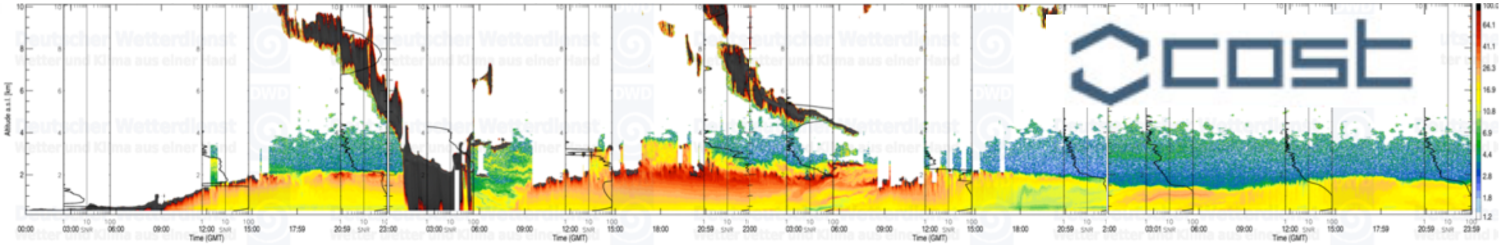


TO-PROF EU COST ACTION (ES-1303)

AUTOMATIC LIDARS & CEILOMETERS (ALC)
WG1

Martial Haeffelin, WG chair (IPSL); Ina Mattis, WG co-chair (DWD)

(TOPROF Objective 1) To implement a harmonized ALC network

(TOPROF Objective 2) To evaluate the backscatter profiles predicted by NWP

(TOPROF Objective 3) To set up a system to monitor aerosol properties, mixing height, low visibility alerts

4 September 2017
EMS Dublin

OUTLINE

Objective 1: To implement a harmonized ALC network
- Quick update on E-PROFILE ALC network status - M. Hervo
- Report on ALC errors and uncertainties (SWG) - I. Mattis

Objective 2: To evaluate the backscatter profiles predicted by NWP
- Report on DA of ALC in operational NWP (SWG) - M. Haeffelin
- Report on ALC DA at ECMWF (STSM) - M. Hervo

Objective 3: To set up a system to monitor aerosol properties, mixing height, low visibility alerts
- Report on ABL review (SWG) - J-A. Bravo
- Update on ABL Height retrievals – S. Kotthaus
- Short update on aerosol properties retrievals – B. Heese; G-P. Gobbi
- Short update on fog warning using ALC - M. Haeffelin

E-PROFILE PROGRAM

Maxime HERVO
Meteoswiss

RAW2L1 UPDATES

https://sourcesup.renater.fr/frs/?group_id=1869

- Now in version 2.1.19 (2.1.4 in june 2016)
- Correct bugs detected by e-profile
  - CHM15k
    - Calculation of rcs (background is not substracted anymore)
    - Bug with new firmware version 0.747
    - Cloud offset
  - CL31/CL51
    - Add variable *vertical visibility*
    - Bug with CLH and CBH conversion into meter
  - CS135
    - Add variables *vertical visibility* and *highest signal received*
- New readers
  - SigmaSpace MiniMPL
  - Leosphere WLS70 and WLS7 v2 1 minute and 10 minutes text files
  - RPG hatpro
  - Reader for LICEL data format (experimental)

ALC MEASUREMENT UNCERTAINTIES

Ina MATTIS
DWD

SWG in Payerne, March 2017

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

SWG Meeting
Errors and uncertainties of aerosol profiling with ALCs

14-16 March 2017, Payerne

Ina Mattis

23 Participants

- I. Mattis, M.Pattantyús-Ábrahám *(DWD Hohenpeißenberg)*
- M. Haeffelin (*IPSL*)
- M. Hervo (*EPROFILE, Meteo Swiss*)
- A. Haefele, G. Martucci, Y. Poltera, D. Ruffieux, M. CollandCoen, J. Varin (*Meteo Swiss*)
- M. Wiegner (*LMU Munich*)
- E. Hopkin, S. Kotthaus, A. Illingworth (U *Reading*)
- F. Wagner (*KIT Karlsruhe*)
- A. Cazorla (*University Granada*)
- H. Diemoz (*ARPA Valle d'Aosta*)
- D. Dionisi (*CNR ISAC, Italy*)
- S. Egert (*Israel*)
- M. Brettle (*Campbell Scientific*)
- C. Münkel, R. Keranen, R Roininen (*Vaisala*)

12 of them with COST travel support

Objective

Summary of all uncertainties and systematic effects
➔ which influence the accuracy of aerosol profiles
➔ which are retrieved in an automated way
➔ from automated lidars and ceilometers (ALC)
➔ in the framework of E-PROFILE and TOPROF
➔

For all effects and uncertainties:
Tables with a formalized description of the
➔ nature,
➔ Strength
➔ methods for correction

Topics

- ➔ Uncertainties of 'raw' data
  - ➔ Water vapor absorption
  - ➔ Near-range effects
  - ➔ Overlap issues
  - ➔ Signal artifacts in free troposphere
- ➔ Uncertainties of cloud calibration
  - ➔ Multiple scattering
  - ➔ Water vapor absorption
  - ➔ Signal saturation
  - ➔ Contributions from aerosols below cloud / signal artifacts in free troposphere
- ➔ Uncertainties of Rayleigh calibration
  - ➔ Correction of atmospheric transmission due to aerosols (lidar ratio assumption)
  - ➔ Temperature
  - ➔ Noise
- ➔ Extrapolation of past calibrations to the actual measurement
- ➔ Uncertainties of backscatter, extinction and volume concentrations

Example

(Davide Dionisi, Henri Diémoz)

Uncertainties of
particle extinction coefficients and
volume concentration
caused by lidar ratio assumption

	With known aerosol type	Aerosol type unknown
Affected instrument types	all	
Affected altitude range	all	
Systematic error	The results depend on the aerosol type => site-dependent	
Statistical error	30-35%	40%-50%
Can be corrected	Any previous a-priori characterization of the aerosol can be used to constrain the aerosol type simulated in the model to improve the accuracy of the method	
Uncertainty of correction		
Methods for quantification	Comparison to OPCs, better NOT at ground (e.g., Jungfraujoch) or tilted installation, tethered balloon	
references	Barnaba and Gobbi, 2001 and 2004 (532 nm) Dionisi et al., 2015 (1064 nm, continental) Dionisi et al., 2017 (in preparation) Davide's STSM report Diémoz et al., 2017 (in preparation)	

Achievements: summary tables for most common types

CHM15k version > 0.7*	
Altitude [km]	
0-0.2[11]	
0.2-0.5[12]	
0.5-1.2[13]	
1.2-15	

[3] with correction of aerosol transmission
[4] in case of backward integration at 1064 nm
[5] In case of unknown aerosol type
[6] use overlap function as provided from manufacturer
[7] Use correction of overlap function as described by Hervo and Poltera
[8] Use temperature dependent correction of overlap function as described by Hervo and Poltera
[9] after correction of the temperature dependency, relevant only for version 0.5* with not fixed Temperature option
[10] for measurements where Tlom is not constant
[11] where ovl function is smaller than 0.05
[12] where ovl function is smaller than 0.8
[13] where ovl function is larger than 0.8, but not equal 1

Achievements: summary tables for most common types

CHM15k version > 0.7*													
Altitude [km]	Attenuated bsc									Bsc coef	Ext coef	Mass concentr.	
	overlap			Rayleigh calibration[3]					noise	Ir[4 5]	Ir[5]	Bsc-vol-ratio[5]	density[5]
	No corr[6]	corr[7]	Corr with T[8]	Ir	noise	T[9]	Interpo-lation						
							temp[10]	all					
0-0.2[11]	Do nor use data for aerosol profiling												
0.2-0.5[12]	±50%	±25%	±5%										)%
0.5-1.2[13]	±10%	0%	0%										)%
1.2-15	0%	0%	0%										)%

[3] with correction of aerosol transmission
[4] in case of backward integration at 1064 nm
[5] In case of unknown aerosol type
[6] use overlap function as provided from manufactur
[7] Use correction of overlap function as described by [illegible]
[8] Use temperature dependent correction of overlap function as described by Hervo and Poltera
[9] after correction of the temperature dependency, relevant only for version 0.5* with not fixed Temperature option
[10] for measurements where Tlom is not constant
[11] where ovl function is smaller than 0.05
[12] where ovl function is smaller than 0.8
[13] where ovl function is larger than 0.8, but not equal 1

Similar tables for CL31 and CL51

For details see scientific report

Publish results in a paper

Achievements: summary tables for most common types

CL51[14]											
Altitude [km]	Attenuated bsc[15]										
	ovl[16]	NR effect[17]	WV absorption		Background profile[18]		Cloud calibration				noise
			no corr	With corr	no corr	With corr	Mult scat[19]	Aerosol below cloud[20]	WV[21]	Extr apol.	
0-0.12	>±20%	±20%	≥5%	±1%	0	0	±5%	-5 ..0%	±2%	±5%	Calc from std dev
0.12-0.5	0..20%	0%	≥5%	±2%	0	0	±5%	-5 ..0%	±2%	±5%	
0.5-14.8	0%	0%	≥50%	±5%	2E-7 $m^{-1}sr^{-1}$	5E-8 $m^{-1}sr^{-1}$	±5%	-5 ..0%	±2%	±5%	

for details see scientific report

Achievements: summary tables for most common types

CL31[14]											
Altitude [km]	Attenuated bsc[15]										
	ovl[16]	NR effect[17]	WV absorption		Background profile[18]		Cloud calibration				noise
			no corr	With corr	no corr	With corr	Mult scat[19]	Aerosol below cloud[20]	WV[21]	Extr apol.	
0-0.09	>±20%	±20%	≥5%	±1%	0	0	±5%	-5 ..0%	±2%	±5%	Calc from std dev
0.09-0.5	0..20%	0%	≥5%	±2%	0	0	±5%	-5 ..0%	±2%	±5%	
0.5-7	0%	0%	≥50%	±5%	2E-7 $m^{-1}sr^{-1}$	5E-8 $m^{-1}sr^{-1}$	±5%	-5 ..0%	±2%	±5%	

for details see
scientific report

ASSIMILATION & MODEL VERIFICATION

Martial HAEFFELIN,
IPSL

SWG in Paris, December 2016

Evaluation and Data Assimilation in Atmospheric Models using Automatic-Lidar-and-Ceilometer Measurements

21 participants (ECMWF, Met Office, DWD, Meteoswiss, Meteo-France, ARPA, IPSL, CNR, DTU, U. Granada, U. Reading, NIMH)

- Assimilating Attenuated Backscatter vs Backscatter coefficient vs Extinction coefficient
- Simulating attenuated backscatter based on model output also requires assumptions to be made in the forward model

- Different approaches exist for Aerosol forward modelling. Depend on the aerosol description in the model inputs.
- Parametrisations vs Mie calculations and look-up tables
- Hygroscopic growth is non trivial
- Should we move to a general, community forward operator ?

- Standardized calibrated attenuated backscatter profiles as provided by E-PROFILE is significant improvement to continuous access to ALC data
- Depolarization measurements would be an added value to constrain LR

MODEL VERIFICATION

Maxime HERVO,
Meteoswiss

STSM in Reading, May 2017

→ Open other PPTX

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

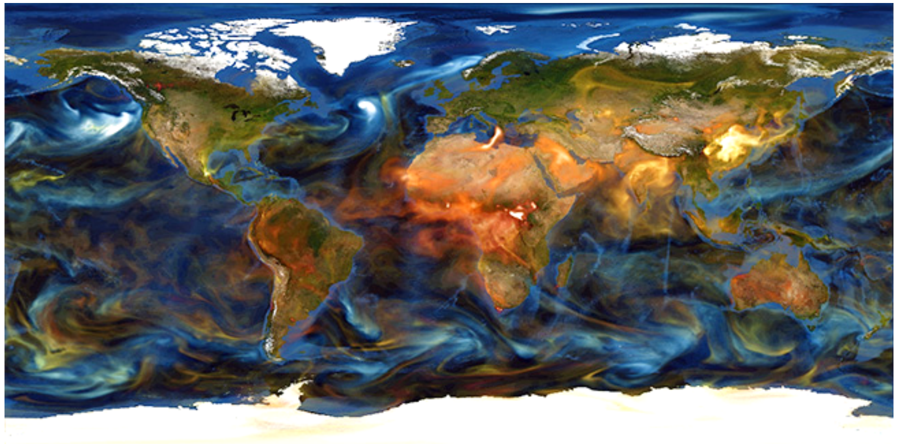
Swiss Confederation

Federal Department of Home Affairs FDHA
Federal Office of Meteorology and Climatology MeteoSwiss

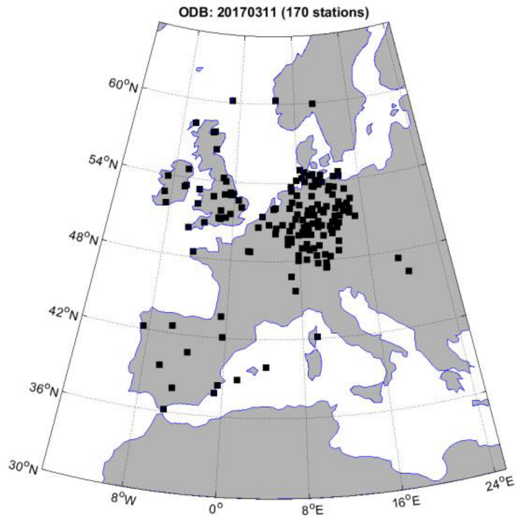
Short Term Scientific Mission: Assimilation of aerosol profiles measured by E-PROFILE ceilometer network in ECMWF C-IFS model

Maxime Hervo To Julie Letertre-Danczak (ECMWF)

The plan
Assimilating 170 stations for a Dust Event



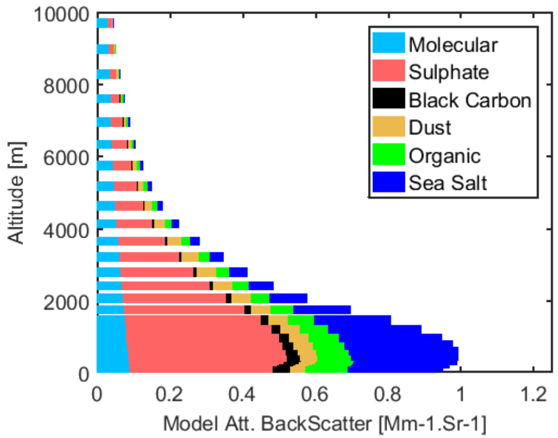
CAMS Model
State of the art aerosol forecast

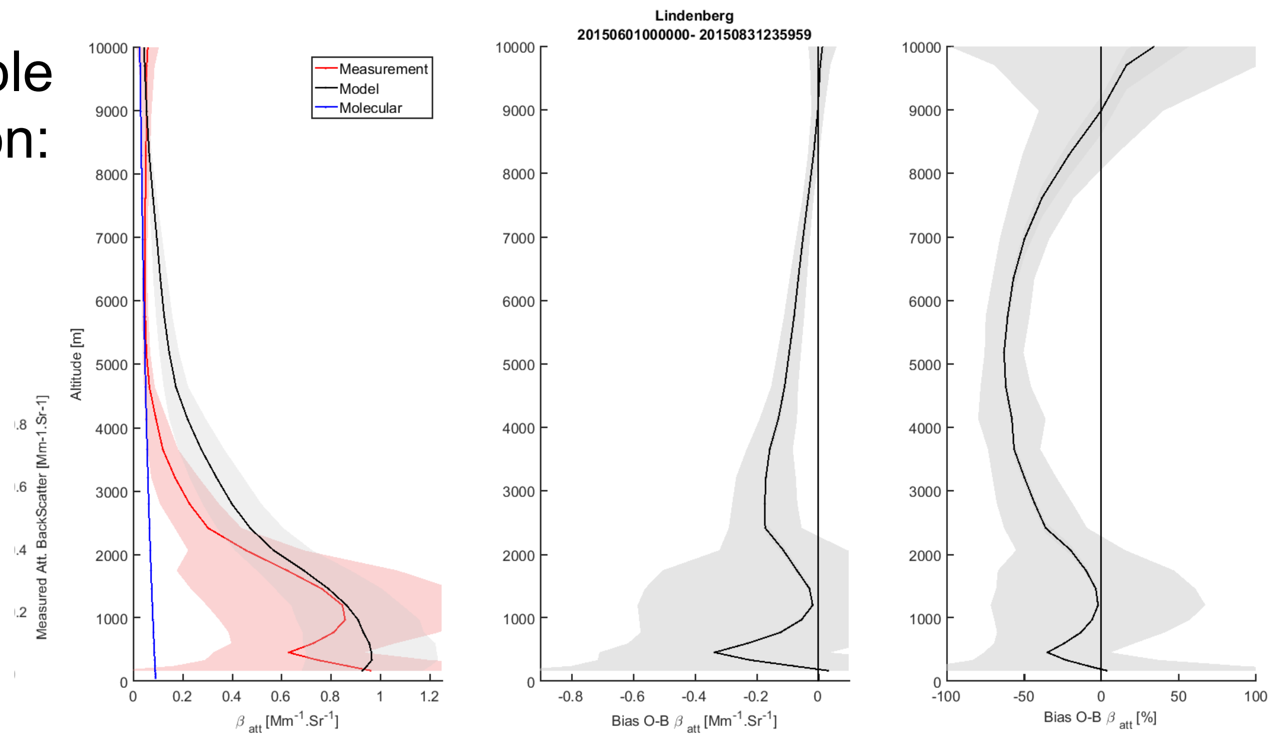


E-PROFILE
European ALC network

O – B: Statistics

- Bias < 50%
- Overlap artefact visible
- Model over-estimation:
  - FT: Sulfate

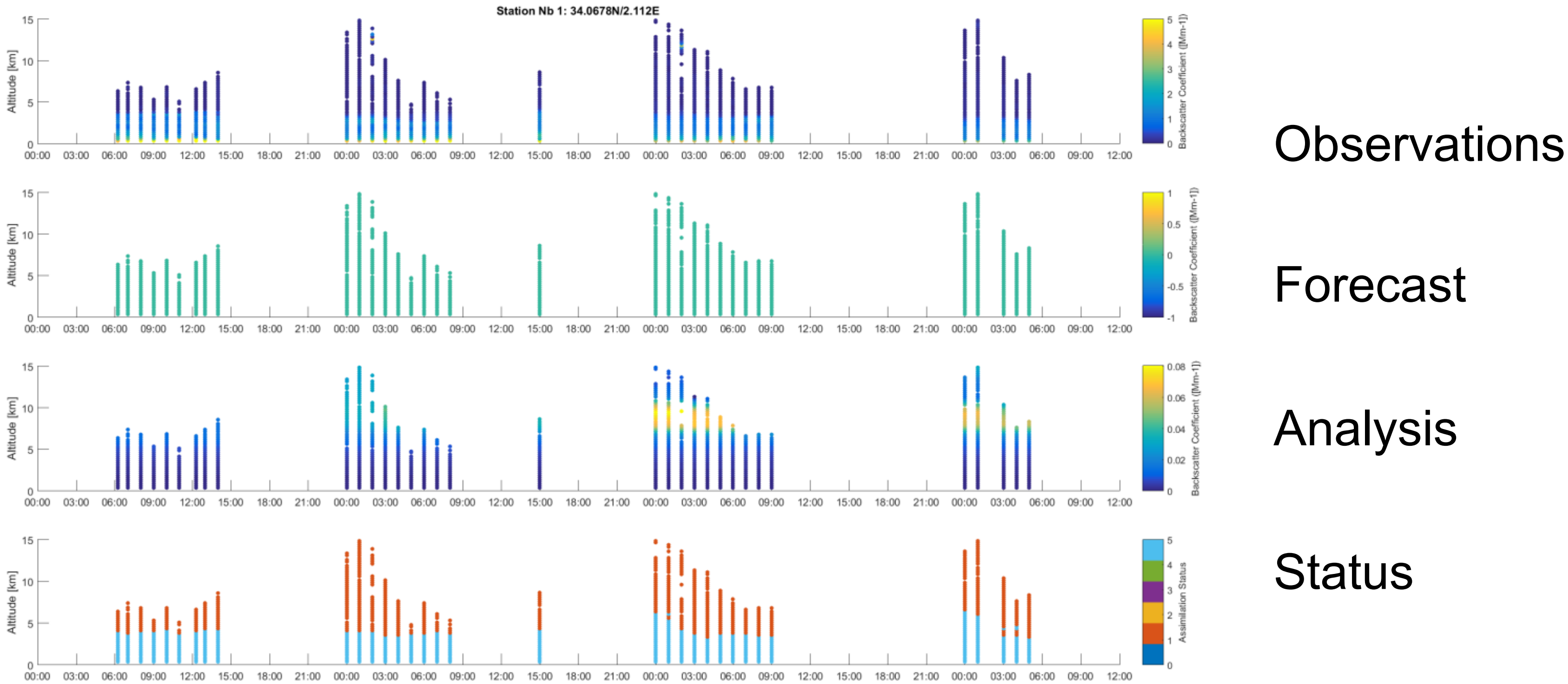




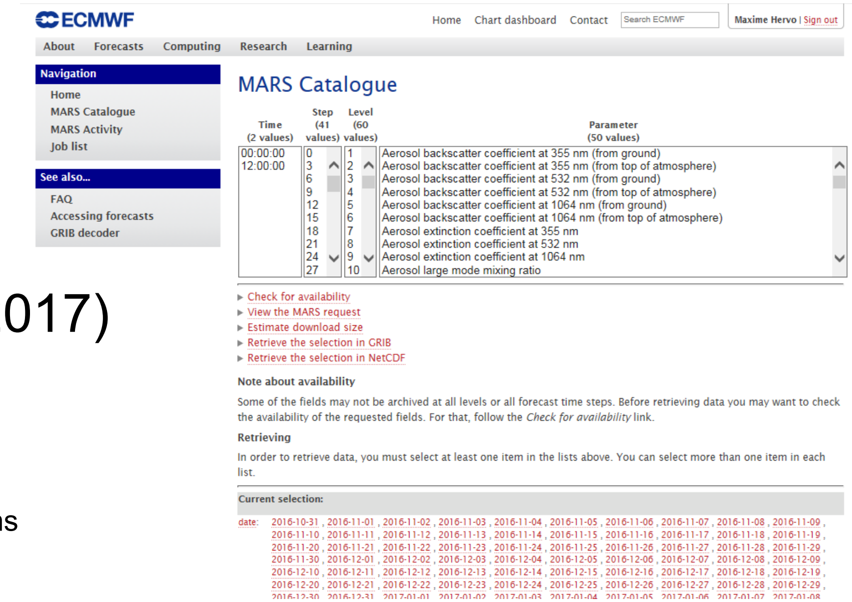
Challenges

- IFS is a complex forecast weather forecast
- CAMS is a complex aerosol model
  - Complex DA acquisition
  - Complex lidar forward operator
- Handling 100 Ceilometers is … complex

The result


Station Nb 1: 34.0678N/2.112E
Altitude [km]
Backscatter Coefficient ([Mm-1])
Assimilation Status
Observations
Forecast
Analysis
Status

Outlook



- Aerosol scheme modification (09/2017)
  - So2 conversion,
  - Sea Salt sedimentation

https://atmosphere.copernicus.eu/implementation-ifs-cycle-43r3cams

- Lidar Forward Operator now implemented operationally at ECMWF
  - Benedetti 2009
  - Can be downloaded from ECMWF website

ABL HEIGHT REVIEW

Juan-Antonio Bravo Aranda,
IPSL

SWG in Paris, April 2017
Involving WG1, 2, 3

Motivation

State of the art

- Advances on the last years concerning BL parameter observations:
  - Relevant increase on **networking capabilities**
  - more sensitivity, more resolution, more parameters, more spatial coverage ⇒ **more confusing**
- Increase of end-user demand: specifically on NWP (Numerical Weather Prediction), CTMs (chemical transport models) and air quality
- Last review on 2008 (Seibert et al., 2000 and Emeis et al., 2008)

Why do we need this publication?

Highlight new networking capabilities

Need for **clarification**

Need for **harmonization** (convergence of concepts between experts and end-users)

10 years from the last review paper on this topic

Manuscript section

1. Introduction
2. Definitions of the Atmospheric Boundary Layer and sublayers
3. Methodological achievements / ABL retrieval methods
4. Instrument-type intercomparison
5. Instrument synergy
6. ABL climatology
7. Model evaluation

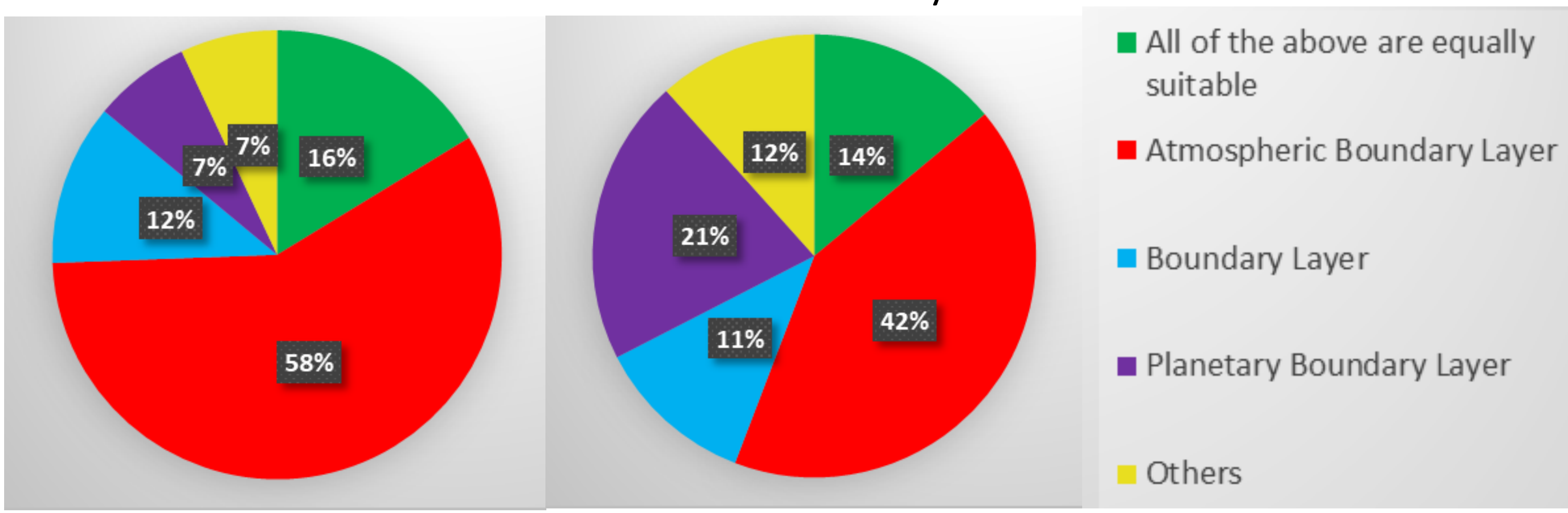
2. Definitions

DEFINITION A: 'The part of the troposphere that is directly or indirectly influenced by the Earth's surface (land and sea), and responds to gases and aerosol particles emitted at the Earth's surface and to surface forcing at time scales of hours. Forcing mechanisms include heat transfer, frictional drag and terrain-induced flow modification.'

Which label most accurately describes the layer referred to by DEFINITION A above?

In **your opinion**

In your **community** or field of activity



ABL dominates in the individual/community responses (convergence is possible!)
PBL also large community use, but less on individual level

ABL HEIGHT RETRIEVALS

Simone KOTTHAUS,
IPSL

ABL algorithm development

STRAT-2D, STRAT+, Haeffelin et al. (2011), Pal et al. (2013)

PathfinderTURB, Poltera et al. (2017)

Similarities

Combination of gradient & variance fields

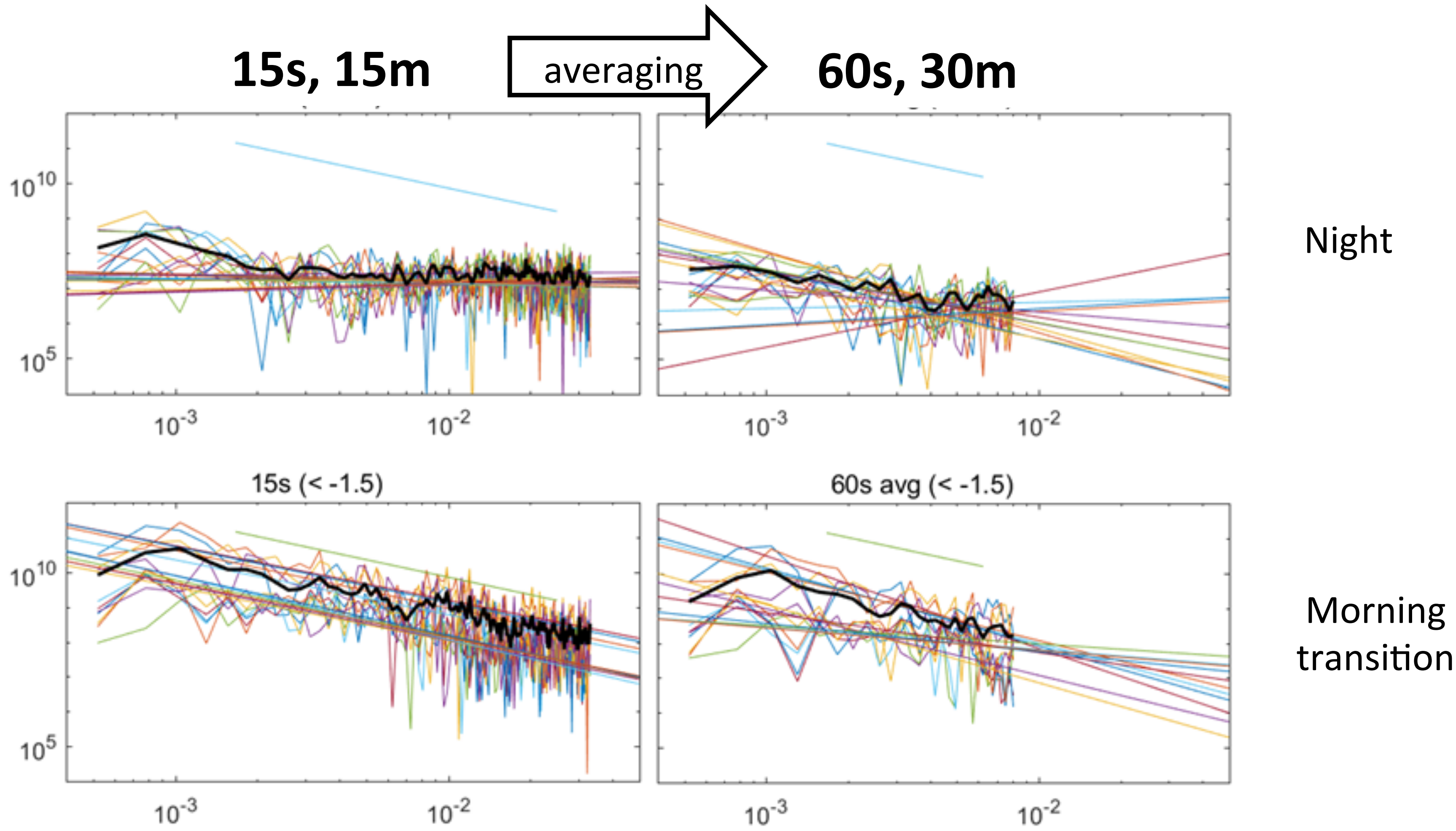
Limits set based on climatology (max & GR) and CBH

Differences

STRAT-2D, STRAT+		PathfinderTURB
frequency	**Low-pass filter**	power
atmospheric	**Variance**	atmospheric/total
24h	**Layer**	daytime
More time-specific	**Limits**	Patterns of +/- gradients, turbfit (spectral slope)
Select gradient guided by variance	**Tracing**	Shortest past through weights (grad + variance)

STRATfinder

Variance & temporal resolution



→ β shows turbulent behaviour of inertial sub-range consistently during morning transition

→ Variance calculation should be performed on highest available resolution

ABL algorithm development

STRAT-2D, STRAT+, Haeffelin et al. (2011), Pal et al. (2013)

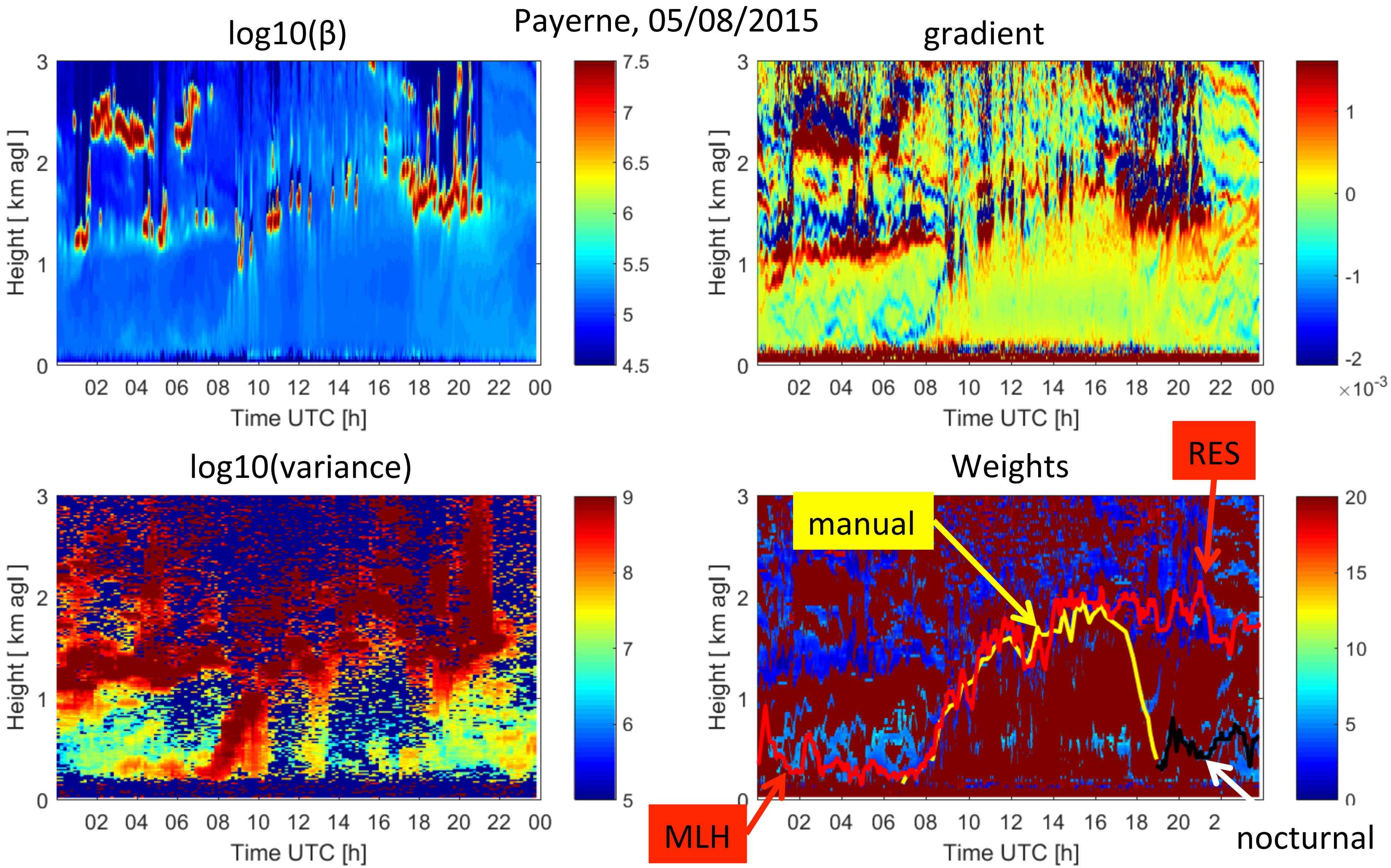
PathfinderTURB, Poltera et al. (2017)

frequency	**Low-pass filter**	power
atmospheric	**Variance**	atmospheric/total
24h	**Layer**	daytime
More time-specific	**Limits**	Patterns of +/- gradients, turbfit (spectral slope)
Select gradient guided by variance	**Tracing**	Shortest past through weights (grad + variance)

Trace mixing layer + residual layer → full ABL

STRATfinder

STRATfinder



Outlook

1) Finalise STRATfinder by end of 2017
   - Use pre-processed data from E-PROFILE hub (overlap correction, calibration, …)
   - Apply to PAY and SIRTA long-term observations
   - Evaluate against references (manual detection, radiosonde)
2) Implement **operational, near real-time ABLH detection** for **E-PROFILE / ICOS** at sites running Lufft CHM15K
3) Expand to other high-power Vaisala CL51
   - Evaluate feasibility (e.g. variance fields)
   - Address instrument-specific issues (overlap, near-range artefacts, instrument background noise, etc.)
4) Expand to low-power Vaisala CL31
   - Merge with CABAM algorithm (Kotthaus and Grimmond, in prep.)

AEROSOL RETRIEVALS

Gian Paolo Gobbi,
CNR-ISAC

The «Monte-Carlo» Aerosol Optical Model

Within the TOPROF framework, we implemented a methodology to retrieve some key aerosol properties (extinction coefficient, surface area and volume) from lidar/ceilometer backscatter measurements.

The method is based on results from a "Monte-Carlo" numerical model, devised to find statistical relationships between backscatter coefficient and surface area and volume and extinction coefficient of the atmospheric aerosols.

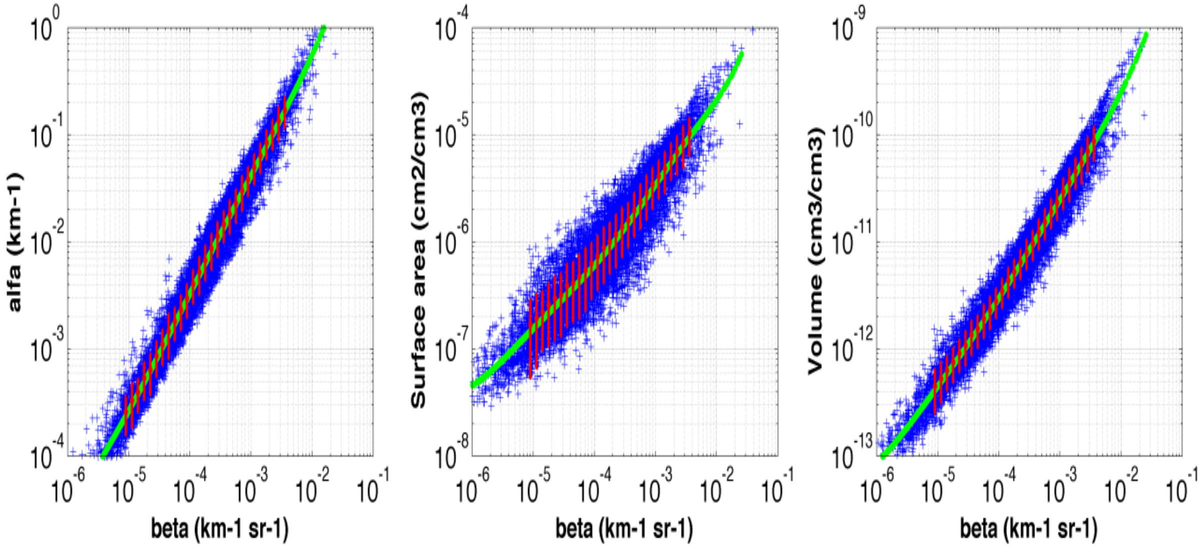
→

The model has been implemented for "continental aerosols" including a "coarse mineral fraction"

→

The functional relationships fitting model-generated data clouds then allow for retrieving aerosols backscatter and extinction profiles, plus volume and surface area from single wavelength lidars operating at 355, 532 and 1064 nm.

SIMULATIONS @ λ = 1064 nm

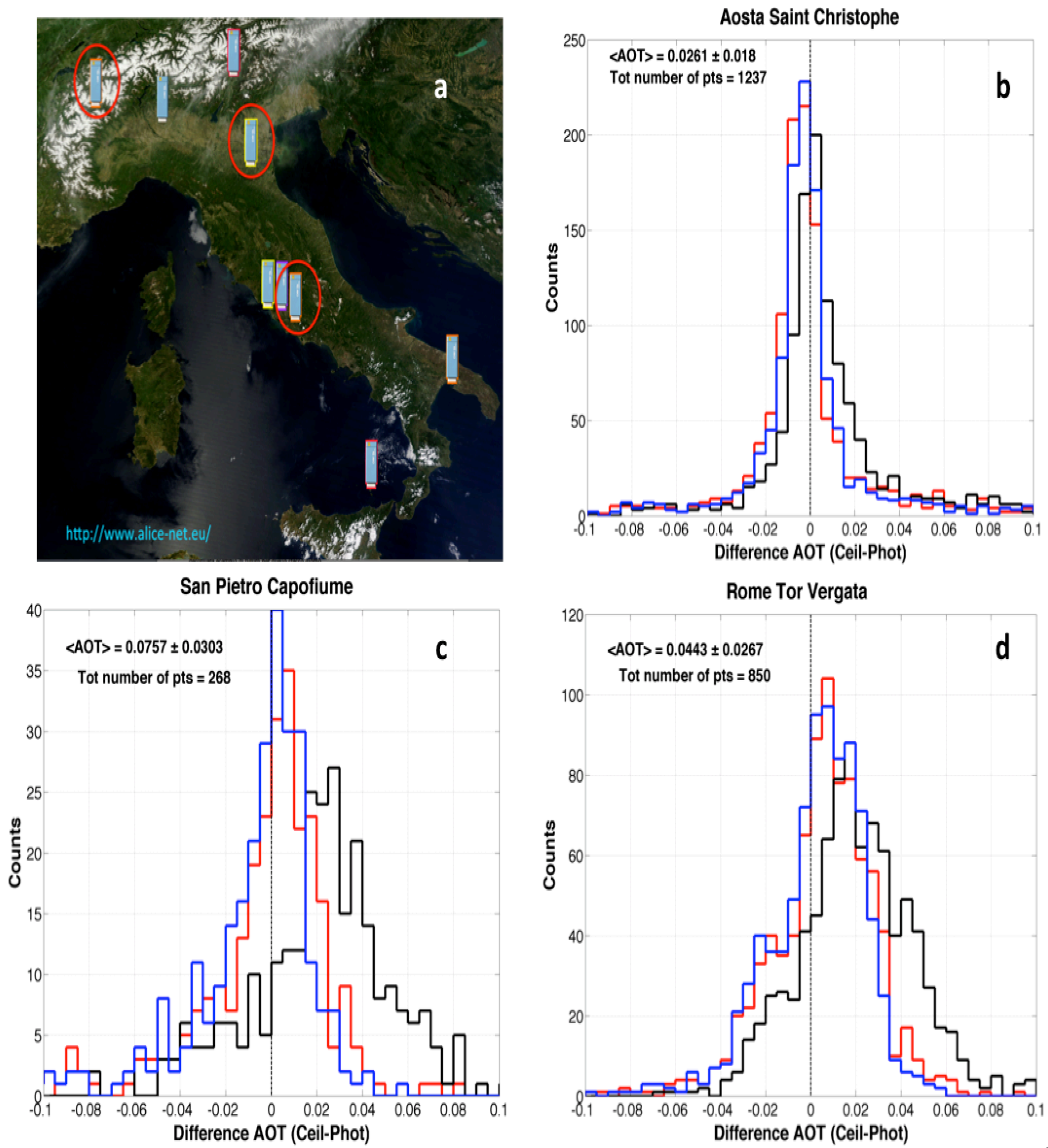


Testing the model-assisted retrievals: Long-term AODs.

Comparisons against Aeronet or Sky-net sunphotometer AODs

Data acquired in the periods:
(ASC) April 2015 – June 2017,
(SPC) June 2012 – June 2013,
(RTV) February 2014 – Septembe
2015.

SPC	<dAOT/AOT>
LR = Model	-0.005 ± 0.28
LR= 52 sr	0.330 ± 0.35
LR= 38 sr	-0.043 ± 0.24

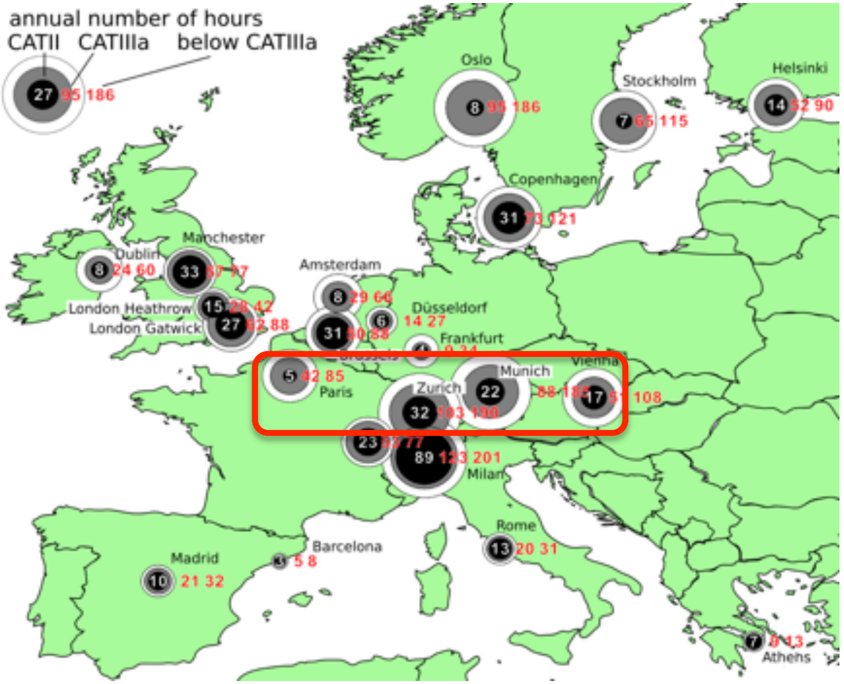


FOG WARNING

Martial HAEFFELIN,
IPSL

FOG DETECTION AND ANTICIPATION

1. Motivation



Christmas travel chaos warning as fog grounds planes

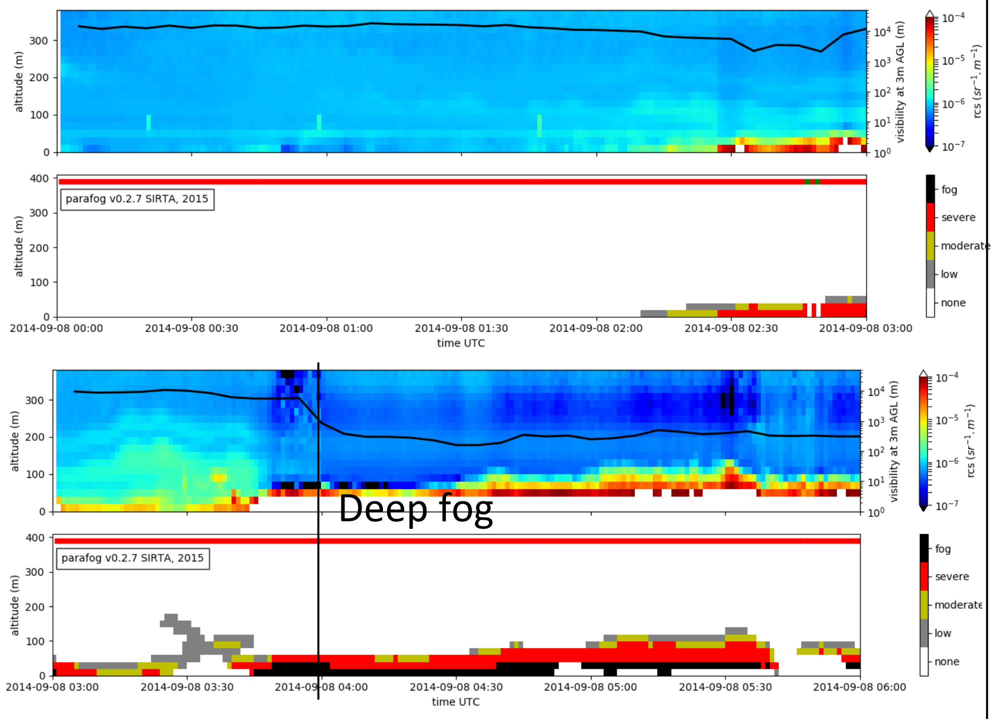
- BA to axe 40% of flights to and from Heathrow today
- Record 3 million planning to go abroad over holiday

Need decision-support tools in addition to NWP forecasts, satellite imagery, ground-based measurements

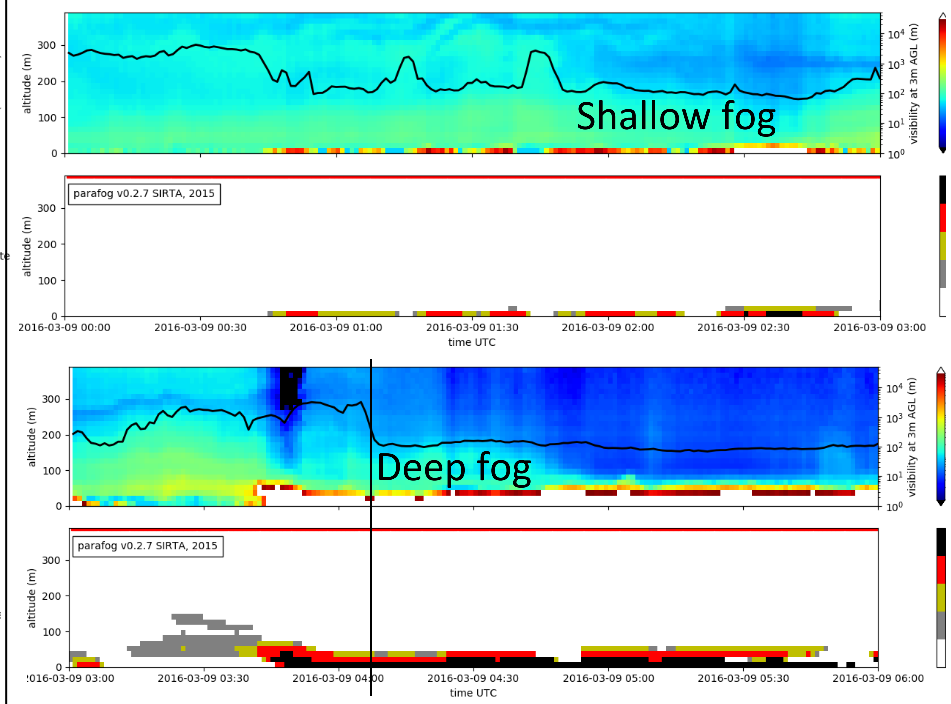
PARAFOG: fog cases analysis

- PARAFOG applied on ALC datasets of Uccle and SIRTA sites and also on ALC datasets of airports (Zurich, Vienna, Munich, Roissy)

Vienna

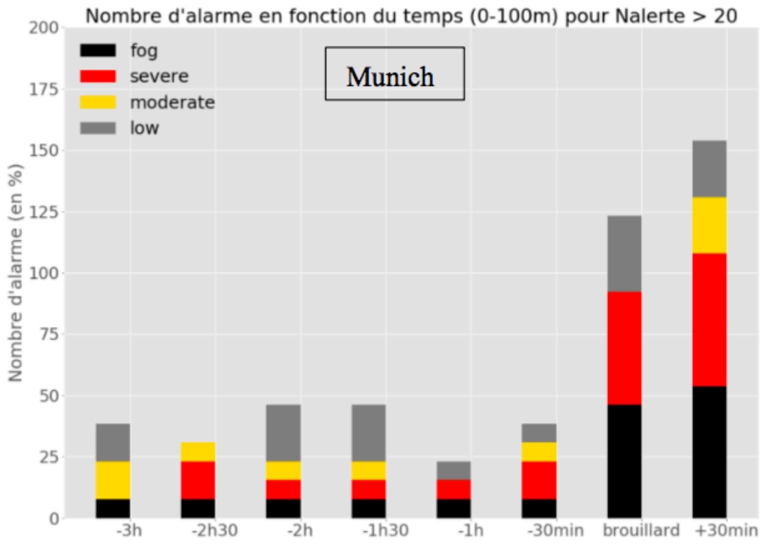


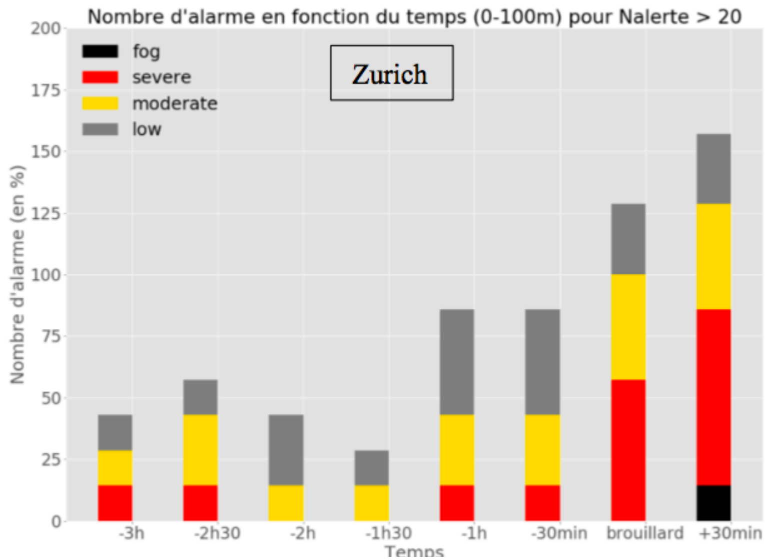
Munich

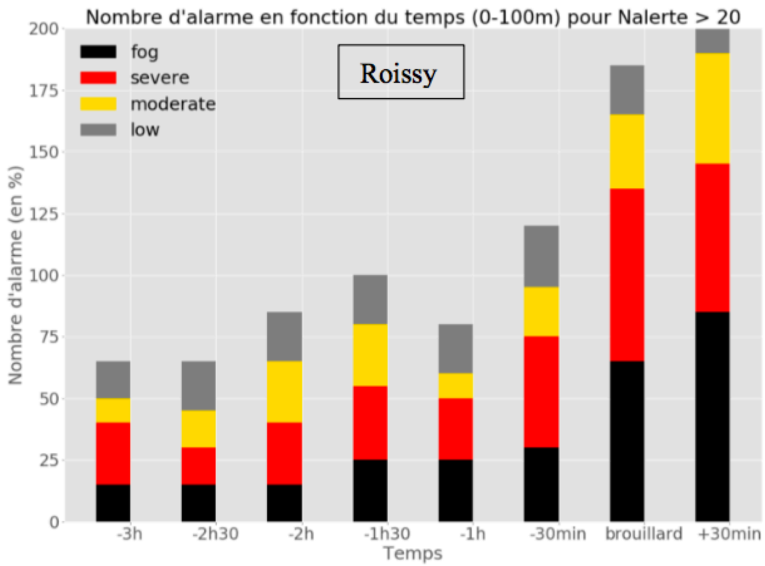


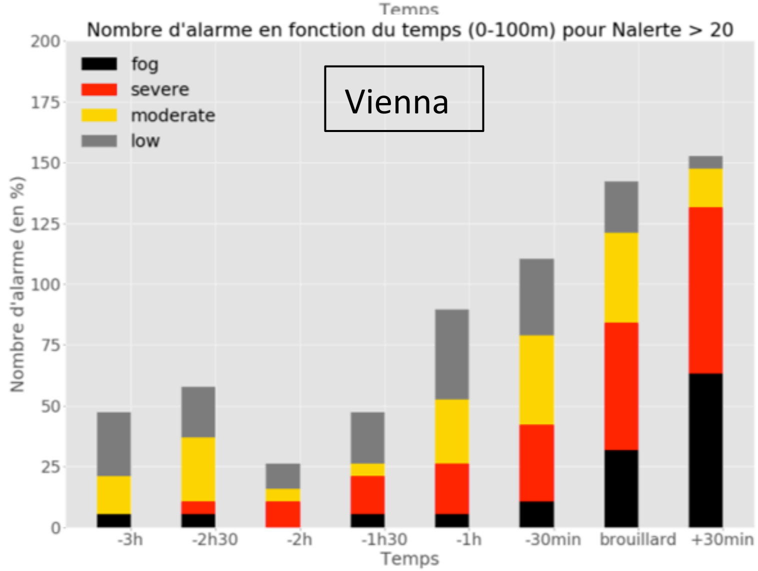
FOG DETECTION AND ANTICIPATION

Performance









ACHIEVEMENTS AND PUBLICATIONS

Published

- Wiegner et al. 2015 water vapor absorption in Vaisala ALC
- Hervo et al. 2016 optical overlap correction in Lufft ALC
- Kotthaus et al. 2016 pre-processing for signal correction in Vaisala ALC
- Haeffelin et al. 2016 anticipation of fog formation using Vaisala ALC
- Lotteraner and Piringer 2016 mixing layer depth retrieval
- Schween et al. 2014 mixing layer depth from DL and ALC

In preparation

- Bravo Aranda et al. ABL review
- Mattis et al. Summary of Ceilinex achievements
- Haeffelin et al. Review of recent ALC progress
- Haefele et al. E-PROFILE ALC program

ALC PAPERS IN PREPARATION

Papers in preparation for 2017-2018

1. Kotthaus and Grimmond, ABL retrievals in London
2. Bravo Aranda et al. ABL review
3. ***Mattis et al. Summary of Ceilinex achievements***
4. ***Haeffelin et al. Review of recent ALC progress***
5. ***Haefele et al. E-PROFILE ALC program***
6. Dionisi aerosol property retrievals (Alicenet)
7. Diemoz et al. retrieval properties of aerosols in Aosta Valley
8. Hopkin et al. Cloud calibration
9. Kotthaus et al. BL and air quality in Beijing
10. Piringer et al. Saharan dust with ceilometers in Austria (AE, under review)
11. Haeffelin et al. Fog anticipation
12. Cazorla et al. Iberian ceilometer network (ACP under review)
13. Warren et al. paper Met Office ALC FWD operator
14. Rizza et al. AE or ACP: Dust advection using WRFchem and ALC network (published)
15. Gryning et al. CL51 at Station North greenland, ABLH retrievals
16. Conseicao et al. electric fields and BL, in BLM
17. WG1 Contribution to TOPROF BAMS

EMS 2017 PRESENTATIONS

1. Mattis et al. **The international ceilometer inter-comparison campaign CeiLinEx2015 - uncertainties and artefacts of aerosol profiles**
2. Hervo et al. **The E-PROFILE/TOPROF network of automatic lidars and ceilometers for cloud and aerosol/ash profiling**
3. Charlton − Perez et al. **Ceilometer Firmware Intercomparison at the Met Office, UK**
4. Wiegner et al. **The influence of water vapor absorption on ceilometer measurements: Relevance for aerosol retrievals**
5. Dionisi et al. **A model-assisted retrieval of aerosol properties from elastic backscatter lidar and ceilometer measurements**
6. Heese et al. **Automatic Ceilometer-based Backscatter Coefficient Retrieval – Improving Network Capabilities by combining Ceilometer Networks and AERONET**
7. Laffineur et al. **ALC profiling: valuable information to support the radiation fog forecasting in the airports**
8. Kotthaus et al. C**haracterising the atmospheric boundary layer based on ceilometer observations**
9. Hopkin et al. **Calibration of the Met Office Ceilometer Network using the Cloud Method**
10. Bravo Aranda et al. **A better understanding of the atmospheric boundary layer structure using ALCs, MWRs and Doppler lidars in the framework of TOPROF**