Coupled Model Intercomparison Project Phase 6 (CMIP6) - an Overview of Activities

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1-2 November 2016

WGCM-20

University of Princeton, USA

CMIP
The World Climate Research Programme's
Coupled Model Intercomparison Project

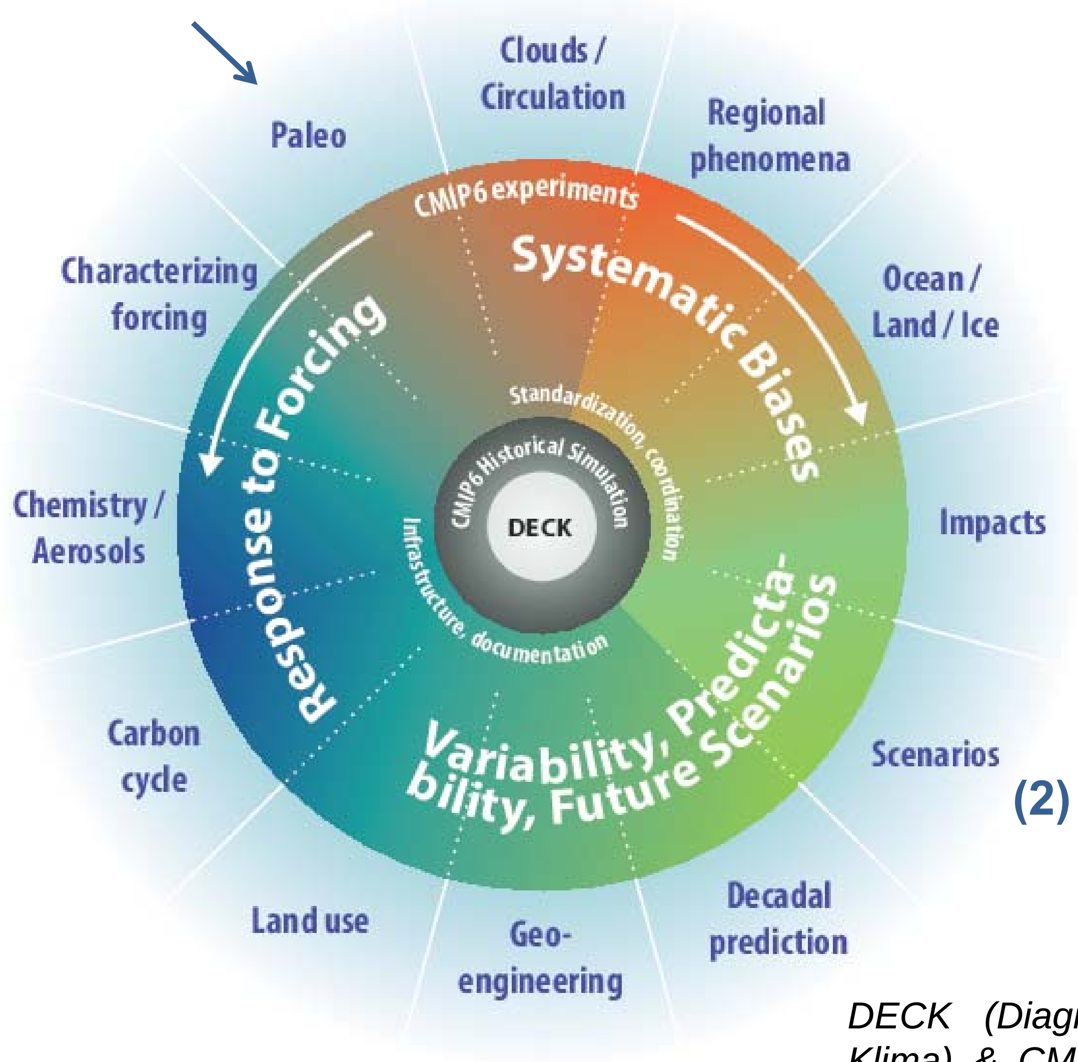
DLR

Outline

1. CMIP6 Experimental Design and Update on CMIP6 Special Issue in GMD (see http://www.geosci-model-dev.net/special_issue590.html)
2. Overview Status CMIP6-Endorsed MIPs & Feedback for WGCM
3. Overview Participating Modelling Groups & Feedback for WGCM
4. Overview Forcings for CMIP6 & Feedbacks from Model Groups
5. First Recommendations for Future CMIP Phases
6. Summary and Outlook
7. Action items WGCM-20

CMIP: a More Continuous and Distributed Organization

(3) CMIP-Endorsed Model Intercomparison Projects (MIPs)



Eyring et al., GMD, 2016

(1) A handful of common experiments

DECK (entry card for CMIP)

i. AMIP simulation (~1979-2014)
ii. Pre-industrial control simulation
iii. 1%/yr CO_2 increase
iv. Abrupt 4xCO_2 run

CMIP6 Historical Simulation (entry card for CMIP6)

v. Historical simulation using CMIP6 forcings (1850-2014)

(2) Standardization, coordination, infrastructure, documentation

DECK (Diagnosis, Evaluation, and Characterization of Klima) & CMIP6 Historical Simulation to be run for each model configuration used in CMIP6-Endorsed MIPs

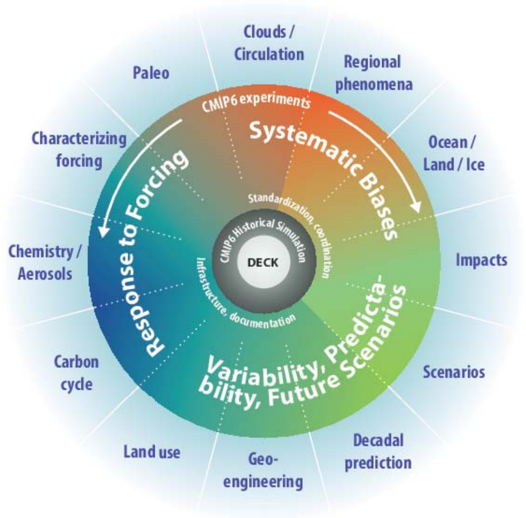
CMIP6 Overview Paper

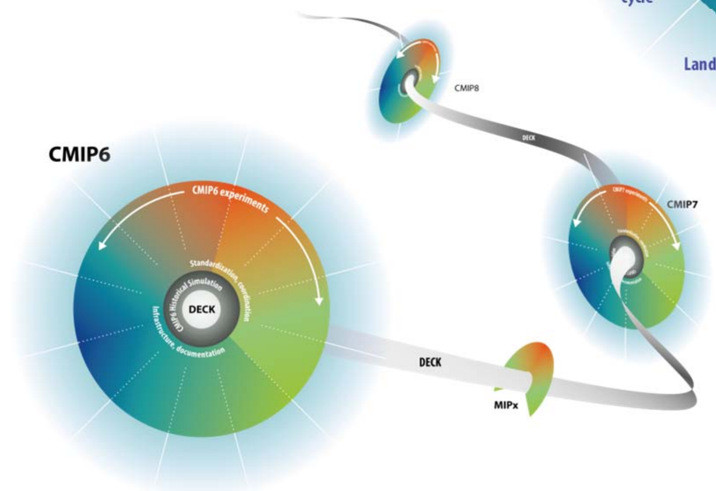
26 May 2016

Model experiment description paper

Overview of the Coupled Model Intercomparison Project Phase 6 (CMIP6) experimental design and organization

Veronika Eyring[1], Sandrine Bony[2], Gerald A. Meehl[3], Catherine A. Senior[4], Bjorn Stevens[5], Ronald J. Stouffer[6], and Karl E. Taylor[7]



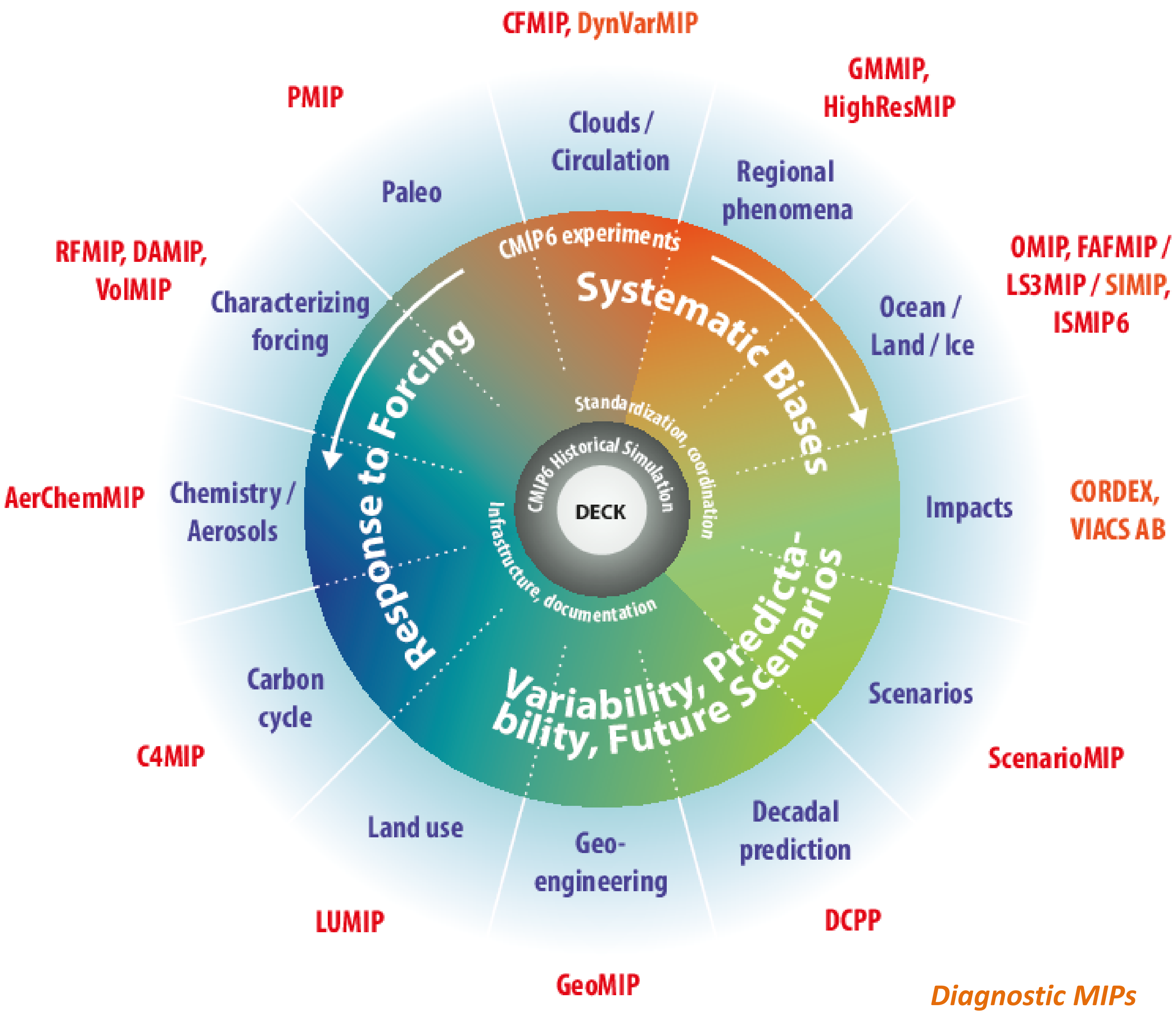


	Questions: Response to Forcing	Questions: Systematic Errors	Questions: Variability, Predictability & Projection	Grand Science Challenges: Clouds, Circulation, Sensitivity	Grand Science Challenges: Melting Ice	Grand Science Challenges: Climate Extremes	Grand Science Challenges: Changes in Water Availability	Grand Science Challenges: Regional Sea Level Change	Grand Science Challenges: Biogeochemistry	Grand Science Challenges: Near Term Prediction
AerChemMIP	●		○						●	○
C4MIP	●		○				○		●	
CFMIP	●	○		●			○			
DAMIP	●		○		○	●				
DCPP	○		●				○	○		●
FAFMIP	●	○		○				●		
GeoMIP	○		●	●		○	○			
GMMIP		●	○	●			○			○
HighResMIP	○	●		○			●			
ISMIP6	●		○		●			●		
LS3MIP	○	●			○		●			
LUMIP	●		○				○		●	
OMIP		●	○					○	○	●
PMIP	●	○		●					○	
RFMIP	●		○	●						○
ScenarioMIP	○		●			●	●		○	
VolMIP	●	○		○						○
CORDEX	○		●			●	○			
DynVarMIP	○	●		○						○
SIMIP	○	●			●					
VIACS AB	○		●			●	○	○		

Eyring et al., GMD, 2016

21 CMIP6-Endorsed MIPs

- All papers submitted ~on the agreed timeline (end of April 2016) to the CMIP6 Special Issue in GMD!
- Peer-reviewed by at least 2 referees
- Additional review of the majority of the MIP papers by the CMIP Panel.
- Additional comments from individual scientists.



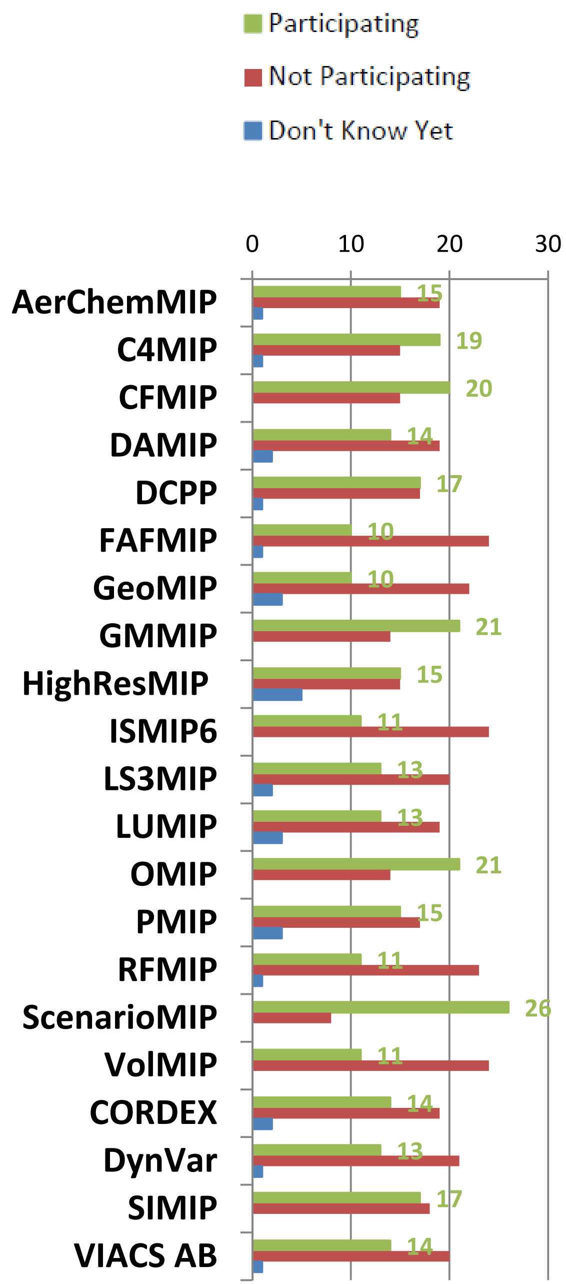
Eyring et al., GMD, 2016

Status CMIP6-Endorsed MIPs and Feedback for WGCM

- Detailed overview on the status of the CMIP6-Endorsed MIPs from the co-chairs of each MIP: see separate presentation.
- Open issues and discussion points for WGCM
  - PMIP GMD paper: a worrying large number of papers ‘to be submitted’
  - CORDEX Reviewer Comment: CORE framework appears as a race for higher resolution against GCMs
  - CMIP6 Data Request: massive delays and huge
- Specific feedback from the MIPs for WGCM
  - **AerChemMIP:** latest excel tables not yet correctly included in CMIP6 data request despite that this version was sent in may 2016 to BADC .
  - **ISMIP6:** clarification from CMIP as to whether the ssp extension scenarios should be described as split from the 100 year scenario or one simulation.
  - **RFMIP**: biggest issue for RFMIP has been coordination with the infrastructure.
    - It would be useful to have something **beyond a single point of contact** for the data request, and to ensure that feedback on revisions to the data request was timely.
    - It would be useful to have a list of contacts or some mechanism where one could bring issues related to input4MIPs and the provisioning of forcing data.
  - **HighResMIP:**
    - Volumes from HighResMIP (and CMIP6 more generally) becoming huge (many PetaBytes)
    - Impractical to download multiple ensemble members to local machine (even for DECK?)
    - How can we best enable data sharing and effective analysis?
    - PRIMAVERA will use the CEDA JASMIN platform – from which the CMIP6 ESGF node is directly accessible. What is the international strategy; what prospects are there of equivalent platforms elsewhere?

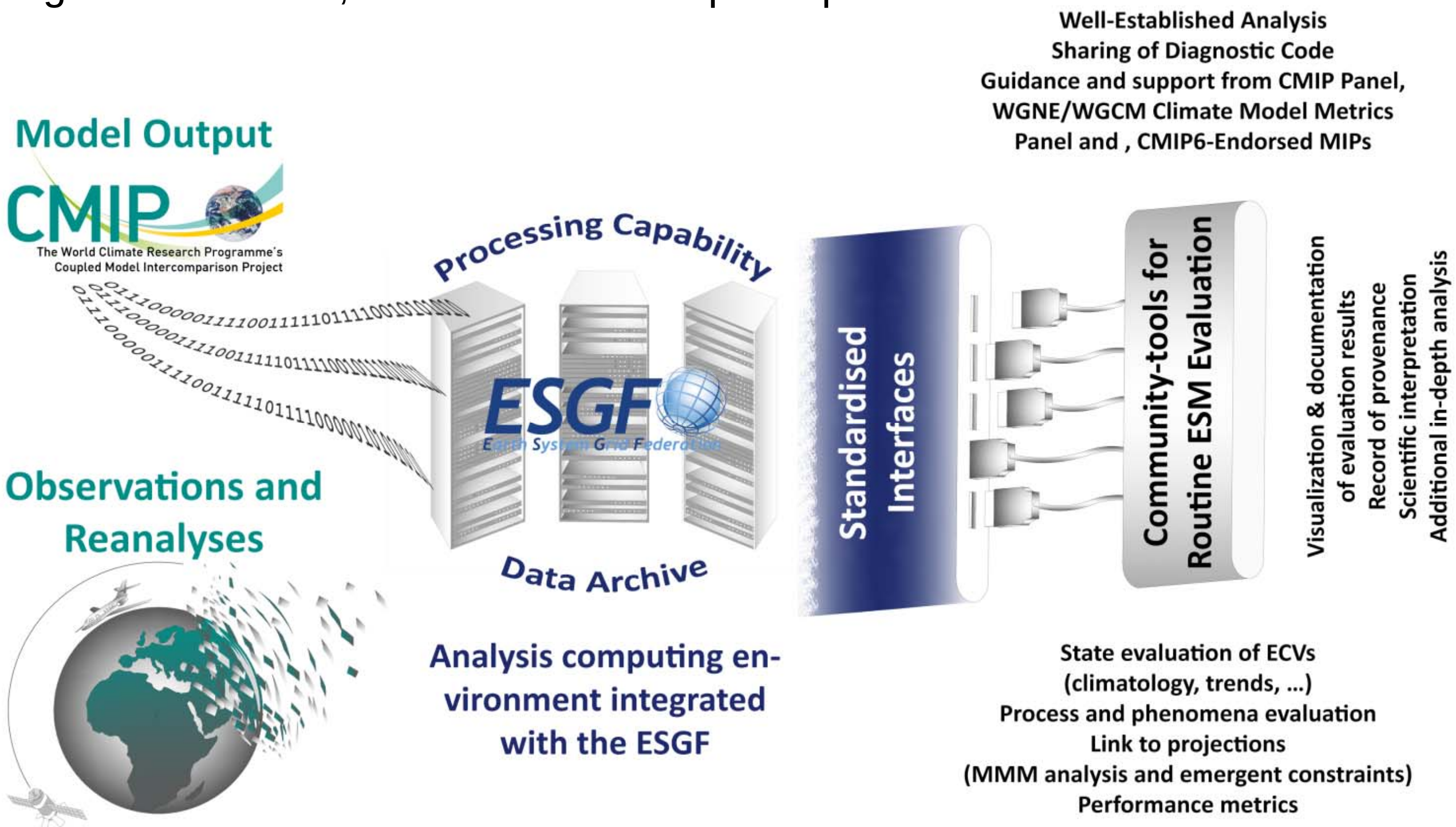
Model Groups' Commitments to participate in CMIP6-Endorsed MIPs

	Long Name of MIP (Short Name of MIP)	
1	Aerosols and Chemistry Model Intercomparison Project (AerChemMIP)	GMDD
2	Coupled Climate Carbon Cycle Model Intercomparison Project (C4MIP)	GMD
3	Cloud Feedback Model Intercomparison Project (CFMIP)	GMDDa
4	Detection and Attribution Model Intercomparison Project (DAMIP)	GMD
5	Decadal Climate Prediction Project (DCPP)	GMD
6	Flux-Anomaly-Forced Model Intercomparison Project (FAFMIP)	GMDDa
7	Geoengineering Model Intercomparison Project (GeoMIP)	GMD
8	Global Monsoons Model Intercomparison Project (GMMIP)	GMD
9	High Resolution Model Intercomparison Project (HighResMIP)	GMDDa
10	Ice Sheet Model Intercomparison Project for CMIP6 (ISMIP6)	GMDD
11	Land Surface, Snow and Soil Moisture MIP (LS3MIP)	GMD
12	Land-Use Model Intercomparison Project (LUMIP)	GMD
13	Ocean Model Intercomparison Project (OMIP)	GMD
	Biogeochemical OMIP	GMDD
14	Paleoclimate Modelling Intercomparison Project (PMIP)	GMDD
15	Radiative Forcing Model Intercomparison Project (RFMIP)	GMD
16	Scenario Model Intercomparison Project (ScenarioMIP)	GMD
17	Volcanic Forcings Model Intercomparison Project (VolMIP)	GMD
18	Coordinated Regional Climate Downscaling Experiment (CORDEX)	GMDDa
19	Dynamics and Variability Model Intercomparison Project (DynVarMIP)	GMD
20	Sea-Ice Model Intercomparison Project (SIMIP)	GMD
21	Vulnerability, Impacts & Adaptation and Climate Services AB (VIACS AB)	GMD



Envisaged Workflow for Routine Model Evaluation in CMIP6

- We argue that the community has reached a critical juncture at which many baseline aspects of ESM evaluation need to be performed much more efficiently
- The resulting, increasingly systematic characterization of models with community evaluation tools such as the ESMValTool or the PCMDI Metrics Package will, compared with early phases of CMIP, more quickly and openly identify strengths & weaknesses of the simulations.
- This activity also aims to assist modelling groups in improving their models
- Running alongside the ESGF, as soon as the output is published



Eyring et al., ESD (2016)

See also talk by Peter Gleckler

CMIP6: Participating Model Groups

1	**ACCESS-ESM**	Australia	13	**EC-Earth3**	Europe	24	**MIROC-CGCM**	Japan
2	**AWI-CM**	Germany	14	**EMAC**	Germany	25	**MIROC-ESM**	Japan
3	**BCC**	China	15	**FGOALS**	China	26	**MPI-ESM**	Germany
4	**BESM**	Brazil	16	**FIO**	China	27	**MRI-ESM2**	Japan
5	**BNU**	China	17	**GFDL**	USA	28	**MRI-AGCM3**	Japan
6	**CAMS-CMS**	China	18	**GISS**	USA	29	**NICAM**	Japan
7	**CanESM**	Canada	19	**IITM-ESM**	India	30	**NorESM**	Norway
8	**CasESM**	China	20	**HadGEM3**	UK	31	**NUIST**	China
9	**CESM2**	USA	21	**INM**	Russia	32	**TaiESM**	Taiwan
10	**CESS-THU**	China	22	**IPSL -CM6**	France	33	**UKESM**	UK
11	**CMCC**	Italy	23	**K-ACE**	Republic of Korea	34	**VRESM**	South Africa / Australia
12	**CNRM**	France						

New in CMIP:

2 new model groups from Germany (AWI-CM, EMAC)
4 new model groups from China (CAMS-CMS, CasESM, CESS-THU, NUIST)
1 new model group from Brazil (BESM)
1 new model group from India (IITM)
1 new model group from Taiwan (TaiESM)
1 new model group from Republic of Korea (K-ACE)
1 new model group from South Africa / Australia (VRESM)

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=> 11 new model groups

The World Climate Research Programme's Coupled Model Intercomparison Project

General Feedback from Model Groups for WGCM

- **EC-Earth**: It is not nice that the format of the forcing files of the **final** releases does change again when they are put to input4mips, this has happened to SST/SIC and to GHG forcing.
- **IPSL:** Most forcing datasets are not documented and have not undergone any sort of review process. What if reviews on the forthcoming GMD forcing papers request corrections to the datasets?
- **IPSL:** Emissions for future scenarios are not yet available. There is of course a requirement of continuity in the emissions in 2014, but it would be nice if there is also a requirement of continuity in the first derivative (to avoid unrealistic scenarios that have a change of slope in 2014).
- **CNRM-CERFACS plan to begin their CMIP6 simulations by late November 2016** due to strong constraints on supercomputing. CNRM-CERFACS have decided that no post-processing will be applied to their model output (in other words, all the configurations used directly produce data which can be directly published on CNRM's ESGF datanode). To this end, CNRM-CERFACS **urgently** need to know when stabilized reference versions of the following will we available :
  - Data Request. By default, CNRM-CERFACS will only publish data on their native grid. If requested by CMIP6, some output may also be interpolated to regular grids. Again, we would like to stress that this interpolation step will be applied « on line » (once a simulation is finished, nothing else than available model output will be produced). **Therefore, we need a definition of the aimed regular grids and which variables need to be interpolated to these grids before late November 2016. We also need a stabilized variable request for every MIP by then.**
  - A technical specification of the needed output (DRS, CMIP6 CV). CNRM-CERFACS also wonder if the CMIP6 panel would allow changes of the DRS and CMIP6 CV during the exercise.

Overview Preindustrial and Historical Forcing Datasets

For overview on the status of the implementation of the forcings at each model group, please see separate presentation)

Forcing Dataset	GMD Paper	Provided by	PI	Historical
SLCF Emissions	Not yet	Steve Smith		
Biomass Burning	Not yet	Margreet van Marle, Guido van der Werf		
GHG Emissions	Not yet	Steve Smith, Bob Andres		
Land-use	Not yet	George Hurtt		
GHG concentrations	**GMDD**	Malte Meinshausen		
Ozone concentrations	Not yet	Michaela Hegglin		
Nitrogen deposition	Not yet	Michaela Hegglin		
Simple plume aerosol	**GMDD**	Bjorn Stevens		
Solar	**GMDD**	Katja Matthes, Bernd Funke		
Stratospheric aerosol	Not yet	Beiping Luo, Tom Peter, Larry Thomason		
AMIP SST and SIC	Not yet	Paul Durack, Karl Taylor		

KEY: **OK** | **Soon** | **Available but issues noted**

See CMIP Panel website at https://www.wcrp-climate.org/wgcm-cmip/wgcm-cmip6 for details

input4MIPs Contributed Forcing Data Status (CMIP6 DECK)

Forcing Dataset	Status	Temporal Coverage	Latest Data Version(s)	Contact
SLCF Emissions	Available	1750-01 to 2014-12	2016-06-18, 2016-06-18-sectonDimV2, 2016-07-26, 2016-07-26-sectorDim	Steven Smith
Biomass Burning	In Review	1750-01 to 2015-12	1.1 (2016-10-24; **v1.0 2016-06-30 hosted**)	Margreet van Marle
GHG and SLCF Emissions	Unknown	-	-	Steven Smith
Land-use	In Review	850 to 2015	2.0 (2016-10-24; **hosted externally**)	George Hurtt
GHG concentrations	Available	0-01 to 2015-12	1.2.0 (2016-07-01)	Malte Meinshausen
Ozone concentrations	Available	1850-01 to 2014-12	1.0 (2016-07-11)	Michaela Hegglin
Nitrogen deposition	Available	1850-01 to 2014-12	1.0 (2016-08-01)	Michaela Hegglin
Simple plume aerosol	Via GMD	-	-	Bjorn Stevens
Solar	In Review	1850-01 to 2299-12	3.2 (2016-10-24; **hosted externally**)	Katja Matthes
Stratospheric aerosol	In Review	1850-01 to 2014-12	2.0 (2016-06-02; **hosted externally**)	Beiping Luo
AMIP SST and SIC	Available	1870-01 to 2016-06	1.1.1 (2016-10-20; **v1.1.2 due April 2017**)	PCMDI

Status Key: Available | In Review | Unknown

Download links, input4MIPs website https://pcmdi.llnl.gov/search/input4mips
For further information on datasets see the live google doc at https://goo.gl/r8up31

SLIDES kindly provided by Paul Durack – THANKS!

input4MIPs Contributed Forcing Data Status (Satellite MIPs)

Satellite MIP	Status	Host(s); Version	Plans for input4MIPs hosting	Contact
CFMIP	Ready	See details at http://doi.org/10.5194/gmd-2016-70	?	Mark Webb mark.webb@metoffice.gov.uk
DCPP	Ready	https://pcmdi.llnl.gov/search/input4mips; 1.0 (2016-10-21)	Yes	Christophe Cassou
FAFMIP	Ready	http://www.met.reading.ac.uk/~jonathan/FAFMIP/; (2015-08-21)	Yes	Jonathan Gregory
HighResMIP	In Prep.	-	?	Malcolm Roberts
LS3MIP	Unknown	-	?	Sonia Seneviratne
OMIP	Ready	CORE (Ready); JRA55 (In Prep.)	Yes	Gokhan Danabasoglu
PMIP	Unknown	https://pmip4.lsce.ipsl.fr/doku.php; ?	Yes	Masa Kageyama
RFMIP	In Prep.	- ; 1.0 (2016-06-01)	Yes	Robert Pincus
ScenarioMIP	Unknown	-	Yes/?	Detlef van Vuuren
VolMIP	Ready	ftp://iacftp.ethz.ch/pub_read/luo/CMIP6/; 1.0 (2016-06-02)	Yes	Davide Zanchettin

Status Key: Ready | In Prep. | Unknown

Download links, input4MIPs website https://pcmdi.llnl.gov/search/input4mips

For further information on datasets see the live google doc at https://goo.gl/r8up31

CMIP6 – Historical Anthropogenic Emissions

SLIDES kindly provided by Steve Smith – THANKS!

STATUS

- Complete and available on ESGF with following meta data:

  :activity_id = "input4MIPs";
  :dataset_category = "emissions";
  :realm = "atmos";
  :institute = "PNNL-JGCRI"
  :product = "primary-emissions-data"

- Paper drafting underway. Not yet submitted to GMD.
- Working with integrated assessment model teams to supply data needed to harmonize with future emission scenarios.
  - Future emission scenarios will be consistently gridded using the same software and procedures.

Key Features

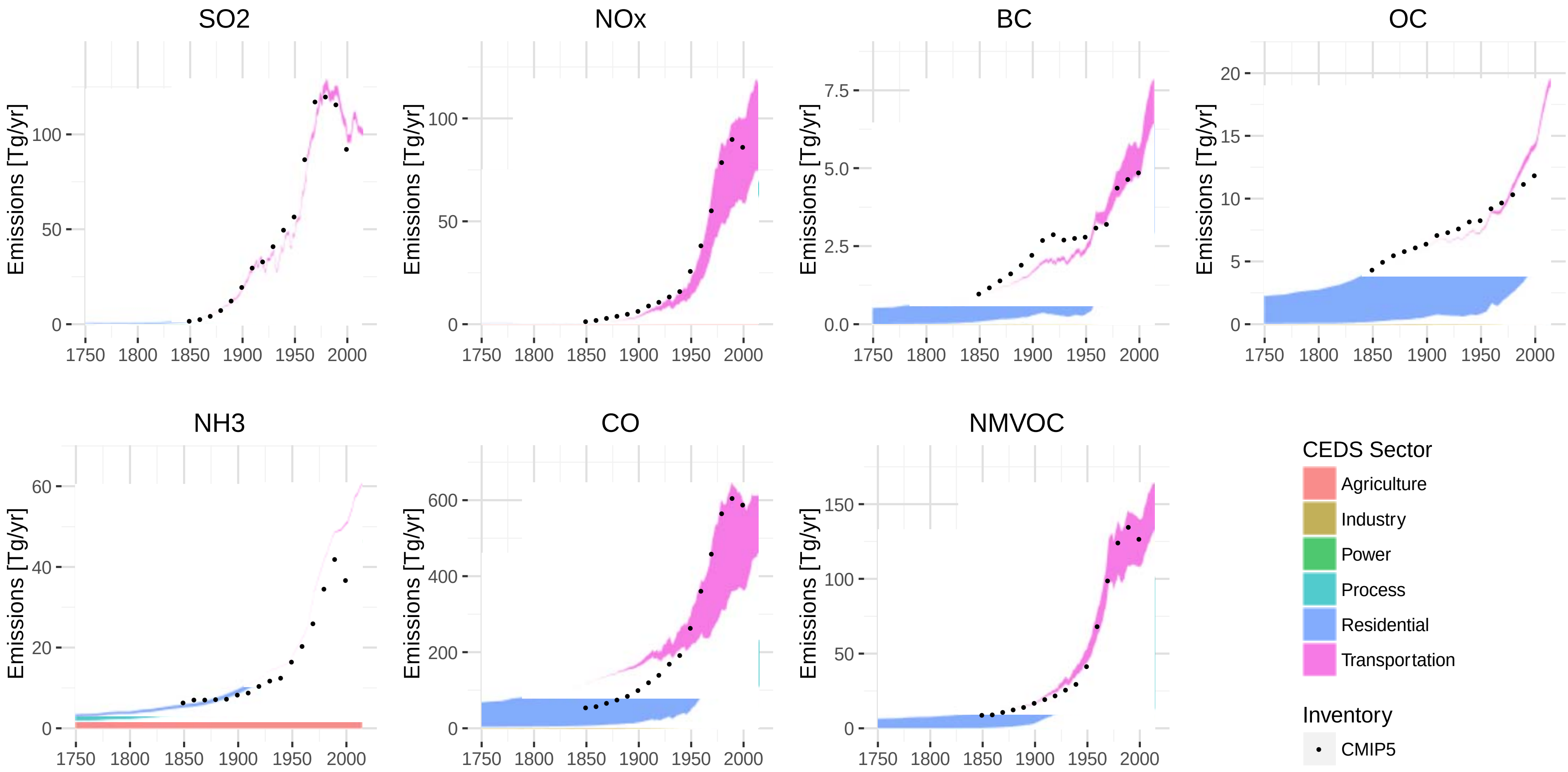
- Annual estimates, 1750 – 2014
- CO, NO_X, SO_2, OC, BC, NH_3, NMVOC (CO_2 and CH_4 forthcoming)
- All emissions estimated at the country level
- Mapped to 0.5 degree grids in 9 sectors for CMIP6
- Monthly Seasonality for gridded data in all sectors
- NMVOC Speciation

Produced by the Community Emissions Data System (CEDS)
http://www.globalchange.umd.edu/ceds/

Contact: ssmith@pnnl.gov

CMIP6 Emissions Compared to CMIP5

- Residential biomass are the dominant emissions in early years 1850. (Except NH3, where manure emissions are dominant, and NO_X, which is relatively small at this point.)
- Residential biomass has large contribution to BC and CO even to current day
- Transportation sector has large contribution to recent trends for NO_X and CO



Like with like comparison does not include aviation, international shipping or agricultural waste burning.

CMIP6 – Historical Anthropogenic Emissions

Improvements Relative To CMIP5

- More robust emission trends
  - Consistent methodology across all years
  - All emission species use same driver data
  - Consistently calibrated to country-level inventories where available
- Annual data resolves important socio-economic events
- Emissions estimates out to 2014 to capture recent trends as best as possible
  - *Albeit with additional uncertainty (which is now being estimated)*
- 1850 Emissions – CO higher and NO_X lower, due to explicit representation of biomass and coal emissions for all species.
- New sectors included
  - Residential waste burning
  - Flaring (from ECLIPSE project)
  - Fossil-fuel Fires (from EDGAR)
- Reproducible emissions generation process
  - CEDS data system and most input data will be released as open source software
  - Updated data such as new country inventories and energy driver data can be readily incorporated to allow annual updates
  - Modular system facilitates data updates (e.g., "drag and drop" capability)

CMIP6 – Historical Anthropogenic Emissions

Issues and Limitations

- Extrapolation before 1970/1960 can be improved
  - Collection of additional driver data and consideration of changes in emission factors
  - Focus on residential sector, however, captures major transitions over this time
- A number of gridding proxies are static over time
  - Residential (and related) emissions distributed using population distribution, which changes over time. These are dominant in earlier years, so much of the major shifts in spatial distribution with a country is being captured.
  - Other sectors have mix of proxies, few of which are newer than 2010, and most were kept static over time

Future Work

- Consistent estimation of uncertainty over time
  - Focusing first on estimation of additional uncertainty in recent years to aid in interpretation of current data.
  - Extended uncertainty estimation will allow construction of ensembles of emission data sets.
- Data system release
  - Will allow evaluation and improvement of assumptions and conduct of emissions-related research.
- General data system and estimation method improvements

SLIDES kindly provided by
Margreet van Marle – THANKS!

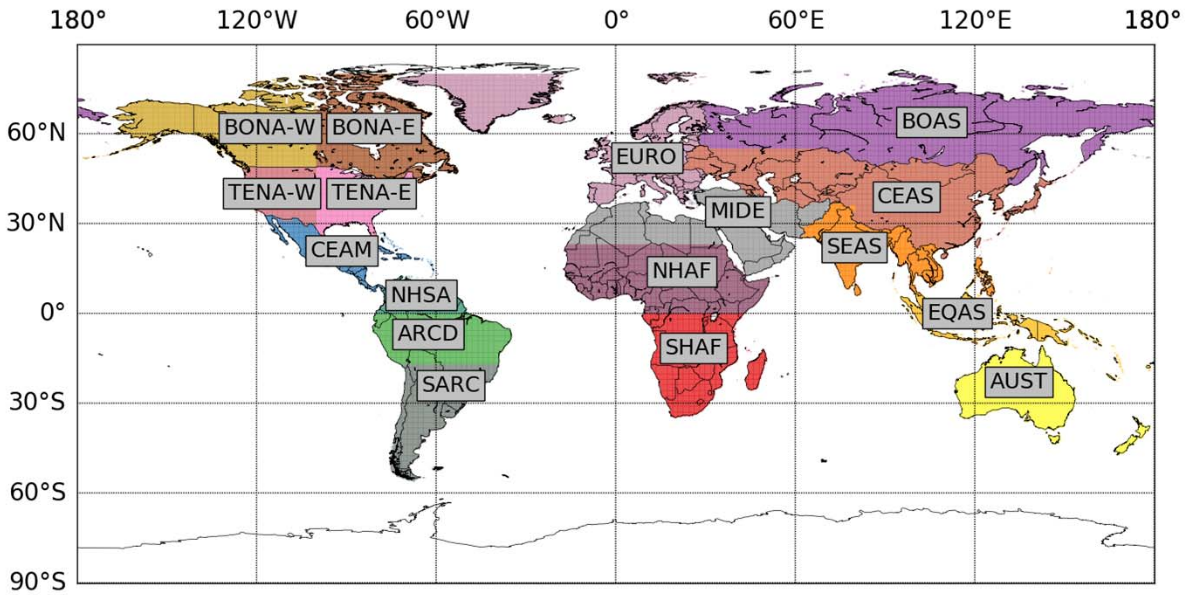
Biomass burning emissions (1750-2015)

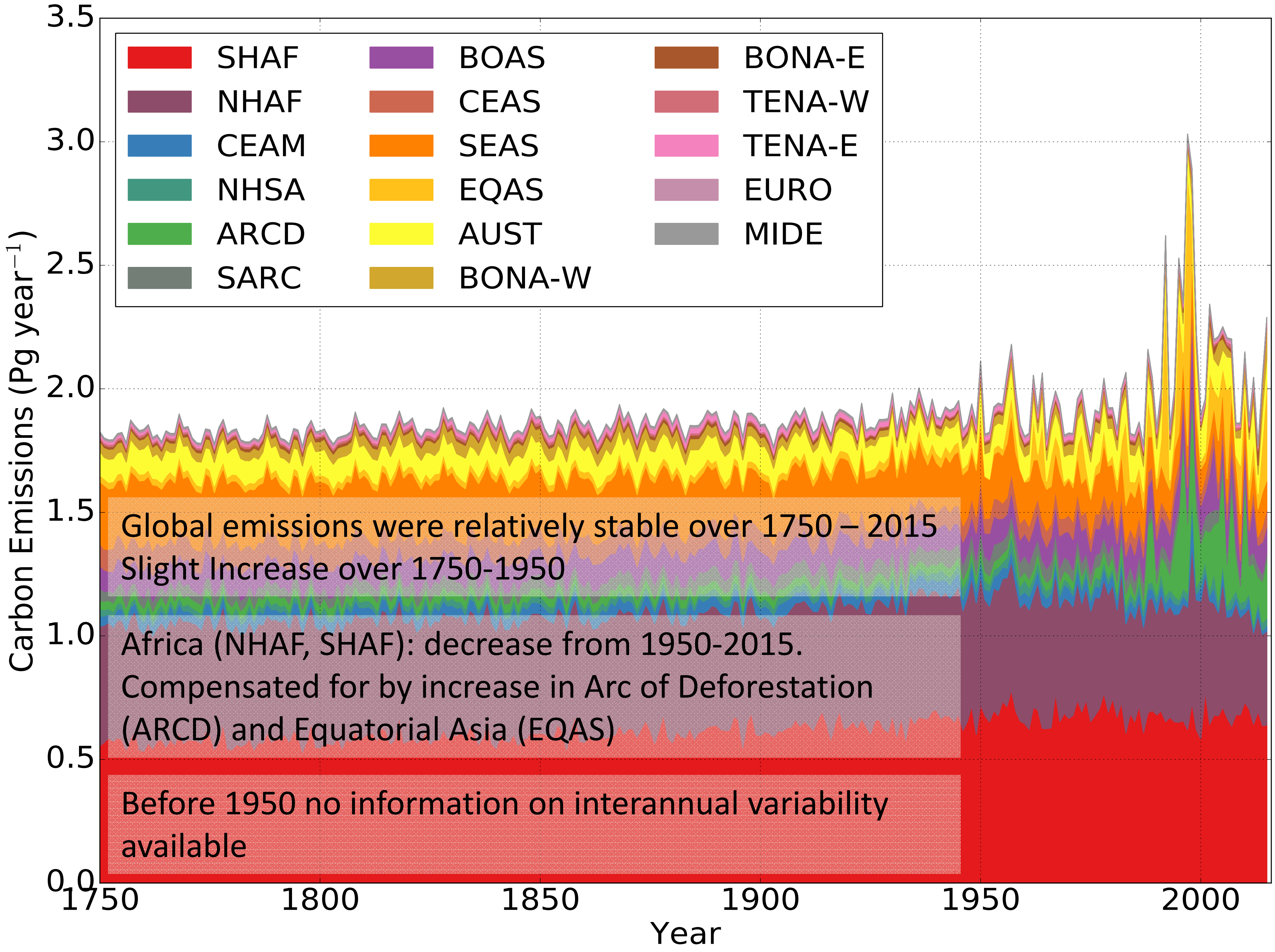
Merging information from proxies, models and satellite observations.

Margreet van Marle, Silvia Kloster,
Brian Magi, Jennifer Marlon,
Johannes Kaiser, Guido van der Werf, and
FireMIP Modellers

Regional approach

- We calculated fire histories for 17 regions
- For 1997-2014 we used the Global Fire Emissions Database (GFED4) version 4s
- Before satellite era various proxies and models were used:
  - Visibility observations at WMO station for tropical deforestation regions, calibrated and scaled to GFED for overlapping period
  - Charcoal records in boreal and temperate North America and Europe
  - For other regions we used FireMIP model medians





SHAF
NHAF
CEAM
NHSA
ARCD
SARC
BOAS
CEAS
SEAS
EQAS
AUST
BONA-W
BONA-E
TENA-W
TENA-E
EURO
MIDE
Carbon Emissions (Pg year^{-1})
Year
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
1750
1800
1850
1900
1950
2000
Global emissions were relatively stable over 1750 – 2015
Slight Increase over 1750-1950
Africa (NHAF, SHAF): decrease from 1950-2015.
Compensated for by increase in Arc of Deforestation
(ARCD) and Equatorial Asia (EQAS)
Before 1950 no information on interannual variability
available

CMIP6 versus CMIP5 fire datasets

- While missions increase over time in the CMIP5 dataset, our CMIP6 dataset indicates relatively stable emissions.
- Magnitude of emissions somewhat larger (10-20%)

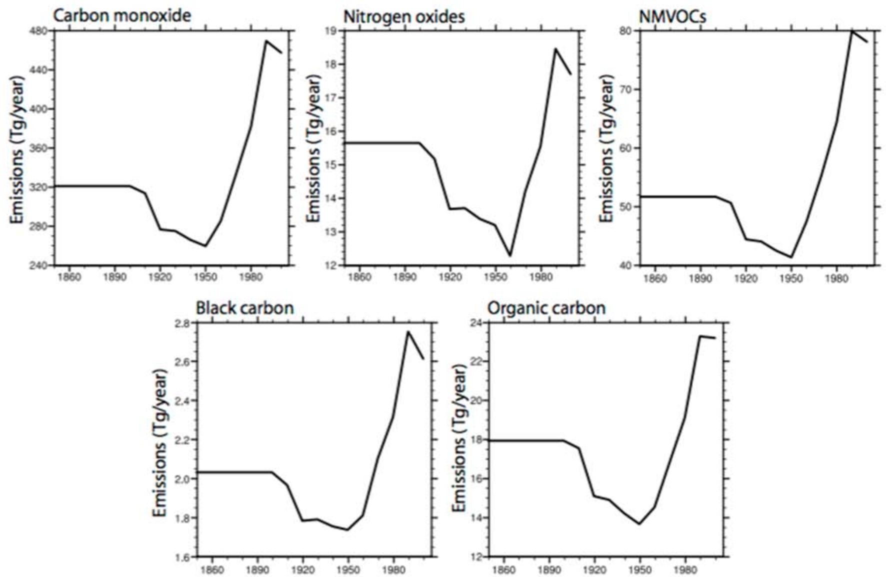


Fig. 3. Time evolution of the total open biomass burning (forest and grassland) emissions for carbon monoxide (Tg(CO)/year), NO_x ($Tg(NO_2)$/year), NMVOC (Tg(NMVOC)/year, black carbon (Tg(C)/year) and organic carbon (Tg(C)/year).

CMIP5 biomass burning emissions: *Lamarque et al., ACP, 2010*

Status of publication

- Version 1.1, creation date 2016-10-24, is uploaded to the server and will be published on input4MIPs shortly
- CMIP6 fire emissions paper will be send to FireMIP modellers to final round and submitted to GMDD this year

Model Groups' Feedback on Forcing Datasets

- Historical SLCF and GHG (CO_2 and CH_4) Emissions -

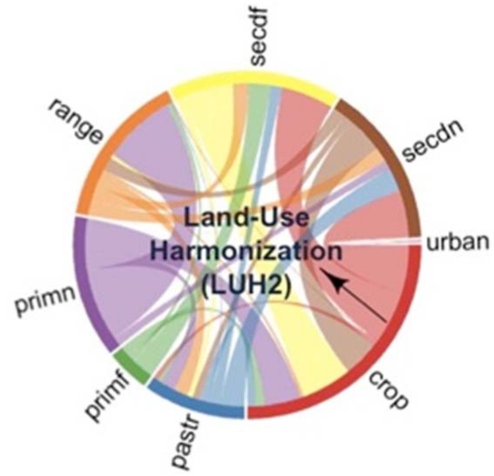
- **EC-Earth:** Anthropogenic (CEDS) emissions and biomass burning emissions are provided as separate data sets, resulting in different file conventions and NMVOC splits.
- **IPSL:** The biomass burning emission dataset has a monthly resolution and relies on observations, hence includes real-world interannual variability that would not necessarily be in phase in *historical* simulations. **It makes sense to smooth the BB emission data and a CMIP Panel recommendation on this would be welcomed.**
- **IPSL:** GHG (CO_2 and CH_4) Emissions not yet available but required

Main Comments GMD Paper:

- not yet submitted to GMD, so no review comments yet

CMIP
The World Climate Research Programme's Coupled Model Intercomparison Project

LUMIP
Land Use Change



G. Hurtt
D. Lawrence

Land-use Forcing

FUTURES: In progress now (6). Finalizing input datasets from IAMs, generating draft harmonized datatsets, reviewing and iterating with each IAM teams as needed, monthly with all IAM teams.

HISTORICAL: LUH2 v2h Release (10/14/16): The updated release of the historical land-use forcing dataset (LUH2 v2h) covers the period 850-2015 and corrects all known issues and notices identified with the previous version (LUH2 v1.0h). This dataset replaces the previously released dataset (LUH2 v1.0h). This product is the result of a series of prototypes released previously, uses the established data format, and will connect smoothly to gridded products for the future. Additional 'High' and 'Low' historical products in development.

Data Availability: http://luh.umd.edu (available), CMIP (in progress)

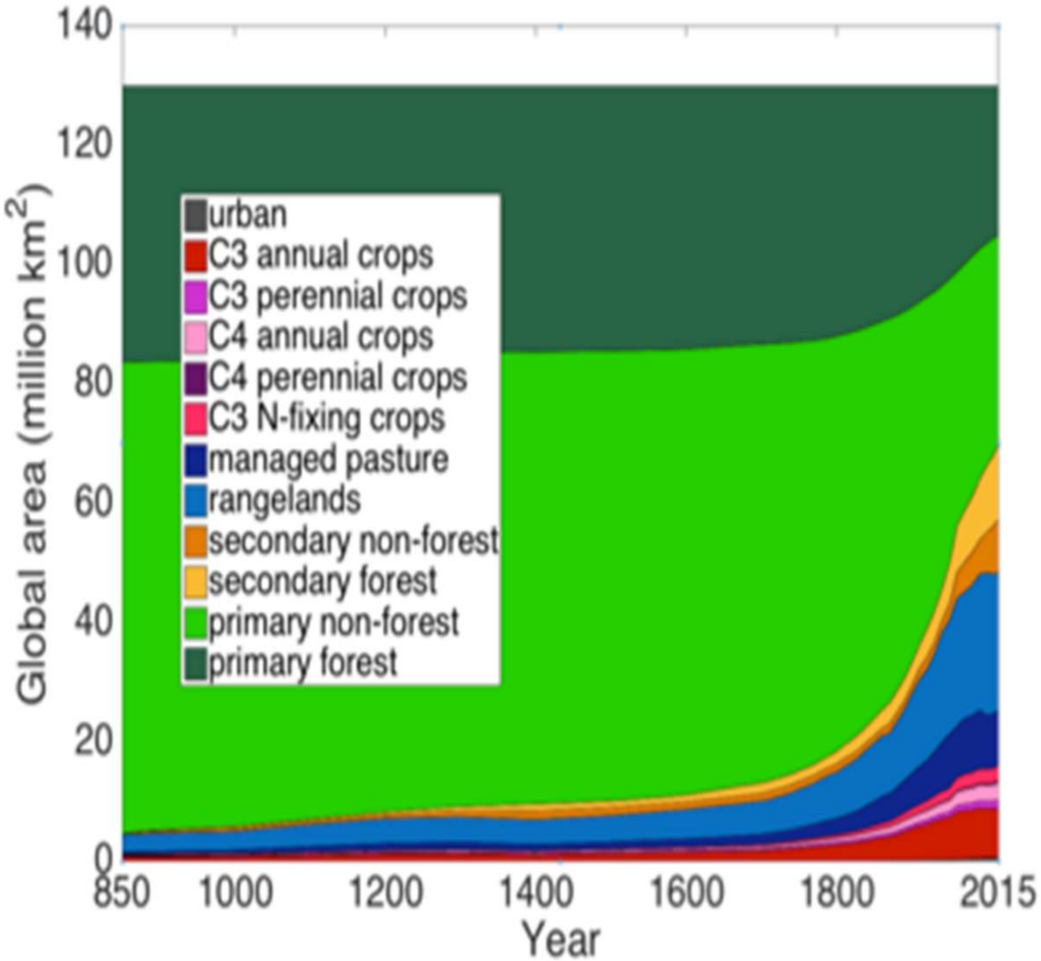
LUMIP: Paper published (Lawrence et al 2016),
Kickoff telecon October 26, 2016.

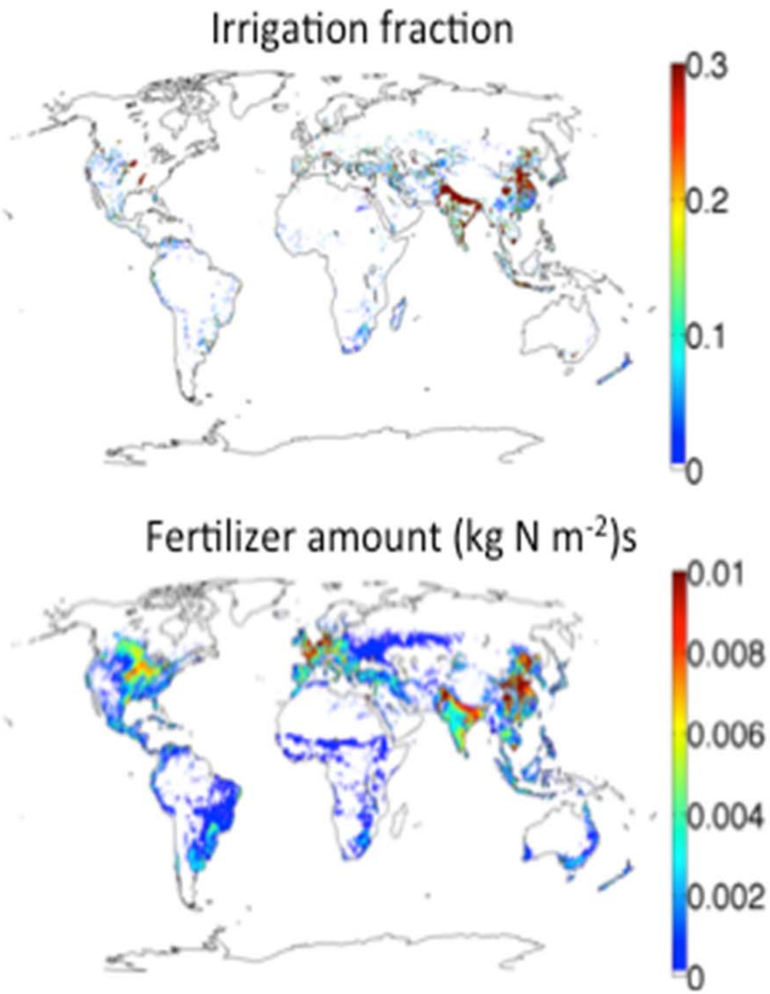
SLIDES kindly provided by George Hurtt – THANKS!

LUH2 Major Attributes for CMIP6

- LUH2 v2h (historical update) released October 14, 2016
- Updated Common history Reference, + High and low* cases
- Multiple harmonized futures, CMIP6 ScenarioMIP (6), Added 1.5 degree cases* (6)
- Spatial domain, Global
- Spatial resolution, 0.25 x 0.25 degree
- Temporal domain, 850-2100 (850-2300*)
- Temporal resolution, annual
- 12 possible land-use states including separation of Primary and Secondary natural vegetation into Forest and Non-forest sub-types, Pasture into Managed Pasture and Rangeland, and Cropland into multiple crop functional types (C3 annual, C3 perennial, C4 annual, C4 perennial, N fix)
- >100 possible land-use transitions per grid cell per year, including crop rotations, shifting cultivation, ag changes, wood harvest
- Updated static basemaps, historical inputs, shifting cultivation estimates
- F/NF (LandSat) constraints
- Gridded agriculture management layers including irrigation, fertilizer, tillage*, and biofuel management
- Partitioning of woof harvest fuel/non-fuel
- Expanded Diagnostic Package

>50x CMIP5 data

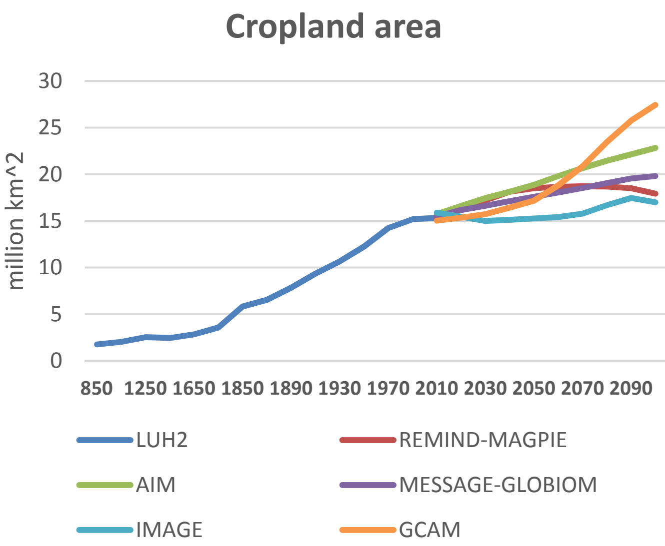


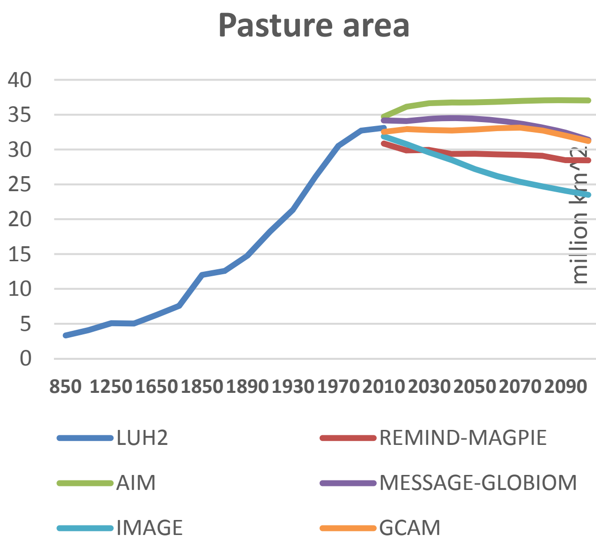


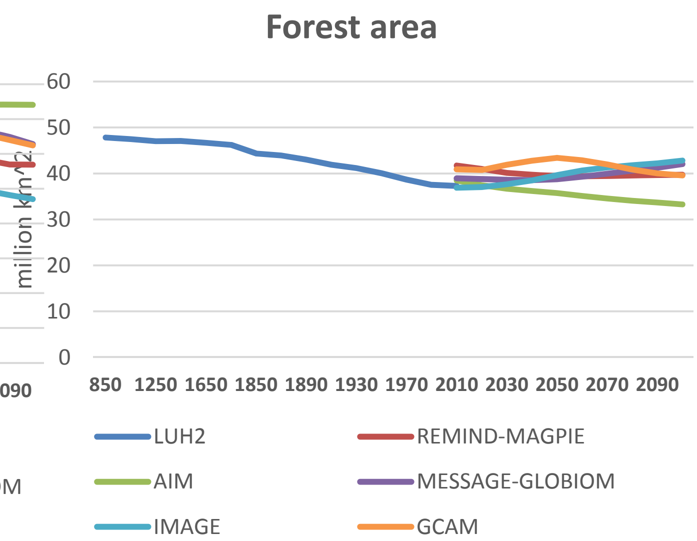
LUH2 v1.0h (April 29, 2016)

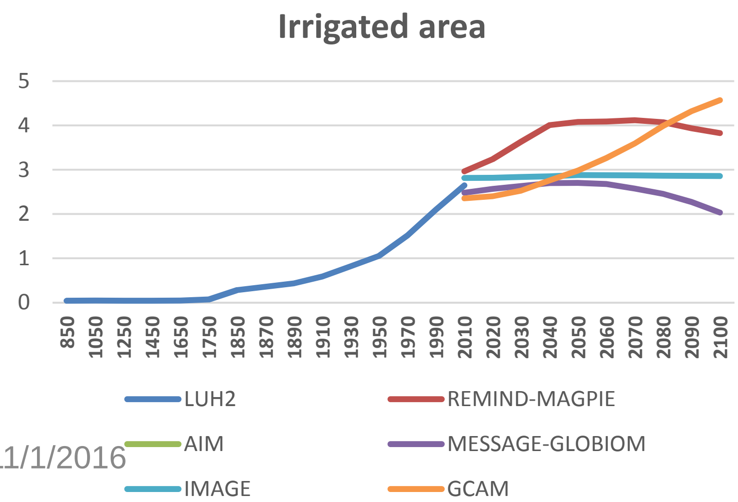
Lawrence et al 2016

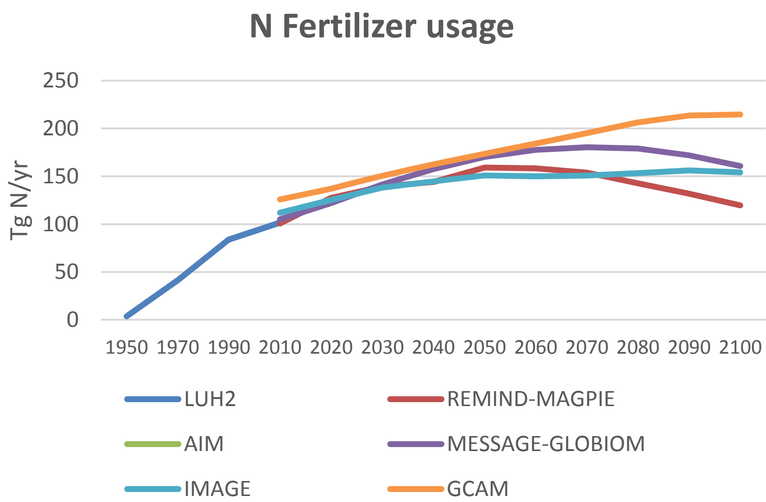
Pre-harmonization Comparison LUH2 and IAMs



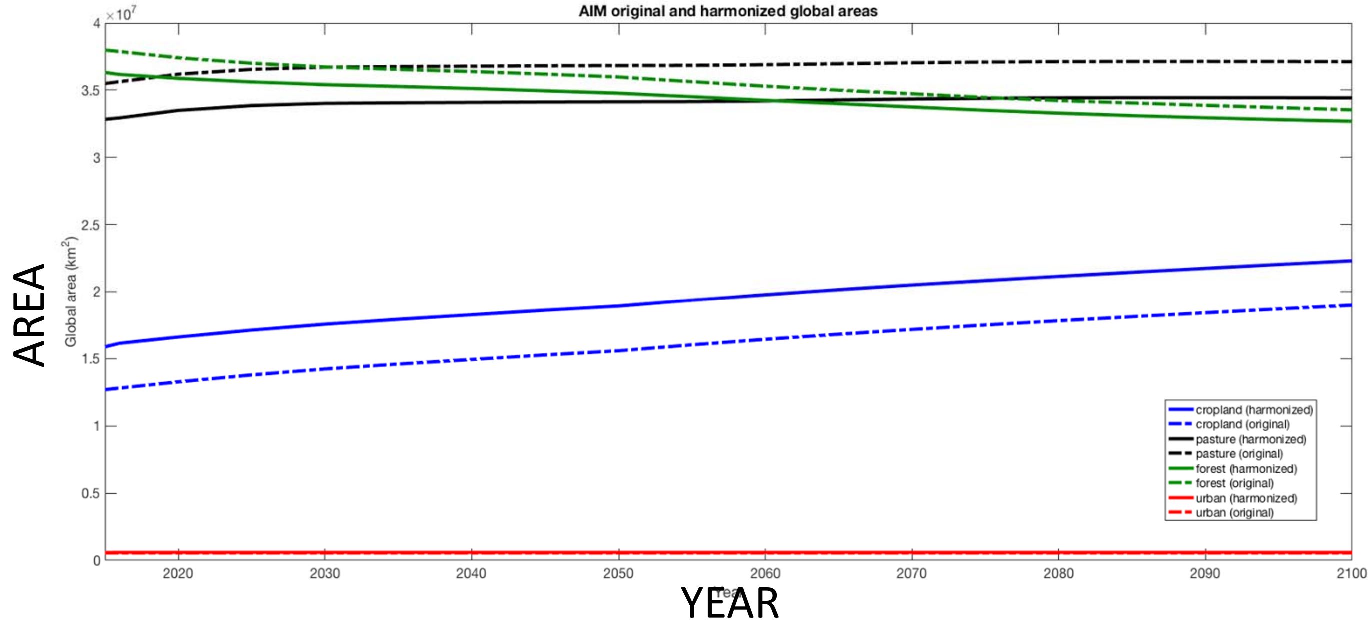


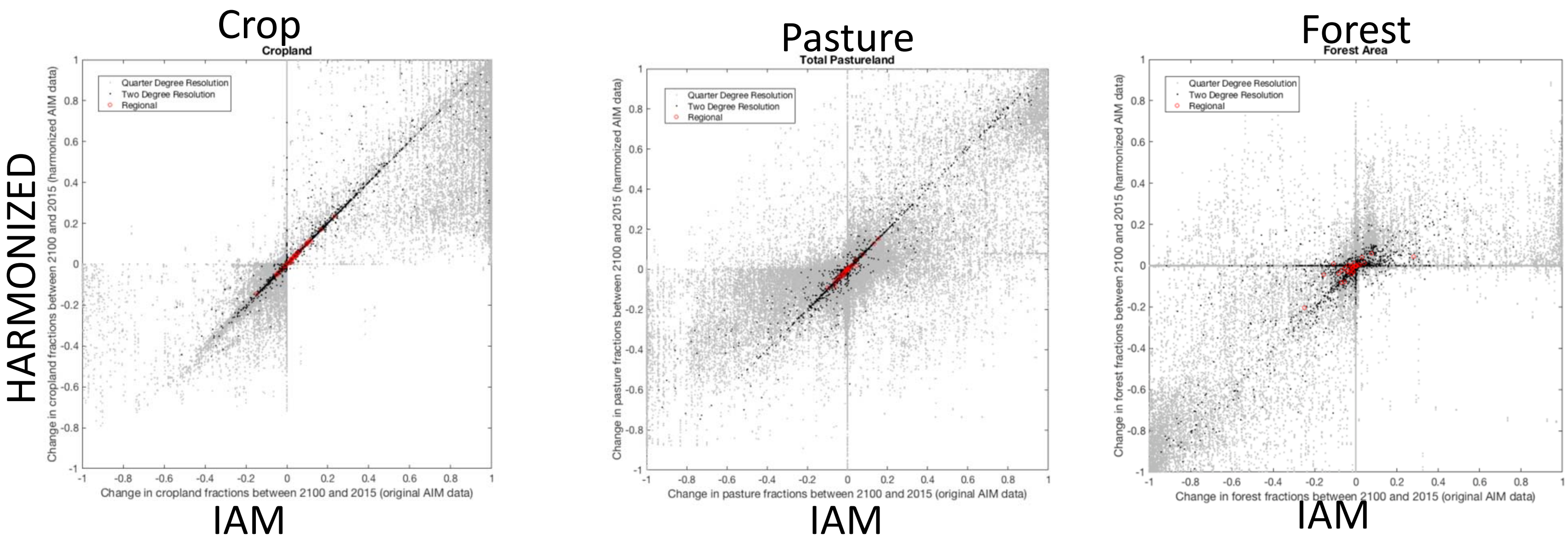






Draft Harmonization (SSP3-7 AIM)





Model Groups' Feedback on Forcing Datasets

- Global Gridded Land-use Forcing Datasets -

- No specific feedback on this dataset included in the slides from model groups

Main Comments GMD Paper:

- not yet submitted to GMD, so no review comments yet

CMIP
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CMIP6 historical GHG surface concentrations


Geosci. Model Dev. Discuss., doi:10.5194/gmd-2016-169, 2016
Manuscript under review for journal Geosci. Model Dev.
Published: 5 August 2016
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Geoscientific Model Development Discussions

Historical greenhouse gas concentrations

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Abstract. Atmospheric greenhouse gas concentrations are at unprecedented, record-high levels compared to pre-industrial reconstructions over the last 800,000 years. Those elevated greenhouse gas concentrations warm the planet and together with net cooling effects by aerosols, they are the reason of observed climate change over the past 150 years. An accurate representation of those concentrations is hence important to understand and model recent and future climate change. So far community efforts to create composite datasets with seasonal and latitudinal information have focused on ... layer conditions and recent trends since 1980s. Here, we provide consolidated data ... mixing ratios of 43 greenhouse gases specifically for the purpose of ... AGAGE and NOAA networks and a large set of ... are latitudinally resolved, and ...

Broad international collaboration with special thanks to AGAGE and NOAA networks!

Malte Meinshausen[1,2,3] Elisabeth Vogel[1,2], Alexander Nauels[1,2], Katja Lorbacher[1,2], Nicolai Meinshausen[4], David Etheridge[5], Paul Fraser[5], Stephen A. Montzka[6], Peter Rayner[2], Cathy Trudinger[5], Paul Krummel[5], Urs Beyerle[7], Josep G. Canadell[8], John S. Daniel[9], Ian Enting[10], Rachel M. Law[5], Simon O'Doherty[11], Ron G. Prinn[12], Stefan Reimann[13], Mauro Rubino[5,14], Guus J.M. Velders[15], Martin K. Vollmer[13], Ray Weiss[16]

SLIDES kindly provided by Malte Meinshausen – THANKS!

Contact: malte.meinshausen@unimelb.edu.au

CMIP6 historical GHG surface concentrations

Gases covered:

- **43** 'long-lived' GHG surface concentrations, i.e. CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3 and other fluorinated compounds

Four resolutions offered:

1. **Annual global mean (=CMIP6 default/minimum recommendation)**
2. Monthly global & hemispheric means
3. Monthly latitudinal zonal means ('native' 15-degree lat resolution)
4. Interpolated mean-preserving monthly zonal means (at 0.5 degree lat) to ease application in ESMs

Equivalence species:

- In addition to 43 GHGs, 3 equivalence species offered with inflated concentrations to minimise # of compounds:
  - **Option 1 - Subset**: Use subset of 43 GHGs (8/15 most important species cover 99.1% and 99.7% of total rad. Forcing)
  - **Option 2 – CFC-11-eq:** Use CO_2, CH_4, N_2O, CFC-12 and lump all others into (inflated) CFC-11-equivalence concentrations
  - **Option 3 – CFC-12eq and HFC134a-eq:** Use CO_2, CH_4, N_2O, CFC-12-eq for CFCs and HFC134a-eq for all others

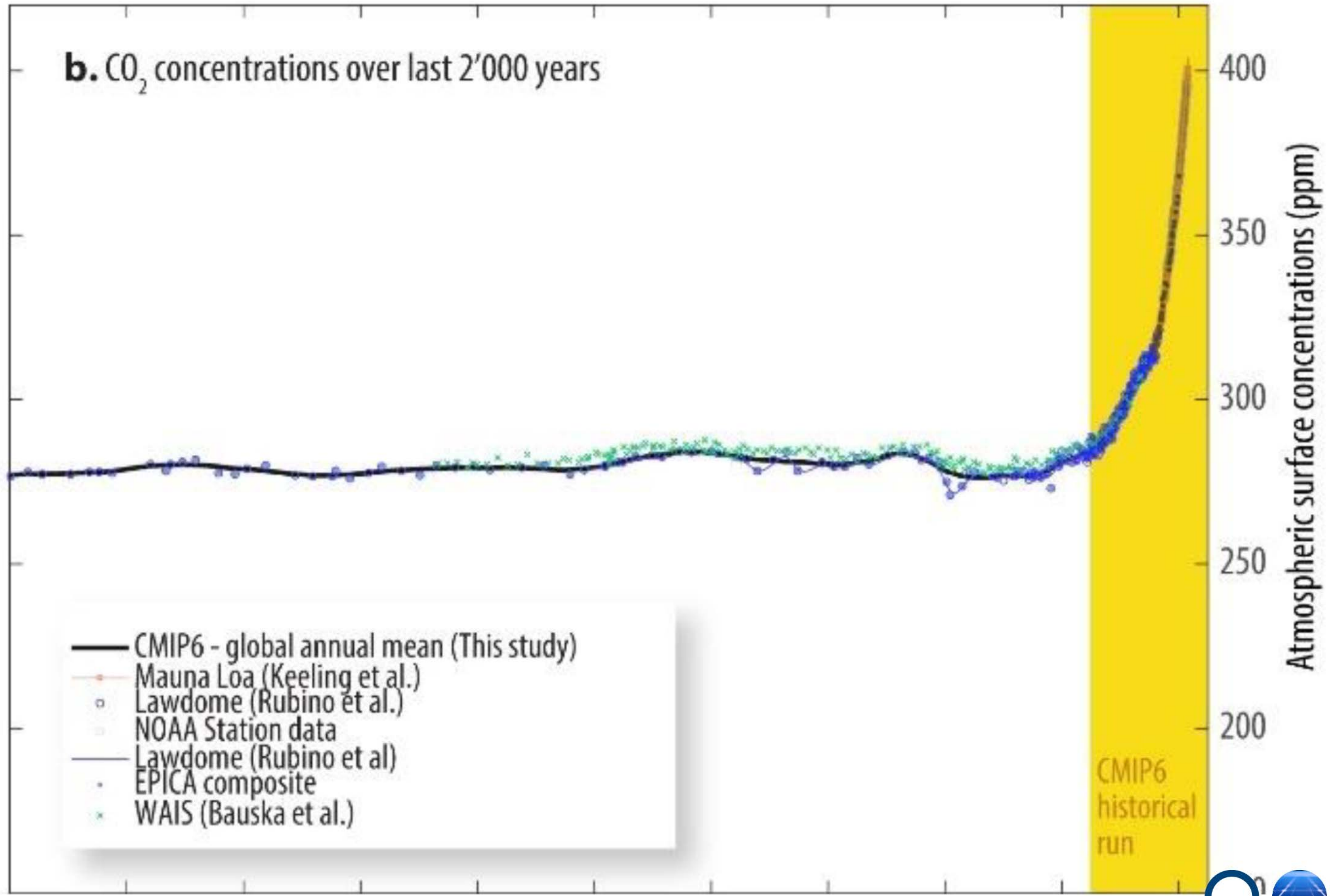


Fig. 1 - Meinshausen et al. GMDD, doi:10.5194/gmd-2016-169, 2016

Time span covered by data:
Beginning of Year 0 (= Year 1BC)
to end of year 2014

Years 0 to 1850:
Useable for PMIP

Years 1850 to 2014:
CMIP6 historical

Year 1850:
CMIP6 picontrol,
and usable for abrupt4x, 1pctCO_2

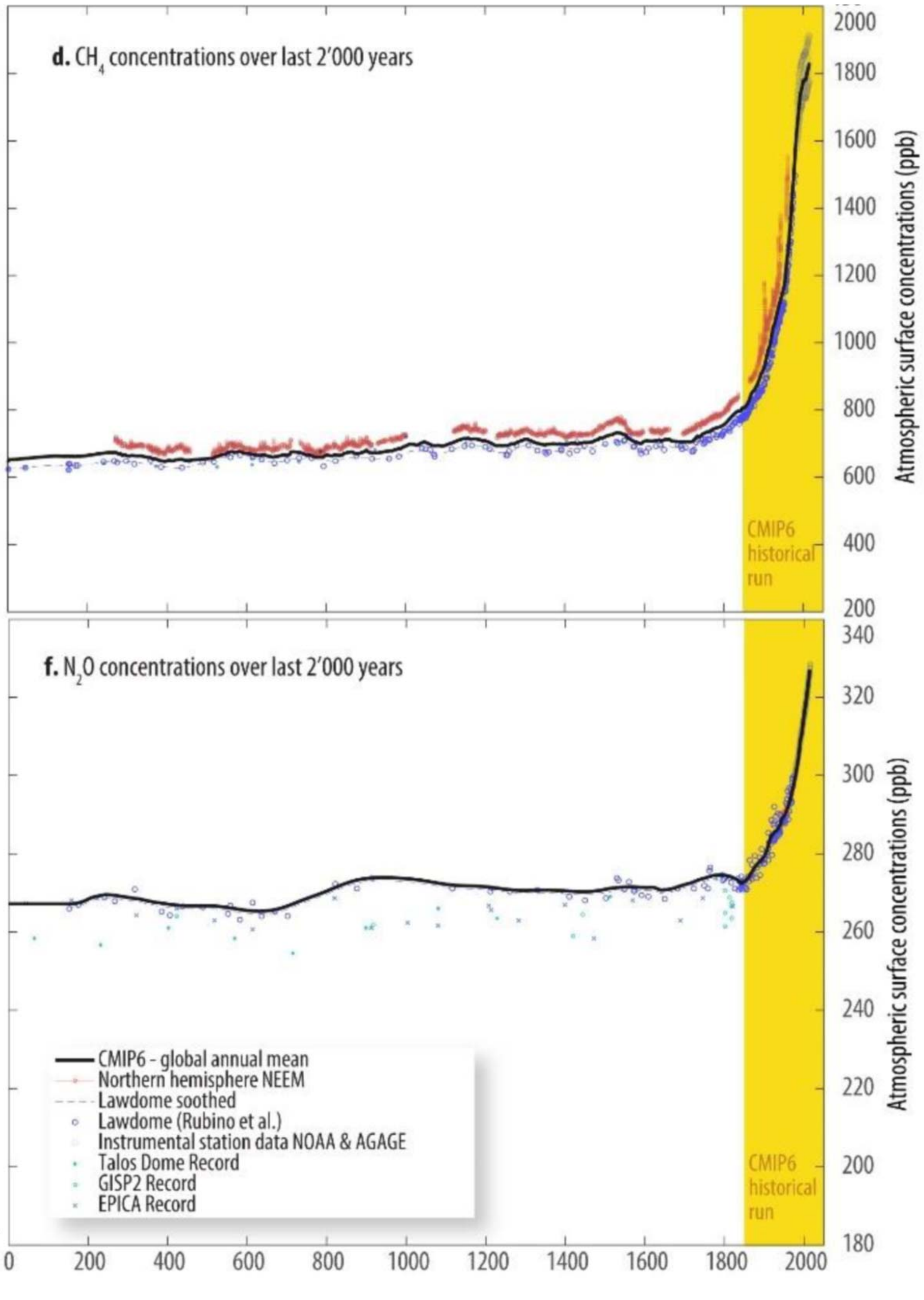


Fig. 1 - Meinshausen et al. GMDD, doi:10.5194/gmd-2016-169, 2016

CMIP6 historical GHG surface concentrations: Key benchmark values

Table 5 – picontrol: **Global- and annual-mean surface mixing ratios for the picontrol CMIP6 experiment. The hemispheric and latitudinally resolved mixing ratios for 43 greenhouse gases and three aggregate equivalent mixing ratios are provided in the accompanying historical run dataset for the year 1850. The complexity reduction options for capturing all GHGs with fewer species than 43 are indicated in the Table as Option 1, Option 2, and Option 3, with 'x' denoting relevant columns under each option.**

Years	CO_2	CH_4	N_2O	CFC-12-eq	HFC-134a-eq	CFC-11-eq	CFC-12	Other
Option 1	x	x	x				x	x
Option 2	x	x	x			x	x	
Option 3	x	x	x	x	x			
Units:	ppmv	ppbv	ppbv	pptv	pptv	pptv	pptv	
1850	284.317	808.25	273.02	16.51	19.15	32.11	0.00	All or a subset of other 39 individual gases, available in Supplementary

Issue to be aware of:

- 1850 picontrol run CO_2 concentrations: 284.3 ppm
- This is slight difference to 1750 (radiative forcing baseyear): 277.1 ppm

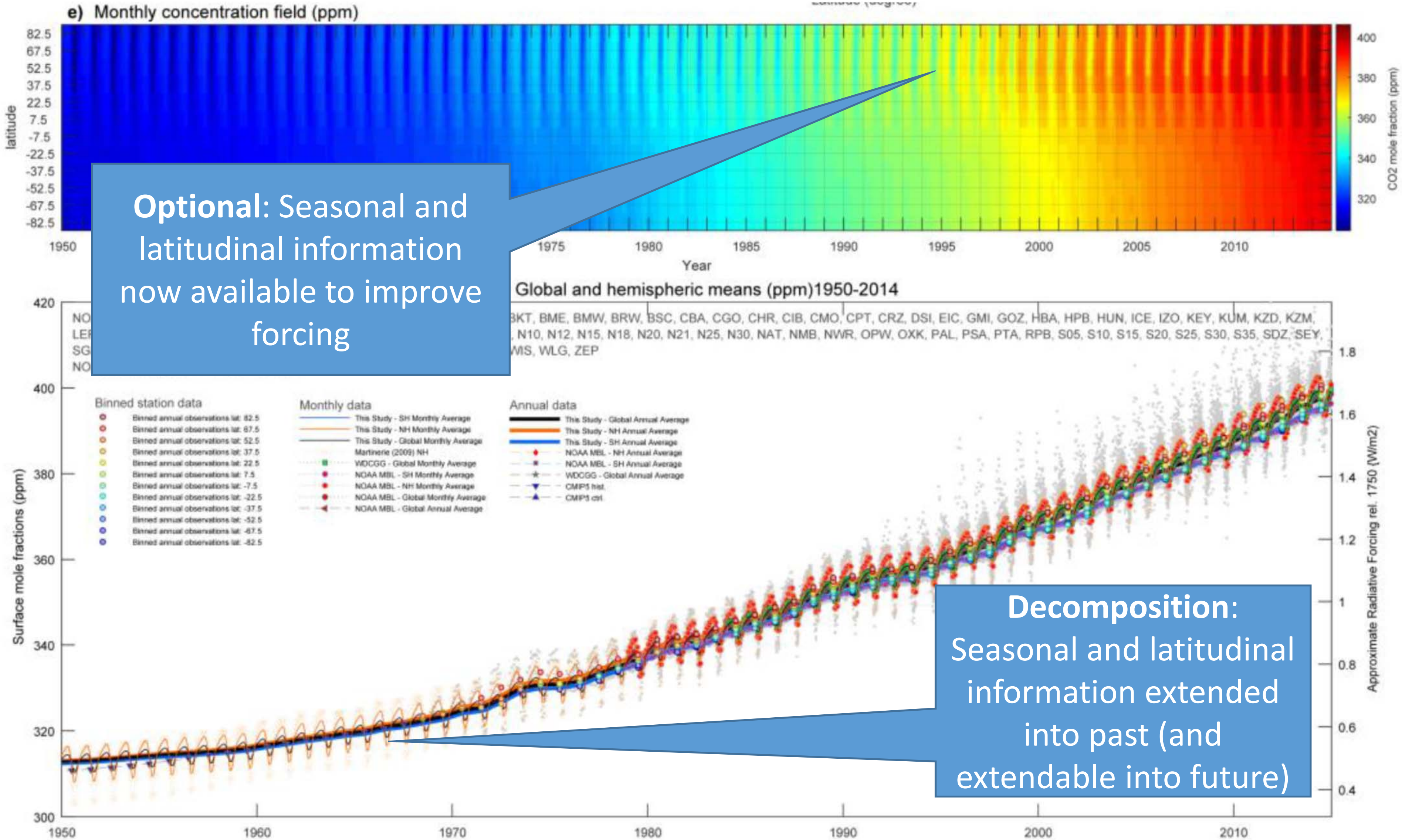
Table. 5 - Meinshausen et al. GMDD, doi:10.5194/gmd-2016-169, 2016

Fig. 2e/f - Meinshausen et al. GMDD, doi:10.5194/gmd-2016-169, 2016

THE UNIVERSITY OF MELBOURNE

AUSTRALIAN-GERMAN CLIMATE & ENERGY COLLEGE

Example: CO_2 concentrations

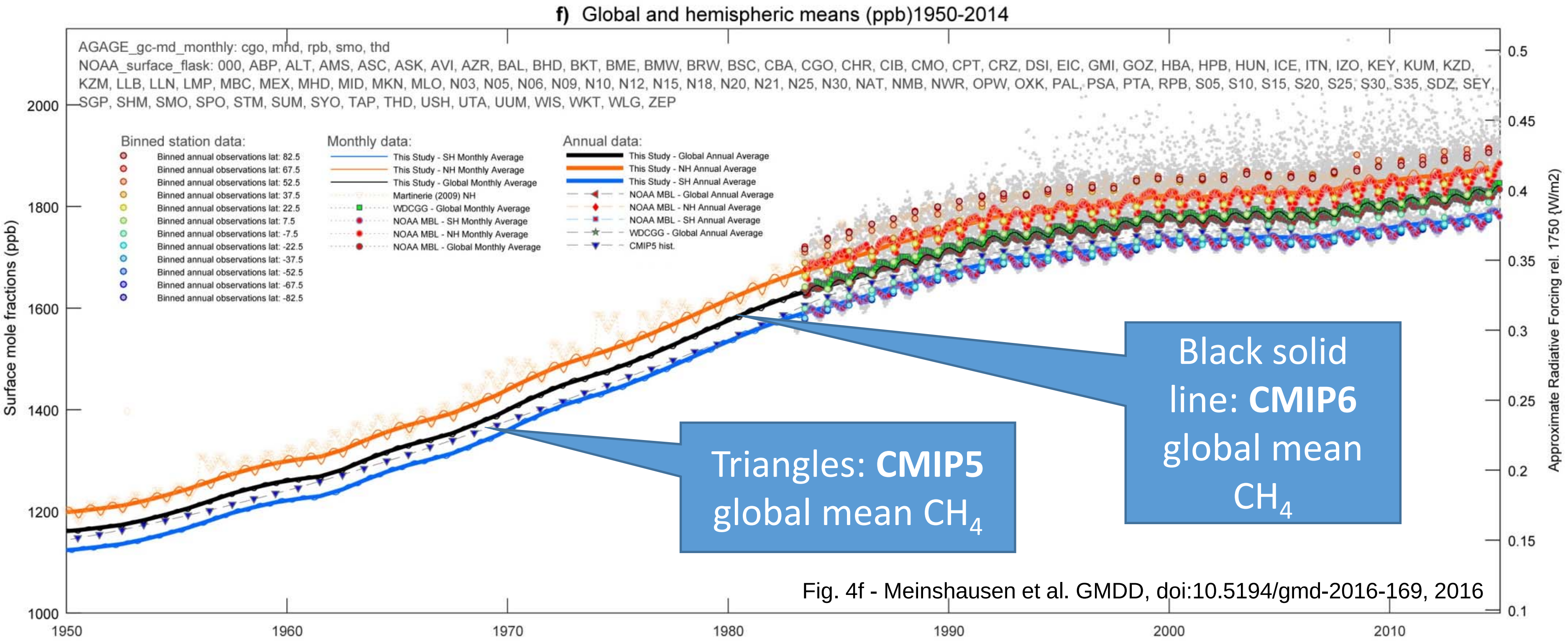


Optional: Seasonal and latitudinal information now available to improve forcing

Decomposition: Seasonal and latitudinal information extended into past (and extendable into future)

CMIP6 historical GHG surface concentrations: Differences to CMIP5

- Several species updated. For example, CH_4 concentrations corrected to global-mean (CMIP5 CH_4 was biased towards high-latitude southern hemisphere)
- Now optional latitudinal and monthly data available
- Suggestions for vertical extension provided.



CMIP6 historical GHG surface concentrations: Data & Paper

Known issues:

- Many uncertainties in regard to historical global mean, seasonal, and latitudinal data (e.g. 1600 CO_2 blip observed in Lawdome, not in WAIS record). Uncertainties not represented.

Data

- ESGF: Yes, tick.
  All data (in various resolutions) as netcdf files available on input4MIPs via ESGF (select institution: UoM – University of Melbourne)
- Data also available (in CSV, XLS, MAT & NETCDF formats) via www.climatecollege.unimelb.edu.au/cmip6 and ETH Zuerich ftp server ftp://data.iac.ethz.ch/CMIP6/input4MIPs/UoM/GHGConc/CMIP (thanks to Urs Beyerle!)

Paper

- Available at GMDD (discussion closed): dx.doi.org/10.5194/gmd-2016-169
- Final GMD paper to be submitted beginning of November 2016

CMIP6 historical GHG surface concentrations: Feedback

Thanks!

- For organising the work across a large and diverse community

In regard to GHG concentrations

- CMIP7 could make monthly and spatially varying concentration fields the default recommendation for concentration-driven runs (incl. vertical resolution) for allowing advances in detection and attribution, feedback derivation – historical constraining etc.

Model Groups' Feedback on Forcing Datasets

- Historical GHG concentrations -

- No specific feedback on this dataset included in the slides from model groups

Main Comments GMD Paper:

- Robert Pincus: level of detail provided by this reconstruction of greenhouse gas concentrations is appropriate for CMIP?
- Piers Forster: There are numerous extensions over their CMIP5 efforts that together make considerable progress on a number of fronts

CMIP
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Coupled Model Intercomparison Project

METEOROLOGY

University of Reading

CMIP6 OZONE AND N-DEPOSITION DATABASES

Michaela I. Hegglin, University of Reading UK *(co-chair IGAC/SPARC CCMI)*

Douglas Kinnison, NCAR US
David Plummer, CCCma CA
Jean-François Lamarque, NCAR US
Irene Cionni, ENEA IT
Ramiro Checa-Garcia, University of Reading UK

OZONE DATABASE

University of Reading

Main characteristics

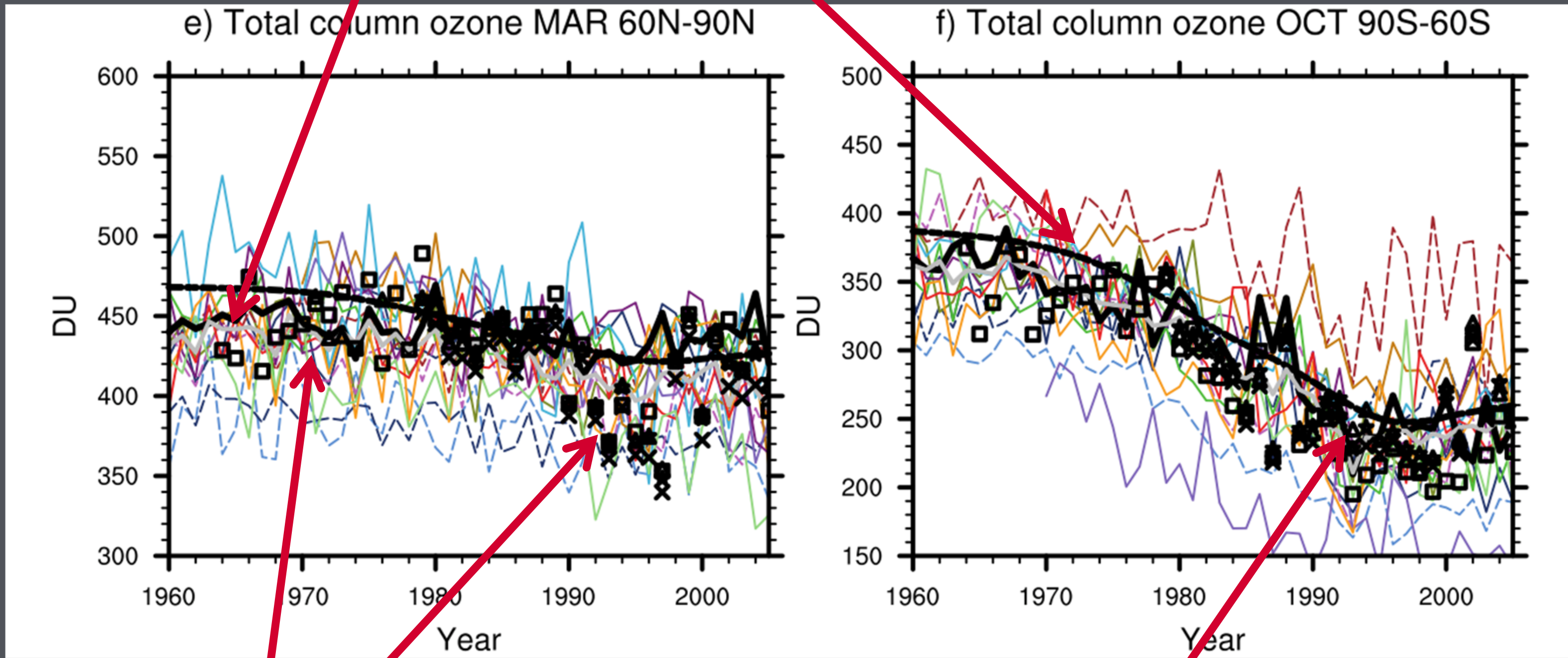
Variable name: vmro3
Unit: [mole $mole^{-1}$]
Spatial domain: 3D
Spatial resolution: 96x144 latxlon
66 pressure levels (between 1000 and 0.0001 hPa)
Temporal resolution: monthly means

Main differences/advances compared to CMIP5

- Model-based only and not merged to observations, which led to inconsistencies in CMIP5:
  - Antarctic ozone hole was not deep enough in CMIP5
  - There was no ozone recovery at Northern Hemisphere mid-latitudes in CMIP5
- Produced using two well-characterized, stratosphere-troposphere resolving CCMs:
  - Stratospheric ozone distribution now resolved in 3D (not 2D as in CMIP5)
  - Stratosphere-troposphere transition now 'smooth' and without jumps (unlike in CMIP5)
  - Model data in the stratosphere now also into the past (1850-1950).
- Includes modelled year-to-year variability, not smooth 'idealized' fields as in CMIP5.
- Will have RCP2.6/4.5/6.0/8.5 scenarios into the future.

OZONE DATABASE

Black wiggly solid: CMIP6, black dashed: CMIP5, symbols: obs, colored: CCMVal models



Absolute mean values agree better than in CMIP5, but missing variability including some very low years in NH obs in both CMIP5/6.

Better agreement with obs in SH, improvement again in mean value over CMIP5.

NITROGEN-DEPOSITION DATABASE

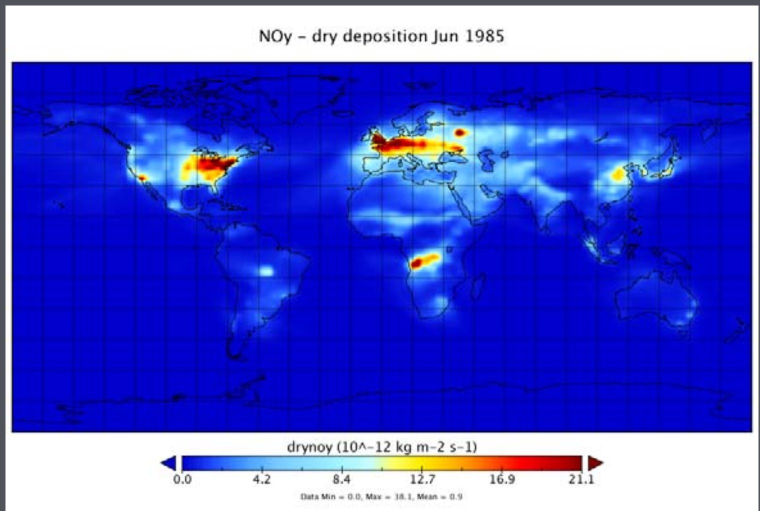
University of Reading

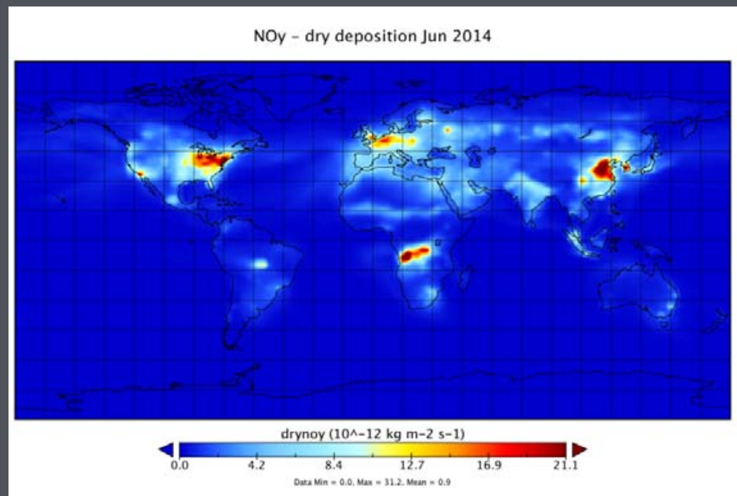
Main characteristics

4 variables: wetnh3 / drynh3 / wetnoy / drynoy
Unit: [kg m^{-2} s^{-1}]
Spatial domain: 2D (surface fluxes)
Spatial resolution: 96x144 latxlon
Temporal resolution: monthly means

Main differences compared to CMIP5

- Based on 1 model only (NCAR).
- Deposition fields consistent with the forcings in the CMIP6 ozone database.





STATUS OF DATA SUBMISSION

University of Reading

Available via ESGF Input4MIPs at https://pcmdi.llnl.gov/search/input4mips/

Ozone database

- 1850 (control): ready for use version 1.0 (submission date: 11-07-2016)
- 1859-2014 (historical): ready for use version 1.0 (submission date: 11-07-2016)
- 2015-2100: in preparation (expected submission date 31-12-2016)

Nitrogen deposition database

- 1850 (control): ready for use version 1.0 (submission date: 01-08-2016)
- 1859-2014 (historical): ready for use version 1.0 (submission date: 08-01-2016)
- 2015-2100: in preparation (expected submission date 31-12-2016)

1. **input4MIPs.UReading.surfaceFluxes.CMIP.NCAR-CCMI-1-0.mon.drynhx.gr**
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OTHER INFORMATION

University of Reading

(c) Status of the corresponding GMD paper:

Not yet submitted. Paper currently in preparation. Submission expected by Dec 2016.

Hegglin, M. I., D. Kinnison, D. Plummer, et al., CCMI ozone database (1850-2100) in support of CMIP6, GMD, in preparation.

(d) Other open issues?

Variability in the current historical ozone dataset could be better synchronized with observations between 1979-2014. **An improved ozone database could be ready by the end of the year. Is there time/interest that this work could/should be done?**

(e) Any other feedback you like to provide to the WGCM?

Future period of databases will not be fully consistent with SSPs, but follow CMIP5 RCP scenarios. Users seem unsatisfied, but deadlines could not be adhered to if we had awaited the new SSP emission scenarios to produce our simulations.

Recommendation: Timeline should be adjusted for CMIP7, asking future emission scenarios to be ready 4-6 months earlier or ozone/N-dep databases 4-6 months later.

Finally, many thanks to Paul Durack for most helpful support with checking data format and uploading the files to the Input4MIPs data server!

Model Groups' Feedback on Forcing Datasets

- Ozone Concentrations and Nitrogen (N)-Deposition -

- No specific feedback on this dataset included in the slides from model groups

Main Comments GMD Paper:

- not yet submitted to GMD, so no review comments

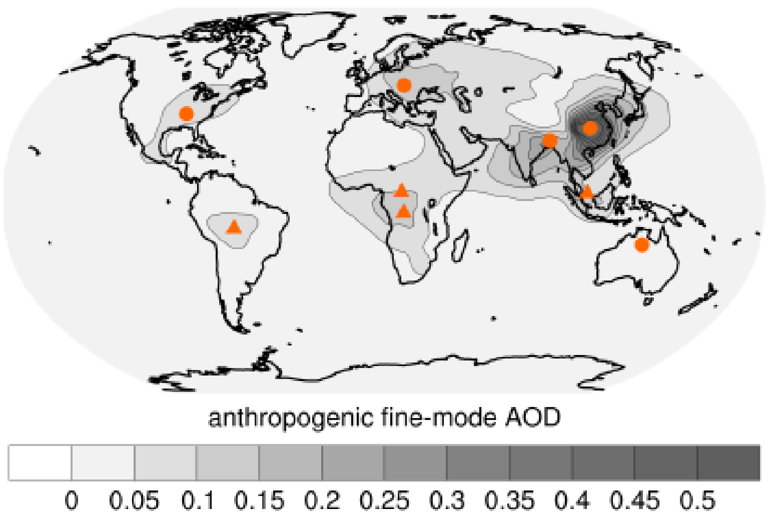
Aerosol Optical Properties and Relative Change in Cloud Droplet Number Concentration

Max Planck Institute Aerosol Climatology

SLIDES kindly provided by Bjorn Stevens – THANKS!

MACv2-SP

B. Stevens, S. Fiedler and Co-Authors (GMD in review — finalized with no further changes anticipated.)



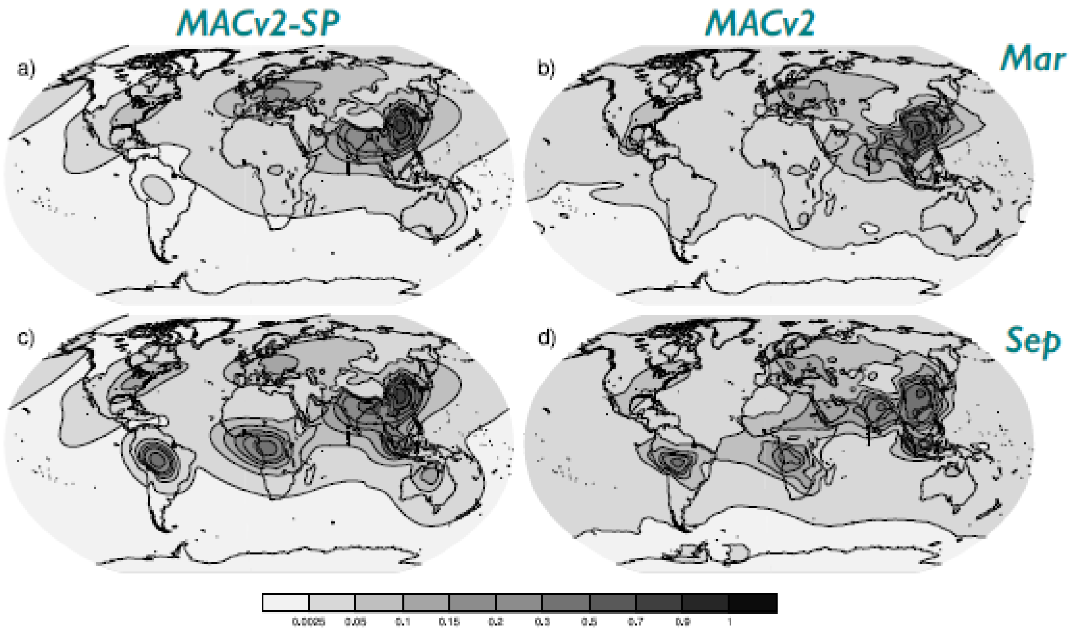
- Nine plumes are fit to the observed climatology of anthropogenic aerosol optical and cloud optical properties as described by the Hamburg Aerosol Climatology (Kinne et al. 2013, 2016)
- The plumes have an analytic form and capture the distribution (x,y,z,t) of anthropogenic aerosol optical properties (optical path, single scattering albedo and asymmetry parameter) as a function of wavelength, as well relative perturbation in liquid cloud droplet population density
- Plume amplitudes are scaled based back and forward in time based on a linear combination of SO2 and NH2 aggregated from the CEDS data base over the regions defined by the plumes.
- The approach is designed not to interfere with the control (pre 1850) climate of the host model and is simple, compact and easy to use and (eventually modify)

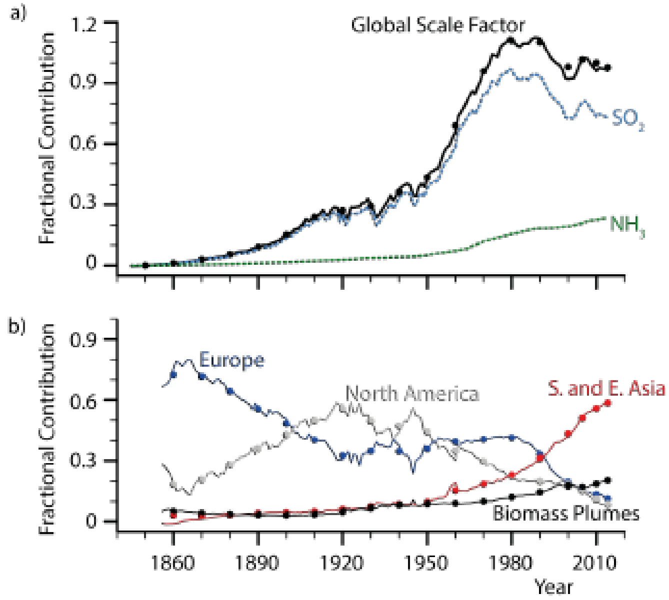
The main idea is to give a consistent description of aerosol forcing across models so as to help identify robust responses to aerosol-like forcing

Aerosol Optical Properties and Relative Change in Cloud Droplet Number Concentration

Column anthropogenic aerosol optical depth

Spatial and temporal distribution





- MACv2-SP captures seasonal cycle.
- Pattern of Twomey effect follows that of AOD.
- Droplet population density perturbations (not shown) are scaled to give the desired mean radiative response

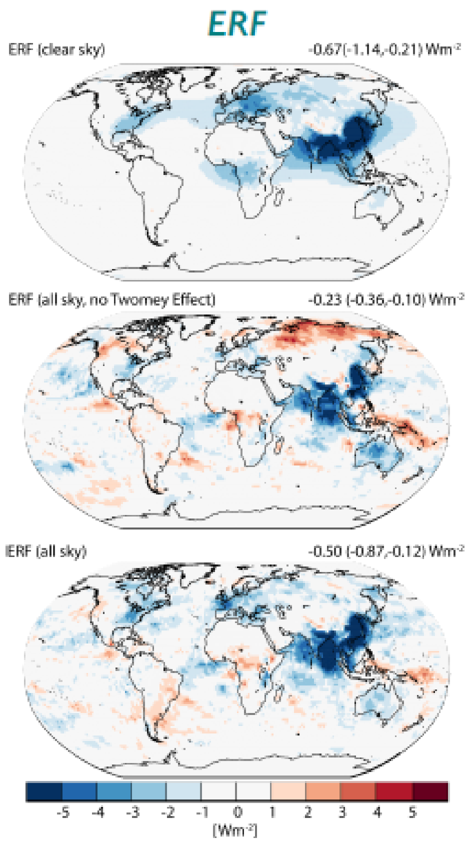
Aerosol Optical Properties and Relative Change in Cloud Droplet Number Concentration

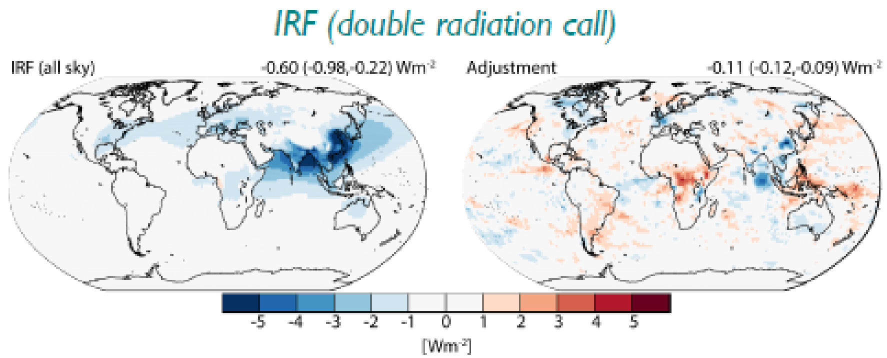
Pattern of forcing using ensembles of MPI-ESM simulations

Instantaneous Radiative Forcing

Clear-sky ERF

All-sky ERF with / without aerosol-cloud-interaction



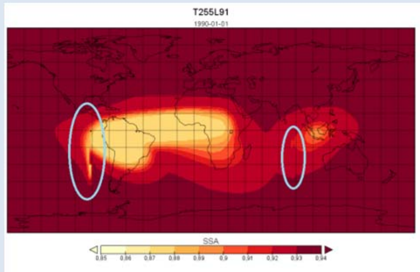


- Total ERF of 0.5 Wm^{-2}, about equally split between ACI (Twomey effect) and ARI.
- Easy to tune or modify and use to explore hypotheses, such as: the effect of shifts in the pattern of aerosol forcing; the effect of differences in the weighting of ARI and ACI; changes in the properties of the aerosol over the instrumental record.
- Sensitivity studies suggest that more than 30 years of AMIP (Hansen-like) forcing runs are needed to estimate forcing to with 0.1 Wm^{-2} in an uncoupled model.
- Even with a correct implementation we expect some scatter in forcing estimates due to different background conditions and different cloud distributions, but the simulations will help identify sources of uncertainty in forcing estimates.

Model Groups' Feedback on Forcing Datasets

- Aerosol Optical Properties / Relative Change in Cloud Droplet Number Concentration -

- **EC-Earth:** In the MACv2-SP code, there is an error in the calculation of the background optical depth, which subsequently is used in the calculation of the CDNC scale factor (dNoverN). This factor effectively sets the aerosol indirect effect. The error persists in the latest release (MACv2-SP_v1). The error has been reported to MPI-M.
- **EC-Earth:** The distribution of the single-scattering albedo (SSA) from MACv2-SP_v1 shows some unrealistic small-scale features (see figure below). The impact is expected to be small.



Main Comments GMD Paper:

- Impact of the strong assumptions that are made in the paper on radiative forcing not clear and have to further explored
- MAC-v2-SP assumes constant in time aerosol optical properties. This is a major issue for those interested in the time evolution of the aerosol forcing.
- For cloud-active properties concerns that the analysis is based on AeroCom 1 models. Those models were run in the early 2000s.
- Concerns about the strongly negative clear-sky radiative forcing efficiency

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Geosci. Model Dev. Discuss., doi:10.5194/gmd-2016-91, 2016
Manuscript under review for journal Geosci. Model Dev.
Published: 6 June 2016

Geoscientific Model Development Discussions
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SLIDES kindly provided by Katja Matthes – THANKS!

Solar Forcing for CMIP6 (v3.1)

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[4]University of Reading, Reading, United Kingdom
[5]EAWAG, Dübendorf, Switzerland
[6]University of Montreal, Canada
[7]British Antarctic Survey (NERC), Cambridge, UK
[8]LPC2E, CNRS and University of Orléans, France
[9]Physikalisch-Meteorologisches Observatorium Davos/World Radiation Center, Davos, Switzerland
[10]Emeritus, NASA Goddard Space Flight Center, Greenbelt, MD, U.S.A.
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[16]Karlsruhe Institute of Technology, Karlsruhe, Germany
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Revision of discussion paper under review since 20.10.2016

CMIP6 Solar Forcing in a Nutshell

- Historical forcing: 1850 – 2014
- Future forcing: 2015 – 2300
- Preindustrial (Pi) control forcing
- Data version 3.2 (October 2016)
- Available at http://solarisheppa.geomar.de/solarisheppa/cmip6
- In the process of being downloaded to input4mips ESGF (in contact with Paul Durack)
- Forcing data description: *Matthes et al., Solar Forcing for CMIP6 (v3.1), Geosci. Model Dev. Discuss., doi:10.5194/gmd-2016-91, in review, 2016.*

CMIP6 Forcing Data File

netCDF4, daily resolution (monthly resolution files are also provided for TSI/SSI)

	variable	units	dimension
TSI	tsi	$W\ m^{-2}$	time
SSI	ssi	$W\ m^{-2}\ nm$	time, wlen
F10.7	f107	$10^{-22}\ W\ m^{-2}\ Hz^{-1}$	time
Ap	ap	nT	time
Kp	kp		time
MEE IPR	iprm	$g^{-1}\ s^{-1}$	time, plev, glat
Proton IPR	iprp	$g^{-1}\ s^{-1}$	time, plev, glat
GCR IPR	iprg	$g^{-1}\ s^{-1}$	time, plev, glat

NOx UBC is provided as IDL/MATLAB package on the SOLARIS-HEPPA CMIP6 webpage:

Input: forcing nc file, model grid (lat,plev), start/end dates

Output: NOy concentration (cm^{-3}) or NOy flux ($cm^{-2}\ s^{-1}$) on model grid.

What is new in CMIP6 (wrt CMIP5)?

- New SSI reference (NRLSSI2+SATIRE-TS)/2 CMIP5: NRLSSI1
- New TSI reference value: 1361.0+/-0.5 W/m^2 SC 23 average (Mamajek et al., 2015) CMIP5: 1365.4 W/m^2 (recommended to scale to TIM)
- Inclusion of complete EUV dataset (F10.7 and SSI @ 0-115 nm) CMIP5: only available since 1882
- Inclusion of particle forcing (protons, electrons, GCR)

  CMIP5: none
- Secular variations in future scenario 2015-2300 (solar activity reduction to a Gleissberg-type minimum around 2070)

  CMIP5: repetition of SC23 (SC21-23)

In addition: non-standard datasets for sensitivity studies:

- „Extreme“ future scenario (Maunder-type minimum)
- Variable piControl forcing (SC variability without secular variations)

Model Groups' Feedback on Forcing Datasets

- Solar forcing-

- **IPSL:** The daily solar forcing could be useful to study high-frequency variations in the stratosphere but requires adopting a Gregorian calendar for historical and future simulations (and hence on piControl?), **a CMIP6 panel recommendation on this would be welcomed.**

Main Comments GMD Paper:

- Averaging two quantities that disagree produces a result that is also not likely to be correct. Calling this "the most reasonable approach" is perhaps controversial.

CMIP
The World Climate Research Programme's
Coupled Model Intercomparison Project

Stratospheric aerosol forcing

SLIDES kindly provided by
Beiping Luo and Tom Peter – THANKS!

- Status: Ready for use as of June 2, 2016
- Published on input4MIPs via ESGF
- We have been getting some feedback from users so it is apparently being used by some groups
- 1850 – 1978: Pre-satellite time, using AER models using estimates of volcanic emission, calibrated using photometer data when available.
- 1979 – 2014: SAGE I, SAM, SAGE II, OSIRIS and CALIPSO data

Stratospheric Aerosol Forcing

Changes from previous versions - Improvements

- CLAES is now used to fill in most of the period in which SAGE II is missing after the Pinatubo eruption (1991-1993).
  - It is empirically scaled to SAGE II at 1020 nm based on regions/time periods where values for both instruments exist
  - HALOE aerosol extinction is also used until 1995 to fill some gaps in the SAGE record following a similar process
- The period between 2005 through 2014 is now a mix of CALIPSO backscatter and OSIRIS limb scatter measurements.
  - For continuity reasons, OSIRIS 525 nm estimates from Rieger and Bourassa are scaled by 0.8. CALIPSO backscatter is scaled by 53 str-1
  - OSIRIS is not used with 2 km of the tropopause to concerns with cloud contamination
- Data missing at high latitude winters in the SAGE II era is now filled using an equivalent latitude/latitude process that appears far superior to brute interpolation used in the past

Stratospheric Aerosol Forcing
Changes from previous versions - Cautions

- The CLAES/SAGE Pinatubo depicted appears substantially improved, however the period prior to October 1991 involves assumptions. It is not clear how good a zonal average for this period is due to inhomogeneity.
- Higher extinction at high latitudes below 20 km after change from SAGE II to OSIRIS/CALIPSO.
- Continuing issues removing PSCs particularly from the CALIPSO data set but to a lesser extent all data sets since particularly STS is subtle.
- Data below the tropopause is only available is some periods and should be used with substantial caution (see below).
- Issues with extrapolating multispectral and potentially aerosol size dependent properties during low aerosol loading, single channel periods (e.g., after 2005).
    - We do not recommend using 1020 nm estimates after 2005 though 525 nm values appear robust.

SAD in the lowermost stratosphere

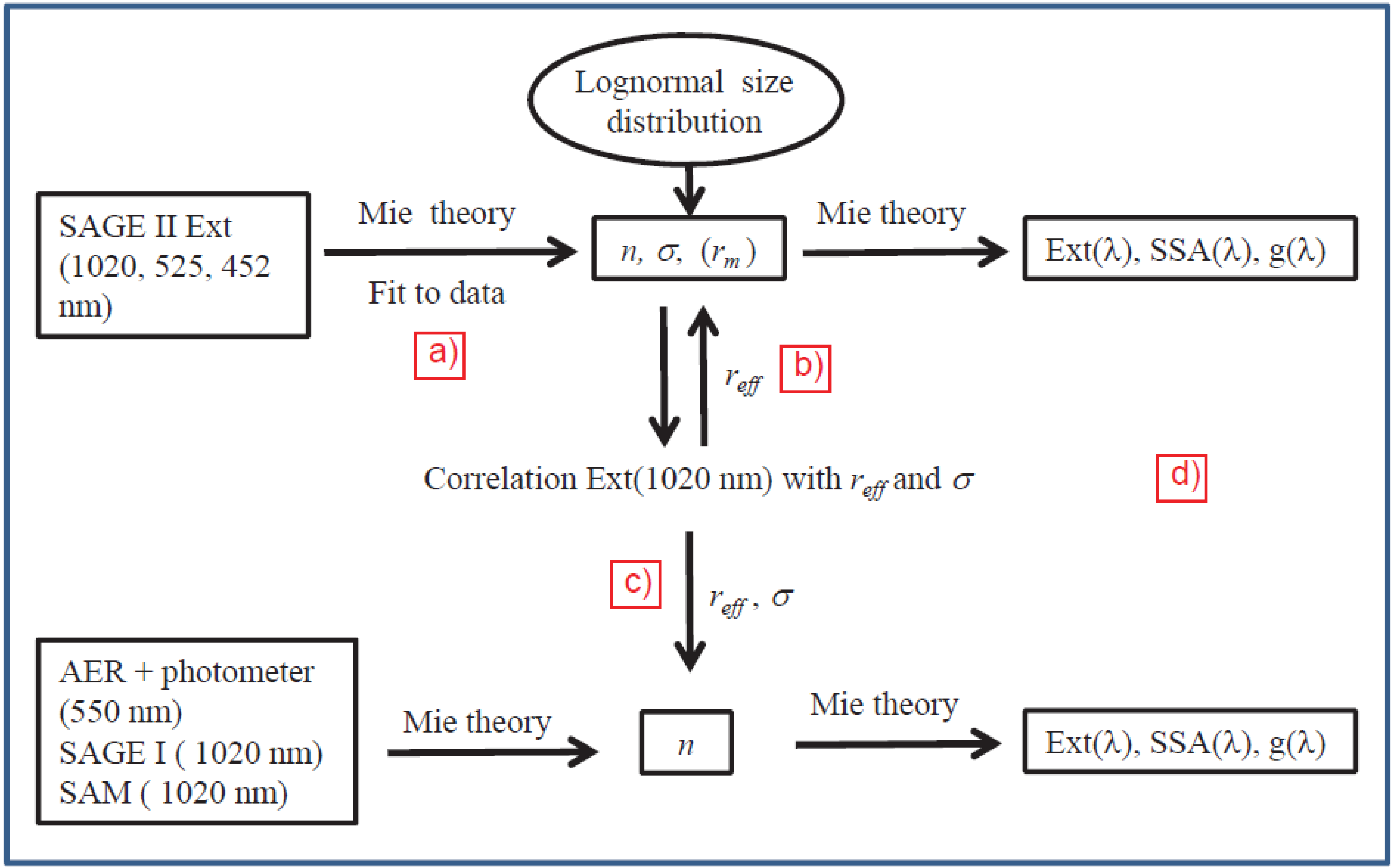
- The satellite-based 3λ-method underestimates SAD at lowermost stratosphere and upper troposphere significantly.
- In this region, there are many small particles ($n > 100\ cm^{-3}$, $r < 10$ nm). These small particles contribute substantially to SAD, but only marginally to extinction coefficients at SAGE wave lengths.
- Using the SAD measured by OPC, we were able to quantify the SAD contribution of small particles.
- In the CMIP6 data set, we add this missing SAD of small particles to 3λ-SAD.
- The CMIP6 stratospheric data set should only be used in the stratosphere. Modellers must themselves determine the local tropopause and ensure that the CMIP6 stratospheric data is used only at the tropopause and above. The CMIP6 data must not be used in lieu of upper tropospheric aerosol data.

Status of the corresponding GMD paper

- Aerosol extinction coefficient climatology
- Derived stratospheric aerosol property climatology

  - Paper is about ¾ written, we expect to submit it in a month or two
  - Data set will also be archived with a DOI at the NASA Atmospheric Data Center shortly. Approximately annual updates will be made available at this location for all interested parties

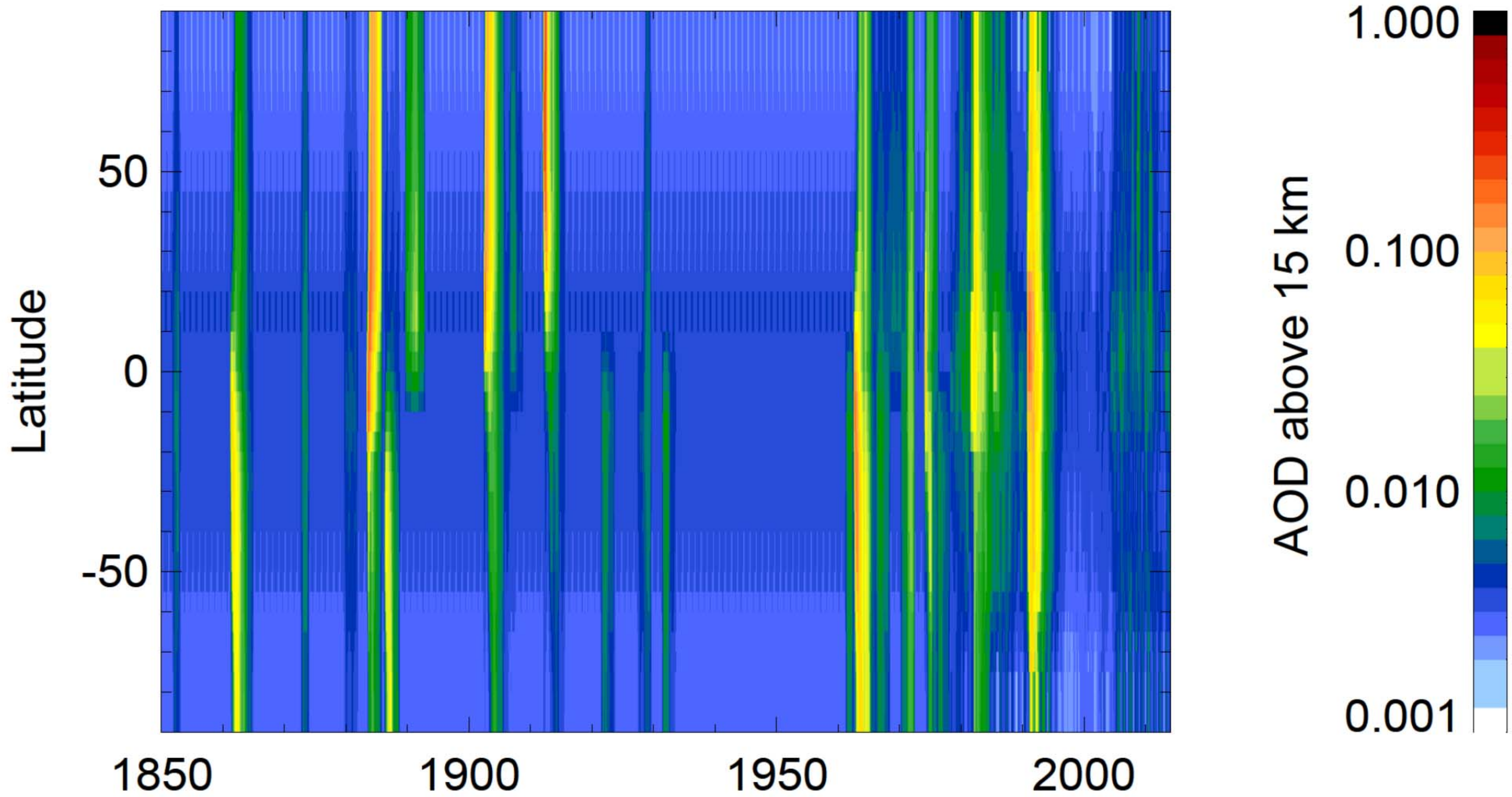
Retrieval scheme used in CMIP6



Summary Retrieval

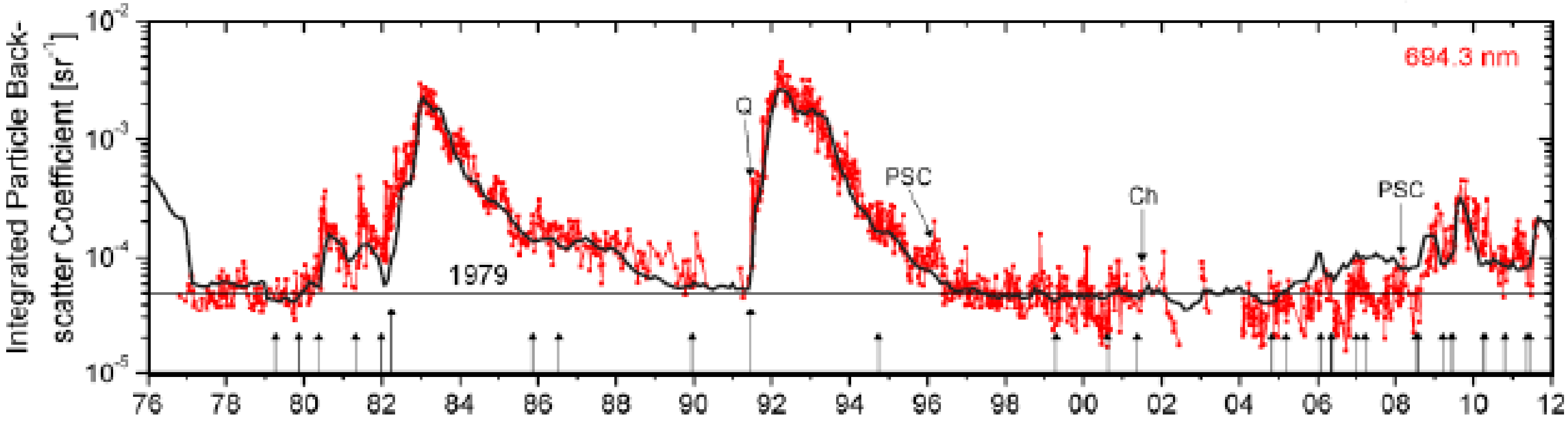
a) A lognormal distribution of aerosol is assumed. The size parameters (n, σ, r_{mode}) are derived fitting to the SAGE II data at 3 wave lengths
b) A correlation $r_{eff} \leftrightarrow$ extinction is used to reduce the scatter of retrieved products.
c) A extra correlation ($\sigma \leftrightarrow$ extinction) is used , when only extinction at one wavelength is available.
d) The forcing is calculated using the obtained lognormal distribution for all CCMs.

AOD at 550 nm above 15 km



Groud based lidar comparison

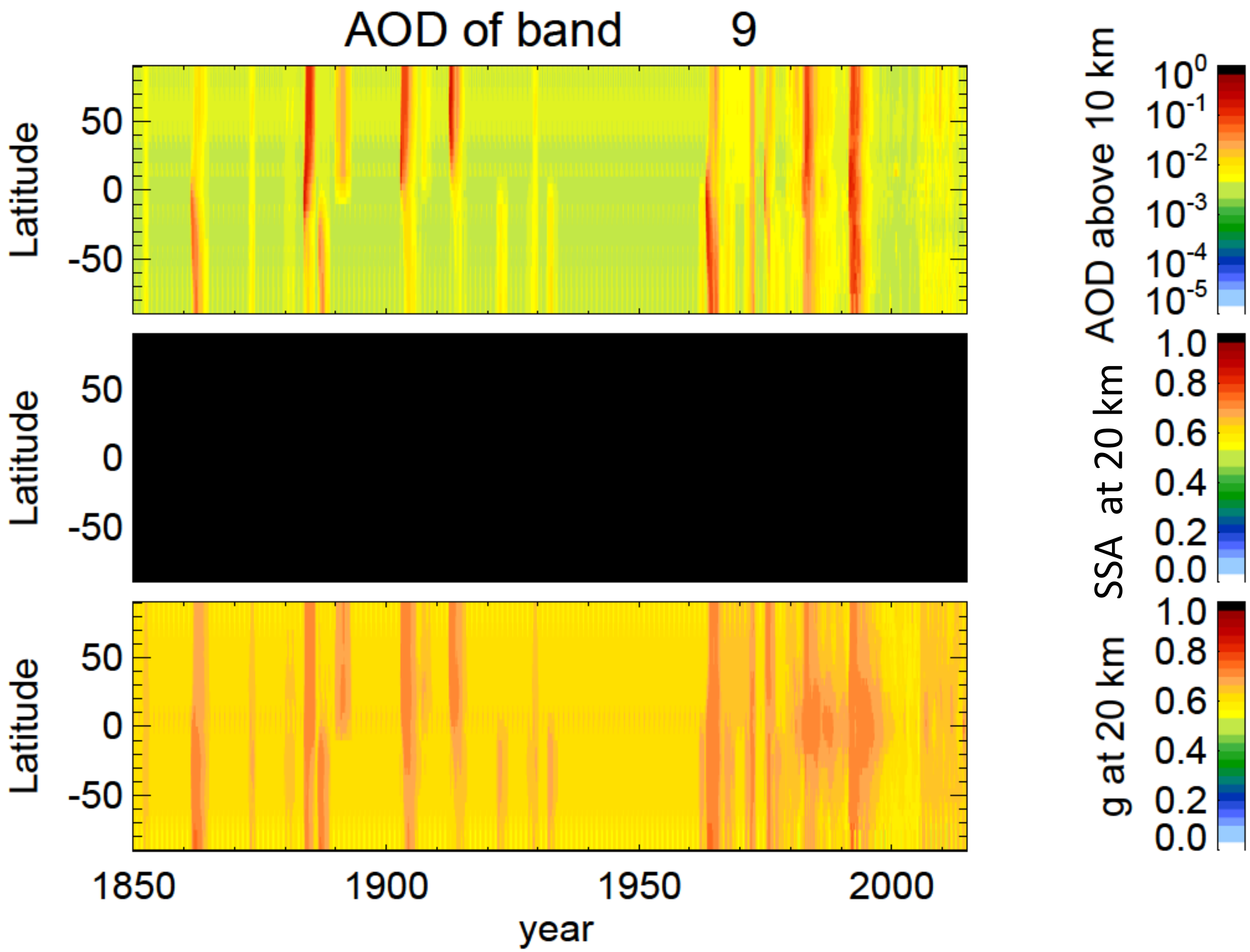
Red: data ober Garmisch-Patenkirchen
Black: CMIP6 (lognormal distribution)



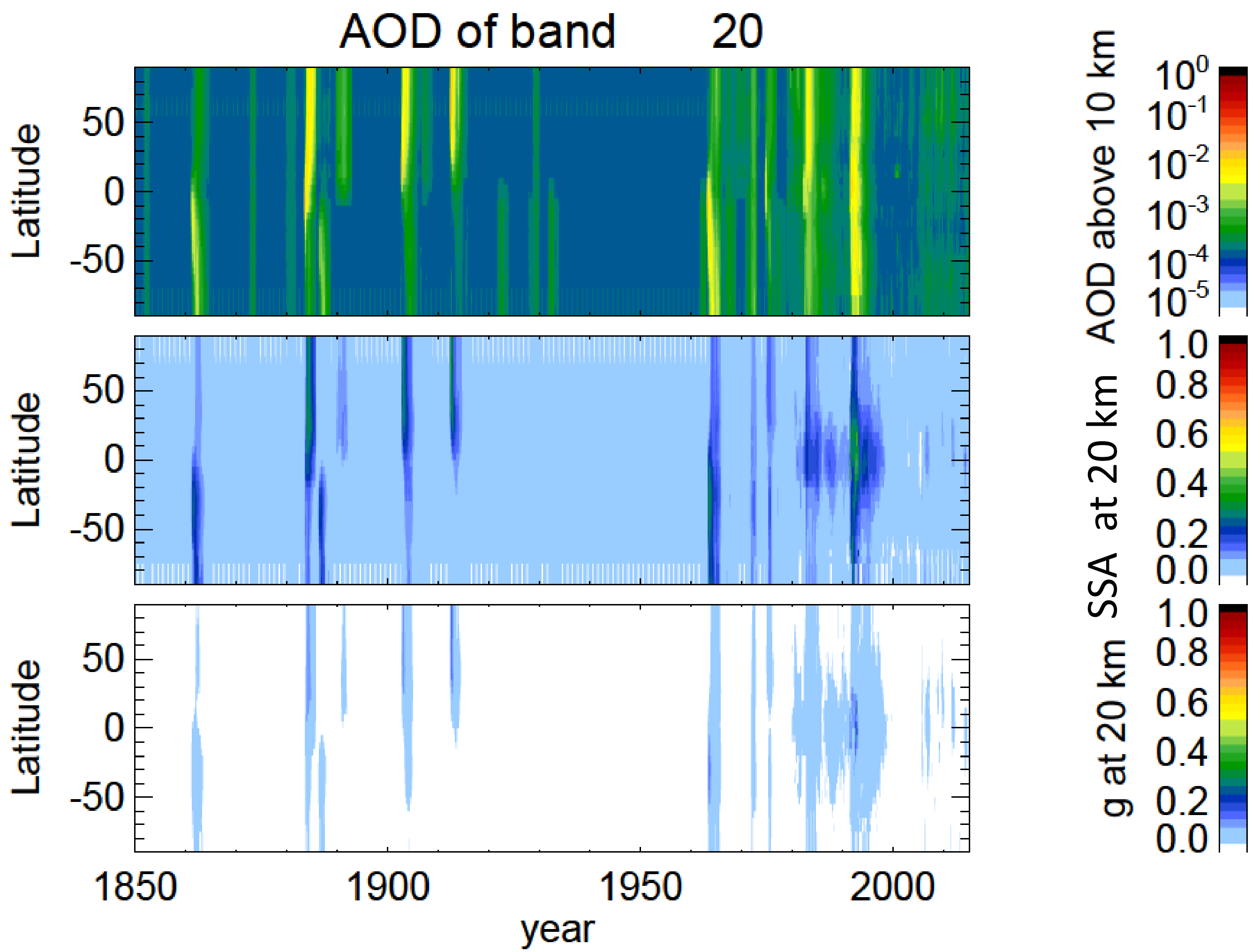
There is a good agreement between Lidar data and simulated signal using the lognormal distributions obtained from 3λ method.

Combing CALIPSO+ OSIRIS
post SAGE II,

Examples of Forcing data: ECHAM6 0.625-0.778 µm



Examples of Forcing data:
ECHAM6 10.2-12.195 µm



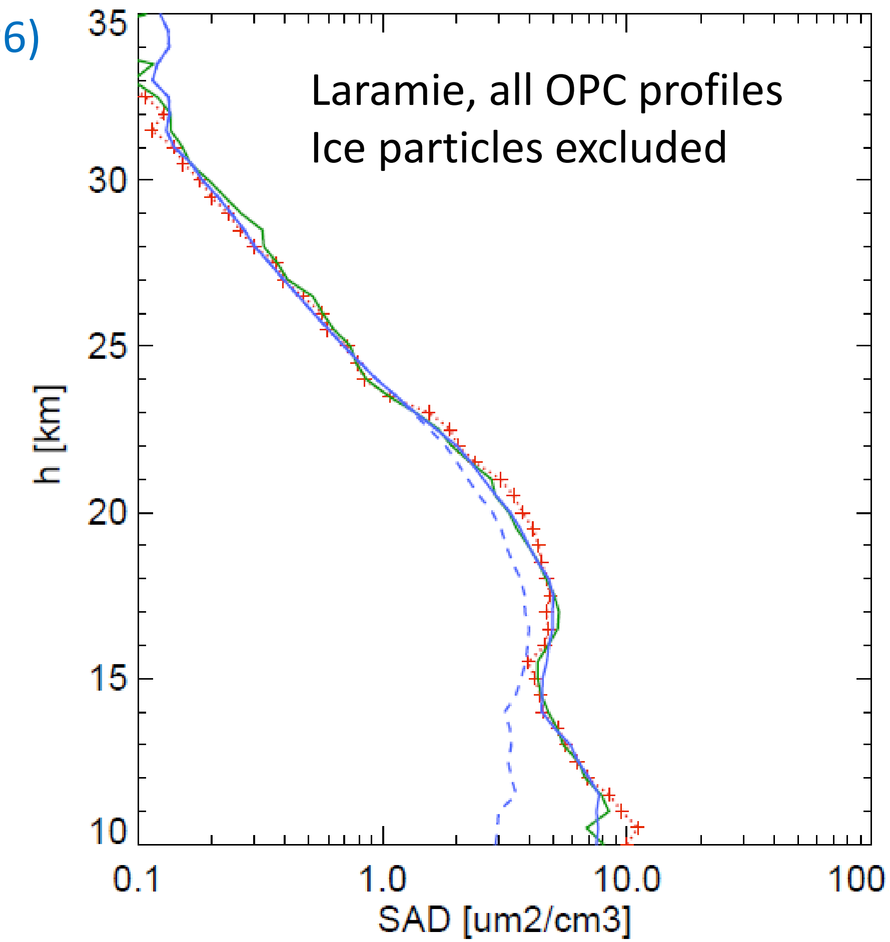
SAD Correction based on OPC data

CMIP6 w. OPC correction (used in CMIP6)

CMIP6 w.o. OPC correction termed 3λ

new estimate of OPC data

+: original OPC data



3 λ -SAD (dashed) agrees with OPC (green and blue) in Junge layer, underestimate near tropopause largely.

We corrected SAD based on OPC data for the lowermost stratosphere. There are 100s of tiny particles (r < 10 nm), which contributes to SAD significantly and has only a negligible effect on radiation. The radiation properties are calculated only using the lognormal distribution.

Model Groups' Feedback on Forcing Datasets

- Stratospheric Aerosol Data Set -

➢ **IPSL:** Model-tailored stratospheric aerosol datasets do not include information on the 550 nm extinction coefficient, yet stratospheric aerosol optical depth at 550 nm is a variable requested by several MIPs. It cannot be delivered with precision in the current state of play.

➢ **IPSL:** The stratospheric aerosol dataset include some upper tropospheric aerosols in a way that is not consistent over time, yet it does not include information on the tropopause height so we have no other solution at the moment than using the model tropopause height (either interactive or climatological) to mask tropospheric aerosols. This issue has been flagged to ETZH, but has received no answer (even a “not possible” one).

➢ **MPI-ESM:** How to handle (i.e. to cut off) tropospheric values in the stratospheric aerosol dataset was not agreed upon. We chose to use a climatological tropopause (as defined by the WMO) of our model. We acknowledge that the difference may be small, but different models may have different tropopause heights which could potentially lead to different forcing fields.

Main Comments GMD Paper:

➢ not yet submitted to GMD, so no review comments yet

CMIP
The World Climate Research Programme's
Coupled Model Intercomparison Project

PCMDI AMIP Boundary Conditions (SST, SIC)

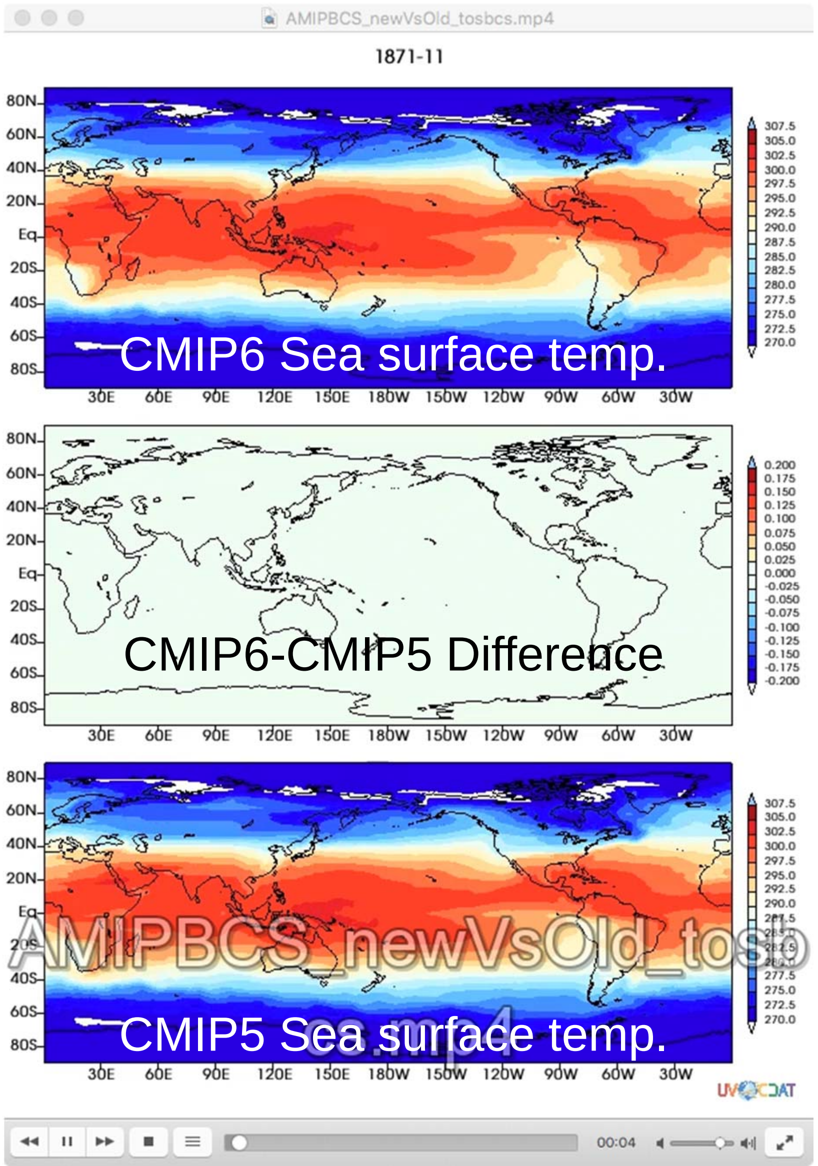
Data characteristics

- Variables
  - Sea surface temperature (SST)
    - Observed monthly means
    - Mid-month values used for AMIP
  - Sea ice concentration/fraction (SIC)
    - Observed monthly means
    - Mid-month values used for AMIP
  - Ocean cell area (areacello)
- Data grid
  - 1x1 degree grid
  - 90S to 90N
- Data sources (monthly mean)
  - 1870-01 to 1981-10 HadISSTv1
  - 1981-11 to 2016-06 NOAA/NCEP OIv2
- Processing method
  - Hurrell *et al*. (2008; *J. Clim*.: https://doi.org/10.1175/2008JCLI2292.1)
  - Taylor, K., D. Williamson and F. Zwiers (2000, PCMDI Report 60: https://pcmdi.llnl.gov/home/projects/amip/details/)

SLIDES kindly provided by Paul Durack– THANKS!

CMIP6 – CMIP5: Differences in AMIP SST's and SIC

- Temporal coverage
  - **CMIP5** 1870-01 to 2008-12
  - **CMIP6** 1870-01 to 2016-06 (v1.1.1)
- Data structure and format
  - CMIP6 Version 1.1.0+ uses a CMIP/CMOR3 data format (single file per variable)
  - Global attribute metadata conforms (where appropriate) with CMIP6 model output specs.
- Changes in data
  - No significant difference in actual data for the period available for CMIP5
  - Data updated to near-present



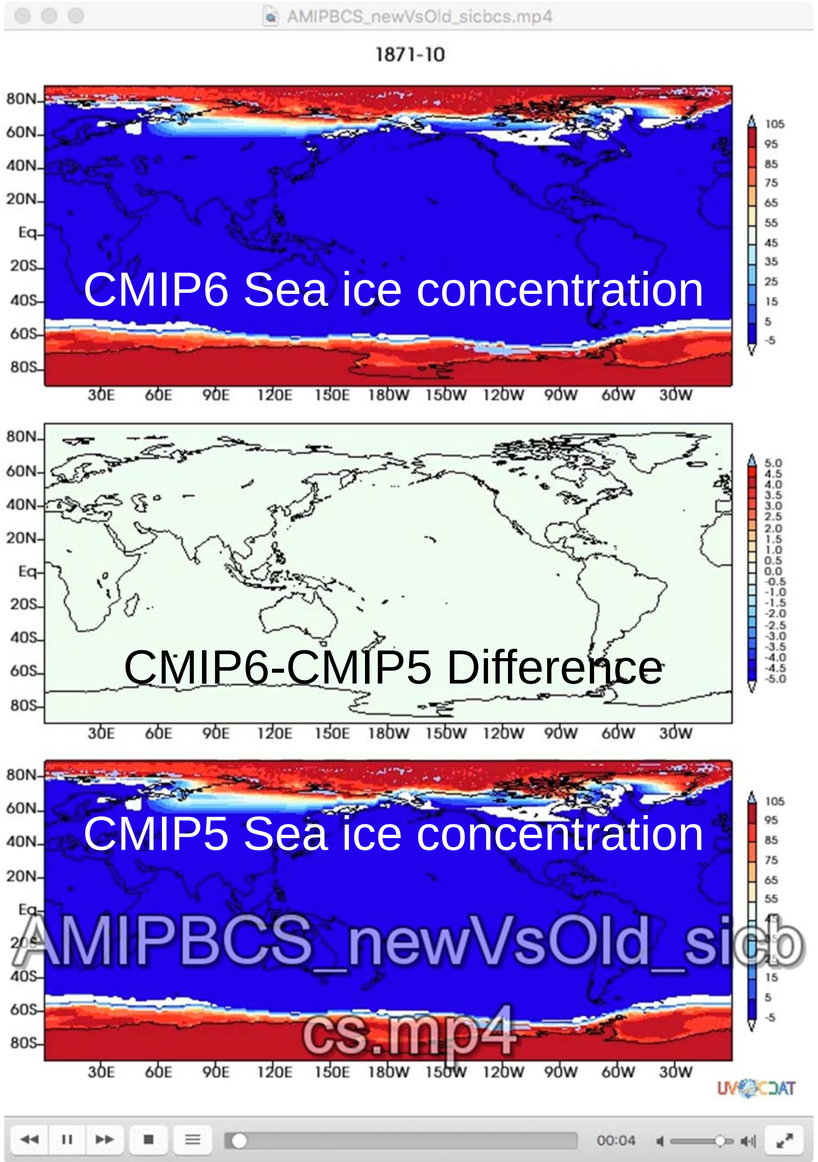
PCMDI AMIP Boundary Conditions (SST, SIC)

Status of data publication

- Availability
  - Version 1.1.0+ hosted on the ESGF input4MIPs site
- Update frequency
  - Prior to data version 1.0.0 (2016-06-22) releases were intermittent and had multiple institutional dependencies
  - Data version 1.0.0+ produced six-monthly updates (scheduled for April and October each year) providing yearly and half-yearly updates respectively

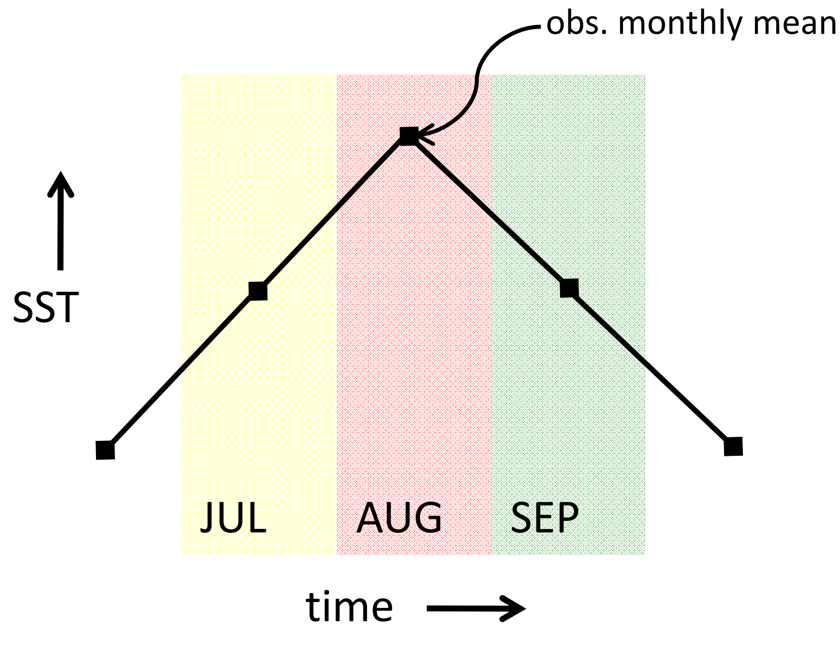
Status of GMD paper

- Paper in preparation
- Will describe the dataset and the dataset history (through AMIP cycles)
- Plans to submit in second quarter of calendar year 2017



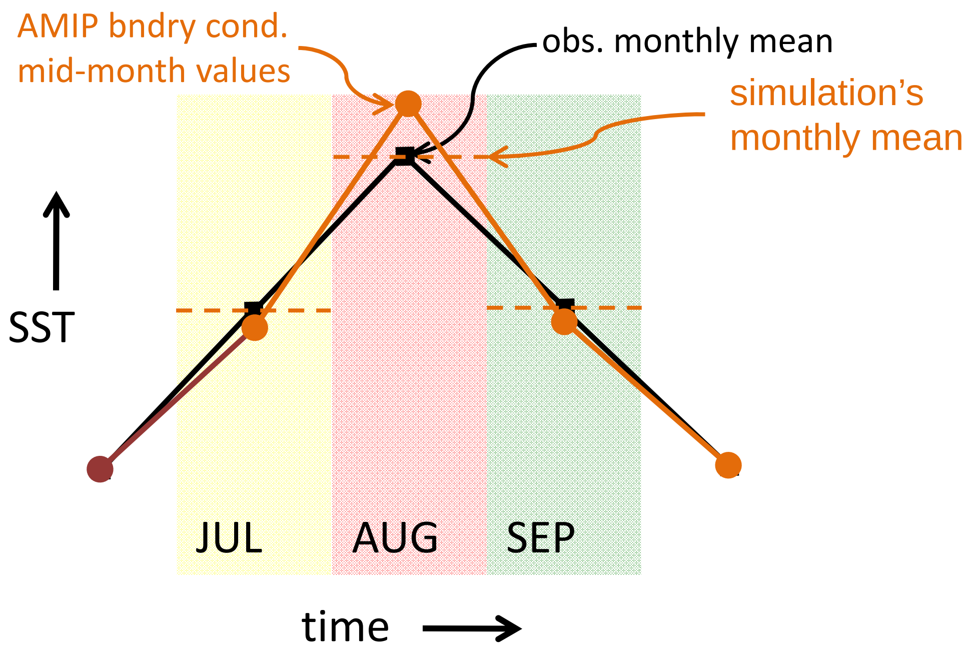
CMIP requirements for AMIP boundary conditions specifications

- SST's and sea ice prescribed should reproduce the observed monthly means.
- Simple interpolation from observed monthly means to daily values does not meet CMIP requirements:

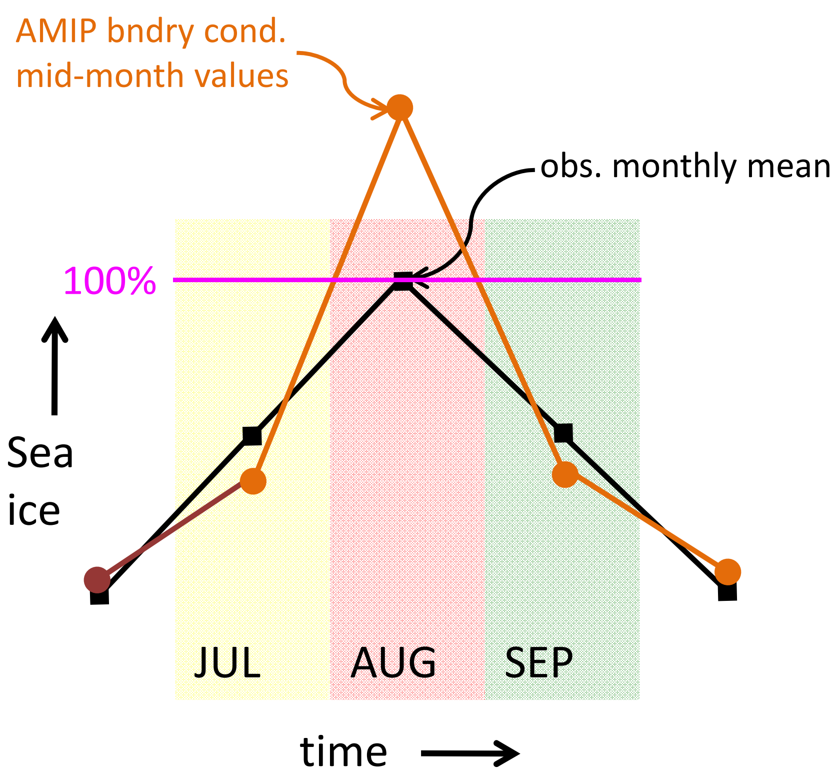


One solution to the problem

- Generate mid-month values that when interpolated to daily values and time-averaged yield the correct monthly means.
  - Sheng and Zwiers (Clim. Dyn., 1998)
  - Taylor et al., (http://www-pcmdi.llnl.gov/projects/amip/AMIP2EXPDSN/BCS/index.php, 2000)

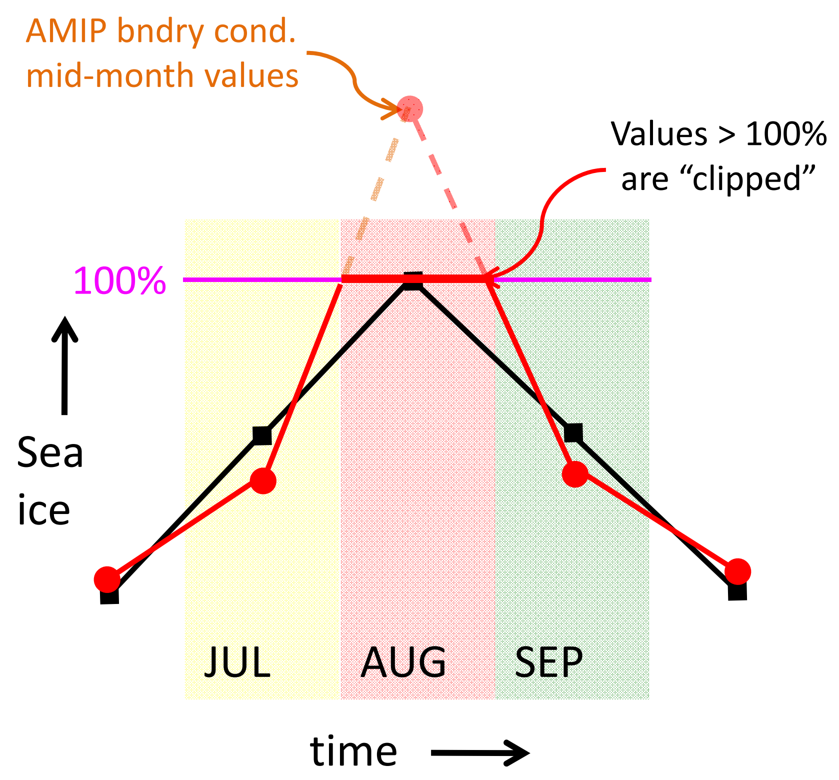


Sea ice has limits which complicates things



Sea ice has limits which complicates things

Mid-month values have been defined such that after “clipping” interpolated values (to permitted range) observed monthly means are recovered



CMIP6 and onward

- Consider
  - Updating to new versions of HadISSTv1.1 and NOAA OI
  - Considering other data sources
  - Higher resolution?
  - Different methods of generating daily values?

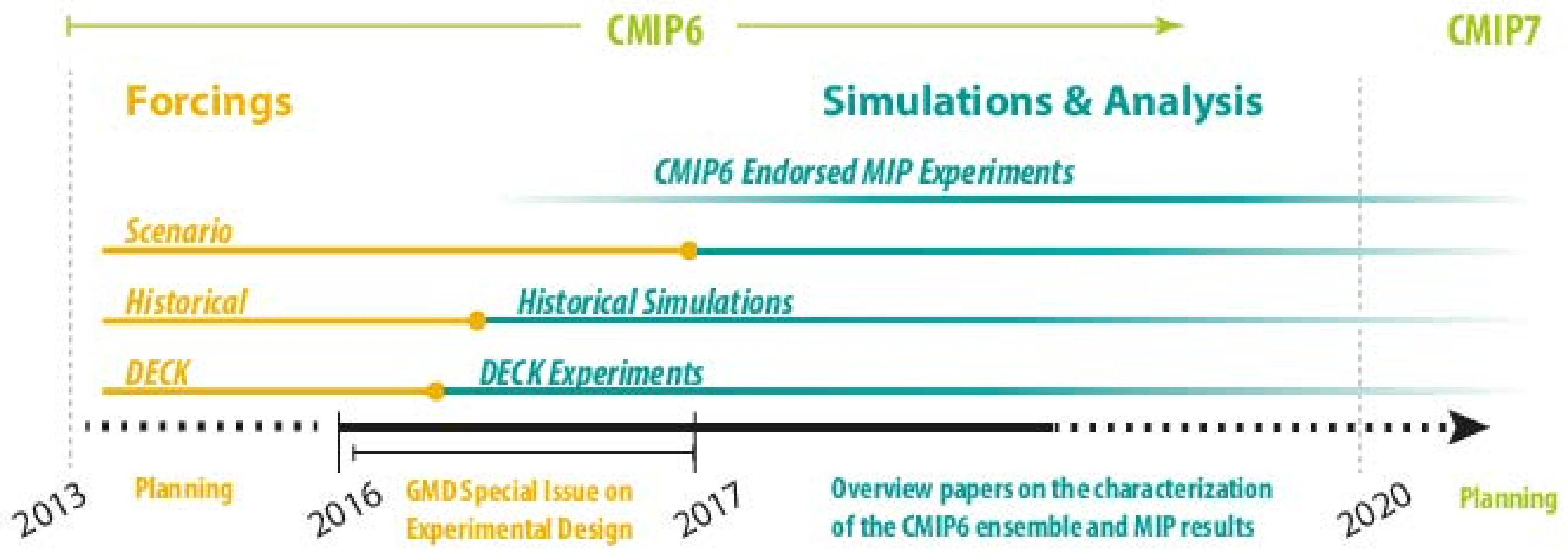
Model Groups' Feedback for Forcing Datasets
- AMIP Sea Surface Temperature and Sea Ice Datasets -

- No specific feedback on this dataset included in the slides from model groups

Main Comments GMD Paper:

- not yet submitted to GMD, so no review comments yet

CMIP6 Timeline



Eyring et al., GMD, 2016

Initial Goal: CMIP6 Data Request finalized and approved at WGCM-19

First Recommendations for CMIP7

CMIP Organization

- **Seeking community input** in each phase of the definition of the CMIP design is essential and should be kept (e.g. CMIP5 survey, iteration of CMIP design, Special Issue, forcings etc.)
- The more distributed organization with the **CMIP Panel** overseeing CMIP DECK and historical simulations and entire CMIP process and the **CMIP-Endorsed MIPs** works well so far and should be kept.
- Too many essential deliveries rely on **single people** (e.g. data request, forcings)
- Too many essential deliveries are **unfunded**

Forcings:

- Writing of early initial descriptions of the forcings and review by the model groups and MIPs was a good initiative, but hasn't worked since we hardly received any feedback / key questions remained open => **Create more formal link by asking each model group to assign one person for each forcing dataset early on in the process.**
- **Ideally have an organization** in charge for each forcing dataset.
- **Forcing papers should be submitted well before forcings are due** so that review comments can be considered in the final data product.
- **Data standards and formats** need to be finalized well before forcings are due.
- **The publication to the ESGF** takes long and was not built into the CMIP timeline; this should be included as formal step in the CMIP7 timeline.

CMIP6 Data Request:

- Many issues; requires more than one person in charge, should be a group of people that oversees the technical and scientific part of the data request => **CMIP Data Request Panel**?

Status and Outlook

CMIP6 Status

- CMIP6 Experimental Design finalized on time
- Forcing datasets for DECK and CMIP6 historical simulations finalized nearly on time
- CMIP6 Data Request: substantial delays
- CMIP6 Simulation Period (2016-2020)
- Infrastructure in preparation by WGCM Infrastructure Panel (WIP)

CMIP6 Participating Model Groups: > 30 using a wide variety of different model versions

21 CMIP6-Endorsed MIPs that build on the DECK and CMIP historical simulations to address a large range of specific questions with WCRP Grand Challenges as scientific backdrop.

CMIP6 Climate Projections part of a CMIP6-Endorsed MIP (ScenarioMIP)

- New scenarios span the same range as the RCPs, but fill critical gaps for intermediate forcing levels and questions for example on short-lived species and land-use.
- Forcings for future scenarios available by end of 2016, climate model projections expected to be available within the 2018-2020 time frame.

A Central Goal of CMIP6 is Routine Evaluation of the Models with Observations

- Community evaluation tools: development and coupling to ESGF well underway; Concept towards improved and routine evaluation of ESMs in CMIP developed (Eyring et al., ESD, 2016)

Geosci. Model Dev. Special Issue on CMIP6 Design

- Overview of the CMIP6 Experiment Design and Organization (Eyring et al., GMD, 2016)
- Experimental design from all 21 CMIP6-Endorsed MIPs (22 contributions)
- Description of the CMIP6 forcing datasets (~10 contributions, 3 submitted and in review)
- CMIP6 infrastructure (WIP, Balaji et al., in prep.)

=> We expect CMIP6 to continue CMIP's tradition of major scientific advances

Action Items for WGCM-20

Forcings

- Any remaining issues with historical forcings?
- Declare historical forcings (and formats) finalized?
- How long until they are all published on input4MIPs?

Responses to Feedback from Model Groups and CMIP6-Endorsed MIPs (see slides highlighted in blue)

Announce CMIP model evaluation capability to the modelling groups and CMIP6-Endorsed MIPs (Veronika and Peter)

Decide on official acknowledgement for CMIP6 and put on CMIP Panel website

- **CMIP5:** We acknowledge the World Climate Research Program's (WCRP's) Working Group on Coupled Modelling (WGCM), which is responsible for CMIP, and we thank the climate modelling groups for producing and making available their model output. For CMIP the U.S. Department of Energy's Program for Climate Model Diagnosis and Intercomparison provides coordinating support and led development of software infrastructure in partnership with the Global Organization for Earth System Science Portals **=> Needs to be modifiedE**
- **WCRP request for acknowledgement** Example 1: We acknowledge the [Name of the specific project/group] for making the [concerned data, simulations, etc.] available for the work described in this article. These activities have been undertaken under the guidance and sponsorship of the World Climate Research Programme.

CMIP6 Data Request

- Identify a group of people to finalize the data request