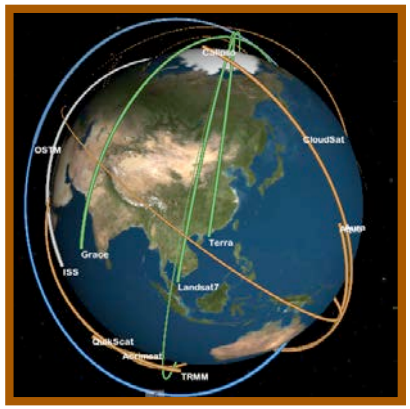
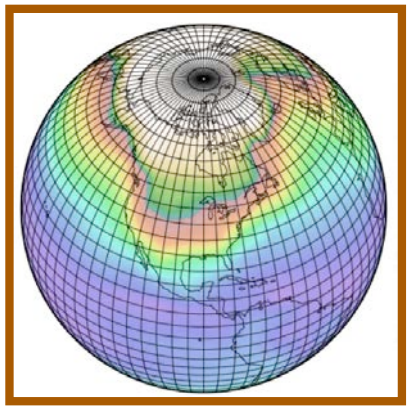
obs4MIPs: An Overview and Update



Obs4MIPs



Obs4MIPs is a pilot effort to improve the connection between data experts and scientists involved in climate model evaluation.

It is closely aligned with CMIP5.

Initiated by NASA & U.S. DOE, there are now a variety of NASA products available.

A current priority is to enable other data communities to contribute data.

Oversight and endorsement of this activity is needed.

Contributors to date

D. Waliser, J. Teixeira, R. Ferraro, D. Crichton, L. Cinquini, others...
JPL

P. Gleckler, K. Taylor, D. Williams
PCMDI

G. Potter, P. Webster
GSFC

T. Lee, J. Kaye, M. Maiden, S. Berrick
NASA Headquarters

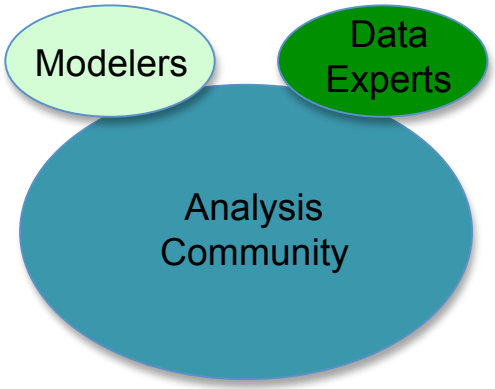
NASA Science teams: AIRS, AMSR-E, CERES, MLS, MODIS, OSTM, OVW, TRMM, (PO)DAAC, …

CFMIP-OBS Collaborators

NASA-obs4MIPs Science Working Group
Members: J. Bates (NOAA), K. Bowman, A. da Silva, P. Gleckler (PCMDI), F. Landerer, C. Peters-Lidard, N. Loeb, R. Nemani, S. Platnick, D. Waliser (chair)
Program Executive: T. Lee, **Program Manager**: Robert Ferraro

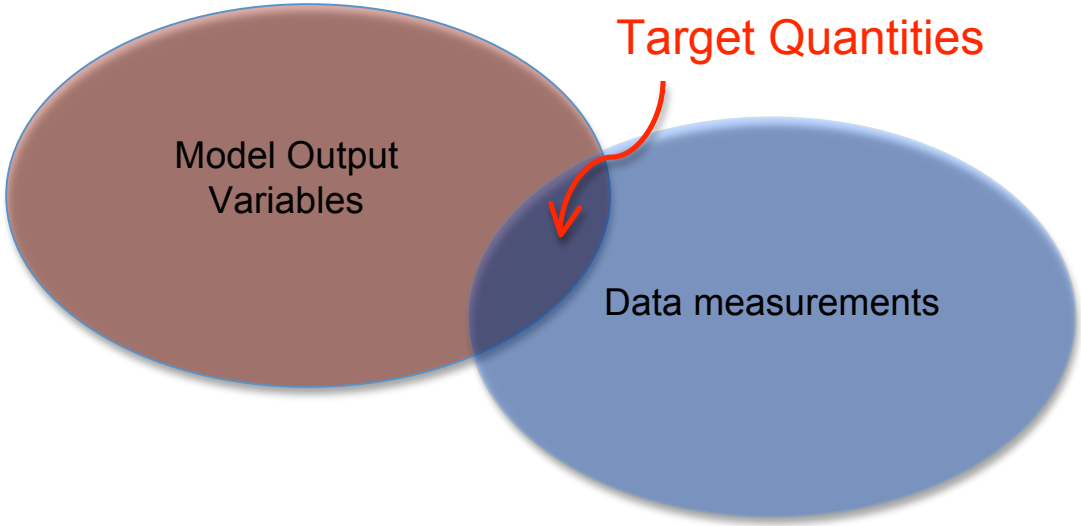
Some Basic Tenets of the Initial Activity

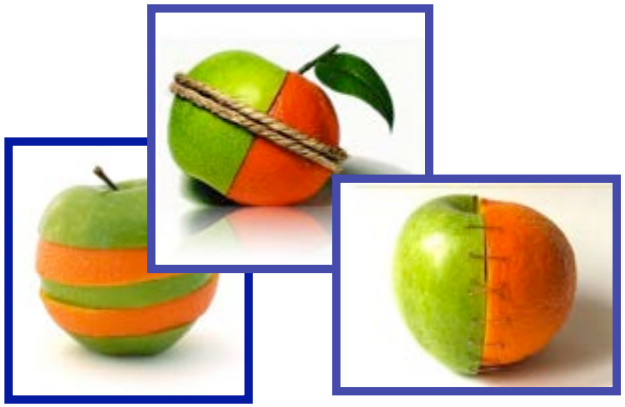
- Use the CMIP5 simulation protocol as guideline for deciding which observations to select.
  Initial Target was monthly averaged (OMON, AMON) products on 1 x 1 degree grid
- Convert Observations to CMIP5 model output format
  CMOR output, NetCDF files, CF Convention Metadata, CMIP standard pressure levels, etc.
  Not a new product. Independent QC check before release.
- Includes a 6-8 page Technical Note describing strengths/weaknesses, uncertainties, caveats regarding comparisons with models.
  (at graduate student level)
- Available via ESGF
  (analogous to CMIP5)



Model and Observation Overlap

For what quantities are these comparisons viable?





After much scrutiny and two workshops, only ~20 NASA satellite variables were identified as being “safely” comparable in the pilot effort.

NASA-related Datasets for CMIP5

Datasets are Gridded Monthly Averages – Unless otherwise noted

Separate files containing Nobs & StdErr for each grid cell are available

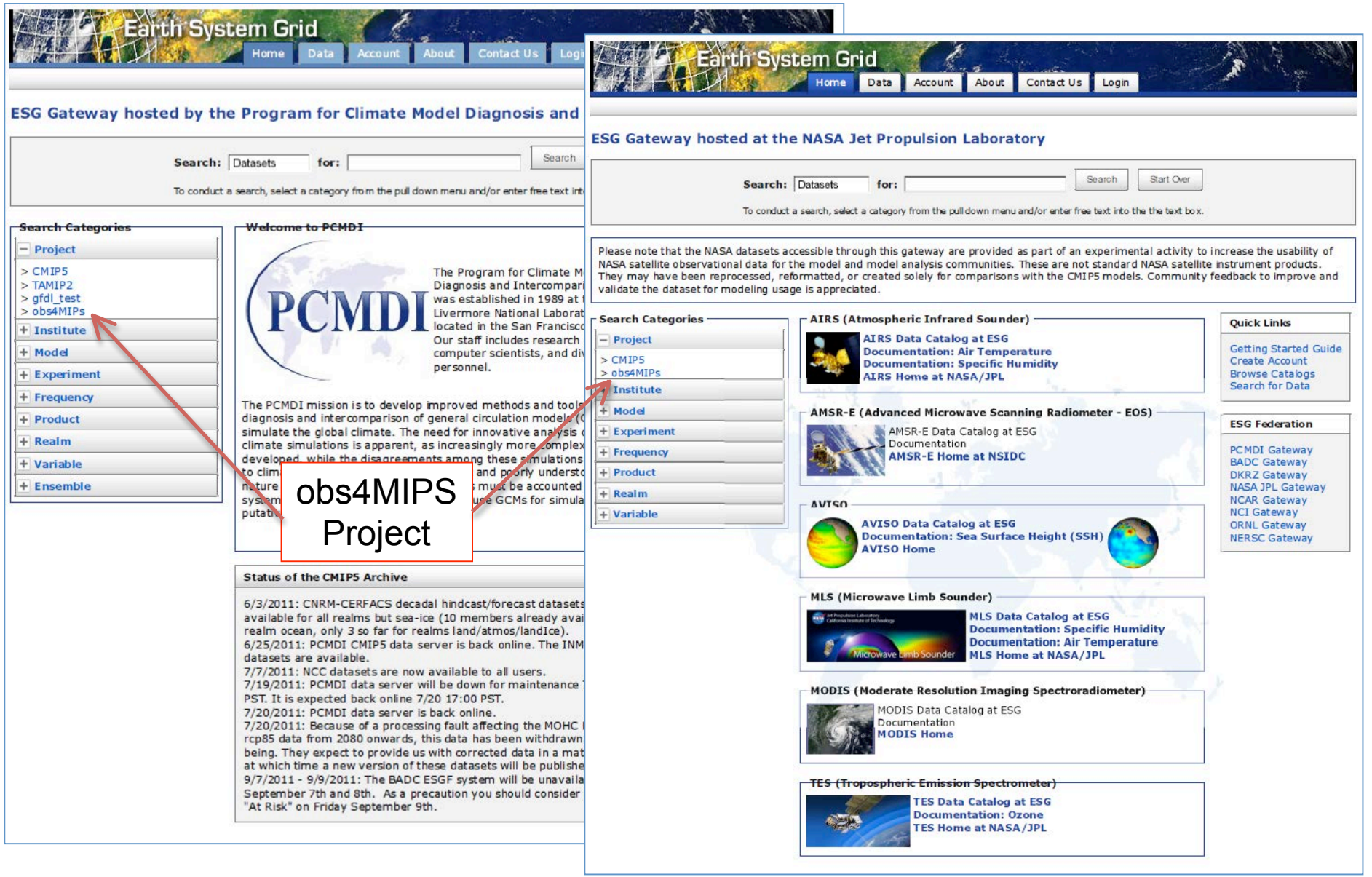
CMIP Protocol Variables	Data Source	Time Period	Comments
ta - Atm Temp	AIRS (≥ 300 hPa) MLS (< 300 hPa)	9/02 – 8/04 -	AIRS +MLS needed to cover all pressure levels
hus - Specific Humidity	AIRS (≥ 300 hPa) MLS (< 300 hPa)	9/02 – 8/04 -	
tro3 – Mole Fraction of Ozone	TES	2004 -	Undergoing QC checks
tos - Sea Surface Temperature	AMSR-E	6/02 -	SST science team recommends multiple products
rlut, rlutcs, rsdt, rsut, rsutcs – TOA outgoing LW & SW Radiation, Incident SW Radiation	CERES	3/00 -	
clt – Total Cloud Fraction	MODIS	2/00 -	
zos - Sea Surface Height Above Geoid	TOPEX/JASON series	10/92 -	AVISO Product
pr - Total precipitation	TRMM	1997 -	Monthly Ave + 3 hourly products
sfcWind, uas, vas - Surface (10m) zonal wind	QuikSCAT	1999 – 2009	Oceans only. No land products.
Land Surface products (TBD)	MODIS	2/00 -	Perhaps 2 CMIP variables, TBD

Orange datasets are still in process

Other NASA Datasets under consideration

- Sea Ice - NSIDC
- AOD over land – MISR
- AOD over ocean – MODIS
- Aerosol Extinction – CALIPSO
- Snow cover – MODIS
- CERES surface radiation
- MODIS albedo
- MODIS LAI and FPAR

ESGF Gateway : Side by Side Archive with CMIP



"Technical Note"

Each Dataset has an accompanying Technical Note

Target audience is modeling and model-evaluation community members who often have little experience with the given dataset of interest.

Content

Intent of the Document/POC

Data Field Description

Data Origin

Validation and Uncertainty Estimate

Considerations for Model – Observation Intercomparison

Instrument Overview

References

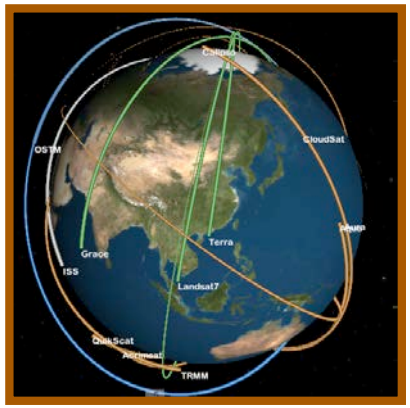
Revision History

Looking forward

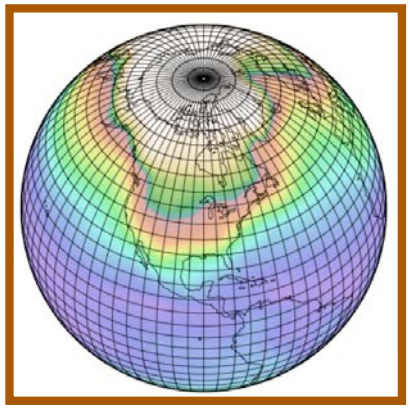
- It is hoped that the WDAC can provide primary oversight to this activity
- Encouragement/feedback from WGCM is still very helpful. What additional products would be particularly helpful for advancing model development/evaluation?
- Further coordination with CFMIP-OBS and other efforts is a priority. ESA and NOAA have expressed interest.
- The protocol for data contributions will be strengthened to ensure other data providers can contribute
- If successful, Obs4MIPs will improve the connection between modeling groups, analysts and the data experts/providers which will be encouraged to keep their product versions and documentation up-to-date on ESGF.

A more detailed presentation (following slides) was given to the WCRP Data Advisory Group (WDAC) in July, 2012

obs4MIPs: An Overview and Update



Obs4MIPs



Obs4MIPs is a pilot effort to improve the connection between data experts and scientists involved in climate model evaluation. It is closely aligned with CMIP5, with encouragement from the WGCM and WGNE. NASA and the U.S. DOE have initiated the project with significant contributions of appropriate NASA products. An overarching goal is to enable other data communities to contribute data to Obs4MIPs, but guidance and endorsement of this activity is now needed.

for presentation to the
WCRP Data Advisory Group (WDAC)
Prepared June 2012

Acknowledgements

D. Waliser, J. Teixeira, R. Ferraro, D. Crichton, L. Cinquini, others....

Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA

P. Gleckler, K. Taylor, D. Williams

Program on Climate Modeling Diagnostics and Intercomparison (PCMDI/DOE), Livermore, CA

G. Potter, P. Webster

Goddard Space Flight Center, Greenbelt, MD

T. Lee, J. Kaye, M. Maiden, S. Berrick

NASA HQ

AIRS, AMSR-E, CERES, MLS, MODIS, OSTM, OVW, TRMM, (PO)DAAC, others…

MANY OTHERS

NASA obs4MIPs Science Working Group

Members: J. Bates (NOAA), K. Bowman, A. da Silva, P. Gleckler (PCMDI), F. Landerer, C. Peters-Lidard, N. Loeb, R. Nemani, S. Platnick, D. Waliser (chair)

Program Executive: T. Lee, **Program Manager**: Robert Ferraro

Observations for CMIP5 Simulations
History/Timeline

Mid 2007-Mid 2009: JPL discussions on how to improve satellite usage in CMIPx/IPCC ARx.

July 2009: JPL/PCMDI IT for Climate Research Workshop held in Pasadena to discuss technical challenges and progress of sharing observations.

September 2009: Briefing to WGCM on plans to make satellite observations more accessible for CMIP5/AR5; received WGCM support and encouragement.

December 2009: Brief NASA HQ (Lee, Kaye) on plan, solicit support for pilot effort (JPL, GSFC, PCMDI present)

March 2010: Briefings to WOAP Meeting & NOAA-led IPCC-observation meeting, Asheville, NC.

Spr-Sum 2010: Start work at JPL for prototyping data preparation, documentation and ESG implementation.

October 2010: Briefing/update to WGCM on initiative progress.

October 2010 : NASA Datasets for IPCC Workshop hosted by PCMDI – identify requirements and NASA or closely-related data sets readily available for CMIP5/AR5 analysis.

November 2010 : NASA IT for IPCC Workshop hosted by GSFC – identify IT resources and requirements.

December 2010: Update NASA HQ on status of activity, securing continued support for pilot effort.

June 2011: JPL/NASA ESG Gateway online and ready to accept/serve obs4MIPs data sets.

October 2011: Briefing/update to WGCM & WGNE on initiative progress.

Fall 2011: Deliver a number of satellite datasets that are formatted, documented, sampled (e.g. monthly, daily) in a manner analogous to the model outputs, make available via ESG – tagged as “obs4MIPs”

October 2011: Recommendation to WCRP to foster activity via Observation Data Council.

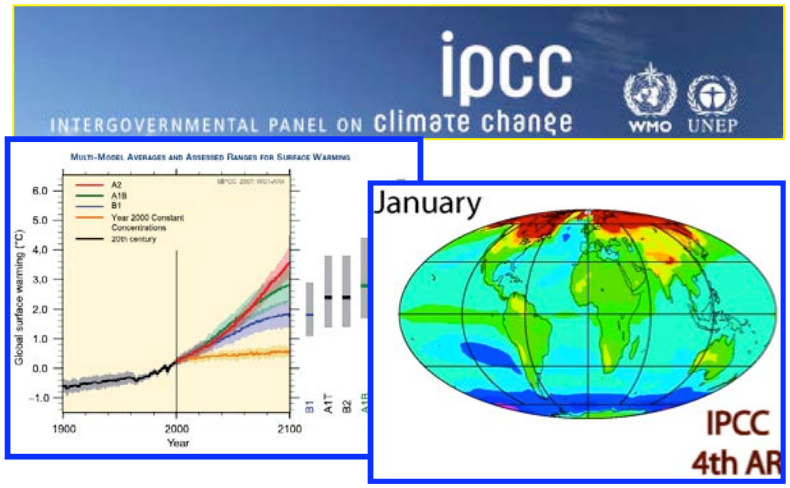
December 2012: NASA forms Science Steering Group to shepherd NASA component of activity and provide guidance/leadership for including additional agencies/datasets. Meeting at AGU with most members and NASA HQ program executive.

March 2012: Obs4MIPs wiki page made public and highlighted at CMIP5 Hawaii Workshop.

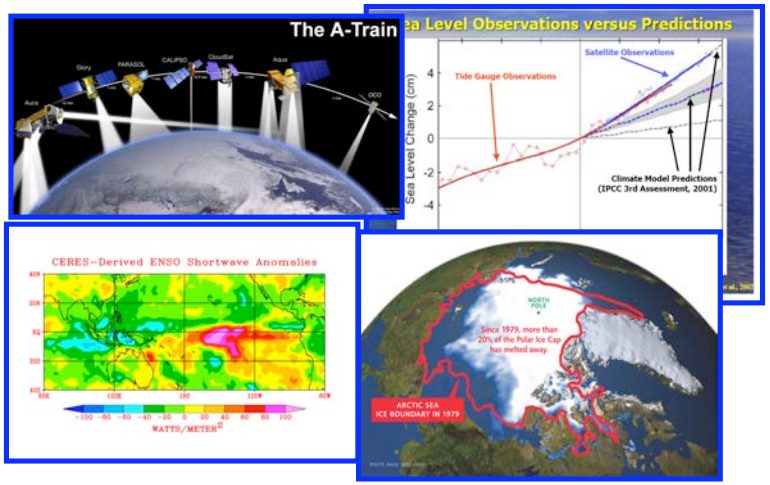
April 2012: Obs4MIPs briefing at CEOS-Climate Workshop, Asheville to broaden agency participation.

May 2012: 1st NASA obs4MIPs Science Steering Group Meeting

(Satellite) Observations and CMIP/IPCC: Better Linkage



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



How to best utilize the wealth of Earth observations for the IPCC process?

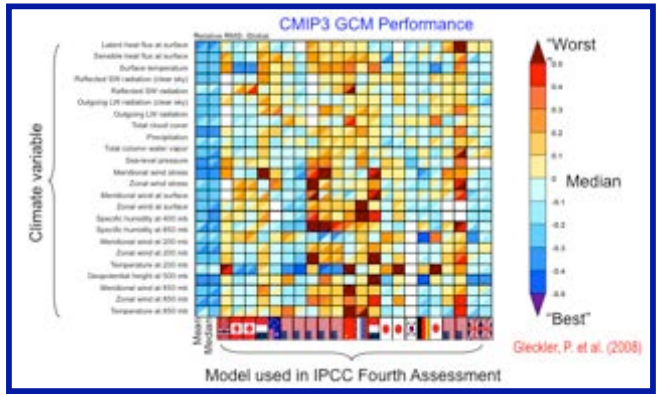
AR5 – initial target

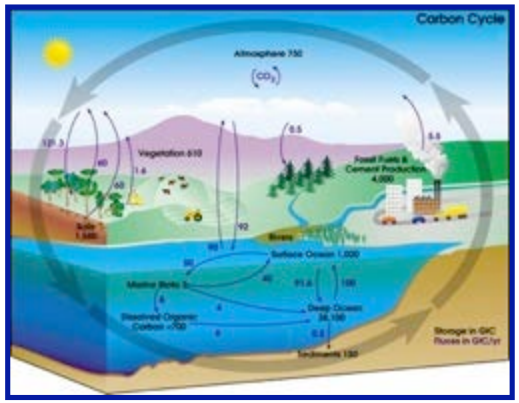
AR6 and other MIPs – long-term targets

Observations for CMIP and IPCC ARs

Why is this timely for AR5 and beyond?

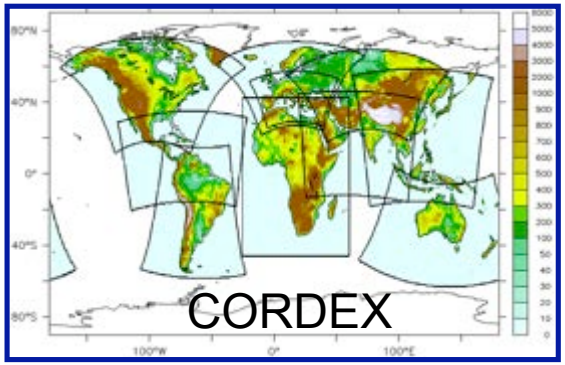
Model Scoring w/ Observations: "1 model – 1 vote" to weighting projections based on observation metrics.





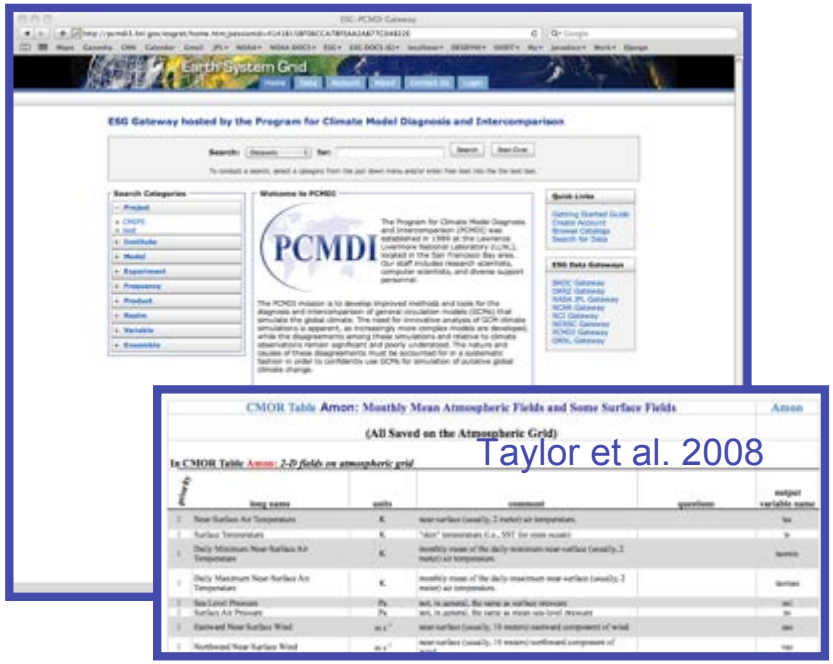
Earth System Modeling (e.g. Coupled Carbon-Climate): added complexity, more degrees of freedom, need for observational constraints

Decadal Predictions: Downscaling GCMs with regional models is key to many decision-support issues.



Model and Observation Overlap

For what quantities are comparisons viable?



Taylor et al. 2008

~120 ocean
~60 land
~90 atmos
~50 cryosphere

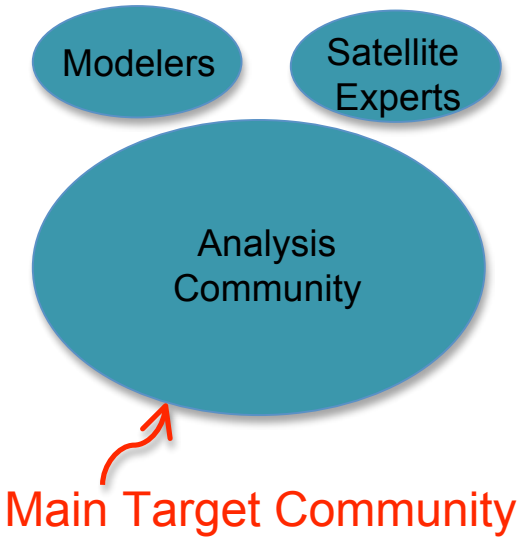
Example: Current NASA Missions ~14
Total Missions Flown ~ 60
Many with multiple instruments
Most with multiple products (e.g. 10-100s)
Many cases with the same products

Over 300 Variables in (monthly) CMIP Database

Over 1000 satellite-derived quantities

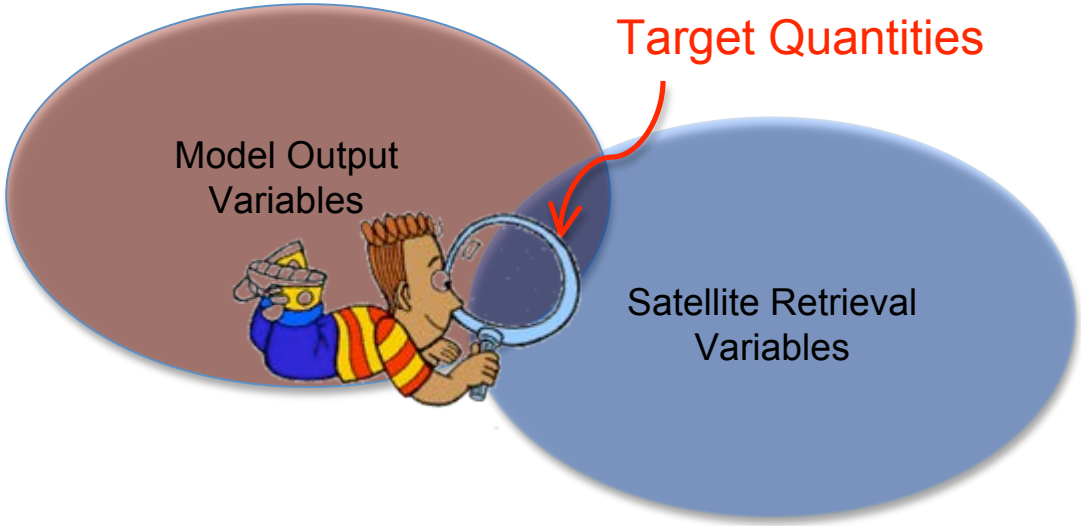
Some Basic Tenets of the Initial Activity

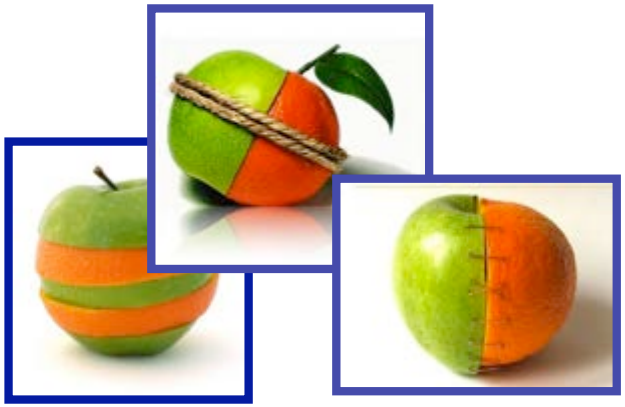
1. Use the CMIP5 simulation protocol (Taylor et al. 2009) as guideline for deciding which observations to select.
   Initial Target was monthly averaged (OMON, AMON) products on 1 x 1 degree grid
2. Convert (Satellite) Observations to CMIP model output format
   CMOR output, NetCDF files, CF Convention Metadata, CMIP standard pressure levels, etc.
   Not a new product. Independent QC check before release.
3. Includes a 6-8 page Technical Note describing strengths/weaknesses, uncertainties, caveats regardingcomparisons with models.
   (at graduate student level)
4. Host side by side on the ESG with CMIP5



Model and Observation Overlap

For what quantities are these comparisons viable?





After much scrutiny and two workshops, only ~20 satellite variables were identified as being “safely” comparable in the pilot effort.

NASA-related Datasets for CMIP5

Datasets are Gridded Monthly Averages – Unless otherwise noted

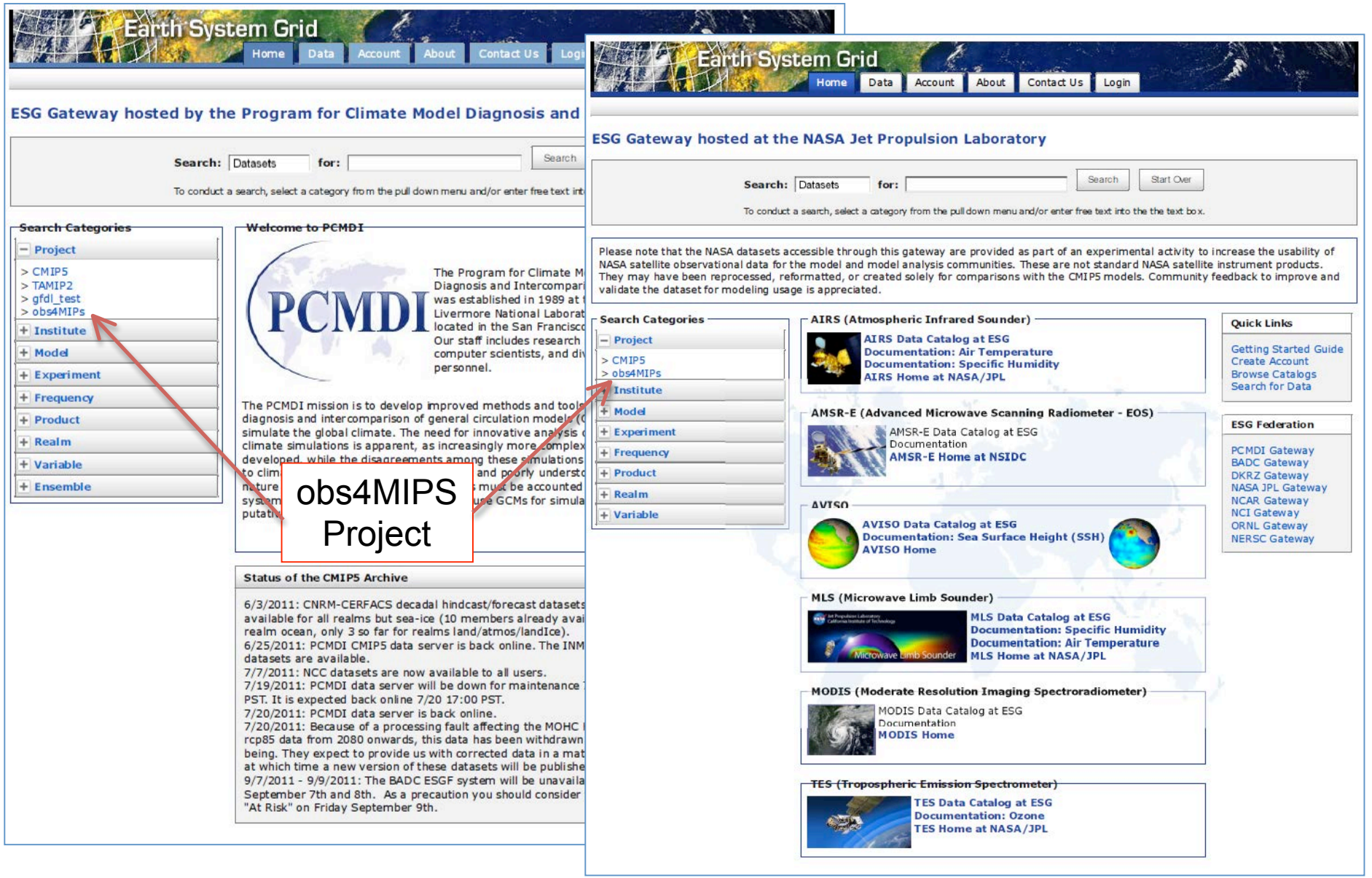
Separate files containing Nobs & StdErr for each grid cell are available

CMIP Protocol Variables	Data Source	Time Period	Comments
ta - Atm Temp	AIRS (≥ 300 hPa) MLS (< 300 hPa)	9/02 – 8/04 -	AIRS +MLS needed to cover all pressure levels
hus - Specific Humidity	AIRS (≥ 300 hPa) MLS (< 300 hPa)	9/02 – 8/04 -	
tro3 – Mole Fraction of Ozone	TES	2004 -	Undergoing QC checks
tos - Sea Surface Temperature	AMSR-E	6/02 -	SST science team recommends multiple products
rlut, rlutcs, rsdt, rsut, rsutcs – TOA outgoing LW & SW Radiation, Incident SW Radiation	CERES	3/00 -	
clt – Total Cloud Fraction	MODIS	2/00 -	
zos - Sea Surface Height Above Geoid	TOPEX/JASON series	10/92 -	AVISO Product
pr - Total precipitation	TRMM	1997 -	Monthly Ave + 3 hourly products
sfcWind, uas, vas - Surface (10m) zonal wind	QuikSCAT	1999 – 2009	Oceans only. No land products.
Land Surface products (TBD)	MODIS	2/00 -	Perhaps 2 CMIP variables, TBD

Match up of available NASA datasets to PCMDI priority list

Orange datasets are still in process

ESG Gateway : Side by Side Archive with CMIP



"Technical Note"

(See Appendix II)

Each Dataset has an accompanying Technical Note

Target audience is modeling and model-evaluation community members who often have little experience with the given dataset of interest.

Content

Intent of the Document/POC

Data Field Description

Data Origin

Validation and Uncertainty Estimate

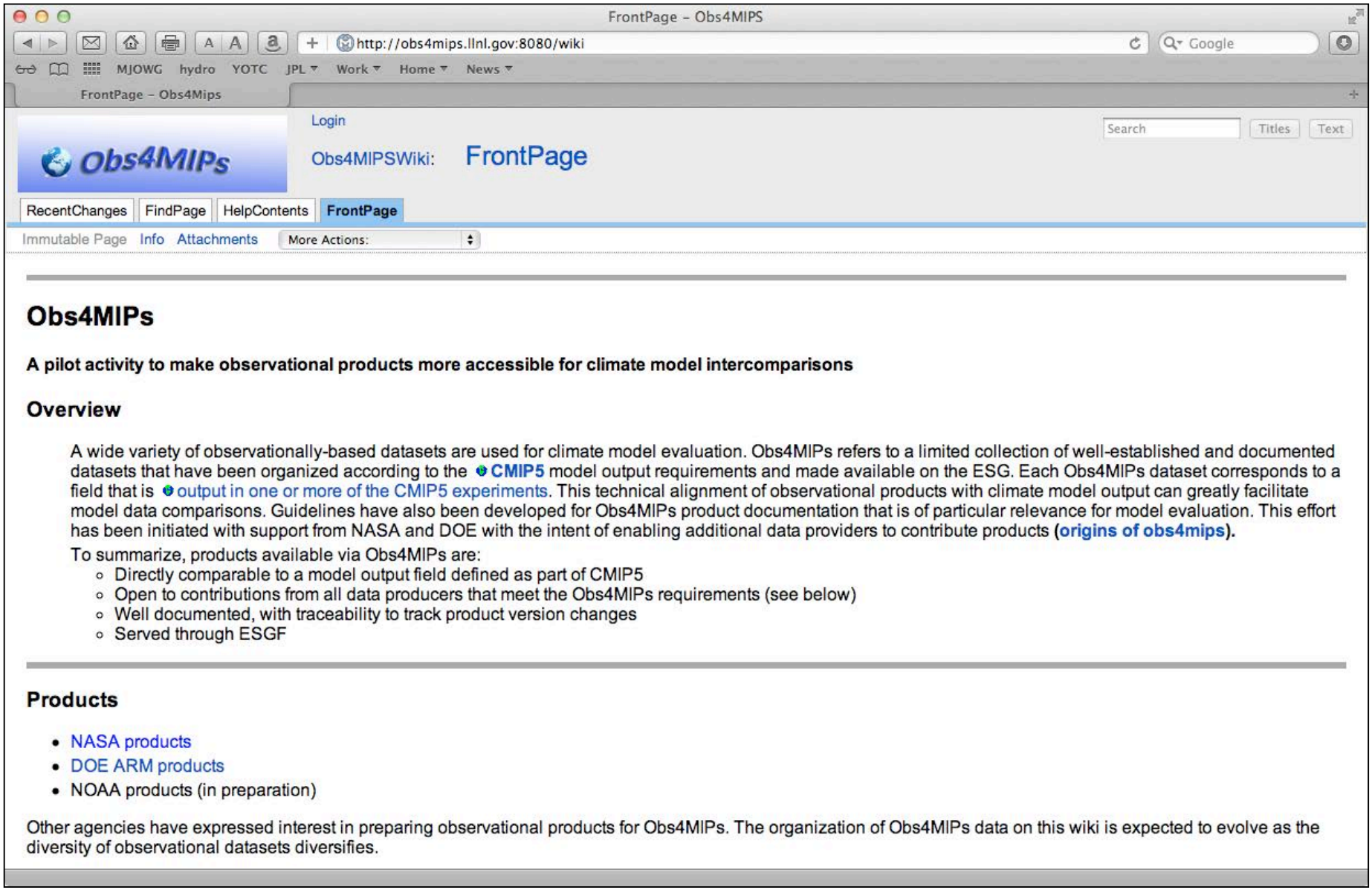
Considerations for Model – Observation Intercomparison

Instrument Overview

References

Revision History

obs4mips Wiki : Documentation and Expansion



Satellite Observations for Evaluating CMIP5 SUMMARY

- NASA-PCMDI pilot Project to establish a (satellite) observation capability for the climate modeling community to support model-to-data intercomparison. This involves IT, satellite retrieval, data set, modeling and science expertise.
- ~13 satellite-based datasets currently available on the ESG – more coming; including sea ice, with near-term effort to identify a snow cover, aerosol, additional land and composition products, and CFMIP cloud products.
- We are seeking inputs with CMUG/ESA, have engaged CEOS-Climate Working Group and work closely with the WGNE/WGCM Climate Metrics Panel.
- **A priority now is to increase collaboration with other agencies and international partners to expand this effort and solicit feedback from model analysis community.**
- NASA has formed a Science Working Group, including rep from PCMDI and NOAA to help guide the expansion and direction of this activity. The activity has already expanded to include ARM and reanalysis data sets.

(Satellite) Observations for IPCC / Climate Modeling

Future Emphases and Needs

- Identify additional observations to include in this activity.
- Continue to develop cultivate collaboration / data utilization from NOAA and international (e.g. ESA CCI) partner data sets.
- Maintain/Strengthen links to WGCM/WGNE Climate Metrics Panel.
- Continue to work with the ESG community and PCMDI to facilitate the *means* to utilize the observations for model evaluation.
- Encourage satellite and other observing programs to develop products analogous to model output.
- Encourage modeling community to develop the means to output quantities analogous to satellite retrieved or other observed quantities.
- Encourage satellite programs to provide modeling community with satellite simulators for more direct comparisons with observations (e.g. CFMIP).
- Provide guidance on future funding solicitations.
- Cultivate more coherent input from the modeling community on observations critical to model development/evaluation.

Challenges and Questions

Specific areas that present challenges and questions include:

•What observations go into obs4MIPs*? A fundamental criteria is there has to be a 1-to-1 correspondence with a CMIP model output variable. A second criteria is that the product be well documented with peer-reviewed publications, ideally with examples of use for model evaluation.*

•What to do when there is more than one observation product for a given variable – 1) keep it simple for the user and attempt to choose the "best", 2) select the "best" two to account for some observational uncertainty, 3) select more than two if available but run the risk of the offerings become overly complex for the non-expert. For 1) and 2) – by what criteria is this decided?

•What if the data sets don't quite match e.g. product is total column (ozone) but CMIP only requests the vertically resolved profile?

•What guidelines should there be regarding update frequency and process?

•Who provides quality control over the technical documentation and data set content?

•Thus far technical documents were made one per variable, in some cases it may be advantageous to document more than one in the same technical note, how is this decided?

Recommendation

What role could WDAC play for Obs4MIPs?

- General oversight on the advancement of Obs4MIPs

e.g., via annual updates provided to WDAC, and along the lines of the AMIP and CMIP panels established by the WGNE and WGCM to guide climate model intercomparisons.

WDAC establish an Obs4MIPS panel to:

- Ensure that the datasets contributed to Obs4MIPs are appropriate for model evaluation
- Advance guidelines that are used to recommend, select and document the data
- Identify the highest priority observations for model diagnostics and evaluation
- Encourage additional contributions to Obs4MIPs and promote activity

WDAC Obs4MIPs panel membership and organization

- NASA volunteer to chair the group and provide some support for annual meetings
- Membership should consist of a mix of observation providers and model experts
- WDAC/WCRP to recommend members
- Obs4MIPs to report annually to WDAC/WCRP and WMAC/WCRP

Appendix I

Data Set Recommendation Form

obs4MIPs Data Set Form
Draft V 1.0; June 23, 2012

To complete this document, you will need to refer to:
http://cmip-pcmdi.llnl.gov/cmip5/docs/standard_output.xls
and be aware of the "technical note template" that can be found at:
http://obs4mips.llnl.gov:8080/wiki/requirements

1. **Proposer's Contact Information**
   - Name : _____
   - Email : _____
   - Phone : _____
   - Affiliation : _____
2. **Physical Quantity :** _____
   (e.g. zonal surface wind, total column water vapor)
3. **Data Set "Common Name" :** _____
   (if variable has a well-recognized, commonly used name, provide here, otherwise leave blank)
4. **CMOR Long Name from *standard_output.xls*:** _____
   (e.g. "Eastward Near-Surface Wind", "Water Vapor Path")
5. **Worksheet Name and Row Number from *standard_output.xls*:** _____
   (e.g. "Amon 22", "Amon 53")
6. **Data Set Producer:** _____

   _____

   _____
   (e.g. NASA and mission team, DOE and organization, NOAA and organization, PI and Institution; where possible include a specific contact name, organization, email, and phone number)
7. **Responsible party or parties for data set delivery according to obs4MIPs requirements, including proper file formatting and technical note development:**

   Science Contact: _____

   _____

   Technical Contact: _____

   _____
   (e.g. Include a contact name, organization, email, and phone number)

1. **Primary observation basis: satellite, in-situ, or re-analysis :** _____

   _____
2. **Temporal Character :** _____
   (e.g., monthly, daily, mean annual cycle)
3. **Time Span :** _____
   (e.g., 1979-1987; Mar 1999 to Sep 2007; Jan 2002 to present)
4. **Spatial Domain :** _____
   (e.g., global, tropics, land-only, poleward 60N, and combinations)
5. **Spatial Resolution :** _____
   (e.g., 100km, 0.5°)
6. **Relevant Website if available :** _____
7. **Any Established Procedure or Frequency for Updates :**

   _____

   _____

   _____
8. **Principle Publication(s) on Dataset Description and/or Methodology:**

   _____

   _____

   _____
9. **If available, publications on Dataset Validation and/or Uncertainties:**

   _____

   _____

   _____
10. **If available, publications illustrating application to model evaluation:**

    _____

    _____

    _____

Appendix II

Example Technical Documentation: AIRS Specific Humidity

Atmospheric Infrared Sounder/Advance Microwave Sounding Unit (AIRS/AMSU)

Specific Humidity Description

1. Intent of This Document

1a) This document is intended for users who wish to compare satellite derived observations with climate model outputs in the context of the CMIP5/IPCC historical experiments. Users are not expected to be experts in satellite derived Earth system observational data. This document summarizes essential information needed for comparing this dataset to climate model outputs. References are provided at the end of this document to additional information for the expert user.

This NASA dataset is provided as part of an experimental activity to increase the usability of NASA satellite observational data for the model and model analysis communities. This is not a standard NASA satellite instrument product. It may have been reprocessed, reformatted, or created solely for comparisons with the CMIP5 model. Community feedback to improve and validate the dataset for modeling usage is appreciated. Email comments to HQ-CLIMATE-OBS@mail.nasa.gov .

Dataset File Name (as it appears on the ESG):

hus_AIRS_L3_RetStd-v5_200209-201105.nc

husStderr_AIRS_L3_RetStd-v5_200209-201105.nc

husNobs_AIRS_L3_RetStd-v5_200209-201105.nc

1b) Technical point of contact for this dataset:

Baijun Tian, Baijun.Tian@jpl.nasa.gov

2. Data Field Description

CF variable name, units:	hus, 1
Spatial resolution:	The vertical resolution is determined by the CMIP5 mandatory levels. The longitude and latitude resolution is 1 degree by 1 degree.
Temporal resolution and extent:	This data product is a regularly gridded, monthly averaged specific humidity measured by AIRS between September 2002 and May 2011.
Coverage:	Global.

Note: The vertical pressure levels (plev) include all the CMIP5 mandatory levels from 1000 hPa to 10 hPa. However, we only provide the data up to 300 hPa and assign a missing value (1.e20) for levels above 300 hPa because AIRS measurements are not as reliable for levels above 300 hPa as other instruments such as Microwave Limb Sounder (MLS), which is specially designed for the accurate measurements of the atmospheric profiles in the upper troposphere and lower stratosphere.

3. Data Origin

The data used to make this product was obtained from the Goddard Earth Science (GES) DISC data access [1].

The AIRS/AMSU instrument suite is carried on the NASA Aqua spacecraft, in a sun-synchronous orbit at 1:30 local time. The southward/northward moving observations are obtained during daytime/nighttime. (See Section 6 below for an Overview of the AIRS/AMSU instrument suite.) The AIRS/AMSU specific humidity is derived from infrared and microwave radiances measured from space, so is not an *in situ* measurement. The infrared emission radiations emitted by different Earth scenes are remotely sensed by a spectrometer, and the microwave observations are obtained by a radiometer [2]. A single AMSU channel provides a constraint on total precipitable water vapor. First, measurements are transformed into calibrated radiances for all footprints and all channels [3]. Then, physical quantities such as the specific humidity are derived ('retrieved') from these geolocated radiance products [4]. The retrieved physical quantities are then averaged over a month [5]. The data we obtained from the GES DISC [1] was at this last processing level. We then applied an additional processing step to adapt the data according to the CMIP5 model output format.

This data product is the monthly average of the AIRS/AMSU retrieved specific humidity profiles in the regularly gridded 1 degree by 1 degree latitude and longitude boxes. In the AIRS/AMSU original data [1], the specific humidity is reported in terms of layer averages. In order to convert from layer amounts to level amounts, we treat the original layer averages as level amounts at the midpoint in log(pressure) of the layers and then logarithmically interpolate in log(pressure) to the desired levels. For the 1000 hPa level this interpolation is replaced by an extrapolation. The extrapolation is done logarithmically in log(pressure) just like the interpolation. It has to be an extrapolation because there is no layer with a higher midpoint pressure than 1000 hPa.

The values described here are means of the daytime and nighttime values, provided there are enough observations in each category to make the values statistically significant. The minimum is 20 observations each, except for latitudes beyond +/- 80 degrees, where we relax the limits to compensate for a much lower number of observations. Since clouds have a significant effect on observed infrared radiances (see section 5.1 below), the retrieval process includes steps to retrieve the specific humidity from radiance in the presence of clouds. The horizontal resolution of each AIRS/AMSU scene is 45 km, and the instrument samples in a swath are 30 scenes wide (see Figure 3 below), yielding 324,000 scenes per day. However, the specific humidity can be inferred in about 70% of these scenes, with the remainder affected by thick clouds or precipitation.

Appendix II…cont

Example Technical Documentation: AIRS Specific Humidity

4. Validation

AIRS retrievals have been validated against a variety of in situ data (radiosondes, airborne sun photometer, ship based measurements), other remote measurements from other satellites and model-generated data (fully coupled global ocean- atmosphere General Circulation Models, collocated model forecasts compared with radiosondes). The table below summarizes these findings and can be found in reference [6].

Geophysical Conditions Studied	Uncertainty Estimate
Non-polar ocean, surface to 300 hPa	15-25%
Non-polar land 2 km to 300 hPa.	15-25%
Non-polar land, surface to 1-2 km	30-40%
Polar	30-40%
Tropical upper troposphere.	25%
Middle and high latitude upper troposphere.	30-50%

Table 1: uncertainty estimate for different conditions.

The uncertainty estimates are calculated based on the difference between AIRS retrievals and radiosonde observations. They are given for 2 km layers.

5. Consideration for Model-Observation Comparisons

Because this data product is observational data, there are several aspects that distinguish this product from model outputs. The user of this data product should be aware of them in order to make judicious model-observation comparisons.

5.1 Clouds influence

AIRS/AMSU coverage is limited by the presence of optically thick clouds because AIRS is an infrared instrument. The combination of infrared and microwave radiances allows retrieval of high-resolution humidity profiles for infrared cloud fraction (the product of emissivity and

coverage) up to about 70% [7]. This limitation of the infrared measurement makes the AIRS/AMSU observation scene dependent and in turn, causes a spatially inhomogeneous sampling as illustrated on Figure 1. The AIRS sampling is low (~60) in cloudy regions, such as the Intertropical Convergence Zone (ITCZ) (e.g., the equatorial western Pacific warm pool) and the midlatitude storm tracks (e.g., north Pacific, north Atlantic and 60°S latitude belt). The AIRS sampling is high (~150) in clear regions, such as subtropics and midltitude land regions. See reference [8] for more on the implication of cloud-induced sampling in AIRS/AMSU observations.

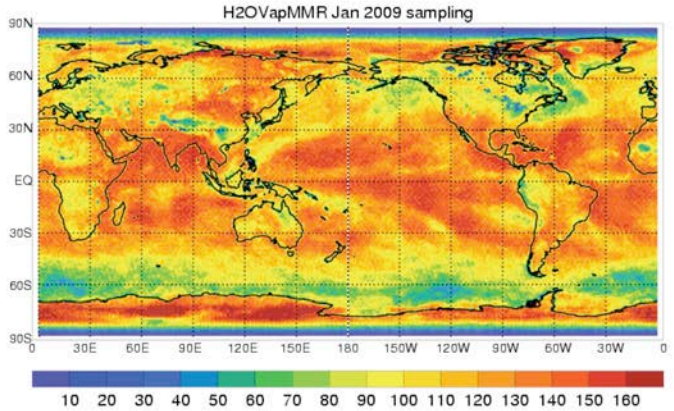


Figure 1: Water vapor sampling at 550 hPa for the month of January 2009.

5.2 Asynoptic Time Sampling

Because Aqua satellite is in a sun-synchronous polar orbit, AIRS samples the atmosphere at two fixed local solar times at each location (e.g. 1:30 AM and 1:30 PM at the equator) and cannot fully resolve the diurnal cycle. In contrast, typical model monthly averaged outputs contain the averaged values over a time series of data within a fixed time interval (e.g. every 6 hours). For specific humidity over ocean and in the upper atmosphere with a small diurnal cycle, this difference is not likely a problem. However, for specific humidity in the boundary layer or over land regions strongly influenced by the diurnal cycle, this time sampling limitation should be considered.

Appendix II…cont

Example Technical Documentation: AIRS Specific Humidity

5.3 Inhomogeneous Sampling

Because the monthly averaged value in this AIRS data product is an average over observational data available in a given grid cell (see Figure 1), the number of samples used for averaging varies with the geo-location of the cell. Because of the convergence of longitude lines near the poles, the time range of data collection broadens as one moves from the equator toward either pole, with the ranges in the polar regions including all times of day and night [9]. So, there are more observations in the regions near the poles (~70° to ~85°) than the rest of the area.

5.5 Missing data

AIRS went into a safe mode at the end of October 2003 to avoid possible damage from a large solar flare. It did not resume data flow until mid November 2003. Our preparation of this product for CMIP5 added a requirement of a minimum number of observations for each grid square from each of ascending and descending orbits. With only half of a month data, many grids cells do not meet these criteria for November 2003. The only significant outage since December 2003 was the safe mode event from January 9th to the 26th, 2010. So the January 2010 product has about half the data of a full month. However, there should be no bias introduced in comparing the data from January 2010 to January of other years.

Furthermore, we excluded the AIRS data within 100 hPa above the land surface. As a result, most AIRS data are missing over land for 1000 hPa and 925 hPa levels.

6. Instrument Overview

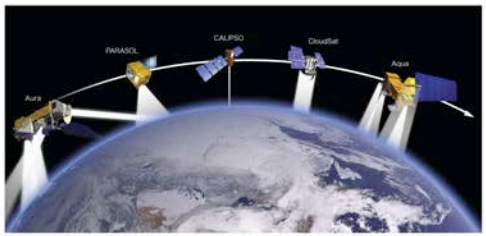


Figure 2: NASA's A-train group of Earth observing satellites.

Launched into Earth-orbit on May 4, 2002, Aqua is part of NASA's "A-train" satellite constellation (see Figure 2), a series of high-inclination, Sun-synchronous satellites in low Earth orbit designed to make long-term global observations of the land surface, biosphere, solid Earth, atmosphere, and oceans. The Atmospheric Infrared Sounder (AIRS) and its partner microwave instrument, Advanced Microwave Sounding Unit (AMSU), share the Aqua satellite with the Moderate Resolution Imaging Spectroradiometer (MODIS), Clouds and the Earth's Radiant Energy System (CERES), and the Advanced Microwave Scanning Radiometer-EOS (AMSR-E). AIRS/AMSU observe the global water and energy cycles, climate variation and trends, and the response of the climate system to increased greenhouse gases. The term "sounder" in the instrument's name refers to the fact that temperature and water vapor are measured as functions of height.

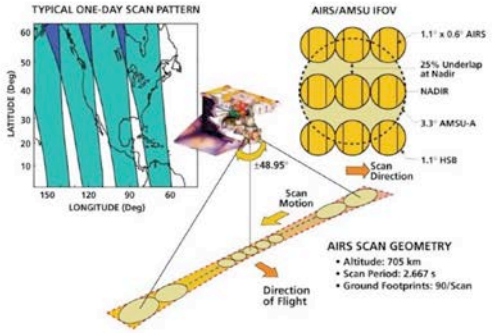


Figure 3: AIRS scanning and coverage geometry.

AIRS coverage is pole-to-pole and covers the globe two times a day. Because the swaths (scanning sweeps) do not overlap at low latitudes, some points near the equator are missed. However, these points are eventually scanned within 2-3 days. As depicted on Figure 3, AIRS scans laterally with respect to its direction of flight. With the scanning angle being 49.5 degree about nadir, the swath width is 1650 km. One orbit period is 98.8 minutes [10].

Appendix II…cont

Example Technical Documentation: AIRS Specific Humidity

7. References

[1] http://disc.sci.gsfc.nasa.gov/AIRS/data-holdings

[2] Hartmut H. Aumann *et al.* (2003), "AIRS/AMSU/HSB on the Aqua Mission: Design, Science Objectives, Data Products, and Processing Systems", IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING, VOL. 41, NO. 2.

[3] Level-1B AIRS IR

[4] Level-2 Standard Products Quick Start

[5] Level-3 Standard 1x1° Gridded Products Quick Start

[6] V5_CalVal_Status_Summary.pdf, page 8. Note: there are some errors in the document V5_CalVal_Status_Summary.pdf, page 8. We corrected these errors in the present document.

[7] Joel Susskind *et al.* (2003), "Retrieval of Atmospheric and Surface Parameters From AIRS/AMSU/HSB Data in the Presence of Clouds", IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING, VOL. 41, NO. 2, page 390.

[8] Fetzer, E. J., *et al.*, (2006), Biases in total precipitable water vapor climatologies from Atmospheric Infrared Sounder and Advanced Microwave Scanning Radiometer, *J. Geophys. Res., 111*, D09S16, doi:10.1029/2005JD006598.

[9] Claire L. Parkinson (2003), "Aqua: An Earth-Observing Satellite Mission to Examine Water and Other Climate Variables", IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING, VOL. 41, NO. 2.

[10] http://airs.jpl.nasa.gov/instrument/coverage/

8. Revision History

Rev 0 – Tuesday, September 6, 2011