SPARC Report

Quentin Errera (quentin@oma.be) Belgian Institute for Space Aeronomy (BIRA-IASB)

Thanks to Masatomo Fujiwara, Laura Pan and Scott Ospray

31st WGNE session, April 26-29, 2016

CSIR, Pretoria, South Africa

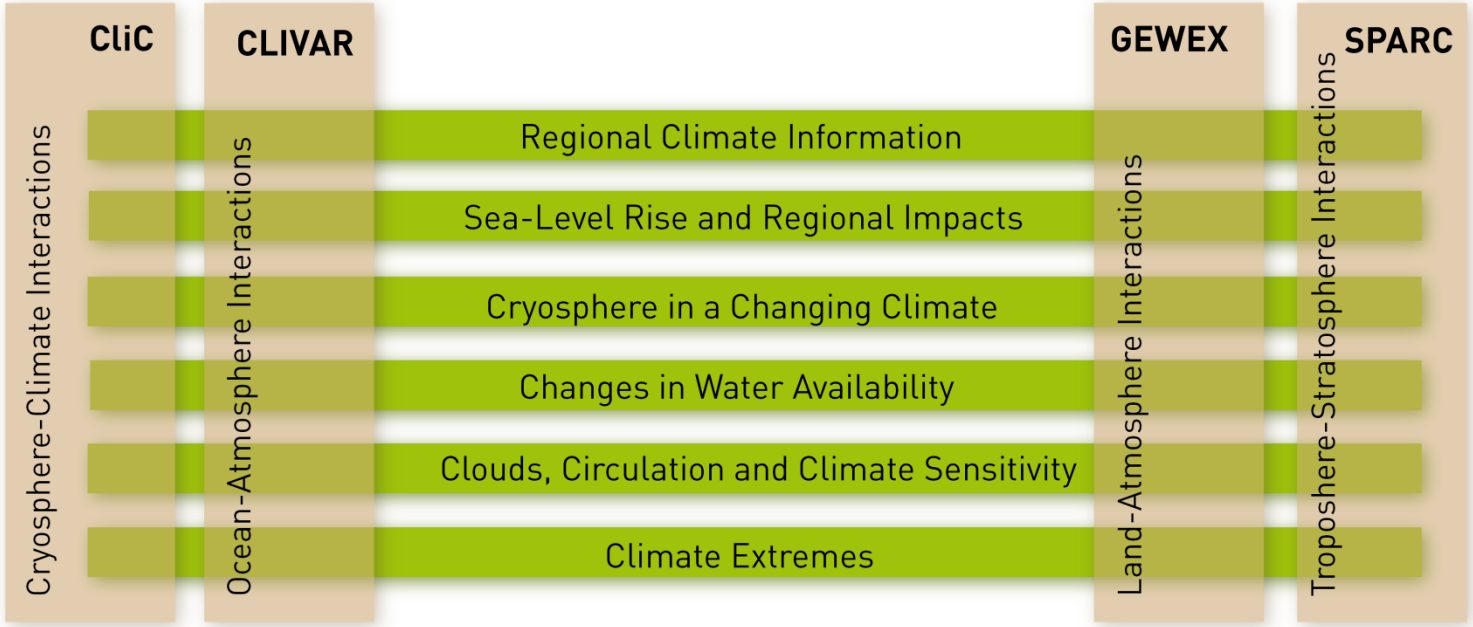
Stratosphere-troposphere Processes and their Role in Climate (SPARC)

WCRP Organization

Joint Scientific Committee | **Joint Planning Staff**

Modeling Advisory Council | **Data Advisory Council**

Working Groups on: Coupled Modelling (WGCM), Regional Climate (WGRC), Seasonal to Interannual Prediction (WGSIP), Numerical Experimentation (WGNE)

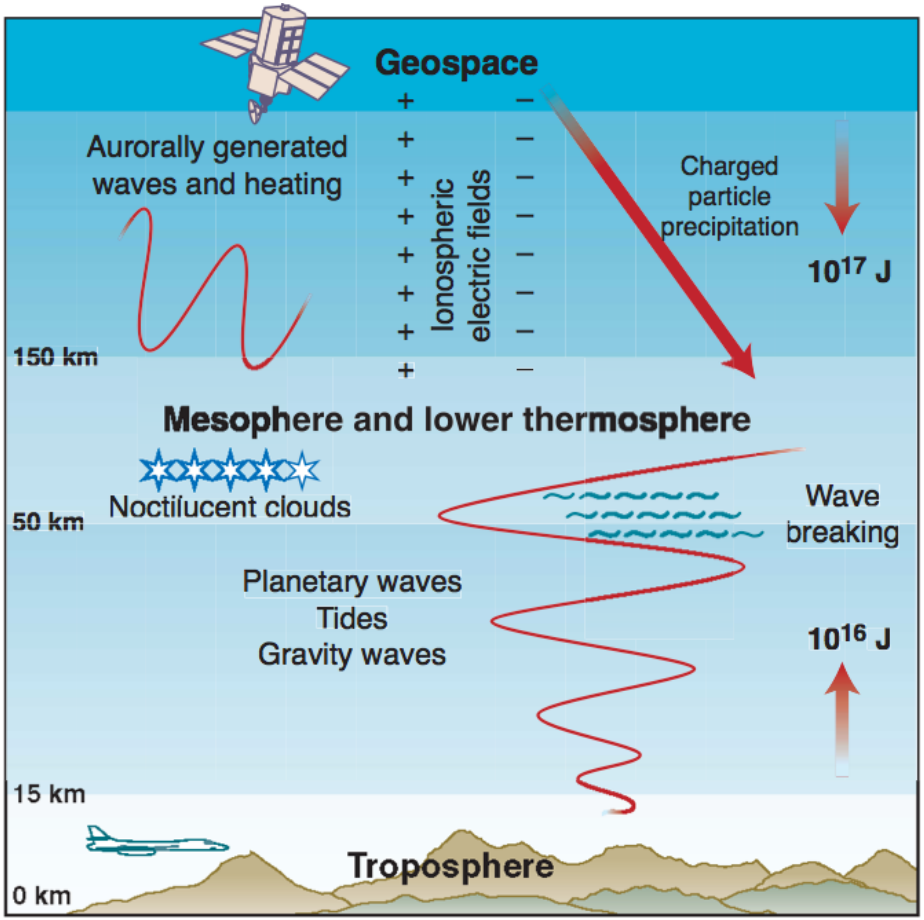


SPARC goals

- To promote and coordinate research on chemical and physical processes in the atmosphere and the interaction with climate and climate change
- Historically SPARC concentrated on the stratosphere but adopt a “Whole Atmosphere” approach
- SPARC contributes to policy-relevant global change research
  - WMO/UNEP Ozone Assessments in support of the Montreal Protocol
  - IPCC Reports in support of the UNFCCC

SPARC: a whole atmosphere approach

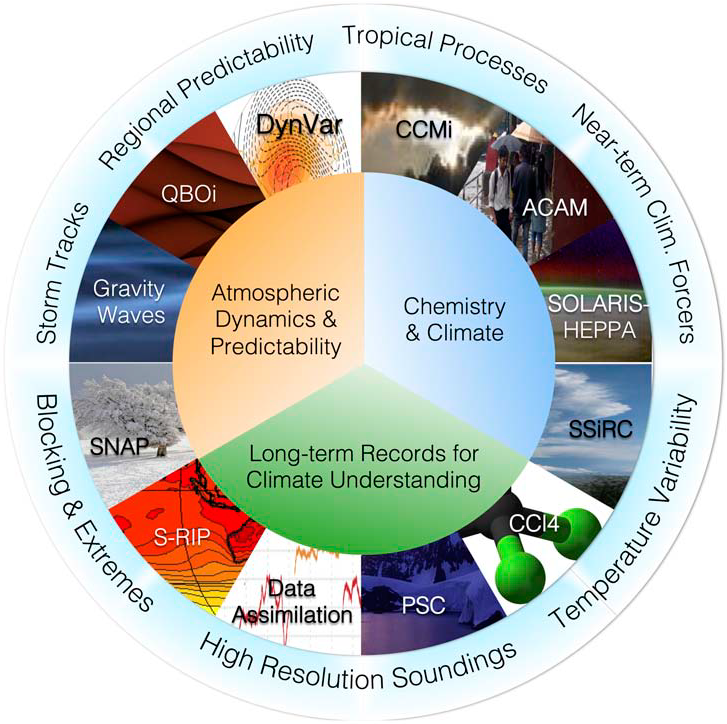
"**Whole Atmosphere**": *Treating the **Stratosphere-Troposphere** as one system.*



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

Schematic of SPARC organization

- 3 themes (inner circle)
- Activities (middle ring) in 2015
- The outer ring shows the areas in which new activities are being considered and the WCRP Grand Challenge topics in which SPARC is involved
- http://www.sparc-climate.org/



S-RIP: SPARC-Reanalysis Intercomparison Project

URL: http://s-rip.ees.hokudai.ac.jp/

Activity leaders:

- Masatomo Fujiwara (Univ. of Hokkaido, fuji@ees.hokudai.ac.jp)
- Gloria Manney (NWRA)
- Lesley Grey (Oxford university)

S-RIP

- Motivations: Atmospheric reanalyses are key climate data sets to understand processes and variability in the atmosphere
- The goals of S-RIP are to:
  - Create a communication platform between the SPARC community (middle atmosphere, UTLS, etc.) and the reanalysis centres
  - Understand current reanalysis products and contribute to future reanalysis improvements in the middle atmosphere region (including UTLS, strato-tropo coupling, etc.)
  - Write up the results of the reanalysis intercomparison in peer reviewed papers (e.g., in ACP special issue on "the S-RIP") and two SPARC reports

- S-RIP "interim" Report (2016), for the basic chapters
- S-RIP "full" Report (2018), for all chapters

S-RIP: Outline Plan for Report

	Chapter Title	Chapter Co-leads
1	Introduction	Masatomo Fujiwara, Gloria Manney, Lesley Gray
2	Description of the Reanalysis Systems	Jonathon Wright, Masatomo Fujiwara, Craig Long
3	Climatology and Interannual Variability of Dynamical Variables	Craig Long, Masatomo Fujiwara
4	Climatology and Interannual Variability of Ozone and Water Vapour	Michaela Hegglin, Sean Davis
5	Brewer-Dobson Circulation	Thomas Birner, Beatriz Monge-Sanz
6	Stratosphere-Troposphere Coupling	Edwin Gerber, Patrick Martineau
7	Extratropical UTLS	Cameron Homeyer, Gloria Manney
8	Tropical Tropopause Layler	Susann Tegtmeier, Kirstin Krüger
9	QBO and Tropical Variability	James Anstey, Lesley Gray
10	Polar Processes	Michelle Santee, Alyn Lambert, Gloria Manney
11	Upper Strato. Lower Mesosphere	Lynn Harvey
12	Synthesis Summary	Masatomo Fujiwara, Gloria Manney, Lesley Gray

Chapters 1-4: Basic chapters due in 2016

Chapters 5-11: Advanced chapters due in 2018

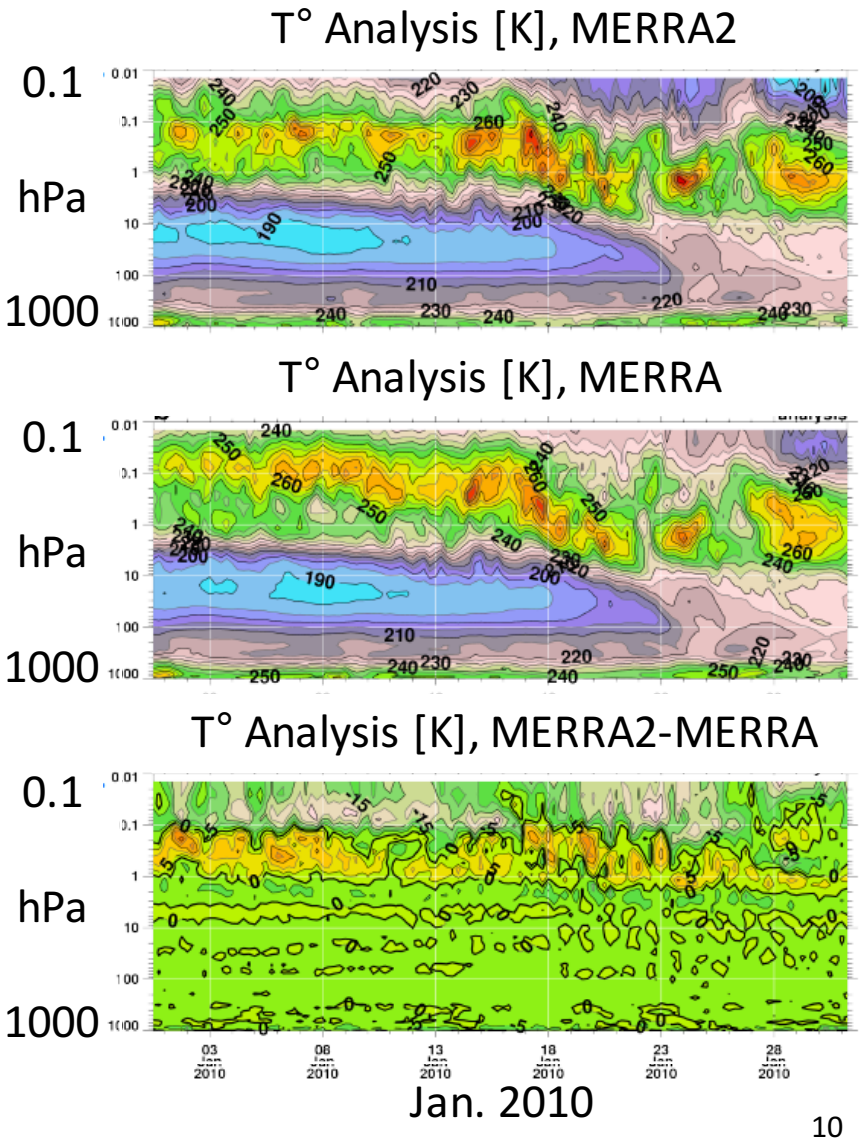
S-RIP participants

Reanalysis Centre	Products	Contacts for S-RIP
ECMWF	ERA-40, ERA-Interim, ERA-20C, [ERA5]	Rossana Dragani
JMA (& CRIEPI)	JRA-25/JCDAS, JRA-55, [JRA-3Q]	Kazutoshi Onogi & Yayoi Harada
NASA	MERRA, MERRA-2	Steven Pawson
NOAA NCEP	NCEP/NCAR (R-1), NCEP/DOE (R-2), NCEP-CFSR	Wesley Ebisuzaki & Craig Long
NOAA & Univ. Colorado	20CR	Gilbert Compo & Jeffrey S. Whitaker

- Reanalysis data sets are obtained from reanalysis-centre websites and/or other archives (e.g., NCAR RDA) by individual researchers.
- S-RIP also has a data archive space at the BADC, where processed data sets (e.g., with standard formats and resolutions, those directly used in the figures of the reports, etc.) will be archived for, e.g., the ease of future comparisons with new and old reanalyses.

NASA MERRA-2 released in October 2015

- QBO is improved with the newly tuned GWD parameterizations
- MLS T° assimilated above 5 hPa from 2004
  - Better analysis (T°, winds) but model forecast have same quality than in MERRA (see Hogan and
  - Discontinuity in 2004
- Assimilation of GPS RO data (below 30 km)



Temperature bias in GCM

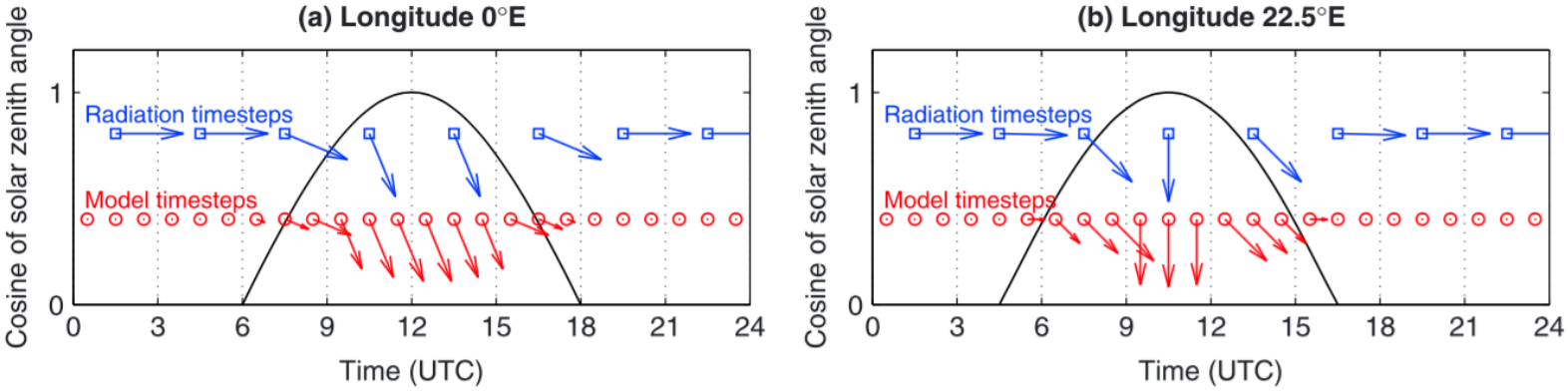
Effect of solar zenith angle specification in models on mean shortwave fluxes and stratospheric temperatures

Robin J. Hogan[1] and Shoji Hirahara[1,2]

[1] European Centre for Medium-Range Weather Forecasts, Reading, UK. [2] Japan Meteorological Agency, Tokyo, Japan

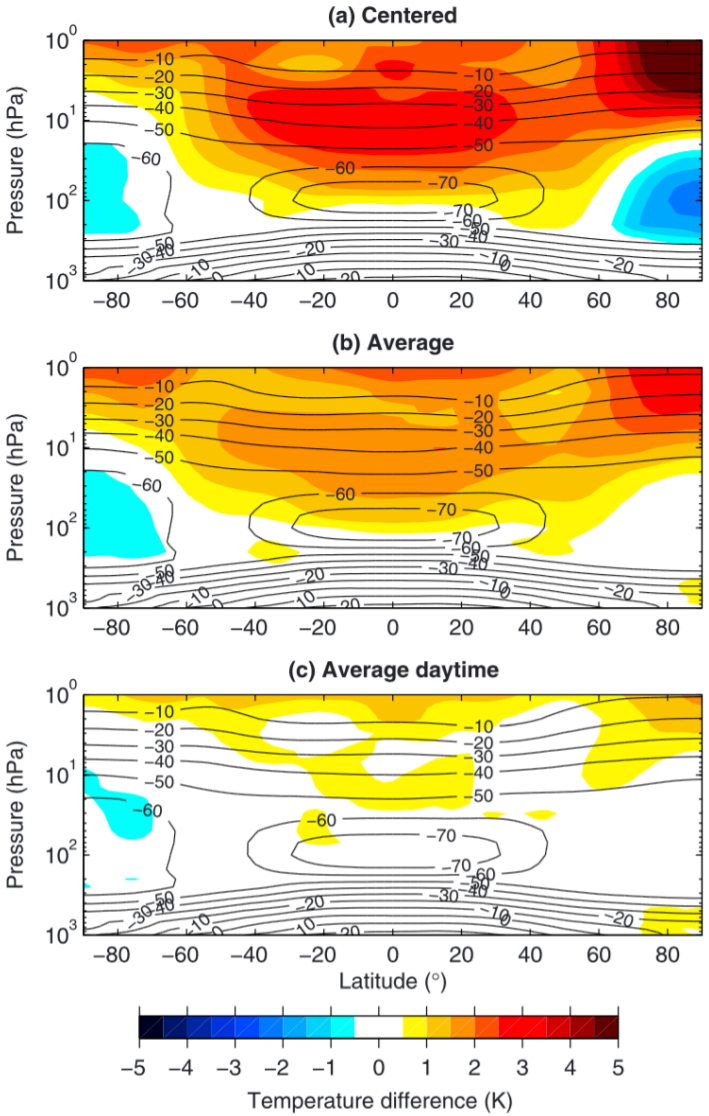
GRL 2016

Abstract Many weather and climate models call their radiation schemes only every 3 h, which we show can lead to a stratospheric temperature overestimate of 3–5 K and wavenumber 8 fluctuations in top-of-atmosphere (TOA) net shortwave flux around the tropics of amplitude 1.6 W m^{-2}. Solving this problem while retaining a 3h radiation time step requires careful treatment of the cosine of the solar zenith angle, μ_0, which appears twice in the calculation of shortwave fluxes, scaling the following: (1) TOA incident flux and (2) the path length of the direct solar beam through the atmosphere. If μ_0 is calculated as the average over the radiation time step, rather than at the central time, then the fluctuations are removed, but the stratosphere is still too warm by 2–3 K. It is only if the second μ_0 is averaged only over the sunlit part of the radiation time step that the temperature bias is removed.



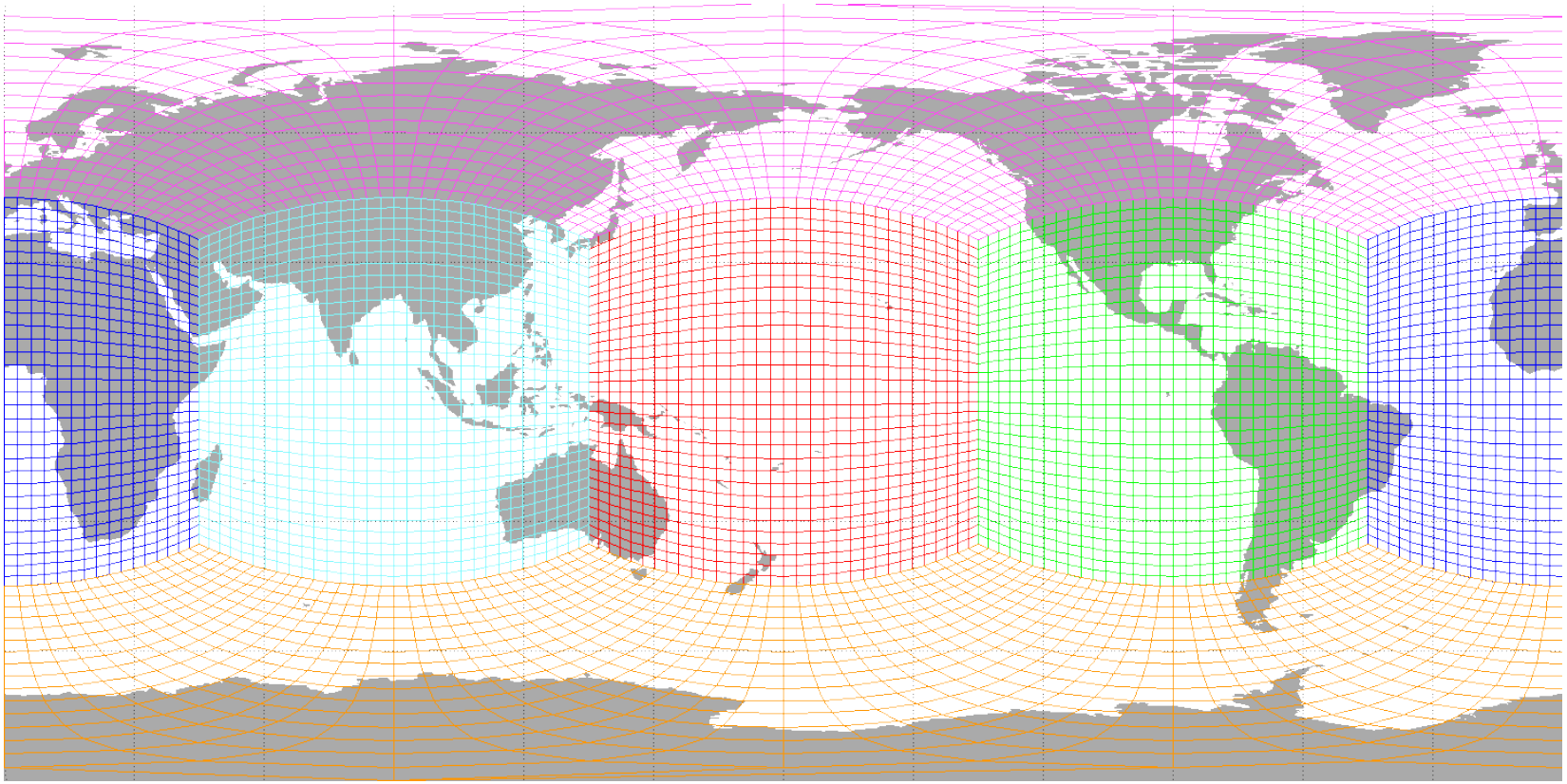
Temperature bias in GCM

Figure from Hogan and Hirahara: The black contours show the annual mean temperature for model simulations with the radiation scheme called every 3 h, where the three panels correspond to the three model configurations described in the caption of Figure 3. The colors show the differences between these temperature fields and a reference simulation in which the radiation scheme was called every model time step (30 min).

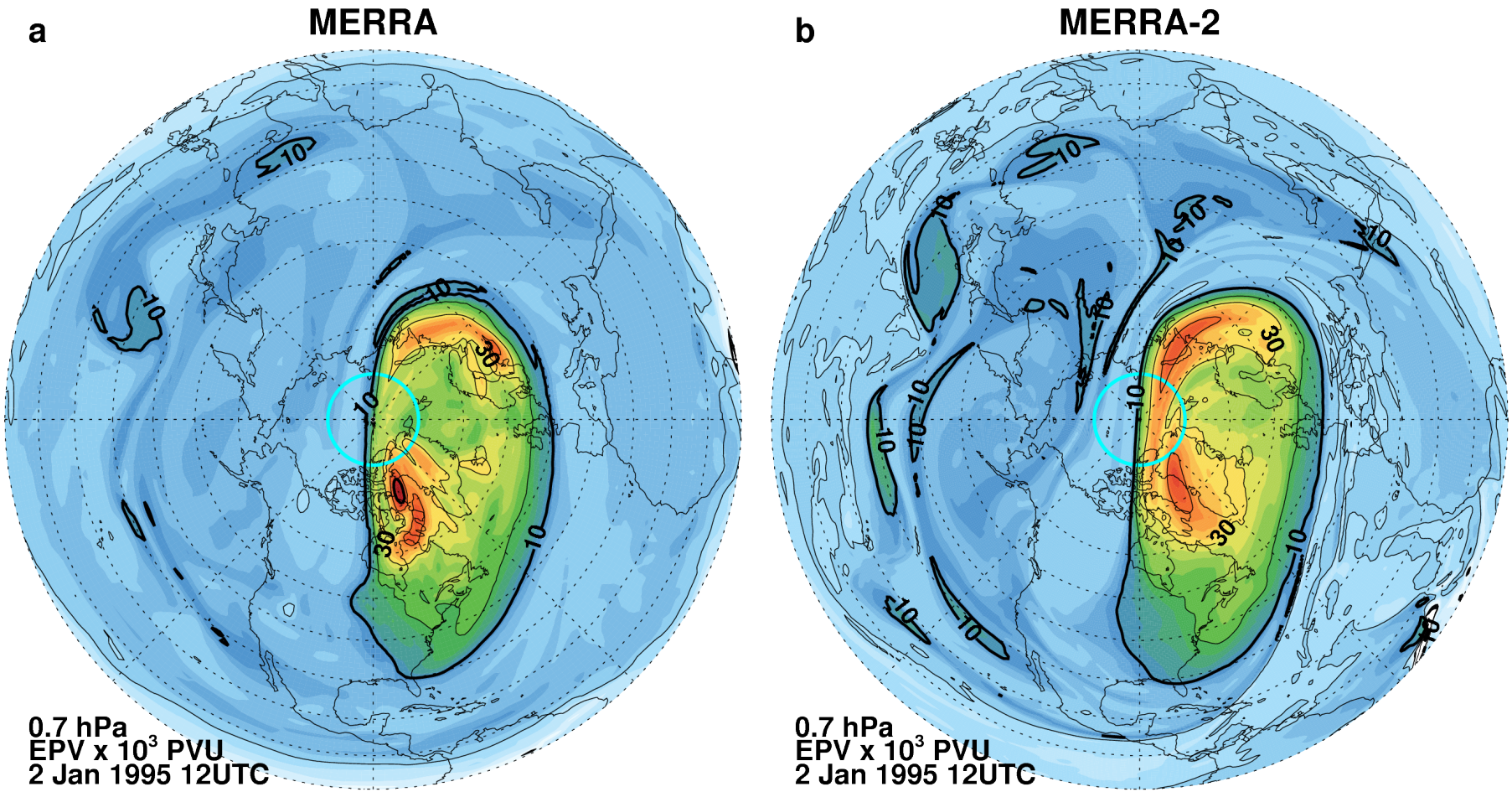


NASA MERRA-2

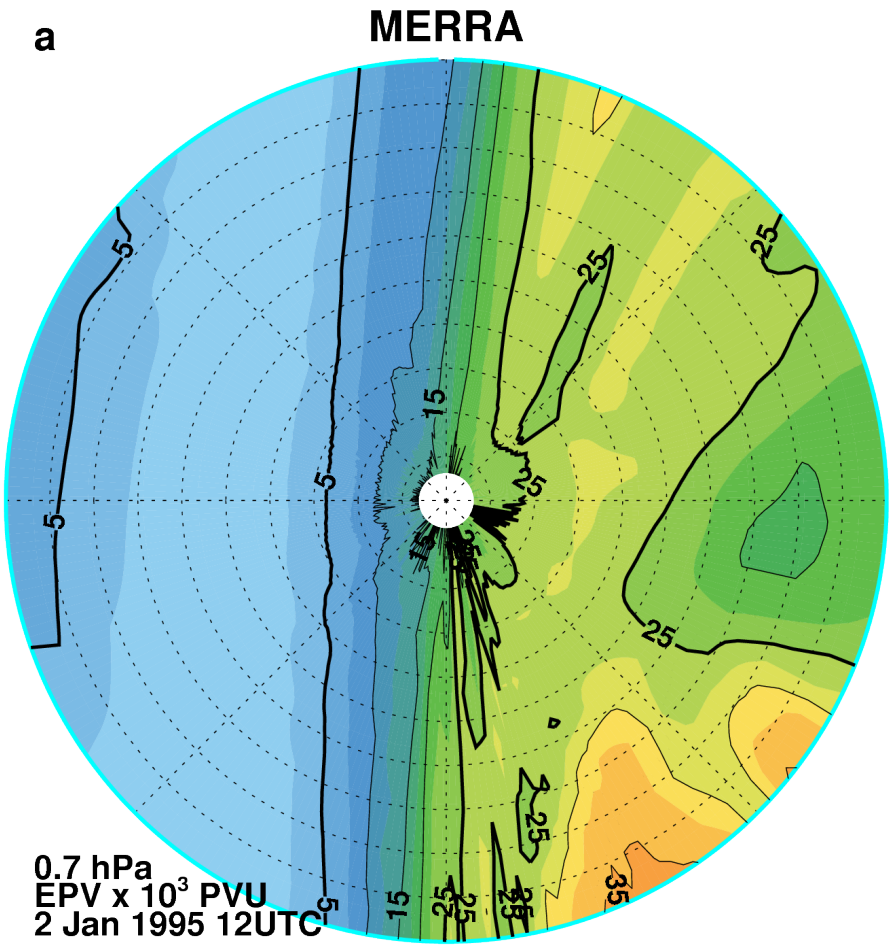
- Cubed Sphere Grid and Cross Polar Flow => improvement of analyzed winds over the pole

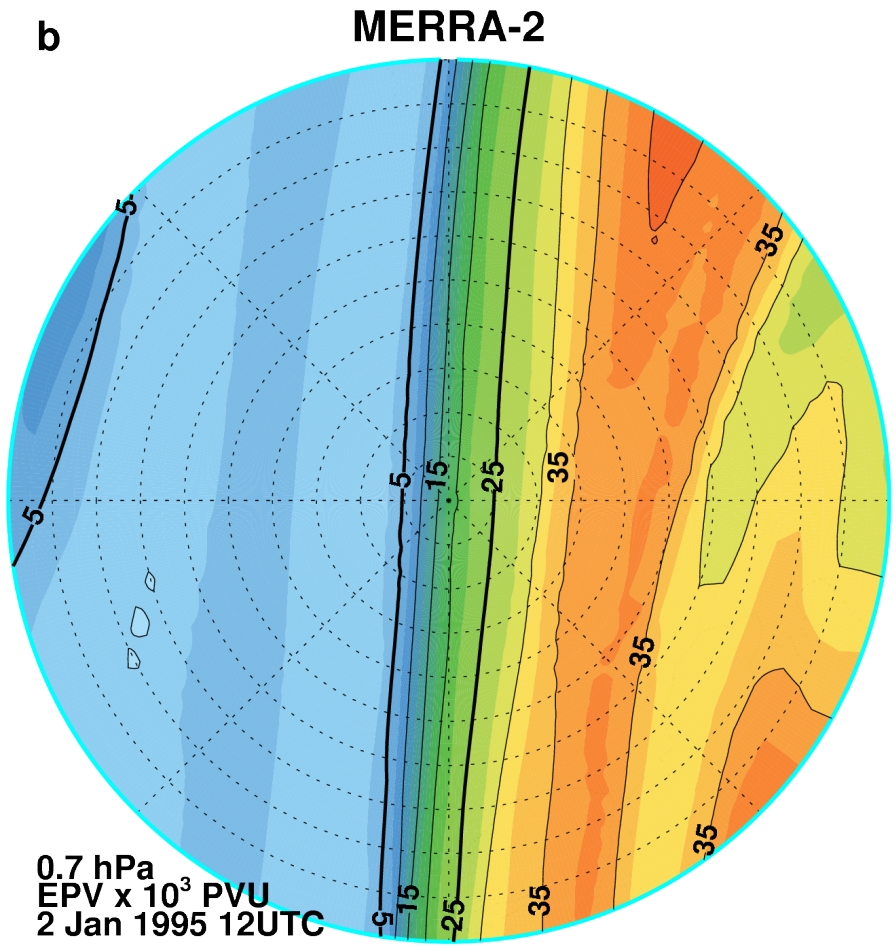


NASA MERRA-2



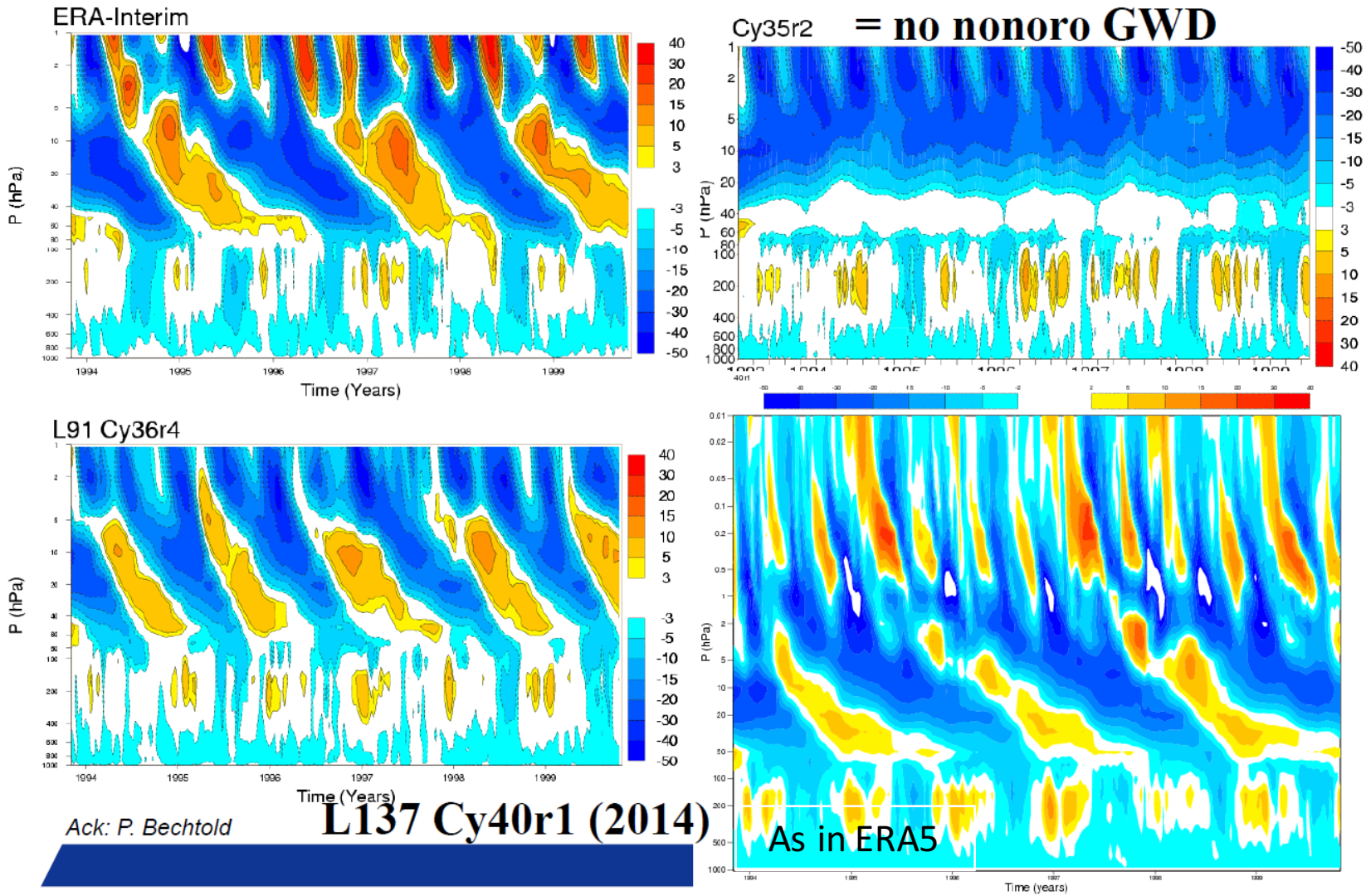
NASA MERRA-2





ECMWF New reanalysis ERA5 (in production)

QBO : Hovmöller U from free 6y integrations



S-RIP Progress to Date / Schedule

- June 2011: Discussion started at 8th SPARC Data Assimilation (DA) workshop, Brussels
- February 2012: S-RIP became an *emerging* activity of SPARC
- Summer 2012: Scientific Working Group was formed
- April-May 2013: S-RIP Planning Meeting at Exeter, UK
- January 2014: S-RIP side meeting; S-RIP Implementation Plan; S-RIP officially endorsed by the SSG as a *full* activity of SPARC
- September 2014: S-RIP (& DA) Workshop, USA
- October 2015: S-RIP (& DA) Workshop, France
- (October 2016: S-RIP (& DA) Workshop, Canada)

- 2016:
  - complete "basic" chapters (Chapters 1-4) → "S-RIP 2016 Report"
  - complete first order draft for Chapters 5-11
- 2018:
  - complete all chapters (Chapters 1-12) → "S-RIP 2018 Report"
  - review S-RIP and decide on extension of activity

- S-RIP workshop every year: this year at Victoria (BC, Canada), October 19-21, 2016
- Write peer-reviewed papers at any appropriate time (e.g., ACP special issue on "The SPARC Reanalysis Intercomparison Project (S-RIP)")

ACAMi: Atmospheric Composition and the Asian Monsoon initiative

Joint activity with IGAC

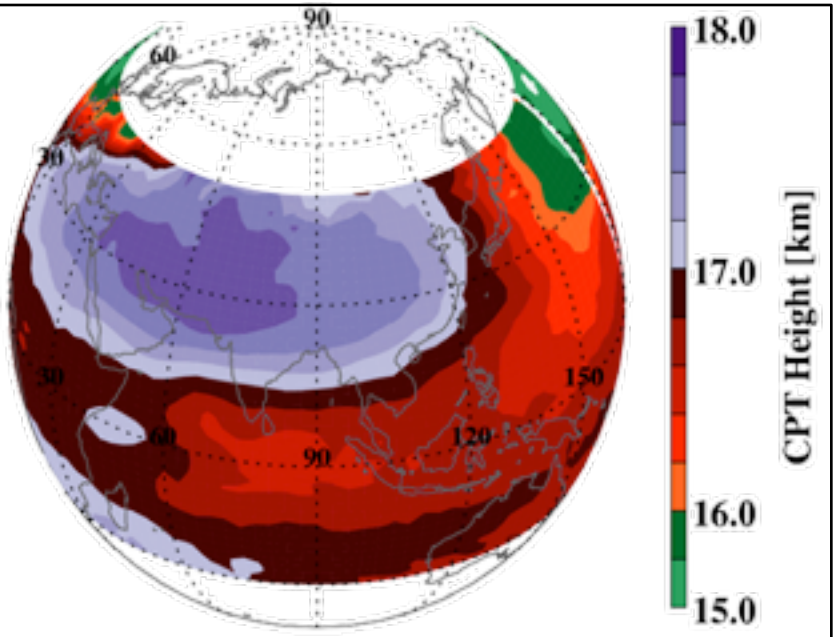
URL: www2.acom.ucar.edu/acam

Activity leaders

- Laura Pan (NCAR, liwen@ucar.edu)
- Jim Crawford (NASA, j.h.crawford@larc.nasa.gov)

ACAMi Motivations

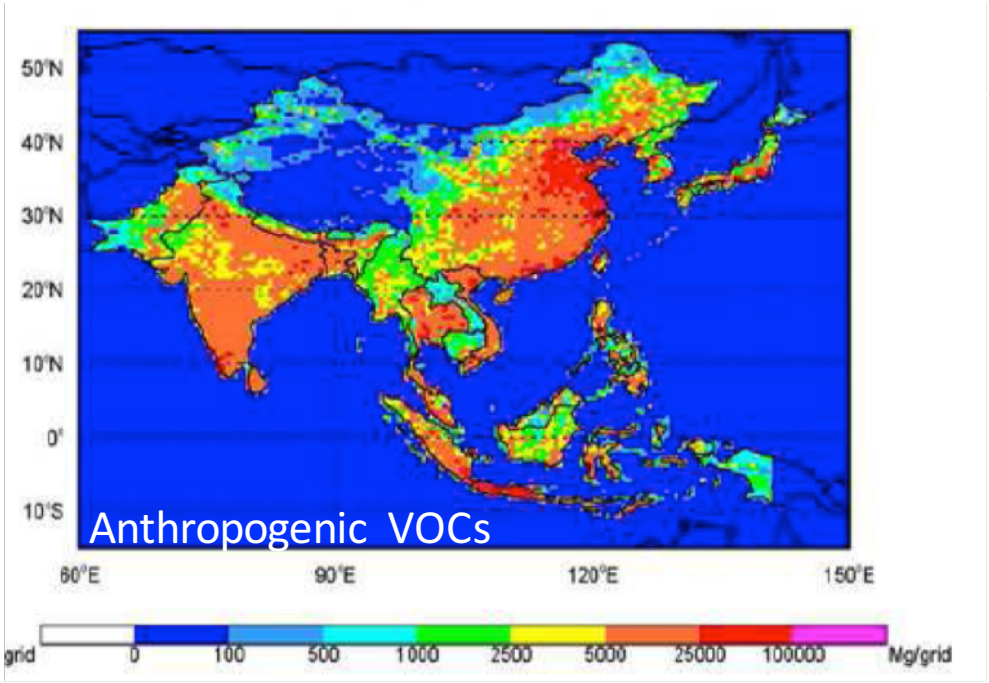
- Asian summer monsoon is the "global chimney" coupling the tropo and the stratosphere



Cold point tropopause height from GPS data (Munchak and Pan, 2014)

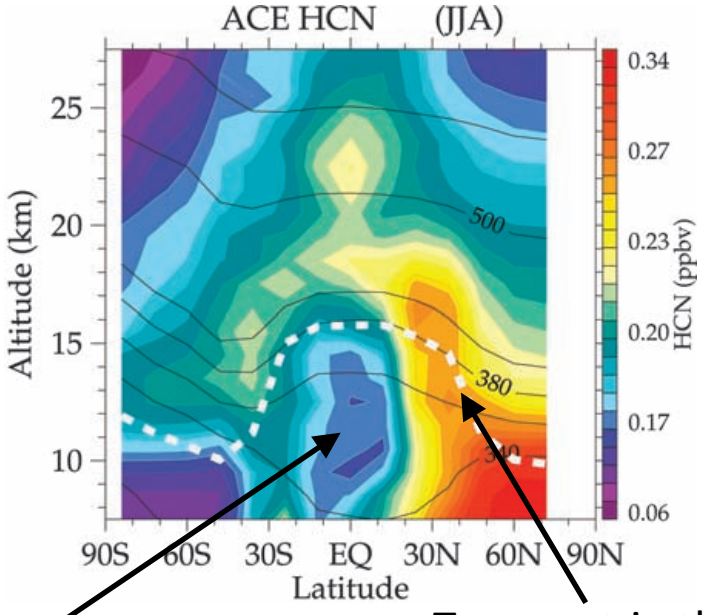
ACAMi Motivations

The monsoon is in region of growing emission…



… coupled with deep convection

JJA and zonal average of HCN observations from ACE-FTS measurements. (From Randell et al., 2010)



Tropical minimum

Transport in the stratosphere via monsoon

ACAMi Motivations

- The monsoon system is relevant to regional air quality, climate change, and global chemistry-climate interaction
- Accurate representation of this system in global chemistry-climate models (CCMs) is critical to predict future change in this region
- To characterize and quantify the impact of the monsoon, **integrated study is essential**, including observations (in situ and remote sensing) from the surface through the troposphere and stratosphere as well as modeling from regional to global scales
- To be successful, it is necessary to build strong international collaborations (activity) to obtain the diverse expertise, resources, and access to the monsoon region for international research teams

ACAM themes and organization

Four science themes

- **Emissions and air quality** in the Asian monsoon region
- **Aerosols, clouds, and their interactions** with the Asian monsoon
- Impact of monsoon **convection** on chemistry
- **UTLS Response** to the Asian Monsoon

Four working group

- Organizing **data sharing** for ACAM-relevant measurements
- Forming a **partnership with the CCMI activity** to facilitate two-way interaction
- **Field campaign concept development**
- Sponsorship of **training schools** on model use for ACAM regional young scientists

QBOi: the Quasibiennial Oscillation initiative

URL: http://users.ox.ac.uk/~astr0092/QBOi.html

Activity leader:

- Scott Ospray (Oxford Univ., sosprey@atm.ox.ac.uk)
- Neal Butchart (UK Met Office)
- Kevin Hamilton (International Pacific Research Center, USA)
- James Anstey (CCCma)

QBOi: Towards Improving the Tropical Stratosphere in Global Climate Models

Motivations

- QBO influence the transport across the TTL and the processes at the TTL (stratospheric water vapour)
- QBO influence the position of subtropical transport barriers and their seasonality
- Important in ***Projections*** of future stratospheric composition
- QBOi will address these questions using GCMs experiments

QBOi Experiments 1 & 2

- **Exp. 1:** AMIP – specified interannually varying SSTs, sea ice, and external forcing
- **Exp. 2:** 1xCO_2 - identical simulations to the AMIP except employing repeated annual cycle SSTs, sea ice, and external forcings
- Goal:
  - evaluate the realism of modelled QBOs under present-day climate conditions
  - Evaluate the impact of interannual forcing on the modeled QBO
  - Exp 2 is a control for the climate projection experiments

QBOi Experiments 3 & 4

- **Exp 3:** 2xCO_2 - as Exp 2, but with a change in CO_2 and SSTs appropriate for a 2xCO_2 world
- **Exp 4:** 4xCO_2 - as Exp 2 but with a change in CO_2 and SSTs appropriate for a 4xCO_2 world
- Goal:
  - To identify aspect of models that determine the spread (uncertainty) of the QBO in response to CO_2 forcing
  - These aspects should receive the most attention in order to quantify the uncertainty in future projections
  - Such experiments also will inform the community what the general uncertainty in future predictions might be for state-of-the-art QBOs in CMIP6 projection experiments

QBOi Experiments 5

- **Exp 5:** A set of initialized QBO hindcasts, with 9-12 month range. Observed SSTs and forcing specified as in Exp 1, with reanalysis providing initial atmospheric conditions for a set of given start dates
- Goals:
  - To indicate what aspects of modelled QBOs determine the quality of QBO prediction, so that these aspects can receive attention in order to improve prediction
  - The hindcast framework may be helpful assessing model changes, to help drive improvements in free-running models
  - Can these experiments help narrow the range of plausible models for climate change experiments?

QBOi Workshop

- SPARC QBO Workshop, "The QBO and its global influence – Past, Present and Future", September 26-30 2016, Oxford UK, Abstract deadline May 31, 2016
- The Workshop will:
  1) evaluate present-day and projected QBO variability in observations and models, including reporting results from the joint model experiments that were planned at the 2015 QBO workshop,
  2) explore modelled and observed teleconnections in the climate system, also including those linked with the QBO and
  3) design joint numerical experiments following discussions during special breakout sessions
- The emphasis of (3) will be for addressing the impact of tropical variability on other parts of the climate system.
- More QBOi information including the SPARC QBO Workshop can be found at http://users.ox.ac.uk/~astr0092/OC_Home.html

DAWG: Data Assimilation Working Group

URL: http://www.sparc-climate.org/activities/data-assimilation/

Activity leader:

- Quentin Errera (Belgian Institute for Space Aeronomy, quentin@oma.be)

DAWG: Aims and scopes

- Discussion forum for data assimilators, data providers, modelers and users of data assimilation products that focus on the SPARC themes
- This is done throughout (almost) annual workshops with suggested themes and invited speakers
- Next meeting will be held in Victoria (BC, Canada), Oct. 17-19, 2016, joint with S-RIP
- There will by funding to support one or two early career scientist and or scientist from developing countries

Future of Limb Sounders

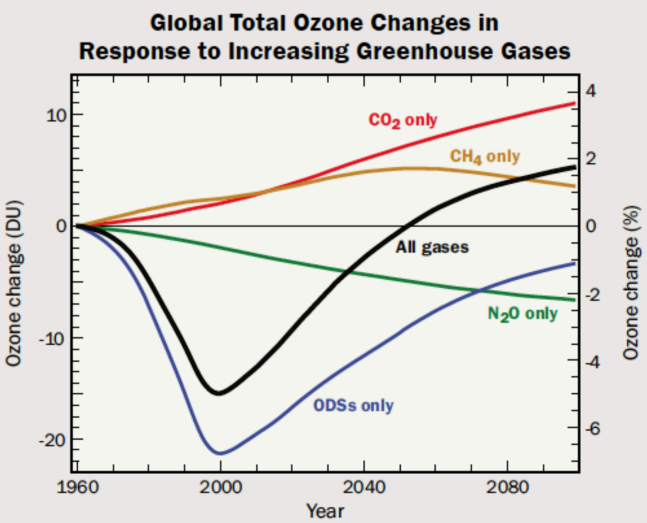


Figure 1: *Impact of GHGs from tropospheric sources on ozone total column. From Hegglin et al., WMO, 2015 after Fleming et al., ACP, 2011*

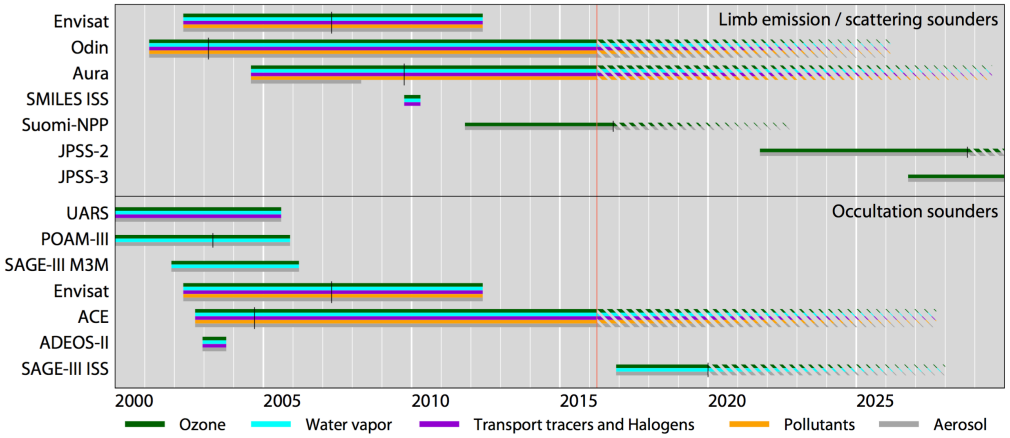


Figure 2: *Timeline of high vertical resolution satellite Upper Troposphere / Stratosphere observations. Vertical black lines indicate design lifetime / end of prime mission; hatching indicates potential extended mission operations.*

SPARC send two white papers at the NASA decadal survey on Earth observations

SPARC General Assembly, Kyoto, October 2018

Thank you for your attention