CLOUD: The influence of cosmic rays on clouds and climate

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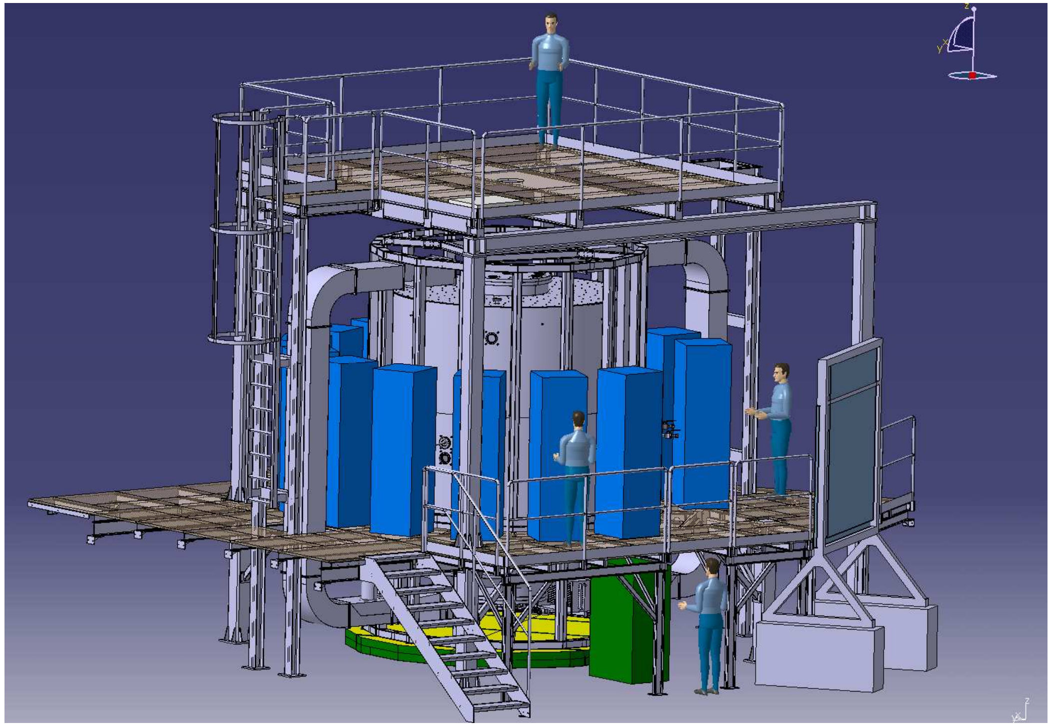
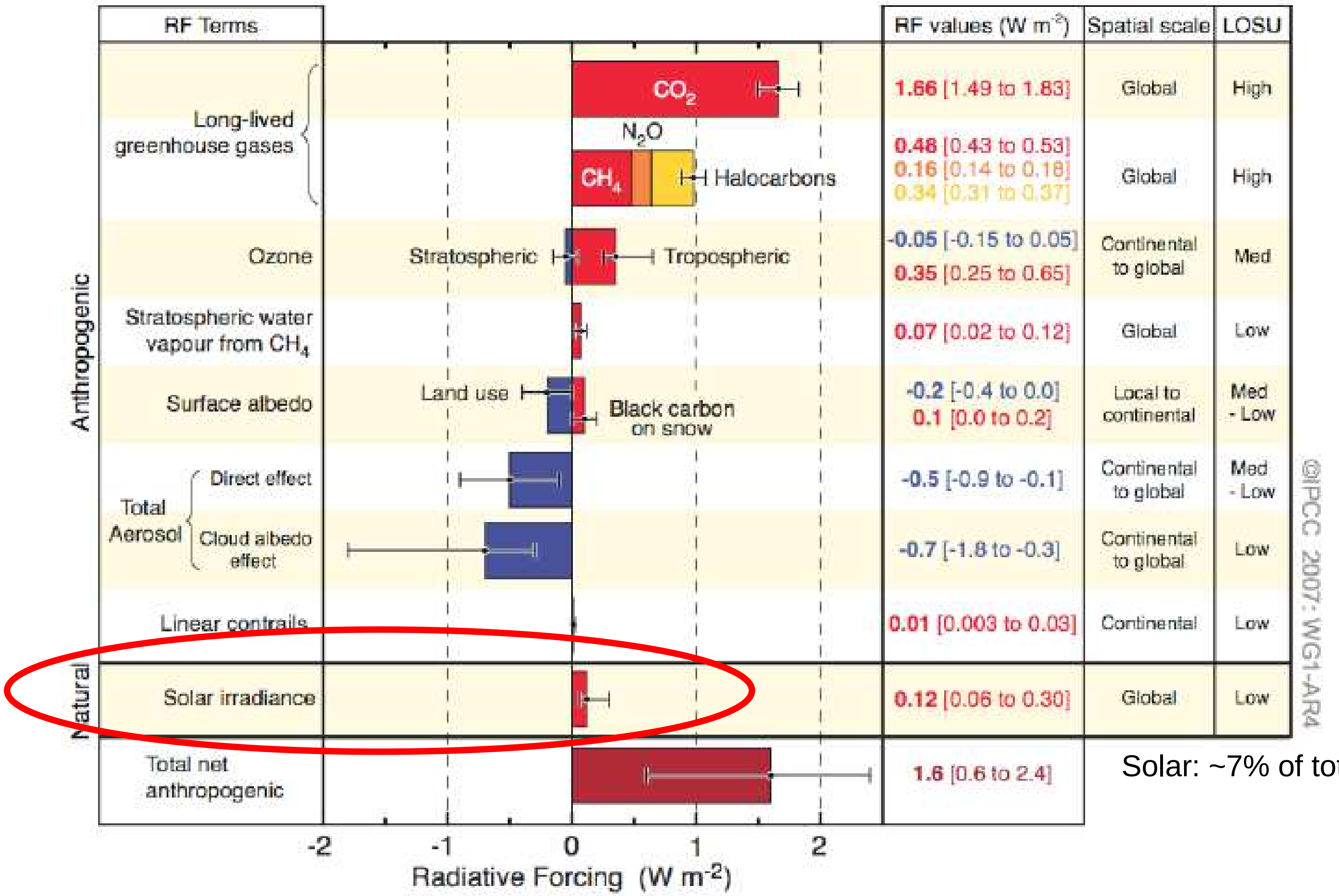


2009 CHIPP Plenary Meeting
Appenberg, 24-25 August, 2009

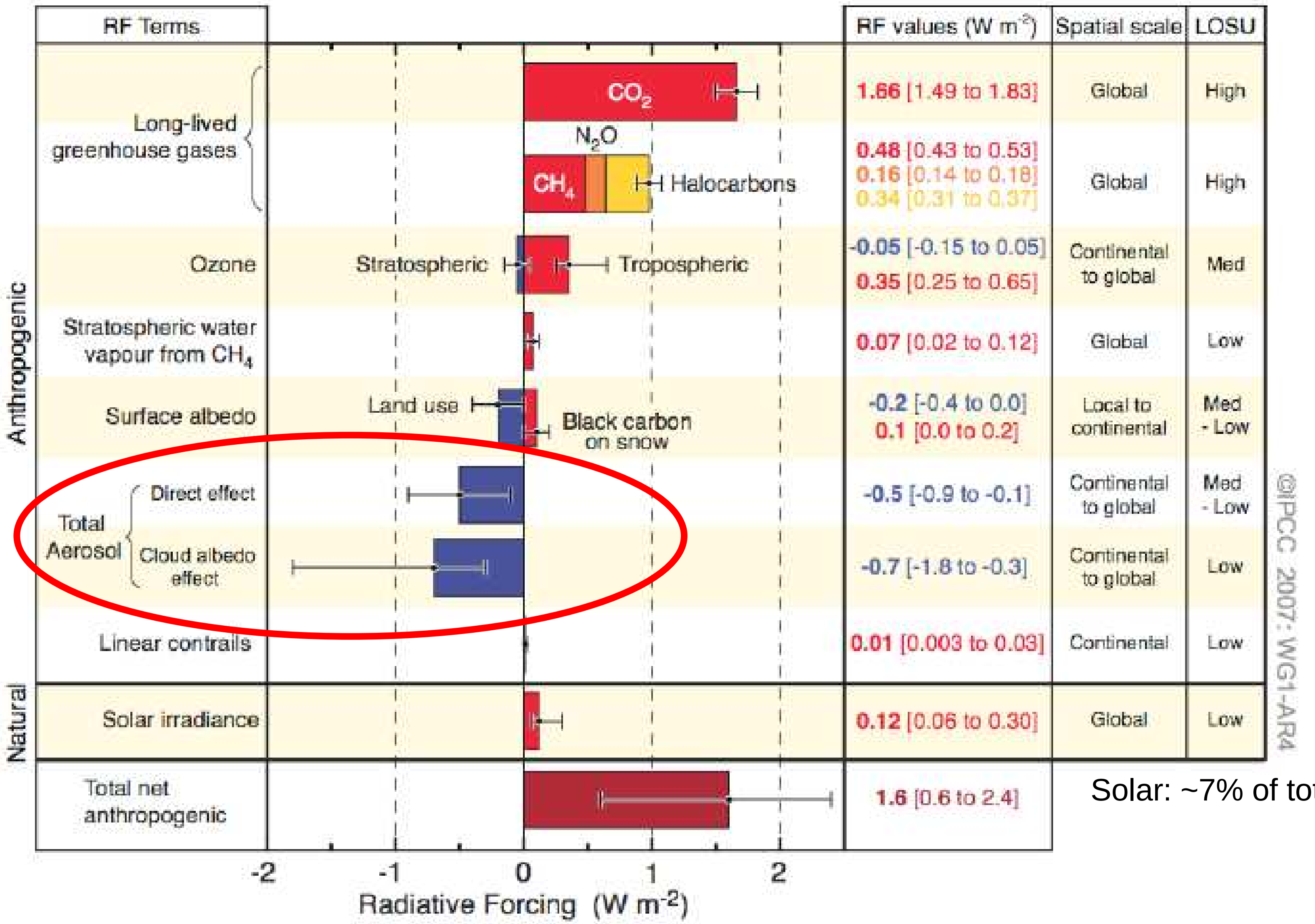
The global radiative forcing (2005, compared to 1750): Solar effect small



Solar: ~7% of total forcing

www.ipcc.ch

The global radiative forcing (2005, compared to 1750) Other effects, e.g. via aerosols?



Solar: ~7% of total forcing

www.ipcc.ch

Why clouds are important for climate change

John Constable, Cloud study, 1821

- Clouds cover ~65% of globe, annual average
- Net cooling of 30 W/m^2
- c.f. 1.6 W/m^2 total anthropogenic

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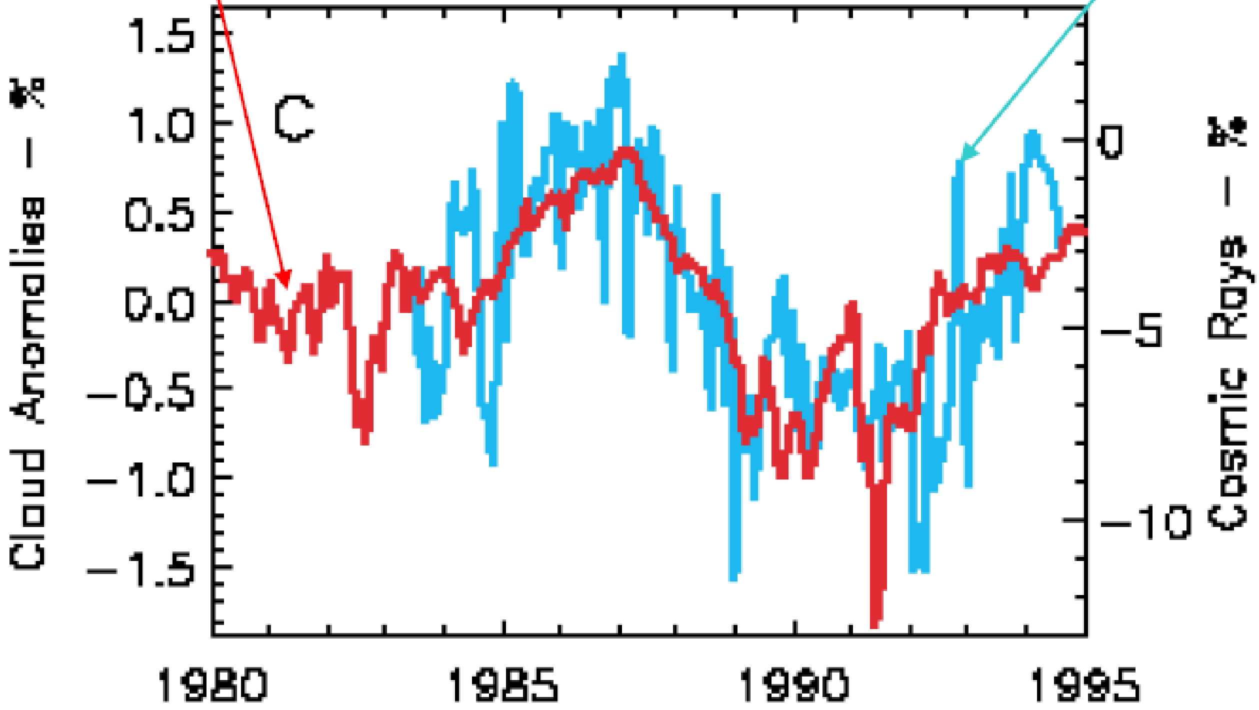
The Svensmark hypothesis: Correlation between galactic cosmic rays (GCR) and cloud cover (IR only)

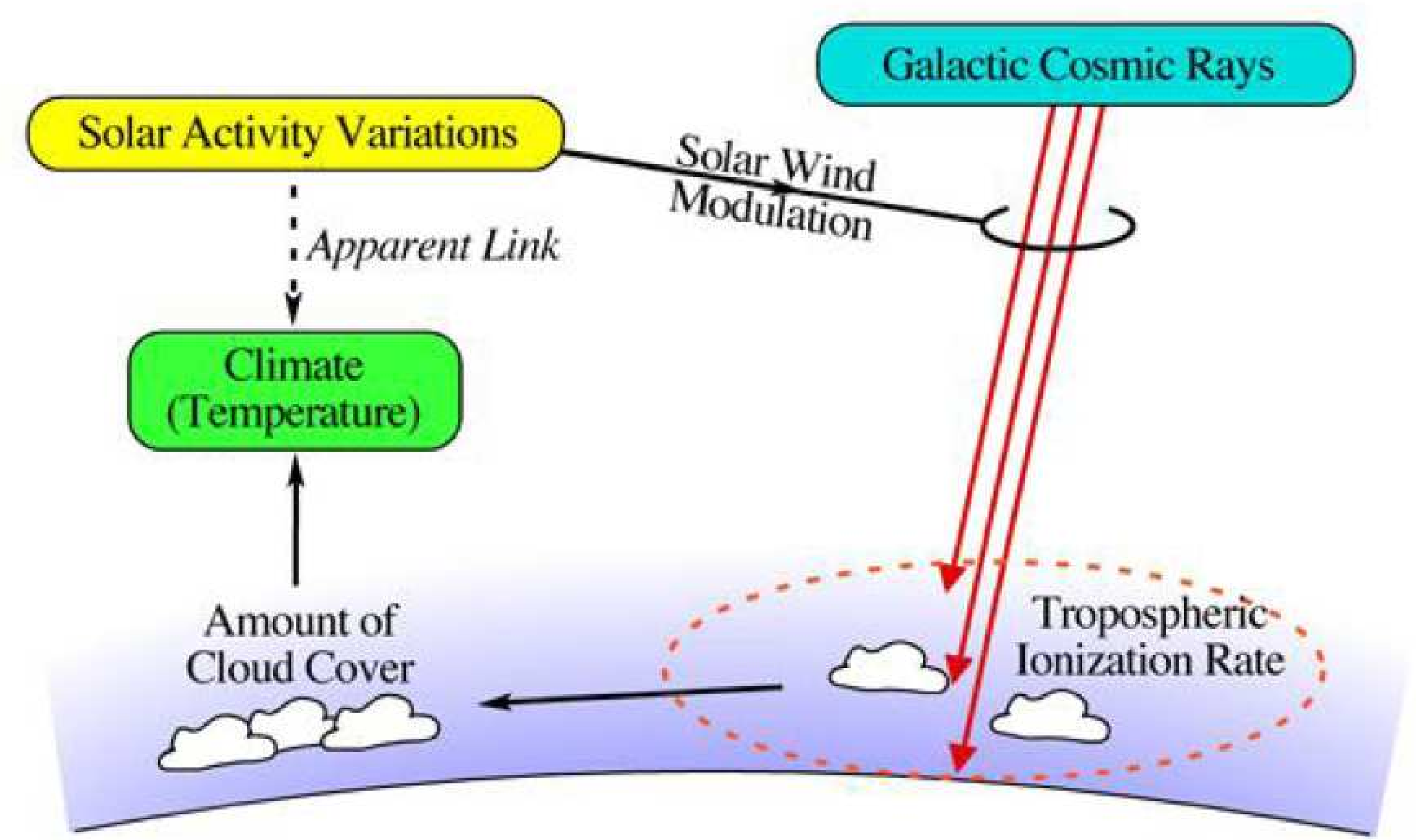
Cosmic rays

cloud cover



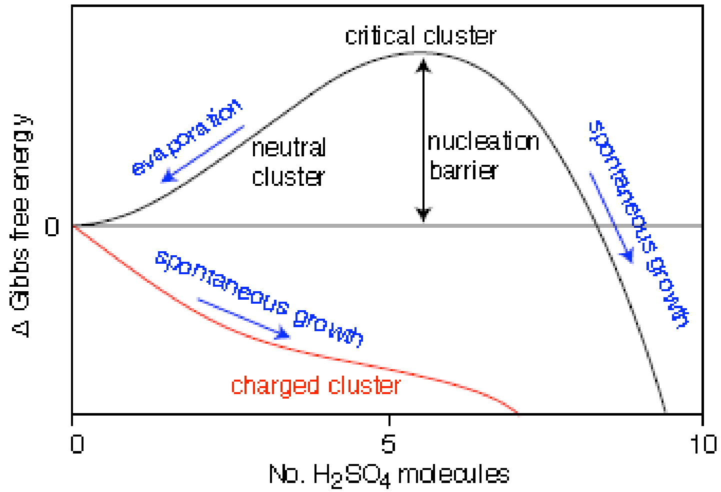
Marsh and Svensmark, 2000

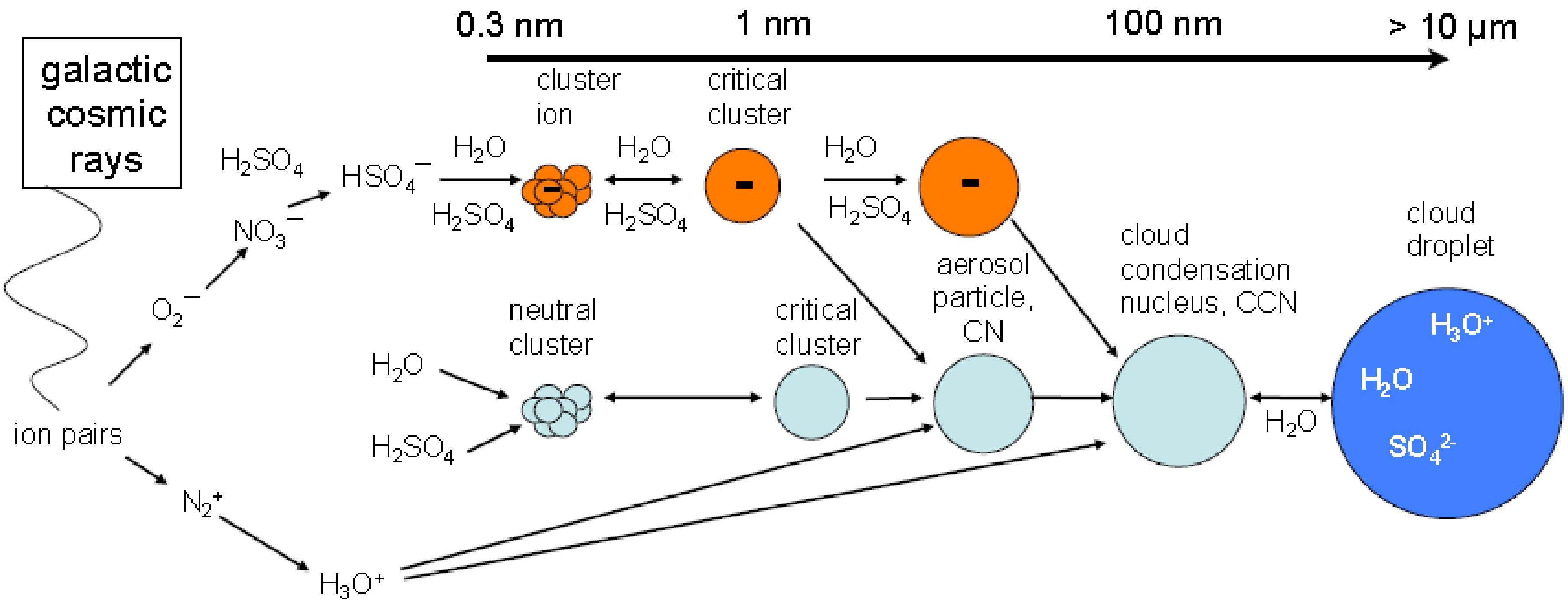
The Cosmic Ray-Cloud-Climate Hypothesis



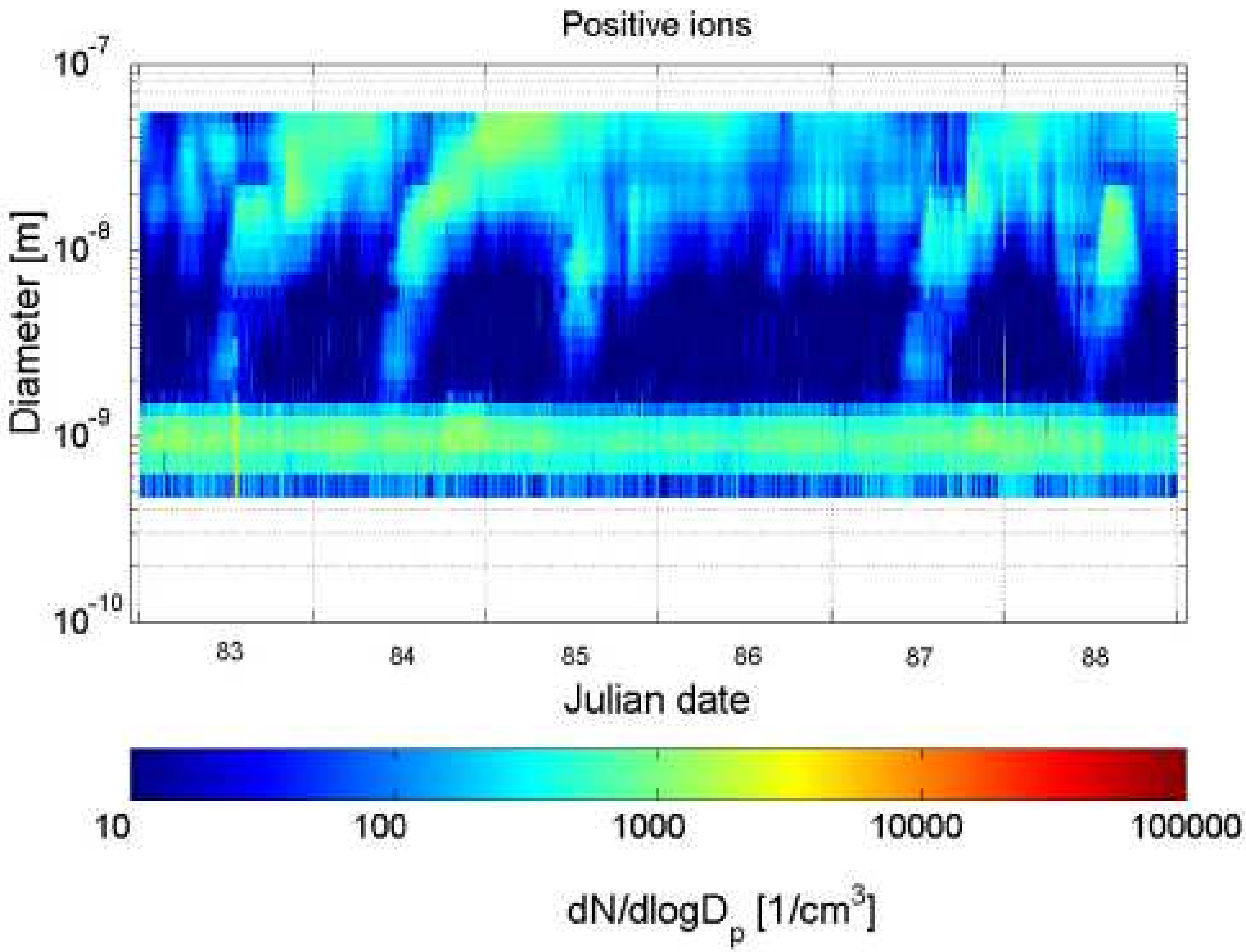
A possible mechanism: Ion induced nucleation

- Important source of cloud condensation nuclei is gas-to-particle conversion:
  trace gas → CN → CCN
- Ion-induced nucleation pathway is energetically favoured but limited by the ion production rate and ion lifetime



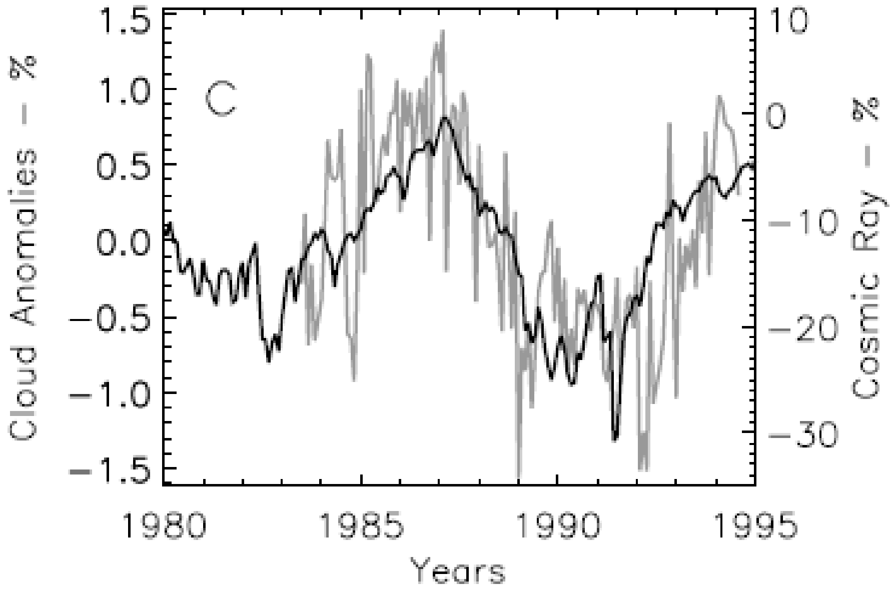


Field data show that ions are ubiquitous



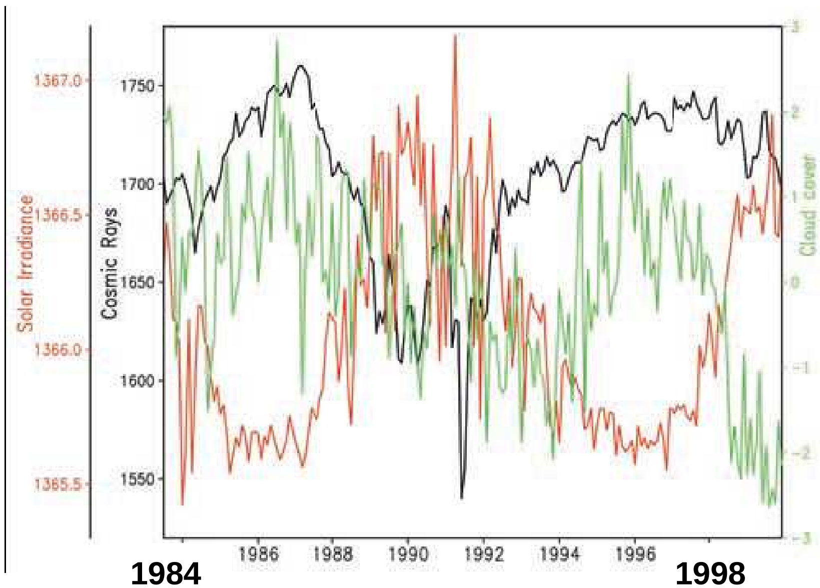
Conflicting data
Cosmic rays and cloud cover

Cosmic rays
Cloud cover



Marsh and Svensmark, 2000

Solar irradiance
Cosmic rays
Cloud cover

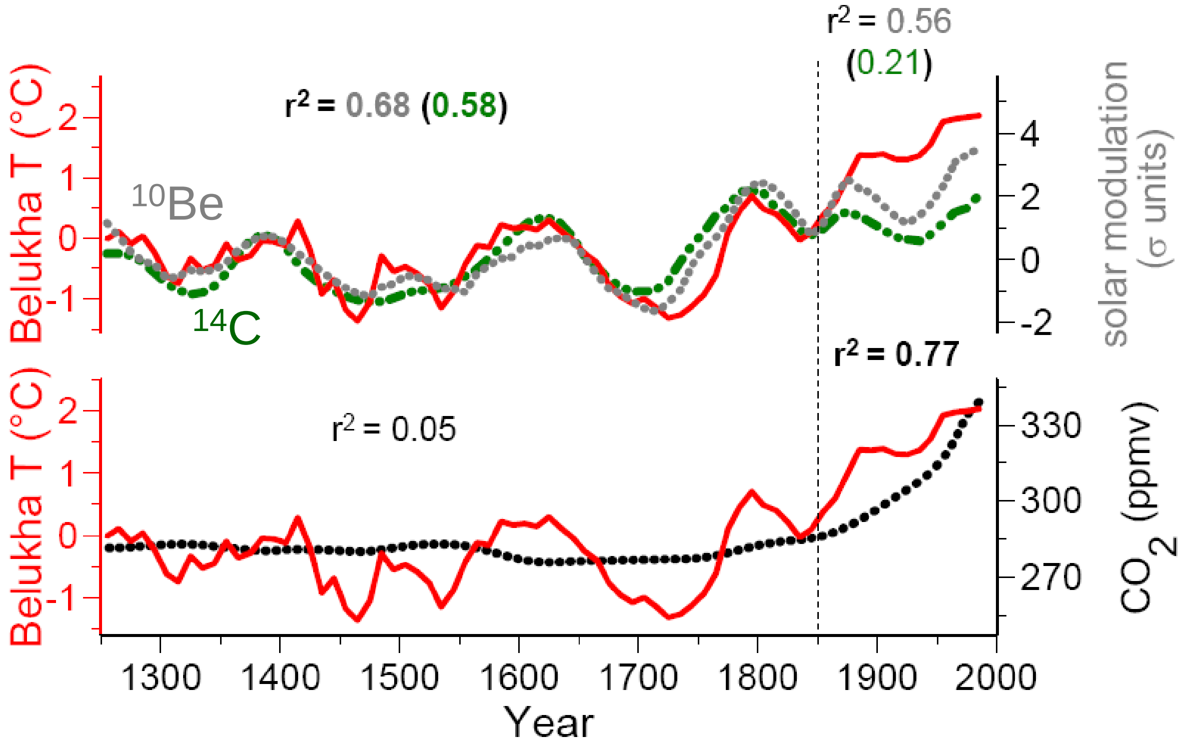


Kristjansson et al., 2002

Information from ice cores

LRC

Changes in solar activity was the main driving force of temperature changes before 1850 in the Central Asian Altai; no longer after 1850



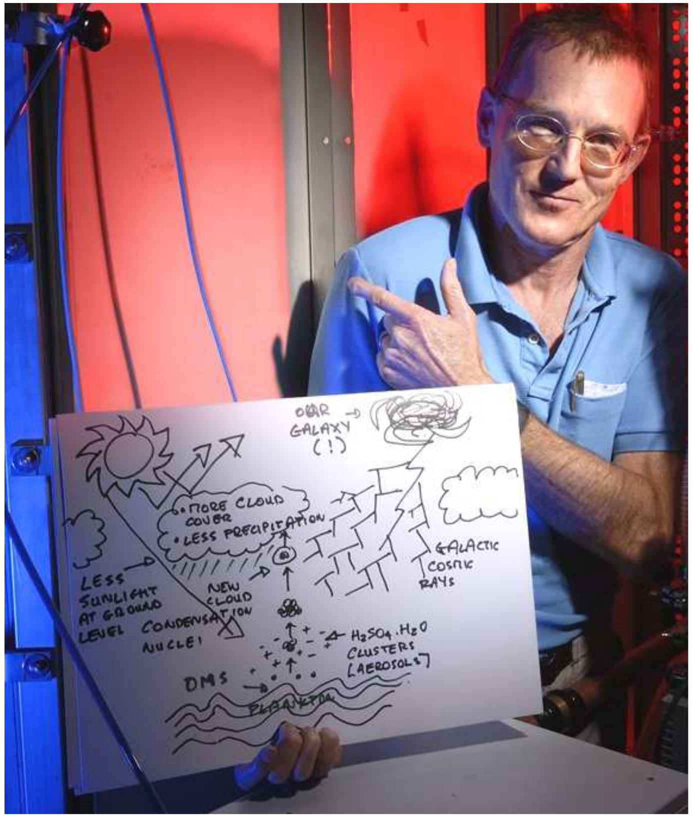
Eichler et al. GRL 2009

CLOUD
Cosmics Leaving OUtdoor Droplets

- Measurement of cosmic ray induced nucleation of aerosols, cloud droplets and ice crystals under controlled atmospheric and ionisation conditions

- Provide quantitative basis for development of numerical atmospheric models (aerosol physics, cloud models, climate models)

- Mk1 experiments focussed on formation of charged molecular clusters, aerosol nucleation and growth



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CLOUD collaboration

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cloud

- 19 institutes from Europe, Russia and USA
- 14 atmospheric institutes + 5 space/CR/particle physics
- CLOUD-ITN network of 10 Marie Curie fellows: 8 PhD students + 2 postdocs

- **Support in Switzerland:**
  - FORCE project
  (linked to smog chamber project at PSI)

- **Support in Germany:**
  - BMBF

Austria:
University of Innsbruck, Institute of Ion Physics and Applied Physics
University of Vienna, Institute for Experimental Physics

Bulgaria:
Institute for Nuclear Research and Nuclear Energy, Sofia

Estonia:
University of Tartu, Department of Environmental Physics

Finland:
Helsinki Institute of Physics and University of Helsinki, Department of Physics
Finnish Meteorological Institute, Helsinki
University of Kuopio, Department of Physics
Tampere University of Technology, Department of Physics

Germany:
Goethe-University of Frankfurt, Institute for Atmospheric and Environmental Sciences
Leibniz Institute for Tropospheric Research, Leipzig

Portugal:
University of Lisbon, Department of Physics

Russia:
Lebedev Physical Institute, Solar and Cosmic Ray Research Laboratory, Moscow

Switzerland:
CERN, Physics Department
Fachhochschule Nordwestschweiz (FHNW), Institute of Aerosol and Sensor Technology, Brugg
Paul Scherrer Institute, Laboratory of Atmospheric Chemistry

United Kingdom:
University of Leeds, School of Earth and Environment
University of Reading, Department of Meteorology
Rutherford Appleton Laboratory, Space Science Department

United States:
California Institute of Technology, Division of Chemistry and Chemical Engineering

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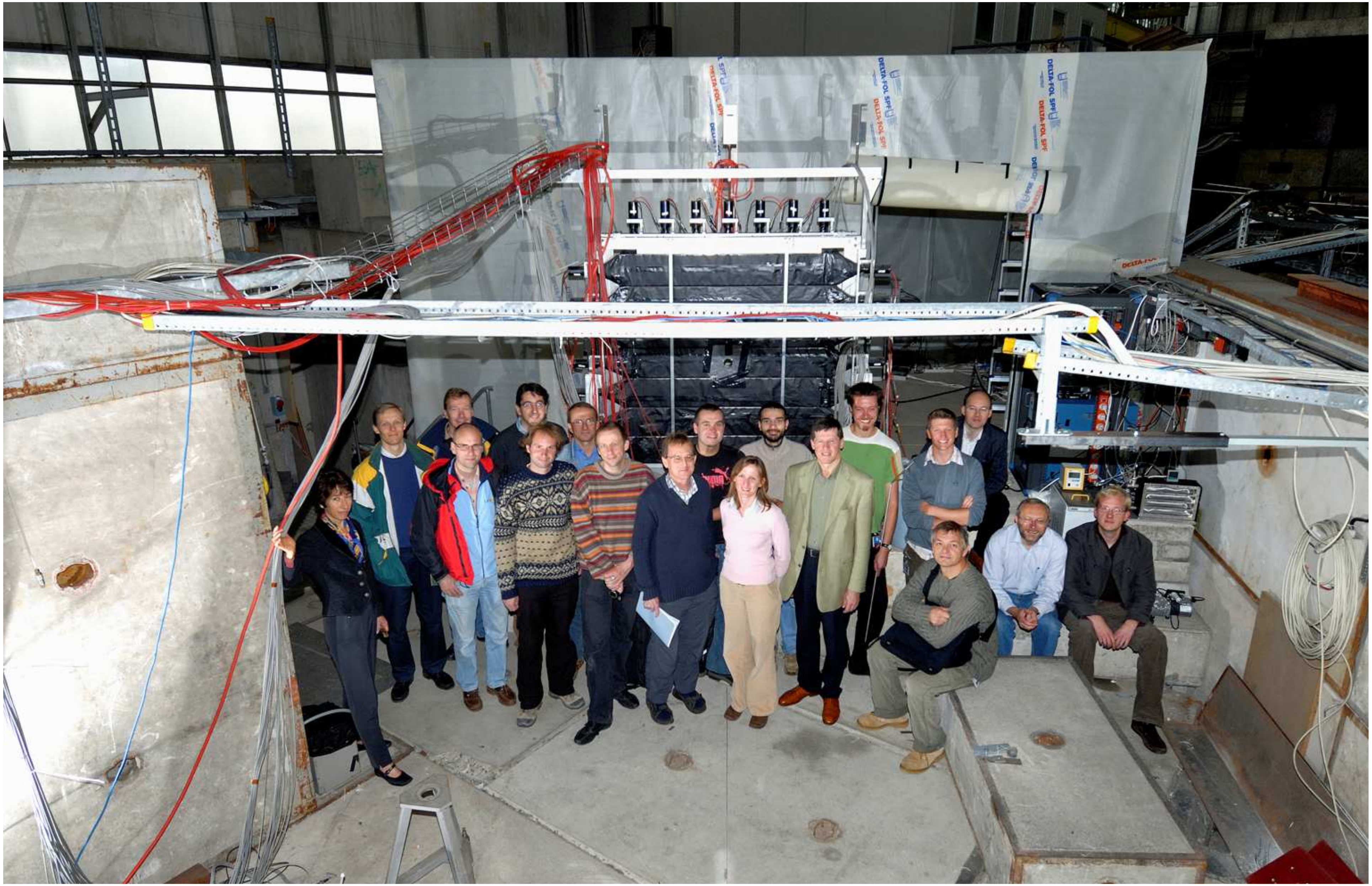
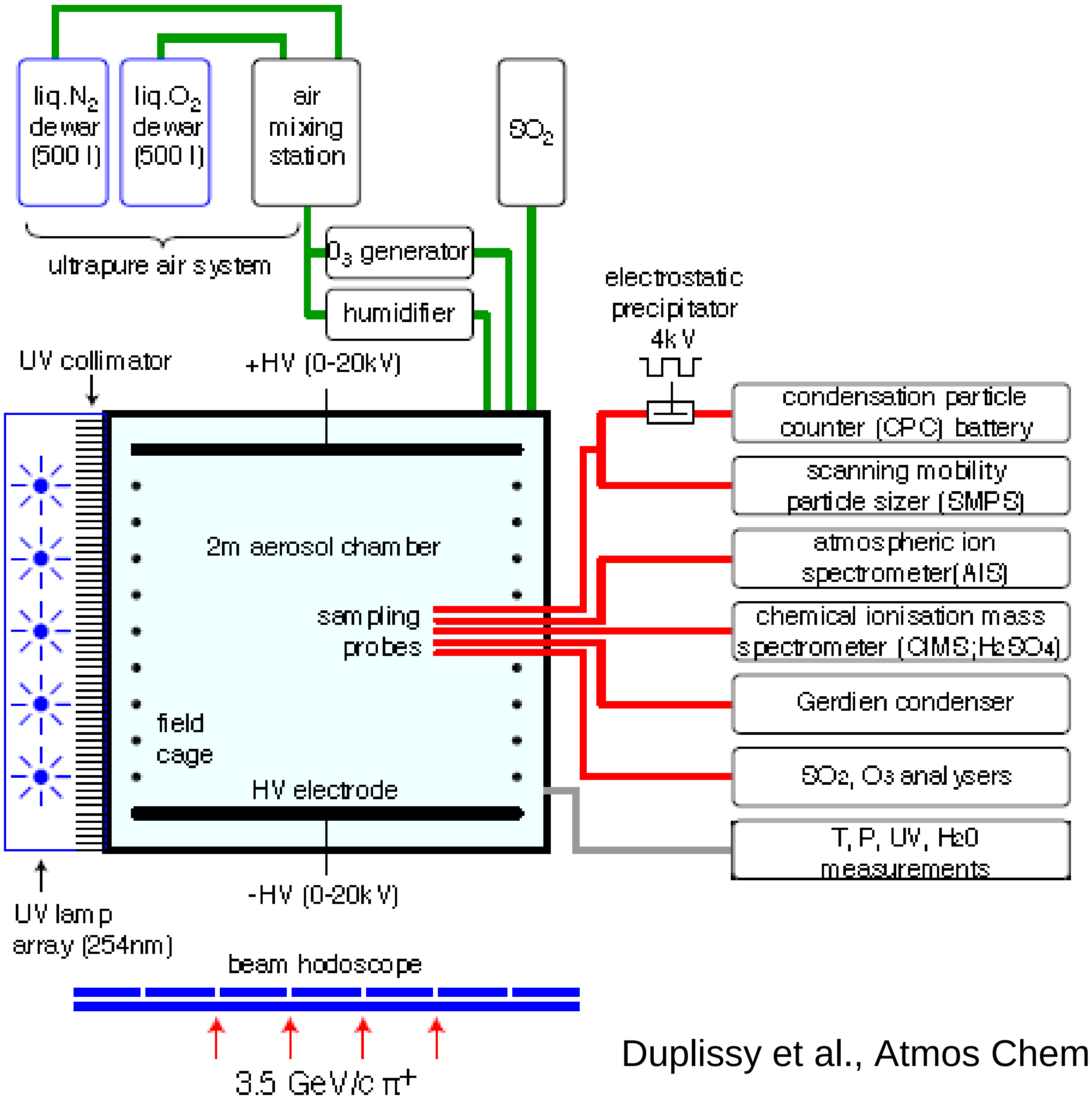
Results of the 2006 experiment at CERN

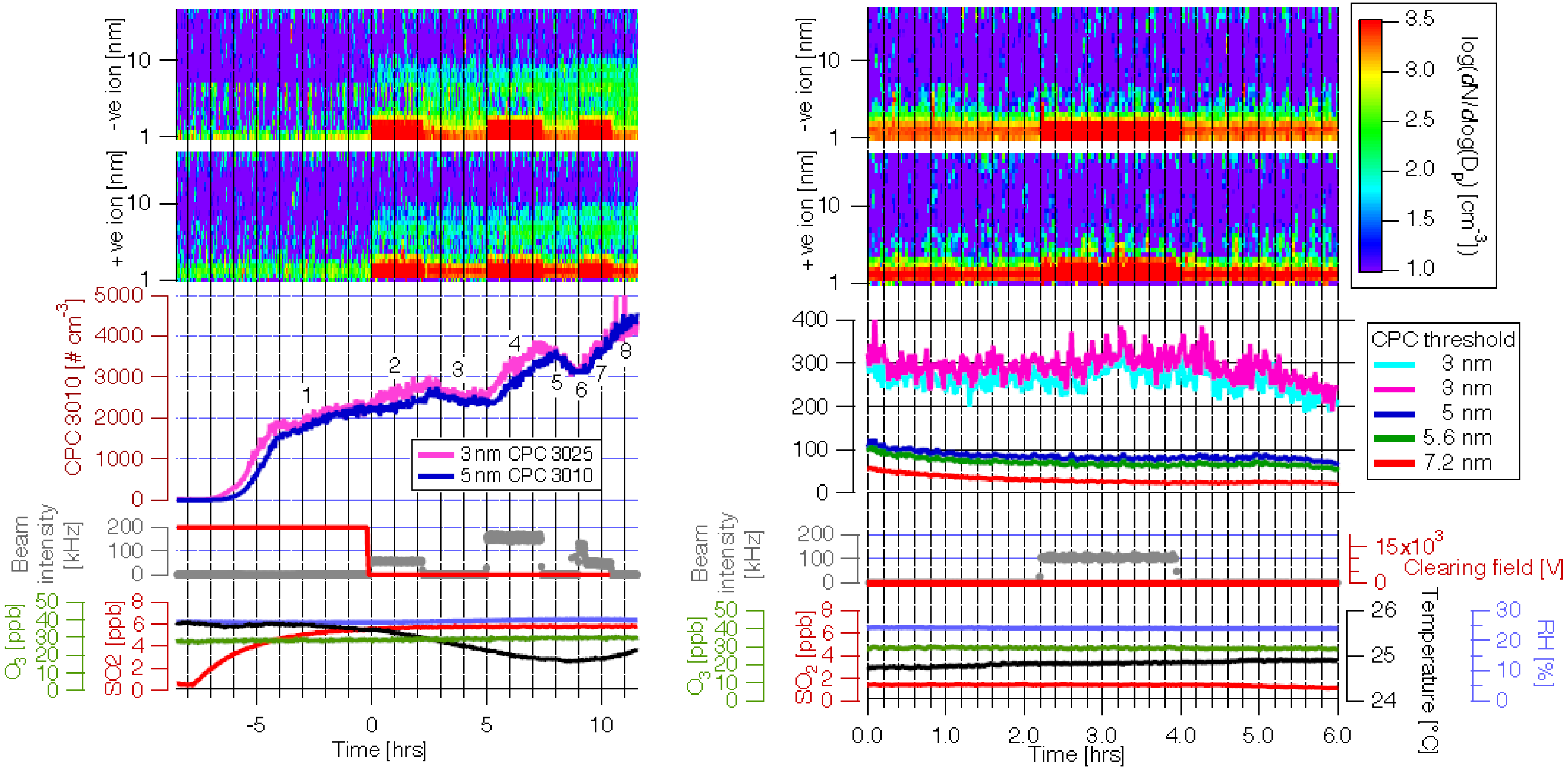


Setup of the 2006 experiment



Duplissy et al., Atmos Chem Phys., submitted

Conflicting results: one experiments shows an influence, all others don‘t



Duplissy et al., Atmos Chem Phys., submitted

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CLOUD-09 design requirements

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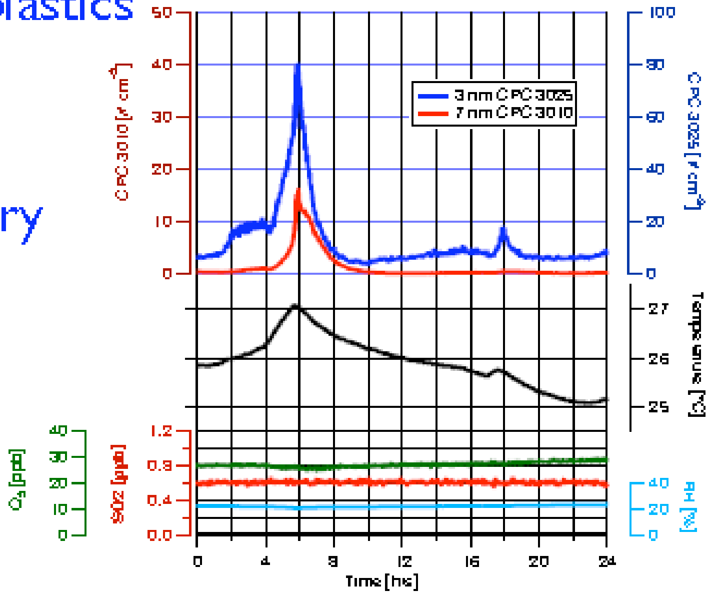
- Large chamber:
  - Diffusion lifetime of aerosols/trace gases to walls ~L^2
  - Dilution lifetime of makeup gases ~L^3

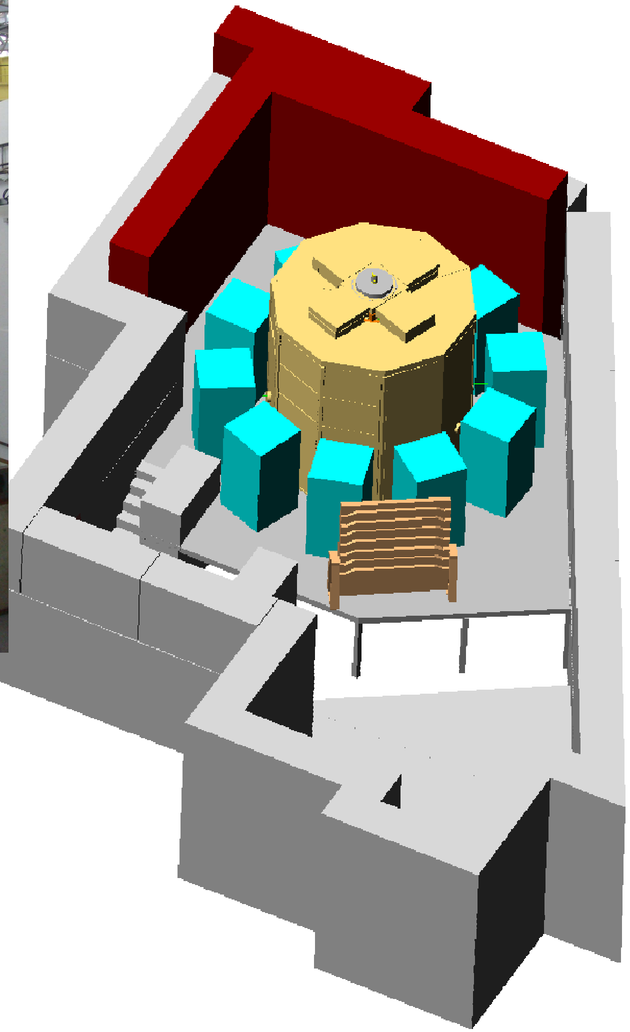
  => 3m chamber has typically 5-10 hr lifetimes
- Ultra-clean conditions:
  - Condensable vapours, eg. [H_2SO_4] ~0.1 pptv
  - Ultrapure air supply from cryogenic liquids
  - UHV procedures for inner surfaces, no plastics
- Temperature stability and wide T range
  - 0.1°C stability
  - Fibre-optic UV system for photochemistry
  - -90C → +100C range
- Field cage up to 30 kV/m:
  - Zero residual field
- Particle beam
  - Wide beam for ~uniform exposure
- Comprehensive analysers (measure "everything", as for collider detectors...)
  - Mass spectrometers for H_2SO_4, organics, aerosol composition



CLOUD plans

- 2009:
  - commission CLOUD-09
  - study H_2SO_4-H_2O nucleation with and without beam
  - reproducibility of nucleation events
  - PTR-Mass Spect. to measure organics at 10 pptv level
  - new ion-TOF Mass Spect. for ion characterisation
- 2010:
  - commission thermal system (-90C → +100C)
  - study H_2SO_4/water + volatile organic compounds with and without beam
  - temperature dependence (effect of altitude)
- 2011-2013:
  - extend studies to other trace vapours, and to cloud droplets & ice particles (adiabatic expansions in chamber)

The current status




Thank you for your attention