

Ozone data assimilation based on GOME, SCIAMACHY and OMI data

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Contents:

- Total column assimilation: GOME, SCIAMACHY, OMI
- Forecasts
- SCIAMACHY ozone column retrieval validation
- Ozone hole 2006



Ozone assimilation at KNMI

Operational analyses and forecasts since 2000,
based on GOME, SCIAMACHY and OMI data:

www.temis.nl

www.gse-promote.org

Motivation:

- Extend satellite work:
 added value products, validation
- Monitoring, case studies

Segers et al., Q.J.R. Meteorol. Soc., 131, 477-502, 2005

Eskes et al., Q.J.R. Meteorol. Soc., 129, 1663-1681, 2003



Ozone assimilation at KNMI

Chemistry-transport assimilation model:

- TM model: 2 degree resolution, 44 layers, second moment advection
- ECMWF analyses of winds, temperatures
- Stratospheric chemistry parametrizations
 - Gas-phase
 - Heterogeneous
- GOME / SCIAMACHY / OMI / GOME-2 / TOMS ozone columns
- Kalman-type data assimilation scheme

*Eskes et al. Q. J. R. Meteorol. Soc., **129**, 1663-1681, 2003*

Forecast error modelling

Sub-optimal Kalman filter approach:

Forecast covariance = time-dependent variance * fixed correlations

Correlation matrix:

function of the distance only

functional form determined from OmF statistics

Variance:

- Model error, growth of the forecast variance with time
- Advection of the forecast variance
- Analysis equation for forecast variance

(3 tracer fields)

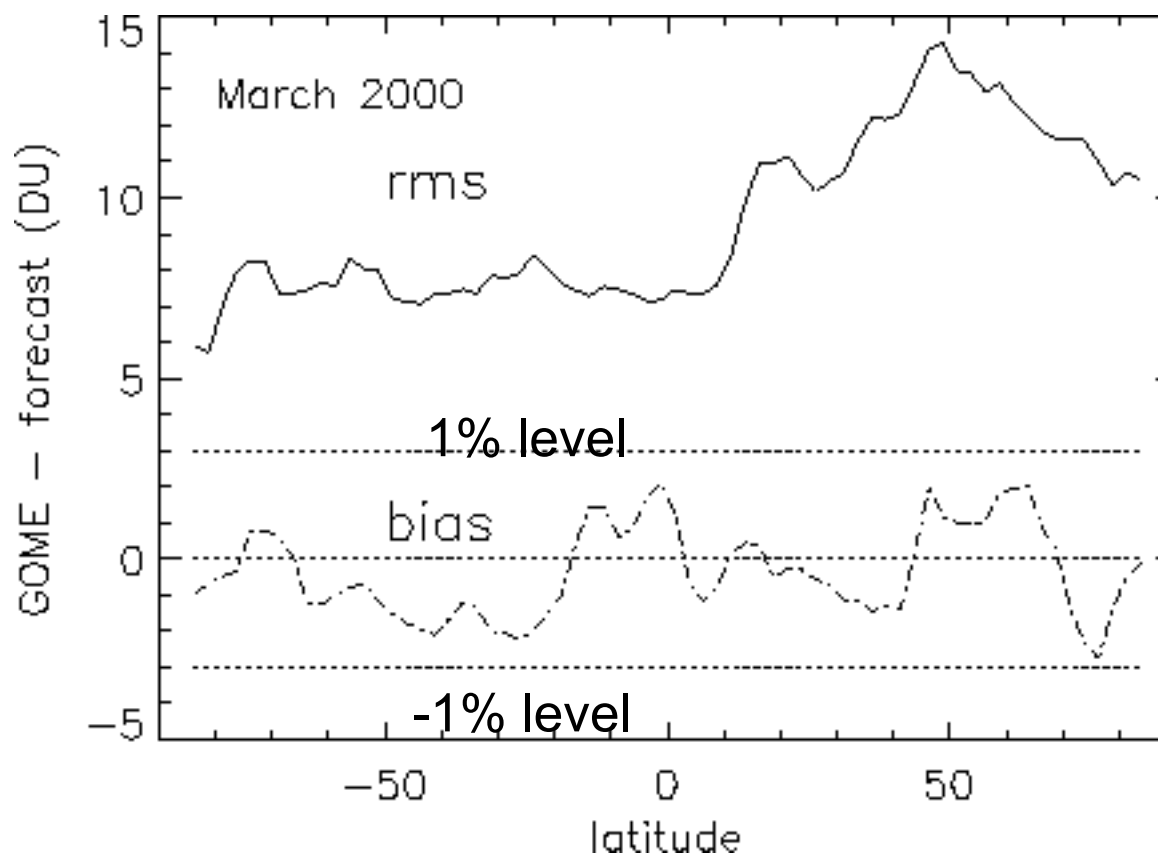


Typical forecast performance: OmF

total ozone

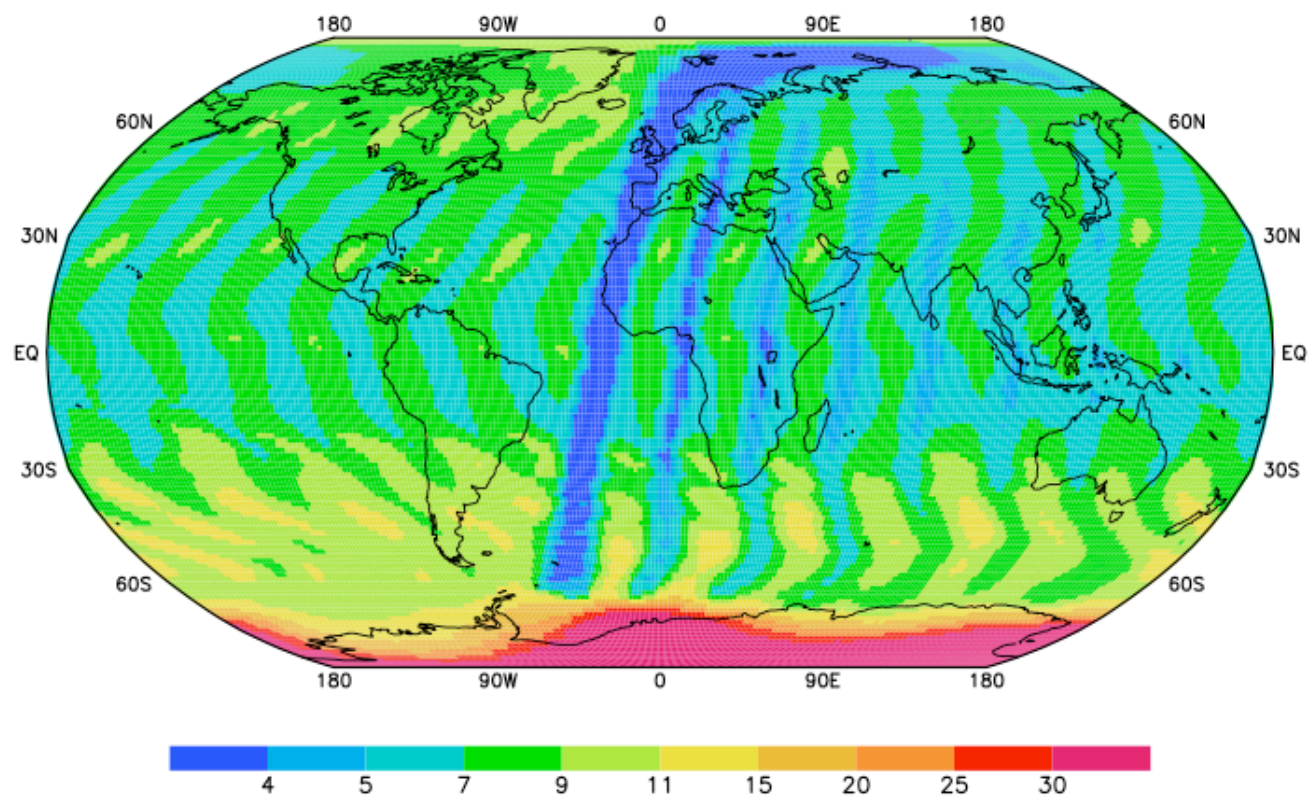
rms(OmF)
typically 3%

bias within 1%

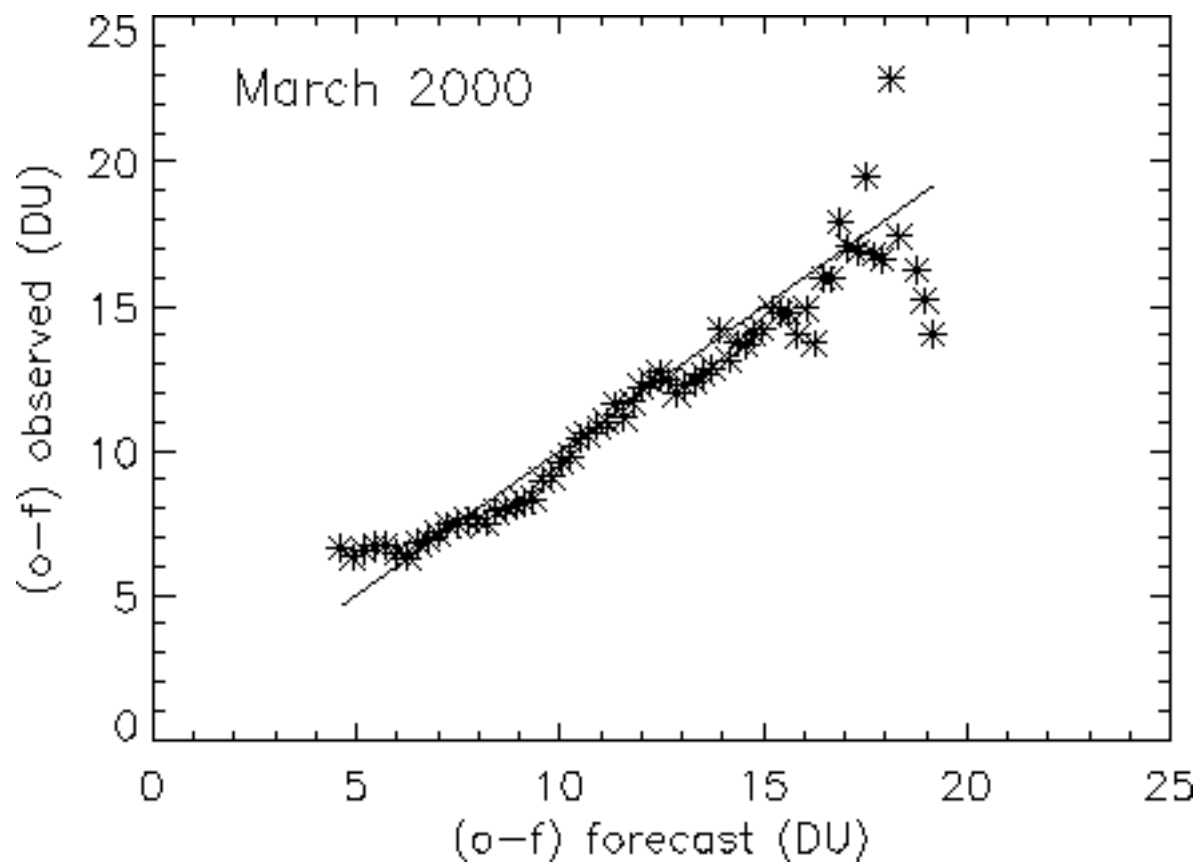


Forecast error modelling

- Analysis
- Advection
- Model error

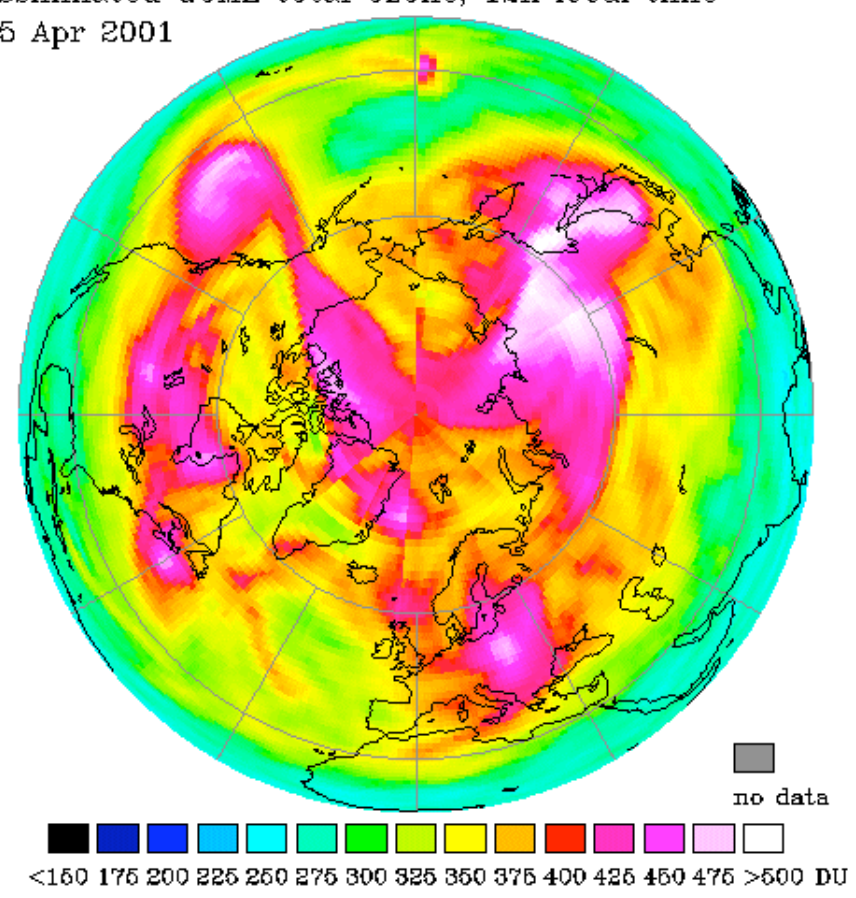


Forecast error verification

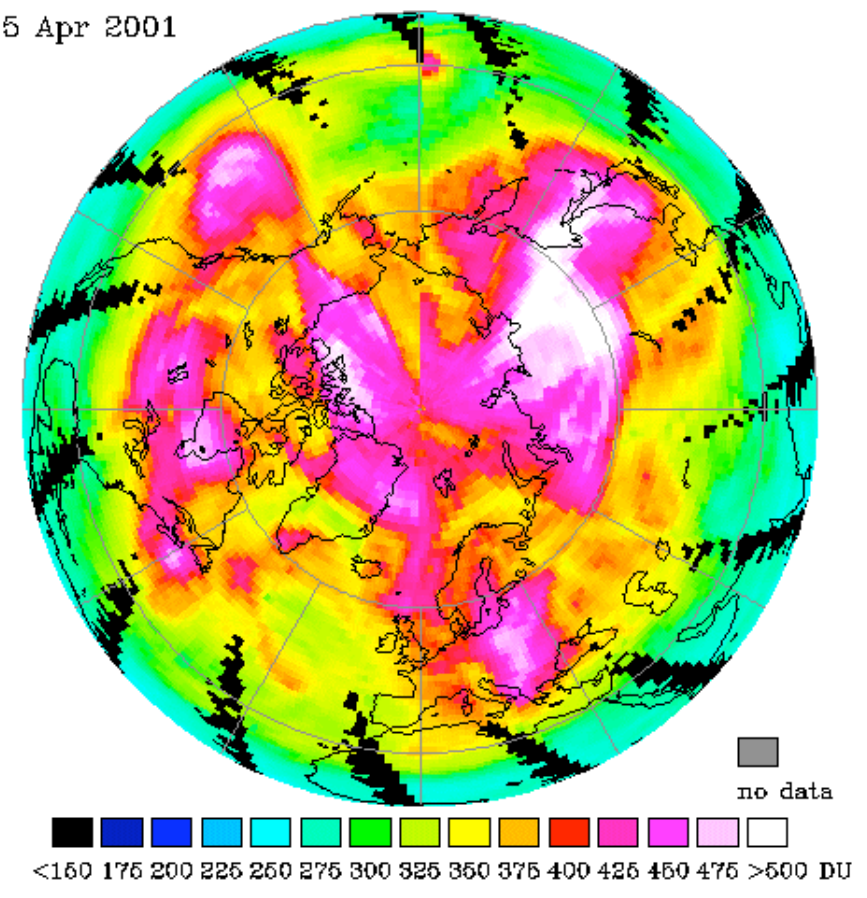


Analysis vs TOMS: 15 April 2001

Assimilated GOME total ozone, 12h local time
15 Apr 2001



NASA Earth Probe TOMS
15 Apr 2001

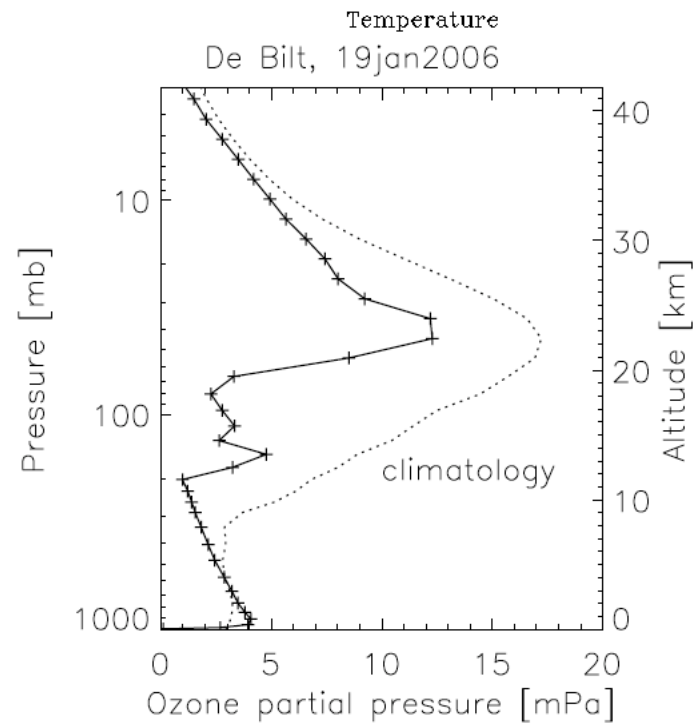
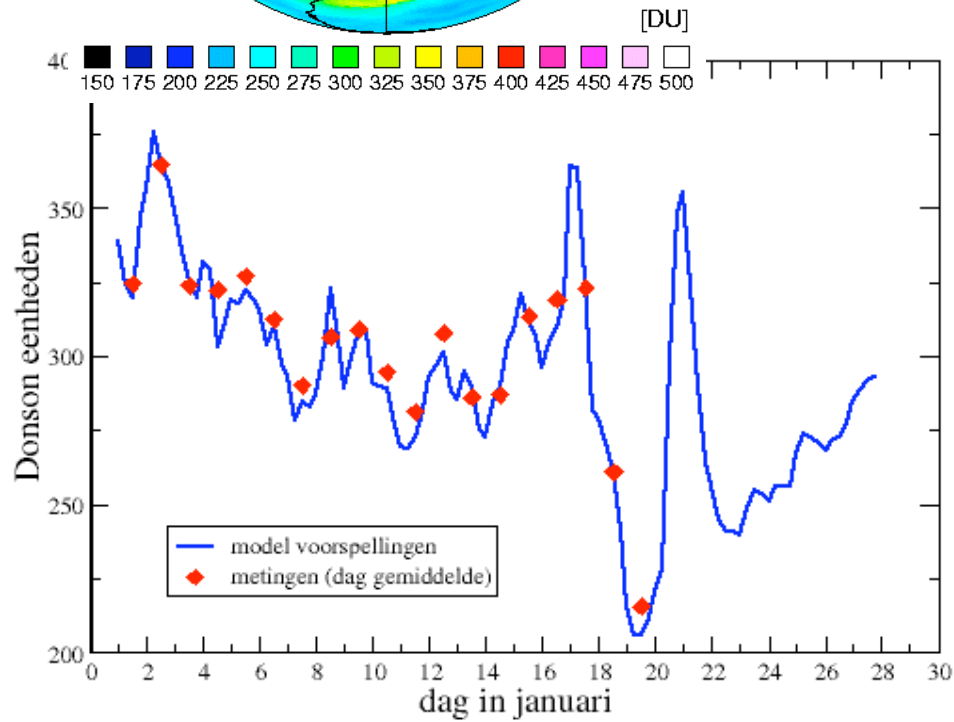
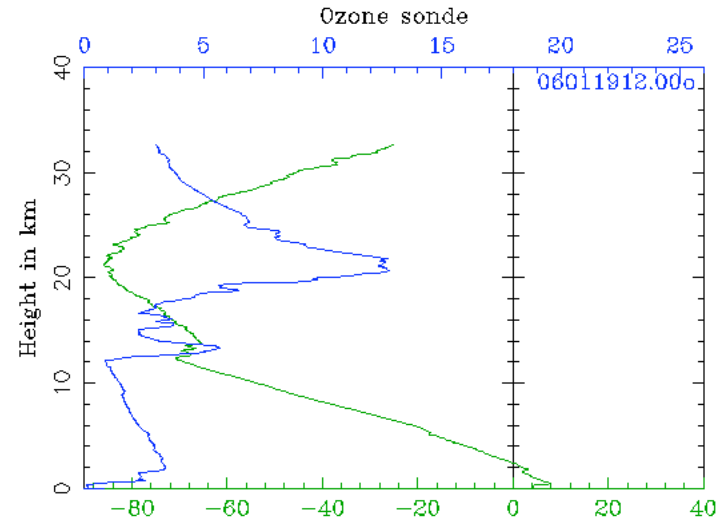
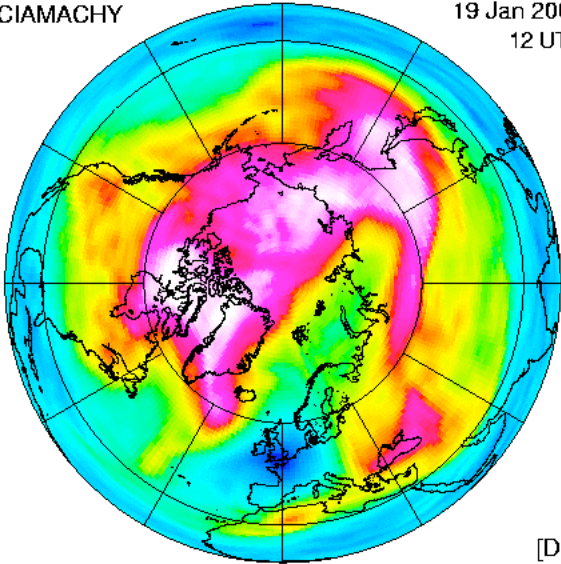


Low ozone, 19 January 2006

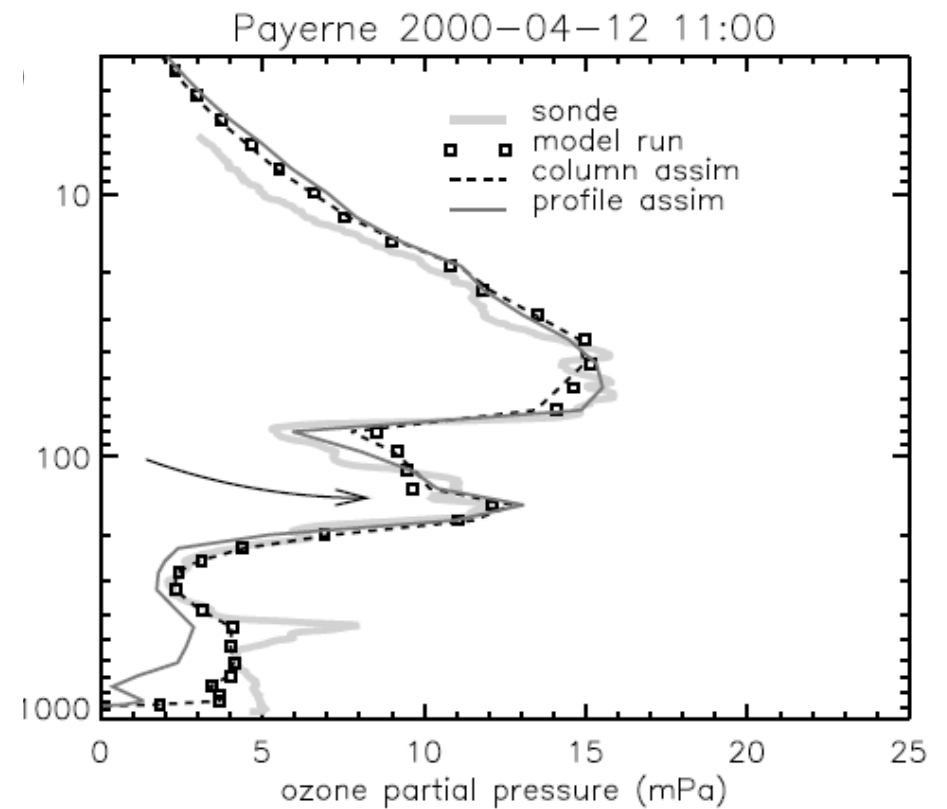
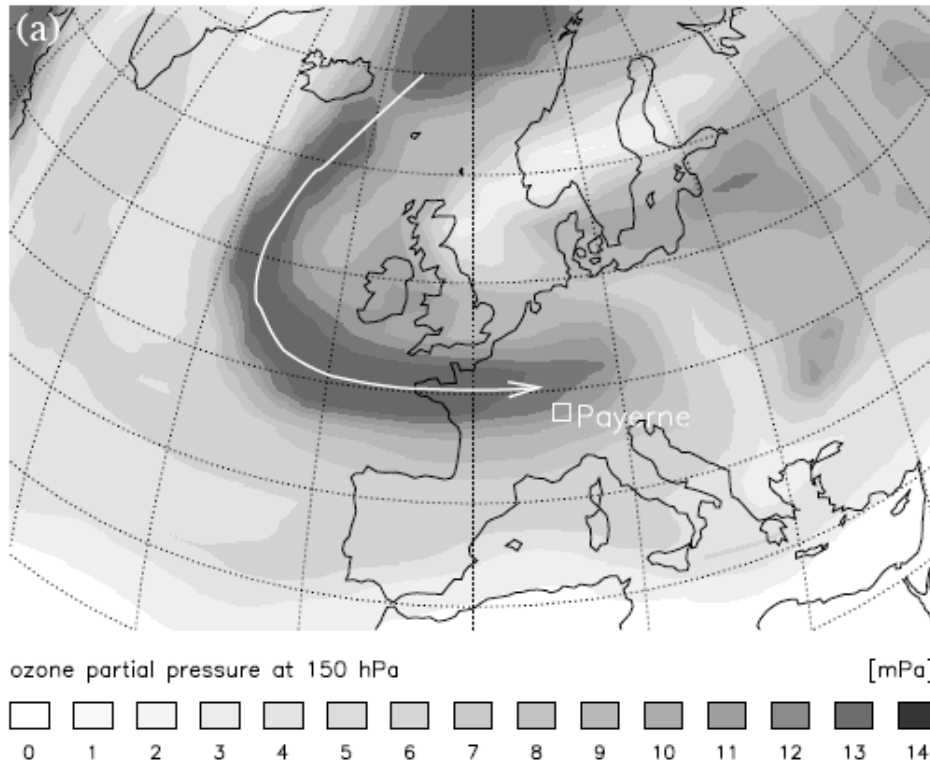


KNMI / ESA
SCIAMACHY

Assimilated total ozone
19 Jan 2006
12 UTC



GOME nadir profile assimilation



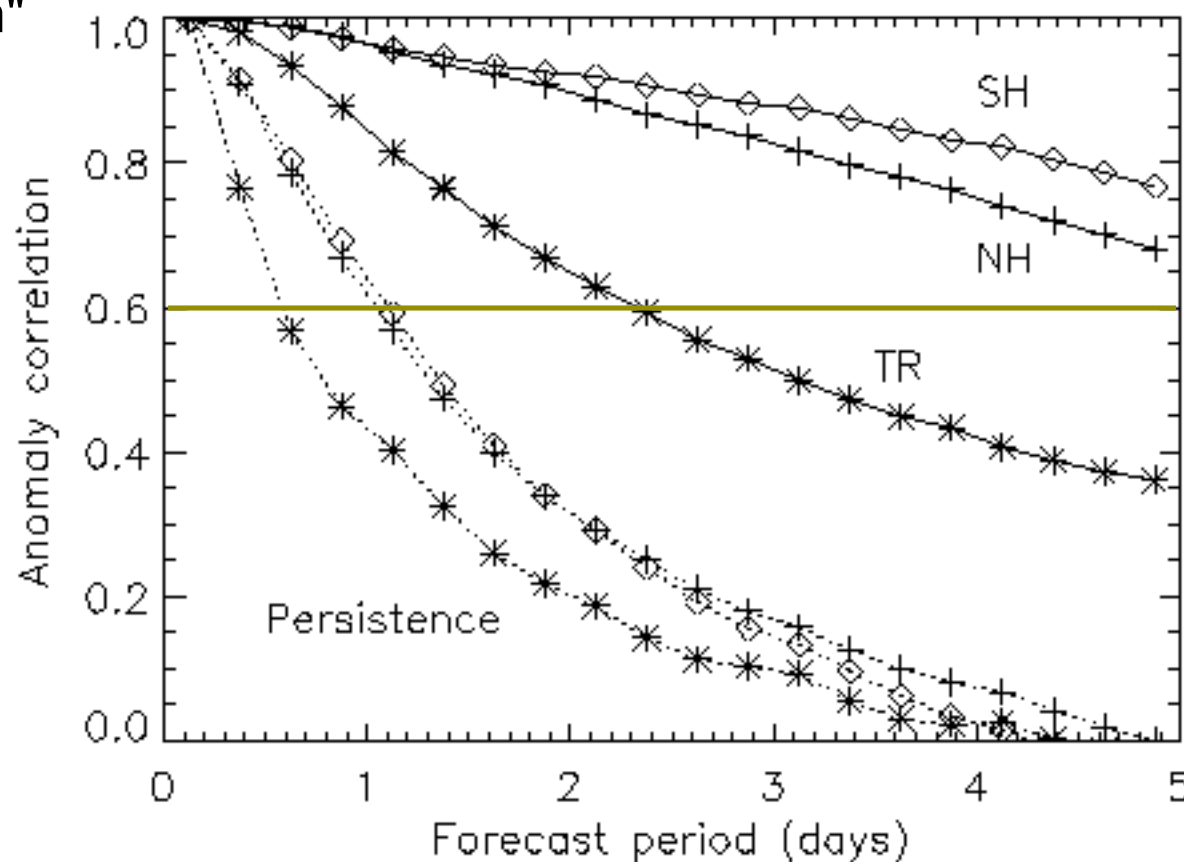
Segers et al., Q.J.R. Meteorol. Soc., 131, 477-502, 2005



Ozone forecasts

"Anomaly correlation"
for total ozone

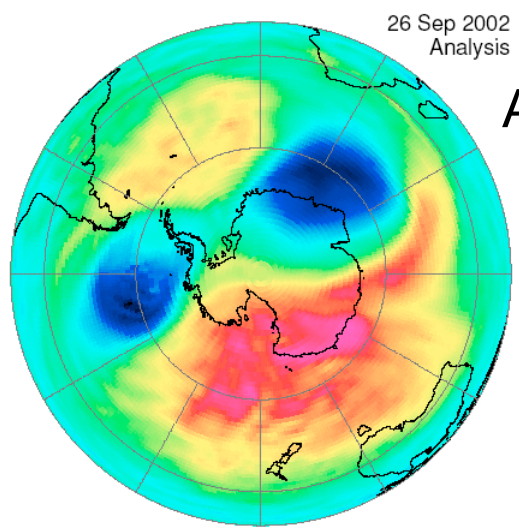
meaningful
forecasts
up to 7 days
(outside tropics)



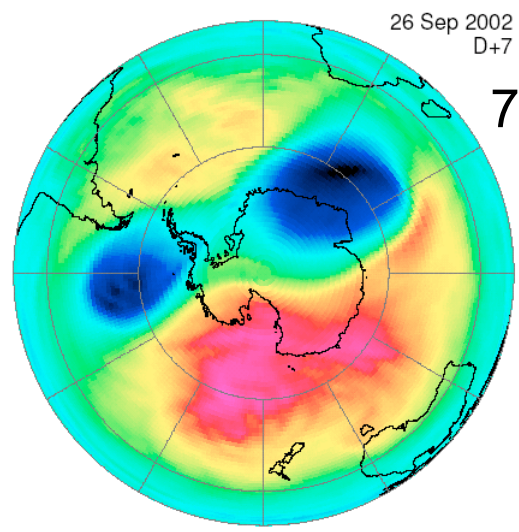
Eskes et al., ACP, 2, 271, 2002



Forecast of the 2002 ozone hole split event



Analysis

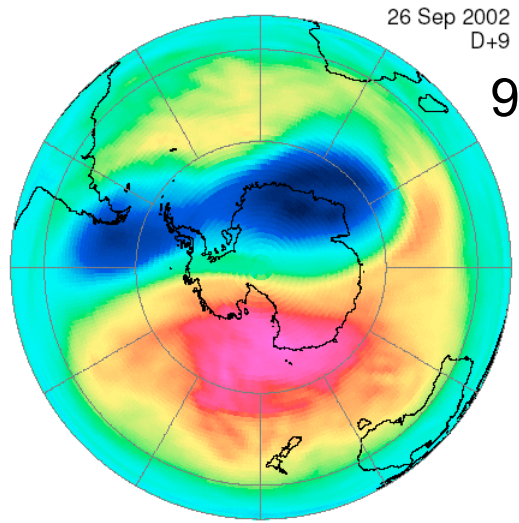
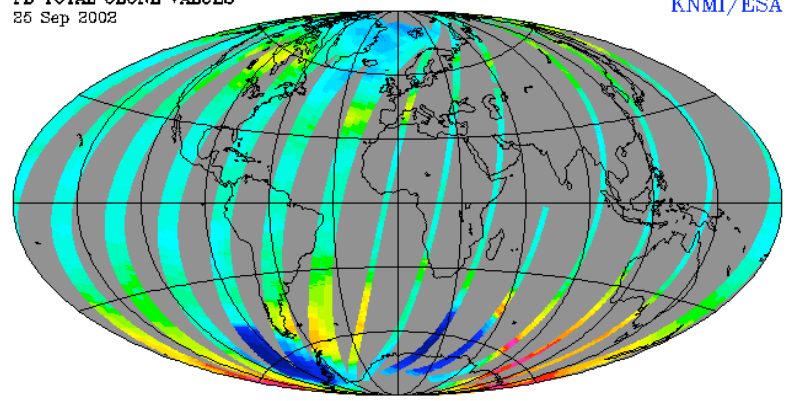


7 day forecast

GOME 25 Sep 2002

FD TOTAL OZONE VALUES
25 Sep 2002

KNMI/ESA



9 day forecast



Henk Eskes, SPARC 2006 ESTEC

Validation using data assimilation: SCIAMACHY ozone column

Eskes et al., Atmos. Chem. Phys. Discuss, 5, 4429-4475, 2005

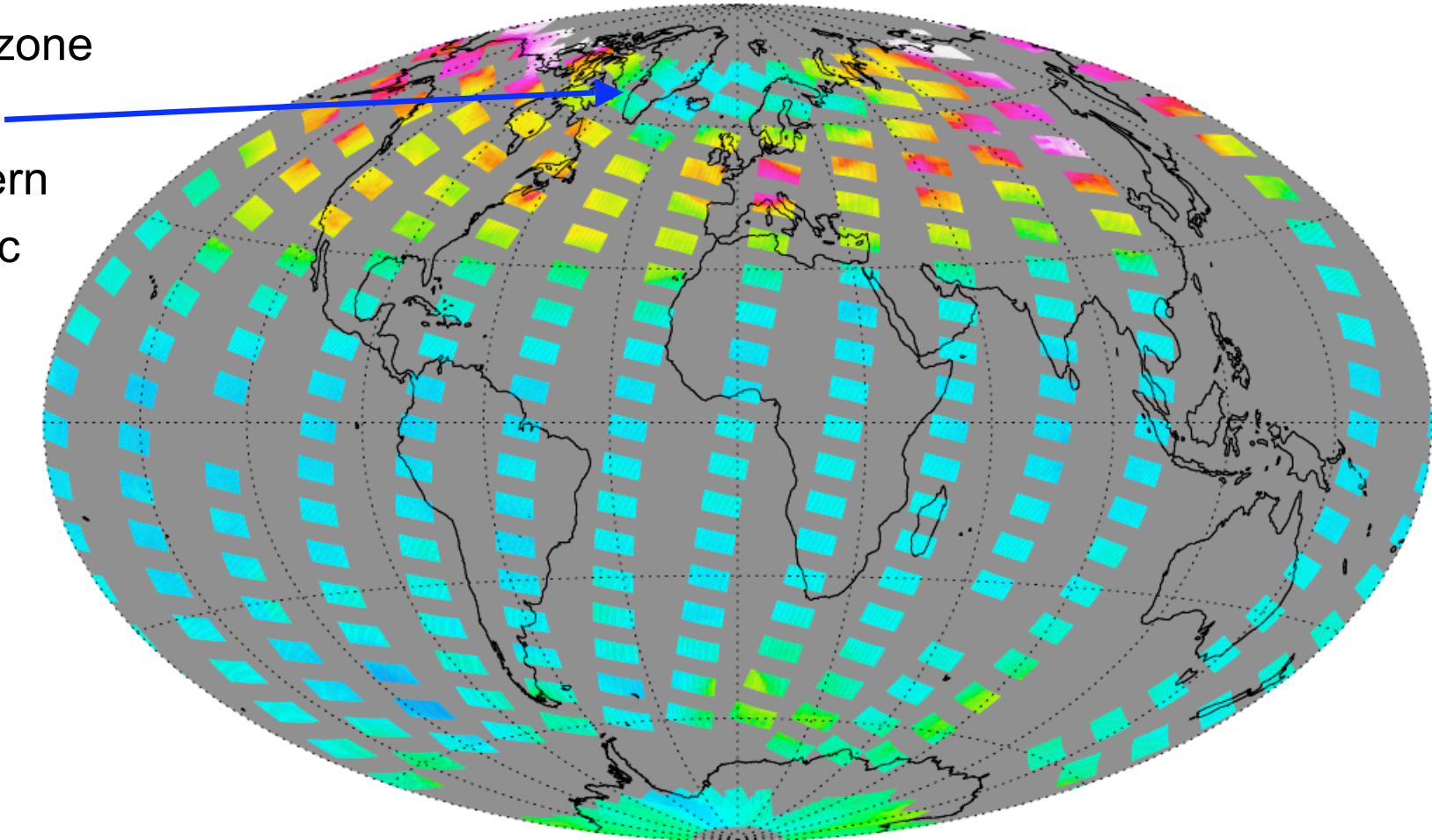
SCIAMACHY Tosomi ozone retrieval: Feb 2005



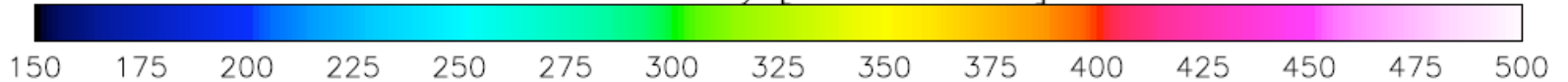
Sciamachy total ozone 23-02-2005

KNMI/ESA

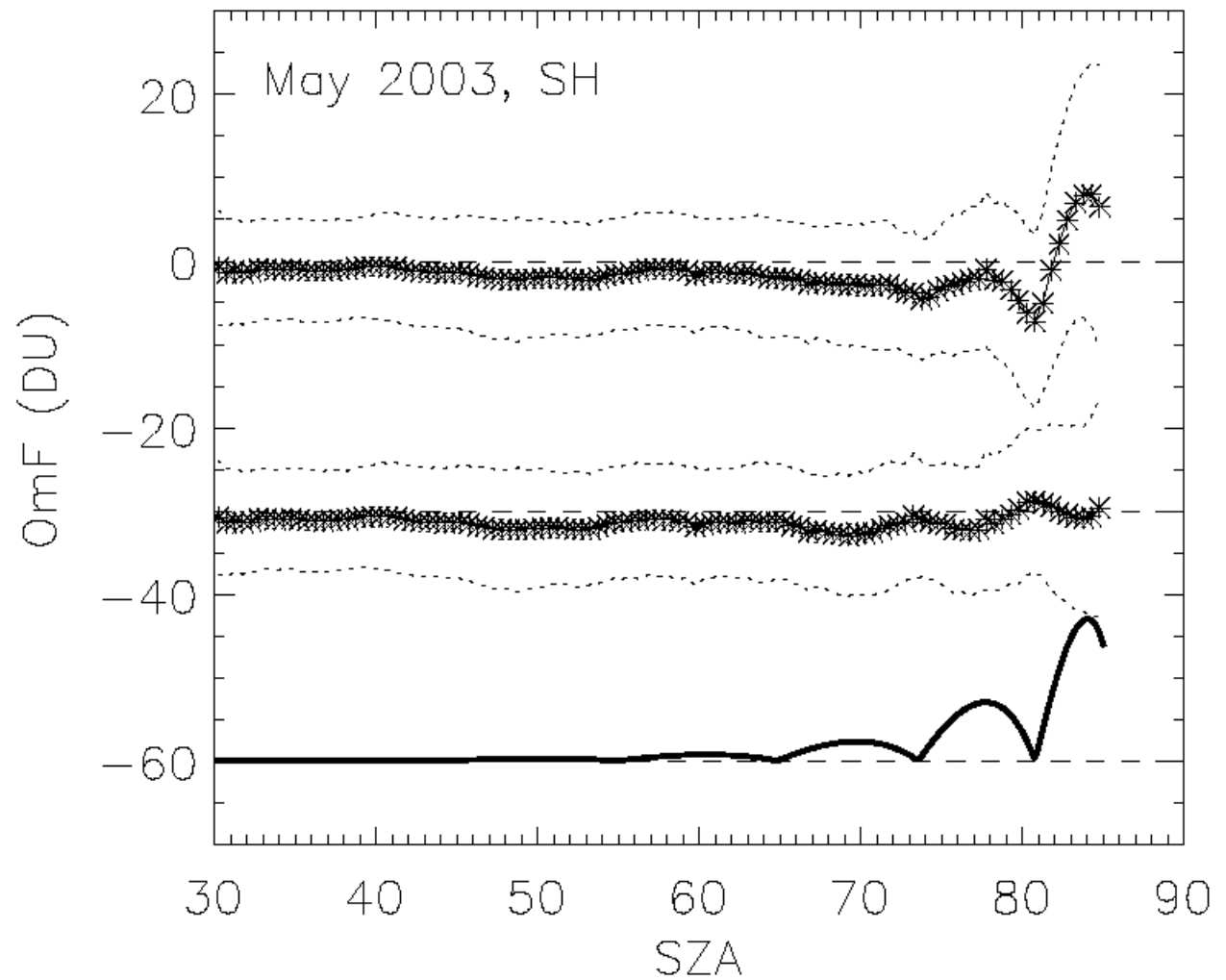
Low ozone
over
Northern
Atlantic



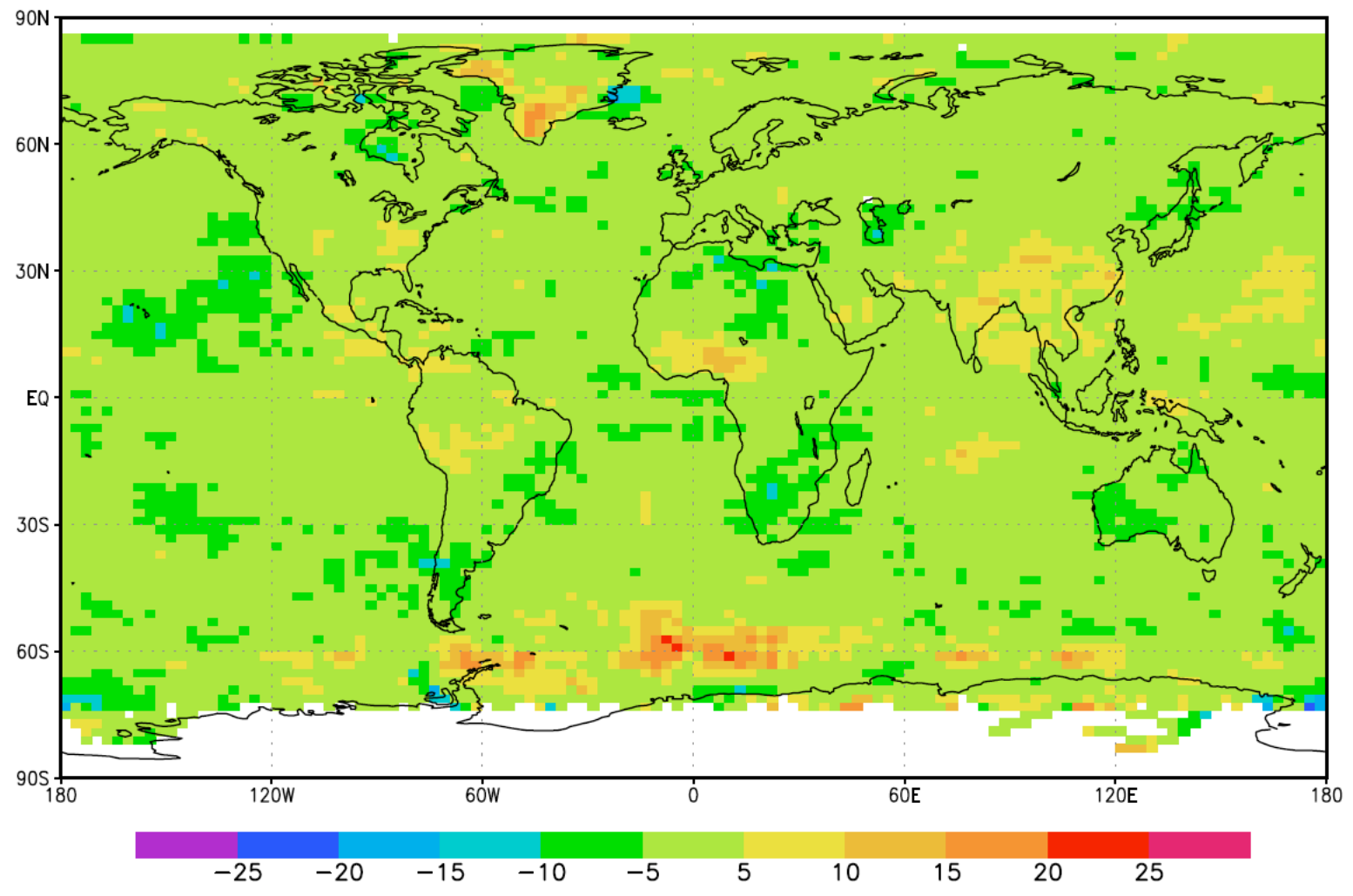
Ozone density [Dobson Units]



SCIAMACHY total ozone: Tosomi retrievals

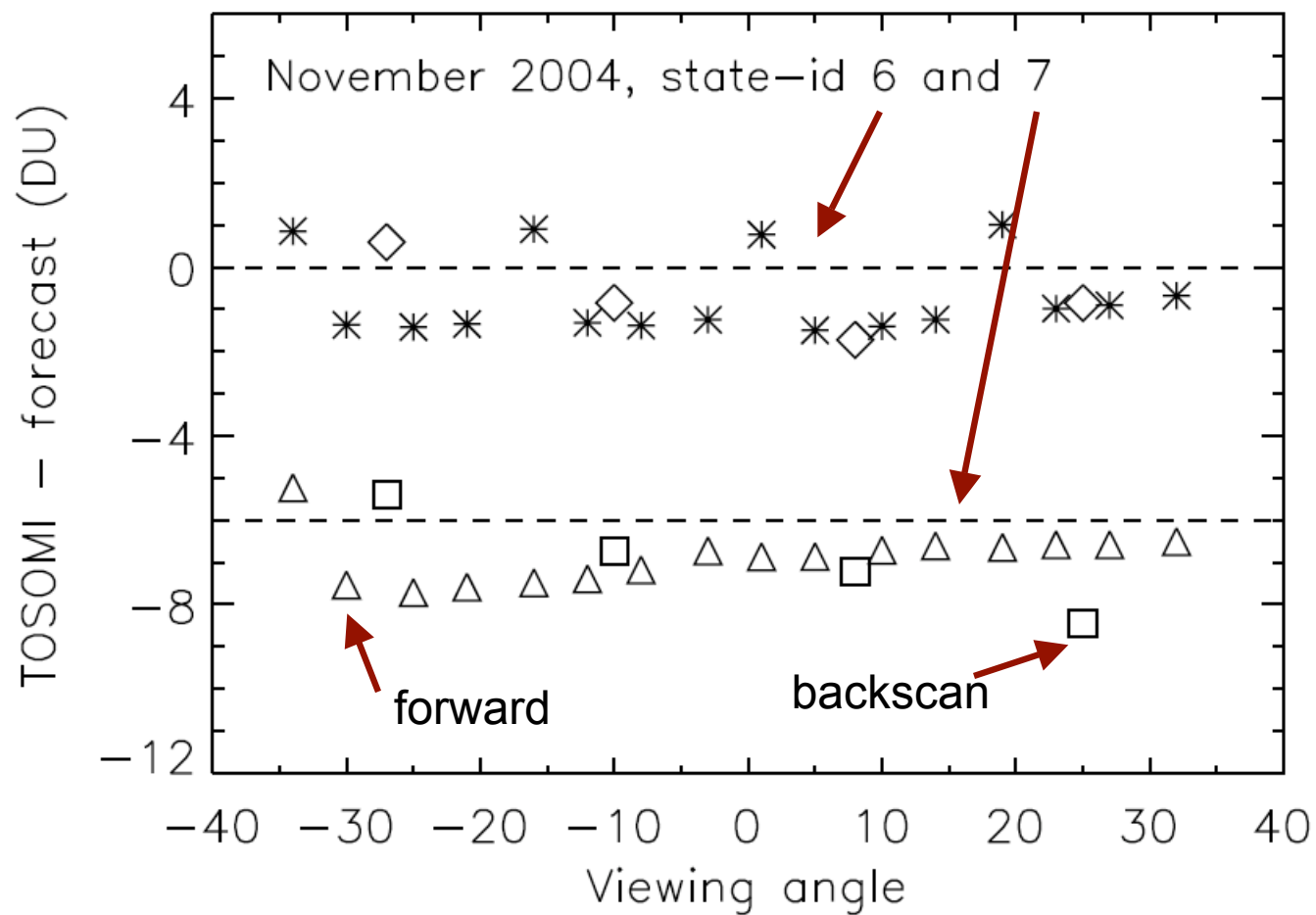


Tosomi vs assimilation

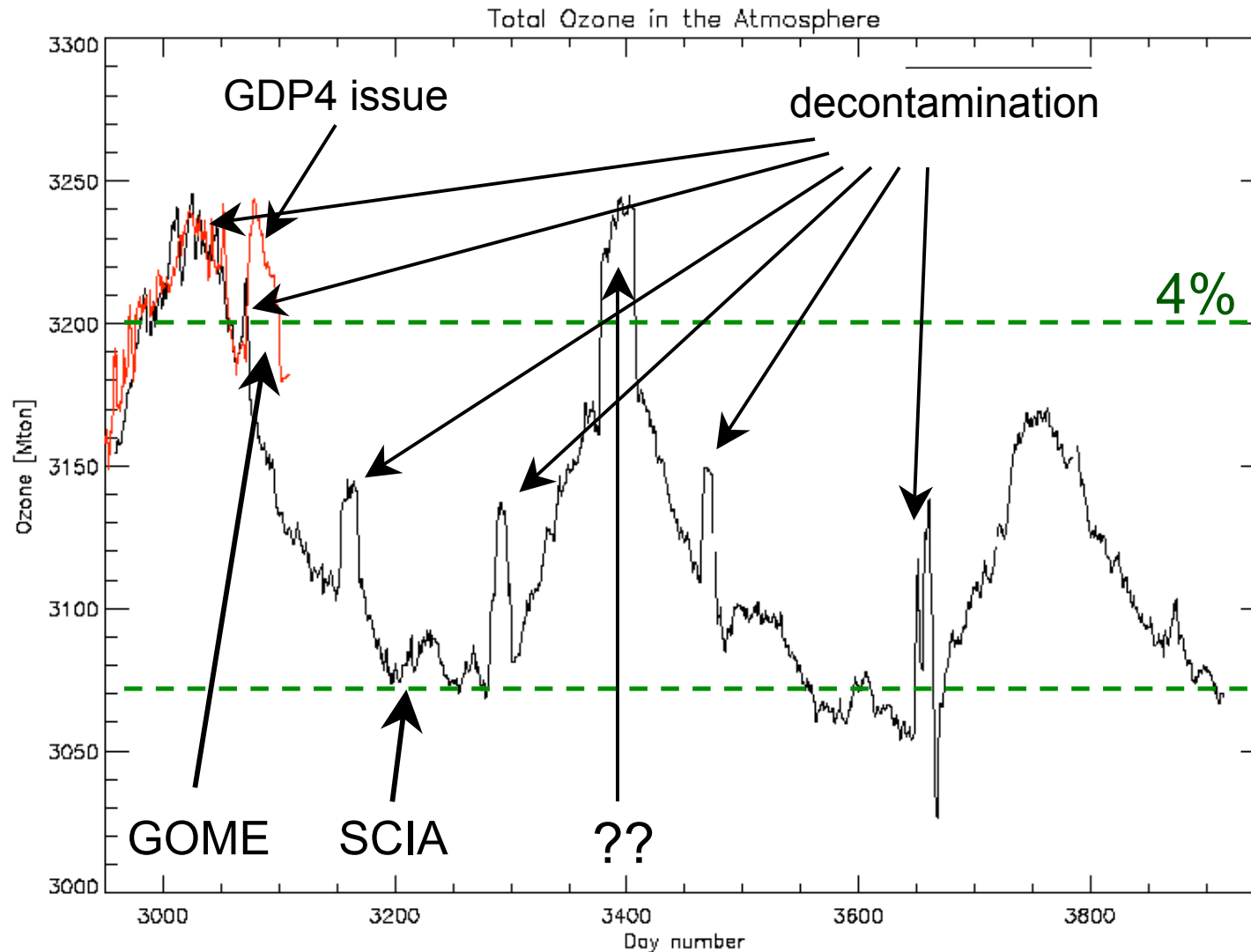


Tosomi vs assimilation

Several features < 1% partly understood



Total ozone mass



2003

2004

Hei 2005 PARC 2006 ESTEC

ASSET: Ozone data assimilation intercomparison



A. Geer et al,
ACPD 2006

ASSET
"Assimilation of
Envisat Data"



ECMWF operational

ECMWF MIPAS

DARC/Met Office UM

KNMI SCIA profiles

KNMI TEMIS

BASCOE v3d24

BASCOE v3q33

MOCAGE-PALM Cariolle v2.1

MOCAGE-PALM Reprobus

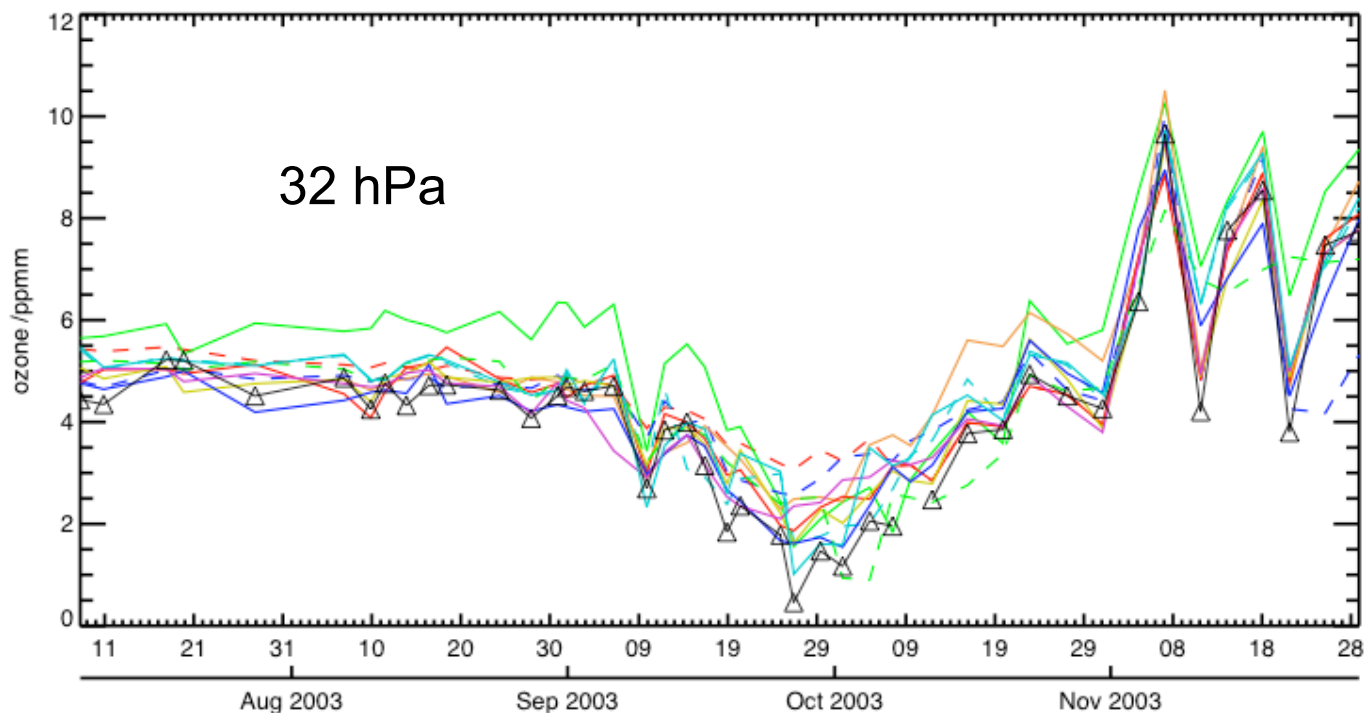
Juckes

MIMOSA

Logan/Fortuin/Kelder climatology



ASSET ozone assimilation intercomparison



Green solid: KNMI SCIAMACHY ozone column analysis

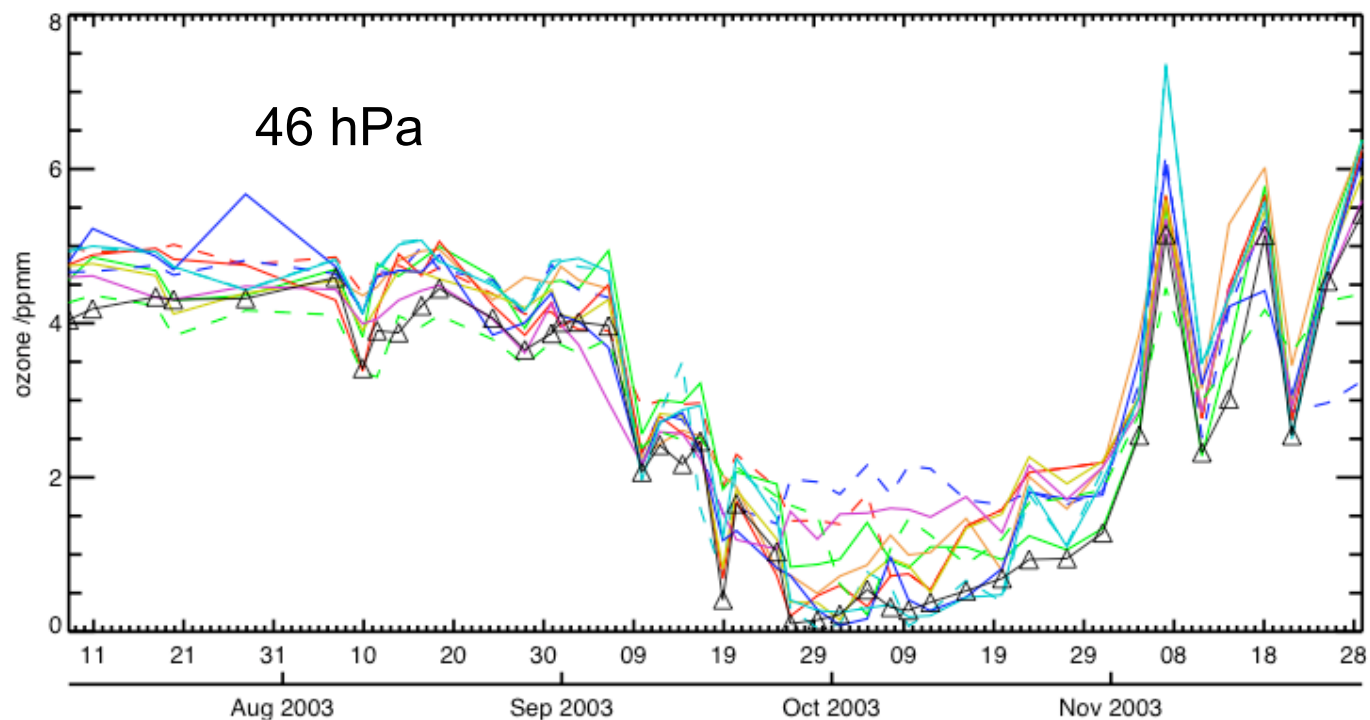
Green dash: KNMI SCIAMACHY ozone profile analysis



A. Geer et al, ACPD 2006

Henk Eskes, SPARC 2006 ESTEC

ASSET ozone assimilation intercomparison



Green solid: KNMI SCIAMACHY ozone column analysis

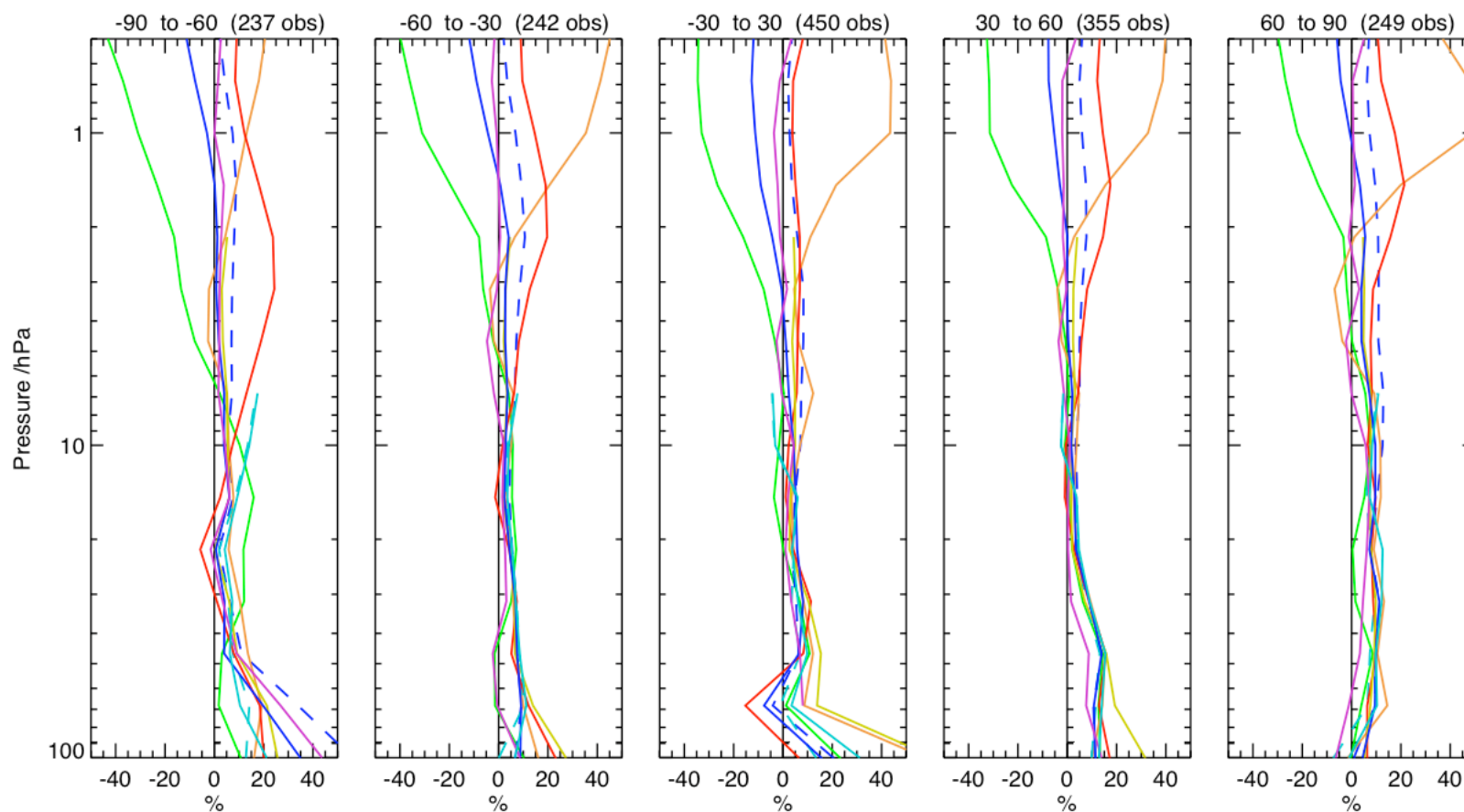
Green dash: KNMI SCIAMACHY ozone profile analysis



A. Geer et al, ACPD 2006

Henk Eskes, SPARC 2006 ESTEC

ASSET ozone assimilation intercomparison



Compared with HALOE

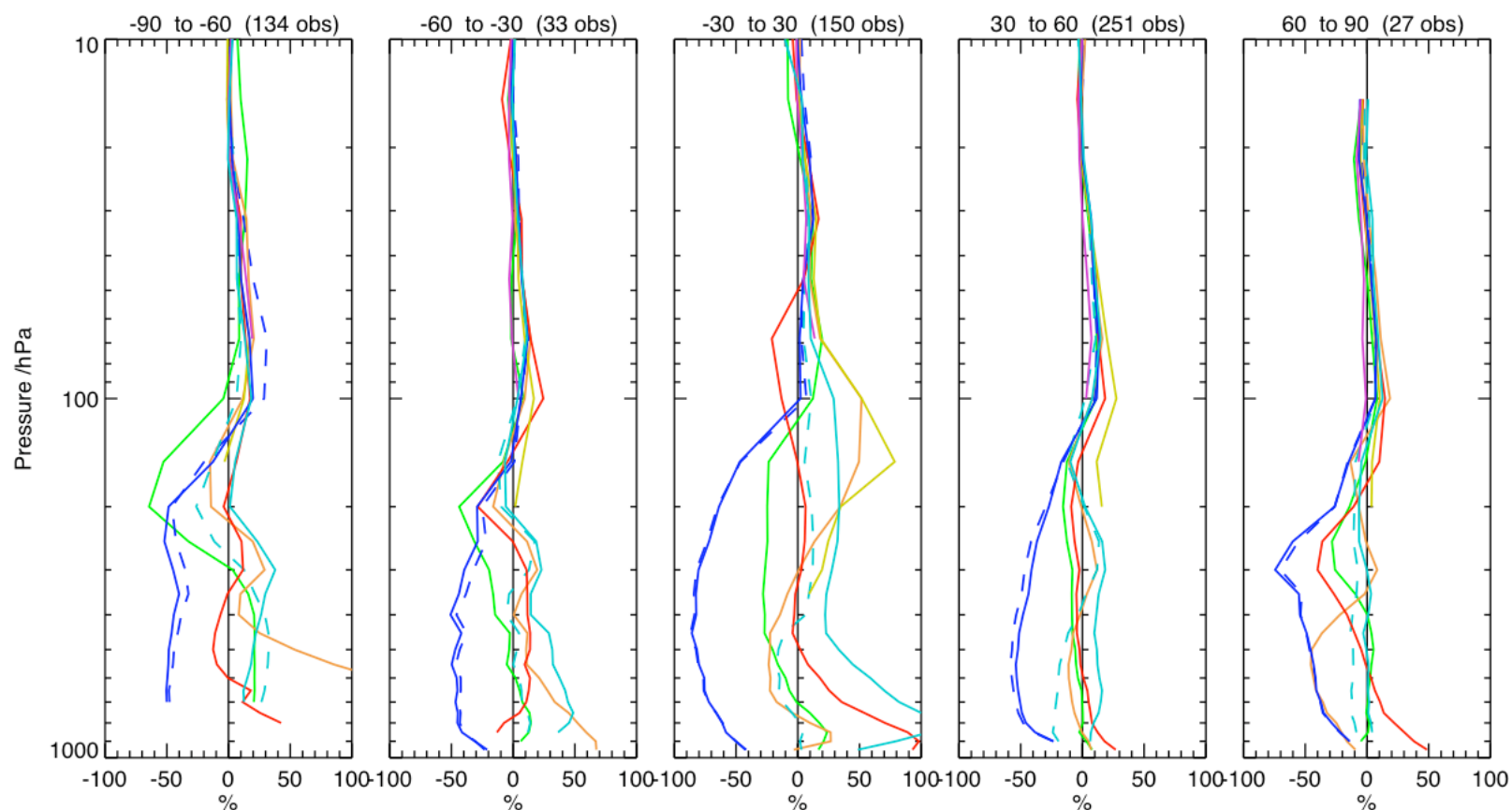
Green solid: KNMI SCIAMACHY ozone column analysis



A. Geer et al, ACPD 2006

Henk Eskes, SPARC 2006 ESTEC

ASSET ozone assimilation intercomparison



Compared with ozone sondes

Green solid: KNMI SCIAMACHY ozone column analysis



A. Geer et al, ACPD 2006

Henk Eskes, SPARC 2006 ESTEC

Conclusions of ASSET intercomparison

KNMI SCIA ozone column assimilation:

- shows best comparison with TOMS total ozone
- reasonable profiles, comparable with others (based on MIPAS profiles)
profile biases found in upper stratosphere (due to chemistry param)
and at South Pole ozone hole

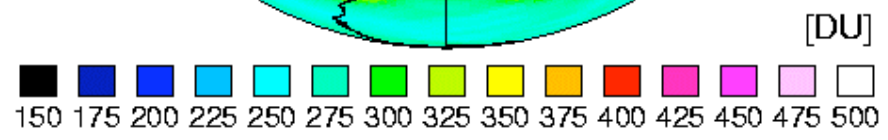
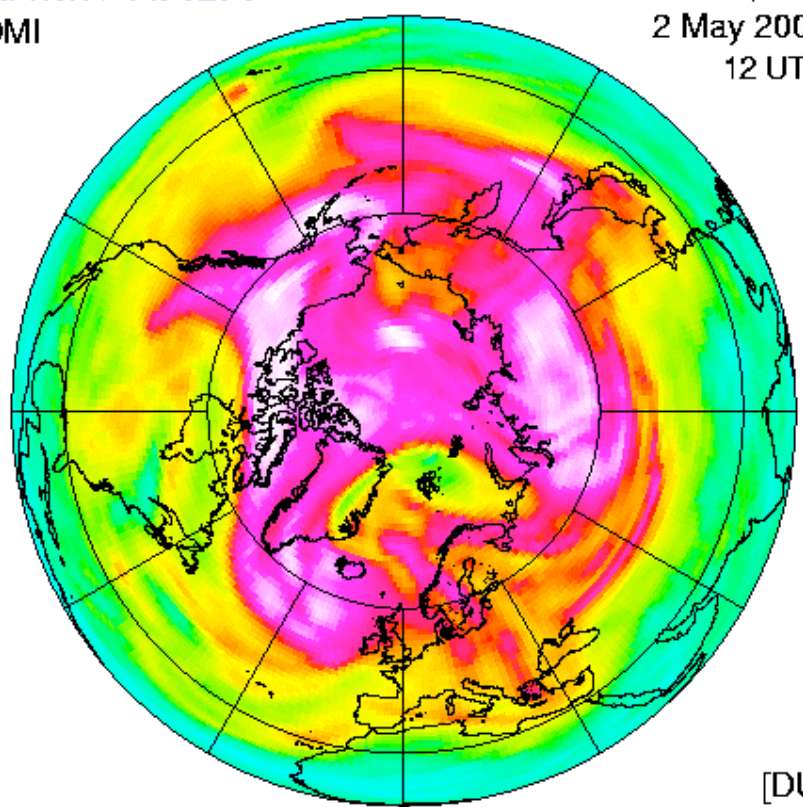
KNMI SCIA ozone limb profile assimilation:

- Improves profile shape at South Pole (compared to column assimilation)

Assimilation of OMI vs SCIAMACHY

KNMI / NASA
OMI

Forecast total ozone (D+1)
2 May 2006
12 UTC

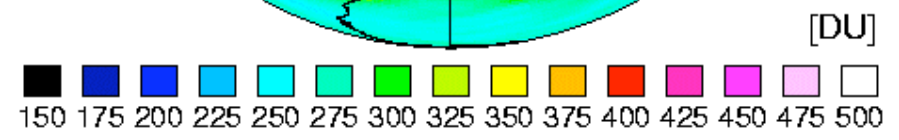
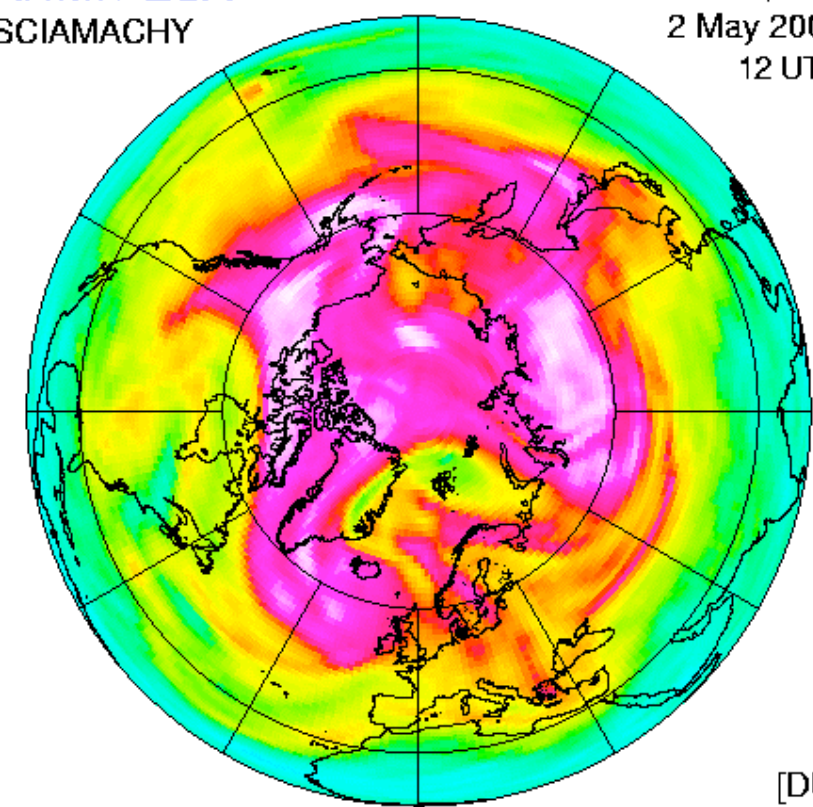


OMI operational analysis



KNMI / ESA
SCIAMACHY

Forecast total ozone (D+1)
2 May 2006
12 UTC



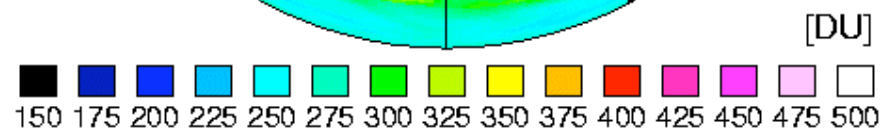
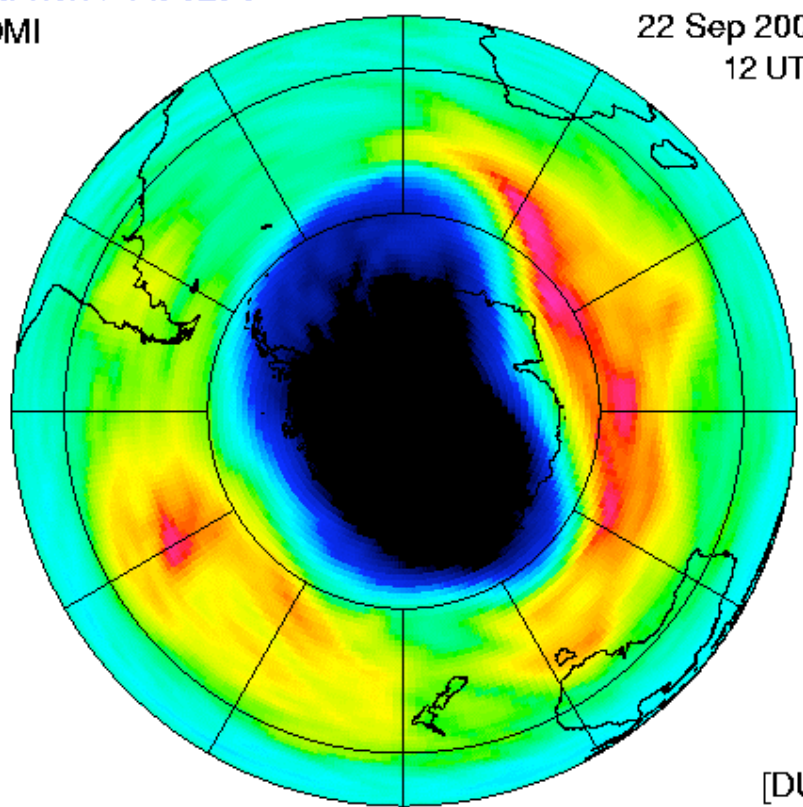
SCIA operational analysis

Henk Eskes, SPARC 2006 ESTEC

Assimilation of OMI vs SCIAMACHY

KNMI / NASA
OMI

Assimilated total ozone
22 Sep 2006
12 UTC

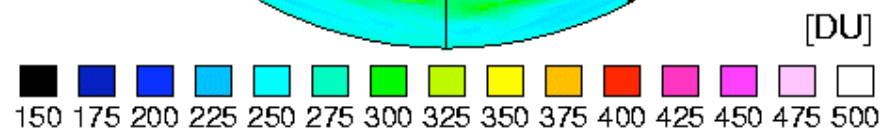
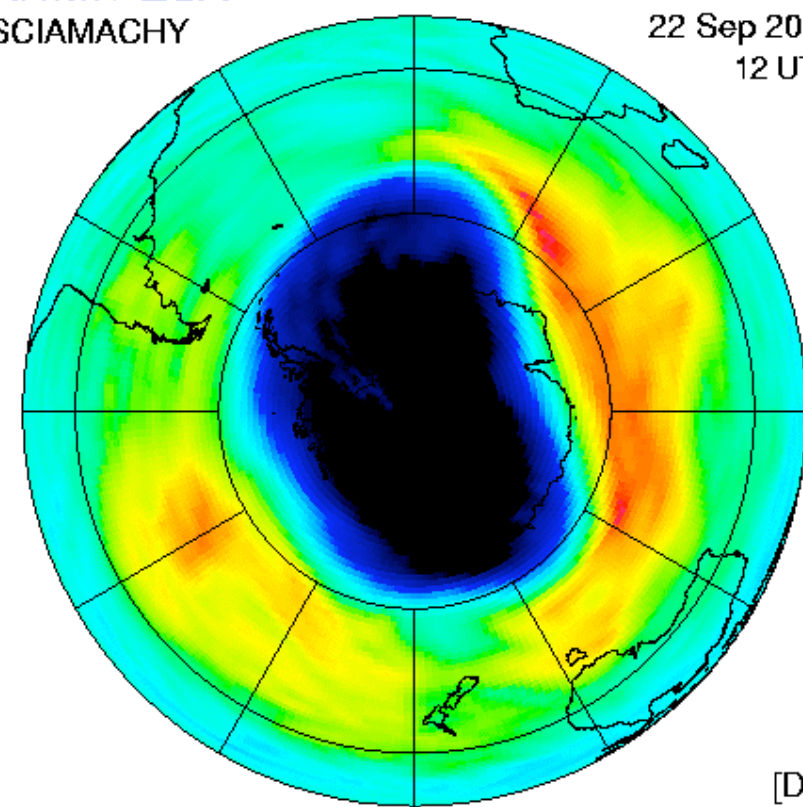


OMI operational analysis



KNMI / ESA
SCIAMACHY

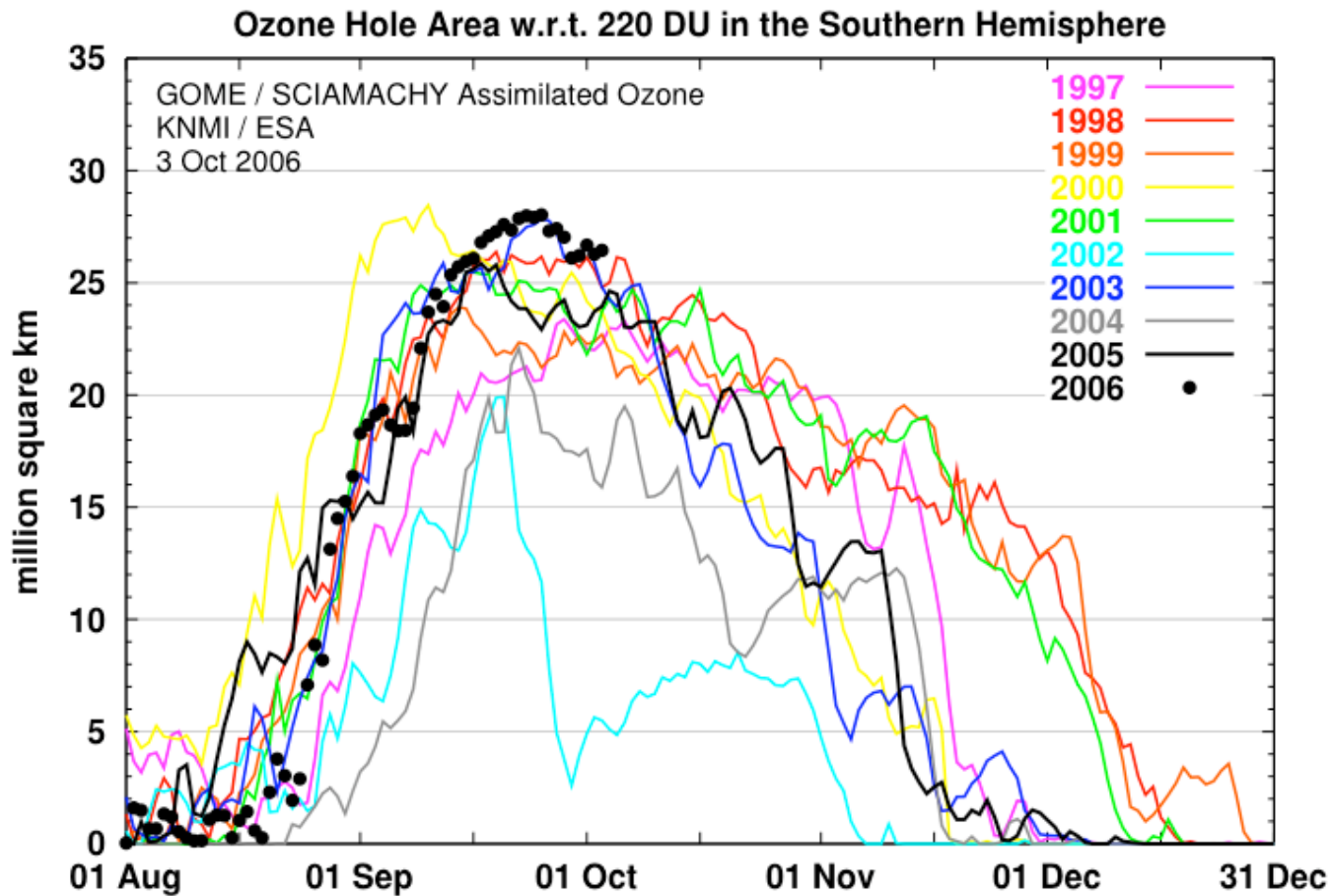
Assimilated total ozone
22 Sep 2006
12 UTC



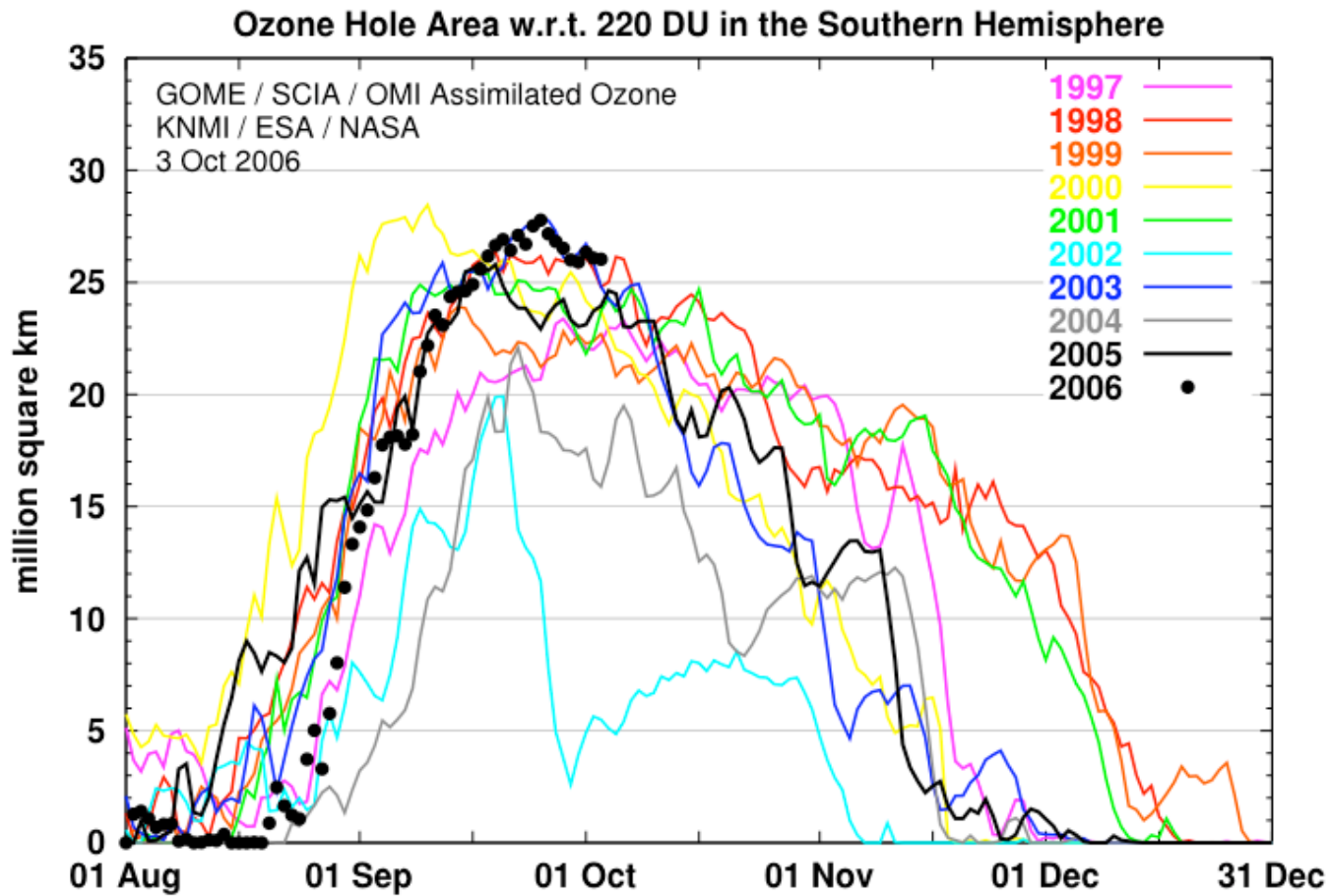
SCIA operational analysis

Henk Eskes, SPARC 2006 ESTEC

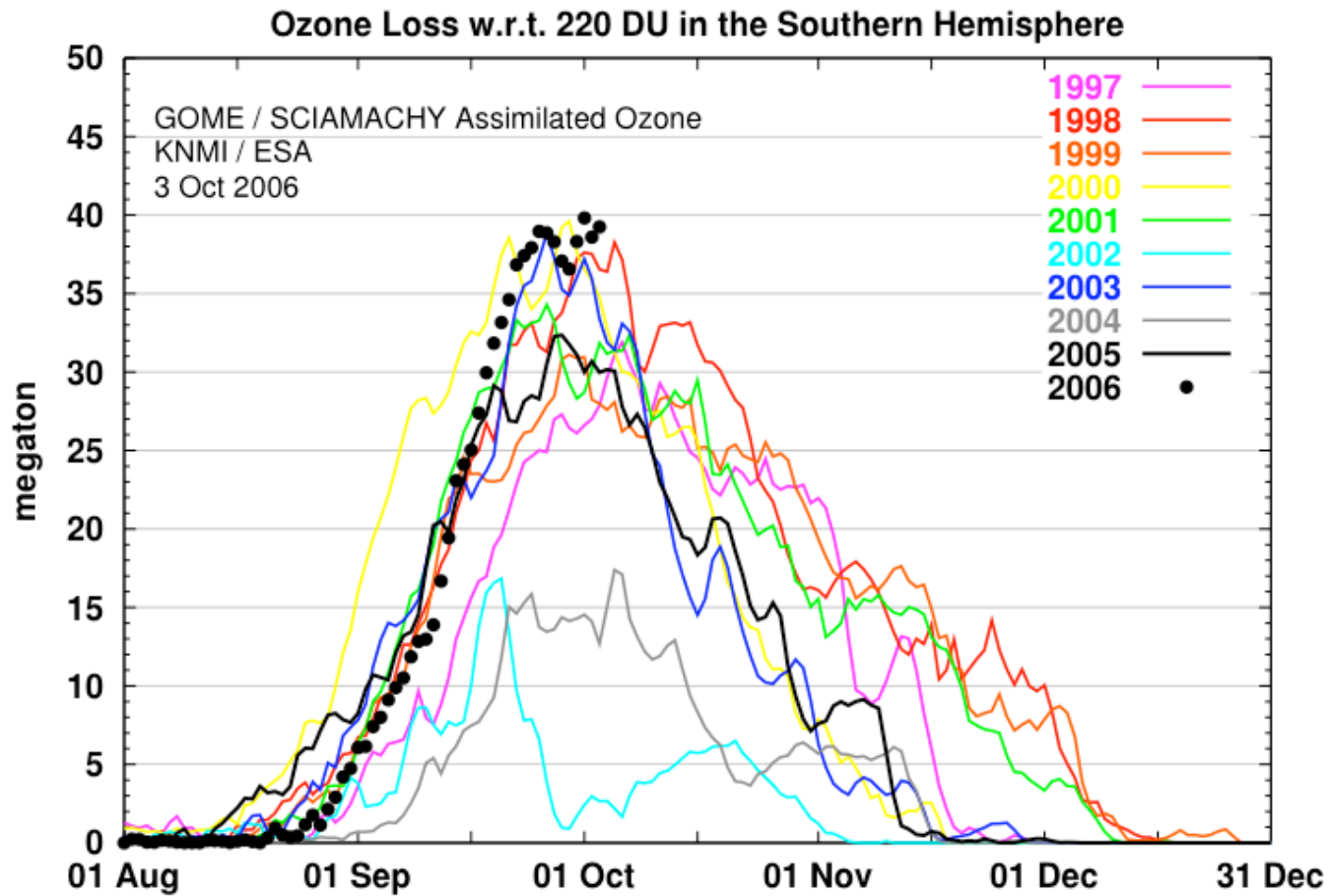
August 2006: is ozone hole breaking the record ?



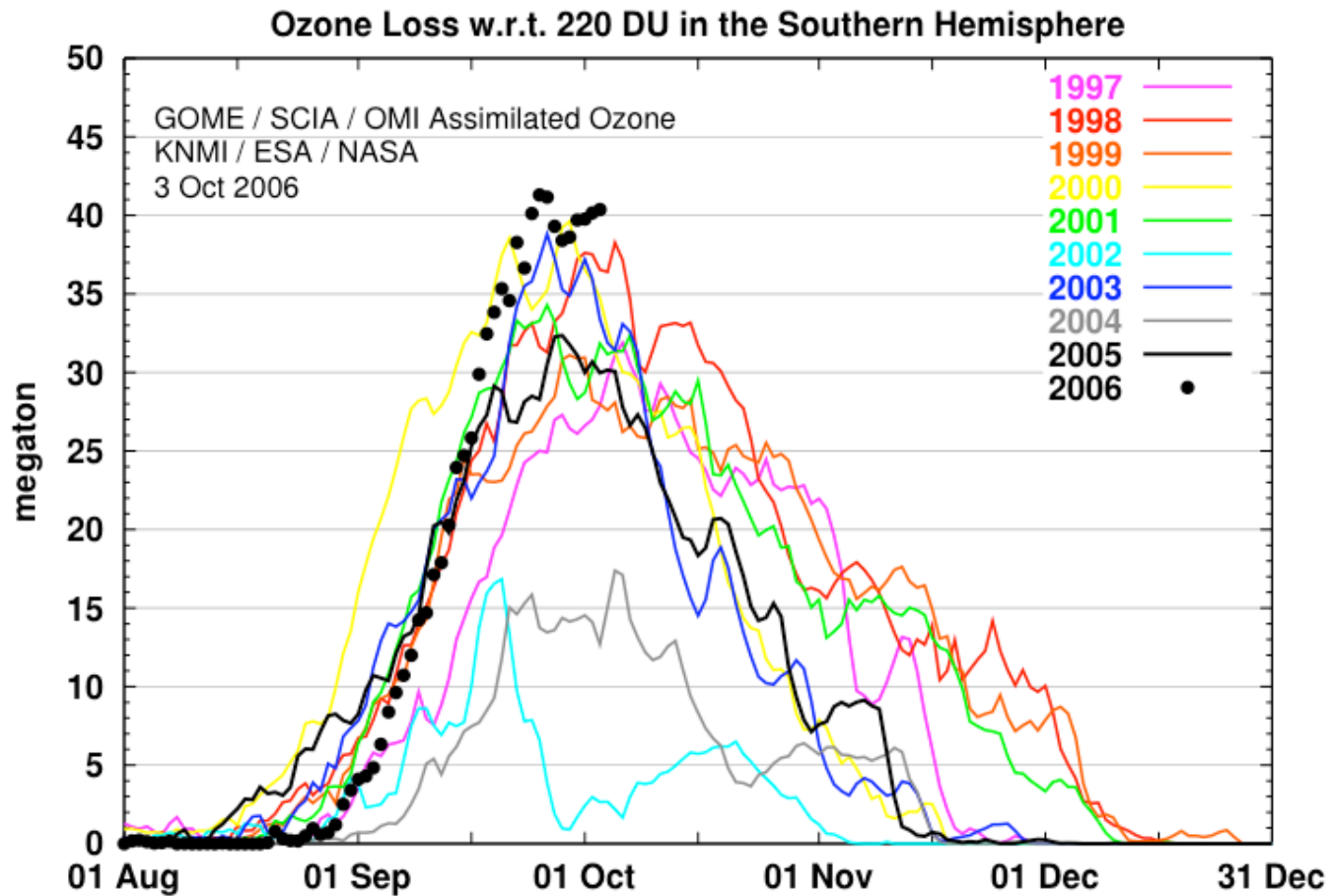
August 2006: is ozone hole breaking the record ?



August 2006: is ozone hole breaking the record ?



August 2006: is ozone hole breaking the record ?





Extra sheets

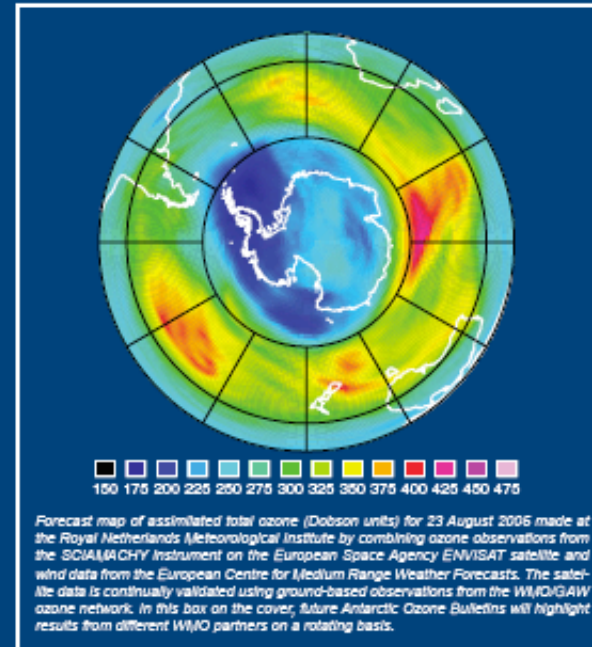


WMO ozone bulletin #1, 2005



Antarctic Ozone Bulletin

No 1
23 August 2005



Executive summary

During the May-August 2005 time period, the temperature conditions in the south polar stratospheric vortex have been close to the 1995-2004 average. The vortex is colder than at the same time in 2004, but somewhat milder than in 2003. Total ozone column values are quite low along the edge of the polar vortex and lower than at the same time in both 2003 and 2004. It is still too early to give a reliable statement about the development of this year's ozone hole, so WMO and the scientific community will use ozone observations and meteorological data to keep a close eye on the development during the coming weeks and months.

Global Atmosphere Watch



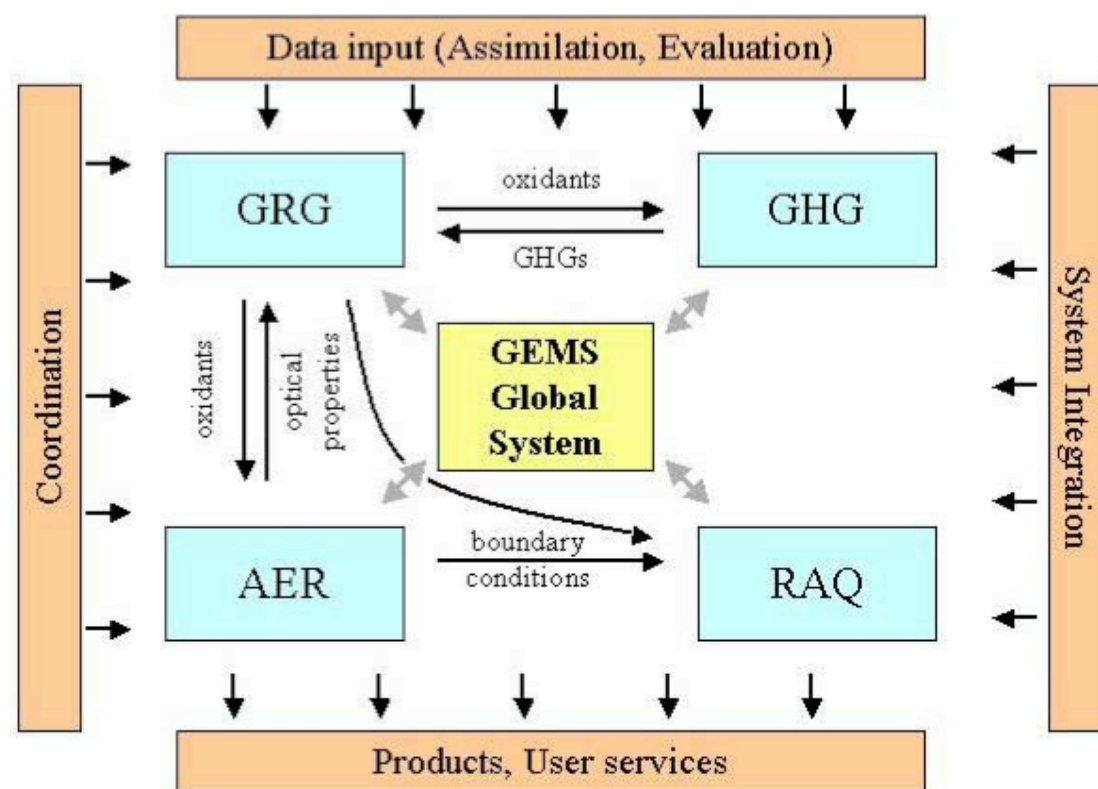
The GEMS Project

Global & regional Earth-system Monitoring using Satellite and in-situ data
 EU 6FP, GMES, 2005-2009, 27 partners

Subprojects:

- Greenhouse gases
- Reactive gases
- Aerosols
- Regional air quality
- Production
- Validation

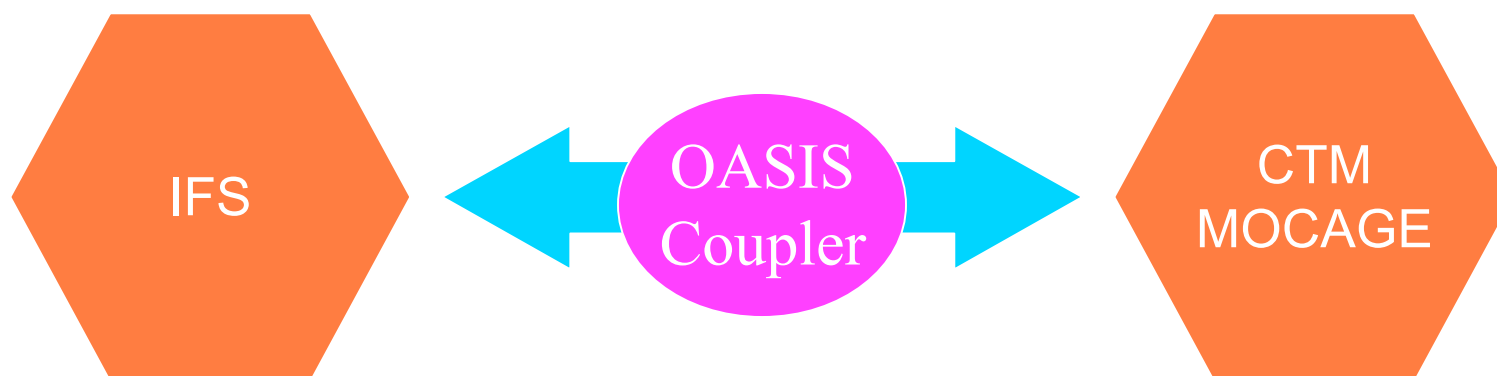
First (trial) reanalysis
 (2003/2004)
 will start at end of 2006



GEMS: Reactive gas subproject

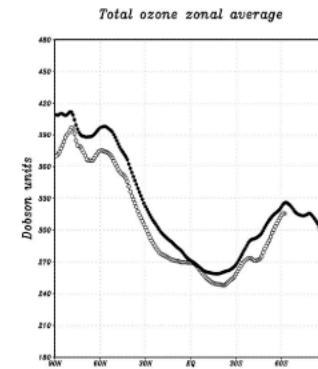
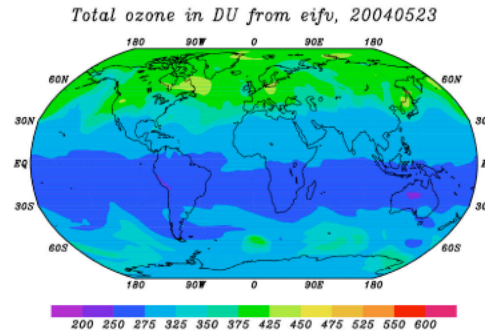
Aspects:

- Two way coupling of ECMWF model with three CTMs: Mozart, Mocage, TM5, coupling via OASIS-4
- Assimilation for ozone, CO, NO₂, SO₂, CH₂O, methane based on 4D-Var system of ECMWF
- Delivery of boundary conditions for RAQ
- Initial focus on troposphere



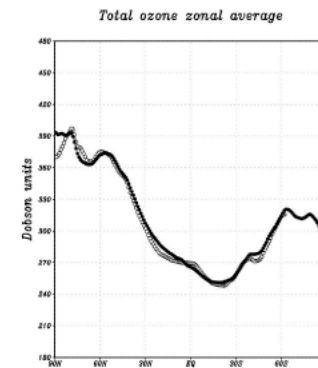
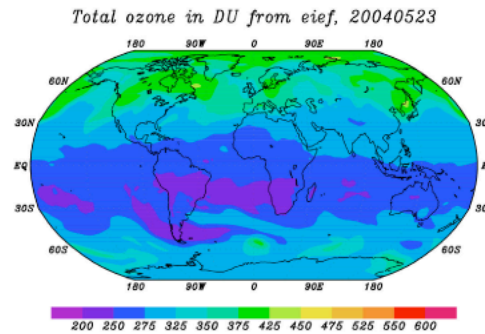
ECMWF: Assimilation of SCIAMACHY-TOSOMI

No SCIA

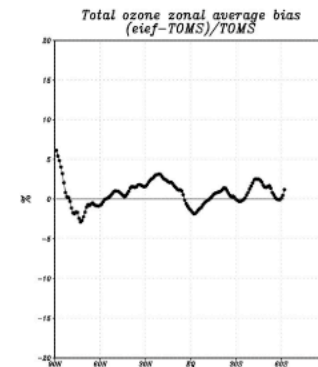
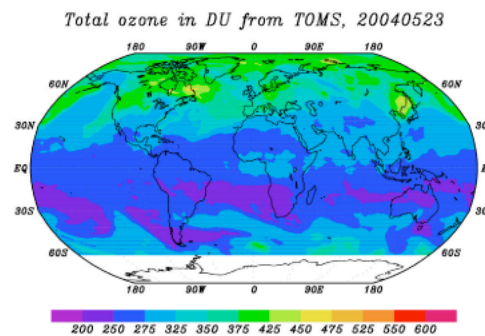


23 May 2004

With SCIA

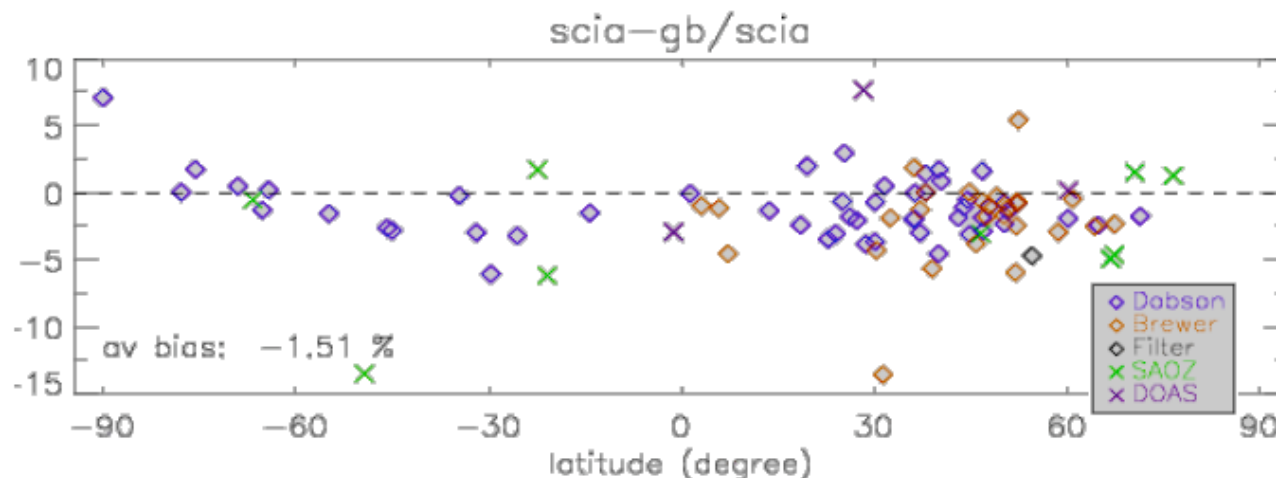


TOMS



Tosomi vs Brewer, Dobson ...

World-wide validation for 2 years of SCIA-Tosomi ozone columns
(Ellen Brinksma)



Main conclusions:

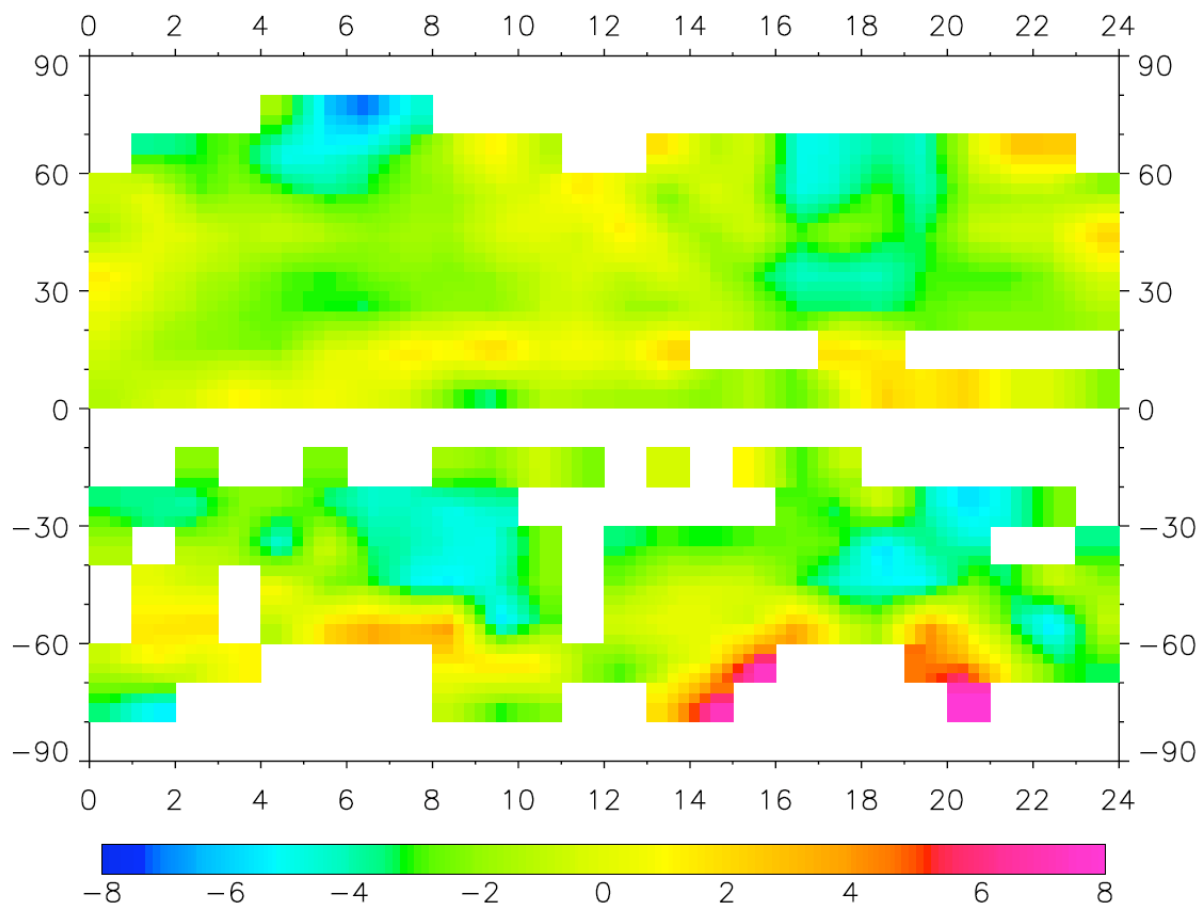
- Tosomi 1.5% lower than ground based
- RMS about 5%
- No clear geographical location or seasonal dependence !
- Stable product



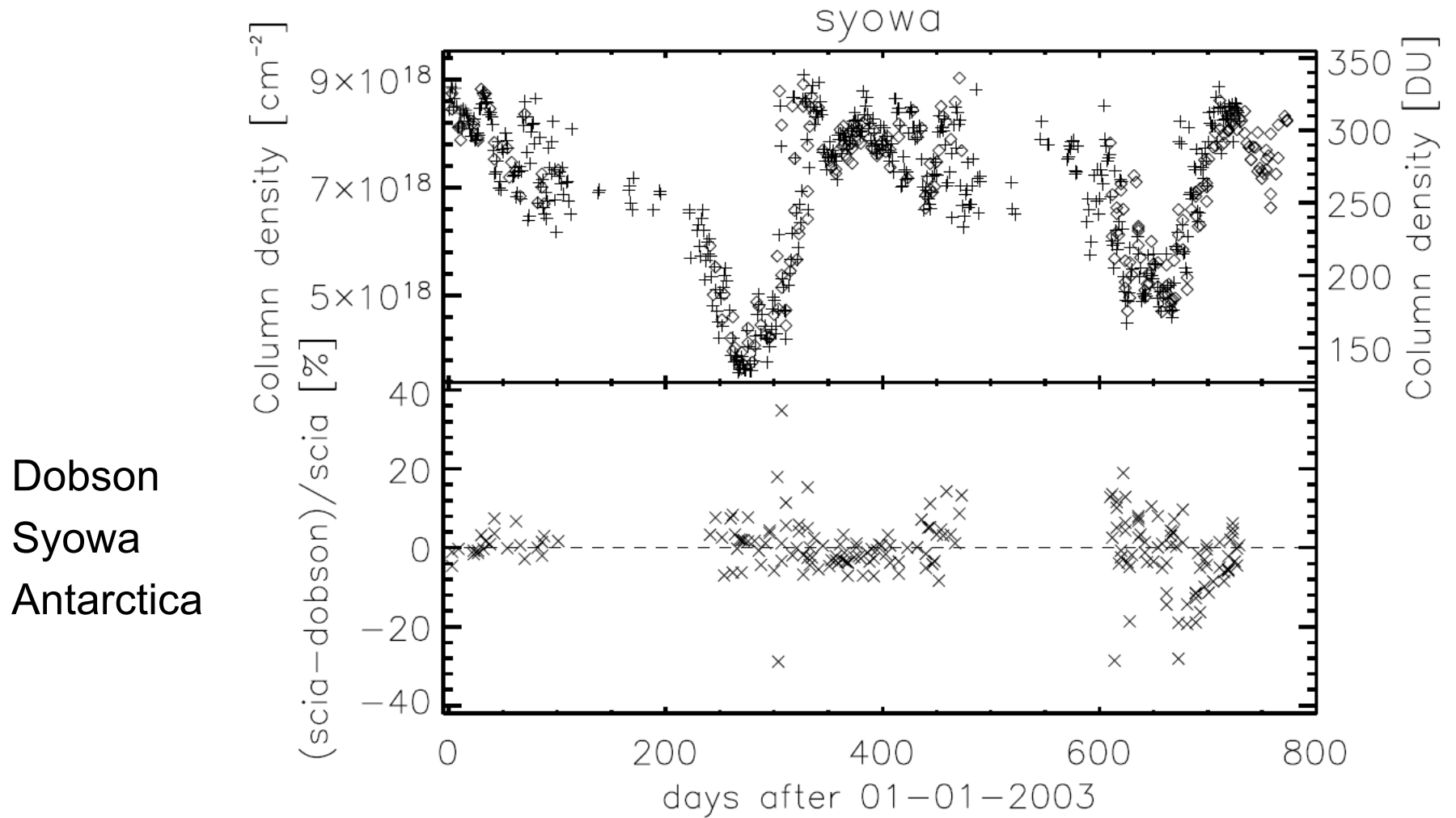
Tosomi vs Brewer, Dobson ...

2003, 2004

Are differences
mainly due to
Dobson/Brewer or
SCIA Tosomi ??



Tosomi vs Brewer, Dobson ...



Dobson
 Syowa
 Antarctica

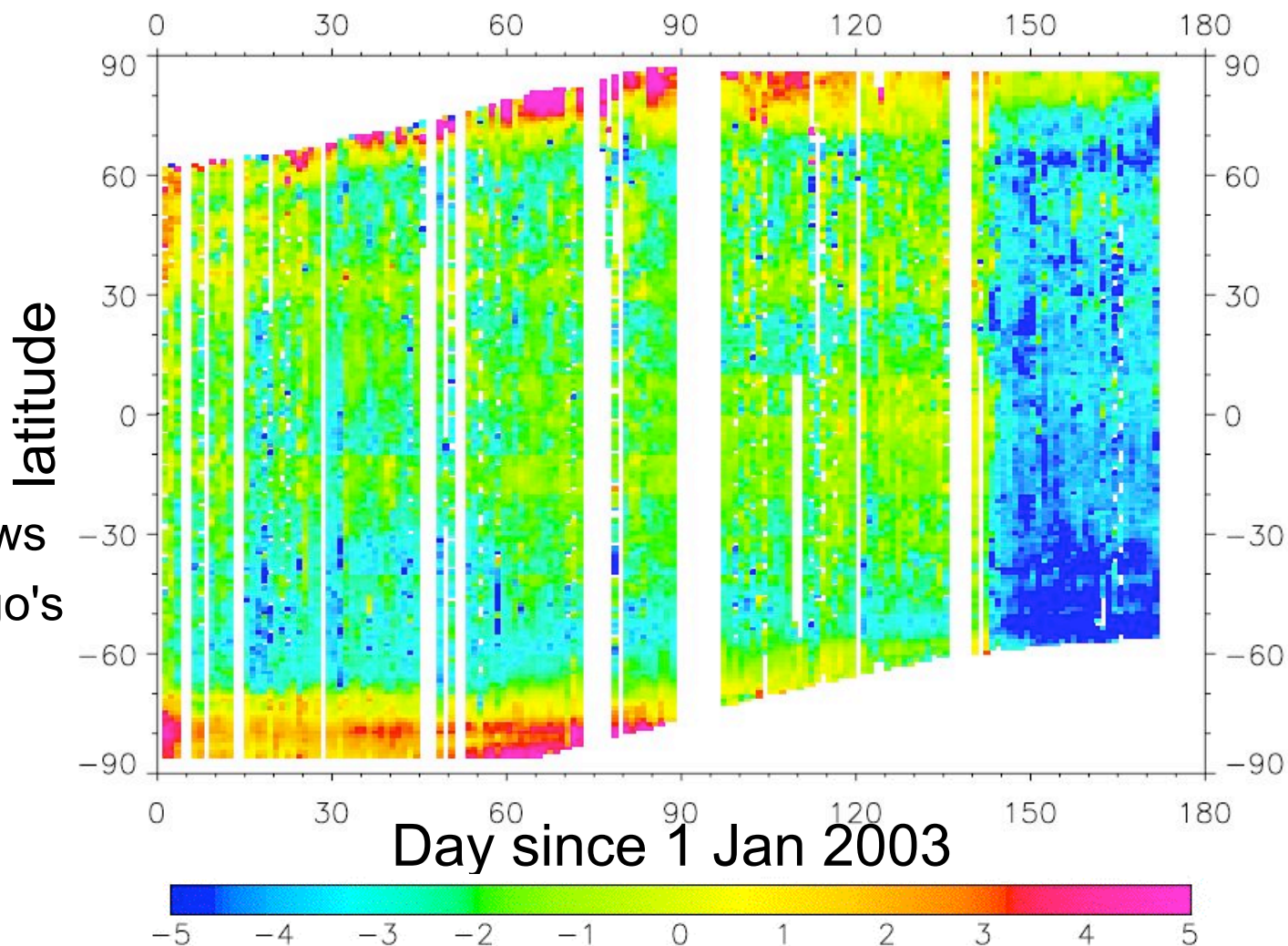


Tosomi vs GOME GDP-4

Good agreement
GDP-4 and
Tosomi

High SZA shows
differences algo's

After day 140:
Offset due to
GOME GDP-4



Tosomi vs GOME Togomi

Variations
small
RMS 0.7%
Bias -1.3%

TOSOMI,
TOGOMI
and
GDP-4
in good
agreement

