Time-Series Analysis:
A Cautionary Tale

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What is time-series analysis?

• Useful tool for analysis of long-term data

• Lots of math and statistics

• Common pitfalls (bad assumptions)

• Practical example: Derivation of long-term trends in stratospheric ozone
Ozone is Important

- Earth’s “sunscreen”

- Destruction from CFCs (and other man-made compounds containing Cl and Br)


- Is it recovering?
How has it changed?
Methodology

• Data Resolution

• Regression Model
  – Choosing Predictor Variables
  – Orthogonal Function Analysis

• Multiple Linear Regression
  – Autocorrelation
  – Heteroscedasticity

• Residual Filtering
• Coefficient Filtering
Check your fits ...

Ozone at 23 km (10S-10N)

Ozone at 42 km (40N-50N)

Ozone at 32 km (60S-50S)
... and your residuals
Residuals Matter

Total Residuals

Uncorrelated Residuals
Sampling is Critical!

- SAGE observes the same latitude at the same times during the year
- Orbital degradation increases precession and causing a drift in sampling

- Diurnal variability (geophysical or algorithmic) is important at higher altitudes
Sampling Induced Biases

Sunrise Bias (25.0 km)

Sunrise Bias (45.0 km)

Sunset Bias (25.0 km)

Sunset Bias (45.0 km)
Trend Comparisons (Decline)
Trend Comparisons (Recovery)


Linear Trend or EESC?

Change from 1985 at 50° N (Piecewise)

Change from 1985 at 50° N (EESC)

Change from 1985 at Equator (EESC)

Change from 1985 at 50° S (EESC)
Conclusions

• Know your limitations! (watch out for pitfalls)
• Can mitigate biases introduced by non-uniform sampling
• Reproduce others’ work before doing something new
• Don’t be afraid to challenge the scientific community

• Want to know more?
  – http://www.atmos-chem-phys.net/14/13455/2014/acp-14-13455-2014.html
Extra Slides
Creation of volcanic proxy
Final volcanic proxy

MLR Volcanic Term

Latitude

LOG$_e$(Relative OD)

Result from regression

Peak Pinatubo Response

Altitude (km)

Latitude

Percent of Mean

-20 -10 0 10 20