

宇宙ステーションからの撮像画像を用いた
中間圏大気光メソスケール波状構造の研究

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- メソスケール 数100 - 数1000 km
- 中間圏は地上イメージャーでは小さなスケールまでしかみれない。
(~ 100 km)
- 過去の衛星観測では平均化された大きな構造が注目されている。潮汐のスケール。WINDIIなど。
- メソスケールの中間圏での波動は、地上観測の観測量の時間変化で見られているが、2次元的な構造は不明。
- 2次元的な構造がわかると波の生成機構などの議論が進められる。

The diagram illustrates a logarithmic scale of spatial scales. The top horizontal axis is labeled 'Global' and has tick marks at 10000, 1000, 100, 10, and 1km. Below this, two white double-headed arrows indicate the ranges of different observation methods: '衛星観測' (Satellite Observation) covers the range from 10000 to 100 km, and '地上イメージャー' (Ground-based Imager) covers the range from 100 to 1 km. A yellow double-headed arrow is positioned below the ground-based imager range, spanning from approximately 1000 km to 100 km, representing the mesoscale.

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- 全球
- 10000 1000 100 10 1km
- 衛星観測
- 地上イメージャー

A-IMAP mission

- Astronaut - Ionosphere, Mesosphere, upper Atmosphere, and Plasmasphere mapping mission
- ISSの窓から高感度デジタルカメラNikon D3sで大気光をリム方向に撮影。
- 2014年で 1/30、3/4、3/29、5/28、7/3、7/25、8/26、10/24の8回の観測を実施済み。

- カメラの感度

大気光
スペクトル

Counts VS. Wave Length (Exposure Time 4.0 sec ISO 12800*8)

RAYLEIGH/ANGSTROM

Broadfoot and Bellaire 1999

The figure consists of two vertically stacked plots. The top plot, titled 'Counts VS. Wave Length (Exposure Time 4.0 sec ISO 12800*8)', shows 'Total Counts' on the y-axis (0 to 6x10^5) versus 'Wave Length (nm)' on the x-axis (400 to 700). It features three curves: a blue curve peaking at ~2.2x10^5 at 480nm, a green curve peaking at ~4.2x10^5 at 550nm, and a red curve peaking at ~4.5x10^5 at 600nm. The bottom plot, titled 'RAYLEIGH/ANGSTROM', shows the 'Atmospheric Light Spectrum' on the y-axis (0 to 250) versus wavelength on the x-axis (5200 to 7200 nm). It displays a continuous spectrum with several labeled emission lines: [NII] (5220), [OII] (5277), HeI (5896), [OII] (6300), [OI] (6364), and [OII] (6354). The spectrum is recorded under 'O2 ATMOSPHERIC' conditions.

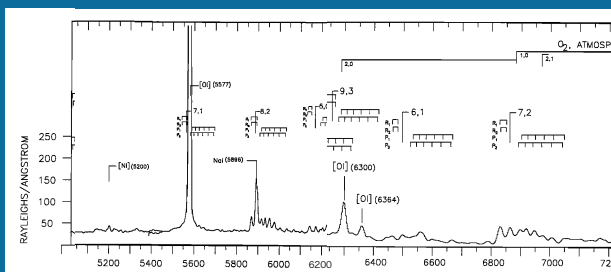
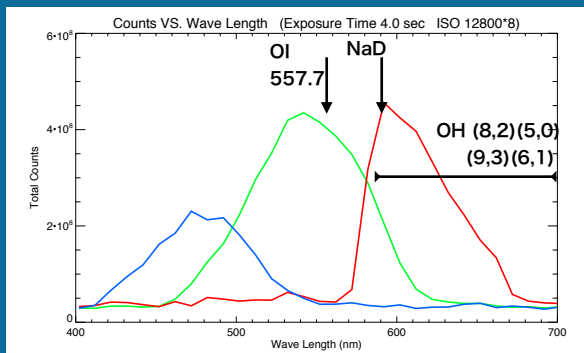
Counts VS. Wave Length (Exposure Time 4.0 sec ISO 12800*8)

Wave Length (nm)	Blue Curve (Total Counts)	Green Curve (Total Counts)	Red Curve (Total Counts)
400	~0.2 × 10 ⁶	~0.2 × 10 ⁶	~0.2 × 10 ⁶
450	~1.2 × 10 ⁶	~0.2 × 10 ⁶	~0.2 × 10 ⁶
480	~2.2 × 10 ⁶	~0.5 × 10 ⁶	~0.2 × 10 ⁶
500	~1.8 × 10 ⁶	~1.5 × 10 ⁶	~0.2 × 10 ⁶
550	~0.5 × 10 ⁶	~4.3 × 10 ⁶	~0.2 × 10 ⁶
580	~0.2 × 10 ⁶	~3.0 × 10 ⁶	~4.5 × 10 ⁶
600	~0.2 × 10 ⁶	~1.5 × 10 ⁶	~4.0 × 10 ⁶
650	~0.2 × 10 ⁶	~0.2 × 10 ⁶	~2.0 × 10 ⁶
700	~0.2 × 10 ⁶	~0.2 × 10 ⁶	~0.2 × 10 ⁶

Broadfoot and Bellaire 1999

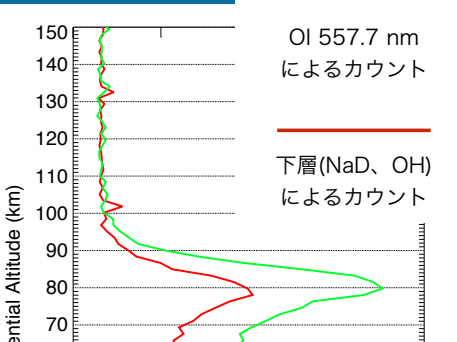
[illegible]

Broadfoot and Bellaire 1999



過去の観測による
大気光高度
OI ~96 km
NaD ~89km
OH ~89km

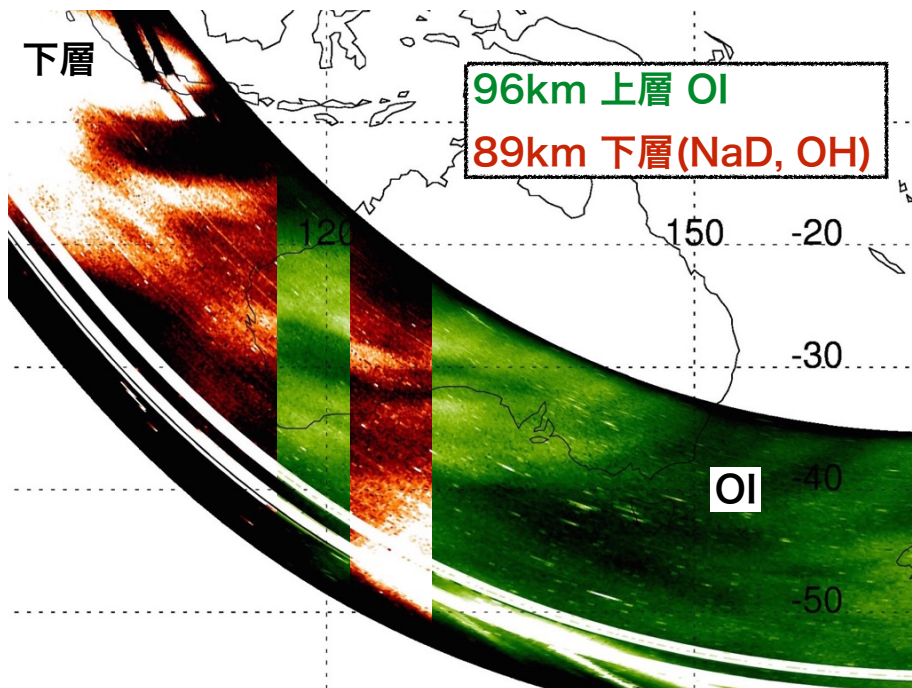
Shepherd et al.,2012
DM Packer 1958 など



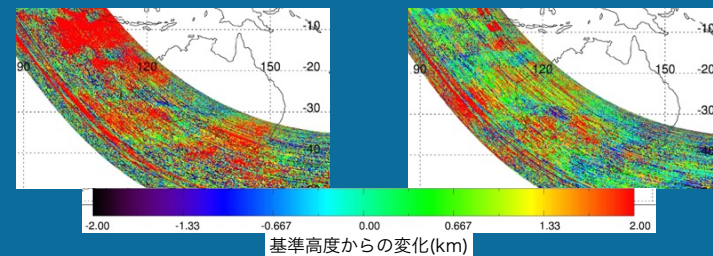
A photograph of Earth from space, showing the horizon and city lights at night. The image captures the curvature of the planet with a bright orange glow along the horizon line, likely from the setting or rising sun. Below the horizon, the dark surface of the Earth is covered with numerous small, bright white lights representing cities and urban areas. The background is a deep black space filled with stars. A small portion of a satellite or spacecraft structure is visible on the left edge.

Figure 1 is a map of the Pacific Ocean showing the distribution of peak counts for the 2010-2011 season. The map covers the area from 39500 to 46500 on the x-axis and 30 to -60 on the y-axis. A color scale at the bottom indicates peak counts from 39500 (dark green) to 46500 (light green). A blue dashed box highlights a region of high peak counts in the central Pacific.

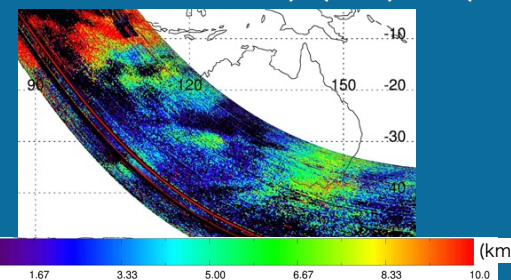
Figure 1 is a map of the Pacific Ocean region, specifically focusing on the area around Southeast Asia and the central Pacific. The map displays a color-coded distribution of peak counts, with a color scale at the bottom labeled "[Peak Count]". The scale ranges from 38500 (dark brown) to 40500 (light orange). A blue rectangular box highlights a specific area of interest in the central Pacific, roughly between 10°N and 20°N latitude and 150°E and 180° longitude. The map includes latitude and longitude markings, with latitude ranging from 30°N to 50°S and longitude from 120°E to 180°.



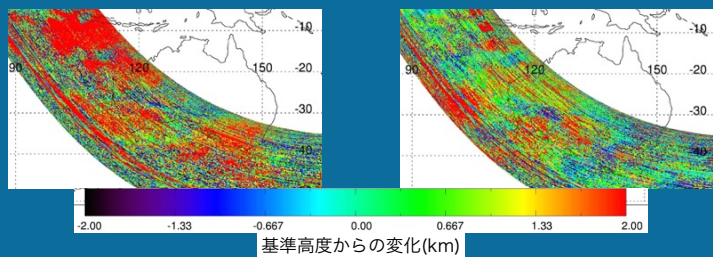
O発光層ピークの変化 下層発光層ピークの変化



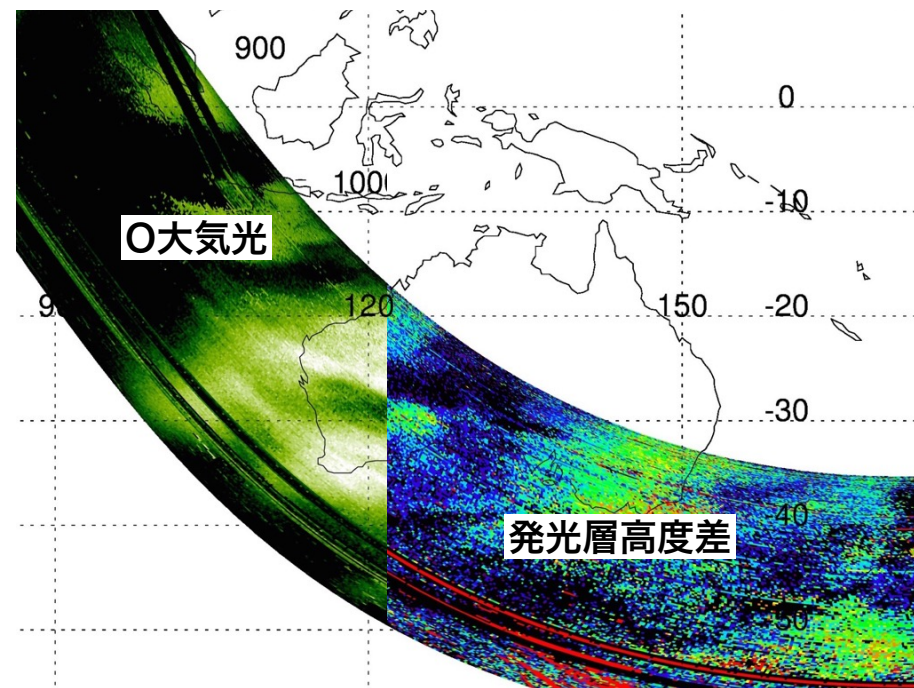
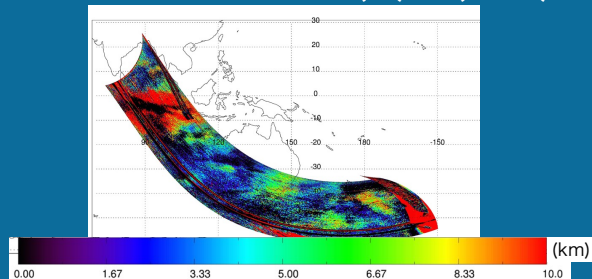
発光層の高度差 H(O)-H(下層)



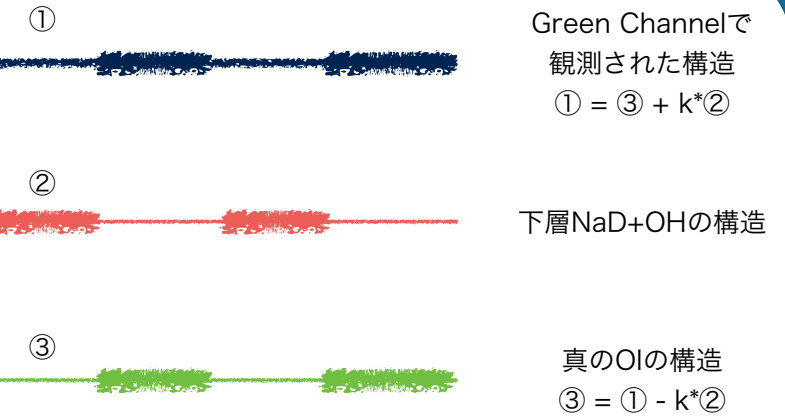
O発光層ピークの変化 下層発光層ピークの変化



発光層の高度差 H(O)-H(下層)



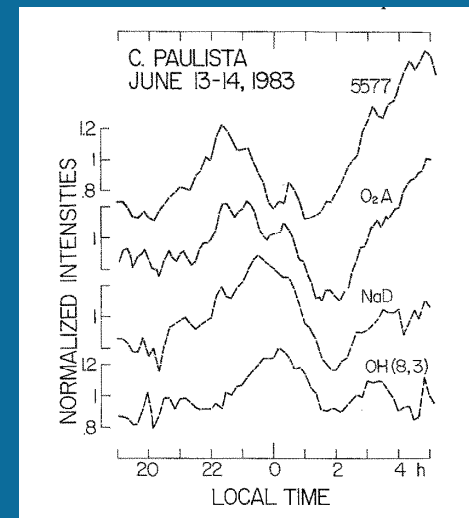
下層発光のGreen Channelへの寄与



議論

どのような現象を考えれば
観測を説明できるか？

発光層高度差の1/2の鉛直波長を持つ波動

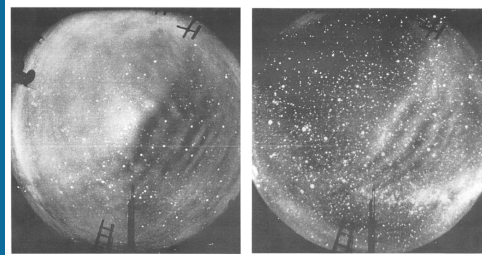


Takahashi et al., 1995

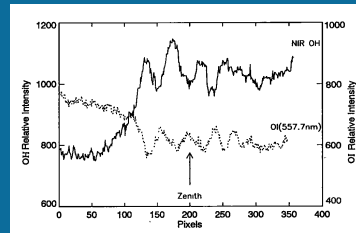
Mesospheric Bores

O558nm
上層

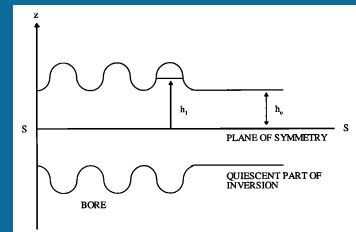
OH
下層



Taylor et al., 1995



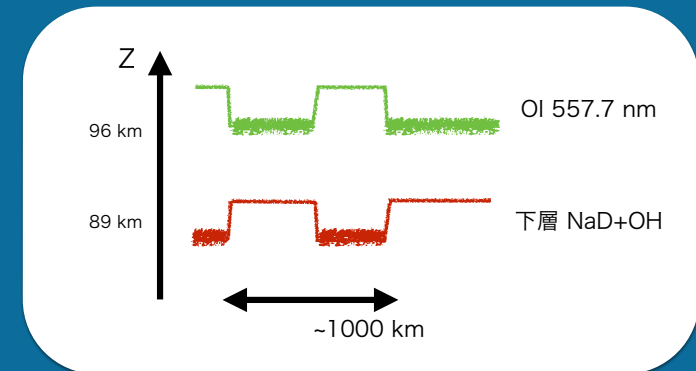
Taylor et al., 1995



Dewan and Picard, 1998

生成機構 2つの可能性

- 発光層高度差の1/2の鉛直波長を持つ波動
- 2層の間を伝搬する波。(Mesospheric Bores)



今後

- 地上イメージャー、ライダー、レーダーなど同時観測。時間発展、高さ方向の構造、風速などがわかる。
- 分散関係や波のソースの議論ができるようになる。

まとめ

- ISSからのデジカメ画像で中間圏大気光のメソスケール構造を捉えることに成功した。
- 発行高度の上下動を伴う発光強度の増減の波状構造を見つけた。約2000 km x 3000 kmの範囲で、波長は1000 km弱。上層、下層大気光は逆位相を持つ。
- 発光層高度差の1/2の鉛直波長を持つ波動、2層の間を伝搬すると2つの生成機構の可能性を示した。