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3D reconstruction of atmospheric gravity waves and derivation of vertical wave parameters with tomography applied to data from two ground-based cameras observing OH airglow

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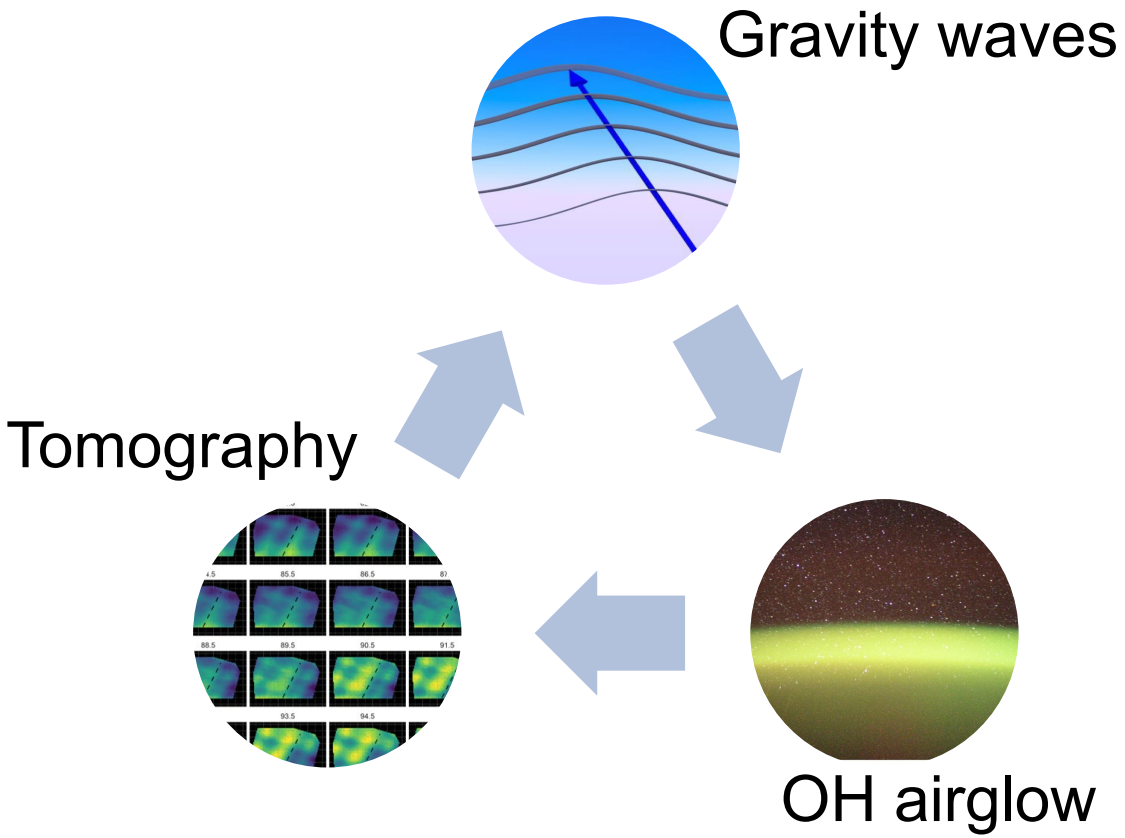
What you will hear in the next 10min



Why gravity waves in the middle atmosphere?

- Meridional circulation
- „Breaking zone“
- Better understanding of coupling between atmospheric layers

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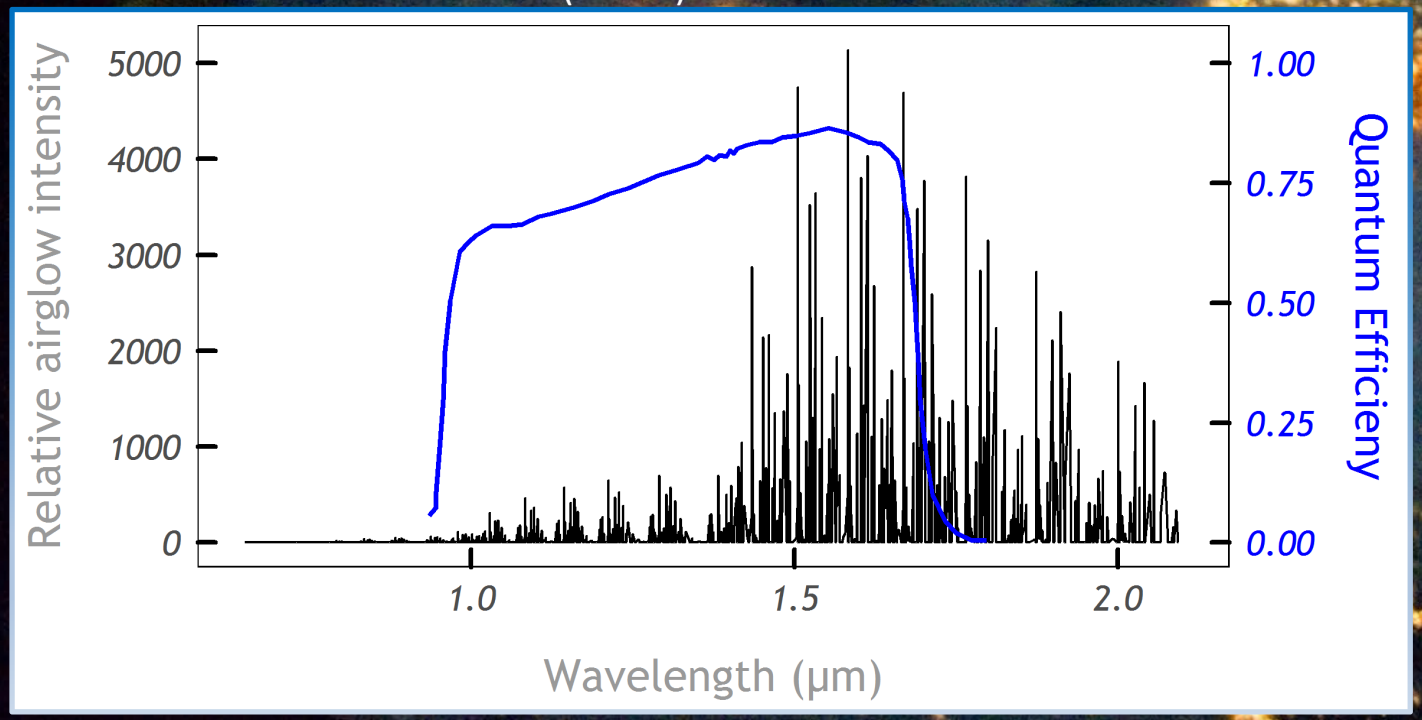
OH Airglow

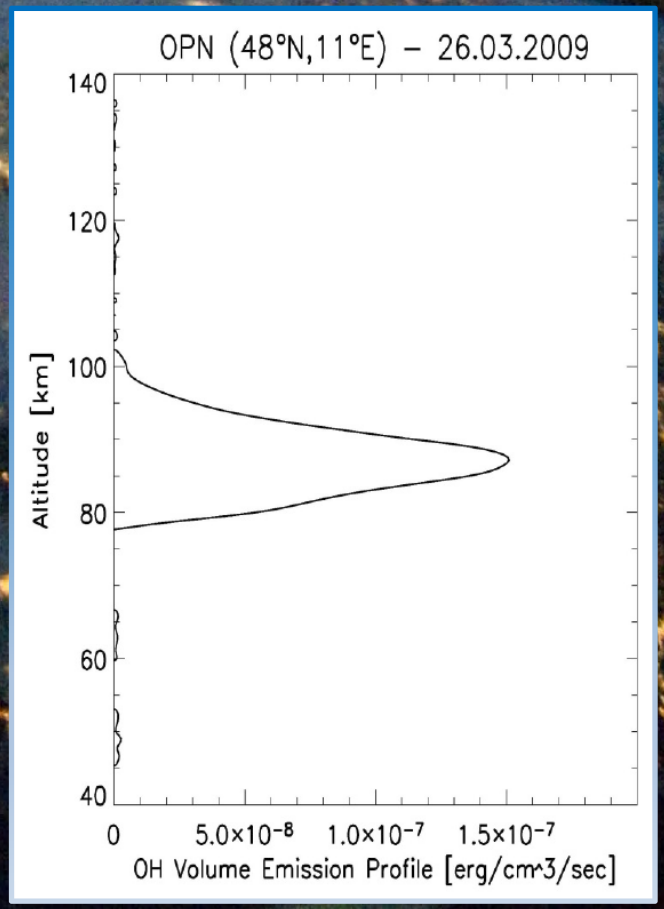
Chemiluminescent layer

Airglow intensity modulated by gravity waves (among others)

86 ± 4 km altitude

Emission in short-wave infrared(SWIR)





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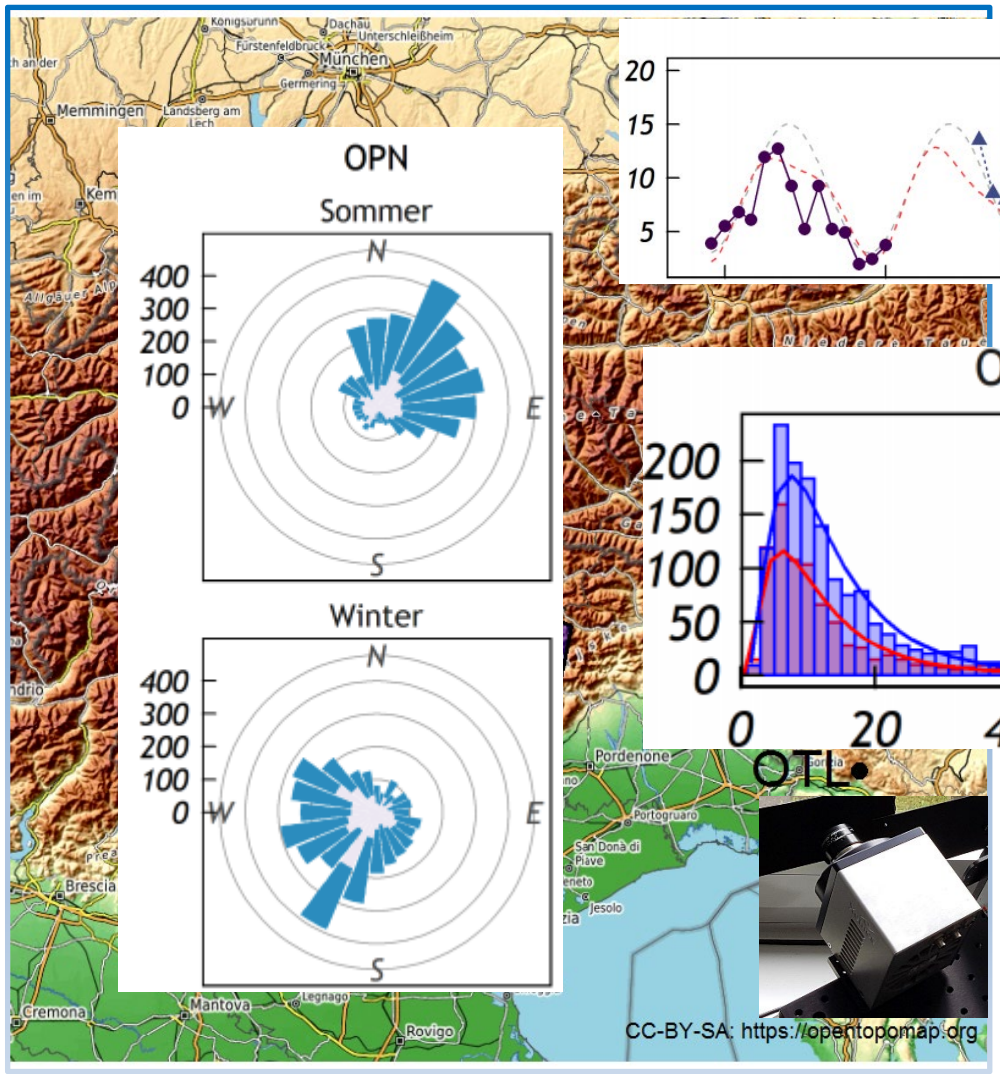
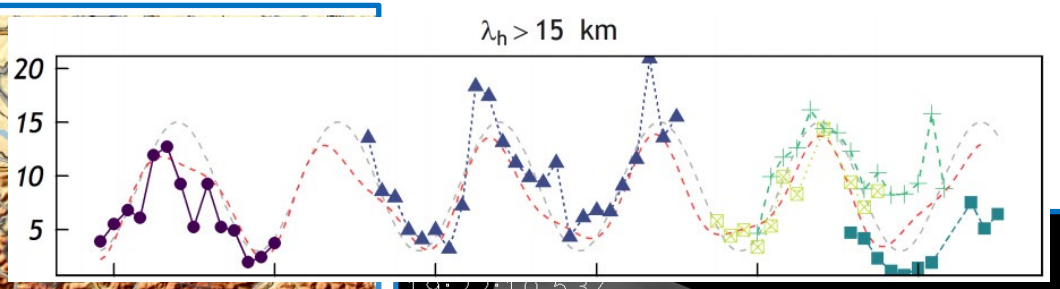
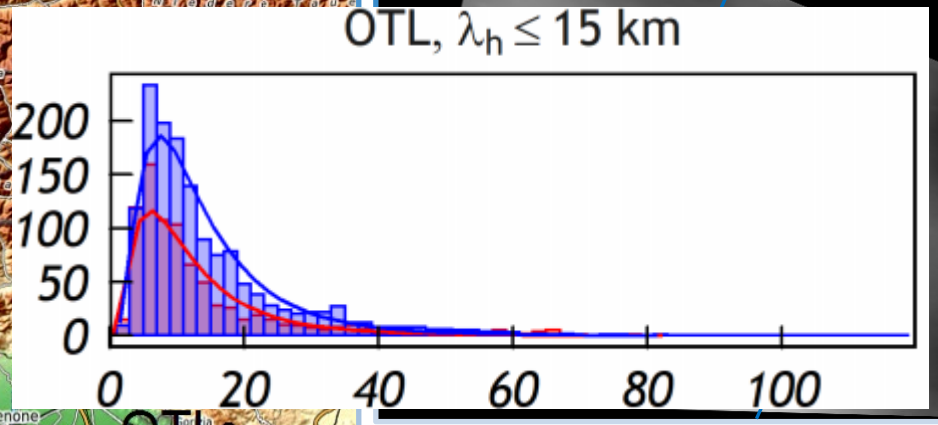
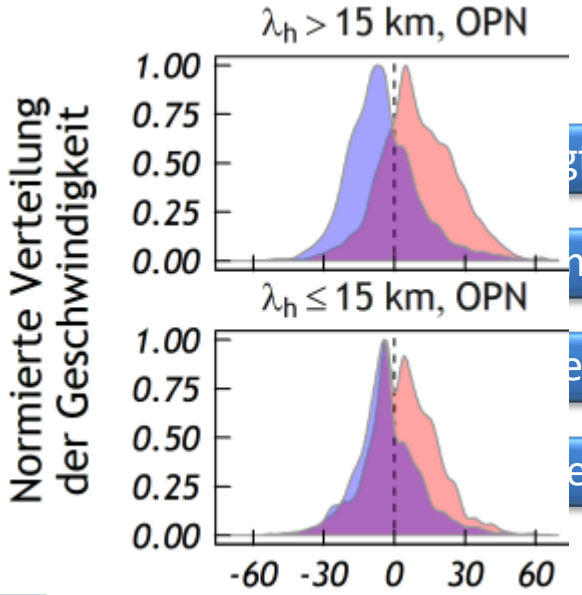
Usual airglow camera observations with a Fast Airglow IMager (FAIM)









gth (km)

n direction

eriod (min)

eed (m/s)

Many thanks to the University of Nova Gorica for hosting and maintaining our instrument!

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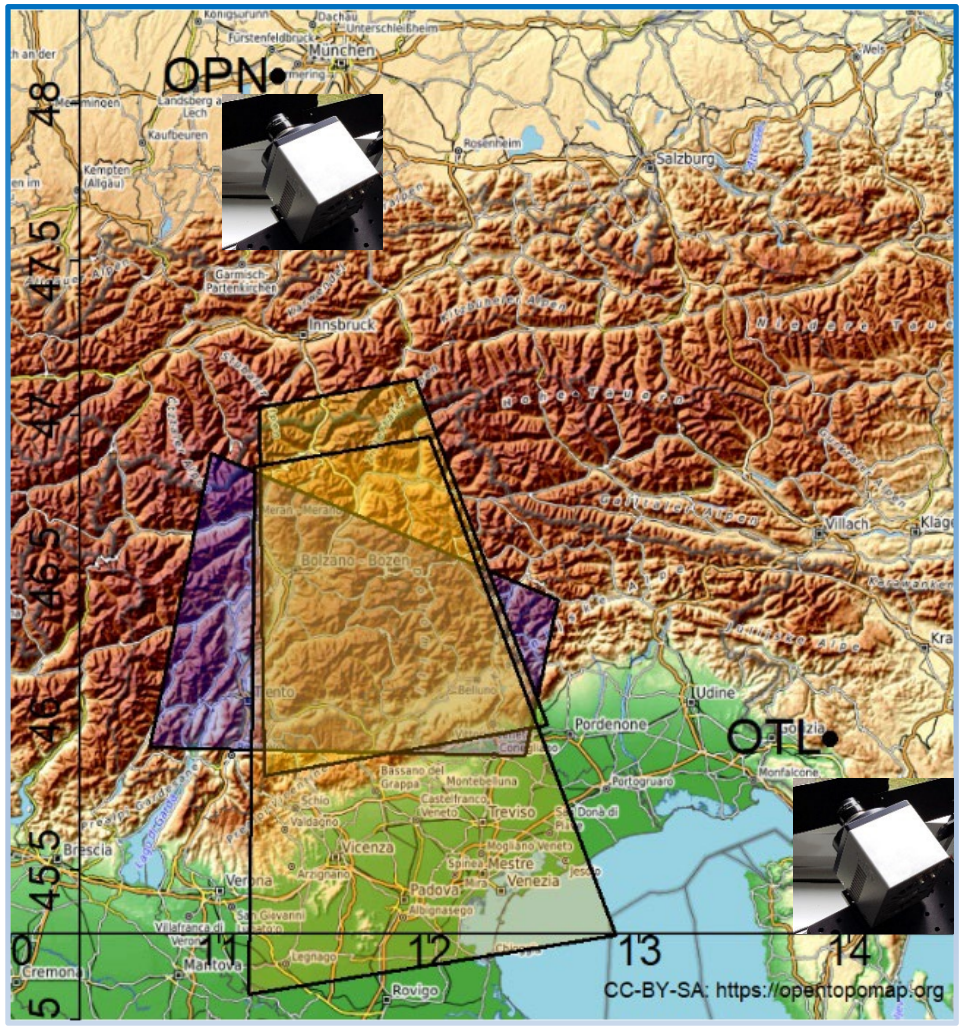
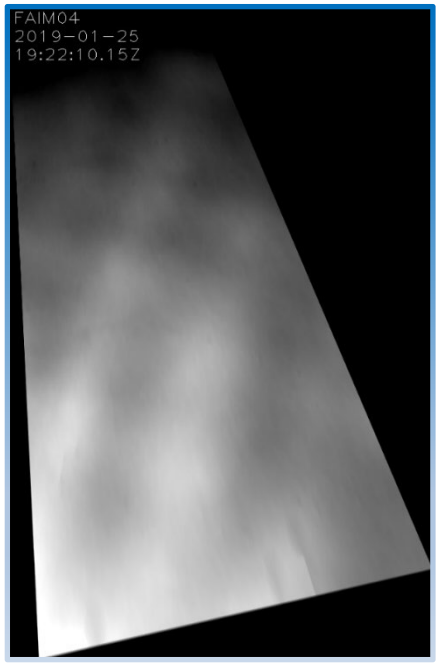
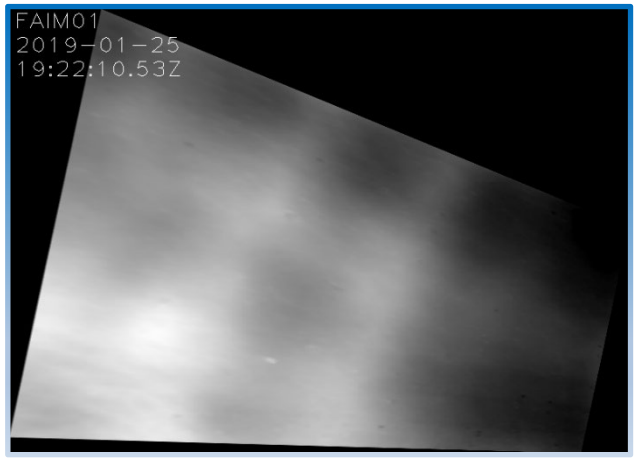
Tomography setup with two FAIM camera systems



Tomography possible with the information of two overlapping FOV.
Derivation of vertical gravity wave information now possible.





Analysis of 121 image pair sequences.
Overall about 370h of tomographic airglow data available.

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Tomography

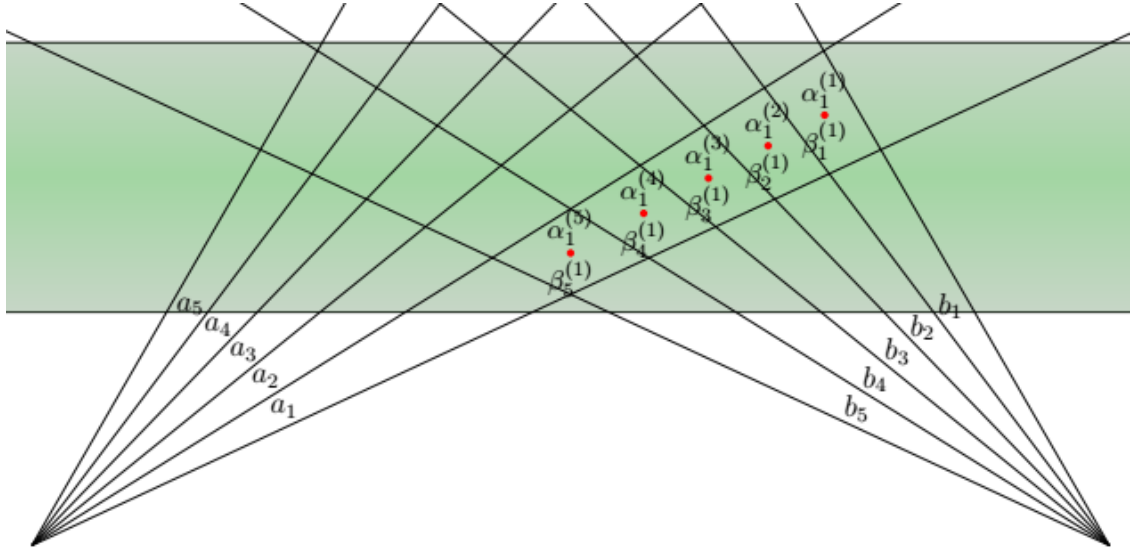
- 3D-Grid (24 x 160 x 160)
  - 76.5 – 99.5: 1km resolution
  - 45°N – 47°N: ~1.4km resolution
  - 10.7°E – 12.8°E: ~ 1km resolution

- Aim: Get the intensity of each volume element (voxel)

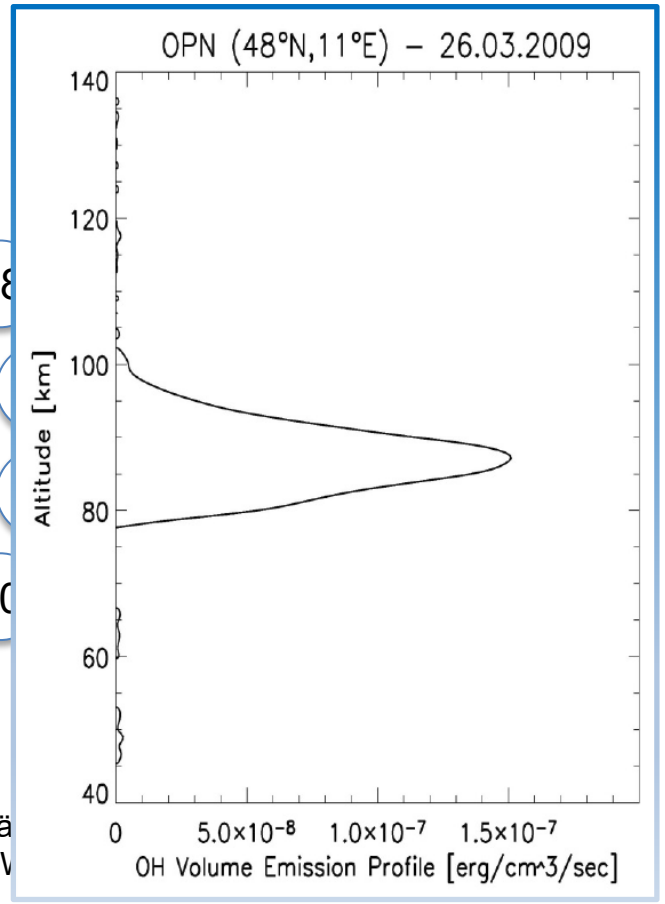
- To solve the underconstraint equation system:

  - derive **8 basic-functions** of OH-profiles from statistics of TIMED-SABER measurements

  - Two step **LSMR-Algorithm** (an iterative least square algorithm by Fong and Saunders 2011)
    - **with Tikhonov-Regularisation** of zeroth order: find a 'smooth‘ solution based on a damping parameter



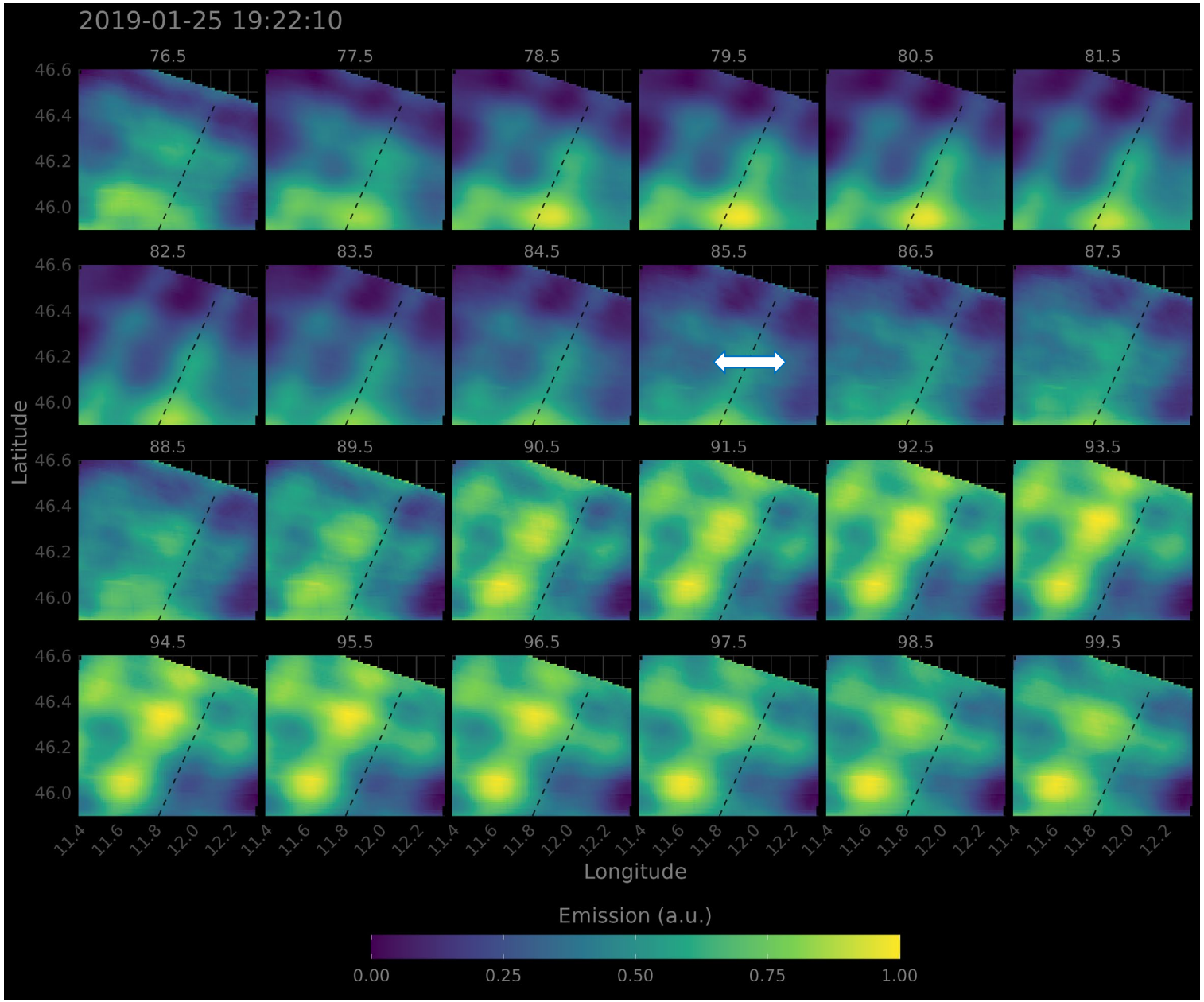
Tomography case study



Brunt-Väisälä
climatology (V

GW dispersion relation (for large vertical wavelengths; e.g. Fritts et al. 2003):

$$\frac{\lambda_h^2}{\lambda_z^2} = \left(\frac{N^2}{\sigma^2} - 1\right)$$



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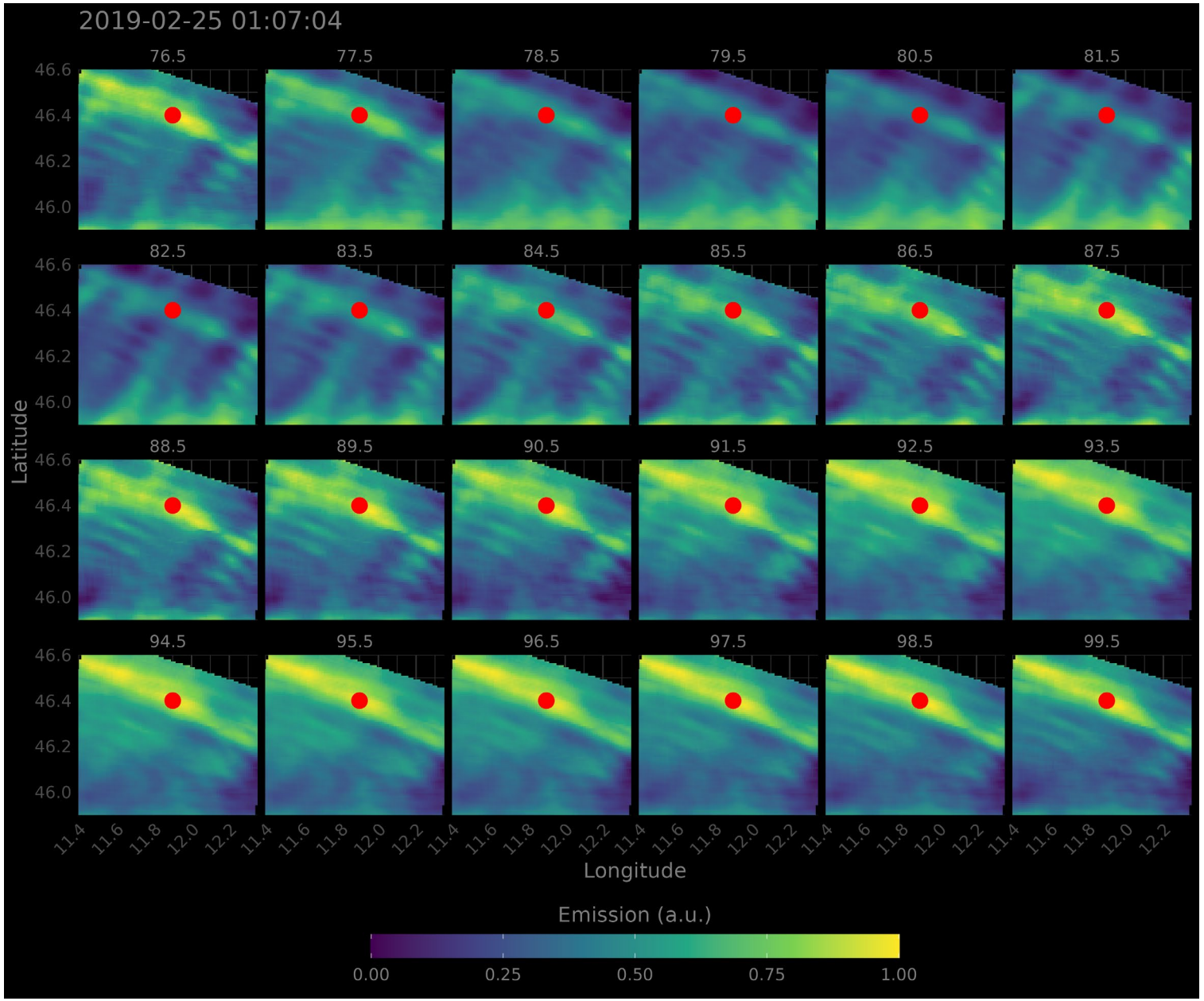
What else can be observed?
„Two single wavefronts with small waves/ripples in parallel"



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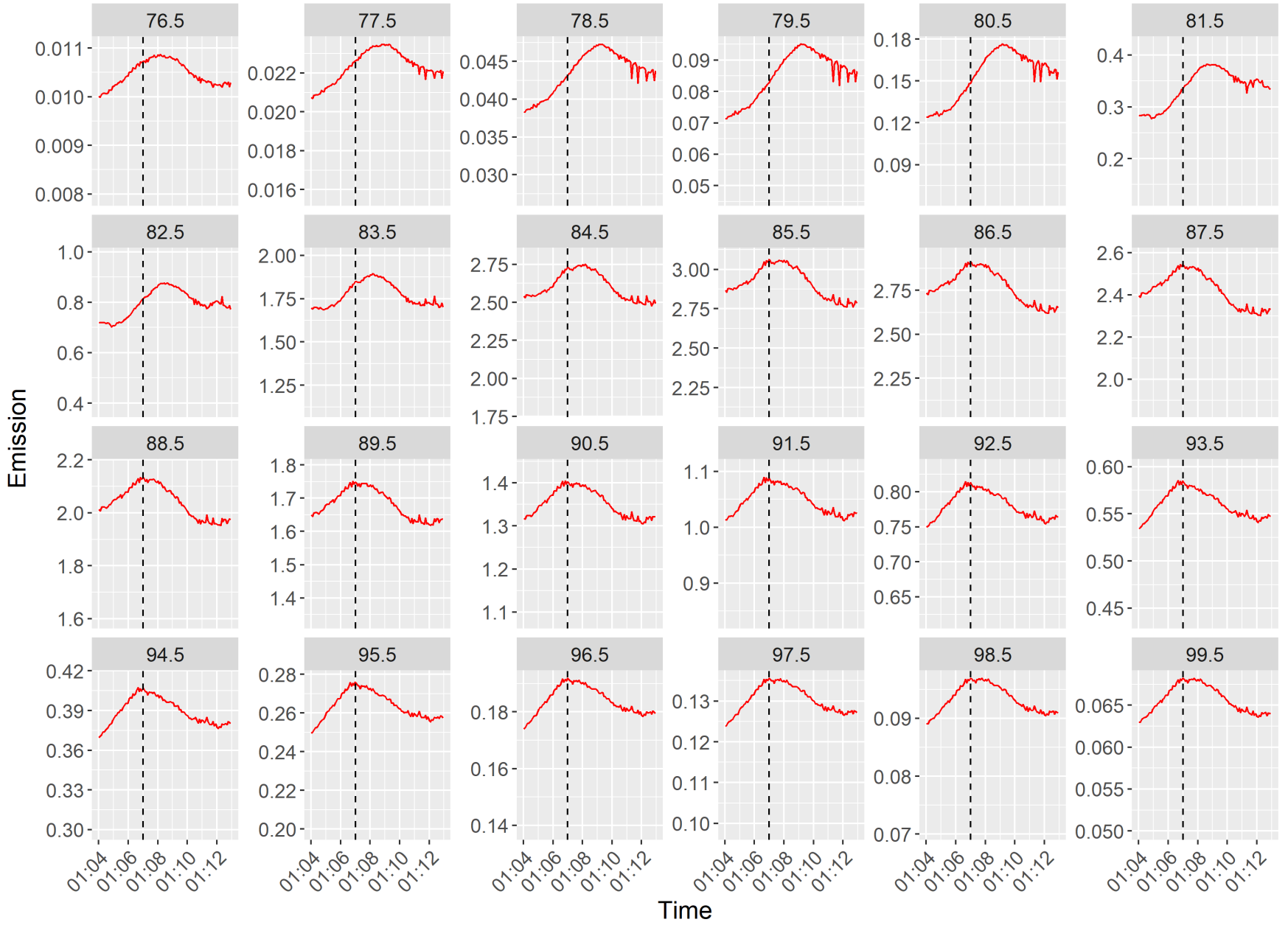
What else can be observed?
„Two single wavefronts with small waves/ripple in parallel„

=> second wave front



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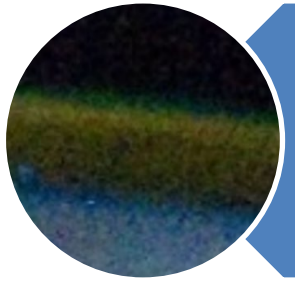
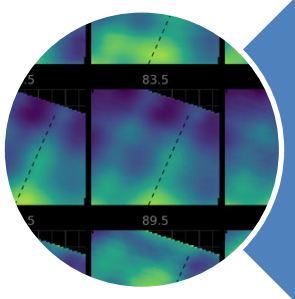


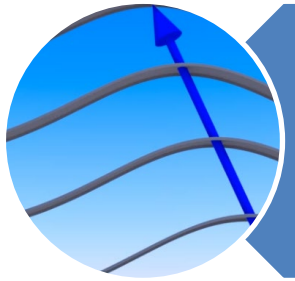
Airglow

- Phenomenon in middle atmosphere
- Used as trace for atmospheric dynamics



Tomography

- With two ground-based FAIM camera systems observing OH airglow.
- Algortihm fed with OH airglow profiles from TIMED-SABER on a statistical basis.
- LSMR algorithm to solve sparse least square problem.



Gravity waves

- derivation also of vertical wave parameters = full characterization possible
- Examples of small scale gravity waves, ripples, single wave fronts, wave breaking

What comes next?

- In detail analysis of selected cases (wave breaking, single wave fronts, ripples, etc.)
- Statistical analysis of the 370h tomographic airglow results (e.g. with spectral analyses).
- Maybe future satellite mission doing airglow tomography.

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