AEROSAT
International Satellite Aerosol Science Network
Second Meeting,
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Introduction

AEROSAT goals (1)

- **make satellite aerosol data as useful as possible to customers, especially climate modelers (e.g., AeroCom)**
- **achieve open and active exchange of information**
  - retrievals and their strengths and limitations
  - match requirements of users to technical capabilities
  - benefit from the latest technological advances
  - standardization (data formats, data standards)
- **Forum for satellite aerosol retrieval experts**
  - learn from each other
  - 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 on climate, climate change, air quality and atmospheric processes
- **Forum with satellite data users** (AEROCOM models, ICAP forecasts) and data providers (AERONET reference, space agencies)
  - listen to their needs and limitations
  - motivate new activities
  - Contribute to integration of all observations

… important for Aerosol_cci international embeding

Goals of the meeting

- Substantiate 5 prioritized working groups
  - Pixel level uncertainties
  - Aerosol satellite product inter-comparisons
  - Aerosol typing
  - Inter-comparisons (model / in-situ / ground-based / satellite)
  - Aerosol climate data records

- focus on discussion
- only short introductory presentations / seed questions
- -> refine current concepts / develop new ideas

Aerosol satellite product inter-comparisons (WG 3)

(introduction / seed questions)

Inter-comparison questions

- Review of existing inter-comparisons

- -> can we identify gaps?
  - What to compare / which focus
  - Which reference datasets
  - Which metrics
  - Which approach (experiments, statistics, sensitivities, information content, synthetic simulations, …)

- Can we define additional meaningful exercise(s)?
  - -> seek funding

Inter-comparison potential gaps

- aerosol properties: fine mode AOD, …
- geostationary (several SEVIRI algorithms; GEO - LEO)
- Climatologies of AOD (and aerosol properties)
- (regional) trends and anomalies (using same time windows, same background period)
- …?

Inter-comparison table (ocean and dust)

publication	variables	method(s)	sensors: VIIRS	SeaWIFS	AVHRR	TOMS	MODIS	MISR	POLDER	AATSR	MERIS	SYNAER	OMI	AIRS	IASI	CALIOP	SEVIRI	period	regions	references
Smirnov, et al. (2011), AMT, 4, 583-597, doi:10.5194/amt-4-583-2011	AOD	Lv2 statistics					x	x										2006-2010 (80 cruises)	Global oceans	MAN
Kinne, S. (2009), edited by A.Kokhanovsky and G. de Leeuw, Springer ISBN: 978-3-540-69396-3	AOD	L3 scoring (various algorithms for one sensor)			x	x	x	x	x									Various multi-annual	Global ocean; regions	AERONET, SKYNET
Myhre, et al., (2005), ACP, 5, 1697-1719, doi:10.5194/acp-5-1697-2005	AOD	Monthly means (various algorithms for one sensor)		x	x	x	x	x				x						Various, 1997-2000 / 8M of 2000	Global oceans; regions	AERONET, campaigns
Sayer, et al., (2012), JGR, 117, D03206, doi:10.1029/2011JD016599	AOD	Lv3		x			x	x		x	x							Multi-year	Global ocean	AERONET
Kahn, et al. (2007)., JGR, 112, D18205, doi:10.1029/2006JD008175.	AOD, ANG, size distribution, refr indices	L2					x	x										2001-2005 case studies	Over-water case studies	AERONET
Carboni, et al. (2012), AMT, 5, 1973-2002, doi:10.5194/amt-5-1973-2012	Dust AOD	L3 statistics (various algorithms for one sensor)															x	March 2006	Saharan Dust Plume	AERONET
Banks, et al. (2013), RSE, 136, 99-116, doi: 10.1016/j.rse.2013.05.003	Dust AOD	Lv2 statistics					x	x							x		x	June 2011	Sahara	AERONET + Fennek campaign (ground, air, lidar)

Inter-comparison table (land)

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								Single cases	Single cases	Simulations

Inter-comparison potential gaps

- aerosol properties: fine mode AOD, AAOD, …
- geostationary (several SEVIRI algorithms; GEO - LEO)
- Climatologies of AOD (and aerosol properties)
- (regional) trends and anomalies (using same time windows, same background period)
- Spatial variability – Dragon campaigns / plume detection frequency/high AOD episodes, pdfs

Aerosol_cci comparisons

Lessons learned and plans

ACCI comparisons

- Improve: Workshops + algorithm experiments (1 month)
  - Optical models, cloud masks, (surface)
  - Post-processing (cloud contamination, bright surface)

Holzer-Popp, et al., AMT 2013

- Select: Round robin exercise (4 months)
  - Best versions for all algorithms

de Leeuw et al., RSE 2013, in press

- Validate: Full ECV products (entire 2008)

Kinne, et al., in preparation

- At all steps application of the same validation tools and statistics
  - Level 2 and level 3
  - Global + regional statistics
  - Scoring (spatial / temporal correlation)
  - Against AERONET / MAN + MODIS / MISR / CALIPSO

ACCI experiences

- Improvement achieved by
  - working groups, algorithm experiments, iterated validation
- Level / amount of analysis needed
  - 4 months (all seasons) global analysis sufficient (equals 12 months)
  - Lv3 (AEROCOM grid) results overall similar to lv2
- Limited coverage of reference data
  - Oceans, Southern hemisphere, near clouds
  - Aerosol properties for low AOD (all inversions)
- Filters matter
  - Common points - “fair” comparison
  - All points – deserves separate focus (coverage, difficult cases)
  - Land / ocean / coast / regions / seasons
    - needed for problem identification

ACCI plans (- 2017)

- Round robin comparison 4 IASI "dust AOD" algorithms
  - "Greater Sahara" region / 1 year
- Fine mode AOD, dust AOD from AATSR, …
- Use POLDER / GRASP as "quasi-reference"
  - 4 diagnostic sites (1200 x 1200 km^2) with few AERONET
  - land regimes (biomass burning, dust, pollution), oceans
- Suggested optional round robin exercises of pathfinder algorithms responding to user needs
  - AAOD (glint, mixing fractions, AAI)
  - Layer height (O2A, IASI spectra)
  - MERIS algorithms

GCOS requirements

variable	resolution			accuracy	Stability [/ decade]
	Horizontal [km]	Vertical [km]	Temporal		
Aerosol optical depth (column)	5-10	N / A	4 h	Max (0.03; 10%)	0.01
Single scattering albedo (column)	5-10	N / A	4 h	0.03	0.01
Aerosol layer height	5-10	N / A	4 h	1 km	0.5 km
Aerosol extinction coefficient (profile)	200-500	1k (~10km) 2k (~30km)	1 week	10%	20%

Aerosol typing
(WG 5)

Introduction / seed questions

(with Lucia Mona / WG lead)

Aerosol type

- … is a categorial / qualitative variable
- … is input needed for (ill-posed) retrievals / affects accuracy (AOD …)
- … is estimated from ground-based data (sampling!) and model climatologies
- … is output from retrievals to some extent (AERONET, satellite)
- Different instruments
  - … need different definitions
  - … have different / limited information content for aerosol type

Aerosol typing

Aerosol typing procedures differ in many aspects:

- approach
- nomenclature (e.g. same name for different definitions)
- assumed number of components (e.g. TOMS: 3 – MISR: 74)

- parameters used for the classification
  - Particle size
  - Particle shape
  - Absorbing properties
  - Aerosol load
  - Location
  - Seasonal behavior

- approach
  - by source (e.g. dust, sulfates)
  - by optical properties (e.g. aspherical, absorbing)

Examples

MODIS

Fine (<1μm)

Coarse (>1μm)

WEAKLY ABSORBING	MODERATL Y ABSORBING	STRONGLY ABSORBING	COARS E

CALIPSO

non-depolarizing

depolarizing

high aerosol content

POLLUTED CONTINENT AL	SMOKE

small aerosol content

CLEAN MARIN	CLEAN CONTINENT AL

over the Sea

more

less

DUST	POLLU TED

Questions?

What is needed?

- review of aerosol typing assumptions
- harmonization of the nomenclatures
- harmonization of the procedures

→ Long-term perspectives (WG2)
Validation (WG3)
Improved accuracy(WG4)

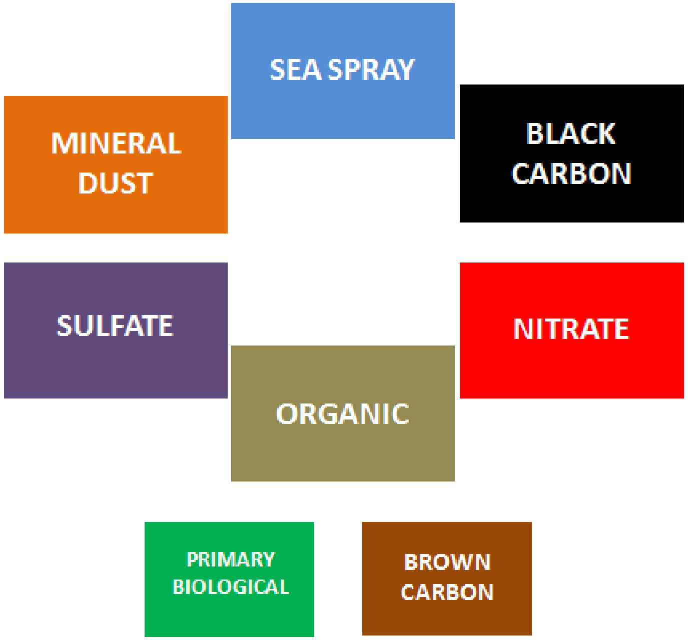
Can / we find one overarching nomenclature?
Do we see a need / benefit in it?

Critical points

- how realistic is an overarching common definition of aerosol types?

- GB communities (e.g. AERONET, EARLINET, in situ) also have different procedures for the typing, even in the same network

- the 2013 IPCC report classification mainly relies on near-surface typing



Simple aerosol typing in Aerosol_cci

Simple concept

- 4 basic components
- Reflects theoretical information content
- External mixtures with 3 mixing fractions
- Evaluation ongoing of information content

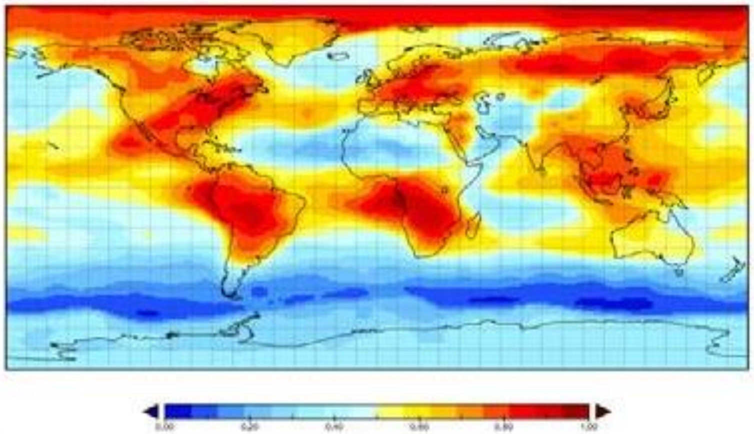
- Output (easier to validate / compare)
  - Fine mode AOD (fine mode / total mixing fraction)
  - Dust AOD (dust / total coarse mode mixing fraction)
  - [AAOD (absorption fraction in fine mode)]

4 aerosol components

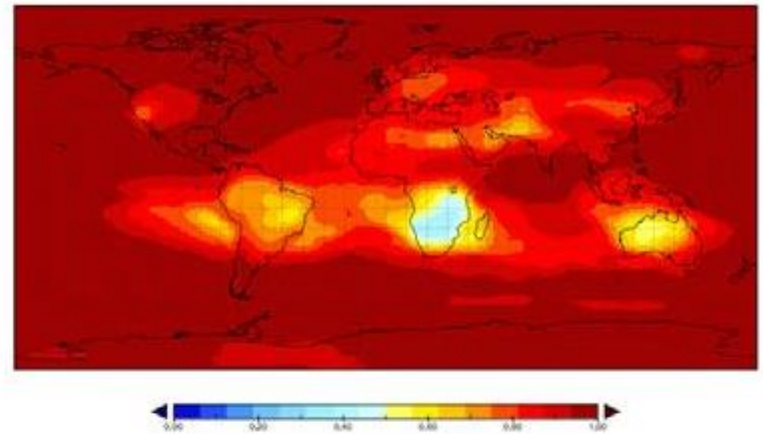
aerosol component	Refr. index, real part (55µm)	Refr. Index, imag part (.55µm)	reff (µm)	geom. st dev (σ_i)	variance (ln σ_i)	mode. radius (µm)	comments	aerosol layer height
Dust	1.56	0.0018	1.94	1.822	0.6	0.788	non-spherical	2-4km
sea salt	1.4	0	1.94	1.822	0.6	0.788	AOD threshold constraint	0-1 km
fine mode weak-abs	1.4	0.003	0.140	1.7	0.53	0.07	(ss-albedo at 0.55 µm: 0.98)	0-2 km
fine mode strong-abs	1.5	0.040	0.140	1.7	0.53	0.07	(ss-albedo at 0.55 µm: 0.802)	0-2 km

AOD mixing (fractions) from AEROCOM

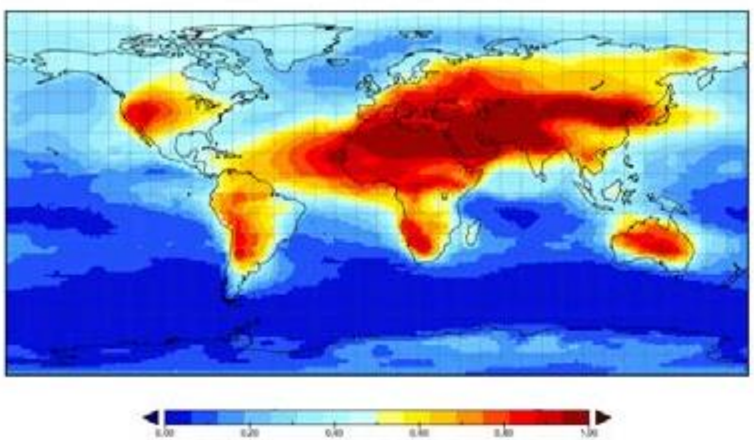
Fine mode fraction



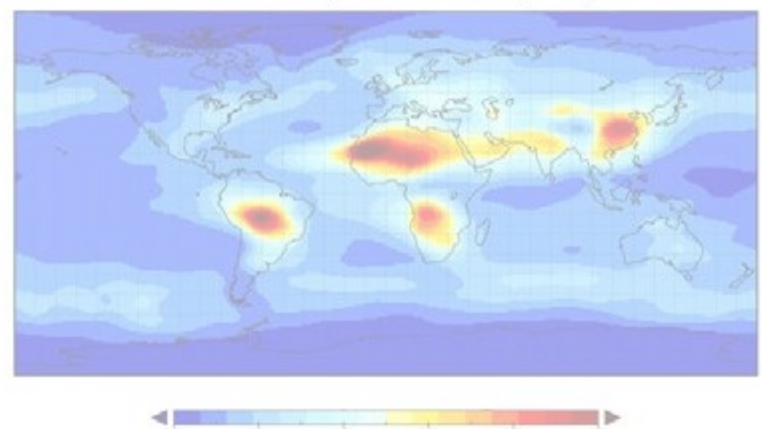
Fraction of the less absorbing component in the fine mode



Fraction of dust in the coarse mode

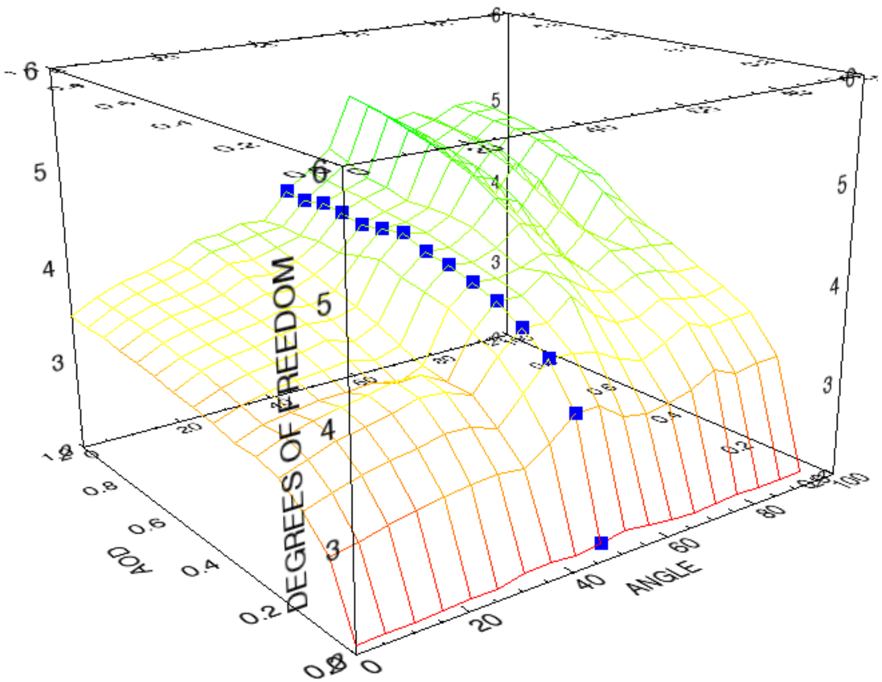


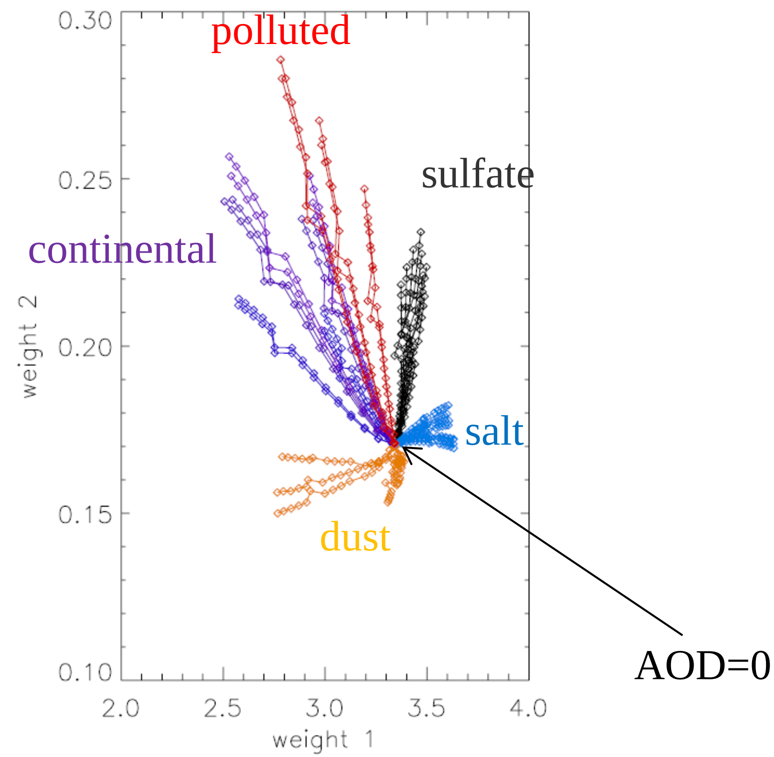
AOD550 (not used as a priori)



Information content analysis (SYNAER/SCIA)

A tool to identify systematically strengths and limitations





DOF as f(AOD, θ_0)

PCA weights a and 2

Comparing satellite to other datasets

lessons learned in Aerosol_cci

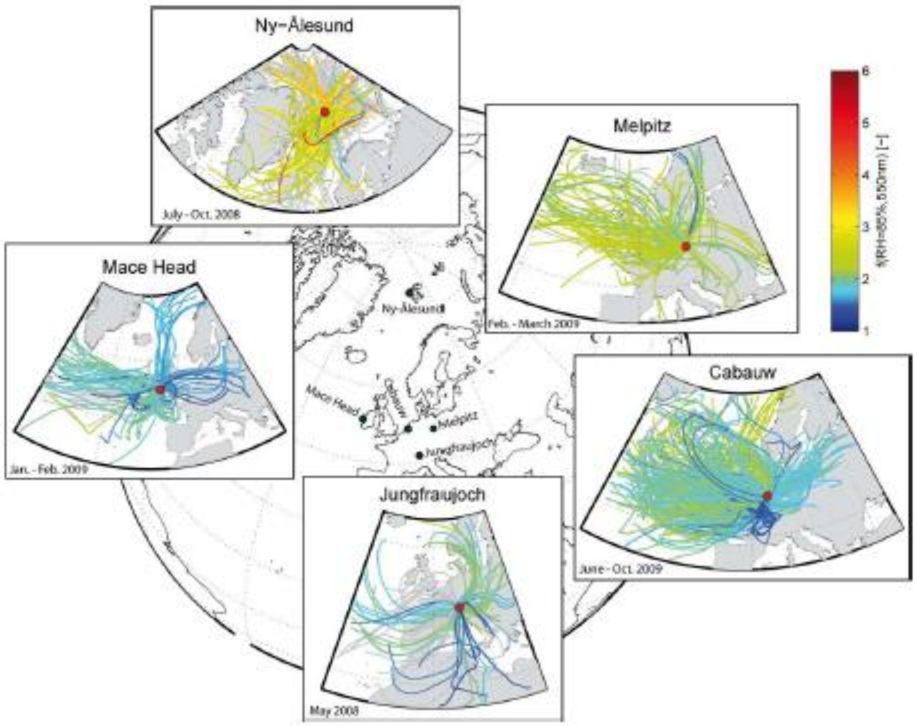
Can we use in situ data for satellite validation?

- Why?
  - AERONET inversions have assumptions
  - In situ can tie to SI standards / understand biases
  - Joint view can help understand statistics / relevance of biases

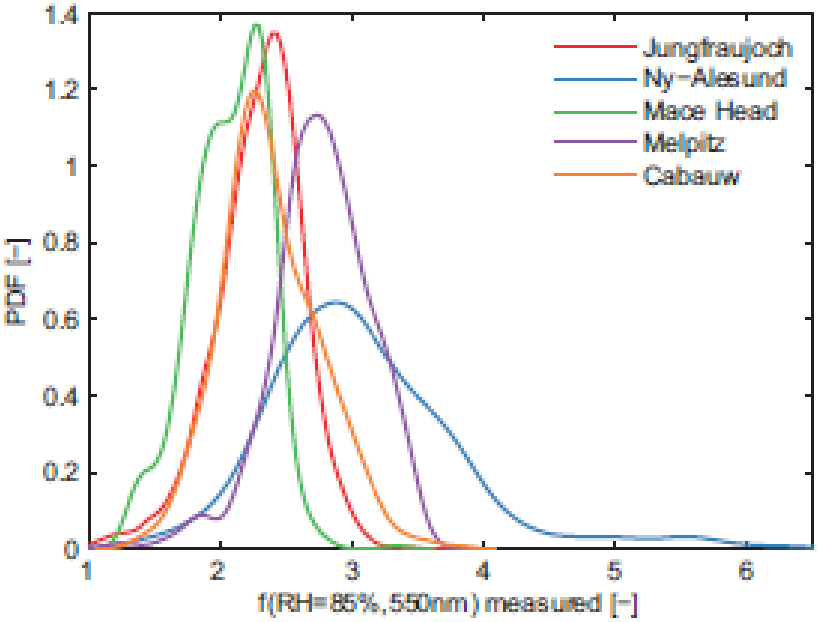
- Why is it difficult?
  - Problems of closure: vertical, hygroscopicity

- Suggested approaches (M. Fiebig)
  - extensive campaigns
    - Which parameters? Representativity?
  - High-resolution chemical transport model
    - Which requirements? Correlation lengths?

Issues
for use of in situ data

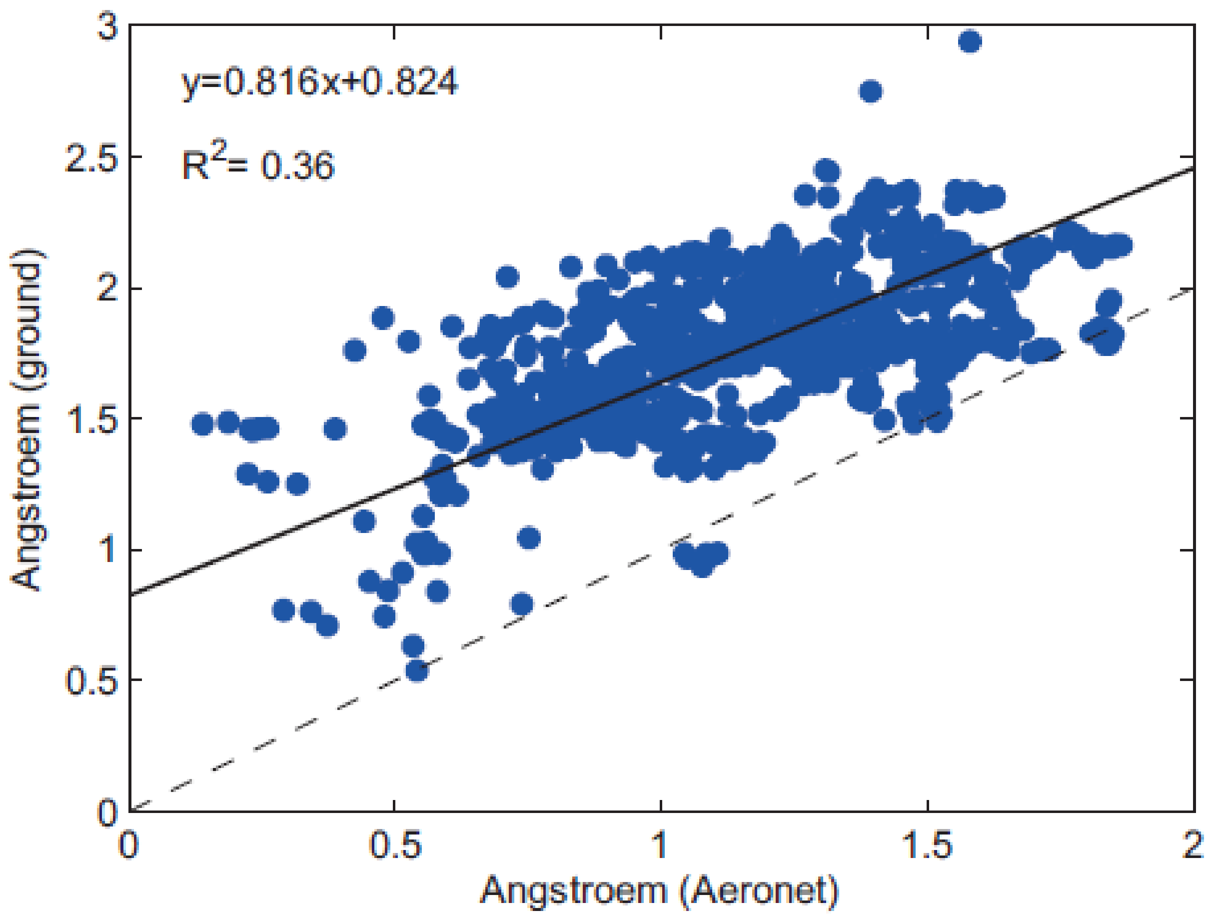


72hr trajectories; colours f(85%)

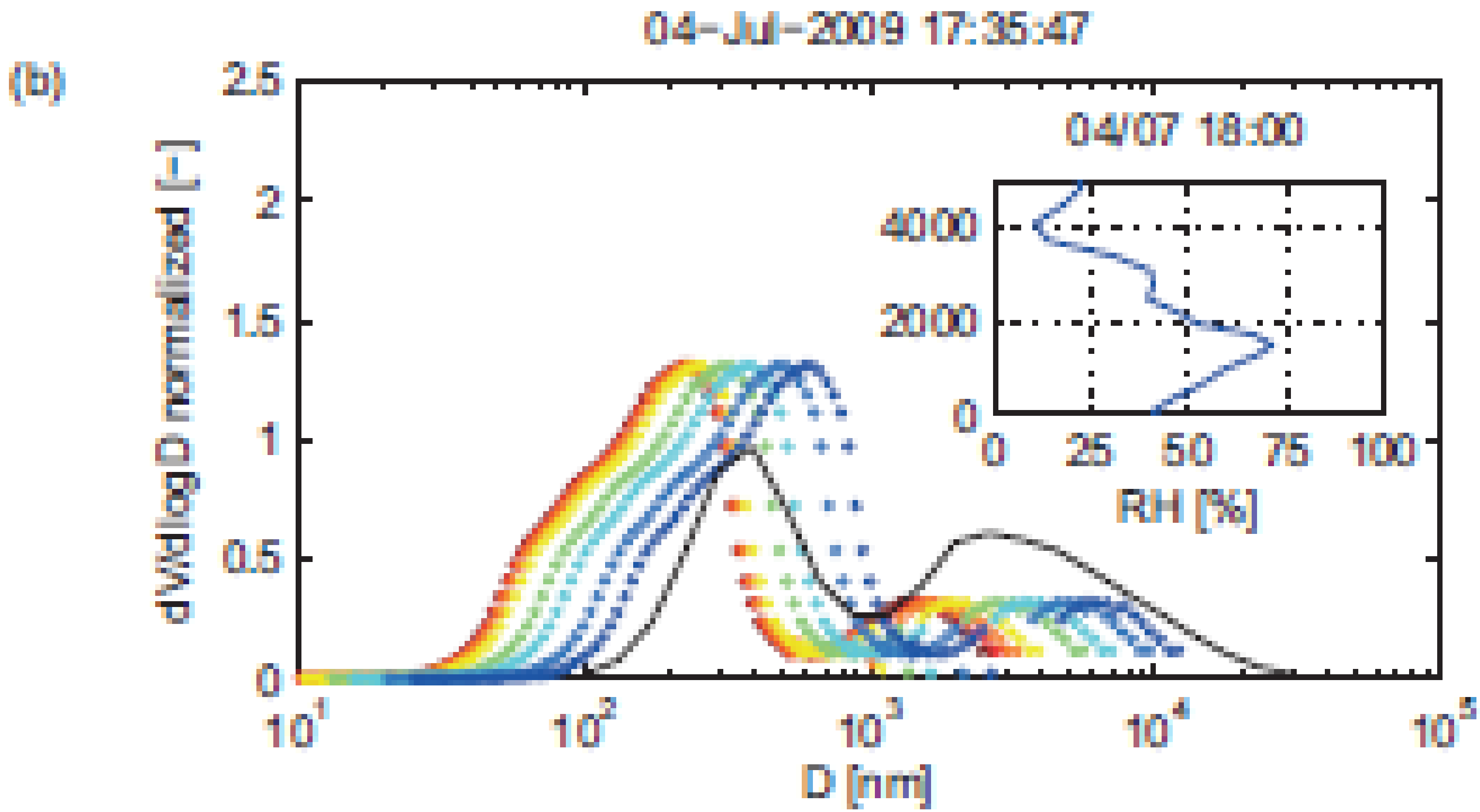


Pdfs of f(85%) for 5 stations
-> 40% uncertainty

Issues for use of in situ data



Issues for use of in situ data



AERONET (black) vs in situ for different RH