Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Eidgenössisches Departement des Innern EDI
Bundesamt für Meteorologie und Klimatologie MeteoSchweiz

WMO

GAW

Empa
Materials Science and Technology

World Calibration Centre WCC-Empa Audits at Bukit Kototabang and world-wide

Christoph Zellweger

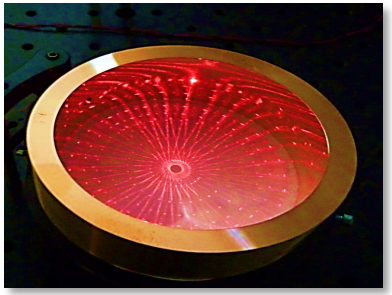
Empa Dübendorf, Switzerland

BMKG Webinar, 6 August 2021

Empa's Research Focus Areas

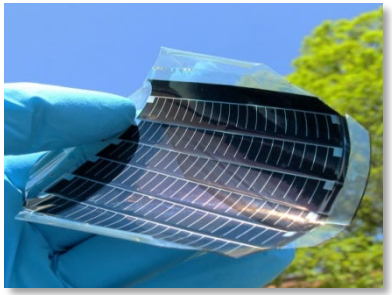
Health & Performance

Nanoscale Materials & Technologies



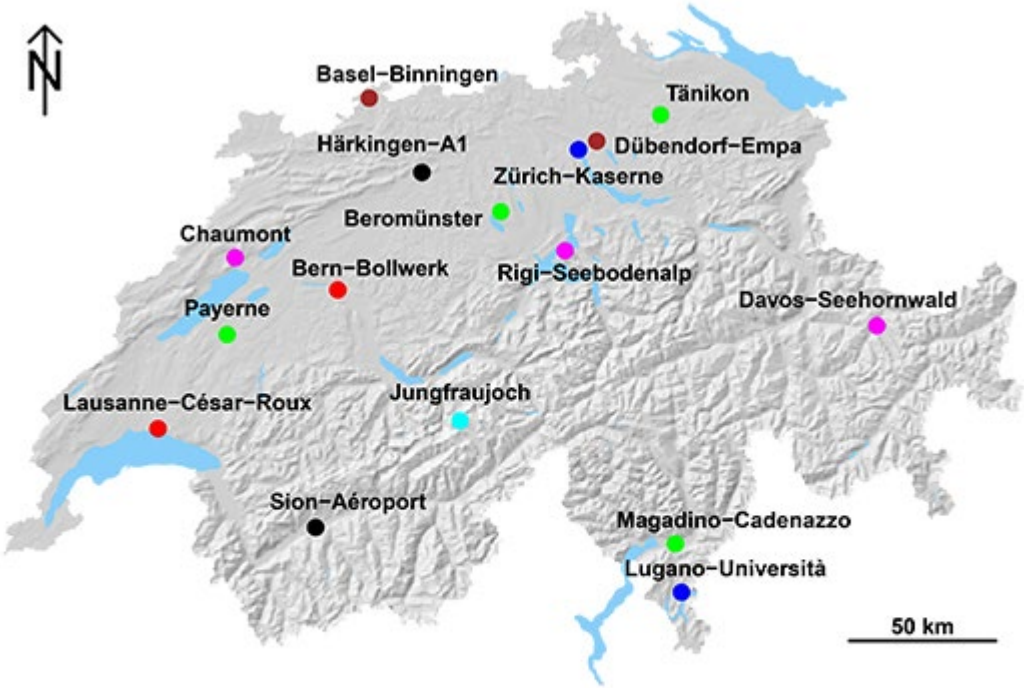
Resources & Pollutants

Sustainable Built Environment



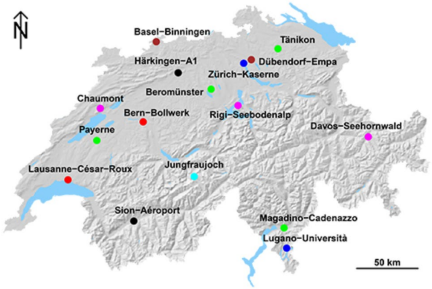
Energy

Swiss Air Pollution Monitoring Network (NABEL)



Air Pollution and Environmental Technology Lab

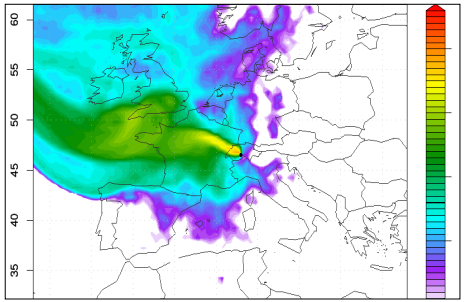
Measurement



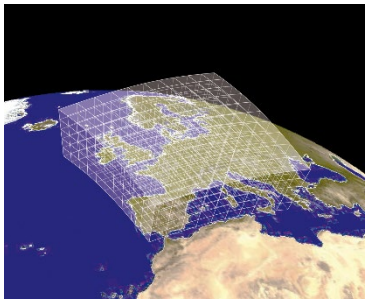
National Air Pollution Monitoring Network (NABEL)

WMO World Calibration center for O_3, CO, CO_2, CH_4

Modelling



GHG modelling



Air pollution and urban modelling

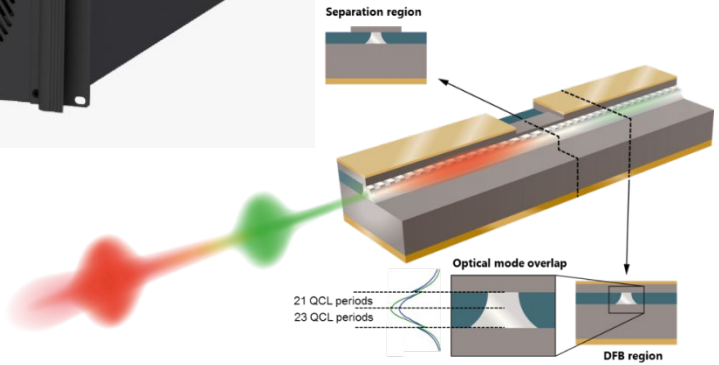
Instrumental Development

MIR Laser Spectroscopy

Gas Chromatography

Spin-off: http://www.miro-analytical.com

High-precision Multicompound Gas Analyzer



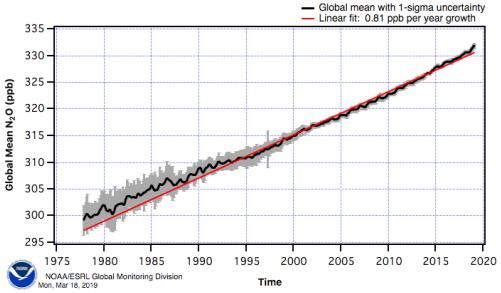
Performance

Trace gas	Best precision, ppb	Range, ppm
NO	0.08	0 - 100
NO_2	0.02	0 - 40
CO	0.08	0 - 20
CO_2	80	0 - 8000
CH_4	tbd	0 - 200
N_2O	0.05	0 - 20
NH_3	0.02	0 - 15
O_3	0.11	0 - 300
SO_2	tbd	0 - 150
H_2O	70 ppm	0 - 15%

Supporting climate policy and research

- Need for reliable / traceable data

Well-established integrated global observations are essential for understanding the global carbon cycle and the role of greenhouse in climate change.



https://www.esrl.noaa.gov/gmd/

- Global Atmosphere Watch (GAW)

Currently GAW coordinates activities and data from 30 global stations, more than 400 regional stations, and around 100 contributing stations.

http://www.wmo.int/pages/prog/arep/gaw/gaw_home_en.html

- GAW QA/QC framework

Measurements must be expressed in the same units and on the same scale and data from different countries and from different sites are must be comparable.

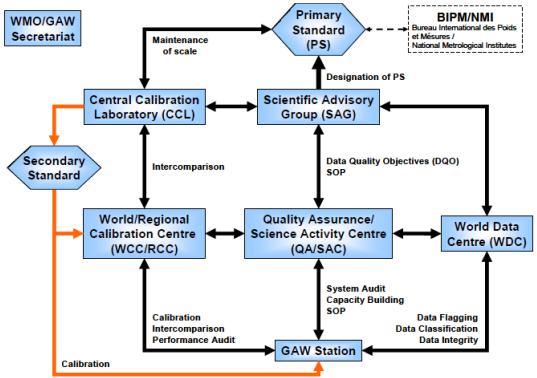
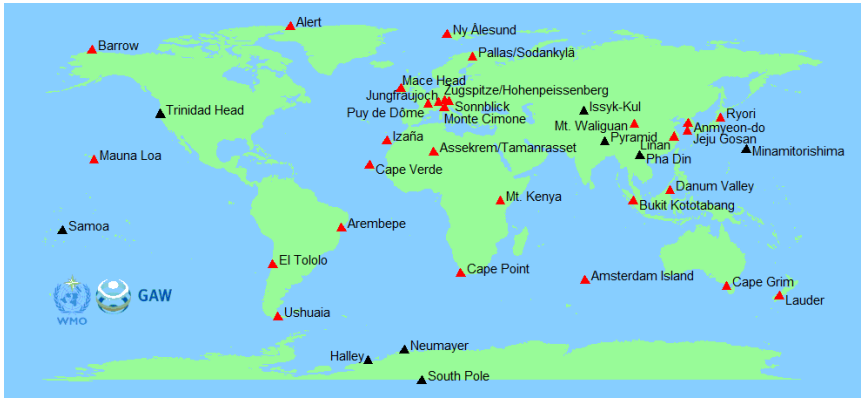


Figure 15 - Elements of the Quality Assurance system, QA activities and workflow in GAW

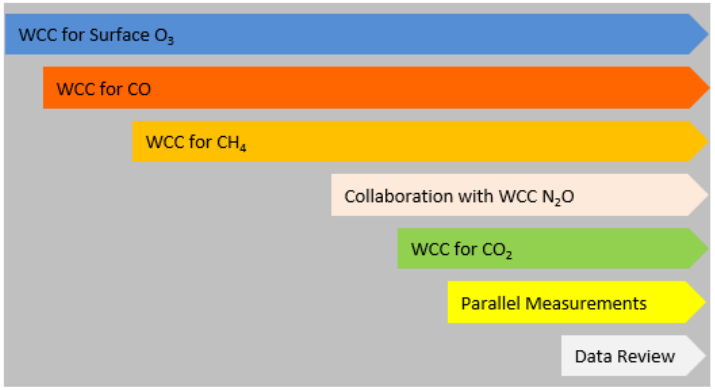
GAW Implementation Plan for 2016-2023

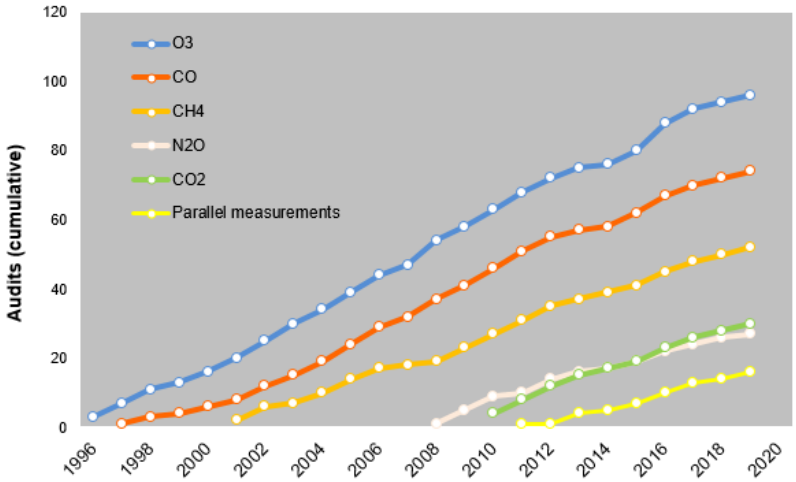
World Calibration Centre WCC-Empa

- Supports global research and policies since 1996
- More than 100 station audits at mainly global GAW stations
- Covers four important greenhouse and reactive gases
- Collaborates with other calibration centres to improve traceability
- Assesses the performance of stations also with parallel measurements
- Audit procedure includes data and metadata review



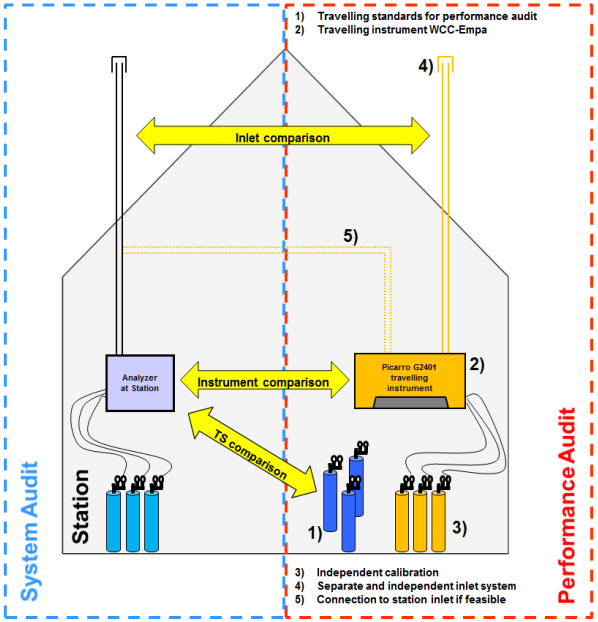
Audited stations by WCC-Empa since 1996 (red triangles)





Scope (top) and cumulative number (bottom) of WCC-Empa audits

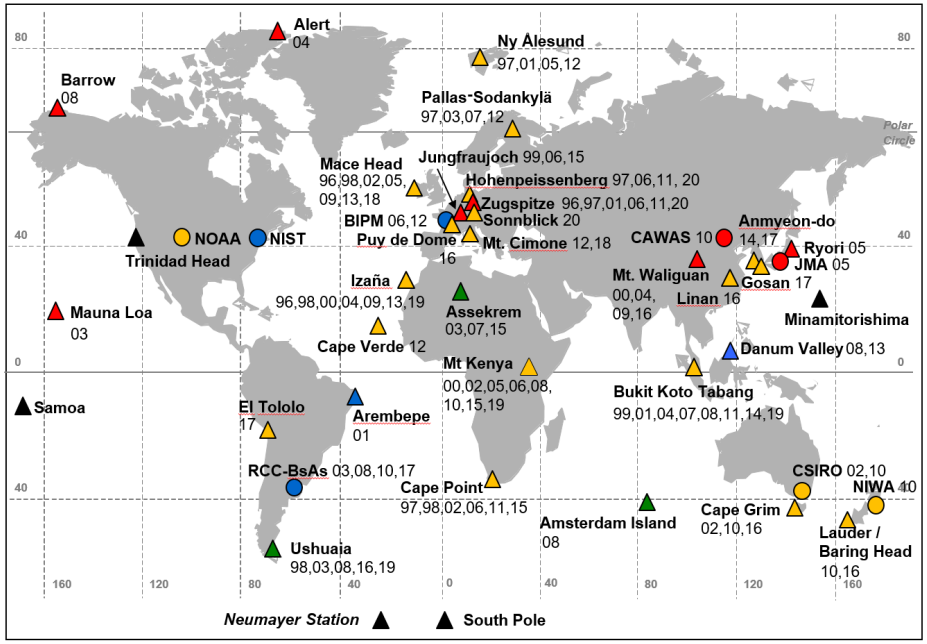
Audits: Travelling Standards vs. Parallel Measurements



- 😐 Only instrument comparison
- 😐 Snapshot in time
- 😐 Special care might influence results
- ☺ Covers wider mole fraction range
- ☺ Repeatability conditions

- ☺ Assessment of the whole system
- ☺ Longer time period
- ☺ Less influence by operator
- 😐 Limited to ambient mole fraction range

WCC audits at Bukit Kototabang and worldwide



1999 2001 2004 2007 2008 2011 2014 2019

History of BKT and Empa's BMKG support

- 1995: Station established. Initial twinning partner CSIRO, Australia.
- 1999: First system and performance audit (O_3) at BKT by WCC-Empa (Alex and Brigitte).

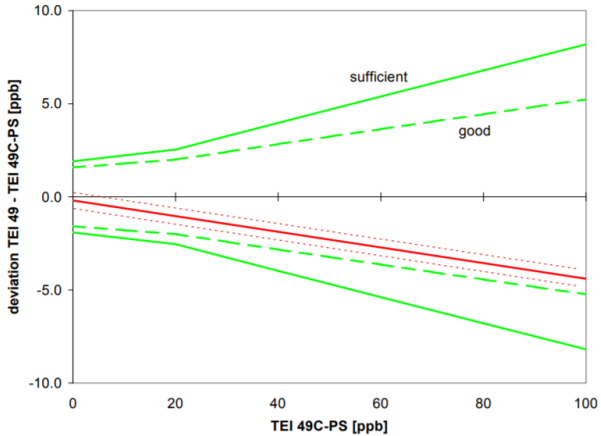
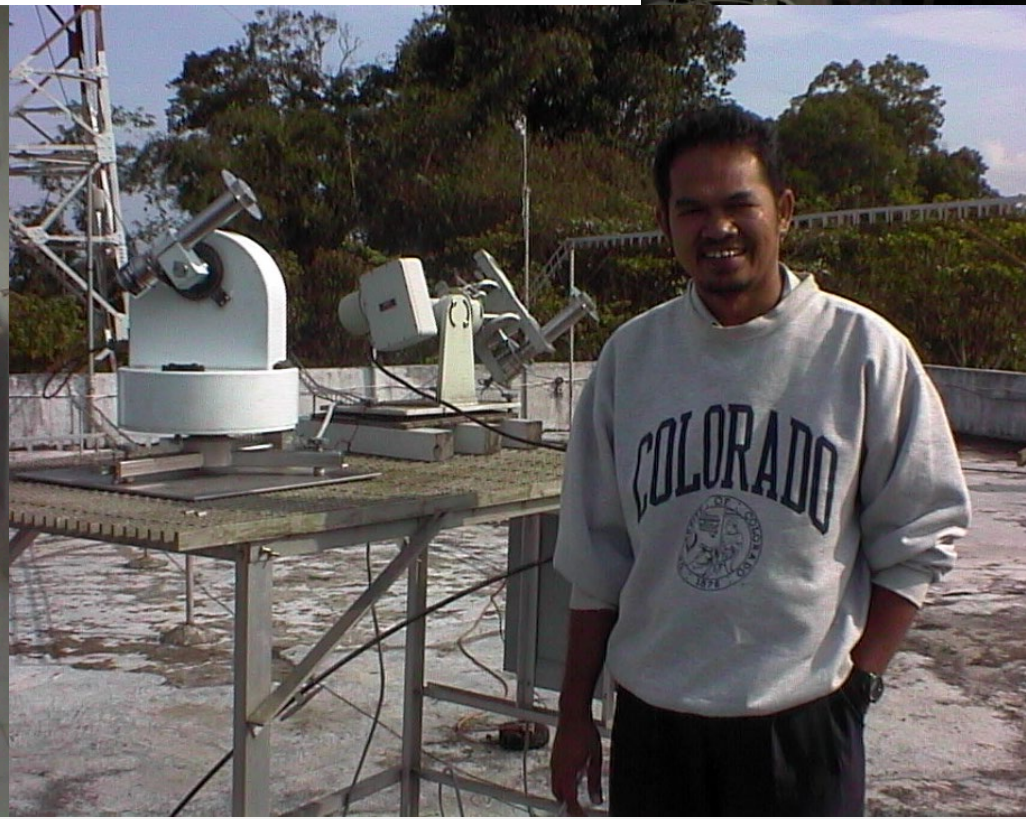


Figure 12: Intercomparison of ozone monitor TEI 49 (linear regression with prediction interval 95%)

2nd Audit BKT 2001: Installation of CO measurements

- 2001: Second audit and installation of first CO instrument by Empa / WMO.



3rd Audit BKT 2004 by Christoph Zellweger and Jörg Klausen

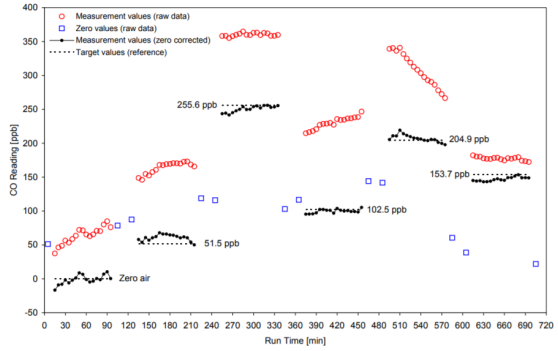


Figure 20: Raw measurement (red circles) and zero (blue squares) values. Zero corrected measurement values (black circles) were calculated by using nearest zero values. Zero drift was assumed to be linear between two zero measurements. Target values (dotted lines) are also shown.

4th Audit BKT 2007 by Christoph Zellweger and Jörg Klausen

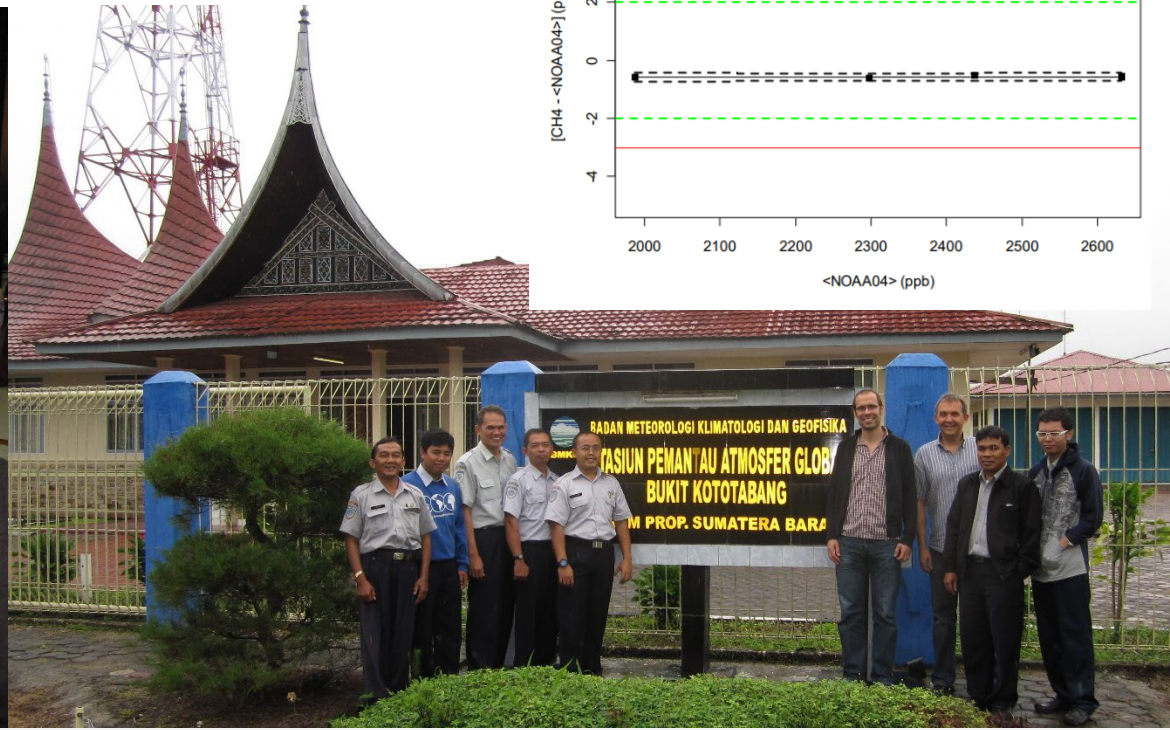
- 2007: First assessment of new O_3 instrument (replacement by Empa / WMO 2006).

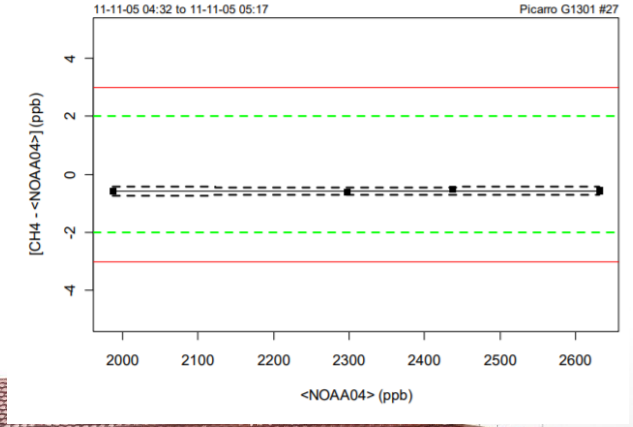
5th Audit BKT 2008 jointly with WCCAP

- 2008: 5th audit jointly with WCCAP.
- First assessment of new CO instrument (replacement by Empa / WMO 2007).

6th Audit BKT 2011: First assessment of GHG measurements

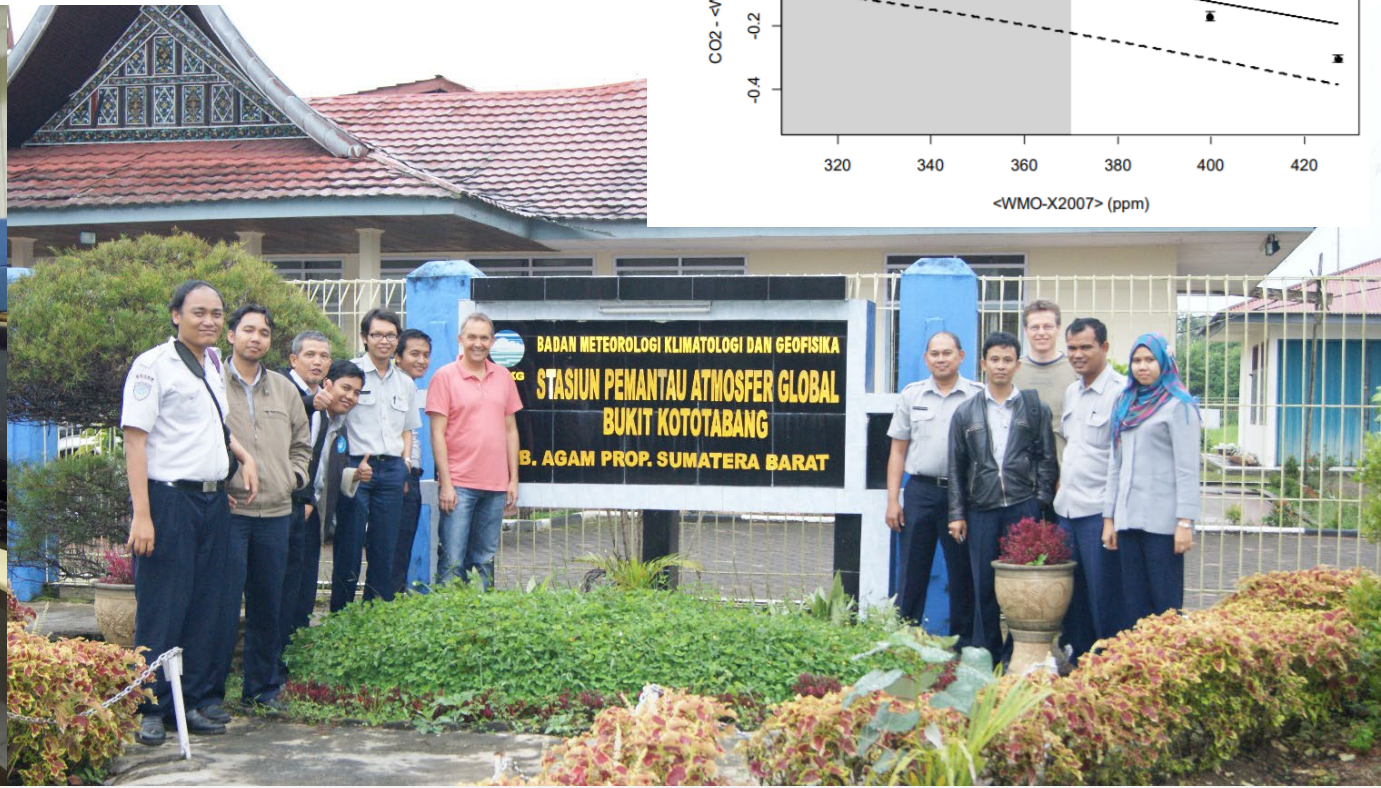
- 2011: First assessment of GHG measurements (Implemented jointly by QA/SAC Switzerland and BMKG in 2009).

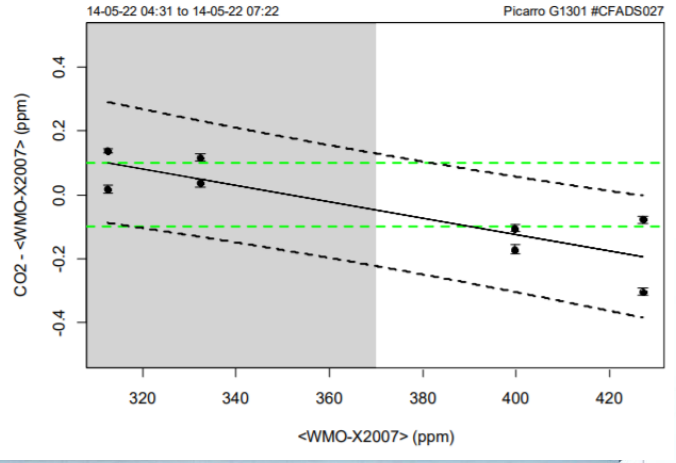




7th Audit BKT 2014

- 2014: Recommendations regarding GHG calibration.

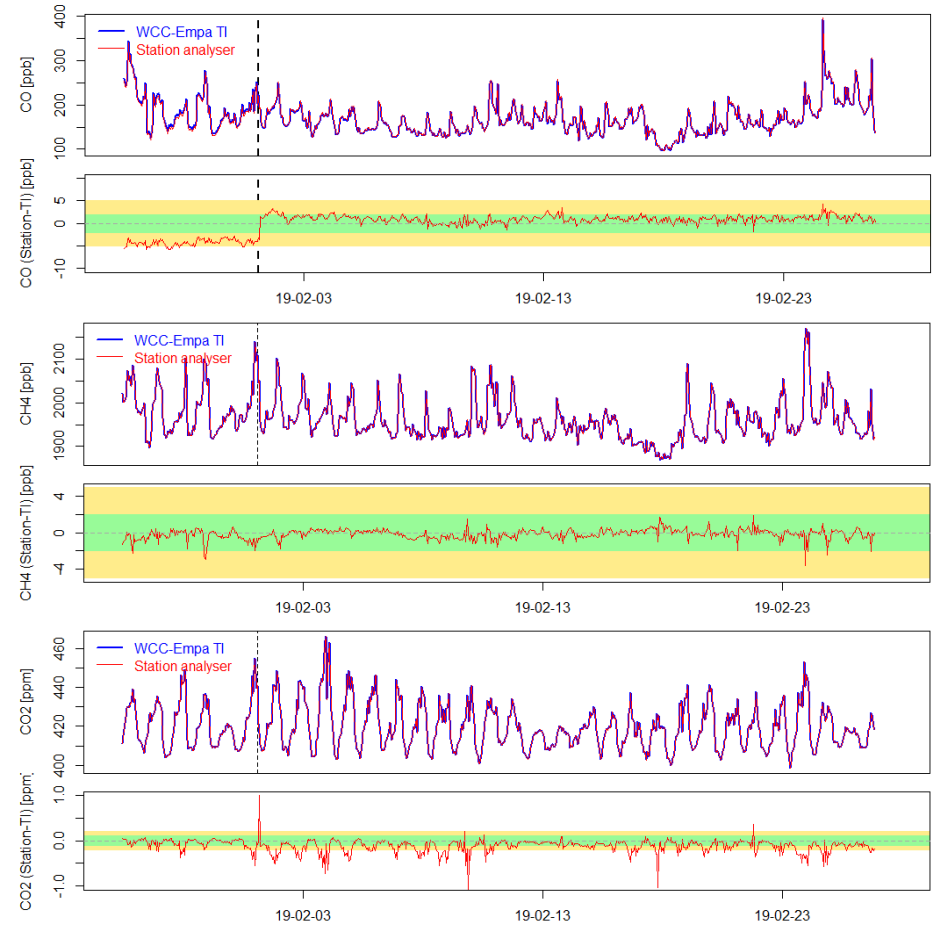




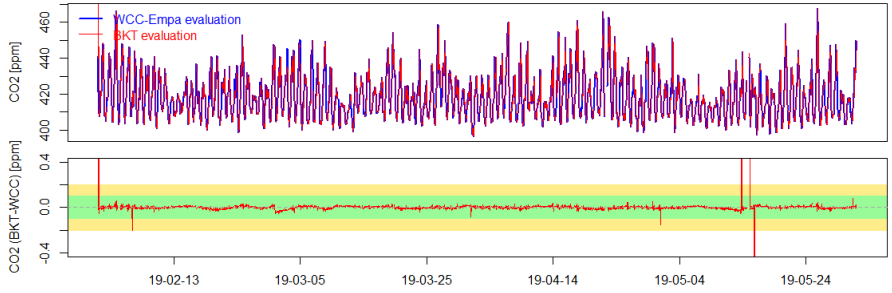
8th Audit BKT 2019 by Christoph and Martin

2019

Audit BKT 2019 parallel measurements

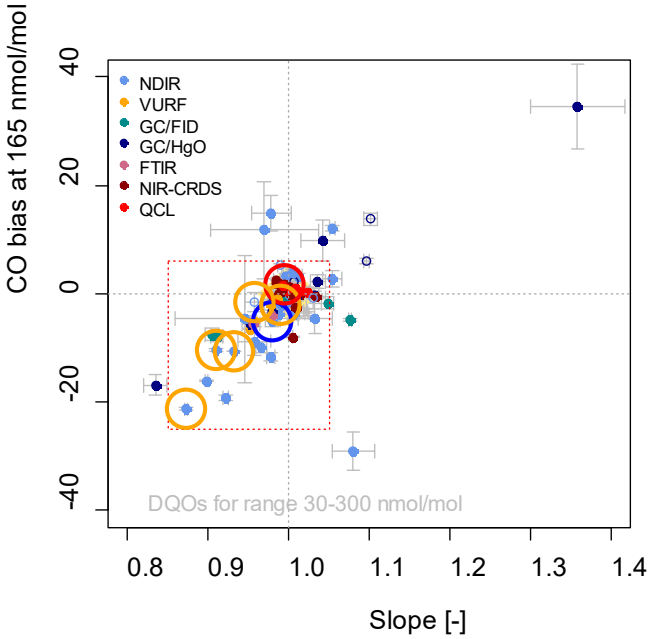


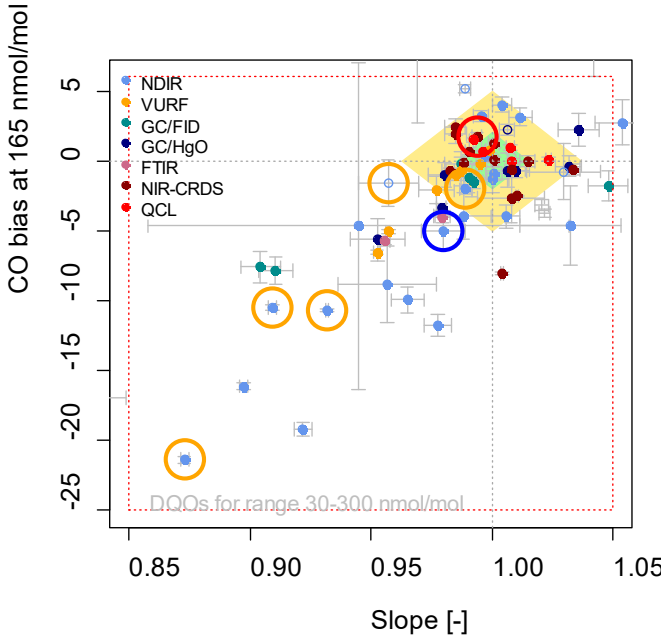
- 2019: Support in upgrading the GHG measurements.
- Installation of Nafion dryer to improve CO measurements.
- First parallel measurements between WCC-Empa and BKT.
- Further training of station staff.
- BKT operators are now fully capable of GHG data evaluation.



Progress at Bukit Kototabang

- Example CO measurements.
- CO measurements are challenging, many stations to not comply with the WMO/GAW compatibility goals.
- CRDS instrument (Picarro) performs better compared to NDIR systems (Thermo and Horiba).





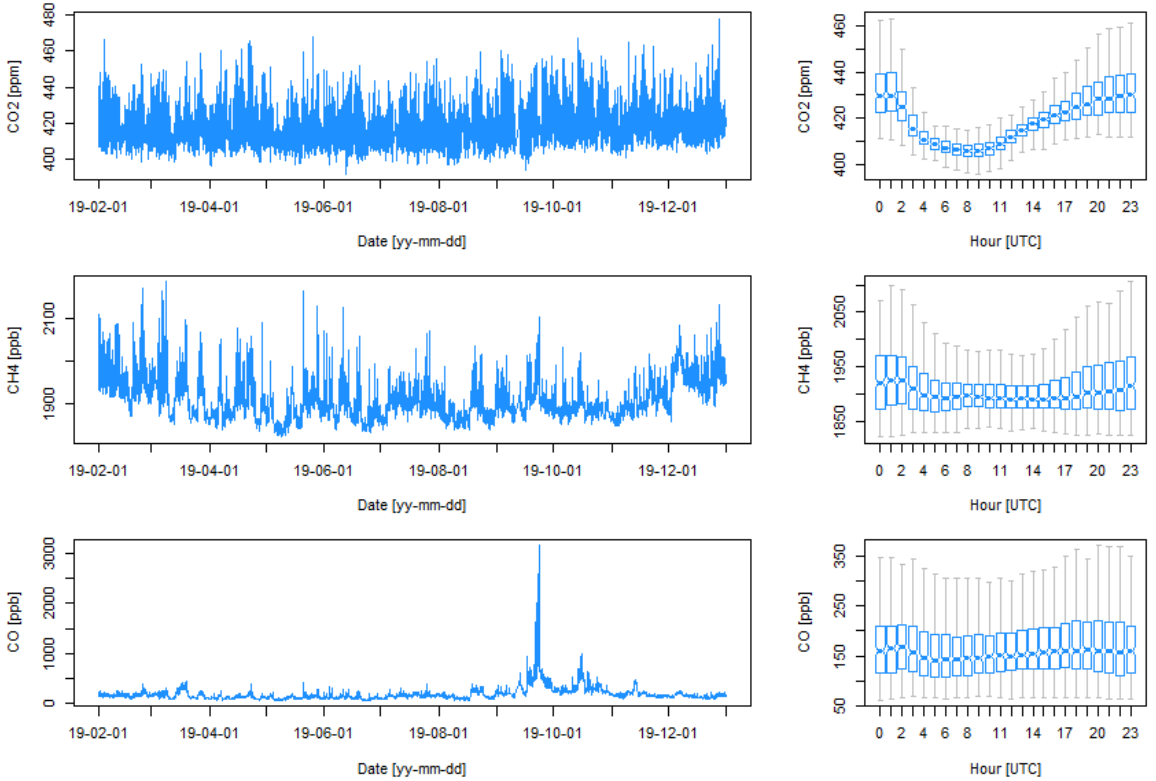
Thermo 48C-TL

Horiba APMA360

Picarro G2401

Summary and conclusions

- Significant progress has been made over the last two decades.
- Improved instrumentation and skills.
- Challenges: Future applications require 24/7 data availability in near real time.
- Instruments can fail, repair might by very costly and time consuming.
- Spare instruments should be available.
- Calibration (appropriate standards) might be difficult to obtain.
- Ongoing training of staff is needed, and know-how transfer must be ensured.



BKT CO_2, CH_4 and CO time series (2019, hourly averages)

Thank you!