AerChemMIP and RFMIP Planned Papers

This document provides a summary of papers planned using AerChemMIP/RFMIP multi-model output. Papers are divided under two themes - 1) Forcing, Response & Feedbacks and 2) Atmospheric Composition and Air Quality. Information provided below includes a tentative title with lead author, submission date, science questions being covered, simulations being analyzed, and a point of contact.

Authorship Policy for AerChemMIP/RFMIP papers: Modelers should be given co-authorship on papers that use their model output at least for those submitted in 2019. It is expected that authors will adhere to the CMIP6 Terms of Use and citation requirements.

Theme 1: Forcing, Response & Feedbacks

- **Effective Radiative Forcing and Rapid Adjustments in CMIP6 Models** (**Chris Smith et al.**) - submission by December 31, 2019
  - Uses RFMIP Tier 1 experiments to assess ERF, IRF and rapid adjustments to components of present-day forcing
  - Will provide an update of methods for diagnosing ERF
  - Comparison of methods to determine cloud rapid adjustments
  - Contact: c.j.smith1@leeds.ac.uk

- **Effective Radiative forcing from emissions of reactive gases and aerosols (Gill Thornhill et al**) - submission by December 31, 2019
  - Quantifying the ERFs from pre-I to present emission changes in reactive gases and aerosols (concentration changes for CH4, N2O and Halocarbons).
  - Quantifying the contributions to these emission-driven ERFs through changes in aerosol AOD, ozone (trop and strat) burden, methane lifetime
  - Will use AerChemMIP piClim-xx
  - Contacts: g.thornhill@reading.ac.uk; w.collins@reading.ac.uk

- **Pre-industrial to present-day forcing in the UKESM model** (**Fiona O'Connor et al.** - mostly UK Met Office authors) - submission by December 31, 2019
  - Rigorous breakdown of chemical and physical adjustment processes in UKESM
  - methane forcing attribution
  - Contact: Fiona.oconnor@metoffice.gov.uk

- **The HadGEM3 radiative kernel and the importance of a well-resolved stratosphere** (**Chris Smith, Ryan Kramer**) - submission before December 31, 2019
  - will make recommendations for kernel usage
  - uses RFMIP-ERF Tier 1 4xCO2
  - introduces new HadGEM3-GA7.1 radiative kernel

- Contact: c.j.smith1@leeds.ac.uk

- **Historical aerosol forcing diagnosis and analysis in CMIP6, AerChemMIP and Aerocom models (Michael Schulz, Gunnar Myhre et al.)** - submission before December 31, 2019
  - Document available historical aerosol forcing estimates (ERF, IRFs, double call results) available in CMIP6, AerChemMIP, RFMIP and Aerocom 2019 simulations
  - Analysis of forcing efficiency wrt to lifetime, load, optics and emission evolution
  - Relate to aerosol evaluation and comparison to observed aerosol trends (see below)
  - Investigate impact of natural aerosols on forcing history
  - Contact: michaels@met.no

- **Other papers evaluating aerosol properties and trends in historical and PD conditions / AeroCom+AerChemMIP** submission intended before December 31, 2019
  - PD optical properties (Jonas Gliss et al. jonasg@met.no)
  - Regional aerosol trends (Augustin Mortier et al. augustinm@met.no)
  - Absorption by aerosols (Bjørn Samset et al. b.h.samset@cicero.oslo.no)
  - Aircraft data on vertical distribution (duncan.watson-parris@physics.ox.ac.uk)
  - ATOM experiment (Huisheng Bian, huisheng.bian@nasa.gov)
  - TOA fluxes aerosol effect (Wenying Su, wenying.su-1@nasa.gov)
  - Multiple satellite data w exact colocation (Nick Schutgens, n.a.j.schutgens@vu.nl)
  - In-situ optical properties (Betsy Andrews, Betsy.Andrews@noaa.gov)
  - Anthropogenic dust (Paul Ginoux, paul.ginoux@noaa.gov)
  - Volcanic ACI experiment (Florent Malavelle F.Malavelle@exeter.ac.uk)

- **Ozone forcing history (Ragnhild Skeie, G Myhre et al)** - submission before December 31, 2019
  - Retrieve ozone forcing history using kernels
  - Contact: Ragnhild Bieltvedt Skeie r.b.skeie@cicero.oslo.no

- **Towards a better understanding of the spread in anthropogenic aerosol forcing and response with RFMIP-SpAer** (**Stephanie Fiedler et al.**) - submission by December 31, 2019
  - IRF, ERF and response from RFMIP-SpAer experiments
  - Comparison of forcing spread in SpAer to RFMIP
  - Additional participants for the data analysis
  - Contact: stephanie.fiedler@mpimet.mpg.de

- **Impact of near term climate forcers and aerosols on 20th century climate (Robert Allen et al.) -** December 2019 submission goal
  - Primary simulations analyzed: NTCFs (hist-piNTCF), aerosols-only (hist-piAer), and HCs (hist-1950HC).
  - Questions: How have NTCFs impacted surface temperature evolution? Regional precipitation (Monsoons, ITCZ)? Atmospheric/oceanic circulation (e..g, Jets/Hadley Cell,

AMOC)? Modes of climate variability (ENSO, NAO)? Linking regional ERFs to T/Pr responses (requires SST experiments)
    - Contact: rjallen@ucr.edu
    - Coauthors: Dan Westervelt, Laura Wilcox, Alcide Zhao, others

- **Tentative title: 21st century climate impact of air pollution policies (Robert Allen et al.) -** December submission goal
    - Primary simulations analyzed: (ssp370 vs. ssp370-lowNTCF)
    - Questions: Similar questions as above, but focused on the climate impacts of strong versus weak stringent air pollution policies.
    - Contact: rjallen@ucr.edu
    - Coauthors: Dan Westervelt, Laura Wilcox, Alcide Zhao, others

- **Impacts on climate extremes (Alcide Zhao, RJ Allen et al.) -** Post December 2019
    - analysis of temperature/precipitation extremes (daily data)
    - Contact: Alcide.Zhao@ed.ac.uk

- **Precipitation and circulation rapid adjustments (Prodromos Zanis, RJ Allen, et al.) -** Post December 2019
    - analysis of temperature/precipitation/circulation using the piClim simulations, including anthropogenic and natural NTCFs
    - Contact: P. Zanis (zanis@geo.auth.gr)

- **Chemistry and aerosol climate feedbacks in Earth system models (Gill Thornhill et al.) -** submission by December 2019
    - Diagnosing climate feedbacks (in W/m2/K) from changes in chemistry and aerosols
    - Primarily analysing feedbacks involving natural emissions. May also be able to consider climate-induced changes in aerosol deposition, ozone and methane chemistry.
    - Based on piClim-2x and abrupt4xCO2, 1pctCO2
    - Contact: g.thornhill@reading.ac.uk; w.collins@reading.ac.uk

- **Other papers diagnosing and characterizing earth system BGC feedbacks -** submission intended before December 31, 2019:
    - Oceanic emissions (Dirk Olivie et al. dirkjlo@met.no)
    - Dust emissions (Ramiro Checa-Garcia et al. ramiro.checa-garcia@lsce.ipsl.fr)
    - Sea-salt emissions (GFDL-ESM4; Fabien Paulot et al. Fabien.Paulot@noaa.gov)
    - BVOC emissions (Catherine Scott et al. C.E.Scott@leeds.ac.uk)

- **Constraining uncertainty in aerosol direct forcing (Duncan Watson-Parris et al.)** - submission by December 2019
    - A strong relationship is demonstrated between total present-day aerosol loading and the anthropogenic contribution, across a variety of models
    - Observational constraints on the total present-day aerosol loading can thus be interpreted as a constraint on anthropogenic aerosol.

- Using a relationship with the (constrained) anthropogenic aerosol loading we estimate the clear-sky RFari to be -0.63 ± 0.14 Wm-2.
- Contact: duncan.watson-parris@physics.ox.ac.uk

- **Benchmark calculation of radiative forcing by greenhouse gases (Pincus et al.)** submission by December 2019
  - Based on off-line radiative transfer experiment rad-irf.
  - Assess agreement in global-mean IRF among benchmark line-by-line models for RFMIP offline cases.
  - Compares the level of agreement among benchmarks to the scale of errors from a small number of parameterizations.
  - May include rough estimates of more ERF-relevant quantities (stratospheric adjustment, tropopause IRF, cloud masking).
  - Contact: Robert.Pincus@colorado.edu

- **The contribution of radiative transfer error and base state diversity to inter-model differences in greenhouse gas instantaneous radiative forcing (Ryan Kramer et al.)** - submission post December 31, 2019
  - Current GCMs exhibit notable inter-model spread in greenhouse gas instantaneous radiative forcing (IRF), even under clear-sky conditions and despite almost no uncertainty in radiative transfer theory.
  - This spread stems from differences in computationally efficient parameterization of radiative transfer across GCMs and from the sensitivity of IRF to the unique base state of each GCM.
  - We intend to quantify the relative contribution of each source of spread using GCM annd reference model output from the RFMIP-IRF-GHG experiments, output from relevant RFMIP-ERF piClim experiments, as well as double radiation calls and additional offline radiative transfer calculations from other relevant MIPs.
  - Contact: ryan.j.kramer@nasa.gov

- **An investigation into sources of solar radiative parameterization biases in the determination of model aerosol instantaneous radiative effect (S. Freidenreich, et al.) -** submission by December 31, 2019
  - Global benchmark line-by-line+doubling-adding (LBL+DA) computations have been utilized to diagnose solar radiative parameterization flux biases in the aerosol Instantaneous Radiative Effect (IRE) (clear-sky minus clean-sky), for two different climate models, GFDL's AM4 model and the NCAR CESM model version 1.2.2.
  - Two sources of these clear-sky IRE differences between the two models reported on there are investigated: 1) how the two stream scattering method used by each model compares to the DA method, and 2) how the spectral dependencies of absorption and scattering are resolved through partitioning of the solar spectrum into bands regions. Also, these two factors are investigated with respect to the individual clean-sky and clear-sky components of the IRE between the two models.
  - Contact: stuart.freidenreich@noaa.gov, David.Paynter@noaa.gov

- **Parameterization error in the treatment of absorption by greenhouse gases in CMIP6 models (Pincus/open to other leads) -** 2020 submission.
  - Based on off-line radiative transfer experiment rad-irf.
  - Assess error in instantaneous radiative forcing at TOA, surface, within atmosphere for CMIP6 models
  - Contact: Robert.Pincus@colorado.edu

- **Assessing error in aerosol IRF with LBL across models (David Paynter, Dan Feldman et al.**,) - post December 2019 submission
  - depends on who submits RFMIP-IRF-AER results
  - Contacts: David.Paynter@noaa.gov, drfeldman@lbl.gov

Theme 2: Composition and Air Quality

- **Pre-industrial to end 21st century projections of tropospheric ozone from the Aerosols and Chemistry Model Intercomparison Project. (Griffiths et al.) -** submission by December 31, 2019
  - How well do global models simulate tropospheric ozone versus present-day and historic observations?
  - What do models predict for historical and future trends in tropospheric ozone?
  - Contact: ptg21@cam.ac.uk
  - Co-authors: Paul Griffiths, Alex Archibald, Birgit Hassler, Lee Murray, Vaishali Naik, Fiona O'Connor, Prodromos Zanis, Guang Zeng + others.

- **Tropospheric ozone trends, radiative forcing and attribution to emissions in Aerosols and Chemistry Model Intercomparison Project. (Lee Murray et al.)** - submission by December 31, 2019
  - What is the anthropogenic radiative forcing from tropospheric ozone since the preindustrial?
  - What is the uncertainty in the estimate?
  - What are the relative contributions from NO_x, CO, and VOCs?
  - Contact: lee.murray@rochester.edu
  - Coauthors: Alex Archibald, Paul Griffith, Birgit Hassler, Vaishali Naik, Fiona O'Connor, Prodromos Zanis, Guang Zeng + others.

For both papers, we are presently limited by the availability of model runs on ESGF. In the case of the RF attribution, we are especially likely to be limited by the reliance on Tier 3 simulations. Lee and Paul will be following up over the AerChemMIP email list next week to see which groups plan on performing the necessary runs (and those that may be able to share in advance of uploading to ESGF), and reaching out to additional colleagues from the ozone satellite/in situ measurement community (e.g., TOAR) to contribute to the assessment.

- **Assessing total column ozone changes from 1850-2100 in CMIP6 models (James Keeble et al.) -** submission by December 2019

- Assessment of stratospheric/total column ozone changes in the CMIP6 models from 1850-2014 in the historical simulations, and from 2014-2100 in the scenario simulations,
- evaluation of the models against observations and comparison of the model-model spread.
- Further analysis to include (in no order of preference): the ozone response to 4xCO2 perturbations, specific focus on particular regions (Antarctic ozone hole recovery, dynamical variability in the Arctic, ozone in the tropics), ozone zonal asymmetries, ozone radiative forcing, ozone profile trends in the recent period for comp with satellites, ozone-climate coupling. Some of these may be analysed as part of the main paper, but the hope is for a series of papers lead by different contributors.
- Contact: jmk64@hermes.cam.ac.uk

- **Analysis of stratospheric water vapour in CMIP6 models (TBD) -** TBD

- **Current and future changes in air pollutants across CMIP6 models (Steven Turnock et al) -** submission by December 31, 2019
  - Multi-model regional, seasonal surface ozone and PM2.5 evaluation of CMIP6 models,
  - future regional/seasonal changes under different CMIP6 scenarios
  - Need surface O3 and PM2.5 concentrations in historical (2000-2014) and future Scenario MIP (or whatever is available)
  - Contact: Steven.turnock@metoffice.gov.uk
  - Coauthors: Jordan Schnell with Birgit Hassler, Vaishali Naik and others

- **Heatwaves and future air quality episodes (Jordan Schnell et al.)** - submission by December 31, 2019
  - How do future heatwaves affect air quality episodes across CMIP6 models
  - hourly/daily surface O3 and PM2.5 concentrations for period in historical and future SSP3 scenario
  - Contact: jordan.schnell@earth.northwestern.edu
  - Coauthors: Jason West and others

- **Human Health impacts under the SSP scenarios (Drew Shindell et al.)** - submission post December 2019
  - Analyse changes in surface PM2.5 and ozone, and from those calculate the human mortality and morbidity (e.g. labor, hospitalization, indirect productivity losses) burdens along with the associated economic costs across CMIP6 models and for different scenarios
  - Contact: drew.shindell@duke.edu
  - Coauthors: Jordan Schnell, Jason West and others

- **Atmospheric oxidising capacity and methane lifetime past and future, in response to emissions and climate changes (Alcide Zhao et al) -** submission by December, 2019

- Analyze hist and histSST simulations to assess historical changes, uncertainty across ensemble members and inter-model. Compare to 1980-present derived from top-down inversions. Relate OH changes/variability to methane growth rate.
- Analyse sensitivity runs with fixed 1850s components (histSST simulations from Table 2 of Collins et al., 2017) to isolate drivers of OH change (cf. Murray et al., 2014).
- Analyse future simulations, at least SSP370 and SSP370-NTCF.
- Analyse variability and relate to ENSO (cf. Turner et al., 2018) and lightning NOx using piControl but may not have enough time or output.
- Lee's paper analyzing the reasons for inter-model diversity in ACCMIP/CCMI will inform AerChemMIP analysis.
- Contacts: Alcide.Zhao@ed.ac.uk, David.S.Stevenson@ed.ac.uk
- Coauthors: Alcide Zhao, David Stevenson, Fiona O'Connor, Simone Tilmes, Lee Murray, Vaishali Naik, Guang Zeng and others

- **Historical and future human land cover change impacts on surface air quality and the short-lived climate forcers** (**Scott, Unger, Spracklen et al., 2020**) - submission post December 2019
  - LUMIP historical simulations with and without land cover change - in dialogue with LUMIP leaders about models that include BVOCs and atmospheric chemical composition (relevant diagnostics turned on)
  - Analyse available future world SSP370SST-ssp126Lu and SSP370SST output. Human land cover is the only difference - new information about the sensitivity of SLCFs to future land cover change.
  - Contacts: C.E.Scott@leeds.ac.uk

- **Future climate change impacts on global air quality (Unger, Scott, Spracklen et al., 2020)** - submission post December 2019
  - Climate change only runs depending on how many centers run them
  - Analyse differences between between ssp370_2014SST and ssp370SST
  - Focus on changes to natural emissions, surface ozone and PM2.5
  - Contact: N.Unger@exeter.ac.uk