Observational constraints on ensemble climate models for the IPCC AR5: a potential ACC project

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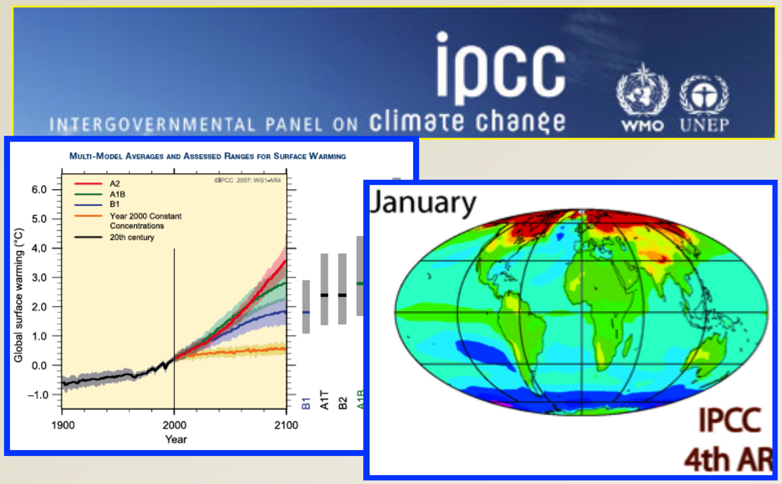
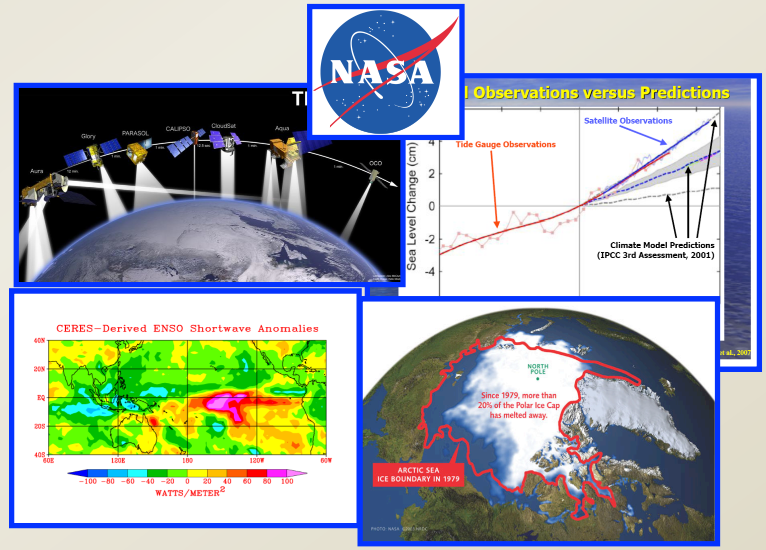
Satellite observations and the IPCC

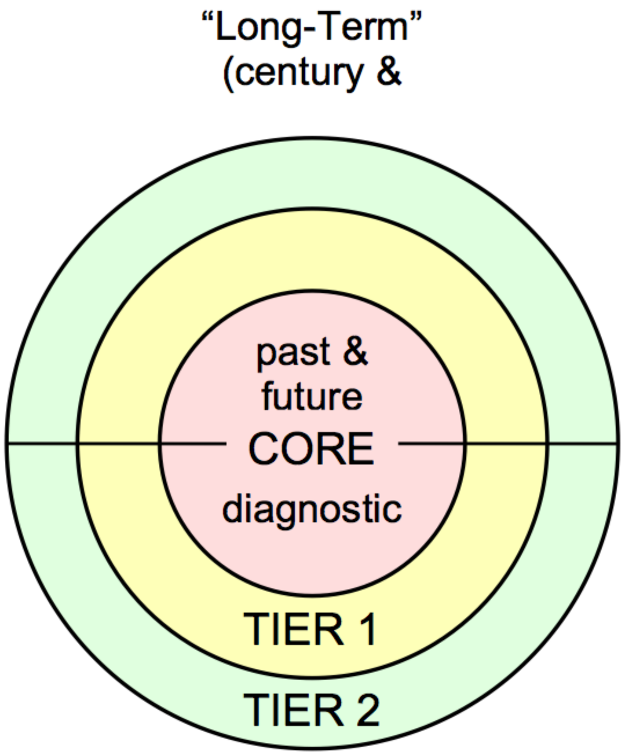


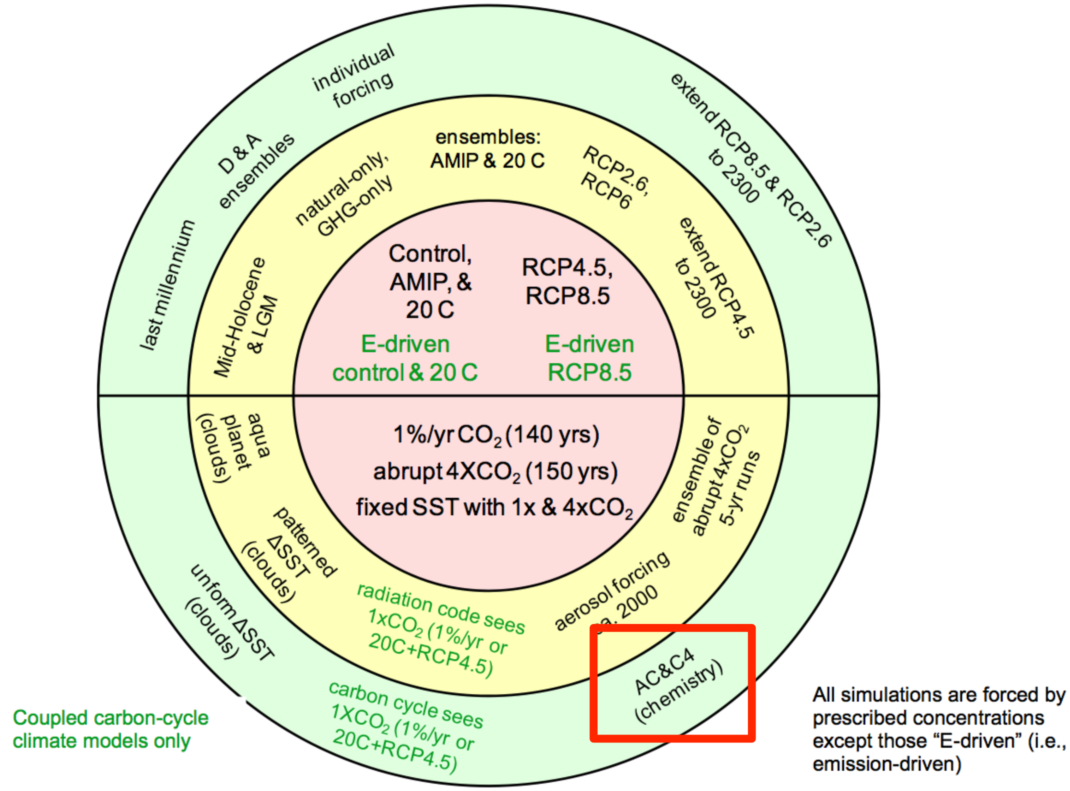
How to bring as much observational scrutiny as possible to the IPCC process?



How to best utilize the wealth of satellite information for the IPCC process?

The IPCC Tier Experimental Design





The IPCC AR5 includes vastly more experiments than AR4 including coupled carbon-climate and chemistry-climate

Atmospheric composition plays an important role both in terms of radiative forcing, feedbacks, and response through Core, Tier 1, and Tier 2

Observations for CMIP5 Simulations

- A collaborative effort between JPL/NASA and PCMDI is underway to provide the community of researchers that will access and evaluate the CMIP5 model results access to analogous sets of observational data.

- A number of NASA satellite data sets have been identified that have model equivalents. Thus far: AIRS, MLS, TES, QuikSCAT, CloudSat, Topex/Poseidon, CERES, TRMM, AMSR-E.

- Plans have been developed for converting the data into CF-compliant format, documenting it for technical details for their use/application to IPCC model assessment, and to make them available via ESG and links from PCMDI model access web portal.

- This activity is being carried out in coordination with the corresponding CMIP5 modeling entities and activities (e.g. WGCM, PCMDI).

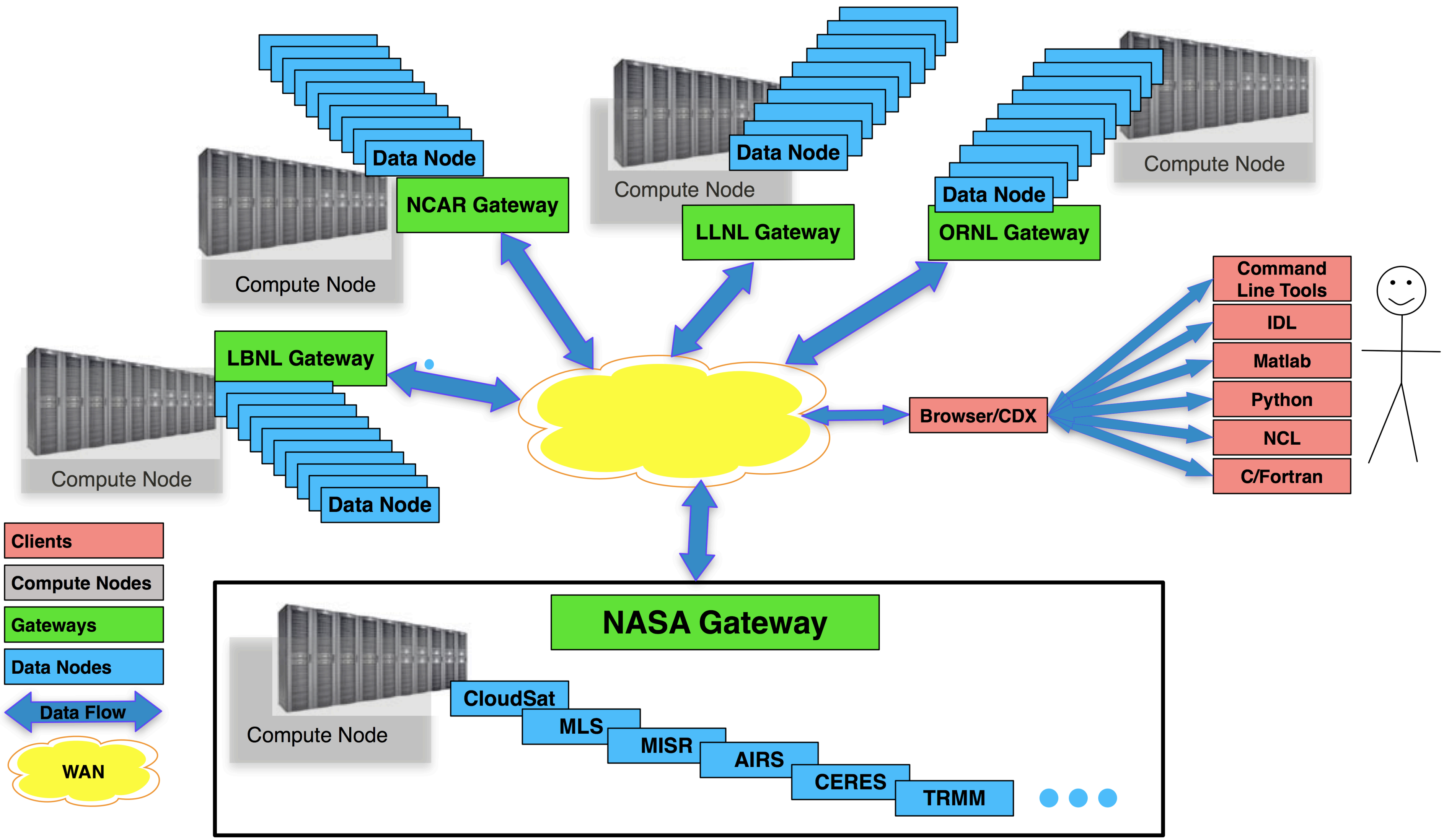
Observations for CMIP5 Simulations

Initial Set of NASA-based Satellite Observations

- AIRS –*temperature profiles and tropospheric water vapor profiles*
- MLS – upper troposphere / lower stratosphere temperature, water vapor and ozone
- TES – tropospheric ozone
- QuikSCAT – surface wind vectors
- CloudSat – reflectivity profiles and ice water content profiles
- Topex/Jason – sea level
- CERES – top of the atmosphere and surface longwave and shortwave radiation and cloud forcing
- TRMM – precipitation
- AMSR-E – total column water vapor

More being considered…..

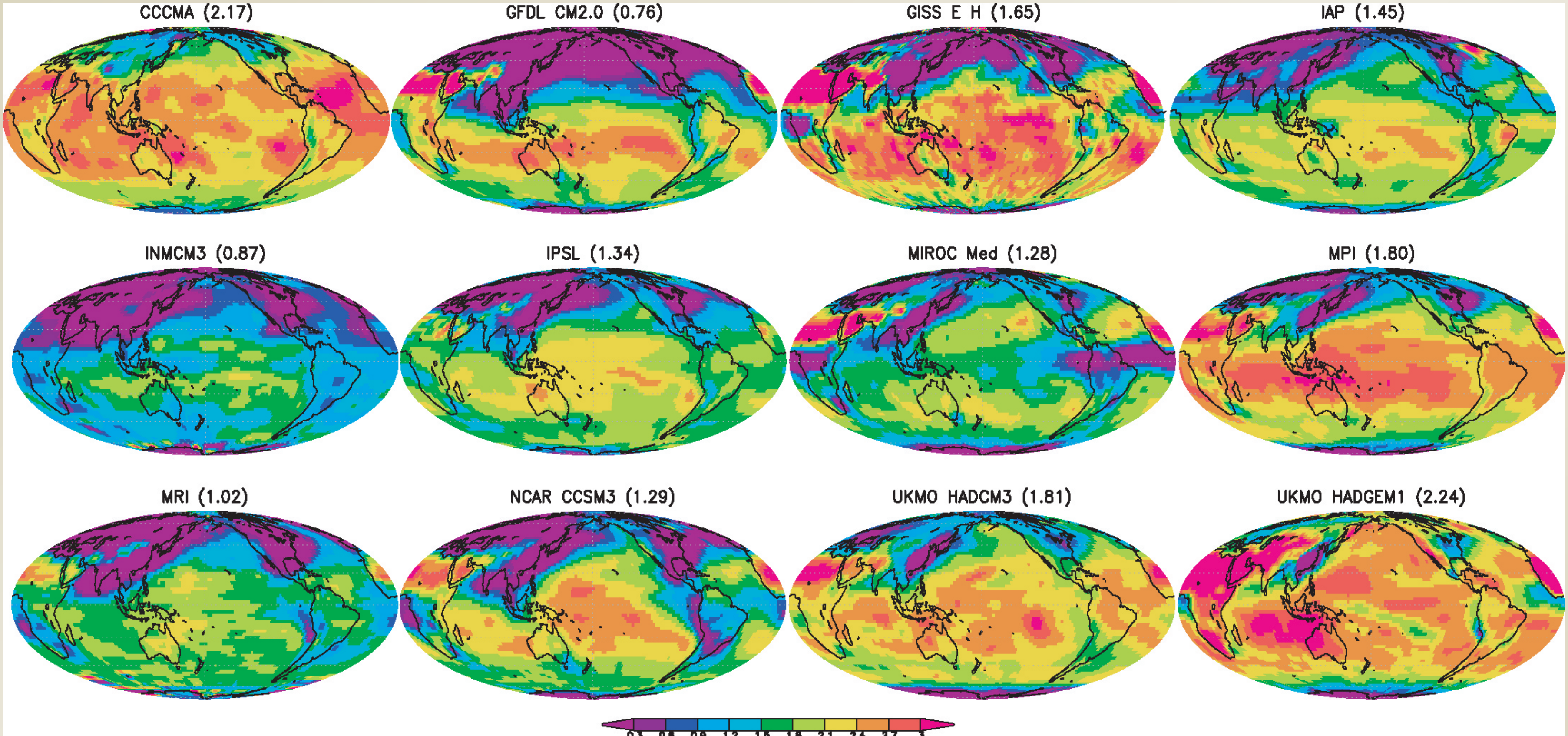
NASA, PCMDI and ESG



Observations for CMIP5 Simulations

- Taylor et al (2008) have defined the protocol for the IPCC AR5 CMIP5 simulations.
- The protocol defines the model diagnostic output variables and their spatio-temporal scales
- Observational datasets must be gridded to those outputs.
- The satellite datasets are still under discussion between NASA and PCMDI.
- Only limited composition measurements are currently included.

ACC-MIP: Simulations to compliment CMIP5

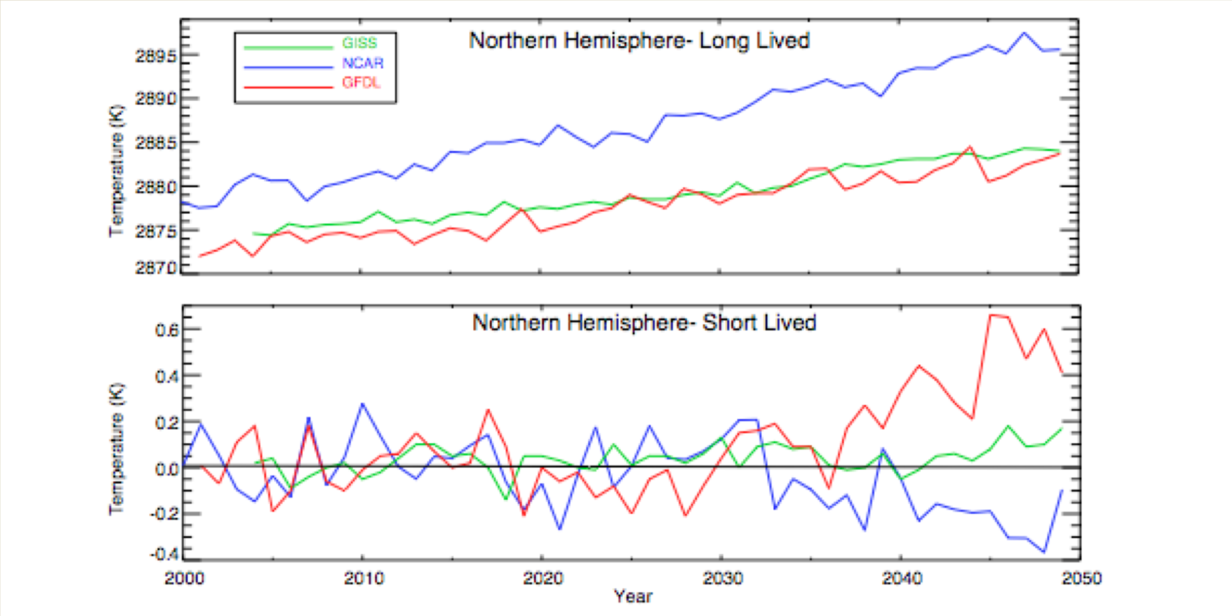


0.3 3.0 W/m^2

Radiative forcing in the CMIP3 20th century simulations as inferred from the geographic distribution of surface temperature change and climate sensitivity/feedbacks of each model.

B. Soden, pers. comm., 2009

Implications of non-uniform RF



Shindell *et al* 2008

- Models in the climate modeling intercomparison project (CMIP3) used vastly different forcings for the 20th century due primarily to short-lived climate forcing (SLCF) agents
- Negative forcing from aerosols dominates the total in Northern Hemisphere for some models
- Global mean radiative forcing differs by up to a factor of 2 across models while regional forcings vary enormously in magnitude and are inconsistent in sign.
- Need to characterize the forcings imposed for the IPCC AR5 as well as diagnostics to allow us to understand the causes of the differences in forcings from model to model.
- Need to assess whether the forcings and the processes controlling them are consistent with observations.

WCRP
World Climate Research Programme

Physical climate system

SPARC Project:
Stratospheric Processes and their Role in Climate
(stratosphere focus)

GLOBAL IGBP CHANGE

Biosphere-geosphere interactions

IGAC Project:
International Global Atmospheric Chemistry Project
(troposphere focus)

WCRP-SPARC / IGBP-IGAC

Atmospheric Chemistry & Climate Initiative

- **Objectives of AC&C:**
  - Understanding role of emissions on atmospheric composition
  - Relating concentrations to radiative forcings/climate change
  - Improving process understanding and representation

AC&C Hindcasts Activity 1

Four sets of Hindcasts:

- *Aerosols (under Aerocom)*
- *Long-lived tracers (*AC&C Activity 1)
- *Ozone (*AC&C Activity 1)
- *Methane with Variable Oxidants (*AC&C Activity 1 – phase 2)

Each hindcast experiment defined by:

- a multi-year series (post-1980)
- a clear objective grading criteria for evaluating model success.
- a set of required diagnostics to facilitate model comparison and evaluation.
- multi-year external forcings (e.g., emissions) needed to drive the simulations.
- guidelines on the types of chemical models and meteorological fields that can usefully participate

ACC-MIP-AC&C Activity 4

- The atmospheric chemistry-climate model inter-comparison project (ACC-MIP)
- ACC-MIP will produce a suite of ACC model transient climate simulations and future projections
  - Uses a consistent historic emissions of ozone and aerosol precursors.
  - All representative concentration pathways (RCPs) are connected to historic emissions at 2000
  - Provides 3D time series of short-lived species concentrations to drive GCMs for AR5
- ACC-MIP science goals
  - Regional and global radiative forcing of short-lived climate forcers (SLCF)
  - Understanding of processes controlling SLCF
  - Sensitivity of climate and chemistry projections to model parameters.
- Expected that ACC-MIP analysis activities will impact the content of AR5
- Satellite observations can play a crucial role in assessing the SLCF distribution and processing controlling them

CEOS-IGAC-IPCC

- The IGAC and AC&C leadership have expressed an interest for the ACC-CEOS community to participate in the AC&C 1 and 4 activities.
- Initial focus on trace gases for ACC-MIP:
  - Model diagnostics already defined
  - Satellite observations need to be gridded and sampling effects characterized, e.g. "average of averaging kernels"
- The ACC-MIP needs to be incorporated within the Earth System Grid (ESG) with hooks into CMIP5
- Propose that ACC-CEOS communicate to sponsor agencies interest in collaboration with IGAC in support of IPCC AR5.
  - Need sponsor agency financial support for IT integration of products
- Leverage off of existing PCMDI/NASA collaboration for incorporation of other ACC-CEOS satellites products into the ESG nodes.
- Will be participating at a NASA-PCMDI meeting in Oct.

Phased Strategy for AR5 and AR6

Phase: Pilot (2010/2011)

Phase: Full Capabilities (2012+)

Science + Data System → AR5

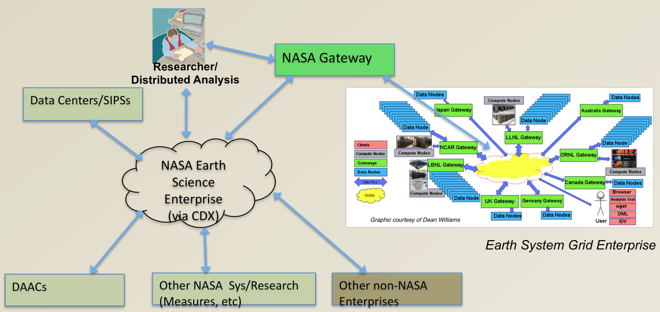
Apply Lessons Learned →

Science + Data System → AR6

<u>AR5 Objective</u>: Provide key NASA observations along side climate models; Integrate through an ESG Gateway customized for observations

<u>AR6 Objective</u>: Apply lessons learned and establish a NASA-wide capability to support model-to-data verification and data analysis

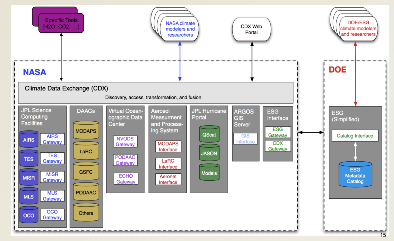
Climate Model-Data Intercomparison Technical Roadmap



ESG/NASA Simple Integration

- Common NASA Gateway/Portal for accessing Observations from ESG
- Centralized data management systems, where needed
- Federated access, where possible
- No data transformation services
- Some one-off support for AR5
- ESG/CDX Pilot

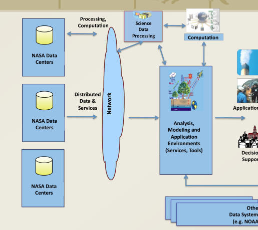
Simple access to observational data for AR5



Integrated Service Architecture

- Operational web services access to NASA DAAC and SCFs
- Standard interfaces for access, some computational libraries for intercomparison
- On the fly transformation between HDF and NetCDF

Move towards supporting analysis through a SOA/web-services based framework



Distributed Analysis Environment for model-data comparison

- Computational services deployed at data centers
- Access to NASA data and computational services available at researchers desktop
- Computational libraries to support model-to-data comparison
- Sharing of software infrastructure and services between NASA and DOE
- Integration with ESDIS program architecture

Integrated analysis environment for AR6

2011 (Phase I) **2013 (Phase II)** **2015 (Phase II)**