

European Studies

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NCAR Strategic Initiative: Ice Initiation in Clouds
Workshop June 7+8, 2004, Boulder, CO

Overview

- Laboratory Studies:

AIDA Karlsruhe, MPIC/U Mainz, TU Ilmenau
(ETH Zürich)

- Field Studies:

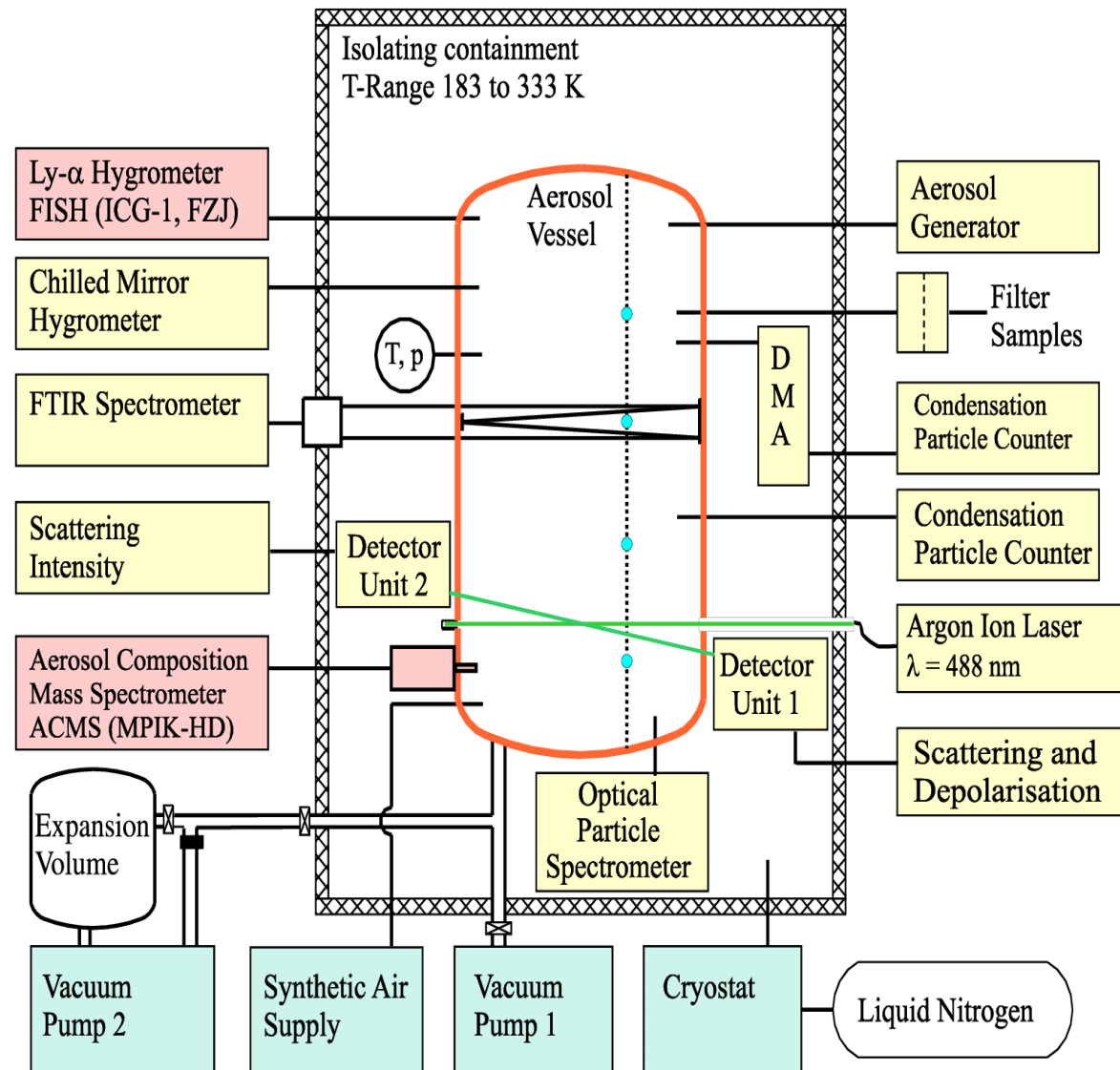
CLACE, CIRCLE, activities at IPSL, UK-activities,
TROCCINOX, SCOUT-O3
(TROPEIS, QPP)

Overview may not be complete ...

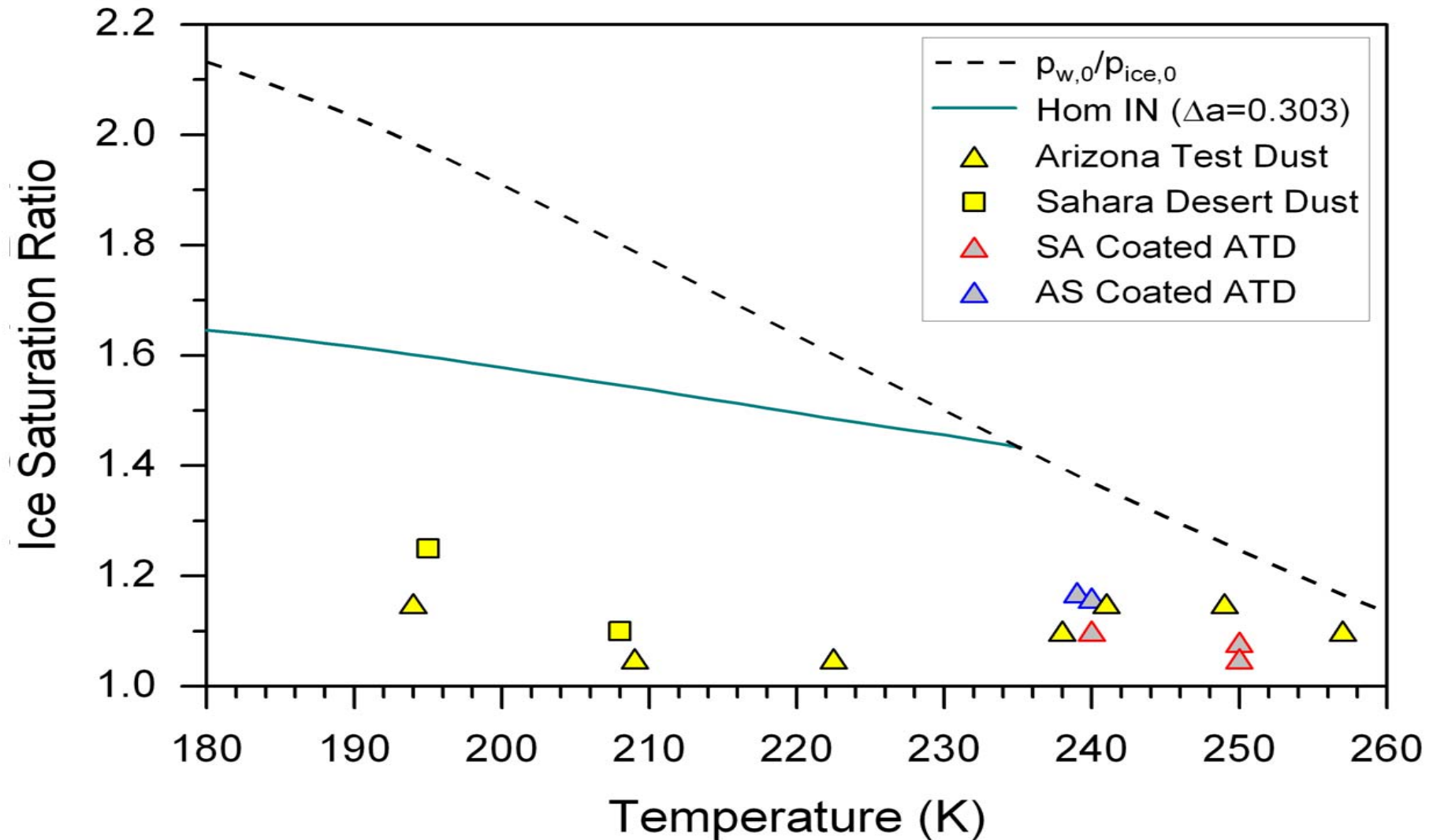
Lab studies - aerosol chamber, Research Center Karlsruhe

- aerosol / cloud chamber AIDA
- 84 m³ coolable vessel with microphysical and optical instrumentation
- cirrus and PSC conditions (aerosol, T, p, dT/dt)
- homogeneous freezing experiments with aqueous H₂SO₄ and H₂SO₄ / HNO₃ completed in 2002 (Möhler et al. & Haag et al., ACP, 2003)
- ongoing experiments with IN
- new instruments include TDL, SID, CPI,

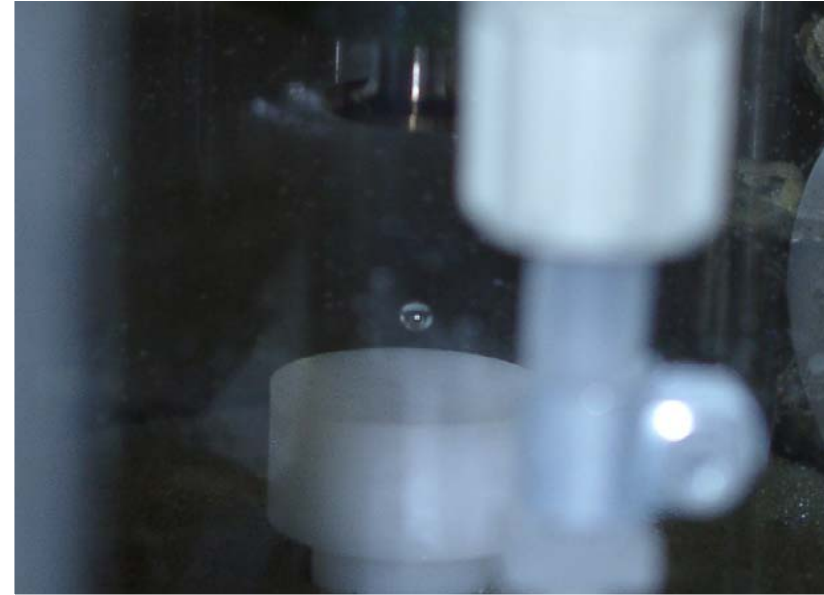
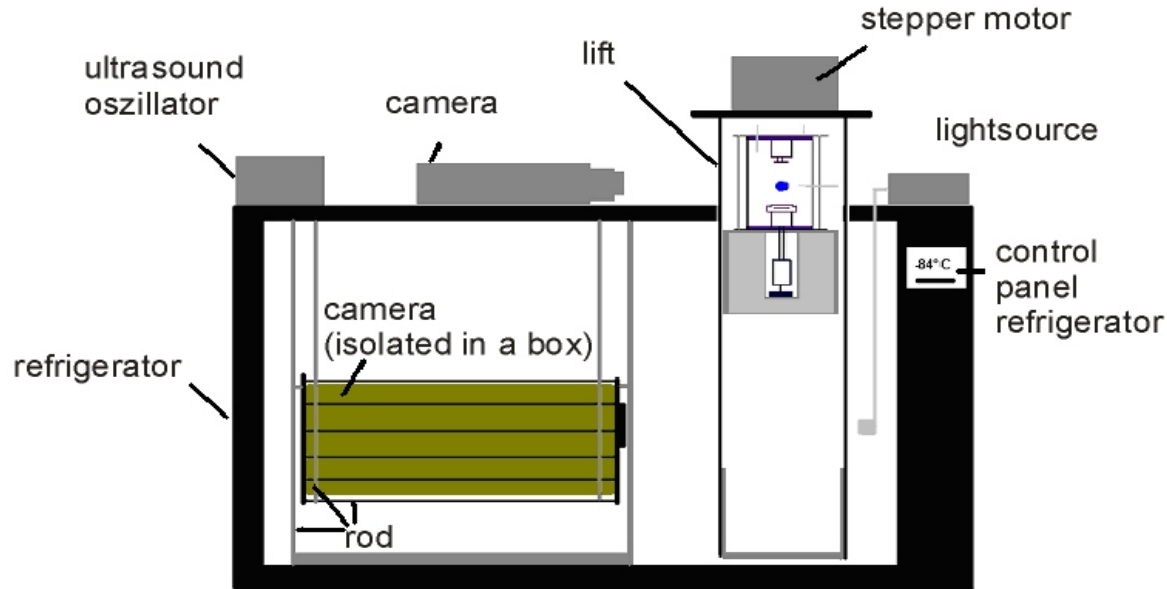
<http://imk-aida.fzk.de/>



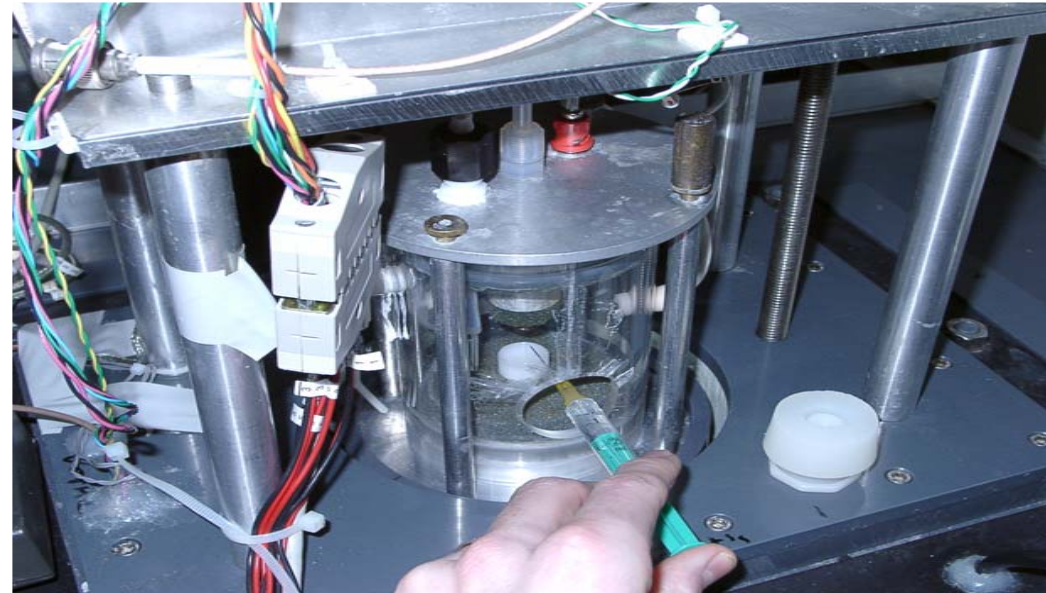
Lab studies - aerosol chamber, Research Center Karlsruhe



Lab studies - acoustic trap, University of Mainz / MPIC



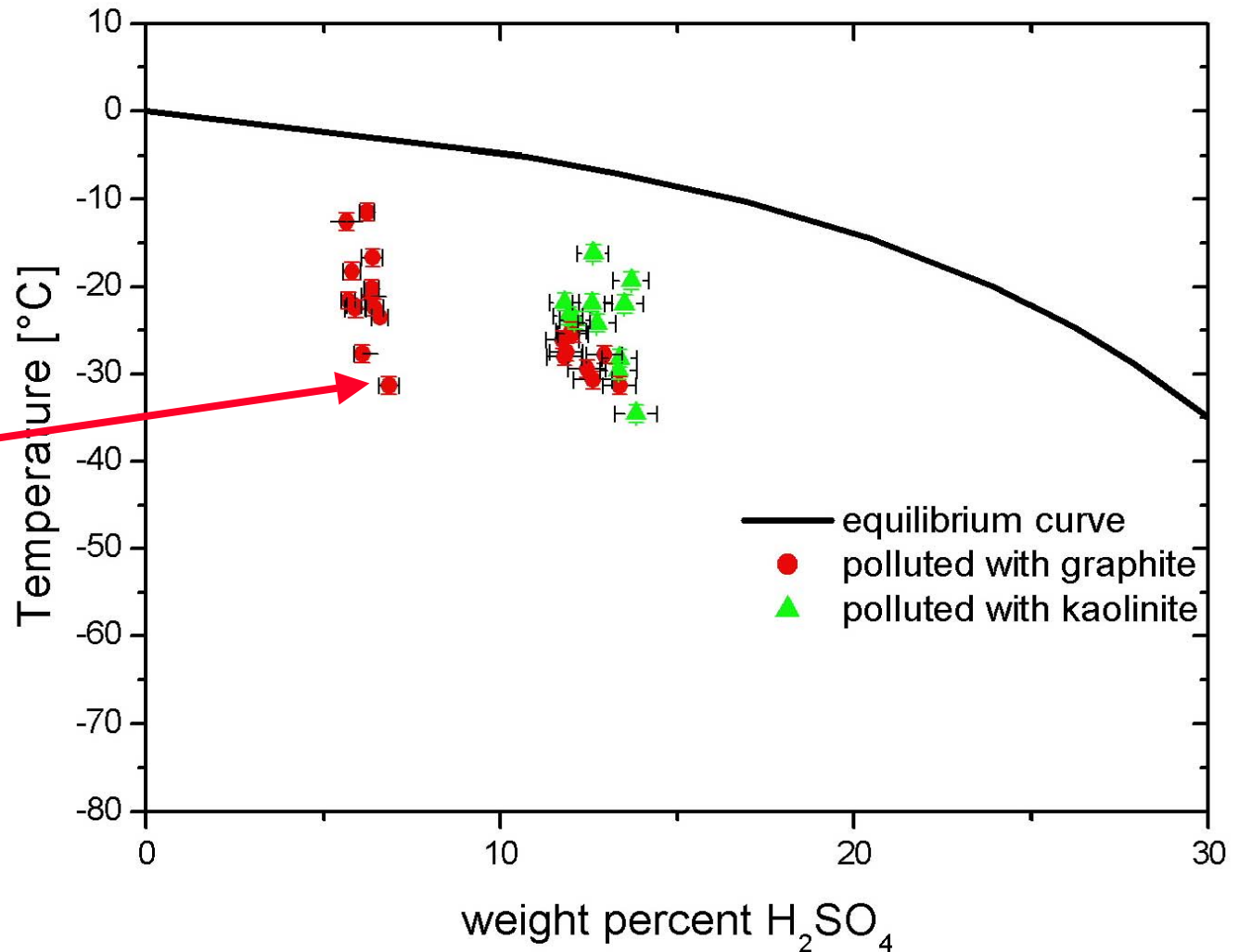
- deep freezer with movable ultrasonic trap
- injection of droplet into node by syringe
- first results published by Ettner et al., ACPD 4, 1887-1909, 2004



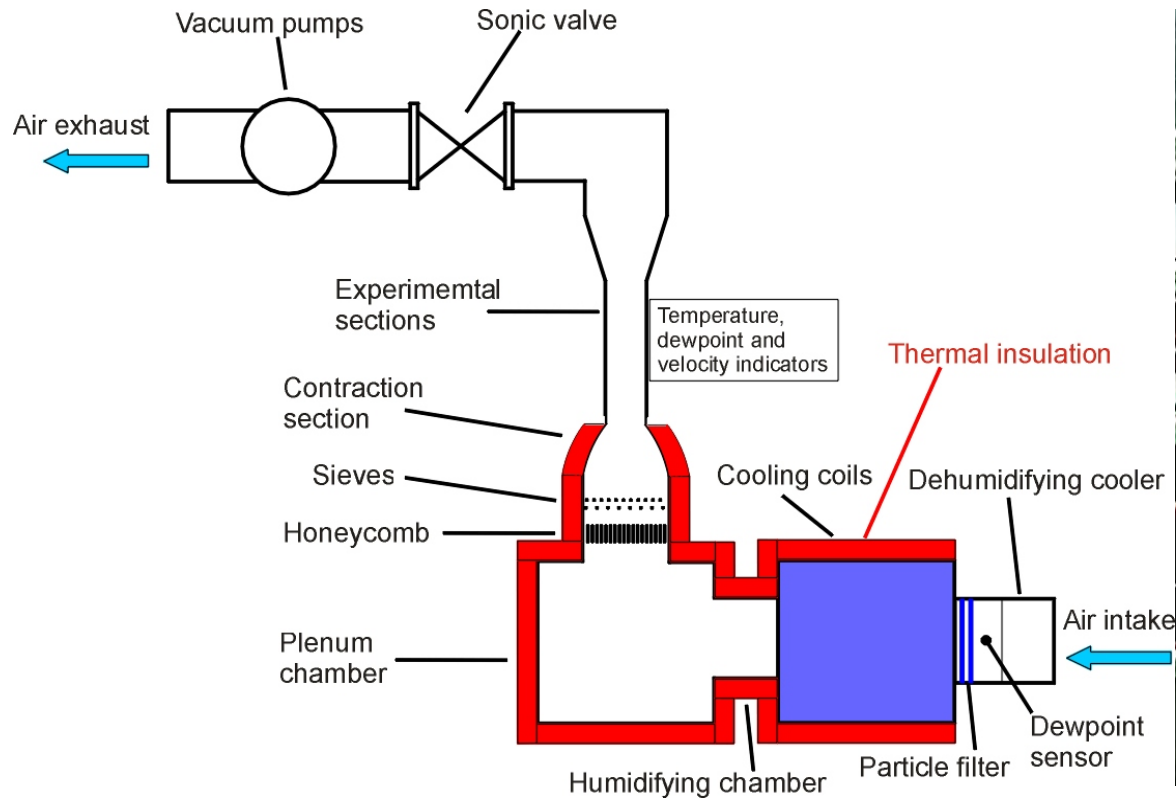
Lab studies - acoustic trap, University of Mainz / MPIC

Results of heterogeneous freezing experiments

- near homogeneous threshold: probably only few graphite particles present
- number of nuclei in drop may be important



Lab studies - wind tunnel facility, University of Mainz / MPIC



Operating conditions

Temperature range

– 30°C to 30°C

Dew point

– 40°C to air temperature (saturation)

Wind speed range

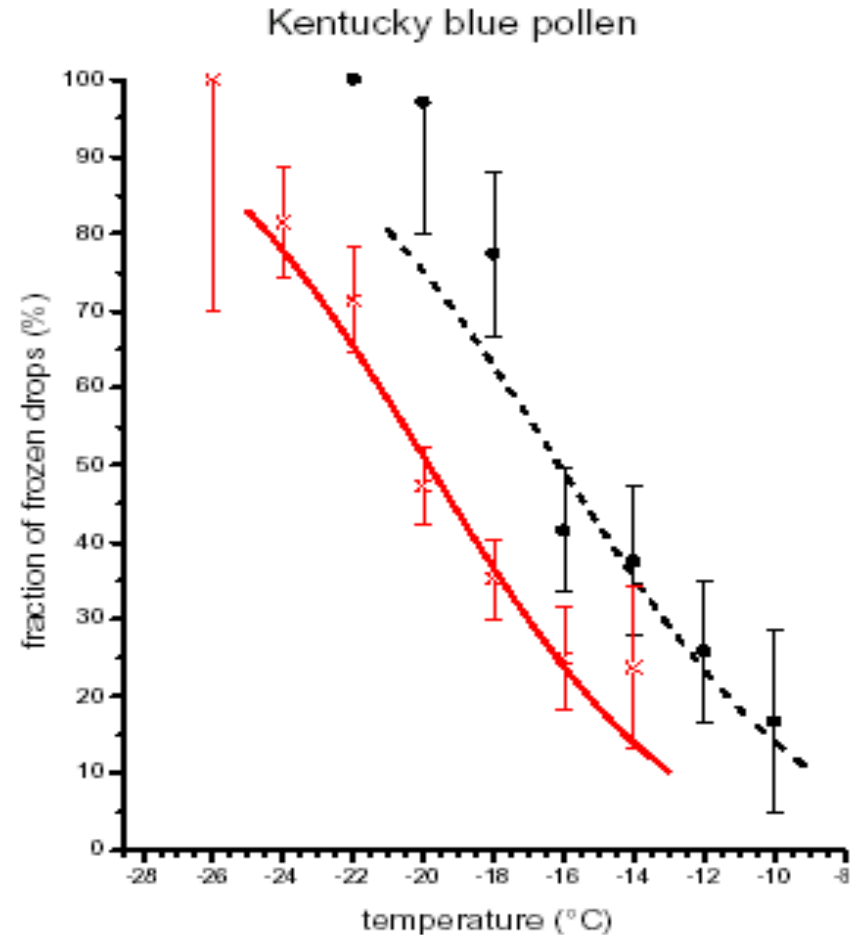
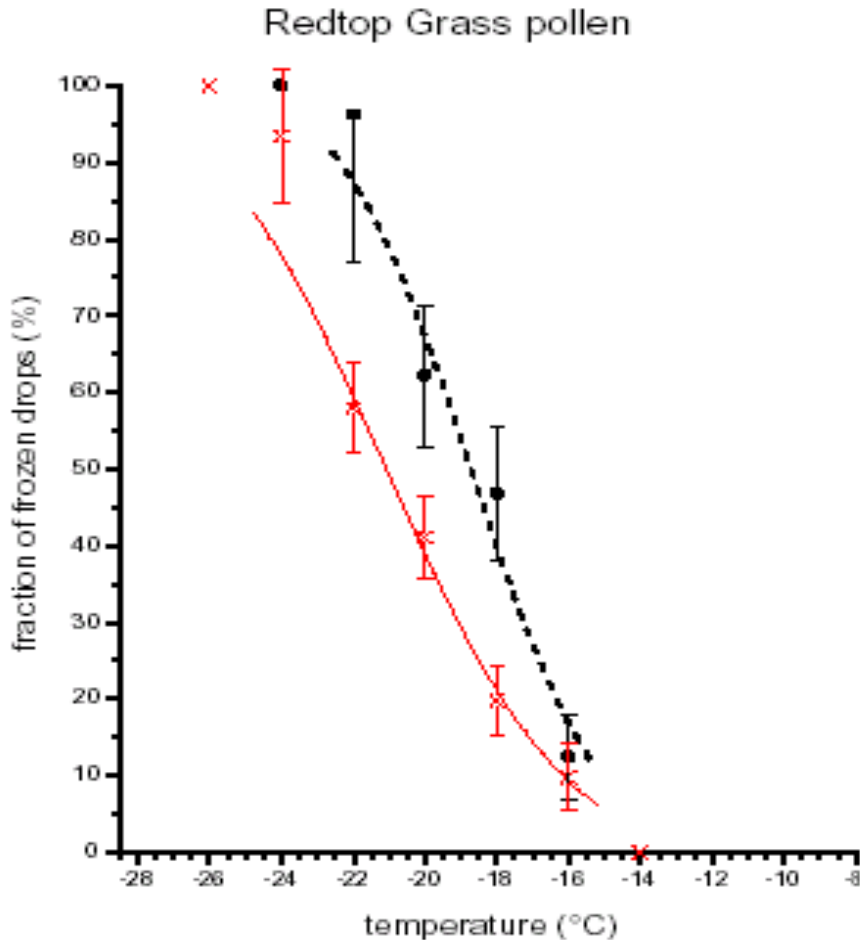
10 cm/s to 40 m/s (i.e. from 30 μ m diameter drops up to hailstones of 5-6 cm diameter can be kept afloat.)

Studies on

contact/immersion freezing, riming, trace gas and aerosol uptake

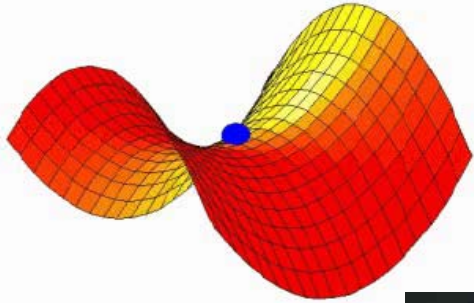
Lab studies - wind tunnel facility, University of Mainz / MPIC

Fraction of drops frozen due to immersion freezing (solid red) and contact freezing (dashed) for various types of pollen as a function of temperature



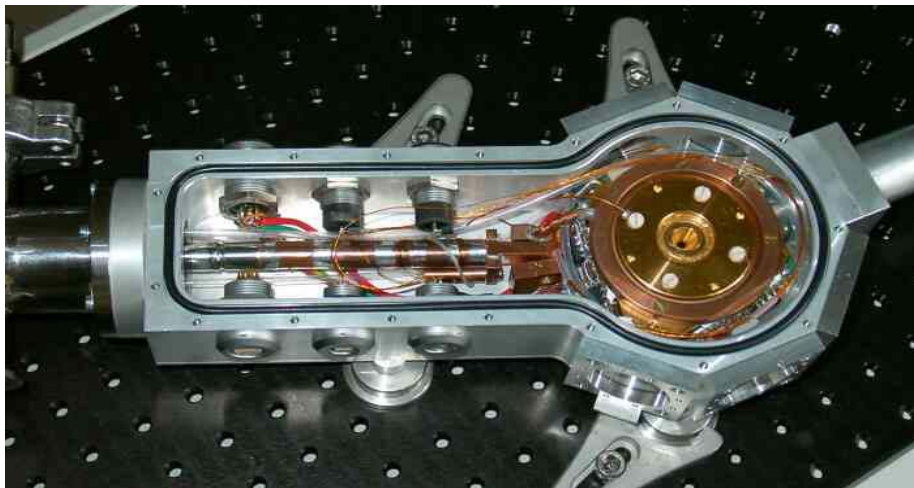
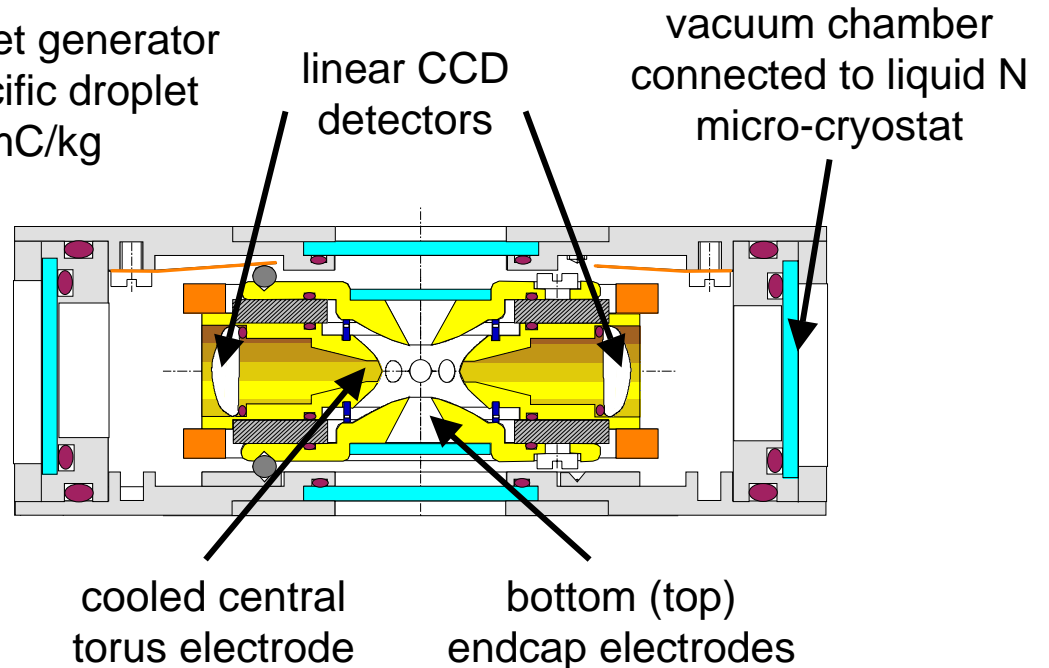
Lab studies - Paul trap, Technical University Ilmenau

Electrodynamic levitation of single water microdroplets



piezoelectric droplet generator
(not shown); specific droplet
charge 0.1 mC/kg

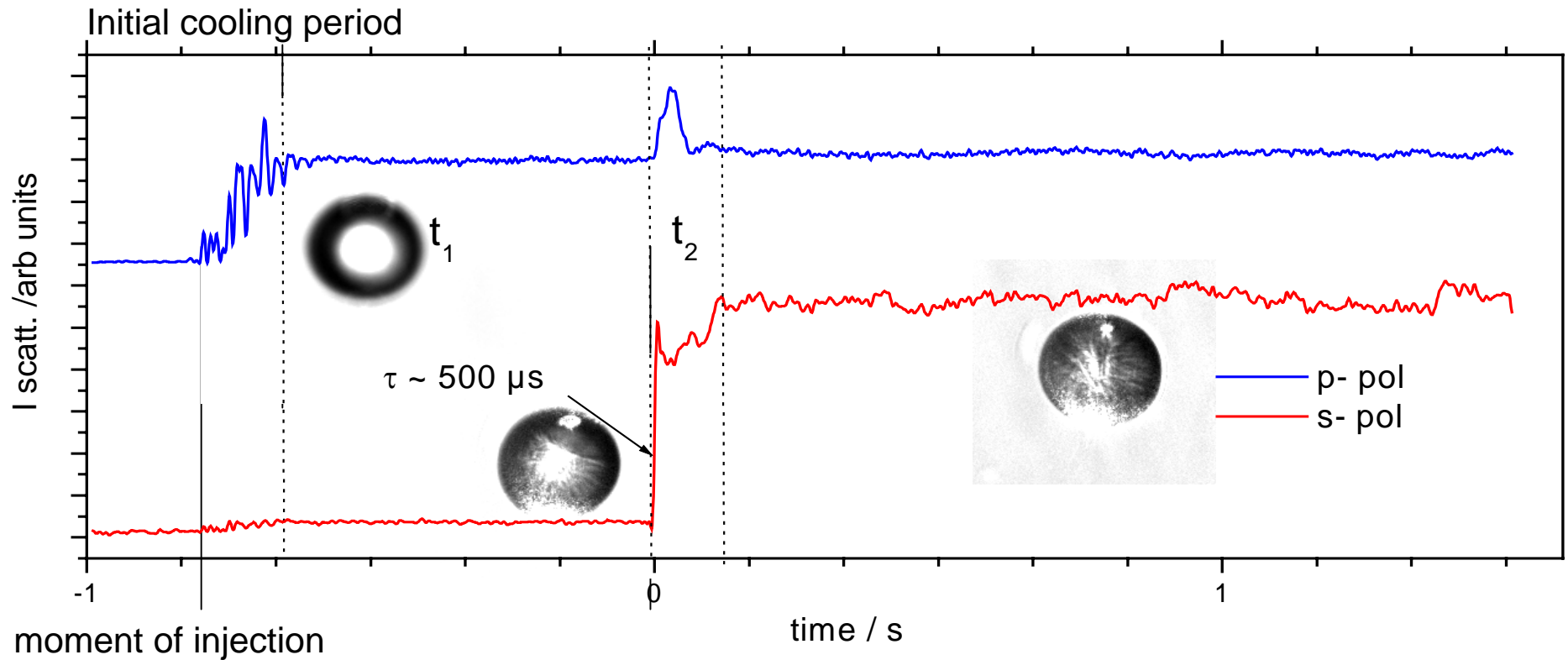
levitator and
vacuum system



- CCDs measure angular resolved light scattered by drop from HeNe laser beam
- analysis of phase function allows size and refractive index of individual drops to be determined

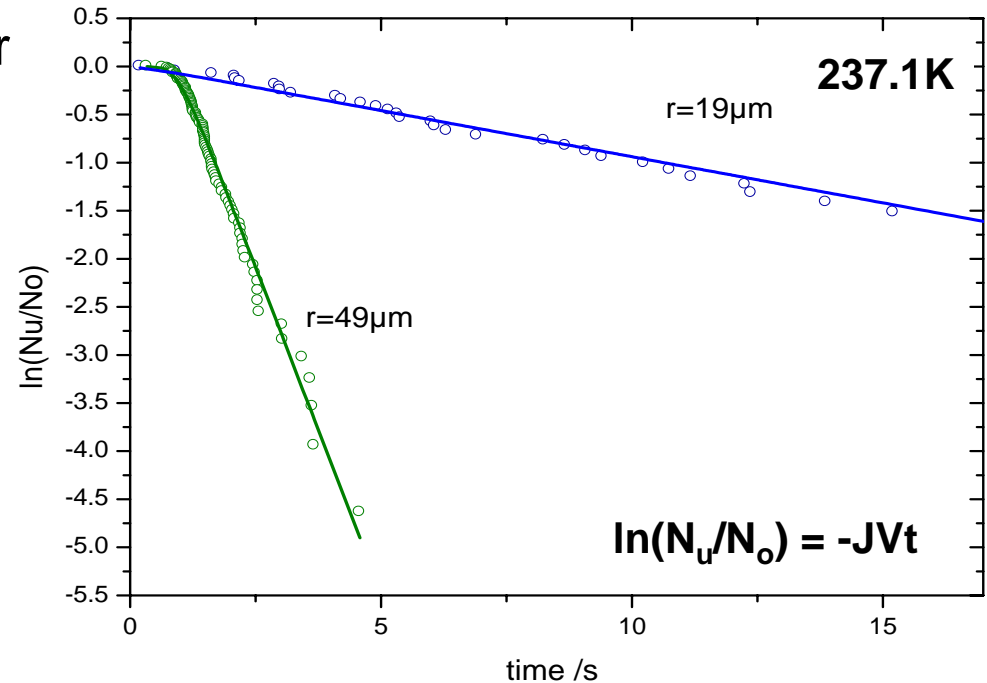
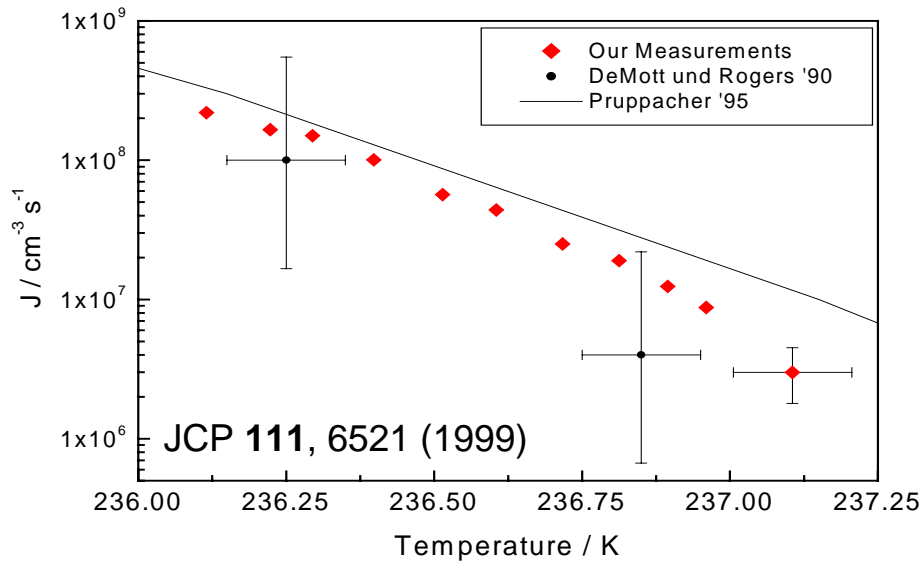
Lab studies - Paul trap, Technical University Ilmenau

Determination of onset of droplet freezing



Lab studies - Paul trap, Technical University Ilmenau

Homogeneous freezing of pure water



- Homogeneous freezing of droplets of different sizes scales with droplet volume; no evidence for surface nucleation for drop radii $r > 1 \mu\text{m}$
- Future activities include: droplets with surfactant layers; inorganic/organic core shell systems; influence of charge and ionizing radiation on freezing; IN

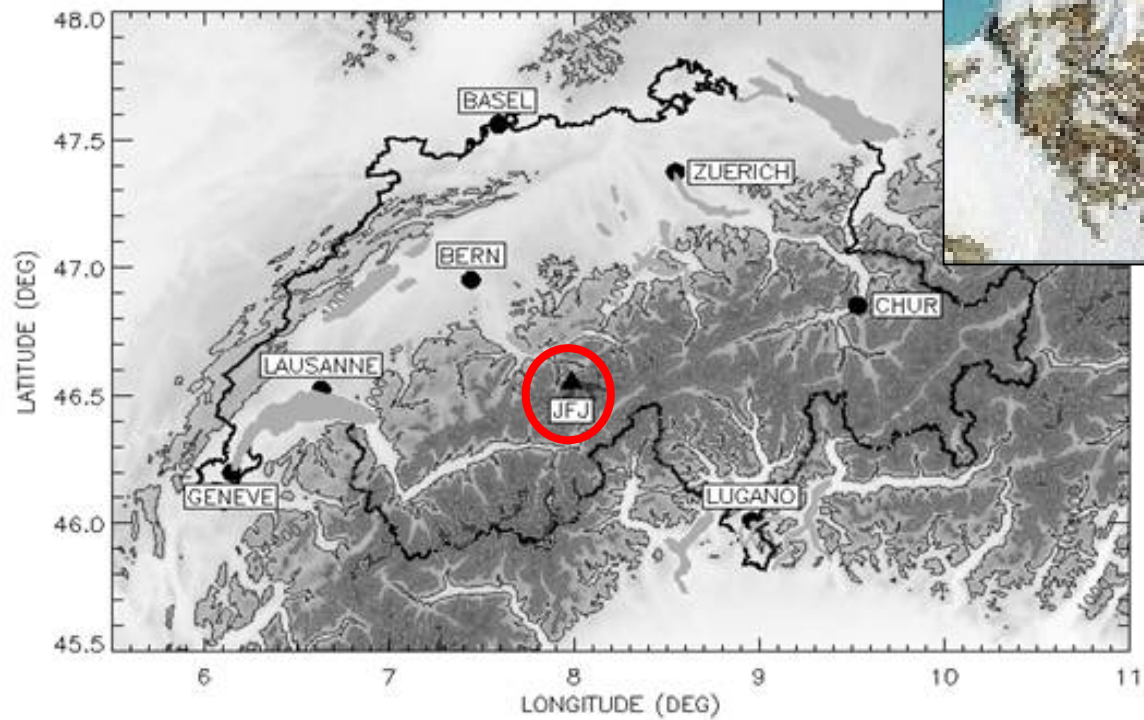
Field studies - CLACE (CH)

- Cloud and Aerosol Characterization Experiment in the Free Troposphere, series of intensive observation periods at the high alpine research station Jungfrauoch (3580 m asl, 46.55°N, 7.98°E)

<http://aerosolforschung.web.psi.ch/>

- Experiments designed to investigate the chemical composition of aerosol particles, their hygroscopic properties, and their interactions with clouds; gas measurements include CO, NO_x, NO_y, O₃; automated weather station
- GAW station, high annual mean cloud frequency (37%), many previous cloud-scavenging experiments
- Participation of Swiss (PSI, ETHZ), German (IfT, DLR, U Mainz, TU Darmstadt), British (UMIST), and Danish (U Copenhagen) institutes

Field studies - CLACE (CH)



Field studies - CLACE (CH)

- CLACE-1 (winter 2000) most important instruments

mobile TOF laser MS with bipolar ion detection; HTDM measuring hygroscopic growth at ambient T; SMPS measuring particle size distributions at ambient T and RH; dual inlet system for measuring interstitial and total aerosol

- CLACE-2 (winter 2002) additional instruments

AMS coupled to dual inlet system; FSSP for cloud droplet size distributions; phase Doppler anemometry system

- CLACE-3 and -4 (Feb/Mar 2004 and 2005) additional instruments including

CVI within new sampling system separating small ice particles from large ice crystals, cloud droplets, and interstitial aerosol particles under ambient conditions; cloud condensation nucleus counter; IN counter for contact and deposition nuclei; CPI; Formvar replicas; OPC; scanning e⁻ microscopy

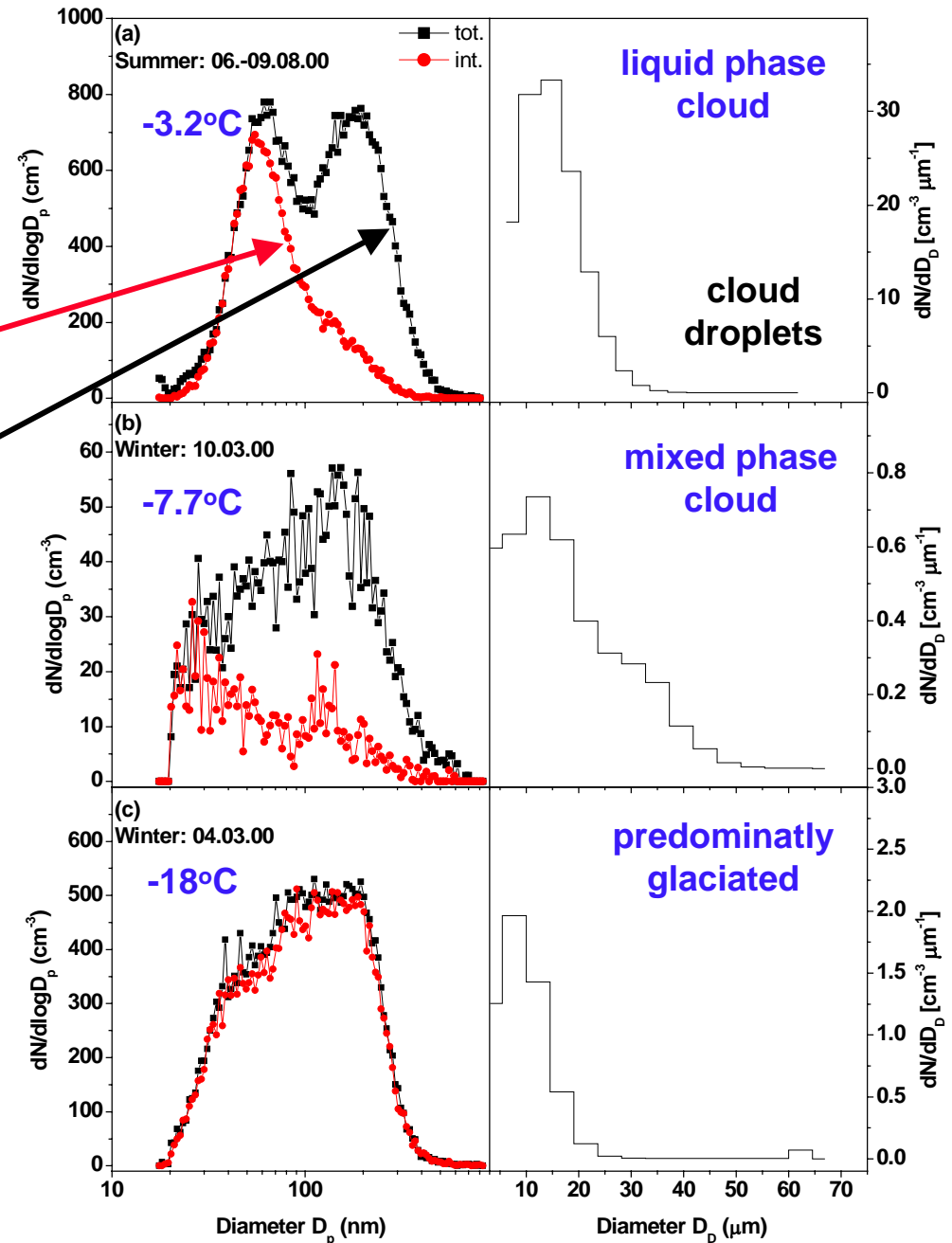
Field studies - CLACE (CH)

- CLACE-1/-2 results on aerosol partitioning in mixed-phase clouds (Henning et al., GRL, 2004)

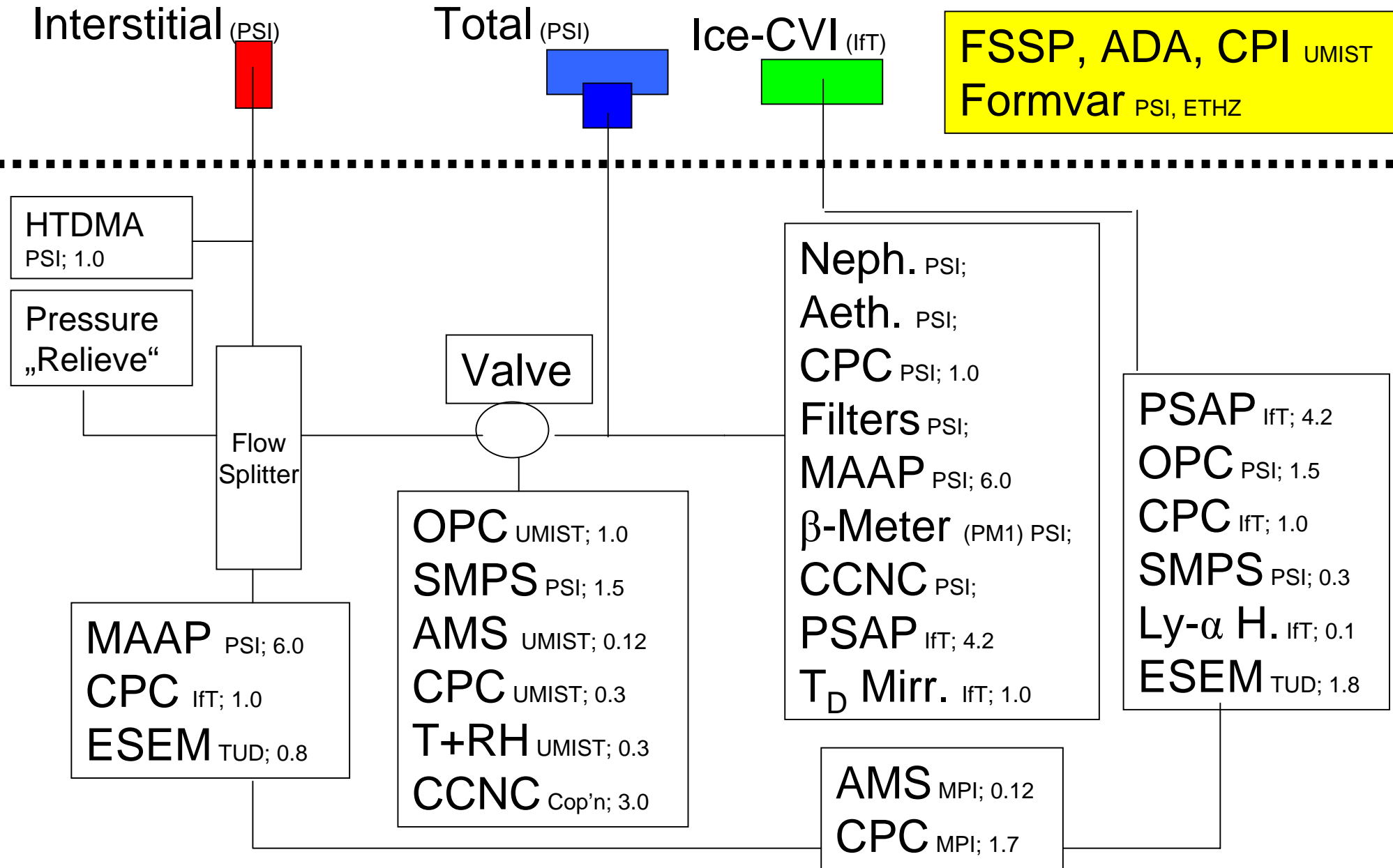
interstitial aerosol

total aerosol

- interesting interpretation of these data wrt Bergeron-Findeisen mechanism
- upcoming from CLACE-3: physical and chemical characterization of IN



Field studies - CLACE (CH): Inlets & Instruments CLACE-3



Field studies - CIRCLE (GER)

- Cirrus Cloud Experiments, within DLR/HGF project PAZI (Particles and Cirrus Clouds), 2004-2007

<http://www.pa.op.dlr.de/pazi/>

- CIRCLE-1 (fall 2005) Experimental evidence for heterogeneous freezing in ice-supersaturated regions in cirrus conditions

Extensive microphysical and chemical characterization of interstitial and activated particles & total and gas phase water

- CIRCLE-2 (fall 2006) Quantification of optical properties of cirrus particles using airborne, space-borne, and ground-based instruments

Extensive characterization of cirrus cloud optical and radiative properties to improve satellite retrievals and radiation parameterizations in global models

Field studies - CIRCLE-1 Falcon Instrumentation

Interstitial Aerosol	Microphysics size distribution, volatility, mixing state, optical properties, hygroscopic growth, multi-channel CPC, OPC, volatility analyser, MAAP (BC mass concentration and absorption coefficient @ 670 nm, HTDMA	DLR
Air Ions	Electrostatic Probe	MPI-K
Cloud Elements	CVI + CPC and OPC FSSP 100 ER Ice water sampler	ITM DLR FZJ
Cloud residuals	Aerosol Mass Spec connected to CVI	MPI-C
Water	FISH, Frost Point Hygrometer	FZJ, LaMP

Field studies - CIRCLE-2 Falcon Instrumentation

Interstitial Aerosol

Microphysics
size distribution, volatility,
mixing state, optical properties,
multi-channel CPC, OPC, DMA
volatility analyser, MAAP

DLR

Cloud Elements

Optical properties
Polar Nephelometer, CPI

LaMP

Vertical cirrus profiles

Aerosol and water vapor Lidar
Mobile Ground-based Lidar MARL
Rayleigh-Mie Lidar

DLR

AWI

OHP, SIRTA

French Falcon 20

instrumentation for CALIPSO level 2 validation flights,
including RALI (95 GHz Doppler-Radar + backscatter Lidar)

Space Instruments

CALIPSO and MSG overpasses

<http://www-calipso.larc.nasa.gov/>

Field studies - TROCCINOX (EU 5th FP)

Tropical Convection, Cirrus, and Nitrogen Oxides Experiment

Two field experiments with key objectives:

- improve knowledge about lightning-produced NO_x in tropical thunderstorms by quantifying produced amounts, comparing them to other NO_x sources, and assessing its global impact with models
- improve knowledge on occurrence of other trace gases (including H_2O) and particles (cirrus and aerosols) in connection with deep convection and large-scale upwelling

TROCCINOX-1: Feb/Mar 2004 Falcon, base Sao Paulo, Brazil: NO_x , convection

TROCCINOX-2: planned for Nov-Feb 2004/-05 Falcon/Geophysica: gases, aerosols, and clouds

<http://www.pa.op.dlr.de/troccinox/>

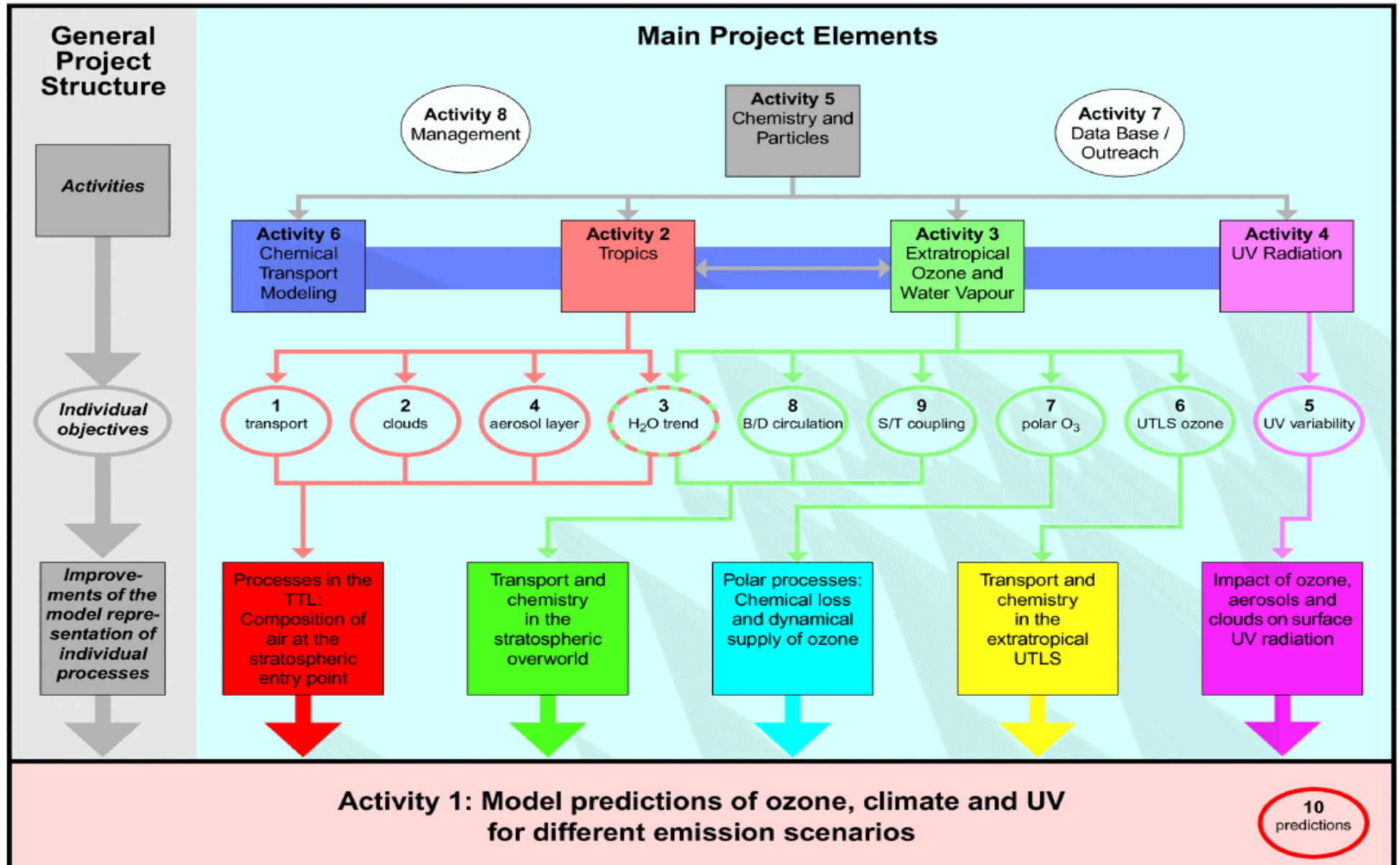
Field studies - SCOUT-O3 (EU Integrated Project 6th FP)

- Stratosphere-Climate Links With Emphasis on UTLS-Ozone
- expect major contribution to global change studies by focus on chemistry/climate issues (forecasts of the evolution of the coupled climate/chemistry system is major deliverable) after 5 project years
- coordinated by John Pyle and Neil Harris (U Cambridge, U.K.)
- Kick-off assembly in Cambridge, June 14-16, 2004
- detailed implementation plan for the first 18 project months available
- 8 activities each with 3-9 workpackages
- scientific involvement of 64 institutions
- second project phase includes tropical field campaigns winter 2005/2006

Official web site will be set up by NILU, Norway.



Field studies - SCOUT-O3 (EU Integrated Project 6th FP)



Studies on mixed-phase clouds and cirrus at IPSL (Paris, F)

Lidar/Radar observations and passive remote sensing combined with in situ measurements for process studies and methodological developments; use of French research aircraft and IPSL ground site

- radiation-microphysics interaction processes (H. Chepfer)
- new analysis methods (V. Noël)
- cloud dynamics from radar and radar/lidar (RALI) (A. Protat)
- mesoscale and GCM cloud modeling (Y. Lemaître, S. Bony)
- CALIPSO mission preparation within A-train (J. Pelon)

Ongoing and planned studies at IPSL mostly addressing cloud microphysics and dynamics

- field experiment planned in the CALIPSO validation phase (summer/fall 2005) with deployment of RALI
- aerosol-radiation-dynamics interaction experiments (in collaboration with DLR-IPA, LAMP, LOA)
- impact of tropical cyclogenesis within AMMA; CRYSTAL follow-on ?

ICE AND SUPERCOOLED CLOUD PARTICLES EMBEDDED IN STRATIFORM CLOUDS OF FRONTAL SYSTEMS (ML)

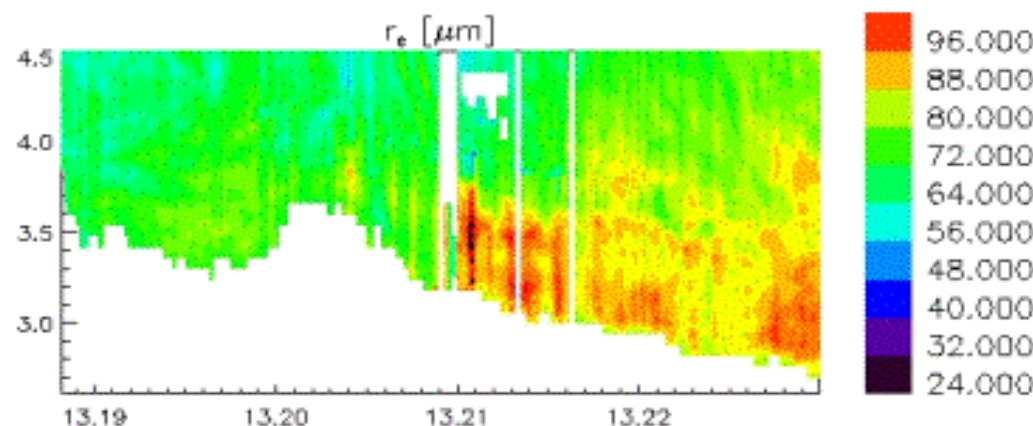
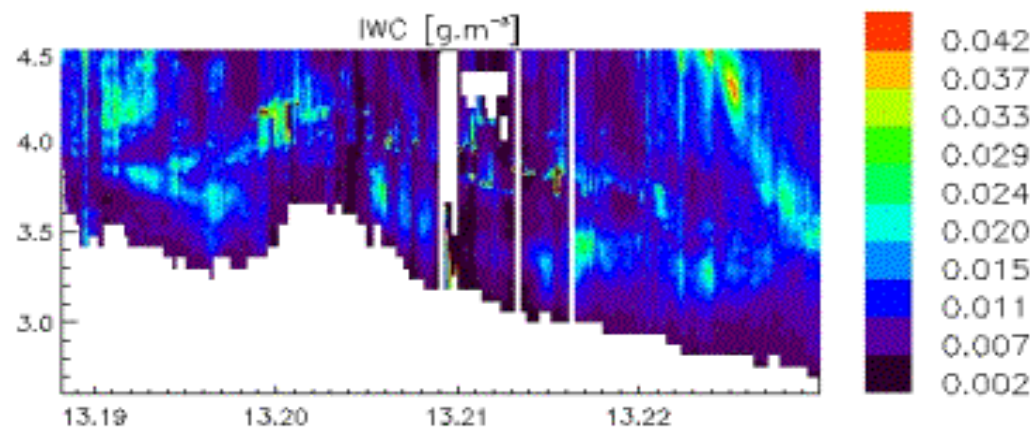
Early lidar observations from Platt (1978) in As from ground
→ Better observations in nadir viewing (weaker attenuation)

Retrieval from combined
lidar and radar

Development of new
algorithms

→ D_e , IWC, LWC, w

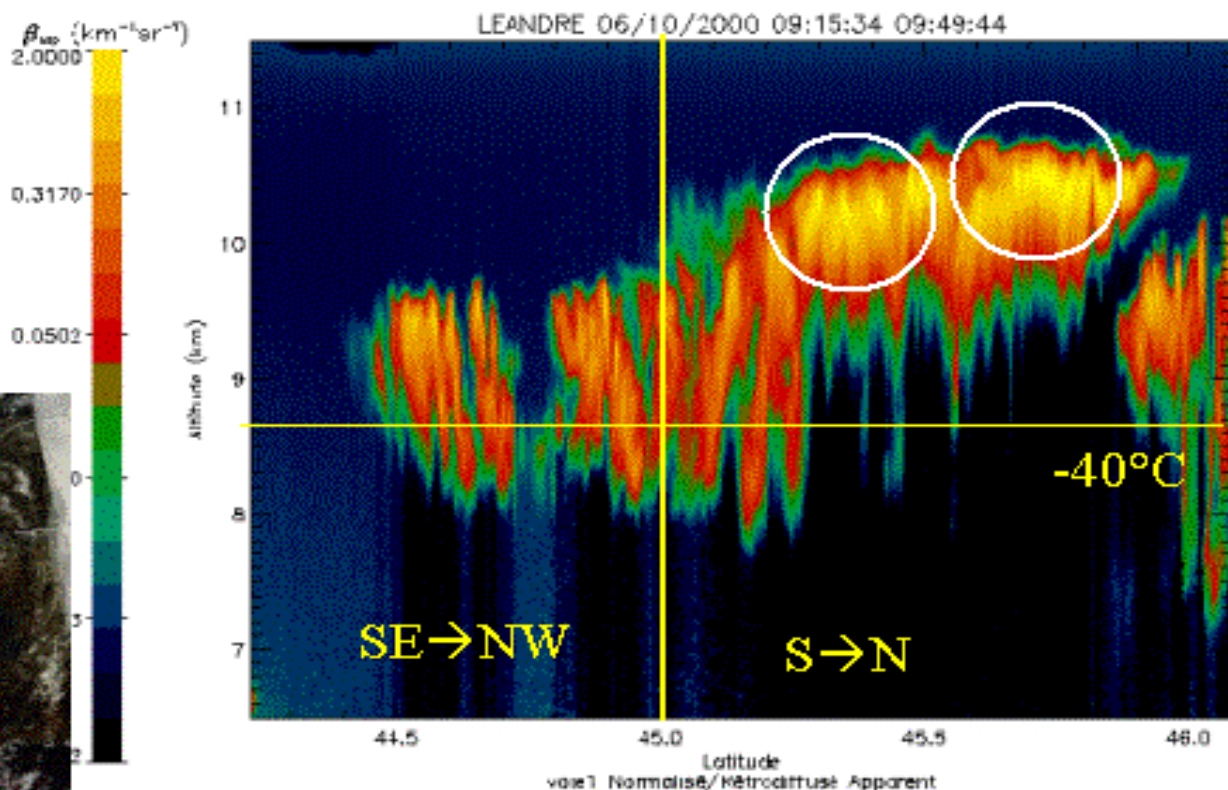
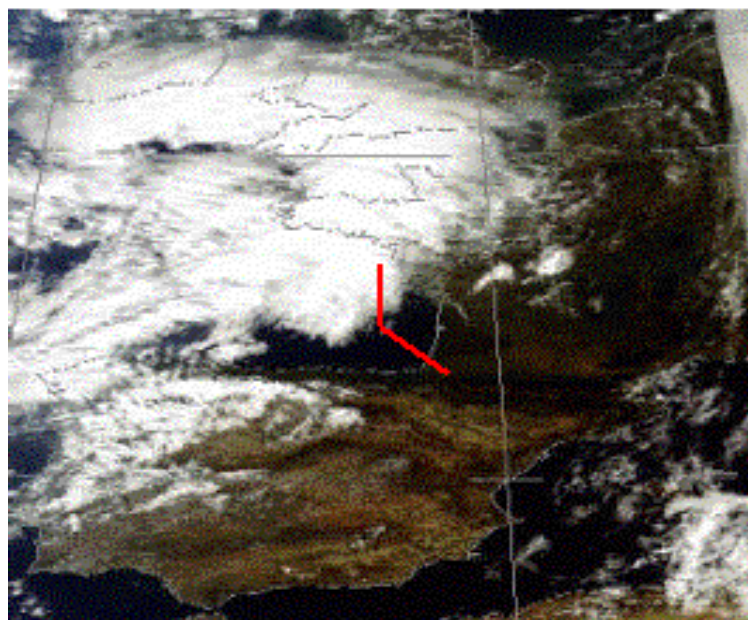
Example from European field
campaign CARL 2000
in a frontal cloud system



ICE NUCLEATION IN FRONTAL CIRRUS CLOUDS AT MID-LATITUDES

Generation of GW by convection/instabilities in fronts

→ Locally forced upward motions



Example of FRENCH campaign (2001)

UK activities

CWVC (Clouds/Water-Vapor/Climate) aircraft expts in conjunction with Chilbolton radar autumn 2004; mixed-phase clouds and embedded convection

NU-WAVE aircraft expts studying het nucleation principally from -15 to -35°C, flights involving single and trains of wave clouds, orographic cirrus sheets

ICEPIC (Ice and precipitation initiation in cumulus) focussing on the origin and development of the ice phase in supercooled clouds; autumn 2005

CAESAR - series of flights to be used for intercomparison with CLOUDSAT, autumn 2005

Laboratory studies at ETH Zürich

Freezing modes of organic particles, effects of surfactants

Field studies - TROPEIS and QPP

Tropospheric Ice Phase and Quantitative Precipitation Prediction are long term national projects (>3-5 years) funded by the German Science Foundation (DFG); field studies mostly in second project phase

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