Development of a Radiation Climate Data Record Combining ERBE and AVHRR

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Outline

- Brief Project Overview
- Approach
- Results/Accomplishments (unfiltering process, SSF product produced with AVHRR clouds and CERES Aqua ADMs)
- Validation Strategy/Results (ERBS, NOAA9, NOAA10, nonscanner and scanner)
- Algorithm/Product Maturity
- Issues (Aerosol optical properties)
- Schedule
- Transition Plan
- Societal Benefits
- Resources

Overview

- Provide radiation data from February 1985 to January 1987 (NOAA 9) and from January 1987 to May 1989 (NOAA 10) for climate studies.
- Use algorithms consistent with the CERES process

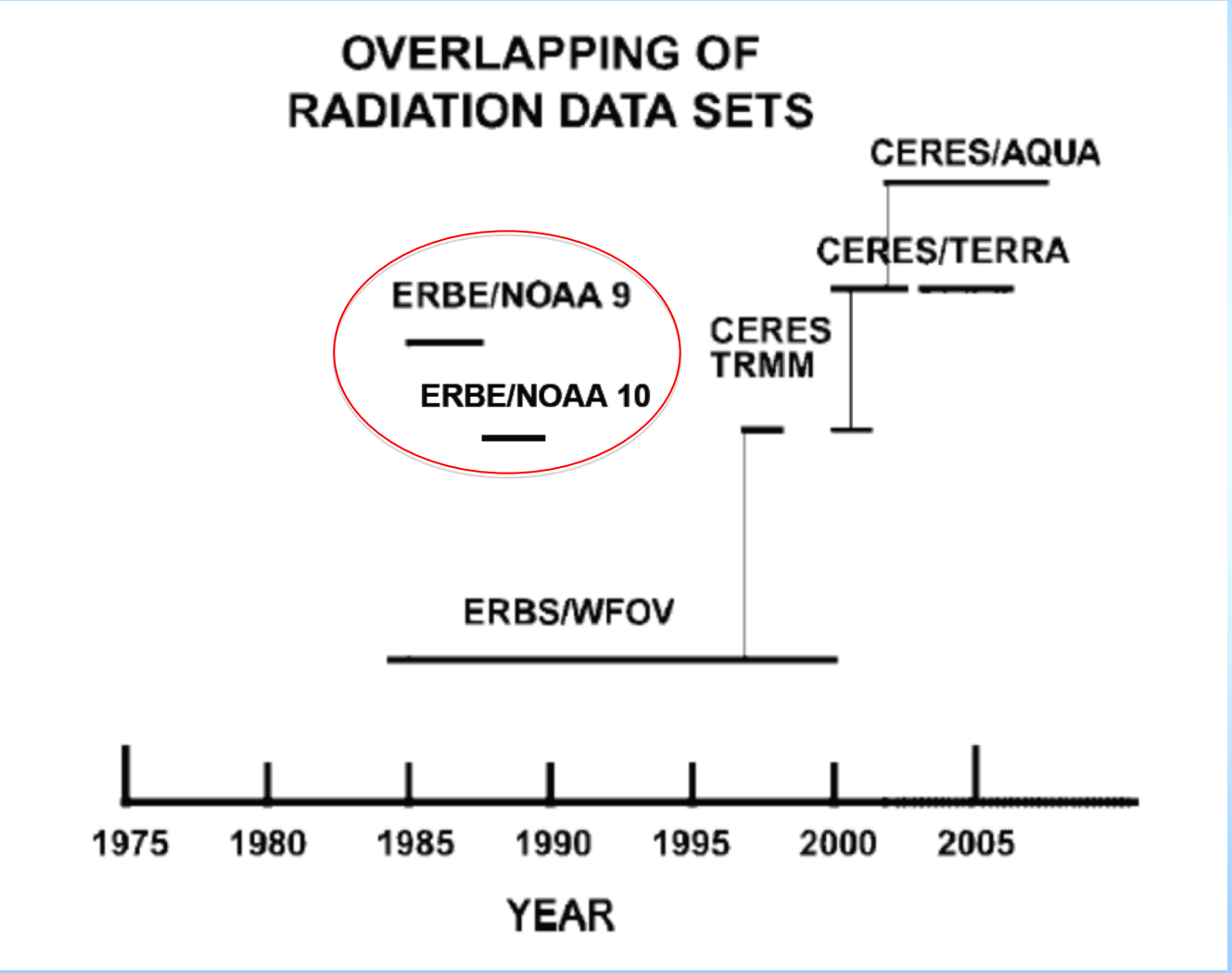
- Source Data
  - ERBE (broadband SW LW)
  - AVHRR (clouds and aerosols)
  - MERRA (atmospheric thermodynamic properties)
  - Geostationary satellites (ISCCP B1, diurnal cycles)

Overview

- Deliverables
  - TOA SW and LW radiative flux (Level 2 and 3)
  - Radiative flux at surface and atmospheric (at 70, 200, and 500 hPa)
- ECVs addressed
  - TOA and surface radiation budget
- Review Product Description matrix

➢ Product description matrix (http://www.ncdc.noaa.gov/cdr/grants.html) is valid.

ERBE and CERES observations



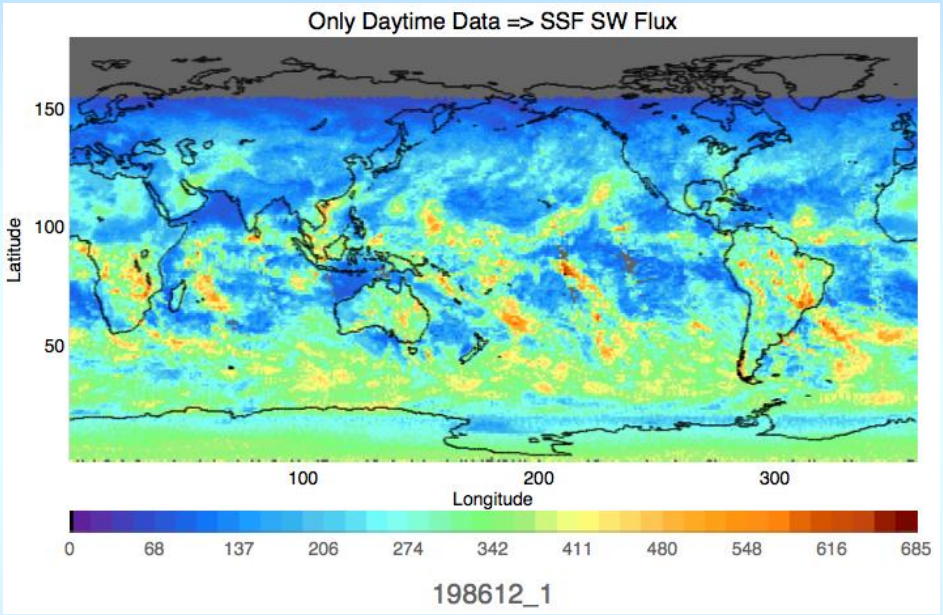
Approach

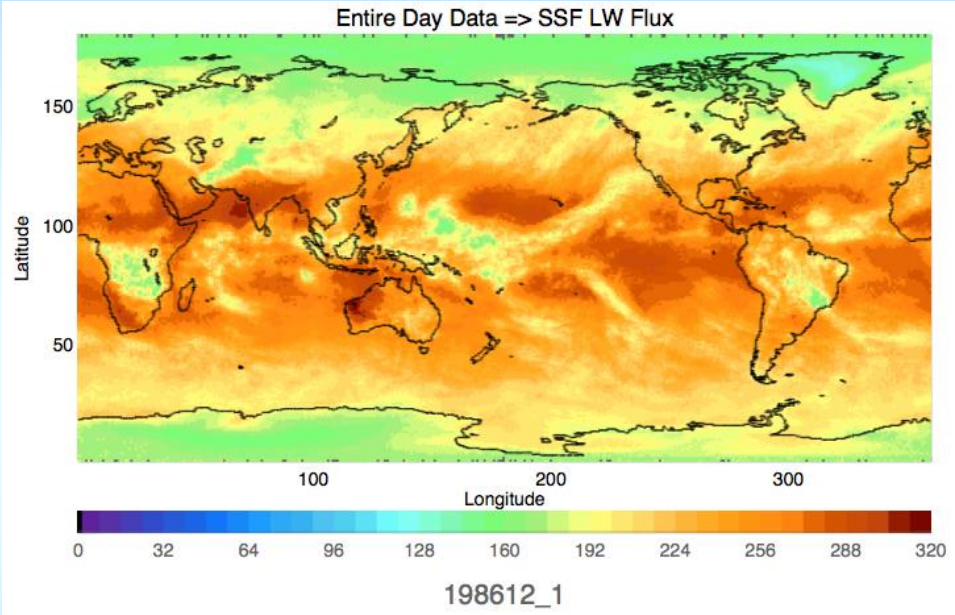
- Apply CERES unfiltering process to ERBE data
  - ERBE filter function
  - Scene dependent unfiltering coefficient based on AVHRR derived scene type

- Apply CERES (Aqua Ed 2) Angular distribution models based on AVHRR derived scene type
- Compute surface irradiances using AVHRR derived cloud and aerosol properties

TOA SW and LW irradiances derived from CERES (Aqua) ADMs

SSF level 2 product

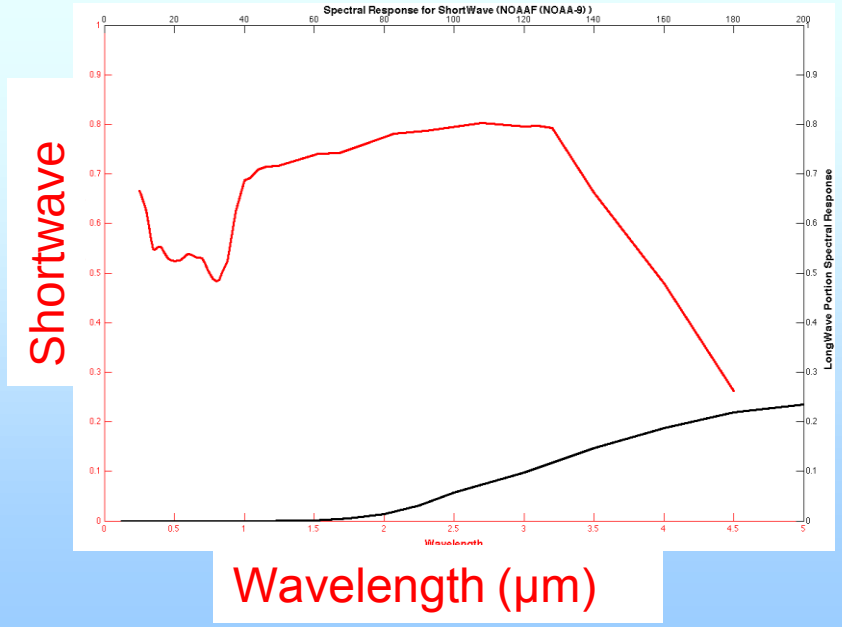




5 days mean from December 1986
Irradiance will change after calibration processes

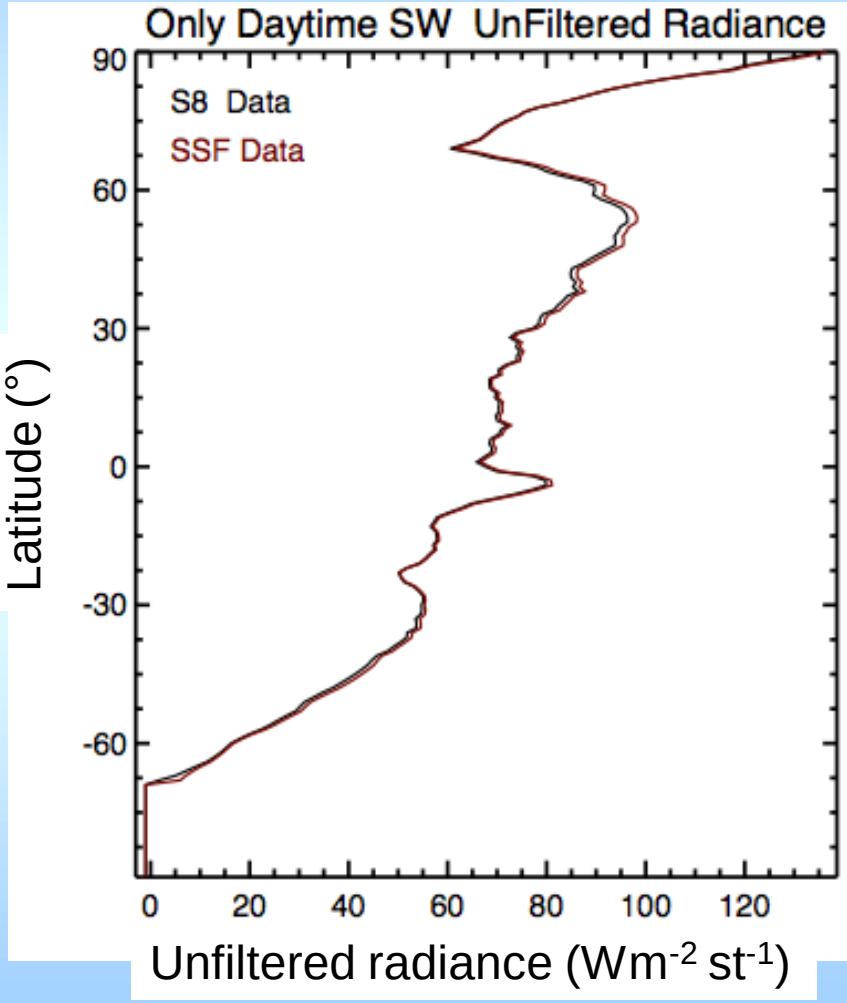
Unfiltering process

- Surface type (Ocean, land or desert, and snow) and scene type (clear and cloudy, shortwave only) dependent unfiltering coefficients

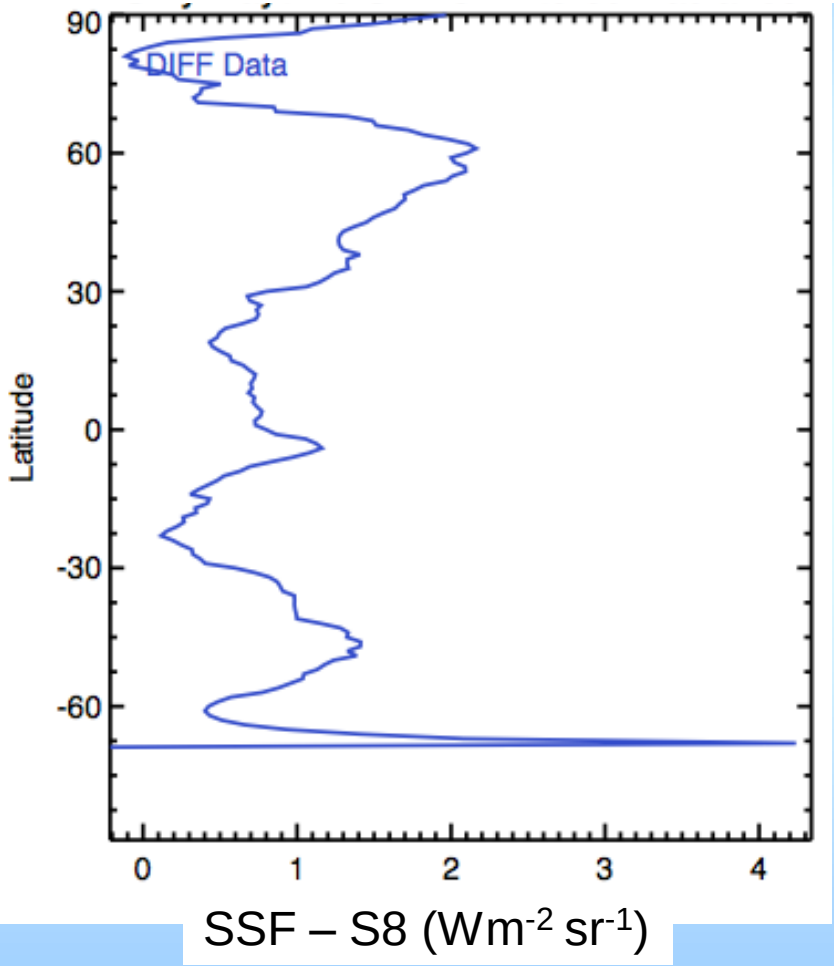


Unfiltering process converts the radiance to that measured by a instrument with a spectrally flat filter function

SW zonal unfiltered radiance difference



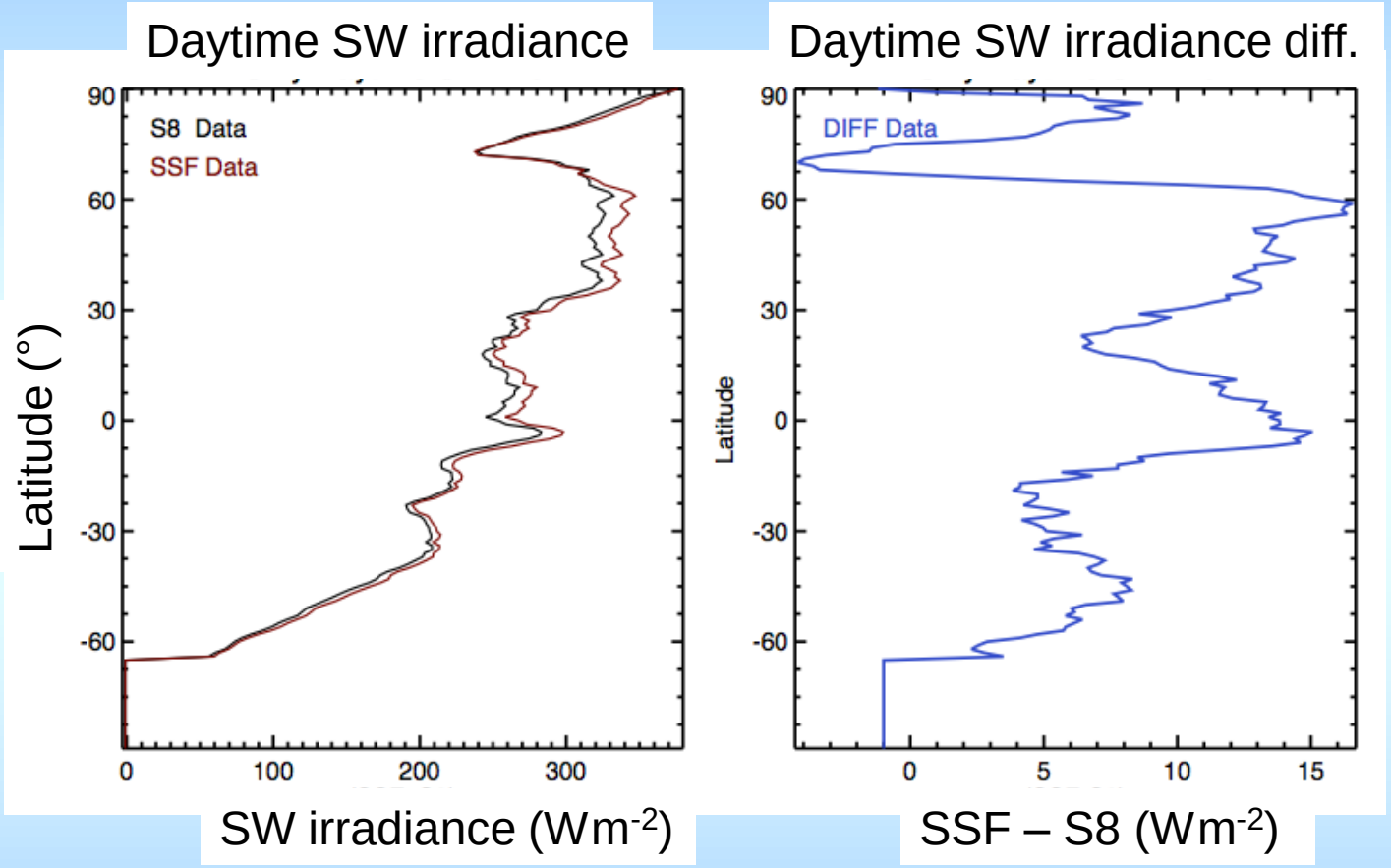
Daytime SW unfiltered radiance difference



TOA irradiance

- Apply CERES Aqua angular distribution models (ADMs) to unfiltered radiances
- ADM is collection of anisotropic factors that are function of surface and scene type in addition to viewing geometry (viewing zenith, relative azimuth, and solar zenith angles).

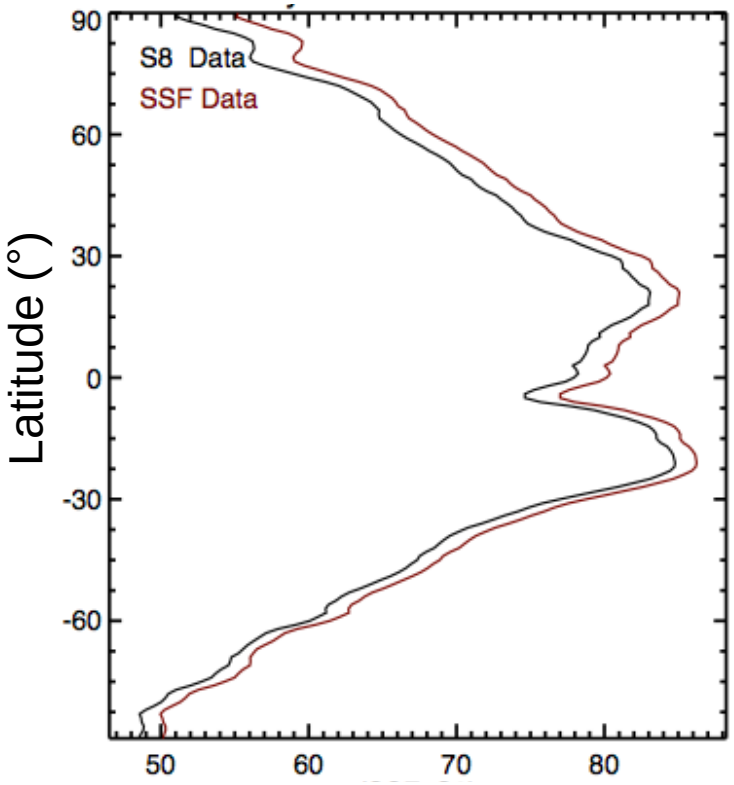
SW zonal irradiance difference (Instantaneous)



SSF Irradiance changes depending on calibration (unfiltered radiance)

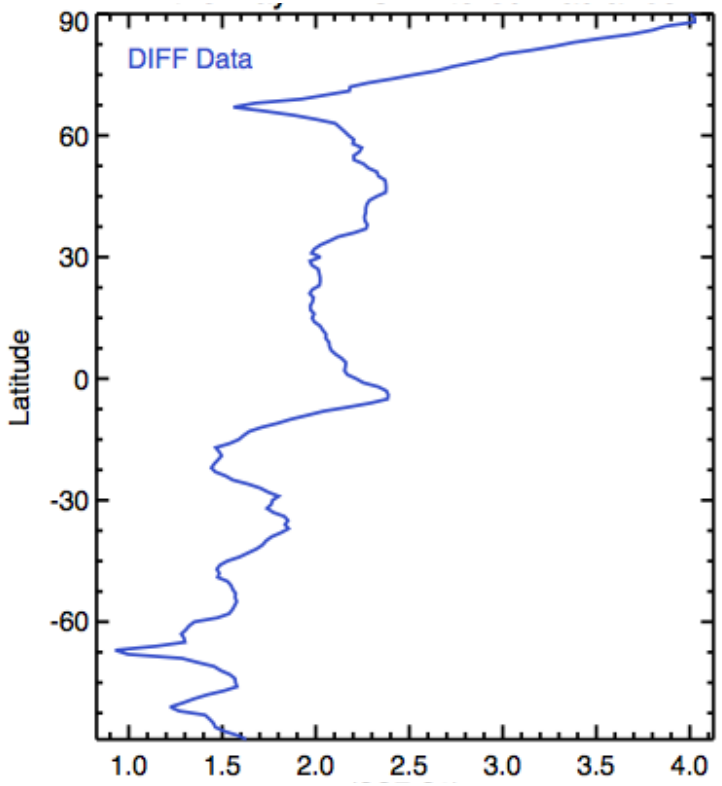
LW zonal unfiltered radiance difference

Day+night unfiltered radiance



LW unfiltered radiance (Wm^{-2})

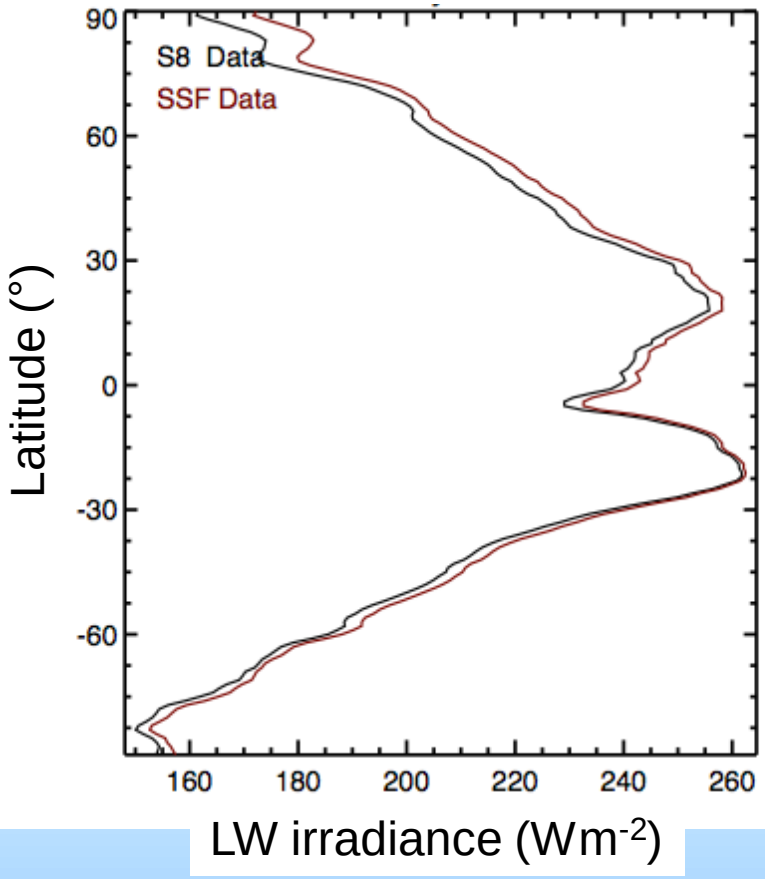
Day+night unfiltered radiance difference



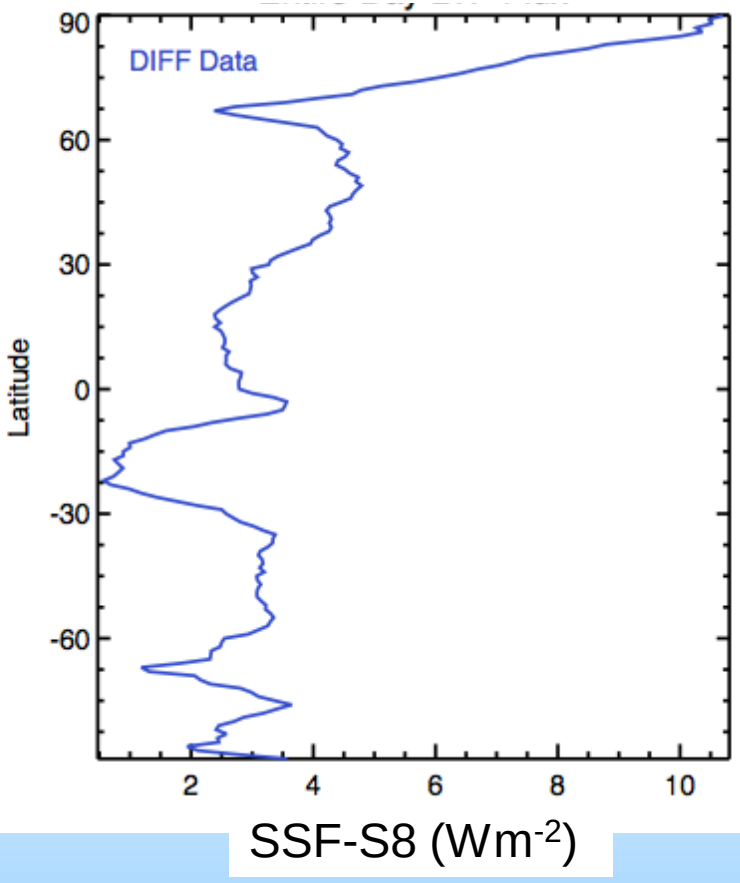
SSF-S8 (Wm^{-2})

LW zonal irradiance difference

Day + Night LW irradiance



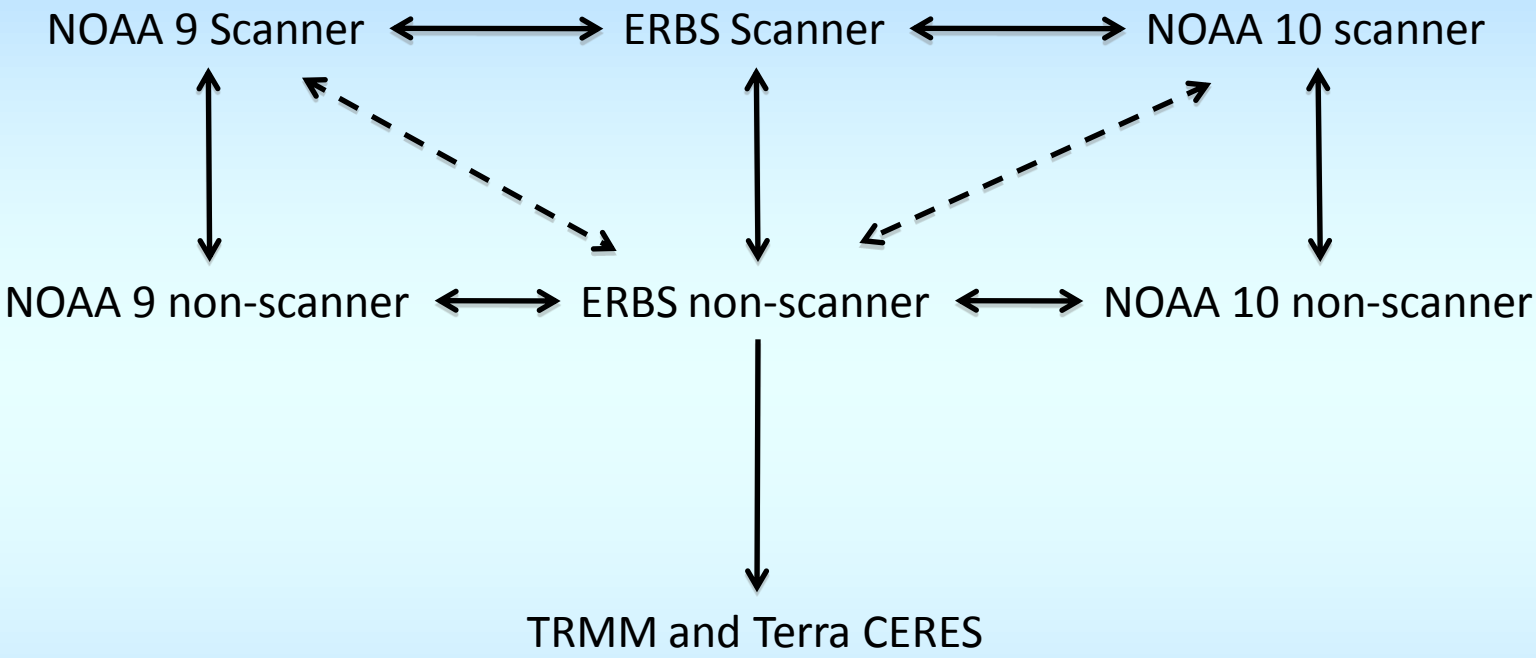
Day + Night irradiance difference



SSF Irradiance changes depending on calibration (unfiltered radiance)

Validation Strategy

NOAA 9, 10 scanner calibrations



NOAA 9, 10 non-scanners are calibrated using ERBS non-scanner
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ERBS non-scanner is used to tie CERES instruments

Surface modeled irradiances (aerosol)

- Aerosol optical properties are needed for modeling

  Use AVHRR derived aerosol optical thickness (Mishchenko et al. 1999) at 0.65 and 0.85 □m.

  Classify aerosol type and use fixed aerosol optical properties for a given aerosol type.

  - Total Aerosol AOD
  - Type 0 => Dust < 0.5um AOD
  - Type 1 => Dust > 0.5~1.0um AOD
  - Type 2 => Dust 3 AOD
  - Type 3 => Dust 4 AOD
  - Type 4 => Sulfate AOD
  - Type 5 => Sea Salt AOD
  - Type 6 => Hydrophilic black carbon AOD
  - Type 7 => Hydrophobic black carbon AOD
  - Type 8 => Hydrophilic organic carbon AOD
  - Type 9 => Hydrophobic organic carbon AOD

Aerosol type classification

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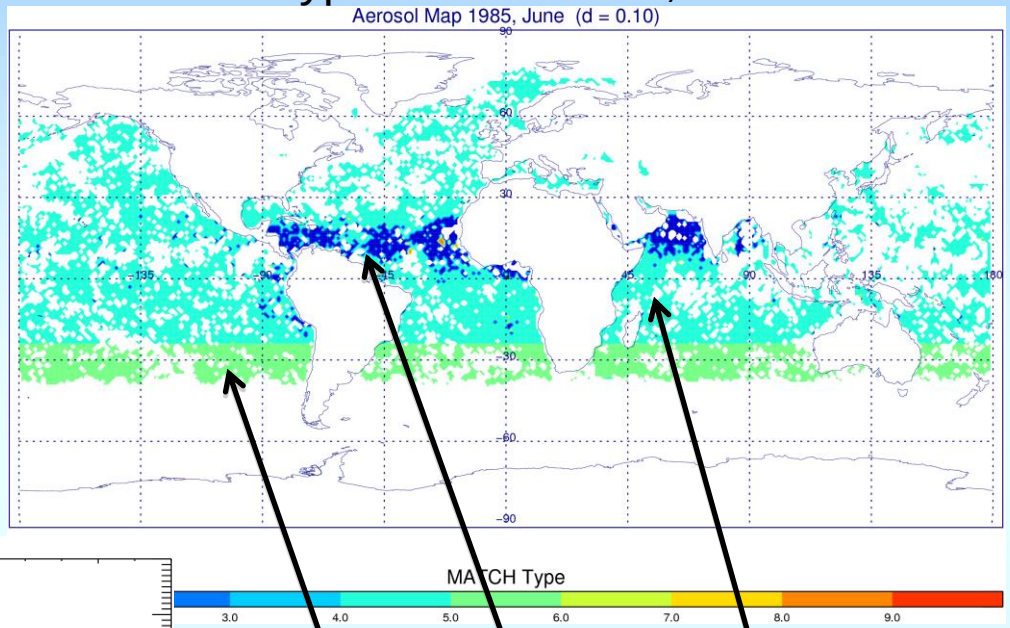
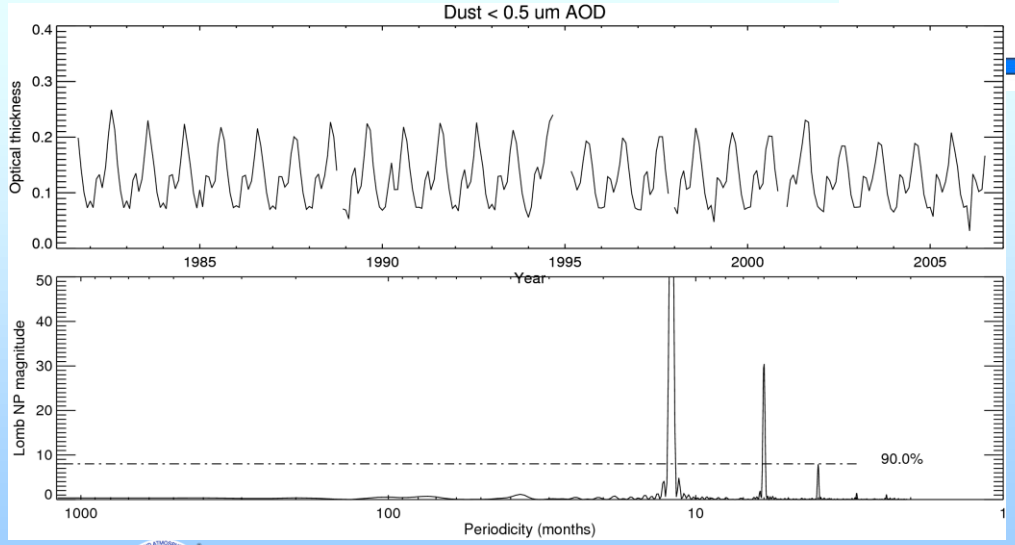
Aerosol type classification, June 1985





Lomb periodogram (Lomb 1976)

Schedule

- Process SSF (with NOAA 9 AVHRR-derived clouds) [Fall 2011, Y2]
- Compute unfiltered radiance (NOAA 9) [Fall 2011, Y2]
- NOAA 9 ERBE calibration [Fall & Winter 2011, Y2]
- Re-process SSF [Winter 2011, Y2]
- Compute surface irradiances [2012, Y2-Y3]
- Time and Spatial sampling (GEO, Level 3 gridded monthly data product) [2012-2013, Y3]

Transition Plan

- DOCUMENTATION
  - Climate Algorithm Theoretical Basis Document (C-ATBD)
    - See CDR web site: http://www.ncdc.noaa.gov/cdr/guidelines.html
    - C-ATBD template is listed under "Development Guidelines"
  - Data Flow Chart and Maturity Matrix
    - See CDR web site: http://www.ncdc.noaa.gov/cdr/operationalcdrs.html
    - Examples are in the right column

- DATA SET(S)
  - HDF and/or netCDF
  - SSF (level 2) ~500 Mb/day

- SOURCE CODE
  - Language, FORTRAN, and C.

- CONCERNS (Risks)
  - Coverage of the documentation is large, calibration, ADM, clouds, radiative transfer model, time and spatial sampling (diurnal correction)
  - A large part of algorithms is ERBE instruments specific

CDR Maturity Matrix

Level	Sensor Use	Code Stability	Metadata & QA	Documentation	Validation	Public Release	Science & Applications	IV&V
1	Research Mission	Significant changes likely	Incomplete	Draft ATBD	Minimal	Limited data availability to develop familiarity	Little or none	
2	Research Mission	Some changes expected	Research grade (extensive)	ATBD Version 1+	Uncertainty estimated for select locations/times	Data available but of unknown accuracy; caveats required for use.	Limited or ongoing	ATBD Review
3	Research Missions	Minimal changes expected	Research grade (extensive); Meets international standards	Public ATBD; Peer-reviewed algorithm and product descriptions	Uncertainty estimated over widely distribute times/location by multiple investigators; Differences understood.	Data available but of unknown accuracy; caveats required for use.	Provisionally used in applications and assessments demonstrating positive value.	NOAA Operations Review
4	Operational Mission	Minimal changes expected	Stable, Allows provenance tracking and reproducibility; Meets international standards	Public ATBD; Draft Operational Algorithm Description (OAD); Peer-reviewed algorithm and product descriptions	Uncertainty estimated over widely distribute times/location by multiple investigators; Differences understood.	Source code released; Data available but of unknown accuracy; caveats required for use.	Provisionally used in applications and assessments demonstrating positive value.	
5	All relevant research and operational missions; unified and coherent record demonstrated across different sensors	Stable and reproducible	Stable, Allows provenance tracking and reproducibility; Meeting international standards	Public ATBD, Operational Algorithm Description (OAD) and Validation Plan; Peer-reviewed algorithm, product and validation articles	Consistent uncertainties estimated over most environmental conditions by multiple investigators	Source code portable and released; Multi-mission record is publicly available with associated uncertainty estimate	Used in various published applications and assessments by different investigators	CDR Certification Review
6	All relevant research and operational missions; unified and coherent record over complete series; record is considered scientifically irrefutable following extensive scrutiny	Stable and reproducible; homogeneous and published error budget	Stable, Allows provenance tracking and reproducibility; Meeting international standards	Product, algorithm, validation, processing and metadata described in peer-reviewed literature	Observation strategy designed to reveal systematic errors through independent cross-checks, open inspection, and continuous interrogation	Source code portable and released; Multi-mission record is publicly available from Long-Term archive	Used in various published applications and assessments by different investigators	

Benefit to the Science Community

- Combined with CERES and ISCCP data sets, users can study TOA radiation budget difference separated by 2 decades
- Combined with GEWEX SRB data, users can study surface irradiance and aerosol direct radiative effect changes separated by 2 decades (e.g. global dimming and brightening, Wild 2009 JGR).

- Using scene identification from AVHRR and applying CERES angular distribution models provide better TOA irradiances (Wielicki et al. 1995 BAMS; Loeb et al. 2007 JAOTech).

Benefit to Society

- Climate research
  - Helps climate researches by providing radiation budget data from 80s.
  - Understand surface radiation budget variability separated by 2 decades help agricultural research (NOAA economics).
  - Data products from our work help to achieve NOAA's objective of "improve scientific understanding of the changing climate system and its impacts" (2010, NOAA's next-generation strategic plan).
- Energy sector
  - Understand variability of surface irradiance for solar energy planning and agricultural research (accord with NOAA's long-term goal of climate adaptation and mitigation).

Resources

- Number of personnel employed for project
  - *2 persons (full time), 2 persons (part time including AVHRR and GEO calibration)*
- Key equipment or observatories used
  - ERBE and AVHRR (NOAA 9 and NOAA 10)
- Key collaborating projects or personnel
  - NOAA CDR, PI: P .Minnis (co-I of this project)
  - NASA CERES, PI: N. Loeb (co-I of this project)
  - NASA ERBE nonscanner, T. Wong
  - GEWEX SRB, PI: P. Stackhouse
  - NASA GACP, PI: M. Mishchenko
- NOAA points-of-contact or collaborators, as applicable
  - Tom Zhao, NCDC
- Target NOAA Data Center
  - NCDC
- How can the CDR Program Office help you?