Earth System Research Laboratory
Global Monitoring Division

CIRES
Cooperative Institute for Research in Environmental Sciences

Effect of a Proposed Change of Ozone Cross-sections on the Historical Record of Stratospheric Ozone at Selected Stations using Dobson Ozone Spectrophotometers in the US Network

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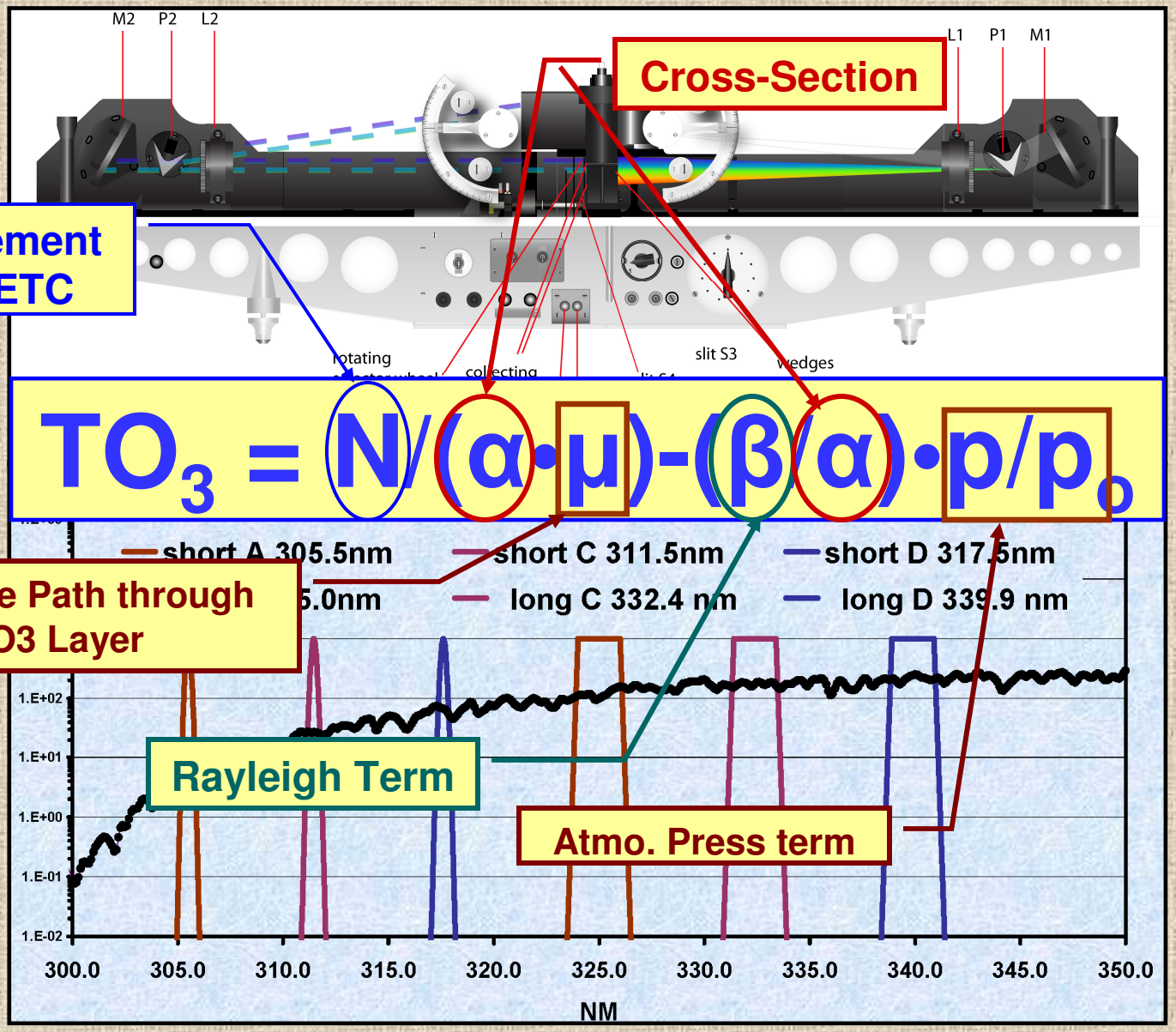
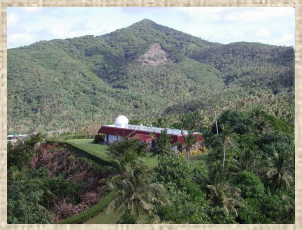

M2
P2
L2
L1
P1
M1
Cross-Section
Measurement term - ETC
rotating
collecting
slit S3
wedges
$TO_3 = N/(\alpha \cdot \mu) - (\beta/\alpha) \cdot p/p_o$
Relative Path through O3 Layer
short A 305.5nm
short C 311.5nm
short D 317.5nm
long C 332.4 nm
long D 339.9 nm
Rayleigh Term
Atmo. Press term
1.E+02
1.E+01
1.E+00
1.E-01
1.E-02
300.0
305.0
310.0
315.0
320.0
325.0
330.0
335.0
340.0
345.0
350.0
NM

Four stations

Boulder, Colorado USA
40N, 105 W, 1600 mmsl (BDR)
1966- 2008, total ozone range 220-510 (min-max)

Mauna Loa, Hawaii, USA
20N, 156W, 3400 mmsl (MLO)
1963-2008, total ozone range 200-360 (min-max)

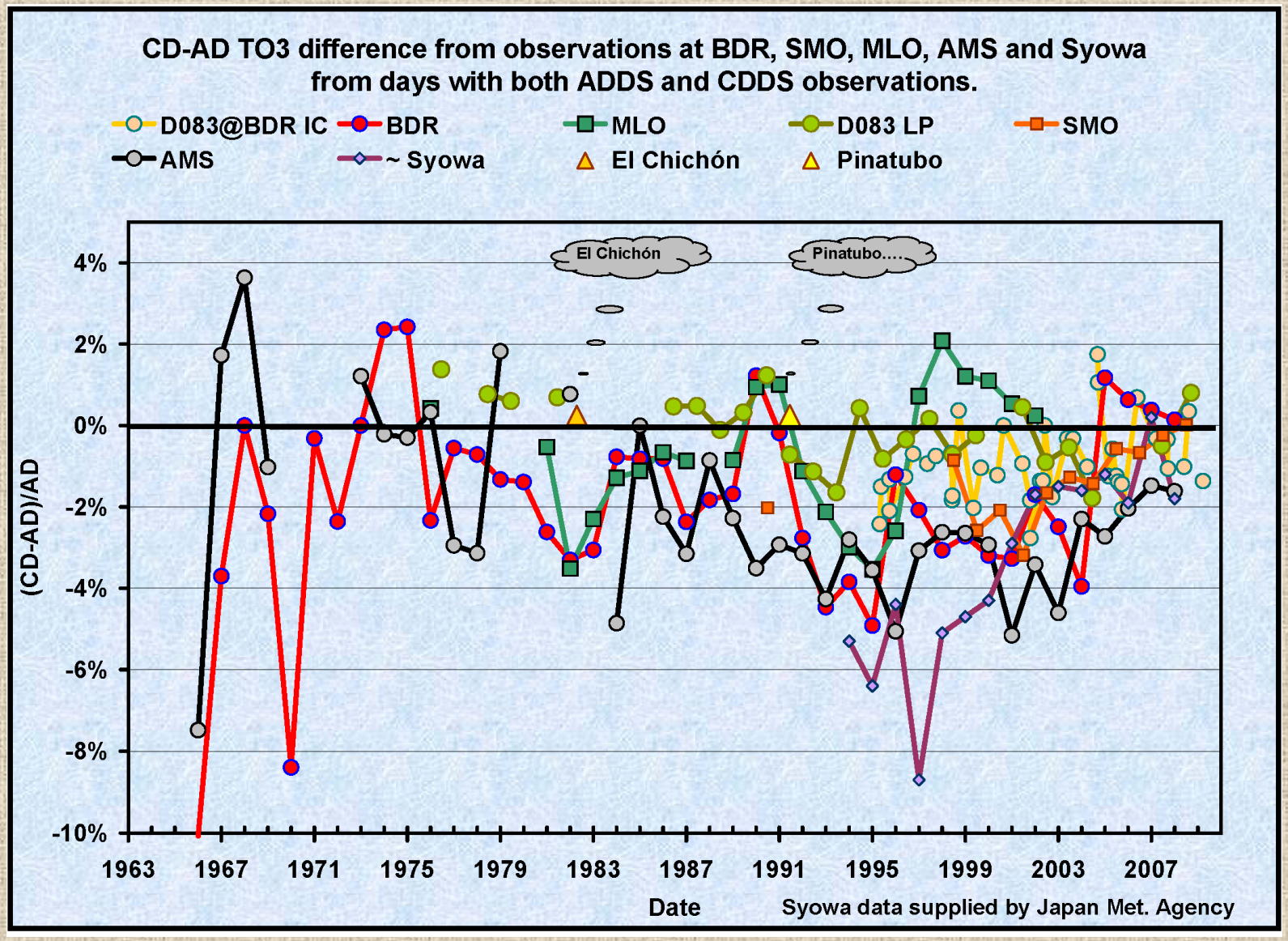


Tutuila Island, Amer. Samoa USA.
14S, 171W, 82 mmsl (SMO)
1976-2008, Total ozone range 200-340 (min-max)

Amundsen-Scott Station, Antarctica
90S, 2810 mmsl (AMS)
1965-2008, total ozone range 100-500 (min-max)

What problems are seen using the existing set (PB1992) of Cross-sections for Dobson Instruments?

- Ozone calculated from measurements using the different wavelength pairs, and double pairs is different – in the same observation.
  - Minor problem,
    - Single Pair Observations are not normally reported.
    - The Operations Handbook for the Dobson instrument (**WMO Report No.183**) has the procedure to normalize the CD results to the AD results level.
- Stations with Dobson instruments discover differences in the total ozone derived from other, co-located measurements, relative to the Dobson results.
  - Not necessarily the result of the incorrect cross-sections.
  - Dobson (and the other) instruments have some other issues to consider.

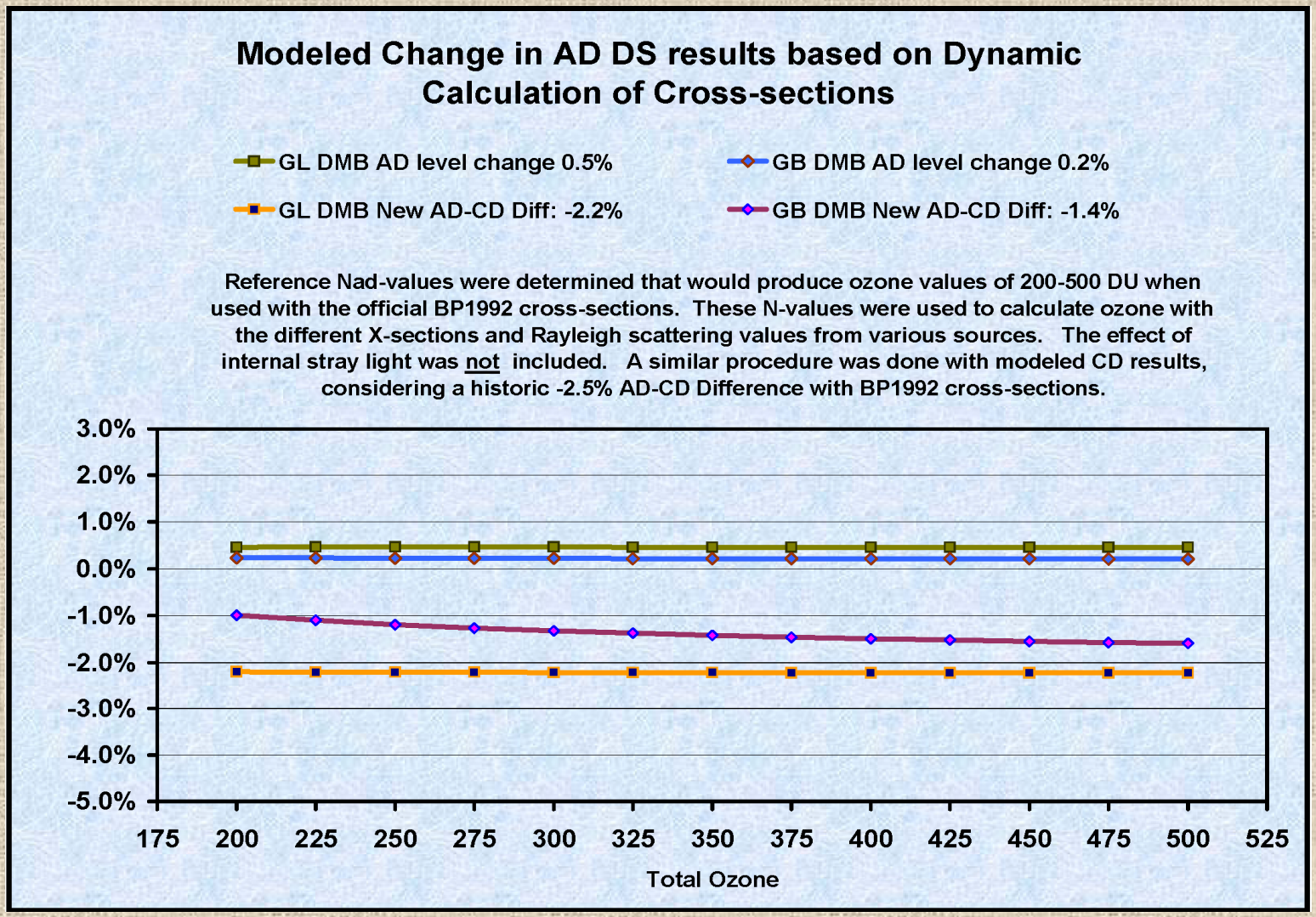

CD-AD TO3 difference from observations at BDR, SMO, MLO, AMS and Syowa
from days with both ADDS and CDDS observations.
D083@BDR IC
BDR
MLO
D083 LP
SMO
AMS
~ Syowa
El Chichón
Pinatubo
El Chichón
Pinatubo....
4%
2%
0%
-2%
-4%
-6%
-8%
-10%
(CD-AD)/AD
1963
1967
1971
1975
1979
1983
1987
1991
1995
1999
2003
2007
Date
Syowa data supplied by Japan Met. Agency

DMB Cross-sections

There are several determinations of Dobson cross-sections derived from Daumont-Malicet-Brion (DMB) Laboratory measurements by:

- NASA: Gordon Labow
- Outside the "system": Germar Bernhard (Biospherical Instruments, Inc)

Modeled Change in AD DS results based on Dynamic Calculation of Cross-sections



What will a change in ozone cross-sections do to the records of these stations?

Not much

- If the change is just to the ozone term: the only change is in the average.
  - **If the Rayleigh term is re-determined, and it's much different, then the trend and seasonality will change.**

- CD direct sun observations will still be normalized to the AD direct sun level, same as before. Normalization factor will change.
- The Zenith observations will be reduced to ozone constrained by the AD direct sun results, same as before.
- Existing data set can be adjusted by some multiplying factor.

What will a change in ozone cross-sections do to the calibration process?

Not much

- The Langley Plot calibration of the primary standard results are independent of the cross-sections; very slightly dependent of the Rayleigh term.
- The scheme of transferring the calibration to the network is independent of the cross-sections

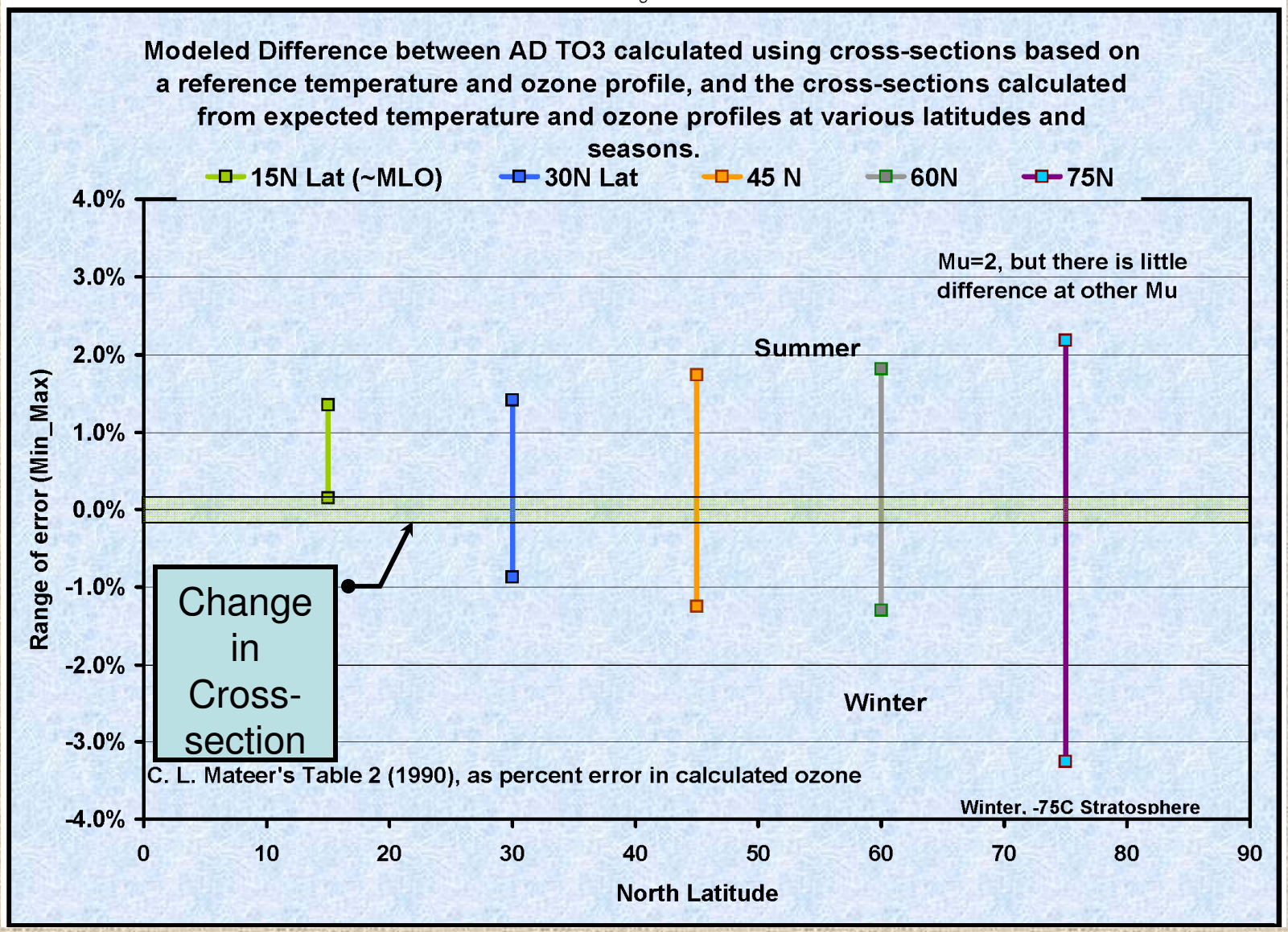
Improvement?

- The average accuracy is perhaps improved.
- The precision– defined as the repeatability of the measurements – is unchanged.
- The envelope on the accuracy remains the same
  - at best ±1%, clear tropical conditions to ±5% at high latitudes, before considering other instrument limitations.

What problems are still with us?

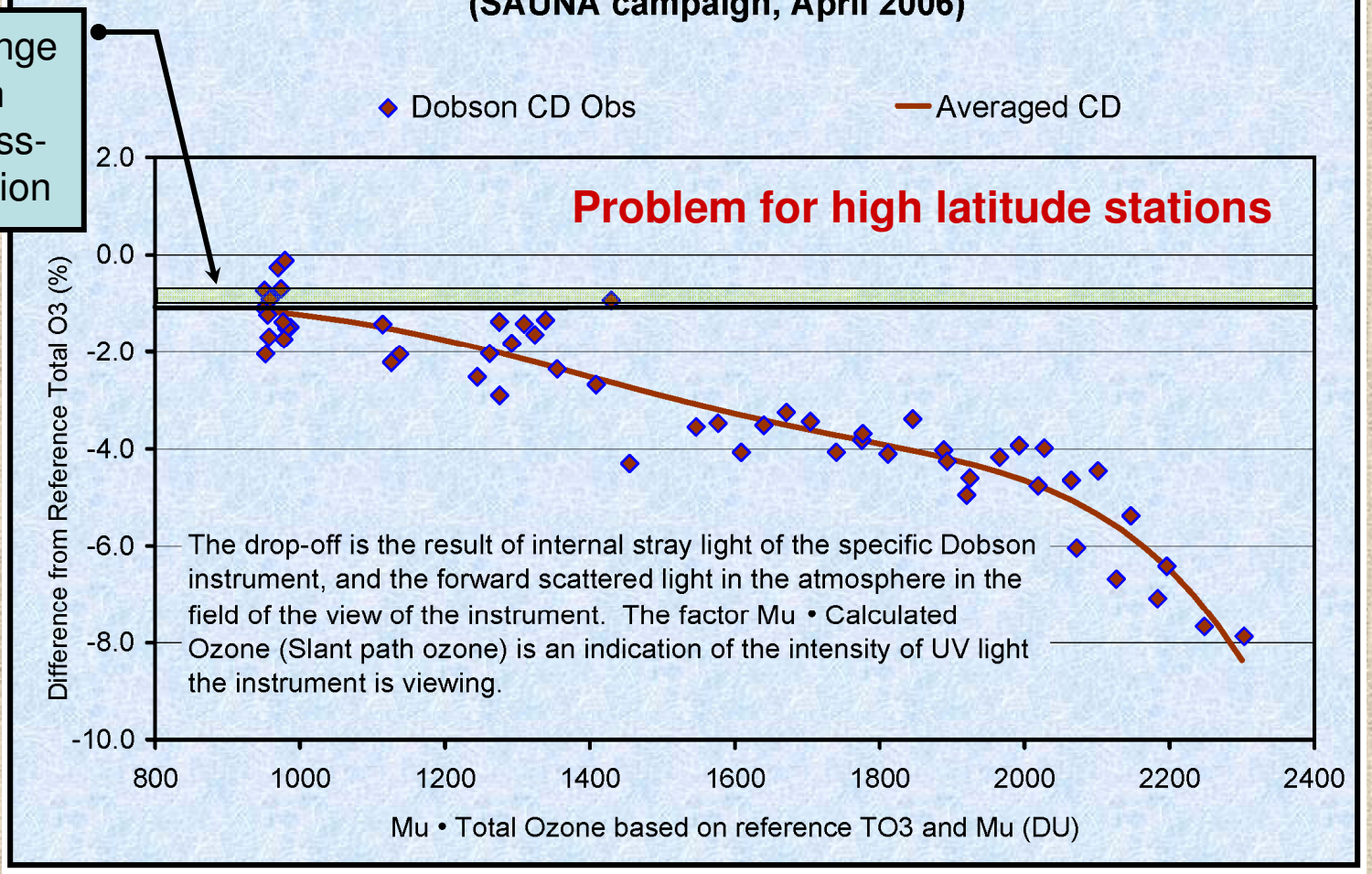
Comparison with other instruments will still show differences, as the cross-section is only part of this issue.

- The cross-sections are still defined for a single, specific set of atmospheric conditions. The accuracy varies by station latitude and season.
- The instrument limitations remain the same.
- The specific place and time of measurements determines from where the information used by the instrument comes. (field of view)


Modeled Difference between AD TO3 calculated using cross-sections based on a reference temperature and ozone profile, and the cross-sections calculated from expected temperature and ozone profiles at various latitudes and seasons.
15N Lat (~MLO)
30N Lat
45 N
60N
75N
Range of error (Min_Max)
4.0%
3.0%
2.0%
1.0%
0.0%
-1.0%
-2.0%
-3.0%
-4.0%
Mu=2, but there is little difference at other Mu
Summer
Winter
Change in Cross-section
C. L. Mateer's Table 2 (1990), as percent error in calculated ozone
Winter, -75C Stratosphere
0
10
20
30
40
50
60
70
80
90
North Latitude

Example of the Drop-off in Calculated Ozone from Dobson Measurements Against a Reference Formed from Calculated Ozone from Double-monochrometer Brewers (SAUNA campaign, April 2006)

Change in Cross-section



Bottom Line

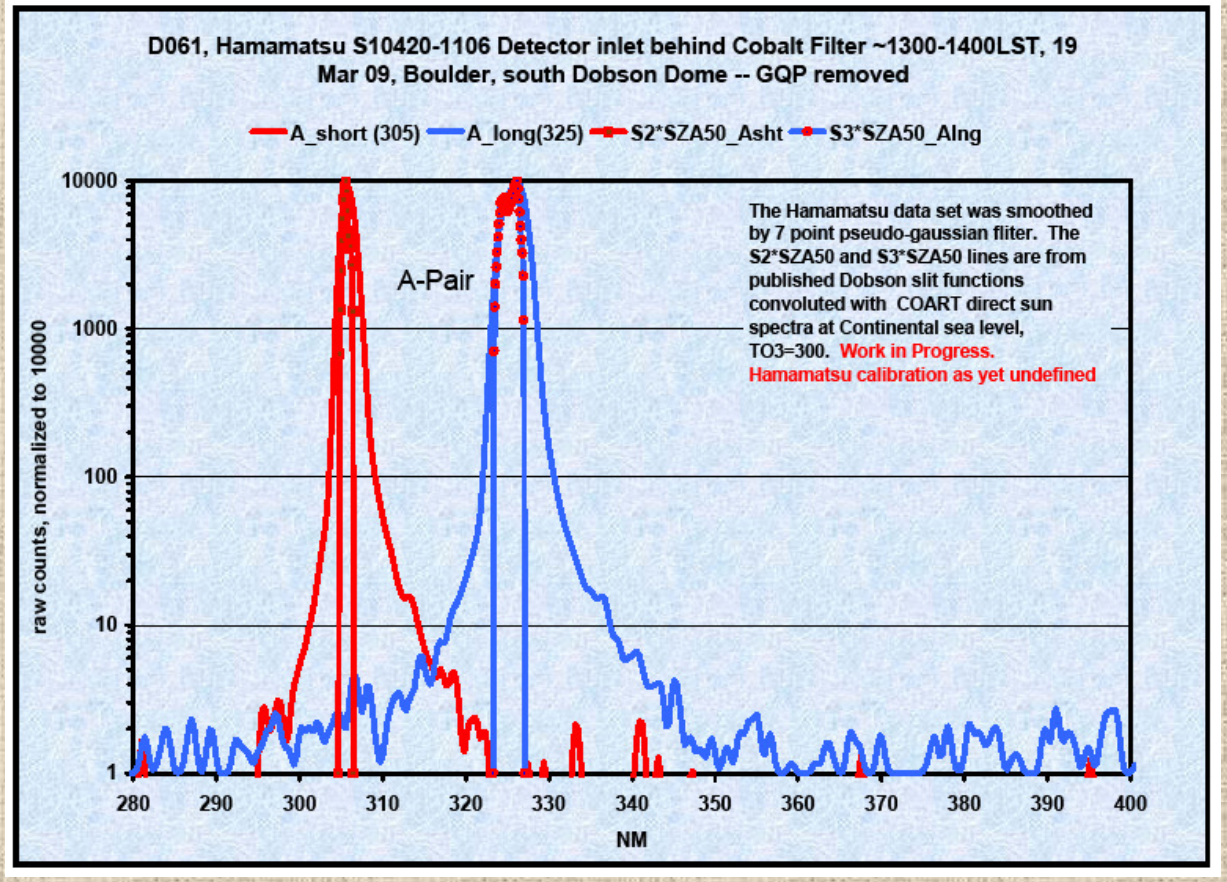
Bass-Paur versus Daumont-Malicet-Brion (DMB) cross-sections for the Dobson instruments is a minor issue.

Define existing PB cross-sections as being the same as the DMB scale.

More benefit from:

- Including the temperature dependence of cross-sections in calculation of ozone from the Dobson instrument measurements. (Need an evaluation scheme for the existing data record.)
- Characterizing the internal stray light of the Dobson instrument, and also incorporating that information into the calculation.

With NASA assistance, a method of reading the actual spectra within the photomultiplier box of the Dobson instrument is being developed. This will allow evaluation of the correct slit functions and internal stray light level for individual instruments.



Thank you for your attention.

Special Thanks to:

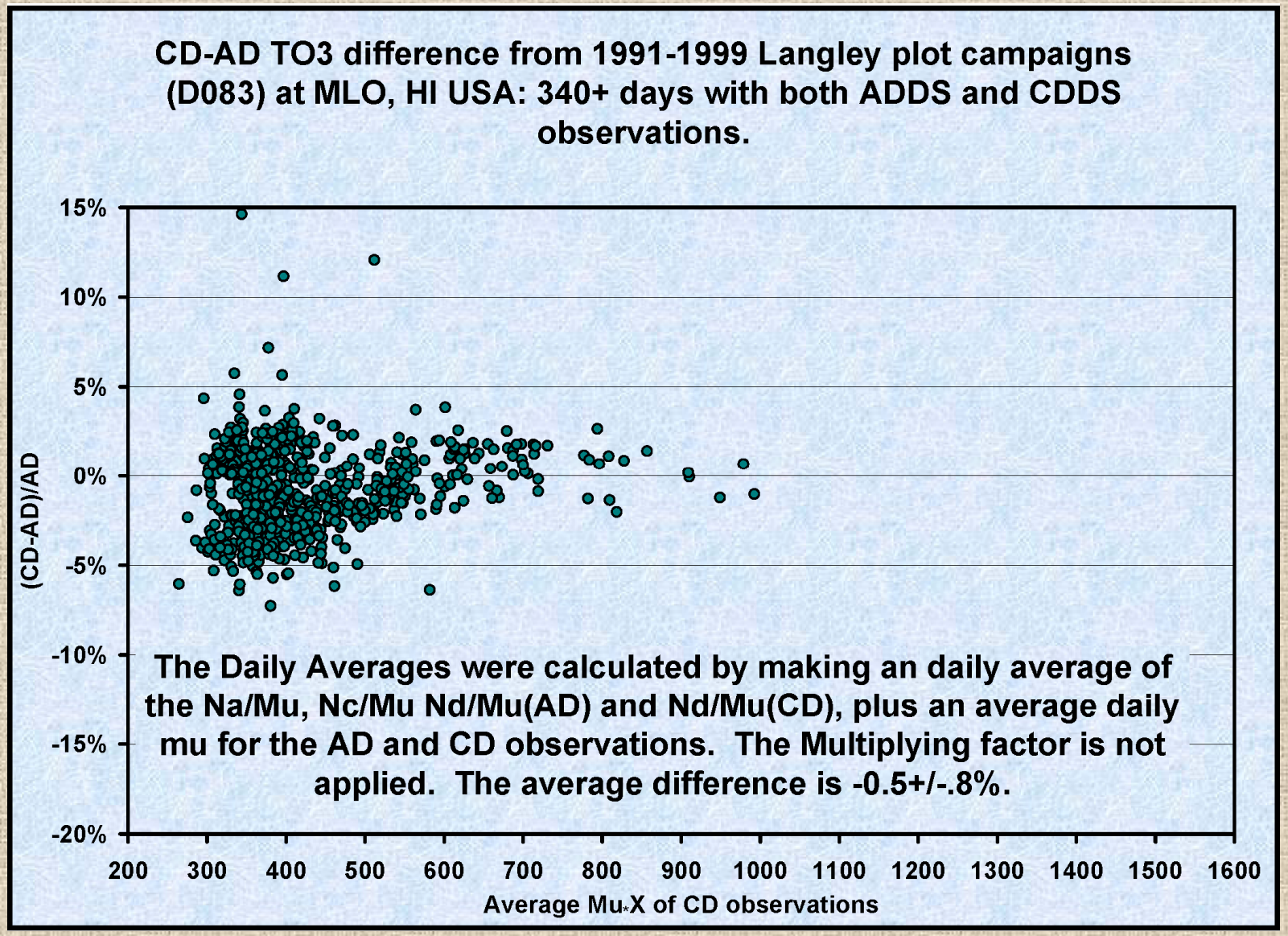
Germar Bernhard

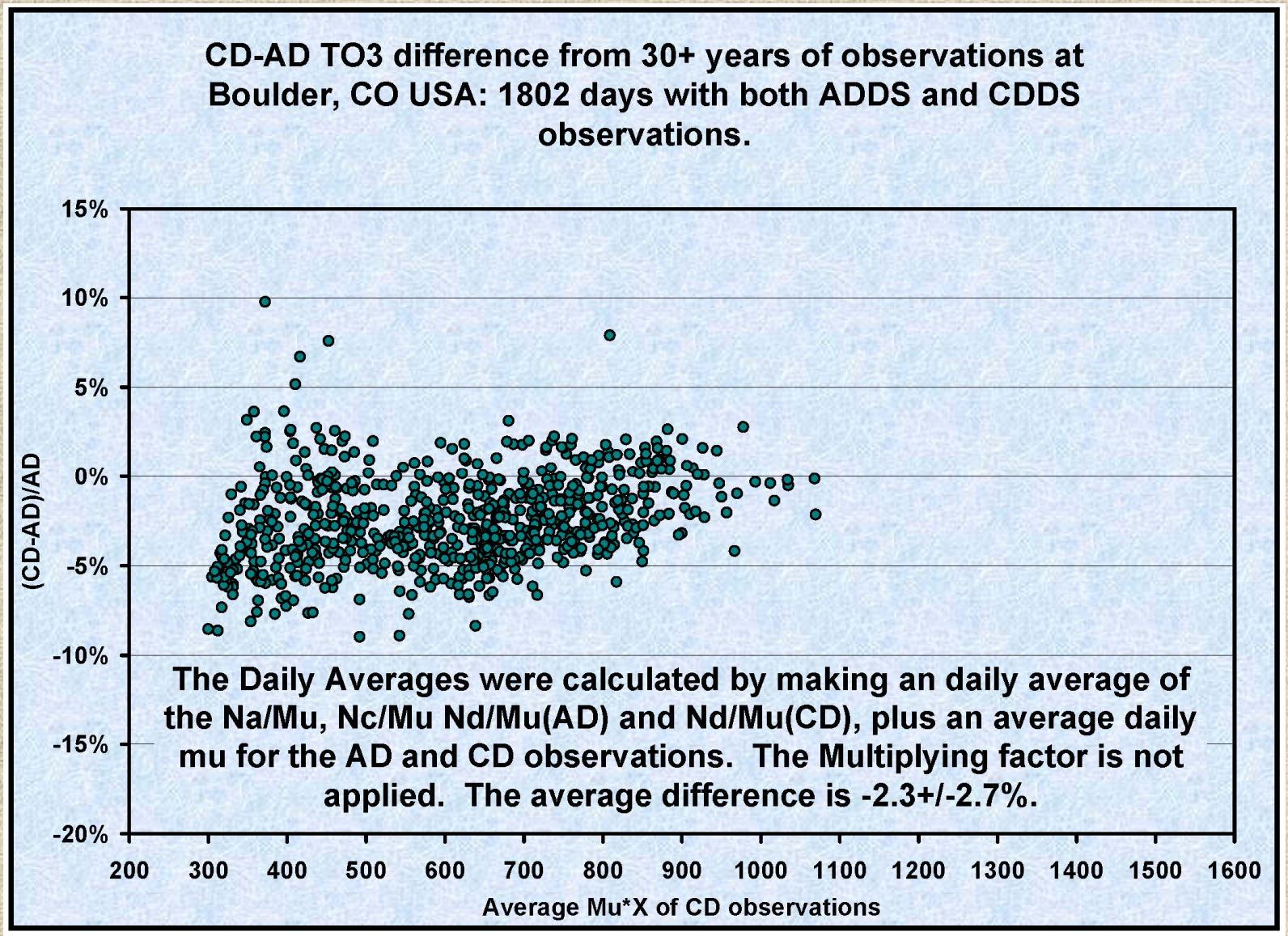
Gordon Labow

Rich McPeters

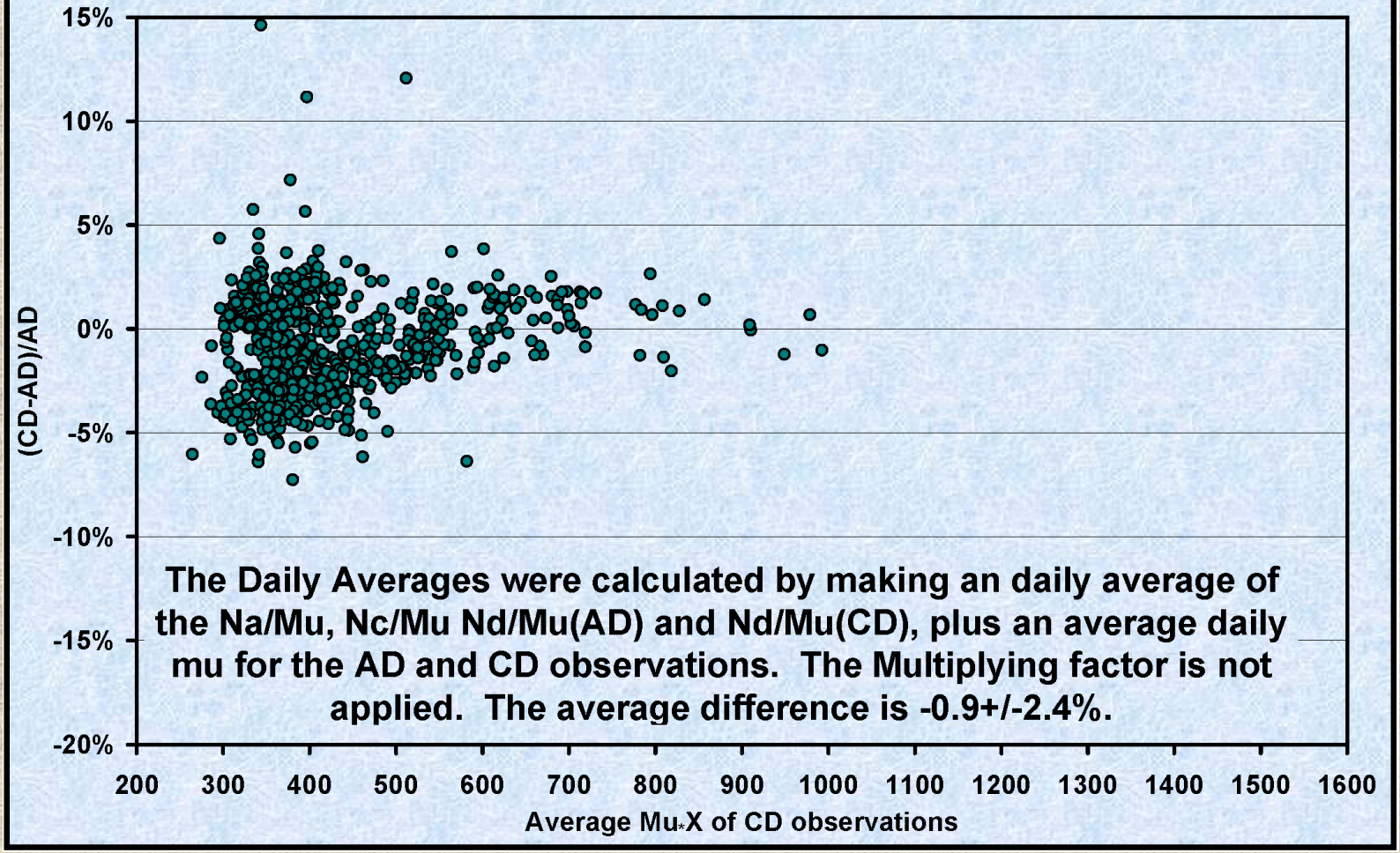
Koji Miyagawa

Supplemental Slides

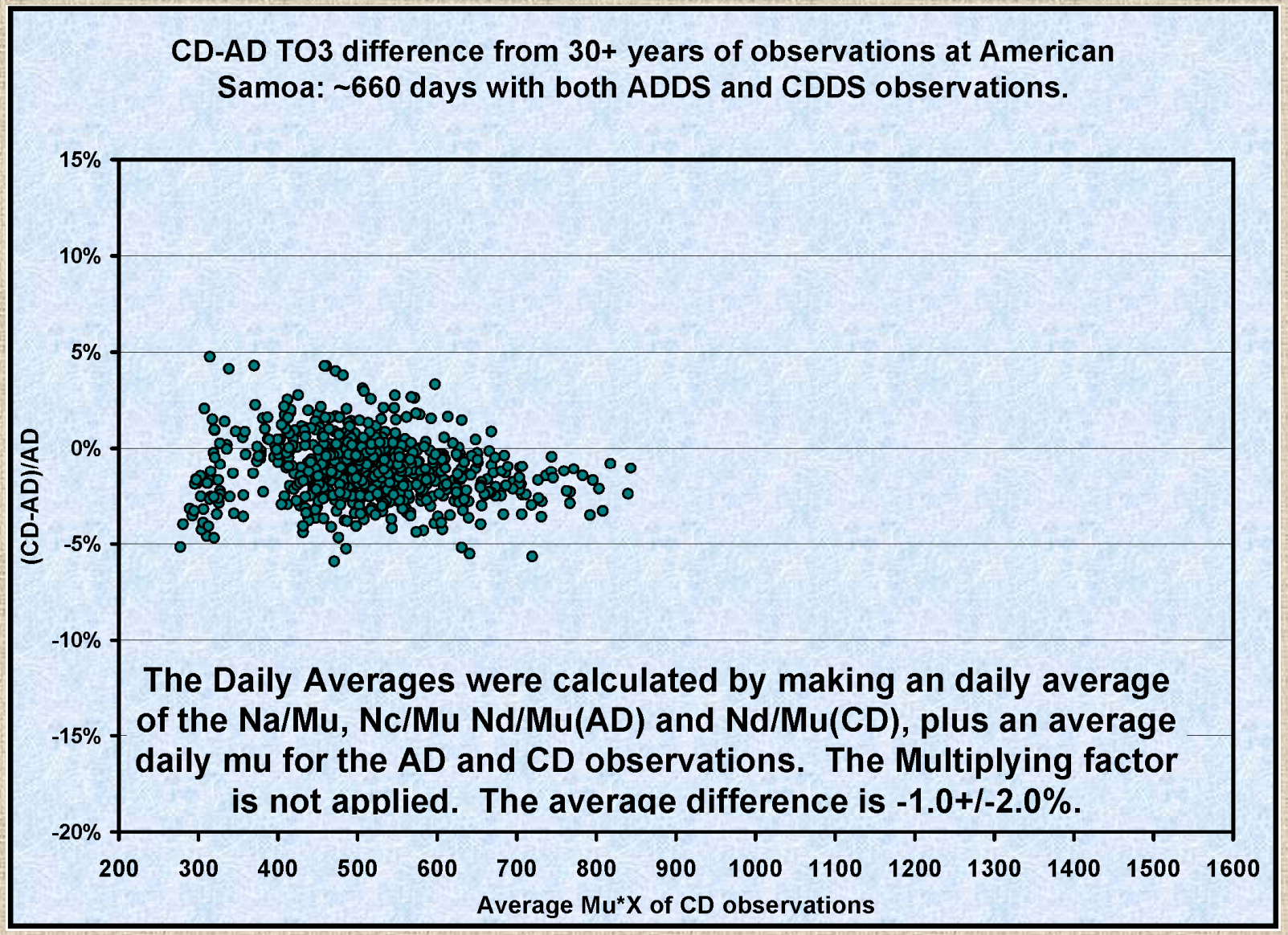

CD-AD TO3 difference from 1991-1999 Langley plot campaigns (D083) at MLO, HI USA: 340+ days with both ADDS and CDDS observations.
15%
10%
5%
0%
-5%
-10%
-15%
-20%
(CD-AD)/AD
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
Average Mu*X of CD observations
The Daily Averages were calculated by making an daily average of the Na/Mu, Nc/Mu Nd/Mu(AD) and Nd/Mu(CD), plus an average daily mu for the AD and CD observations. The Multiplying factor is not applied. The average difference is -0.5+/-.8%.

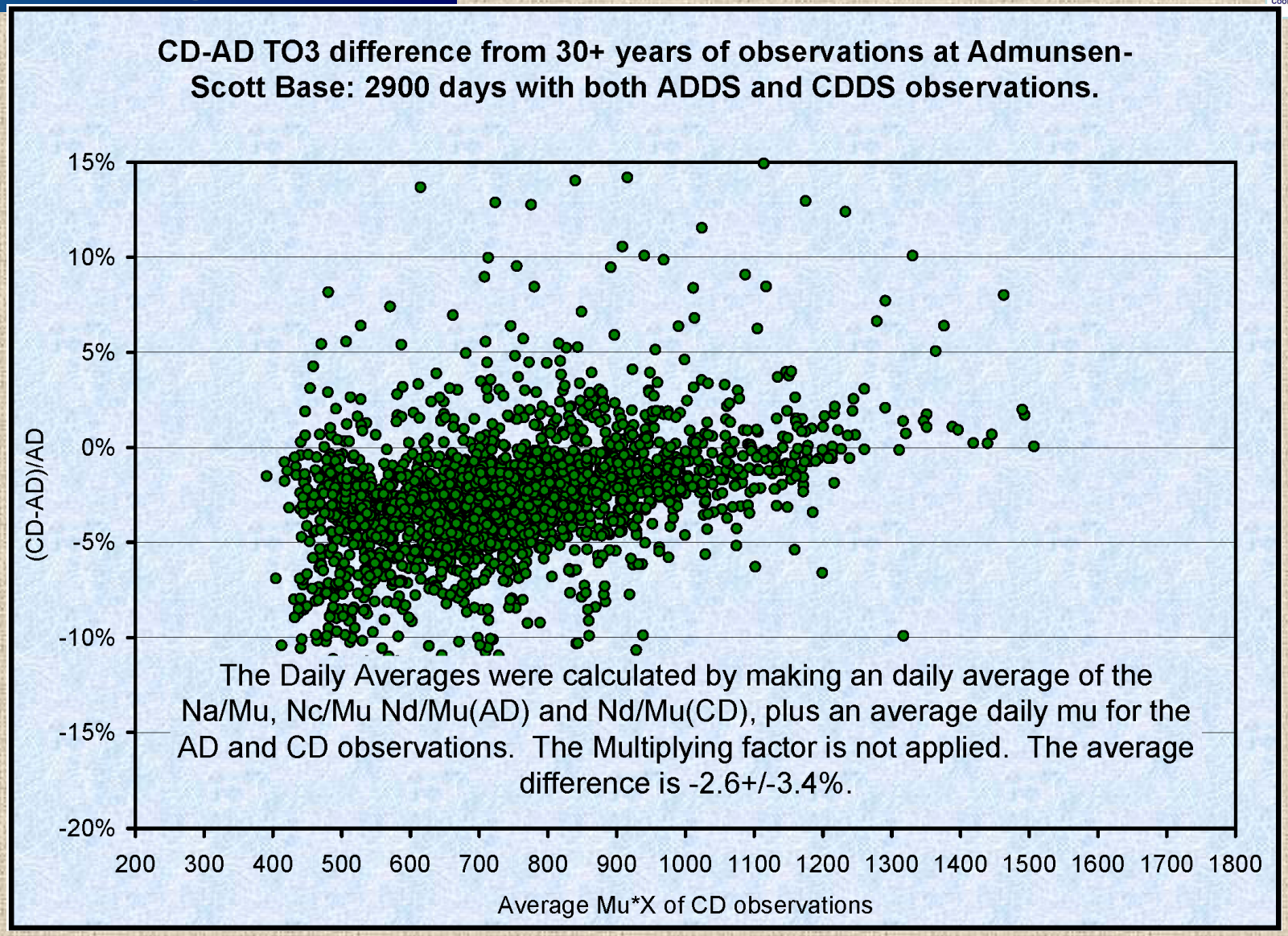

CD-AD TO3 difference from 30+ years of observations at Boulder, CO USA: 1802 days with both ADDS and CDDS observations.
15%
10%
5%
0%
-5%
-10%
-15%
-20%
(CD-AD)/AD
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
Average Mu*X of CD observations
The Daily Averages were calculated by making an daily average of the Na/Mu, Nc/Mu Nd/Mu(AD) and Nd/Mu(CD), plus an average daily mu for the AD and CD observations. The Multiplying factor is not applied. The average difference is -2.3+/-2.7%.

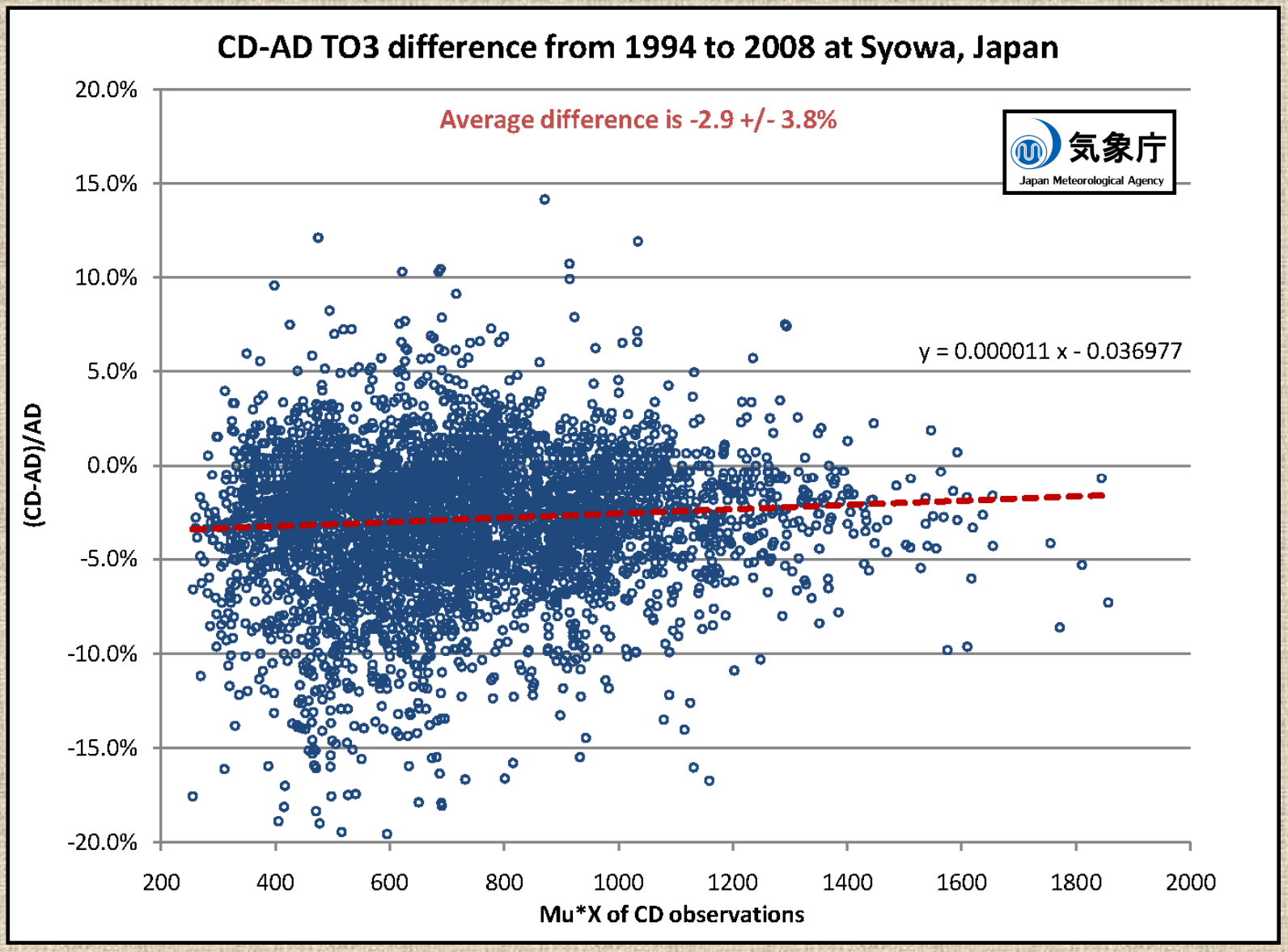
CD-AD TO3 difference from 30+ years at MLO, HI USA: 700+ days with both ADDS and CDDS observations.

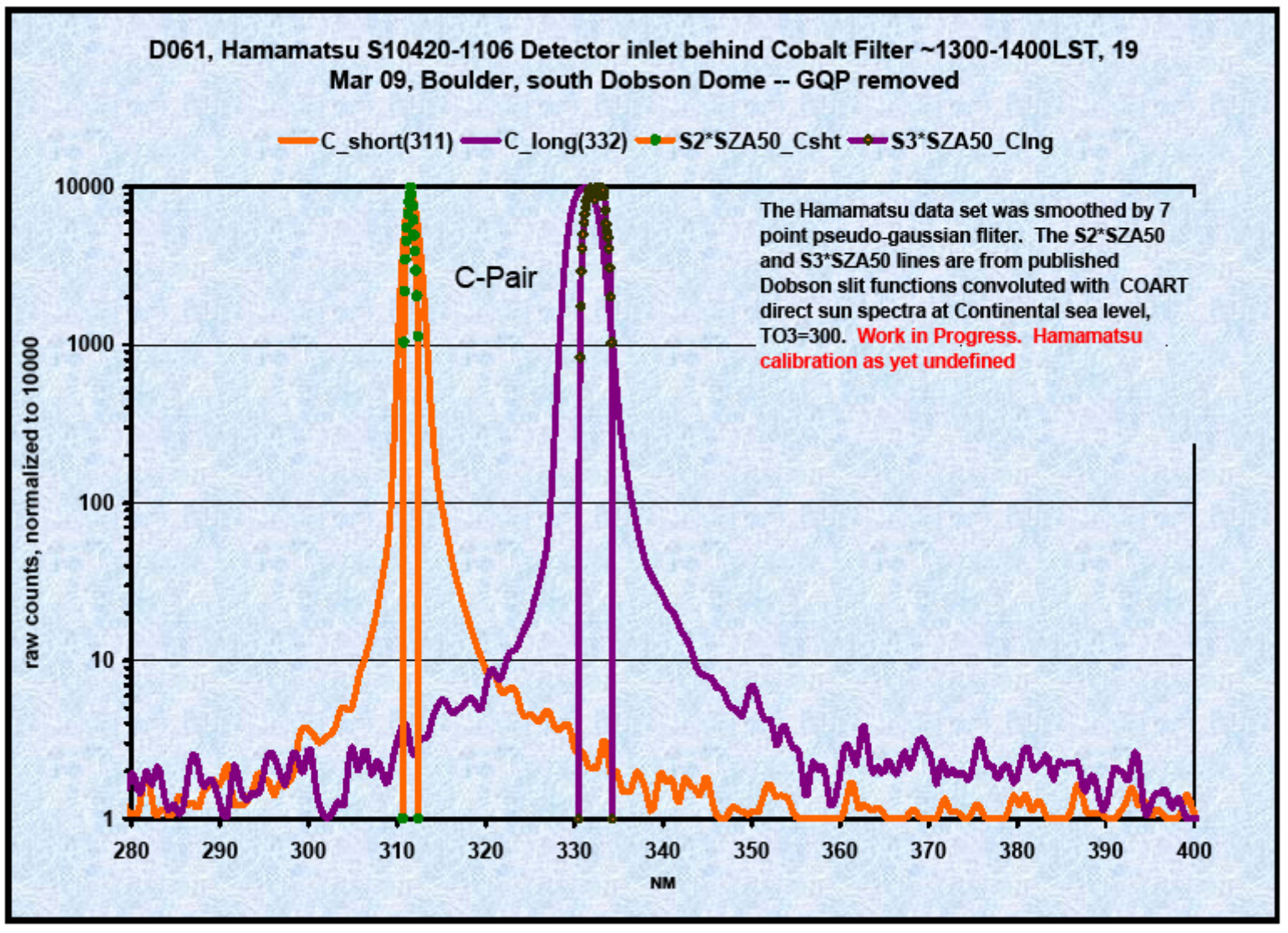


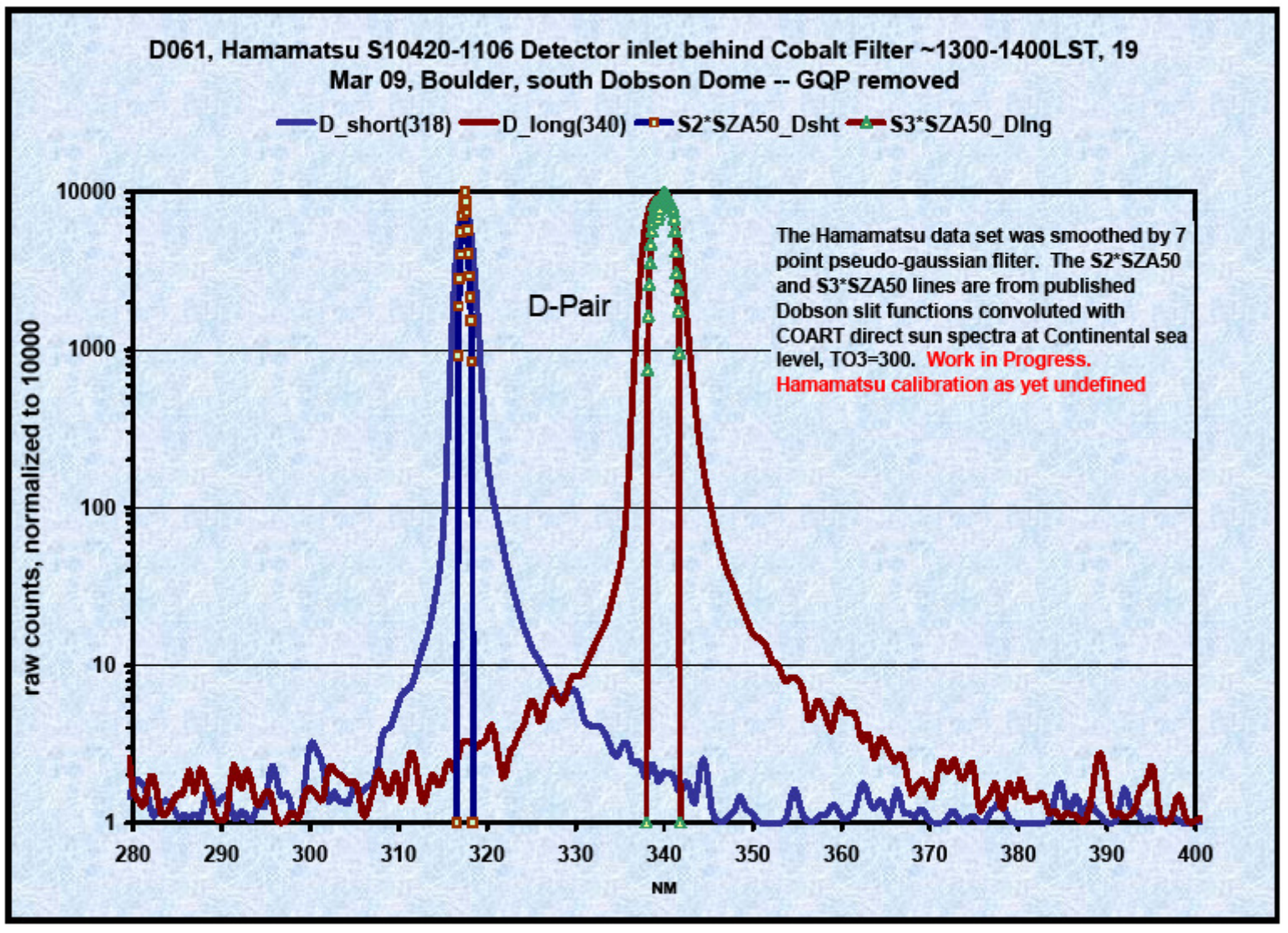
The Daily Averages were calculated by making an daily average of the Na/Mu, Nc/Mu Nd/Mu(AD) and Nd/Mu(CD), plus an average daily mu for the AD and CD observations. The Multiplying factor is not applied. The average difference is -0.9+/-2.4%.


CD-AD TO3 difference from 30+ years of observations at American Samoa: ~660 days with both ADDS and CDDS observations.
15%
10%
5%
0%
-5%
-10%
-15%
-20%
(CD-AD)/AD
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
Average Mu*X of CD observations
The Daily Averages were calculated by making an daily average of the Na/Mu, Nc/Mu Nd/Mu(AD) and Nd/Mu(CD), plus an average daily mu for the AD and CD observations. The Multiplying factor is not applied. The average difference is -1.0+/-2.0%.


CD-AD TO3 difference from 30+ years of observations at Admunsen-Scott Base: 2900 days with both ADDS and CDDS observations.
15%
10%
5%
0%
-5%
-10%
-15%
-20%
(CD-AD)/AD
200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800
Average Mu*X of CD observations
The Daily Averages were calculated by making an daily average of the Na/Mu, Nc/Mu Nd/Mu(AD) and Nd/Mu(CD), plus an average daily mu for the AD and CD observations. The Multiplying factor is not applied. The average difference is -2.6+/-3.4%.


CD-AD TO3 difference from 1994 to 2008 at Syowa, Japan
Average difference is -2.9 +/- 3.8%
気象庁
Japan Meteorological Agency
y = 0.000011 x - 0.036977
(CD-AD)/AD
20.0%
15.0%
10.0%
5.0%
0.0%
-5.0%
-10.0%
-15.0%
-20.0%
200
400
600
800
1000
1200
1400
1600
1800
2000
Mu*X of CD observations


D061, Hamamatsu S10420-1106 Detector inlet behind Cobalt Filter ~1300-1400LST, 19 Mar 09, Boulder, south Dobson Dome -- GQP removed
C_short(311)
C_long(332)
S2*SZA50_Csht
S3*SZA50_Clng
C-Pair
The Hamamatsu data set was smoothed by 7 point pseudo-gaussian fliter. The S2*SZA50 and S3*SZA50 lines are from published Dobson slit functions convoluted with COART direct sun spectra at Continental sea level, TO3=300. Work in Progress. Hamamatsu calibration as yet undefined
raw counts, normalized to 10000
10000
1000
100
10
1
280
290
300
310
320
330
340
350
360
370
380
390
400
NM


D061, Hamamatsu S10420-1106 Detector inlet behind Cobalt Filter ~1300-1400LST, 19 Mar 09, Boulder, south Dobson Dome -- GQP removed
D_short(318)
D_long(340)
S2*SZA50_Dsht
S3*SZA50_Dlng
raw counts, normalized to 10000
10000
1000
100
10
1
D-Pair
The Hamamatsu data set was smoothed by 7 point pseudo-gaussian fliter. The S2*SZA50 and S3*SZA50 lines are from published Dobson slit functions convoluted with COART direct sun spectra at Continental sea level, TO3=300. Work in Progress.
Hamamatsu calibration as yet undefined
280
290
300
310
320
330
340
350
360
370
380
390
400
NM

AD-CD Difference is Approximately -2.5%

- Instrument dependent: (example: D065 has ~1% lower CD results than D083 in intercomparisons.)
- Station dependent
  - D083 has higher CD results at MLO versus Boulder.
  - D083 AD-CD difference at MLO is -0.1%±0.8 for long term average
- Some long term time dependence.
- Can reflect the AD Mu dependence of a specific instrument.

There is a difference in the total ozone calculated from the AD and CD direct sun observations

- Attributed to the uncertainty in cross-sections, and handled by a procedure to normalize the CD results to the AD level – which seems to work well.
- CD observations are not made at many stations where the sun is high enough for ADDS measurements year round.
- Normalization factor evaluated for calibration periods (The long term change has not been investigated by NOAA)
- As the intercomparison scheme is based on the Nad difference, Ncd differences are not considered in the determination of the calibration change.
- There is some interesting information in the differences.