ESA Climate Change Initiative (ESA CCI) – Provision of long-term data sets for climate research

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ESA Climate Change Initiative (ESA CCI)

- The aim is to realise the full potential of the **long-term global Earth Observation archives** that ESA, together with its member states, has established over the last thirty years, as a significant and timely **contribution to the Essential Climate Variable (ECV) databases** required by United Nations Framework Convention on Climate Change (UNFCCC).
- The goal is to **provide stable, long-term, satellite-based ECV data products** for climate modellers and researchers. The ECVs will be derived from multiple satellite data sets (not just ESA but all sources via international collaboration) and include specific information on the errors and uncertainties of the data set.

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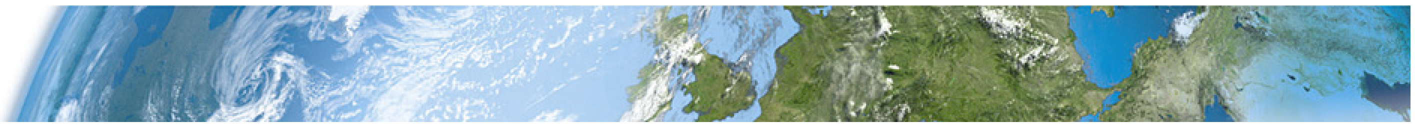

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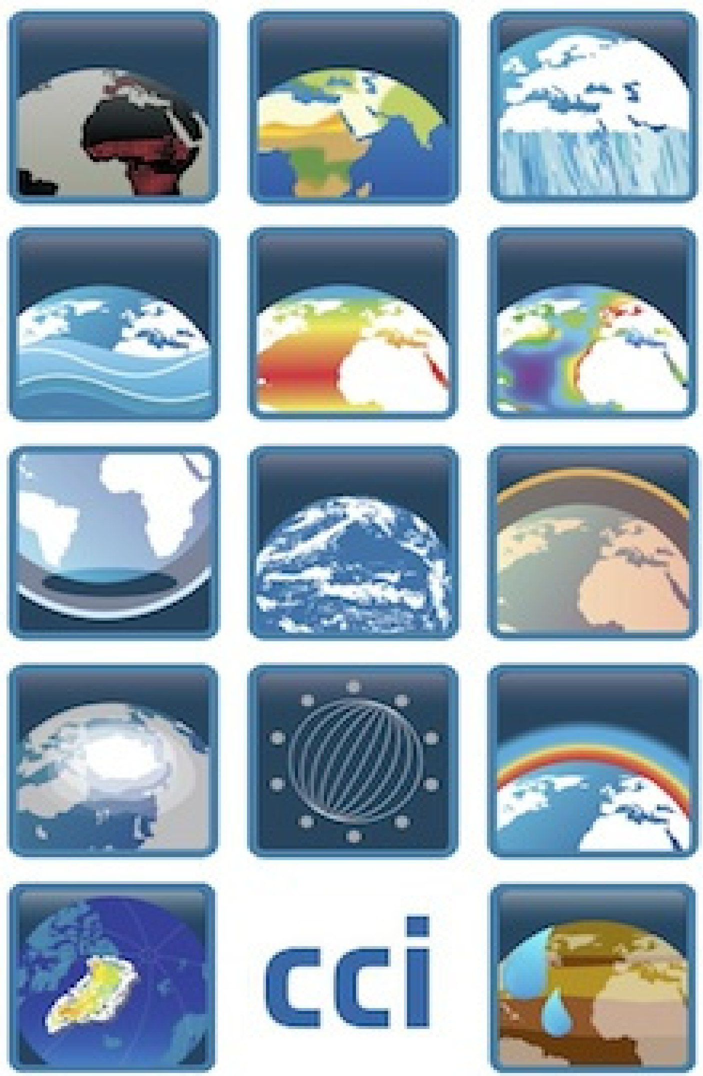
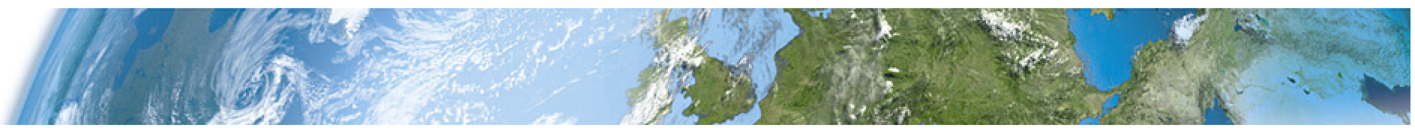


- Aerosol
- Cloud
- Fire
- Greenhouse Gas
- Glacier
- Ice Sheet
- Land Cover
- Ocean Colour
- **Ozone**
- Sea Ice
- Sea Level
- Sea Surface Temperature
- Soil Moisture

➢ Climate Modelling User Group



The ESA Ozone_cci project

- Ozone_cci aims at generating new high-quality satellite data sets that are essential to assess the fate of atmospheric ozone and better understand its link with anthropogenic activities.

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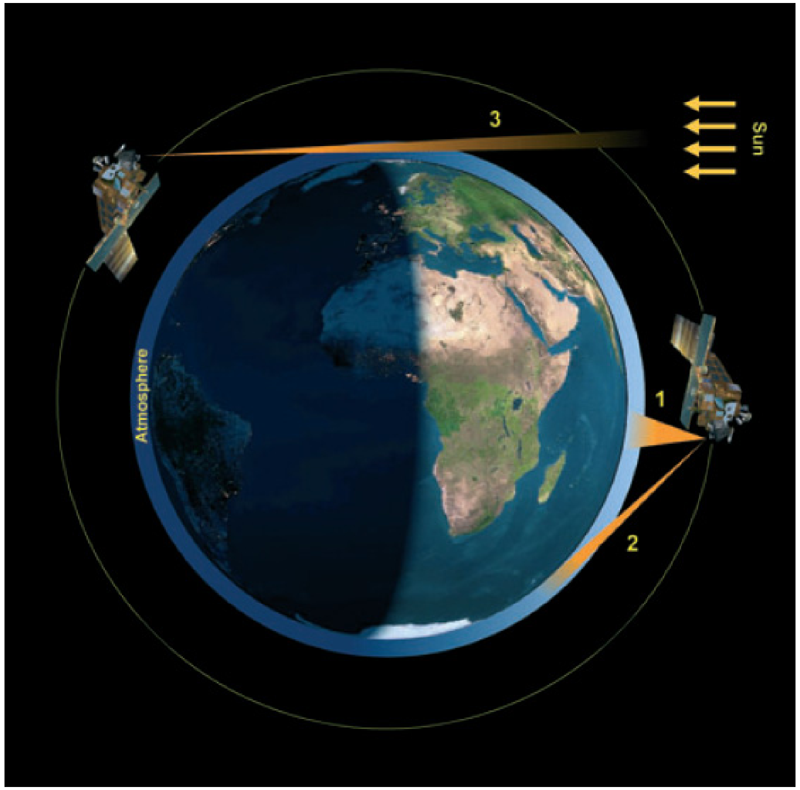
Ozone Data Products

- Ozone total columns and profiles from nadir sensors in 0-50 km altitude range.
- Ozone profiles from limb/occultation sensors in 10-100 km altitude range (UTLS, stratosphere and mesosphere).
- Tropospheric ozone products using a range of different retrieval approaches.



1. Nadir, 2. Limb, 3. Occultation

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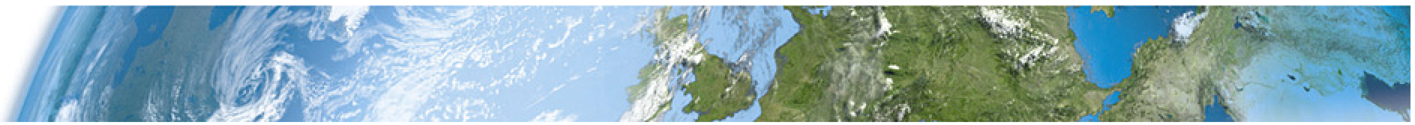
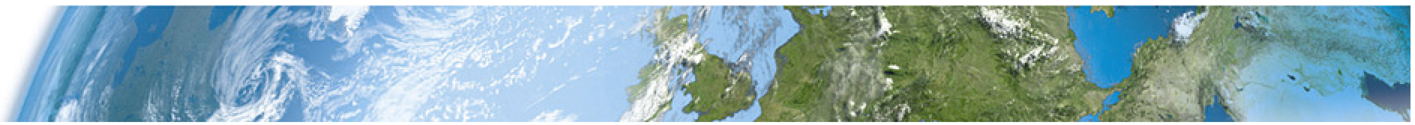
Sensors and platforms

Agency	Satellite platform	Sensors
ESA	ERS-2	GOME
ESA	ENVISAT	SCIAMACHY, GOMOS, MIPAS
EUMETSAT	METOP-A	GOME-2, IASI
	METOP-B	GOME-2, IASI
NASA	NPP-Suomi	OMPS
NASA	AURA	OMI, MLS
NASA	UARS	HALOE
NASA	ERBS	SAGE-II
NASA	TIMED	SABER
SNSB CSA	ODIN	OSIRIS, SMR
CSA	SCISAT	ACE

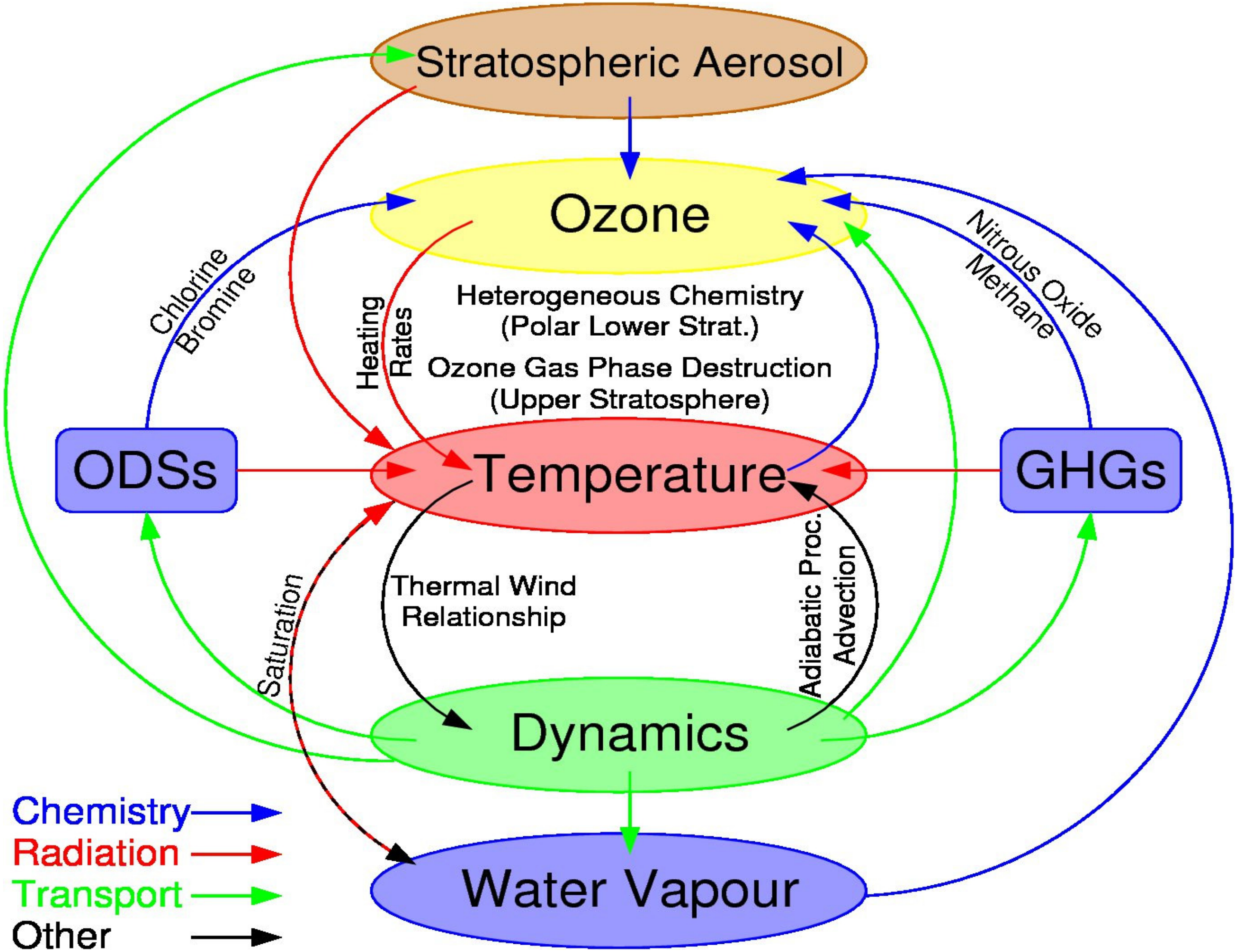


Scientific challenges

- Comparison of Ozone_cci data products with Chemistry-Climate Models (CCMs) and Chemical-Transport Models (CTMs); evaluation of model results.
- Trend estimates and robust prediction of ozone return date to historical levels and further evolution of the ozone layer.
- Improved understanding of dynamical, chemical and radiative processes in an atmosphere with enhanced greenhouse gas concentrations.
- Insight of stratosphere-troposphere coupling in a future climate.

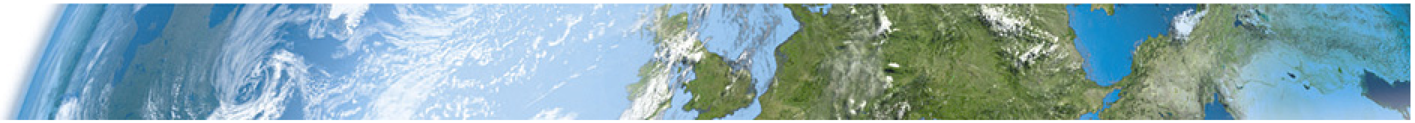


Climate-Ozone connections



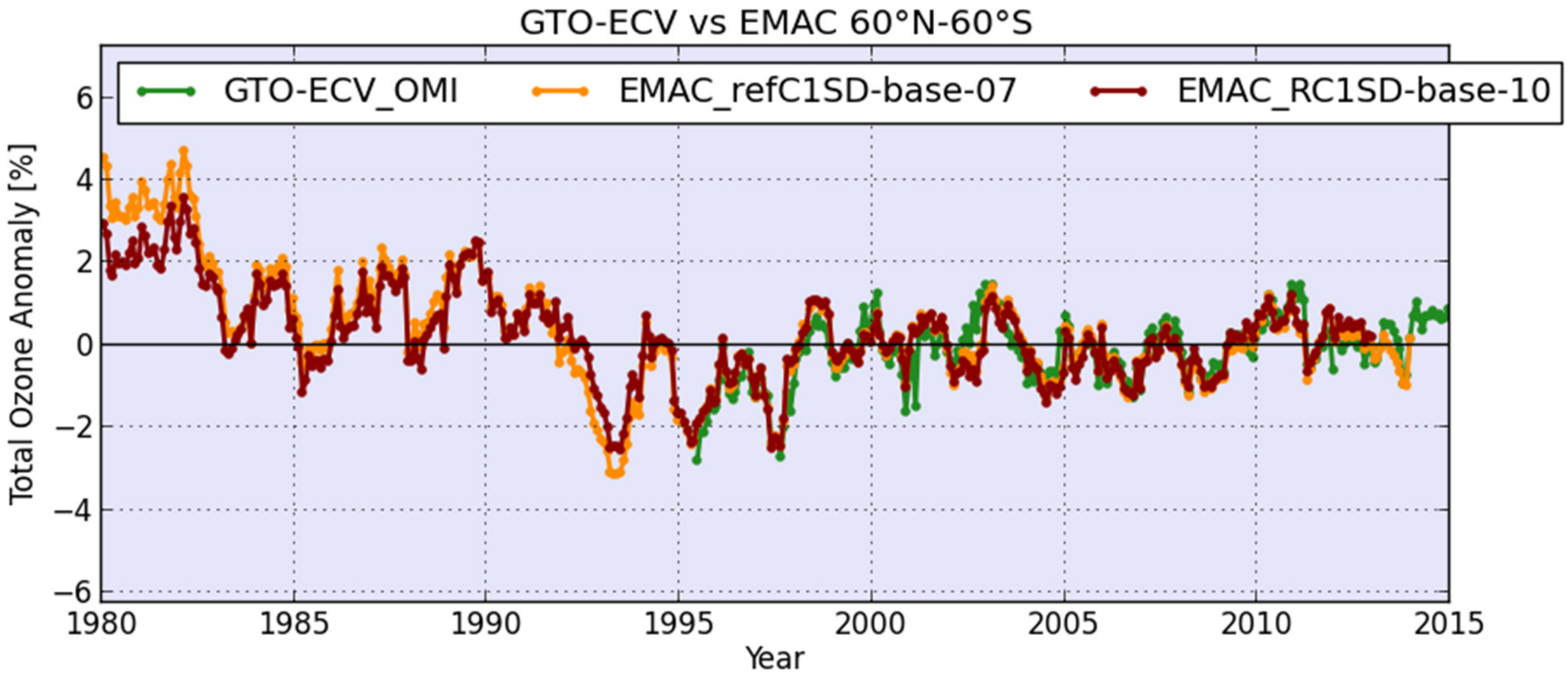
Climate Research Group activities

- Chemistry-Climate Model EMAC (based on ECHAM 5),
- using a full set of stratospheric and tropospheric chemistry;
- the CCM can be 'nudged' with reanalysis data (specified dynamics) in addition to a "free-running" model configuration ('climate mode').
- EMAC nudged set-up:
  - ➢ Resolution: T42/L90 (T42: 2.8°x2.8°, L90: 0-80 km).
  - ➢ Forcing: 6 hourly ERA-Interim with vertically varying relaxation time constants.
  - ➢ Middle and upper stratosphere (>30 km) free running.
  - ➢ Strategy: 1950-1979 free running model (whole atmosphere), 1980-today 'nudged' integration.



Evaluation of CCM EMAC

Global Ozone Monitoring Experiment (GOME)-type total ozone-essential climate variable (GTO-ECV) has been compiled from European satellite sensors GOME, SCIAMACHY, GOME-2, and (new) OMI (total: 1995-2014).



Near global mean (60°N-60°S)

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Evaluation of CCM EMAC

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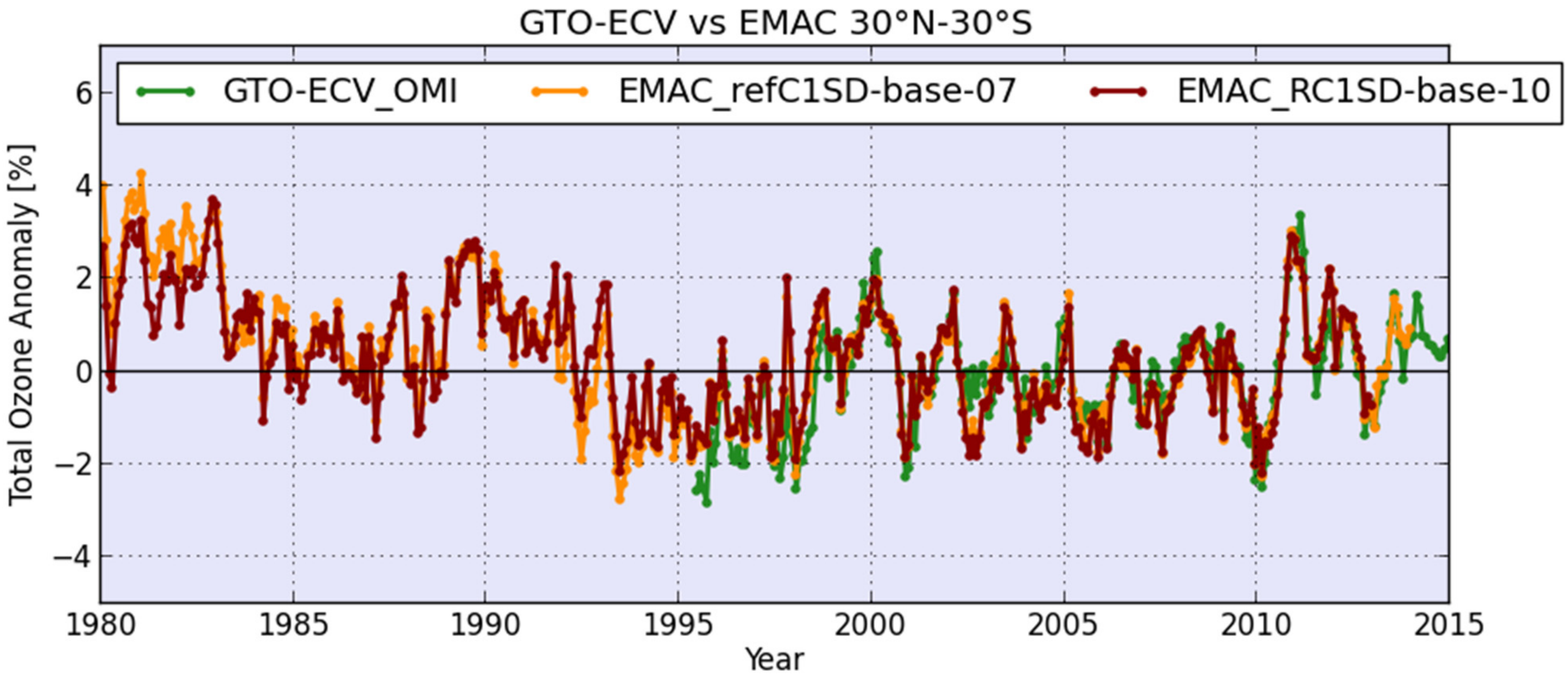

Tropical region (30°N-30°S)

Evaluation of CCM EMAC

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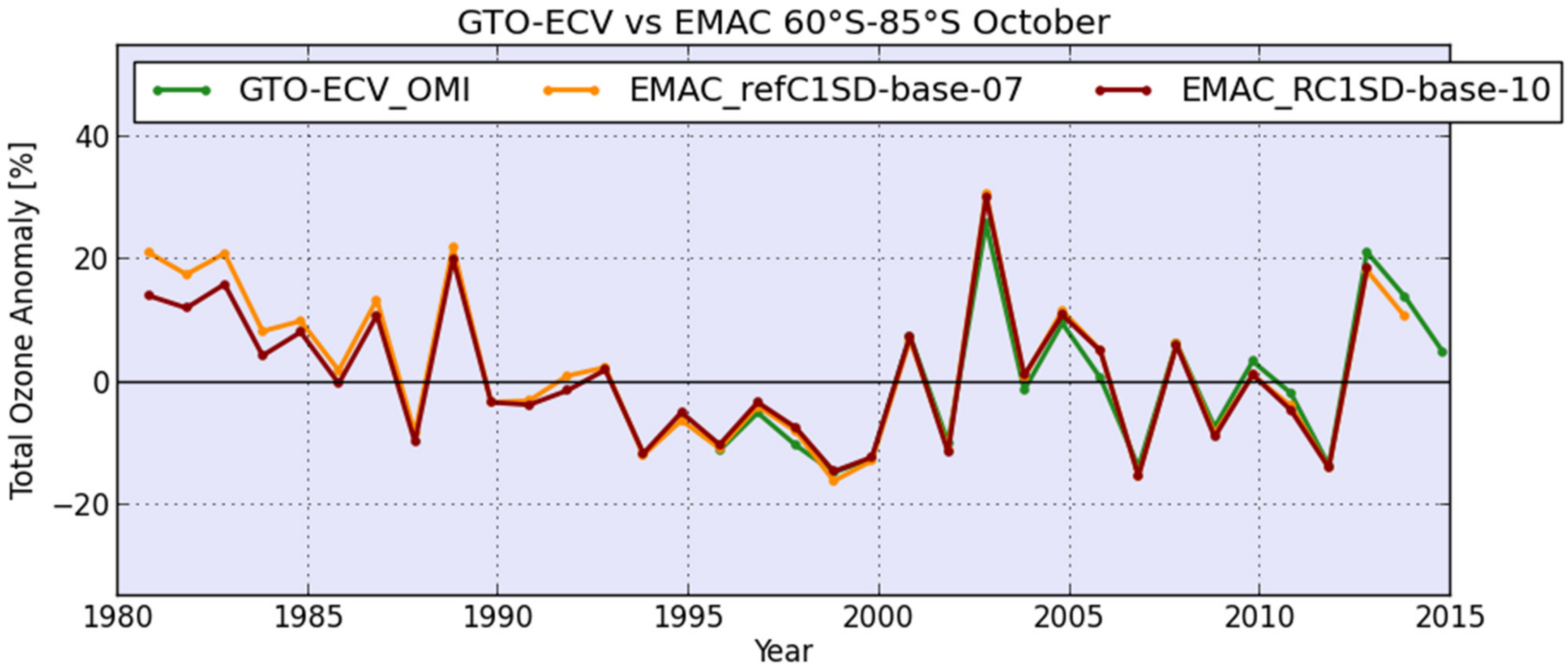
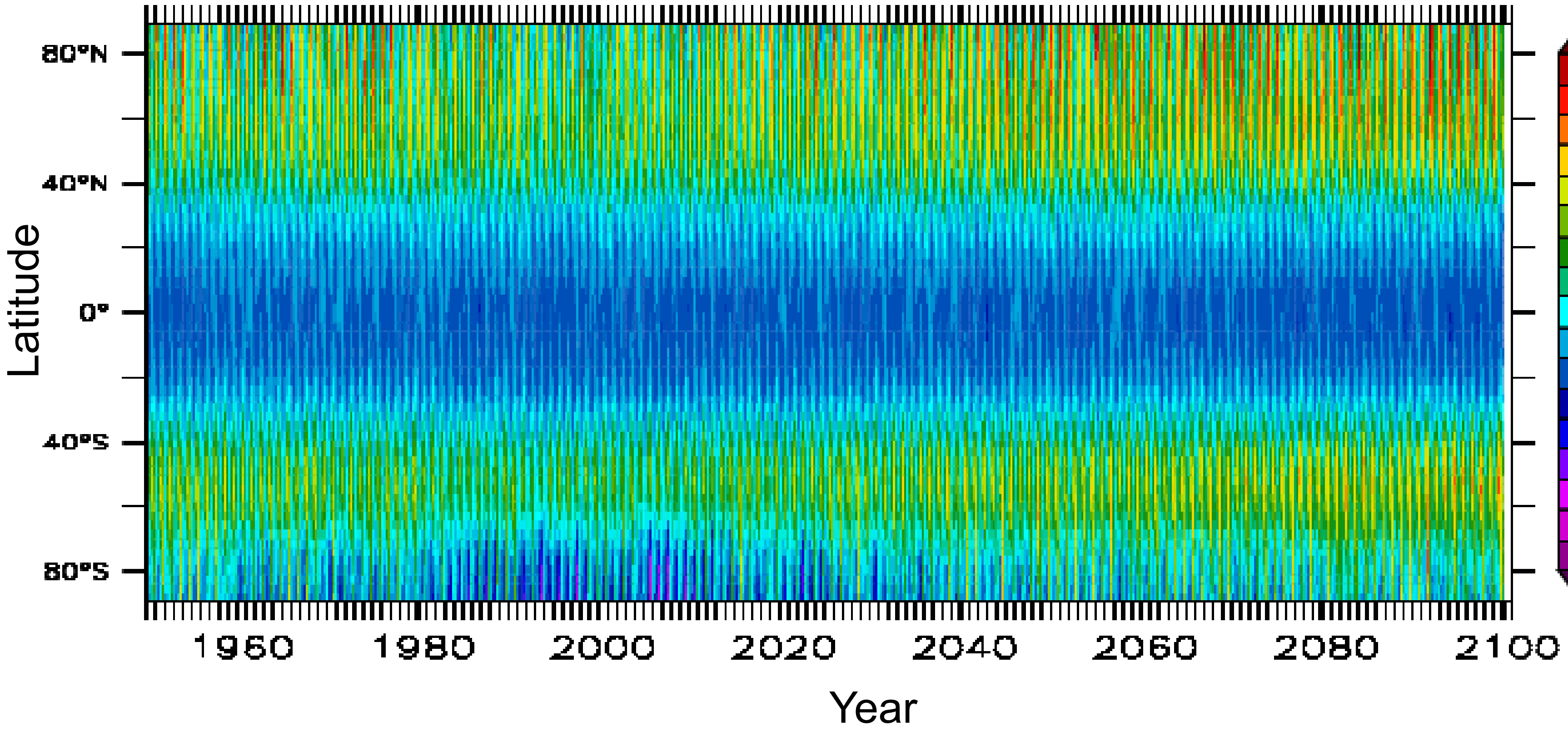


Antarctic (60°S-85°S; October)

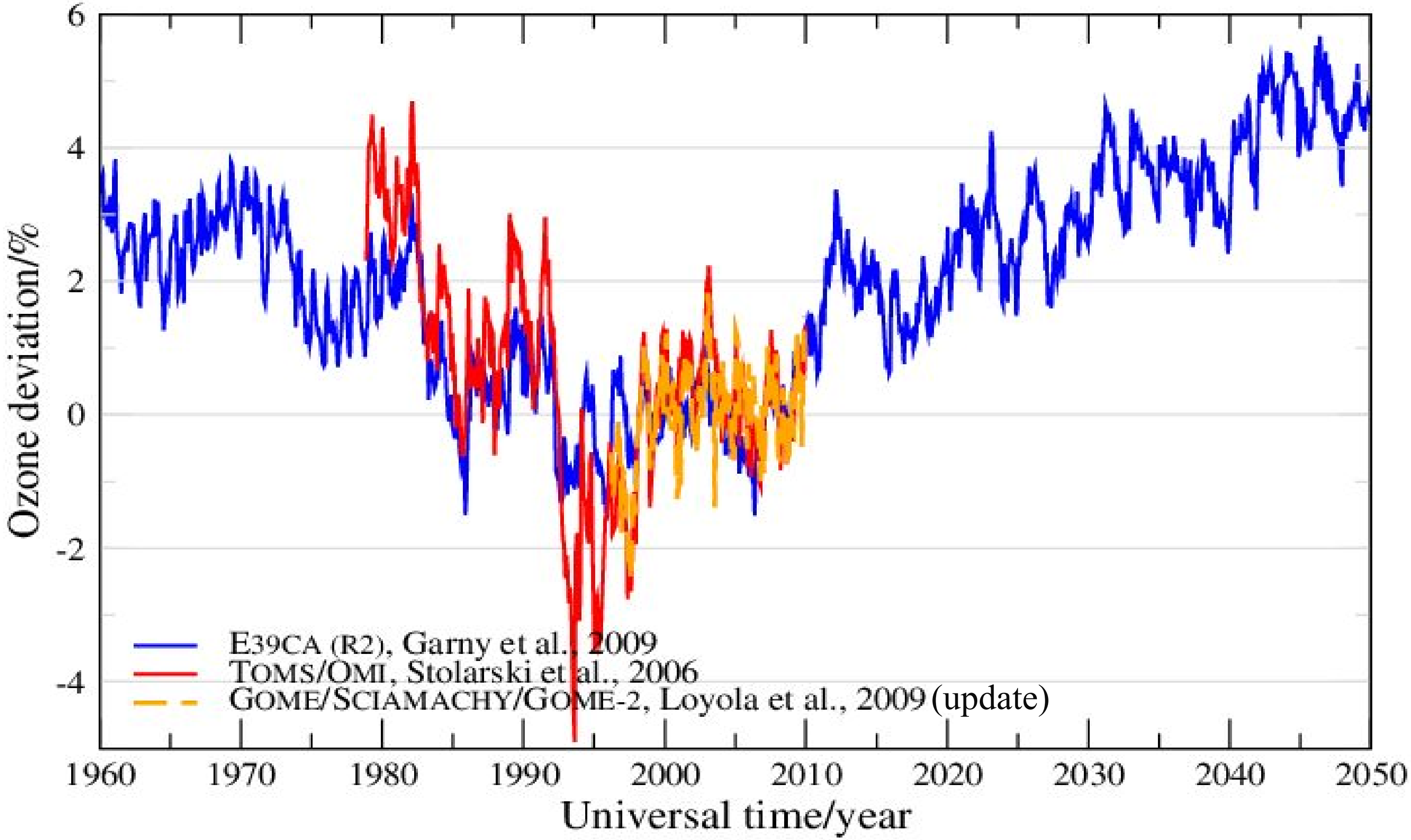
Long-term simulations with CCMs

Zonally averaged ozone column (in Dobson Units)



Evolution of total ozone: 60°S-60°N

Satellite and model data (1960-2050)



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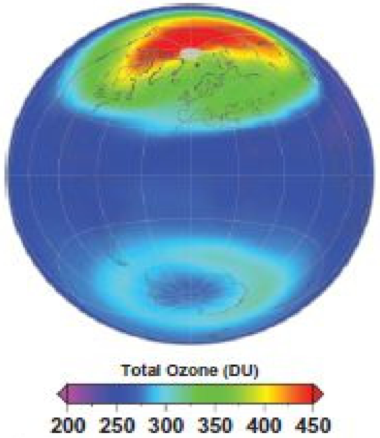
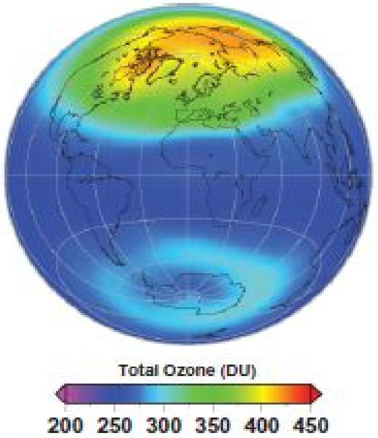
Evaluation: Seasonal mean total ozone

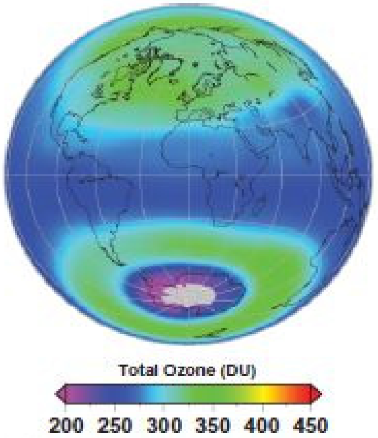
Satellite and model data (1995-2008)



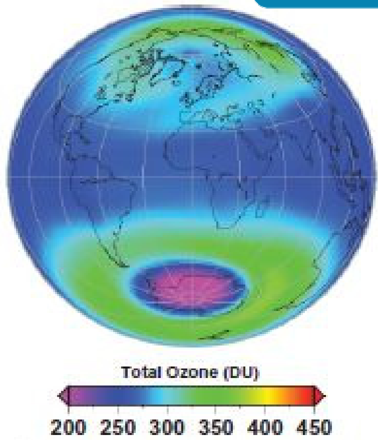
(a) Satellite total ozone winter (DJF)



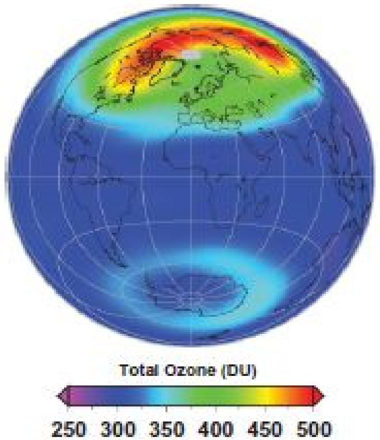
(b) Satellite total ozone spring (MAM)



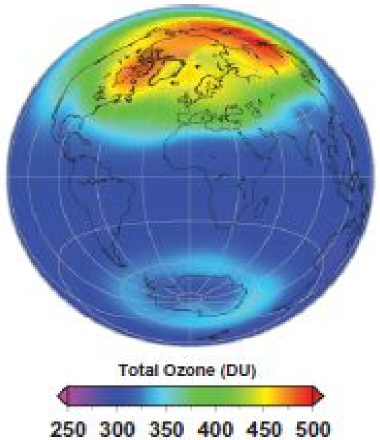
(c) Satellite total ozone summer (JJA)



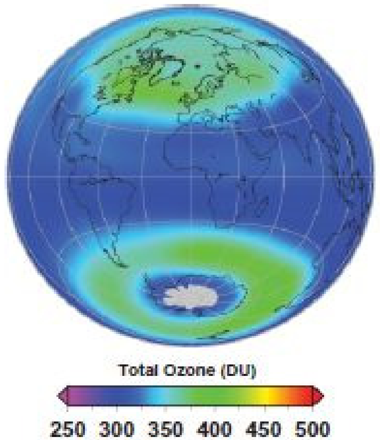
(d) Satellite total ozone autumn (SON)



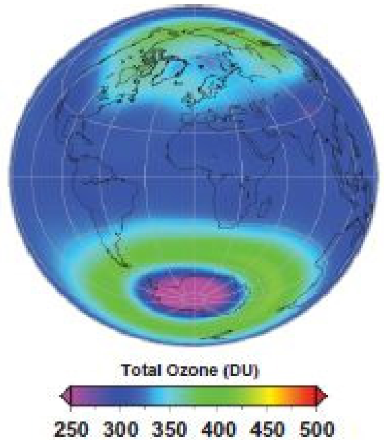
(e) E39C-A total ozone winter (DJF)



(f) E39C-A total ozone spring (MAM)

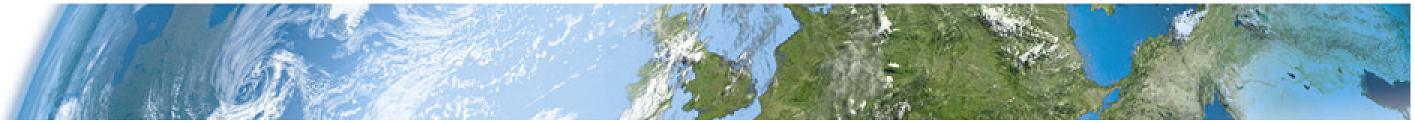


(g) E39C-A total ozone summer (JJA)



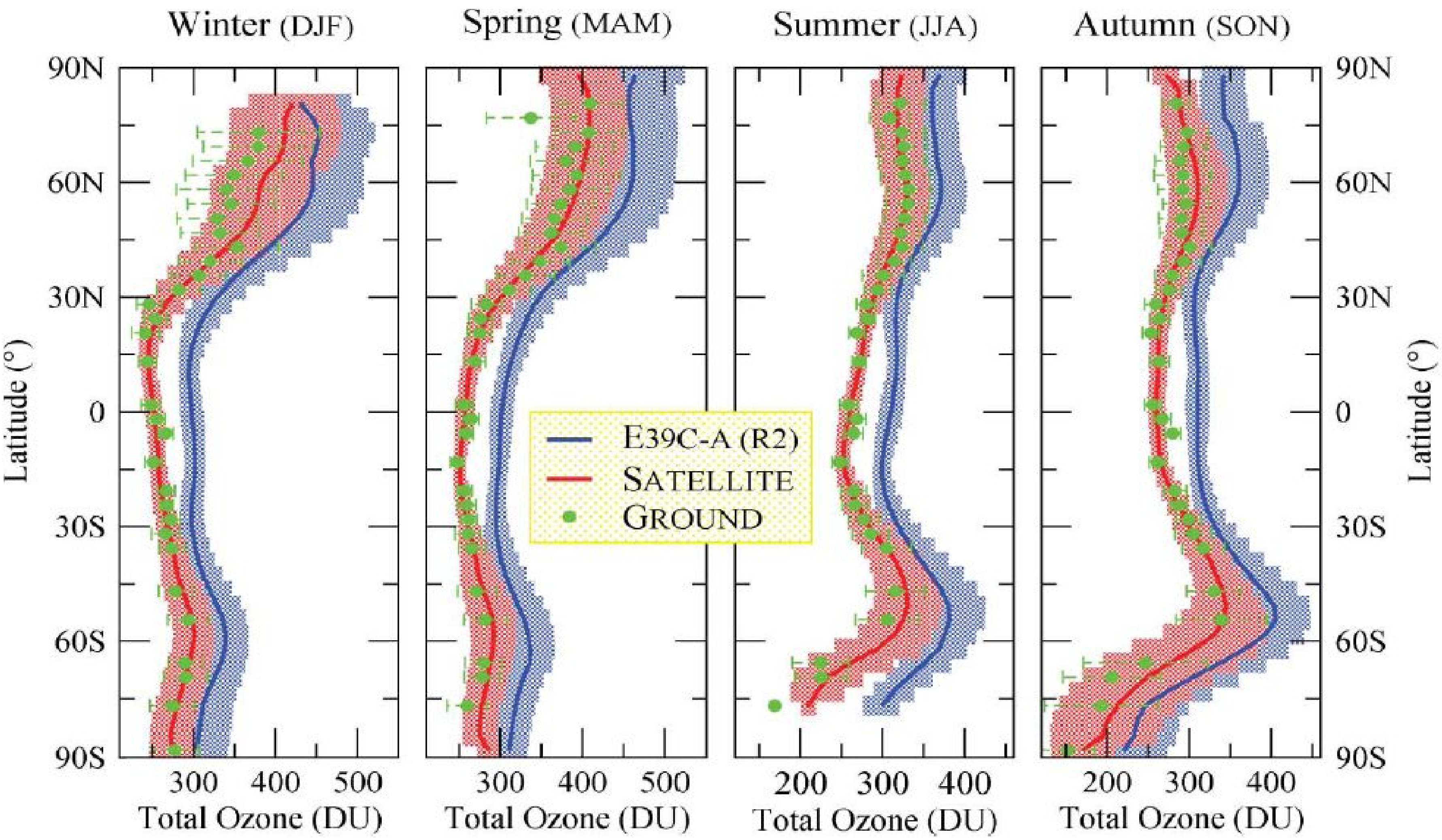
(h) E39C-A total ozone autumn (SON)

DLR



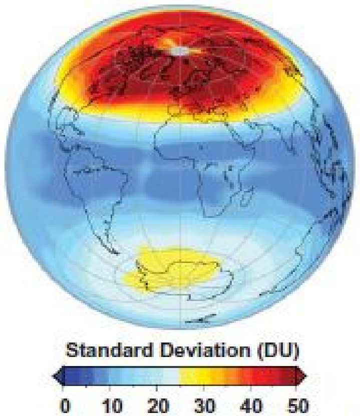
Evaluation: Zonal mean total ozone

Satellite, ground based and model data (1995-2008)

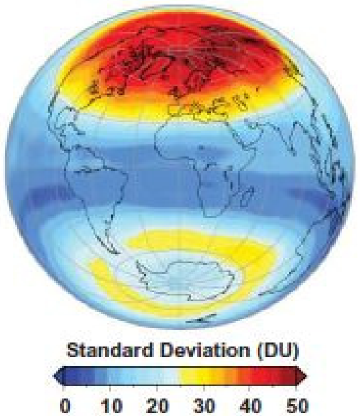


Evaluation: Standard dev. of total ozone

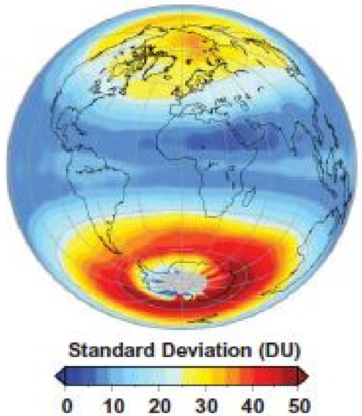
Satellite and model data (1995-2008)



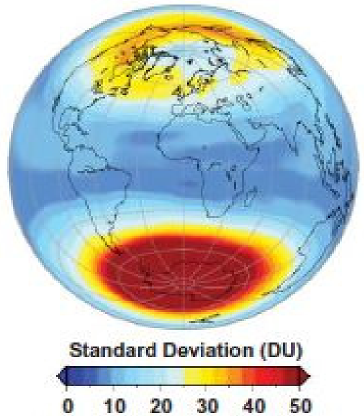
(a) Satellite total ozone standard dev. winter (DJF)



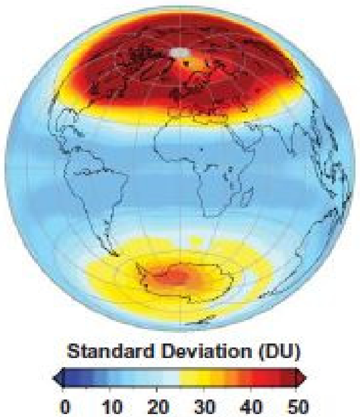
(b) Satellite total ozone standard dev. spring (MAM)



(c) Satellite total ozone standard dev. summer (JJA)



(d) Satellite total ozone standard dev. autumn (SON)



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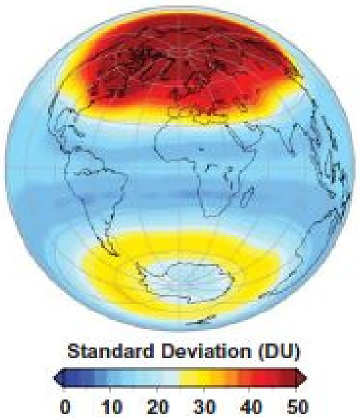
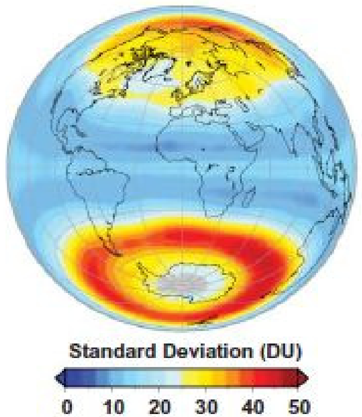
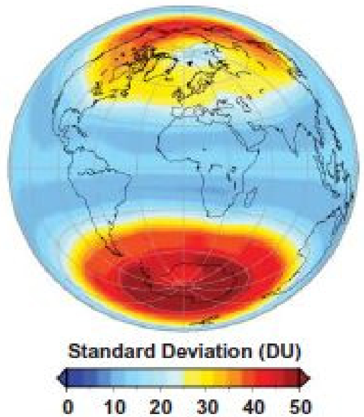


(f) E39C-A total ozone standard dev. spring (MAM)



(g) E39C-A total ozone standard dev. summer (JJA)



(h) E39C-A total ozone standard dev. autumn (SON)

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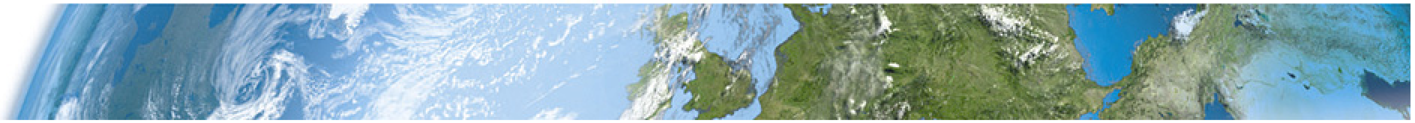
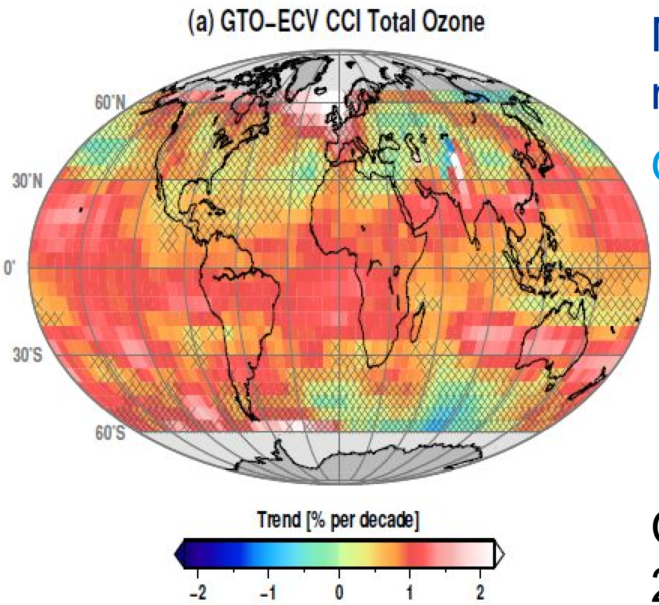


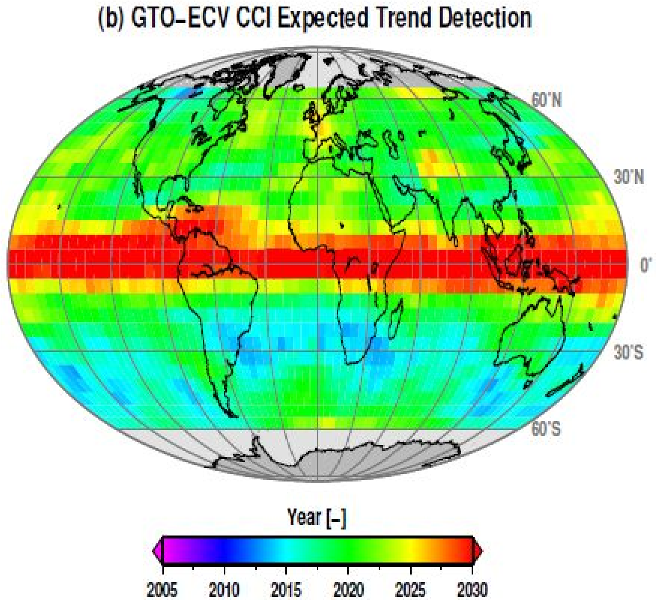
Ozone trend and variability (1995-2013)

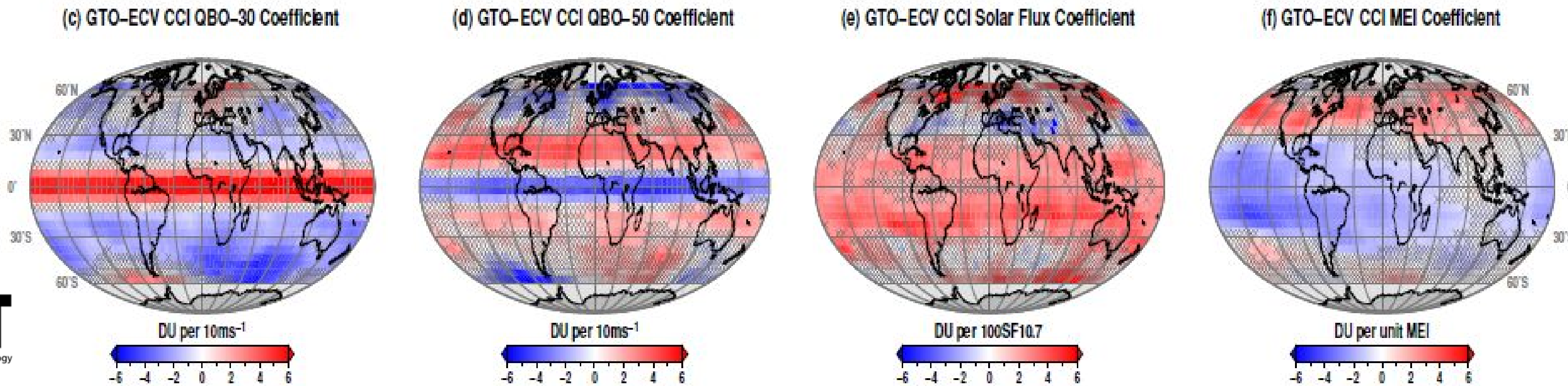


Multiple linear regression model:

$$
\begin{aligned}
O_3(m) = A &+ B_0 \cdot m \\
&+ C \cdot SF(m) \\
&+ D \cdot QBO30(m) \\
&+ E \cdot QBO50(m) \\
&+ F \cdot MEI(m) \\
&+ X(m)
\end{aligned}
$$

Coldewey-Egbers et al., 2014 (GRL)





Karlsruhe Institute of Technology

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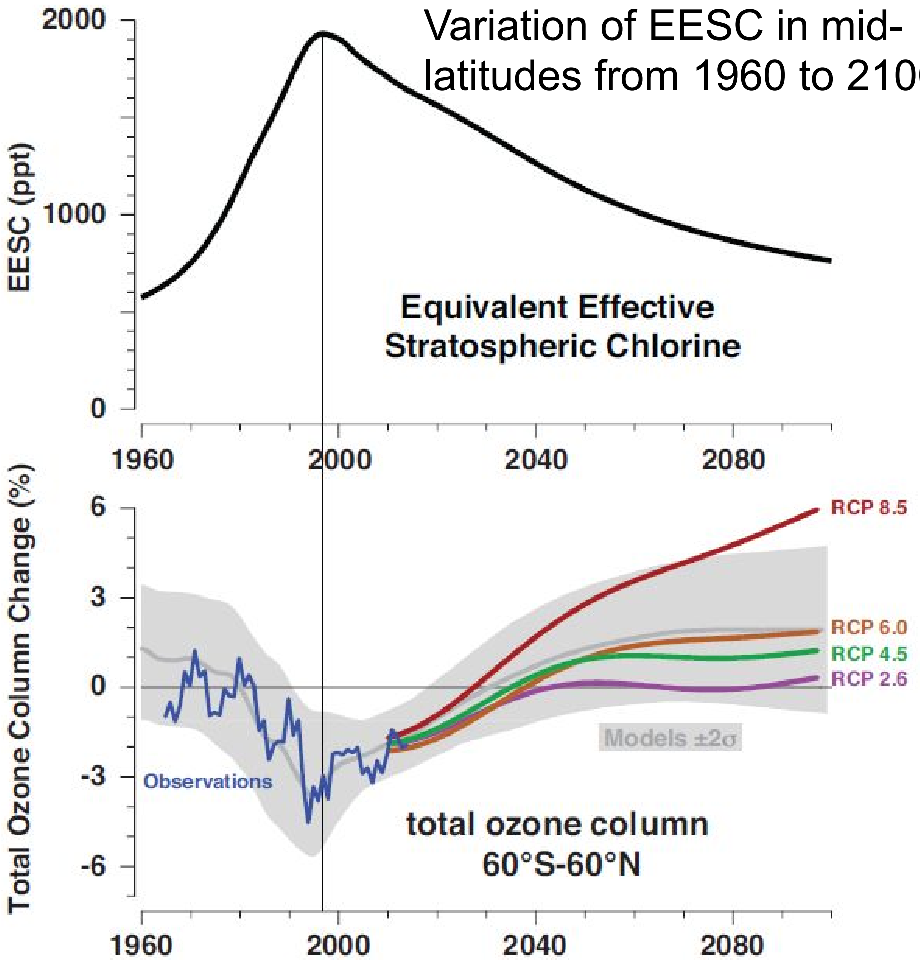
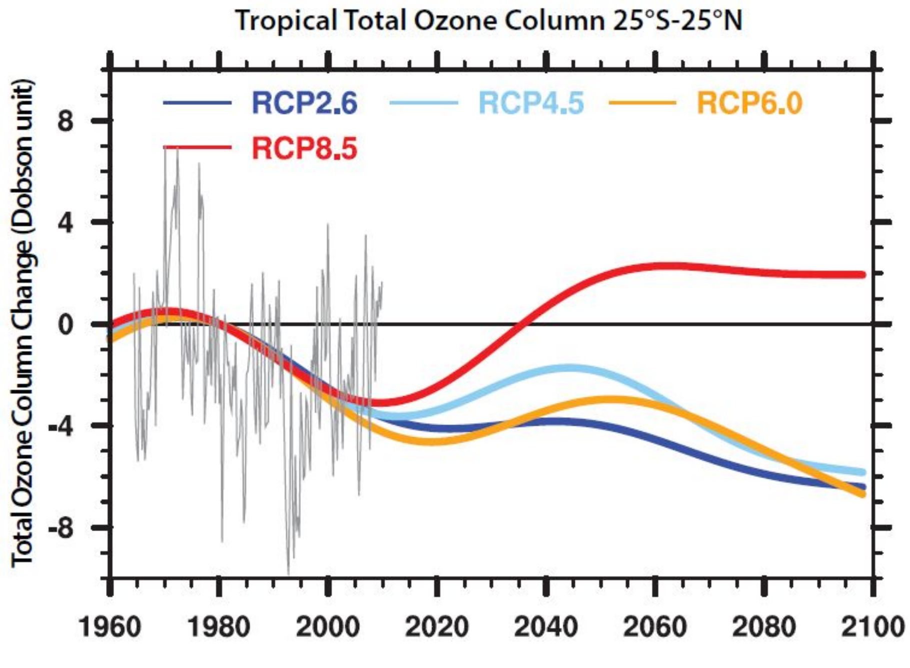
Evolution of the ozone layer

Variation of EESC in mid-latitudes from 1960 to 2100





WMO, 2014

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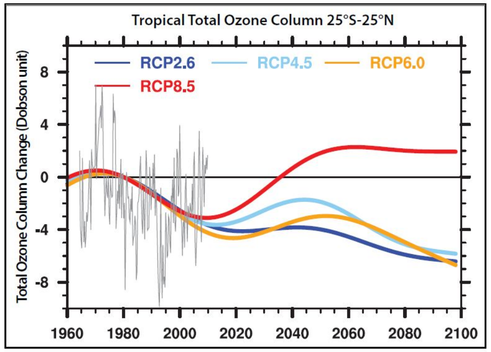
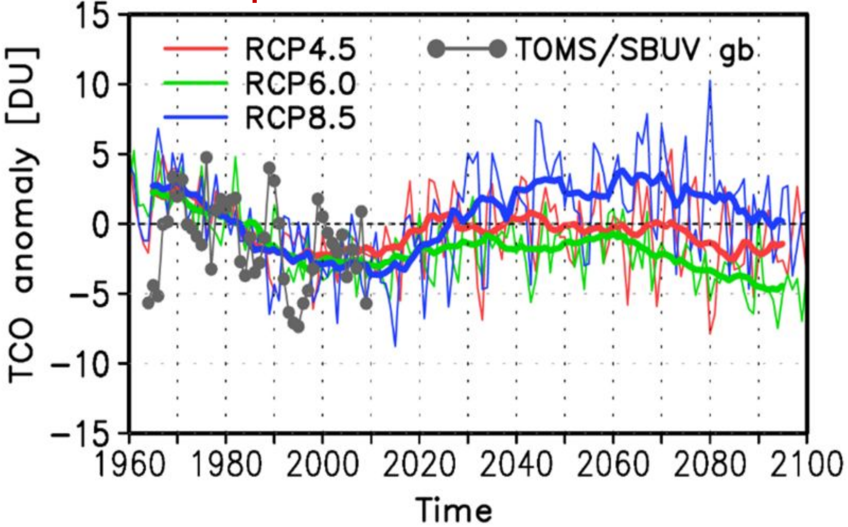
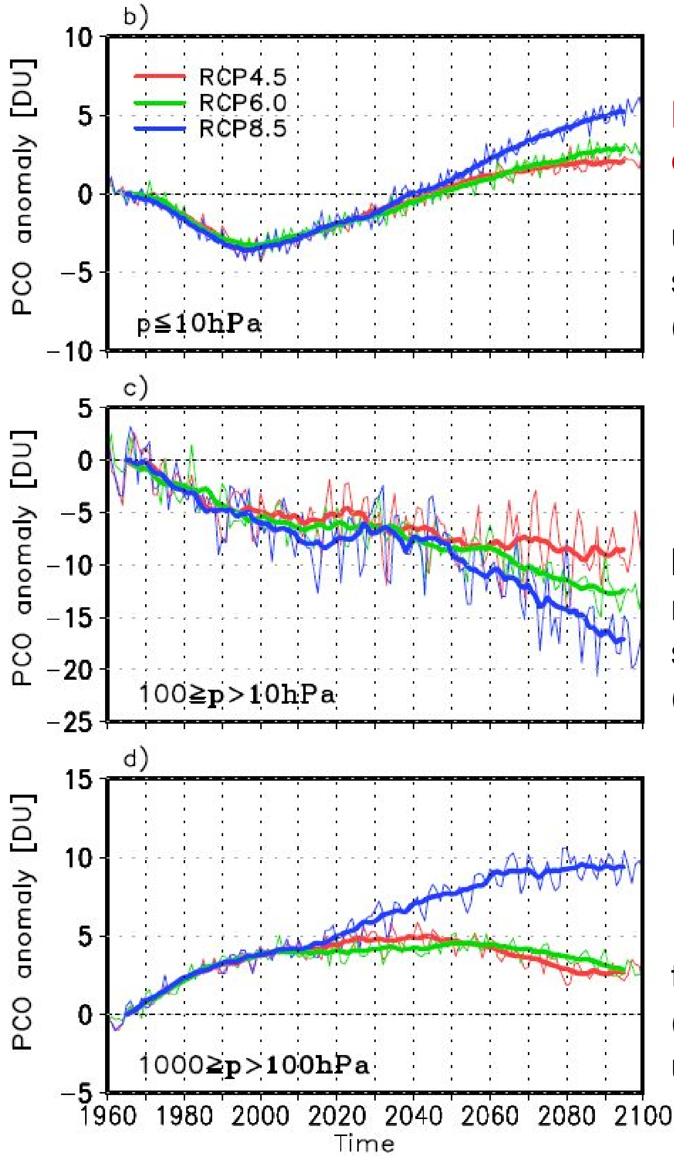
Tropical ozone trend (DLR together with FU Berlin)



a) Tropical total ozone column



Meul et al., 2016 (GRL)



Partial ozone columns

upper stratosphere (above 30 km)

lower and middle stratosphere (15-30 km)

troposphere (surface up to 15 km)

Plans in ESA Ozone_cci

- **Spectrum of variability as a constraint for Earth-System Models**
  - Look at spectra of variability – are models and satellites seeing the same amount of variance at key frequencies? How are the different key frequencies linked?
- **Extreme ends of the spectrum**
  - Trends: latitude and altitude dependencies.
  - Diurnal cycle: use models to better understand its importance for trend estimates.
- **Data from archive will be complemented with case studies**
- **Links to international activities**
  - WCRP Coupled Model Intercomparison Project Phase 6 (CMIP6).
  - IPCC assessment report.
  - SPARC/IGAC Chemistry-Climate Model Initiative (CCMI).
  - UNEP/WMO Scientific Assessment of Ozone Depletion 2018.