The APOLLO project: an integrated platform for air quality monitoring over Italy

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September 10, 2009

SUMMARY

- Introduction
- User requirements
- Outline of the project
- Phase 1
  - Ground Ozone spatial characterization
  - TOC from satellite measurements
- Phase 2
  - Correlation of GOs and TOCs
- Conclusion and future work

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INTRODUCTION (1/3)

- Increased knowledge of causes and impacts of atmospheric pollution in the past half-century;
- Ozone is a major air pollutant: harmful for humans and ecosystems;
- Reliable monitoring of ozone levels as a crucial issue for emission control policies;
- **EO data as an important support to existing ground networks**.

INTRODUCTION (2/3)

Project: monitoring Atmospheric POLLution with earth Observations (APOLLO)

Data User Element Innovators II programme

The mission of DUE is to encourage the establishment of a long-term relationship between user communities and Earth Observation

The Innovators II projects will give to the end-users, industry and research communities the opportunity to develop and demonstrate innovative Earth Observation services and products using existing ESA, ESA third-party mission and other EO datasets.

At least one end-user entity shall be actively involved in each project and will be responsible for providing the detailed service and product requirements, as well as support the interpretation and validation of the service products, and assess the adequacy of and benefits of the service.

User driven project

INTRODUCTION (3/3)

Tool for atmospheric pollution monitoring

Pollutant: **Tropospheric Ozone** towards **Ground Ozone**

Geographical domain: **Italy**

Datasets: **OMI** + **ground measurements**

Inversion scheme: **NNs algorithms**

User: **ISPRA**

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USER REQUIREMENTS (1/2)

End user

End User: **ISPRA**

Istituto Superiore per la Protezione e la Ricerca Ambientale

- ex-**APAT**, Italian Environment Protection and Technical Services Agency
- ex-**INFS**, National Institute for Wildlife
- ex-**ICRAM**,Central Institute for Scientific and Technological Research applied to the Sea

Relevant project: EU SEIS–Near Real Time- Air Quality Information

Available data: Ground measurements of pollutants in Italy including ozone via BRACE database

USER REQUIREMENTS (2/2)

Requested service:

- Tropospheric Ozone concentration maps from EO data;
- Integration with ISPRAs ground measurements network;
- User friendly IDL software environment for the analysis and visualization.

Motivation and **expectation**:

- To support ISPRA's ground network for a reliable national coverage;
- To fill spatial and temporal gaps;
- To monitor ground stations calibration.

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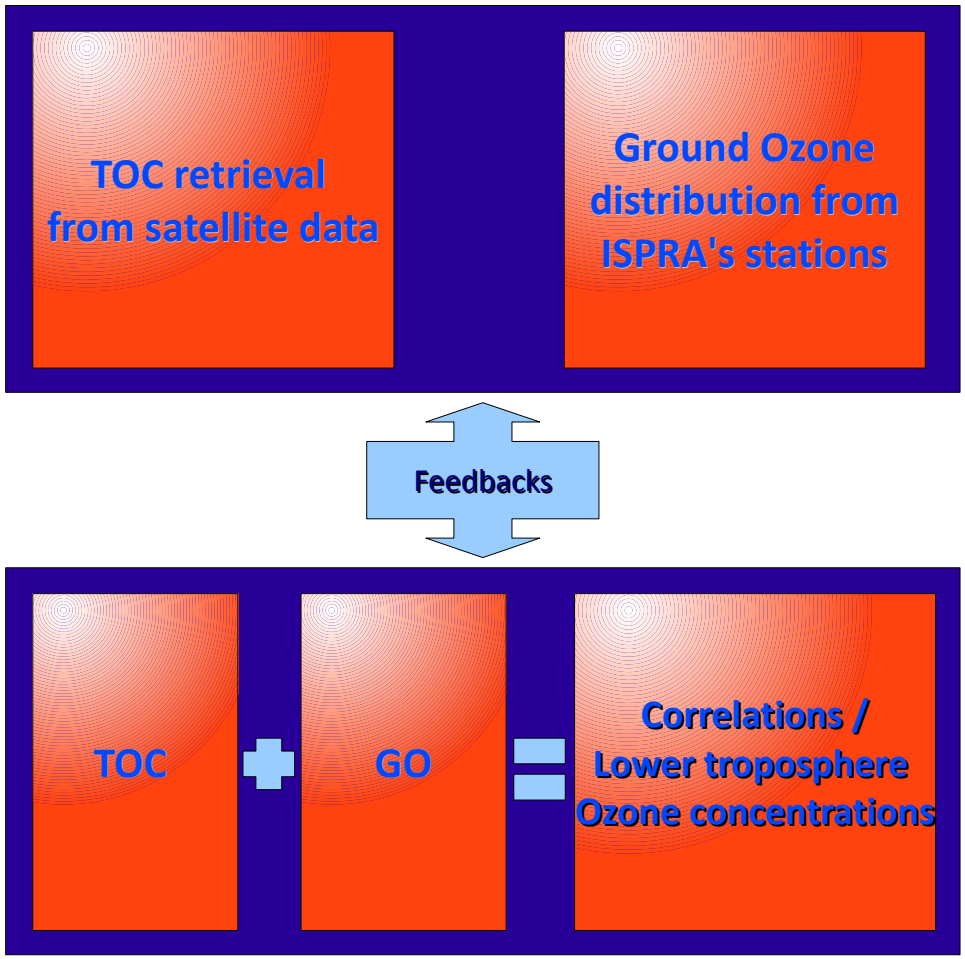
OUTLINE OF THE PROJECT (2/3)

Scheme of the project (1/2)

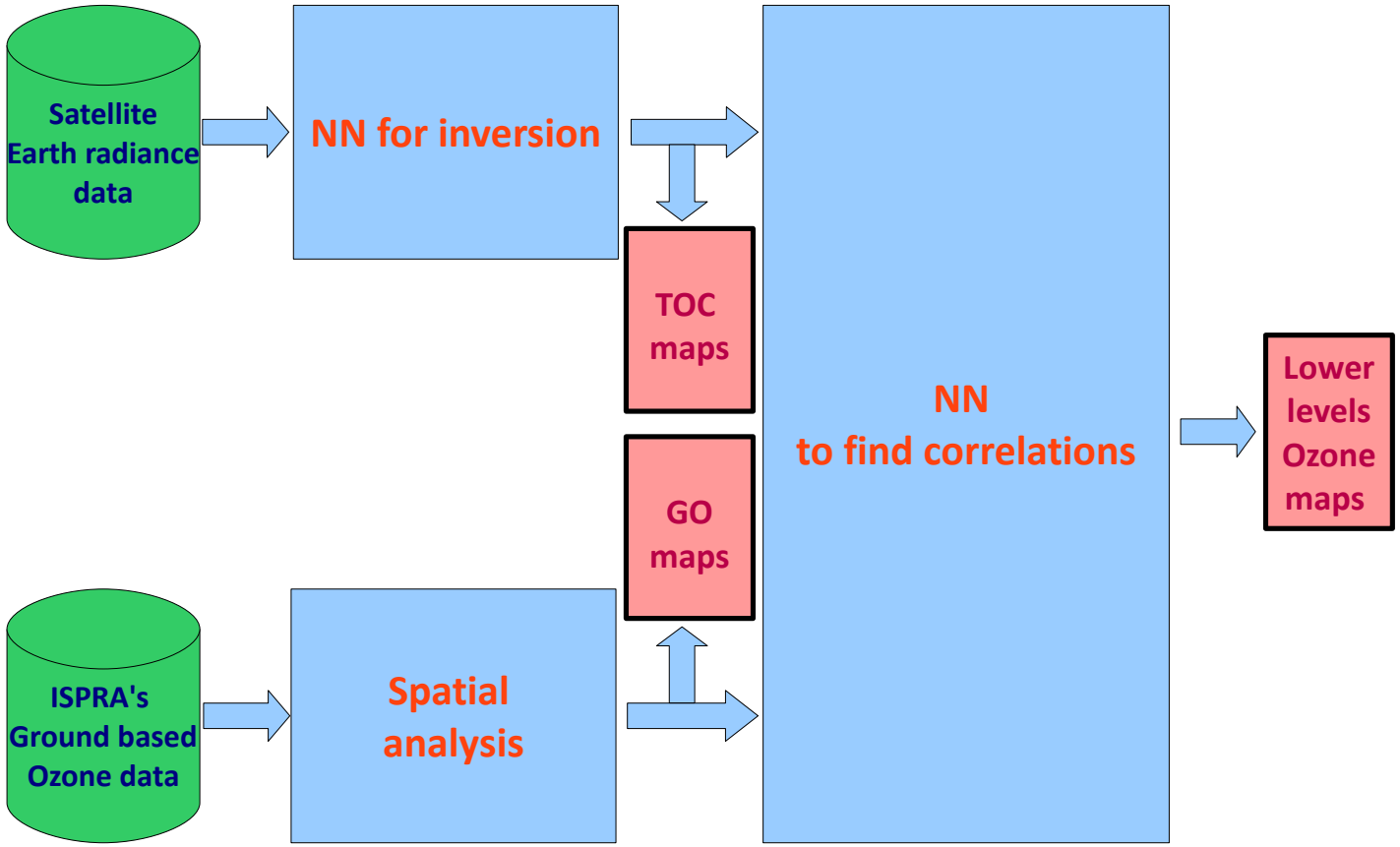


Phase 1:
- Concluded -

Phase 2:
- Started -

OUTLINE OF THE PROJECT (3/3)

Scheme of the project (2/2)



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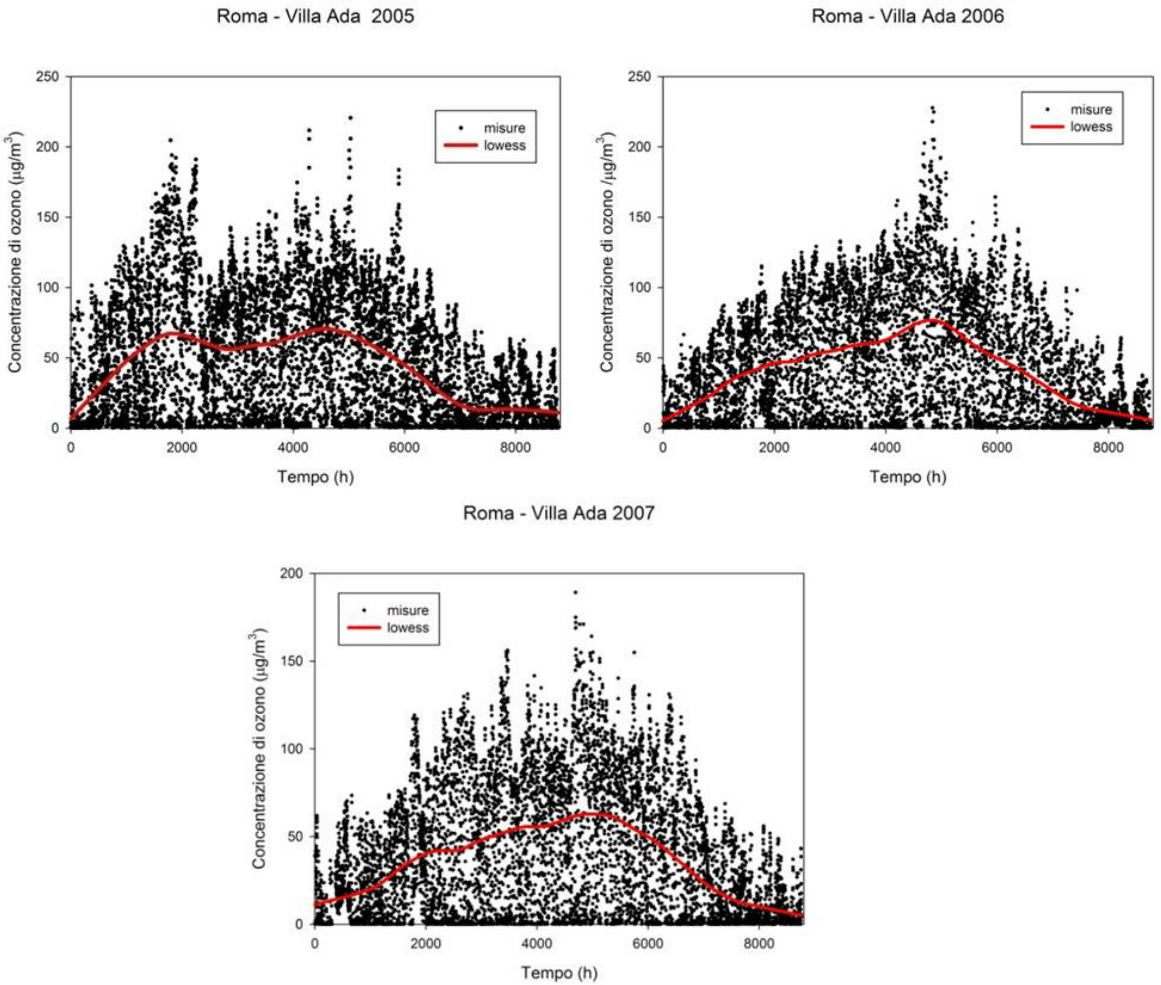
Ph. 1: GO SPATIAL CHARACTERIZATION (1/5)

ISPRA GO data

ISPRA dataset: about 300 GO stations designed to operate hourly



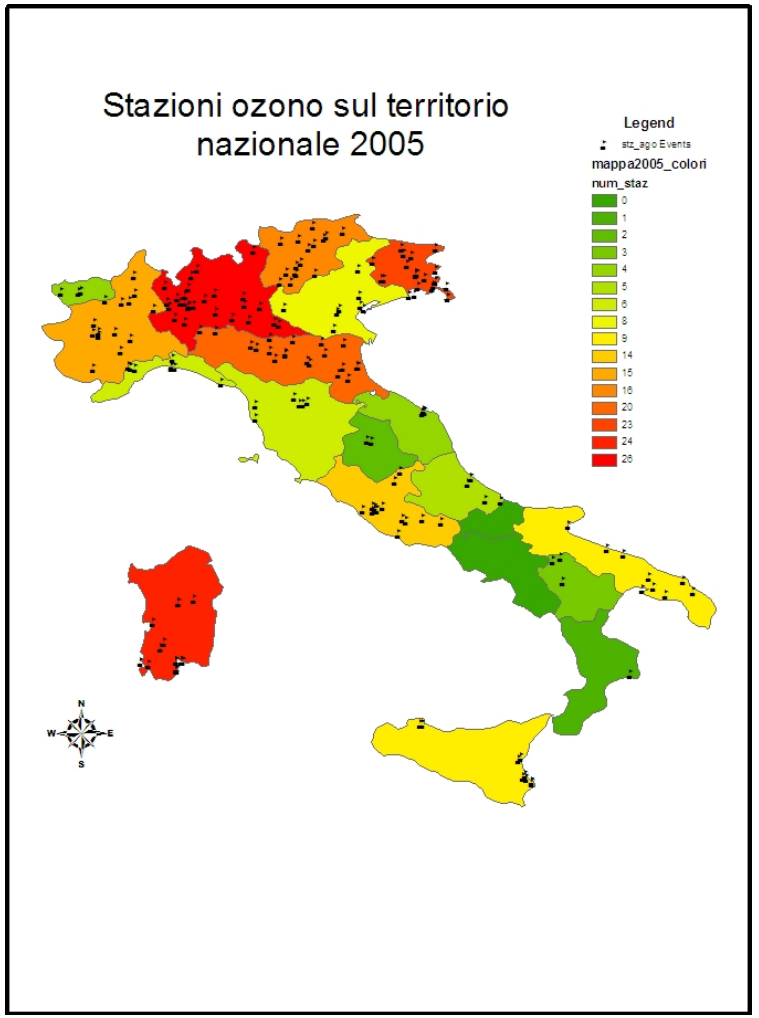
Ph.1: GO SPATIAL CHARACTERIZATION (2/5)

Distribution and availability

- Three years of data fully available

  2005
  2006
  2007

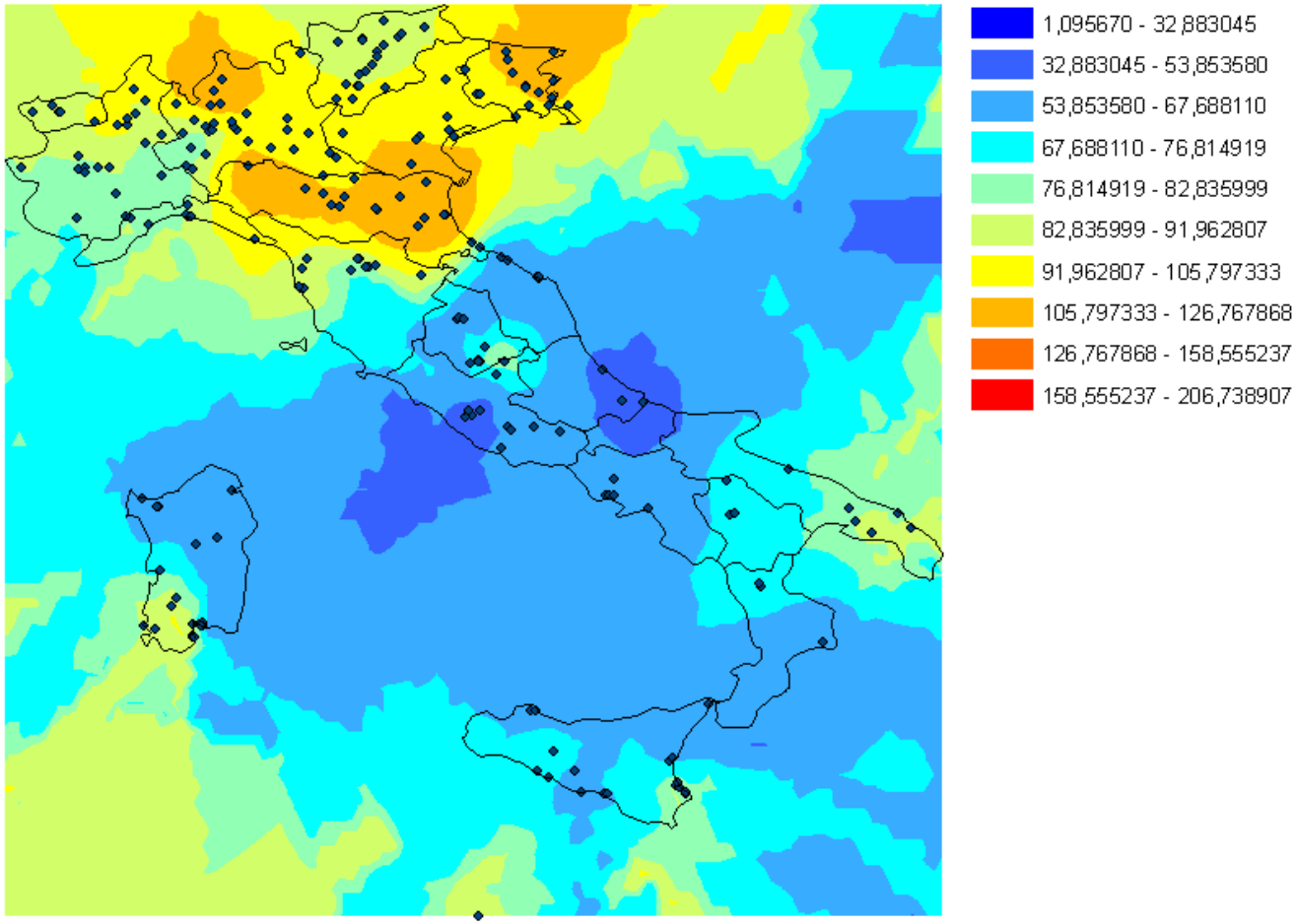
- Incomplete provision of real time data



Ph.1: GO SPATIAL CHARACTERIZATION (3/5)

Spatial Interpolation - some examples (1/3)

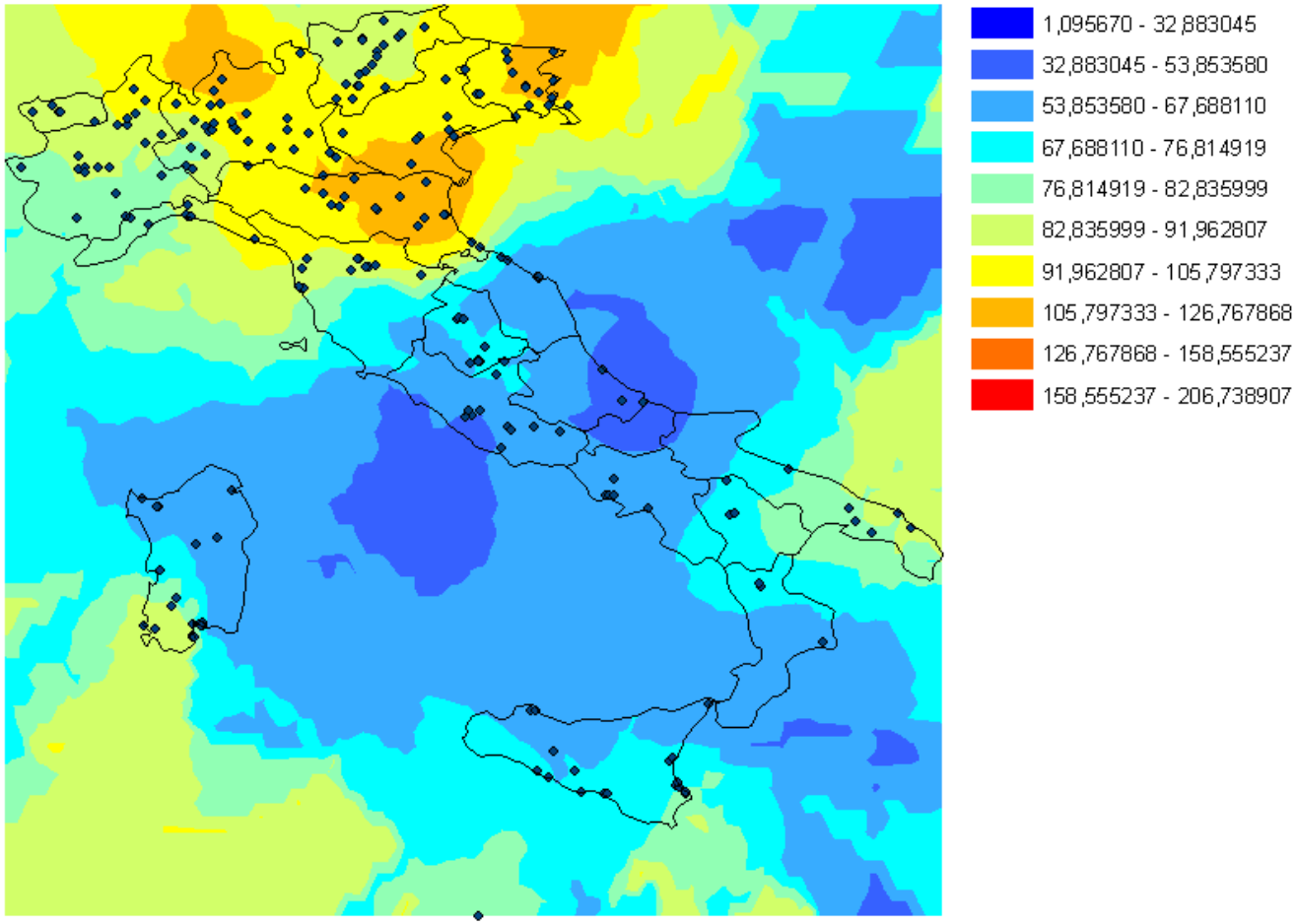
Kriging with spherical variogram model



Ph.1: GO SPATIAL CHARACTERIZATION (4/5)

Spatial Interpolation - some examples (2/3)

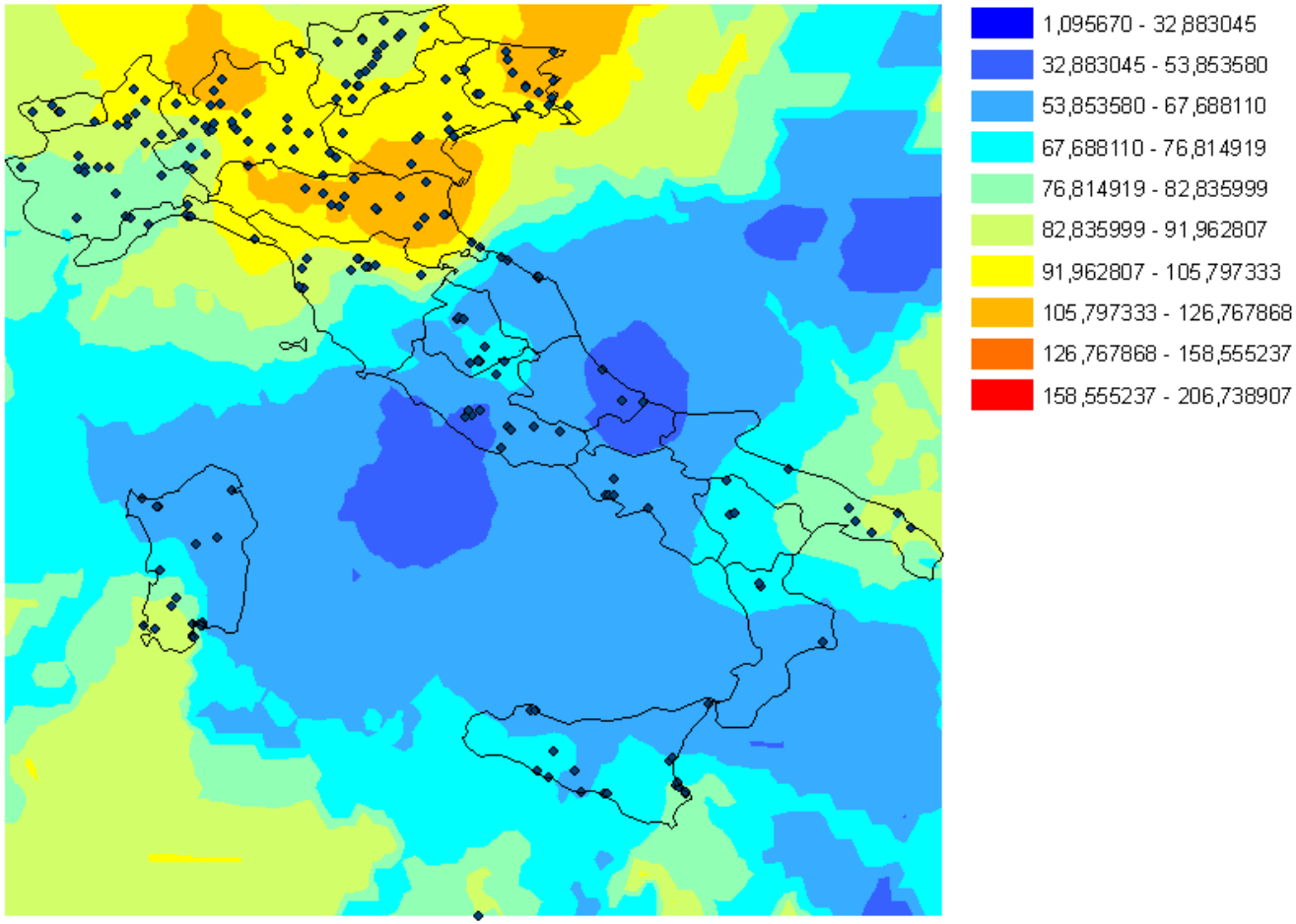
Kriging with exponential variogram model



Ph.1: GO SPATIAL CHARACTERIZATION (5/5)

Spatial Interpolation - some examples (3/3)

Kriging with Gaussian variogram model



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Ph1: TOC FROM SATELLITE (1/11)

Introduction

- ☺ EO useful where ground information is lacking
- ☹ Scarce sensitivity to ozone variations at lower altitudes
- ☺ NNs to find weak non-linear relationships

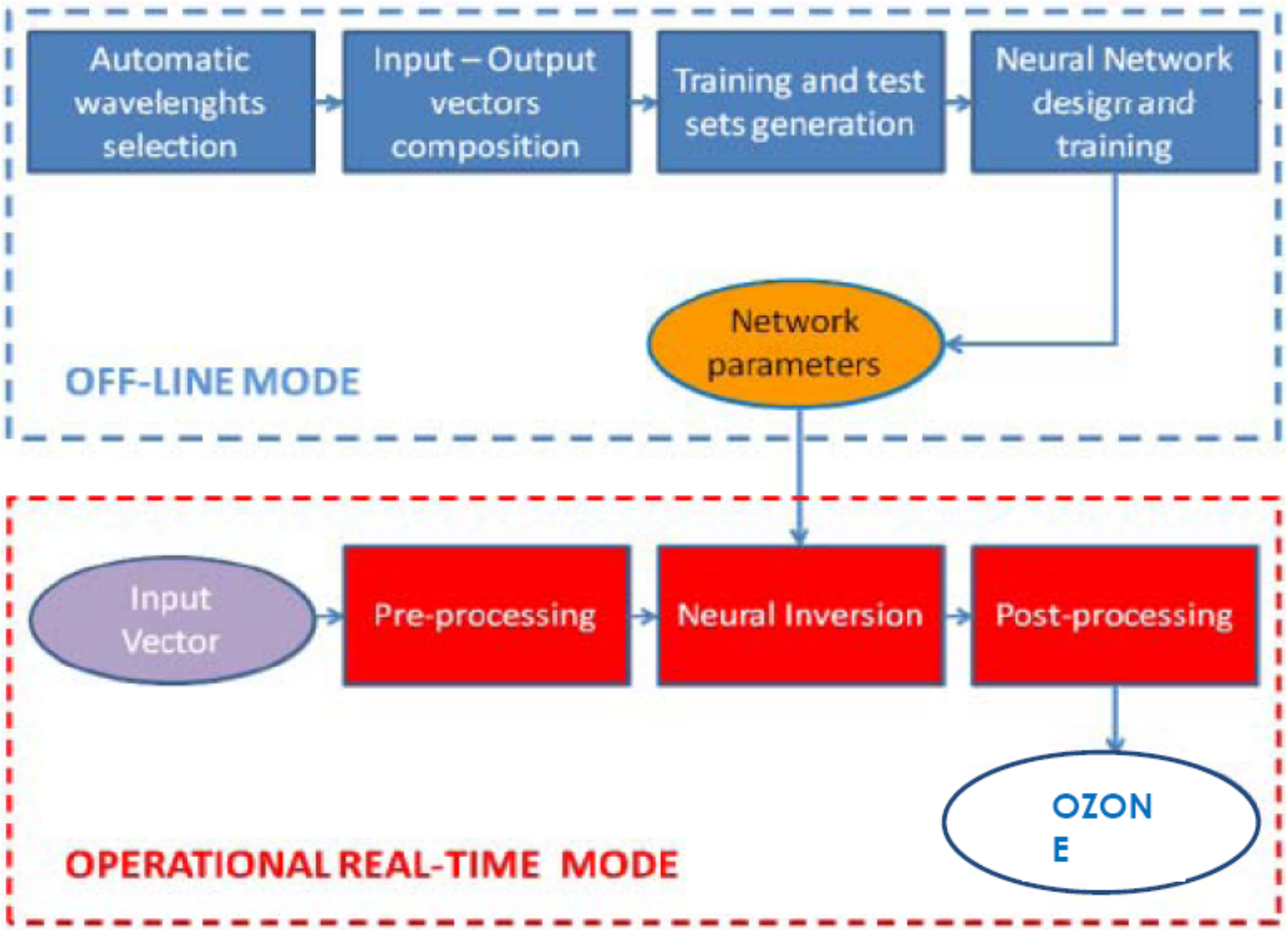
Ph1: TOC FROM SATELLITE (2/11)

Motivation for NNs

1. Robust to:
   - systematic errors
   - calibration uncertainties
2. Less sensitive to direct model uncertainties:
   - aerosols
   - clouds
3. Operate in real time

Ph1: TOC FROM SATELLITE (3/11)

General methodology



Ph1: TOC FROM SATELLITE (4/11)

A NN algorithm for TOC retrieval from OMI Level1b data

We chose Aura OMI data:

- Relatively high horizontal resolution;
- Daily global coverage;
- Proven sensitivity at the operating UV/VIS wavelengths;

Features matching User Requirements

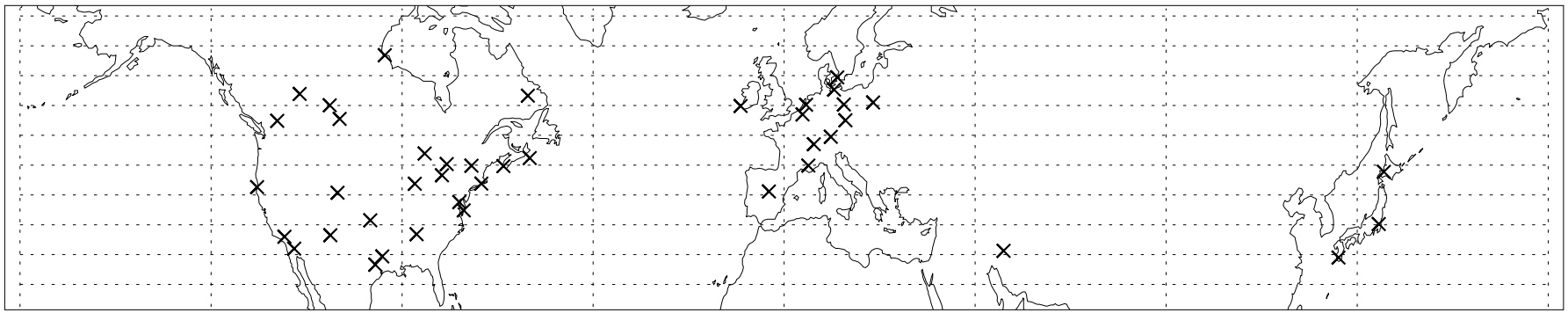
We applied our general methodology, starting from our past activities

Ph1: TOC FROM SATELLITE (5/11)

Available data (1/3)

AVDC OS dataset (thanks to AVDC staff and Xiong Liu):

10999 measurements overall / **4604** at northern mid-latitudes (30°N-60°N)



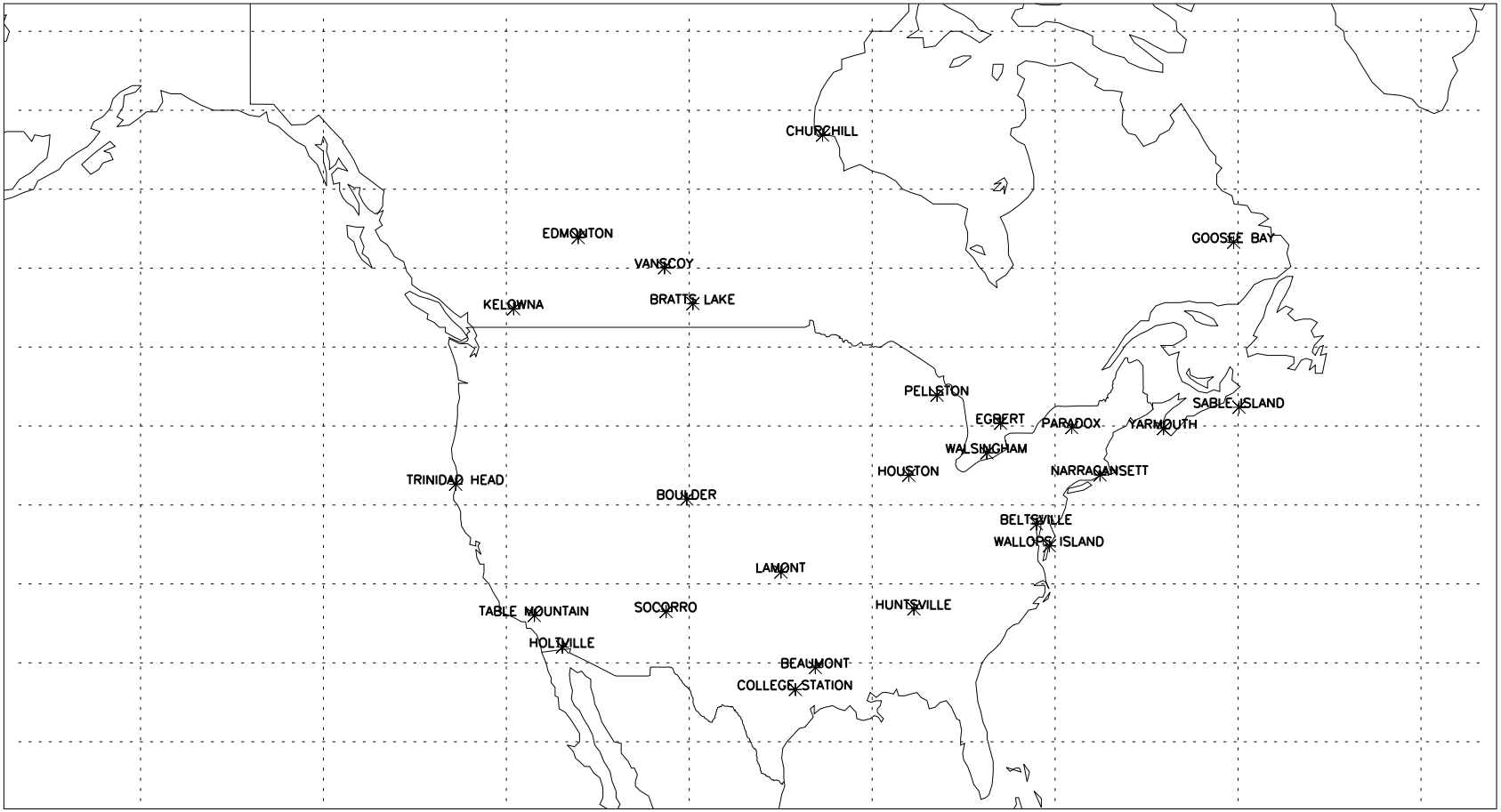
Ph1: TOC FROM SATELLITE (6/11)

Available data (2/3)

Active stations:
12 in Europe
25 in North America
3 in Japan
1 somewhere in m-E

Ph1: TOC FROM SATELLITE (7/11)

Available data (3/3)



Ph1: TOC FROM SATELLITE (8/11)

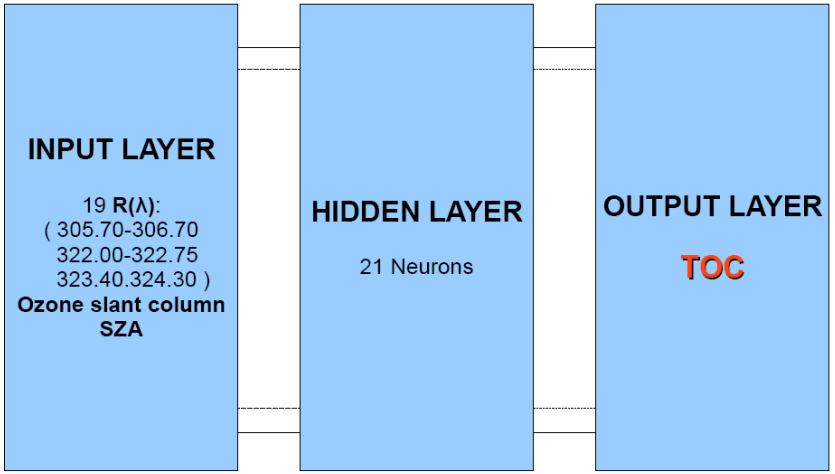
Matching procedure and dataset preparation

- Measured reflectances from OMI Level 1b data quality checked via several quality flags;
- Only OML1BRUG files considered for v1.0 - VIS spectra to be included in input for v2.0;
- TOCs (ground-to-200 hPa) from AVDC OS dataset;
- Northern mid-latitudes subset (30°N-60°N);
- Matching space distance: OS within the OMI pixel;
- Matching time distance: within the same day.

Ph1: TOC FROM SATELLITE (9/11)

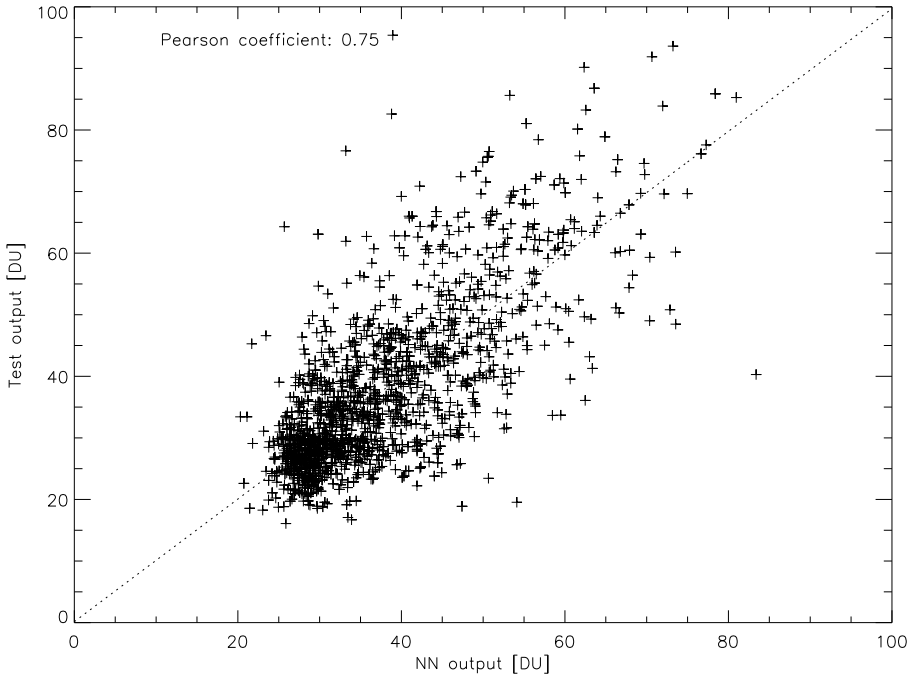
Training and optimization

- Input dimensionality reduction;
- Optimal number of hidden layers and hidden neurons;
- Training/test with about 3500/1500 input-output pairs;
- SCG learning algorithm;
- Early stopping procedure;
- NEAT-OMITOC converged after about 1500 epochs;

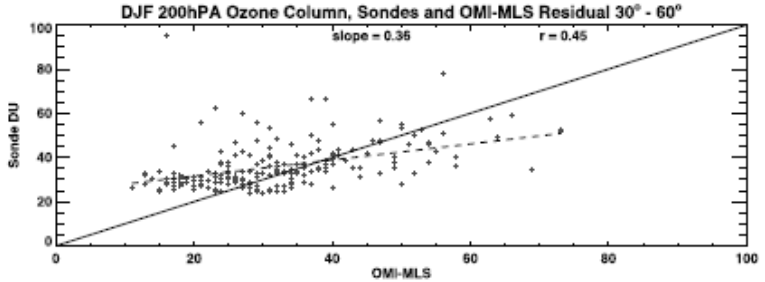


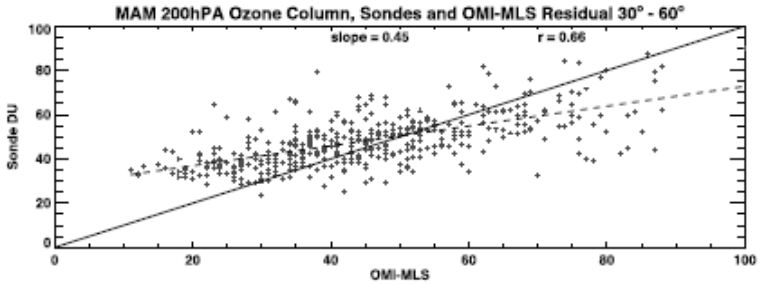
Ph1: TOC FROM SATELLITE (10/11)

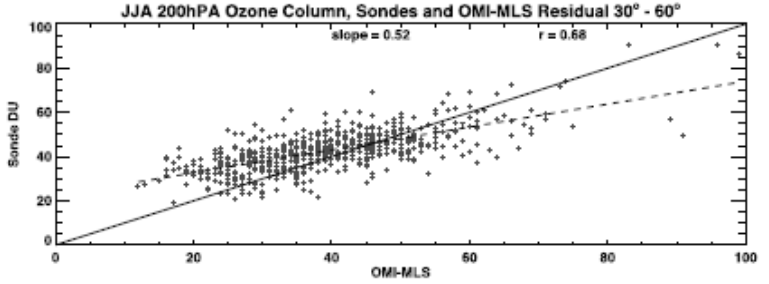
Test of the algorithm (1/2)

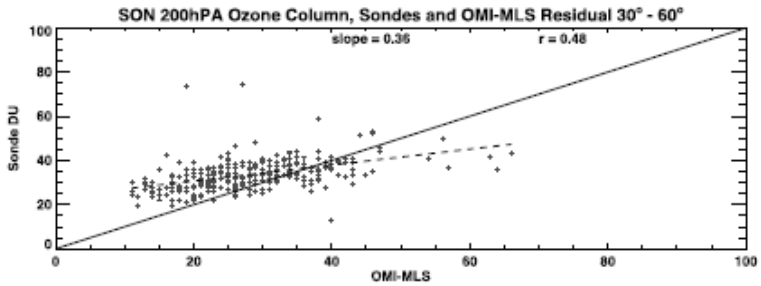


Schoeberl et al., JGR, 2007 ⟶



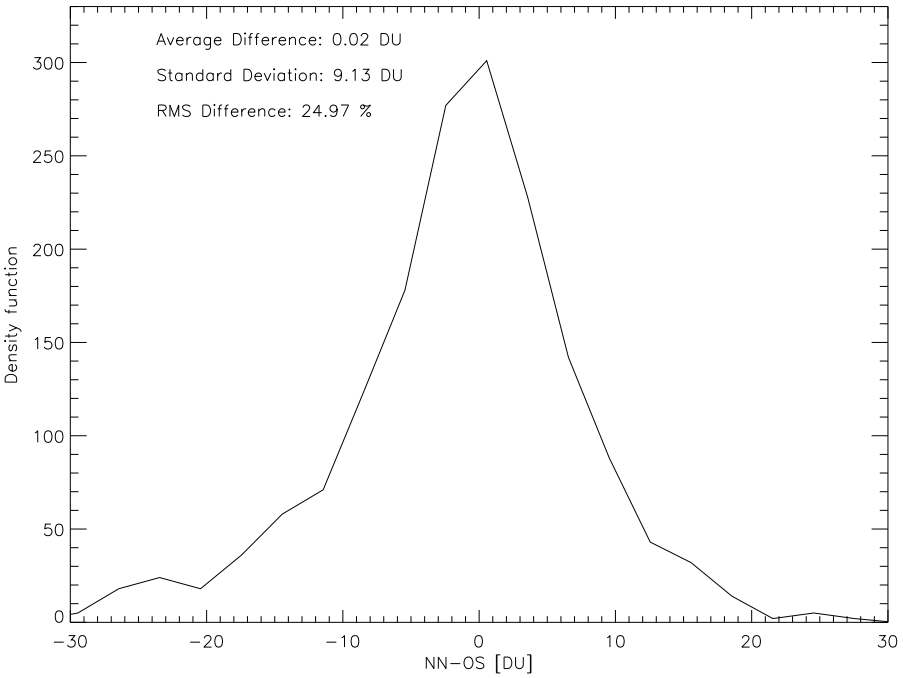






Ph1: TOC FROM SATELLITE (11/11)

Test of the algorithm (2/2)



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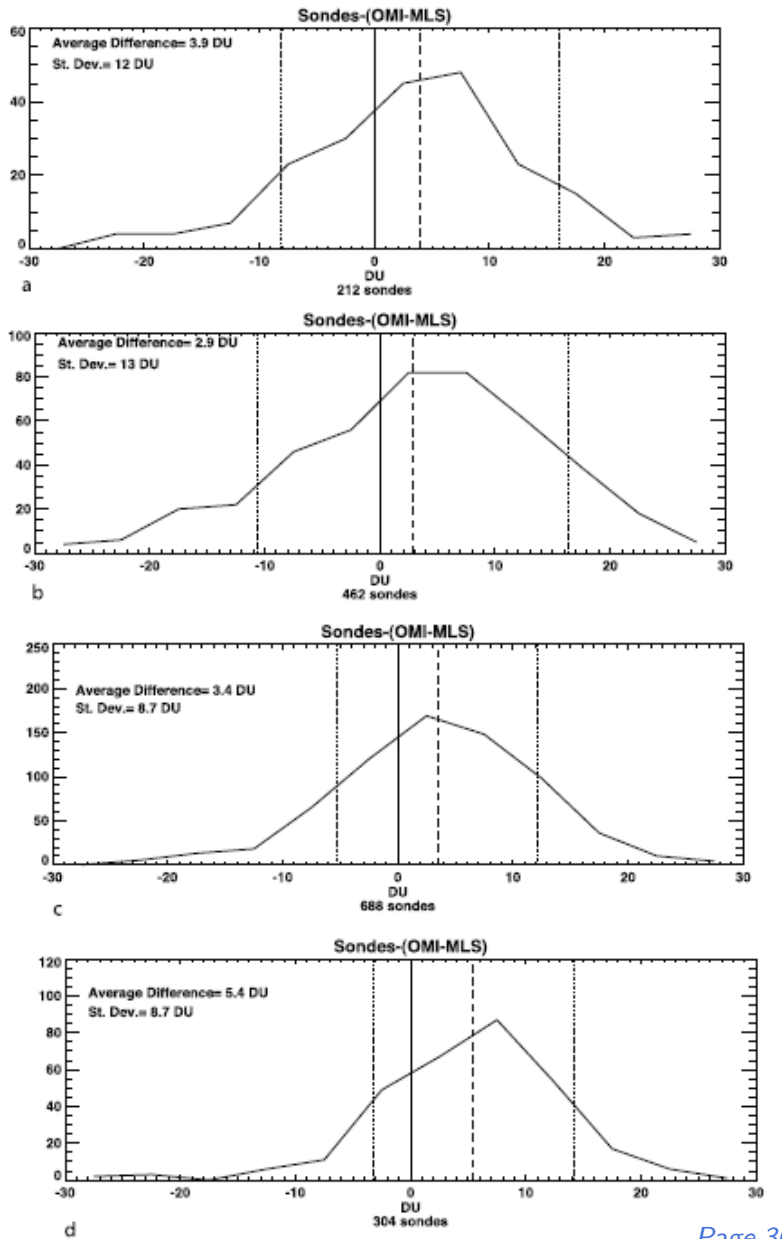

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Ph2: CORRELATION OF GOs AND TOCs

Our goals:

- to investigate the correlation between GOs and TOCs;
- to use this correlation to produce integrated ozone info from local and EO measurements;
- to help EO data in the retrieval of lower altitudes ozone information.

Matching strategies under investigation

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CONCLUSION AND FUTURE WORK (1/3)

- The APOLLO project fulfilled the expected activities: Phase 1 before KO + 7 months;
- We proposed an additional contribution to enhance vertical resolutions: Phase 2;
- NEAT-OMITOC algorithm can retrieve TOCs with the expected accuracy: RMS differences $<$ 25.0% over a test OS dataset;

CONCLUSION AND FUTURE WORK (2/3)

Future work regarding Ph.1: NEAT-OMITOC NN

- Extension of the considered band to the VIS;
- Dedicated wavelengths selection activity:
  - EP;
  - AANN;
- Investigation on the impact of clouds and aerosols;
- Investigation on the impact of systematic/calibration errors;
- Experiments over lower columns to enhance the vertical resolution;
- Validation;
- Implementation issues.

CONCLUSION AND FUTURE WORK (3/3)

Future work regarding Ph.2 and final service

- Study of matching criteria for GOs vs TOCs;
- Study of algorithms to correlate data;
- Finalization of the product and refinement of software implementation (prototype software + GUI exist).

BYE

THANKS FOR YOUR ATTENTION!