CMIP5 Experiments: What are they for?

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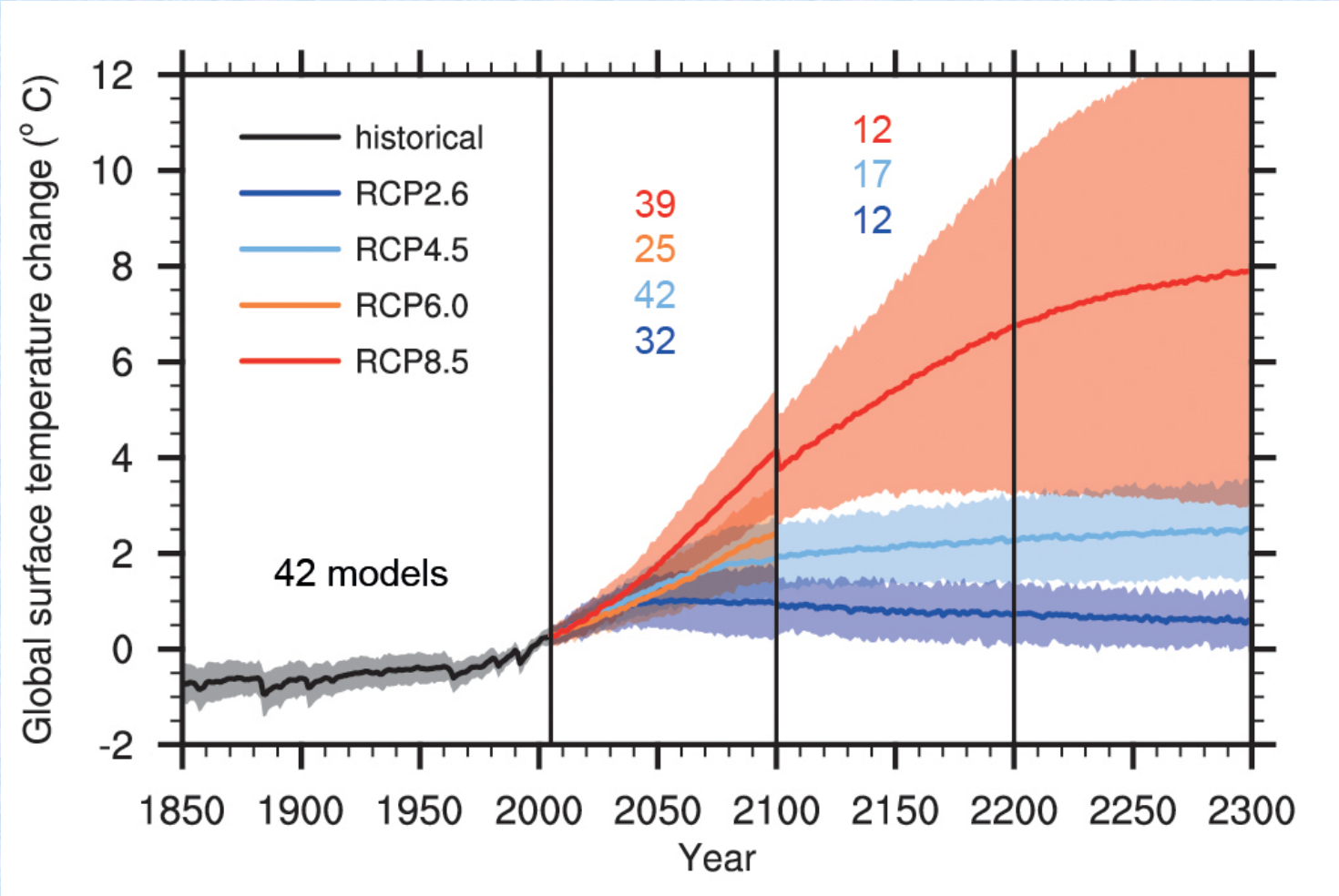
CMIP5 provides model projections, but what else?



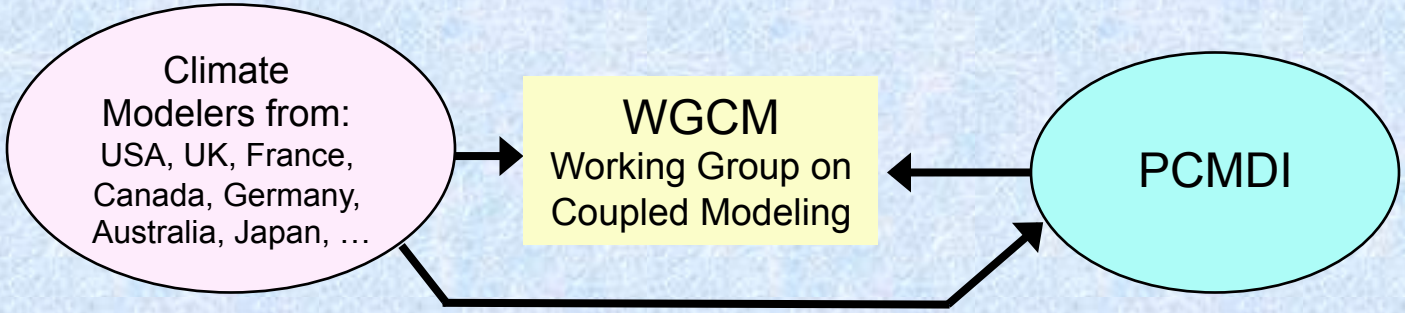
IPCC AR5

PCMDI

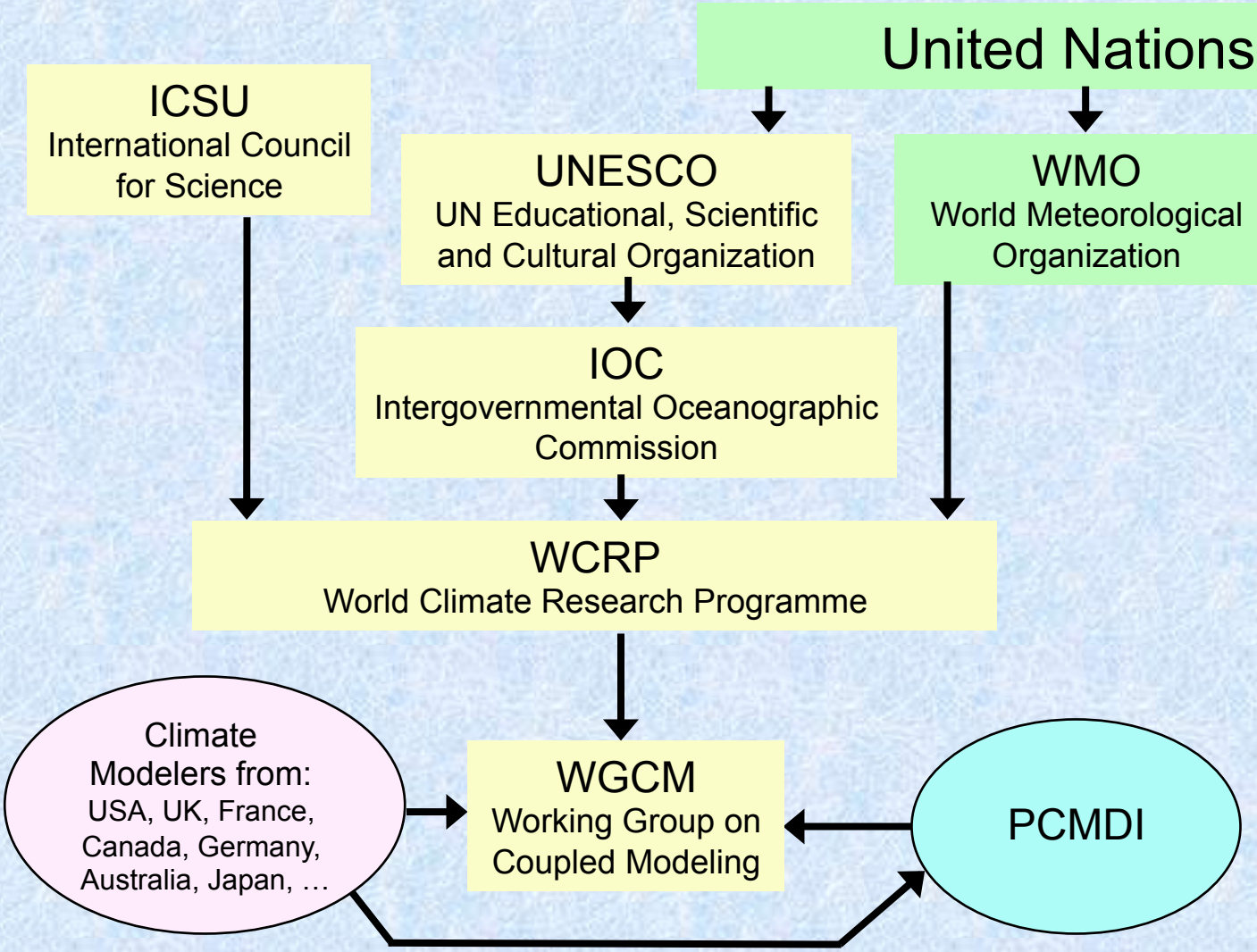
Outline

- CMIP5 organization and overview
- Three groups of experiments
  - "Long-term" experiments
  - Decadal prediction experiments
  - Atmosphere-only experiments
- Helpful resources
- Summary

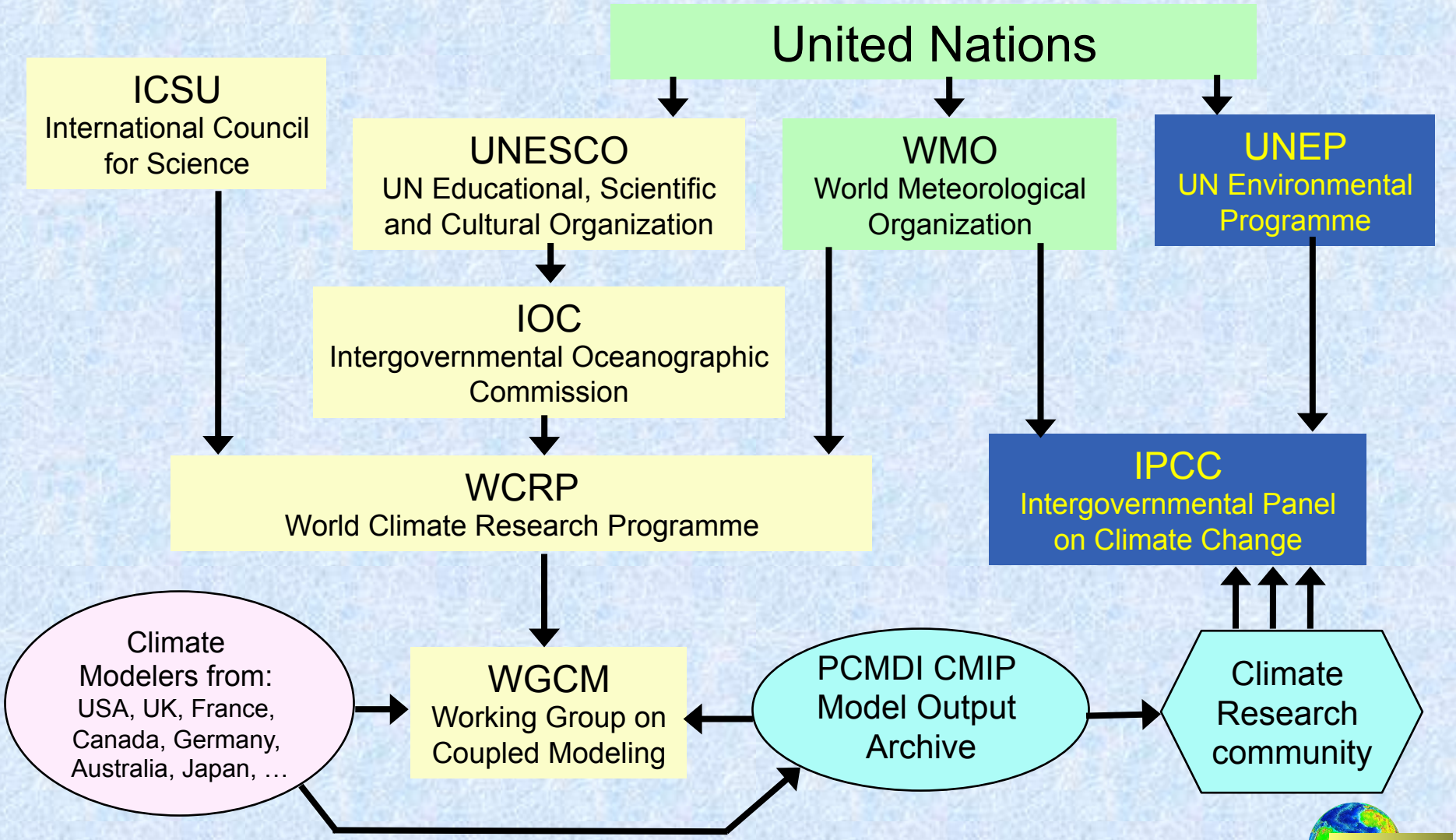
CMIP organization: A grass-roots collaborative effort



CMIP: Under the umbrella of an internationally-coordinated research program



IPCC assessments are separate from the international climate research programs



CMIP5 participating groups (29 groups; 63 models)

Primary Group	Country	Model
CAWCR	Australia	ACCESS
BCC	China	BCC-CSM1.1
GCESS	China	BNU-ESM
CCCMA	Canada	CanESM2, CanCM4, CanAM4
CCSM	USA	CESM1, CCSM4
RSMAS	USA	CCSM4(RSMAS)
CMCC	Italy	CMCC- CESM, CM, & CMS
CNRM/CERFACS	France	CNRM-CM5
CSIRO/QCCCE	Australia	CSIRO-Mk3.6
EC-EARTH	Europe	EC-EARTH
LASG, IAP	China	FGOALS- G2.0, S2.0 & gl
FIO	China	FIO-ESM
NASA/GMAO	USA	GEOS-5
GFDL	USA	GFDL- HIRAM-C360, HIRAM-C180, CM2.1, CM3, ESM2G, ESM2M
NASA/GISS	USA	GISS- E2-H, E2-H-CC, E2-R, E2-R-CC, E2CS-H, E2CS-R
MOHC	UK	Had CM3, CM3Q, GEM2-ES, GEM2-A, GEM2-CC
NMR/KMA	Korea / UK	HadGEM2-AO
INM	Russia	INM-CM4
IPSL	France	IPSL- CM5A-LR, CM5A-MR, CM5B
MIROC	Japan	MIROC 5, 4m, 4h, ESM, ESM-CHEM
MPI-M	Germany	MPI-ESM- HR, LR
MRI	Japan	MRI- AGCM3.2H, AGCM3.2S, CGCM3, ESM1
NCC	Norway	NorESM1-M, NorESM-ME, NorESM1-L

For a complete list see: http://cmip-pcmdi.llnl.gov/cmip5/docs/CMIP5_modeling_groups.docx

CMIP5 overview

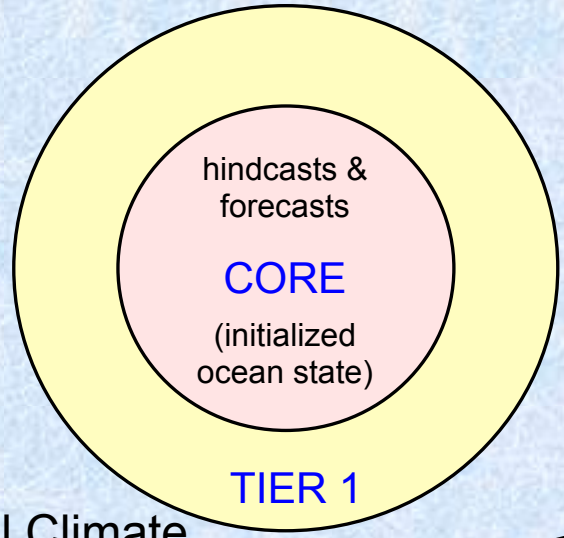
- CMIP5 built on but was much more ambitious than its predecessors
  - Addressed more research questions
  - Included more comprehensive models
  - Produced more output fields
  - Called for more complete documentation of models/experiments
  - Required a new delivery system for data
- It was designed to
  - Meet the needs of the climate research community
  - Provide a basis for papers of interest to the IPCC's AR5

CMIP5 experiments serve many purposes but together can help address a single overarching question:

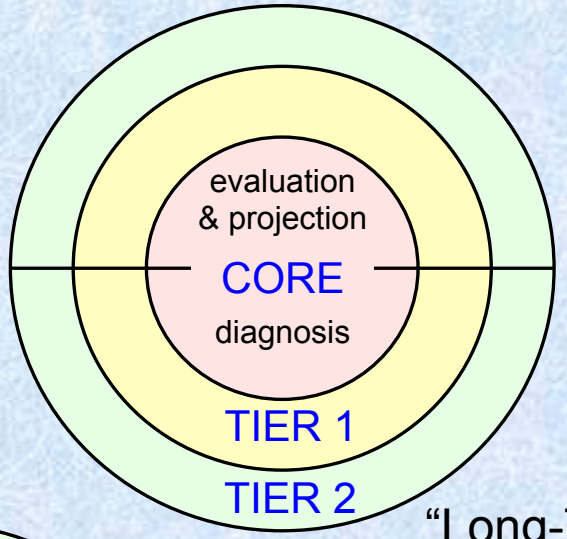
How reliable/uncertain are climate projections on decadal and longer time-scales?

- Observational record not long enough to quantify skill based on hindcasts (except for the shorter time-scales)
- We attempt to build confidence that models accurately represent the physics (and dynamics) of the climate system
  - Ability to simulate important climate phenomena
  - Ability to represent individual processes
  - Ability to forecast weather and climate (on decadal and shorter time-scales)
  - Ability to simulate paleoclimates
- But we don't know the relationship between skill in simulating things we can observe and projection skill.

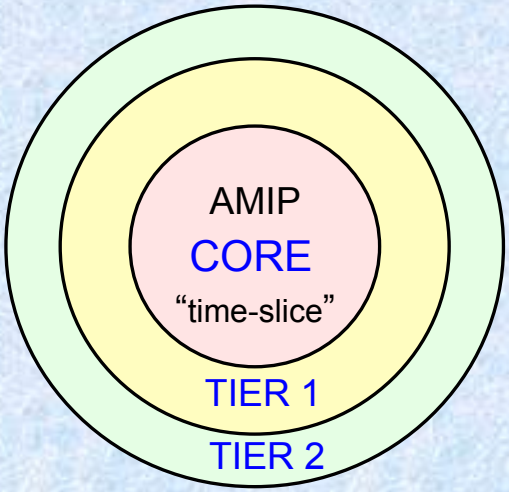
CMIP5 is organized around three types of simulations



Decadal Climate Prediction



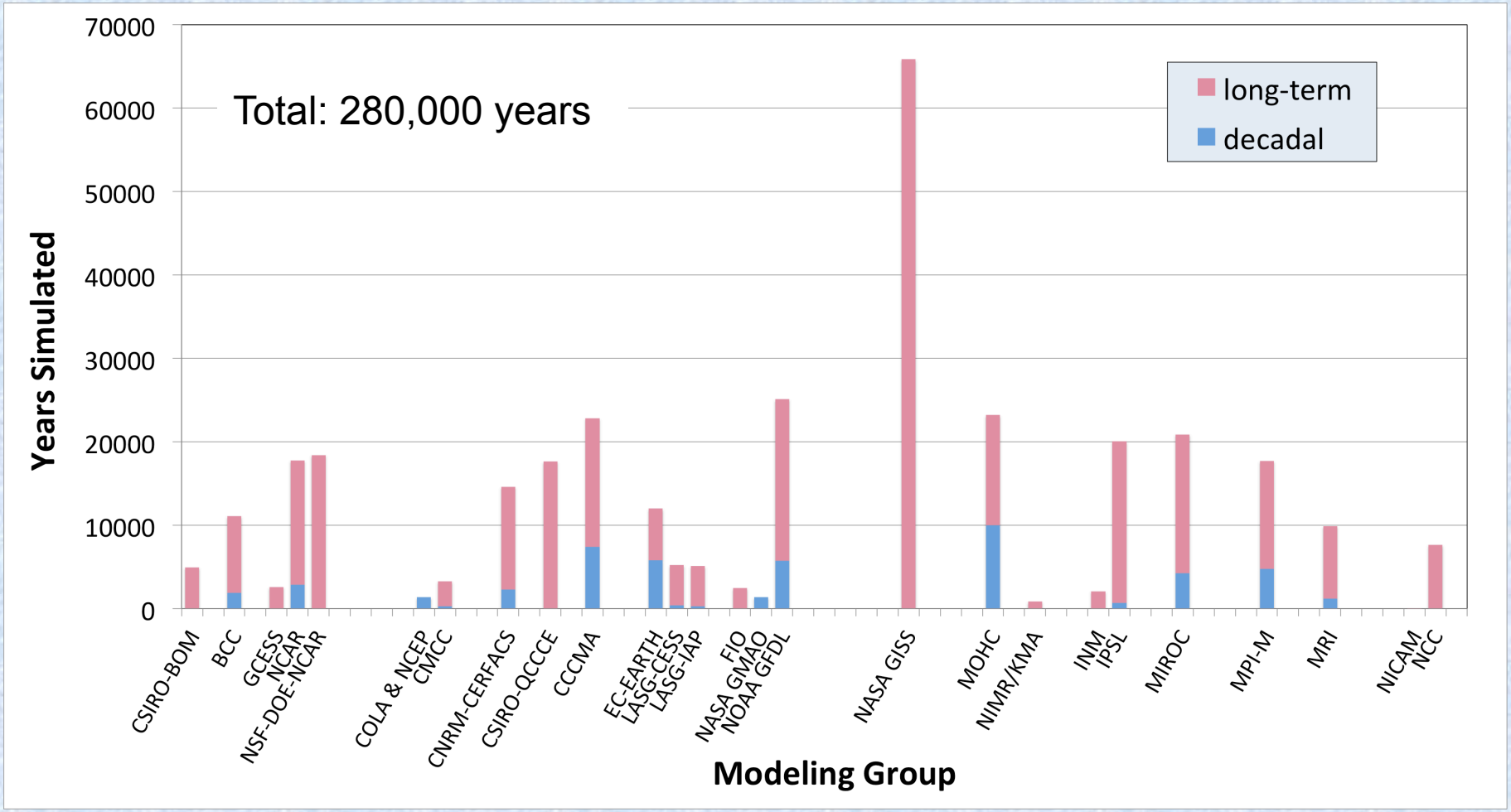
"Long-Term" Projections (century & longer)



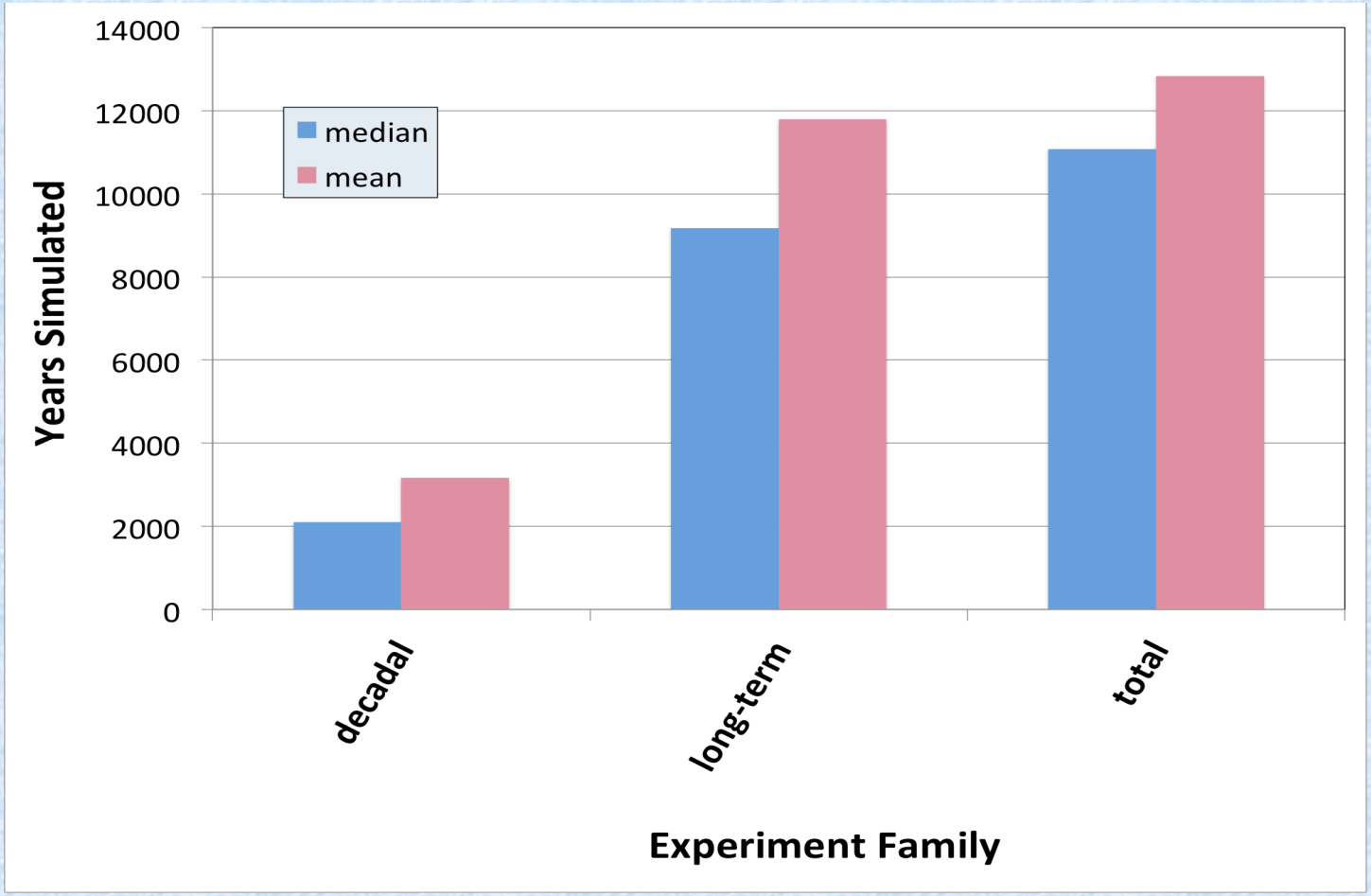
Atmosphere-Only Simulations

(for computationally demanding and NWP models)

CMIP5: Number of years simulated per modeling group



CMIP5: Mean and median number of years simulated per modeling group participating in expt. family.



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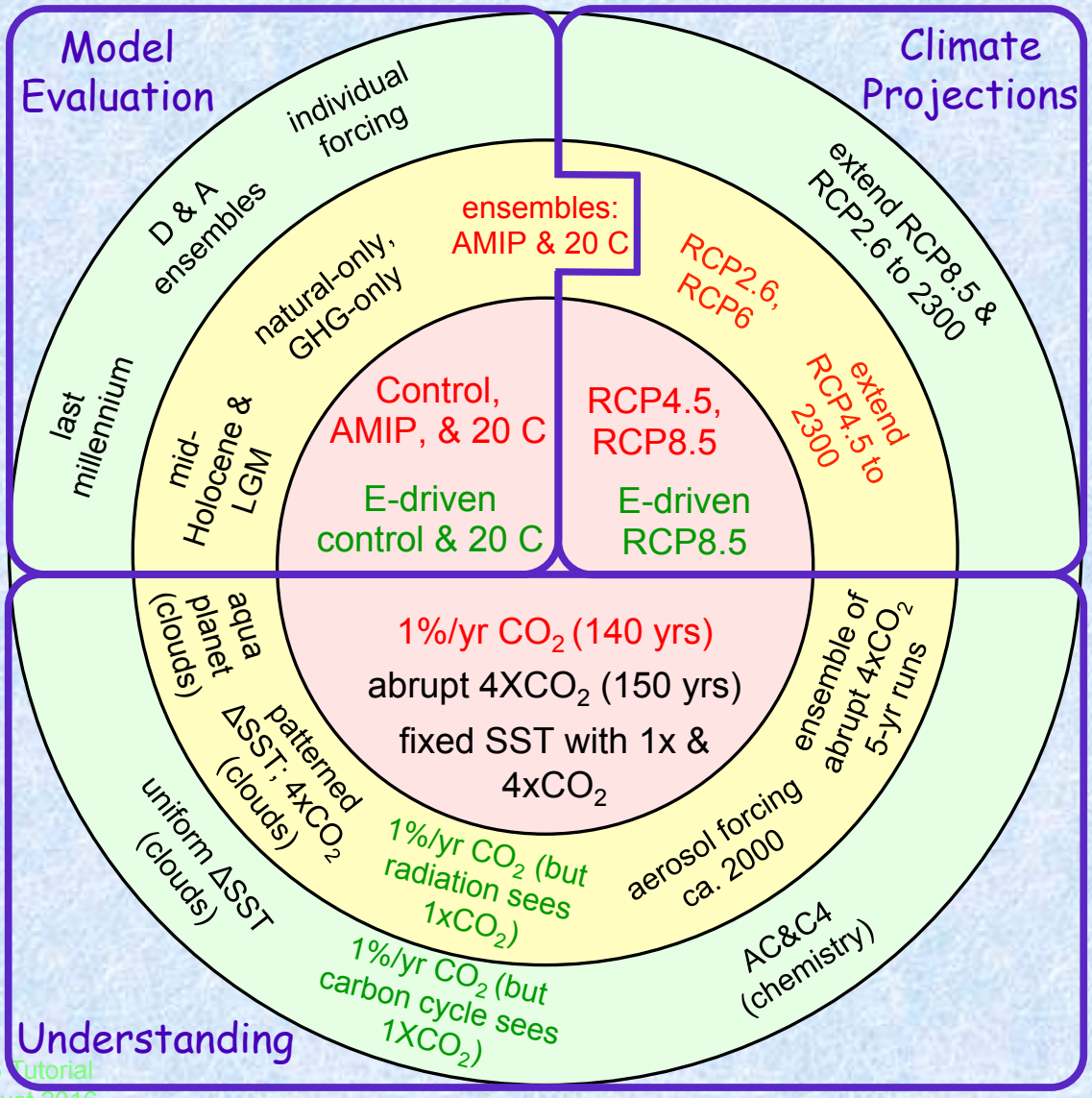
A rich set of CMIP5 experiments, drawn from several predecessor MIPs, focuses on model evaluation, projections, and understanding

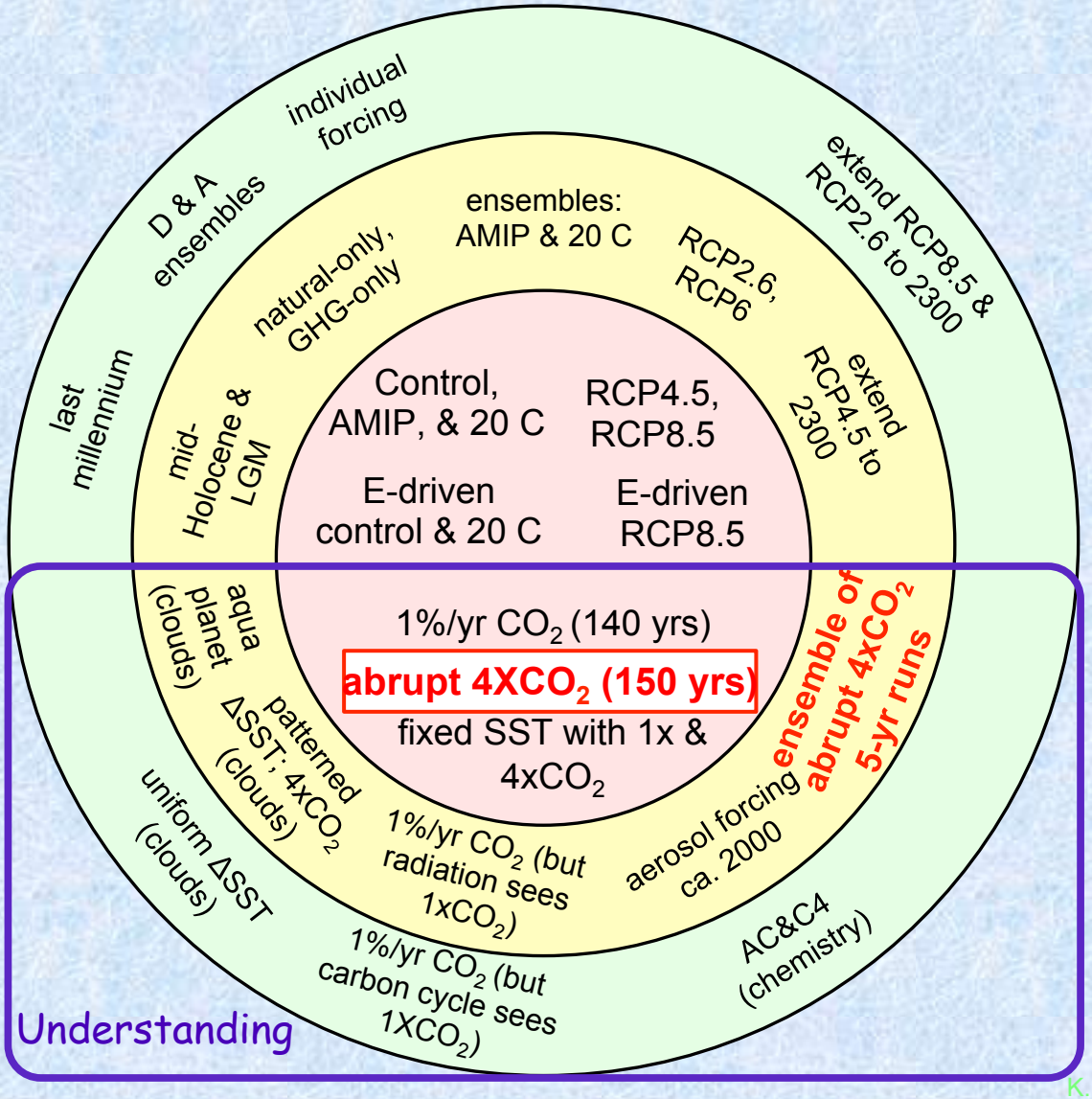


Red subset matches the entire CMIP3 experimental suite

Green subset is for coupled carbon-cycle climate models only

Adapted from Taylor *et al.*, BAMS, 2011

Abrupt 4xCO2 simulation yields estimates of model differences in climate "sensitivity" and "forcing"



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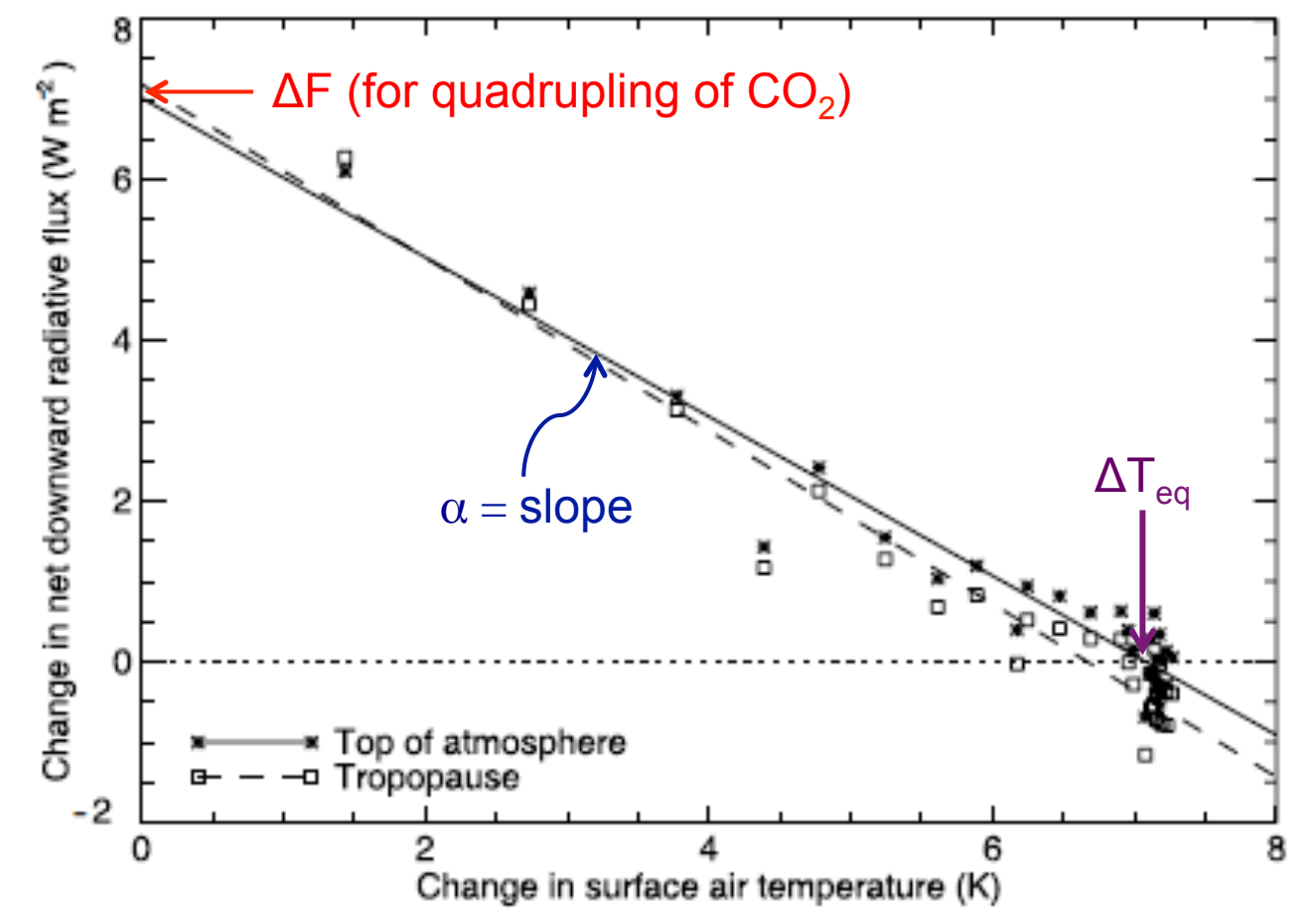
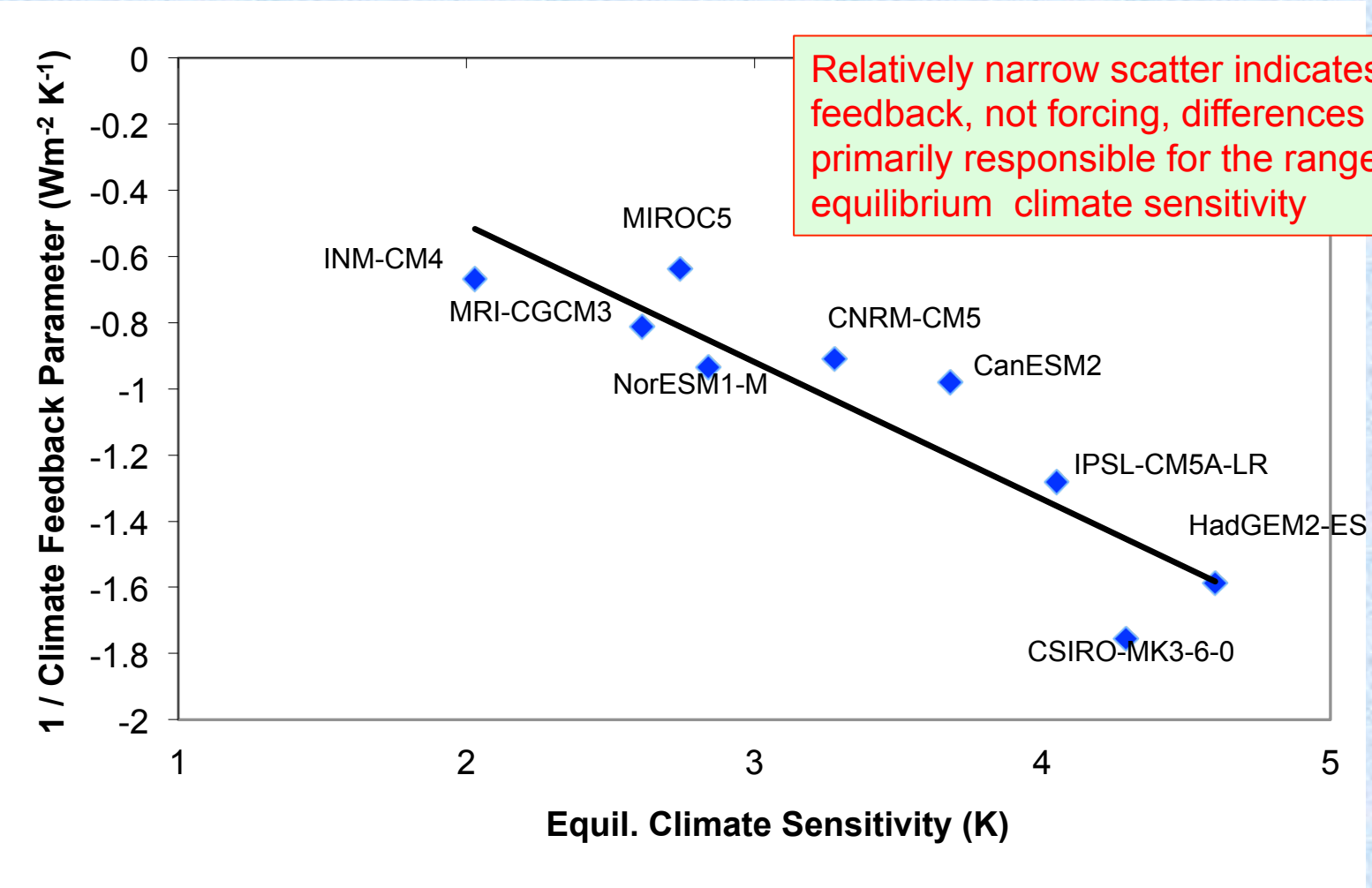
CMIP5 idealized experiments designed to quantify differences in model forcing and global climate sensitivity



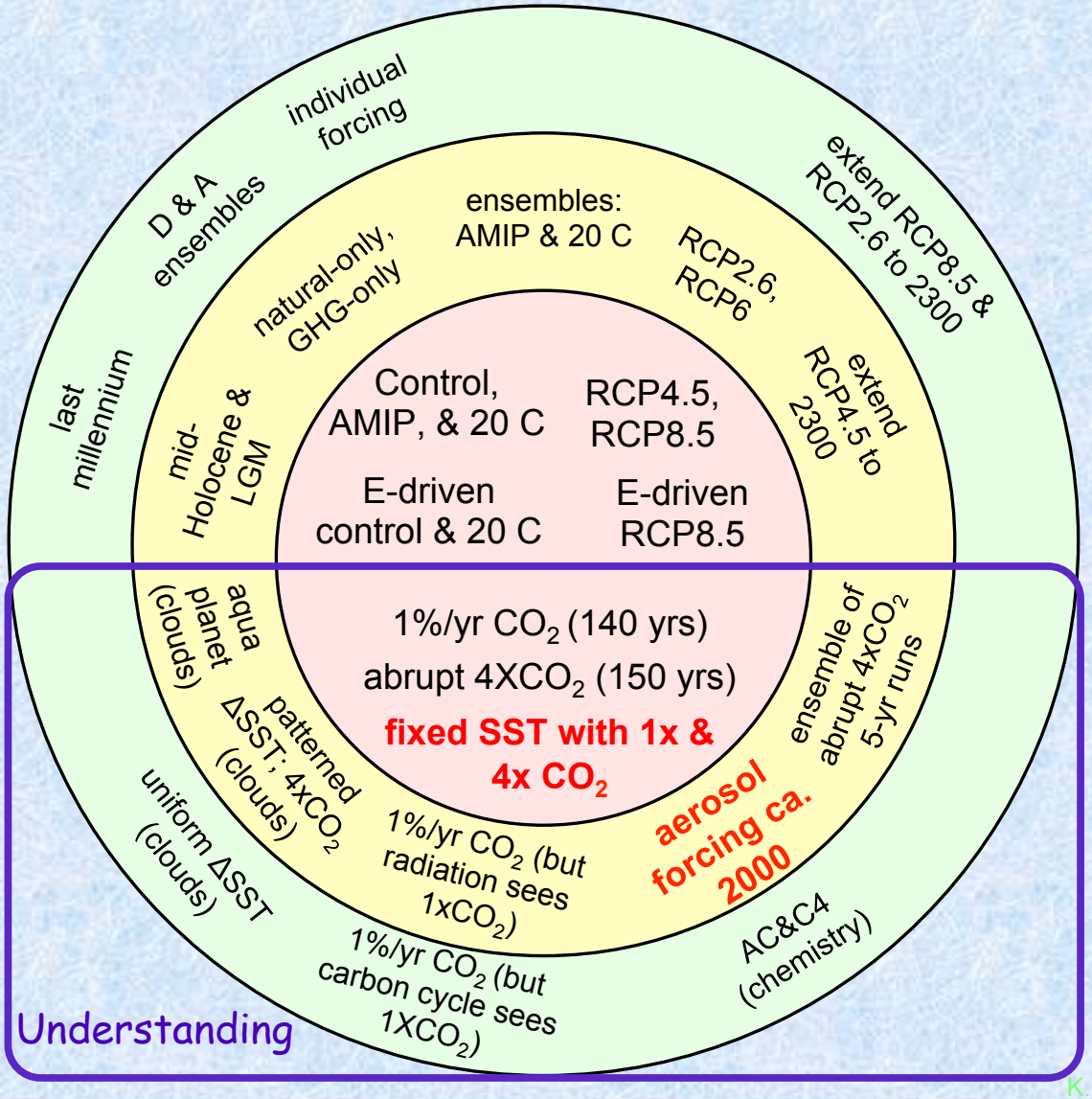
Gregory *et al.*, 2004

Idealized CMIP5 simulations show that the range of climate sensitivities is mainly attributable to differences in feedbacks, not forcing.



Andrews et al., GRL, 2012

CO2 forcing and aerosol forcing can be quantified using an alternative method.



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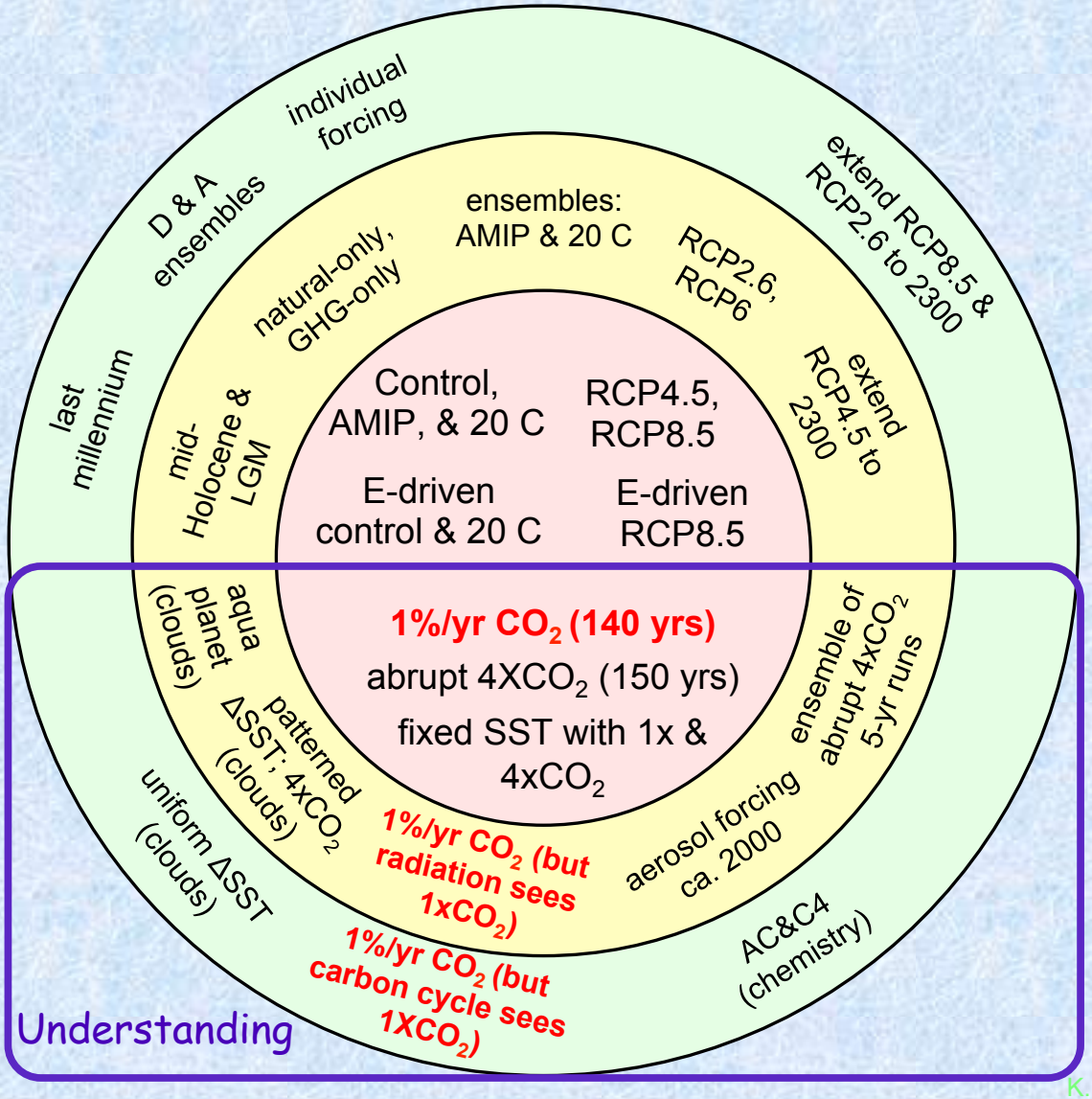
Carbon cycle feedbacks can be diagnosed



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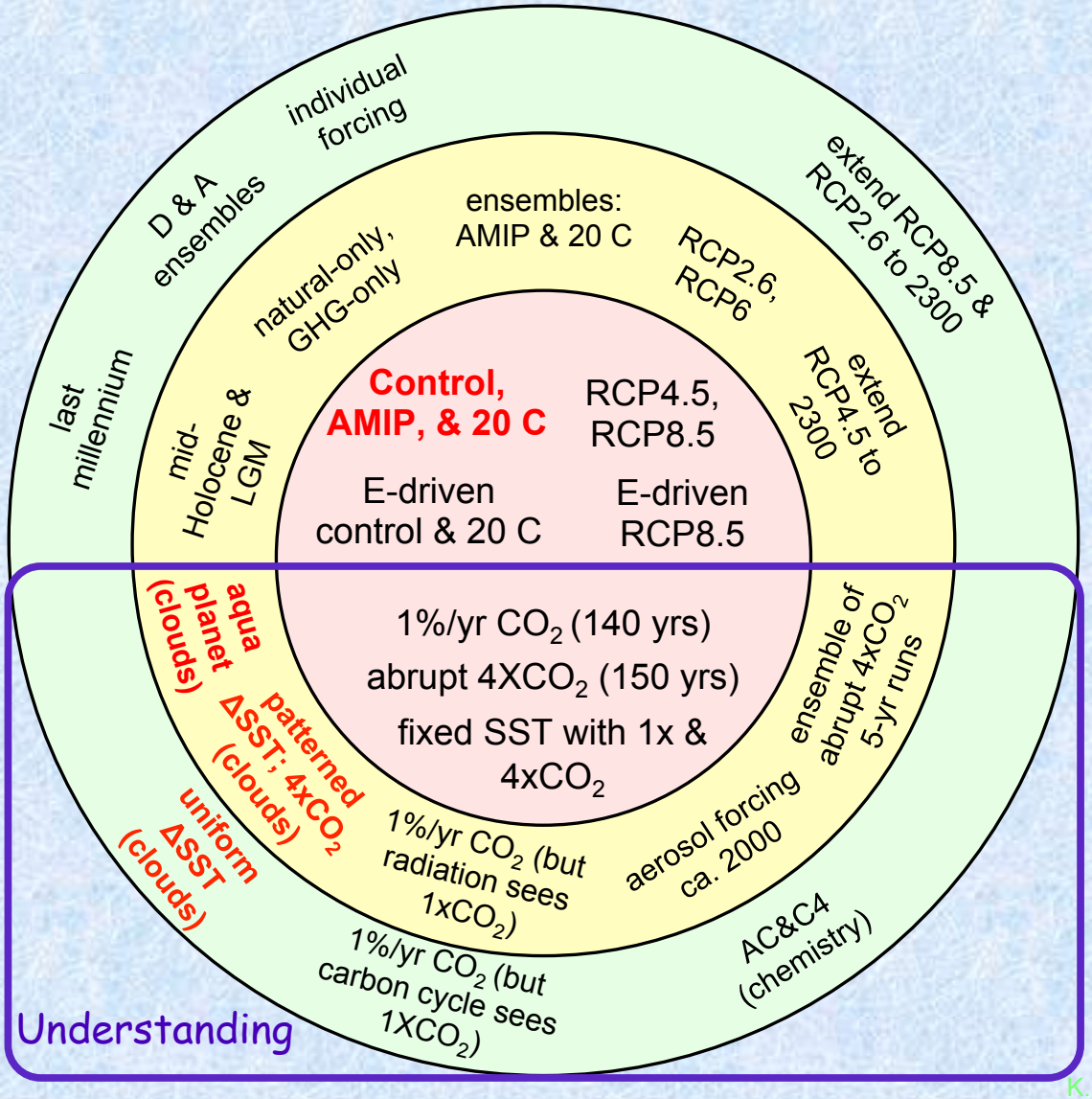
Representation of clouds can be studied under realistic and idealized conditions with help of "satellite simulator" output (CFMIP)



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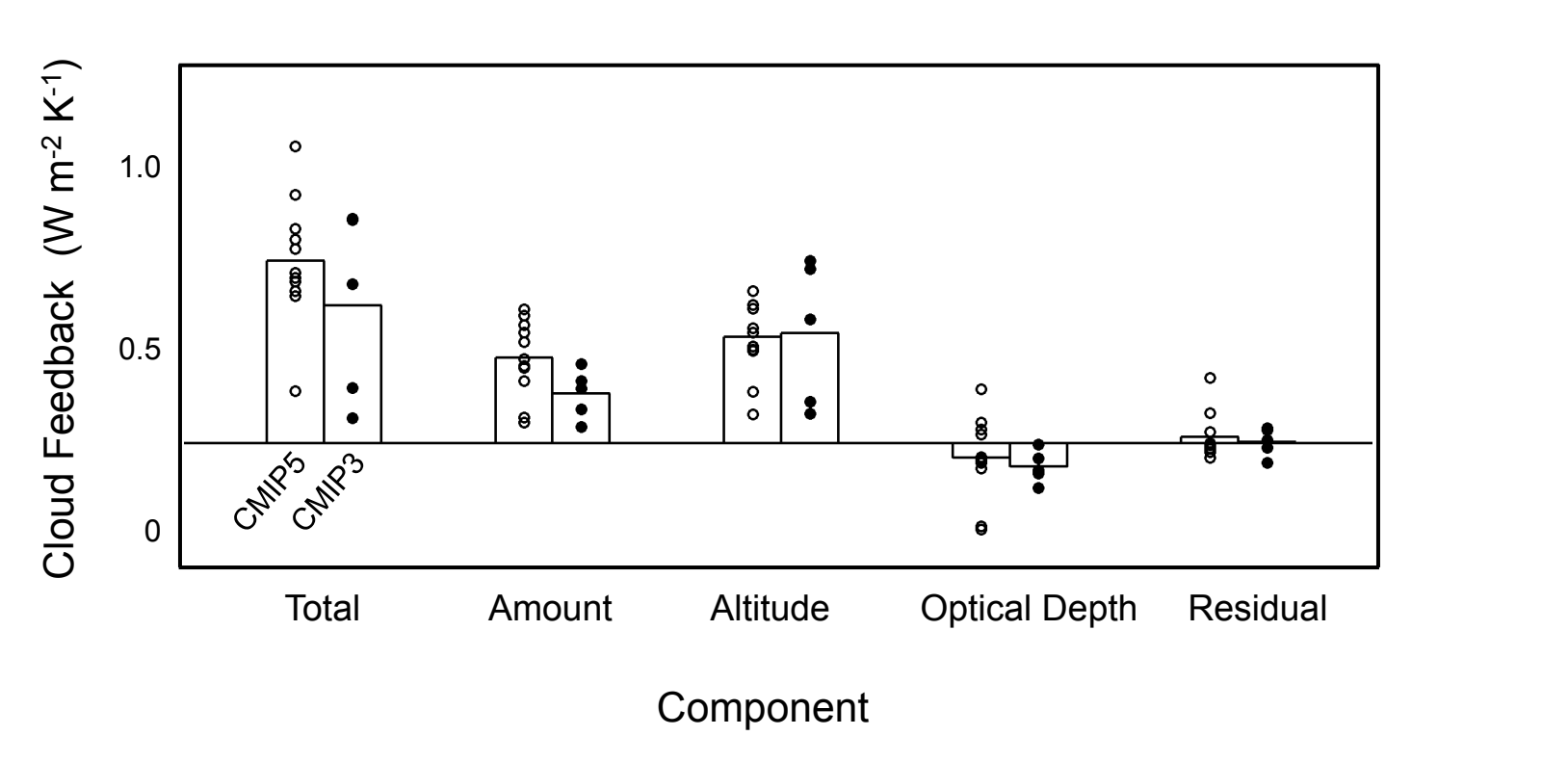
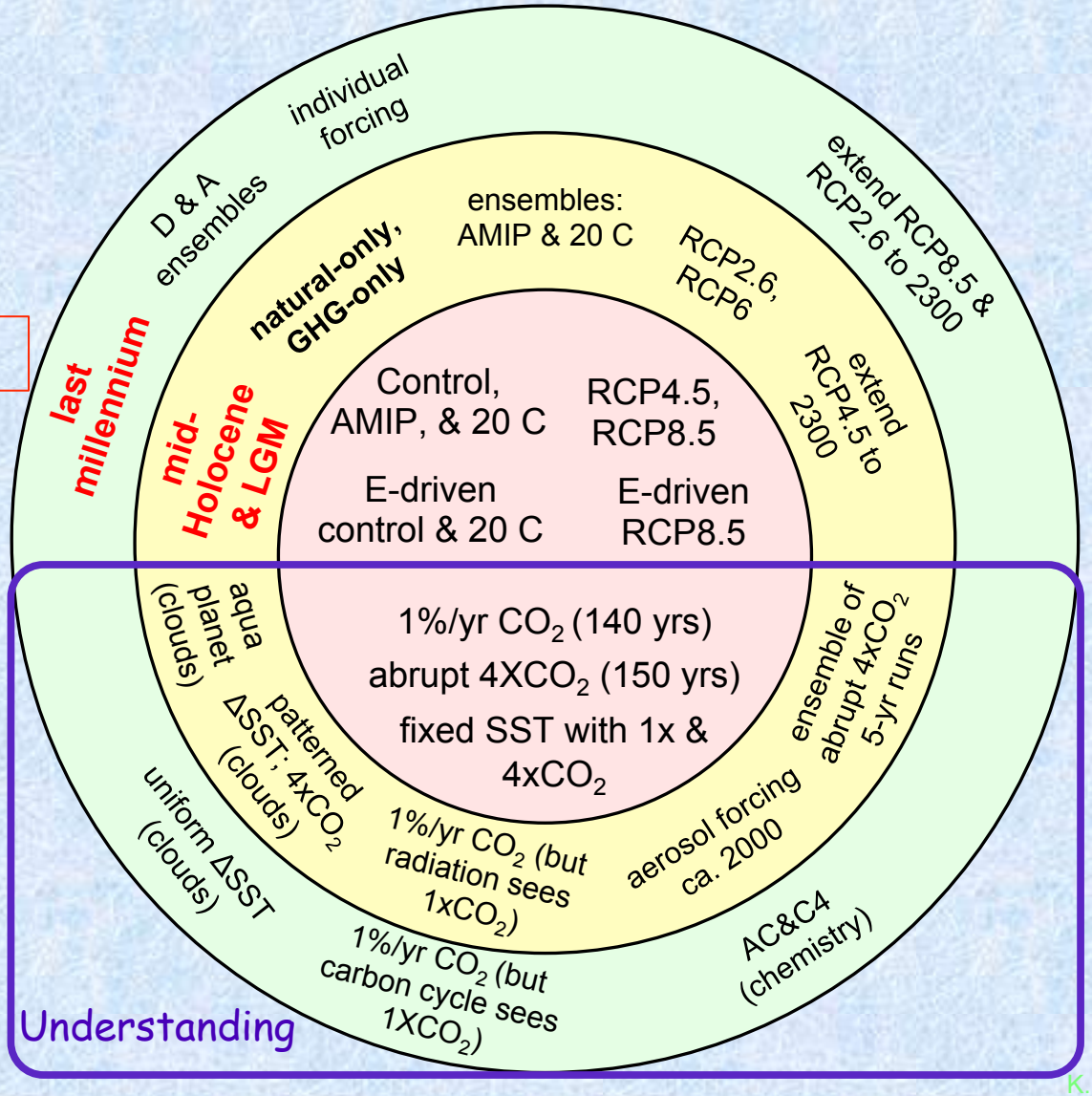
Idealized experiments and cloud simulator package (COSP) enable more detailed feedback analysis



Zelinka et al., *J. Climate*, 2012

Ability to simulate climates of the past that are substantially different from today can be assessed

PMIP runs



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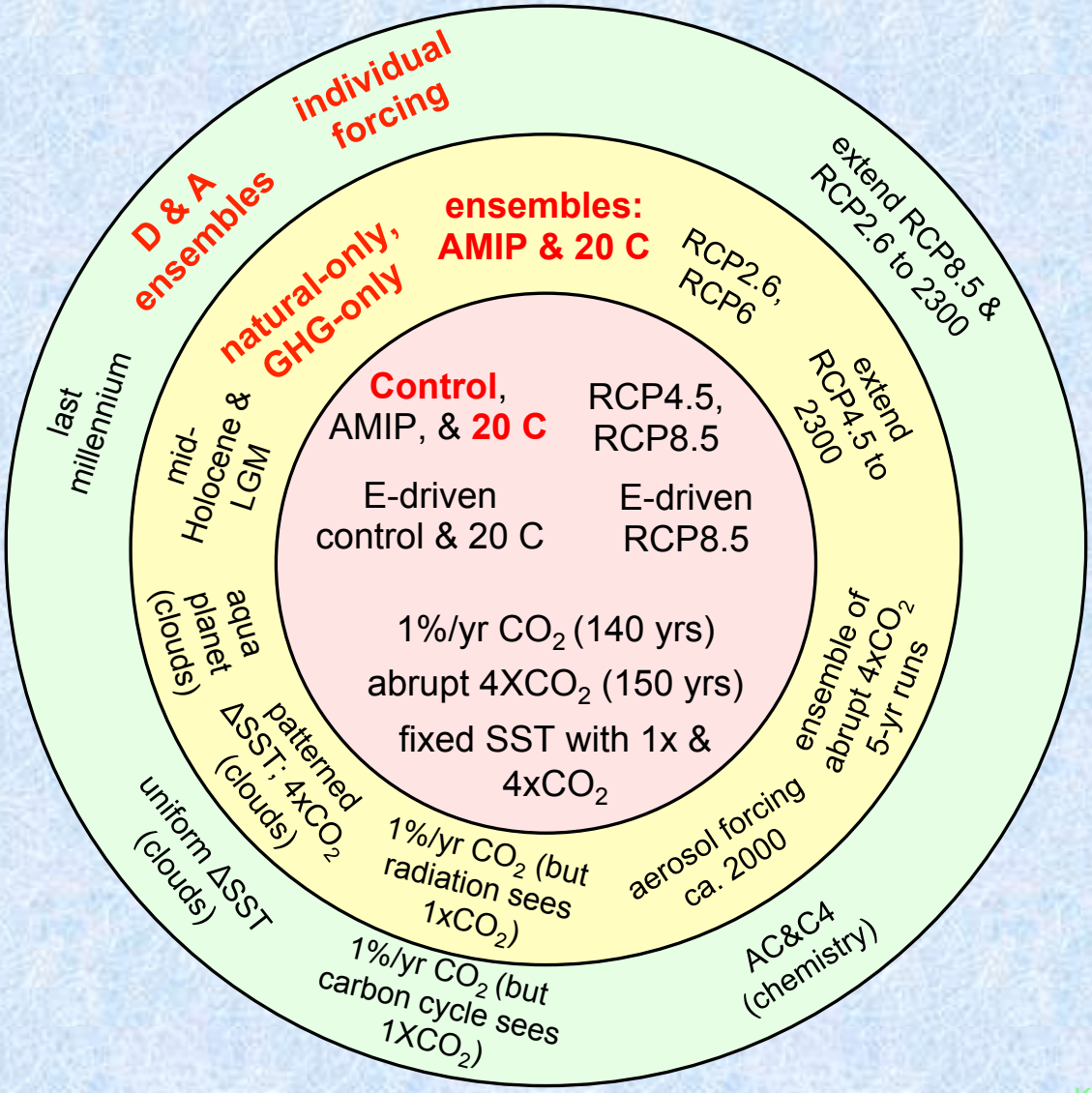
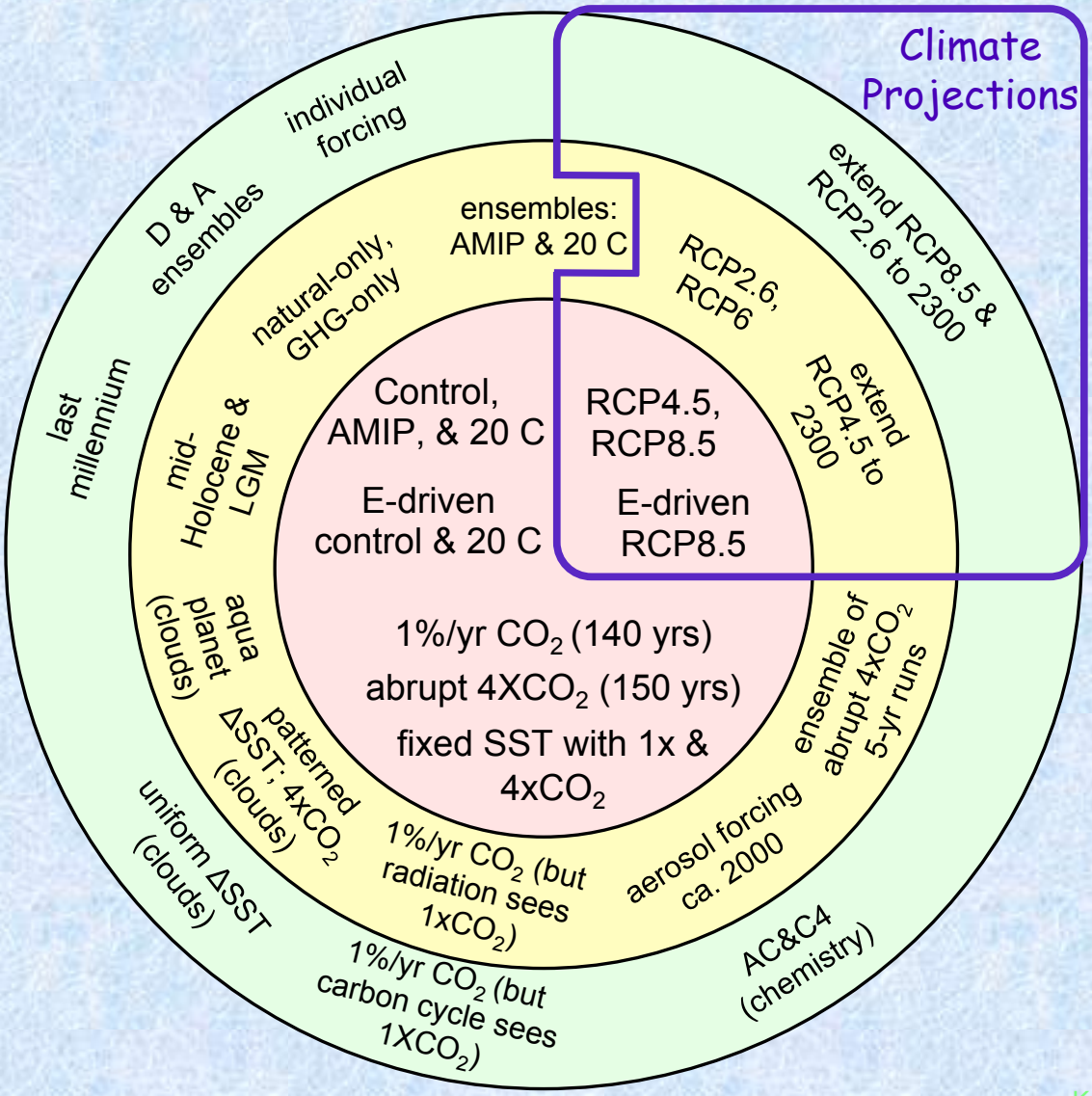
Ability to simulate trends can be evaluated with "detection and attribution" focused simulations



Climate projections



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"Long-term" experiments: model participation

** Core simulations*

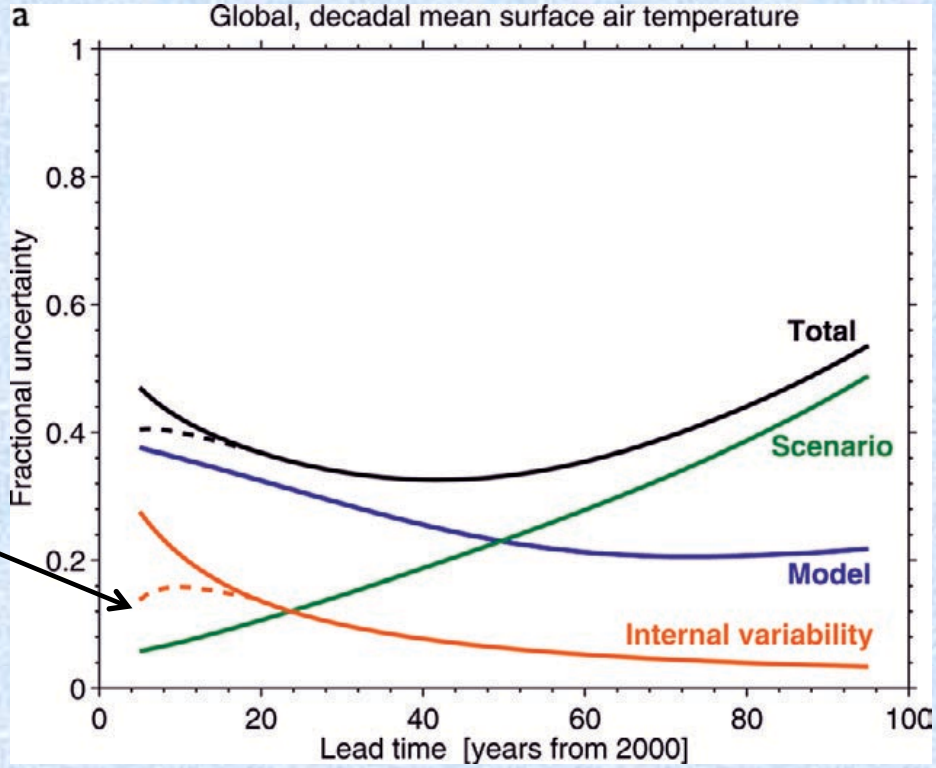
Experiment(s)	# of models
* Control & historical	~50
* AMIP	31
* RCP4.5 & 8.5	~45
RCP2.6	30
RCP6	22
RCP's to year 2300	~10
* 1% CO2 increase	34
* Fixed SST CO2 forcing diagnosis	16
* Abrupt 4XCO2 diagnostic	31

Experiment(s)	# of models
Fast adjustment diagnostic	7
Aerosol forcing	11
*ESM control, historical & RCP8.5	19
Carbon cycle feedback isolation	14
Mid-Holocene & LGM	14
Millenium	9
CFMIP runs	15
D & A runs	20

CMIP5 also includes models initialized with the observed climate state (particularly, the upper ocean)

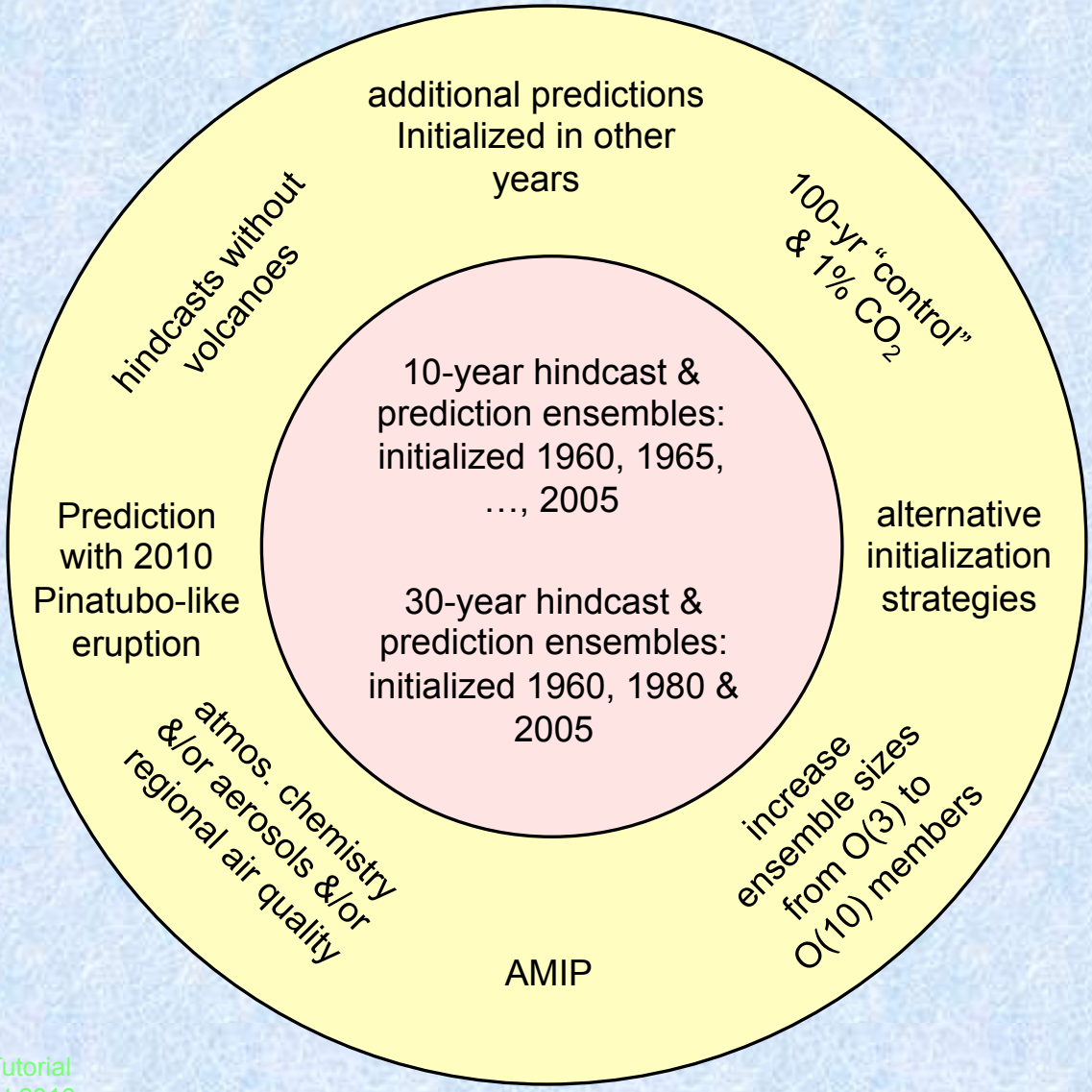
- Through initialization models should be able to predict the actual trajectory of "unforced" climate variations.

The deviation from observations caused by unforced variability can to some extent be reduced through initialization.



Hawkins & Sutton, 2009

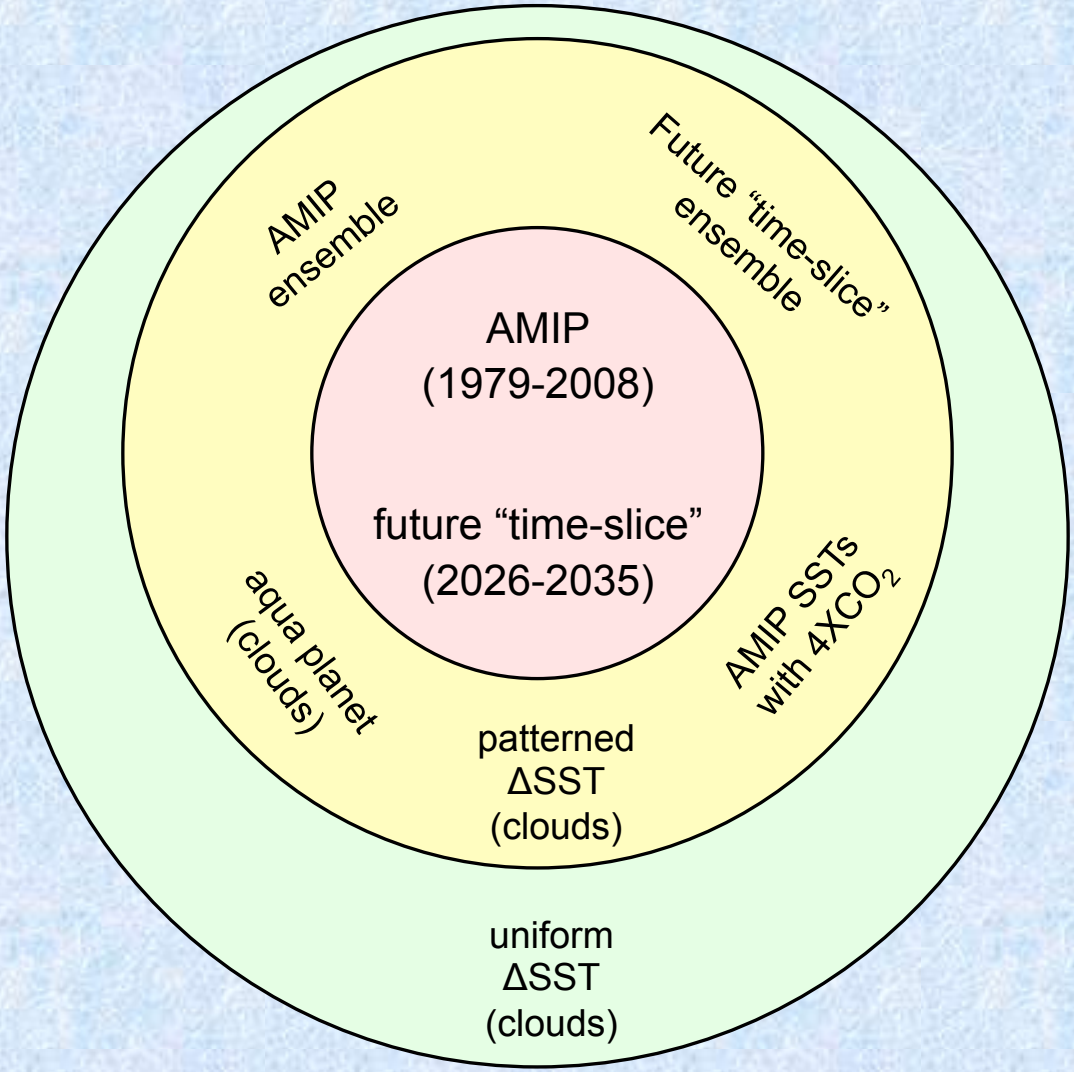
The new "near-term" experiments attempt "predictions" of the climate state, including some "unforced" variations



18 models performed decadal runs

Adapted from Taylor *et al.*, BAMS, 2011

CMIP5 Atmosphere-Only Experiments (targeted for computationally demanding and NWP models)



12 models performed future "time-slice" run

Helpful resources:

- CMIP5 website http://cmip-pcmdi.llnl.gov/cmip5/
- Information of most use by analysts
  http://cmip-pcmdi.llnl.gov/cmip5/guide_to_cmip5.html
  - Experiment design
  - Experiment names
  - Forcing
  - Model output specifications
  - Acknowledgement guidance
  - Models and modeling group names
- CMIP5-based publications http://cmip-pcmdi.llnl.gov/cmip5/publications.html
- CMIP5 errata http://cmip-pcmdi.llnl.gov/cmip5/errata/cmip5errata.html
- esDocs (model documentation http://compare.es-doc.org/)
- ESGF CoG interface to CMIP5 data https://pcmdi.llnl.gov/projects/cmip5/

Concluding remarks

- CMIP5 provides results from an unprecedented variety of climate models and experiments
- It has resulted in over 1000 peer-reviewed publications
- Yet only a tiny fraction of the information content has yet been examined.
- Your challenge: Find the nuggets!