AEROSAT
Introduction

Thomas Popp / DLR
Ralph Kahn / NASA-GSFC

AEROSAT Goals (1)

- **Work with modelers to make satellite aerosol data as useful as possible for climate modeling (e.g., AeroCom)**
- **Achieve open and active exchange of information**
  - Retrievals and their strengths and limitations
  - Match requirements of users to technical capabilities of the data
  - Share the latest technological advances
  - Work toward inter-operability (data formats, data standards)
- **Forum for satellite aerosol retrieval experts**
  - Learn from each other, collaborate as appropriate
  - Initiate new developments
  - Discuss harmonization

AEROSAT Goals (2)

- **Promote the use of satellite data**
  - As **complementary** to other sources of information
  - To better understand the role of aerosols in climate, climate change, air quality, and atmospheric processes
- **Forum includes satellite data users** (AEROCOM / CCMI models, ICAP forecasts) **and data providers** (AERONET reference, space agencies)
  - Listen to each others' needs and limitations
  - Discuss what is possible; Motivate new activities
  - Contribute to integration of satellite & suborbital observations
- AEROSAT is an unfunded network (like AEROCOM)

Challenges for Satellite Aerosol Remote Sensing

- Providing *Consistent, Global, 3-D Aerosol Amount and Type* products
- Providing *Quantitative, Credible Uncertainty Estimates*
- Producing *Long-term* satellite data records
- Applying satellite datasets to *Constrain* and/or *Validate Models*
- *Using Models* to supplement measured quantities
- Exploit satellite information content to constrain aerosol type
- Finding *CNN proxies*
- Using *Multiple Data Sources* to constrain models
- Providing *"Deliverables"* (results) on zero budget...

AeroSat in the First Four Years

- **Joint Sessions with AeroCom**
  - Needs of modelers ←→ Possibilities & limitations of data producers
  - Common understanding of definitions
- **Internal Retrieval Expert Discussions**
  - Principles, *consistent definitions*, strengths / limitations
  - Constraining *aerosol type* with satellite data
  - Deriving *pixel-level uncertainties*
  - Producing *long-term* satellite data records
  - Satellite capabilities / limitations for *air quality applications*
- **Summary (draft) outcomes**
  - Intensified dialogue (among retrieval experts & with modelers)
  - List of long-term datasets
  - List of inter-comparison studies
  - Inventory of aerosol-type products & definitions
  - Review of validation metrics (linear regression; confidence intervals, etc.)
  - Major advances in assigning *pixel-level uncertainties*
  - Satellite constraints on *biomass burning injection height & source strength*

Long-term Data Record Table 2015

AEROSAT Working Group on Climate Data Records

List of candidate aerosol CDRs currently available:

Satellite Instrument	*Algo*	*Main Retrieved Quantities*	*Time Span*	*Provider*	*Access*	*Reference*
NOAA-AVHRR	2-channel	AOD (ocean)	1981-2009	NOAA	NOAA CLASS	Heidinger et al., 2014: The Pathfinder Atmospheres–Extended AVHRR Climate Dataset. Bull. Amer. Meteor. Soc., 95, 909–922.
TOMS	near-UV	AOD, AAI	1979-2005[1]	NASA	ozoneaq.gsfc.nasa.gov	O. Torres, P. K. Bhartia, J. R. Herman, A. Sinyuk, Paul Ginoux, and Brent Holben, 2002: A Long-Term Record of Aerosol Optical Depth from TOMS Observations and Comparison to AERONET Measurements. *J. Atmos. Sci.*, **59**, 398–413.
SAGE	ver 7.0 (SAGE II) ver 4.0 (SAGE III)	Aerosol extinction coefficient profiles from cloud top to 40 km at 4 wavelengths in the UV-vis-NIR	1984-2005[2]	NASA LaRC eosweb.larc.nasa.gov	sage.nasa.gov	R. P. Damadeo, R. P., J. M. Zawodny, L. W. Thomason, and N. Iyer, SAGE Version 7.0 Algorithm: Application to SAGE II, Atmos. Meas. Tech., 6, 3539-3561, 2013 www.atmos-meas-tech.net/6/3539/2013/, doi:10.5194/amt-6-3539-2013 Thomason, L. W., James R. Moore, Michael C. Pitts, Joseph M. Zawodny, and Er-Woon Chiou, An Evaluation of the SAGE III Version 4 Aerosol Extinction Coefficient and Water Vapor Data Products, Atmos. Chem. Phys., 10, 2159-2173, 2010 www.atmos-chem-phys.net/10/2159/2010/

[1] TOMS data after 2001 should not be used for trend analysis. TOMS instruments were flown on the following satellites: Nimbus-7 (Nov 1978 - May 1993), Meteor-3 (Aug 1991 - Dec 1994), Earth Probe (July 1996 - Dec 2005), and ADEOS (Sep 1996 - June 1997)

[2] SAGE II (Oct 1984-Aug 2005), SAGE III-Meteor-3M (Feb 2002-Dec 2005). Older data sets from SAM II (1975-1978) and SAGE I (1979-1981) also exist.

Table collected from AEROSAT Participants

This is 1 of 6 pages

… Table needs updating

Avoid duplicating other activities (e.g. CEOS ECV inventory)

Aerosol Product Inter-Comparison Table (land) 2014

Publication	variables	method(s)	sensors															period	region(s)	reference(s)
			VIIRS	SeaWIFS	AVHRR	TOMS	MODIS	MISR	POLDER	AATSR	MERIS	SYNAER	OMI	AIRS	IASI	CALIOP	SEVIRI			
Kahn et al. (2011), JQSRT, 112:901–909. doi:10.1016/j.jqsrt.2009.11.003	AOD	L2 statistics					x	x										3 months 2006	Global	-
Liu, et al. (2014), JGR, 119, 3942–3962, doi:10.1002/2013JD020360.	AOD	L2 statistics	x				x											2012/13	global	AERONET, MAN
Kinne, et al. (2003), JGR, 108, 4634, doi:10.1029/2001JD001253	AOD	Monthly means			x	x	x												global	AERONET, AEROCOM
Kittaka et al. (2011), AMT, 4, 131–141, doi:10.5194/amt-4-131-2011	AOD	Collocated pairs, 5 deg					x									x		2006-2008	global	-
Sayer, et al. (2012), AMT, 5, 1761, doi:10.5194/amt-5-1761-2012	AOD	Lv3		x			x	x										Multi-year	global	AERONET
Redemann, et al. (2012), ACP 12, 3025-3043, doi:10.5194/acp-12-3025-2012, 2012	AOD	L2					x									x		4M 2007 & 2009	Global CALIOP tracks	-
Carlson and Lacis (2013), JGR, 118, 8640–8648, doi:10.1002/jgrd.50686	AOD	PCA analysis		x			x	x										2002-2010	Global ocean	-
Kahn,et al. (2009), TGARS 47, 4095-4111, doi: 10.1109/TGRS.2009.2023115	AOD, ANG	L2 statistics					x	x										2M of 2006	Global	-
Bréon,et al., (2011), RSE 115, 3102	AOD, ANG	L2 statistics					x		x		x					x	x	various,	global; sea/land	AERONET
de Leeuw, et al., RSE (2014) doi: 10.1016/j.rse.2013.04.023	AOD, ANG	Lv2 / L3 L3 scoring				various algorithms for one sensor												4M of 2008	global;,	AERONET
Holzer-Popp, et al., AMT, 6, 1919 - 1957, (2013) doi:10.5194/amt-6-1919-2013	AOD, ANG	L3 statistics algorithm experiment				various algorithms for one sensor												1M of 2008	Global; regions	AERONET
Kokhanovsky, et al. (2010), AMT, 3, 909-932, doi:10.5194/amt-3-909-2010	AOD, optical properties	Single cases				various algorithms for one sensor	x	x	x	x	x							Single cases	Single cases	Simulations

Table collected from AEROSAT Participants

2nd table over ocean

… Tables need updating

Overview of typing procedure

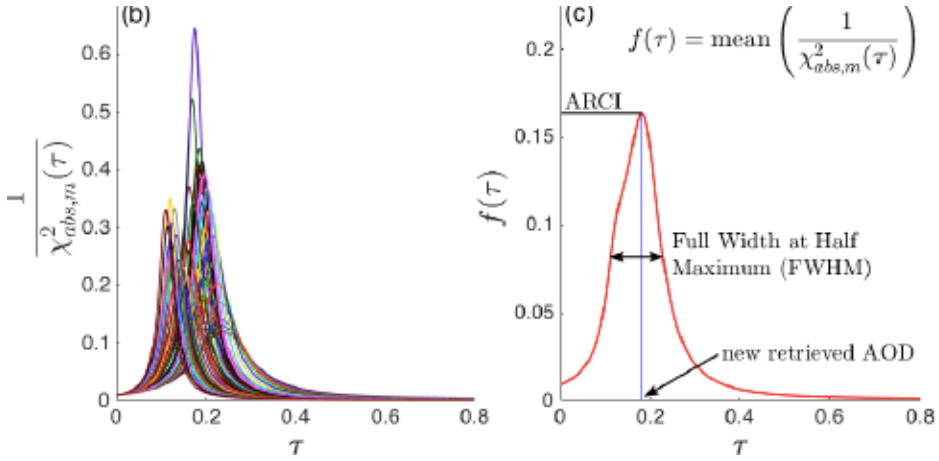
The nomenclature is very heterogeneous among different platforms.

Optical Constraints vs. Compositional Inferences

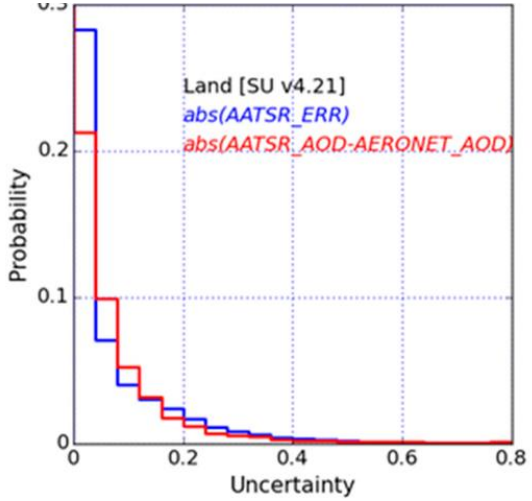
6 main classes could be identified grouping the different nomenclatures.

Useful validation metrics

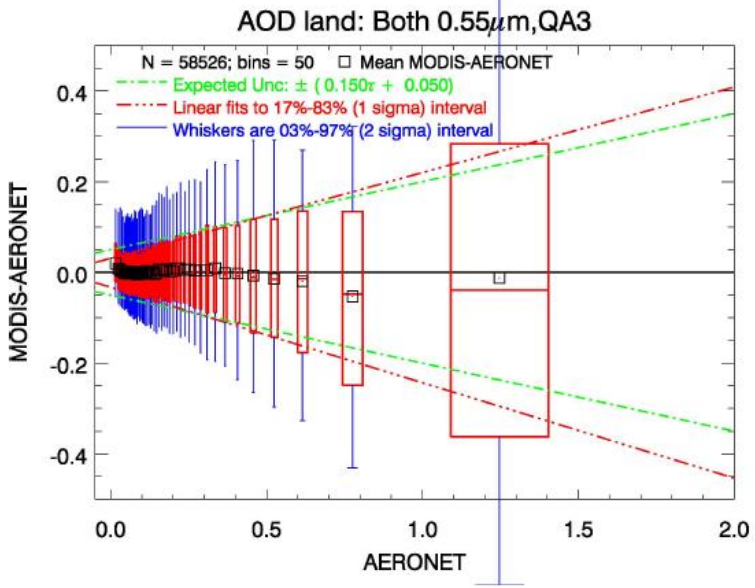
Inverse goodness-of-fit metric



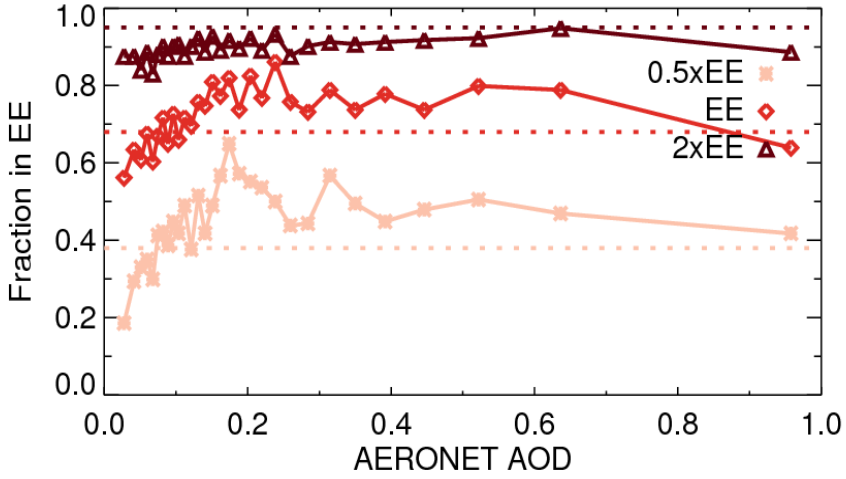
Compliance with uncertainty estimates



Error statistics as function of AOD



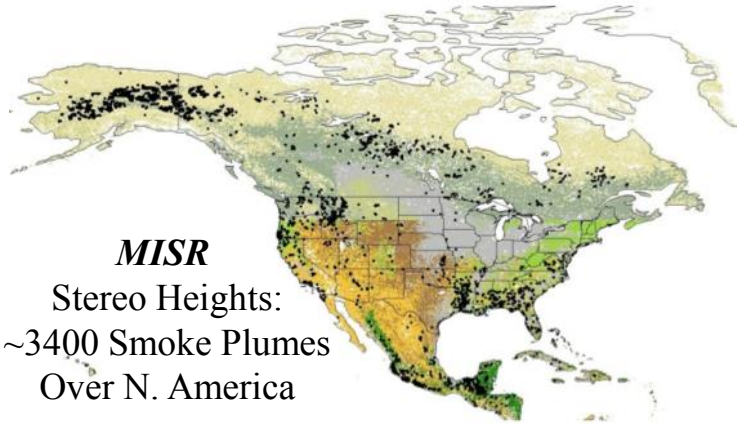
Fraction of pixels within error envelope



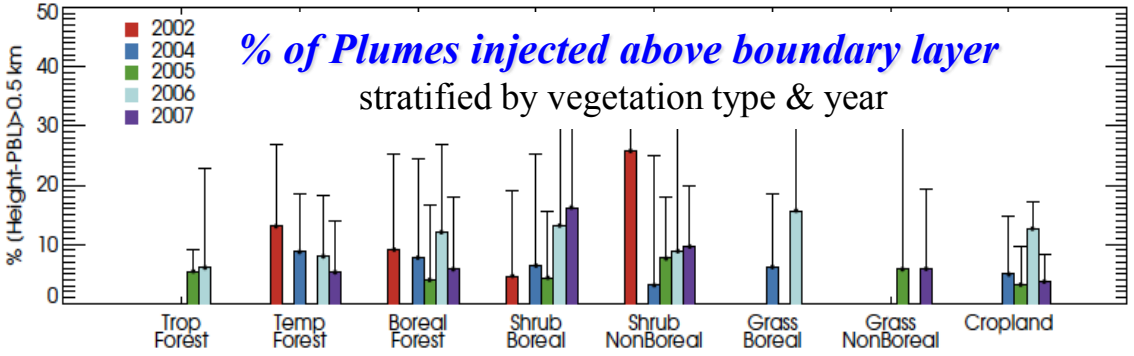
Modified from: Andrew Sayer, AEROSAT 2016 Beijing

Wildfire Smoke *Injection Heights* & *Source Strengths*

[These are *the two key parameters* representing aerosol sources in climate models]

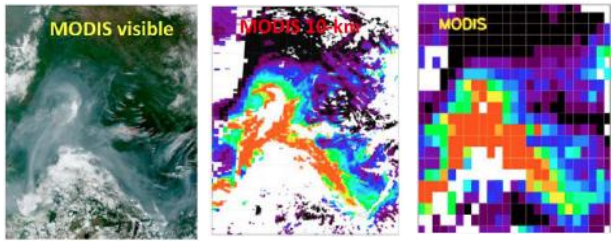


MISR
Stereo Heights:
~3400 Smoke Plumes
Over N. America

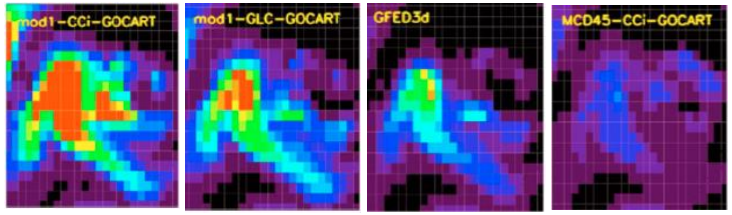


% of Plumes injected above boundary layer
stratified by vegetation type & year

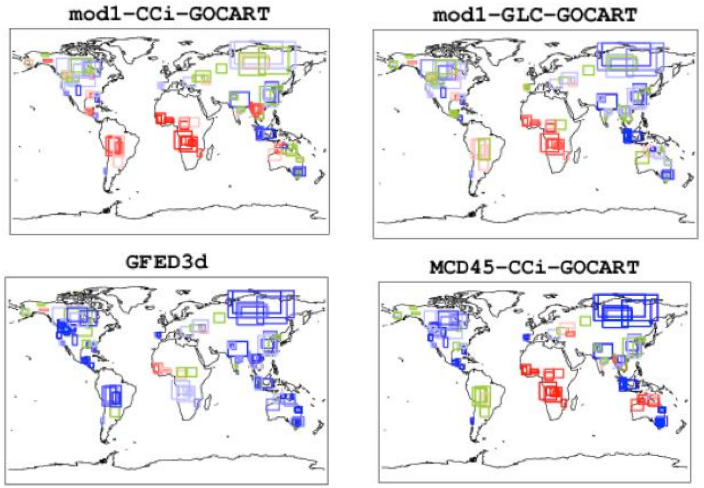
Val Martin et al. ACP 2010, 2012, 2018



MODIS Smoke Plume Image & Aerosol Amount Snapshots



GoCART Model-Simulated Aerosol Amount Snapshots
for *Different Assumed Source Strengths*



Different Techniques for *Assuming Model Source Strength*
Overestimate or ***Underestimate*** Observation
Systematically in Different Regions

Petrenko et al., JGR 2012, 2017, 2018

AeroSat 2017 (last year)

- **Continue *Presentation & Discussion* of Strengths & Limitations**
  - How to document added-value and guide product usage
  - AERONET new version
  - GRASP multi-sensor algorithm
  - SATELLITE – MODEL optics inter-comparison
  - Variables beyond AOD (ANG, Aerosol Type)
  - Validation of pixel-level uncertainties
  - …

- **Discuss new element: Possible AeroSat Experiments**
  - Study sensitivities / spread of results
  - Investigate approaches to ***constraining and/or validating models***
  - Investigate ways to ***add value to satellite products*** for model use
  - Study scientific questions

- **Possibilities for contributing to aerosol-cloud interaction studies**

New AeroSat (and AeroCom) Experiment Task groups (2017)

- ***Aerosol Retrieval Comparison*** [*Kinne, Schuttgens*]

- ***Characterizing retrieval uncertainties*** [*Sayer, Povey, Govaerts, Levy, Patadia, Witek, Kahn, Dubovik, Mei, Rozanov, Thomas, Kolmonen, Stebel, Limbacher, Lyapustin, Popp*]

- ***Joint Remote-Sensing AOD and Type*** [*Kinne, others*]

- Connecting ***model – satellite aerosol type*** [*Mona, Kahn, Tsigaridis*]

- Constraining ***Aerosol Vertical Distribution*** [*Winker, Kahn, Nowotnick, Colarco*]

- ***Consistent multi-sensor trends*** [*Sogachewa, Schulz, Popp*]

- ***CCN new approach*** [*Rosenfeld, Christensen, Bauer, Shanzuka, Stier*]

New AeroSat (and AeroCom) Experiment Task groups (2017)

Task groups should

- Invite other interested colleagues
- Define the experiment
- Start test the core of an experiment with few participants
- Involve more participants when basic concept is mature

- ***Report at AEROSAT 2018***

Experiments

- Are voluntary and unfunded
- Not all progressed as hoped

We need a realistic update of experiment status

ESA ITT for Aerosol CCI+ project (2019-2021) contains small support to experiments / assessments

- Proposal(s) are currently under evaluation

AeroSat Way of Working

Focus on *discussion:*

- Only a few, brief overview presentations invited to stimulate discussion
- Presentations mostly on broader context or new concepts
- Individual work mostly on posters

A key role is therefore given to chairs and rapporteurs

Session chairs are invited to:

- Introduce the session (five minutes, two or three slides) to lay out the key issues
- Keep invited talks strictly to time
- Moderate the discussion, referring to the key issues at times

Rapporteurs are invited to …

- Kindly summarize main ***discussion contributions***

There is no need to report on the talks (those will be added to the website)

AeroSat website (aerosat.org or aero-sat.org)

- Currently in transfer from Simon Pinnock to DLR
- Currently inactive due to pending approval (GDPR)

AeroSat 2018

- **Continue *Discussion* of Strengths & Limitations**
  - Help guide users dealing with larger / multiple datasets
    - Re-activate GEWEX assessment
    - Experiments to compare
    - How to judge / improve consistency?
  - Aerosol type
    - Progress on translation between satellite and modelling worlds

- **AeroSat Experiments**
  - Assess first set of experiments
  - Critical review of what is possible (unfunded)
  - Learn from AEROCOM

- **Possibilities for contributing to aerosol-cloud interaction studies**

- **GCOS statement of guidance / requirements**

Thursday, October 18, 2018

AeroCom / AeroSAT

	SESSION 9	**AeroCom tasks**
9:00 – 10:00	**M. Schulz**	*AeroCom wrap-up and outlook* *Questions / issues for AEROSAT* *Experiments: lessons from AEROCOM for AEROSAT*
10:00 – 10:15	**Introduction to AeroSat 2018**	*Kahn/Popp*
10:15 – 10:45	coffee-break	
		chair: N. Schultgens; *rapporteur:* E. Nowottnick
	SESSION 10	**data and modeling**
10:45 – 11:00	**P. Colarco**	*reflections on modeling needs / integration model + satellite*
11:00 – 11:15	**M. Chin**	AeroCom and ACAM – common interests
11:15 – 12:00	**all**	*AeroCom-AeroSat joint discussion*
12:00 – 12:30	**poster introductions (part 2)** **max 1 ppt slides / 1 minute poster introduction**	*in alphabetical order* *(of those not present on Monday)*
12:30 – 13:30	lunch	
		chair: L. Remer
	SESSION 11	**challenges in remote sensing**
13:30 – 14:00	**H. Liu**	Consistent Algorithm Science Across Multiple Satellite Sensors for AOD Retrieval *(**keynote** - day 4)*
		chair: O. Torres; *rapporteur: M. Lufarelli*
	SESSION 12	**working group on climate records** (high-quality, long-term, consistent)
14:00 – 14:05	**chair**	*introduction, questions*
14:05 – 14:20	**L. Sogacheva**	*merging aerosol optical depth from multiple satellite missions*
14:20 – 14:35	**H. Jethva**	AOD above clouds: 12-year OMI record and others
14:35 – 14:45	**O. Kalashnikova** (remote? tbc)	GCOS aerosol requirements /statement of guidance
14:45 – 15:30	**all**	*discussions* o *Feedback on GCOS requirements and statement of guidance* o *Suitable merging methods* o *Quality assessment*
15:30 – 16:15	extended coffee-break with poster viewing	
		chair: A. Povey; *rapporteur: L. Mei*
	SESSION 13	**working group on pixel uncertainties**
16:15 – 16:20	**chair**	*introduction, questions*
16:20 – 16:35	**A. Sayer**	Characterizing retrieval uncertainties– interim status
16:35 – 16:50	**F. Patadia**	Update on MODIS-DT and other pixel level uncertainties
16:50 - 17:30	**all**	*discussions* o …

Friday, October 19, 2018

Chair: F. Seidel

	SESSION 14	**new opportunities**
9:00 – 9:15	**F. Seidel**	introduction, NASA response to Aerosol 'Designated Observable' in 2017 Earth Science Decadal Survey
9:15 – 9:45	**C. Williamsen**	NASA's *Atmospheric Tomography Mission* (**keynote** - *day 5)*
9:45 – 10:00	**K. Knobelspiesse**	*Aerosol remote sensing with the upcoming NASA PACE mission*

chair: R. Levy; *rapporteur: J. Limbacher*

	SESSION 15	**working group on inter-comparisons**
10:00 – 10:05	**chair**	*introduction, questions*
10:05 – 10:10	**S. Kinne**	GEWEX-GDAP inter-comparisons
10:10 – 10:25	**A. Lipponen**	Can we improve satellite retrievals of Angström exponent over land?
10:25 – 10:55	**all**	*discussions* ○ …
10:55 – 11:15	coffee-break	

chair: G. Schuster; rapporteur: A. Lipponen

	SESSION 16	**working group on aerosol typing**
11:00 – 11:05	**chair**	*introduction, questions*
11:05 – 11:20	**L. Mona**	*connecting model – satellite aerosol type (via remotely connected)*
11:20 – 11:35	**S. Kinne**	*components derived from MAC v2 optics (modal AOD, AAOD, re)*
11:35 – 11.50	**N. Meskhidze**	*global aerosol types for assessment of direct radiative effects*
11:50 – 12:30	**all**	*discussions* ○ *How link aerosol type definitions in models and retrievals* ○ *How best use satellite constraints* ○ *What to use as "ground truth"*
12:30 – 13:30	lunch	

chair: B. Lefer; *rapporteur: Z. Zhang*

	SESSION 17	**focus: aerosol cloud interactions**
13:30 – 13:35	**chair**	*introduction, questions*
13:35 – 13:50	**Y. Shinozuka**	*Satellite-based ACI estimates with refined CCN approximations*
13:50 – 14.05	**G. Luo**	*Droplet number concentrations: GEOS-Chem/CAM vs MODIS retrievals*
14:05 – 15:00	**all**	*discussions* ○ *How best use satellite constraints* ○ *What to use as "ground truth"*

	SESSION 18	**AeroSAT tasks**
15:00 – 16:00	**T. Popp / R. Kahn**	*AeroSAT wrap-up and outlook* *Way forward with AEROSAT experiments*
	all	*Final discussion*