



Met Office  
Hadley Centre

# EUCLIPSE simulations in the context of CFMIP2/CMIP5

Mark Webb, Met Office Hadley Centre, UK

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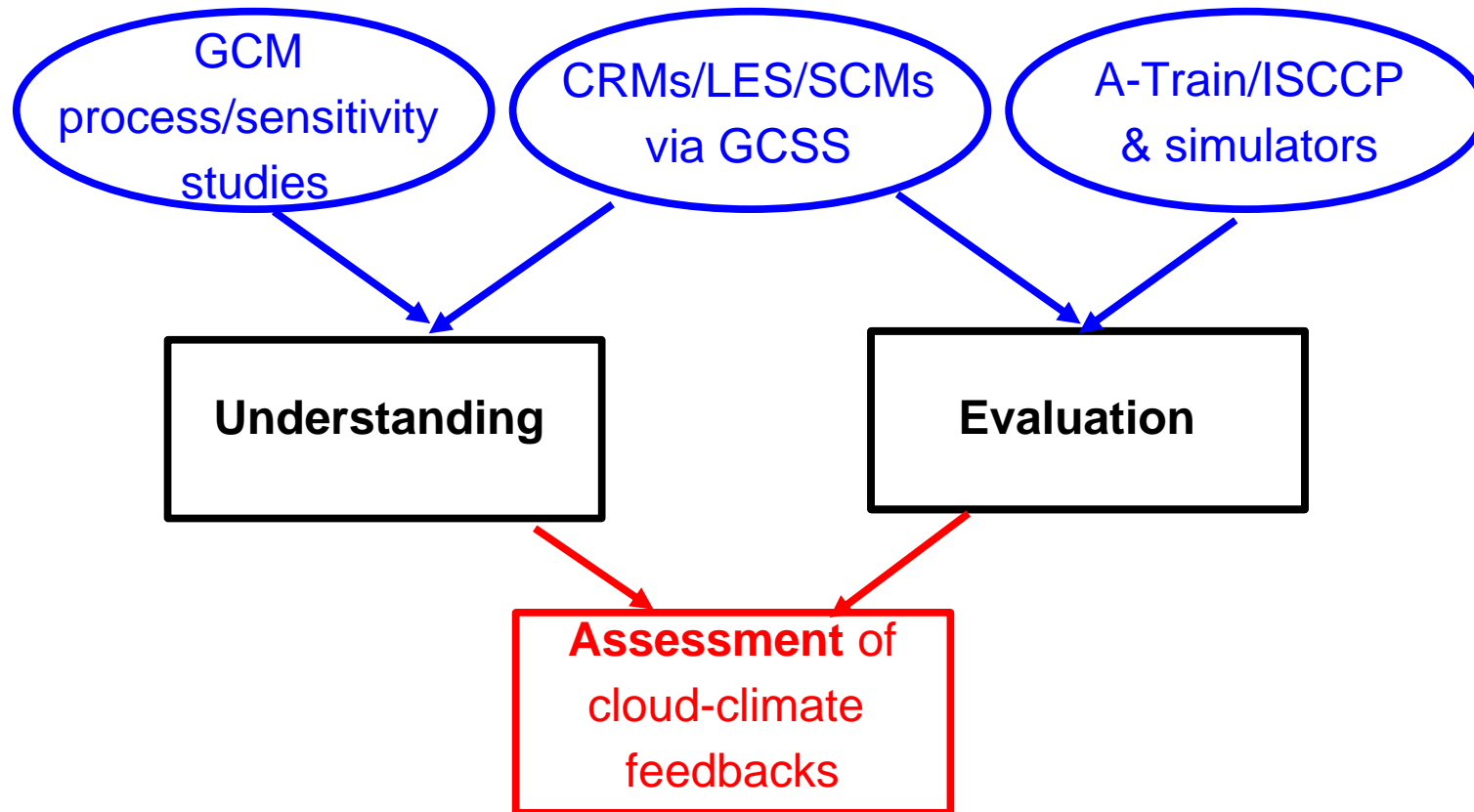


# Background: Coordinated experiments used in IPCC AR4 cloud feedback analysis

- Coupled Model Intercomparison Project (CMIP3)
  - AOGCM, Slab (Atmosphere-Ocean Mixed Layer), monthly means
  - Radiative fluxes, ice/liq water path, total and model level cloud
- US Climate Process Team on low latitude feedbacks (CPT)
  - Composite SST patterned forcing, +2K SST, aquaplanet+2K
  - High frequency outputs at specified locations (ARM, GPCI)
- Cloud Feedback Model Intercomparison Project (CFMIP-1)
  - ATM +2K and Slab, monthly and daily means
  - ISCCP simulator, convective/stratiform cloud fractions/ice liquid water contents on model levels



# Cloud Feedback Model Inter-comparison Project Phase 2 (CFMIP2) [www.cfmip.net](http://www.cfmip.net)



CFMIP committee: Mark Webb and Sandrine Bony (Co-chairs)

Chris Bretherton, Steve Klein, Pier Siebesma, George Tselioudis, Minghua Zhang



## CFMIP-2: Understanding and evaluating cloud processes and feedbacks in climate models

- Evaluation of clouds in CMIP5 climate models
  - Continuing use of the ISCCP simulator in CFMIP2/CMIP5
  - Development of new radar/lidar simulators for CFMIP2/CMIP5 (COSP)
- Understanding cloud feedback mechanisms in models
  - Hierarchy of climate change experiments (ESM->AGCM->SCM->LES)
  - Timestep model outputs at fixed sites ( ARM, GPCI, CEOP, ...)
  - Temperature, water vapour and cloud condensate tendencies
  - Sensitivity experiments to test physical mechanism hypotheses
- Assessing physical credibility of cloud feedback mechanisms
  - CFMIP-GCSS Intercomparison of SCM and LES (CGILS)



# CFMIP2/CMIP5 Experiments and Output

- Details/links to CMIP5 information are available at <http://www.cfmip.net> -> CMIP5 information
- List of CMIP5 experiments (including CFMIP2 subset)
- List of CFMIP related outputs
- Table showing which are required in which experiment

# CFMIP2/CMIP5 Experiment Hierarchy

<i>Pre-industrial</i>	<i>Historical/ present</i>	<i>CO<sub>2</sub> forcing / adjustments</i>	<i>Climate feedbacks</i>	
<p><b>3.1 ESM pre-industrial control</b></p>	<p><b>3.2 ESM historical</b></p> <p><b>3.3E AMIP SST</b></p>		<p><b>6.3,6.3E ESM Abrupt 4CO<sub>2</sub></b></p> <p><b>6.1 ESM 1% per year CO<sub>2</sub></b></p>	
<p><b>6.2a ATM + control SST climatology</b></p>	<p><b>6.4a/b ATM + control SST, present aero</b></p>	<p><b>6.2b ATM + control SST 4CO<sub>2</sub></b></p>	<p><b>CMIP5 Experiments with COSP</b></p>	
<p><b>CFMIP /CMIP5 Expts with full CFMIP outputs</b></p>	<p><b>3.3 ATM AMIP SST</b></p> <p><b>6.7a ATM Aquaplanet control</b></p>	<p><b>6.5 AMIP + 4CO<sub>2</sub></b></p> <p><b>6.7b ATM Aquaplanet + 4CO<sub>2</sub></b></p>	<p><b>6.8 AMIP uniform +4K</b></p> <p><b>6.7c Aquaplanet Uniform+4K</b></p>	<p><b>6.6 AMIP +4K SST pattern</b></p> <p><i>no carbon cycle or interactive vegetation</i></p>
<p><b>CGILS Experiments SCM &amp; LES</b></p>	<p><b>3 GPCI points AMIP SST</b></p>		<p><b>3 GPCI points AMIP SST+2K</b></p>	



# CMIP5 Standard Output

## Required in all CMIP5 experiments

Supports large scale feedback analysis / monthly compositing -  
Bony and Dufresne 2005, Webb et al 2006, Wyant et al 2006,  
Williams et al (2006), Gregory and Webb (2008), Medeiros et al  
(2008), Wyant et al (2010)

- 2D TOA/surface radiative/turbulent fluxes, precipitation
- Cloud fraction / water contents and convective mass flux on model levels
- Temperature, relative and specific humidity, winds and omega on 17 pressure levels





# CFMIP Monthly on model levels (cfMon) Requested in all CFMIP experiments

For better understanding of feedback mechanisms

- 3D radiative fluxes for unambiguous attribution of cloud feedbacks to different levels
- Temperature and humidity plus tendencies from advection, diffusion, radiation, cloud+precip, boundary layer / convection
- Convective/stratiform cloud fraction and liquid/ice water contents plus tendencies from microphysics etc
- Up/down shallow/deep convective mass fluxes, eddy diffusivities



# CFMIP Instantaneous CO<sub>2</sub> forcing Requested in CMIP/CFMIP controls

For better understanding of radiative forcings

- Instantaneous 4CO<sub>2</sub> top-of-atmosphere radiative forcing
- Instantaneous 4CO<sub>2</sub> 3D radiative forcing in atmosphere



# CFMIP monthly COSP (inline) All CFMIP and some CMIP5 expts (30 and 20 year sections)

For climatological / monthly compositing evaluation using ISCCP, CALIPSO and PARASOL e.g. Webb et al (2001), Zhang et al 2005, Williams et al (2006), Ringer et al (2006), Chepfer et al (2008)

- ISCCP Total cloud, cloud albedo and cloud top pressure
- ISCCP tau-cloud top pressure histogram
- CALIPSO cloud fraction total, low, mid, high and 40 level
- PARASOL reflectance (5 bins of solar zenith angle)



# CFMIP 2D daily outputs

## All CFMIP and some CMIP5 expts (30 and 20 year sections)

For 'Lightweight' clustering evaluation e.g. Gordon et al (2005), Williams and Webb (2009)

- TOA & surface fluxes, surface temp, pressure, precip
- Total cloud fraction, ice/liq water path
- 700mb T, 500mb omega, convective precip/cloud base/top
- ISCCP Total cloud, cloud albedo and cloud top pressure
- CALIPSO total, low, mid and high cloud fraction
- PARASOL reflectance (5 bins of solar zenith angle)



# CFMIP Daily 3D (cfDa)

## All CFMIP and 5 year sections in some other CMIP5 experiments

- For compositing / clustering cloud evaluation and relation to environmental thermodynamic profiles – Webb et al 2001, Williams and Tselioudis (2007), Zhang et al (2010)
- Cloud fraction and liquid / ice water contents model levels
- Temperature, relative and specific humidity, omega, winds, conv mass fluxes and pressure on model levels
- ISCCP Total cloud, cloud albedo and cloud top pressure
- ISCCP tau-cloud top pressure histogram
- CALIPSO cloud fraction total, low, mid, high and 40 levels
- PARASOL reflectance (5 bins of solar zenith angle)



# CFMIP offline COSP output CFMIP AMIP, +4K x 2, 4CO<sub>2</sub> (2008 only)

Regime/clustering evaluation with CloudSat - Bodas et al 2008, Zhang et al 2010, Marchand et al (2009)

- CFMIP orbital and monthly gridded
- CloudSat Radar Reflectivity (40 levels x 15 bins)
- Orbital track information (latitude, longitude, time)
- CALIPSO cloud fraction total, low, mid, high and 40 level
- CALIPSO Cloud Fraction not seen by CloudSat 40 levels
- CALIPSO Scattering Ratio (40 levels x 15 bins)
- PARASOL reflectance (5 bins of solar zenith angle)

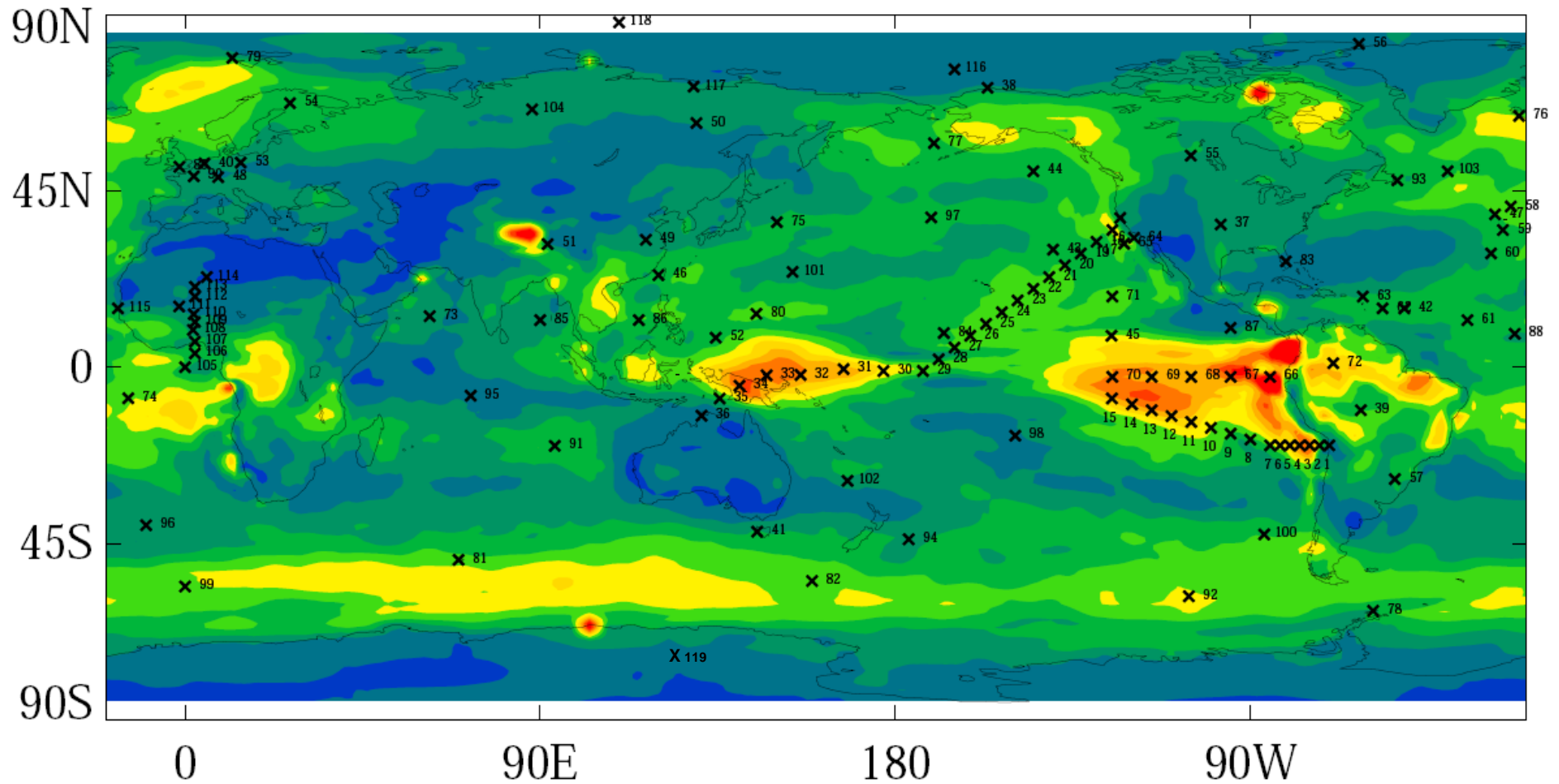


# CFMIP 3-hourly instantaneous 'snapshots' CFMIP AMIP only (2008)

Mainly for future simulator development

- All 2D variables from standard monthly CMIP5 output
- COSP inputs:
  - cloud fraction, ice and liquid water content, optical thickness, emissivity
  - Snow, rain and graupel fluxes
  - Effective radii for all hydrometeors
- Temperature, humidity and model level heights/pressures

# Timestep outputs at fixed sites (119 locations)



GPCI / Tropical West & South East Pacific / AMMA sections  
ARM sites/GCSS field studies/locations with feedback spread





## CFMIP 20-30min timestep station data Requested in all CFMIP experiments (cfSites)

For model evaluation using in situ obs ( ARM, field campaigns)  
Teixeira et al (2010), Mapes et al (2010)

Understanding feedback mechanisms (Bretherton et al 2004)

- 119 locations in AMIP control, Uniform/Pattern +4K, 4CO<sub>2</sub>
- 73 locations along 0E in aquaplanets
- Most quantities from other tables except COSP and cloud tendencies

<b>CFMIP diagnostic packages</b>	<b>Table</b>	<b>Priority</b>
CMIP5 standard output (Amon, Amon 2D etc)	aMon	Top Priority
CFMIP monthly 3D -- Clouds, temperature, humidity etc on model levels	cfMon	Top Priority
CFMIP monthly inline -- monthly mean in line ISCCP/CALIPSO/PARASOL simulator output	cfMon	Top Priority
CFMIP daily 2D -- daily mean 2-D fields including inline ISCCP/CloudSat/CALIPSO/PARASOL simulator output	cfda	Top Priority
CFMIP daily 3D -- daily mean 3-D fields on model levels plus CALIPSO and ISCCP cloud fractions	cfda	Top Priority
CFMIP 3-hourly orbital offline -- CloudSat/CALIPSO /PARASOL simulator output in orbital curtain format	cf3hr	Top Priority
CFMIP monthly offline -- monthly mean gridded simulator output based on 3-hrly orbital offline	cfOff	Top Priority
CFMIP timestep station data -- 2-D and 3-D fields on model levels at 20 to 30 minute intervals at 119 point locations.	cfSites	Top Priority
CFMIP monthly 3D -- Clouds, mass fluxes, internal radiative fluxes, tendencies temperature, humidity and cloud.	cfMon	Can be later
CFMIP 3-hrly inline -- Instantaneous 3 hourly global 'snapshots' for future COSP development	cf3hr	Can be later
CFMIP monthly 4CO2 2D -- monthly mean TOA radiative fluxes calculated by instantaneously quadrupling CO2.	cfMon	Can be later
CFMIP monthly 4CO2 3D -- monthly mean 3-D radiative fluxes calculated by instantaneously quadrupling CO2.	cfMon	Can be later

<b>CMIP5 Experiment Name</b>		<b>CMIP5 Priority</b>	<b>CFMIP2 / EUCLIPSE Priority</b>
CFMIP2 AMIP	3.3	Core	Top priority
CFMIP2 4xCO2 AMIP	6.5	Core	Top priority
CFMIP2 AMIP plus 4K pattern	6.6	Core	Top priority
CFMIP2 AMIP plus uniform 4K	6.8	Tier 1	Top priority
CFMIP2 Aqua planet control	6.7a	Tier 1	Can be later
CFMIP2 4xCO2 aqua planet	6.7b	Tier 1	Can be later
CFMIP2 Aqua planet plus 4K anomaly	6.7c	Tier 1	Can be later
A OGCM pre-industrial control	3.1	Core	
A OGCM historical	3.2	Core	
A OGCM 1 percent per year CO2	6.1	Core	
Abrupt 4XCO2	6.3	Core	
Abrupt 4XCO2 11x5 years	6.3-E	Tier 1	
Control SST climatology	6.2a	Core	
Control SST + 4CO2 forcing	6.2b	Core	
Control SST+ present day total aerosol	6.4a	Tier 1	
Control SST+ present sulphate aerosol	6.4b	Tier 1	



# Summary

- CFMIP-2/CMIP5 experiments and diagnostics will provide an unprecedented amount of information to evaluate and understand clouds and cloud feedbacks in the AR5 models.
- CFMIP-2 experiments based on realistic AMIP SSTs should ideally be submitted first, while aquaplanet experiments can be later
- Simulator and timeseries at fixed locations should ideally be submitted first, while 3D snapshot data, tendency terms, instantaneous radiative forcings and fluxes on model levels can be later



# Supplementary slides

<b>Estimated dates for implementation of CFMIP diagnostic packages</b>	<b>CMIP5 table</b>	<b>UKMO - HadGEM2</b>	<b>ECHAM6-MPIOM</b>	<b>CNRM-CM5</b>	<b>IPSL CM5a/b</b>	<b>KNMI EC-Earth</b>
CMIP5 standard output (Amon, Amon 2D etc)	aMon	DONE	DONE	DONE	Q4/10	DONE
CFMIP monthly 3D -- Clouds, mass fluxes, internal radiative fluxes, tendencies temperature, humidity and cloud.	cfMon	DONE	PART	PART	Q4/10	Q4/10
CFMIP monthly 4CO2 2D -- monthly mean TOA radiative fluxes calculated by instantaneously quadrupling CO2.	cfMon	DONE	DONE	Q3/10	Q4/10	Q4/10
CFMIP monthly 4CO2 3D -- monthly mean 3-D radiative fluxes calculated by instantaneously quadrupling CO2.	cfMon	DONE	DONE	Q3/10 Net	Q4/10	Q4/10
CFMIP monthly inline -- monthly mean in line ISCCP and CALIPSO/PARASOL simulator output from COSP	cfMon	DONE	DONE	DONE off-line	DONE	Q4/10
CFMIP daily 2D -- daily mean 2-D fields including inline ISCCP/CloudSat/CALIPSO/ PARASOL simulator output	cfda	DONE	Q4/10	DONE off-line	Q4/10	Q4/10
CFMIP daily 3D -- daily mean 3-D fields on model levels plus CALIPSO and ISCCP cloud fractions	cfda	DONE	Q4/10	DONE off-line	Q4/10	Q4/10
CFMIP 3-hourly orbital offline -- CloudSat/CALIPSO /PARASOL simulator output in orbital curtain format	cf3hr	DONE	Q4/10	Q4/10	Q4/10	Q4/10
CFMIP 3-hrly inline -- Instantaneous 3 hourly global 'snapshot' data for future simulator development	cf3hr	DONE	Q4/10	DONE	Q4/10	Q4/10
CFMIP monthly offline -- monthly mean gridded simulator output based on CFMIP 3-hrly orbital offline	cfOff	DONE	Q4/10	Q4/10	Q4/10	Q4/10
CFMIP timestep station data -- 2-D and 3-D fields on model levels at 20 to 30 minute intervals at 118 point locations.	cfSites	DONE	Q4/10	Q4/10	Q4/10	Q4/10

CMIP5 Experiment Name		UKMO - HadGEM2	ECHAM6 MPIOM	CNRM- CM5	IPSL CM5a	IPSL CM5b	KNMI EC-Earth
CFMIP2 AMIP	3.3	Q4/10	Q1/11	Q1/11	Q4/10	Q1/11	Q1/11
CFMIP2 4xCO2 AMIP	6.5	Q4/10	Q1/11	Q1/11	Q4/10	Q1/11	Q1/11
CFMIP2 AMIP plus 4K pattern	6.6	Q4/10	Q1/11	Q1/11	Q4/10	Q1/11	Q1/11
CFMIP2 AMIP plus uniform 4K	6.8	Q4/10	Q1/11	Q1/11	Q4/10	Q1/11	Q1/11
CFMIP2 Aqua planet control	6.7a	Q4/10	Q1/11	Q1/11	Q4/10	Q1/11	?
CFMIP2 4xCO2 aqua planet	6.7b	Q4/10	Q1/11	Q1/11	Q4/10	Q1/11	?
CFMIP2 Aqua planet plus 4K anomaly	6.7c	Q4/10	Q1/11	Q1/11	Q4/10	Q1/11	?
AOGCM pre-industrial control	3.1	Q4/10	Q1/11	Q4/10	Q4/10	Q1/11	Q3/11
AOGCM historical	3.2	Q4/10	Q1/11	Q4/10	Q4/10	NO	Q1/11
AOGCM 1 percent per year CO2	6.1	Q4/10	Q1/11	Q4/10	Q4/10	Q1/11	Q1/11
Abrupt 4XCO2	6.3	Q4/10	Q1/11	Q4/10	Q4/10	Q1/11	?
Abrupt 4XCO2 11x5 years	6.3-E	Q4/10	Q1/11	NO	Maybe	Maybe	?
Control SST climatology	6.2a	Q1/11	Q1/11	Q1/11	Q4/10	?	Q1/11
Control SST + 4CO2 forcing	6.2b	Q1/11	Q1/11	Q1/11	Q4/10	?	Q1/11
Control SST+ present day total aerosol	6.4a	Q1/11	Q1/11	NO	Q4/10	?	Q1/11
Control SST+ present sulphate aerosol	6.4b	Q1/11	Q1/11	NO	Q4/10	?	Q1/11