

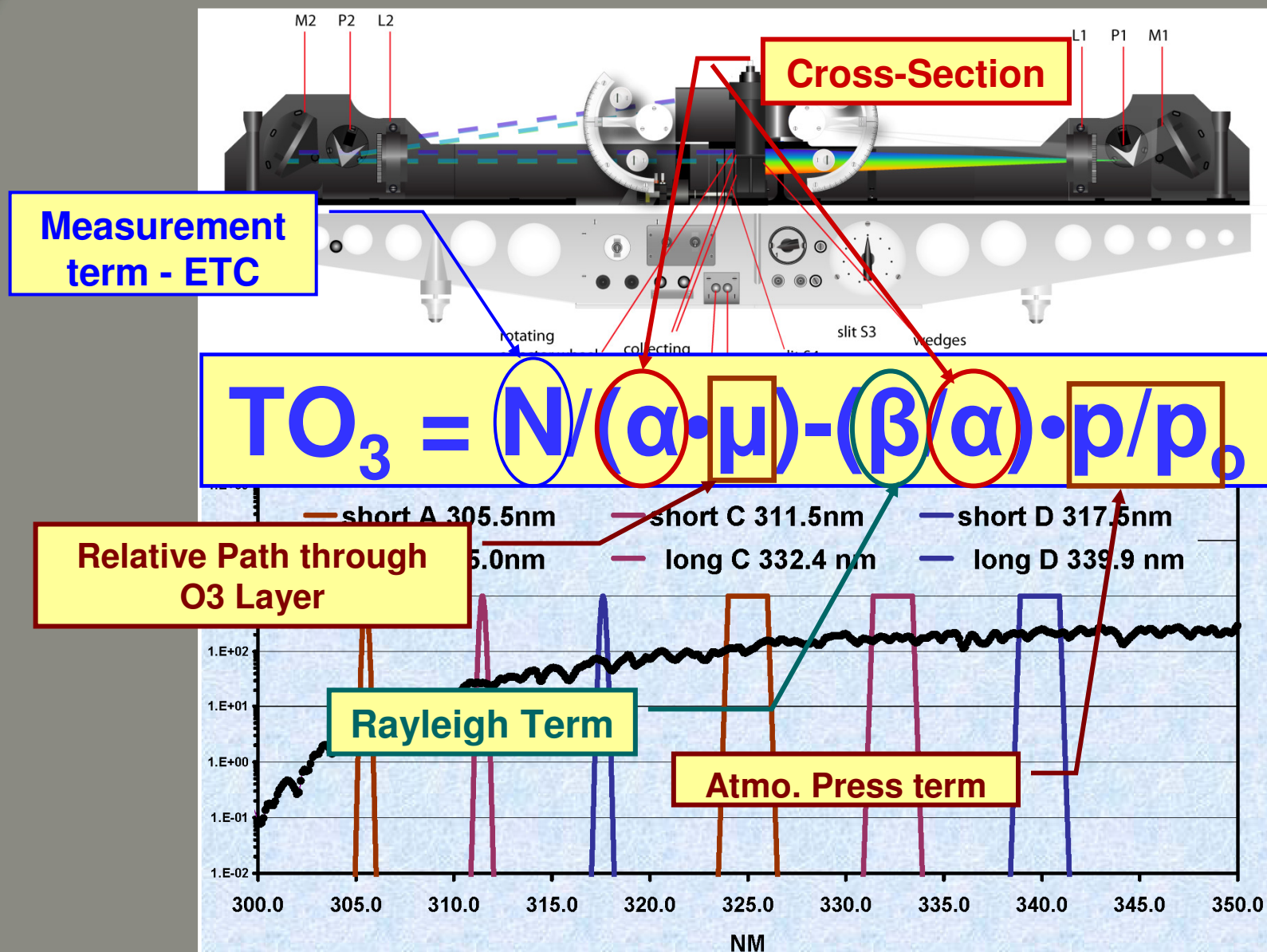
Effect of a Proposed Change of Ozone Cross-sections on the Historical Record of Stratospheric Ozone at Selected Stations using Dobson Ozone Spectrophotometers in the US Network

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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

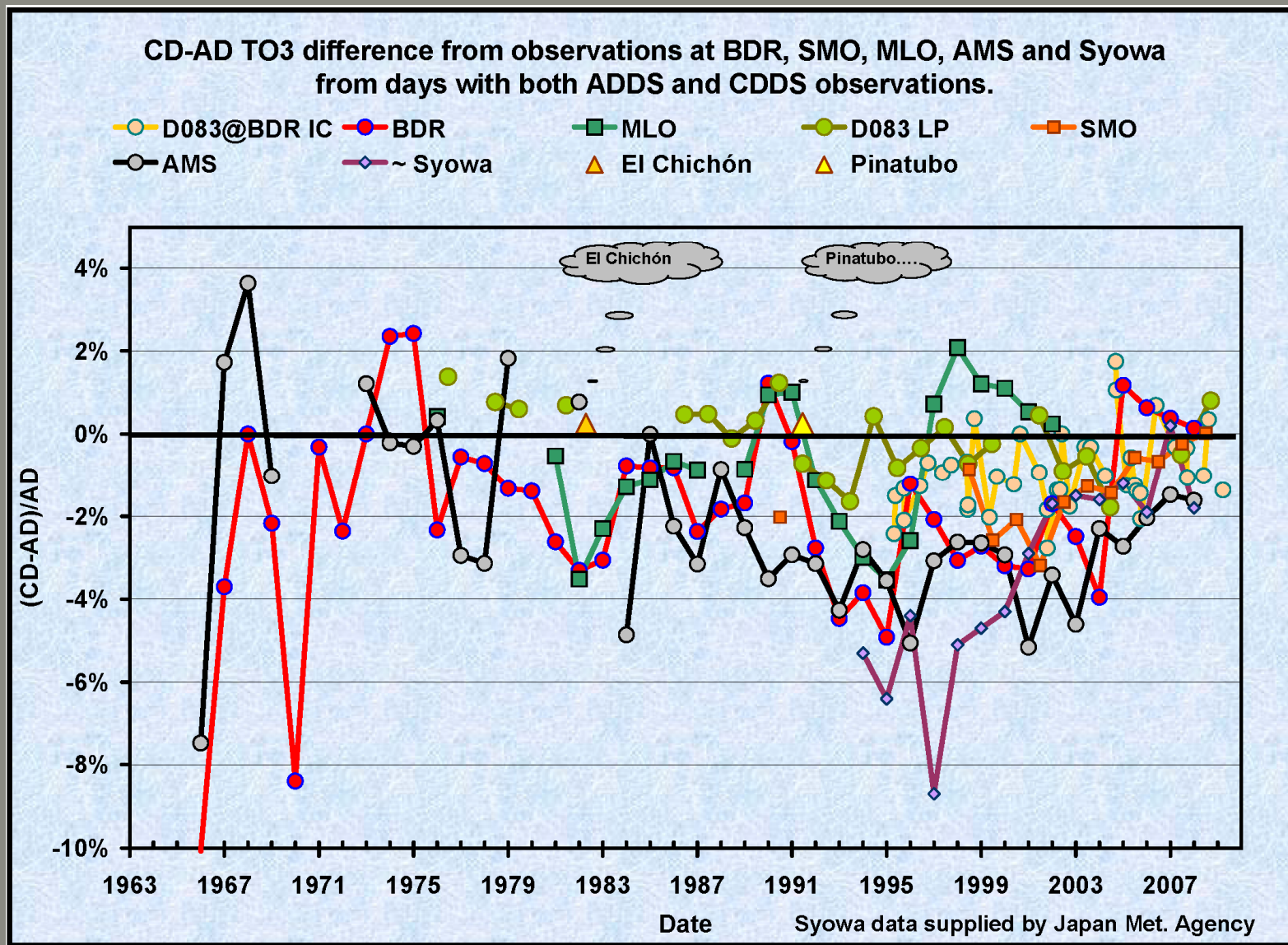
90S, 2810 mmsl (AMS)

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.



DMB Cross-sections

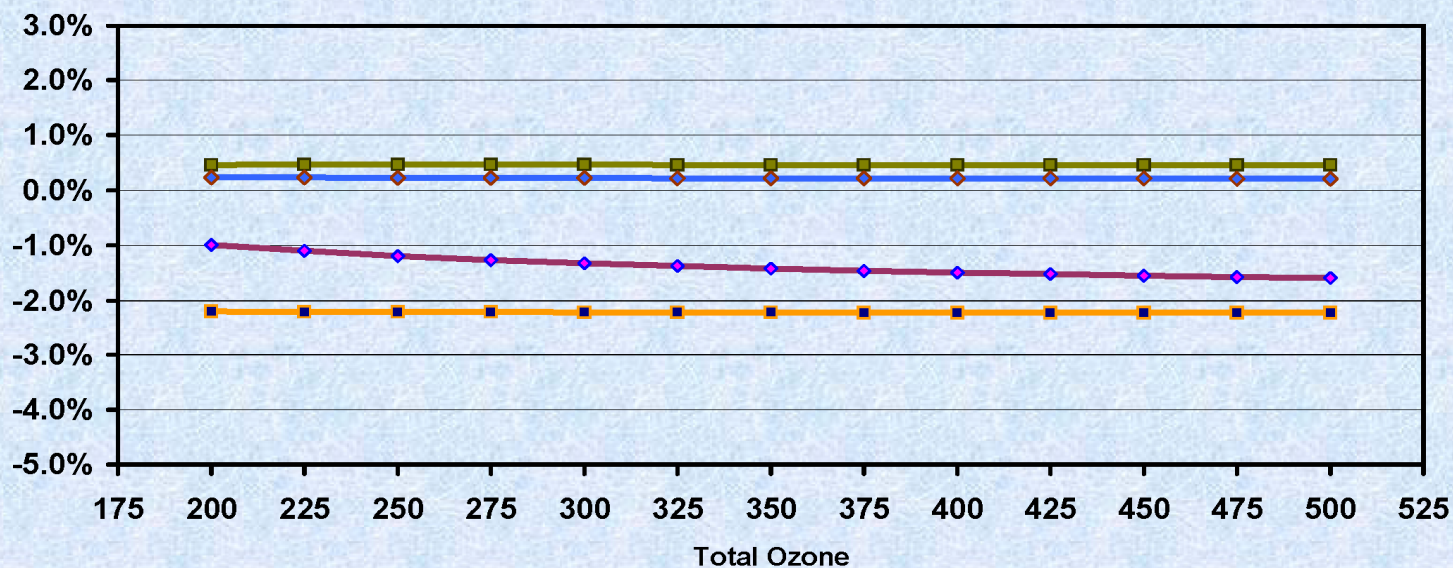
There are several determinations of Dobson cross-sections derived from Daumont-Maliget-Brion (DMB) Laboratory measurements by:

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

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

- GL DMB AD level change 0.5%
- GB DMB AD level change 0.2%
- GL DMB New AD-CD Diff: -2.2%
- GB DMB New AD-CD Diff: -1.4%

Reference Nad-values were determined that would produce ozone values of 200-500 DU when used with the official BP1992 cross-sections. These N-values were used to calculate ozone with the different X-sections and Rayleigh scattering values from various sources. The effect of internal stray light was not included. A similar procedure was done with modeled CD results, considering a historic -2.5% AD-CD Difference with BP1992 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 on the Rayleigh term.
- The scheme of transferring the calibration to the network is independent of the cross-sections

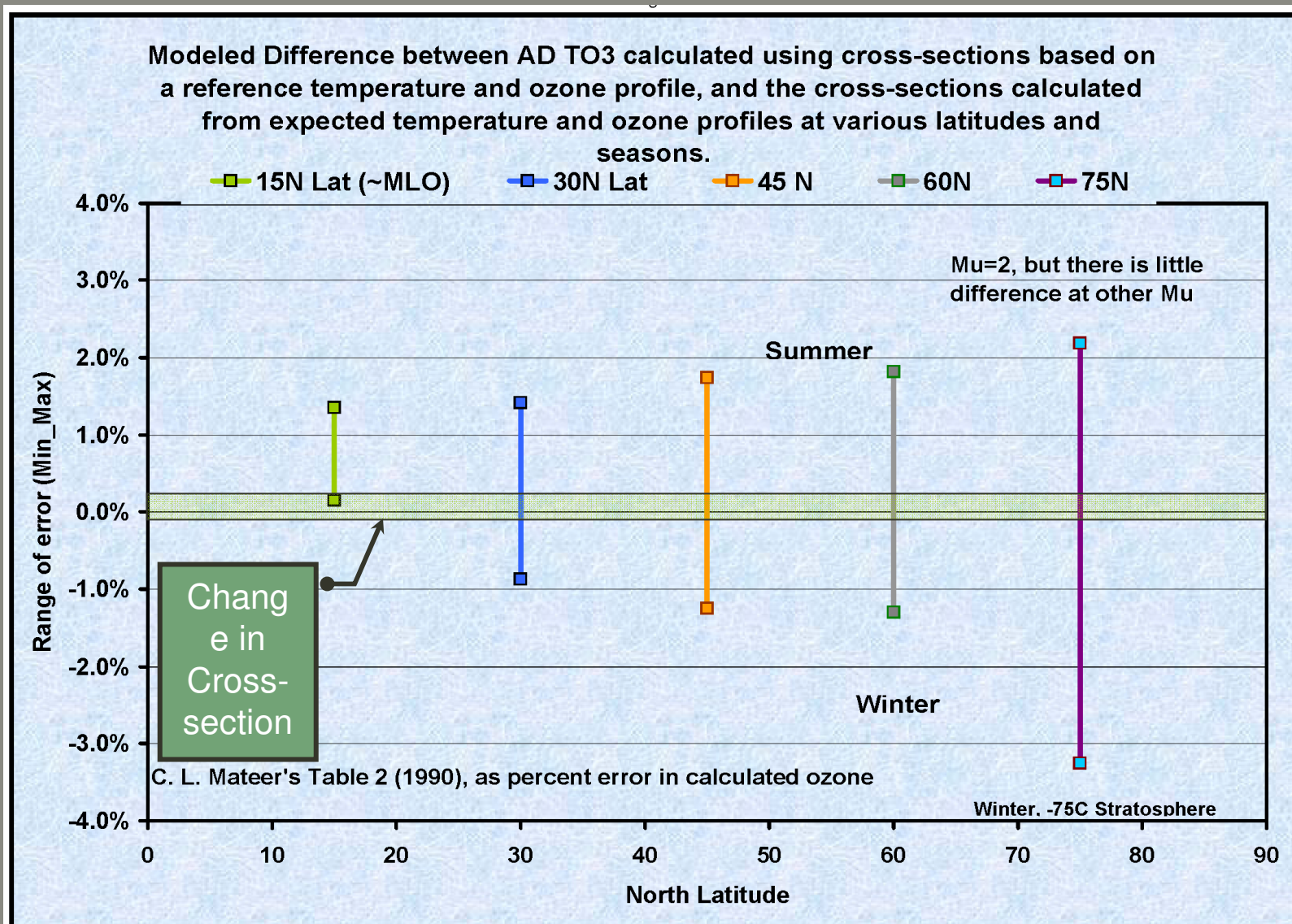
Improvement?

- 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 $\pm 1\%$, clear tropical conditions to $\pm 5\%$ at high latitudes, before considering other instrument limitations.

What problems are still with us?

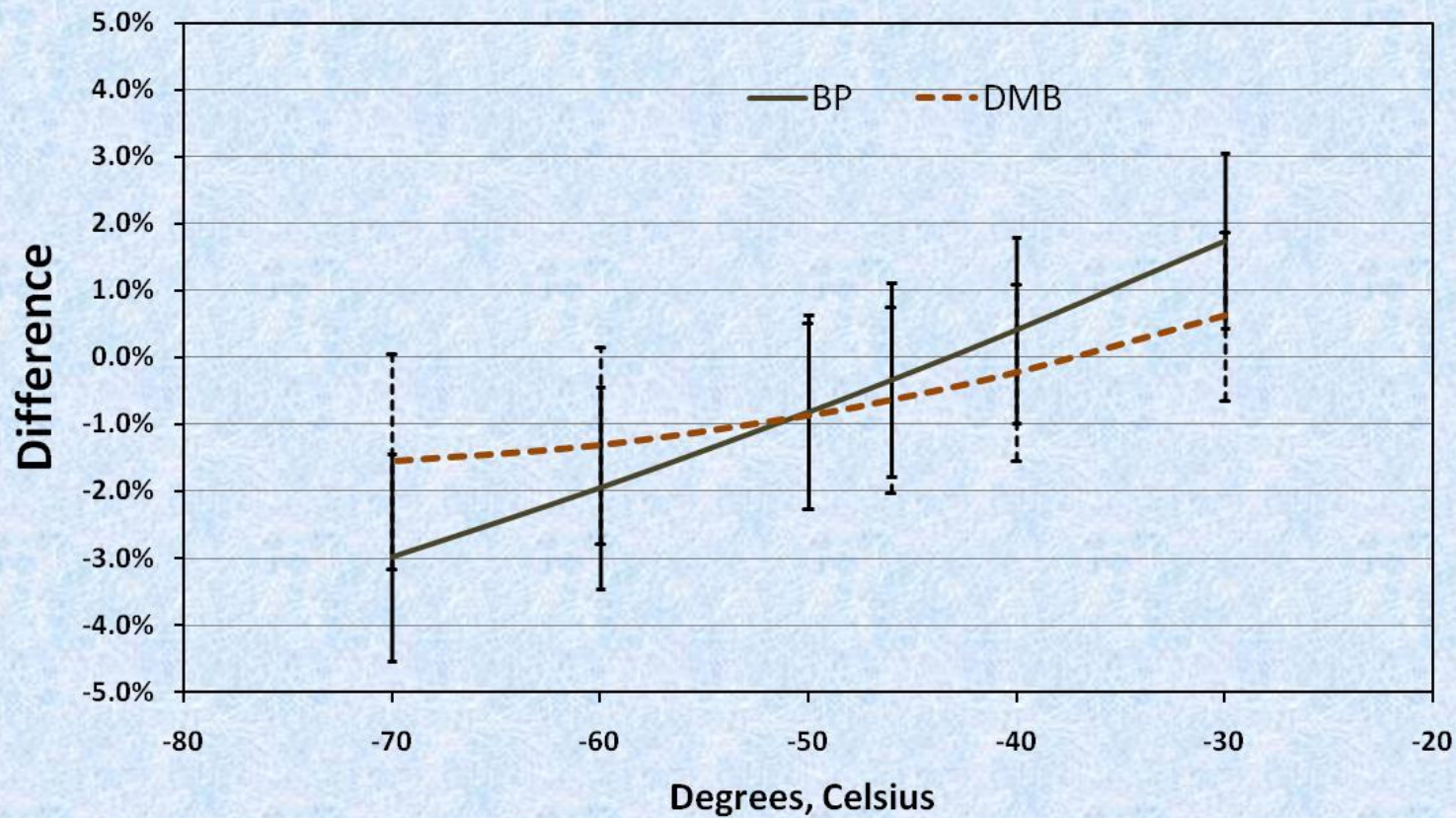
Comparison with other instruments will still show differences, as the cross-section is only part of this issue.

- 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)



There is a difference in the temperature response between the two sets.

The percent difference between the calculated ozone using a fixed temperature and using true ozone weighted temperature, DMB and BP compared



Using the 20hp temperature as a proxy for the ozone weighted temperature.

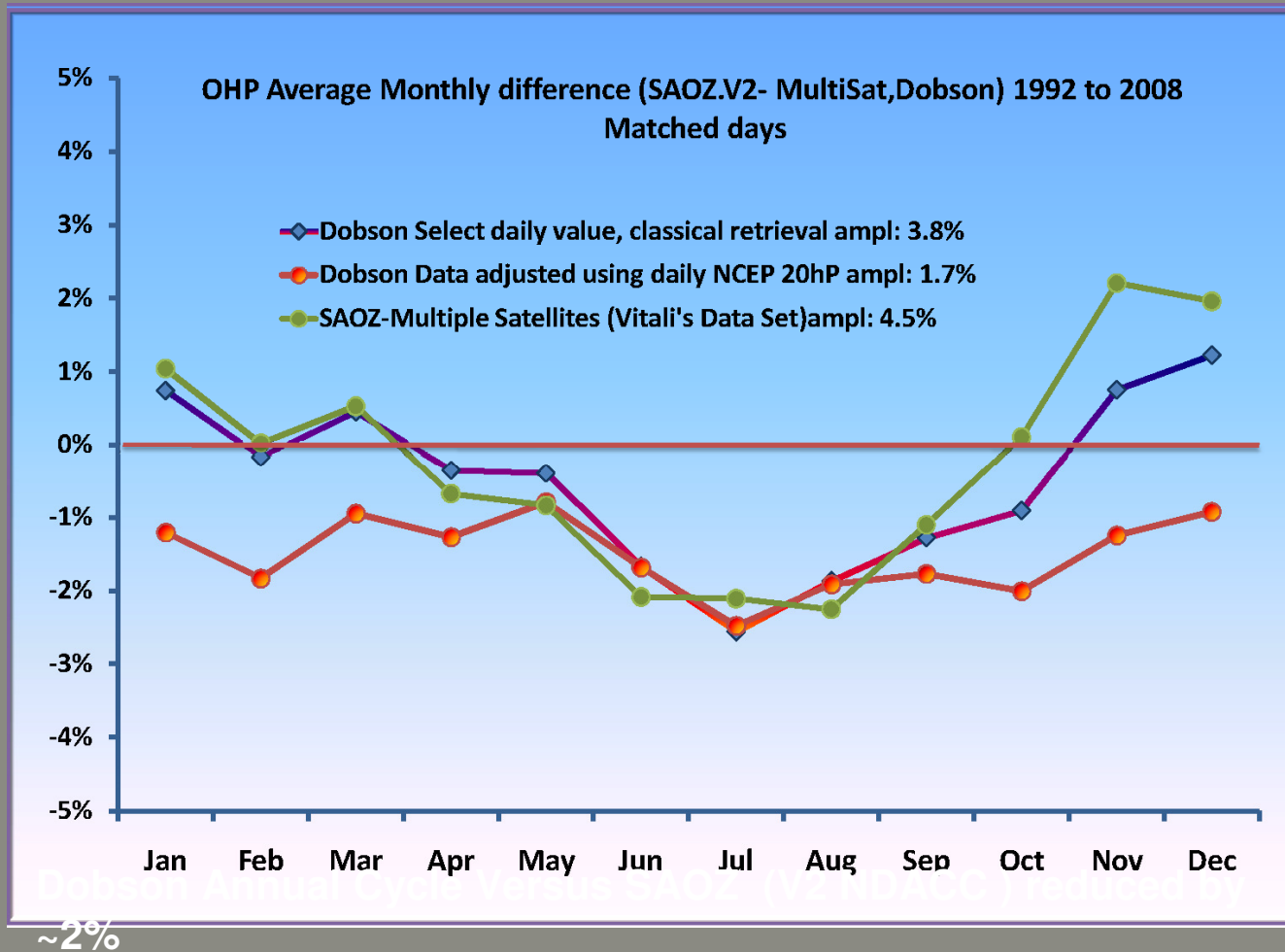
- Dobson data set from the WOUDC archive includes all observation types.
- Simple adjustment based on the temperature difference from -46.3C.
- Note that investigation is still required to relate the 20hP temperature to ozone weighted temperature.
- There are seasonal variations in ozone layer height not yet considered.

North mid-latitude station l' Observatoire de Haute Provence

- Co-located SAOZ instrument (Ozone results from this type of instrument are not considered to be dependent on the stratospheric temperature.)
<http://www.aerov.jussieu.fr/~fgoutail/SAOZ-consol.html>
- Has a record of Ozone-sonde flights to evaluate scheme of NCEP adjusted record (not yet used in this study.)



Saoz, satellites, Dobson

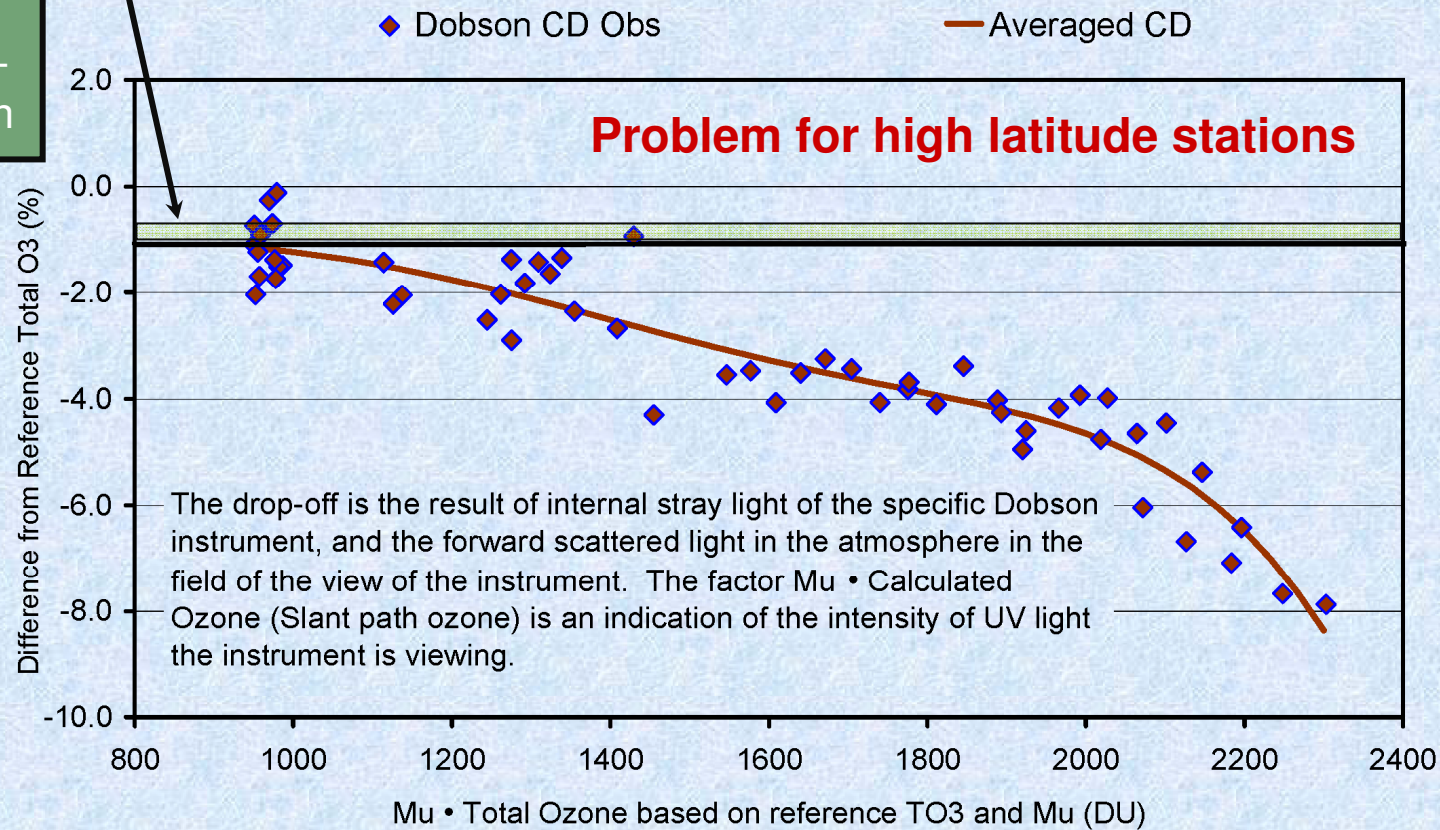


NCEP-based Reprocessing has promise.

- Still needs more study. The next station we study will be Lauder, New Zealand.
- Has assumptions:
 - the ozone values from zenith observations are tied to the ADDS results. The zenith observations are looking through the same atmosphere, and thus have the same dependence to stratospheric temperature.
 - The temperature changes are more important than the peak altitude changes.
- Allows re-analysis of existing Dobson ozone sets without resorting to using the original data (N-values, observation time, etc).
- **But! does not address internal scattered light effect (lower values at low sun and high ozone).**

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

Change in Cross-section



Bottom Line

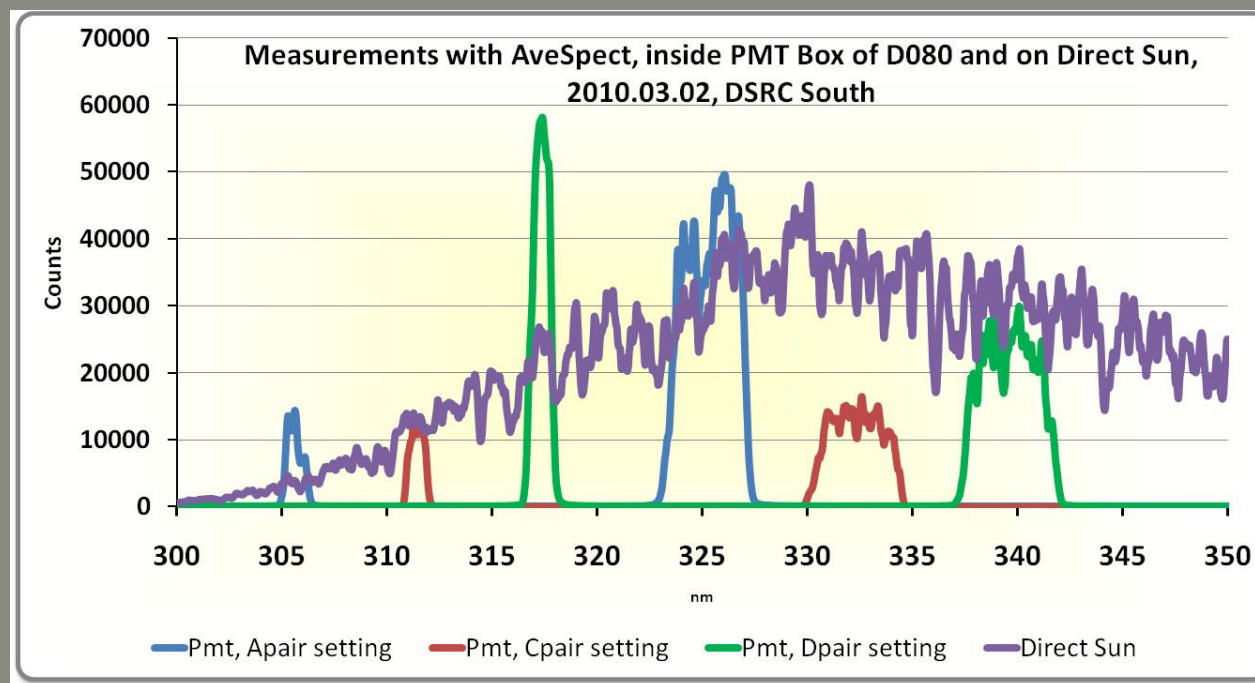
Bass-Paur versus Daumont-Malicet-Brion (DMB) cross-sections for the Dobson instruments is a minor issue.

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.

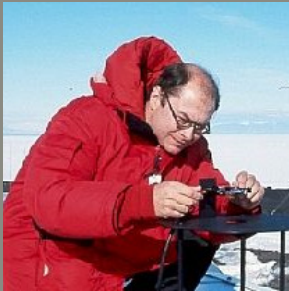
With NASA assistance, a method of reading the actual spectra within the photomultiplier box of the Dobson instrument is being developed. This will allow evaluation of the correct slit functions and internal stray light level for individual instruments.



Thank you for your attention.

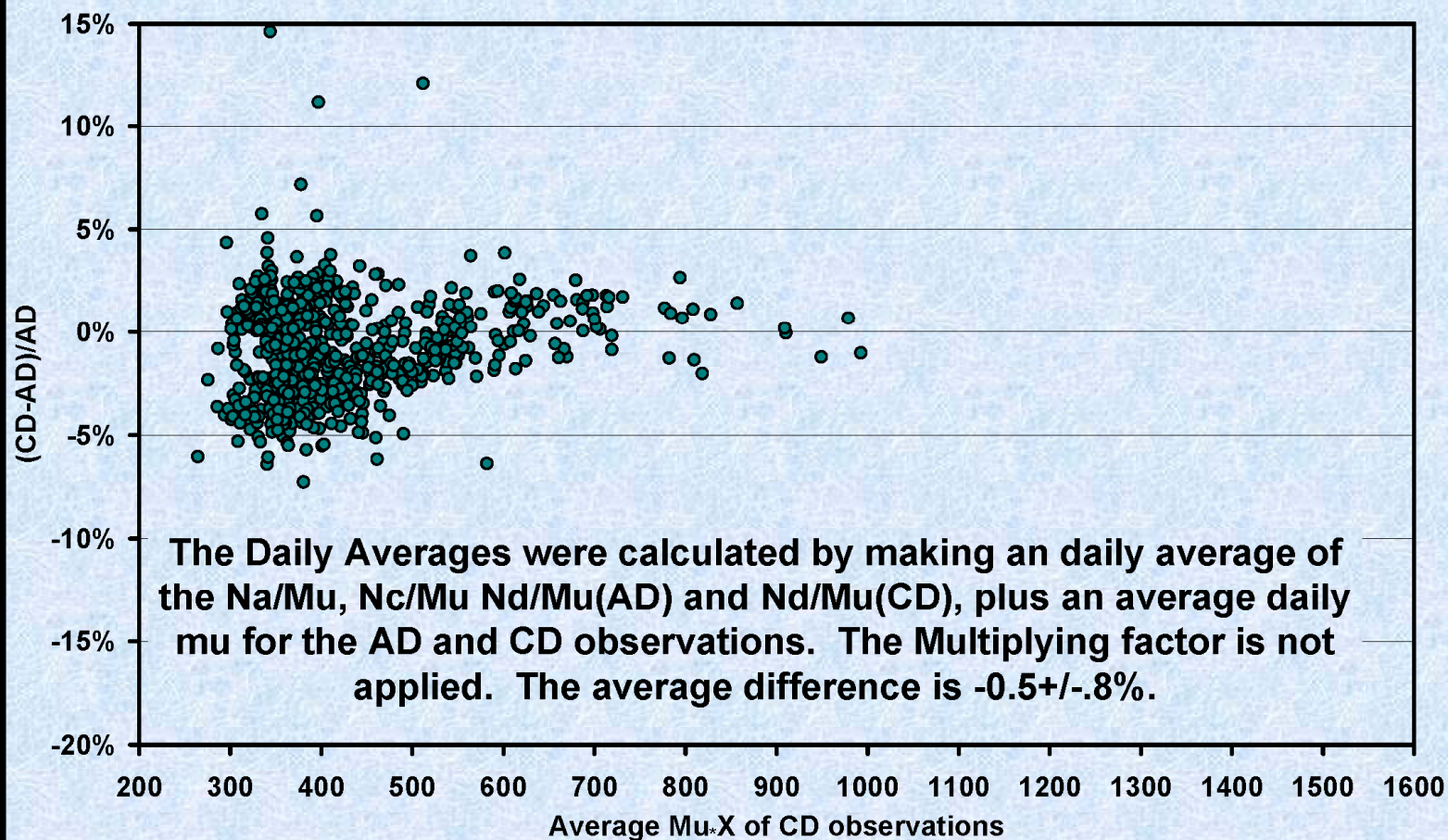
Special Thanks to:

Germar Bernhard
Gordon Labow
Rich McPeters
Koji Miyagawa

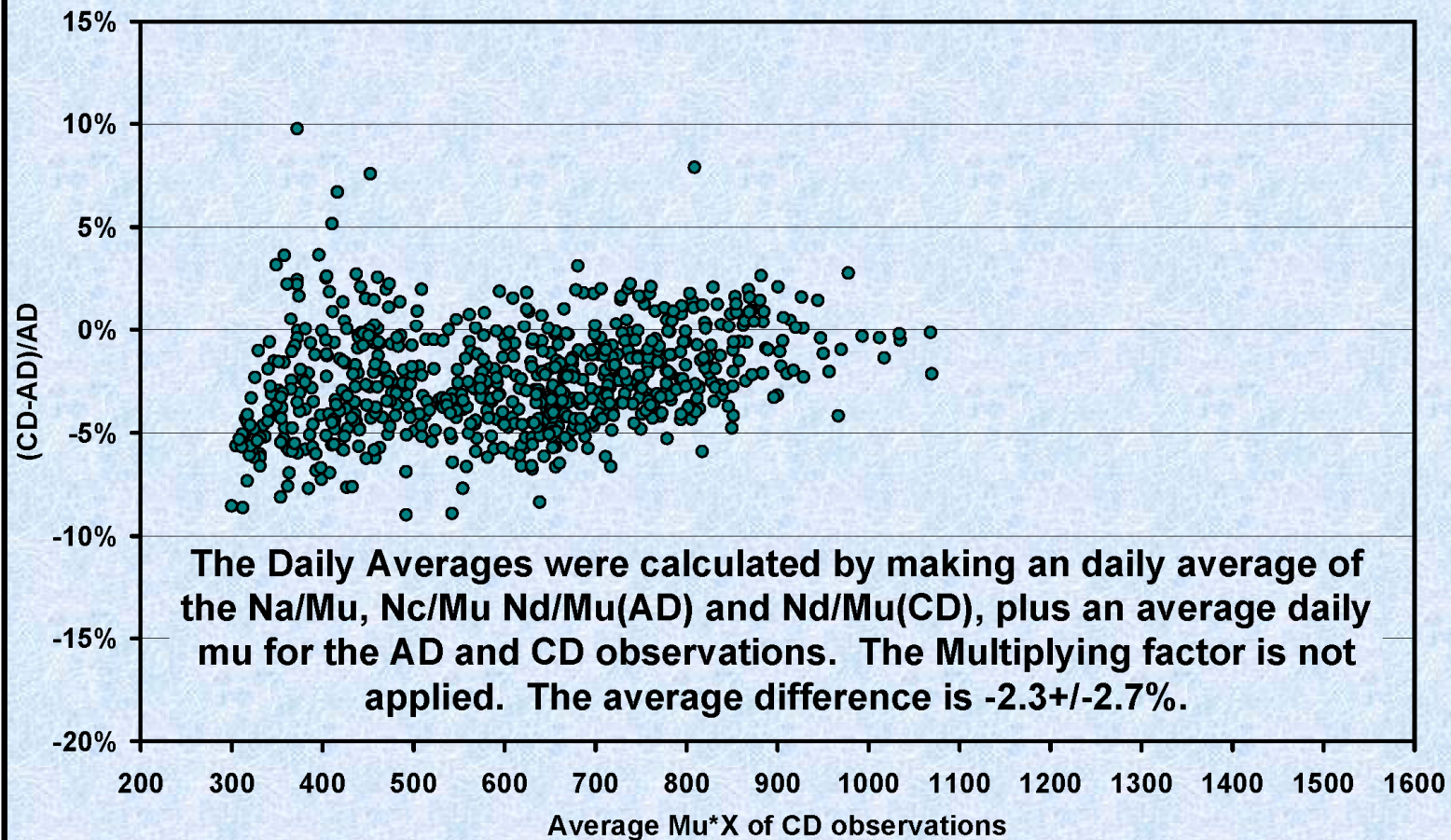


Supplemental Slides

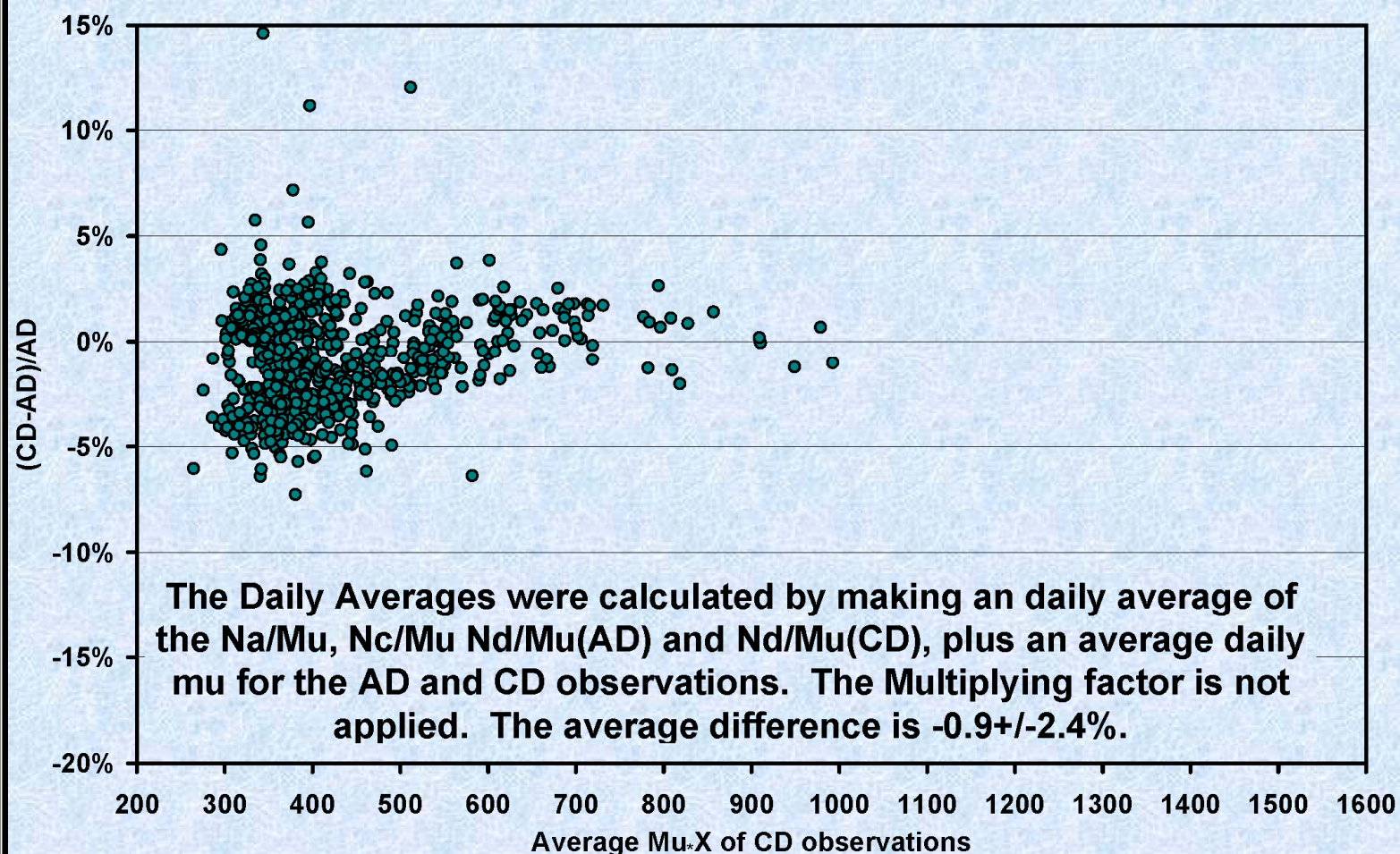
CD-AD TO3 difference from 1991-1999 Langley plot campaigns (D083) at MLO, HI USA: 340+ days with both ADDS and CDDS observations.



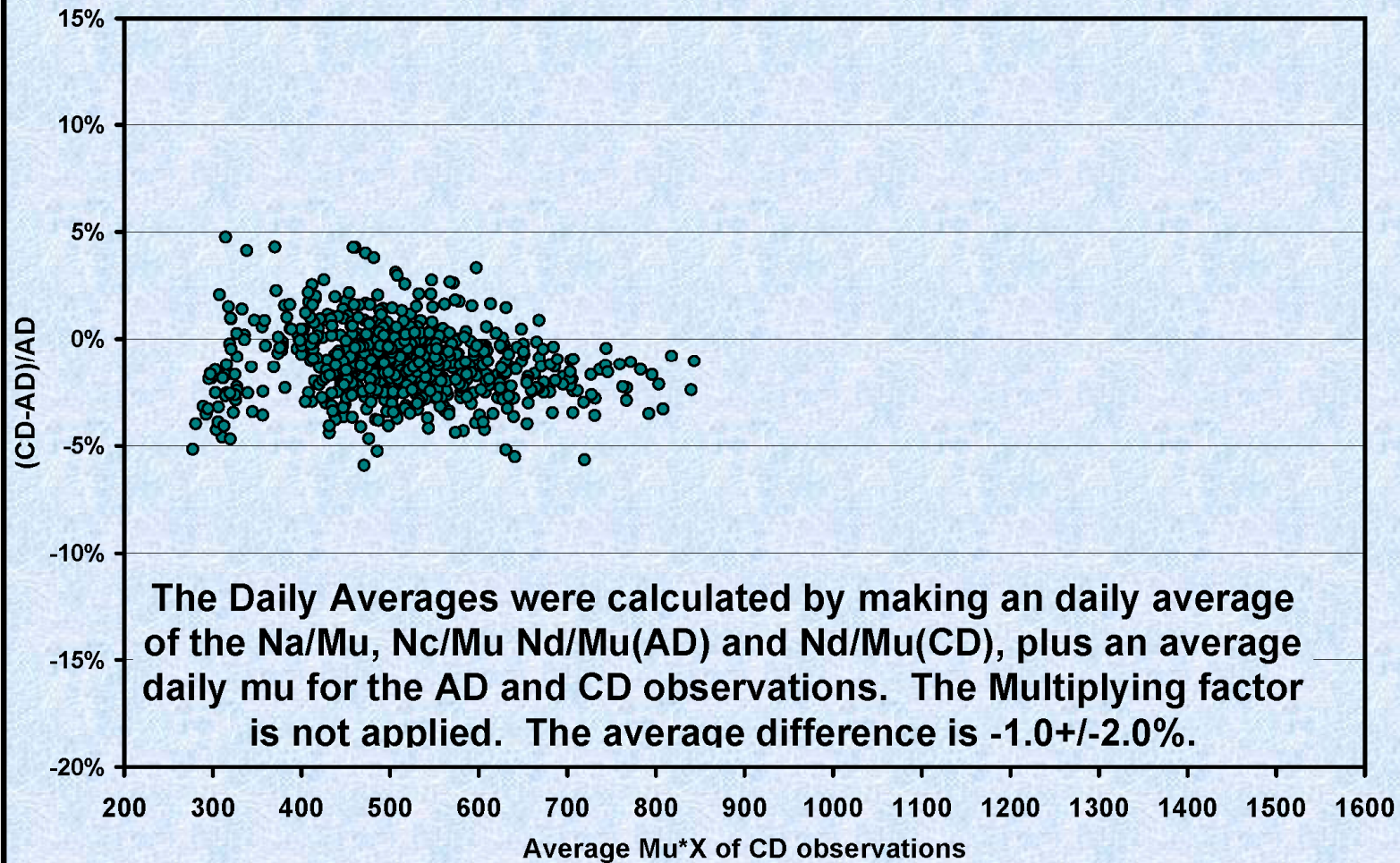
**CD-AD TO3 difference from 30+ years of observations at
Boulder, CO USA: 1802 days with both ADDS and CDDS
observations.**



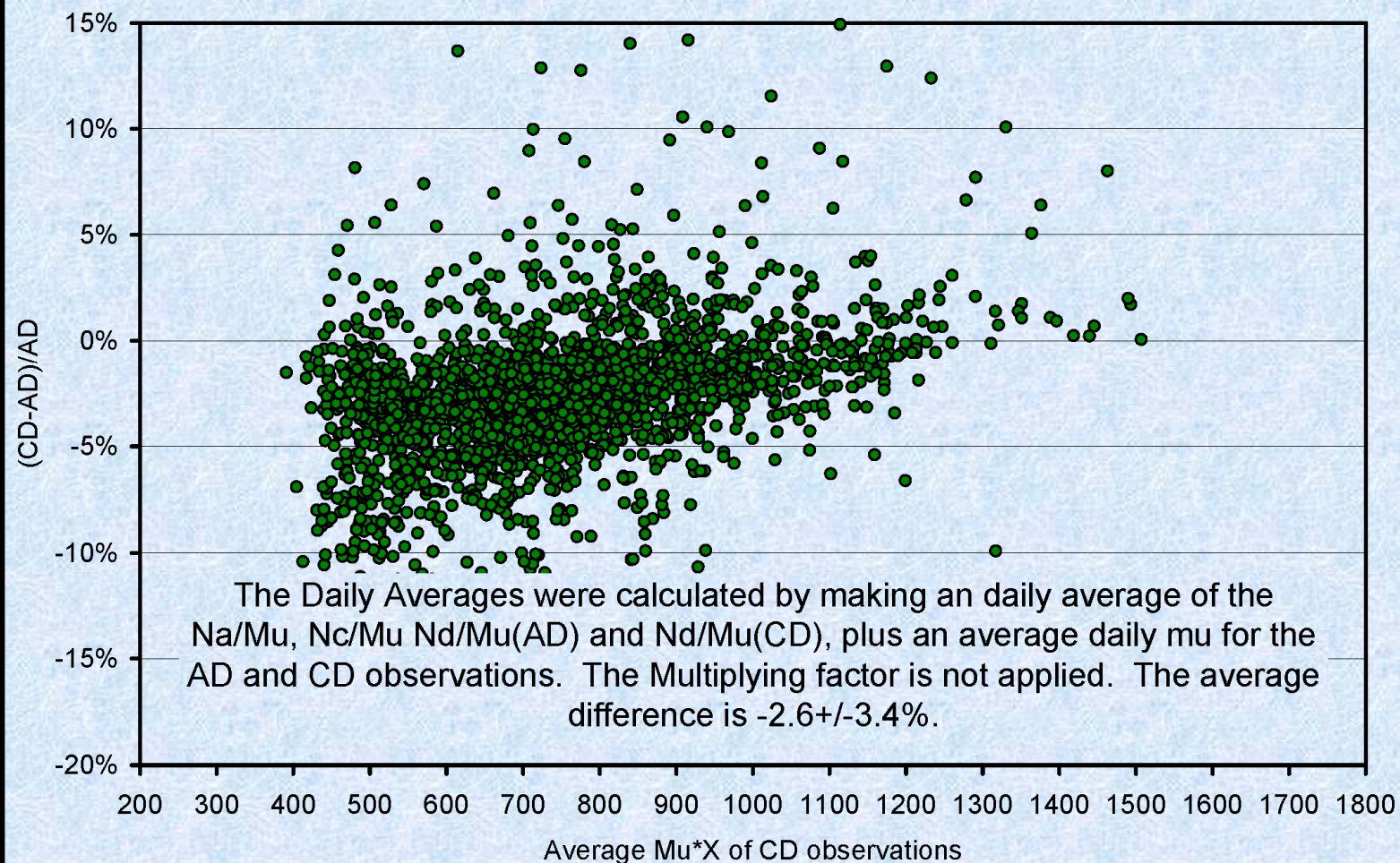
CD-AD TO3 difference from 30+ years at MLO, HI USA: 700+ days with both ADDS and CDDS observations.



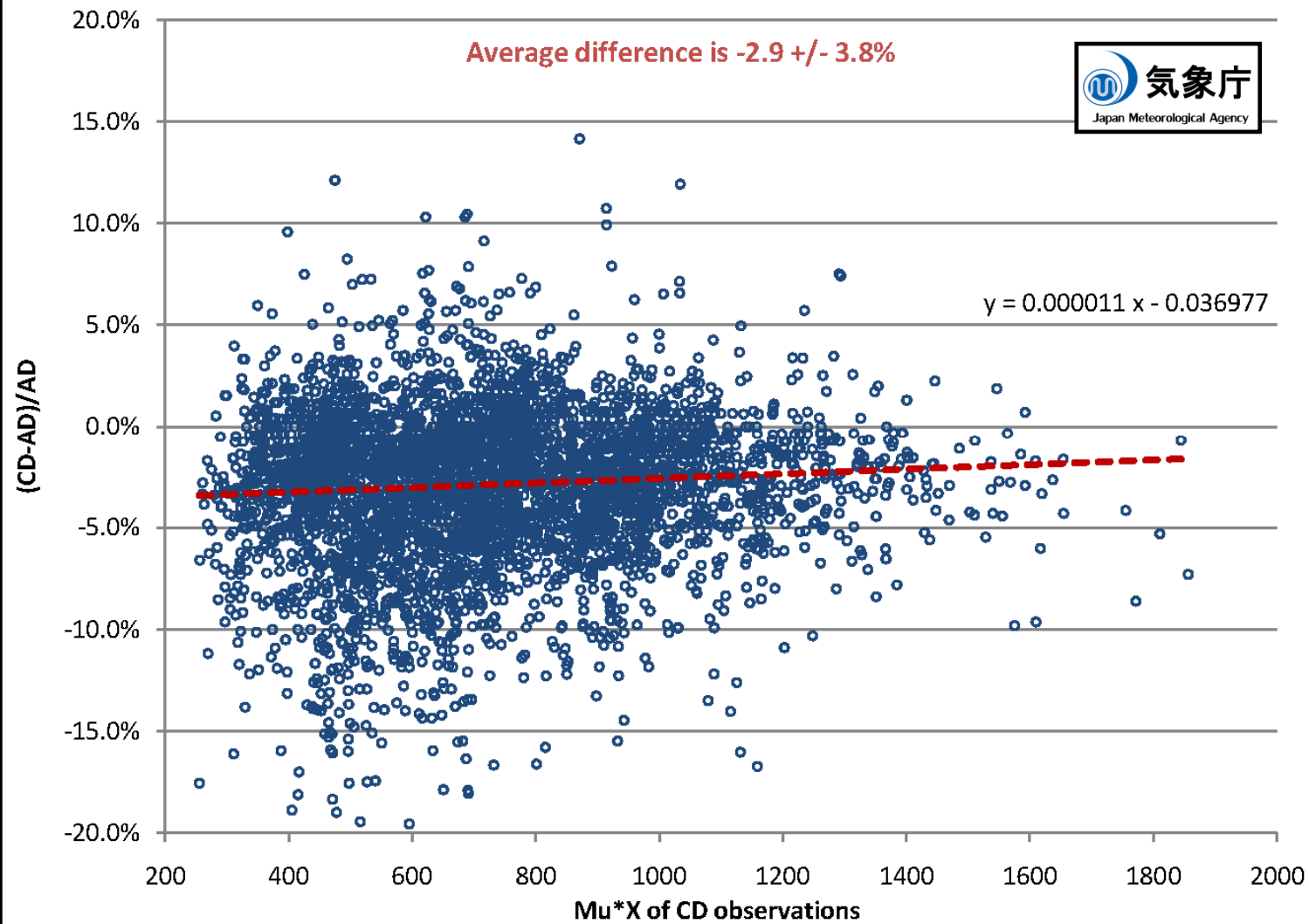
CD-AD TO3 difference from 30+ years of observations at American Samoa: ~660 days with both ADDS and CDDS observations.



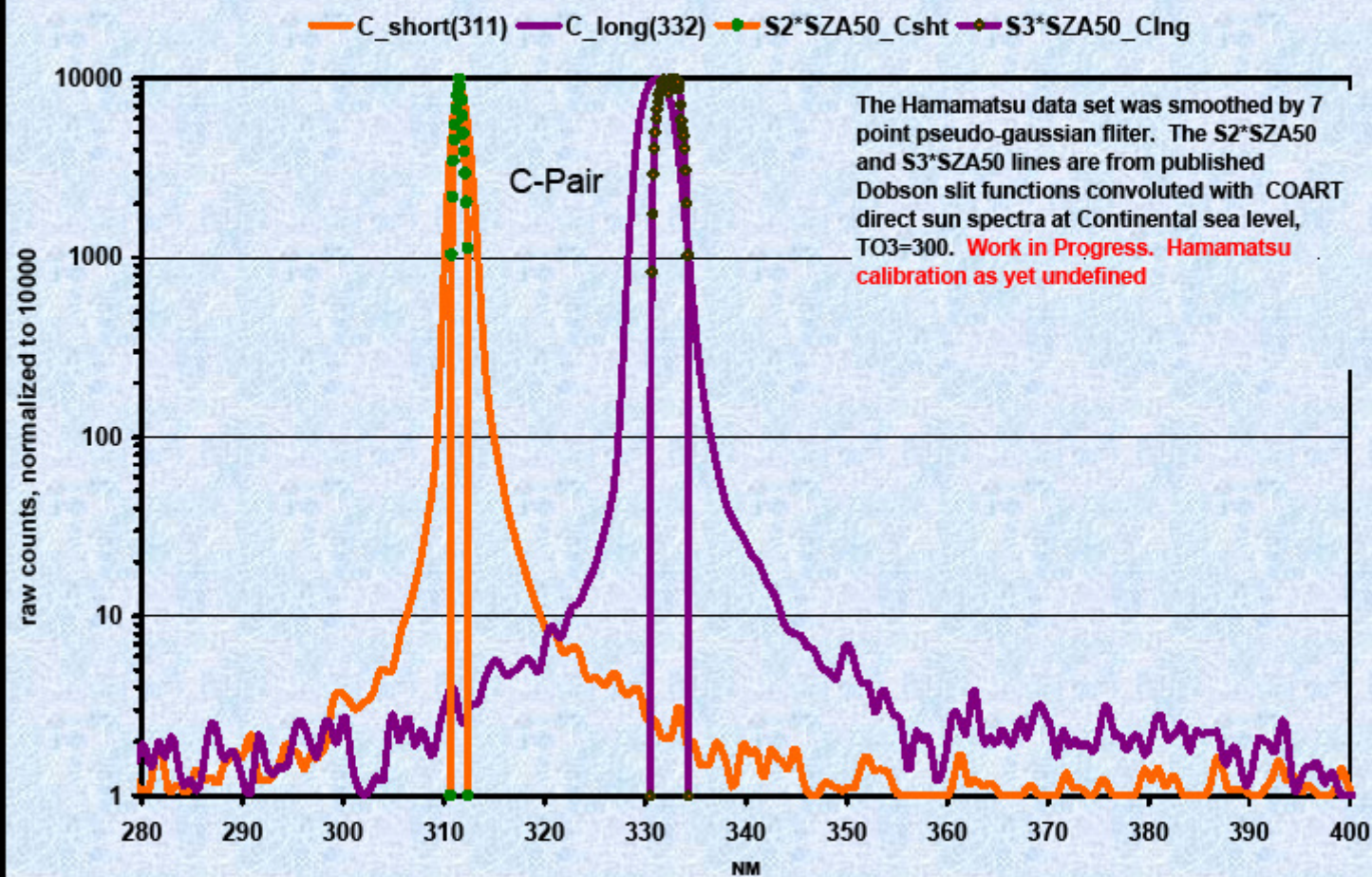
**CD-AD TO3 difference from 30+ years of observations at Admunsen-
Scott Base: 2900 days with both ADDS and CDDS observations.**

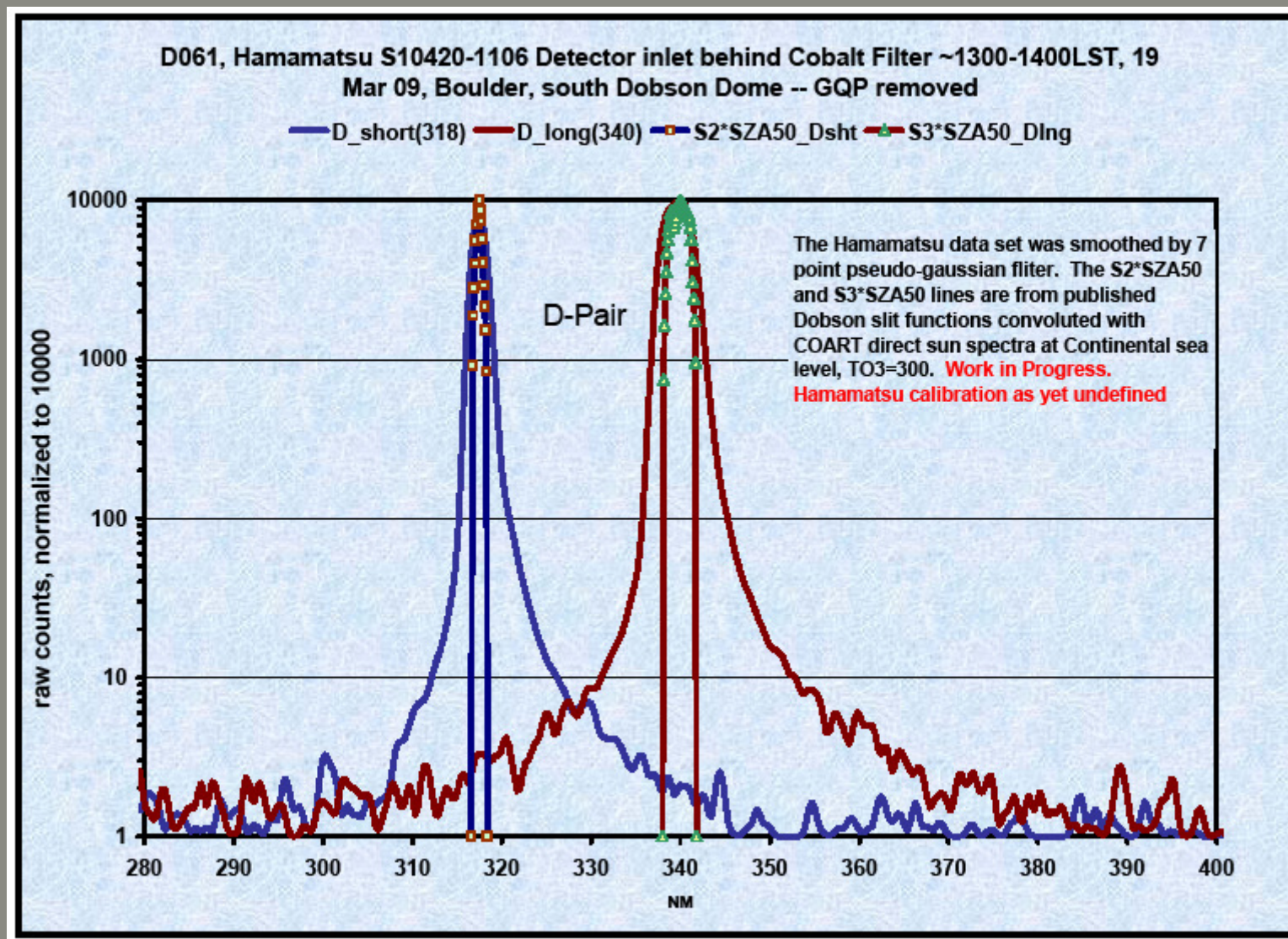


CD-AD TO3 difference from 1994 to 2008 at Syowa, Japan



D061, Hamamatsu S10420-1106 Detector inlet behind Cobalt Filter ~1300-1400LST, 19
Mar 09, Boulder, south Dobson Dome -- GQP removed





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 $-0.1\% \pm 0.8$ 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.