Neural Network based Ozone Profile Retrieval Using Combined UV/VI and IR Satellite Data

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Outline

1. Start with TOVS
2. NNORSY and Optimal Estimation (OE)
3. Approach for NNORSY
4. Local error estimation
5. Results of NNORSY-GOME/TOVS
6. Summary and future
Monthly mean values of 56 WOUDC ground stations also used for TOMS validation

NNORSY-NOAA-TOVS zonal mean 1987 - 2000

NNORSY-TOVS L3 (09/79 – 12/02)

Dobson Units

<table>
<thead>
<tr>
<th>global</th>
<th>TOVS</th>
<th>TOMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMS:</td>
<td>9.1 D.U.</td>
<td>8.0 D.U.</td>
</tr>
<tr>
<td>Bias:</td>
<td>2.0 D.U.</td>
<td>-2.8 D.U.</td>
</tr>
</tbody>
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Optimal Estimation

\[ p(x|y) = \frac{p(y|x)p(x)}{p(y)} \]

\( x \) is the GOME spectrum, \( y \) is the \( O_3 \) profile.

\( k(x,y) \) is the collocated measurements.

\( \sim 1 \text{ ms/profile} \) (\( ! \))

Optimal Estimation

\( \sim 1 \text{ min/profile} \)

Comparison of retrieval approaches

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Overview NNORSY

Operation

GOME profiles

operational real-time processing

Training

quality check

neural network training

random data mixing

Training data

test data

eval. data

collocated spectra/profiles

network param.s

Preprocessing

SAGE, POAM, HALOE profiles

GOME TOVS N14 Level 1 data

SHADOZ sondes

WOUDEC sondes

colocation

collocation

collection

collection

collocated spectra/profiles
NNORSY: Collocation Example

test data set: 01/1996 – 07/2001, 12000 collocations

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"learning process": minimize $E = \sum_i (o(y_i) - t_i)^2$

Quality check by cross-validation
NNORSY Input Parameters

**Input data for neural network**

- GOME spectral data
- Geolocation
- Meteorol. info
- Climatological predictors
- TOVS Tb
- GEOS4 temperature profile
- HIRS Tb
- LOS type (east, nadir, west)
- SZA, SAA
- Season and sensor age

270 – 325 nm \((\text{O}_3 \text{ Hartley & Huggins})\)
380 – 385 nm \((\text{atmosph. window})\)
598 – 603 nm \((\text{O}_3 \text{ Chappuis})\)
758 – 772 nm \((\text{O}_2 \rightarrow \text{cloud info})\)
Estimation of Local Retrieval Error

Example for NNORSY Ozone Retrieval

training data 1

training data 2

error network training

NNORSY-GOME

NNORSY retrieval

NNORSY-GOME error estimation

4-JAN-2000
lat./lon. 49.930 / 136.900

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NNORSY NN configurations: training/test

GM: GOME
TV: TOVS
Tp: temperature profile
NNORSY NN configurations: profiles

GM: GOME
TV: TOVS
Tp: temperature profile

Improvement using TOVS

absolute bias error of different NN configurations
NNORSY-GOME Single Ozone Profile II

O3 NNORSY vs O3S Neumayer - 01-Oct-1997 09:33:06

Altitude (km)

O3 Nb Dens. ($10^{12}$ mol/cm$^3$) / Temperature (K)

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Correlative Analysis: Artic

O3 NNORSY vs O3S Ny-Alesund AWI (78.9°,11.9°)

NNORSY

O3S

Relative Difference

O3 (10^12 molec cm⁻³)

G.P.H. (km)

G.P.H. (km)

G.P.H. (km)

G.P.H. (km)

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Correlative Analysis: $40^0$ S / New Zealand

**O3 NNORSY vs O3S Lauder NIWA ($-45.0^\circ, 169.7^\circ$)**

**O3 NNORSY vs LID Lauder RIVM ($-45.0^\circ, 169.7^\circ$)**

**Relative Difference**

**O3 NNORSY vs SAGE II v6.2 ($-45^\circ$ to $-50^\circ$)**

**CHIMPS: NNORSY vs SBUV ($-45^\circ$ to $-50^\circ$)**

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NNORSY-CLIMA (TLLO): H-Peiss. lat: 47.80 lon: 11.02

Ozone number density / $[10^{12} \text{ cm}^{-3}]$
NNORSY-Climatology (T110): Single Profiles for Antarctic

x: 1893 Date: 04/10/95-0551 Lat: -69.81 Lon: 36.8 DU: 136.

x: 1667 Date: 08/10/99-0648 Lat: -69.47 Lon: 40.7 DU: 163.
NNORSY: Summary and Current

- 10 year NNORSY-GOME ozone profile data set
- Comparison/validation with sonde/lidar/satellite and data assimilation
- Combining GOME with TOVS: small improvements in troposphere
- New dynamic ozone profile climatology available

- Using NNORSY for setup of new ozone profile retrieval
  - NNORSY application to SCIAMACHY nadir
  - NNORSY-OMI for ozone profile retrieval
NNORSY-MetOp: Future

- Total ozone column
  - ATOVS, IASI, GOME, GOME+IASI
- Ozone profiles
  - IASI, GOME, GOME+IASI
International TOVS Study Conference, 15th, ITSC-15, Maratea, Italy, 4-10 October 2006