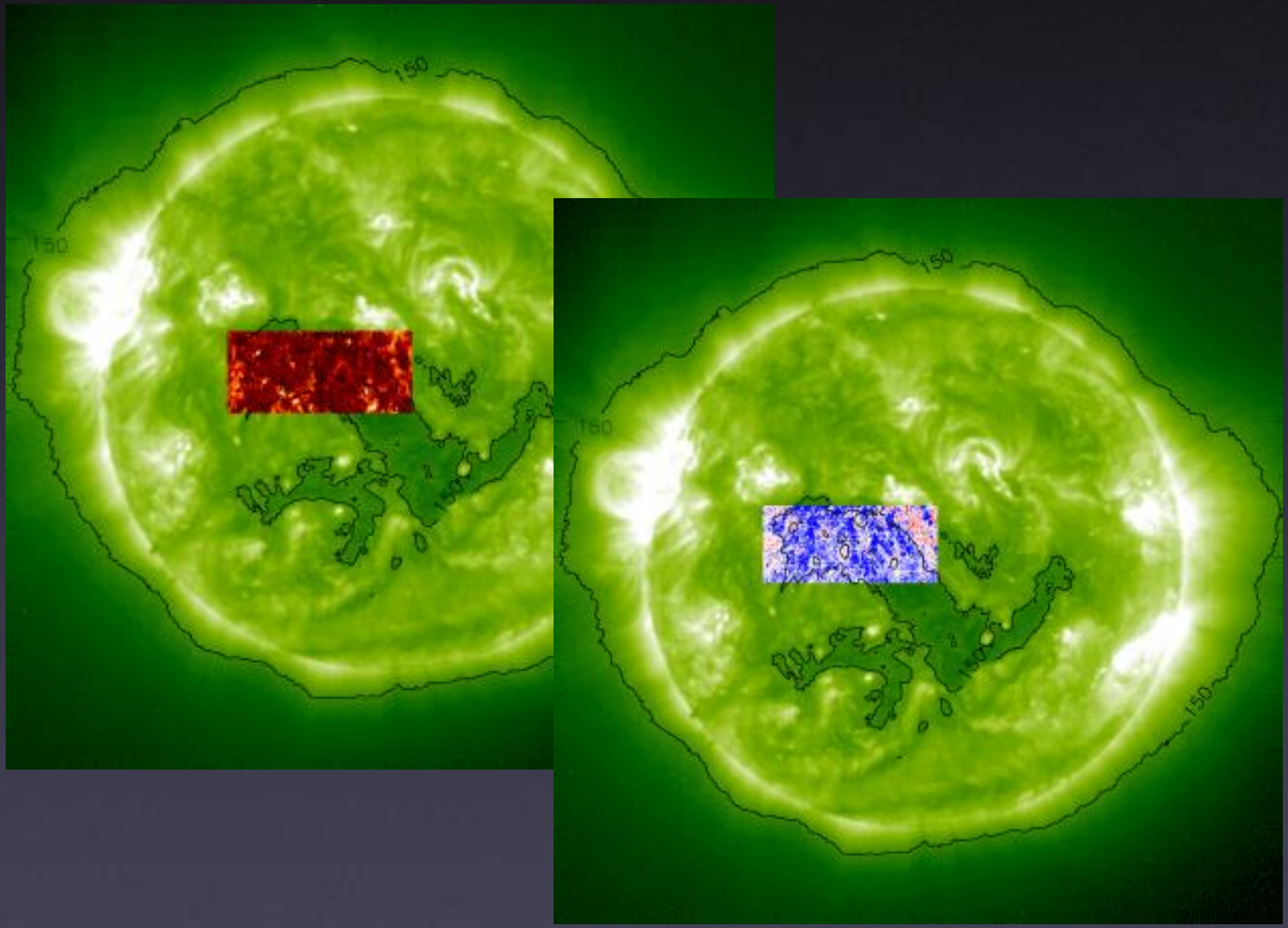
Does the Chromosphere Have Heliospheric Impact?



Scott W. McIntosh
mcintosh@boulder.swri.edu
Department of Space Studies
Southwest Research Institute
Boulder, CO 80503

Ably Assisted by:
Stuart M. Jefferies, James D. Armstrong (UNM, MSRC)
Robert J. Leamon (L3com, NASA/GSFC)

Overview

Overview of observations and primary results

Results give rise to two complimentary questions:

- Is there a chromospheric footprint to the solar wind?
- Does the chromosphere have heliospheric “impact”?

“Looking” to the future....

Scott W. McIntosh
mcintosh@boulder.swri.ed
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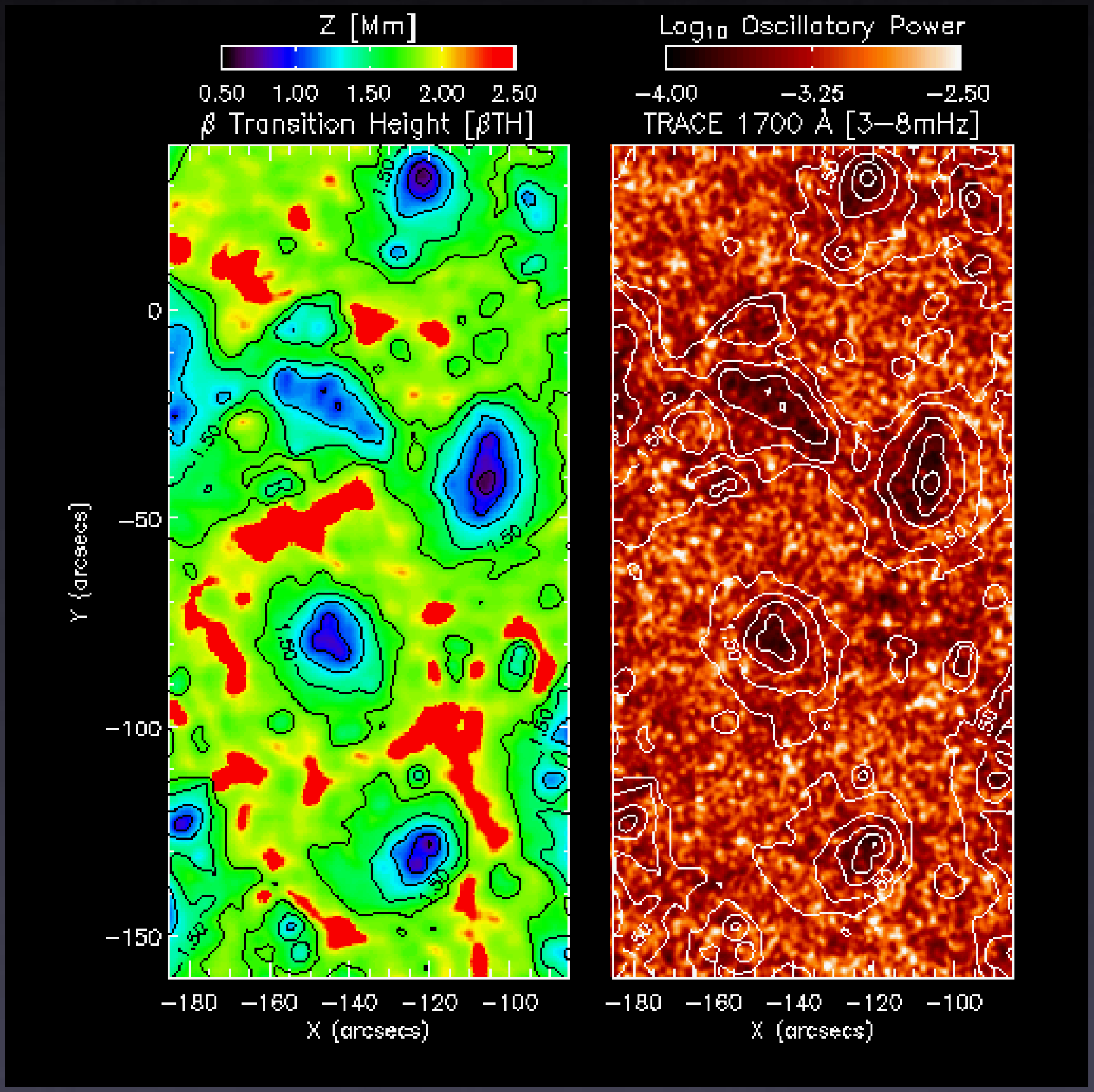
Observations & Early Results

The TRACE Inter-Network Oscillation (INO) program was designed to study the interplay of the chromospheric magnetic environment and the ubiquitous 5 minute oscillations.

Waves are significantly modified by the expanding magnetic “canopy”, where pλασμα–βετα =1...... and by the partitioning of the environment into **open** and **closed** regions.



Observe changes in:

Frequency

Power

Phase/“Travel-Time”

Travel-time studies are direct measures of the plasma topography; our focus for the remainder.

Scott W. McIntosh
mcintosh@boulder.swri.edu

TRACE Sample

July 14 2003
TRACE 1600Å
Duration 78 mins.
Cadence 12s
0.5”x0.5” Pixels

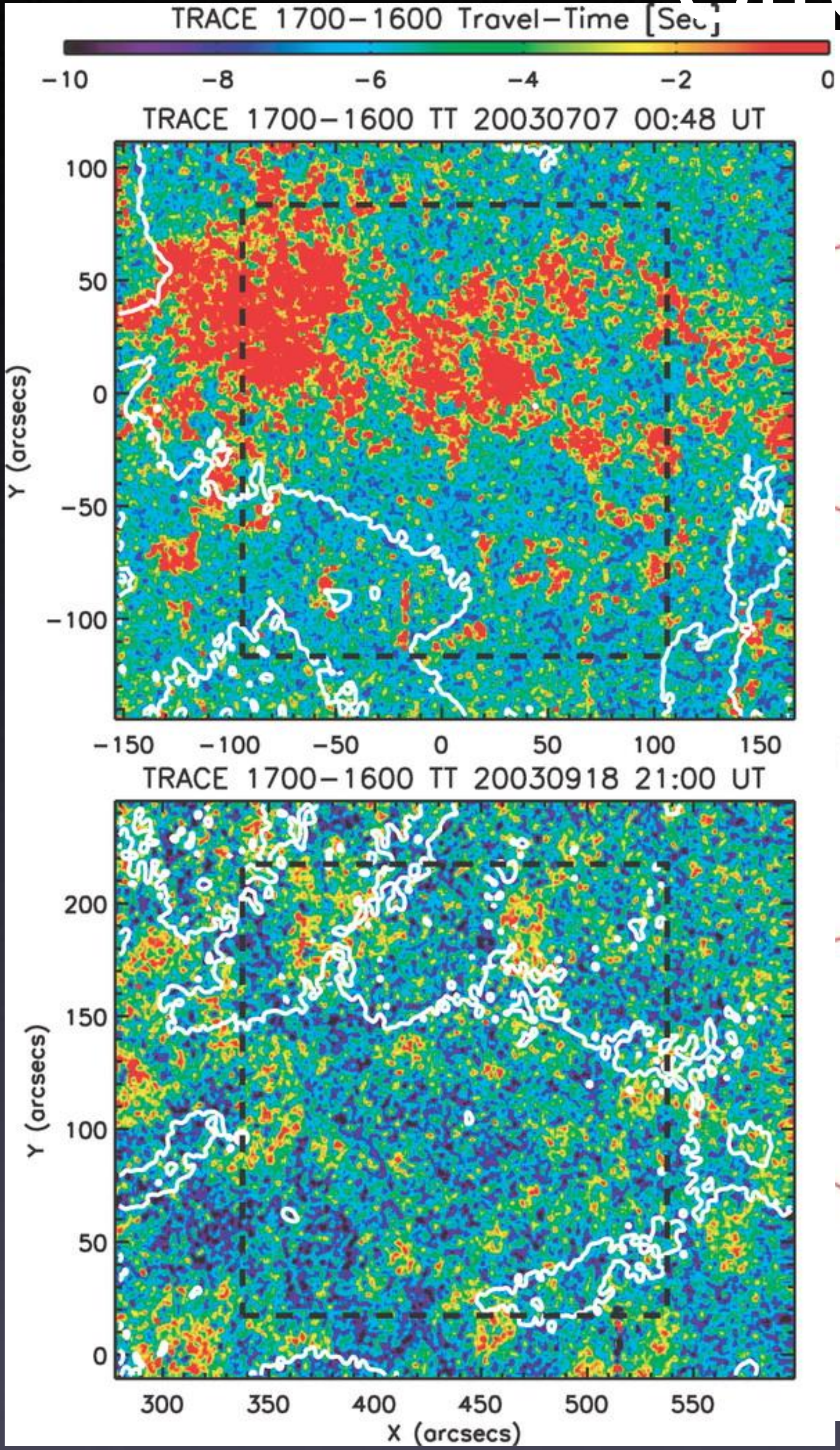
Pixel-scale travel-times of ~8-10s expected in the QS between the TRACE continua.

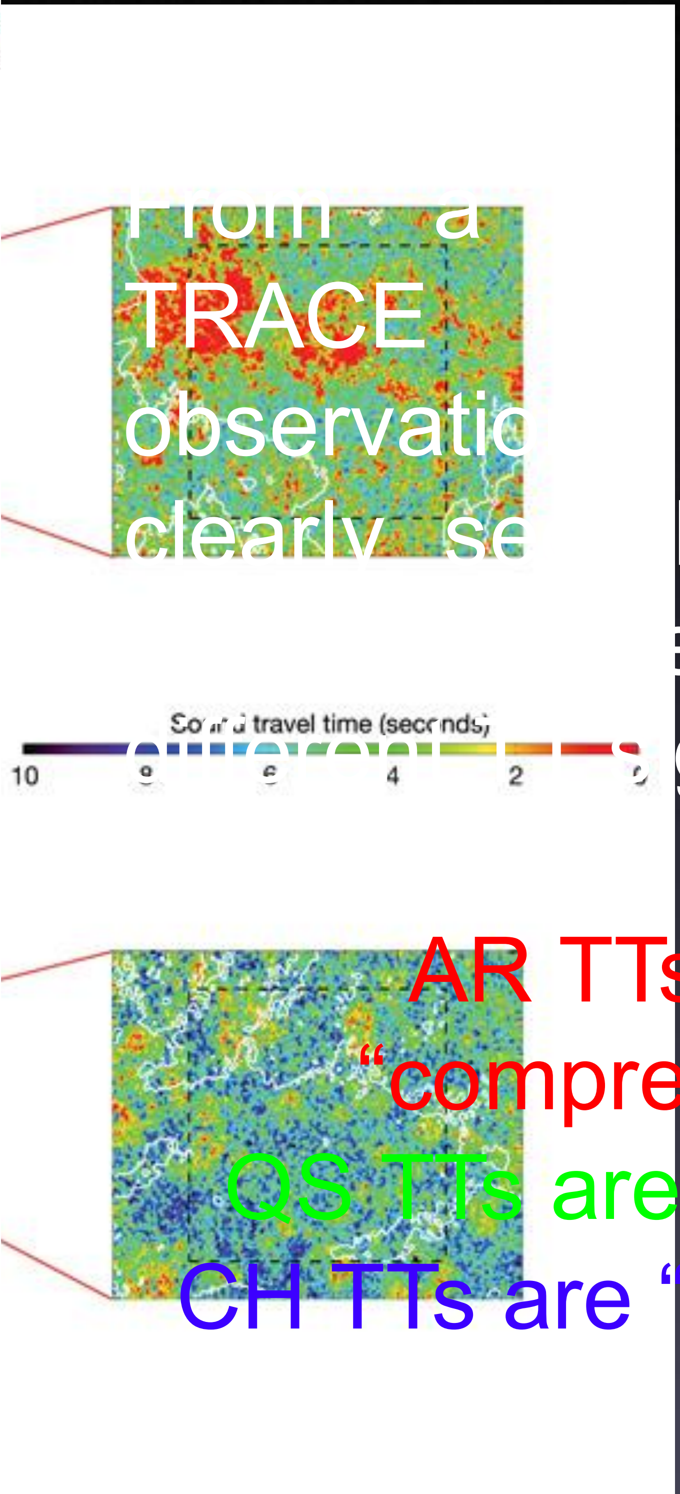
256 arcseconds

340 arcseconds

Scott W. McIntosh
mcintosh@boulder.swri.edu

Different Strokes....





From a ... ite of 13 TRACE ... INO observatio... we can clearly se... hat different ... e Sun have different ... gnatures:

AR TTs are "compressed"

QS TTs are "normal"

CH TTs are "stretched"

Question One:

If the travel-time from a coronal hole region is significantly different from a region of QS then.....Is there a chromospheric footprint of the Solar Wind?

Or......

Can we correlate chromospheric structure with insitu measurements of the solar wind?

Scott W. McIntosh
mcintosh@boulder.swri.edu

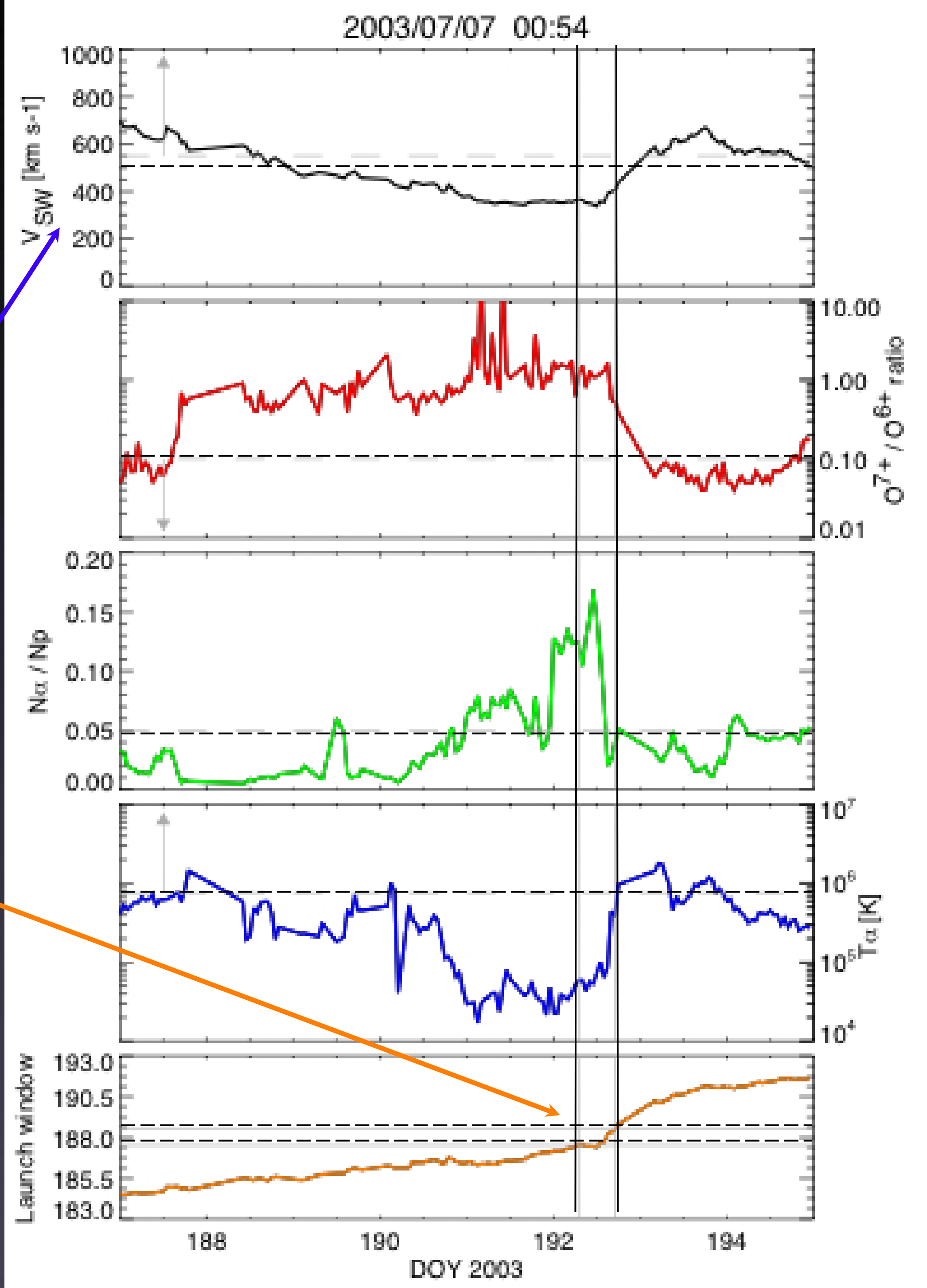
Connecting to 1 AU

Use One Hour ACE data

Compute “ballistic” travel time of parcel from V_{sw} at observing time. ($T_b = 149 \times 10^6$ km / V_{sw})

Account for Solar Rotation (if necessary)
Find “launch window” for parcel

Correlate mean in situ variables with Δz......



Scott W. McIntosh
mcintosh@boulder.swri.edu

V_{SW} & Composition Correlations

All power law fits:

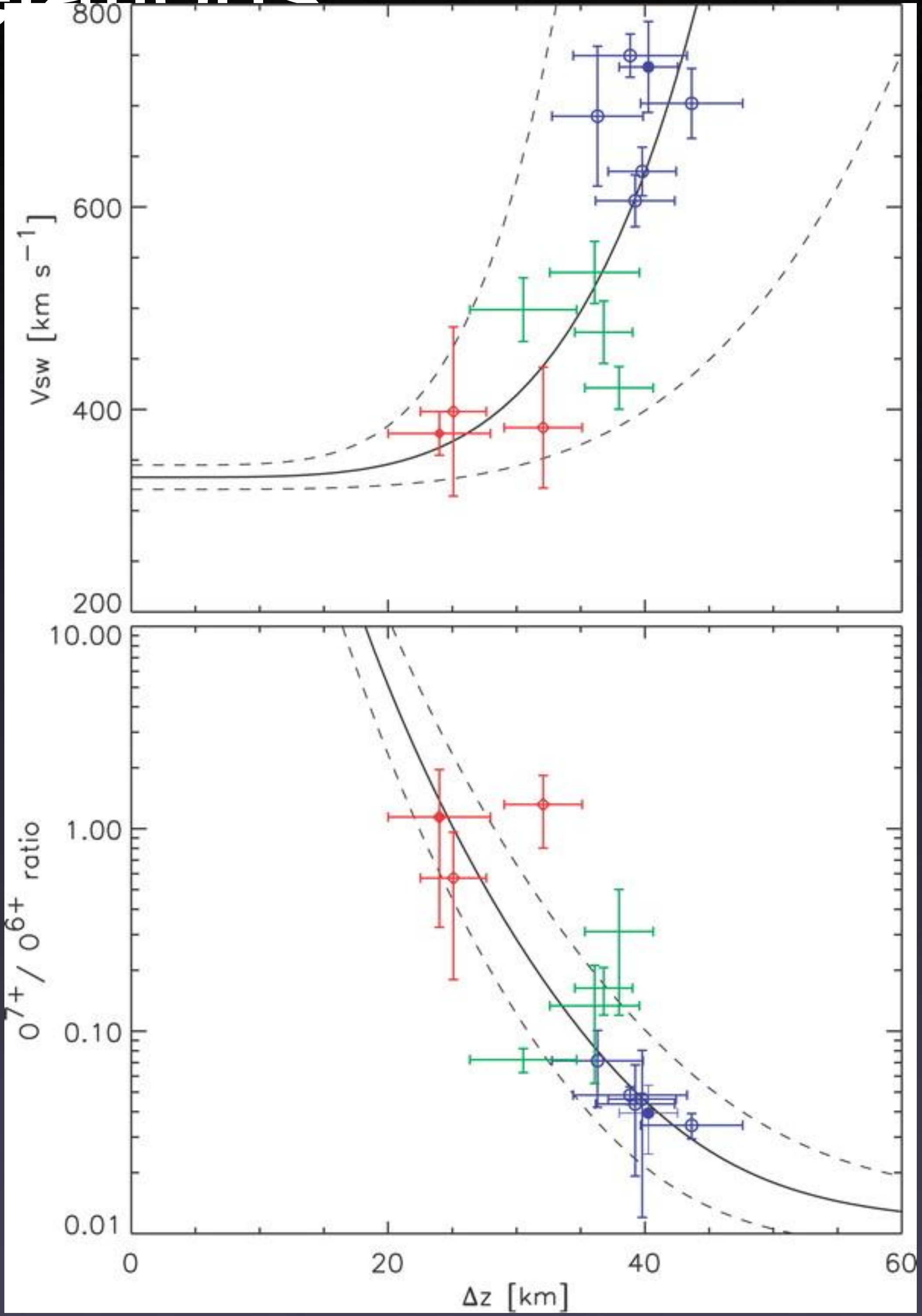
$Y = A * (\Delta z)^B + C$

V_{SW}:

$A = (1.49 \pm 0.19) \times 10^{-5}$
$B = 4.56 \pm 0.33$
$C = 333 \pm 12$

O^{7+}/O^{6+}:

$A = (1.22 \pm 0.11) \times 10^{10}$
$B = -7.21 \pm 0.23$
$C = 0.011 \pm 0.003$



Chromosphere-Solar Wind Correlations

*plots later if time permits

Spearman rank-order correlation coefficients between Chromospheric structure and in situ observations

O^{7+}/O^{6+}	-0.909		
V_{sw}	0.736	N_{alpha}/N_p	-0.682
T_{proton}	0.864	N_{proton}	0.109
T_{alpha}	0.818	Βετα	0.064
V_{rms}	0.727	T_α/T_p	0.209

McIntosh & Leamon, 2005, GRL, In Prep.

Results & Implications

Regions where separation is small correspond to regions of slow, hot solar wind. The atmosphere is “compressed” in and around active regions.

Intermediate values largely correspond to quiet Sun regions and give intermediate values of speed and temperature.

Regions where separation is large correspond to regions of fast, cool solar wind. It appears as though the atmosphere is “stretched thin”. These are coronal holes.

Consistent with the “solar wind scaling law” of Schwadron & McComas (2003, ApJ, 599,1395). Not to mention earlier work (Leer & Holzer 1979).

Appears to provide a analog diagnostic to “dial in” solar wind parameters from on-disk observations. Implies, a predicitve capability?

Scott W. McIntosh
mcintosh@boulder.swri.edu

Conclusions

Timeseries observations of the chromosphere….

Provide diagnostics of wave properties and the magnetic environment through which they propagate.

Point to a connection between the chromospheric plasma, its structure and the speed and composition of the solar wind measured in situ.

It is, as yet, unclear why the chromosphere should care about the magnetic topology above is “open” or “closed” to the heliosphere above.

Future Efforts

Theoretical / Analysis / Modeling Investigations

Investigate the predictive capability of chromospheric structure
Identify and Study “events” in MOTH data to study signature & timing
Developing a clearer picture of wave/field interaction in the chromosphere
Low-Frequency energy flux in magnetic network

Observational Investigations

TRACE’s end time is nigh!

- Get more observations of varied chromospheric topographies

MOTH II Deployment Austral Summer 2005/6

- Doppler Observations at multiple (five) heights are key
- Coordination with TRACE/SOHO

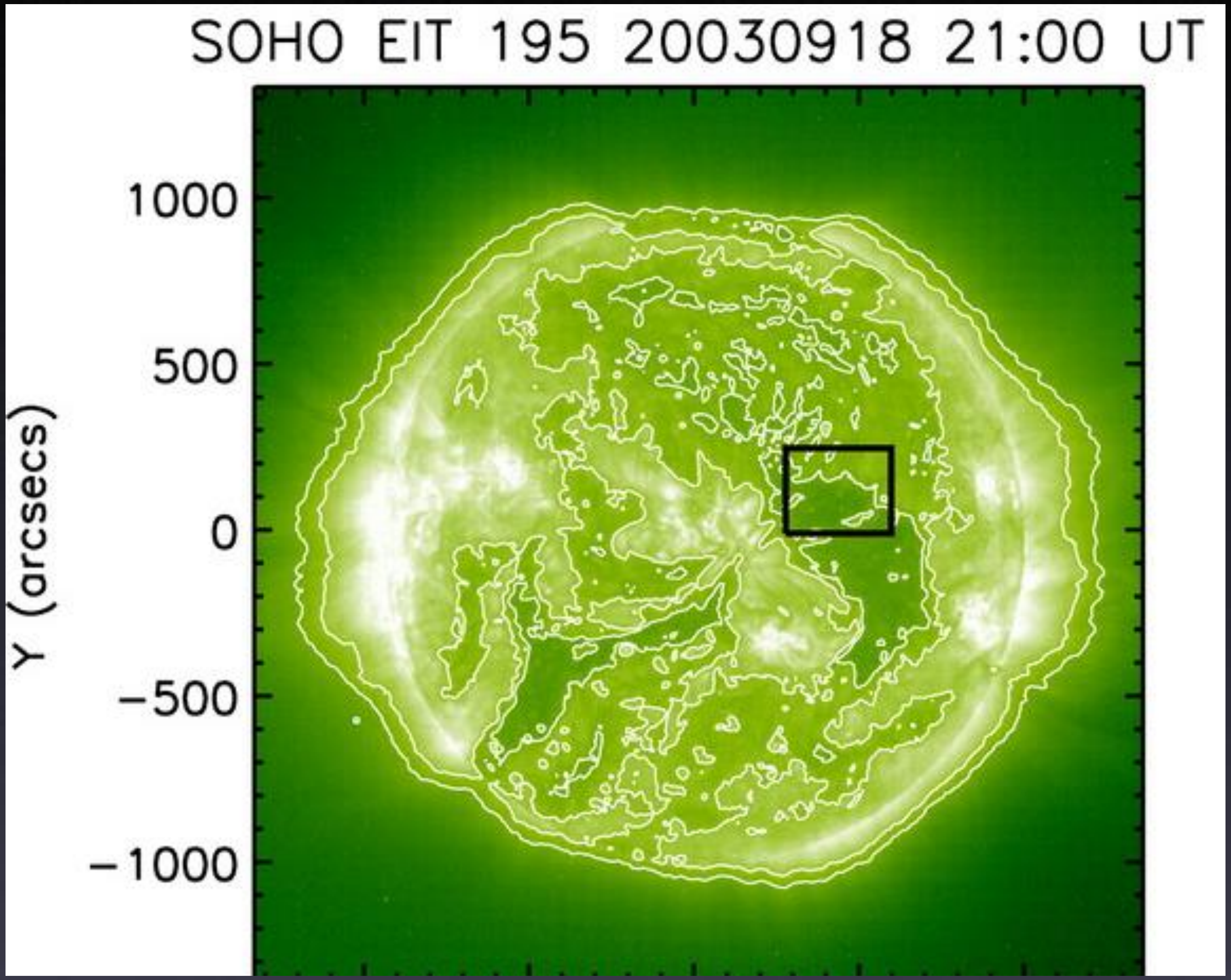
Rapid Aquisistion Imaging Spectrograph (RAISE) Sub-Orbital Sounding Rocket Observations - Summer 2006

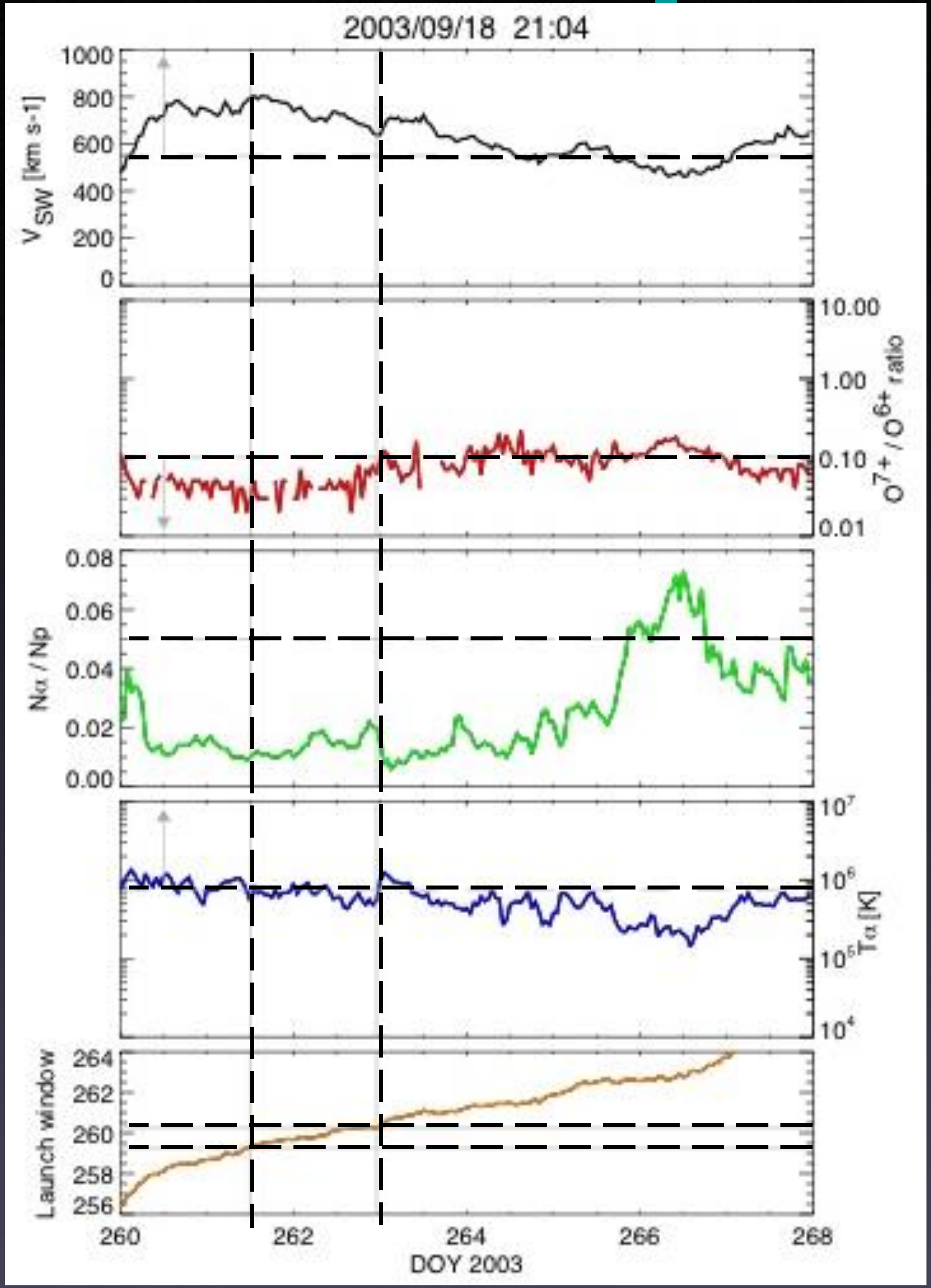
- 10Hz 1600Å imaging, Ly-alpha, Si II, C IV, Ne VIII 1Hz raster spectra

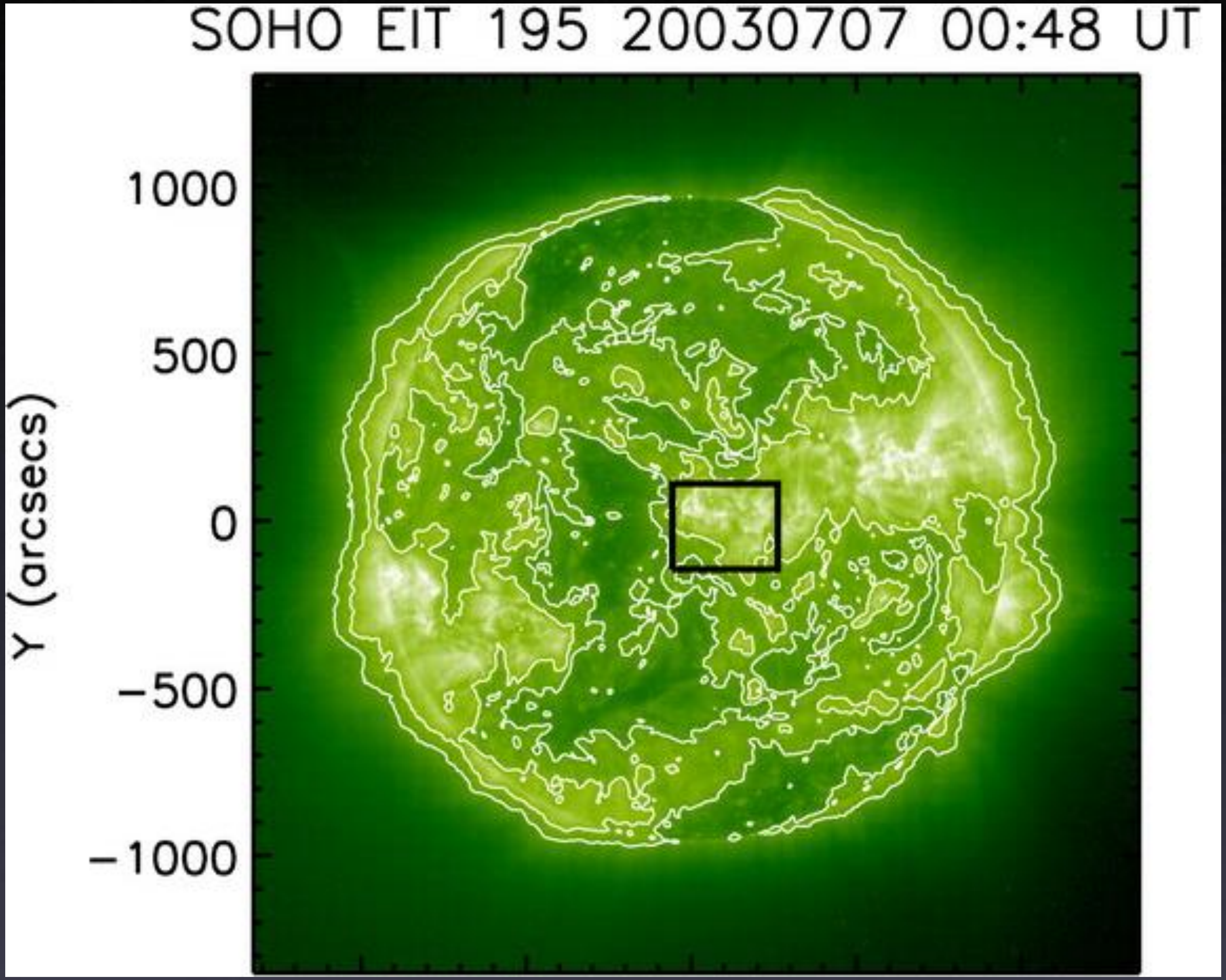
Extra Slides

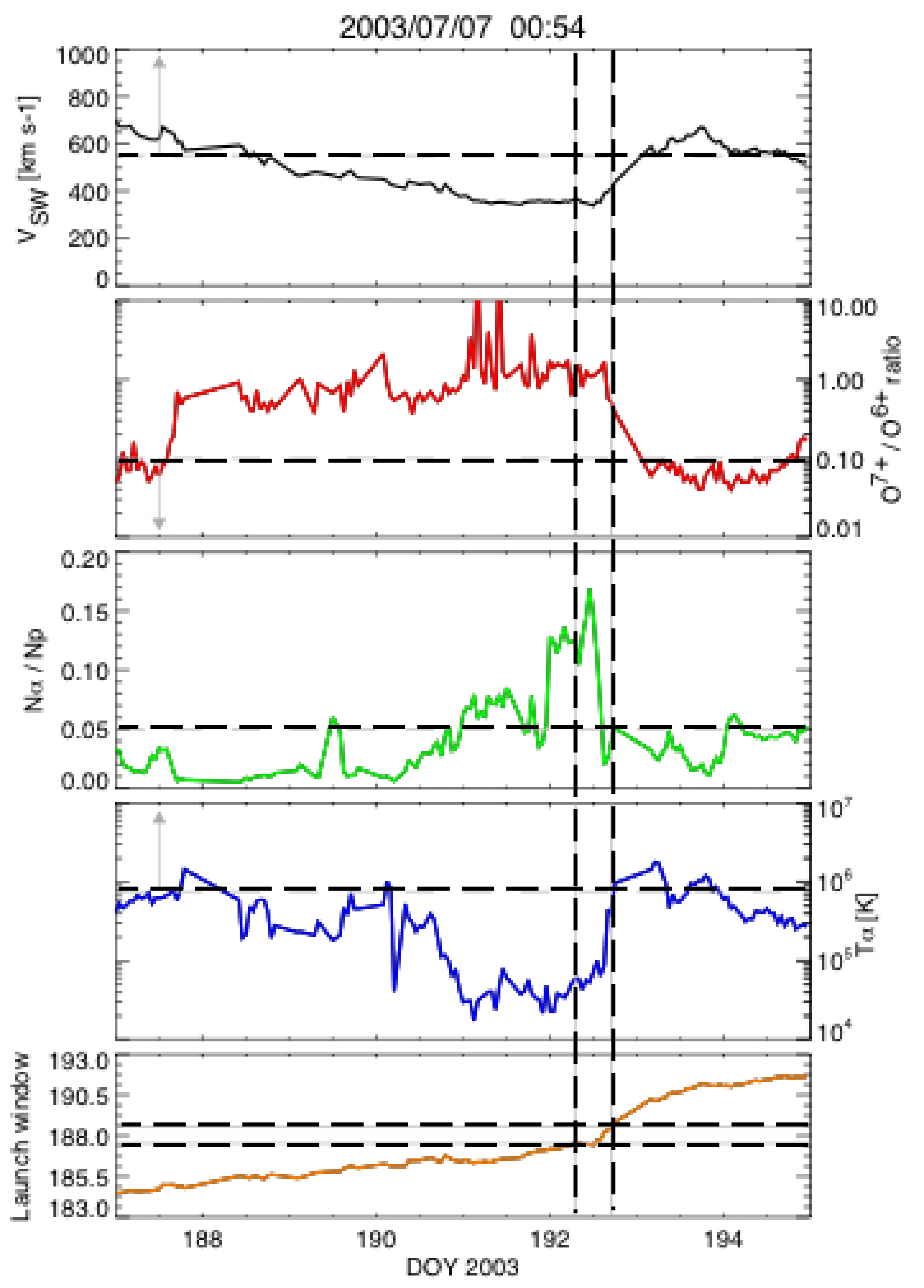
We discuss new results derived from timeseries observations of the solar chromosphere by the TRACE spacecraft and the MOTH experiment on the South Pole Solar Observatory. Inferred diagnostics of the chromospheric wave field near the "magnetic transition region" are indicating that changes in the chromospheric plasma reflect properties of eruptive processes readily observed in the EUV corona and properties of the nascent solar wind measured in situ. We discuss the implications of these efforts and look to near future capabilities.

Scott W. McIntosh
mcintosh@boulder.swri.edu


SOHO EIT 195 20030918 21:00 UT
Y (arcsecs)
1000
500
0
−500
−1000




SOHO EIT 195 20030707 00:48 UT
Y (arcsecs)
1000
500
0
−500
−1000


2003/07/07 00:54
V_SW [km s-1]
1000
800
600
400
200
0
10.00
1.00
0.10
0.01
O7+/O6+ ratio
Nα / Np
0.20
0.15
0.10
0.05
0.00
10^7
10^6
10^5
10^4
Tα [K]
Launch window
193.0
190.5
188.0
185.5
183.0
188
190
192
194
DOY 2003

Scott W. McIntosh
mcintosh@boulder.swri.edu

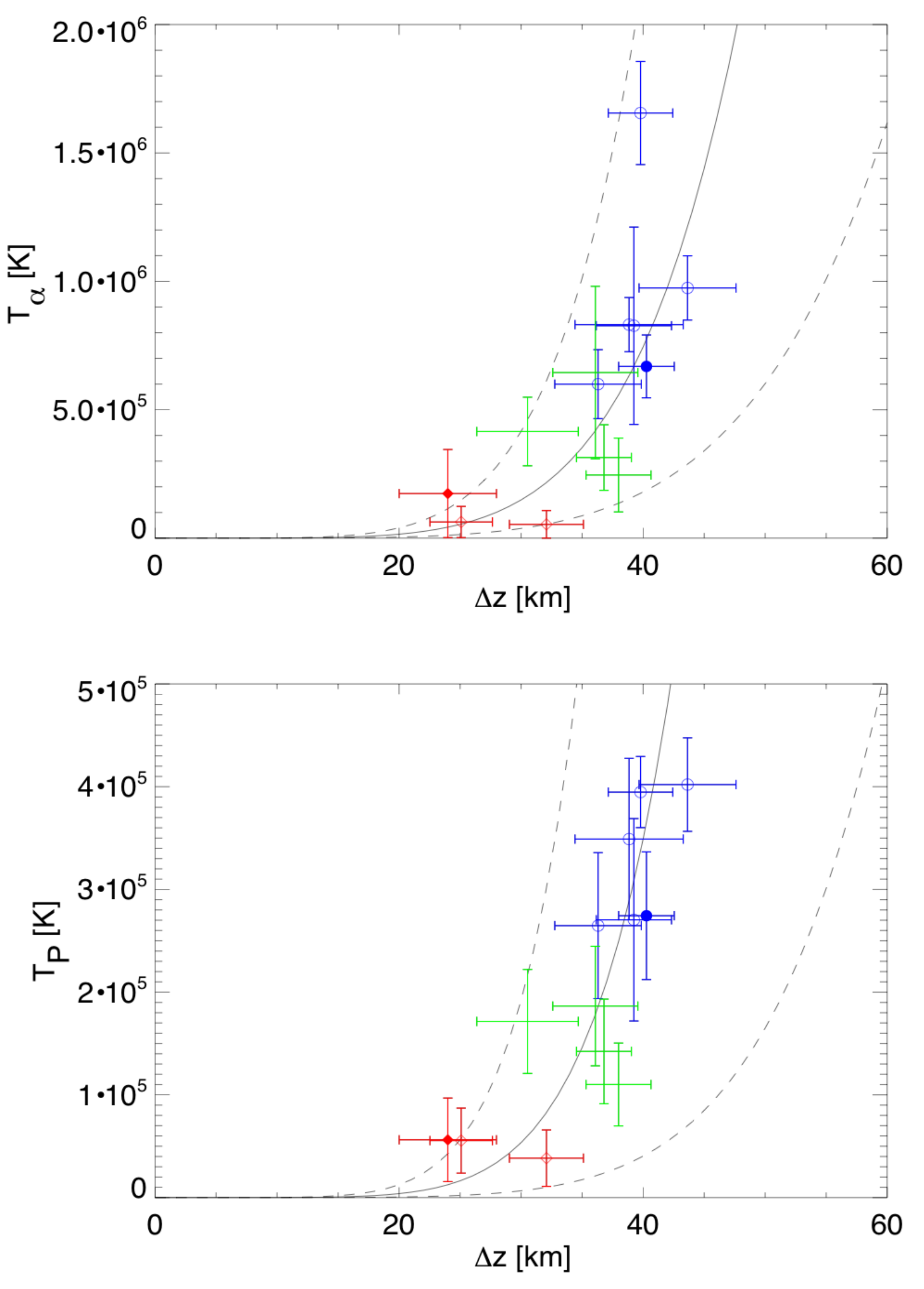
Alpha & Proton Temperatures

$T_{\alpha\lambda\pi\eta\alpha}$

A = (8.07 ± 4.36) x 10^{-4}
B = 5.60 ± 0.17
C = 8.11 ± 7.77

T_p

A = (1.23 ± 0.92) x 10^{-5}
B = 6.42 ± 0.24
C = 43 ± 3



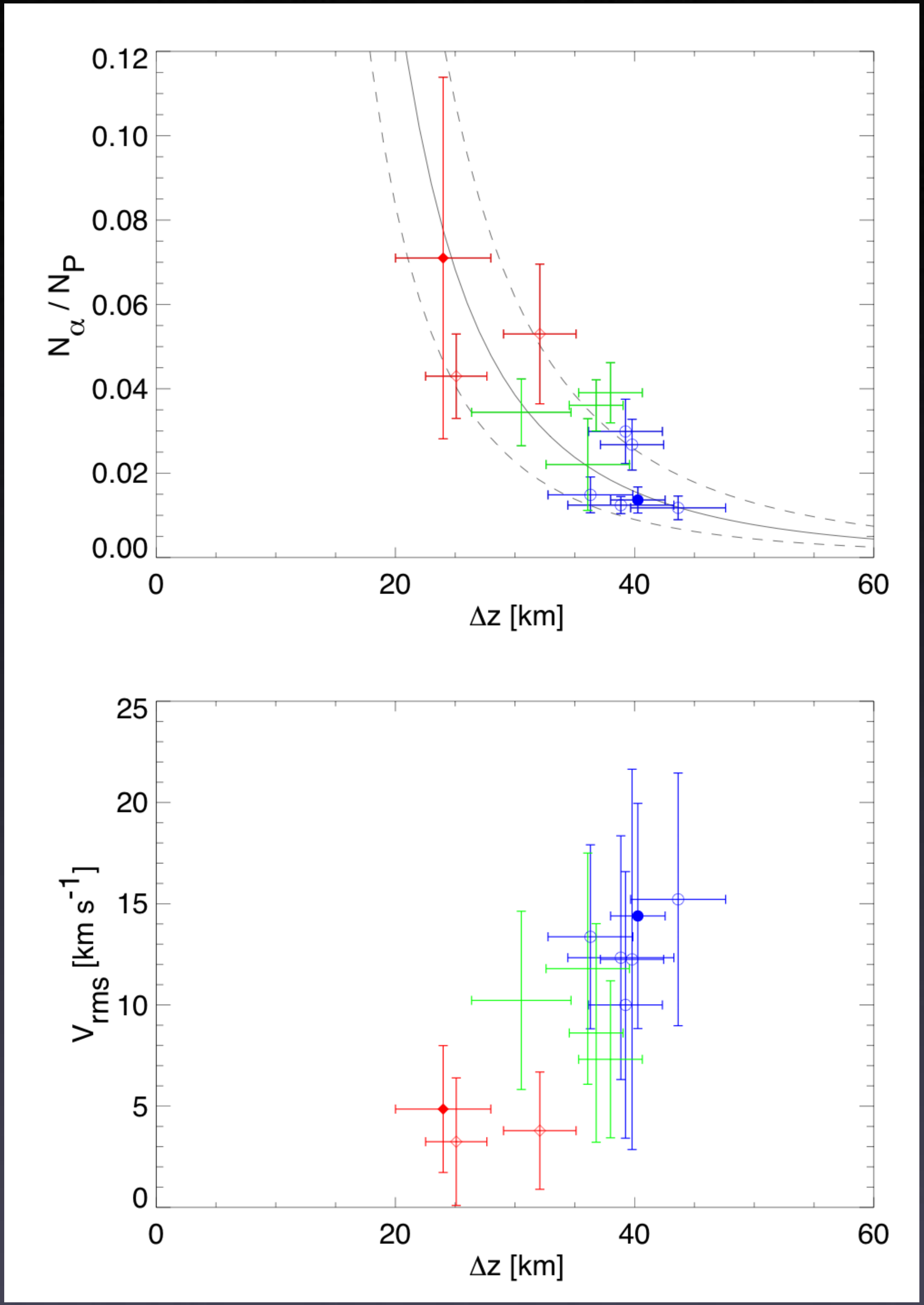
Alpha & Proton Numbers

$N_{\alpha\lambda\pi\eta\alpha}$ /N_p:

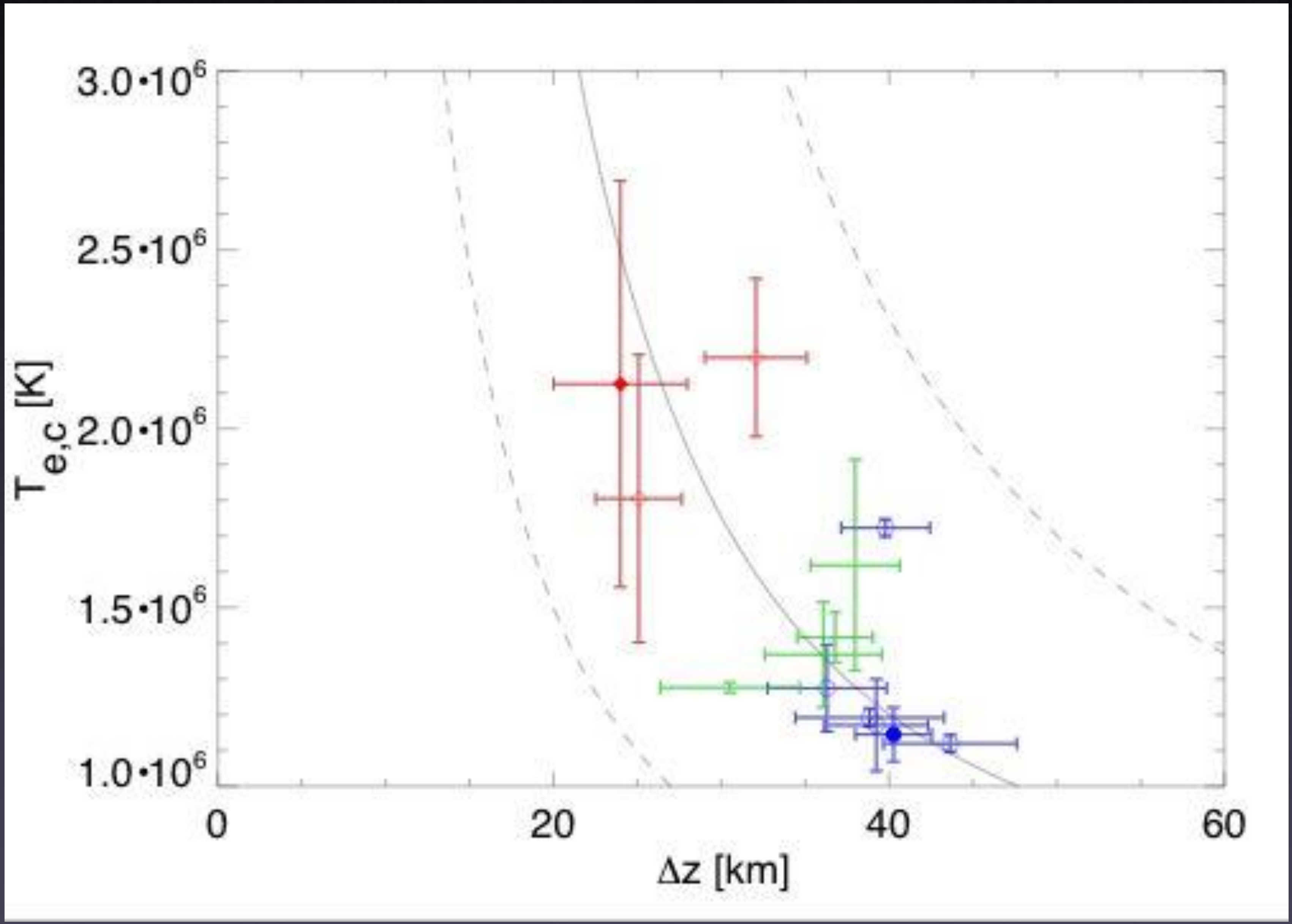
A = (8.07 ± 4.36) x 10^{-4}
B = 5.60 ± 0.17
C = 8.11 ± 7.77

V_{rms}:

strong correlation on data points; large error bars. Not fitted, but shown for the interested…



Inferred Coronal Electron Temperature;

Use method of Ko et al, 1997, Sol. Phys., 171, 345