Earth Radiation Budget Observation Requirements: Discussion

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Importance of Earth Radiation budget:

- Climate is determined by the amount and distribution of incoming solar radiation absorbed by Earth.
- In response to energy imbalances, complex processes give rise to energy flows within the atmosphere, hydrosphere, lithosphere, cryosphere and biosphere occurring over a range of time-space scales.
- TOA radiation budget observations provide an important constraint on cloud feedback, a primary uncertainty in determining climate sensitivity.
- Surface radiation budget determines how much energy is available to drive the hydrological cycle.
- Surface radiation data becoming increasingly important in Applied Sciences (solar energy community, agriculture, etc.).
- Vertical profiles of atmospheric radiation key for process studies.

Thoughts about ERB Requirements

- **Holistic view of observing system is needed.**
  - Consider collective strengths/weaknesses of satellite and in-situ obs.
  - Do not assume any one individual observation type (e.g., satellite) can solve all problems.
  - Need for multiple measurement types/approaches (satellite broadband, imagers, solar spectral, lidar, radar, sun-sync & geostationary, in-situ ocean heat content, ground observations (e.g., BSRN), reanalysis, etc.).
- Climate use of ERB data is the main driver for TOA ERB observation requirements since it demands highest accuracy/stability.
  - Accuracy/stability requirements less stringent for applied sciences (but the data are needed near-real time).
- **Continuity is perhaps the most important and difficult requirement.**
  - Climate occurs on time scales much longer than typical satellite missions and demands long observational records.
  - Gaps in the record "kill" the CDR.
  - Climate monitoring is generally not a top priority for space or weather agencies.
- **Need for a consistent homogeneous record.**
  - Technological advances can provide additional capabilities but if implemented without ensuring "backward compatibility" with earlier measurements, the long-term record will be compromised.

Accuracy and stability

	GCOS requirement*		CERES observations	
	Accuracy	Stability/Decade	Accuracy	Stability/Decade
TOA SW reflected	0.8 W/m2 on global mean	0.2 W/m2/decade	Monthly regional: 4 W/m2 at 1σ	0.3 W/m2 per Decade at 2σ
TOA LW	1 W/m2 on global mean	0.2 W/m2/decade	Monthly regional: 2 W/m2 at 1σ	0.2 W/m2 per Decade at 2σ
Surface ERB SW (downward for CERES)	1W/m2 on global mean	0.2 W/m2/decade	Monthly regional: 10 W/m2 at 1σ	0.8 W/m2 per Decade at 1σ
Surface ERB LW (downward for CERES)	1W/m2 on global mean	0.2 W/m2/decade	Monthly regional: 14 W/m2 at 1σ	0.8 W/m2 per Decade at 1σ

*NOAA Tech Report NESDIS 134

My take:

- TOA LW: For nighttime, 0.5% or 1 Wm^{-2} (1σ); For day+night, 0.75% or 1.8 Wm^{-2} (1σ).
- Given the indirect nature of satellite-based surface radiative flux estimates, GCOS surface downward radiation accuracy/stability requirements are unrealistic (too stringent by about a factor of 3 to 5).

ERB Community Workshop – TOA Radiation Budget Requirements (Instrument)

Parameter	CERES	Objective
Wavelength Range	0.3 to 5 μm (SW) 5 to >50 μm, or 8 to 12 μm (LW) * 0.3 to >100 μm (TOT)	0.3 to 5 μm (SW) 5 to >50 μm (LW) 0.3 to >100 μm (TOT)
Radiometric Accuracy (End of Life. i.e. 5-yrs for CERES, 10-yrs for CERB)	1.0% (SW), k=1** 0.5% (LW), k=1 (5-year requirement) 0.5% (TOT), k=1	1.0% (SW), k=2** 0.5% (LW), k=2 (10-year requirement) 0.5% (TOT), k=2
Radiometric Stability	2%/decade, k=1 (Allocated from accuracy requirement)	0.3%/decade, k=2 (All wavelength ranges)
Radiometric Precision	<0.2 W/m2-sr + 0.1% of measured <0.45 W/m2-sr + 0.1% of measured <0.3 W/m2-sr + 0.1% of measured	<0.2 W/m2-sr + 0.1% of measured <0.45 W/m2-sr + 0.1% of measured <0.3 W/m2-sr + 0.1% of measured
Linearity	0.3% from linear over dynamic range, k=2	0.3% from linear over dynamic range, k=2
IFOV	~20 Km @ nadir (LEO)	~20 Km @ nadir (LEO)
Field of Regard	Limb to Limb	Limb to Limb
Operation	Continuous	Continuous
Design Life	5 years @ 0.85 probability	7 years @ 0.85 probability
Orbits (minimum of 1, 2	13:30 & 10:30 primary	13:30 primary, 10:30 secondary

Source: Workshop on Continuity of Earth Radiation Budget (CERB) Observations: Post-CERES Requirements. NOAA Technical Report NESDIS 134, May 2011.