Global Atmosphere Watch (GAW) Applications for VA

Matthew Hort (UK MetOffice), Alexander Baklanov (WMO)

and GAW Aerosol and Application SAGs (see on slides),

Atmospheric Research & Environment (ARE) Branch

Research Department (RES), WMO, Geneva

7th VASAG Meeting 2017

Vancouver, WA, USA

21-23 August 2017

WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

WMO OMM

World Meteorological Organization
Organisation météorologique mondiale

GAW

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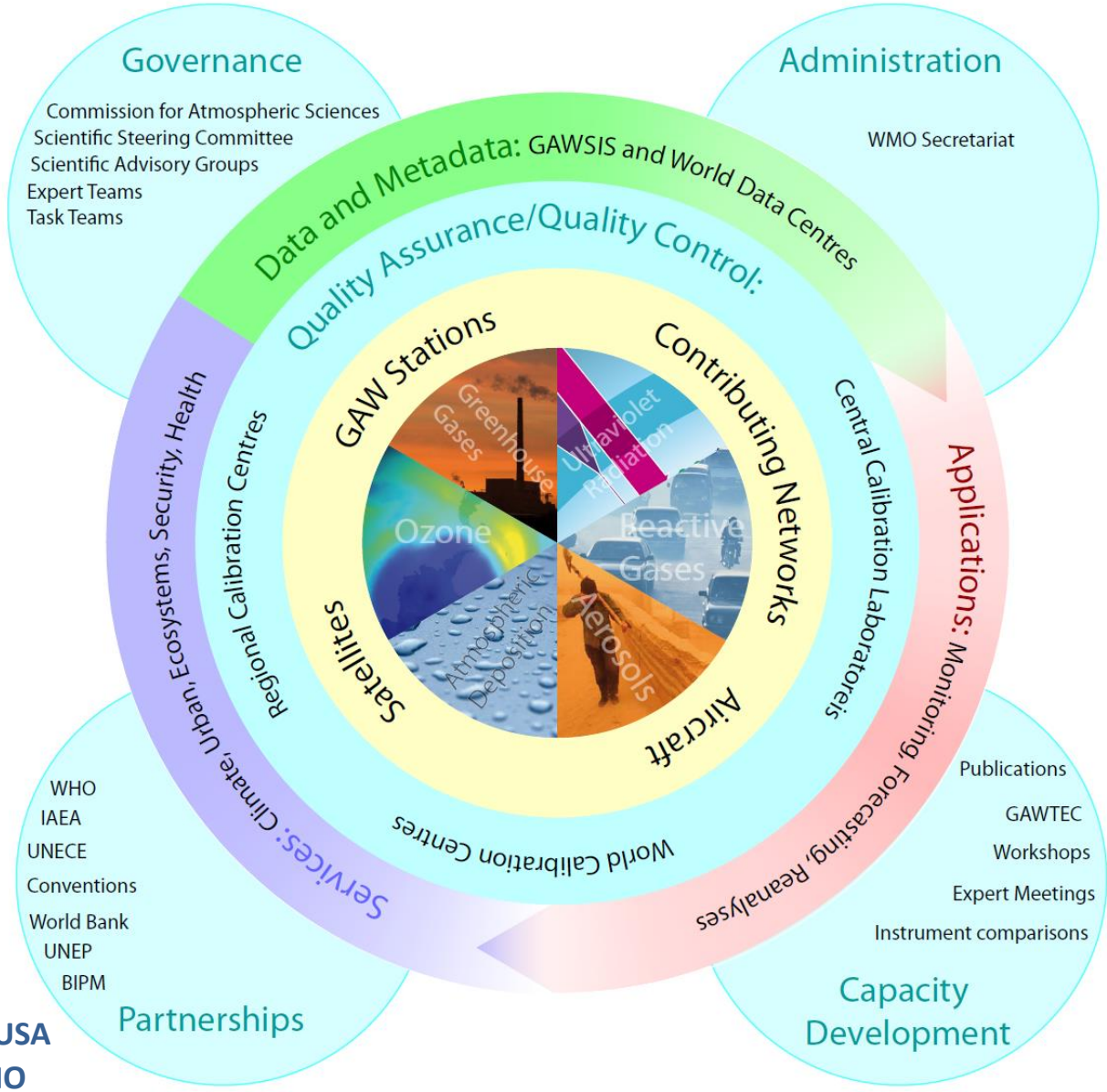
THE GAW MISSION

- Systematic long-term monitoring of atmospheric chemical and physical parameters globally
- Analysis and assessment
- **Development of predictive capability**

  (GURME and Sand and Dust Storm Warning System)

  and now for chemical weather (e.g. incl. **volcanic ash**)



Greg Carmichael, Chair GAW SSC, USA
Oksana Tarasova, Chief AERD, WMO

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Overview of the Structure of GAW

•More than 100 countries have registered **more than 800 stations** with the GAW Station Information System (**GAWSIS**). Established 27 years ago.

•Various **GAW expert groups and central facilities** exist under the oversight of the WMO Commission for Atmospheric Sciences (CAS) and its Environmental Pollution and Atmospheric Chemistry Scientific Steering Committee (EPAC SSC)

•**8 Scientific Advisory Groups** (SAGs) to organise and co-ordinate GAW activities by parameter and application, and the Expert Team on World Data Centres (ET-WDC).

•4 Quality Assurance/Science Activity Centres (QA/SACs) perform network-wide **data quality and science-related functions**.

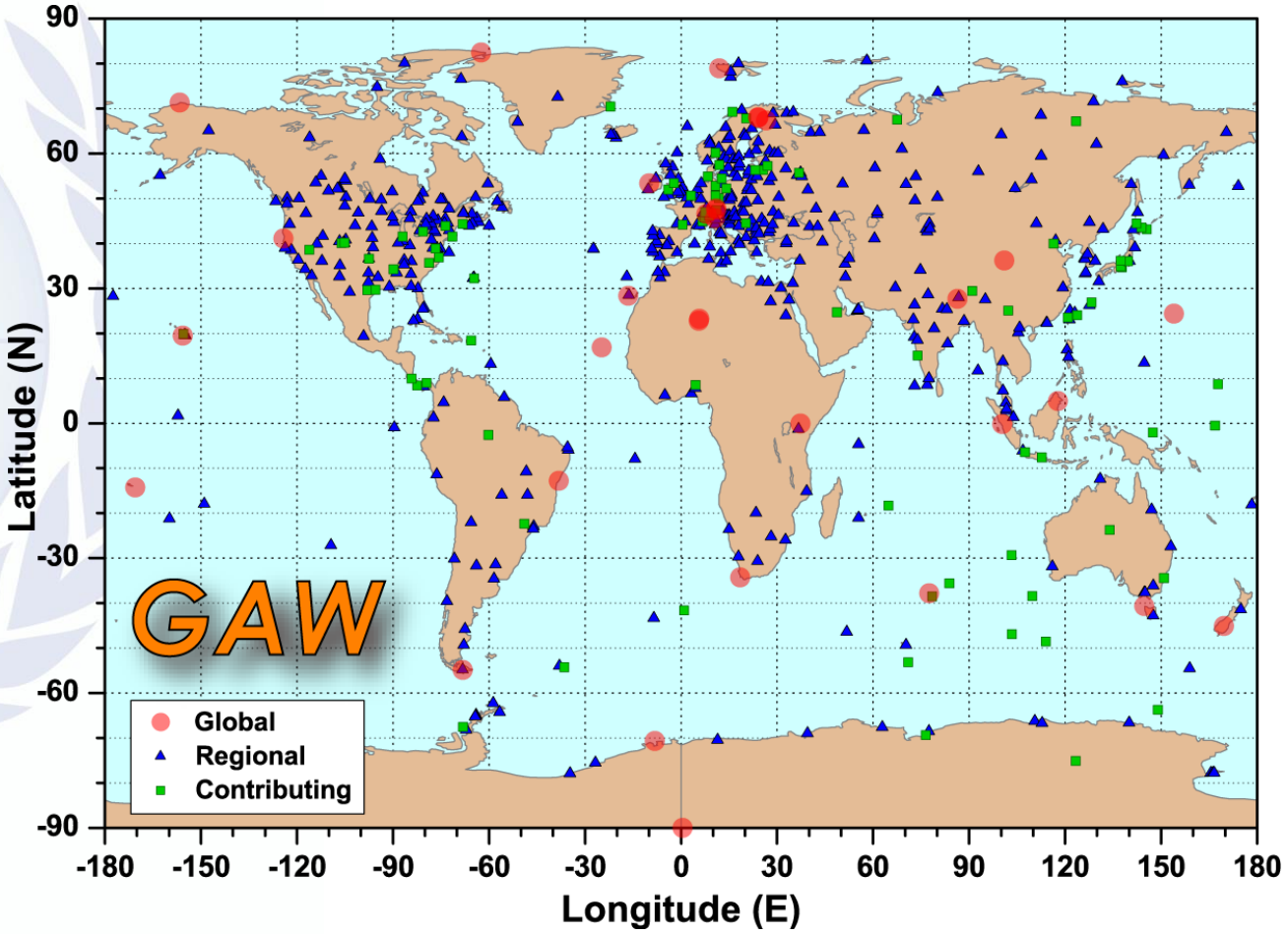
•35 Central Calibration Laboratories (CCLs) and World and Regional **Calibration Centres** (WCCs, RCCs) maintain calibration standards and provide instrument calibrations and **training** to the stations.

•**6 World Data Centres** archive the observational data and metadata, which are integrated by the GAW Station Information System (GAWSIS).

•**GAW Training** (GAWTEC): More than 270 persons trained from 58 countries

GAW stations network

Versatile station information is available through the GAW Station Information System GAWSIS (http://gaw.empa.ch/gawsis/).



Aircraft and satellite measurements also contribute to the observations

GAW Aerosol Variables

- Column and profile
  - Multi-wavelength aerosol optical depth (AOD)
  - Vertical distribution of aerosol backscattering and extinction
- Chemical (in two size fractions)
  - Mass and major chemical components
- Optical coefficients at various wavelengths
  - Light scattering and hemispheric backscattering
  - Light absorption
- Physical
  - Number size distribution and total concentration
  - Cloud condensation nuclei number concentration at various super-saturations
- **GALION:** GAW Aerosol Lidar Observation Network (Lidars and Ceilometers)

Aerosol SAG Chair: Paolo Laj, CNRS, France

Ceilometer network – www.dwd.de/ceilomap

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

About 2180 Lidars und ceilometers globally (April 2016): 2016 ceilometers and 160 Lidars

Courtesy of Werner Thomas, DWD

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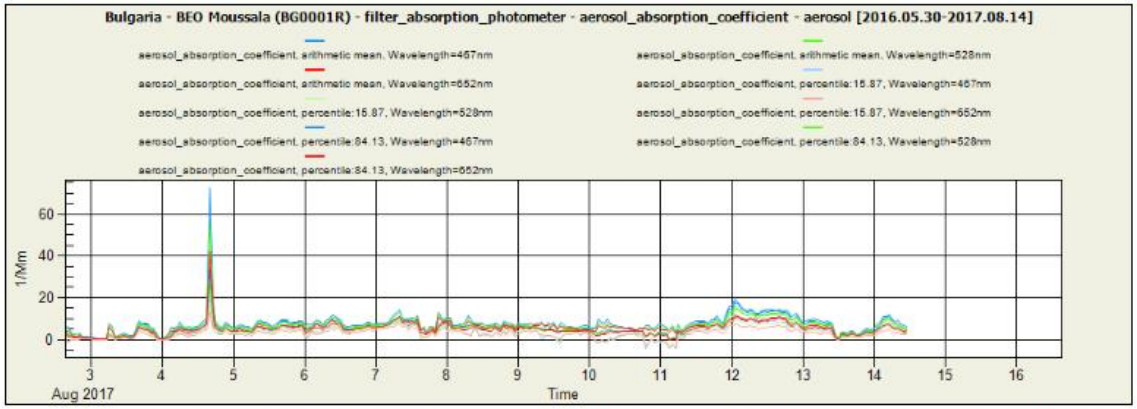
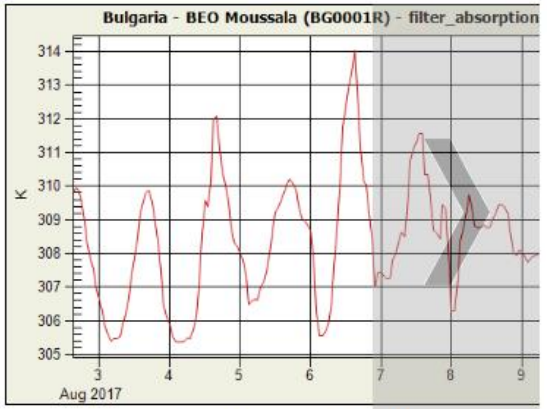
GAW Near Real Time Data Access

Latest Near-Real-Time Data

http://ebas-nrt-showcase.nilu.no/





This service has been funded or supported by the Norwegian Institute for Air Research (NILU), the EU research infrastructure ACTRIS (Aerosols, Clouds, and Trace gases Research InfraStructure), the European Monitoring and Evaluation Programme (EMEP), and the WMO Global Atmosphere Watch (GAW) programme.

GLOBAL ATMOSPHERE WATCH

NILU Norsk institutt for luftforskning Norwegian Institute for Air Research

ACTRiS

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WMO feasibility study toward a WMO intercomparison of volcanic ash observation tools

- In December 2014, the 13th meeting of the WMO-CIMO management group has nominated Météo-France in conducting a feasibility study about an inter-comparison of instruments for the detection of aerosols and volcanic ash.
- The management group and task team are established.
- This was initially focused on lidars and ceilometers. Since WMO-CIMO requested a widening of the scope: Space-based systems and in-situ measurements
- May 2016, WMO, Geneva: A meeting is arranged as a face-to-face and supplemented by webconf
- The goals will be to discuss about progress, difficulties and specific issues and to discuss further the issues
- The deliverable of the Task Team is the feasibility study requested by WMO-CIMO based on the LET report and on other documents (and) covering the perimeter required.

Courtesy of Florence Besson and Pablo Ristori

METEO FRANCE

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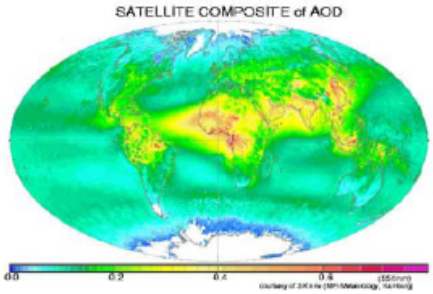
Integrated Global Aerosol Observing System

Global Products

RI for Calibration & Quality Assurance

Data Archival and/or Access Facilities (e.g. WDCA; WDC-RSAT)



Real-Time Data Delivery

Reanalysis

Satellites:
MODIS, CALIPSO, MISRMSG

Aircraft: IAGOS

Surface-based :
Remote sensing: AOD
Remote Sensing: GALION
In situ: PM, optical, etc
In situ: chemistry

Data Assimilation By Forecast Models (e.g. MACC; SDS-WAS etc.)

1. Data Uses/Applications
2. Air Quality Warnings
3. WMO SDS-WAS Assessments
4. WMO SDS-WAS Warnings
5. Aerosol Bulletins
6. Surface and air transport
7. Improved Weather Forecasts
8. Improved Climate Prediction

Observation Optimization

Air/Surface Exchange & Emissions

GAW Report No. 207

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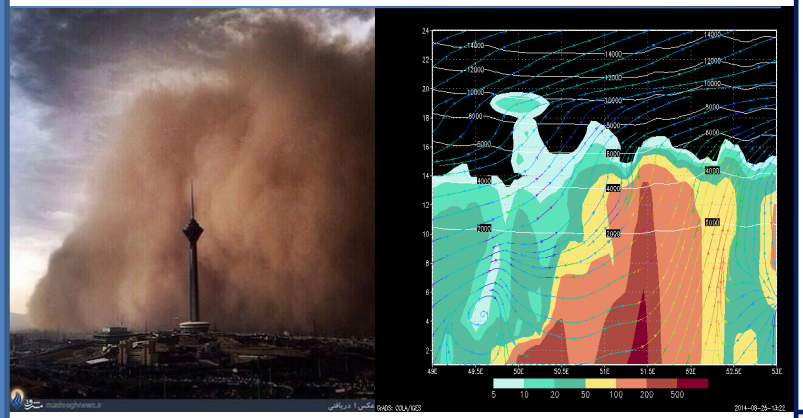
WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS)

WWRP 2015 - 5

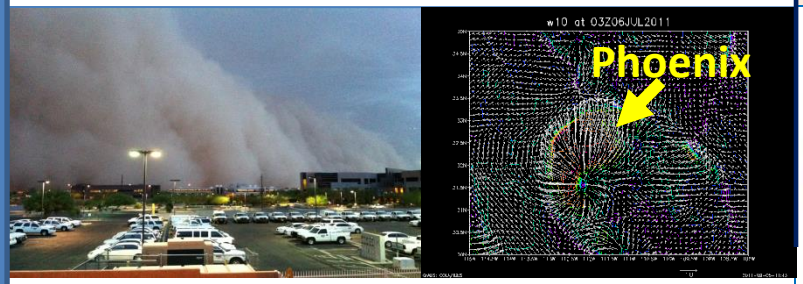
https://www.wmo.int/sdswas

Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS)
Science and Implementation Plan 2015-2020

High resolution modelling

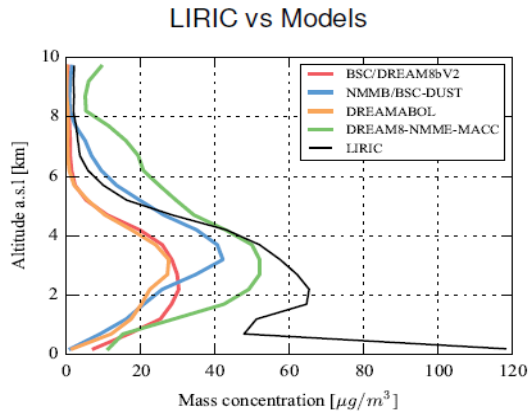


Tehran June 2014 SDS

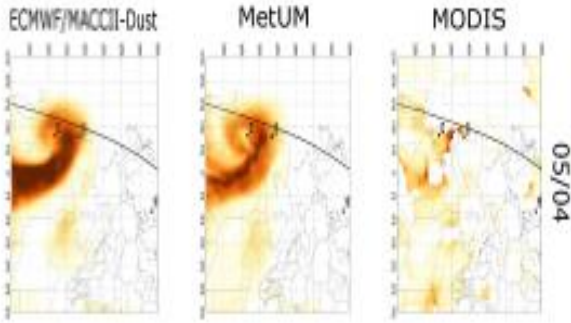


Phoenix Jul 2011 “haboob”

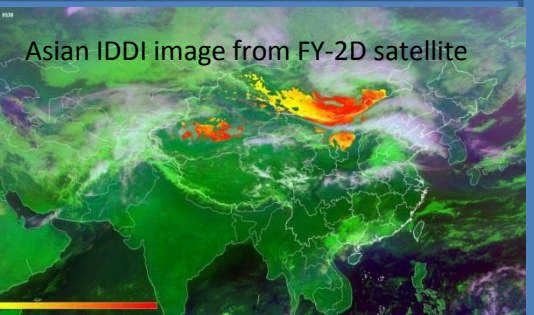
Models vs. lidars (GALION)

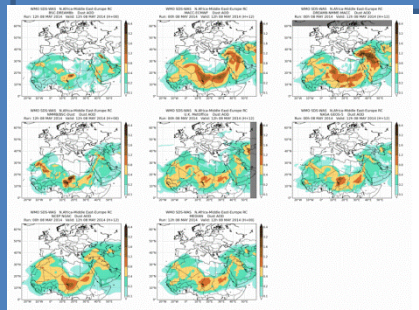


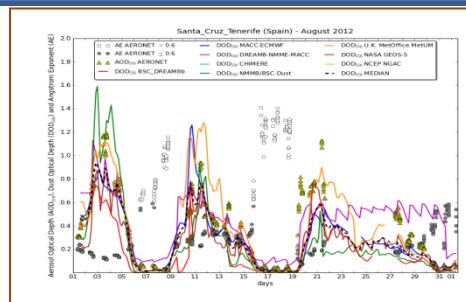
Using satellite data



SDS-WAS studies / Model vaidation / Data assimilation







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Recommendation from Satellite Research Community

- VAACs, VOs, and the remote sensing research community are encouraged to form collaborative links for training and interpretation of events.
- The volcano ash community is encouraged to formulate requirements (parameters, data formats, latency, possibly sites) to the GALION (WMO Global Atmosphere Watch Lidar Observation Network) and the ground-based aerosol network should also be considered.
- The providers of volcanic ash detection and retrieval products should liaise with data assimilation centres to foster modelling and forecasting capabilities.

WORLD METEOROLOGICAL ORGANIZATION

COMMISSION FOR BASIC SYSTEMS

OPEN PROGRAMME AREA GROUP ON INTEGRATED OBSERVING SYSTEMS

INTER-PROGRAMME EXPERT TEAM ON SATELLITE UTILIZATION AND PRODUCTS

SCOPE-Nowcasting Pilot Project 2 : Globally consistent Volcanic Ash Products

Meeting on the Intercomparison of Satellite-based Volcanic Ash Retrieval Algorithms

Madison WI, USA

29 June – 2 July 2015

FINAL REPORT

ACTRiS

http://www.wmo.int/pages/prog/sat/documents/SCOPE-NWC-PP2_VAIntercompWSReport2015.pdf

SAG-APPs

GAW Scientific Advisory Group (SAG) on Modelling Applications (SAG-APPs)

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

GAW SAG on NRT Modelling Applications

Established in 2016 by WMO Congress to enhance the exchange between the GAW observational community, the modelling communities and other-end users of atmospheric composition data.

- SAG will contribute to enhancing exchanges between the GAW community and different end-user and modeling communities with respect to atmospheric composition data, especially for near-real-time data applications on regional to global scales
- SAG-Apps is to demonstrate the usefulness of exchanging chemical observational data in Near-Real-Time in support of monitoring and forecasting applications.

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GAW SAG on NRT Modelling Applications

Science Advisory Group members

Vincent-Henri Peuch, co-chair, ECMWF, UK

Frank Dentener, co-chair, JRC, HTAP, Italy

Arlindo Da Silva , NASA, USA

Georg Grell, NOAA, USA

Mathew Hort, Met Office, UK

Michaela Hegglin, UniReading, UK

Michail Sofiev, FMI, Finland

Paul Makar, ECCC, Canada

Taichu Tanaka, Japan, ICAP

Zhou Chunhong, CMA, China

Alexander Baklanov - WMO Secretariat representative

Ex-officio from other SAGs:

Greg Carmichael, Iowa Uni, USA – Chair GAW SSC

Angela Benedetti, ECMWF – SDS-WAS

Gelsomina Pappalardo, Italy - Aerosol SAG

Johannes Kaiser, MPIC, Germany - IBBI

Veronique Boucher, ECCC, Canada - GURME SAG

Valerie Thouret, France - RG SAG

Alex Vermeulen, Sweden - GHG SAG

Enric Terradellas, Spain – SDS-WAS SC

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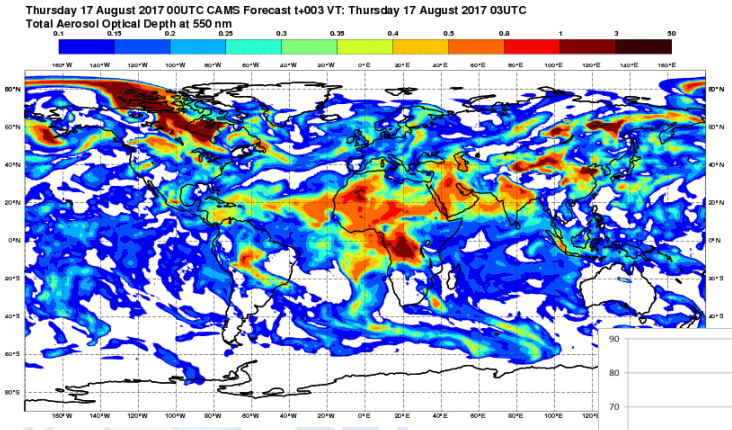
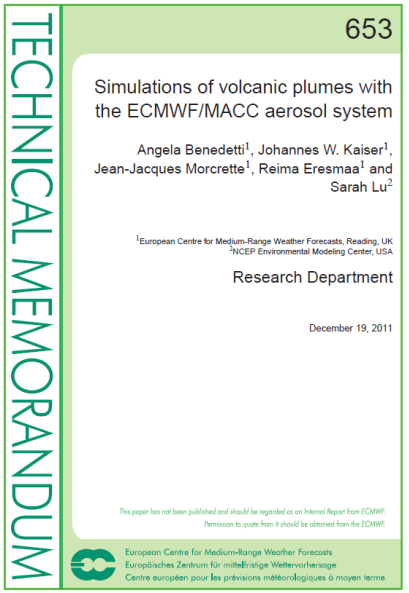
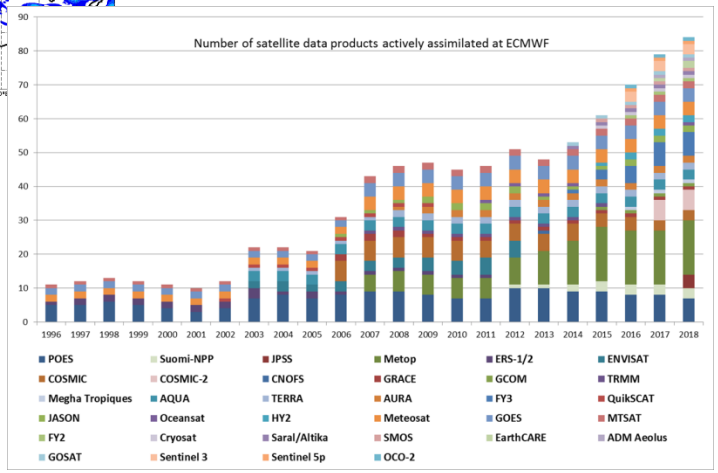
ECMWF and CAMS experience

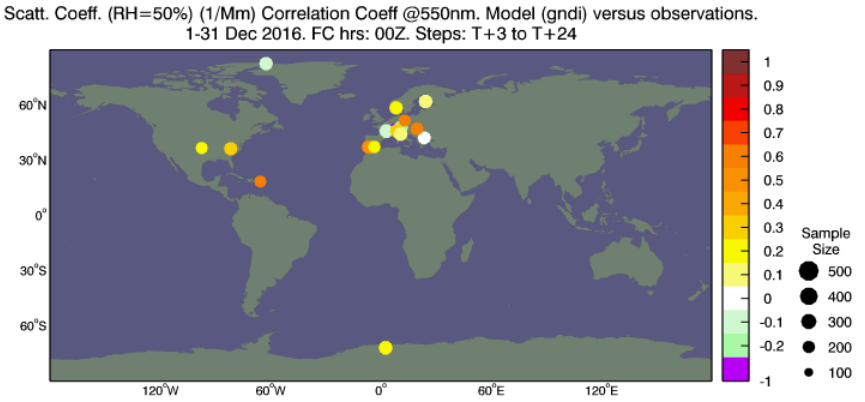






- SO2 and aerosol global forecasting for VA
- Data assimilation of AOD and gases
- Forecast evaluation vs GAW observations
- …

https://www.atmos-chem-phys.net/17/1945/2017/



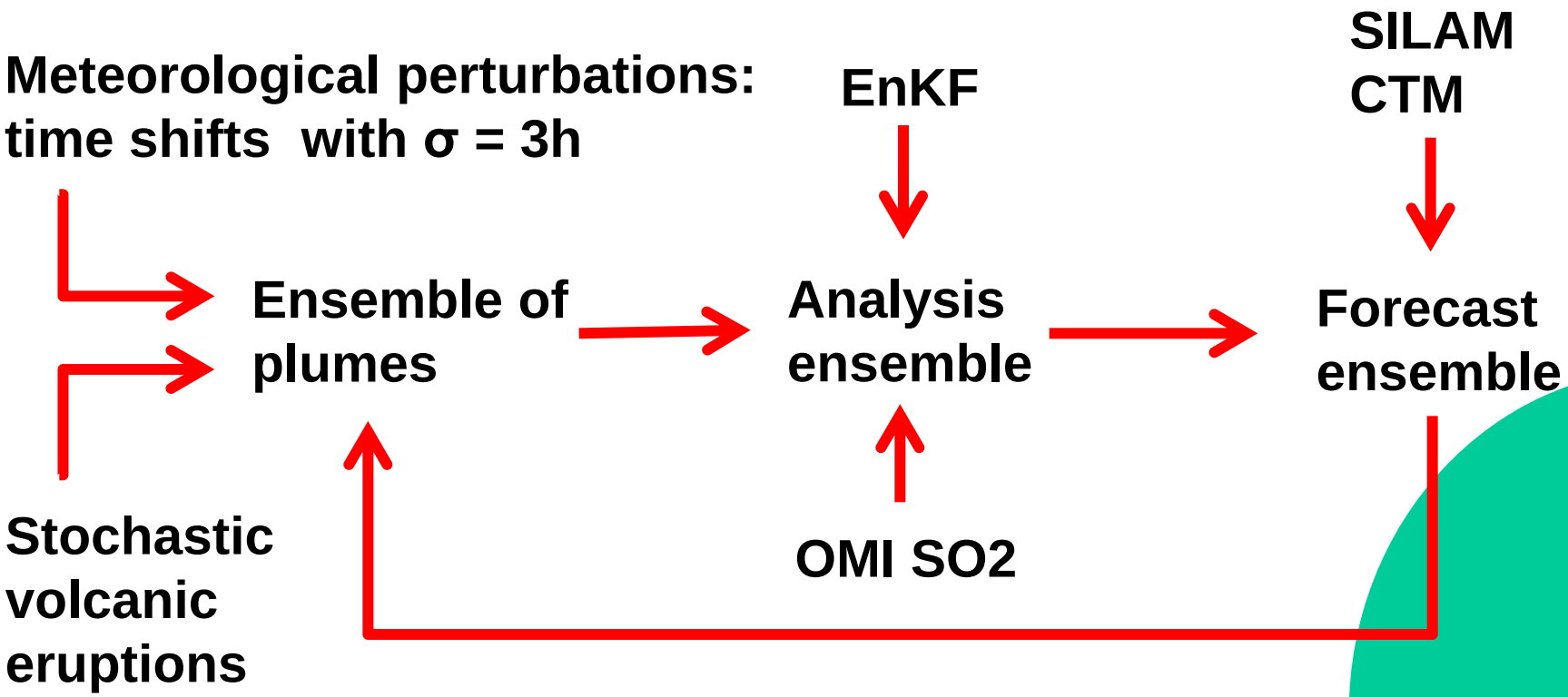
FMI Experience: Data assimilation for predicting a volcanic tracer

- How to combine 2D map of column density retrievals of **SO2** with transport modelling to obtain a realistic 3D prediction of a volcanic plume
- Can we do this without inverse modelling of the source term – instead, by continuously updating the prediction with observations?
- Can we provide error estimates accounting for both model and observation errors?
- Application to the Kasatochi SO2 release during 2 weeks following the eruption on 7-8 August 2008

Courtesy of Julius Vira, Nicolas Theys and Mikhail Sofiev

See also Vira et al (2017) – Eyjafjallajokull application

Ensemble assimilation for tracking a volcanic tracer



Courtesy of Julius Vira, Nicolas Theys and Mikhail Sofiev

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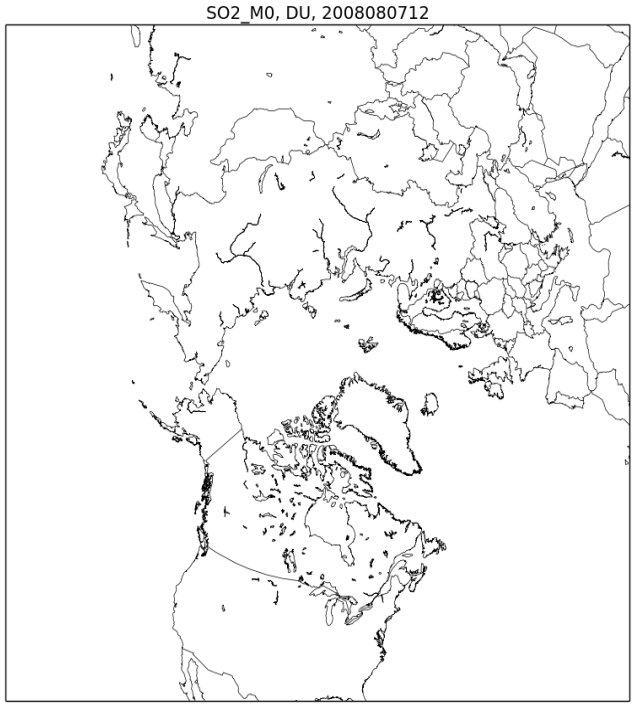
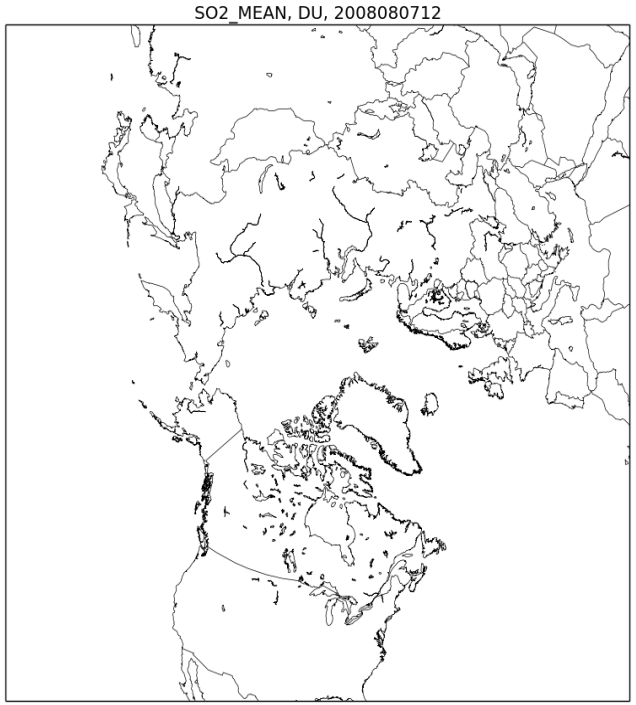
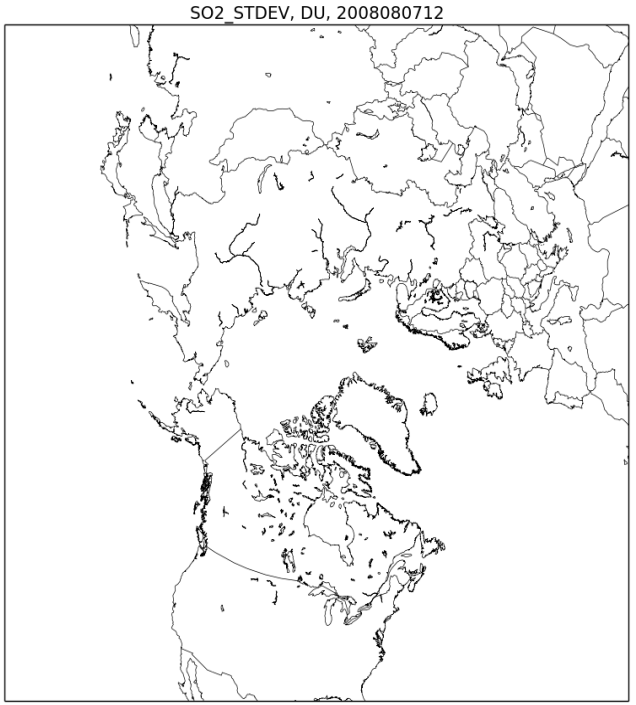
Kasatochi EnKF



Single member

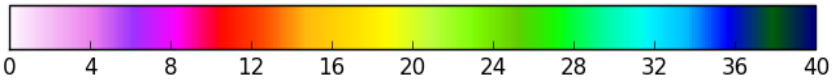


Ensemble mean



Ensemble standard deviation

ECMWF oper meteo data
BIRA OMI SO2 product



DU

Courtesy of Julius Vira, Nicolas Theys and Mikhail Sofiev

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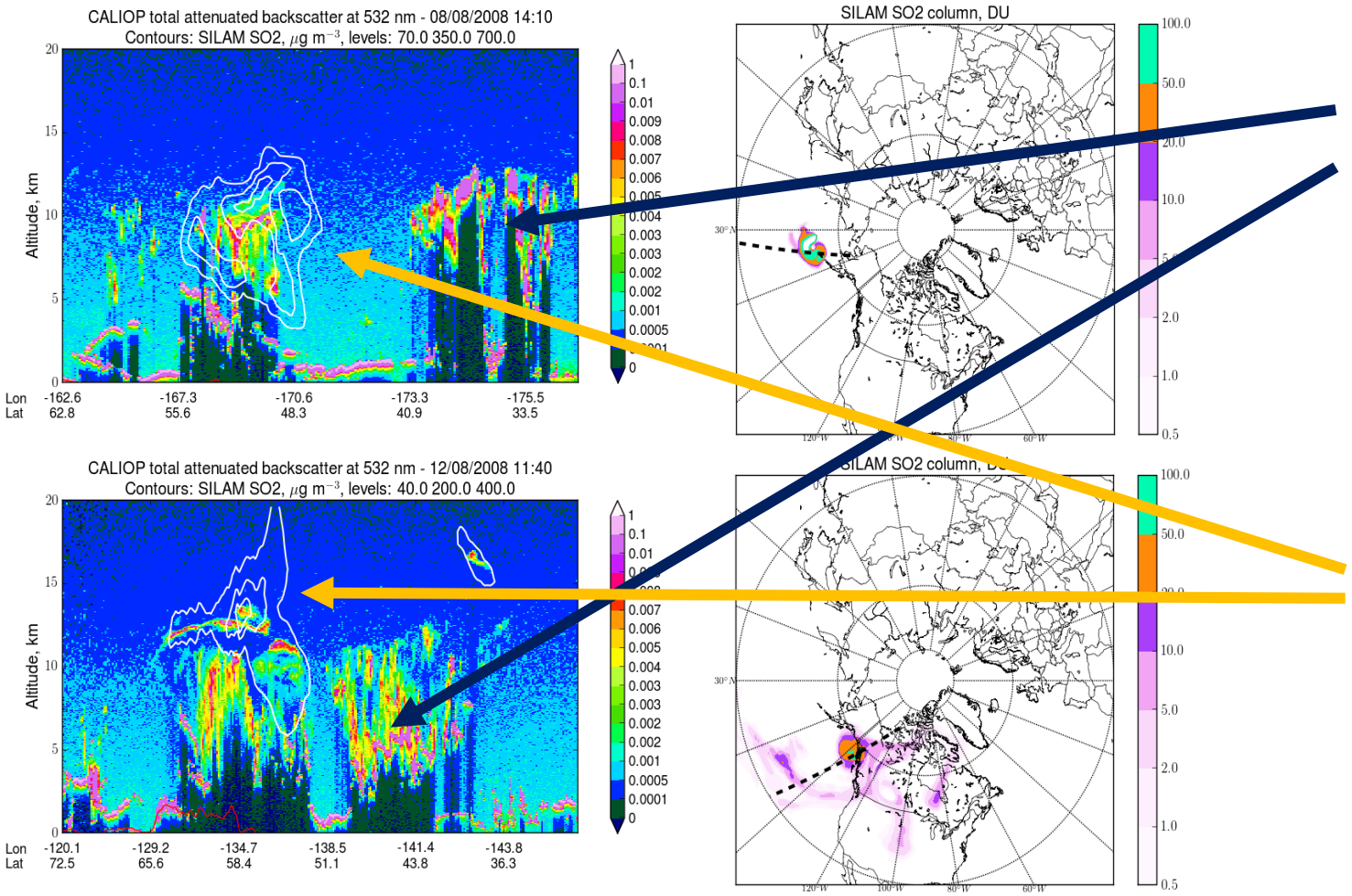
Vertical distribution: CALIOP Lidar data



Probably regular clouds

Analysis SO2 drawn in white contours

Courtesy of Julius Vira, Nicolas Theys and Mikhail Sofiev, FMI

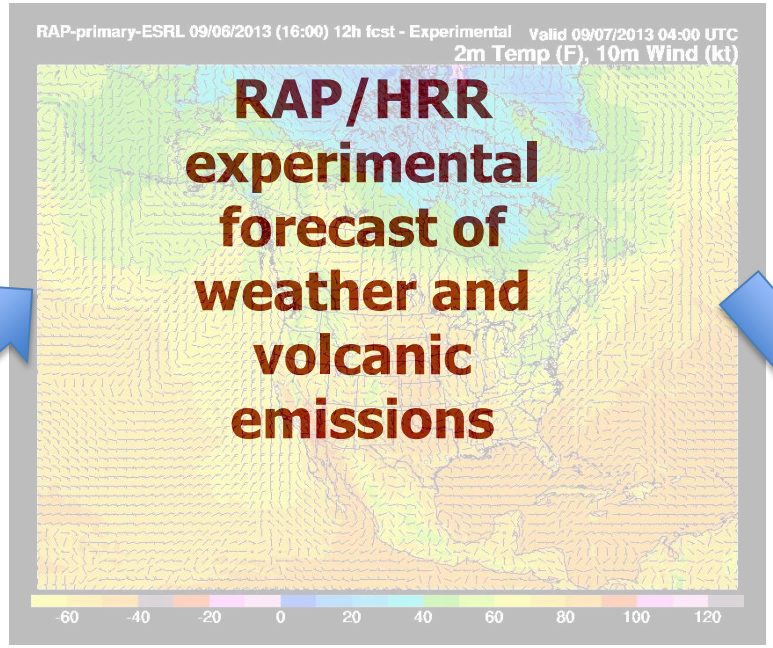
GOES-R Volcanic Ash Risk Reduction: Operational decision support within NOAA's Rapid Refresh (RAP)

Martin Stuefer (UAF), Peter Webley (UAF), Georg A Grell (NOAA-ESRL), Mike J Pavolonis (NOAA-NESDIS)

GOAL: Implement volcanic ash parameters within NOAA's Rapid Refresh (RAP/HRR) modeling system as a pathway to operational volcanic ash prediction using GOES-R data assimilation. Initial steps are

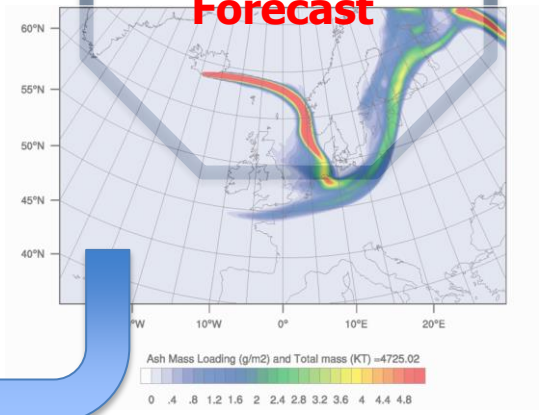
- **Extend RAP/HRR with WRF-Chem volcanic emission model.**
- **Case studies and comparison with GOES-R volcanic ash detection and height baseline product.**
- **Assess computational costs.**
- **Use VAAC volcanic activity data feed to initiate near real time WRF-Chem model runs (currently WRF-Chem runs are performed daily at the University of Alaska Fairbanks).**

THE VISION: INCLUDE GOES-R VOLCANIC BASELINE PRODUCT IN RAP/HRR



GOES-R Volcanic Emissions Baseline Product Data

Volcanic Emissions Forecast



Hourly Re-Cycle with Updated Emissions and Weather

GAW Modelling SAG
Suggestions for joint activities

Possible Initial tasks:

- Summary of current state of VAAC modelling, inversion and use of observations - both in operational use and what is being developed (overview / white paper as 1st task)
  - Aim: Expose existing R&D to enable wider R&D

- GAW assistance/collaboration in NRT access of GAW and other available observation data for VA modelling (Lidars, ceilometers, satellite, aircraft, in-situ,..)
  - Aim: Maximize use and utility of observation networks

- Collaboration with VASAG/VAACs, CIMO team is needed
  - Aim: To support VAAC and VASAG activity better

GAW Modelling SAG
Suggestions for joint activities

Possible further/future tasks (dependent on outcomes of earlier work):

- Analysis of new scientific achievements for VA modelling (includes inversion/DA) improvements
  - Aim: Recommendations for longer term research

- Modelling studies:
  - Model evaluation/analysis (VAAC and other models)
    - Aim: Draw out key aspects of models impacting forecasts
  - Inversion and data assimilation for volcanic plumes transport modelling and prediction
    - Aim: Compare current approaches to help inform future developments.

- Other ideas, suggestions, thoughts ?

WMO

World Meteorological Organization

A United Nations Specialized Agency

Working together in Weather, Climate and Water

Thank you for your attention

GAW and WWRP publications available from:

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

and

http://www.wmo.int/pages/prog/arep/wwrp/new/wwrp_new_en.html