# PLENARY SESSION 10

## *BREAKOUT- GROUP SUMMARIES*

(BREAKOUT GROUP RAPPORTEURS)

# BREAK-OUT SESSION 1

## *AEROCOM – EXPERIMENT STATUS*

HERBERT (RAPPORTEUR)

# Breakout Session 1 summary
## Experiment Status (overview of AeroCom experiments)

### Betsy Andrews – AP3 evaluation with optical property observations (see Gliss et al ACPD)
- models tend to underestimate aerosol optical properties (AOD, column AE, surface scattering / absorption coeffs)
  - models still simulate too fine dust (or overestimate fine mode fraction of coarse aerosol)
  - aerosol water component deserves more attention
- some discussion on measuring / using spectral dependence for improving AE (also discussed in session 9)
  - .. also the discrepancy of classification between fine and coarse modes in observations and models..
- Nick S suggested aerocom models report column average aerosol size

### Steven Smith – Emissions MIP
- "Probe model behaviour with climatically relevant aerosol/precursor emission perturbations"
  - PHASE 1: decadal long atmos only runs for $1^{st}$-order evaluation, PHASE 2: fully coupled ensembles
- showed some prelim results on sensitivity to SO2 emissions seasonality
- suggestion to add additional diagnostics to try understood the sulphur cycle problems – Jane Mulcahy also looking at sulphur cycle in UKESM
- More models wanted?

### Paul Zieger / Maria Burgos – Aerosol Hygroscopicity
- diversity of model scattering enhancement factor – driven by model param. of hygroscopicity and model chemistry
- recommend updating hygroscopicity params for some components and test models against f(RH) 'observations'
- highlighted issues of different RH values used for 'dry' state in models and measurements
- additional issues due to missing particle size information from models

## what would you like to see / what do you need …

### Mian Chin – UTLS experiment
- model processes determine diversity in aerosol composition – would like to implement transport and removal tracers as a diagnostic tool – e.g. CO50, Rd210

### Dongchul Kim –  DUSA (dust source attribution)
- more model participation! Michael: requests to add more size diagnostics (maybe revise what to ask models for)

### Paul Kim – Trajectory Experiment
- 1st stage participation good, still waiting for results from 2nd stage
- INPUT NEEDED: please pick favourite 5 stations for analysis in core experiment https://forms.gle/EqMpALo8GFBh63KYA

### Gunnar Myhre – historical experiments
- want to include more CMIP6 results – contact Gunnar
- planning on using similar method as Harri Kokkola to understand model diversity

### Xiaohua Pan – biomass burning emission injection height experiment
- need observation data from Arctic and Russia to validate (Betsy: can supply surface aerosol data)
- Ralph can provide MISR plume heights for Siberian fires – get in contact if interested

### Duncan Watson-Parris – Aircraft Comparison and BC MMPPE
- want more models! Philip stresses the requirements are quite manageable…

### Hongbin Yu – Trans-Atlantic Dust Deposition
- only 50% of models provide info on dust size distributions  - also need information on the vertical profiles

## Final remark – maybe organise a telecon after AeroCom to discuss next steps for all experiments...

# BREAK-OUT SESSION **2**

## *AEROCOM – NEW MODEL RESULTS*

### WILCOX (RAPPORTEUR)

# Breakout 2: new modelling results

**Qi An:** simulated effective radiative forcing of nitrate

**Ramiro Checa-Garcia:** Modelling of mineral dust in CRESCENDO-ESM

**Chiu Cheng:** Size-resolving aerosol microphysics scheme…

**Jeff McQueen:** NOAA's global aerosol modelling progress

**Mariusz Pagowski:** NAOO's data assimilation ensemble system

**Yves Balkanski:** Aerosol absorption: dust causes Sahel precipitation

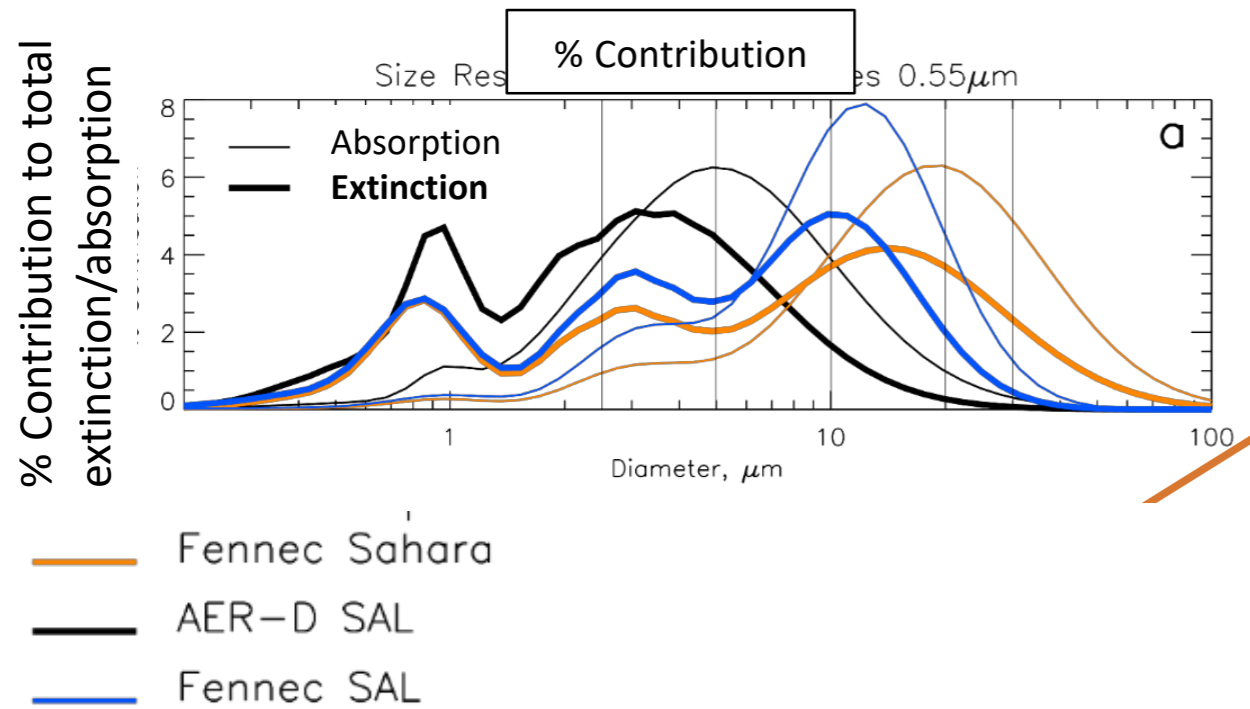**Christoph Bruehl:** Pinatubo volcanic eruption: direct and indirect effects

**Ross Herbert:** Asian summer monsoon response to future aerosol changes

**David Neubauer:** Soot acing by ozone/sulphuric acid…

**Claire Ryder:** Aircraft observations of coarse dust
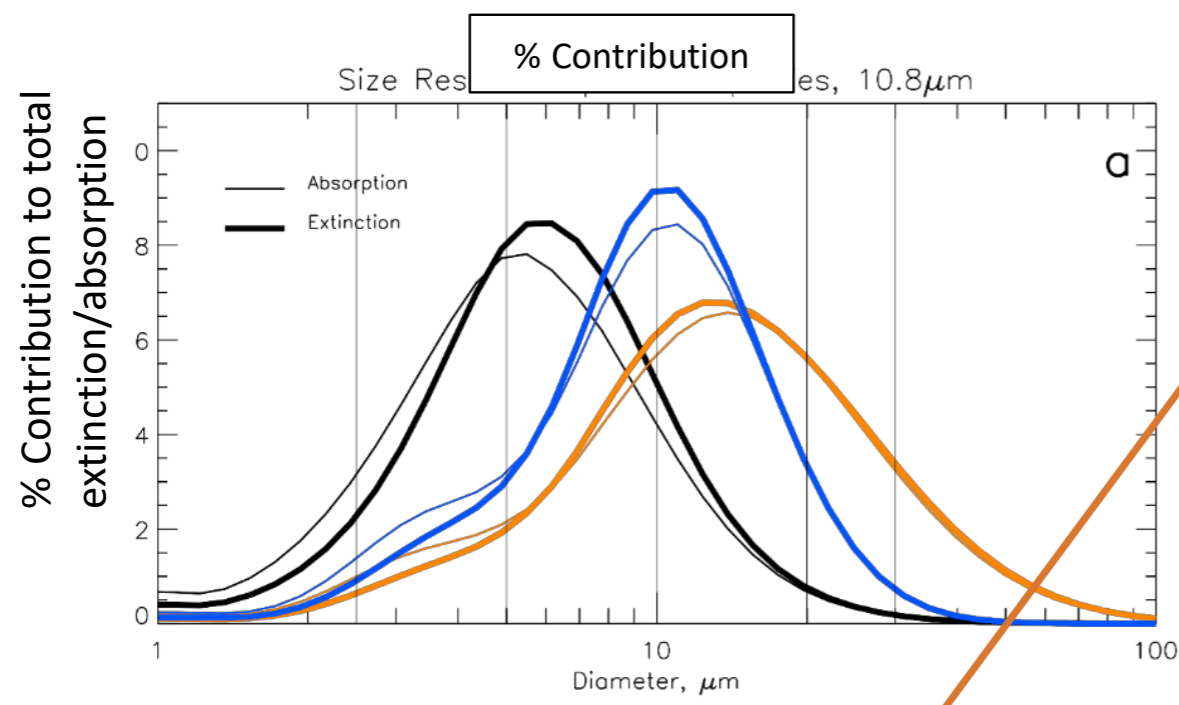
**Kai Zhang:** Microphysics parameterisations in MAM

# Breakout 2: new modelling results

**SW extinction**

**LW extinction**

**Dust optical properties can be significantly different when accounting for the full size range.**

**Models will be significantly underestimating SW and LW extinction and absorption by underestimating coarse dust concentrations.**
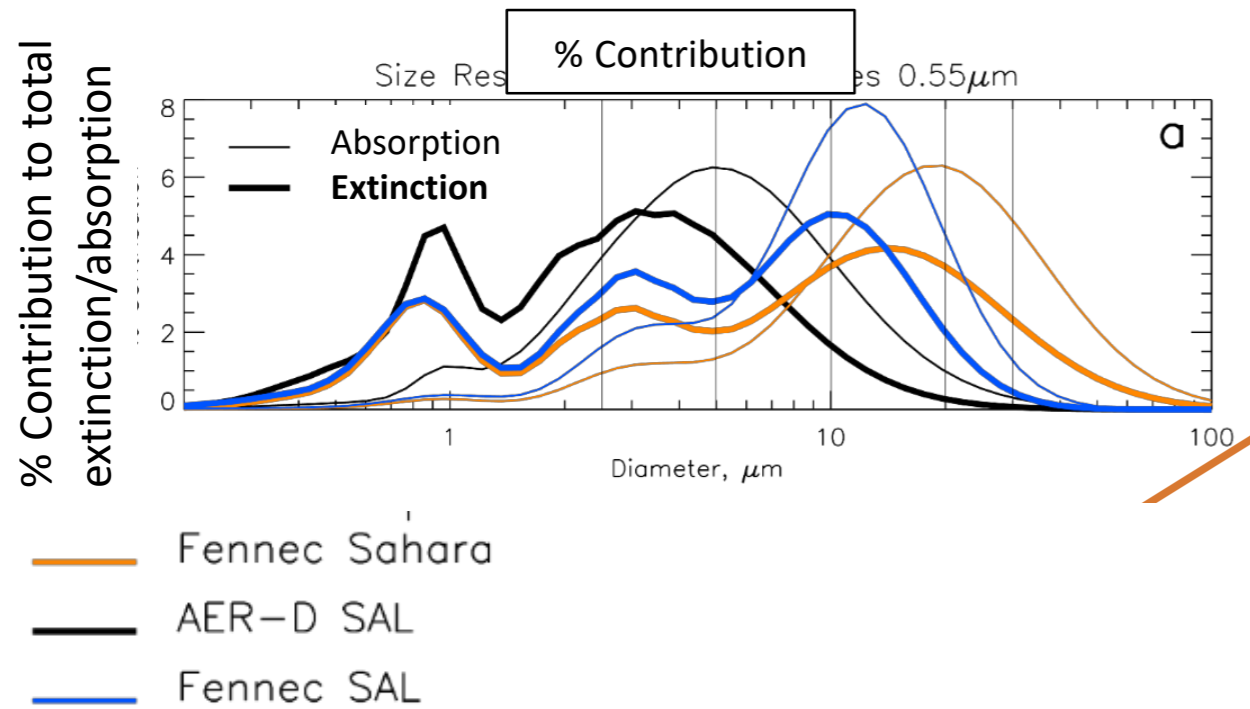
But how do we keep these particles aloft in models?

Do we need a different distribution for super coarse modes?

Plots: Claire Ryder

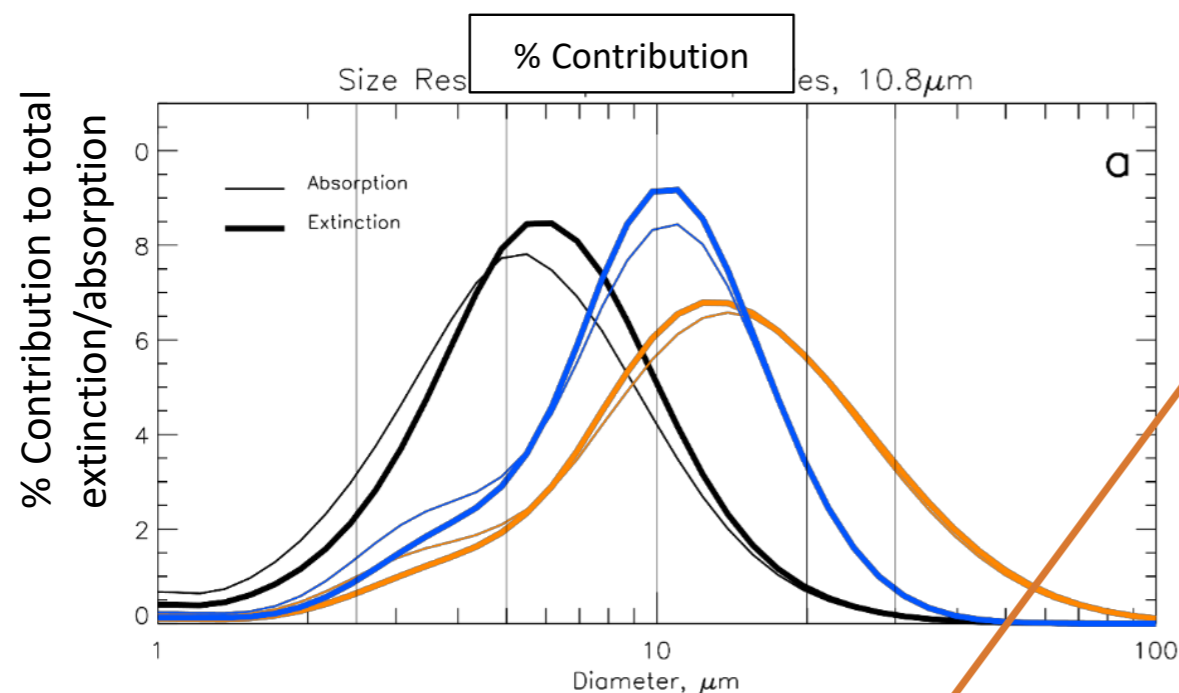# Breakout 2: new modelling results



SW extinction

LW extinction

Processes important for long range transport?

Self-lofting?

Electrostatic charge?

Non-spherical effects?

Emission height?

➡ Lots of recent attention on dust emission - needs to be matched with focus on transport and deposition.

➡ Need to think about what we can learn from high resolution models.

Plots: Claire Ryder

# BREAK-OUT SESSION 3

## AEROCOM – NEW ACTIVITIES

JOHNSON (RAPPORTEUR)

**AEROCOM / AEROSAT, October 2020.**

**Summary of discussions during break out session 3 on Day 2 "Modelling and methods II"**
 *(Moderator: Duncan Watson-Paris, Rapporteur: Ben Johnson)*

Constraining models with satellite remote sensing obs

Three promising directions were briefly considered:

1. Combining retrievals from a range of sensors to get better or "best" estimates of quantities like AOD from the multi-retrieval ensemble, along with a characterization of the spread or uncertainty that arises from sensor-specific or retrieval-specific errors and assumptions.

2. The development of multi-sensor retrievals were mentioned too as an alternative to exploit the multiple constraints into one retrieval algorithm. However, we did not go into any specifics of how thinking / R&D on this is maturing.

3. Use of machine learning to disentangle big satellite data is also showing encouraging results.
Early work on this is demonstrating machine learning might offer new ways to retrieve aerosol and cloud quantities from satellite data.
Machine learning has been used to develop an experimental dust AOD product using IASI data. It was only trained to output AOD, but it performed better than other more "conventional" retrievals.

Biomass burning and brown carbon

Big uncertainties in modelling biomass burning emissions and aerosol properties still remain. We are still not sure why modelled AOD in BB regions often fails to match observations without tuning up emissions from GFED / QFED / GFAS.
Brown carbon increasingly highlighted as playing an important role and getting included in more models, but observational evidence still paints a complex and confusing picture of how BrC evolves and how/where it is makes a significant impact on optical properties.

# BREAKOUT SESSION 4

## SUBORBITAL & BIOMASS

### HICKMAN (RAPPORTEUR)

# Breakout session 4 Presentations

**Thomas Eck** described Aeronet detection of brown carbon in biomass burning; anomalous observations over Maryland on September 15, 2020 at 500nm, suggestive of growth of biomass burning-derived aerosols following long-range transport from the west coast.  Detection and time series of both brown carbon and desert dust iron oxides were presented.

**Rich Ferrare** introduced an alternative method for deriving above cloud AOD and aerosol extinction profiles from CALIOP observations.  The method provided improved observations of the altitude of enhanced AOD relative to cloud top, with application over the Atlantic and western coast of central Africa.

**Ben Johnson** examined the magnitude of self-raising in aerosols as a result of radiative heating.  Statistically significant elevation of aerosols was observed over the tropical Atlantic, with the strongest heating at 700 mb, and ~1km elevation of black carbon over the Atlantic during the central/southern African biomass burning season.  Of potential interest is how black carbon deposition in the Arctic might be affected by self-raising.

**Anin Puthukkudy** conducted and evaluated aerosol retrievals from AirHARP observations during ACEPOL 2017 using the Generalized Retrieval of Aerosol and Surface Properties (GRASP) approach.  Demonstrated the ability to retrieve low, medium, and high AOD from a HARP instrument.  There is some sensitivity for polarization and potential insight into spherical fraction, but this product does not yet have high confidence.

# Breakout session 4 Discussion

- **Aeronet measurement of SSA**: Some discussion about the degree to which SSA is accurately measured in Aeronet given the bias in size distribution—i.e., if giant particles are present, but are not accounted for in the retrievals.  It was argued that SSA should still be robust because SSA is calculated using both the size distribution and retrieved refractive index, and bias in the size distribution is offset by the second parameter.  Aeronet SSA matches angular scattered radiation within 5% or better of L2 retrievals.

- **Modeling self-lofting of aerosols**, and the balance between retaining real meteorology as well as interactive processes needed to simulate self-lofting.  In some 10X black carbon experiments using both nudged and free-running simulations, self-lofting still emerges in the nudged experiments so long as the nudging isn't too tight.  However, nudging suppresses broader teleconnections that emerge in the free-running simulations.

- **The potential for the ORACLES campaign to be leveraged for model improvement.**  One challenge is that currently most/all models have difficulty capturing the cloud deck in the ORACLES region.  More regional analyses may be required.  On a practical level, there is a need for biomass burning emissions, which are only available in beta from GFED for 2017-present (GFED is used in CEDS, which most models rely on).  It may be desirable to have ATOM- or ORACLES-specific biomass burning emission runs using a non-GFED database.

- Some initial discussion about species retrievals and size distributions using Aeronet.  Also some brief discussion about the potential insights from EMIT.

# BREAK-OUT SESSION 5

## *AEROSOL & CLOUDS*

**GYRSPEEDT** (RAPPORTEUR)

# Breakout session 5

- ▶ Improving the ACI diagnostics in AeroCom experiments
  - ▶ Aim for simple properties (LWP, CF, cloud top Nd), rather than derived ones. Restrict to 2D.
  - ▶ Consider integrating into CTRL simulation
  - ▶ Collect a list of useful diagnostics that could be added to experiments that make them useful for ACI analyses (*Ed Gryspeerdt*)
  - ▶ Please send your favourite variables to *e.gryspeerdt@imperial.ac.uk*

- ▶ Closer link with higher resolution studies
  - ▶ Follows a move to more high resolution modelling generally
  - ▶ Could link with ACPC, particularly with natural laboratories
  - ▶ Perhaps through groups that contribute to both initiatives

- ▶ Natural experiments work beyond Holuhraun
  - ▶ SE Atlantic ship corridor (if appropriate scale)
  - ▶ Perhaps implemented as emissions perturbation for CTRL (PI, PD, PD+)
  - ▶ *Velle Toll* had some ideas for how this could be implemented (also *Michael Diamond?, Rob Wood?*)

# BREAK-OUT SESSION 6

## *TRENDS*

**TSIKERIDEKIS** (RAPPORTEUR)

# AEROCOM 2020 - Break-out 6

**General discussion focused on AOD, AAOD, forcing, and uncertainty confronting models with observations. Specific points were mostly focused on plenary presentations of session 7 (Thursday)**

**Nick Schutgens -** Schutgens et al., ACP in press, https://acp.copernicus.org/preprints/acp-2019-1193/

- A lot of uncertainty sources don't occur in isolation but are structured and link with each other.

- We don't have sufficient satellite AAOD retrievals to get a meaningful satellite diversity, as we do for total AOD.

- Diversity is a fair proxy for uncertainty in satellite AOD. The paper also notes a few AERONET sites where all retrievals seem to do poorly. Pick one of these regions and figure out why diversity is high there! Potential topic for a future AeroSat experiment??

**Wandji William -** Wandji Nyamsi et al., 2020, AMT, https://amt.copernicus.org/articles/13/3061/2020/amt-13-3061-2020.html

- Based on William's work **Tomas Popp** suggested to use Sunshine Duration AOD as a way to evaluate satellite observations, before AERONET stations were widespread (e.g. AVHRR, ATSR2, early GEO)

**Wenying Su:**

- With CERES we can combine AOD and flux to estimate forcing efficiency, which is not AAOD, but is something related for model evaluation.

**Larisa Sogacheva -** Sogacheva et al., 2020, ACP, https://acp.copernicus.org/articles/20/2031/2020/

- Inter-comparison of satellite monthly AOD over different regions.

# BREAK-OUT SESSION 7

## *AEROSOL TYPE*

YU (RAPPORTEUR)

# Breakout7: Aerosol Type

Moderator: Thomas Popp          Rapporteur: Hongbin Yu

**Goal:** to address three questions through discussions motivated by 9 presentations in Breakout#7 and Plenary#9:

1. *How can we progress on constraining aerosol type with satellite observations?*

2. *How can satellite AOD at multiple wavelengths be used in modeling?*

3. *How far can satellite interpretation schemes for aerosol type be applied to models?*

# Breakout Session 7. *Aerosol type from satellite*

*Moderator:* **Thomas Popp**      *Rapporteur:* **Hongbin Yu**

**Start: EU 5:30 PM / NY 11:30 AM / CA 8:30 AM / JP 0:30 AM / CN 11:30 PM**

Posters (5 min each presentation, including questions)
**Anu Kauppi:** Aerosol estimates when applied to TROPOMI
**Quianqian Song:** Dust Climatology derived from CALIOP and MODIS
**Ying Zhang:** Improved inversion of aerosol components
**Jason Tackett:** CALIOP Aerosol Typing Performance
**Soheila Jafariserajehlou:** PMAp: synergistic aerosol products from Metop
**Antti Lipponen:** Retrieval Post-Process Corrections

Talks also to be considered in in the general discussion
**Hongbin Yu:** African Dust Intrusion into the Caribbic
**Kostas Tsigaridis:** Clear-sky AOD in modelling
**Tero Mielonen:** Comparing aerosol types

General discussion
Follow-up from plenary session 9
Focus on aerosol type retrieval methods from satellite

# *Q1: How far can we progress on constraining aerosol type with satellite observations?*

- **Presentations**
  - Applying/modifying heritage aerosol type (OMI) for new sensor (TROPOMI)
  - PMAp – synergistic aerosol retrieval from GOME-2 (e.g., identifying ash from AVHRR+IASI, as well as dust from IASI)
  - Improving CALIOP stratospheric aerosol typing (pyroCb smoke vs. ash/sulfate)
  - Using ML technique to post process MODIS DT retrievals over land  *(bias correction)*

- **Discussion/Recommendations**
  - Focus on some major events (e.g., wildfires, dust storms, volcanic eruptions)
  - Need to update aerosol models on a regular basis based on emerging data (e.g., dust size and shape)
  - To form a commission on "constraining aerosol properties" – many volunteers!

# Q2: How can satellite AOD at multiple wavelengths be used in modeling?

- Multi-spectral AOD AEROSAT exercise (*recommended at last year's meeting*)
  - go beyond AOD at 550 nm
  - data collected: MODIS, VIIRS, MISR, SLSTR, POLDER
  - so far not too many datasets have AOD at other wavelengths
  - also aerosol type (or aerosol model for satellite retrieval) – *differing among sensors*

- **Discussion/Recommendations**
  - Evaluating multi-wavelength AOD will provide additional insights into deficiencies in aerosol modeling. We should do it.
  - Asking modelers to calculate TIR AOD *(needed for comparing with IASI retrievals)*

# Q3: How far can satellite interpretation schemes for aerosol type be applied to models?

- **Presentations**
  - Comparing satellite-model aerosol typing *(qualitative)*
    - Applying an AERONET-based aerosol classification algorithm (FMF, SSA) to 2 models *(similar patterns)*
    - AATSR vs models - 8 components based on AE & SSA - *large discrepancies between satellite and models*
  - Deriving aerosol components from remote sensing observations *(quantitative)*
    - Global dust climatology from CALIOP and MODIS (dust vs non-dust)
    - Aerosol components (8) from China's SONET

- **Discussion/Recommendations**
  - "satellite aerosol type" is "descriptive" & "empirical", and depends on sensor, which makes it hard to be used by models in a quantitative way. For example, for a dust-smoke mixture, we don't know the amount of dust vs. smoke.
  - "We need to define a commonly agreed upon approach" – size, source, composition, etc?
  - It should be *"purpose driven"* (e.g., what science questions to address?) and *"feasible"*.
  - To form a commission on developing satellite-based aerosol components that modelers can use quantitatively, including:
    - Dust optical depth climatology (several size-based and shape-based methods)
    - Fine AOD vs coarse AOD

# BREAK-OUT SESSION **8**

## *NOT JUST AOD*

### SOGACHEVA (RAPPORTEUR)

# Breakout Session 8. *Not Just AOD*

*Chairs:* **Ralph Kahn / Larisa Sogacheva**    *Rapporteur:* **Andrew Sayer**

**Reed Espinosa** – *Surface/Aerosol RT simulation + GRASP retrieval testbed*

**Athanasios Tsikerdekis** – *Aerosol size and absorption from POLDER/PARASOL*

**Bastiaan van Diedenhoven** – *RSP retrievals from CAMP2Ex, results & issues*

**Pete Colarco** – *June 2020 Saharan Dust Event – Testing ICAP models w/data*

**Daniel Robbins** – *AI to separate Himawari smoke/cloud for the 2020 Australia fires*

**Marta Luffarelli** – *Toward consistent cloud/arsl SS properties & surf. refl. retrievals*

- Two presentations (**Espinosa, van Diedenhoven**) focused on capabilities of next-generation: retrieval simulations and airborne prototype, respectively

- These link to presentation by **Tsikerdekis** on the utility of aerosol size and absorption (in addition to AOD) for aerosol data assimilation

- Two presentations (**Robbins, Luffarelli**) dealt with better strategies to distinguish clouds from heavy aerosols, especially important for extreme events.

- Presentation by **Colarco** tied some of these threads together showing utility of AOD assimilation at constraining spatial patterns of transport (though not magnitude or source strength) for an extreme Saharan dust storm

# Breakout Session 8. *Not Just AOD*

*Chairs:* **Ralph Kahn / Larisa Sogacheva**    *Rapporteur:* **Andrew Sayer**

Bigger-picture thoughts and next steps:

- Challenges include translation between satellite and model optical properties; lack of sufficient **lab/airborne measurements** (see also plenary 11)

- Emulators (e.g. GEOS5 work with CALIOP, OMI) can be a **"middle ground"** between (a) constraining model w/satellite-retrieved optical properties and (b) radiance assimilation; could help both sides retrievals refine assumptions.
  - -- Could apply **properties satellites can retrieve** in emulation, e.g., FMF, non-spherical AOD fraction, light-absorbing AOD fraction (maybe also absorption AOD spectral slope)
  - -- Some consensus to focus on **light-absorption** as the next key retrieved property

    Possible future AeroCom - AeroSat joint experiment?

- Open questions include: (1) When to use empirical **neural networks** (including suitable training data) vs. physical retrievals, (2) How to determine **error covariance matrices** for optimal estimation retrievals

# BREAK-OUT SESSION 9

## *NEW RETRIEVALS*

### KOLMONEN (RAPPORTEUR)

# General

The new advances in the aerosol retrieval are here collected from the breakout session divided into three categories:

- Enhancement or re-use of existing methods (ORAC ATSR/SLSTR, GRASP S5P & 3MI)
- New methods (NN approach to ash retrieval MSG-SEVIRI). New methods with instrument synergy (Dust retrieval IIR/CALIOP)
- Geometry effects on retrieval (Scattering angle sampling for Multi-Angle Polarimeters, dual-view SLSTR)

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# Remarks

- Quite some development is currently concentrated on studying the retrieval geometry
  - Detecting deficiencies in aerosol retrieval performance and determining the information content as a function of the geometry
  - Studying the scattering angle for future mission recommendations
- Neural networks as a retrieval method is pursued.
- Combining data from two instruments is seen beneficial in special circumstances. In this session no general aerosol retrieval with synergy approach was presented. (See plenary Friday 16th for a GEO/LEO use.)

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