# IGAC/SPARC Chemistry-Climate Model Initiative (CCMI)

*Veronika Eyring (DLR), Michaela Hegglin (University of Reading) and Jean-Francois Lamarque (NCAR)*

WGCM 17th Session

Victoria, Canada

1-3 October 2013

# CCMI Background and Goal

**Background:**

(i) Increasingly, the **chemistry and dynamics of the stratosphere and troposphere are being modeled as a single entity in global models** (and increasingly a coupled ocean).

(ii) Tropospheric and stratospheric global chemistry-climate models are continuously being challenged by new observations and model intercomparisons.

(iii) There is a need to better coordinate the previously separate activities addressing these two domains and to **assess scientific questions in the context of comprehensive stratosphere-troposphere** resolving models with chemistry.

**CCMI Goals**

1.Better understand the role of chemistry-climate interactions

2.Contribute to the understanding and improved representation of chemistry-climate processes in global models

3.Facilitate and improve comparability for model-observation comparison

4.Provide simulations & analysis for process studies and in support of upcoming assessments (WMO, IPCC)

# CCMI Organization

**Co-Chairs CCMI:**

Veronika Eyring (DLR), Michaela Hegglin (Univ. of Reading), Jean-François Lamarque (NCAR)

- Michaela Hegglin (Univ. of Reading) was elected as CCMI co-chair by the CCMI SSC in June 2013
- Veronika Eyring will step down as co-chair of CCMI and move to the CCMI SSC at the end of 2013.

**CCMI Scientific Steering Committee (SSC):**

- Stephan Bojinski (WMO Space Programme and GCOS; Switzerland)
- Irene Cionni (CCMI diagnostic tool, regional modeling; Italy)
- Bryan Duncan (tropospheric satellite products; US)
- Arlene Fiore (tropospheric chemistry and climate; US)
- Andrew Gettelman (clouds, UTLS; US)
- Peter Hess (CCMI hindcast, transport, tropospheric chemistry; US)
- Hong Liao (vegetation-chemistry-aerosol-climate interactions, air quality; China)
- Gunnar Myhre (aerosols, radiative forcing, Norway)
- Tatsuya Nagashima (chemistry-climate interactions; Japan)
- Keywan Riahi (Integrated Assessment Modeling, human health impacts; Austria)
- Tom Ryerson (insitu observations for model evaluation; US)
- Ted Shepherd (large-scale dynamics in the stratosphere and troposphere, UK)
- Drew Shindell (radiative forcing, chemistry-climate interactions; US)
- Darryn Waugh (stratospheric impacts on climate, performance metrics; US)
- Paul Young (CCMI hindcast, tropospheric chemistry, stratospheric water vapor, UK)

# IGAC/SPARC CCMI 2013 Science Workshop

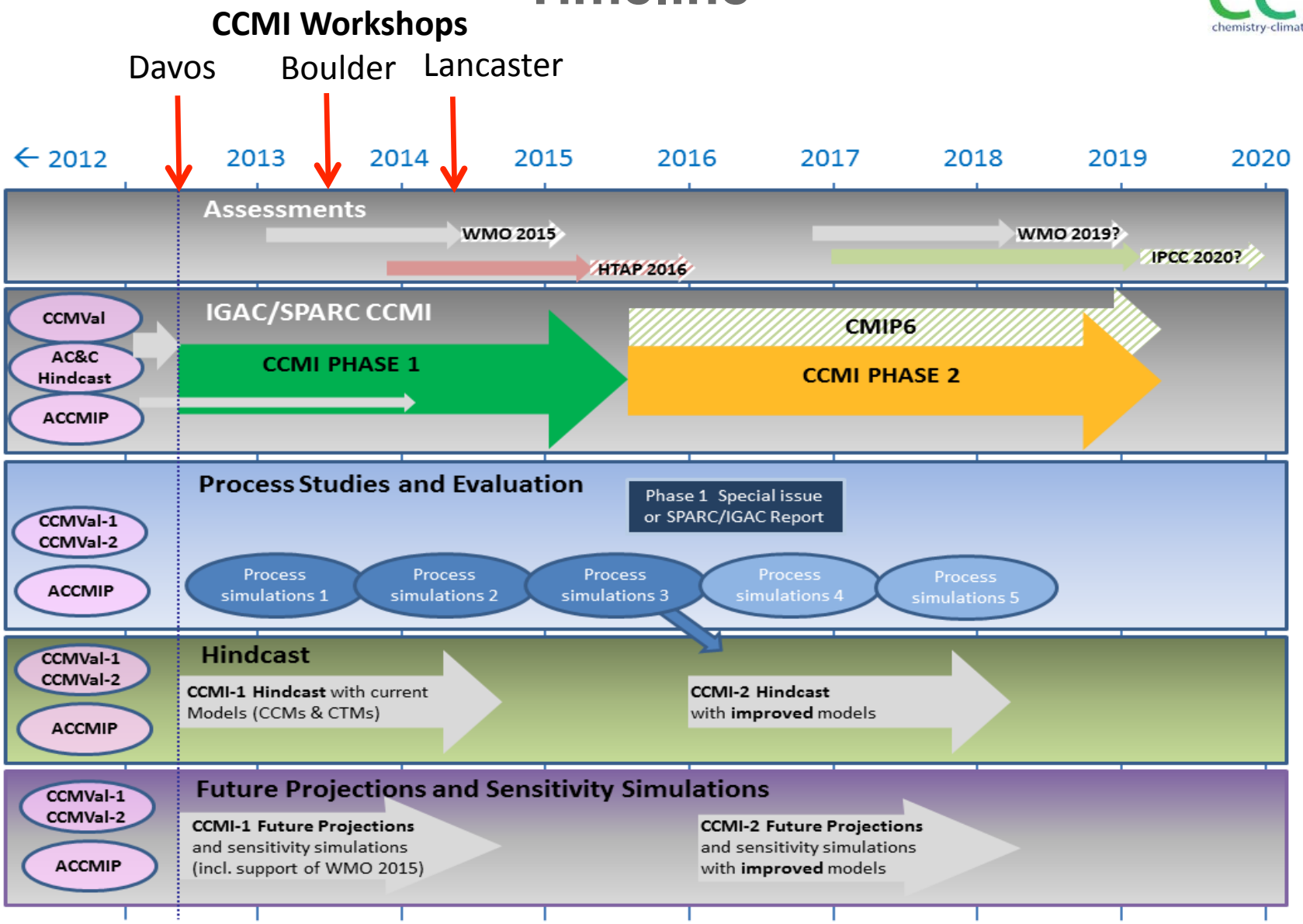
NCAR, Boulder, CO, 14-16 May 2013

Co-Chairs: Veronika Eyring & Jean-Francois Lamarque

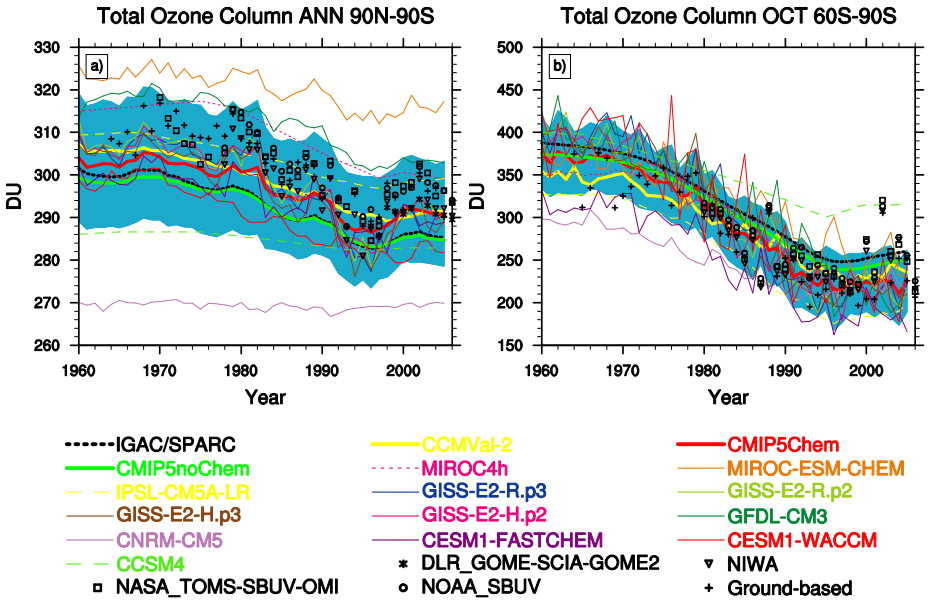
# Future direction of the activity (scientific questions to be addressed, timelines, etc.)

- How well does the current generation of global chemistry models capture the observed interannual variability in tropospheric and stratospheric constituents? To what extent do the satellite retrievals of tropospheric and stratospheric constituents constrain constituent variability over the last 10-15 years?
- How have changes in atmospheric forcings impacted chemical composition and chemistry over the last 30 through 50 years? These forcings include: a) changes in climate forcing with resulting impacts on temperature, water vapor and meteorology, possibly extending to stratosphere-troposphere exchange, b) changes in ozone and aerosol precursor emissions, c) changes in land cover, and d) changes in ODSs.
- How have changes in aerosol loading impacted oxidative capacity of the troposphere over the last 30 to 50 years?
- How well do we understand the budget of tropospheric OH? Can we capture the estimated interannual variability and trends?
- What is the role of very short-lived halogen species (VSLS) on tropospheric and stratospheric chemistry?

# Timeline


CCMI Workshops
Davos
Boulder
Lancaster
← 2012
2013
2014
2015
2016
2017
2018
2019
2020
Assessments
WMO 2015
HTAP 2016
WMO 2019?
IPCC 2020?
CCMVal
AC&C Hindcast
ACCMIP
IGAC/SPARC CCMI
CCMI PHASE 1
CMIP6
CCMI PHASE 2
Process Studies and Evaluation
Phase 1 Special issue or SPARC/IGAC Report
CCMVal-1
CCMVal-2
ACCMIP
Process simulations 1
Process simulations 2
Process simulations 3
Process simulations 4
Process simulations 5
Hindcast
CCMI-1 Hindcast with current Models (CCMs & CTMs)
CCMI-2 Hindcast with improved models
Future Projections and Sensitivity Simulations
CCMI-1 Future Projections and sensitivity simulations (incl. support of WMO 2015)
CCMI-2 Future Projections and sensitivity simulations with improved models

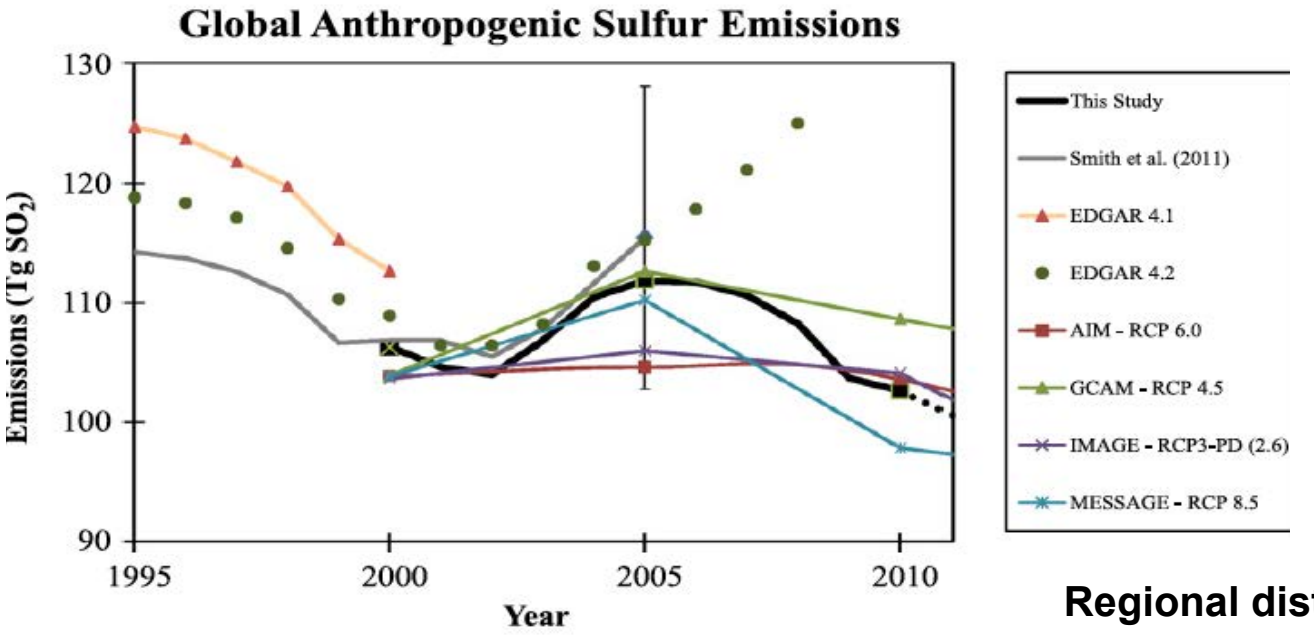
# Ozone in CMIP5 simulations




*Eyring et al., JGR, 2013*

- **Time-varying ozone is now included in the latest suite of models, either prescribed or calculated interactively.** Although in some models there is only *medium agreement* with observed changes in total column ozone**, the inclusion of time-varying stratospheric ozone constitutes a substantial improvement since the AR4 where half of the models prescribed a constant climatology**. As a result, there is *robust evidence* that **the representation of climate forcing by stratospheric ozone has improved** since the AR4 *(ES Ch09 IPCC AR5).*

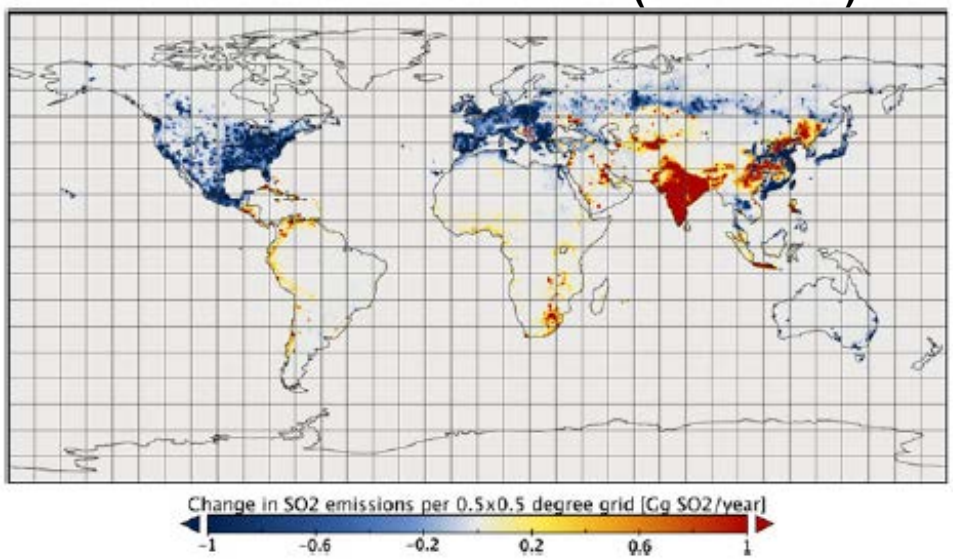
# Focus on SO2 and recent hiatus




*Klimont et al., 2013*

- While there is a **net increase over 2000–2010 period from the EECCA** (Eastern Europe, Caucasus and Central Asia), China, India, and international shipping, these increases were smaller than **emission reductions in North America** (US and Canada) and Europe, **leading to a net decrease in global emissions**.
- **2010 estimated to be lower than in 2000 by about 3%.**

**Regional distribution of anthropogenic land based SO2 emissions (2010-2005)**



# CCMI contributions to CMIP6

**CMIP5 Synthesis Paper:** No contribution from CCMI (see ACCMIP and "CCMVal" papers)

**Proposed Structure for CMIP of a more distributed organization:** Well received by CCMI

**CMIP6 Data Request**

- CCMI follows CMIP standards in terms of data format and documentation
- We plan to provide a data request for models with and without interactive chemistry (will be a reduced version compared to CCMI-1 data request)

**Emissions and Concentrations**

- Update the IGAC/SPARC ozone database (Cionni et al., 2011) for CMIP6 models with prescribed ozone
- Contribute to the update of the historical emissions and harmonization with scenarios(Workshop in Nov organized by Claire Granier)
- Possibly provide aerosol concentrations in collaboration with AeroCom (under discussion whether really needed)

**Model Evaluation**

- Evaluate chemistry-climate interactions in the CMIP6-DEC simulations
- Diagnostics & metrics will be implemented in the ESMValTool for routine use

# CCMI contributions to CMIP6

**CMIP6 Science Questions, contributions to**

- **Systematic biases**
- **Response to forcings**
- Variability, **predictability** (e.g., role of the stratosphere and uncertainty in emissions in decadal predictions) and **future scenarios** (e.g. understanding the role of aerosols and other SLCF)

**Additional Simulations beyond the CMIP-DECK simulations** (preliminary, to be discussed at CCMI workshop in Lancaster in May 2014)

- **Simulation 1: Understanding the role of specific air quality/SLCF measures?**
  - **Quantify the climate and air quality impacts of specific measures or policies** (such as emphasis on natural gas and associated methane release)
  - Focus on short-lived species and air quality
  - Will require coordination with IAMs and Scenario-MIP
- **Simulation 2: Understanding the climate impact of regional emissions of short-lived climate forcers or their precursors**
  - Defines the fingerprint of specific forcers (e.g. US emissions of $SO_2$)
  - EasyAerosols and other idealized experiments (possible synergies with other CMIP6 satellites, e.g. D&A, CFMIP)

# Questions/Issues for CMIP6

- New harmonization period: 2010(ish) for emissions and 2015(ish) for LLGHG concentrations? GEIA-led workshop in Hamburg, November 2013
- What to do for near-term projections beyond harmonization time?
- Propagation of emission uncertainty?
- Who will redo the historical emissions?
- Do we need higher resolution (possible target: 0.1o)?
- Multi-ESM generation of concentrations (ozone, aerosols, CH4?) & nitrogen deposition data. To 2200-2300? Is it still needed?
- Gridding with consideration of projected population changes? Specific regulations (HTAP)?
- Consistency with LU change & CO2 for biomass burning?
- Allow time for early testing and iterations!