Validation of SCIAMACHY trace gas data products by comparison with measurements from other satellite sensors

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Satellite-Validation of GOMOS, MIPAS und SCIAMACHY

Instrument	*Data product*	*Geometry*	*SCIA product*
SAGE II (10/84)	O_3 profiles NO_2 profiles H_2O profiles*	Occultation	L-IUP,O-IUP L-IUP,O-IUP L-op
HALOE (9/91)	O_3 profiles NO_2 profiles H_2O profiles CH_4 profiles	Occultation	L-IUP,O-IUP L-IUP,O-IUP L-op L-op
POAM III (3/98)	O_3 profiles NO_2 profiles	Occultation	L-IUP,O-IUP L-IUP,O-IUP
GOME (4/95)	O_3 columns NO_2 columns O_3 profiles*	Nadir	N-op N-op,N-IUP L-op, N-IUP
TOMS (7/96)	O_3 columns	Nadir	N-op
MIPAS (3/02)	O_3profile**/*** NO_2 profiles **	Limb	L-IUP L-IUP
GOMOS *SABER (12/01)* *ACE (8/03)*	O_3 profiles NO_2 profiles H_2O profiles CH_4 profiles	Occultation Limb Occultation	L-op,L-IUP L-op,L-IUP L-op L-op

Cooperations:
GOMOS: ACRI (Gilbert Barrot)
MIPAS: IMK (Mathias Milz), DLR, Univ. of Oxford
SAGE II : L. Thomason (NASA LaRC)
HALOE, SABER: J.M. Russell III, E. Thompson (Hampton Univ.)
POAM III: R. Bevilacqua (ONR, CNES, NRL)
GOME, SCIAMACHY: IUP Bremen
TOMS: E. Hilsenrath, R. Mc Peters (NASA GSFC)
ACE-FTS: P. Bernath, K. Walker (Univ. of Waterloo)

green: first validation
blew: new instruments

* = right now data quality to bad for validation
** = MIPAS IMK-Retrieval-Profiles
*** = MIPAS operational product

Overview

- SCIAMACHY validation results

  nadir: operational O_3-columns with GOME and TOMS

  NO_2-columns operational and retrieved by IUP with GOME

  occultation: O_3-profiles retrieved by IUP with SAGEII

  limb: O_3-profiles retrieved by IUP with HALOE

  NO_2-profile retrieved by IUP with HALOE

  O_3-profiles retrieved by IUP with MIPAS

  NO_2-profile retrieved by IUP with MIPAS-E

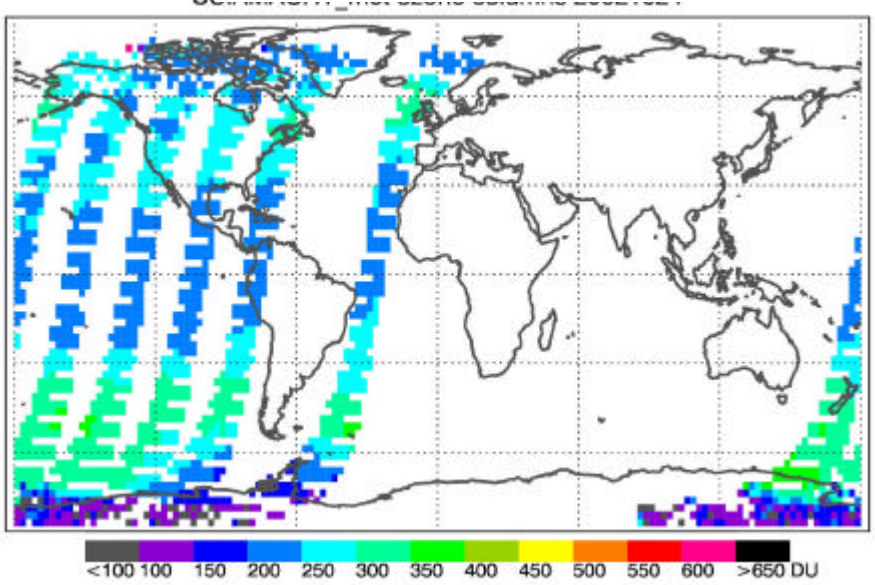
  Concluding remarks

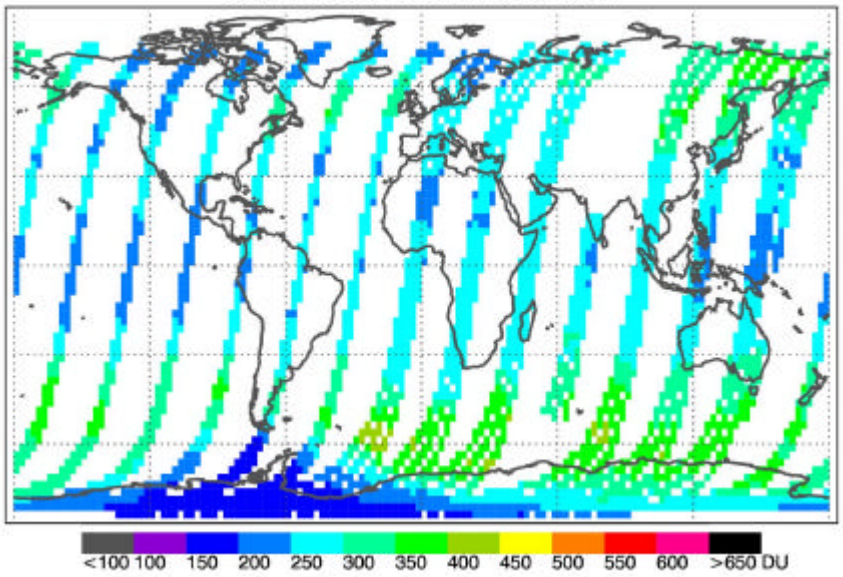
- work plan until end of project

Comparison of SCIAMACHY O_3 total columns with GOME & TOMS

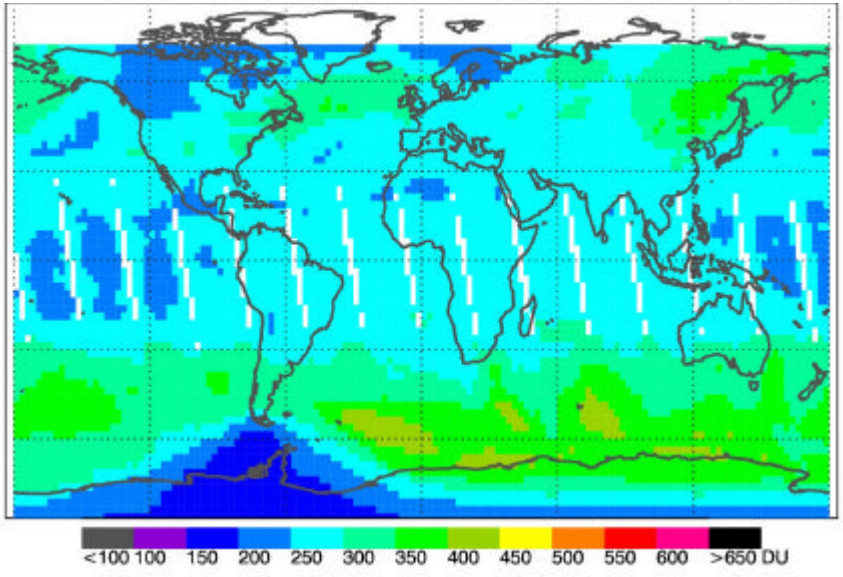
at 2002/10/24

SCIAMACHY 3.53





GOME 3.0



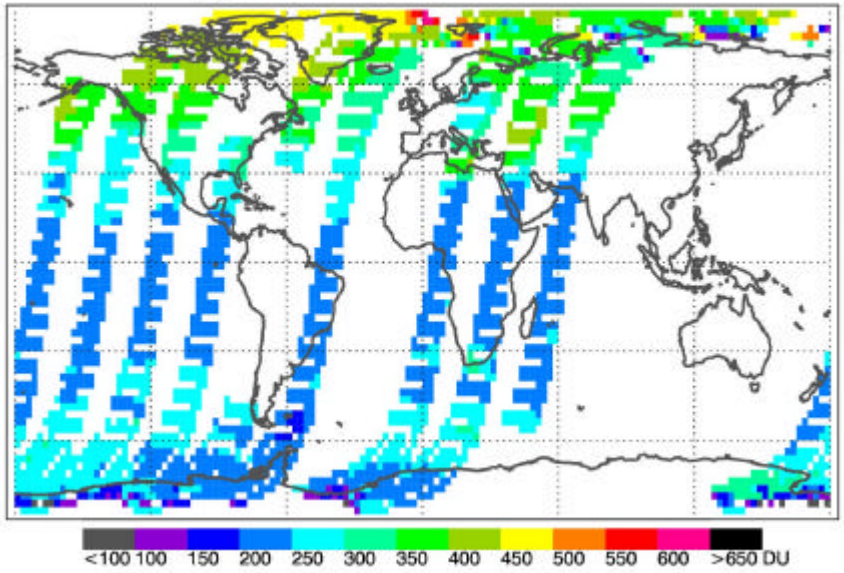
TOMS 7.0

All O_3 data of time period in 2.5° X 2.5° grids and comparison of SCIAMACHY, TOMS and GOME within the same grid

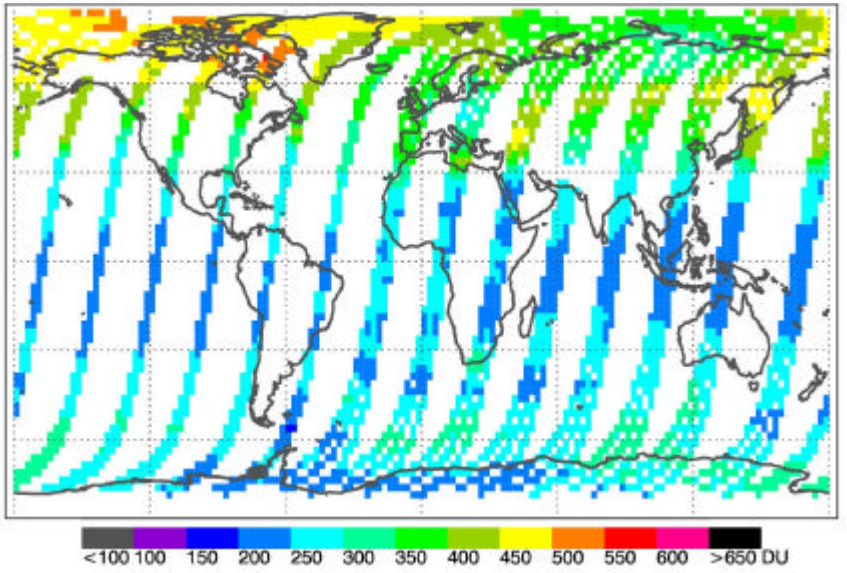
Comparison of SCIAMACHY O_3 total columns with GOME & TOMS

at 2003/03/24

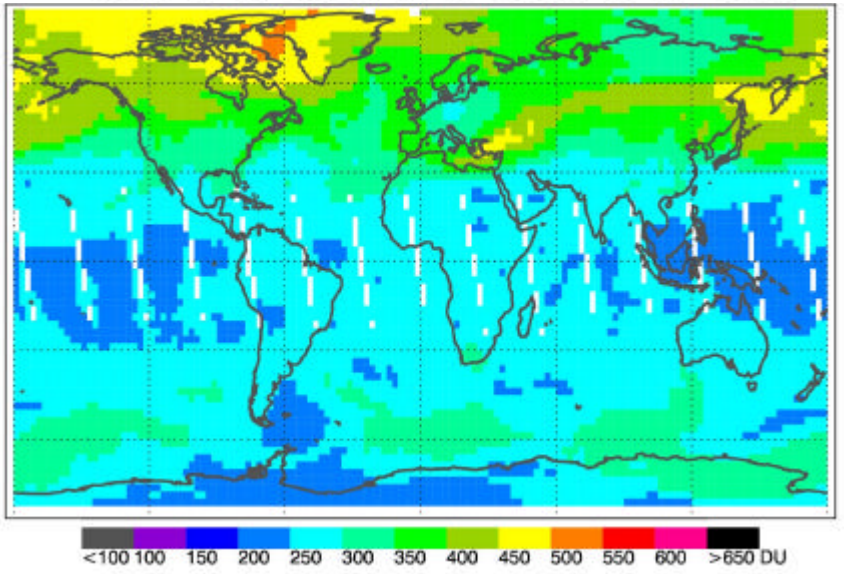
SCIAMACHY 4.0



GOME 3.0

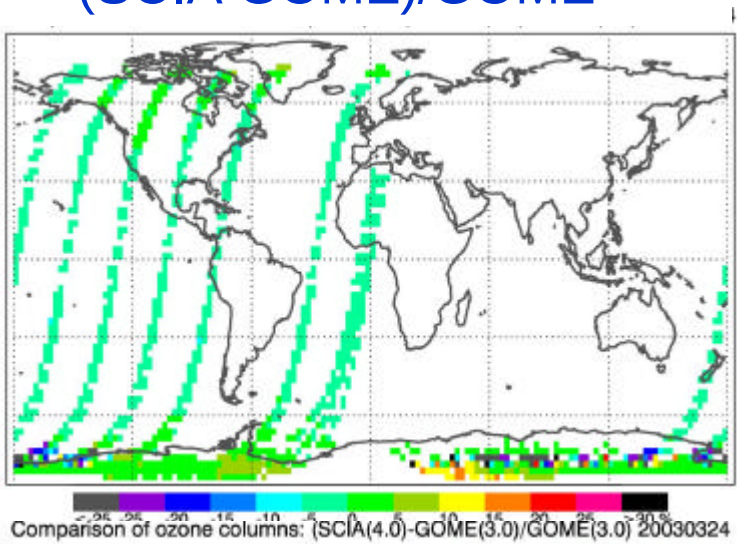


TOMS 7.0



Comparison of SCIAMACHY O_3 total columns with GOME & TOMS

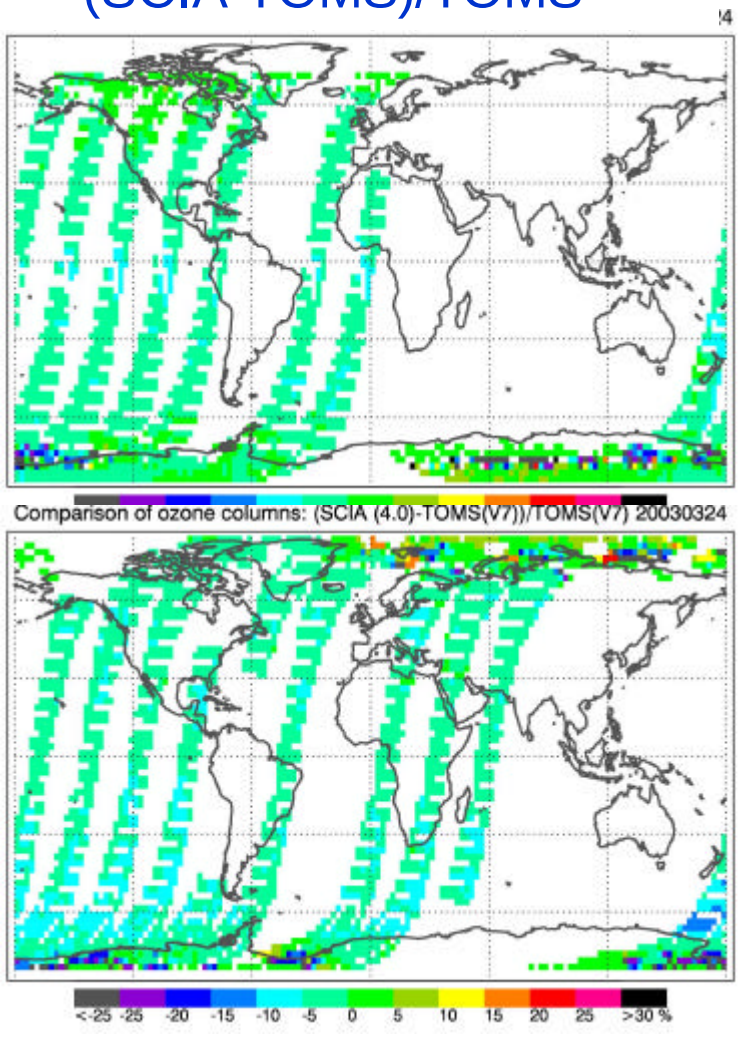
(SCIA-GOME)/GOME



at 2002/10/24

at 2003/03/24

(SCIA-TOMS)/TOMS

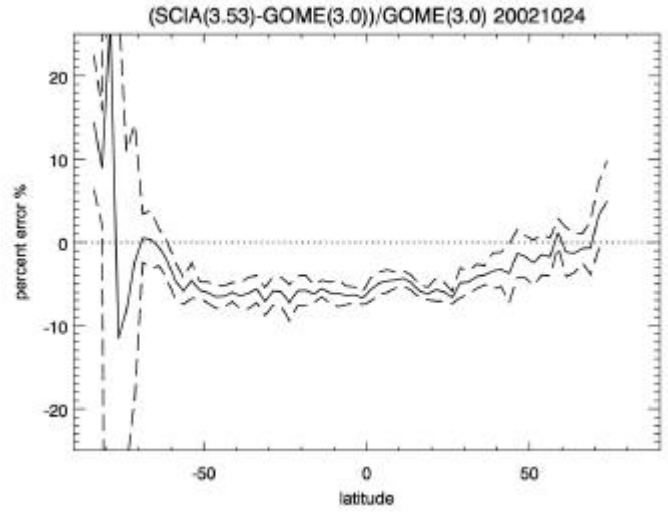


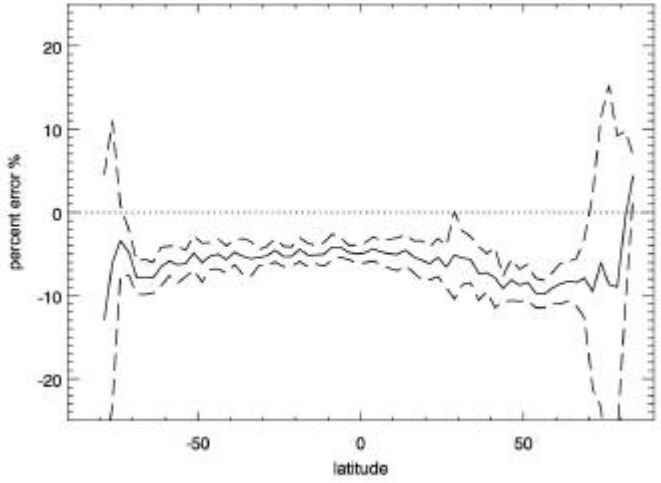
SCIA (3.53 & 4.0) ~ –5 % to GOME (3.0)

SCIA (3.53 and 4.0) ~ >–5 % to TOMS (7.0)

Comparison of SCIAMACHY O_3 total columns with GOME & TOMS

(SCIA-GOME)/GOME



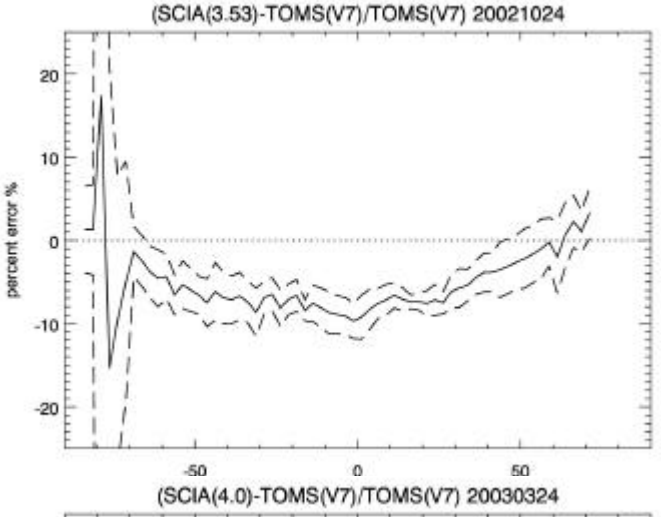


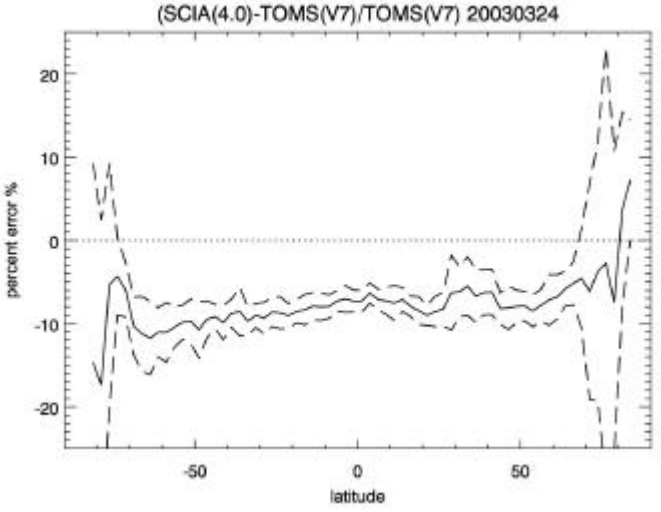
at 2002/10/24

Exception:
at high northern latitudes in fall ~ 0% deviation
in spring deviation as everywhere else

at 2003/03/24

(SCIA-TOMS)/TOMS



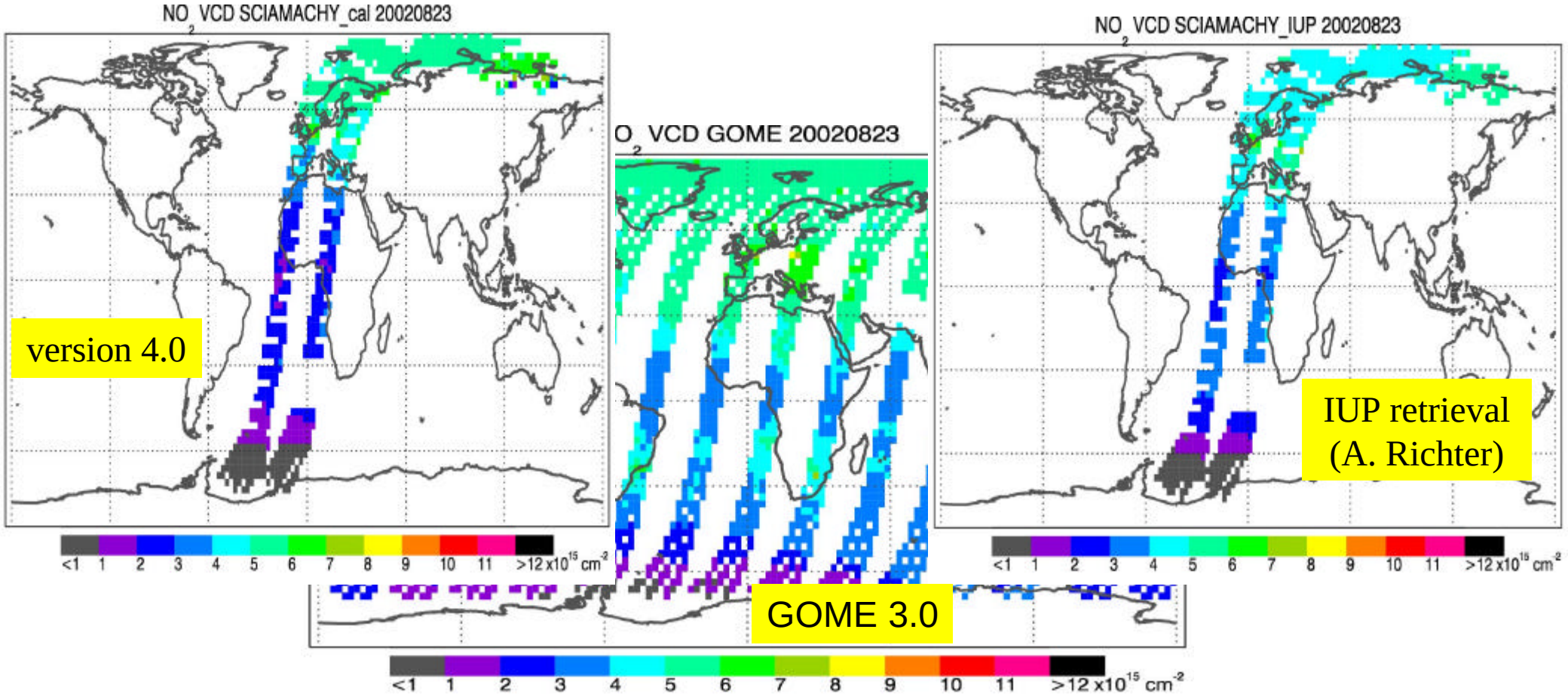


SCIA (3.53 & 4.0) ~ –5 % to GOME (3.0)

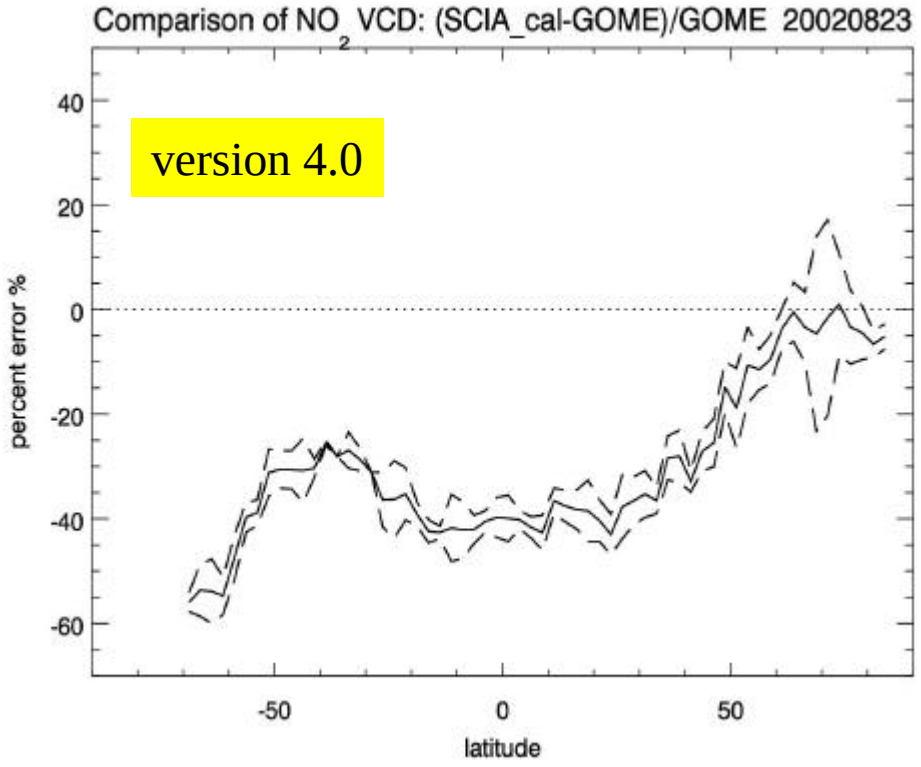
SCIA (3.53 and 4.0) ~ –8 % to TOMS (7.0)

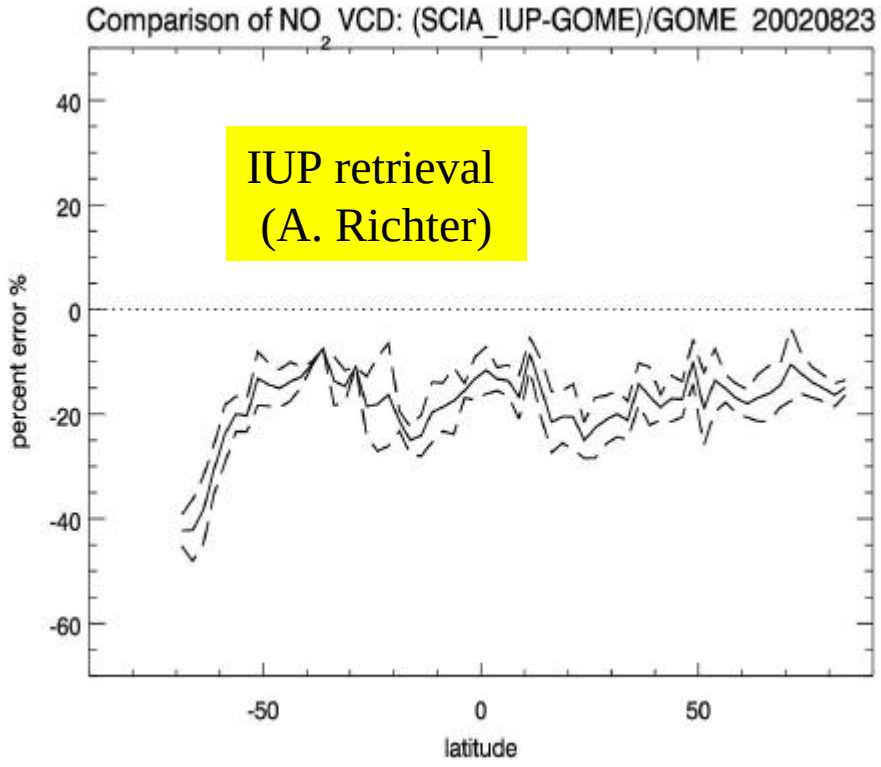
Comparison of SCIAMACHY NO_2 total columns (VIS) with GOME

Calibration orbits 2509 and 2510



Comparison of NO_2 total columns: (SCIA-GOME)/GOME

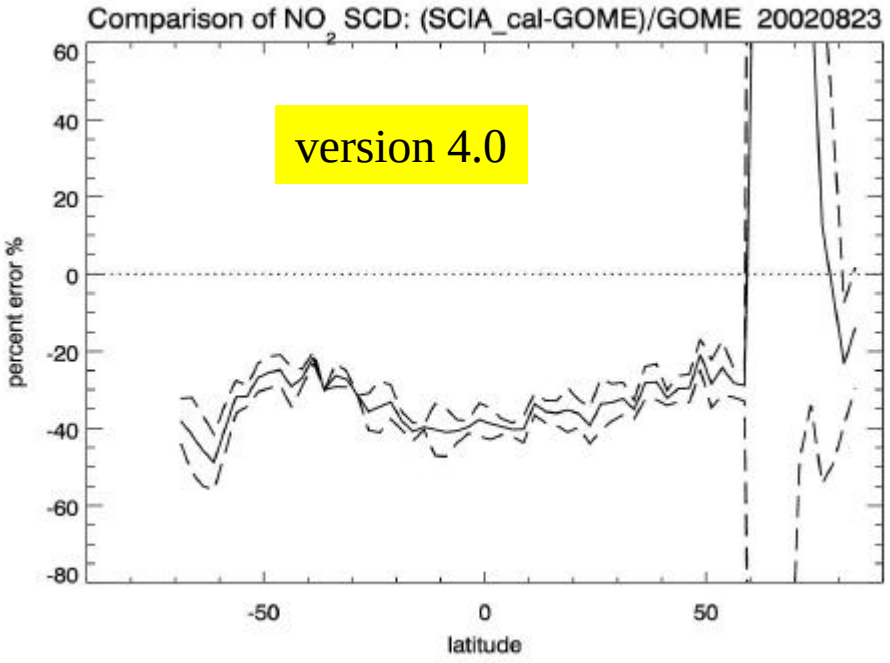


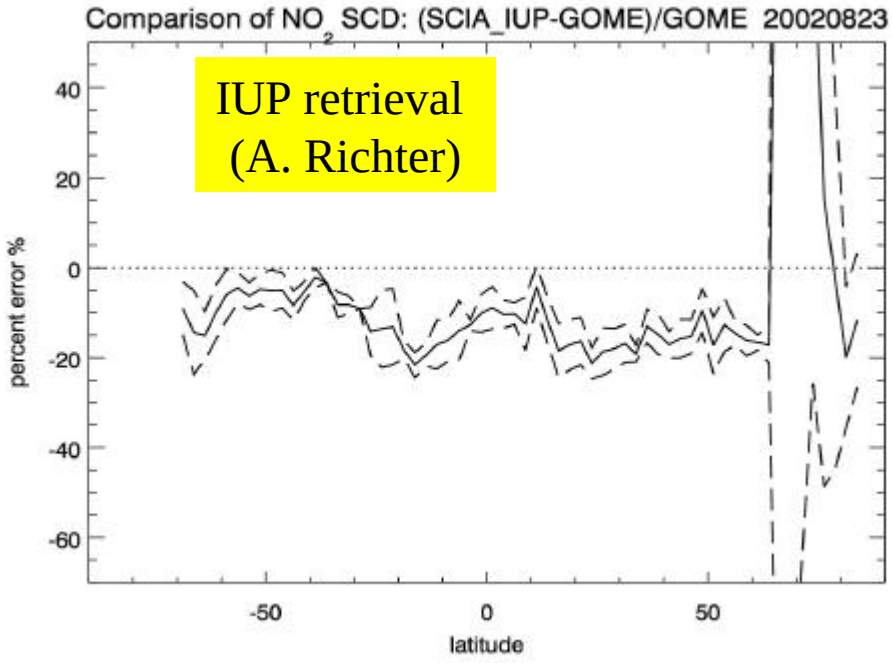


•strong variation with latitude:
–60% at 70°S to 0% at 70°N

• stable offset of –20%,
•<-60° down to –40%

Comparison of NO_2 slant columns: (SCIA-GOME)/GOME

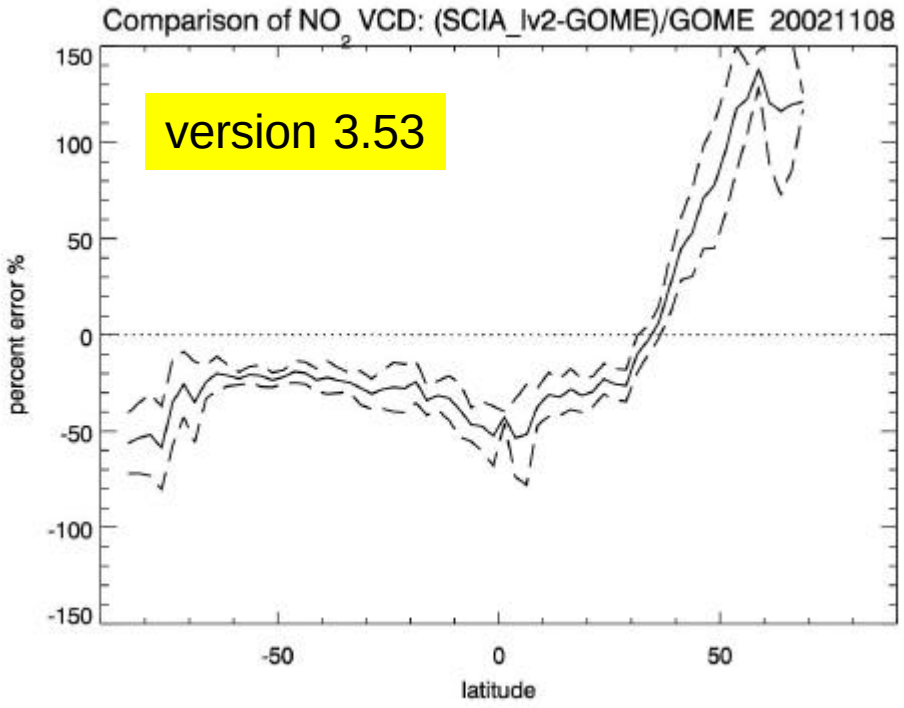


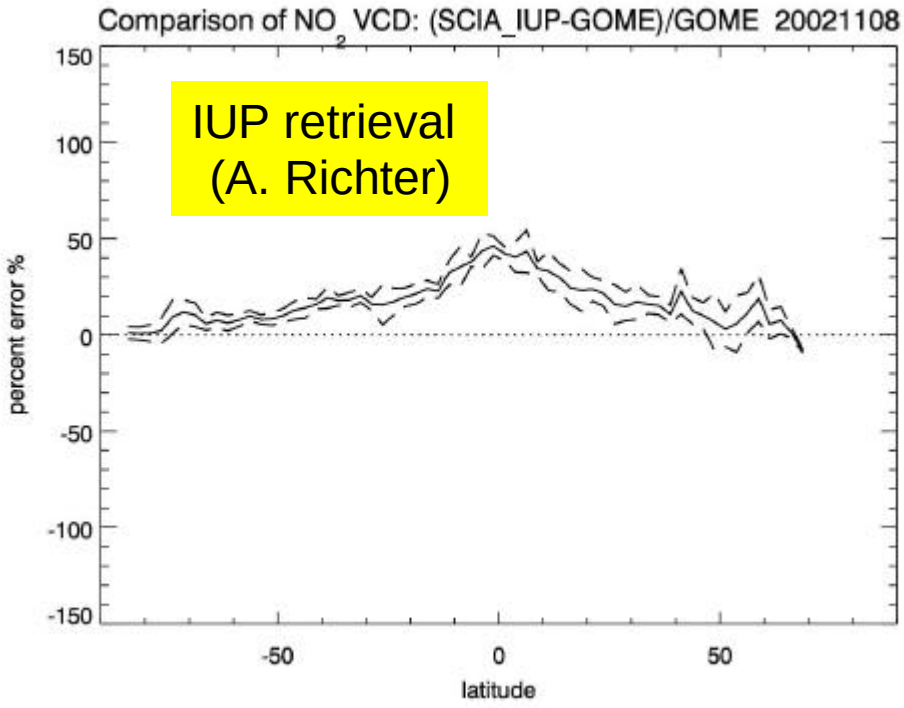


- at 70°S –50°N both retrievals show negative offset
- –10% with strong scatter for SCIAMACHY IUP Retrieval
- –30% with strong scatter for SCIAMACHY 4.0

→ largest contribution to total column error of operational product from AMF

Comparison of NO_2 total columns: (SCIA-GOME)/GOME

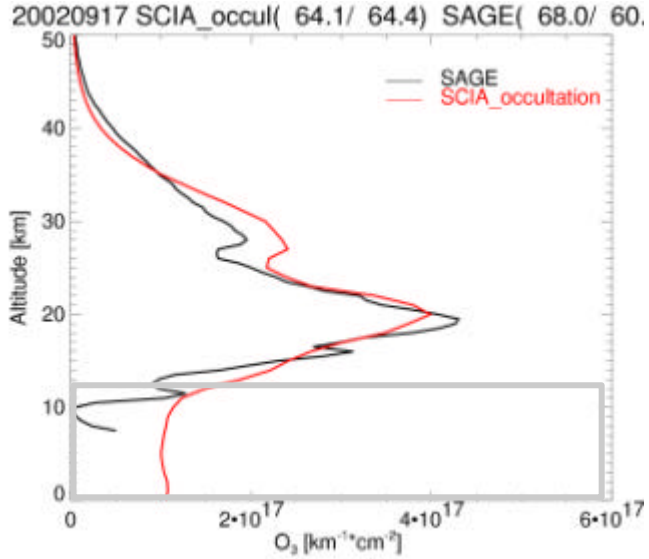


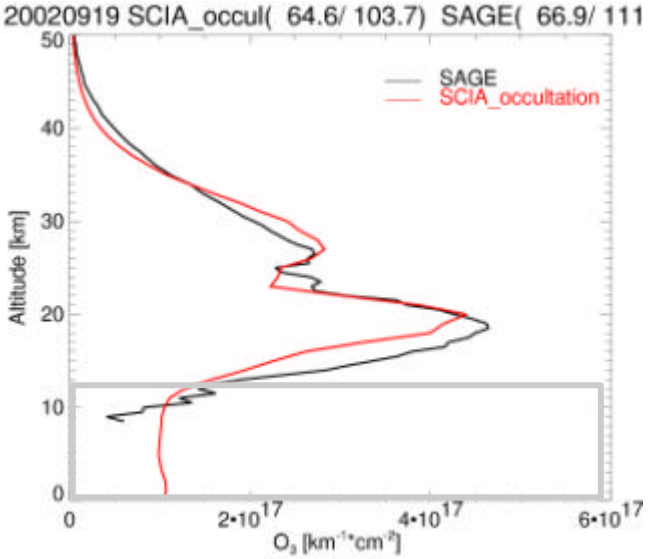


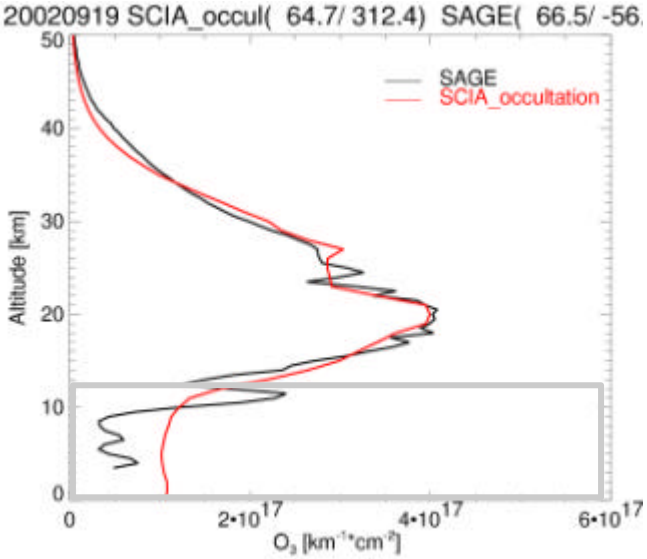
- much worse than version 4.0 (there in lv1 data: better polarisation correction, sun spectrum)
- strong variation with latitude:
  –50% at 70°S to +140% at 70°N

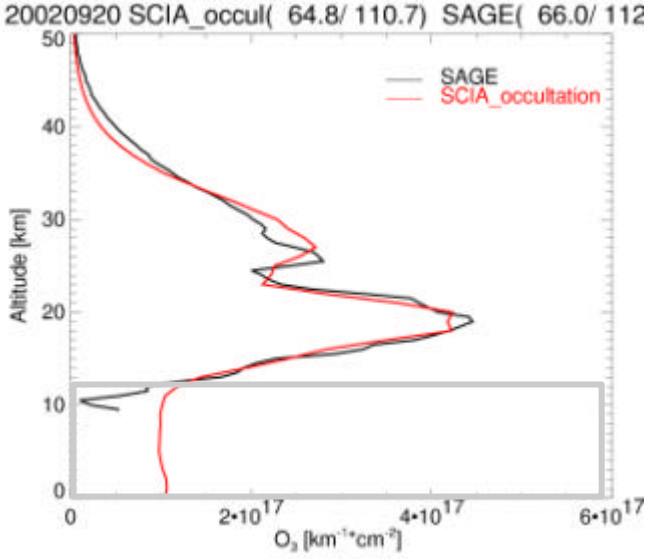
- variation from 0% at high latitudes to +50% in the tropics
- no sun spectrum used, fitted against SCIA spectrum in the tropical Pacific

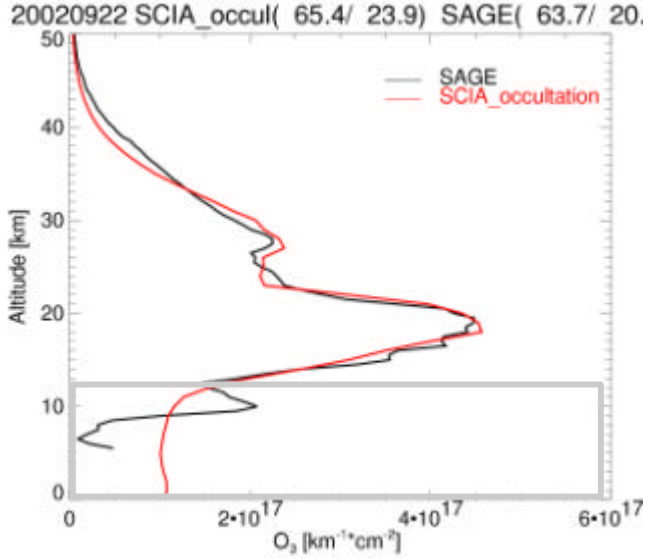
SCIAMACHY IUP O_3 occultation profiles compared to SAGE II









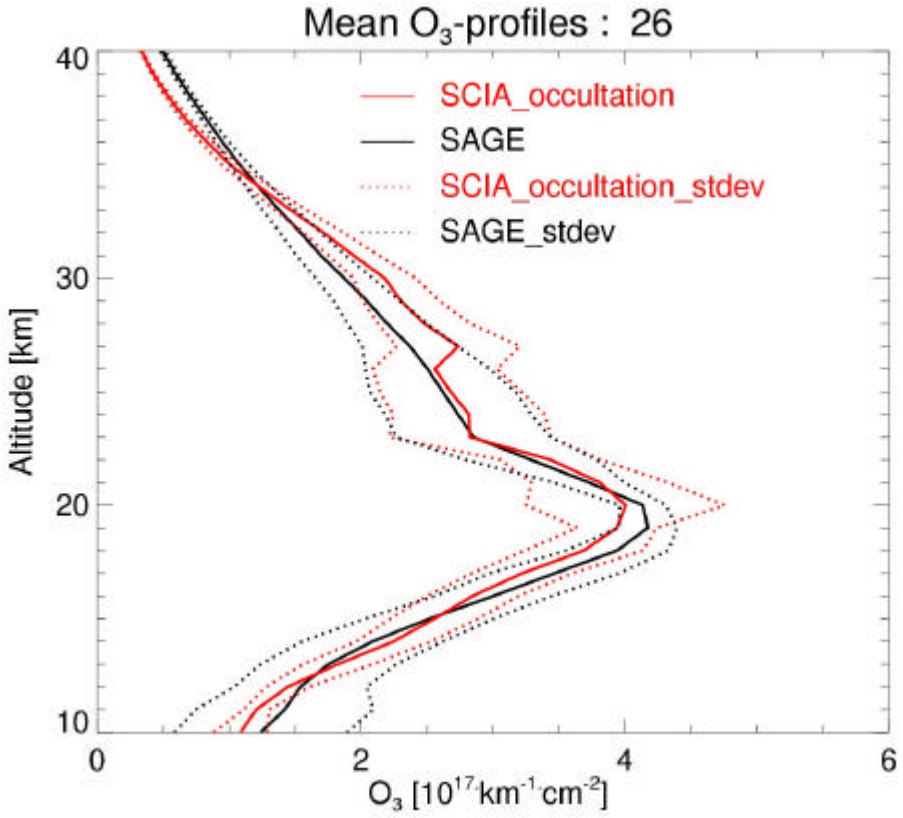


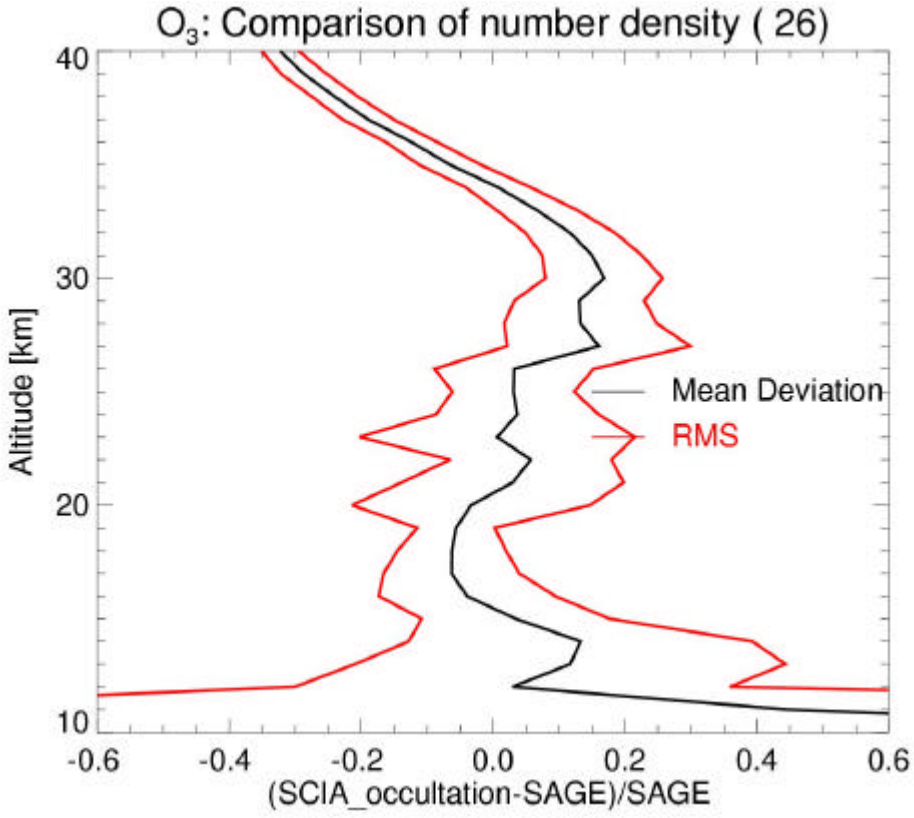
All available SCIA occul. data (all at 64°N – 66°N) searched for SAGE II within 500 km of SCIA at the same day

Accuracy of SAGE II:
10 – 50 km 10%

Sensitivity of SCIA_IUP occultation at 13 – 50 km

SCIAMACHY IUP O_3 occultation profiles compared to SAGE II





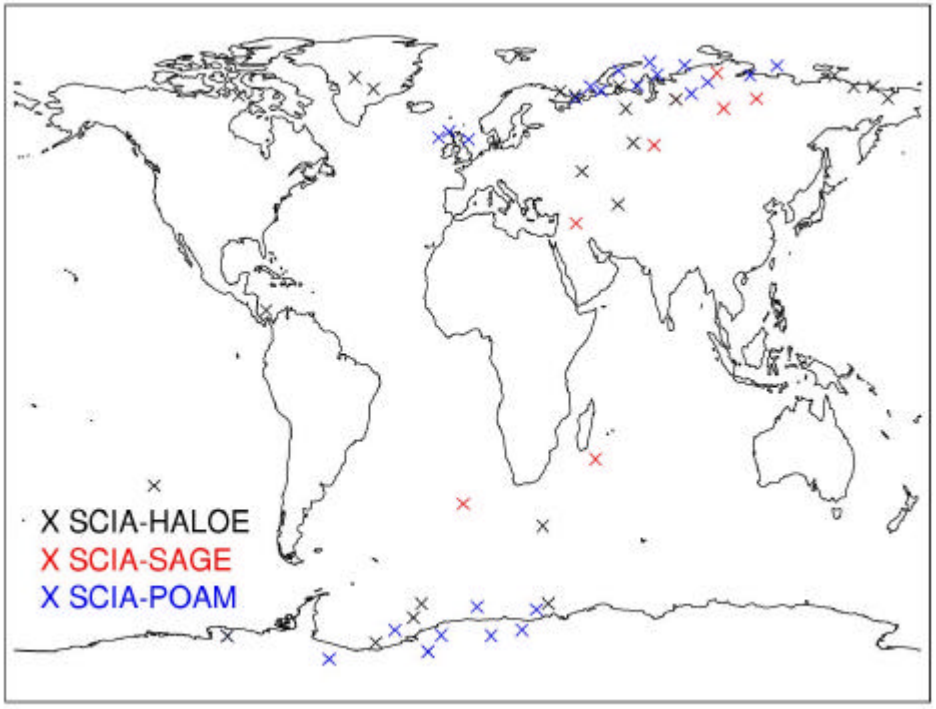
26 collocations

15 – 35 km: -7 – 15% (+/- 5-20%)

>35 km differences in *a priori* dominating ?

Comparison of SCIAMACHY IUP O_3 and NO_2 limb profiles with HALOE

All available SCIAMACHY Lv-0 and Lv-1 limb from July – December 2002
Criteria for coincidences: HALOE within 500 km of SCIAMACHY at the same day



23 coincidences with HALOE

O_3 :

Rozanov: differential fitting employing Chappuis bands

Savigny: 3 wavelengths of O_3 Chappuis bands
Tangent height (TH) corrected –2 km (limb pointing offset)

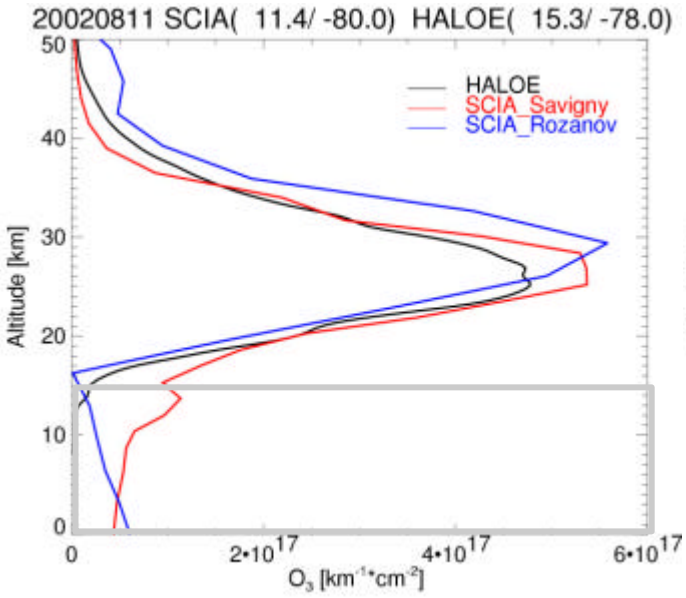
NO_2:

Rozanov: spectrum of 420 – 490 nm and ratio of limb measurements at different TH (45 km TH as reference)

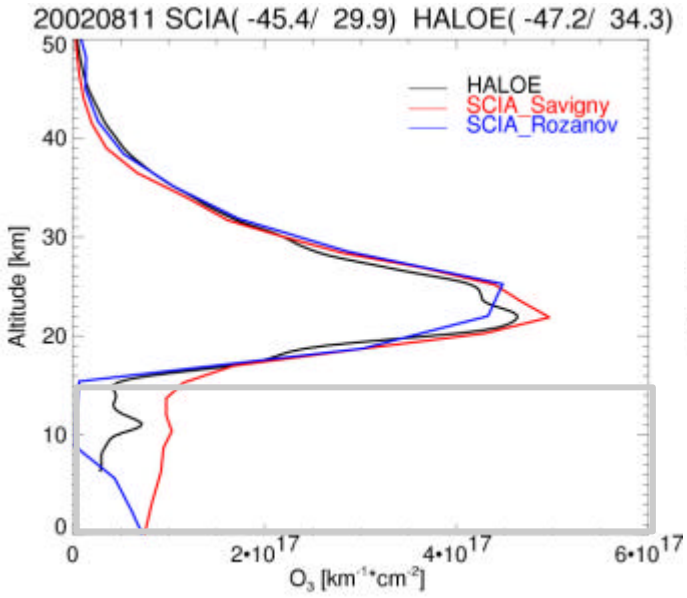
Comparison of SCIAMACHY IUP limb O_3 profiles with HALOE

Examples

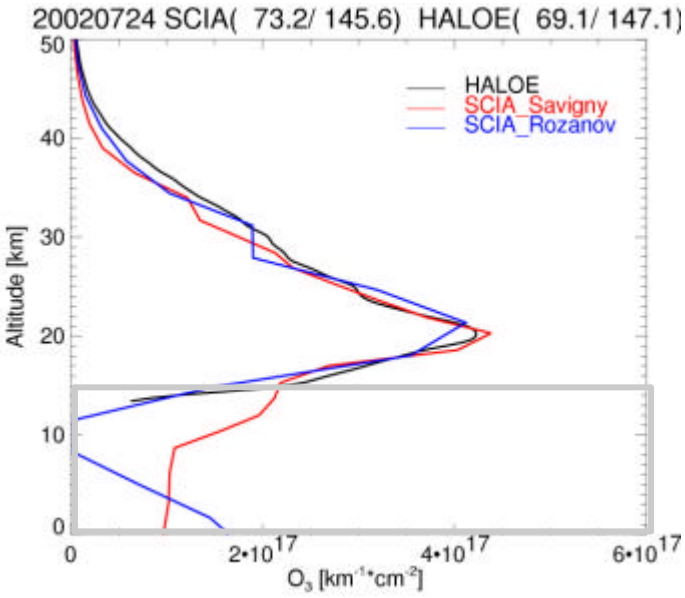
tropics



mid latitudes



high latitudes

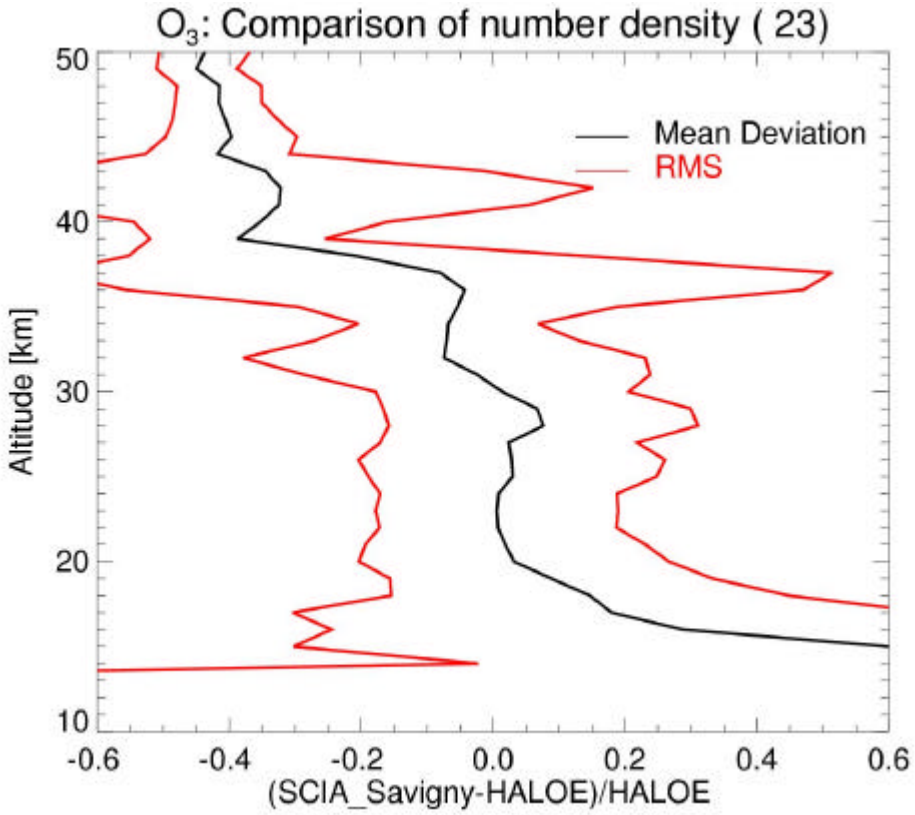


Accuracy of HALOE O_3 profiles: 30 – 60 km 6%; 15-30 km 20%
Sensitivity of SCIAMACHY_Savigny O_3 profiles at 15 – 35 km
Sensitivity of SCIAMACHY_Rozanov O_3 profiles at 15 – 35 km

Comparison of SCIAMACHY IUP limb O_3 profiles with HALOE

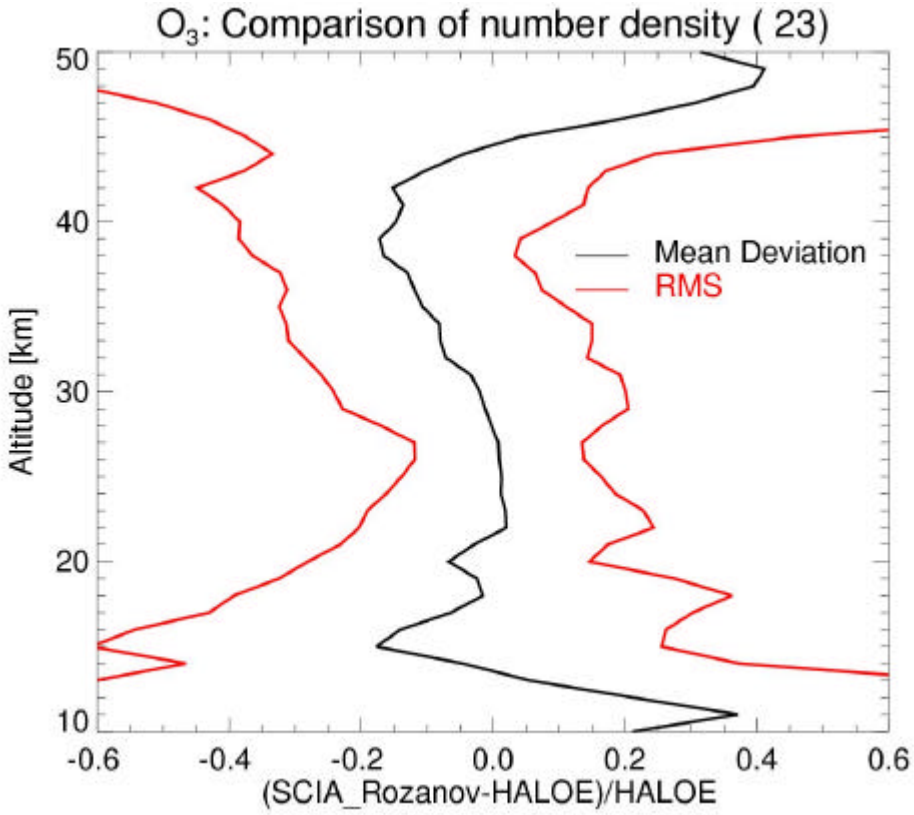
Statistics over all coincidences

SCIAMACHY O_3 of C. von Savigny



19 – 35 km: -5 – +5% (+/- 15%)

SCIAMACHY O_3 of A. Rozanov

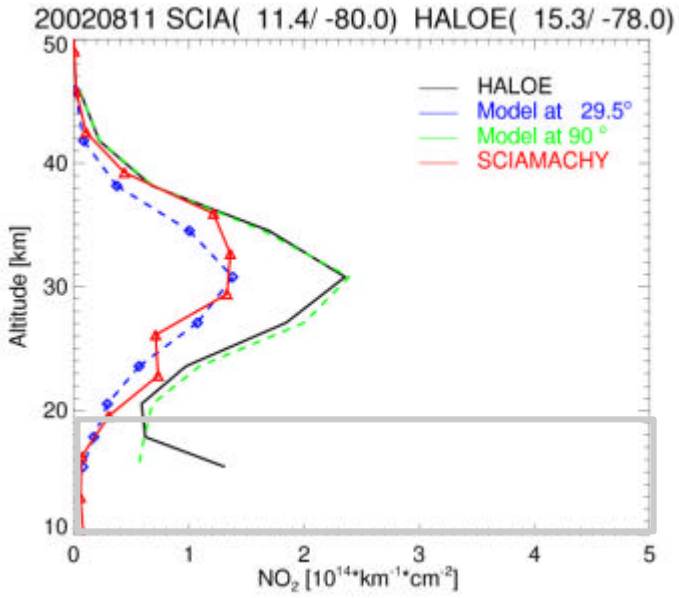


18 – 38 km: -10 – 0% (+/- 15%)

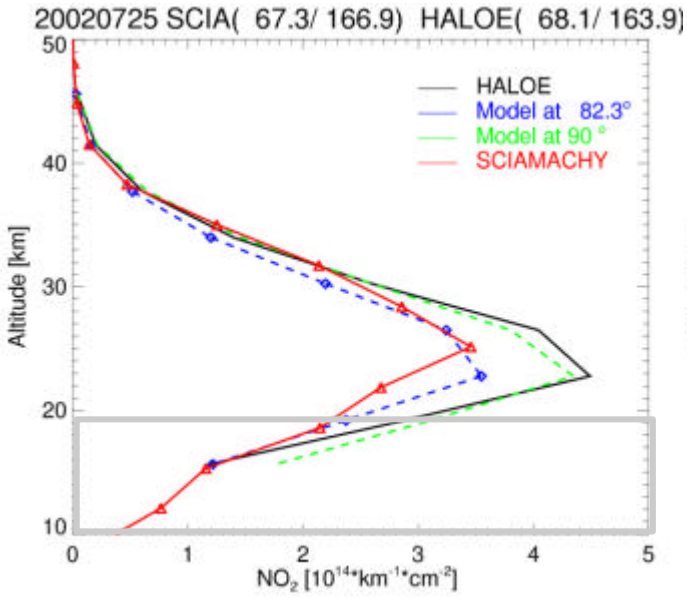
Comparison of SCIAMACHY IUP limb NO_2 profiles with HALOE

Examples

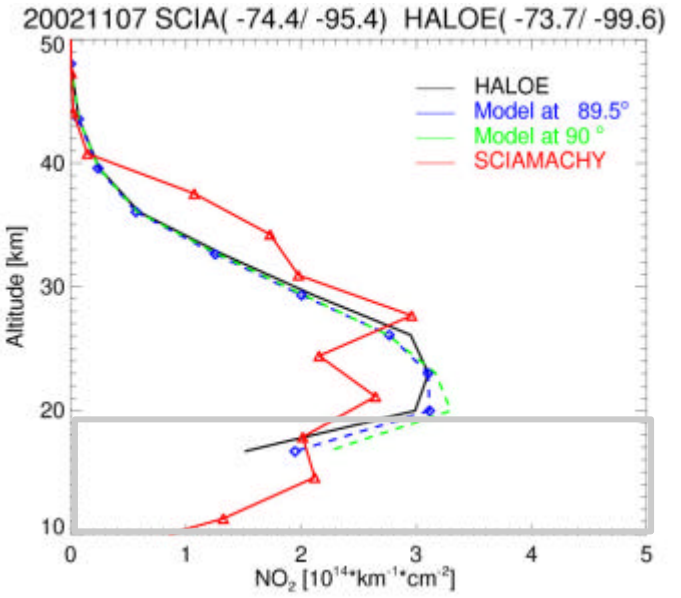
SZA ~30°



SZA ~80°



SZA ~90°



HALOE NO_2 scaled to SCIAMACHY SZA

using a 1-dim version of SLIMCAT chemistry & photolysis model (Chipperfield 1999)
with reaction rates & photolysis cross sections from JPL 2000 data base

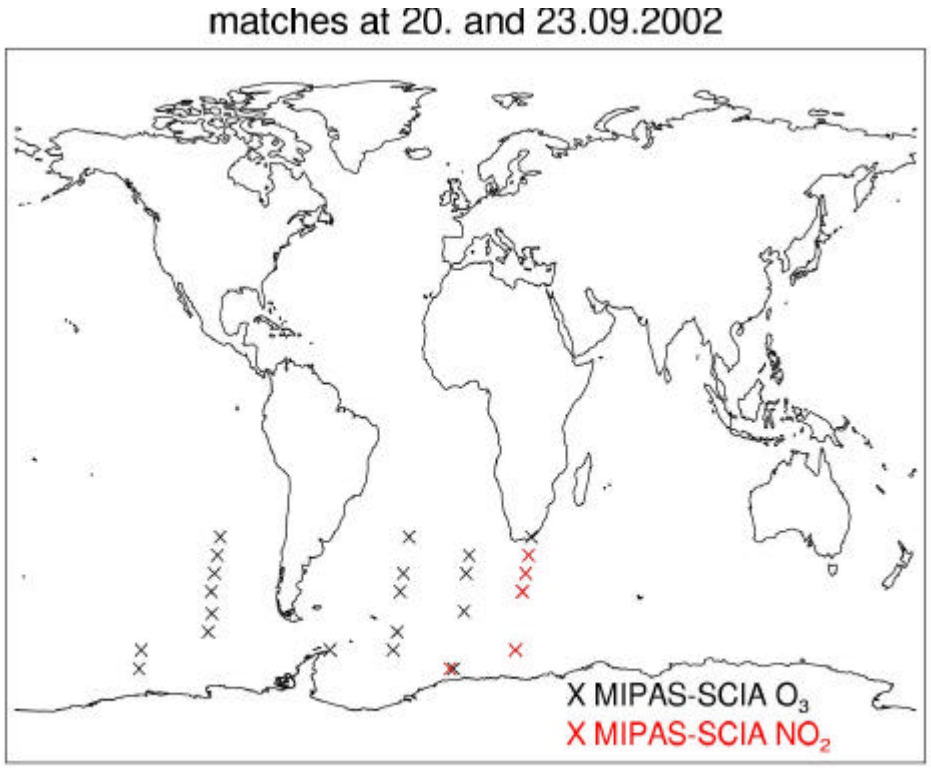
Accuracy of HALOE NO_2 profiles: 20 – 45 km 10 – 15%

Sensitivity of SCIAMACHY_Rozanov NO_2 profiles at 17 – 40 km

MIPAS-IMK and SCIAMACHY-IUP limb cross validation

O_3 and NO_2 products from both instruments compared from 20. and 23.09.02

Coincidences: MIPAS tangent point within of 650 km of SCIAMACHY tangent point from the same orbit (19) or next orbit (6)



pixel size	across scan	along scan
MIPAS	30 km	~400 km
SCIAMACHY	960 km	~400 km

Coincidences checked for PV at 475 K:

PV < -40 PVU	within polar vortex
-30 to -40 PVU	at edge of polar vortex
> -30 PVU	outside polar vortex

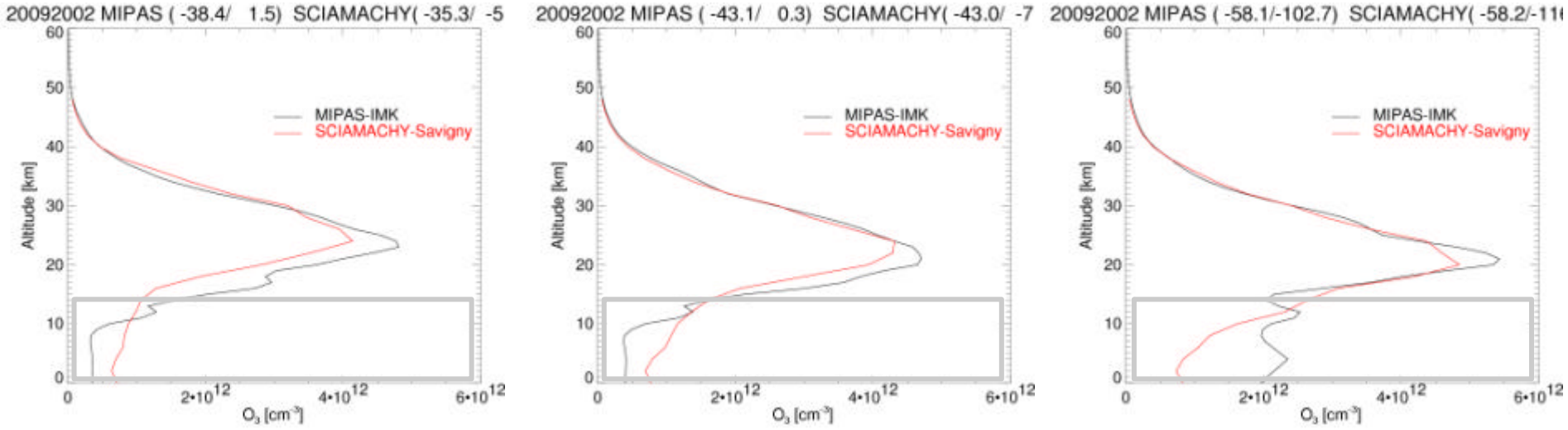
Out of 25 matches for O_3:

both matches within polar vortex = 6
outside polar vortex = 15

6 matches for NO_2

Comparison of SCIA IUP limb O_3 profiles with MIPAS IMK

Both coincidences are outside the polar vortex

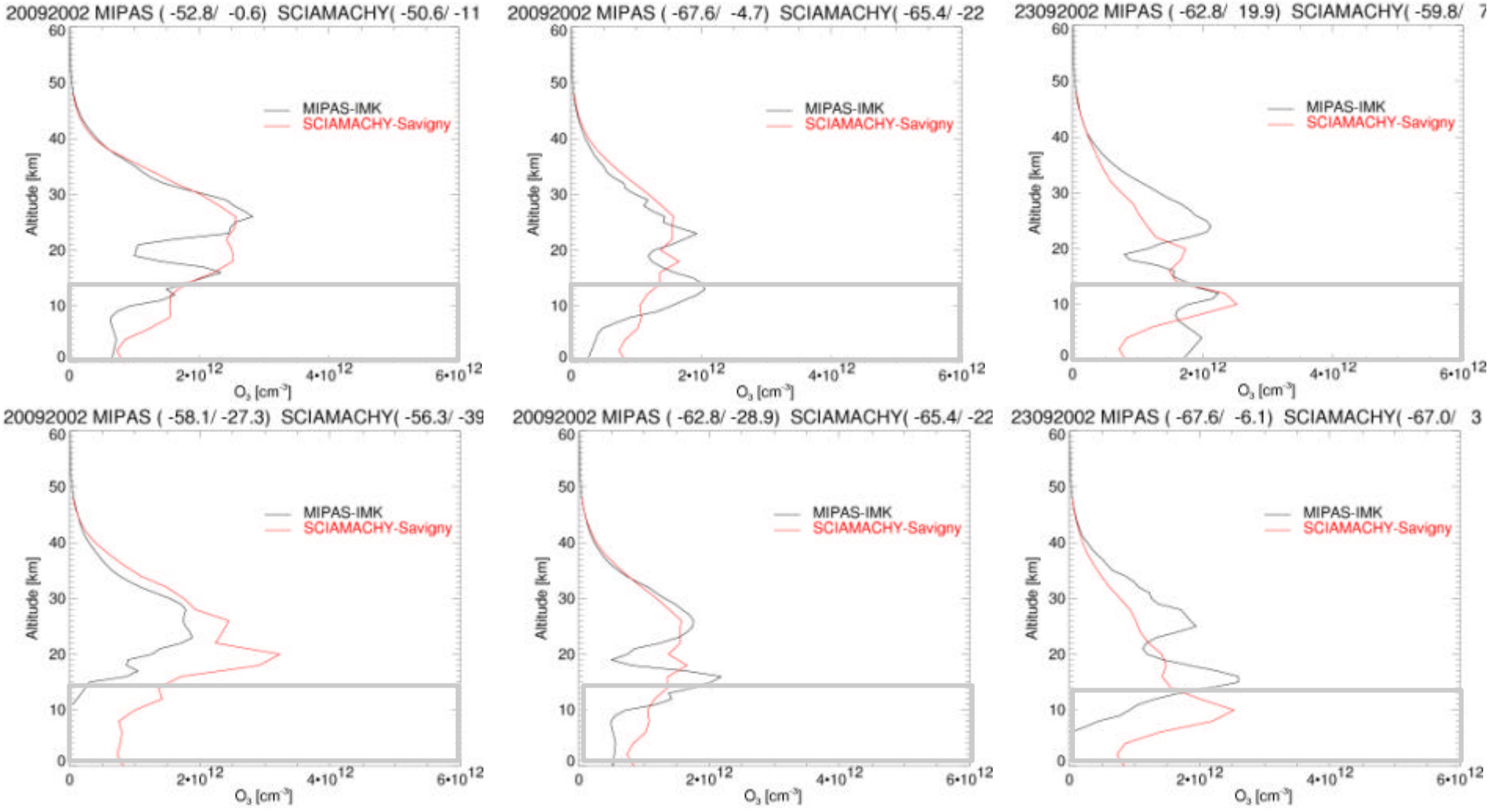


SCIAMACHY_Savigny O_3 sensitive at 15 – 35 km

MIPAS_IMK used tangent heights ~7-13 km to ~69 km

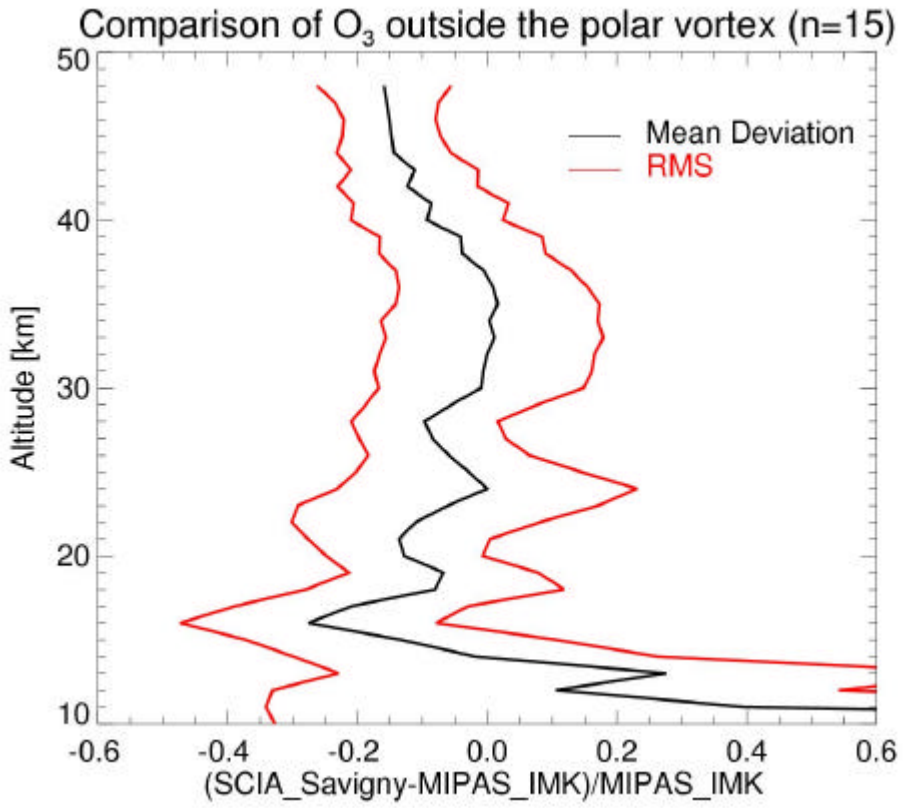
Comparison of SCIA IUP limb O_3 profiles with MIPAS IMK

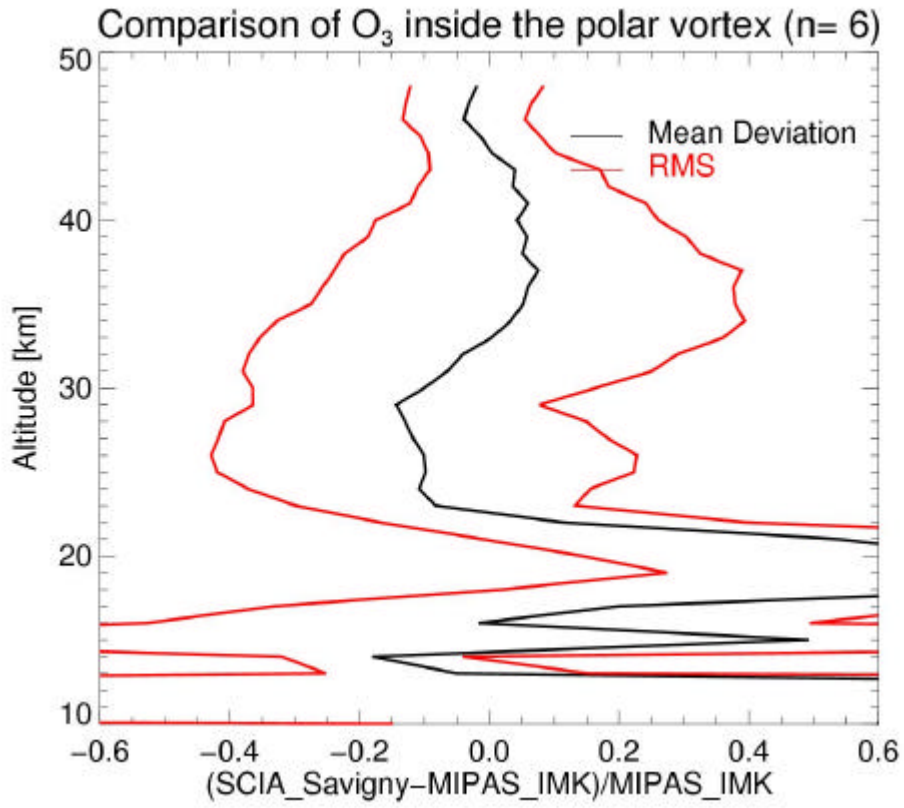
Both coincidences are inside the polar vortex



Comparison of SCIA IUP limb O_3 profiles with MIPAS IMK

Statistics over all coincidences



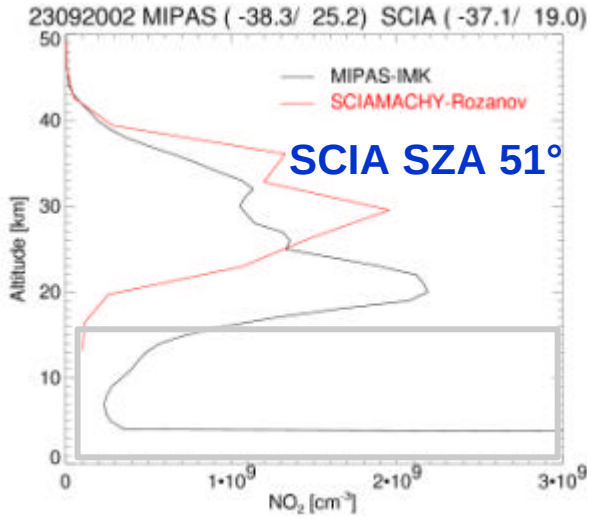


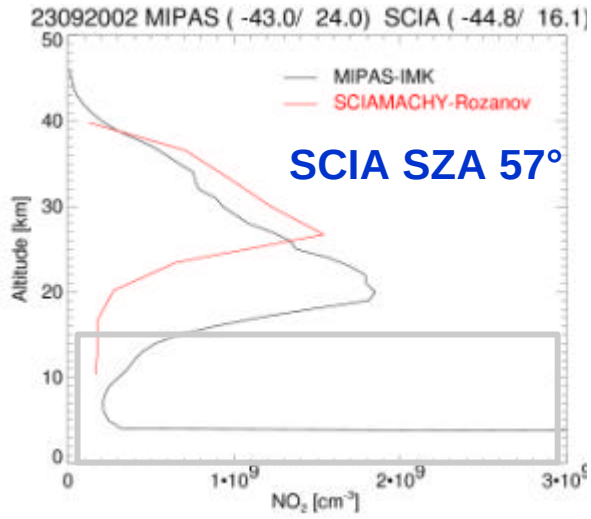
18 – 48 km: -15 – +1% (+/- 10 – 20%)

23 – 48 km: -10 – +15% (+/- 10 – 20%) due to different pixel sizes not comparable below 23 km

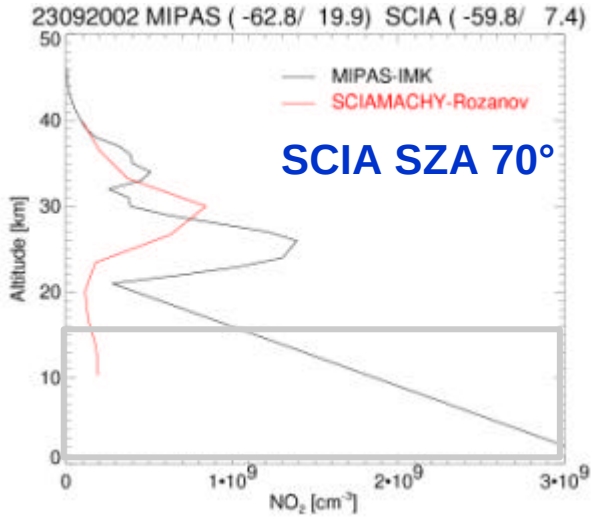
Comparison of SCIA IUP limb NO_2 profiles with MIPAS IMK

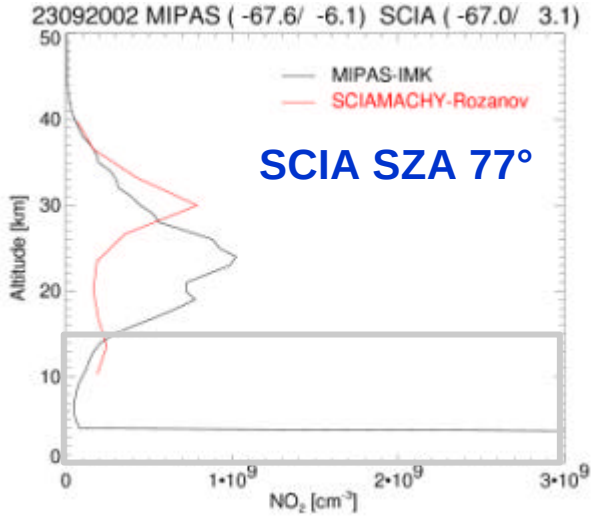
outside the polar vortex





inside the polar vortex





SCIAMACHY_Rozanov NO_2 sensitive at 15 – 40 km

MIPAS_IMK used tangent heights ~ 16.5 km to ~69 km

MIPAS_IMK maxima too low (at low depths too strong regularisation and influence by *a priori*)

SCIAMACHY nadir products

Total O_3 (3.53 and 4.0):	ca. - 5% to GOME 3.0
	ca. - 8% to TOMS V7.0
NO_2 SCD (4.0):	consistent offset to GOME GDP 3.0
NO_2 VCD (4.0):	AMF problems –60%- 0%, but version 3.53 much worse

→ Update of SCIAMACHY Lv-2 equivalent to GOME 3.0
(with improved NO_2 and O_3 climatologies and iterative air mass factors)

→ Incorporation of SCIAMACHY trace gas absorption cross sections in Lv1/2 processing

SCIAMACHY occultation products retrieved at the IUP

O_3:	good agreement with SAGE II	at 15 – 35 km	-7 – +15% (+/- 5 – 20%)

SCIAMACHY limb products retrieved at the IUP

COMPARISON TO HALOE

O_3: good agreement: for O_3 by Savigny at 19 – 35 km -5 – +5% (+/- 15%)
for O_3 by Rozanov at 18 – 38 km -10 – 0% (+/- 15%)

NO_2: first results show good profiles can be retrieved from SCIAMACHY limb data

COMPARISON TO MIPAS-IMK

O_3: good results outside polar vortex with slight positive bias of MIPAS to SCIA
at 18 – 48 km -1 – +15% (+/- 10 – 20%)
comparable data inside polar vortex, but SCIA‘s large pixel size can‘t resolve small scale differences at 23 – 48 km -15 – +10% (+/- 10 – 20%)

NO_2 : large deviations between the two instruments.
Improvements after reprocessing of MIPAS-IMK NO_2 expected

Mispointing of ENVISAT causes an offset in tangent heights of SCIAMACHY limb and occultation measurements: → correction scheme based on engineering and orbit model update has to be set up now!

Work plan until end of project (12/2004)

5/03 Cross validation of (operational and scientific) MIPAS, GOMOS and SCIAMACHY (unitl now: only O_3 and NO_2)

~8/03 Validation of ESA data produtcs after reprocessing
First validation of operational SCIAMACHY limb products (only O_3 and NO_2)

10/03 ACVE-2 workshop: progress report and recommendations for Lv-1/ Lv-2 algorithm

~11/03 Comparison of SCIAMACHY limb and occultation with SABER and ACE-FTS
Validation of ESA data produtcs after reprocessing

~4/04 Progress report and recommendations to ESA

~5/04 Comparison of SCIAMACHY limb H_20 and CH_4 products with SAGE II, HALOE, SABER,ACE-FTS, GOMOS, MIPAS
Validation of ESA data products after reprocessing

~11/04 Progress report and recommendations to ESA

12/04 Final report

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