# CMIP5 Datenmanagement – erste Erfahrungen

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**HELMHOLTZ** | **GEMEINSCHAFT**
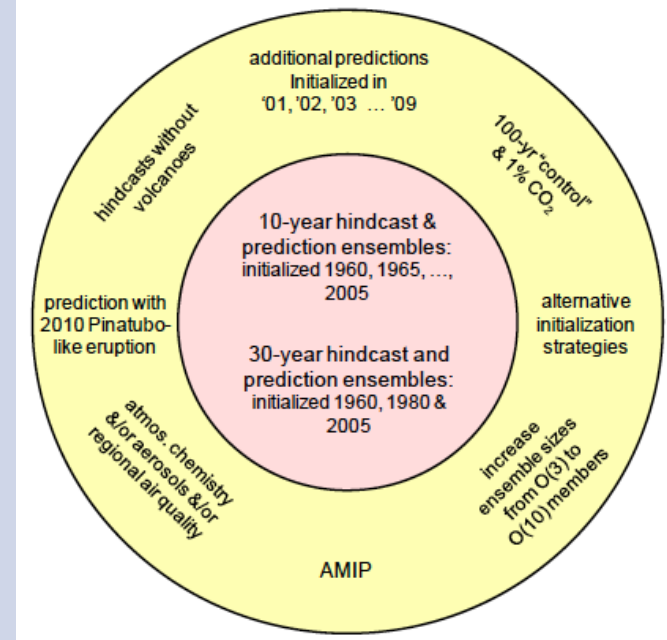
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# CMIP5 Protocol + Timeline

Taylor et al (2009), "A Summary of the CMIP5 Experiment Design"
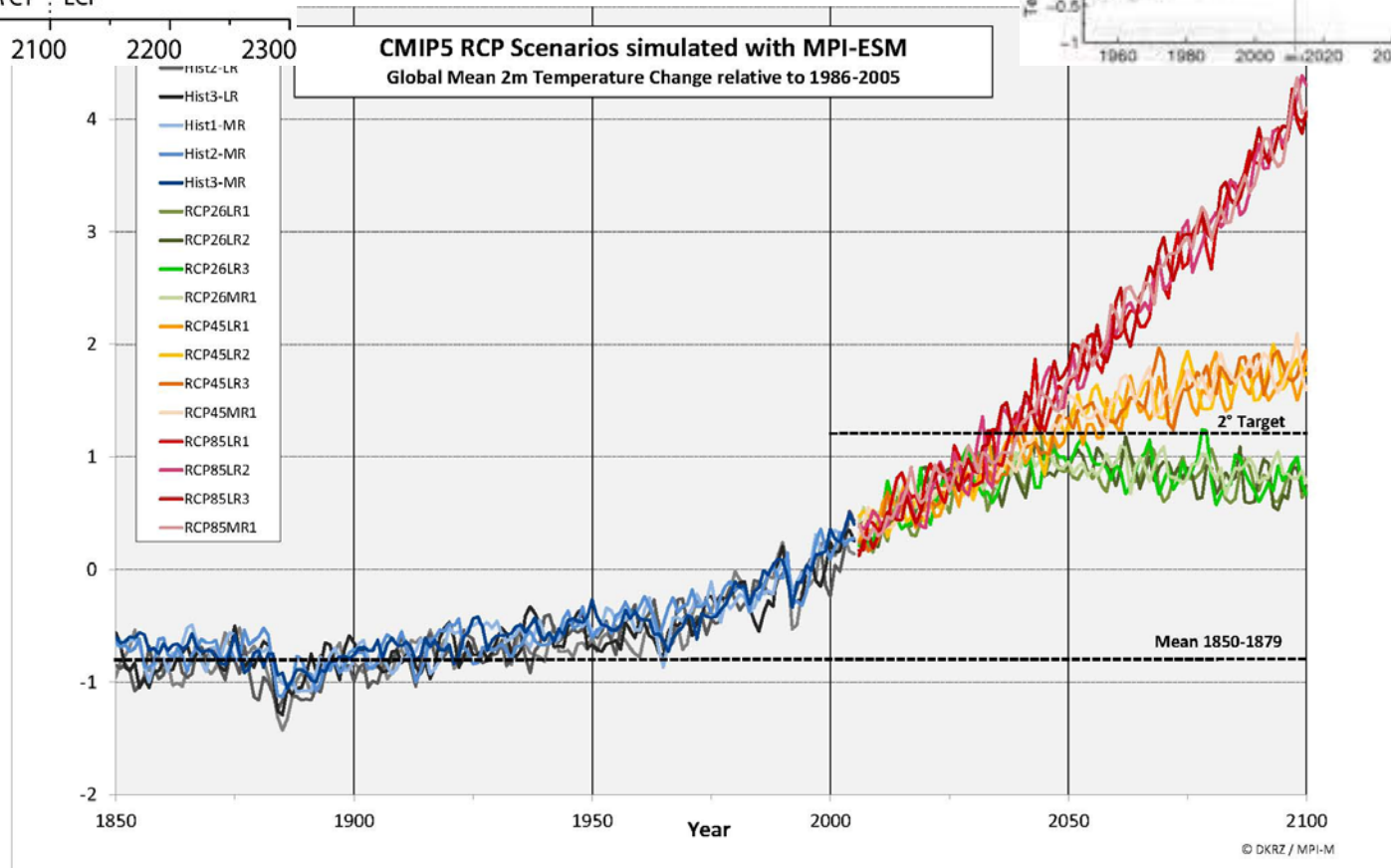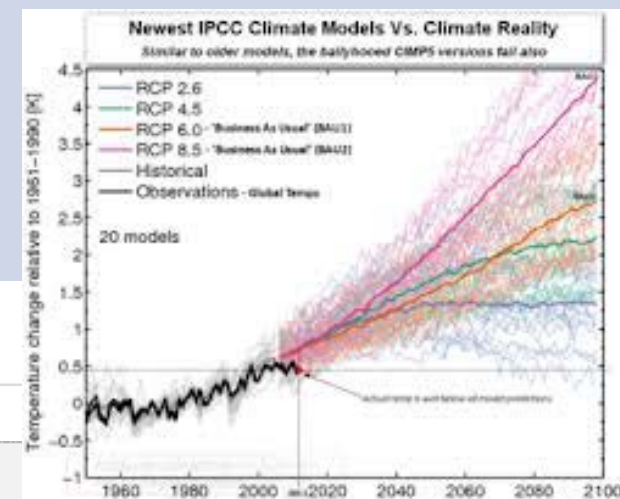
Centennial Experiments
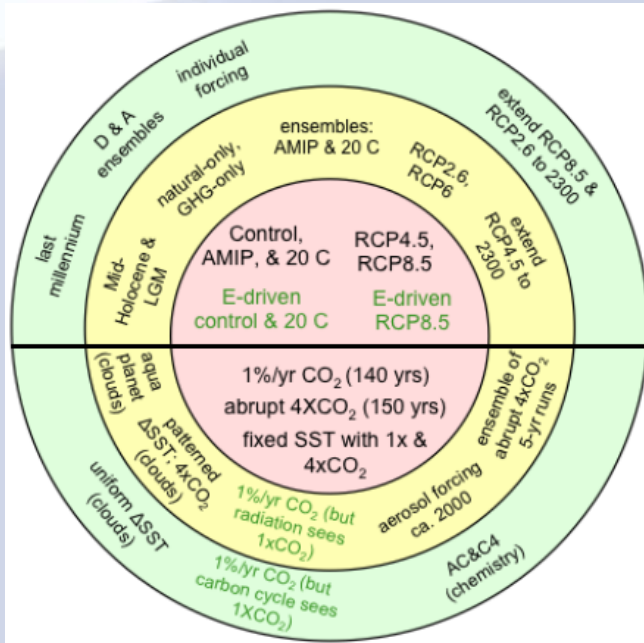


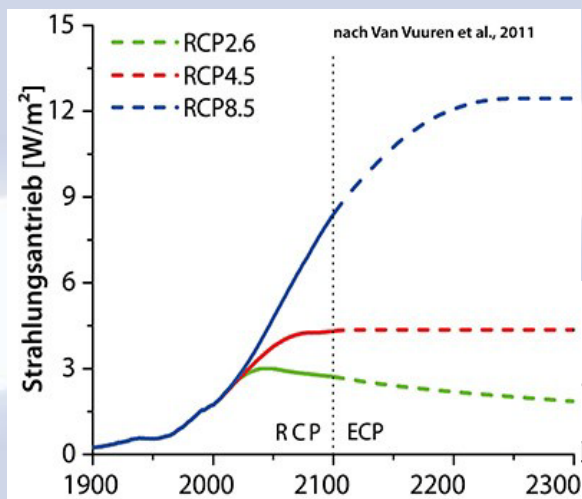Decadal Experiments

## Timeline:

- 2007 – 2009: CMIP5 definition with Taylor et al (2009) as result

- 2010 – 2011: Climate model calculations and archive design

- 2011 – 2013: CMIP5 archive build up (presentation at CAS2K11)

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# CMIP5 Results



CMIP5 RCP Scenarios simulated with MPI-ESM
Global Mean 2m Temperature Change relative to 1986-2005

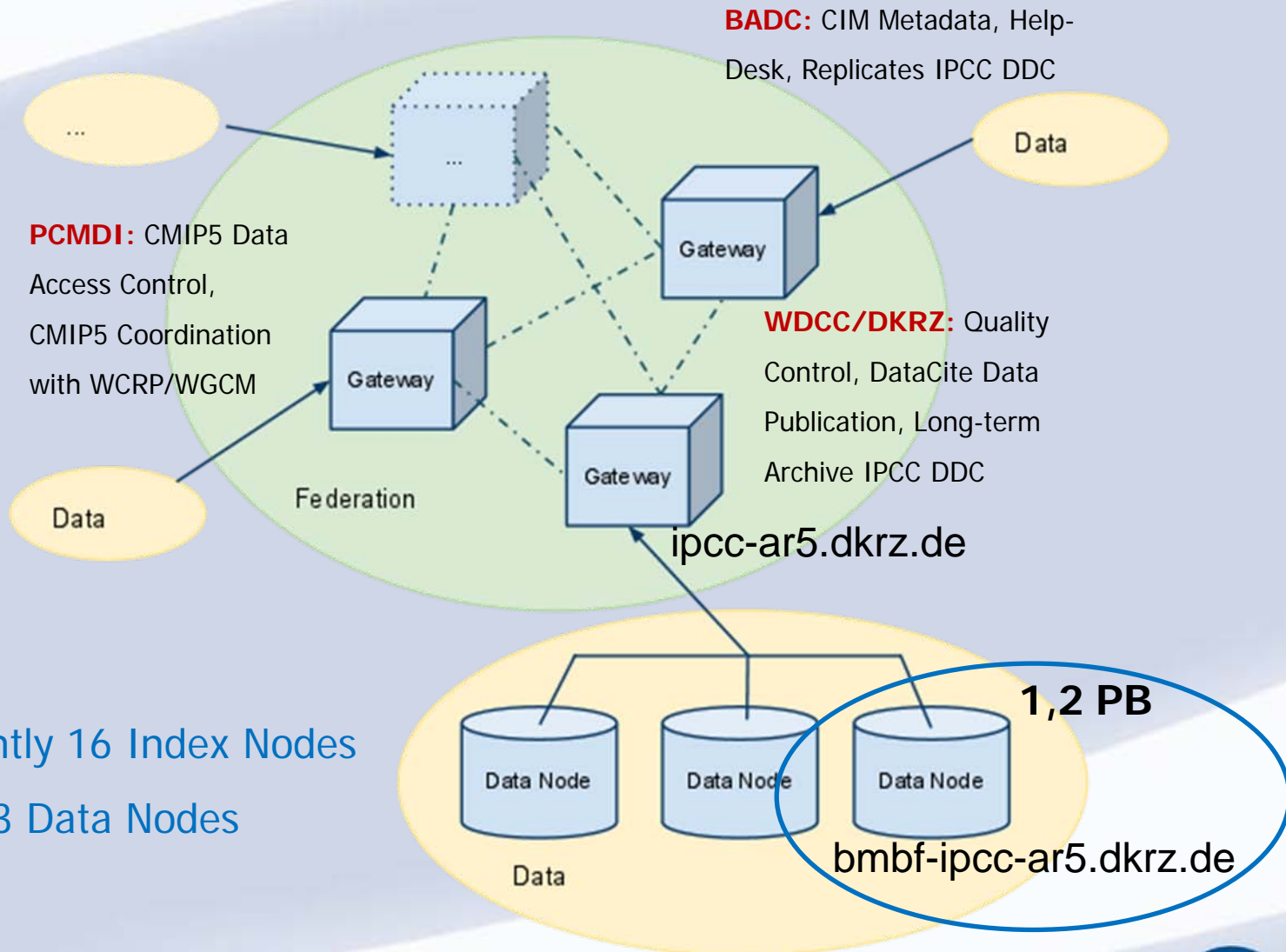CMIP5 Release WS MPI-M/DKRZ (Feb. 2012)

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# Data Amounts CMIP3/CMIP5

- CMIP3 / IPCC-AR4 (Report 2007)
  - Participation: 17 modelling centres with 25 models
  - In total 36 TB model data central at PCMDI and ca. ½ TB in IPCC DDC at WDCC/DKRZ as reference data

- CMIP5 / IPCC-AR5 (Report 2013/2014)
  - Participation: 29 modelling groups with 61 models
  - Produced data volume: ca. 10 PB with 640 TB from MPI-ESM
  - CMIP5 requested data volume: ca. 2 PB (in CMIP5 data federation)
  - Data volume for IPCC DDC: ca. 1 PB (complete quality assurance process) with 60 TB from MPI-ESM

- Status CMIP5 data archive (June 2013):
  - 1.8 PB for 59000 data sets stored in 4.3 Mio Files in 23 data nodes
  - CMIP5 data is about 50 times CMIP3

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# Usage Requirements for CMIP5

- Results from CMIP5 (Coupled Model Intercomparison Project No. 5) are for
  - Model intercomparisons with respect to climate model improvement and consolidation of the climate system knowledge
  - Usage as common data basis for scientific publications as basis for the IPCC Assessment Report No. 5 (IPCC-AR5)
- New in IPCC-AR5: all three working groups should use the same model data base
- Resulting interdisciplinary applications (*IAV – Impact, Adaptation/Mitigation, Vulnerability*) imposes high requirements to data quality and documentation
- This has implications for treatment and provision of climate data in the IPCC DDC (IPCC Data Distribution Centre) compared to AR4
- This means accomplishment of quality control and data documentation in connection or just after the climate model runs in order to remove data errors and inconsistencies prior to the (interdisciplinary) usage.

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# CMIP5 Data Federation (P2P)

**BADC:** CIM Metadata, Help-Desk, Replicates IPCC DDC

**PCMDI:** CMIP5 Data Access Control, CMIP5 Coordination with WCRP/WGCM

**WDCC/DKRZ:** Quality Control, DataCite Data Publication, Long-term Archive IPCC DDC

ipcc-ar5.dkrz.de

**1,2 PB**

bmbf-ipcc-ar5.dkrz.de

Currently 16 Index Nodes and 23 Data Nodes

Webinar-18 (Lautenschlager, DKRZ)

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# European Contribution to ESGF-CMIP5
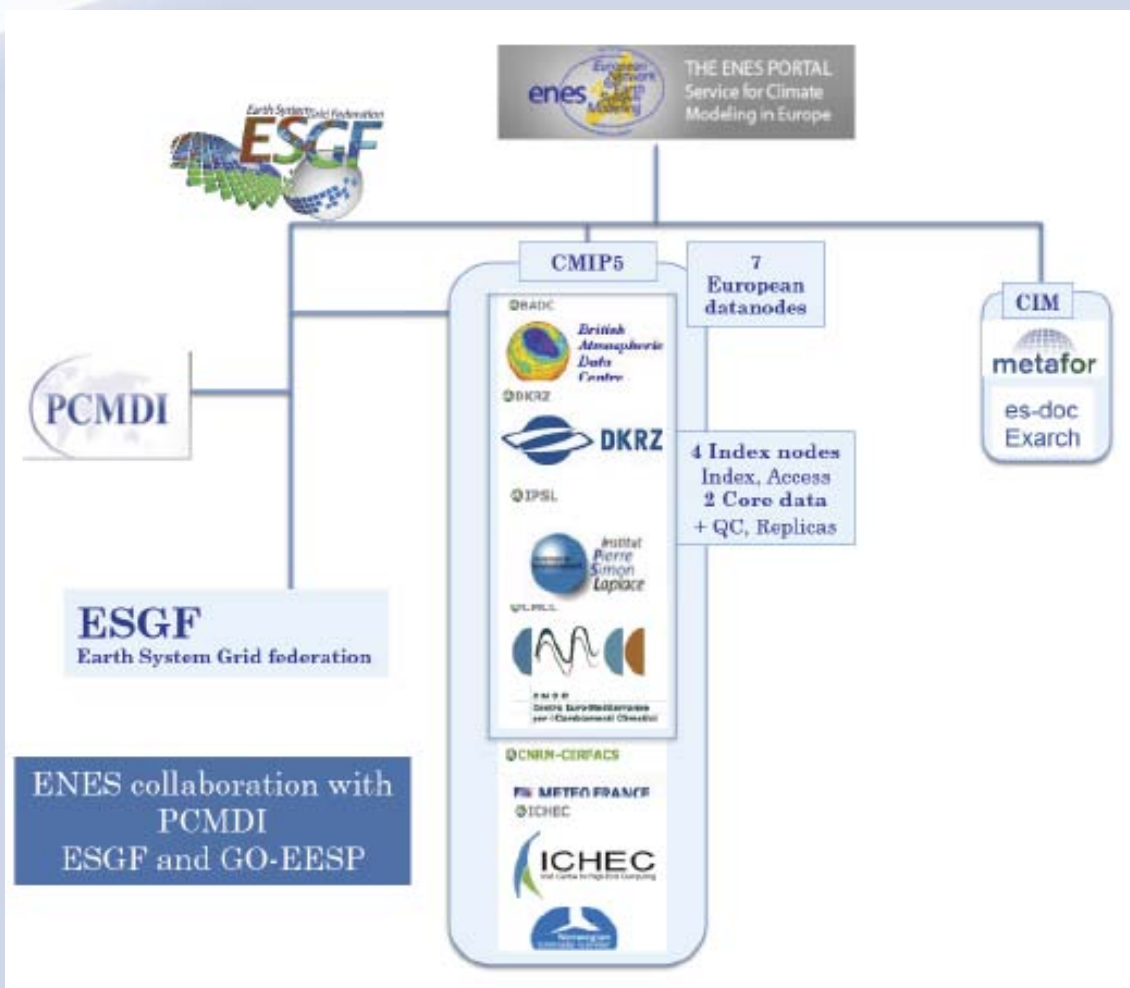


The FP7 project IS-ENES contributes to ESGF-CMIP5 with 7 European data nodes and 4 index nodes

# CMIP5 Data Federation

- 3 central management components have been planned for interdisciplinary data re-use

  - Highly structured data files in self-descriptive data format NetCDF/CF with use-metadata

  - New: searchable model and experiment descriptions (CIM metadata from EU-Project METAFOR)

  - New: 3 layer quality assurance concept for data and metadata

    - QC-L1: ESGF publisher conformance checks

    - QC-L2: Data consistency checks

    - QC-L3: Double- and cross-checks of data and metadata and DataCite data publication
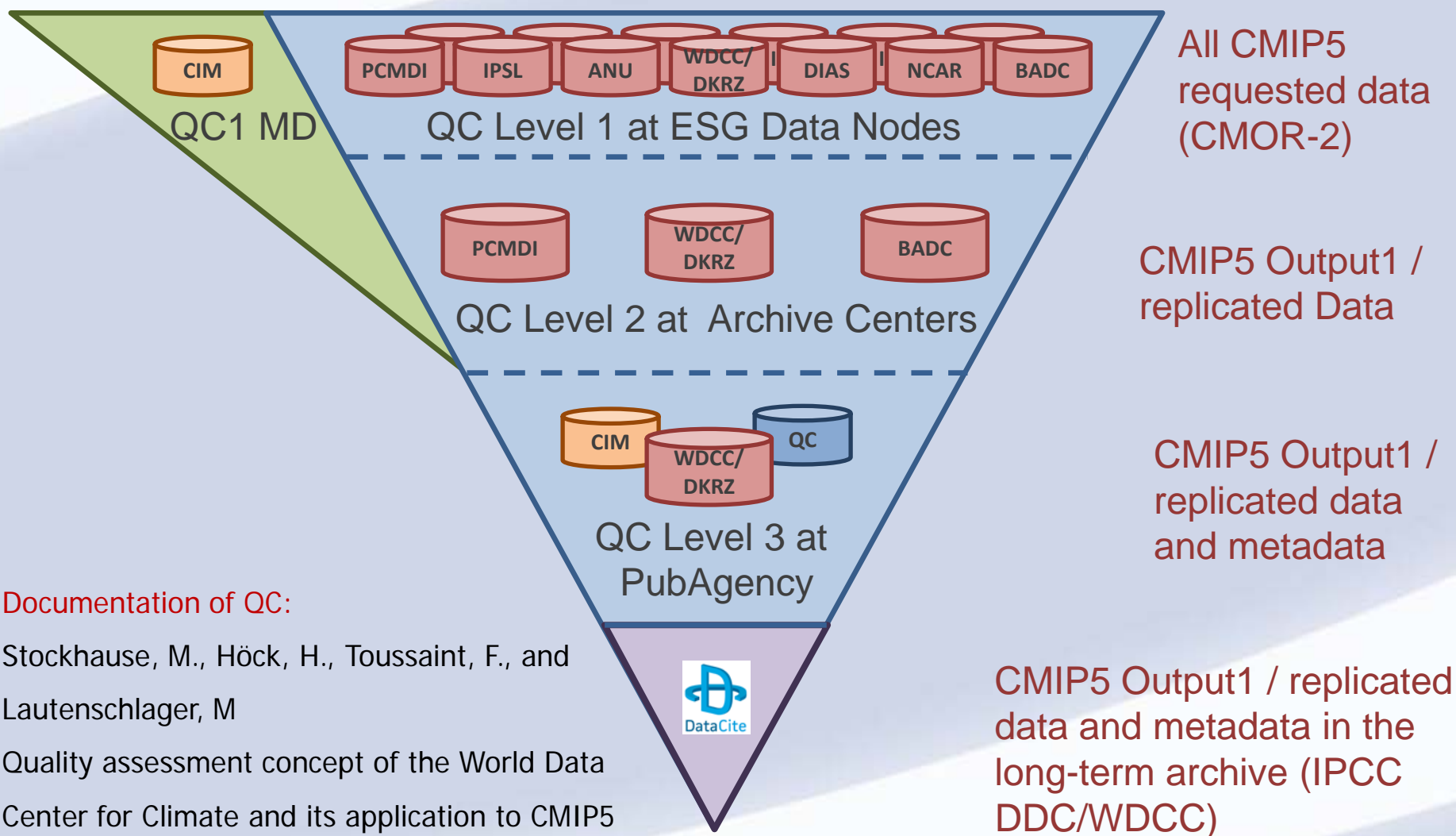
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# CIM Metadata
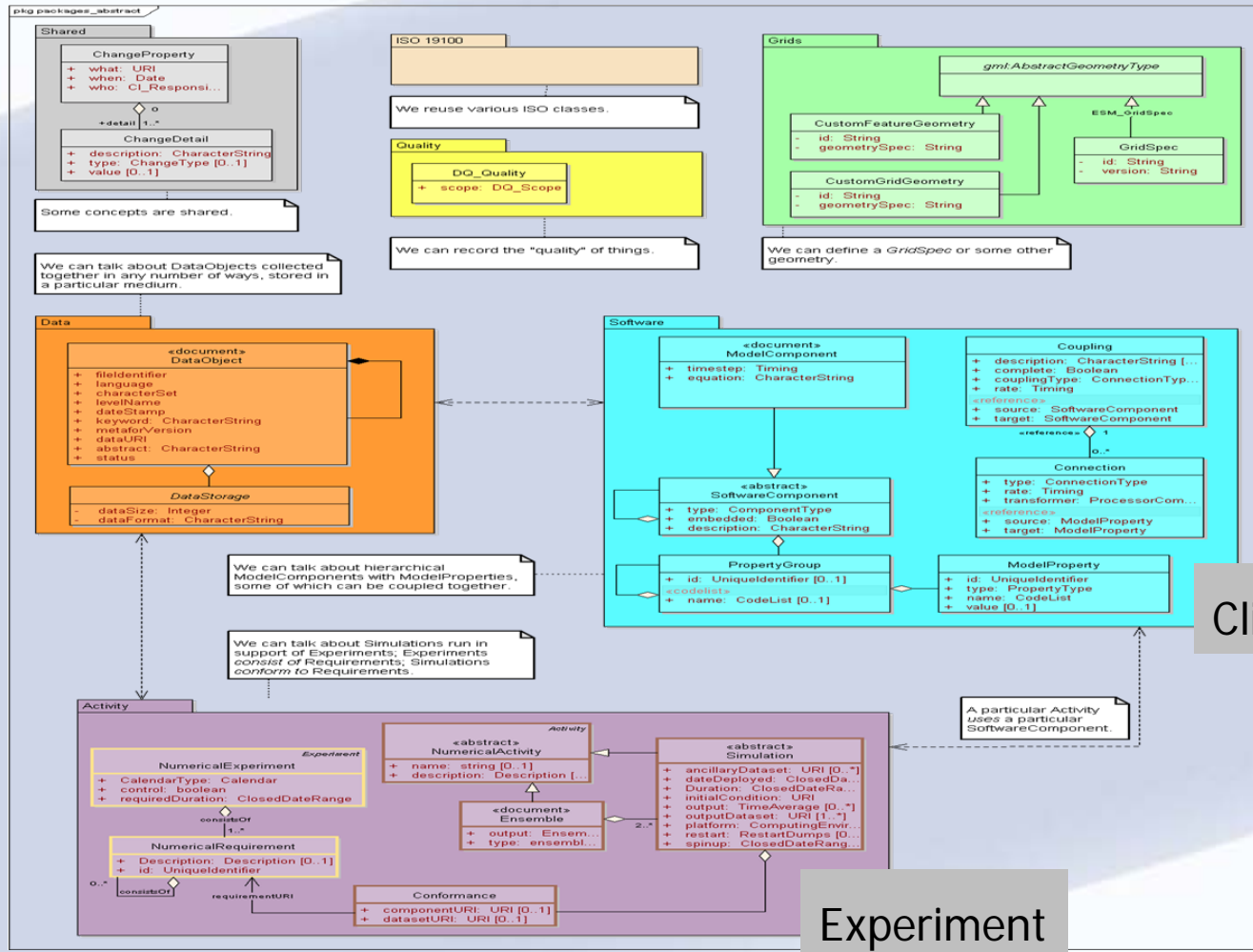


- Development: FP7 METAFOR
- New: Documentation of data creation process in close connection with climate data
- Improvement: Searchable model and experiment description

# 3-Layer Quality Assurance Concept



All CMIP5 requested data (CMOR-2)

QC1 MD

QC Level 1 at ESG Data Nodes

CMIP5 Output1 / replicated Data

QC Level 2 at Archive Centers

CMIP5 Output1 / replicated data and metadata

QC Level 3 at PubAgency

CMIP5 Output1 / replicated data and metadata in the long-term archive (IPCC DDC/WDCC)

Documentation of QC:

Stockhause, M., Höck, H., Toussaint, F., and Lautenschlager, M

Quality assessment concept of the World Data Center for Climate and its application to CMIP5 data. Geosci. Model Dev., 5, 1023-1032 , 2012

**DOI :** 10.5194/gmd-5-1023-2012

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# Finalisation of Quality Assessment

- After final control of data and metadata (CIM und CF) CMIP5 data are transferred from the ESGF archive (*most recent version*) into the reference data archive (*snapshot around March 2013*)
  - Quality status: „approved by author"
  - Data are marked as irrevocable
  - Long-term archiving in WDC Climate of DKRZ
- Final step is the DataCite data publication and integration of associated citation reference into library catalogues
  - Data entity (here one climate model experiment) receives a citation reference for direct usage in scientific publications and a DOI (Digital Object Identifier) for the transparent data access
  - Citation reference contains data author and title as well as WDC Climate as DataCite DOI publisher and the DOI
  - Resolution of the DOI leads to a „Landing Page", which address is stored in the central data base of the DOI Handle Server at DataCite

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# DOI Landing Page

**Title**
cmip5 output1 NCC NorESM1-M piControl, served by ESGF

**Citation**
Bentsen, Mats; Bethke, Ingo; Debernard, Jens; Drange, Helge; Heinze, Christoph; Iversen, Trond; Kirkevåg , Alf; Seland, Øyvind; Tjiputra, Jerry (2011): cmip5 output1 NCC NorESM1-M piControl, served by ESGF. World Data Center for Climate. DOI:10.1594/WDCC/CMIP5.NCCNMpc. http://dx.doi.org/10.1594/WDCC/CMIP5.NCCNMpc
*[Creator (Publication Year): Title. Publisher. Identifier]*

**Publication date**
2011-10-10

**Contact for data entity**
Trond Iversen

**Link to external metadata**
http://cera-www.dkrz.de/WDCC/ui/Entry.jsp?acronym=NCCNMpc

**Summary**
piControl is an experiment of the CMIP5 - Coupled Model Intercomparison Project Phase 5 ( http://cmip-pcmdi.llnl.gov/cmip5/ ). CMIP5 is meant to provide a framework for coordinated climate change experiments for the next five years and thus includes simulations for assessment in the AR5 as well as others that extend beyond the AR5.

3.1 piControl (3.1 Pre-Industrial Control) - Version 1: Pre-Industrial coupled atmosphere/ocean control run. Imposes non-evolving pre-industrial conditions.

Experiment design: http://cmip-pcmdi.llnl.gov/cmip5/docs/Taylor_CMIP5_design.pdf
List of output variables: http://cmip-pcmdi.llnl.gov/cmip5/docs/standard_output.pdf
Output: time series per variable in model grid spatial resolution in netCDF format
Earth System model and the simulation information: CIM repository

Entry name/title of data are specified according to the Data Reference Syntax ( http://cmip-pcmdi.llnl.gov/cmip5/docs/cmip5_data_reference_syntax.pdf ) as activity/product/institute/model/experiment/frequency/modeling realm/MIP table/ensemble member/version number/variable name/CMOR filename.nc .

**Quality**
Accuracy: ;In addition to CMORs automated quality checks we performed manually checks on a data sample for each output variable. These comprise:
-visual inspection using ncview
-check whether min/max values are in physical range and consistent with variable units
-direction of flux variables and positive attribute
-consistency of data with vertical axis definition (i.e. whether data is flipped)
-land/ocean/sea ice masking
-rotation of vector data ;SQA - Scientific Quality Assurance 11/10/2011 10:28:03

Consistency: Quality Control Levels in CMIP5:
* Level 0: Spot checks on selected data
* Level 1: CMOR2 and ESG publisher conformance checks
* Level 2: Data consistency checks
* Level 3: Double- and cross-checks of data and metadata and data publication as DataCite DOI
QC Result Access: http://cera-www.dkrz.de/WDCC/CMIP5/QCResult.jsp?experiment=cmip5/output1/NCC/NorESM1-M/piControl

Completeness: [CMIP5:AuthorComment=We are still in the process of filling out the METAFOR CMIP5 questionnaire. Therefore its contents might be subject to change. Publications based on NorESM1-M are under preparation.]

Specification: [CMIP5:QualityLevel=3] [CMIP5:QualityFlag=approved by author] according to CMIP5 quality control rules http://cmip5qc.wdc-climate.de [CMIP5:DateOfQualityControl2=2011-10-10] [CMIP5:QualityControl2Comment=QC Level2 assigned at 2011-10-11 11:17:51 UTC: assignment confirmed by NCC (Ingo Bethke)] [CMIP5:CimMetadata=CMIP5 questionnaire data not found or not accessible] [CMIP5:TQA=done according to criteria for QCL3 defined at https://redmine.dkrz.de/collaboration/projects/cmip5-qc/wiki/Qc_l3#Criteria-for-QC-L3DOI-publication ] [CMIP5:SQA=checked by author] [CMIP5:DateOfQualityControl3=2011-12-01]

**Link to primary data**
Links.jsp?acronym=NCCNMpc

Citation Reference

Contact Person

Metadata

Summary

Information

on Quality

Assurance

**Direct Access**

**to Climate Data**

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# Status QC for CMIP5

- QC Status CMIP5 (7. Januar 2014)
    - Quality Control 1:          1142 Experiments
    - Quality Control 2:          897 Experiments (finalised 606)
    - Quality Control 3:          257 Experiments
    - DataCite DOI:               249 Experiments (WDCC / IPCC-DDC)
                                  RCPs, AMIP, Historical

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# CMIP5 data management achievements

- CMIP5 federation with 3 core data nodes (PCMDI, DKRZ, BADC), 16 index nodes and 23 data nodes operates an distributed archive of nearly 2 PB of climate model data which is an increase by a factor of 50 compared to the last CMIP in 2007.

- A searchable data catalogue is available across the federation.

- A description of climate models and experiments has been established.

- A three layer quality assurance process has been established which ends in a DataCite data publication for finalised reference data.

- Long-term archiving of reference data in the WDCC/DKRZ and integration in the ICSU WDS (World Data System) and the WIS (WMO Information System)

- Approved terms of use are available with open access for non-commercial use and 2/3 of the archive is available without any restrictions.

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# Future

- ESGF started to analyse the CMIP5 experiences in order to improve the ESGF data infrastructure:
  - Managing large data archives is not only a technical problem.
  - The establishment of a stable distributed ESGF infrastructure requires stable commitments and funding
- ESGF has requests from alternative modelling efforts and related observations to be included in ESGF in order to have all these data more easily inter-comparable.
- Federated data infrastructures like ESGF or Data Clouds seem the way to go for the next generation of climate data archives
  - CMIP3 to CMIP5: 36 TB to 1.8 PB, which means factor 50 increase
  - CMIP5 to CMIP6: 1.8 PB * 50 = 90 PB for one these MIPS
  - If a few or several of these MIPs are considered then ……
- Requested improvements
  - Usability of ESGF data access interface
  - Automated data replication between ESGF data nodes
  - More powerful, more stable and scalable wide area data networks (service level agreements)

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