



Galileo in ionospheric research

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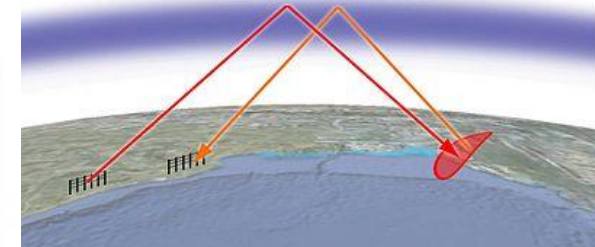
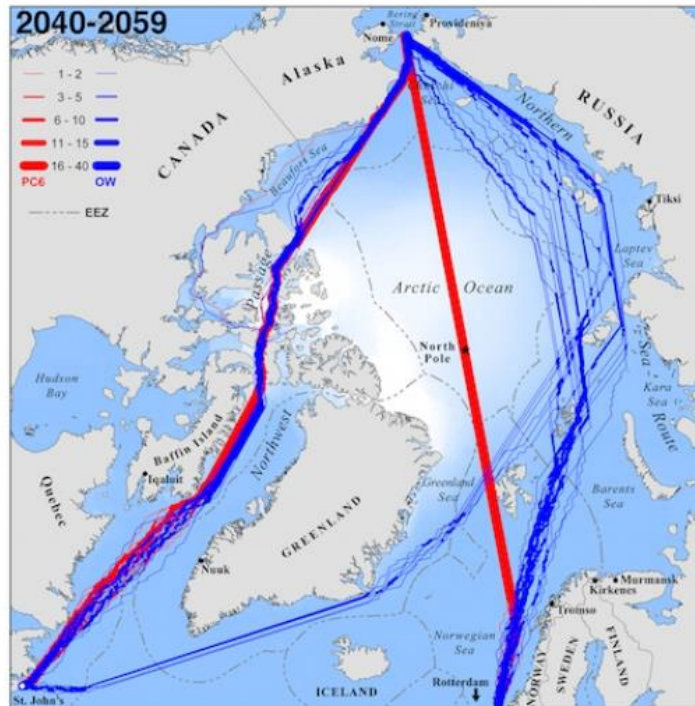
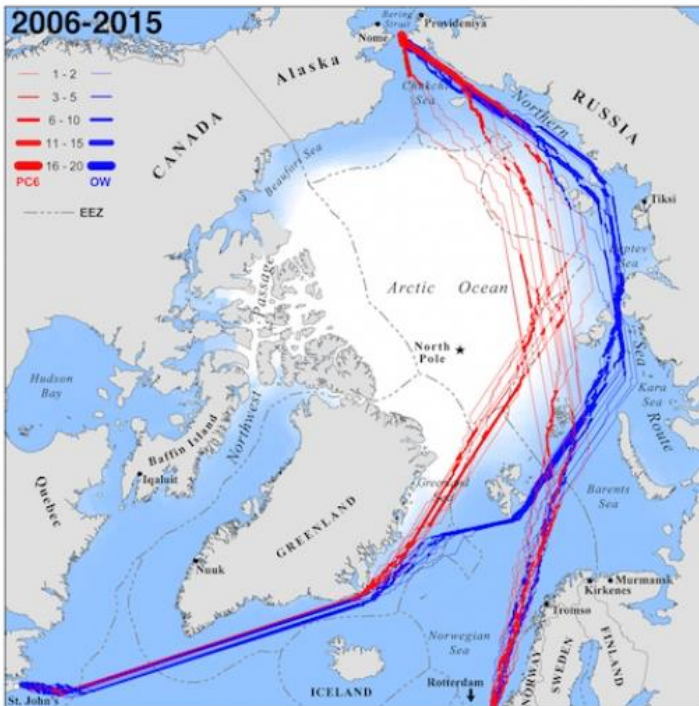
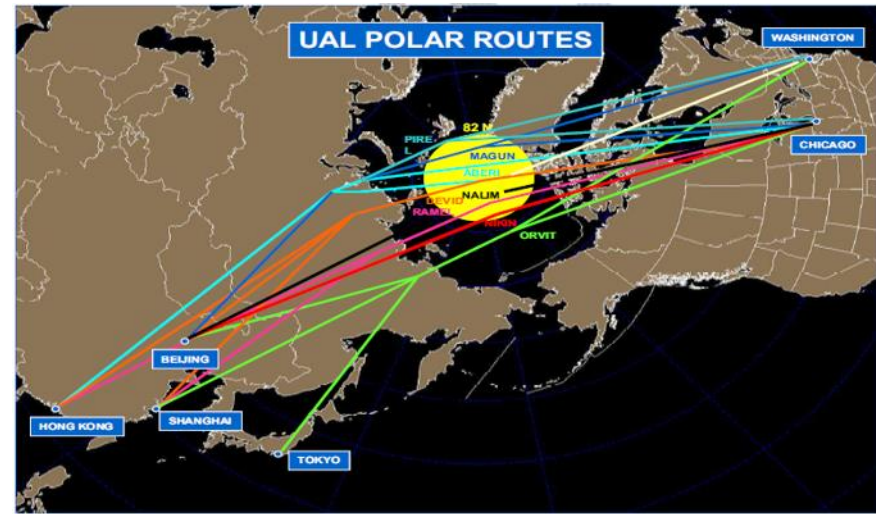


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Ionosphere disturbs signals

- Over the horizon communication with HF radio waves is used in arctic shipping and in aviation on polar routes
- Global warming opens new routes for arctic shipping
→ Saves time and money
- HF reflection conditions depend critically on ionospheric electron density conditions

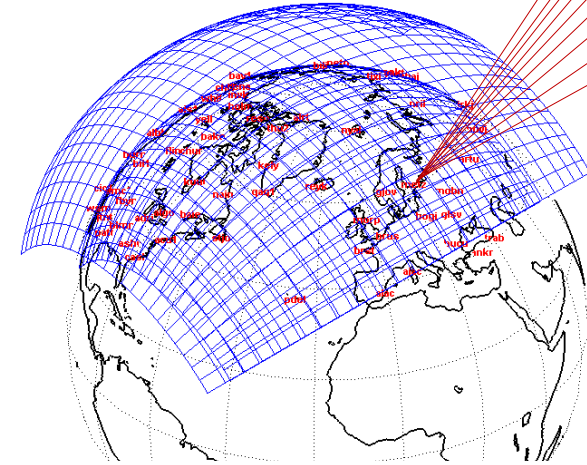
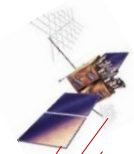


Figures:
Wikipedia
United Airlines
NAS

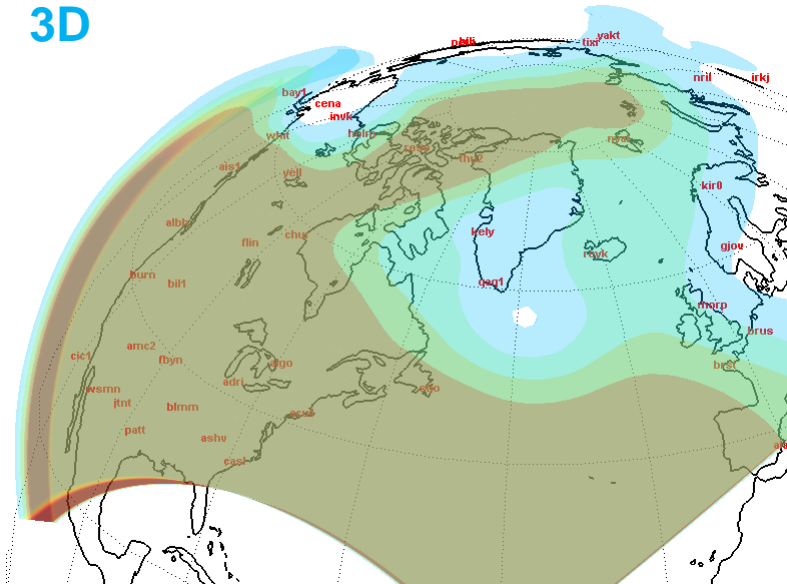
GNSS receiver networks are widely used in ionospheric research

- From the combination of L1 and L2 signals integrated electron density (N_e) along the signal path can be deduced
- Near-real-time data available from several networks → Suitable approach also for operational services
- Works well at low and mid latitudes and in global scales

$$\text{TEC} = \int_S^R N_e ds$$

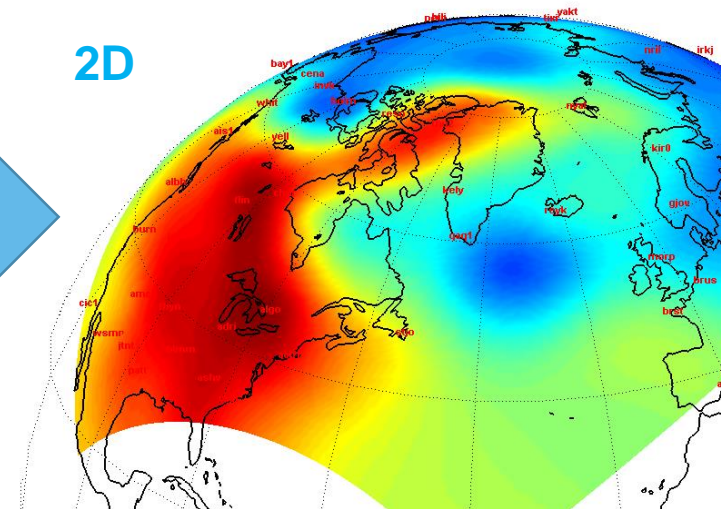


3D



Altitude integration

2D

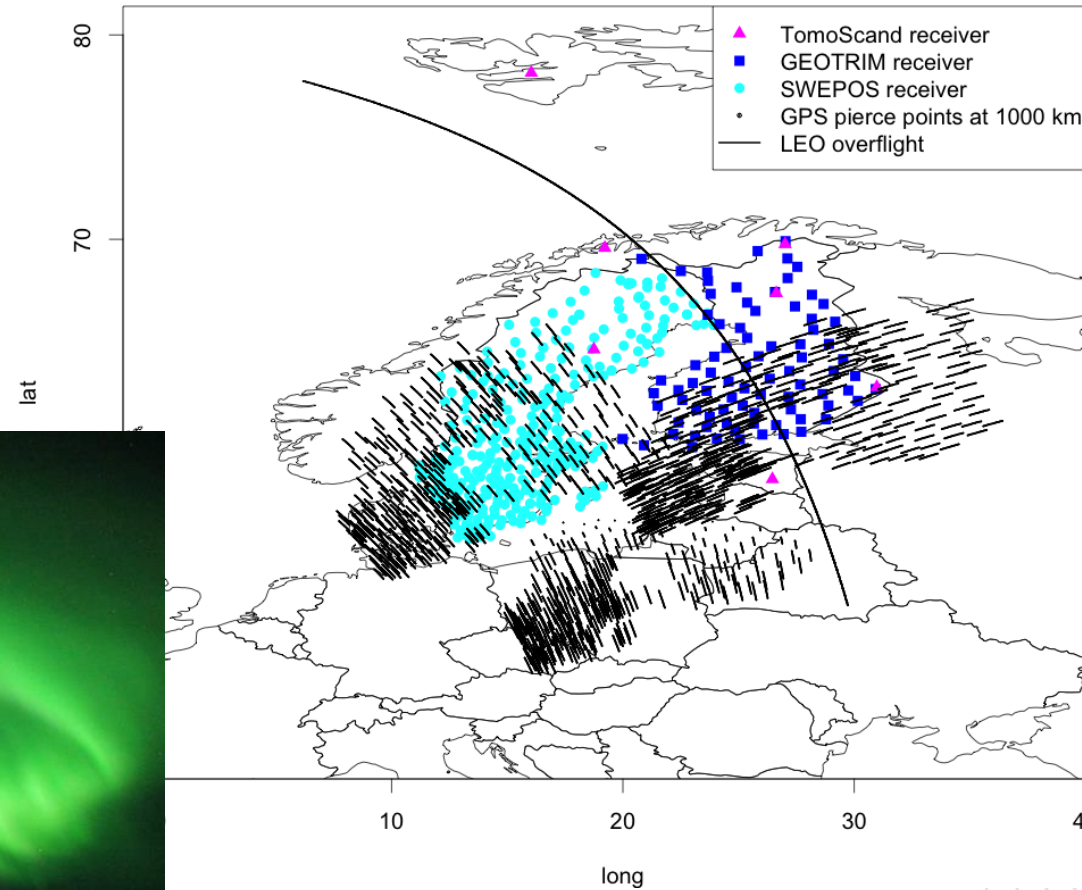


Figures: Pokhotelov et al, 2010



Challenges in the Arctic ionosphere

- Auroral activity causes dynamic small scale structures in the ionosphere
 - ➔ high space and time resolution needed
- GNSS signals available only at low elevation
 - ➔ less information from the regions where disturbances are strongest





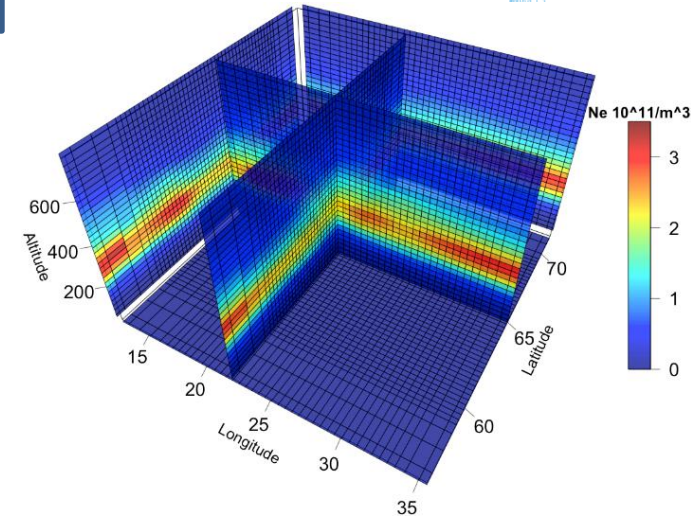
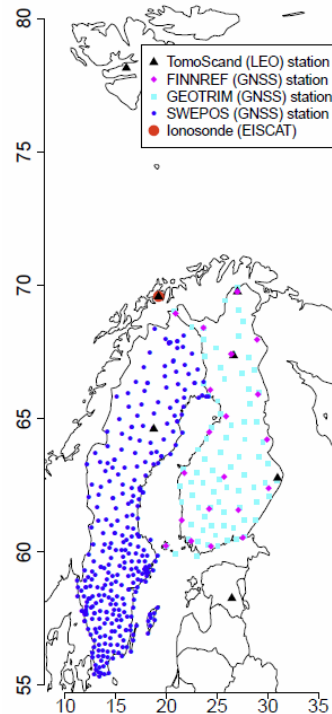
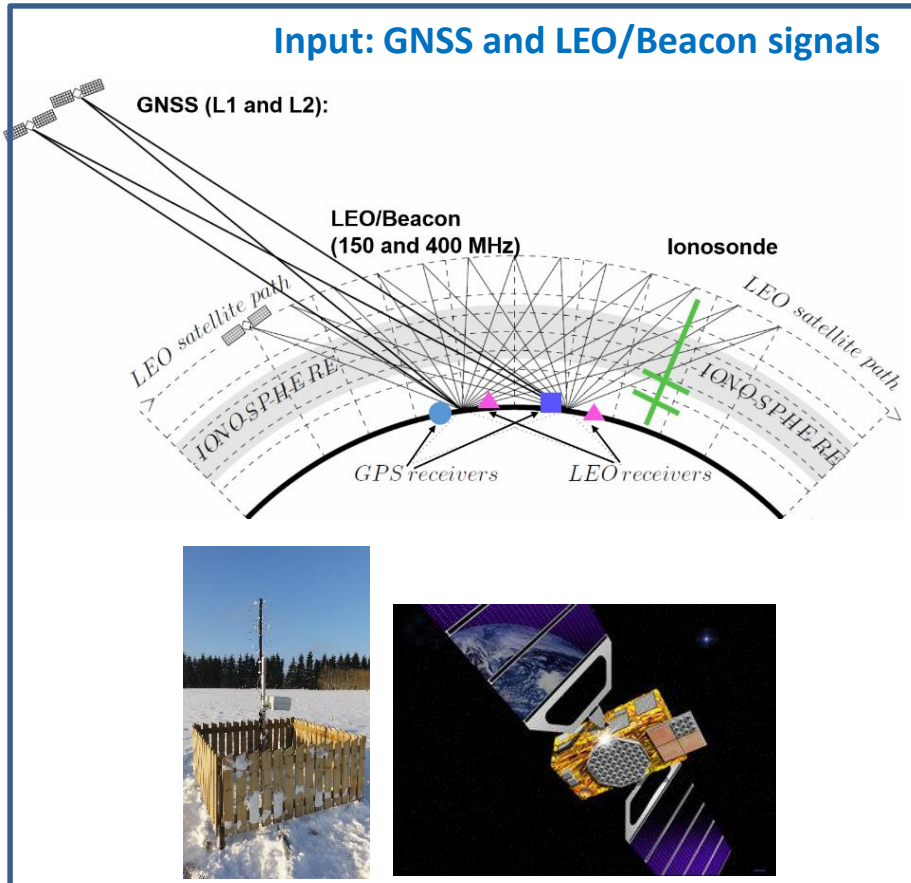
TomoScand – IONOSPHERIC TOMOGRAPHY

3D reconstruction for ionospheric electron density over Fennoscandia
Spatial resolution 5-20 km (typically ~100 km in global inversions)

Input: GNSS and LEO/Beacon signals

Bayesian statistical inversion

3D image of electron density

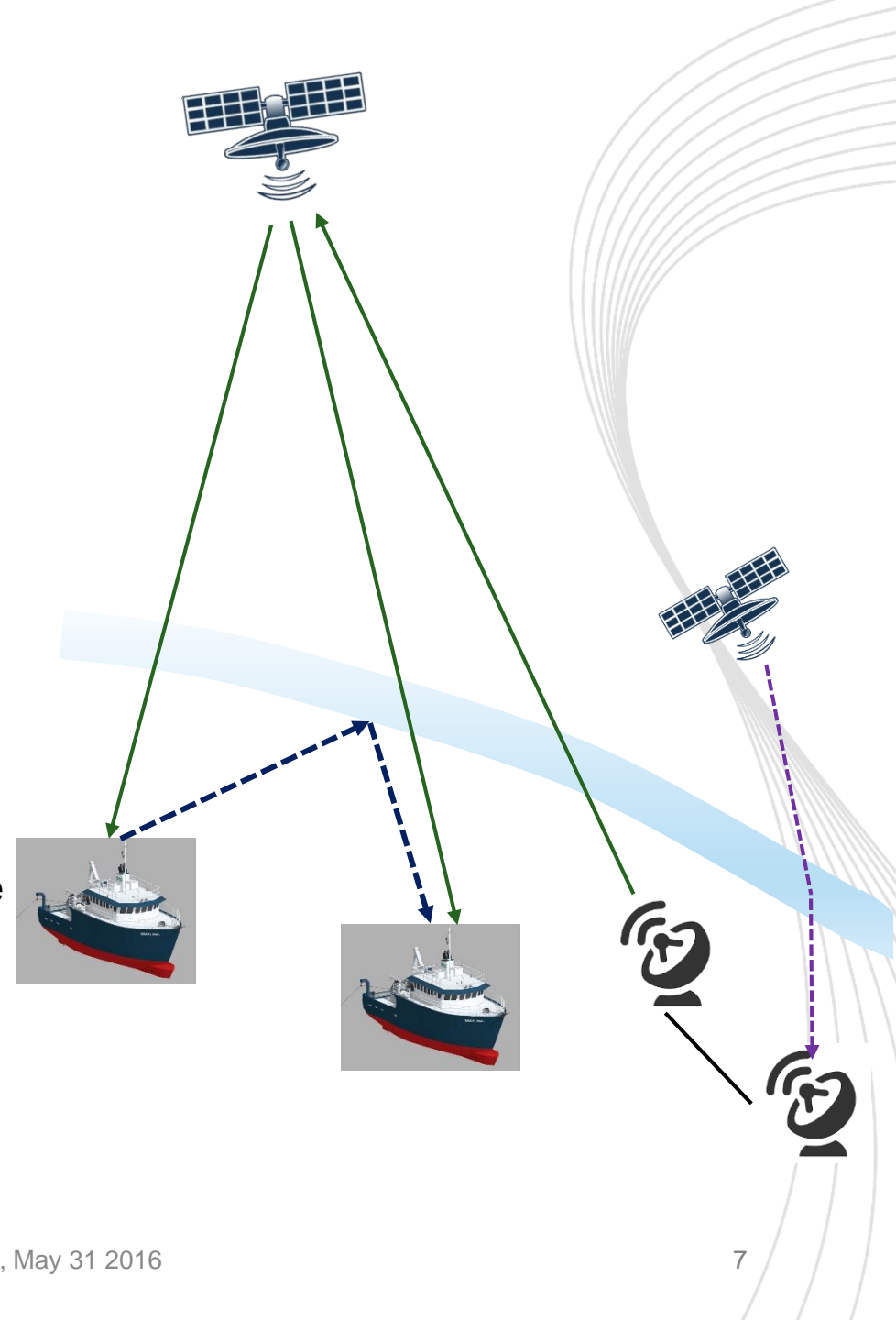


- **GNSS:** Continuous signal but limited in latitude and elevation angle
- **Beacon:** A snapshot over the whole area with a range of elevation angles but available only ~4 times per day



Future prospects

- Ionospheric weather service to support arctic HF communication:
- A combination of
 - Galileo signals
 - Beacon transmissions from polar LEO orbits
 - Tomography with computationally efficient, advanced inversion with error estimates
 - A communication satellite to transmit data for/from inversion
- LEO satellites:
 - i. Cubesats during the demonstration phase
 - ii. Beacon transmitters to future polar weather satellites
- Collaboration with Canada:
 - Ground-based instrumentation in archipelago to cover polar cap properly





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