Atmospheric Spectroscopy with AERI and AERI-X

Dave Tobin, Hank Revercomb, Paul van Delst, Bob Knuteson

University of Wisconsin–Madison

AIRS STM, October 22-24 1997

Lockheed Martin IRIS, Lexington, Mass.

AERI - Forward Model Issues

- H_2O line parameters
- 8-12 μm H_2O self-broadened continuum
- $\sim$1250-1350 cm^{-1} H_2O continuum self/air-broadened crossover
- 700-850 cm^{-1} CO_2 lineshape validation
- $\sim$1950-2150 cm^{-1} H_2O continuum self/air-broadened crossover
- $\sim$2370-2450 cm^{-1} CO_2 lineshape validation ???
- N_2 CIA band
- etc

H_2O spectral line parameters

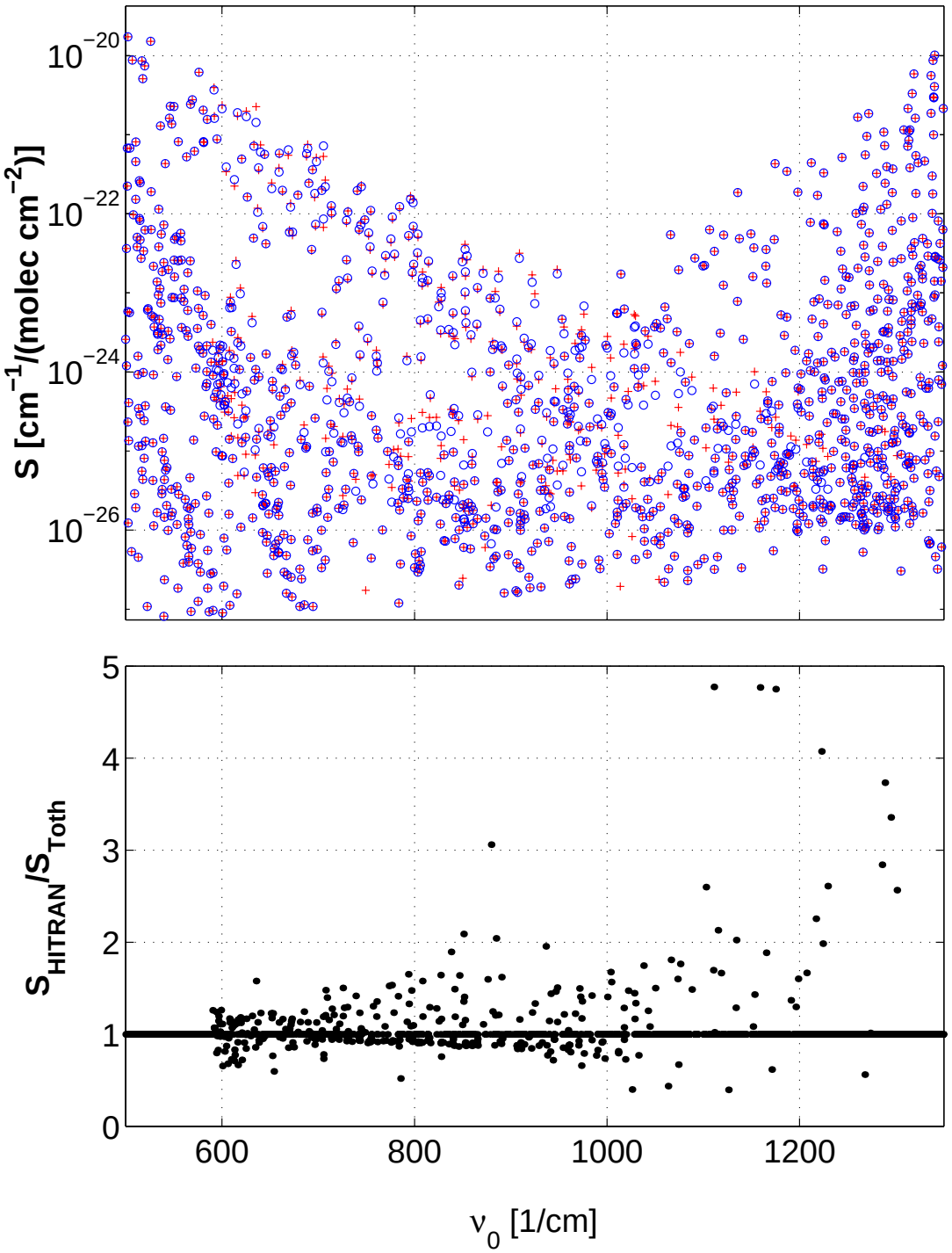
- 3 line parameter sets

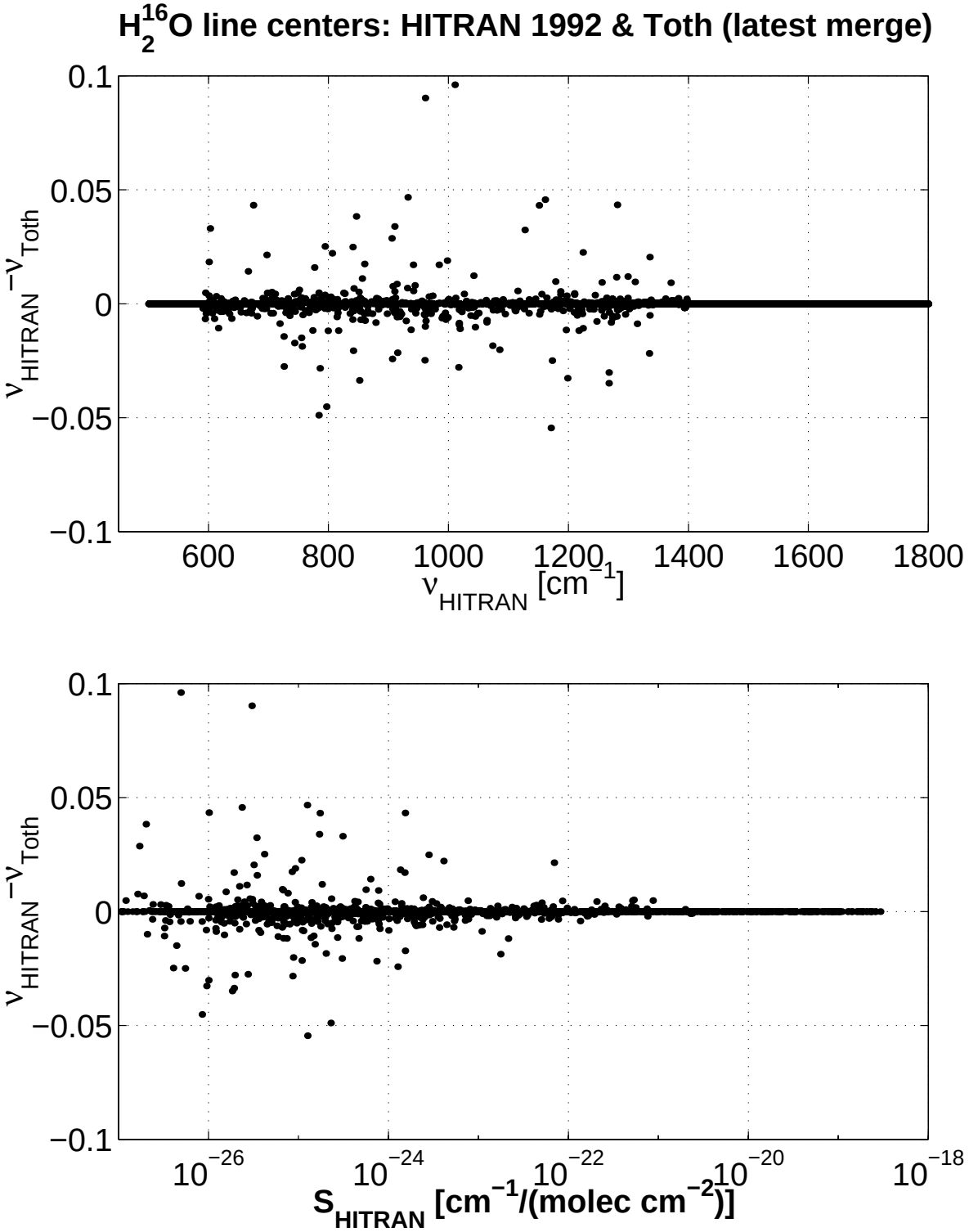
1. k-CARTA: combination of HITRAN '92 and Jan'95 Toth release
2. Toth's latest measurements, including high J rotational band strengths, line centers, and line center shifts
3. HITRAN '92 and '96

$\rightarrow$ Toth's rotational band strengths were not included in k-CARTA $\rightarrow$ new values up to $\pm$ 30% of existing HITRAN/k-CARTA values for many strong 10μm window region lines

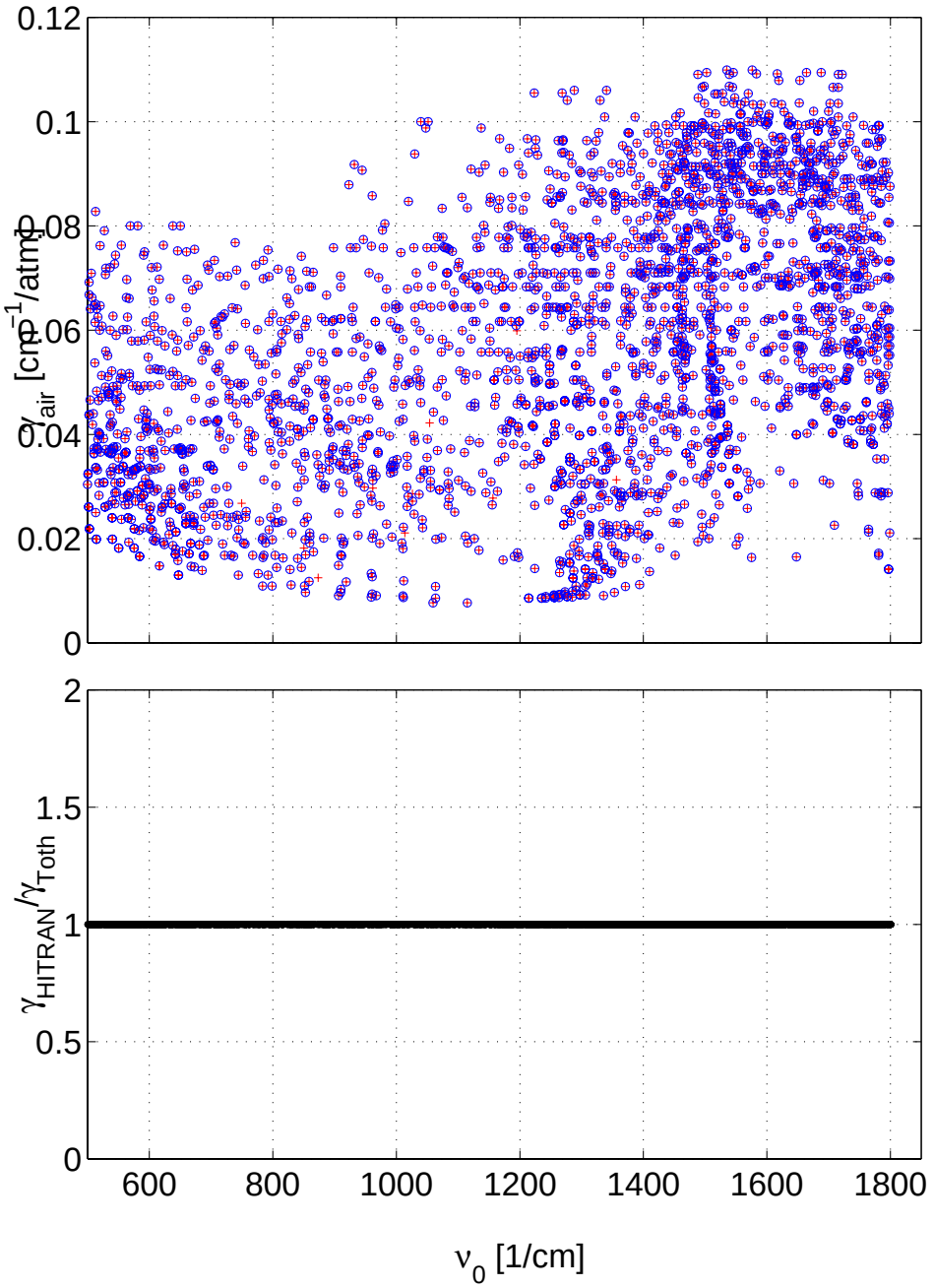
$\rightarrow$ no ν_2 band air-broadened $H_2^{16}O$ widths measured by Toth – adjusted $H_2^{18}O$ values used in k-CARTA

$H_2^{16}O$ line strengths: HITRAN 1992 (red) & Toth (latest merge) (blue)

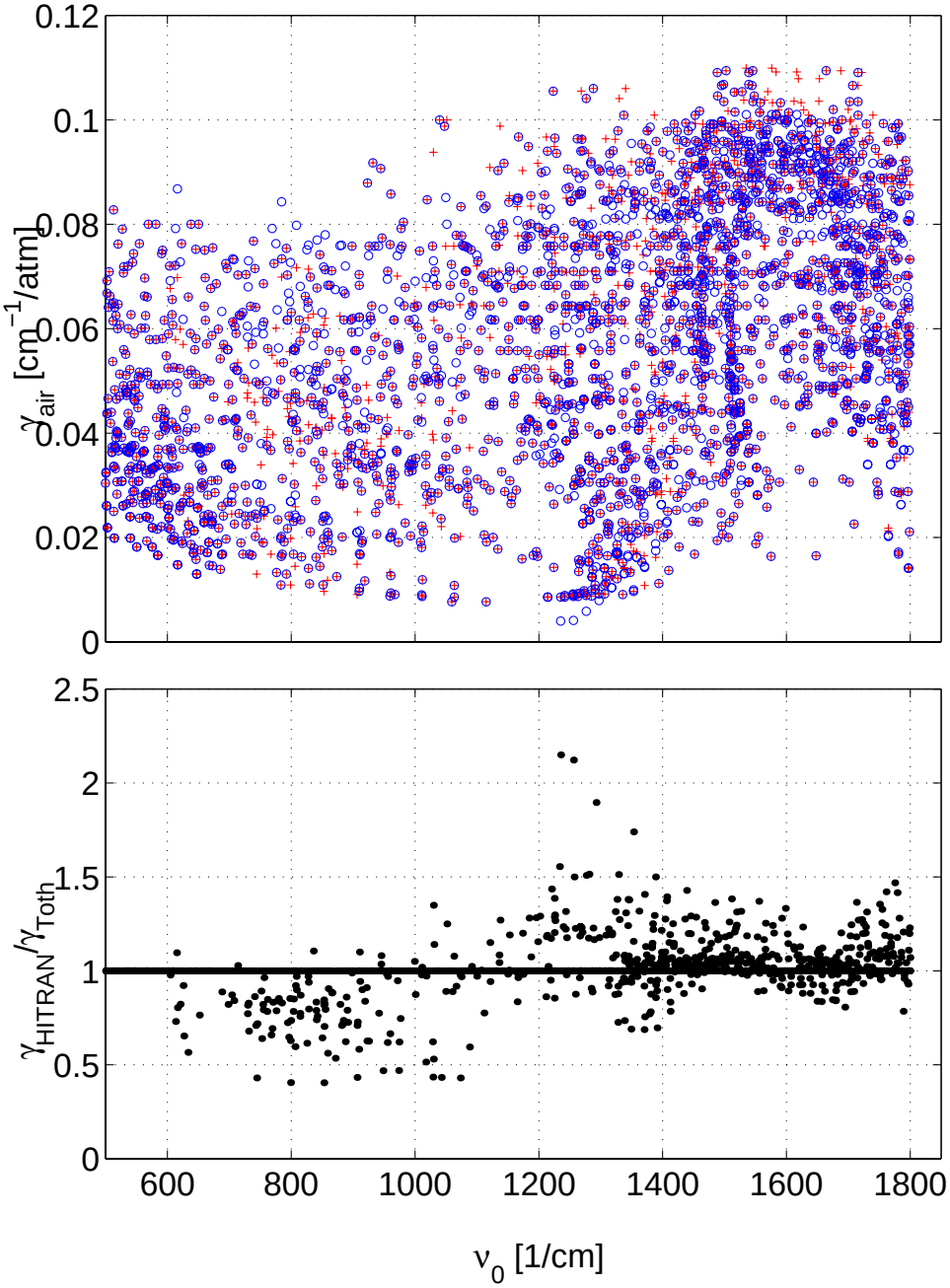


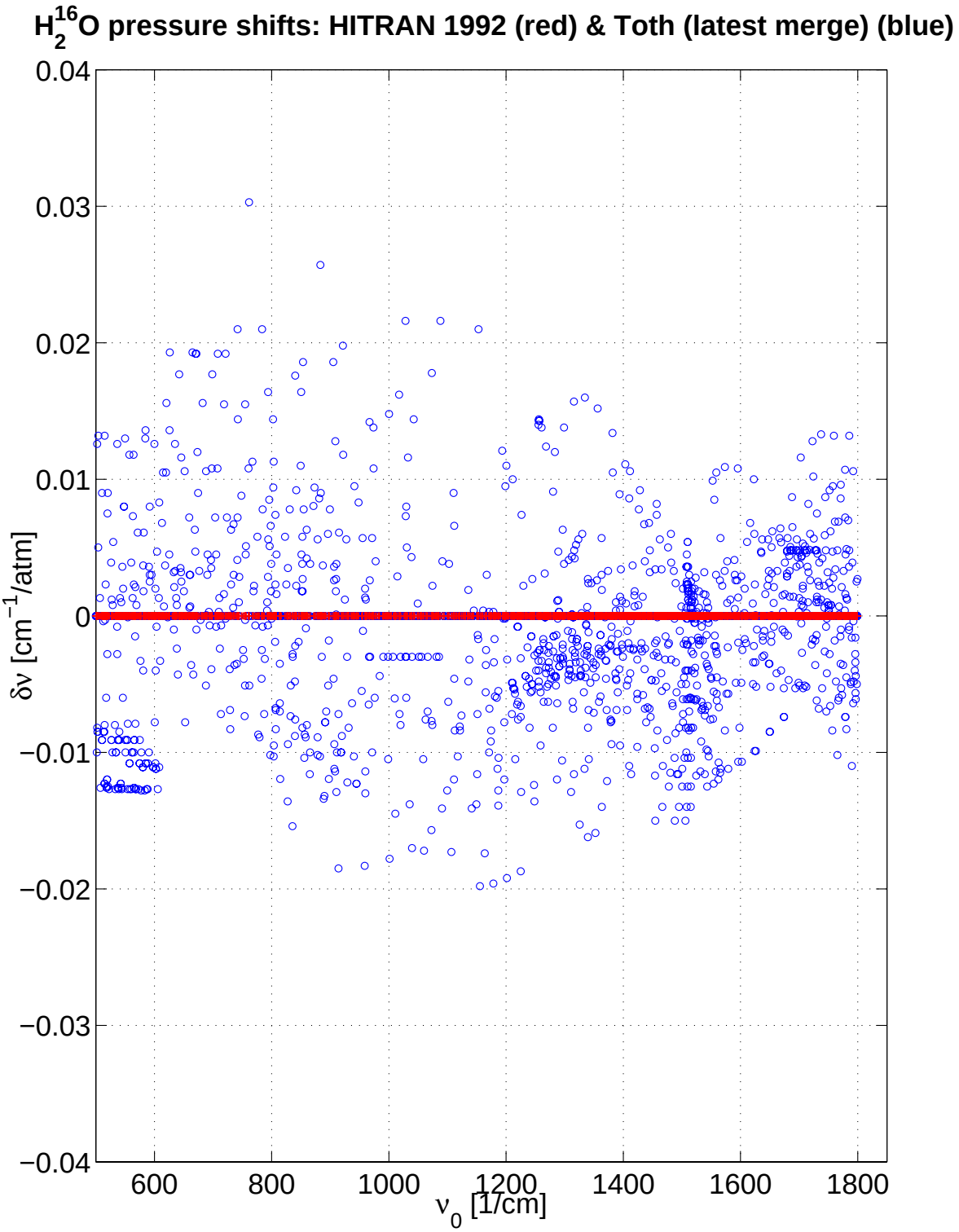

$H_2^{16}O$ line centers: HITRAN 1992 & Toth (latest merge)
0.1
0.05
0
−0.05
−0.1
$\nu_{HITRAN} - \nu_{Toth}$
600
800
1000
1200
1400
1600
1800
ν_{HITRAN} [cm^{-1}]
0.1
0.05
0
−0.05
−0.1
$\nu_{HITRAN} - \nu_{Toth}$
10^{-26}
10^{-24}
10^{-22}
10^{-20}
10^{-18}
S_{HITRAN} [cm^{-1}/(molec cm^{-2})]

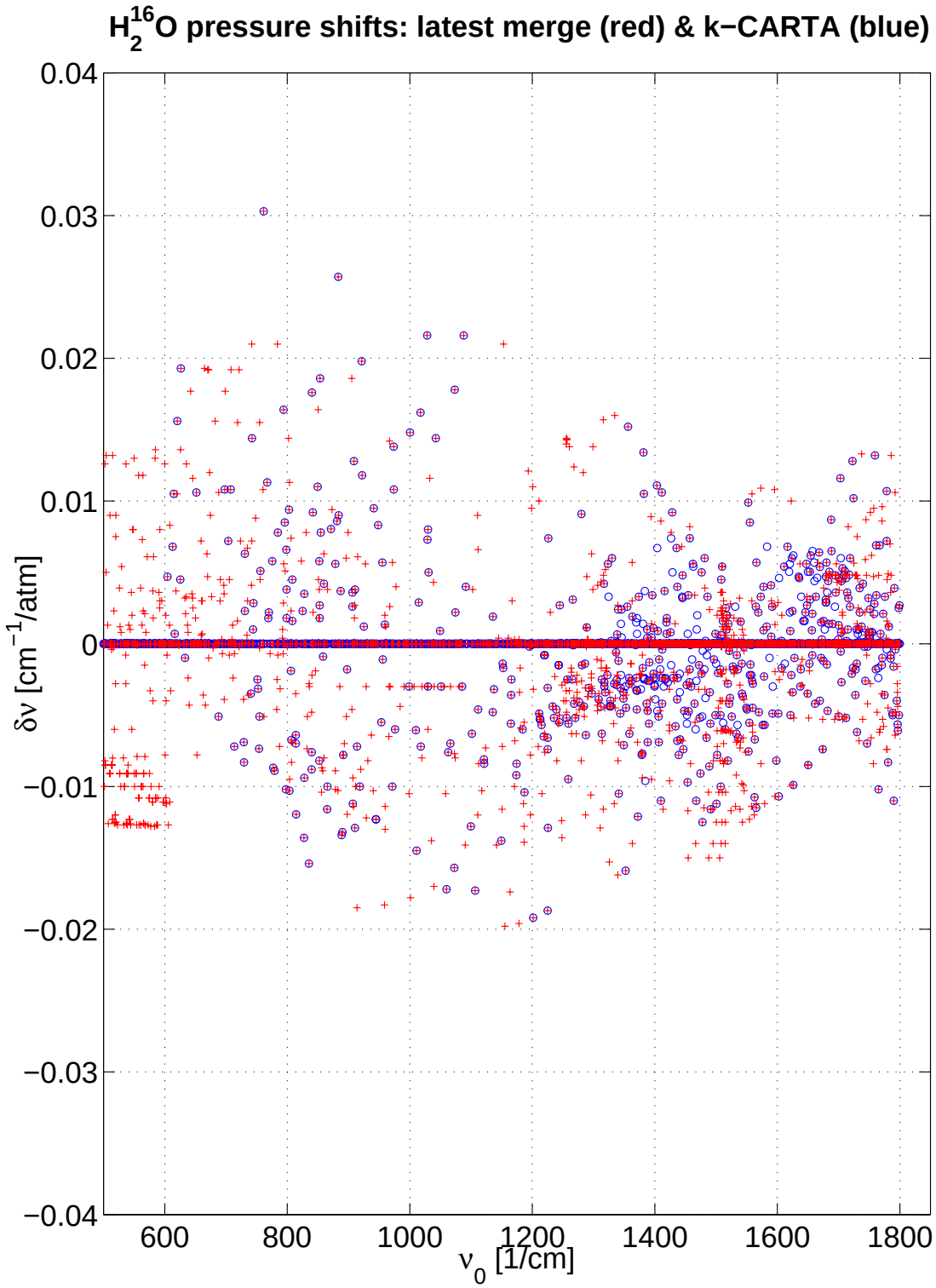
$^{16}_{2}$O air−broadened half widths: HITRAN 1992 (red) & Toth (latest merge) (blue

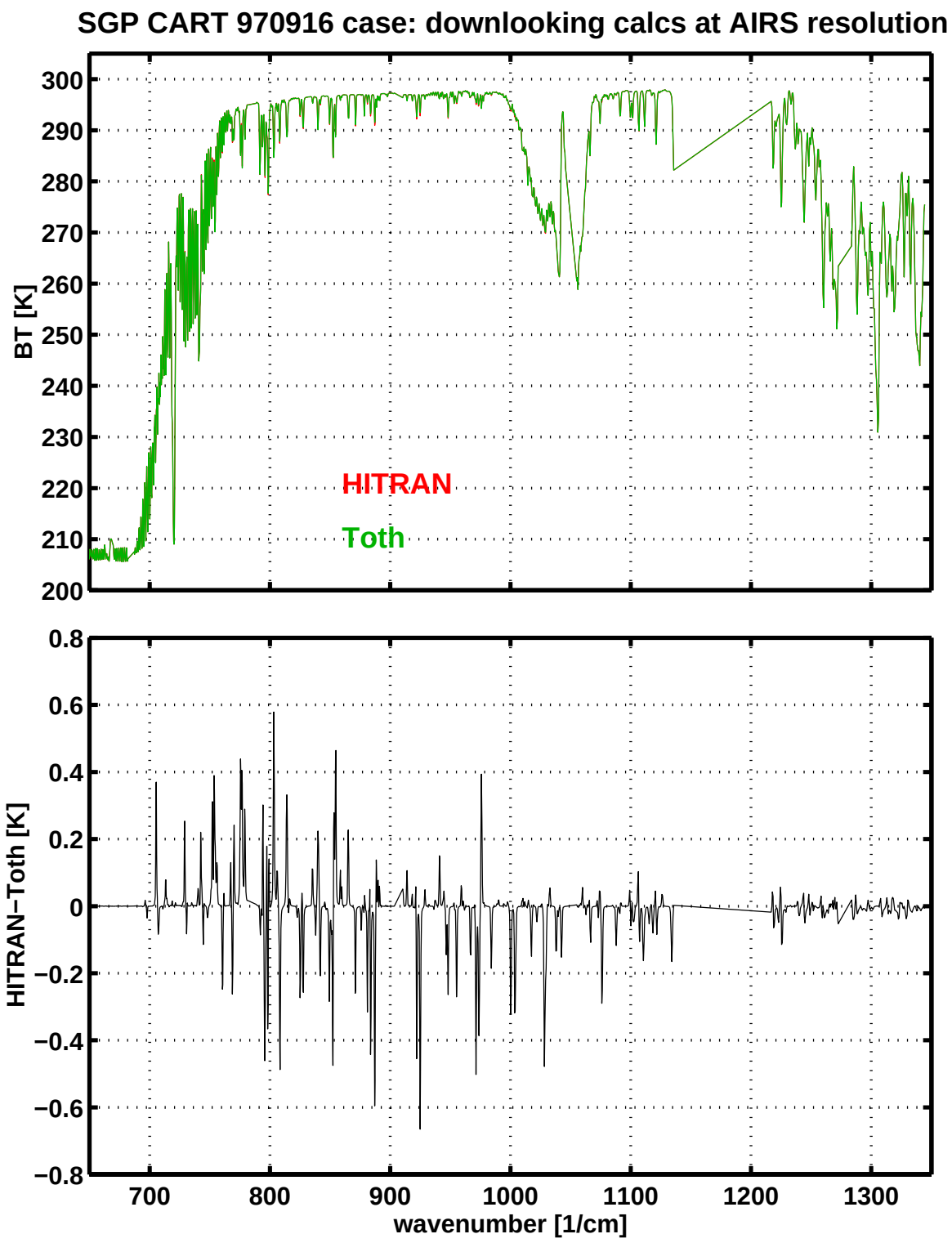


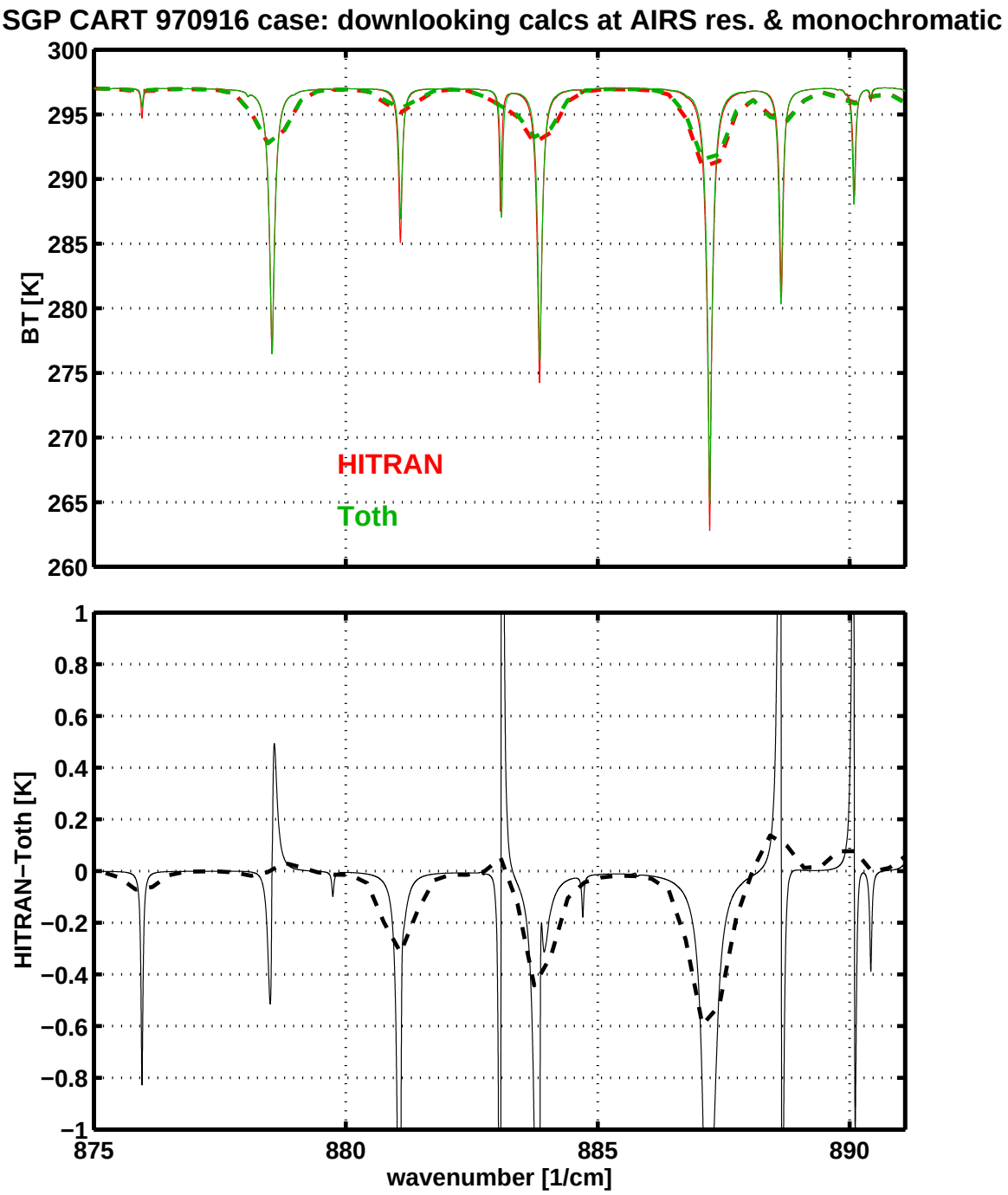
$H_2^{16}O$ air−broadened half widths: HITRAN 1992 (red) & Toth (k−CARTA) (blue)

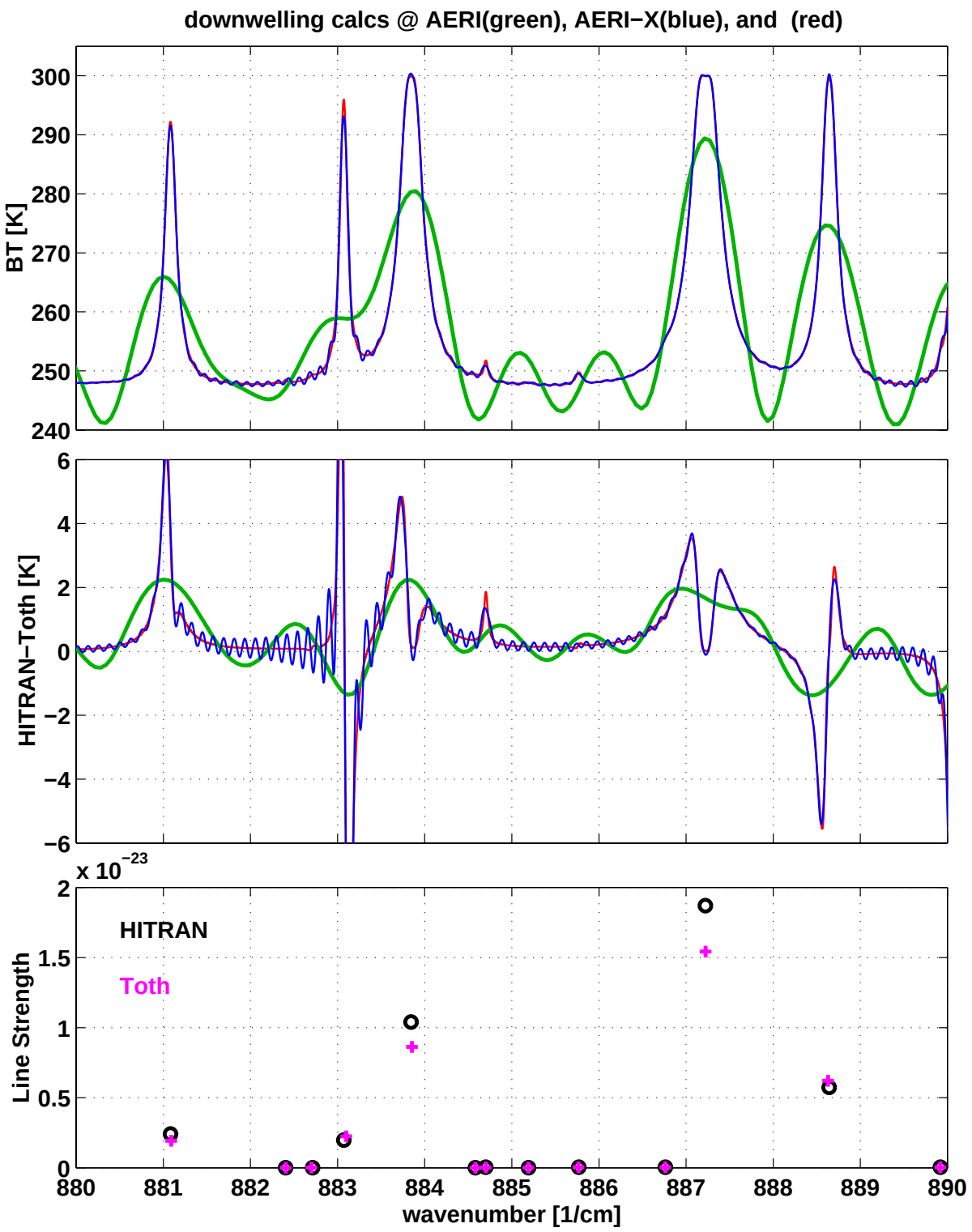


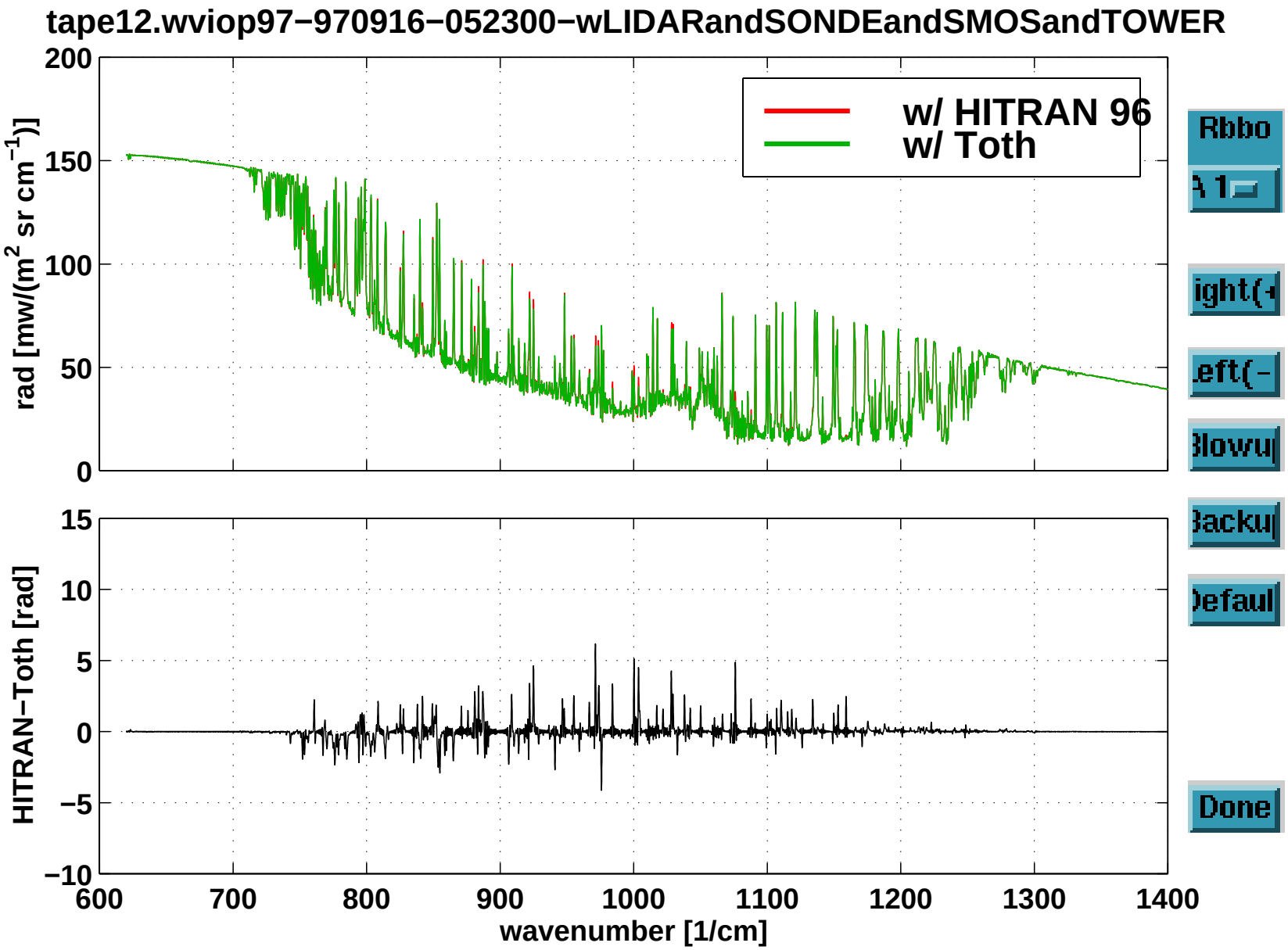

$H_2^{16}O$ pressure shifts: HITRAN 1992 (red) & Toth (latest merge) (blue)
0.04
0.03
0.02
0.01
0
−0.01
−0.02
−0.03
−0.04
δν [cm^{-1}/atm]
600
800
1000
1200
1400
1600
1800
ν_0 [1/cm]


$H_2^{16}O$ pressure shifts: latest merge (red) & k−CARTA (blue)
0.04
0.03
0.02
0.01
0
−0.01
−0.02
−0.03
−0.04
δν [cm^{-1}/atm]
600
800
1000
1200
1400
1600
1800
ν_0 [1/cm]


SGP CART 970916 case: downlooking calcs at AIRS resolution
BT [K]
300
290
280
270
260
250
240
230
220
210
200
HITRAN
Toth
HITRAN−Toth [K]
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
700
800
900
1000
1100
1200
1300
wavenumber [1/cm]


SGP CART 970916 case: downlooking calcs at AIRS res. & monochromatic
BT [K]
300
295
290
285
280
275
270
265
260
HITRAN
Toth
HITRAN−Toth [K]
1
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−1
875
880
885
890
wavenumber [1/cm]


downwelling calcs @ AERI(green), AERI−X(blue), and (red)
BT [K]
300
290
280
270
260
250
240
HITRAN−Toth [K]
6
4
2
0
−2
−4
−6
x 10^−23
Line Strength
2
1.5
1
0.5
0
HITRAN
Toth
880
881
882
883
884
885
886
887
888
889
890
wavenumber [1/cm]


tape12.wviop97−970916−052300−wLIDARandSONDEandSMOSandTOWER
w/ HITRAN 96
w/ Toth
rad [mw/(m2 sr cm−1)]
HITRAN−Toth [rad]
wavenumber [1/cm]
200
150
100
50
0
15
10
5
0
−5
−10
600
700
800
900
1000
1100
1200
1300
1400
Rbbo
ight(
eft(-
Blowu
Backu
Defaul
Done

Preliminary WVIOP '97 case studies

970916: ∼4.0 cm precip. water vapor, $T_s \simeq$ 300 K, GSFC Raman LIDAR

→ shows residuals similar to CSP results

970926: ∼1.2 cm precip. water vapor, $T_s \simeq$ 290 K, CART and GSFC Raman LIDARs, North Dakota Citation flight w/ chilled mirror, ∼10 tethered balloon chilled mirror profiles

970918: ND Citation flight & kite-based chilled mirror profiles to ∼330 meters

970919:

970928: King Air flight, LANDSAT overpass during day, LIDARs

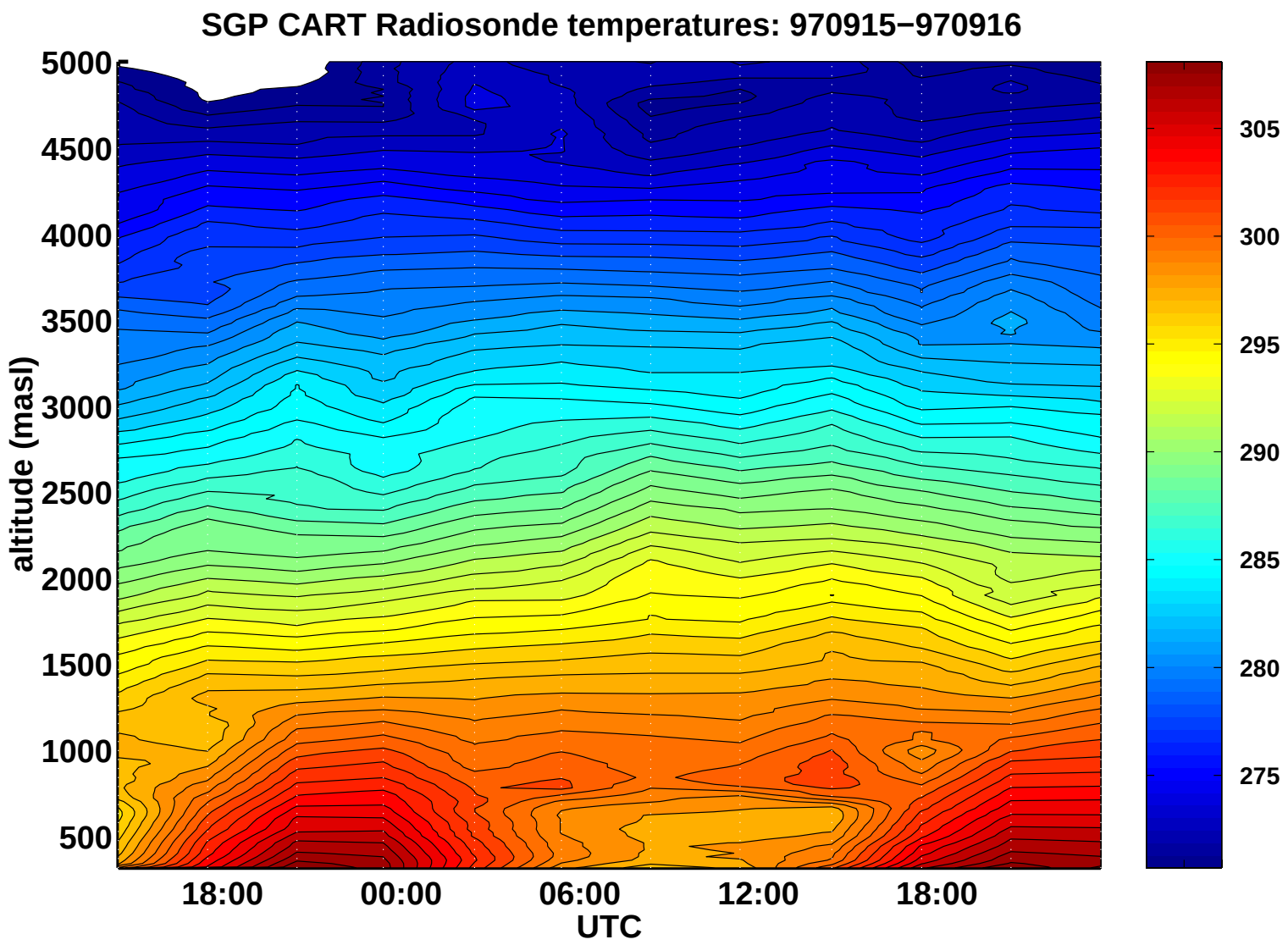
970930: King Air and Gulf Stream flights, LIDARs, ∼10 tethered balloon chilled mirror profiles

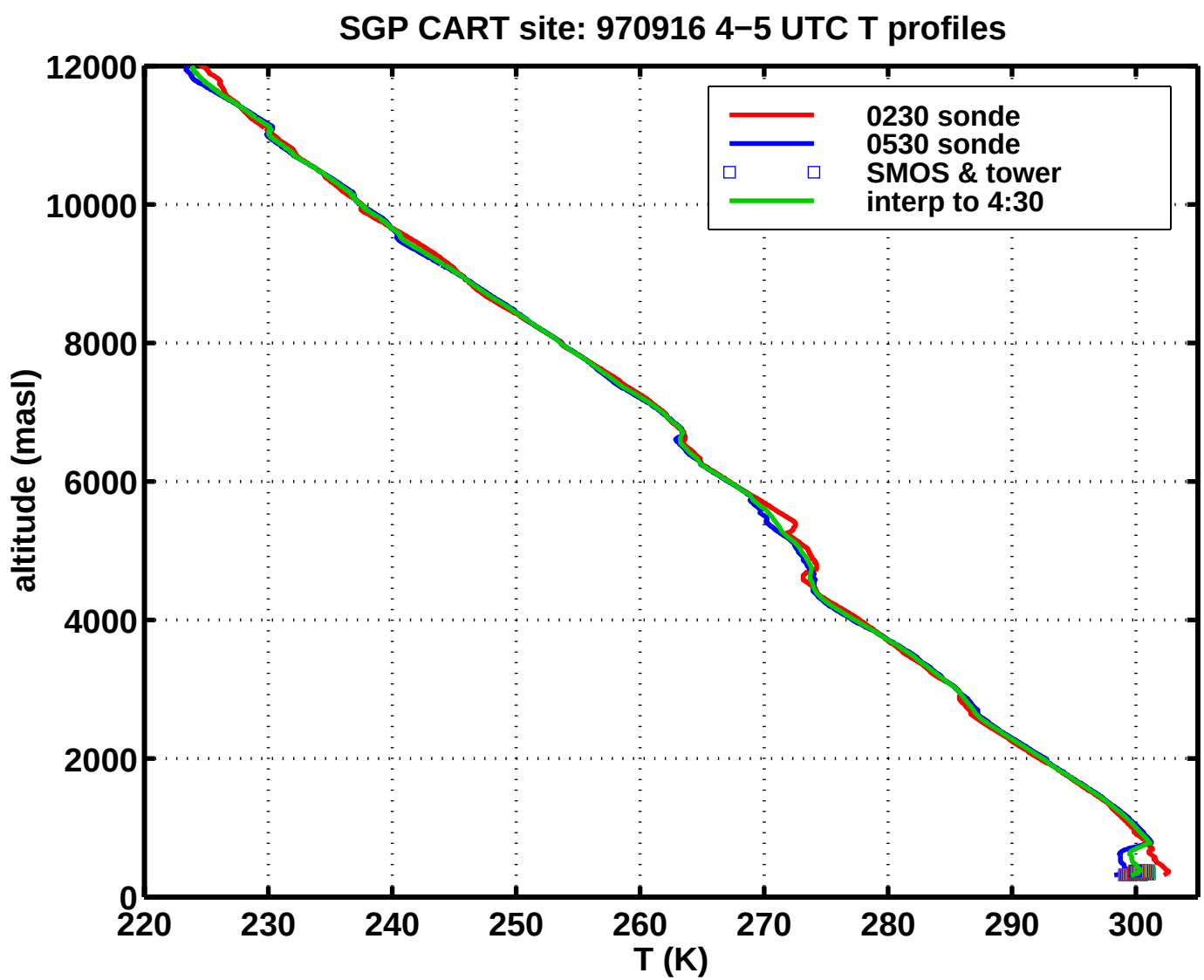
971001: ND Citation flight: chilled mirror + frost point, LIDARs, 17+ kite based chilled mirror profiles

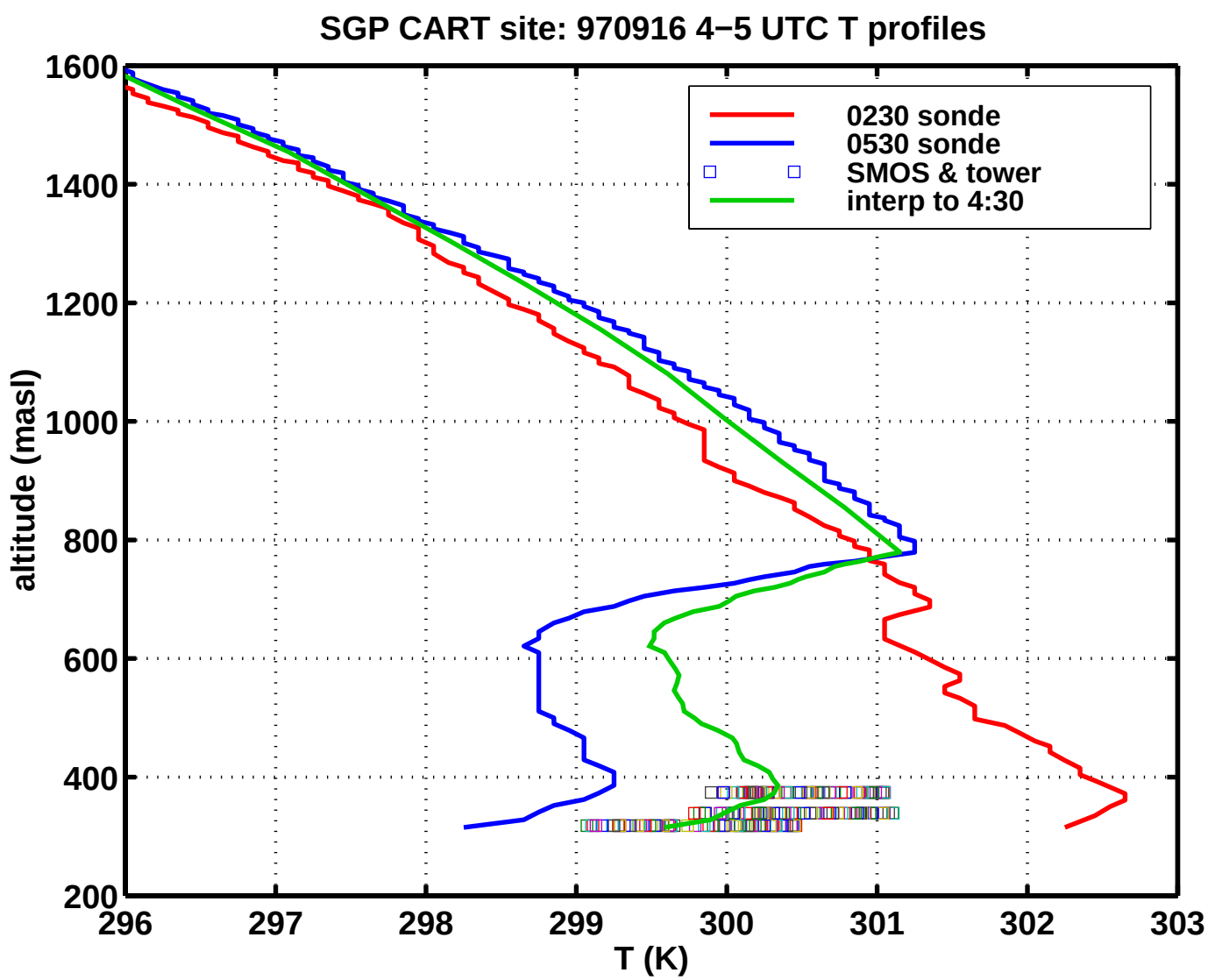
971002: ND Citation flight w/ chilled mirror, LIDARs, 6 kite based chilled mirror profiles

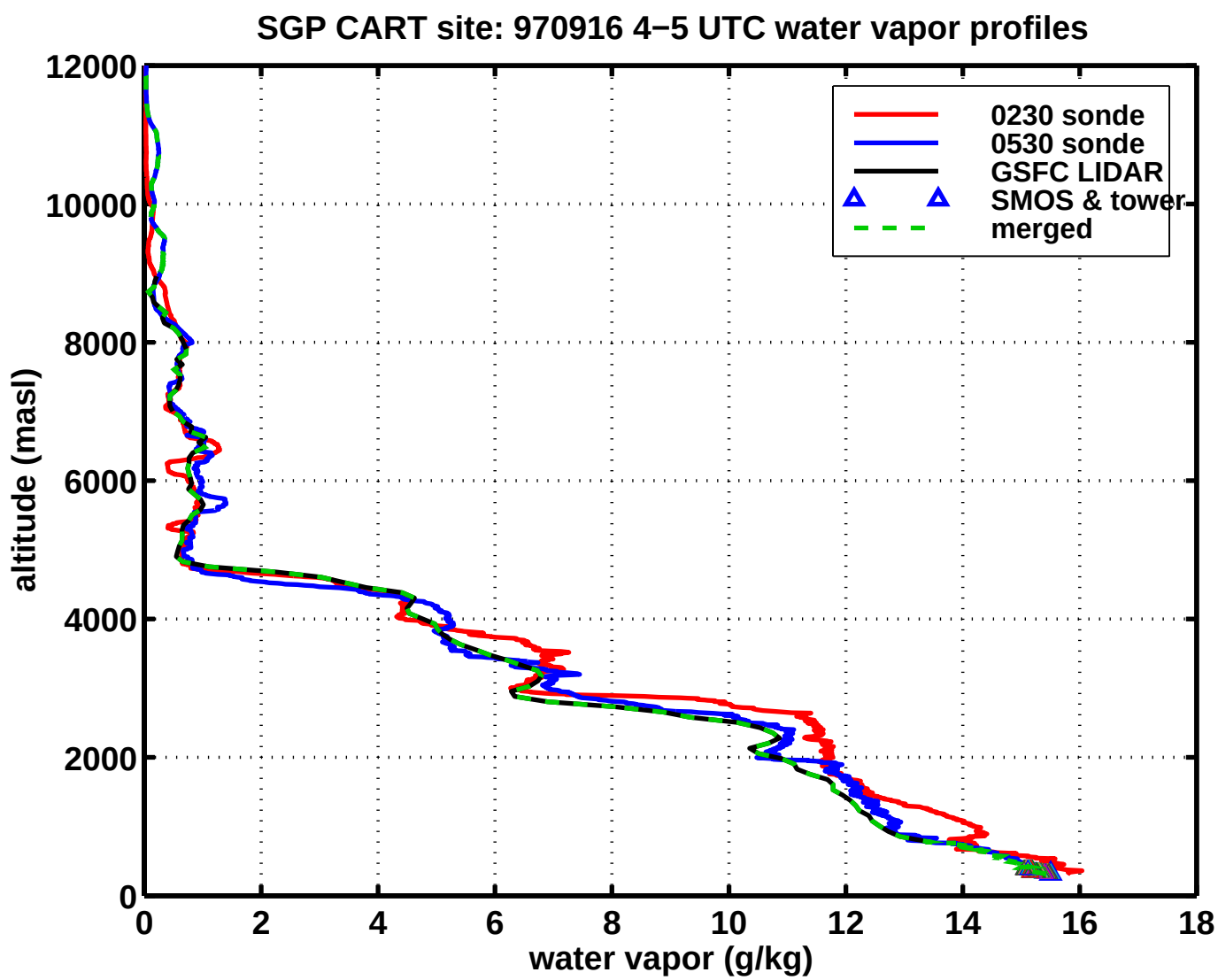
971003:

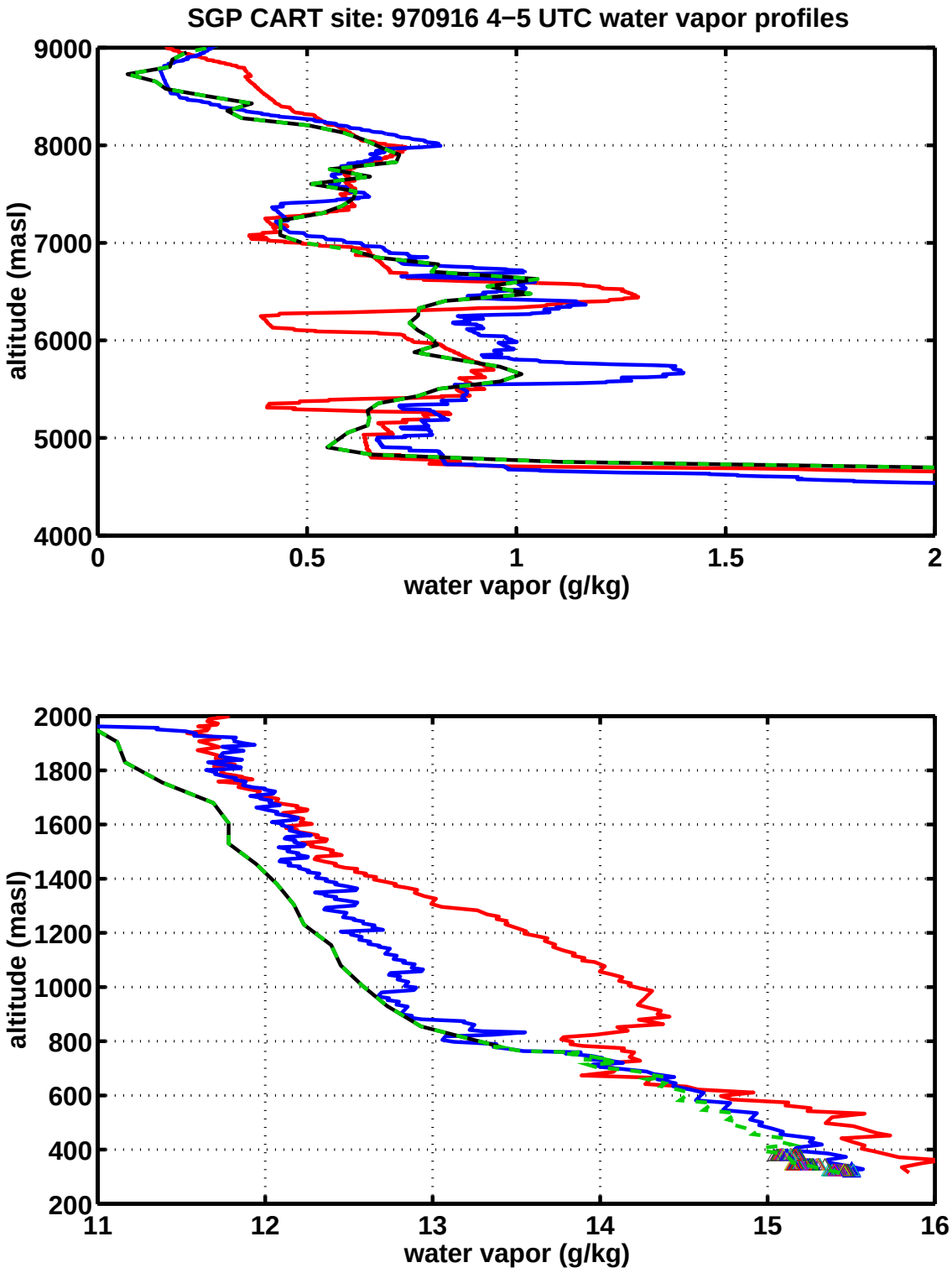
971004: King Air and ND Citation flights, LIDARs

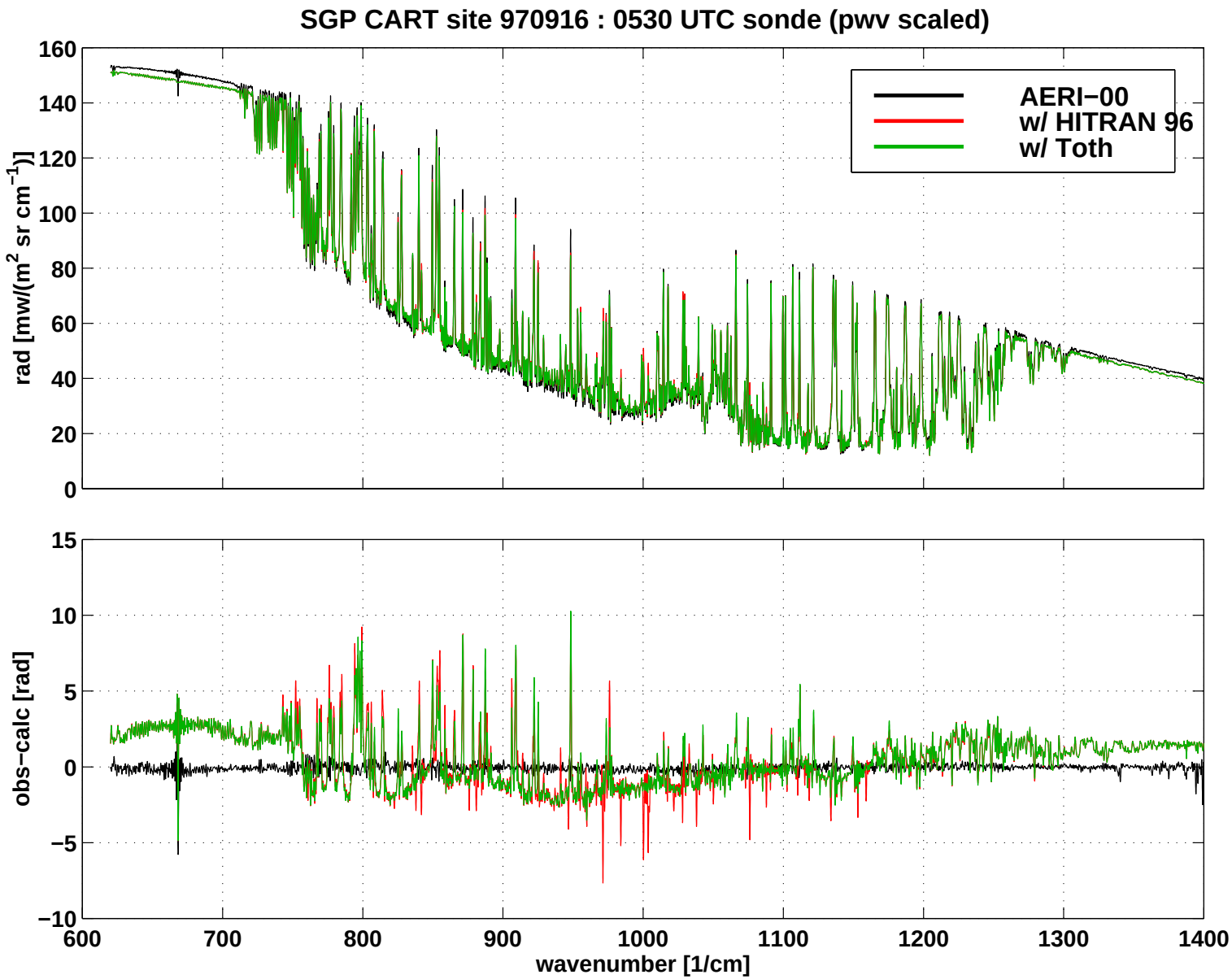

SGP CART Radiosonde temperatures: 970915−970916
altitude (masl)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
18:00
00:00
06:00
12:00
18:00
UTC
305
300
295
290
285
280
275

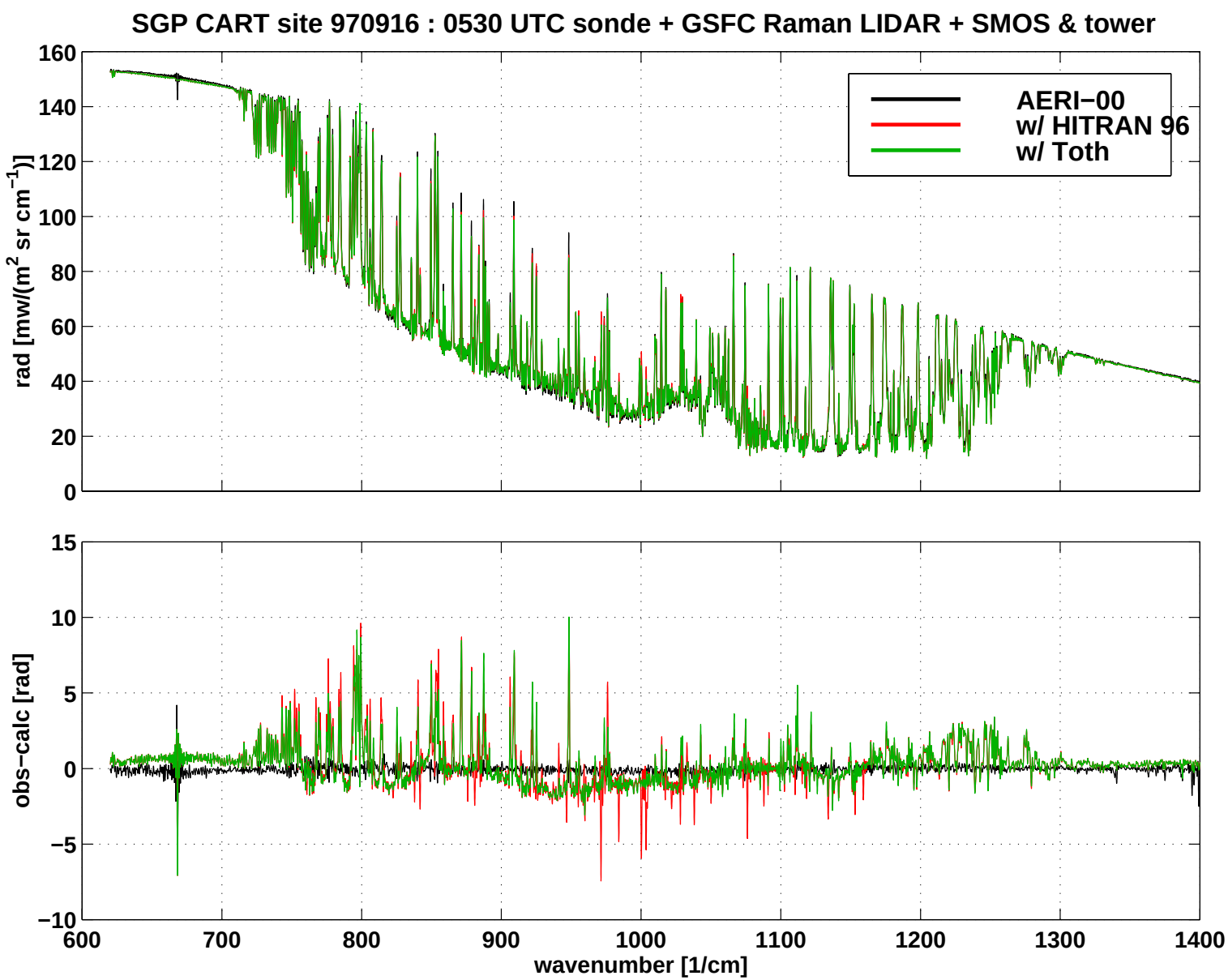

SGP CART site: 970916 4−5 UTC T profiles
0230 sonde
0530 sonde
SMOS & tower
interp to 4:30
altitude (masl)
T (K)
0
2000
4000
6000
8000
10000
12000
220
230
240
250
260
270
280
290
300

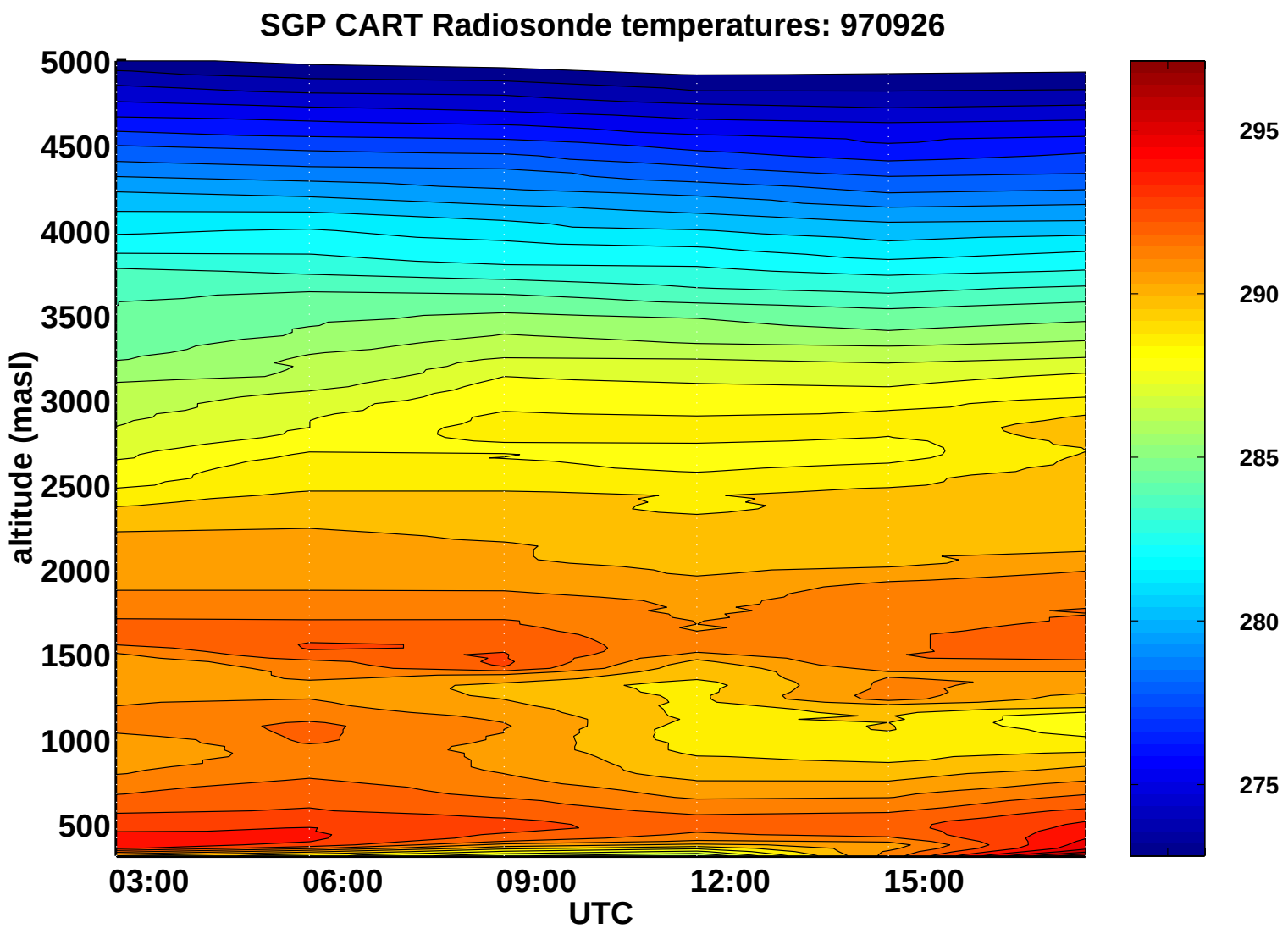

SGP CART site: 970916 4−5 UTC T profiles
0230 sonde
0530 sonde
SMOS & tower
interp to 4:30
altitude (masl)
1600
1400
1200
1000
800
600
400
200
296
297
298
299
300
301
302
303
T (K)

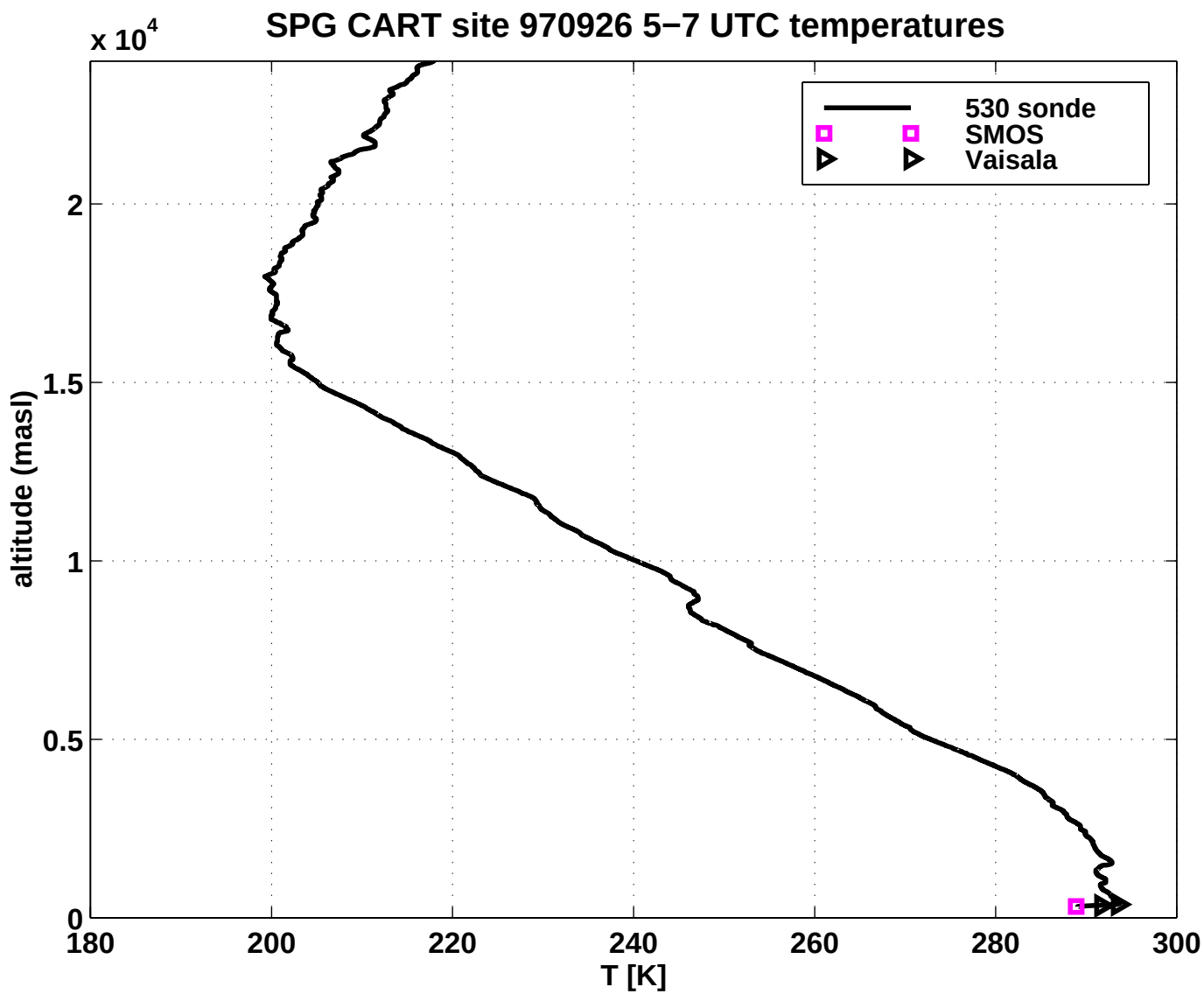

SGP CART site: 970916 4−5 UTC water vapor profiles
0230 sonde
0530 sonde
GSFC LIDAR
SMOS & tower-merged
altitude (masl)
water vapor (g/kg)
0
2000
4000
6000
8000
10000
12000
0
2
4
6
8
10
12
14
16
18

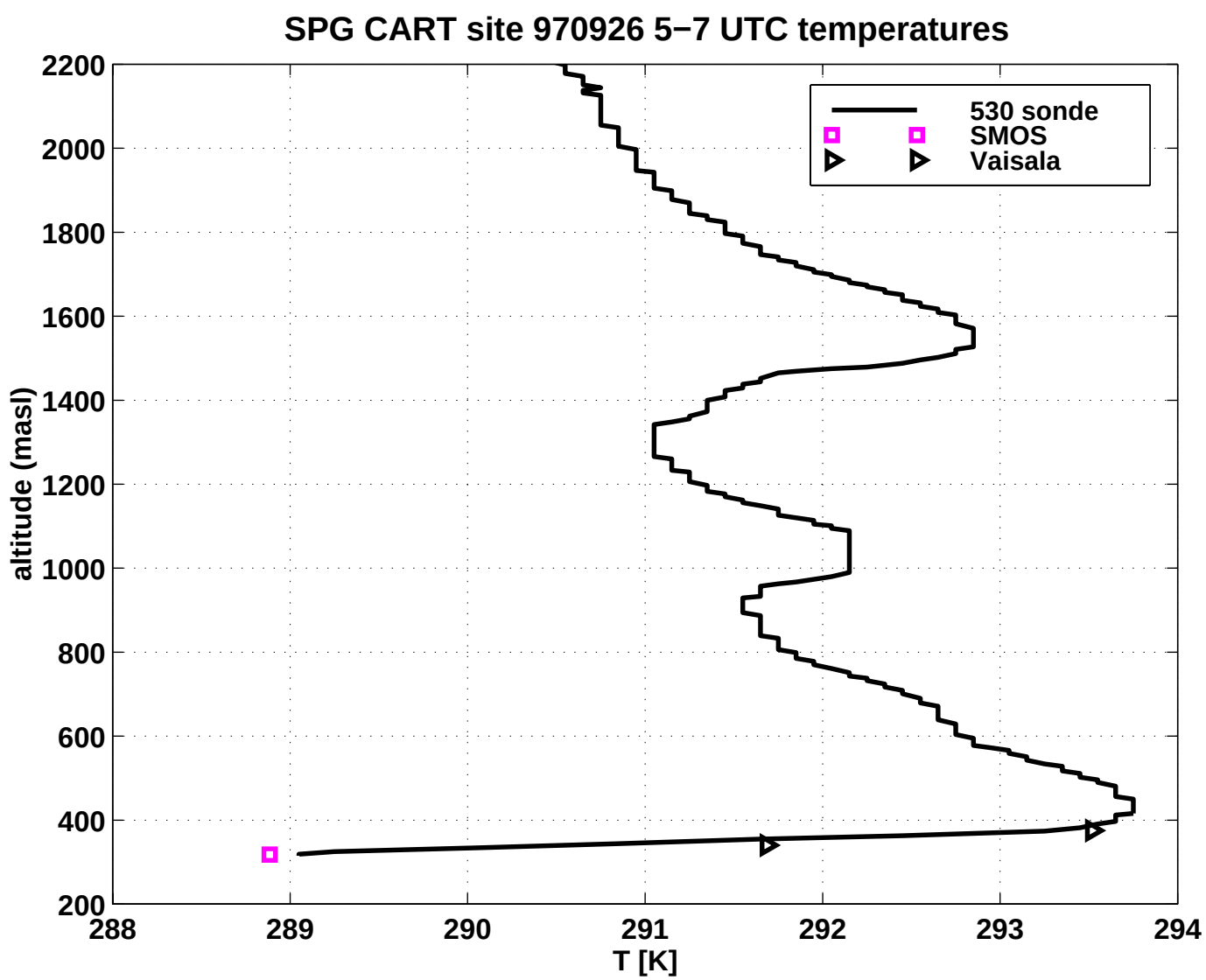

SGP CART site: 970916 4−5 UTC water vapor profiles
altitude (masl)
9000
8000
7000
6000
5000
4000
0
0.5
1
1.5
2
water vapor (g/kg)
altitude (masl)
2000
1800
1600
1400
1200
1000
800
600
400
200
11
12
13
14
15
16
water vapor (g/kg)

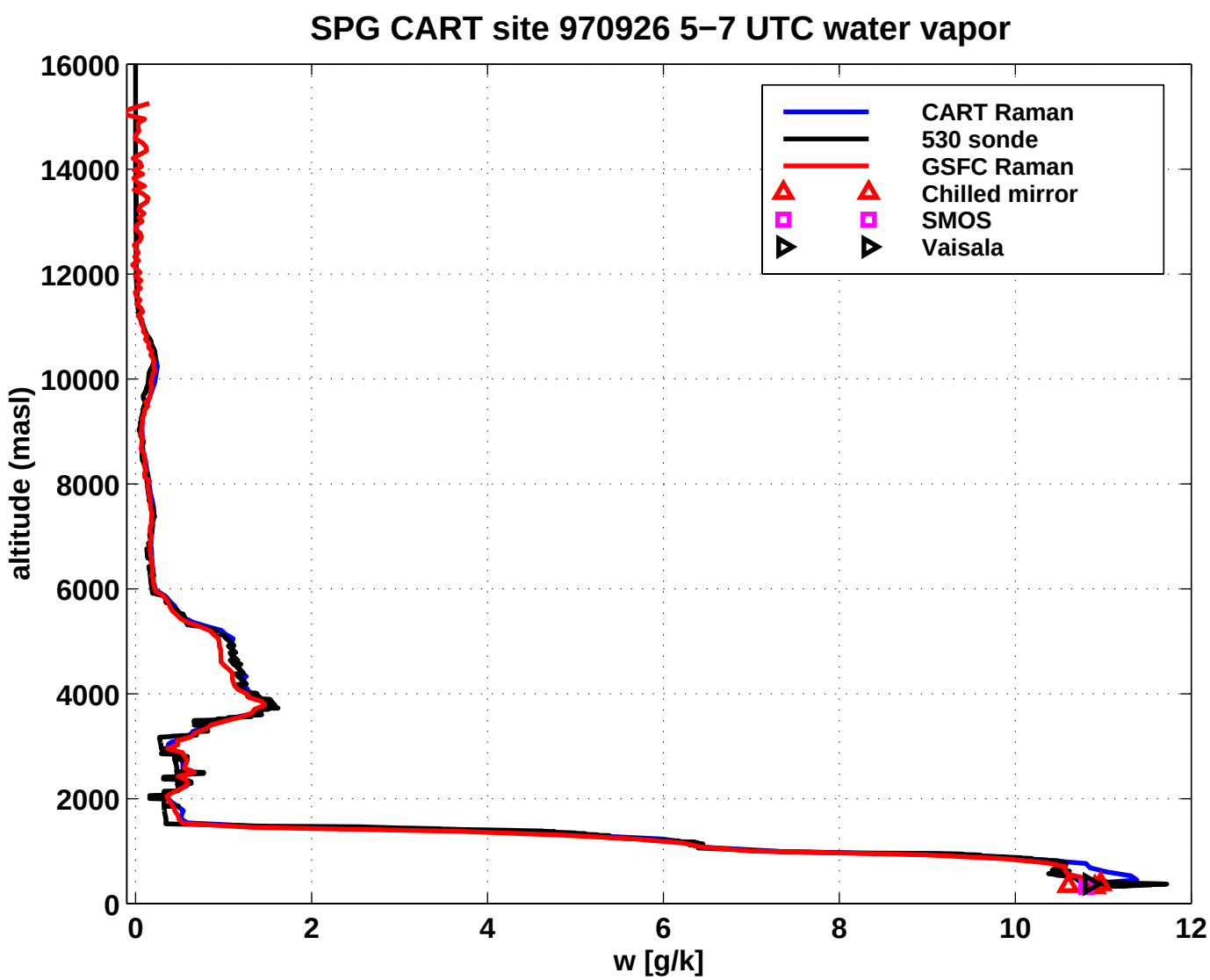

SGP CART site 970916 : 0530 UTC sonde (pwv scaled)
AERI−00
w/ HITRAN 96
w/ Toth
rad [mw/(m2 sr cm−1)]
obs−calc [rad]
wavenumber [1/cm]
160
140
120
100
80
60
40
20
0
15
10
5
0
−5
−10
600
700
800
900
1000
1100
1200
1300
1400

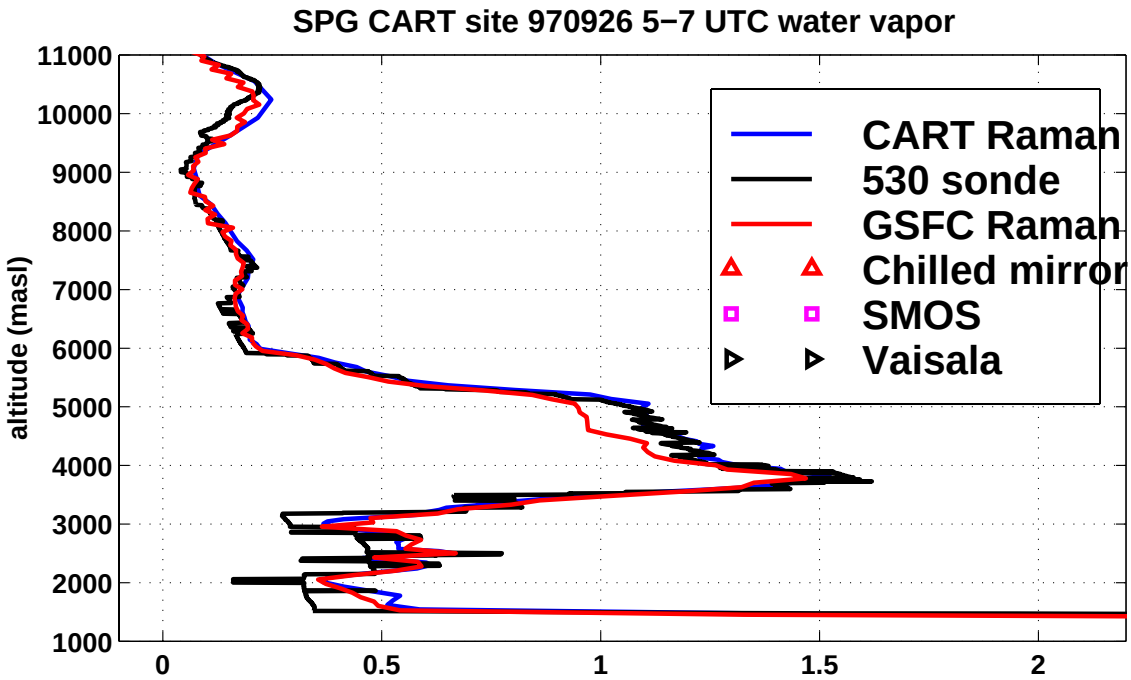

SGP CART site 970916 : 0530 UTC sonde + GSFC Raman LIDAR + SMOS & tower
AERI−00
w/ HITRAN 96
w/ Toth
rad [mw/(m2 sr cm−1)]
obs−calc [rad]
wavenumber [1/cm]
160
140
120
100
80
60
40
20
0
15
10
5
0
−5
−10
600
700
800
900
1000
1100
1200
1300
1400

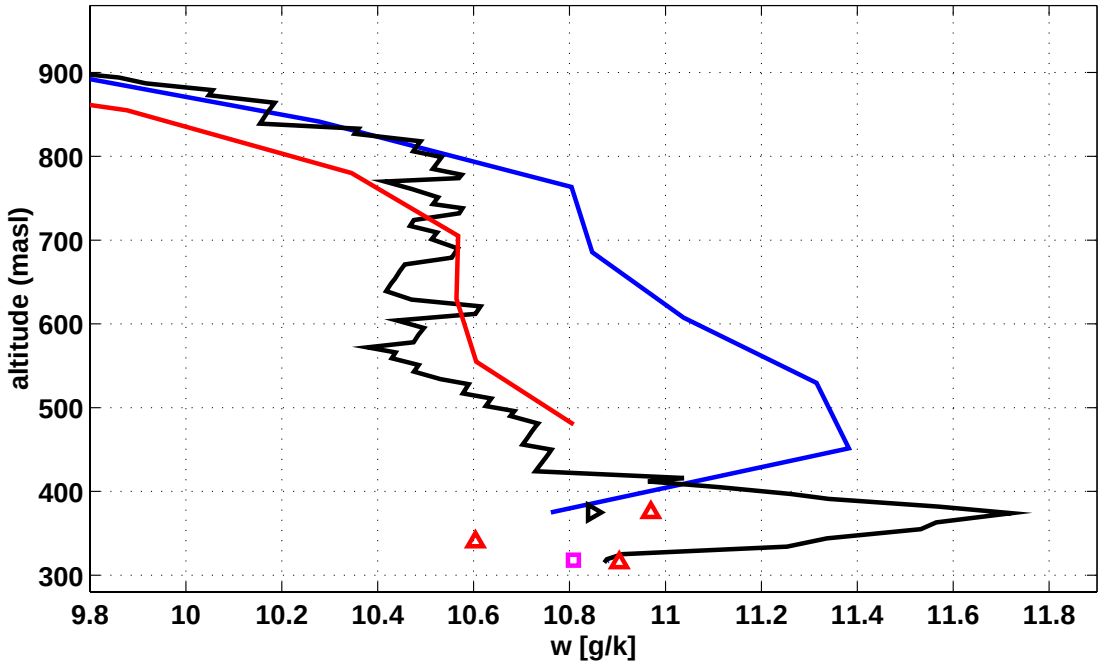

SGP CART Radiosonde temperatures: 970926
altitude (masl)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
03:00
06:00
09:00
12:00
15:00
UTC
295
290
285
280
275

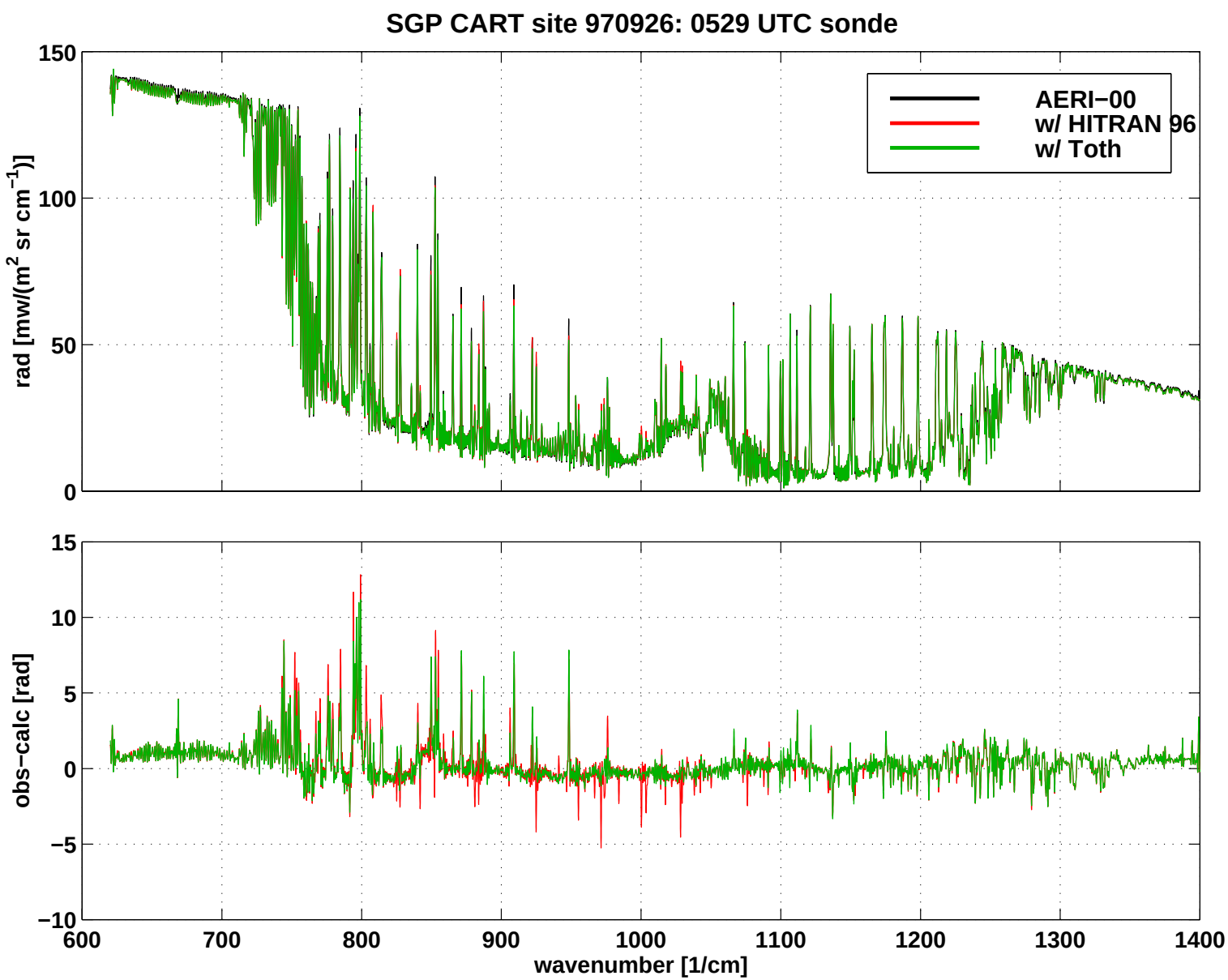

SPG CART site 970926 5−7 UTC temperatures
x 10^4
altitude (masl)
T [K]
530 sonde
SMOS
Vaisala
0
0.5
1
1.5
2
180
200
220
240
260
280
300


SPG CART site 970926 5−7 UTC temperatures
530 sonde
SMOS
Vaisala
altitude (masl)
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
288
289
290
291
292
293
294
T [K]


SPG CART site 970926 5−7 UTC water vapor
CART Raman
530 sonde
GSFC Raman
Chilled mirror
SMOS
Vaisala
altitude (masl)
w [g/k]
0
2000
4000
6000
8000
10000
12000
14000
16000
0
2
4
6
8
10
12


SPG CART site 970926 5−7 UTC water vapor
altitude (masl)
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0.5
1
1.5
2
CART Raman
530 sonde
GSFC Raman
Chilled mirror
SMOS
Vaisala


altitude (masl)
900
800
700
600
500
400
300
9.8
10
10.2
10.4
10.6
10.8
11
11.2
11.4
11.6
11.8
w [g/k]


SGP CART site 970926: 0529 UTC sonde
AERI−00
w/ HITRAN 96
w/ Toth
rad [mw/(m2 sr cm−1)]
150
100
50
0
obs−calc [rad]
15
10
5
0
−5
−10
600
700
800
900
1000
1100
1200
1300
1400
wavenumber [1/cm]

SGP CART site 970926: CART Raman LIDAR + SMOS & tower
AERI−00
w/ HITRAN 96
w/ Toth
rad [mw/(m2 sr cm−1)]
150
100
50
0
obs−calc [rad]
15
10
5
0
−5
−10
600
700
800
900
1000
1100
1200
1300
1400
wavenumber [1/cm]