A new statistical method for determining regional baseline concentrations of atmospheric trace gases

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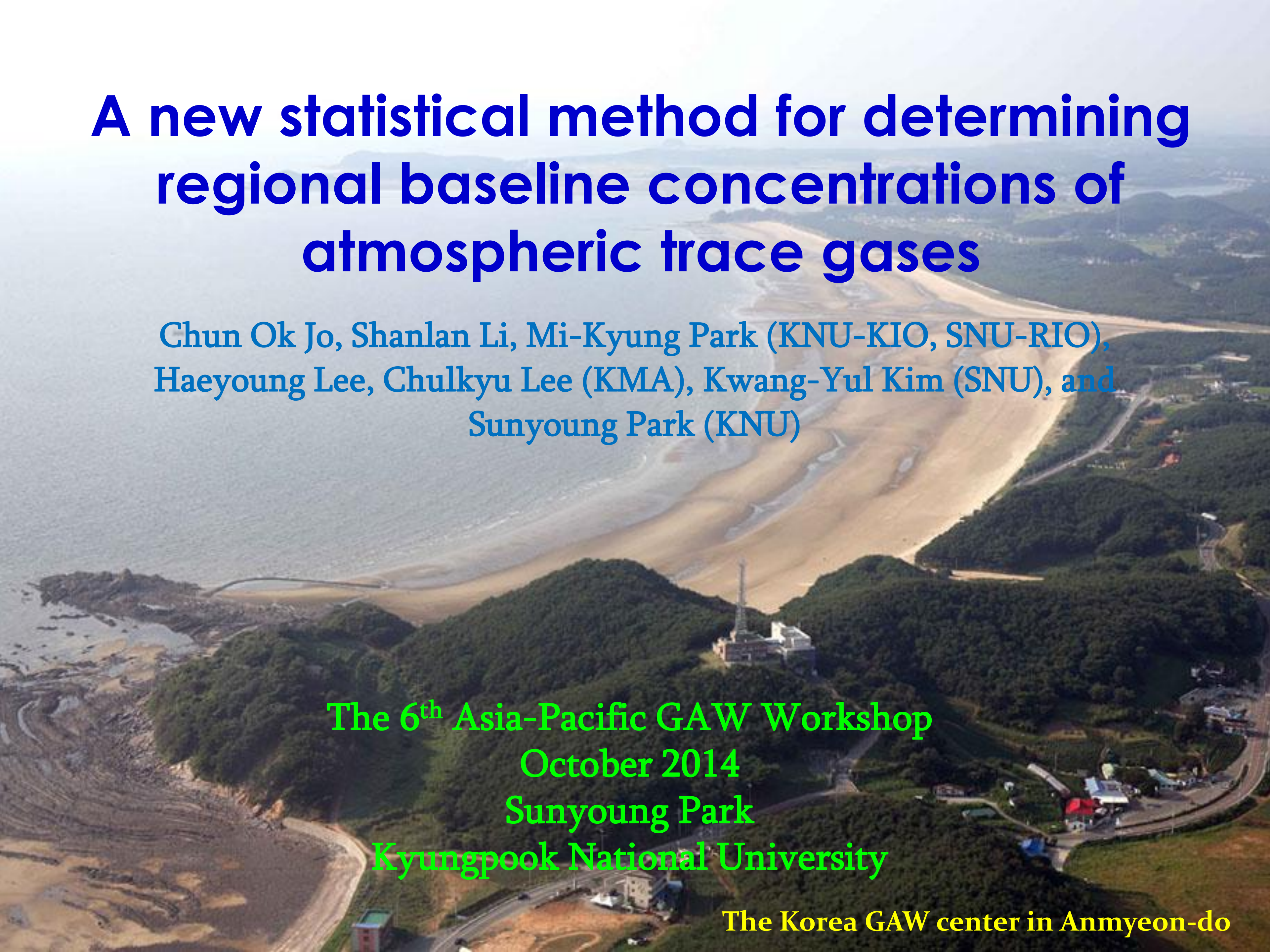
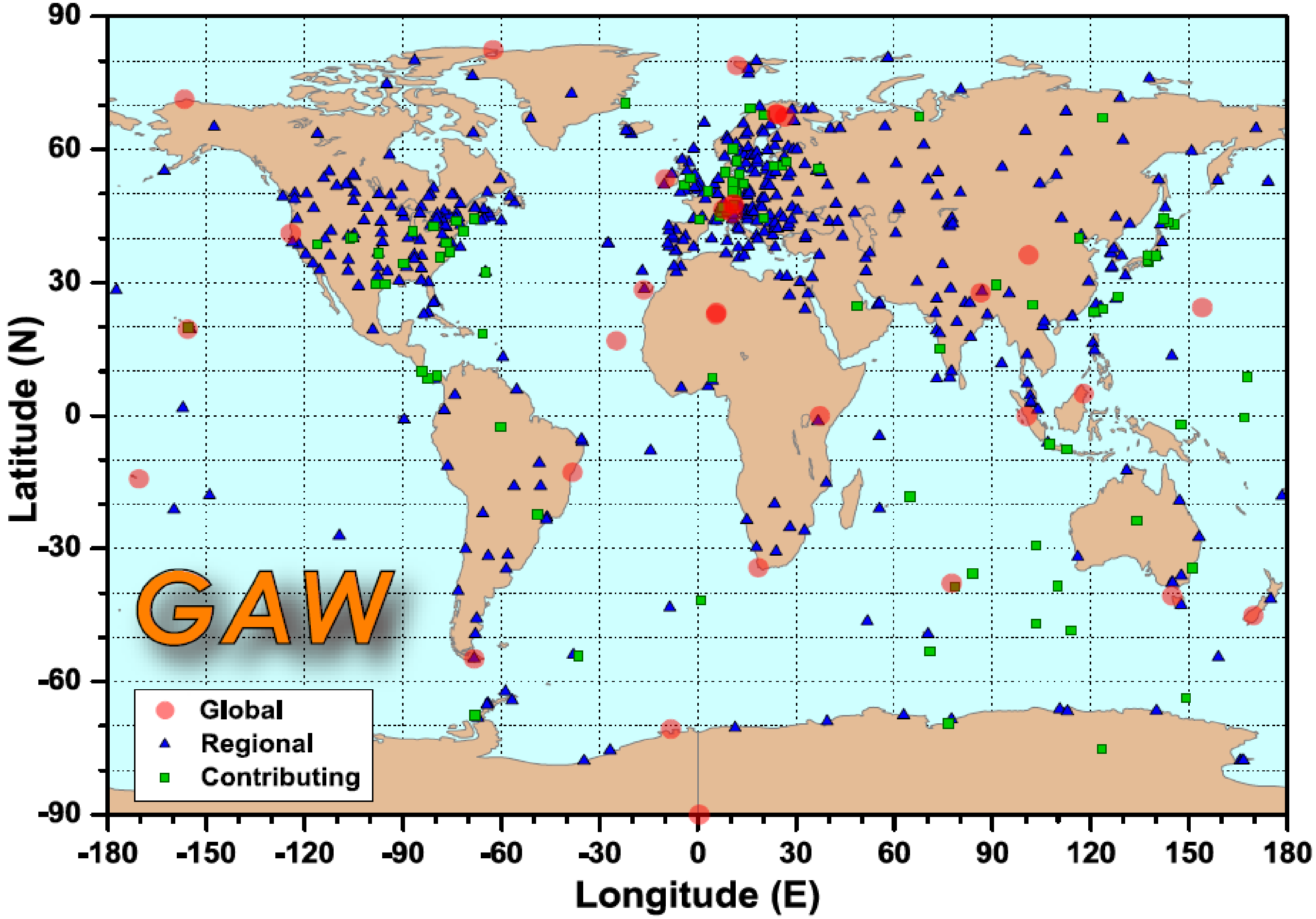
Kyungpook National University



The Korea GAW center in Anmyeon-do

GAW Monitoring Stations

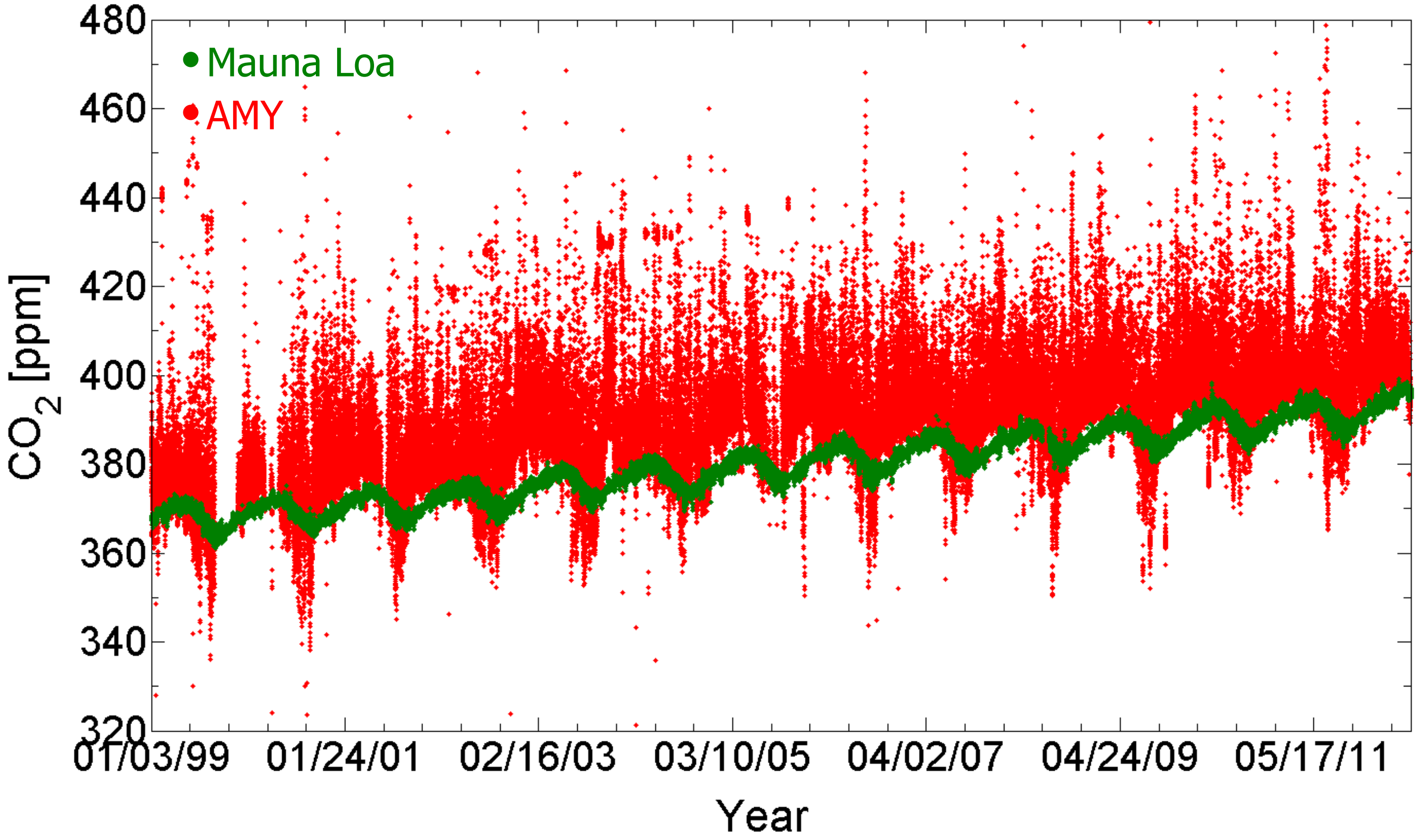
Global vs. Regional



- Atmospheric CO_2 concentrations at "regional" GAW stations: ***a complex mix of local, regional, global sources and sinks***

GAW Monitoring Stations

Global vs. Regional



- Atmospheric CO_2 concentrations at "regional" GAW stations:
  a complex mix of local, regional, global sources and sinks

Baseline Concentrations of Trace Gases

Underlying concentration in the absence of all local and regional effects

Why important?

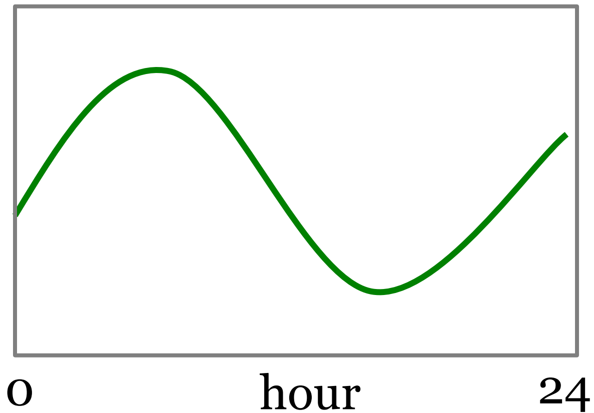
- To investigate the natural variations and trend in atmospheric concentrations and the regulating processes
- To identify the contribution of local and regional pollutions
- To provide appropriate data for model-observation comparisons

Baseline CO_2 Concentration

Fundamental components of baseline signal:
Diurnal variations + Seasonal cycle + Trend

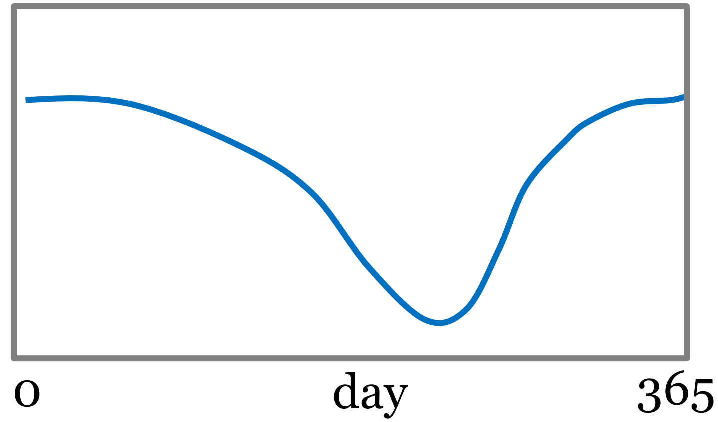



Natural Variations

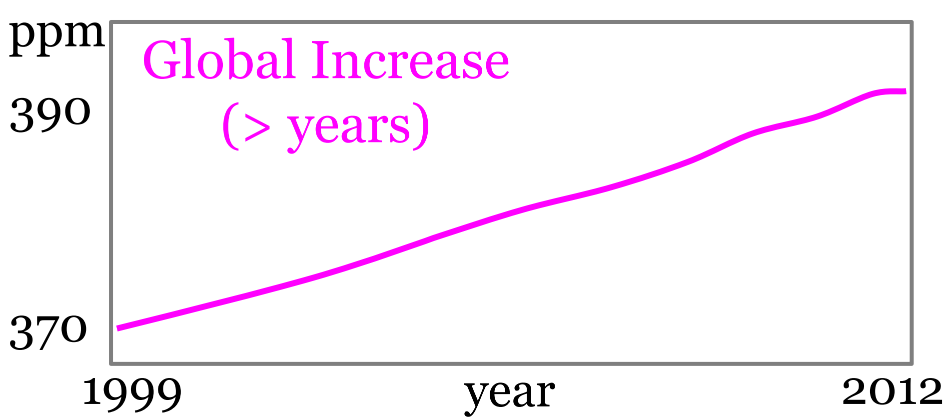


24 hours

+



365 days



Baseline CO_2 Concentration

A new method based on cyclostationary empirical orthogonal function (CSEOF) analysis

$$\boxed{C(t) = \sum_n B_n(t) T_n(t)}$$

Loading vector: $B_n(t) = B_n(t+d)$ Physical Evolution (deterministic)

PC time series: $T_n(t)$ Temporal undulation (stochastic)

d, d': nested periods

$$\boxed{T_n(t) = \sum_m D_m^{(n)}(t) P_m^{(n)}(t)}$$

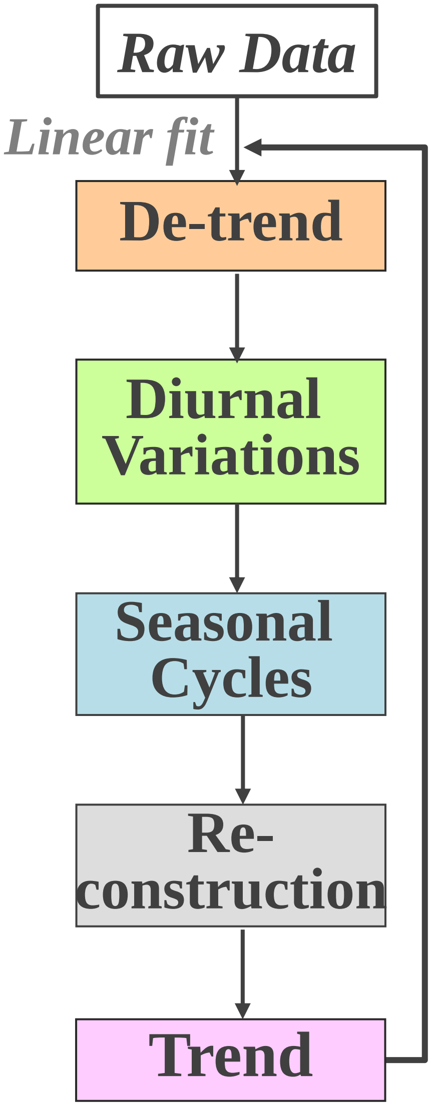
Loading vector: $D_m^{(n)}(t) = D_m^{(n)}(t+d')$

PC time series: $P_m^{(n)}(t)$

- CSEOF analysis decomposes time series data into a series of physical (deterministic) evolution and corresponding amplitude (stochastic) time series.

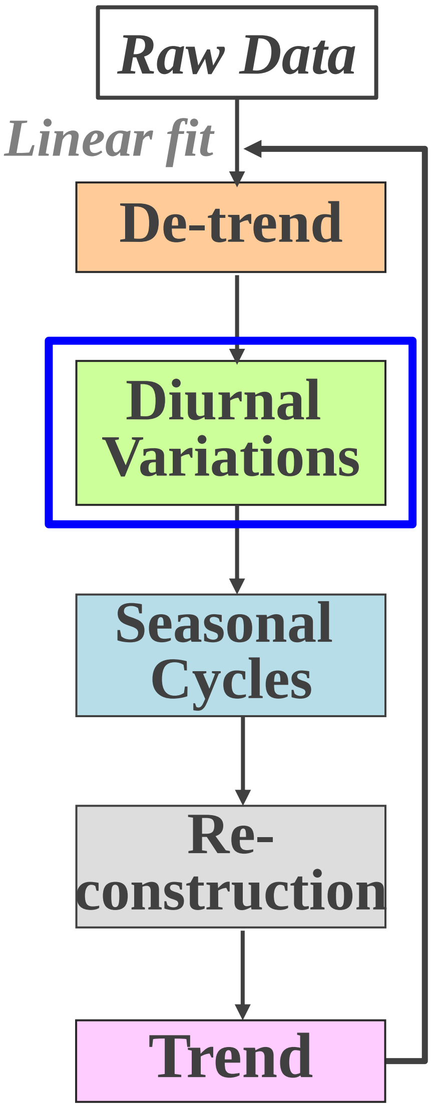
Kim, K.-Y., and G. R. North, 1997

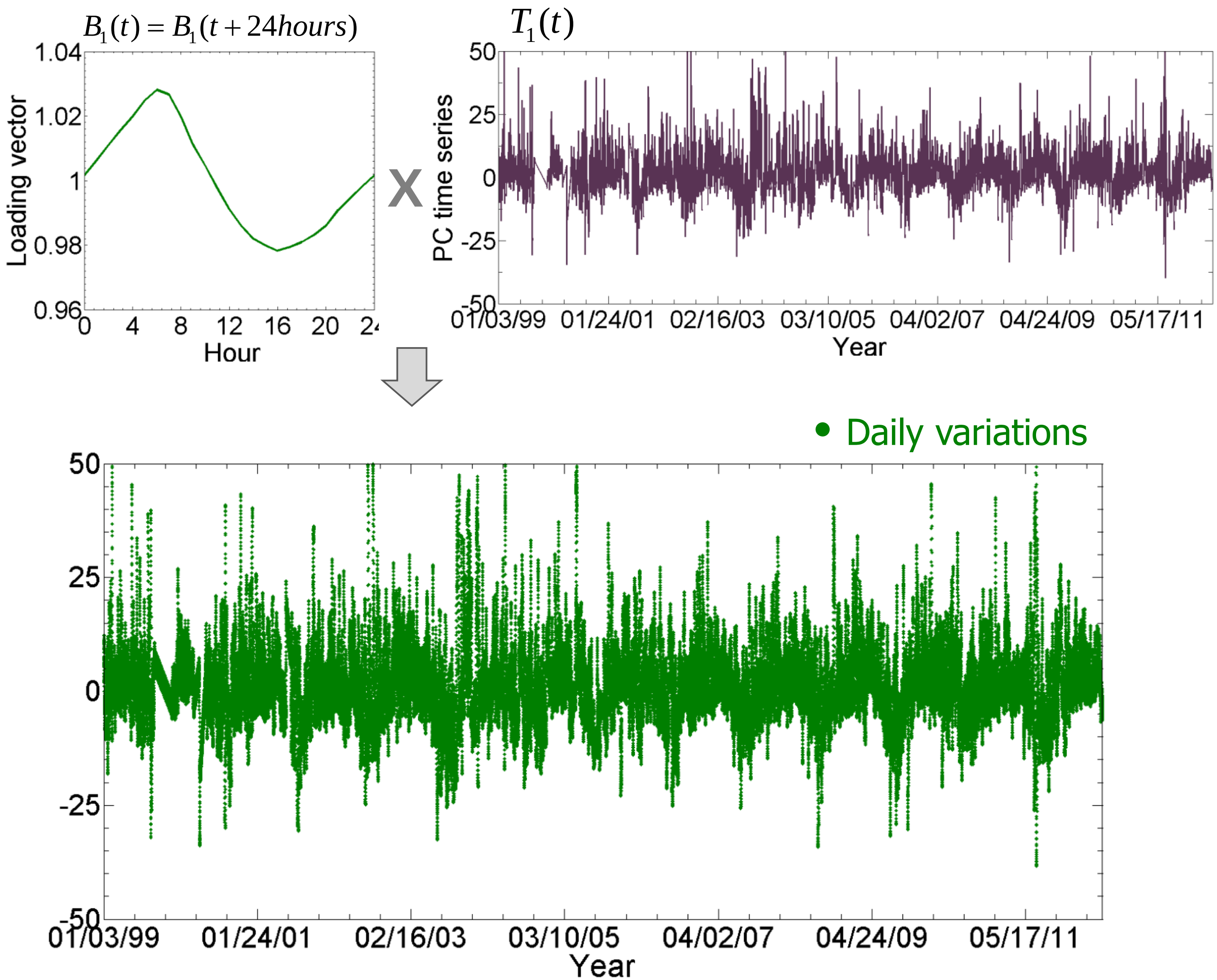
KIO Method


Raw Data
Linear fit
De-trend
Diurnal Variations
Seasonal Cycles
Re-construction
Trend

KIO Method for Regional KGAWC Station

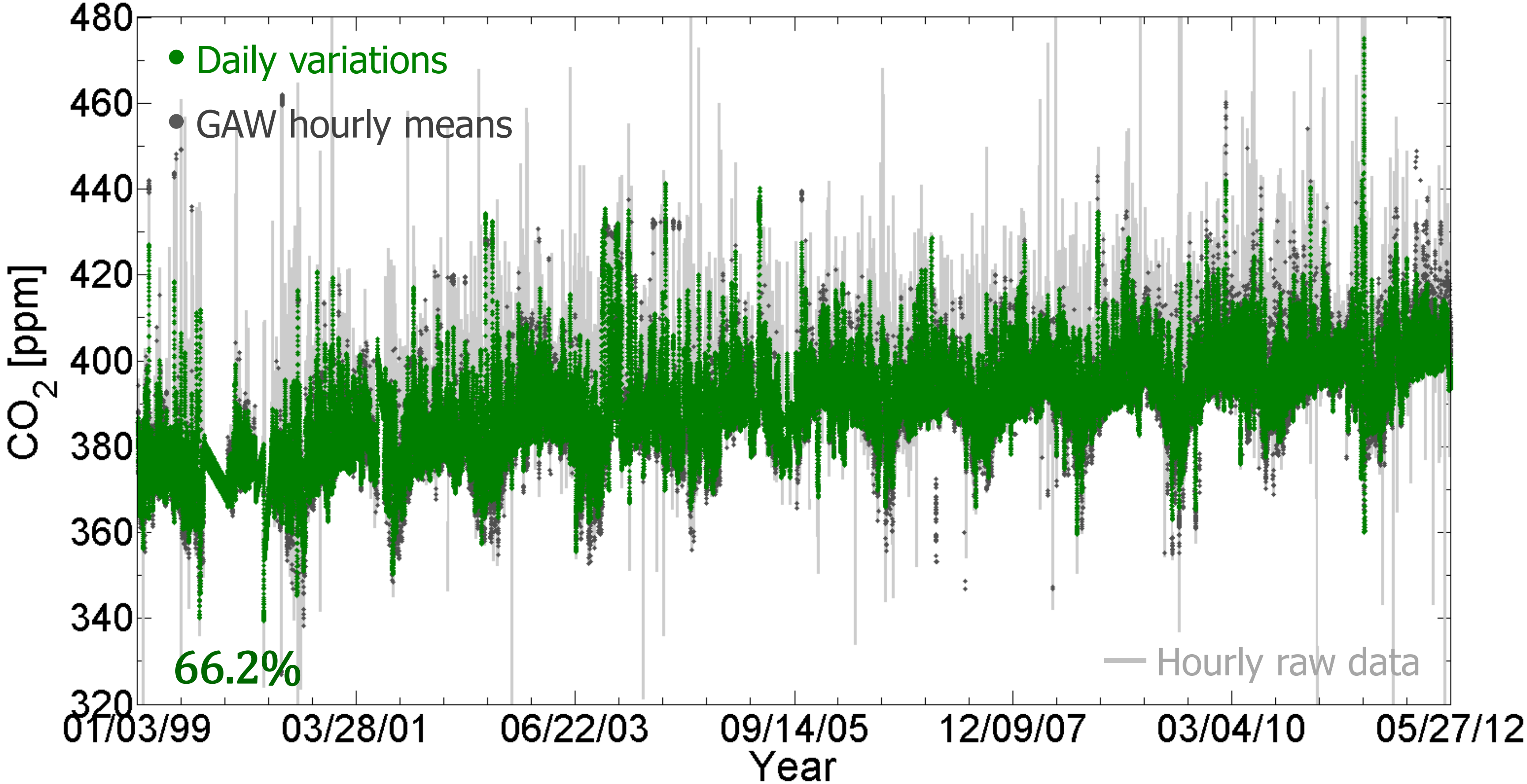
Signals representing daily variations





KIO Method for Regional KGAWC Station

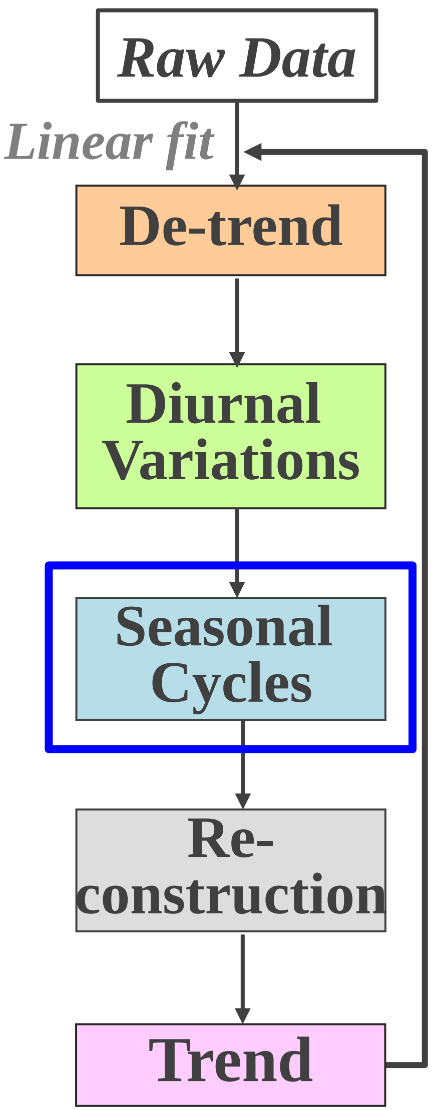
Signals representing daily variations

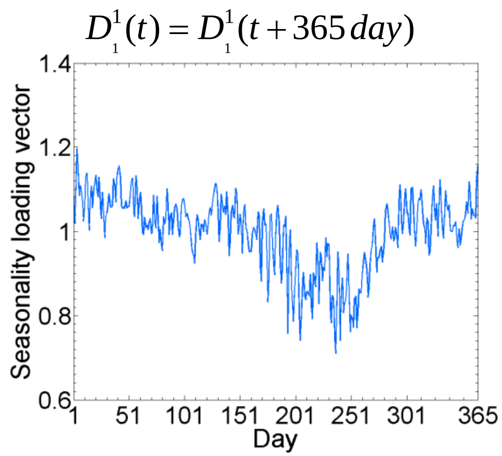


- Reconstructed hourly concentration data from daily variations in good agreement with the hourly data selected based on the GAW criteria

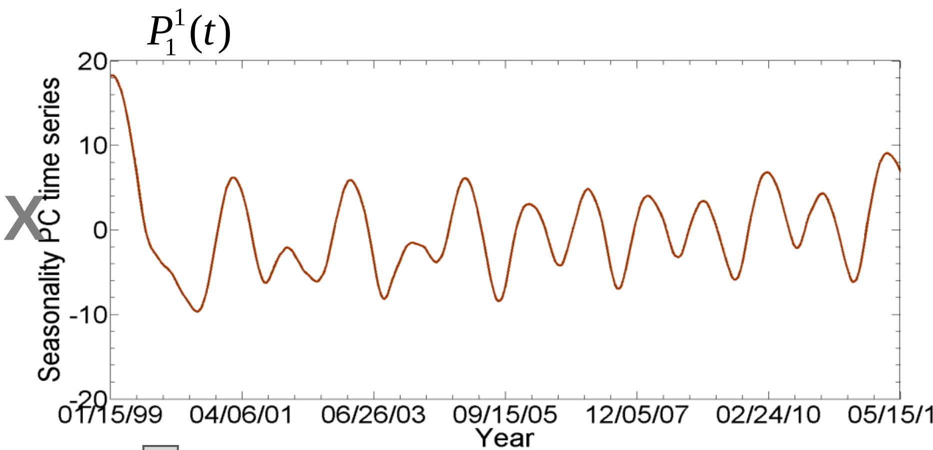
KIO Method for Regional KGAWC Station

Signals representing seasonal cycles

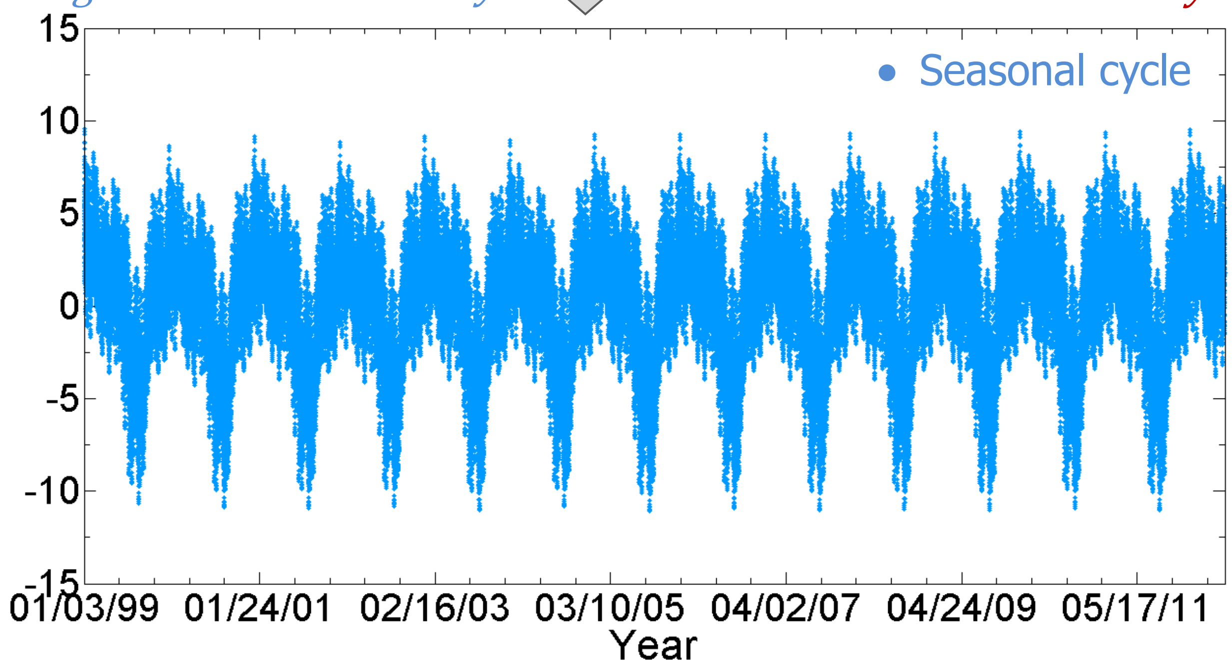




X

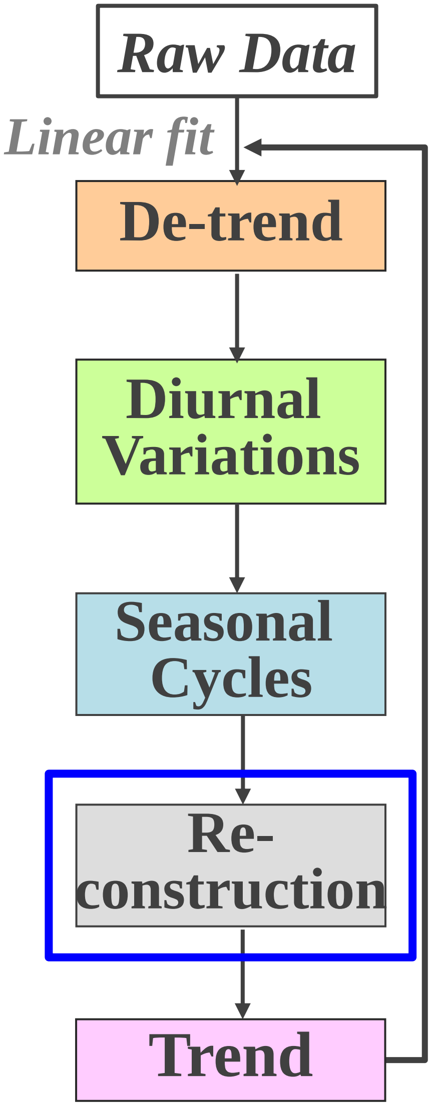


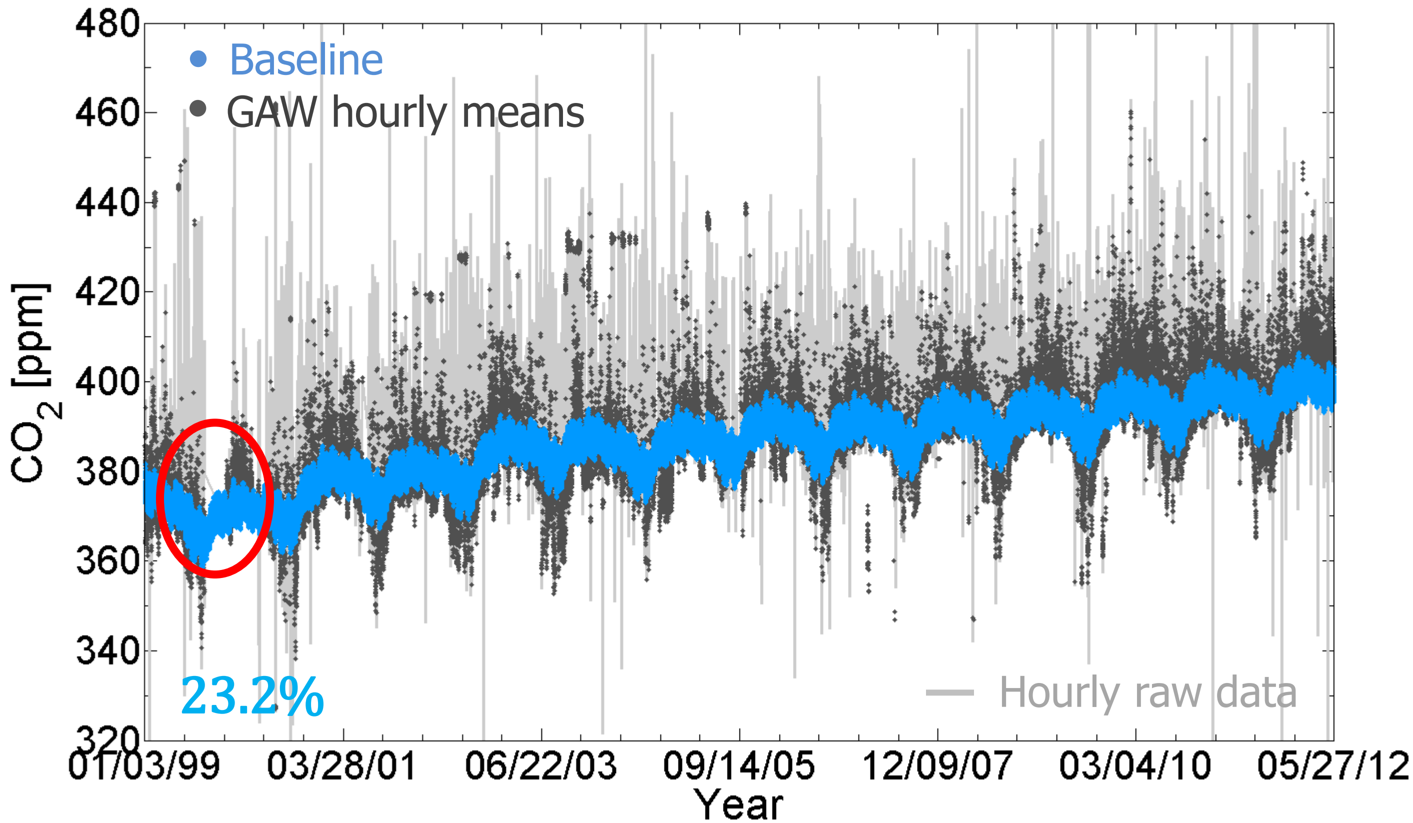
Loading vector for Seasonality *PC time series for Seasonality*



KIO Method for Regional KGAWC Station

Reconstructed baseline concentration data

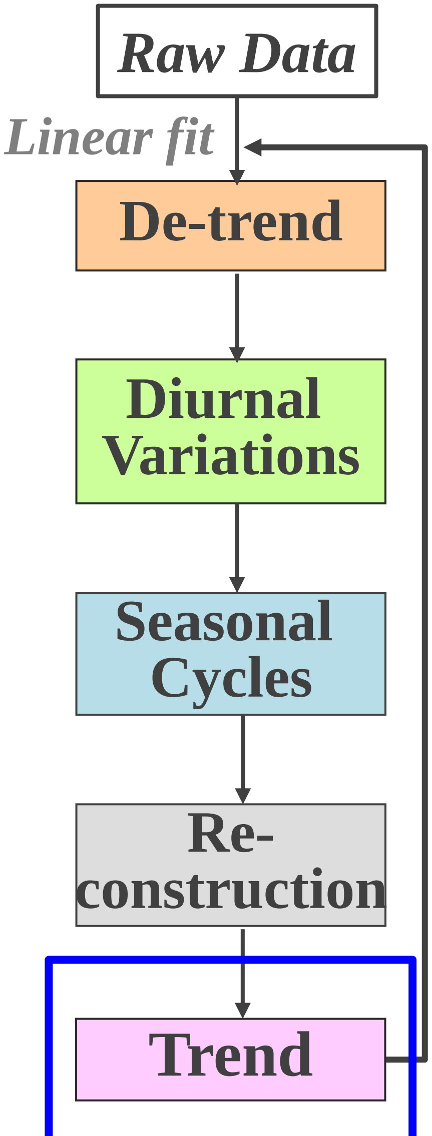


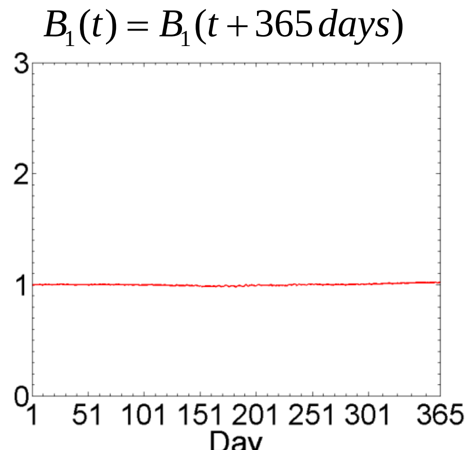


- ➢ Unlike conventional methods, it describes temporally evolving pattern of periodic components (i.e., time-variant amplitudes of seasonality)
- ➢ Missing data are well reconstructed

KIO Method for Regional KGAWC Station

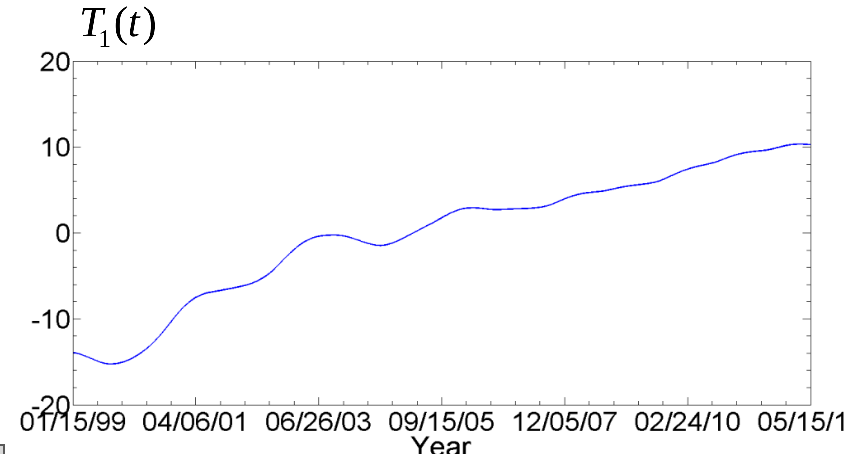
Year-to-year variations in the increasing tend



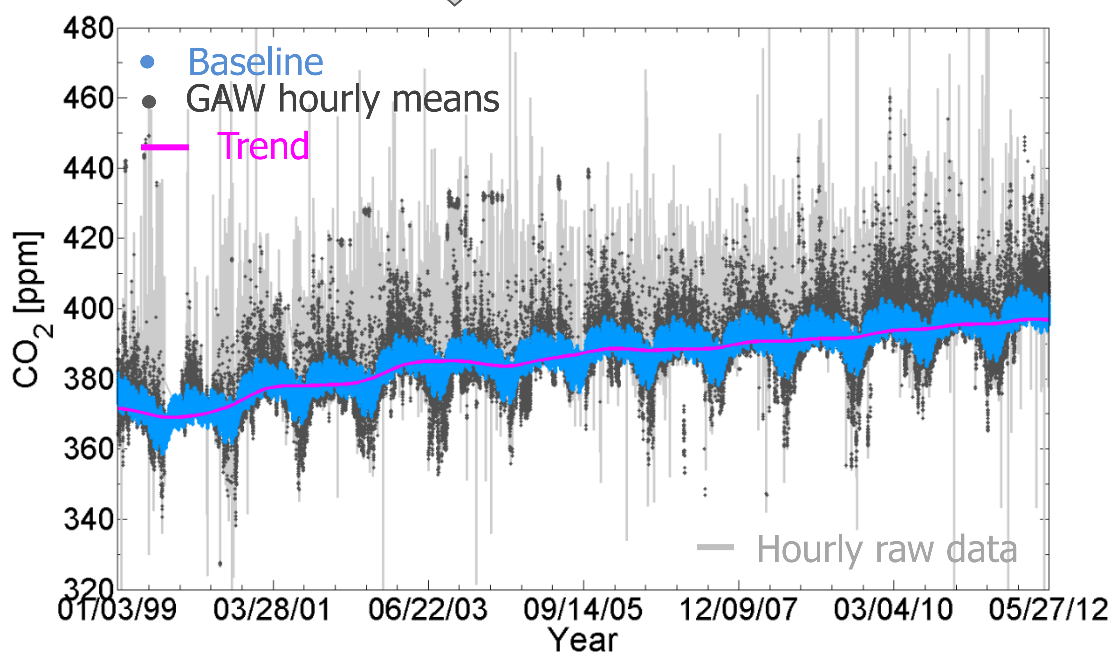


Loading vector for Trend

X

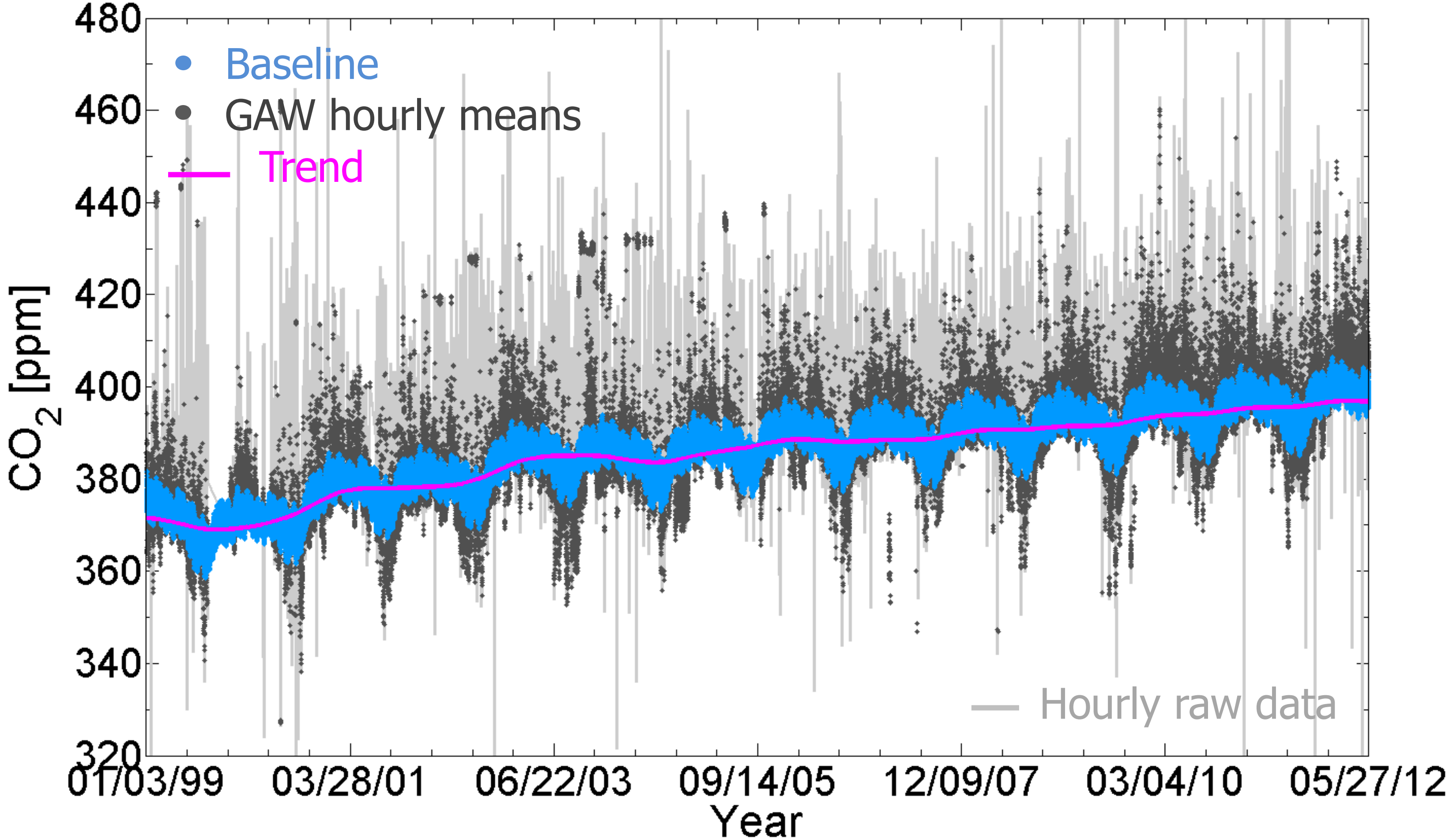


PC time series for Trend



KIO Method for Regional KGAWC Station

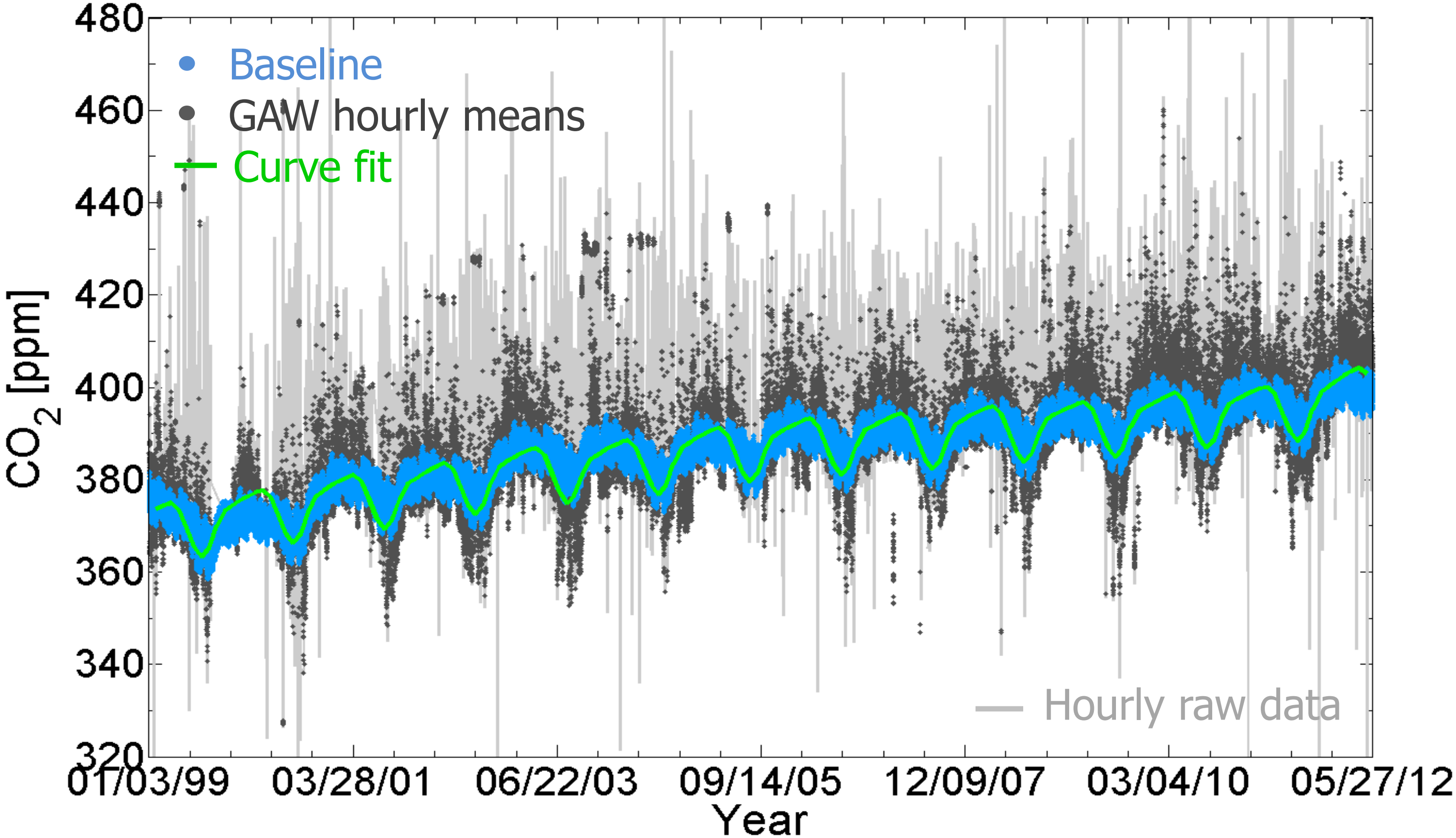
Comparison with the conventional curve fit



- Reconstructed hourly baseline concentration data correspond to a curve fit for the daily data selected by a low-pass filter

KIO Method for Regional KGAWC Station

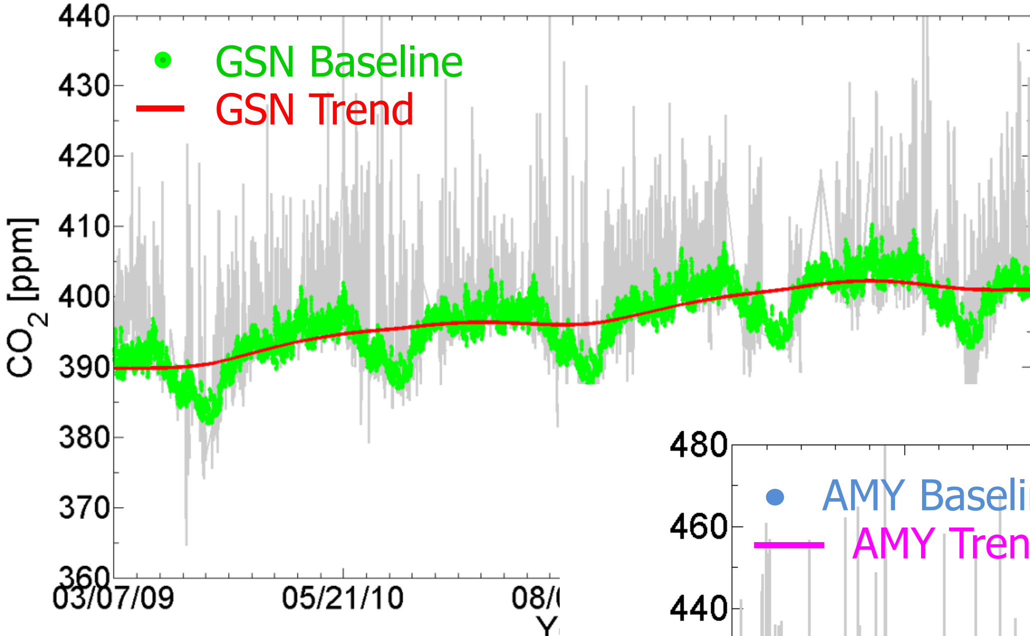
Comparison with the conventional curve fit



➢ Reconstructed hourly baseline concentration data correspond to a curve fit for the daily data selected by a low-pass filter

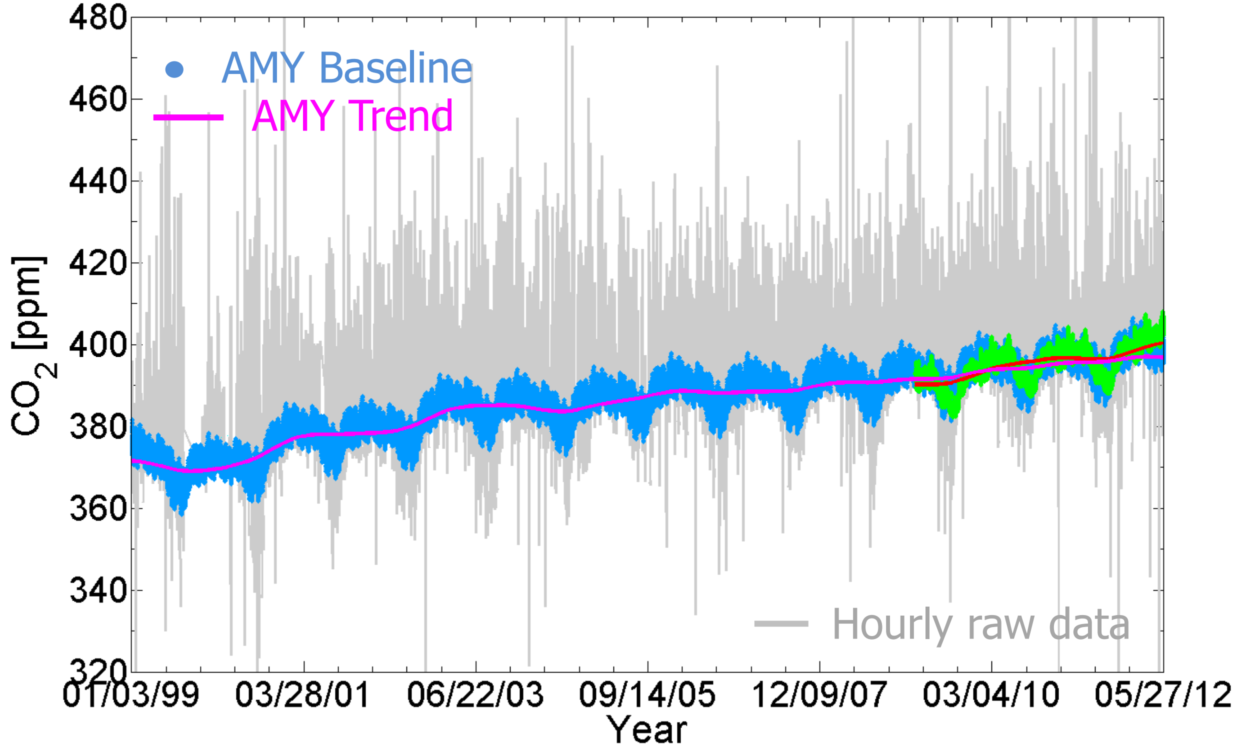
KIO Method for Regional KGAWC Station

Comparison with other regional stations

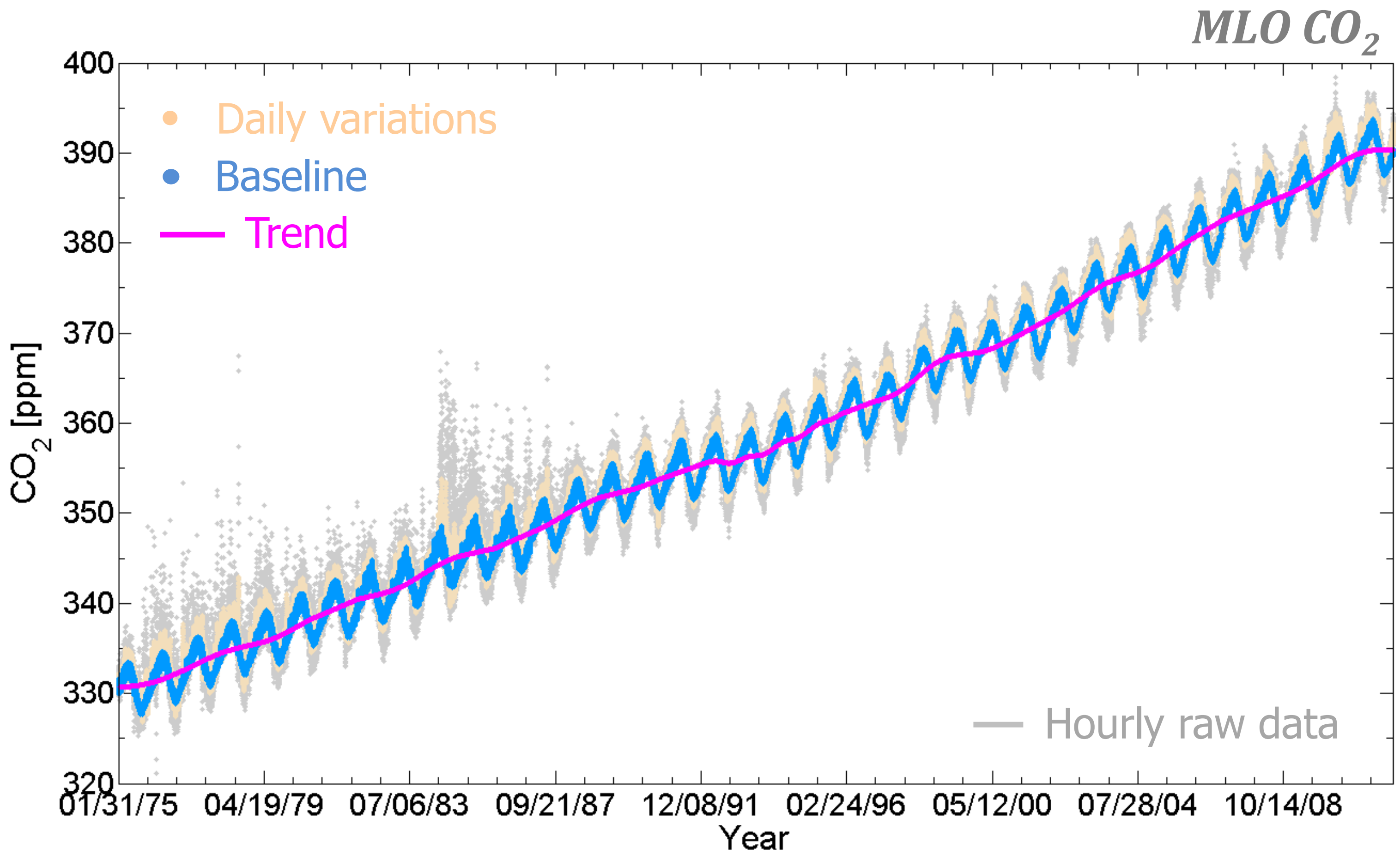


CO_2 at Gosan 2009 – 2012

Ameony-do vs. Gosan

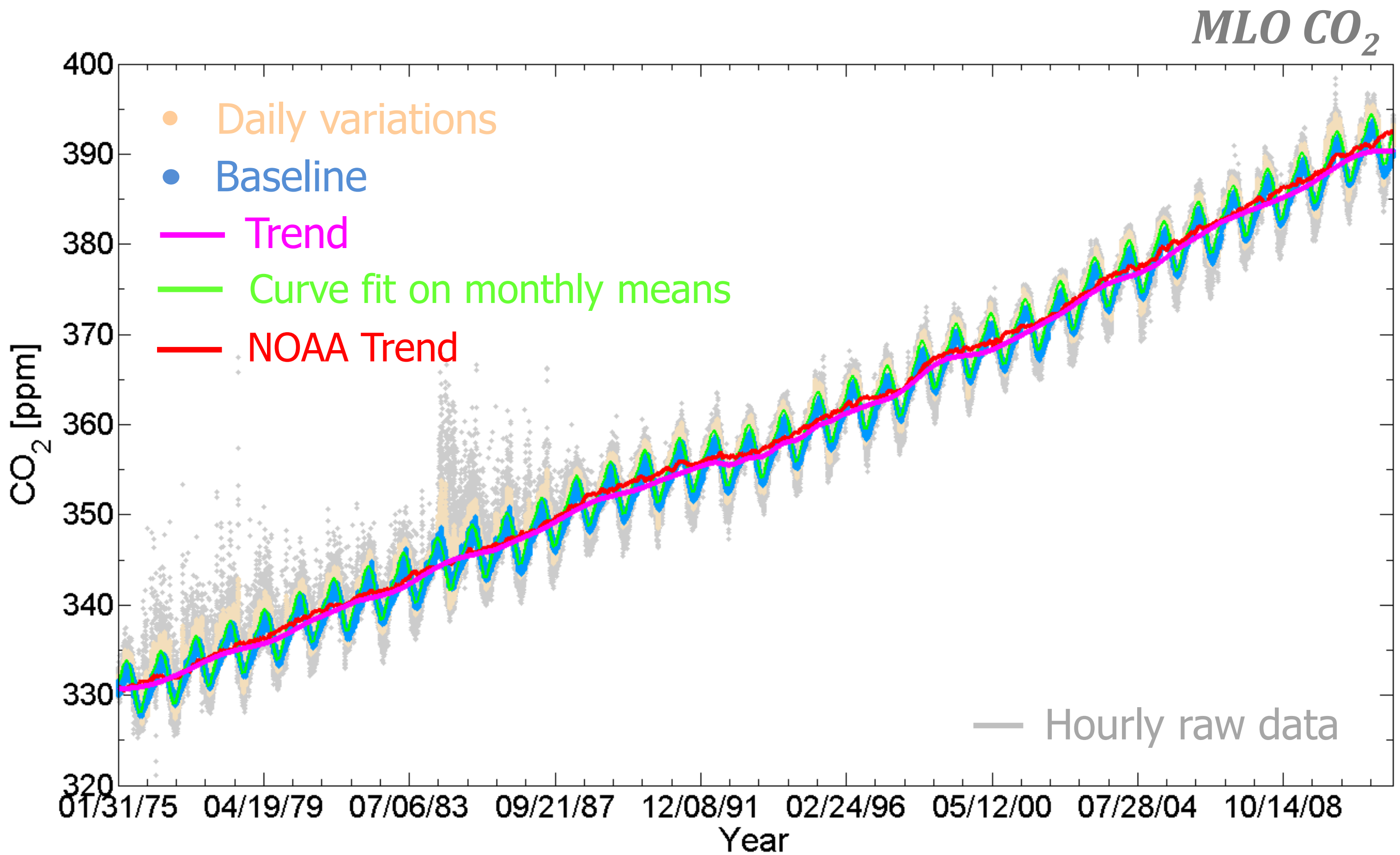


KIO Method for Global GAW Stations



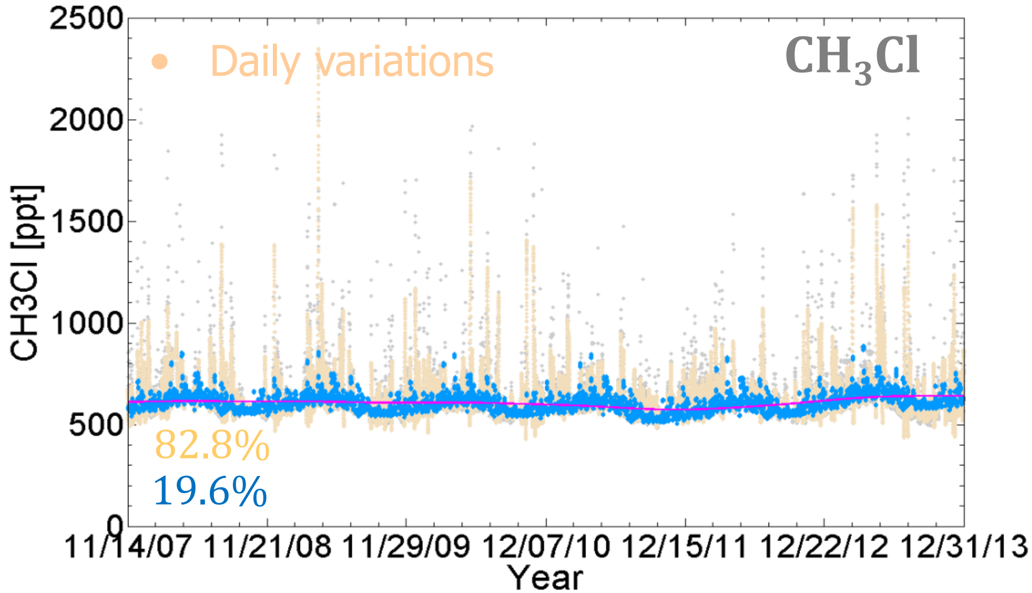
- The seasonal cycles and long-term trends derived by this approach are appropriate for the 40-year time series data of global background CO_2 concentrations from NOAA observatories at Mauna Loa, Samoa, Barrow, and South Pole

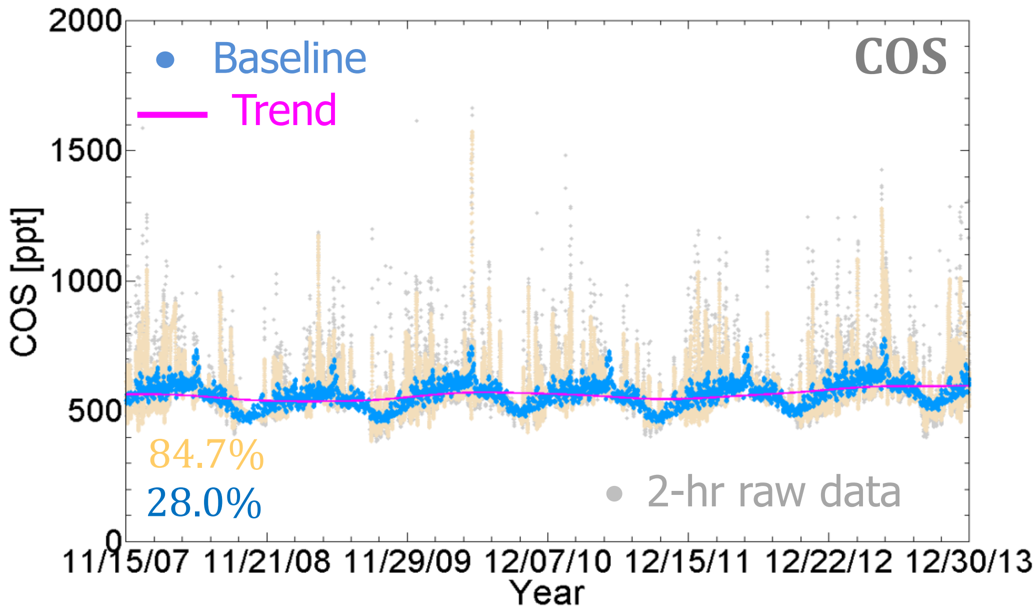
KIO Method for Global GAW Stations



- Detectable discrepancies of 0.5 – 0.8 ppm from the seasonal cycles and trends determined based on monthly means of selected data
- Different baseline definitions cause the discrepancy even at the global stations

KIO Method for Other Atmospheric Species



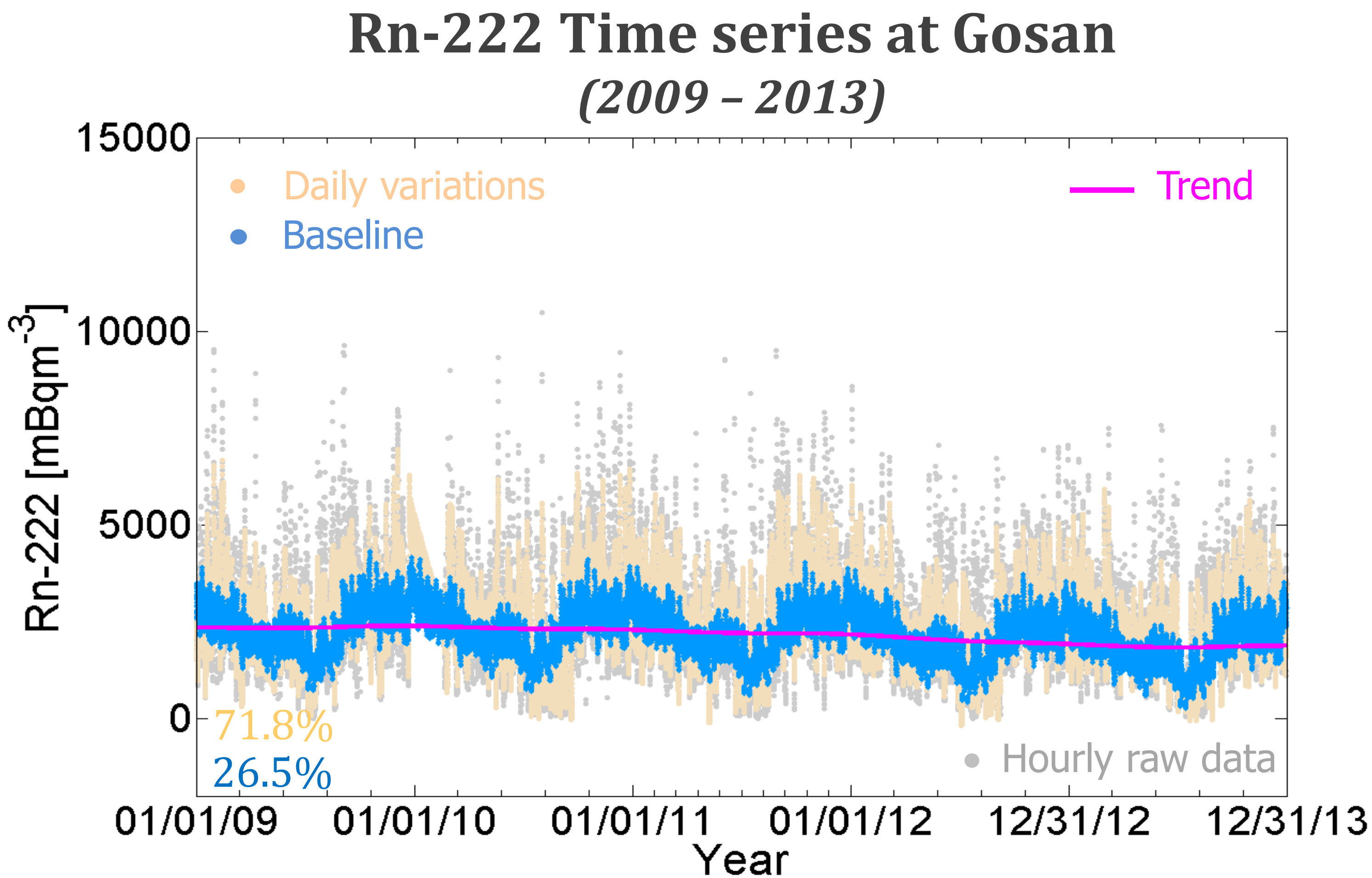


Time series at Gosan

(Mid-2007 – 2013)

- Natural variability due to production and consumption by marine biota
- Terrestrial photosynthesis driven seasonal cycles

KIO Method for Other Atmospheric Species



- This approach is useful to identify baseline signals for other atmospheric trace species having natural variations upon which local and/or regional influences act on.

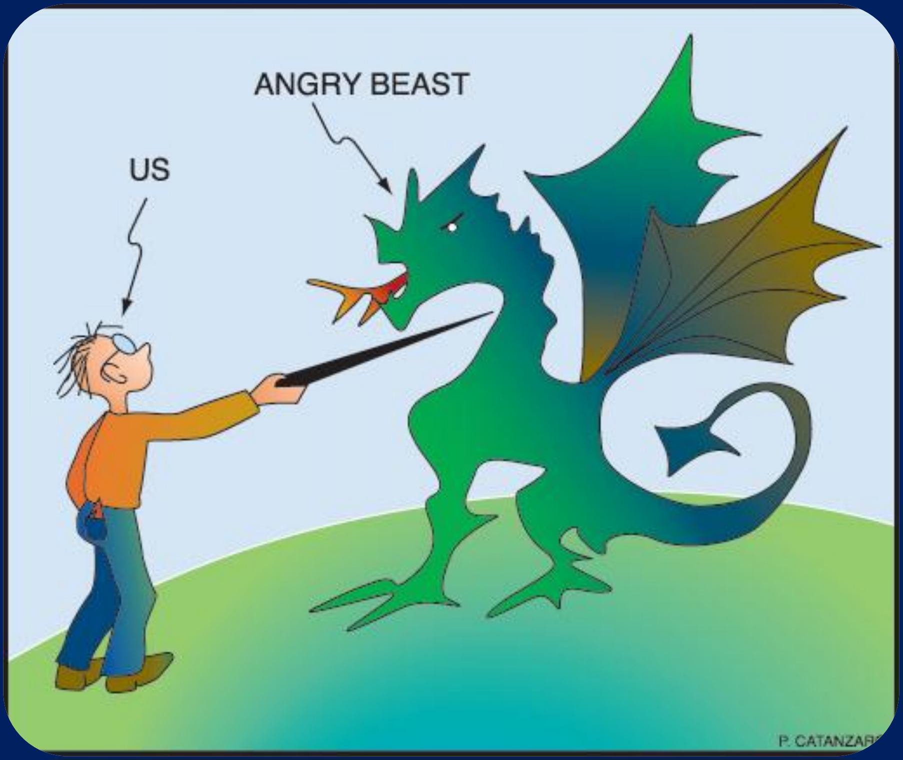
Summary

- ✓ A simple algorism based on CSEOF analysis were proposed to extract daily variations, seasonal cycles and trend from time series influenced by local/regional pollution events.
- ✓ Empirically-determined criteria for data selection and low-pass filters are not necessary.
- ✓ Time-variant magnitudes of periodicity and year-to-year variations in the trend are described.
- ✓ Baseline concentrations for other atmospheric species can also be reconstructed.

Some caveats:

I. Seasonality may not be 100% extracted only by the most dominant mode.

II. For the species without diurnal patterns, the baseline might be overestimated due to high-frequency pollution influences.



" By adding greenhouse gases to the atmosphere we are poking an angry beast!"

– Wallace Broecker

Thank you