# SPECTRAL OPTIMIZATION OF THE BASELINE DCC METHOD FOR NEXT GENERATION ADVANCED GEO IMAGERS (AHI, ABI, MTG, ETC.)

RAJ BHATT*, DAVID. R. DOELLING, CONOR HANEY, ARUN GOPALAN, AND BENJAMIN SCARINO

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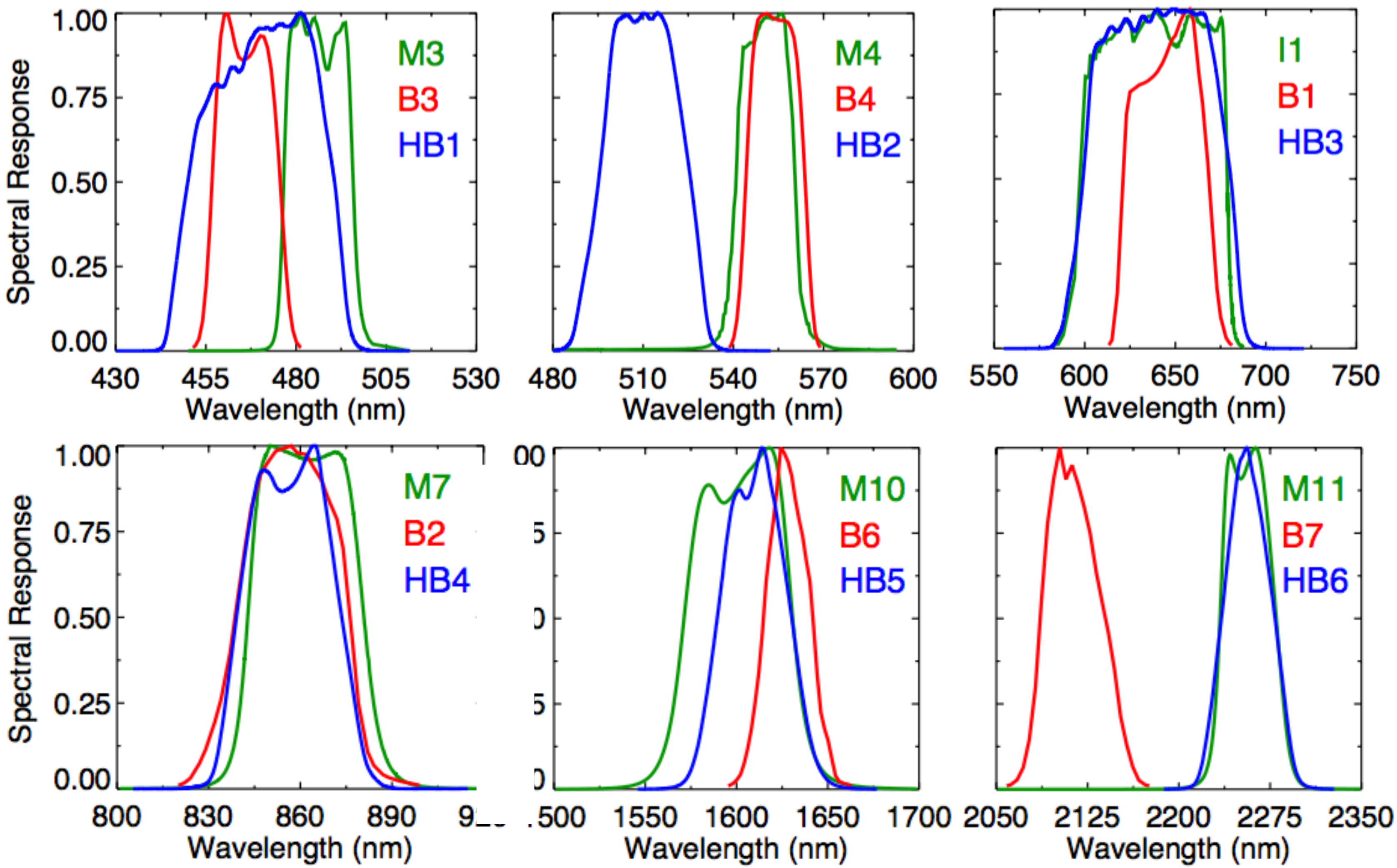
*Contact: rajendra.bhatt@nasa.gov

# BACKGROUND

- **Current GSICS DCC calibration ATBD applies to the VIS channel (0.65µm) of GEO imagers.**
- **Next generation GEO imagers (such as AHI, ABI, and MTG) have multiple channels in VIS, NIR and SWIR spectral regimes.**
- **Performance of the baseline DCC method needs to be evaluated for other spectral channels.**
- **This study uses globally acquired (±20° latitude) VIIRS DCC pixels to customize the DCC method for individual spectral channels.**

# WHY VIIRS?



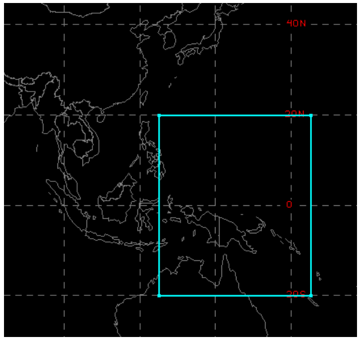

**Because the Himawari-8 AHI spectral bands (HBx) better resembles the VIIRS channels (M and I) than the corresponding MODIS bands (Bx).**

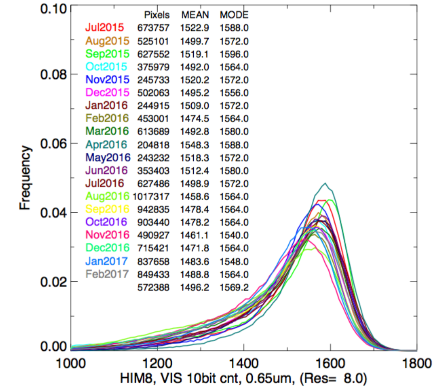
**MODIS has bad detectors in some SWIR channels.**

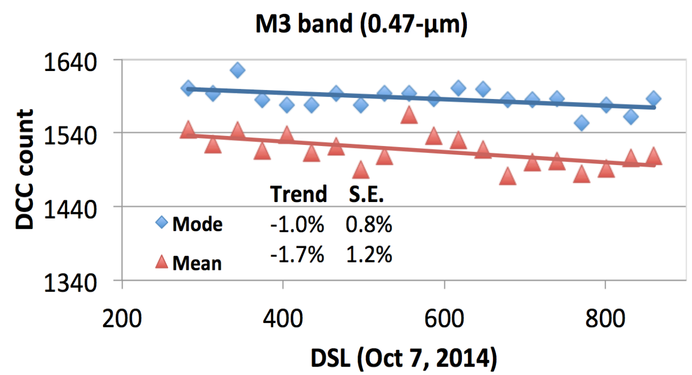
# BASELINE DCC CALIBRATION APPROACH

- **Deep convective clouds are an ideal visible calibration target because**
  - they are the brightest terrestrial invariant targets
  - the impact of water vapor absorption and aerosols in TOA reflectance measurements is minimal
  - they are viewed by all satellites
- **For each GEO, a fixed DCC domain is used with center at its sub-satellite point and extending ±20° along latitude and longitude.**
- **DCC pixel selection criteria: BT11µm < 205K, SZA < 40°, VZA < 40°, 10° < RAA < 170°, σ(BT11µm) < 1K, and σ(VIS) <3% .**
- **Anisotropic correction applied to each DCC pixel using the Hu ADM.**
- **DCC pixels are then compiled into monthly probability distribution functions (PDFs).**
- **Statistical mode is computed for each monthly PDF, and is tracked over time.**
- **GSICS DCC implementation package**

TWP DCC domain for HIM8-AHI

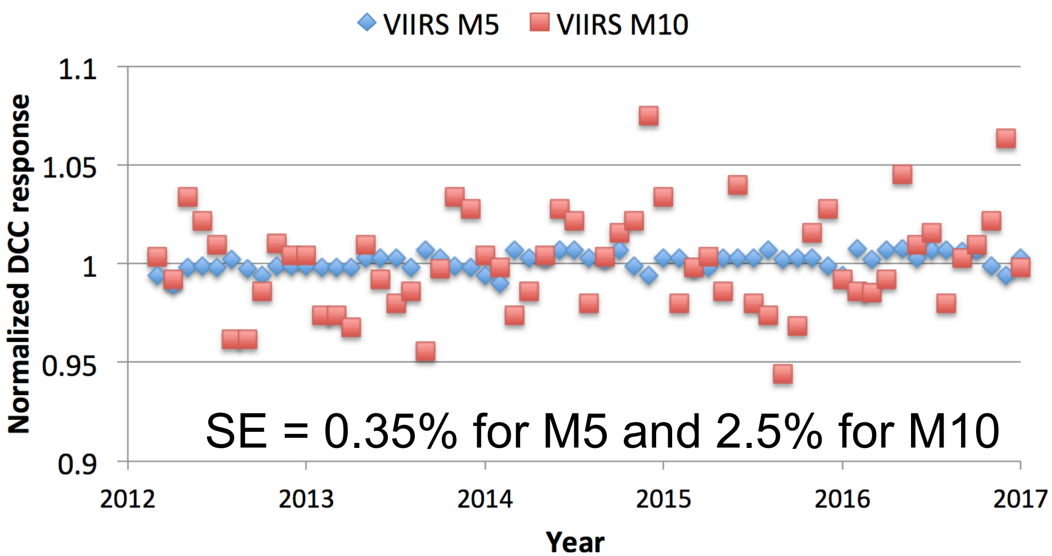





http://gsics.atmos.umd.edu/pub/Development/DccWorkArea/DCC_Verification_Data_Package.zip

# SPECTRAL OPTIMIZATION APPROACH




**Temporal standard error (SE) is the primary measure of trend uncertainty.**

**Spectral optimization is achieved by analyzing the SE of the DCC mean and mode response trends for**

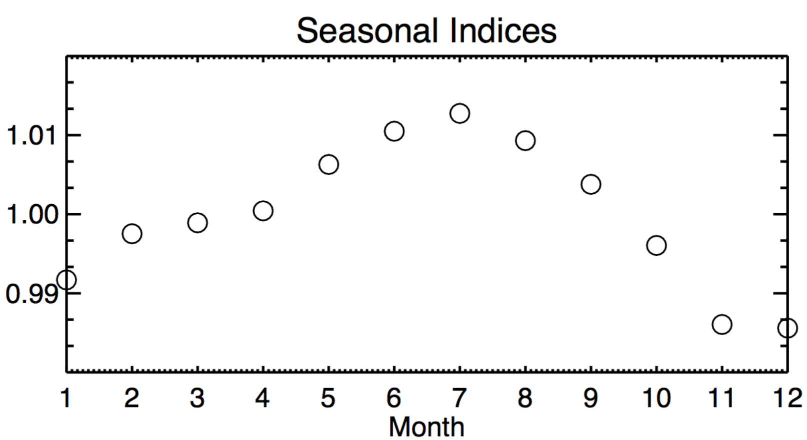
- varying BT threshold
- BRDF vs. non-BRDF cases
- Land-and-ocean vs. ocean-only DCC conditions
- deseasonalization of time series

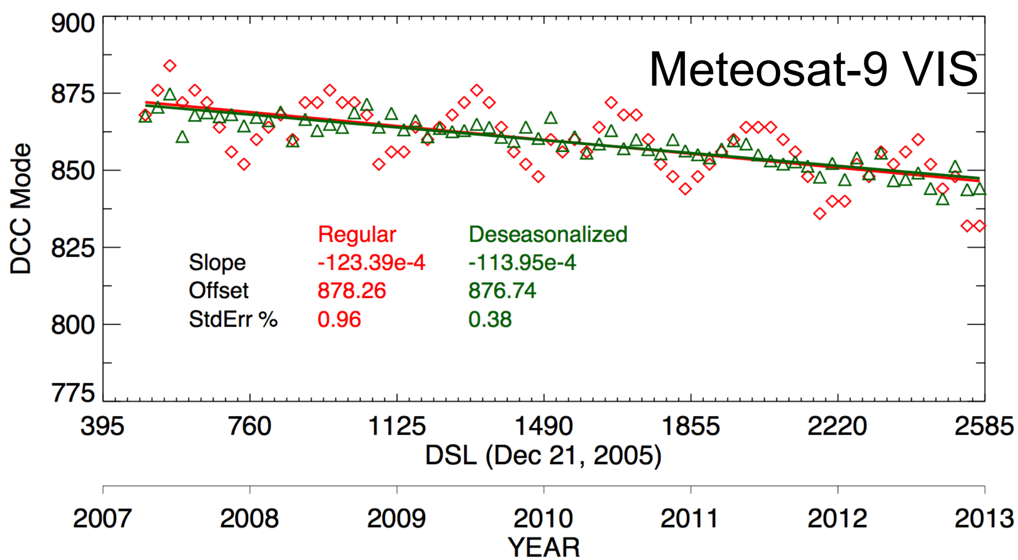
**Optimized DCC results are compared against the baseline approach to evaluate improvements in terms of trend detection capability.**

# DESEASONALIZATION

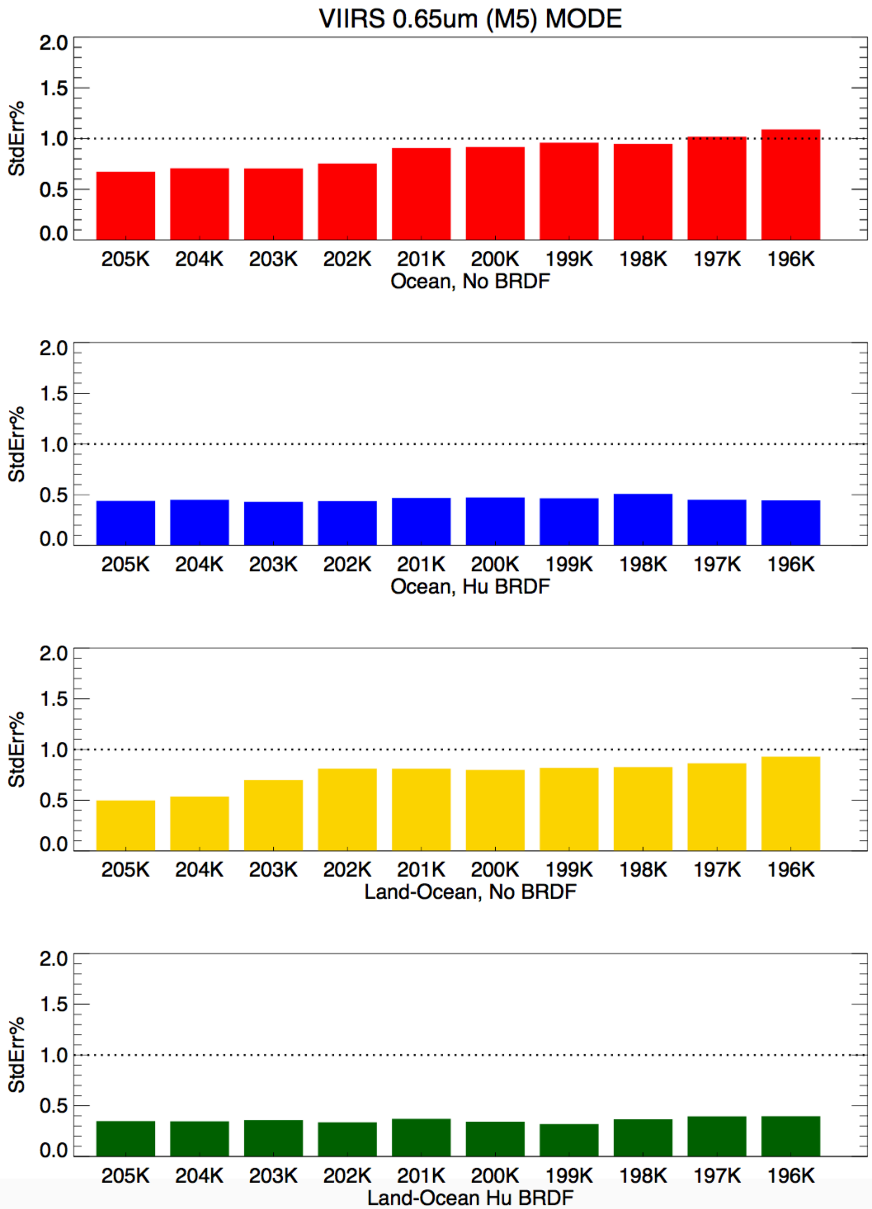
**Uses a simple ratio-to-moving-average method that is performed in four steps:**

1. A 12-month centered running mean is computed.
2. Then, a relative ratio between the actual month value and the running mean is determined
3. Next, an average relative ratio for each month is computed, which is known as seasonal index (SI)
4. Finally, the DCC modes are divided by month-specific SIs to yield seasonally adjusted time series

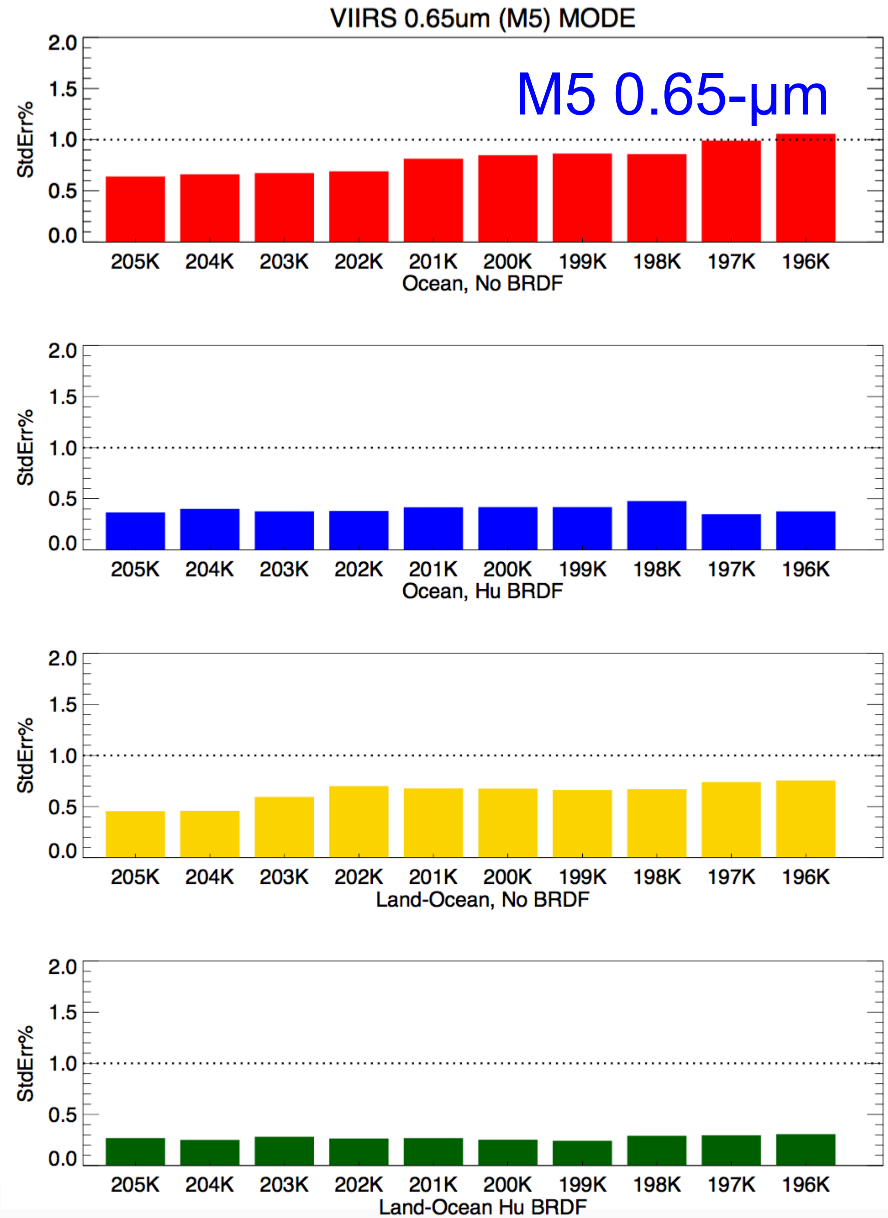


## Mode without de-seasonalization

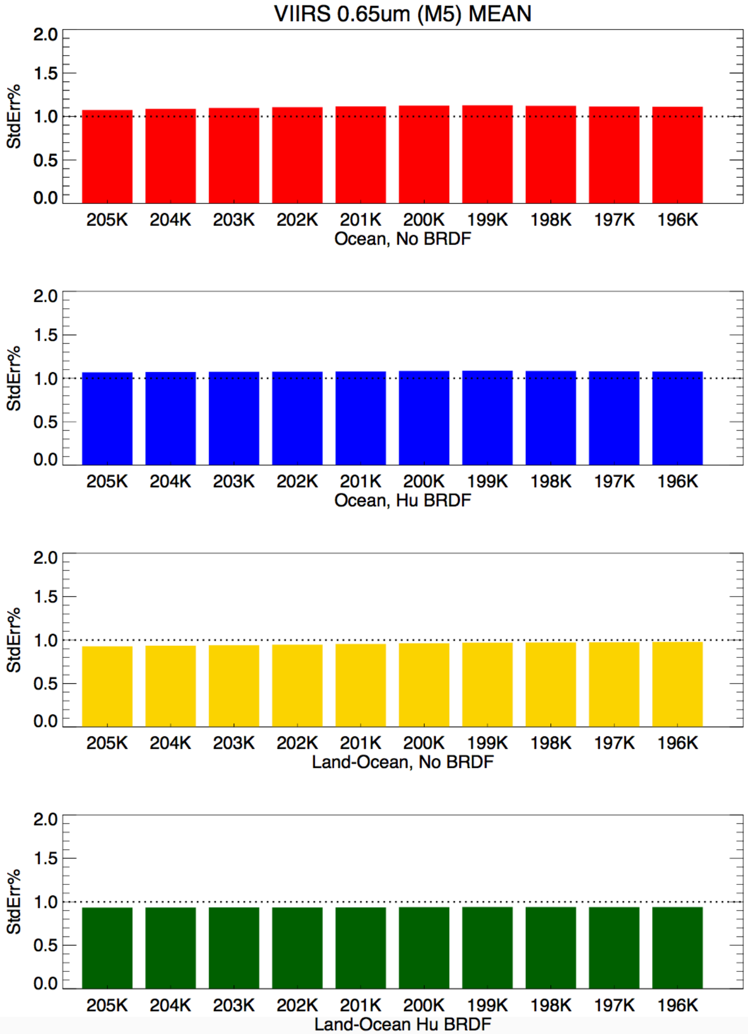



## Mode with de-seasonalization

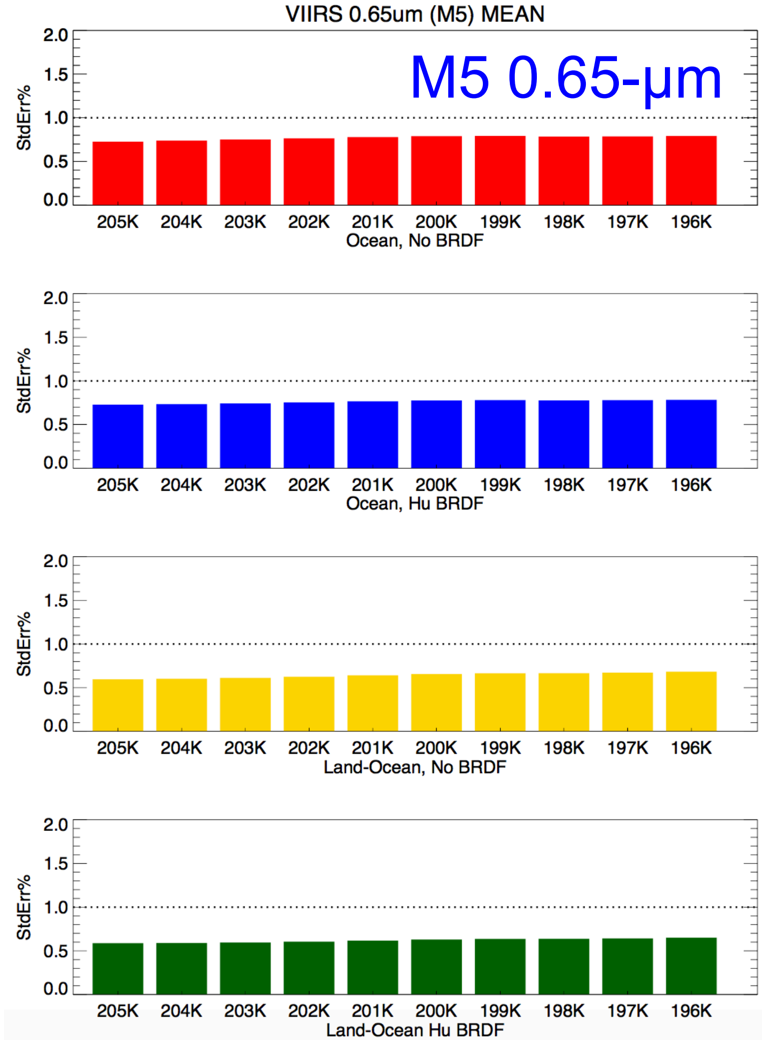


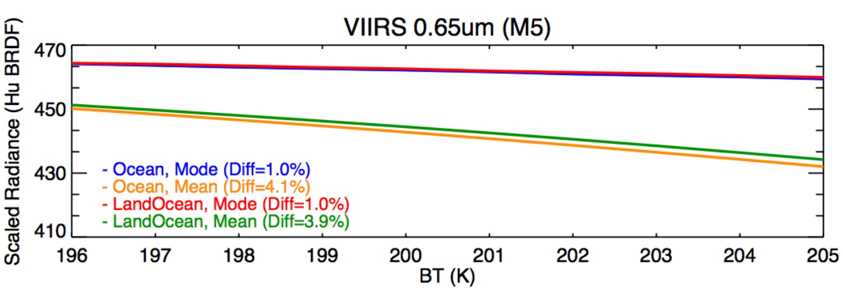

- Land and ocean DCCs, monthly PDF mode with Hu-BRDF applied is very stable.

Monthly mean without de-seasonalization



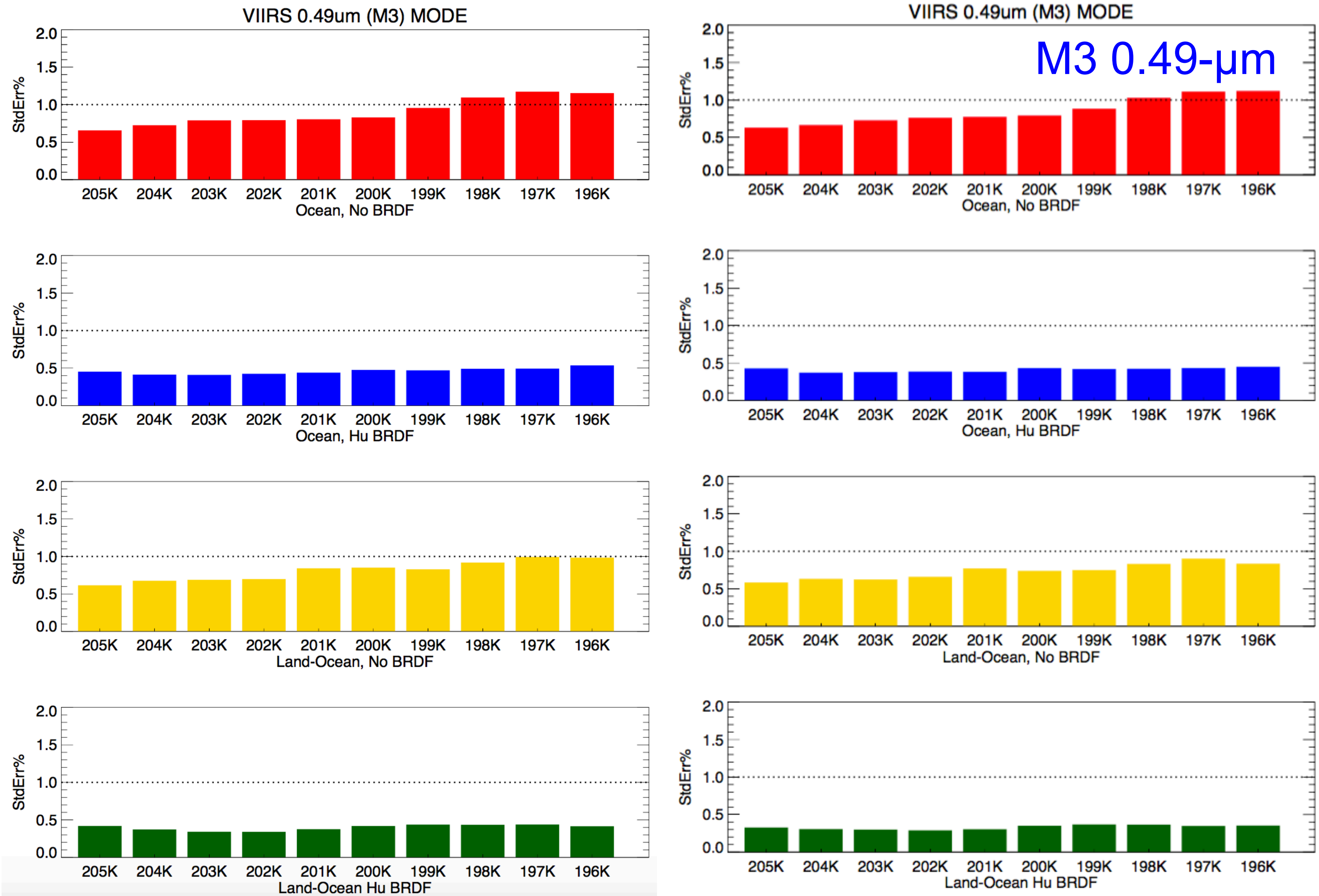

Monthly mean with de-seasonalization




- Monthly DCC means exhibit larger temporal standard error
- De-seasonalization is effective in reducing the temporal variability to half
- **Issue:** Mean DCC response is sensitive to BT threshold

## Mode without de-seasonalization Mode with de-seasonalization

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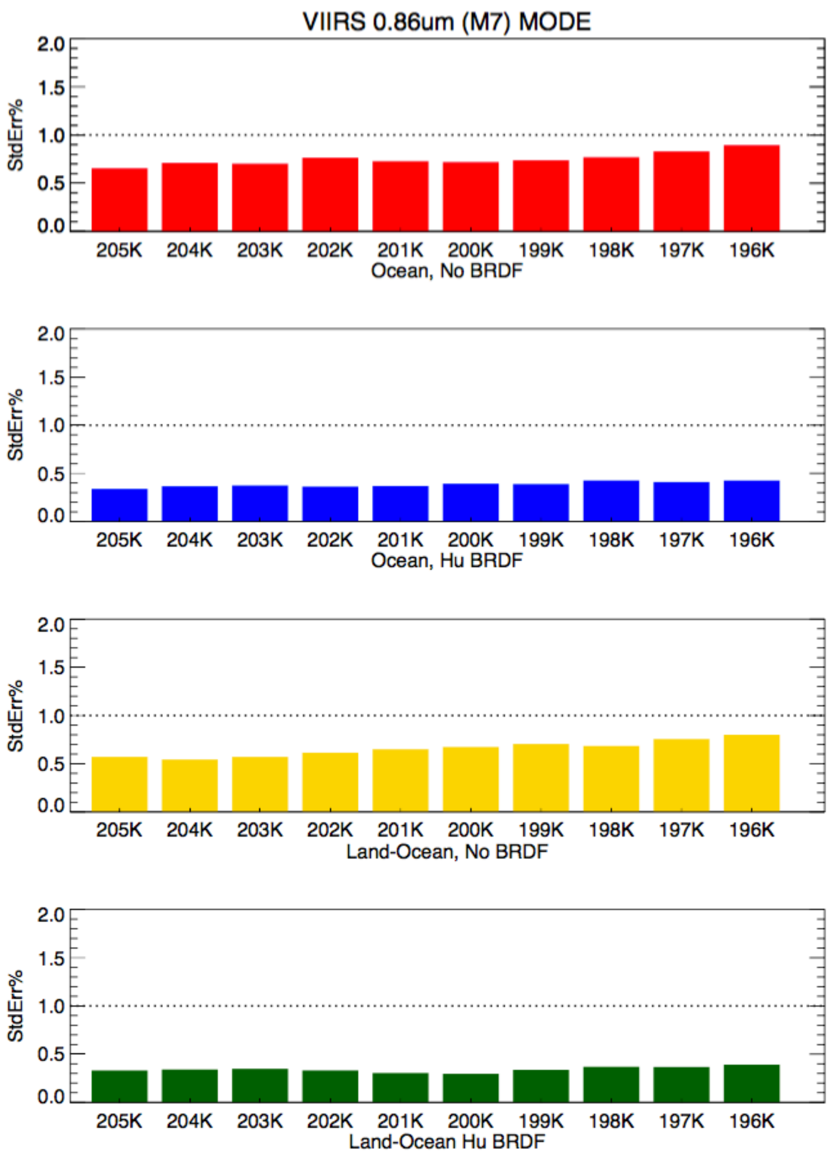
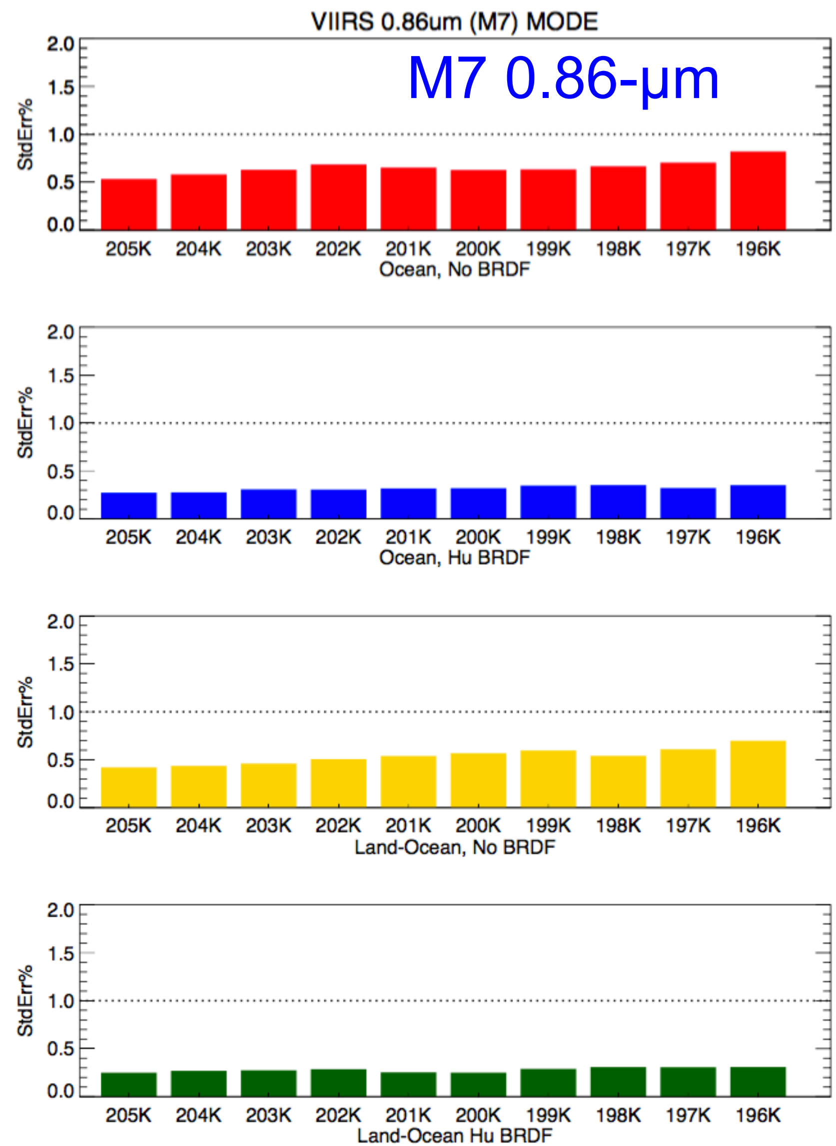
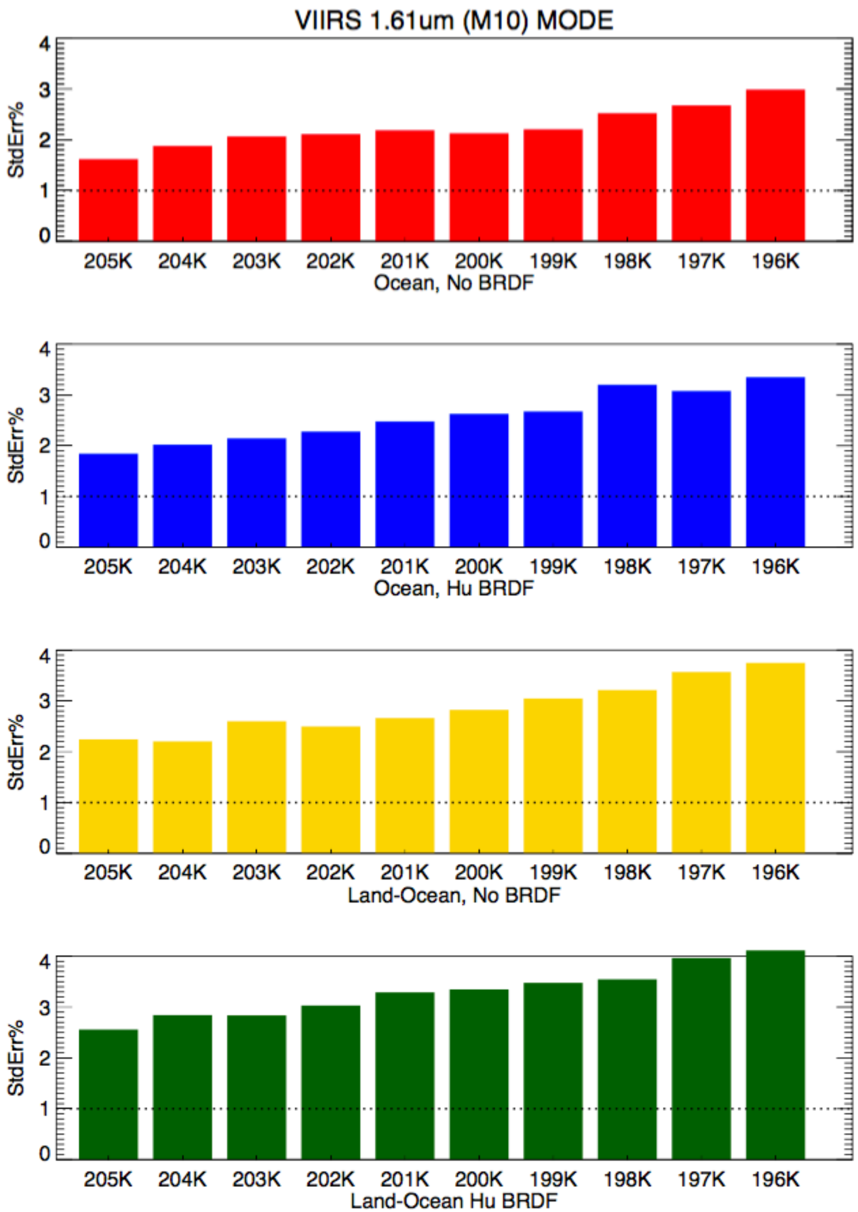



## Mode with de-seasonalization

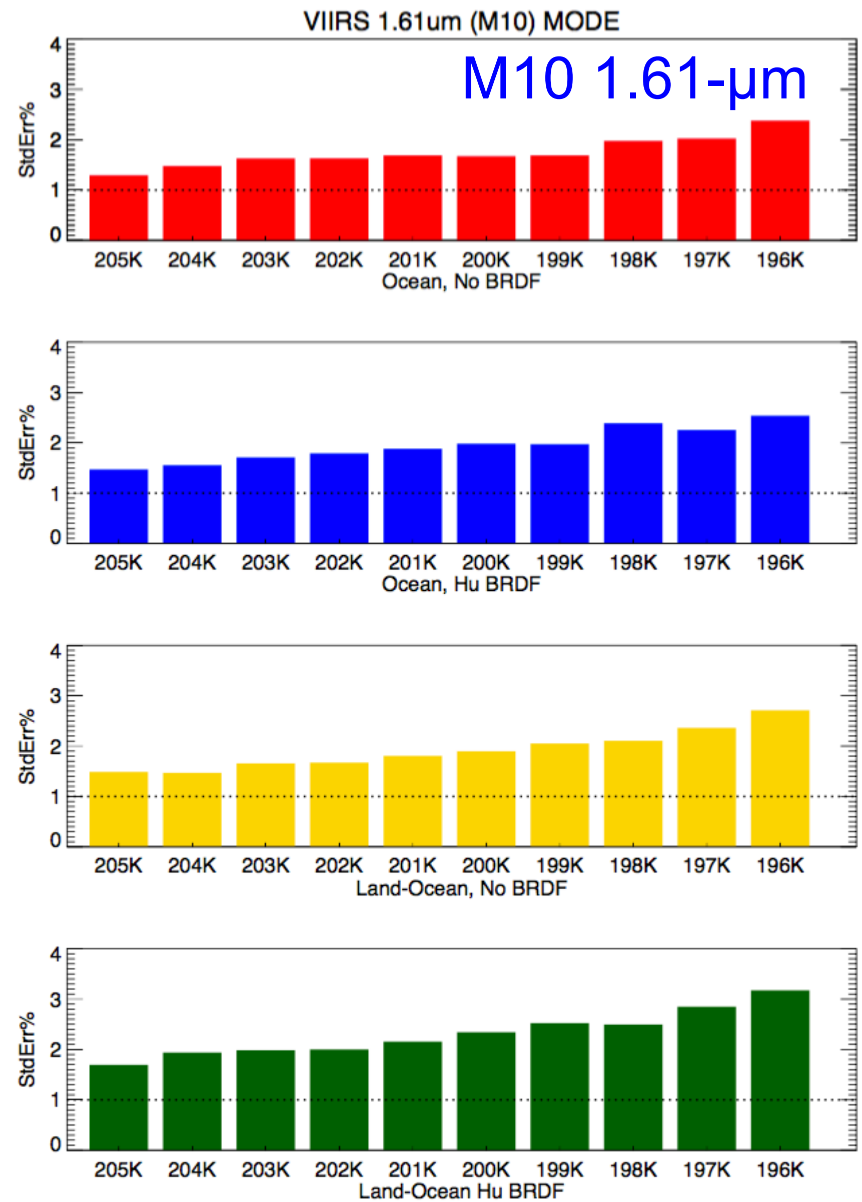



- Land and ocean DCCs, monthly PDF mode with Hu-BRDF applied is very stable.
- Seasonal cycles are minimal.

Mode without de-seasonalization

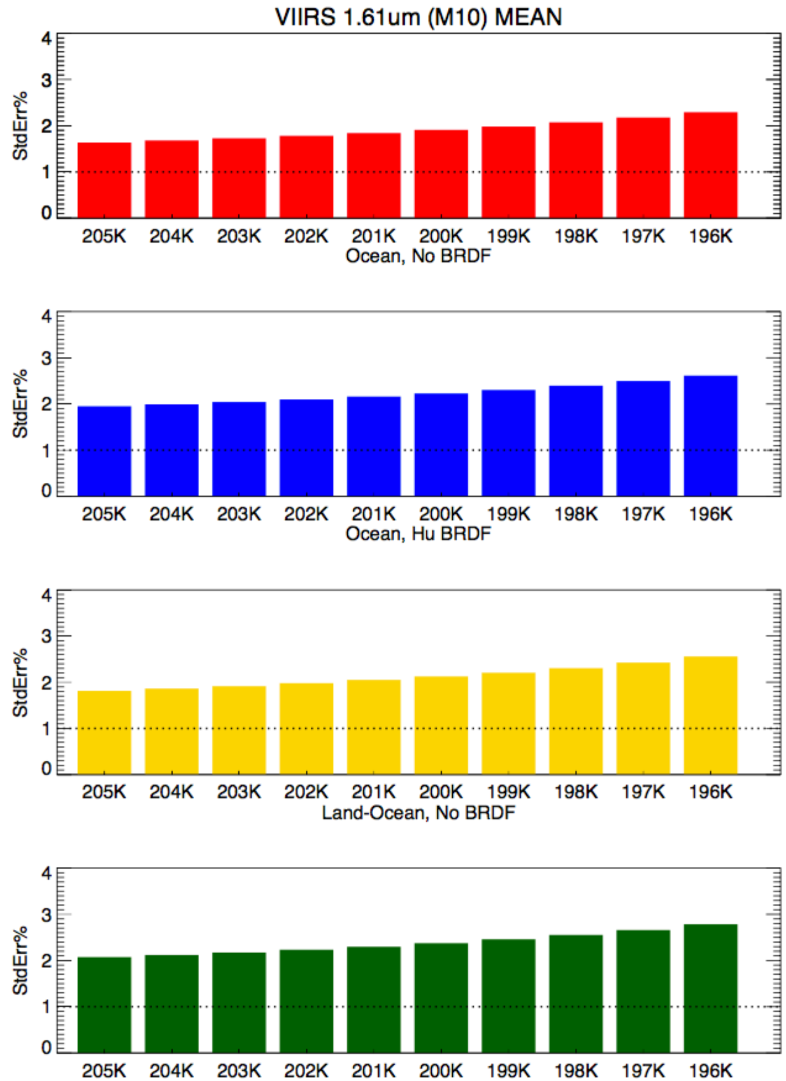



Mode with de-seasonalization

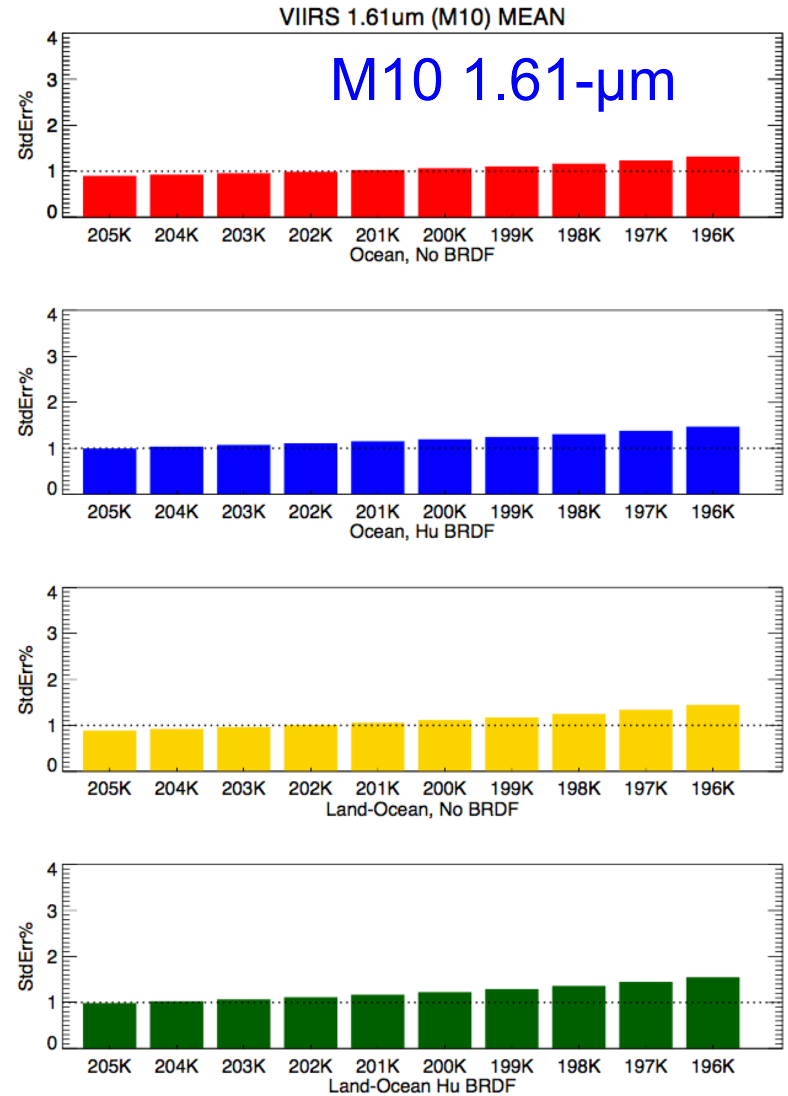


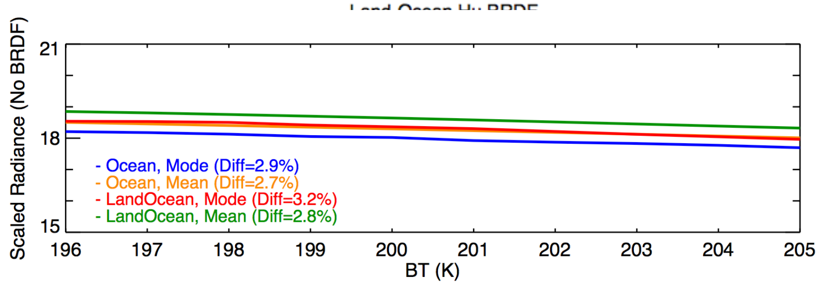

- Ocean only with no BRDF corrections is more stable
- Deseasonalization helps to reduce the temporal standard error to ~1%.

## Mean without de-seasonalization



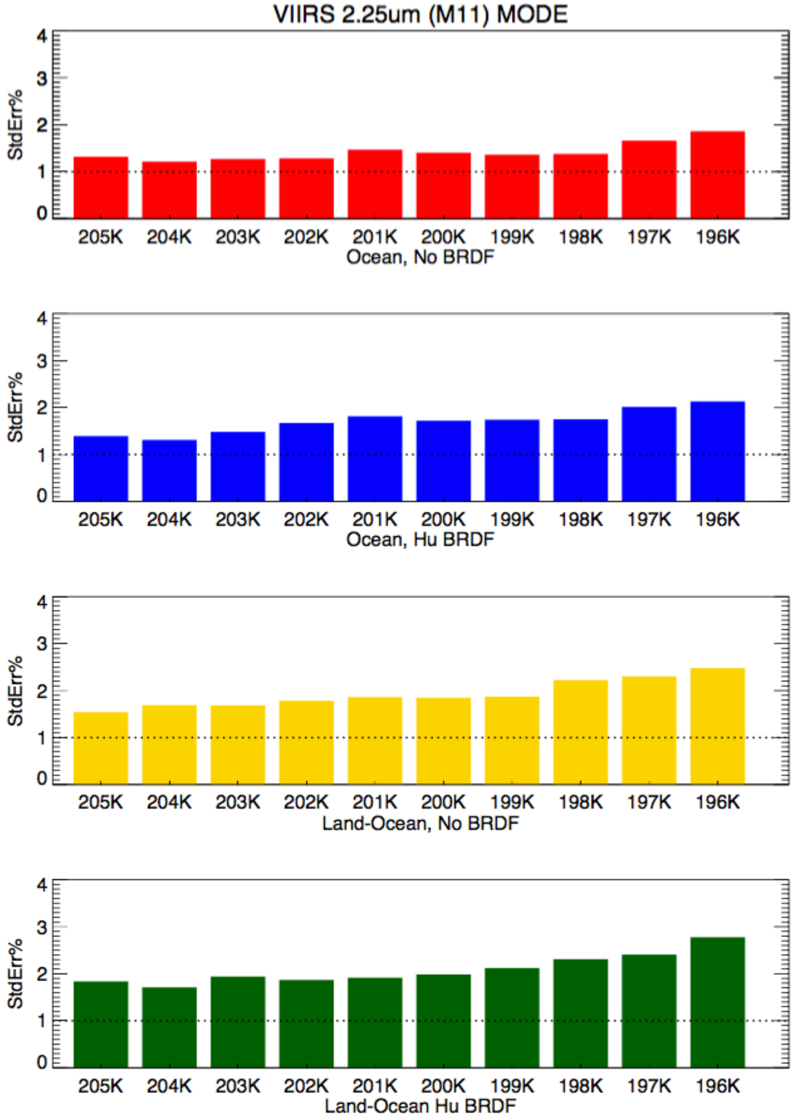

## Mean with de-seasonalization

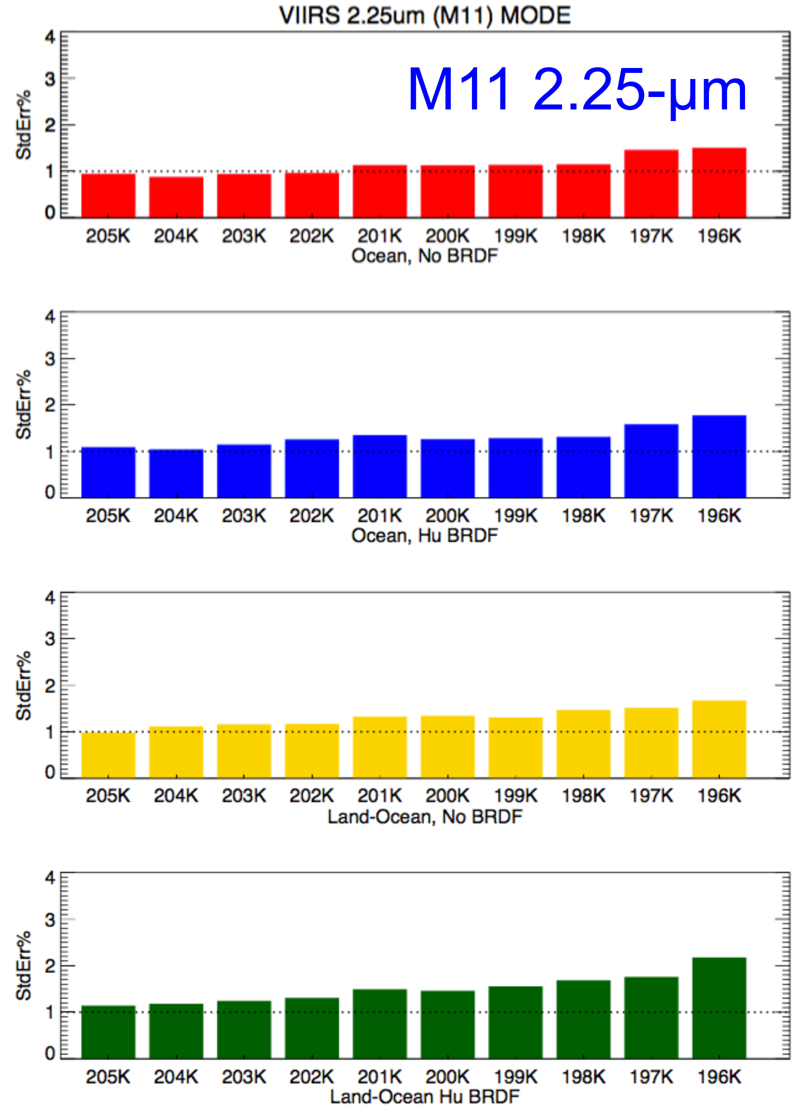



- Monthly mean with no BRDF corrections is more stable than mode.
- Large seasonal cycles.

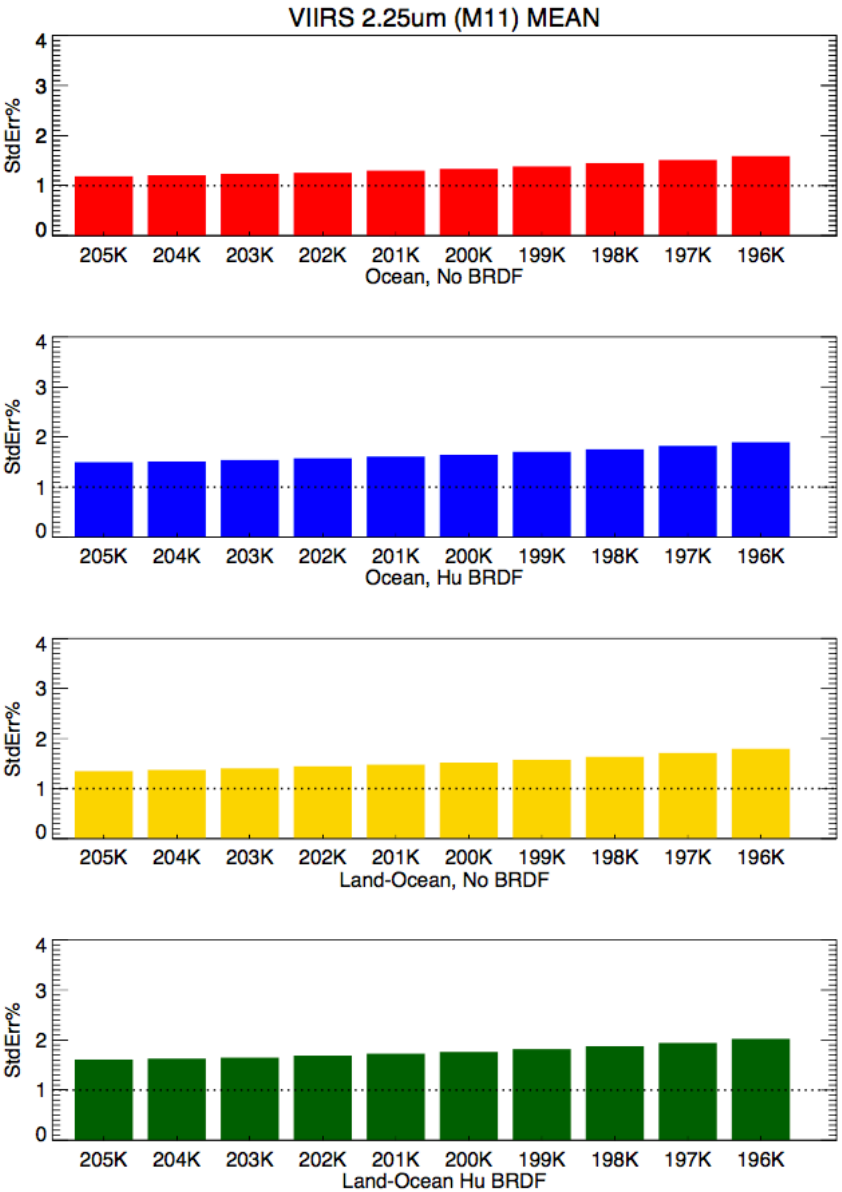
Mode without de-seasonalization Mode with de-seasonalization

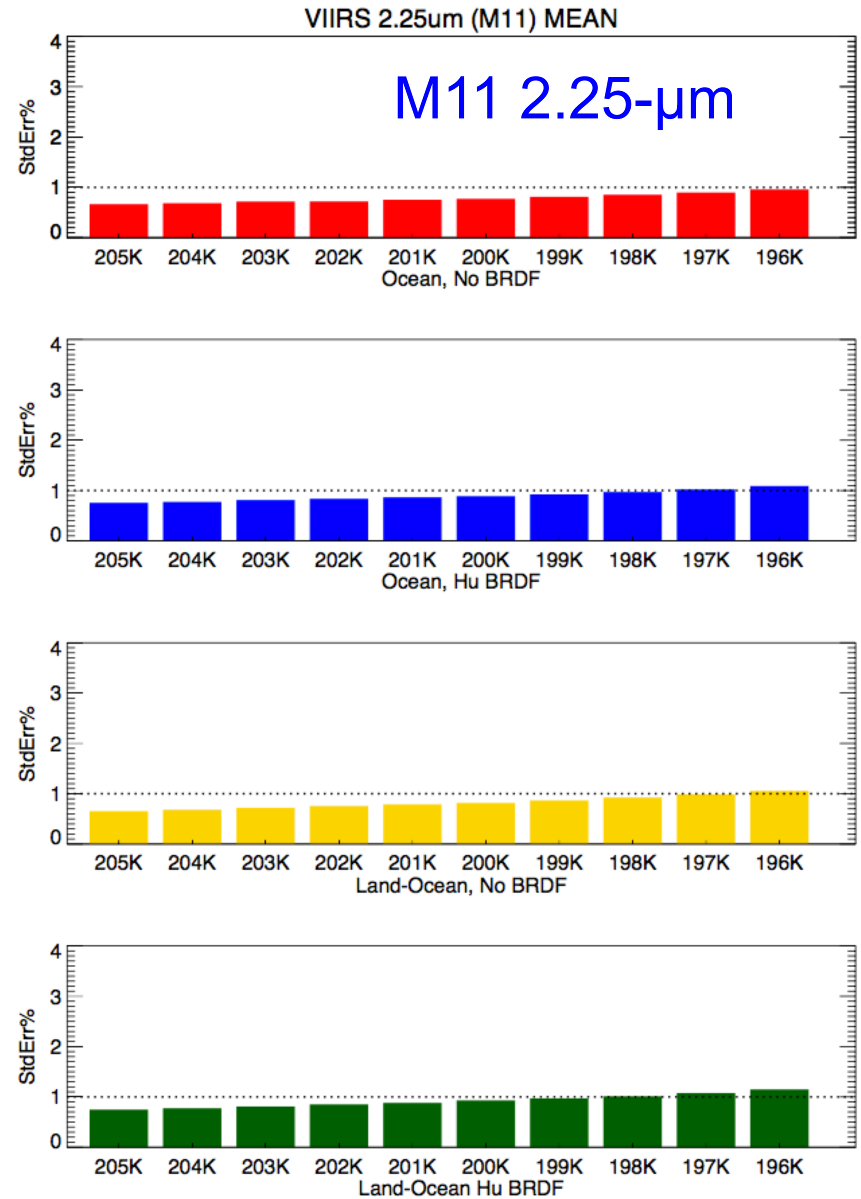



- Ocean only with no BRDF corrections is more stable.
- Deseasonalization helps to reduce the temporal standard error to ~1%.

Mean without de-seasonalization | Mean with de-seasonalization




- Monthly mean with no BRDF corrections is more stable than mode.
- Large seasonal cycles.
- With deseasonalization, temporal variability can be reduced to <1%.

# SPECTRAL OPTIMIZATION SUMMARY

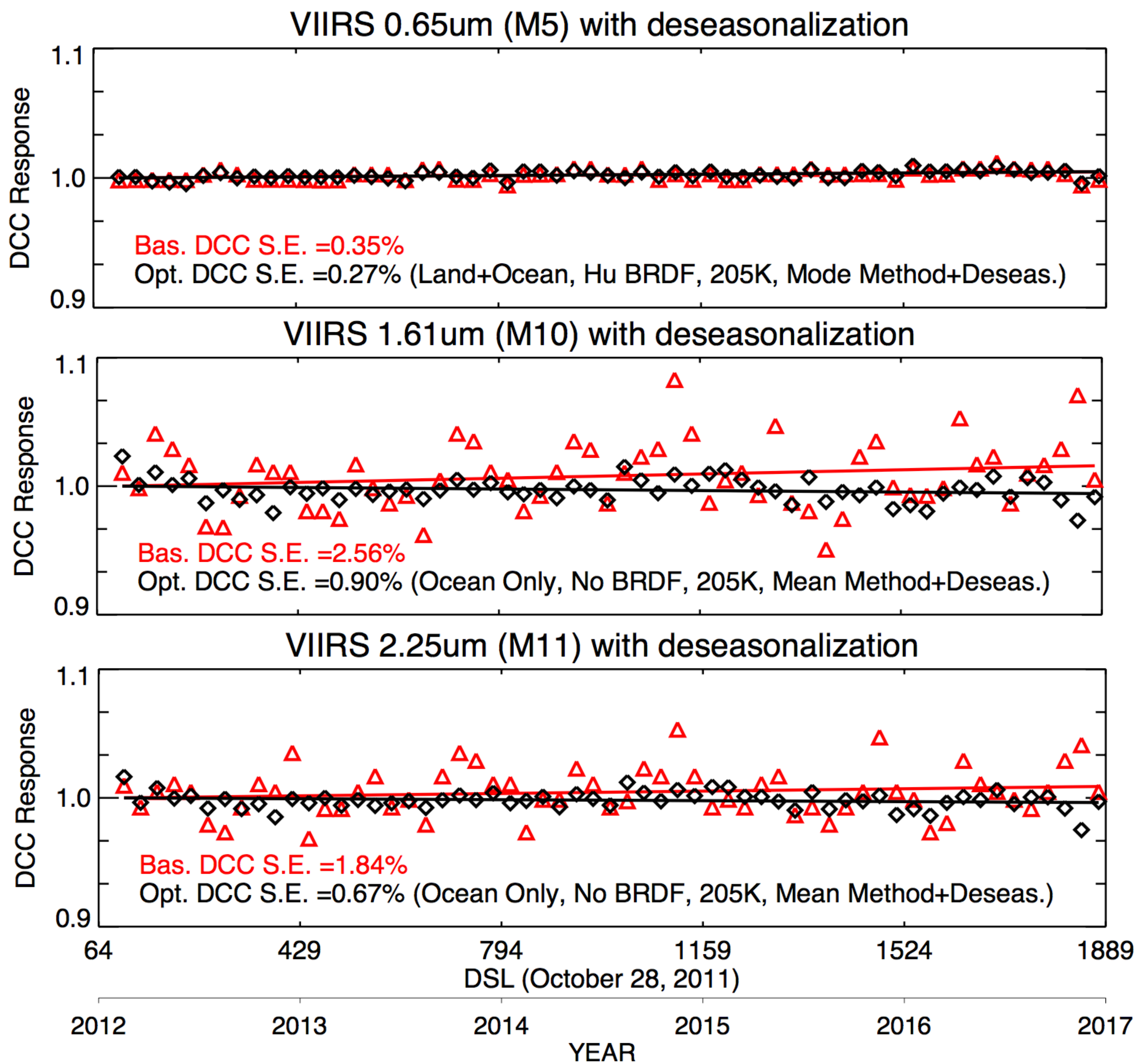
**For VIS and NIR bands, use**

- BT<205K
- land and ocean DCC conditions
- Hu-BRDF
- monthly mode statistic
- deseasonalization

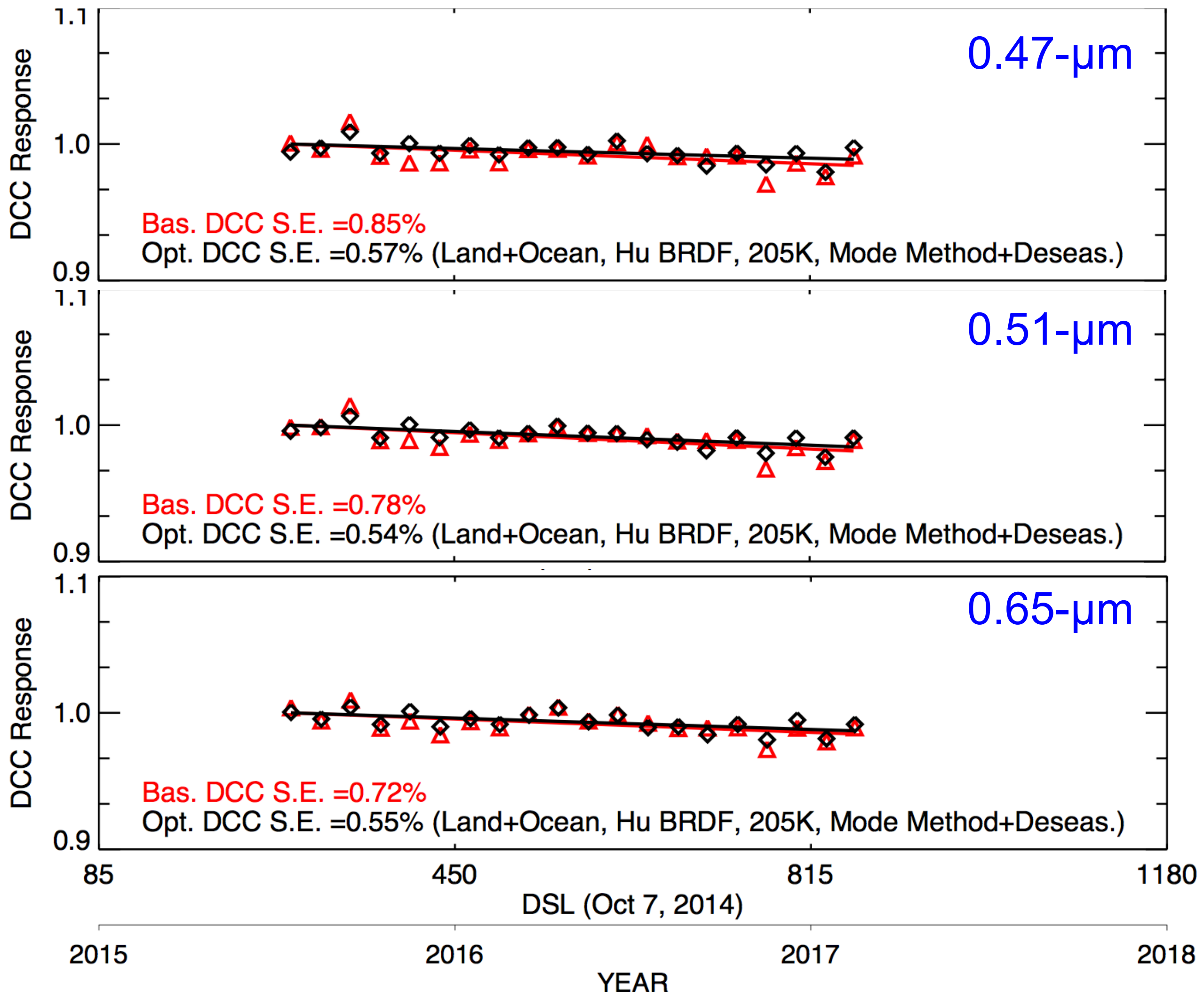
**For SWIR channels (1.6-µm and 2.25-µm), use**

- BT<205K
- ocean only DCC pixels
- No-BRDF
- monthly mean statistic
- deseasonalization

# VIIRS RESULTS

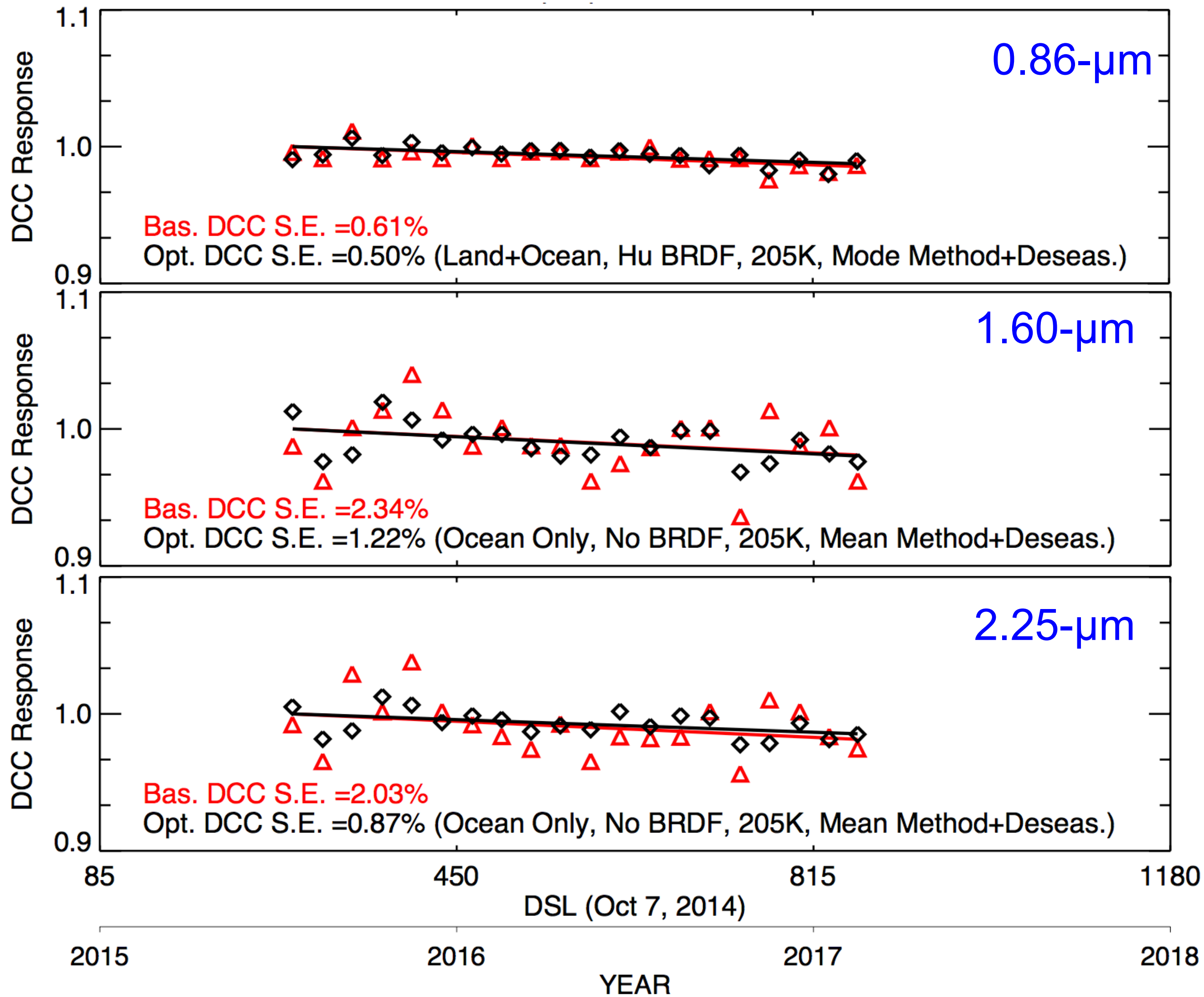


# HIMAWARI-8 AHI RESULTS




Deseasonalization is helpful in further reducing the temporal variability in the DCC time series of the Himawari-8 AHI VIS channels.

# HIMAWARI-8 AHI RESULTS




VIIRS based spectral optimization is effective in reducing the temporal variability in the corresponding Himawari-8 AHI SWIR channels.

# DETECTION OF TREND

**Detection of trend in time series (Weatherhead et al. 1998) is affected by**

- size of trend ($\omega_0$)
- length of data record (N)
- magnitude of variability or noise ($\sigma$)

For a given magnitude of trend ($\omega_0$) to be statistically significant (95% confidence limit), the required number of years of observation is given by

$$\mathbf{N} = \left(\frac{2\sigma_N}{|\omega_0|}\sqrt{\frac{1+\emptyset}{1-\emptyset}}\right)^{2/3}$$

**Detection of smaller trends require longer time span of data and lower variance.**

**Compared to the baseline DCC, the optimized method reduces the variance, and is more robust in detecting smaller magnitude of trends in DCC time series for VIS, NIR, and SWIR channels.**

# IMPACT ON TREND DETECTION

| VIIRS channels | Min. detectable trend in %/yr based on ~5 years of data | |
|---|---|---|
| | Baseline DCC | Optimized DCC |
| M3 (0.49-µm) | 0.11 | 0.08 |
| M4 (0.55-µm) | 0.10 | 0.09 |
| M5 (0.65-µm) | 0.10 | 0.07 |
| M7 (0.86-µm) | 0.09 | 0.06 |
| M8 (1.24-µm) | 0.20 | 0.07 |
| M9 (1.38-µm) | 0.30 | 0.10 |
| M10 (1.61-µm) | 0.70 | 0.21 |
| M11 (2.25-µm) | 0.45 | 0.14 |
| I1 (0.65-µm) | 0.11 | 0.07 |
| I3 (1.61-µm) | 0.64 | 0.22 |

| Himawari-8 AHI channels | Min. detectable trend in %/yr based on 19 months of data | |
|---|---|---|
| | Baseline DCC | Optimized DCC |
| B1 (0.47-µm) | 1.08 | 0.58 |
| B2 (0.51-µm) | 1.14 | 0.69 |
| B3 (0.64-µm) | 0.89 | 0.60 |
| B4 (0.86-µm) | 0.74 | 0.65 |
| B5 (1.60-µm) | 2.50 | 1.39 |
| B6 (2.25-µm) | 2.02 | 1.05 |

**Detectability of trend is significantly improved for SWIR bands after optimization.**

# CONCLUSIONS

- **GSICS baseline DCC calibration method is effective for radiometric trending of all VIS and NIR bands (less than 1-µm).**
- **For SWIR bands,**
    - Ocean-only DCC pixels exhibit more stable response
    - monthly statistical mean is more stable than mode.
- **Use of deseasonalization**
    - significantly reduces the temporal variance in the SWIR bands DCC time series data
    - enhances the trend detectability
- **DCC method has potential to accurately quantify the long-term radiometric trending of satellite optical sensors at VIS, NIR, and SWIR wavelengths.**