Aethalometer™ Data Post Proccessor ('Masher') Update: Spot Loading Correction

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See also: Evaluation of the Magee/TAPI model AE33/633 "next generation" Aethalometer

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INTRODUCTION

- Aethalometer post-processing pgm (aka 'DataMasher') upgraded
  Generates correction for filter spot loading artifact

- What's a Masher?
  Reads raw Aeth data files (digital output)
  Outputs clean, fully populated cycle and 'valid' 1-h data files
  - provides level 0.5 QC (internal instrument parameters)
  Developed by users (Jay Turner, George Allen), not MageeSci

- A short Masher history:
  Digital Aeth data output preferred over analog
  - large dynamic range, inclusion of negative data
  Need easy way to generate 1-h means from digital output
  First masher: available 2003
  http://tinyurl.com/old-masher

- Additional background: 2006 Las Vegas NAMC Aeth presentation: http://tinyurl.com/2006aeth

- Today: Describe corrections for "spot loading" artifact

  ==> Decrease in BC response with filter spot aerosol loading

- BC on 'new' (clean) spot higher than old spot BC

  - "Sometimes", some sites

  - worse in winter than summer (in northeast)

  Loading effect introduces substantial BC artifacts

  Worst on "fresh" BC; when BC dominates fine PM

  - larger maximum attenuation (max-atn) ==> larger error!

- Aeth optical 'attenuation' value: "how dark is the spot" metric

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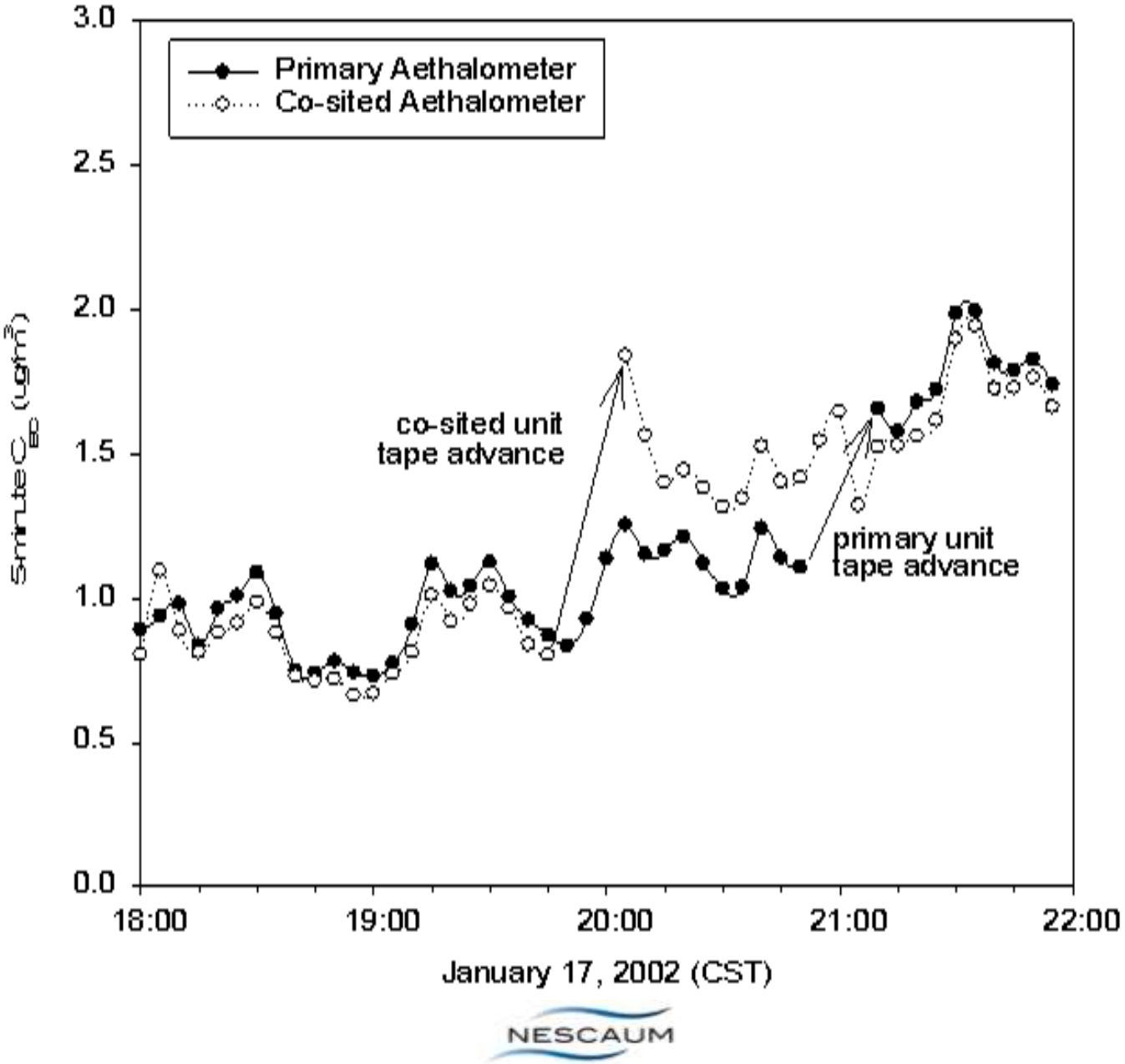
Examples of spot loading artifact: Collocated Aeths, E.STL, 5-minute BC



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Seasonal Bias Example: Aeth BC and Sunset thermal EC

Table 1. Linear least squares slope of hourly BC vs SUNSET EC at the South Bronx.

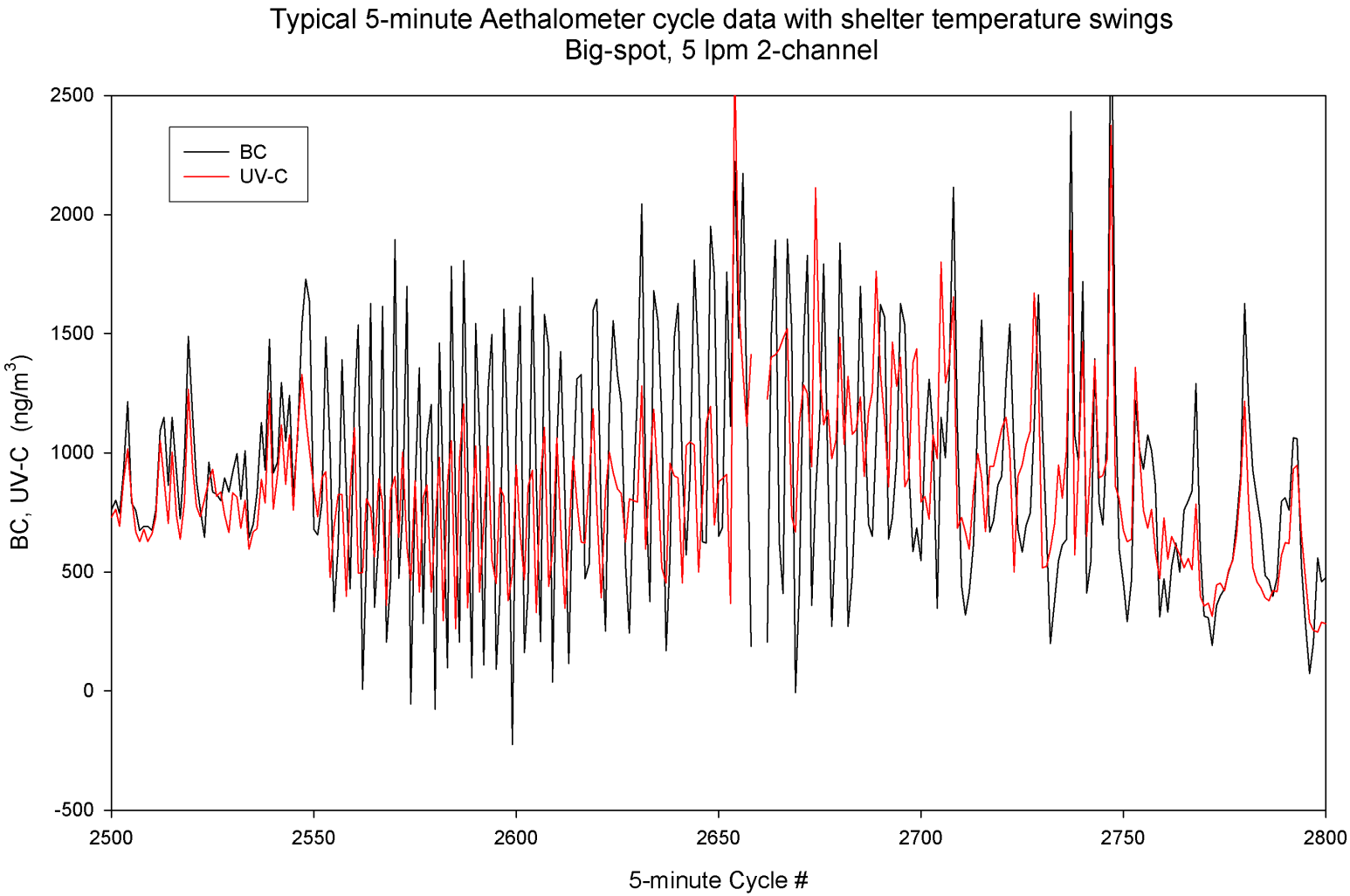
Hourly Aethalometer BC is highly correlated with Sunset EC with R^2>0.7. However, from April to October BC is biased approx. 30% higher than EC whereas, from November to March BC is equal or lower than EC.

BC vs EC	slope	R2
Jul-05	1.3	0.9
Aug-05	1.2	0.86
Sep-05	1.2	0.86
Oct-05	1.19	0.7
Nov-05	1.02	0.78
Dec-05	0.82	0.78
Jan-06	0.98	0.81
Feb-06	1.05	0.88
Mar-06	1.03	0.83
Apr-06	1.4	0.76
May-06	1.31	0.85
Jun-06	1.31	0.85
Jul-06	1.39	0.85

Source: Oliver Rattigan, NYS-DEC

- "Classic" (Virkkkula gap) correction:
  based on BC change over spot-change data 'gap'
  assumes BC does not change over 10-15 minutes of gap
    - requires smoothing over many (20-40) spot changes

Gap method degraded by "noisy" BC data:



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- A dynamic correction factor “K” is generated
  to best match BC over data gaps (spot changes)

- Definition of K: $BC_{(adj)} = BC_{(raw)} * (1+atn*K)$
  K ranges from ~ 0.000
  white aerosol (SO4, NO3, OC) with a bit of soot
  to ~ 0.010
  mostly dark aerosol, fresh soot

- Examples of how K effects BC for atn=100:

  K=0.000: no adjustment
  BC*(1+100*0)=BC

  K=0.010: no adjustment to factor of ~2x adjustment (atn=100)
  BC*(1+100*0.01) = BC*(1+1) = BC*2
  ==> adjustment increases as atn value increases

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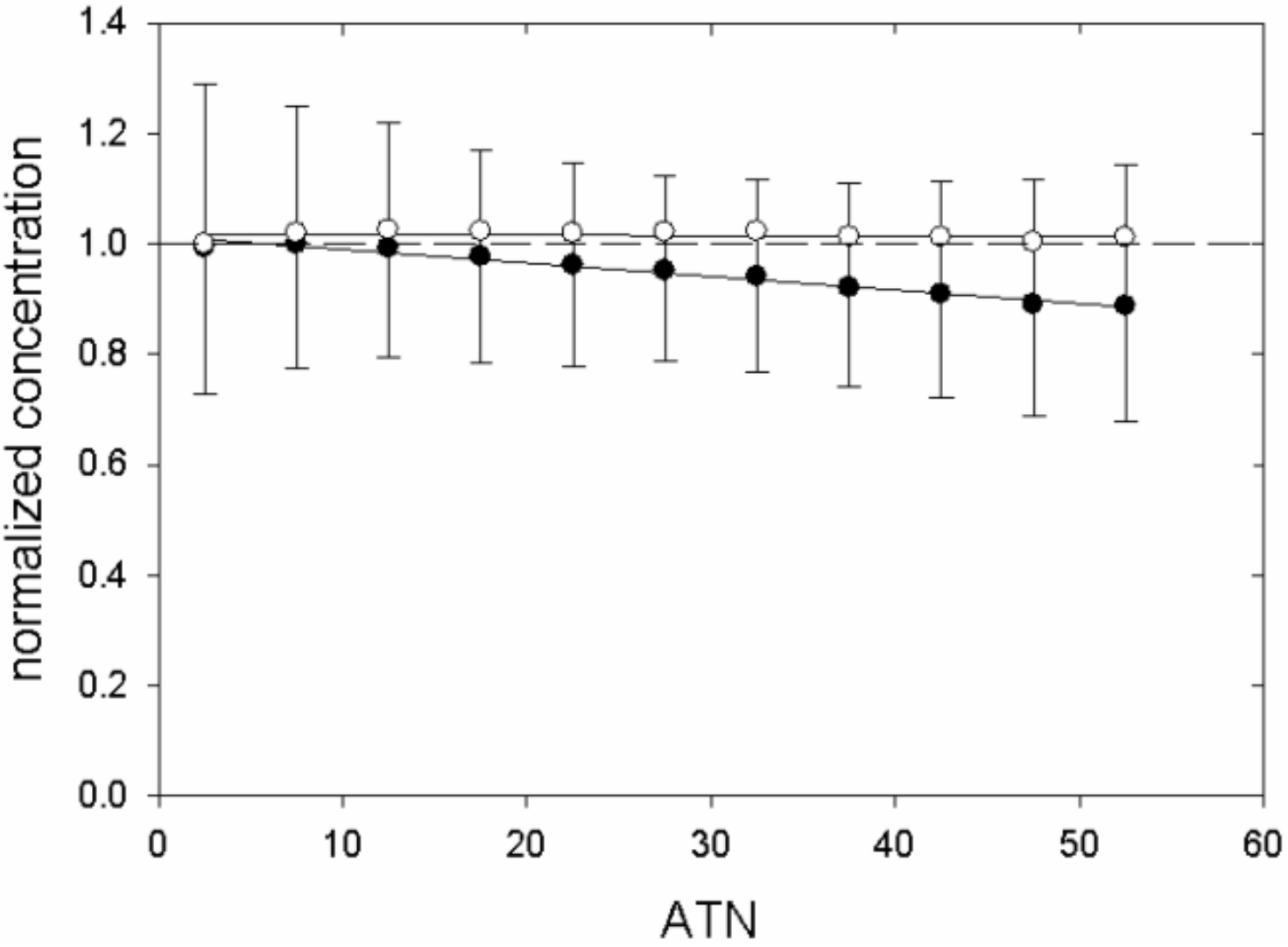
- Another correction approach:
  "Bin" BC data by atn value (eg, spot loading)
  Assumes true BC is not a function of atn
    - usually true

Binned K:
Regress BC concentration vs. atn bin values

Slope is K;
Smoothing still needed since BC varies over time



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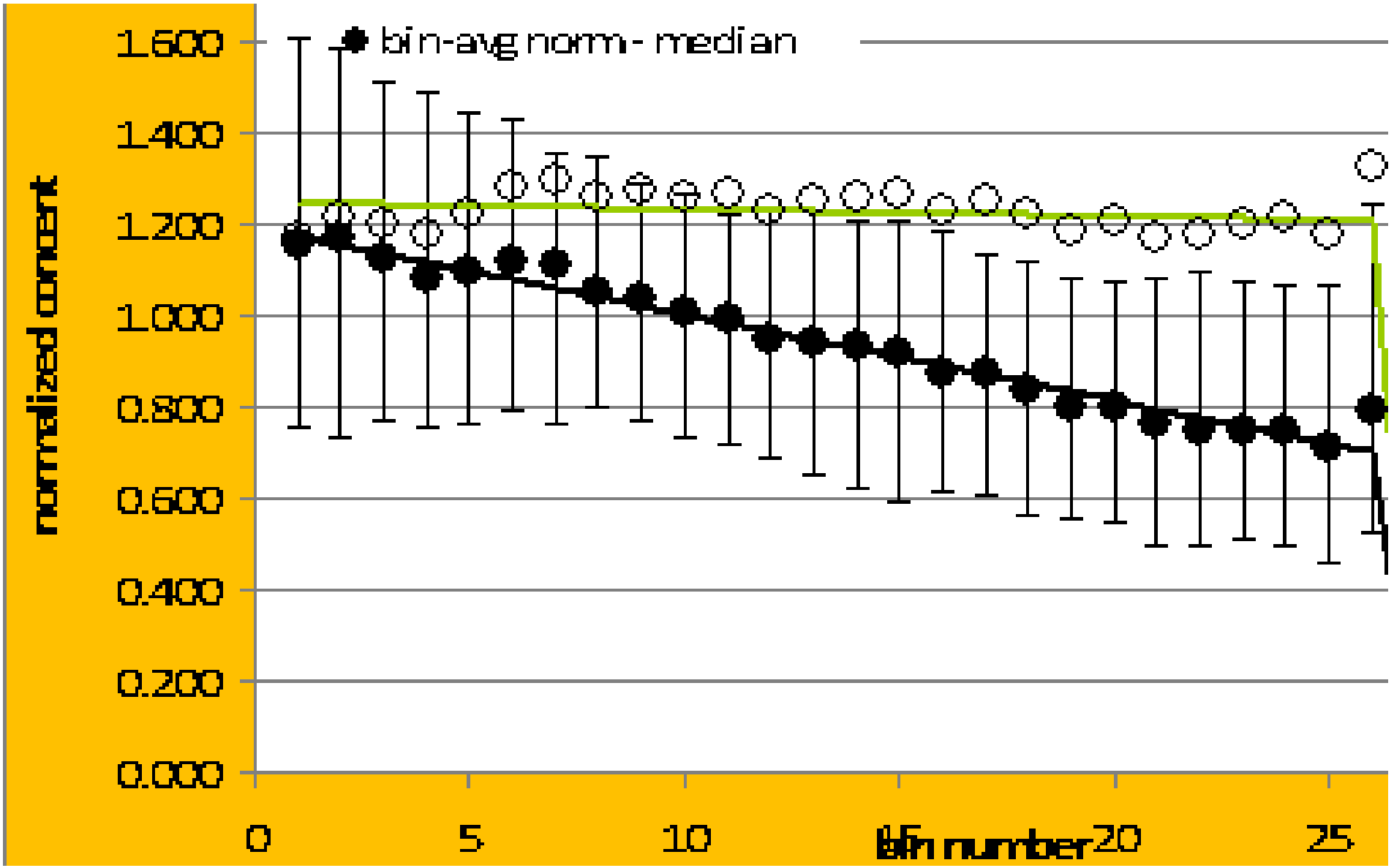
- Other key advantages of binning vs. gap correction:
  - Not as affected by short term noise
  - Regressions provide quality of correction metric
    - ‘How valid are the underlying assumptions about the data’
  - More masher parameters to choose from
    - not just # of tape changes
    - vary settings to match the type of data (optimization)

- Binned masher also outputs classic ‘gap’ data for comparison

- Reality sets in...
  - Simple binned BC vs. atn not robust on real data
  - Sensitive to nature of data

- Use normalized median for BC bin value
  - More robust
  - Masher outputs all 6 regression variations as diagnostics

Binned masher diagnostic output example (1-year of data):



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Binned Masher diagnostic output, continued.

Method	Mean-Median	Intercept(ATN=0)	Slope(ATN=0)	Intercept=1?	Slope(k-value)	Slope C.I.
raw data	mean	0.5907	-0.0017	0.9863	0.0045	0.0005
raw data	median	0.4101	-0.0012	0.9999	0.0043	0.0008
bin-avg conc	mean	1.3031	-0.0037	0.9688	0.0045	0.0005
bin-avg conc	median	0.9206	-0.0027	0.9751	0.0045	0.0006
norm bin conc	mean	1.1945	-0.0030	0.9981	0.0036	0.0007
norm bin conc	median	1.1826	-0.0038	0.9580	0.0053	0.0005
classic (tape-advanced based) median k-value					0.0042	
		Int(recon)	Slope(recon)			
raw data	mean	0.6106	0.0000			
raw data	median	0.4223	0.0000			
bin-avg conc	mean	1.3603	-0.0003			
bin-avg conc	median	0.9611	-0.0003			
norm bin conc	mean	1.2378	-0.0005			
norm bin conc	median	1.2456	-0.0003			

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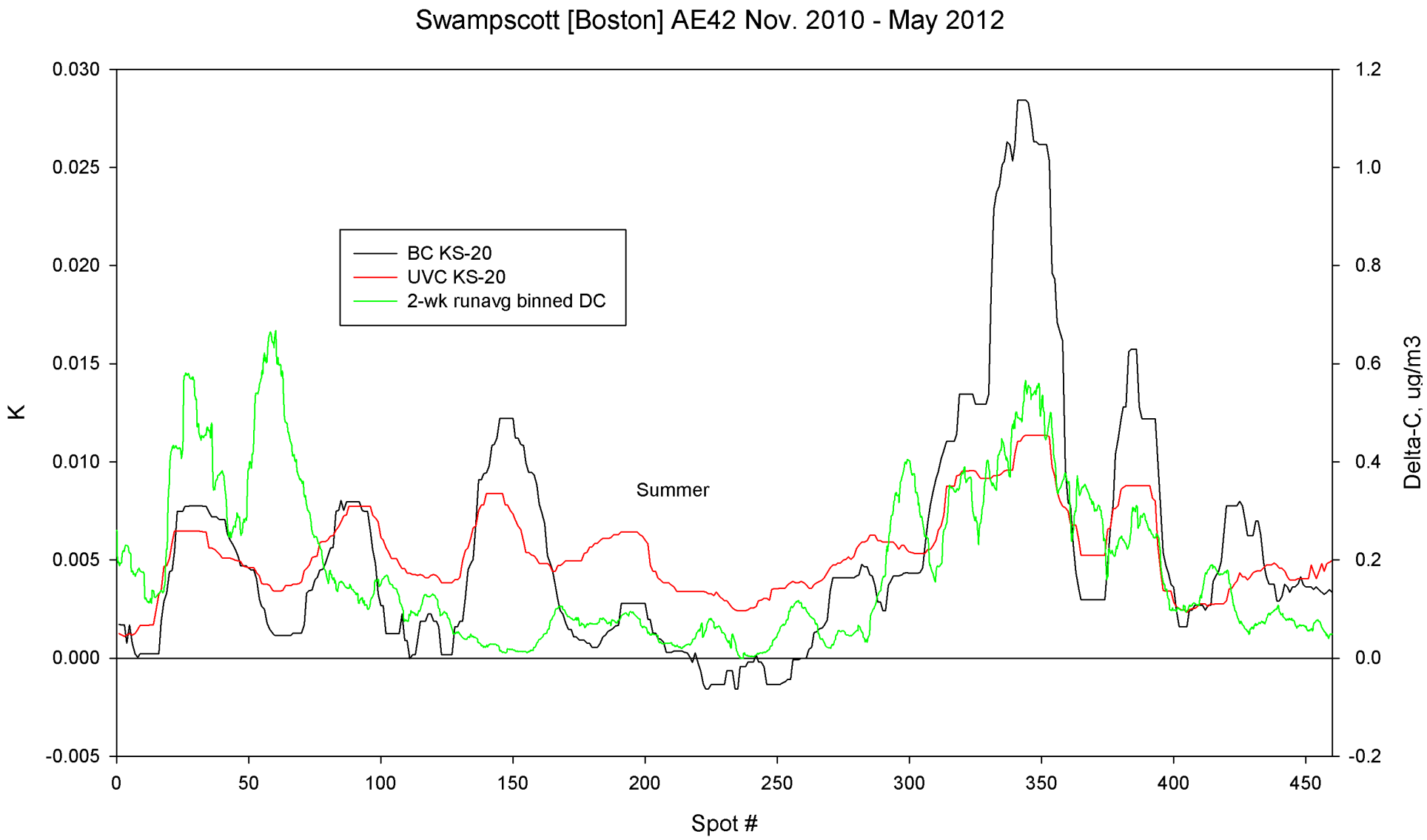
Dynamic smoothed K time-series: Applied to masher data output



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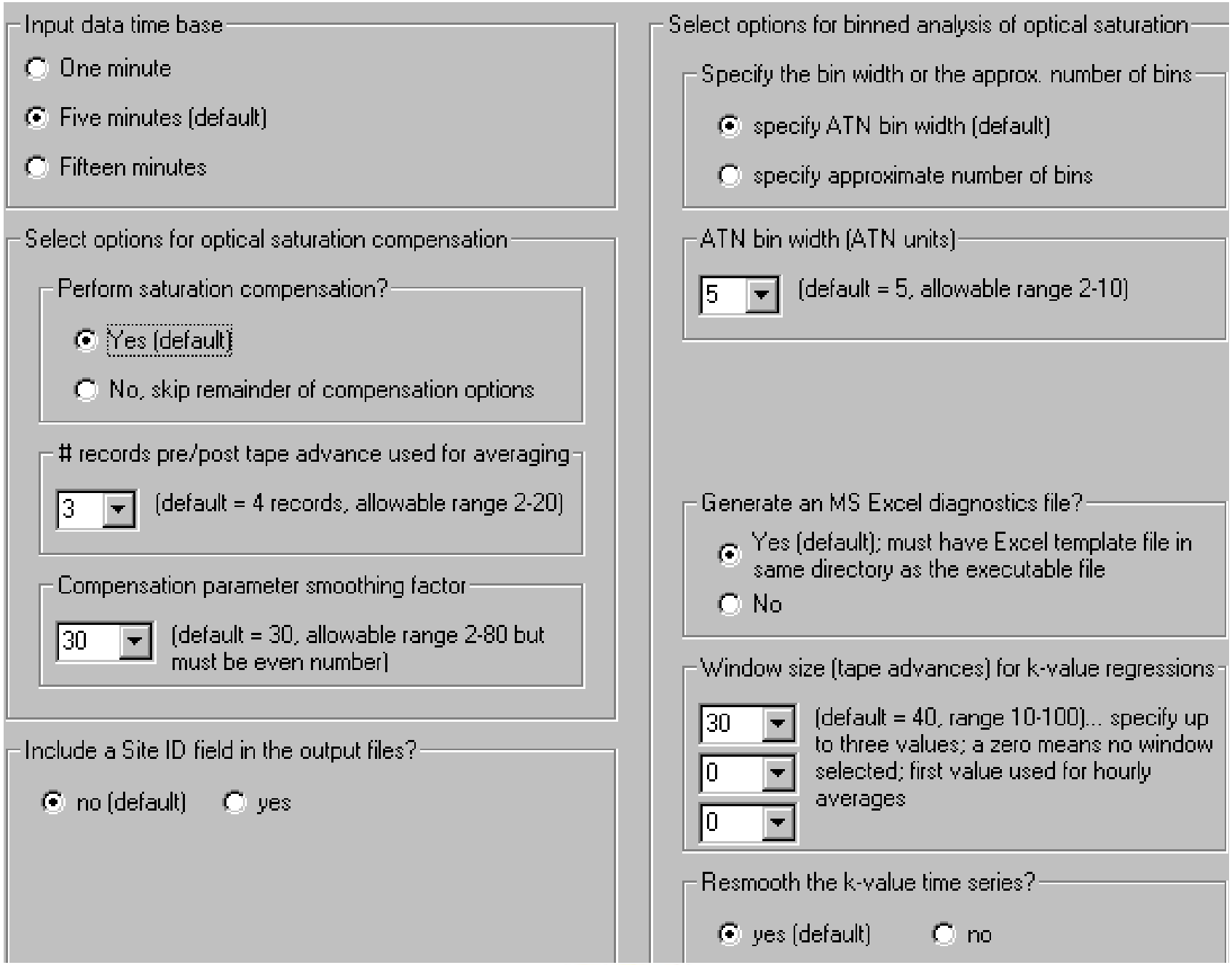
Binned Masher Screen Shot: Advanced Options



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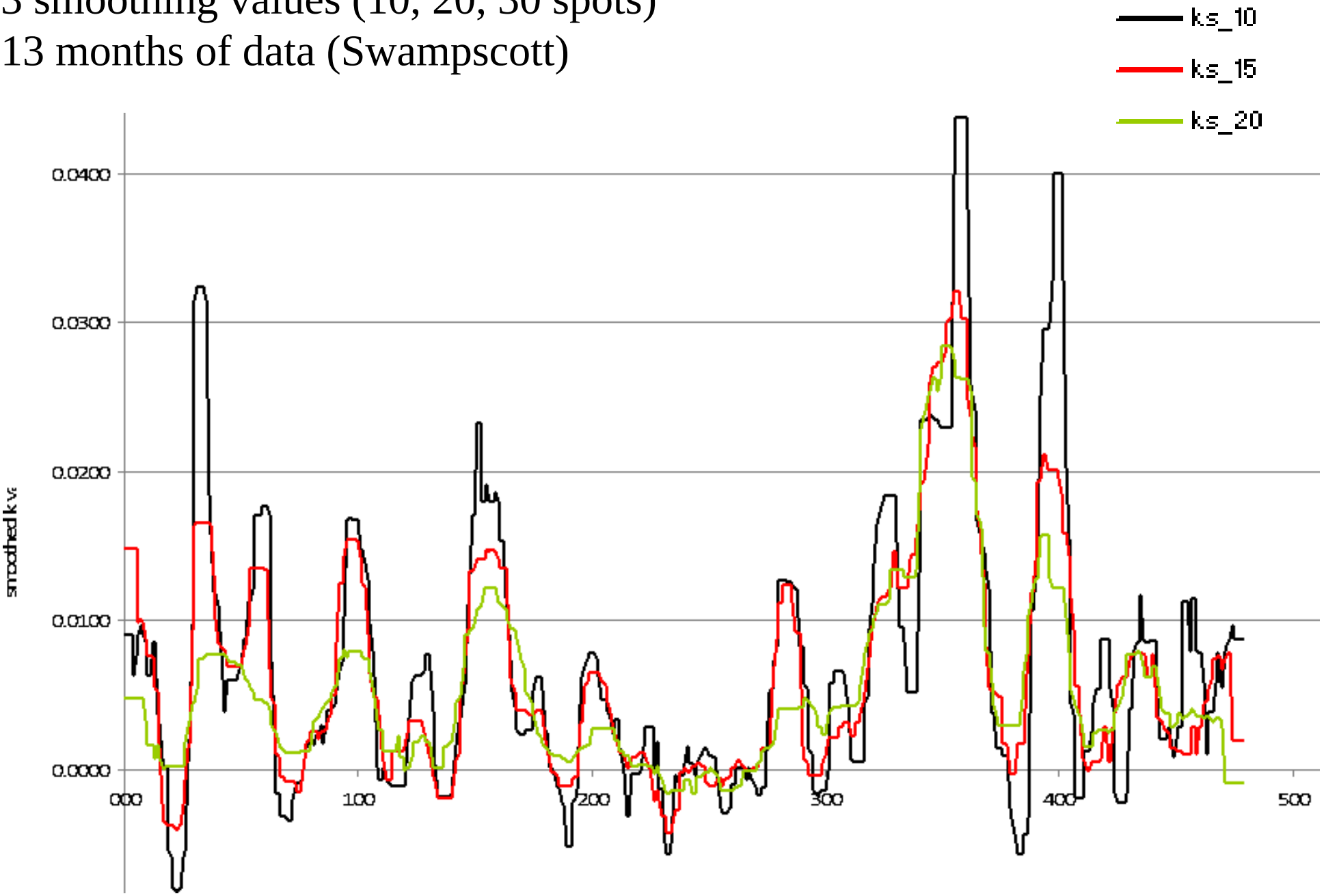
3 smoothing values (10, 20, 30 spots)
13 months of data (Swampscott)



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CONCLUSIONS

- Binned approach:
  incremental improvement over gap method

- Biggest advantages:
  Handles noisy data better
  Quality metrics guide user in understanding data
  - choose appropriate masher advanced settings
  Defaults best for most users

- How important is saturation correction? Depends... on:
  Max-atn instrument setting
  UV-channel on or off (factor of 2.4)
  Critical for Delta-C woodsmoke/biomass signal

- Binned Masher availability:
  Now on request to gallen@nescaum.org
    - limited user support (unfunded)
  Later this year: general distribution
    - with documentation (support still limited)

FUTURE WORK

- Complete documentation (this year)

- Adapt for AE33/633 “NextGen” data format?
  Best correction is “time-centered”
  AE33/633 data can benefit from post-processing

Flashback to 2006 Vegas: "The near future" slide:

- Embed the correction code into the next-generation Aethalometers (spring/summer 2007)
- Revise the "Turner/WUAQL Aeth Data Masher" to include correction
- ? Provide a drier option to minimize summer water-related effects
- Provide a thermally stable short-term measurement fix (5-min noise)
  ==> active optical feedback compensation

Spring 2012: ✔

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