Combined measurements with the EISCAT radar and the Nordic Meteor Radar Cluster to determine AGW-TID wave parameters

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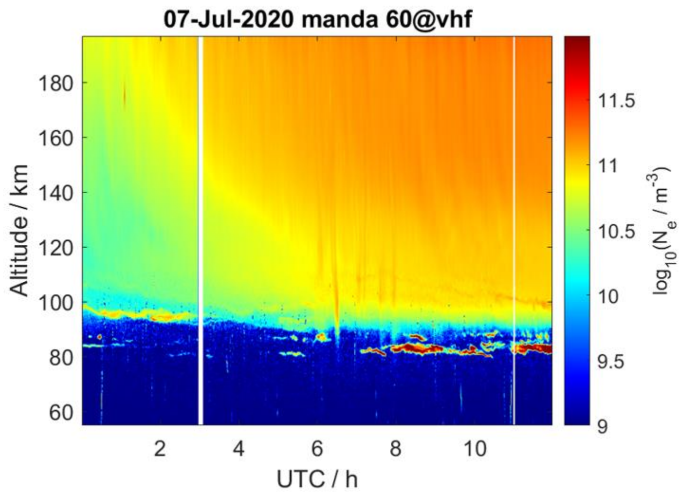
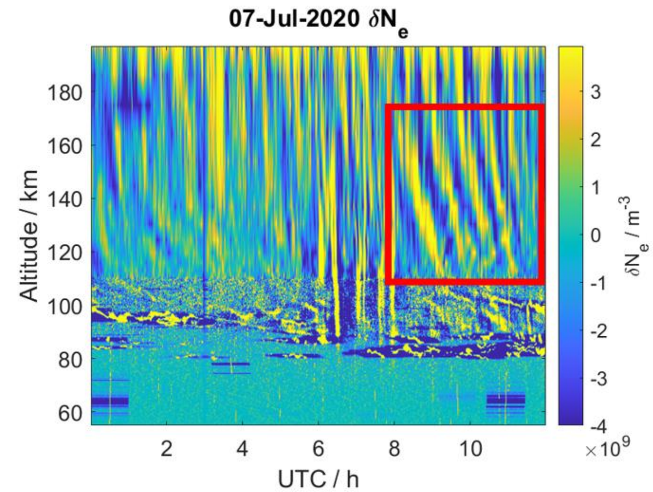
Combined vertical and horizontal measurements

vertically resolved measurements:

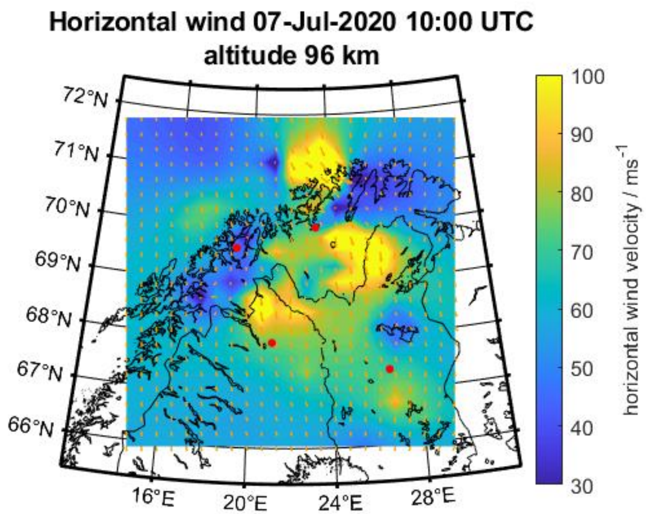
EISCAT

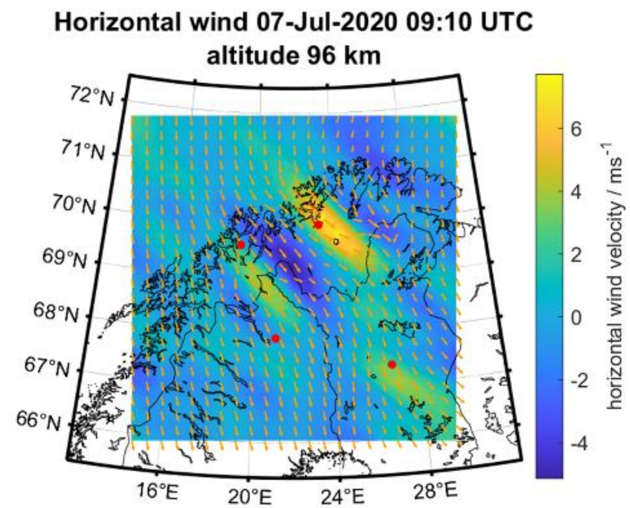




horizontally resolved measurements:

Nordic Meteor Radar Cluster





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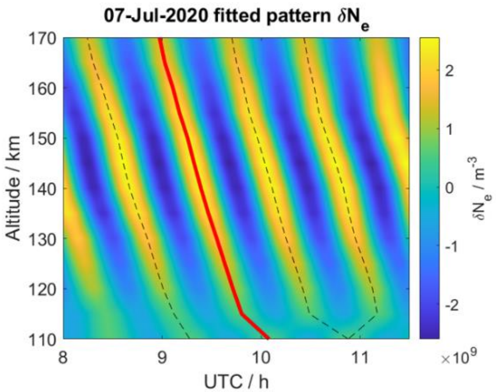
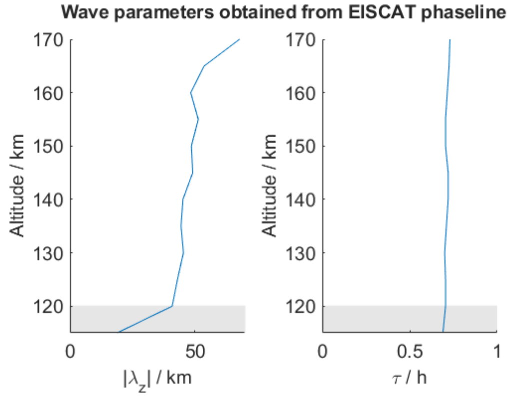
Vertical wave parameter determination

- apply 2D Fourier filter to separate different wave modes with respect to propagation direction, τ and λ_z
- fit wave separately at each altitude: $dN_e = A \cdot \cos(2\pi t/\tau + \delta)$ for A, τ, δ

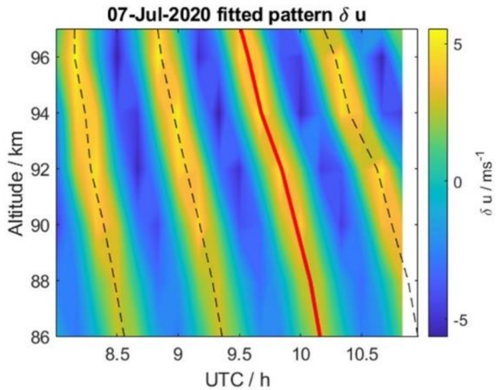
➔ $\tau(z)$ and $\delta(z)$ ➔ $t_{max}(z) = -\frac{\delta(z)\cdot\tau(z)}{2\pi} + t_0 + n \cdot \tau$ ➔ phase line

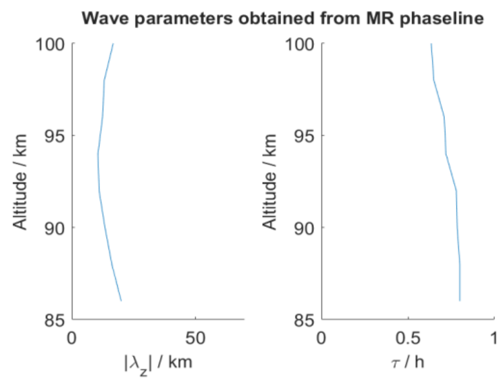




$$k_z = \frac{2\pi}{\tau} \cdot \frac{dt_{max}}{dz}$$

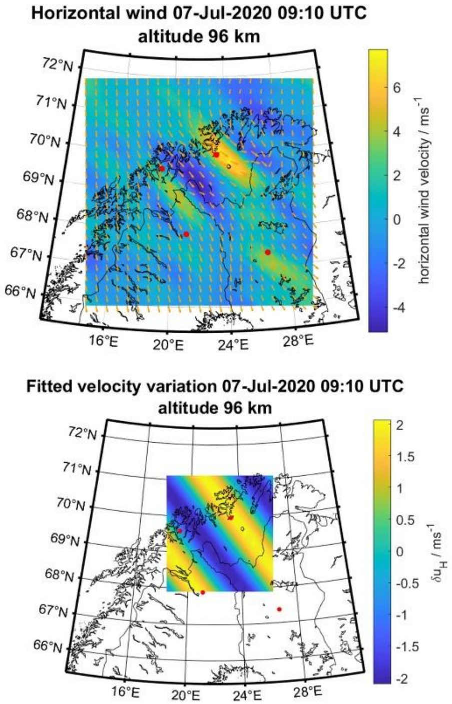
$$\begin{cases} k_z < 0 & \text{upward propagation} \\ k_z > 0 & \text{downward propagation} \end{cases}$$

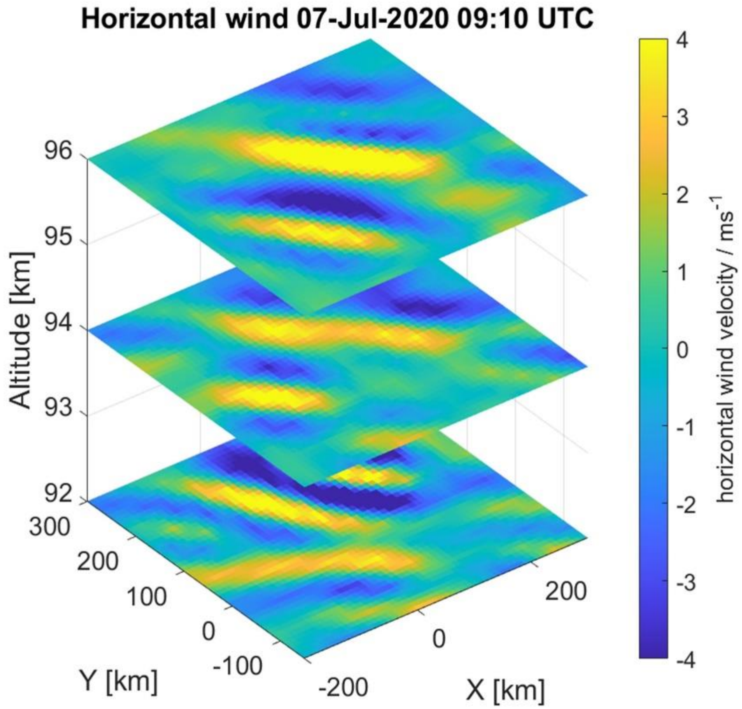




- nearly constant wave period $\tau = 43.5 \pm 2.7$ min
- λ_z shows reasonable range of values ; profiles agree in trend and absolute values

Horizontal wavelength & propagation direction





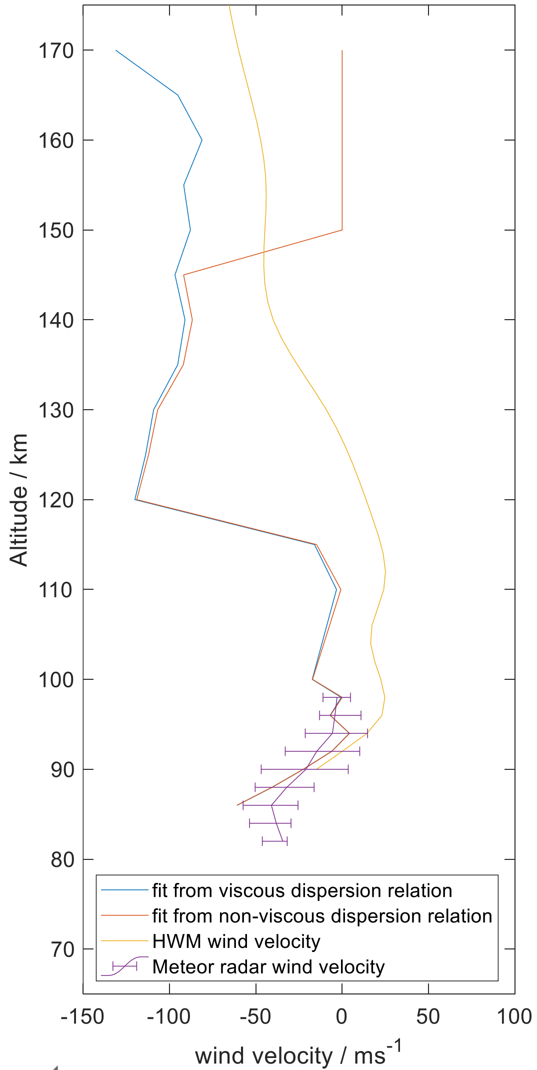
λ_z	$\sim 10 - 70$ km
λ_H	230 km
τ	~ 43 min
α	$0.644\ (= 37.9°)$

(α: angle of propagation direction in counter-clockwise rotation from geographic east)

- wave mode can be detected at multiple altitude levels
- horizontal wave is fitted as:

$$\delta v = A \cdot \sin\left(\cos\alpha \cdot \frac{2\pi}{\lambda_H} \cdot x + \sin\alpha \cdot \frac{2\pi}{\lambda_H} \cdot y + \delta\right)$$

Inferring wind velocities along propagation direction



$$\boldsymbol{k}^2 = \frac{N^2 k_H^2}{\omega_I^2} \cdot \gamma - \frac{1}{4H^2}$$

$$\omega_I = 2\pi/\tau - \boldsymbol{k_H} \cdot \boldsymbol{U}$$

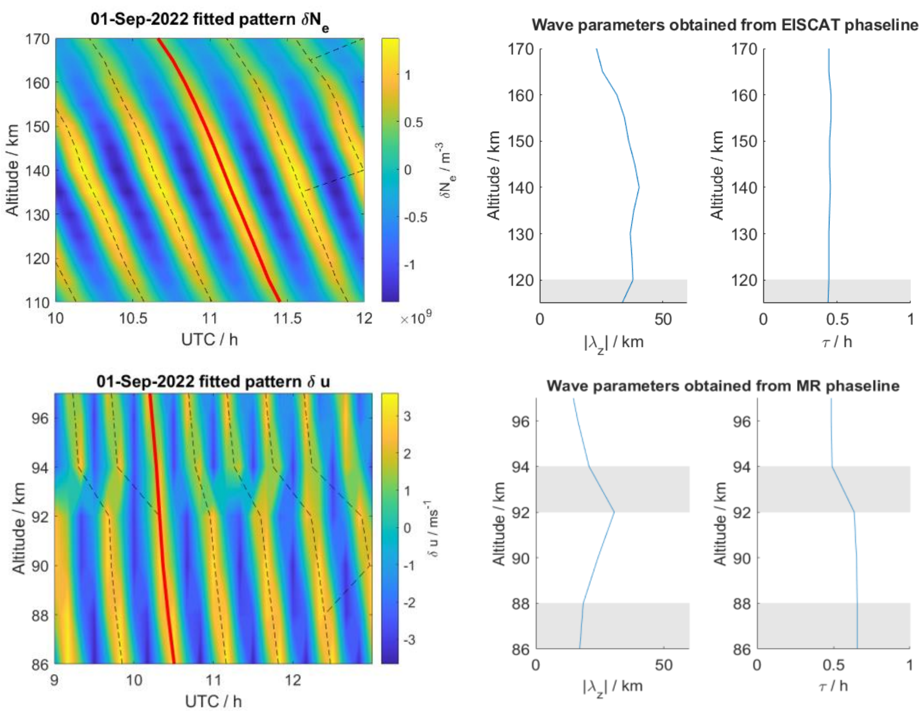
- gravity wave dispersion relation includes wind velocity along the propagation direction
- apply wave parameters and NRLMSISE-00 background atmosphere
- perform non-linear least square fit of the viscous and the non-viscous dispersion relation

➔ good agreement with Meteor Radar measurements (9 – 11 UTC); error bars mark quartiles

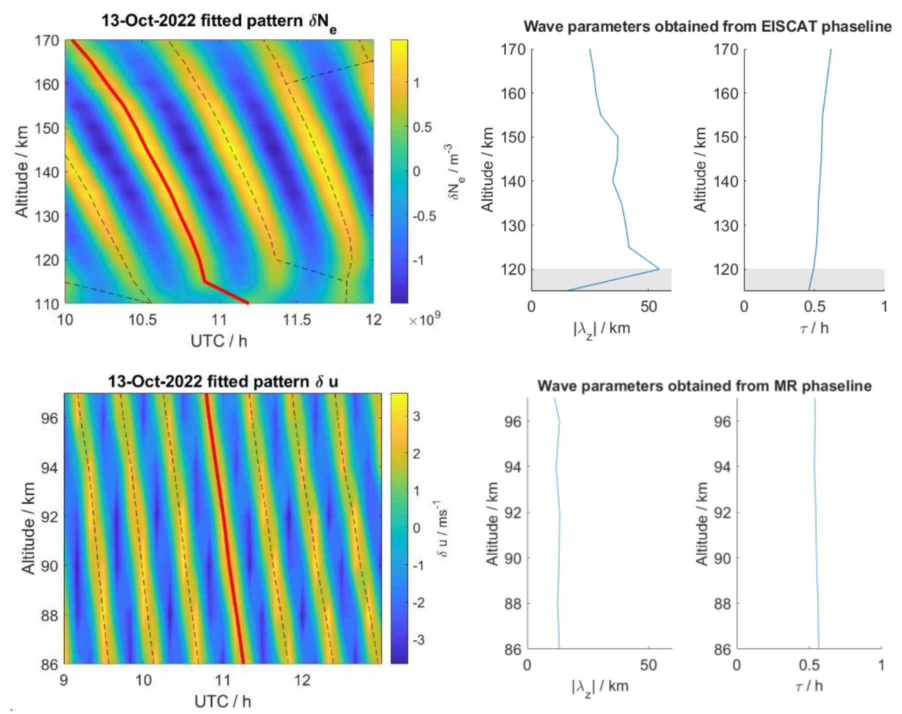
➔ non-viscous fit does not converge above 145 km

Parameters impacted by MLT fall transition 2022

September 01, 2022

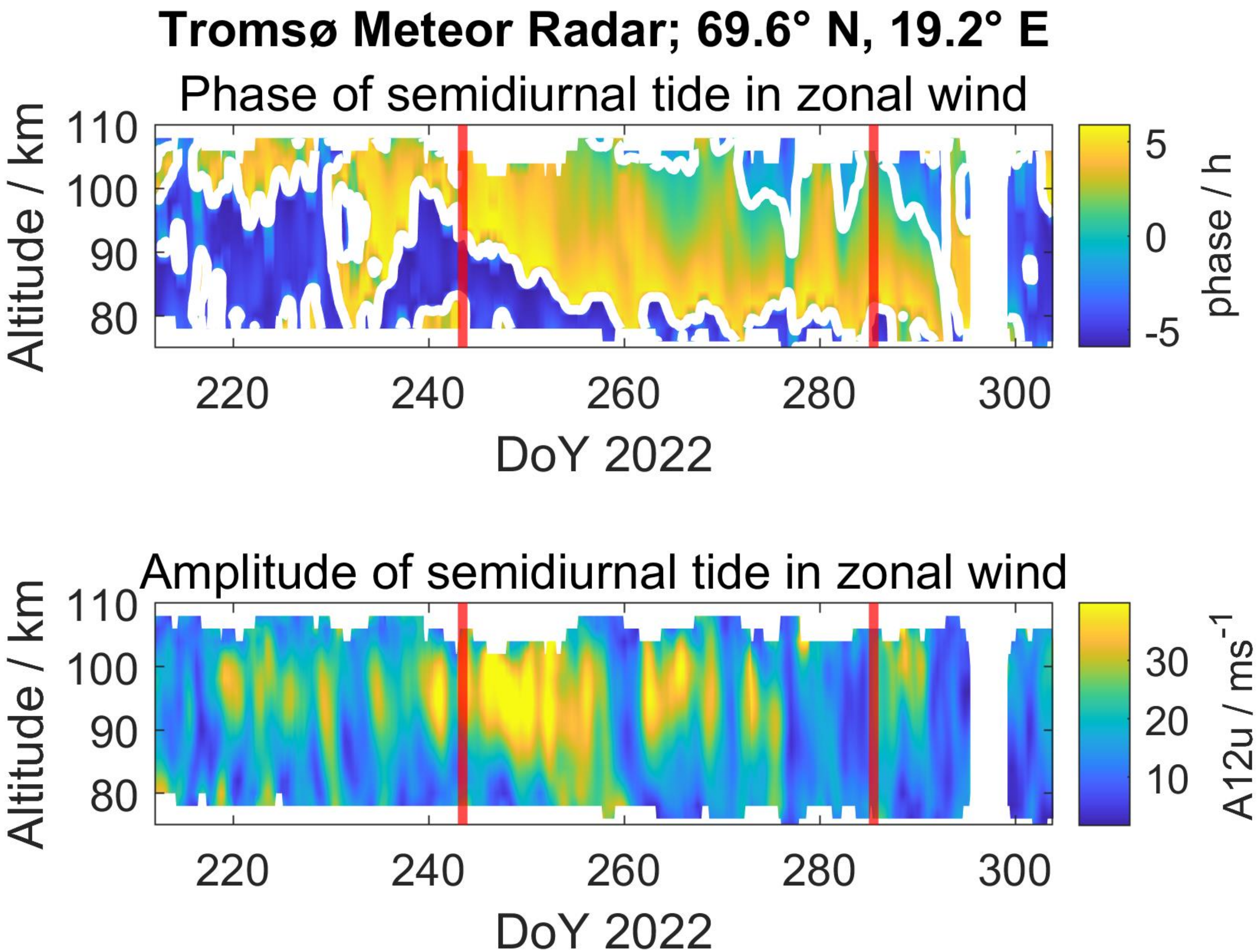


October 13, 2022



➔ September 01: wave period undergoes shift at $\sim 92 - 94$ km altitude
➔ October 13: wave period is constant with altitude

Parameter transition coincides with tidal maximum



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Summary

- 3D measurement of a single AGW-TID wave mode possible with the EISCAT radar and the Nordic Meteor Radar Cluster
- Fourier filtering and wave fitting give vertical and horizontal wave parameters
- wave parameters notably impacted by atmospheric variability as shown for the amplification of the semidiurnal tide before the MLT fall transition
- vertical profile of thermospheric winds can be inferred from wave parameters with moderate accuracy

see also:

F. Günzkofer *et al.*: EGUsphere [preprint], https://doi.org/10.5194/egusphere-2023-678, 2023.

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