Measuring mesopause temperature perturbations caused by infrasonic waves – An innovative sensor approach

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The OH* airglow phenomenon

\[ \text{O}_3 + \text{H} \rightarrow \text{O}_2 + \text{OH}^* \]

\[ \text{OH}^* \rightarrow \text{OH} + h\nu \]

Generated by a nocturnal chemical reaction in the OH*-layer at 87 km (mesopause) altitude.

\[ \rightarrow \text{IR-radiation (} h\nu \text{) is a measure for the kinetic temperature of this altitude} \]

[false colour image taken by s/c clementine, U.S. Naval Research Laboratory]
The GRIPS instrument

**Ground-based infrared P-branch spectrometer**
– presently 50 measurement sites coordinated by DLR

CTBT S&T 2011 Poster T1-P45. E. Blanc et al.: The ARISE project
Synergy between infrasound, lidar and airglow layer observation networks for atmospheric studies

http://wdc.dlr.de/ndmc
Operational temperature measurements in 87 km height

GRIPS 6 nightly mean OH(3-1) rotational temperatures

nightly mean OH temperatures (version 1.0)
MSIS00 midnight temperatures for 87 km height
measurement duration
2h limit for calculation of nightly mean values
equinoxes and solstices

NDMC station:
Oberpfaffenhofen (OPN), Germany
48.09°N, 11.28°E

http://wdc.dlr.de
http://wdc.dlr.de/ndmc
Typical nocturnal GRIPS time series

Atmospheric tides

Atmospheric gravity waves

→ Typical wave structures on different time scales in temperature and airglow intensity
Long period infrasonic GRIPS signatures

doninant period: 190 s

GRIPS 6 - February 23th, 2010

GRIPS 6 - August 30th, 2009

GRIPS 6 - December 4th, 2009

doninant period: 270 s

doninant period: 300 s
Infrasound in mesopause temperatures: developed within the GI-TEWS\textsuperscript{1} project

Mesopause airglow layer (in ~87 km altitude)

Infrasound
(Pressure perturbation)
Temperature fluctuation

Infrared light
(Airglow intensity)

GRIPS (Ground-based Infrared P-branch Spetrometer)
Instrument

Infrasonic source

Infrasonic signal

\( \Delta t \approx 5-10 \text{ min.} \)

\textsuperscript{1}German Indonesian Tsunami Early Warning System, see Bittner et al. (NHESS, 2010)
Impact of strong infrasound on mesopause airglow

100 Pa source signal, 0.01 Hz (100 s) attenuation

Altitude [km]

Distance from infrasound source on ground [km]
Propagation duration of infrasound to the OH* layer

OH*-Layer

Range (West -> East), km

Height, km

t = 02 min 30 sec

Height, km

Range (West -> East), km

t = 05 min 00 sec

Height, km

Range (West -> East), km

t = 10 min 00 sec

Height, km

Range (West -> East), km

t = 15 min 00 sec
Each source of infrasound has its own fingerprint

Observation of Tsunamis due to earthquakes

Infrasound due to major explosions
→ Monitoring of the Comprehensive Nuclear-Test-Ban Treaty (CTBT)

Observation of Aurora due to e.g. magnetic storms

Observation of volcanic activity

Infrasound due to storms
→ component for a better prediction of storm tracks
Summary

- We perform airglow observations in 87 km altitude using ground-based infrared spectrometers (e.g. GRIPS) in the context of NDMC.

- We detect dynamics on different time scales (seasonal, diurnal, hourly, and down to seconds) associated to e.g. planetary wave, atmospheric tide, gravity wave and infrasound activity.

- These efforts are accompanied by infrasound propagation modeling and source identification and discrimination issues.

- This work supports the understanding of atmospheric dynamics at different time scales and in different altitudes of the atmosphere.

... and thereby supports the detection and verification of infrasonic signatures relevant to the infrasound community and the CTBTO.

THANK YOU FOR YOUR ATTENTION!