# CHAPTER 12

# INTEGRATION OF INDEPENDENT CALIBRATION SOURCES (4/14/94)

## 12.1

# Calibration Philosophy:

**Multi-path calibration approach can provide high radiometric accuracy**

# Expectation:

- **High potential for reflectance bands**
- **Marginal value for emissive bands**

# Data Available from pre-launch calibration

1. **Initial calibration algorithms provided by SBRC**

2. **Laboratory measurement characteristics and data**

3. **Ambient and T/V measurement data for on-board calibrators**

# On-orbit relative calibration:

**Within-band image-derived calibration**

- **Destriping images by scene histogram equalization**

**SRCA/SD calibration consistency check**

1. **Calibrate with SRCA**
2. **Then radiance spectrum of SD**
3. **Compare with computed radiance spectrum from SD BRDF and Labs & Neckel solar spectral irradiance**

# On-board and vicarious calibration sources

## On-board calibrators

- Solar diffuser and SDSM
- SRCA (spectral, radiometric, and spatial)
- Space view (zero radiance)
- Blackbody at 285K or 315K

## Vicarious calibration methods

- Aircraft radiance measurement
- Ground reflectance-based calibration
- Radiance-based measurement by lunar observation
- Oceanic ship and buoy measurement
- Cross calibration with other on-board sensors

## Image-derived calibration/correction

- Correct* radiometric errors introduced by stray light and ghosting
- Destriping* within-band image
- Long-term radiometric stability monitoring using 10-100 earth sites
- Night viewing of earth for space radiometric bias in reflective bands
- Automated calibration-site-based radiometric rectification
- MTF inversion of scenes using pre-launch characterization data

* Strong candidate for PGS

# Absolute radiometric

## 1. VIS/NIR/SWIR

| | |
|---|---|
| • Solar diffuser, SDSM, SRCA | ±4.0% (SBRC) |
| • Aircraft radiance measurement* | ±3.8% (GSFC) |
| • Ground-based reflectance calibration | ±3.5% (U of A) |
| • Ground radiance-based calibration | ±3.0% (U of A) |
| • Solar-radiation-based calibration | ±2.0% (SBRC, U of A) |
| • Radiance-based measurement by lunar observation** | ±3.0% (USGS) |
| • Cross calibration with other satellites (assume other sensors have ±3% accuracy) | ±3.5% (U of A) |

## 2. MWIR/LWIR

| | |
|---|---|
| • On-board blackbody, space view | ≤1.0% (SBRC) |
| • Vicarious method | TBD (U of A) |
| • Cross calibration | TBD (U of W) |

* An improved instrument would yield ±2%; need funding

** Currently about 15%

# On-orbit calibration activities

- **Compare instrument output to pre-launch characteristics***
- **Produce calibration coefficients after assigning weights** to each calibration source.**
  - **-Detailed error analysis**
  - **-Compare on-orbit with T/V data**
  - **-Compare results from on-board, vicarious***, and image-derived calibration for systematic offsets and noise.**
- **Calibration committee (MODIS Science Team and MCST) coordinates MODIS calibration**
- **Verification, diagnosis, and improvement of calibration performance**

* Characteristics include gain, offset, wavelength, temperature, interdependencies, etc.
** This will be estimated pre-launch and updated regularly via committee
*** Vicarious methods' error budgets will be peer reviewed prelaunch

## Weighted average calibration coefficient

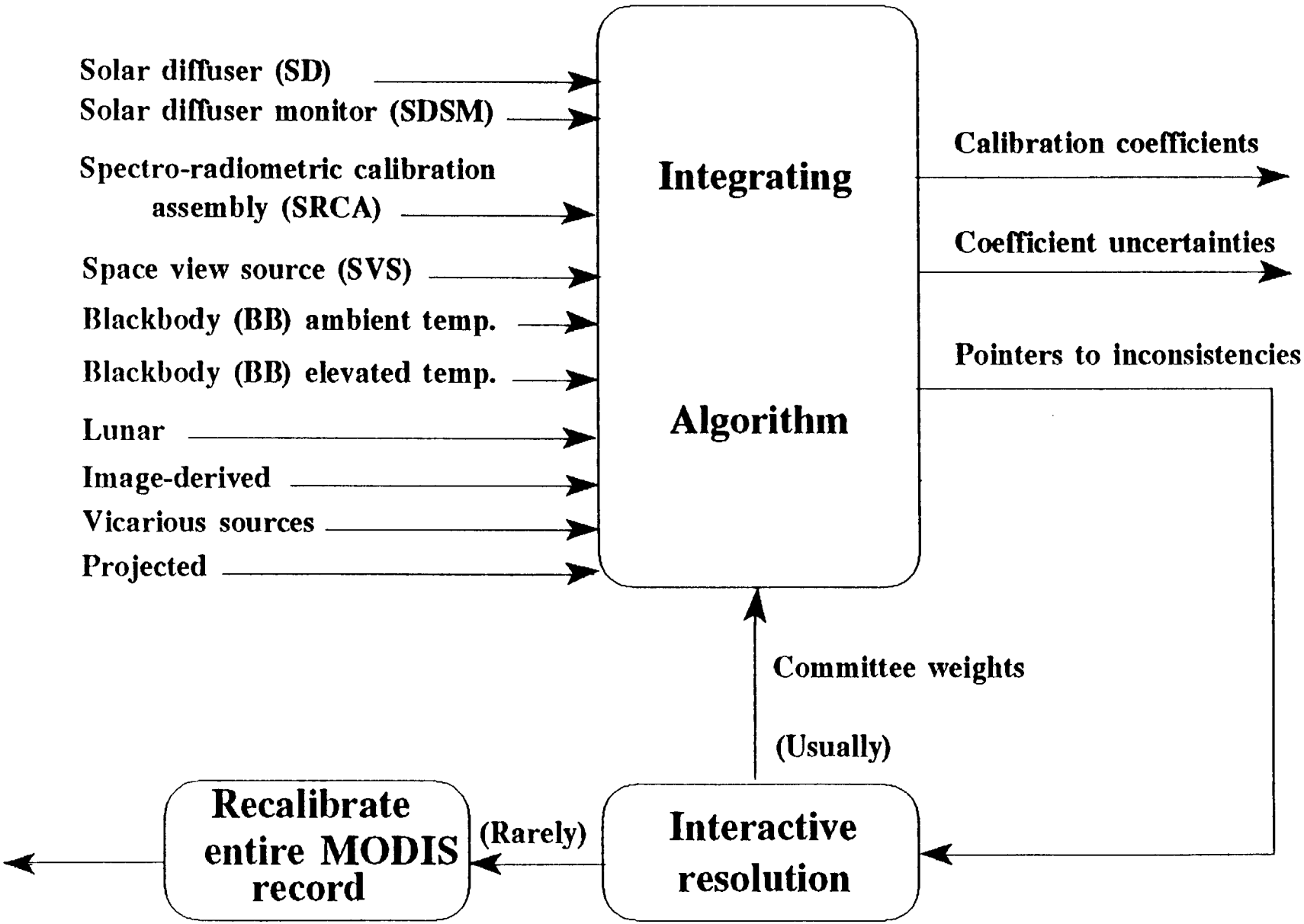
$$\langle P \rangle = \frac{\sum_{i=1}^{N} W_i P_i}{\sum_{i=1}^{N} W_i} = \frac{\sum_{i=1}^{N} \frac{P_i}{\sigma_i^2}}{\sum_{i=1}^{N} \frac{1}{\sigma_i^2}}$$

where $P_i$ is independent estimate of i-th method.

The weighting coefficient, $W_i$, is given by $W_i = 1 / \sigma_i^2$ .

The variance of $\langle P \rangle$ is

$$\sigma_{\langle P \rangle}^2 = \frac{1}{\sum_{i=1}^{N} \frac{1}{\sigma_i^2}}$$


Solar diffuser (SD)
Solar diffuser monitor (SDSM)
Spectro-radiometric calibration assembly (SRCA)
Space view source (SVS)
Blackbody (BB) ambient temp.
Blackbody (BB) elevated temp.
Lunar
Image-derived
Vicarious sources
Projected
Integrating
Algorithm
Calibration coefficients
Coefficient uncertainties
Pointers to inconsistencies
Committee weights
(Usually)
Interactive resolution
(Rarely)
Recalibrate entire MODIS record

# Expectation

**Required absolute accuracy will be achieved because a multi-path approach is being employed**

# Risk Assessment

- **Solar radiation based calibration is essential**
- **Elimination of OBCs (except BB) from EM increases risk and ultimately cost**
- **SRCA is at partial aperture**
- **Future cost cutting activities place the SRCA at risk. Elimination of SRCA would devastate calibration of MODIS**