Calibration for GEMS Data, Concepts and Issues

Myoung-Hwan (MH) AHN & Mina Kang

Department of Atmospheric Science and Engineering
Ewha Womans University

이화여자대학교
EWHA WOMANS UNIVERSITY

4th GEMS Science Meeting
(2013.10.14~10.16.)

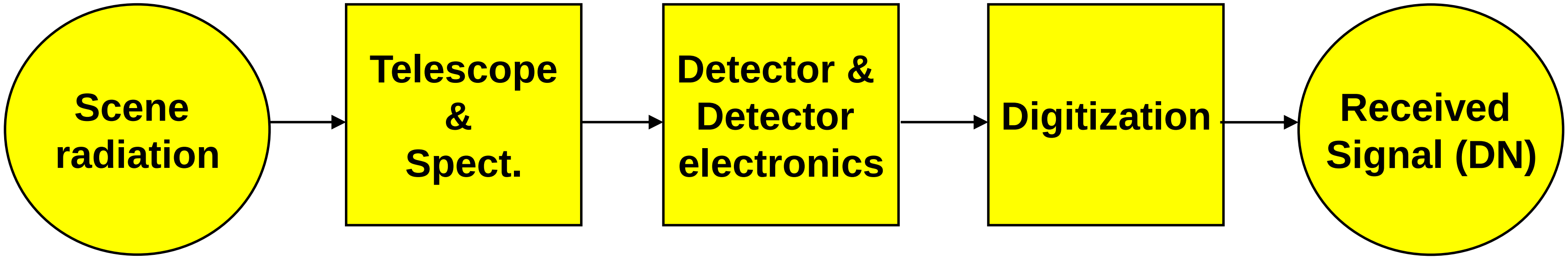
Contents

I. Data quality

- Determined by three important processes
  - Spectral Calibration
    - Assignment of wavelength value to each CCD pixel (the 1st order spectral calibration will be prepared by instrument manufacturer)
    - For a better accuracy, additional steps could be taken
  - Radiometric Calibration
    - Convert the downlinked digital number to physical parameter (here, either radiance or irradiance)
    - Need comprehensive ground test and onboard operations for the confirmation or re-characterization
  - Geometric Calibration
    - Assignment of geo-location information to each CCD pixel and corresponding observation angles (solar/satellite zenith angle, ...)
    - Dependent not only on instrument characterizations, but also on the spacecraft and ground processing
    - Need early test for the landmark performance with the reduced spatial resolution data

II. Radiometric calibration

◆ Signal chain equation



– Then, the digital number received at the ground is determined by;

$$\mathrm{DN} = \mathrm{C} \times \left\{ G \left[\int_{v_1}^{v_2} I(v) T(v) \, \frac{D^2 A}{fl^2} R(v) \, dv + \varepsilon_o \right] + \varepsilon_e \right\} \qquad (1)$$

here,

DN: $digital\ number$, C: $conversion\ constant$, G: $amplification\ gain$,
$I(v)$: $input\ radiance$, $T(v)$: $optical\ transmittance$
D: $Aperture\ diameter$, A: $detector\ area$, fl: $focal\ length$
$R(v)$: $detector\ spectral\ responsivity$
v: $wavenumber$, ε_o: $opitcal\ error$, ε_e: $electronic\ error$

II. Radiometric calibration

- Calibration equation
  - Chain equation can be inverted to give a band-averaged input radiance ($\bar{I}$) value such as;

$$\bar{I} = \frac{1}{G'C} \frac{1}{\int_{v_1}^{v_2} T(v)\, R(v)\, dv} \{DN - C\varepsilon_e - CG\varepsilon_o\}$$
$$= \frac{k}{\tau} DN' \qquad (2)$$

$$where$$
$$k = \frac{1}{G'C},$$
$$\tau = \int_{v_1}^{v_2} T(v)\, R(v)\, dv,$$
$$DN' = DN - C\varepsilon_e - CG\varepsilon_o$$

  - Here, k is ground determined and time invariant, while $R(v)$ weighted $T(v)$ (or called throughput) and error terms ($\varepsilon_e \& \varepsilon_o$) are all time dependent

II. Radiometric calibration

- Calibration equation
  - As the throughput degrades/varies with time, the normalized radiance (w.r.t to the simultaneous solar irradiance value) has long been used
  - Similar to the radiance calibration equation, irradiance calibration equation can be denoted as;

$$F = \frac{k_s}{\tau} DN_s' \frac{1}{g\tilde{T}}$$

  - Here, g is the goniometry (angular response to the solar radiation, and $\tilde{T}$ is the transmissivity of the transmissive diffuser used for irradiance observation
  - Then, the normalized radiance becomes

$$\frac{I}{F} = \frac{k}{k_s} \frac{DN'}{DN_s'} g\tilde{T} \qquad (3)$$

II. Radiometric calibration

◆ Key issues with the radiometric calibration

$$\frac{I}{F} = \frac{k}{k_s}\frac{DN'}{DN_s'}g\tilde{T} \qquad (3)$$

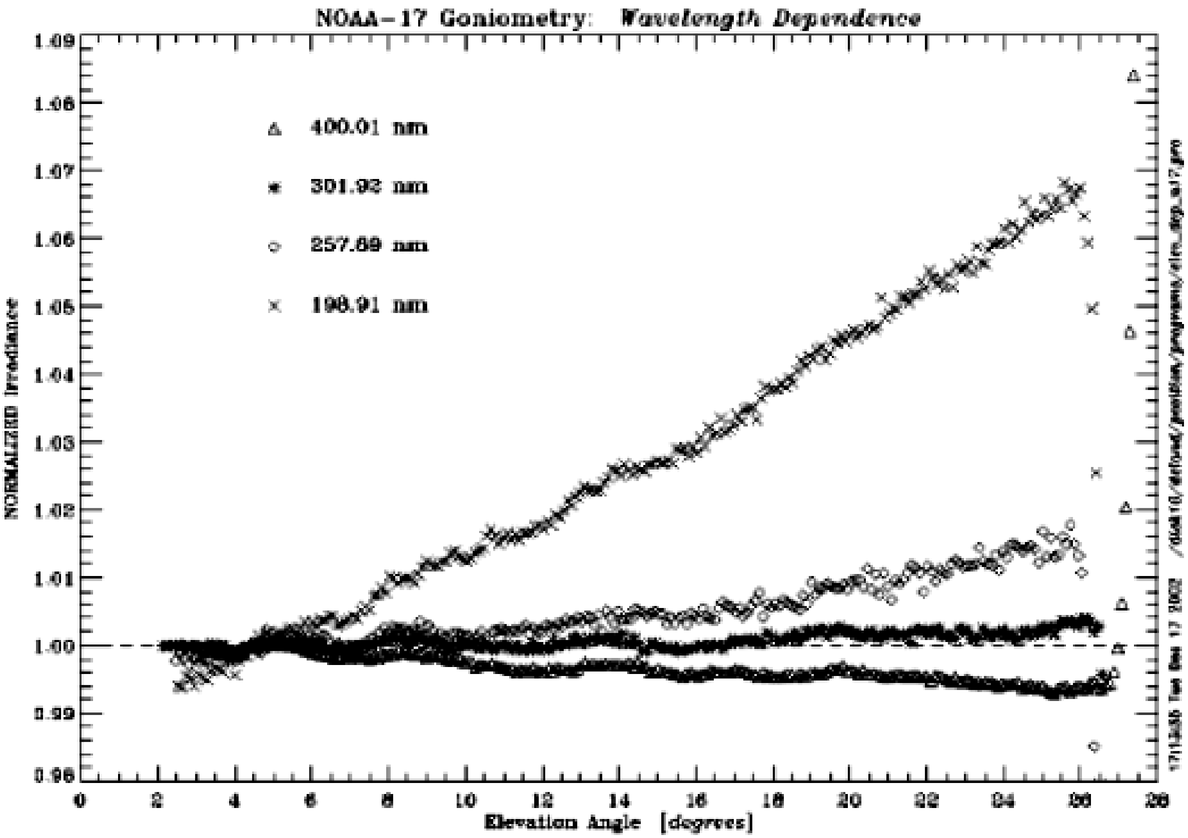
- Acquiring accurate ground measured calibration parameters (calibration constants, goniometry, non-linearity, CCD alignment characteristics, baseline solar irradiance, etc.)
- Characterization of noise counts for both optics and electronics from the on-orbit observation data
- Any degradation of the goniometry parameter with time?
- How can we best utilize the frequent observation of solar radiation (proposed for twice a day)
- Do we need additional normalization to control PRNU within a certain threshold value?

II. Radiometric calibration

- Solar radiation for absolute calibration
  - Use transmissive diffuser to measure solar irradiance twice a day
    - Are the measured solar irradiance going to be used for the derivation of the normalized radiance?
    - What time are we going to measure the solar irradiance?
    - Does GEMS have enough FOR to have 0.53 degree solid angle sun without satellite tilting?
    - How are these frequent solar irradiance data going to be used?
  - Then, how often the reference diffuser should be used?
  - Are we going to use the reference and working diffuser with the similar concept applied for the OMPS nadir spectrometer?
  - How accurately can we measure the goniometry parameter at the ground testing? Can IOT tests provide better information?

II. Radiometric calibration

◆ Goniometry effect



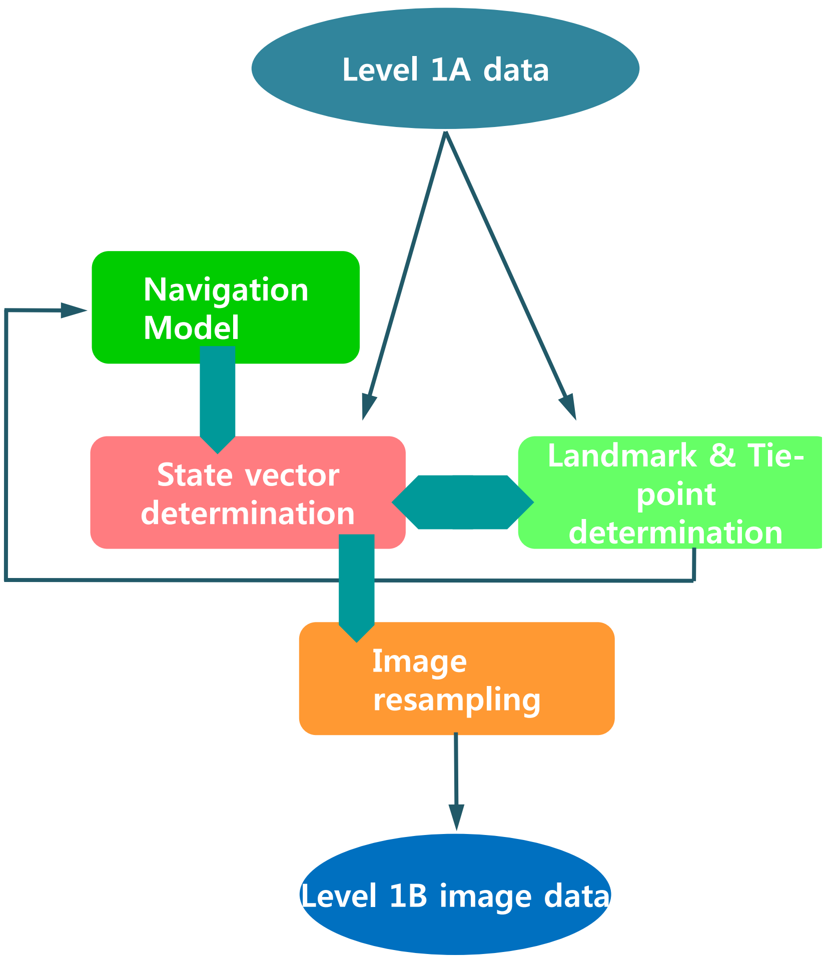
L. Flynn et al, (2011)

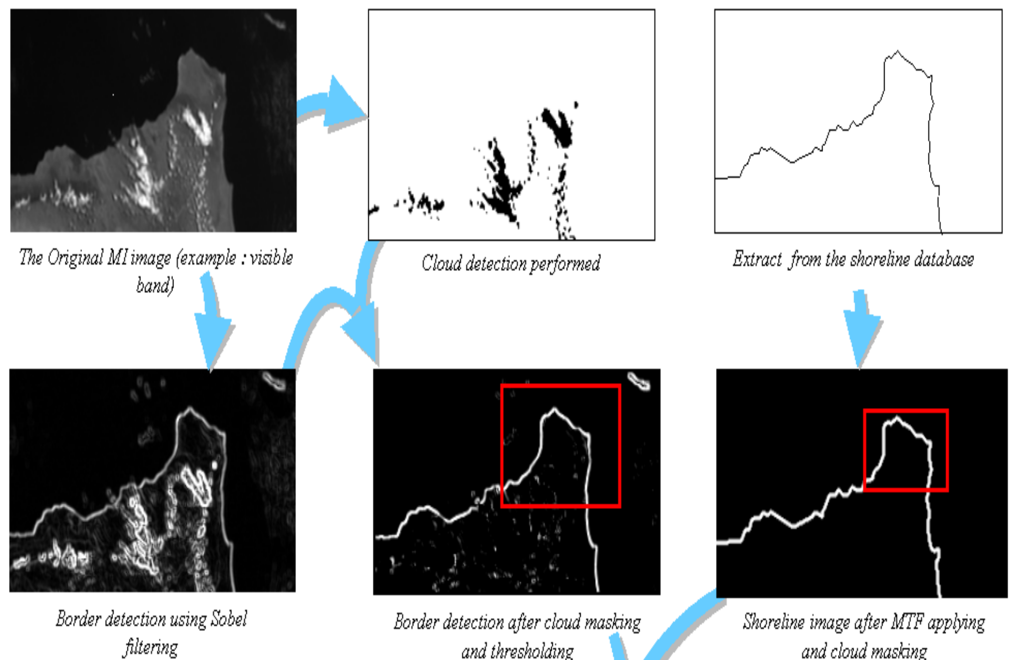
II. Radiometric calibration

- How accurately can we correct the background noise
  - Are we going to have a tool to correct the stray light effect in the measured radiance?
    - Will depend on the wavelength and scene type. How are we going to implement laboratory obtained information to the real data?
  - Striping caused by the PRNU and other reasons are observed quite often. What kind of protective measures do we have/expect to have or do we anticipate?
  - How exactly are we going to measure the LED signal and use the signal for the calibration (linearity trending)?
  - Smearing effect would depend on the observation environment. What kind of correction measures are we going to have?

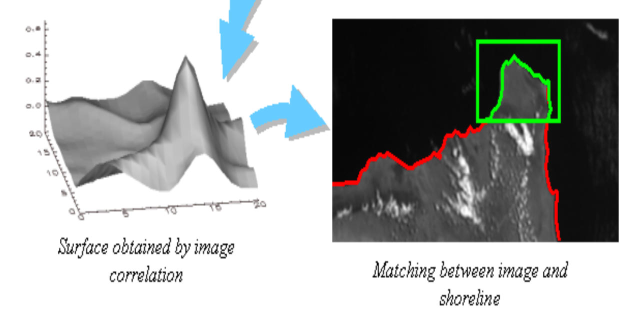
III. INR and Issues

◆ COMS INR





Landmark matching is performed on visible band and IR bands, excepted the WV one

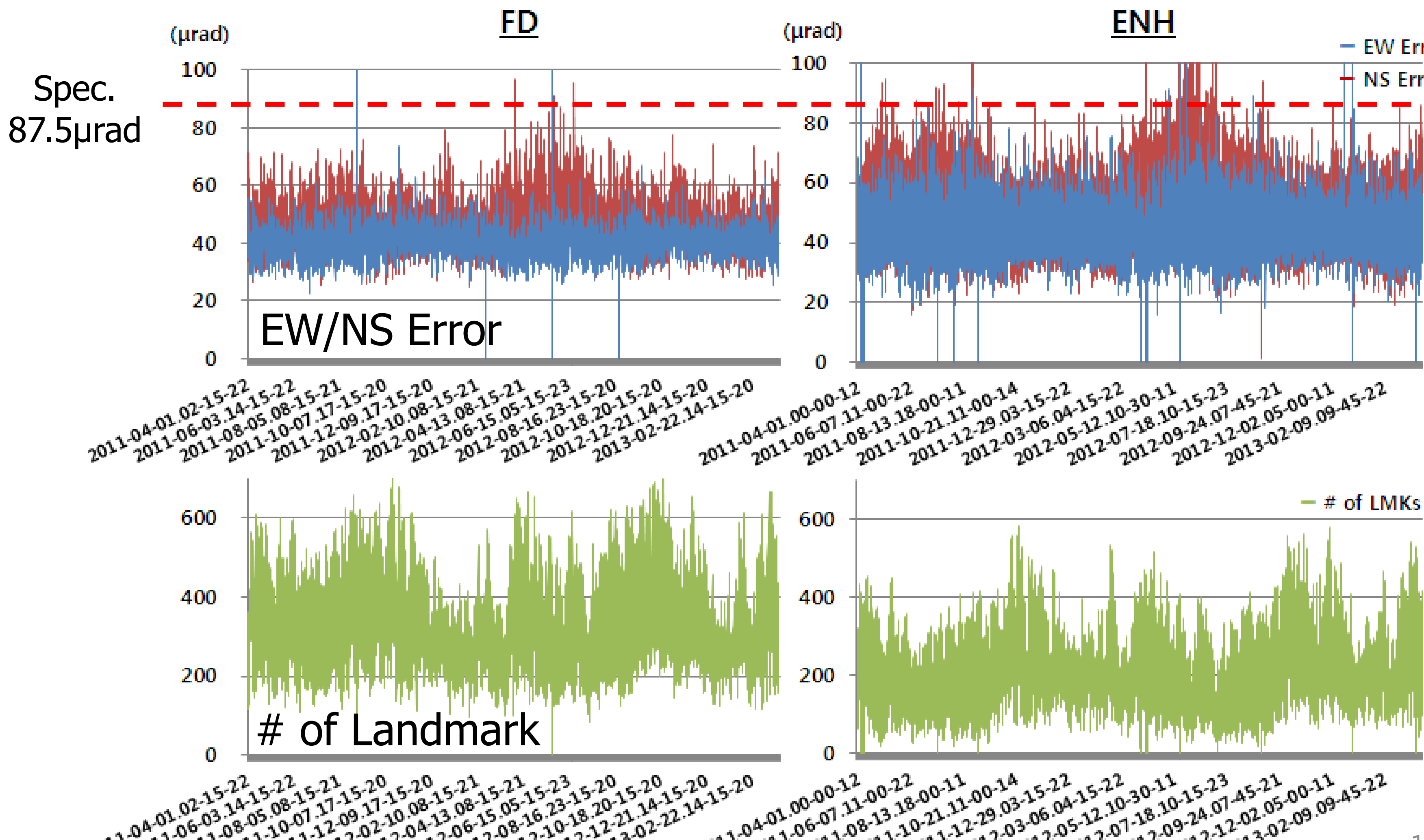


=> Heavily dependent on Landmark

From BI Lee(NMSC)

III. INR and Issues

◆ COMS INR



From BI Lee(NMSC)

III. INR and Issues

- GEMS Issues with INR
  - Slow scan rate with relatively small FOR
    - Reduces available number of good landmarks within the FOR
    - Require more uniformly distributed good landmarks and better ranging information
  - Spatial resolution
    - Increased possibility of cloud contaminated pixel which could decrease available number of landmark.
    - Lower spatial resolution means a larger landmark size (to have same number of coastal pixel number) resulting decreased number of landmark
  - Limited number of observation
    - The first scene without recent state vector information (such as the first scene of a day, or, after spacecraft maneuvering such as station keeping and wheel-off loading)
    - Limited portion of spectral data will be used for Landmark extraction, which may introduce spectral mis-alignment

IV. Summary

- Many aspects are new for the geostationary platform
- Interesting and exciting activities are ahead
- Need closer cooperation
  - Image quality is the most important for the better utilization of GEMS data
  - It is determined by at least three important calibration activities, Geometric, Spectral, and Radiometric.
  - All of these calibration require a closer collaboration of all stakeholder including user, sensor/spacecraft engineer, ground processing and scientific algorithm developer

Thank you