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Scandinavian Lithosphere Structure derived from Surface Waves and Ambient Noise

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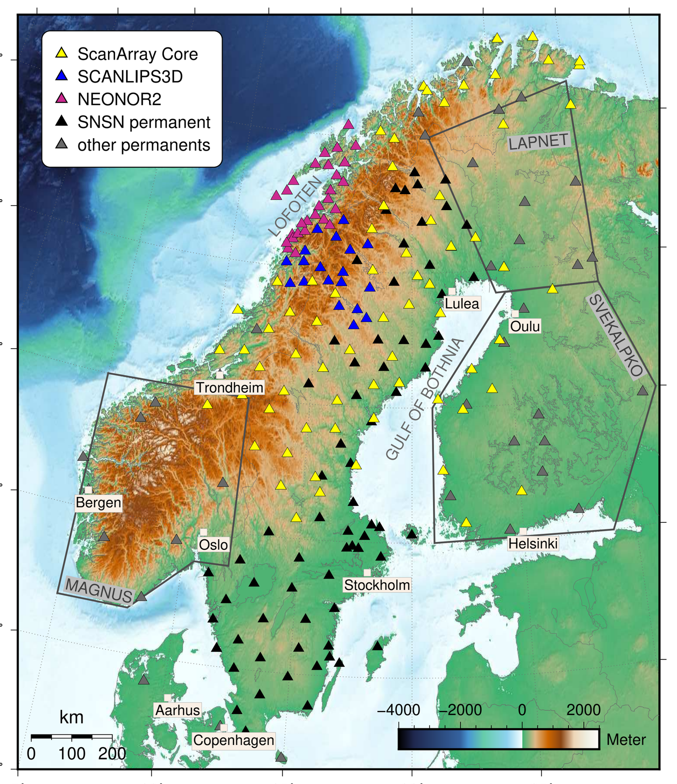
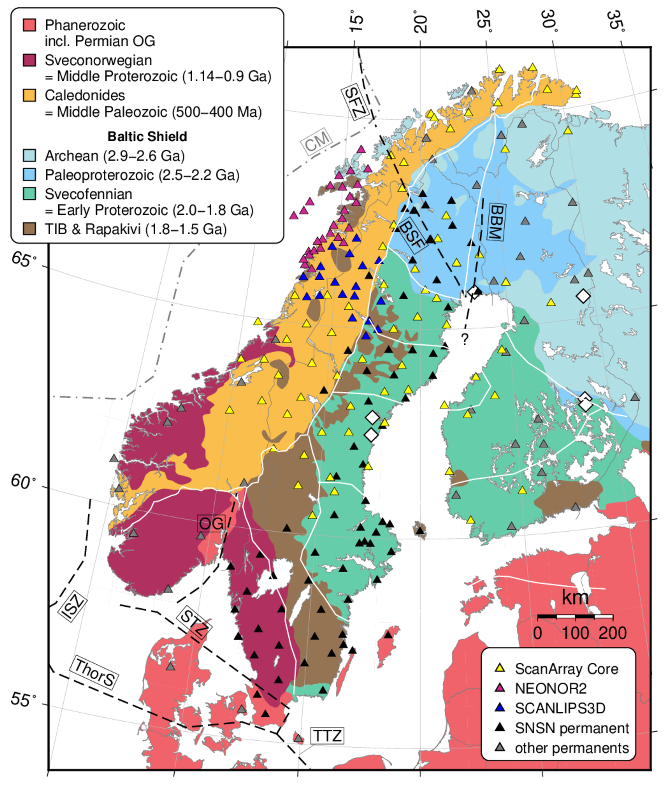
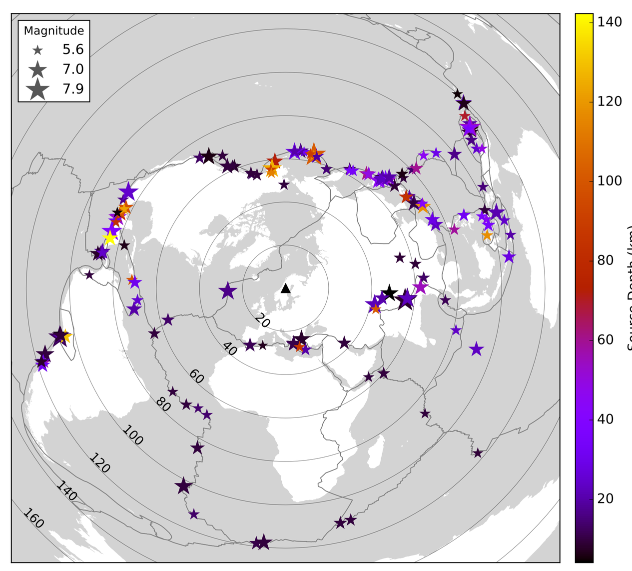
1 Study Region

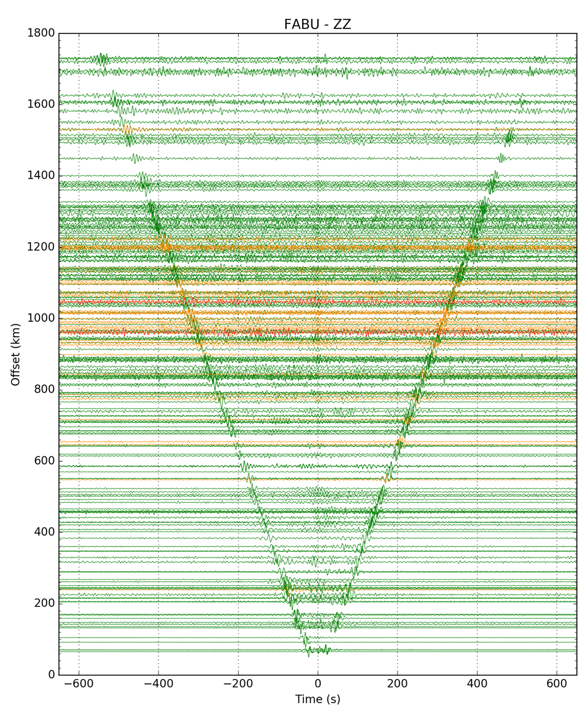




- Scandes mountain range runs along the western margin of Scandinavia with highest topography in southern and northern Norway
- **Unusual high topography at passive continental margin** in the absence of recent compressional tectonic settings
- The Scandes mountain range generally consists of the Caledonian eroded core (yellow region, ca. 420 Ma old)
- ScanArray project has available more than 220 stations
  - core network 1G with 72 stations operated between 2013 and 2017 [Grund et al, 2017]
  - NEONOR2 subnetwork 2D with 28 stations
  - Scanlips3D network ZR with 20 stations
  - 72 Swedish permanent stations from SNSN (UP)
  - ca. 40 other permanent stations (FN, HE, NO, NS, DK)
- Previous studies in southern Norway indicate a shallow LAB with low V_S and no crustal root beneath the mountains. The LAB is deepening towards the east [Maupin et al, 2013]

2 Methods





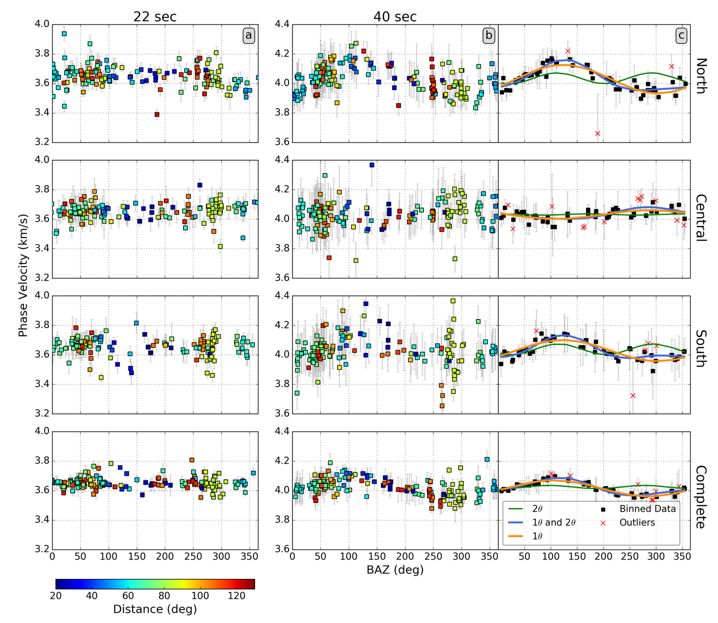
Surface Waves

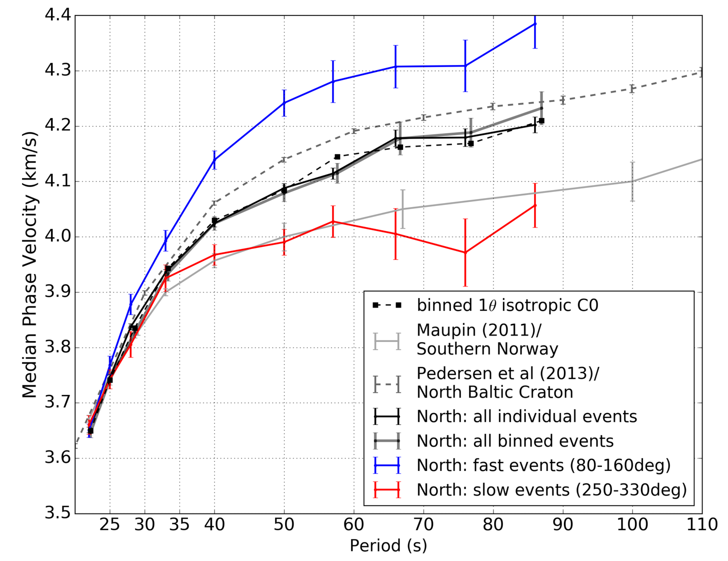
- Rayleigh waves from ~190 events with $M_S > 5.7$
- We use the beamforming technique after Maupin et al, 2011 to investigate phase velocity-BAZ dependencies in three sub-regions: South, Central, North (*see Box 3*).
- Phase velocity maps up to 160 sec were generated using the two plane waves method (TPW) by Forsyth & Li, 2005 (*see Box 4*).
- For the V_S-depth inversion (*see Box 5*) we apply a transdimensional Bayesian method [*BayHunter* by Dreiling & Tilmann, 2019; see poster D1473 | EGU2020-11544 (same session)]

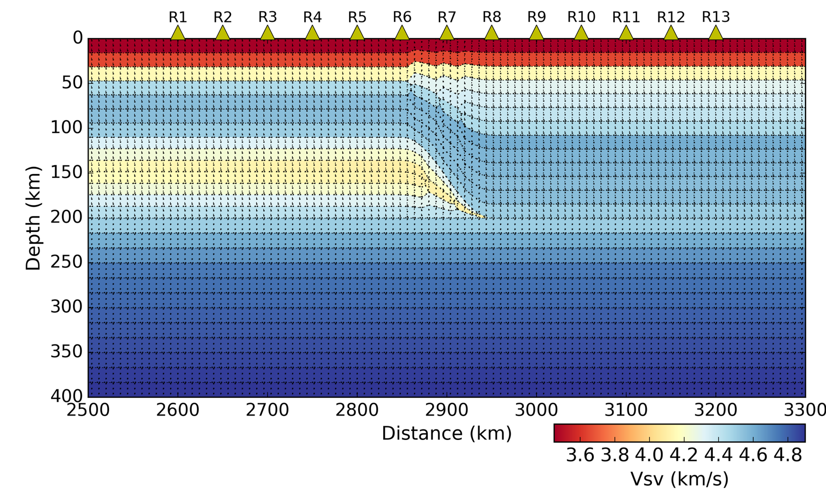
Ambient Noise

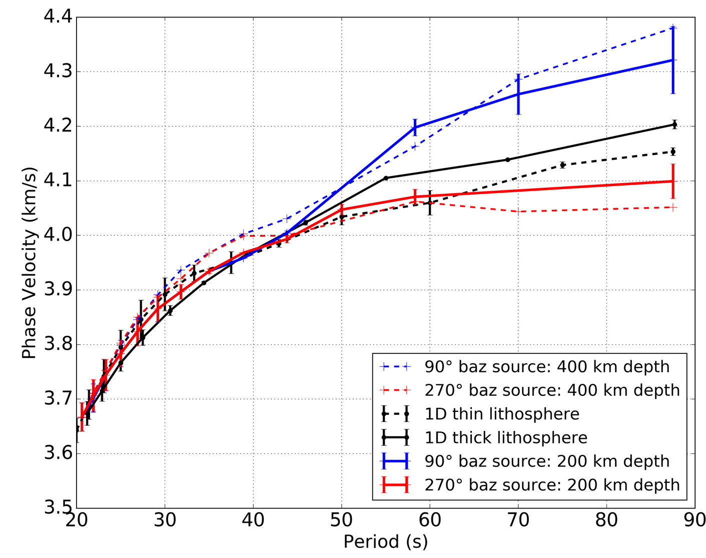
- Cross-correlations from ~20,000 station pairs were analysed up to a period of 50 seconds and station distance of 1800 km. Dispersion curves were automatically picked after Sadeghisorkhani et al, 2018
- Phase velocity maps were calculated using a transdimensional McMC approach after Tilmann et al, 2020

3 Beamforming and Azimuthal Variation









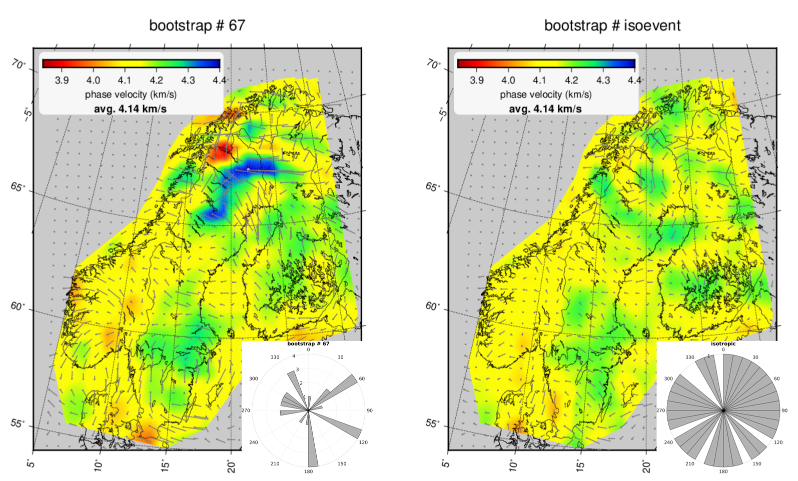
Beamforming of Rayleigh Data

- Northern and Southern regions show a surprising **360° ($sin(1\theta)$) variation with BAZ** for periods > 35 sec with ±2.5% velocity variation, measured for backazimuths of 120° and 300° [Mauerberger et al (in revision)]
- In the **Central area** this fluctuation is **absent** for all periods
- We do not observe systematic deviations from the theoretical BAZ for any region

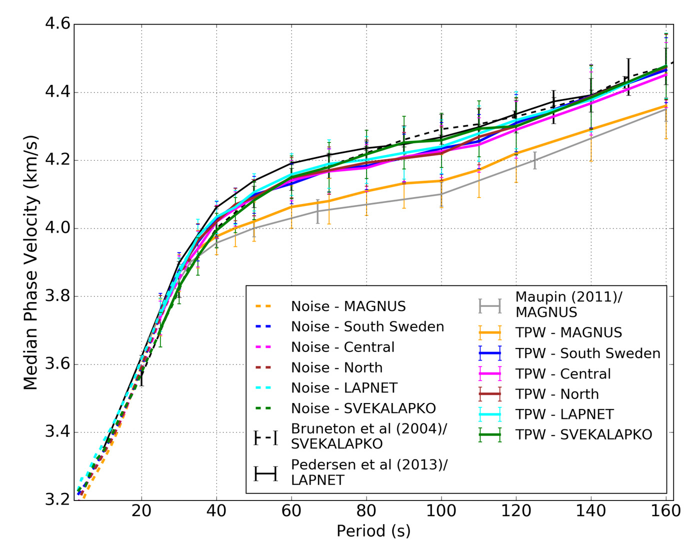
2D Full Waveform Modeling

- We can relate the 1θ variation to a sharp lateral and vertical gradient in the lithosphere
- Phase velocities are increased for waves propagating from thicker to thinner lithosphere. For waves propagating from thinner to thicker lithosphere the phase velocities are clearly decreased in agreement with our observations
- We attribute this effect to a complex interaction of forward and backward scattered surface waves

4 Surface Waves



Phase velocity maps at 80 s obtained from TPW. To estimate the azimuthal bias assumed from our 1θ observation, we conducted an event bootstrapping 100 times. Different strong small-scale artefacts are found for unequal event distributions in the north (one example shown left). Using uniform event distributions the artefacts disappear (right).



Comparison of median dispersion curves from the ambient noise and surface wave phase velocity inversions for several sub-regions. Only southern Norway has significantly lower velocities for >40 s.

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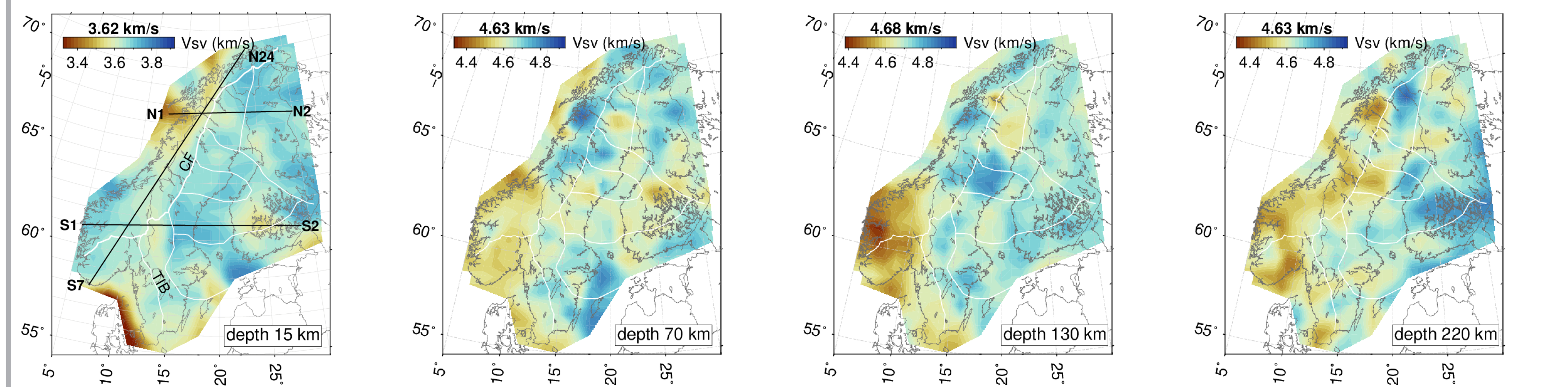
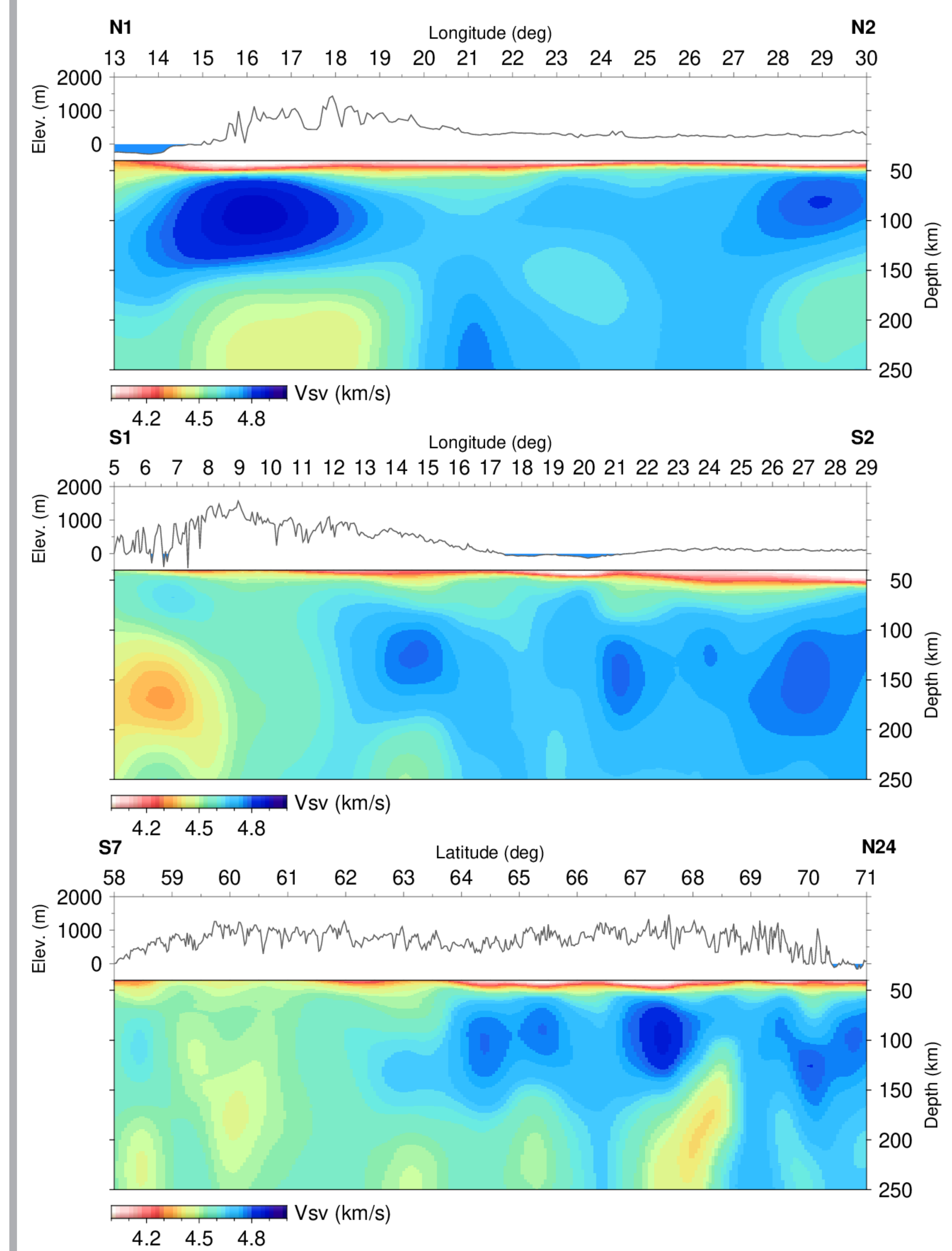
5 Final Lithospheric V_S Structure





- We can trace the low-density Transscandinavian Igneous Belt (TIB) at 15 km depth from southern Sweden towards the Lofoten/Nordland province in agreement with magnetic data
- No clear signature of the Caledonian front (CF) is present at any depth nor a pronounced crustal root throughout the Scandes
- LAB beneath northern Scandes yields even stronger V_S contrast of ~10% (compared to the south with ~6%, S1-S2) and an exceptional high-velocity lid <150 km depth (N1-N2).
- Central area shows less V_S perturbations from west to east
- These strong **vertical and lateral gradients** in the **North** and the **South** can be **related to the 1θ phase velocity variations**
- V_S heterogeneities beneath the Scandes (S7-N24) support the assumption of **different uplift mechanisms** for the **northern** and **southern** Scandes. We interpret the **central** Scandes as transition between both mechanisms resulting in lower surface topography
- We propose small-scale edge-driven convection along with mantle upwelling to sustain the northern Scandes topography
- Low-velocity region is imaged below the Paleoproterozoic northern Finland for >150 km depth (N1-N2, >28°E)
- Deep cratonic keel is obtained beneath the northernmost Finnmark region (S7-N24, >69°N), although overlain by Caledonian nappes (i.e. lithosphere has not been reworked since accretion)