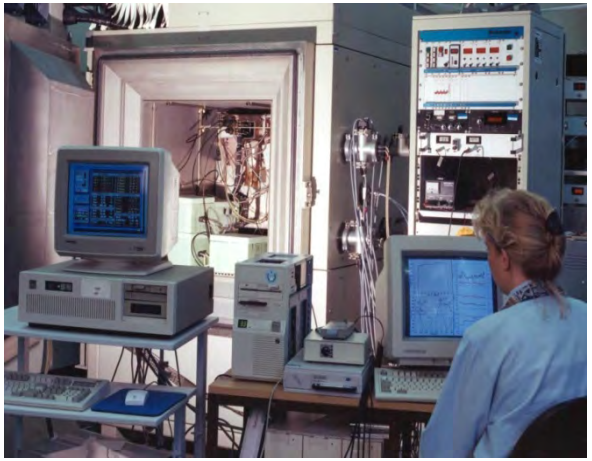
Mitglied der Helmholtz-Gemeinschaft

JOSIE 2017-SHADOZ at WCCOS:

Jülich Ozone Sonde Intercomparison Experiment

Herman G.J. Smit & Anne Thompson & JOSIE-SHADOZ Team

Quality Assurance (QA) of Ozone Sonde (O3S) Data



ASOPOS

Assessment for Standard Operating Procedures for Ozone Sondes

JOSIE

Jülich Ozone Sonde Intercomparison Experiment

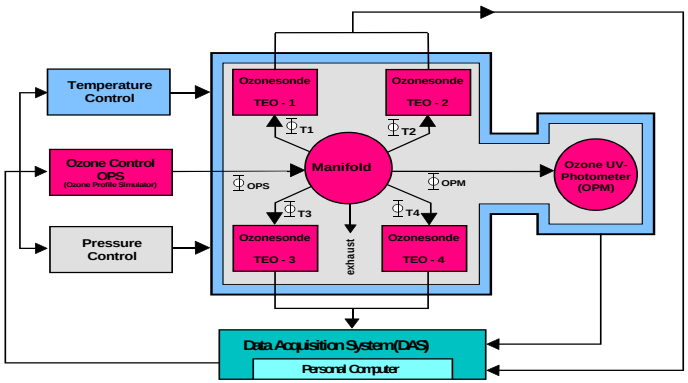
Since 1996

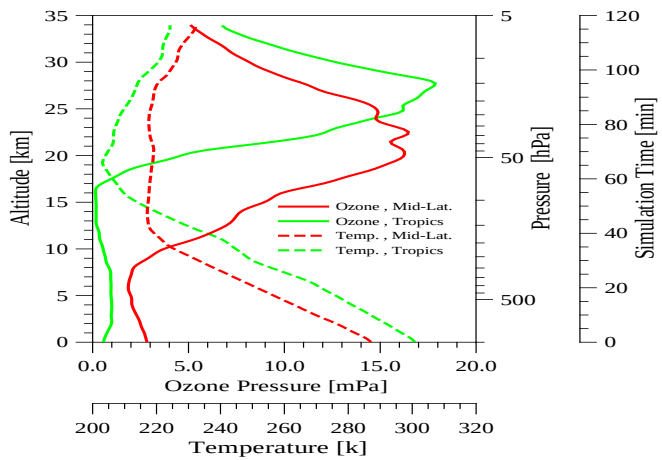
O3S-DQA

Ozone Sonde Data Quality Assurance

Standard operating procedures (SOP's) and Homogenisation of O3S data records can improve precision & uncertainty better ±5%

Activities of the World Calibration Centre for Ozone Sonde





The facility enables control of pressure, temperature and ozone concentration and can simulate quasi realistic flight conditions of ozone soundings from surface to Z=35 km
A dual beam UV-photometer serves as a reference (uncertainty better than ±5 %)

- **JOSIE 1996:** QA-Operation
  >> Small changes/differences of instruments or operating procedures can have significant impact on data quality!!!!
- **JOSIE 1998:** QA-Manufacturers
  >> Differences between manufacturers
- **JOSIE 2000:** QA-Procedures
  >> Differences between sensing solutions
- **ASOPOS 2001:** Evaluation of JOSIE 2000
  >> Definition of provisional SOP‘s
- **BESOS 2004:** Testing of provisional SOP‘s in the field
- **ASOPOS 2004:** Evaluation JOSIE & BESOS
  >> Unanimous agreement on SOP‘s
- **ASOPOS 2009:** Approval SOP’s by WMO
  >> GAW Report #201
- **JOSIE 2009-2011:** QA-Manufacturers
- **O3S-DQA Activity 2011-2017:**
  >> Homogenisation long term O3S records
- **JOSIE 2017/SHADOZ:**
  >> QA-Tropical profiling capabilities
- **ASOPOS 2.0 (2018-2019):** Upgrade of SOP’s

SHADOZ:

Southern Hemisphere ADditional OZonesondes

[http://tropo.gsfc.nasa.gov/shadoz]

The **SHADOZ** project coordinated by Anne Thompson (NASA/GSFC) began in 1998 as a coordinated effort among NASA, NOAA and international partners to coordinate an operational network of tropical and remote ozone sounding sites. **To date, more than 7000 sets of ozone and P-T-U radiosonde measurements have been collected.**

JOSIE 2017 in collaboration with SHADOZ

Objectives:

- Tropical Profiling Capabilities
- Critical instrumental issues: Background Current, Pump flow Corrections and Sensing Solution Type
- Capacity building (support from UNEP-Vienna Convention Trust Fund (Montreal Protocol))
- Testing to upgrade SOP's: ASOPOS 2.0 (Reload)

- Week 1: Present Status SHADOZ : Inhomogeneity in SOP's
- Week 2: Future more homogeneity in SOP's

Goal: Through better standardization of ground equipment and preparation procedures and instructions to achieve uncertainty better than 5%

JOSIE 2017-SHADOZ: Participants

VTCF-Funded Operators		
Name	Affiliation	Country
Ernesto Corrales	University of Costa Rica	Costa Rica
Tshidi Machinini	South African Weather Service	South Africa
Nguyen Thi Hoang Anh	National Hydro-Meteorological Service of S.R. Vietnam	Vietnam
George Paiman	Meteorological Service of Suriname	Surinam
Françoise Posny	Université La Réunion, Météo-France, CNRS	France
Francisco R. da Silva	Brazilian Space Agency	Brazil
Kennedy Thiongo	Kenyan Meteorology Department	Nairobi
Zamuna Zainal	Malaysian Meteorological Department	Malaysia

Other Operator Participants		
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Katherine Wolff	NASA/Wallops Flight Facility	USA
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Roeland van Malderen	Royal Meteorological Institute of Belgium	Belgium

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Gilbert Levrat		
Gonzague Romanens		
Greg Kok	ENSCI	USA
Nakano Tatsumi	Japan Meteorological Agency	Japan
Jacquelyn Witte	NASA/Goddard Space Flight Center	USA

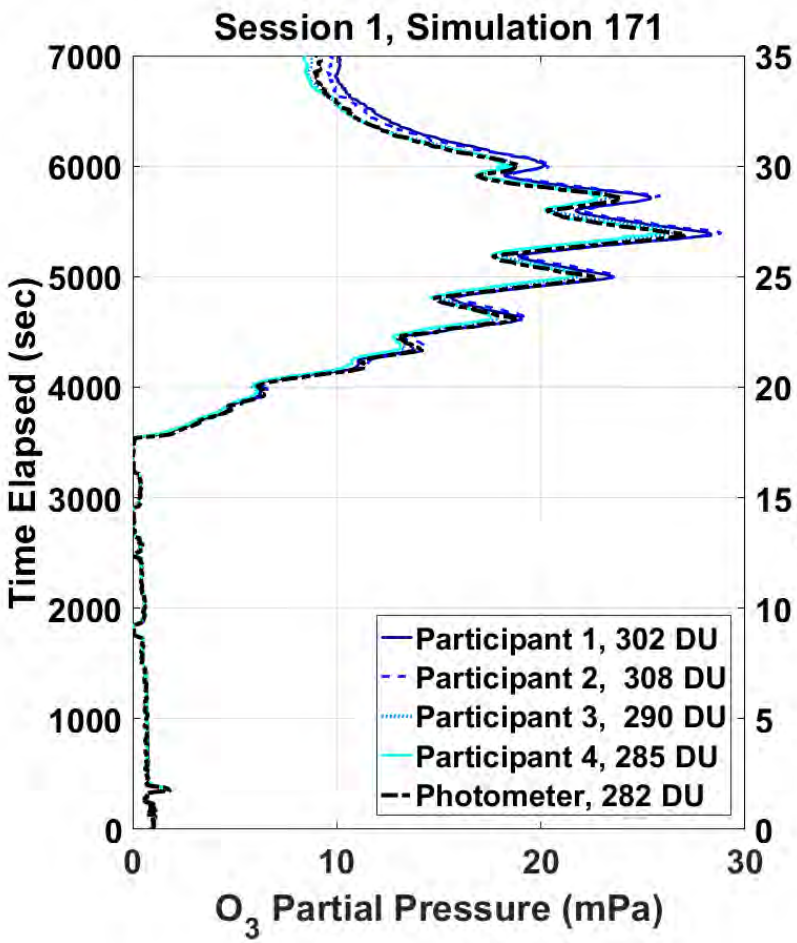
JOSIE 2017-SHADOZ: Session Schedule for 2 Weeks. Session 1: 9-20 Oct. Session 2: 23 Oct-3 Nov. 2017

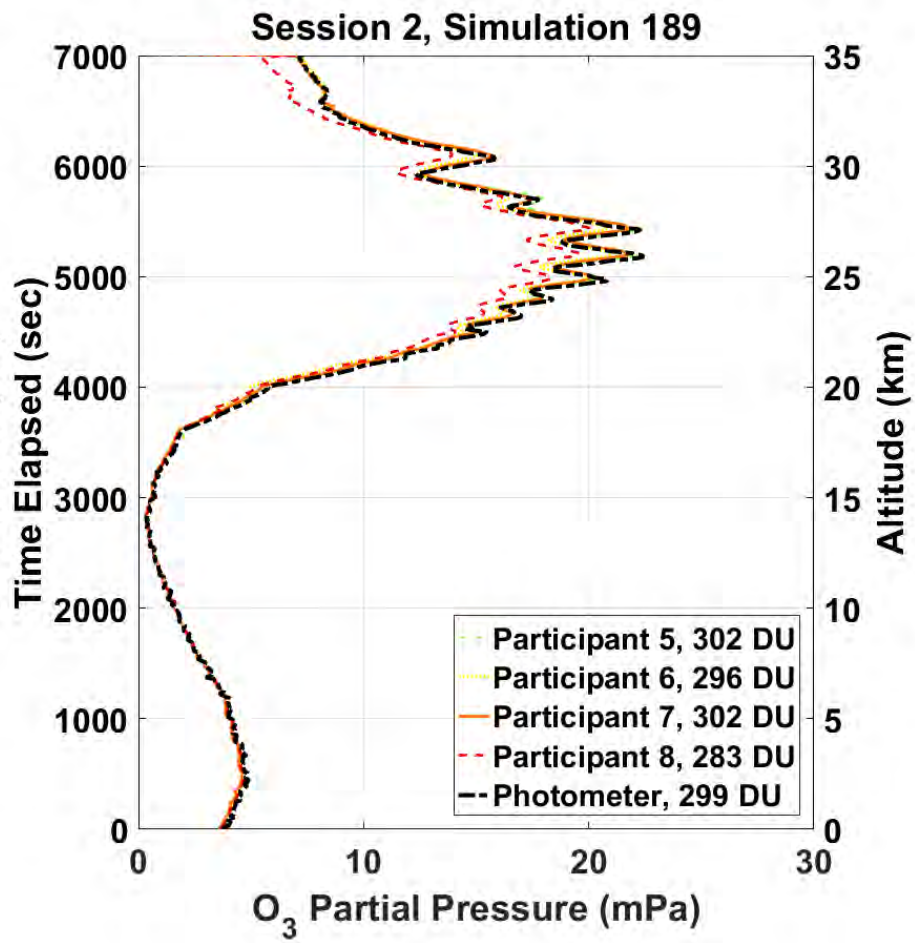
Day	Lecture	Tutorial	Activity
Sunday (Day#01)			Arrival
Monday (Day#02)	Principles of an ozone sounding		Installation Ground Equipment 3-5 days preparation of O3S
Tuesday (Day#03)	Standard Operating Procedures (SOPs)	Preparation of an ozone sonde in practice	Test of O3S-simulation run
Wednesday (Day#04)	Post-flight data processing	Post-flight data processing in practice	First O3S simulation run Evaluation of first results
Thursday (Day#05)	Chemistry of O3+KI		Two O3S simulation runs
Friday (Day#06)	Pumpflow efficiency		Two O3S simulation runs
Saturday (Day#07)	Uncertainty analysis	Uncertainty analysis in practice	
Sunday (Day#08)			Sight seeing
Monday (Day#09)	Radiosonde-PTU & GPS/Wind/Altitude		Mid-term evaluation meeting on the results of O3S
Tuesday (Day#10)	Background current		Two O3S simulation runs
Wednesday (Day#11)	Total ozone column/normalisation		Two O3S simulation runs
Thursday (Day#12)	QA/QC-evaluation	QA/QC-evaluation in practice	Last O3S simulation run
Friday (Day#13)			Final evaluation meeting Packing
Saturday (Day#14)			Departure

Present Status: Inhomogeneity in SOP's

Future Status: More homogeneity in SOP's

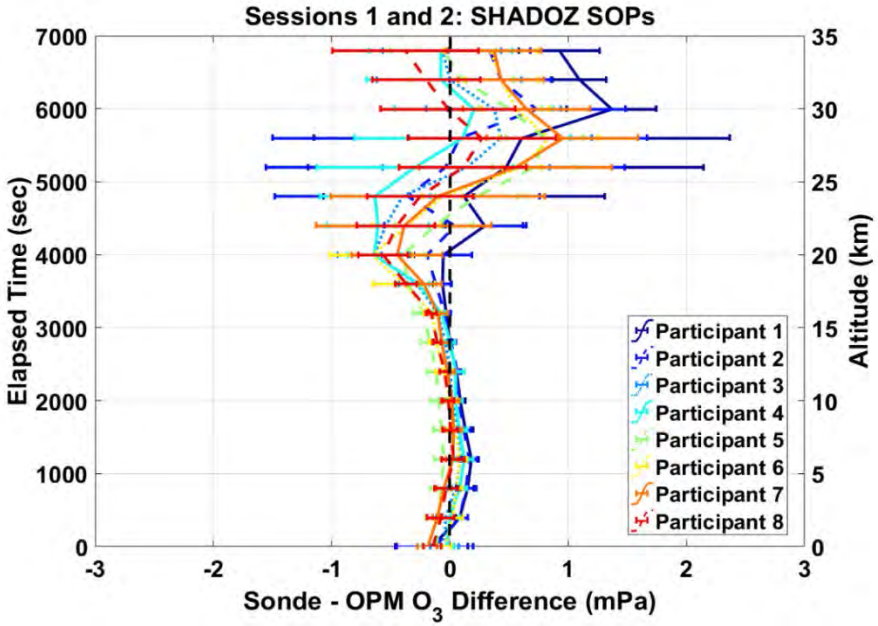
JOSIE 2017-SHADOZ: First Results of 2 Simulation Flights

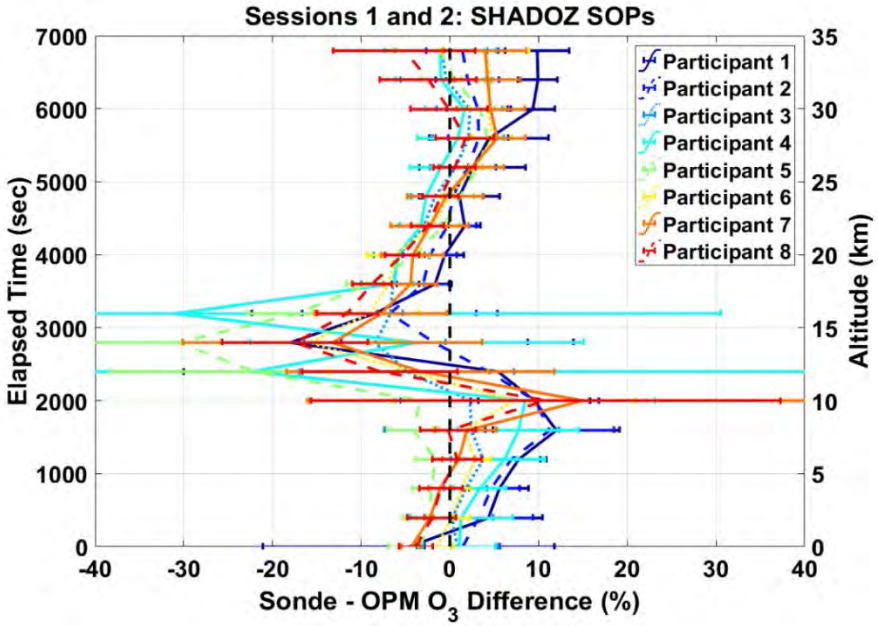




JOSIE 2017-SHADOZ: Comparison Sondes to UV-Photometer (OPM) using SHADOZ-SOP's

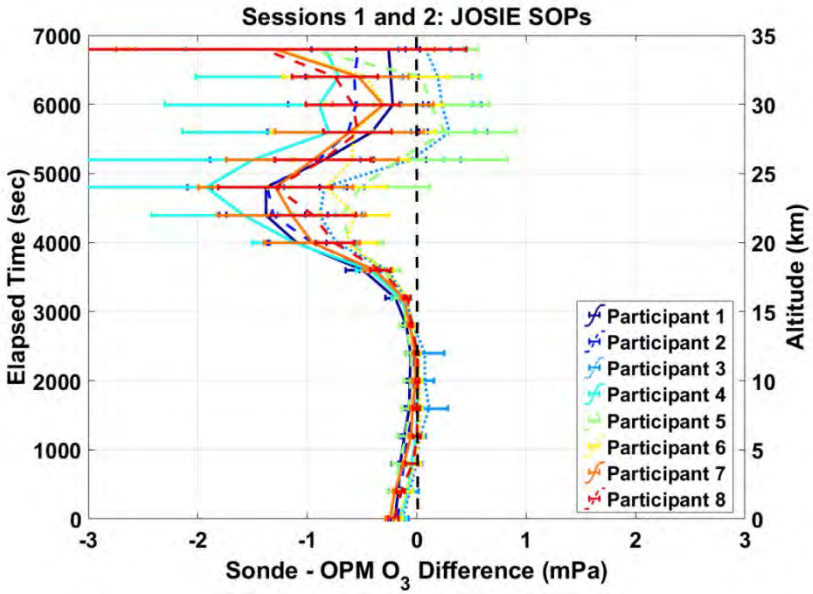
Individual mean deviations to OPM in partial pressure (mPa) (left) and relative (%) (right) for SHADOZ SOP's for both sessions. Based on 5 runs of each station

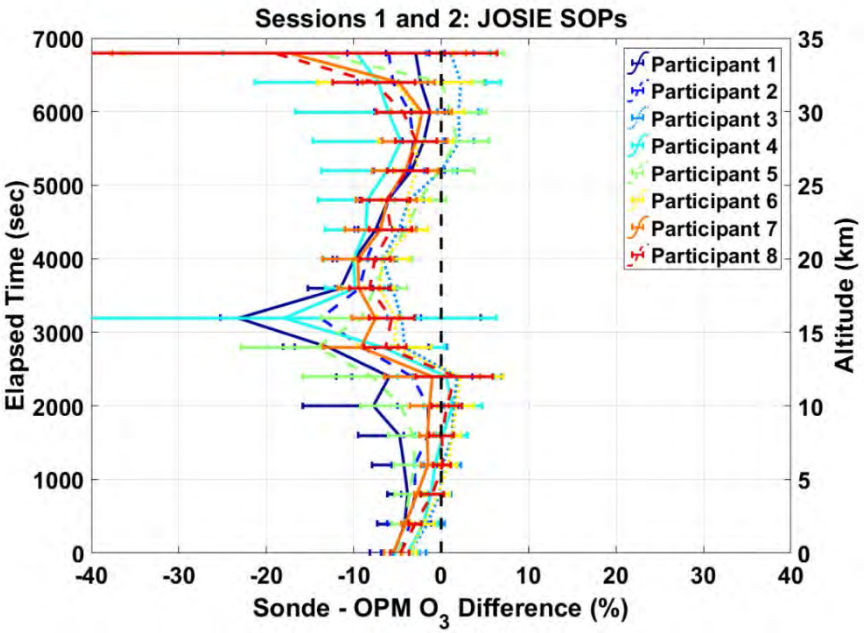




JOSIE 2017-SHADOZ: Comparison Sondes to UV-Photometer (OPM) using JOSIE-SOP's (Slightly Revised WMO/GAW SOP's

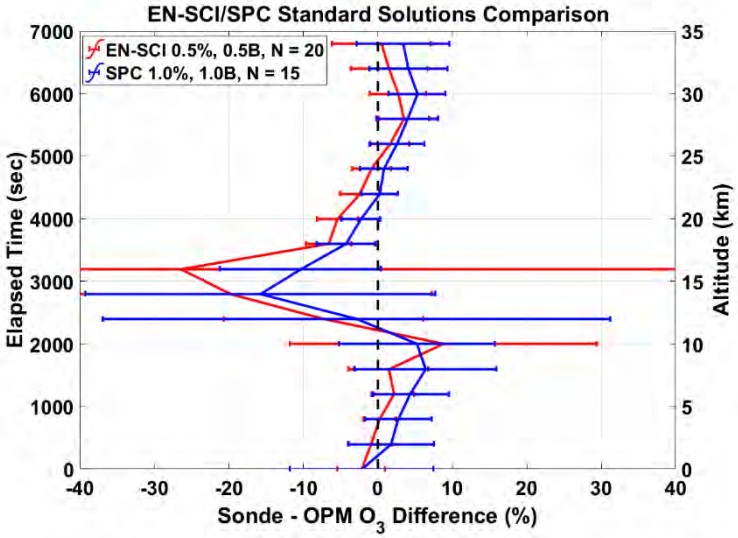
Individual mean deviations to OPM in partial pressure (mPa) (left) and relative (%) (right) for SHADOZ SOP's for both sessions. Based on 5 runs of each station





JOSIE 2017-SHADOZ:
SHADOZ SOP's versus JOSIE-SOP'

A



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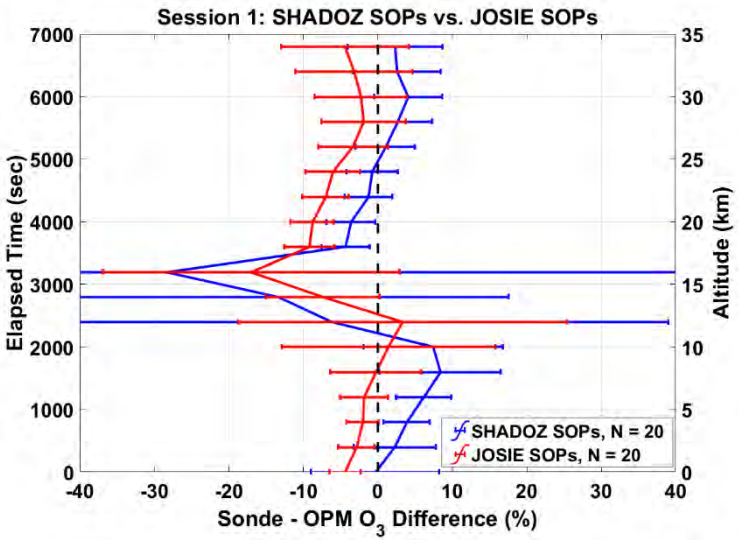

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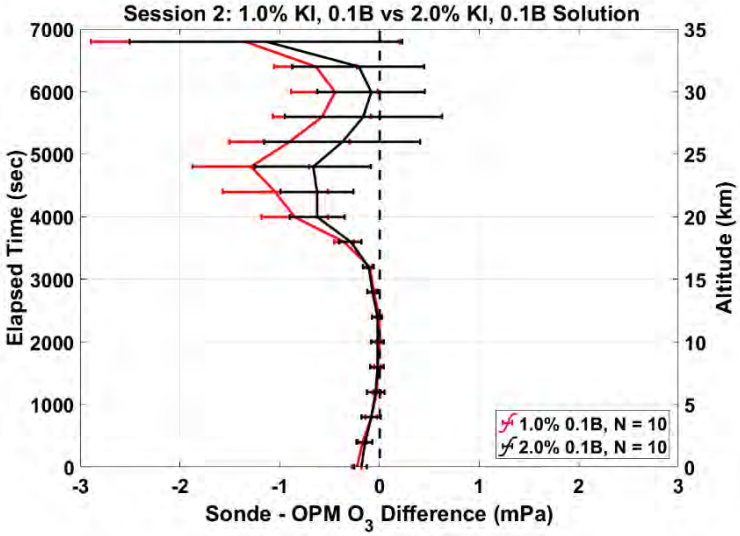

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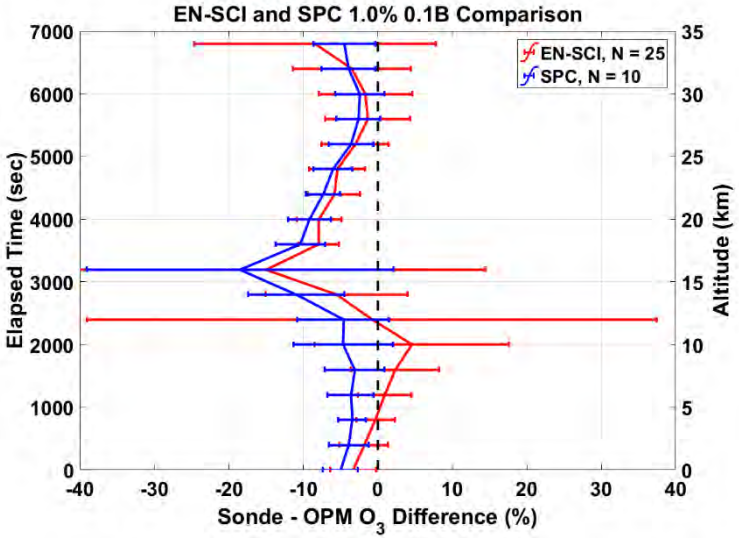


JOSIE 2017-SHADOZ: Achievements

- 2 x 2-Weeks-sessions with 2x4 SHADOZ stations
- 2 x 10-Similation experiments of tropical profiles
- 2 x 40-Ozonesonde-profiles versus UV-Photometer for further investigations!
- Requirement for more standardization of ground equipment and preparational procedures
- Capacity building: Intensive training of station operators plus lectures by coaches and referees

JOSIE 2017-SHADOZ: Preliminary Findings

- The SPC / ENSCI offsets seen in JOSIE-2000 (Smit et al., 2007) & BESOS-2004 (Deshler et al., 2008) are confirmed in JOSIE-2017.
- With uniform preparation procedures, SHADOZ profiles agree within 5% with the UV photometer.
- Reducing the buffer in the sensing solution improves O_3 accuracy near the tropopause
- …….. *Results Under Investigations*…….

JOSIE 2017-SHADOZ: Outlook

- "The JOSIE-SHADOZ Experience": BAMS-Paper
- Evaluation of JOSIE 2017 results
- Evaluation existing SOP's:

>>> Start of ASOPOS 2.0 Reload

[Assessment of Standard Operating Procedures for Ozone Sondes]

JOSIE-SHADOZ & ASOPOS Workshop 17-19 Sept. 2018 in Switzerland (Geneva area) after the NDACC-Annual SSC Meeting

Outcome of ASOPOS 2.0 Reload in 2019/2020 :

1. **More strict SOP's**
2. **Standardization of ground equipment for preparation of O3-sondes**

JOSIE 2017/SHADOZ: Acknowledgements

- JOSIE-SHADOZ support comes from **FZ-Jülich, NASA and NOAA** with special travel support from the **UNEP Vienna Convention Trust Fund**.
- Ozone sondes (more than 100) were supplied by **NOAA, NASA, Environmental Canada, FMI, Meteo Suisse, KMI, KNMI, NIWA**
- Participating organizations:

- Last but least now **4 minutes of 4 weeks of JOSIE 2017/SHADOZ** campaign: https://vimeo.com/240986625 by Patrick Cullis (NOAA, Boulder)

O3S-DQA: Last, but Not Least.....

Very important QA/QC factor to achieve the best data quality starts at the launch site:

(1) Good quality of preparation equipment, which is well maintained

(2) Well trained and motivated sonde operator & scientist

(3) Good & regular communication between scientist & sonde operator

COST-Action on Vertical Ozone Profiling???

..... Presently elaborating the feasibility to submit a proposal for a EU-COST action on the harmonisation of ozone profiling data from different ground based platforms.....

..... Ozone sondes , Lidars, In Service-Aircraft and others.....

..... Focus on Troposphere + Tropopause region until Z= 20 km .....

..... EU-COST action is a networking activity.....

..... Funded by the European Commission for 4 years.....

..... Majorly covering the costs of meetings, trainings, summer schools, short scientific missions (< 1-2 weeks).....

..... Call for proposals in Fall 2018.....

..... Oversigned by factor 5-10.....

..... Several administrative thresholds/obstacles to be taken.....

.....Realism: Limited chances of success.....

- **JOSIE-Fun: https://vimeo.com/240986625** by Patrick Cullis (NOAA, Boulder)

Reserve Slides

Ozone Sonde (O3S) in Global Networks

- Longest time series of vertical ozone distribution
- Cost efficient for process studies (e.g. MATCH, SHADOZ)
- Backbone of satellites: Provide a-priori profiles for satellite retrievals and important to validate satellites on their long-term stability
- Small changes of instrument or operating procedures can have large impact on data quality
- Trend assessments show need for more homogenity of data

WCCOS:

World Calibration Centre for Ozone Sondes

Part of Quality Assurance (QA) plan of WMO/GAW

(World Meteorological Organization / Global Atmosphere Watch)

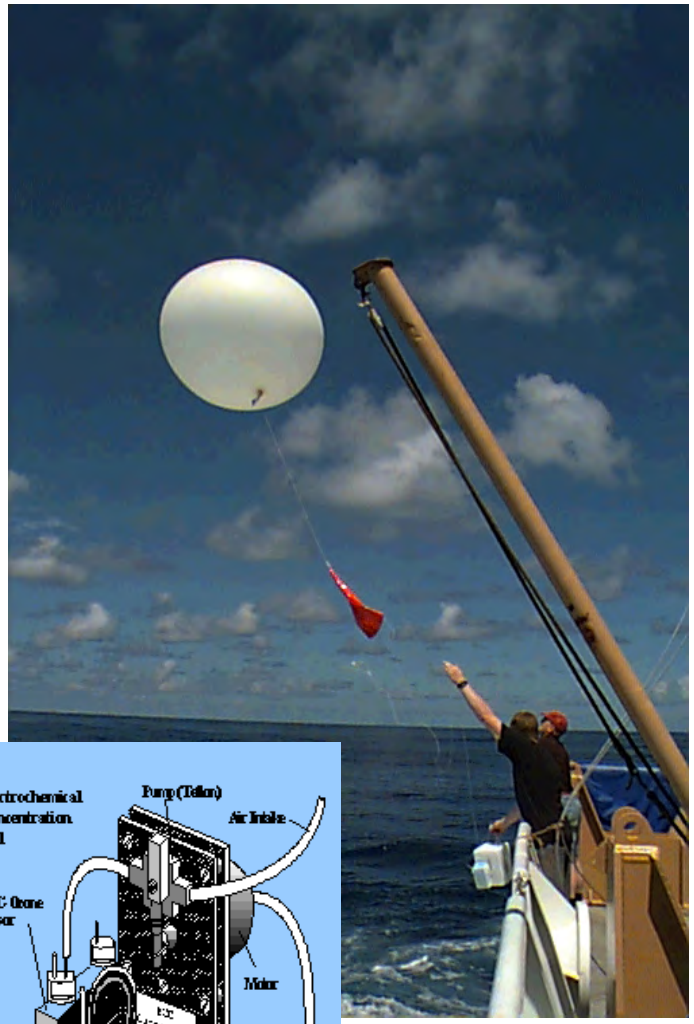
Tasks:

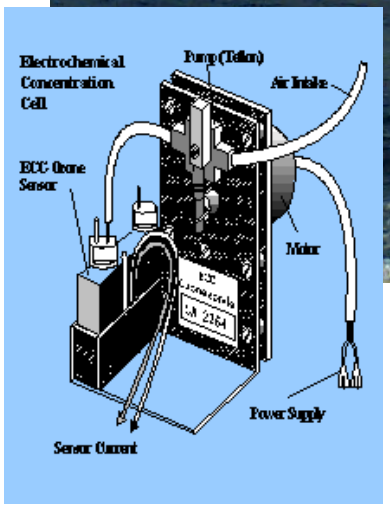
- ❖ **QA-Manufacturers**
- ❖ **QA-Operation**
- ❖ **QA-Procedures**

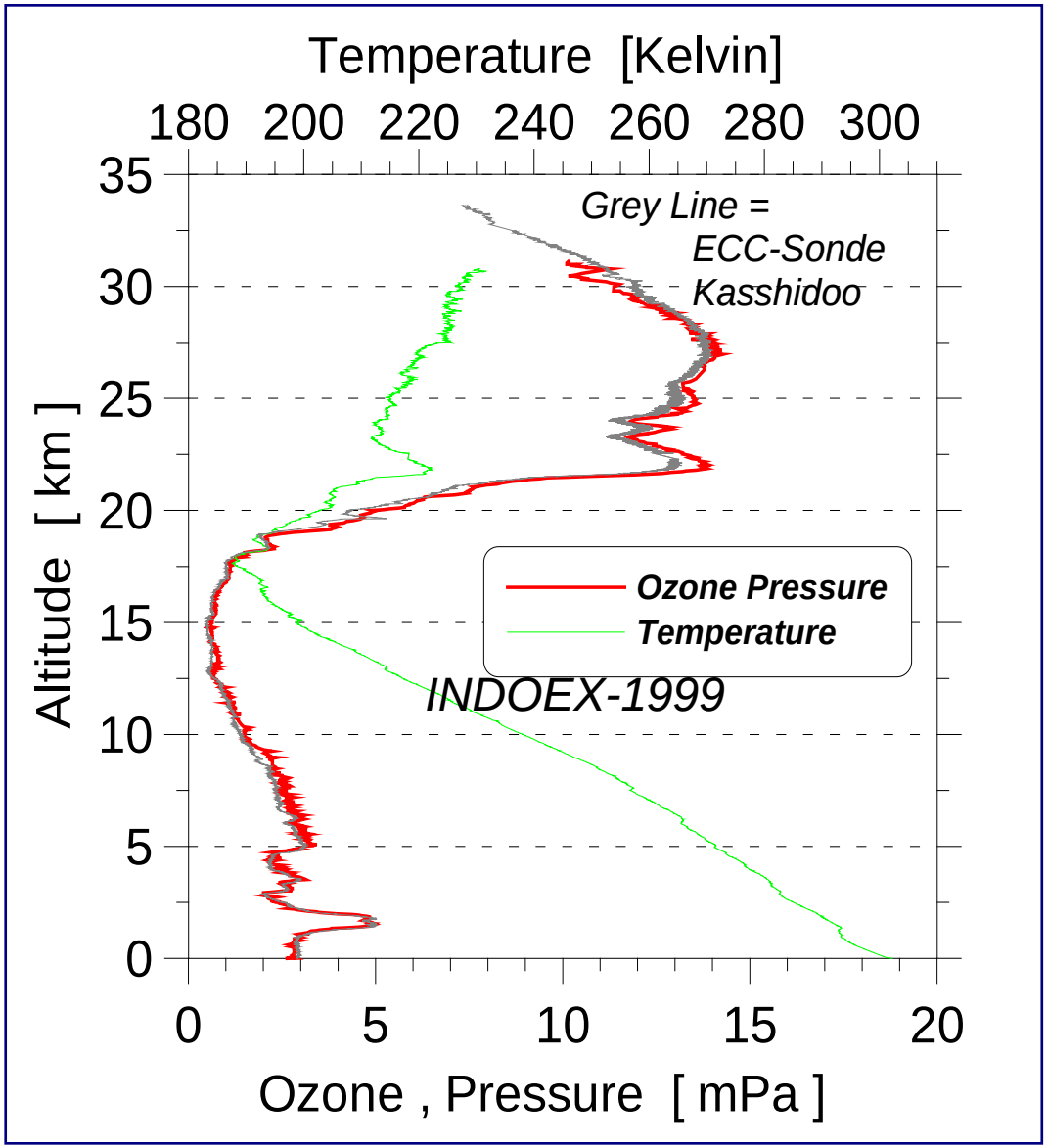
Activities:

- ◆ **JOSIE (1996, 1998, 2000, 2009 & 2010, 2017/2018)**
- ◆ **ASOPOS & O3S-DQA**

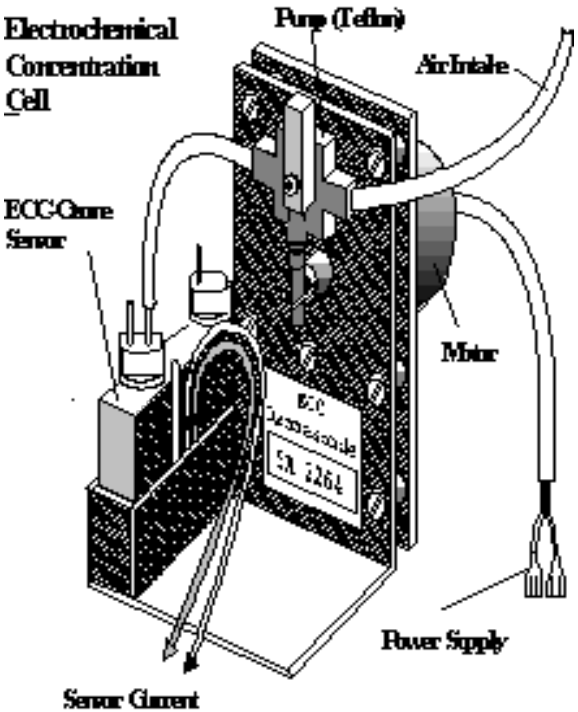
What Is An Ozone Sounding ?







Electrochemical Ozone Sonde: Introduction



In an electrochemical cell:

- A small pump forces ambient air through a KI-solution
- Ozone is converted into iodine by the reaction:

$$2KI + O_3 + H_2O \rightarrow I_2 + O_2 + 2KOH$$

- At a Platinium cathode the Iodine is converted to Iodide: $I_2 + 2e \xrightarrow{Pt} 2I^-$
- In external electrical circuit a current is generated directly related to the uptake rate of ozone in the sensing solution

Pump Temperature [K]

Background Current [μA]

Ozone Pressure [mPa]

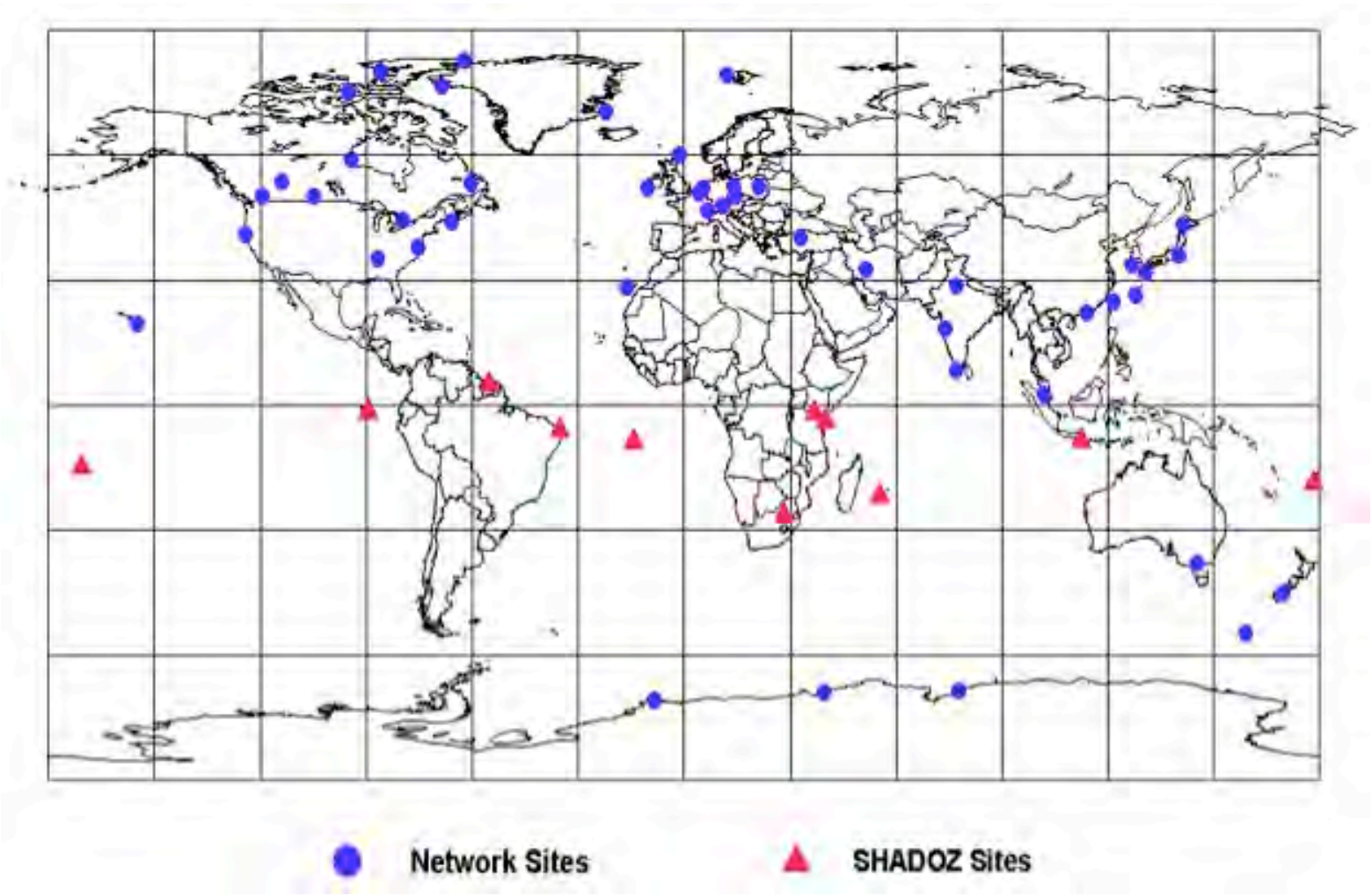
$$P_{O3} = 0.04307 \cdot \eta_C \cdot \frac{T_P}{\Phi_P} \cdot (I_M - I_B)$$

Conversion Efficiency

Pump Flow [cm3/s]

Measured Current [μA]

Global Ozone Sonde Network
(GAW-NDACC-SHADOZ-GRUAN)



Why JOSIE?

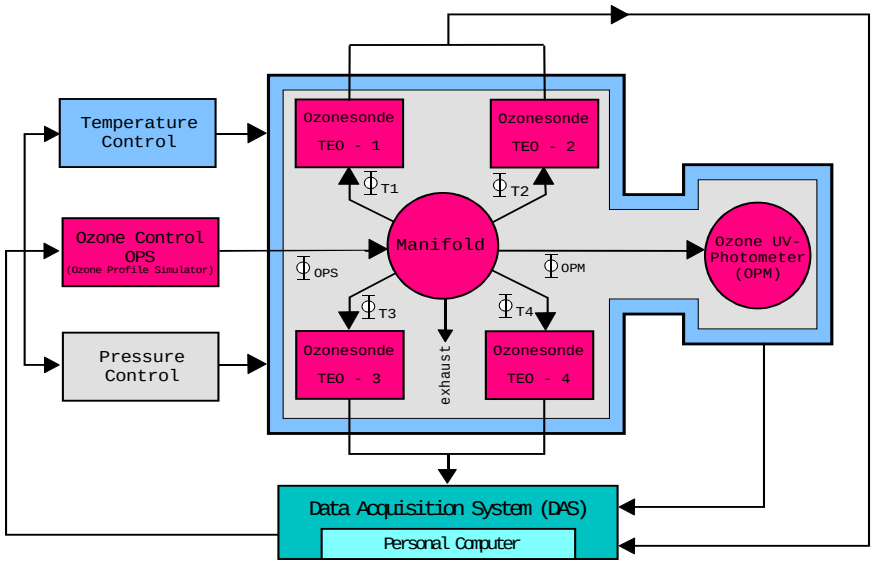
The overall objective of JOSIE (Jülich Ozone Sonde Intercomparison Experiment) is to establish **quality assurance guidance** for the global ozone sonde community.

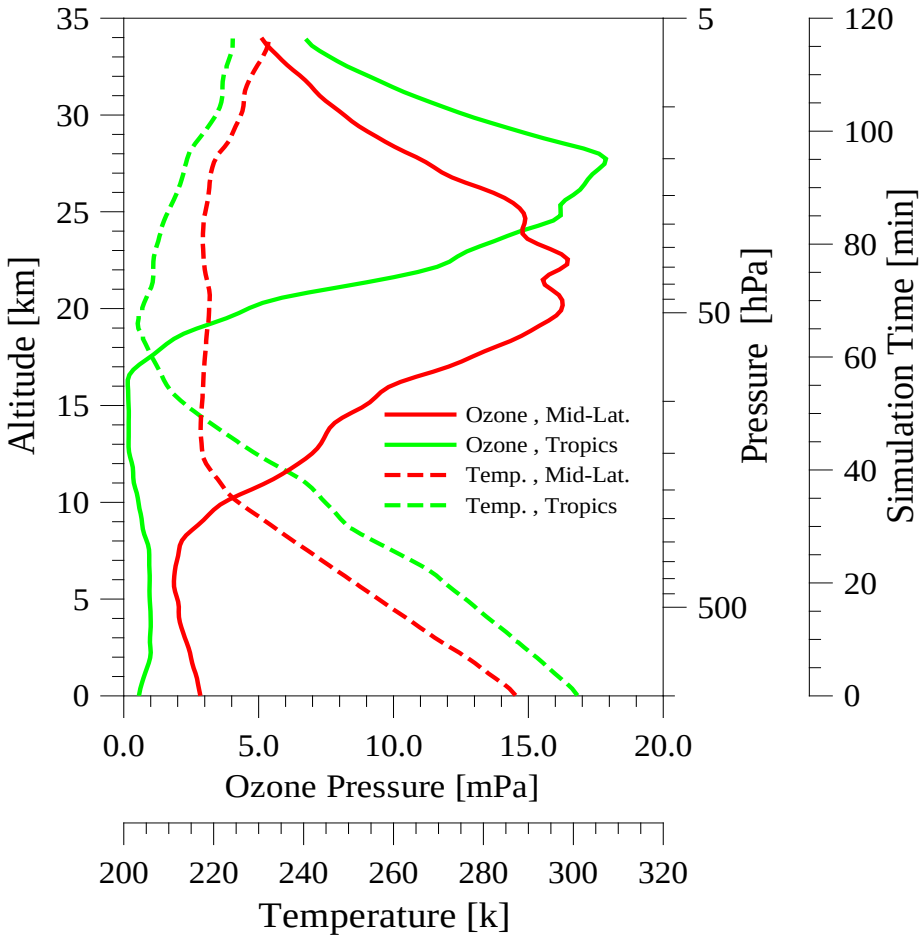
- To assess the performance of the various ozone sonde instrument types the environmental simulation chamber at the Forschungszentrum Jülich was established as the World Calibration Center for Ozone Sondes (WCCOS) in 1996.

- The chamber simulates flight conditions of ozone sonde soundings up to 35 km. This controlled environment allows for accurate comparisons of ozonesonde profiles to the reference UV-photometer.

Environmental Simulation Facility for O3S:

Simulation of Ozone Soundings Under Quasi Realistic Atmospheric Conditions of Pressure, Temperature and Ozone





Ozone Reference

Dual Beam UV-Photometer:

- response: 1 s
- precision: ±0.025mPa ,
- accuracy: ± 2 % (0-25 km),
  ±3.5% (30-35km)

JOSIE 2017/SHADOZ: Participating Stations

SHADOZ-Site	ECC–O3S / Sensing Solution	Station Principal Investigator
Irene, South Africa	SPC-6A / SST1.0%-Full Buffer	G. Coetzee (SAWS)
Natal, Brasil	SPC-6A / SST1.0%-Full Buffer	F. Da Silva (CRN-INPE)
Ascension Island	ENSCI-Z / SST0.5%-Half Buffer	A.M. Thompson (NASA)
Costa Rica	ENSCI-Z / SST1.0%-0.1 Buffer	B. Johnson (NOAA)
Paramaribo, Suriname	SPC-6A / SST1.0%-Full Buffer	A. Piters (KNMI)
Kuala Lumpur, Malaysia	ENSCI-Z / SST0.5%-Half Buffer	Maznorizan Mohamad (MMD)
Reunion, France	ENSCI-Z / SST0.5%-Half Buffer	F. Posny (CNRS)
Hanoi, Vietnam	ENSCI-Z / SST0.5%-Half Buffer	Shin-Ya Ogino (JAMSTEC)

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Gilbert Levrat		
Gonzague Romanens		
Greg Kok	ENSCI	USA
Nakano Tatsumi	Japan Meteorological Agency	Japan
Jacquelyn Witte	NASA/Goddard Space Flight Center	USA

JOSIE 2000 & BESOS 2004:
Comparison SPC-6A&ENSCI-Z @ Different Sensing Solutions

SST1.0 (1.0%KI,Full Buffer), SST0.5 (0.5%KI,Half Buffer), SST2.0 (2.0%KI, No Buffer)
[Data processed after Komhyr 1986, IB0 (PO2), No Total O3 Normalization]

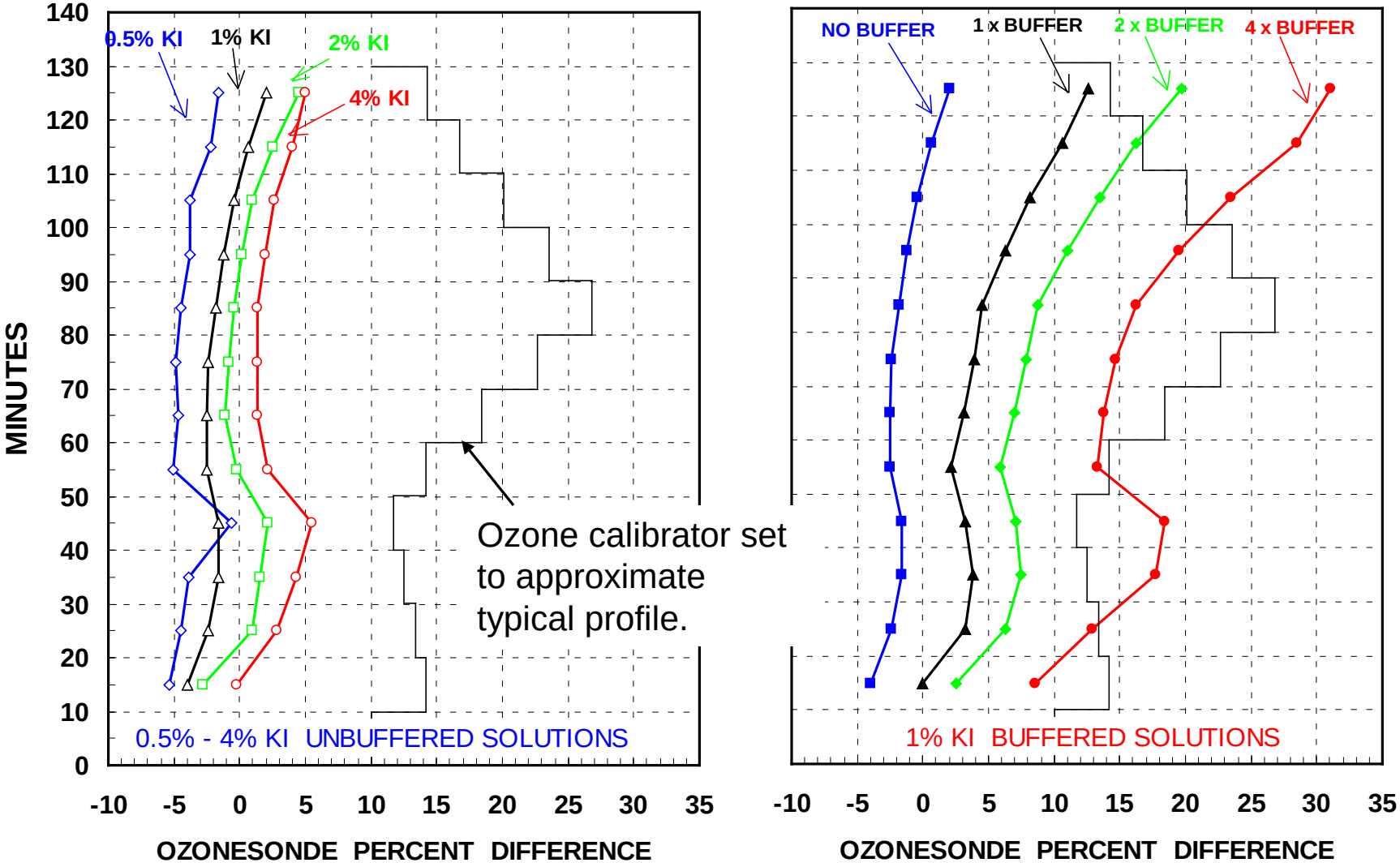
Each sonde type (ENSCI or SPC):

- ❖SST1.0 ≈ 5% larger than SST0.5
- ❖SST0.5 ≈ 5% larger than SST2.0
- ❖SST1.0 ≈ 10% larger than SST2.0

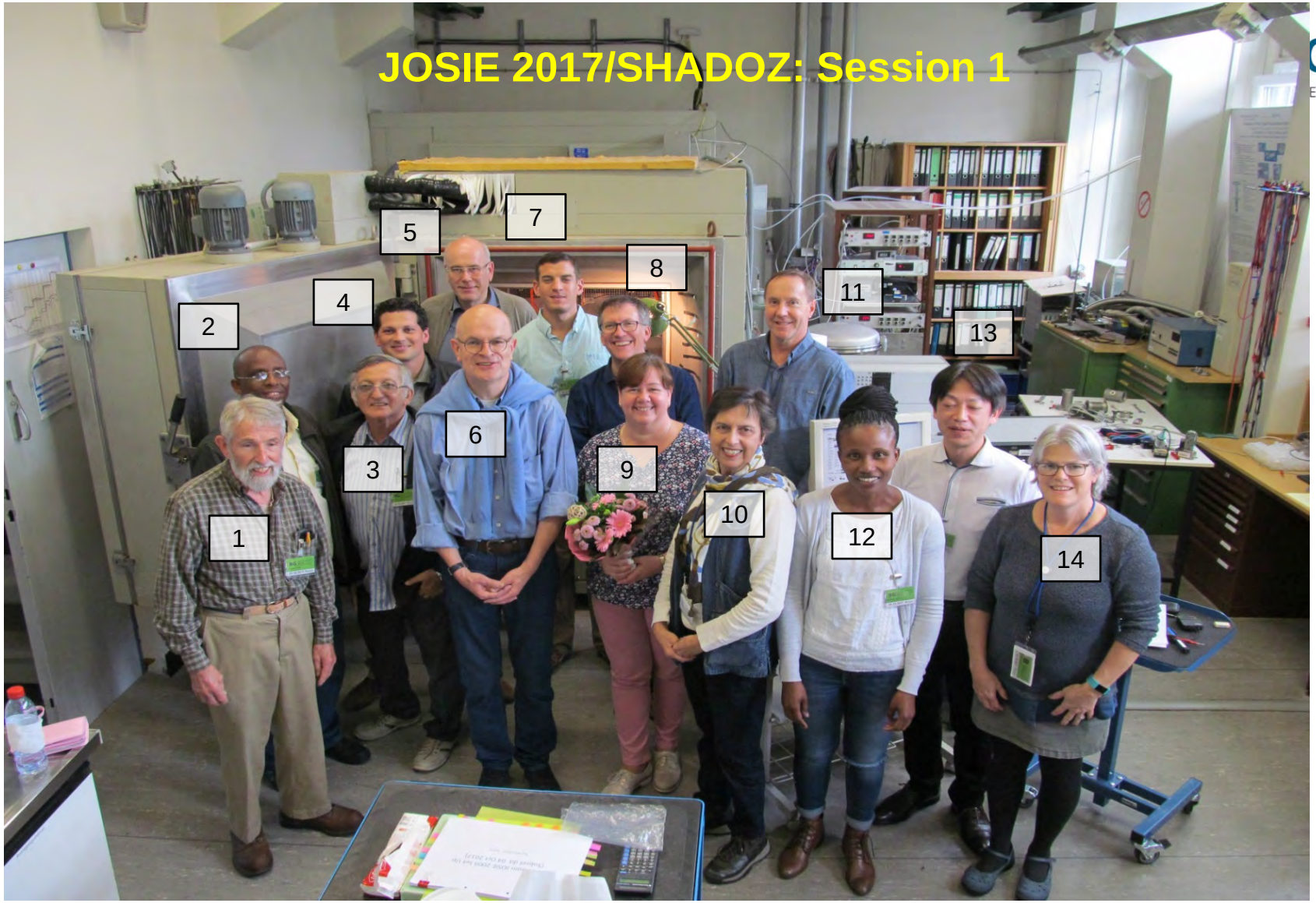
For each Sensing Solution Type (SST1.0 , SST0.5, and SST2.0) :

- ❖ ENSCI 5-10 % higher than SPC
- ❖ Precision about 3-6 %

Summary Of Unbuffered Versus Buffered Cathode Solution Tests (Source: Johnson et al., JGR, 2002): Tests were done at room pressure and temperature.

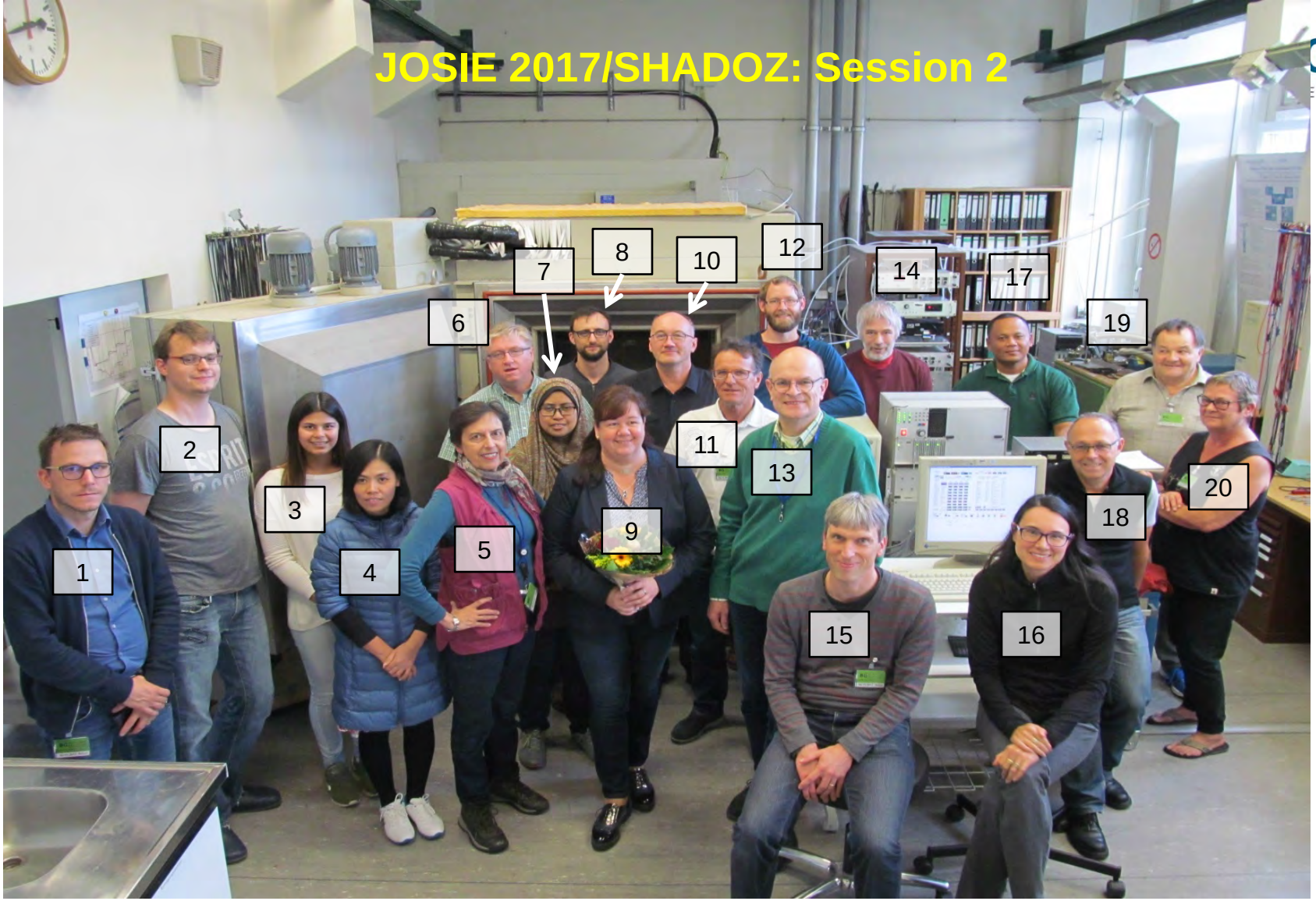


JOSIE 2017/SHADOZ: Session 1



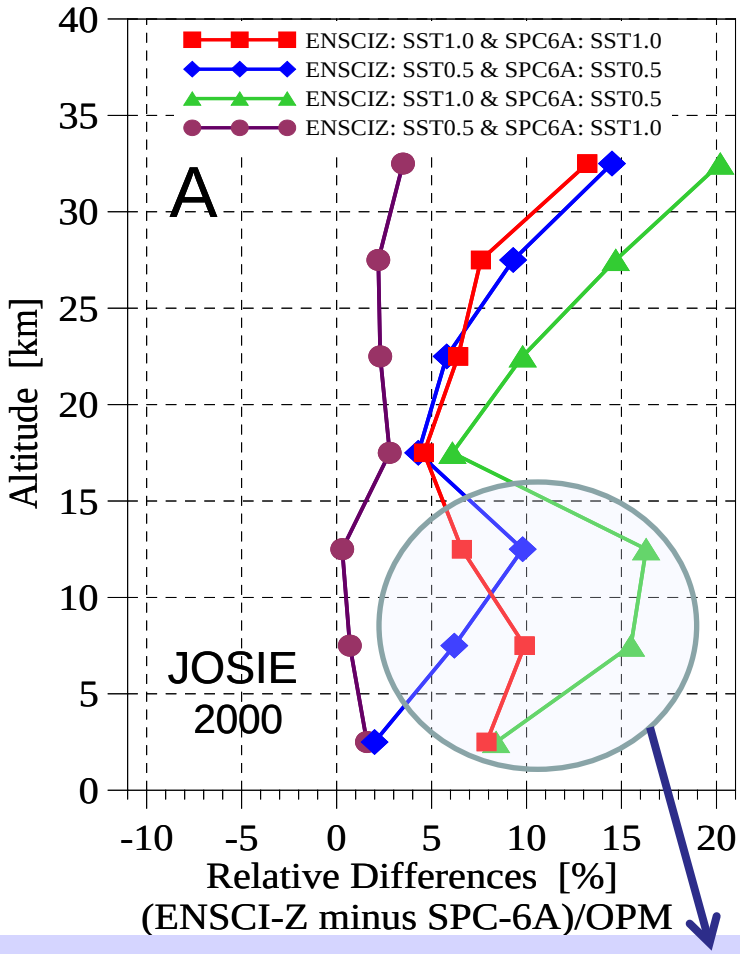
Session 1: (1) George Brothers (NASA/WFF); (2) Kennedy Thiong'o (Kenya Met Dept.); (3) Francisco Raimundo da Silva (INPE Natal); (4) Ernesto Corrales (Univ. Costa Rica); (5) Peter von der Gathen (Alfred Wegener Institute); (6) Herman Smit (FZ Jülich); (7) Ryan Stauffer (NASA/GSFC); (8) Gary Morris (St. Edward's Univ.); (9) Gabi Nork (FZ Jülich); (10) Anne Thompson (NASA/GSFC); (11) Bryan Johnson (NOAA ESRL); (12) Tshidi Machinini (South African Weather Service); (13) Nakano Tatsumi (Japan Met Agency); (14) Rhonie Wolff (NASA/WFF)

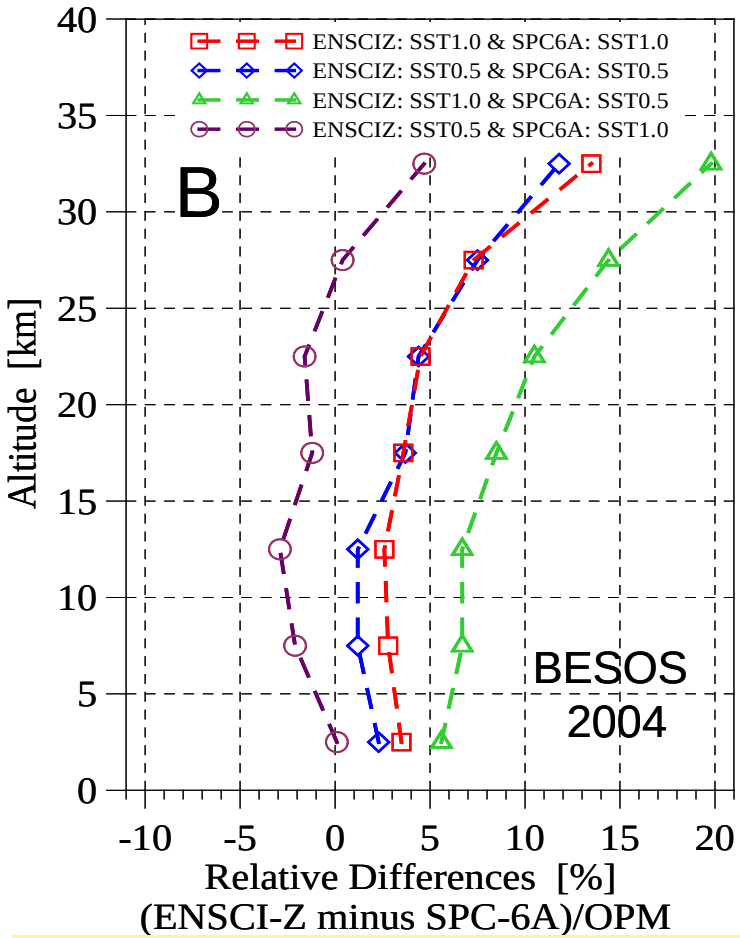
JOSIE 2017/SHADOZ: Session 2



Session 2: (1) Gonzague Romanens (MeteoSwiss); (2) Torben Blomel (FZ Jülich); (3) Jennifer Gläser (FZ Jülich); (4) Nguyen Thi Hoang Ahn (National Hydro-Meteorological Service of Vietnam); (5) Anne Thompson (NASA/GSFC); (6) Jonathan Davies (Env. Climate Change Canada); (7) Zamuna Zainal (Met Malaysia); (8) Patrick Neis (FZ Jülich); (9) Gabi Nork (FZ Jülich); (10) Rigel Kivi (FMI); (11) Rene Stübi (MeteoSwiss); (12) Patrick Cullis (NOAA ESRL); (13) Herman Smit (FZ Jülich); (14) Marc Allaart (KNMI); (15) Roeland Van Malderen (Royal Meteorological Institute of Belgium); (16) Jacquelyn Witte (NASA/GSFC); (17) George Paiman (Met Dept. of Suriname); (18) Andreas Petzold (FZ Jülich); (19) Gilbert Levrat (MeteoSwiss); (20) Françoise Posny (Univ. of La Réunion)

BESOS 2004 versus JOSIE 2000: SPC-6A & ENSCI-Z @ SST1.0% & SST0.5%

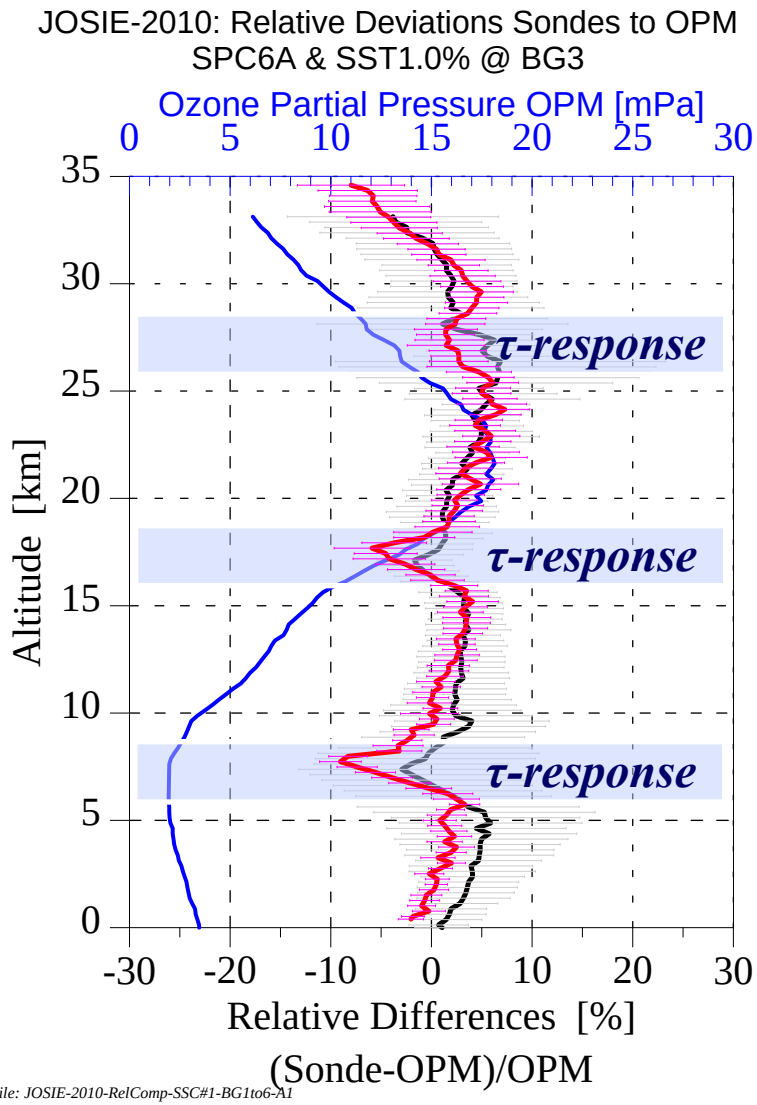


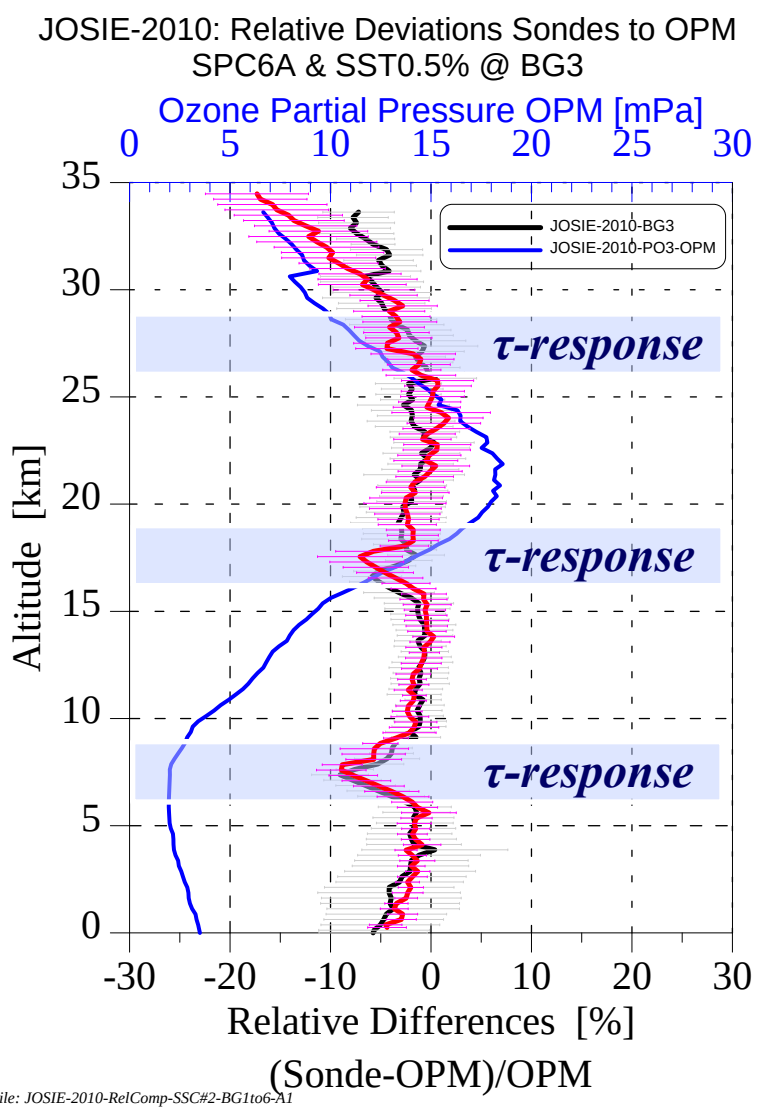


JOSIE 2000:
Different Operating Procedures

BESOS 2004:
Standard Operating Procedures

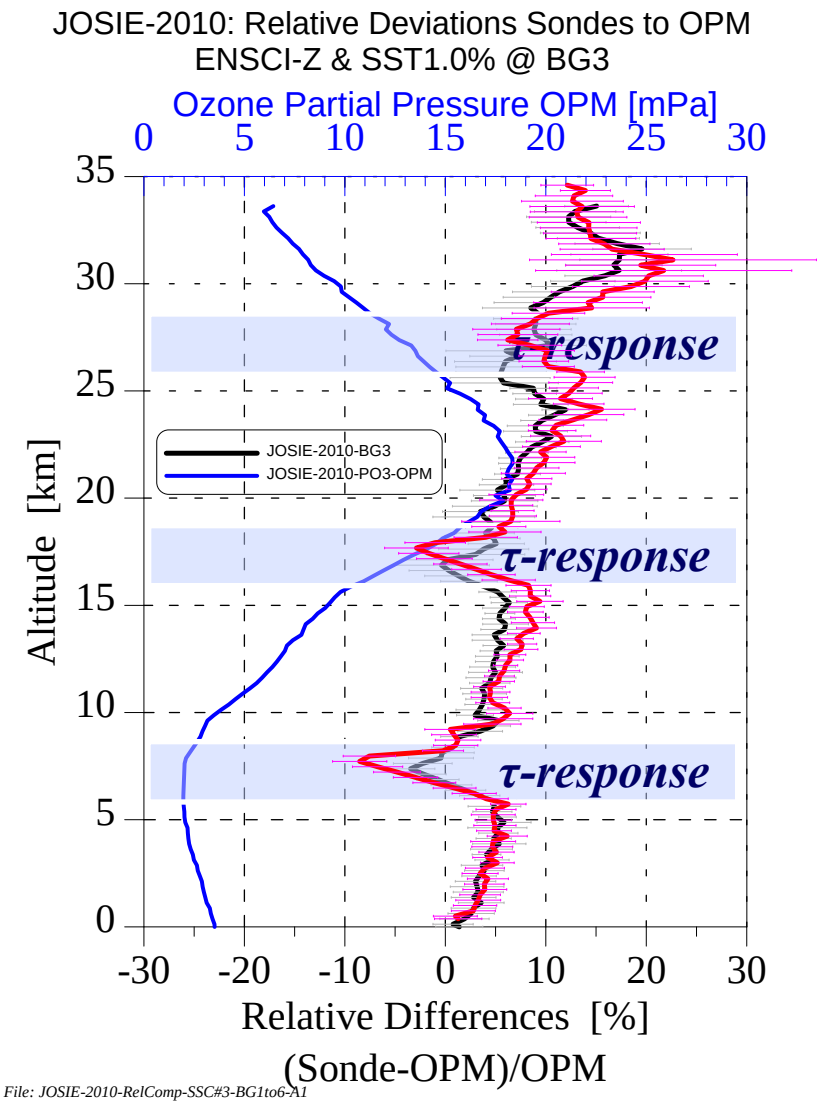
JOSIE-2009/2010: SPC-6A Sondes
Relative Deviations to OPM @ SST1.0% & SST0.5% (BG3)

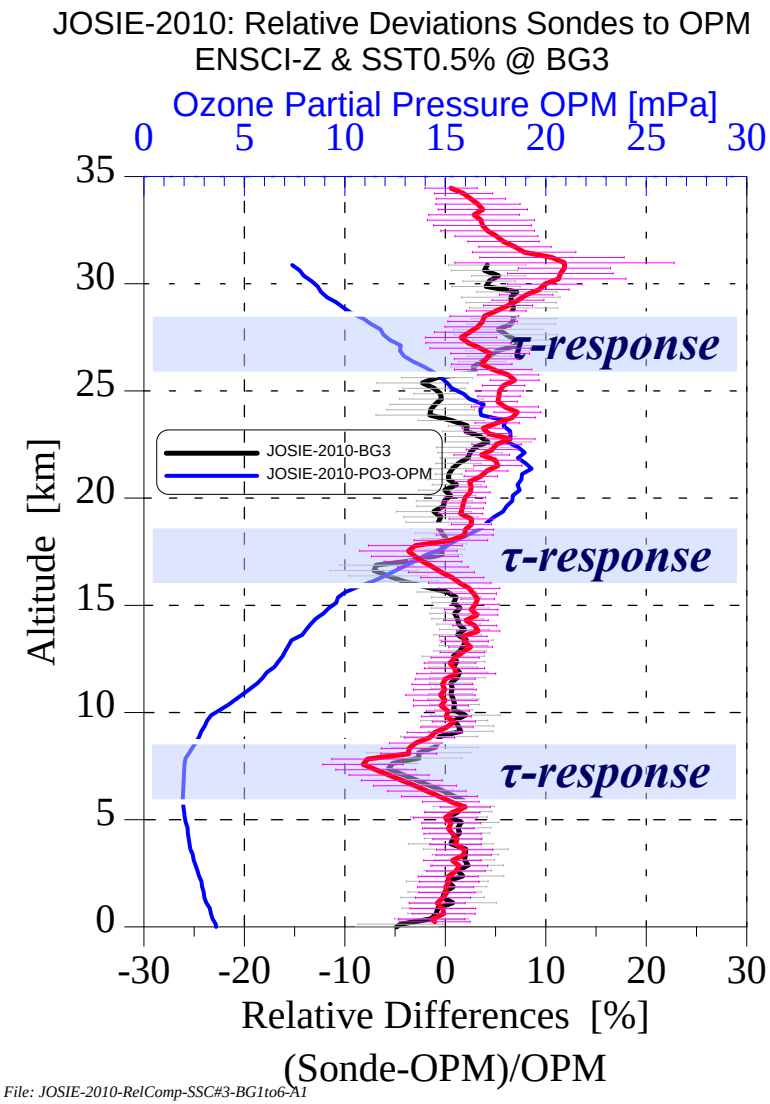




JOSIE-2009/2010: ENSCI-Sondes

Relative Deviations to OPM @ SST1.0% & SST0.5% (BG3)

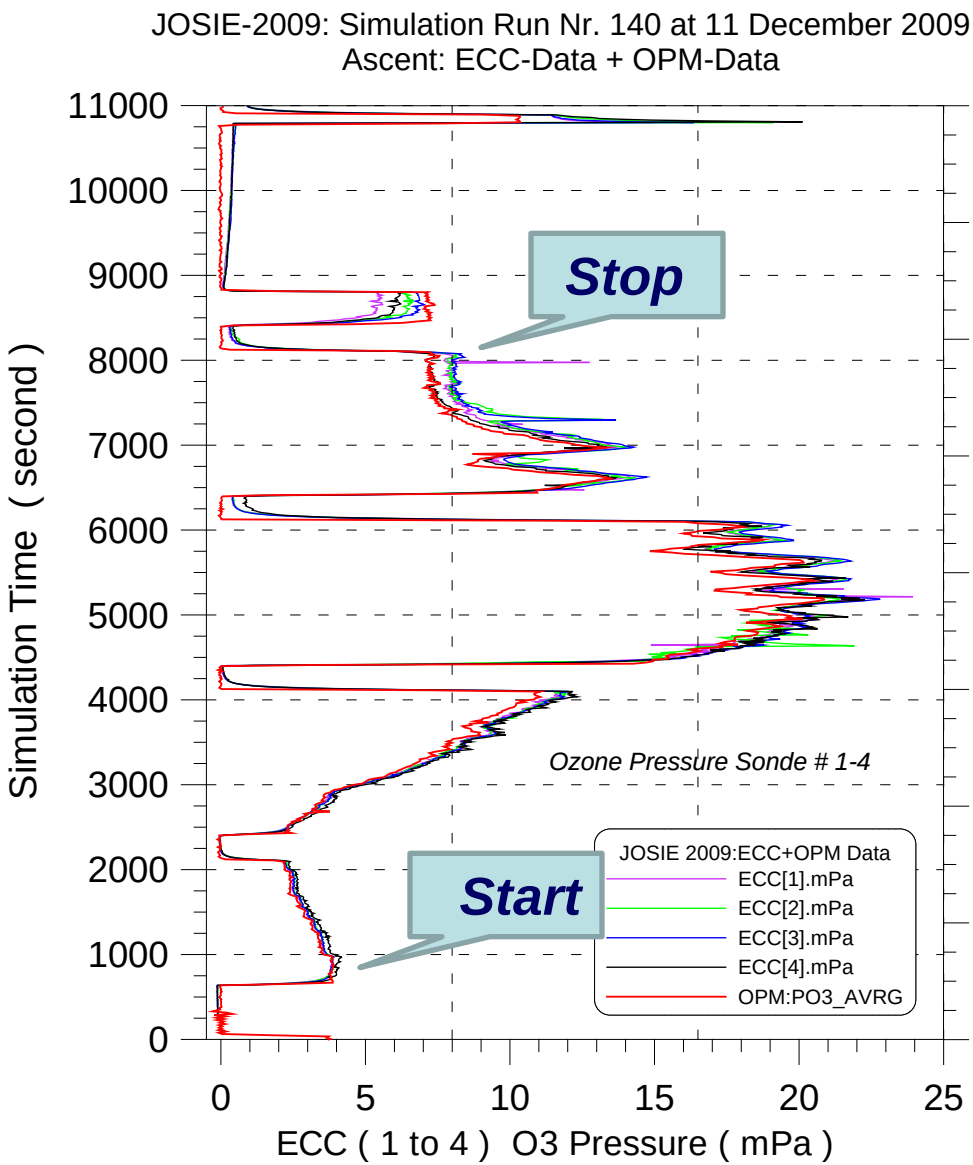


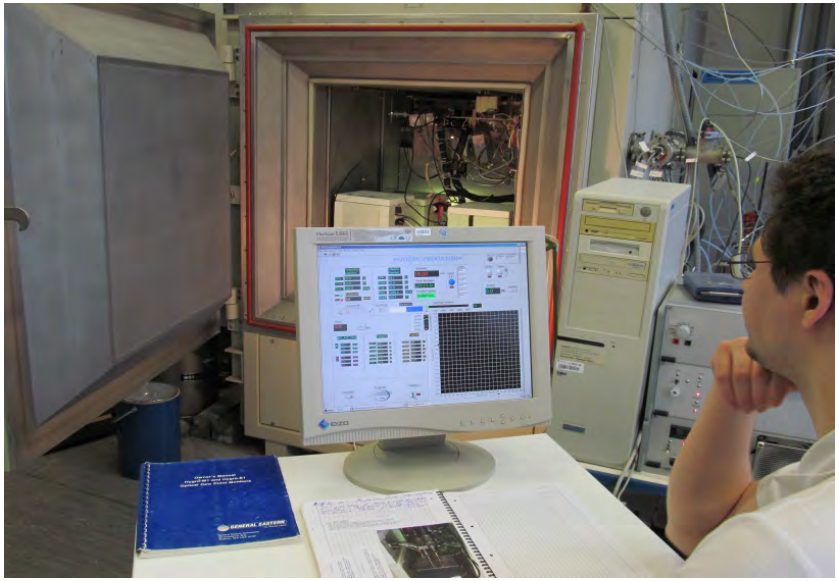


JOSIE 2017: Pump Flow Efficiencies (part 1)

"Pres(hPa)"	"Ratio_K95_CMDL"
1000	1
500	1
100	1.0278053624628
50	1.0333988212181
30	1.041788143829
20	1.045148895293
10	1.0741088180113
7	1.1039558417663
5	1.125

JOSIE: Simulation Run





Ozone Reference

Dual Beam UV-Photometer:

- response: 1 s
- precision: ±0.025mPa ,
- accuracy: ± 2 % (0-25 km),
  ±3.5% (30-35km)

Lessons We Learned With ECC's Again and Again

At the first sight it seems all fine and not to worry, because from Design, Components and Type all ECC Types look the Same

But:

Small changes of instrument or operating procedures or changing manufacturers can have large impact on data quality (e.g. JOSIE & BESOS)

Warning:

Cautious with regard to any changes

(Remind, that the devil is always hiding himself in the details)