

D/E region variability with regionally refined WACCM (WACCM-RR)

Marcin Kupilas



- D/E regions exist in the MLTI system between $\sim 60 - 100$ km.
- Models can struggle to represent the variability of this part of the atmosphere \rightarrow poor forecasting capability.
- This is important as its behaviour can couple to regions above and below, impacting climate and space weather.
- Better understanding of MLTI variability is needed to improve forecasting capabilities.
- WACCM-RR

WACCM-RR

- WACCM with regional refinement capability via spectral element dynamical (SE) core.
- All capabilities of WACCM SE but with refined mesh
- Build grid using VRM Editor software

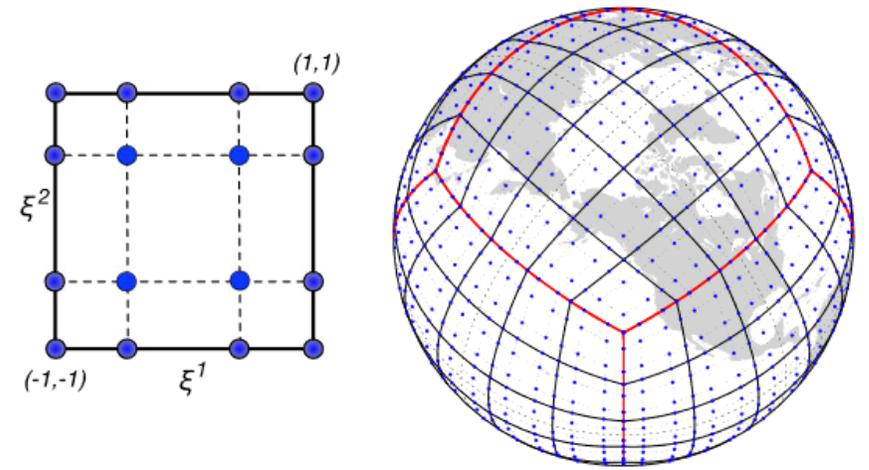
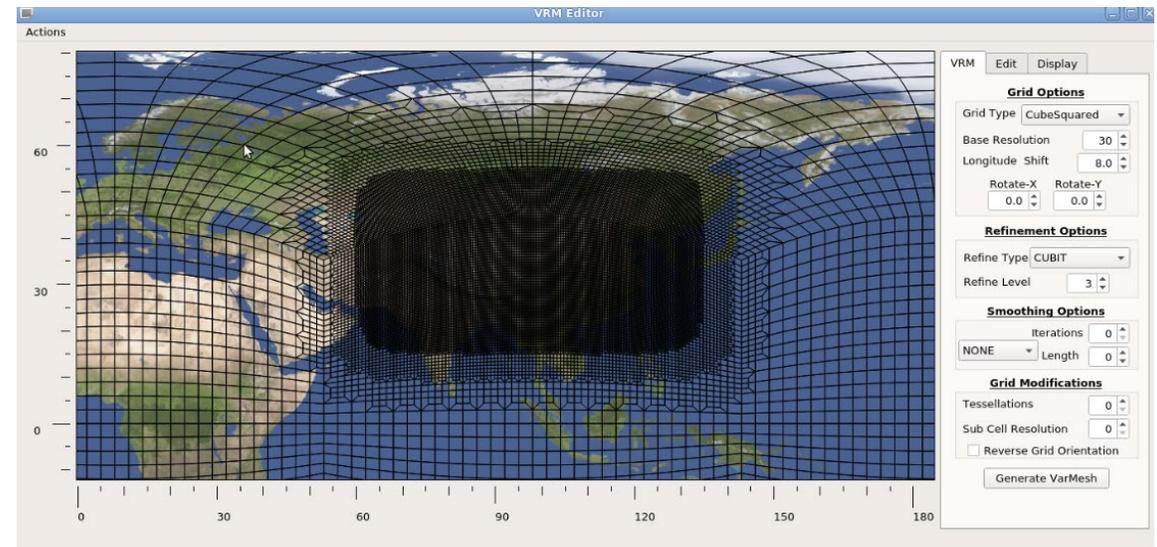


Figure 2. The left panel shows the Gauss-Lobatto-Legendre (GLL) grid with $N_p \times N_p$ quadrature points defined on a standard element $[-1, 1]^2$, where $N_p = 4$. The right panel shows the cubed-sphere (S) grid system tiled with $6N_e^2$ spectral elements Ω_e , where N_e is the number of elements in each coordinate direction on a panel (in this case $N_e = 5$). Each element Ω_e on S has the GLL grid structure.

Lauritzen et al. (2018)





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WACCM-RR: A Regionally-Refined Version of the Whole Atmosphere Community Climate Model

ATMOSPHERIC SCIENCES

GRAVITY WAVES

MESOPAUSE

MESOSPHERE AND LOWER THERMOSPHERE

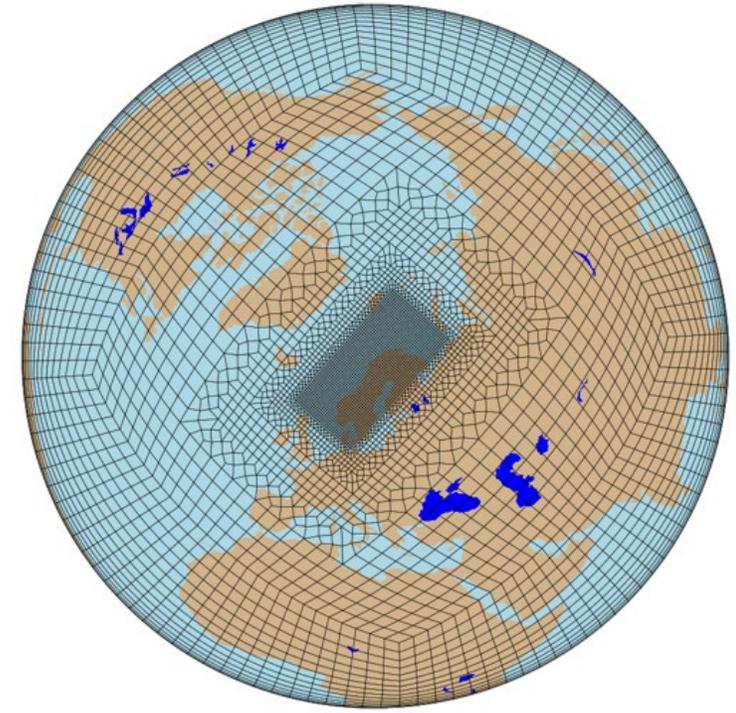
VERTICAL MIXING



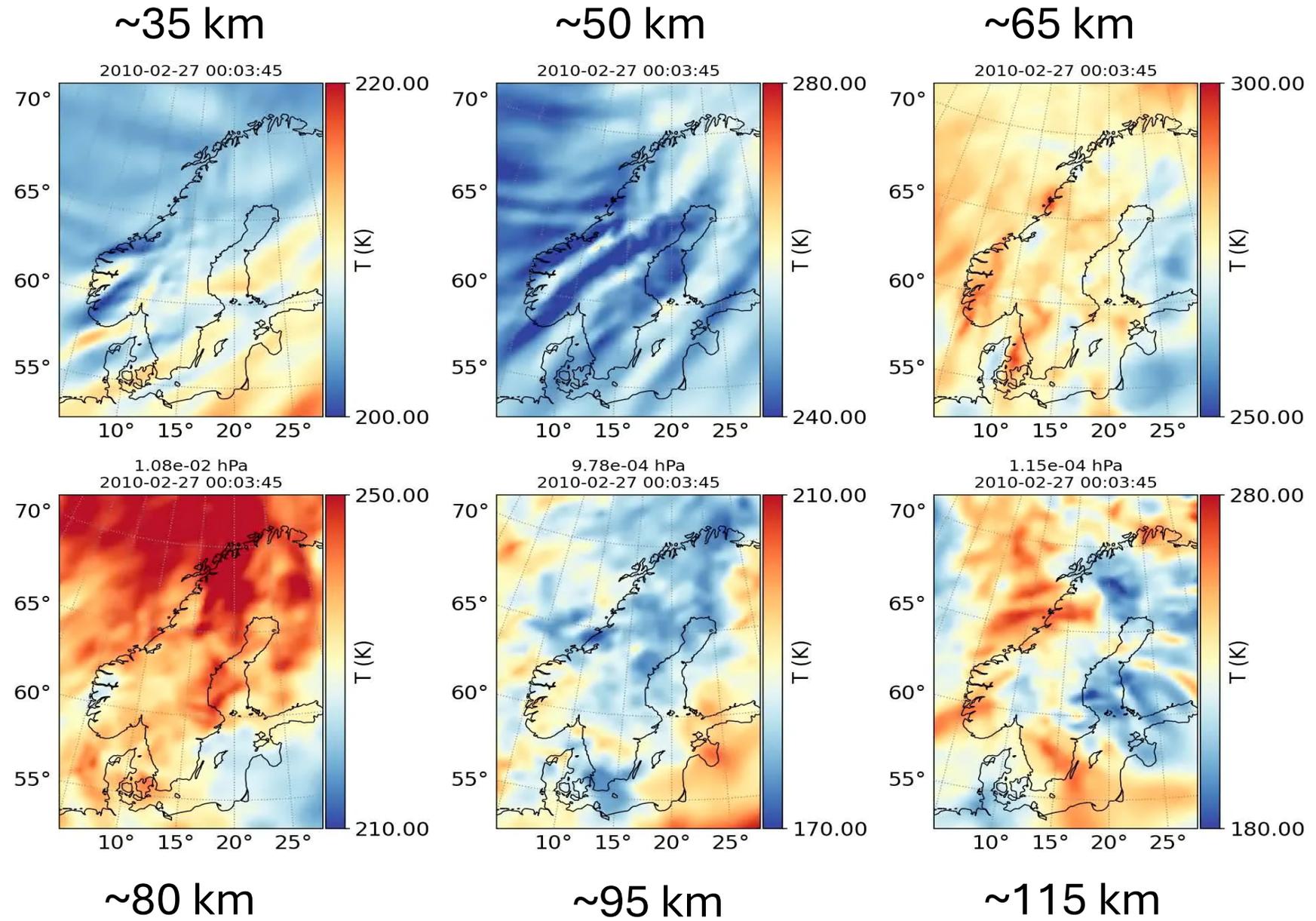
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Chester S. Gardner , Maria Vittoria Guarino , Joanna Victoria Egan , Wuhu Feng ,
John Maurice Campbell Plane

Scandi-RR

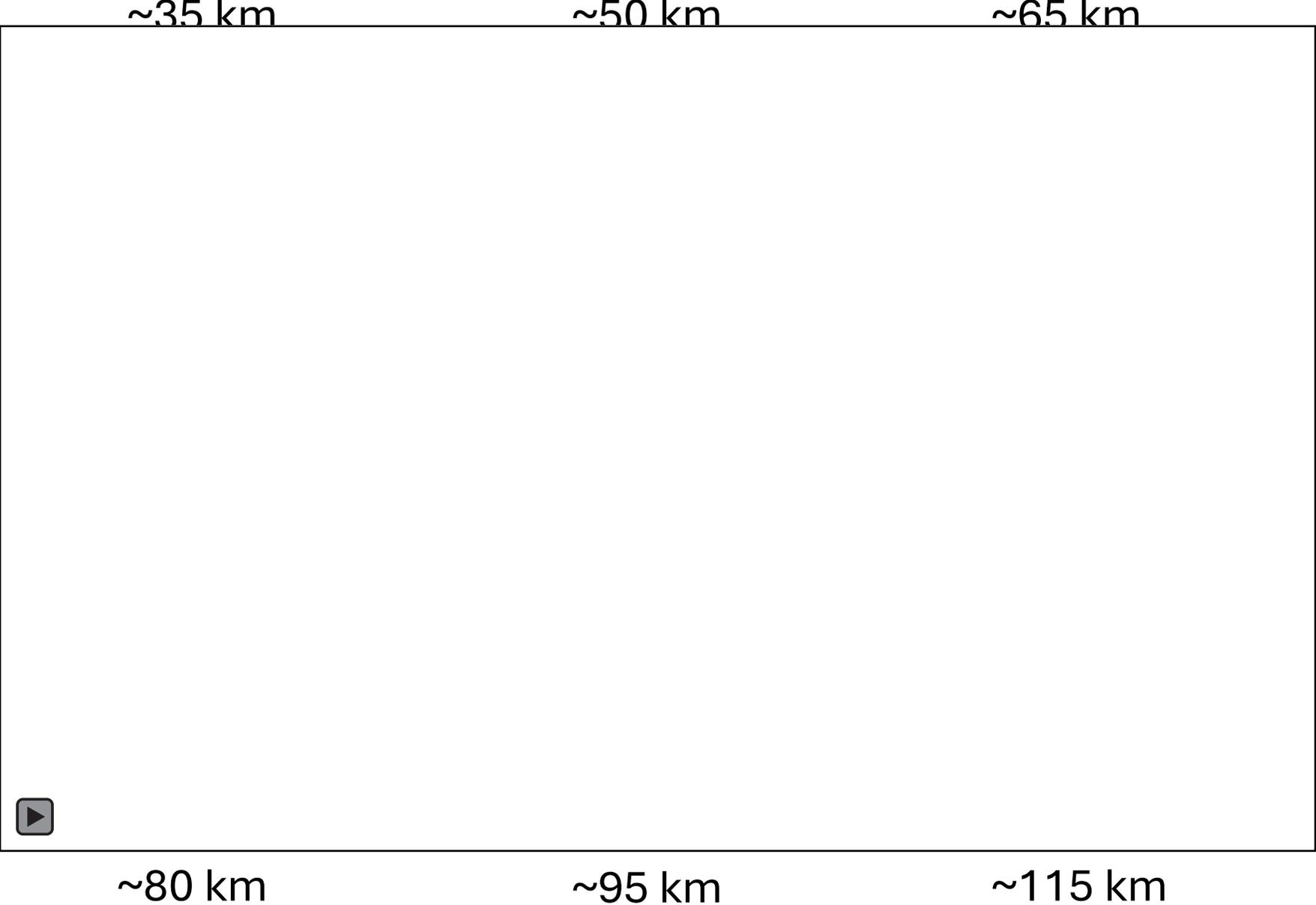
- $\Delta x, \Delta y = 1/8^\circ$ over Scandinavia, 1° elsewhere
- 135 vertical levels up to ~ 140 km, $\Delta z \sim 2.5$ km in MLTI
- $\Delta t = 3$ min 45 s
- Ran from mid March – mid April 2010
- Historical atmosphere (FWmaHIST)
- GW param off over $45^\circ < \text{latitude} < 90^\circ\text{N}$, $40^\circ\text{W} < \text{lon} < 75^\circ\text{E}$



Scandi-RR Temperatures – February conditions



Scandi-RR Vertical winds – February conditions



Scandi-RR Electron density – February conditions

~65 km

~80 km

~95 km

~115 km

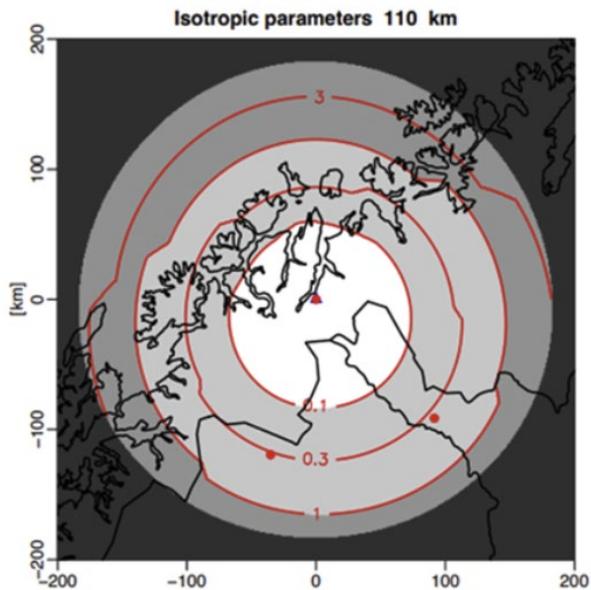
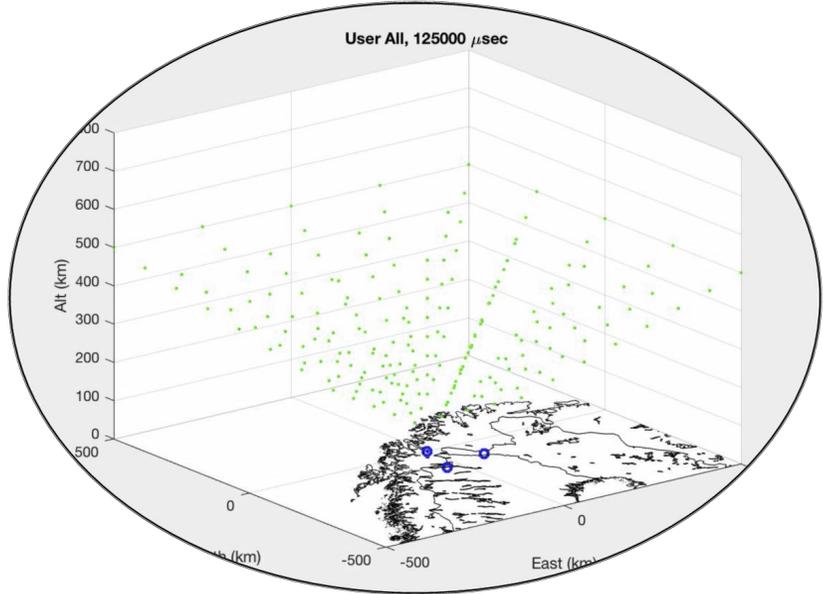


What would EISCAT 3D see?

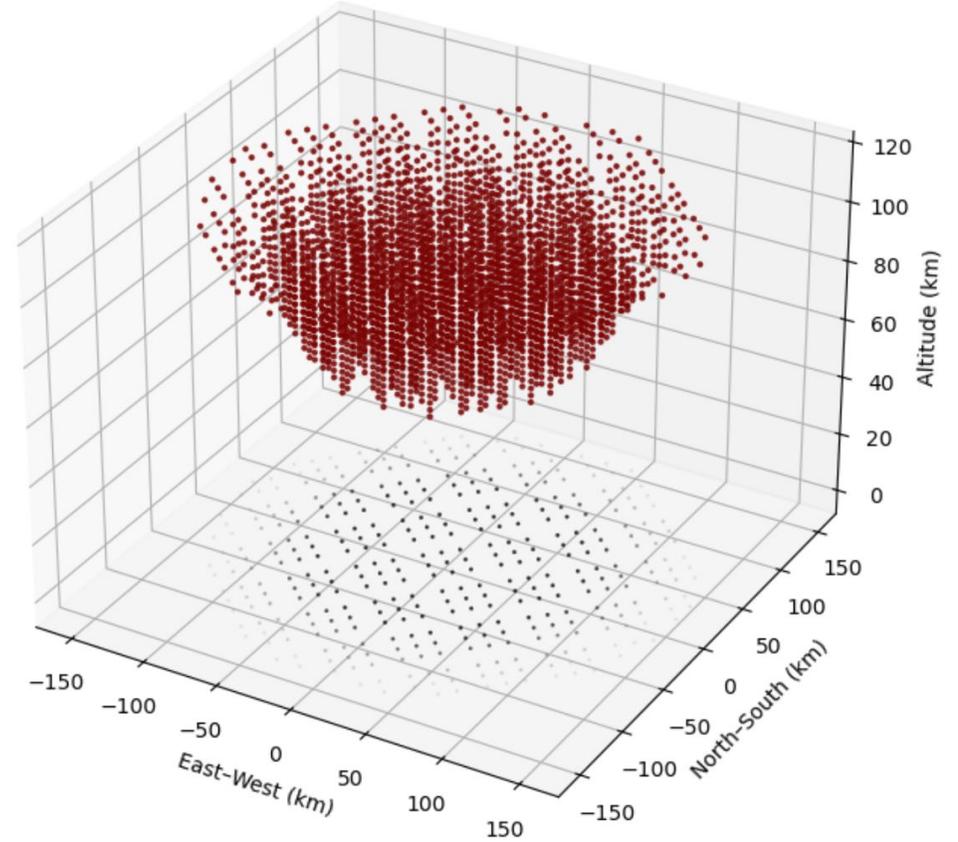
Artist impression of new EISCAT 3D site at Skibotn, Norway (~ 70N, 20E)

Kuva: NIPR

EISCAT 3D



Scandi-RR



- Different instrument viewing modes
- Model can be sampled at/near observed point (e.g., see Phoebe)

Scandi-RR Temperature - March conditions

80 km

95 km



Scandi-RR Vertical wind - March conditions

80 km

95 km



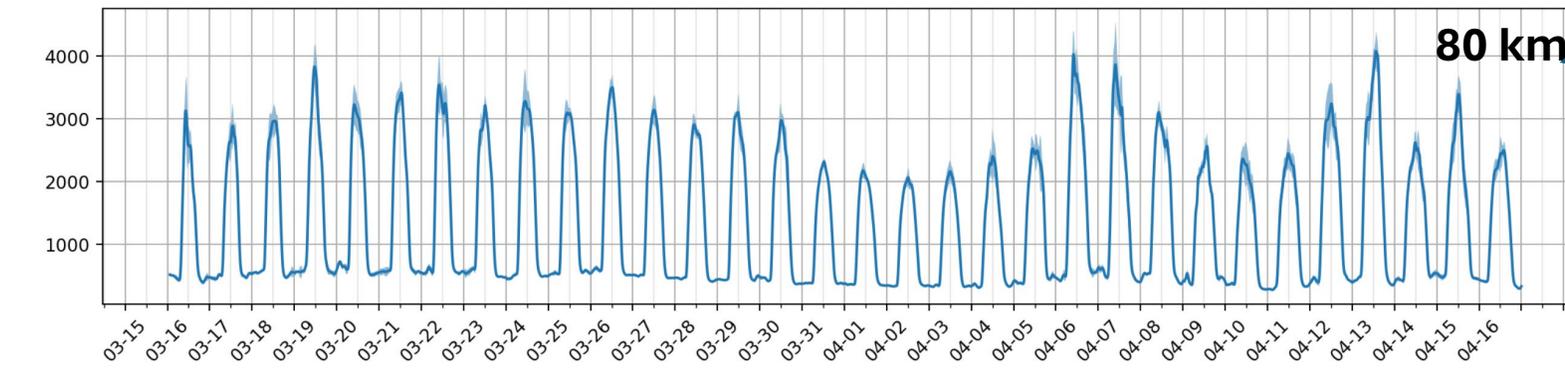
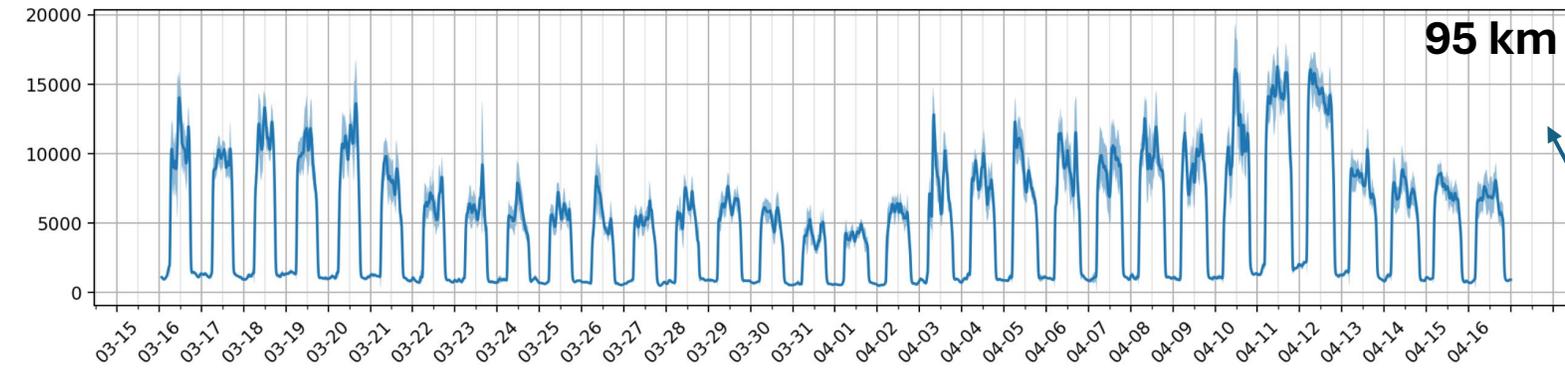
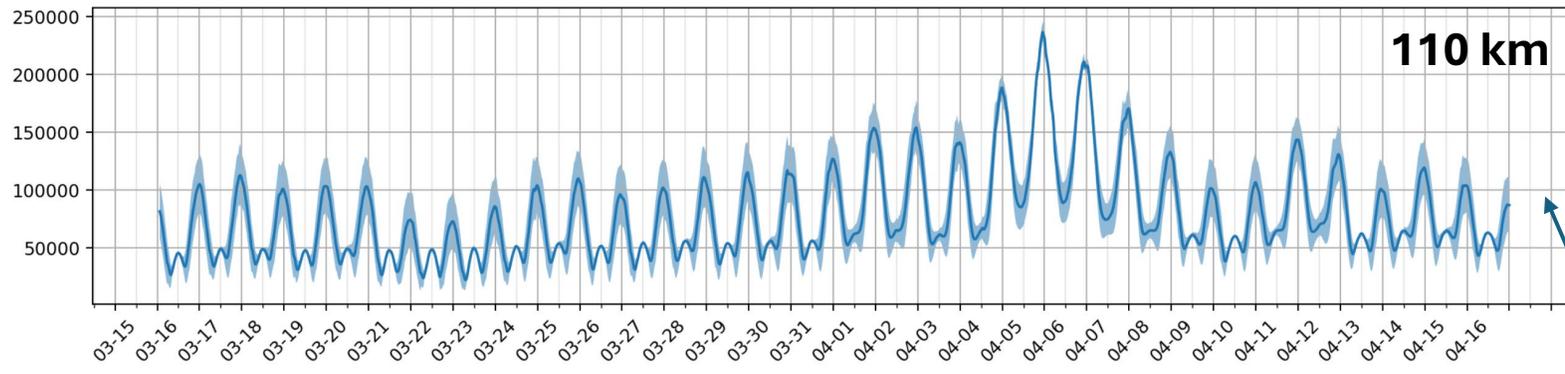
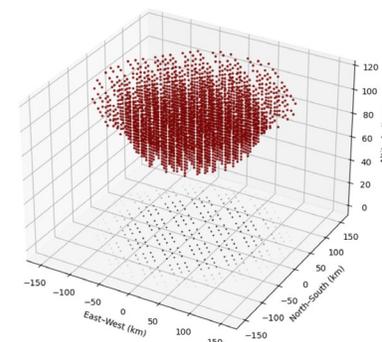
Scandi-RR Electron Density - March conditions

80 km

95 km



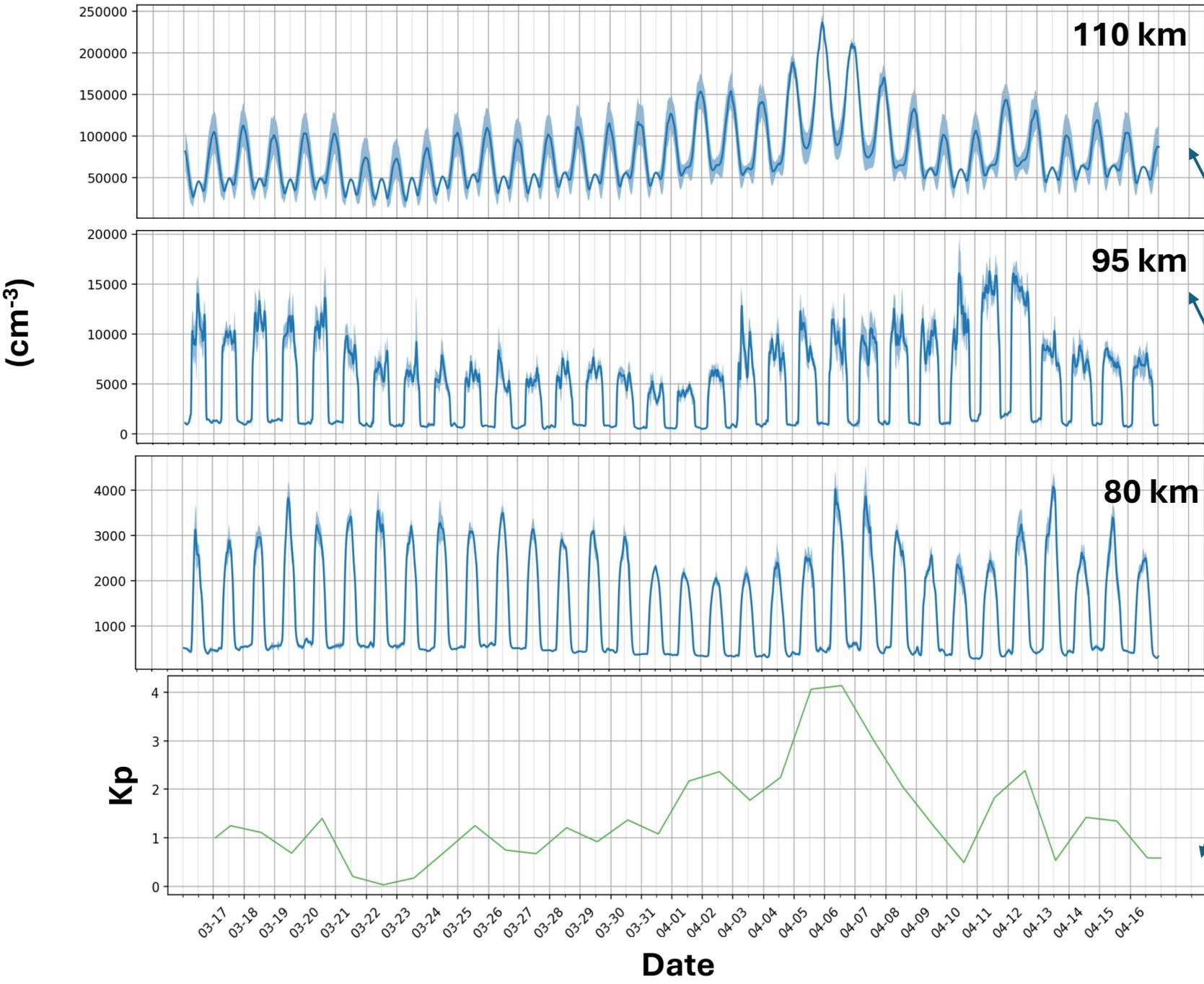
[e] (cm^{-3}) mean in E3D FOV



(cm^{-3})

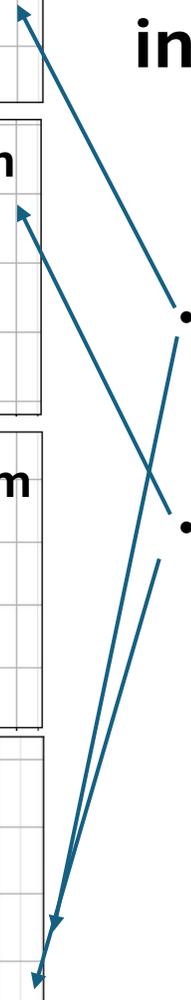
date

- Day/night cycle
- Sub-seasonal variability
- Short-scale variability
- Aurora dominates at night
- Photoionization dominates in the day



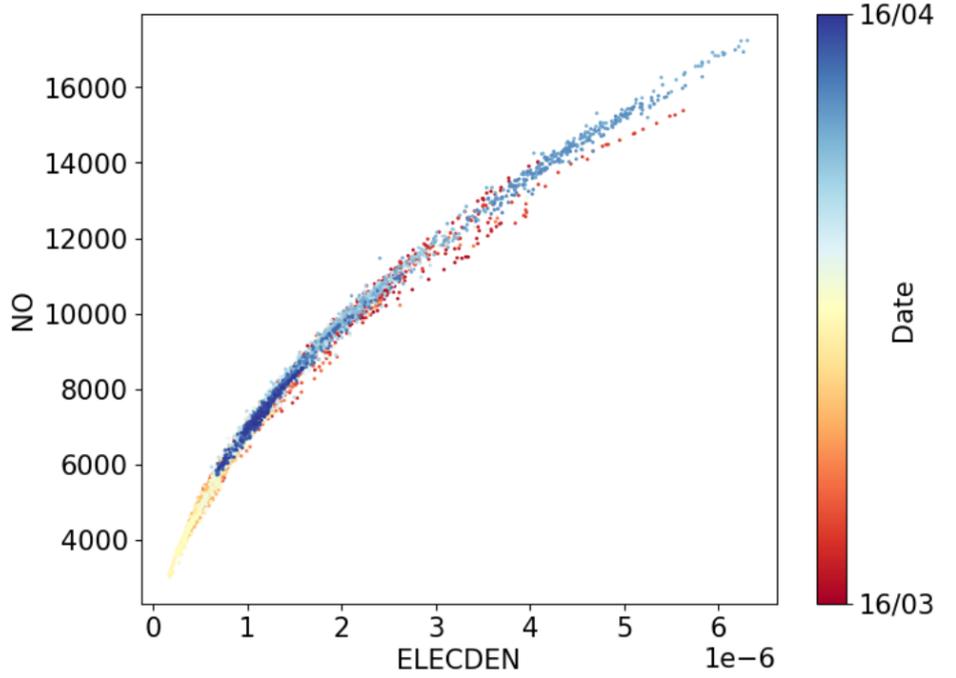
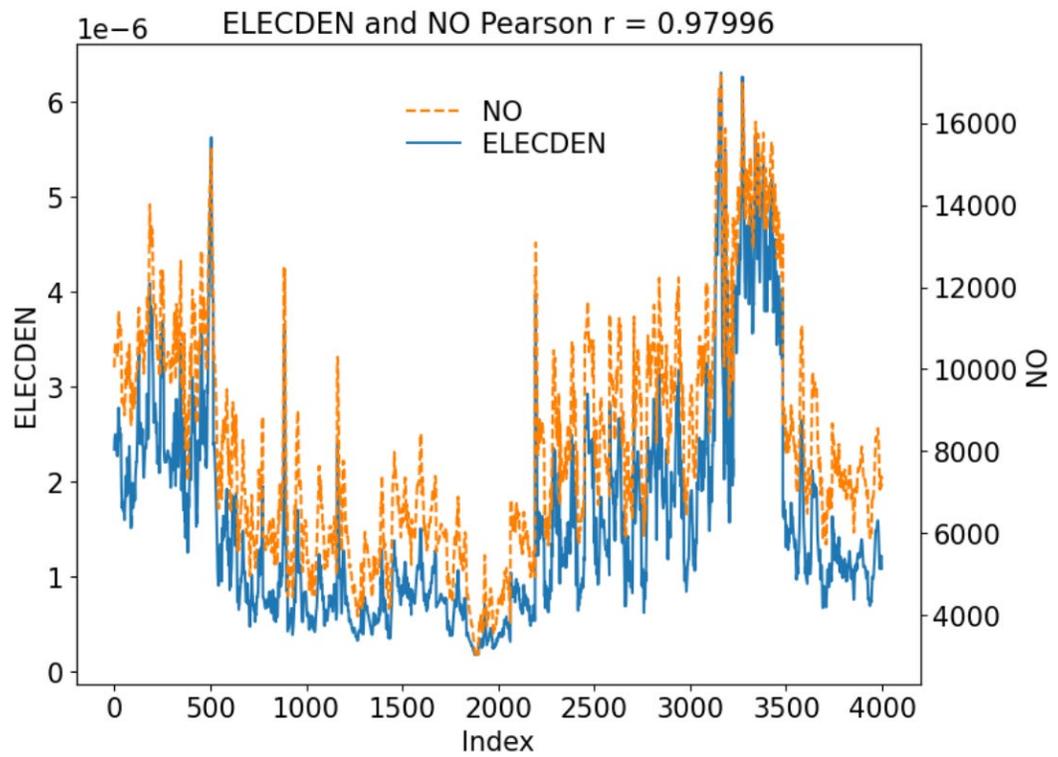
**[e] (cm⁻³) mean in
E3D FOV and Kp
index**

- Variability matches
- Lagged variability



Correlation of daytime Electron density and NO at 70N 20E 95 km Mid March – mid April

R = 0.98



Strong correlation between Elec den and NO on sub-seasonal and hourly timescales.

What's driving NO variability?

Summary

- WACCM-RR produces small-scale variability.
- Scandi-RR: Small-scale variability seen in electron density which is perturbed by NO.
- Next step: What is perturbing NO?

Thank you

Andrew Kavanagh, Chester Gardner, Corwin Wright, Daniel Marsh, John Plane, Juliana Jaen, Maria-Vittoria Guarino, Nicholas Davis, Peter Lauritzen, Phoebe Noble, Tracy Moffat-Griffin, Wuhu Feng