EVALUATION TOOLS FOR BLACK CARBON MODELING.

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“Methods for evaluation of black carbon modeling”
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in preparation

Background

- BC is:

  an operational definition based on measurements of aerosol optical properties (LABS) aiming to quantify soot aerosol.

- BC is important for:

  air quality due to possible health effect

  influence on climate (direct effect, Radiative Forcing: 0.20 ± 0.15 Wm^{-2}; (IPCC, 2007))

What are we measuring?

LABS → BC mass

$$*M_{BC} = LABS / \sigma_{abs}$$

$$\sigma_{abs} = f(\lambda, \text{radius})$$

In ambient aerosol

$$\sigma_{abs} = f(\lambda, \text{radius, morphology, mixing state})$$

*Lambert-Beer equation – theoretical model

Goal

- Model/experiment agreement is commonly evaluated by comparison of mean values, but values do not follow a normal distribution. We need a more accurate model evaluation tool.
- We present 3 different approaches to compare/integrate the information gathered in experiment and model data

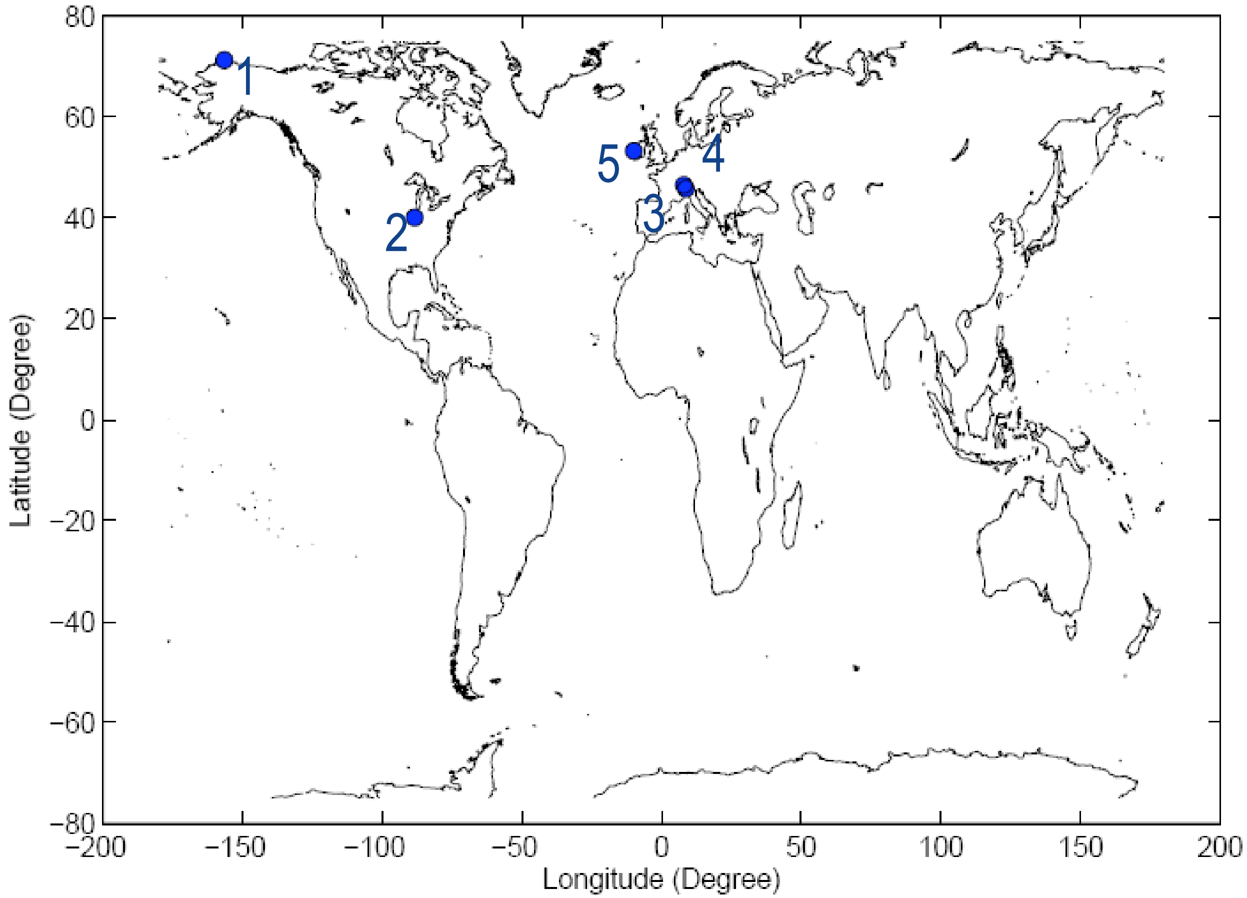
I. Correlation of medians

II. Frequency curves

III. Fourier transform

Database

- Model: TM5/M7 output with 1X1/6x4 resolution/ 2002-2003
- Experiment: GAW data (EBC and LABS) /2002 - 2003 *

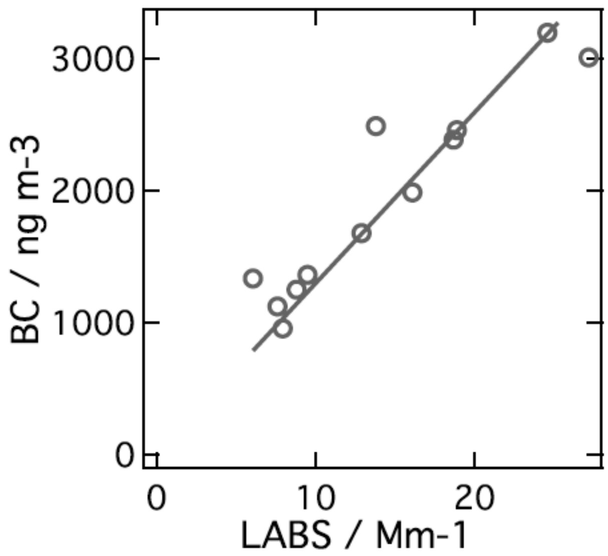


1. Point Barrow – LABS
2. Bondville – LABS
3. Ispra – LABS
4. Jungfraujoch – EBC
5. Mace Head – LABS

*Ispra 2004-2005

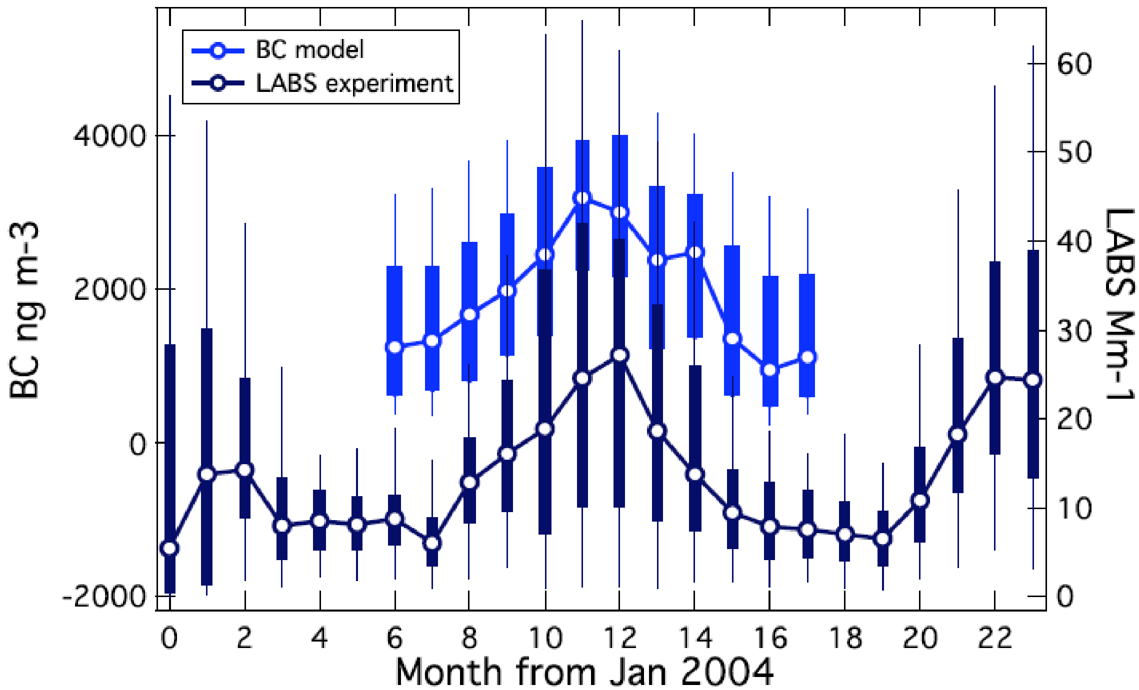
Correlation of monthly medians

- First overview of agreement
- Definition of σ abs to calculate EBC from LABS.



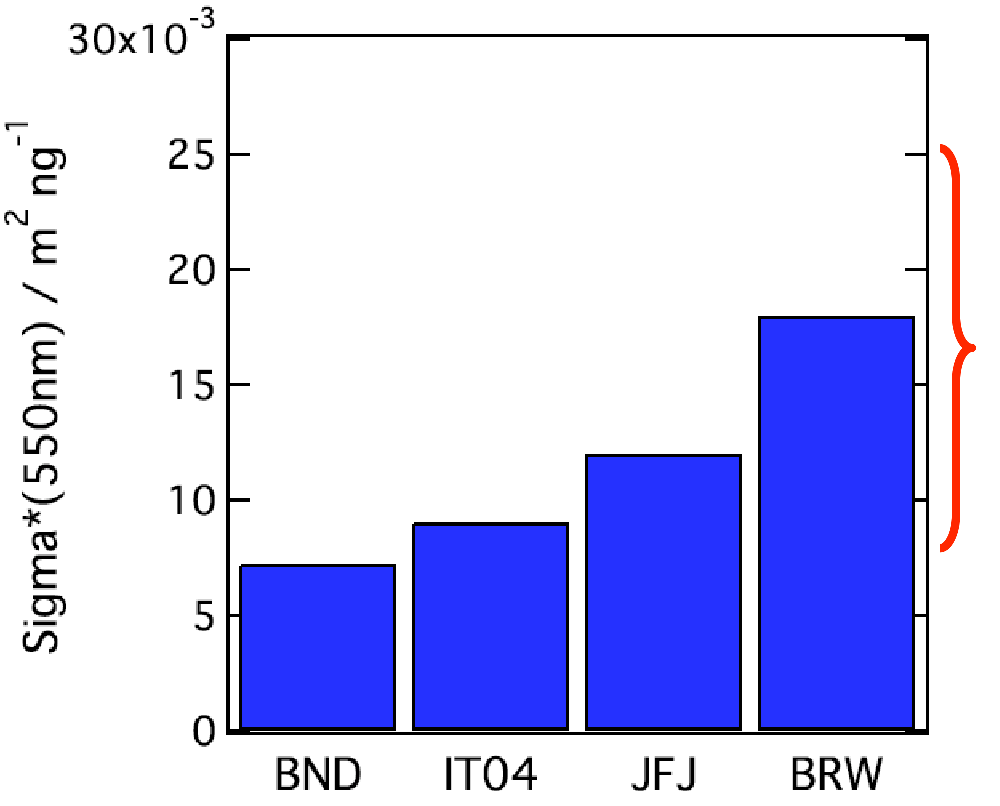
BC = (0.0075 ± 0.0003)*LABS

R2 = 0.8888

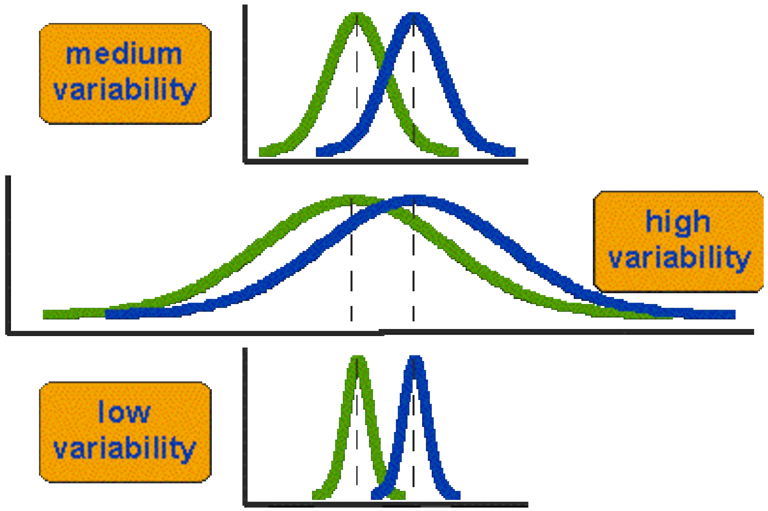


σ abs at 550nm obtained from correlation of TM5 and experiment median values

- σ at MHT agrees with values measured by Junker at al. (1995) for clean sector air masses.
- σ calculated are in the range of sigma values reported in literature/empirically (Liousse et al. 1993)



Frequency distribution curves



- Normal distribution comparison is based on t-test where mean and standard deviation defines the agreement.
- For non normal distributions we estimate the agreement by calculating directly the overlapping area of normalized frequency curves

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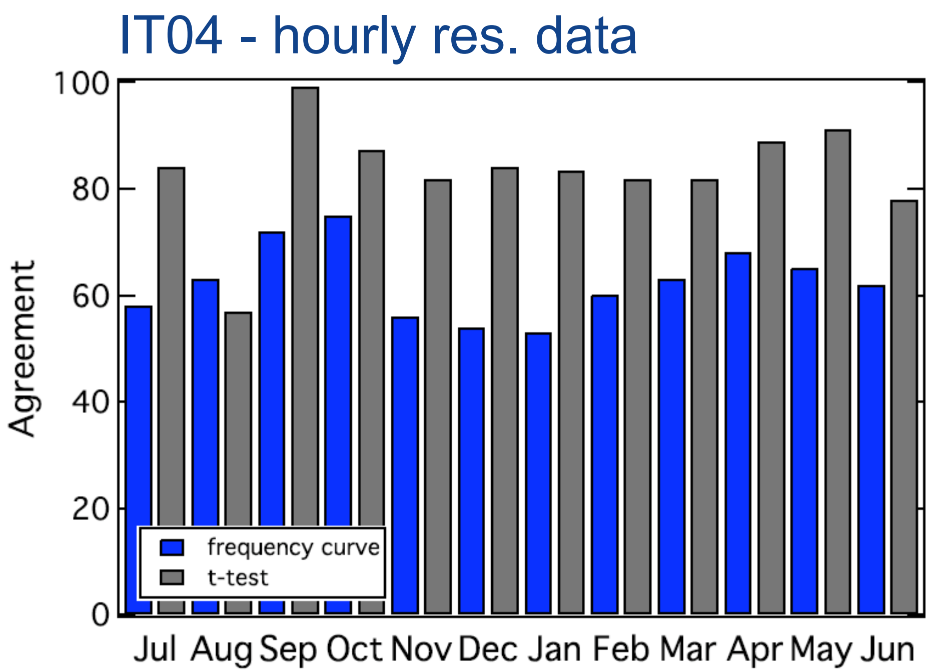
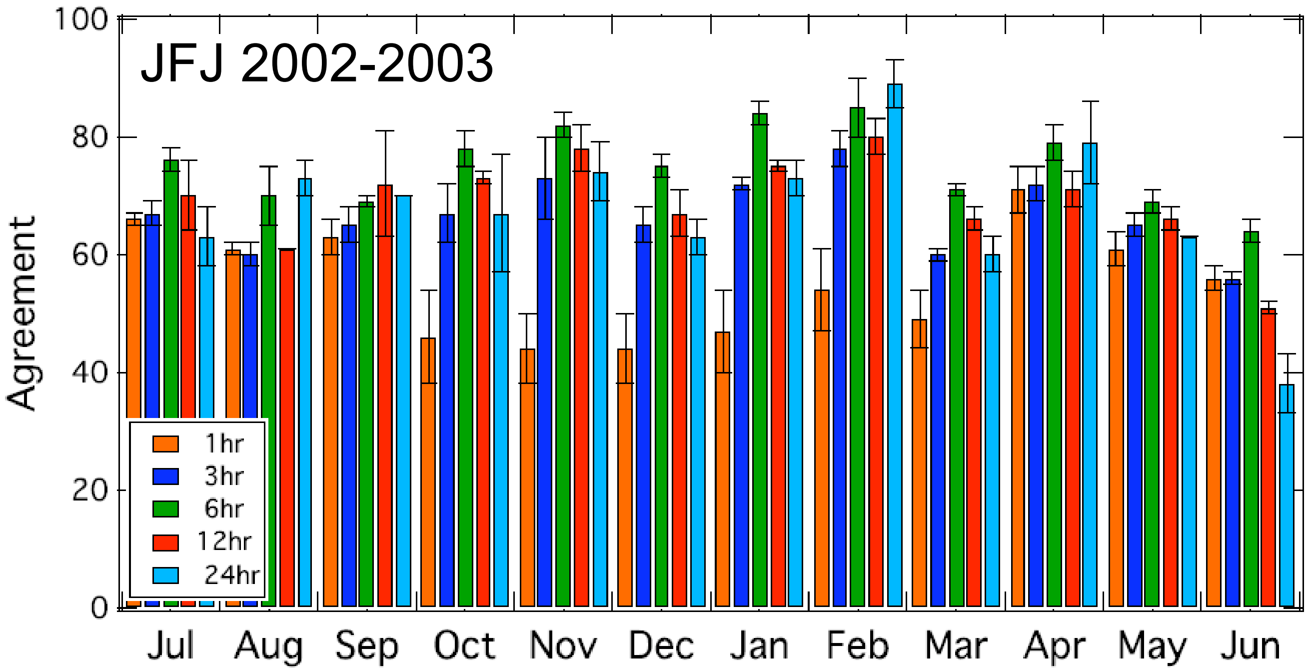
Comparison with statistical tests

- t-student test overestimates the agreement of more than 20%;
- Mann-Whitney underestimates dramatically when dataset sizes differ.
- Frequency curve method is a non-parametric test.



Time resolution: the best averaging time



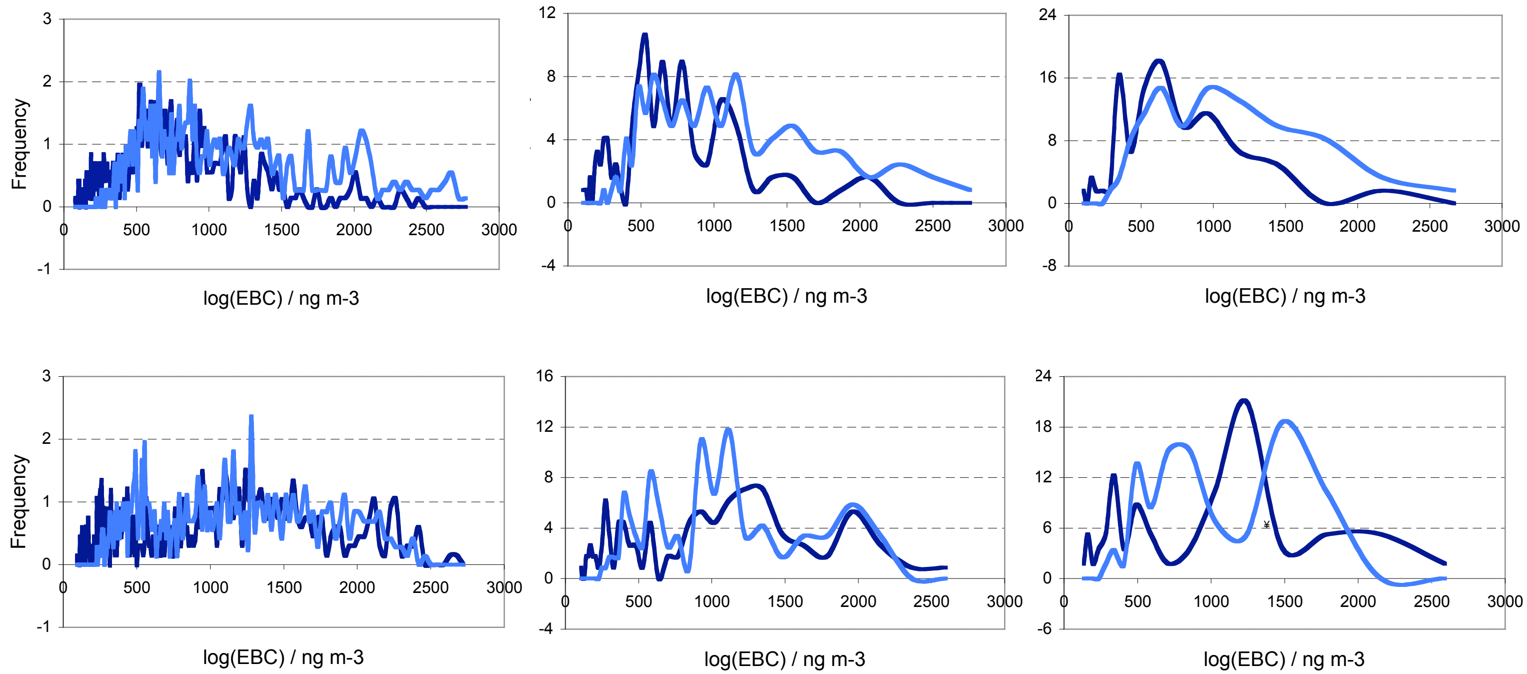
Averaging over 24 hours removes high frequency signal (1 few hours); agreement is expected to stay constant or increase.

…in detail

1 hour resolution | 6 hour resolution | 24 hour resolution

Agreement is constant with longer resolution

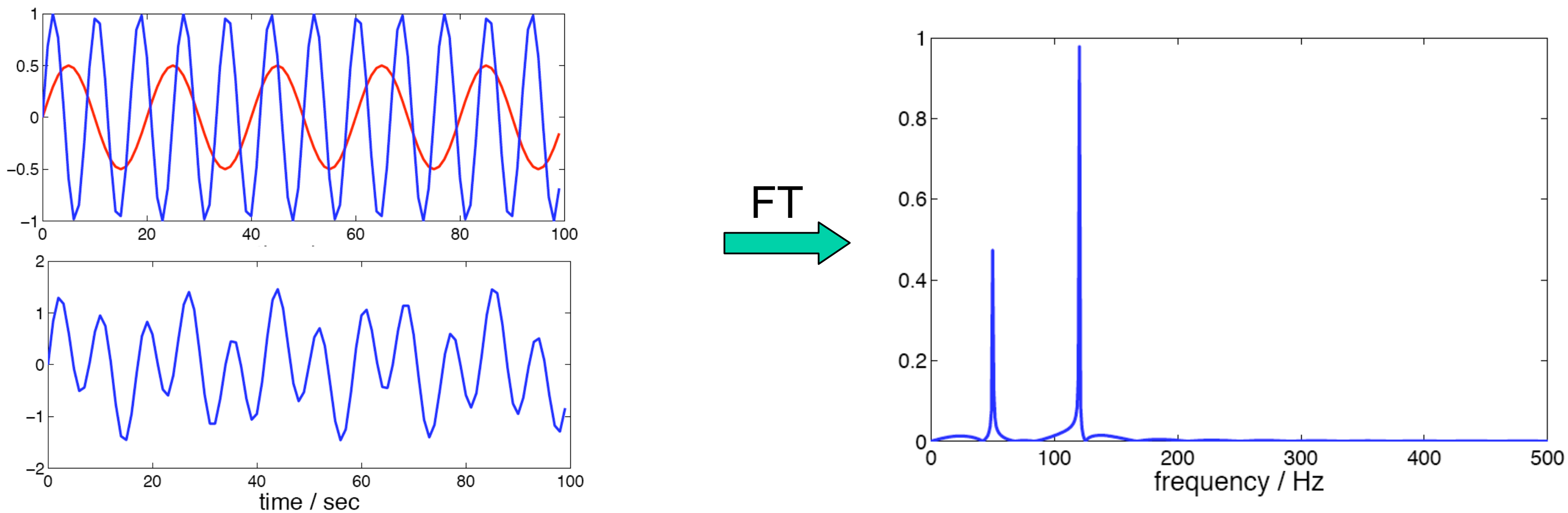
Agreement decreases with longer resolution



Evaluation of model performance from high resolution data is misled by large variability.

model
experiment

Fourier Transform: looking for signal modulation



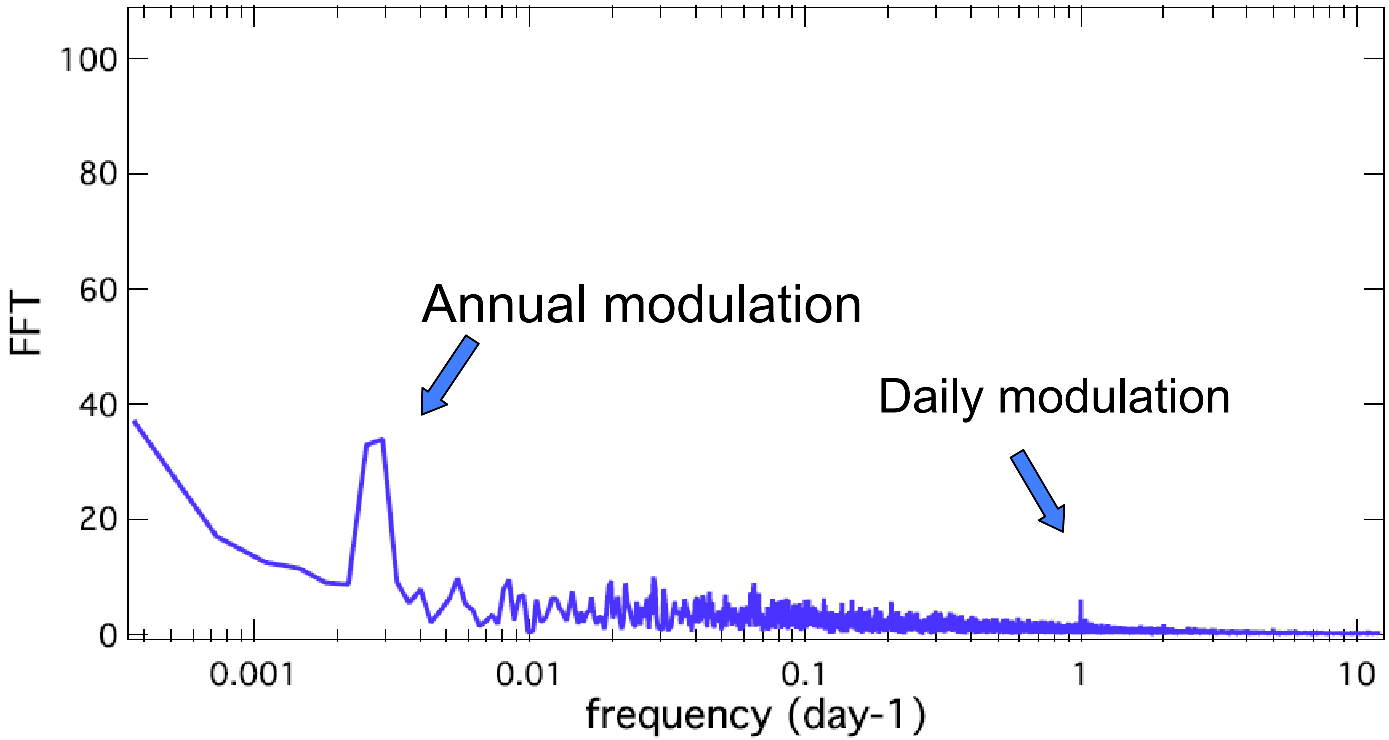
Value at the origin

$F(0) = \int f(t)\,dt$ the value of F(v) at the origin is equal to the mean value of f(t)

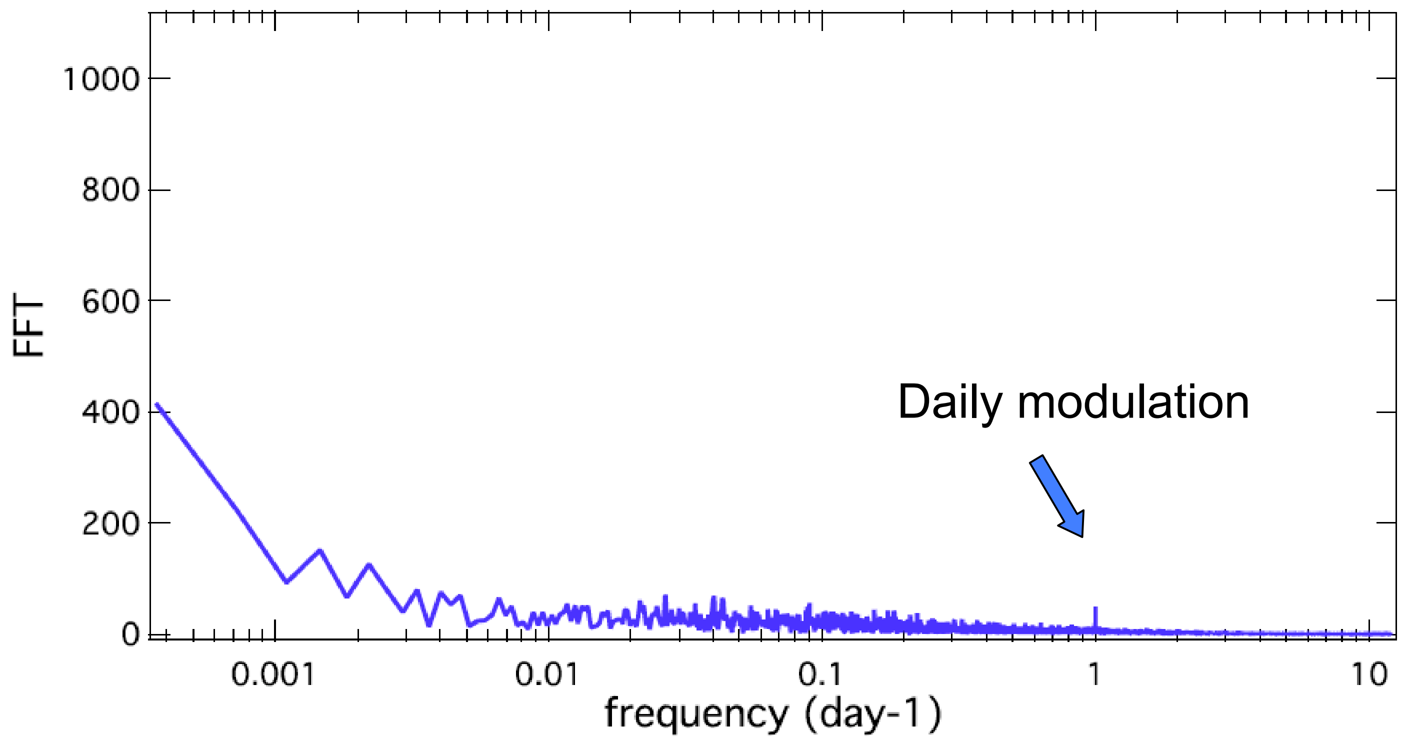
Linearity

The amplitude of f(t) modulation is proportional to the amplitude of F(v) at the frequency of modulation v.

FFT of JFJ experimental data from January 2000 to December 2005



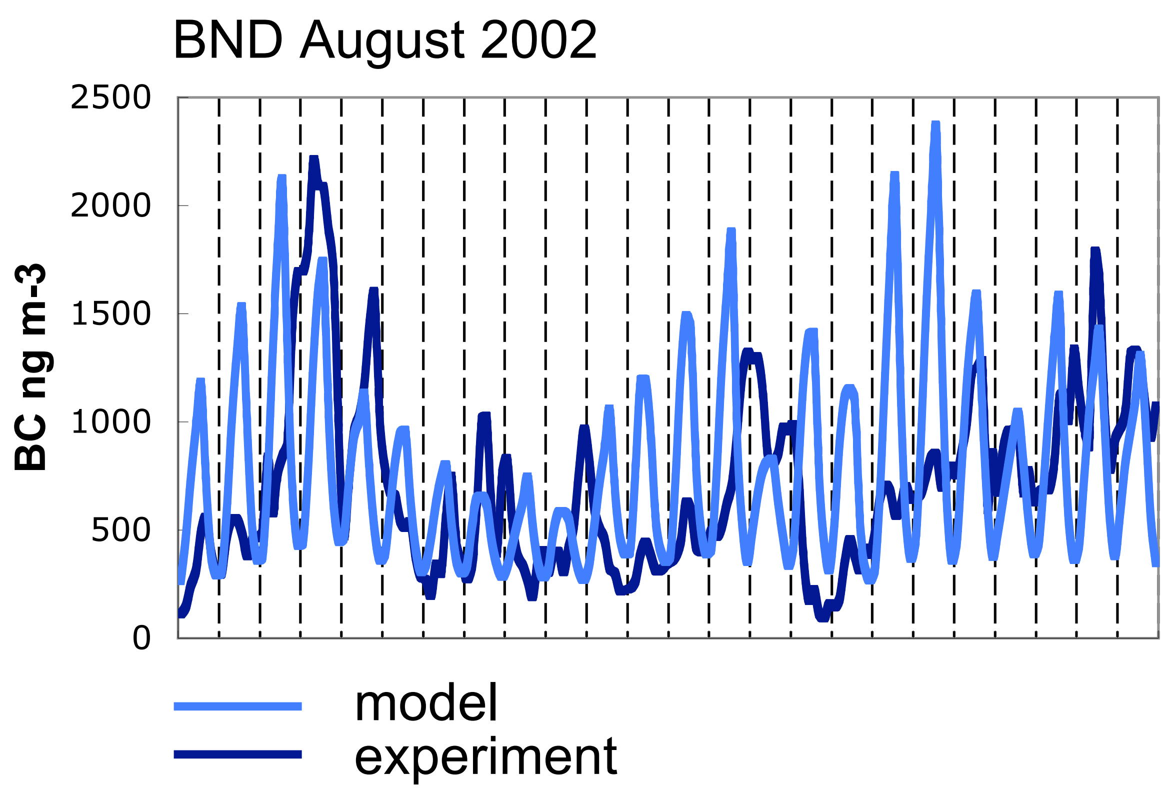
FFT of BND experimental data from January 2000 to December 2005



Amplitude of daily modulation

	Mean Exp	Mean TM5	1day mod Exp	1day mod TM5
JFJ	111	96	6.9 ± 1.6	5.3 ± 0.7
BND	1250	1600	60 ± 11	400 ± 9
IT04	4250	4100	560 ± 36	1100 ± 17
MHT	440	370	55 ± 7*	27 ± 3.2

Amplitude of daily modulation



Overestimation of daily cycle in the model.

Conclusions

- Correlation of medians: useful to link BC from model to LABS from experiment - not accurate.
- Frequency curve: accurate, more efficient than traditional statistical methods, and no need for high time resolution data - non parametric method.
- Fourier Transform: information on timescale of model failure - needs high time resolution data.

Acknowledgements

- World Data Centre for Aerosol (ftp-ccu.jrc.it/pub/WDCA/NARSTO_archive/2.301/parameters/Chemistry)
- Dr John Ogren (NOAA Colorado)
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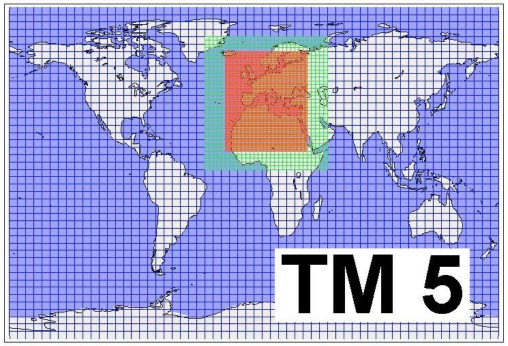
For further details on TM5/M7 refer to:

"Definition and representation of black carbon in models, two sources of uncertainties in the global estimates"

E. Vignati, M. Karl, M. Krol, J. Wilson, P. Stier

- Chemistry Transport Model TM5 (Krol. et al., 2005): 25 vertical hybrid sigma-pressure layers, global resolution of 6°x4° and a two-way zoom down to 1°x1°, driven by ECMWF ERA40 reanalysis data



- BC emission inventories:
  - Fossil and bio fuel, 4.67 TgC (Bond et al., 2004)
  - Large scale biomass burning, 3.62 TgC (van der Werf et al., 2004)

- Runs with meteorology of 2002-2003, 2 aerosol schemes

- **BULK:**
  - mass
  - considered accum. mode for removal processes (mass mean radius = 0.14 μm)
  - cloud-free atmosphere: hydrophobic
  - in cloud: 30% interstitial, 70% scavenged (stratiform clouds); 0% interstitial in convective clouds

- **DYNA:**
  - size resolved BC, mass and number in: insoluble Aitken; soluble Aitken, accumulation and coarse modes
  - aerosol dynamics in the microphysical aerosol model M7 (Vignati et al., 2004): nucleation, coagulation, condensation of H_2SO_4
  - in-cloud processing of accumulation and coarse soluble modes