



AEROSOL PHYSICS AND
ENVIRONMENTAL PHYSICS



universität
wien

The Cosmics Leaving OUtdoor Droplets (CLOUD) experiment

nanc *Dynamite*

Paul M. Winkler

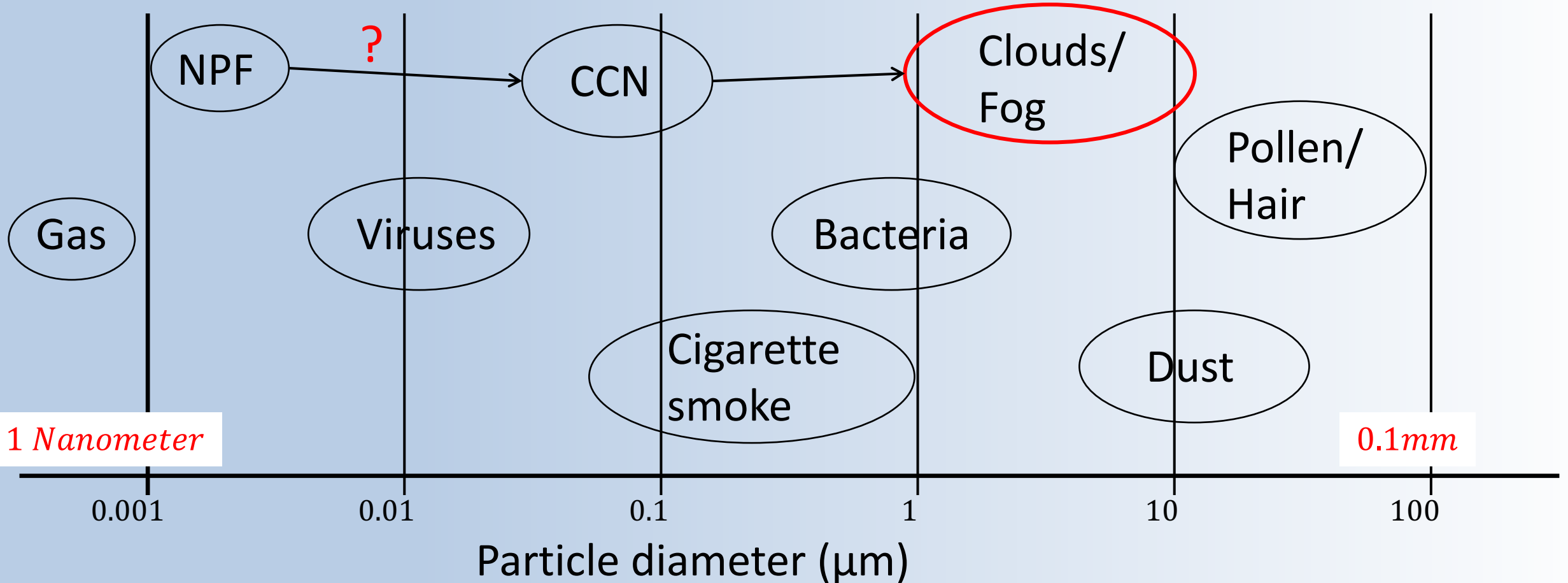
Faculty of Physics, University of Vienna

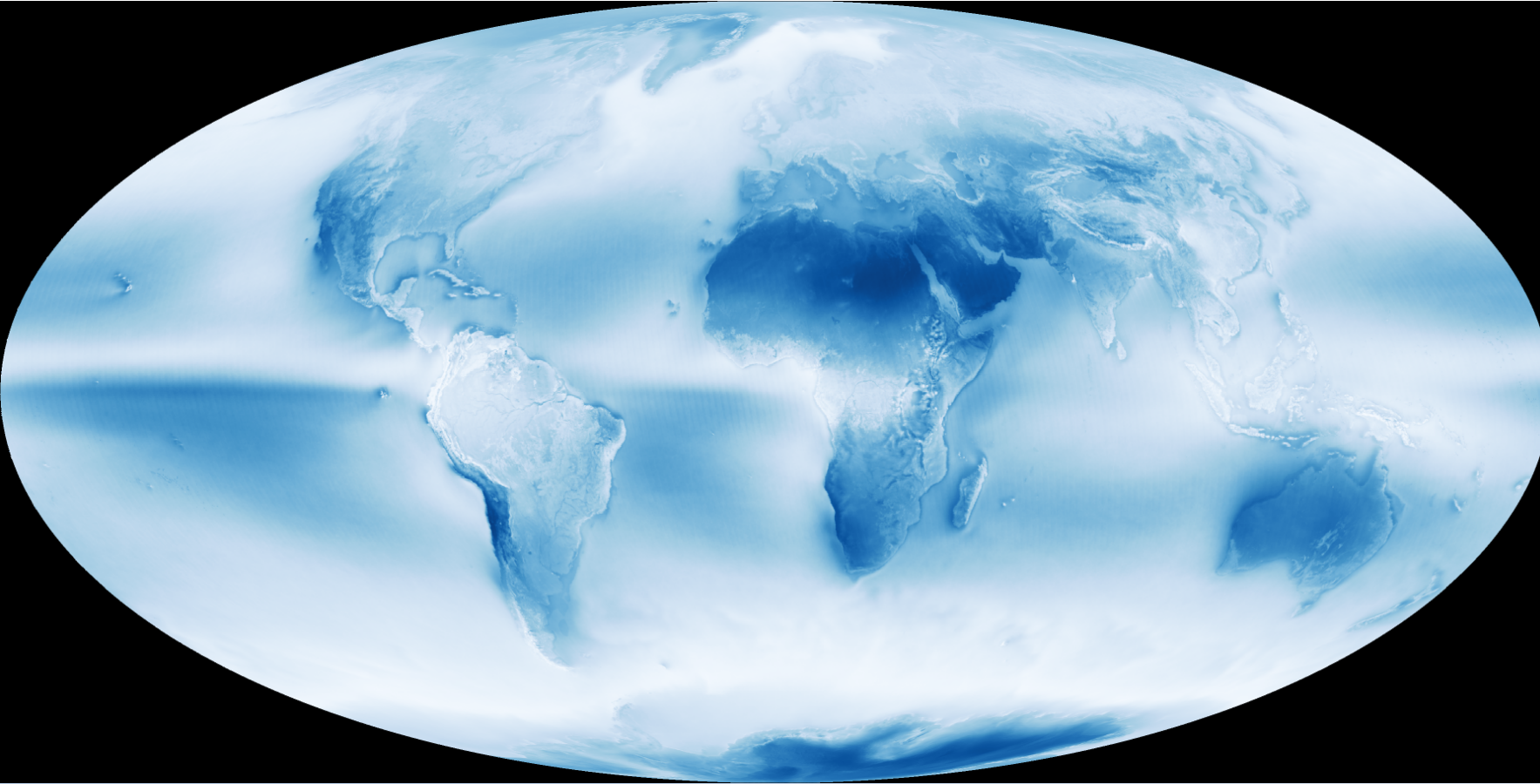
Sizes of common aerosol particles



NPF: new particle formation

CCN: cloud condensation nuclei

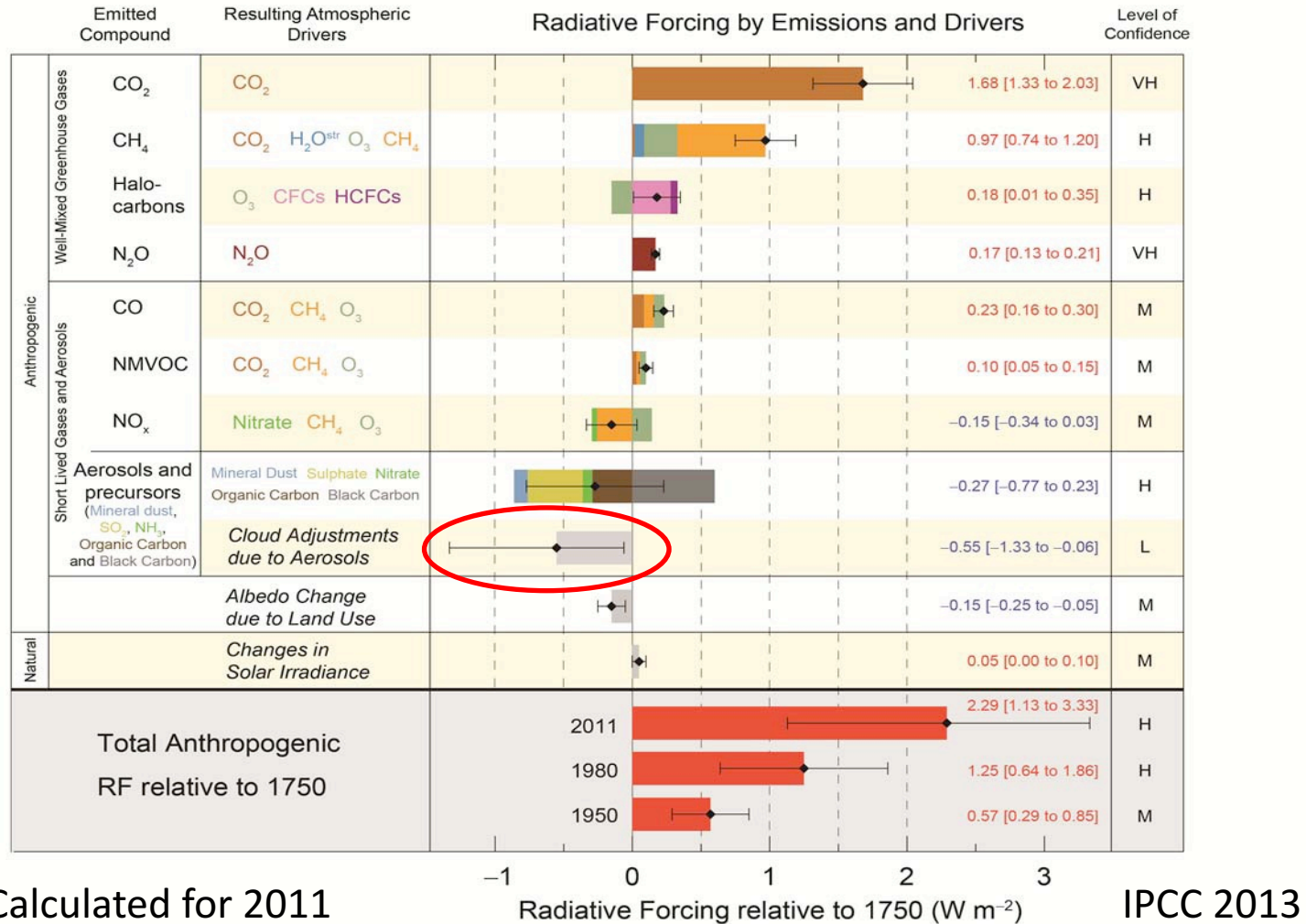


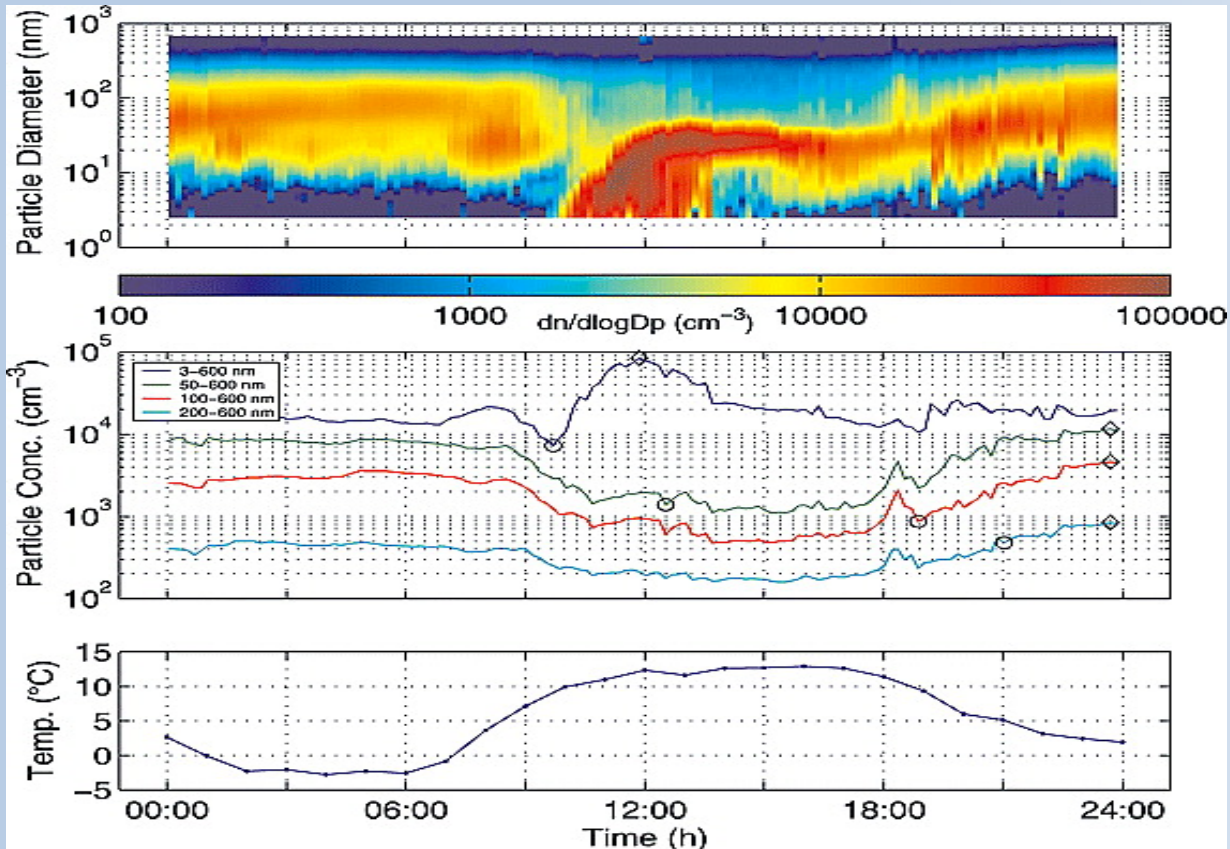


<http://earthobservatory.nasa.gov/>

- ☁ Clouds indicate global circulation
- ☁ 90% of oceans permanently covered with clouds

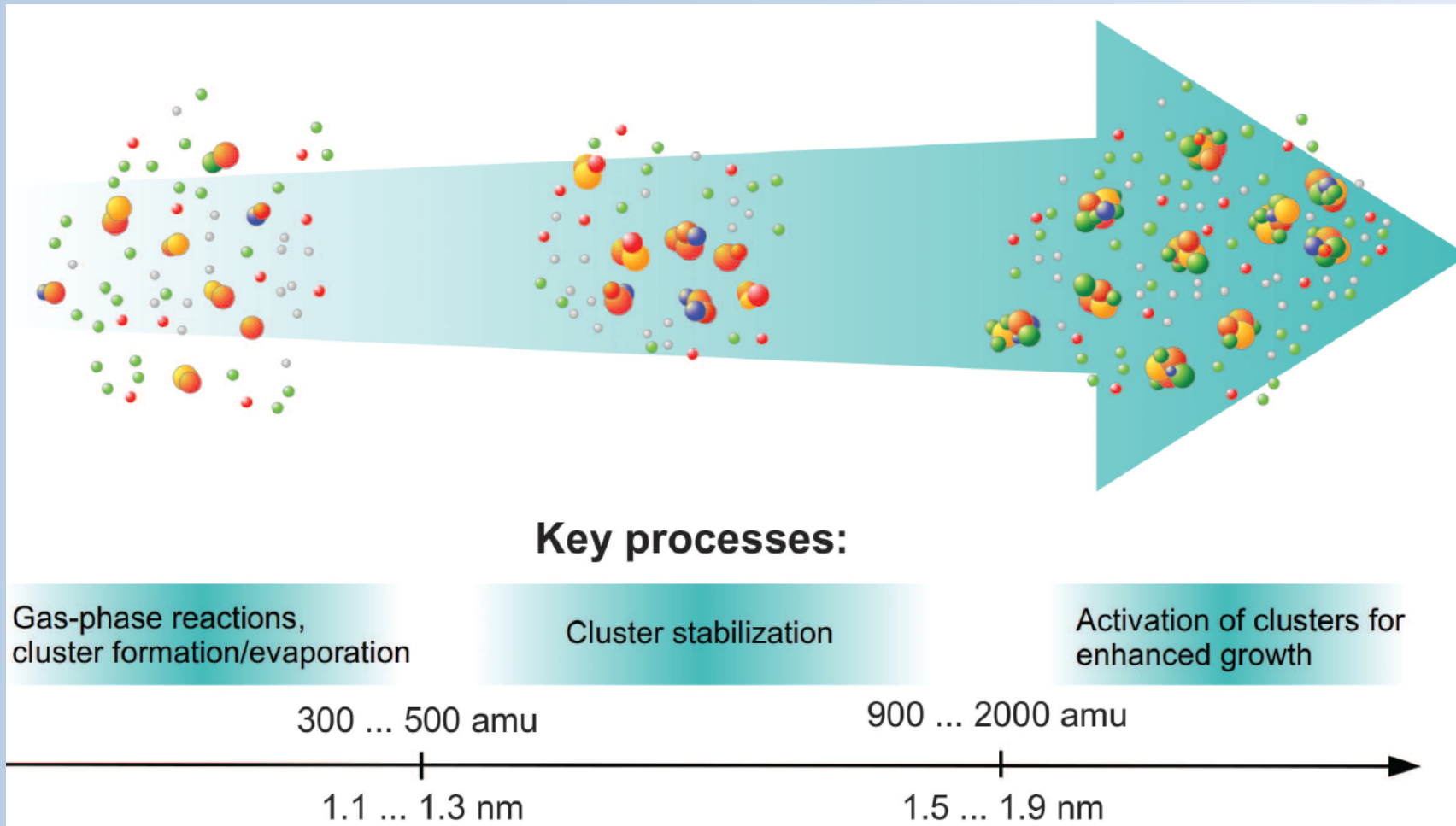
Climate relevance of clouds and aerosols





Laaksonen et al., *GRL*, 2005

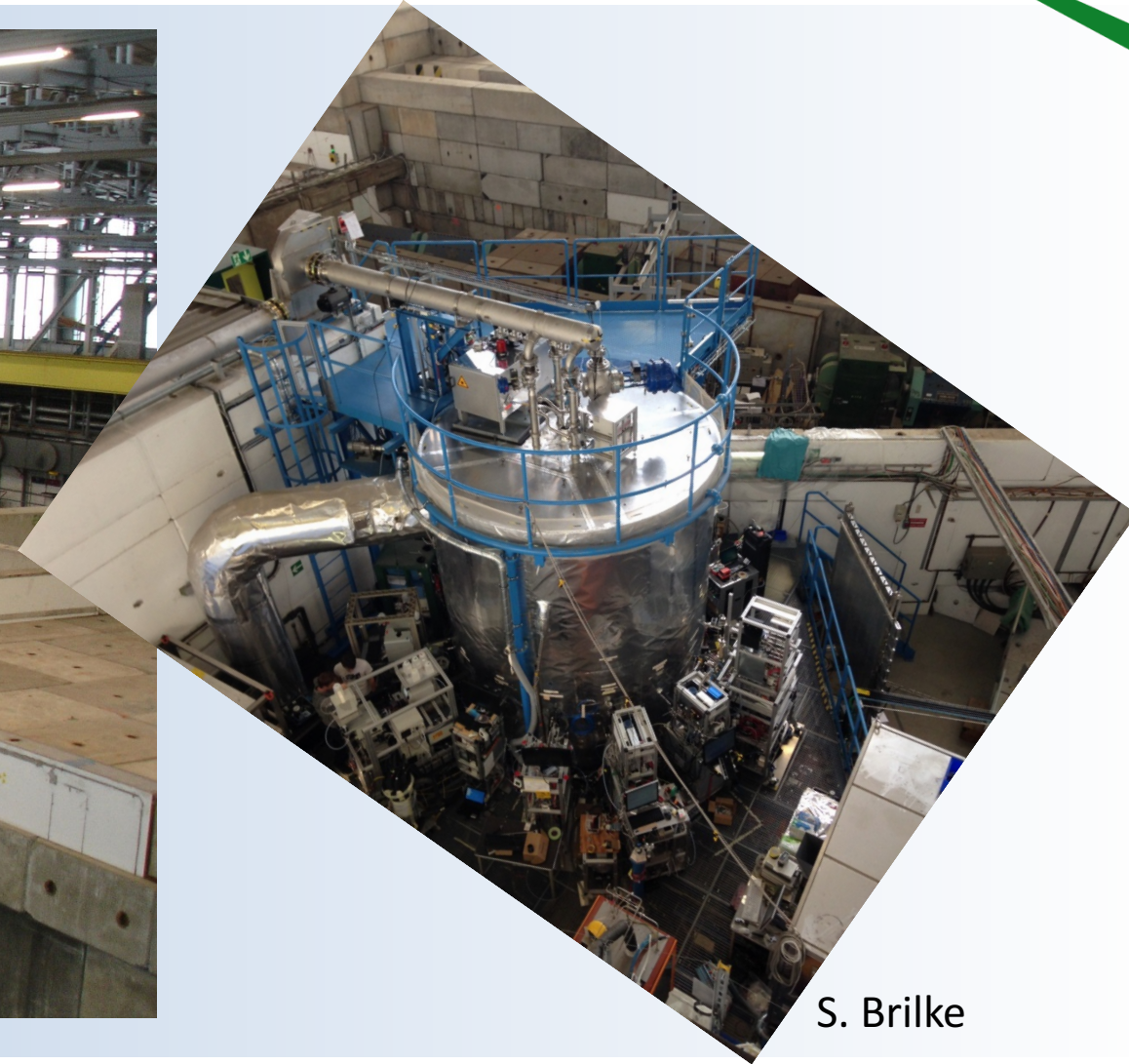
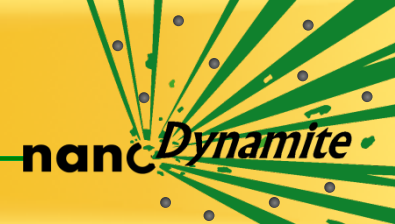
- Huge uncertainties in predictions of the role of aerosols in climate
- Model estimates suggest that about half of the cloud condensation nuclei originate from new particle formation (Merikanto et al., *ACP*, 2009)



- Formation depends on nucleation, evaporation, condensation, coagulation.
- Growth rate determines survival probability.

Kulmala et. al, (2013)

The CLOUD chamber at T11



S. Brilke

- Gas phase composition (molecules)
 - Proton-transfer-reaction mass spectrometer (PTRMS): organics
 - Chemical ionization mass spectrometer (CIMS): sulfuric acid
- Cluster composition ($\sim 1 - 2$ nm)
 - Atmospheric pressure interface mass spectrometer (API-ToF-MS)
- Particle phase ($\sim 1.5 - 100$ nm)
 - Differential mobility particle sizer (DMPS): size distribution
 - Condensation particle counters (CPC): number concentration
 - Thermal desorption chemical analyzers: chemical composition

-  Austria 
 - University of Innsbruck
 - University of Vienna
-  Finland 
 - University of Helsinki
 - Finnish Meteorological Institute
 - University of Eastern Finland
-  Germany 
 - Goethe University of Frankfurt
 - Karlsruhe Institute of Technology
 - Leibnitz Institute for Tropospheric Research
-  Portugal 
 - University of Lisbon

-  Russia 
 - Lebedev Physical Institute
-  Sweden 
 - University of Stockholm
-  Switzerland 
 - CERN
 - Paul Scherrer Institute
-  UK 
 - University of Leeds
-  USA 
 - California Institute of Technology
 - Carnegie Mellon University



University of Innsbruck

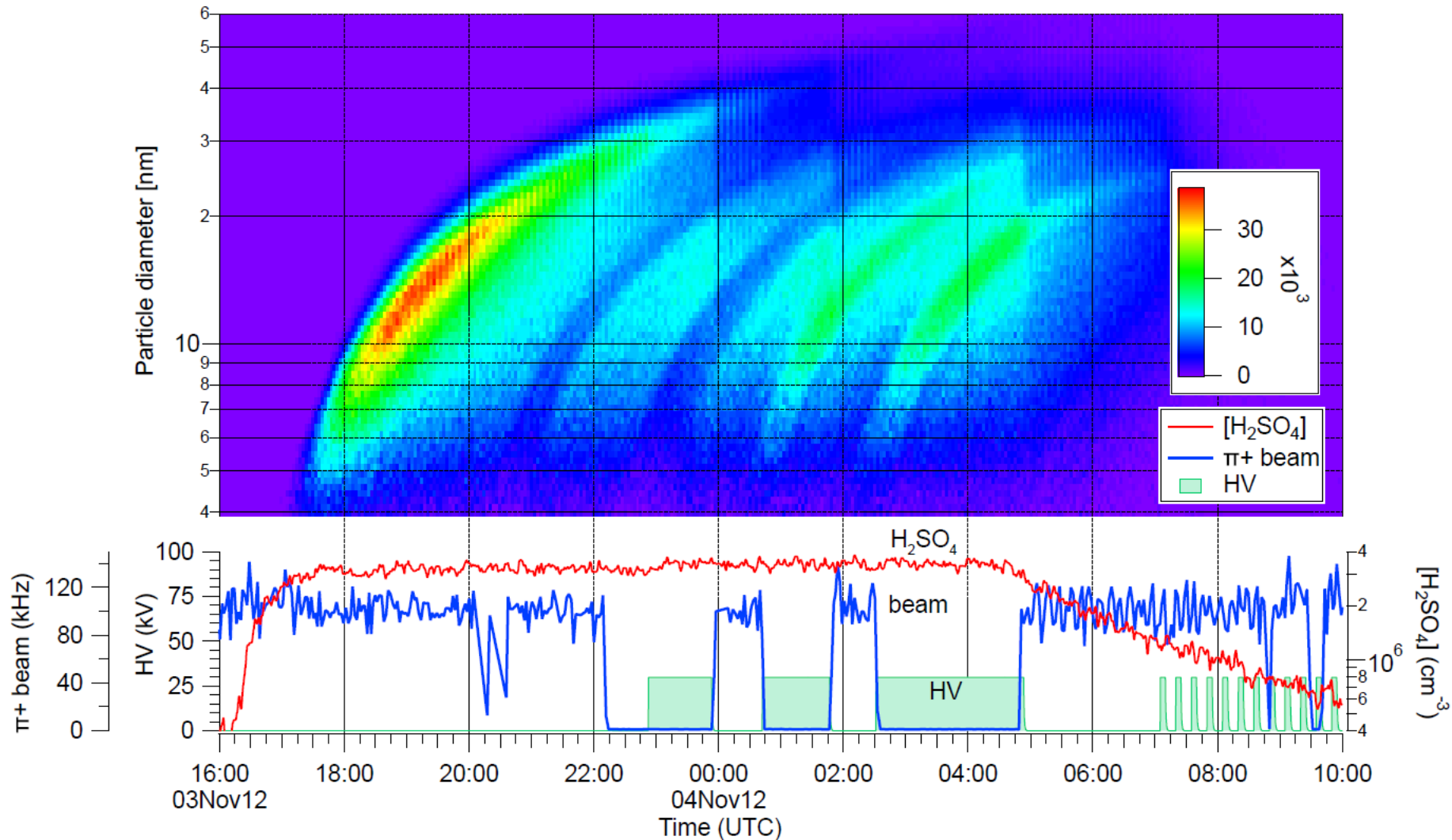
- Team leader: Armin Hansel, Institute for Ion and Applied Physics
- Main contribution: gas-phase composition measurements by proton transfer reaction mass spectrometry



University of Vienna

- Team leader: Paul Winkler, Faculty of Physics
- Main contribution: sub-10 nm particle sizing by differential mobility analysis

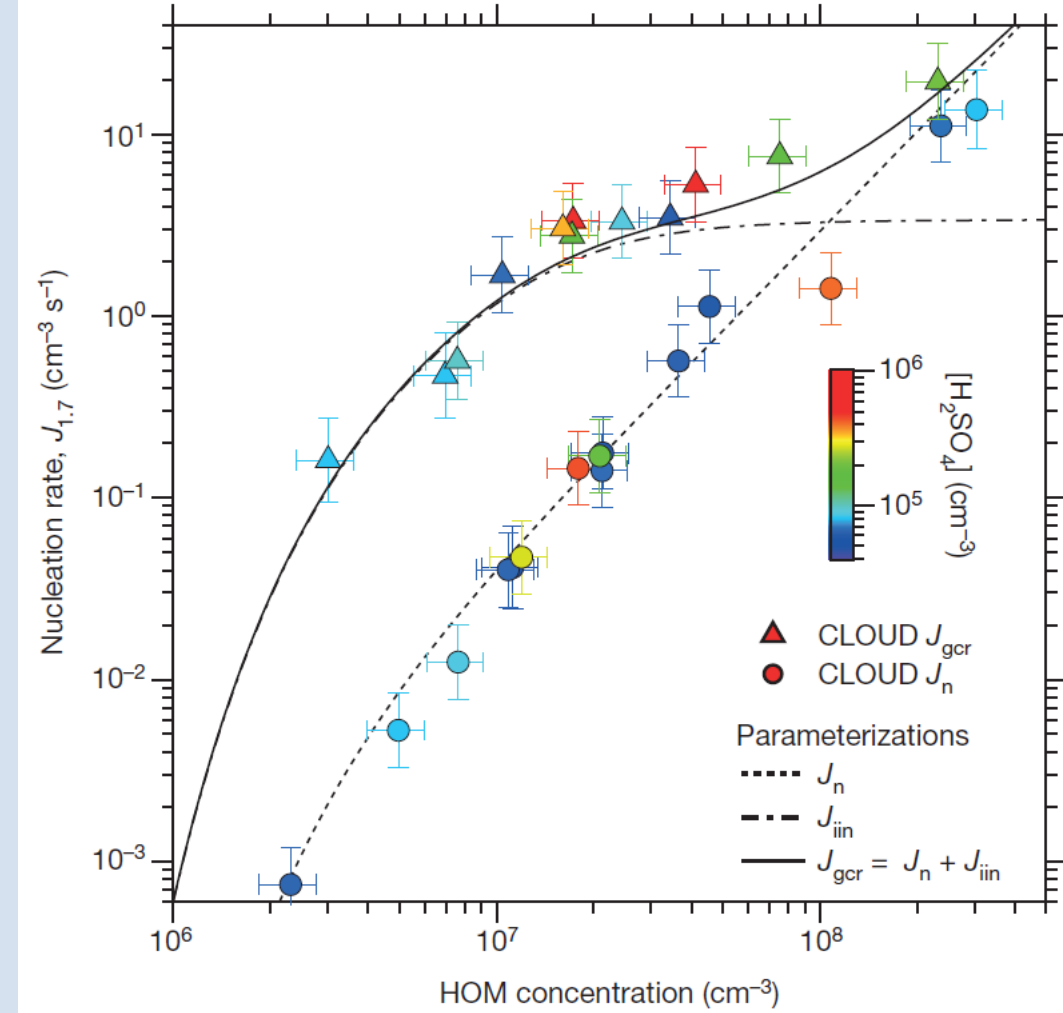
Particle formation in the CLOUD chamber



Influence of cosmic rays on new particle formation



- In clean environments ion-induced nucleation can enhance particle formation
- Sulfuric acid not necessarily needed
- How does this affect anthropogenic aerosol forcing?
- Global modelling suggests important role of pure biogenic nucleation in pre-industrial conditions



Kirkby et. al, (2016)

- ☛ CLOUD aims at settling the GCR-cloud-climate question*
- ☛ CLOUD is the unique chamber to have reached demanding performance*
- ☛ Trace gases at pptv levels can enhance nucleation rate by several orders of magnitude*
- ☛ CLOUD has introduced a large new community to CERN*
- ☛ CLOUD is acknowledged as the world's leading experiment for these studies*

- Kirkby et al., Nature 476, 429 (2011)
- Almeida et al., Nature 502, 359 (2013)
- Schobesberger et al., PNAS, 110, 17223 (2013)
- Kirkby et al., Nature 533, 521(2016)
- Tröstl et al., Nature 533, 527 (2016)
- Bianci et al., Science 352, 1109 (2016)
- Gordon et al., PNAS, 113, 12053 (2016)
- Dunne et al., Science (2016)

