BACCHUS

Impact of Biogenic versus Anthropogenic emissions on Clouds and Climate: towards a Holistic UnderStanding

Collaborative Project

SEVENTH FRAMEWORK PROGRAMME

ENV.2013.6.1-2

Atmospheric processes, eco-systems and climate change

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SUMMARY OF RESULTS

1. Report on Task 1.1 Database structure development process

In BACCHUS, we collect different types of data, ice nuclei (IN), cloud condensation nuclei (CCN), in-situ cloud microphysical and satellite data. We will set up a BACCHUS database, which archives primarily IN data. All other above mentioned data will be stored on other already existing databases, on a ETH – provided FTP-server, or physically at the originator and made available on request.

1.1 IN Database

During meetings at the start of BACCHUS, it was suggested by one of the attendees (Prof Ken Carslaw, University of Leeds) that the BACCHUS IN database could utilise a design under construction at the time for the GASSP project (http://gassp.org.uk/). To provide easy access to the GASSP partner institutions, the GASSP database is hosted in the UK Centre for Environmental Data Archival (CEDA, http://www.ceda.ac.uk/) Jasmine facility (http://www.jasmin.ac.uk/). The current arrangement provides read access to scientists participating directly in GASSP, along with those who have accepted the GASSP Data Exchange Protocol (DEP). Write access to the database is handled by the project DataBase Administrator (DBA, Dr Carly Reddington, Post-Doc, University of Leeds). As the database scripts run in Perl and its computer processing and space requirements are limited, it is planned to transfer a copy of the GASSP scripts to a second facility, such as ETH Zürich.

In addition to formalising the data storage location, the DEP makes the following provisions:

1. The ultimate owner of the data is the data originator, even after the culmination of the project.
2. The data is available to all project partners, who are obliged to sign the DEP, and can be made available to external users upon acceptance of the DEP. Any external access needs to be accepted by the data owner.
3. A list of all approved data users will be maintained on the project website.
4. In cases of data appearing in publications, joint authorship, along with the rights to intellectual input, must be offered to the data owner and all scientists who performed substantial processing.
5. The data owner explicitly retains the right to veto the appearance of their data in a publication.
6. Unauthorised redistribution to non-approved users is not allowed.

A similar protocol will be set up for BACCHUS, especially with regards to historical datasets. While the second half of the provisions in the DEP seem quite strict, it is doubtful that the research bodies that funded such observation campaigns would agree to a weaker protocol. The BACCHUS database will be stored in a separate location to the GASSP database, preventing access to BACCHUS data by GASSP scientists and vice versa, allowing for separate DEP's for the two projects.

For the data provider, the database operation is simple – data following the defined format (see subsection 1.1.1 IN Data Format below) is submitted to the DBA with the understanding that its use will adhere to the DEP (Figure 1). The DBA is then responsible ensuring the correct format of the data and insertion into the database. For the data end-user, a Perl based script is used to search through the data tags (see below).

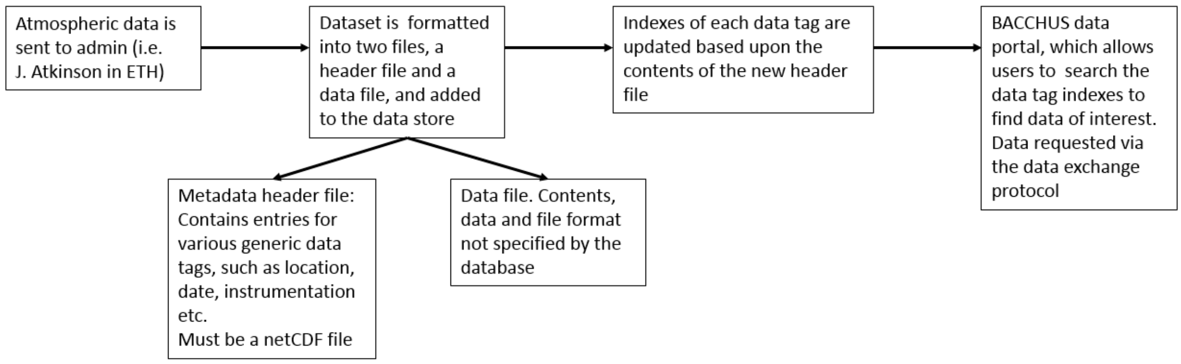

Figure 1. Schematic of the operation of the BACCHUS database, detailing the flow of data from the provider through to the end user.

Data Tag	Description
Species_Short_Name	Measured aerosol species
Data_Info	Information about the measured species or the quantity measured
Additional_Data_Info	Any additional info. that may be important to know when using the data
Instrument	The instrument used to make the measurements
Model_Serial_Number	The model number and/or serial number of the instrument used
Cutoff_Low_Diameter	Lower detection limit (diameter) of the instrument
Cutoff_High_Diameter	Upper detection limit (diameter) of the instrument
Size_Definition	Definition of the size measurement used by the instrument e.g. aerodynamic, volume equivalent, mobility etc.
Calibration_Material_Method	Method and/or material used to calibrate the measurements
Error_Absolute	Absolute error of the measurement
Error_Relative	Relative error of the measurement
Error_Characteristics	Characteristics of the measurement error
Error_Bias_Correction	Details of any error bias correction
pT_Conditions	The temperature and pressure conditions in which the measurement is reported (e.g. ambient or STP)
Inlet_Sample_Flow_Dry	Is the sample flow or the inlet dried? (yes or no)
Other_Inlet_Info	Any additional info. about the inlet e.g. type of inlet used
Platform_Type	Platform type
Platform_Name	Name of the platform used e.g. aircraft/station/ship name
Station_ID	Ground station ID used by the network if applicable e.g. CH0001R
Station_Altitude	Altitude (above sea level) of ground station (only applicable if Platform=station)
Station_Lon	Longitude of ground station (only applicable if Platform=station)
Station_Lat	Latitude of ground station (only applicable if Platform=station)
Project_Name	Project name (full name or acronym)
Project_URL	Address of main project website (if available)
Measurement_Mode	Mode of data collection i.e. campaign (short term) or long term monitoring
Environment	General location (e.g. Europe, Arctic, Pacific etc.) and type of environment in which the measurements were made (e.g. continental, marine, coastal, urban, rural etc.)
Sampling_Conditions	Details of the type of sampling conditions experienced during the measurement period e.g. polluted, clean, biomass burning-influenced, anti-cyclonic, etc.
Season	Season during which the measurements were made (if mode is "long term" then select more than one season)
Altitude	General section of the atmosphere sampled during the measurement period i.e. BL, LT, FT, UT (more than one can be selected)
PI	Full name of the principal investigator(s) of the project
Institute	Name of the institute that the data belongs to (address can also be provided)
Data_Contact	Full name and email address of person responsible for the specific dataset
Data_Source	Where the data was obtained for GASSP database e.g. website (give URL), ftp site (give address), database (give name), direct from data_contact etc.

Table 1. The MetaData Matrix Array (MDMA) tags already present in the GASSP database (Reddington 2014) and adopted to the BACCHUS database.

Data tag	Description
AP ambient	Is the ambient aerosol concentration also observed? (y/n)
IN_collection_method	Method used to collect particles for IN measurement, e.g. filter, direct flow
IN_comp	Is IN composition observed? (y/n)
IN_conc	Is IN concentration observed? (y/n)
IN_instrument_depRHrange	Range of possible RH for deposition freezing (i.e. with respect to ice)
IN_instrument_condRHrange	Range of possible RH for condensation freezing (i.e. with respect to liquid)
IN_instrument_Trange	Range of possible temperatures for observations
IN_instrument_INrange	Range of observable IN concentrations
IN_mode	Freezing mode measured, e.g. deposition, immersion
IN_observation_depRHrange	Range of observed RH for deposition freezing (i.e. with respect to ice)
IN_observation_condRHrange	Range of observed RH for condensation freezing (i.e. with respect to liquid)
IN_observation_Trange	Range of observed temperatures for observations
IN_observation_INrange	Range of observed IN concentrations

Table 2. The proposed extension to the MDMA for BACCHUS (see Table 1 for the GASSP MDMA).

Item	Notes	Units
Latitude	Required	Decimal
Longitude	Required	Decimal
Altitude	At least one altitude types is required	m
Altitude pressure	At least one altitude types is required	hPa
End latitude	To support aircraft transects, not applicable for stationary observations	Decimal
End longitude	To support aircraft transects, not applicable for stationary observations	Decimal
End altitude	To support aircraft transects, not applicable for stationary observations, at least one altitude types is required	m
End altitude pressure	To support aircraft transects, not applicable for stationary observations, at least one altitude types is required	hPa
Date/time	Required	YYYYMMDD hhmmss
Ambient T	Desirable	K
Ambient RH	Desirable	%
Ambient aerosol concentration	Optional	cm^{-3}
Ambient aerosol concentration uncertainty	Required if Ambient aerosol concentration is included	
Ambient aerosol size distribution	Optional, in a number of diameter bins which must be defined in the file descriptor	Bins: µm Concentration: cm^{-3} per bin
Ambient aerosol size distribution uncertainty	Required if Ambient aerosol size distribution is included	
Wind direction	Optional	Degrees
Wind horizontal speed	Optional	$m\ s^{-1}$
Wind vertical speed	Optional	$m\ s^{-1}$
In cloud	Optional	yes/no
Analysis T	Required	K
Analysis T uncertainty	Required	
Analysis pressure	Required if different to ambient	hPa
Analysis RH	Required for condensation and deposition freezing, with respect to ice or liquid must be defined in the file descriptor	%
Analysis RH uncertainty	Required for condensation and deposition freezing	
IN concentration	Desirable, if absent composition must exist	L^{-1}
IN concentration uncertainty	Required if IN concentration is included	
IN composition	Desirable, if absent composition must exist. A number of compositional 'bins', which must be defined in the file descriptor	Weight %
IN composition uncertainty	Required if IN composition is included	

Table 3. A list of the data items for each observation. The database will retain a maximum of flexibility by only requiring spatial and temporal details, and either/both IN concentration and composition.

The actual data is converted into two files: a data file, with no format or file type restrictions defined by the database architecture (see subsection 1.1.1 IN Data Format below), and a metadata header file, with a strictly controlled format and layout. The GASSP database is structured such that the control and search scripts do not need to access the data file. Hence its precise layout and content are not prescribed within the database, allowing for the flexibility of a newly designed data layout and the possibility of multiple data-file layouts for different purposes – e.g. for immersion freezing vs. deposition nucleation, or ground vs. airborne data. This also means that, in cases where the transfer of data to the BACCHUS database is prohibited (for example, by a funding body), a metadata header file for this dataset could be inserted into the BACCHUS database with instructions for access directly from the data originator. Due to the method used for enabling the searching of data, the file type and format of the header file is strictly controlled. The file has to be in netCDF format and contains entries for a number of metadata tags. These tags cover details ranging from generic information such as the project leader and location, to specific details such as the instrument type and specifications (Table 1; in the following, we refer to MetaData Matrix Array (MDMA) as the tags-entry table). The majority of details that would be needed in the IN database already exist in the proposed GASSP metadata tags, and it is possible to add further tags to the system (Table 2). After the header file has been created and uploaded, a script is run by the DBA which collates an index of the contents of each metadata tag to allow searching in the end-user web-portal.

1.1.1 IN Data Format

As noted above, the data file format is not specified within the GASSP database. For the BACCHUS IN database it is planned to use the netCDF file definition. For each observation a number of data items will be supported, some of which will be required, some of which will be optional depending upon the observational type. The planned data items are listed in Table 3. Because the insertion of data into the database is performed by a centralised administrator, a degree of data harmonisation can be achieved by converting all data into the same units. However, it must be noted that full harmonisation of all IN data is not possible as certain types of data are not directly comparable, such as deposition nucleation and immersion freezing data.

1.1.2 IN Observations

Invitations to contribute IN observations, historical, current and/or future, have been sent out to scientists at over 40 different institutions around the world, so far with replies from approximately a quarter of institutes including institutes from the USA, India, Israel, Australia and Argentina (see Figure 2). Once the BACCHUS DEP and database requirements are finalised, it will be possible to start requesting and receiving data from these campaigns.

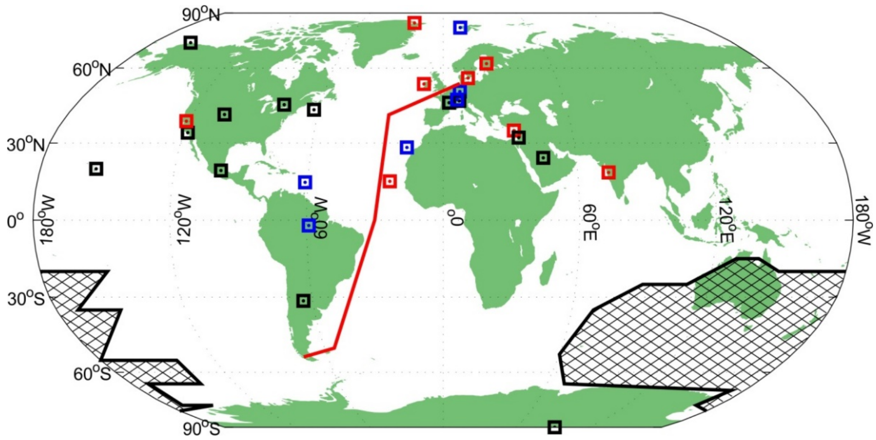

Figure 2. Locations of atmospheric observations of ice nuclei, past, current and future, currently confirmed to be available to BACCHUS. Historical data is coloured black and includes the hatched area, future campaigns expected to participate in BACCHUS are red, and locations with ongoing observations or historical and future campaigns planned are in blue. The red line through the Atlantic Ocean is a planned research ship cruise.

1.2 CCN Data

CCN observations taken within the framework of BACCHUS will ultimately be provided to the ACTRIS data network and hence handled according to the ACTRIS data protocol. This ensures best possible dissemination of the long-term data sets to the research community. As such the CCN data will be formatted to match the ACTRIS requirements. However, before and during quality control, this data will be stored in the short-term in the BACCHUS internal data store (see Sect. 1.5 below). This will give rapid access to preliminary results to the rest of the BACCHUS consortium. During this temporary storage an MDMA describing each dataset will be posted upon the BACCHUS internal Wiki; the MDMA definition for this will be based on the requirements of the ACTRIS data network, extended to provide any additional detail defined by the proposed BACCHUS IN MDMA (Figure 3, Table 1/2/3). The BACCHUS data will be highly self-consistent between the IN and CCN input, taking GASSP and ACTRIS standards into consideration. Parallel submission of data sets to the ACTRIS network is encouraged and supported. The ACTRIS data policy and data format descriptions are available online (data policy: http://actris.nilu.no/Content/Documents/DataPolicy.pdf; data format: http://www.actris.net/Portals/97/Publications/quality%20standards/aerosol%20insitu/WP3_D3.13_M24_CCNC_SOP_v130514.pdf) and have also been made available in the BACCHUS internal wiki.

1.3 Database for in-situ measured cloud-microphysical data

Data from campaigns at Jungfraujoch (Switzerland), the Arctic and the Amazon will be used as a priority for model case studies. When possible, aerosol data from these campaigns will be archived through the GASSP network and other networks; however there is no pre-arranged destination for cloud microphysical data and this will need to be stored through the BACCHUS system. This extends the MDMA defined above (Tables 1+2, see Table 5), as well as a separate data file definition (Table 6). While these data are in a preliminary state they may be stored in the BACCHUS internal data store.

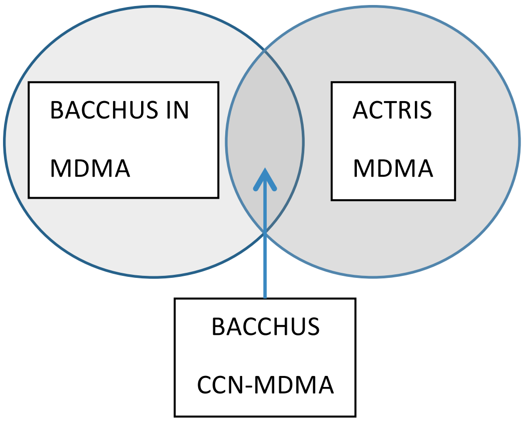

Figure 3. Idea of tailoring the BACCHUS CCN MDMA (Meta Data Matrix Array) to overlap between the BACCHUS-IN and ACTRIS platforms.

Station	Partner	Instrument	Operation mode
Puy de Dôme	CNRS	2 x SCRIPPS	polydisperse
Birkenes	NILU	DMT	polydisperse
Cabauw	TUD	DMT	polydisperse
Jungfraujoch	PSI	DMT	polydisperse
Vavihill	ULund	DMT	polydisperse
Mace Head	NUIG	DMT	polydisperse
Melpitz	TROPOS	DMT	monodisperse
Hyytiälä	UHEL	DMT	mono- and polydisperse

Table 4. Sites at which CCN observations are being collected for the database framework of BACCHUS.

1.4 BACCHUS Internal data service

An internal data store will be set up for use within BACCHUS, according to the need of the involved groups/scientists. This space aims to allow for the efficient exchange of data collected within BACCHUS, and to provide a platform for the partners to inform themselves on the status of data availability. For the experimentalists, an MDMA will be required similar to the ones discussed above, so that the technical effort for internal data exchange and transfer to existing databases is minimized. For the modellers, a matching framework still has to be developed.

The data will either be stored on an ETH-provided FTP-server with user-interface, or physically at the originator - based on the complexity needed. A section on the BACCHUS Wiki will provide the MDMAs and access instructions for each dataset.

2 Contribution to deliverable 1.1 from task 1.5 concerning cloud products and satellite observations

The remote sensing team of BACCHUS (Task 1.5) will deliver reports and data including all BACCHUS-related observations and findings of the planned closure studies. Case studies of aerosol-cloud-dynamics relationships and respective statistical data analysis will be discussed in these reports. Such reports are most useful for modelers. The observed data sets (a complex set of data files for numerous aerosol, cloud and meteorological state parameters) obtained with high vertical, horizontal, and temporal resolution are much too complex to be integrated into the planned BACCHUS CCN/IN/cloud databases. Long-term experience shows that such data will not be used. However, specific observational data will be made available to the modelers on request for model-observation comparisons.

In the following a short overview is given on Task 1.5-related actions (Dec 2013 – July 2014 period).

Data Tag	Description
CAP_method	Method used (i.e. angular scattering of light; imaging; depolarisation, bio-fluorescence)
CAP_inlet	Was anti-shatter technology used (Y/N or N/A)?
CAP_corrections	A description of any corrections applied to the data - e.g. inter-arrival time corrections.
CAP_sampling	Method used to sample the air (i.e. pump down a line, open inlet on an aircraft)
CAP_observation_Crange	Range of observed concentrations
CAP_observation_Trange	Range of observed temperatures for observations

Table 5. The extensions to the MDMA (Tables 1+2) required to enable the storing of cloud microphysical data.

Item	Notes	Units
Latitude	Required	Degrees
Longitude	Required	Degrees
Altitude	Required	m
Date / time	Required	UTC (e.g. decimal days from reference)
Ambient T	Desirable	K
Wind direction	Optional	Degrees
Wind horizontal speed	Optional	$m\ s^{-1}$
Wind vertical speed	Optional	$m\ s^{-1}$
Lower size bins	Required	m
Upper size bins	Required	m
Particle size distribution01*	Required	m^{-3} within time and size bins and with an extra bin for different particle classes (see below)
Particle classes	Required	Text string (i.e. total, ice, bio, non-bio, etc) describing each array in the above

Table 6. A list of the data items stored for cloud microphysical observations. *: there may be more than one particle class analysed – separate particle size distributions will be recorded for each class.

1. Coordinating the field campaigns

We compiled a coordination table of all the BACCHUS campaigns (see Appendix 1). We defined the closure studies and prepared a list of parameters to be measured or retrieved in these closure field campaigns (see Appendix 2 and also the next action item #2 below). Each closure field study will last for several weeks or even longer time periods. We fixed the locations and time periods of the field campaigns to be conducted in 2014 and 2015. Closure studies will be performed at Leipzig, Germany (in 2014 and 2015), Mace Head, Ireland (August 2015), Nicosia/Limassol, Cyprus (March-April 2015), Hyytiälä, Finland (including the use of the mobile ARM site), and in Amazonia (September 2014).

2. Development of the theoretical basis for satellite closure

The following publications were written in this context and include first cloud and satellite products:

a. Setting the stage for BACCHUS by the publication of the following paper in Science: Rosenfeld D., S. Sherwood, R. Wood, L. Donner, 2014: Climate Effects of Aerosol-Cloud Interactions. Science, 343, 379-380.

b. Testing the closure methodology on the DOE/SGP data and proving its concept, in the paper: Rosenfeld D., B. Fischman, Youtong Zheng, T. Goren, D. Giguzin, 2014: Combined satellite and radar retrievals of drop concentration and CCN at convective cloud base. GRL, DOI:10.1002/2014GL059453.

c. Developing the framework for measuring cloud base updrafts from satellite measurements alone, having submitted the paper: Zheng Y., D. Rosenfeld, Z. Li, 2014: Satellite inference of thermals and cloud base updraft speeds based on retrieved surface and cloud base temperatures. Submitted to JGR.

Appendix 2 provides more explanations.

3. Conducting of first (or planning of new) coordinated flight campaigns, all based on the flight planning strategy defined by D. Rosenfeld (HUJI) for obtaining closure between aerosols and cloud properties over ground measuring sites and coordinated with satellite overpasses.

The specific tasks included:

a. Coordinate research flights over California in the framework of CALWATER-2 during January and February 2015. The planning meeting took place in LaJolla on 22-24 April 2014.

b. Coordinated plans for closure studies over China with a research aircraft and ground measurements, over Taiyuan, China, during July and August 2014.

c. Coordinated plans for the second phase of the GO_AMAZON campaign, during a meeting at INPE near Sao Paulo, which took place on 20-22 May 2014.

4. Completion of first closure field campaigns. The following work (spaceborne remote sensing) has been completed (until August 2014) or will be performed by the end of2014:
    a. Analysis of satellite data for Phase-1 of GO-Amazon (February-March 2014) and validation efforts regarding the closures.
    b. Results of the satellite closures for the DEO/SGP have been summarized in a report.
    c. Research flights in China, during summer 2014, are conducted for closure studies.
    d. Research flights in the Amazon with the German G5 HALO aircraft, along with the German ACRIDICON project, will take place in September 2014.

Appendix 1 (Sites of closure campaigns and list of quantities to be measured or retrieved)

Cyprus

	Parameter	Surface	Radar	Lidar	UAV	Aircraft	Sounding	Satellite	Calculate
Ta	Air temperature	CUT, CyI			CyI, CNRS		TROPOS		
Td	Dew point	CUT, CyI			CyI, CNRS		TROPOS		
U, V	Horizontal wind	CUT			CNRS		TROPOS		
P	Air pressure	CUT			CyI, CNRS		TROPOS		
H	Height				CyI, CNRS		TROPOS		
CN	N of cond. nuclei			CUT/ TROPOS					
Tt	Cloud top temperature						TROPOS	HUJI	
Tc	Cloud temperature				CNRS		TROPOS		
Tg	Cloud glaciation Temp			CUT/ TROPOS				HUJI	
Ni	Ice concentration								
ISD	Ice size distribution								
IN	Ice Nuclei concentration	ETHZ		CUT/ TROPOS	CyI*				
Re	Effective radius							HUJI	
DSD	Drop size distribution								
Nd	Cloud droplet concentration								
D*	Depth for initiation of rain							HUJI	
Tb	Cloud base temperature			CUT/ TROPOS	CNRS		TROPOS	HUJI	
Na	Number of activated CCN at cloud base								
W	Vertical velocity			TROPOS	CNRS				
Wb	Cloud base vertical velocity			TROPOS	CNRS				
SS	Cloud base super satur.				CNRS				
CCNb	Cloud base cond. nuclei			CUT/ TROPOS					
CCN	Cloud cond. nuclei			CUT/ TROPOS					
GCCN	Giant CCN Concentration								
ASD	Aerosol size distribution	TROPOS							
k	kappa								
Aero_ chem	Aerosol chemistry								
Gas_c hem	Gas phase measurements								
Mod	Modelling input								

*: In collaboration with WI and UF

	2014												2015											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
CUT																								
CyI											x	x	x	x	x	x	x	x	x	x	x	x	x	x
Tropos							x	x	x*	x	x	x	x	x	x	x								
CNRS															x	x								
HUJI/sat	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
ETHZ															x	x								

*: Reconnaissance visit to Cyprus by Tropos in September 2014 to inspect sites for UAV and LIDAR observations in spring 2015.

Go Amazon

	Parameter	Surface	Radar	Lidar	UAV	Aircraft	Sounding	Satellite	Calculate
Ta	Air temperature					HUJI	HUJI		
Td	Dew point					HUJI	HUJI		
U, V	Horizontal wind					HUJI	HUJI		
P	Air pressure					HUJI	HUJI		
H	Height					HUJI	HUJI		
CN	N of cond. nuclei								
Tt	Cloud top temperature							HUJI	
Tc	Cloud temperature					HUJI			
Tg	Cloud glaciation Temp					HUJI		HUJI	
Ni	Ice concentration					HUJI			
ISD	Ice size distribution					HUJI			
IN	Ice Nuclei concentration								
Re	Effective radius					HUJI		HUJI	
DSD	Drop size distribution					HUJI			
Nd	Cloud droplet concentration					HUJI			
D*	Depth for initiation of rain					HUJI		HUJI	
Tb	Cloud base temperature					HUJI		HUJI	
Na	Number of activated CCN at cloud base					HUJI			
W	Vertical velocity					HUJI			
Wb	Cloud base vertical velocity					HUJI			
SS	Cloud base super satur.								HUJI
CCNb	Cloud base cond. nuclei					HUJI			
CCN	Cloud cond. nuclei					HUJI			
GCCN	Giant CCN Concentration					HUJI			
ASD	Aerosol size distribution					HUJI			
k	kappa					HUJI			
Aero_chem	Aerosol chemistry								
Gas_chem	Gas phase measurements								
Mod	Modelling input								

	2014												2015											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
HUJI/amf	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
HUJI/AC									x															

MACE HEAD

	Parameter	Surface	Radar	Lidar	UAV	Aircraft	Sounding	Satellite	Calculate
Ta	Air temperature	NUIG			CNRS				
Td	Dew point	NUIG			CNRS				
U, V	Horizontal wind	NUIG			CNRS				
P	Air pressure	NUIG			CNRS				
H	Height		NUIG (cloud top)	NUIG cloud base	CNRS				
CN	N of cond. nuclei	NUIG							
Tt	Cloud top temperature						NUIG (Hatpro)	HUJI	
Tc	Cloud temperature				CNRS		NUIG (Hatpro)		
Tg	Cloud glaciation Temp							HUJI	
Ni	Ice concentration								
ISD	Ice size distribution								
IN	Ice Nuclei concentration	NUIG ETHZ*							
Re	Effective radius		NUIG					HUJI	NUIG
DSD	Drop size distribution								NUIG
Nd	Cloud droplet concentration								NUIG
D*	Depth for initiation of rain							HUJI	
Tb	Cloud base temperature			NUIG	CNRS		NUIG (Hatpro)	HUJI	
Na	Number of activated CCN at cloud base								
W	Vertical velocity		NUIG	NUIG	CNRS				
Wb	Cloud base vertical velocity		NUIG		CNRS				
SS	Cloud base super satur.				CNRS				
CCNb	Cloud base cond. nuclei								
CCN	Cloud cond. nuclei	NUIG							
GCCN	Giant CCN Concentration	NUIG							
ASD	Aerosol size distribution	NUIG							
k	kappa	NUIG							
Aero_chem	Aerosol chemistry	ETHZ*							
Gas_chem	Gas phase measurements								
Mod	Modelling input								

	2014												2015											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
NUGI																								
CNRS										x	x													
HUJI/sat	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
ETHZ*																				x				

*the participation of ETHZ is still under discussion for the following instrumentation: IN counter (ice nuclei concentration), ATOFMS (single particle chemistry)

Leipzig

	Parameter	Surface	Radar	Lidar	UAV	Aircraft	Sounding	Satellite	Calculate
Ta	Air temperature	TROPOS					TROPOS		
Td	Dew point	TROPOS					TROPOS		
U, V	Horizontal wind	TROPOS					TROPOS		
P	Air pressure	TROPOS					TROPOS		
H	Height	TROPOS					TROPOS		
CN	N of cond. nuclei			TROPOS					
Tt	Cloud top temperature		TROPOS				TROPOS	HUJI	
Tc	Cloud temperature		TROPOS	TROPOS			TROPOS		
Tg	Cloud glaciation Temp		TROPOS	TROPOS			TROPOS	HUJI	
Ni	Ice concentration		TROPOS						
ISD	Ice size distribution		TROPOS						
IN	Ice Nuclei concentration								
Re	Effective radius		TROPOS	TROPOS				HUJI	
DSD	Drop size distribution								
Nd	Cloud droplet concentration			TROPOS					
D*	Depth for initiation of rain		TROPOS					HUJI	
Tb	Cloud base temperature			TROPOS			TROPOS	HUJI	
Na	Number of activated CCN at cloud base			TROPOS					
W	Vertical velocity			TROPOS					
Wb	Cloud base vertical velocity		TROPOS	TROPOS					
SS	Cloud base super satur.								
CCNb	Cloud base cond. nuclei			TROPOS					
CCN	Cloud cond. nuclei			TROPOS					
GCCN	Giant CCN Concentration								
ASD	Aerosol size distribution	TROPOS							
k	kappa	TROPOS							
Aero_chem	Aerosol chemistry								
Gas_chem	Gas phase measurements								
Mod	Modelling input								

	2014												2015											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Tropos	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
HUJI/sat	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

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	Parameter	Surface	Radar	Lidar	UAV	Aircraft	Sounding	Satellite
Ta	Air temperature	UHEL, AMF2				UHEL (IOP)	AMF2	
Td	Dew point	UHEL, AMF2				UHEL (IOP)	AMF2	
U, V	Horizontal wind	UHEL, AMF2					AMF2	
P	Air pressure	UHEL, AMF2				UHEL (IOP)	AMF2	
H	Height						AMF2	
CN	N of cond. nuclei	UHEL, AMF2						
Tt	Cloud top temperature							HUJI
Tc	Cloud temperature							
Tg	Cloud glaciation Temp							HUJI
Ni	Ice concentration							
ISD	Ice size distribution							
IN	Ice Nuclei concentration	ETHZ*, UEF (IOP)						
Re	Effective radius							HUJI
DSD	Drop size distribution							
Nd	Cloud droplet concentration							
D*	Depth for initiation of rain							HUJI
Tb	Cloud base temperature							HUJI
Na	Number of activated CCN at cloud base							
W	Vertical velocity							
Wb	Cloud base vertical velocity							
SS	Cloud base super satur.							
CCNb	Cloud base cond. nuclei							
CCN	Cloud cond. nuclei	UHEL (size resolved + total), AMF2 (total)				FMI (IOP)?		
GCCN	Giant CCN Concentration							
ASD	Aerosol size distribution	UHEL+AMF2				UHEL (IOP)		
k	kappa	UHEL (supersat), AMF2 (subsat)				FMI (IOP)?		
Aero_ chem	Aerosol chemistry							
Gas_ chem	Gas phase measurements							
Mod	Modelling input							

	2014												2015											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
UHEL	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
AMF2		x	x	x	x	x	x	x	x															
HUJI /sat	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
ETHZ*									x															

*Not confirmed yet

Airborne IOPs:	#1: 24.3.-11.4. 2014
Cessna 172	#2: 19.5.-8.6. 2014
with aerosol payload	#3: 18.8.-19.9. 2014

+ 8 flight hours with skyvan (CCN counter + AMS, not yet confirmed)

Appendix 2

Requirements for closure between surface and satellite based measurements

1. How do we define a closure?

Closure between surface and satellite based measurements means that the calculated cloud properties from the surface measurements agree within useful error bounds with the satellite retrieved cloud properties. This can pertain to the following properties:

- Cloud base height and temperature, T_b
- Cloud base updraft, W_b
- Cloud base drop concentration, N_d
- CCN supersaturation activation spectrum at cloud base, CCN(S)
- Cloud depth for initiation of warm rain, D^*
- Cloud glaciation temperature, T_g

2. Satellite retrievals of the closure parameters

These satellite retrievals became recently possible with sufficient accuracy for closure, based on the high resolution (375 m) data of the recently launched imager of the VIIRS onboard the NPP satellite (Rosenfeld et al., ACP 2014). It builds on the methodology for retrieving cloud drop effective radius and vertical microphysical zones using AVHRR as described by Rosenfeld and Lensky (BAMS, 1998). The number of activated CCN into drops at a convective cloud base (N_a) can be retrieved from the vertical profile of cloud drop effective radius (r_e) (Freud et al., ACP 2011). This requires the knowledge of cloud base temperature and pressure, as described by Zhu et al. (GRL 2014). Calculating CCN(S) at cloud base requires the knowledge of both cloud base updraft (W_b) and drop concentrations (N_d). This can be achieved using ground based measured W_b by Doppler radar or lidar, as was done by Rosenfeld et al. (GRL 2014). Furthermore, cloud base updraft can be retrieved by satellite alone, as shown by Zheng et al. (2014). This allows eventually retrieving CCN(S) at cloud base by satellite alone, for convective clouds with roots in a well-mixed boundary layer.

The cloud depth for rain initiation (D^*) is achieved at the height where r_e exceeds 14 µm, as shown by Freud and Rosenfeld (JGR 2012). The glaciation temperature T_g can be obtained by the methodology of Rosenfeld and Lensky (1998). It was shown to be rather sensitive to the aerosol types and cloud drop size (Rosenfeld et al., GRL 2011). Strong updrafts in severe convective storms can delay T_g to colder temperatures (Rosenfeld et al., JGR 2008).

3. Surface based calculations of the closure parameters

Convective cloud base height can be observed directly by lidar and a ceilometer, and estimated indirectly by the surface temperature and dew point.

Cloud base updraft can be obtained directly by vertically pointing Doppler radar and lidar. It can be also estimated indirectly by surface sensible vertical heat flux, horizontal winds and cloud base height, as shown by Zheng et al. (2014).

CCN(S) at the surface can be measured by a CCN chamber. During well mixed boundary layer, which can be verified by the sounding and lidar, the surface CCN can be the same that reach the cloud base. A correction for air density must be applied when comparing to satellite-retrieved CCN, because the dilution of the air and its aerosol content with height.

Cloud base drop concentration (N_d) can be calculated based on the surface measured CCN(S) and lidar or radar cloud base updraft. Furthermore, this can be used for calculating of D^*, by simply assuming an

adiabatic cloud parcel (Freud and Rosenfeld, JGR 2012). Lidars can be used also to directly retrieve cloud base drop concentrations, as done in MACE Head. However, the accuracy of these retrievals cannot be assumed as better than the satellite retrievals.
An estimated glaciation temperature can be done for deep convective clouds based on ice nuclei (IN) measurements, taking into account the CCN. The effect of the IN is not expected to be discernible from satellites in clouds where r_e > 12 µm at the -5°C isotherm, due to the intense formation of secondary ice (i.e., ice multiplication) in such conditions (Rosenfeld et al., GRL 2011).

4. Aircraft measurements of the closure parameters

Aircraft and UAVs will be used in this context for:

- Testing the assumption that the CCN measured near the surface are the same that arrive at cloud base under well mixed conditions.
- Validating the accuracy of the retrievals that are based on the surface based instruments such as radar, lidar and passive remote sensing instruments.
- Validating the accuracy of the satellite retrieved closure parameters, and hence the goodness of the closure.

5. Time of satellite overpasses

The closure with satellites can be made during the daytime overpass, when the sun is at least 20 degrees above the horizon. We will focus on the NPP satellite, because it provides the most accurate data by far. The times of NPP overpasses are given in https://www.ssec.wisc.edu/datacenter/npp/. The orbits of one day are given in Figure 4. The quantitatively useful coverage for cloud microphysical properties occurs between the satellite track and a quarter of the distance to the track to the east of it. Therefore, good coverage occurs on average once every 4 days. For these events completeness of data should be striven for, and timing of aircraft measurements should be prioritized.

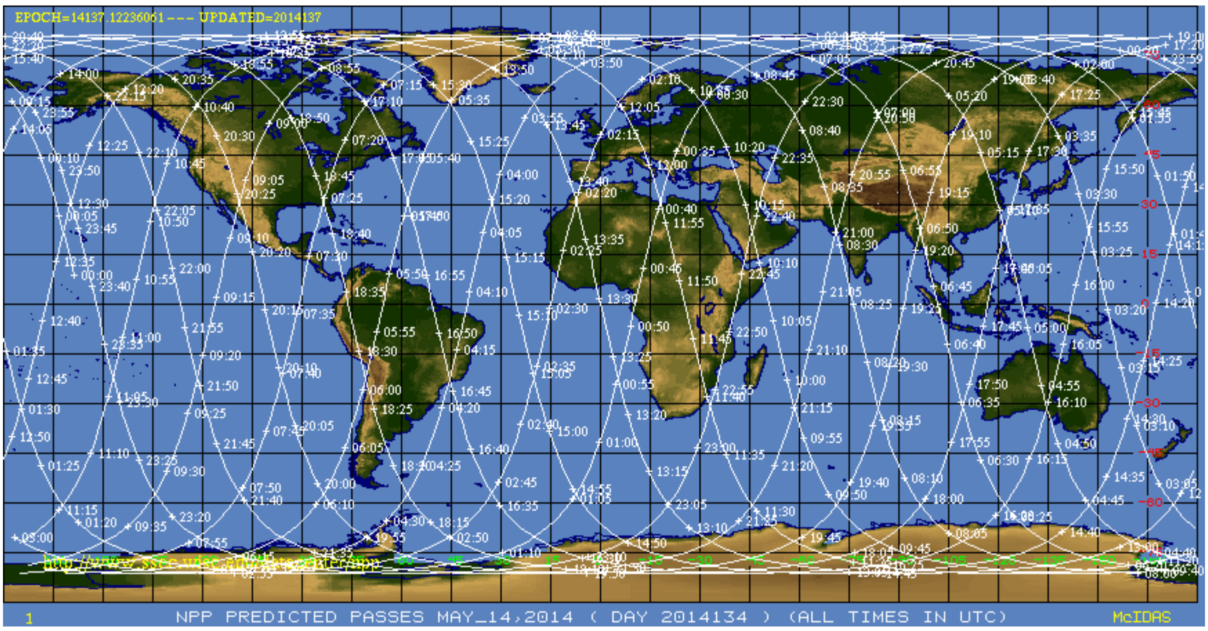

Figure 4: An example of the orbit tracks of the NPP satellite for one day. The overpass times in GMT are denoted on the tracks every 5 minutes. The quantitatively best coverage occurs between the satellite track and a quarter of the distance to the track to the east of it.

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Changes with respect to the DoW

DoW: "Definition of the BACCHUS aerosol/cloud database (structure, contents), first preliminary data set (some cloud products from satellite observations and first CCN/IN data)"

- The BACCHUS database structure and content related to CCN/IN/cloud microphysics – the actual focus of BACCHUS – is clearly defined within D1.1. In-situ measurements to be performed within BACCHUS (cloud products, remote sensing and satellite observations) are strongly integrated.
- D1.1 prescribes the definition/layout of an aerosol database. However, global aerosol cloud and CCN databases already exist making duplication unnecessary and undesirable, especially due the level of complexity and amount of data available. Thus, the handling of such data will entirely build on existing frameworks (e.g. WMO Global Atmospheric Watch – world data center for aerosols, ACTRIS, GASSP etc.) and is therefore not discussed in here. Only aerosol data directly related to BACCHUS' scientific tasks and collected within BACCHUS will be handled according to the internal data service as outlined in Section 1.5. Submission of BACCHUS data sets to the existing networks is imperative as long as the data sets match the specific network requirements.
- First preliminary IN and CCN data sets have been collected and analysed already. Historical IN data has been gathered. However, due to the complex task to actually define and set-up an adequate database structure, an implementation was not possible yet. This is also due to the delayed recruitment of the post-doctoral scientist (Dr James Atkinson) working on task 1.1, who actually started his position on March 1st. First cloud products are already published in the above-mentioned articles.

Dissemination and uptake

- The database structure presented herein is built for adoption by atmospheric scientists outside of the BACCHUS community. The database idea and its broad range of application due to the integration of GASSP and ACTRIS was already presented by James Atkinson at the 14th Conference on Cloud Physics, 7-11 July 2014, Boston, MA, and the Workshop on Data Analysis and Presentation of Cloud Microphysical Measurements, July 5-6, 2014, Boston, MA, hosted by the Massachusetts Institute of Technology.
- The operational principle of the BACCHUS database will be provided to the DACCIWA FP7 partner project for the later integration of the observational parameters into the BACCHUS structure.