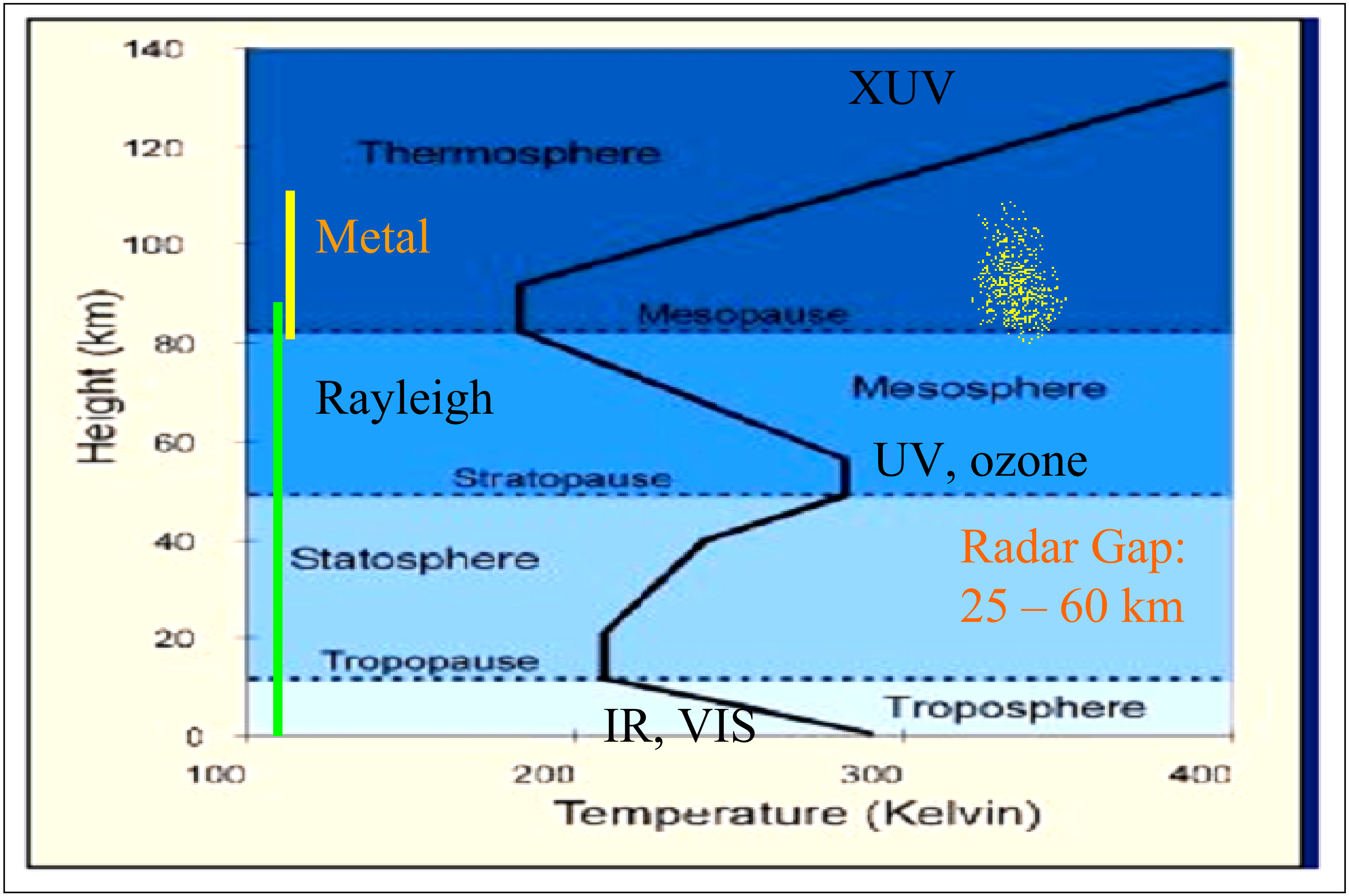
The challenge of a modern aeronomer – A bias view

March 5, 2006

A presentation for potential researchers at CU and CSU

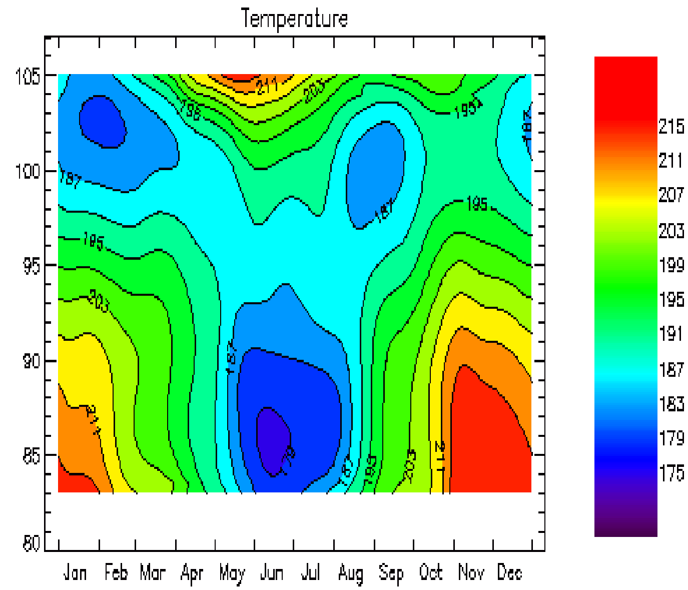
Sensing of atmospheric layers from ground

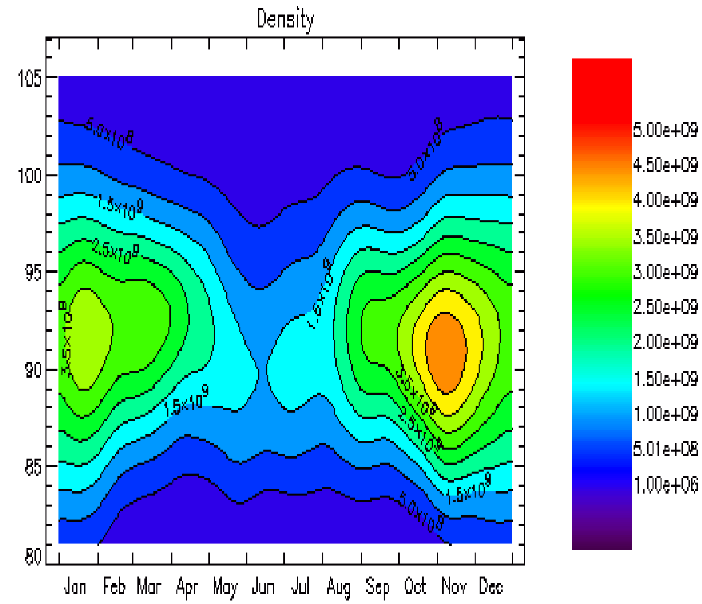


Upper Atmospheric Research: Challenges and Strategies

- Since atmospheric perturbations increase as height increases, one would expect to observe larger signal on global change in the upper atmosphere. However natural variability, such as solar cycle (11 year) effect need to be carefully evaluated – A long data set in temperature observation is necessary.
- Counter-intuitive thermal structure: Resulting from gravity (buoyancy) wave (GW) upward transport and breaking leading to pole-to-pole (summer to winter) circulation and associated summer cooling and winter warming.
- Much are still observational science in the discovery mode: Imager observation (since '93) has identified wave breaking signatures; radar and lidar quantitative characterization (horizontal wind and temperature profiles) began only in the past few years.
- To understand waves (tide, planetary wave and GW) and their interactions and impact, tidal (largest) waves and their variations must be determined: Need multiple-day 24-hr continuous, TUV observation.

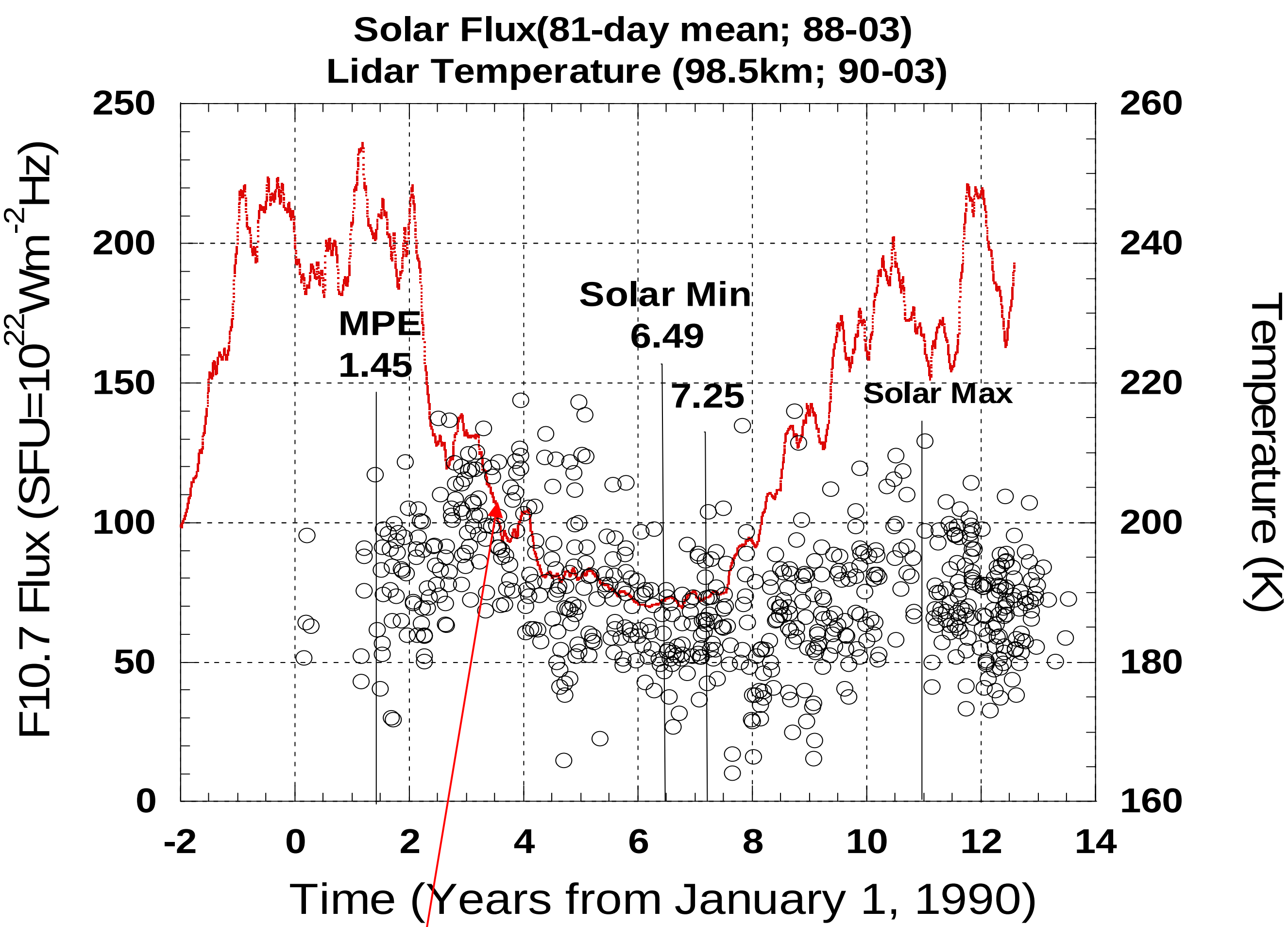
Climatology – Two-level Mesopause





Eight-year Fort Collins climatology of 3.7 km and 1 month smoothed nocturnal temperature (left) and Na density (right) – <u>She et al. GRL 2000</u>

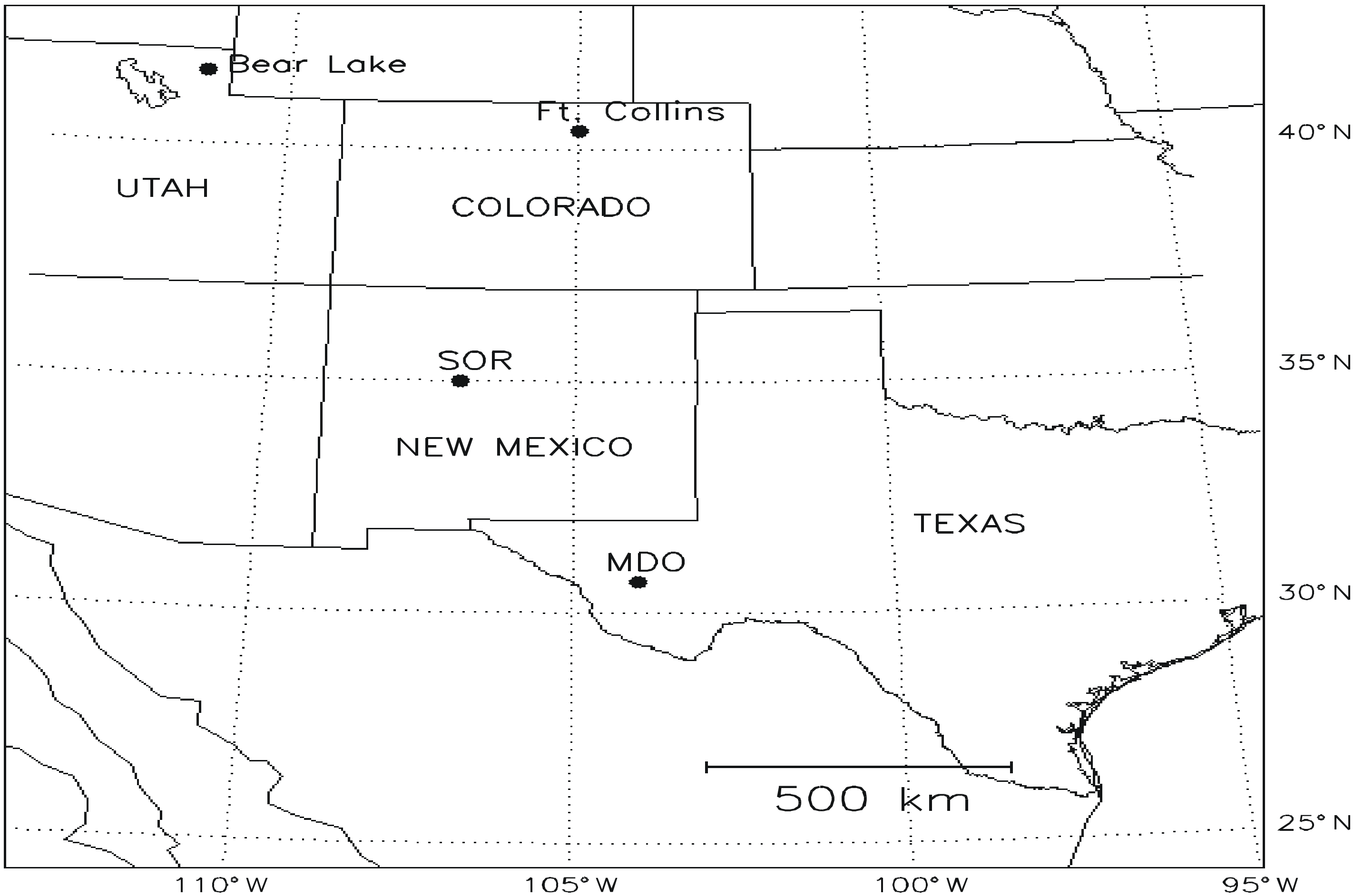
Colorado State University
Knowledge to Go Places



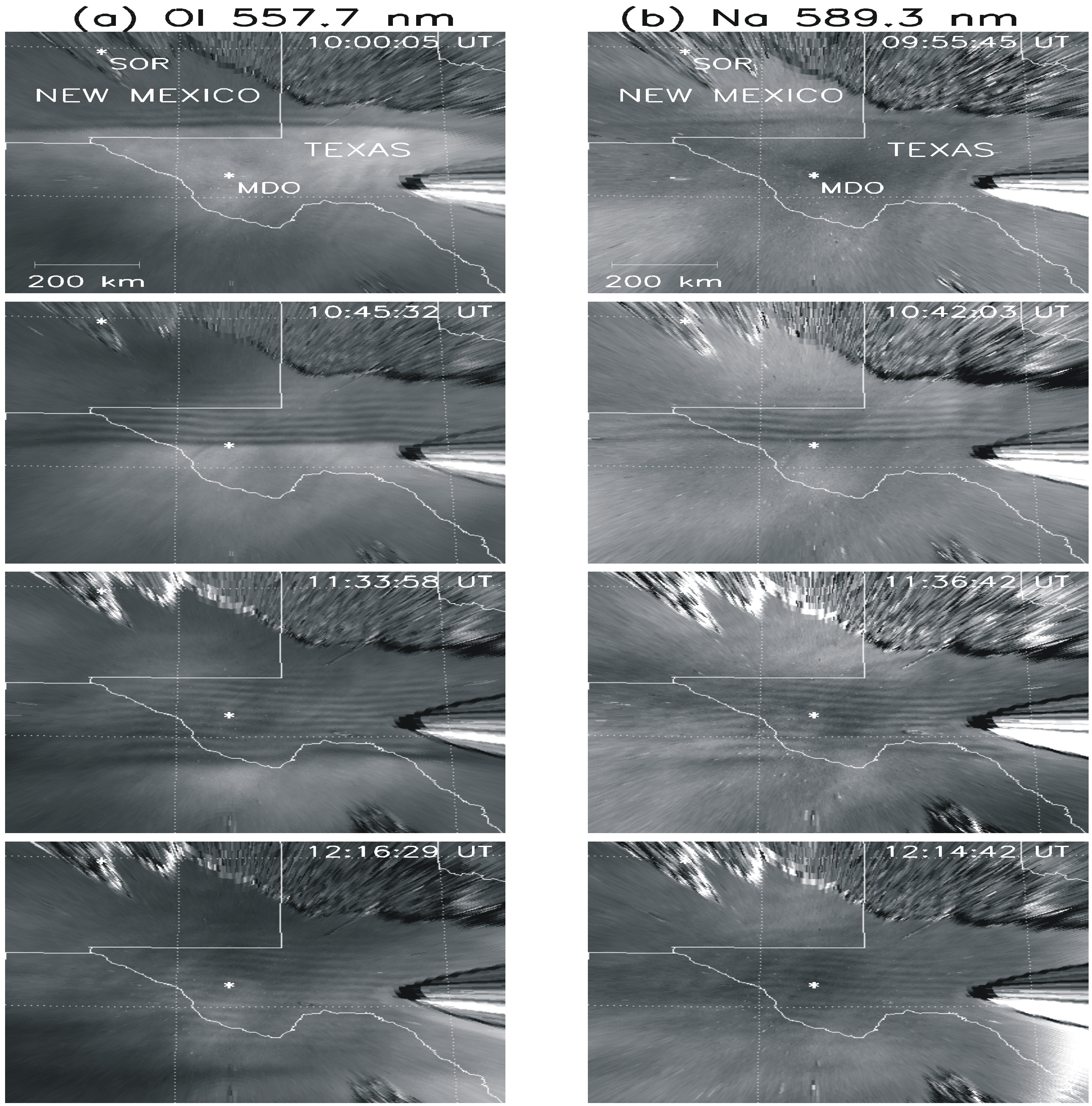
Solar cycle effect observed _ Solar-terrestrial connection
Un-expected Pinatubo warming
Entertain temperature trend and global change study

Mesospheric bore (JGR, 2003) observed by BU imager at MDO

Smith, Taylor, Swenson, She, Hocking, Baumgardner, Mendillo

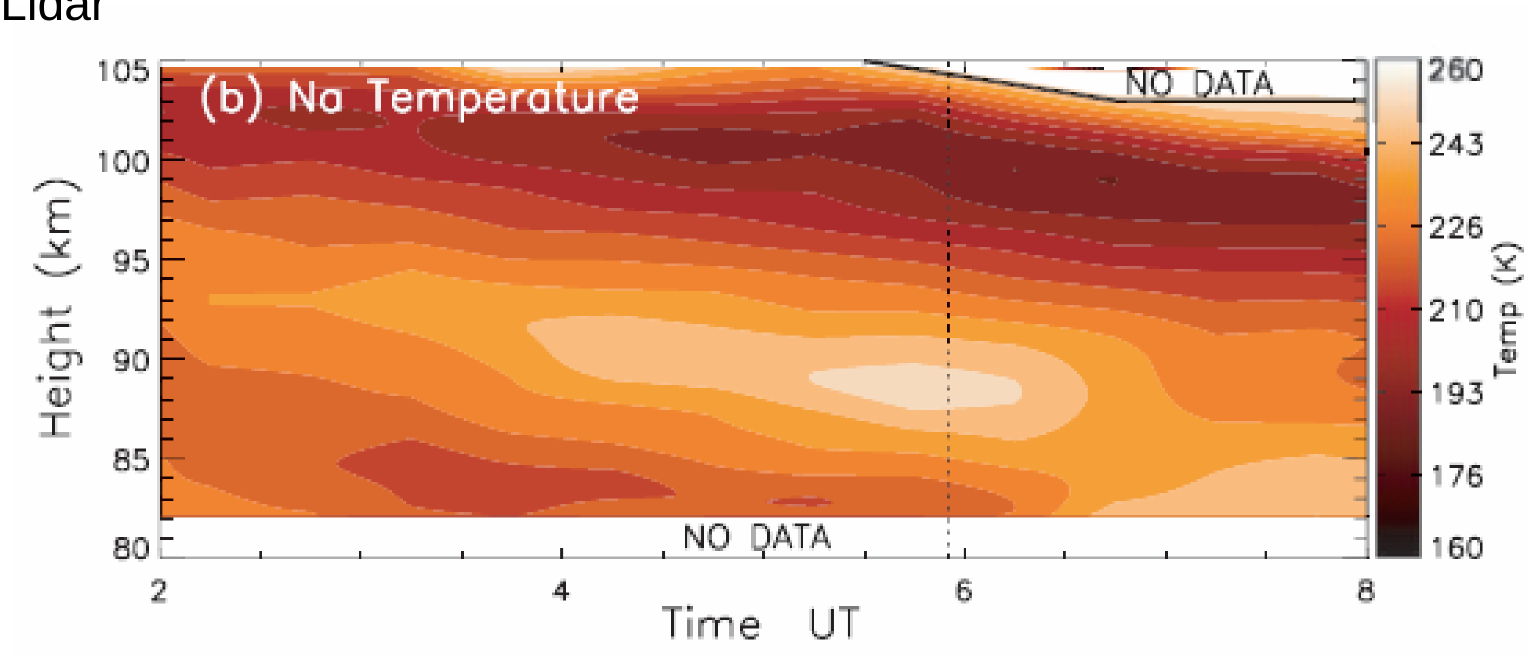


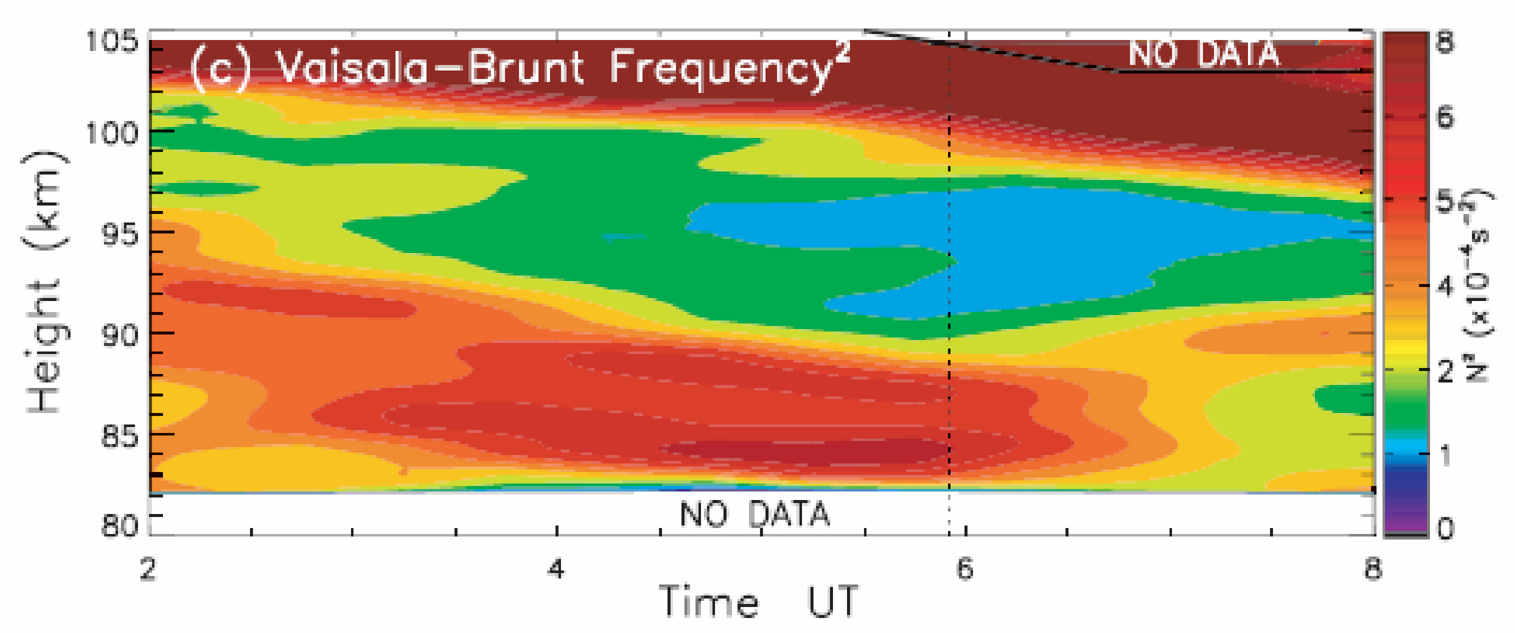
Wave front travels with a speed ~60m/s; it takes ~5 hours from Fort Collins, CO to (Temperature Inversion?) McDonald Observatory, TX (~1100km).



(a) OI 557.7 nm
(b) Na 589.3 nm
10:00:05 UT
SOR
NEW MEXICO
TEXAS
MDO
200 km
09:55:45 UT
SOR
NEW MEXICO
TEXAS
MDO
200 km
10:45:32 UT
10:42:03 UT
11:33:58 UT
11:36:42 UT
12:16:29 UT
12:14:42 UT

CSU Lidar

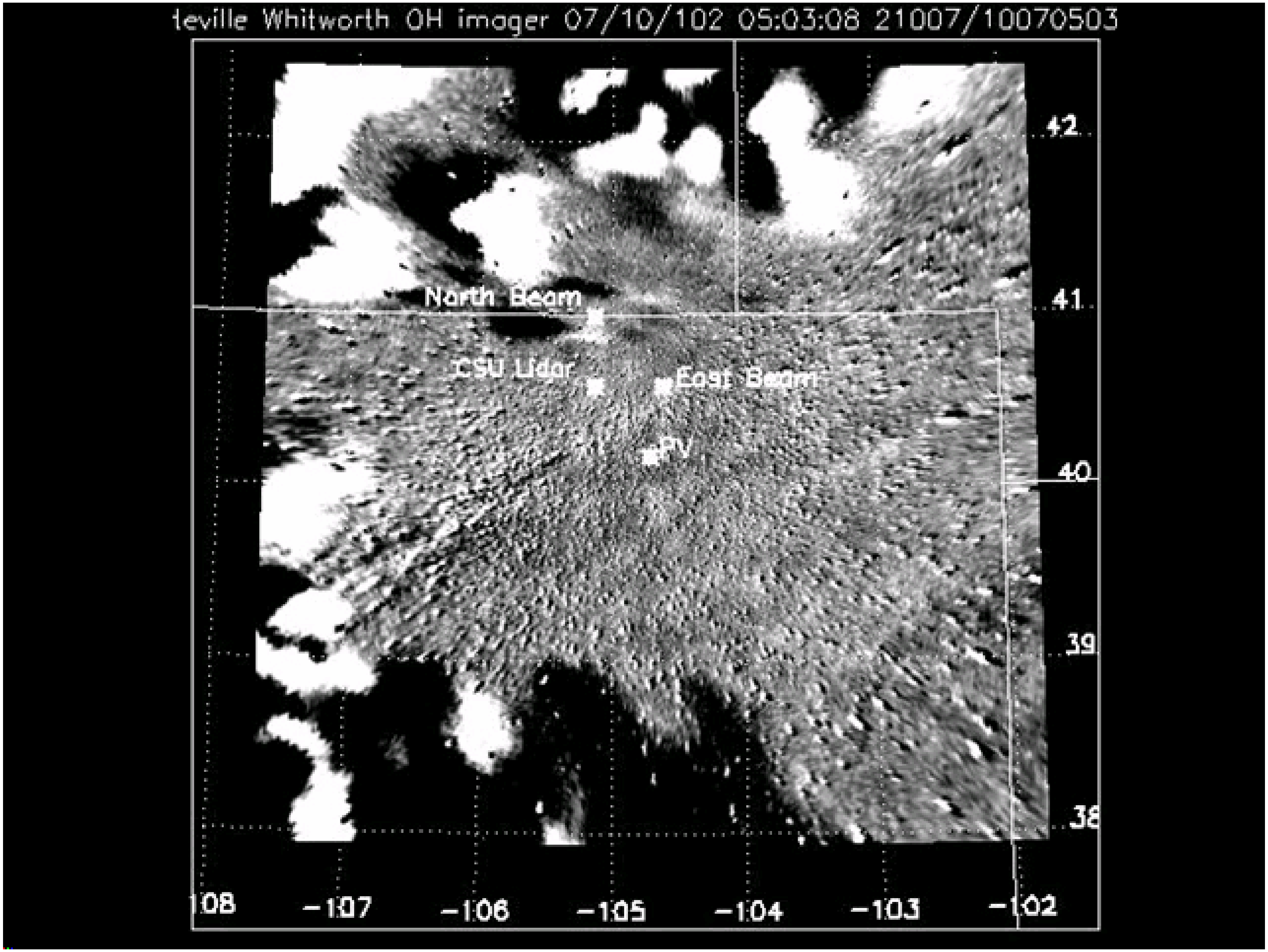




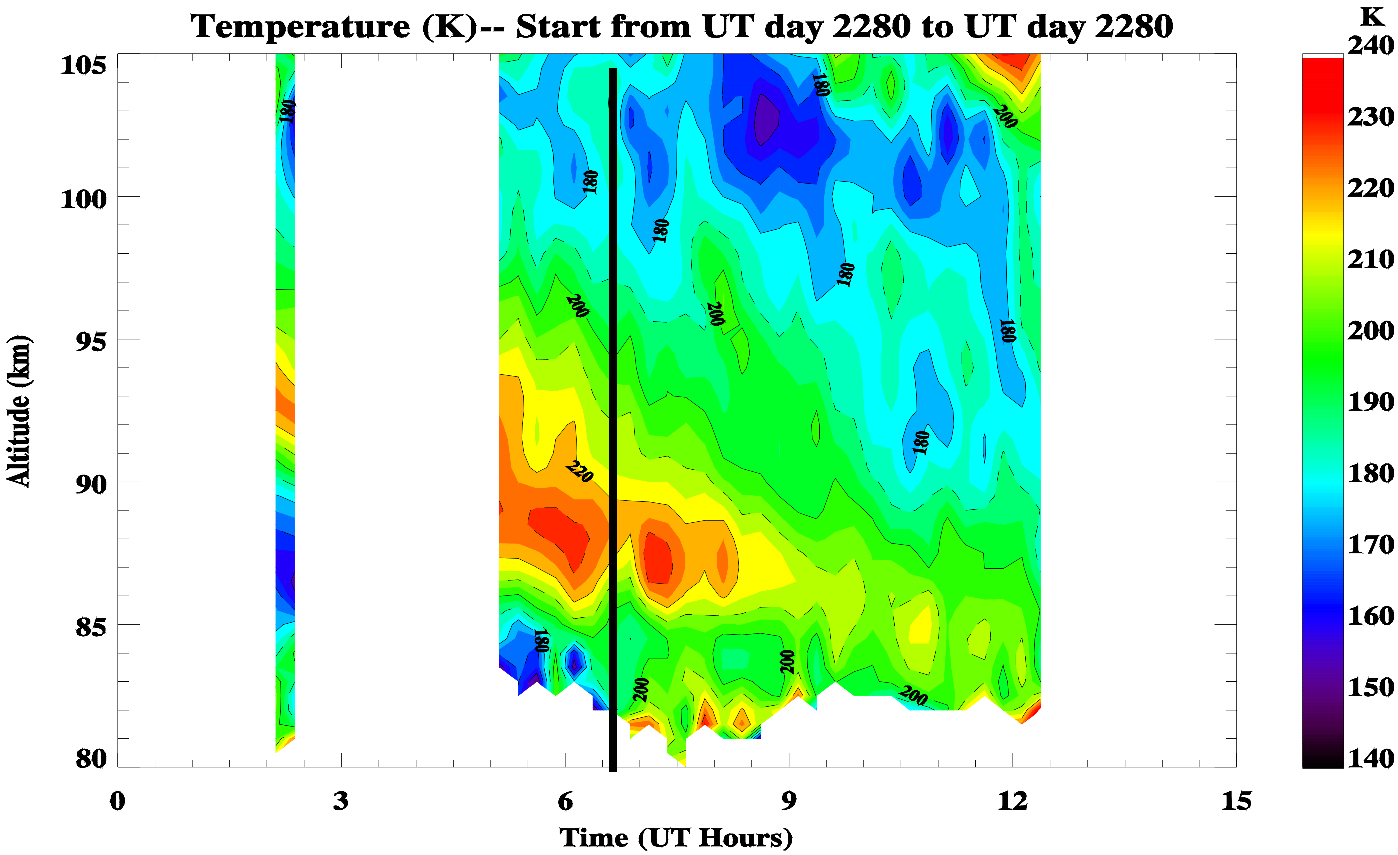
Temp Inversion → Duct

CSU Observation

05:03, 05:55 (E), 06:14 (N), 06:40 (turbulence), 7:30



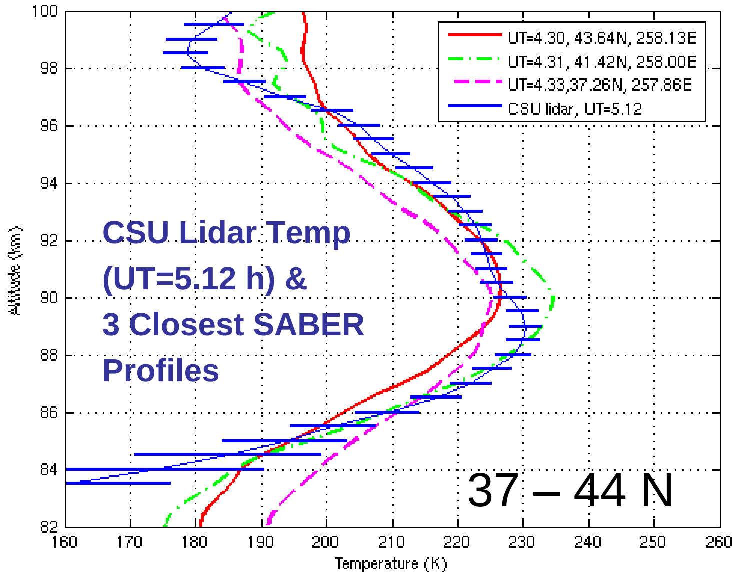
Duct for bore and bore stability

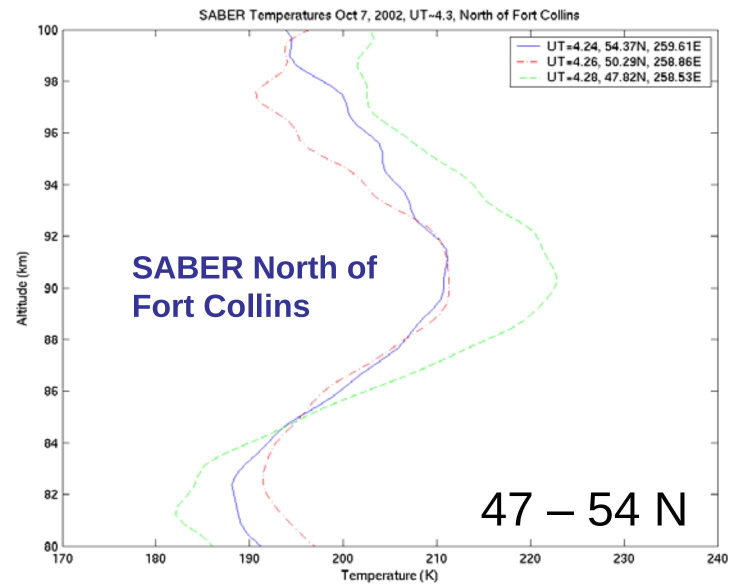


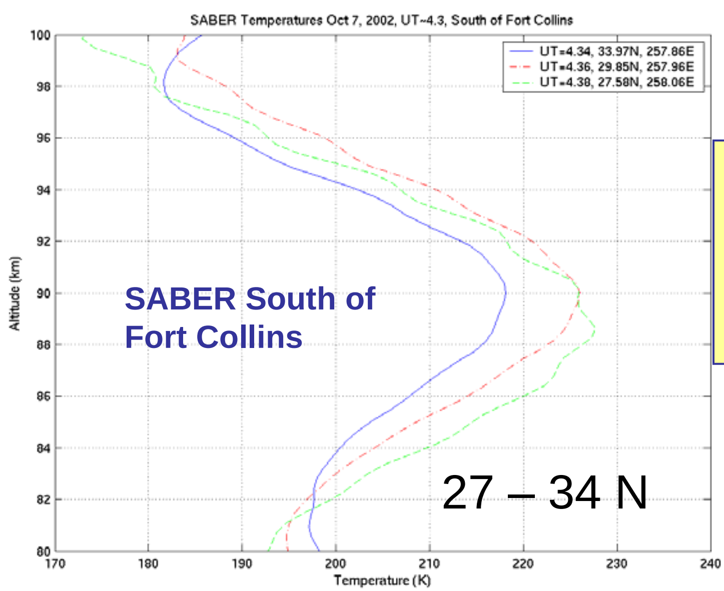
First direct confirmation of theory of mesospheric bore and first observation of undular – turbulent bore transition

She, Li, Williams, Yuan, And Picard, JGR, 2004

Comparison of SABER and Ft. Collins (40.6N, 255E) Lidar Mesosphere Temp. Inversion Layers, 7 Oct 2002





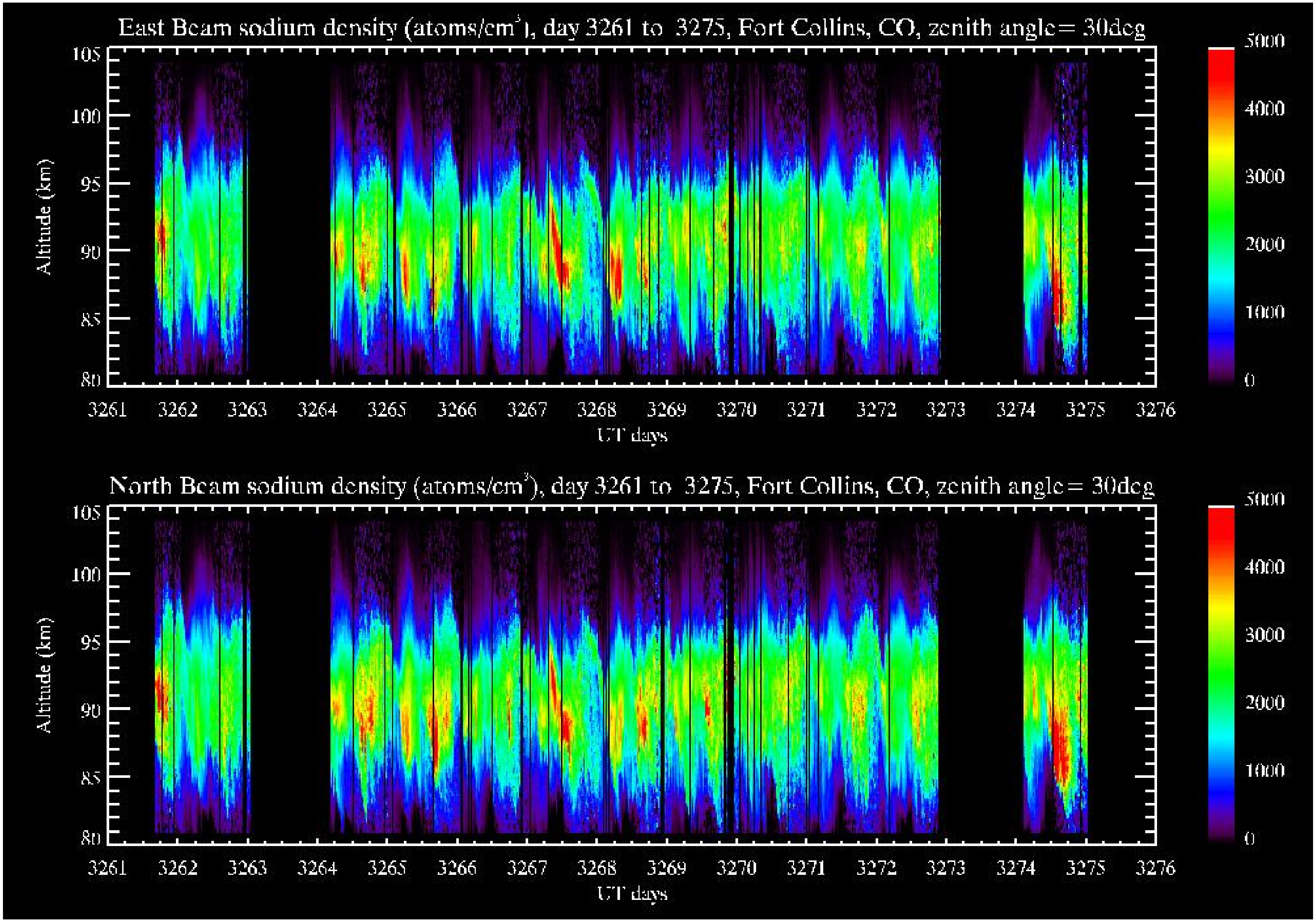


Temperature

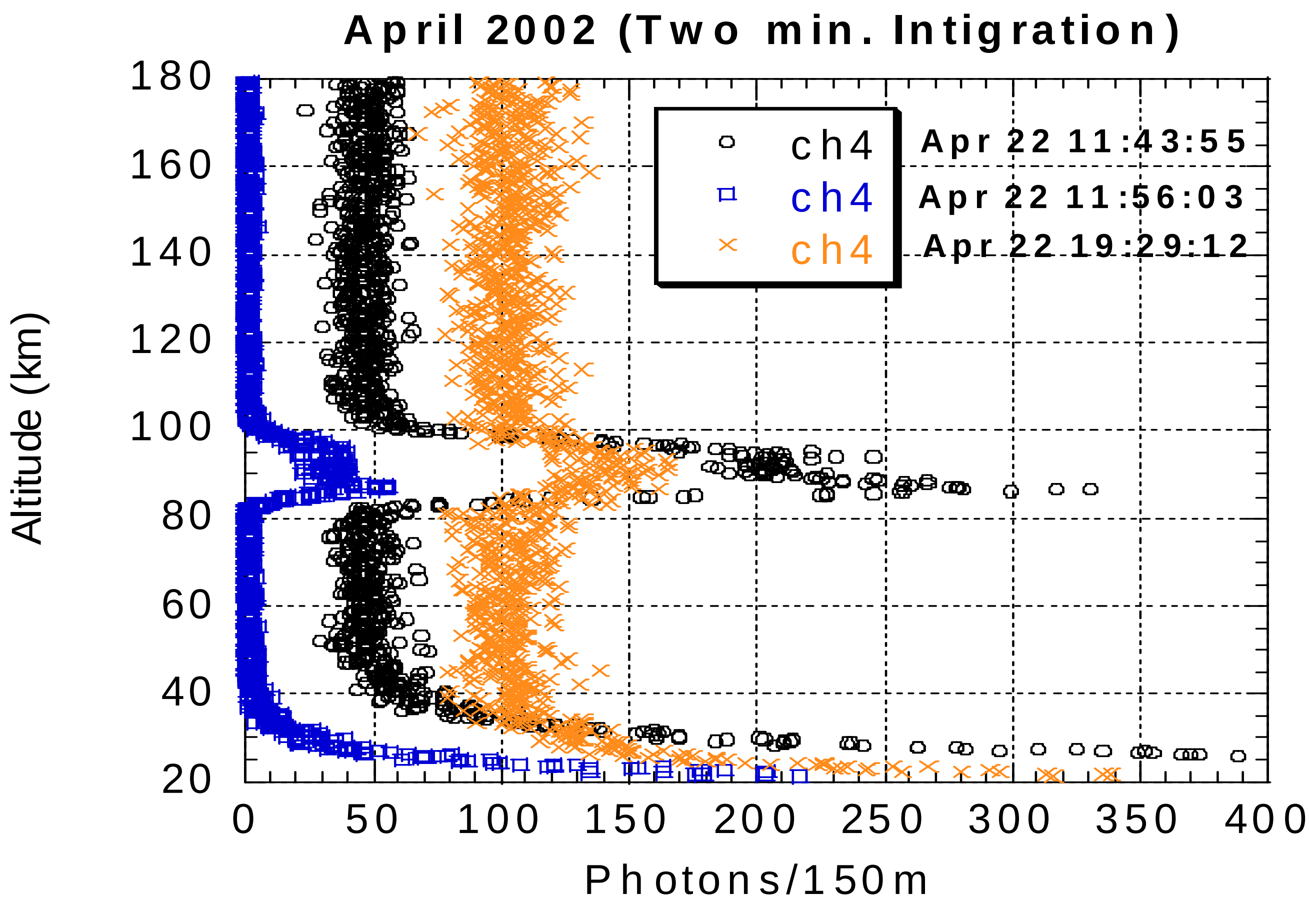
- **SABER data allows study of spatial extent of Temperature Inversion layers on global scale**
- **This layer extends at least 5000 km along track**

Courtesy of Richard Picard (2004)

Tides and tidal variability – CSU Lidar Observation (raw data)



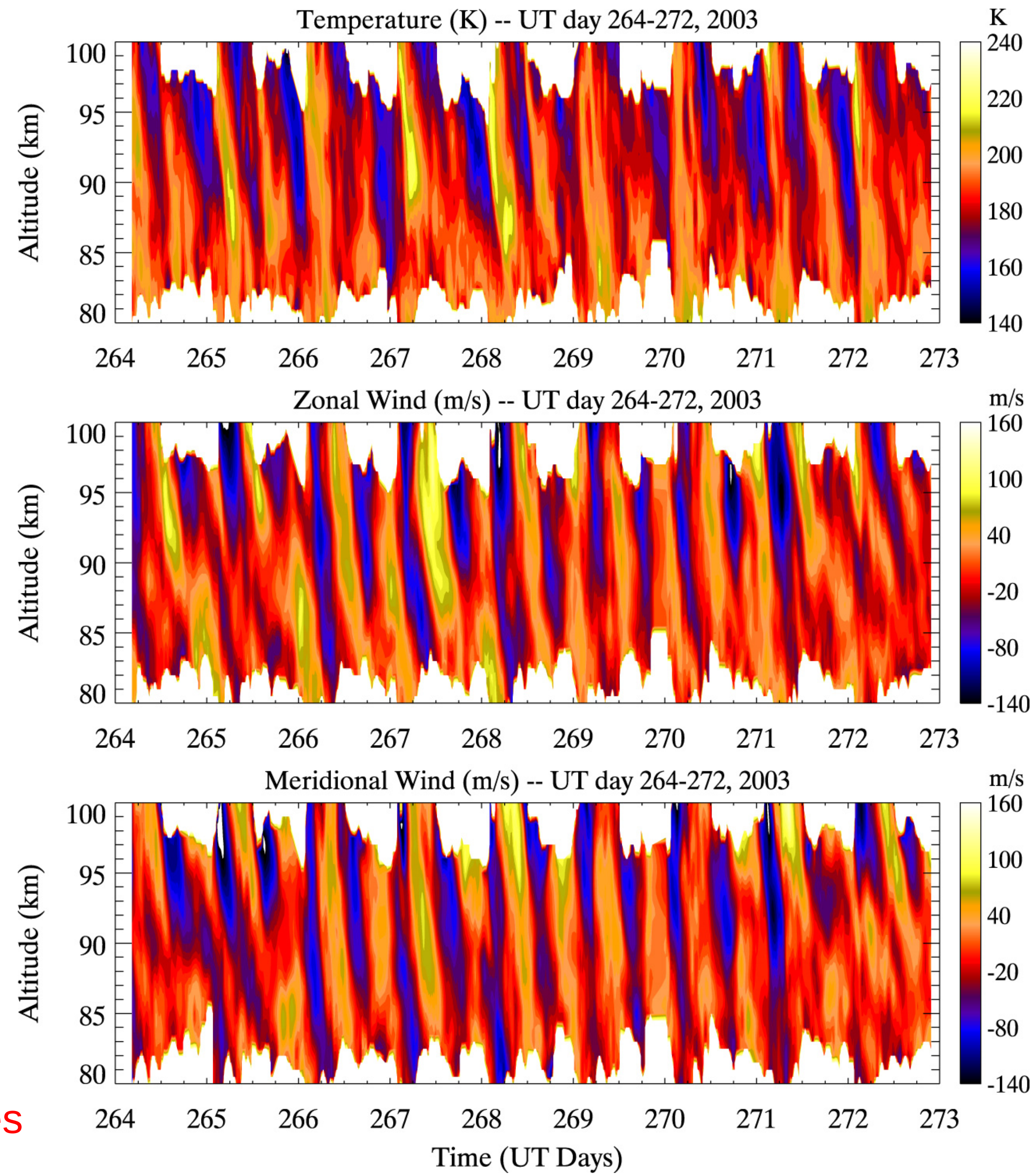
Raw Photon Files (35cm telescope)



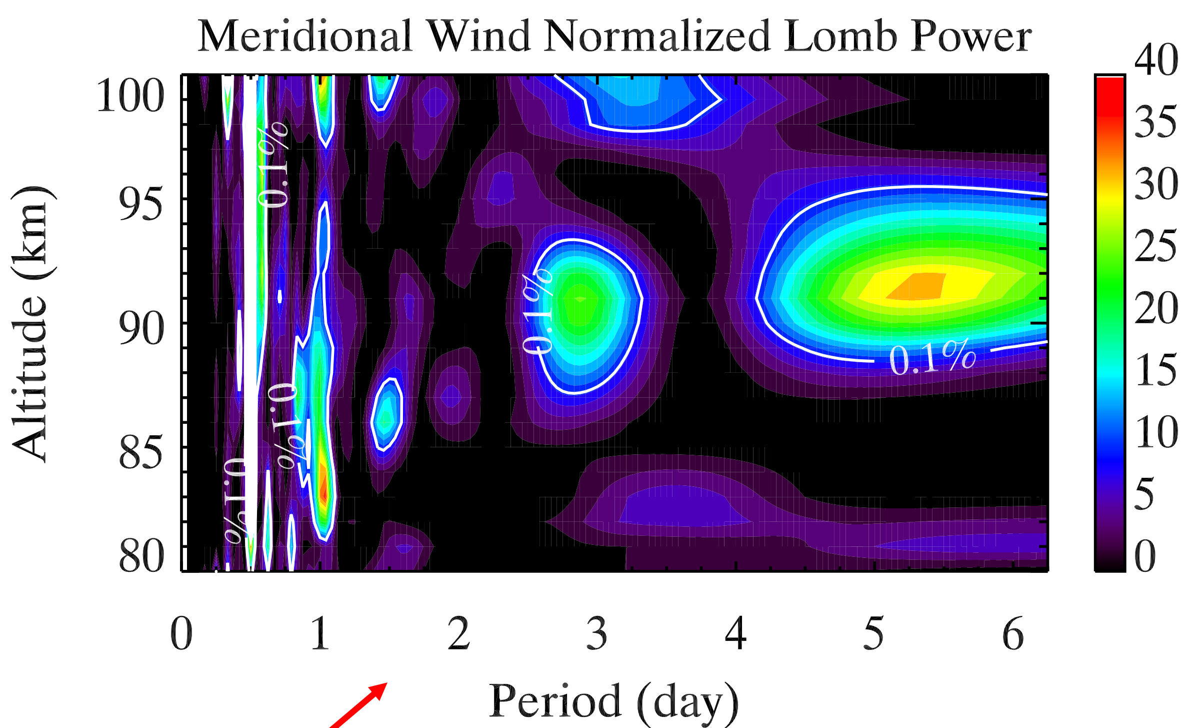
Atmospheric waves
In the mesopause region
(80 – 100 km):

Solar tides
Planetary waves (> days)
Buoyancy waves (< hours)

Notice the temperature
and wind scales:
strong wind and
cold temperature



Data excited dynamicists,
easily appreciated by novices



She et al.
(GRL, 2004)

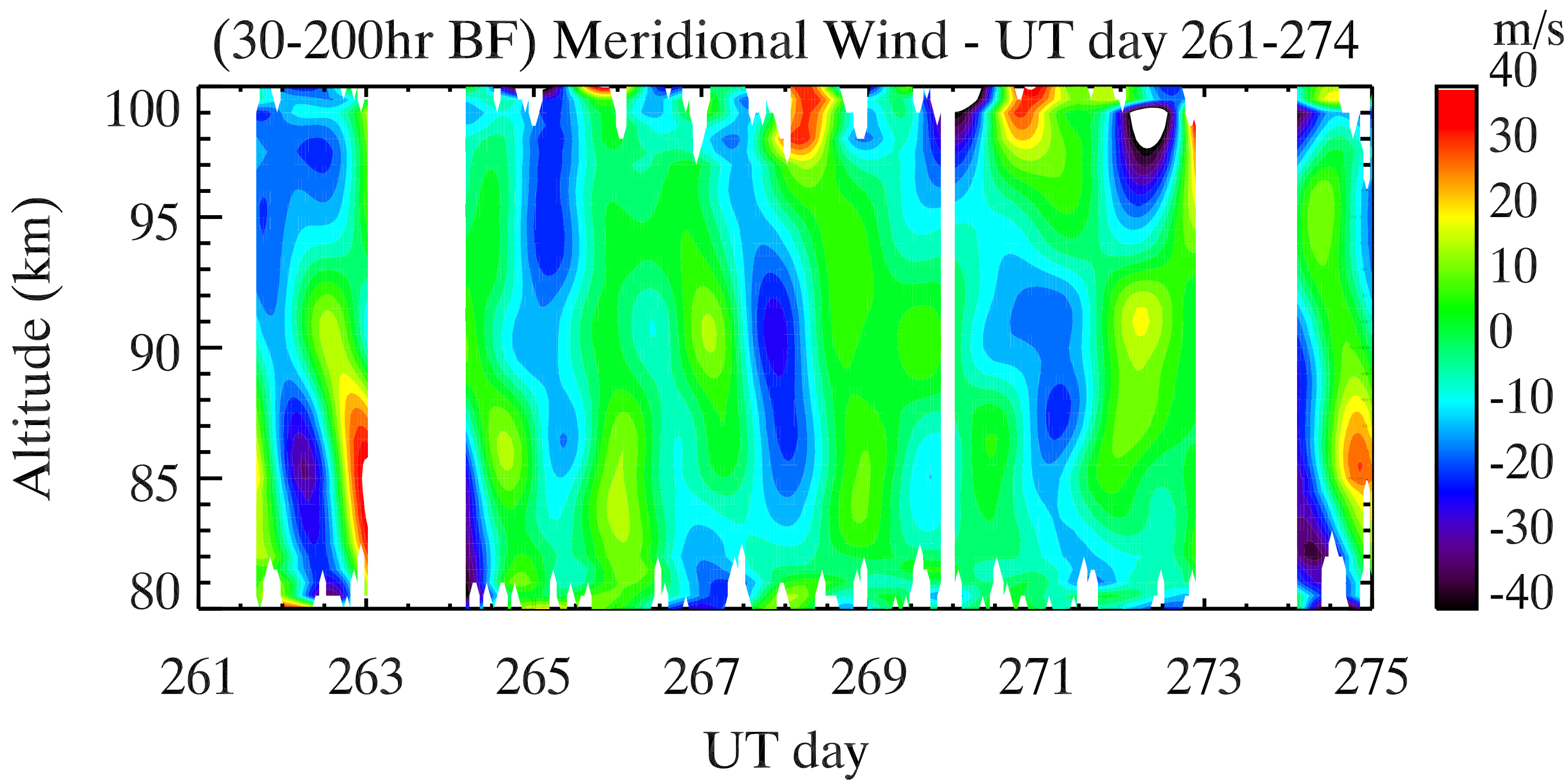
Meridional Wind
Periodogram

Non-tidal periods:
Planetary waves
Non-linear interactions

Significant non-tidal-period oscillations

Dynamic field	Period	Range (km)	Sources (primary periods)
Meridio-nal wind	10hr	87-90	Nonlinear (12h, 3d)
	14hr	90-100	Nonlinear (12h, 3d)
	20hr	85-89	Nonlinear (1d, 5d)
	36hr	85-88	Quasi 1.5-day
	70hr	87-94	Quasi 3-day
	130hr	89-95	Quasi 5-day

Observation of planetary waves

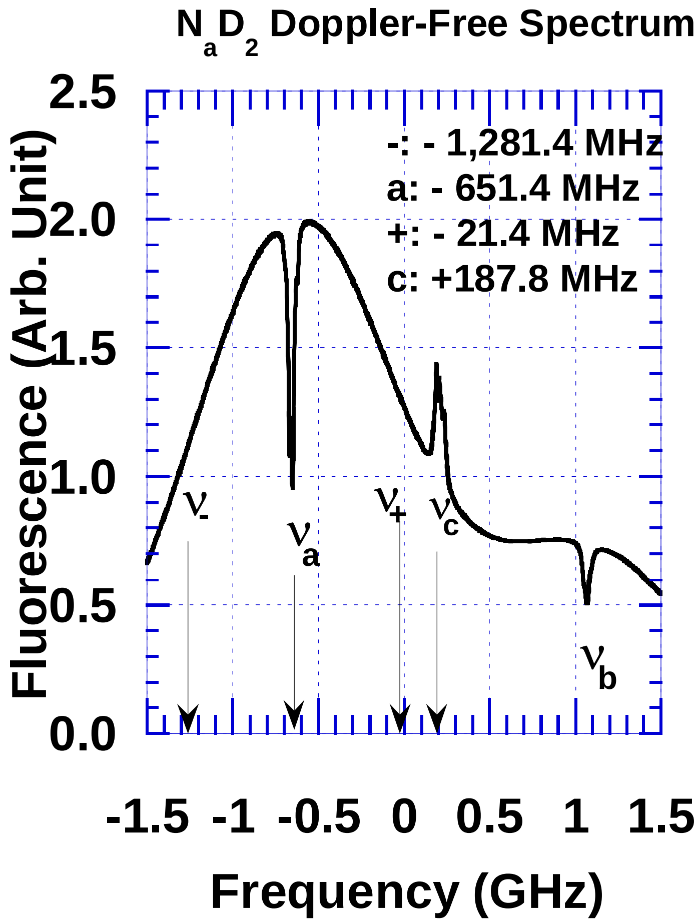


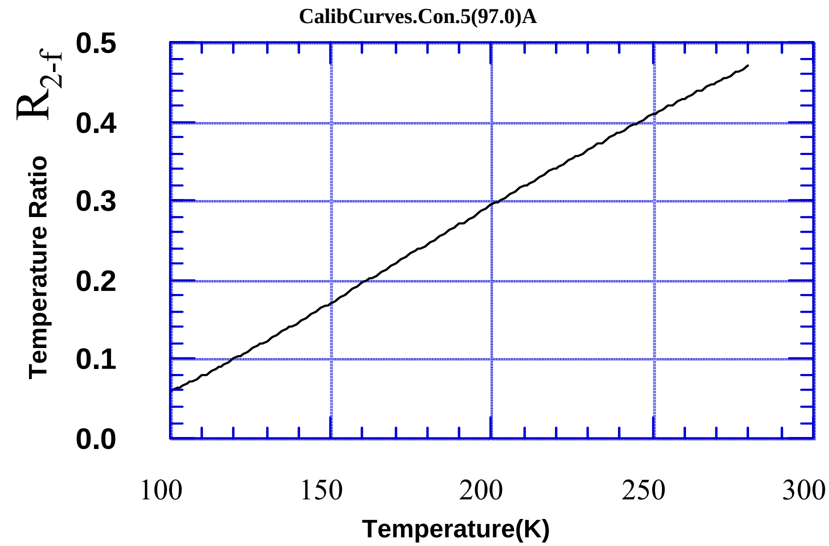
She et al., GRL, 2004

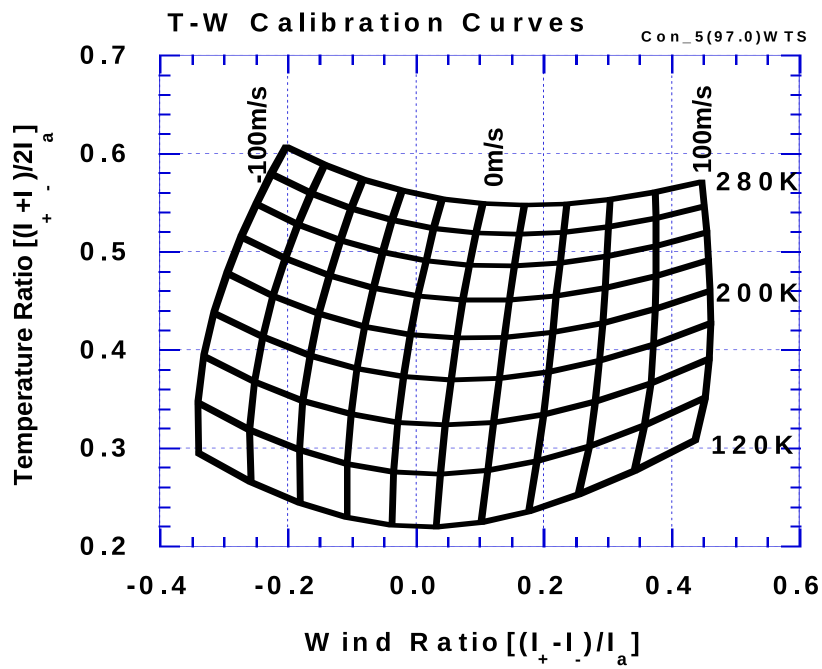
Conclusion

- I hope I have introduced you an emerging field of interesting discovery.
- A field that

  - principles of physics may be creatively applied to create innovative instrumentation that lead to data sets, which
  - enable new science investigations in the upper atmosphere and near space
- A field that is still young, in which both theorists and experimentalists can work together to make important contributions.



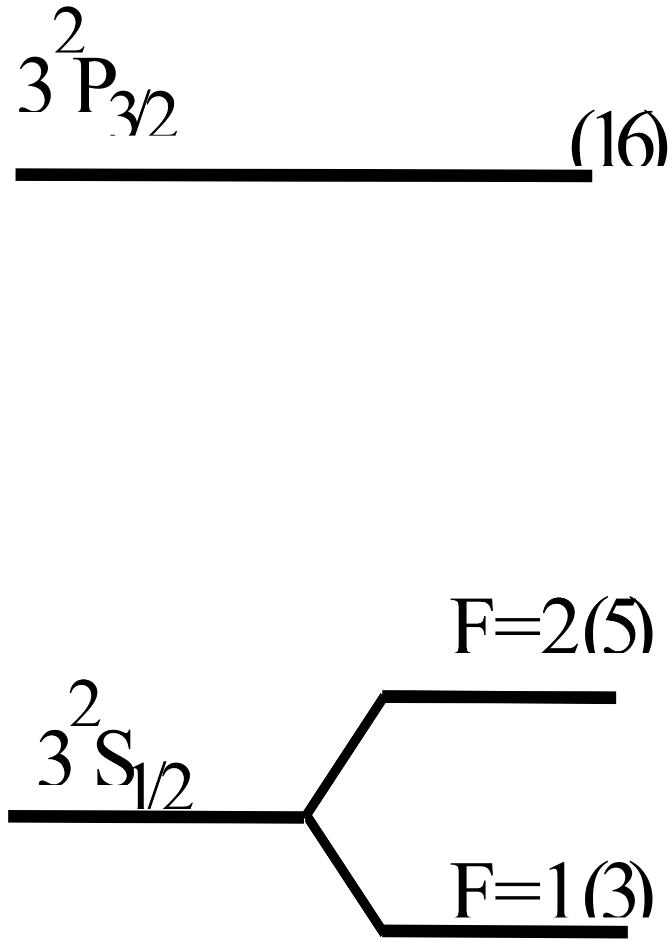


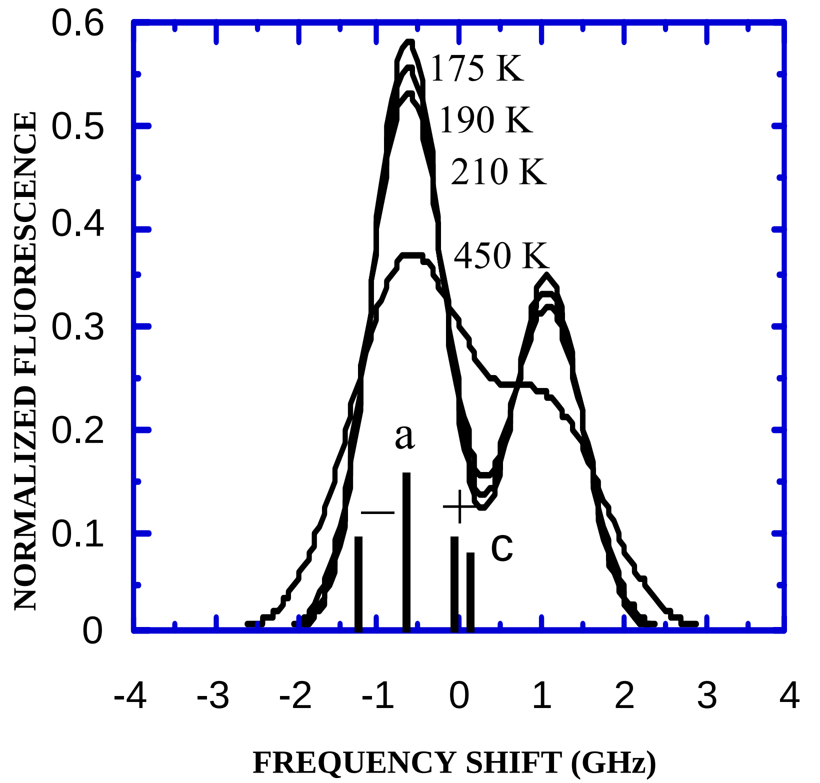


$$R_{2\text{-}f} = I_c / I_a$$

$$R_T = (I_+ + I_-) / 2I_a; \; R_W = (I_+ - I_-) / I_a$$

Laser induced fluorescence:
T (2-freq) or T-W (3-freq) measurement





1nm = 35 cm^{-1}; 1cm^{-1} = 30 GHz
1MHz = 0.6m/s; 2MHz ~ 0.3K

- $\mathbf{R_{2\text{-}f} = I_c / I_a}$
- $\mathbf{R_T = (I_+ + I_-) / 2I_a; \; R_W = (I_+ - I_-) / I_a}$