CANADA’S NATIONAL REPORT

The eleventh meeting of the Ozone Research Managers
July 19–23, 2021
CURRENT STATE OF OZONE AND UV MONITORING

**BREWERS:**
- Data up to Apr. 2021 available from WOUDC for eight sites (incl. 3 Arctic sites: Alert, Eureka and Resolute Bay) – Individual measurements and average daily values
- Data used in Quadrennial WMO/UNEP Scientific Assessment of Ozone Depletion; annual BAMS State of the Climate reports; research (e.g., 2020 Arctic ozone hole, satellite validation)
- Two instruments permanently (20+ years) at MLO in support of absolute calibration activities
- Instrument at SPO (NOAA collaboration) – Antarctic ozone hole

**OZONESONDES:**
- New report Assessment of Standard Operating Procedures (ASOPOS 2.0).
- Canadian long-term record revised; improved knowledge of measurement uncertainties; continuing international collaboration to evaluate possible sonde bias-shifts.
- Participating in Long-term Ozone Trends and Uncertainties in the Stratosphere (LOTUS) activity
- Data used as transfer standard and stable reference for satellite validation
- Trend-quality long-term records below ~18 km
- Tropospheric budget, transport studies
PEARL AND TAO OZONE MEASUREMENTS

(PEARL = Polar Environment Atmospheric Research Laboratory, TAO = University of Toronto Atmospheric Observatory)

- Ozone measured by PEARL FTIR, UV-VIS, and DIAL and by TAO FTIR and Pandora
- Data used for scientific studies (e.g., 2020 Arctic ozone depletion – shown) and satellite validation (e.g., ACE, OSIRIS, TROPOMI)
- Data contributed to NDACC and Copernicus Atmospheric Monitoring Service

Network for the Detection of Atmospheric Composition Change

www.ndacc.org

Bognar et al., JGR, 2021
The triads have met the WMO requirement for better than 1% precision
First assessment of double Triad (Mark III): better stray light control; more observations in low solar zenith-angle conditions
Triads were assessed with three statistical models
The triads have been compared with Pandora, satellites (11 datasets), and reanalysis model
All triad data are available from the WOUDC
ECCC carried out calibrations at 8 Canadian sites and 2 international sites.

In collaboration with IOS, ECCC transferred calibrations from Brewer world reference to 150+ Brewers in 48 countries.

Time series of calibration transfers carried out by IOS from 1988 to 2020.
CALIBRATION ACTIVITIES

• Brewer Central Calibration Laboratory activities
  • Brewer triad ETC calibrations at MLO
  • Ozone absorption calculation
  • Calibration products’ uncertainty estimation and budget calculation
• In collaboration with AEMET, preparing science papers (for peer-reviewed journals)
  • Brewer reference triads, e.g., documentation of primary calibration procedures
  • Brewer calibration transfer to field instruments world-wide

• Ozone sounding:
  • ECCC provided scientific/technical support as well as sondes and test equipment to the 2017 campaign of the WMO-sponsored 2017 Jülich Ozone Sonde Intercomparison Experiment
  • Canada has been a key participant in these experiments over the last 25 years with this latest event focused on validation of the current WMO recommendations for sonde operations
The ACE satellite mission consists of an infrared Fourier Transform Spectrometer (ACE-FTS) and a UV-VIS-NIR grating spectrometer (MAESTRO) that have been measuring continuously since February 2004 (17 year data set) from the SCISAT platform.

- MAESTRO provides O$_3$, NO$_2$ and H$_2$O
- ACE-FTS measures more than 40 different species and nearly 20 isotopologues – including O$_3$, CFCs, HFCs, HCl, ClONO$_2$, N$_2$O, NOy...
- Solar occultation technique used by ACE provides excellent long-term precision and accuracy for the measurement time series to examine trends over mission.

Deseasonalized time series examples shown for CFC-11, HCFC-22, and HFC-23 at 8.5 km, global zonal average.
OSIRIS – Optical Spectrograph and Imager System

- OSIRIS (launched 2001) has been in orbit for 20 years on the Odin satellite
  - OSIRIS observes UV-visible limb-scattered sunlight which is used to derive atmospheric profiles of O$_3$, NO$_2$, BrO, and aerosol extinction in the UTLS and stratosphere
- Version 7.x of O$_3$, NO$_2$ and aerosol extinction products are now available
  - Improved convergence and pointing accuracy; correction for temperature effect on OSIRIS optics; retrievals extend further into troposphere when appropriate
- OSIRIS O$_3$ merged with SAGE II, SAGE III, Envisat instruments, and OMPS-LP for trend analysis

O$_3$ trends derived from SAGE II + OSIRIS + OMPS-LP, %/decade

- SAGE II + OSIRIS used to derive long-term variations in stratospheric NO$_2$
- OSIRIS NO$_2$ + constrained photochemical box model used to develop stratospheric NOx product
• Validation at high temporal resolution (not only for daily means)
• Validation of multiple orbits with ECCC Arctic and Antarctic instruments
• Validation of ozone and UV index products using the Canadian Brewer Spectrophotometer Network as well as ECCC’s ozone data assimilation output and UV index forecasts

- Percentage difference and standard deviation of TROPOMI TCO compared to Canadian Brewers
- Diurnal variation in TCO measured by TROPOMI and Canadian Brewers

Garane et al. AMT 2019
New simulations are being produced with the Canadian Middle Atmosphere Model (CMAM) to provide updated guidance for the 2022 Ozone Assessment – one of approximately 10 models contributing to a multi-model effort organized by the Chemistry Climate Model Initiative (CCMI)

- simulations include a historical hindcast (ref-D1 – shown here) for 1960 – 2018 and new projection scenarios for 1960 – 2100

REF-C1SD: ‘specified dynamics’ (nudged to reanalysis) simulation

REF-C1: historical hindcast from phase 1 of CCMI

REF-D1: historical hindcast for 1960 – 2018 for CCMI-2022
STRATOSPHERIC OZONE FORECASTING AND DATA ASSIMILATION WITH UV INDEX PREDICTION

• Preparation targeting Fall 2021 application as part of the operational Global Deterministic weather Prediction System
  – Linearized stratospheric ozone model integrated as part of the GEM weather forecast model
    • Radiatively active prognostic ozone (i.e. impacts stratospheric temperatures)
  – Added 3D-Var assimilation of TROPOMI (S5P), OMI (Aura), GOME-2 (MetOp-B), OMPS-NM (Suomi-NPP and NOAA-20) and OMPS-NP (NPP), MLS (Aura) and SBUV/2 (NOAA-19)
  – Clear-sky and all-sky UV Index integrated as part of GEM and reliant on the model surface UV band irradiances
    • Hourly forecasts covering 10 days.
  – Successfully completed Summer and Winter final cycles in 2020 prior to application in near-real-time parallel runs as of early 2021 (parallel runs have operational configurations)
Sample evaluation figures of final cycle covering 13 June to 31 August 2019

Comparison of MLS to model analyses and forecasts with and without ozone data assimilation

- Assimilation impact weaker above 1 hPa for analyses and 10 hPa for 5-day forecasts due to relaxation of the chemical model to an ozone climatology.

Differences between new and currently operational 1-day forecasts of column ozone and clear-sky UV Index daily max for Montreal

Advantages of new ozone and UV Index prediction system

- Global coverage
- Hourly values
- Up to 10-day forecasts
- Model also provides all-sky UV Index
- Generally more accurate column ozone
- 3D ozone fields
- Ozone-radiation coupling
Since 2018, ECCC donated three Brewers to WMO for deployment in developing countries.

- Brewer #071 (Nairobi, Kenya)
- Brewer #083 (Issyk-Kul, Kyrgyzstan)
- Brewer #084 (La Parva, Chile)

Brewer Trust Fund:

- Contribution agreement renewed (2021-2025, 37,500 CAD/year)
- Provision of service and calibration of Brewer instruments to ensure high quality of observations in developing countries and their inter-comparability with other global observations
- Participation of Brewer operators from developing countries in inter-comparison campaigns and training on Brewer instrument setup, operation, calibration and maintenance and data QC/QC
THANK YOU