Calibration of Historical and Future AVHRR and GOES Visible and Near-Infrared Sensors and the Development of a Consistent Long-Term Cloud and Clear- Sky Radiation Property Dataset

Patrick Minnis, Kris Bedka, Dave Doelling, Ben Scarino

Climate Sciences Branch

NASA Langley Research Center

757- 864- 5671; p.minnis@nasa.gov

Overview

- Goals
  - Calibrate AVHRR 0.64, 0.87, and 1.6-μm channels
  - Calibrate GOES & SMS imager 0.65-μm channels
  - Generate CERES-like cloud climatology from AVHRR record
- Source Data
  - AVHRR 1, 2, & 3: 1978 – present
  - SMS-1 & 2; GOES-1 thru present
  - SCHIAMACHY spectral data (2004-2009)
- Deliverables
  - Calibrated radiances (calibration coefficients)
  - Cloud temperature, height, optical depth, effective particle size, water path, skin temperature, surface spectral albedo
- ECVs addressed: cloud properties, radiation budget
- Current/expected user communities: GEWEX, GCM community, energy, aviation

Calibration Approach

- Calibrate AVHRR against MODIS
  - Nearly Simultaneous Ray-matched Technique (NSRT)
  - Adjust with spectral correction factors
  - NOAA-14 thru NOAA-18 (2000-2010)

- Cross-calibrate AVHRR against AVHRR
  - NOAA-14 back to NOAA-5

- Determine Deep Convective Cloud Albedo
  - NOAA-18 back to NOAA-5

- Determine desert albedos
  - NOAA-14 back to NOAA-5

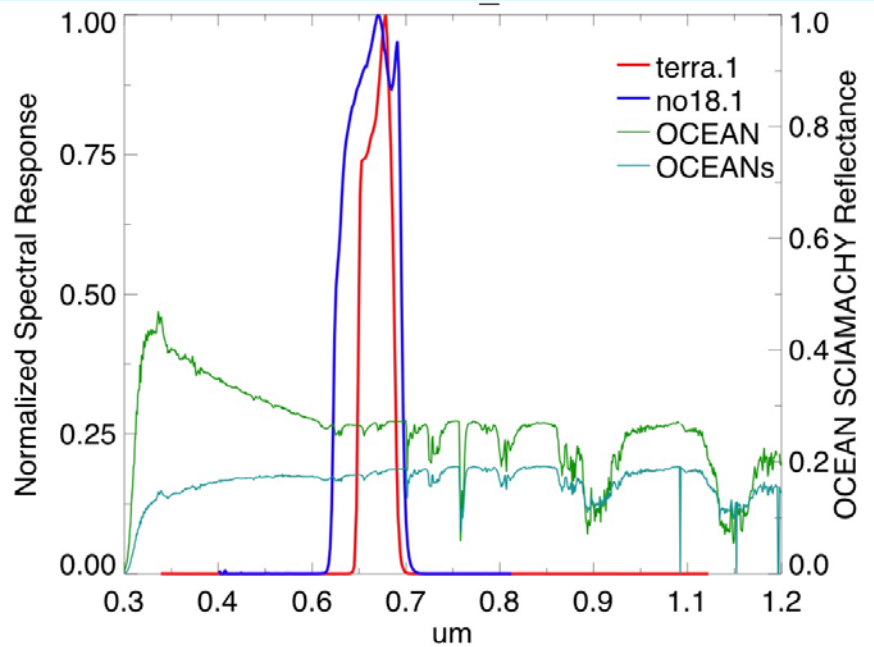
Cloud Analysis Approach

- Apply CERES Ed3 mask to AVHRR
  - Adapt algorithm to limited AVHRR channels
  - Apply to NOAA-18 back to NOAA-5 (1978-2010)

- Apply CERES Ed3 Cloud Property Retrieval System
  - Adapt algorithm to limited AVHRR channels
  - Apply to NOAA-18 back to NOAA-5 (1978-2010)

Results/Accomplishments

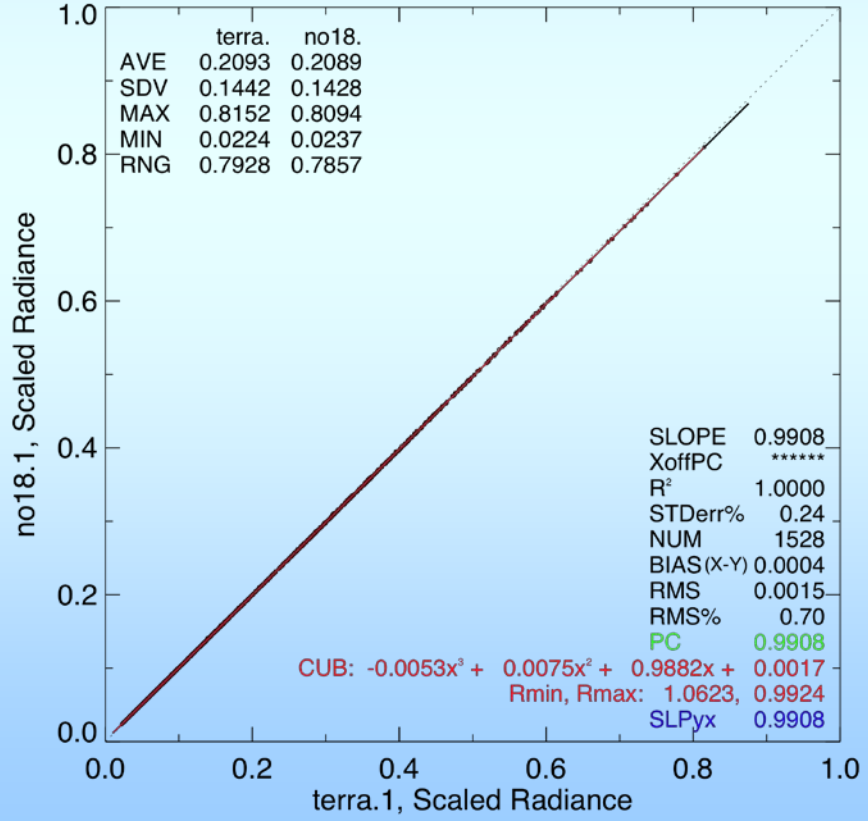
- Developed initial spectral correction factors
  - NOAA-18 vs. Terra from SCHIAMACHY data



SAT	Cum	SCs	SCt	Rads	Radt	Ref
terra.1	0.6466	1542.3	1575.3	130.3	133.0	0.2653
no18.1	0.6366	1595.5	1610.2	134.5	135.8	0.2649
RATIO		0.9666	0.9783	0.9686	0.9800	1.0018

GEO_200507_ocean

terra.1 vs no18.1 (SCIAMACHY)

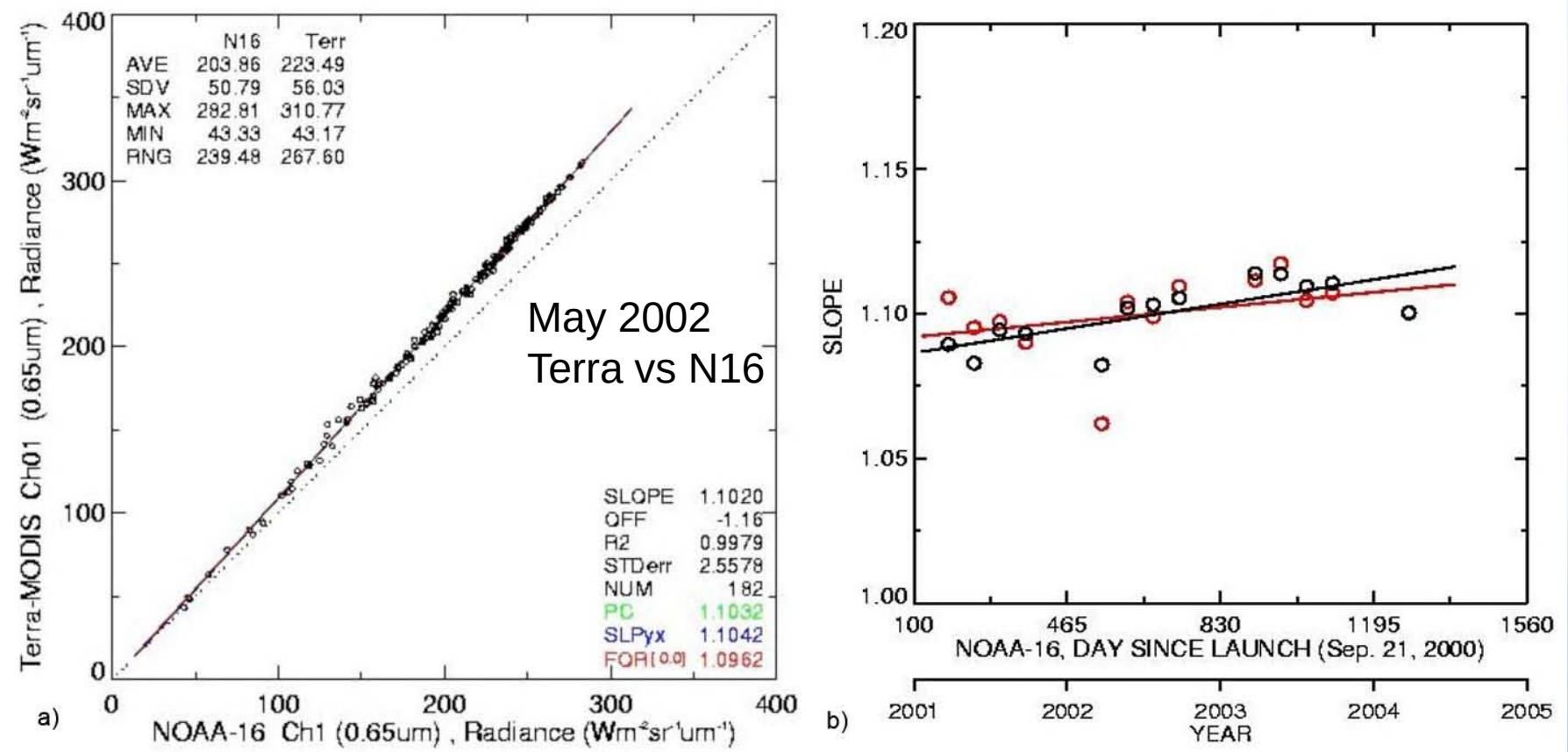


Results/Accomplishments

- Cross-calibrate AVHRR against MODIS
  - Analysis software being revised for NOAA 14-18

Monthly cross-calibration

generation of trend line



- Minnis et al., JCAM 2002

Results/Accomplishments/Validation

- Cross-calibrate AVHRR w/ AVHRR, GOES w/ GOES

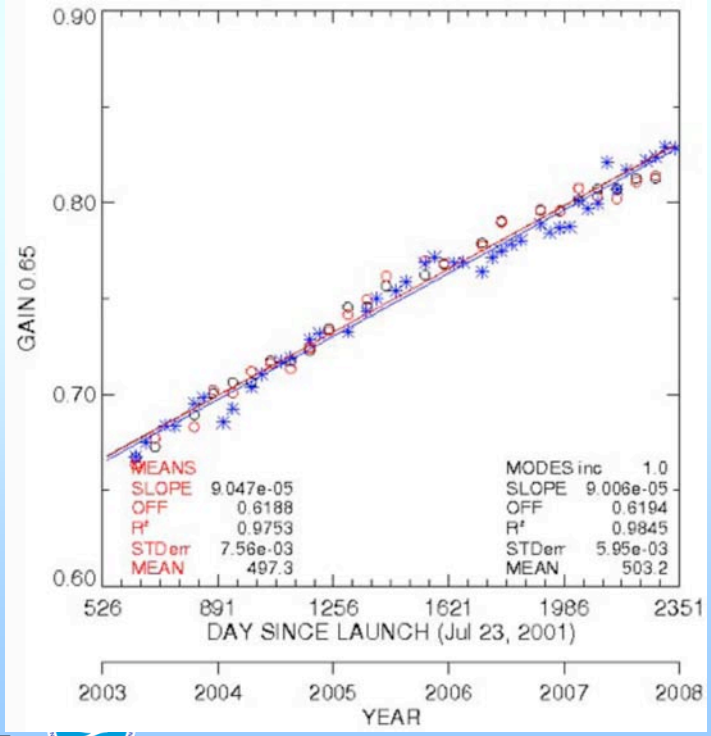
- NOAA-14 to NOAA-5, GOES-14 to SMS-1, software being revised

- Determine Deep Convective Cloud Albedo

- NOAA-18 to NOAA-5, GOES-14 to SMS-1, software being revised

- Determine desert albedos

- NOAA-14 back to NOAA-5, software being developed



Example

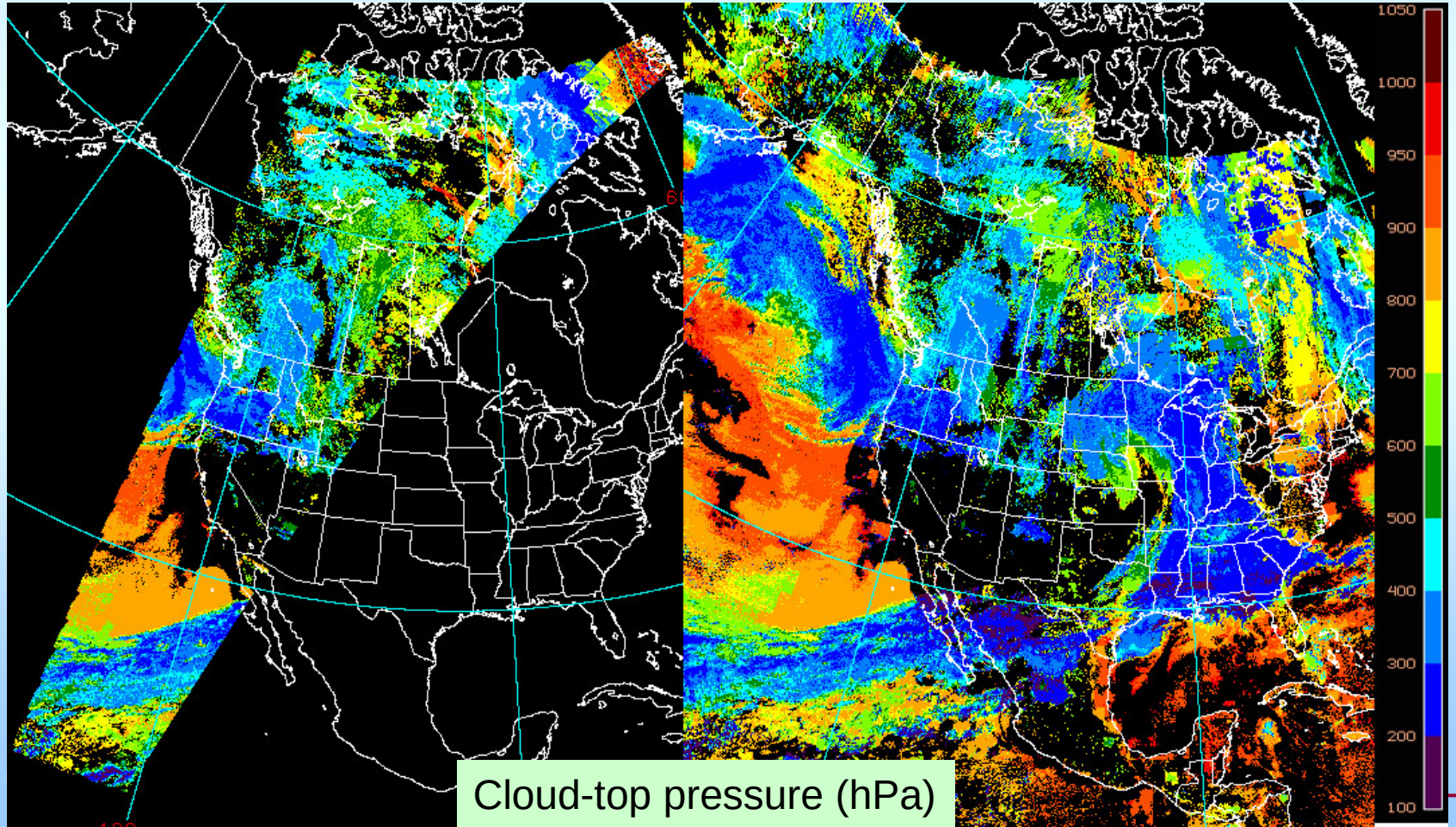
GOES-12 VIS channel trend gains from Terra NSRT (blue) and DCCT (red)

Technique described by Minnis et al. JAOT (2008)

Results/Accomplishments

- Testing begun over North America w/ NOAA-18
  - Nominal calibration, so far
  - compare instantaneous matches w/ GOES & MODIS

NOAA-18, 1020 UTC March 31, 2009 GOES, 1115 UTC



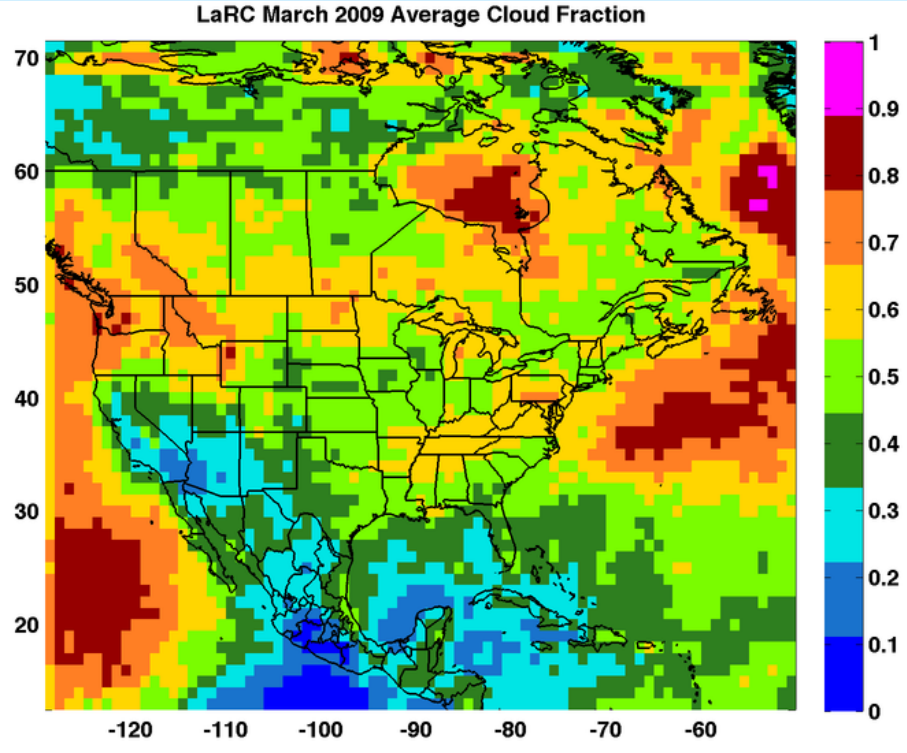
Cloud-top pressure (hPa)

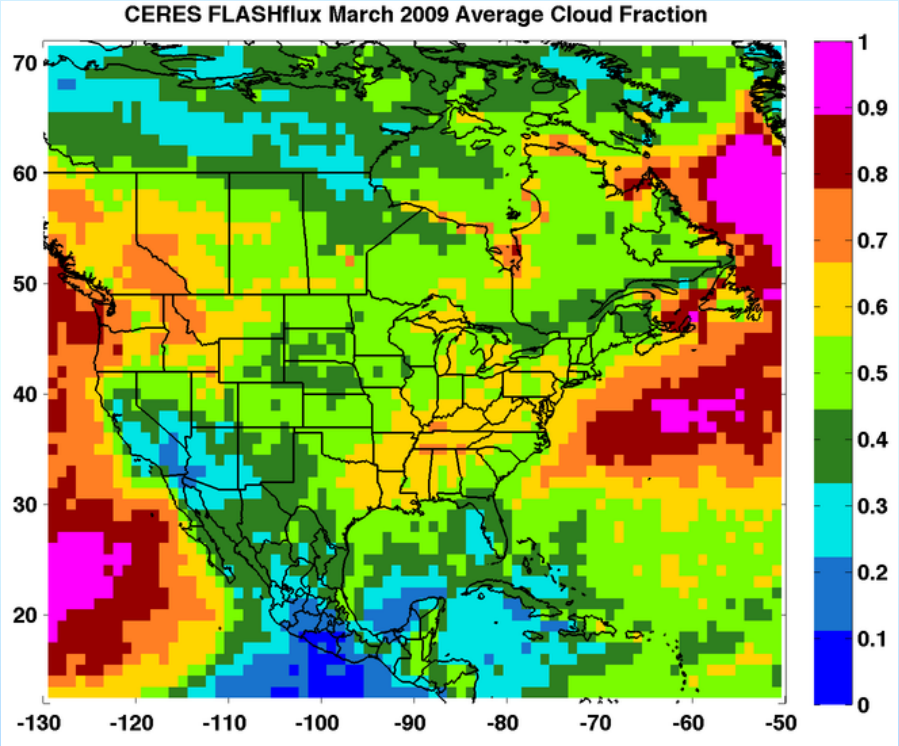
Results/Accomplishments

- Testing begun over North America w/ NOAA-18

Comparing averages with CERES MODIS & GOES

NOAA-18 March 2009 Aqua





Similar patterns but magnitudes off, especially in areas with snow
- need further adjustment of calibration and thresholds

Cloud Validation Strategy

- Compare NOAA 14-18 results w/ CERES & GOES
  - Use closest match (e.g., Aqua w/NOAA-18)
  - Use GOES & Meteosat for off hours
- Compare NOAA-14 -18 w/ARM & CALIPSO data
  - Cloud amounts, heights, & some cloud properties
- Compare long term trends with other climatologies
  - ISCCP, PATMOS-X, surface data

v. June 2010

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.	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	

Issues/Risks & Work- Off Plans

- ISSUES
  - Retrievals over snow, inconsistency with MODIS methods: tuning
  - Spurious calibration changes: examine trend lines
  - Infrared calibrations: need external help
  - 3.7 vs. 1.6-μm Re retrievals: assess differences with MODIS data
  - Time of day sensitivities: measure with GEO and TRMM data
  - Volcano effects, 4 channel AVHRRs

Research- to- Operations or Delivery Plan

- Provide solar channel gains online & in papers
- Output formats, parameters, resolution?
- Apply techniques to VIIRS (NPP & JPSS?) as part of CERES
- Continue with future AVHRRS?

Schedule

Year 1
- Set up QC standards for NSRT & DCCT
- Complete automated integration software for DCCT & NSRT calibrations
- Process contemporaneous AVHRR calibrations (N15, 16, 17, 18)
- Evaluate MODIS data to establish references and uncertainties
- Perform desert site calibrations
- Calibrate contemporaneous GEOsat calibrations (2000-present)
- Set up global automated cloud analysis system to apply to AVHRR
- Perform error analyses for 4 and 5-channel cloud retrievals w/ sampled MODIS data
- Refine polar retrieval method to incorporate improved snow albedo and SIST
- Analyze contemporaneous AVHRR data (N16, 17, 18)
- Compute SRF ratios from SCHIAMCHY data

Year 2
- Calibrate AVHRR (N11-N14)
- Set up website to provide calibration and cloud results
- Coordinate with NSDC to archive results
- Intercalibrate AVHRRs and GEOsats (1991- 2000)
- Perform DCCT analyses on GEOSats and AVHRR (1991 -2000)
- Perform cloud retrievals on AVHRR data (N11- N15
- Compare desert site calibrations to NSRT-DCCT results
- Determine uncertainties in GEOsat and AVHRR calibrations (1991-2010)
- Update MODIS calibrations

Year 3
- Complete record of AVHRR and GEOsat calibrations to 1978
- Complete cloud analyses for AVHRR through 1978 (N5 – N10)
- Complete error analyses
- Provide final reports on TCDR and FCDRs
- Document results in journal articles

Resources

- Number of personnel employed: 2.8 FTE
- Key equipment or observatories
  - Langley AMI system, Dell servers
- Key collaborating projects or personnel
  - CERES
  - NOAA GSICS activity, PI: C. Cao
- NOAA points-of-contact or collaborators, as applicable
  - Ken Knapp, NCDC
- Target NOAA Data Center: NCDC