SPARC Project Report

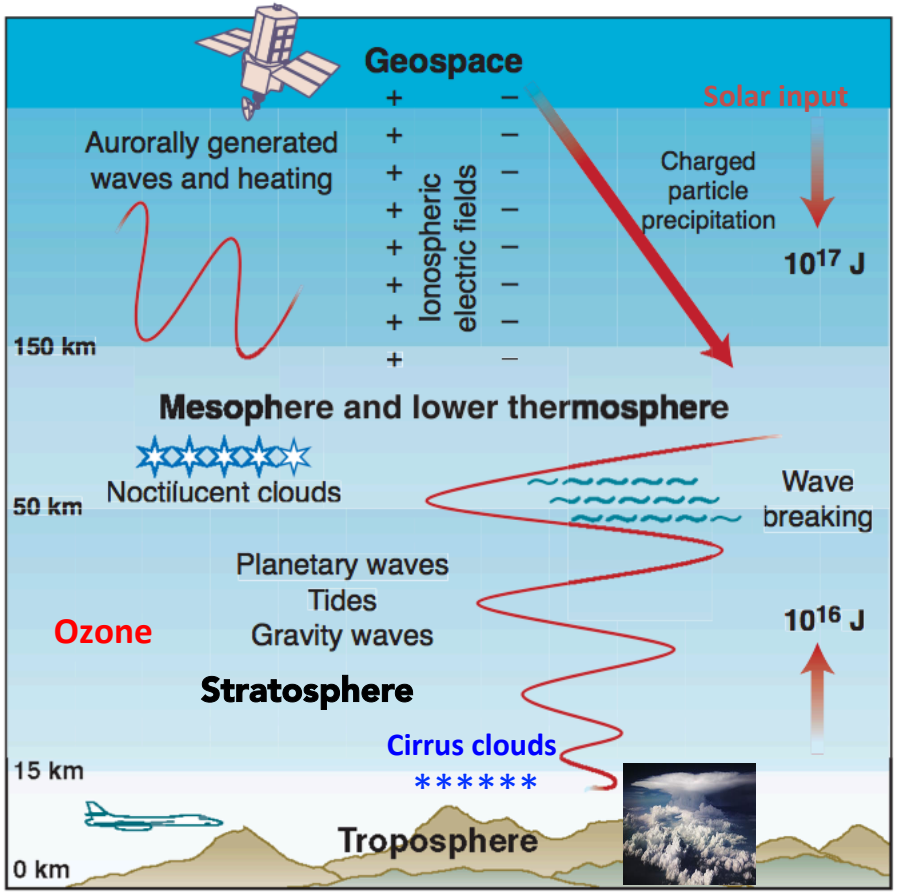
Stratosphere-troposphere Processes And their Role in Climate

Joan Alexander – SSG Co-Chair
Ted Shepherd – Interim vice-Chair
Johannes Staehelin – Office Director
Fiona Tummon – Scientific Officer
Carolin Arndt – Science Communication Officer
Petra Bratfisch – Office Manager
Diane Pendlebury – Project Scientist

Vladimir Ryabinin – JPS Liaison

SPARC Community

- **"Whole atmosphere" approach**
- SPARC has always been a meeting place for traditional tropospheric climate science disciplines with upper atmospheric sciences.
- Term "**Whole Atmosphere**" used in upper atmosphere research (e.g. WACCM).
- ***Meaning for SPARC: Treating the Troposphere-Stratosphere as one system.***
- Links to upper atmosphere and ocean/surface processes.



[adapted from Jarvis, 2001]

Chemistry – Dynamics – Radiation – Volcanic Aerosols – Atmospheric Waves – Solar Fluxes – Chemical Transport – Deep Convection – High-altitude Cirrus

Publications

- SPARC biannual **Newsletter** (distribution ~2400)
- Quarterly SPARC **e-News** (new since May 2012, distribution ~750)
- 2013 **Annual Project Report** (2nd annual)
- **SPARC Reports**: Two new reports this year on

(1) Lifetimes of Ozone-depleting Gases

(2) Trace Gas and Aerosol Climatologies

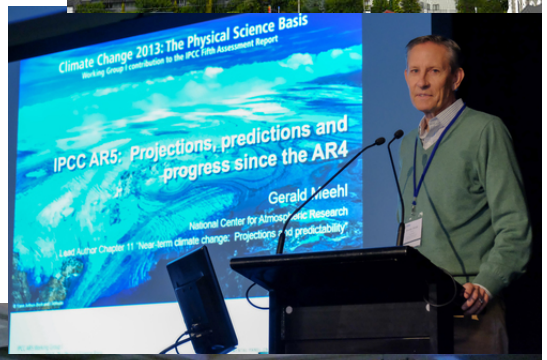
- Website **www.SPARC-climate.org** (>1000 users/mo.)

With science updates, news & calendar streams connecting WCRP, portal to SPARC Data Center now integrated.

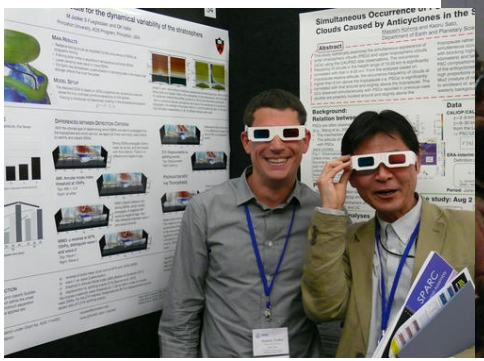
SPARC General Assembly

12-17 January 2014 Queenstown, NZ

- **Sessions:**
  - **Atmospheric Chemistry, Aerosols, and Climate**
  - **Stratosphere-Troposphere-Ocean Dynamics and Predictability of Regional Climate**
  - **Coupling to the Mesosphere and Upper Atmosphere**
  - **Observational Datasets, Reanalyses, and Attribution Studies**
  - **Tropical Processes**



- **Some science highlights…**



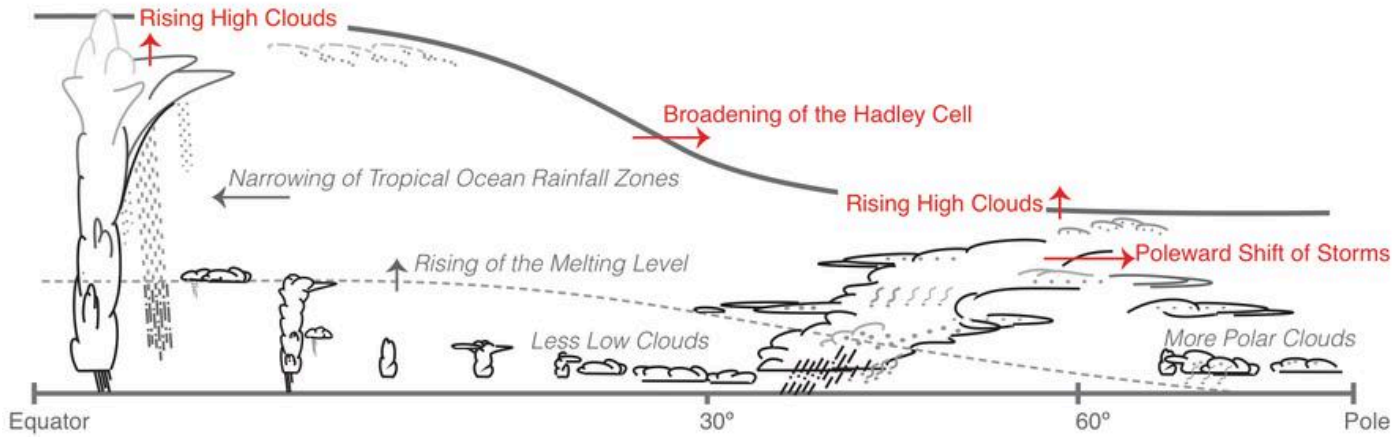
SPARC General Assembly Highlights

Cloud Feedbacks in Transient Climate Response

Presentation of Steven Sherwood

◆ = positive feedback contribution

◆ = ambiguous feedback contribution

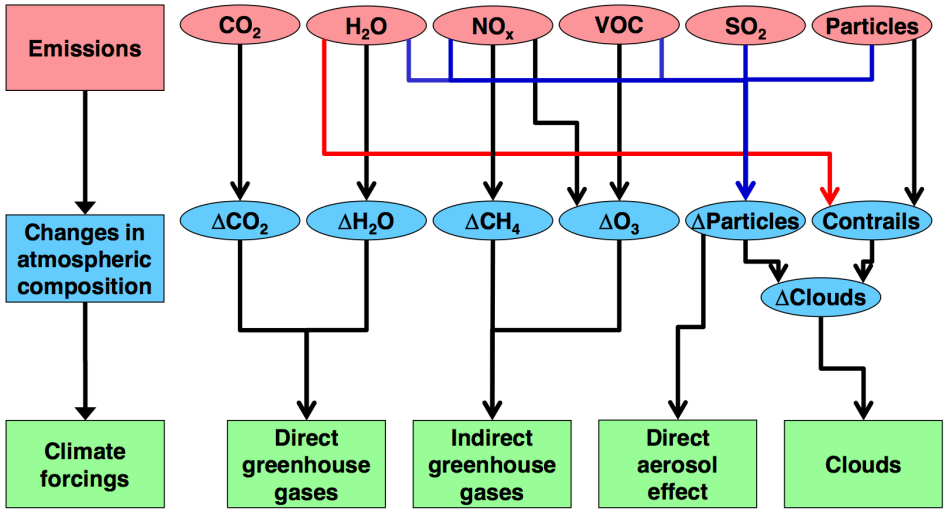


- Summarized robust and non-robust cloud feedbacks in GCMs and dynamical/thermodynamic control mechanisms
- "Cirrus feedbacks remain a wild card [in climate sensitivity] that need more attention"
- Puts a focus on tropical tropopause layer cirrus and dynamical controls that may involve the stratosphere.

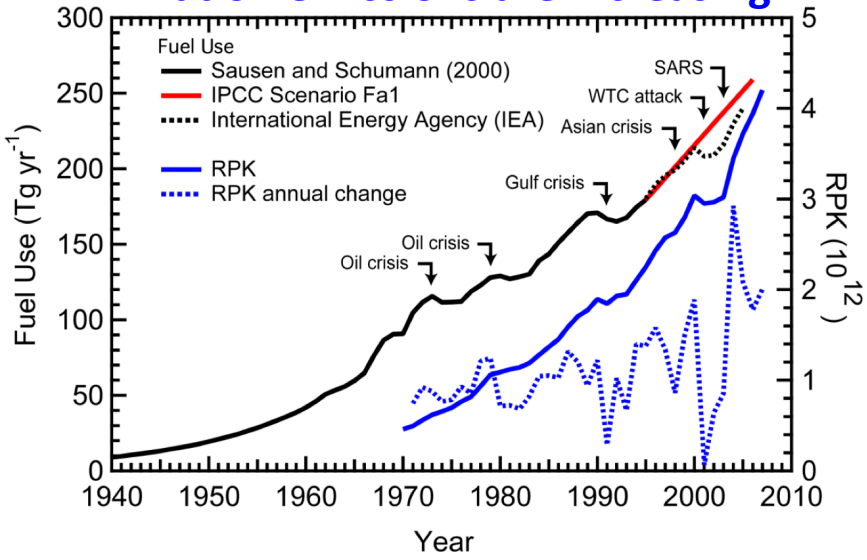
SPARC General Assembly Highlights

Aviation Effects on Climate

Atmospheric effects of emissions from aviation



Aviation emissions are increasing…



Radiative forcing from all aviation effects contributes about 5% to the total anthropogenic radiative forcing. -- *R. Sausen*

Contrails and contrail cirrus

SPARC General Assembly Highlights

"Stratosphere is important in many sources of predictability"

Presentation by Doug Smith

Seasonal:

- Stratospheric sudden warmings (SSW) and predictability of NAM.
- Stratospheric pathway for ENSO influences at high latitude.

Interannual: Quasibiennial oscillation (QBO) in tropical stratospheric winds gives predictability for the NAO.

Decadal:

- Solar cycle: NAO response lags solar max by 3-4yr involving stratosphere-ocean coupling.
- Multidecadal variability in Atlantic currents driven by variability in SSW

SPARC General Assembly Highlights

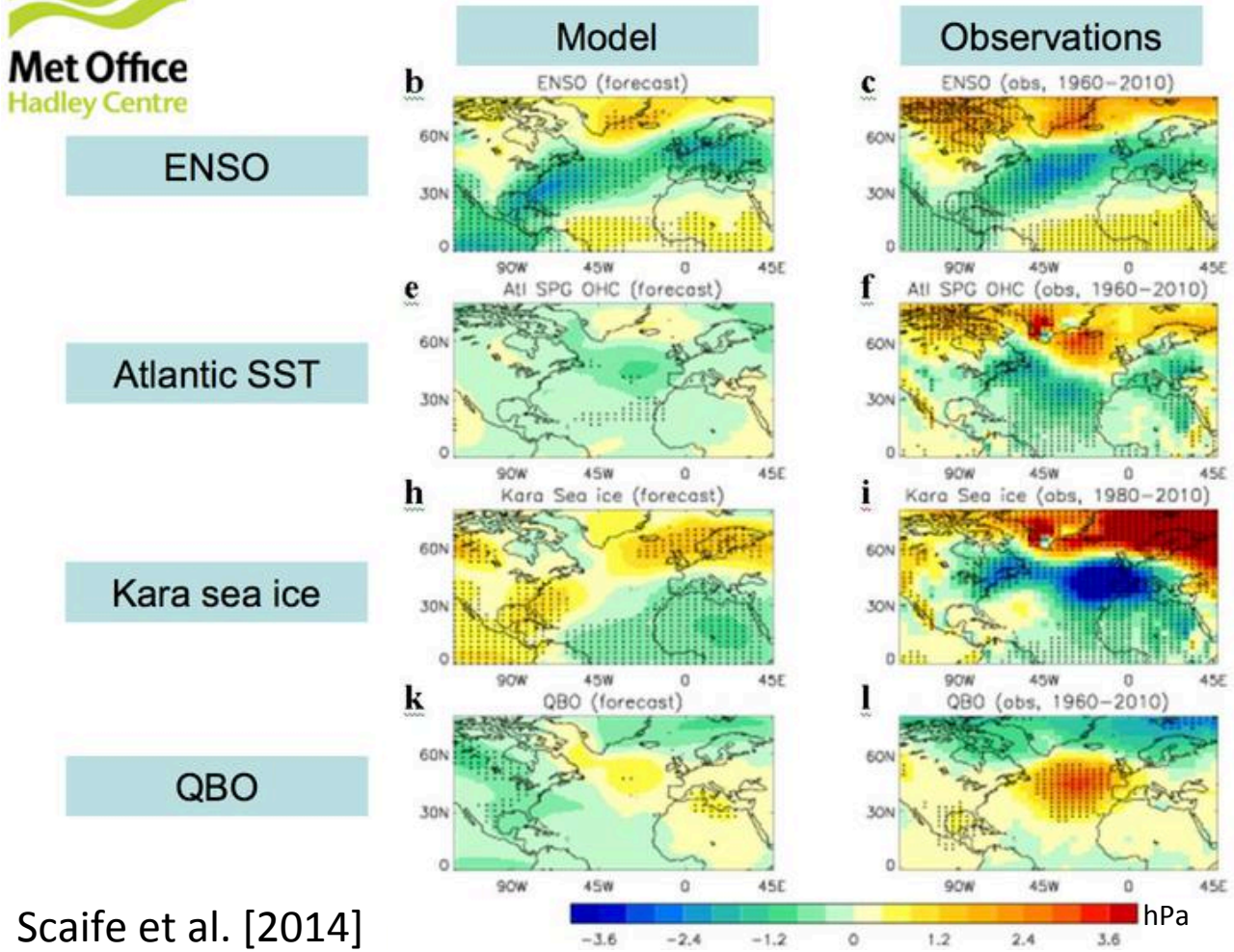
"Emerging evidence that NAO is highly predictable a month ahead" – *D. Smith*

Results from Scaife et al. [2014] shows correlation = 0.62 "highly predictable"

This skill requires deep atmosphere coupling with the ocean and sea ice.

NAO sources of skill

Met Office Hadley Centre



Scaife et al. [2014]

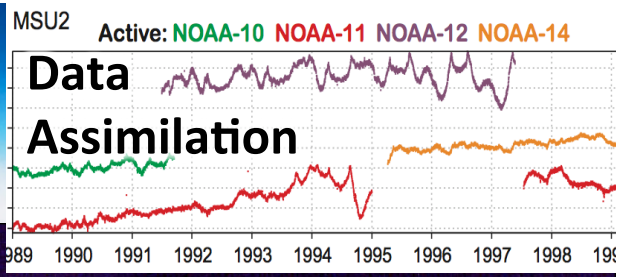
SPARC Scientific Steering Group Members

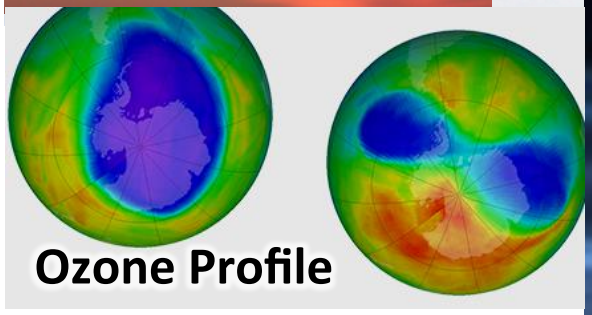
Joan Alexander – USA
Julie Arblaster – Australia
Mark Baldwin – UK
Greg Bodeker – New Zealand
Veronika Eyring – Germany
Edwin Gerber - USA
Thando Ndarana – S. Africa

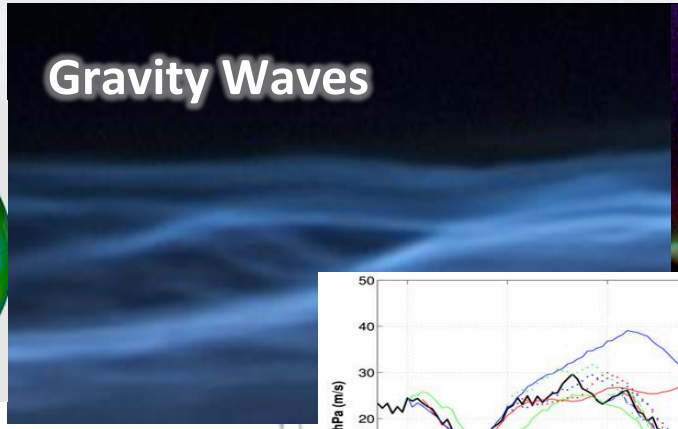
Kusuma Rao - India
Michelle Santee - USA
Kaoru Sato - Japan
Adam Scaife - UK
Martin Schultz - Germany
Seok-Woo Son – S. Korea

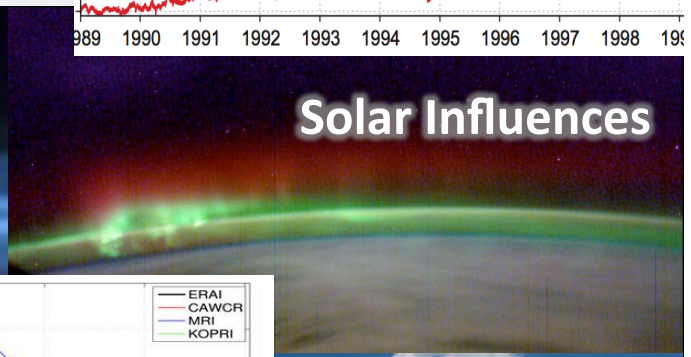
SPARC Activities

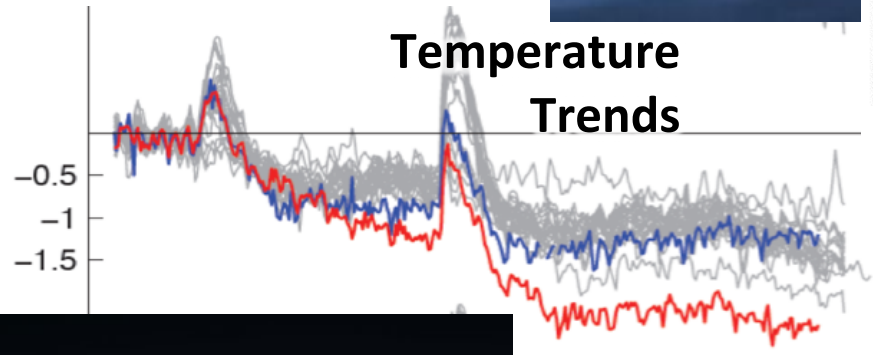
Trace Gas Climatologies

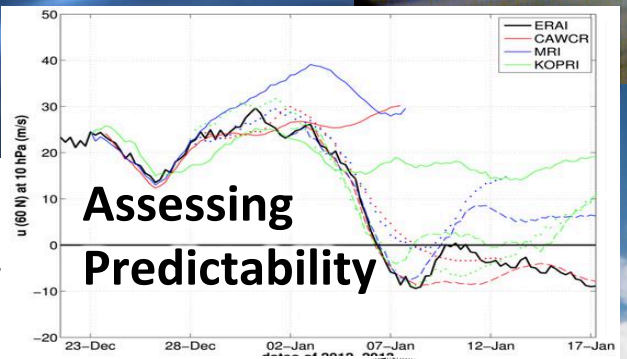


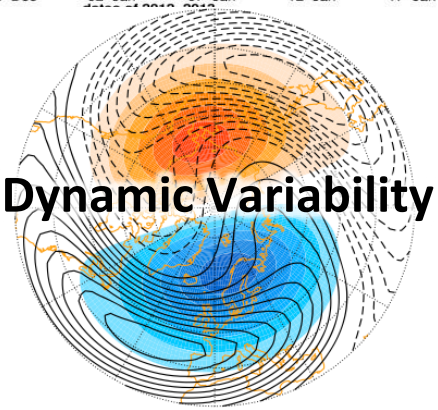


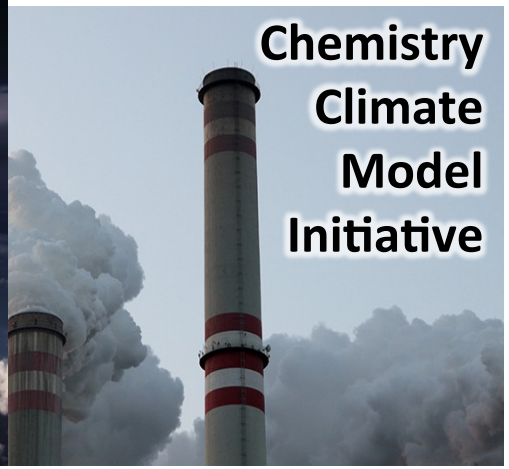












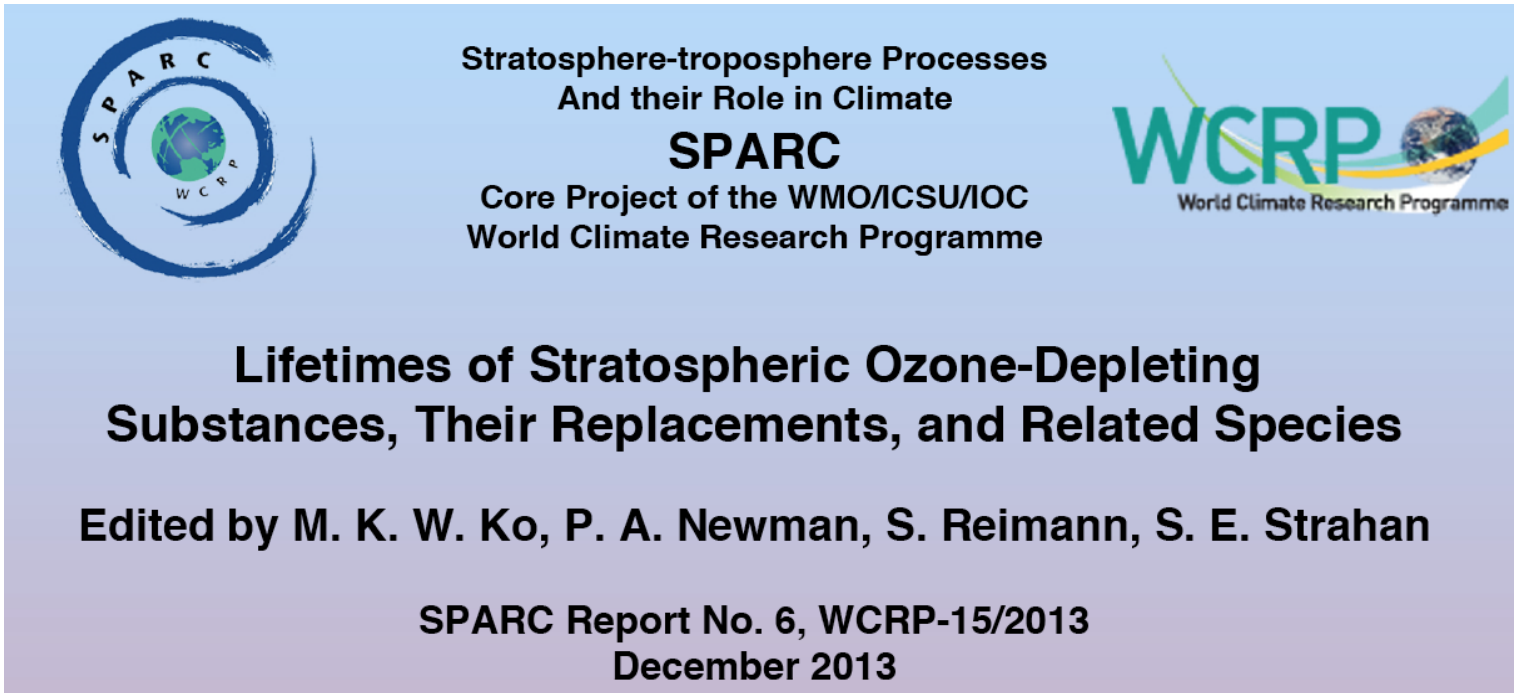
S·RIP

SPARC
Reanalysis Intercomparison Project

SPARC Lifetimes Activity

The latest SPARC Report: a community effort!

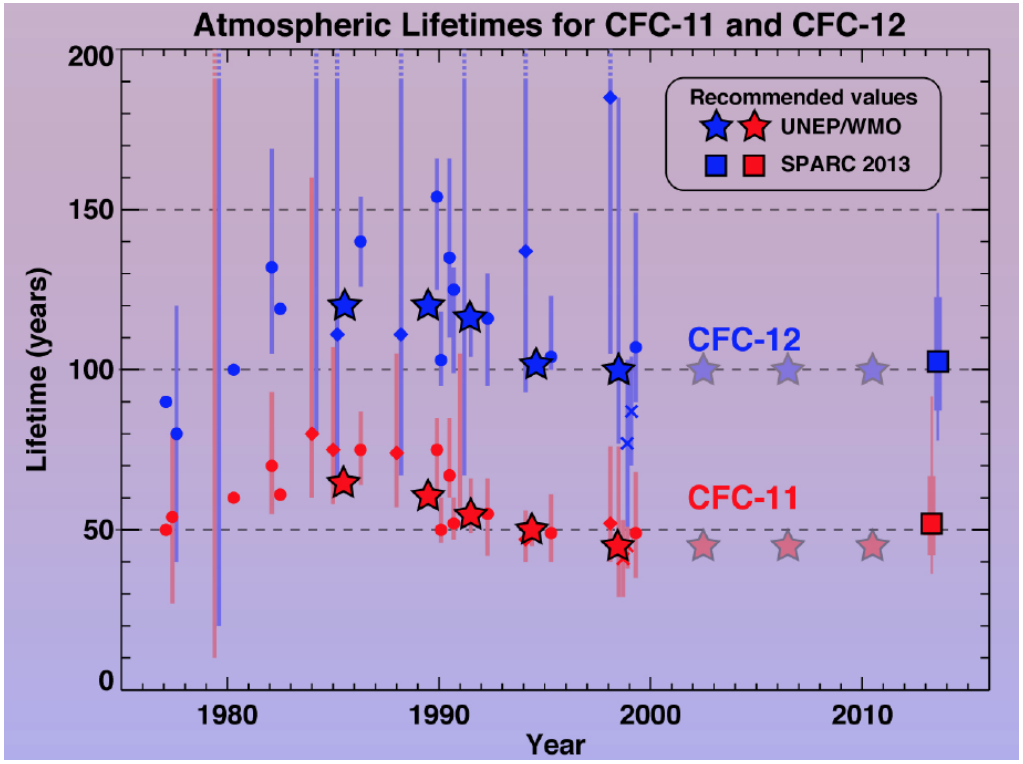
- 12 Lead Authors across 6 chapters, 40 co-authors, 10 Principal Reviewers, 30 other reviewers
- Completed in just under two years; several journal publications
- **Designed to support the 2014 WMO/UNEP Ozone Assessment**



SPARC Lifetimes Activity

- **Lifetimes of ODS and related species had not been updated for nearly 20 years, but were increasingly being questioned**
- **Report considered recent developments in theoretical understanding, new measurements, and state-of-the-art modelling**

Report is cited 24 times by Source Gas chapter of WMO (2014) and 28 times by Scenarios chapter, as well as providing several critical tables



SPARC Ozone Profile Phase II
SI²N

- Experience with open access publication of activity reports and datasets

- **SI²N** is a common activity supported by SPARC, IOC (International Ozone Commission), IGACO-O_3/UV (GAW) and NDACC (Network for Detection of Atmospheric Composition Change) dealing with vertical ozone profile changes relevant to documentation of the effect of the Montreal Protocol.
- **Results are being published in the peer-reviewed literature as a special issue organized between several open-access journals.**

  "Changes in the vertical distribution of ozone – the SI2N report"

  http://www.atmos-chem-phys.net/special_issue284.html

The SI²N Initiative - Reporting of results

(also see: http://igaco-o3.fmi.fi/VDO/index.html)

SI²N summary papers
ACP/AMT/ESSD special issue

Measurements	**Validation**	**Analysis & Interpretation**
Lead	*Lead*	*Lead*
B. Hassler (NOAA)	*J-C. Lambert (BIRA)*	*N.R.P. Harris (Cambridge)*

ACP/AMT/ESSD Special issue	**Other journals**
>40 research papers	*~5 papers*

http://www.atmos-chem-phys.net/special_issue284.html

Chemistry Climate Model Initiative – CCMI

A joint activity with IGAC

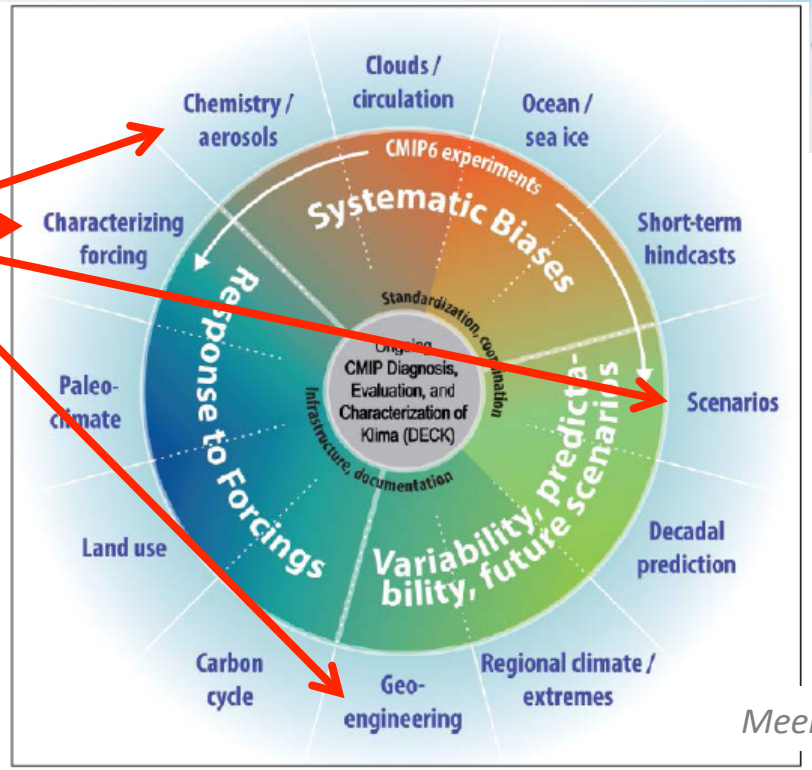
Improve process-level understanding & support ozone and climate assessments:
Chemistry and dynamics of the stratosphere and troposphere modeled as a single system for ozone, anthropogenic emissions and climate impacts and feedbacks.

2014 Update

- Veronika Eyring (former co-chair) has stepped down to lead CMIP6 panel.
- Co-leads Michaela Hegglin (U Reading) and Jean-Francois Lamarque (NCAR)
- Phase I in progress:
  - Data archive at BADC allows modelers to link their simulation data via their own ESGF nodes. Use of ESGF greatly reduces data storage needs at BADC. (Some struggles for smaller university participants to produce ESGF compliant formatted data without additional resources.)
- CCMI Workshop 20-22 May 2014 in Lancaster, UK; 130 participants
- Developing close ties with AeroCom = Aerosol Comparisons btw Obs & Models

CCMI Contributions to CMIP6

Contributions from CCMI



Meehl et al., EOS 2014

- **Forcings:** Update ozone, stratospheric aerosol, and nitrogen deposition databases.
- **Geoengineering:** Contribute simulations that incorporate full chemistry and hence impact on ozone with regional climate aspects.
- **Scenarios:** CCMI simulations to include new Global Emissions InitiAtive (GEIA) emission databases to support database validation.
- **Chemistry/aerosol:** Link with AeroCom and preparing a proposal for CMIP6, emphasizing aerosol-chemistry interactions and their impact on climate (AerChemMIP)
- Also: SPARC contribution with AIMES to 'Theme of collaboration on biospheric forcings' through the IGAC/SPARC CCMI and in collaboration with AeroCom.

SPARC SNAP Activity

SNAP: Assessment of Predictability of major stratospheric events (e.g. SSW)

- Stratosphere-troposphere dynamical coupling is a source of predictability.
- Process-level understanding leads to model improvements.

2014 Update

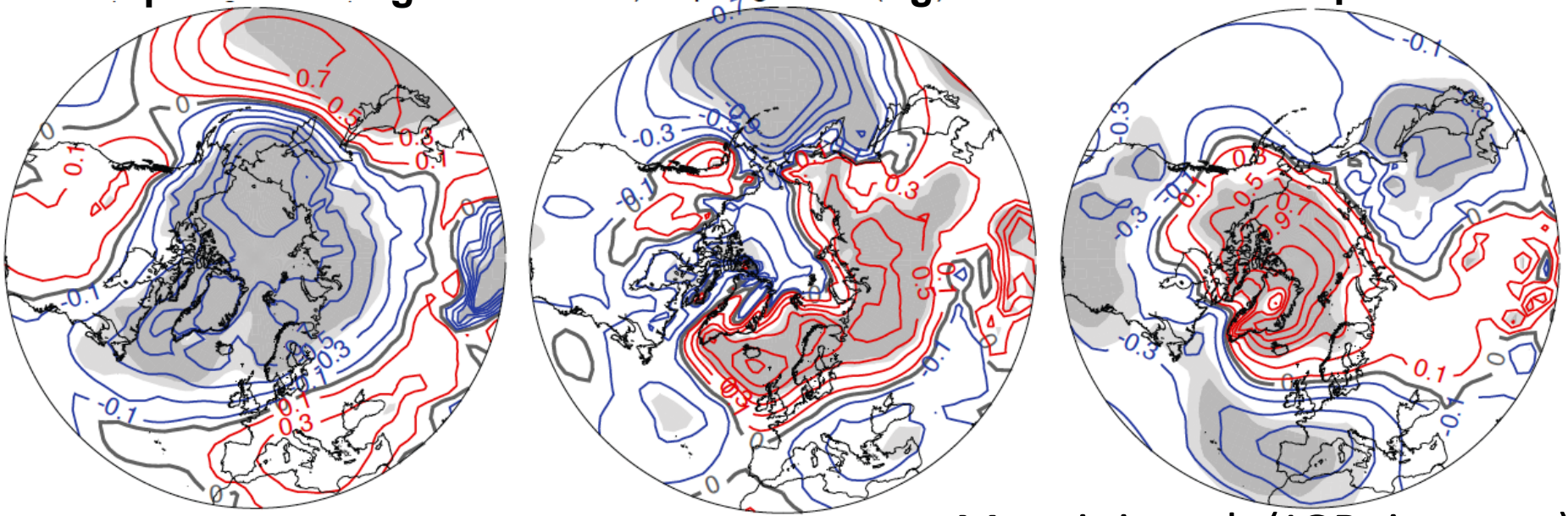
- Connection between **SNAP** (Andrew Charleton) and **S2S** (Frederick Vitart) leadership established (S2S=subseasonal to seasonal prediction)
- SNAP developing close ties to S2S both to make effective use of the S2S experimental data and also pass results related to the stratosphere back to centers that make monthly forecasts.
- SNAP project manager presented at the S2S International Conference on Subseasonal to Seasonal Prediction in College Park, Maryland, 10-13 February 2014:

  Presentation by Om Tripathi (U. Reading): The Stratospheric Network for the Assessment of Predictability (SNAP)
- Ongoing discussions with S2S are an important part of the SNAP Implementation Plan.

SPARC DynVar
Dynamical Variability

- DynVar analysis of CMIP5 simulations suggests GHG-induced changes in wintertime Arctic sea-level pressure are affected as much by changes in the stratospheric polar vortex as by tropical upper tropospheric warming or by Arctic surface warming
- Response to stratosphere is NAO-like and opposite in sign to that from tropical warming, consistent with Scaife et al. (2012)

Tropical warming | **Arctic warming** | **Stratosphere**



Manzini et al. (JGR, in press)

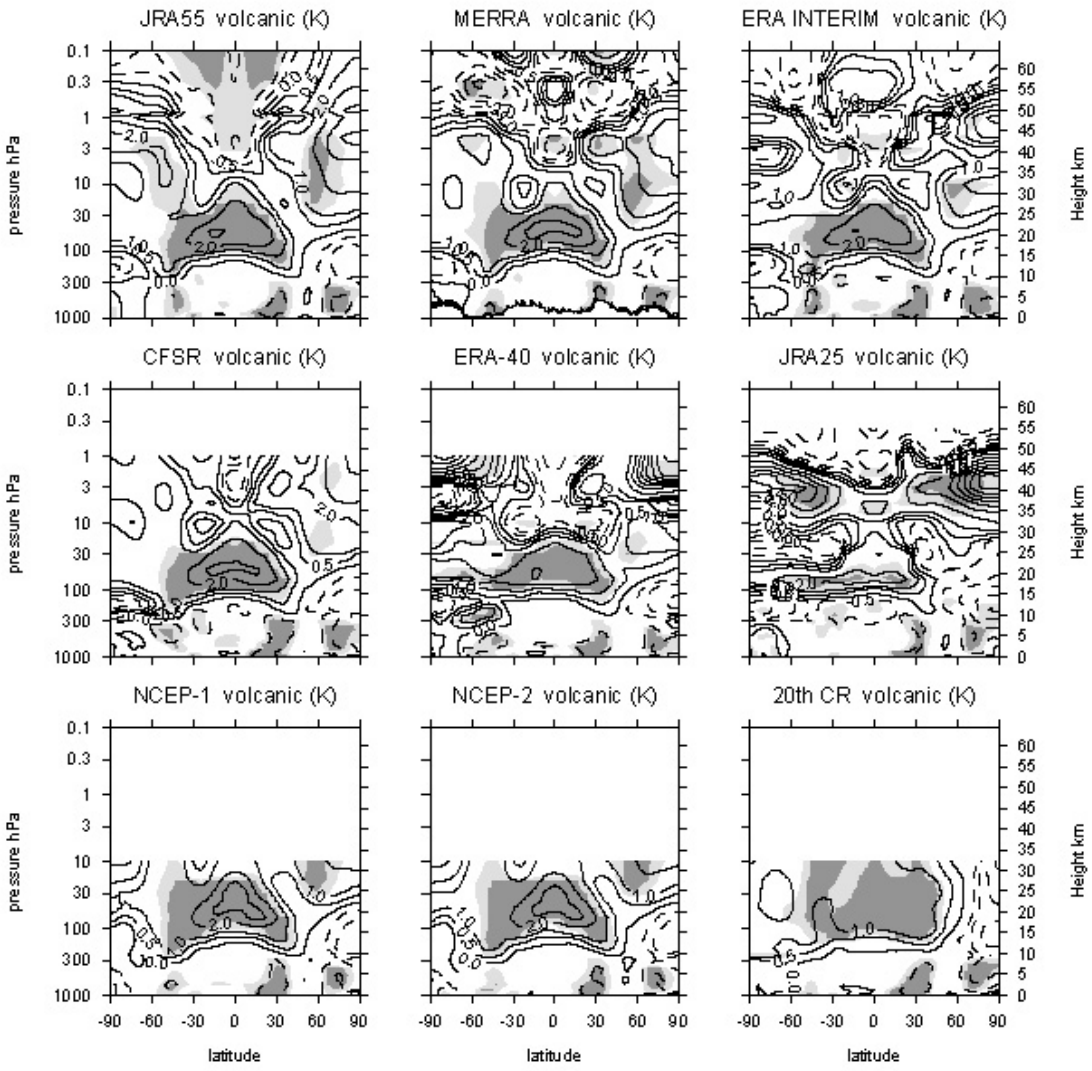
SPARC Reanalysis Intercomparison Project S-RIP

First Results

Volcanic signals

- **Annual temperature response to volcanic eruptions for each of nine reanalyses (Pinatubo standard)**
- Additional results on ENSO, QBO, Solar cycle

Mitchell, D.M. et al. [2014] submitted to QJRMS: "Signatures of natural variability in the atmosphere using multiple reanalysis datasets"



Preview: Planning for a new SPARC Implementation Plan

✧ Themes:

▪ Chemistry in Climate

- Understanding the interactive role of atmospheric chemistry in the climate system demands both new and continuing observations along with chemistry-climate model development and validation.
- *Coupled models with interactive chemistry are increasingly utilized for climate change assessment.*

▪ Atmospheric Circulation in Climate

- Theoretical and observational studies of dynamics and variability of the atmosphere underpin the science of climate responses such as shifting regional patterns and the likelihood of extreme events.
- *Changes in atmospheric circulation are a key uncertainty in climate prediction.*

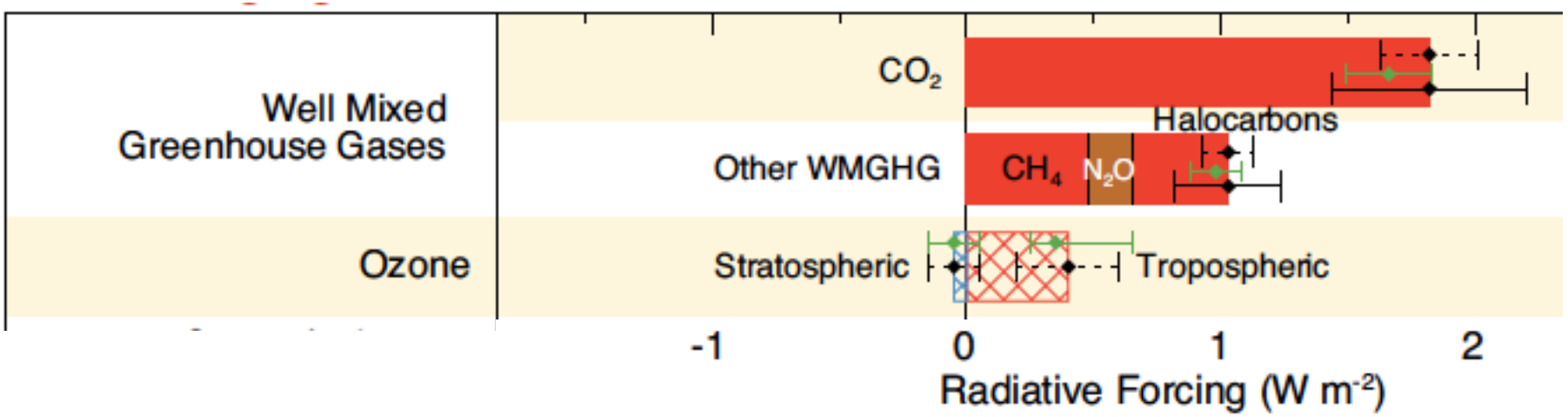
▪ Long-term Records for Climate

- Understanding and detecting climate change requires a dedication to *creating, analyzing and interpreting ground-based and satellite observations.*

Chemistry in Climate

Stratospheric and Tropospheric Ozone

- The traditional approach to radiative forcing separated ozone changes into their stratospheric and tropospheric components (implicitly attributed to halocarbons and to tropospheric ozone precursors)
- This makes the stratospheric contribution look tiny (below)
- **However it is now appreciated that halocarbon-induced ozone depletion also affects the upper troposphere…**

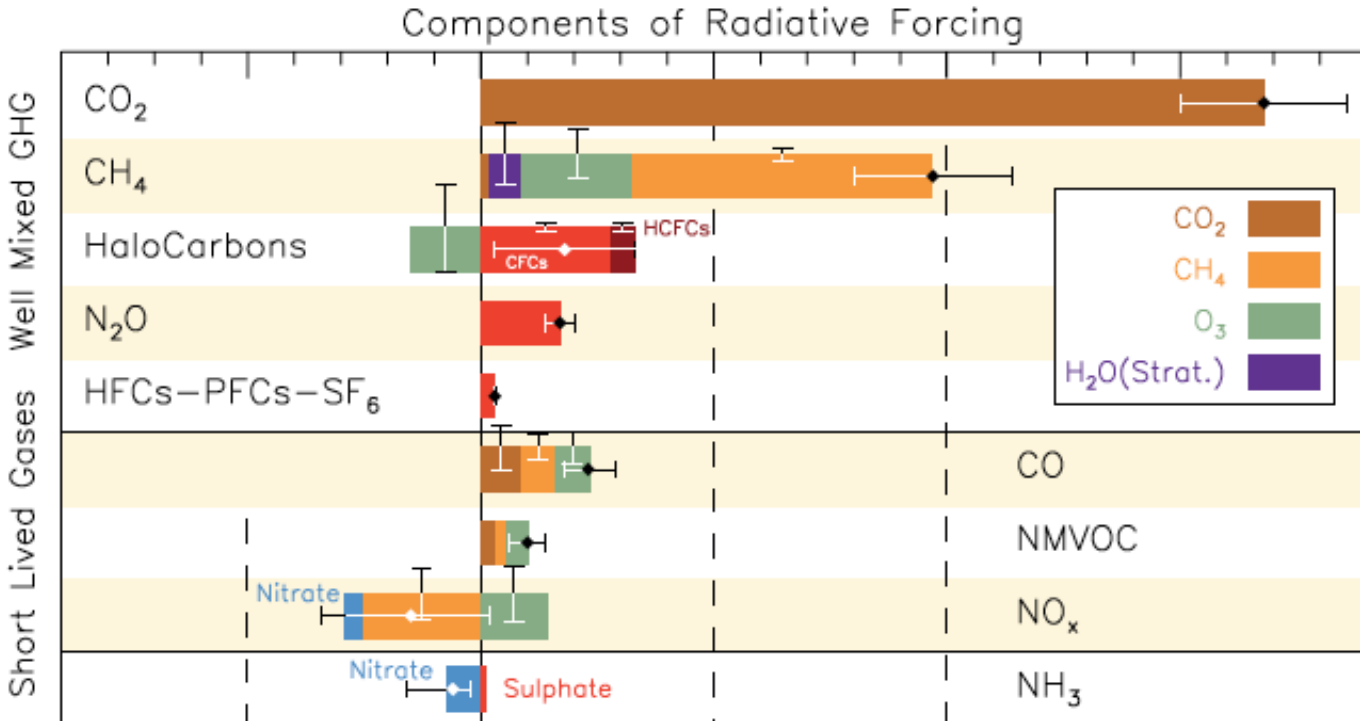


From Technical Summary of IPCC WGI AR5 (2013)

Chemistry in Climate

Stratospheric and Tropospheric Ozone

- The "modern" view of radiative forcing attributes it to drivers rather than to the concentrations of the different gases, which now makes the halocarbon-induced ozone effect much larger
- It is clear that ozone changes must be studied using models representing both tropospheric and stratospheric ozone



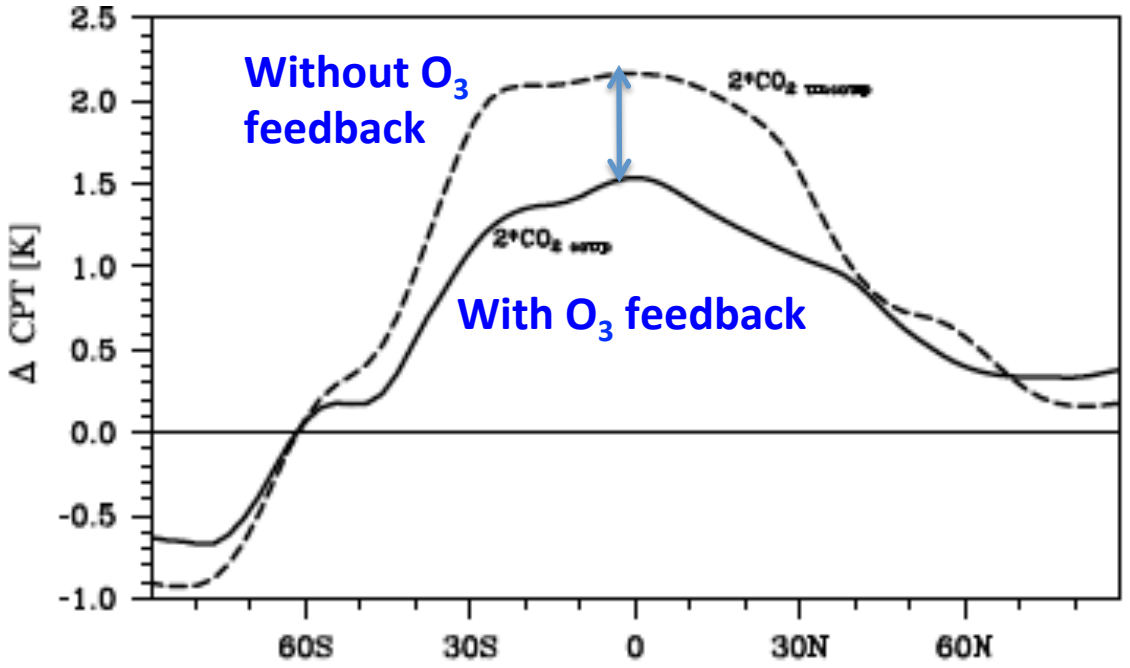
From Technical Summary of IPCC WGI AR5 (2013)

Chemistry in Climate

Radiative Feedbacks w/Coupled Chemistry

- The ozone feedback from strengthened tropical upwelling under climate change reduces tropical tropopause temperatures
- Potentially significant impact on RF via reduction in stratospheric water vapor

Change in cold-point temperature (CPT)



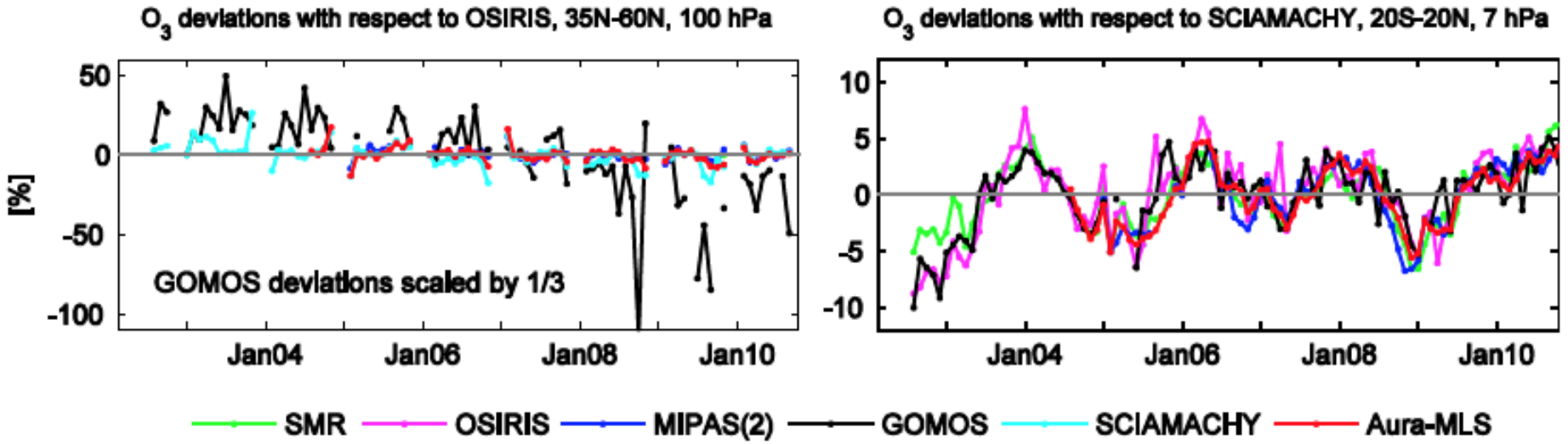
Dietmüller et al. (2014 JGR)

Long Term Records for Climate
SPARC Data Initiative

Brings together teams from limb-viewing instruments for a top-down evaluation of data quality and stability

- A SPARC Report will be published this year
- JGR special issue: 4 papers published, 4 in the works

Example: ozone shows consistency between instruments in midlatitude lower stratosphere except for GOMOS (left), and in tropical mid-stratosphere except for SCIAMACHY (right)



Tegtmeier et al. (2013), used in Global Ozone chapter of WMO (2014)

Long Term Records for Climate
SPARC Temperature Trends Activity

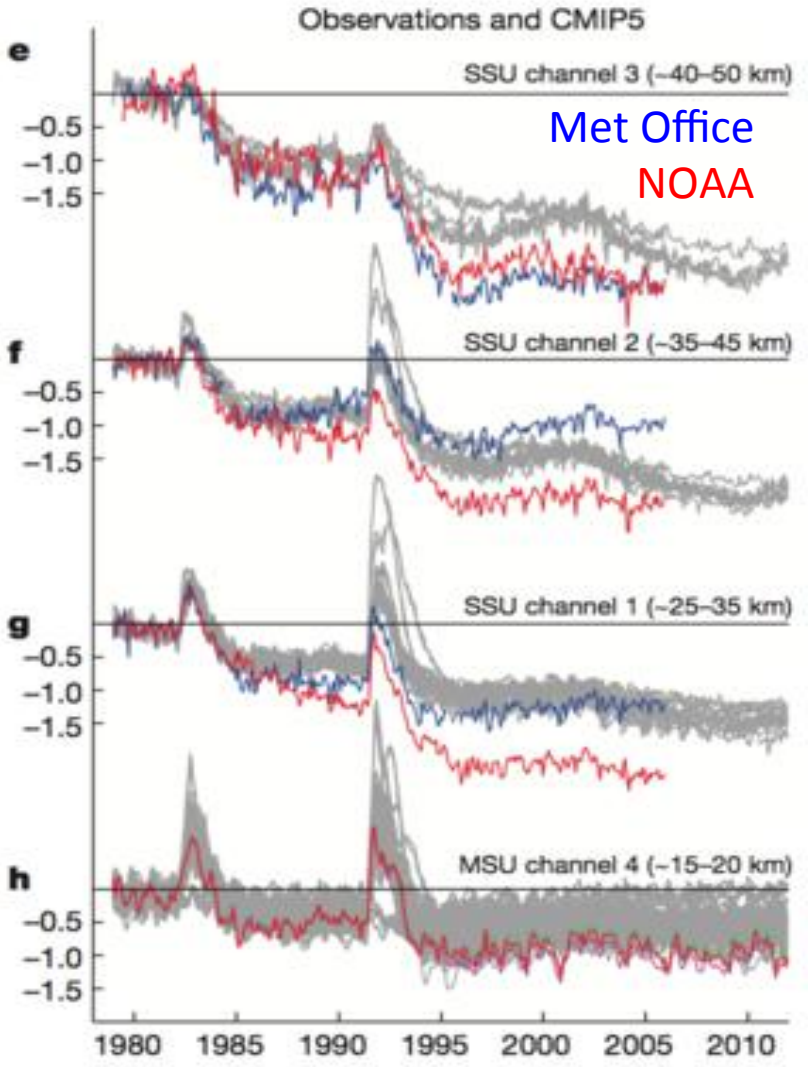


Figure from Thompson et al. 2012: "The Mystery of Recent Satellite Temperature Trends"

2014 Update

- September 2013 Workshop in Reading
- Papers submitted describing both groups' dataset construction/methodology
- New versions do not resolve the "mystery" of the discrepancies
- Gaps in the satellite record are the likely origin of the discrepancies
- Next focus on comparisons to other observations of stratospheric temperature changes during this period of the satellite record

Atmospheric Circulation in Climate
Ongoing and new activities

- **Ongoing activities: DynVar, SNAP, Gravity Waves, SOLARIS**
- **GC on Clouds, Circulation, and Climate Sensitivity**
- WGCM-led Grand Challenge with GEWEX/SPARC collaborations
- Key questions/initiatives emerged from the recent Ringberg workshop in March 2014:
  - ***How will storm tracks change in a future climate?***
  - ***What controls the position and strength of tropical convergence zones?***
  - ***Is convective aggregation important for climate?***
  - ***Does convection determine the strength of cloud feedbacks?***
- SPARC leadership on the Storm Tracks initiative: workshop planned for August-September 2015
- SPARC supporting Chapman Conference on “Widening of the Tropical Belt” July 2015

Atmospheric Circulation in Climate 2015 Workshop Plans

"Storm Tracks, Jets, and their Modes of Variability"

- **Goal: Review recent advances on the dynamics and address key questions related to the regional response to climate change.**
- **Co-Conveners: Tiffany Shaw and Mark Baldwin**
- **Coordination with GC on Clouds, Circulation & Climate Sensitivity and other WCRP projects**
- Proposed Scientific Organizing Committee (weighted toward early career) Tiffany Shaw, Mark Baldwin, Gwendal Riviere, Camille Li, Elizabeth Barnes, Ed Hawkins, Aiko Voigt, Yen-Ting Hwang, Chaim Garfinkel, Paul O'Gorman, Isla Simpson, Carolina Vera
- Planning 60-80 participants
- ~August-September 2015

Atmospheric Dynamics Initiatives
New Meetings: Relation to GCs

- **Cross-cutting Latsis Symposium** – Zurich, June 2014
- Tapio Schneider & Yohai Kaspi, Co-conveners
- ***Goal****: Improved understanding of the dynamical processes shaping climate, and their interactions across an enormous range of scales: from the micrometer scales of cloud droplet formation to the global scales of atmospheric circulations*
- SPARC-CLIVAR-GEWEX cosponsorship: brought young scientists to this interdisciplinary workshop that addresses key goals of the GCs
- ***Themes and Invited Lectures:***

Dynamics of Past Climates: Mark Cane, Eli Tziperman

Tropical Climate, Clouds, Convection*:* Chris Bretherton, Brian Mapes, Adam Sobel, Bjorn Stevens

Extratropical Climate and Large-scale Dynamics: Clara Deser, Dennis Hartmann, Isaac Held, Brian Hoskins, Ted Shepherd

Topical lectures*:* Monsoon dynamics (William Boos), Polar Climate dynamics (Rodrigo Caballero), Tropical precipiation extremes (Caroline Mueller), Modeling the MJO (David Randall), Regional climate dynamics (Tiffany Shaw)

Other Atmospheric Dynamics Initiatives

- WGNE Surface Drag Project: Preliminary focus on NWP models. Expanded focus to include climate models
- SPARC Gravity Wave Activity Momentum Budget project and coordination with WGNE
- New DynVar initiative on modelling the Quasi-Biennial Oscillation (QBOi)

Is there a WCRP Programmatic Gap in Atmospheric Dynamics?

- SPARC: Atmospheric momentum budget
- GEWEX: Energy and moisture budget
- CLIVAR: Air-Sea exchanges
- CliC: Cryosphere-atmosphere interactions

- Gaps are being filled by cooperation through topical meetings and particularly through work on the Grand Challenges.

Other Connections

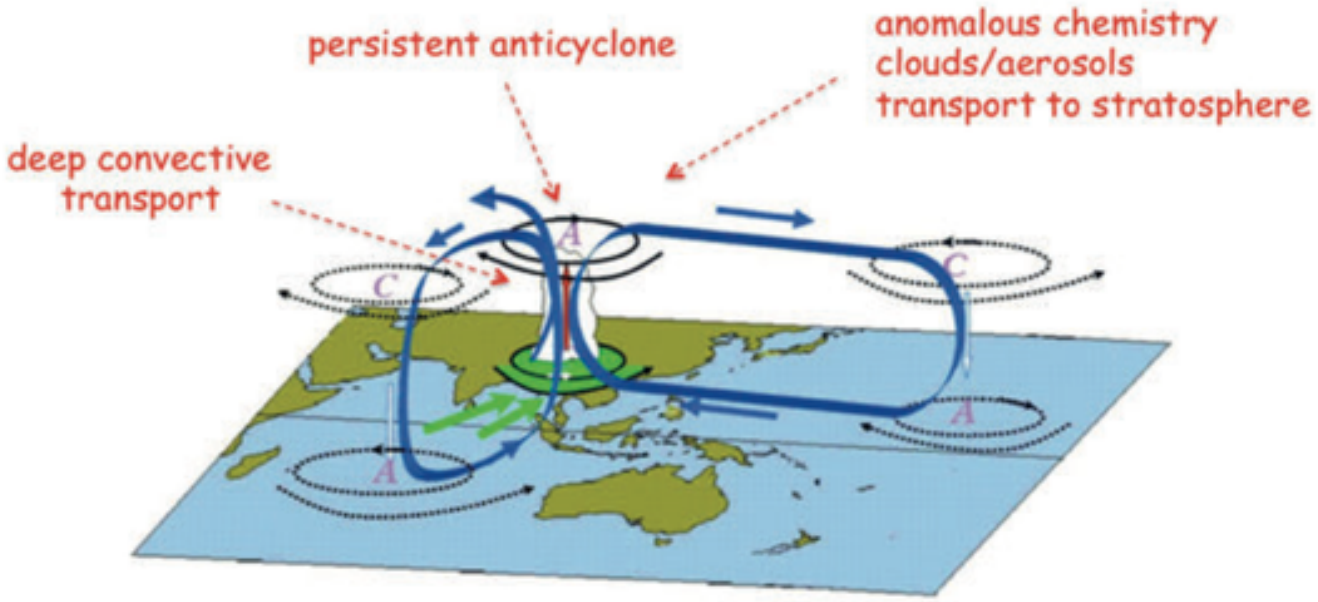
Engagement with FE Partner IGAC
SPARC-IGAC Joint Activities

SPARC partners with **International Global Atmospheric Chemistry (IGAC)** on two current projects, and one proposed:

- **CCMI** = Chemistry-Climate Model Initiative
- **ACAM** = Atmospheric Chemistry and the Asian Monsoon (emerging activity)
- New FE Fast-Track Initiative proposal for a Community Emissions Data System for aerosols and precursor compounds. ("Open-source" concept for historical emissions data.)

Aerosols in regional climate

- SPARC-IGAC “Emerging Activity”: Atmospheric Chemistry and the Asian Monsoon (ACAM)
- Includes a focus on Aerosols, Clouds, and their interactions with the Asian monsoon



Aerosols and Chemistry
AerChemMIP

A new joint initiative of SPARC-IGAC CCMI and AeroCom

- Motivation:
- Address shortcomings of CMIP5 wrt composition (aerosols and ozone)
- Chemistry and aerosol model components are tightly linked
- Define metrics/diagnostics for composition evaluation
- Identify science questions and simulations for CMIP6
- AerChemMIP can provide a single entity to interact with CMIP6 on composition issues including emissions and forcing estimates
- Participation in the AGCI meeting in Aspen, August 2014
- Dedicated workshop planned for fall 2015

Main contributors (so far):

Olivier Boucher, Veronika Eyring, Jean-François Lamarque, Michaela Hegglin, Gunnar Myhre, Michael Schulz, Drew Shindell

AerChemMIP work topics in support of CMIP6

- Interest in having scenarios to look at impacts of SLCFs.
- Other scenarios of interest? Natural gas/methane for power generation?
- Understand trends in composition
- Role of natural aerosols, aerosol-chemistry coupling, other feedbacks
  (Organic, Fires, Dust & Seasalt, OH, Radiation, Dynamics)
- Usage of observational constraints to bracket projections
- Relationship between regional forcing and climate response
- Documentation of composition, forcings and feedbacks in CMIP6
- Provide link to detailed modelling in CCMI & AeroCom
- Propose aerosol and ozone climatology fields for high resolution climate modeling

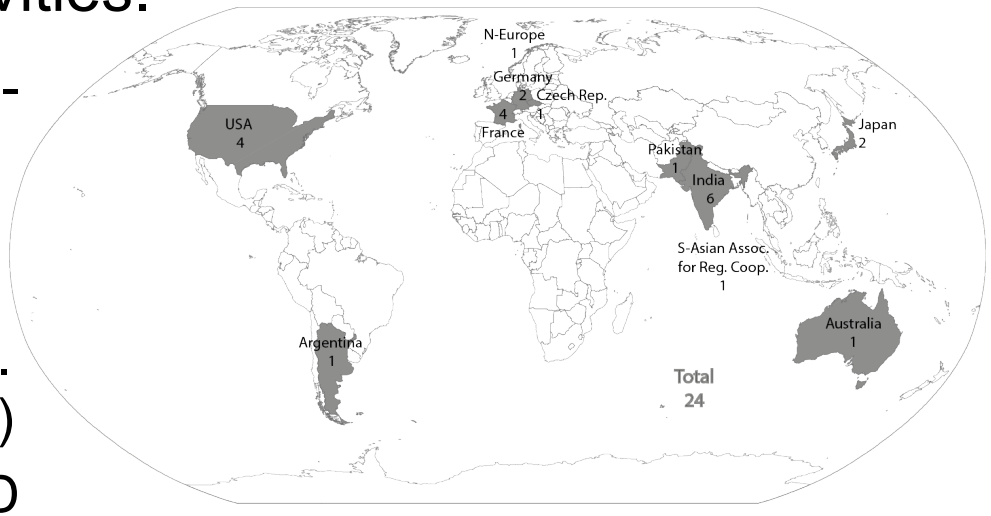
Capacity Development

Work plan in 2014

Thando Ndarana (leader), **Seok-Woo Son** (supporting leader),
Carolin Arndt (SPARC Office support)

I. Community survey in progress to identify SPARC-related country/regional activities.

- New insights on regional SPARC-related activities; institutions involved; key scientists in the regions
- Regional scientific strengths (e.g. modeling, observations, analysis)
- Specific recommendations for CD (e.g. trainings, infrastructure support; improved international involvement)



10% responses so far

Capacity Development

Work plan in 2014

II. Organizing a 2-day workshop:

- Use survey outcome to provide information on capacities and needs
- Develop strategy, work/funding plan with regionally tailored solutions
- 10 participants incl. regional representatives and SPARC SSG
- Meeting format: short presentations & breakout sessions
- Develop CD program of action and roles and responsibilities
- Present the new strategy at the next SPARC SSG

Next SPARC SSG Meeting

- **13-16 January 2015 Instituto de Astrofísica de Andalucía (CSIC), Granada, Spain**
- Regional scientific workshop 12-13 January
- Capacity development workshop 10-11 January