Temperature and wind atmospheric lidars as tools for the validation of infrasound propagation models

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Motivations:

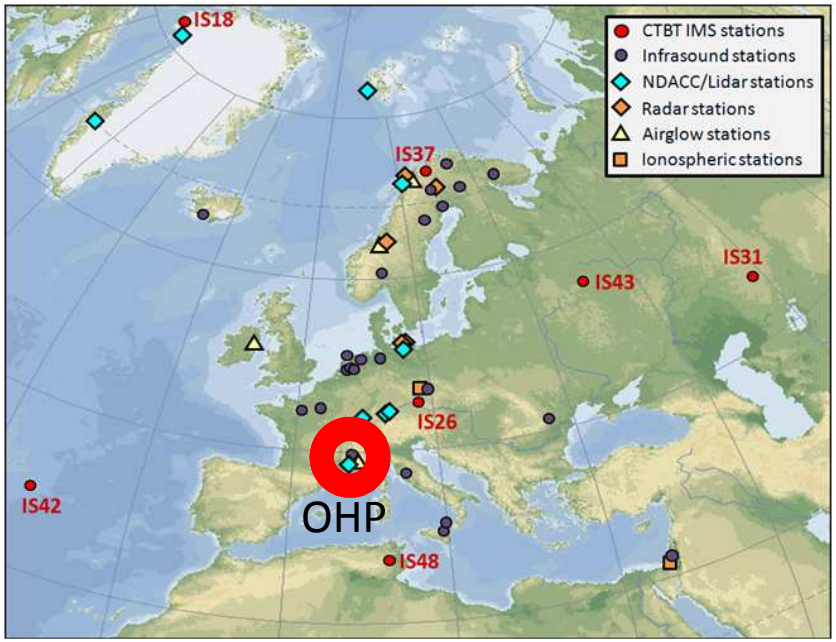
Improve the information on atmospheric dynamics from infrasound network data by using colocated temperature and wind lidar observations

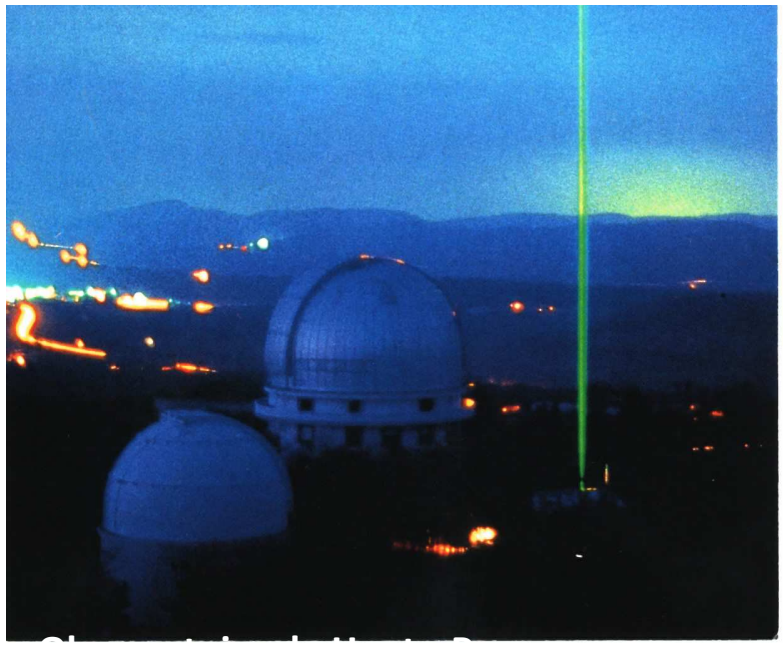
Haute-Provence Observatory (OHP) geophysical station

One of the main stations of two networks:

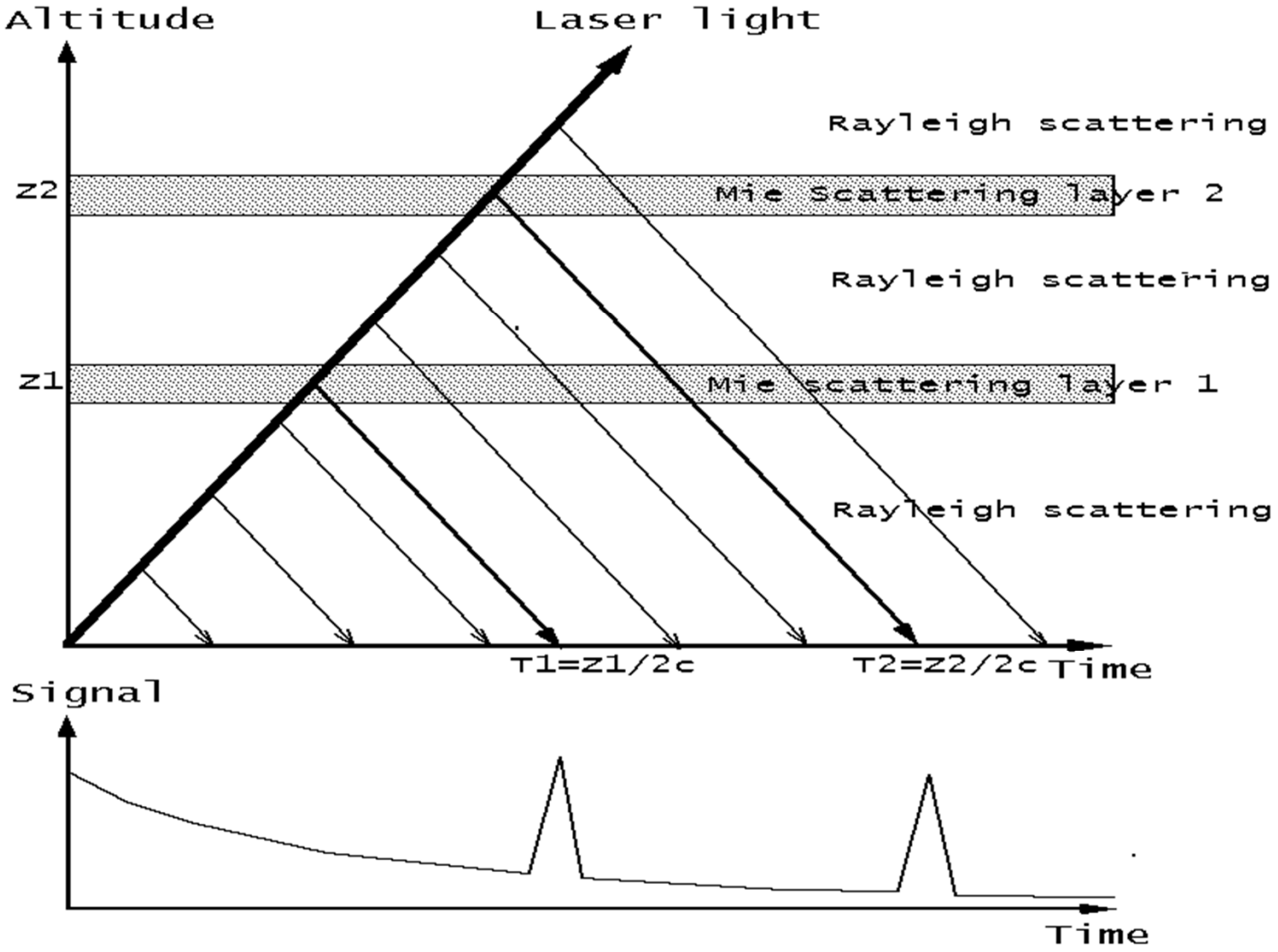
- ARISE (Atmospheric dynamics Research Infrastructure in Europe) project http://arise-project.eu
- NDACC (Network for the Detection of Atmospheric Composition Change) http://ndaccdemo.org

Equipped with powerful atmospheric lidars for temperature, wind, ozone, … (CNRS) and an experimental infrasound array (CEA)





Atmospheric lidar principle



Temperature measurements using Rayleigh Lidar

Required pure molecular scattering (above 30 km)

Density and pressure are relative measurements

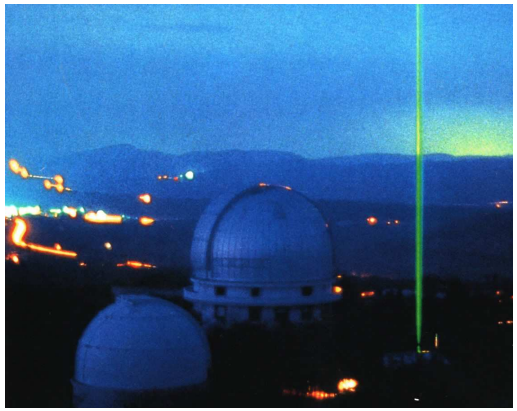
Temperature is absolute

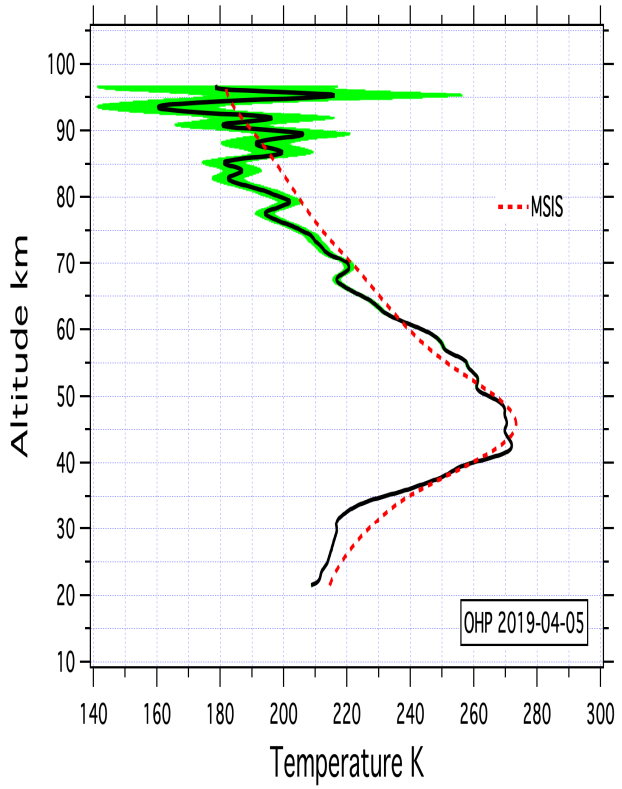
$$\rho(z) = f(N(z))$$

$$dP(z) = -g(z)\rho(z)dz$$

$$T(z) = \frac{MP(z)}{R\rho(z)}$$

$$T(z) = \frac{M}{R}\frac{\sum_{0}^{z} g\rho(z')dz'}{\rho(z)} = \frac{Mg(z)}{R}\frac{\sum_{z}^{top} N(z')dz'}{N(z)}$$





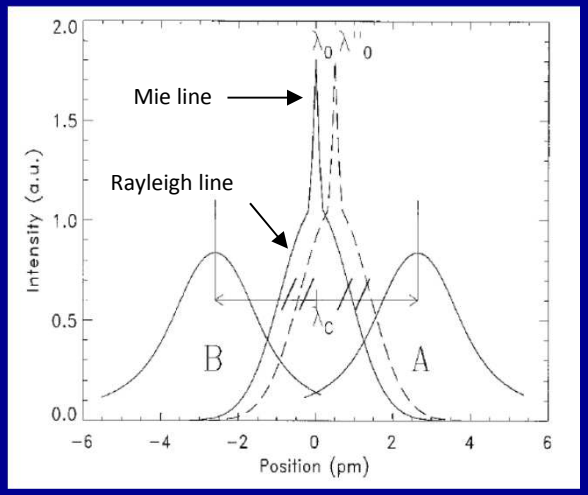
OHP Doppler wind lidar: Principle and Performance assessment

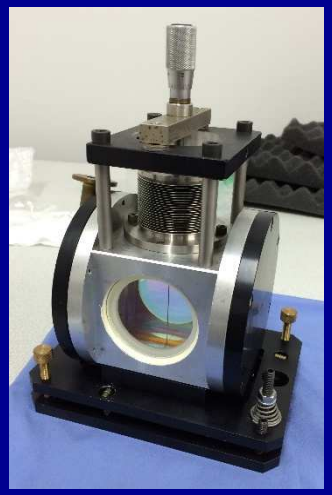
Radial wind proportional to

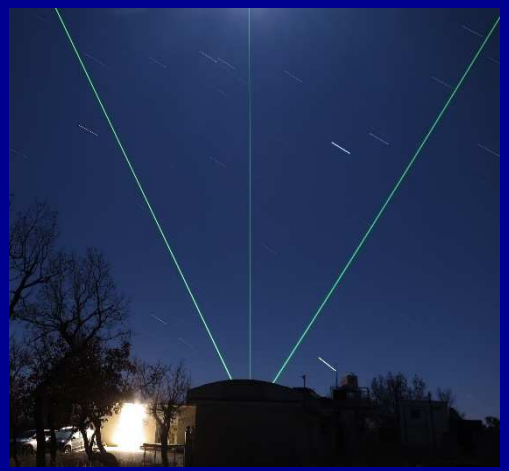
Response to Doppler shift

$$R(z) = \frac{N_A(z) - N_B(z)}{N_A(z) + N_B(z)},$$

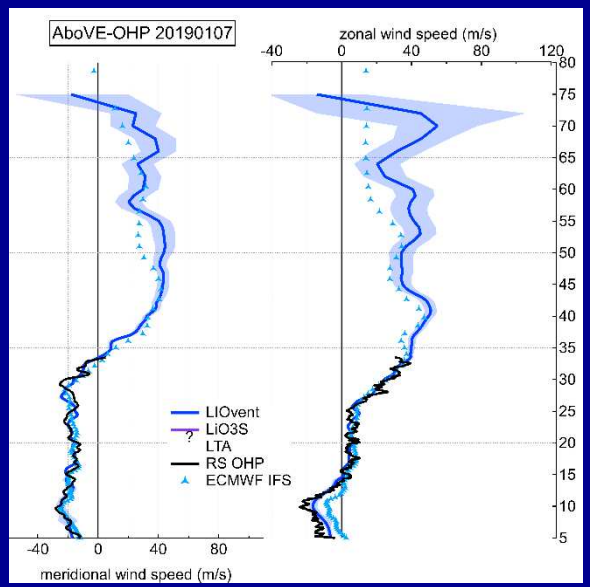
Double edge Fabry-Pérot filter



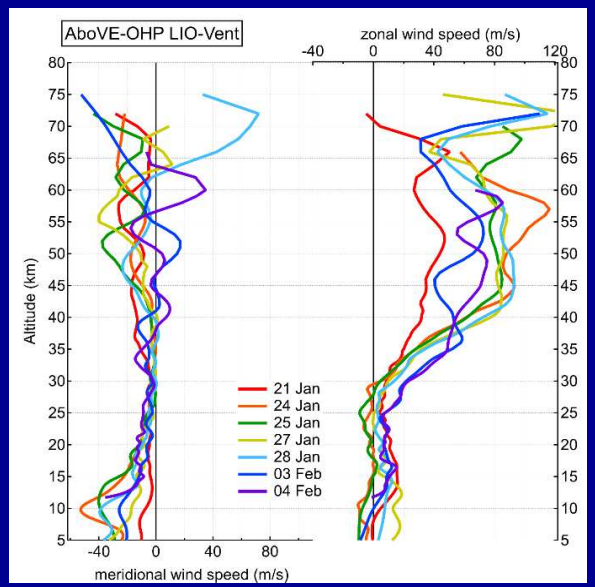




Comparison with ECMWF IFS



Series of wind profiles



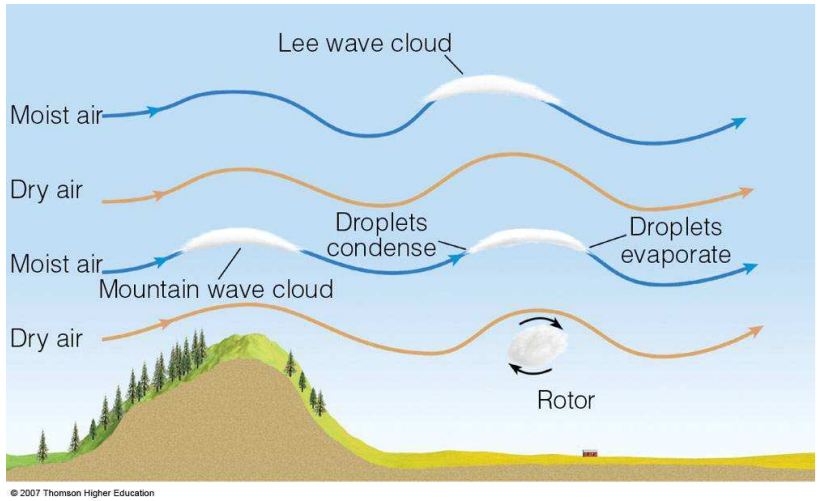
Gravity waves

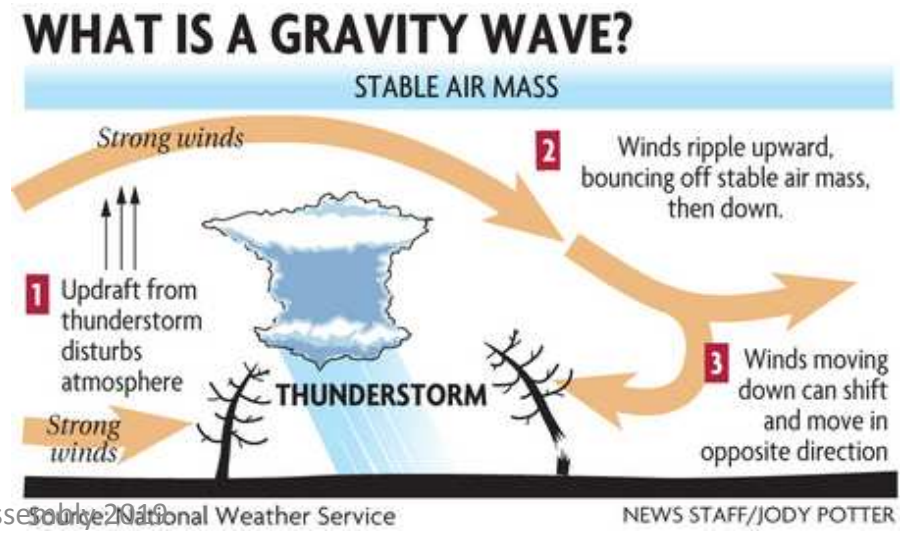
Gravity force

Local extension (10 à 1000 km)

Main sources

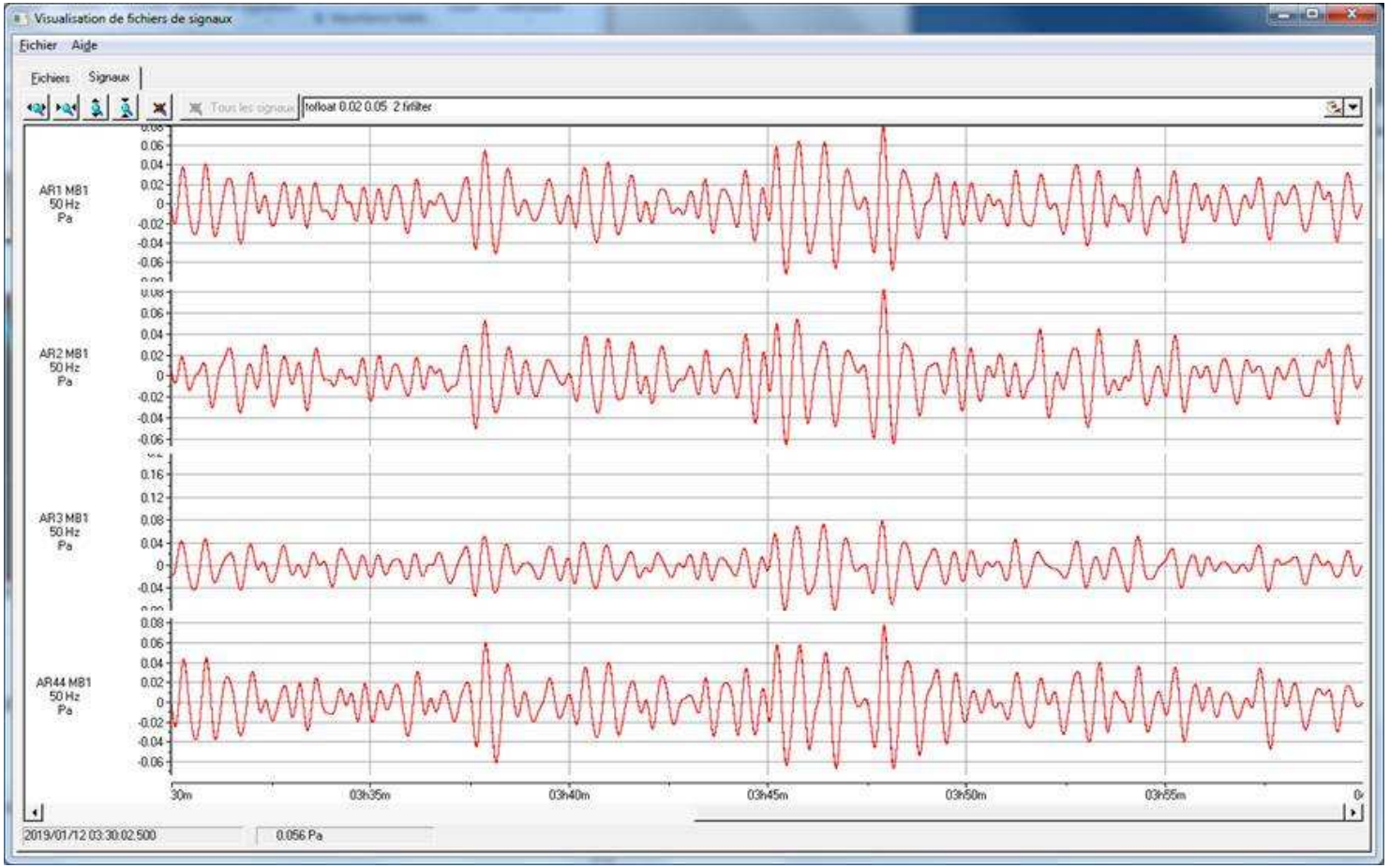
- Orography (Lee waves)
- Deep convection
- Jet stream (geostrophic adjustment)



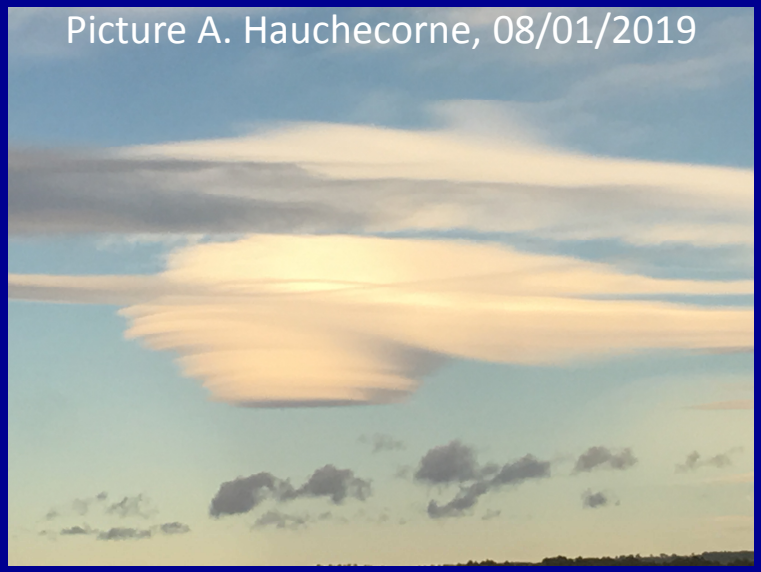


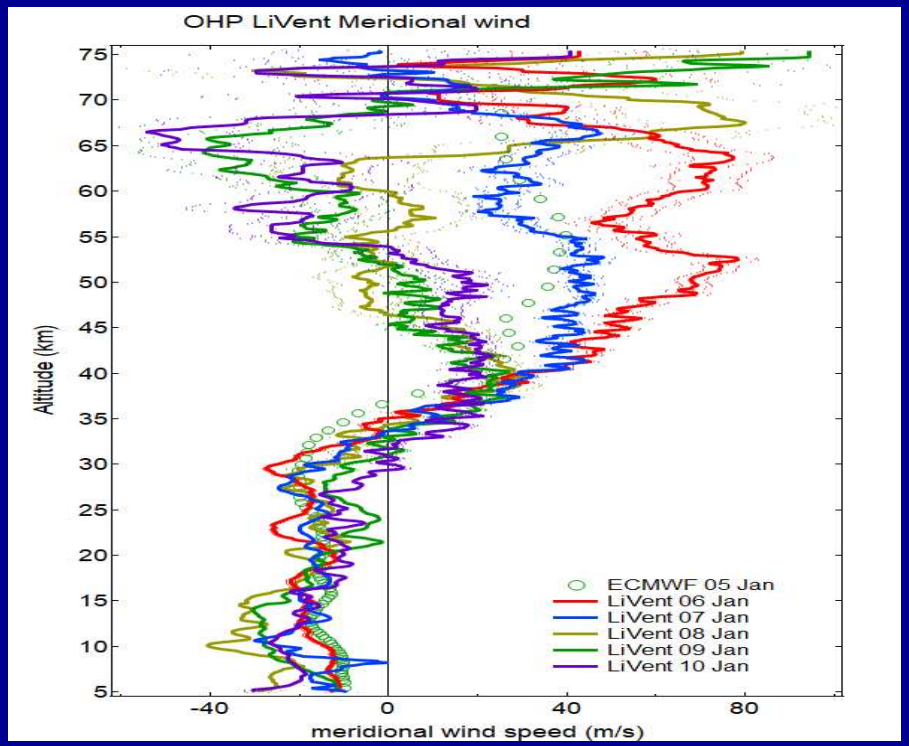
Mountain infrasonic waves

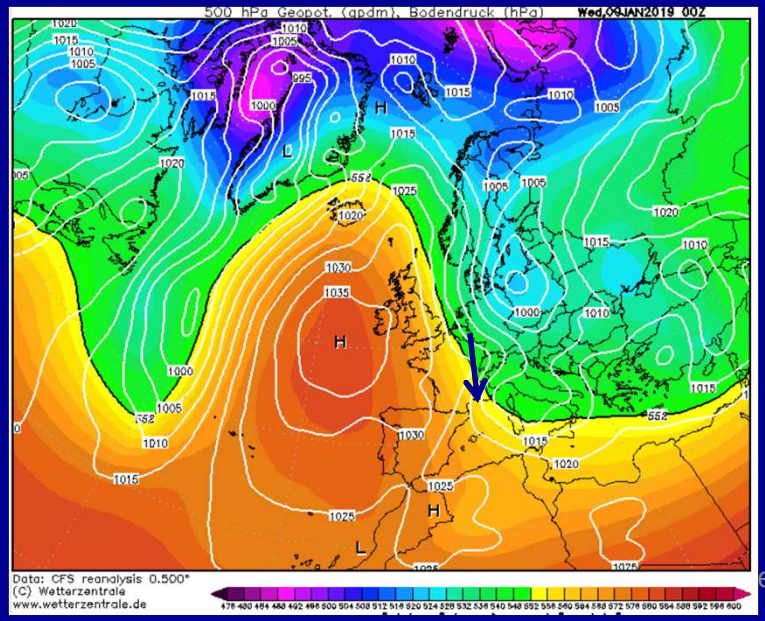
- Generated by the wind above mountains
- Long periods 10-100 seconds
- Can propagate at long distances (several 1000s km) in all directions due to their low attenuation in the termosphere
- The link with gravity waves needs to be studied in more details



Orographic wave event early January 2019



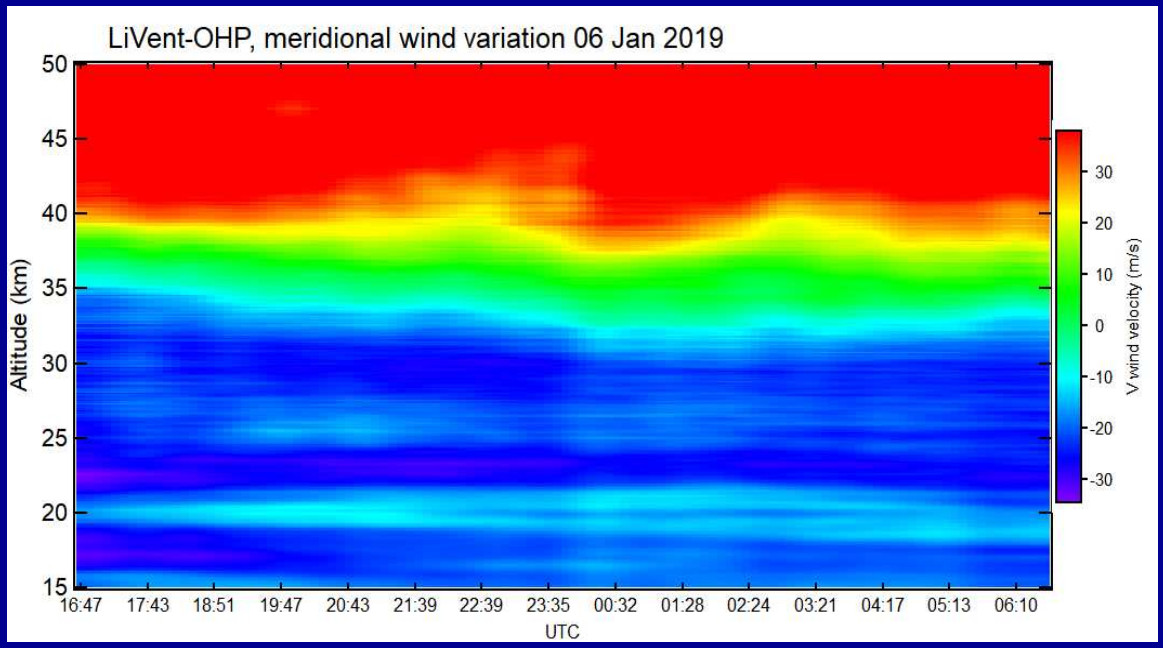


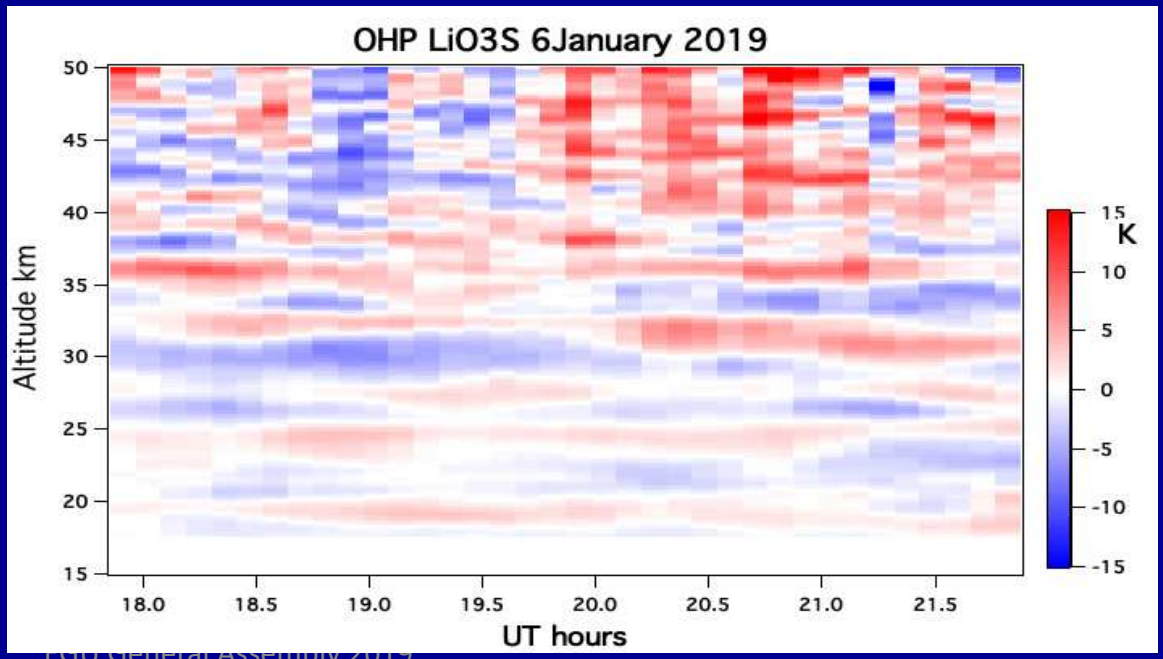


OHP
6 January 2019

Stationary perturbations in both meridional wind and temperature profiles

Indicates the presence of Stationary orographic waves

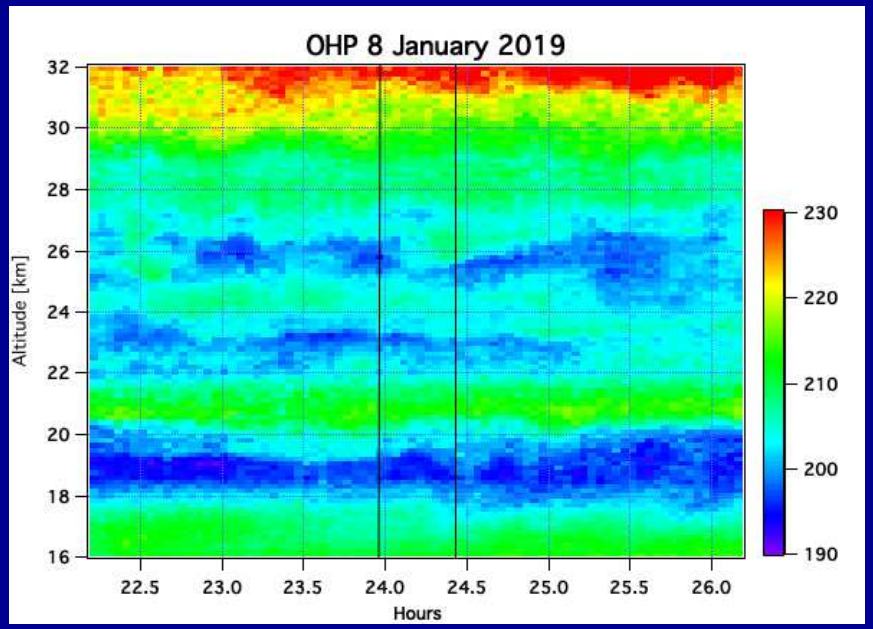




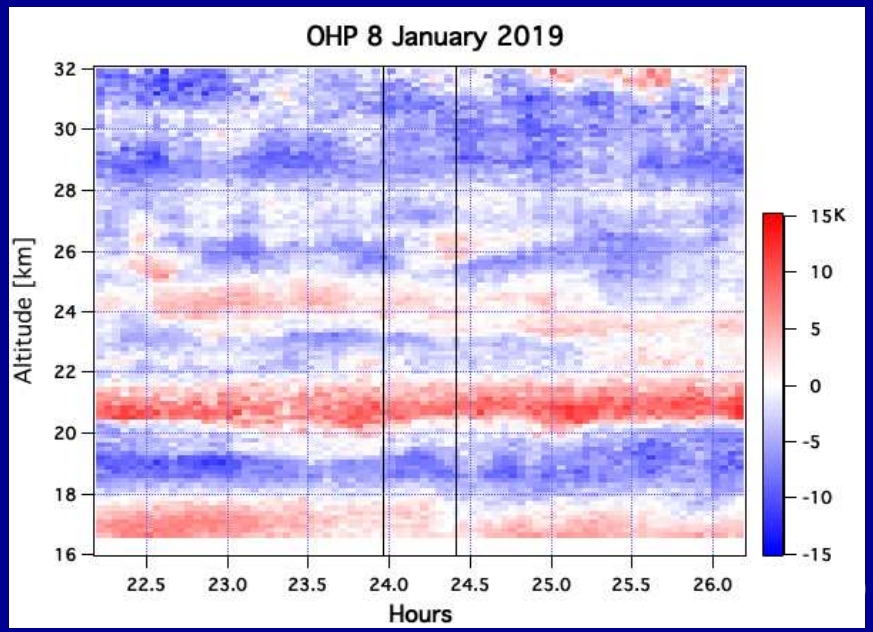
Lidar temperature evolution on 8 January 2010

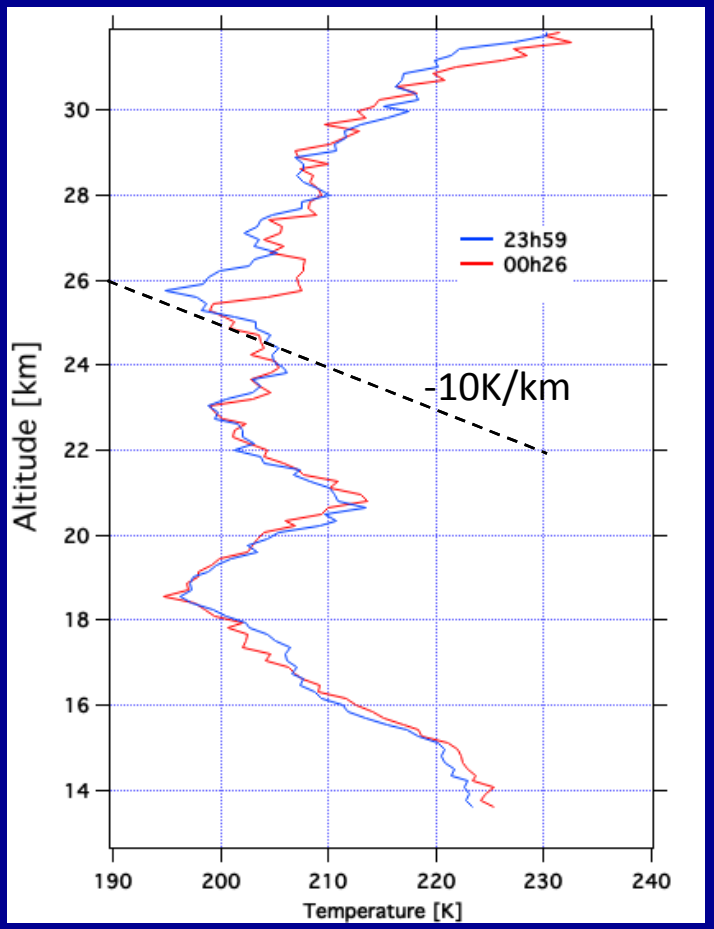
t = 3 min
Δz= 150 m

Temp



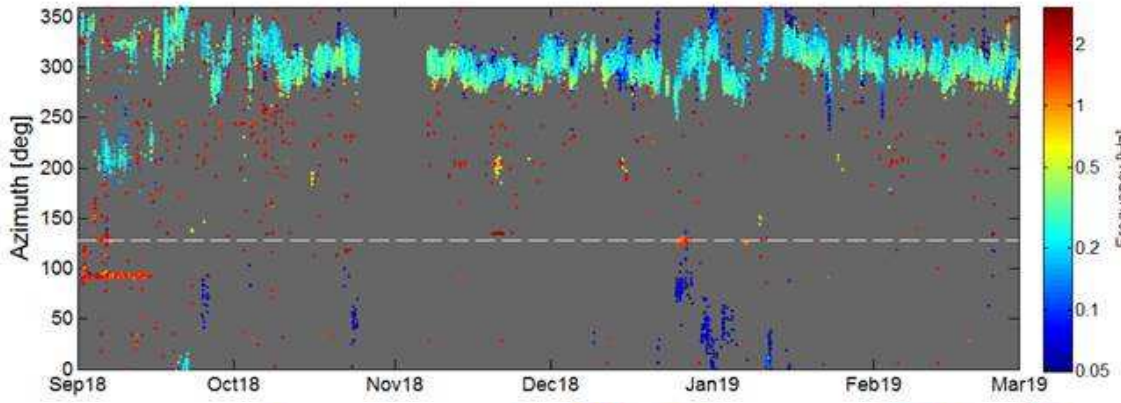
ΔTemp

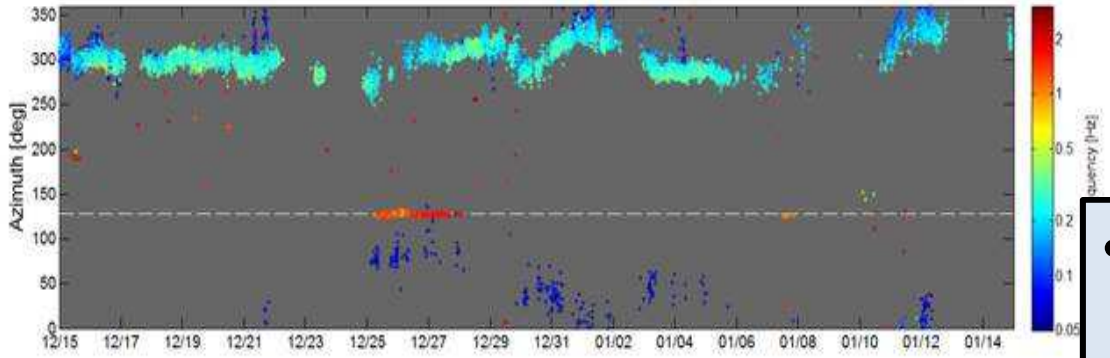


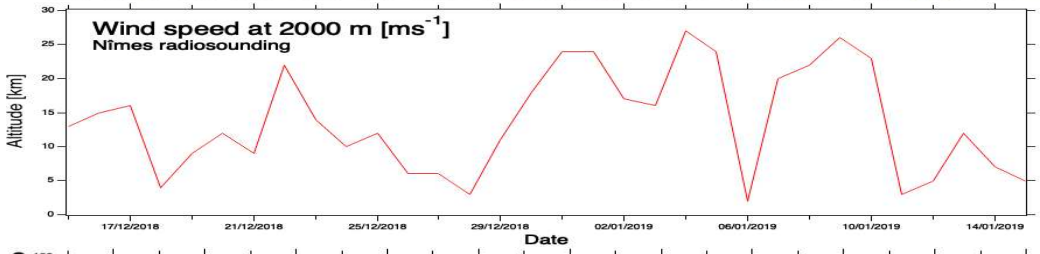


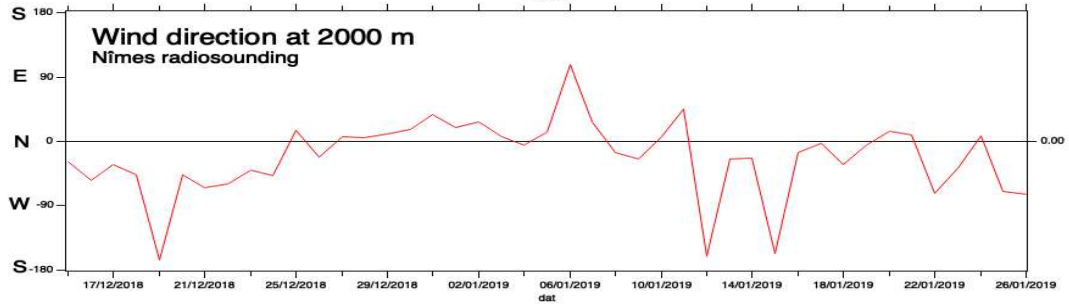
Gravity wave breaking?

Mountain waves in Dec. 2018 – Jan. 2019 at OHP





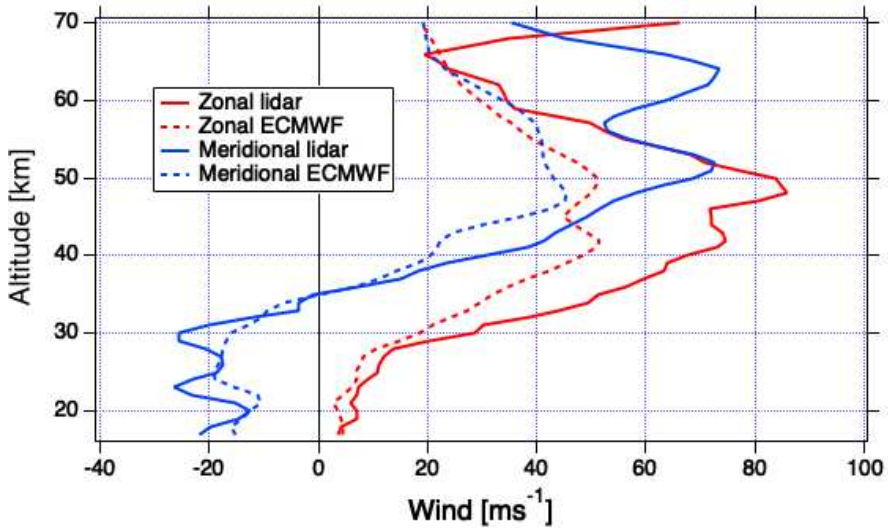


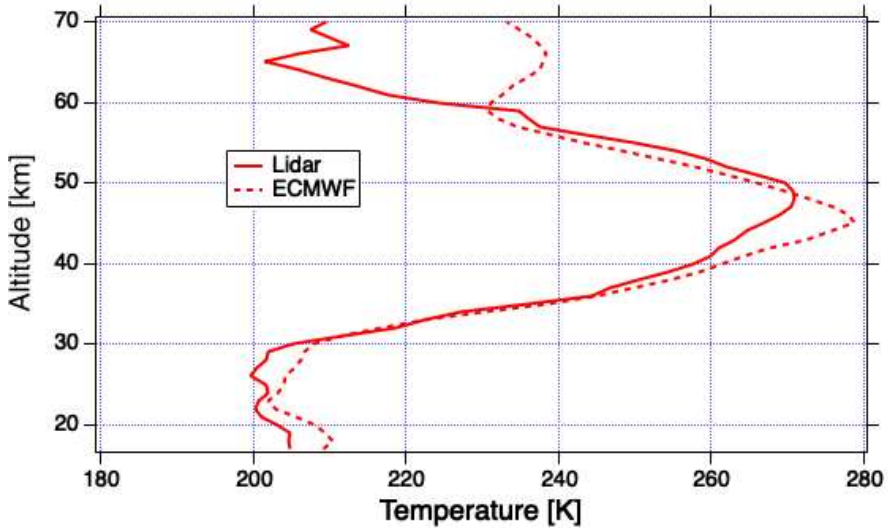


- Detection of mountain waves from 25 Dec. To 12 Jan.
- Azimuth North to East, corresponding to direction of Alps mountain
- Periods of strong wind from North-West to North

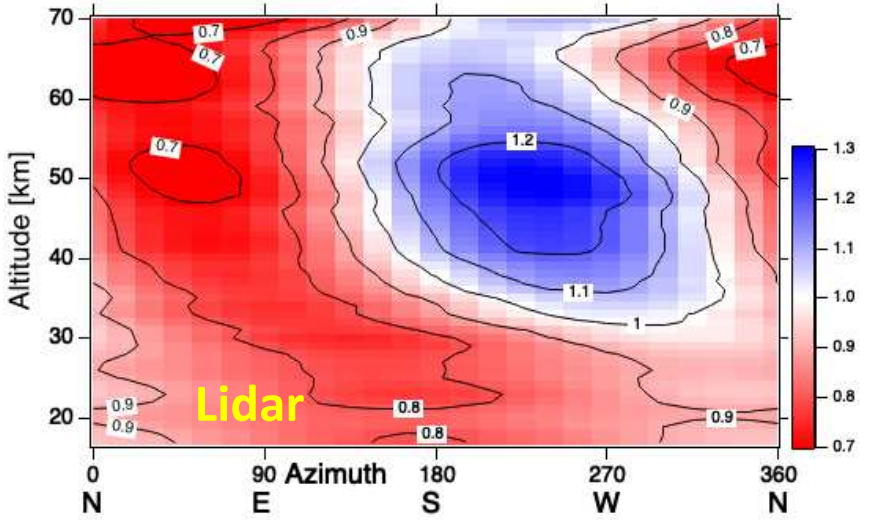
Wind-temperature profiles and infrasound propagation on 6 January 2019

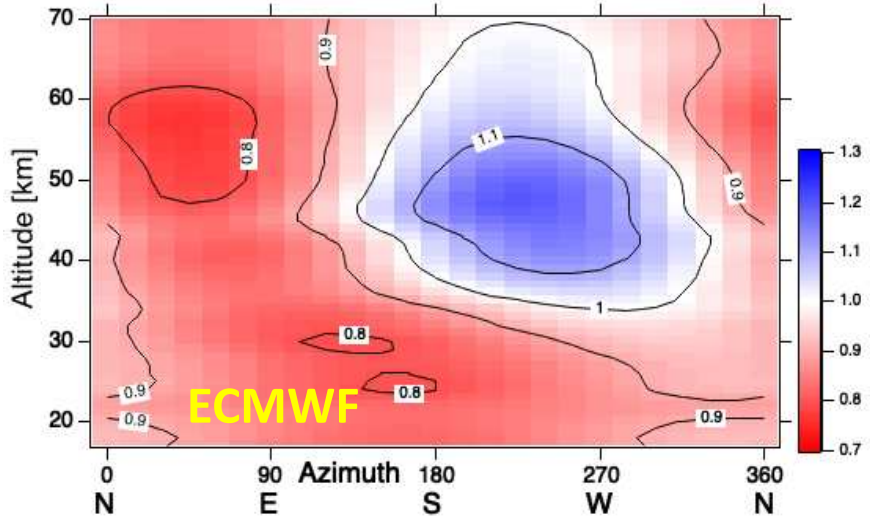
Lidar and ECMWF profiles





Effective sound speed ratio





Conclusions and perspectives

- The synergy between colocated observations of microbarometer arrays and lidars brings new information on the middle atmospheric dynamics
- Temperature and wind lidar profiles help to understand the atmospheric propagation of infrasounds
- Orographic gravity waves and mountain infrasonic waves are both generated by the wind blowing above mountains but further studies are needed to understand the link between the two phenomena

Acknowledgments
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