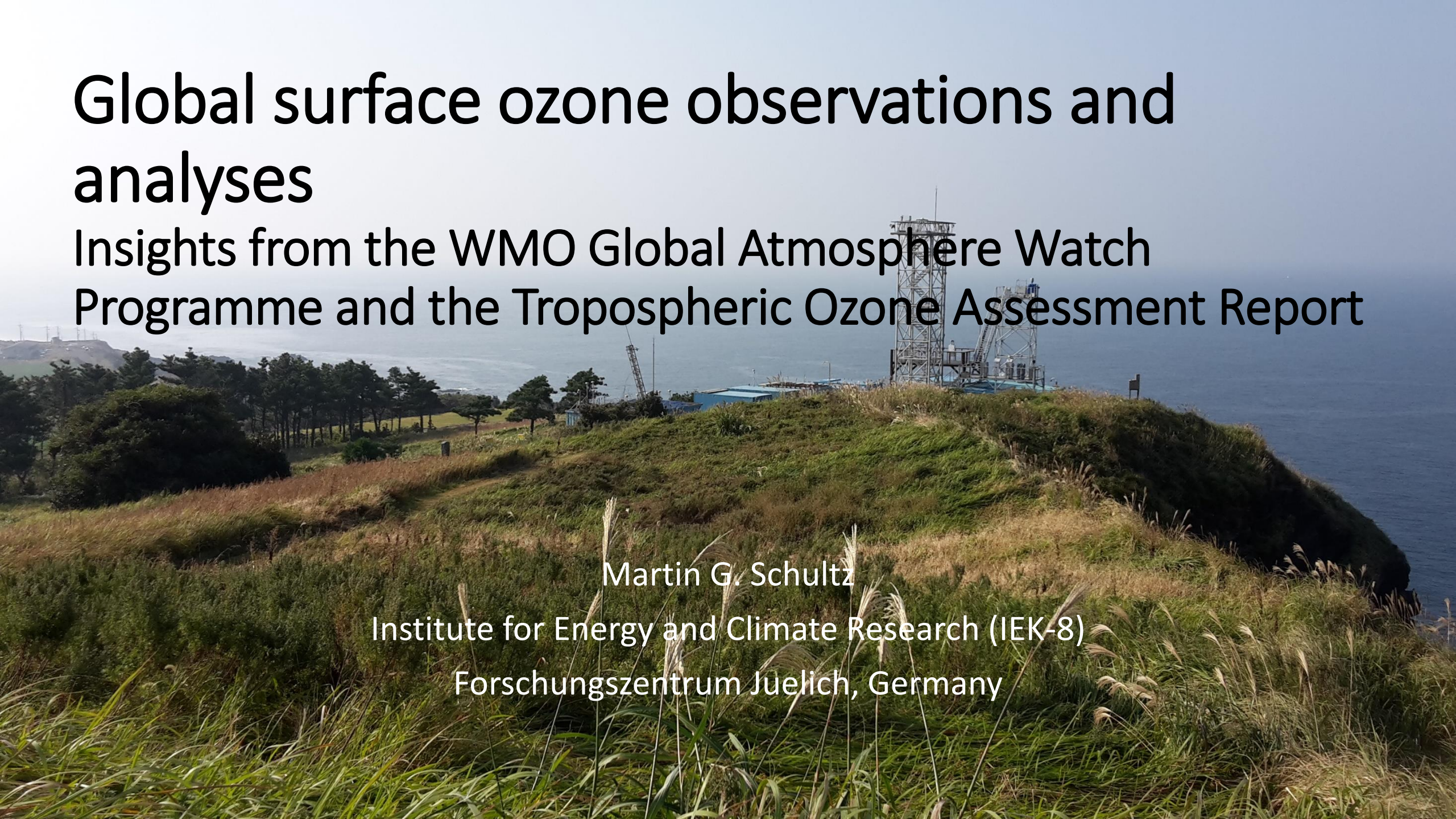
# Global surface ozone observations and analyses

## Insights from the WMO Global Atmosphere Watch Programme and the Tropospheric Ozone Assessment Report



Martin G. Schultz

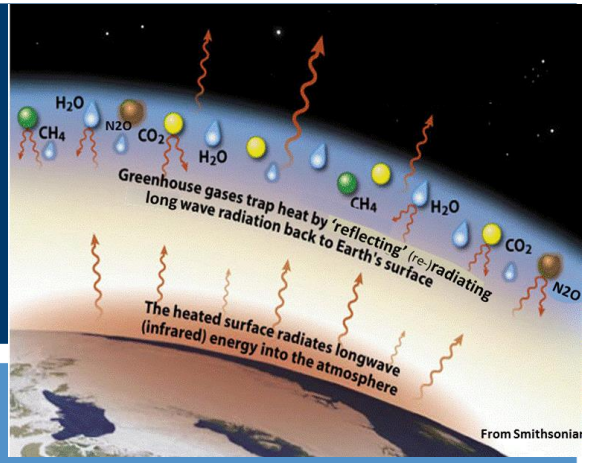
Institute for Energy and Climate Research (IEK-8)

Forschungszentrum Juelich, Germany

# Atmospheric Composition Matters for:

## Weather and climate

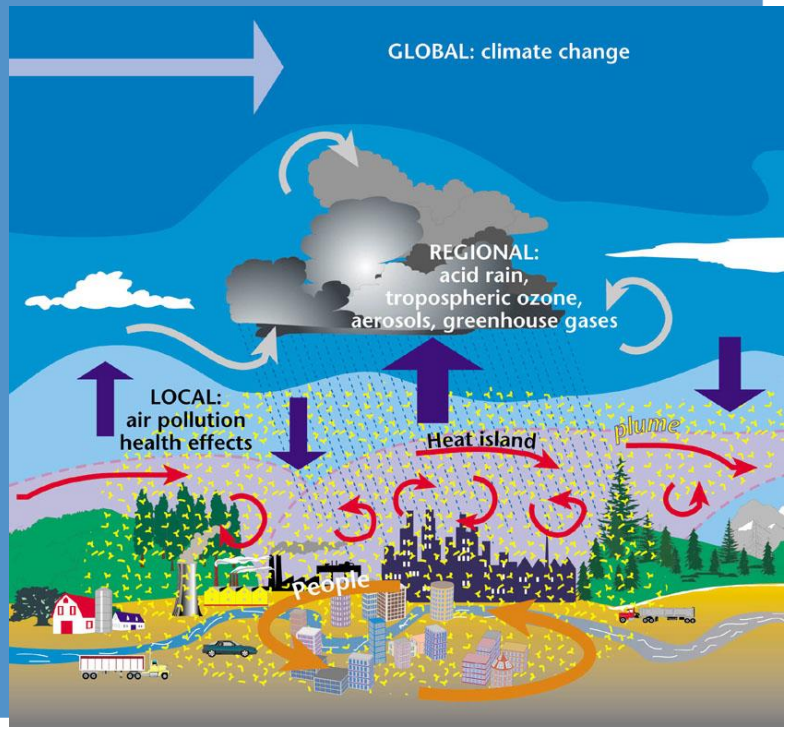
- Long-lived greenhouse gases are the major drivers of climate change
- Short-lived climate pollutants including atmospheric aerosols are impacting climate and regional weather patterns




# Atmospheric Composition Matters for:

## Human health

- 3.2 millions premature deaths per year are caused by outdoor air pollution
- Adequate mitigation requires a combined measurement and modelling strategy
- Air quality forecasting in cities is addressed in GAW through the GURME project



World Meteorological Organization

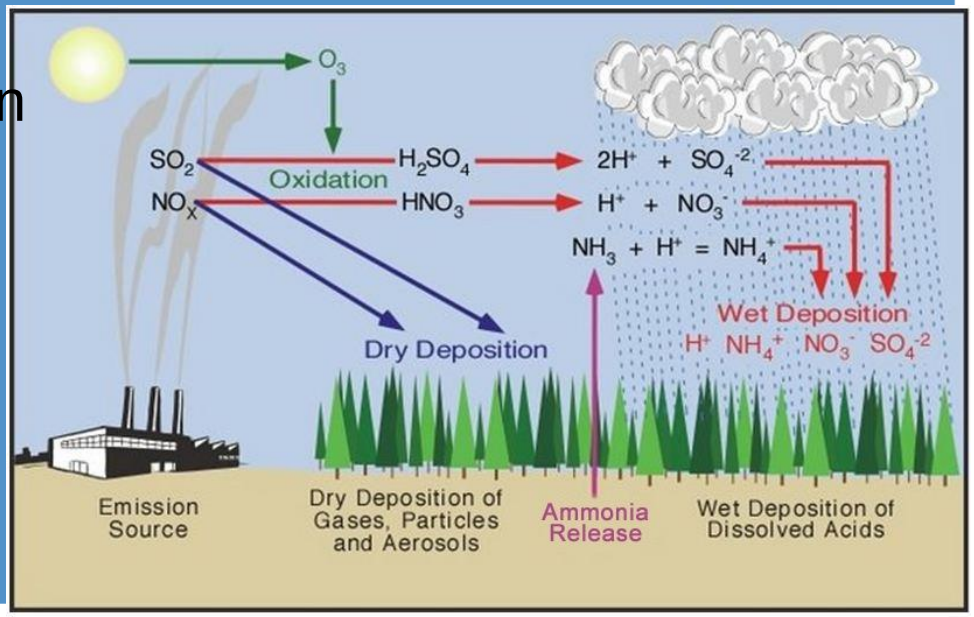
Weather • Climate • Water


# Atmospheric Composition Matters for:

## Ecosystems and agriculture

- Deposition of sulphur and nitrogen impacts soils, fresh water and ocean productivity
- Tropospheric ozone damages plants and causes substantial crop loss

GAW



# Atmospheric Composition Matters for:

## Transport and security

- Volcanic eruptions impact air traffic

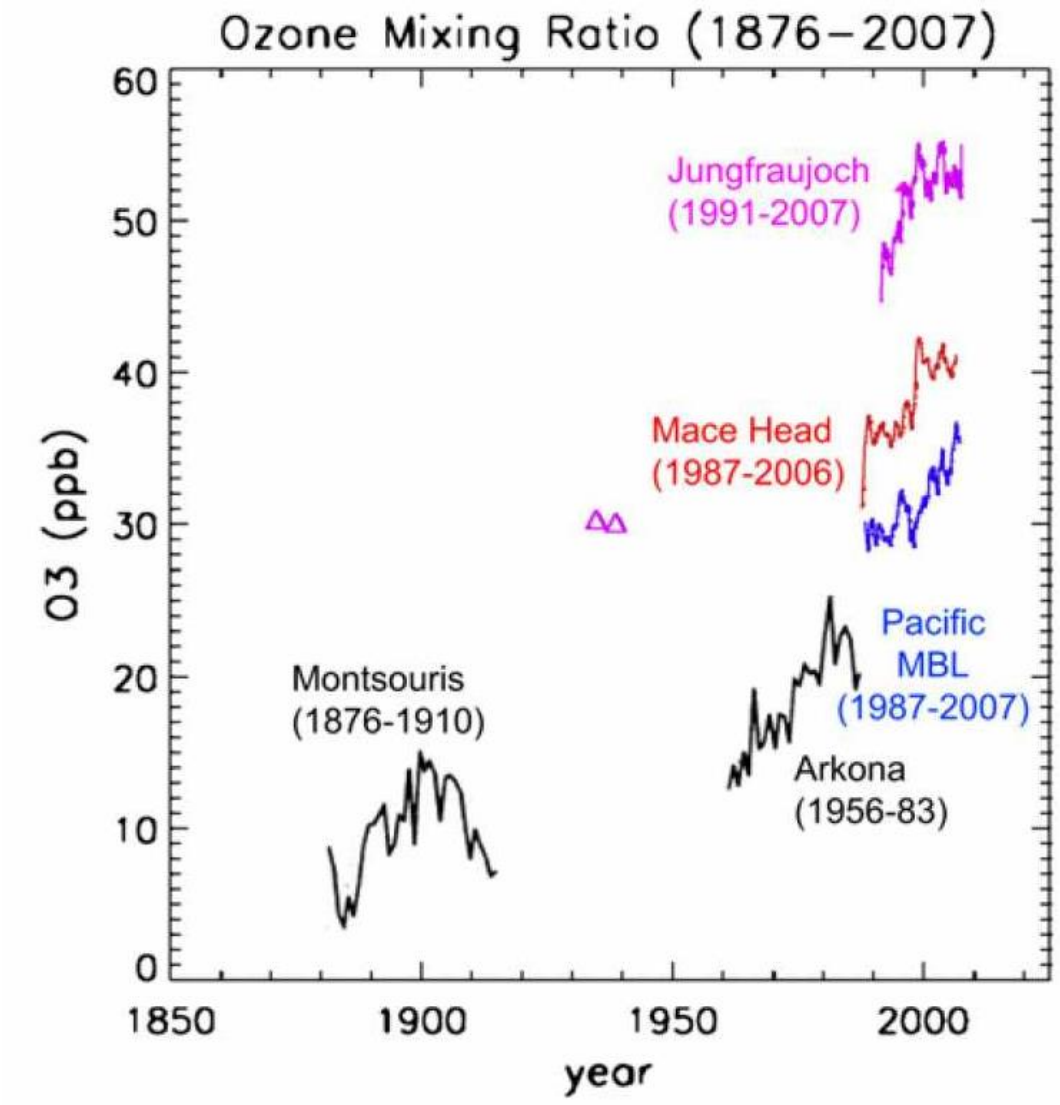
- Sand and dust storms, forest and brush fires lead to road accidents

**10 dead in crashes; I-75 temporarily closed Monday morning**

Reason: smoke from brush fires

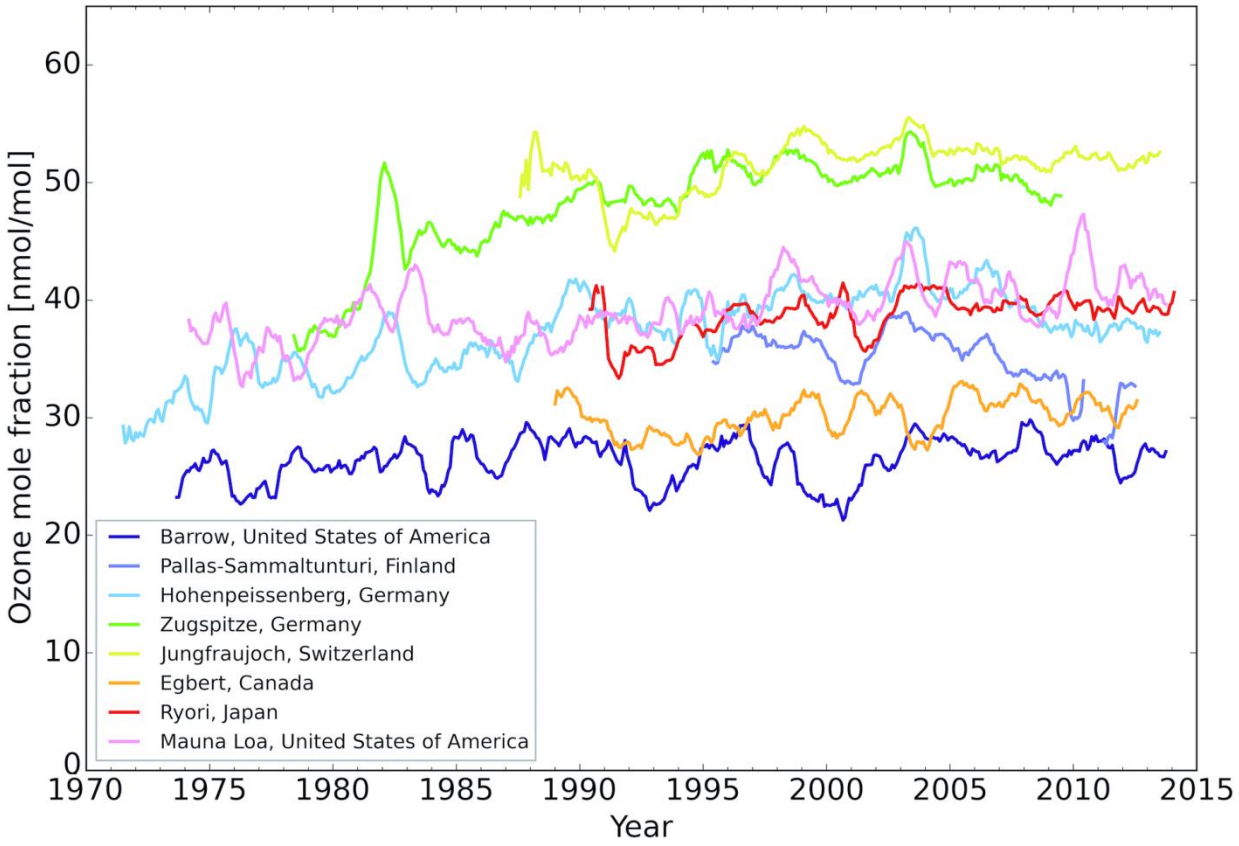
GAW

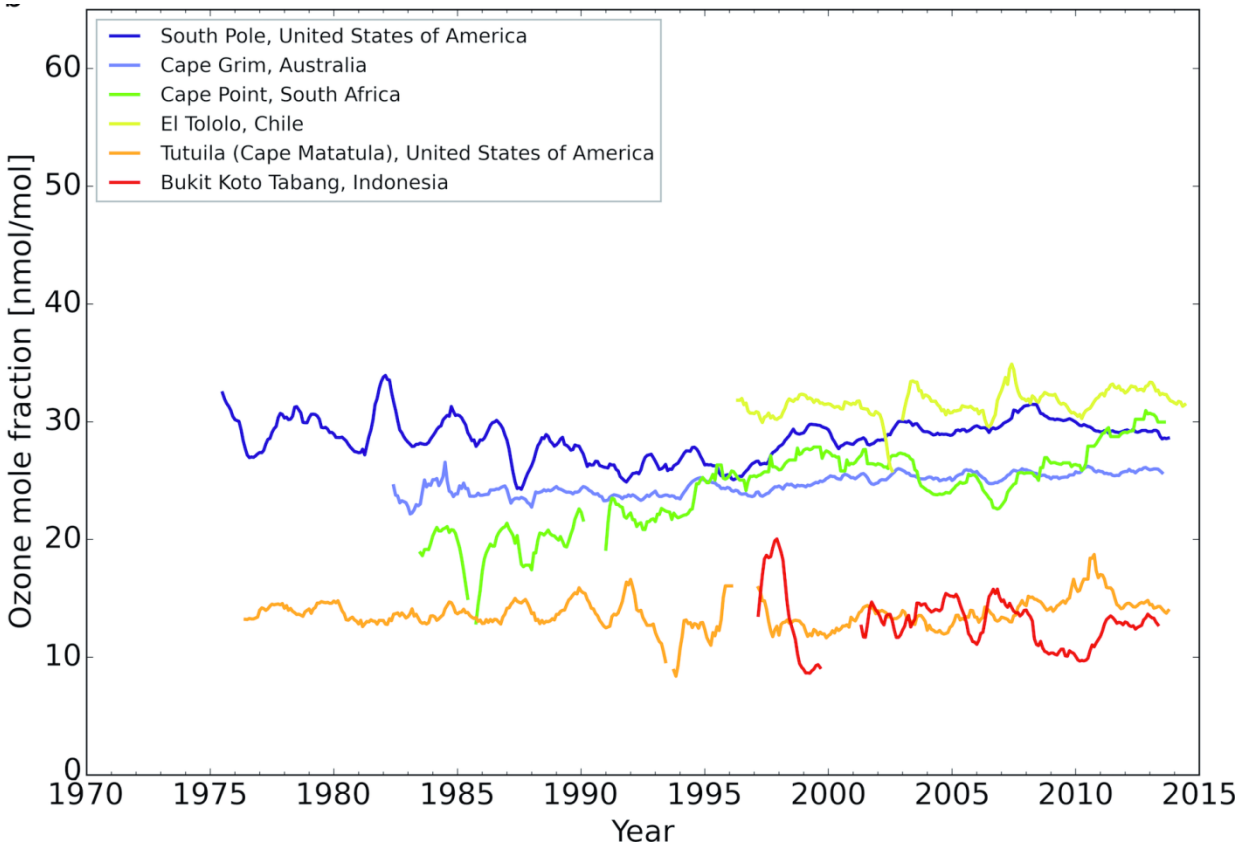
# Tropospheric ozone on the rise




RETRO Final report (2006)

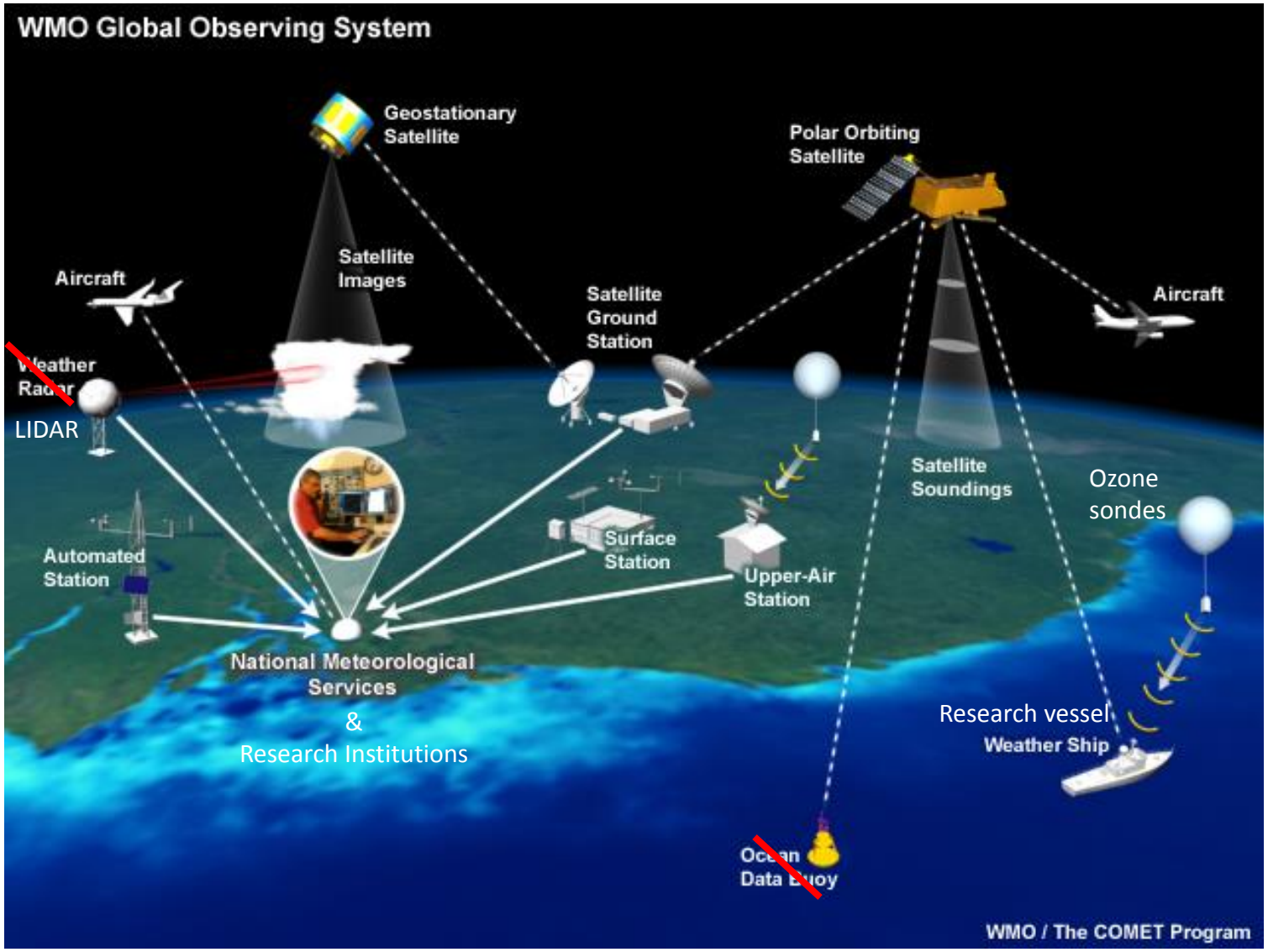
# Tropospheric ozone on the rise?




Schultz et al., Elementa (2015)

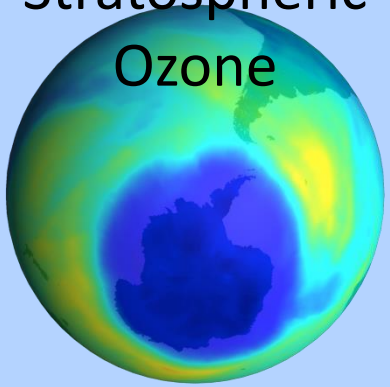
# The global (tropospheric) ozone observing system



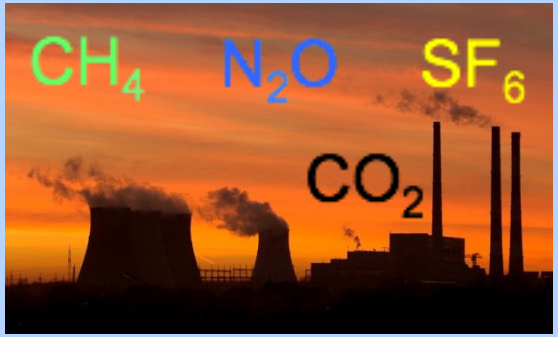
# The WMO/GAW Programme is structured into 6 focal areas

GAW

Stratospheric Ozone

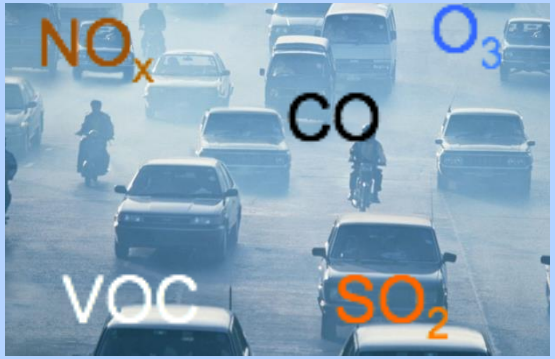


Greenhouse Gases

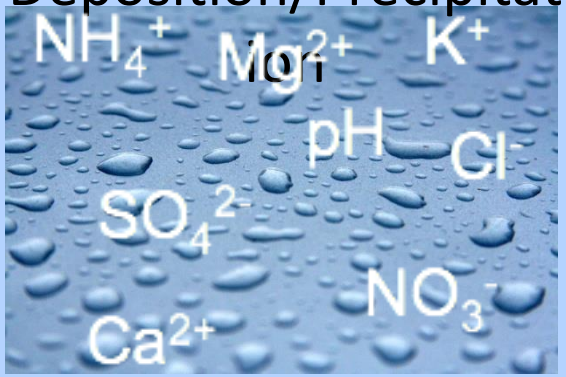



Aerosols

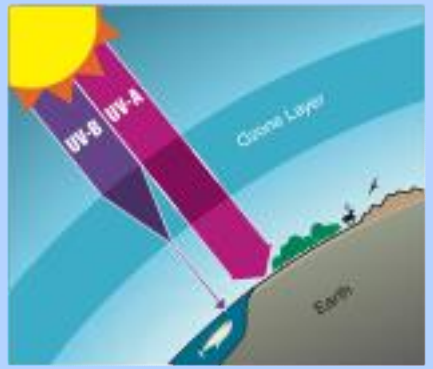
Reactive Gases



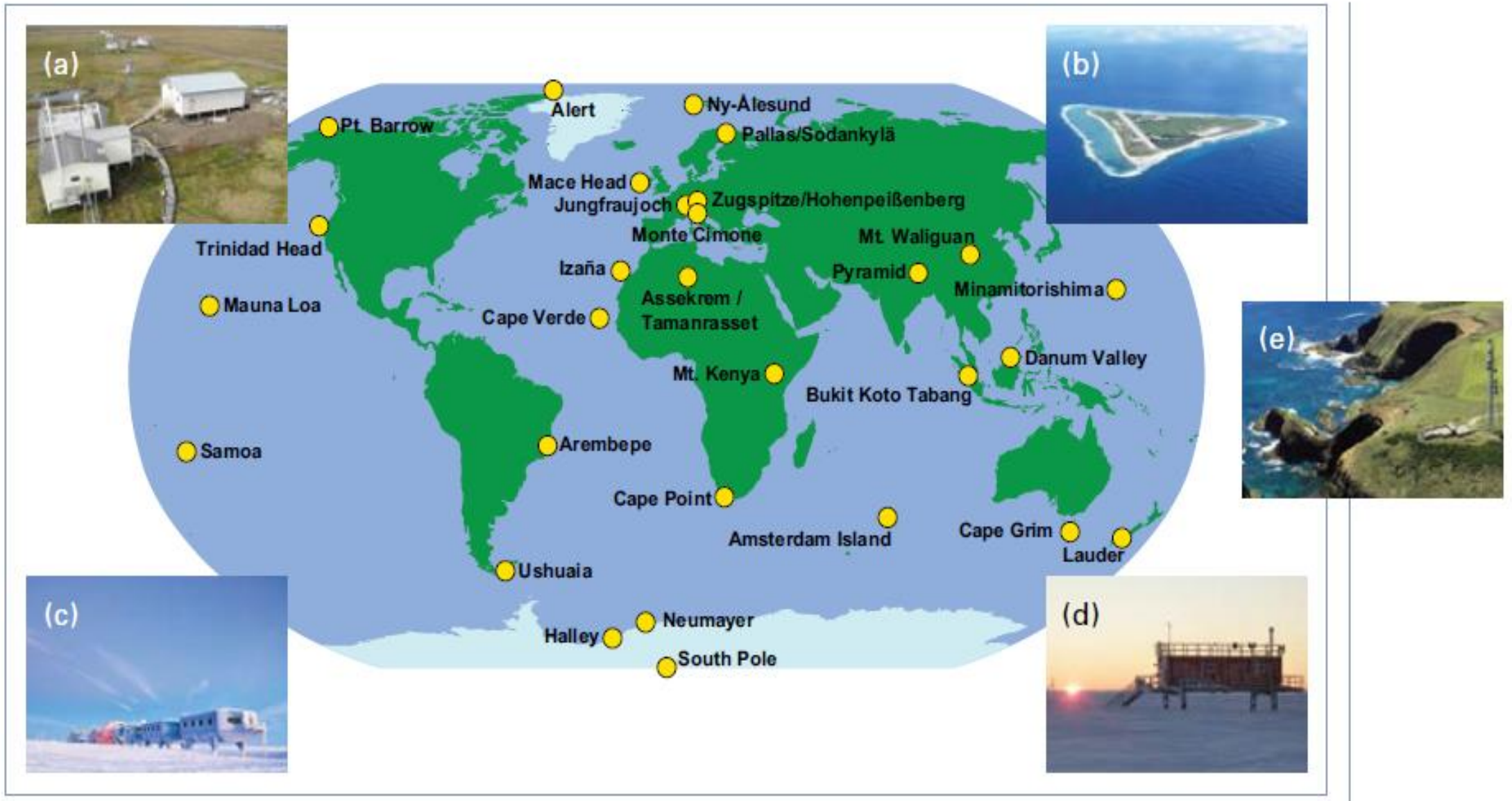

Deposition/Precipitat




UV Solar Radiation



# GAW Global Stations (June 2014)

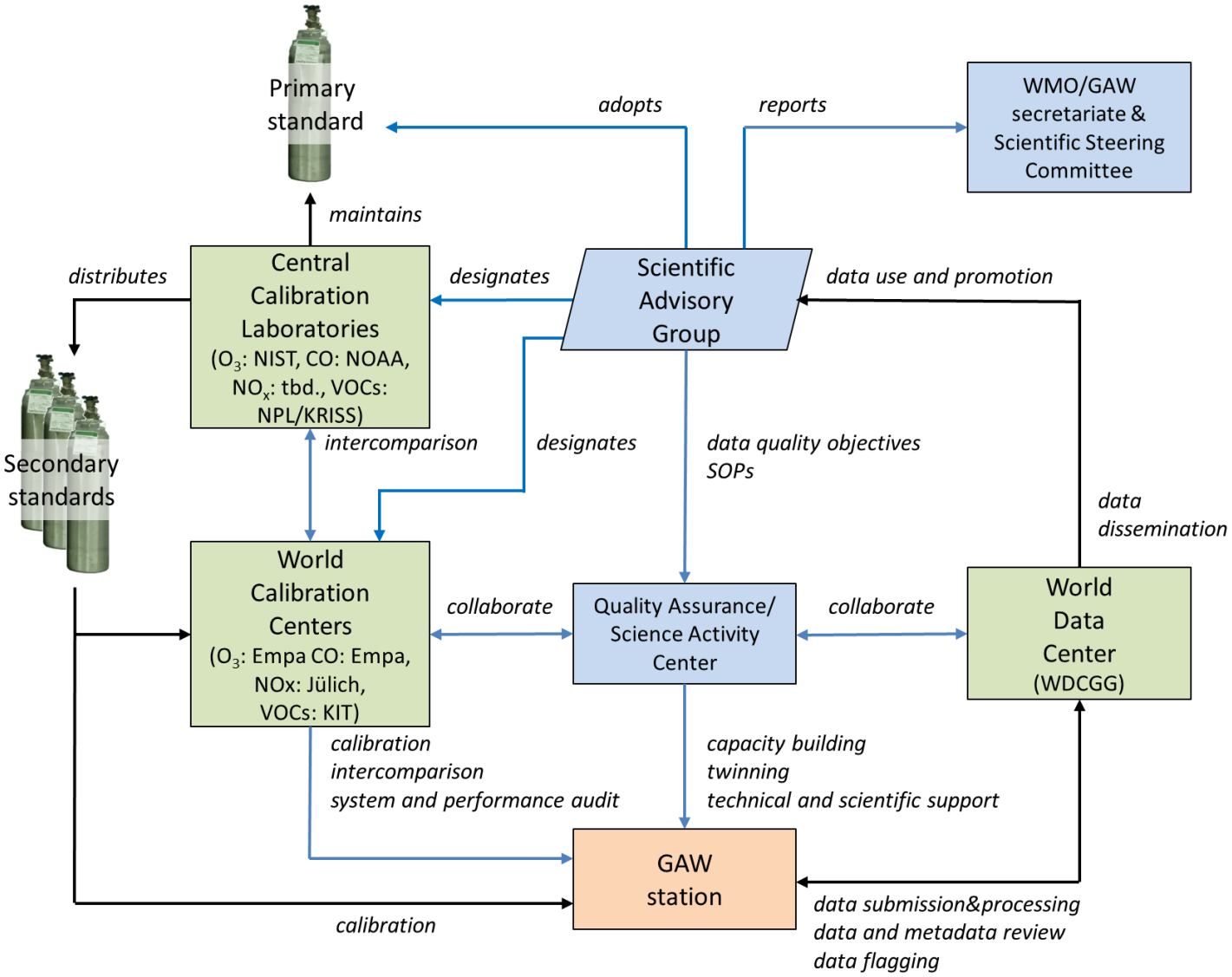


# Why does GAW have its QA principles?

**GAW's Foundation** - ***"Collecting adequate information on the chemical composition of the atmosphere and on the consequences of the anthropogenic impact on a global scale is valuable and possible only IF all the relevant measurements are expressed in the same units or on the same scale and IF data from the countries and at different sites are comparable"***

Only harmonized data sets can be used to calculate global averaged mole fractions and for inverse modelling/evaluation of model simulations

# GAW quality assurance principles




Schultz et al., Elementa (2015)

# GAW Quality Management Framework principles

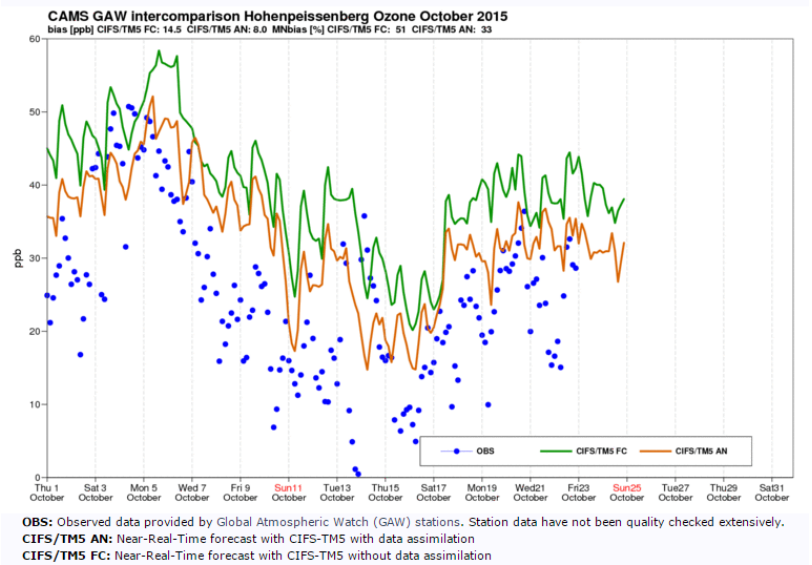
- ✓ Full support of the GCOS Climate Monitoring Principles
- ✓ Network-wide use of only one reference standard or scale (primary standard). In consequence, there is only one institution globally that is responsible for this standard.
- ✓ Full traceability to the primary standard of all measurements made by all GAW stations.
- ✓ Definition of data quality objectives (DQOs).
- ✓ Establishment of guidelines on how to meet these quality targets, i.e., harmonized measurement techniques based on Measurement Guidelines (MGs) and Standard Operating Procedures (SOPs).
- ✓ Use of detailed log books for each parameter containing comprehensive meta information related to the measurements, maintenance, and 'internal' calibrations.
- ✓ Regular independent assessments (system and performance audits).
- ✓ Timely submission of data and associated metadata to the responsible World Data Centre as a means of permitting independent review of data by a wider community.

# Reactive gases in GAW

Focus on:

- Tropospheric ozone
- Carbon monoxide
- NO and $NO_2$
- Volatile organic compounds
- ($SO_2$)

The science advisory group on reactive gases (2014)




Use of NRT GAW data for CAMS forecast evaluation

# The future of GAW

- GAW is presently working on a new Strategic Implementation Plan to cover the period 2016-2020
- Emphasis will shift from providing observations to support establishment of services (“science for service”)
- Enhanced efforts to include entire data processing chain in quality control framework, enable near realtime data transmission, and develop a global portal to distributed observation archives
- Support major application areas: extreme weather, integrated GHG information system ($IG^3IS$), aerosols and their impacts on air quality, weather and climate, and urbanization

atmosphere.copernicus.eu

Copernicus Europe's eyes on Earth — Atmosphere Monitoring Service BETA

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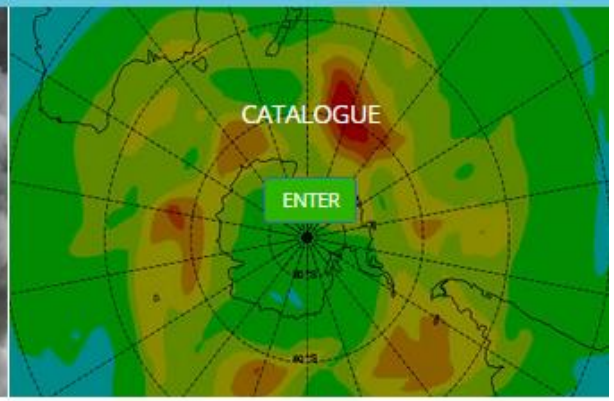
*Supporting the European strategy "Living well within the boundaries of our planet" by combining models and observations to monitor and forecast atmospheric pollution.*

*Contributing to Europe's green economy by providing timely and accurate information on aerosols, chemical pollutants and greenhouse gases.*


## News

16 Oct 2015 Smoke and carbon emission worsen in South East Asia's fires

18 Sep 2015 Copernicus CAMS tracks South East Asia's fires

04 Sep 2015 Upgrade to global monitoring and forecasting system

02 Sep 2015 CAMS contributes to State of the Climate in 2014 report

27 Aug 2015 Become an ECMWF Copernicus external evaluator

More News

## In Focus


### Vincent Henri Peuch on the Copernicus Atmosphere Monitoring Service

Vincent Henri Peuch talks us through the Copernicus Atmosphere Monitoring Service and the benefits of Copernicus for citizens, businesses and governments.Vincent Henri Peuch is head of the Copernicus Atmosphere Monitoring Service, operated by the...

Read more

# CAMS data catalogue

macc.copernicus-atmosphere.eu/catalogue/#details?st=Air%20quality%20and%20atmospheric%20composition&pp=Reactive%20gas&sp=O3&ga=Global&pr=C-IFS-TM

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Product

Air quality and atmospher

Reactive gas

O3

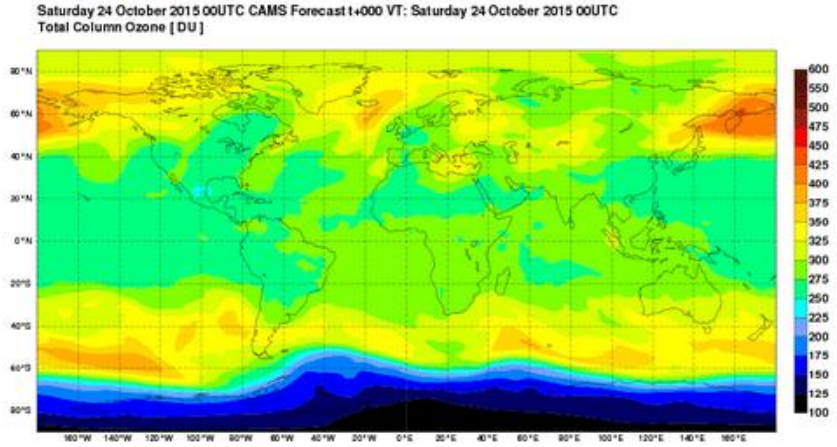
-- Please select a data ty

Global (-180, 180, -90, 9

| Parameter | Service Status |
|---|---|
| O3 | PRE-OP |
| O3 | PRE-OP |
| O3 | PRE-OP |
| O3 | PRE-OP |

**C-IFS-TM5 NRT analyses of global ozone** X

**Description:** This service provides pre-operational daily analyses of Ozone using the C-IFS-TM5 model.




| | | | |
|---|---|---|---|
| **Service type:** | Air quality and atmospheric composition; Ozone and Ultraviolet radiation | **Vertical coordinate:** | Potential temperature; Potential vorticity; Model; Pressure; Surface |
| **Product family:** | Reactive gas; Greenhouse gas | **Time resolution:** | 6-hourly |
| **Parameter:** | O3 | **Data type:** | Analysis |
| **Geographical area:** | Global (-180, 180, -90, 90) | **Service status:** | Pre-operational |

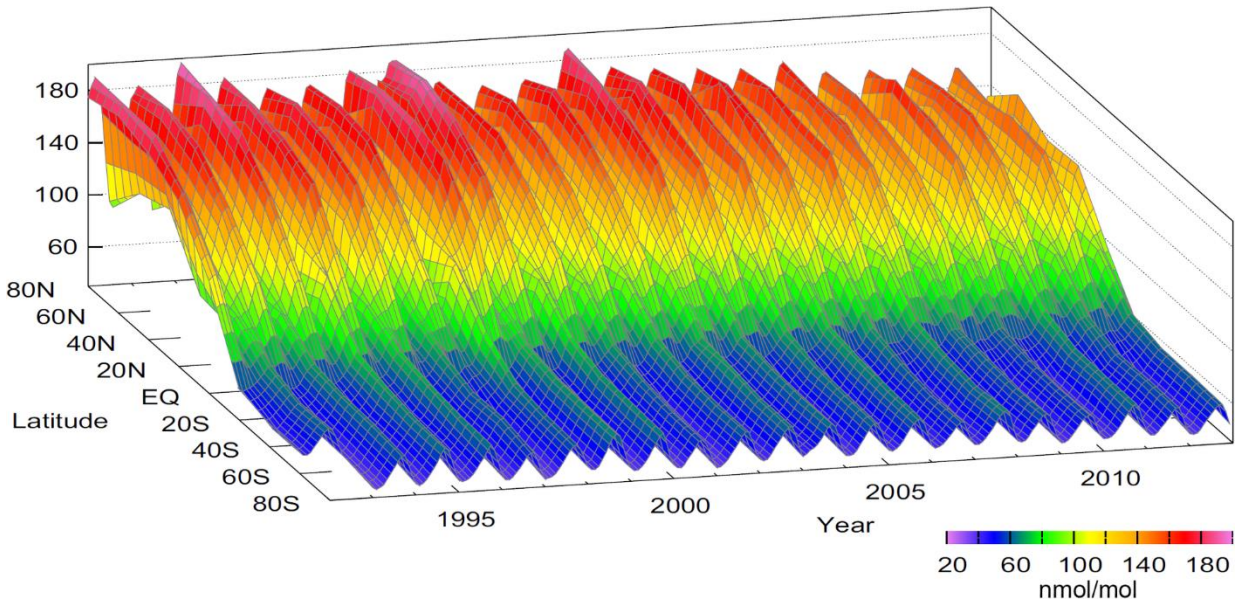
**Links:** Plots Data access Verification results Validation reports Documentation Contact us XML

FUNDED BY THE EUROPEAN UNION

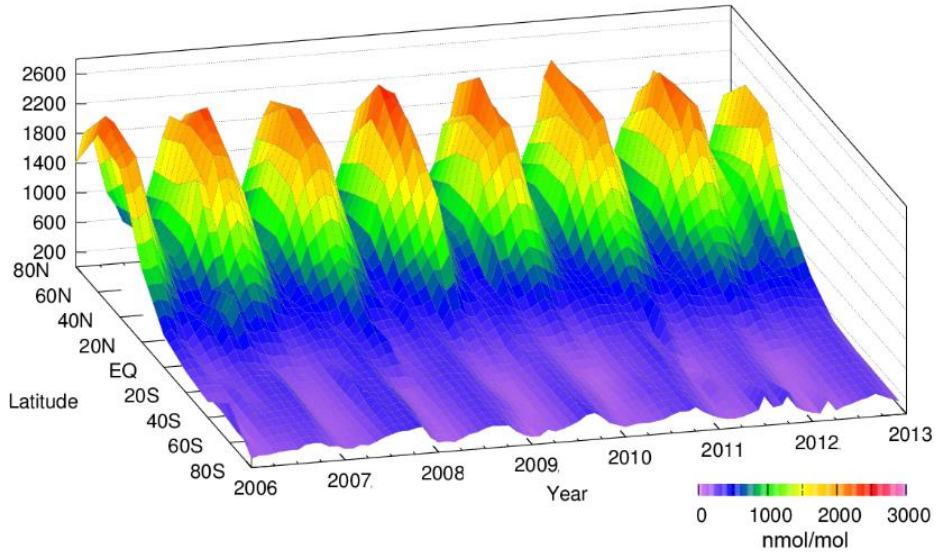
IMPLEMENTED BY ECMWF

# Global view on tropospheric CO and VOCs

## CO



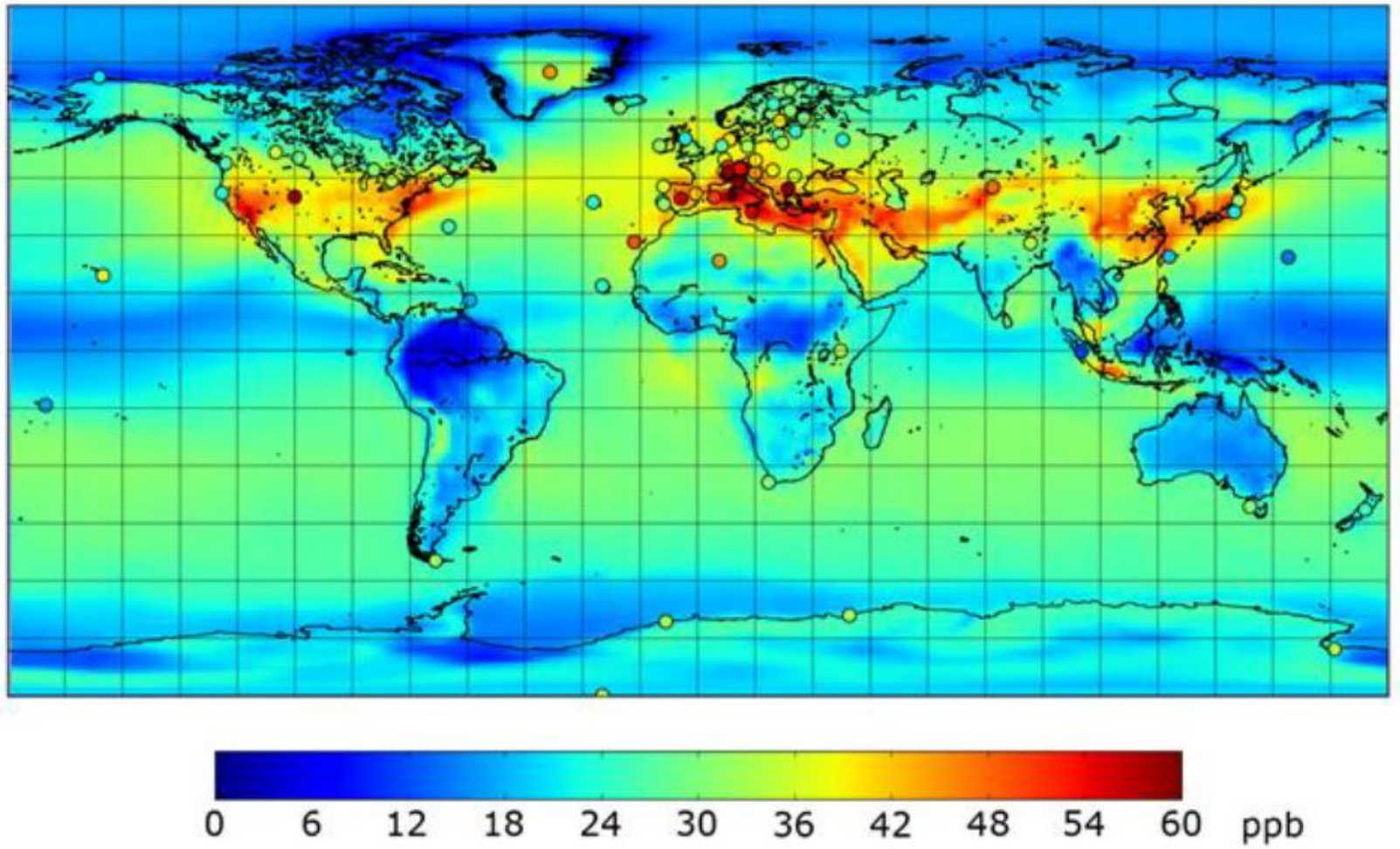

## Ethane




WDCGG data report 39 (2015)

# Global view on tropospheric ozone

## July average surface ozone mixing ratios 2003-2010



# Tropospheric Ozone Assessment Report (TOAR)

## Global metrics for climate change, human health and crop/ecosystem research

**Chair:**
Owen Cooper, NOAA Earth System Research Laboratory/University of Colorado

**Steering Committee Members**

Tropospheric ozone is a greenhouse gas and pollutant detrimental to human health and crop and ecosystem productivity. Since 1990 a large portion of the anthropogenic emissions that react in the atmosphere to produce ozone have shifted from North America and Europe to Asia. This rapid shift, coupled with limited ozone monitoring in developing nations, has left scientists unable to answer the most basic questions: Which regions of the world have the greatest human and plant exposure to ozone pollution? Is ozone continuing to decline in nations with strong emission controls? To what extent is ozone increasing in the developing world? How can the atmospheric sciences community facilitate access to the ozone metrics necessary for quantifying ozone's impact on human health and crop/ecosystem productivity? TOAR is designed to answer these questions through the development of an assessment report based on expert opinion and analysis, and the generation of a range of ozone metrics at hundreds of sites around the world.

**Current Activities**

ACAM

AICI

Air Pollution & Climate

CCMI

DEBITS

Fundamentals of Atmospheric Chemistry

GEIA

HitT

IBBI

OASIS

PACES

TOAR

TOAR
tropospheric ozone assessment report

**Goals:**

1. Produce the first tropospheric ozone assessment report based on the peer-reviewed literature and new analyses.
2. Generate easily accessible, documented data on ozone exposure and dose metrics at hundreds of measurement sites around the world (urban and non-urban), freely accessible for research on the global-scale impact of ozone on climate, human health and crop/ecosystem productivity.

## Implementation:

1. Compile comprehensive report as a series of 8 peer-reviewed publications (plus optional ancillary papers)
2. Establish central database of global surface ozone observations in Juelich
3. Attempt to harmonize and synthesize free tropospheric ozone observations

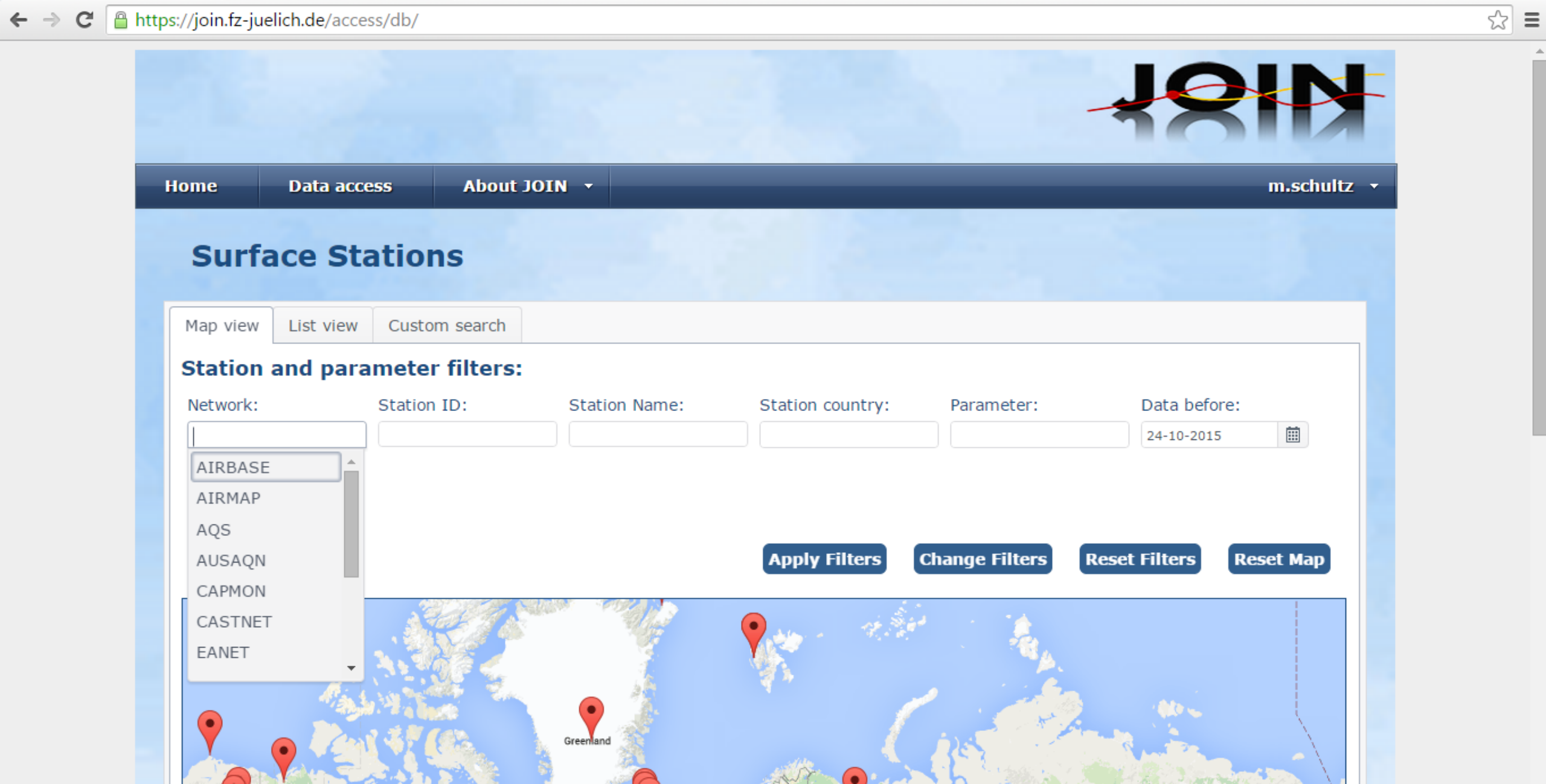
TOAR
tropospheric
ozone
assessment
report

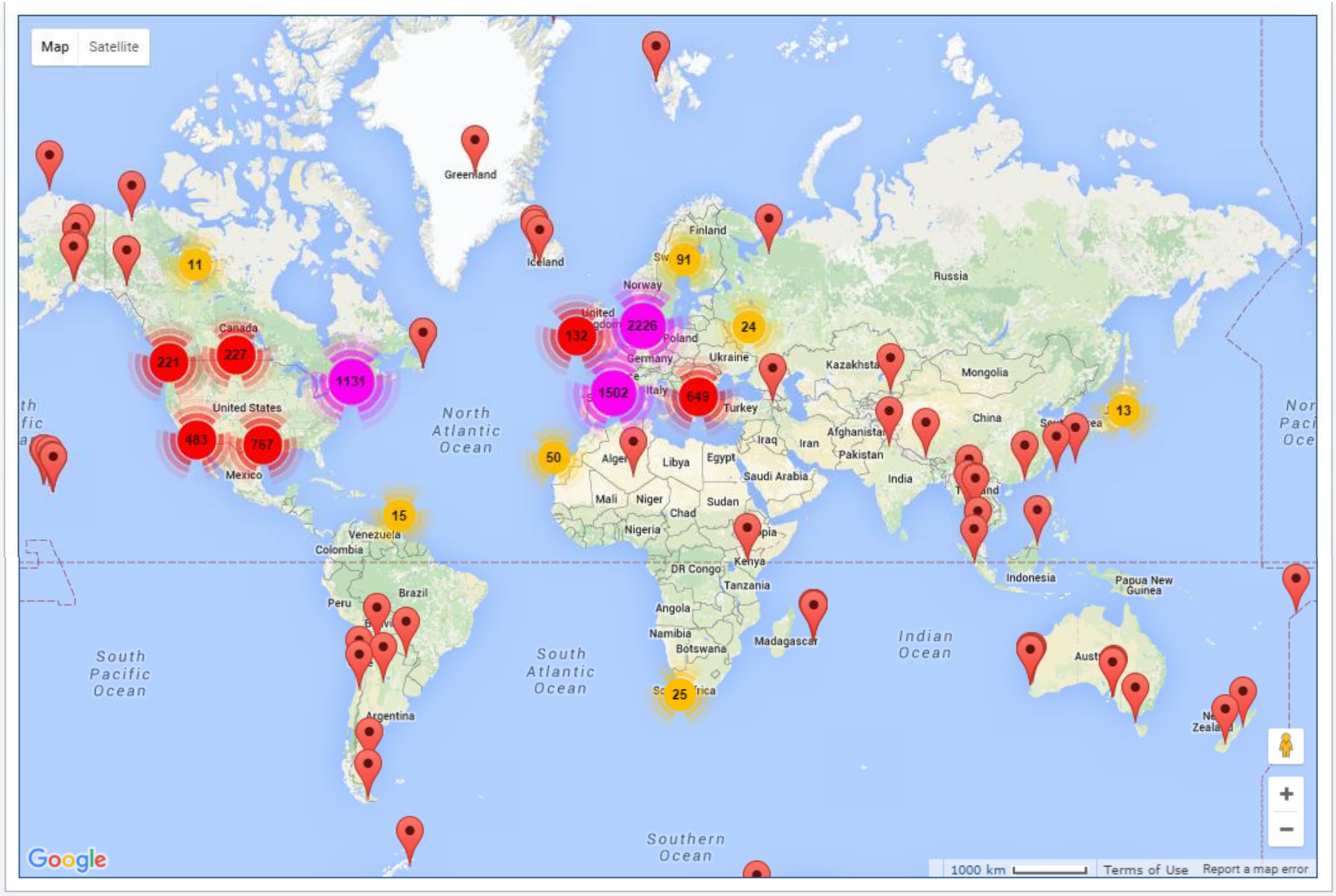
## The TOAR database in Juelich and the JOIN web interface

- Contains the world's largest collection of hourly surface ozone measurements
- Aims at providing harmonized metadata on stations and measurements
- Keeps a close link to original data providers
- Allows for harmonized analysis of a comprehensive suite of ozone metrics globally
- Provides easy access to ozone analyses

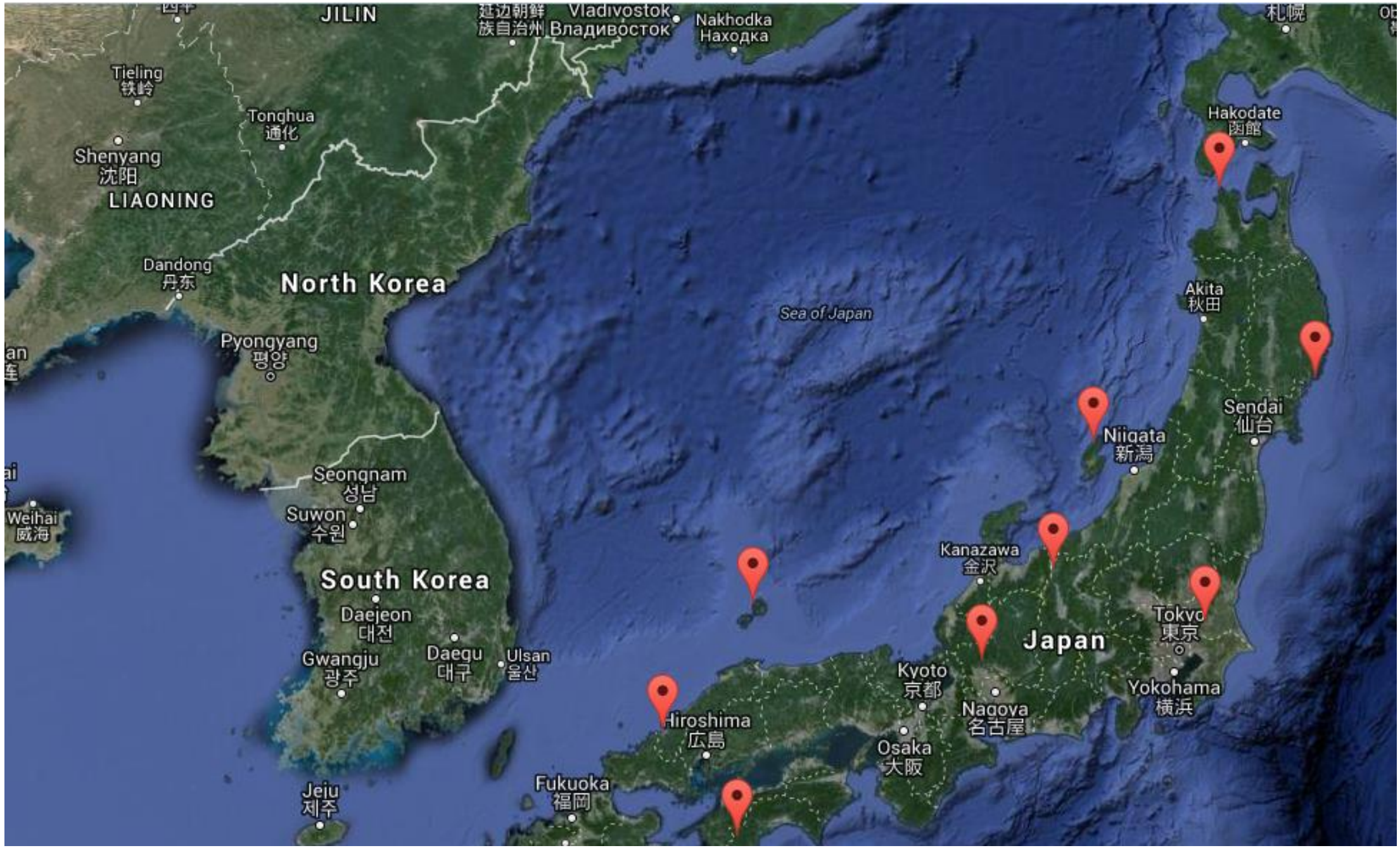
- Does not disseminate the hourly measurement data
  (This is the responsibility of primary data archives or data PIs)

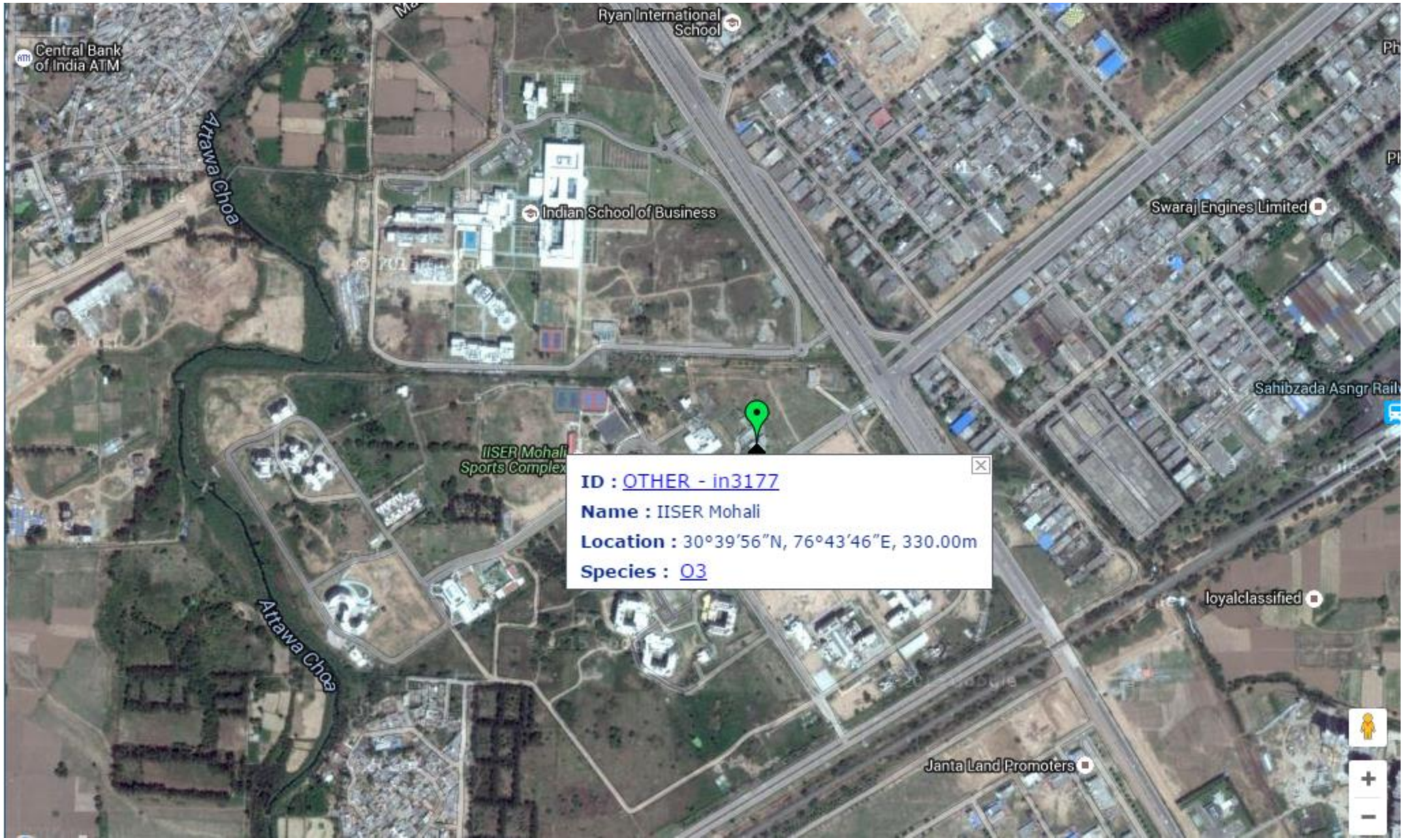
# Easy visualization of ozone data through JOIN

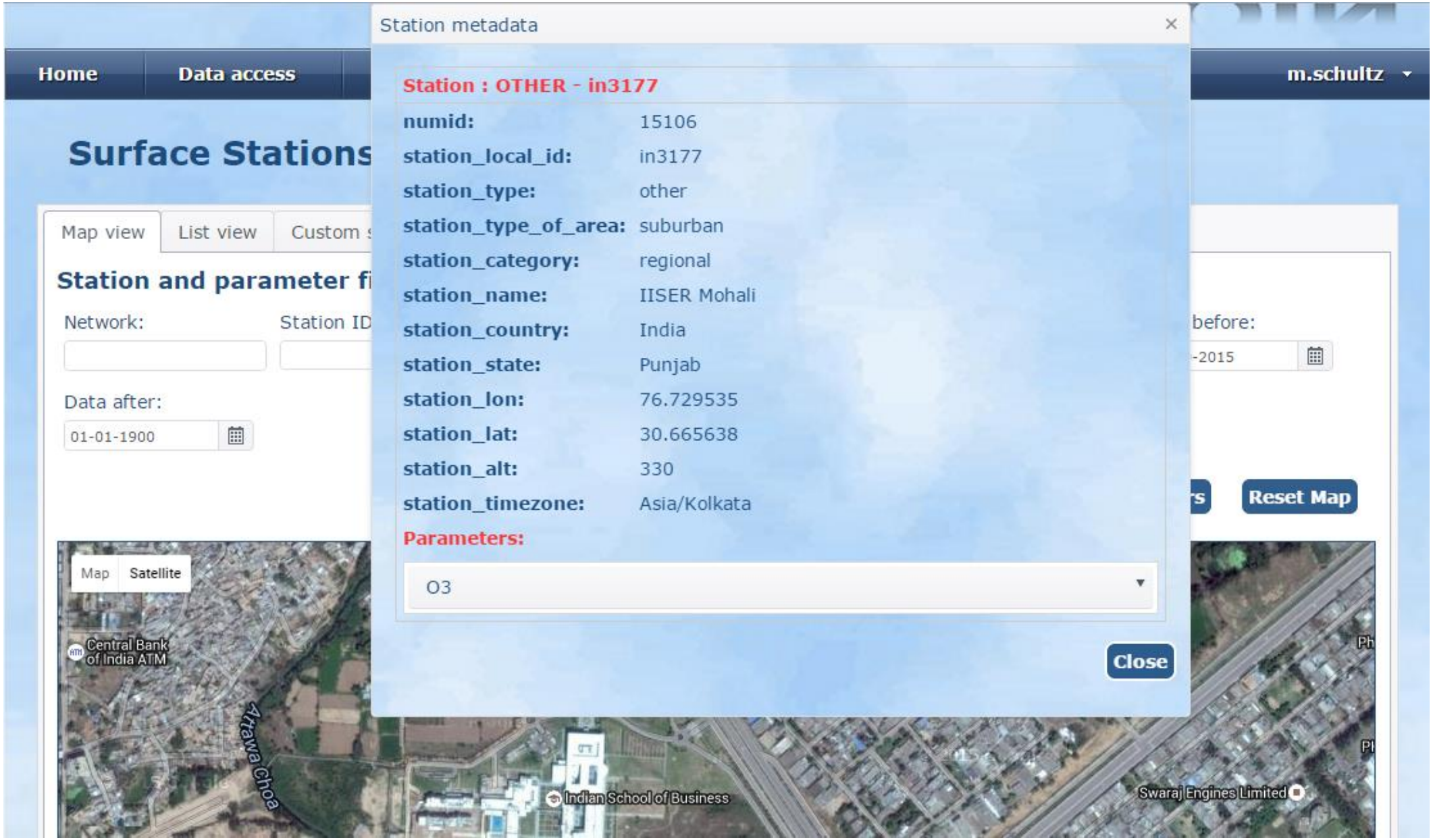


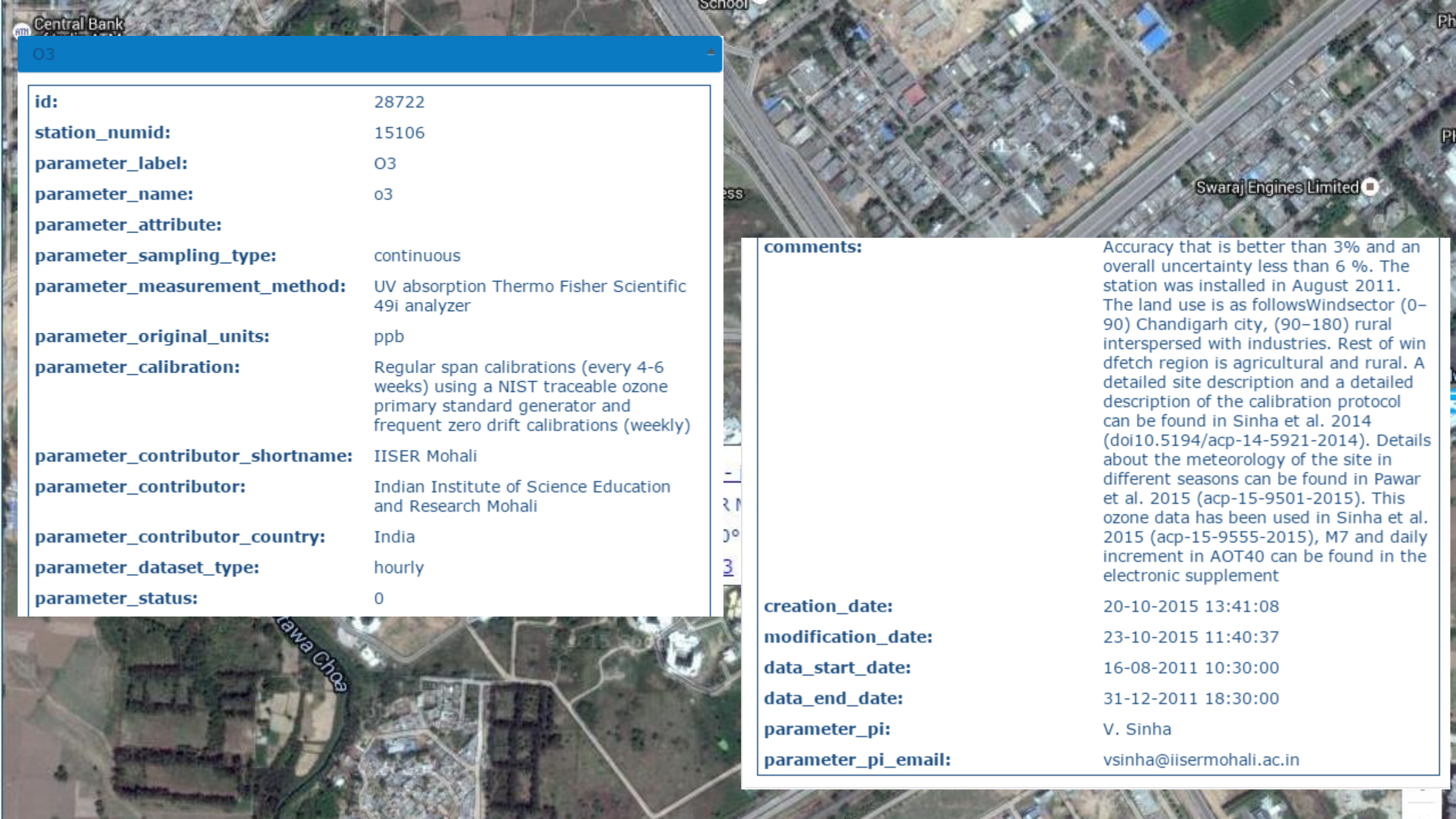



**Displaying 11915 data series out of 11915 at 7658 stations out of 7658**


JILIN
Vladivostok
Владивосток
Nakhodka
Находка
Tieling
铁岭
Tonghua
通化
Shenyang
沈阳
LIAONING
Hakodate
函館
Dandong
丹东
North Korea
Sea of Japan
Akita
秋田
Pyongyang
평양
Sendai
仙台
Niigata
新潟
Seongnam
성남
Suwon
수원
Weihai
威海
Kanazawa
金沢
South Korea
Daejeon
대전
Tokyo
東京
Japan
Gwangju
광주
Daegu
대구
Ulsan
울산
Kyoto
京都
Yokohama
横浜
Nagoya
名古屋
Hiroshima
広島
Osaka
大阪
Fukuoka
福岡
Jeju
제주


Central Bank of India ATM
Ryan International School
Attawa Choa
Indian School of Business
Swaraj Engines Limited
Sahibzada Asngr Rail
IISER Mohali Sports Complex
ID : OTHER - in3177
Name : IISER Mohali
Location : 30°39'56"N, 76°43'46"E, 330.00m
Species : O3
Attawa Choa
loyalclassified
Janta Land Promoters


Home
Data access
m.schultz
Surface Stations
Map view
List view
Custom
Station and parameter fi
Network:
Station ID
Data after:
01-01-1900
before:
-2015
Reset Map
Map
Satellite
Central Bank of India ATM
Indian School of Business
Swaraj Engines Limited
Station metadata
Station : OTHER - in3177
numid: 15106
station_local_id: in3177
station_type: other
station_type_of_area: suburban
station_category: regional
station_name: IISER Mohali
station_country: India
station_state: Punjab
station_lon: 76.729535
station_lat: 30.665638
station_alt: 330
station_timezone: Asia/Kolkata
Parameters:
O3
Close




## O3

| | |
|---|---|
| **id:** | 28722 |
| **station_numid:** | 15106 |
| **parameter_label:** | O3 |
| **parameter_name:** | o3 |
| **parameter_attribute:** | |
| **parameter_sampling_type:** | continuous |
| **parameter_measurement_method:** | UV absorption Thermo Fisher Scientific 49i analyzer |
| **parameter_original_units:** | ppb |
| **parameter_calibration:** | Regular span calibrations (every 4-6 weeks) using a NIST traceable ozone primary standard generator and frequent zero drift calibrations (weekly) |
| **parameter_contributor_shortname:** | IISER Mohali |
| **parameter_contributor:** | Indian Institute of Science Education and Research Mohali |
| **parameter_contributor_country:** | India |
| **parameter_dataset_type:** | hourly |
| **parameter_status:** | 0 |

| | |
|---|---|
| **comments:** | Accuracy that is better than 3% and an overall uncertainty less than 6 %. The station was installed in August 2011. The land use is as followsWindsector (0–90) Chandigarh city, (90–180) rural interspersed with industries. Rest of win dfetch region is agricultural and rural. A detailed site description and a detailed description of the calibration protocol can be found in Sinha et al. 2014 (doi10.5194/acp-14-5921-2014). Details about the meteorology of the site in different seasons can be found in Pawar et al. 2015 (acp-15-9501-2015). This ozone data has been used in Sinha et al. 2015 (acp-15-9555-2015), M7 and daily increment in AOT40 can be found in the electronic supplement |
| **creation_date:** | 20-10-2015 13:41:08 |
| **modification_date:** | 23-10-2015 11:40:37 |
| **data_start_date:** | 16-08-2011 10:30:00 |
| **data_end_date:** | 31-12-2011 18:30:00 |
| **parameter_pi:** | V. Sinha |
| **parameter_pi_email:** | vsinha@iisermohali.ac.in |

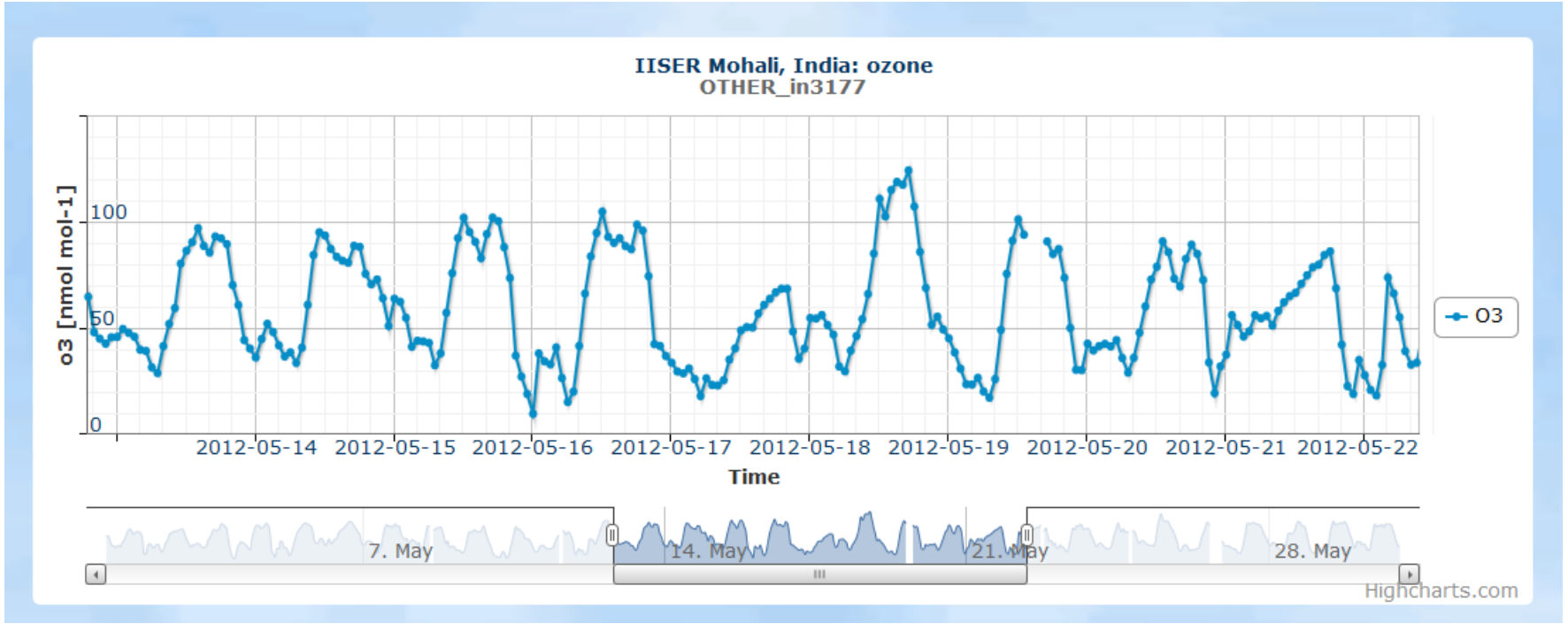

Ryan International School
Central Bank of India ATM
Attawa Choa
Indian School of Business
Swaraj Engines Limited
Sahibzada Asngr Rail
IISER Mohali Sports Complex
ID : OTHER - in3177
Name : IISER Mohali
Location : 30°39'56"N, 76°43'46"E, 330.00m
Species : O3
Attawa Choa
loyalclassified
Janta Land Promoters

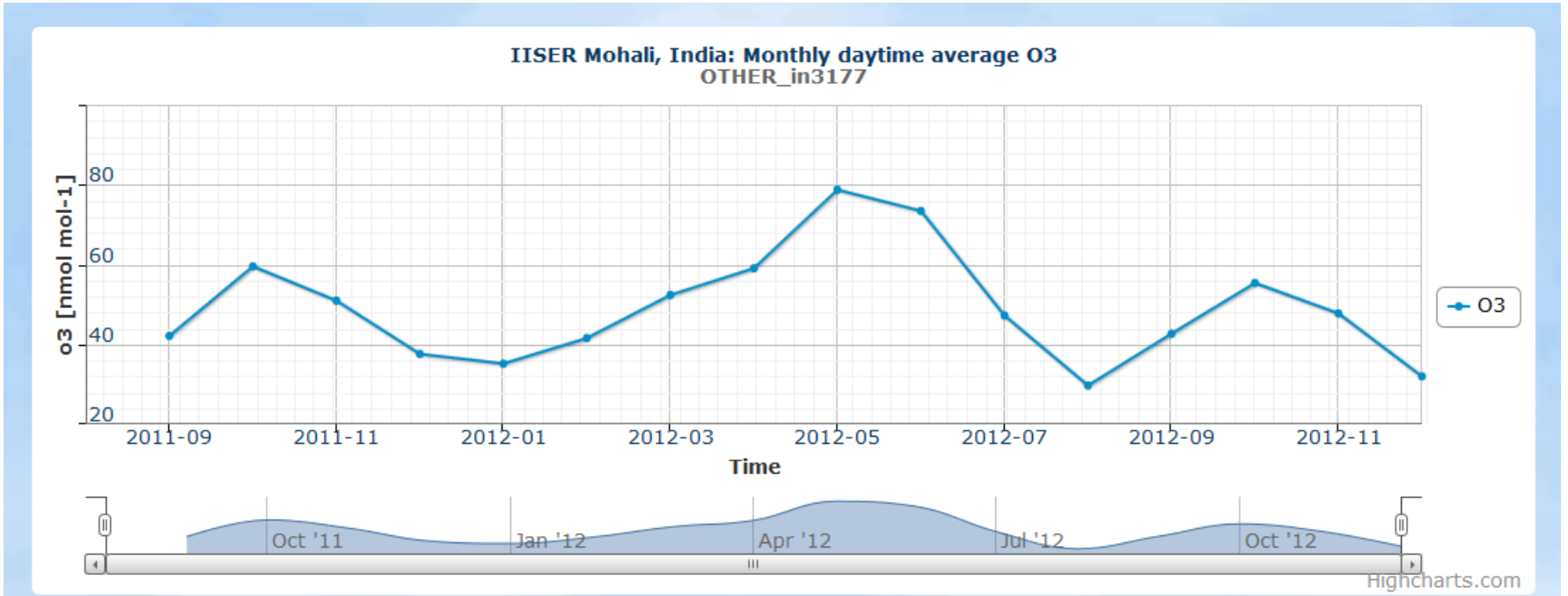

Data extraction options

| | | | |
|---|---|---|---|
| 90%-iles | -- | | |
| 95%-iles | -- | | |
| 98%-iles | -- | -- | |

| Ozone metrics | Daily | Monthly | Annual |
|---|---|---|---|
| Max. 1-h value | | -- | |
| Daily max. 8-h average (US EPA definition) | | -- | |
| Daily max. 8-h average (proposed new US EPA definition) | | -- | |
| Daily max. 8-h average (EU) | | -- | |
| 3-months running mean of DMAX1H | | -- | -- |
| W126 exposure index | | | |
| 24-hour W126 exposure index | | | |
| W90 exposure index | | -- | |

Cancel


IISER Mohali, India: ozone
OTHER_in3177
o3 [nmol mol-1]
100
50
0
2012-05-14
2012-05-15
2012-05-16
2012-05-17
2012-05-18
2012-05-19
2012-05-20
2012-05-21
2012-05-22
Time
O3
7. May
14. May
21. May
28. May
Highcharts.com

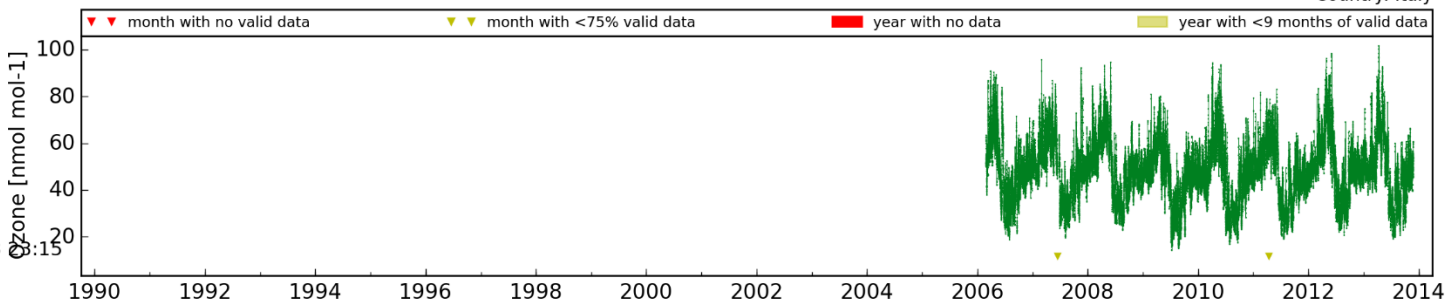

IISER Mohali, India: Monthly daytime average O3
OTHER_in3177
o3 [nmol mol-1]
80
60
40
20
2011-09
2011-11
2012-01
2012-03
2012-05
2012-07
2012-09
2012-11
Time
O3
Oct '11
Jan '12
Apr '12
Jul '12
Oct '12
Highcharts.com

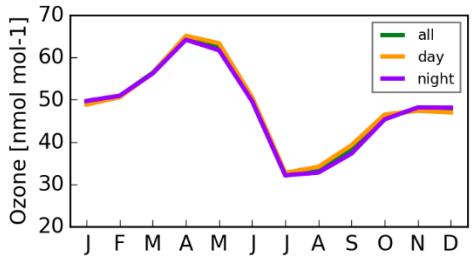
# GAW Everest - Pyramid(PYR227N00) O3

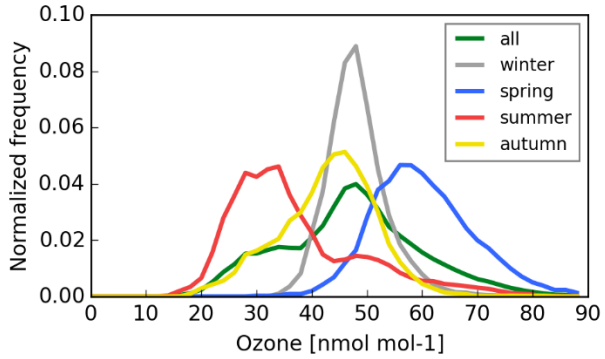
27.96° N 86.81° E 5079 m

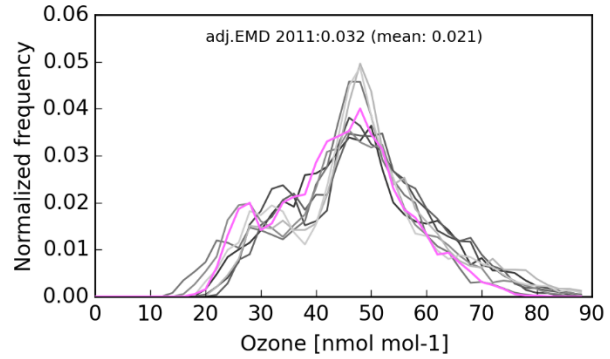
Contributor: National Research Council, Institute of Atmospheric Sciences and Climate
Country: Italy

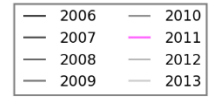
| | |
|---|---|
| station type: | background |
| station area type: | remote |
| station category: | Global |
| data from 01 Mar 2006 00:15 to 25 Nov 2013 03:15 | |
| N years: | 8 |
| N years with > 75% data: | 8 |
| N hours: | 65479 |
| N zero values: | 0 |

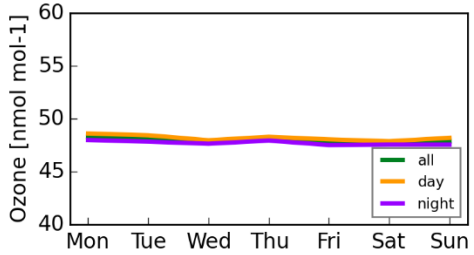


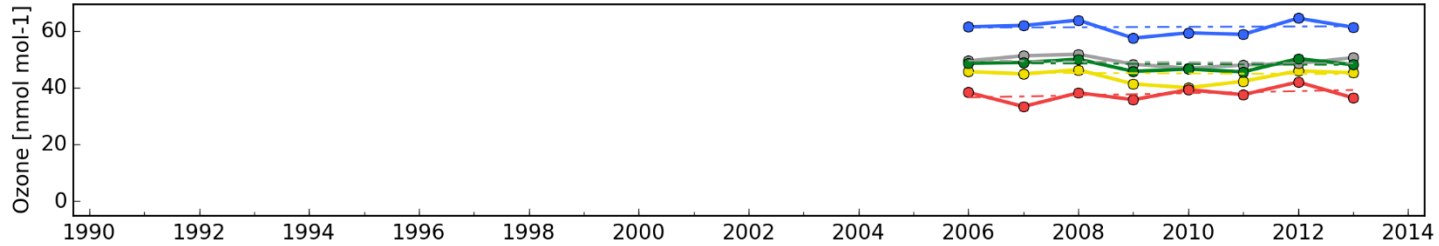



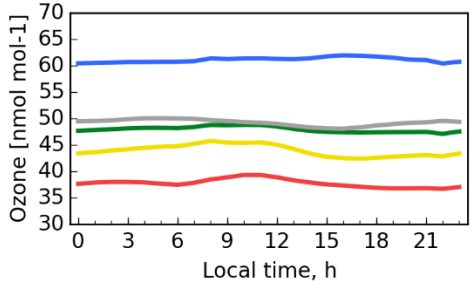



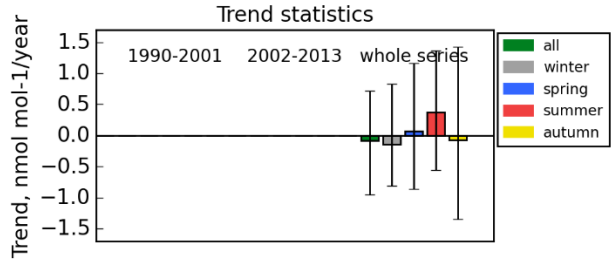




Linear trend parameters, 90 % CI

| | 1990-2001 | 2002-2013 | whole series |
|---|---|---|---|
| all | | | -0.08 (-0.95..0.72) |
| winter | | | -0.14 (-0.82..0.83) |
| spring | | | 0.07 (-0.86..1.16) |
| summer | | | 0.37 (-0.56..1.36) |
| autumn | | | -0.07 (-1.35..1.43) |

TOAR scores

| | |
|---|---|
| length of series | 4.00 |
| completeness | 10.00 |
| consistency | 9.76 |
| baseline stability | 6.41 |
| overall score | 7.54 |

Dataset id: 21906

# Thank you