ACTIVITY REPORT:

Long-term records for climate understanding

Session chairs:
Nathaniel Livesey, NASA Jet Propulsion Laboratory
Andrea Steiner, Wegener Center, University of Graz

27th SPARC SSG meeting

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Boulder, CO, USA

Progress and achievements

Long-term records for climate understanding

LOTUS Long-term ozone trends and uncertainties in the stratosphere

- WMO/SPARC LOTUS 2/2019, GAW Report No. 241
- Results in Ch 3 of the WMO/UNEP Ozone assessment 2018.
- **Status update to 2019 of long-term ozone profile records, uncertainties of measurements and analyses, stratospheric ozone trend models.**
- **LOTUS multiple linear regression (MLR) trend model** for gridded records: additions of seasonal trends, accounting for sampling biases and applying measurement error weighting (covariance)
- Comparison of multiple ozone records EU region
- **Homogenization of ozone records, improve combined records**
- ISSI grant to reconcile difference in satellite & GB records

Progress and achievements

Long-term records for climate understanding

ATC Atmospheric temperature changes & their drivers

- ATC community paper (in prep): **Update on atmospheric trends from observations**
- RO community paper on **structural uncertainty in GNSS RO records from multiple satellites (Steiner et al. AMTD 2019)**
- **Joint paper on the Earth's heat inventory** (in prep); outcome of WCRP EEI workshop co-organized CLIVAR CONCEPT-HEAT, GEWEX, SPARC
- Co-chair A. Maycock is **Lead Author of IPCC AR6 Ch 4** "Future global climate: scenario-based projections and near-term information";
- **Contribution to IPCC AR6 Ch 2 on observations:** temperature trends over 2002-2018 in GNSS RO data
- ISSI Team Bern on synergy between satellite and ground-based observations for the study of middle atmosphere dynamics
- Papers of community members: e.g., BDC (Fu etal. 2019); Signal-to-noise in temperature trends and time of emergence, large ensemble model datasets(Santer et al., PNAS, 2019)

Progress and achievements

Long-term records for climate understanding

WAVASII Water Vapour Assessment II

- ACP/AMT Special Issue on WAVAS-II open until mid-2020: 3 papers published, 1 under review. Papers deal with isotopologues (HDO), comparison to ground-based FTIR measurements in the Arctic.
- 3 further papers in prep. on comparisons with FPHs, satellite instruments descriptionand data sets, comparison in the tropopause range (UTH),
- **WAVAS-II satellite data sets in homogenized format (quantity, vertical gridding) publicly available on data server, and a DOI has been received**.

WAVAS: Karen Rosenlof, Gabrielle Stiller, Tom Peter

Progress and achievements

Long-term records for climate understanding

SSiRC Stratospheric Sulfur and its Role in Climate

- **Revised key aerosol datasets incl. balloon-borne optical particle counter meas. and OSIRIS meas. have been completed**.
- T. Deshler led activity is compiling a **sulfur burden climatology**, incl. sulfur bearing gases and sulfur in particulate.
- **GloSSAC (the Global Space-based Stratospheric Aerosol Climatology) dataset v2.0 is being archived and a paper is being submitted to ESSD**
- ISA-MIP: 2nd phase, running coordinated model experiments, has begun
- –13 global models will participate in ISA-MIP & model specifications will be published on www.isamip.eu

Progress and achievements

Long-term records for climate understanding

SRIP SPARC Reanalysis Intercomparison Project

- ACP/ESSD special issue on "The SPARC Reanalysis Intercomparison Project (S-RIP)" in Atmospheric Chemistry and Physics (ACP) and Earth System Science Data (ESSD) currently has 36 published/accepted papers and one paper under review (as of 18 November 2019).
- SPARC S-RIP Report manuscripts (Chapters 1-11) were submitted to the SPARC Office for the review process on 25 November 2019. Chapter 4 of the S-RIP Report deals with the evaluation of ozone and water vapour in the reanalysis data sets
- **S-RIP has evaluated atmospheric records during the satellite era (1979-) and during the pre-satellite era (back to the mid 20C) for some diagnostics.**

Progress and achievements

Long-term records for climate understanding

OCTAV-UTLS Observed Composition Trends And Variability in the Upper Troposphere and Lower Stratosphere

- **Long-term ground-based data sets were compared to satellite records in different decades (i.e during the SAGE II and Aura MLS time periods) and referenced to the JETPAC derived dynamical coordinates**.
- **Preliminary trend analyses were performed on Aura MLS record to assess reduction of uncertainties in dynamical coordinates.** Reduced variability was found for some sets of dynamical coordinates.
- Long-term UTLS ozone records from commercial aircraft (IAGOS-CARIBIC) were analyzed to investigate the effect of coordinate transformation of ozone on the reduction of variability: The combination of a jet-based (STJ) horizontal and dynamical tropopause vertical coordinate led to the largest variability reduction of ozone.

OCTAV: Peter Hoor, Luis Millán, Irina Petropavlovskikh

Progress and achievements

Long-term records for climate understanding

TUNER Towards Unified Error Reporting

- TUNER developed a **framework unifying error reporting approaches** of
- –A range of remote measurement techniques – limb, occultation, nadir, etc.
- –A range of observing wavelengths – ultraviolet through microwave
- –A range of target parameters – temperature, composition, etc.
- –A range of retrieval approaches
- Foundational paper submitted to AMT(D)
- TUNER members engaged in complementary research that will help make progress in uncertainty quantification for remotely sounded observations
- TUNER is working on links to the wider statistics & metrology communities

TUNER: Thomas von Clarmann, Doug Degenstein, Nathaniel Livesey

Future plans

LOTUS FUTURE plans

- LOTUS-2 workshop in Spring 2020, TRENDS 2020 (May, Helsinki)
- Presentations at AGU2019, EGU2020, QOS2020 Korea (side meeting)
- Collection and archival of updated ozone records (to 2019; new NASA and NOAA SBUV combined; homogenized Umkehr, MW, Lidar, sonde)
- Gridded CCCi satellite record – study regional trends
- Reconciling differences in GB & satellite trends
- Coherence strato/tropospheric/total column ozone
- Trend model optimization for GB records/Trend study in Polar regions
- The repository for LOTUS Phase-1 data is needed (NDACC open-access data archive).
- DOI for the LOTUS products

Future plans

ATC Atmospheric temperature changes & their drivers

- Joint TRENDS 2020 workshop in May 2020 with LOTUS and others
- Finalise contributions to AR6, Finalise papers
- Topic: Uncertainty of observations (paper planned)
- Discuss making available consistent, gridded temperature observation datasets from multiple platforms as a community resource
- Analysis of CMIP6 warming trends in light of recent reports on high ECS and implications for projections
- Attribution studies – vertically resolved data sets

Future plans

Long-term records for climate understanding

WAVASII Water Vapour Assessment II FUTURE plans

- Water vapor data set from TIMED/SABER released, would be desirable to include this data set into the WAVAS-II activity, as well as more recent versions of other satellite instruments (ACE-FTS version 4, MIPAS version 8). Perhaps this could be blended into another activity.
- WAVASII to be completed next year
- Incorporate water vapour into another SPARC activity

SSiRC Stratospheric Sulfur and its Role in Climate FUTURE plans

- 3rd SSiRC general workshop UnivLeeds 30 Mar-1Apr 2020.
- How does ultra-fine ash influence the volcanic SO2 radiative forcing?
- How do anthropogenic emissions of aerosol precursors affect stratospheric aerosol variability?
- How does the tropospheric sulfur cycle respond to climate change and how does that affect stratospheric aerosol?

Future plans

Long-term records for climate understanding

SRIP SPARC Reanalysis Intercomparison Project

FUTURE plans: finalise special issue, BAMS paper

- New products: ERA5 (2020); CRA-40 (2020?); "MERRA-3" (2021?); JRA-3Q (2022); and CFSv3 (2020-22?).
- Phase 2 of this activity will be re-started around 2022. During 2020-2021, we will keep the S-RIP website up-to-date, and maintain a scaled-down formal group to monitor, coordinate S-RIP-related activities.

CCMI Chemistry-Climate Model Initative FUTURE plans:

- Plans for a 'science-driven' second phase of CCMI have been pushed back
  – more time to see state of the science coming out of AerChemMIP (CMIP6)
  – need more time to clearly define our scientific goals
- We are organizing simulations to support the 2022 Ozone Assessment

Future plans

Long-term records for climate understanding

OCTAV-UTLS Observed Composition Trends And Variability in the Upper Troposphere and Lower Stratosphere

FUTURE plans: 3rd OCTAV-UTLS Workshop is planned for 2-5 March, 2020

- We plan a paper aimed at explaining the updated JETPAC output products and showcasing some of the dynamical coordinates selected to reduce ozone variability in the UTLS. To be submitted to ESSD.

TUNER Towards Unified Error Reporting

FUTURE plans: Second paper aimed at data users

- Quantification of the impacts of spatio/temporal variability on "coincidence-based" validation studies

  –Validation of precision estimates by comparison of multiple datasets

  –Characterization of errors that manifest as neither simple "biases" or as "noise", but vary according to atmospheric state

Vision

Long-term records for climate understanding

Which direction would you like to see SPARC move forward to?

- We consider it mandatory to keep a **focus on the "atmosphere" aspect in climate research**, and SPARC needs to fill this role
- Its **focus on the atmosphere; Its balance between observations and modelling; Its balance between dynamics and chemistry**
- SPARC work on **process-level understanding to improve physics in models for timescales from weather to climate**
- more emphasis to "**whole atmosphere**" by extending to the mesosphere-lower thermosphere region (observational and modelling aspects), would be important top boundary regarding predictability

Vision

Long-term records for climate understanding

Which direction would you like to see SPARC move forward to?

Long-term records and infrastructure:

- Make sure observational data with global coverage and good vertical resolution will be available in future! WAVAS, ATC
- Lack of observations will become a problem in the future, how can that loss be mitigated? SSiRC
- Support for continuing observations of atmospheric composition (i.e. WMO GAW, NDACC, SHADOZ, other ozone observing networks) LOTUS
- Advocate for future limb sounder missions DAWG
- High resolution data of high value
- "what observing systems will be needed to address the other questions, and how well to current/planned observing systems meet those needs" TUNER
- Infrastructure aspects (i.e. the role of the SPARC data centre) could be reinforced, specifically regarding the archiving of sustained observations and reference data sets. SOLARIS-HEPPA
- Model data collection and infrastructure (BADC) CCMI

Vision

Long-term records for climate understanding

What are important issues that need to be addressed in the WCRP IP?

Long-term records and infrastructure:

- Observations and climate data records: Supporting a coherent long-term monitoring system, i.e. the Global Climate Observing System (GCOS), including a framing of the integration of data from the private sector.
- Sustaining long-term climate data records (CDRs) of essential climate variables (ECVs) (GCOS 2016).
- Improving the maturity of CDRs by further advancing retrievals and processing methods for providing consistent and homogeneous data sets with uncertainty information.
- Provision of benchmark records as a reference for observations and climate model simulations.
- Regular assessments of atmospheric ECVs, e.g., on upper-air temperature, water vapor, composition, by performing intercomparison studies of observations.

Vision

Long-term records for climate understanding

What are important research questions?

- Improved understanding of the uncertainties of observations (from various platforms) and reanalyses. SSiRC, SRIP, ATC
- Atmospheric composition changes under the climate change. LOTUS
- Improving climate models' representation of natural variability GW, QBOi, SSiRc, FISAPS
- Attribution and detection of climate variability and long-term trends ATC
- Attributions of extreme events ATC
- Attribution and detection of climate variability and trends in particular on a decadal scale, to improve near-term climate predictions and to fill the gap between weather and seasonal predictions and IPCC-type climate projections since this is relevant to society (people would like to know how the weather will look like in 2030, 2040, 2050). SOLARIS-HEPPA

Vision

Long-term records for climate understanding

What are important research questions?

- Advancing science frontiers: Emphasis on fundamental science. Exploiting long-term climate data records for gaining fundamental understanding of short-term climate variability and long-term climate trends from the troposphere to the mesosphere and their causes. How do long-term changes alter atmospheric weather patterns and trigger atmospheric extremes, regional response and surface impacts
- If we pursue a path towards strong mitigation, how can SPARC help to monitor and measure progress towards international targets? RCP8.5 is no longer ”business as usual” - has SPARC caught up? Internal variability, interplay between CO2 and non-CO2. ATC
- Key issues in a rapidly changing world: Meeting societal challenges, Paris Agreement, Global Stocktake, low carbon transitions, geoengineering, impacts on atmospheric composition ATC
- What observing systems do we needed to address the other questions and how well do current/planned observing systems meet those needs?

Links to the WCRP SP and IP

Long-term records for climate understanding

What collaborations should be maintained or started?

- Fostering cooperation across the WCRP between the observation, reanalysis, and modelling communities for improving climate data records and for tackling fundamental science questions.
- Link and work together with the other core programs CLIVAR, GEWEX, CLIC, e.g. Earth's energy imbalance initiative, long-term monitoring, predictability, regional climate
- Continue to build links with GCOS, CEOS, GAW, NDACC
- WGNE & WWRP: Model biases, Role of diabatic processes in weather system dynamics & predictability
- PCPI Polar research: Trends in high latitudes/Detection & attribution analysis
- All SPARC activities already align with one or many of the goals listed in the 2019-2028 WCRP SP. SPARC needs to secure funding to continue successful Workshops & GAs that foster productivity and cross pollination of new ideas.
- SPARC-centric sessions at all major conferences should be organized and travel support for key-note speakers and early-career scientists offered.

Links to the WCRP SP and IP

Long-term records for climate understanding

- "The main point – WCRP isn't a funder of science but both the SP and IP read like it is. WCRP funds collaboration. Similarly the IP is so broad and ambitious that it seems impossible to deliver to a high standard without a major increase in funding from sponsors – is one proposed?"
- How do members of science communities under WCRP have input into the design of research projects that may involve collaborations with groups outside of WCRP? Future Earth?
- It would helpful to better understand the degree to which WCRP leadership interacts (and/or is allowed to interact) with funding agencies, and/or is in a position to provide concrete statements on research priorities that can help shape strategic funding decisions made by those agencies.