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-TOVS L3 (09/79 –12/02)

NNORSY-NOAA-TOVS Total Ozone

NNORSY-NOAA-TOVS zonal mean 1987 - 2000

Dobson Units

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

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

GOME spectrum

Optimal Estimation

z.B. FURM, OPERA, ...

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

O\(_3\) profile

Comparison of retrieval approaches

Optimal Estimation

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

NNORSY

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Overview NNORSY

Operation

GOME profiles

operational real-time processing

Training

network param.s

quality check

neural network training

training data

test data
eval. data

random data mixing

Preprocessing

SAGE, POAM, HALOE profiles

SHADOZ sondes

WUDC sondes

colligation

colligation

colligation

collocated spectra/profiles

GOME TOVS N14 Level 1 data

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NNORSY: Collocation Example

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

ozone sondes
SAGE II
HALOE

POAM III

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

Quality check by cross-validation

NNORSY (Neural Network Ozone Retrieval System)

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**NNORSY Input Parameters**

**Input data for neural network**

- **GOME spectral data**
  - 270 – 325 nm (O₃ Hartley & Huggins)
  - 380 – 385 nm (atmosph. window)
  - 598 – 603 nm (O₃ Chappuis)
  - 758 – 772 nm (O₂ → cloud info)

- **Geolocation**
  - SZA, SAA

- **Meteorol. info**
  - Sensor scan angle
  - LOS type (east, nadir, west)
  - GEOS4 temperature profile
  - Latitude
  - Season and sensor age

- **Climatological predictors**
  - TOVS Tb
  - HIRS Tb
  - MSU
Estimation of Local Retrieval Error

Example for NNORSY Ozone Retrieval

<table>
<thead>
<tr>
<th>training data 1</th>
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<tr>
<td>NNORSY-GOME</td>
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<tr>
<td>NNORSY retrieval</td>
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<th>training data 2</th>
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<th>error network training</th>
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<tr>
<td>NNORSY-GOME ozone profile [10^{18} molec/m^3]</td>
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</tbody>
</table>

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

Normalized RMS for different NN configurations of training data

Normalized RMS for different NN configurations of test data
NNORSY NN configurations: profiles

GM: GOME
TV: TOVS
Tp: temperature profile

Improvement using TOVS

absolute bias error of different NN configurations

GM: GOME
TV: TOVS
Tp: temperature profile

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NNORSY-GOME Single Ozone Profile I

O3 NNORSY vs O3S Payerne - 07-Jul-1997 10:41:38

Altitude (km)

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

O3S
TEMPERATURE
NNORSY

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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

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

O3 NNORSY vs O3S Lauder NIWA ($-45.0^0, 169.7^0$)

O3 NNORSY vs LID Lauder RIVM ($-45.0^0, 169.7^0$)

O3 NNORSY vs SAGE II v6.2 ($-45^0$ to $-50^0$)

O3 NNORSY vs SBUV ($-45^0$ to $-50^0$)

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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 (TIIO): 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