

The measurement of middle and upper atmospheric wind, temperature, density and geomagnetic field with Superconducting Submillimeter-Wave Limb-Emission Sounder-2 (SMILES-2)



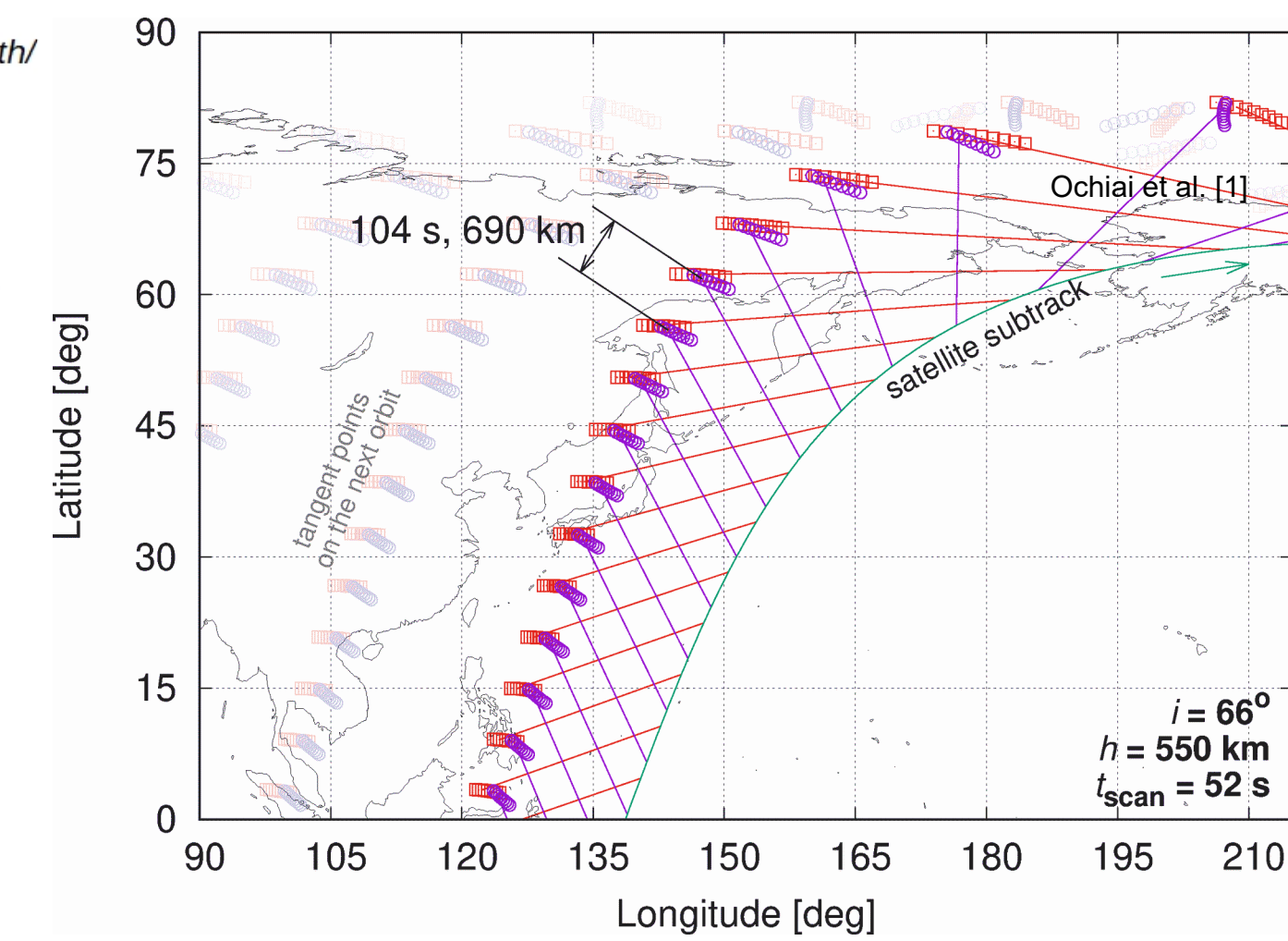
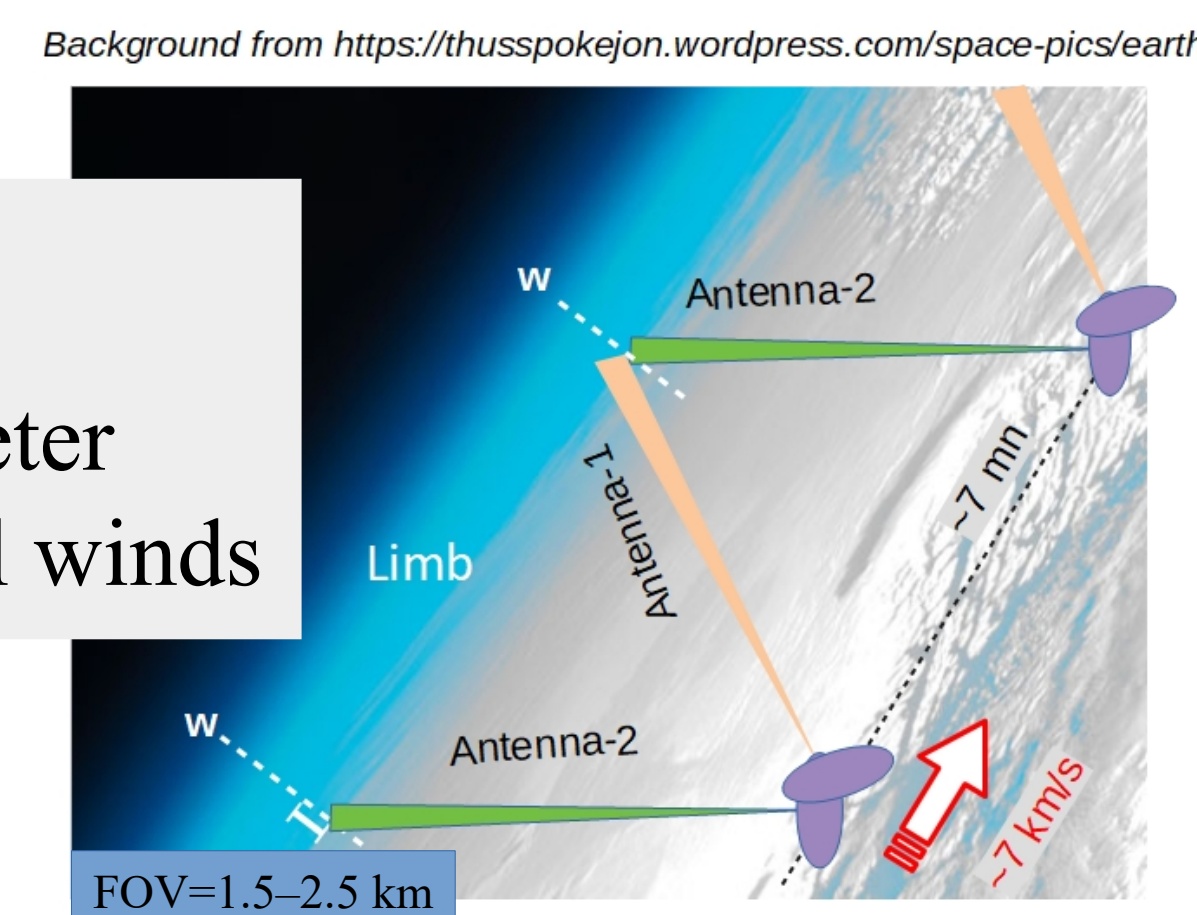
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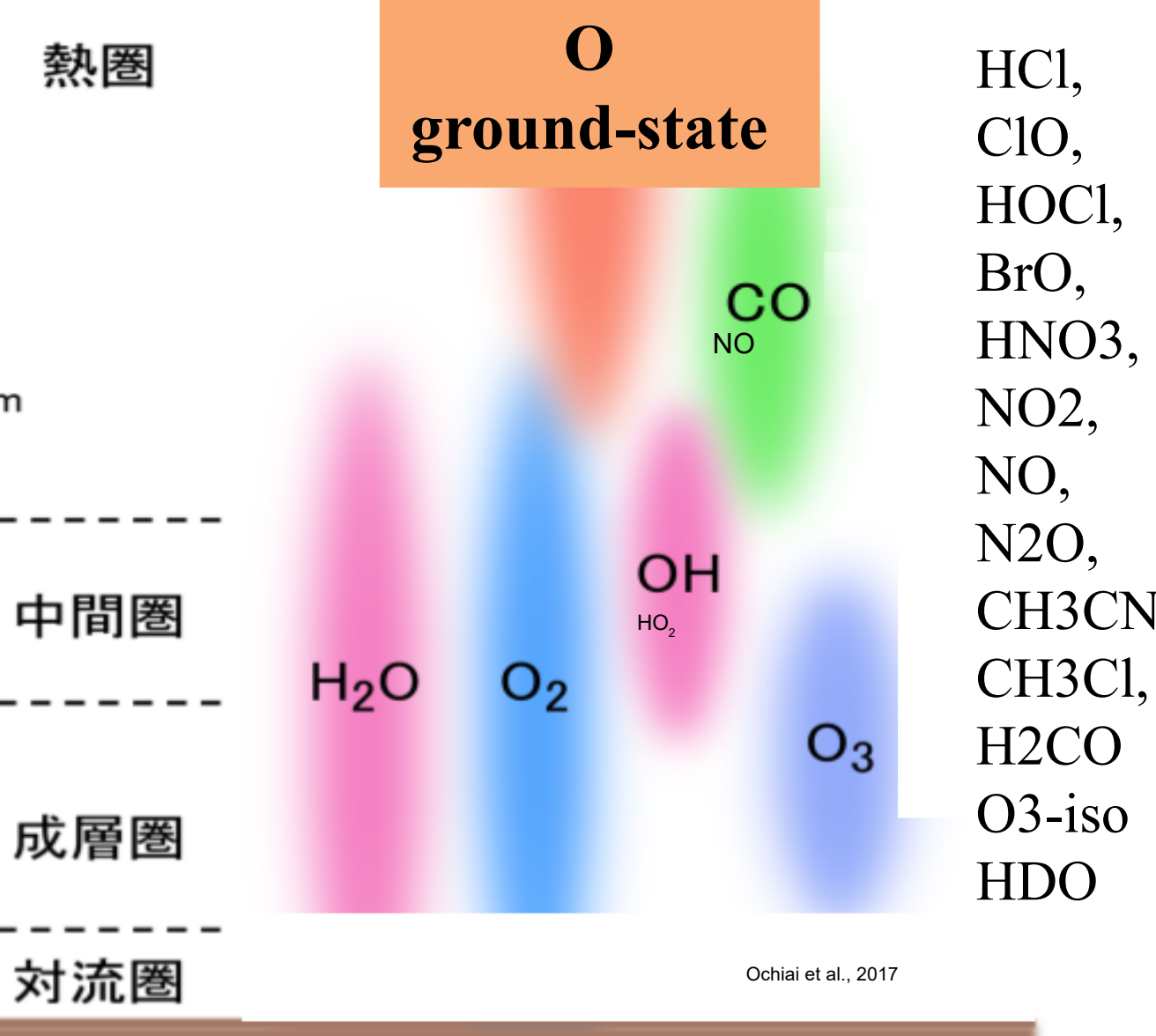
Mission overview

Unprecedented description of the atmosphere between 15–160 km [1,2] (wind, temperature, density, atomic-O, ...)

Limb sounder
4-K cooled THz radiometer
2 antennas for horizontal winds



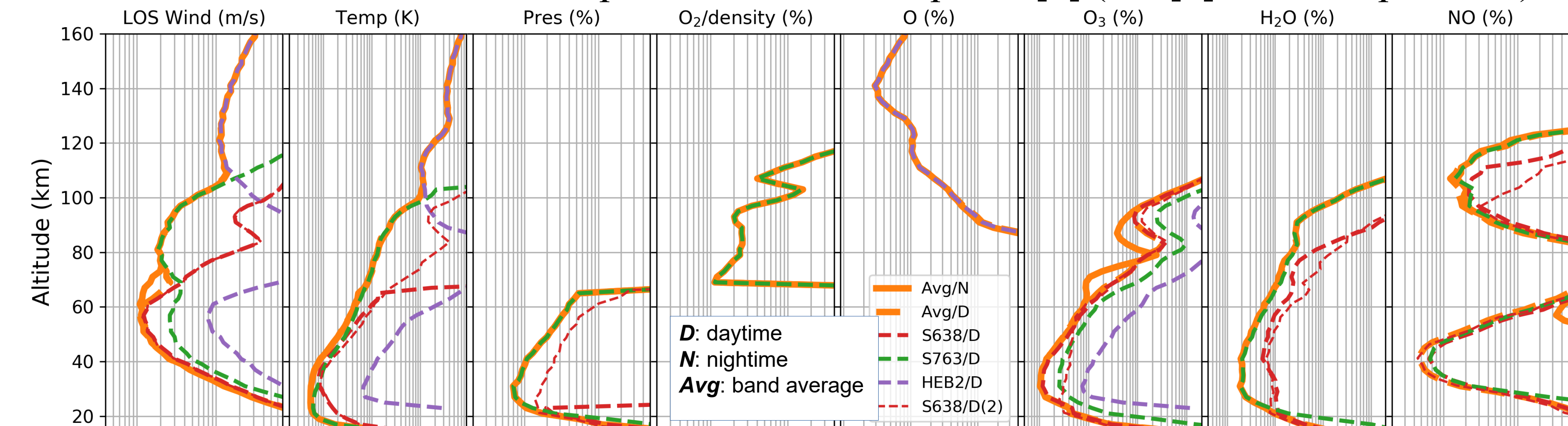
Science objectives [2]:
Diurnal variations, upward and downward couplings, validate and constrain models



Horizontal wind 30–160 km
Temperature 15–160 km
Total density 15–110 km

Measurement performances

Retrieval errors for the main products over the Equator [5] (see [4] for other products)



Errors are computed for a vertical resolution of 2.5 km

HEB2: Results are for the HEB channel tuned on the atomic oxygen line.

The VMR of OH (HEB1) could be retrieved from 20 to 70 km with a precision better than 10% in day time [4]

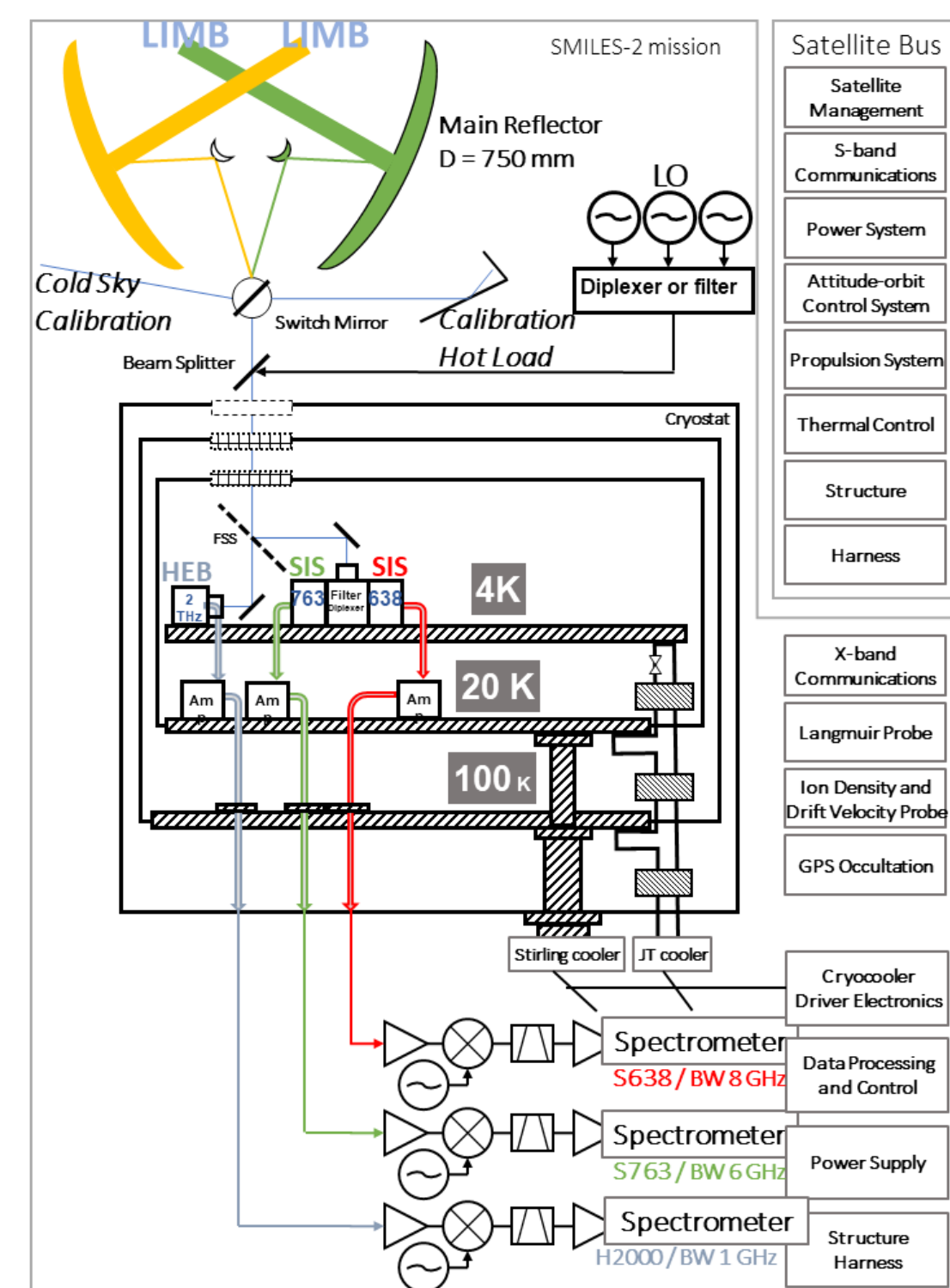
S763: Pressure is retrieved up to 70 km and total density from 70 km

S638:

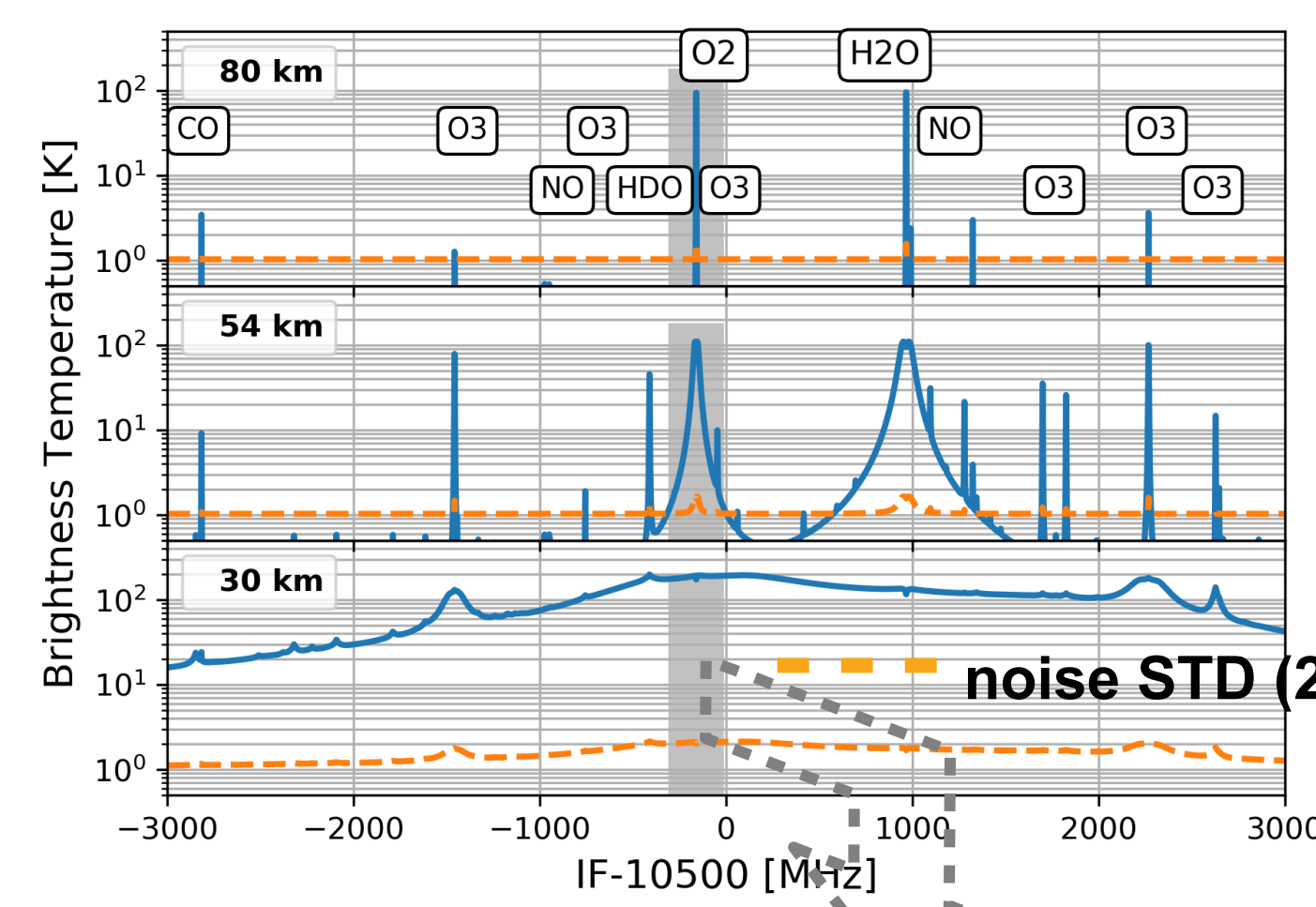
dashed-thick lines: Pressure and temperature are retrieved up to 25 and 70 km, respectively

dashed-thin lines: Pressure and temperature are retrieved up to 70 and 110 km, respectively

Radiometer [3]



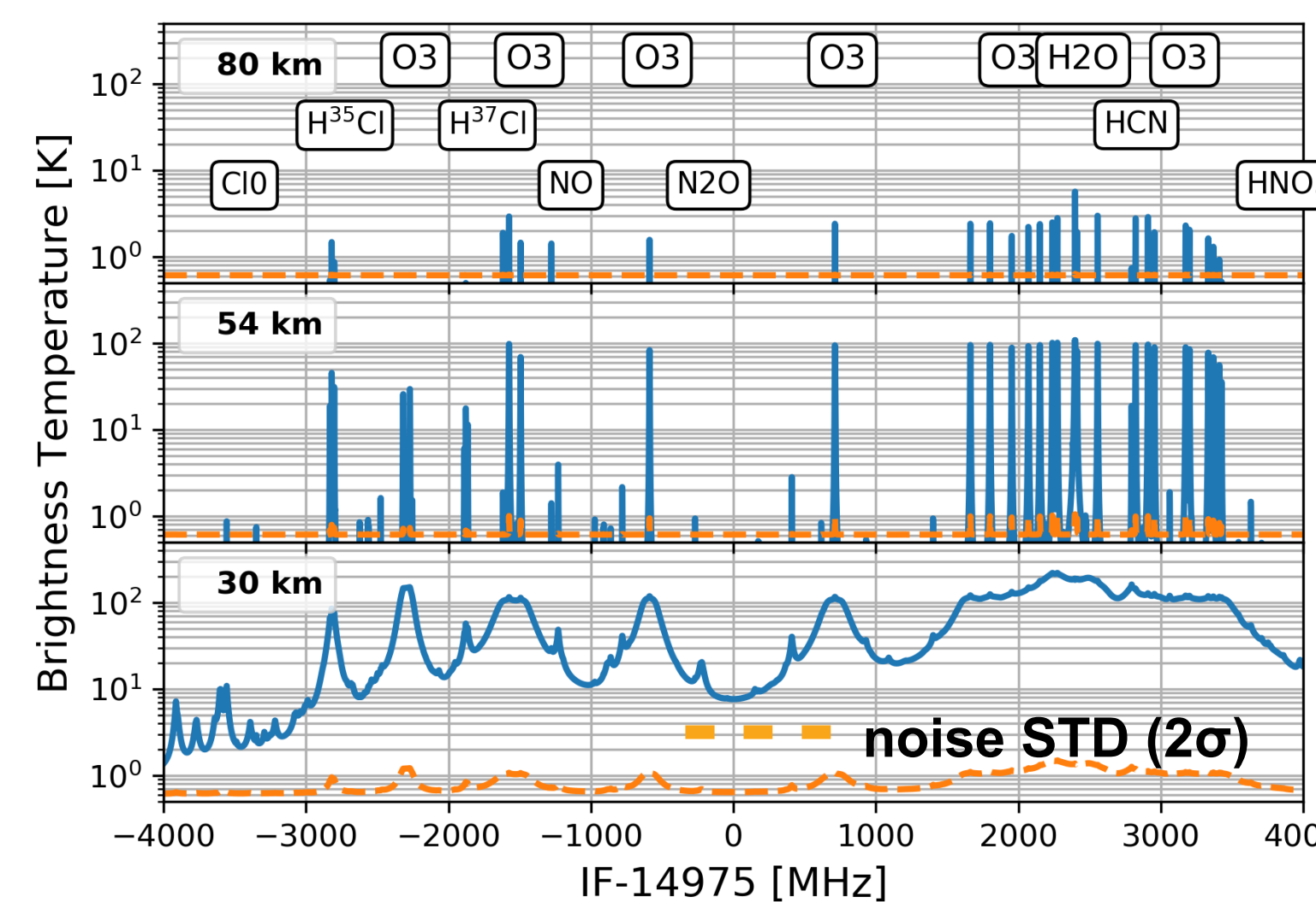
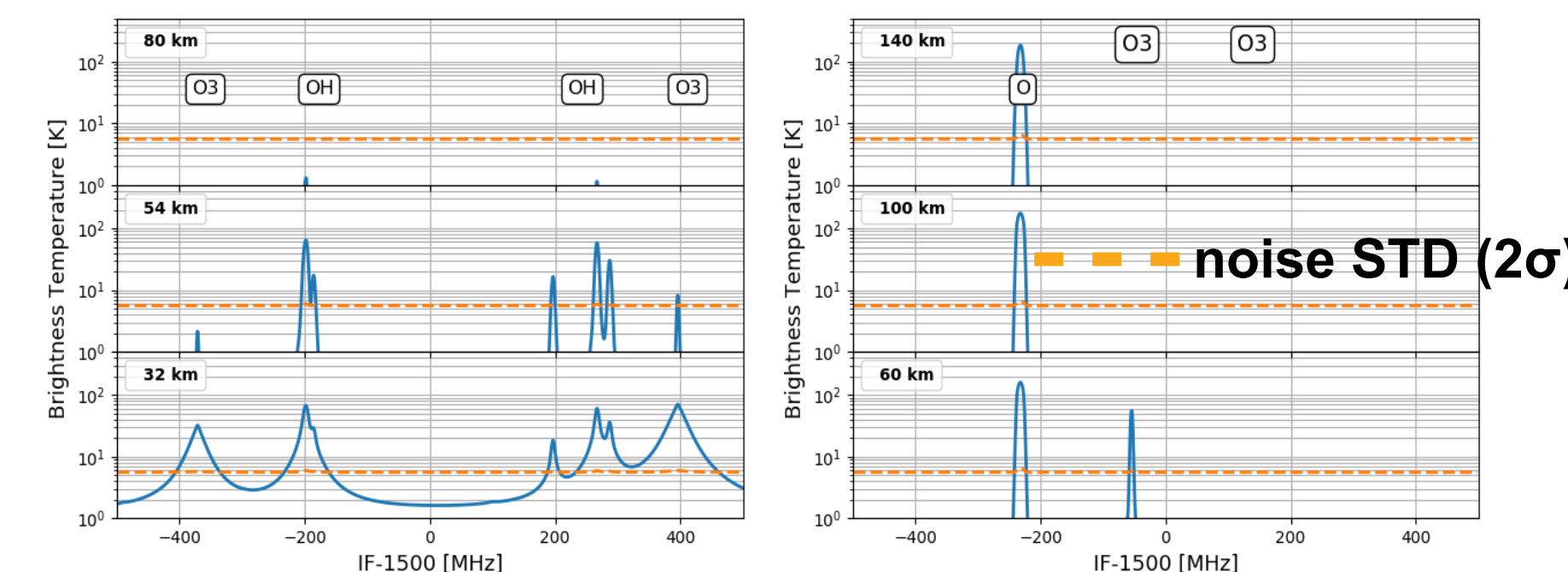
Local oscillator (GHz)	Lower sideband (GHz)	Upper sideband (GHz)	Tsys (DSB)	Radiometer Polarization	Antenna vertical FOV
SIS 638.15	619.1–627.1 O ₃ , HCl at 624 GHz	649.05–657.05 O ₃ at 650 GHz	130 K	Not decided	0.049 ° 2.2 km*
SIS 763.5	750.0–756.0 H ₂ O at 752 GHz	771.0–777.0 O ₂ at 773 GHz	180 K	"	0.0366 ° 1.9 km*
HEB 2058.8 or 1836.05**	2056.3–2057.3 O at 2060.1 GHz	2059.3–2060.3 O at 2060.1 GHz OH at 1835 GHz	990 K	linear	0.0136 °



Left side: **SIS763 band**
The O₂ line (gray area) is computed with a model considering the Zeeman effect.

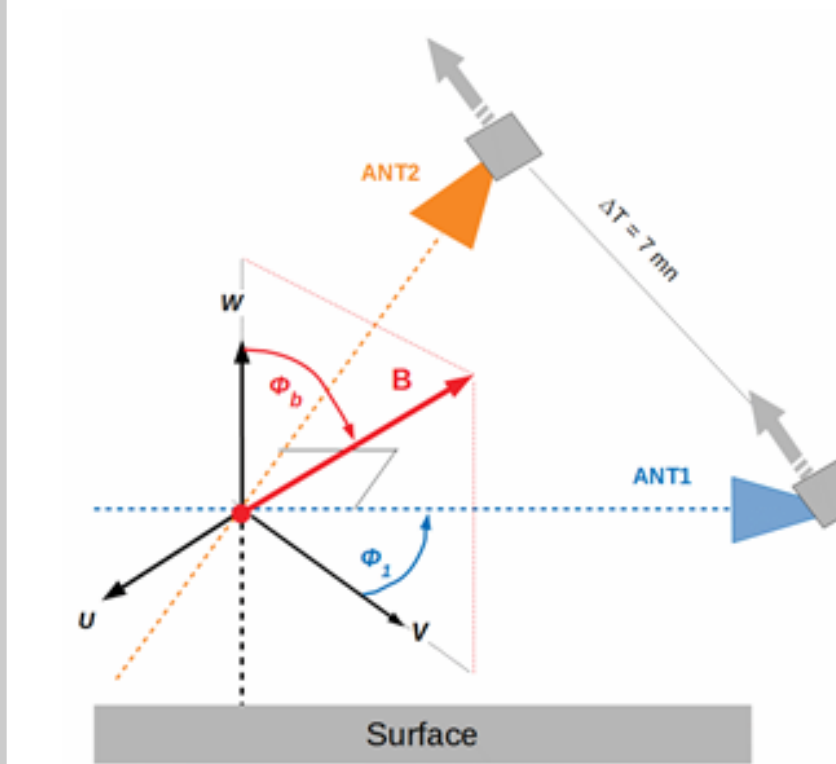
Right side: **SIS638 band**
This band is described in detail for Stratospheric Inferred Winds (SIW), a Swedish mission that will be launched in 2023 [7]

HEB-1 (OH lines) and HEB-2 (atomic oxygen line)

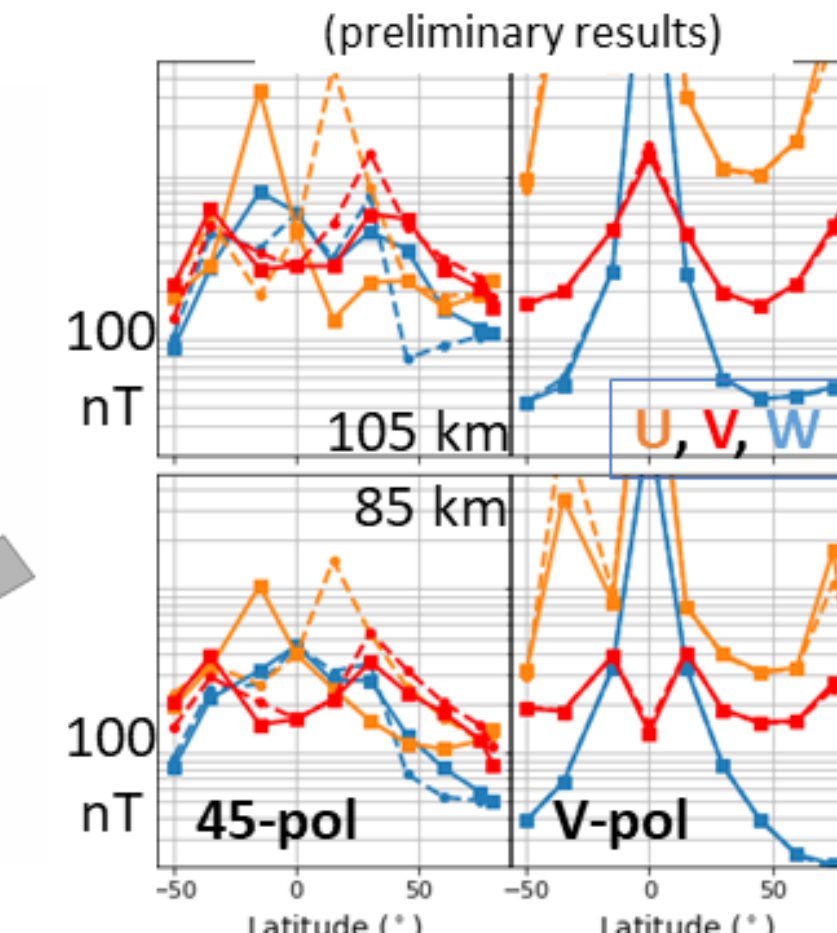


Experimental product: Geomagnetic field

B: geomagnetic field
|B| = 30–60 μT

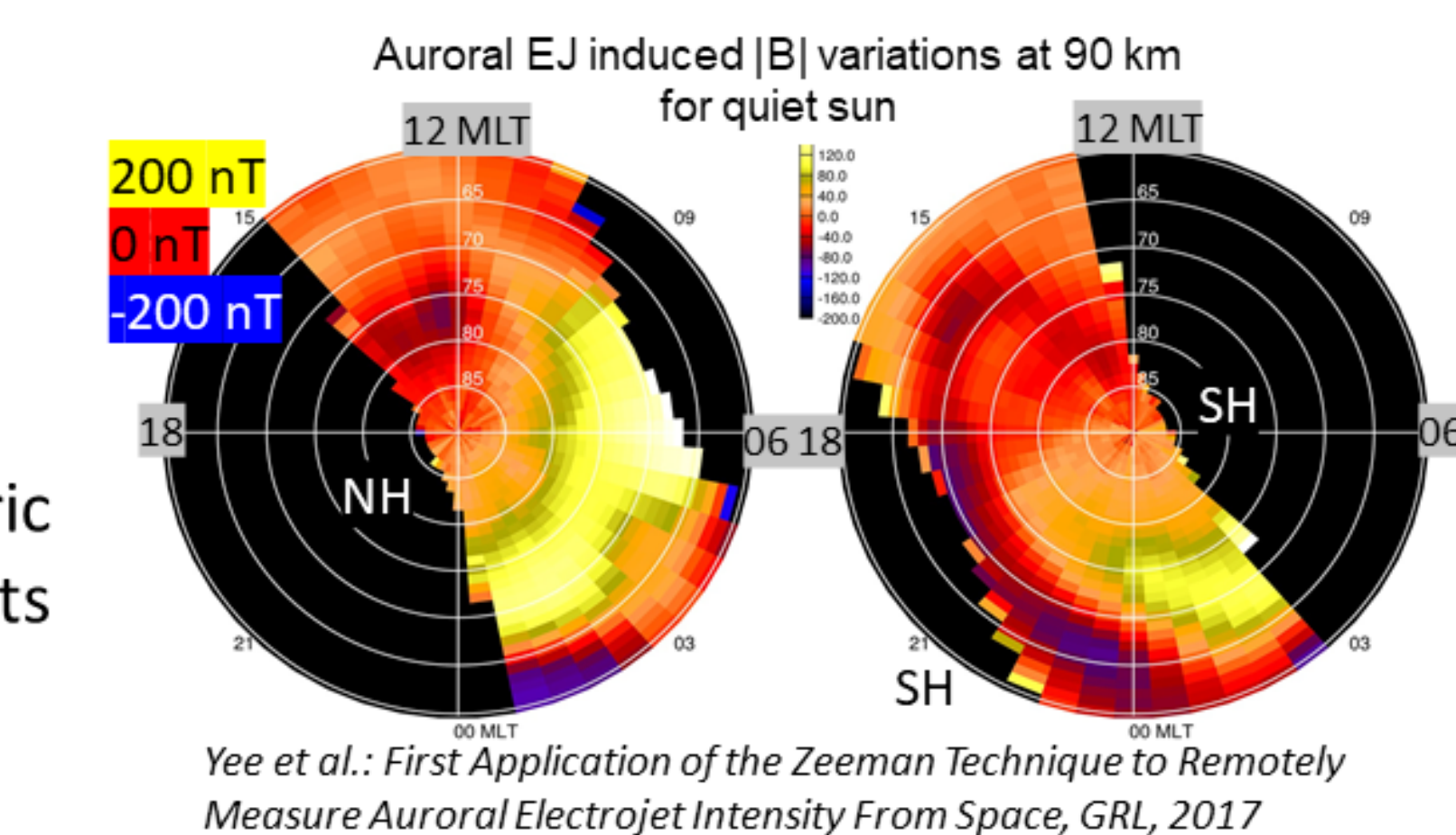
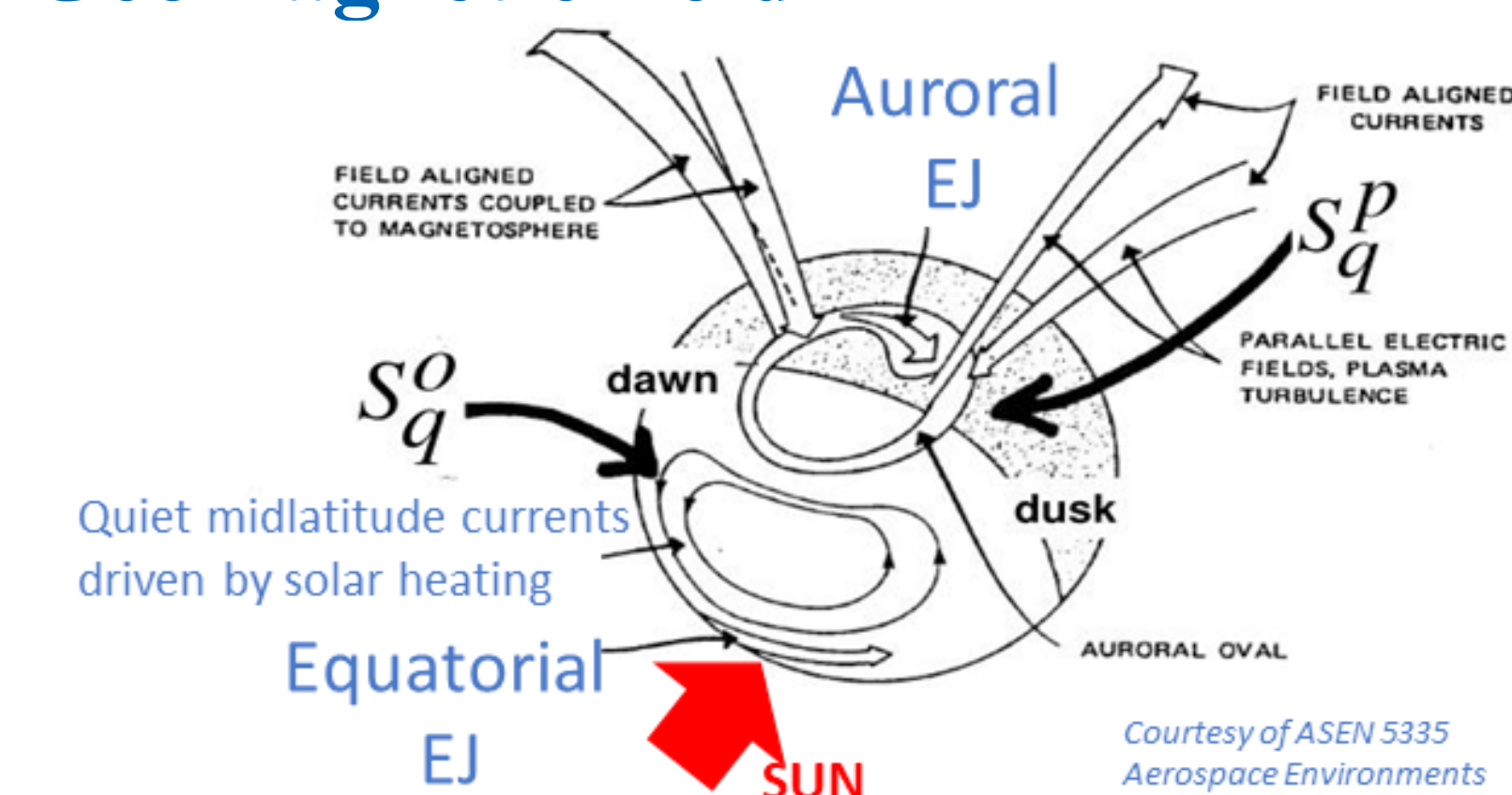


Retrieval error (preliminary results)



✓ Retrievals from O2 line at 774 GHz [6]
✓ [Bu, Bv, Bv] single-scan precision is 50–400 nT

✓ Information on 3d structure of ionospheric electrojets (EJ), especially enhancements induced by Solar flares (Yee et al., GRL, 2017).



- [1] Ochiai S. et al.: “SMILES-2 mission for temperature, wind, and composition in the whole atmosphere”, SOLA, 13A, 13–18., 2017
- [2] Shiotani M. et al., “A proposal for satellite observation of the whole atmosphere - Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES-2), IEEE International Geoscience and Remote Sensing Symposium (IGARSS), submitted, 2019
- [3] Ochiai S. et al., “Conceptual study of Superconducting Submillimeter-Wave Limb-Emission Sounder-2 (SMILES-2) receiver”, IEEE International Geoscience and Remote Sensing Symposium (IGARSS), submitted, 2019
- [4] Suzuki M., et al., “SMILES-2 band selection study for chemical species”, IEEE International Geoscience and Remote Sensing Symposium (IGARSS), submitted, 2019
- [5] Baron P., et al., “Performance assessment of Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES-2)”, IEEE International Geoscience and Remote Sensing Symposium (IGARSS), submitted, 2019
- [6] Baron P. et al.: “The measurement of MLT wind, temperature, density and geomagnetic field with Superconducting Submillimeter-Wave Limb-Emission Sounder-2 (SMILES-2)”, to be submitted to Atmospheric Measurement Techniques, 2019.
- [7] Baron P. et al.: “Simulation study for the stratospheric inferred winds (SIW) sub-millimeter limb sounder”, Atmospheric Measurement Techniques, 11(7):4545–4566, 2018.

Zeeman effect

The molecular and atomic oxygen lines are magnetic dipoles that interact with the geomagnetic field: the line is split and the signal becomes polarized and anisotropic.

- Large impact on the MLT retrievals from the O2 line [6]
- Small impact on the thermospheric atomic oxygen line [5]

