Overview of the CINDI campaign

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LML – Landelijk Meetnet Luchtkwaliteit

ELF 532nm Total Attenuated Backscatter $\beta_{532}$ [km$^{-1}$ sr$^{-1}$]

Residual Layer

Time [UTC]

Altitude [km]

geen/gering  matig  ernstig
Why a CINDI campaign?

- Satellite NO₂ data needs a reference “ground-truth” network adequate for long-term validation over polluted regions.

- Current monitoring networks provide local *in-situ* surface measurements, which cannot easily be compared to column measurements from satellites.

- Remote-sensing from the ground can help in bridging the gap between *in-situ* air quality networks and satellite measurements.

- **CINDI** → benchmark for developing remote-sensing techniques for measuring NO₂, aerosols, ozone and more, towards a network!
Cabauw Intercomparison campaign of Nitrogen Dioxide measuring Instruments
CINDI Participants and Instruments

32 instruments for NO₂
- 21 MAXDOAS-like instruments
- 4 zenith looking instruments
- 1 NO₂ lidar
- 1 NO₂ sonde
- 5 in-situ instruments (4 with photolytic converters, 1 Molyb)

other instruments
- aerosol monitors (in-situ and profile + AERONET)
- ozone sondes (De Bilt)
- tropospheric ozone lidar (Bilthoven)
- meteorological instruments
- wind profiler, total sky imager
- ...and much more

17 participating institutes from 4 continents!
Part 1: Semi-blind Comparison Setup

Period: 16-26 June

- Fixed azimuth direction (287°) for all instruments
- Fixed elevation angle sequence for MAXDOAS-like instruments
- Fixed DOAS settings, wavelength ranges, yielding Slant Column
- “Semi-blind”: referee (H.K. Roscoe) knows who is who in plots

NO₂ slant columns for 18.06.2009 and 2° elevation angle
Part 1: Semi-blind Comparison Method

IUPHD(inst1) NO$_2$ SCD regression lines from reference group (15/06/2009)

Example of regression analysis for 15.06.2009 against campaign reference
Part 1: MAXDOAS NO2 Slant Column
Part 1: MAXDOAS O2O2 Slant Column
Part 1: MAXDOAS NO2 Profile Comparison

- first comparisons sometimes o.k., sometimes not
- challenge is to identify what causes the differences

→ NO₂ profile working group
Part 1: MAXDOAS aerosol retrievals

- BIRA VIS
- Heidelberg VIS
- JAMSTEC VIS

**aerosol extinction [1/km] VIS; Cardiff**

**altitude [km]**
- 0
- 1
- 2
- 3

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**aerosol extinction [1/km] VIS; Cardiff**

**altitude [km]**
- 0
- 1
- 2
- 3

**JAMSTEC VIS**

- fit: $y = 0.81x + (8.74e-002)$
  - corr=0.71, bias=-0.04, stdev=0.12, #=107

- fit: $y = 0.49x + (1.05e-001)$
  - corr=0.74, bias=0.11, stdev=0.18, #=62

- fit: $y = 0.96x + (9.01e-002)$
  - corr=0.74, bias=-0.08, stdev=0.12, #=80

- fit: $y = 1.18x + (1.20e-001)$
  - corr=0.73, bias=0.15, stdev=0.13, #=140
Pandora

Direct Sun Data during CINDI

Alexander Cede
Nader Abuhassan
Jay Herman
PANDORA Direct Sun Observations – NO2

Total NO2 column [DU]

12 Jun 2009
13 Jun 2009
17 Jun 2009
19 Jun 2009
21 Jun 2009
22 Jun 2009
24 Jun 2009
25 Jun 2009
30 Jun 2009
04 Jul 2009
16 Jul 2009

UT HOURS

Pandora
OMI
PANDORA Direct Sun Observations – O3

Total O₃ column [DU]

12 Jun 2009
13 Jun 2009
17 Jun 2009
19 Jun 2009
21 Jun 2009
22 Jun 2009
24 Jun 2009
25 Jun 2009
30 Jun 2009
04 Jul 2009
16 Jul 2009

Total O₃ column [DU]

6 8 10 12 14 16 UT HOURS

Pandora OMI

EOS-Aura Science Team Meeting 12
Boulder, Co, 27-29 Sep 2010
Direct sun NO\textsubscript{2} DOAS retrieval (WSU: ●, BIRA: ○) total NO\textsubscript{2} VCD.

Tropospheric column estimated by subtracting stratospheric component (DS trop. NO\textsubscript{2} column: WSU: ♦, BIRA: ◊).
Under unpolluted conditions and clear skies tropospheric columns derived using DS and MAX-DOAS should match.

WSU MAX-DOAS NO2 during CINDI

E. Spinei
G. Mount
Part 2: Scientific Studies

Measuring from different altitude levels to study the effect of altitude on the retrievals
Part 2: Scientific Studies

- lidar
  - 0.47° (15.6±5 m)
  - 3.16° (105±35 m)
  - 6.16° (205±67 m)
- in-situ monitors
  - 3 m
  - 105 m
  - 205 m

Concentration (μg m⁻³)

Time (UTC)
Part 2: The KNMI NO2 Sonde

18 June 2009

23 June 2009

24 June 2009

25 June 2009

30 June 2009

1 July 2009

altitude (km)

NO2 profile (10e13 cm–3)
CINDI 2009 was a very successful campaign with
- many good measurement days
- good variability in pollution levels
- large tropospheric data set collected for NO2, aerosol, O3, HCHO, ...

Slant columns, total columns, vertical profiles, in-situ
- excellent results from NDACC semi-blind comparison
- very promising profiles but work is ongoing in several working groups
- satellite data validation ongoing
- validation of NO2 lidar system
- first ever NO2 sonde launches

Several papers are in preparation
- semi-blind comparison published paper in AMTD
- NO2 sonde paper published paper in AMTD
- campaign overview in prep. for AMTD
- Lidar truck validation in prep. for AMTD
Credits

Thanks to all CINDI participants for sharing the data, plots and photos used in this presentation.

Local organizing team:
Ankie Piters, Mark Kroon, Jennifer Hains, Marian Koning-Klein, Annelise du Piesanie, Referee Howard Roscoe

Scientific organization team:
Michel Van Roozendael, Ankie Piters, Folkert Boersma, Folkard Wittrock

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participating institutes via national funding
ESA, NASA, ACCENT-AT2
in-kind contributions from KNMI and RIVM
and GEOmon
Main objectives:

• Compare NO₂ measuring instruments that can be used for validation of tropospheric NO₂ from satellites

First Campaign Phase: Semi-Blind Comparison

• Give estimate on accuracy of NO₂ tropospheric columns and profiles for different atmospheric conditions (clouds/aerosols) and viewing geometries using DOAS and MAXDOAS techniques
• Give recommendations for harmonization / standardization of instruments settings and retrieval algorithms

Second Campaign Phase: Additional Measurements

• Study effect of horizontal gradients in the trace gas fields
• Compare other tropospheric measurements, like aerosol, O₃, HCHO, CHOCHO, SO₂, BrO, H₂O
NO2 vertical columns from DOAS instruments

- Good agreement between zenith-sky and MAXDOAS

Courtesy: F. Goutail, CNRS
Part 2: Scientific Studies

a) study the effect of horizontal gradients for satellite validation

Leicester (326°) 10-22 July

IUPB, INTA, JAMSTEC (287°) 10-25 July

NASA_P2 (66°) 14-20 July

KNMI (253°) 14-25 July

NASA_P3 (187°) 14-20 July

more directions anticipated from: BIRA, IUPB, IUPH
Campaign part 2: other studies

b) Mobile measurements to study horizontal gradients for satellite validation

Mini-MAX-DOAS
mounted on car

Reza Shaigan, Thomas Wagner, MPI for Chemistry, Mainz

Elevation sequence:
22°, 22°, 22°, 22°, 45°, 90°

Integration time: ~1 min
Campaign part 2: other studies

b) Mobile measurements to study horizontal gradients for satellite validation

12.06.09
18:42 – 20:40 LT
NO2 troposphere columns (Model vs. OMI)

June 10th-15th, 2009

COSMO-ART modeled NO2 VTC

OMI NO2 VTC (Y. Zhou, AMTD, 2010)

COSMO-ART Regional chemistry model:
Resolution: 0.12° x 0.12°, 40 layers
Chemistry boundaries: MOZART-NCEP
Emission inventory: TNO

OMI NO2 retrieved with:
GTOPO-30 topography dataset
MODIS surface anisotropy model
Lidort on-the fly run

Cloud radiance fraction < 50%

10^15 molec/cm2

Christoph Knote
Yipin Zhou
High Resolution Lidar Aerosol Measurements

CAELI - Overview FFR
Tue, Jun 30, 2009, 08:00 - 09:59 UTC

CAELI - Overview NFR
Tue, Jun 30, 2009, 08:00 - 09:59 UTC

Courtesy: A. Apituley, RIVM
PANDORA Direct Sun Observations – H2O

Pandora Aeronet