The tail pipe of North America

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Outline

1) Introduction and Motivation
   – Location
   – Advantages to an ocean tower
2) Time series analysis
   – Analysis of atmospheric CO₂ measurements
3) Comparison with other results
   – CarbonTracker and Legrangian comparison
4) Conclusions
Motivation
Science Implementation Strategy for the North American Carbon Program (NACP)

Doney et al 2005
Air and Water System

- Insitu atmospheric CO₂ System
- NOAA/GMD 12 pack system

Water system

- Low Power (60W)
  - Passive temperature modulation
  - Mole sieve dryer and gravity feed condensate removal.
- Low standard and gas usage
  - Stop flow system gives 3 year life to each std.
- Remote control
  - completely operable remotely
Motivation

Small Local Footprint

3.5 km

10 m
Motivation

Synoptic scale transport drives variability at tower
Motivation

Location
Martha’s Vineyard CO₂ Record
Time Series

March 2007
Time Series

Fourier Analysis $\Rightarrow \sum_{j=1}^{\lfloor n/2 \rfloor} A_j \cos(k_j x + \varphi_j)$

- **Original time series**
- **1st Harmonic**
- **3rd Harmonic**
- **4th Harmonic**

<table>
<thead>
<tr>
<th>Harmonic</th>
<th>Frequency (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>20</td>
</tr>
<tr>
<td>3rd</td>
<td>5</td>
</tr>
<tr>
<td>4th</td>
<td>2.5</td>
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**Amplitude** and **Phase**
Frequency Spectrum

Parseval’s Theorem \( \Rightarrow \)

\[ \sigma^2 = \sum_{j=1}^{\leq n/2} A_j^2 \]

Slope = 2

2 hours \hspace{2cm} 2 days
Coherence Spectrum

\[ \sum_{j=1}^{\leq n/2} A_j \cos(k_j x + \phi_j) \]

CO\textsubscript{2} and Wind Direction

CO\textsubscript{2} and Barometric Pressure
CarbonTracker

March 2007
CarbonTracker

Jun. 01, 2007

CO₂ (ppm)

Day of year (2007)

June 2007
Tower is **not** capturing diurnal variability

Transport is replicated by CarbonTracker
Transport over Marine Boundary Layer
Conclusion

1. **Small local footprint:** Large (synoptic) scale variability dominates CO$_2$ signal at Martha’s Vineyard tower.

2. **Location:** MVY provides a strong constraint on off-shore and on-shore flow along N.E. coast of US for most of the year. Strong marine boundary gradients makes summer time observations difficult to assimilate.

3. **Representation:** Transport at the tower is well represented by large scale models like CarbonTracker (TM5/ECMWF) and Fluxpart (GFS)