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PHOCUS

Particle interactions in the polar summer mesosphere

Jonas Hedin

Department of Meteorology, Stockholm University (MISU)

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The PHOCUS Team

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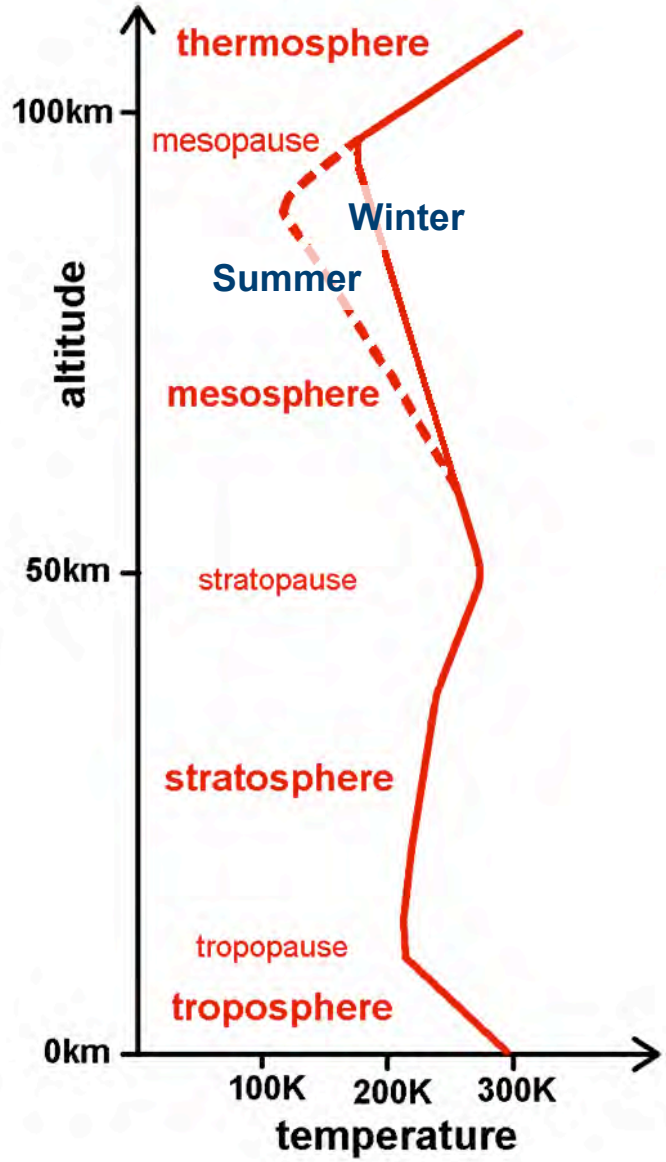
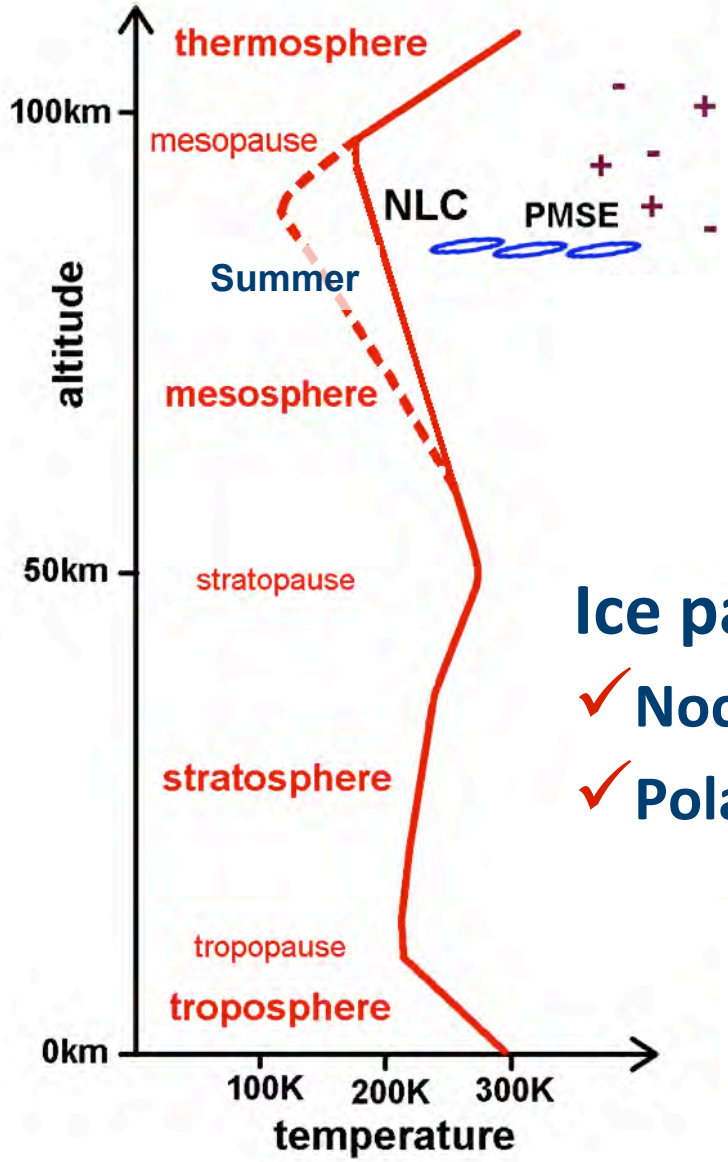
Outline

- ✓ Introduction
  - Scientific questions
  - the PHOCUS idea
  - ✓ Instrumentation
- ✓ Campaign
- ✓ Results
  - Some highlights
- ✓ Conclusion & Outlook


thermosphere
100km
mesopause
Winter
Summer
altitude
mesosphere
50km
stratopause
stratosphere
tropopause
troposphere
0km
100K
200K
300K
temperature

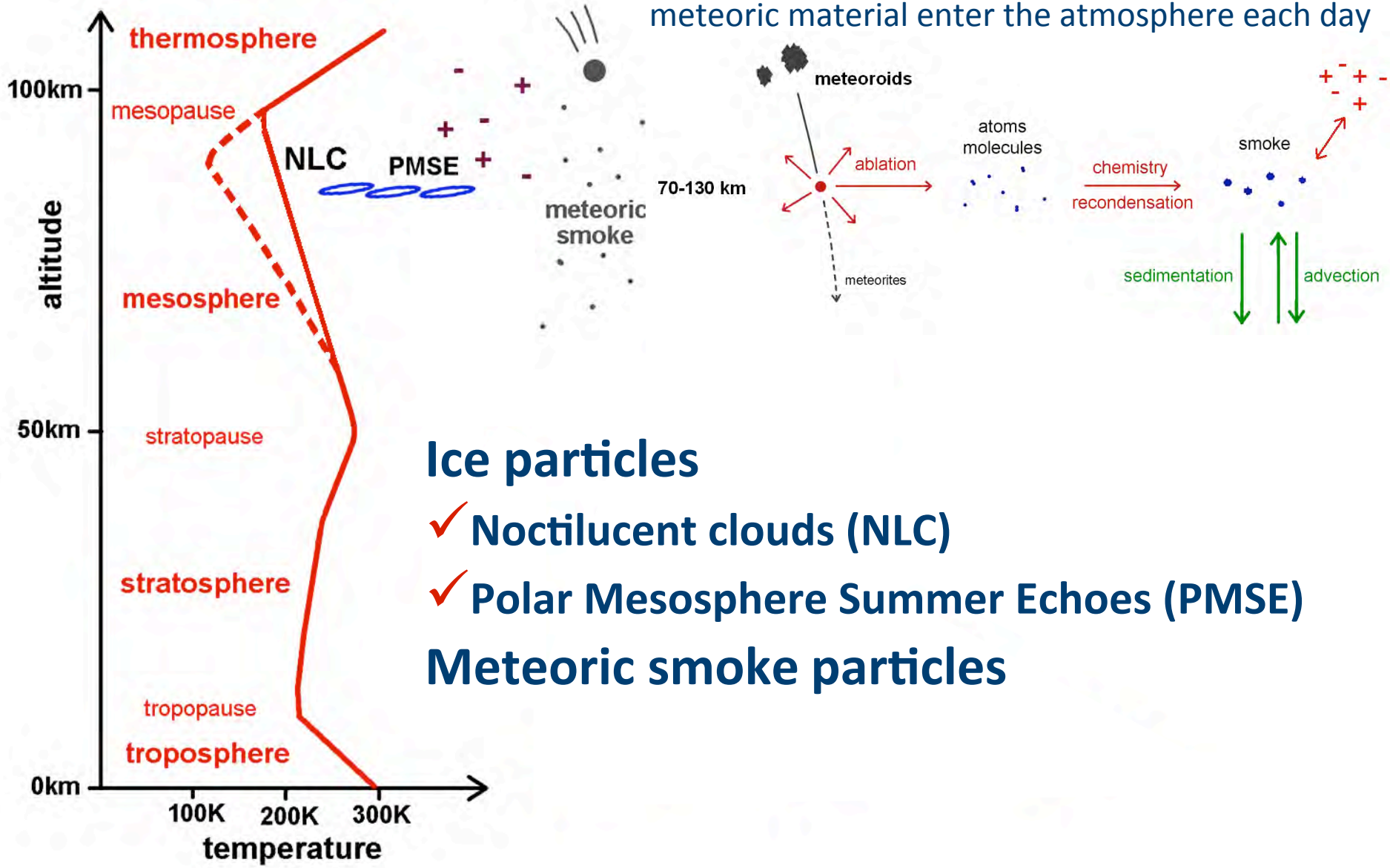


Ice particles

- ✓ **Noctilucent clouds (NLC)**
- ✓ **Polar Mesosphere Summer Echoes (PMSE)**

The summertime polar mesopause is the coldest place on Earth

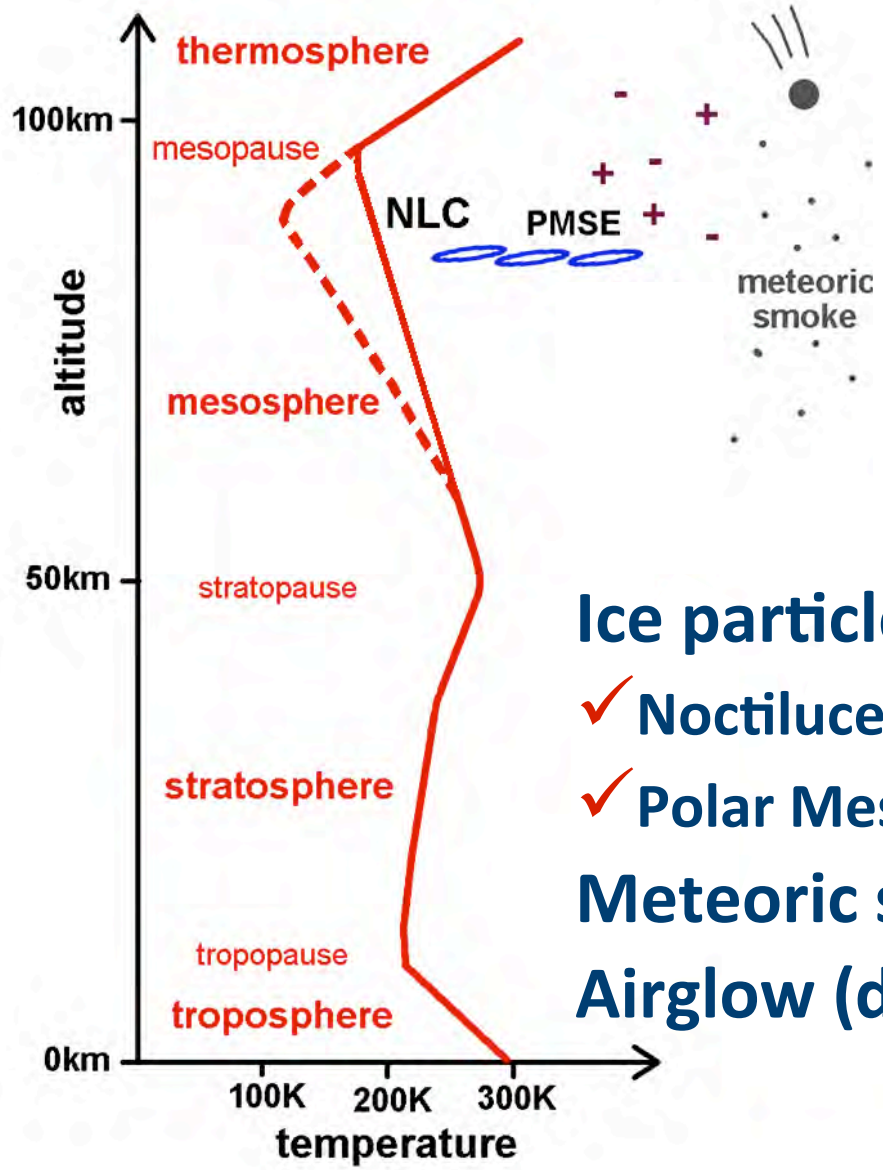
Between a few to several hundred tons of meteoric material enter the atmosphere each day



Ice particles

- ✓ Noctilucent clouds (NLC)
- ✓ Polar Mesosphere Summer Echoes (PMSE)

Meteoric smoke particles

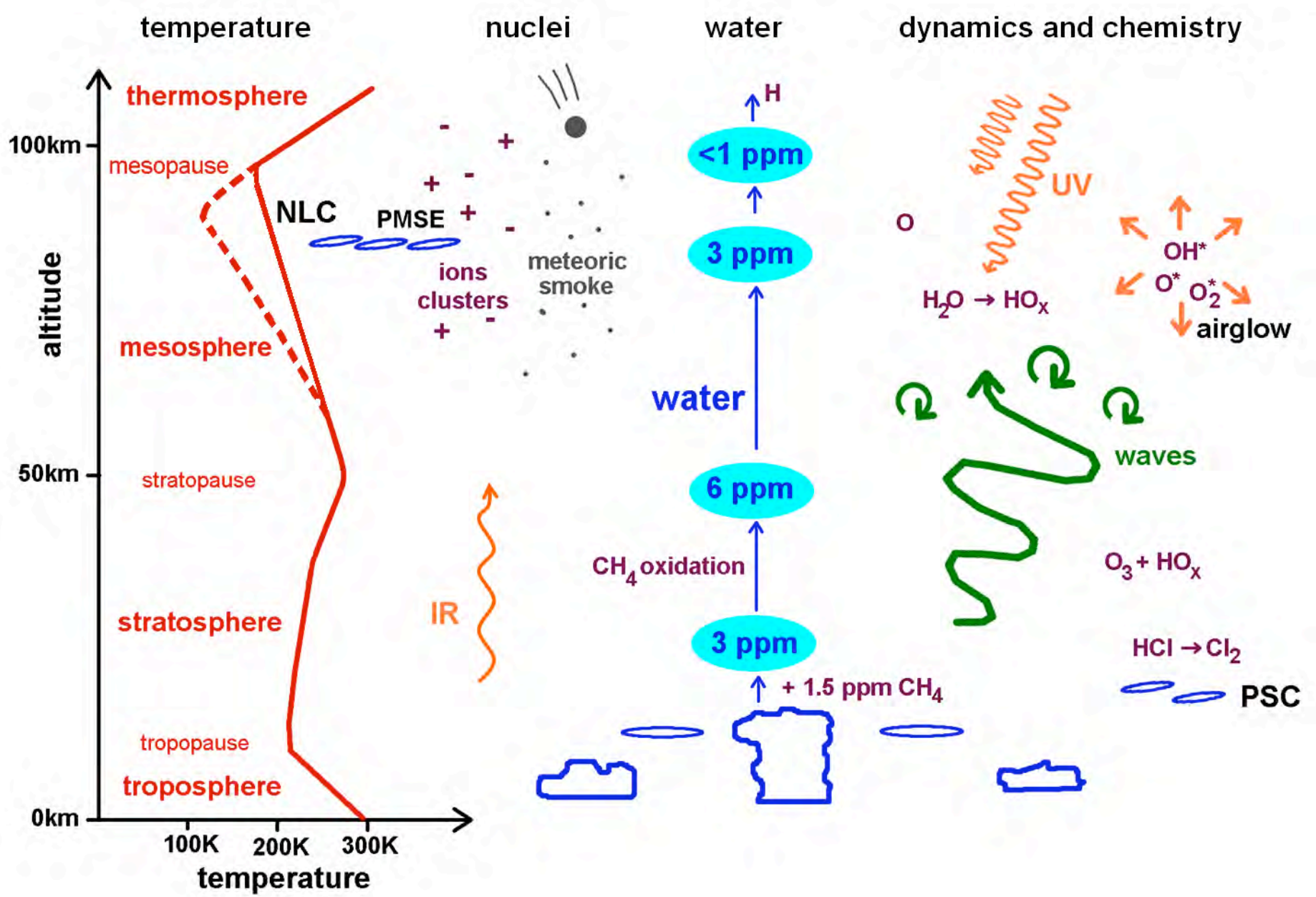


Ice particles

- ✓ Noctilucent clouds (NLC)
- ✓ Polar Mesosphere Summer Echoes (PMSE)

Meteoric smoke particles

Airglow (dayglow, nightglow)


temperature
nuclei
water
dynamics and chemistry
thermosphere
100km
mesopause
NLC
PMSE
ions
clusters
meteoric
smoke
altitude
mesosphere
50km
stratopause
stratosphere
tropopause
troposphere
0km
100K
200K
300K
temperature
IR
H
<1 ppm
3 ppm
water
6 ppm
CH4 oxidation
3 ppm
+ 1.5 ppm CH4
UV
O
H2O → HOx
OH*
O*
O2*
airglow
waves
O3 + HOx
HCl → Cl2
PSC

Introduction

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PHOCUS – Particles, Hydrogen and Oxygen Chemistry in the Upper Summer mesosphere

Aerosol particles & chemistry

(ice particles, meteoric smoke particles…)

Their **sources,**

the **properties** of the particle layers,

their **interaction** with various phenomena in the MLT

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Introduction

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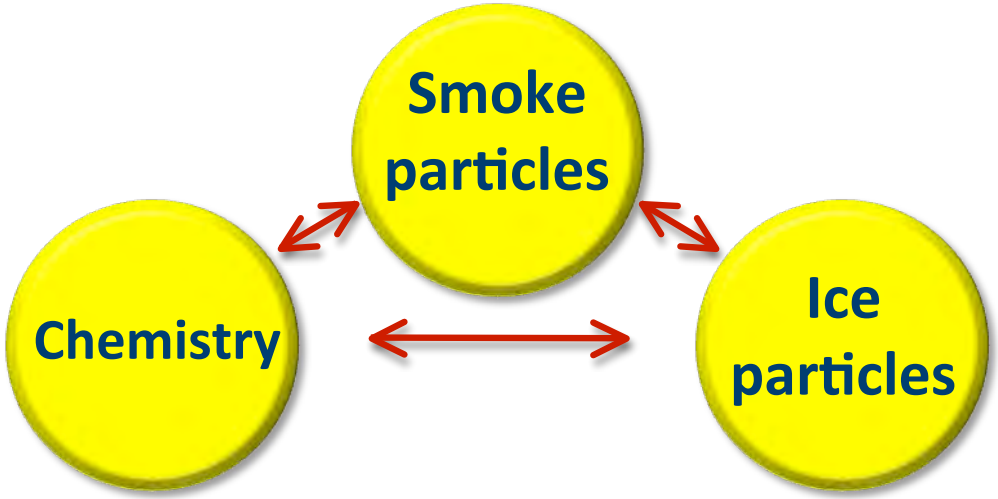
PHOCUS – Particles, Hydrogen and Oxygen Chemistry in the Upper Summer mesosphere



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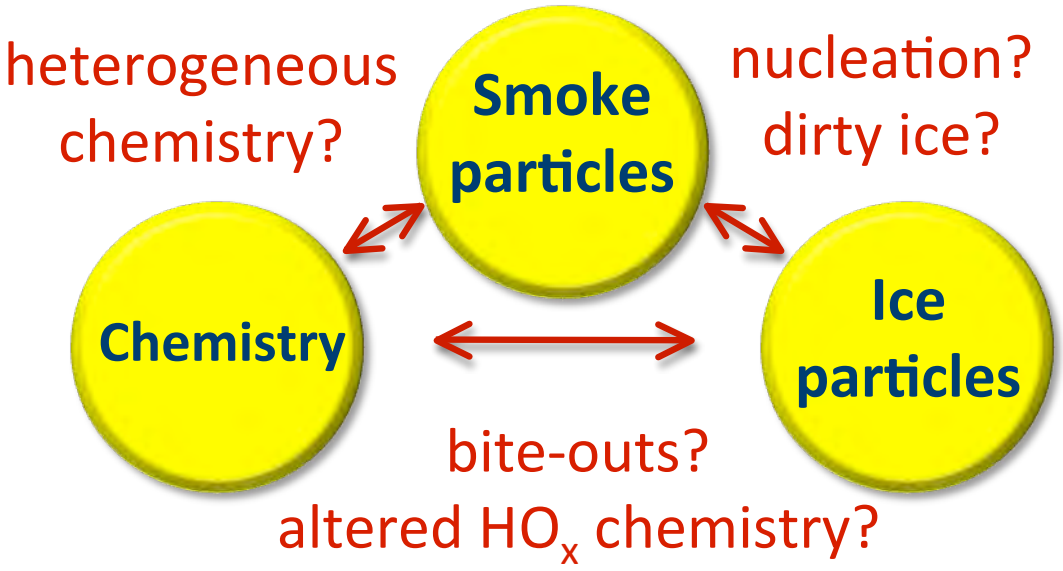
PHOCUS – Particles, Hydrogen and Oxygen Chemistry in the Upper Summer mesosphere



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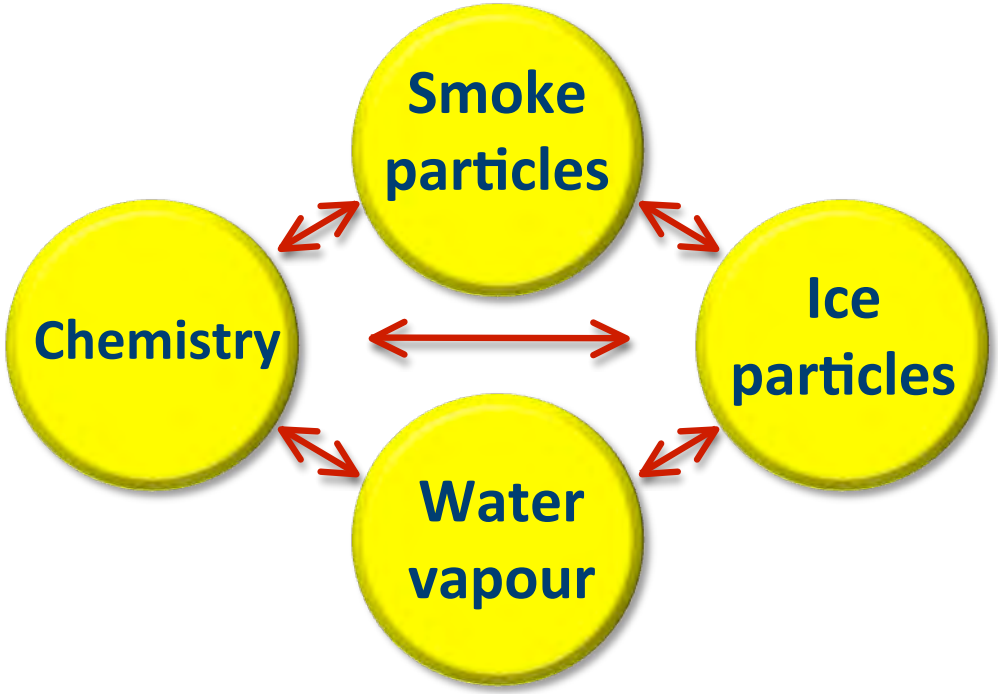
PHOCUS – Particles, Hydrogen and Oxygen Chemistry in the Upper Summer mesosphere



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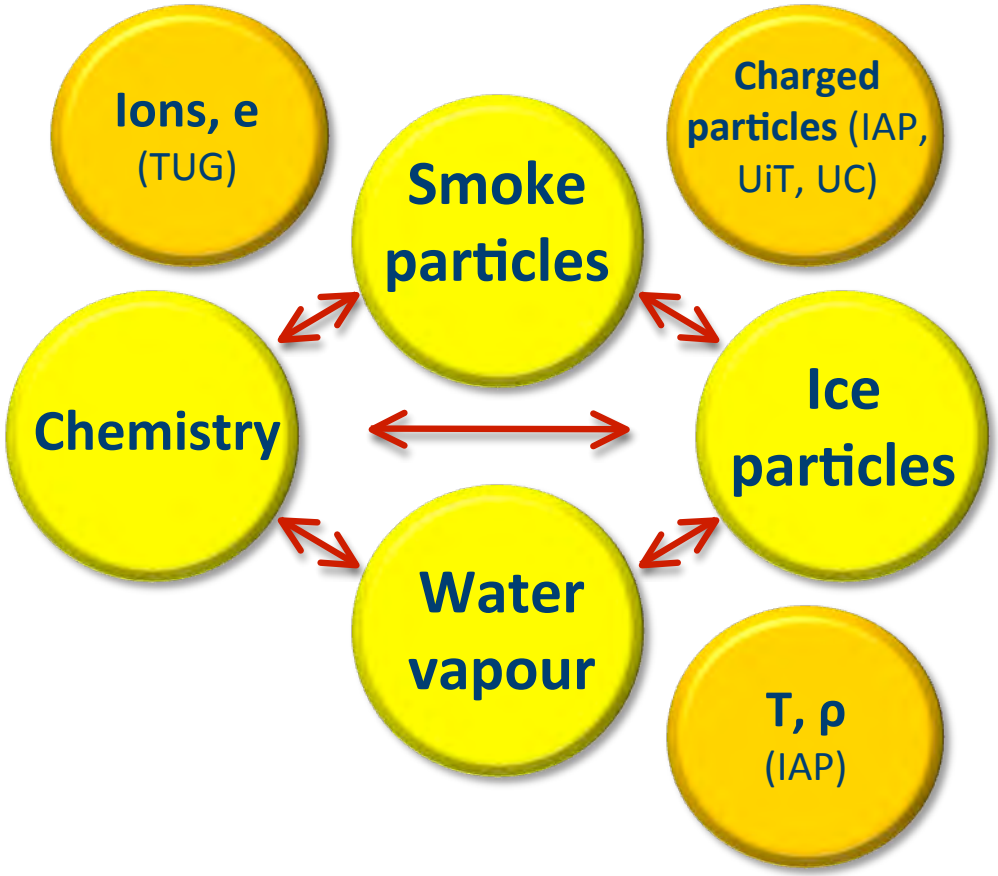

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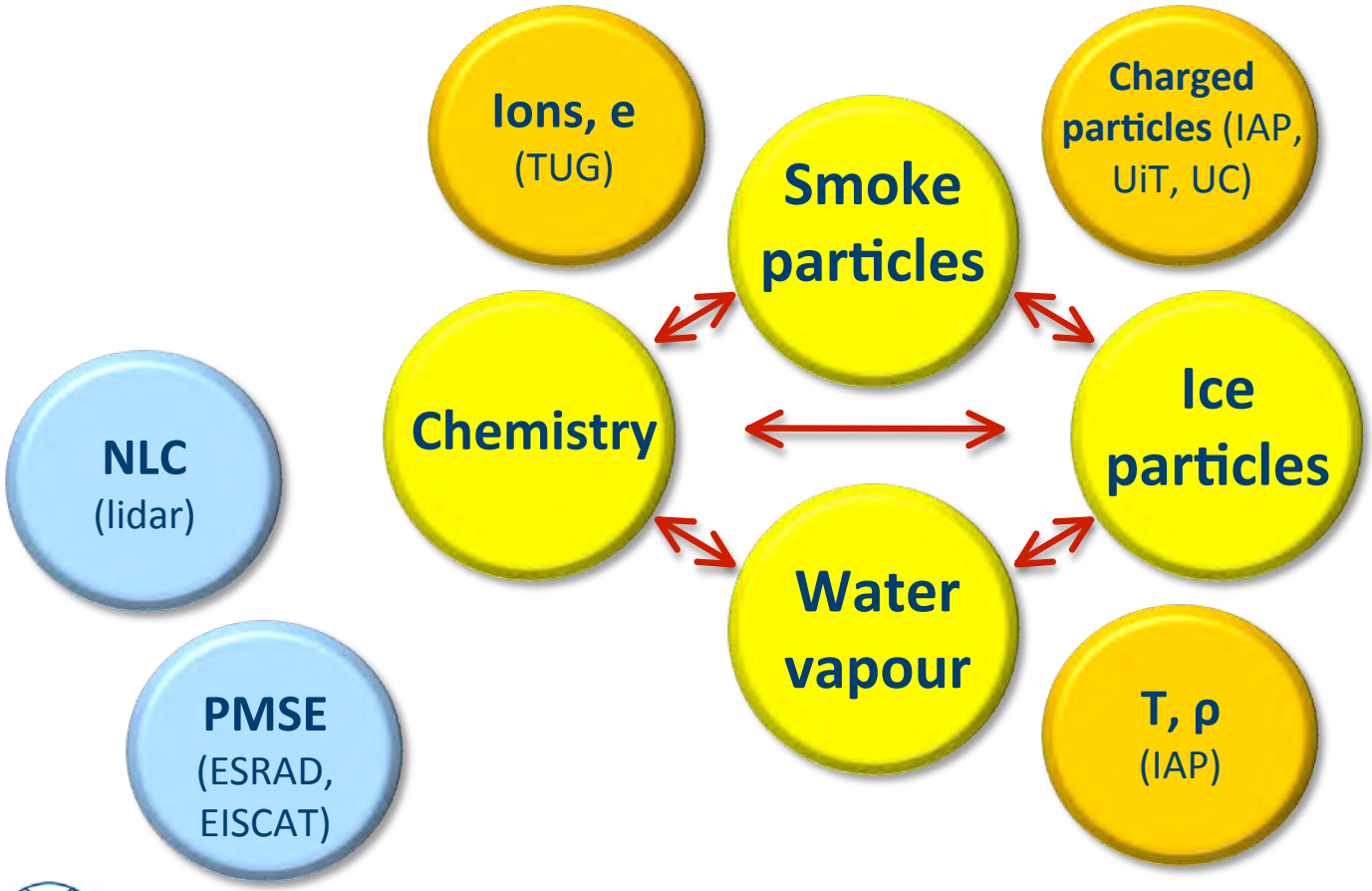

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Instrumentation

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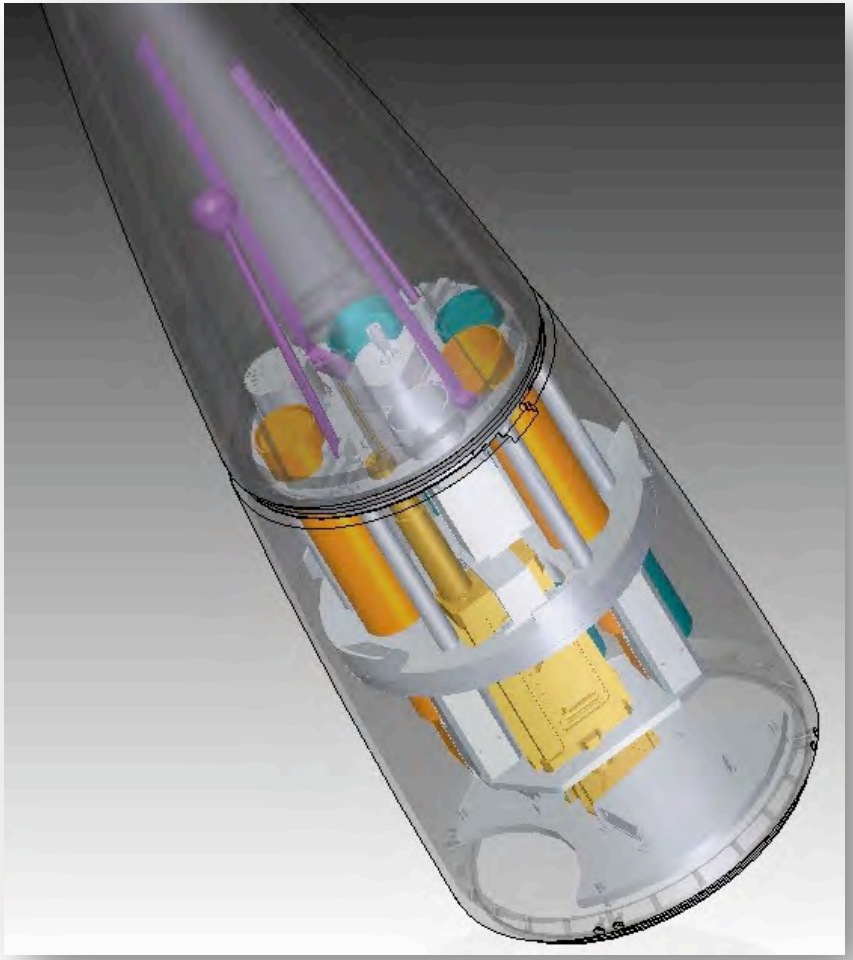

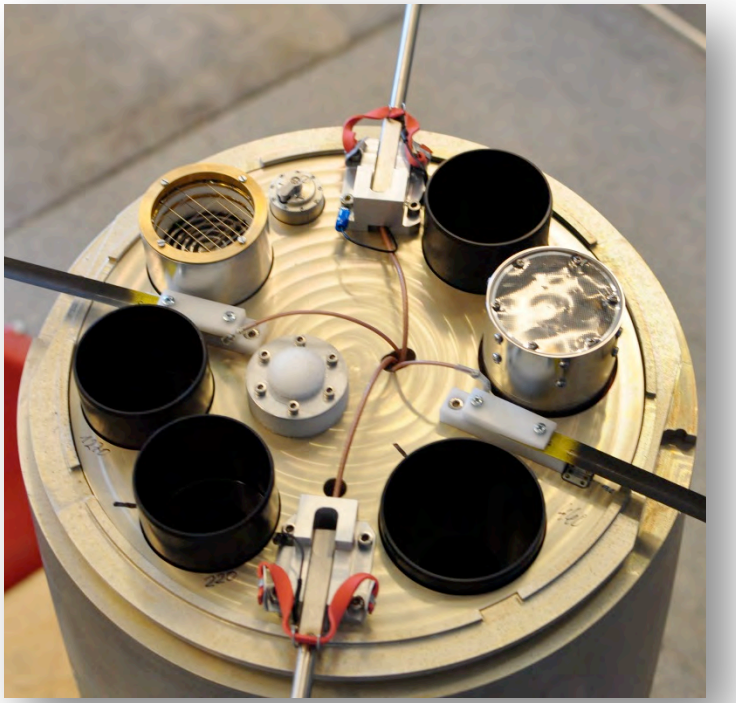

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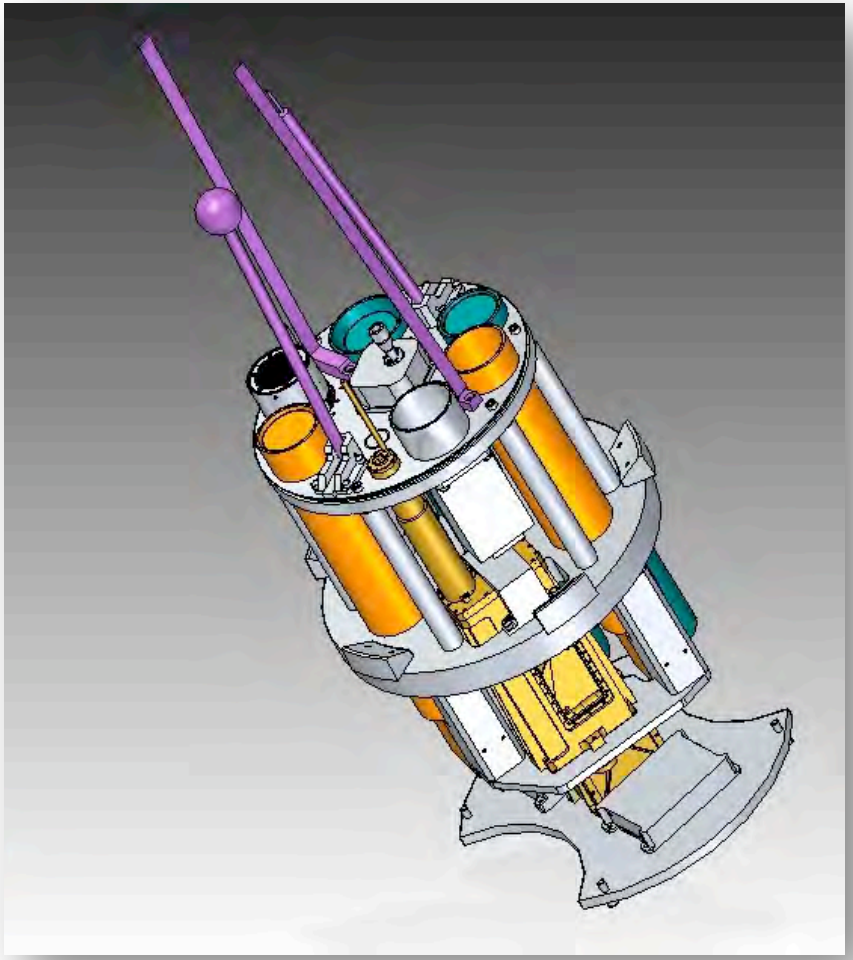

IR photometers

✓O and H related airglow at 1.27/1.99 µm

NLC photometers

✓Light scattering on ice particles at 220/440 nm

Front radiometer

✓Water vapour at 557 GHz

IAP & U. Tromsø detectors

✓Charged ice/smoke particles

MAGIC

✓Particle sampling

Faraday & Probes

✓Ions and electrons

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Instrumentation

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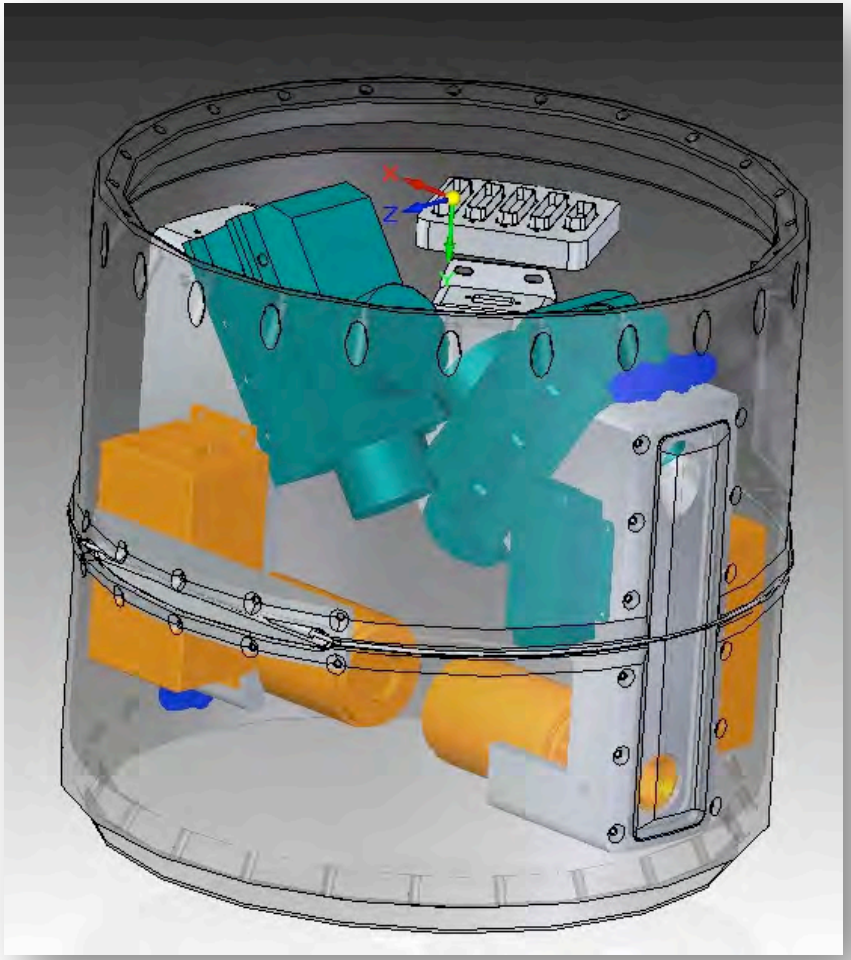
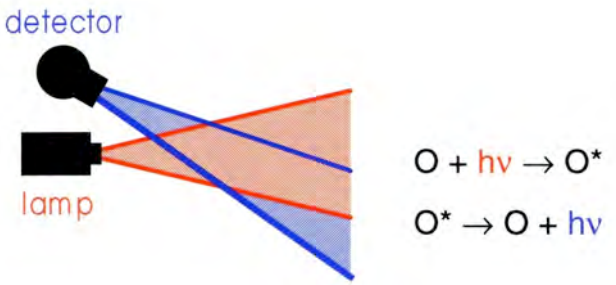


O- and H-probes

✓Resonance fluorescence of atomic hydrogen (121.6 nm) and atomic oxygen (130.6 nm)



✓Light scattering on ice particles at 121.6 nm

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Instrumentation

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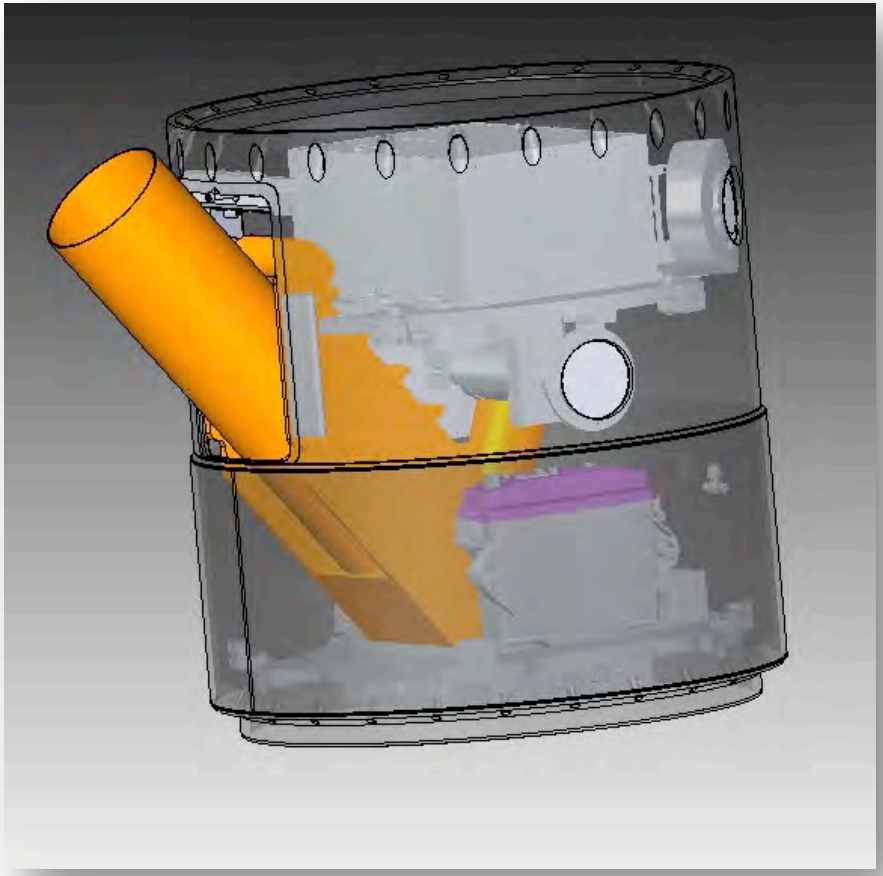

Side photometer

✓Light scattering on ice particles at 220 nm

U. Colorado dust detectors

✓Charged ice/smoke particles

Side radiometer

✓Water vapour at 183 GHz

+ CONE in the rear (IAP)

✓ T and ρ

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Instrumentation

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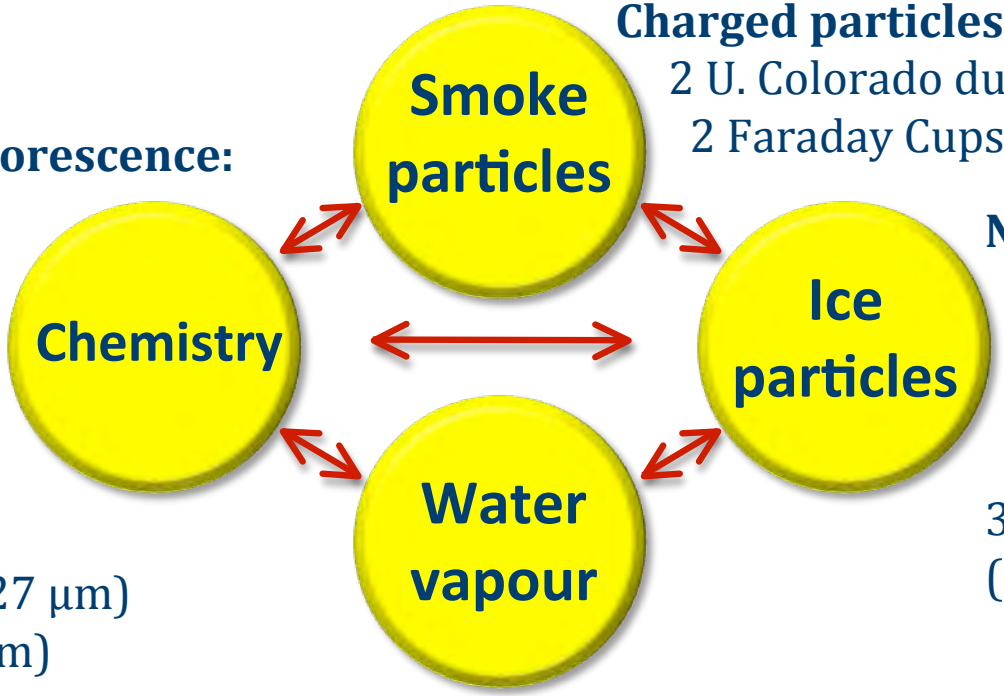
Ions, e, T, ρ:
Faraday rot., e and ion probes (TUG)
CONE (IAP)

Neutral smoke: 1 MAGIC unit
Charged particles:
2 U. Colorado dust detectors and
2 Faraday Cups (IAP & UiT)

UV resonance fluorescence:
- atomic oxygen (130.6 nm)
- atomic hydrogen (121.6 nm)



NLC photometry:
- brightness
- spectral dependence
- angle dependence
- polarisation

3 NLC photometers
(2 front + 1 side)

IR airglow photometry:
- O_2 IR A-band (1.27 µm)
- OH Meinel (~2 µm)

Chalmers microwave experiment:
557 GHz forward channel
183 GHz sideways channel

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Campaign

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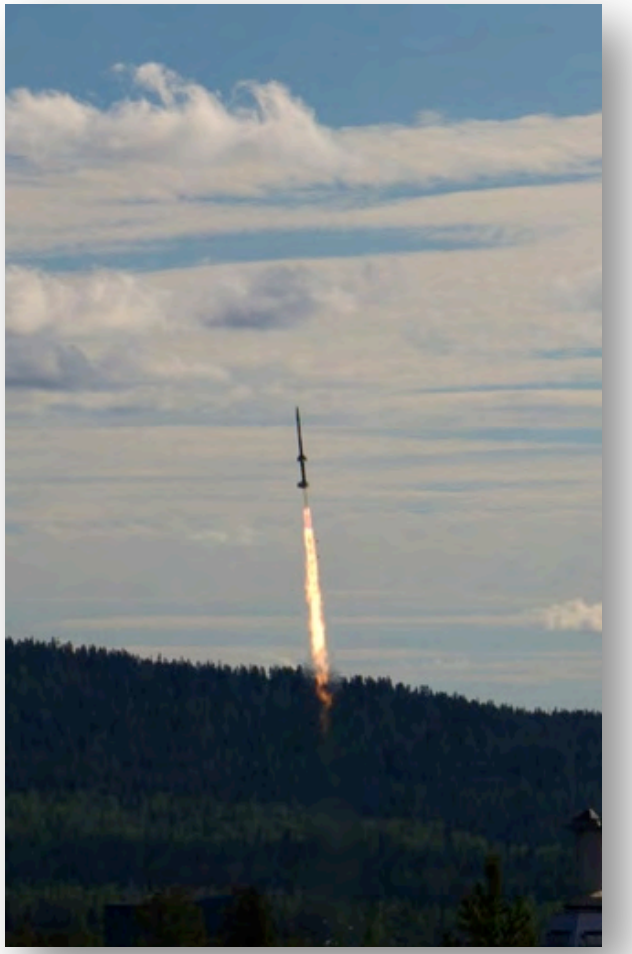

Esrange Space Center

Launch period:

July 6 – Aug. 5, 2011

Launch condition:

Daytime, presence of strong NLC seen by the lidar.

Launched:

July 21, 07:01 UT (09:01 LT)

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Campaign

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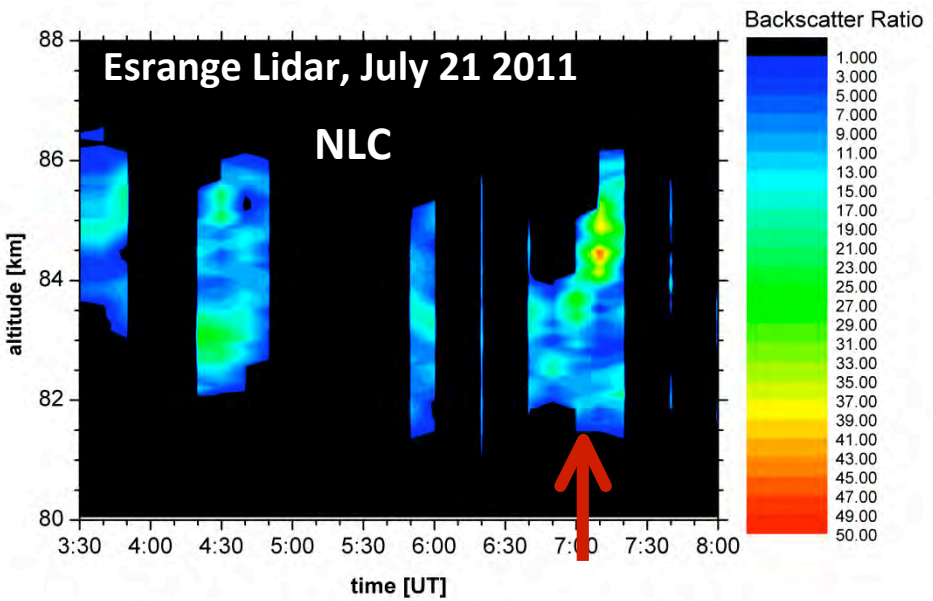
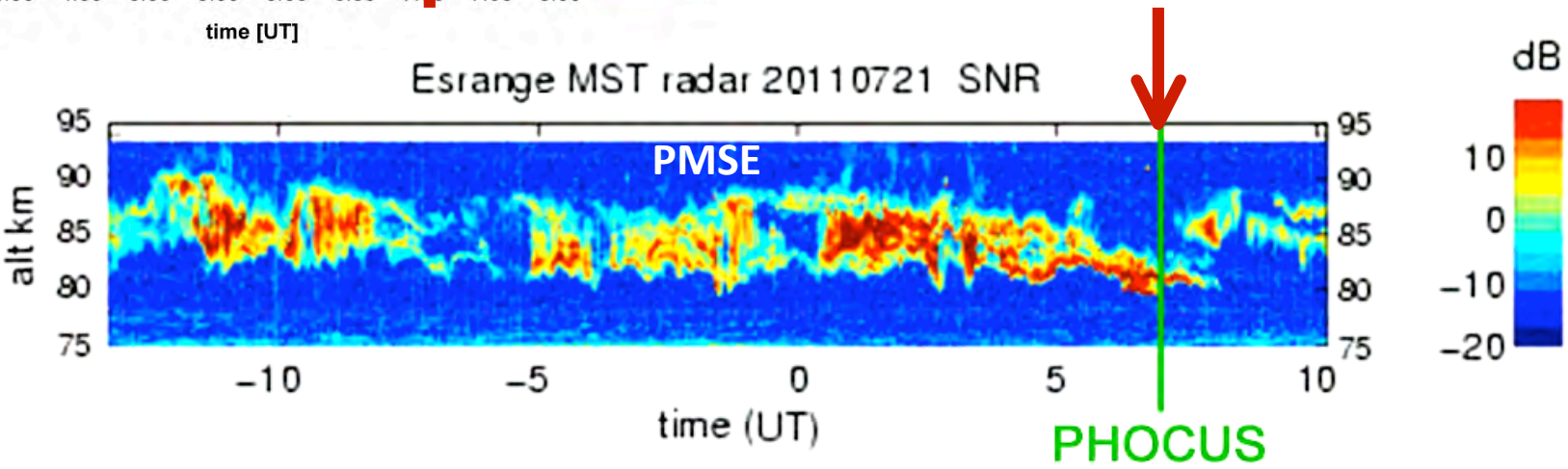


- ✓ We launched into an "aged" mesospheric ice layer near the end of its life cycle.
- ✓ The air between 80 and 90 km had been "well processed" by the ice layer.

Perfect for our sci. objectives



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Results

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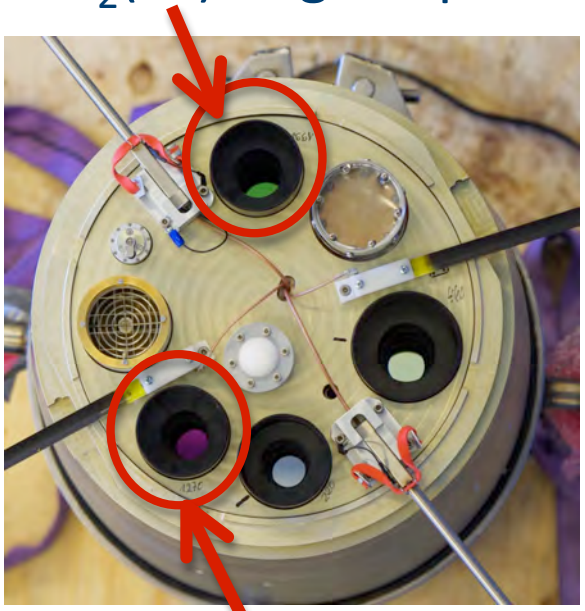
Some highlights…

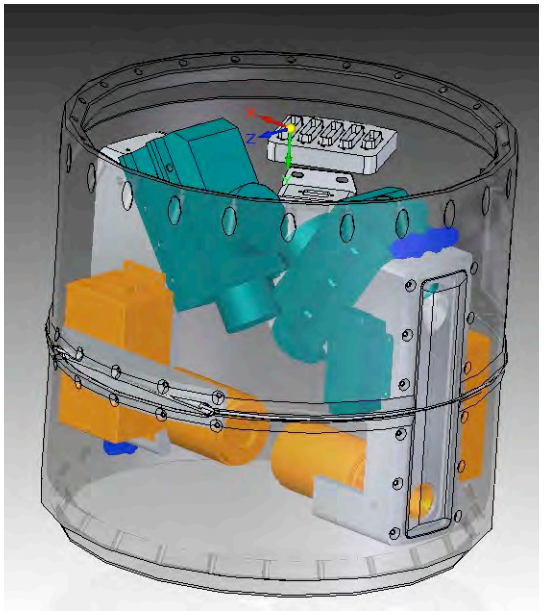
Chemical characterisation of the NLC environment, MISU

$O_2(^1\Delta)$ airglow photometer



OH airglow photometer

Complementary



O and H resonance fluorescence probes

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Results

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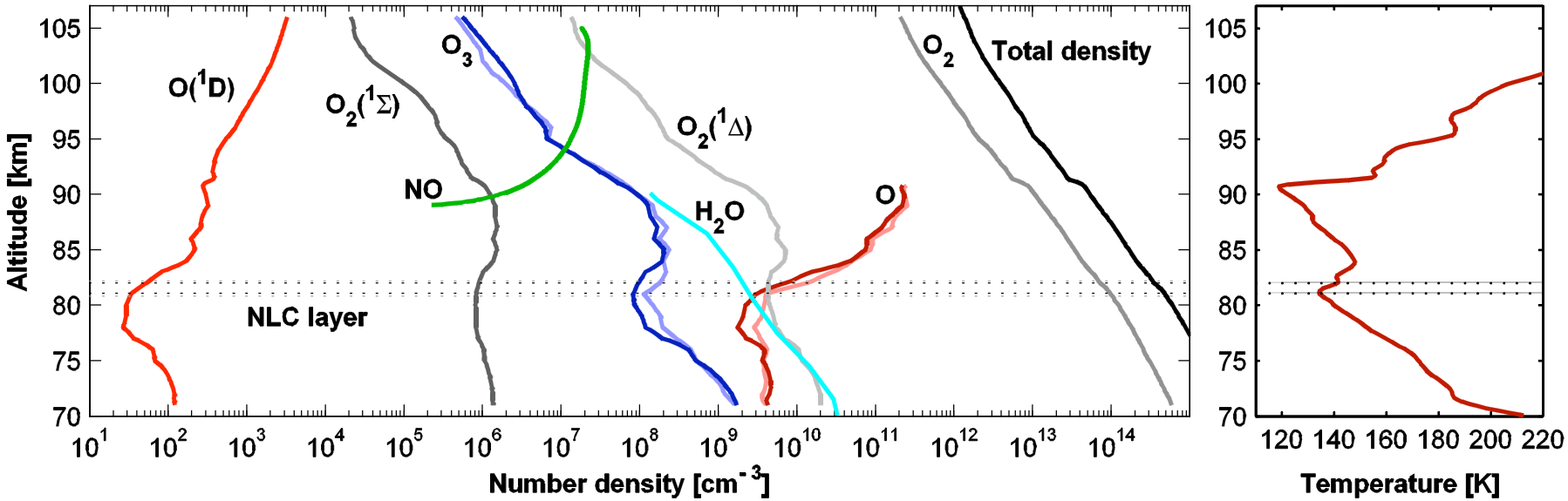
Some highlights…

Chemical characterisation of the NLC environment, MISU

$O_2(^1\Delta)$ airglow photometer

T and ρ from CONE, IAP



NO from NLC photometer, H_2O from radiometer

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Results

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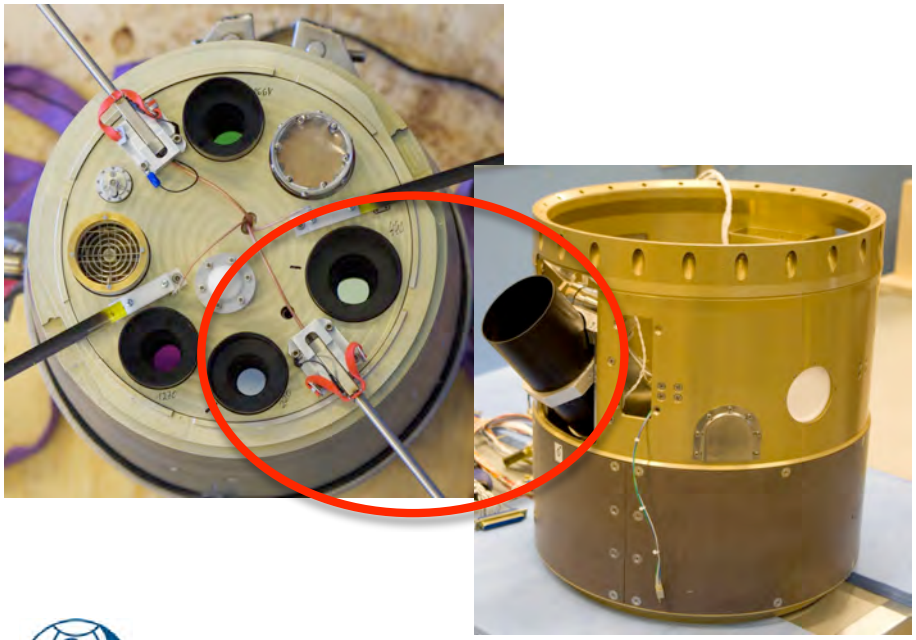
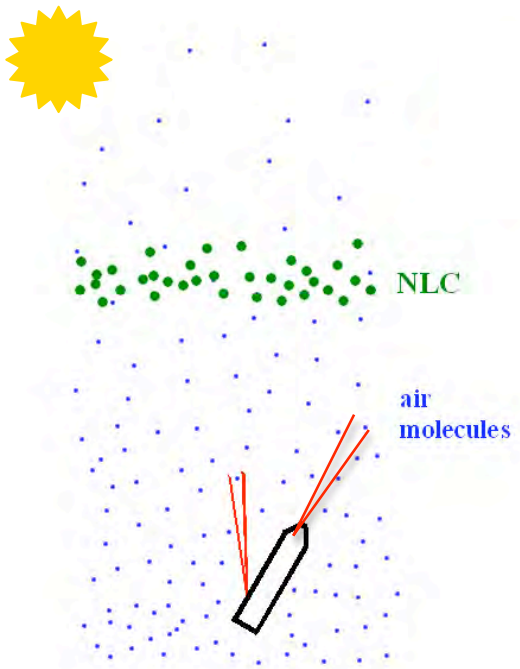
Some highlights…

Simultaneous optical characterisation of NLC particles by spectral analysis, phase function analysis *and* polarisation analysis, MISU





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Results

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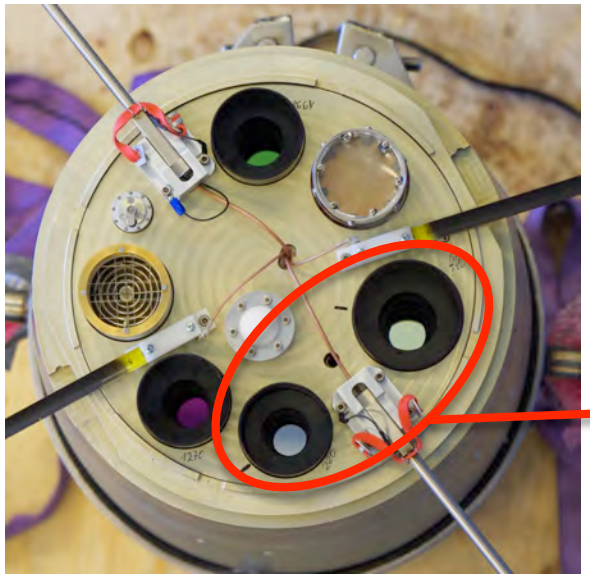

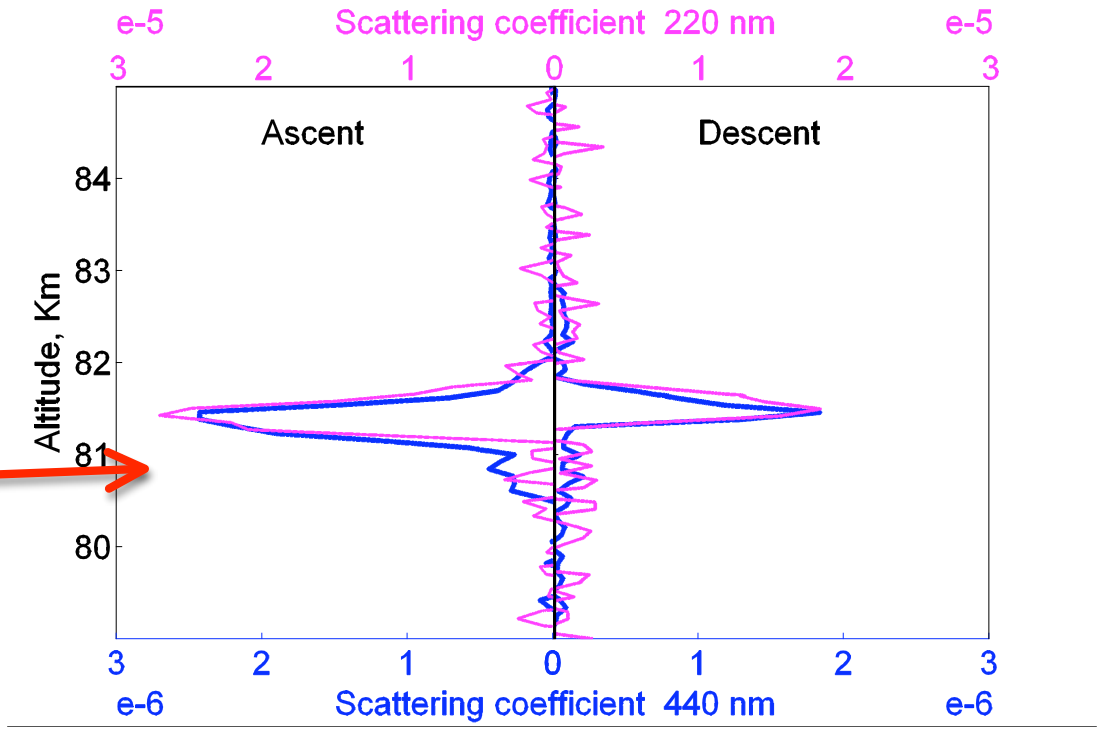

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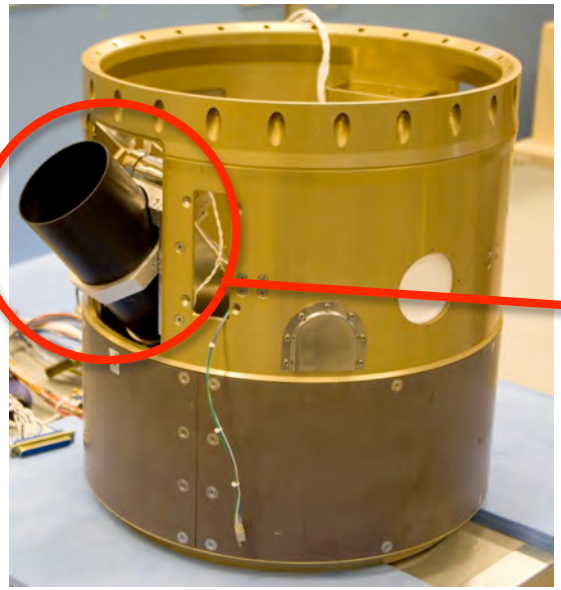

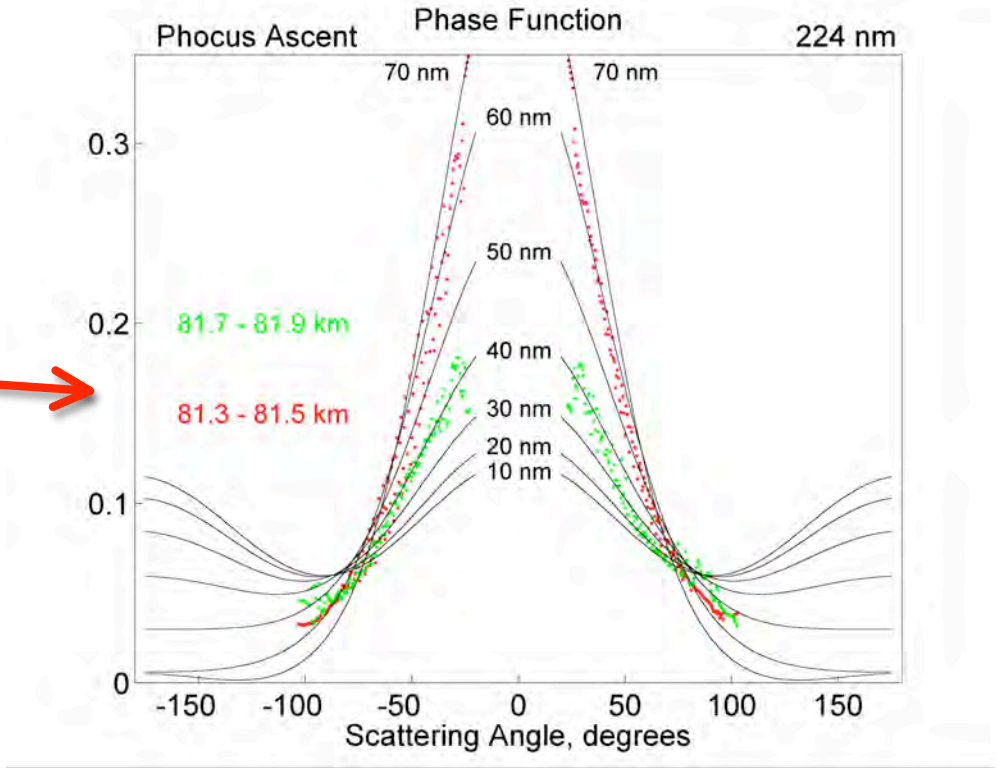

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Results

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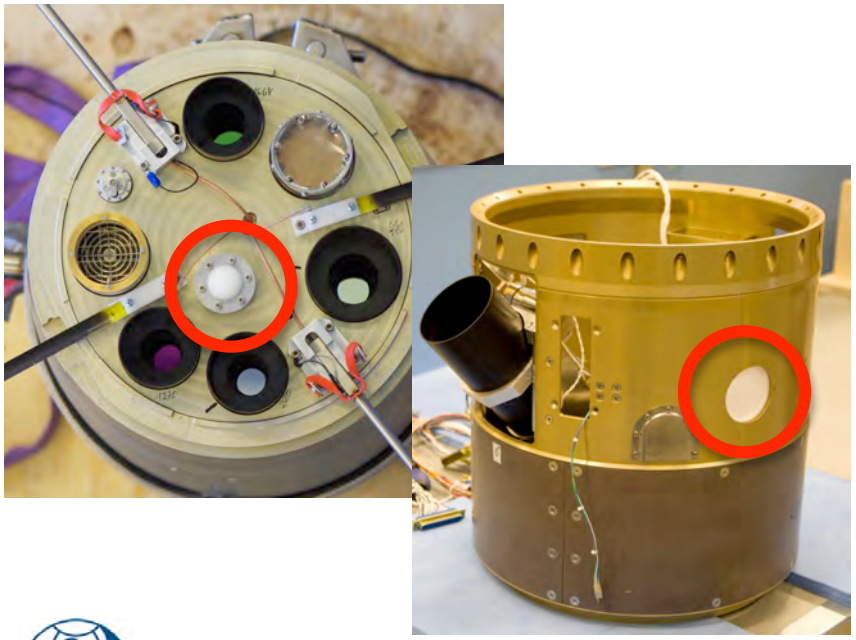
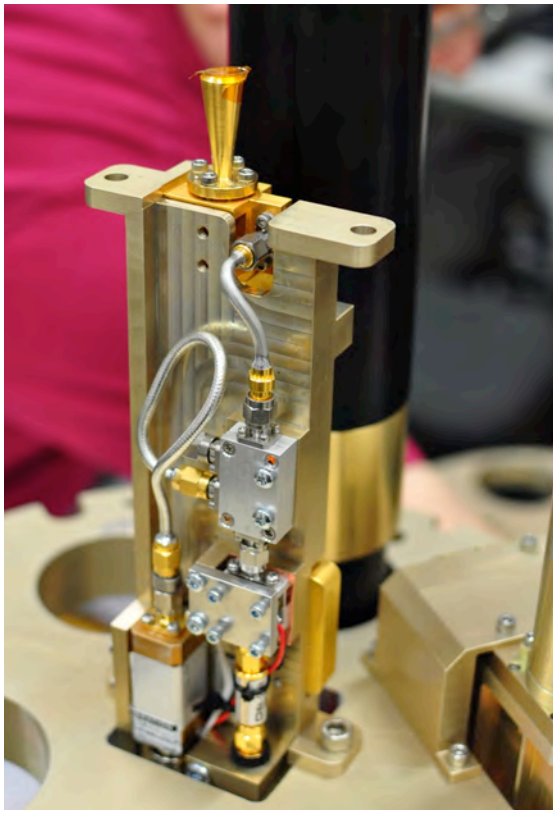
Some highlights…

First rocket-borne measurement of water vapour by microwave radiometry, Chalmers





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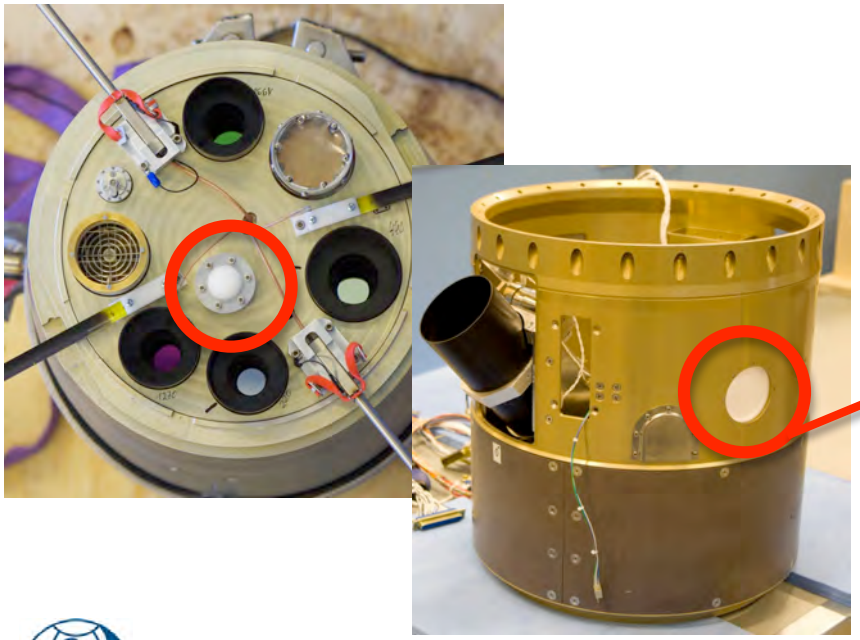

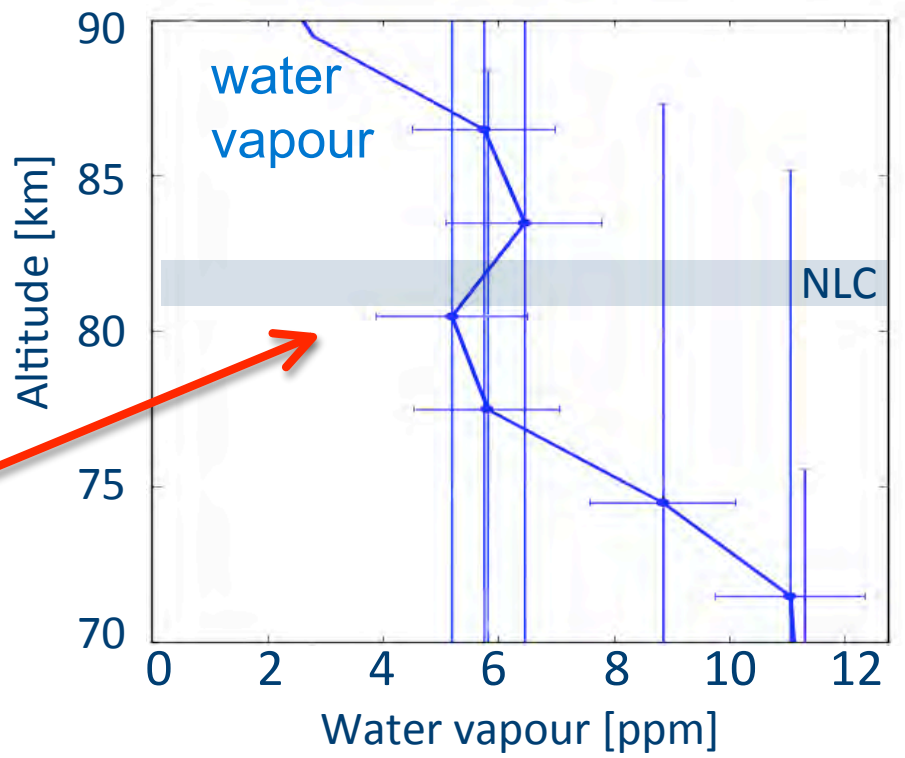

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Results

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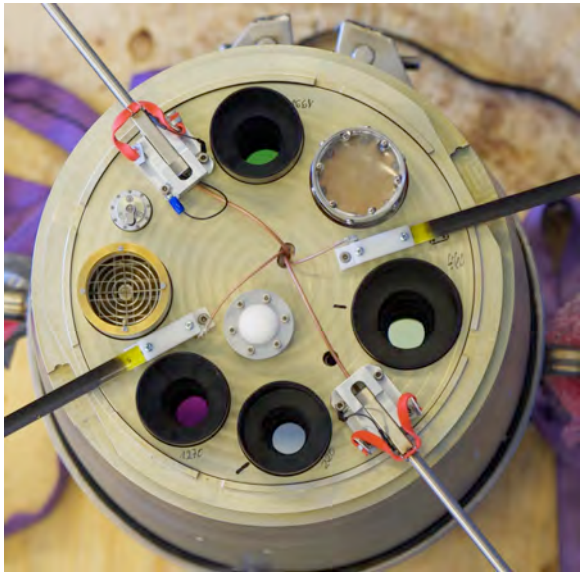
Some highlights…

Multi-instrument analysis of neutral and charged particle layers



Charged particles
3 different impact detectors for charged ice/smoke particles IAP, U. Tromsø and U.Colorado (on the side)

Neutral particles, MISU
NLC photometers (ice, front and side)
(MAGIC particle sampler)

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Results

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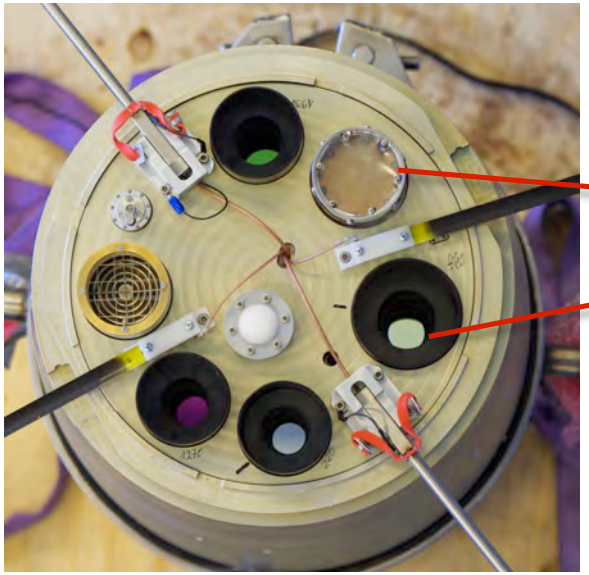
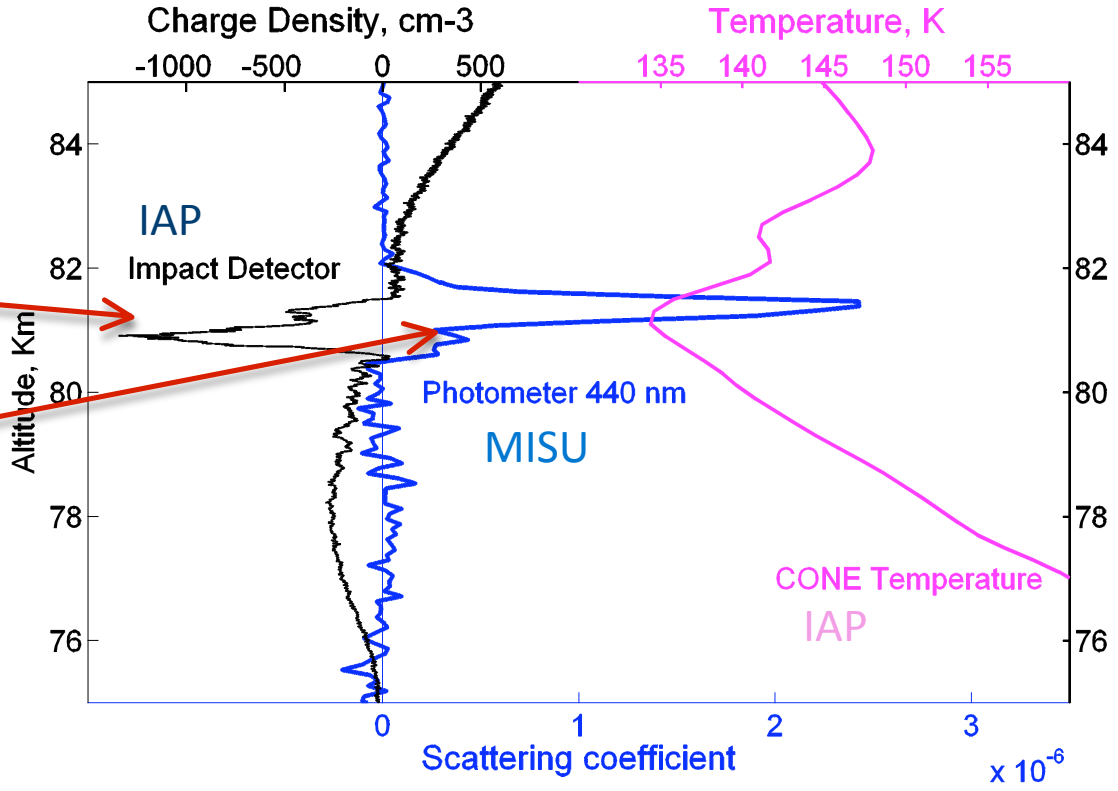
Some highlights…

Multi-instrument analysis of neutral and charged particle layers





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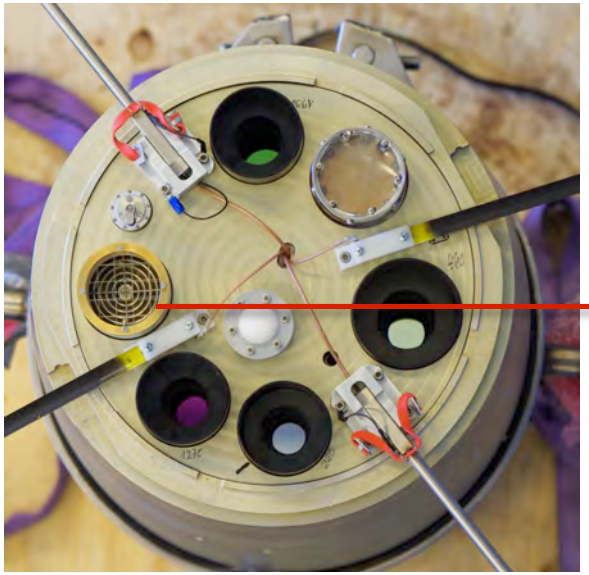

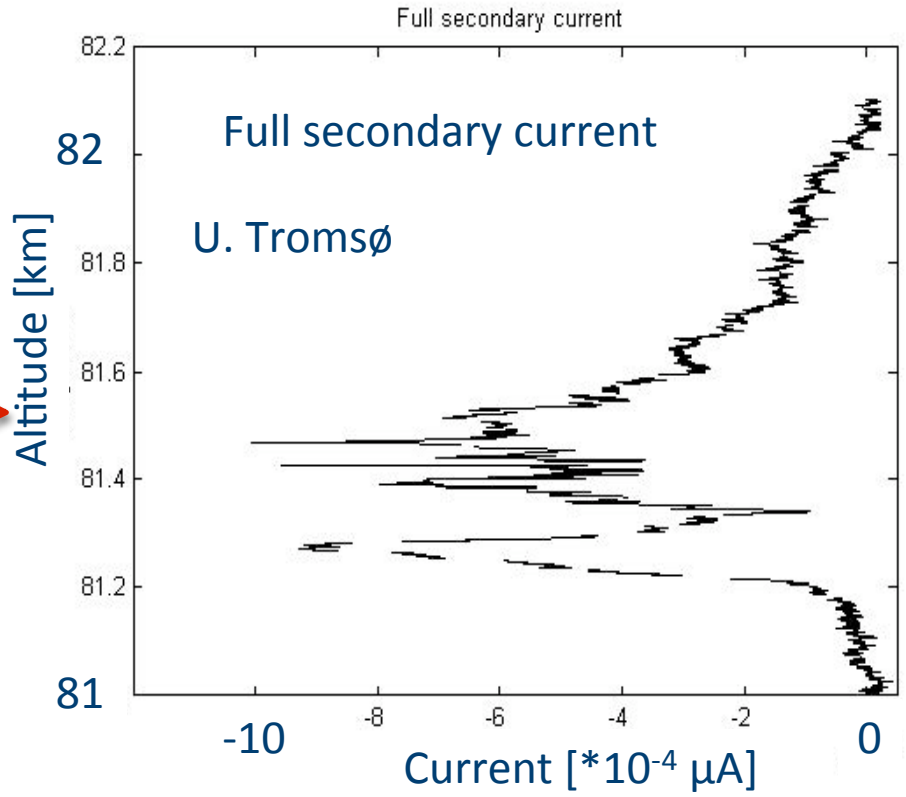

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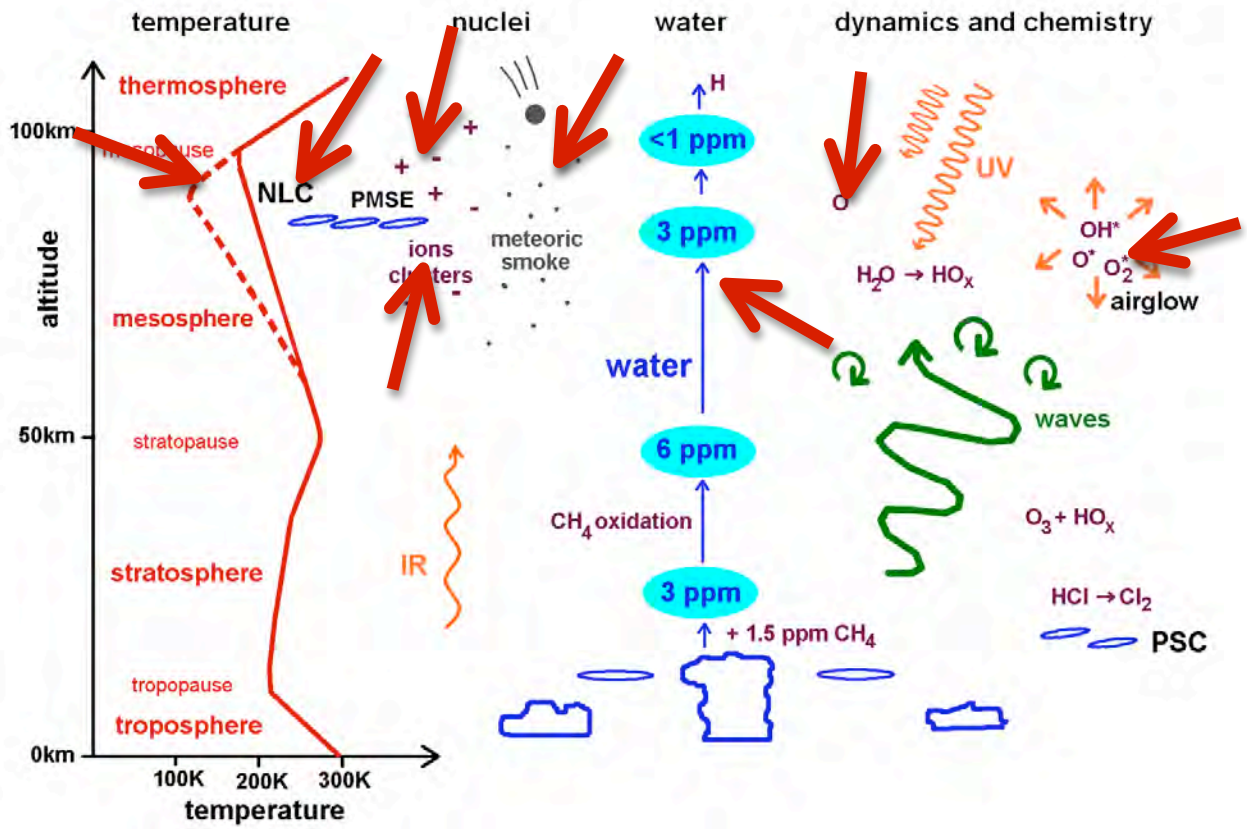
Conclusion



- ✓ Very extensive case study
- ✓ Focused on particles *and* chemistry
- ✓ Valuable dataset

Outlook

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Publish results in Special Issue "Smoke and Ice in the Mesosphere" in Journal of Atmospheric and Solar-Terrestrial Physics

- ✓ Summary of campaign and results (Gumbel et al.)
- ✓ Optical characterisation of noctilucent cloud particles (Khaplanov et al.)
- ✓ Chemical composition from Ox airglow photometry (Hedin et al.)
- ✓ Microwave measurements of water vapour in the vicinity of noctilucent clouds (Murtagh et al.)
- ✓ Charged particle detection and secondary charge production (Havnes et al.)
- ✓ Noctilucent clouds, charged particles and ionospheric conditions (Asmus et al.)
- ✓ Turbulent structures from in-situ and radar measurements (Szewczyk et al.)
- ✓ Direct particle sampling in the mesosphere (Hedin et al.)
- ✓ Smoke capture by ice particles (Gumbel et al.)

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Submission deadline: June 30, 2013.

Outlook

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MaxiDUSTY-1 summer 2014

Norwegian sounding rocket campaign, ice/smoke particle charge state

MISU is invited and will contribute with

- ✓ NLC photometer
- ✓ Particle impact detector

…several different instruments studying charged mesospheric particles

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Thank you

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