Model averaging time adjustment

Are there problems with using a power law to estimate concentrations for different averaging times, as done by Ausplume and Calpuff?

Specifically, is it correct to adjust only σ_y to alter averaging time?

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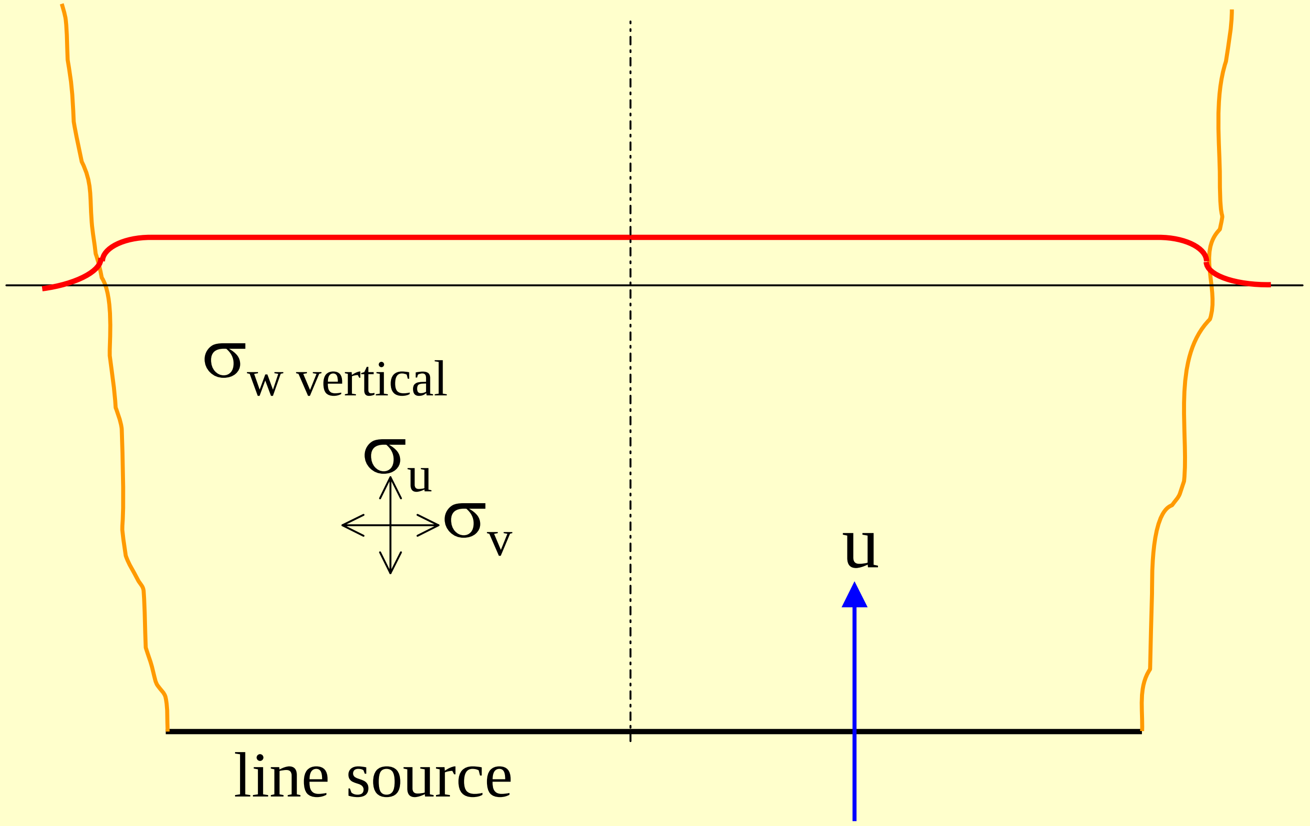
Origins of power law (as explained by CSIRO)

- $C_{max,2} = C_{max,1} (t_1/t_2)^p$ (1)
- p in range 0.1 to 0.4
- p ~ *f*(source type, stability, distance)
- applies to the highest concentration (unpaired) determined over ~1 year
- wrong to apply to a particular hour or to generate time series of concentrations

Power law adjustment of σ_y

- $\sigma_{y\,2} = \sigma_{y\,1}\,(t_2/t_1)^{0.2}$ (2)
  (AMS 1977, Ausplume, Calpuff)
- no accounting for stability or distance from source, so a constant exponent of 0.2 is dubious.
- for a point source Gaussian Plume, **<u>if</u>** $\sigma_{z\,2} = \sigma_{z\,1}$ and GP assumptions hold, eq. 2 comes from eq. 1 with p = 0.2.
- eq. 2 is not correct for convection if t_2 is small
  (vertical motions have timescales >> 3 minutes)
- for volume, area, line sources, C(x,0,0) is not proportional to $\sigma_y^{-1}(x)$, so eq. 2 is not uniquely related to eq. 1. Question validity of eq. 2 (Ausplume method) for these source types.

problem with adjusting σ_y only e.g. very wide line source



problem with adjusting σ_y only

- very long line source with perpendicular wind.
- near plume centreline at medium distance, $C_{max,2} \sim C_{max,1}$, i.e. edge effects not felt.
- however for a line source p ~ 0.25 (Katestone, CSIRO)
- problem – σ_u and σ_w contribute to the actual value of p in eq. 1, but Ausplume applies averaging time correction to σ_v (and therefore to σ_y) only and this correction gets lost in source effects.
- comments??

Alternative to a power law embedded in the model

- the concentration power law, with exponents appropriate for source configuration and stability, can be applied by **pre-processing hourly emissions** (applying scaling factors). To account for distance from the source, separate near-field and far-field model runs may be done.
- alternatively, the concentration power law can be applied in **post-processing** to the concentration grids from **individual sources** before summing.

Unpaired estimates of C_2 from C_1

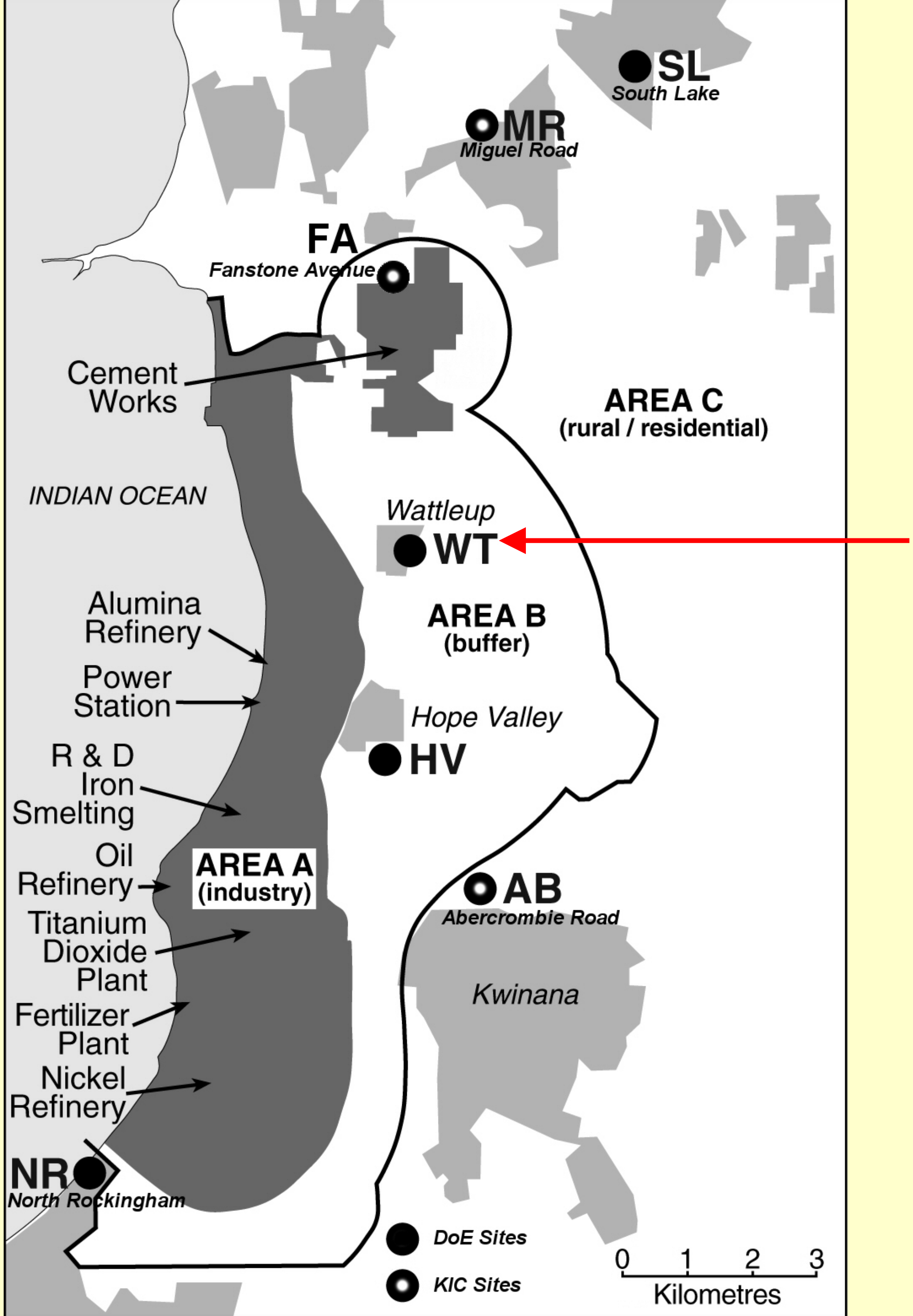
- Ausplume, if run twice for t_1 and t_2, will give time series of C_1 and C_2 which are the same except for a constant ratio.
- It is wrong to assume that the highest C_2 occurs in the same hour as highest C_1.
- However, for a point source, the highest C_2 could be taken to represent the highest t_2 average occurring sometime in the modelling period (consistent with CSIRO view).
- Does this also hold for high percentiles? (*Model users routinely assume so*!)

Maximum annual only? Percentiles?

- e.g. model gives 8760 10-min glcs in 8760 hours (i.e. highest for each model hour) and provides 99.9% (9^{th} highest), 99.5% (44^{th}), etc., as requested.
- can we expect the 9^{th} and 44^{th} highest 10-min glcs to relate to the unpaired 9^{th} and 44^{th} highest 1-hour glcs according to a power law with the same exponent determined as appropriate for the maximum 10-min and 1-hour concentrations?

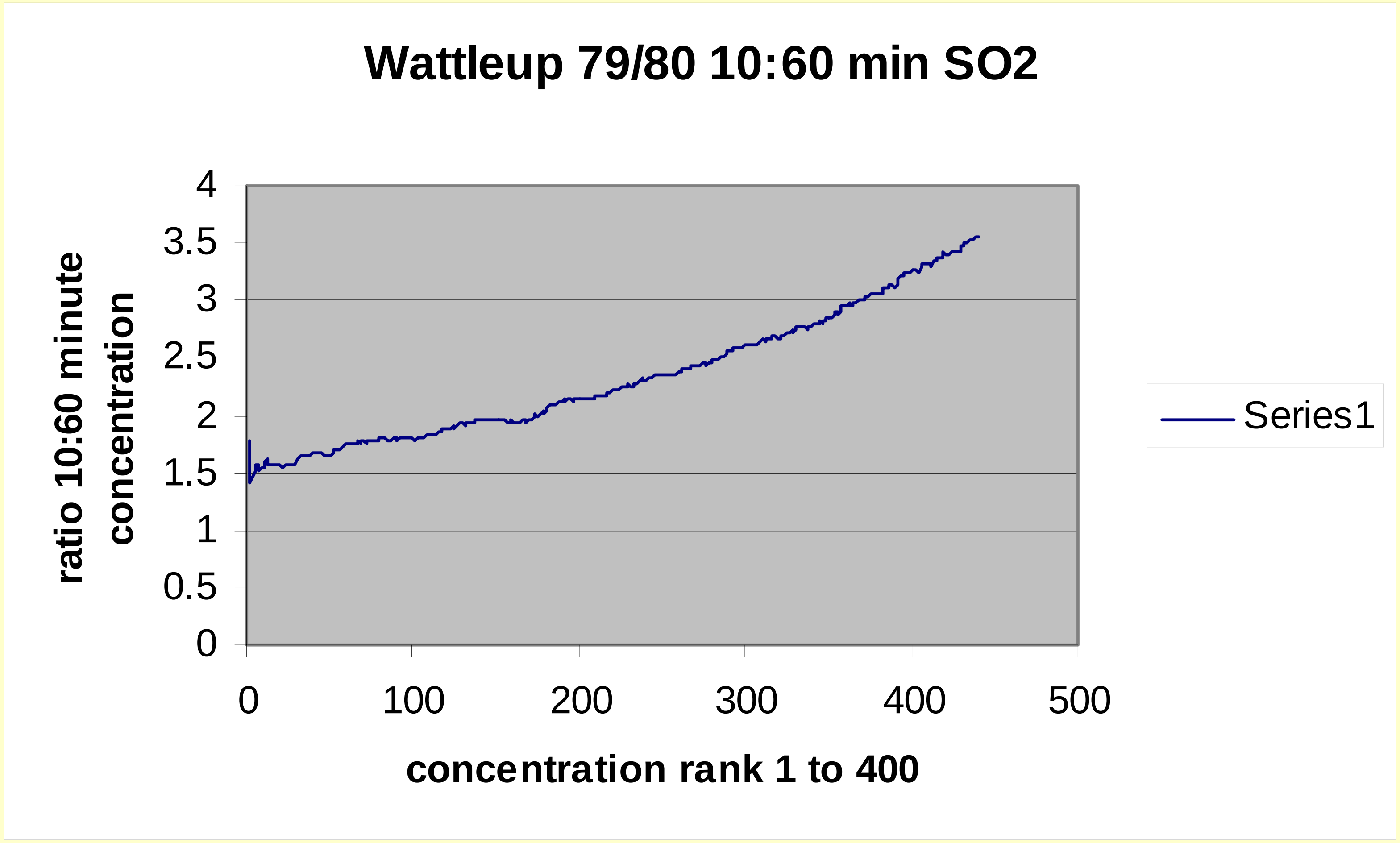
SO_2 monitoring data

- Wattleup – NE of most Kwinana industries, measures SO_2 in sea breezes (shoreline fumigation).
- Kalgoorlie gold roaster satellite monitoring station approximately 2 km NW from the roaster which has a 180 m stack with very large SO_2 emissions and with convective conditions common.

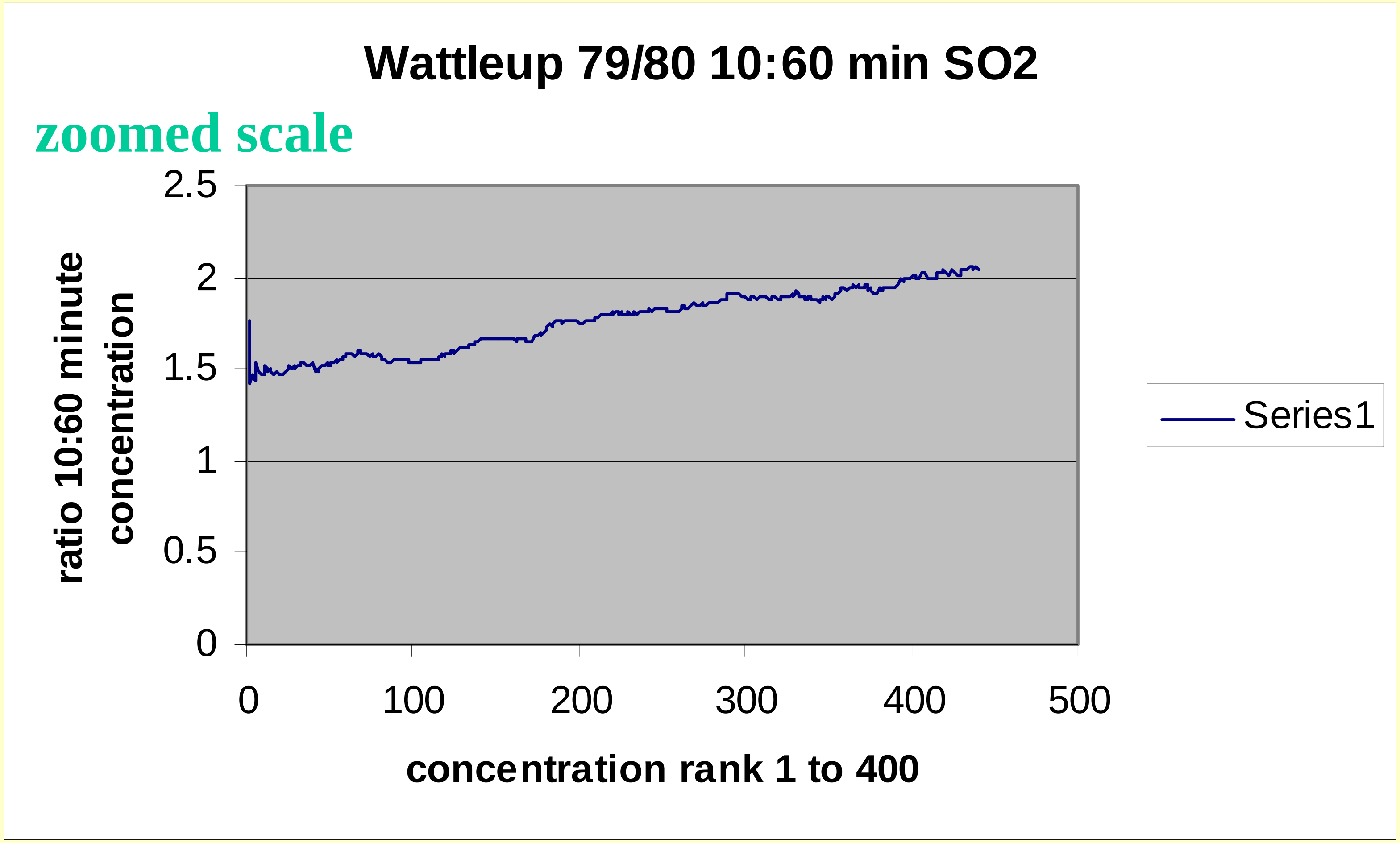


SL
South Lake
MR
Miguel Road
FA
Fanstone Avenue
Cement Works
AREA C
(rural / residential)
INDIAN OCEAN
Wattleup
WT
AREA B
(buffer)
Alumina Refinery
Power Station
Hope Valley
HV
R & D Iron Smelting
Oil Refinery
AREA A
(industry)
Titanium Dioxide Plant
AB
Abercrombie Road
Kwinana
Fertilizer Plant
Nickel Refinery
NR
North Rockingham
DoE Sites
KIC Sites
0 1 2 3
Kilometres

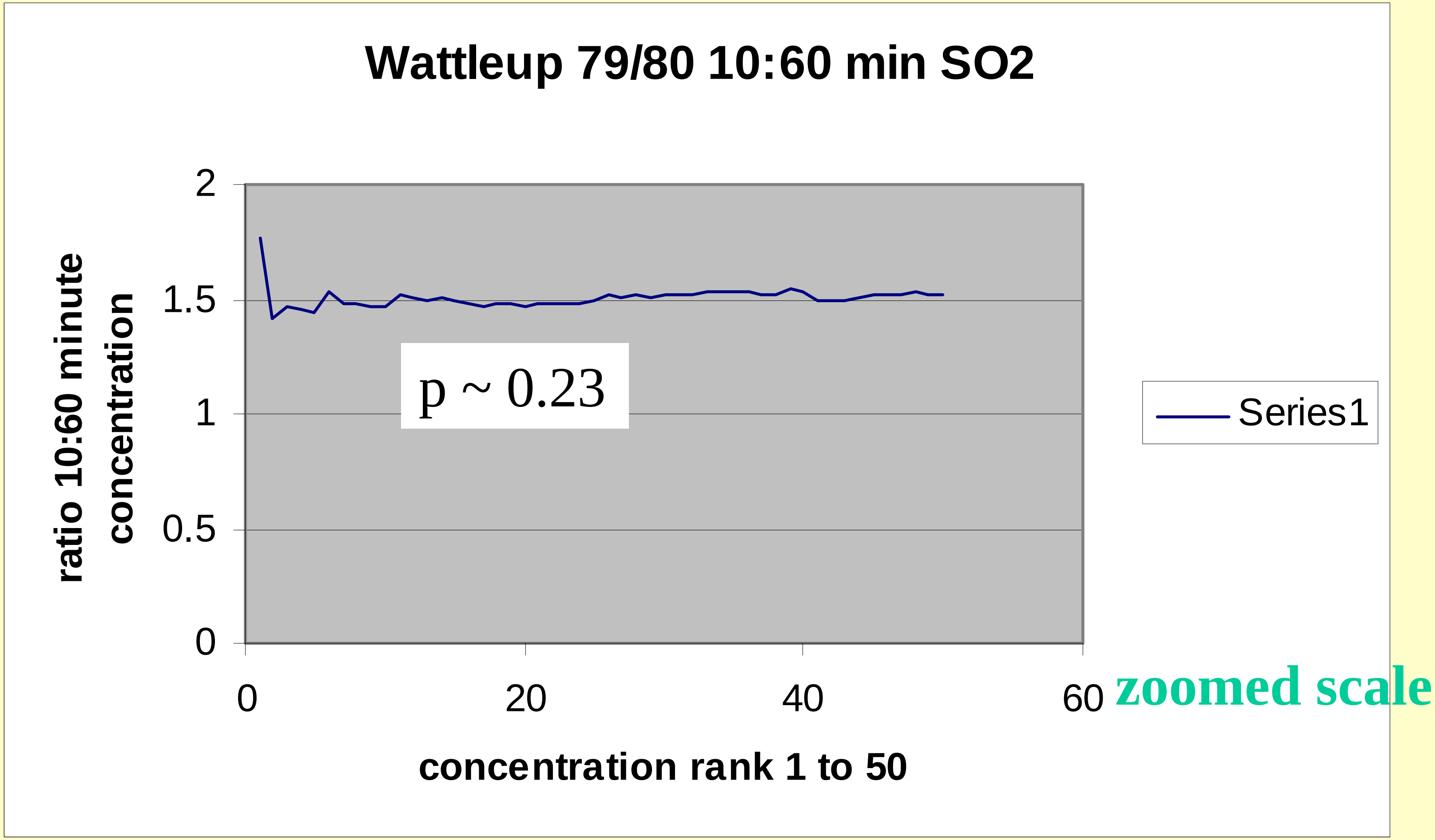
unpaired ranked values (6 x 8760 10-min values per year)



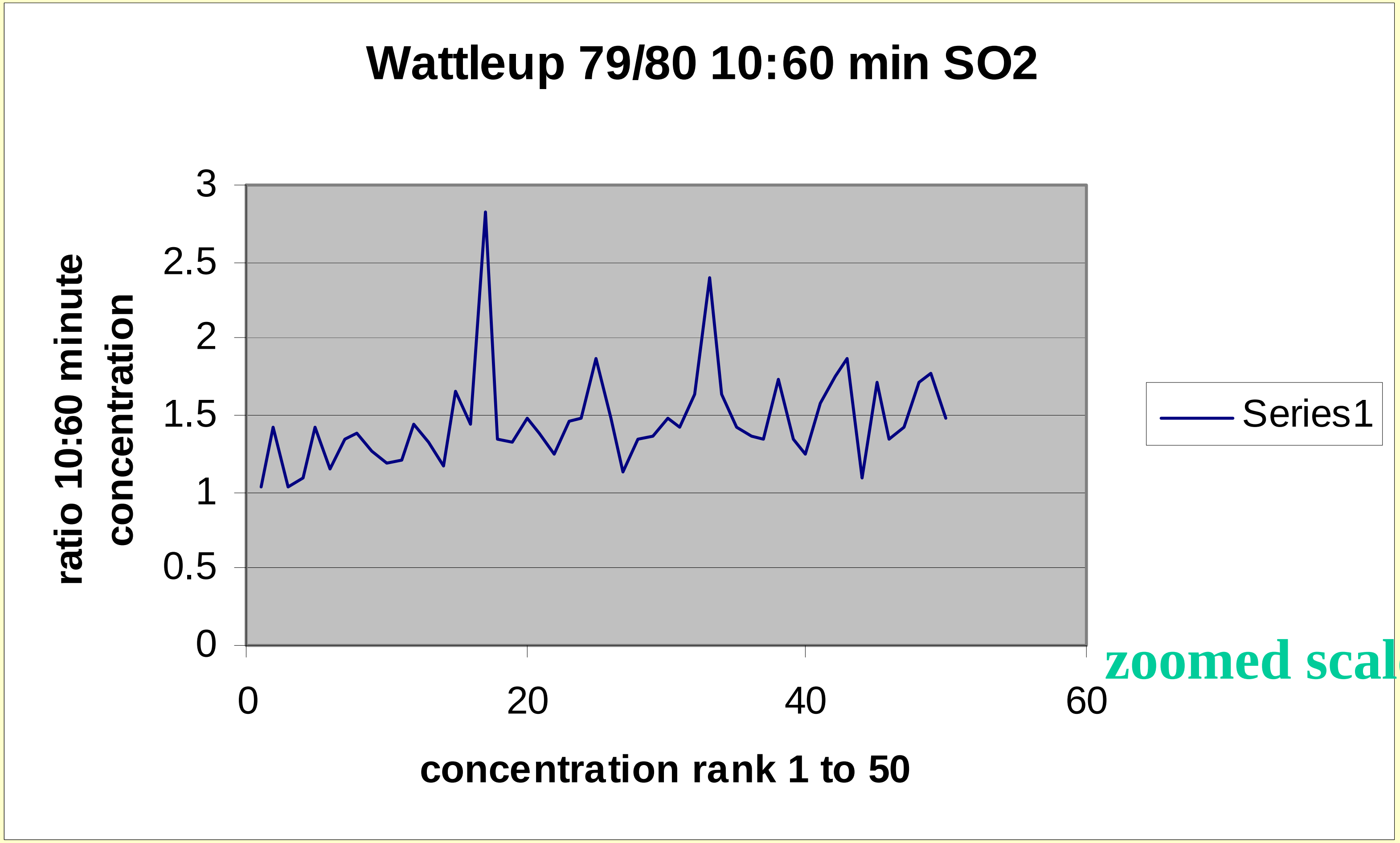
<u>unpaired</u> ranked values of hours and highest 10 min within hours



<u>unpaired</u> ranked values of hours and highest 10 min within hours



paired values of hours and highest 10 min within hours, ranked by the hour values



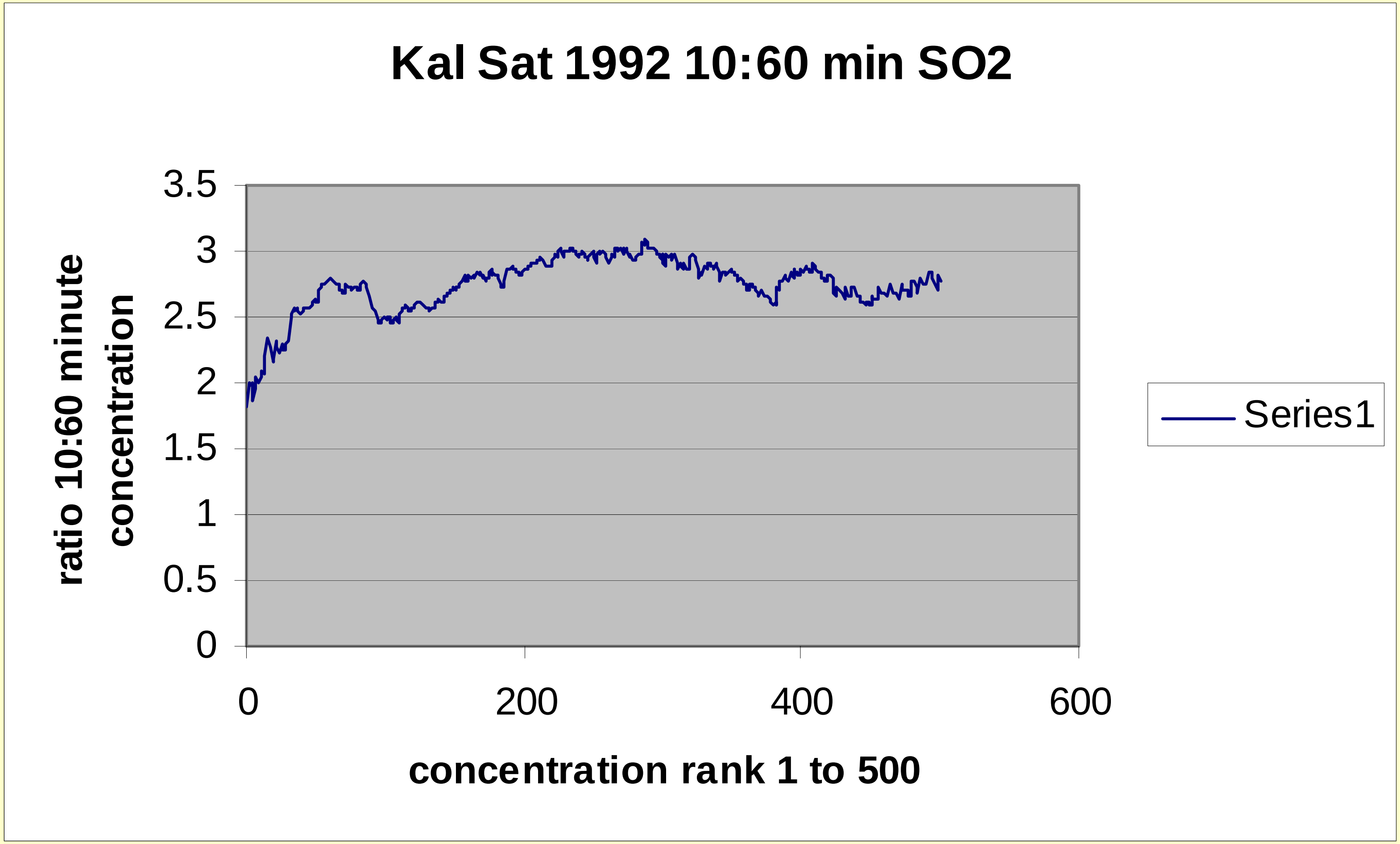
zoomed scale

Date/time of highest hours c.f. 10-min in hours

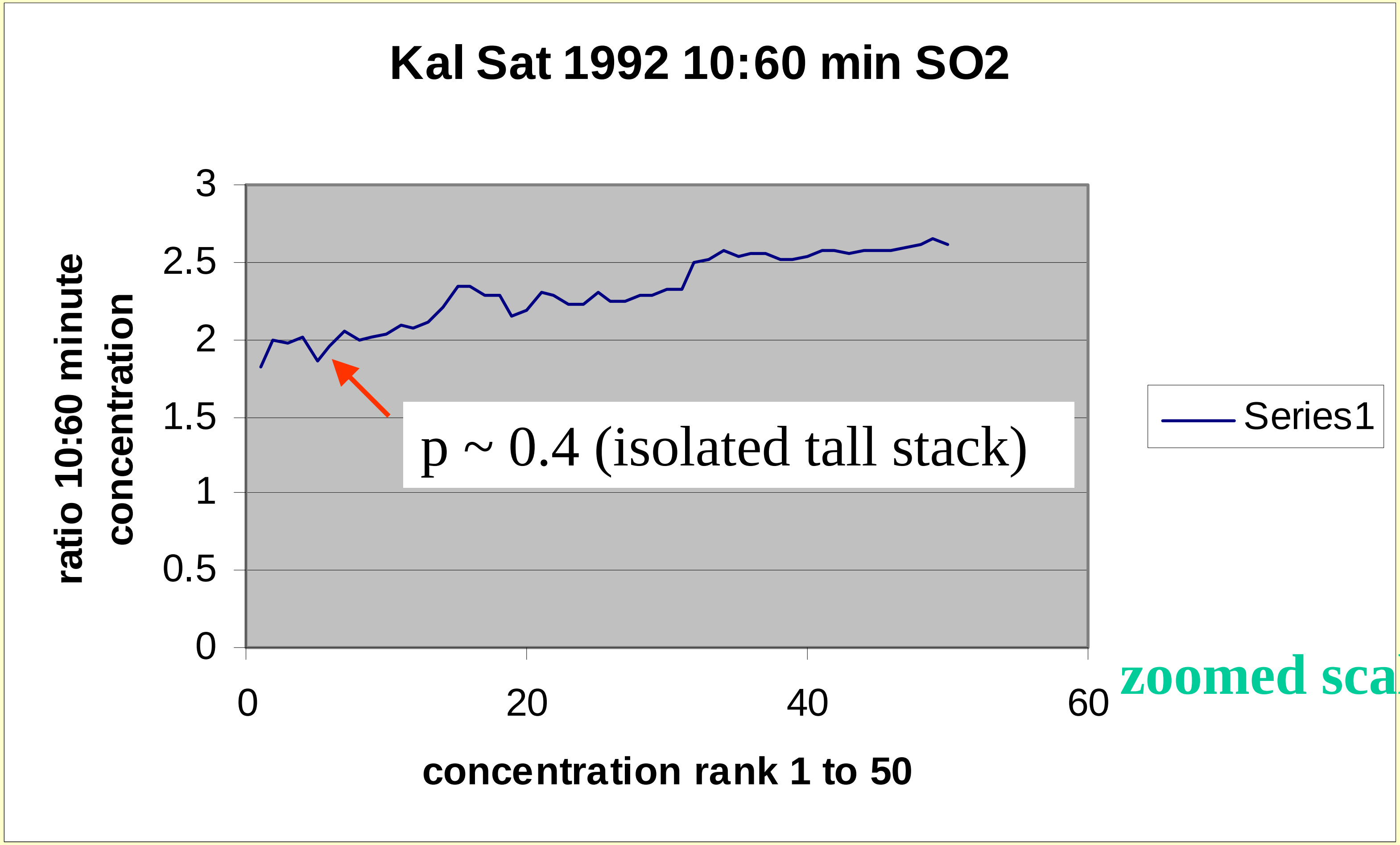
Rank	Hi Hour date	Hi Hour time	Hi 10min in hour date	Hi 10min in hour time
1	27091979	700	22011980	1400
2	20011980	1600	20011980	1600
3	27091979	600	17121979	1500
4	22021980	1500	5031980	1200
5	30031980	1500	6011980	1500
6	10041980	1700	30031980	1500
7	20011980	1700	25121979	1200
8	28021980	1500	27091979	700
9	25021980	1400	9021980	1400
10	27091979	500	5011980	1300
11	18011980	1400	22021980	1500
12	5031980	1700	28021980	1500
13	25021980	1500	20011980	1700
14	25111979	1400	10121979	1500
15	25121979	1200	29021980	1500
16	27091979	800	27091979	600
17	22011980	1400	5031980	1700
18	26011980	1500	11041980	1600
19	30031980	1600	20121979	1500
20	11041980	1600	19121979	1400

← only one simultaneous (rank 2)

unpaired ranked values of hours and highest 10 min within hours

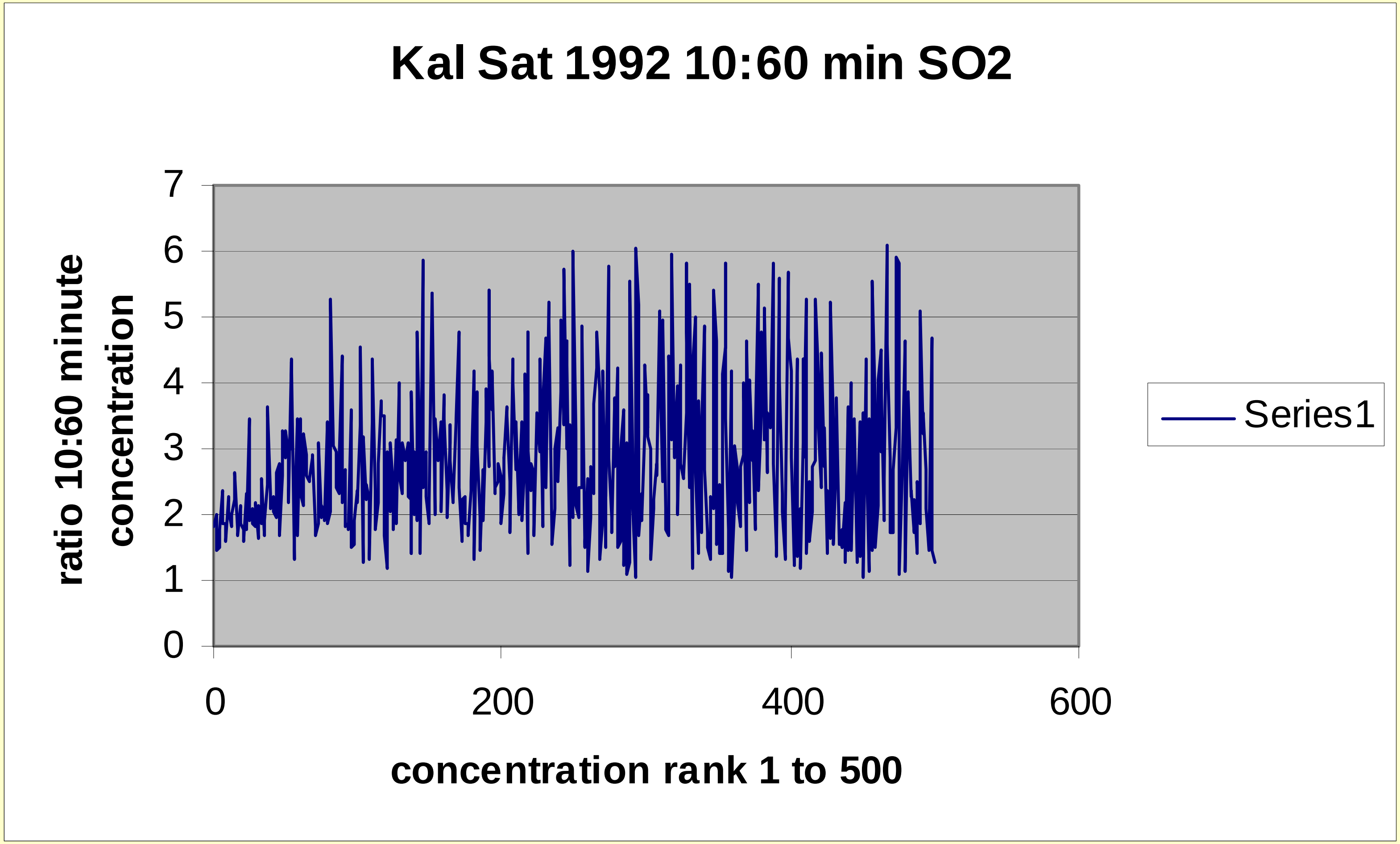


unpaired ranked values of hours and highest 10 min within hours



zoomed scale

<u>paired</u> values of hours and highest 10 min within hours, ranked by the hour values



NSW odour policy extracts (Katestone)

- The mean concentration refers more to the predictable concentration at a given point for an averaging period long enough to reduce stochastic variability to a reasonable level. The generalisations used in most practical models for mean concentrations (such as profile and turbulence parameters) are only valid for an ensemble of realisations. There is an increasing inherent uncertainty (caused by the imprecise specification of turbulence and wind fields) with decreasing averaging time.
- As ensemble averages can only be well-approximated by averages over many time periods of atmospheric motion, the reference time period for mean concentration predictions must be carefully chosen (and is almost certainly not 3 minutes). For convective conditions the relevant time scale is approximately 3 to 5 minutes and hourly averages are a sensible choice. For stable conditions, the time scale may be considerable if mesoscale eddies are present and the averaging period will be at least one hour.

Modelling short-term averages

- if short-term (or "peak") concentrations are to be estimated from modelled 1-hour averages, it is essential that the power law exponent (or P/M ratio) be matched to the model and its assumptions (or vice versa), because various models (or options within a model) account quite differently for dispersion caused by large scale motions.
- e.g. within Calpuff, PG curves give quite different results to the micromet. option (which uses large default lower limits on σ_v to account for plume meander)

Conclusion

- averaging time adjustment as per Ausplume is flawed for volume, area and line sources. Should only be used (with care) for point sources.
- processing of emissions or concentrations using **appropriate** concentration power law exponents to provide unpaired concentration estimates for various source types is feasible.
- ambient monitoring of point source plumes gives some confidence to applying a single power law exponent to high **percentiles**, not just the maxima, i.e. for deriving percentiles of "highest 3 or 10-minute average within hours" from unpaired percentiles of 1-hour averages.