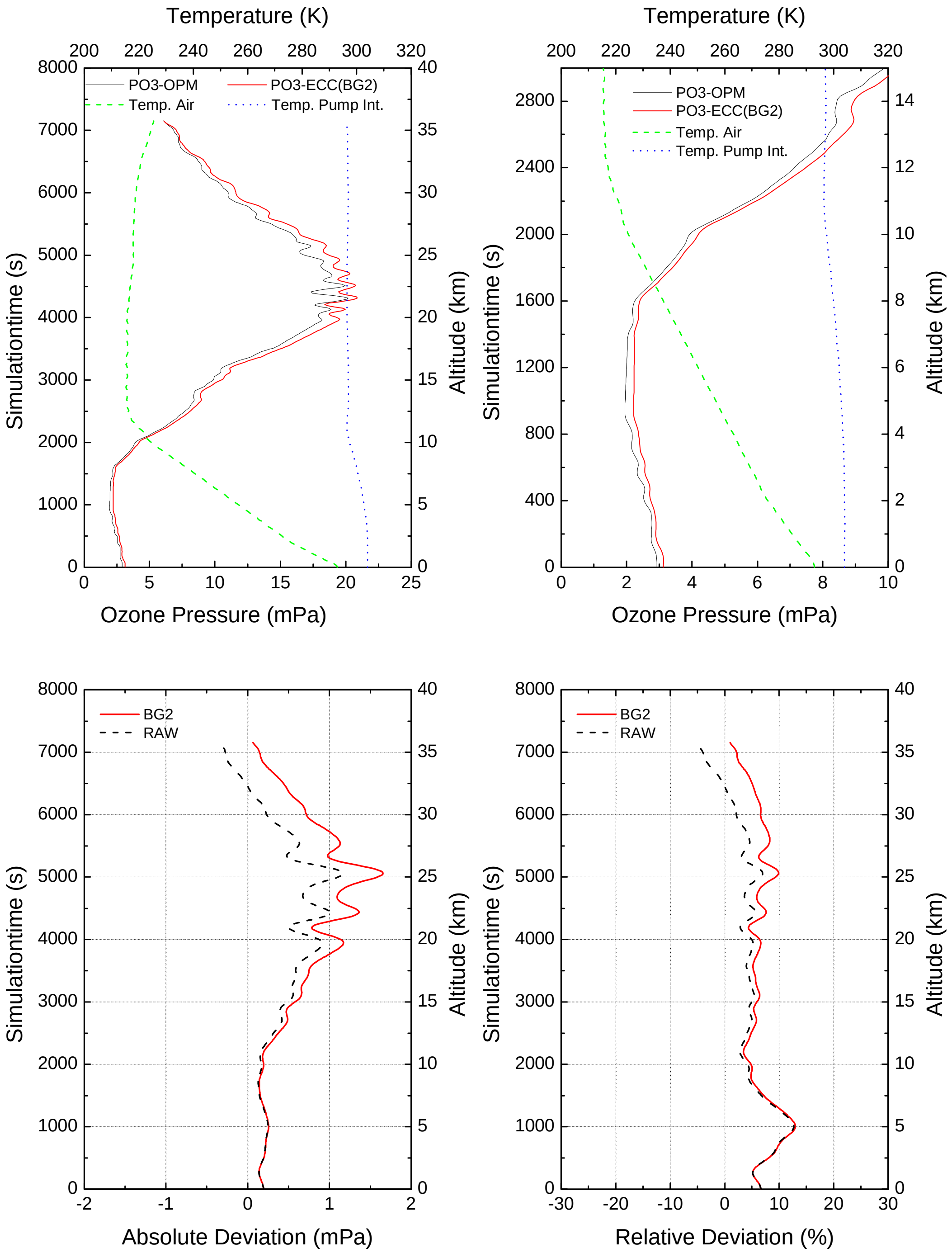
# JOSIE-2002

Sonde No.=06 Sonde Type=SPC-6A Sol. Type=1A Sim. No.=113



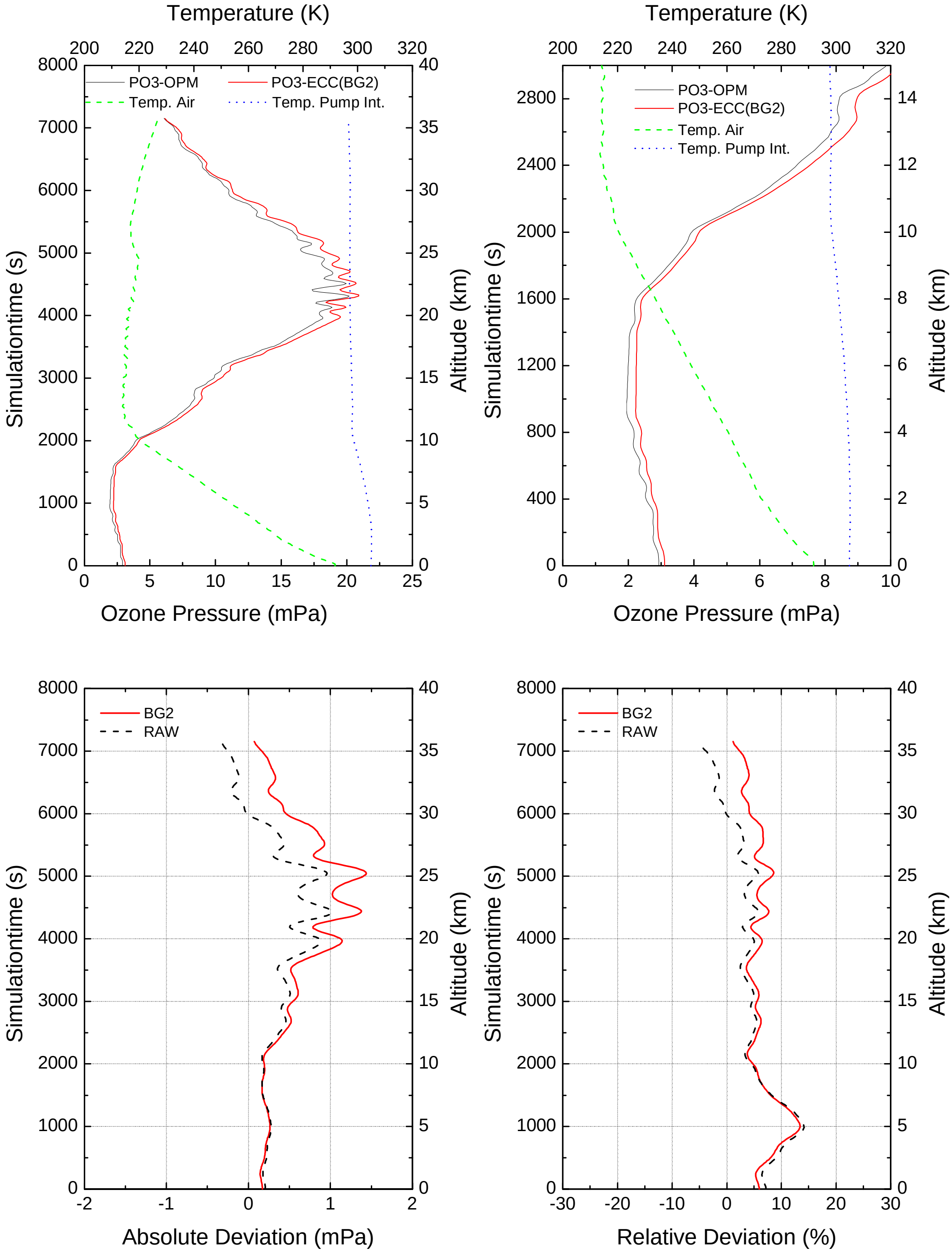
# JOSIE-2002

Sonde No.=07 Sonde Type=SPC-6A Sol. Type=1A Sim. No.=113



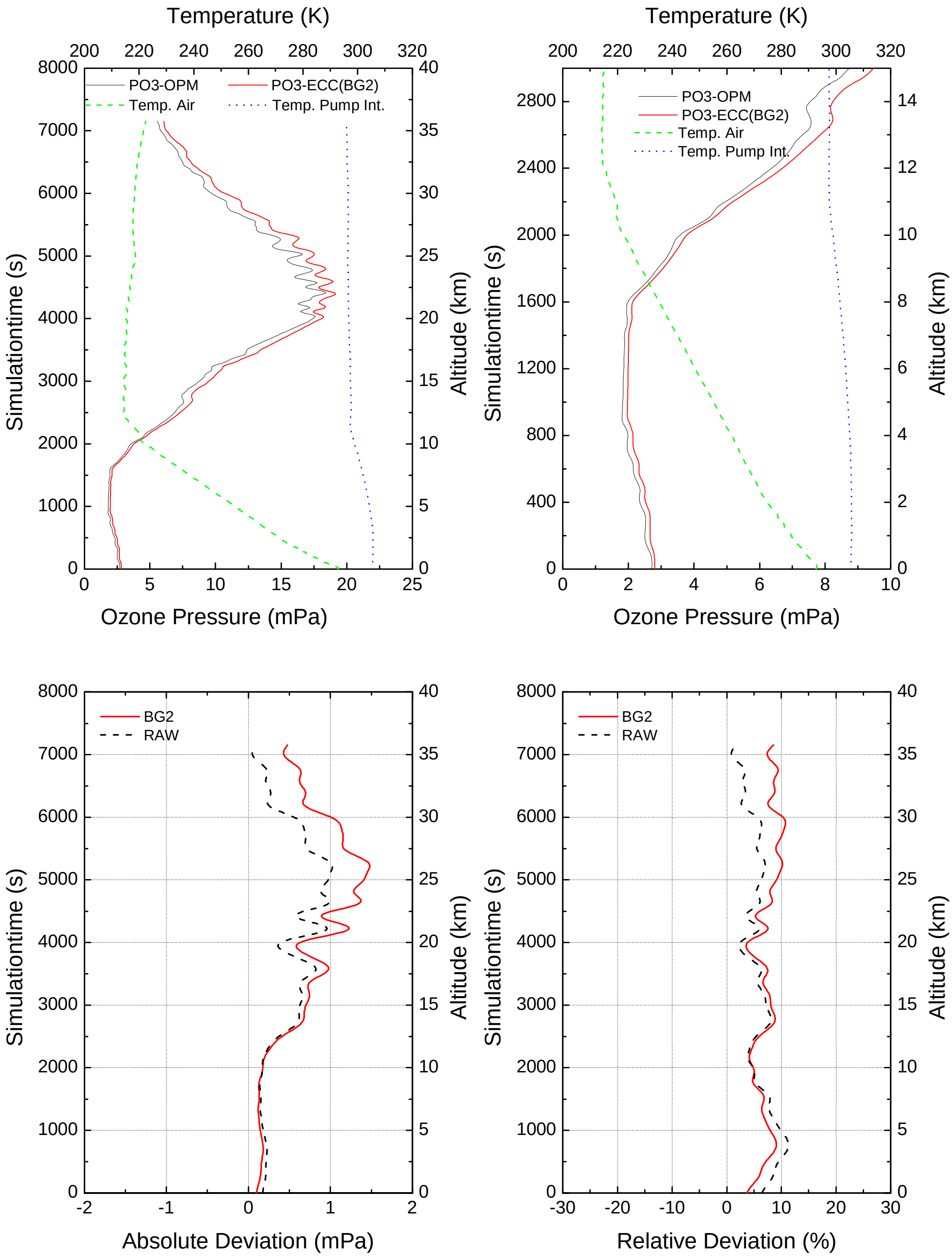
# JOSIE-2002

Sonde No.=08 Sonde Type=SPC-6A Sol. Type=1A Sim. No.=113



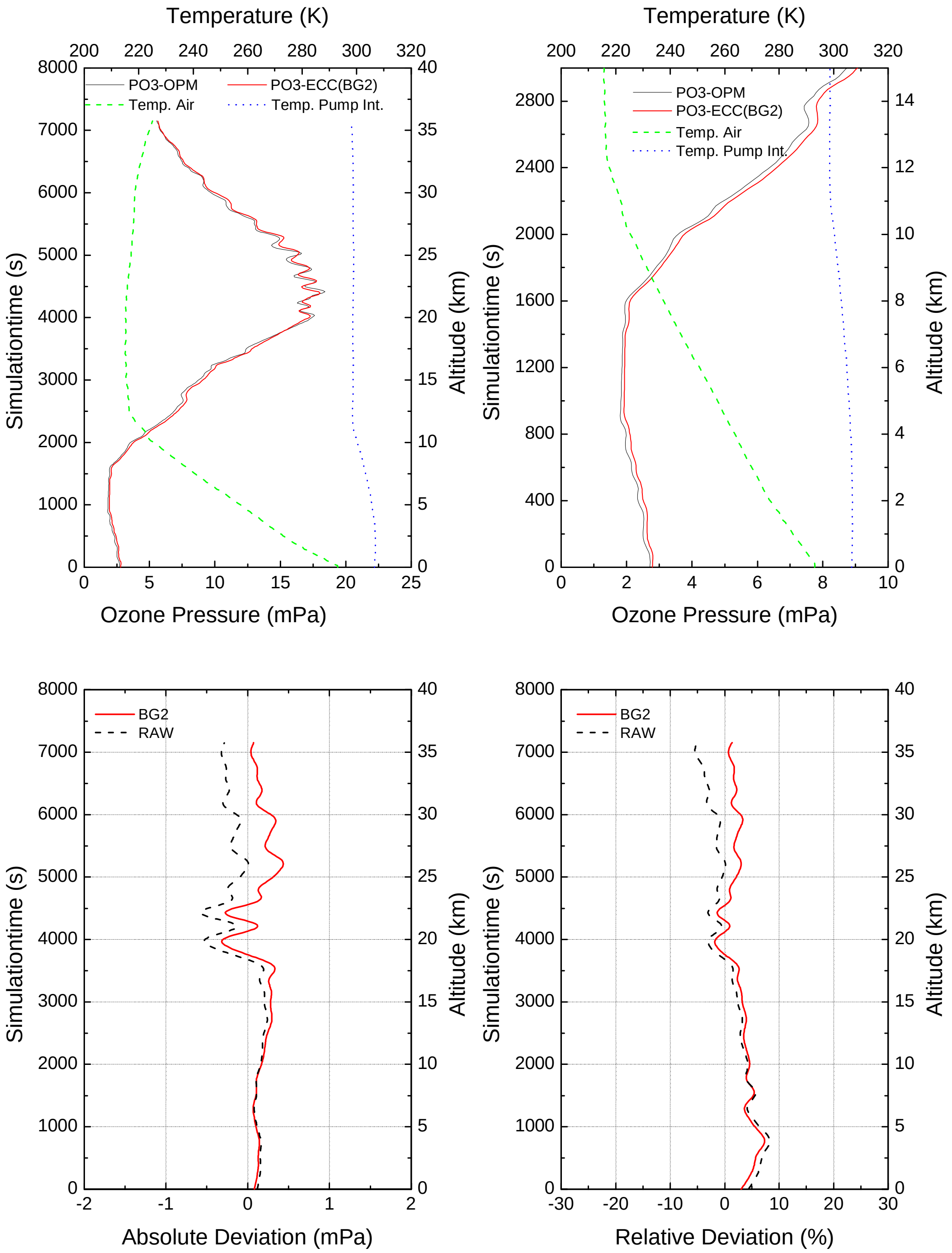
# JOSIE-2002

Sonde No.=09 Sonde Type=SPC-6A Sol. Type=1A Sim. No.=114



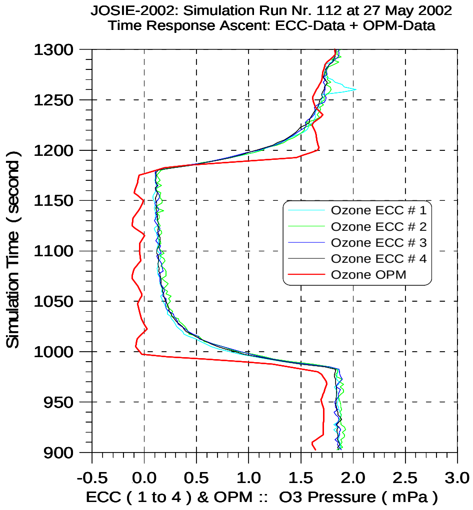
# JOSIE-2002

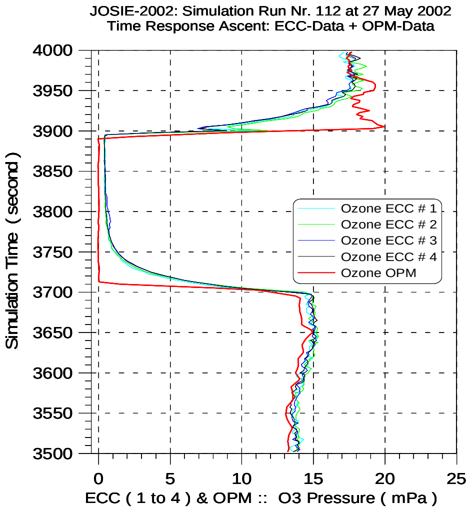
Sonde No.=10    Sonde Type=SPC-6A    Sol. Type=1A    Sim. No.=114

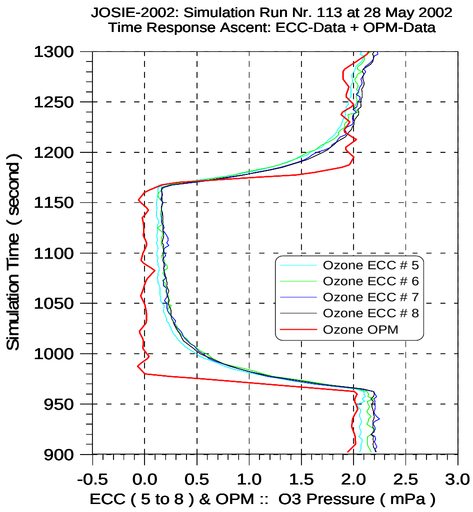


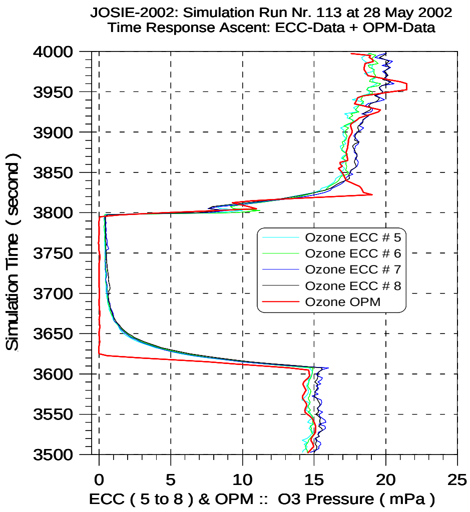
# Annex C:

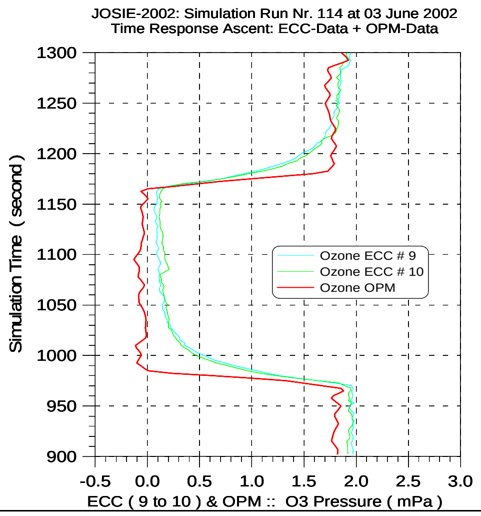
## In-Flight Time Response Tests

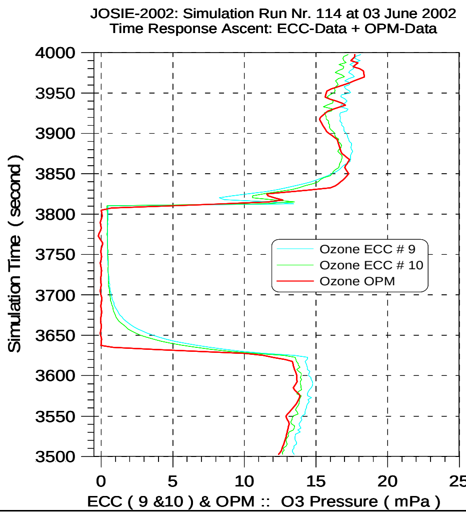


# Annex D:

## Specification of JS02SNii.GS2- & JS02SNii.GSR-Data files

- File Names = JS02SNii.SG2 & JS02SNii.SGR for JOSIE-2002
- Data set for each individual sonde: ii = 01 – 10 for JOSIE-2002

### Extension SG2:

Equisistant (5 seconds in time) simulation profile data, whereby time responses A (in Troposphere) and B (in Stratosphere) are excluded and replaced by linear interpolation between begin and end values of the individual reported parameters of the reponse parts of the profiles, respectively.

### Extension SGR: Time Responses (A & B)

Simulation profile data set with only time response parts A (in Troposphere) and B (in Stratosphere) with time resolution of 2.5 seconds.

**Header of JS02SNii.SG2 & JS02SNii.SGR:**

```
JS02SN01.SG2  =File Name
   1          *Rec_Nr_GC      [Unity ]*Sonde Number (#01-#10)
   1          *Sim_Nr         [Unity ]*Simulation Number
6A7606        *Sonde_Code     [String]*Sonde code from manufacturer
 9.91000E+01  *Motor_Cur_Pre  [mA    ]*Electr.current pump motor at pre-flight
 5.74160E+01  *Mass_Bef_Pre   [gram  ]*Weight ECC before pre-flight check
 1.00000E-02  *I_Back_Bef_Pre [microA]*Background before O3-exposure pre-flight
 2.20898E+02  *Flow_Rate_Pre  [ml/min]*Pump flowrate pre-flight check
 2.99150E+02  *T_Lab_Pre      [Kelvin]*Temperature Laboratory at pre-flight
 9.97200E+02  *P_Lab_Pre      [hPa   ]*Pressuree Laboratory at pre-flight
 4.00000E-02  *I_Back_Aft_Pre [microA]*Background after O3-exposure pre-flight
 2.04000E+01  *Resp_Time_Pre  [second]*Response time ECC at pre-flight check
 9.80000E-01  *Conv_Eff_Pre   [Unity ]*Conversion efficiency ECC at pre-flight
 1.36000E+00  *Offset_Pre     [ppbv  ]*Offset ECC at pre-flight
 5.72180E+01  *Mass_Aft_Pre   [gram  ]*Weight ECC after pre-flight check
 5.53320E+01  *Mass_Bef_Post  [gram  ]*Weight ECC before post-flight check
 6.00000E-02  *I_Back_Bef_Post[microA]*Background before O3-exposure post-flight
 2.21290E+02  *Flow_Rate_Post [ml/min]*Pump flowrate post-flight check
 9.91000E+01  *Motor_Cur_Post [mA    ]*Electr.current pump motor at post-flight
 2.97450E+02  *T_Lab_Post     [Kelvin]*Temperature Laboratory at post-flight
 9.96900E+02  *P_Lab_Post     [hPa   ]*Pressure Laboratory at post-flight
 9.40000E-01  *Conv_Eff_Post  [Unity ]*Conversion efficiency ECC at post-flight
 3.04000E+00  *Offset_Post    [ppbv  ]*Offset ECC at post-flight
 9.00000E-02  *I_Back_Aft_Post[microA]*Background after O3-exposure post-flight
 1.14000E+01  *Resp_Time_Post [second]*Response time ECC at post-flight check
 5.51480E+01  *Mass_Aft_Post  [gram  ]*Weight ECC after post-flight check
 1.00000E-02  *I_Back_Launch  [microA]*Background at start (launch) simulation
 3.62575E+02  *TOC_RAW        [DU    ]*Total ozone column for raw ECC-data
 3.70285E+02  *TOC_EC2        [DU    ]*Total ozone column for corrected ECC-data
 3.56229E+02  *TOC_OPM        [DU    ]*Total ozone column for OPM-data
 9.82499E-01  *TOC_Norm_RAW   [Unity ]*Ratio TOC_OPM / TOC_RAW
 9.62042E-01  *TOC_Norm_Fact_2[Unity ]*Ratio TOC_OPM / TOC_EC2
```

**Data columns of JS02SNii.SG2 & JS02SNii.SGR:**

```
Rec_Nr     * Time_Day   * Time_Sim   * Pres_ESC   * Temp_ESC   * Temp_Inlet * Alt_Sim    *

[Unity]    * [Seconds]  * [Seconds   * [hPa]      * [Kelvin]   * [Kelvin]   * [Km]       *


PO3_OPM    * I_ECC_RAW  * Temp_ECC   * PO3_ECC_RAW* PO3_ECC_BG2*
[mPa]      * [micro-amp]* [Kelvin]   * [mPa]      * [mPa]      *
```

A. **Rec_Nr**= Record Number
B. **Time_Day**= Local day time (in seconds)
C. **Time_Sim**= Actual simulation time (in seconds; start simulation time = 0)
D. **Pres_ESC**= Pressure inside chamber (in hPa)
E. **Temp_ESC**= Temperature inside chamber measured at O3-Manifold (in K)
F. **Temp_Inlet**= Actual temperature at air intake of the sonde, exterior styrofoam box (in K)
G. **Alt_Sim**= Actual simulation height, integrated sum of hydrostatic equation (in km)
H. **PO3_OPM**= Actual ozone pressure measured by UV-Photometer (in mPa).
I. **I_ECC_RAW**= ECC-sensor current signal (in µA):No corrections
J. **Temp_ECC**= Temperature of the ECC-Pump, measured interior of the pump (in K)
K. **PO3_ECC_RAW**= Ozone pressure (in mPa): No corrections
L. **PO3_ECC_BG2**= Ozone pressure (in mPa) according BG2 corrections