Study of Stratospheric Intrusions of Ozone-Rich Air in the Troposphere Exploiting the Synergy between Limb and Nadir Measurements

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1 INTRODUCTION & OBJECTIVES

Tropospheric Ozone is a key air pollutant and greenhouse gas that affects climate and human health. It is not directly emitted but is formed through reactions involving sunlight, volatile organic compounds, and nitrogen oxides, primarily from human activities. **Stratospheric-Tropospheric Exchange** (STE) events also impact tropospheric ozone levels by introducing ozone-rich stratospheric air into the troposphere. Detecting and quantifying these events is essential, and remote sensing measurements from instruments such as the Michelson Interferometer for Passive Atmospheric Sounding (MIPAS-Envisat) and the Infrared Atmospheric Sounding Interferometer (IASI-MetOP) could be crucial . These instruments, with their complementary observation geometries, can be used in data fusion to produce high-quality vertical profiles for studying STE events.

This work explores the potential of MIPAS and IASI **Complete Data fusion** (CDF) to detect and quantify ozone stratospheric intrusions, reserving the possibilities to look at instruments of new generation like the Changing Atmosphere Infrared Tomography (CAIRT), and IASI-New Generation (IASI-NG).

2 COMPLETE DATA FUSION

CDF combines together profiles from different instruments observing the same portion of the atmosphere, with a two-fold aim:

- ❑ Exploit data from more instruments
- ❑ **Reducing error, enhancing** profiles **information content**

INPUTS:
Retrieved profiles
Variance covariace matrices
Averaging kernel matrices
A priori information

↓

CDF

↓

OUTPUT:
Fused profile
Variance covariace matrix
Averaging kernel matrix
A priori information

Why CDF?

- ✓ Simple Algorithm
- ✓ No operational limits in managing large L1 dataset
- ✓ Possibility to manage the a priori constraint of the fused product

CDF limits?

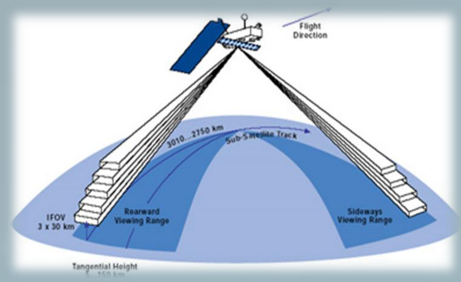
- ✗ Works well mainly with OE-retrieved profiles
- ✗ Requires all the inputs to properly work

3 INSTRUMENT OVERVIEW

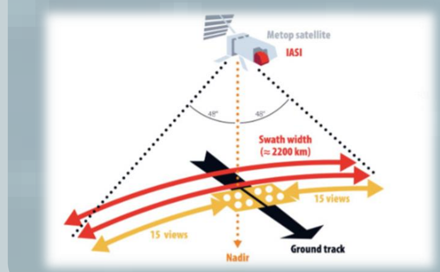
Michelson Interferometer for Passive Atmospheric Sounding (MIPAS)

- ❑ **Limb** observation geometry
- ❑ ENVironmental SATellite (ENVISAT)
- ❑ Activity: **Jul 2002 – Apr 2012**
- ❑ Successor: **CAIRT**

Spectral range:	685 ÷ 2410 cm-1
Spectral resolution:	0.025 cm-1
Altitude range:	6 ÷ 70 km
Vertical sampling:	1.5 ÷ 3 km
Spatial sampling:	410 km



Infrared Atmospheric Sounding Interferometer (IASI)



- ❑ **Nadir** observation geometry
- ❑ EUMETSAT - MetOp A,B,C
- ❑ Activity: **Oct 2006 – present**
- ❑ Successor: IASI-NG

Spectral range:	645 ÷ 2760 cm^{-1}
Spectral resolution:	0.25 cm^{-1}
Altitude sensitivity:	0 ÷ 60 km
Vertical sampling:	-
Spatial sampling:	25 km (nadir)

4 CASE STUDY

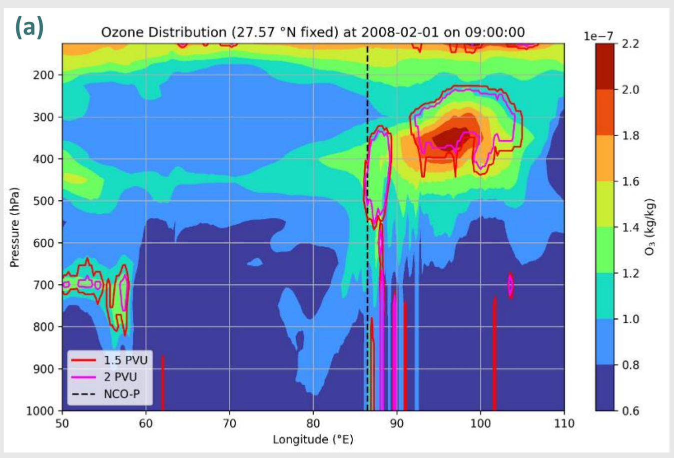


Fig a : SI on Feb 2nd,2008. ERA 5 O_3 mmr vertical meridional. 1.5PVU (red) and 2PVU (magenta) isolines, and station (dashed line) are shown.

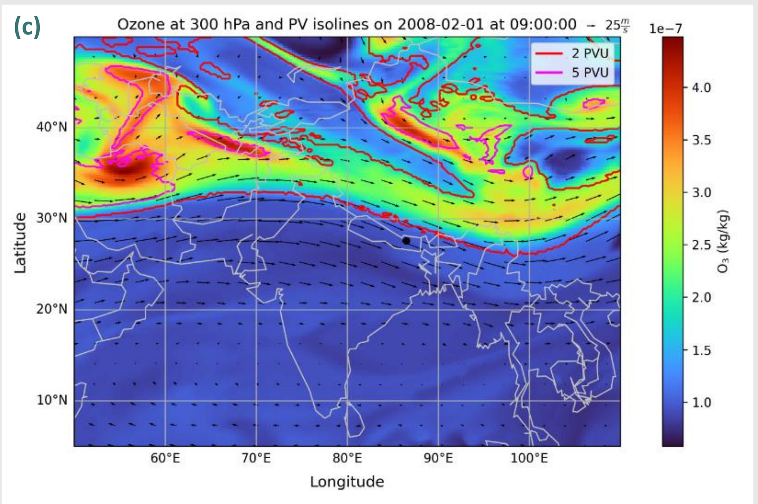


Fig c : 300 hPa SI on Feb 2nd,2008. ERA 5 O_3 mmr horizontal map with 2PVU (red) and 5PVU (magenta) isolines. Station (black dot) and wind arrows are also represented.

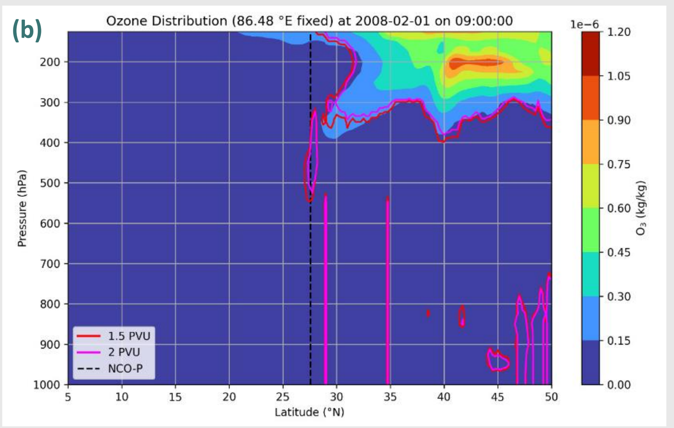


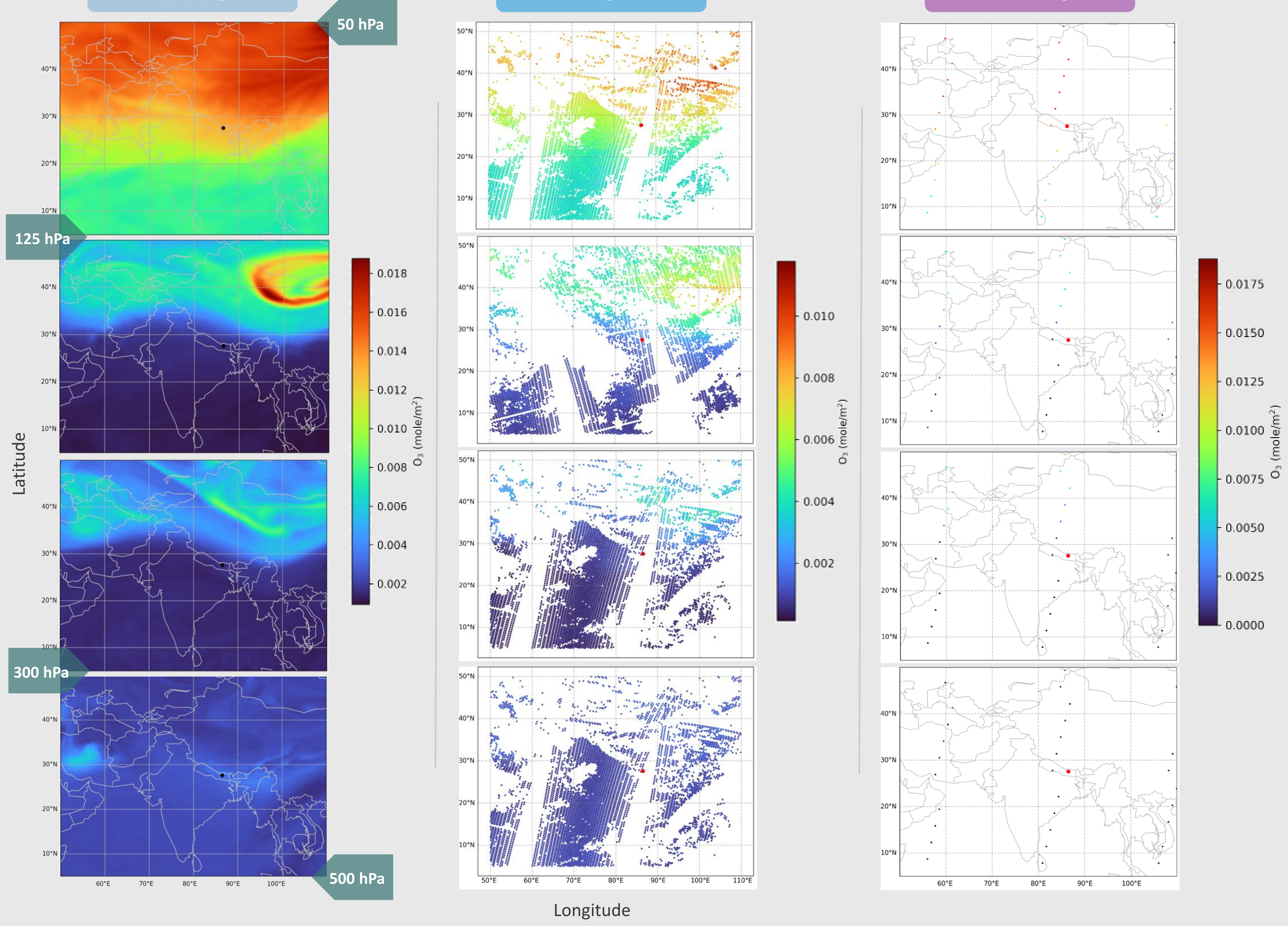
Fig b : SI on Feb 2nd,2008. ERA 5 O_3 mmr vertical meridional. 1.5PVU (red) and 2PVU (magenta) isolines, and station (dashed line) are shown.

2008/01/28 – 2008/02/02
NCO-P in situ station, Himalaya (5079 m slm)

What does IASI see? → What does MIPAS see? → CDF
ERA 5

5 PRELIMINARY RESULTS

- ❑ MIPAS and IASI measurements have been compared to ERA5 data after data standardization (integration to obtain partial columns and interpolation on the same grid).
- ❑ Profiles from MIPAS and IASI have different vertical grids, but the fusion will be performed on a common fusion grid. Each MIPAS profile will be fused with the corresponding IASI profile coinciding with MIPAS.



ERA5, IASI, and MIPAS horizontal maps for different pressure levels (50, 125, 300, and 500 hPa) on February 2nd, 2008. IASI and MIPAS data have been filtered for daytime values to be compared with ERA5 data.

6 DISCUSSION & DEVELOPMENTS

- ❑ From ERA5 data it is clearly visible the shape of the event and ozone data shows good agreement with potential vorticity data.
- ❑ Both MIPAS and IASI data values are compatible with ERA5 values.
- ❑ 15 superposition points have been found in a coincidence length of 5km to perform CDF algorithm.

✓ MIPAS data conversion and IASI state vector expansion → ✓ CDF algorithm dev. and consistency tests → ✓ CDF application considering interpolation and coincidence error

Challenges

- ☑ Data manipulation
- ❑ Choice of the a priori constraint
- ❑ Choice of the fusion grid

Future Developments

- ❑ Exploit fused vertical profiles to detect and quantify intrusions
- ❑ Extend the analysis to other cases

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