Selection of representative atmospheric data from continuous in-situ measurement series

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Background

Global Atmosphere Watch network (GAW)
Background level of atmospheric measurements (baseline concentrations)
Still influenced by local activities (both anthropogenic and biogenic)

Figure 1: 31 GAW Global stations (https://www.wmo.int/pages/prog/arep/gaw/measurements.html).
Research question

How to improve the compatibility of in-situ measurements and extract useful information for the measuring target and measurement site?

Figure 2: Overview of general data flow for continuous measurements in the GAW network.
Data selection

Meteorological, tracer, and statistical selection methods (Ruckstuhl et al., 2012)

Selection by meteorological parameters
- Wind speed and wind direction (e.g., Lowe et al., 1979)
- Fixed time window (e.g., time-of-day filtering, Brooks et al., 2012)

Selection by tracers
- CO, CH$_4$ (e.g., Sirignano et al., 2010)
- Radon (e.g., Chambers et al., 2016)

Selection by statistical properties
- Only on the time series of interest
- Data variability (e.g., within-hour, hour-to-hour, Thoning et al., 1989)
- Statistical model (e.g., REBS, Ruckstuhl et al., 2012)
ADVS

Adaptive Diurnal minimum Variation Selection

An automated algorithm to select data for baseline condition

Based on statistics of diurnal variation

Developed by a study of atmospheric CO$_2$ at elevated mountain stations

- Episodic CO$_2$ enhancement due to anthropogenic emissions (winter)
- Convective upwind transport with depleted CO$_2$ concentrations due to photosynthesis uptake (summer)

Figure 3: Mean diurnal variation of hourly CO$_2$ averages from 2010 to 2015 at Zugspitze-Schneefernerhaus (ZSF).
ADVS

Goal: to select time periods with minimum variation diurnally and dynamically.

Two assumptions for baseline condition at elevated mountain stations

- Air masses measured at elevated mountain stations represent well-mixed air, closest to baseline condition during midnight of the day.
- Time window

- The baseline condition is not subject to local influences and thus represents unperturbed lower free tropospheric air masses.
- Data with minimal variability

Two steps
- Starting selection
- Adaptive selection
Starting selection

Goal: to find the *start time window* for all days.

Example:

Figure 4: Hourly CO$_2$ averages from 2010 to 2015 at ZSF.
Starting selection

1. Detrending by 3-day average.

Example:

Figure 5: Detrended hourly CO$_2$ averages from 2010 to 2015 at ZSF.
Starting selection

2. Calculate detrended mean diurnal variation.
3. Select the time window with the smallest standard deviation.

Example:

Figure 6: Detrended mean diurnal variation of hourly CO$_2$ averages from 2010 to 2015 at ZSF.
Adaptive selection

Goal: to select the most suitable time window for each day.

Figure 7: Stepwise forward adaptive selection of hourly CO$_2$ averages in Jan 2010 at ZSF.
Adaptive selection

Figure 8: Stepwise backward adaptive selection of hourly CO$_2$ averages in Jan 2010 at ZSF.
Figure 9: Example hourly CO$_2$ averages with ADVS data selection results in Jan 2010 at ZSF.
ADVS

Figure 10: Example hourly CO$_2$ averages with ADVS data selection results in Aug 2011 at ZSF.
Measurement series

Target: Hourly CO$_2$ averages at six European mountain stations with GAW network.

- Zugspitze-Schneefernerhaus (ZSF, 2670 m a.s.l.)
- Jungfraujoch (JFJ, 3580 m a.s.l.)
- Sonnblick (SNB, 3106 m a.s.l.)
- Schauinsland (SSL, 1205 m a.s.l.)
- Hohenpeissenberg (HPB, 934 m a.s.l.)
- Izaña (IZO, 2373 m a.s.l.)
Selected results

Figure 12: Hourly CO$_2$ averages with ADVS data selection results at six GAW stations.
Percentage of selected data vs. elevation

Figure 13: Linear regression between percentage of selected data and sampling elevation for continental sites.
Seasonal-trend decomposition

(StL, Cleveland et al., 1990)

**Figure 14:** STL decomposed results from different data selection methods: trend, seasonal and remainder components.
Correlation analysis

Figure 15: Pearson's correlation matrices of trend plus seasonal components (T+S), and remainder components only (R). Values shown are only significant correlation coefficients at 0.95 confidence level.
Conclusions

ADVS: A novel statistical method for selecting representative data of atmospheric CO$_2$ for baseline condition at GAW mountain stations.

- A significant linear relationship between the percentage of ADVS-selected data and sampling elevations of the measurement sites.

- Compared with other statistical methods, ADVS resulted in higher correlations in trend and seasonal components, and lower correlations in remainder components.

- A useful and generalized tool (option) for data selection.

Citation:

A revision of this manuscript was accepted for the journal Atmospheric Measurement Techniques (AMT) and is expected to appear in due course.
Outlook

Other data selection methods (meteorological parameters, tracers, …)

Other types of measurement sites in other regions (seaside stations, …)

**Figure 16:** 30-min CO$_2$ averages in 2016 at ZSF.
Data selection

**Figure 17:** 30-min CO₂ averages with data selection results in 2016 at ZSF.
# Combinations

Table 1: Contingency table of combinations of data selection methods.

<table>
<thead>
<tr>
<th>Set of independently applied selection methods*</th>
<th>Number of selected data in common</th>
<th>Percentages (%) in total number of data (15,285 = 1 year)</th>
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</thead>
<tbody>
<tr>
<td>A,C,W,R</td>
<td>612</td>
<td>4.00</td>
</tr>
<tr>
<td>A,C,W</td>
<td>479</td>
<td>3.13</td>
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<td>A,C,R</td>
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<td>0.17</td>
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<td>4.46</td>
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<tr>
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<tr>
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<td>0.10</td>
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<tr>
<td>A,W</td>
<td>543</td>
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<tr>
<td>A,R</td>
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<tr>
<td>C,R</td>
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<td>1.20</td>
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<tr>
<td>NA</td>
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<td>1.89</td>
</tr>
</tbody>
</table>

*A: ADVS method; C: CH₄ method; W: Wind method; R: Radon method; NA: not selected.*
Thank you very much.

Questions?

Acknowledgements
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Back up: Starting time windows

Figure: Detrended mean diurnal variations at six GAW stations.