SpWx at Spire

SmallSat side meeting:
Space Weather and Small Satellites: How the Sun Impacts LEO

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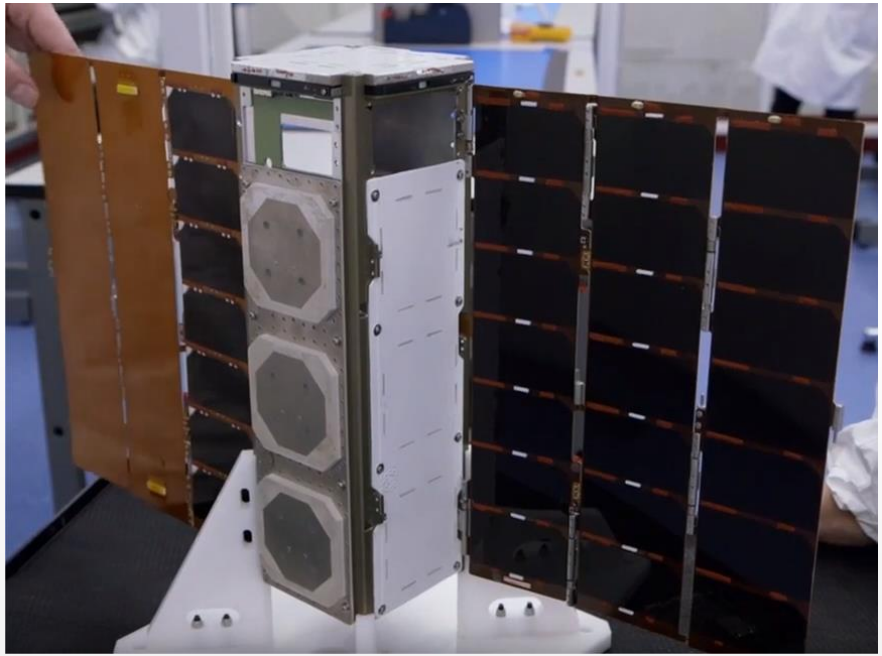
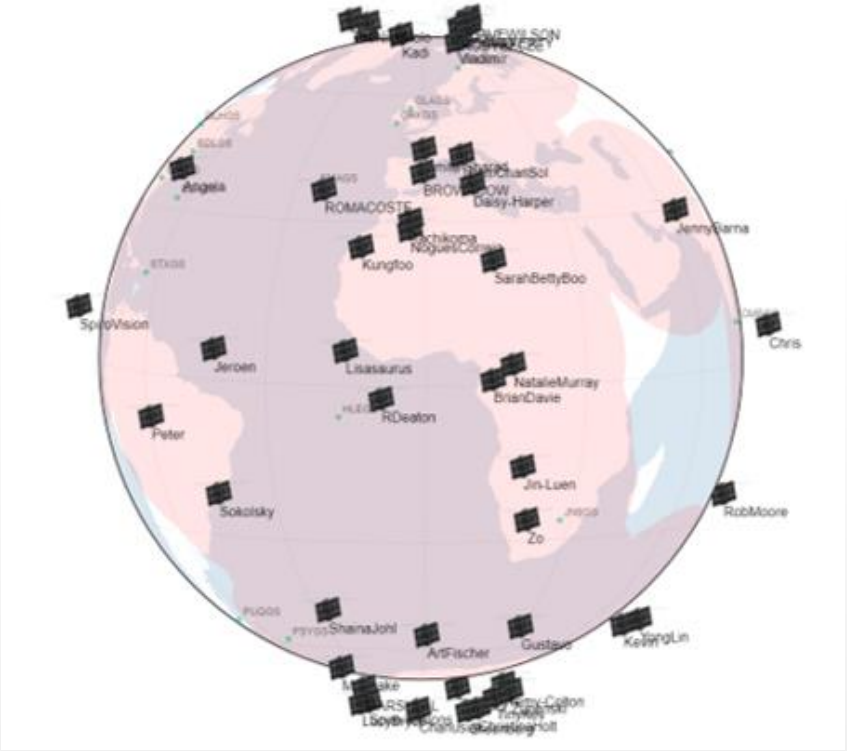
Who & What Is Spire?

- We design, build, launch, and operate one of the largest constellations of satellites
- Perform observations where the number of sensors matters rather than the size.
- Make everything reprogrammable for on-orbit upgrades.
- It’s a Spire product from start to finish (except for the rocket)
    - This allows us to innovate quickly



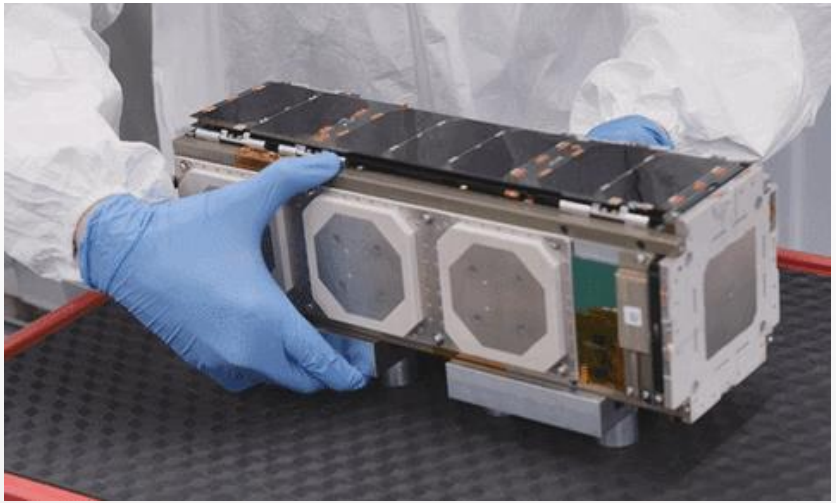
Who & What Is Spire?

- 3U CubeSats (10x10x30 cm)
- 100+ satellites launched
- 80+ satellites in orbit
- 2 - 3 year design lifespan
- 20+ launch campaigns with seven different launch providers
- 30+ globally distributed ground stations
- Complete global coverage in multiple orbit inclinations
    - 400-600 km altitude



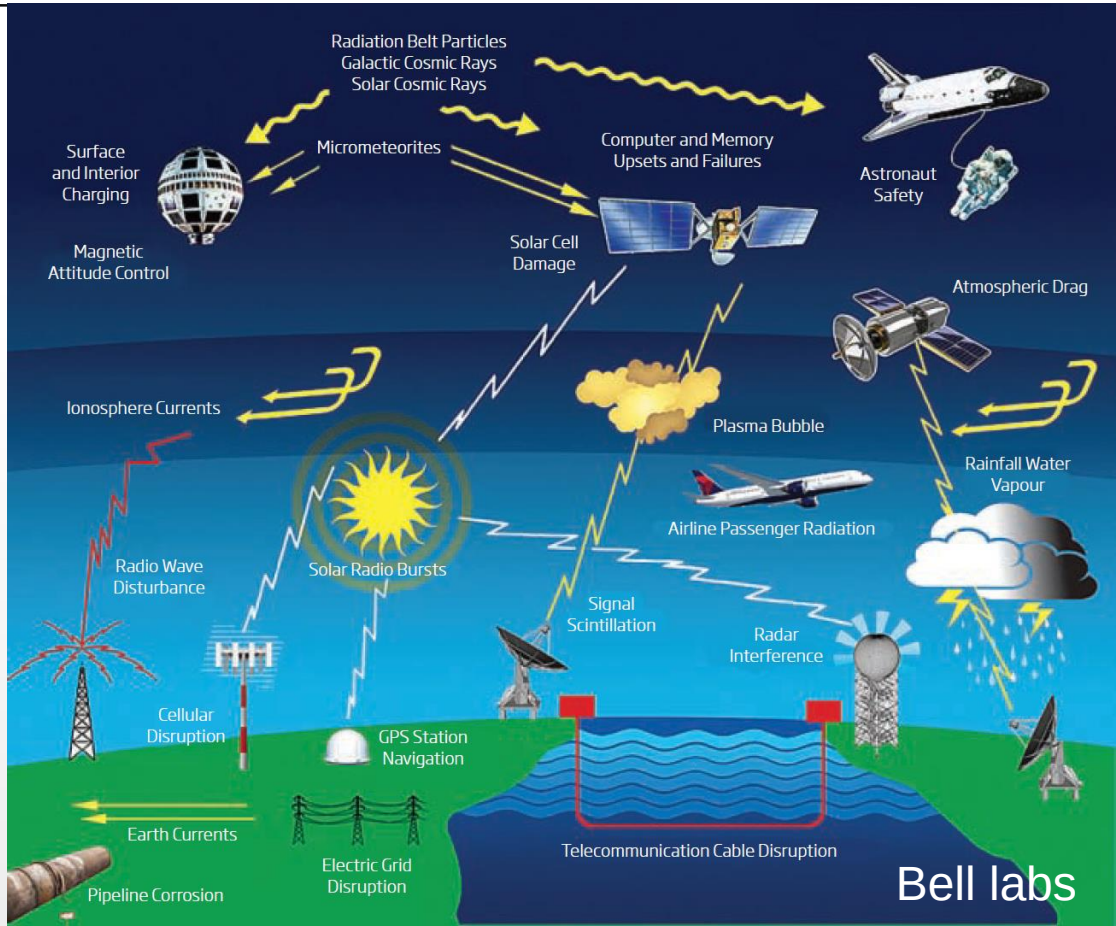
Who & What Is Spire?

- Focus on signals of opportunity
- Software defined radio payloads
  a. GNSS
     i. Radio Occultation (RO)
     ii. Ionosphere (TEC, electron density)
     iii. Surface reflections (GNSS-R)
  b. AIS (ship tracking)
  c. ADS-B (aircraft tracking)
- Hosted payloads / Orbital Services



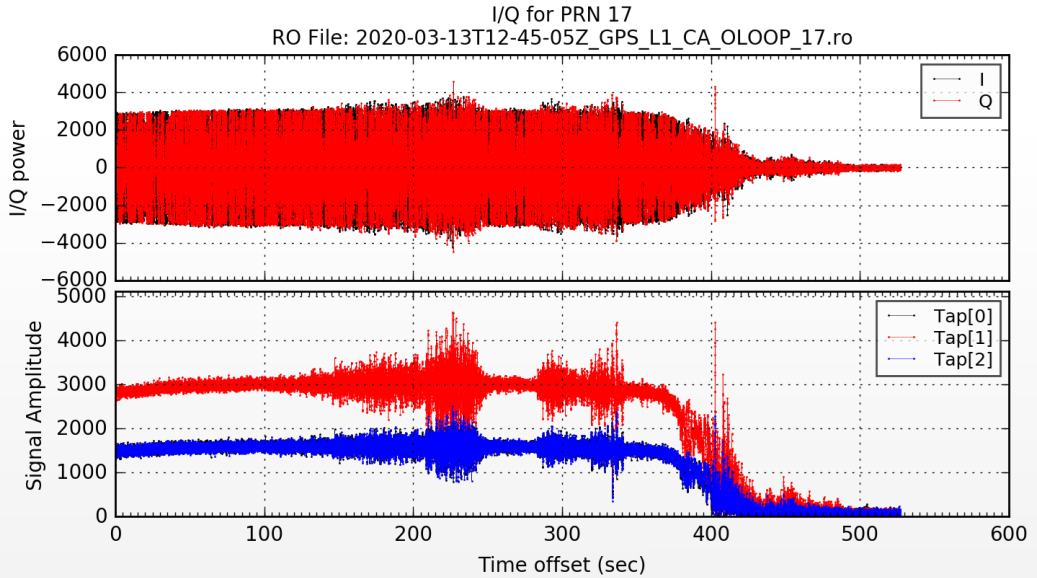
Challenges and Opportunities

- Ionospheric effects
  - Radio propagation
- Thermospheric drag
- Radiation effects



Ionospheric effects - Challenge

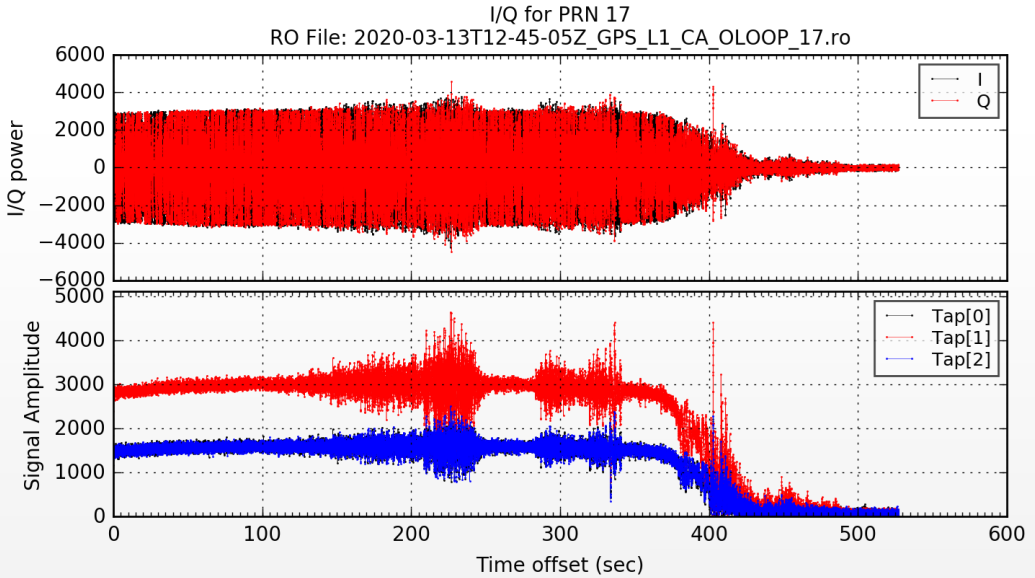
- Ionospheric scintillation can impair the operation of trans-ionospheric radio systems
- Potential for ionospheric impact on V/UHF comms from equatorial ground stations
  - Not observed
- Transitioning to higher frequencies for increased bandwidth will lower impact



Week 2096 SoW 477923.883220 = 2020-03-13T12:45:05.88Z
Week 2096 SoW 478450.886728 = 2020-03-13T12:53:52.88Z
(Duration = 527.0 sec)

Ionospheric effects - Opportunity

- Each Spire satellite carries a dual frequency GNSS receiver
- Direct observations of ionospheric scintillation
- High resolution perturbation detection in the lower ionosphere
- Global, timely specification of the ionospheric electron density



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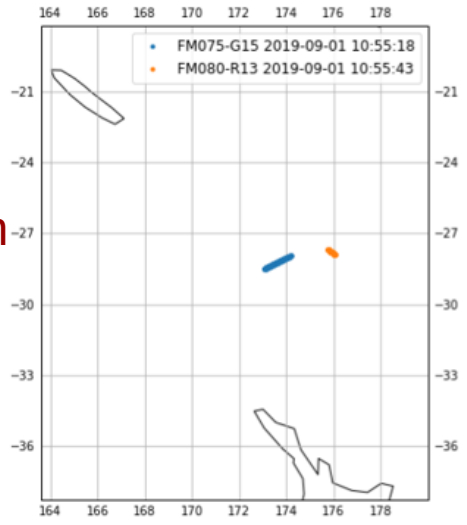

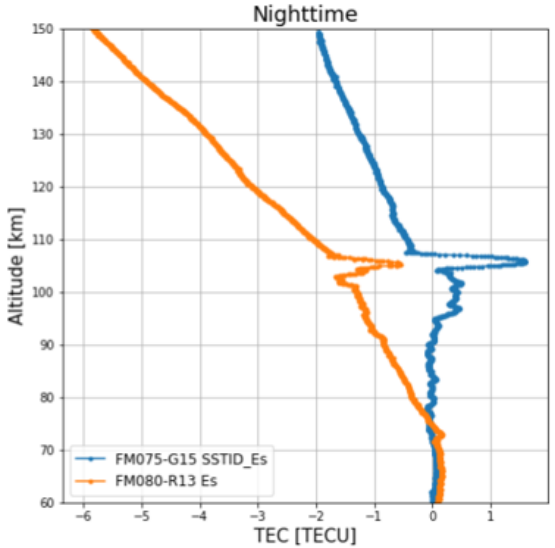

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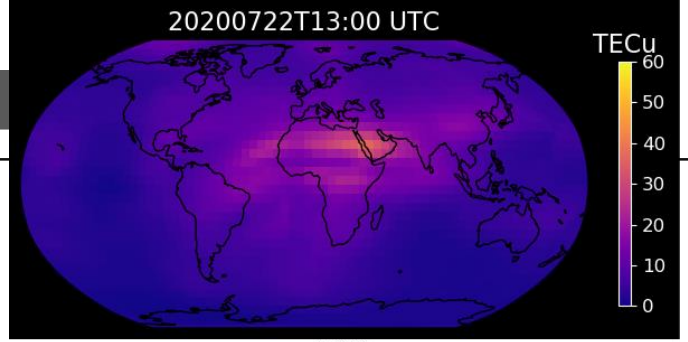
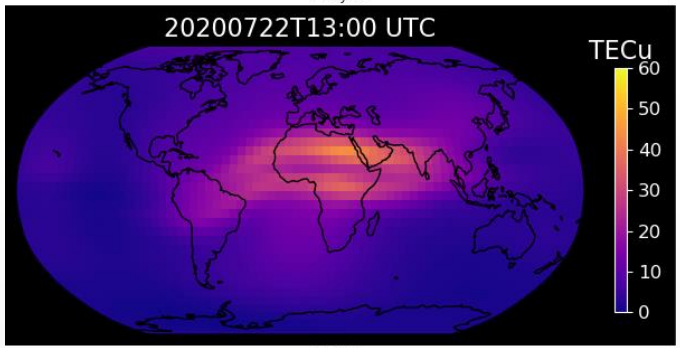


Analysis



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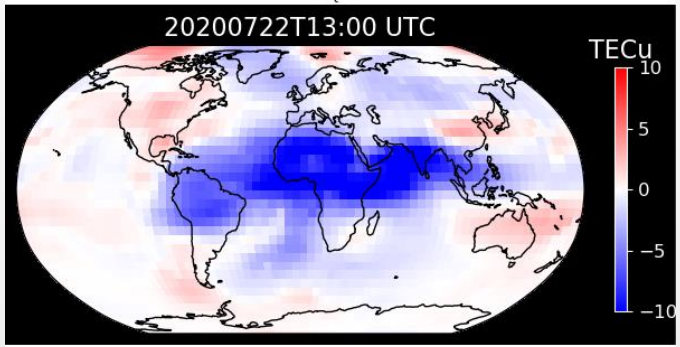
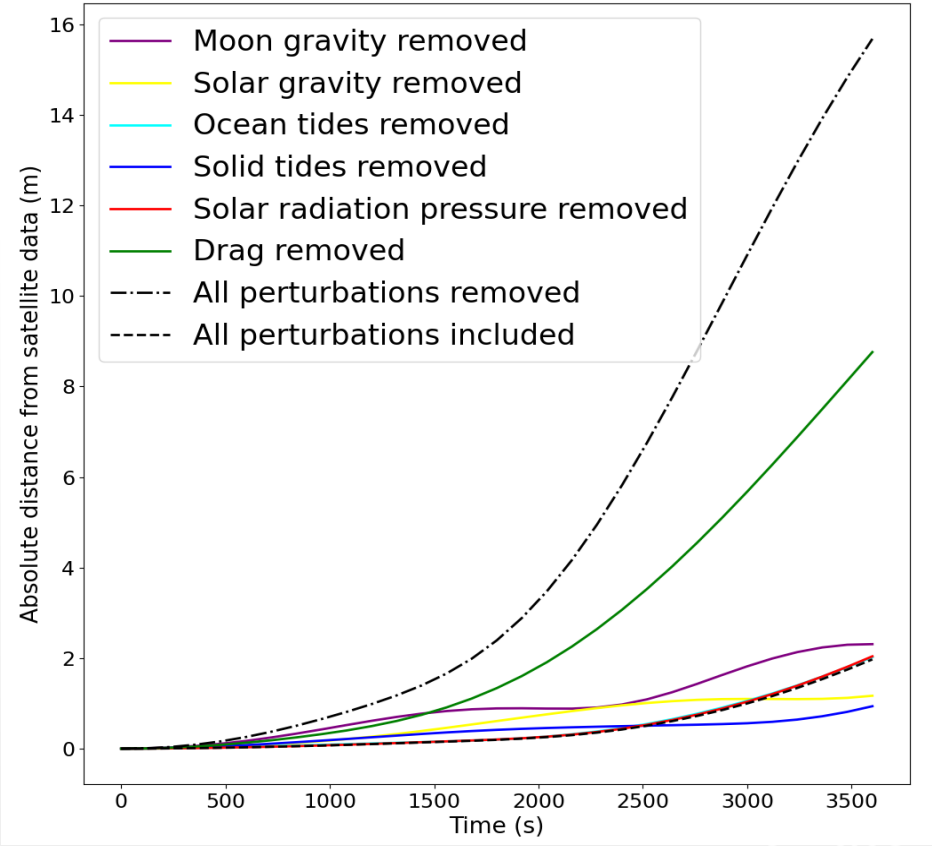


Ana-NeQuick

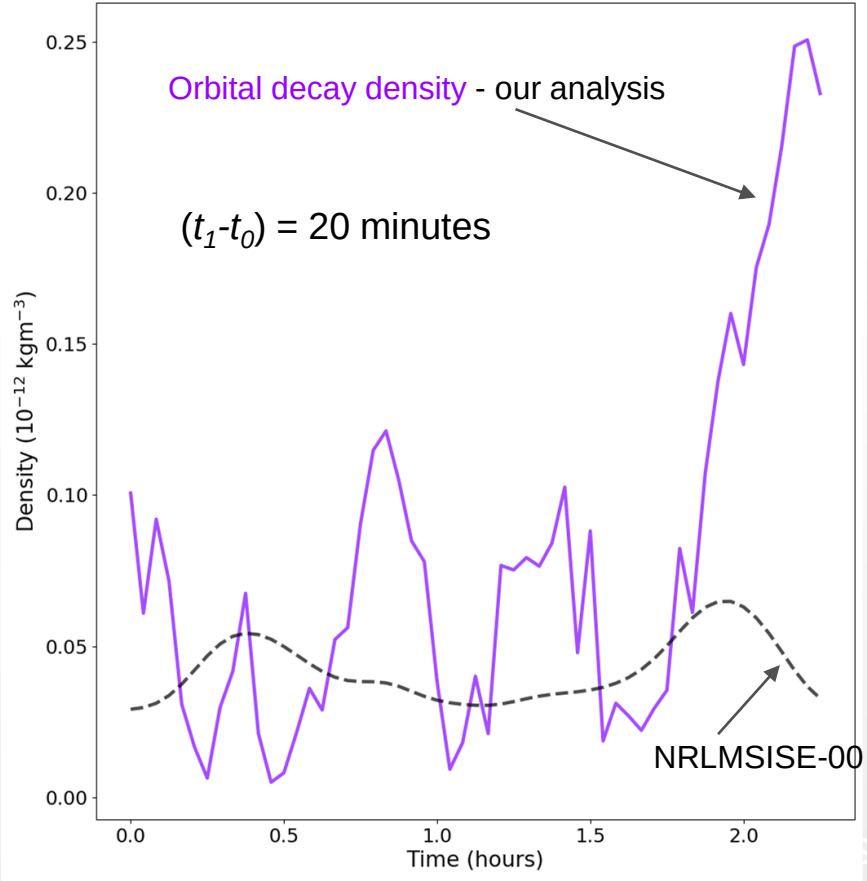
Thermospheric drag - Challenge

- Low orbit and low mass mean that the satellites are affected by drag
- Required to meet UN de-orbiting requirements



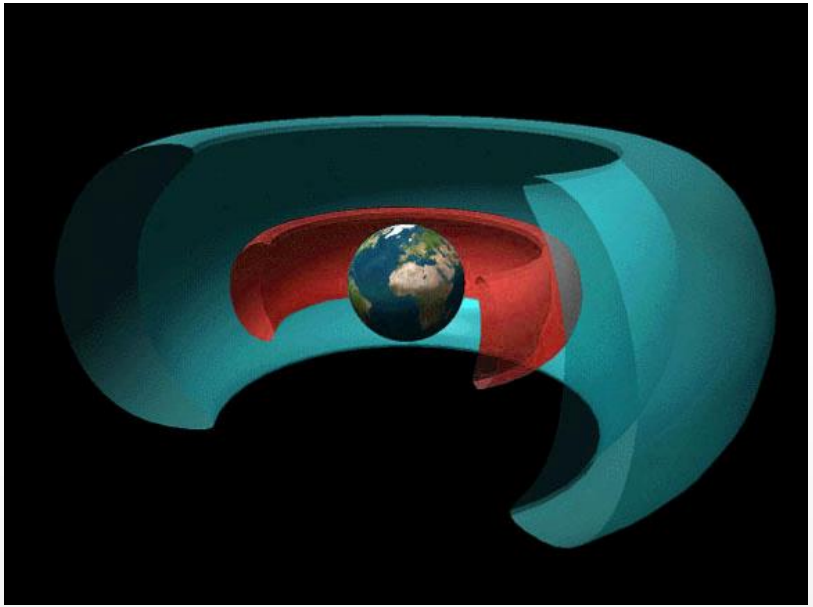
Thermospheric drag - Opportunity

- Can also sense thermospheric density using precise orbit data
- Potential for near real time thermospheric characterisation
- Preliminary work
  - Integrated density direct from orbital decay
  - Vallado, D. A. (2001)
- Monte Carlo estimation of model parameters
  - Simple exponential
  - MSIS



Radiation/charging

- Short design life removes issues of solar panel degradation
- Low orbit results in relatively benign environment
- Some redundancy on each satellite
- Mainly redundancy across the constellation



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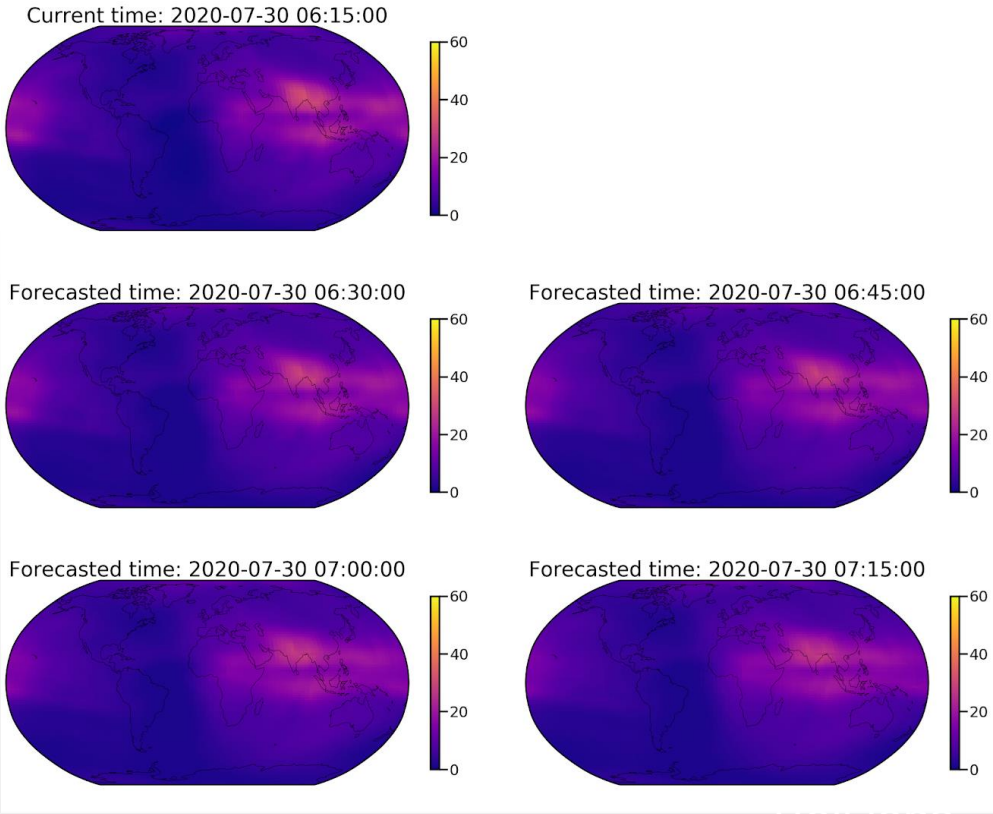
Conclusions

- Challenges and opportunities from a range of SpWx effects
- More opportunity than challenge
  - Due to the design philosophy of the Spire constellation
- Potential for wide area ionosphere and thermosphere characterisation
  - Support to operational systems
  - Increase forecasting capabilities



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