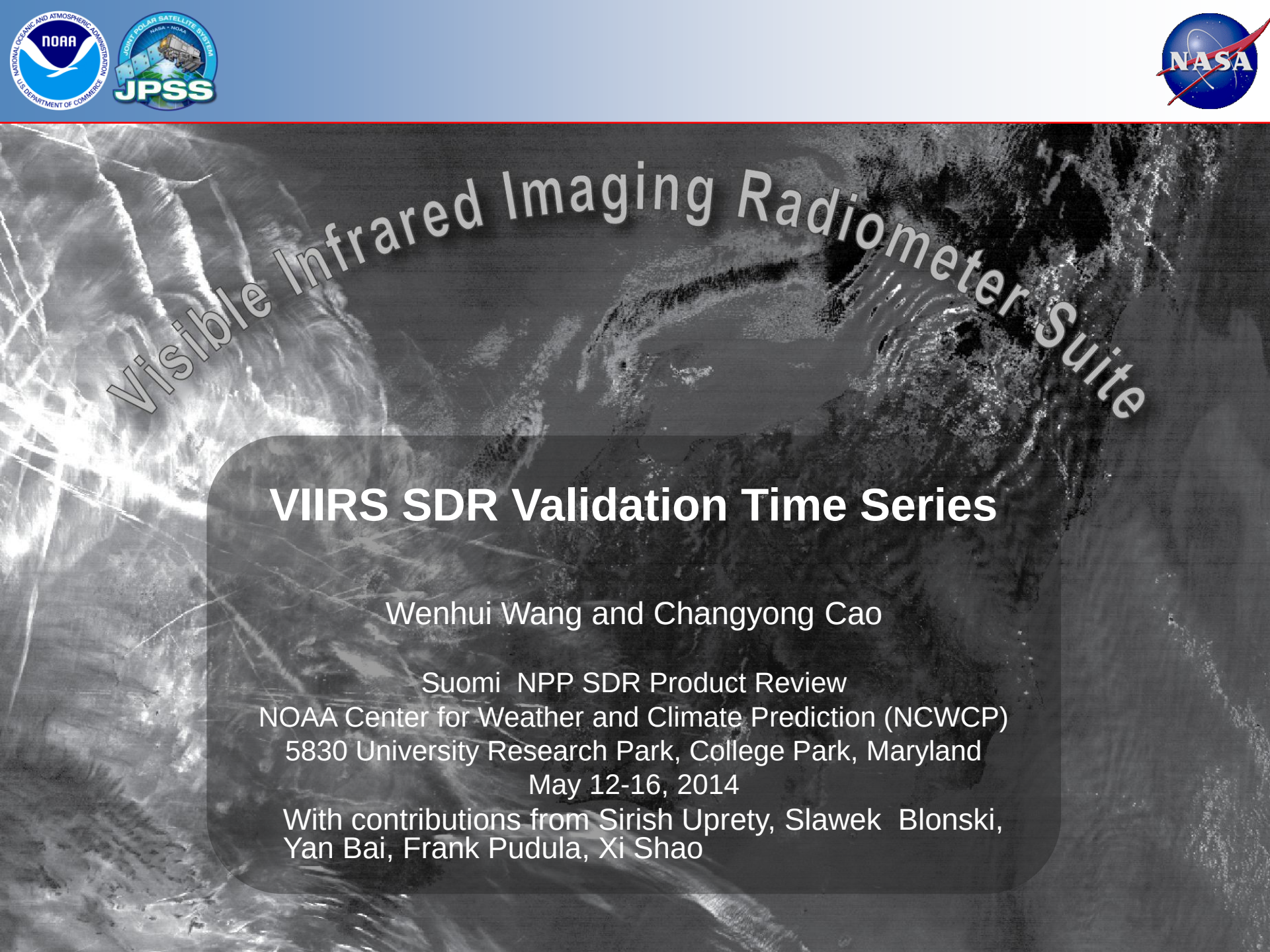

VIIRS SDR Validation Time Series

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Suomi NPP SDR Product Review
NOAA Center for Weather and Climate Prediction (NCWCP)
5830 University Research Park, College Park, Maryland
May 12-16, 2014

With contributions from Sirish Uprety, Slawek Blonski, Yan Bai, Frank Pudula, Xi Shao

Outline

- Background
- Validation sites time series
- Deep Convective Clouds (DCC) time series
- Inter-channel consistency analysis using validation time series
- Summary & future work

Background

- Visible Infrared Imaging Radiometer Suite (VIIRS): 22 spectral bands
  - 14 Solar Reflective Bands (RSB)
  - 7 Thermal Emissive Bands (TEB)
  - 1 Day-Nigh Band (DNB)

- On-board calibration is complex

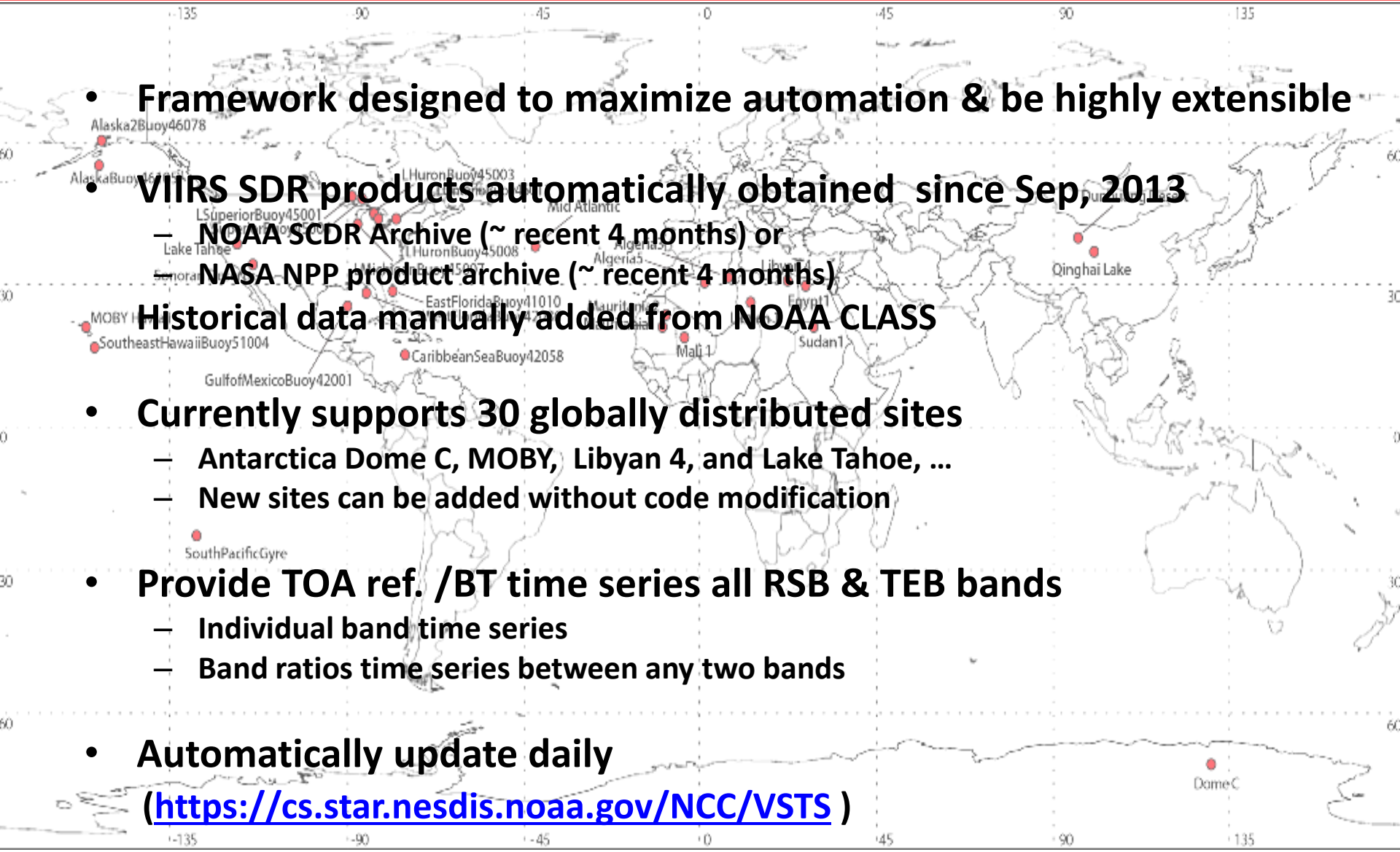
- It is important to use independent validation time series to evaluate post-launch calibration stability
  - Require large volume of data
  - Very time consuming

Objective: develop long-term validation time series for VIIRS calibration stability monitoring

- Validation sites time series over well-establish sites
- Deep Convective Clouds (DCC) Time Series
- Maximize automation

Validation Sites Time Series

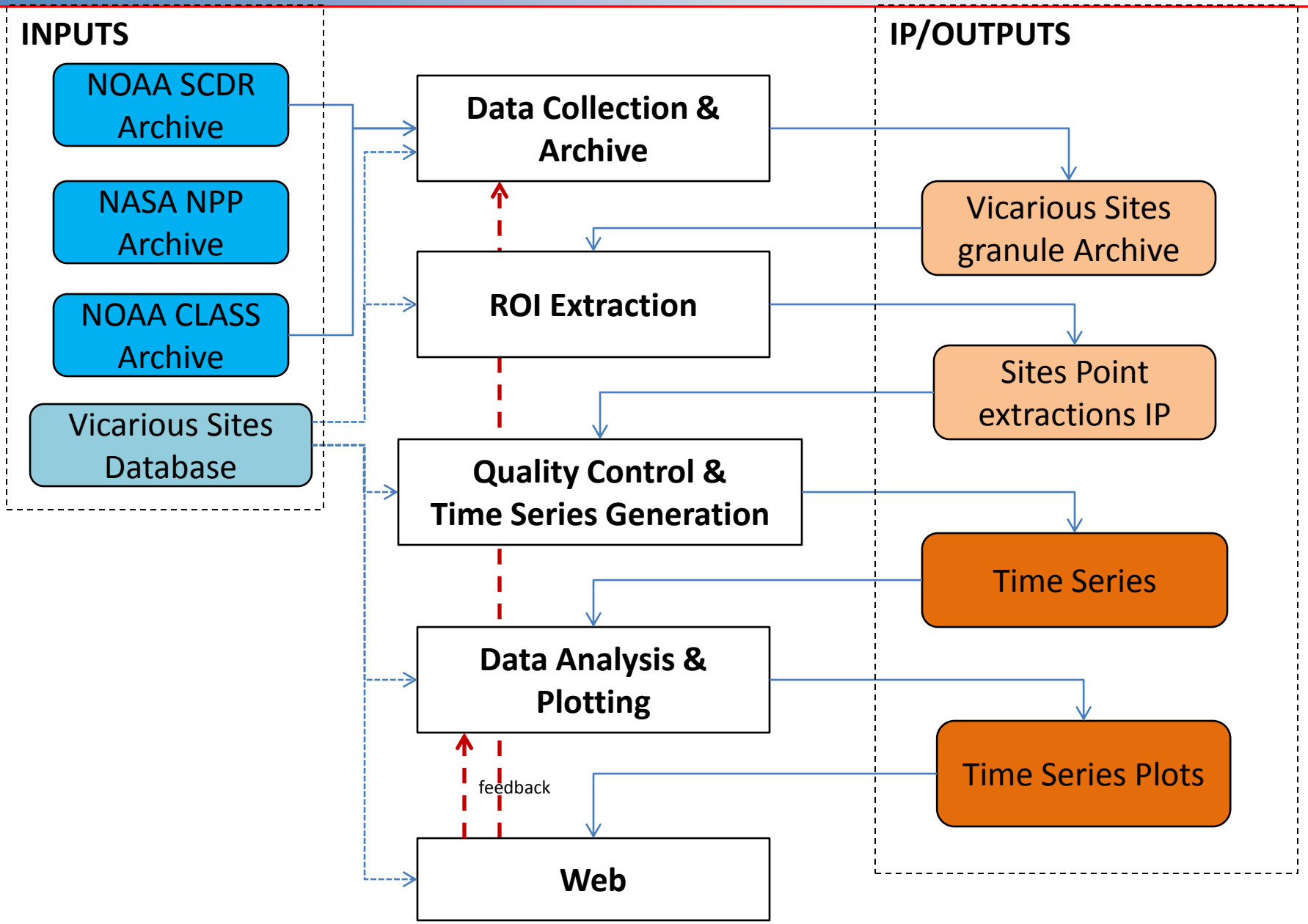
Validation Sites Time Series



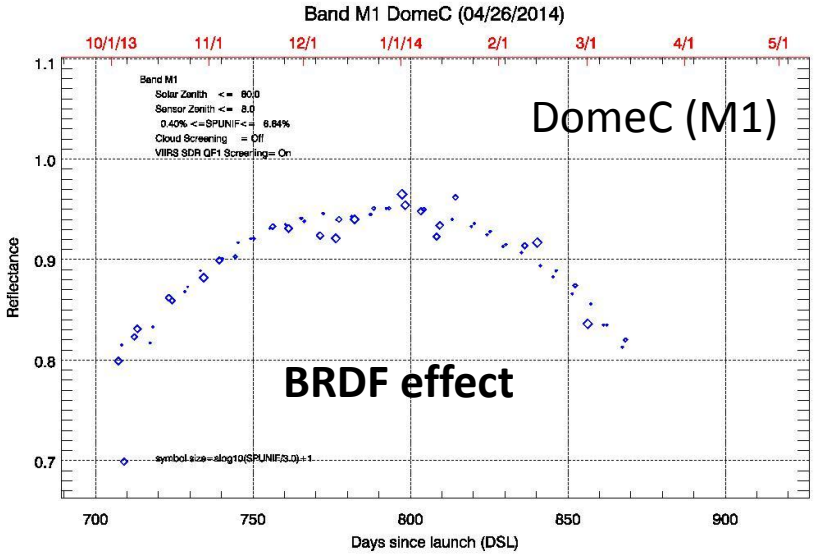
- **Framework designed to maximize automation & be highly extensible**
- **VIIRS SDR products automatically obtained since Sep, 2013**
  - **NOAA SCDR Archive (~ recent 4 months) or**
  - **NASA NPP product archive (~ recent 4 months)**
- **Historical data manually added from NOAA CLASS**
- **Currently supports 30 globally distributed sites**
  - **Antarctica Dome C, MOBY, Libyan 4, and Lake Tahoe, …**
  - **New sites can be added without code modification**
- **Provide TOA ref. /BT time series all RSB & TEB bands**
  - **Individual band time series**
  - **Band ratios time series between any two bands**
- **Automatically update daily**

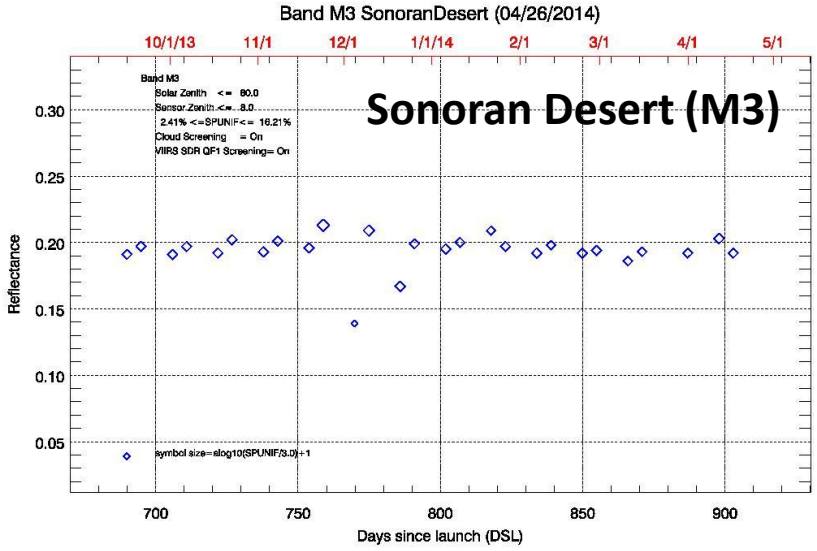
(https://cs.star.nesdis.noaa.gov/NCC/VSTS)

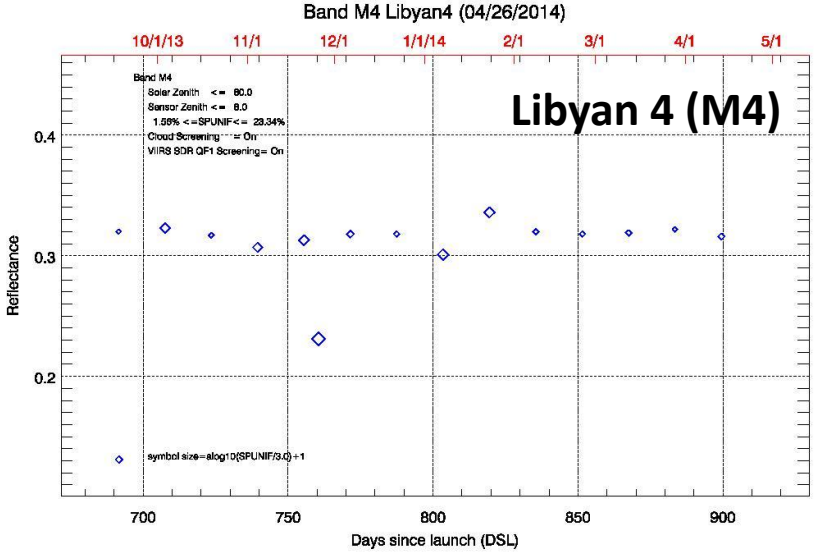
VIIRS Validation Sites Time Series Methodology

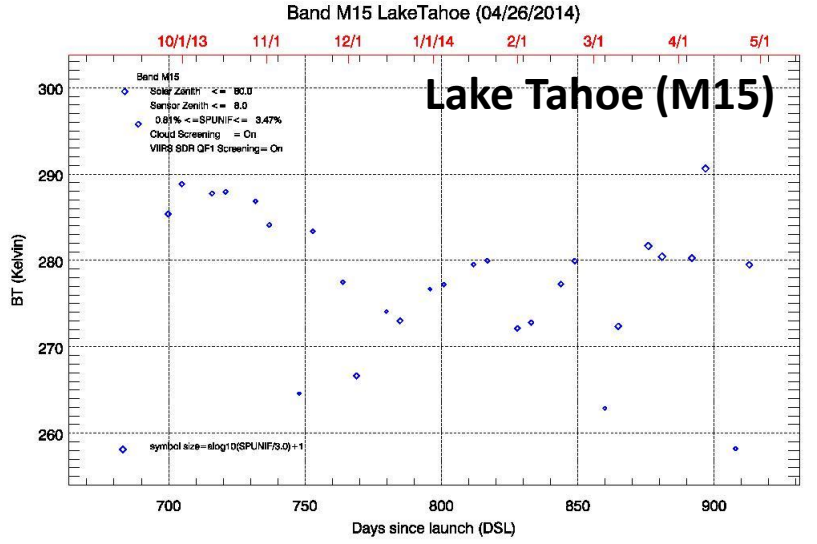


Examples (2013/09 – present)



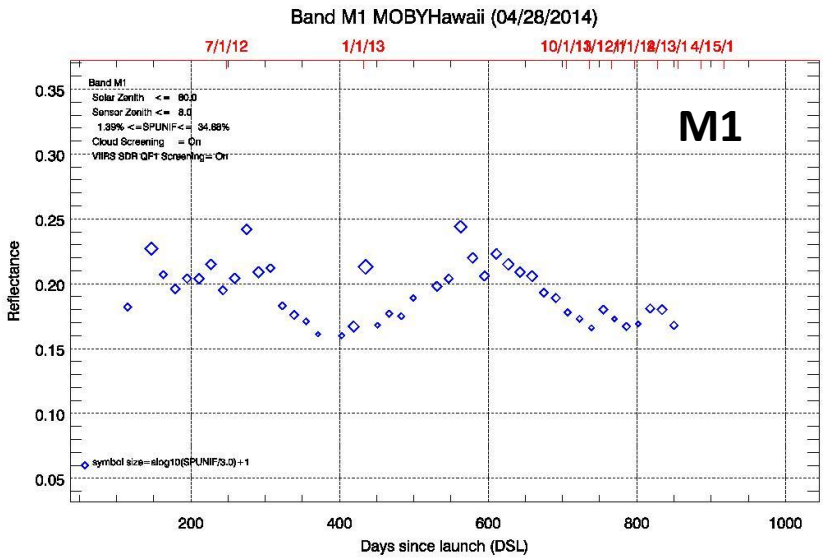


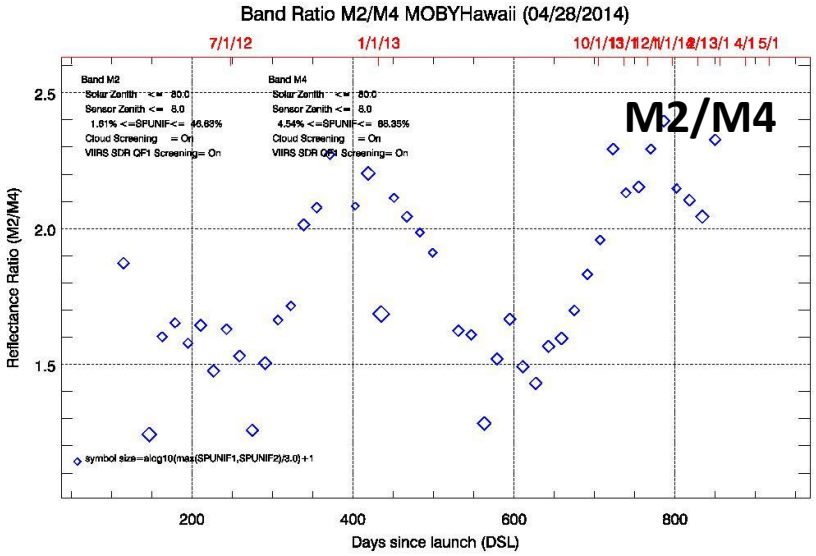


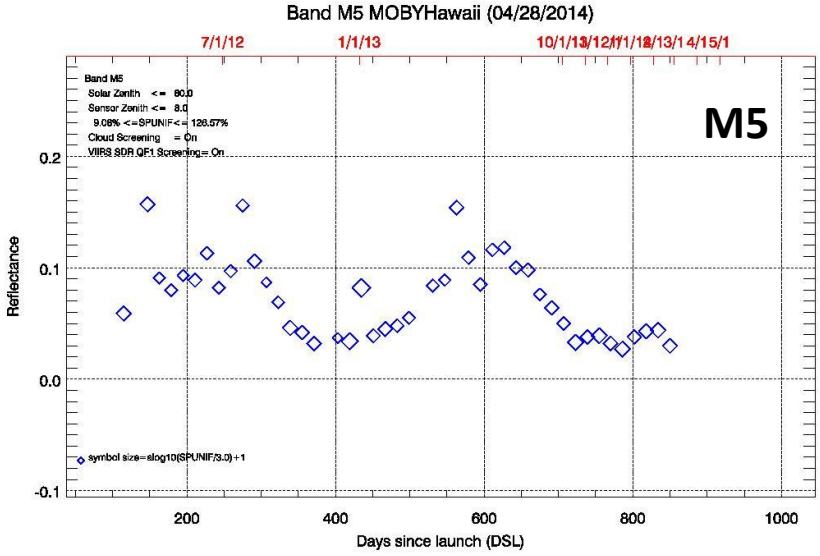


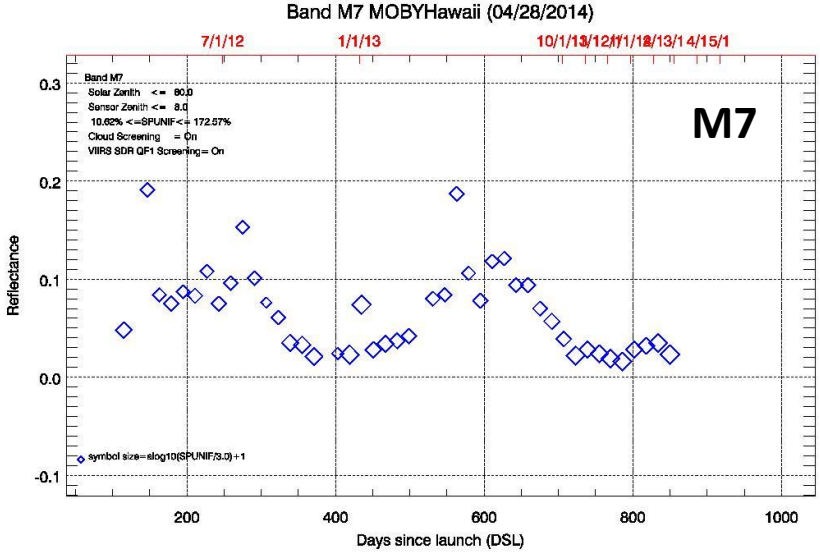
https://cs.star.nesdis.noaa.gov/NCC/VSTS

MOBY Hawaii (2012/02 – present)









Variation not due to calibration, but seasonal cycle https://cs.star.nesdis.noaa.gov/NCC/VSTS

Deep Convective Clouds (DCCs) Time Series

VIIR DCC Time Series

- **Deep Convective Clouds (DCCs)**
  - extremely cold clouds mostly occur over the ITCZ
  - Start from PBL and ascend to the TTL
  - Bright calibration targets with nearly Lambertian reflectance

- **The DCC Technique**
  - Widely used for RSB vicarious calibration
    Hu et al. 2004; Doelling et al. 2013, 2004; Aumann 2007; Minnis et al. 2008 ; Sohn et al. 2009; Fougnie and Bach 2009; Chen et al. 2013
  - Statistical -based
  - Advantages
    - **Above DCCs, minimal atmospheric effects**
    - **Identified using a single LWIR band centered at ~11 µm (TB11)**
    - **Abundance of data**

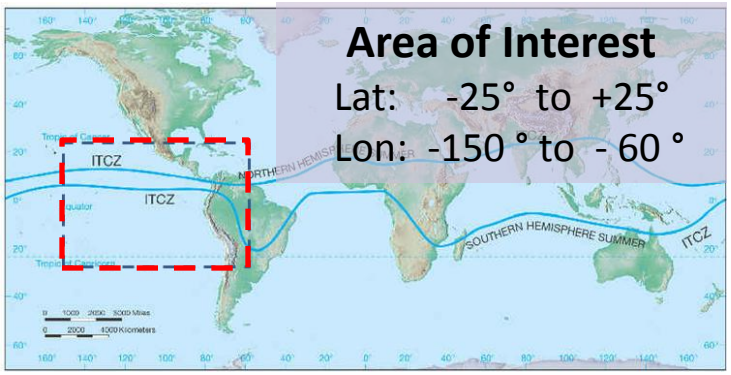
DCC Identification for VIIRS

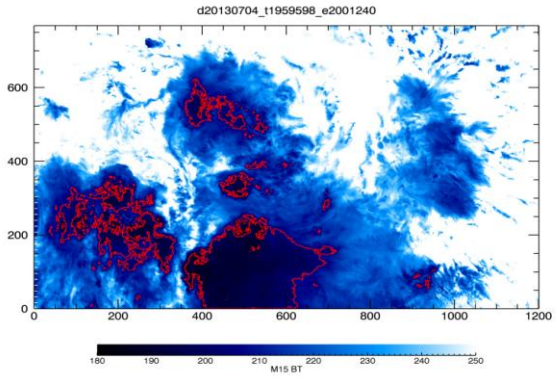
VIIRS DCC Identification Criteria

(Adapted from Doelling et al. 2013; Minnis et al. 2008)

1. TB11 (M15/I5) <= 205 K
2. σ (TB11) of the subject pixel and its eight adjacent pixels <= 1K
3. σ (ref) of the subject pixel and its eight adjacent pixels <= 3%
4. Solar zenith angle (SZA) <= 40°
5. View zenith angle (VZA) <= 35°

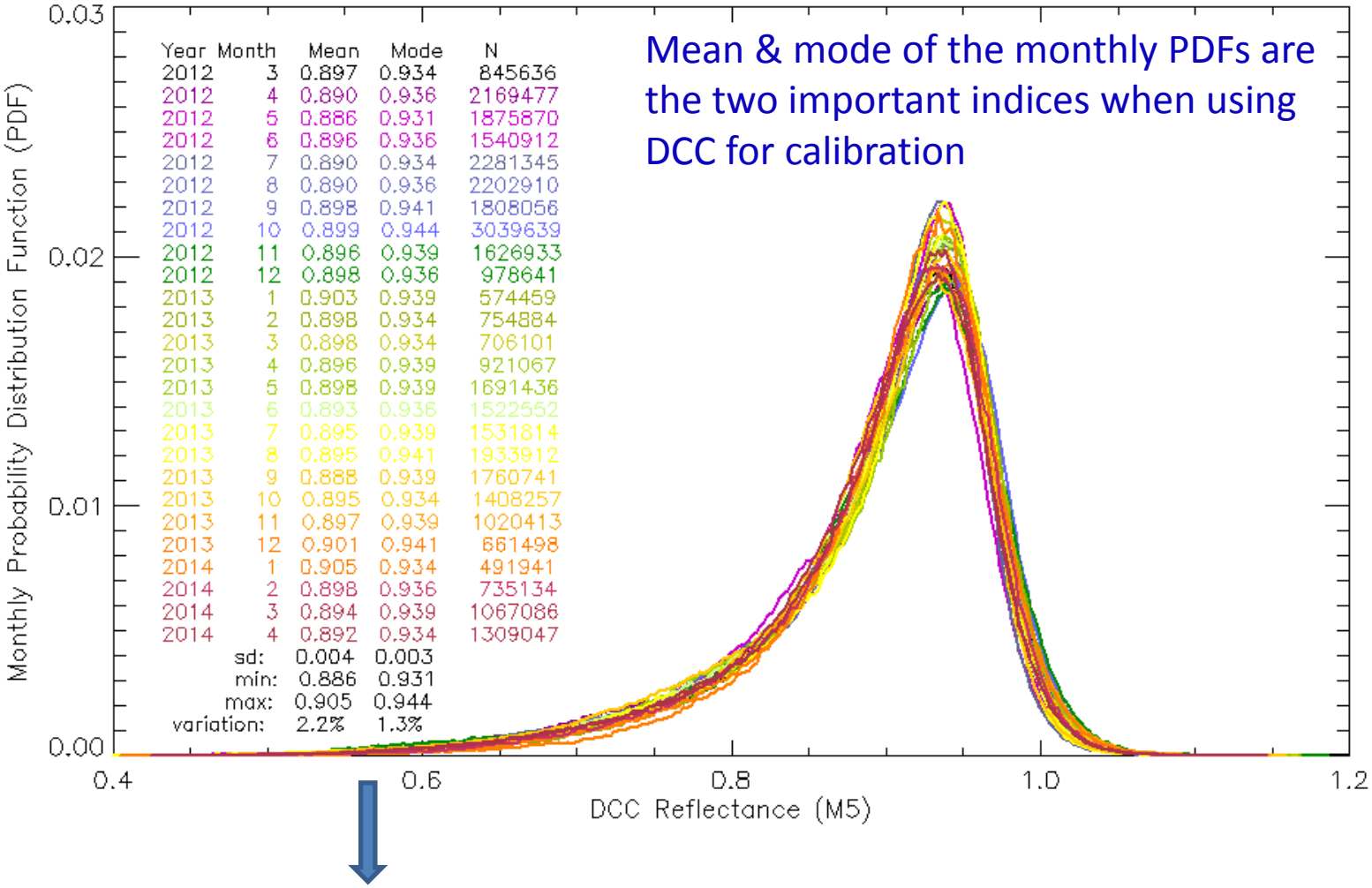
   - to avoid the bow-tie effect in VIIRS SDR product





Monthly Probability Distribution Functions(PDFs)

Anisotropic effects corrected using **Hu et al. (2004)** Angular Distribution Model

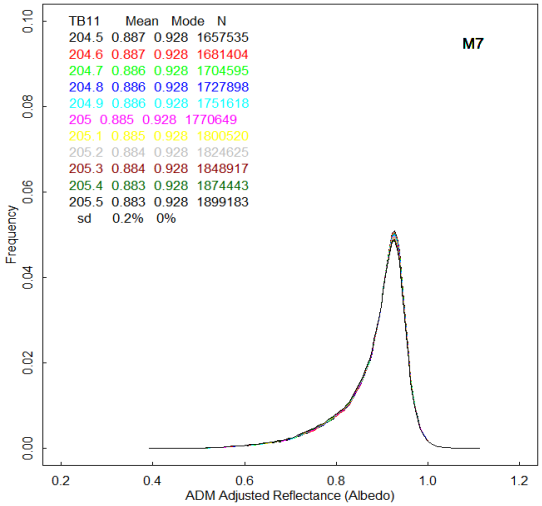


Year	Month	Mean	Mode	N
2012	3	0.897	0.934	845636
2012	4	0.890	0.936	2169477
2012	5	0.886	0.931	1875870
2012	6	0.896	0.936	1540912
2012	7	0.890	0.934	2281345
2012	8	0.890	0.936	2202910
2012	9	0.898	0.941	1808056
2012	10	0.899	0.944	3039639
2012	11	0.896	0.939	1626933
2012	12	0.898	0.936	978641
2013	1	0.903	0.939	574459
2013	2	0.898	0.934	754884
2013	3	0.898	0.934	706101
2013	4	0.896	0.939	921067
2013	5	0.898	0.939	1691436
2013	6	0.893	0.936	1522552
2013	7	0.895	0.939	1531814
2013	8	0.895	0.941	1933912
2013	9	0.888	0.939	1760741
2013	10	0.895	0.934	1408257
2013	11	0.897	0.939	1020413
2013	12	0.901	0.941	661498
2014	1	0.905	0.934	491941
2014	2	0.898	0.936	735134
2014	3	0.894	0.939	1067086
2014	4	0.892	0.934	1309047
	sd:	0.004	0.003	
	min:	0.886	0.931	
	max:	0.905	0.944	
	variation:	2.2%	1.3%	

The mode of monthly PDFs is more stable than the mean (1.3% vs. 2.2%)

DCC Radiometric Sensitivity (M5, M7, I2, June-Sep 2013)

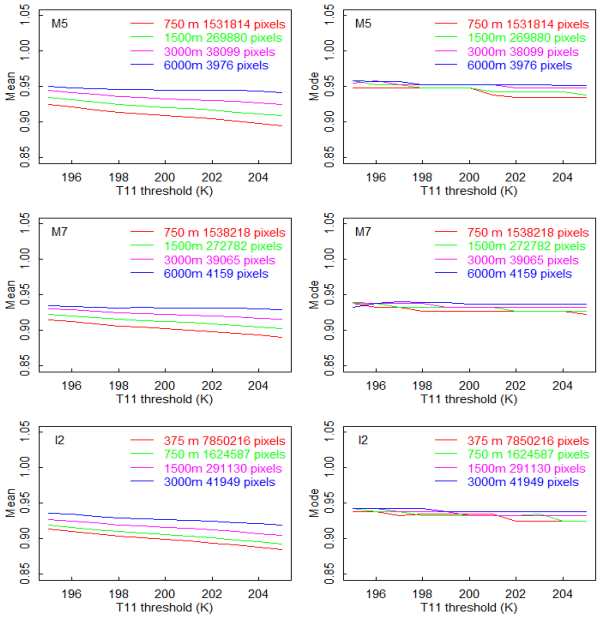
Sensitivity to calibration bias



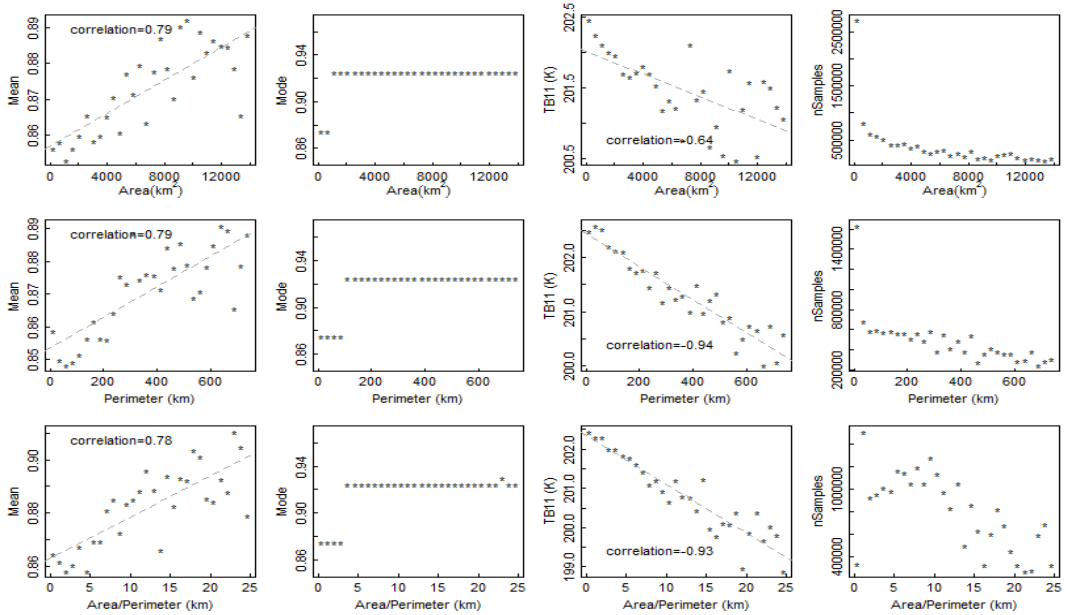
- **Mean & mode insensitive to TB11 calibration bias on the order of 0.5 K**
  - Mode is more stable
- **Mean of monthly PDFs is a function of**
  - TB11, spatial resolution, & cluster size
- **Mode is more stable than mean**, in terms of TB11 threshold, spatial resolution, cluster size, calibration bias

  Also more uniform regionally & temporally (Doelling 2013)

Wang, W. and C. Cao (2014). DCC radiometric sensitivity to spatial resolution, cluster size, and LWIR calibration bias based on VIIRS observations. Submitted to JTECH, under revision.

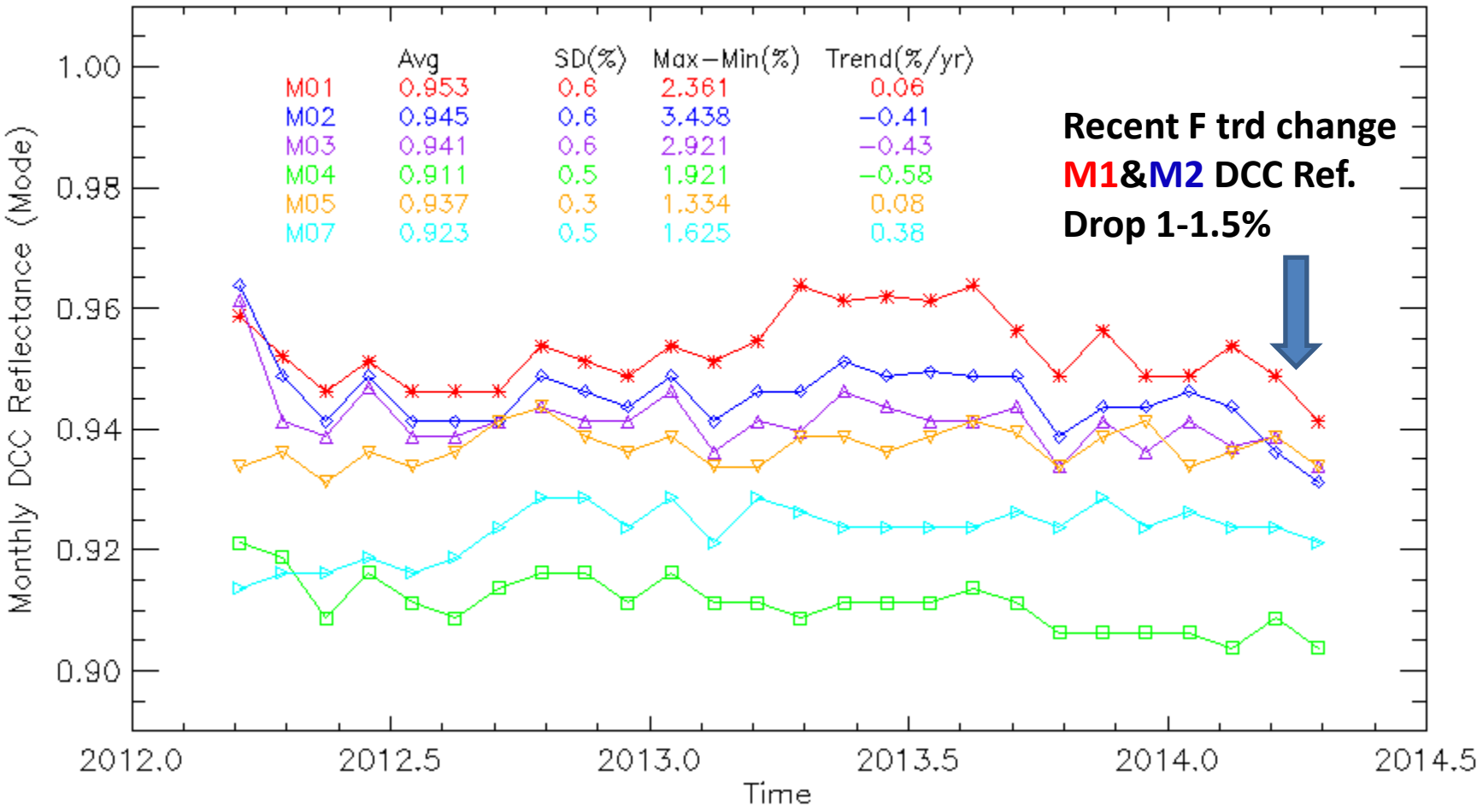


Sensitivity to spatial reso. & TB11 threshold



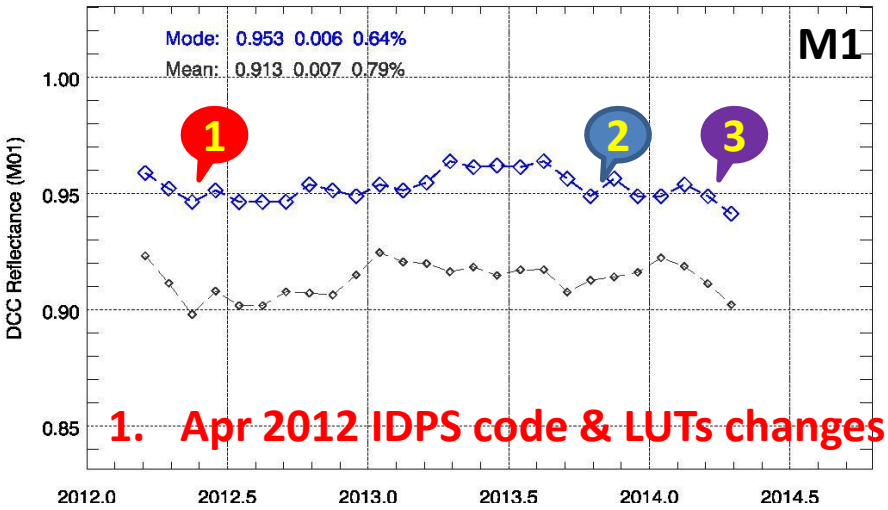
Sensitivity to cluster size & TB11

VIIRS DCC Mode Time Series
(M1-M5, M7)

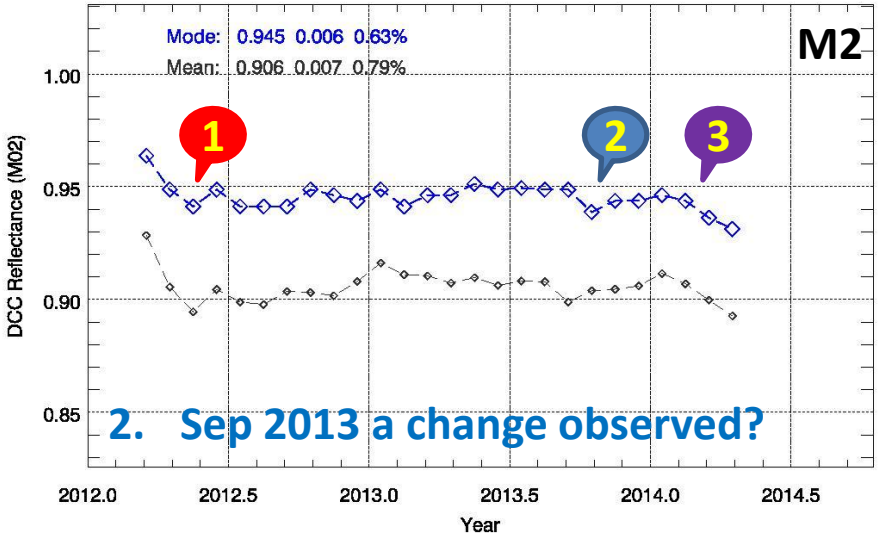


- No obvious seasonal cycle
- σ <=0.6% for all bands
- Max - Min <3.5 % for all bands
- M4, M5 & M7 are more stable

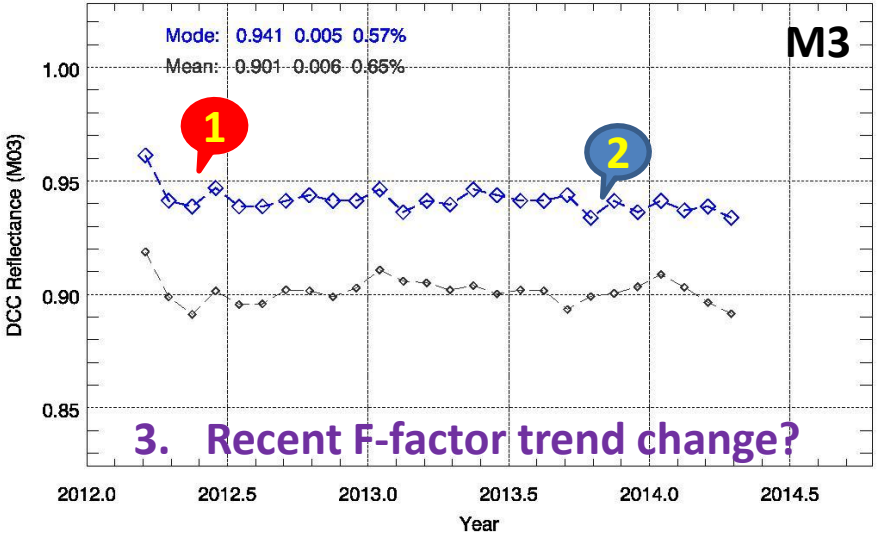
Calibration Changes Detection Using DCC mode time series



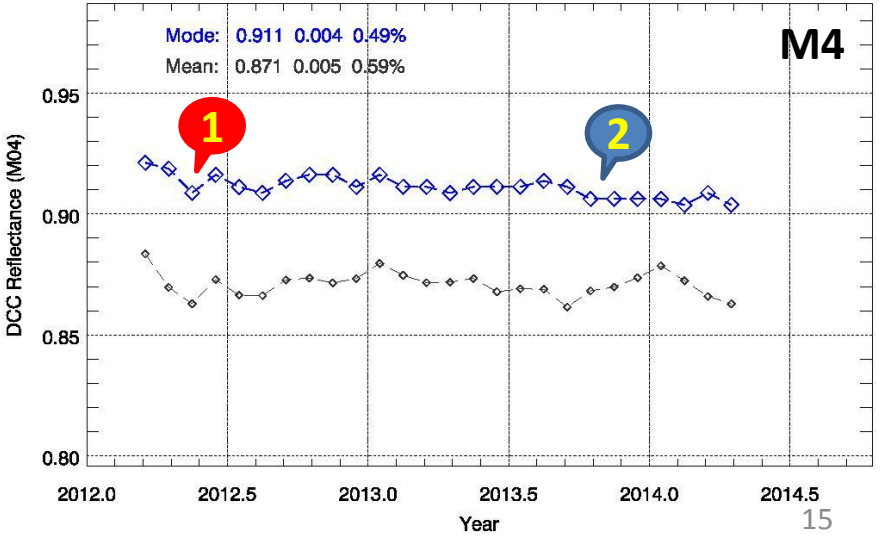
1. Apr 2012 IDPS code & LUTs changes



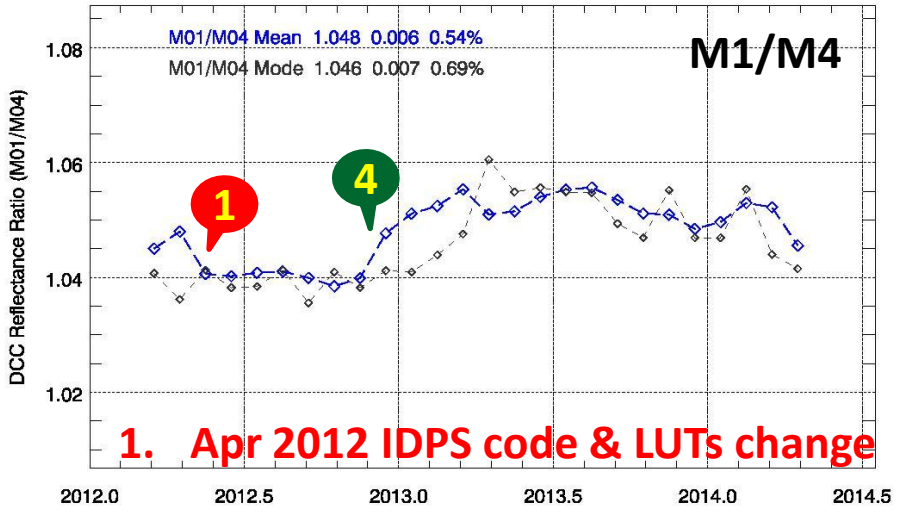
2. Sep 2013 a change observed?

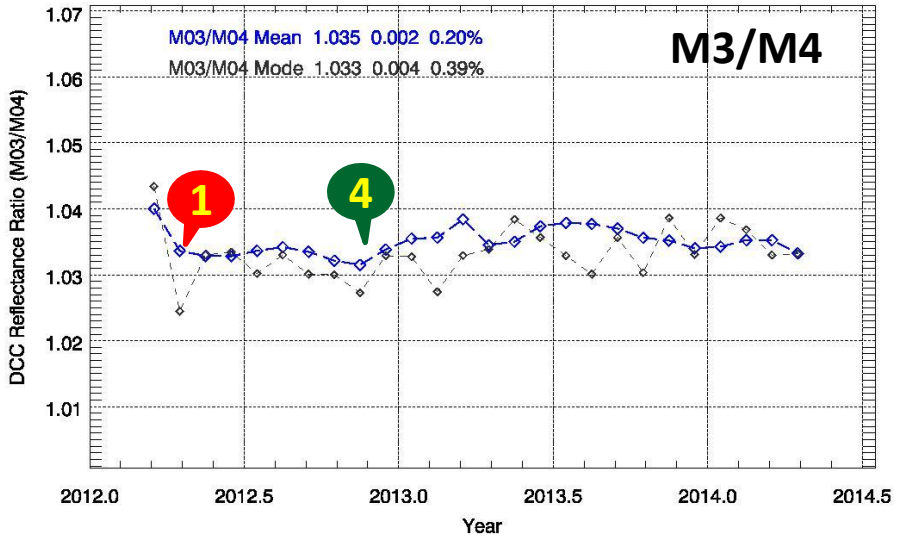


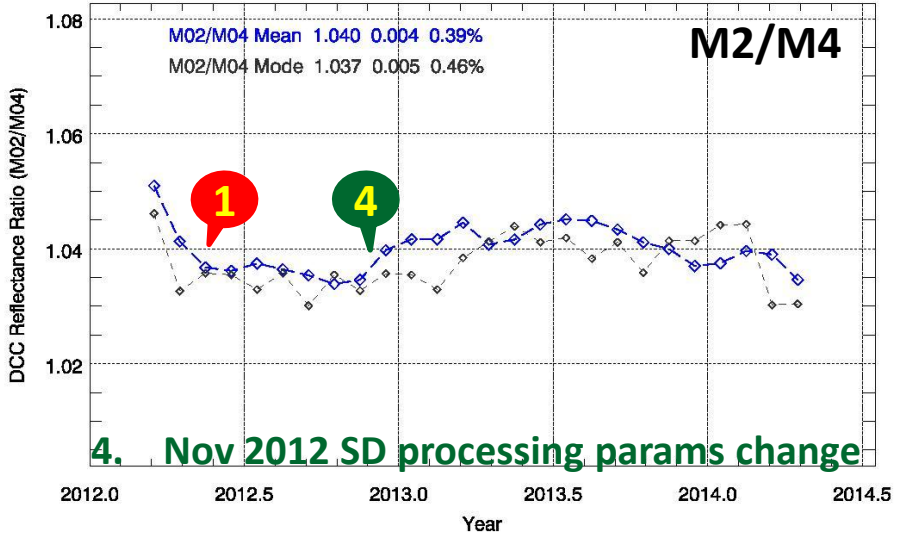
3. Recent F-factor trend change?



Calibration Change Detection Using DCC band ratio time series







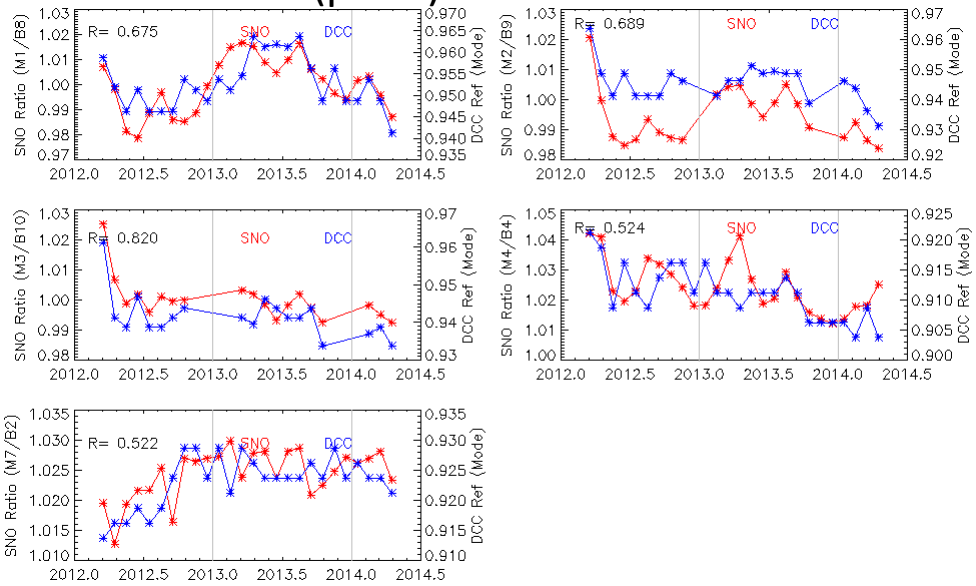
Using M4 as reference

DCC mean ratio is stable than mode ratio, effects due to various factors sig. reduced by ratio

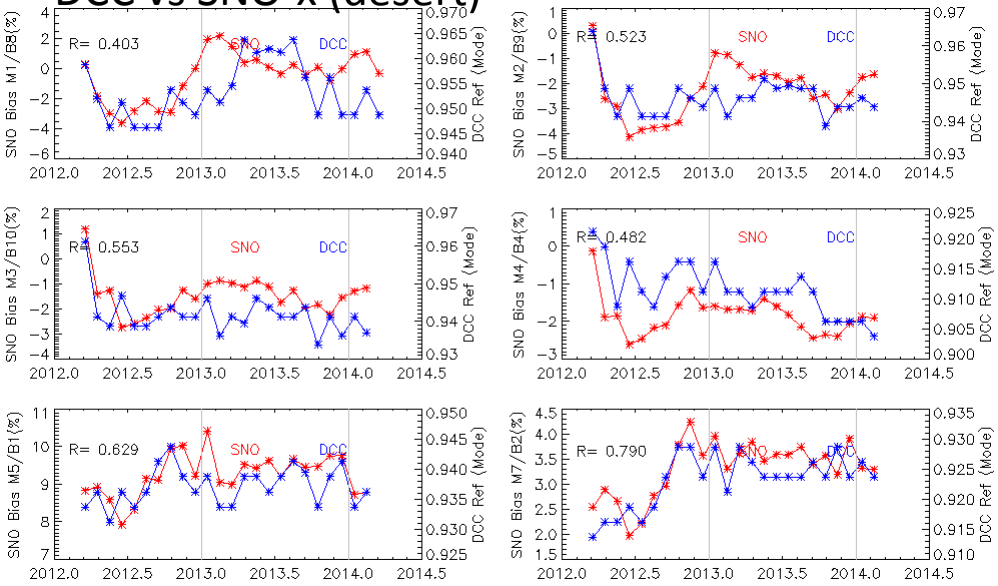
2012 & 2013 show different ratio patterns
→ coincident with OC group complains

VIIRS DCC Mode Time Series vs. VIIRS-MODIS(Aqua-collection6) SNO Time Series

DCC vs SNO (polar)



DCC vs SNO-x (desert)



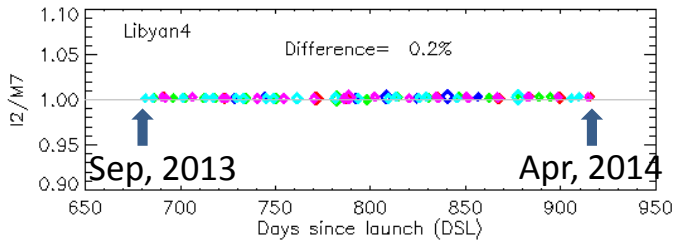
- **DCC time series correlated with SNO & SNO-x time series**
- DCC time series are more stable
  - Scales in the two y-axes are different
- All time series: M5 & M7 more stable than M1-M4
- DCC time series are valuable for monitoring VIIRS calibration stabilities

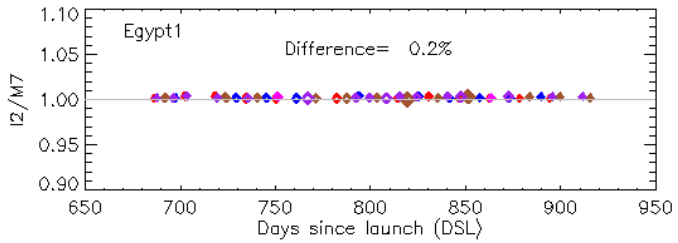
SNO time series courtesy of Slawek Blonskii
SNO-x time series courtesy of Sirish Uprety

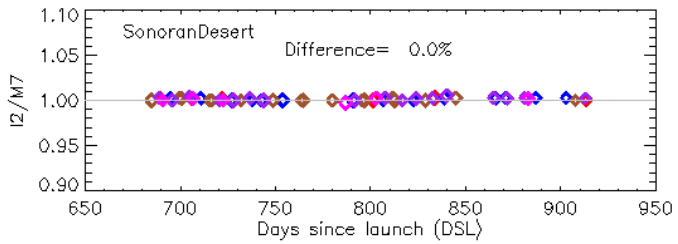
Inter-channel consistency analysis using validation time series

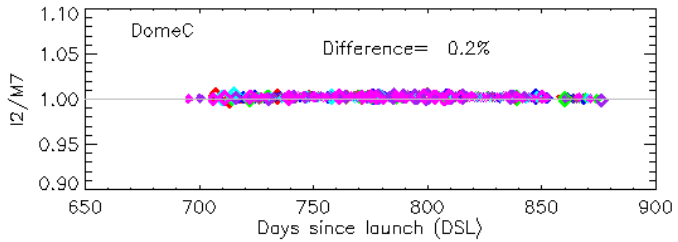
1. M7 vs. I2 comparison
2. M10 vs. I3 comparison

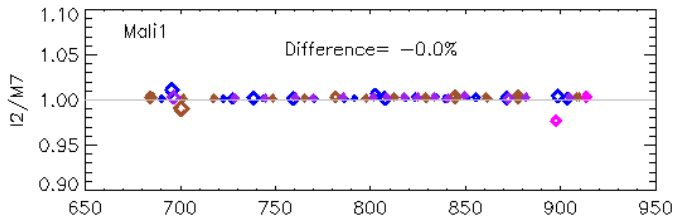
M7 vs. I2 Comparison







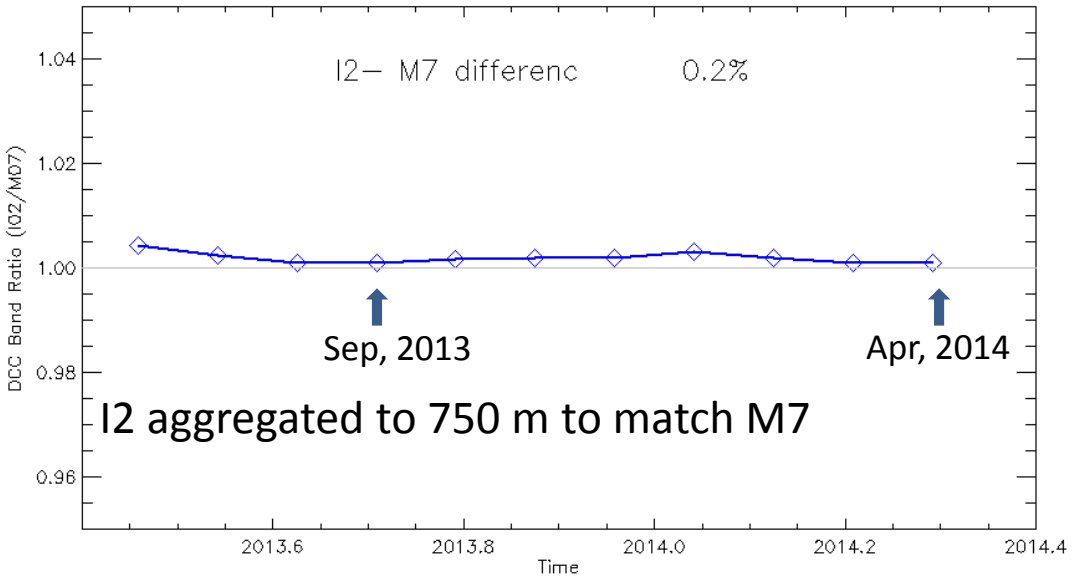




M7 is generally consistent with I2

0-0.2% **(validation sites time series)**

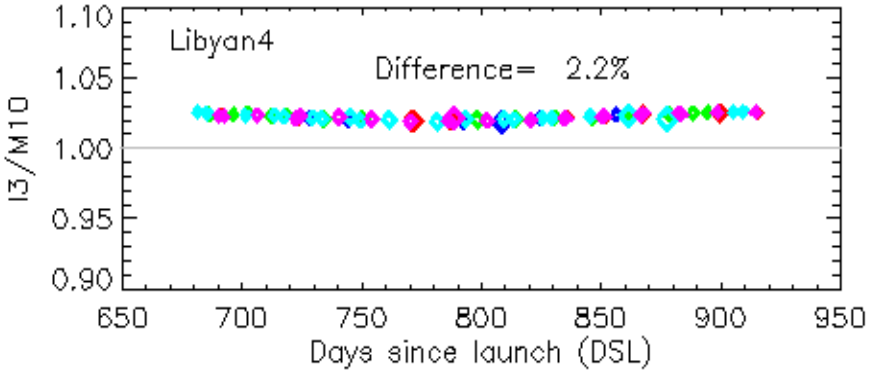
0.2% **(DCC time series)**

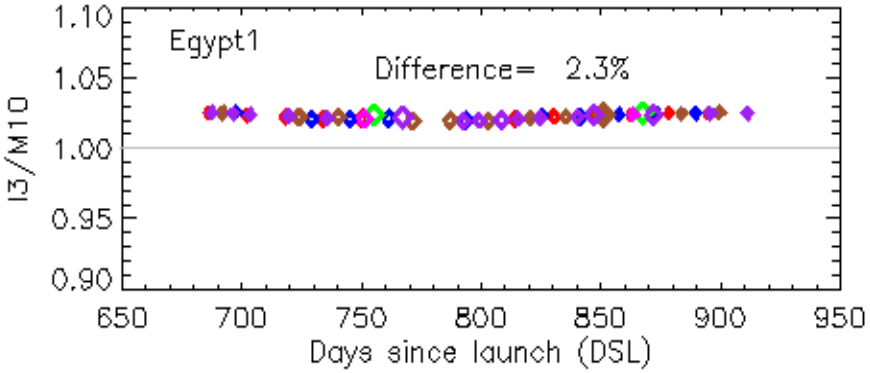


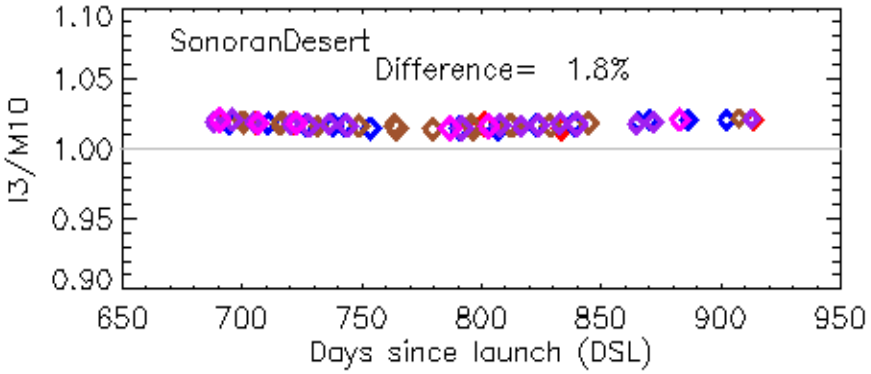
I2 aggregated to 750 m to match M7

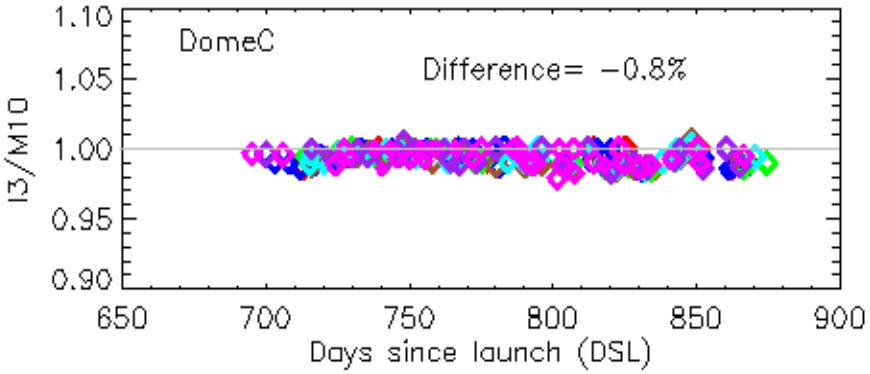
BRDF & atmo. effects cancel out by band ratio

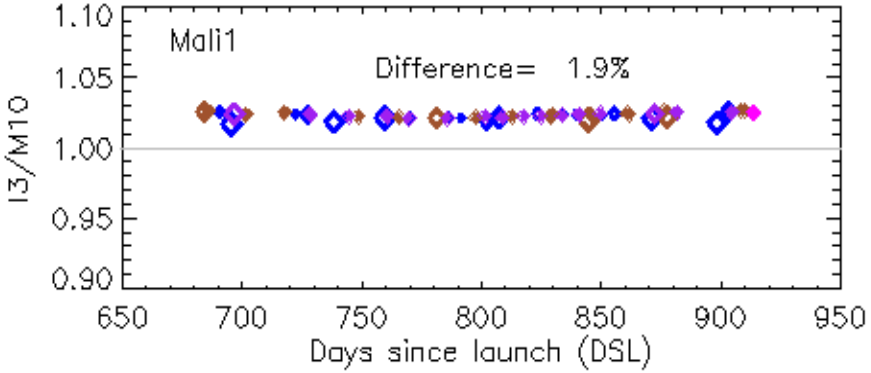
M10 vs. I3 Comparison











Large M10/I3 difference:

-0.8 – 2.3%

scene dependent

Summary & Future Work

- STAR VIIRS SDR support team developed validation time series for VIIRS calibration stability monitoring
  - Validation sites time series
    - Automatic data collection since Sep, 2013
    - 30 globally distributed sites
    - RSB & TEB bands time series & band ratio time series update daily
  - DCC time series
    - Completed M1-M5, M7 (2012/03 – present) , update monthly
    - Capable of capture calibration changes

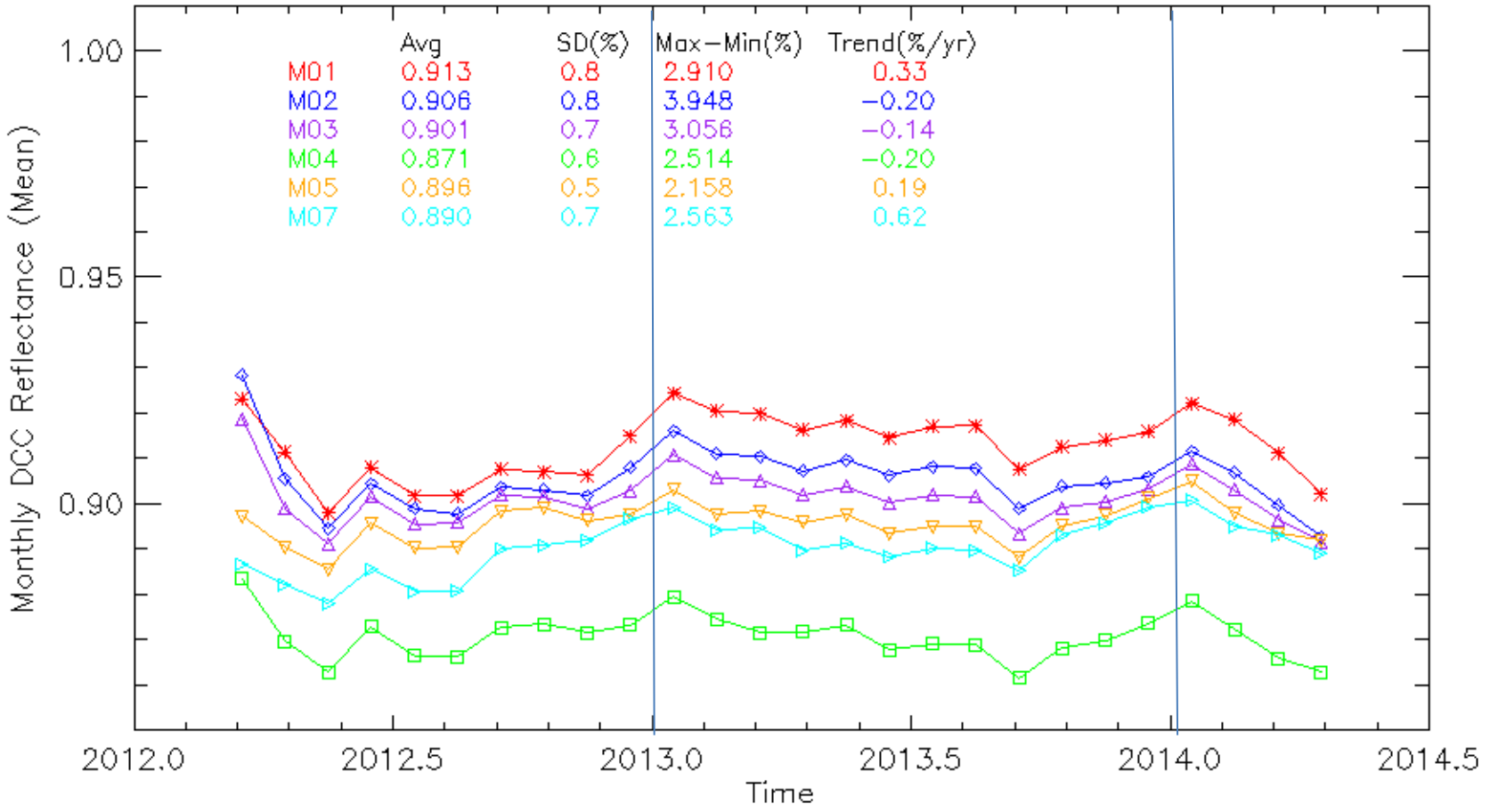
- Next Step
  - Improve quality control for validation time series, esp. for sites over oceans & lakes
  - Support DNB
  - Incorporating historical data for all sites (CLASS)
  - In-depth data analysis (BRDF, atmosphere correction, …)

  - Develop DCC time series for DNB (day/night), M8-M11, I1-I3

- The methodologies can be adapted easily to support future JPSS missions and other instruments such as GOES-R/ABI.

Backups

DCC Time Series (Mean)



Major calibration changes can also be observed in the mean time series
But, annual cycle more obvious than the mode time series