

Minutes from the Expert Team on World Data Centres (ET-WDC)

1-3 October 2019, NASA Langley, Hampton VA, USA



WORLD
METEOROLOGICAL
ORGANIZATION



GLOBAL
ATMOSPHERE
WATCH

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OPENING OF THE MEETING

Welcome by Rosemary Baize, the Deputy Director for Research and Mission Science in NASA Langley Research Center.

- Data management critical for NASA, excited to host this meeting
- Langley has 1800 collaborators, 1500 contractors
- Earth science predominant
- TEMPO mission delivered
- CLARREO Pathfinder (CPF) has passed important milestone
- Airborne campaign for Aeolus validation using lidar
- Airborne campaign Firex-AQ, ACTIVATE
- SAGE, etc
- Need to get results out for applications, many missions will be housed at Langley data center
- Make data available to the people.

Stoyka Netcheva, WMO Secretariat

- Thanked participants for their support of WMO data management, which is very important.
- Metadata sharing, discoverability, access to improve.

1. INTRODUCTION OF PARTICIPANTS

Gao Chen

- Science panel of observational data

Ryan Stauffer (technical), Debra Kollonige (data archiver, took over from Jacquie Witte)

- SHADOZ project
- SCOPE project, AQ in Gulf of Mexico

Kjetil Torseth

- Research Director at NILU
- Acid rain, EMEP, EBAS database
- Head of EMEP CCC
- ACTRIS data center
- Stratospheric research NADIR (no longer active)
- Collaboration with EEA

Richard Eckman

- Programme manager at NASA Langley and Washington for several missions
- Chair on WMO atmospheric variables team

Makhan Virdi

- Science data outreach center
- Host lots of data from aircraft, sondes, ships
- Works with Gao and Nate James

Judd Welton

- Aerosol, clouds
- MPLNet project manager
- Co-chair of GALION
- SDS-WAS Americas Steering Board
- Member of ET-WDC
- Wants to build GALION data center

Enrico Fucile

- WIS branch
- Metadata and data representations
- Used to be at ECMWF leading observations team
- Expertise with data formats and metadata, operational aspects
- WMO moving towards Earth Systems approach, try to harmonize data formats and increase interoperability

Tom Kralidis

- MSC EC, WOUDC
- Geospatial and Open Data Systems (GODS)

Atsuya Kinoshita

- WDCGG
- Senior scientist,
- Involved with WDCGG since 1999

Rosemary Baize

- Research Director, responsible for data center for Langley
- Nasa encouraged to reach out to non-traditional data users
- Think long-term about data mgt for large datasets, cloud vendor lock-in

Keichii Sato

Ted Habermann (from Colorado)

- Metadata standards for airborne data centers
- Used to be at NOAA and involved in WIS
- ISO, ICARTT

Nate James

- Data systems engineer at Nasa Goddard, EOSDIS, core capability
- 12 discipline oriented data archives, Nate is the engineer for atmospheric science data center at Langley

Jörg Klausen

- Scientific advisor at MeteoSwiss
- Chair ET-WDC, Co-chair TT-WMD

**2. REPORT BY CHAIR OF ET-WDC, OBJECTIVES OF MEETING,
APPROVAL OF AGENDA (Joerg Klausen)**

Background, purpose and objectives of the meeting.

To understand what progress is made by WDC and networks and if not why, challenges, how to do things better, agree on vision for the future.

Items 7&8 on Agenda are open for ideas, suggestions, where you fit, what part of the plan and what actions each participant identifies with.

In reference to interoperability – we not only understand mapping code lists but it is open for input and broad ideas.

Item 9 Expected Draft actions to follow up.

Outcome action items will be uploaded on website.

Work of the team set up under OPAG EPAC Technical Commission of Atmospheric Sciences (CAS) with focus on maintaining and improving the World Data Centres, interoperability of data centres with GAWSSIS and its transformation into a centralized catalogue of GAW observations and repository of WMO metadata of composition measurements, increased visibility of those data based on continuous innovation and implementation of technology advancements.

Meeting aims to increase cooperation between data providers, networks and links to data archives and together move towards achieving the goals of WMO for better interpretation and integration of supporting information for improved services.

The importance of physical and chemical parameters of atmosphere in focus area are reflected in GAW Implementation Plan with specific objectives related to data management which need to be updated.

Finally, how to achieve progress as team in harmonized way based on common objectives.

Discussion

- PBL and similar variables have no clear home in GAW but also nowhere else, while they are very important for GAW.
- [Suggestion Chair] discuss later in part where we will try to define variables.

AI2019-1: Bring ancillary variable PBL height (and related variables) to the attention of SSC and discuss how they could fit into the GAW data management (Chair, November 2019).

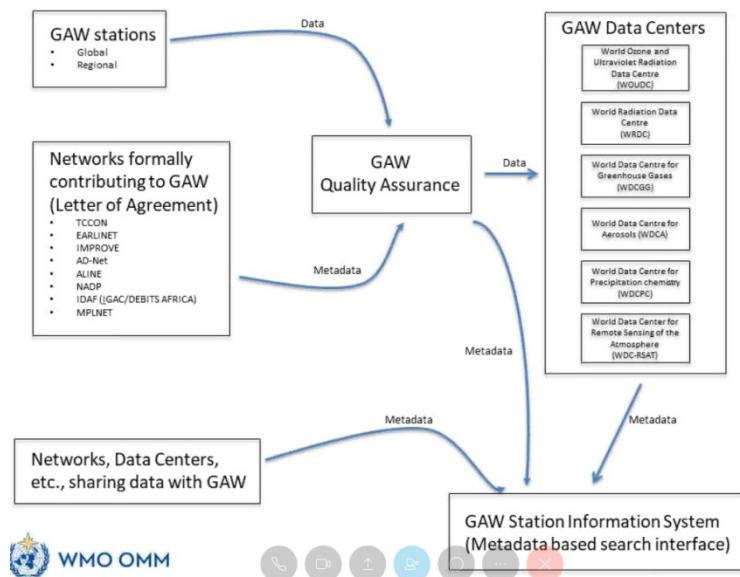
3. RELEVANT OUTCOMES OF WMO CG-18 AND EC-70

(*Stoyka Netcheva*)

Cg-18

1. 5 goals approved
 - a. Serve societal needs
 - b. Enhance Earth system ob and predictions
 - c. Advance targeted research
 - d. Close capacity gap
 - e. Strategic alignment of WMO structure and programmes for effective policy- and decision-making.

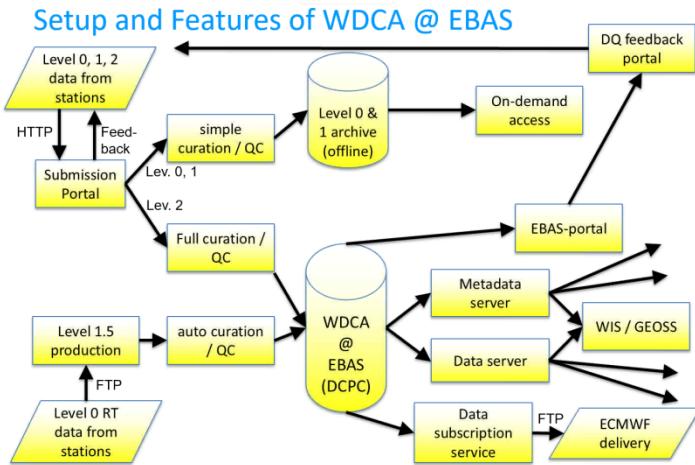
- 2.



- Key priorities
- Actions in GAW IP
 - A-DM-xxx
 - Not too much progress on record, but will take stock after this meeting.

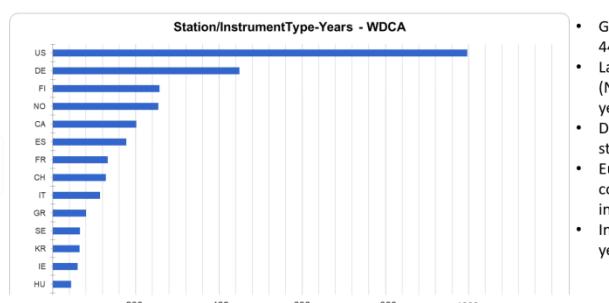
4. REPORTS BY GAW WDCA: ACHIEVEMENTS, STATUS AND PLANS

Doc 4.1 - WDCA



- Data levels agreed throughout Europe
- Continuous effort to develop tools to register data
- Mentions free DAQ s/w for stations wanting to participate in RT delivery
- Ca. 150 instruments reporting each year

Station / Instrument Years Provided, per Country



- Graph shows only 44 countries in total.
- Largest contribution by US (NOAA), 997 instrument years.
- Due long-running own station network.
- European countries contribute ≈2000 instrument years.
- In total 3544 instrument years.

- More KPIs in presentation
- FAIRness and open data present challenges for data archives
- Access to data have different motivations and funding streams

Assisting data originators in submitting data is big task involving development of tools for checks, different initial metadata to move to FAIR principle –rich metadata, low rep and engagement outside Europe, invitations for submissions and follow ups sent.

Reporting templates are extensive for different data levels, check files and clean them, carry out QA and check consistency of data files. Relational database can support any kind of data – different platforms, measuring methods, instruments, different data heavy metals, photochem products, can combine different type of data while retrieving them from portal, feedback is incl. and information for issues on submitted data if problem exists. NRT for operational forecast already developed. Based on FAIR principles to interface with WIS, GEOSS, Vocabulary– to verify consistency with WMO. Needed harmonized vocabulary and to be based on where data are used.

What Are the FAIR Principles?

Designed by FORCE 11 (open data advocate-) group to describe the general requirements that “Open Data” should meet.

Consist of four main points. Data should be:

- Findable
 - (meta)data have globally unique and persistent identifier
 - data are described with rich metadata
 - (meta)data are indexed in a searchable resource
 - metadata specify the data identifier
- Accessible
 - (meta)data are retrievable by their identifier using a standardized communications protocol
 - metadata are accessible, even when the data are no longer available.
- Interoperable
 - (meta)data use a formal, accessible, shared, and broadly applicable language for knowledge representation.
 - (meta)data use vocabularies that follow FAIR principles.
 - (meta)data include qualified references to other (meta)data
- Re-usable
 - (meta)data are with data usage license.
 - (meta)data are associated provenance.
 - (meta)data meet domain-relevant community standards



Discussion

For aerosol applications shown statistics by WDCA covers a small part of aerosol data. Most of aerosol data are outside GAW – for example, AERONET and LIDAR data and are not contributing for various reasons. Half of the contributors are not part of NASA. All existing aerosol data to be put in one place is difficult. What limits integration? Need rational solution to integrate huge suite of valuable measurements. Topic collection? To find a way to harmonize including use of DOIs, data system, metadata standard?

- Enrico Fusile: WMO working on a new data guide that will include the FAIR principles (which can be interpreted and implemented in different ways).
- Ted Haberman: what formats are emitted by the EBAS metadata server?
 - Delivering to WIS, working on WIGOS format.
 - Vocabularies are still a major issue, have advanced quite far with CF, WMDR still a challenge.

European infrastructure project is a challenge. DOIs are considered for final products. Data to be open but their use documented by DOIs, licenses, open licenses to be done in a proper way and kept.

Appears there are different terminologies, different meaning of different levels. Data levels consistency within GAW and WMO.

AI2019-2: Consider WMDS code table 7-06 (Level of data), cf. https://github.com/wmo-im/wmds/blob/master/tables_en/7-06.csv and create issues if necessary. (all, Dec 2019).

Doc 4.2 - WDCRG

WDCGG (June 2015)	WDCRG Sept 2019 (status 2018 in brackets)
<ul style="list-style-type: none"> Total 1076/1137 datasets, the latter number reflects parallel observations at some locations CO: 208/376, NOAA flask samples represents 589 datasets (CO=89, VOCs=500) Remainder (~172 datasets); mainly EMEP data which has been downloaded by JMA to populate WDCGG 	<ul style="list-style-type: none"> Total 2281 datasets (1923) 83 stations (63) 35 countries (28), 129 components (126)
	Historic data (-> 2013): <ul style="list-style-type: none"> 1216 datasets 49 sites 22 countries 111 components
	
	<ul style="list-style-type: none"> Request to re-submit to get data conforming "with our metadata standard". Issue with NOAA flasks not resolved. NOAA VOC flask data not imported yet, because NOAA doesn't report data. NILU mostly working with INSTAAR, not with NOAA directly.

WDCRG Challenges –different standards; training and capacity development needs, how to do different parts of data management; historical data what to do with standards – new metadata, new standards, issue with data versions to not replace new /better version with old one, how to do verification on versions, how to make those available to WIGOS without having duplications. Concern is also conversions and risk of leaving out valuable data. Developed already scripts for importing data but it is challenge to harvest all data. WDCs are for long term archiving –for eternity and challenges related to do that. For old datasets - try to ensure the best data come to DC – and it is an obligation of DC to maintain history of dataset, need contact person and that is a challenge for historical data.

Doc 4.3 - WDCGG

WDCGG Statistics (Data providers/Contributors)

Contributors (Data providers)	Station	Gas species	Country/Territory
Total 69	Total 205	Total 56	Total 56
JMA HAMS GERC	GAW Global	CO ₂ , CO ₂ [C-13], CO ₂ [O-18]	REGION I (Africa) 10
NOAA IAFMS NIES	GAW Regional	CH ₄ , CH ₄ [C-13], CH ₃ D	REGION II (Asia) 13
AEMET IGP NILU	GAW Contributing networks	N ₂ O, SF ₆ , SO ₂ F ₂ , NF ₃ , COS	REGION III (South America) 5
AGAGE IMKIFU METRI	GAW Other elements	Halocarbons 2	REGION IV (North and Central America) 5
AICHI INRNE NIWA	Mobile	CFCs 6	REGION V (South-West Pacific) 6
AIST INSTAAR INNMH		HFCFs 4	REGION VI (Europe) 25
ASTI TO IDEM JAMSTEC		PFCS 11	ANTARCTICA 7
ARSO TNO OSAKAU		Halon 3	MOBILE 6
BAS ISAC PolymJ			
BMKG ITMA RIVM	REGION I	Reactive Gas 10	
CMHI KMA RSE	REGION II	Other Gas 1	
CMA KMD SAIPF	REGION III	Radionuclide 3	
CSIRO KSNU SAWs	REGION IV	TIC	
DNC KUP SHIZU	REGION V		
IAA LA TU	REGION VI		
DWD LAMP UBAG	UNIURB		
ECCC LSCE UBAA	ANTARCTICA		
EMA MGO UNIURB	MOBILE		
Empa MMD UMLT			
ENEA MRI UYRK			
FMI NAGOU UNIVBRIS			
FRA NEDO JAMSTEC			
HKO YNMHA IIA			

Note: There are countries that extend over multiple regions.

How to find/use data (for users)

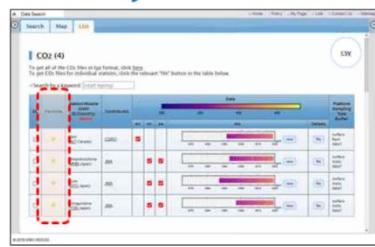
- Download observation data -

Download list



- ✓ Download from multiple observational sites is possible on the new WDCGG website.
- ✓ User ID registration is required to download data.

My Favorite

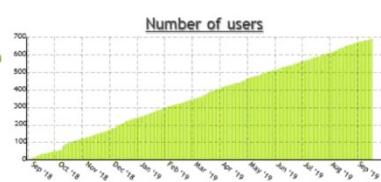
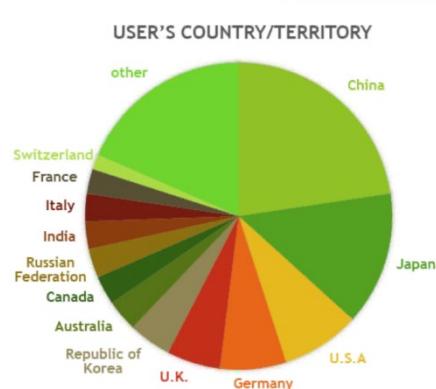


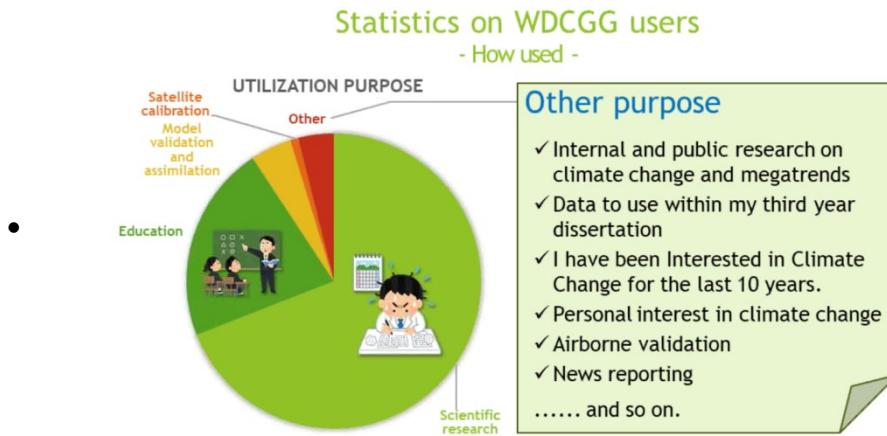
- ✓ If you often look at specific data, please use My Favorite.

When you download, the download information is sent to the data provider(s).

Statistics on WDCGG users

- Who and how many access -





Provision of satellite data since March 2019

Satellite	Organization	Gas Species	Version *- the latest version	Updated Date	Gallery/Metadata
GOSAT	NIES (National Institute for Environmental Studies)	CO ₂	0053-9001-1001-08-08-9999 -2019-03-19-0900*	2019-03-19	View

✓ WDCGG began online provision of CO₂ observation data from Japan's Ibuki Greenhouse gases Observing SATellite (GOSAT).

✓ Monthly global map of column-averaged CO₂ mole fractions can be seen in the Gallery/Metadata.

✓ Downloadable CO₂ data are L2 column volume (SWIR) in daily (combined by month) HDF5 Format.

[Download CO₂ data](#)

- Now also hosting OCO-2 data

Currently working plans

Publication of meteorological data

- ✓ WDCGG started collecting meteorological data records as environmental information for each observation station from this year again.
- ✓ Publication method is undecided yet.

File Name	Period	File Type	Format	Description of the file
file_name_001	-	-	Text file	Explain the observation period and the observation area.
file_name_002	1990-01-01	Year	Text file	Calendar year of observation.
file_name_003	1990-01	Month	Text file	Calendar month of observation.
file_name_004	1990-01-01	Day	Text file	Date of observation.
file_name_005	1990-01-01	Hour	Text file	Time of observation.
file_name_006	1990-01-01	Second	Text file	Second of observation.
file_name_007	1990-01-01	Latitude	Text file	Latitude of the north and south pole of the observation area. Between the two poles, it is divided into 1000 segments.
file_name_008	1990-01-01	Longitude	Text file	Longitude of the east and west pole of the observation area. Between the two poles, it is divided into 1000 segments.
file_name_009	1990-01-01	Altitude	Text file	Altitude of the land surface.
file_name_010	1990-01-01	Pressure	Text file	Pressure at the land surface.
file_name_011	1990-01-01	Temperature	Text file	Temperature at the land surface.
file_name_012	1990-01-01	Humidity	Text file	Humidity at the land surface.
file_name_013	1990-01-01	Cloudiness	Text file	Cloudiness at the land surface.
file_name_014	1990-01-01	Wind	Text file	Wind direction and speed at the land surface.
file_name_015	1990-01-01	Rainfall	Text file	Rainfall amount at the land surface.
file_name_016	1990-01-01	Cloud height	Text file	Cloud height (m) above sea level.

Expansion of satellite data

- ✓ WDCGG plans to continue improving its services for the collection, archiving and distribution of satellite data worldwide, including for GOSAT-2 (the successor to GOSAT).
- ✓ In addition, OCO-2 data will be included.

Future plans

- **netCDF**
Provision of netCDF format data in addition to text data
- ➤ **DOI**
Add DOI to each observation data
- **Uncertainty column**
WDCGG is requested to add the necessary uncertainty columns to data format
(in GGMT-2019)
- **GAWSIS**
Exchange metadata with GAWSIS by automatic reading using API

GAW/WDCGG staff in Atmospheric Environment Division, JMA

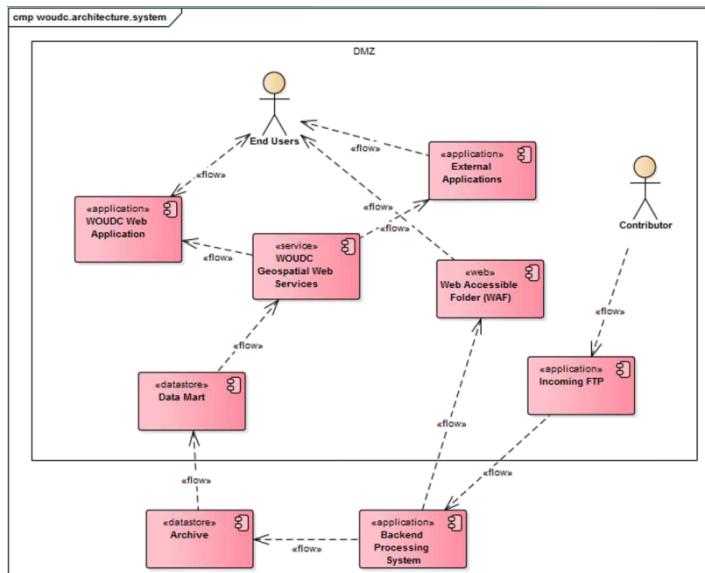


• Thank you for your attention!

FT-WDC meeting, 1 October 2019.

Under Harmonized metadata: information and clarification needed on variables, required format, data originator, DOIs-is planned for each observation data, uncertainty will be included in future, next: exchange with GAWSIS using API. Find harmonized checking and machine reading.

Doc 4.4 - WOUDC



Number of Files 2018

Broad-band	123147
OzoneSonde	90117
Lidar	675
Multi-band	91649
TotalOzoneObs	100804
Spectral	269217
UmkehrN14 2.0	9889
RocketSonde	177
TotalOzone	81608
UmkehrN14 1.0	10522
TOTAL	777805

Downloads 2018

Dataset	WAF (number of files)	Dataset Archive Files	Geospatial Web Services (number of requests)
Total ozone obs	2993589	30	1162
Ozonesonde	266959796	31	8977
Total ozone daily obs	9991490	38	7261
Spectral	999597	25	1226
Multi-band	385929	21	538
Broad-band	253428	23	973
Umkehr 2	327136	25	353
Umkehr 1	354592	23	417
Lidar	6212	25	421
RocketSonde	16174	22	281
Total	282,287,943	263	21,609

Website Visits 2018

Year	Visits (<= 30 min)
2015	17245
2016	59042
2017	98084
2018	547352

- Made Open by default, no login etc. resulted in increased visits and use.

Top Hits by Domain 2018

Domain	Hits
ecmwf.int	281487149
noaa.gov	41143661
oma.be	8906628
auth.gr	3185643
nasa.gov	2946676
kishou.go.jp	1694876
(not set)	1492231
archive.org	759360
chonbuk.ac.kr	461577
knmi.nl	304746
...	
total	343804972

Enhancements

Updates

- Trajectory-mapped Ozonesonde dataset for the Stratosphere and Troposphere (TOST)
- Global and zonal total ozone variations estimated from ground-based and satellite measurements
- HTTPS (w/ HTTP -> HTTPS redirect)
- Station Data Summaries
- Non-standard format support tools
 - SHADOZ
 - Umkehr

Interoperability

Key Drivers: Alignment

- World Meteorological Organization
 - Weather, Climate, Water
- Public Access: Canadian Open Data
 - WeatherCAN: Mobile Weather App
 - Canadian Centre for Climate Services (CCCS)
- Government of Canada Geospatial
 - Federal Geospatial Platform (FGP)
- Beyond: GEOSS, etc.

Interoperability

Core Principles

- FAIR
- Standards
- Open Geospatial Consortium (OGC)
- World Wide Web Consortium (W3C)
- International Organization for Standardization (ISO)

Interoperability

Data Centre Interoperability project (DCIO)

- - Circa 2008
 - Harmonized dataset metadata of information holdings
 - Peering
 - Data discovery
 - Evolution of DCIO project
 - Reduce problems associated with data duplication
 - Authoritative single source
 - <https://evdc.esa.int/documentation/oai-pmh>

NDACC 'integration' by 2020

Evolving standards

OGC API Development Activity

- - W3C [Spatial Data on the Web Best Practices](#)
 - Modernization of API standards (Webby)
 - REST
 - JSON/HTML
 - OpenAPI/Swagger
 - Resource Oriented Architecture
 - Promotion of JSON/GeoJSON and HTML
 - Clean break
 - Lowers barrier to implementation
 - Search engine friendly

Technology

- | | Current | Future |
|------------|------------------|---------------|
| Deployment | Debian | Docker |
| Processing | Python 3 | Python 3 |
| Archiving | PostgreSQL+FS | PostgreSQL+FS |
| Search | PostgreSQL | Elasticsearch |
| API | MapServer, pycsw | pygeoapi |
| UI | PHP, JavaScript | Vue.js |

Developments since introduction of new platform used contributors input and SAG direction. Data cleansing challenge. Delay in submission or not reporting improved using WMO contractor. The search is made friendly, anonymous which increased visitor numbers. Build on FAIR, standards, open, ISO standard. Request from O3 UV SAG for station DOIs. Metadata is part of data file and is extracted from files. WOUDC linked 9 datasets with GAWSSIS. Work on linking with NDACC- SHADOZ and Eubrewnet in progress. Build for finalized data. NRT of Canadian O3 sondes through GTS.

Discussion

- How much should data archivers assist data providers in providing correct data?

Doc 4.5 - WRDC

Head of DC submitted presentation but not participating, not presenting. Not clear exact progress or issues or plans.

To follow up on commitment and progress.

Doc 4.6 - WDCPC (*Chris Lehmann*)

- WDCPC currently managed by Van
- Workplan submitted to NOAA
 - Serve as intake for TAD data
 - Validate data
 - Store data at University of Illinois
 - No replication of existing regional data centers
 - Provide links to these other programmes
 - Fairly well harmonized efforts through SAG TAD.

AtmDep has not taken off since suggested after working on Global Atm Deposition Assessment. WDCPC Precipitation chemistry data center is in exploratory phase, transitioning to new home and management. The current stage is to submit transition plans to NOAA including DB structure, data flow. At this point the work plan is more like a wish list as to what we hope to achieve. Considered now intake of WDCPC data from assessment, standard templates, validation of data. No clear strategy for global coverage, access to global datasets, what is role of Regional centers? Agreement from 2014 is to serve not duplicate Regional Data centers but have archival of data. Standardized – metadata cross walk, seeking guidance for consistent format and by setting it up and can move to WIGOS now. Need formats and how to do metadata exchange. Which one to use? Collect /provide links to orphaned data is challenging as need to find a contact person. Metadata availability – how to get it in WIGOS? WIS? Infrastructure exists but not running at this point. Need to consider harmonization and interaction with other centers.

Discussion

- EANET, EMEP has plans on how to exchange metadata with GAWSIS, how about for NADP, CaPMon, DEBITS.
- NILU has compiled datasets for assessments and keeps relationship with CaPMoN, SAG. Not sure how to set and be searchable and discoverable by Precip Center.
- Some have simple/basic others more complex metadata and might take years to develop while the intention is to preserve developed infrastructure.

Doc 4.7 - WDC-RSAT

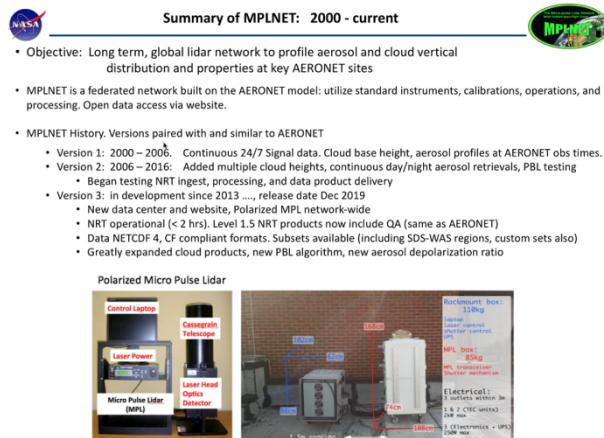
Not represented. To follow up on commitment and progress, status of facility in GAW.

AI2019-3: All WDCs to (re-)establish/confirm metadata exchange with GAWSIS-OSCAR/Surface. Consult with MeteoSwiss and https://library.wmo.int/doc_num.php?explnum_id=5844 (Section 3.12) for guidance and present timeline. (all WDCs, 10 Nov 2019)

5. CONTRIBUTING PROGRAMMES, OTHER DATA ARCHIVES

Doc 5.1 – MPLNet

- Nasa's lidar network, put at key Aeronet stations



- Aeronet reaches 30 yrs, MPLNet reaches 20 yrs, bound to stay, so needs to become more operational.

WMO GAW Aerosol Lidar Observation Network (GALION):

A lidar network of networks organized through the GAW program, and is composed primarily of the world's leading lidar networks. Each is an official contributing network to GAW (or soon will be).

GALION Networks:

EARLINET

AD-NET

CIS-LINET

LALINET

CORALNET

CREST

MPLNET (global)

NDACC (global)

GALION Co-Chairs:

Gelsomina Pappalardo (CNR IMAA)

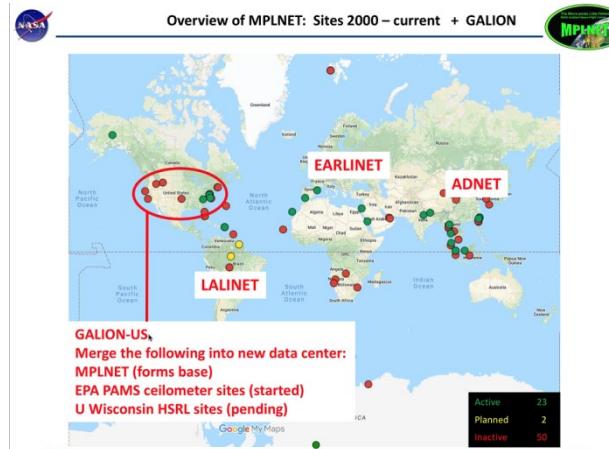
Ellsworth J. Welton (NASA)

Work Groups:

Calibration, QA/QC, processing/products, applications, data center



- CORALNET no longer active



Overview of MPLNET: Version 3 Product Suite

Detailed information on V3 Products: mplnet.gsfc.nasa.gov/product-info/

V3 Product	Descriptions			
NRB	Lidar signals; volume depolarization ratios; diagnostics			
CLD	Cloud heights; thin cloud extinction and optical depths; cloud phase			
AER	Aerosol heights; extinction, backscatter, and aerosol depolarization ratio profiles; lidar ratio			
PBL	Surface-Attached Mixed Layer Top and estimated AOD			
Product File Formats				
Formats	MPLNET V3 products are NETCDF 4, CF compliant files. Subsets for each product may be selected to reduce file sizes.			

Product Levels	Availability	Calibration	QA Screen	Ancillary Input
L1_NRB	Automated Browse: Near Real Time Download: Next Day *	initial, ongoing field calibrations	none	GEOSS Forecast NRT, reprocessed next day with GEOSS Assimilated, AERONET L15 AOD
L1_CLD				
L1_PBL				
L1_AER				
L15_NRB	Automated Browse: Near Real Time Download: Next Day *	initial, ongoing field calibrations	L15	GEOSS Forecast NRT, reprocessed next day with GEOSS Assimilated, AERONET L15 AOD
L15_CLD				
L15_PBL				
L15_AER				
L2_NRB	upon request †	initial, ongoing field calibrations, post calibration, additional‡	L2	GEOSS Assimilated, AERONET L2 AOD
L2_CLD				
L2_PBL				
L2_AER				

* Near real time data can be provided to site partners and forecasting/modeling centers

† L2_AER products subject to availability of L2 AERONET data

‡ Additional L2 calibrations may include corrections for instrument temperature and manual inspection of data

MPLNET: Data Communications



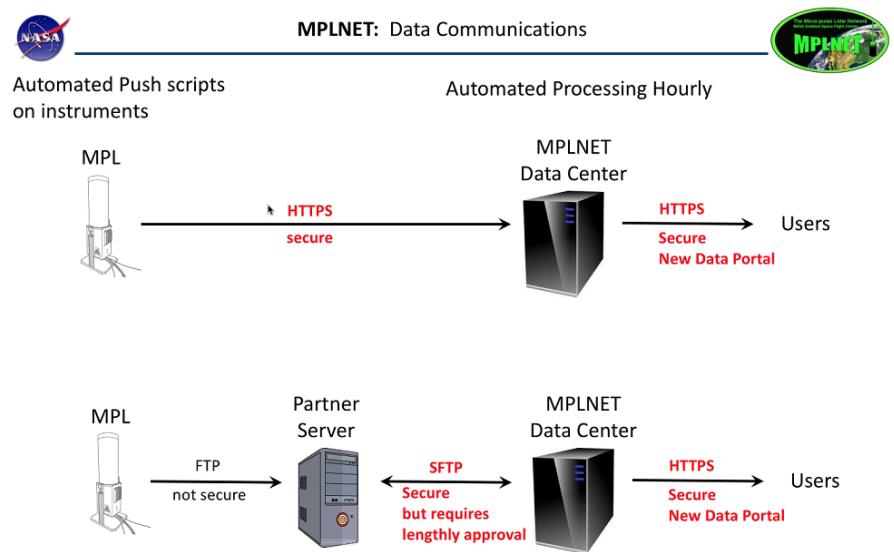
In 2018 NASA declared all data communications must be secure (SFTP, FTPS, HTTPS)

MPLNET Incoming

- Raw data files from network instruments
- Custom binary format from manufacturer (open)
- Previously utilized combination of FTP (primary, push) and SFTP (pull from some partners)
- 2019 converted to a web data portal (HTTPS) for all incoming data
 - Security features
 - Instruments assigned a passcode
 - Uploaded data files are whitewashed and content checked
 - We provide assistance for some partners who need to push files to us

MPLNET Outgoing

- Data products delivered to user community
- Data products have always been open access, no username or password
 - Data quality same as AERONET project, clearly stated on web & data portal
- Webserver converted to HTTPS in 2016
- Version 3 outgoing data portal redesigned in 2018
 - Copied format utilized by NASA Global Modeling and Assimilation Office (GMAO)



MPLNET Network Management: Site Status & Automated Alert System

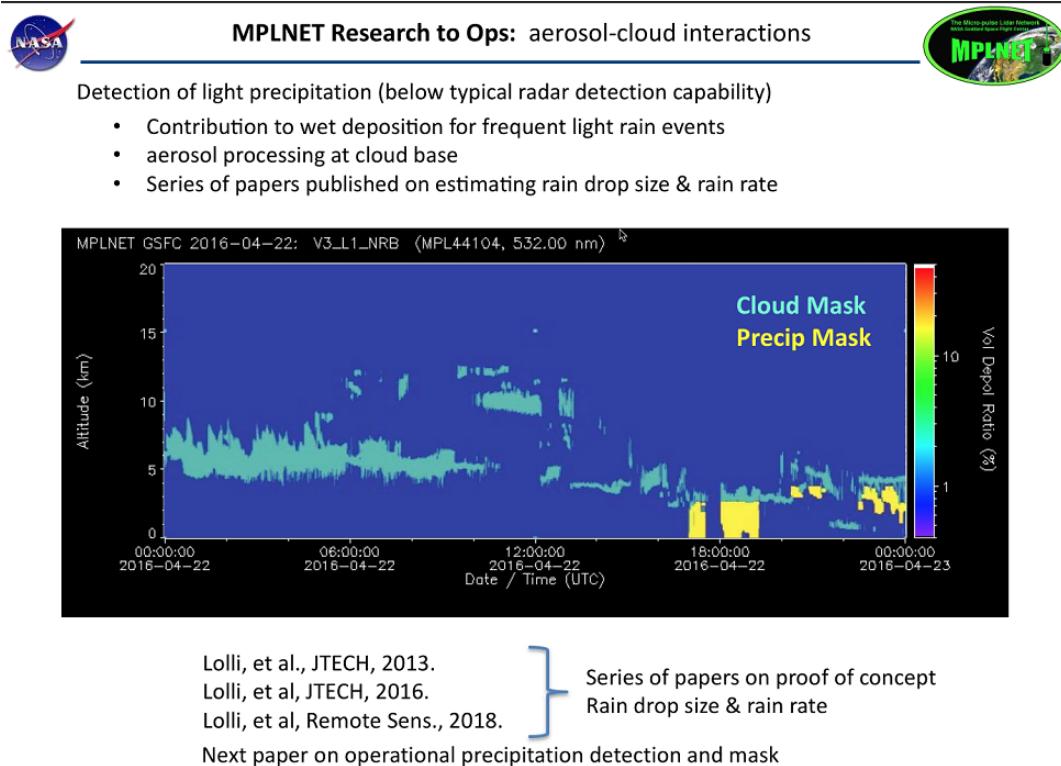
#	Site	Instrument	LO Data	DC Cal Data	AP Cal Data	Energy	Box Temp
8	GSEC	MPL44298	Good	DC Data Overdue	AP Data Overdue	Good	Good
9	Kengur	MPL44240	2019-09-20 13:00:00 10.0 days ago	Good	Good	missing overlap and polarization cal temporarily ignored	Good
10	KAUST_Campus	MPL44233	2019-09-30 16:00:00 61.9 days ago	DC Data Overdue	AP Data Overdue	Low Energy (< 2 uJ)	no set point
11	King_George_Island	MPL55038	Good	Good	Good	no set point	no set point
12	Kuching	MPL44251	Good	Good	Good	no set point	no set point
13	NASA_LaRC	MPL44104	Good	Good	Good	no set point	no set point
14	Princess_Sirindhorn_AstroPark	MPL55038	2019-09-29 06:00:00 1.3 days ago	Good	Good	Good	no set point
15	Santa_Cruz_Tenerife	MPL44255	Good	Good	Good	no set point	no set point
16	SEDE_BOKER	MPL44241	Good	Good	Good	no set point	no set point
17	Sigmar_Space_Corp	MPL44111	Good	DC Data Overdue	AP Data Overdue	Good	Good
18	Sititekun_University	MPL44234	Good	DC Data Overdue	AP Data Overdue	Good	no set point
19	Singapore	MPL44235	2019-09-16 10:00:00 76.0 days ago	DC Data Overdue	AP Data Overdue	Low Energy (< 2 uJ)	temp NaN or INF

Note 1: click on the row number to see plots of the L1 NRB, Volume Depolarization Rate, and Instrument Diagnostics
Note 2: only the last minute of received data is used to determine instrument energy and box temp status, see diagnostic plots for past week statistics
Note 3: the table can be limited to specific sites!, example URL: <https://mplat.gfdl.nasa.gov/operations/status?sites=siteName1,siteName2,siteNameN>

MPLNET Product Variables vs GCOS ECV Proposed List

NRB Product	IPET-OSDE OSCAR/Requirements Workshop Essential Climate Variables (ECV)
NRB Lidar Signal	Cloud Cover (column fraction)
Volume Depolarization Ratio	Cloud Top Height
Lidar Co-pol Signal	Cloud Top Temp
Lidar Cross-pol Signal	Cloud Optical Depth
Diagnostic Variables	Cloud Liquid water path
	Cloud ice water path
	Cloud drop Re
CLD Product	
Cloud Heights * (but base missing)	Aerosol Optical Depth
Cloud Phase	Aerosol Single Scattering Albedo
Cloud Optical Depth *	Aerosol Layer Height
Cloud Fraction Profile (column only)	Aerosol Extinction Coeff (diff between lidar & in-situ)
AER Product	
Aerosol Height	Aerosol Size Distribution
Aerosol Optical Depth *	Aerosol Composition
Sunphotometer & Lidar	Aerosol Refractive Index
Aerosol Backscatter	
Aerosol Extinction	
Aerosol Depolarization Ratio	
Aerosol Lidar Ratio	
PBL Product	
Mixed Layer Height	
Mixed Layer AOD	

(this is a work in progress
.... Some differences with satellite GCOS ECV team)



MPLNet and GALION had been developed as projects and including all functions QC, processing, reprocessing and not easily merged. Measured, available parameters have not been included in GCOS only half of the variables have been listed as essential climate variables ECV. Is there a constraint in the number of variables? Now seems to be review phase of Climate Nomenclature of observed quantities, code of variables published, units. How to overcome limitations related to variables and in particular specific for LIDAR measurements which are used in few AQ applications/ models/ forecasts? Those models/applications have their own specific requirements/formats and have been met on one to one basis. Those variables have not been fully included/reflected in variables definitions produced by (RRR) groups - example PBL height, mixed layer height, aerosol extinction. It seems there are no common definitions of variables. Need to compare what variables are included in GAWSIS, WIGOS, OSCAR/requirements. To review if variables could have been entered under different names. Conversion factors might be provided. A review process of GCOS/WIGOS variables could be used for feedback and suggestions to add missing ones? Protocols and mechanisms for adding variables are in place with WMO involving SAG and review process. NRT processing is in place and automated at 1.5 version, there is no post calibration through GALION data center. NRT data are customer oriented data provision used for forecasting and validation purposes in AQ. Networks are moving away of ftp as NASA new policy for secure communication is implemented and does not allow ftp. Have common approach on level /version data – any convention or guidelines? (→ Consider **AI2019-2**)

Where GALION, AERONET fit within GAW?

LALINET – can the name be updated?

AI2019-4: Send example of metadata to be encoded in WMDR XML to MeteoSwiss (Judd Welton, asap). Judd Welton will review information on WIGOS metadata and elements-variables, prepare BUFR metadata transfer to be available with data.

Discussion

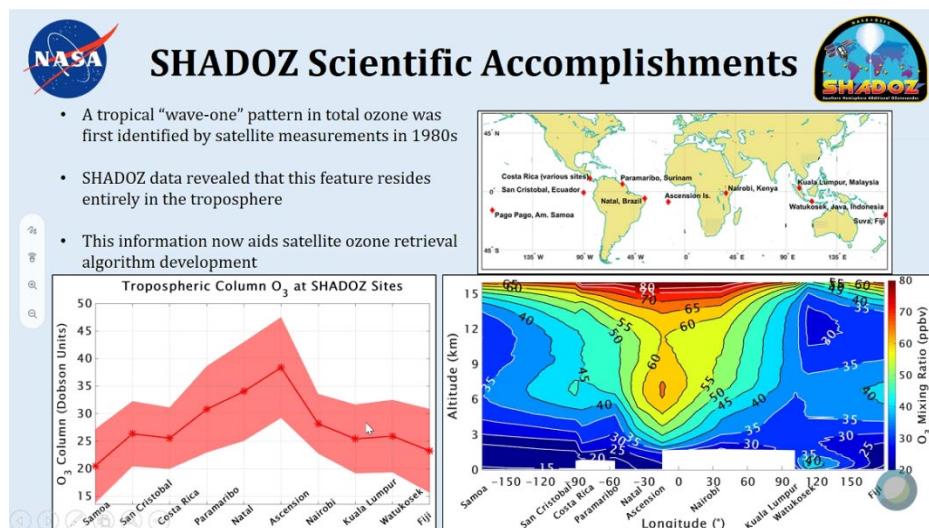
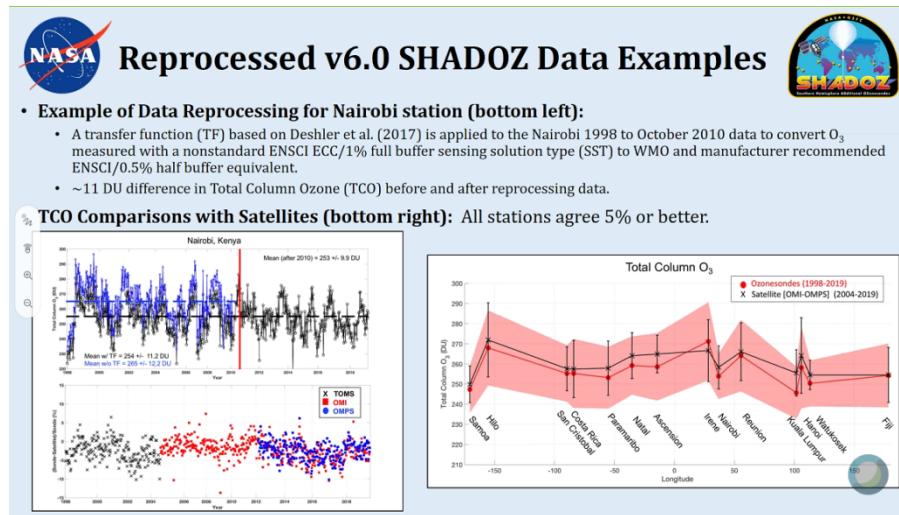
- Tim Haberman: CF attribute convention for attribute discovery.
- Tim Haberman: THREDDS server by UNIDATA.

Doc 5.2 – SHADOZ

The page features a large map titled "SHADOZ sites and partners" showing the global distribution of SHADOZ stations. The map spans from 45° N to 45° S and 135° W to 135° E, with stations marked in red at various tropical and subtropical locations. Logos for various partners are displayed around the map, including NOAA, NDACC, IAP, Royal Netherlands Meteorological Institute, HOKKAIDO, Météo France, USP, INAMHI, NCAR, Kenya Meteorological Department, COSTA RICA, South African Weather Service, and MeteoSwiss. A sidebar on the left lists "Milestones" from 1998, 2009, and the present (NOW).

- Data files are text files, which is what users want

The image shows two journal articles from the *Journal of Geophysical Research: Atmospheres*. The top article is titled "First reprocessing of Southern Hemisphere Additional OZonesondes (SHADOZ) profile records (1998–2015): 1. Methodology and evaluation" and the bottom article is titled "First reprocessing of Southern Hemisphere Additional OZonesondes Profile Records: 3. Uncertainty in Ozone Profile and Total Column". Both articles include author lists, abstracts, and supporting information tables.



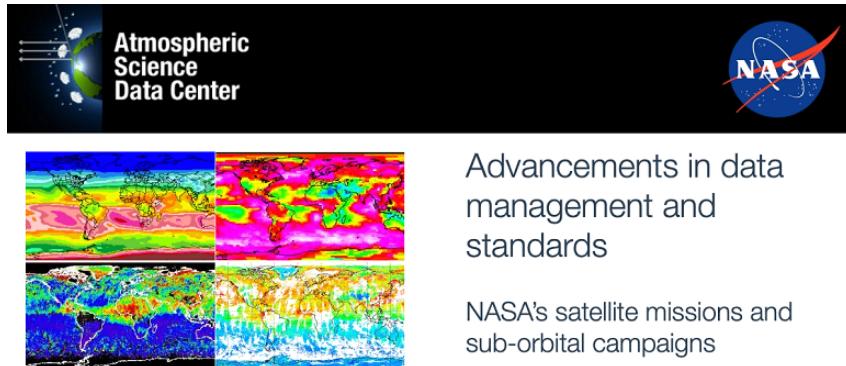
- Maximum explained by biomass burning, as it resides in the troposphere.
- SHADOZ data are submitted to WOUDC every now and then.

- WOUDC doesn't support uncertainties yet, though!

Data format are txt files, record of metadata in data with essential and desired fields, filled in through check list, flight prep information, established and QA, QC parameters. Included is uncertainty of measurements. Required fields are used for validation. Data reside with NDACC under NOAA transitioned to NASA management. MetaData connected(ing) with WOUDC and through that to WIGOS. Continuous effort for standardization, reprocessing and homogenizing data within ozonesonde community for years results in updated versions of data. Most recent review of SOP to be completed this year and to be submitted for publication under WMO. Finalized Data are submitted/linked to WOUDC through once a year update. Version 6 is to be submitted. No correction factor is provided for TOC in SHADOZ.

Doc 5.3 – GCW Not represented?

Doc 5.4 (Other) NASA data centres



Advancements in data management and standards

NASA's satellite missions and sub-orbital campaigns

Makhan Virdi
DAAC Scientist
Atmospheric Science Data Center (ASDC)
NASA Langley Research Center (LaRC)

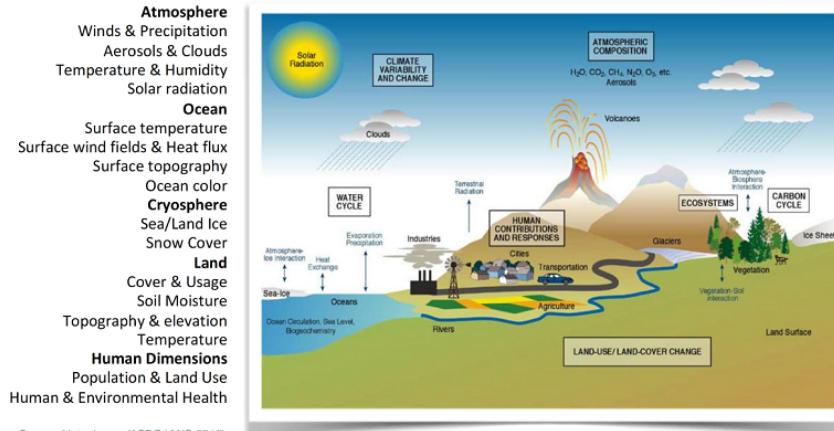
1 October 2019

Atmospheric Science Data Center (ASDC)
NASA Langley Research Center (LaRC)

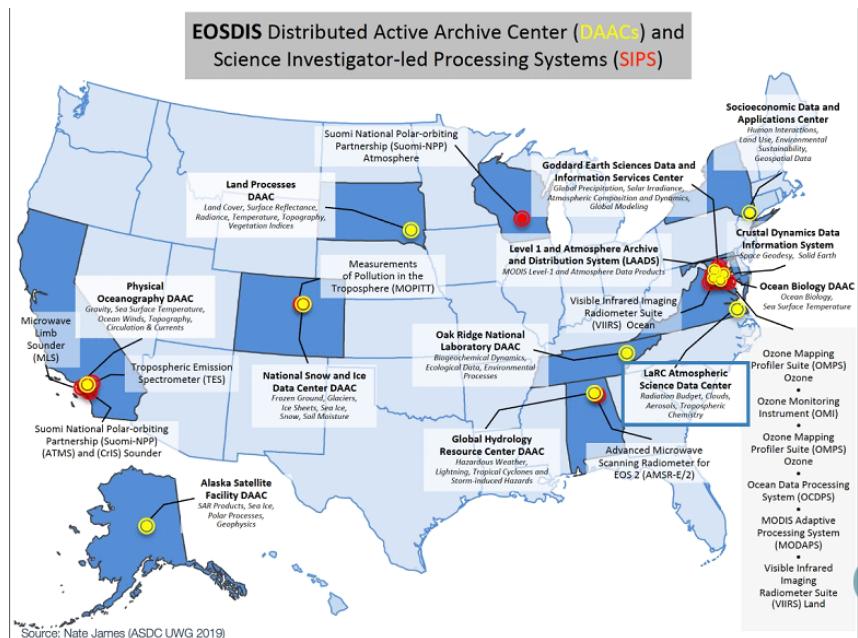


3

EOSDIS Comprises Data of the Whole Earth System



- Valerie Dixon ("Nasa metadata queen")



- All Nasa DAACs are searchable via the Common Metadata Repository

Atmospheric Science Data Center

NASA Earth Science

NASA

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The screenshot shows the NASA Earth Science homepage. On the left, there's a map of the world with various regions highlighted in different colors. Below it is a section titled "New Gravity Recovery and Climate Experiment Follow-On (GRACE-FO) Mission Data". On the right, there's another map of the world, and below that is a table titled "Gridded Population of the World, Version 4 (GPWv4) Administrative Unit Points with Population Estimates, Revision 13". The table contains numerous columns of data, including country names, population estimates, and other administrative unit details.

Source: Nate James (ASDC UWG 2019)

Atmospheric Science Data Center

NASA Earth Science

NASA

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The screenshot shows the NASA WorldView interface. On the left, there's a sidebar with various layers and base layers listed. The main area shows a satellite map of the Earth with some features highlighted in purple and yellow. On the right, there's a search sidebar with a list of environmental data types, each with a red "More" button. The data types include Nitrogen Dioxide, Nitrous Oxide, Ozone, Particulate Matter, Population Density, Radiance, and several others. Under the Radiance section, there are three items checked: Color Radiance (Df, RGB), Color Radiance (Cf, RGB), and Color Radiance (Bf, RGB).

NASA Earth Science

Atmospheric Science Data Center

8 FY2018

EOSDIS has over **30 Petabytes** of accessible Earth science data

- EOSDIS delivered over **1.6 Billion** data products to over **3.1 Million** science users from around the world
- ... ability to search over **33,000 Data Collections** in the CMR (Common Metadata Repository)...
- ... of which 98% of searches for data complete in less than **1 Second**

... and our LANCE system supports over **530** unique near real-time datasets... distributed over 134 million files and produced 1 Petabyte of data **within 3 hours of satellite acquisition**

Source: Nate James (ASDC UWG 2019)

- A collection is a set of data of similar observations
- Most cloud activities use Amazon, but Nasa tries to be vendor-agnostic

Science Outreach Team

Atmospheric Science Data Center

Data Producers

- Data Management Plan (DMP)
- Data Standards (Metadata/Filename)
- Interface Control Document (ICD)
- Science Team Meetings
- Workshops (AGU | AMS)

Data Users

- Micro-articles
- Jupyter Notebooks
- Code Snippets
- ArcGIS StoryMaps®
- Workshops | Webinars

ESDIS EOSDIS

- New Mission 90-day Plan
- Data Accession
- Science Communications Focus Group (UN)
- Earthdata Pub
- ESDS Working Groups

New Missions

- MAIA
- TEMPO
- CLARREO PF
- PREFIRE
- ACTIVATE
- DCOTSS
- BROMEX

Federation of Earth Science Information Partners (ESIP)

Earth Science Data System Working Groups

American Meteorological Society (AMS) American Geophysical Union (AGU)

Webinars | Workshops

Jupyter Notebooks

Sub-orbital Data Search Tool

ArcGIS StoryMaps®



ASDC: Data Discovery



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ASDC Data Distribution: Tools and Services

- ✓ NASA Earthdata Search
 - CMR Search
 - Metadata
- ✓ NASA WorldView
 - GIBS/visualization
- ✓ OPeNDAP transform/distribute
 - subsetting
 - reformatting
- ✓ HTTPS data access
 - datapool
 - permanent URL
 - enables scripts/workflow
- ✓ Example scripts
 - Python/Jupyter Notebook
 - R scripts
 - contributed tutorials/scripts



User Support and Other Resources

Earthdata Login <https://urs.earthdata.nasa.gov>

Earthdata Forum coming soon

ASDC User Support support-asdc@earthdata.nasa.gov

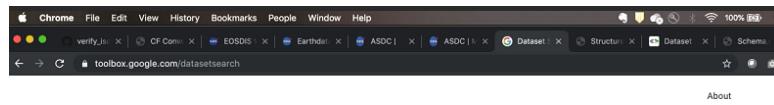
- OPeNDAP / THREDDS to allow sub-setting; requirement is a compliant data format, e.g. netCDF



source: <https://xkcd.com/927/>

Metadata Standards and Data Files Formats

- Data Files
 - File Naming Convention
 - File Formats
 - netCDF, HDF, GRIB
 - ICARTT, CSV
 - Tools
 - GrADS
 - Panoply, HDFView
 - Custom: R, Python/GDAL
 - GIS Tools
- Data Collection
 - Digital Object Identifier (DOI)
 - Landing page for DOI collection
 - Mark up of landing page in JSON-LD (Linked Data)



Google Dataset Search Beta

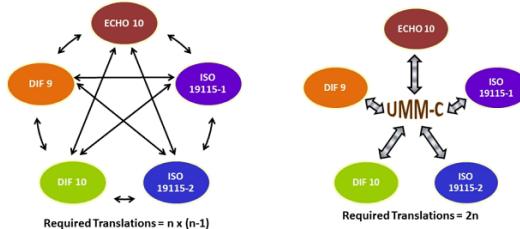
A screenshot of the Google Dataset Search Beta interface. The search bar at the top contains the query "modis". Below the search bar, there is a list of search results:

- MODIS/Terra Snow Cover Daily L3 Global 500m SIN Grid V006
- MODIS Combined 16-Day NDVI
- MODIS_AQUA_L3_SST_THERMAL_ANNUAL_4KM_DAYTIME_V2014.0
- Modified Faine's criteria
- Ishak Modified HAI Score
- MCD43A3.006 MODIS Albedo Daily 500m
- MCD43A1.006 MODIS BRDF-Albedo Model Parameters Daily 500m
- QESDI: MODIS land cover classification data
- Albedo: MODIS and CCAN-Derived NDVI and Trends, North Slope of Alaska, 2000-2015
- MODIS/Terra Net Evapotranspiration 8-Day L4 Global 500m SIN Grid V006

Investigate JSON-LD

Metadata Standards and Data Files Formats

- Standards
 - Climate and Forecast (CF) Metadata ([v1.8](#))
 - ESIP Attribute Convention for Data Discovery ([ACDD](#))
 - NASA's [Universal Metadata Model](#) (UMM)
 - ICARTT metadata



Source: <https://earthdata.nasa.gov/eosdis/science-system-description/eosdis-components/cmr/umm>

UMM-C: Universal metadata model

36, 1001 ← Number of lines in header, file format index (most files use 1001)
 Brune, William ← PI name
 Penn State University ← File volume number, number of file volumes
 ATHOS - OH and HO2 concentrations using cryo water mix ratio data for quenching corrections ← Instrument/Data Source
 ICARTT_INTEX ← Mission name
 1, 1 ← File volume number, number of file volumes
 2004, 07, 12, 2005, 01, 12 ← UTC date when data begin
 0 ← Data Interval [This value describes the time spacing (in seconds)]
 Start_UTC, seconds ← Number of dependent variables
 4 ← Scale factors for variables
 1, 1, 1 ← Missing data indicators for variables
 Stop_UTC, seconds ← Variable names and units
 Mid_UTC, seconds ← Number of special comments
 OH_ppbv_ppbv ← Number of normal comments
 18 ← PL_CONTACT_INFO: Address: 503 Walker Building, University Park,
 PLATFORM: NASA DFRC DC8 - sampling underneath aircraft for
 LOCATION: Aircraft location data in nav_dc8_20040712_R01.ctd file
 ASSOCIATED_DATA: see ftp://ftp-air.larc.nasa.gov/pub/air/INTEX
 INSTRUMENT_INFO: OH/HO2 LIF
 DATA_INFO: Units are ppbv.
 UNCERTAINTY: The absolute accuracy is conservatively estimate
 ULOD_FLAG: -7777
 ULOD_VALUE: N/A
 LLOD_FLAG: -8888
 LLOD_VALUE: N/A
 DM_CONTACT_INFO: Bob Leisher; Penn State University; blesher@psu.edu
 PROJECT_INFO: INTEX Mission 26 June-14 August 2004; California
 STIPULATIONS_ON_USE: Use of these data requires prior approval
 OTHER_COMMENTS: N/A
 REVISION: R0
 R0: Final Data
 Start_UTC, Stop_UTC, Mid_UTC, OH_ppbv, HO2_ppbv
 55524, 55545, 55535, 0.171, 9.791
 55546, 55565, 55555, 0.180, 9.218
 55564, 55585, 55575, 0.186, 9.767
 55586, 55605, 55595, 0.176, 9.996

ICARTT File Format

The scanning program looks for these key words (case insensitive).

PI_CONTACT_INFO: Phone number, mailing address, and email address and/or fax number.

PLATFORM: Platform or site information.

LOCATION: including lat/lon/elev if applicable.

ASSOCIATED_DATA: File names with associated data: location data, aircraft parameters, ship data, etc.

INSTRUMENT_INFO: Instrument description, sampling technique and peculiarities, literature references, etc.

DATA_INFO: Units and other information regarding data manipulation.

UNCERTAINTY: Uncertainty information, whether a constant value or function, if the uncertainty is not given as separate variables.

ULOD_FLAG: -7777 (Upper LOD flag, always -7's).

ULOD_VALUE: Upper LOD value (or function) corresponding to the -7777's flag in the data records.

LLOD_FLAG: -8888 (Lower LOD flag, always -8's).

LLOD_VALUE: Lower LOD value (or function) corresponding to the -8888's flag in the data records.

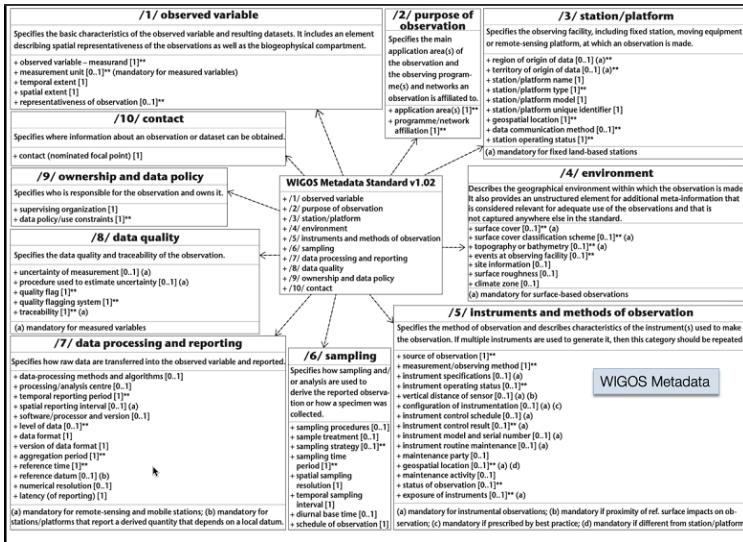
DM_CONTACT_INFO: Data Manager – Name, affiliation, phone number, mailing address and/or fax number.

PROJECT_INFO: Study start & stop dates, web links, etc.

STIPULATIONS_ON_USE: (self explanatory).

OTHER_COMMENTS: Any other relevant information.

REVISION: R# See file names discussion.



NASA DB consolidates 12 centers. Some centers do data processing. Clouds are not only used for depositing but also for some analytics. Google and Amazon work on providing tools for big data. Potential issues: Vendor locking. Taking/downloading data from the cloud is costly that's why processing is done on the cloud. If data are free how do we limit users' downloads? Develop tools for search and discovery of airborne data. Options built to download subset of info or datasets, NCFS(netCDF) compliance for discoverability, cross walk to link 1 center to another, HTML node embedded and part of metadata looks like google scholar, CF compliance, data discoverability -ACDD. Instruments and stations undergo a standardized process, one metadata standard. NASA metadata have minimum essential /requirement fields for metadata in common metadata standard UMM model (online documented), also ISO compliant metadata; DOIs in NASA not to be used due to character of networks and participants.

Clouds provide a new kind of analysis analytics on the cloud data. Amazon focused on facilitating analysis, defining data and metadata at production level by defining minimum requirements for metadata.

Doc 5.5 - EANET (*remotely Keichii Sato*)

- LoA with WMO signed in August 2018

List of items for cooperation (described in LoA)

[Atmospheric composition]

SO₂, O₃, NO, NO₂, HNO₃, HCl, NH₃, PM₁₀, PM_{2.5}, Components in TSP (SO₄²⁻, NO₃⁻, Cl⁻, NH₄⁺, Na⁺, Mg²⁺, K⁺ and Ca²⁺).

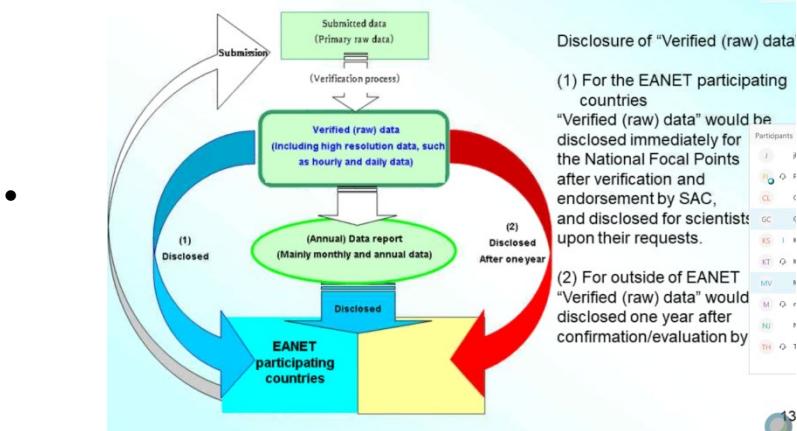
- [Precipitation chemistry]
Precipitation amount, pH, conductivity, and concentrations of SO₄²⁻, NO₃⁻, Cl⁻, NH₄⁺, Na⁺, Mg²⁺, K⁺ and Ca²⁺.

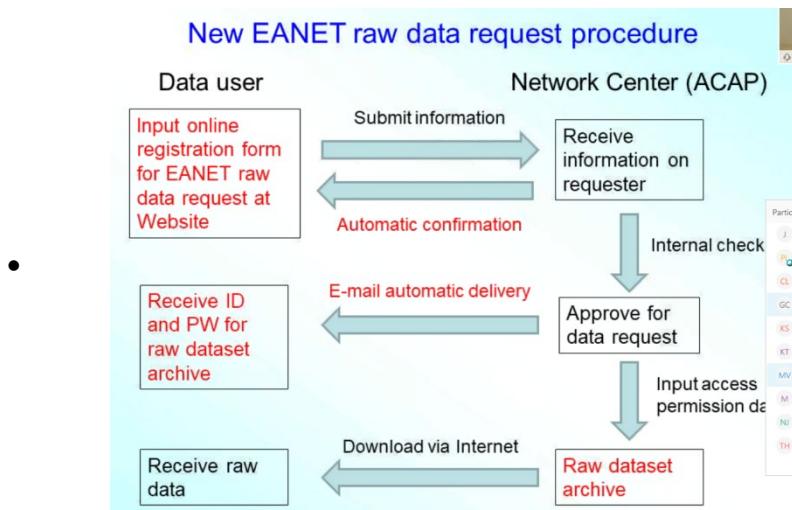
[Meta data]

Site location (Latitude, Longitude, Height), Characteristics of sites (Remote, Rural, Urban), Monitoring items, Sampling interval of each items, Monitoring duration, Monitoring Instruments.

- <https://doi.org/10.5194/acp-2018-1283> (2019)

Procedures on EANET data disclosure





- Data report and QA/QC reports are openly available w/o login
- Data requests require registration
- Investigating use of DOI, but finds it challenging for now
- Currently, about 60 requests for data since April 2019
- Information is needed on how to exchange information with GAWSIS, metadata and in terms of the characteristics and specifics of included data (concentrations, different sampling frequencies, sampling periods are used for different data, its own citation requirements for data users, DOI ..) and how to link with WDCs/WDCPC (precipitation chemistry). How could the flow be organized? Potentially use this link to inform about 10th International Conference on Acid Deposition.

Discussion

- Enrico Fucile: Requirement for DOIs not supported in WIS, but registration in WIS would be possible
- Data access still fairly restrictive
- Vocabularies inline with WMDS?
- Enrico Fucile: Is there any plan to register data in WIS? WIS decided not to use DOIs. A lot of things implemented in EANET are within WIS framework and will not be a problem to register in WIS. Need analysis on what is done, what is missing, how to be done by different DBs not only EANET.

Doc 5.6 - NDACC (presented by Gao Chen on behalf of Martine de Mazière)

- NDACC is the standard for SAGE science team for validation purposes

NDACC's operational start: 1991

2016: Twenty-five years of operations of the Network for the Detection of Atmospheric Composition Change (NDACC) (AMT/ACP/ESSD inter-journal SI), Editor(s): V.-H. Peuch, G. Brasseur, C. Zehner, N. Harris, H. Maring, W. Lahoz, and G. Stiller, https://www.atmos-chem-phys.net/special_issue400_819.html

New NDACC website : www.ndacc.org

Mauna Loa, HI, United States

Latitude: 19.54° N
Longitude: 155.58° W
Elevation: 3397 m asl

Status: Active
Website(s): [Station Page](#)
GMD Dobson
NRL Water Vapor Microwave Instrument Group

Station Representative(s): Dr Russell C. Schnell
Global Monitoring Division
NOAA Earth System Research Laboratory
Colorado, USA

NDACC Measurements at the Mauna Loa, HI, United States Station

Instrument	Period	Parameter	Cooperating Institutions	Comments	Data Link	Metadata link
Dobson (DOB)	1963 – present	Ozone	NOAA/ESRL, USA	20 retrievals per month	View	Metadata
FTIR Spectrometer (Brewer 12SH)	1995 – present	Column - multiple species; Profile - multiple species	NCAR, USA		View	Metadata
FTIR Spectrometer (Brewer DOAS)	1995 – 1995	Column - multiple species	U. Denver, USA		View	Metadata

Facts & Perspectives about NDACC Data Handling Facility (DHF):

Oldest data record in the NDACC archive: Sept, 1966: Boulder Dobson #091

Currently > 140,000 files in the NDACC data archive

Over 1 million file downloads so far in 2018

Files may be in NASA Ames or GEOMS HDF format, or both
See

Agreement with WOUDC for synchronisation of ozone data

Perspectives

DHF is moving from NOAA to Nasa Langley

Data will get a DOI (via NILU/EVDC), a data license, and data policy will be revised correspondingly
- data licenses envisaged are CCO
CC-BY-SA (4.0)
CC-BY-NC-SA

The chart shows the cumulative number of data files in the NDACC database over time, starting from approximately 10 files in 1966 and reaching over 140,000 files by 2018.

Date	Number of Files (Thousands)
1966	10
1970	20
1975	30
1980	40
1985	50
1990	60
1995	70
2000	80
2005	100
2010	120
2015	140
2018	145

[Home](#) / [Data](#) / Data Formats

Data Formats

NDACC accepts data in ASCII Ames or GEOMS compliant HDF4 formats depending on instrument type as follows:

Format Type	Relevant Instruments	Documentation
ASCII Ames	Dobson/Brewer FTIR (total column only) Lidar Microwave Ozonesonde Spectral UV UVVis (total column only)	File Reading Software Format Checking Software Gaines & Hipskind: Format Specifications NDACC Header line NDACC Data Quality Flag NDACC Filenaming NDACC Variable Recommendations Ozonesonde Guidelines
GEOMS/HDF	FTIR Lidar Microwave UVVis DOAS	Generic Earth Observation Metadata Standard (GEOMS) HDF to netCDF Conversion Tools Network of Remote Sensing (NORS) NORS Data User Guide NORS Uncertainty Budgets Additional NORS Documents

- Gao Chen (NASA Langley) taking over the data management for NDACC with a long-term perspective.

Doc 5.7 - ICOS-CP

- Dockerized
- RDF DB w/ SPARQL endpoint
- Open-source, GitHub
- Maximum granularity of data objects
- Support versioning

ICOS Carbon Portal, system elements

- - ✓ All services fully scalable and portable (**dockerized**)
 - ✓ Open software, shared through GITHUB, GPL licence
 - ✓ Data objects in **trusted long term repository** (B2SAFE, 2 replicates)
 - ✓ **Semantic web (WEB 3.0), linked open data**
 - ✓ Metadata based on ontology, all elements have (linked) URIs
 - ✓ nonSQL, RDF database
 - ✓ Open SPARQL endpoint
 - ✓ Versioned meta data store: roll-back, time dependent queries
 - ✓ **Persistent identifiers, linking to data object and metadata: DOI and/or Handle system**
 - ✓ PID based on SHA256 checksum of data object: Data Integrity control
 - ✓ Maximum granularity of Data Objects
 - ✓ Support for versioning, collections for DOI
 - ✓ Machine actionable through standard http(s) protocol, RESTful API in backend and frontend
 - ✓ NGINX proxy redirects to services (<https://service.domain.eu>), domain completely configurable and stylable
 - ✓ Can be deployed as single portal backend with multiple frontends or as set of federated portals using one or more interoperable metadata stores



4

FAIRifying, the process

FAIRness involves “everyone”: data producers, data managers and the end users of our data!

- - documenting data during collection & processing
 - organized & secure repository for data & metadata
 - persistent identifiers for data & resources
 - web portal for search, visualization & download
 - clear licensing
 - linked data approach for metadata cataloguing
 - interfaces for humans and machines
 - support for end users
 - engage with other initiatives projects to share resources
- Life-sciences most advanced in terms of FAIR



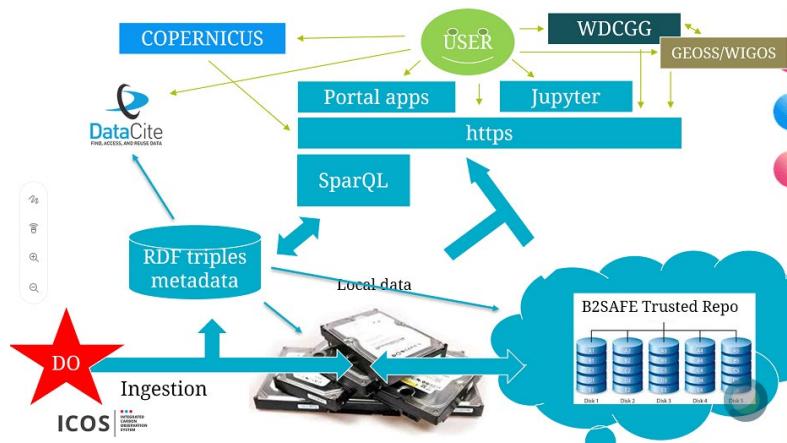
<https://www.coretrustseal.org/>

4

ICOS Carbon Portal as an illustration

- In ICOS all data objects, from raw to model analyses get a PID and/or DOI
- ICOS PID contains checksum of data: data integrity assured!
- Identifiers are essential for data citation!
- Support for collections and data versioning
- Access through RESTful interfaces through a simple URL
Standard HTTP get and put: browser or prompt-cli is enough
- No drivers or proprietary software needed
- All software is versioned and provided open source (e.g., [GitHub](#)), ICOS CP: GPL
- Interfaces build on same protocols and Linked Open Data approach
- Upload restricted to known Data Objects supported by correct metadata by specific authorized users, data validated at ingestion
- All data download open and free according to data license (ICOS: CC4BY)
- High reliability and availability: >99%, persistent data storage
- Now operational for multiple domains

4

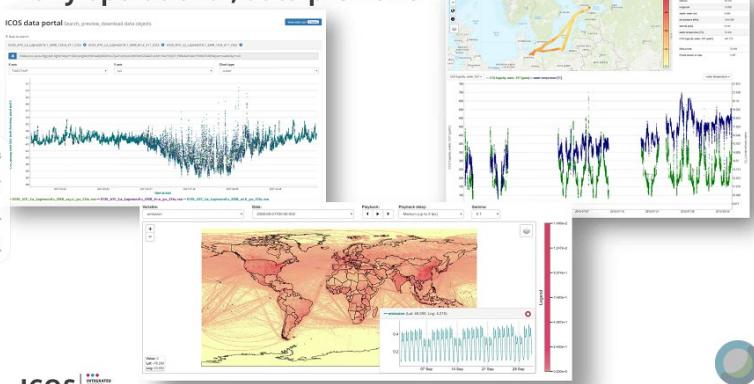


Factsheet Data Sep 2019

- 210 000 data objects
- 450 000 data downloads
- 40 000+ downloads per month
- 24 000 unique users
- 2 700 active users per month
- 294 CP user accounts (56 OrcID)
- 170 users of Nextcloud/OnlyOffice
- >99% uptime
- NRT data for Atmosphere+Ocean, soon Ecosystem
- Level 2 data for all domains
- Jupyter VREs and STILT footprint apps

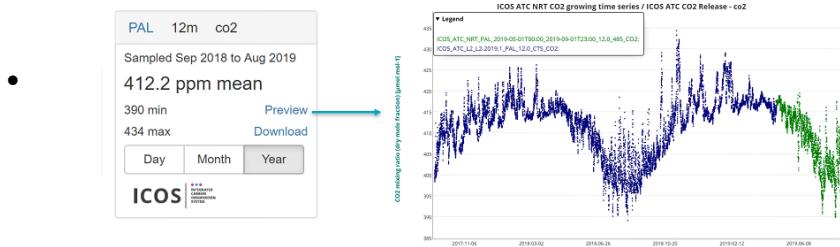


Fully operational, data previews



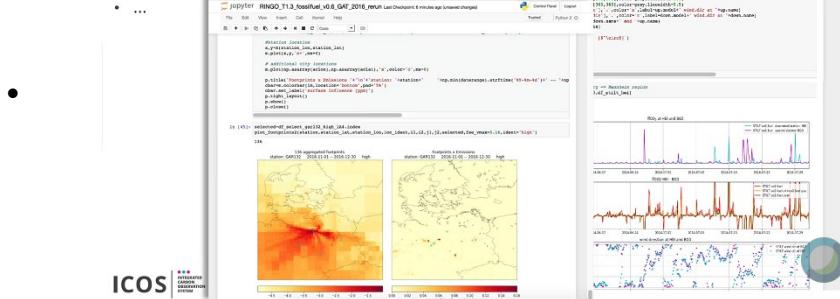
Example dashboard servlet

Station L2+NRT data average for dissemination, e.g. as servlet in news web site:
<https://data.icos-cp.eu/dashboard/?stationId=PAL&valueType=co2&height=12>



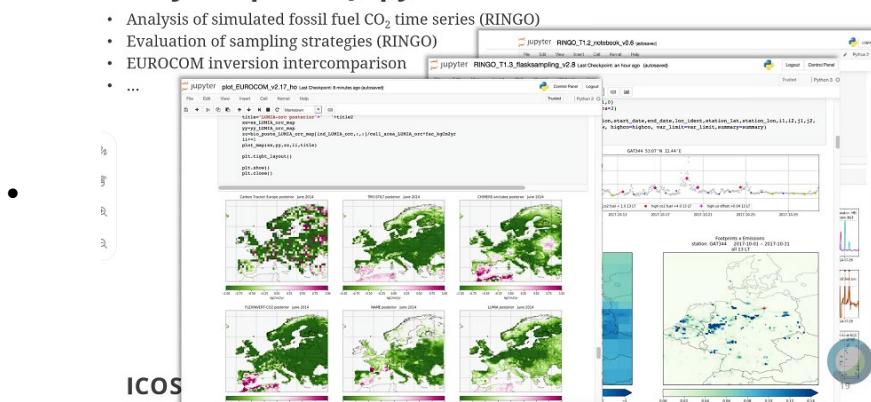
Interactive analysis tools for model results & data

- Analysis of simulated fossil fuel CO₂ time series (RINGO)
- Evaluation of sampling strategies
- EUROCOM inversion intercomparison
- ...

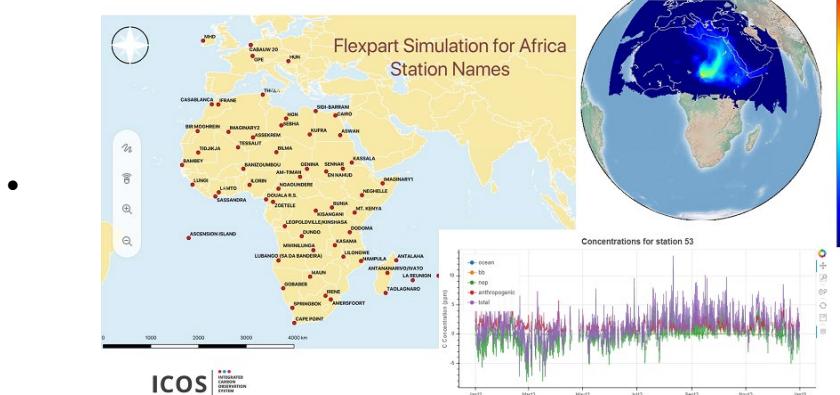


Project-specific Jupyter notebooks

- Analysis of simulated fossil fuel CO₂ time series (RINGO)
- Evaluation of sampling strategies (RINGO)
- EUROCOM inversion intercomparison
- ...



SEACRIFOG



Some selected links to the ICOS data portal	
https://data.icos-cp.eu/portal	Main search interface
https://exploredata.icos-cp.eu	Anonymous Jupyter notebooks
https://www.icos-cp.eu/data-products	Main ICOS obs. data products
https://stilt.icos-cp.eu/viewer/	View footprints and concentrations
https://stilt.icos-cp.eu/worker/	Calculate your own footprints
https://github.com/ICOS-Carbon-Portal	ICOS CP source code repo
https://data.icos-cp.eu/stats/	Download statistics
• Account required:	(any name+password=msa)
https://cpauth.icos-cp.eu/login/	Login/create account
https://jupyter2.icos-cp.eu	Jupyter service (sep. account needed)
https://meta.icos-cp.eu/uploadgui/	User friendly data upload
https://doi.icos-cp.eu/	DOI minting and metadata edit service
https://meta.icos-cp.eu/sparqlclient/	GUI for open SparQL endpoint
https://fileshare.icos-cp.eu	ICOS fileshare, online document editing

ICOS

Used identifiers, licensing, DOIs, Datacite, based on FAIR principles coretrustseal.org, including visualization, various stats, preview, download and advance data products and science applications.

Discussion

- Q: What data formats are accepted, dry mole fraction only, or also others?
- A: ICOS highly standardized
- Q: Are files transformed into a format that is more suited for visualization via web services?
- A: Internal binary format for use in data cubes, most performant; so 2 data.

6. THE BIGGER PICTURE: WMO DATA MANAGEMENT AND HOW GAW CAN/SHOULD CONTRIBUTE

Doc 6.1 - Earth System Prediction: data for services

(*Greg Carmichael, Vincent-Henri Peuch, Frank Dentener, Oksana Tarasova*)

- GAW monitoring and services (GHG bulletin, etc.), but more and more adding enhanced services through measurement-model integration.

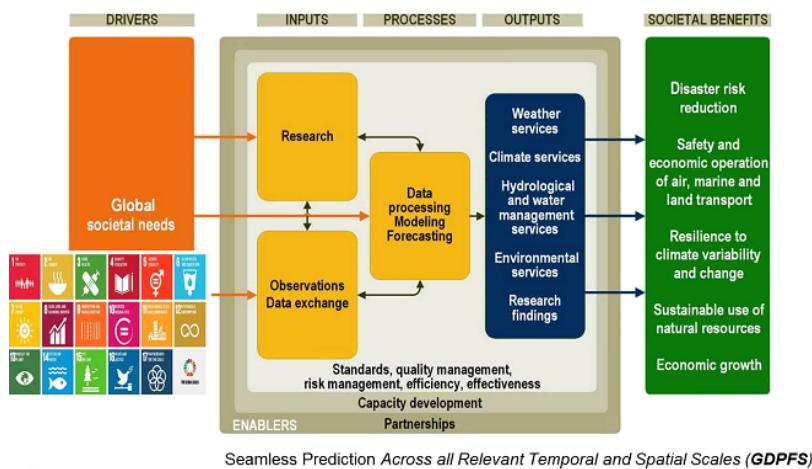
Elements integrated in GAW

- **Observations**
- **Quality assurance**
- **Data management**
- **Modeling and analysis**
- **Joint research**
- **Capacity building**
- **Outreach and communications**



Promote a “value chain” from observations to services

Overarching Objective - Improve Prediction Capabilities via Incorporating/Integrating Composition, Weather and Climate

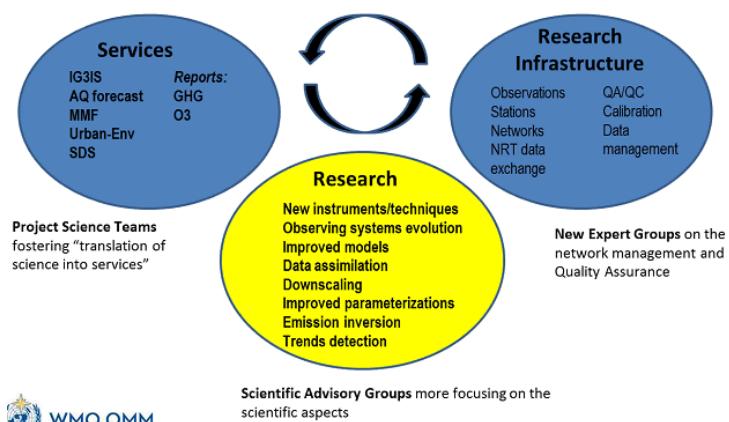


- IG₃IS, Measurement-model fusion, health, integrated urban services
- Reform of WMO asks for:
 - Better service delivery in response to societal needs
 - Enhance Earth system observation and prediction
 - Advance targeted research
 - Capacity building
 - Alignment of structure and way of working.

Structure of WMO constituent bodies

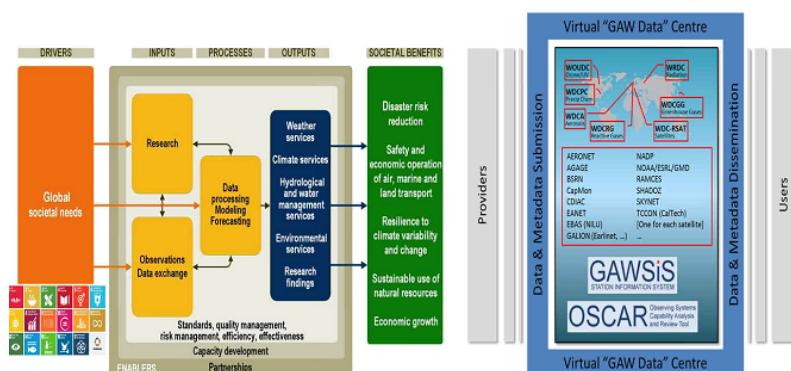


GAW Program Elements: Aligning with new WMO structure



Overarching Objective - Improve Prediction Capabilities via Incorporating/Integrating Composition, Weather and Climate

Earth Systems Modeling Approach



Seamless Prediction Across all Relevant Temporal and Spatial Scales (**GDPFS**)

Promote value chain from observation to service. Improve prediction capabilities via incorporating composition, weather and climate.

Cross-cutting thematic projects to develop new services:

Integrated Global Greenhouse Gas Information System - IG³IS (support of climate services); Measurement-model fusion for total deposition (support of the ecosystem assessment and food security); MAP-AQ (support of the health sector); Contribution to the integrated urban service.

Reform goals are better service to societal needs, enhanced Earth system observations and prediction, advance targeted research, capacity building, alignment of the structure to increase efficiency and effectiveness.

- ET-WDC meeting an important input to SSC meeting in November
- Use of data to further develop models

Discussion

- Ted Haberman: What identifiers are we going to be using to track 'objects' (data granules, stations, etc.) in this data flow?
- New data flows due to low-cost sensors.

Doc 6.2 - Introduction to WIS and WIGOS: organize data for services

- WWW = GTS + GOS + GDPFS
- Changing to WIS + WIGOS + Seamless GDPFS
- WIS moving towards WIS 2.0
- WIGOS tools
 - OSCAR, open access and controlled for changes
 - WDQMS
- WIGOS components go beyond GOS, including GAW, WHOS, GCW, GOOS, GCOS, GTS
- WIS is an operational system
- WIS 2.0 principles
 - Adopt web technologies and leverage best practices and open standards
- <https://www.ietf.org/>, W3C, OGC, ISO
 - Use URLs to identify all objects in WIS
 - Use public networks, e.g. Internet
 - Provide web services and/or API
 - NC and DCPC should provide data reduction services to make big datasets more easily accessible
 - Use open standard messaging protocols based on publish-subscribe message patterns, AMQP, MQTT
 - Real-time distribution to cache/store messages for 24-hours
 - Adopt direct data-exchange between provider (aggregator) and consumer
 - Phase out routing tables

- Catalogue should describe both data and services
- Catalogue should be searchable on public search engines.

Discussion

- Judd Welton: should not use Google to search for scientific data.
- Enrico Fucile: search takes place in the GISC portal, but the right granularity is a challenge.
- Ted Haberman: questions about Google are interesting, Google dataset search is the beginning of a more structured search, we need interoperability, understanding and trust; WIGOS standard has some points in that direction, but it is very old! We require more cutting-edge.
 - WIGOS is nice, it is built on ISO 19156 but uses 19115 MD, which allows only one name, more recent ISO standards allow more names; result quality part points to 19157 which is fairly old.
 - Science community has many requirements and capabilities to driving this forward.
- Uptake and penetration in the global community is a huge challenge, there is no silver bullet.

Doc 6.3 - Data and Metadata exchange in WMO – need for long-term archives, rapid delivery

- WMO 306
 - Vol I.1 (frozen, obsolete)
 - Vol I.2 (easy to maintain)
- BUFR, GRIB
- Table driven
 - Vol I.3 (sustainability problems)
- ML model driven, ISO, OGC
- Mainly IWXXM, difficult to maintain
- WMO CF-netCDF workshop 19-20 Sep 2019
 - Conclusion: need for an ET on CF Conventions
 - Representation from GCW, Satellite community, radar.

WMO Expert Team on CF Conventions

1. To consider specific requirements by WMO Programmes for the implementation of CF-netCDF data profiles and extensions, and evaluate the particular choice of data format in consultation with other expert teams [ET-TDCF] [ET-XML].
 2. To ensure that new proposals are harmonized with existing WMO CF data profiles and extension and coordinate with other Programmes in their further development.
 3. To collaborate with [ET-TDCF] on parallel implementation or mapping using BUFR or GRIB of the WMO CF data profile and extension developed by the team.
 - 4. To collaborate with the CF community through CF processes to participate in the enhancement of the CF conventions and enlargement of CF controlled vocabularies to meet the need of WMO Programmes and avoid nonconformance to CF conventions or CF data model, by evaluating all candidate CF extensions as possible CF enhancements before accepting them as WMO CF extensions.
 5. To avoid the need to create forks of the CF conventions by collaborating with the CF community and considering alternative options.
 6. To provide a technical reference implementation of data validation tools for profiles and extensions proposed.
- Ted Haberman: need to include the ACDD conventions

Amendment of Manuals Simple procedure (fast-track)



Case study: JCOMM

- JCOMM nominated Mr. David Berry (NOC) as coordinator to be part of the IPET-CM to
 1. Propose new BUFR element and sequences
 2. Validate and refine the proposal with the help of IPET-CM members

Discussion

- JW: Many contributors don't know what to do with this, but for GALION, trying to link in. Data format is netCDF, for metadata need some stability.
- GC: some frustration with CF because it doesn't contain much of what he needs; there is a need for a coordinating body.

Doc 6.4 - Archiving and disseminating model data and products

Vincent-Henri Peuch - AQ forecasting

- CAMS
 - Operated at ECMWF delivering a range of services from AQ to atmospheric composition
 - Prototype for where many of the continents are going
 - Relying heavily on NWP infrastructure, synergies with KNMI, MF
 - All operations are integrated in the traditional data flow of ECMWF NWP
 - Some products are disseminating some of the products through the WIS mechanism
 - New services making use of cloud computing, for example, climate data store.
- SAG-APP
 - Help operationalize data flow; what is the best mechanism for future services?
- Avoid single point of failure, coordinated de-centralized approach: methodologies provided centrally, actual data flow de-centralized and from the providers directly.

- Mentions finalizing the contract with MeteoSwiss for GAW4CAMS soon
- Global AQ forecasting, including WHO and UNEP
 - Define framework for global AQ forecasting
 - Enable operational services based on observations.

Frank Dentener – TAD

- Recognized that services are missing for deposition products
- SAG TAD currently defining the objectives for a product on TAD
- Much behind in comparison with AQ forecasting products
- Make better use of data, maps and numerical data.

7. WORKSHOP “CONNECTING THE DOTS”

- Review objectives of GAW Implementation Plan
- Identify common objectives
- Assess readiness to support operational and research needs
- Establish individual action items for 2020-2021.

The following discussion themes for the workshop were considered along with reported and expressed concerns, issued, need of guidance, direction or consensus.

Questions for discussion and brainstorming

- Impact of WMO reform on WMO perspective
- Cloud's role in service delivery
- Earth System approach
- Discoverability
- Targeted service and NRT delivery

KPI what to use

- Indicator for overall health of GAW or WDC?
- Progress to connecting with WIGOS
- Interoperability – how to evaluate progress

Who and how to set priority and what has to be done?

- Where the direction will be coming from? WMO DC tasks and directions are coming from SAGs, OPAG EPAC SSC, Technical Commission of Atmospheric Sciences (CAS) such as linking NDACC ozone data with WOUDC.

The participants agreed on the following workshop discussion topics due to commonality and the need of being addressed in order to achieve progress in priority areas.

Network integration

- How can Aeronet and GALION be somehow integrated?

- KPIs, which ones should be reported, which ones should be provided centrally from OSCAR, which ones by individual data archives?

Data interoperability

- Common data format? How to improve the notion of a 'uniform user experience'?
- SHADOZ vs WOUDC vs NDACC vs GAWSIS: metadata and data management
- Registration of data with WIS.

Metadata

- Is something missing in the WMDR? How can it be improved? Who is willing to contribute?
- WIGOS metadata exchange with GAWSIS
- UMM-C vs WMDR
- DOIs vs WIGOS Identifiers: What are the requirements? Identifiers.org

Publish-subscribe mechanisms, AMQP, MQTT

New data flows due to low-cost sensors.

Concerns raised during discussions or where clarity needed

GAW Station Information System (GAWSIS) serves as a database of the GAW stations and other stations contributing to GAW, and provides links to the data in WDC and contributing data centres. Its role is to serve data discovery and provide information on GAW stations and measurements of contributing networks. WMO Observing System Capability Analysis and Review (OSCAR) system is tool to integrate GAWSIS, WDCs, data centres of contributing networks and other data centres in WIGOS and facilitate data exchange across WMO programmes and disciplines.

WIGOS is not intended for publishing data, WIS is. - Shall a URL be included to find the data or not? GAWSIS-OSCAR/Surface implements the WMDS which supports the specification of a URL for every deployment. WIGOS has approved list of variables with definitions under review now (essential climate variables which is related to development of Climate observing System and services are a part). Other missing items could be added to this list following proper protocol. OSCAR has fixed vocabularies and the definitions are important to ensure what needed is captured under vocabularies

Discussion has already taken place in task team (TT-WMD) if licenses should be included in WIGOS.

AI2019-5: Verify existing recommendation on licenses from TT-WMD, inform ET-WDC (Jörg Klausen, Nov 2019) and suggest additional codelist entries (all WDCs, Dec 2019).

How to connect to GAWSIS, how to interconnect for different maturity networks and centres?

Work is in progress on linking data centres/contributing networks NDACC, Eubrewnet and WOUDC could use this experience and guide future/potential DCIO and basic metadata exchange, discoverability. Will help having developed architecture, framework, API.

WIS- uses URL for resources, based on open standards and public telecoms, web based with API interface, to have direct data provider-consumer exchange, no tables no bulletins, will have catalogues of metadata for data and services.

WMO Manual of codes exists and updated. Uses CF convention – netCDF. Also used by satellite community. Process in place for Amendment of Manuals. More WMO references at the end of the document.

GAW is research programme, data flow specific and large range of info. Not significant part is in NRT. Some participate, some not. Ongoing work with Technical Commission on evolution of observing systems, looking at chemical data consistency, data uncertainty.

Ongoing is the work on RRR related to atmospheric composition. Each application has different requirements making it challenging. Integration of new, more data coming from low-cost sensors and how to use it is a new challenge.

SAG App chair looks at how atmospheric composition is used for services.

Vocabularies are currently reviewed by a joint GAW/GCOS task team (lead: Richard Eckman), possible avenue is mapping vocabularies.

It is not clear who should provide guidance on vertical distribution of properties – which SAG? Aerosols, O3, RG - each in their field of expertise? Input is gathered through communities and experts and used for standardization. Sometimes input is given by invited experts but not included and might be missed. If something is missed, review and feedback process on publications and following protocols could be used in order to add pieces that have been missed (github.com/wmo-im/wmds).

WIGOS metadata standard should be used to talk to WMO and hand shake.

Important is the creation of a Framework where people can address their needs. National Focal Points exists, however, their involvement with GAW is sometimes poor.

If standard changes too much, it is not good, but we also need mechanism/flexibility, duration of standard when to change the standard and how to change in order to evolve and who will propose, make decisions.

Key for metadata is WIGOS compatibility: need to have agreement on names and metadata. A lot of contributing networks are not (yet) compliant with WMDS, how to integrate?

Mapping metadata is a huge effort depending on different users and different requirements but conversion scripts could make conversions on units.

Contributing networks are developed to serve clear user requirements from the start.

Those requirements might be different from WDC in a significant way.

Consider NASA approach - UMM extensible metadata model for mapping between CMR-supported metadata standards which are mapped centrally to UMM. Can it be used to link with GAWSIS/OSCAR and how?

How people/ centres can change and apply one agreed metadata and data format which can be processed by WDC. Add data structures for access and all can benefit from the new dataset that is in the system?

LIDAR network tried to use CF, ICAP model community does not hold for CF metadata NASA uses CF, frequent change of CF versions is a problem.

Metadata description of uncertainties need to be defined. Metadata sometimes are not part of the data or reside at different levels (RT, NRT, science). Mechanism for exchange are different for different streams, different needs. Metadata standards should not be forgotten or missed when data are exchanged.

Archiving and history

Versions of data and metadata and related documentation need to be preserved for the future. History of metadata is important and needs to be included in long-term archiving functions. OSCAR has been built on this approach – history of data and time stamp are exported to user. Specific events on site can be documented and added to the history of the station in OSCAR. Updating data requires updates in OSCAR and this is the responsibility of the data provider. Data and metadata should go together somehow but WIGOS is challenged to keep history development.

8. CONTROLLED VOCABULARIES

- *Doc 8.1 Variables according to WMDS*
- *Doc 8.2 Variables according to OSCAR/Space, Requirements*
- *Doc 8.3 Methods according to WMDS*
- *Doc 8.4 ESDS Atmospheric Composition Variable Standard Names Working Group Report*

9. WAY FORWARD IN ATMOSPHERIC CHEMICAL COMPOSITION DATA MANAGEMENT IN SUPPORT OF RESEARCH AND SERVICES

Doc 9.1 Draft based on

- o NRT document
- o GAW reports on data management (e.g. Summary of Kloten meeting, 2015),
- o Big data essay (Hov et al., 2016; submitted to Executive Council - Sixty-Eighth Session (EC-68))
- o GAW Implementation Plan itself

DCIO/GEOMS (20') – (*Kjetil Torseth, Tom Kralidis*)

EVDC a contract with ESA, operated at NILU

Not an open data archive

Data stored according to GEOMS metadata

[EVDC – ESA Atmospheric Validation Data Centre http://www.esa.int](http://www.esa.int)

metadata harvesting and display of information:

Already implemented:

- EARLINET – harvest and display of metadata, non-GEOMS
- CloudNet – harvest and display of metadata, non-GEOMS

In progress:

- EUMETNET – harvest of metadata, non-GEOMS
- WOUDC – harvest and display of data, non-GEOMS

Currently direct mirror of data:

AVDC (hereunder SHADOZ, WOUDC) NDACC – harvest and display of data, GEOMS

Campaign data from e.g. Sentinel-5P, GEOMS

More information at <https://evdc.esa.int/documentation/oai-pmh/>

EVDC – ESA Atmospheric Validation Data Centre

Harvesting through API:

<https://dcio-ng.evdc.nilu.no/oaicat/> (non-GEOMS)

<https://dcio.evdc.nilu.no/oaicat/> (GEOMS)

Cal/Val search on web:

merged system for GEOMS and GEOMS data in preparation

Similar metadata portal as ACTRIS

EVDC – ESA Atmospheric Validation Data Centre <http://www.esa.int>

Digital Object Identifier – DOI

Updated information on page <http://evdc.esa.int/documentation/doi-docs/>

NILU, on behalf of EVDC, may issue a DOI on datasets or other data products related to ESA Cal/Val. Issuing of the DOI is done through the DataCite metadata service.

When a DOI is issued, there are two things to consider:

- metadata following the XML format
- landing page for the DOI

Documented procedures and guidelines for what defines a DOI

Files in EVDC may contain DOIs issued by others, or DOIs issued by NILU.

The data resource will be available through the presentation page on a EVDC server.

NDACC has asked for support, NDACC example file based on the web example, still a few open issues.

Discussion

- SAG O₃ had asked WOUDC to inject NDACC, but Tom Kralidis was not in favour of creating duplicate datasets
- WOUDC looking into using OAI for exchange
- GEOMS is being used, e.g. by TOLNet
- **AI2019-6:** Gao Chen and Tom Kralidis will follow-up on DCIO/GEOMS exchange mechanisms and inform the next ET-WDC telco
- Input from Tom Kralidis (via E-Mail)

<https://evdc.esa.int/documentation/oai-pmh/>

<https://evdc.esa.int/documentation/geoms/>

DOI (30')

Data providers are not in agreement at what granularity DOI's should be minted.

Minting a DOI requires being able to produce the data

<https://blog.datacite.org/tracking-the-growth-of-the-pid-graph/>

Alex Vermeulen: DOI is a specific use-case for handles

Who makes the decisions on the open questions regarding DOIs?

Alex designated and accepted to inform and involve ET-WDC in work of ENVRI-Fair

<https://www.rd-alliance.org/groups/persistent-identification-instruments-wg>

Input from Martin Schultz (via e-mail)

How about using handle.net PIDs instead of DOI's for this purpose?

See <http://www.handle.net/> and <https://eudat.eu/services/userdoc/pids-in-eudat>.

Is there consensus yet on how detailed the community list should be? I am a bit worried that the effort may lead to a registry which is either too broad to be useful in measurement-centric applications, where detail matters, or too

specific in more general applications, where it is more important to capture the type of an instrument, and perhaps the manufacturer, but not all details.

Is the group aware of the US EPA collections of "allowed" instruments? See <https://www.epa.gov/measurements-modeling/collection-methods>, and as one example (criteria air pollutants) https://www.epa.gov/sites/production/files/2019-08/documents/designated_reference_and-equivalent_methods.pdf

Input from Ted Habermann (via E-Mail)

NRT

WDCGG

- No NRT capabilities

WOUDC

- O₃ sondes from Canadian stations, CREX, send to GTS
- Level 0 (raw data), password protected
- UV made available
- Limited to MSC
- No requirements articulated by SAG
- Discussion:
 - CREX format not recommended and not supported by any of the NWPs.

WDCA, WDCRG

- Fully developed system for WDCA,
- EBAS - GTS connection in place (but not operationalized)
- O₃ sonde service for ECMWF.

MPLNet

- In the past, NRT delivery all test cases, PBL height, aerosol profile information for ECMWF
- South Pole uses lidar as a ceilometer for in and out flights
- EPA Taiwan accesses data in NRT, use unclear
- Version 3
 - delivers within 1 hour, through https, open, unrestricted
 - Quality-screened within 1 day for the public, limit is the assimilated meteorology
 - Custom packaging on a password protected access portal for forecast centers
- ICAP a primary user.

NDACC has some NRT capability under CAMS contract.

Discussion on 'NRT document'

- Document approved by SSC OPAG EPAC based on recommendation by SAG APP. The basic approach of enabling stations to deliver NRT data directly to the GTS is non-negotiable.
- Kjetil Torseth still in total opposition to CAMS giving a contract to MeteoSwiss!
- Currently, there is no contract, and given the delays in the past, it is completely uncertain if/when a contract will be agreed on time to be able to develop and implement something useful.

Time allocated for the workshop and document draft was used to further discussions on agreed topics which were found important to advance understanding of the current stage, capabilities, possible avenues and consensus on the path forward for WMO data management related to atmospheric composition to support research and services. Participants agreed to continue their research, comment and make recommendations on those topics, report on progress made under the GAW Implementation Plan and assist in drafting the document as intended for the last day of the meeting.

Can GALION be discoverable through web entrance from the GAW website, with its two geographically specialized primary nodes of identical metadata and discovery information including a common site database. This site database will be used to provide routine updates to GAWSIS working and learning from experience of other NASA projects and centers. Need to find what is missing, what is needed and to be added in metadata by looking for example at the project of linking NDACC and WOUDC. What files formats are/can be supported and how to improve discoverability. Need to have WIGOS as unifier and simplifier for user service and delivery. Connection to OSCAR is not a problem and MeteoSwiss provides assistance and guidance (cf. **AI2019-4**).

Linking data center, networks and WIGOS:

AI2019-7: Review of project/programme level of variables' names consistency (lead?, deadline?)

WMDR XML Schema for aircraft data looks good and needs to find where there is a need for a change and what. Continue work on this platform will increase the presentation of poorly represented aircraft data in GAWSIS, WIGOS. Need to move closer to mapping with WIGOS.

AI2019-8: How to present metadata/ changing latitude, longitude, altitude for non-stationary platform for GCOS, WIGOS. NCAR experience to be looked at? (Gao Chen, Enrico Fucile?, deadline?)

How to represent uncertainties – clear guideline needed: absolute, %, formula, value, what to use for a day? Can a citation from a publication on the topic in metadata be

used? Requirements are not clear. Metadata description of uncertainties need to be defined. (TT-WMD, 2020)

AI2019-9: TT-WMD and TT-OD, together with OSCAR/Surface team at MeteoSwiss/WMO to draft a document on representation of uncertainties in WIGOS metadata (TT-WMD, 2020).

DOIs should they be site/station specific, instrument specific, campaign/data collection specific, dataset specific, only for finalized data or growing collections. Data providers are not under the same understanding on when, where and how DOI is to be assigned. DOIs provide information on value, reference and use of data for different projects and applications but there is also sensitivity for highly needed data for narrow limited need and funding those. NDACC receives DOIs for data through NILU, WDCGG assigns DOI to each observation data. Granularity is not clear from provider nor from the user perspective. Request from O₃ UV SAG is for station DOIs. DOIs supports different versions. Another aspect comes from archiving functions and preserving all information. DOIs for final data products is also used/considered. Collected information and requirements from providers and users (not only limited to science use, regional, global ...) can be provided on WIS DOI working group as input and considered as part of WIS evolution.

AI2019-10: Alex Vermeulen to inform ET on what has been considered and how with respect to DOIs (Alex Vermeulen, next telco of ET-WDC). Feed into WIS DOI WG (Enrico Fucile, 2020).

WIGOS ID system is doing exactly the same thing as DOI and has room for adding instrument information. One way to go could be: we know and use a unified structure which includes versions and develop handlers to link WIGOS ID with DOIs for data.

Measurements/instruments intercomparability is another issue. How to do those for different types of instrumentation, methods, etc. (depends on WMO Reform and future QC/QA SAG).

NRT no capability in WDCGG. GALION had NRT data processing and submission for forecasting different levels at different timescales from 1.5 hours for level 1.5 and longer. Auxillary data are used to finalize the data for LIDARs. NDACC has a contract for NRT data. O₃ sondes of SHADOZ: NRT not possible due to the nature of data collection - research data archive, not an operational character. WOUDC: Some O₃ sondes level 0 had been paired with GTS data submissions for Total Ozone and UV forecasting. UV is NRT. NILU: some opportunities exists and delivers to ECMWF. There is no global NRT TOC streamlined contribution. Those are preliminary data based on NRT character and need for service. Need clear understanding of what is needed.

AI2019-11: Enrico Fucile to connect Tom Kralidis with people for NRT (Enrico Fucile, Nov 2019).

MPLNet/GALION to produce a few examples for WMD records for Lidar (Judd Welton, timeline to be announced; cf. **AI2019-4**).

AI2019-12: Collaborate with Gao Chen (Tallnet) to produce WMDR records for these networks for the GALION landing page and for GAWSIS/OSCAR (Judd Weldon, Gao Chen).

AI2019-13: Translate metadata formats, MetaDAL project, look into UMM-C model (Makhan Virdi, Tom Kralidis).

AI2019-14: Review WMD code tables (SHADOZ), deliver data to WOUDC, WOUDC to generate the WMDR records to reflect links to WOUDC as well as SHADOZ; same is true for NDACC (Debra Kollonige/Ryan Stauffer, Tom Kralidis, 2020).

AI2019-15: Find consensus on variable names, on the programme level, work with Makhan Virdi for representation of aircraft observations in WMDR (Judd Weldon, Marham Virdi)

Representation of uncertainty, particularly for aircraft data (ICARTT allows 1-2 lines to document this).

Enrico Fucile: Some duplication of efforts perceived; landscape is very fragmented; WIS and WIGOS overlap, which may or may not be useful. Metadata change with time, and that needs to be reflected.

Vocabularies

- Aerosol variables in GCOS/GAW
- Code list 7-06 on data levels (refer to EBAS, NASA)

AI2019-16 (all, November 19): Report progress on GAW Implementation Plan items (10 November) [mostly completed]

<i>Actions in the GAW Implementation Plan</i>	<i>Specific activities, contributors, timelines?</i>
A-DM-1. Establish and implement a federated data management infrastructure including GAW Data Centres, data centres of contributing networks, and GAWSIS that enables interoperable data discovery and access mechanisms.	Next ET-WDC physical meeting to derive work plan (late summer mtg., Q1/2018).
• A-DM-2. Improve open access to data and comprehensive metadata including calibration histories of ground-based, aircraft and satellite observations for the primary GAW variables.	Review/confirm data policy. Private sector requirements may be at variance with fair-use policy. Calibration history is embedded in WIGOS metadata standard. Document calibrations (data providers, TT-WMD)
A-DM-3. Harmonize GAW data management activities with the WIGOS framework, in particular with regards to metadata documentation.	WIGOS provide framework is implemented in GAWSIS. Interaction between data providers and archives needed (see also A-DM-1 activities).
A-DM-4. Develop and promote support of data archiving and analysis centres that address the needs of applications and service delivery.	Strengthen and expand capacity of existing infrastructures to address these needs. Users and archives need to interact to formulate requirements and specifications. Facilitate remote sessions annually between data archives and user communities (stakeholders) for improved interaction.
<i>Actions in the GAW Implementation Plan</i>	<i>Specific activities, contributors, timelines?</i>
A-DM-5. Ensure that data collected and archived by WMO/GAW WDCs and archives of contributing networks are of known quality, adequate for their intended use and documented comprehensively.	Work with WIGOS metadata standard documentation. Establish interoperability checks at data centres. Services like CAMS should feed back to the observation providers. Establish methodology for users to feedback to providers on quality issues. Archives make provision to accept quality flags.
• A-DM-6. Promote delivery of those variables pertinent to air quality and forecasting in NRT, using WMO GTS/WIS as it evolves into an open, decentralized and node-oriented structure. Continue to seize opportunities to expand the NRT delivery services for GAW variables.	In Europe, CAMS is supporting and promoting NRTservices. CAMS is engaging in contracts with ICOS, ACTRIS, GAW, and EMEP. Satellite NRT delivery via direct broadcast could be expanded.
A-DM-7. Develop data submission and data use procedures with the inclusion of uncertainties with the GAW data products, making it possible to select and use data in accordance to the criteria set out by the RRR process.	Implement at GAW data centres where not yet employed. The WIGOS metadata standard supports this activity (as soon as possible)
A-DM-8. Continue to make best efforts towards program-wide adoption of digital object identifiers (doi) for GAW datasets to facilitate proper recognition of the data contributors in scientific analyses and reports and it will also allow for better monitoring of the actual data use.	doi are finding acceptance in the community.

10. SUMMARY OF ACTION ITEMS

AI2019-1: Bring ancillary variable PBL height (and related variables) to the attention of SSC and discuss how they could fit into the GAW data management (Chair, November 2019).

AI2019-2: Consider WMDS codetable 7-06 (Level of data), cf. https://github.com/wmo-im/wmds/blob/master/tables_en/7-06.csv and create issues if necessary. (all, Dec 2019).

AI2019-3: All WDCs to (re-)establish/confirm metadata exchange with GAWSIS-OSCAR/Surface. Consult with MeteoSwiss and https://library.wmo.int/doc_num.php?explnum_id=5844 (Section 3.12) for guidance and present timeline. (all WDCs, 10 Nov 2019).

AI2019-4: Send example of metadata to be encoded in WMDR XML to MeteoSwiss. (Judd Welton, asap). Judd Welton will review information on WIGOS metadata and elements- variables, prepare BUFR metadata transfer to be available with data.

AI2019-5: Verify existing recommendation on licenses from TT-WMD, inform ET-WDC (Jörg Klausen, Nov 2019) and suggest additional codelist entries (all WDCs, Dec 2019).

AI2019-6: Gao Chen and Tom Kralidis will follow-up on DCIO/GEOMS exchange mechanisms and inform the next ET-WDC telco.

AI2019-7: Review of project/programme level of variables' names consistency. (Gao Chen and Tom Kralidis, deadline?)

AI2019-8: How to present metadata/ changing latitude, longitude, altitude for non-stationary platform for GCOS, WIGOS. NCAR experience to be looked at? (Gao Chen, Enrico Fucile?, deadline?)

AI2019-9: TT-WMD and TT-OD, together with OSCAR/Surface team at MeteoSwiss/WMO to draft a document on representation of uncertainties in WIGOS metadata. (TT-WMD, 2020).

AI2019-10: Alex Vermeulen to inform ET on what has been considered and how with respect to DOIs (Alex Vermeulen, next telco of ET-WDC). Feed into WIS DOI WG (Enrico Fucile, 2020).

AI2019-11: Enrico Fucile to connect Tom Kralidis with people for NRT (Enrico Fucile, Nov 2019).

AI2019-12: Collaborate with Gao Chen (Tallnet) to produce WMDR records for these networks for the GALION landing page and for GAWSIS/OSCAR (Judd Weldon, Gao Chen).

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AI2019-15: Find consensus on variable names, on the programme level, work with Makhan Virdi for representation of aircraft observations in WMDR (Judd Weldon, Marham Virdi).

AI2019-16 (all, November 19): Report progress on GAW Implementation Plan items by (10 November) [set up Google Docs].

11. INFORMATION AND RESOURCES

Role of identifiers and what to use for discoverability of data, FAIRfying, from discoverability to share, use, service

<https://evdc.esa.int/documentation/oai-pmh>

FAIR principle coretrustseal.org

Identifiers.org –Catalogue of Identifiers.

WMO new website:

<https://community.wmo.int/activity-areas>

<https://community.wmo.int/activity-areas/wigos>

<https://community.wmo.int/activity-areas/wmo-information-system-wis>

WIGOS Metadata Standard (WMO-No. 1192).

https://library.wmo.int/doc_num.php?explnum_id=3653

http://www.wmo.int/schemas/wmdr/1.0RC6/documentation/WMDR_ModelAndSchemaGuide.pdf

[Manual on Codes \(WMO-No. 306\), Volume I.3 - WMO Library](#)

<https://etrp.wmo.int/course/view.php?id=146>

<https://codes.wmo.int/wmdr>

WMO Technical Regulations; WMO-No. 49, Volume I, Part I – WIGOS and the Manual on WIGOS

Link to GAWSIS and requirements

<https://gawsis.meteoswiss.ch/GAWSIS/#/>

Persistent identifiers for instruments

Home page of the RDA group working on instrument identifiers.

<https://www.rd-alliance.org/groups/persistent-identification-instruments-wg>

<http://identifiers.org/>

http://wiki.esipfed.org/index.php/Attribute_Convention_for_Data_Discovery_1-3

<http://www.geoscienceontology.org/>

Using handle.net PIDs instead of DOI's? See <http://www.handle.net/> and

<https://eudat.eu/services/userdoc/pids-in-eudat>

UMM

<https://earthdata.nasa.gov/eosdis/science-system-description/eosdis-components/cmr/umm>

US EPA collections of “allowed” instruments: <https://www.epa.gov/measurements-modeling/collection-methods>,

one example (criteria air pollutants) https://www.epa.gov/sites/production/files/2019-08/documents/designated_reference_and-equivalent_methods.pdf

<https://www-air.larc.nasa.gov/missions/TOLNet/>

<https://www.ietf.org/>

<https://github.com/wmo-im/wmds>

Ted Habermann on FAIR metadata on the DataCite blog

<https://blog.datacite.org/metadig-recommendations-for-fair-datacite-metadata/>

DCIO and GEOMS

<https://evdc.esa.int/documentation/oai-pmh/>

<https://evdc.esa.int/documentation/geoms/>

GLOSSARY OF ACRONYMS

BUFR	Binary Universal Form for the Representation of meteorological data,	20
CMR	Common Metadata Repository - https://earthdata.nasa.gov/eosdis/science-system-description/eosdis-components/cmr ,	44
DC	Data Center,	3
DCIO	Data Center Interoperability - https://evdc.esa.int/documentation/oai-pmh/ ,	42
DOI	Digital Object Identifier,	30
ICAP	International Cooperative for Aerosol Prediction - http://icap.atmos.und.edu/ ,	44
netCDF	Network Common Data Form - https://en.wikipedia.org/wiki/NetCDF ,	43
OPAG EPAC	Open Programme Area Group on Environmental Pollution and Atmospheric Chemistry,	3
UMM	Unified Metadata Model - https://earthdata.nasa.gov/eosdis/science-system-description/eosdis-components/cmr/umm ,	44

PROVISIONAL AGENDA

Tuesday (09:00 – 17:00)

Welcome by the Deputy Director for Research and Mission Science in NASA Langley Research Center (15') practical arrangements (10')

Baize
Chen
Netcheva

1. Introduction of participants (30')
 - *Doc 1.1 – List of participants (to be completed during meeting)*

2. Report by chair ET-WDC, objectives of meeting, approval of agenda (15')
 - *Doc 2.1 – Report by chair*
 - *Doc 2.2 – Provisional agenda (this document)*

3. Relevant outcomes of WMO Cg-18 and EC-70 (20')
 - *Doc 3.1 – Outcomes Cg-18 and EC*

Coffee break (10:30-11:00)

4. Reports by GAW WDCs: Achievements, status and plans (20' each)
 - *Doc 4.1 WDCA* Tørseth
 - *Doc 4.2 WDCRG* Tørseth
 - *Doc 4.3 WDCGG* Kinoshita

Lunch break (12:30-14:00)

- . Reports by WDCs (20' each)
 - *Doc 4.4 WOUDC* Kralidis
 - *Doc 4.5 WRDC* Tsvetkov
 - *Doc 4.6 WDCPC* Lehmann
 - *Doc 4.7 WDC-RSAT* Meyer-Arnек

Coffee break (15:30-16:00)

5. Contributing programmes, other data archives (120')

- *Doc 5.1 MPLNet* Welton
- *Doc 5.2 SHADOZ* Kollonige
- *Doc 5.3 GCW* Godoy
- *Doc 5.4 (Other) Nasa data centres* Virdi
- *Doc 5.5 EANET* Sato
- *Doc 5.6 NDACC* Chen for De Mazière

Wednesday (09:00 – 18:00)

5. Contributing programmes, other data archives

- *Doc 5.7 ICOS*

6. The bigger picture: WMO data management and how GAW can/should contribute

- *Doc 6.1 Earth System Prediction: data for services* Hov/Carmichael (remote)
- *Doc 6.2 Introduction to WIS and WIGOS: organize data for services* Fucile
- *Doc 6.3 Data and Metadata exchange in WMO – need for long-term archives, rapid delivery* Fucile
- *Doc 6.4 Archiving and disseminating model data and products* (?CAMS, DLR, Vermeulen, GDPFS, FutureEarth?)

Coffee break (10:30-11:00)

7. Workshop “Connecting the dots” All

- *Review objectives of GAW Implementation Plan*
- *Identify common objectives*
- *Assess readiness to support operational and research needs*
- *Establish individual action items for 2020-2021*

Lunch break (12:30-14:00)

Workshop wrap-up

- *Present individual action items*

All

Coffee break (15:00-15:30)

8. Controlled vocabularies

- *Doc 8.1 Variables according to WMDS* Klausen
- *Doc 8.2 Variables according to OSCAR/Space, Requirements* Klausen
- *Doc 8.3 Methods according to WMDS* Klausen
- *Doc 8.4 ESDS Atmospheric Composition Variable Standard Names Working Group Report* Chen

9. Way forward in Atmospheric Chemical Composition Data Management in support of research and services

- *Doc 9.1 Draft based on*
 - o NRT document
 - o GAW reports on data management (e.g. Summary of Kloten meeting, 2015)
 - o Big data essay (Hov et al., 2016; submitted to Executive Council - Sixty-Eighth Session (EC-68))
 - o GAW Implementation Plan itself
-