Atmospheric Research and Meteoric Dust Detection by the All-Sky Polarization Measurements of the Twilight Sky

Oleg S. Ugolnikov, Igor A. Maslov
Space Research Institute,
Russian Academy of Sciences
ougolnikov@gmail.com
Meteorology is the interdisciplinary scientific study of the atmosphere (Wikipedia)
Meteors altitude measurements

Astronomers amaze physicians: How **HIGH** atmosphere is!

80 – 100 km
Heating layers in the atmosphere
Oxygen

«Vacuum ultraviolet» rays
Oxygen and solar UV
Oxygen and solar UV

Upper heating layer

Wavelength, nm
The diagram illustrates the photochemical reaction of ozone (O₃) and oxygen (O₂) molecules. The reaction is initiated by solar ultraviolet radiation (hv), which breaks the O₂ bond to form an activated oxygen atom (O). This atom then reacts with another O₂ molecule to form O₃. The process is cyclic, with O₃ eventually breaking down back into O₂ and O₂, maintaining the ozone layer.
Oxygen, ozone and solar UV

Upper heating layer
Oxygen, ozone and solar UV

Upper heating layer

Lower heating layer

Wavelength, nm
Noctilucent clouds

Astronomers amaze physicians once more: How **COLD** atmosphere can be!

Summer: $T < 150$ K!

Altitude about 85 km

Pressure 0.000005 atm

Water ice!
Noctilucent clouds

Were NOT observed until 1885!

Krakatoa eruption, 1883

Comet Encke’s orbit evolution
β-Taurids
(comet Encke, late June)

Activity is BELOW sporadic level
The reason of clouds appearance:

- Volcanoes
- Comet Encke orbit evolution

WE ARE
The reason of clouds appearance:

Mesosphere is not just cold. It is GETTING COLDER!
Mesosphere
(or Ignorosphere)

Too low

Too high
Orbital measurements

TIMED / SABER
launched in 2001
CO₂ emission

EOS Aura / MLS
launched in 2004
O₂ emission
Orbital measurements

TIMED / SABER launched in 2001 CO₂ emission

EOS Aura / MLS launched in 2004 O₂ emission

Schwartz et al., JGR, 2008

Temperature difference

20° to 50° lat
MLS minus SABER

50° to 90° lat
MLS minus SABER

70 km
Methods of sounding

- TIMED Spacecraft
- Space Shuttle
- Communications Satellite
- MLTI Atmospheric Region Studied by TIMED Spacecraft
- Sounding Rocket
- Air Glow
- Optical
- Noctilucent Clouds (Polar Mesospheric Clouds)
- Balloons
- Airplane

Ground-based Instrumentation:
Twilight sounding

Experimental separation method using wide-angle polarization analysis

Multiple scattering
Observations

All-sky camera, designed for polarization measurements

540 nm, Polarization filter

Latitude +55°
Temperature measurements

Ugolnikov, Maslov, 2013, 2014
Polarization

- Gas medium
- Scattering angle, $\gamma$
- $p (\gamma = 90^\circ) \sim 1$
- Dust
- $p (\gamma = 90^\circ) < 1$

SUN
Polarization of scattered emission (80 km)

- morning, 26.05.2012
- morning, 10.08.2013

Polarization degree, $\rho$ vs. Scattering angle, $\gamma$
Polarization of scattered emission (80 km)

- morning, 26.05.2012
- morning, 10.08.2013
Temporal profile - summer

Polarization characteristics, $q = p(t)/p_r(t)$

Day of year:
- May
- June
- July
- August

Pure Gas

Molecular scattering

PERSEIDS
Temporal profile - August

Polarization characteristics, $q = p(t)/p_R(t)$

Perseids 2013 Meteor Activity Index
(Television observations from nearby location, Kartashova et al., 2014)

Tiny Perseids $m \sim 10^{-4}$ g
(Belkovich, Ishmukhametova, 2006)

Perseids 2013
(International Meteor Organization)

Date (August, 0$^{\text{th}}$ UT)

Evening Morning
- 2012
- 2013

Solar Longitude (2013), °

130 135 140 145 150
Twilight sounding

Altitude: 81-83 km
Noctilucent clouds

Altitude: 81-83 km
Thank You!

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