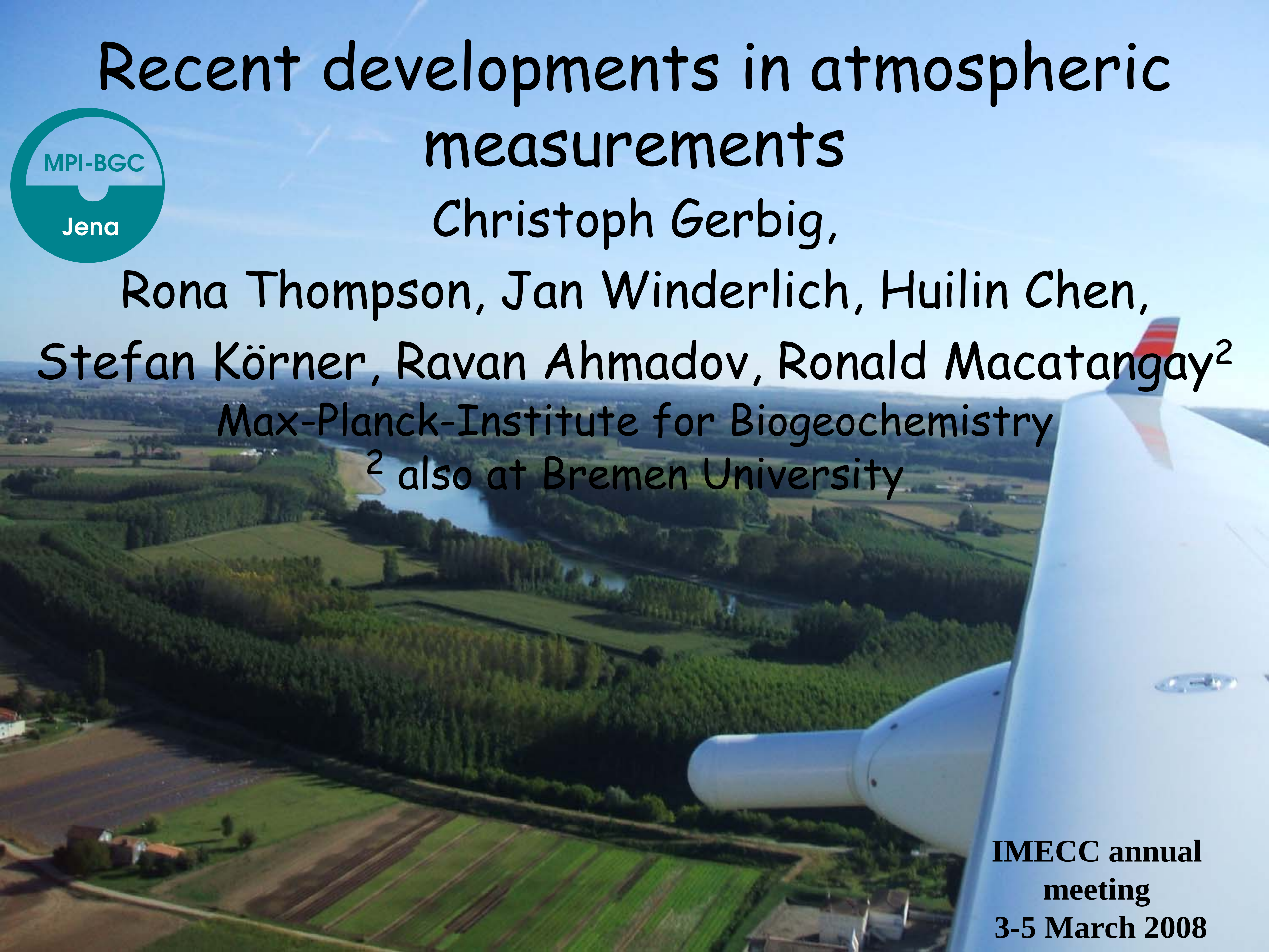


Recent developments in atmospheric measurements

Christoph Gerbig,
Rona Thompson, Jan Winderlich, Huilin Chen,
Stefan Körner, Ravan Ahmadov, Ronald Macatangay[2]
Max-Planck-Institute for Biogeochemistry
[2] also at Bremen University

MPI-BGC Jena

IMECC annual meeting
3-5 March 2008

Overview

- Introduction
  - From model uncertainty to network components
- Covering the 3rd dimension: Vertical profile approaches
  - Some laboratory experiments: Picarro
- Covering the „near field“
  - reducing representation errors
- Closing remarks

Motivation

Add profiling information

Atmospheric measurements

tall towers

Vertical transport uncertainty

Uncertainty in fluxes

Transcom models compared to airborne profile measurements:
„… no single model captures both the seasonal and annual-mean observed gradients accurately“

[Stephens et al., Science 2007]

ECMWF temperature profiles compared to radiosonde data:
The uncertainty „was on average 3.5 ppm, or 30% of the simulated CO2 from biospheric fluxes … expected for a relative uncertainty in mixing heights of 40%“

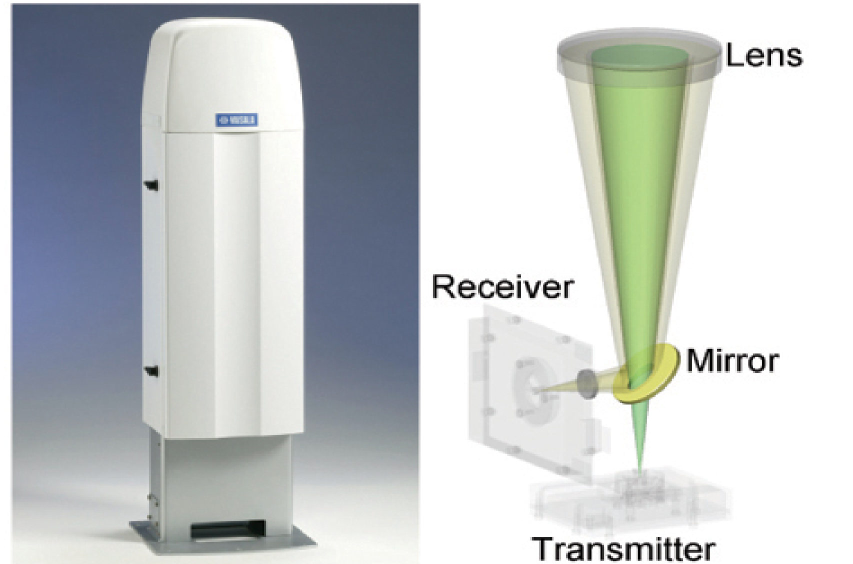
[Gerbig et al., ACP 2008]

process studies
inventories
remote sensing

Photo taken onboard Dimo during CERES 2007

Vertical transport uncertainty → monitor mixing height

- Ceilometer (operational at many airports and weather stations, globally ~5000)
  - Vaisala CL31:
    - Cheap LIDAR, usable profile of backscatter up to 7.5 km
    - Installed at Bialystok



Vaisala CL31 Ceilometer

JENOPTIK

  - Jenoptik CHM 15k:
    - usable profile of backscatter up to 15 km
    - **Installed at ~100 German Weather Service stations**

LIDAR

Intercomparison of different techniques needed

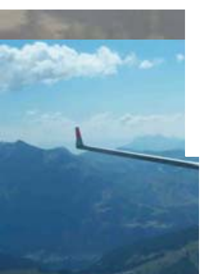
Vertical transport uncertainty → monitor profiles of tracers

- Remote sensing of columns
  - FTIR

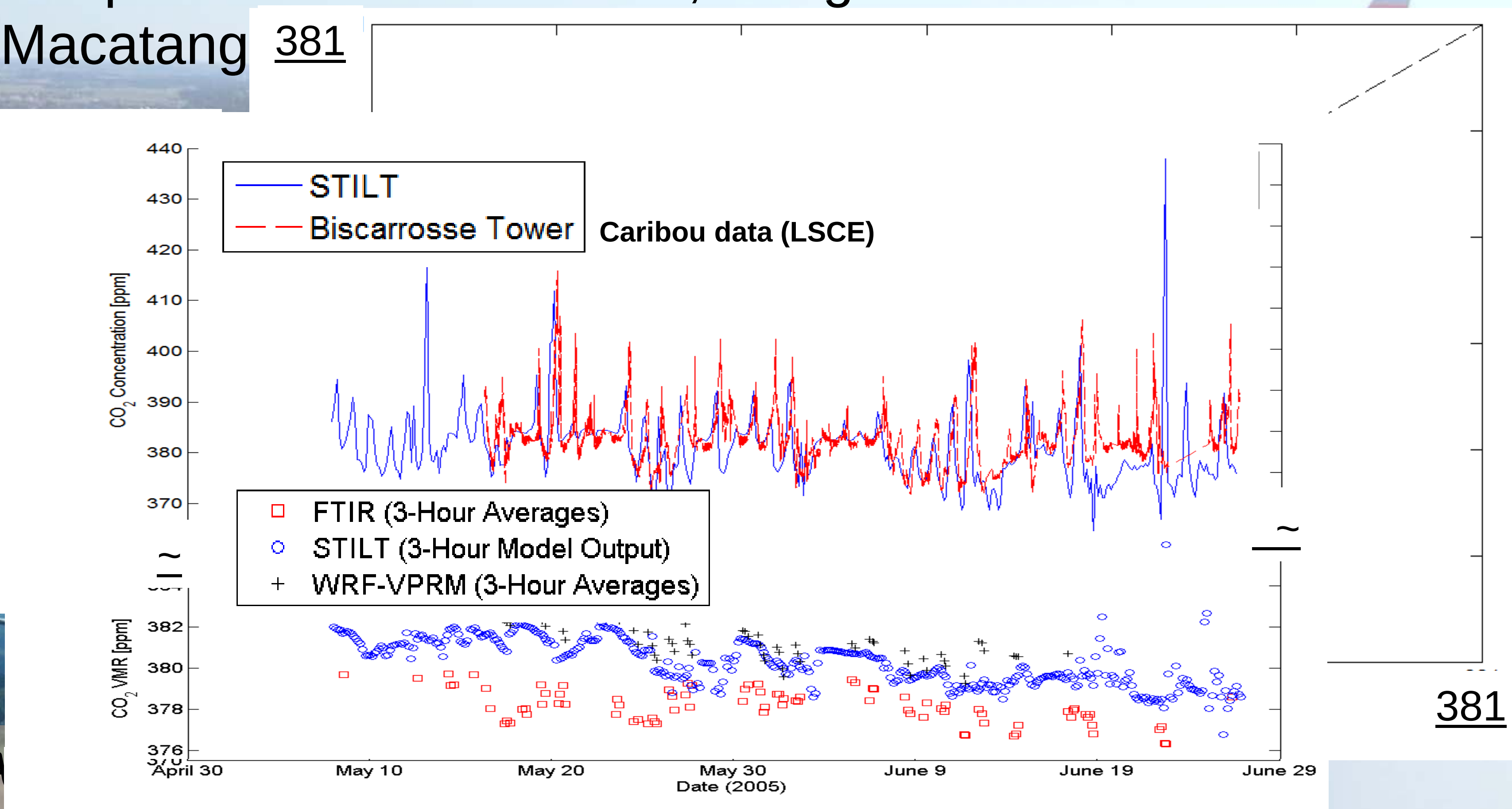
Vertical transport uncertainty → monitor profiles of tracers

- Validating FTIR – column measurements
  - Airborne profiles
  - Comparison with tower data, using STILT as link [Macatang

Bruker
(U.



MetA



Vertical transport uncertainty → monitor profiles of tracers

- Remote sensing of columns
  - FTIR
  - OCO, Gosat
- Airborne profiles
  - Rental aircraft
  - Commercial airliner

IAGOS (Integration of routine Aircraft measurements into a Global Observing System)

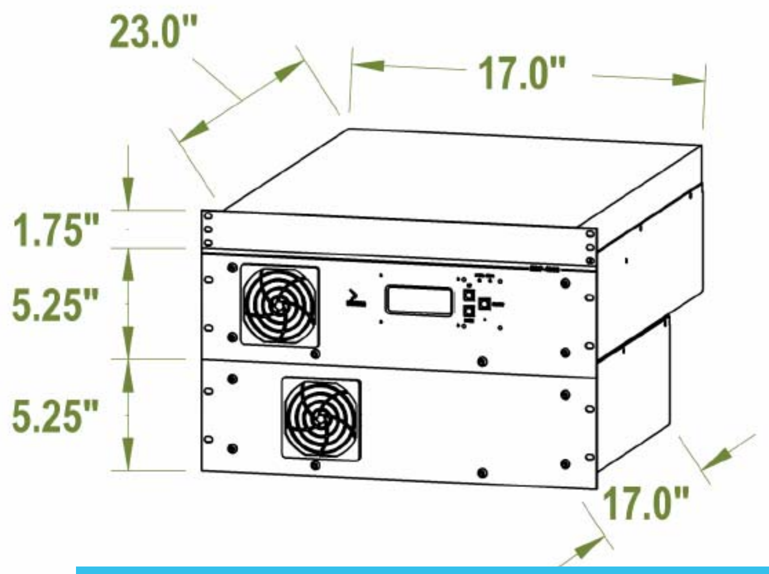
IAGOS: FP6 design study
IAGOS-ERI: European research infrastructure

Max-Planck-Institut für Biogeochemie

MPI-BGC
Jena

Forschungszentrum Jülich
in der Helmholtz-Gemeinschaft

Picarro CRDS system



SBIR (Small Business Innovation Research) project with Picarro & NOAA

- Modifications to ensure stability
- Size/weight reduction
- Repackaging & Certification
- First deployment in 2011, up to 7

Prime candidate for FTIR validation within IMECC JRA 2

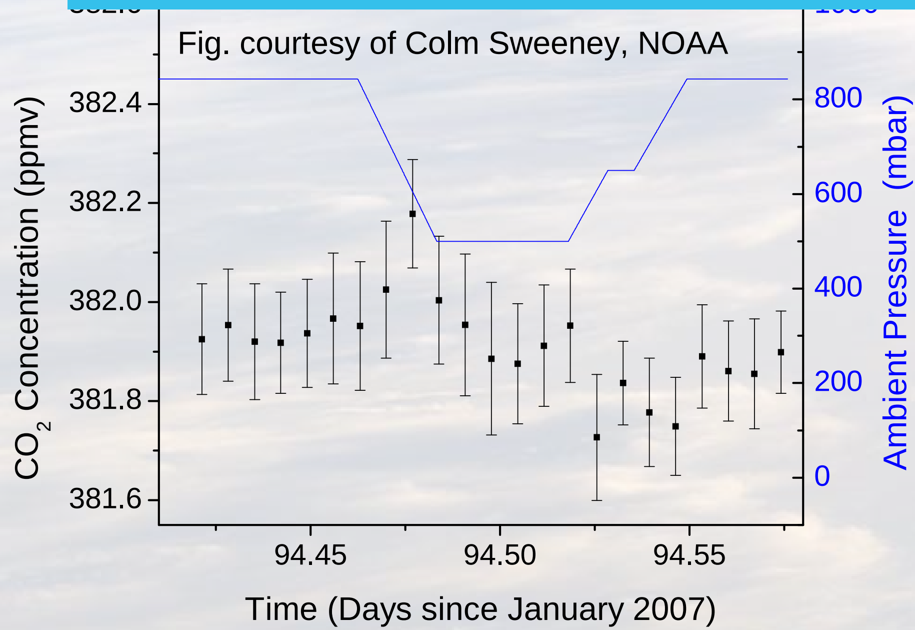
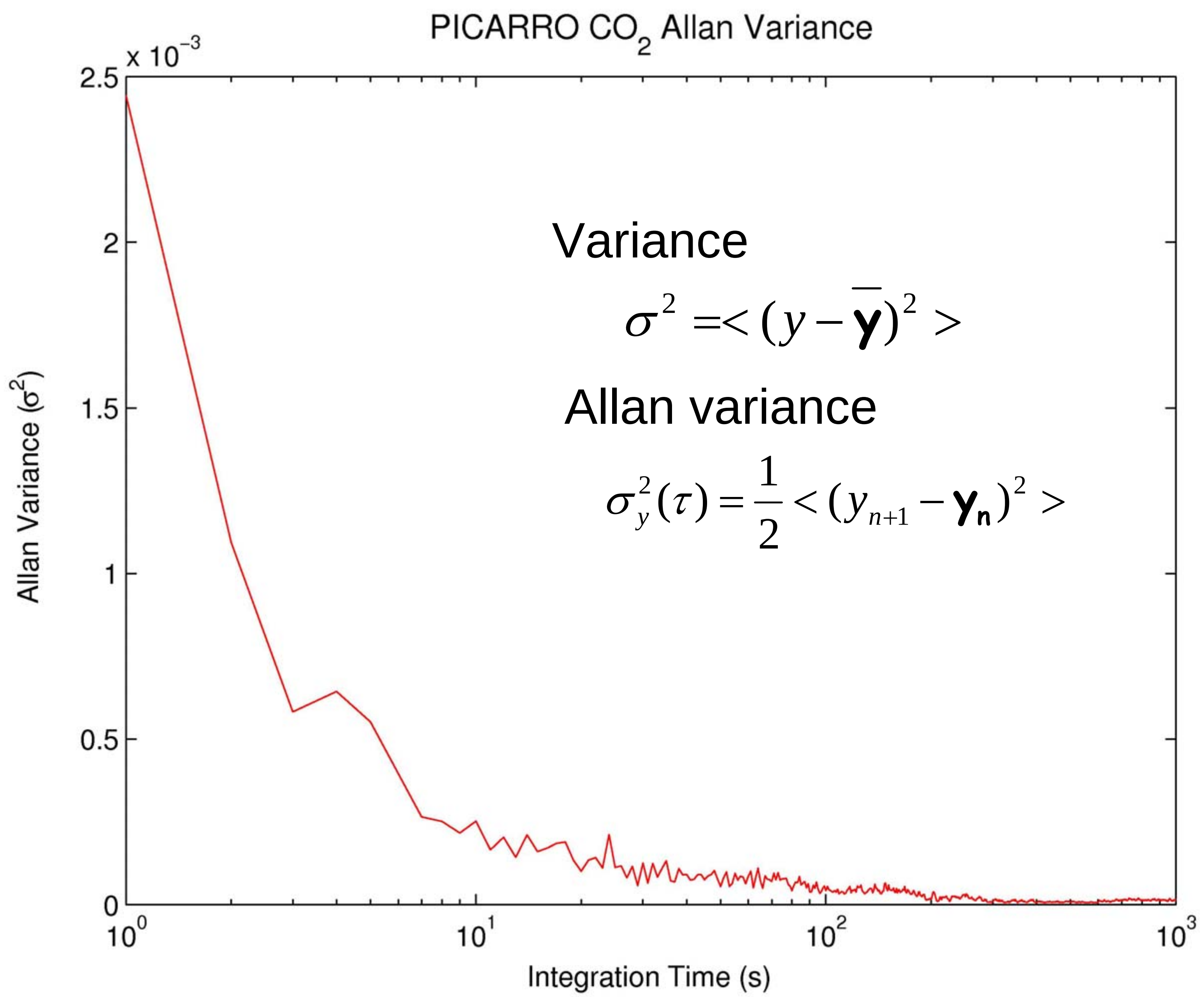


Fig. courtesy of Colm Sweeney, NOAA

Specification	Value
CO_2 Precision	< 100 ppbv
CH_4 Precision	< 1 ppbv
H_2O Precision	< 50 ppmv
Measurement Speed	< 1 second
Drift (30 hours)	< 150 ppbv

Piccaro tests at MPI



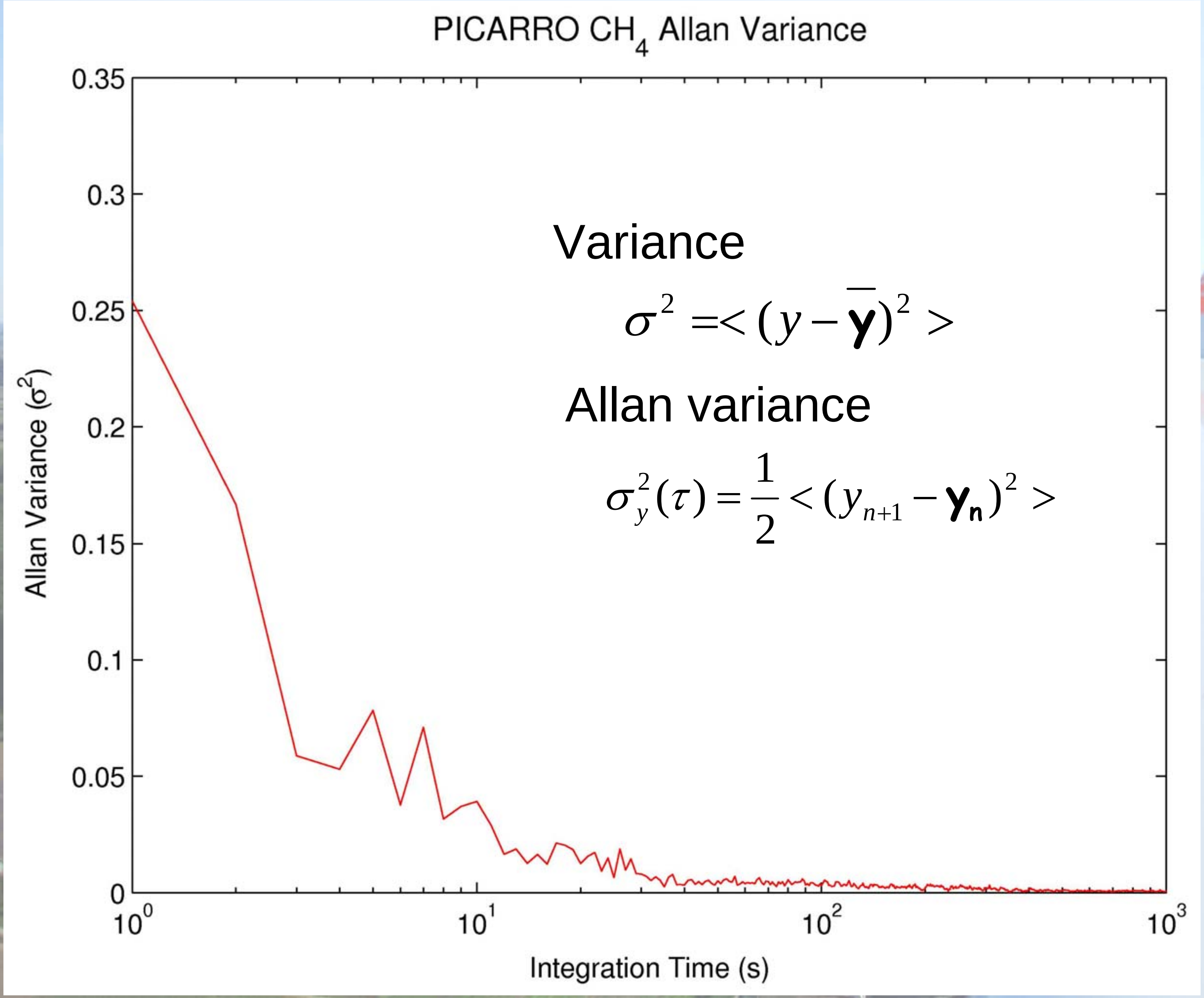
Variance

$$\sigma^2 = \langle (y - \bar{y})^2 \rangle$$

Allan variance

$$\sigma_y^2(\tau) = \frac{1}{2} \langle (y_{n+1} - y_n)^2 \rangle$$

Piccaro tests at MPI



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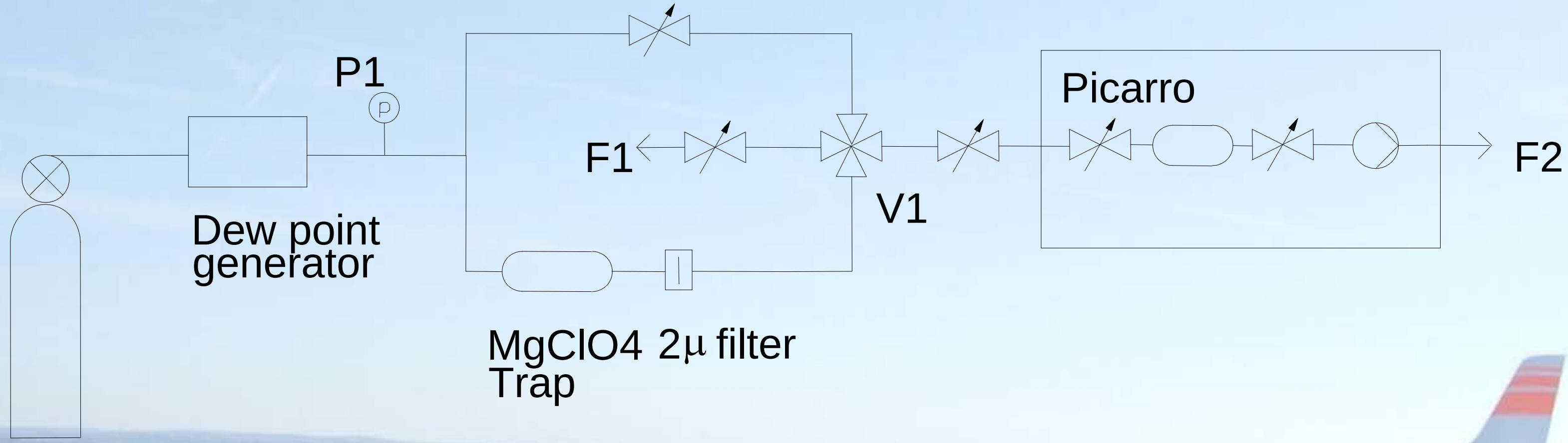


Dewpoint	CO_2 (wet) - CO_2 (dry) after correction (dilution and p-broadening)	CH_4 (wet) - CH_4 (dry) after correction (dilution only)
0 °C	0 ppm	0.5 ppb
5 °C	0 ppm	1.0 ppb
10 °C	0 ppm	1.5 ppb
15 °C	0.2 ppm	1.75 ppb

The bigger H_2O issue: transient effects on wet walls of inlet tubing

Motivation

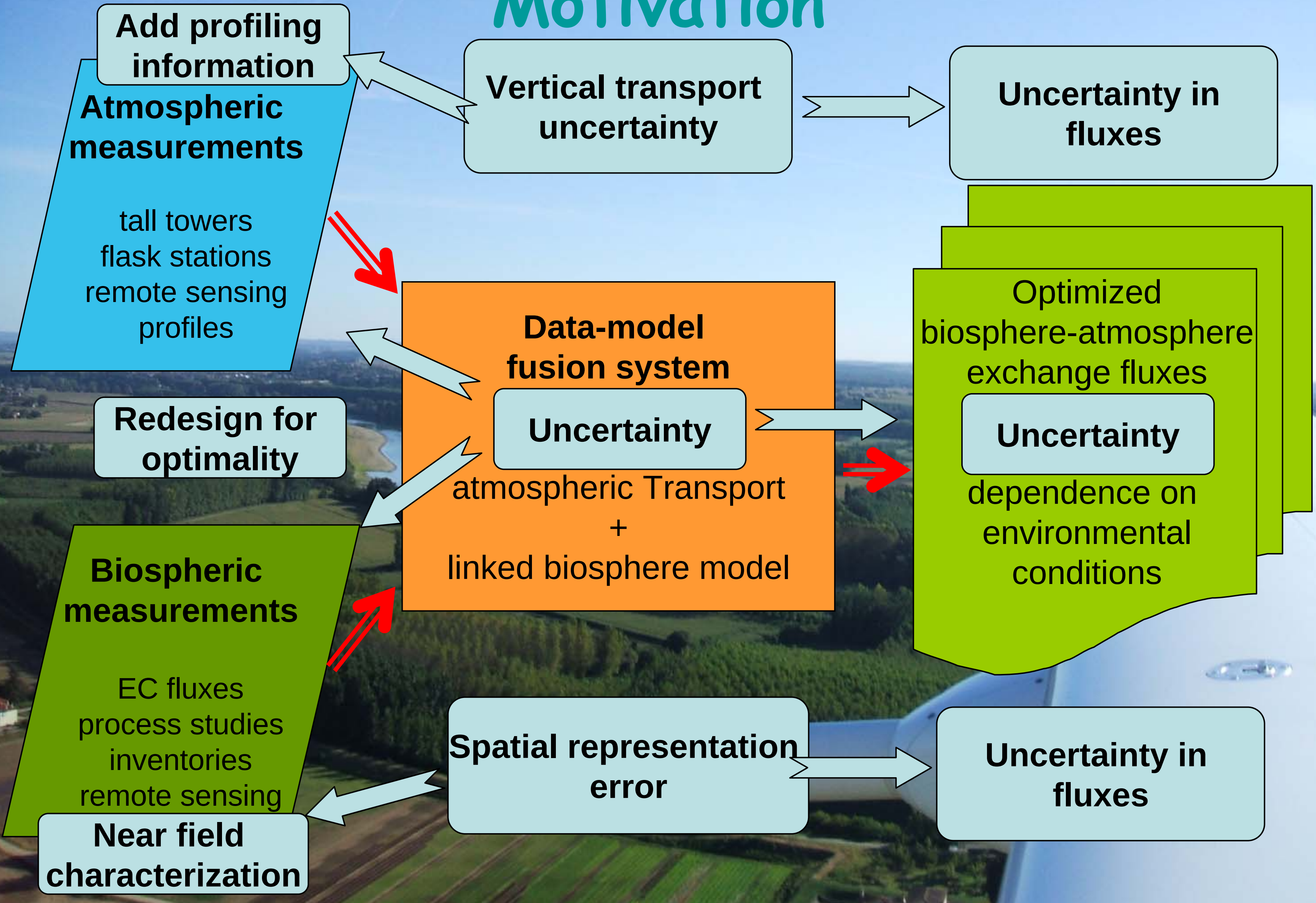


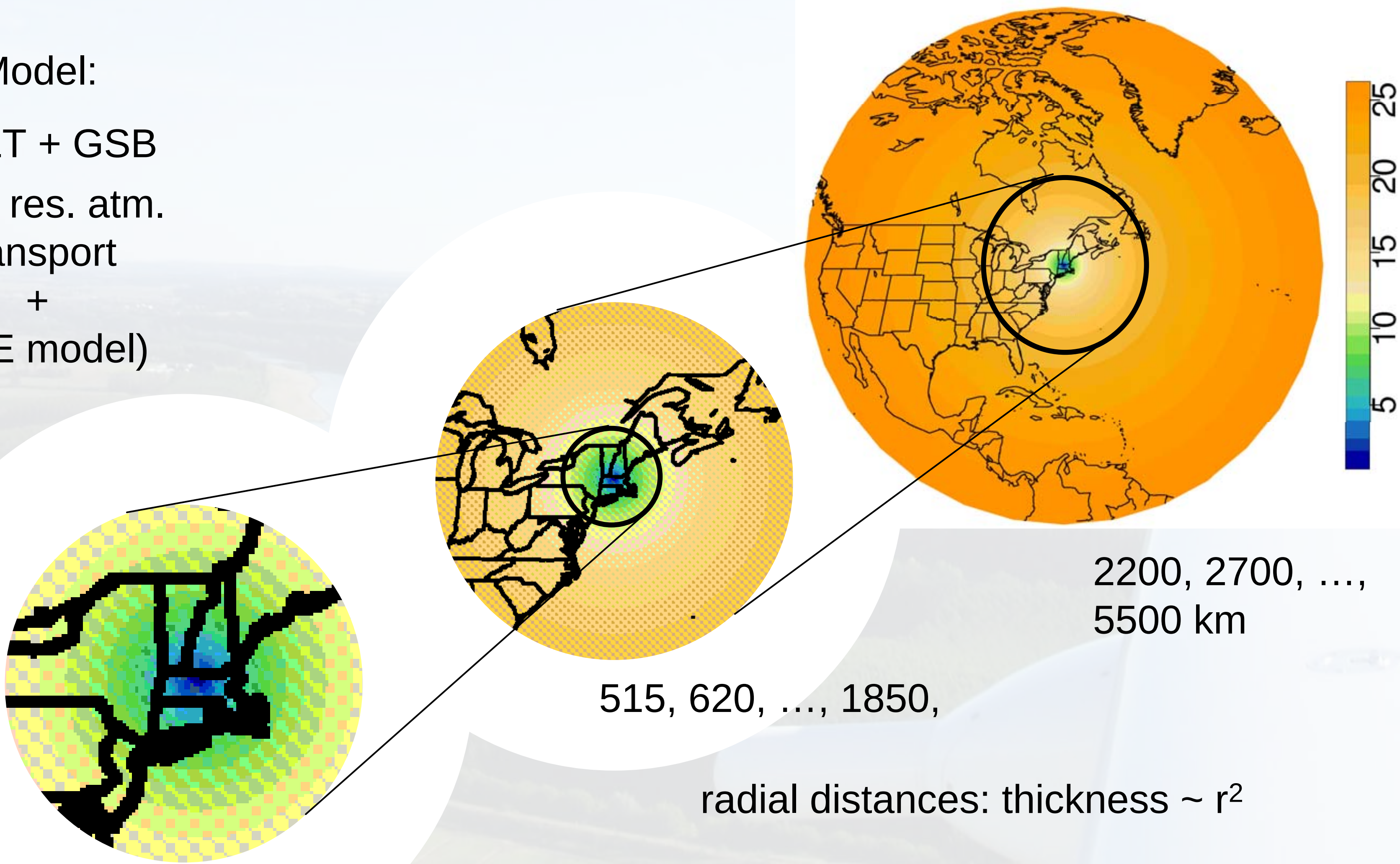
Photo taken onboard Dimo during CERES 2007

The true footprint of atmospheric measurements: which signal comes from which distance?

Model:

STILT + GSB

(high res. atm. transport + LUE model)



2200, 2700, …, 5500 km

515, 620, …, 1850,

radial distances: thickness ~ r^2

20, 40, …, 120, 144, …, 430,

The true footprint of atmospheric measurements

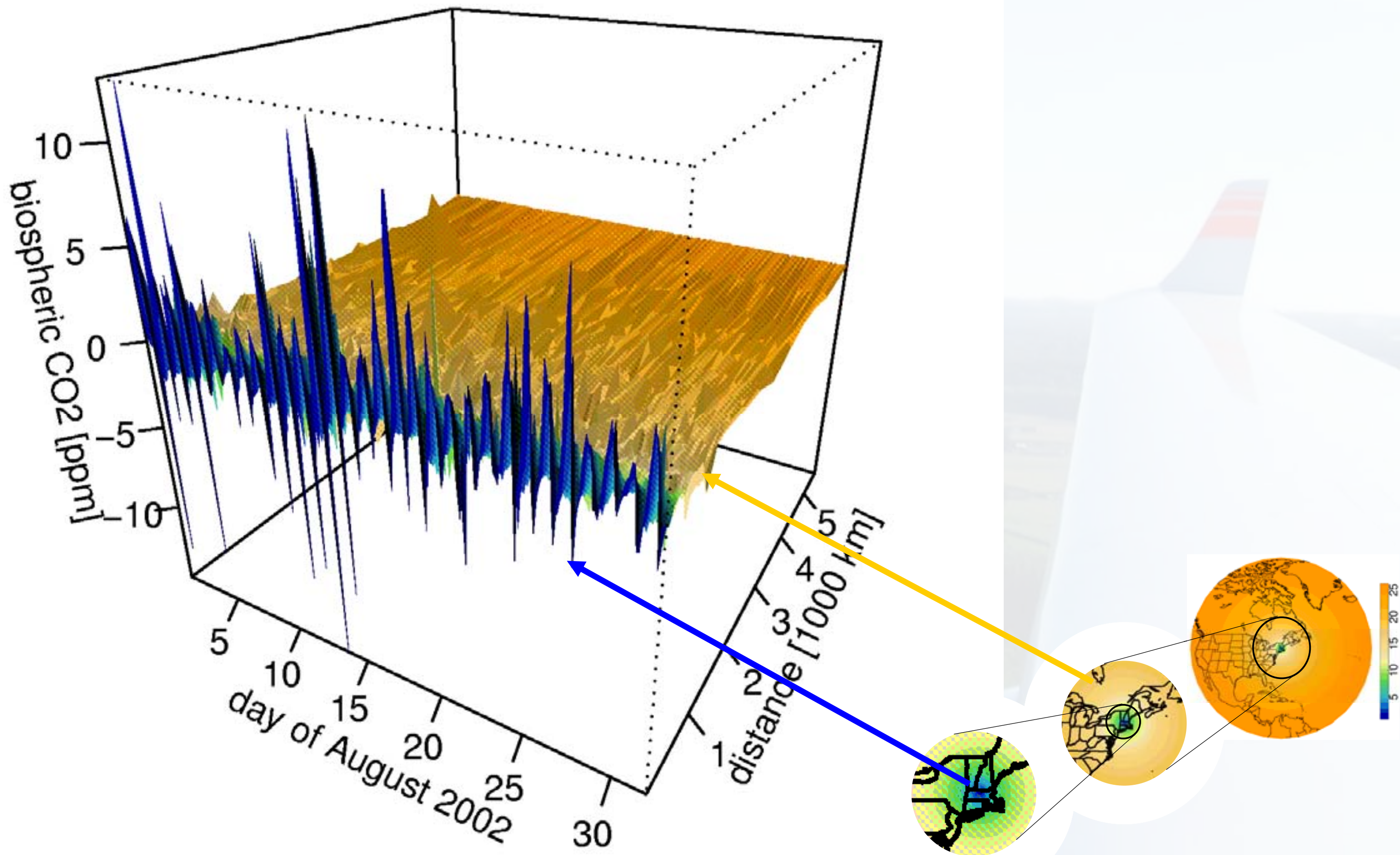
contributions to biospheric CO_2 by distance

3-hourly data

Model:

STILT + GSB

(high res. atm. transport
+
LUE model)



Contributions to biospheric CO2 time series from different distances

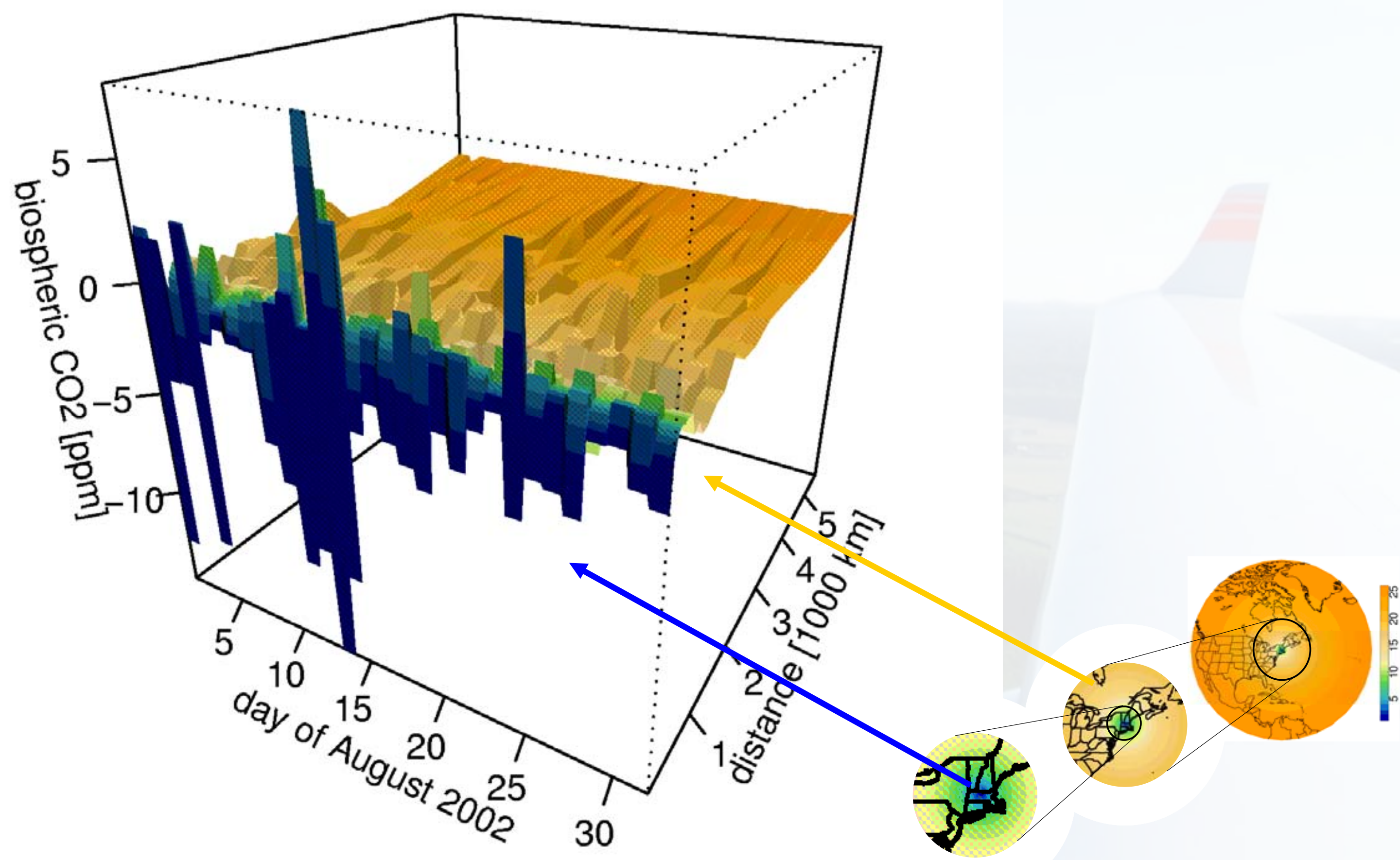
The true footprint of atmospheric measurements
contributions to biospheric CO_2 by distance

15:00 only („well-mixed afternoon“)

Model:

STILT + GSB

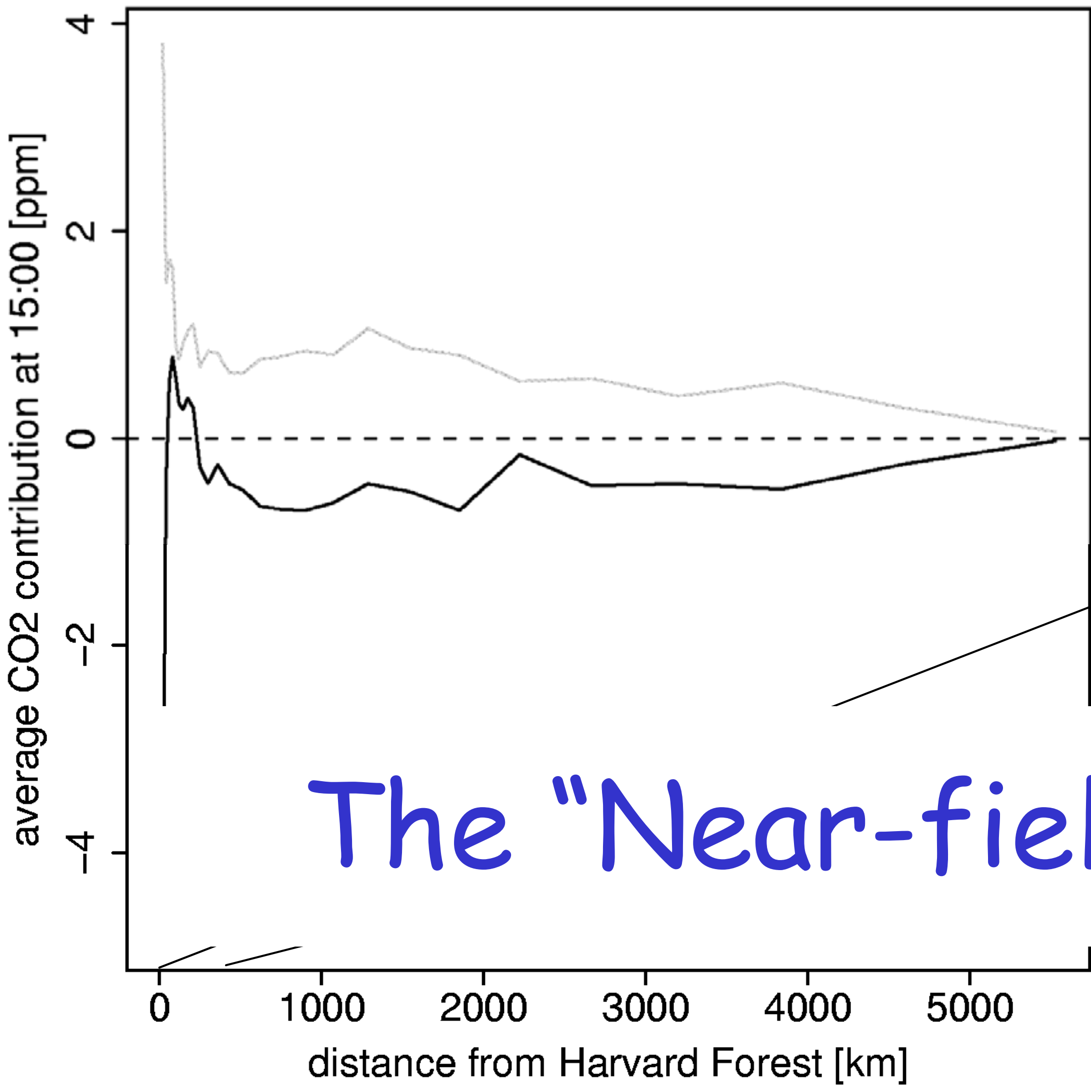
(high res. atm. transport
+
LUE model)

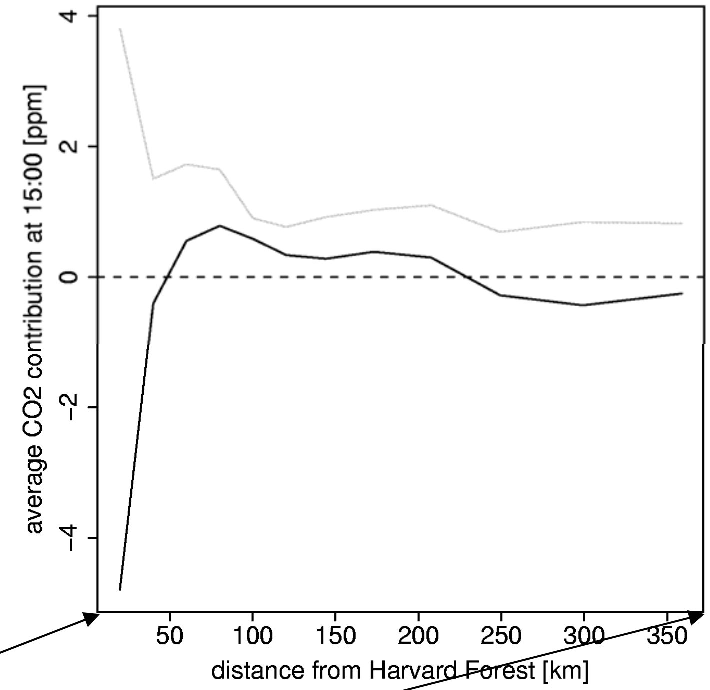


Contributions to biospheric CO2 time series from different distances

The true footprint of atmospheric measurements

contributions to biospheric CO_2 by distance





The "Near-field problem"

"Near-field problem"

- Good characterization of near field required
  - Flux stations in near field for better synergy
  - Remote sensing
    - Vegetation spectral reflectances
    - Vegetation structure (airborne Scanning Lidar)
  - Additional short towers in near-field?

=> Better prior flux information for near field than elsewhere

Closing remarks

- Taking into account model error:
  - Important for design of the network and its elements
  - Without this we might end up with a system that can not constrain budgets and climate – carbon cycle feedback on relevant scales
- Vertical transport uncertainty:
  - Is large in current generation models
  - Add observational constraints (Ceilometer)
  - Compensate by using profile information (example: IAGOS-ERI)
  - Picarro tests at MPI: promising technology, also for airborne
- The "near fiel problem":
  - Needs to be addressed.