Setting up of Continuous measurement stations for Carbon Dioxide and Methane in India

Nuggehalli K Indira, Michel Ramonet, Bhuwan C Bhatt, Marc Delmotte, Martina Schmidt, Cyrille Vuillemin, Thomas J Conway, Philippe Cias, P S Swathi, and Vinod K Gaur

C-MMACS and IIA, Bangalore
LSCE, France

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Carbon Fluxes in India and Central Asia

CaFICA

2003-2008

Indian Astronomical Observatory, Hanle
Hanle (HLE)
32.779°N - 78.964°E - 4517 m asl

The highest CO$_2$ observatory in the world Probably the only one powered by solar energy
CARIBOU: High precision \( \text{CO}_2 \) analyzer

Reproducibility over a couple of days

0.017 ppm
Running the Hanle station

1. Remote control of the CO₂ analyzer

2. Support from IIA engineers & infrastructure
Pondicherry: flask sampling

1 lt. glass flask

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Pondicherry: in-situ CO2/CH4

32 m high tower close to the sea shore

CO$_2$/CH$_4$ analyzer started in Aug. 2011

25th Oct 2011
Port Blair: flask sampling

32 m high tower close to the sea shore

$\text{CO}_2/\text{CH}_4/\text{N}_2\text{O}/\text{CO}$ analyzer will start in 2012

25th Oct 2011
Hanle (HLE)
Pondicherry (PON)
Port Blair (PBL)
Long term observatory for background measurements

Mauna Loa

Hanle

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Mauna Loa
Hanle, India
Waliguan, China
Plateau Assy, Kazakhstan

CO$_2$ in Central Asia

Trend

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Analysis of short term CO$_2$ variations

2005-2009
- Spring
- Summer
- Autumn
- Winter

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CO$_2$ seasonal cycle

Plateau Assy - KZM - 2519m asl (NOAA/ESRL flask program)
Mt. Waliguan - WLG - 3810m asl (NOAA/ESRL flask program)
Hanle - HLE - 4517m asl

$\text{CO}_2$ (ppm)

Jan Mar May Jul Sep Nov Jan

2005-2009

25th Oct 2011
Initial Data from Pondicherry

- CO2
- CH4

25th Oct 2011
Trace gases over India
The mean seasonal cycles

CH$_4$ (ppb)

CO$_2$ (ppm)

CO (ppb)

SF$_6$ (ppt)

N$_2$O (ppb)

Hanle  Pondicherry

SUMMER MONSOON WINDS  WINTER MONSOON WINDS
**Atmospheric transport model**

**Forward mode**

\[
\text{Sc} - \nabla \cdot (\rho C \mathbf{V}) = \frac{\partial}{\partial t} (\rho C)
\]

- **CO₂ net fluxes a priori estimation** \(x_b\); var/cov \(P\)
- Atmospheric transport \(H\)
- Atmos. Conc. simulated \(y_{model}\)
- Observations \(y_o\); var/cov \(R\)

**Inverse mode**

- World map
- Global network - 2001
Some Results of the ongoing programme

- Global CO2 distribution modelled with MOZART
- Background CO2 simulations from Fossil fuel, NEP and Ocean fluxes
- Computation of CO2 distribution from a pulse emission for a month for each calendar month from 11 land and 11 ocean regions
- The basis functions from these pulse-runs will be used to calculate CO2 fluxes from the differences between observed CO2 concentrations and concentrations from background fluxes.

The resolution of the transport model is T42 which is 2.8 deg x 2.8 deg.

It has 28 vertical levels. The model uses NCEP winds to transport species.

We follow TransCom Protocol for forward and inverse modelling with Bayesian Inversion
Equations:

\[ \tilde{D} = J\tilde{S} \]

\[ \chi^2 = \frac{1}{2}(\tilde{S} - \tilde{S}_0)C(\tilde{S}_0)^{-1}(\tilde{S} - \tilde{S}_0)^T + \frac{1}{2}(\tilde{D} - J\tilde{S})C(\tilde{D})^{-1}(\tilde{D} - J\tilde{S})^T \]

\[ \tilde{S} = \tilde{S}_0 + \left( C(\tilde{S}_0)^{-1} + J^T C(\tilde{D})^{-1} J \right)^{-1} J^T C(\tilde{D})^{-1}(\tilde{D} - J\tilde{S}_0) \]

\[ C(\tilde{S})^{-1} = C(\tilde{S}_0)^{-1} + J^T C(\tilde{D})^{-1} J \]
Achievements

• Successfully set up GHG measurement stations in India
• One of the few groups in India measuring CO₂ with such a high precision
• Only Group in India performing continuous measurement and modelling of CO₂
Thank you