Ozone-cci

Science challenges and anticipated outcomes

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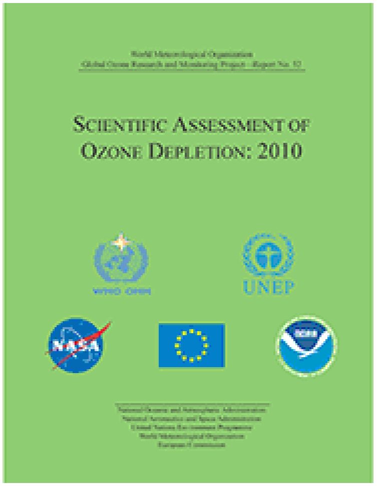
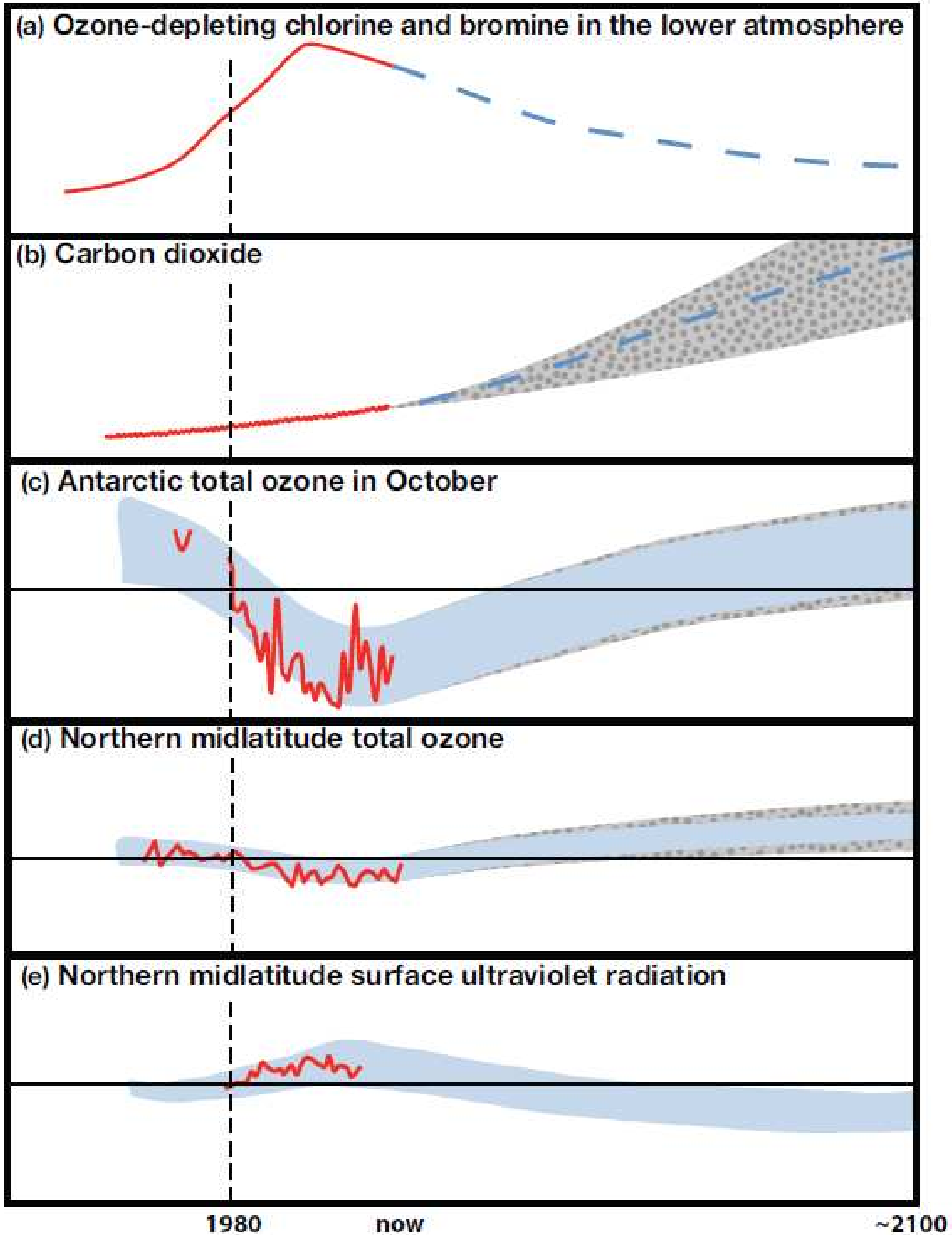
Content

- Scientific challenges
- Climate ozone connections - first results
- Why are the new data products beneficial?
- Benefits for users of new data products
- Success stories
- Links to other ECVs
- Integration within international research framework
- Anticipated outcomes

WMO/UNEP Scientific Assessment of Ozone Depletion 2010



"There is now new and stronger evidence of the effect of stratospheric ozone changes on Earth's surface climate, and of the effects of climate change on stratospheric ozone. These results are an important part of the new assessment of the depletion of the ozone layer presented here."



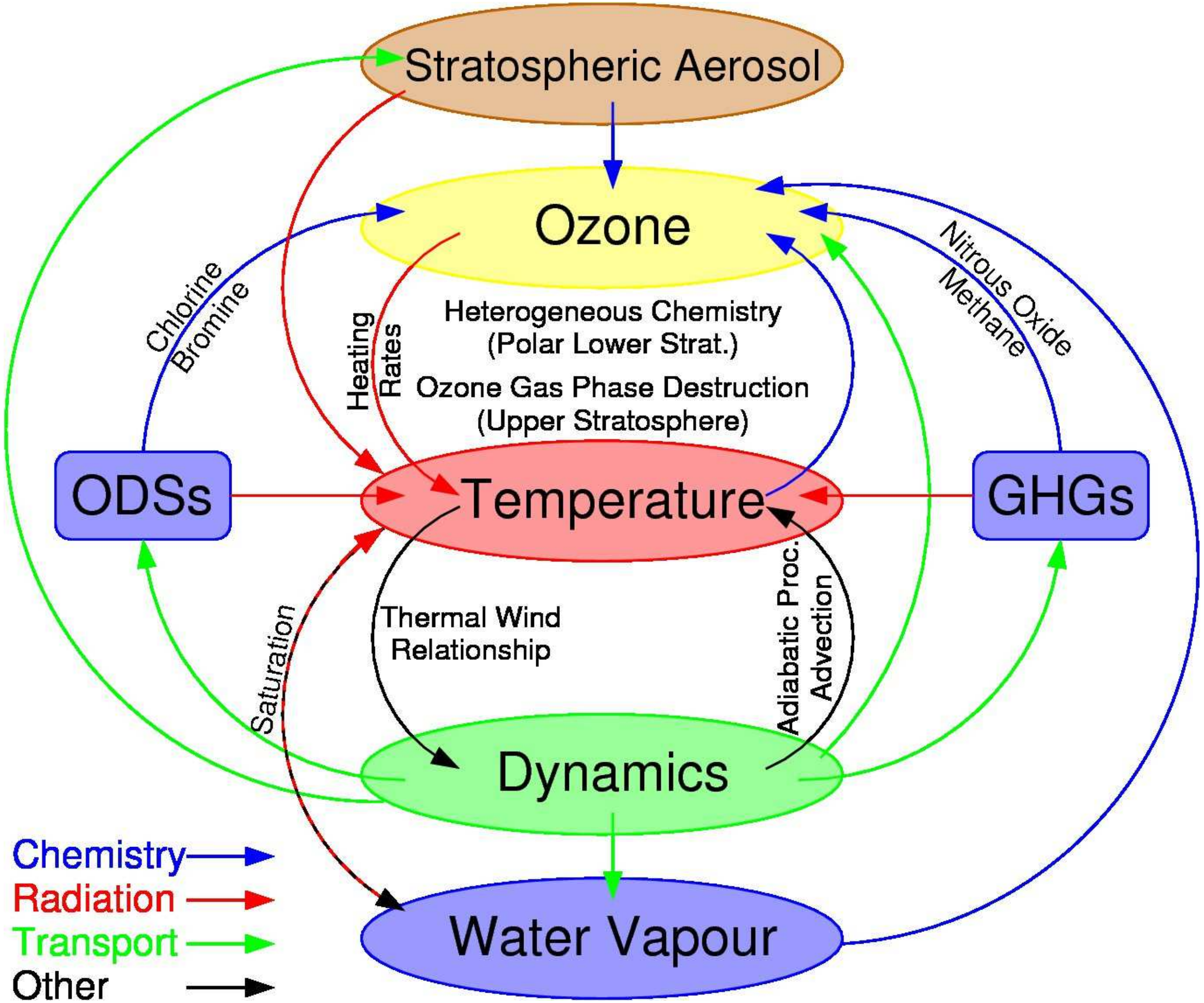
Ozone_cci challenges

- Creation of a continuous, precise, global, 3-dimensional, multi-year ozone data set with good temporal and spatial coverage to attribute and quantify short- and long-term fluctuations and trends
  - Determination of hemispheric differences and vertical dependence
  - Evaluation of natural and anthropogenic forcing
  - Assign dynamical and chemical mechanisms to ozone changes

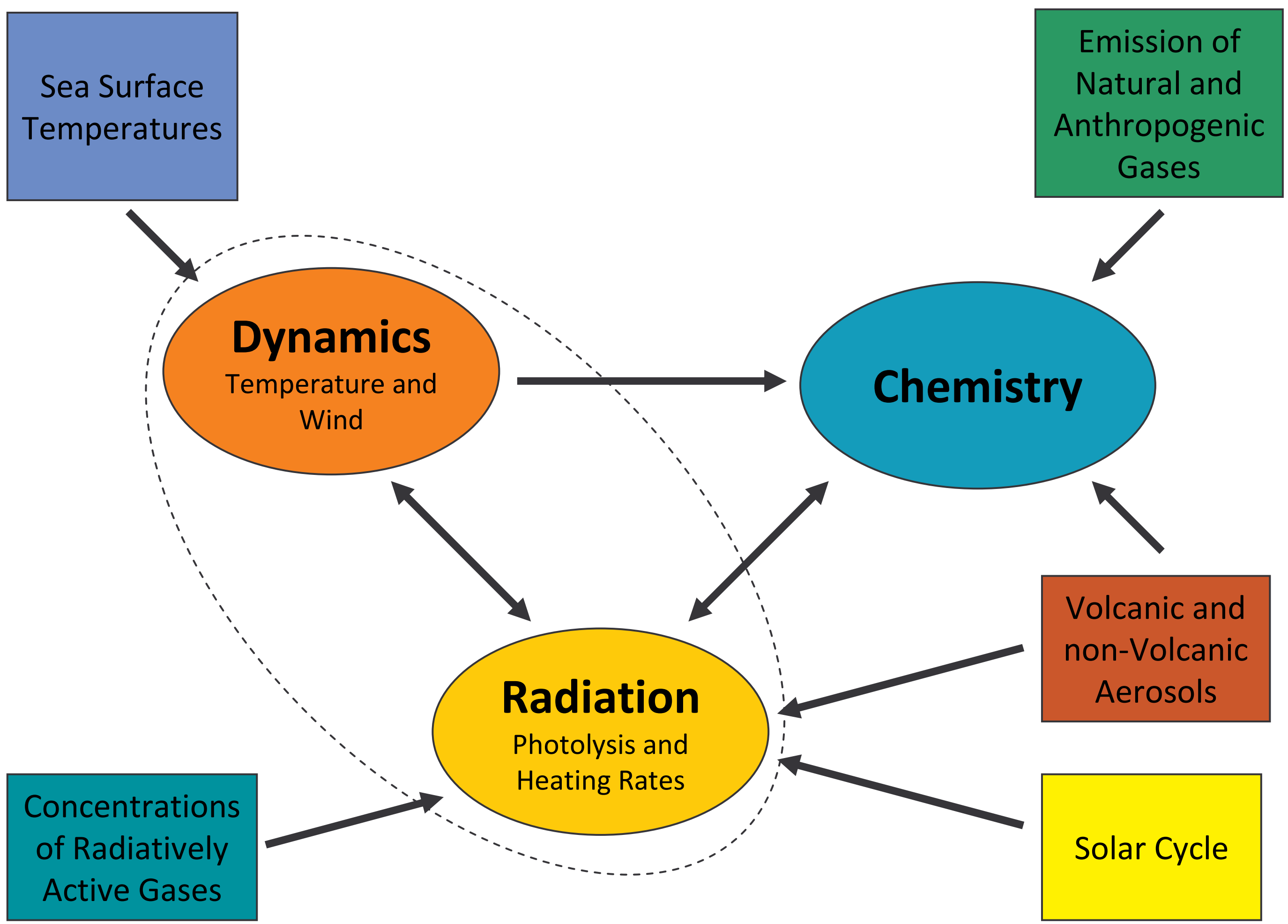
Scientific challenges

- Understanding of dynamical, chemical and radiative processes (including feedback mechanisms) in an atmosphere with enhanced greenhouse gas concentrations
- Insight of stratosphere-troposphere coupling in a future climate
- Robust prediction of ozone return date to historical levels and further evolution of the ozone layer
- Determination of the role of the stratosphere for climate and weather

Climate-Ozone Connections

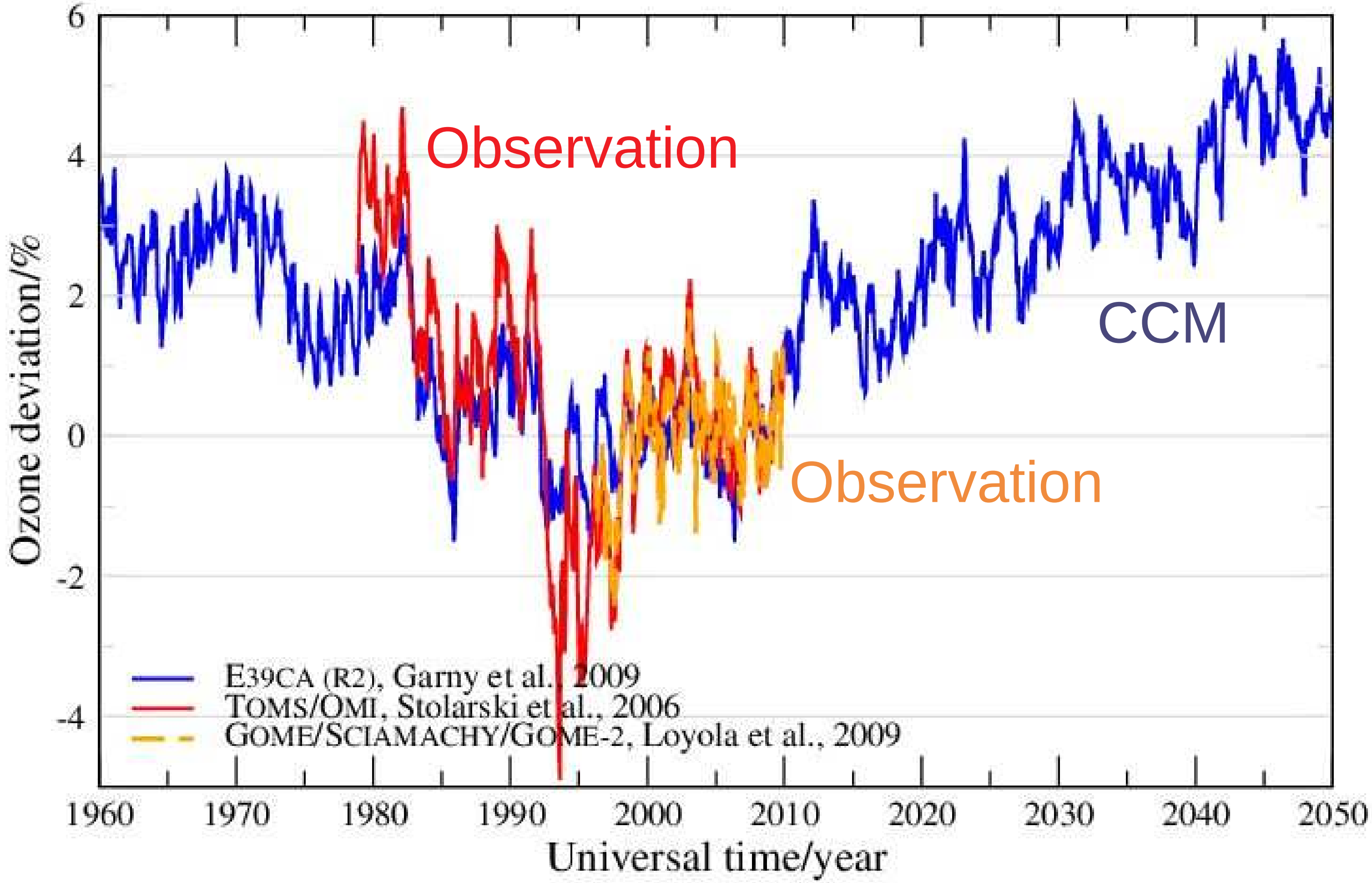


Climate-Chemistry Model (CCM)



Evaluation and prediction

Temporal evolution of total ozone column (60°S – 60° N)

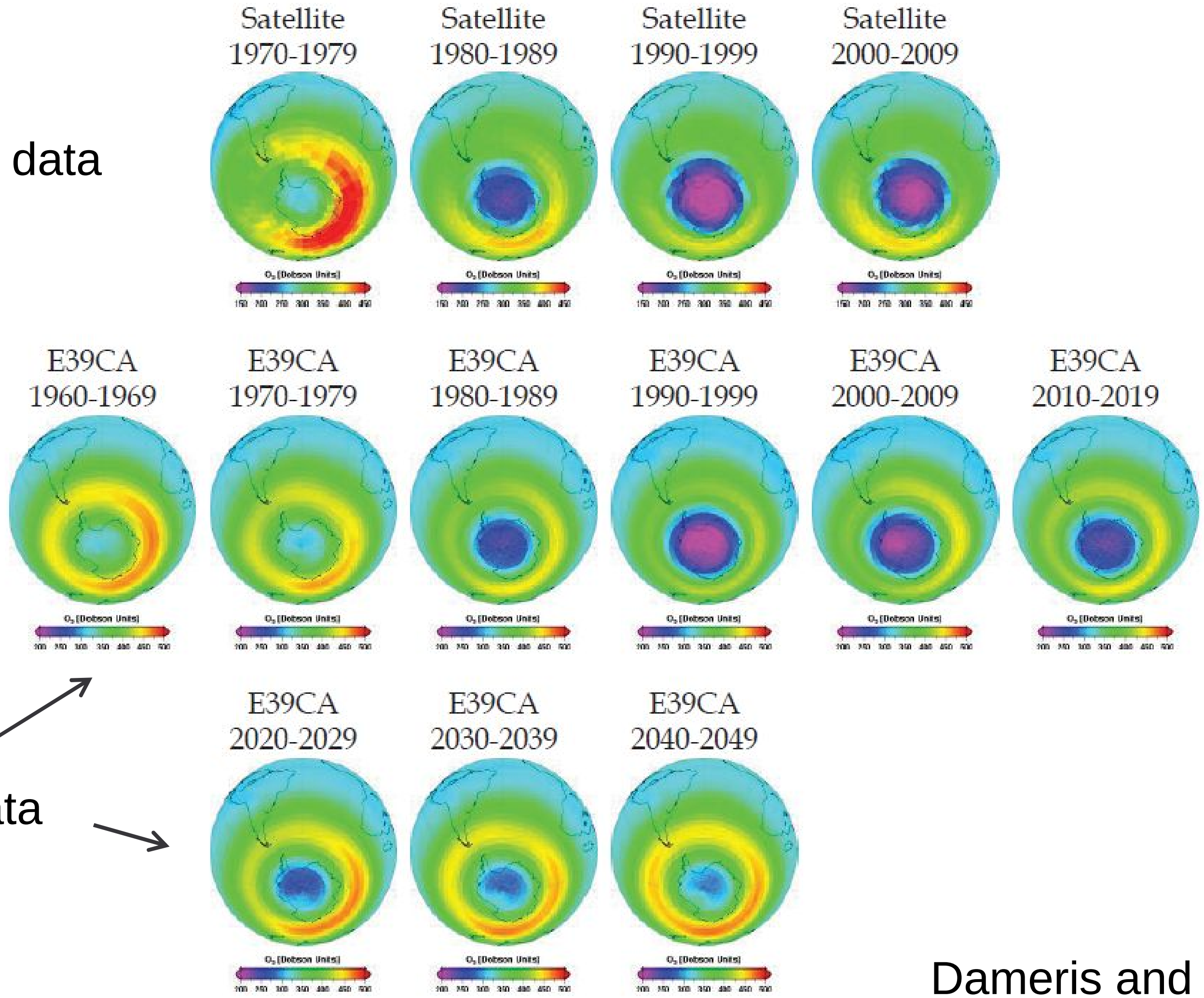


Dameris and Loyola, 2011

Evaluation and prediction

Satellite data

CCM data

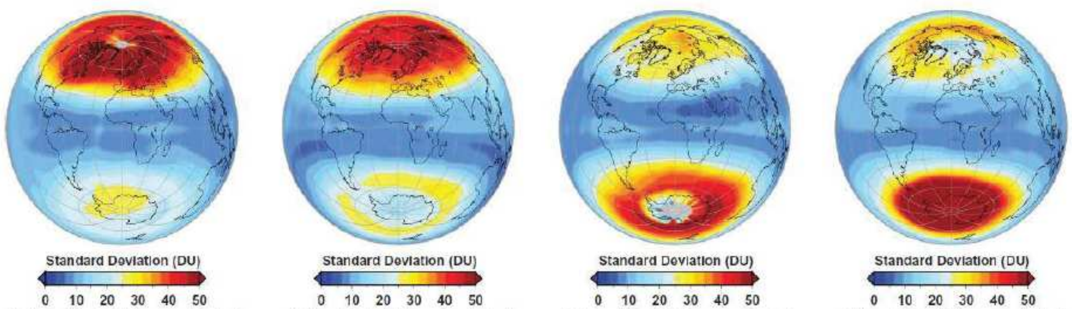


Dameris and Loyola, 2011

Evaluation and prediction

Standard deviation: A measure for internal variability

Sat. data



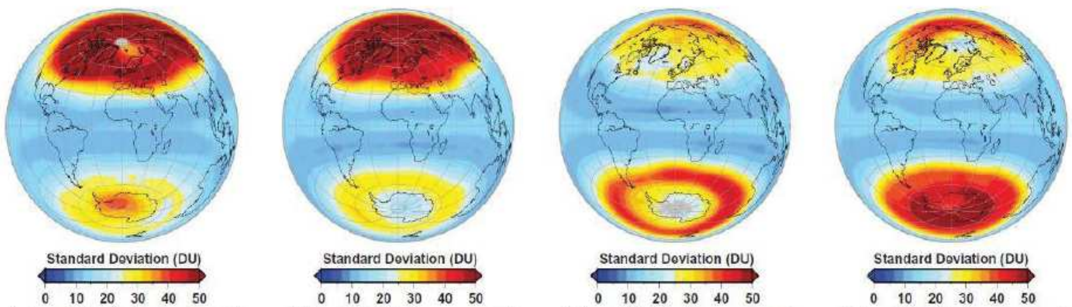
(a) Satellite total ozone standard dev. winter (DJF)

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

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

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

CCM



(e) E39C-A total ozone standard dev. winter (DJF)

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

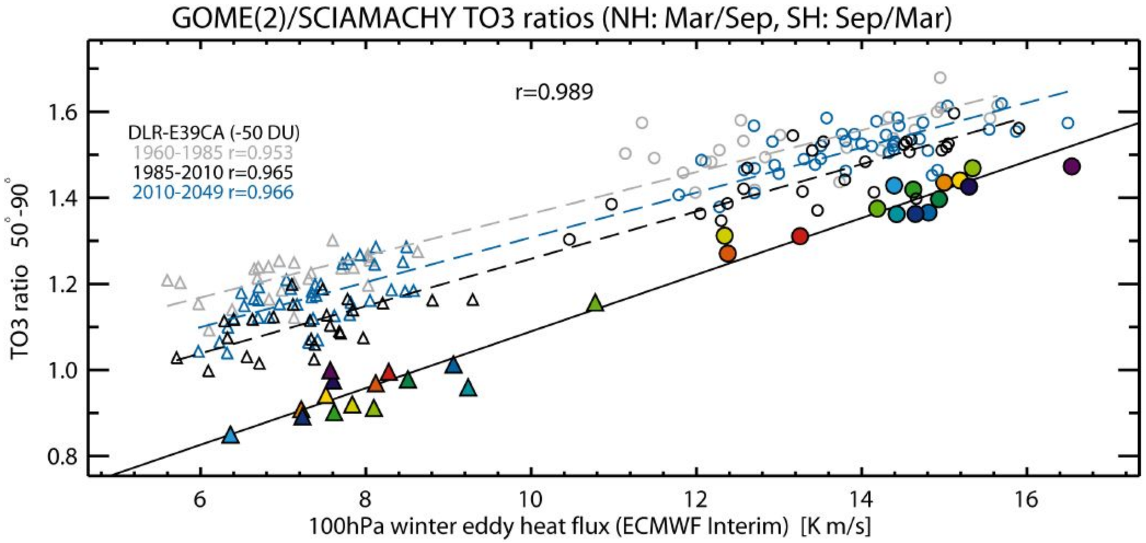
(g) E39C-A total ozone standard dev. summer (JJA)

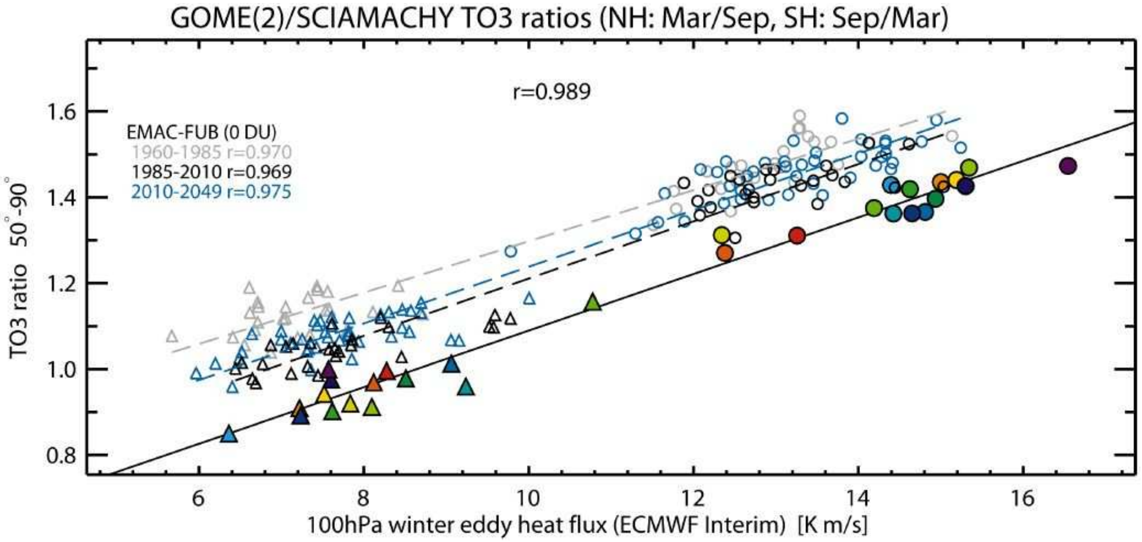
(h) E39C-A total ozone standard dev. autumn (SON)

Accounting for variability properly requires long (expensive) model integrations and high quality measurements over many years!

Dameris and Loyola, 2011

Evaluation and prediction





Spring-to-fall ratio of polar cap total ozone (>50°) as a function of the absolute extra-tropical winter mean eddy heat flux from observations and the CCMs E39CA (top) and EMAC-FUB (bottom).

The reduction of biases, both in models (here compactness and slope) and observations, are still a challenge!

Weber et al., 2011

Currently most missing

- Consistent multi-decadal, global time series of all ozone total column (TC) data

  → combination of European satellite data sets with respective US data sets (1979 – today)

- Consistent multi-year, global time series of ozone profiles (i.e. NP and LP)

  → conflation of available satellite data sets

Benefits

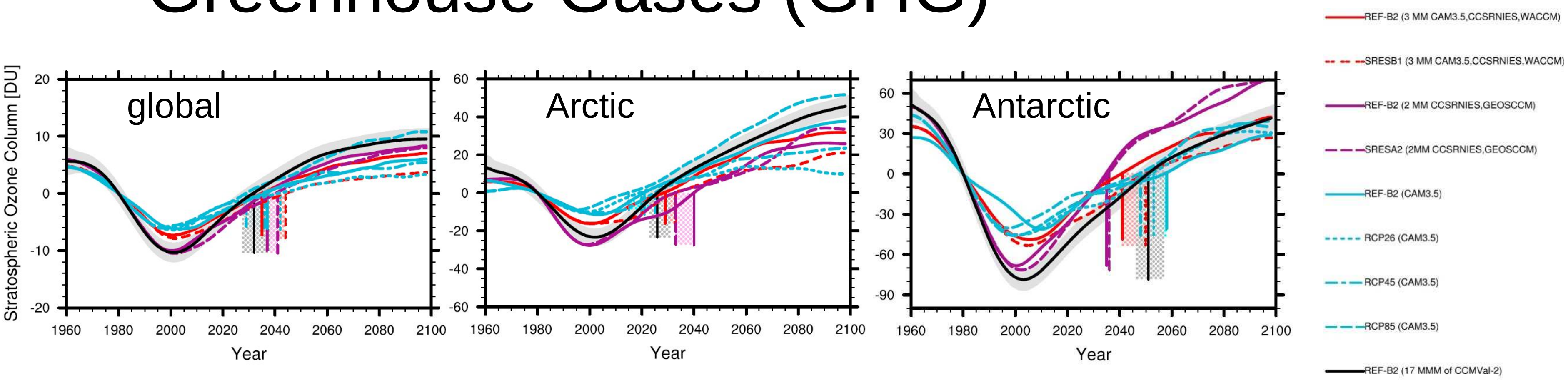
- What can be done better with improved data sets?
  - Process-oriented investigations, e.g. studying interactions of dynamical, chemical and radiative processes
  - Attribution of (natural) ozone fluctuations and determination of (anthropogenic) trends
  - Investigation of links between climate change and atmospheric chemistry and composition, e.g. the impact of climate change on the recovery of the ozone layer ("super-recovery")
  - Evaluation of the role of the stratosphere for (surface) climate change and weather
  - Numerical modelling $\Rightarrow$ climate and (seasonal) weather prediction

Success stories so far

- Initiation of coordinated activities between different groups using different space-borne measurements and retrieval algorithms (e.g. linking MIPAS retrieval teams within RR exercise, linking ENVISAT instrument teams, etc)
- Consolidation of European position in Earth observation (e.g. role in SI^{2}N initiative on assessment of ozone profile changes)
- Effective discussions and agreements between data producers and the user community, e.g. climate modellers, ECMWF

Links to other ECVs, e.g.

- Greenhouse Gases (GHG)



Sensitivity of 21st century stratospheric ozone to greenhouse gas scenarios

→ Example for climate-ozone connection

CCM time series of total ozone for different GHG scenarios: global mean (left), Arctic in March (middle), and Antarctic in October (right)

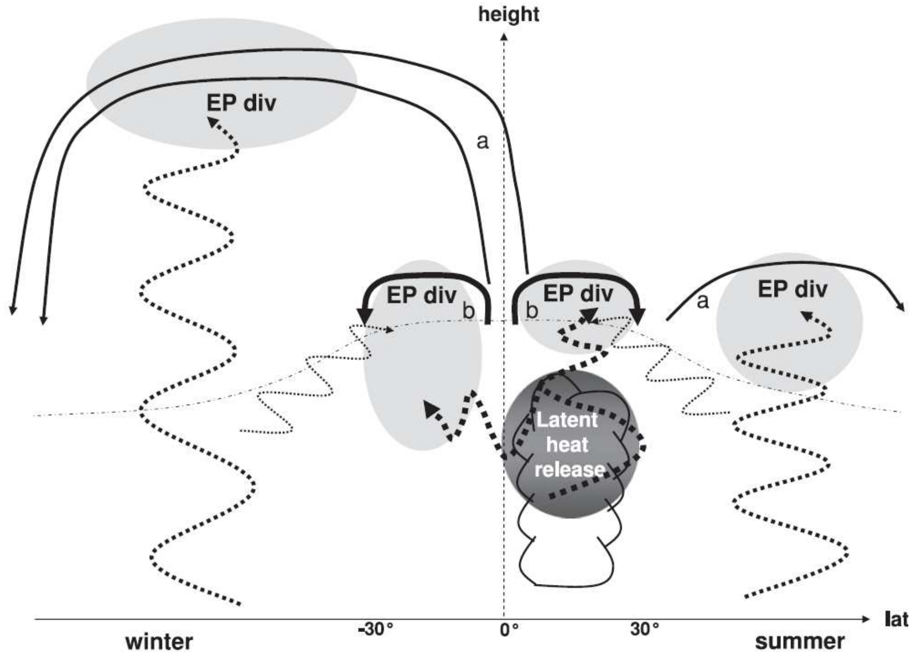
Eyring et al., 2010

Links to other ECVs, e.g.

- Sea Surface Temperature (SST)

Impact of tropical SST changes on tropical upwelling, the Brewer-Dobson circulation and ozone transport

→ Example for climate-ozone connection



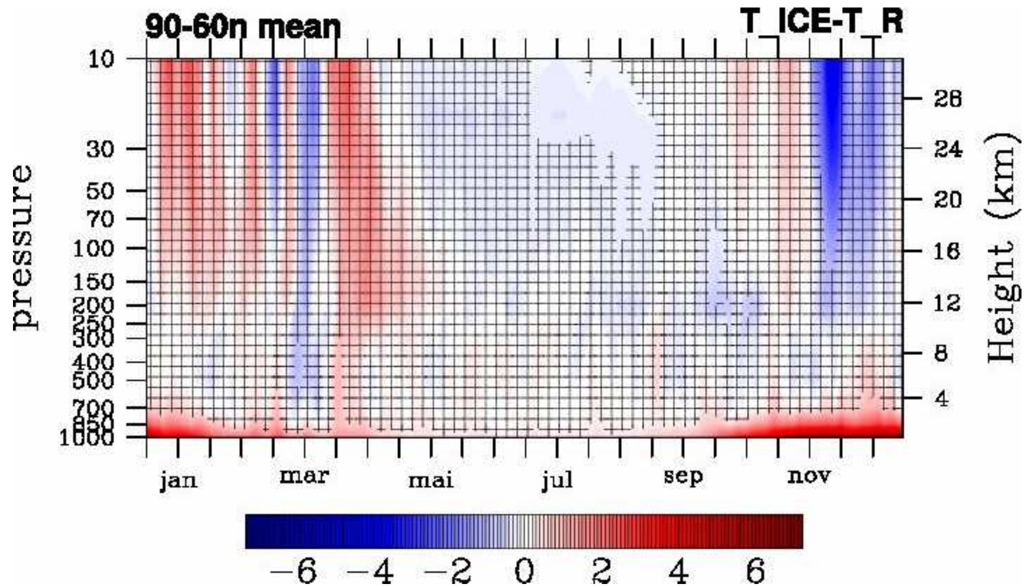
Idealised schematic of the two branches of the meridional circulation in the stratosphere and its wave driving

Garny et al., 2011

Links to other ECVs, e.g.

- Sea Ice (SI)

Implications of all season Arctic sea-ice anomalies on stratospheric tempe-rature, dynamics and ozone distribution



Temperature changes (in ℃) due to Arctic sea-ice loss

→ Example for climate-ozone connection

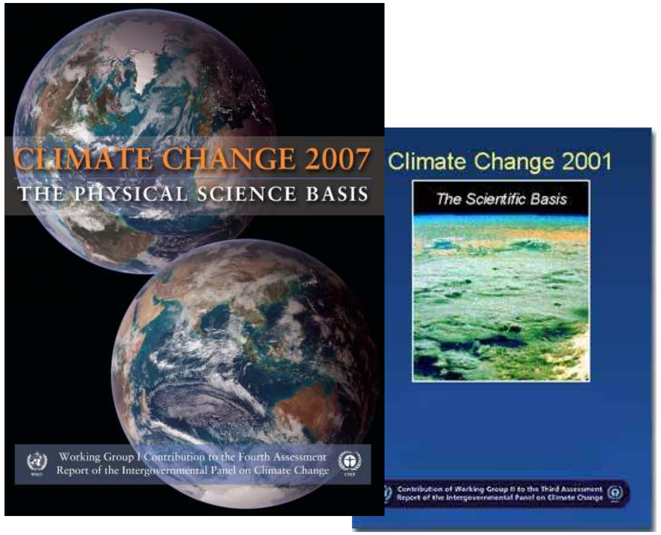
Cai et al., 2012

Integration

Significant contributions to future

- UNEP/WMO Scientific Assessment of Ozone Depletion: 2014
- 5th IPCC Assessment report on climate change (2013/14)
- SPARC*-initiatives, e.g. the CCM validation activity (CCMVal)

[*Stratospheric Processes And their Role in Climate]



Anticipated outcomes (end phase 1)

- Confrontation of
  - L2 (TC and NP),
  - L3 (TC, NP, and LP), and
  - L4 (NP)

  ozone data products for the years 2007 and 2008 with data derived from CCM simulations performed in nudged mode (i.e. relaxed to meteorological re-analyse data)
- Quantitative comparison of L3 (TC and LP) time series (2002-2011); evaluation of respective CCM data
- First assessment of temporal and spatial evolution of the stratospheric ozone layer after the peak in atmospheric chlorine loading

Data products (end phase 1)

Product identifier	Source/ Processing center	Time periods																
		95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11
Level-2 Data Sets																		
TC_L2_GOME	BIRA/DLR	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
TC_L2_SCIA	BIRA/DLR								■	■	■	■	■	■	■	■	■	■
TC_L2_GOME2	BIRA/DLR													■	■	■	■	■
NP_L2_GOME	RAL/KNMI			■														
NP_L2_SCIA	RAL/KNMI													■	■			
NP_L2_OMI	KNMI													■	■			
NP_L2_GOME2	RAL/KNMI													■	■			
Level-3 Data Sets																		
TC_L3_MRG	DLR/BIRA	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
NP_L3_MRG	RAL/KNMI			■										■	■			
LP_L3_SCIA	IUP-Bremen								■	■	■	■	■	■	■	■	■	■
LP_L3_MIPAS	TBD[1]													■	■			
LP_L3_GOMOS	FMI								■	■	■	■	■	■	■	■	■	■
LP_L3_OSIRIS	SASK							■	■	■	■	■	■	■	■	■	■	■
LP_L3_MRG	EOST-3 team													■	■			
Level-4 Data Sets																		
NP_L4_MRG	KNMI			■										■	■			

Data products (end phase 2, 2016)

Product identifier	Source/ Processing center[1]	Time periods																
		95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11+
Level-2 Data Sets																		
TC_L2_GOME	BIRA/DLR	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
TC_L2_SCIA	BIRA/DLR								■	■	■	■	■	■	■	■	■	■
TC_L2_GOME2	BIRA/DLR													■	■	■	■	■
NP_L2_GOME	RAL/KNMI		■	■	■	■	■	■										
NP_L2_SCIA	RAL/KNMI								■	■	■	■	■	■	■	■	■	■
NP_L2_OMI	KNMI										■	■	■	■	■	■	■	■
NP_L2_GOME2	RAL/KNMI													■	■	■	■	■
LP_L2_SCIA	TBD[2]								■	■	■	■	■	■	■	■	■	■
LP_L2_MIPAS	TBD[2]								■	■	■	■	■	■	■	■	■	■
LP_L2_GOMOS	TBD[2]								■	■	■	■	■	■	■	■	■	■
LP_L2_OSIRIS	SASK							■	■	■	■	■	■	■	■	■	■	■
Level-3 Data Sets																		
TC_L3_MRG	DLR/BIRA	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
NP_L3_MRG	RAL/KNMI		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
LP_L3_SCIA	IUP-Bremen								■	■	■	■	■	■	■	■	■	■
LP_L3_MIPAS	TBD								■	■	■	■	■	■	■	■	■	■
LP_L3_GOMOS	FMI								■	■	■	■	■	■	■	■	■	■
LP_L3_OSIRIS	SASK							■	■	■	■	■	■	■	■	■	■	■
LP_L3_MRG	EOST-3 team							■	■	■	■	■	■	■	■	■	■	■
Level-4 Data Sets																		
NP_L4_MRG	KNMI		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

Why are the new data beneficial?

- Better understanding of errors and determination of uncertainties
- Benchmark for future pursuing measure-ments and model evaluation
- Will enable consistent investigations of ozone fluctuations and trends in
  - tropical and extra-tropical regions
  - the upper troposphere and the lower, middle, and upper stratosphere