# New insights from the Jülich Ozone-Sonde Intercomparison Experiments (JOSIE): calibration functions traceable to one ozone reference instrument

R. Van Malderen, H. G. J. Smit , D. Poyraz, A. M. Thompson, D. W. Tarasick,
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# More information

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**New Insights From The Jülich Ozone-Sonde Intercomparison Experiments: Calibration Functions Traceable To One Ozone Reference Instrument**

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+ all results for 4 other sonde type – sensing solution combinations, relative contributions of the different components of the TRCC method, uncertainty estimation of the TRCC method

# Outline

- Introduction
- Principles of “new” method
- Data
- Time Responses Correction (TRC) Method
- Application on JOSIE data
- Application on sounding data
- Conclusions and outlook

# Introduction

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$$P_{O3} = 0.043085 * \frac{T_P}{(\eta_P * \eta_A * \eta_C * \Phi_{P0})} * (I_M - I_B)$$

1. improper Komhyr pump efficiency corrections $\eta_P$
2. 
3. 

- However, we know…

1. **measured** pump efficiency factors, consistent between different labs in several decades
   → Johnson et al. (2002), Nakano & Morofuji (2023)
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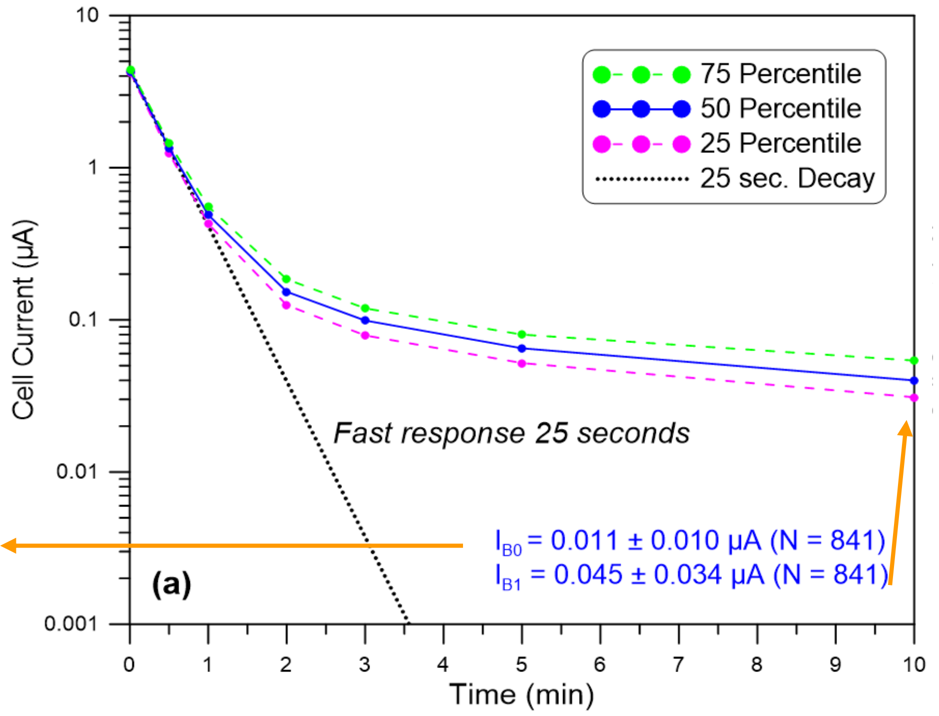
3. conversion efficiency increases in the course of a sounding (evaporation of solution)
4. the primary chemical reaction (95%) has a fast time response with time constant 20-25 s → corrections proposed in Imai et al. (2013), Huang et al. (2015)

# Principles of “new” method

## Pre-launch procedure at Uccle (N = 365-840)

a) 10 min @ 150-200 ppb → 10 min @ no $O_3$ → switch pump off
b)




Findings:

- ✓ fast time response (t = 20-25 sec) dominates when switching to no $O_3$
- ✓ almost no contribution of fast component to $I_M$ after 4 minutes
- ✓ slow time response (t = 20-25 min) of signal takes it over afterwards
- ✓

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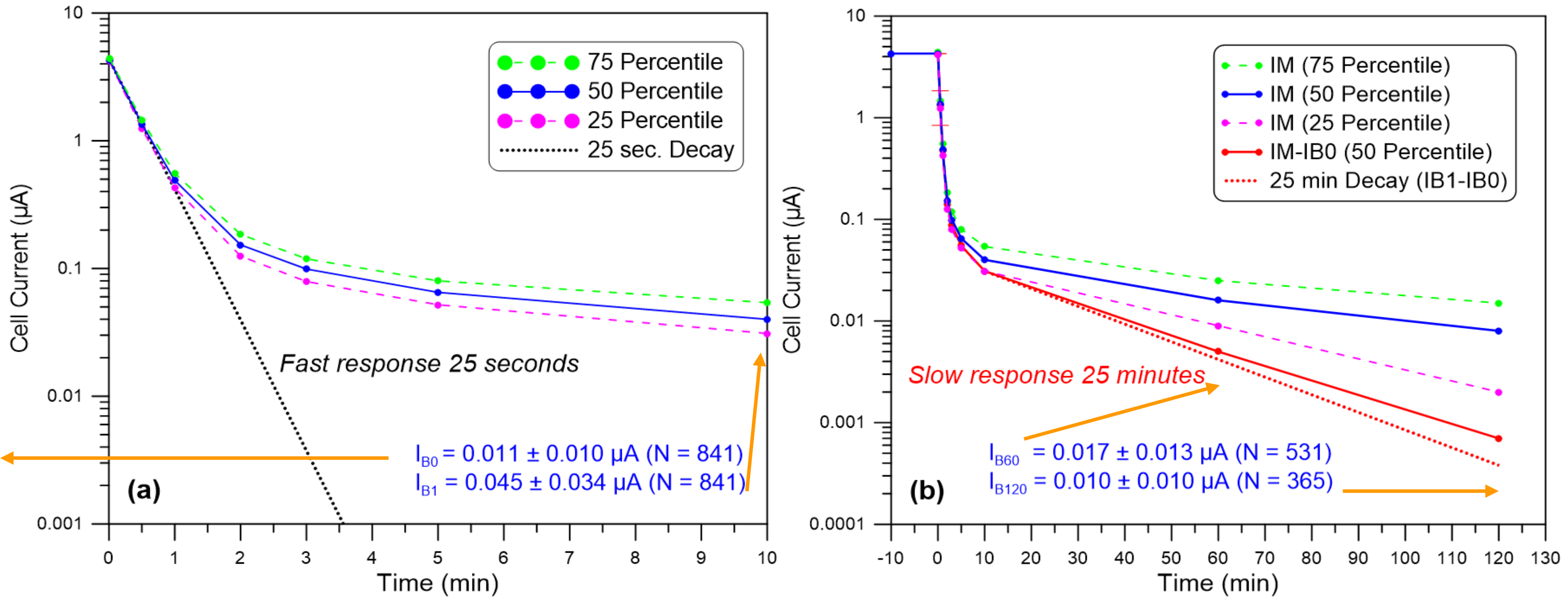
b) no $O_3$ @ 60 min, 120 min (pump on again)




→ $I_M = I_F + I_S + I_{B0}$

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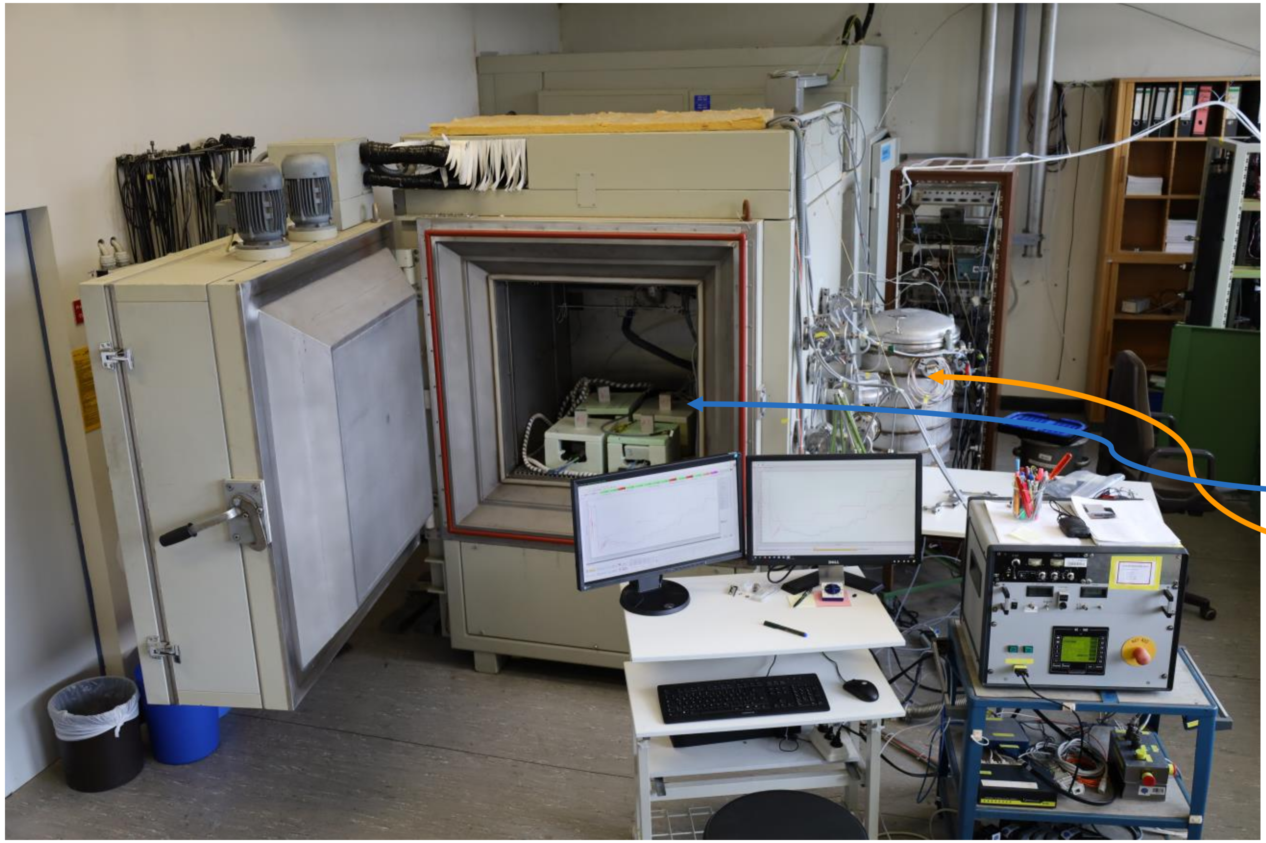
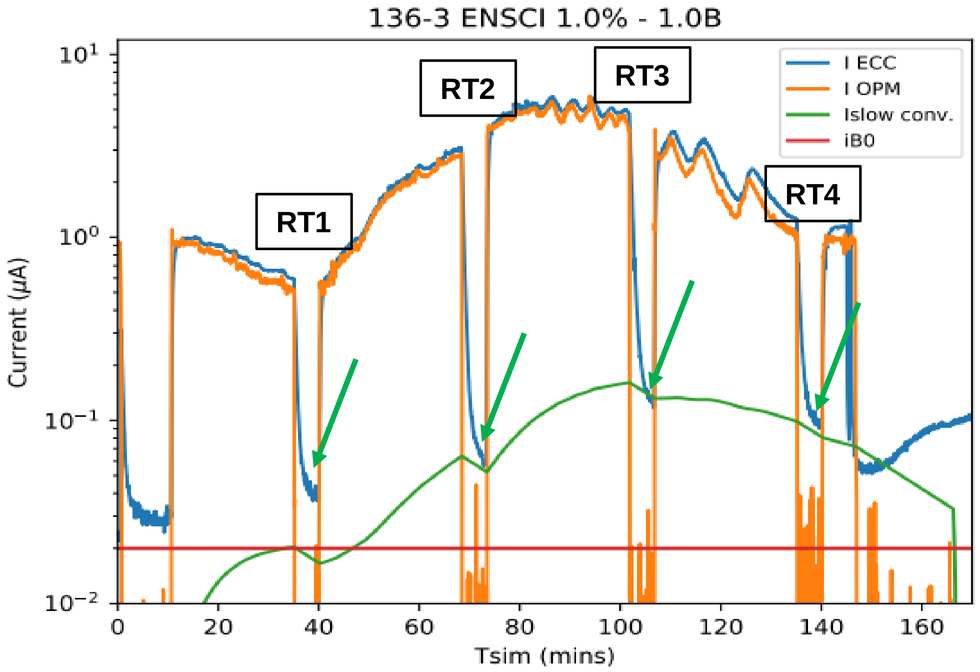
- ✓ slow time response (t = 20-25 min) of signal takes it over afterwards
- ✓ at 60 min & 120 min: excess current w.r.t. slow response: $I_{B0}$ (current measured before $O_3$ exposure)

# JOSIE measurements in Environmental Simulation Facility in Jülich

- response test (RT) intervals in JOSIE 2009/2010
- 2 manufacturers (ENSCI, SPC), two solution strengths
- reference photometer in chamber





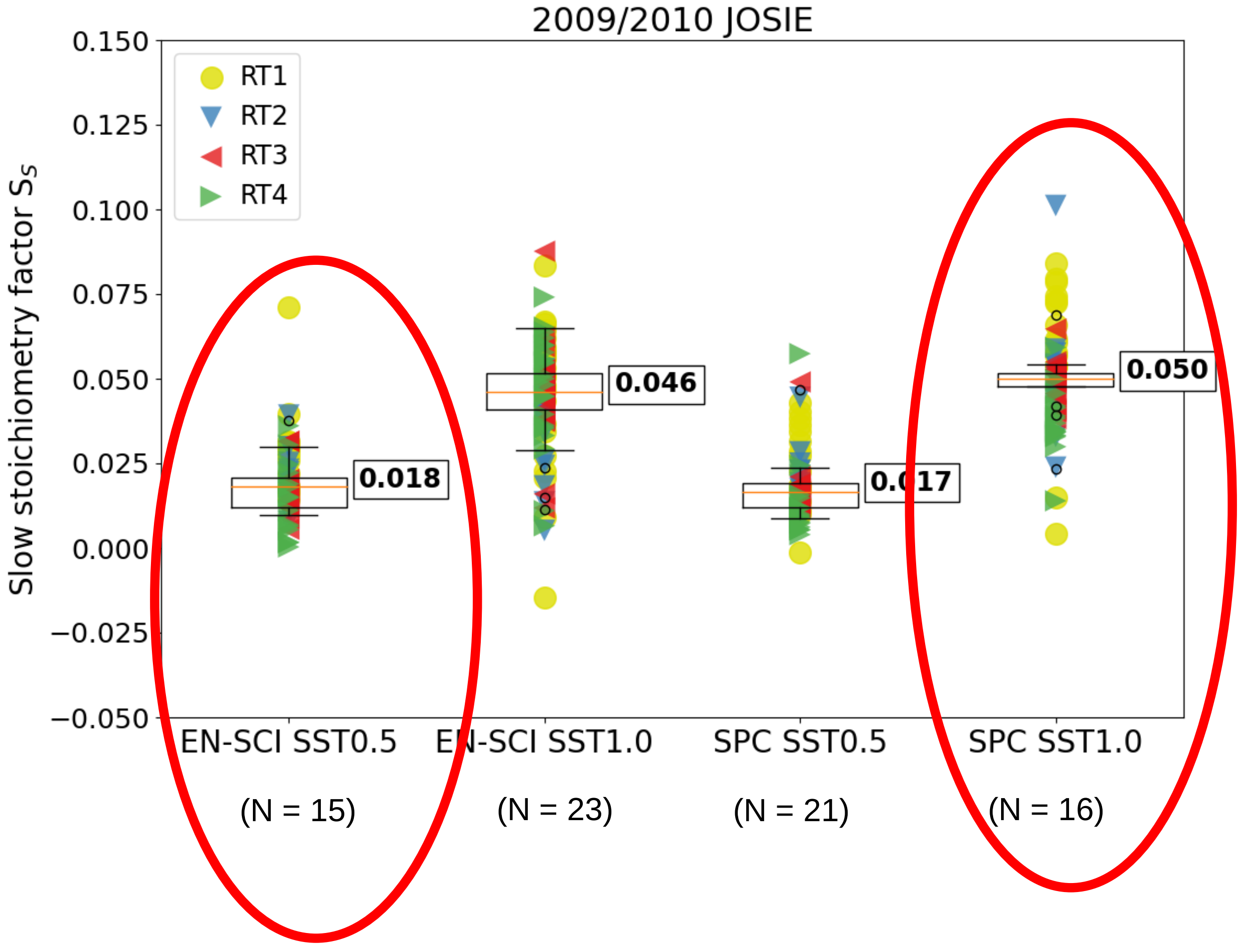

- I ECC: original ECC current
- I OPM: current measured by reference photometer in Jülich
- I slow conv.: convolved "slow" part of the signal
- iB0: background current before $O_3$ exposure

➔ contribution $S_S$ of slow component?

# Time Responses Correction Method

## Contribution $S_S$ of slow component?

- ✓ contribution ranges between 1.7 and 5%
- ✓ similar solutions = similar contributions
- ✓ larger contributions for higher KI concentration and **higher buffer strength**
- ✓ independent of sonde manufacturer
- ✓ independent of response test interval used (atmospheric conditions)

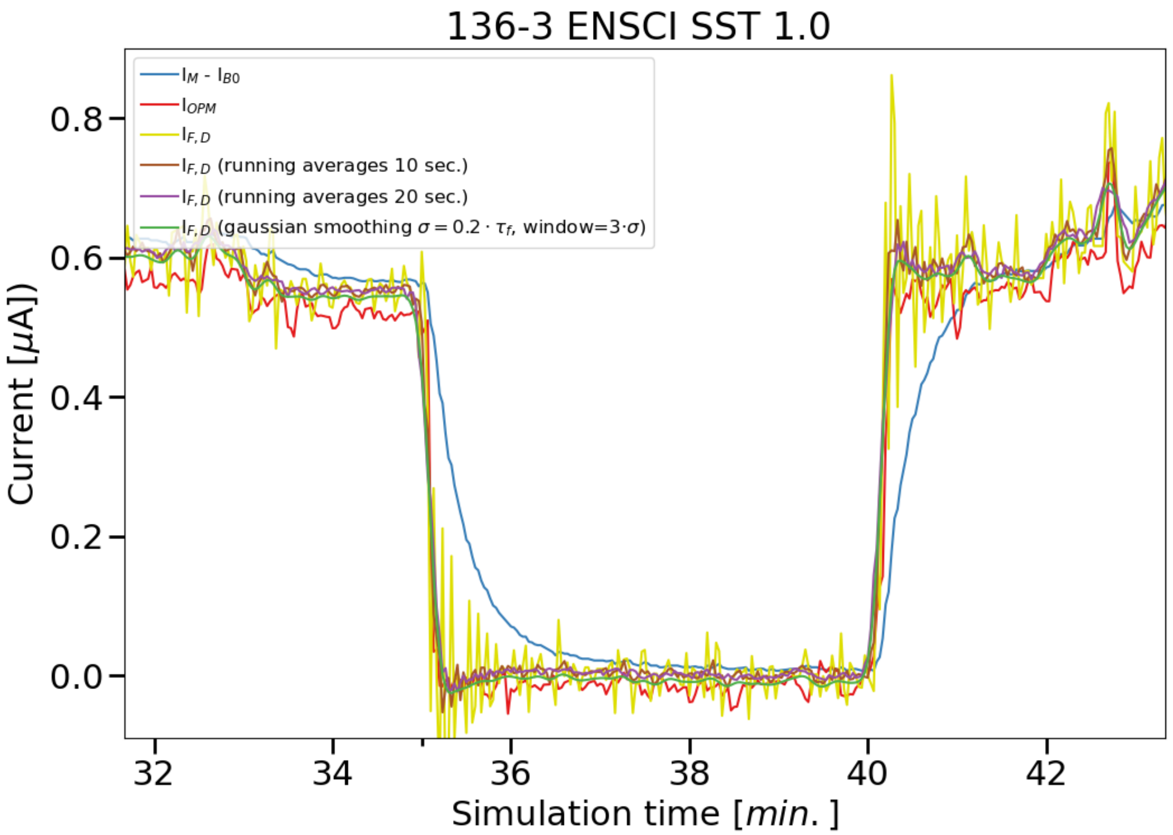


# Time Responses Correction Method

In practice: $(I_M = I_F + I_S + I_{B0})$

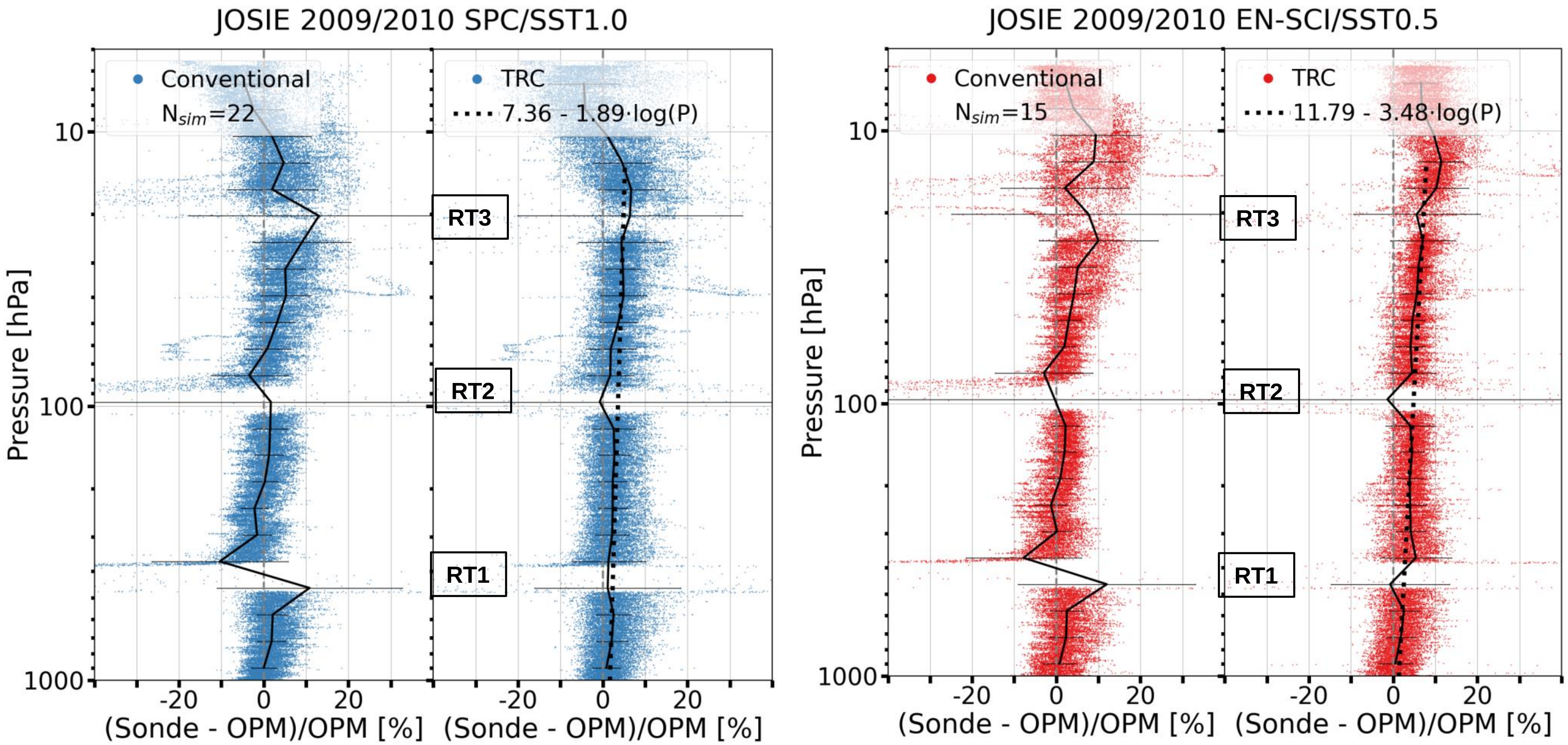
- subtract $I_{B0}$ from measured currents $I_M$ $(I_A = I_M - I_{B0})$
- determine slow component $I_S$,
  - ✓ calculated as 25 minute (exponential) delayed signal, multiplied with its relative contribution $S_S$
  - ✓ subtract from the ECC current ("background current", but time/ozone exposure dependent)
- remaining fast component $(= I_A - I_S)$ can be corrected for 20-25 s time response ($I_{F,D}$).

=> TRC method, see also Vömel et al. (2020)
<> role of $I_{B0}$, smaller $S_S$



# Application on JOSIE

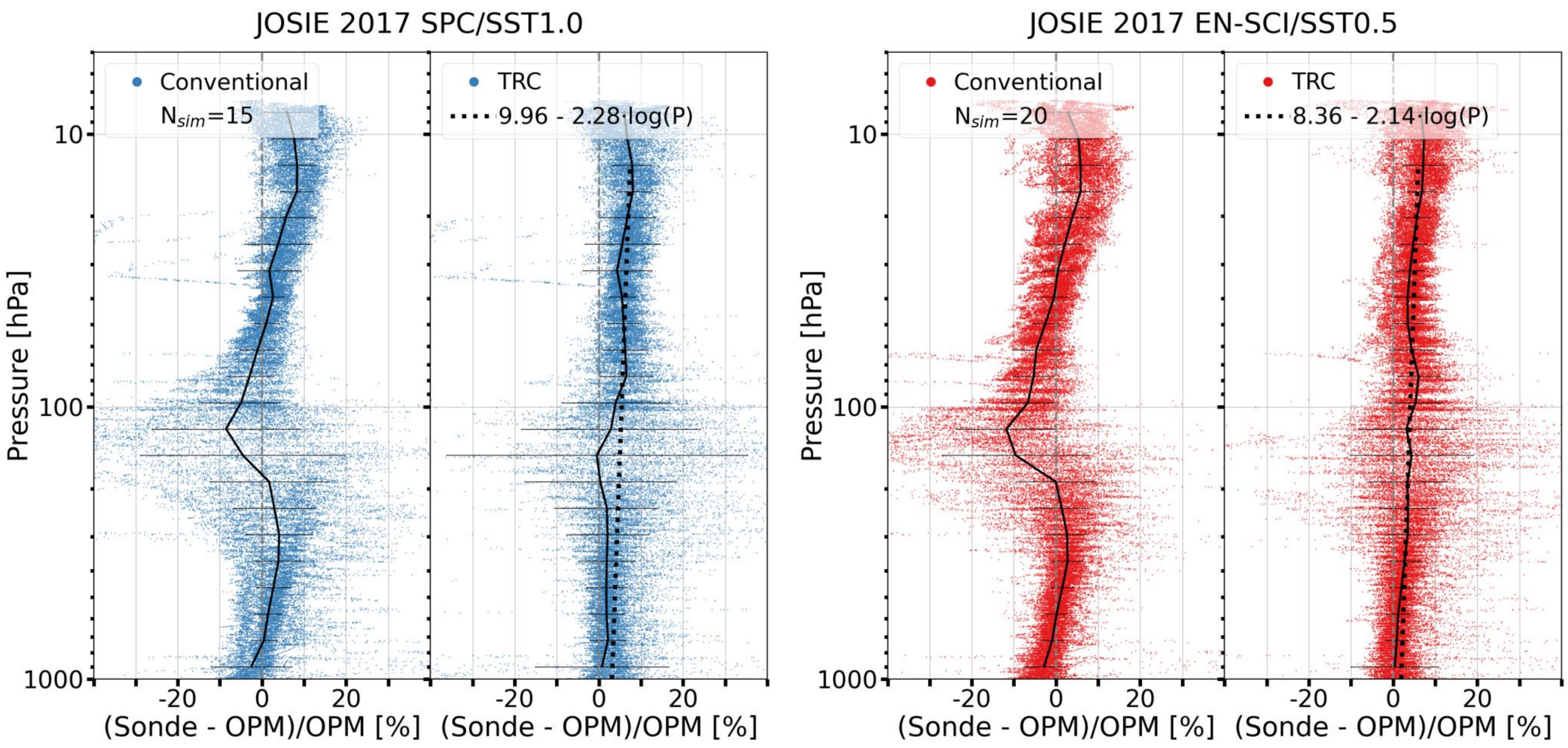
## Application on JOSIE 2009/2010 (mid-latitude) data




2 recommended standards in the network

- ✓ large reduction of rel. differences around response time (RT) intervals
- ✓ major improvement with TRC: independent on ozone profile or pressure
- ✓ slightly linearly increasing bias with decreasing pressure

# Application on JOSIE 2017 (tropical) data




- ✓ large reduction of rel. differences UT!
- ✓ major improvement with TRC: independent on ozone profile or pressure
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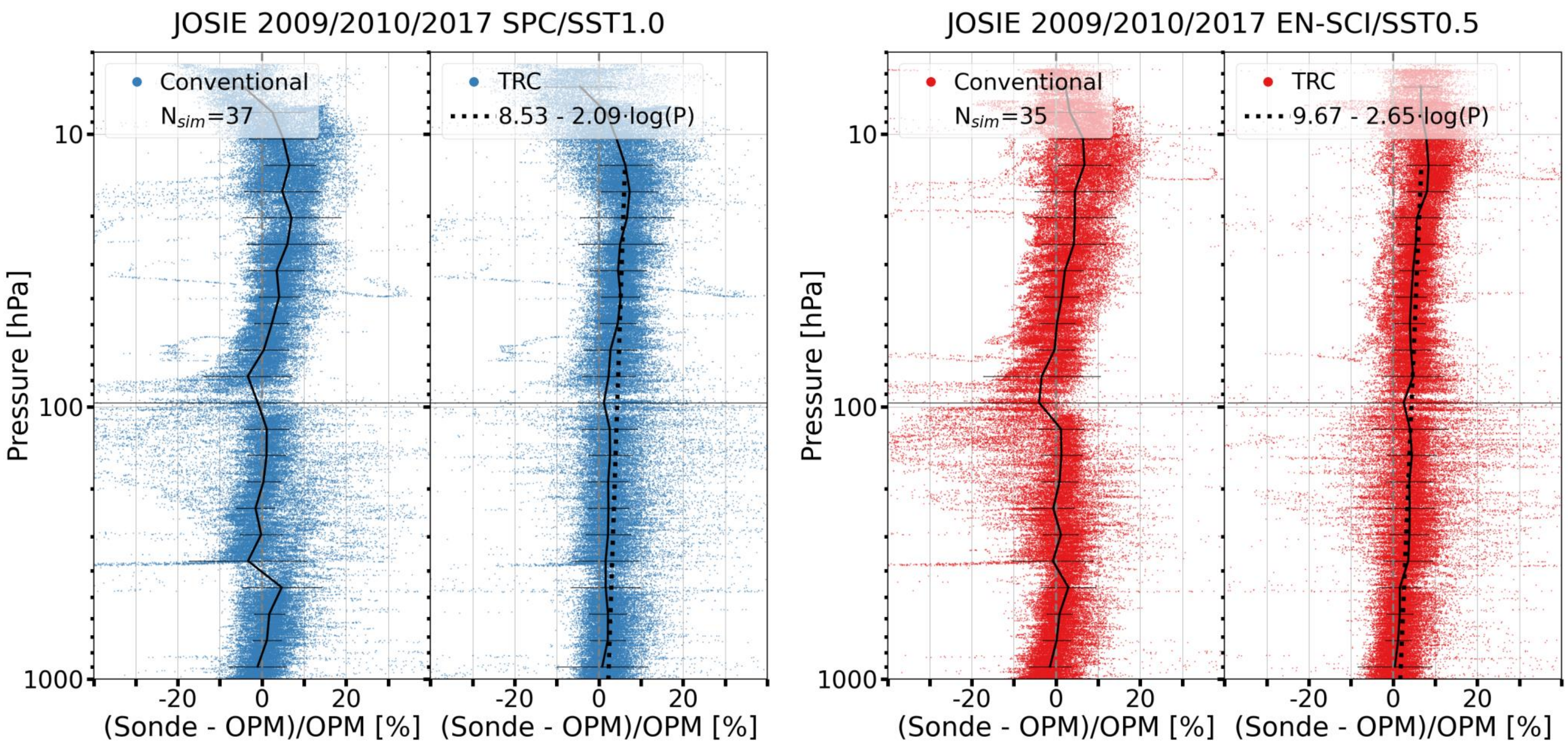
2 recommended standards in the network

# Application on JOSIE

## Determination of calibration functions

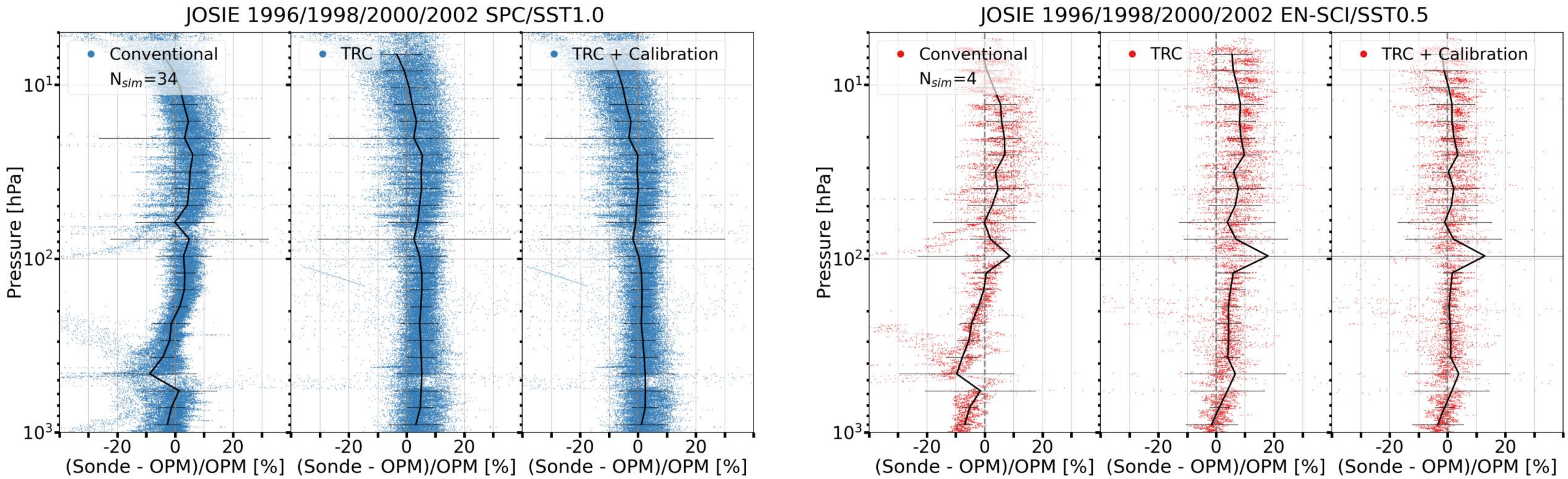



2 recommended standards in the network

- ✓ remaining linear regression lines are very similar for both campaigns (mid-lat vs. tropical)
- ✓ calculate those for the entire samples, for every sonde type – SST combination
- ✓ “calibration functions” to the OPM (conversion efficiency)

# Application on JOSIE

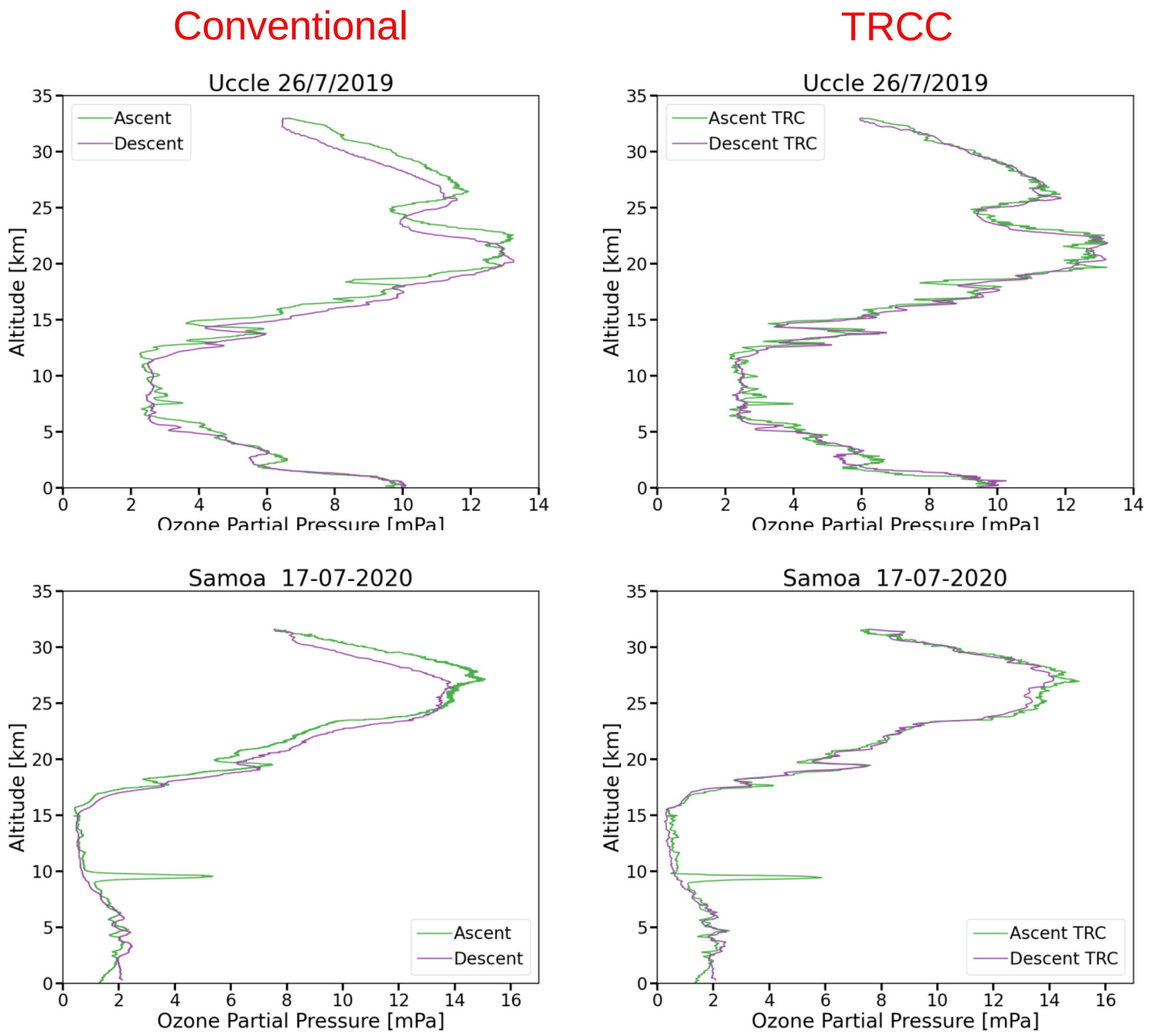
## Application on early JOSIE data (1996, 1998, 2000, 2002)




2 recommended standards in the network

- ✓ after applying the TRC + calibration functions ("TRCC"): differences are within ±1% for almost the entire pressure range (except the lowest pressures)
- ✓ now referenced to the OPM

# Application on sounding data




- ✓ remarkably improved agreement between ascent and descent profiles (→ correction for fast time response component) with TRCC
- ✓ also better agreement in ascent/descent profile shapes with TRCC
- ✓ lower UT ozone concentrations in tropical Samoa and ozone hole at South Pole
- ✓ amplification of features in TRCC profiles after correcting for the fast time constant (>< increased noise?)

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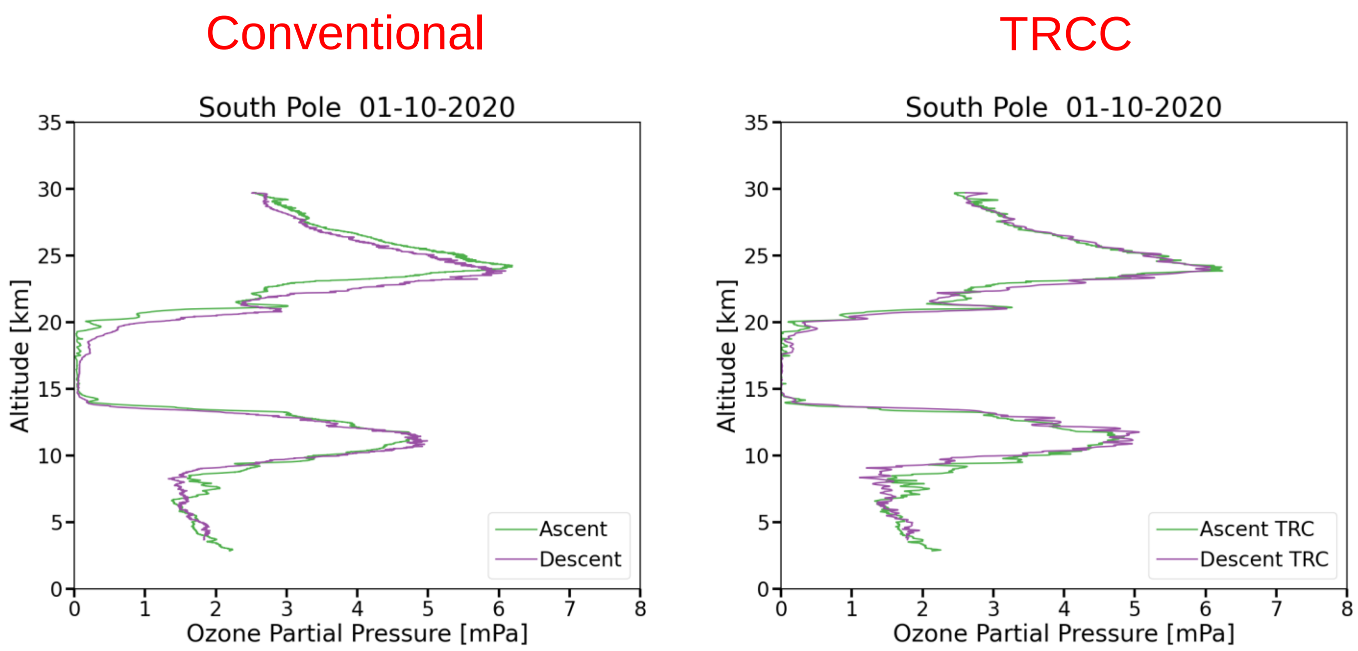


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# Conclusions and outlook

- Time Reponses Correction method as described/illustrated by *Tarasick et al. (2021) & Vömel et al. (2020)* further developed with all available JOSIE data

- Time Responses Correction method looks very promising, implementing all the (real pump efficiency) measurements and (chemical) knowledge we have
  - ✓ role for $I_{B0}$
  - ✓ relative contribution of slow component *(= signal convolved with t= 25 min exponential delay)* varies between 1.5 and 5%
  - ✓ correction for fast time response *(= deconvolved $I_M$-$I_{B0}$-$I_S$ with t=20-25 s exponential delay)* improves ozone gradient and amplifies features (smoothing!)

- but: need for calibration functions ("conversion efficiency") to trace observations back to the photometer in Jülich → related to fast primary chemical reaction???

- still a lot to be learned about (the chemistry of) the ozonesonde

- implementation in the global ozonesonde network is envisioned.

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