Contributions to the “DEEPWAVE” Mission - Mesospheric Gravity Waves and Temperature Mapping

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What?
How?
Why?
Airglow from the International Space Station

NASA: Airglow and Aurora Australis, 09/18/2011
Gravity Waves Imaged in the NIR OH Airglow emission (~87 km)

Bear Lake Observatory, UT (41.6 °N, 111.6 °W), June 4-5, 2002
OH emission, altitude ~87 km
Atmospheric Gravity Wave Coupling

- Generated mainly by weather disturbances in the troposphere
- Amplitudes grow as energy propagates upwards through the middle atmosphere
- Short-period waves (<1 hour) break at high altitudes depositing large amounts of energy and momentum globally.
- Profound influence on the regional, seasonal and global mesospheric dynamics.

Hines, 1960

Courtesy J. Alexander
Advanced Mesospheric Temperature Mapper

- New High-resolution mesospheric gravity wave intensity and temperature mapping capability.
- IR imager (~1.55μm) OH (3,1) band at ~87 km.
- Large format (120° FOV) fast (f/1) telecentric optics. Precision ~1 K in <30 sec.
- New GV AMTM (80° x 60°) or 120 km x 80 km FOV. Operates at very high 4 sec cadence, 12 sec for temperature map, precision 1-2 K.

ALOMAR (69.3° N, 16.0° E) South Pole (90°S)

Data since 2011 (3 winters each site)

PFRR Aurora + Airglow

Temperature: ratio of P_1(2) and P_1(4) lines
DEEPWAVE Test Flights - Broomfield CO, 2013
Summary AMTM Movie
RF-01 (6/7 June) South Island
Summary AMTM Movie
RF-01 (6/7 June) South Island
Summary AMTM Temperature Movie
RF-01 South Island (range 195-225K)
Summary “Wing Camera” Movie
RF-02 Tasmania Over-flight
RF-05 South Island (14/15 June)
OH Wave Activity and AIRS Structures

OH Waves (~87 km)

AIRS Waves (~40 km altitude)
Lauder AMTM Movie 30-31 May (13 hrs)
Lauder Movie During RF-06 (Tasmania)
Mountain Waves and Chaos!
RF-07 (19/20 June) Steve Smith,
Example of Lauder OH Data
Summary (to date)

- T-Mapper instrument suite working well. Enables detailed measurements of the characteristics and dynamics of GW from the GV (lateral spatial coverage ~1000 km).
- Airborne mesospheric GW measurements starting to show correlations with the stratospheric AIRS wave maps.
- Possible evidence for more wave activity over land than over Oceans?
- Coordinated measurements at Lauder indicate Mountain Wave activity on at least 5 nights so far (May 30th to date). not during strong forcing?
- Overall: Wave data are very, very interesting but not yet exceptional in amplitude or spatial/temporal characteristics..waiting for stronger forcing conditions!
OH $P_{12} (3,1)$ line

OH $(3,1)$ rotational temperature

$\lambda_z = 30$ km
$V \sim 44$ m/s
$T = 11.4$ min
Direction $= 114^\circ$
OH (3,1) Temperature Keogram - Feb22-23

1st loop  6 hr duration  2nd loop

No aircraft data
Imaging Mesospheric Emissions

Airglow Layer

Space Shuttle

Airglow Emission Chemistry

\[ H + O_3 \rightarrow OH^* (v'\leq9) + O_2 \]
(Bates and Nicolet, 1950)

\[ OH^* (v') \rightarrow OH^* (v'') + h\nu \]
Vis-NIR light (0.4 - 4 \mu m)

\[ OH + O \rightarrow H + O_2 \]
\[ O + O_2 + M \rightarrow O_3 + M \]

Airglow Spectrum (Broadfoot and Kendal, 1968)