DWTS

The Doppler Wind and Temperature Sounder

Quantifying the Neutral Drivers of
Weather and Space Weather

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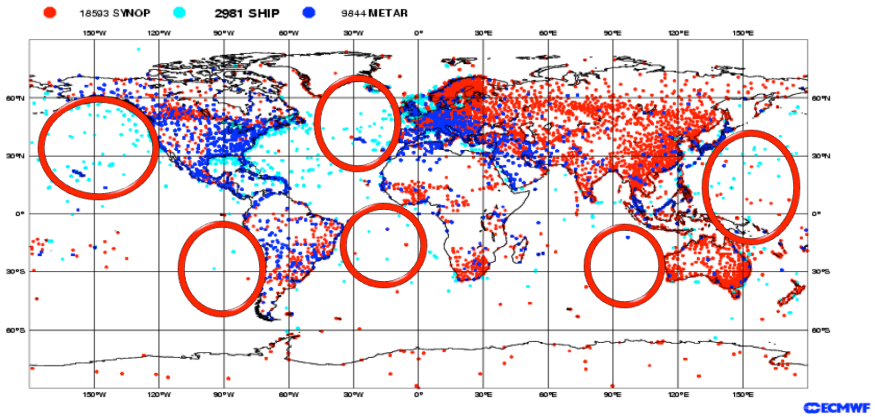
GLOBAL ATMOSPHERIC TECHNOLOGIES AND SCIENCES (GATS)

Outline

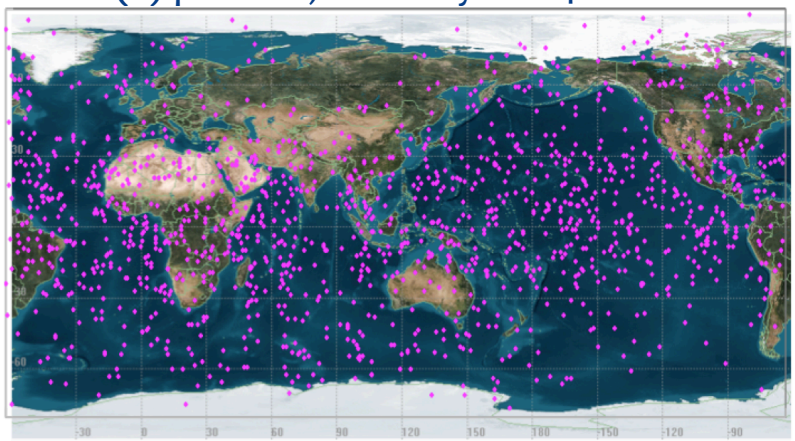
- Need for more complete V and T measurements
- DWTS instrument and measurement capabilities
  - Sampling enabled by one or multiple DWTS
- Science, Weather, and Space Weather benefits

Motivations: 1. current measurements provide inadequate global and altitude coverage

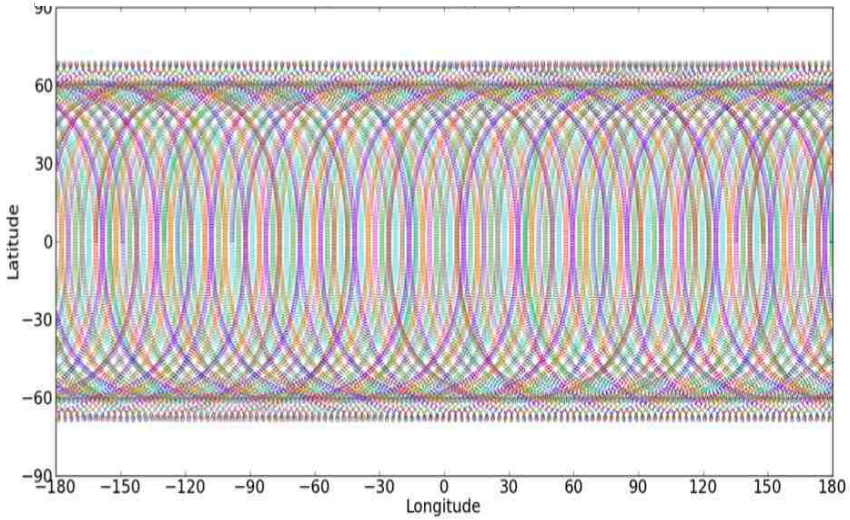
Radiosonde "voids", altitudes to ~30 km, are large impediments to NWP & climate models



COSMIC-2 GPS/RO will provide broad coverage with T(z) profiles, but only to ~40 km

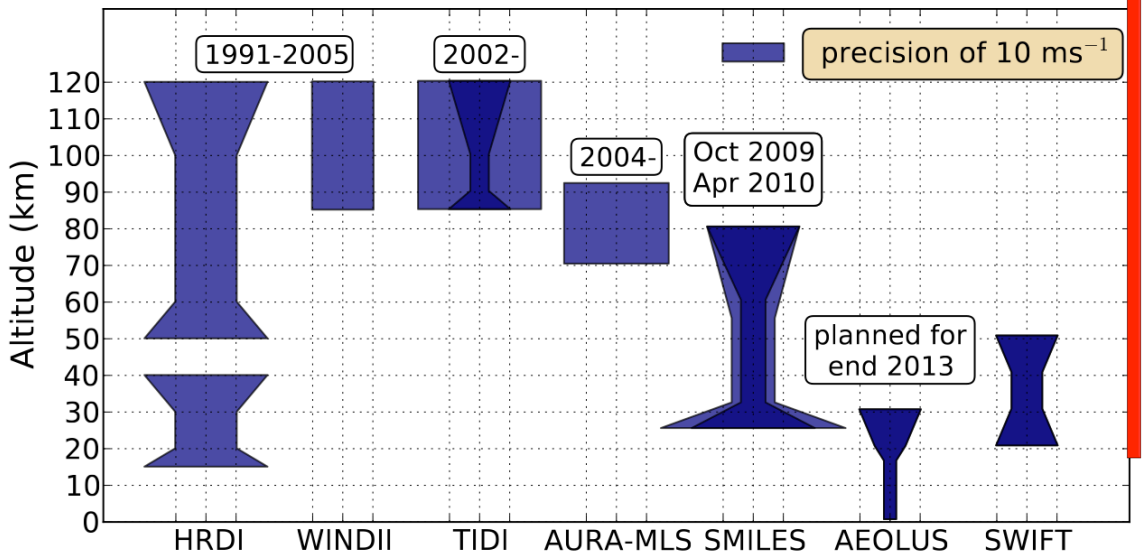


DWTS daily coverage, 6 dual-sided satellites **~600,000** profiles/day, (**U, V, T**) ~17-200+ km



Motivations: 2. current measurements provide inadequate altitude, day/night coverage

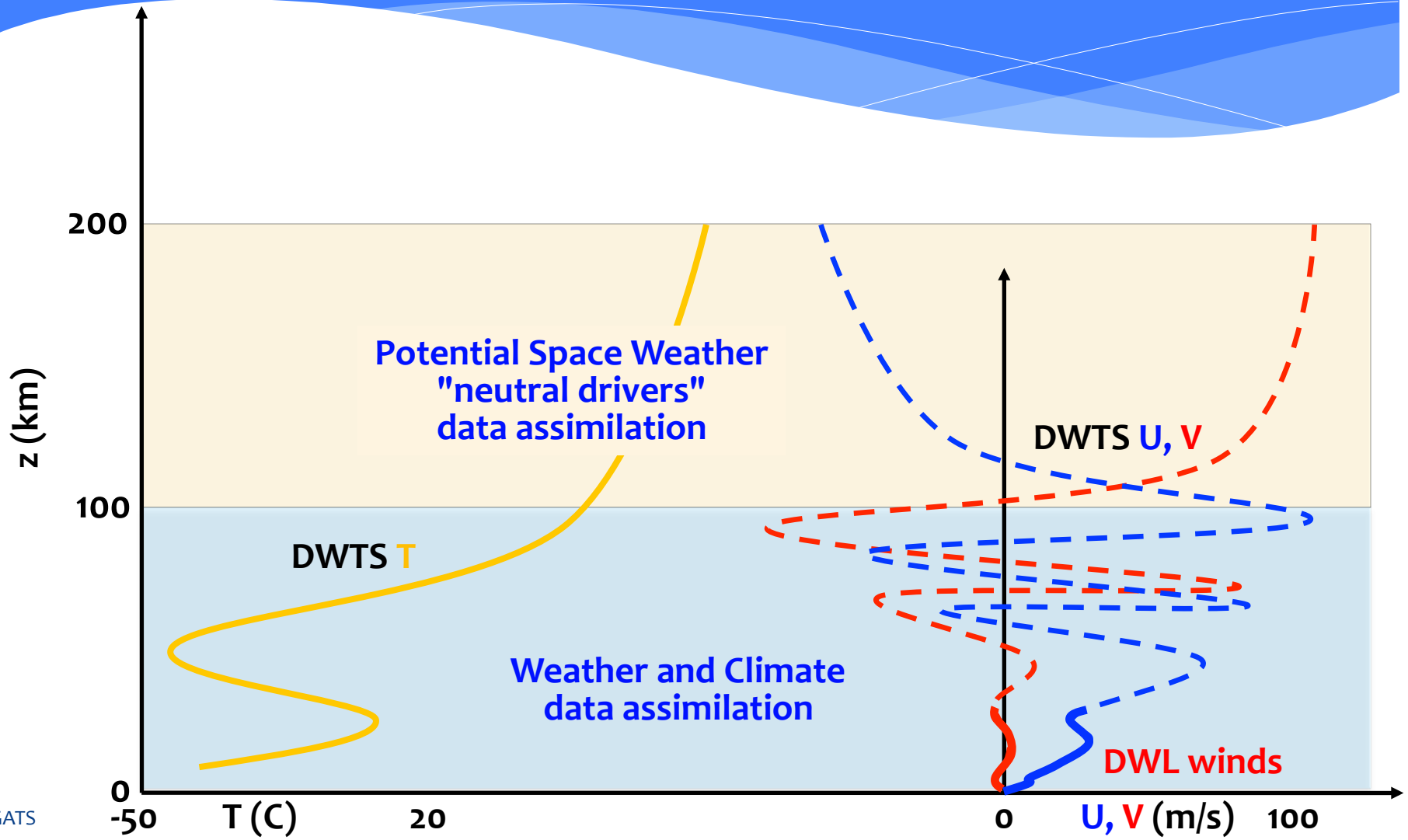
- Current instrument - TIDI/TIMED
  - day/night coverage ~80-105 km
- Planned instruments
  - AEOLIS ~0-30 km
  - SWIFT ~20-50 km



Baron et al. (2013) – SMILES paper

- **DWTS**
  - **continuous V & T profiles**
  - **day/night ~17 – 200 km**
  - **high resolution and precision**
  - **dense global coverage**

DWTS – DWL Synergism



DWTS Instrument and Capabilities Overview

Instrument

IR camera measuring Doppler shifts and widths of emission spectra of NO, N2O, and CO2 using gas correlation

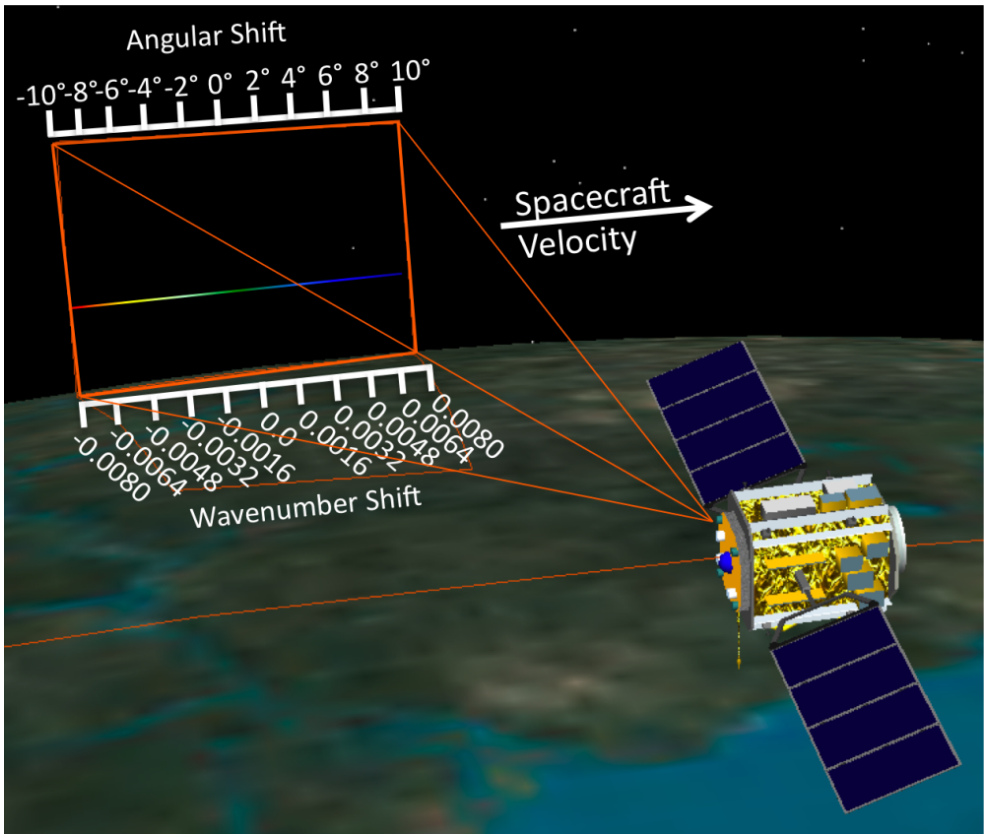
Measurements

* Continuous day and night observations of temperature and wind from 17-200+ km
  * 10 km along-track resolution
  * Precision of 2 K and 2 m/s (cross track)
  * along-track winds from 30-55 km and 90-200+ km with less precision

Benefits

* Forecasting improvements and science never before possible
  * large-scale atmospheric structure (V & T) 17-80 km daily
  * large-scale "Space Weather" environment every orbit

DWTS Operational Concept



DWTS continuously images the limb on both sides of the spacecraft (single view shown here)

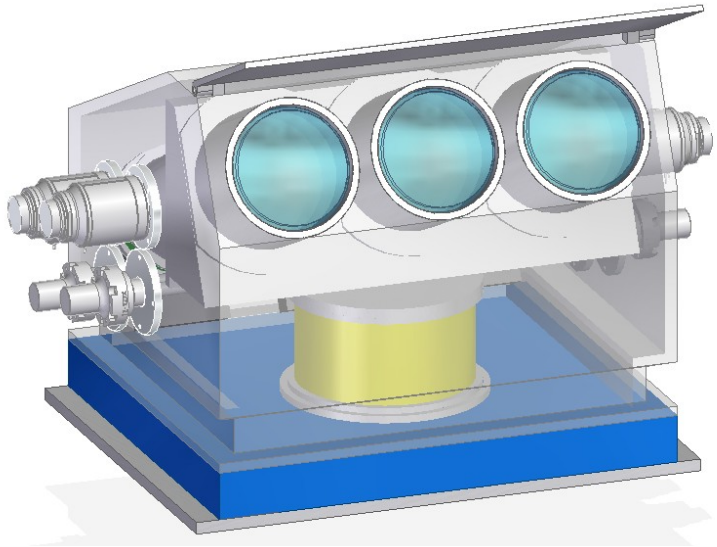
Collects integrated emission spectra from NO, CO_2 and N_2O

Retrieved profiles span ~17-200+ km

Provides full diurnal coverage

Accommodation Parameters

SWAP	Pathfinder (1-sided, 2 gases)	Operational (2-sided, 3 gases)
Mass:	7 kg	10 kg
Power:	7 W	10 W
Volume:	10 x 20 x 30 cm	14 x 20 x30 cm
Data rate:	20 kbps	40 kbps

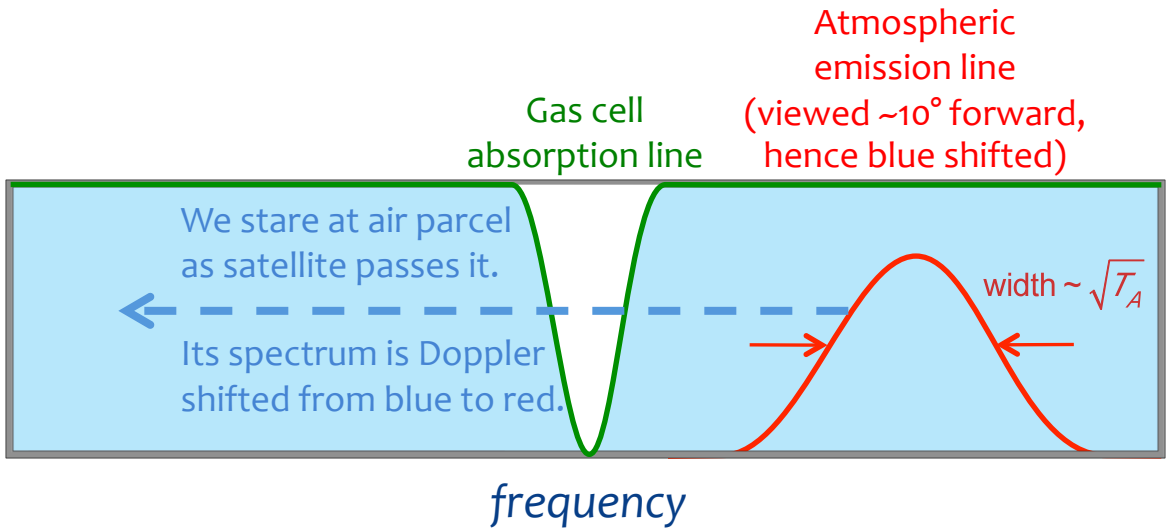


Detectors:	static, moderately cooled, Mid-IR camera with 5 cm apertures	
Gas Cells:	1. NO (high alt)	1829 – 1873 cm^{-1}
	2. $^{13}CO_2$ (mid alt)	2258 – 2282 cm^{-1}
	3. N_2O (low alt wind) (operational only)	2120 – 2160 cm^{-1}

DWTS Measurement Technique

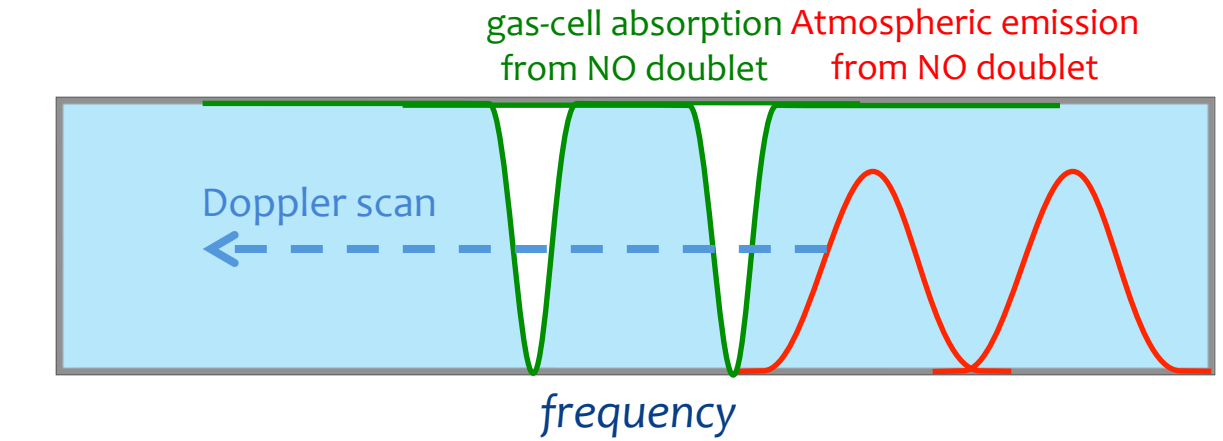
High resolution Doppler correlation spectroscopy

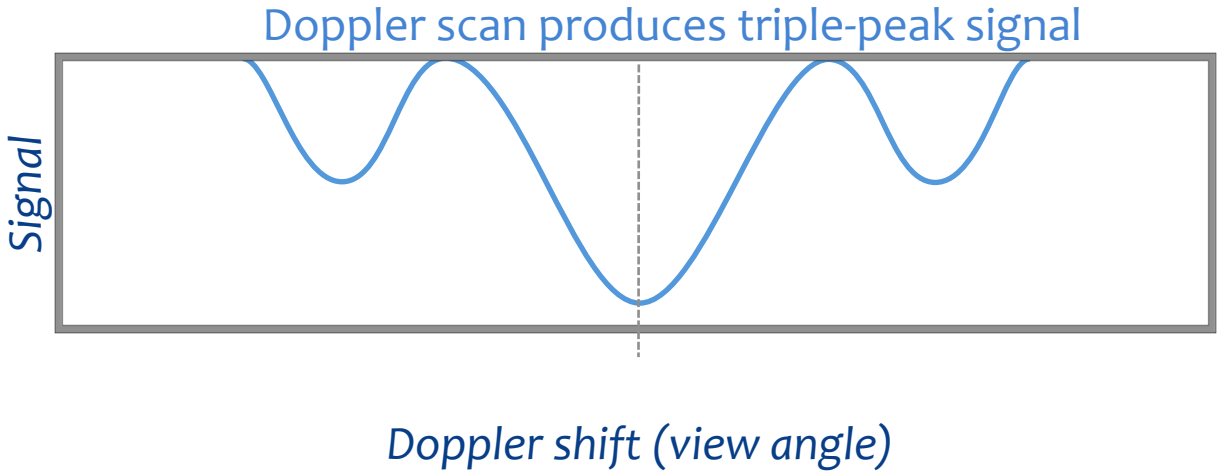
Doppler Spectroscopy



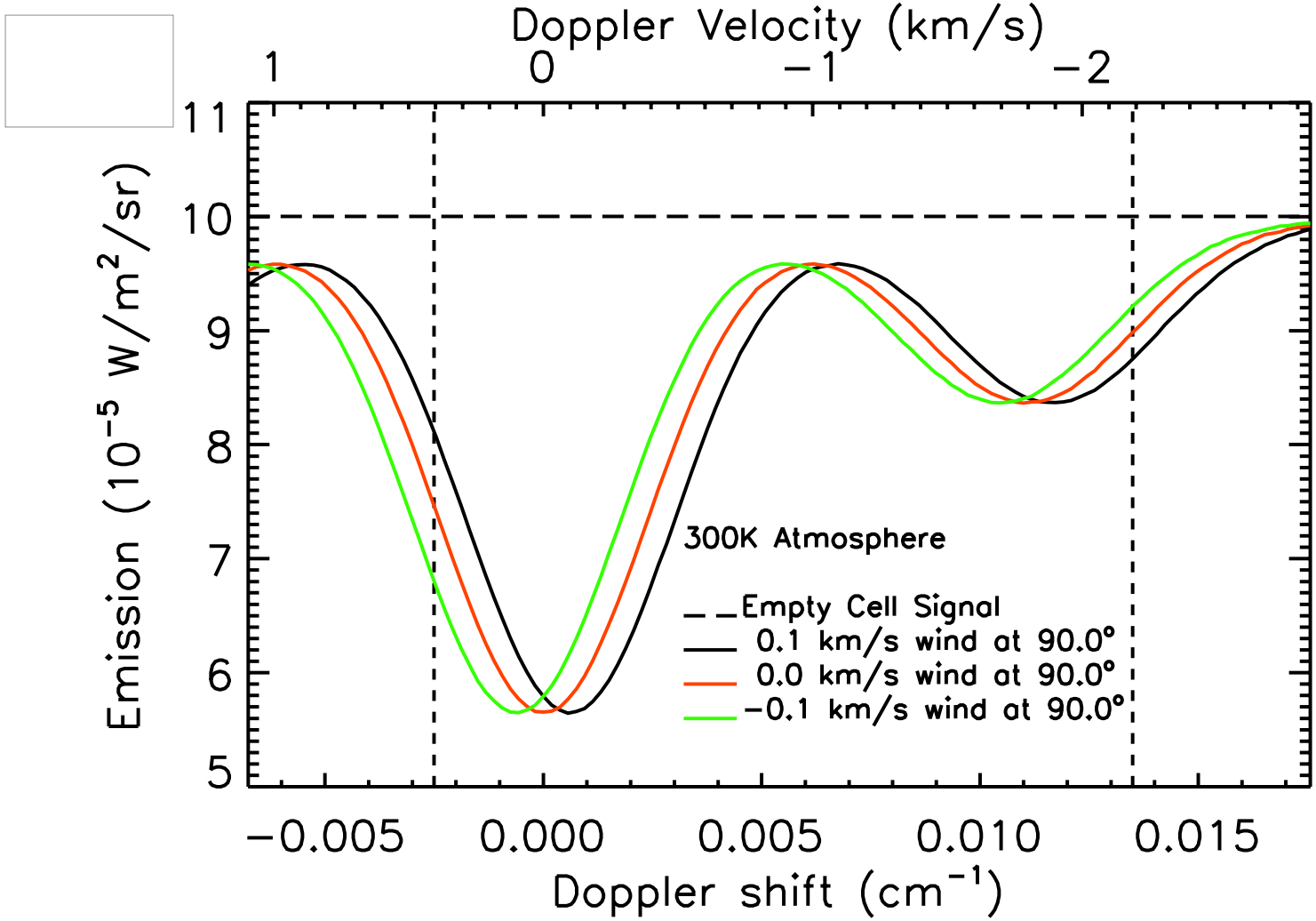
$$\text{width} \sim \sqrt{T_A + T_G}$$

NO doublets produce multi-peak signal

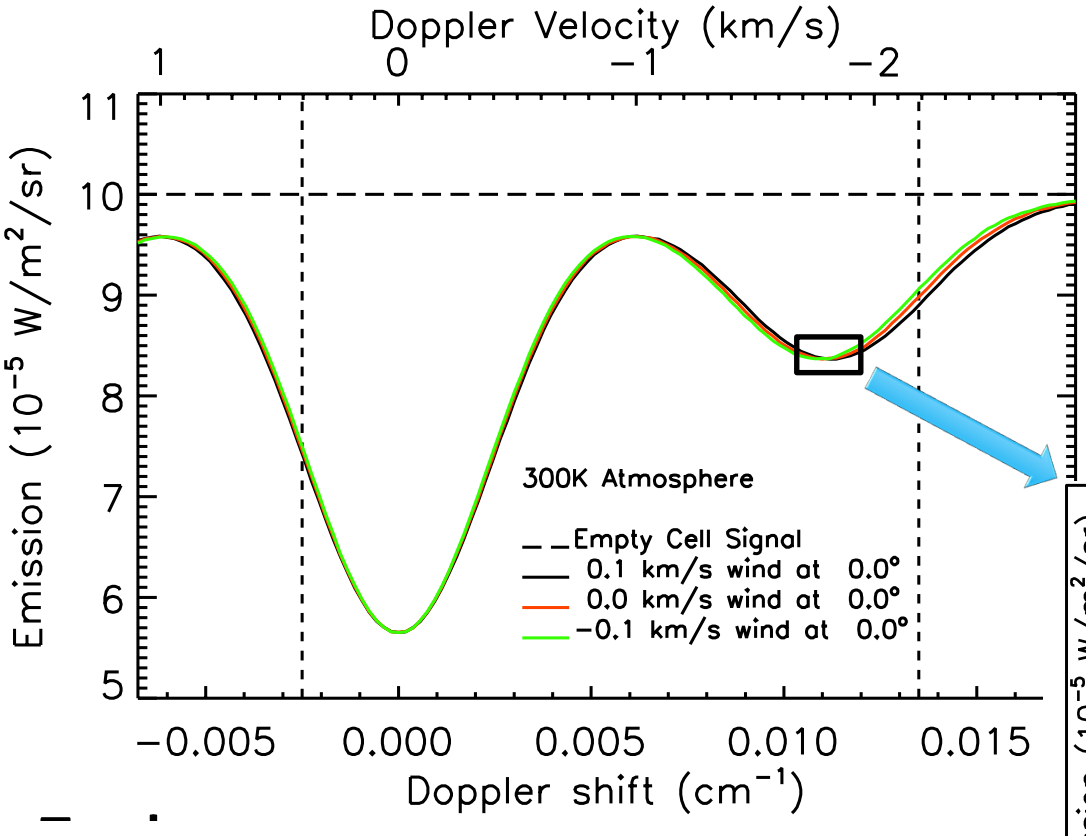




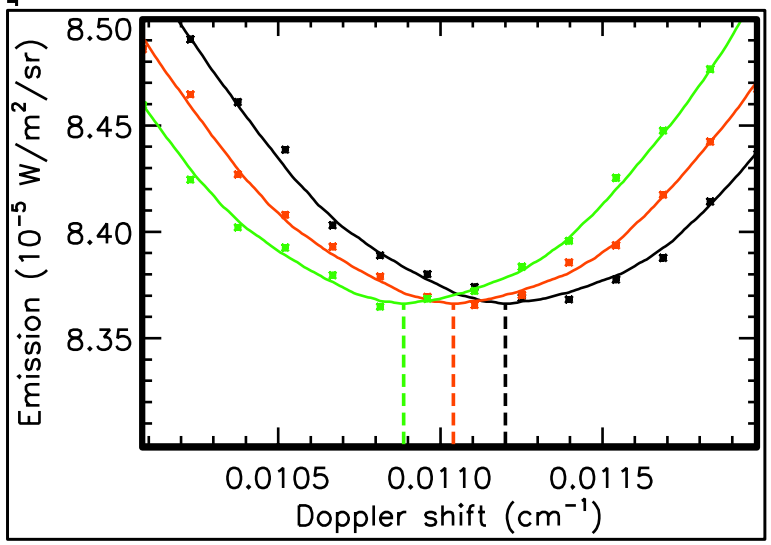
Cross-track winds *shift* the signal



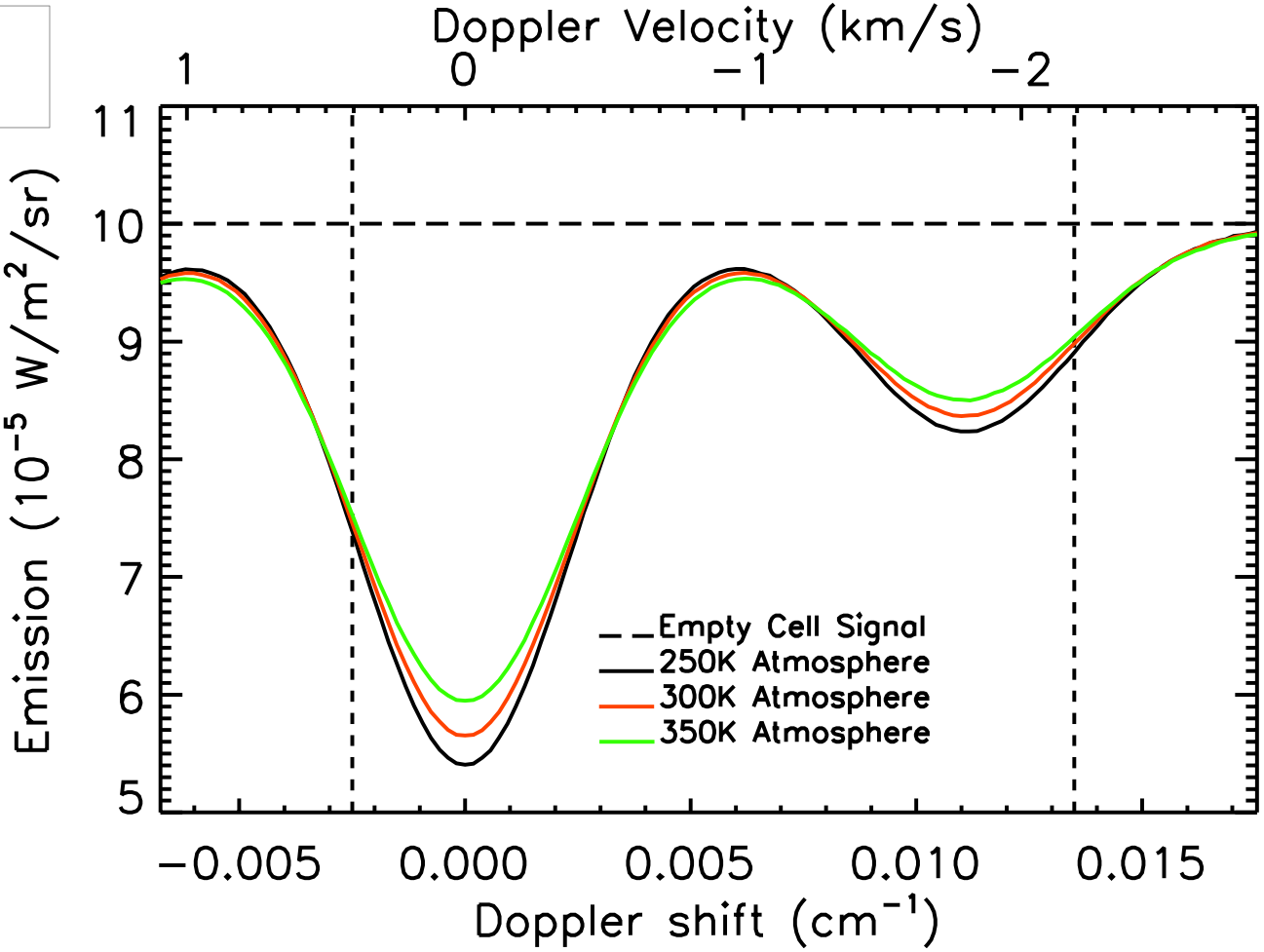
Along-track winds *scale* the spectrum



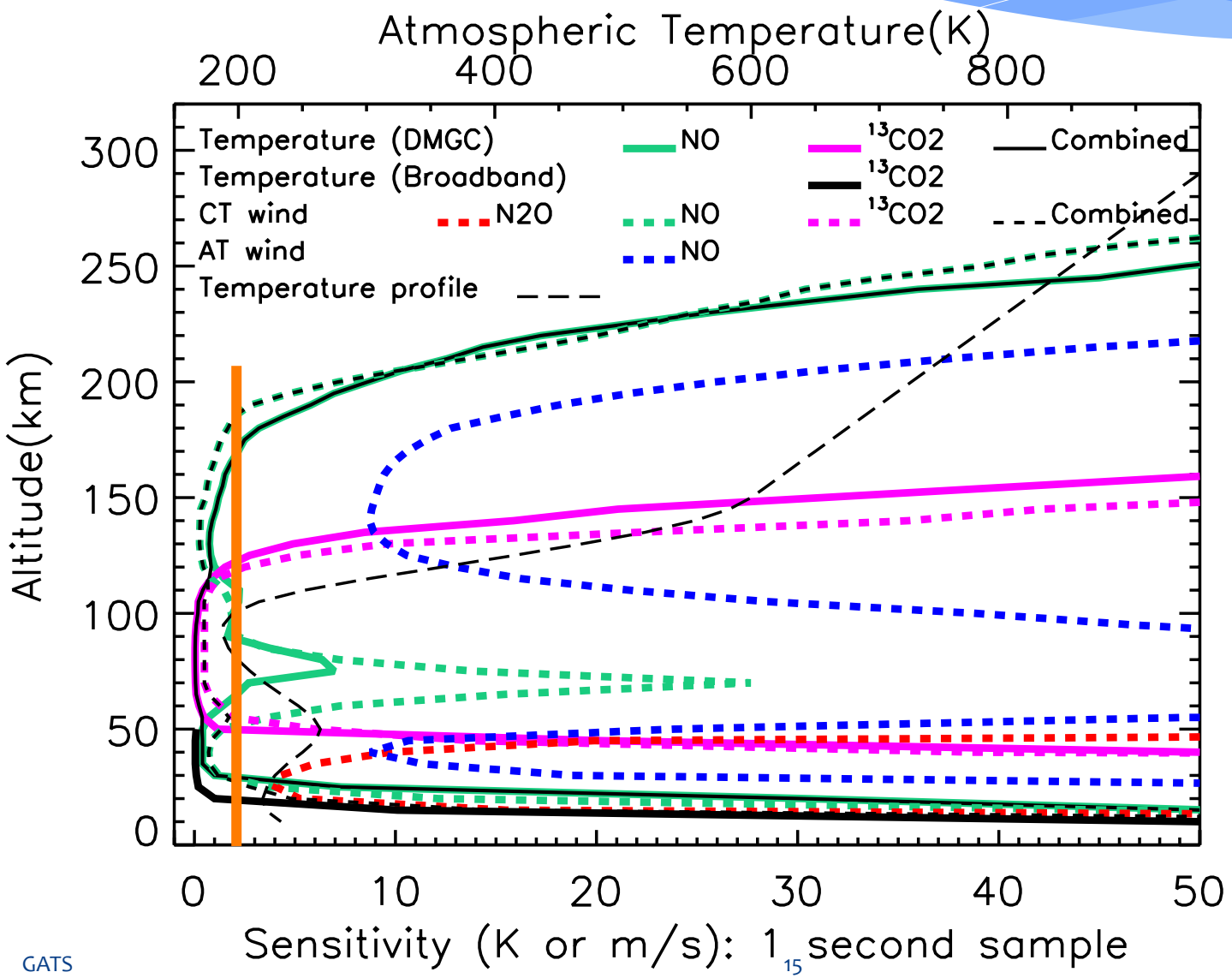
Three-hump signal from NO λ-doublets reveals this scaling



Signal *width* indicates temperature



DWTS Precision



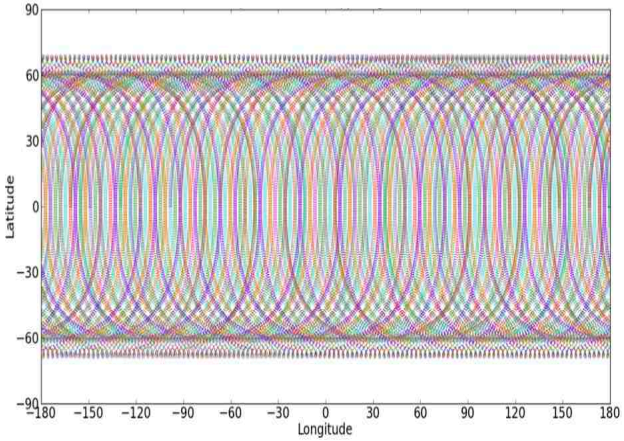
ΔT < 2 K and
ΔV < 2 m/s

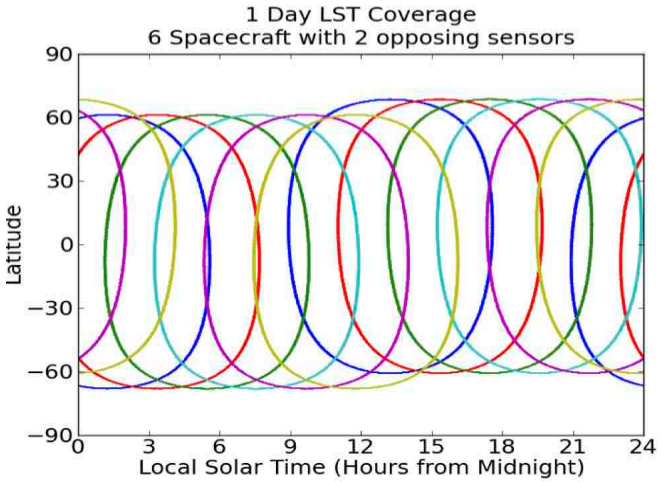
for 20-180 km range

with 1 s integration

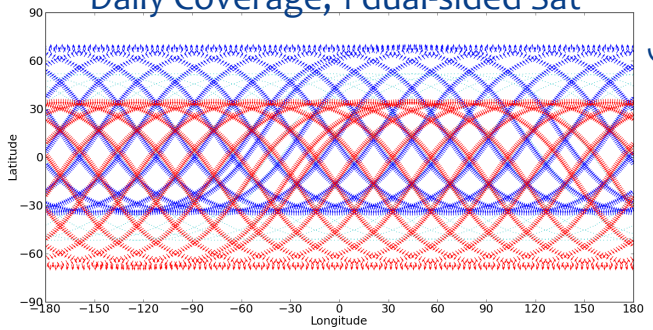
Geographic and LST Coverage

Daily coverage, 6 dual-sided Sats

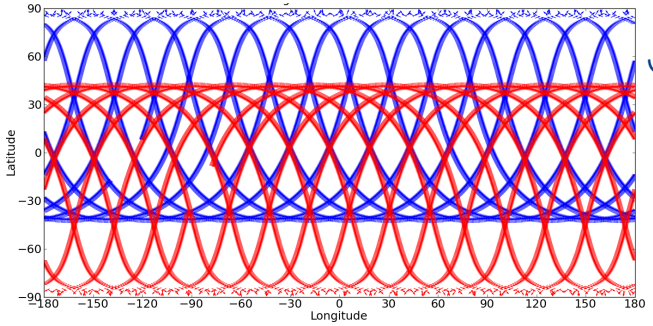




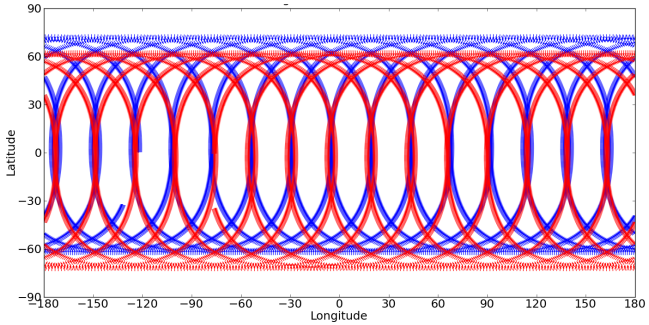
Daily Coverage, 1 dual-sided Sat



52° inclination



65° inclination



86° inclination

- Global definition of *V* & *T* from 17 to over 200 km for improved weather and space weather prediction
- 24 LST daily measurements
- Mean wind, tidal, and planetary wave drivers of “Space Weather” system every 100 min from 100 to over 200 km (higher for stronger solar conditions or solar storms)

Summary of DWTS Key Aspects

First global *V* & *T* measurements

- day and night
- high precision
- 600,000 profiles/day (6 satellites)
- 17 to 200 km

None of this was possible with previous instrumentation.

Benefits

- Full 3D definition of stratosphere and mesosphere daily (NWP)
- Full 3D definition of V, T, tides, and PWs in MLTI – every orbit (SWP)
- Global characterization of important small-scale gravity wave MLTI dynamics and influences
- Assimilation and improvement of weather, climate, and Space Weather models
- Support of other atmospheric science goals, environmental context for large majority of ground-based measurements

DWTS

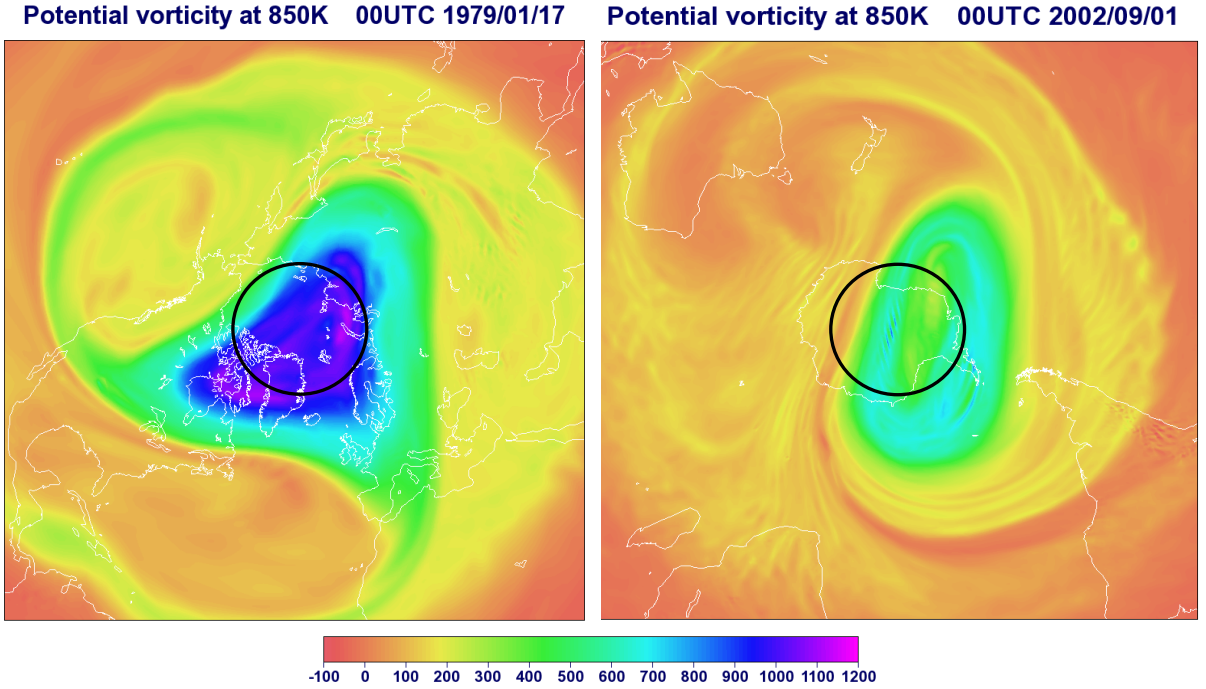
Doppler Wind and Temperature Sensor

Science Motivations

Global Atmospheric Dynamics

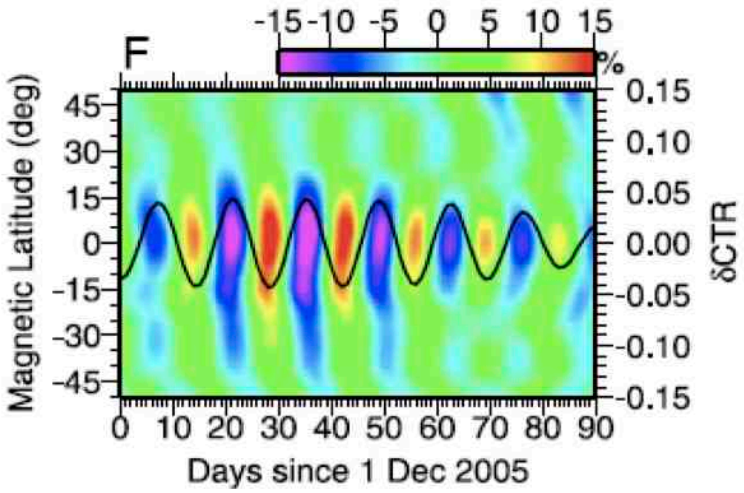
Atmospheric dynamics are of central importance,
but have never been fully quantified

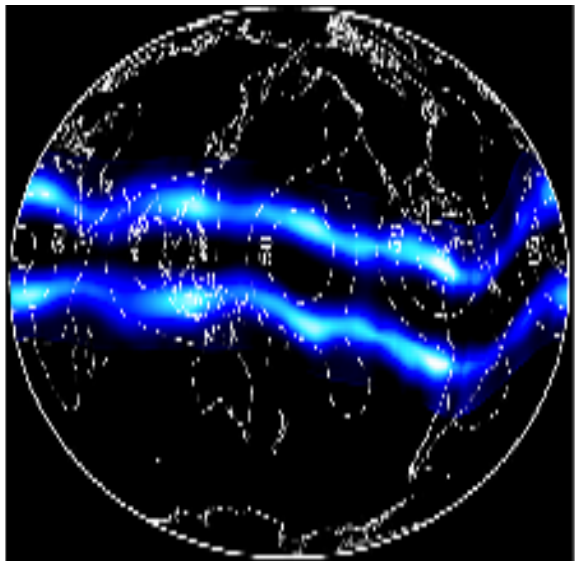
Lack of knowledge of the multi-scale structure of the lower-middle atmosphere (10-100 km) is a major impediment to quantitative understanding and prediction



PW and tidal Structures and Interactions

16-day PW modulations of TEC



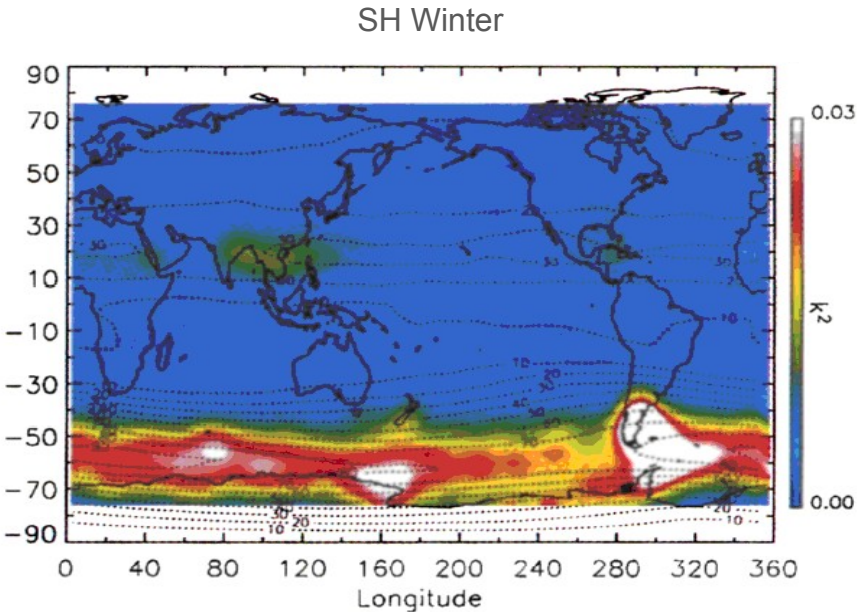


Very hard to diagnose Tidal-PW interactions with current satellite observations (SABER and/or TIDI) due to long averaging times

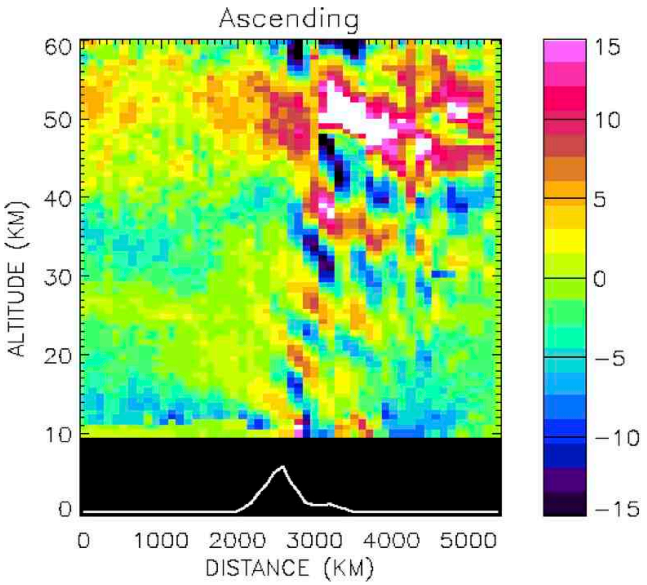
DWTS data will allow definitions of these dynamics (and all *E-P* fluxes) every orbit

Gravity Waves

Neither radiosonde, GPSRO, nor current satellite data (AIRS) adequately describe regions of small scale gravity wave forcing throughout the lower and middle atmosphere



MLS, Jiang et al. (2002)



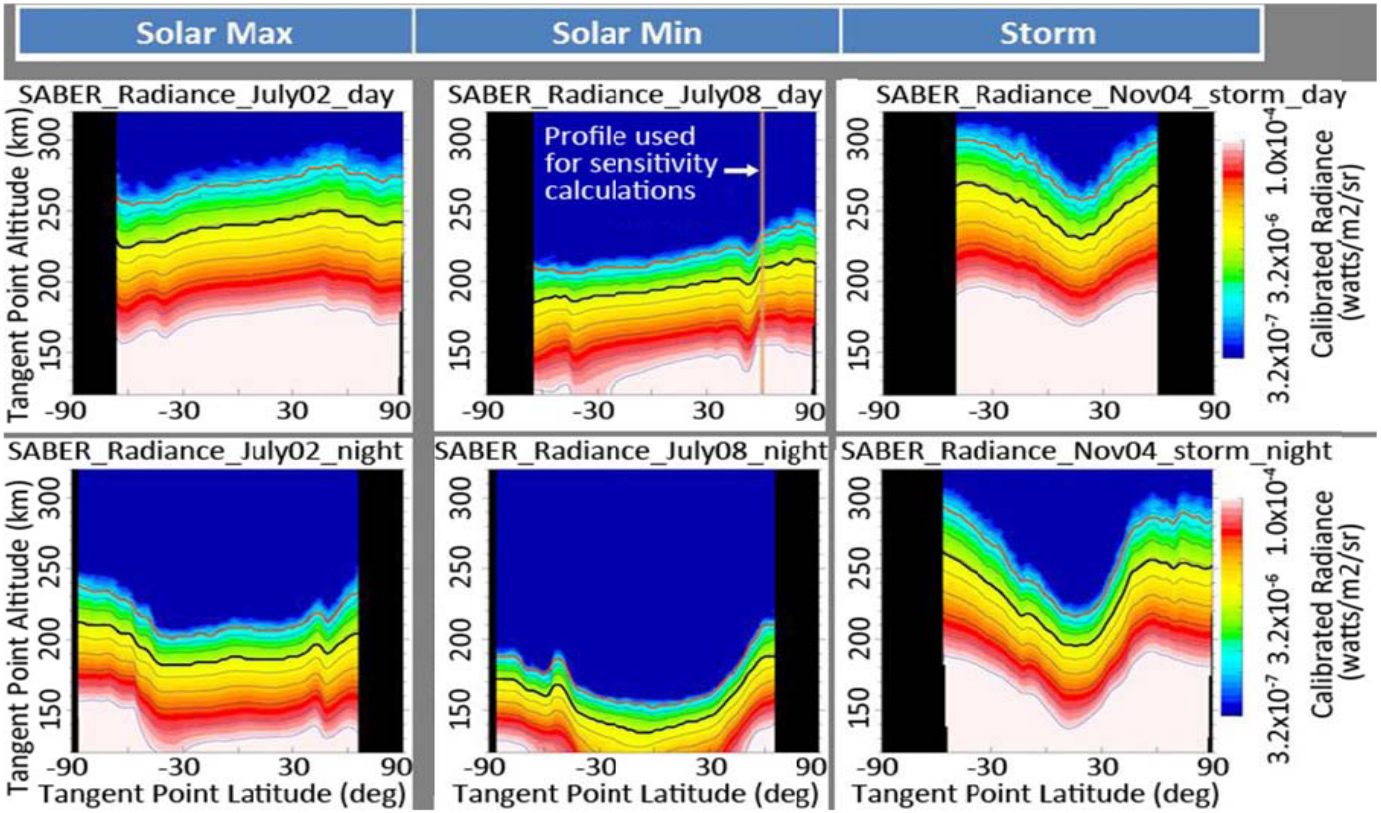
Backup Slides

High Altitude Coverage

Simulation based on NO levels from SABER (DWTS will be more sensitive)

High-precision measurements to over 200 km at mid and high latitudes

Continuous measurements, both day and night



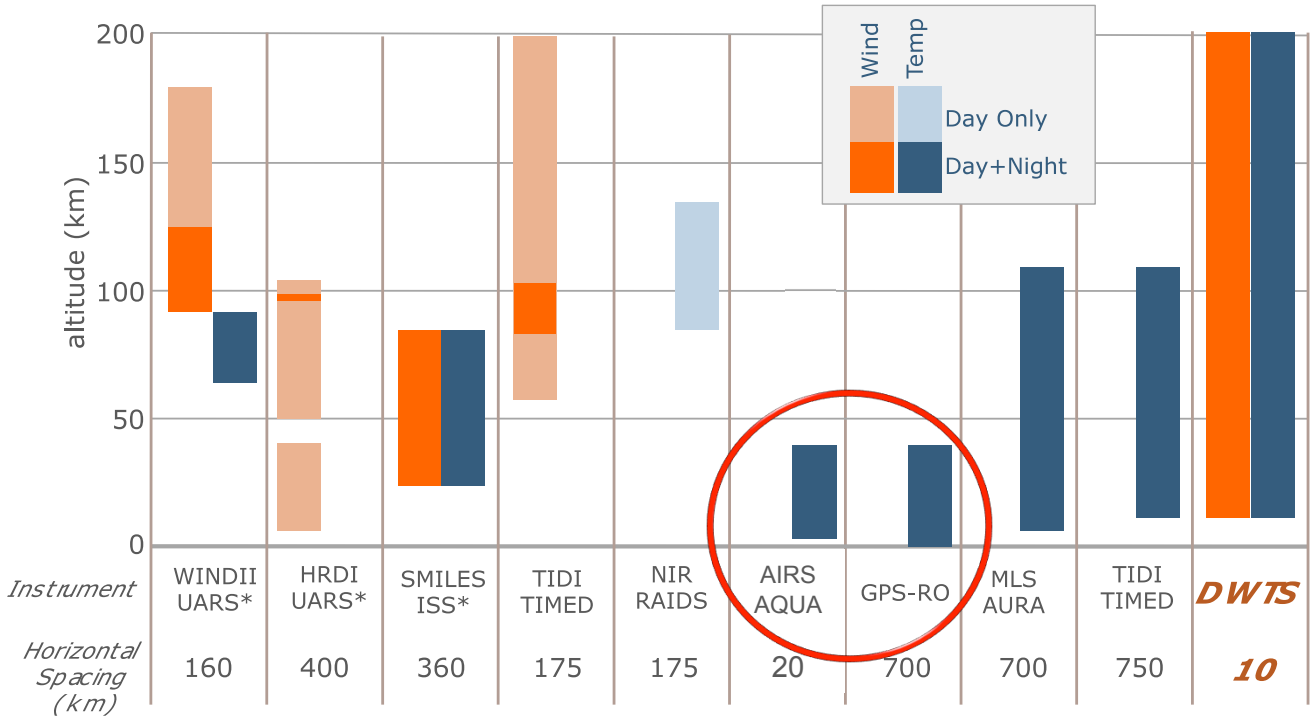
DWTS – AIRS Comparison

Parameter	AIRS	DWTS
temperatures	yes	yes
horizontal winds	no	yes
altitude coverage	~0 - 40 km	~17 – 200+ km
horizontal sampling	2 LTs/day	24 LTs/orbit, most longitudes
altitude resol.	7 - 15 km	2 km
along-track resol.	18 km	11 km
T accuracy	1.6 - 3 K	1 K
spatial coverage	20^{o} swath	600,000 profiles/day; spanning all LTs

*DWTS measurements, **especially winds** from ~17-100 km will yield major advances in weather and climate prediction*

DWTS measurements in the thermosphere, ~100 km and above, will enable "Space Weather" real-time monitoring, forecasting, and prediction, which are now impossible.

Motivations: 2. current measurements provide inadequate altitude, day/night coverage



- Current instruments
  - confined to altitudes <40 km
  - no global winds
- **DWTS**
  - **continuous V & T profiles**
  - **day/night ~17 – 200 km**
  - **dense global coverage**