The diurnal cycle of stratospheric ozone in MACC, ERA-I, WACCM and NORS observations

Ansgar Schanz et al.

Institute of Applied Physics and
Oeschger Centre for Climate Change Research
University of Bern

NORS Workshop, Brussels, 6 Nov. 2014

Collaboration

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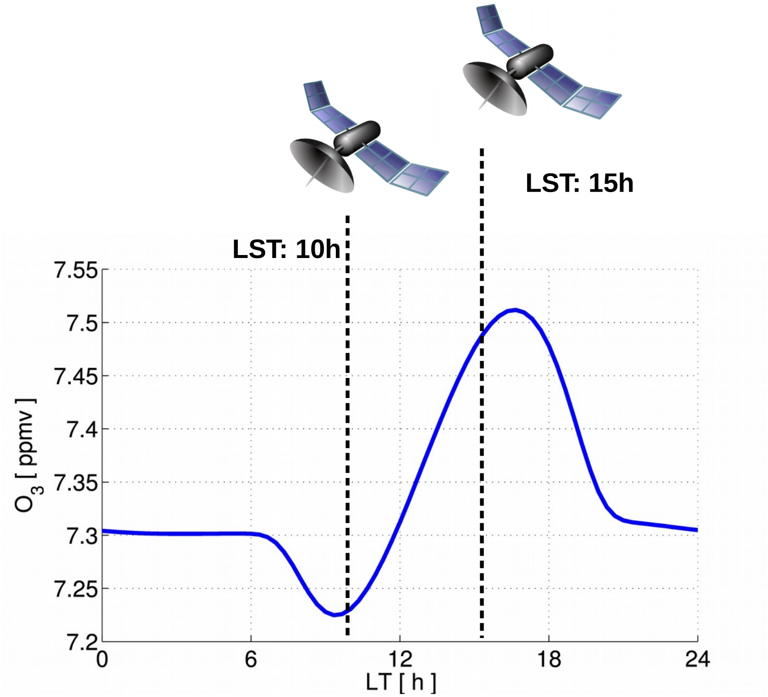
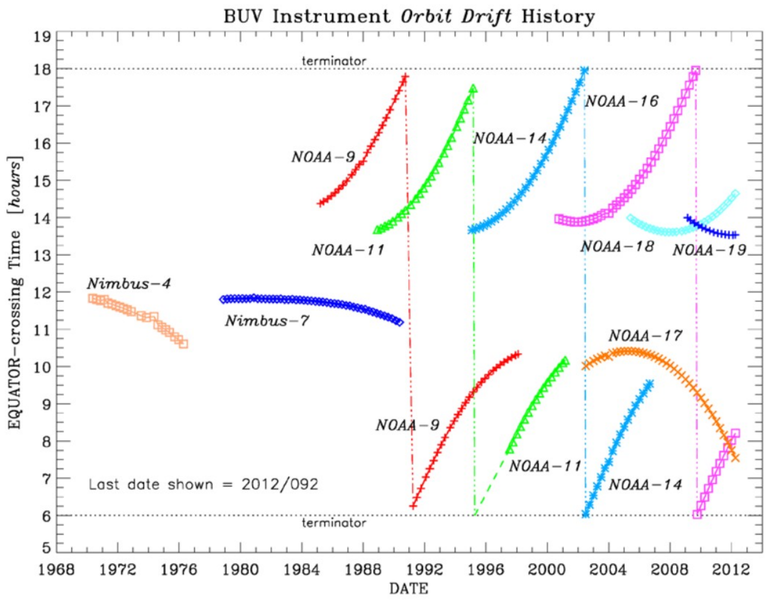
Schanz, A., Hocke, K., Kämpfer, N.	Institute of Applied Physics, *Bern, CH*
Chabrillat, S.	Belgium Institute of Space Aeronomy, *Brussels, Belgium*
Inness, A.	ECMWF, *Reading, UK*
Palm, M., Notholt, J.	Institute of Environmental Physics, *University of Bremen, Bremen, Germany*
Boyd, I., Parrish, A.	Department of Astronomy, University of Massachusetts, *Amherst, MA, USA*
Kasai, Y.	Department of Environmental Chemistry and Engineering, Tokyo Institute of Technology, *Tokyo, Japan*

Diurnal sampling effects in O_3 trends



SBUV orbit drift



[DeLand et. al., *AMT,* 2012; Bhartia et al., *AMT*, 2013]

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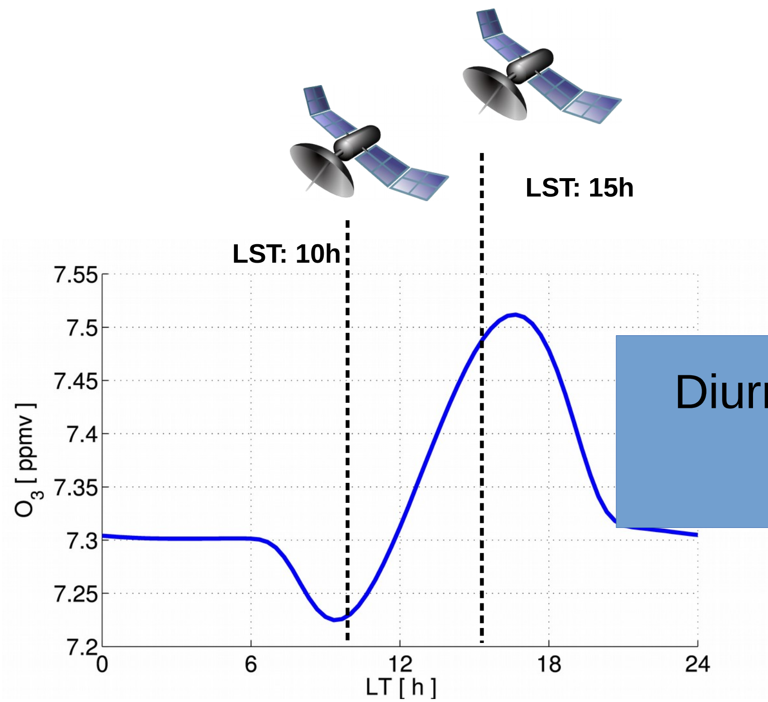
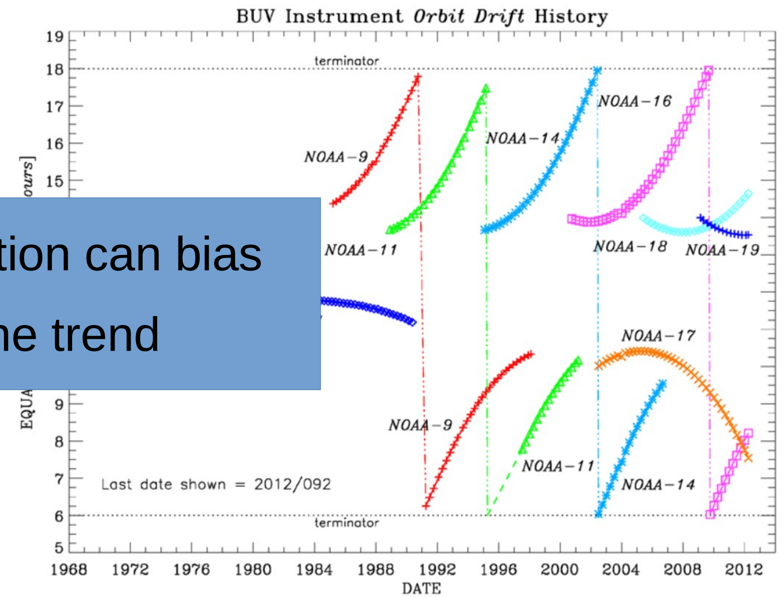


Diurnal variation can bias the ozone trend

SBUV orbit drift



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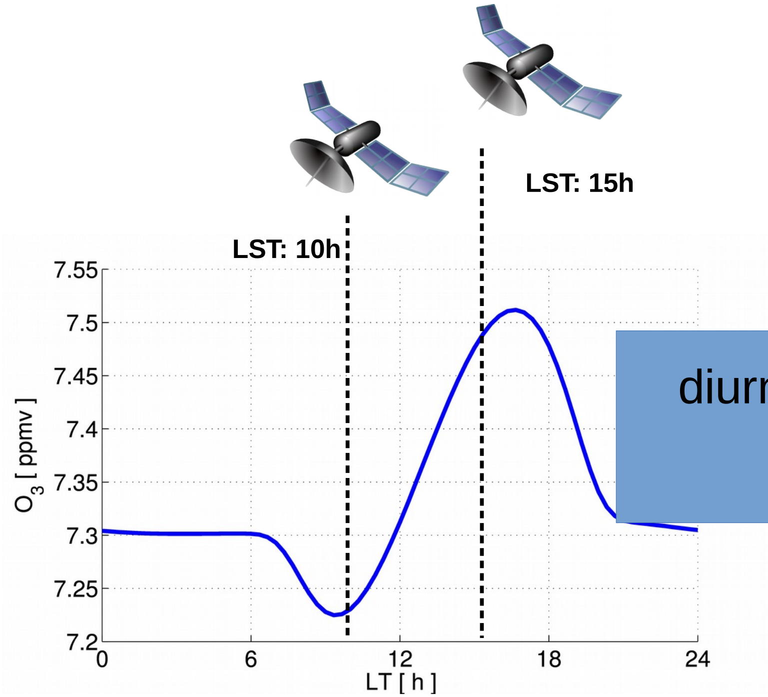

diurnal variation can bias the ozone trend

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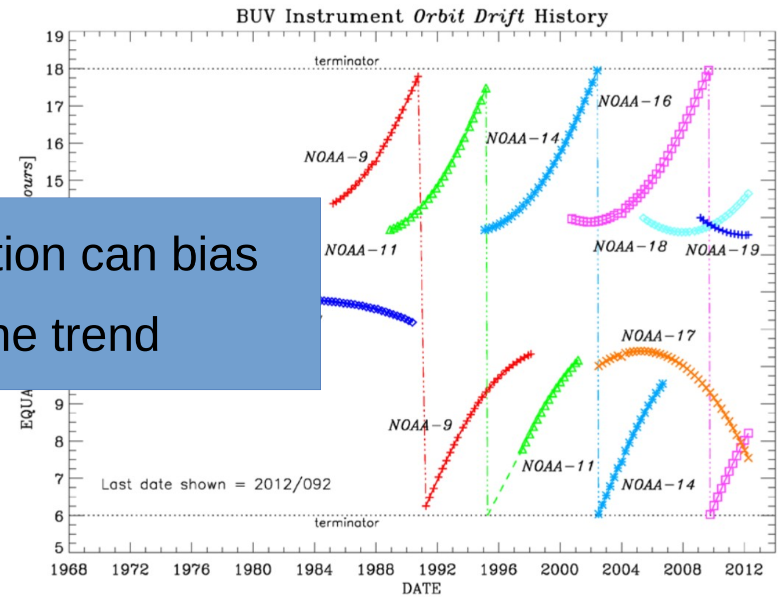

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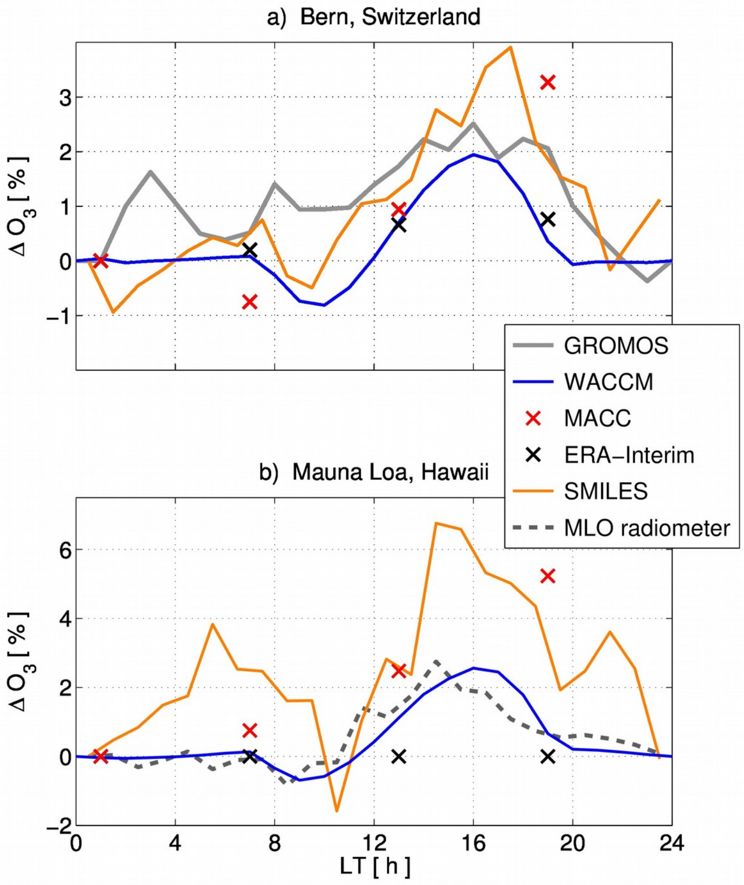
Can we correct for the diurnal sampling effects?

The daily ozone cycle

p = 5 hPa



SMILES: Submillimeter-Wave Limb-Emission Sounder

Characteristics of the diurnal ozone variation at tropics and midlatitudes:

- Morning minimum
- Afternoon maximum
- Variations are within a few percent

Photochemistry during day time:

- Fast O_3 depletion by NO_x after sunrise
- Slow accumulation of O_3 during the day (Chapman cycle)

Model systems

	WACCM	MACC reanalysis	ERA-I reanalysis
Type	Global circulation-chemistry model	Chemical weather forecast system	Weather forecast system
Coupling	online chem ↔ dyn	60 min chem ↔ dyn	60 min ozone ← dyn
Chemistry	3D MOZART (stratosphere)	3D MOZART (tropo- and stratosphere)	Linearized 2D (lat,alt) photochemical model
Data assimilation	-	4D-VAR (gases, aerosols)	4D-VAR (O3, humidity)
Temporal res.	15min / 1h output	15min / 6h output	6h output
Range	0 - 140 km	0 - 65 km	0 - 65 km
Horizontal res.	1.9° lat x 2.5° lon	1.125° x 1.125°	0.7° x 0.7°

WACCM: Whole Atmosphere Community Climate Model

Intercomparison

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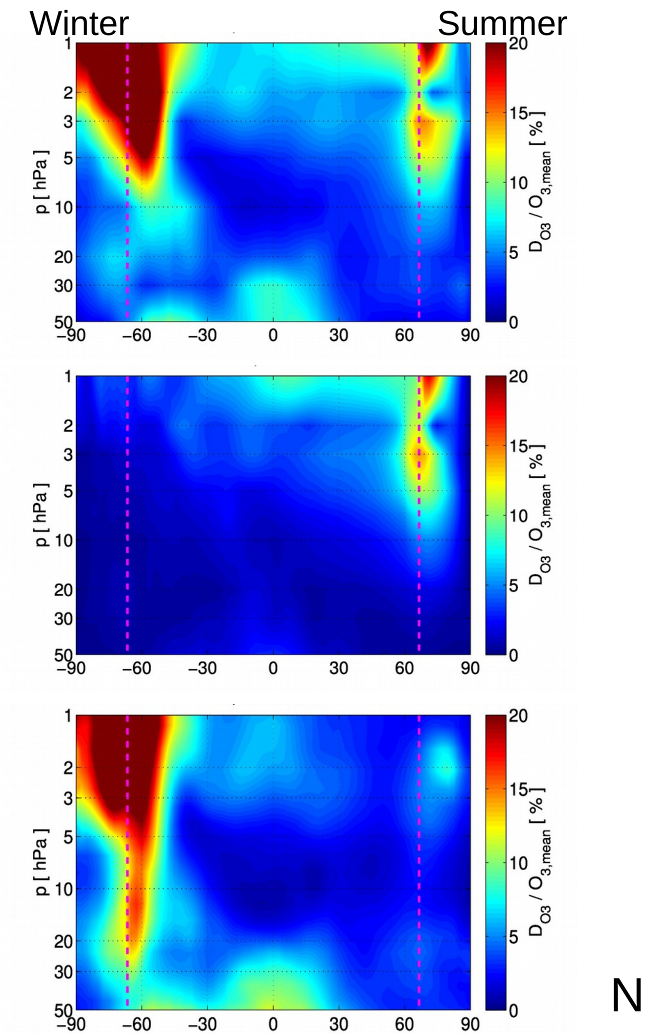
macc Monitoring atmospheric composition & climate

WACCM

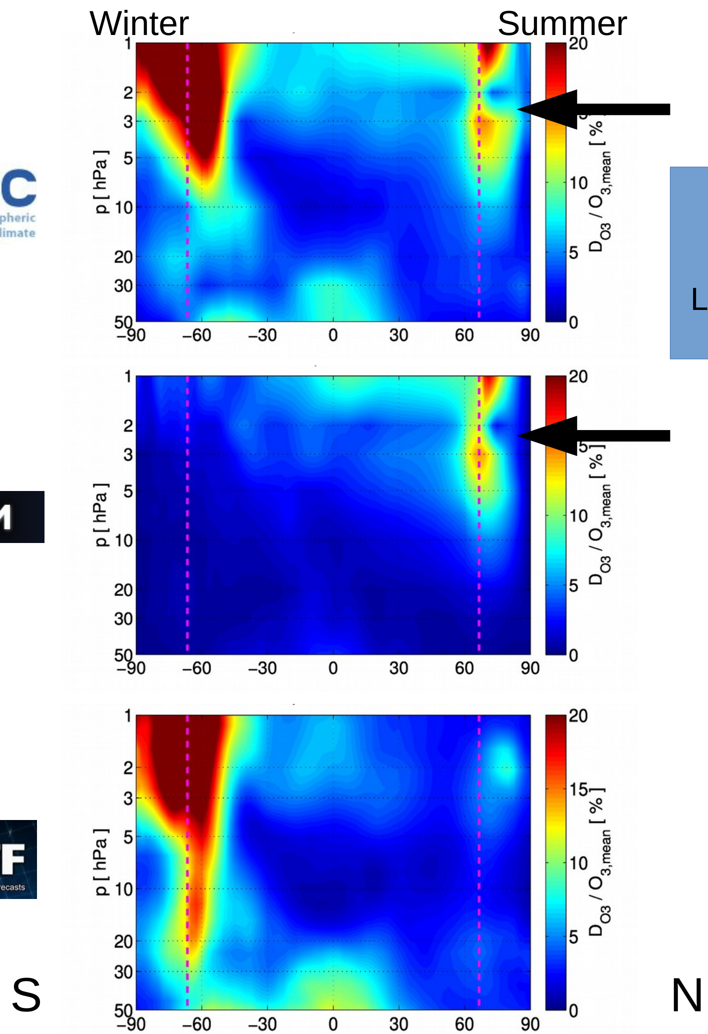
ECMWF European Centre for Medium-Range Weather Forecasts



Mean total difference in O_3 VMR during a day in June 2012:

$$D_{O_3} = \frac{O_3(max) - O_3(min)}{O_3(mean)}$$

Intercomparison



Photochemical effects: 15 %

Long sunshine duration → strong accumulation of ozone

up to 15 %

Intercomparison

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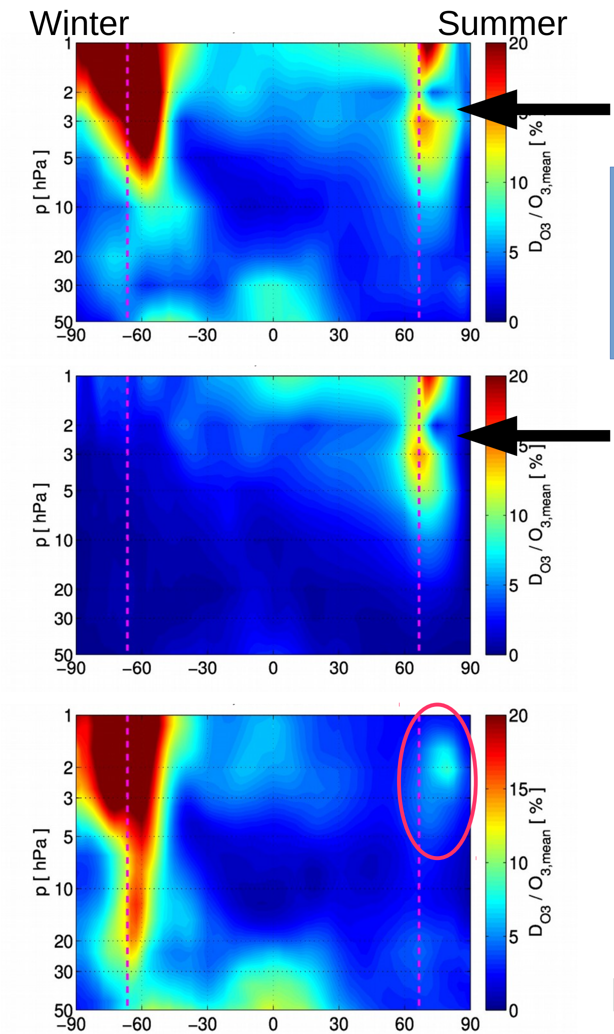

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WACCM

ECMWF – European Centre for Medium-Range Weather Forecasts

S

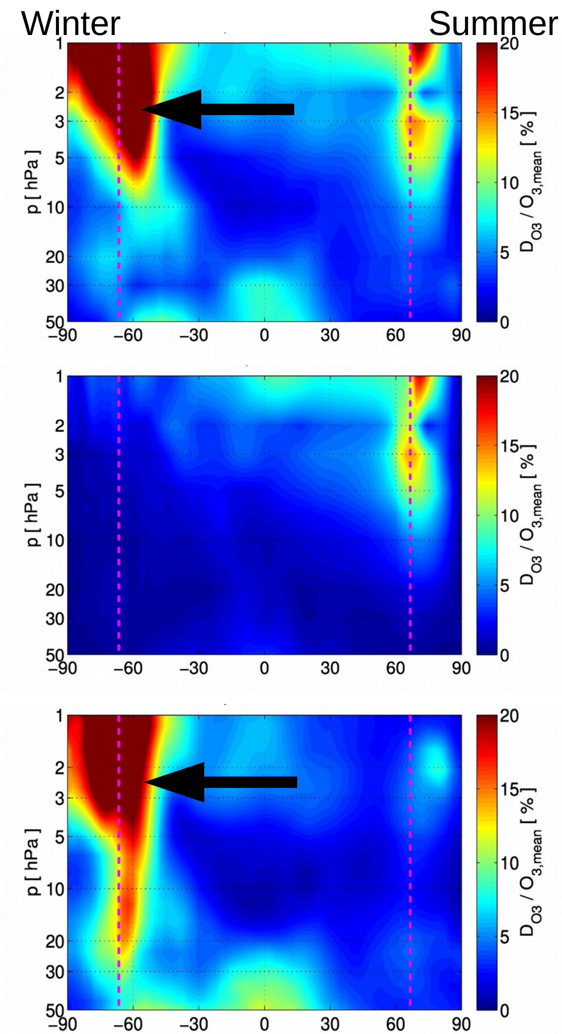
N

Photochemical effects: 15 %

Long sunshine duration → strong accumulation of ozone

→ weak photochemical signal in ERA-I

Intercomparison



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Advection effects: 45 %

Diurnal and subdiurnal transport of ozone

Intercomparison

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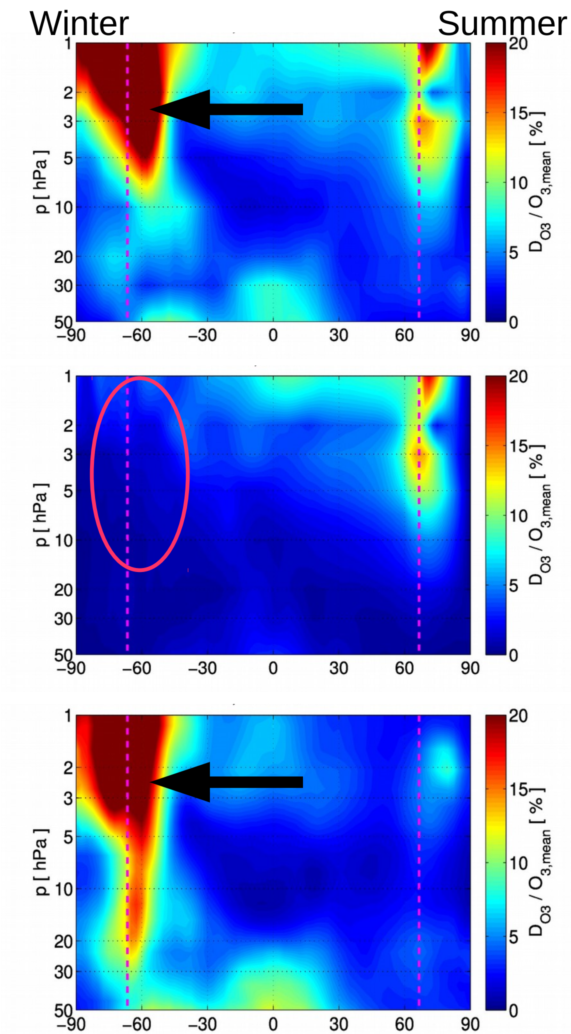

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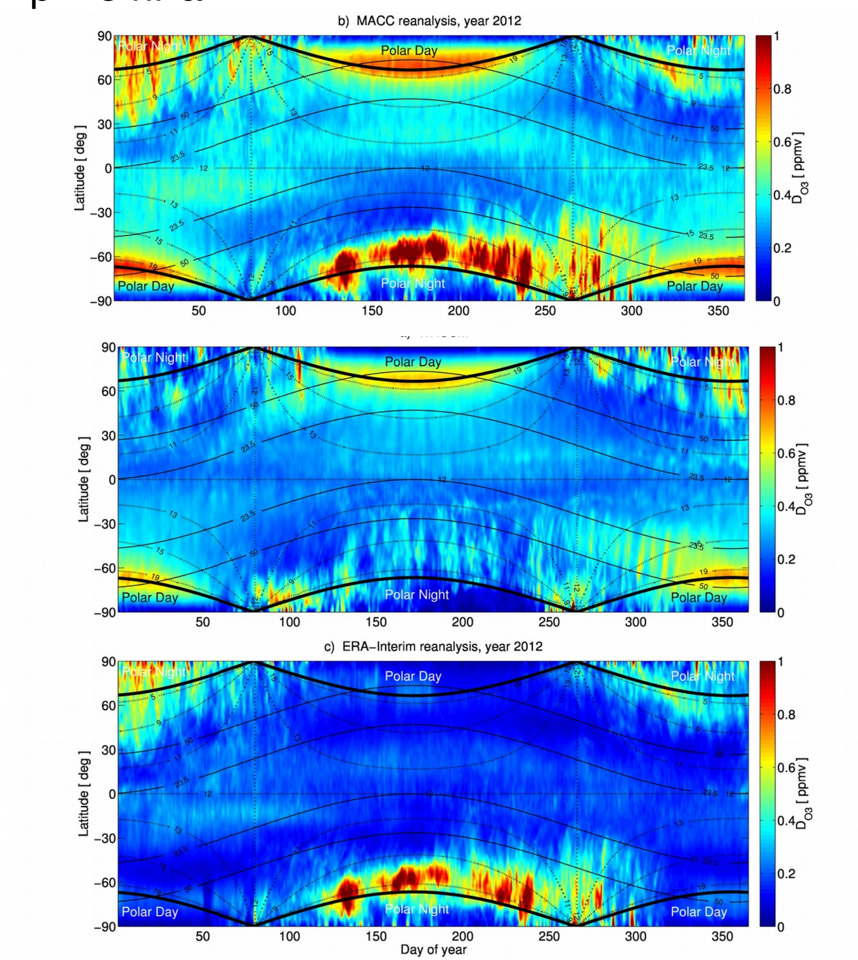
Advection effects: 45 %

Diurnal and subdiurnal transport of ozone

→ weak advection effects in WACCM

Intercomparison

p = 5 hPa



Polar winter: > 1 ppmv

Polar summer: 0.8 ppmv

Intercomparison

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p = 5 hPa

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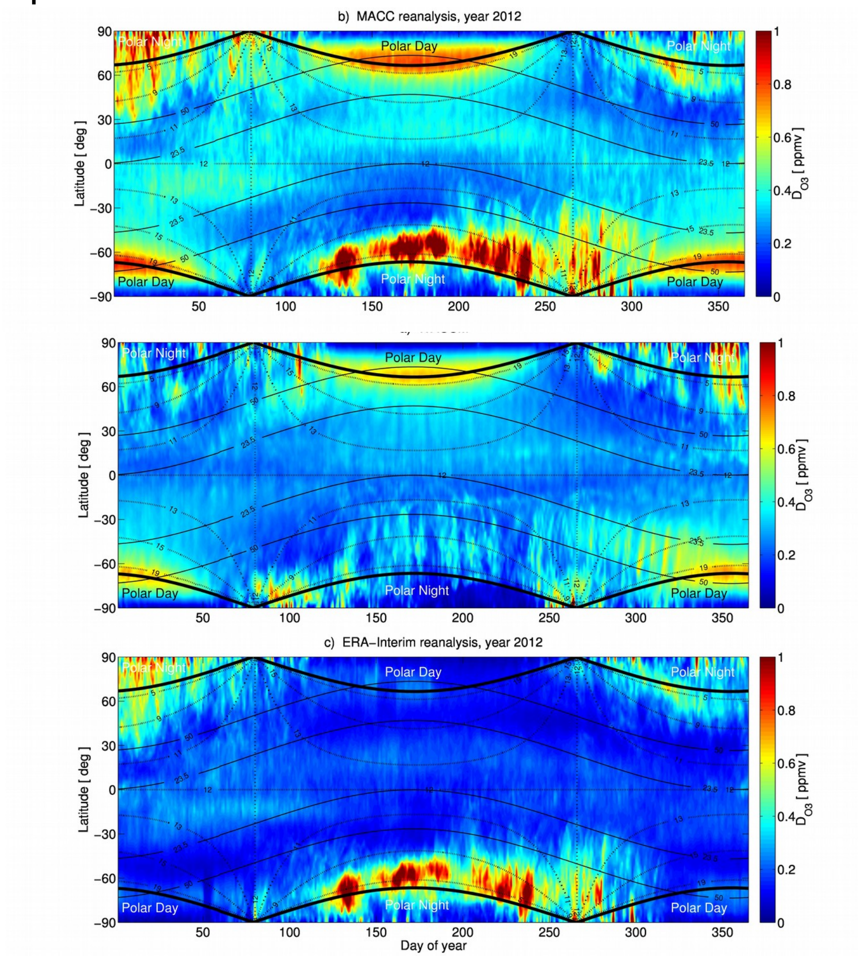

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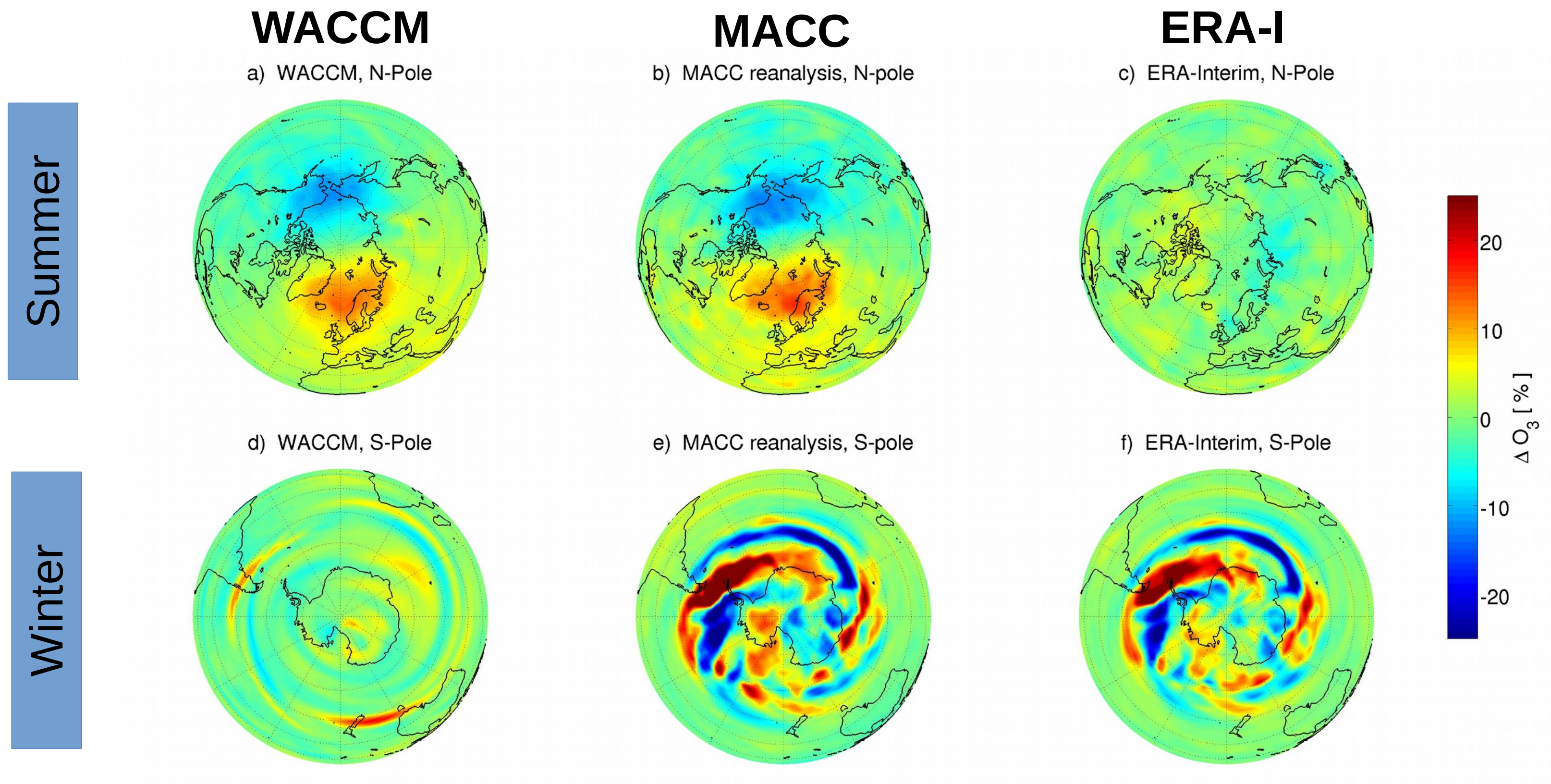
Polar summer: 0.8 ppmv

The Polar regions are most interesting!

Intercomparison



$$D_{O_3} = \frac{O_3(18\text{UT}) - O_3(6\text{UT})}{O_3(6\text{UT})}$$

21 June 2012

NORS remote sensing at Ny-Alesund

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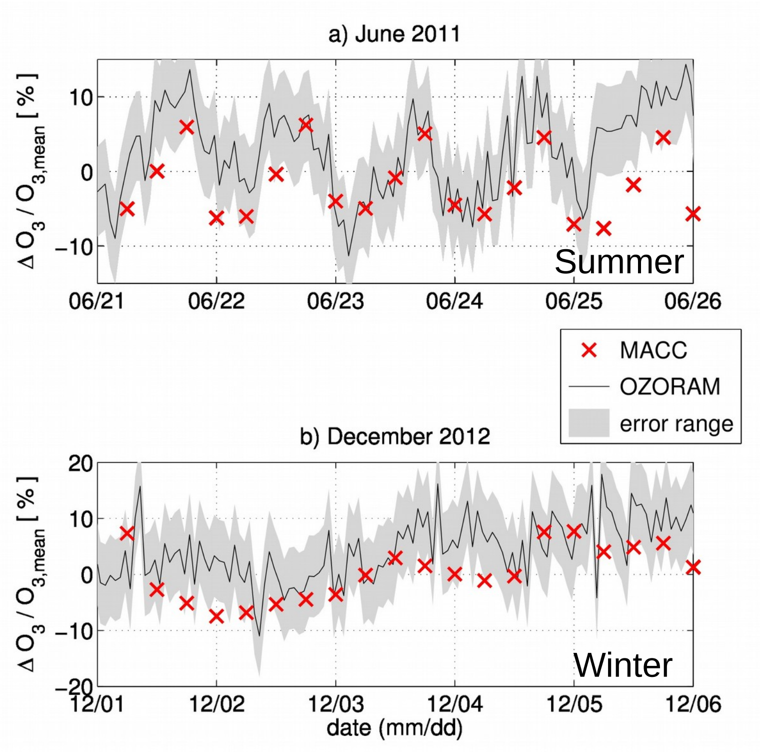

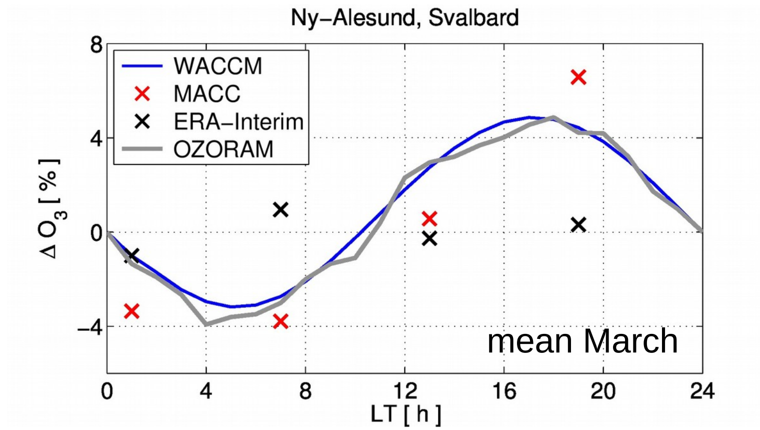

- OZORAM microwave radiometer located at 78.9° N
- OZORAM confirms the strong daily cycle in polar ozone

OZORAM: Ozone Radiometer for Atmospheric Measurements, operated by **Mathias Palm, IUP, Bremen**

Conclusions

- Diurnal ozone variation is strong in the polar region in summer (15 %) and winter (45%) due to photochemistry and advection.
- Correction of diurnal sampling effects could be feasible with models
- Daily ozone cycle in MACC is most realistic (photochemistry & dynamics)

Conclusions

- Diurnal ozone variation is strong in the polar region in summer (15 %) and winter (45%) due to photochemistry and advection.
- Correction of diurnal sampling effects could be feasible
- Daily ozone cycle in MACC is most realistic (photochemistry & dynamics)

Thank you for your attention!

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Acknowledgements

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SEVENTH FRAMEWORK PROGRAMME

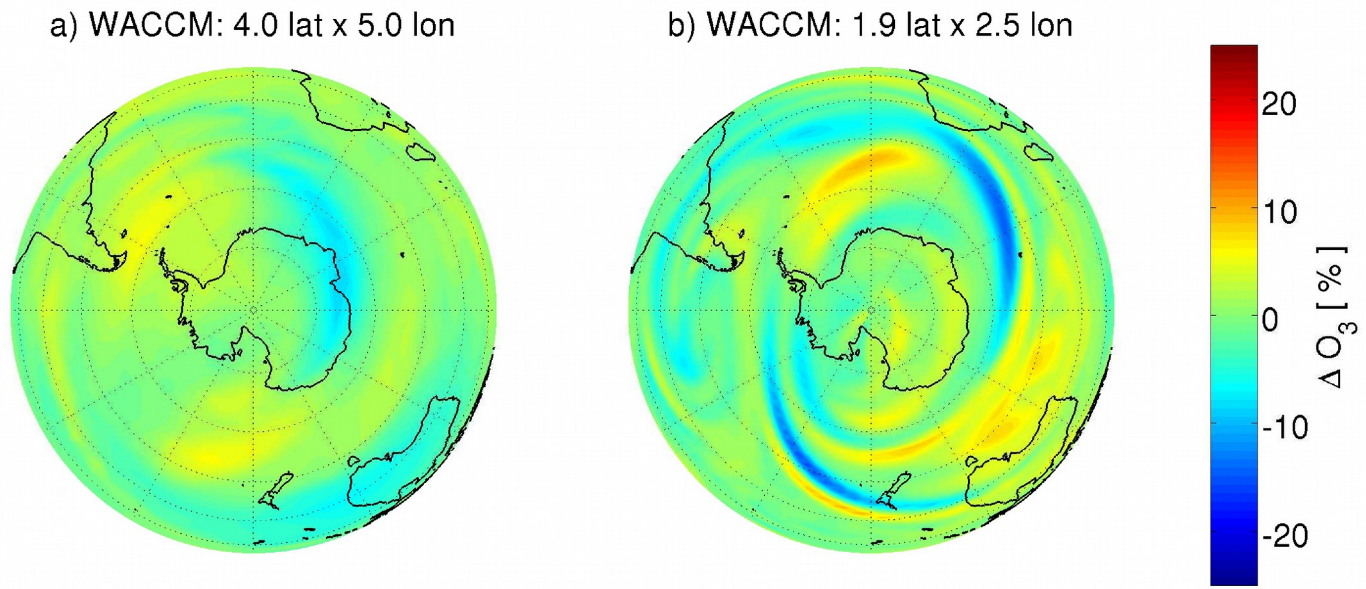
References

Schanz, A., Hocke, K., and Kämpfer, N.: Daily ozone cycle in the stratosphere: global, regional and seasonal behaviour modelled with the Whole Atmosphere Community Climate Model, *Atmos. Chem. Phys.*, 14, 7645-7663, doi:10.5194/acp-14-7645-2014, 2014.

Schanz, A., Hocke, K., Kämpfer, N., Chabrillat, S., Inness, A., Palm, M., Notholt, J., Boyd, I., Parrish, A., and Kasai, Y.: The diurnal variation in stratospheric ozone from the MACC reanalysis, the ERA-Interim reanalysis, WACCM and Earth observation data: characteristics and intercomparison, submitted: *Atmos. Chem. Phys. Discuss.*.

Horizontal resolution

$$D_{O_3} = \frac{O_3(18\mathrm{UT}) - O_3(6\mathrm{UT})}{O_3(6\mathrm{UT})}$$



- Stratospheric variability at short time scales depends on resolution
- Gravity wave parametrization, 2-day wave, extreme events as SSW

Exemplary day