Strategies and preliminary results of comparing FM5 with FM3/FM1

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Opening remarks

- S-NPP has completed its first repeat cycle of 432 days a year ago!
  - Enough data to look at CERES differences
  - Unfiltered radiances to avoid uncertainties of ADMs
  - Preliminary numerical results because:
    - Edition1-CV for FM5
    - Edition3 for FM1 and FM3
  - Three different complementary strategies for comparison between FM5 and FM3/FM1

FM3 and FM5 comparison

- There are two different methods:
  - Strategy 1: “Simultaneous Earth observations”
    - Comparison data available b/c of configuration of orbits
    - Less than 1 minute apart in cross-track
    - Scanning the same 1° × 1° gridded geolocations
    - Each opportunity lasting about 20 minutes
    - Day and night comparison data, and no geo bias!
  - Strategy 2: “Matched sites targeting”
    - Afforded by the use of a nadir dwell scan profile
    - Time differential < 5 min.
    - Ground-track differences: lat < 0.5°, lon < 0.25°
    - Comparison at the nadir within the size of a footprint
    - Varying duration of each event from 1 to 4 minutes

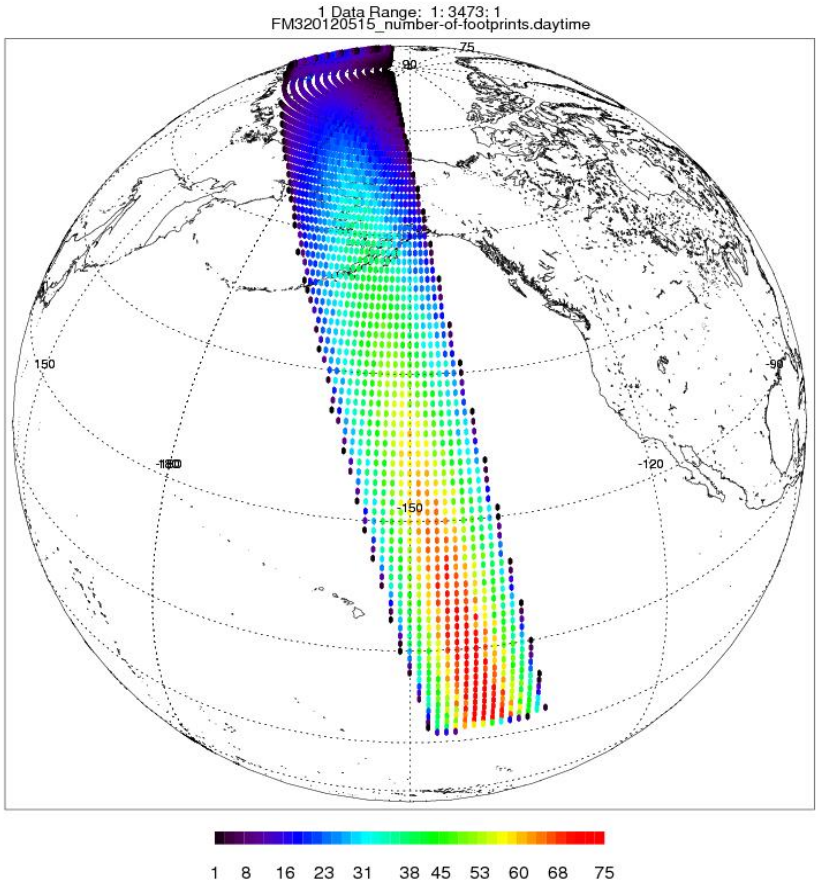
FM1, FM3 and FM5 comparison

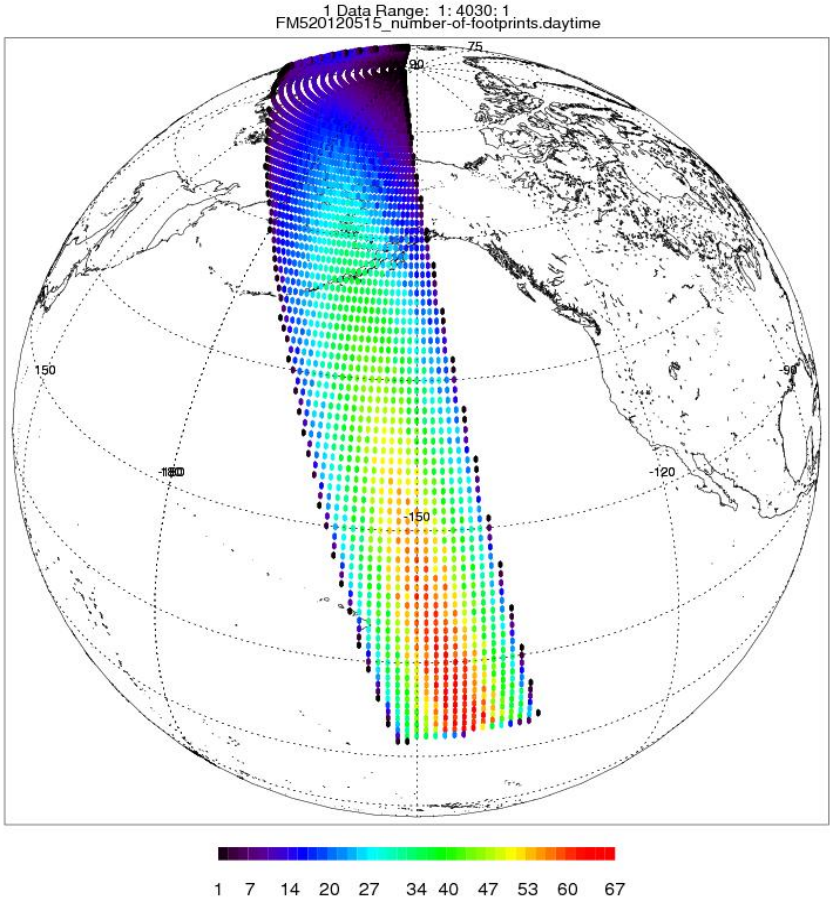
- Strategy 3: “Minor plane radiation measurements”
  - FM1/FM3/FM5 scan in the minor plane
    - During the summer solstice since 2012
    - All three scanners use a double nadir scan profile
      - Time differential for FM1/FM5 < 5 minutes (May-July)
      - Time differential for FM1/FM3 < 18 minutes (June)
      - Comparison region is around 68° N
      - Duration of each comparison event is about 2.5 minutes

Strategy 1: "Simultaneous Earth Observations"

- Both instruments stay in the XT
  - Every 64 hours AQUA and NPP fly in "tandem"
  - time difference of less than 60 sec for about 20 min.
    - gridded 1°×1° geolocations for comparison
      - RAZ < 10 deg; VZA < 15 deg
      - Difference in mean radiances for a grid (20-25 footprints)
      - Data collection completed for the first repeat cycle of 432 days
      - Statistics continuously improve with time

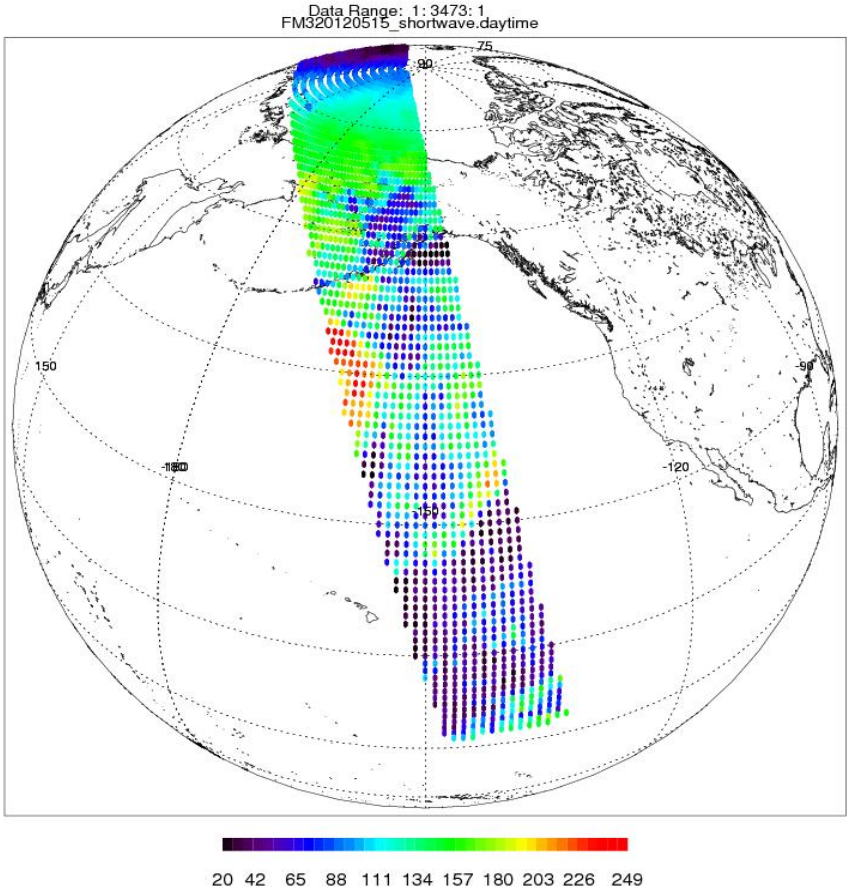
Example of a comparison region

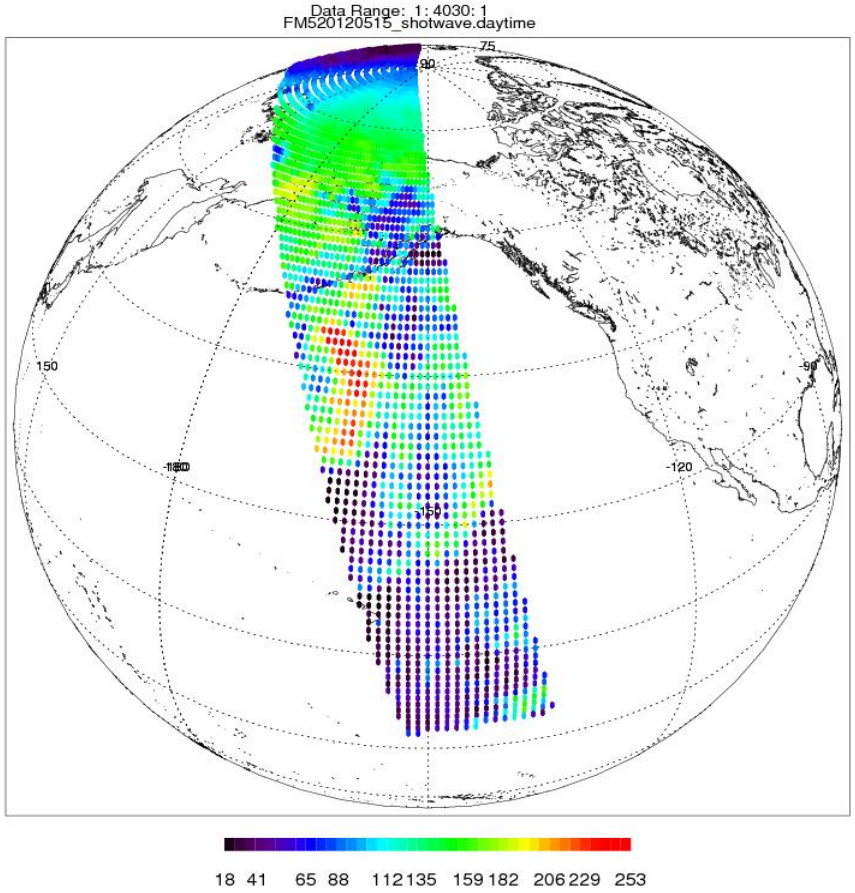




Number of footprints shown in each 1°×1°grid

Example of a comparison region





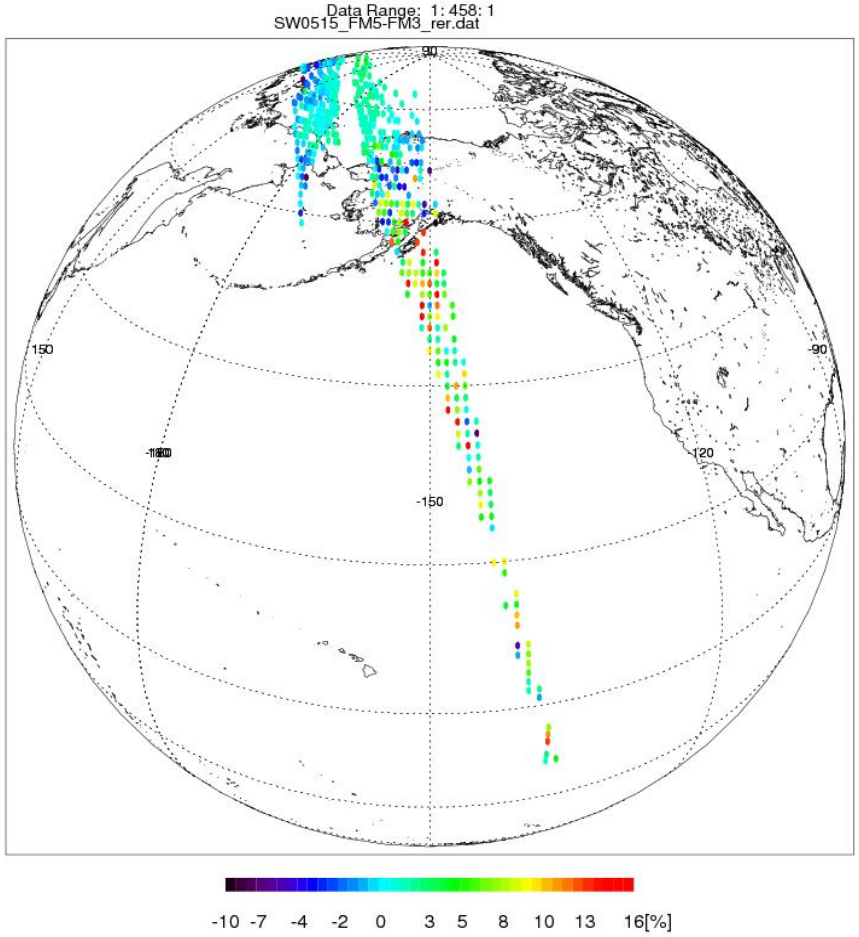
Averaged unfiltered radiance shown in each 1°×1°grid

Example of a comparison region

{VZA} = 25°

ΔVZA = 1.7° (σ = 3.3°)

ΔRAZ = 0.8° (σ = 2.1°)



Relative difference shown for each matched 1°×1°grid

Results for Strategy 1

All-sky

February 2012 – April 2013; First repeat cycle of 432 days

(FM5-FM3)/ FM5	Radiance [W m^{-2} sr^{-1}]	Relative Error [%]	α-confidence	Number of samples
Shortwave	**80.53**	**3.16**	**0.44**	**82**
LW daytime	**75.96**	**-1.39**	**0.13**	**84**
LW nighttime	**67.79**	**-0.50**	**0.11**	**102**

Shown differences are statistically significant

Additional Results for Strategy 1

February 2012-April 2013 CLEAR SKY OCEAN

(FM5-FM3)/ FM5	Radiance [W m^{-2} sr^{-1}]	Relative Error [%]	α-confidence	Number of samples
Shortwave	27.83	10.75	1.23	56
LW daytime	89.67	-0.33	0.11	63
LW nighttime	92.36	-1.06	0.16	55

February 2012-April 2013 OVERCAST

(FM5-FM3)/ FM5	Radiance [W m^{-2} sr^{-1}]	Relative Error [%]	α-confidence	Number of samples
Shortwave	120.98	1.51	0.49	71
LW daytime	62.18	-2.27	0.24	77
LW nighttime	57.20	-0.37	0.15	102

Summary for Strategy 1

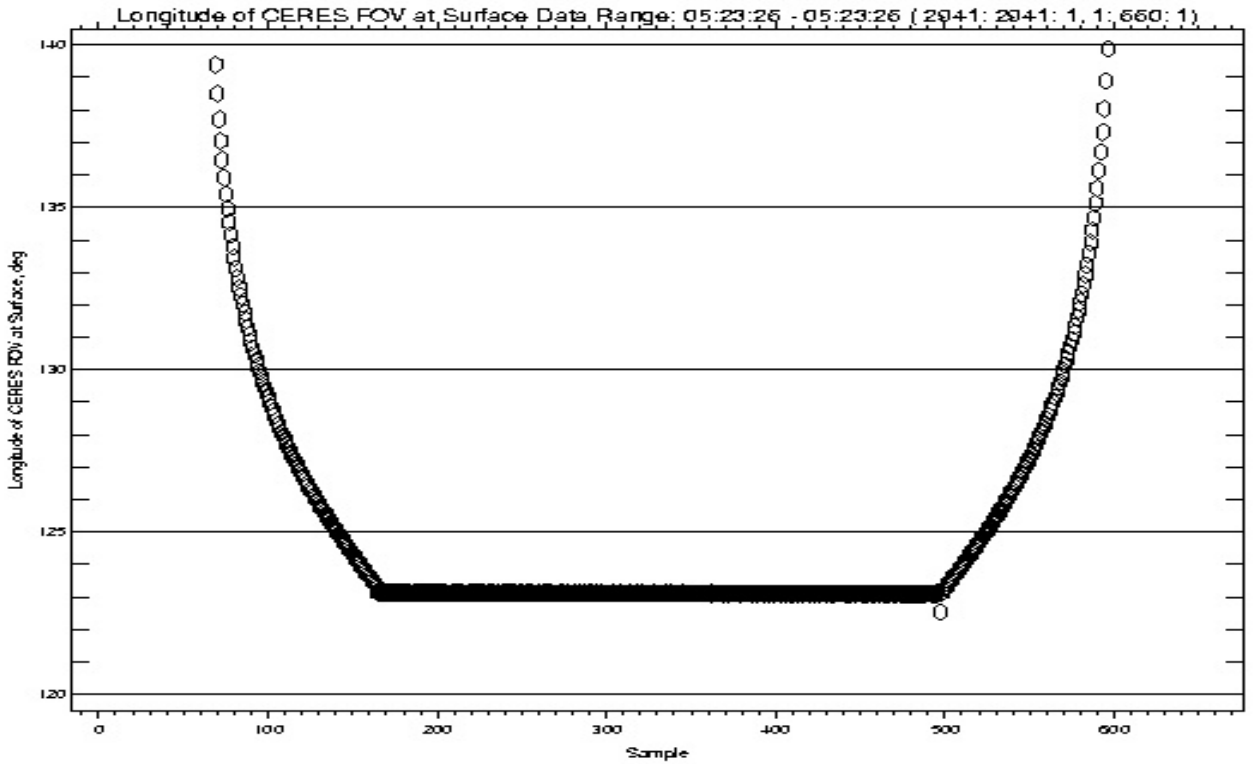
- Results for the first repeat cycle (432 days)
  - All-sky shortwave results show
    - FM5 is greater than FM3 by about 3%
    - For each SID, the difference is positive
- All-sky longwave nighttime shows
    - FM3 > FM5 by about 0.5%
    - FM3 is greater for each SID

Strategy 2:
"Matched sites targeting"

- FM5 and FM3 use a nadir dwell scan profile
  - $\Delta T < 5$ minutes; lat $< 0.5°$, lon $< 0.25°$
    - 8 nadir dwells per minute for up to 4 minutes
    - VZA $< 0.2°$
    - Unprecedented spatial match of measurements
    - High confidence mean radiances (average of 330 footprints)
    - Selection of uniform scene types for scheduling
    - Complementing simultaneous observations
    - Impossible to predict the cloud coverage beforehand

Trailblazer comparison opportunity in remote sensing

Nadir dwell scan profile

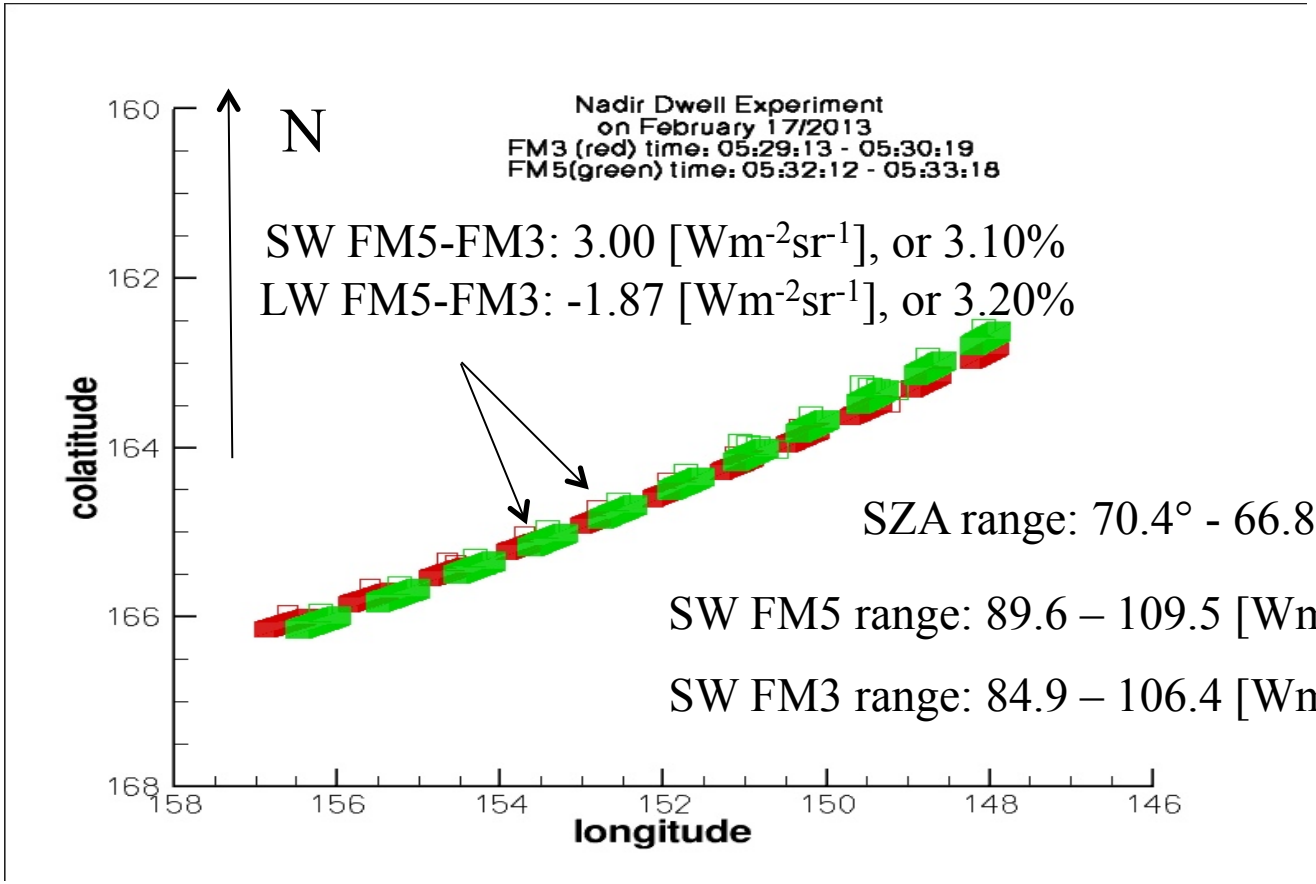


A factor of 3 higher precision of an average radiance then for a cross-track gridded average

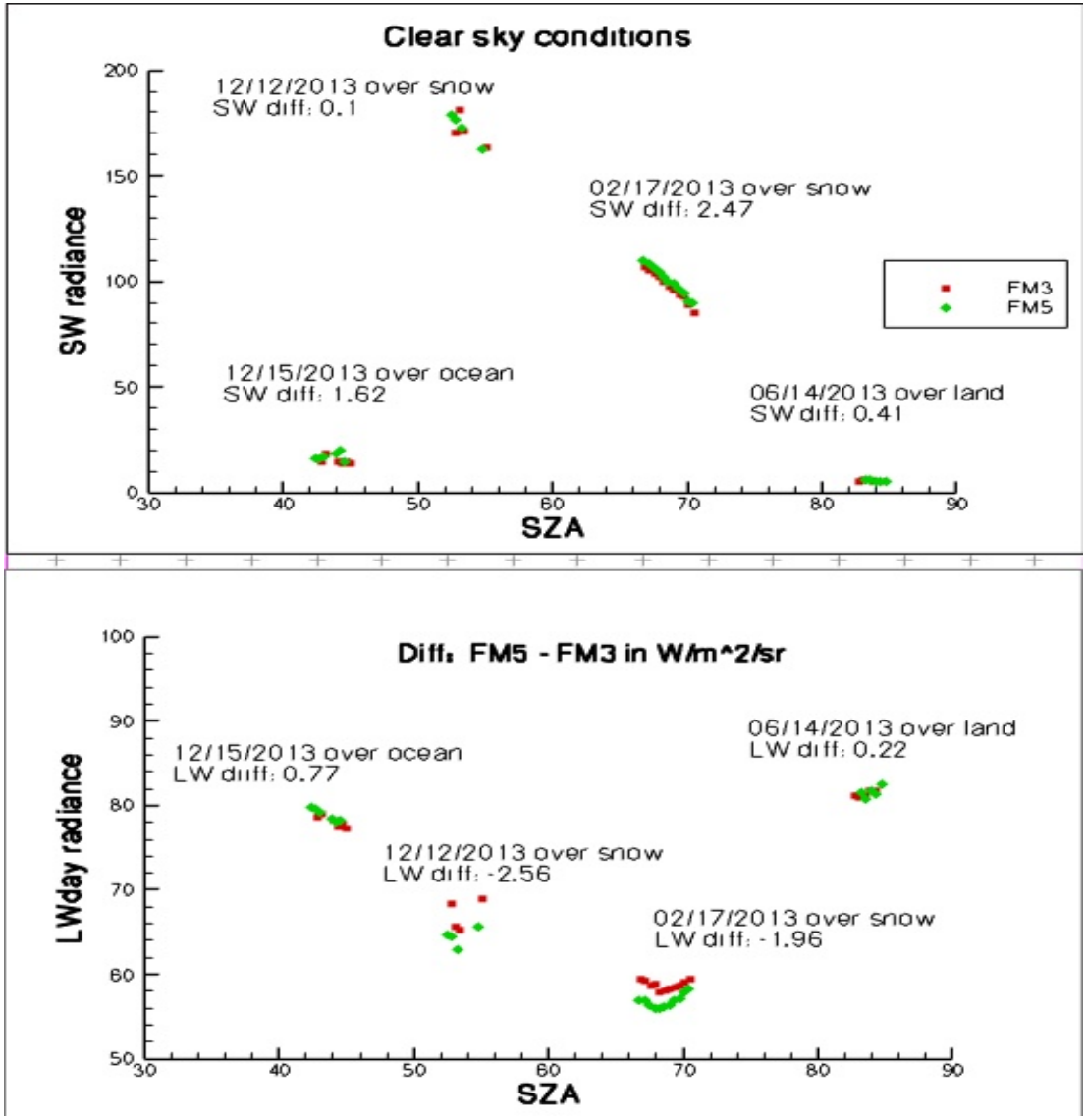
Nadir dwell experiments in 2013

- 7 experiments were done in 2013
  - On February 17 over Antarctica daytime
  - On June 14 over Alaska at night
  - On July 17 over Pacific Ocean at night
  - On August 20 over ocean off New Zealand daytime
  - On October 1 over Patagonia daytime
  - On December 12 over South Atlantic daytime
  - On December 15 over South Indian Ocean daytime
- All of them have been processed using ES8s

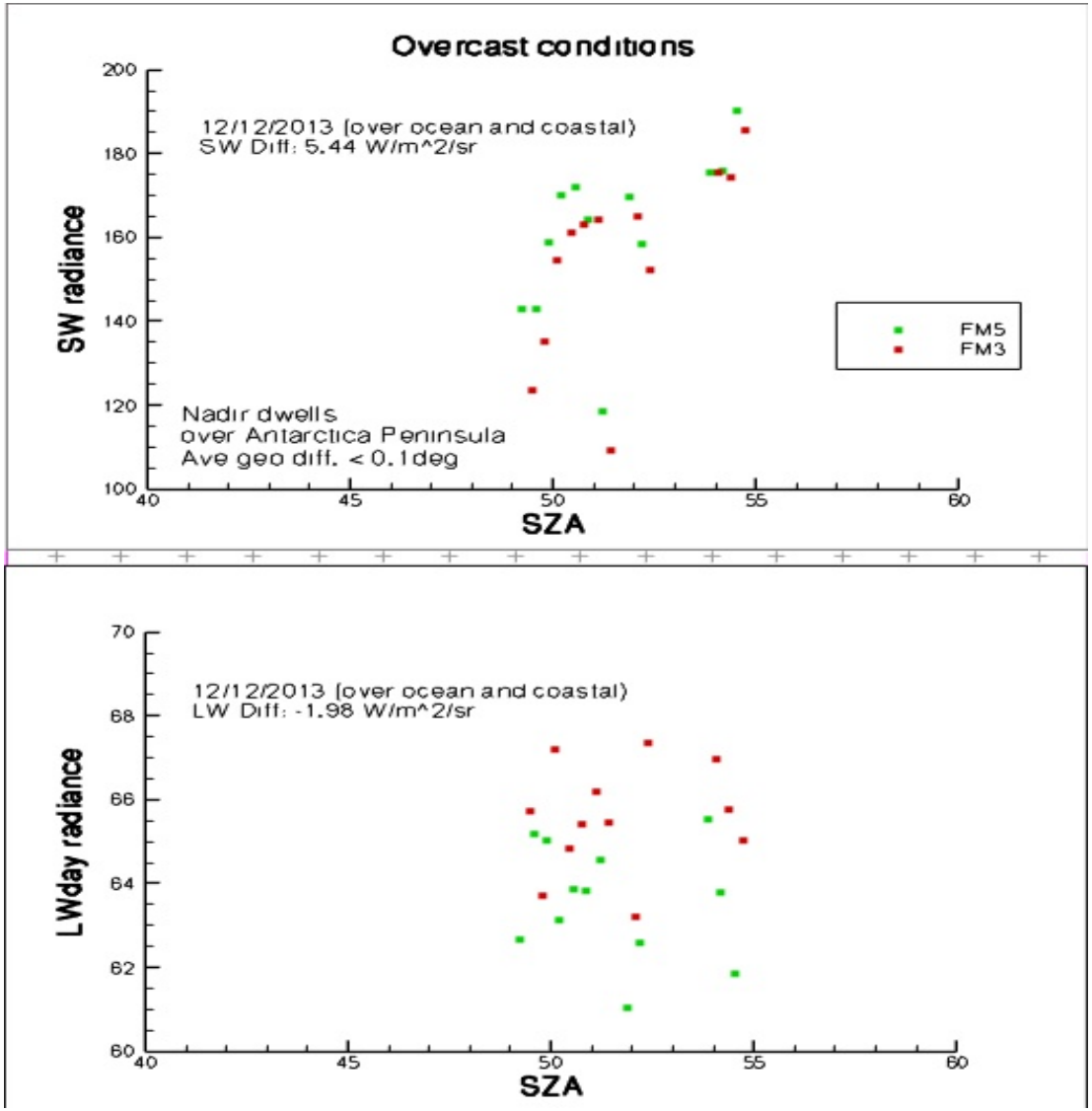
Nadir dwell scanning on 02/17 Antarctica (clear sky snow)



Nadir dwells with clear sky



Nadir dwells with overcast



Summary for Strategy 2

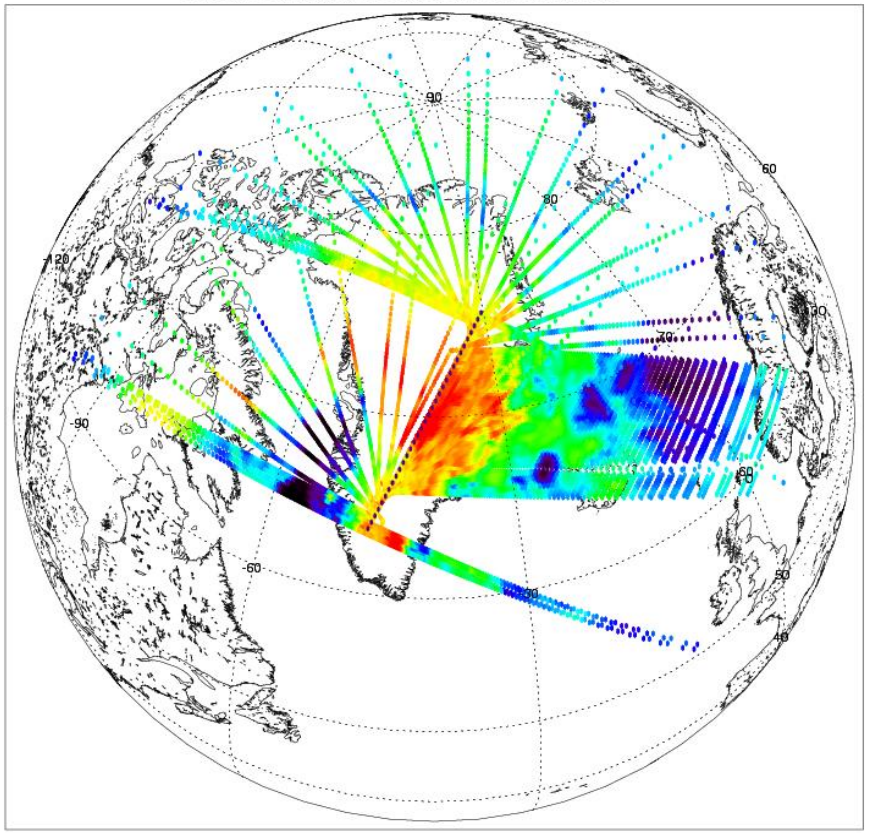
- All seven events has been processed (ES8)
  - For SW with clear sky conditions
    - FM5 is consistently greater than FM3
  - For LW daytime with clear sky conditions
    - FM3 is greater than FM5 for most cases
  - For overcast only one event was processed
    - Nadir dwells "center" were < 0.1° apart
    - Similar differences as for clear sky
- Nadir dwells need to be processed with imager data to further quantify the clouds

Strategy 3:
"Minor plane radiation measurements"

- FM1/FM3/FM5 scan in the minor plane
  - During the summer solstice starting in 2012
  - All three scanners use a double nadir scan profile
    - Time differential for FM1-FM5 < 5 minutes
    - Time differential for FM1-FM3 < 18 minutes
    - Comparison region is around 68° N
    - Duration of each opportunity is about 2.5 minutes
  - FM1/FM5 lasted from May 1 to July 31 (120 orbx)
  - FM1/FM3 lasted from June 1 to June 30 (410 orbx)

Example of a comparison region

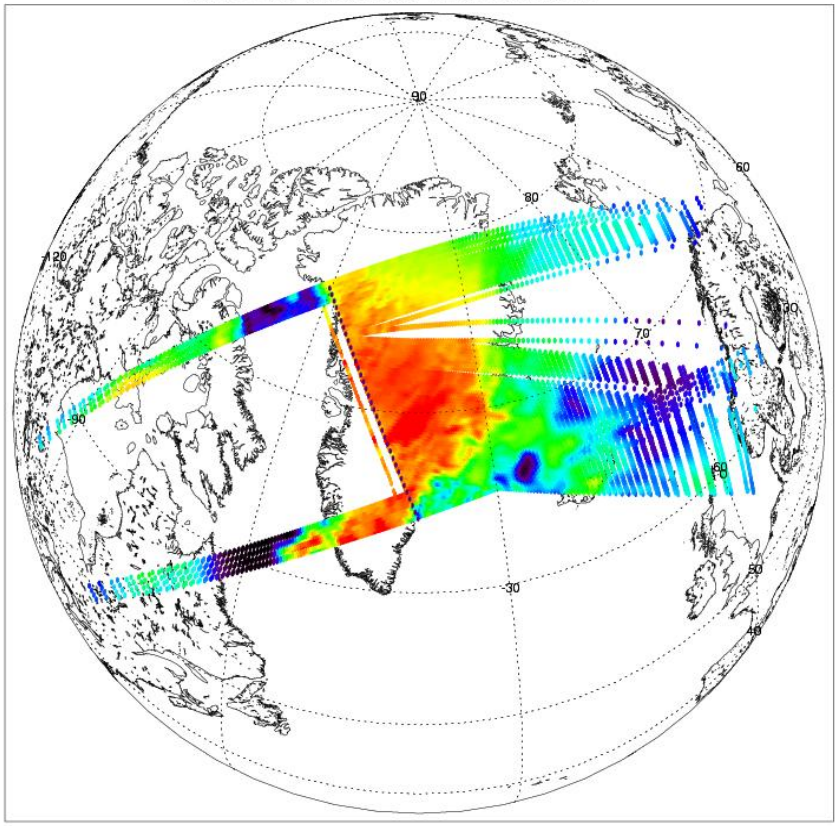
CERES SW Filtered Radiances Upwards Data Range: 14:45:03 - 14:48:35 (8047: 8079: 1; 1: 660: 1)
CER_BDS_Terra-FM1_Baseline1-QC_300301.20120616



11 26 41 57 72 88 103 118 134 149 165

Watts per square meter per steradian

CERES SW Filtered Radiances Upwards Data Range: 14:50:03 - 14:53:47 (8092: 8126: 1; 1: 660: 1)
CER_BDS_NPP-FM5_Baseline1-QC_300301.20120616



12 27 42 57 72 87 102 117 132 147 162

Watts per square meter per steradian

Results for Strategy 3

FM5/FM1 All-sky

June 15-July 31/2012

Edition1-CV for FM5 and Edition3 for FM1

(FM5-FM1)/ FM5	Radiance [W m^{-2} sr^{-1}]	Relative Error [%]	α-confidence	Number of samples
Shortwave	84.49	0.69	0.31	46
LW daytime	78.82	-0.40	0.15	49

May 1-July 31/2013

(FM5-FM1)/ FM5	Radiance [W m^{-2} sr^{-1}]	Relative Error [%]	α-confidence	Number of samples
Shortwave	101.57	0.85	0.17	108
LW daytime	76.11	-0.51	0.10	112

Results for Strategy 3

FM3/FM1 All-sky

June 1 – June 30/2013

Edition3 for FM3 and FM1

(FM3-FM1)/ FM3	Radiance [W m^{-2} sr^{-1}]	Relative Error [%]	α-confidence	Number of samples
Shortwave	95.17	-0.18	0.17	390
LW daytime	78.58	0.33	0.19	409
LW nighttime	55.70	0.09	0.03	409

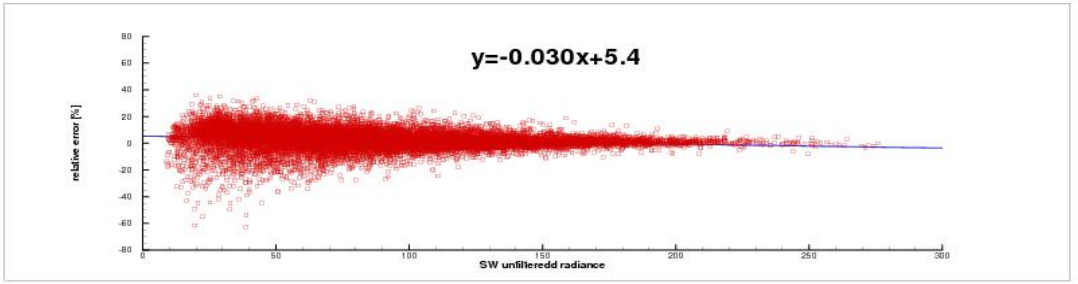
Summary for Strategy 3

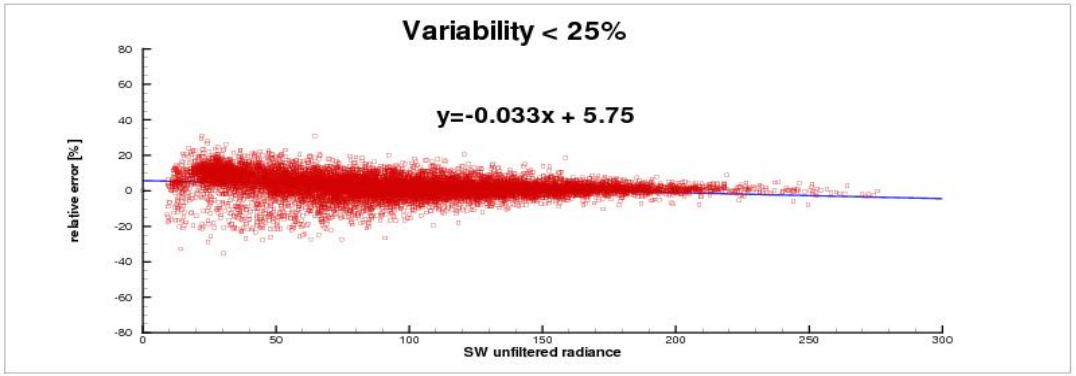
- All-sky shortwave results are consistent
  - FM5 is greater than FM3 and FM1 (FM5 > FM1 > FM3)
  - FM1 is greater than FM3 (FM1 > FM3)
- All-sky longwave nighttime is plausible
  - FM3 > FM1
  - FM1 > FM5
  - No nighttime results for FM5 and FM1
- All-sky longwave daytime is consistent
  - FM3 > FM1 > FM5
- "all-sky" composition is NOT the same!

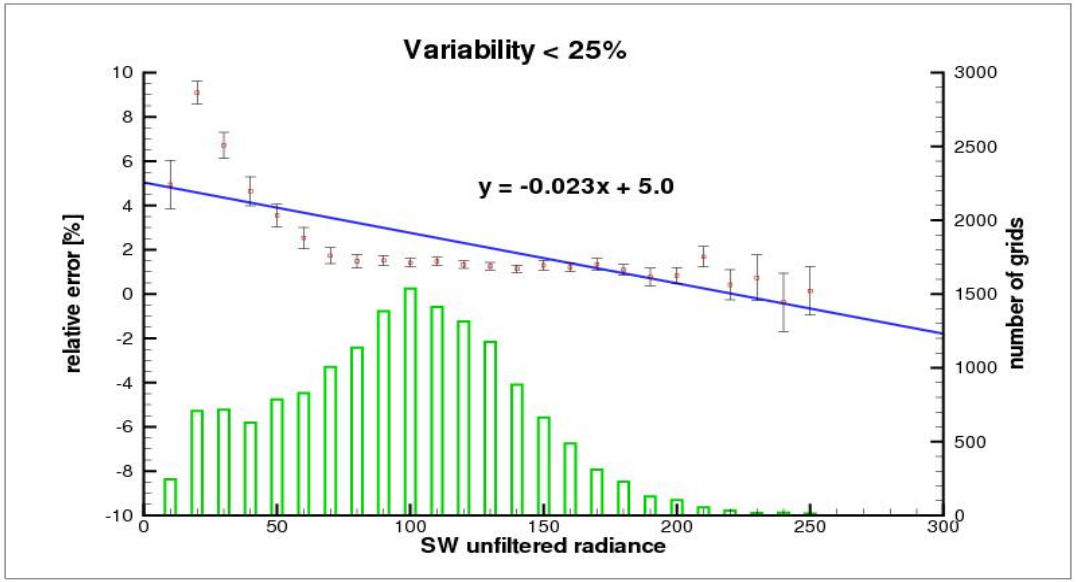
Conclusions

- For all analyzed cases SW on FM5 is greater than on FM1/FM3
  - Analyses need to be repeated for Edition 4
  - Nadir dwells have to be analyzed with SSFs
- All-sky longwave nighttime is within 1% for all three instruments
- FM5 provides an opportunity for further increase in consistency of CERES scanners

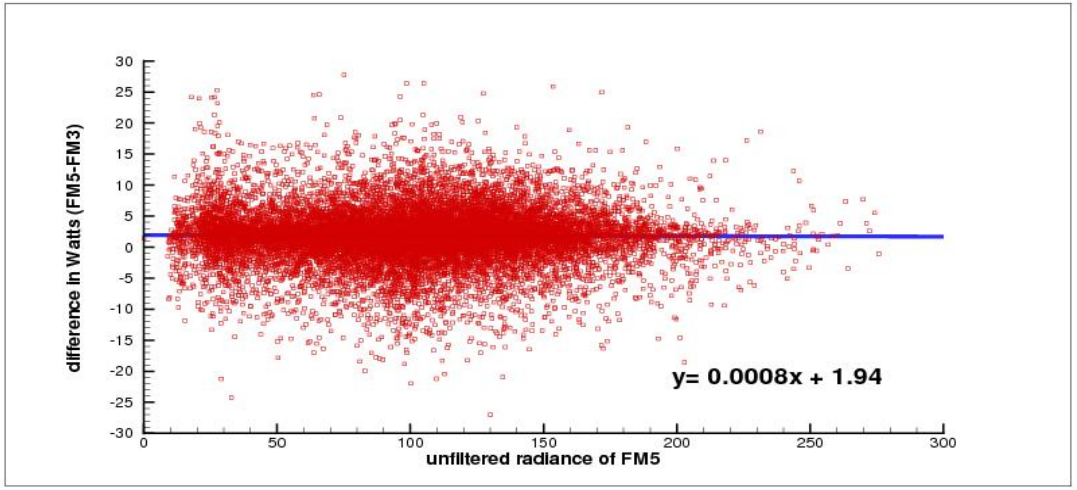
- SW all-sky results for the repeat cycle (432 days)
  - Analysis of the relative difference
  - (FM5-FM3)/FM5*100%

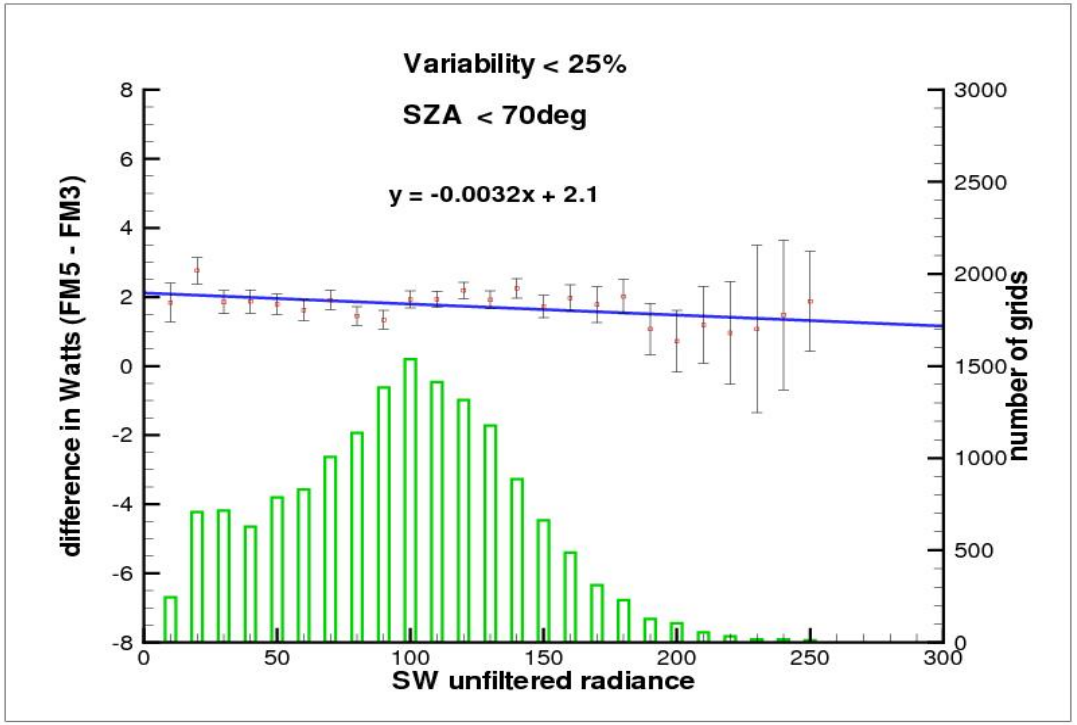






- SW all-sky results for the repeat cycle (432 days)
  - Analysis of the absolute differences (FM5-FM3)





- LW all-sky results for the repeat cycle (432 days)
  - analysis of differences