StratoClim 3rd Annual Meeting

6. - 8. November 2017
Consiglio Nazionale delle Ricerche, CNR
CNR Headquarters
Rome, Italy

Venue

The 3rd annual StratoClim meeting will be held at **Consiglio Nazionale delle Ricerche, Headquarters** – Piazzale Aldo Moro 7 in **Aula MARCONI**.
https://www.cnr.it/en/headquarters

There are three **Metro** stations close by CNR headquarters: **Termini** (line A and B), **Castro Pretorio** (line B) and **Policlinico** (line B). Easiest way is to walk from Termini Metro (and Railway) station according to the Map below. Consider a 20 min. walking.

From Fiumicino Airport to Termini station, take the Leonardo Express train: this is a direct train to the Rome Termini station, which departs from Fiumicino Airport every 30 minutes, the ticket costs 14 EUR. More information at www.trenitalia.it

Enter from the **Main Entrance from Piazzale Aldo Moro 7**. A white marble façade.

All registered participants are listed at the entrance guard post and should get direct access. **Please bring an ID document with you.**
Aula Marconi is on the **1st Floor.** Pass the guard post, climb the stairs on the left of the entrance and follow the signs for Aula Marconi.

A registration desk will be placed close to the Aula Marconi, where you can **pay the Meeting fee and get a receipt.** Please, provide the exact amount of **130€** since we will not be able to give change.

Joint Dinner

We will have a Social Dinner on **Tuesday**, at the restaurant "**Pastificio San Lorenzo**" (http://www.pastificiosanlorenzo.com/). It is at walking distance from CNR headquarters. Follow the map below.

Agenda

StratoClim 3rd Annual Meeting - November 6–8, 2017

Agenda Summary - times are approximate for the Monday campaign science meeting.

	Monday Nov 6	Tuesday Nov 7	Wednesday Nov 8
8.00 - 9.00	Registration		
9.00 - 10.00	Aircraft Campaign Science meeting: General part and Remote sensing	Aircraft Campaign meeting summary (WP1) WP2 session	WP4 session
10.00 - 11.00	Coffee break		Coffee break
11.00 - 12.00	Aircraft Campaign Science meeting: Remote sensing	Coffee break WP3 session	WP6&7 session
12.00 - 13.00	LUNCH		SAB feedback and presentation - Laura Pan General discussions
13.00 - 14.00	Aircraft Campaign Science meeting: Remote sensing	LUNCH	
14.00 - 15.00	Aircraft Campaign Science meeting: Aerosol measurements	WP5 session	
15.00 - 16.00	Coffee break	Coffee break	
16.00 - 17.00	Aircraft Campaign Science meeting: Aerosol measurements	Poster session	
17.00 - 18.00	Aircraft Campaign Science meeting: General discussions		
18.00 - 19.00	ExGroup meeting		
		Joint Meeting Dinner 19.30	

Monday 6.11.2017	Aircraft Campaign Science Meeting	
8:00 - 9:00	**Registration**	
9:00 - 9:05	**Session start and Welcome**	Markus Rex
9:05 - 9:25	**General Part**	
9:05 - 9:10	General Issues, course of the meeting	Fred Stroh
9:10 - 9:25	Meteorological Campaign Overview	Bernard Legras
9:25 - 10:50	**Remote Sensing Measurements and Results**	**Chair: Fred Stroh**
9:25 - 9:45	First ammonia observations in the Asian monsoon upper troposphere with GLORIA	Sören Johansson et al.
9:45 - 10:00	MAL 1/2	Valentin Mitev et al.
10:00 - 10:20	The 2017 Asian Summer Monsoon: an Aura MLS Perspective	Michelle Santee et al.
10:20 - 10:50	**Coffee Break**	
10:50 - 11:10	In situ tracer measurements inside the Asian Monsoon Anticyclone during the 2017 Geophysica campaign	C. Michael Volk et al.
11:10 - 11:30	WAS	Thomas Röckmann (t.b.d.)
11:30 - 11:45	Upper tropospheric and lower stratospheric CO and N2O during the Asian summer monsoon season, provided by the instrument COLD in the frame of the StratoClim campaign	Silvia Viciani et al.
11:45 - 12:05	AMICA	Marc von Hobe, Corinna Kloss et al.
12:05 - 13:05	**LUNCH**	
13:05 - 13:20	FOZAN	Fabrizio Ravegnani et al.
13:20 13:35	Mesoscale variability of water vapour in AM TTL from FLASH hygrometer, dehydration vs hydration	Sergey Khaykin et al.
13:35 - 13:50	CHIWIS	Elizabeth Moyer et al.
13:50 - 14:05	CIMS Measurements of SO2 and H2SO4 in the Asian Summer Monsoon Anticyclone	Hans Schlager et al.
14:05 - 14:20	NO and NOy mixing ratios affected by the Asian Monsoon Anticyclone during STRATOCLIM - airborne measurements on board the M55 Geophysica	Greta Stratmann et al.
14:20 - 14:35	FUNMASS	Talat Khattatov et al.

Monday 6.11.2017	Aircraft Campaign Science Meeting	
14:35 - 16:20	**Aerosol Measurements and Results**	**Chair: Francesco Cairo**
14:35 - 14:55	Mainz Aerosol Package	Stephan Borrmann et al.
14:55 - 15:15	Mainz CCN Package	Ralf Weigel et al.
15:15 - 15:45	**Coffee Break**	
15:45 - 16:00	MAS	Francesco Cairo et al.
16:00 - 16:20	NIXE-CAPS Cloud Particle Measurement in the Asian Monsoon Region	Armin Afchine et al.
16:20 - 18:00	**General Discussions**	**Chair: Fred Stroh**
16:20 - 17:50	General Discussion of Preliminary Results	
17:50 - 18:00	Publication Issues (t.b.d.)	
18:00 - 19:00	**Executive Group meeting**	For ExGroup members only

Tuesday 7.11.2017	StratoClim Annual Meeting	
9:00 - 9:30	**Aircraft Campaign Science meeting summary (WP1)**	**Fred Stroh**
9:30 - 11:00	**WP2 session**	**Chair: Markus Rex**
9:30 - 9:45	WP2 Overview and progress	Markus Rex
9:45 - 10:15	Palau Ground Station and Bhola Island activities	Markus Rex
10:15 - 10:45	Balloon measurements of UTLS water vapor, ozone and aerosol backscatter during StratoClim 2017	Simone Brunamonti
10:45 - 11:00	Discussions	
11:00 - 11.30	**Coffee Break**	
11:30 - 13:00	**WP3 session**	**Chair: Gabriele Stiller**
11:00 - 11:45	WP3 Overview and progress	GabrieleStiller
11:45 - 12:05	MIPAS observations of volcanic sulphate aerosol and sulphur dioxide in the stratosphere	Guenther et al.

Tuesday 7.11.2017	StratoClim Annual Meeting	
12:05 - 12:20	The characterisation of upper-tropospheric -lower stratospheric secondary sulfate and non- sulfate aerosols from thermal infrared satellite instruments in low Earth and geostationary orbit	Sellitto et al.
12:20 - 12:35	Cloud cover observed with geostationnary data during summer over Sahara and the associated circulations patterns	Seze et al.
12:35 - 12:50	Geostationary satellites retrieval of cloud top and cloud type discrimination in the Asian Monsoon Region	Bucci et al.
12:50 - 13:00	Discussions	
13:00 - 14:00	**LUNCH**	
14:00 - 15:30	**WP5 session**	**Chair: Martin Dameris**
14:00 - 14:30	WP5 Overview and progress	Martin Dameris
14:30 - 14:50	The QBO/ENSO connection in climate models	Bo Christiansen
14:50 - 15:10	ATAL simulated with a coupled aerosol-chemistry-climate model: enhanced H_2SO_4-H_2O droplets, HNO_3-H_2SO_4-H_2O ternaries, organics, ice, or a mix?	Thomas Peter
15:10 - 15:30	First comparison of model data with campaign measurements in the tropopause monsoon region	Christoph Brühl
15:30 - 16:00	**Coffee Break**	
16:00 - 18:00	**Poster session**	
19:30	**Joint Meeting dinner**	

Wednesday 8.11.2017	StratoClim Annual Meeting	
9:00 - 10:30	**WP4 session**	**Chair: Rolf Müller**
9:00 - 9:10	WP4 Overview and progress	Legras / Müller
9:10 - 9:30	Nucleation mechanism of the tropopause cirrus observed during The STRATOCLIM aircraft campaign	Bei-Ping Luo
9:30 - 9:50	Aircraft trace gases measurements (preliminary results) and Lagrangian analysis of air masses origin, 2017 STRATOCLIM campaign.	Silvia Bucci

Wednesday 8.11.2017	StratoClim Annual Meeting	
9:50 - 10:10	Lagrangian simulations of transport of young air masses to the top of the Asian monsoon anticyclone and beyond	Bärbel Vogel
10:10 - 10:25	Three-Dimensional modelling of the long-term variability of tracer transport in the Asian Summer Monsoon anticyclone	Giorgio Taverna
10:25 - 10:30	Back trajectories starting at the flight paths (with and without convection)	Ingo Wohltmann
10:30 - 11:00	**Coffee Break**	
11:00 - 12:00	**WP6 and 7 session**	**Chair: Kain Glensor**
11:00 - 11:30	WP6 Overview and progress	Kain Glensor
11:30 - 12:00	Stakehoder activities during the aircraft campaign	Fred Stroh, Markus Rex
12:00 - 12:30	**Asian summer monsoon Chemical and Climate Impact Project (ACCLIP)**	**Laura Pan, StratoClim SAB**
12:30 - 13:00	**General Discussions and EU reporting**	

List of Posters

AUTHOR	TITLE
Benjamin Clouser	Measurements of the HDO/H2O Ratio in the Asian Summer Monsoon
Sören Johansson	First ammonia observations in the Asian monsoon upper troposphere with GLORIA
Li, Yun	FUNMASS: Concept, Lessons and First Results from StratoClim
Silvia Viciani	Upper tropospheric and lower stratospheric CO and N2O during the Asian summer monsoon season, provided by the instrument COLD in the frame of the StratoClim campaign
Federico Fierli	Analysis of Kalamata M55 observations
Sergey Khaykin	Mesoscale variability of water vapour in AM TTL from FLASH hygrometer, dehydration vs hydration
Teresa Jorge	Cryogenic Frost Point Hygrometer Contaminated by Mixed Phase Clouds, Computational Fluid Dynamics Study
Ruud Dirksen	Investigating the differences between the Vaisala RS92 and RS41 radiosondes by performing twin soundings at Kathmandu University, Dhulikhel (Nepal), during StratoClim 2017
Thibaut Dauhut	Giga-LES of Hector the Convector, How does the very deep convection hydrate the stratosphere?
H. S. Harsha	Analysing the air mass origins of ATAL based on balloon measurements during the Campaign at Nainital using CLaMS backward trajectory calculations
Bernard Legras	Sources of the air sampled during the StratoClim campaign
Tatsuo Onishi	StratoClim aircraft campaign, Tracer forecasts and first analysis runs using WRF
Giorgio Taverna	Three-Dimensional modelling of the long-term variability of tracer transport in the Asian Summer Monsoon anticyclone
Ingo Wohltmann et al.	Back trajectories starting at the flight paths (with and without convection)
Erik Romanowsky et al.	The role of stratospheric ozone for Arctic-midlatitude linkages
Christoph Bruehl	Simulation of stratospheric aerosol and its radiative forcing with the comprehensive chemistry climate model EMAC and the importance of aerosol transport by the Asian Monsoon
Imre M. Jánosi	Comprehensive climatology of stratospheric ozone, water and temperature over the polar and equatorial regions

James Keeble	Diagnosing the radiative and chemical contributions to future changes in tropical column ozone with the UM-UKCA chemistry-climate model
Ulrike Niemeier	Stratospheric circulation responses to volcanic and geoengineered aerosols
Matthias Nuetzel	Variability of transport from the planetary boundary layer to the South Asian High
Philip Rupp	The dynamics of the monsoon anticyclone
Federico Serva	Influence of ENSO on the QBO in a multimodel ensemble
Claudia Timmreck	Radiative forcing imbalance by stratospheric sulfate aerosols Limitation Uncertainties Challenges
Jacob Smith	Determining stratospheric water vapour variability in global climate models

Abstracts

Aircraft Campaign Science meeting (WP1)

Vertical distribution of sub-µm sized aerosols in the UT/LS of the Asian Monsoon region

Ralf Weigel, Institute for Physics of the Atmosphere, Mainz University

In the 15th year of continuous operation on board the M-55 Geophysica the 4-channel condensation particle counter COPAS (COndensation PArticle counting System) has been deployed for investigating aerosol related properties in the UT/LS. Three of the four channels operate with different 50% detection particle diameters dp50 (i.e. 6 nm, 10 nm and 15 nm). The fourth COPAS channel (with dp50 = 10 nm) counts aerosols after their exposure to heat (250°C) resulting in numbers of non-volatile (nv) particles (e.g. soot, mineral dust, metallic aerosols, etc.) (cf. Weigel et al., 2014 and references therein). Mixing ratios of particles larger than 10 nm in diameter to up to about 1 µm are denoted as n10. The fraction f of non-volatile particles is the percental ratio of n10nv and n10 as only non-volatile particles of dp > 10 nm are detected. Since the year 2010, a dual-stage impactor system is part of the COPAS instrumentation, nowadays enabling up to 12 in-flight aerosol samples (per flight) for subsequent offline single particle's physico-chemical analysis by using Scanning Electron Microscopy (Ebert et al. 2016).
StratoClim comprises a two-tier field mission, one part of which was conducted over the Mediterranean (Kalamata, Greece, August/September 2016). The second part of the mission took place during the monsoon season over the Indian subcontinent (Kathmandu, Nepal, July/August 2017). During StratoClim three measurement flights were performed at mid-latitudes and eight flights over Nepal, India and Bangladesh (cf. Fig. 1). The particle mixing ratios obtained from selected flights over the Mediterranean and from Nepal in comparison to earlier findings by colleagues (cf. Brock et al., Science, 1995) and to results attained from COPAS at mid-latitudes and the tropics. The most striking finding is the difference in the resulting mixing ratios between Greece and Nepal. At mid-latitudes the values range at, or slightly above, mixing ratios typical for that region. Over Nepal, the abundance of sub-µm aerosol particles is excessive until reaching 420 K (Θ). Up to these altitudes the results generally exceed all expected mixing ratios from earlier findings by at least one order of magnitude (cf. $\Theta \approx 360$ K, i.e. below the tropopause) if not even more than that (cf. 370 K < Θ < 380 K, i.e. at tropopause level) likely due to new particle formation (NPF). The prevailing abundance of aerosols at higher altitudes (380K<Θ<425K) illustrates how effective the monsoon- driven vertical transport of aerosol proceeds across the tropopause. At highest levels ($\Theta > 430$ K), particle mixing ratios decline to values which compare to the references. Detected mixing ratios n10nv exhibit a maximum at the tropopause ($\Theta \approx 370$ K). The fraction f, however, has its maximum (~ 70 %) further above at $\Theta \approx 400$ K, where f is additionally most variable over the entire vertical range with values down to 15 %.

Aircraft Campaign Science meeting (WP1)

The 2017 Asian Summer Monsoon: an Aura MLS Perspective

M.L. Santee[1], N.J. Livesey[1], J.L. Neu[1,] G.L. Manney[2,3,] L.F. Millán[1], and M.J. Schwartz[1]

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[2]NorthWest Research Associates, Socorro, NM, USA
[3]New Mexico Institute of Mining and Technology

The Aura Microwave Limb Sounder (MLS), launched in July 2004, makes simultaneous colocated measurements of trace gases and cloud ice water content (a proxy for deep convection) in the upper troposphere / lower stratosphere (UTLS) on a daily basis. With its dense spatial and temporal sampling, extensive measurement suite, and insensitivity to aerosol and all but the thickest clouds, Aura MLS is well suited to characterizing UTLS composition in the region of the Asian summer monsoon (ASM) and quantifying the considerable spatial and seasonal variations therein. In addition, the 13-yr MLS data record is invaluable for assessing interannual variability in the impact of the ASM on the UTLS. Here we use MLS measurements to place the 2017 ASM observed in detail by the StratoClim campaign into the context of other recent monsoon seasons. MLS data indicate that in 2017 the behavior of several species (notably water vapor and pollution tracers) differed from that in most previous ASM seasons observed by Aura, especially at higher levels (e.g., 390 and 410 K). In particular, ASM moistening of the UTLS was more pronounced than average in 2017, whereas the signature of pollution trapped in the ASM anticyclone was considerably weaker. In contrast, the seasonal evolution of stratospheric species such as ozone was more typical.

Aircraft Campaign Science meeting (WP1)

Measurements of the HDO/H2O Isotopic Ratio in the Asian Summer Monsoon

Benjamin Clouser et al., University of Chicago

The Asian monsoon is one of the world's largest weather systems, and has been thought to be one of the main pathways by which water vapor enters the UT/LS. The Chicago Water Isotope Spectrometer (ChiWIS) participated in the July/August 2017 Kathmandu StratoClim aircraft campaign, measuring water vapor and its isotopic composition between 12 and 20 kilometers to diagnose water transport processes. Water isotopic measurements can characterize the importance of overshooting convection and the extent to which convection-driven water vapor perturbations propagate to higher altitudes and contribute to the overall stratospheric water budget. Measurements during StratoClim confirm the results of satellite measurements of the HDO/H2O ratio of UT/LS water, which show significant differences between the Asian and North American monsoons. Although we see numerous instances of detraining convection to or above 380 K, these events appear not to produce the strong isotopic enhancements seen over the North American monsoon. One potential implication is that overshooting convection may not routinely reach altitudes where the stratosphere is profoundly undersaturated, and that ice from Asian monsoon convection largely precipitates out of the UT/LS before sublimation. We discuss the instrument, its performance, and further implications of these results.

Aircraft Campaign Science meeting (WP1)

Analysis of Kalamata M55 observations

S. Bucci, F. Fierli and the M55 team

We present the analysis of one flight during the Kalamata Campaign where the M55 sampled the edge of the Asian Anticyclone in the Eastern Mediterranean. Carbon Monoxyde observations indicates a clear enhancement related to the penetration in the AA area. Comparative analyses of satellite Microwave Limb Sounder observations provide a clear agreement among data. Dynamics of the AA is studied with Lagrangian analysis and global coupled chemistry climate models to provide a characterization of transport and the global behaviour of the Anticyclone structure.

Aircraft Campaign Science meeting (WP1)

Large amounts of NH3 discovered by GLORIA in the Asian Monsoon Upper Troposphere

S. Johansson (1) M. Höpfner (1) C. Ullwer (1) R. Ruhnke (1) F. Friedl-Vallon (1) J. Ungermann (2) and the GLORIA team (1,2)

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(2) Institut für Energie und Klimaforschung, Stratosphäre, IEK-7, Forschungszentrum Jülich, Jülich, Germany

We will present measurements of ammonia obtained by the GLORIA (Gimballed Limb Observer for Radiance Imaging of the Atmosphere) instrument that has been operated on the Geophysica research aircraft during the StratoClim campaign in area of the Indian subcontinent with basis in Kathmandu, Nepal in July/August 2017.

We will show retrievals of two-dimensional ammonia distributions derived from GLORIA observations performed with high and medium high spectral resolution. For a first scientific analysis, comparisons to atmospheric model simulations from the ICON-ART (ICOsahedral Nonhydrostatic model - Aerosols and Reactive Trace gases) model will be discussed. The origin of air masses with high ammonia volume mixing ratio are estimated by using backward trajectory calculations of the NOAA HYSPLIT (Hybrid Single-Particle Lagrangian Integrated Trajectory) model.

Aircraft Campaign Science meeting (WP1)

FUNMASS: Concept , Lessons and First Results from StratoClim

Yun Li, Talat Khattatov, Sascha Albrecht, Jochen Barthel, Vicheith Tan, Axel Schönfeld, Anne Richter, Markus Dick, Heinz Rongen, Herbert Schneider, Thomas Kulessa, Johannes Schillings, and Fred Stroh
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FUNMASS is an innovative and versatile chemical ionization time-of-flight mass spectrometer developed to do airborne measurements of ultra-trace species in the upper troposphere and lower stratosphere region. It was deployed for the first time in a full measurement mode onboard M55 Geophysica during the StratoClim Asian Monsoon Field Campaign in summer 2017. Due to major problems with the inlet system FUNMASS only obtained ambient air measurements during flight 7 on 08.08.2017.
Here we summarize the instrument setup and specifications, the calibration procedure and first results obtained for nitric acid, HNO3.

Aircraft Campaign Science meeting (WP1)

CIMS Measurements of SO2 and H2SO4 in the Asian Summer Monsoon Anticyclone – First STRATOMAS results

Hans Schlager, Heinfried Aufmhoff, Jule Heuchert, Frank Arnold, Greta Stratmann
DLR-Institut für Physik der Atmosphäre, Oberpfaffenhofen, Germany

We present first results of the new STRATOMAS instrument obtained during two Geophysica flights in the frame of the StratoClim campaign in Kathmandu in July/August 2017. The experimental technique of SO2 und H2SO4 measurements by active and passive chemical ionization mass spectrometry will be briefly described. SO2 and H2SO4 profile measurements in the central region of the Asian Summer Monsoon Anticyclone (ASMA) will be discussed. First analysis of the origin of distinct layers observed with enhanced SO2 mixing ratios will be presented. SO2 and H2SO4 measurements in the ASMA will be compared with previous observations near the western boundary of the ASMA and at mid-mid-latitudes.

Aircraft Campaign Science meeting (WP1)

Upper tropospheric and lower stratospheric CO and N2O during the Asian summer monsoon season, provided by the instrument COLD in the frame of the StratoClim campaign

S. Viciani[1], A. Montori[1], A. Chiarugi[2], F. Ravegnani3, A. Ulanovsky[4], S. Bucci[5], B. Legras[5], F. Fierli[6], C. Cagnazzo[6], F Cairo[6], K. Law[7], T. Onishi[7] and F. D'Amato[1]

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We present the in-situ measurements of carbon monoxide (CO) and nitrous oxide (N2O) in the upper troposphere and lower stratosphere (UTLS) during the Asian summer monsoon season, obtained in the frame of the StratoClim campaign in July-August 2017. The concentration measurements are provided by the instrument COLD (Carbon Oxide Laser Detector) installed in the dome of the M55 Geophysica Aircraft. COLD is an unpressurized mid-infrared Quantum Cascade Laser spectrometer based on direct absorption technique in combination with a multi-pass cell, which provides the absolute mixing ratio values of the analyzed molecules without any kind of calibration.

The CO and N2O data, collected during the 8 scientific flights of the campaign, are presented, with emphasis on (i) CO mean vertical profile during the campaign and (ii) enhanced CO layers that are often observed in UT.

We perform a comparison with CO from Microwave Limb Sounder (MLS) for the whole campaign to evaluate the background conditions. CO positive anomalies are analyzed jointly with aerosol / cloud observations and convective tracers from lagrangian and eulerian models to identify convective influence and source region of potential pollutants in the UT. Moreover, correlation with other species (i.e. Ozone from FOZAN, Fast OZone ANalyser) is also outlined. A preliminary analysis shows that CO concentrations exhibit, on average, limited latitude gradient with a frequent presence of filamentary structure likely originated from recent convective transport.

Aircraft Campaign Science meeting (WP1)

Mesoscale water vapour variability in AM TTL from FLASH onboard Geophysica: dehydration vs hydration

S. Khaykin[1,2], A. Lykov[2], V. Yushkov[2], I. Formanyuk[2], V. Volkov[2], FISH team[3], MAL team[4]

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[2] Central Aerological Observatory of Roshydromet, Dolgoprudny, Moscow Region, Russian Federation
[3] Forschungszentrum Jülich, Institute for Energy and Climate Research (IEK-7), Jülich, Germany
[4] Centre Suisse d'Electronique et de Microtechnique, Neuchatel, Switzerland

FLASH hygrometer performed impeccably during all eight KTM flights plus transfers and provided a wealth of new information on AM water vapour distribution and variability. High quality of the measurements is ensured by close agreement with clear-air FISH measurements. The collected data reflect the diversity of TTL conditions encountered. A significant variability of water vapour along isentropes above 390 K on a scale of few tens of kilometers was observed in particular flights. We present preliminary analysis of cases pointing out concurrent dehydration and hydration processes that drive water content above the cold point tropopause. Total water (FISH) and cloud (MAL) measurements are invoked for the analysis.

Ground Stations (WP2)

Balloon measurements of UTLS water vapor, ozone and aerosol backscatter during StratoClim 2017

S. Brunamonti[1], T. Jorge1, P. Oelsner[2], S. Meier[2], S. Hanumantu3, F.G. Wienhold[1], S. Fadnavis[4], M. Naja[5], R. Kayastha[6], J. Bian[7], B. P. Luo[1] and T. Peter[1]

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[4] Indian Institute of Tropical Meteorology (IITM), Pune, India

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Simultaneously with the Geophysica aircraft campaign, the StratoClim balloon cam- paign was conducted from Kathmandu University campus at Dhulikhel, Nepal (27.6°N, 85.5°E) between 30 July - 12 August 2017. In total 28 balloon launches were per- formed, with different combinations of VAISALA RS41 radiosondes (28 deployments), CFH frost-point hygrometers (11), ECC ozonesondes (12) and COBALD backscatter sondes (3). Here we present an overview of these observations, and compare them with the observations made during the StratoClim 2016 balloon campaign conducted from Nainital, India (29.4°N, 79.5°E) in August 2016. The two sites are both located at the southern slopes of Himalaya, a key region for troposphere-stratosphere exchanges within the Asian monsoon system. The comparison reveals strong differences in the thermal structure of the upper troposphere – lower stratosphere (UTLS) and in the distribution of water vapor. The cold-point tropopause was found to be colder (by 5 K on average) and higher (by 600 m) in 2017 than in 2016, causing systematically higher humidities in the upper troposphere and hence likely higher cloud frequency of occurrence. Water vapor exhibits lower mixing ratios (by about 2 ppmv) near the cold- point in 2017 compared to 2016, while higher mixing ratios (by 1 ppmv) are found in the lower stratosphere. Further investigation is ongoing to assess whether these differences can be attributed to interannual variability of the Asian monsoon system, or to different mesoscale meteorological features between the sites of observation.

Ground Stations (WP2)

Investigating the differences between the Vaisala RS92 and RS41 radiosondes by performing twin soundings at Kathmandu University, Dhulikhel (Nepal), during StratoClim 2017

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In the GRUAN network, radiosondes are employed to provide high-quality reference observations for climate records. One of GRUAN's core values is proper management of changes in the measurement systems to prevent inhomogeneities in climate data records. In 2014 Vaisala announced the phase-out of the RS92 radiosonde by then end of 2017, and that it would be replaced by a new model, the RS41. This announced change, which is currently ongoing, poses a major challenge for GRUAN as the majority of the GRUAN sites employ the RS92, which essentially makes it GRUAN's backbone in terms of radiosounding. For a proper management of this change, it is essential to quantify offsets and biases as well as changes in errors and uncertainties between both radiosonde types. Examples of such changes in errors concern the radiation-induced error of the temperature and/or humidity sensors or differences in response time of the humidity sensor at low temperatures (time lag). Intercomparison soundings, where two –or more-radiosondes are carried by the same balloon, are commonly used for the characterization of differences between radiosonde under identical measurement conditions.

This paper presents first results of the RS92-RS41 intercomparisons that were performed between 30 July and 12 August at Kathmandu University, Dhulikhel, in the framework of the StratoClim campaign. In total, 28 balloon launches were performed, 17 of which during daytime; several flights comprised of extended payloads, including cryogenic frostpoint (CFH), COBALD and ozone sondes. The analysis focuses on the differences between the temperature and humidity measurements of both radiosonde types.

These intercomparison measurements provide important information on the RS92- RS41 differences in tropical regions, and especially for the challenging meteorological conditions that prevail during the Indian monsoon, such as a cold and humid tropopause region.

Ground Stations (WP2)

Cryogenic Frost Point Hygrometer Contaminated by Mixed Phase Clouds: Computational Fluid Dynamics Study

T. Jorge, S. Brunamonti, F. G. Wienhold, B. P. Luo and T. Peter
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During the 2016 StratoClim Balloon Campaign in Nainital, India, there were several contaminated water vapor observations by the CFH in the lower stratosphere, showing unrealistic high values of water vapor. This year balloon observation from Dhulikhel in Nepal yield similar contaminated observations. Two CFD studies were conducted: one focusing on contamination inside the inlet tube and other on contamination from the instrument housing. The inlet-tube study was able to reproduce the observed values by introducing ice boundary conditions at the top of the inlet tube and around the sensor head. The envisioned cause for this ice deposition is the traverse of mixed phase clouds in the troposphere. Further steps involve the matching of evaporated ice in the stratosphere with the deposited ice in the inlet tube during ascent. The housing contamination study shows how the asymmetry of the instrument with respect to the inlet might be a cause for contamination. Results of simulations with longer and shorter inlet tubes will be presented.

Satellites (WP3)

Contribution of CNRS to WP3: The characterisation of upper-tropospheric–lower-stratospheric secondary sulfate and non-sulfate aerosols from thermal infrared satellite instruments in low Earth and geostationary orbit

P. Sellito[1], B. Legras[1], G. Sèze[1], H. Guermazi[1], H. Herbin[2]
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Nadir-viewing thermal infrared (TIR) satellite instruments are potentially well adapted to study atmospheric composition, including aerosols, at the regional scale. Nevertheless, their use to monitor upper-tropospheric—lower-stratospheric (UTLS) aerosols and their processes is limited, at present. To $ll this gap, we have developed a comprehensive theoretical basis for the observation of UTLS secondary sulphate aerosols (SSA) from TIR nadir satellite instruments [Sellito and Legras, 2016], including broad-band and high-spectral resolution sensors.

The objectives of the works performed a0er the 2nd StratoClim meeting and summarised in this presentation are the following :

- applying the outcomes of the mentioned theoretical basis to SSA detection to broad-band radiometers on a geostationary orbit [Sellito et al., 2017];
- quantifying the mutual interferences of co-existing SO2 and SSA burdens in an observed scenarios, which constitutes a potentially blocking factor to the operational application of these retrievals techniques [Guermazi et al., 2017];
- Extend this theoretical basis to non-sulphate aerosols.

  These works and the perspective towards the development of operational products for IASI and geostationary instruments will be briefly discussed.

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[Sellito et al., 2017] P. Sellito, G. Sèze, B. Legras, Secondary sulphate aerosols and cirrus clouds detection with SEVIRI during Nabro volcano eruption, International Journal of Remote Sensing, 38(20), 5657-5672, 2017.

Satellites (WP3)

Cloud cover over west sahara during summer and summer circulation

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West Sahara region is a deserted and mountainous area dynamically connected to the Atlantic to the west, the Mediterranean to the north, and West Africa to the south. In boreal summer, desert surface heating leads to the development of a near surface thermal low pressure, called the Saharan Heat Low (SHL), which contrasts an anticyclonic circulation in the mid troposphere. The SHL activity is connected with the West African Monsoon and the Mid-latitude circulation, with a prominent role of dust concentration and water vapour transport in modulating its variability. In this context, the role of clouds over West Sahara still remains to be investigated. In this study, we focus on two questions: Which are the main characteristics of cloud cover over West Sahara? Is the occurrence of clouds accompanied by changes in the humidity fluxes over the region and the mean regional and large scale dynamical features? To characterise cloud cover over West Sahara, we use the multi-spectral capabilities of the Spinning Enhanced Visible and Infrared Imager (SEVIRI) on board the Meteosat Second Generation (MSG) geostationary satellite, with a resolution of 3km2 (1km2 for the High Resolution Visible channel) and 15' repeat cycle, which allow large improvements in cloud detection and cloud property retrieval compared to the first generation Meteosat satellite period. Moreover, the retrieval method developed in the frame of SAFNWC (Satellite Application Facility for Now Casting) gives access to observations of cloud type occurrence. We used these observations to determine the occurrence frequency of clouds and their vertical distribution over central West Sahara and Hoggar mountains for summer months (June to September) in the 2008-2014 period. We document the variability of cloud occurrence at diurnal, daily, intra-seasonal and inter-annual scale.
From daily frequencies of cloud occurrence, cloudy and non-cloudy days are selected. For the two regions, ERAI reanalysis are used to quantify the differences in the humidity budget between cloudy and non-cloudy days. From vertical profiles of horizontal and vertical winds and humidity along meridional and zonal transects, the changes in regional and large scale circulation associated with humidity fluxes and cloud occurrence are discussed.

Satellites (WP3)

Geostationary satellites retrieval of cloud top and cloud type discrimination in the Asian Monsoon Region

S.Bucci, B. Legras, G. Séze

With the purpose of improving the understanding on penetrating overshoot and detraining clouds in the Asian Monsoon region, we analyze cloud properties retrieval from the MSG1 and HIMAWARI geostationary satellites over the summer 2017 period. From these observations Météo-France developed the Satellite Application Facility in support to Nowcasting and Very Short Range Forecasting (SAF NWC) products, to provide cloud parameters as cloud types, cloud top temperature and height. The algorithm is based on a multi-spectral technique of thresholds derived from ancillary data as atlas, climatology maps and numerical weather prediction.
Exploiting the SAFNWC data on the time span of the 2017 summer season, we carry out a comparison of the clouds parameters (in particular cloud top temperature, pressure and cloud type) on the region of overlap of the two satellites, identifying and analyzing the main differences in the classifications. After verifying the top pressure and temperature properties of each cloud class, we exploit the cloud type classification to study the frequency and the geographical distribution of the convective clouds during the 2017 summer season. Results are then compared to the cloud top estimates from brightness temperature threshold applied on the European Centre for Medium-Range Weather Forecasts (ECMWF) simulations.

Process Studies and mesoscale modelling (WP4)

Nucleation mechanism of the tropopause cirrus observed during The STRATOCLIM aircraft campaign

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During the Stratoclim Field Campaign, cirrus clouds at very high altitude (up to 20 km) were charac- terized by the Miniature Aerosol Lidar (MAL) on board of Geophysica. Balloon sonde measurements show extremely low temperatures close the tropopause and high water mixing ratios between 50 – 100 hPa, favoring cirrus cloud formation. These cirrus clouds are most likely formed in-situ. In this study, we use the Zurich Optical Microphysical column Model (ZOMM) to study the nucleation mechanism behind this cirrus cloud formation.

Were this nucleation homogeneous, i.e. without participation of foreign ice nucleating particles (INP), this would lead to very high number densities of ice particles and much too high backscatter ratios than the measured ones. Conversely, heterogeneous nucleation with a proper number density of nuclei could explain the observed backscatter.

The possible candidates of INPs are:

(1) biological or mineral dust particles with number density of ≈ 0.1 cm-3 of natural or anthropogenic origin stemming from a surface source,

(2) organic particles which become glassy and suitable INPs at low temperature with a number density of 5 – 10 cm-3,

(3) meteoritic smoke particles of extraterrestrial origin with a number density of 1 cm-3 and radius of 20 nm.

The number densities mentioned in (1)-(3) were obtained in order to achieve agreement with lidar observations. (1) and (3) are using the active site model. Candidate (1) are much larger in size than the meteoritic smoke particles candidates (3) and therefore, contains active sites in all particles.

Candidate (1) can be excluded, because the number density of ≈ 0.1 cm-3 is typically not reached, unless possibly in severe dust storms.

The aerosol mass spectrometer data (ERICA) of MPI Mainz, which flew onboard Geophysica during StratoClim suggest significant occurrence of organic and meteoritic particles. Further studies, including the results from ERICA will be presented.

Process Studies and mesoscale modelling (WP4)

Giga-LES of Hector the Convector - How does the very deep convection hydrate the tropical stratosphere?

Thibaut Dauhut
Laboratoire d'Aérologie, Université de Toulouse, CNRS, UPS, France

The tropical thunder storms play an uncertain role in the transport of tropospheric air in to the stratosphere, limiting our capability to predict the future climate. The transport by the thunderstorms may be underestimated by the climate models, due to their coarse resolutions. The efficiency of this transport is analysed using numerical simulations of the thunderstorm Hector the Convector with resolutions down to 100m , the finest ever used for a case of very deep convection.

The overshoots, that were observed at its top at 18km altitude, are captured and the net hydration of the stratosphere is quantified. The contribution of the tropical thunderstorms to the water flux from the troposphere to the stratosphere is then estimated to about 20% (Dauhut et al.2015).

The almost convergence at 200m and 100m suggests that such resolutions are necessary to correctly represent the updrafts. The individual analysis of the updrafts indicates that the two tallest contribute beyond 90% of the mass flux into the stratosphere (Dauhut et al. 2016).

They are larger, more vigorous and contain more water than the tallest updrafts one hour before and one hour after, and their convective core was weakly diluted. The supply from the surface by the convergence lines, intensified by the cold pools, and the weak dilution of the two tallest updrafts are determinant for the development of very deep convection. The isentropic analysis of the over turning inside Hector (Dauhut et al.2017) confirms the mass flux computed with the updrafts analysis. It corrects the estimate in the lower troposphere by taking in to account the turbulent flux, and in the upper troposphere by filtering out the gravity waves. It highlights the importance of the latent heating due to ice formation in the two tallest updrafts during the phase of overshoot into the stratosphere.

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Process Studies and mesoscale modelling (WP4)

Analysing the air mass origins of ATAL based on balloon measurements during the Campaign at Nainital using CLaMS backward trajectory calculations

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We will present balloon measurements of the Asian Summer Monsoon 2016 conducted during the StratoClim Campaign at Nainital, India. The payload contained atmospheric water vapour sensor Cryogenic Frost-point Hygrometer (CFH), the aerosol sensor Compact Optical Backscatter Aerosol Detector (COBALD), ECC Ozonesonde and Radiosonde (RS92 & RS41). The Asian Monsoon Anticyclone (AMA) is playing a key role in creating the transport pathways into the Stratosphere and is important in the process of accumulation of Asian tropical pollutants in this altitude region. We are interested in understanding the role of AMA for the formation of the ATAL (Asian Tropopause Aerosol Layer). So from the campaign data we specifically looked at the measurements which are representing ATAL. We also took non-ATAL case to compare. During the campaign in Nainital several balloon profiles with and without ATAL signatures were measured in August 2016.

Analysis based on ClaMS (Chemical Lagrangian Model for Stratosphere) backward trajectory calculations. CLaMS 40-day backward trajectory calculations will be presented to understand the origins of air masses and their contribution to ATAL and non-ATAL measurements. We can clearly see the strong vertical transport above the Himalayan region and also at the western Pacific region. Further, slow upward transport around the AMA occurred above 360K potential temperature. By using a Probability Density Function (PDF) technique we are able in identifying the origin of the air mass within the UTLS region of ATAL and non ATAL cases depending on trajectory length.

Process Studies and mesoscale modelling (WP4)

Meteorological conditions and source distribution during the StratoClim campaign

Bernard Legras, Silvia Bucci, Silvia Viciani, Francesco D'Amato
Laboratoire de Météorologie Dynamique – CNRS and PSL University – Paris, F Istituto Nazionale Ottica, CNR, Firenze, I

The poster will present for each flight a summary of the meteorological conditions and of the composition of air parcels along the flight according to their origin determined by Monte-Carlo backward trajectories (stratospheric, AMA resident, convective). The convective sources are described using a regional division of the Asian monsoon region. Ages and altitude sources are also provided. This product is intended as a help to interpret the tracer measurements and to identify the structures worth of further studies. This is demonstrated by a comparison with CO measurements. The product will be available on the campaign site.

Process Studies and mesoscale modelling (WP4)

Aircraft trace gases measurements (preliminary results) and Lagrangian analysis of air masses origin, 2017 STRATOCLIM campaign.

S. Bucci, F. D'Amato, F. Fierli, B. Legras, F. Ravegnani, A. Ulanovsky, S. Viciani

We analyse the dynamics of air masses transport during the Kathmandu aircraft campaign of summer 2017, focusing on the individuation of air masses uplifted from convective source regions, their pathways and their mixing into the upper troposphere and stratosphere. The study is based on trace gases measurements, lagrangian simulations and ECMWF products analysis. In particular we analyse the CO and O3 data collected during the 8 flights by the COLD and FOZAN instruments, respectively. Then, to understand the origins of the observed features, we compare the time evolution of the trace gases concentration along the flight with cluster trajectories analysis (the system and the methods adopted are presented and discussed in B. Legras & S.Bucci talk). Is thus possible to describe, along the observations, the relative contribution of different regions, the state of mixing and the age of the air parcels. A more comprehensive understanding of the dynamics of the anticyclone, in relation with the observed features, is finally offered by the comparison with the chemical fields from the CAMS model.

Process Studies and mesoscale modelling (WP4)

Sources of the air sampled during the StratoClim campaign

Bernard Legras & Silvia Bucci
Laboratoire de Météorologie Dynamique – CNRS and PSL University – Paris

The origin of air sampled during the StratoClim campaign is studied from diffusive backward trajectories launched at a rate of 1000 parcels per second along the flight track and integrated backward in time during one month using ECMWF operational winds.
The location of parcels along trajectories are compared to the location of cloud tops derived from high resolution and high frequency images obtained by the MSG1 and Himawari geostationary satellites, in order to determine the convective sources of the parcel.
The main products that will be discussed is the distribution of sources along the flight tracks as a function of the origins and a preliminary interpretation of the tracer measurements from the proportion of continental versus maritime air present at each location of the flight track.

Process Studies and mesoscale modelling (WP4)

StratoClim aircraft campaign: Tracer forecasts and first analysis runs using WRF

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The WRF (Weather Research Forecast) model ver. 3.8 was used in forecast mode during the aircraft campaign in the summer of 2017 in Nepal. The model was run at 25km resolution using meteorological analyses from GFS with specified tracers for carbon monoxide (CO), Sulphur dioxide (SO2) and black carbon (BC) and provided 72-hour forecasts of the tracers every day. Tracers were emitted from the surface using the emission inventory REAS v2.1 (Regional Emissions in Asia). Tracers were not subject to loss by chemistry or wet/dry deposition and there was no input of tracer though lateral and upper boundaries. Surface-origin tracers represent concentrations above background. Short-lived BC tracer was reset in each new forecast and indicated regions influenced by recent convection (< 72 hours), whereas CO and SO2 concentrations were re-used in the initialization of each new forecast, providing an indication of air masses influenced by convective uplift over a longer period.

We have also performed WRF tracer runs for the campaign period based on GFS analyses. The model was run with different cumulus convection parameterization schemes. Apart from Grell 3D ensemble scheme used in the campaign, Betts-Miller-Janjic scheme and Kain-Fritsch-Cumulus Potential (KF-CuP) (Berg et al., 2015) were used. Simulated spatial and vertical distributions of clouds as well as the convective available potential energy (CAPE) are examined and compared to available data. We will also compare with available CO measurements as an indication of recent convection. Runs with the WRF-Chem chemical-aerosol model are also planned.

Process Studies and mesoscale modelling (WP4)

Three-Dimensional modelling of the long-term variability of tracer transport in the Asian Summer Monsoon anticyclone

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The Asian Monsoon spreads over an important region well known for the transport of climate- relevant gases from the troposphere to the stratosphere. Recent works by several groups have focused on quantifying processes which contribute to coupling in the upper troposphere-lower stratosphere (UTLS), including transport during the Asian Summer Monsoon (ASM). Troposphere-to-stratosphere transport in this region has been the focus of a number of recent campaigns, including the EU "StratoClim campaign" in Greece 2016 and Nepal 2017.
Anthropogenic compounds such as CO, Very Short-Lived Substances (VSLS), which destroy stratospheric ozone and sulphur compounds, which maintain the stratospheric aerosol layer, are among the important species involved in large convective systems transport such as the ASM. An important question for halogenated VSLS is whether ASM-associated transport can take place on timescales which are short relative to their chemical lifetimes of days to months. This poster will present results of the TOMCAT/SLIMCAT off-line 3-D chemical transport model to investigate these issues using moderate-resolution simulations (2.8°x2.8°, 60 levels from surface to 60 km). The model is forced by ECMWF ERA-Interim reanalyses.
Two different definitions of "center" of the anticyclone, chosen from the most recent literature will be used. In order to represent the interannual variability of the confinement of tracers in the anticyclone, the model results are compared with vertical shear of the zonal wind between 850 and 200 hPa averaged over the 0-20N, 40-110E during northern summer season. Comparisons will be made with in-situ and remote satellite data, where possible.

Process Studies and mesoscale modelling (WP4)

Lagrangian simulations of transport of young air masses to the top of the Asian monsoon anticyclone and beyond

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Abstract.

Simulations with the Chemical Lagrangian Model of the Stratosphere (CLaMS) will be presented using artificial tracers of air mass origin. With this technique the impact of young air masses continuously released since the pre-monsoon season (1st May 2008) in the model boundary layer over the course of the simulation on the composition of the Asian monsoon anticyclone 2008 and above in the lower stratosphere can be determined. The CLaMS model results are compared with global HCFC-22 measurements of the MIPAS instrument onboard the ENVISAT satellite for the monsoon season 2008. Because HCFC-22 is emitted in locally restricted regions, in particular in eastern Asia and therefore in the Asian monsoon region, this trace gas is very well suited for studying transport processes in the region of the Asian monsoon anticyclone. Measurements of HCFC-22 confirm our model results that young are masses from Asia are transported to the top of the Asian monsoon anticyclone.

Above the anticyclone, young air masses are found up to 440-460 K. Between 360 K and 400 K highest fractions of young air masses mainly from India/China are found in the core of the Asian monsoon anticyclone, however between 420 K and 460 K highest contributions are found around the edge of the anticyclone. CLaMS trajectory calculations demonstrate that at these altitudes vertical upward transport of young air masses occurs at the edge of the anticyclone and not inside the anticyclone itself. Therefore, young air masses from outside the Asian monsoon anticyclone (e.g. Southeast Asia, western Pacific, northern Africa) are also transported into the lower stratosphere (above the thermal tropopause) and contribute to the composition of air masses beyond the anticyclone.

In addition, a two-monsoon-season simulation will be discussed covering the time period from 1 May 2007 to 31 October 2008, including both the Asian monsoon season 2007 and 2008 to study the upwelling of surface emissions into the lower stratosphere during the course of two succeeding monsoon seasons. Air masses form India/China are transported into the middle stratosphere in the upward Brewer-Dobson circulation within the tropical pipe within a time period of about a year. Thus, air masses from the Asian monsoon anticyclone are uplifted from the upper troposphere and lower stratosphere (UTLS) during the subsequent winter within the tropical pipe up to around 600 K potential temperature.

Process Studies and mesoscale modelling (WP4)

Back trajectories starting at the flight paths (with and without convection)

Ingo Wohltmann, Markus Rex
Alfred Wegener Institute

As a service to all which interpret the measurements from the flight campaign, we would like to offer back trajectory calculations showing the air mass history of the air parcels probed along the flight paths, based on the AWI campaign planning tool.

In addition to simple back trajectories driven by the large scale wind,

our trajectory model is able to provide statistical ensembles of trajectories at every location of the flight path calculated with a statistical convection model using the convective mass fluxes and detrainment rates provided by ECMWF.

Possible applications are the calculation of the probability that the air parcel took part in convection in the last days along the flight path and showing probable source regions of air at the ground considering convection.

We will show back trajectories without convection for all flights and a proof of concept for one flight with convection (since detrainment rates and mass fluxes are not available from ECMWF for summer 2017 so far).

Global climate modelling (WP5)

Simulation of stratospheric aerosol and its radiative forcing with the comprehensive chemistry climate model EMAC and the importance of aerosol transport by the Asian Monsoon

Christoph Brühl, Jennifer Schallock, Jos Lelieveld, Stephan Borrmann, MPIC Mainz
Michael Höpfner, KIT Karlsruhe
Christine Bingen, BIRA Brussels
Marc von Hobe, Corinna Kloss, FZ Jülich
Ralf Weigel, Univ. Mainz

Results of transient simulations for 2002 to 2012 using the chemistry climate model EMAC in different versions with interactive tropospheric and stratospheric aerosol processes are presented. The simulations include up to about 230 volcanic SO2 injections into the UTLS using estimates from satellite data (MIPAS, GOMOS). The lower boundary conditions for the different aerosol types are based on MACCity and GFED for organic and black carbon (OC, BC) and sulfur, and online schemes for mineral dust. We show that the volcanoes are essential to reproduce observed stratospheric aerosol optical depth and derived radiative forcing. We demonstrate that in the Asian monsoon region CO, OCS, black carbon, but also mineral dust are strongly enhanced in the UTLS. OC, BC and dust appear to contribute significantly to extinction and forcing as indicated by GOMOS. We also show that the monsoon circulation transports anthropogenic SO2 and sulfate, originating in China and India, to the lower stratosphere. This is dependent on uncertain emission assumptions and the parameterization for aerosol chemistry, as shown in sensitivity studies. The presentation will include some preliminary comparisons with COPAS, UHSAS, COLD, FOZAN and AMICA data of the Geophysica Campaign.

Global climate modelling (WP5)

StratoCLIM-Community Derived Diagnostics

C. Cagnazzo & all StratoCLIM Partners

The Objective is to develop diagnostics (also ideally metrics) for Global and Regional Climate Models, based on all data available: from already existing satellite and in situ observations (including campaigns), to reanalyses, to future available observations, to already existing or future existing trajectories. The idea is to derive those products as a result of the StratoCLIM Project (and of interest to ACAM) and to propose those possible process-based diagnostics to the community outside StratoCLIM. The derived diagnostics/metrics come from the joint use of observations (already available or available during the project) and the model simulations (already available or available during the project). A diagnostic is used to describe a specific process; a process-based metric, that is based on a diagnostic, is a measurement of the distance between the model "world" and the observations, therefore it tells you how good the model is in representing that specific process and it may become a sort of "score" for that model and that process. Therefore diagnostics may provide a qualitative comparison of the models with observations. Diagnostics may be new or based on existing literature. We present a list and examples of process-based diagnostics per scientific themes.

Global climate modelling (WP5)

Influence of ENSO on the QBO in a multimodel ensemble

Federico Serva, Chiara Cagnazzo (likely presenter), Angelo Riccio, Bo Christiansen and Shuting Yang

In the recent work of [Christiansen et al., 2016] it has been demonstrated that strong warm El Nino-Southern Oscillation (ENSO) events can lock the phase of the stratospheric quasi-biennial oscillation (QBO) in the 2-4 years following the warming of the tropical Pacific. In this work, we aim at studying whether this behaviour is reproduced in multimodel ensemble simulations, in atmosphere-only and coupled configurations. By means of an EOF/PC representation of the stratospheric zonal winds, we find that cold/warm ENSO events modulate the phase progression and the amplitude of the QBO. This modulation (present in observational data) differs between individual models, and is also dependent on the model horizontal resolution. We also discuss the alignment of the QBO after the major historical warm ENSO events in atmospheric simulations.

Global climate modelling (WP5)

The complex behaviour of El Niño winter 2015-2016

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We examine the outstanding characteristics of the strong 2015–2016 El Niño (EN), one of the strongest in record, and its impact over the European region through the stratospheric pathway. Despite being classified as a strong eastern Pacific (EP) EN event, our analysis reveals its complex nature, with some signatures that are more typical of central Pacific (CP) EN events instead. The CP-EN behavior of this event is based on first, the value of the CP index, which reached a historical record. Second, the polar stratospheric signal, as a stronger and colder polar vortex in early and mid-winter in relation to reduced upward wave propagation and a weak Aleutian low; which resembles the typical behavior reported for CP- EN. Third, the occurrence of one of the earliest Stratospheric Final Warmings (SFWs) on record; which are found to be more prone to occur during CP-EN than EP-EN events. In addition, anomalies following the SFW descended from the stratosphere into the troposphere and influenced the surface weather during spring. Thus, persistent blocking conditions over Greenland diverted the Atlantic storm-tracks to the south, resulting in above-normal precipitation over southern Europe. These results highlight the importance of considering early SFWs as mediators in El Niño teleconnections.

Global climate modelling (WP5)

Comprehensive climatology of stratospheric ozone, water and temperature over the polar and equatorial regions

Imre M. Jánosi, Eötvös Loránd University, Faculty of Science

"Our primary goal was to validate ERA Interim stratospheric records by comparing ozone, water vapor and temperature data with Aura-MLS satellite observations. ERA Interim data sets cover the period from 1 January 1979 onward and continue to be extended in near-real time. Gridded data sets are produced with a sequential data assimilation scheme using real observations and forecast models. MLS observes thermal microwave emission from the Earth's "limb" (the edge of the atmosphere) viewing forward along the Aura spacecraft's flight direction, scanning its view from the ground up to 90 km altitude in every 25 seconds. As Earth rotates underneath it, the Aura orbit stays fixed relative to the sun giving daily global coverage with 15 orbits per day.

We determined daily mean values for the three variables at 38 (MLS) and 17 (ERA Interim) pressure levels in the overlapping temporal period of 02.08.2004 - 01.12.2016, and also for the full available interval 01.01.1979 - 01.02.2016 for the ERA Interim data base. Climatological mean, anomaly time series, vertical mean profiles for each calendar months, and cross correlation functions

are computed for five geographic bands:

- northern polar region: 60 degN - 82 degN
- northern midlatitude band: 40 degN - 50 degN - equatorial band: 5 degS - 5 degN
- southern midlatitude band: 50 degS- 40 degS -southern polar region: 82 degS - 60 degS

Merged data sets from the two different sources exhibit high consistency, with some systematic deviations (examples are shown). One of the most interesting results is the correlation behavior of the ozone – temperature. Over both poles, the apparent equal-time cross-correlation changes sign at a pressure level, where the maximum value is situated in the mean vertical ozone concentration profile. Correlation does not mean causality, nevertheless this behavior (which is present in all geographic bands) suggests significant differences in the dynamics and/or chemistry of ozone between the upper and lower stratosphere."

Global climate modelling (WP5)

Diagnosing the radiative and chemical contributions to future changes in tropical column ozone with the UM- UKCA chemistry-climate model

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Chemical and dynamical drivers of trends in tropical total column ozone (TCO3) for the recent past and future periods are explored using the UM-UKCA chemistry-climate model. A transient 1960-2100 simulation is analysed which follows the representative concentration pathway 6.0 (RCP6.0) emissions scenario for the future. Tropical averaged (10°S-10°N) TCO3 values decrease from the 1970s, reach a minimum around 2000, and return to their 1980 values around 2040, consistent with the use and emission of halogenated ozone depleting substances (ODS), and their later controls under the Montreal Protocol. However, when the ozone column is subdivided into three partial columns (PCO3) that cover the upper stratosphere (PCO3US), lower stratosphere (PCO3LS) and troposphere (PCO3T), significant differences in the temporal behaviour of the partial columns is seen. Modelled PCO3T values under the RCP6.0 emissions scenario increase from 1960-2000 before remaining approximately constant throughout the 21st century. PCO3LS values decrease rapidly from 1960-2000, remain constant from 2000-2050, before gradually decreasing further from 2050-2100, never returning to their 1980s values. In contrast, PCO3US values decrease from 1960-2000, before increasing rapidly throughout the 21st century, returning to 1980s values by ~2020, and reach significantly higher values by 2100. Using a series of idealised UM-UKCA time-slice simulations with concentrations of well-mixed greenhouse gases (GHG) and halogenated ODS species set to either year 2000 or 2100 levels, we examine the main processes that drive the PCO3 responses in the three regions, and assess how these processes change under different emission scenarios. Finally, we present a simple, linearised model to describe the future evolution of tropical stratospheric column ozone values based on terms representing time-dependent abundances of GHG and halogenated ODS.

Global climate modelling (WP5)

Variability of transport from the planetary boundary layer to the South Asian High

Matthias Nützel, DLR

We present multiannual backward trajectory calculations started within the monsoon anticyclone during boreal summer and calculations with artificial tracers in a GCM to investigate the transport from the planetary boundary layer (PBL) to the South Asian High (SAH). Special focus is put on the east-west shifts of the SAH on interannual timescales. Our results show that there is strong interannual variability of the source regions and that transport from the PBL to the SAH is not notably related to the east-west shifts of the SAH on interannual basis. Further, transport from the Tibetan Plateau to the SAH is mainly focused to August, as prior to August, the subtropical westerly jet is located above the Tibetan Plateau and thus impedes vertical transport to the SAH core. The multiannual statistics and the presented results may help to put former results regarding transport from the PBL to the SAH into perspective.

Global climate modelling (WP5)

The role of stratospheric ozone for Arctic-midlatitude linkages

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Observations show a negative phase shift in wintertime Arctic Oscillation (AO) related to the loss of Arctic sea-ice in recent decades. A lot of climate models are not able to clearly reproduce this important signal for Arctic-midlatitude linkages, which are strongly influenced by planetary wave propagation pathways through the stratosphere and the interaction with the polar vortex. One important open question is how stratospheric ozone chemistry impacts this pathway. Therefore, we coupled the computationally fast interactive stratospheric chemistry module SWIFT with the atmospheric general circulation model ECHAM6. SWIFT is based on a set of coupled differential equations, which simulate the polar vortex-averaged mixing ratios of the key species involved in polar ozone depletion. This new setup was then used to investigate the influence of low and high Arctic sea ice conditions on Arctic-midlatitude linkages via the stratospheric pathway. The interactive chemistry enhances the dynamical response to Arctic sea ice reduction, and the simulated dynamical characteristics are in much better agreement with ERA-Interim reanalysis data. This shows that for an improved understanding of Arctic-midlatitude linkages the coupling between dynamics and stratospheric ozone chemistry is fundamental.

Global climate modelling (WP5)

The dynamics of the monsoon anticyclone - a single-layer model study

Philip Rupp, Cambridge University

The potential importance of the Asian monsoon anticyclone to the stratosphere, transport and climate motivates a reinvestigation of the corresponding dynamics and controlling processes. The broader relevance of this work is that week-to-week time variations of the monsoon anticyclone may be due as much to the upper-level dynamics illustrated by this model as to variations in the monsoon convective heating determined by dynamics in the lower and middle troposphere. Furthermore such the variations of the anticyclone are important in determining its effectiveness in exchanging air between tropical upper troposphere and extratropical lower stratosphere. The work is also relevant to many aspects of the anticyclone can be conveniently studied in a single-layer model, with the upper-level effects of the monsoon convective heating represented as a prescribed, local and continuous mass source. Such a model is used to investigate the structure and evolution of the anticyclone. Particular focus is hereby given on the transition between parameter regimes with a linear, steady response or a non- linear, spontaneously unsteady response. This work is intended to be relevant to understanding differences between models in their representation of the monsoon anticyclone and also how the monsoon anticyclone might change in the future.

Global climate modelling (WP5)

Determining stratospheric water vapour variability in global climate models

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Water vapour is a key greenhouse gas and its concentrations in air entering the stratosphere are strongly influenced by temperatures at the tropical tropopause cold point where dehydration is strongest. While the drivers of the annual cycle in tropical stratospheric water vapour are fairly well understood, the processes that determine variations on interannual and longer timescales are subjects of ongoing investigation. Further, global climate models may misrepresent these. For example, such models overestimate of the annual mean temperature near the tropical tropopause compared to observations [Hardiman et al. 2015, Kim et al. 2013].

We use offline kinematic trajectory calculations to study the dehydration characteristics of air parcels entering the stratosphere in a global climate model. Trajectories are calculated from 3-D winds and temperature provided at 6-hour intervals from HadGEM UKCA.

First we compare ensemble properties of the dehydration events against calculations with reanalysis data. This includes the spatial sampling of the temperature field, and the effect of different timescale variations in the experienced temperature field. As found with reanalysis data, variations on timescales of less than one month have a significant effect on dehydration. A strong effect of the diurnal cycle is also noted.

We then show that while water vapour concentrations predicted by the trajectory calculation are smaller than the Eulerian field calculated by the model, interannual variations correlate better than simpler temperature-based proxies.

We also quantify sensitivity to time resolution in the provided wind and temperature fields as a guide to requirements of any future model-output based offline calculations.

These dehydration calculations identify how transport processes occur in global models and how their contribution affects the variability of the stratospheric water vapour field. The influence of other relevant processes is a subject of further study.

Global climate modelling (WP5)

ATAL simulated with a coupled aerosol-chemistry-climate model: enhanced H2SO4-H2O droplets, HNO3-H2SO4-H2O ternaries, organics, ice, or a mix?

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ATAL is characterized by enhanced aerosol scattering in the altitude range 90-130 hPa measured by instruments such as CALIOP or COBALD. We modeled the sulfur budget of ATAL and its dependence on precursor emissions using the coupled aerosol-chemistry-climate model SOCOL-AER. The aerosol module comprises gaseous and aqueous sulfur chemistry and comprehensive microphysics with 40 size bins spanning radii from 0.39 nm to 3.2 μm. In a sulfur-only mode the model is capable of correctly reproducing ATAL's geographic position and altitude range, with ≈0.25 ppbv of H2SO4 in the ATAL par- ticles or about double the amount than at the same altitude far from ATAL. Not surprisingly, the back- scatter of the modeled sulfur-only ATAL is too low by factors 2-3. However, the ATAL aerosol appears exactly in the coldest region of the atmosphere, namely at most 1 K above the frost point (Fig. 1C). At such temperatures, HNO3 in air partitions to the particle phase, forming ternary HNO3-H2SO4-H2O solution droplets. Preliminary results of NO and NOy measurements by SIOUX aboard Geophysica suggest mixing ratios χHNO3 ≈ χNOy − χNO ≈ 1–3 ppbv. The uptake of this HNO3 might result in a growth of the ATAL particles, which may explain the missing BSR in SOCOL's ATAL. The HNO3 uptake might be further enhanced in the presence of NH3. Also, SOCOL suggests that iso-prene might be transported into ATAL, which substantially contributes to global SOA. Anthropogenic emissions influence both, HNO3 and organic precursors. Finally, dispersed ice particles may contribute to the backscatter. We will discuss the related mechanisms in the light of StratoClim measurements.

Global climate modelling (WP5)

Radiative forcing imbalance by stratospheric sulfate aerosols -Limitation, Uncertainties, Challenges -

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The stratospheric aerosol layer is a key component in the climate system. It affects the radiative balance of the atmosphere directly through interactions with solar and terrestrial radiation, and indirectly through its effect on stratospheric ozone. Volcanic aerosols are the most prominent factor of natural variability and one of the most discussed geoengineering techniques is the one via stratospheric sulfur solar radiation management. To understand how the stratospheric aerosol layer is formed, sustained and may drive future climate change and vice-versa, we use on one hand a sophisticated global stratospheric aerosol model and on the other hand an Earth system model. This enables us to separately investigate both pathways, from the source to the forcing and from the forcing to the feedback. On the poster, we will discuss this for two examples a geoengineering and a volcano case study. In the geoengineering study, we investigate whether we can increase the injection rate strongly without reaching a limit where forcing efficiency (forcing per injection rate) gets too small with increasing injection rate. In the volcano study, we focus on the largest eruption of the past 500 years, the one of Mt. Tambora in April 1815 which is an excellent test case to understand the formation and development of the volcanic aerosol size distribution and the climatic effects of large stratospheric sulfur dioxide (SO2) injections.

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