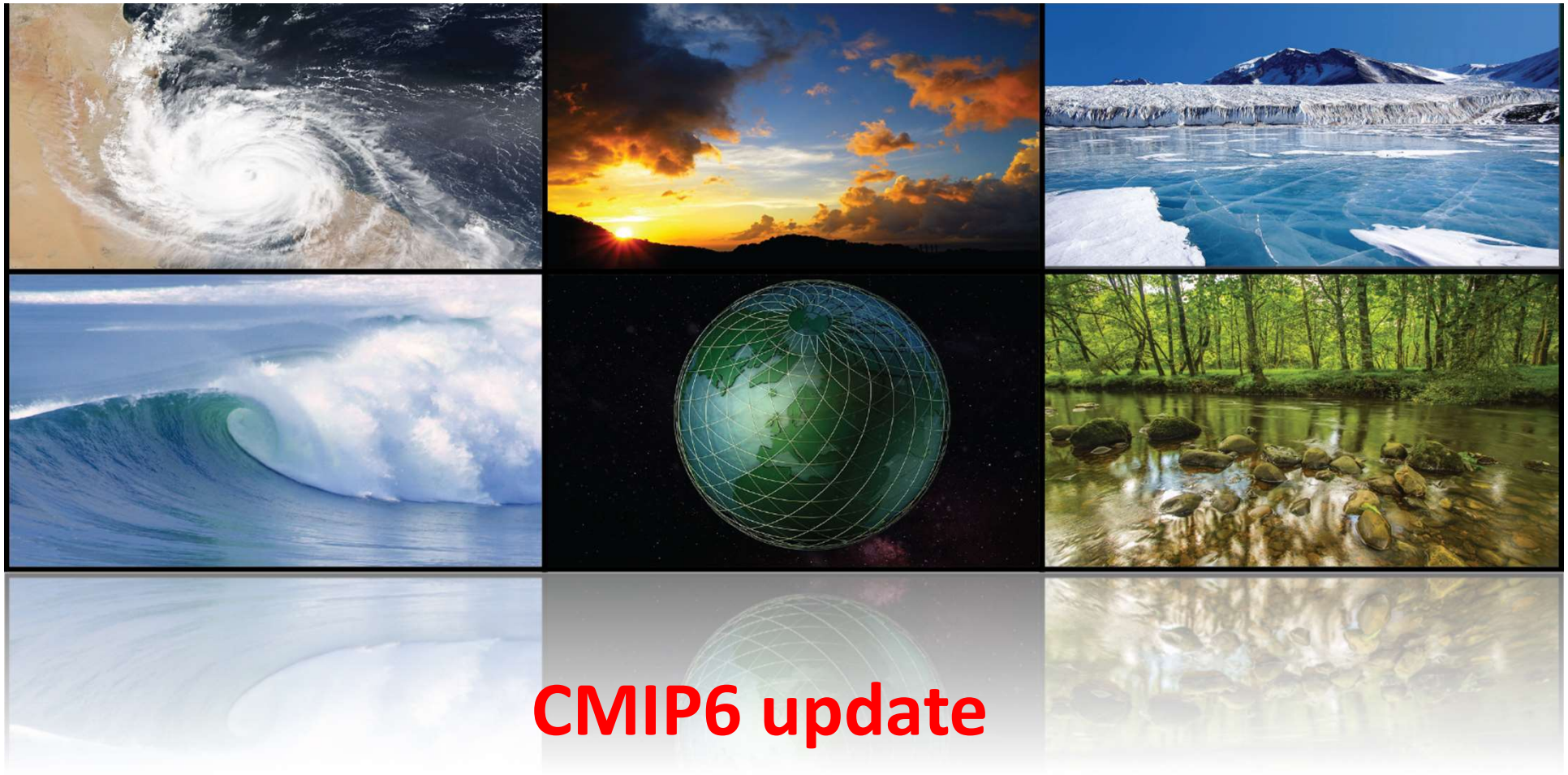

CMIP6 update

WGNE 34, DWD Offenbach

Catherine Senior, WGCM co-chair

September 2019

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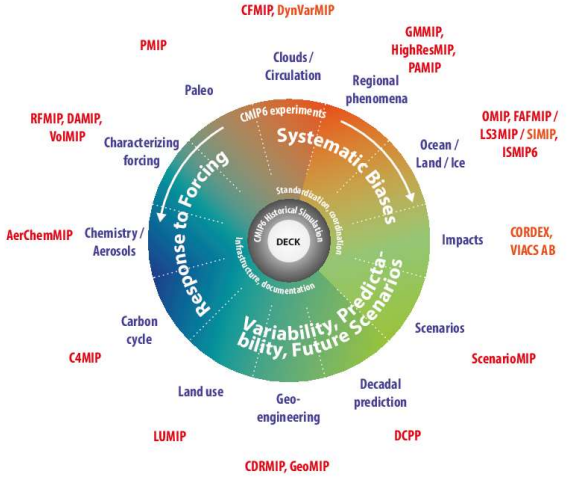
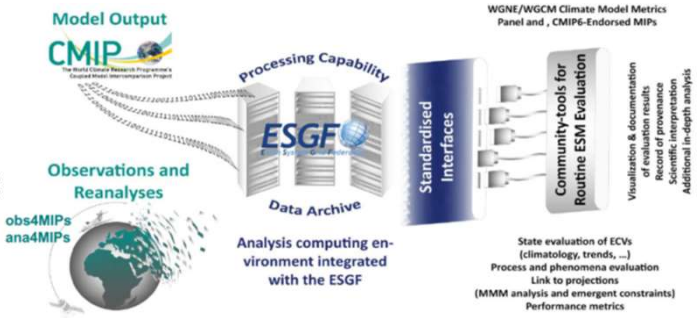
Progress and achievements

- Model simulations for CMIP6 are now progressing with rapid activity over the next few months as the AR6 timelines approach (December 2019 for submitted papers)
- Model output now being served by ESGF from 21 institutions (45 models)
- Much output will be made available over the coming months
- ESMValTool now routinely applied to CMIP6 data as it is uploaded to ESGF



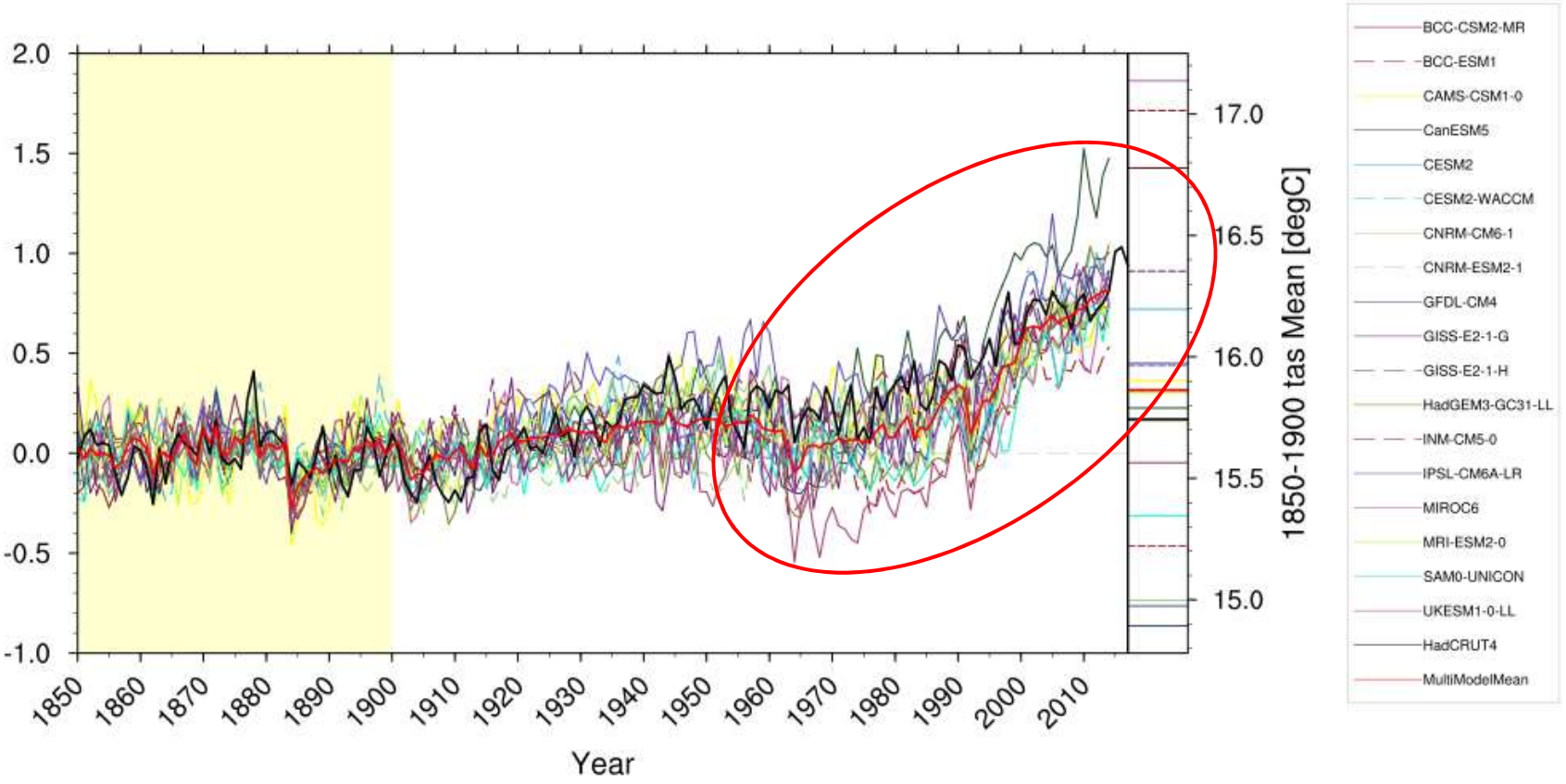


https://pcmdi.llnl.gov/CMIP6ArchiveSatistics/esgf_data_holdings/

model	# of activities	AerChemMIP	C4MIP	CDRMIP	CFMIP	CMIP	DAMIP	DCPP	FAFMIP	GMMIP	GeoMIP	HighResMIP	LS3MIP	LUMIP	OMIP	PAMIP	PMIP	RFMIP	ScenarioMIP	VolMIP
# of models	**162**	**15**	**6**	**3**	**10**	**27**	**9**	**4**	**2**	**9**	**4**	**20**	**4**	**7**	**8**	**2**	**3**	**9**	**19**	**1**
AWI-CM-1-1-MR	**3**	50				960													50	
BCC-CSM2-MR	**8**		514		844	2161	1481			413			41	858					884	
BCC-ESM1	**2**	2988				1631														
CAMS-CSM1-0	**3**	65				643													325	
CESM2	**12**		890	134	1126	15567	1380			291			265	3574	1546	55700		742	5492	
CESM2-WACCM	**4**	2149				7143					678								5357	
CMCC-CM2-HR4	**1**											70								
CMCC-CM2-VHR4	**1**											70								
CNRM-CM6-1	**12**	1931			1447	7052	5161	16519		832		674	153	153	7			580	5457	
CNRM-CM6-1-HR	**1**											410								
CNRM-ESM2-1	**9**	12401	2296			9190				181	2038			668	136			1278	15481	
CanESM5	**15**	6901	1540	2379	1790	22928	33798	130356	1703	2130	1022			680		64199		2934	32054	1700
E3SM-1-0	**1**					710														
EC-Earth3	**3**	975				2478													4387	
EC-Earth3-Veg	**3**	234				997													1175	
ECMWF-IFS-HR	**1**											303								
ECMWF-IFS-LR	**1**											307								
FGOALS-f3-L	**3**					267				450					30					
GFDL-AM4	**1**					69														
GFDL-CM4	**5**				401	2015									52			46	644	
GFDL-CM4C192	**1**											165								
GFDL-ESM4	**4**		111	57		1397													599	
GFDL-OM4p5B	**1**														21					
GISS-E2-1-G	**5**				332	5984	4150							830			166			
GISS-E2-1-H	**2**				143	1868														
HadGEM3-GC31-HM	**1**											318								
HadGEM3-GC31-LL	**3**					4060	2242					340								
HadGEM3-GC31-LM	**1**											172								
HadGEM3-GC31-MM	**1**											496								
IITM-ESM	**1**					1														
IPSL-CM6A-ATM-HR	**1**											250								
IPSL-CM6A-LR	**14**	9667			3621	37495	19638	116604		558	1161	271	176	3433	642		2177	5897	15219	
MIROC-ES2L	**3**	259				1585													1295	
MIROC6	**10**	3957			420	2347	2205	49000	545	450					38			1638	1624	
MPI-ESM1-2-HR	**3**	517										74							2068	
MPI-ESM1-2-XR	**1**											75								
MRI-AGCM3-2-H	**1**											125								
MRI-AGCM3-2-S	**1**											125								
MRI-ESM2-0	**7**	368			812	3925	1377			246								606	1957	
NESM3	**3**					1527											65		875	
NICAM16-7S	**1**											79								
NICAM16-8S	**1**											79								
NICAM16-9S	**1**											79								
SAM0-UNICON	**1**					840														
UKESM1-0-LL	**5**	3932	520			6040												373	7807	

CMIP6: Surface Temperature Anomaly

CMIP6 (18 models)

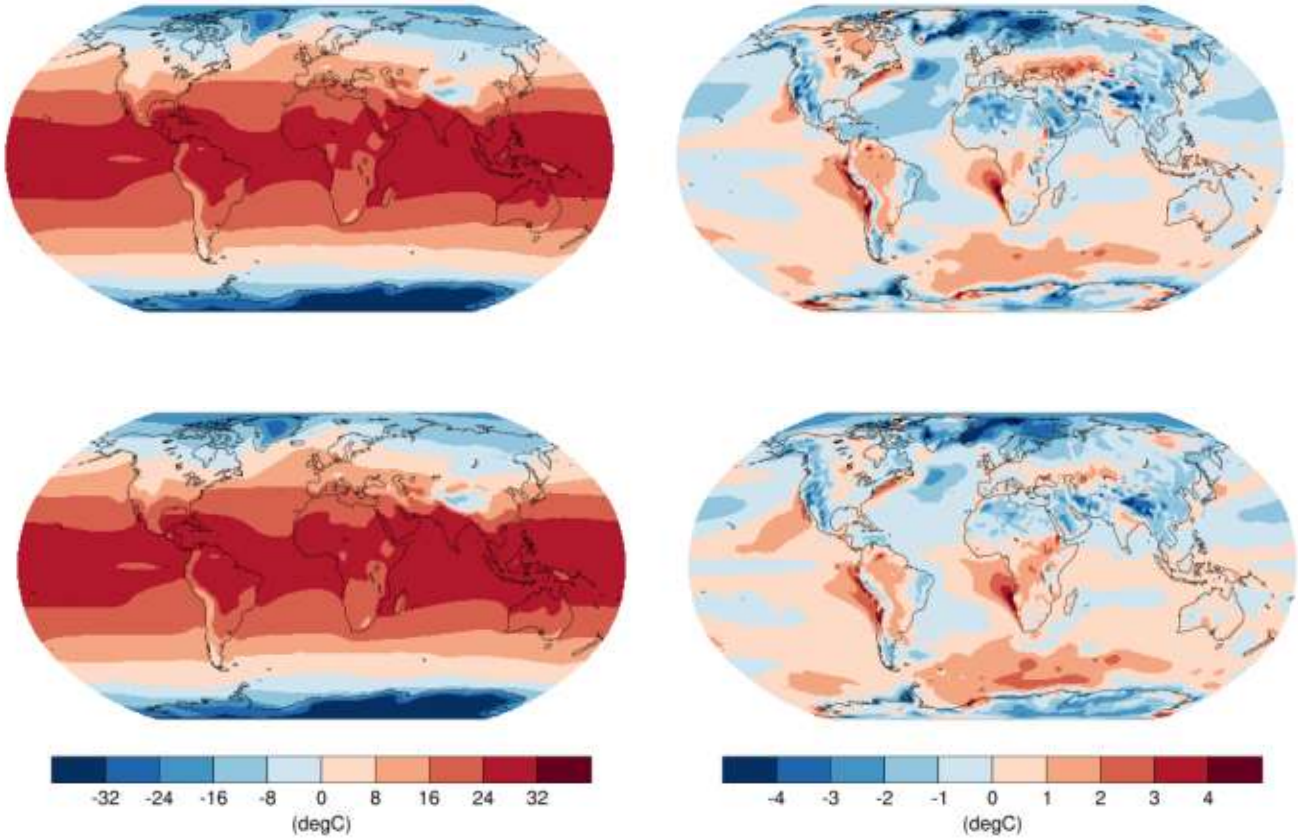


CMIP6: Surface Temperature Bias

CMIP5 (34 models)

Model Mean

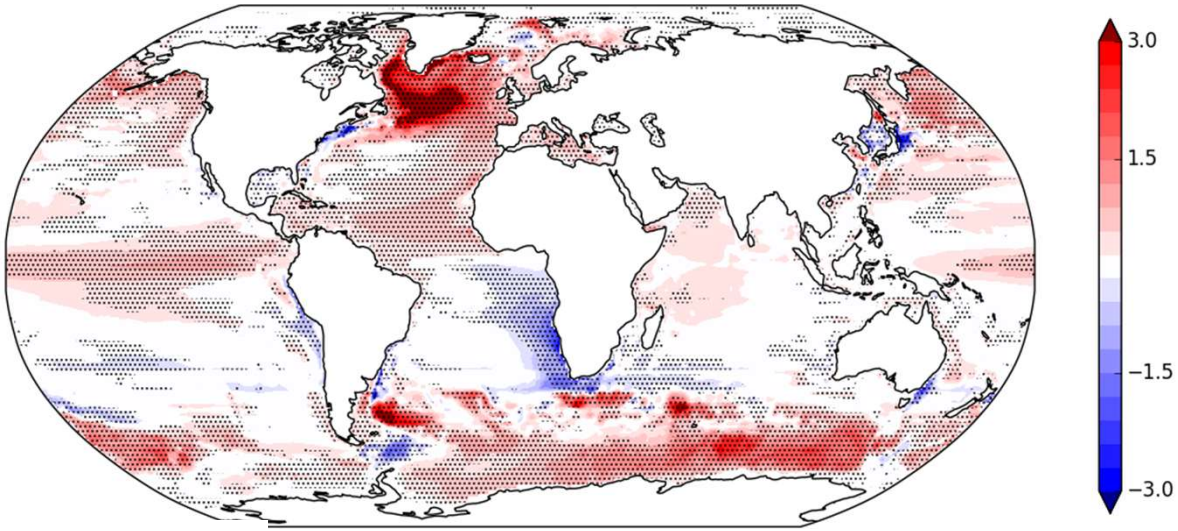
Multi Model Mean Bias (Ref dataset ERA-I)



CMIP6 (18 models)

High resolution modelling: SST

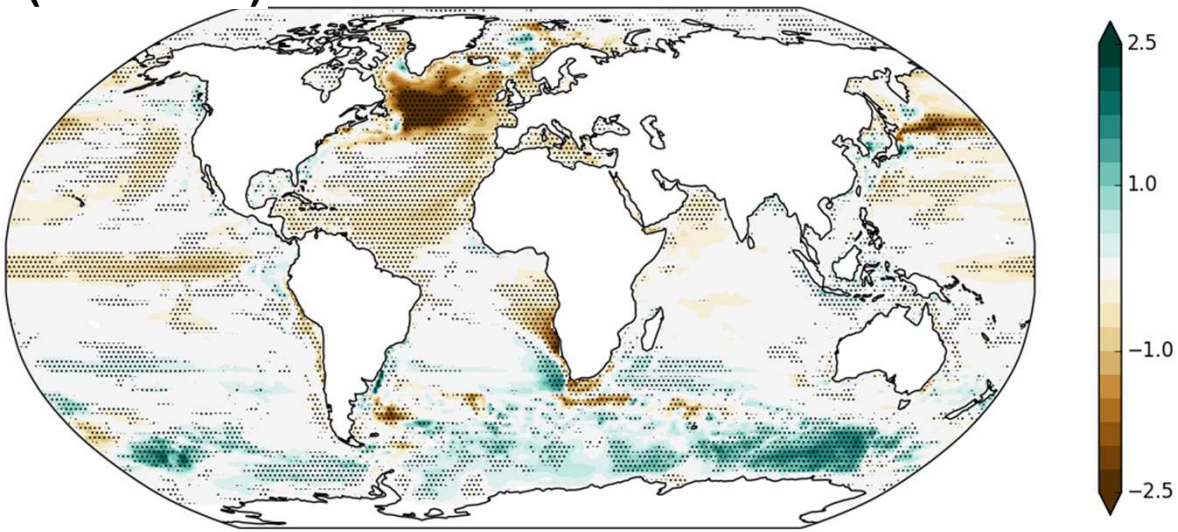
CMIP6 HighResMIP



Multi-model mean SST difference between high and low resolution coupled models

→ **Reduction in some long-standing regional model errors**

(5 models)



Multi-model mean of the change in SST bias between high and low resolution coupled models (using RMS difference from EN4 1950-54 mean)

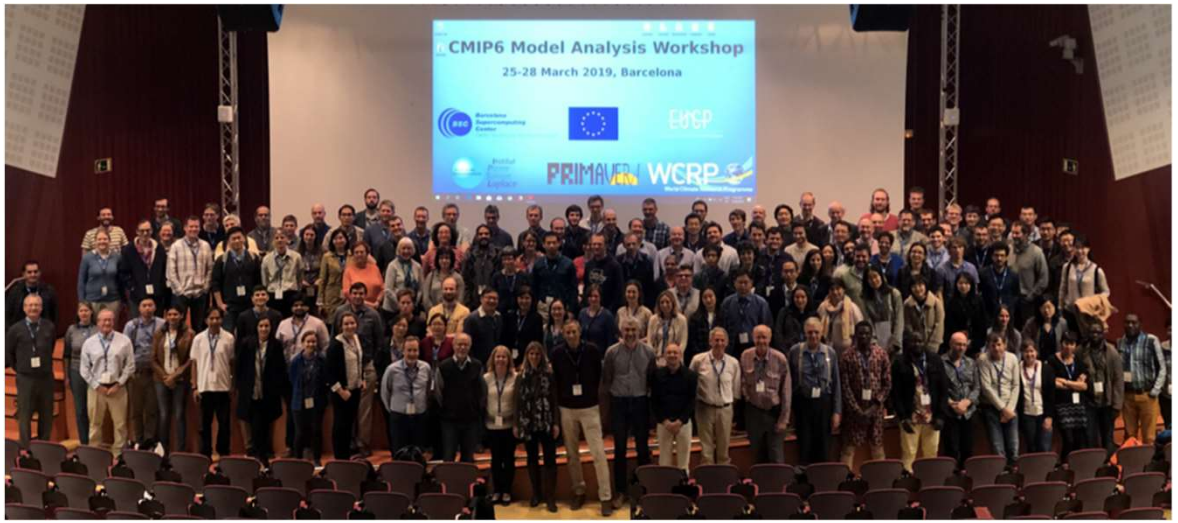
M. Roberts et al. 2019, in prep.

Progress and achievements

- 249 participants from 26 countries with a high representation of ECRs
- Representatives from at least 20 CMIP6-Endorsed Model Intercomparison Projects (MIPs) and 25 modelling groups
- IPCC CLA/LAs from all AR6 chapters
- Many parallel scientific meetings (WGCM-22, WMAC, GC on Carbon cycle).

CMIP6 Analysis Workshop,

Barcelona, March 24-28th, 2019



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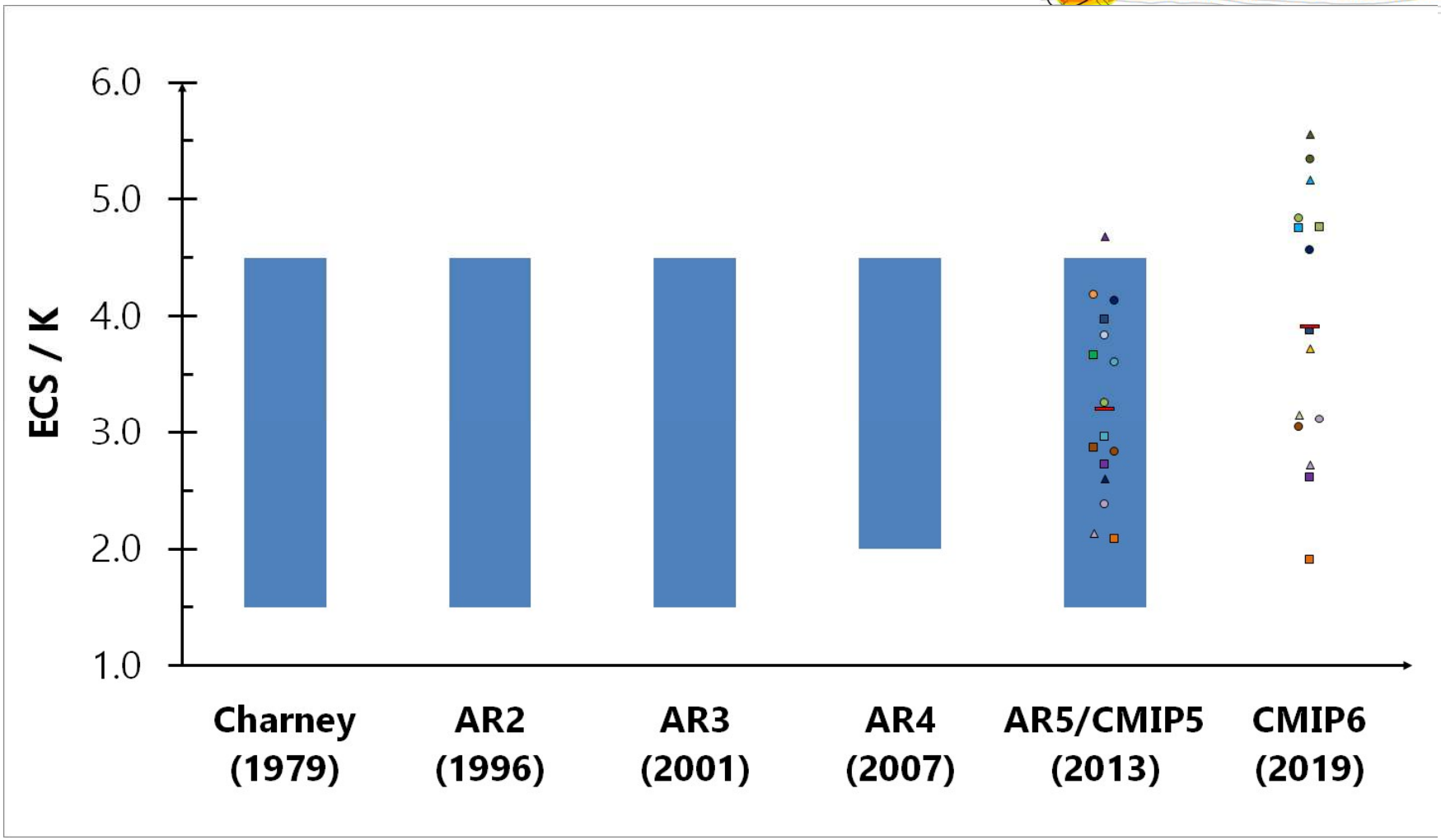
Emergent Properties - Climate Sensitivity



- There are a number of high sensitivity models (above the top of the CMIP5 range)
- The WCRP sponsored ECS assessment is probably going to lower *very unlikely* from 6 to 4.8
- WGCM are taking a lead on a perspectives paper on these emergent results to support the AR6 assessment

WGCM Report

WGNE 34, DWD Offenbach

Catherine Senior, WGCM co-chair

September 2019

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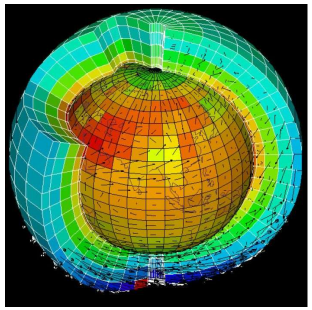
WGCM Aims

- **Review and foster the development of coupled ocean-atmosphere and Earth system models**



- **Co-ordinate model intercomparisons to**;
  - *better understand natural climate variability*
  - *predict the climate response to natural and anthropogenic perturbations*
  - *assess the climate predictability at the decadal timescale*

e.g. CMIP (Coupled Model Intercomparison Project), CFMIP (Cloud Feedbacks Intercomparison Project), PMIP (Palaeoclimate Model Intercomparison Project), Transpose-AMIP (climate model used in NWP mode), C4MIP (Carbon cycle Intercompariosn Project)

- **Promote and facilitate the models evaluation and diagnosis of shortcomings, and understanding of processes and feedbacks in the climate system**

- **Done in collaboration with many partners; WGNE (atmospheric process community), WGSIP (decadal forecasting community) , many MIPs**

WGCM promotes a balance between simulation – evaluation - understanding

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Progress and achievements

Grand Challenge on Clouds, circulation and climate sensitivity

Science Question Workshops in 2018

- Storm tracks, monsoons and tropical rainbelts


LA meeting, Edinburgh, 2-7 July, 2018

Two WCRP/GC Assessments

- Climate Sensitivity: synthesis across multiple lines of evidence; robust 5-95% ranges
- Aerosol Radiative forcing: synthesizes lines of evidence for weak/strong forcing

  => Both aiming to deliver review papers for AR6

Future Activities

- ICTP summer school: Convection organization and climate sensitivity (July 2019)
- EUREC4A field experiment (2020) and grey-zone project

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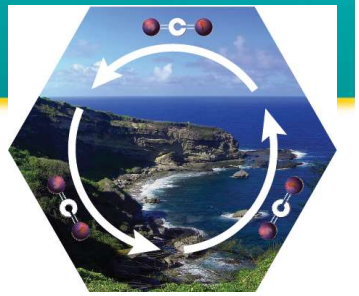
Progress and achievements



Grand Challenge on Carbon Cycle

Carbon Cycle Predictability

- Predictions and predictability of the carbon cycle (Workshop 21 September 2018, Boulder)
- Towards decadal predictions including carbon-climate feedbacks (Workshop 28 March 2019, Barcelona)

Climate-Carbon Cycle Feedbacks

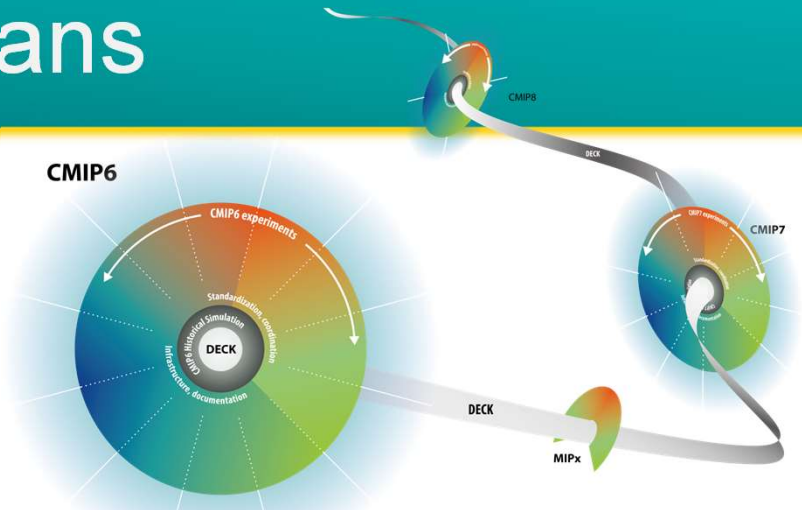
- Workshop on extending the Climate-Carbon Cycle Feedback Framework (April 2018, Bern)

EU H2020 Project CCICC (coordinator P. Friedlingstein, starting June 2019)

- WP1 Understanding the contemporary carbon cycle
- WP2 Predicting the carbon cycle and climate for the global stocktake to the horizon of 2030
- WP3 Projecting the required mitigation effort

Future plans

CMIP continuity and way forward



- Distributed CMIP organization has had both successes and challenges
- Separation of the timescales e.g.
  - DECK, historical + scenarios?) go on faster timescales; more automatic infrastructure in place, smaller burden on modelling centres
  - Science questions planned in CMIP6-Endorsed MIPs to continue over next phase (CMIP7) on longer timescales. More robust Infrastructure also needed.
- Enough experiments and research questions in CMIP6 to fuel research over the next phase
- Further discussion will engage all modelling centres

CMIP infrastructure and WMO task force

- CMIP essential infrastructure is currently delivered by volunteer efforts by the WGCM members, the CMIP Panel, the WIP (WGCM Infrastructure panel) and individual scientists in often partly/un-funded effort.
- Infrastructure includes;
  - 'forcing data' for climate model simulations
  - development of data formats and standards
  - documentation and software to contribute model output to the ESGF and allows users from around the world to access this massive multi-model data set.
- WCRP Csc (Pavel Kabat) has successfully lobbied WMO for financial and project support for CMIP infrastructure to put (at least) parts of CMIP on a more operational footing
- A task-force is now being set up to scope how this will work

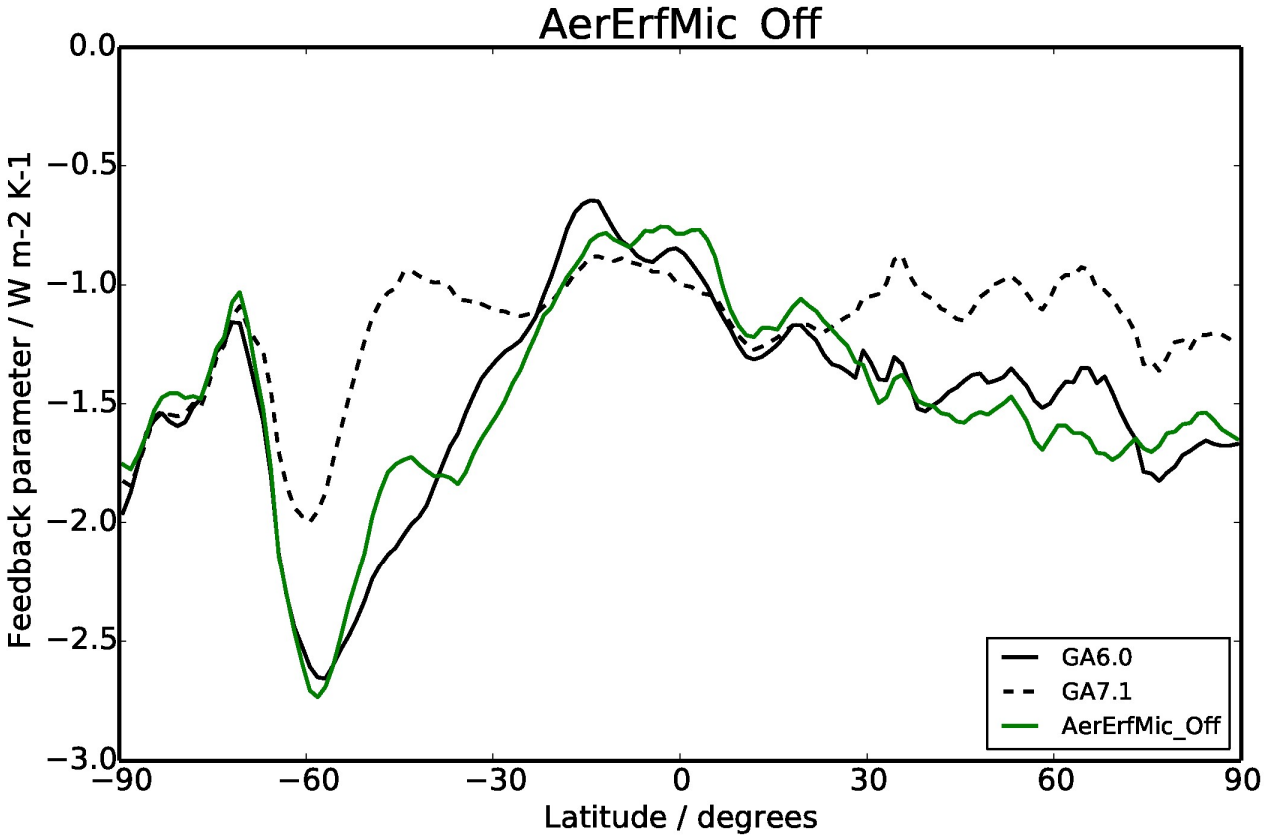
Links to the WCRP Strategic and Implementation Plans

- WGCM and the CMIP Panel are well situated within the WCRP structure at the moment.
- WGCM and CMIP produce some of the most visible and influential outcomes of WCRP, and leverage a huge investment by many countries.
- Our concerns related to the Strategic Plan relate to maintaining (ideally improving) this visibility and effectiveness.
- We believe that WGCM has played a crucial role in both fundamental model development and coordinated intercomparison projects, providing high-profile input to climate assessments and policy development. These activities should remain core features of the new Strategic Plan, the Implementation Plan, and any revision to the WCRP structure.

Earth System Modelling and Climate Prediction

- WGCM has a long track record on Earth system Modelling
- Links with AIMS and more now through direct membership on aerosols, carbon cycle, atmospheric chemistry
- WGCM also is directly linked to model development through its representation of modelling centres
- Understanding climate feedbacks and their link to modelled processes is at the core of our work – e.g. Grand Challenges on Climate Sensitivity and Carbon cycles
- WGCM is also involved in Climate Prediction (S2D)
- WGCM, WGNE (and WGSIP) need to ensure that understanding of climate feedbacks and seamless prediction feeds directly into model development
- This could work through regular joint meetings (which we already do!)
- Joint input into 'Modelling task force'

Understanding feedback changes



#11 Implement new ice PSD
#13 Revised cloud top entrainment
#15 McICA upgrades
#16 Improved treatment of gaseous absorption
#17 New ice optical properties
#44 Convective cores
#52 Implement new warm rain microphysics scheme
#58 PC2 / Convection Coupling

Experiments:

- amip and amip-p4K
- 1979/01 – 1989/12 (11yr)
- 1979/01 – 2014/12 (36 yr)
- N96L85
- ~800 years of simulations

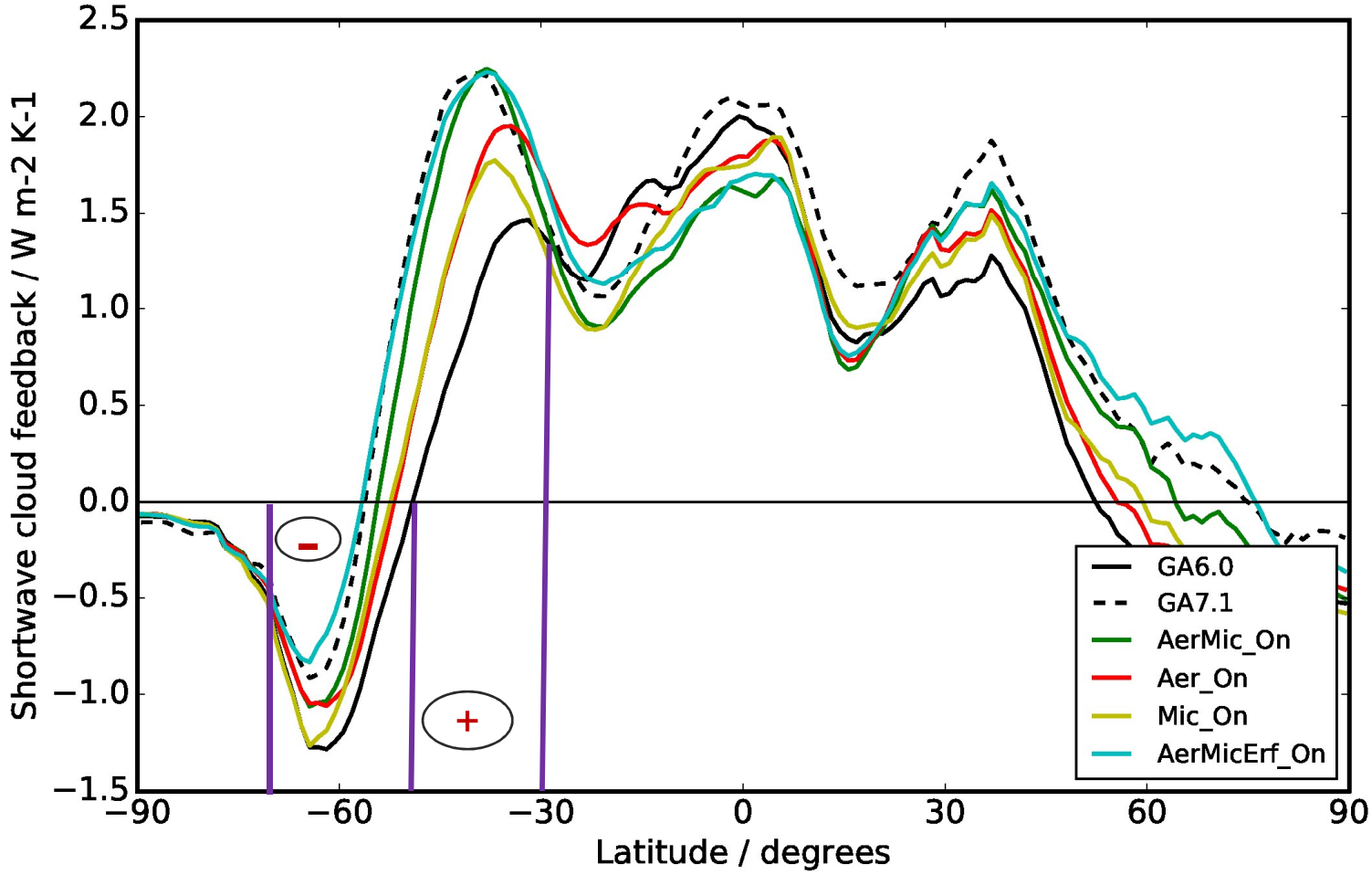
#154 Generate Kettle (1999) DMS datasets through general regriddi
#155 Generate Reynolds SST ancils via general regridding.
#156 New land fraction files for coupled models for use with the GO
#158 Fix bit-comparison issue with TRIP river routing in UM/JULES.
#161 Set reference height used in the ENDGame w-damping code to
#162 Retune cloud threshold for shear dominated BL in GA7.
#165 Non-orographic (USSP) GWD scheme launch factor tuning in re

Packages (collection of changes that went in GA7 that are logically related):

- Radiation
- Convection
- Cloud
- B. Layer
- GWD
- Dynamics
- S. physics
- Aerosols
- Microphysics
- Land

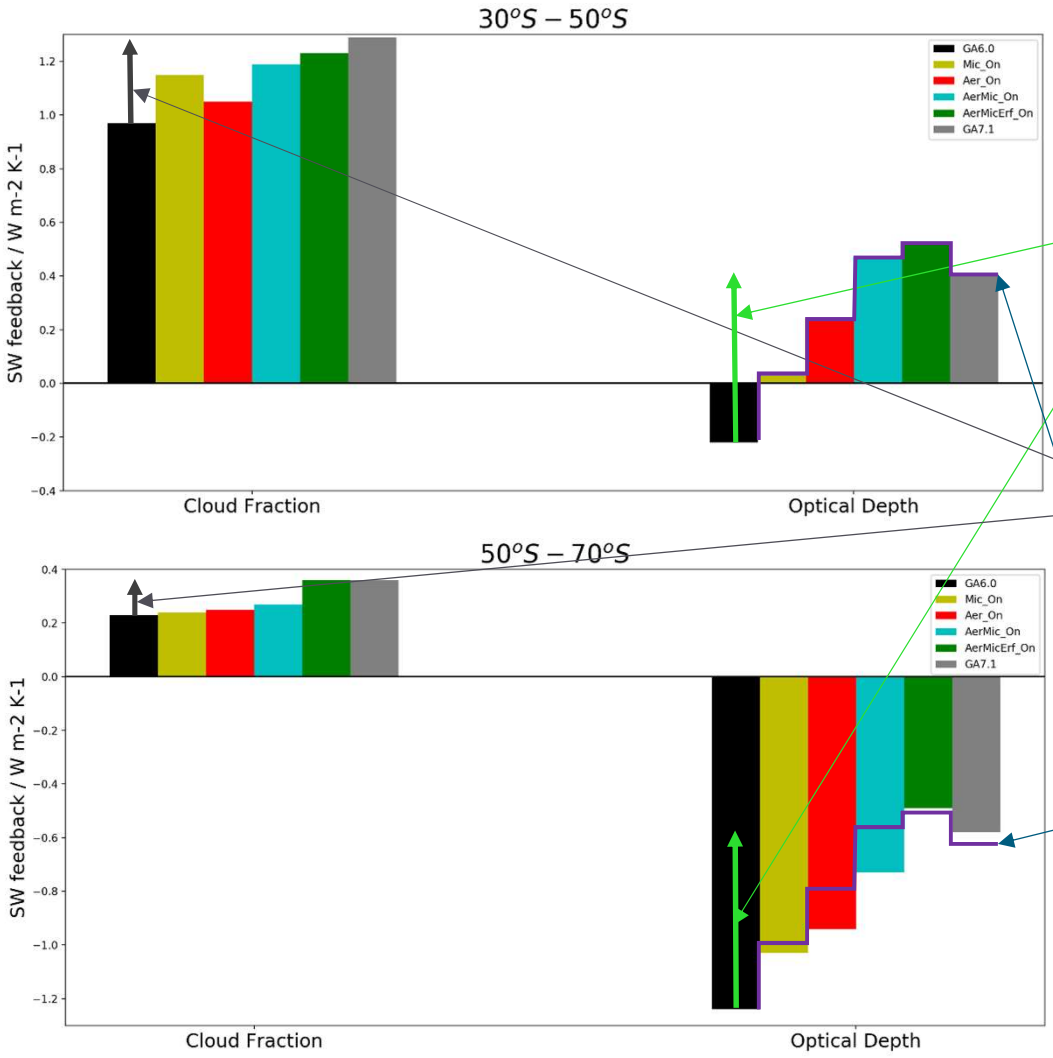
Alejandro Bodas-Salcedo

Zonal mean Shortwave cloud feedback



Response is a complex interaction between changes in climatology and climate change response of cloud radiative properties: fraction, LWP, R_{eff}.

Met Office Hadley Centre



Larger contributions from optical depth feedbacks.

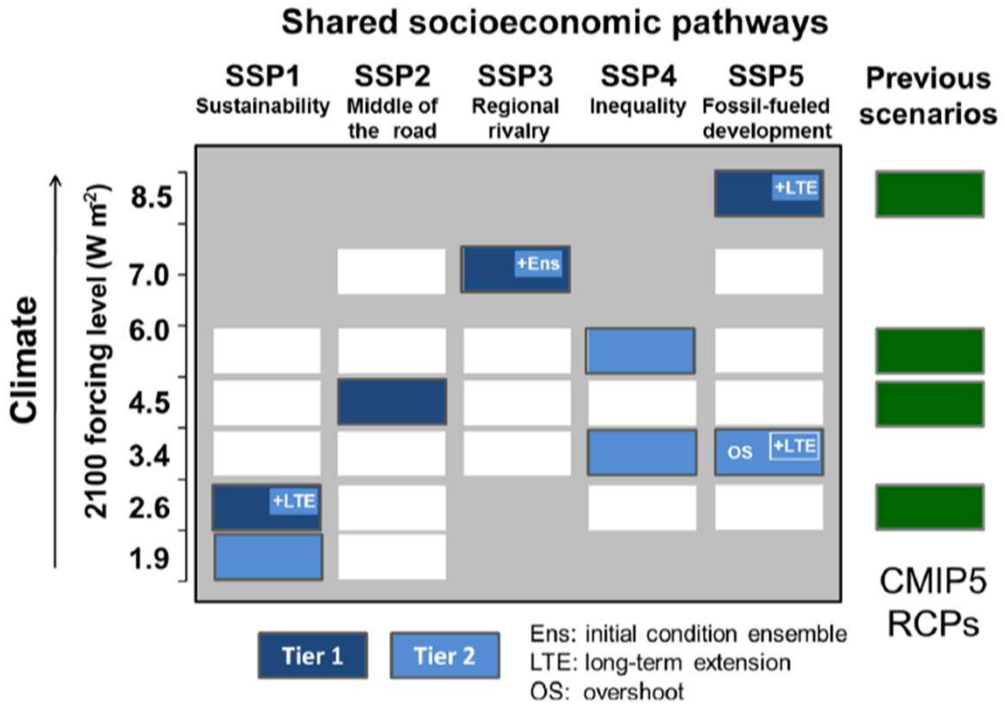
Cloud fraction changes difficult to attribute.
=>Climatological component.
=>feedback change much weaker in 50-70.

Optical depth feedback changes partition quite similar in both regions, although *Aer* effect is stronger in 30-50.

CMIP6 update on scenario simulations/data

Key scenarios

- Cross-WG Scenario BOG request to all chapters to show 5 key scenarios
- 4 ScenarioMIP "tier-1" scenarios
  - SSP1-2.6, SSP2-4.5, SSP3-7.0, SSP5-8.5
- Plus: SSP1-1.9

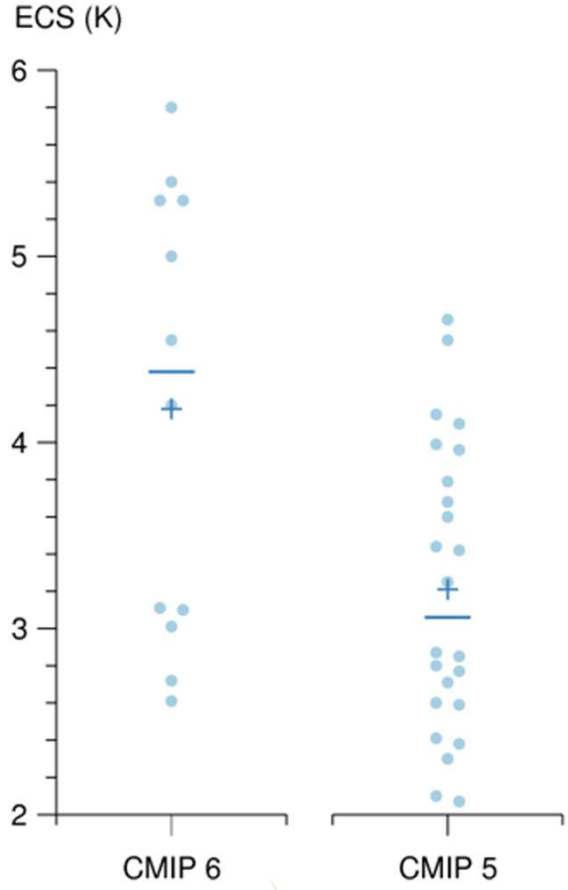


Future plans

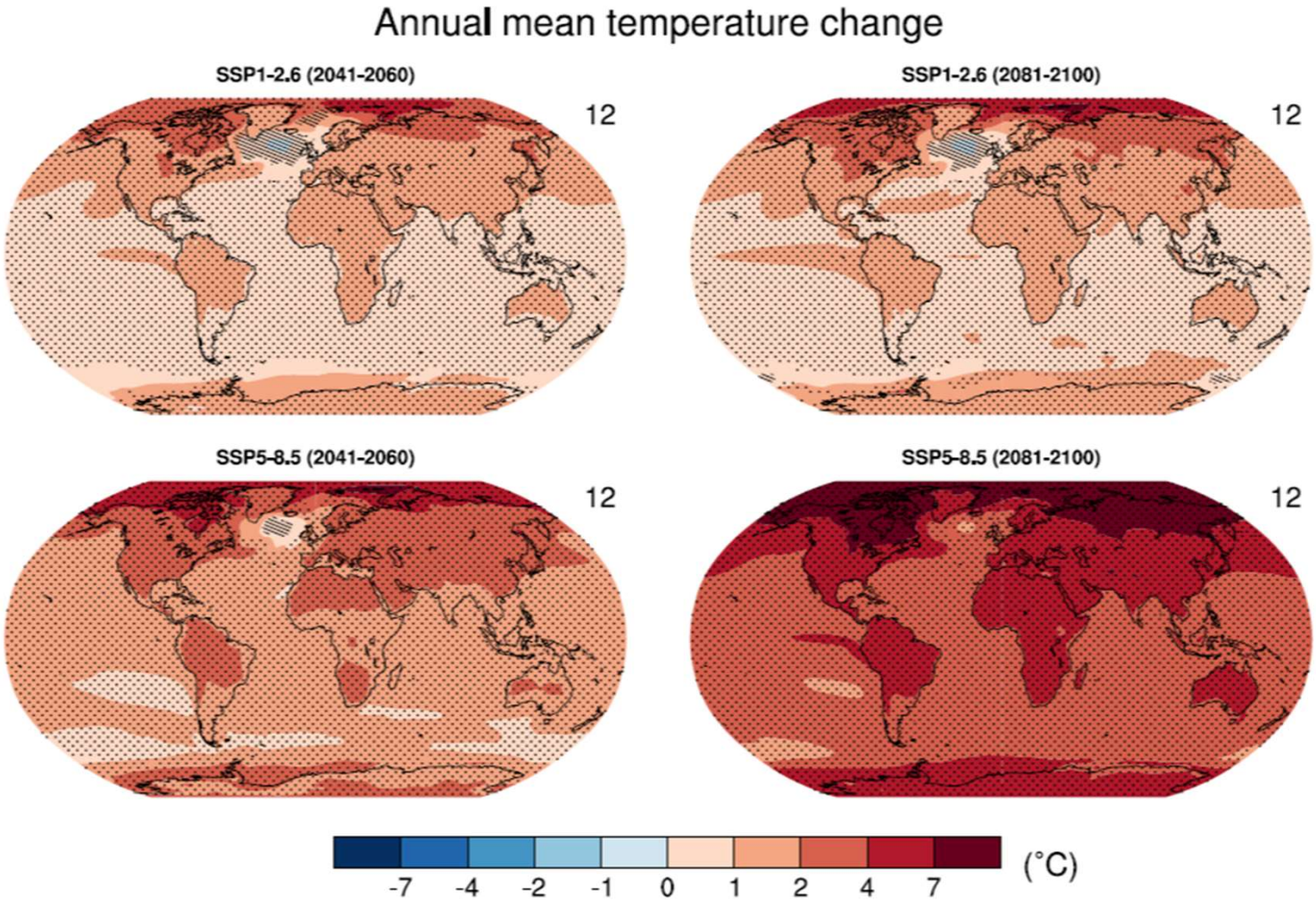
Emergent Properties of the CMIP6 ensemble

Effective Climate Sensitivity

- There are going to be a number of high sensitivity models (above the top of the CMIP5 range)
- The WCRP sponsored ECS assessment is probably going to lower *very unlikely* from 6 to ~4.5
- WGCM will take a lead on a perspectives paper on these emergent results to support the AR6 assessment
- More detailed further analysis will be actively encouraged in the MIPS
- Further workshops will be held



e.g. results


Annual mean temperature change
SSP1-2.6 (2041-2060)
12
SSP1-2.6 (2081-2100)
12
SSP5-8.5 (2041-2060)
12
SSP5-8.5 (2081-2100)
12
-7 -4 -2 -1 0 1 2 4 7
(°C)