An Assessment of Radiation at the TOA and Surface as Derived from Satellite and In-Situ Surface Measurements

Under the Auspices of the GEWEX Radiation Panel

June 11, 2008

Note: Red text indicates work that cannot be done with the data currently included in the RFA archive.

1.0 Executive Summary

2.0 Introduction

Chapter lead: Rossow

2.1 Assessment Objectives

2.1.1 Decadal variability
2.1.2 Defining accuracy of TOA and surface data
2.1.3 Long term goal is merged TOA, atmosphere, sfc Data

Responsible: Rossow with Wielicki, Stackhouse, Raschke, Ohmura

2.2 Observation System Requirements

2.2.1 Climate model natural variability: defining the limits of observing system accuracy.
2.2.2 Observing requirements driven by climate radiative forcing, cloud feedback, aerosol indirect effect issues.
2.2.3 Long term goal is climate prediction uncertainty driven requirements (climate prediction.net example)

Responsible: Rossow with Slingo/Wielicki/Stackhouse

3.0 Conclusions and Recommendations

Chapter leads: Wielicki and Stackhouse

3.1 Assessment of TOA fluxes

3.2 Assessment of Surface fluxes

3.3 Assessement of Atmospheric Divergence

3.4 Identification of Key issues

4.0 Incoming Solar Radiation at TOA

Chapter lead: Raschke with Kopp

4.1 Uncertainties of Solar Constant Measurements

4.2 Global/Seasonal Distribution

4.3 Representation in Satellite Products

4.4 Survey of Models

5.0 Long-Term TOA Flux Data Product Comparisons

Chapter leads: Wielicki and Rossow

5.1 TOA Flux Comparison Studies

5.1.1 Monthly Gridded Maps
Parameters: for All-sky and Clear-sky (Type 1&2)
- SW up, LW up, SW down
- for entire record length
- in native grid
Responsible: (Wong)

5.1.2 Monthly Time Series: Global Land/Ocean, Zonal Land/Ocean
- parameters same as in item 3.2.1
- Hovmöller Latitude/Time: monthly by native grid latitude steps
- viewable picture plus downloadable ascii files
Responsible: (TBD Rossow, Wielicki, Stackhouse, Harries, Hollmann)

5.1.3 Seasonal Gridded Map of Diurnal Cycle
- provide Time of Max, Time of Min, Max-Min Amplitude
- every season in data set.
- DJF, MAM, JJA, SON
- diurnal cycles constructed by averaging at each local time of day then over month/season
Responsible: (Rossow, Wielicki, Stackhouse, Harries, Hollmann)

5.1.4 Characterize Variability of Global, Zonal, Regional

5.1.4.1 Observation Variability
- provide Tables of variability
- land and ocean separated
- standard deviation for the same TOA flux parameters as in 5.1.1 and same surface flux parameters used in 6.2 comparisons
- instantaneous, daily, monthly, seasonal, annual, decadal time scales
- grid scale for all time scales
- zonal, global for monthly to decadal time scales
- provide for all observation data set (e.g. ERBE, CERES, SRB, FD, GERB)
Responsible: Wong and TBD for time series

5.1.4.2 Model Variability
- same variables and space/time scales as observations in 5.1.4.1
- provide for Climate Models in coupled ocean/atmoshere runs with fixed boundary conditions (long-term equilibrium control runs) (e.g. UKMO, NCAR, CCSR, GFDL, MPI, LMD)
- provide for Climate Models in coupled ocean/atmosphere 20th century forcing runs. same models as fixed boundary conditions
- provide for Reanalysis Models (e.g. ERA-40, GEOS-4, NCEP/NCAR)
- used for setting observation requirements and for evaluation of model variability.

Responsible: Slingo contact modeling centers)

5.1.5 Time Series at Selected Surface Sites

5.1.5.1 Surface flux working group identifies list of surface sites for long time series comparisons to satellite data. Includes BSRN, ARM, CMDL,SEAFLUX (ships and buoys), Ocean Reference Buoys (Weller)

5.1.5.2 Clarify impact of 3-hourly average flux (FD, CERES), versus instantaneous 3-hourly flux (SRB)

5.1.5.3 Time series plots of satellite/surface comparisons
- satellite grid box to individual surface sites
- satellite grid box to average of sites in box
- satellite pixels to surface sites

5.1.5.4 Time series done for both TOA and Surface satellite fluxes and surface site flux.

Responsible: Rossow: will subset FD over surface site, Rutan will subset CERES (CAVE), Stackhouse will subset SRB

5.1.6. High Time/Space Resolution Comparisons: June and July 2004
- global, but focus on GERB/MSG area
- focus on diurnal cycles
- TOA/SFC combined activity
- Provide full space/time resolution of all data
- Expect spring 2005 availability of CERES and GERB. ISCCP/FD/SRB by Dec 2004.
- SAFs
- CEOP sites (DAAC subset sat data?)

Responsible: (Richard Bantges)

5.1.7 Error Budget at Varying Time and Space Scales
- statistics for errors include
- mean, stddev of each data set (validating and estimating)
- mean stddev of difference of two data sets
- correlation coefficient of two data sets
- slope of regression, uncertainty of slope
- intercept, uncertainty of intercept
- number of points used in comparison
- 20-50 km: instantaneous, daily, monthly, annual, decadal. bias/sigma
- 100-250km spatial: instantaneous, daily, monthly, annual, decadal
- zonal monthly, annual, decadal
- global monthly, annual, decadal

- cloud regimes: 250km, instantaneous, daily, monthly, annual, decadal
- all-sky vs. clear-sky
- objects, instantaneous, daily, monthly, annual, decadal

- Taylor diagrams and scatter plots for visualization and table of numbers
Responsible: (Loeb)

6.0 Long-Term Surface Flux Data Product Comparisons

Chapter leads: Stackhouse, Wild, and Ohmura

6.1 Surface In-Situ Measurement Product Comparisons

6.1.1 Measurement Uncertainty Estimates (*Responsible: Dutton*)

Proposed Content:

Establish uncertainty characteristics of the following parameters:

- Parameters for comparison: All-sky and Clear-sky; SW dn, SW dir dn, SW dif dn, SW up, LW dn, LW up
- Temporal Averages: Monthly, daily averaged, monthly averaged diurnal cycles,1-3 hour average, Instantaneous

6.1.1.1 Uncertainty analysis for various time scales up to annual averages to be completed (Dutton, Long, others?)

- BSRN (including SurfRad)
- CMDL??
- GEBA??
- Upward measurements will be characterized for quality
- Both downward and upward can be characterized for instantaneous measurement spatial scales

6.1.1.2 Relative importance of absolute accuracy vs. long-term stability
6.1.1.3 Best practices for monthly and monthly diurnal averaging

Proposed Conclusions and Recommendations

• BSRN surface measurements have established operational uncertainty of +/- 5 W m^{-2} for most parameters.
• BSRN-quality long-term uncertainty estimates to standard of approximately 0.1% (Paul, what does this mean?)
• In general, the assessment team recommends that monthly means be computed from a monthly averaged diurnal cycle.

- Algorithms for computation of monthly averages show that data gaps can make differences up to a maximum 10 W m^{-2}.
- Differences depend upon the algorithm and the nature of the data gaps.

6.1.2 Summary of In Situ Surface Flux Derived Products (*Responsible: Long*)

Proposed Content:

6.1.2.1 Available Derived Products
- Identify available products for this report
- Include some explanation of the products (may just point to documentation, references and/or appendices)

6.1.2.2 Quality and Uncertainty of Derived Products
- detectibility limits summarized for cloud detection/cloud optical depths, etc.

Proposed Conclusions:

- Flux derived products provide a powerful constraint for comparison of measurements to satellite-estimates, especially clear/cloudy sky scene identification.

6.1.3 Long-Term Surface In Situ Time Series Analysis (*Responsible: Liepert, Wild(?)*)

Proposed Content:

6.1.3.1 Long-term mean and variability characteristics of 6.1.1 parameters
- Issues relating to surface in-situ measurement stabilities.
- autocorrelation, Fourier, EOF, other descriptions?

6.1.3.2 Analysis of ensembles of point measurements
- Potential effects of local processes
- Ensembles scalable to regions? What processes determine?

6.1.3.3 Choosing statistical methods for long-term time series analysis
- Describe statistical characteristics of data sets that are important in the use statistical methods treating processes (like autocorrelation) for determination of long-term changes and variability
- Bias removal? Calibration drift removal?

6.1.3.4 Summary of Analysis of Long-term Flux Products

Proposed Conclusions:

- Long-term surface measurements establish an important and reliable representation of natural and long-term variability that should be detectible by satellite measurements
  - Depends on space and time scales
- Spatial ensembles of surface measurements may not necessarily be indicative of larger scale (i.e., continental, oceanic, global)
  - Point-spatial representativeness depends on location's dominant large-scale features (seasonal dependence?)
  - Local scale changes regarding total aerosols/urbanization must be characterized
  - An ensemble of surface measurements may not necessarily correlate with global mean changes

- However, regional changes due to global processes may be represented and resolved above noise (Has this been proven?)

- Estimation of long-term changes requires more rigorous statistical definition
  - Changes should not always be assumed linear
  - More robust measures of confidence needed
- Derived flux products time series useful for explaining long-term changes (or limiting potential causes)

6.1.4 Surface in-situ measurement needs and issues (*Responsible: Rutan, Dutton*)

Proposed Content:

6.1.4.1 Spatial representativeness of sites - site to site studies only??
- Summary of ARM results (Long et al)
- Other studies available?

6.1.4.2 Unsampled climate types and regions (oceans??)

6.1.4.3 Summary of issues related to ocean measurements (Weller? Ohmura?)
- Does lack of validation of satellite over ocean surfaces compromise ocean surface albedo estimation (is ocean reflectance models now the most reliable?) and effects of thin clouds and aerosols (missing physics???)?
- Undersampling of oceans due to limited platforms compromises ensemble usage of measurements for estimate of global radiative flux trends

6.1.4.4 Measurements needed for poorly characterized spectral bands (Pinker)
- UV and PAR

6.1.4.5 Characterization/usefulness of upwelling measurements

The following sections have been moved to the appendix:

6.1.4.3 Operational uncertainties due to precipitation and other meteorology

6.1.4.4 Biases of older pyranometer measurements due to thermal offset problems

Proposed Conclusions:

- The degree to which data from a site is representative of a region depends upon the temporal averaging scale.
  - An ensemble of surface measurements may not necessarily correlate with global mean changes
  - However, regional changes due to global processes may be represented and resolved above noise (Has this been proven?)

6.1.5 Summary
- Recommend more collocated radiative and aerosol measurements?

6.2 Satellite Estimate-Surface In-Situ Measurement Comparisons

6.2.1 Statistical Analysis *(Responsible: Stackhouse, Hinkelman)*

Proposed Content:

Bias, RMS, and correlation for various time-space scales (polar, mid-latitudes, tropics, surface climate types; use long and limited-term in-situ surface measurements)

- Parameters for comparison: All-sky and clear-sky; SW dn, SW dir dn, SW dif dn, SW up, LW dn, LW up
- Temporal Averages: Monthly, seasonal, annual, daily averaged, monthly averaged diurnal cycles,1-3 hour average, instantaneous
- Monthly-diurnal in terms of transmission?
- Include higher resolution comparisons by reference (Hollmann)

- Difference with surface measurements scale with temporal averaging according to sample size showing effects of time/space subsampling noise (quantify?)
  - Use GEWEX RFA data sets only (2.5° data)
  - Monthly, seasonal, and annual scales

Proposed Conclusions:

- Ensemble differences between GEBA and BSRN sites and SW satellite data from various data sets at 2.5° resolution vary from 15 to 25 W m^{-2}.
  - Systematic differences exist and some are large.
  - These differences are attributed mostly to uncertainties in input quantities.

6.2.2 Long-term Time Series Characteristics *(Responsible: Hinkelman and others)*

Proposed Content:

- Long-term mean and variability characteristics of same parameters.
- Long-term intercomparison of correlations; issues (satellite and in-situ measurement stabilities).

Proposed Conclusions:

- SRB/ISCCP long-term satellite products are consistent with long-term BSRN measurements to within 4 W m^{-2} SW and 3 W m^{-2} LW.
  - Changes in ensembles of surface measurements are useful for evaluation of satellite flux estimate variability.
  - Currently observed long-term linear changes are not large enough compared to noise to establish statistical significance of changes within (quantify limits here).
  - However, large (quantify) changes can be determined to be outside the acceptable levels of variability.
- Observed long-term changes are highly sensitive to gaps in surface measurements and/or large changes at ends of time series.

- The most contiguous ensembles of surface sites show no long-term linear changes, but rather show significant fluctuations.
- Satellite time records correlate well with these fluctuations.
- Long-term records of contiguous sites do not show statistical significance in determining globally linear changes.

6.2.3 Issues in satellite-surface validation *(Responsible: Rutan, Zhang, et al.)*

Proposed Content:

- SRB/ISCCP Tables of sensitivities of fluxes to uncertainties in input properties
  - skin temperature
  - albedo variability
  - aerosol absorption and heterogeneity
  - cloud heterogeneity (function of cloud type)
- Space-time sampling and mismatching issues
- Representativeness of upwelling fluxes (from measurements)

Related work:

Single vs. 5 pyranometers (Ohmura)
Data upscaling (Pinker)
Long study, Li study

Proposed Conclusions:

- Near surface properties largest uncertainties for LW fluxes: 4 W m^{-2} SW and 3 W m^{-2} LW.
- Albedo: +/- 0.07% uncertainty??
- Other examples

6.3 Satellite-based Surface Radiation Budget Data Product Comparisons

6.3.1 Long-term characteristics *(Responsible: Zhang)*

Proposed Content:

Comparisons of monthly averaged maps
Parameters: All-sky and clear-sky; SW dn, SW dir dn, SW dif dn, SW up, LW dn, LW up
- for entire record length
- if diurnal cycle include 3-hourly monthly
- use GEWEX-RFA resolution data sets

Proposed Conclusions:

6.3.2 Monthly Time Series: Global Land/Ocean, Zonal Land/Ocean
(Responsible: Kinne, Raschke)

Proposed Content:

Characterize variability on different time/space scales
- parameters same as in item 6.3.1
- Hovmöller Latitude/Time: monthly by native grid latitude steps
- viewable picture plus downloadable ascii files

Proposed Conclusions:

- SRB/ISCCP-FD globally averaged changes show significant fluctuations that are largely consistent (within σ = 2-4 W m^{-2}), but not large enough relative to variability to establish long-term trends with statistical significance (definition according to Weatherhead)
  - ISCCP and SRB are not currently sufficiently accurate to directly observe decadal trends. New methods of intercalibration with ERBS and/or deep convective clouds should be explored to improve the 1983 through current ISCCP/SRB record. This is key given the 15-20 year time series at climate accuracy needed for climate change detection of SW flux equivalent to low cloud feedback.
  - Statistical significance of regional changes can be established (i.e., Australia) despite the noise (quantify slope/noise measures?)

6.3.3 Monthly Diurnal Cycle *(Responsible: TBD. Delete section?)*

Proposed Content:

- provide Time of Max, Time of Min, Max-Min Amplitude
- every season in data set.
- DJF, MAM, JJA, SON
- diurnal cycles constructed by averaging at each local time of day then over month/season

Responsible: (Rossow/Zhang, Stackhouse, Pinker, others?)

Proposed Conclusions:

6.3.4 Characterize Variability of Global, Zonal, Regional
(Responsible: Friedenreich, Kinne, Wild)

6.3.4.1 Observation Variability

Proposed Content:

- provide tables of variability

- land and ocean separated
- standard deviation for the same surface flux parameters as in 6.3.1 and same surface flux parameters used in 4.5 (??) comparisons
- instantaneous, daily, monthly, seasonal, annual, decadal time scales
- grid scale for all time scales
- zonal, global for monthly to decadal time scales
- provide for all data sets

Responsible: Rossow, Stackhouse, Pinker, Rutan

Proposed Conclusions:

- SRB/ISCCP-FD: significant zonal averages found to +/- 50 W m^{-2}
- Long-term zonal averages show lesser uncertainty (mean, range)
- Results in terms of zones, surface types
  - However, large (quantify) changes can be determined to be outside the acceptable levels of variability.

6.3.4.2 Model Variability (not too long, since data not included)

Proposed Content:

- same variables and space/time scales as observations in 6.3.4.1
- provide for climate models in coupled ocean/atmoshere runs with fixed boundary conditions (long-term equilibrium control runs) (e.g. UKMO, NCAR, CCSR, GFDL, MPI, LMD)
- provide for climate models in coupled ocean/atmosphere 20th century forcing runs. same models as fixed boundary conditions
- provide for reanalysis models (e.g. ERA-40, GEOS-4, NCEP/NCAR)
- used for setting observation requirements and for evaluation of model variability.
- sensititivity studies for inputs (by literature reference)
- run algorithms with same inputs? (Stefan)

Proposed Conclusions:

- Something about GCM cloud shortcomings

6.3.5. High Time/Space Resolution Comparisons: July 2004 and January 2005
(Responsible: Hollmann)

Proposed Content:

- global, but focus on GERB/MSG area
- focus on diurnal cycles, evaluate using SEVIRI
- TOA/SFC combined activity

- Provide full space/time resolution of all data
- Expect spring 2005 availability of CERES and GERB. ISCCP/FD/SRB by Dec 2004.
- SAFs
- CEOP sites (DAAC subset sat data?)

Proposed Conclusions:

- Higher spatial/time resolution better resolve only certain local effects at monthly scale, but do significantly reduce RMS. However, increased space/time do decrease shorter time averaged estimates. 5

6.3.6 Summary Uncertainty Budget at Varying Time and Space Scales
(Responsible: Stackhouse, Wild, Ohmura)

Proposed Content:

- Statistics for errors include
    - mean, stddev of each data set (validating and estimating)
    - mean stddev of difference between data sets
    - correlation coefficient between data sets
    - slope of regression, uncertainty of slope
    - intercept, uncertainty of intercept
    - number of points used in comparison
- Space Scales:
    - 20-50 km: instantaneous, daily, monthly, annual, decadal. bias/sigma
    - 100-250km spatial: instantaneous, daily, monthly, annual, decadal
    - zonal monthly, annual, decadal
    - global monthly, annual, decadal
- Cloud regimes: 250km, instantaneous, daily, monthly, annual, decadal
- Parameters: all-sky vs clear-sky
- Time Scales: objects, instantaneous, daily, monthly, annual, decadal
- Analysis: Taylor diagrams and scatter plots for visualization and table of numbers

Proposed Conclusions:

7.0 Vertical Column Flux Divergence

Chapter leads: Raschke and Zhang

7.1 Current Understanding

7.2 Uncertainties

7.3 Future Needs

8.0 Global Energy Budget Diagram

Chapter lead: Loeb

8.1 Prior Formulation

8.2 Updated Version

8.3 Remaining Uncertainties

Appendices

Appendix A Data Product Descriptions

Chapter lead: Pinker

A.1 Brief Summary of Available Long-Term TOA products

(LW, SW, Net, All-Sky, Clear-sky)

A.1.1. ERBE Non Scanner
- A.1.1.1 Description
- A.1.1.2 Calibration
- A.1.1.3 Conversion to fluxes and time integration
- A.1.1.4 Need to complete nonscanner data: 1999-2004

Responsible: Wong

A.1.2 ERBE Scanner
- A.1.2.1 Description
- A.1.2.2 Calibration
- A.1.2.3 Conversion to fluxes and time integration
- A.1.2.4 Need to reprocess ERBE scanner with CERES ADMs

Responsible: Wong

A.1.3 CERES Scanner
- A.1.3.1 Description
- A.1.3.2 Calibration
- A.1.3.3 Conversion to fluxes and time integration

Responsible: Doelling

A.1.4 GEWEX SRB
- A.1.4.1 Description
- A.1.4.2 Calibration
- A.1.4.3 Conversion to fluxes and time integration

Responsible: Stackhouse (Cox & Mikovitz)

A.1.5 ISCCP FD

A.1.5.1 Description
A.1.5.2 Calibration
A.1.5.3 Conversion to fluxes and time integration
Responsible: Rossow, Zhang

A.1.6 ScaRaB
A.1.6.1 Description
A.1.6.2 Calibration
A.1.6.3 Conversion to fluxes and time integration
Responsible: Vollier, Duvel

A.1.7 UMD HIRS OLR
A.1.7.1 Description
A.1.7.2 Calibration
A.1.7.3 Conversion to fluxes and time integration
Responsible: H.T. Lee, Ellingson

A.1.8 Model Re-Analyses
A.1.9.1 NCEP R2 *Yang?*
A.1.9.2 ERA-40 *Morcrette*
A.1.9.3 GEOS-4 *Wu*

A.2 Brief Summary of Surface In-Situ Measurement Data Products

Poll each dataset for description (i.e., parameters, space and time scales, availability, etc.), method (calibration procedures and estimates of operational uncertainty), and temporal averaging algorithms. For derived data products, this would include a description of input parameters and algorithms, including assumptions made.

Other issues include:
Operational uncertainties due to precipitation and other meteorology
Biases of older pyranometer measurements due to thermal offset problems

A.2.1 Global (multi-continent) data sets
A.2.1.1 GEBA *(Ohmura, Wild)*
A.2.1.2 BSRN *(Wild?)*
A.2.1.3 CMDL *(Dutton)*
A.2.1.4 Long derived parameters *(Long)*

A.2.2 Regional data sets
A.2.2.1 ASRB *(Philipona)*
A.2.2.2 University of Oregon Solar Monitoring Network *(Vignola)*

A.3 Brief Summary of Long-Term Satellite Surface Flux Data Products

Poll each dataset for description (i.e., parameters, space and time scales, availability, etc.), method (general description of input parameters and algorithms including assumptions made), and temporal and spatial averaging algorithms.

A.3.1 Global Data sets:

A.3.1.1 GEWEX SRB *(Stackhouse)*

A.3.1.2 ISCCP FD *(Zhang and Rossow)*

A.3.1.3 ESRB (from ISCCP C2; *Vardavas*)

A.3.1.4 CERES SARB and SOFA (*Rutan and Charlock*) SRBAVG (Doelling) ?

A.3.1.5 UMD Pathfinder (SW, *Pinker*)

A.3.1.6 SWnet (from ERBE, *Li and Leighton*)

A.3.1.7 MODIS based products – SW (*Pinker*)

A.3.1.8 ISIS (*Lohmann*)

A.3.1.9 Re-analysis models:

- ERA 40 (*Morcrette*)
- NCEP R2 (*Yang??*)
- GEOS-4 (*Man-Li Wu?*)

A.3.1.10 GCM's from AMIP II (*Wild and Freidenreich*)

A.3.2. Regional Data Sets

A.3.2.1 GEWEX Continental Scale Experiments (*GCIP/GAPP, LBA, BALTEX, GAME*)

A.3.2.2 Brazilian products

- INPE (*Pereira-solar energy applications, Brazil only*)
- INPE/CPTEC (*operational product, all of S. America*)

A.3.2.3 Tropical surface fluxes (SeaWifs, *Chou*)

A.3.2.4 ISCCP DX (GOES/METEOSAT) (*Pinker*)

A.3.2.5 SUNY-Albany (*Perez et al.*)

A.3.2.6 Polar Fluxes (*Key*)

A.3.2.7 MSG

a. MSG SEVIRI/GERB and NOAA (DWD-SW and LW-*Hollmann and Gratzki*)

b. MSG SEVIRI only (DLR-SW only-*Meyer/Hollmann*)

c. MSG SEVIRI, GOES and NOAA (CMS-SW and LW *Marsouin*)

Appendix B Supporting Detail for Data Error Sources and Estimates

Chapter lead: Dutton

B.1 Satellite TOA Flux Data Product Error Analysis

B.1.1 ERBE Broadband Nonscanner (Wong)

B.1.1.1 Calibration

B.1.1.2 Spectral Sampling

B.1.1.3 Spatial Sampling
B.1.1.4 Viewing Angle Sampling
B.1.1.5 Time Sampling (includes Solar Zenith effects)
B.1.1.6 Gap Filling Methods (missing time/space data)
B.1.1.7 Error Table Summary
- by time scale: instantanous, daily, monthly, annual, decadal
- by spatial scale: pixel, grid, zonal, global
- by cloud type or meteorological regime

B.1.2 ERBE Broadband Scanner (Wong)
Same sections as B.1.1

B.1.3 ScaRaB Broadband Scanner (Viollier)
Same sections as B.1.1

B.1.4 CERES Broadband Scanner (Doelling? From Bruce's slides?)
Same sections as B.1.1

B.1.5 GEWEX SRB (Stackhouse – Cox & Mikovitz)
Same sections as B.1.1

B.1.6 ISCCP FD (Rossow)
Same sections as B.1.1

B.1.7 UMD HIRS OLR (H.T. Lee)
Same sections as B.1.1

B.2 Surface Site Radiative Flux Data Products Error Analysis

B.2.1 BSRN
B.2.1.1 Calibration (Direct, Diffuse)
- Absolute, Stability, Precision, Drift between calibrations
B.2.1.2 Effects of icing, precipitation, condensation
B.2.1.3 Pointing (shading, direct beam)
B.2.1.4. Site Specific Corrections (e.g. obstructions)
B.2.1.5 Gap Filling
B.2.1.6 Site surface homogeneity, horizontal representativeness

B.2.2 CMDL
same as B.2.1

B.2.3 SURFRAD
same as B.2.1

B.2.4 GEBA
same as B.2.1

B.2.8 Long Derived Parameters
same as B.2.1

B.3 Satellite Surface Flux Data Product Error Analysis

B.3.1 GEWEX SRB
B.3.1.1 Calibration
B.3.1.2 Spectral Sampling
B.3.1.3 Spatial Sampling
B.3.1.4 Viewing Angle Sampling
B.3.1.5 Time Sampling (includes Solar Zenith effects)
B.3.1.6 Gap Filling Methods (missing time/space data)
B.3.1.7 Radiative Model Description and Errors (If applicable)
B.3.1.8 Error Table Summary
- by time scale: instantanous, daily, monthly, annual, decadal
- by spatial scale: pixel, grid, zonal, global
- by cloud type or meteorological regime

B.3.2 ISCCP FD
Same sections as in B.3.1

B.3.3 CERES
Same sections as in B.3.1

B.3.4 ESRB
Same sections as in B.3.1

B.3.5 U.Md.
Same sections as in B.3.1

Appendix C Radiative Model Comparisons

Chapter lead: Kato

C.1 Model Descriptions

C.2 Model Results in ICCRCM

C.3 Sensitivity to Input Parameters (table example from Rossow)

C.4 Comparisons using Data Products

C.5 Input Data Sources

C.5.1 Surface Albedo Maps

C.5.2 Surface Emissivity
C.5.3 Aerosol
C.5.4 Solar Spectrum and Solar Constant
C.5.6 Cloud Particle Optics

Appendix D Contributed Chapters

Chapter leads: Co-chairs

D.1 Effect of Ancillary Data on Cloud and Radiation Products
Raschke, Kinne, and Zhang

D.2 Fluxes and Cloud Effects in Climatologies in Global Modeling for the IPCC-4AR
Kinne, Raschke

D.3 Meteorological Regimes (possible)
- Use ISCCP cloud data to classify regimes by cloud pressure/tau frequency distributions. One type for each 250km grid box and each day. Two latitude bands15S to 15N, and 30-65N and 30-65S.
- Have surface sites classify regime using these daily grid box classifications
- Provide co-locator tool to provide classification for any specified lat/lon/day

Responsible: Jakob, Rossow

D.4 Cloud System Classification (possible)
- Instantaneous Cloud Systems from CERES data will be provided for 4 cloud types: trade cu, broken stratus, stratus, and deep convection
- For each cloud system provide location, size, time, cloud physical properties, TOA and Surface fluxes, and ECMWF or GEOS-4 meteorological state profiles (T,q,wind) and advective tendencies.
- Initially Jan-Aug 1998, Mar 2000 TRMM data later additional CERES months.
- provide co-locator tool for finding cloud systems given lat/lon/time.

Responsible: Xu.

Appendix E Lessons Learned

Chapter leads: Co-chairs, local organizing committee

E.1 Data Management
E.1.1 Data Access and Delivery (GEBA example)
E.1.2 Data Analysis Tools
E.1.3 Data Archive: long-term archive issues

E.2 Data gap issues
E.2.1 Satellite
E.2.2 Surface in-situ

E.3 Observation vs. Climate Model Incomparisons in nonparallel world

E.3.1 Twilight issues
E.3.2 Reference altitude

E.4 Assessment Web Site Support

- Web site supported by NASA Langley DAAC or GEWEX web site
- Support for monthly data sets
- All data available and freely accessible
- Current versions of assessment documents, including text drafts
- Current versions of contributed analyses and results
- Pointers to all full resolution data sets
- Full resolution data for June and July 2004.

Responsible: (Chambers and Hinkelman)