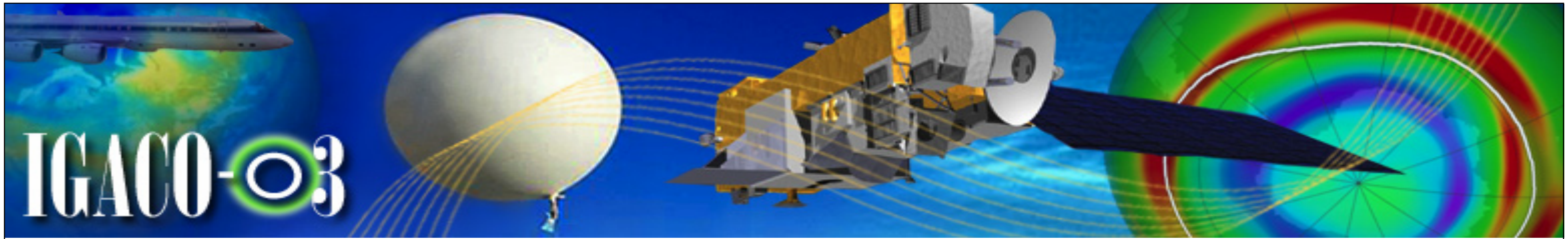
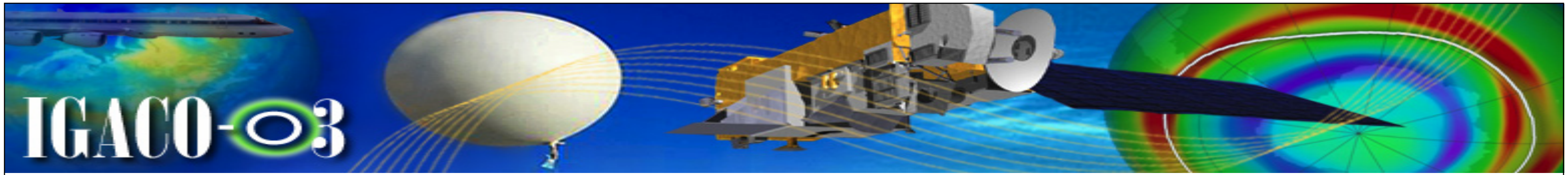


ACSO – Absorption cross sections of ozone

J. Tamminen, J. Orphal and J. Staehelin

Based on reports by McPeters, Bhartia, Labow, Veefkind, Sneep, Flittner, Pitts, Kyrölä, Liu, Chance, Lerot, Van Roozendael, Weber, Chehade, Spietz, Evans, McConville, Otlmans,Quincy, Savastiouk, McElroy, Petropavlosvskikh, Godin-Beekmann and Nair

June 21-22, CEOS-ACC, Baltimore, USA

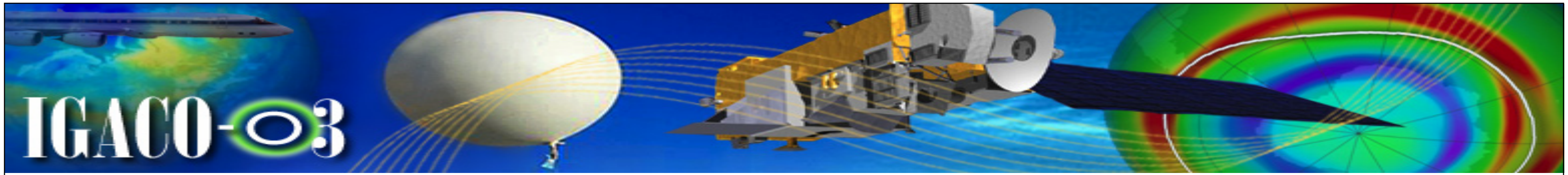


ACSO

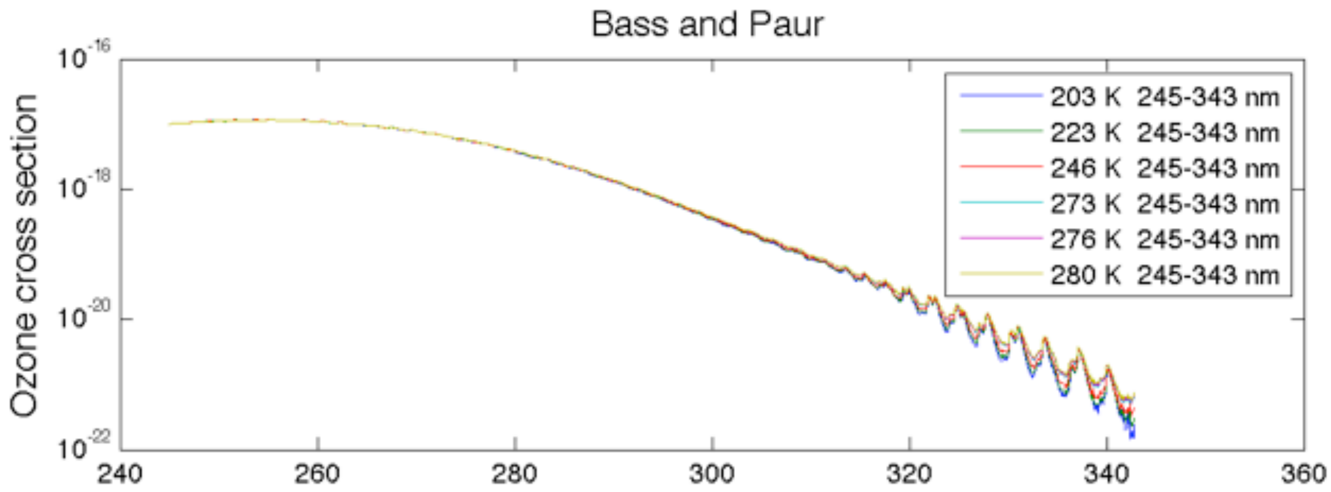
- The committee "ACSO" ("Absorption Cross Sections of Ozone") established in spring 2009 is a joint ad hoc commission of the WMO SAG-ozone of GAW, IGACO-O3/UV and IO_3C of IAMAS.

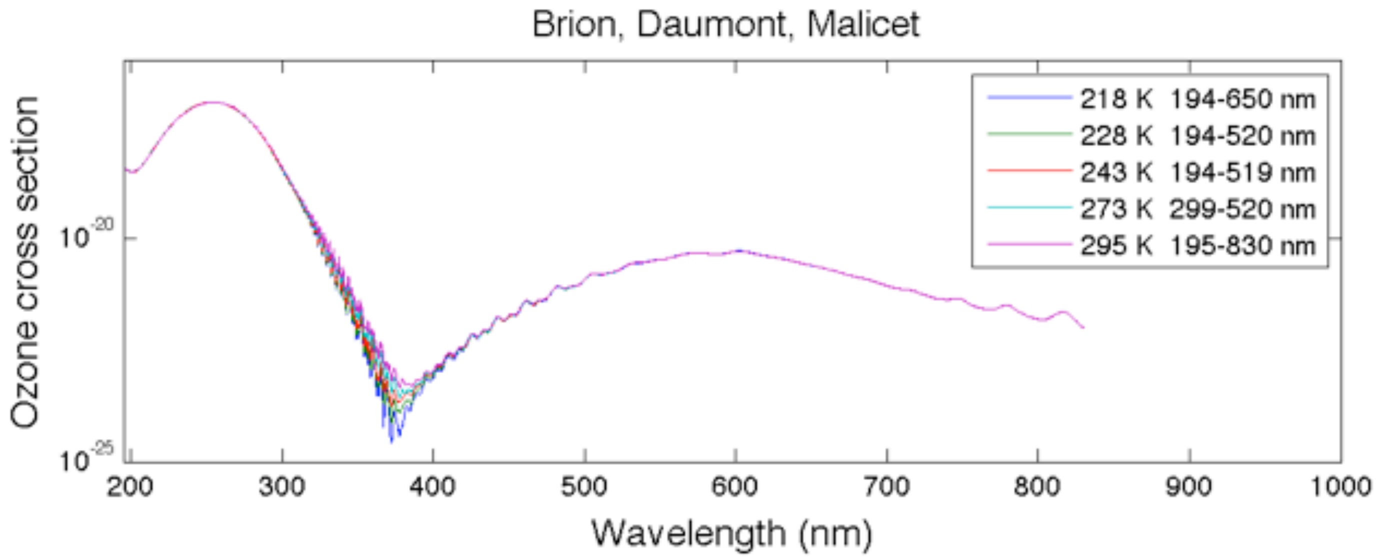
The mandate of ACSO includes:

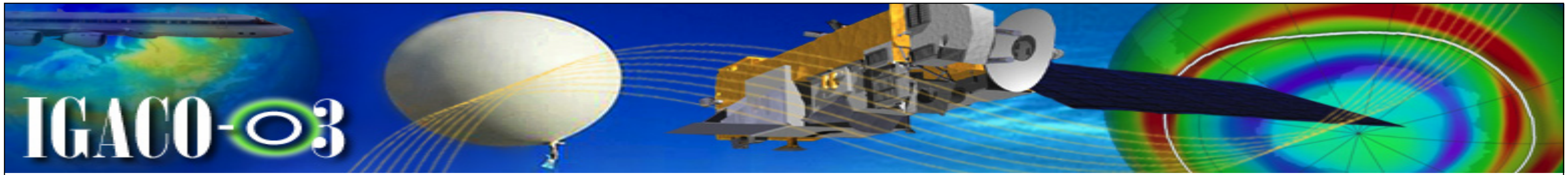
- **Review** the presently available ozone absorption cross sections. Priority on Huggins band, in particular cross sections by:
  - **(BP) Bass and Paur, 1985**
  - **(BDM) Brion, Daumont, Malicet, 1995**
- **Determine the impact** of changing the reference ozone absorption cross sections for all of the commonly used (both ground-based and satellite) atmospheric ozone monitoring instruments.
- **Recommend** whether a change needs to be be made to the



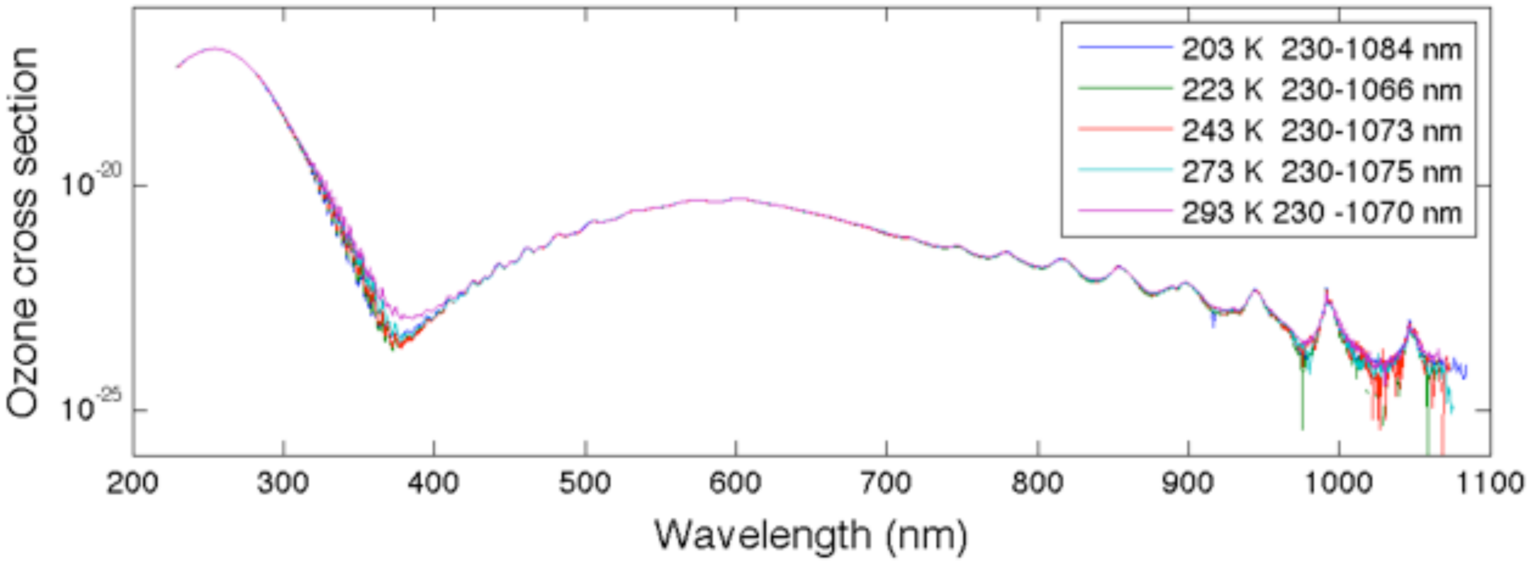
Cross sections

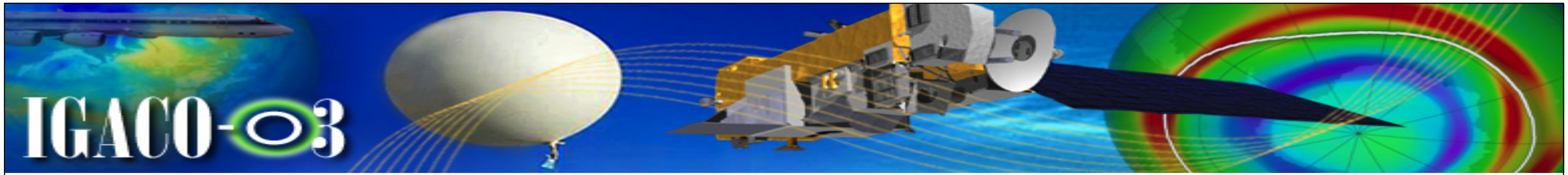






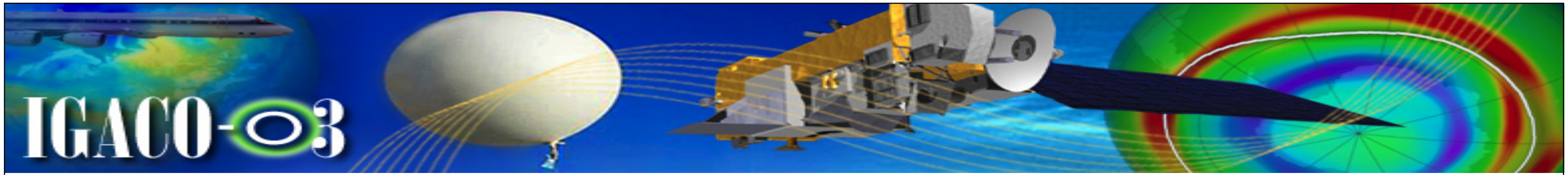
SCIAMACHY FM





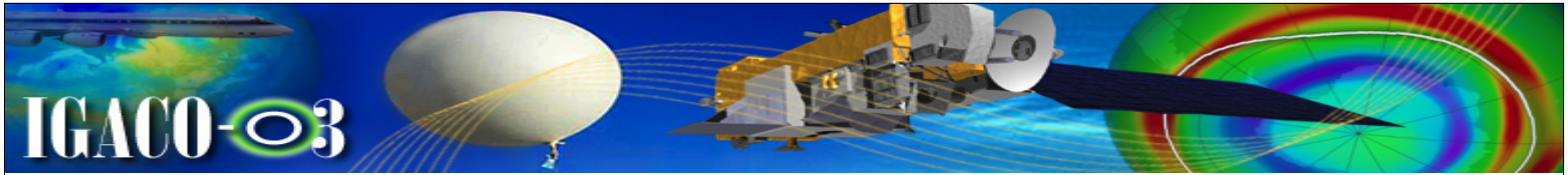
Working groups

- Laboratory measurments:
  - BIPM Paris, NOAA Boulder, LMPAA Paris, IUP Bremen
- Ground based data:
  - Total ozone: Brewer, Dobson
  - Ozone profiles: Umkehr, DIAL-LIDAR
- Satellite data:
  - Total ozone: TOMS, OMI, GOME, SCIAMACY, GOME-2
  - Nadir ozone profiles: SBUV, OMI, GOME, SCIAMACHY, GOME-2
  - Ozone profiles: SAGE, GOMOS, OSIRIS, SCIAMACHY
- **Work led by Johannes Orphal, KIT, Germany**



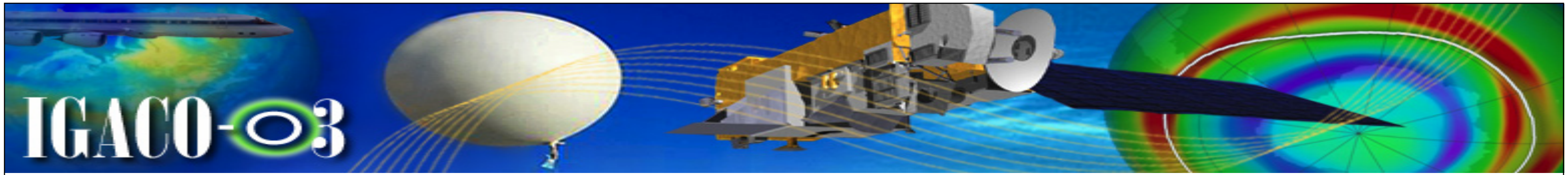
"ACSO" Laboratory activities since 2009

- **BIPM Paris (J. Viallon, R. Wielgosz, et al.):**
  - quantification of all systematic errors (especially for the Hartley band peak at 253 nm)
- **NOAA Boulder (J. Burkholder et al.):**
  - tuneable laser measurements (selected wavelengths in Hartley-Huggins bands, incl. T-dependence)
- **LPMAA Paris (C. Janssen et al.):**
  - tuneable mid-IR laser measurements and simultaneous UV (Hartley band peak) measurements
- **LISA Paris-Créteil (A. Gratien et al.):**
  - simultaneous mid-IR FTS and UV (Huggins bands) measurements using long-path absorption cell
- **IUP Bremen (M. Weber, A. Serdyuchenko et al.):**
  - broad-band measurements using CATGAS and dedicated spectrometers (Echelle, FTS)
  - merging of existing data sets measured at IUP (GOME-1, FTS-Voigt, SCIAMACHY, GOME-2



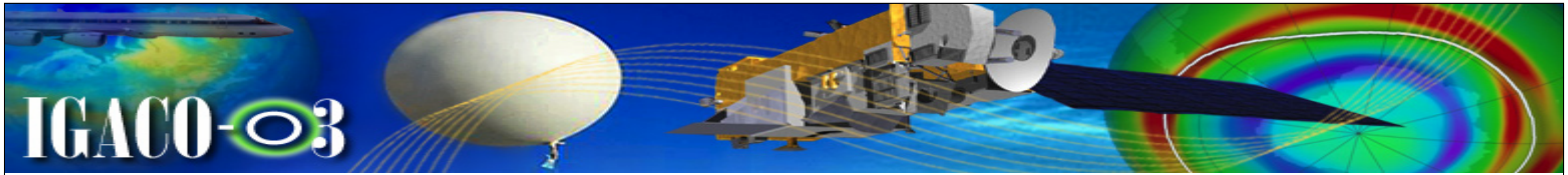
Lab measurements: General results

- **High quality of BDM O3 cross-sections clearly confirmed by NOAA and IUP measurements (incl. T-dependence)**
- **ACSO "switch" from BP to BDM O3 cross-sections very well justified from the laboratory perspective**
- New cross-sections from IUP Bremen seem promising but will need validation by ACSO-like activities (i.e. 2012 and beyond)
- Existing data sets need to be accessible (e.g. ACSO WWW site) to avoid circulation of conflicting data versions
- ~5% systematic discrepancy between UV (Hartley-Huggins) cross-sections and mid-IR line intensities is confirmed (LPMAA, LISA)



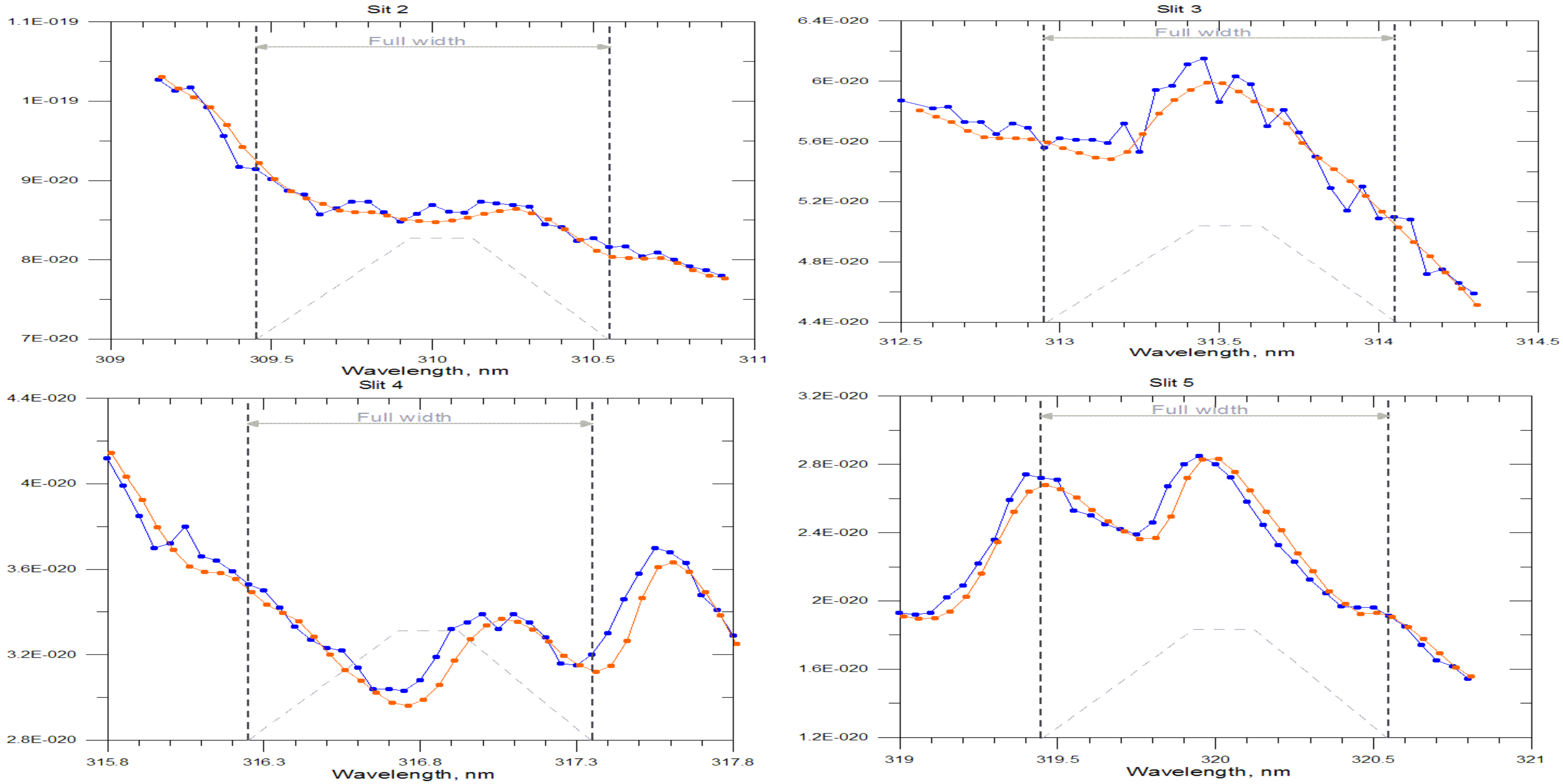
Dobson

- Little effect when using the operational retrieval algorithm (AD observations)
- Sensitivity of total ozone observations on atmospheric temperature smaller when using BDM instead of BP
- Other findings:
  - Discrepancy between AD and CD observations not smaller when using BDM instead of BP: probably because of another problem in Dobson spectrophotometry (stray light problem ?)
  - Consider improvement of retrieval algorithm: Atmospheric temperature profile dependency strongly determines accuracy of total ozone measurements of Dobson instruments when using present retrieval algorithm

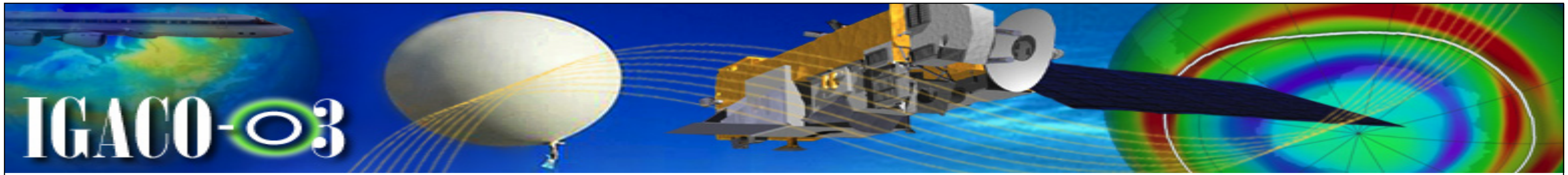


Brewer total ozone

Ozone absorption cross section for different slits (**blue: BP**, **red: BDM**)

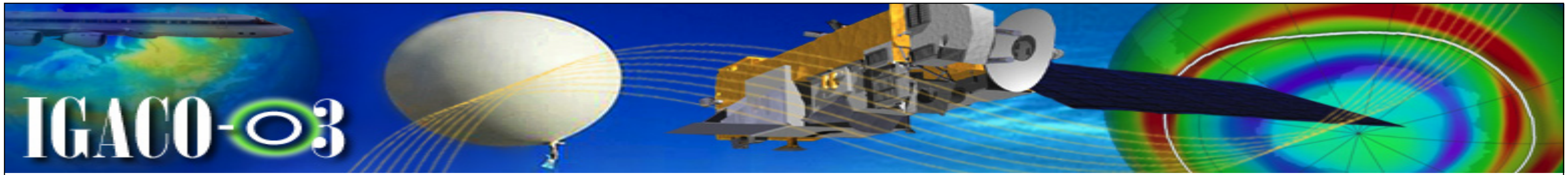


(V. SAVASTIOUK, and C.T. MCELROY)



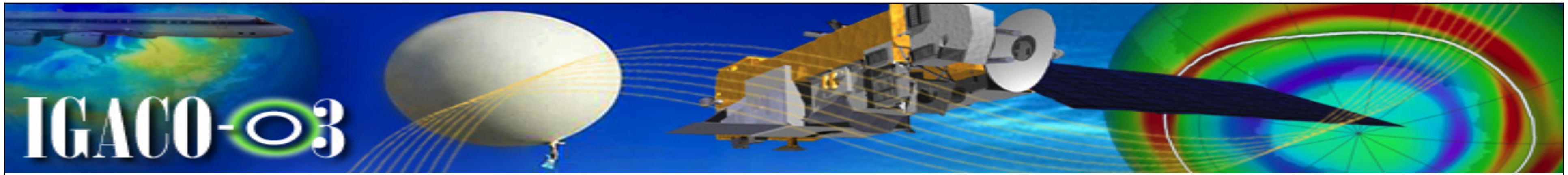
Brewer

- Better quality of ozone absorption cross sections BDM over BP:
  - Better accuracy and precision of Brewer total ozone measurements expected
- When using BDM instead of BP:
  - lower column ozone results are expected (3% in average)
- Changing from BP to BDM requires recalculation of calibration information using the new cross sections.



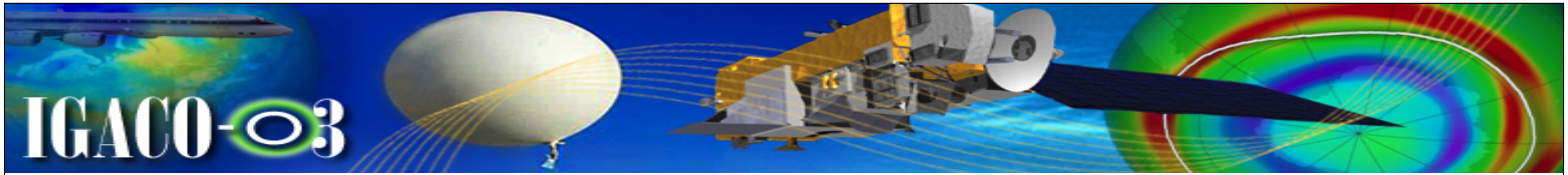
Ground based ozone profiles

- DIAL-lidar
  - Effects for (mean profiles) in terms of absolute ozone mixing ratios small
  - Largest effects for ozone in the upper stratosphere (1.8%) and in the tropics at ~15 km (-1.5%).
- Umkehr ozone profiles
  - The change has small impact (± 2%) and within the retrieval uncertainty.



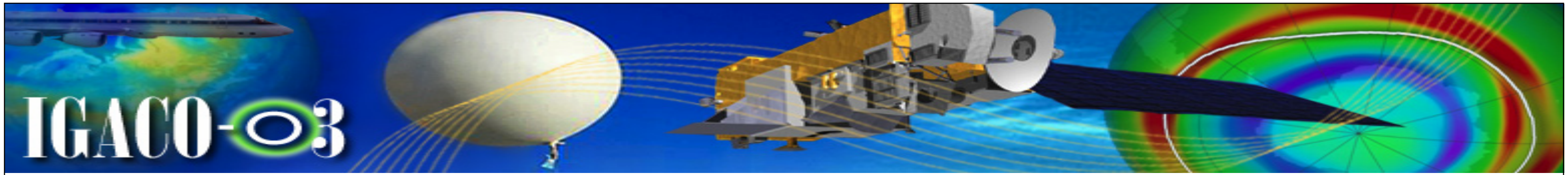
Conclusions: ground based instruments

- Effects of changes absorption cross sections from BP to BDM expected to be small for Dobson total ozone, Dobson and Brewer Umkehr and DIAL-lidar, largest effects predicted for Brewer total ozone (- 3%).
- Difference between co-located Brewer and Dobson (AD) measurements expected to become larger when using BDM instead of BP.
- Brewer ozone profiles expected to be of higher quality when using (BDM) due to better quality of cross sections.
- Change to BDM seems feasible, but the introduction in the operational network requires subtantial effort that needs additional evaluation and planning.



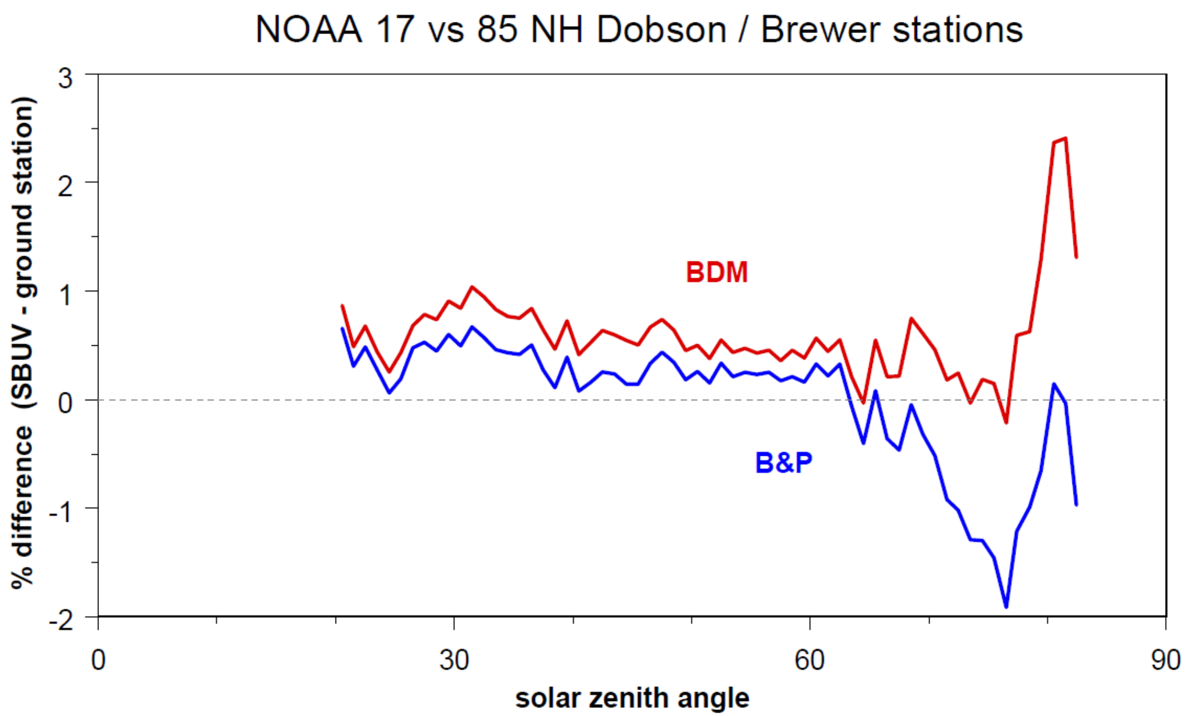
Satellite sub-group

- **Topics studied**
  - Differences in cross sections and their temperature dependence
  - Chances in residuals
  - Impact in fitting effective temperature
  - Impact of changing cross sections in ozone
  - Agreement with ground based measurements
  - Need for more laboratory measurements

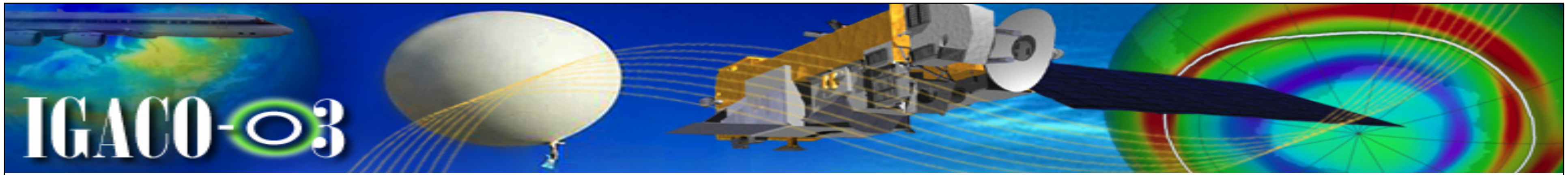


SBUB ozone

- Total column ozone from NOAA-17 SBUV/2 has a strong SZA dependence relative to ground based instruments when processed with BP cross sections that goes away when BDM cross sections are used.
- This indicates that the BDM cross sections are more accurate

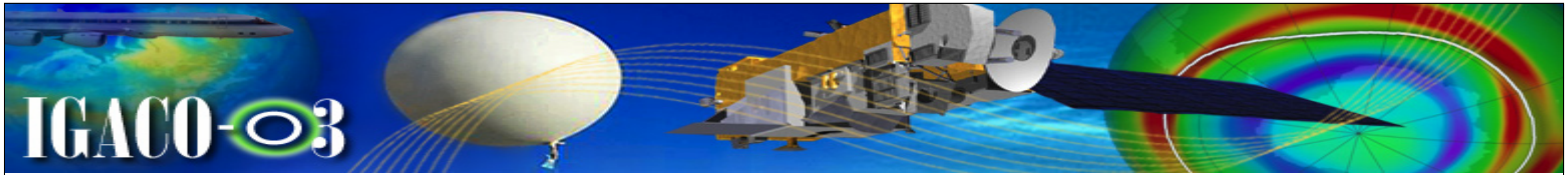


(McPeters and Labow)



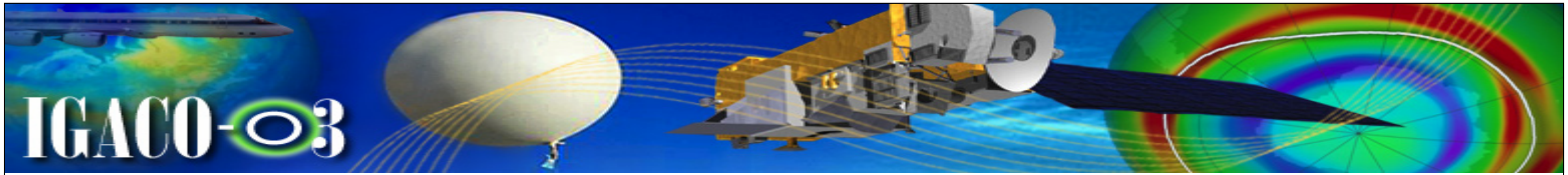
Total ozone profile - summary

Instrument/ algorithm	**Residuals**	**wl calibr.**	**other tests and validation (eg. effective temperature)**
TOMS	BDM better than BP		BDM better temperature dependence
OMI DOAS	BDM marginally worse than BP		BDM better effective temp
GODFIT	GOME: BDM best, BP worst SCIA/GOME-2: BP worst GOME-FM & BDP equal	BDP more accurate than BP/GOME-FM	Effective temperature using GOME: BDM agree well with ECMWF, BP and GOME-FM result lower values.
WFDOAS	BP worse than BDM and satellite FM BDM slightly better than satellite FM	BDP more accurate than GOME-FM and SCIA-FM	Effective ozone temperature can vary by up to 15 K depending on cross-section choice



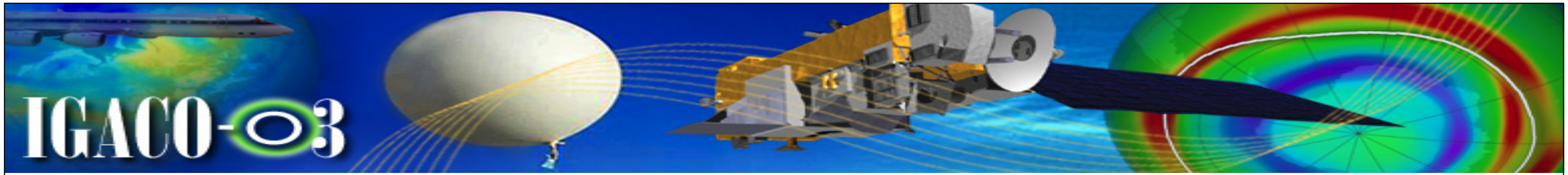
Nadir ozone profile - summary

Instrument/ algorithm	Residuals	wl calibr.	other tests and validation
SBUV profile			BDM: no solar zenith angle dependence in comparison to Brewers/Dobsons. BP: clear dependence
OMI Profile	BDM better than BP		Reflectance cost functions indicate that BDM better than BP (TBC)
GOME profile (Liu, Chance)	BDM better than BP GOME-FM better than BP, but worse than BDM		Tropospheric ozone columns show better agreement at two sites when using BDM.



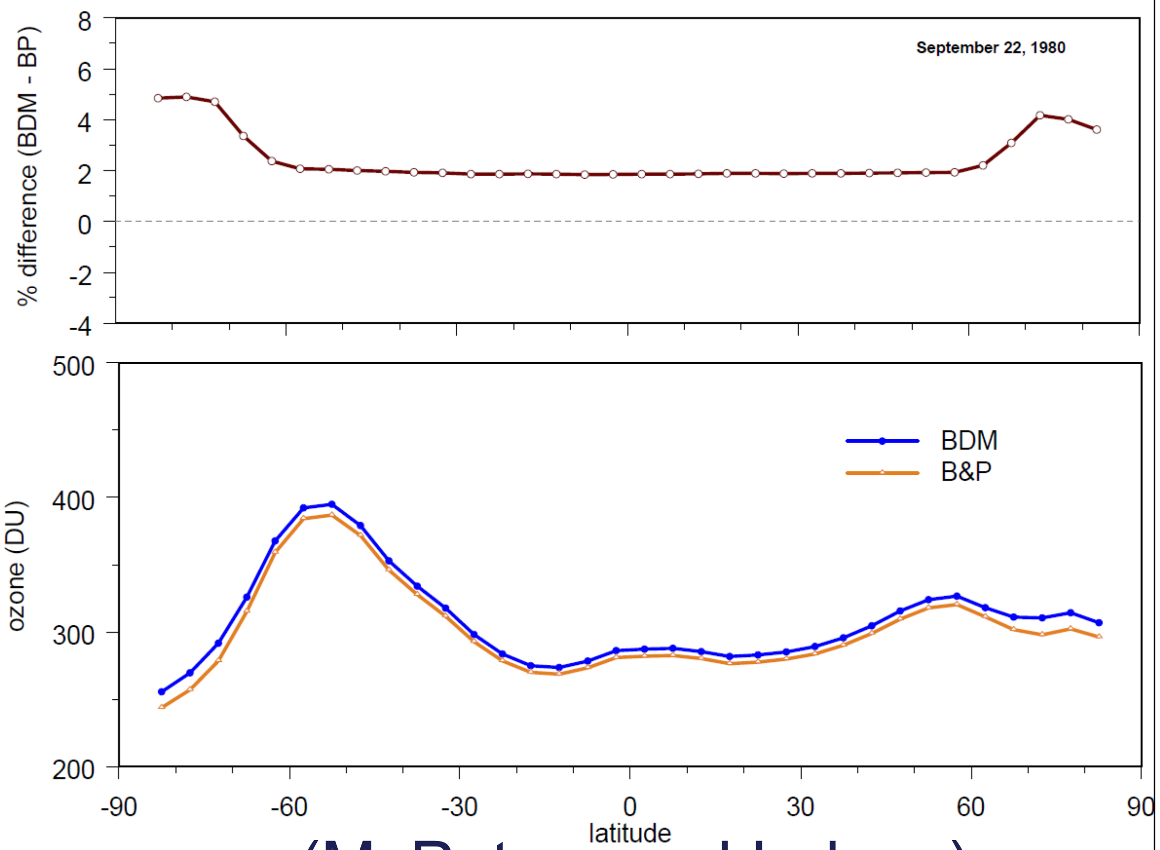
Summary

- General agreement: BDM more accurate than BP
  - wavelength calibration good
  - temperature dependence better
- Residuals typically slightly better when changing to BDM

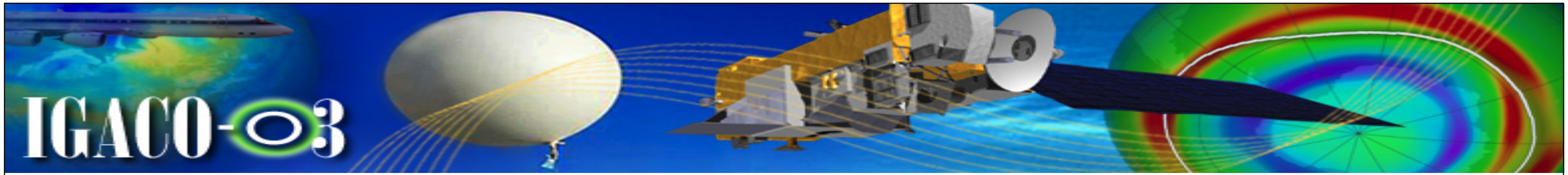


TOMS total ozone

- Effect of using BDM cross sections on N7 TOMS retrievals for data from September 22, 1980.
- Average offset +1.9% <50° latitude

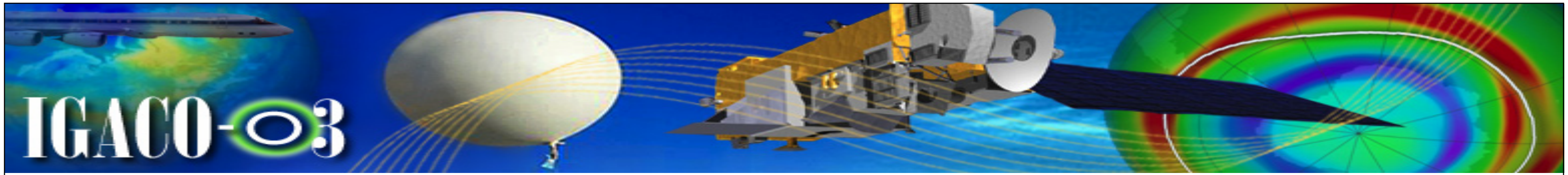


(McPeters and Labow)



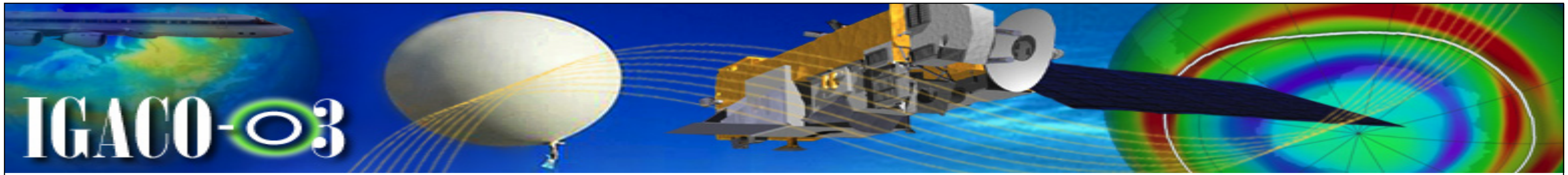
Total ozone column - summary

Instrument/ algorithm	Baseline up till now/ compared to	Difference expected if changed	Sign
TOMS	BP Reprocessing BDM	+1.5 … +2 %	Pos
OMI DOAS	BP	< 1% on average (std 2.5%)	Pos
GODFIT	GDOAS (GOME-FM?) GODFIT baseline BDM	+2 … 3%	Pos
WFDOAS	GOME-FM SCIA-FM	+2.5%	Pos



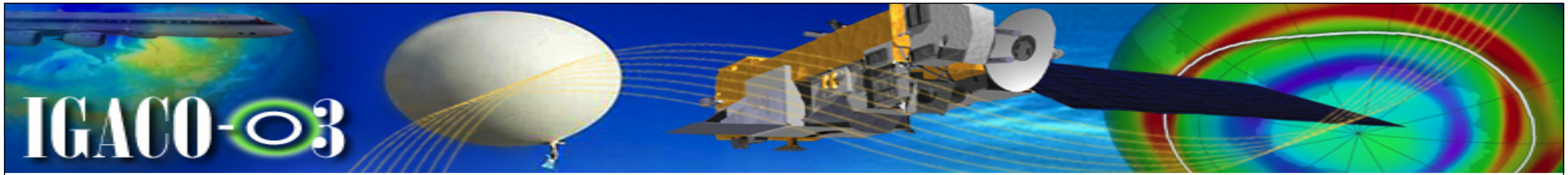
Nadir ozone profile - summary

Instrument /algorithm	Baseline up till now/compared to	Difference expected if changed to BDM	Sign
SBUV profile	BP Re-proccessed BDM	±5%, pos. troposphere neg. stratosphere Tot 0.5%-1% less	Mixed tot: neg
OMI Profile	Baseline BDM	1% total average higher at indiv layers ~10%	Pos
GOME profile (Liu, Chance)	BP vs BDM	0.5% column 1-2.5% Tropo column Large difference at indiv. layers (up to 100% in low ozone conditions)	Pos



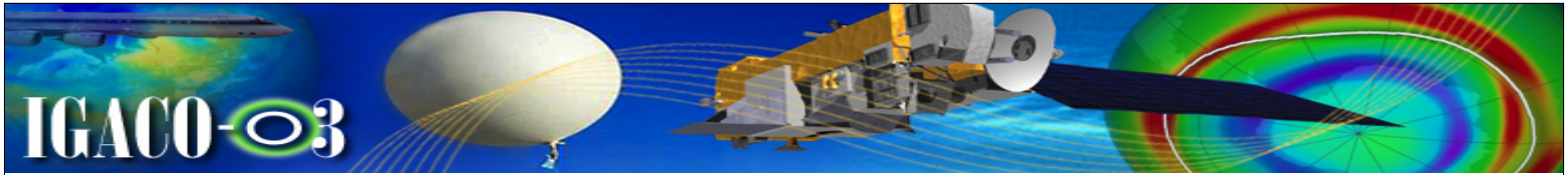
Limb/occultation ozone profile - summary

Instrument /algorithm	**Baseline up till now/compared to**	**Difference expected if changed to BDM**	**Sign**
GOMOS	Bogumil	0 …+1.5%	Pos
OSIRIS	Bogumil	4 %	Pos
SAGE III	Bogumil	max 1% (mesosph.) 1% (stratosphere)	Pos
SAGE II	Shettle and Anderson	-1 %	Neg



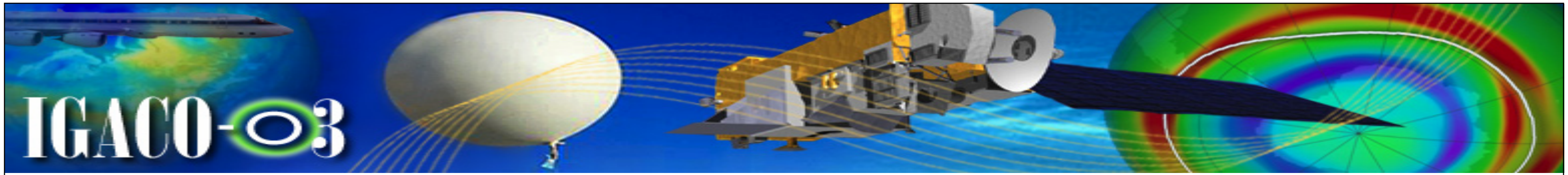
Satellite summary

- BDM more accurate than BP (good wavelength calibration, temperature dependence better)
- Residuals and effective temperature typically slightly better when using BDM
- Total ozone and low resolution ozone profile groups generally in favour of changing to BDM (with the exception of Bremen group favouring instrument FM cross sections).
- For high resolution ozone profile instruements the BDM set is not fully suitable: need for consistent cross sections with wide wavelength coverage from UV to NIR and good temperature coverage 190-300K



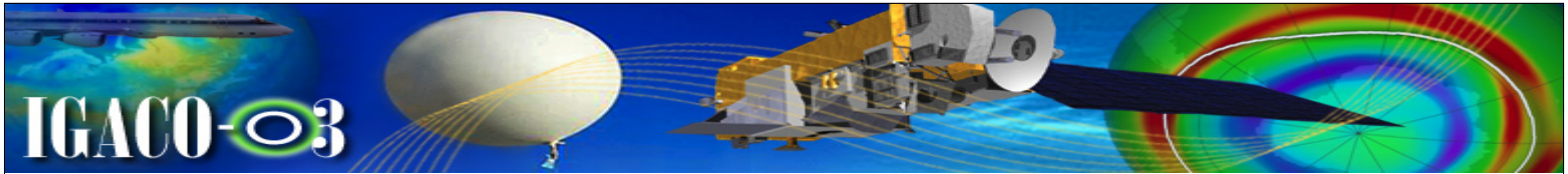
Satellite summary (cont.)

- Differences expected when changing from to BDM
  - Typically 1-3 % difference in total ozone
  - Larger differences (tens of %) with low resolution ozone profiles from nadir instruments.
  - Typically 1-2 % difference at individual layers in ozone profiles in occultation instruments and up to 4% in limb scatter instrument.
  - The agreement btw TOMS and SBUV will increase.



ACSO web-pages:
http://igaco-o3.fmi.fi/ACSO

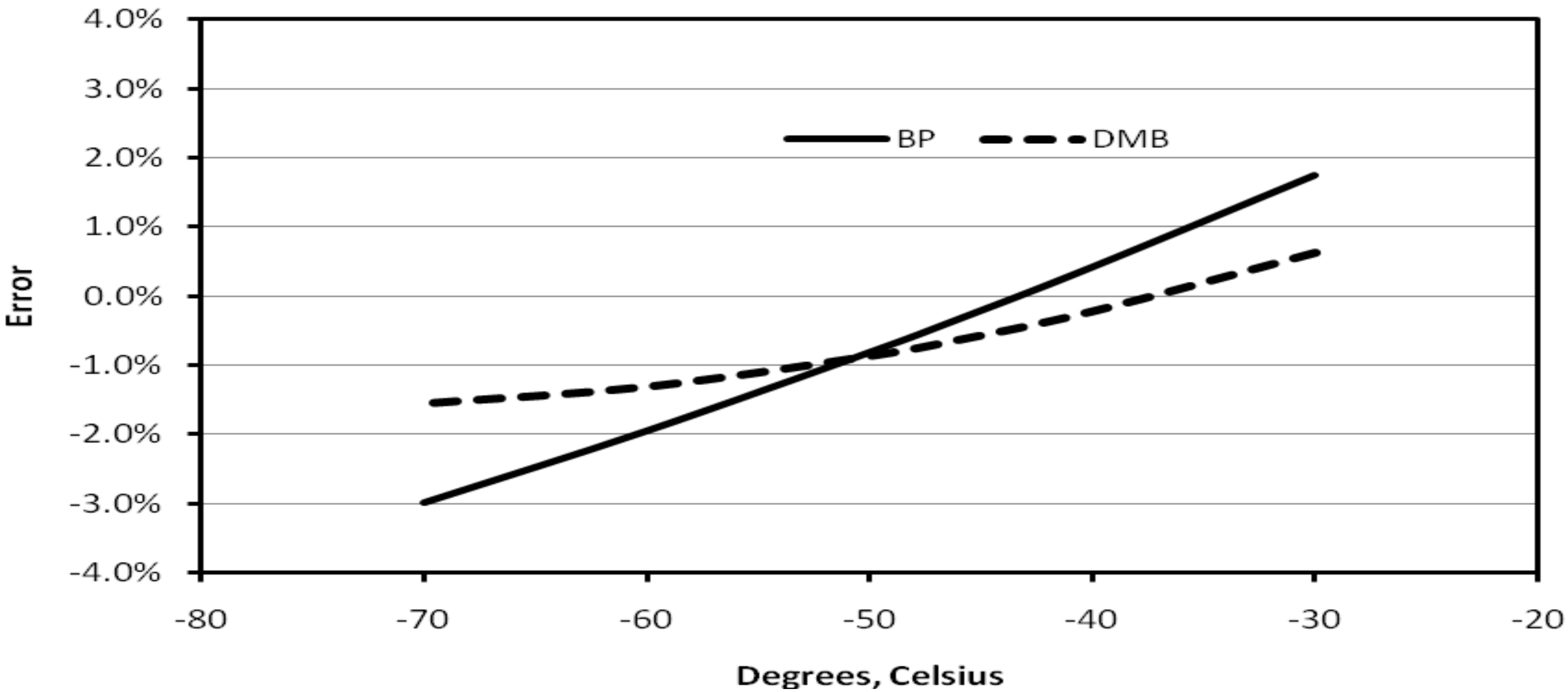
- Ozone cross sections:
  - **BP - Bass and Paur**
  - **BDM – Brion, Daumont and Malicet**
  - **Bogumil et al (SCIAMACHY FM)**
  - **Burrows et al (GOME FM)**
  - **Planned: Shettle and Andersson compilation, GOME-2 FM**
- References
- Presentations at Ozone Theme Meetings 2009, 2010

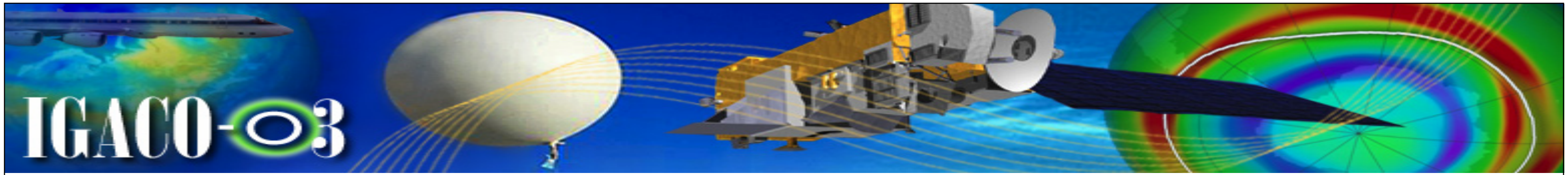


Dobson Total Ozone (R. Evans et al)

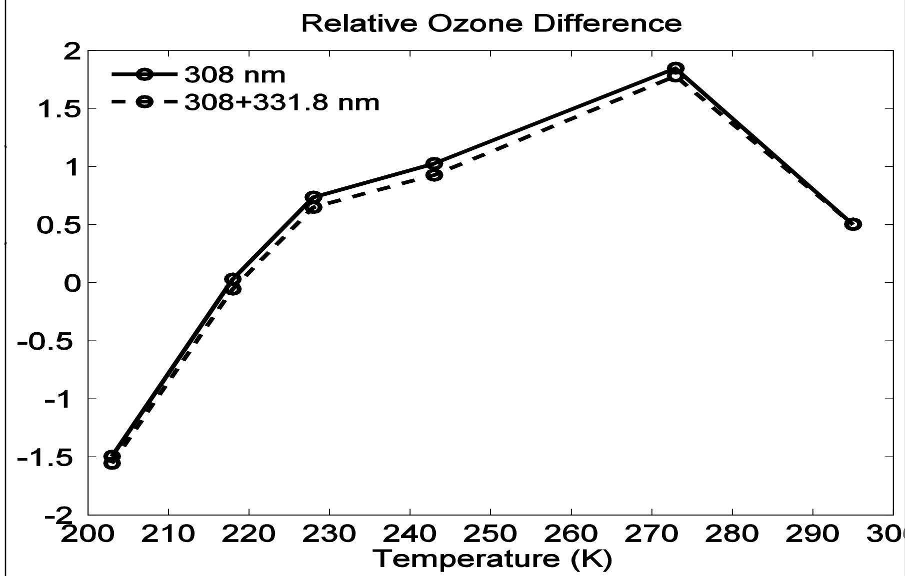
Effect of a Proposed Change of Ozone Cross-sections on the Historical Record of Stratospheric Ozone from Stations using Dobson Ozone Spectrophotometers in the US Network

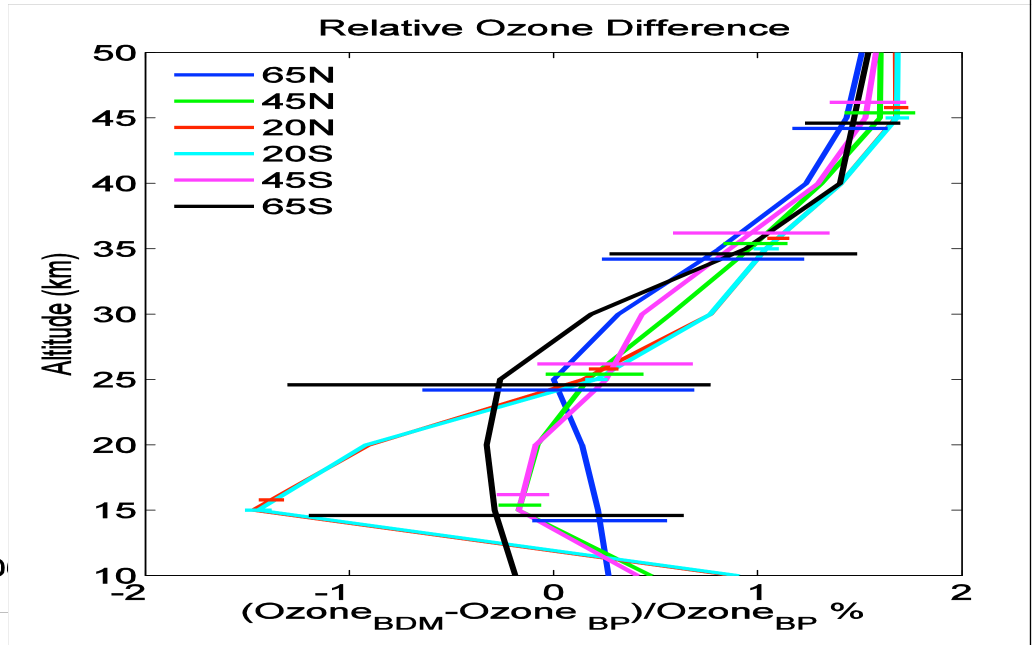
AD total ozone measurements as function of temperature:





DIAL-lidars (Godin-Beekman and Nair)





Relative difference of DIAL ozone retrieved with BDM and BP as function of temperature - for Rayleigh (based on 308 nm) and Raman (based on combination of 308 and 331.8 nm) DIAL retrievals

Annual average difference between ozone vertical distributions retrieved with BDM and BP ozone cross-sections for various latitude bands (from CIRA 86 atmospheric model).