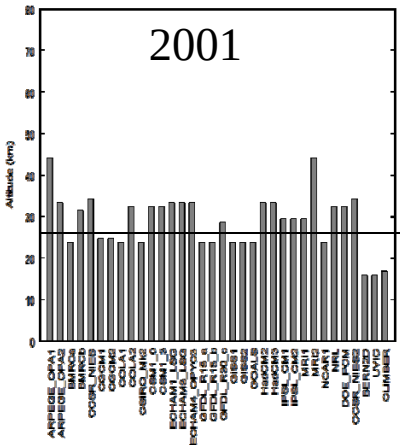
Atmospheric Science at NTNU

- Atmospheric and environmental physics group within the Department of Physics, NTNU
  - Patrick Espy, Professor
  - New professor, Autumn 2021
  - Robert Hibbins, Professor II
  - Yvan Orsolini, Professor II
  - Wim van Caspel, NTNU stipendiat
  - Ekatarina Vorobeva, NTNU stipendiat
  - Stefan Bender, Post-doctoral fellow
  - Post-doctoral fellow currently being hired
  - Typically 4-6 MSc students per year

Guiding models with observation

- Atmospheric models required to predict future weather & climate
- But models require mechanistic processes be known and understood before inclusion
- Many “tele-connection” mechanisms appear to occur through the upper atmosphere
- Long-term forecasts must include upper-atmospheric processes (many sub-grid-scale)
- Models therefore evolving higher into atmosphere **as processes become known**
- **NTNU is (hopefully) providing some of that observational knowledge**



IPCC climate assessments

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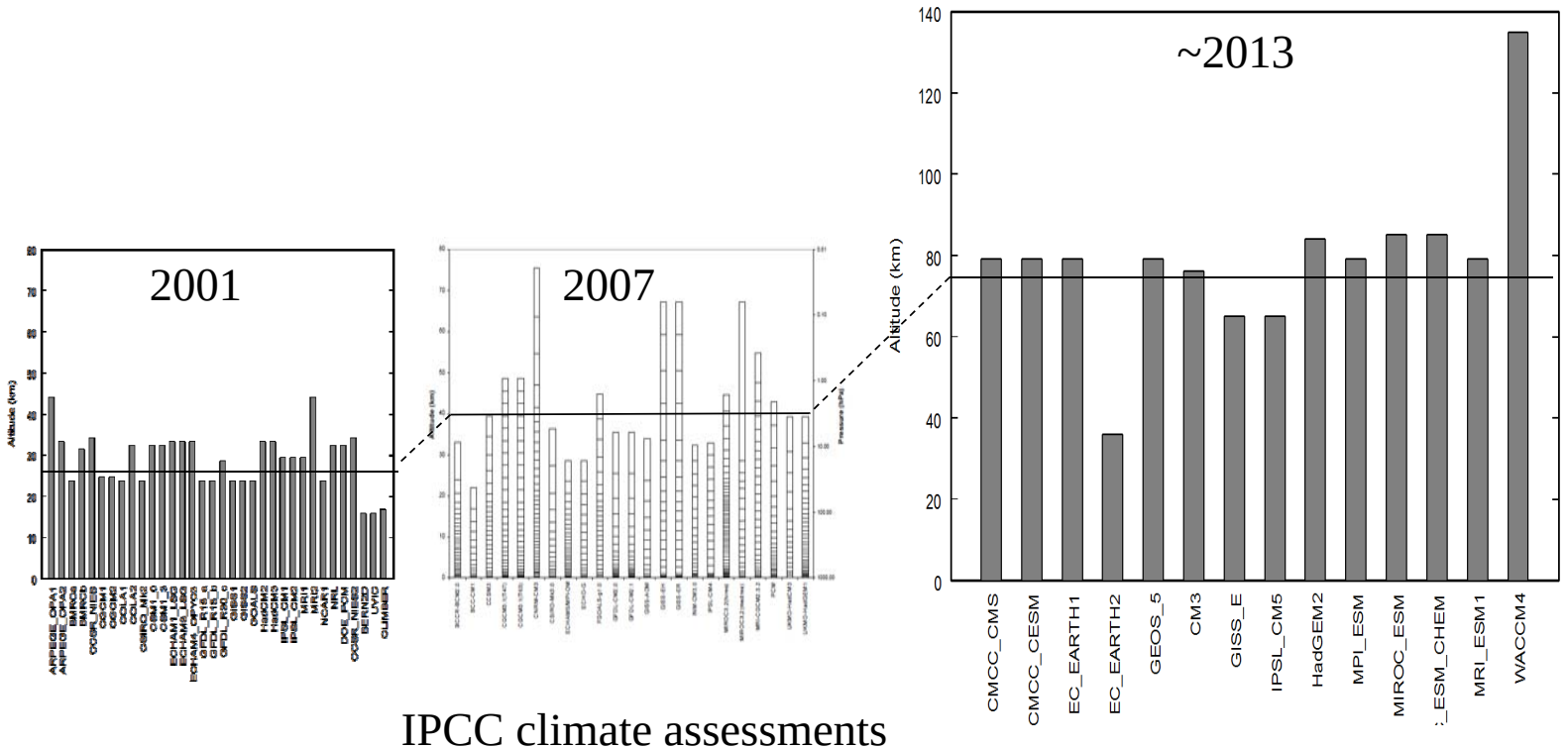

IPCC climate assessments

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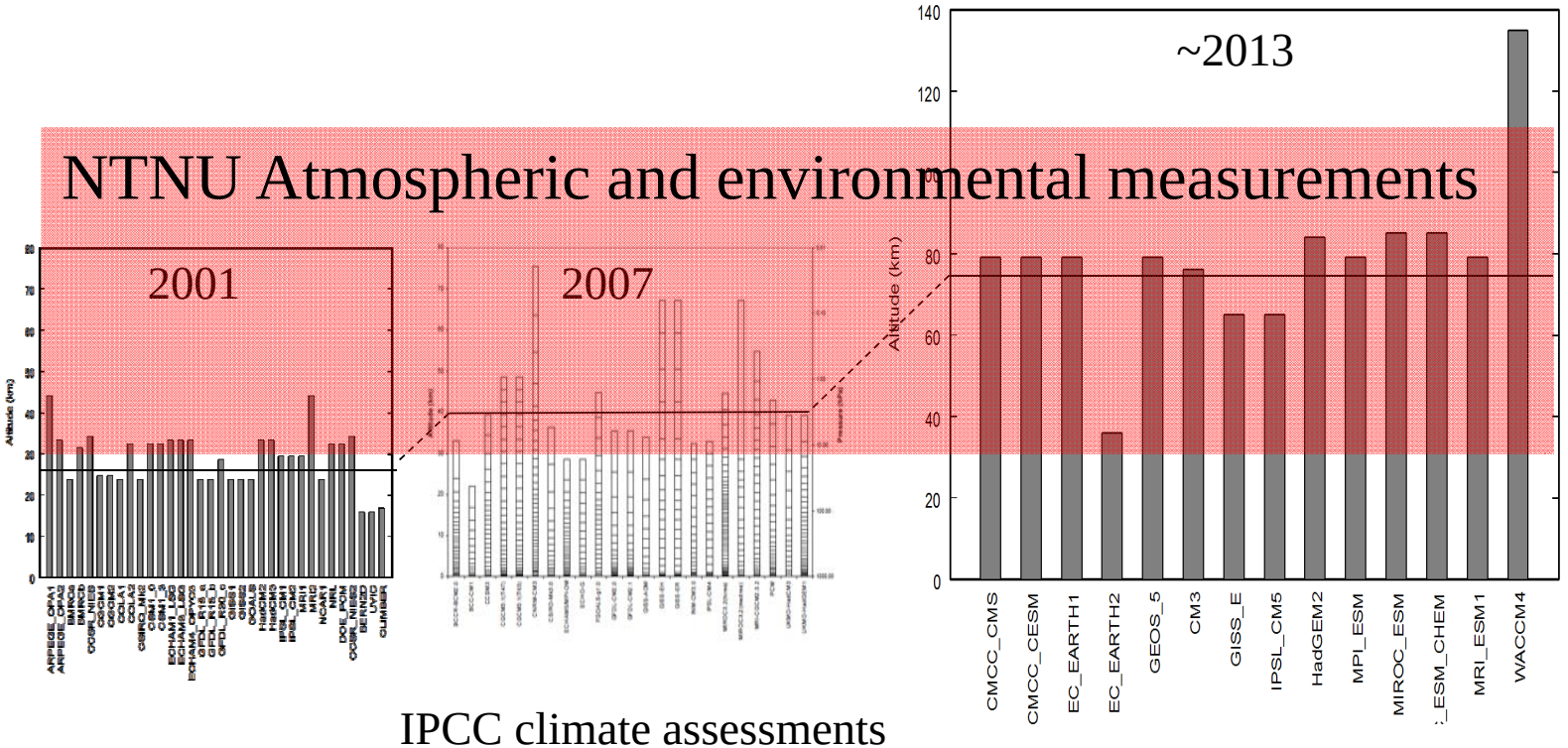
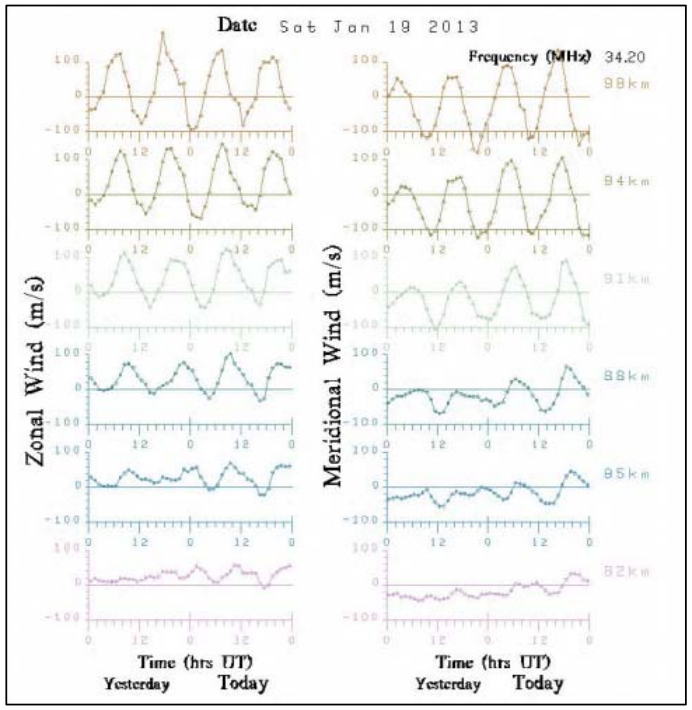


IPCC climate assessments

Atmospheric Science at NTNU

- Remote sensing of atmospheric chemistry, composition and dynamics from 30-120 km
  - Ground based:
    - Advanced meteor-wind radar at Trondheim
    - Airglow imaging and spectroscopy at Trondheim
    - mm-wave radiometer for atmospheric composition in Antarctica
    - EISCAT
    - Global Infrasound network
  - Space borne
    - Members of NASA satellite science teams (AIM, SABER)
    - Collaborator on ASIM aboard ISS
  - Master's projects listed at: https://folk.ntnu.no/espy/

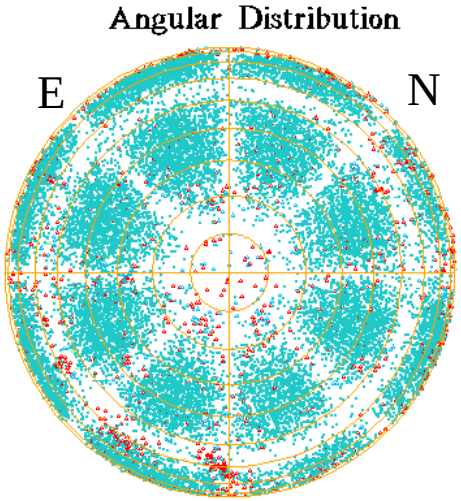
Advanced Meteor Radar at the Dragvoll Campus of NTNU

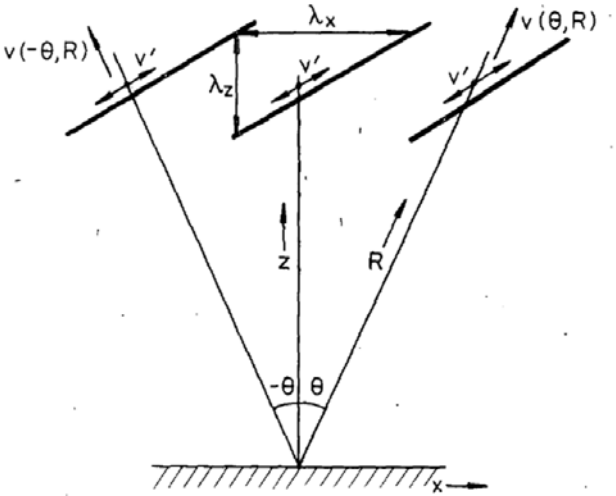


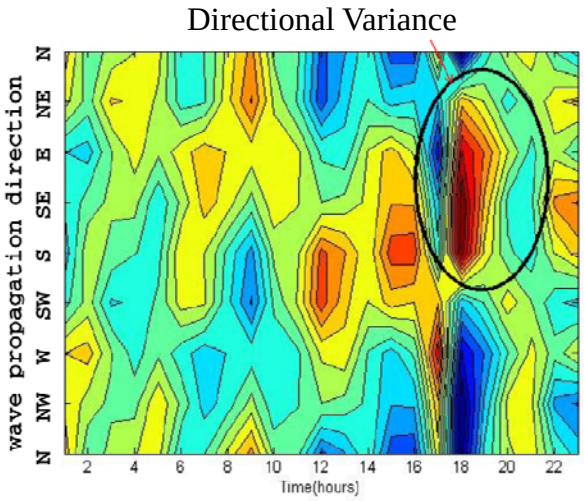
Momentum-flux meteor radar

Winds, Temperatures and momentum from 70 to 110 km

Individual gravity waves observed



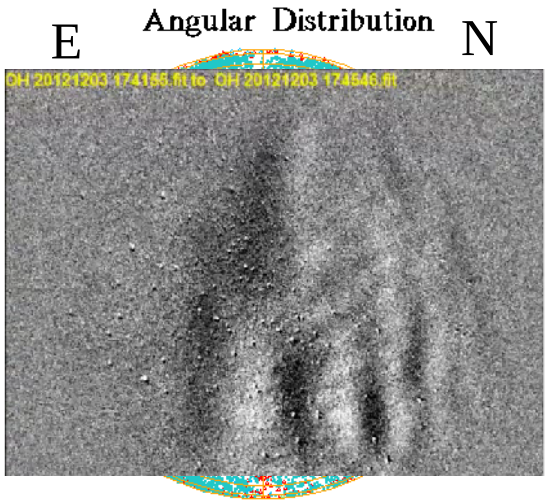


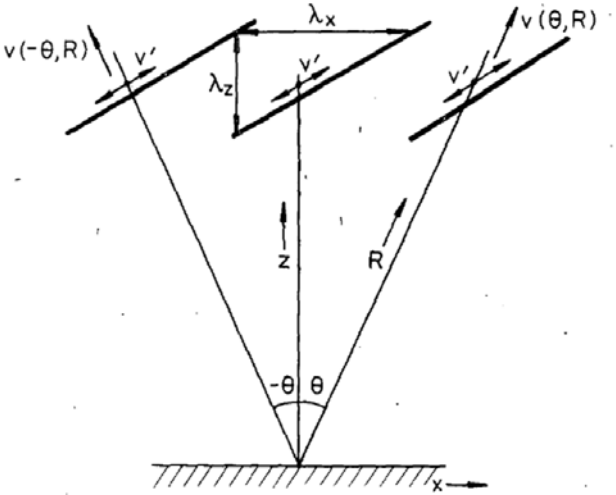


Can use this information to construct *gw momentum flux* with altitude, which gives us the *gw forcing*

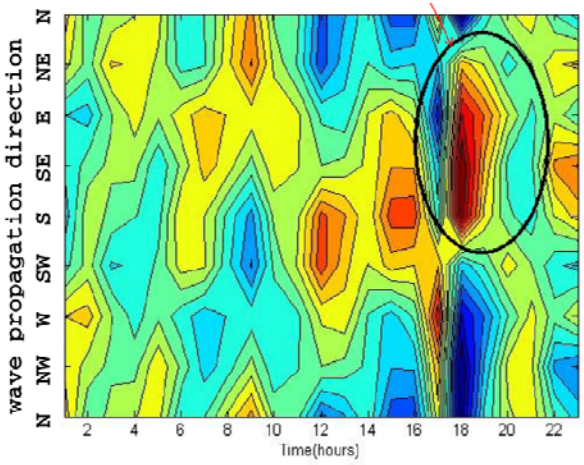
Individual gravity waves observed

Use an all-sky OH camera to image gravity waves





Directional Variance



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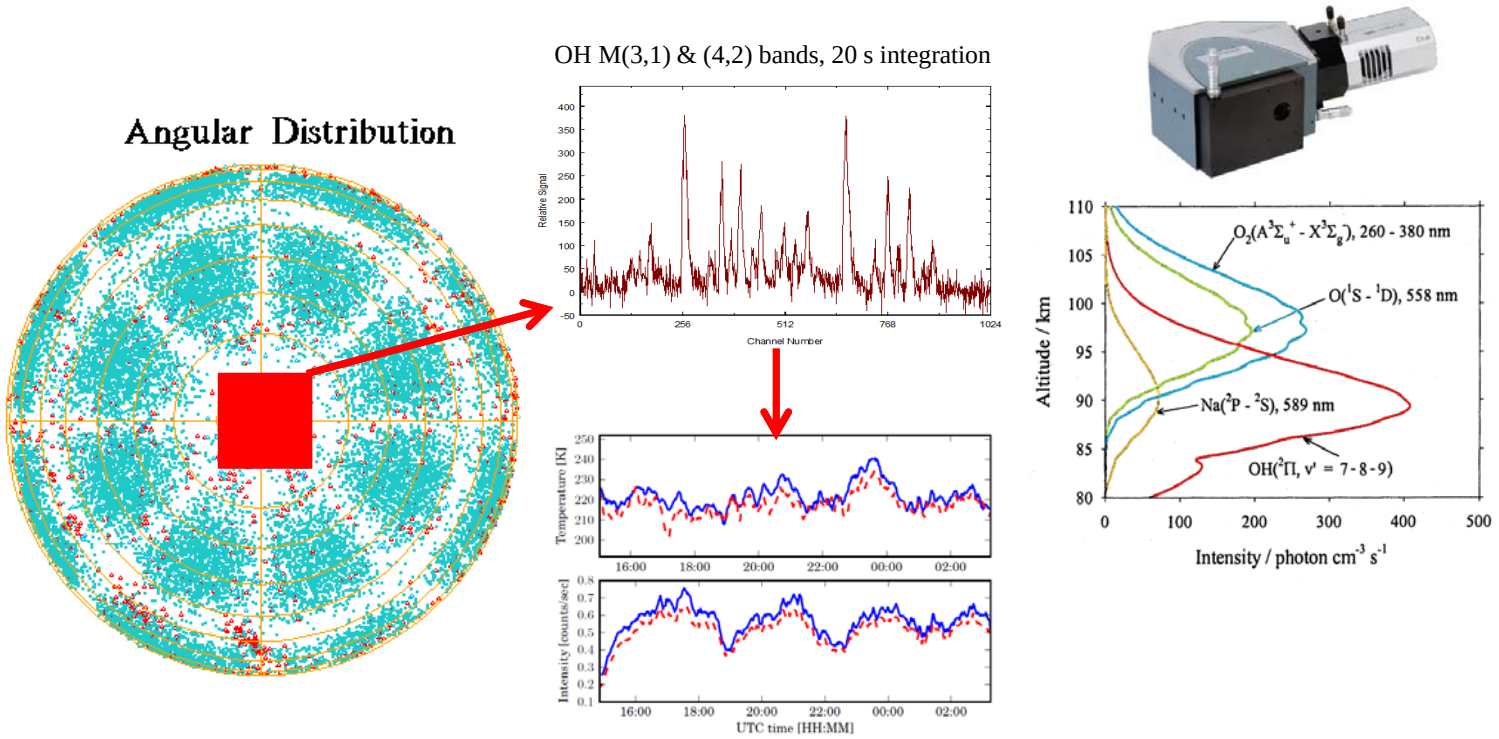
OH spectral measurements give temperature

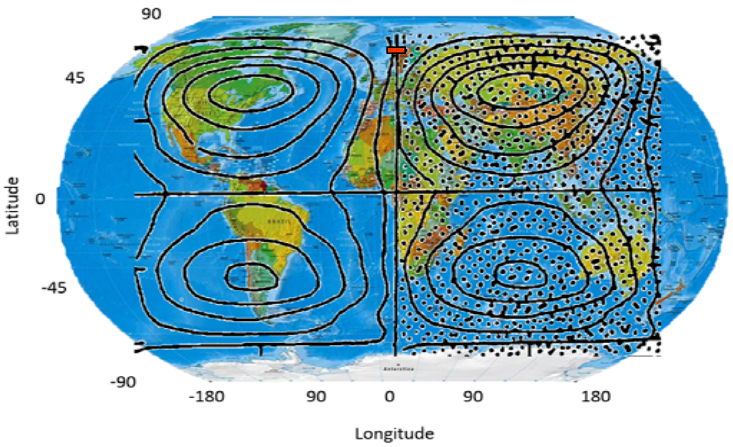


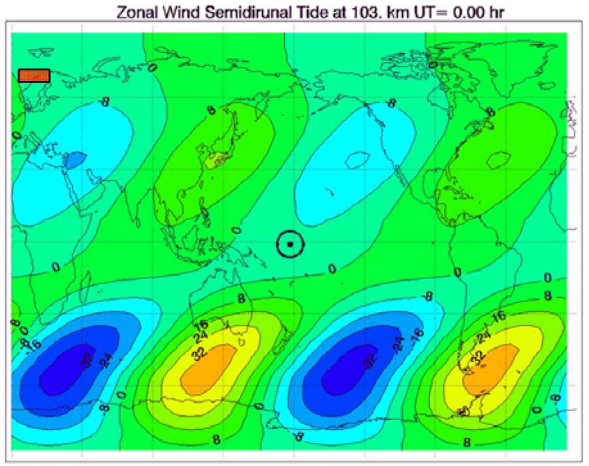
Hydroxyl Airglow Co-Located with meteors

Spectrometer characterizes the temperature/density fluctuations at a point in the radar

Large scale waves and tides

Planetary Wave 1, 5-day wave

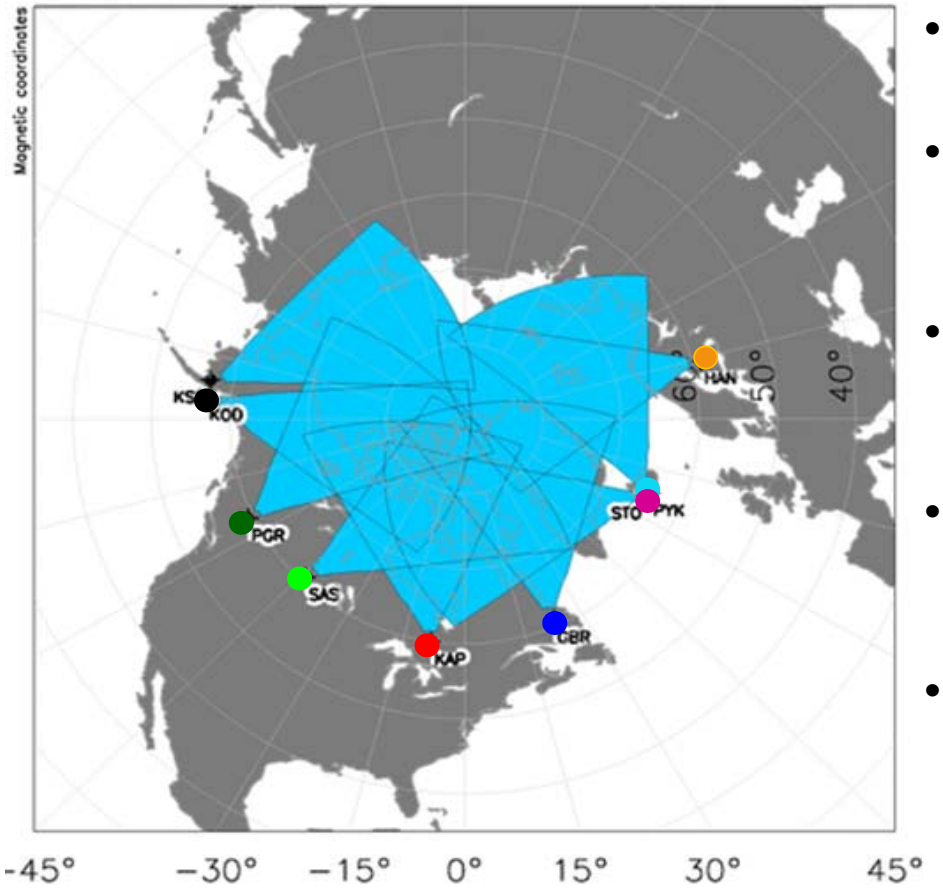




Hagan et al. GSWM (June)

- Planetary Waves
  - Variations of temperature and wind on global scales
  - Changes in [O]/[N_2] ratio at base of ionosphere
- Tides-multiple spatial modes of Semi-Diurnal Tide
  - Modes (SW1, SW2, SW3, etc.) not separable from single station
  - Each mode propagates differently into the ionosphere
  - Superposition of modes creates temperature & wind variations on global scales

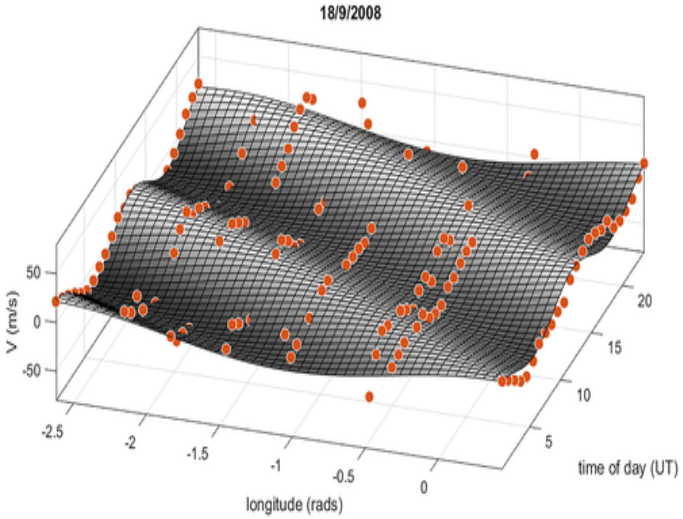
Mesospheric multiple station data from SuperDarn meteor-radars ("a ground-based satellite")



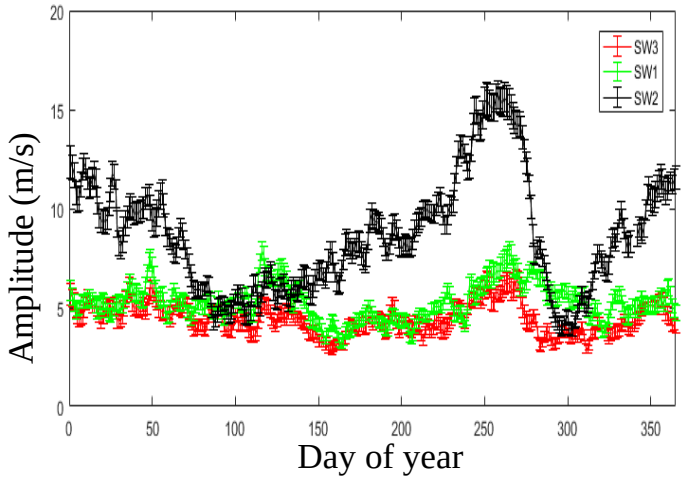
- 8 SuperDARN radar systems
- Distributed over ~180° of longitude and between 50 and 65°N
- Meteor radar component yields hourly meridional winds near 95 km
- Unlike satellites, data from all geographic stations are simultaneous
- Removes spatial-temporal alias
  - All components of tides and planetary waves

Image from Boston University - Centre for Integrated Space Weather Modelling
http://vt.superdarn.org/assets/img/fovsNmidlat.gif

Fit the tidal S_1, S_2 and S_3 spatial components over *each day* as a function of time and location of the SuperDARN



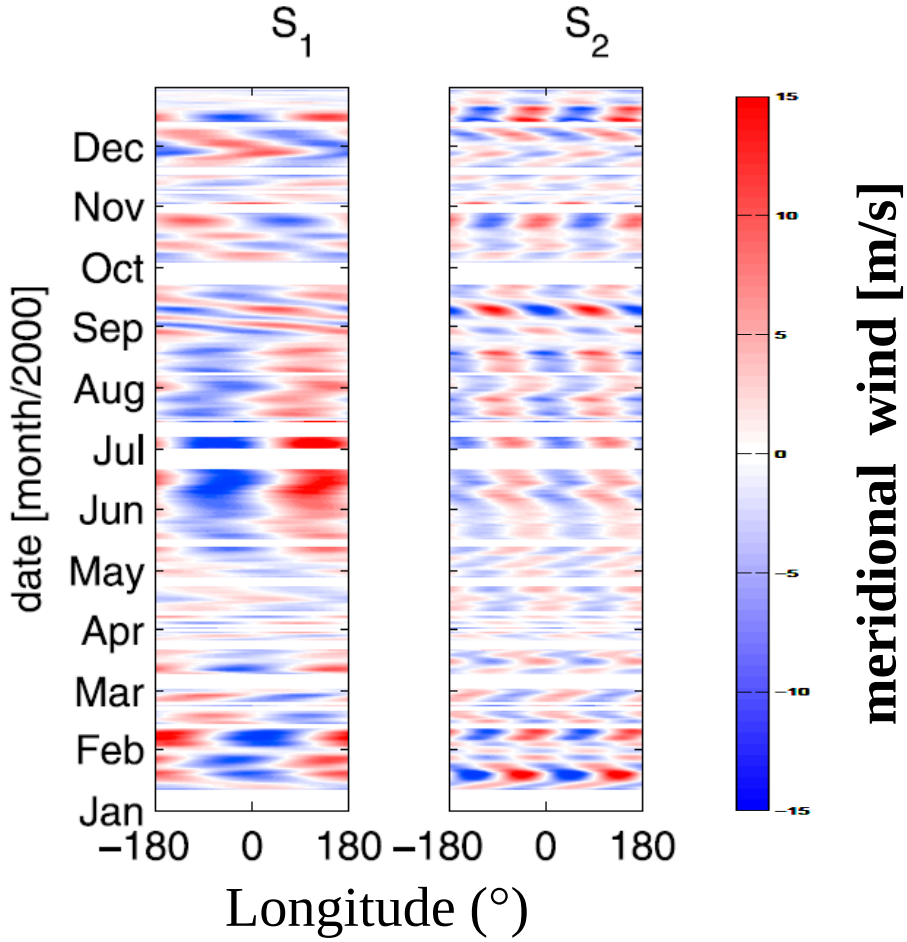
Example surface fit to 24 hours of data (red dots) from all 8 radars (8 different longitudes)



- Separates the components of the total Semi-Diurnal Tide
- Different components affect the ionosphere and radio communication differently

Hibbins et. al, JGR,124 4862, doi:10.1029/2018JD030157, 2019

Independent fit across the *daily means* at each station yields Hovmöller diagram of PW strength and phase velocity in the mesosphere



Kleinknecht et al., *J. Geophys. Res.*, 119 (3), 1292-1307, doi: 10.1002/2013JD019850.

Many other projects using satellite, model, and ground based data.

- Eastward-propagating planetary waves in SuperDARN radar wind observations
- The secondary ozone layer and energetic particle precipitation
- Planetary waves over Antarctica
- Coupling of chemistry and dynamics
- Modeling and observing the 8-hour atmospheric tide

- For complete descriptions, go to:

https://folk.ntnu.no/espy/

- Use link to Doodle poll to select projects of interest