

# COMBINING IMAGING STATISTICS AND SIDE SLITHER IMAGERY TO ESTIMATE RELATIVE DETECTOR GAINS

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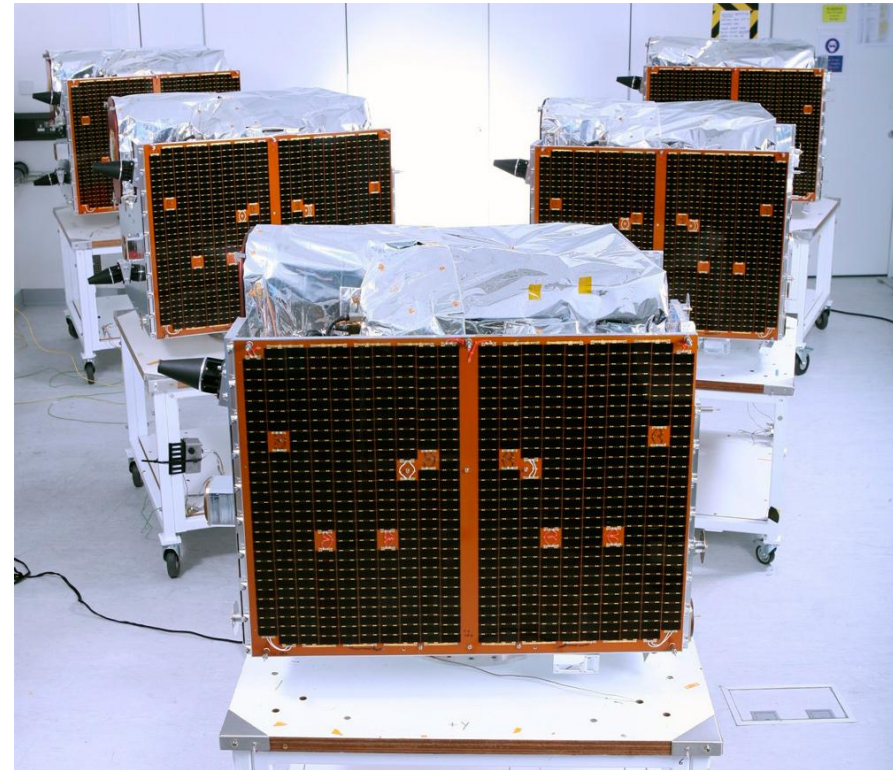
Calcon

August 27, 2012

# BACKGROUND

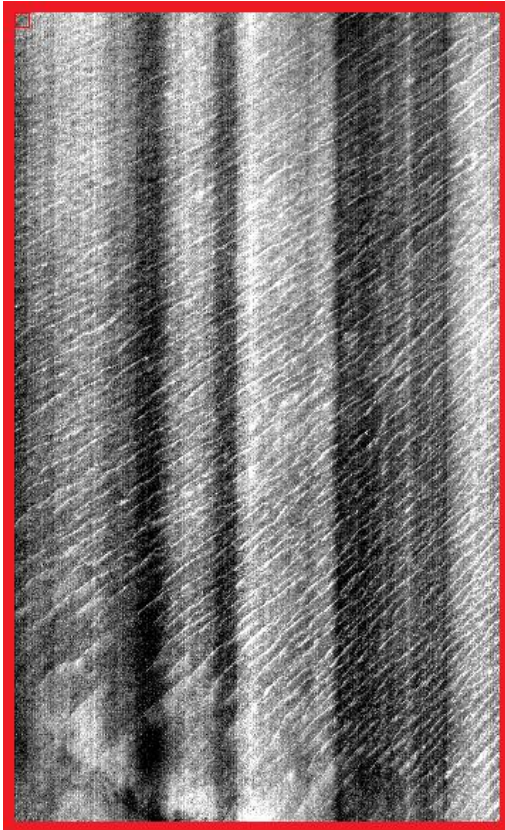
## RapidEye operates a constellation of 5 optical satellites.

- 5 spectral bands Blue (440-510 nm), Green (520-590), Red (630-685), Red-Edge (690-730), NIR (760-850).
- 6.5 m GSD, 77km swath-width.
- >5 million sq km/day imaging capacity.
- Daily revisit of any target possible!

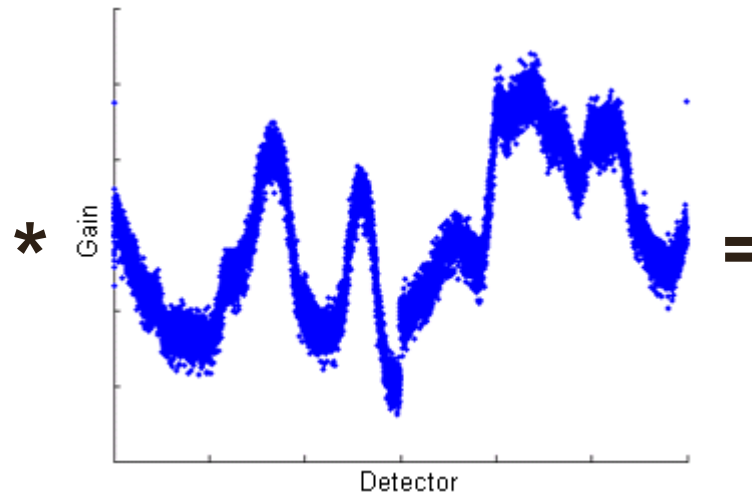


# RELATIVE GAINS

## Raw Image



## Relative Gains

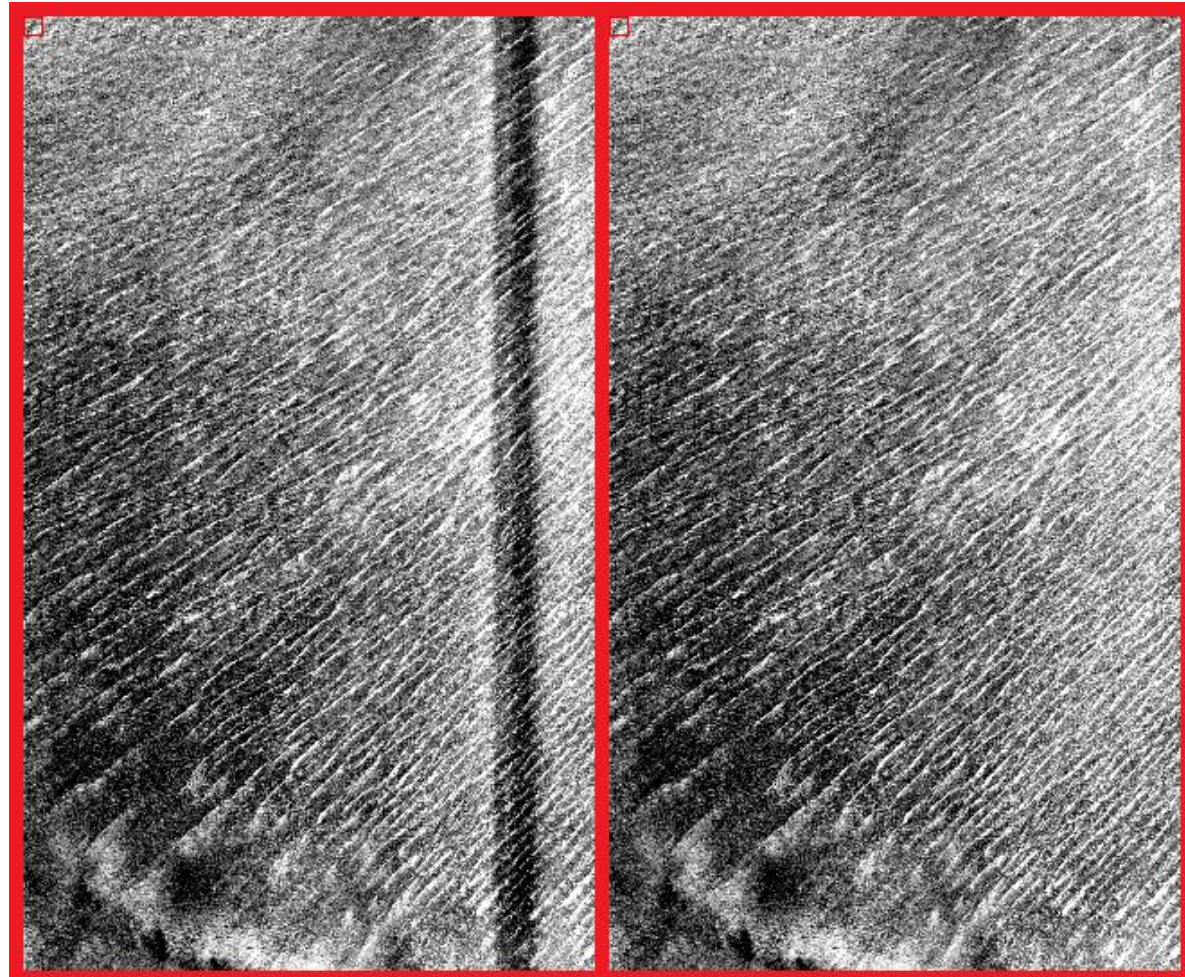


## Corrected Image



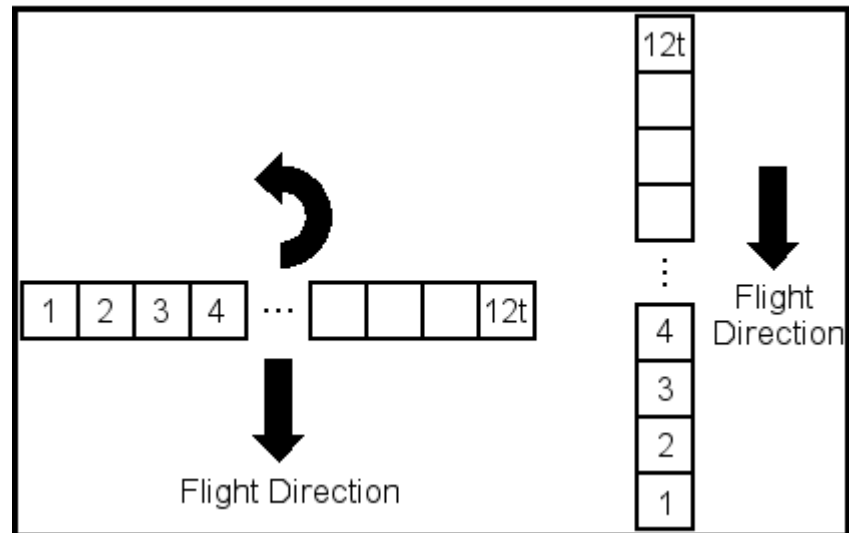
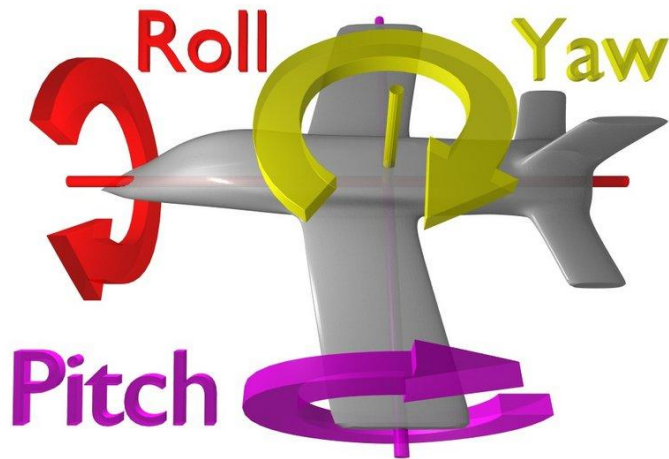
# PROBLEM DEFINITION

- A group of detectors can lose sensitivity fairly suddenly resulting in visible banding.
- Customer order deadlines don't always allow for adequate statistics to be collected.
- A side slither maneuver can take away from customer collects and may take multiple days to pass over the site.
- A method to quickly and accurately correct new banding is needed.



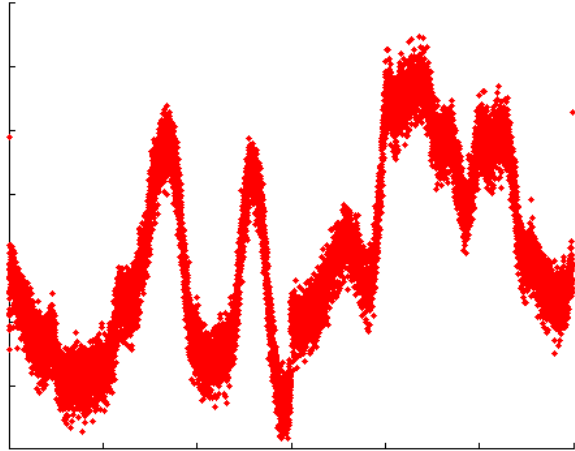
# SIDE SLITHER MANEUVER

- The side slither maneuver (SSM) involves yawing the satellite 90°.
- The focal plane is aligned with the flight direction.
- Each detector views the same location on the ground.



# PROCEDURE

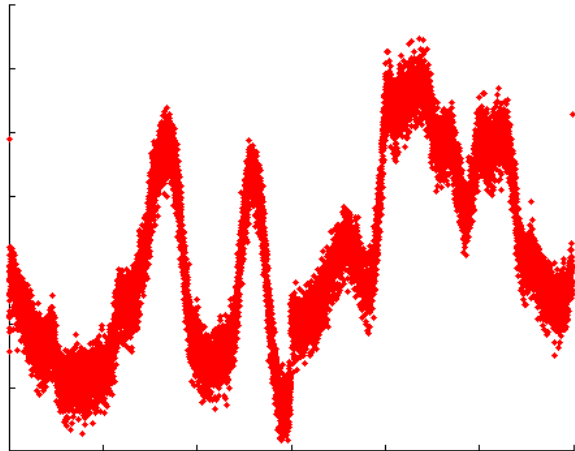
# PROCEDURE



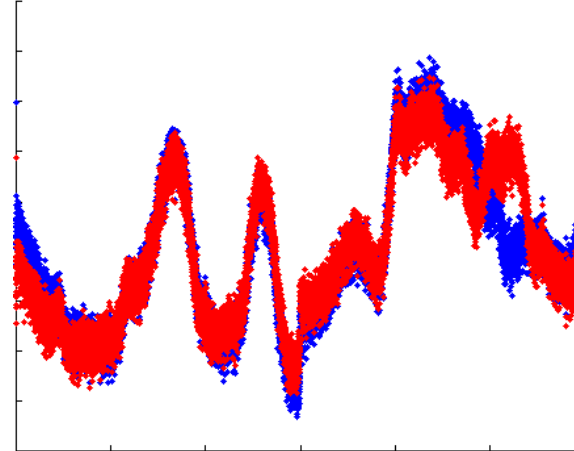
Collect **Image Means**



# PROCEDURE

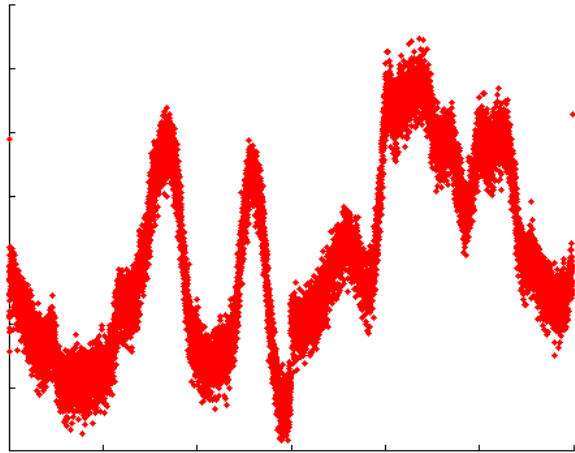


Collect **Image Means**

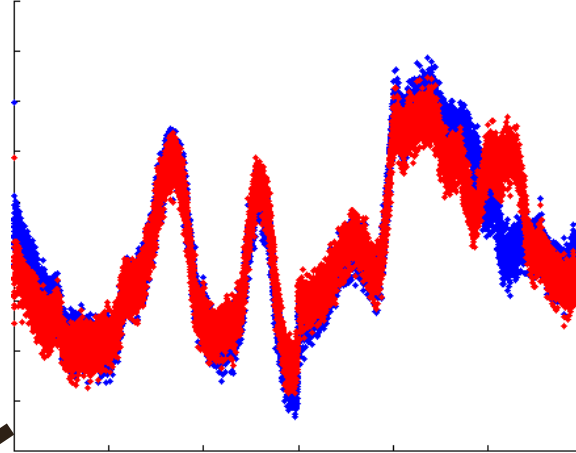


Compare to **Previous Side Slither**

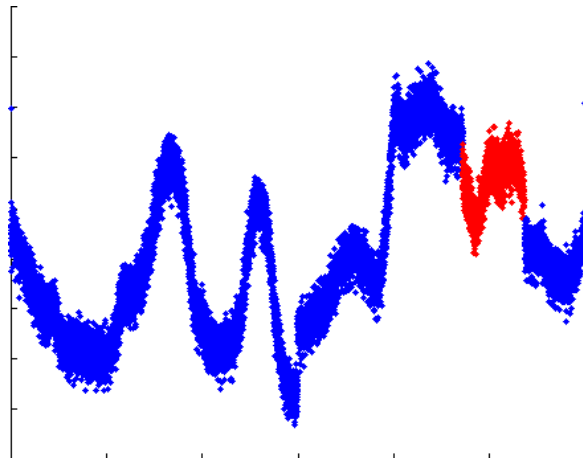
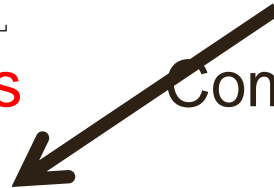
# PROCEDURE



Collect **Image Means**

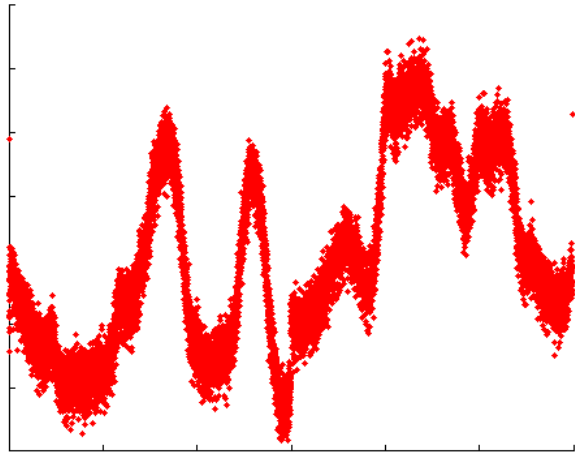


Compare to **Previous Side Slither**

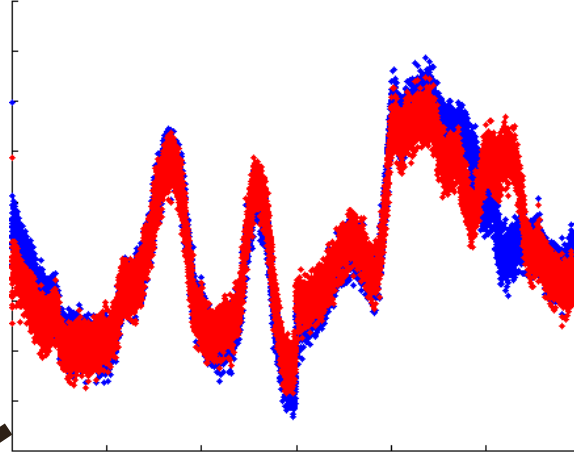


Locate **New Banding**

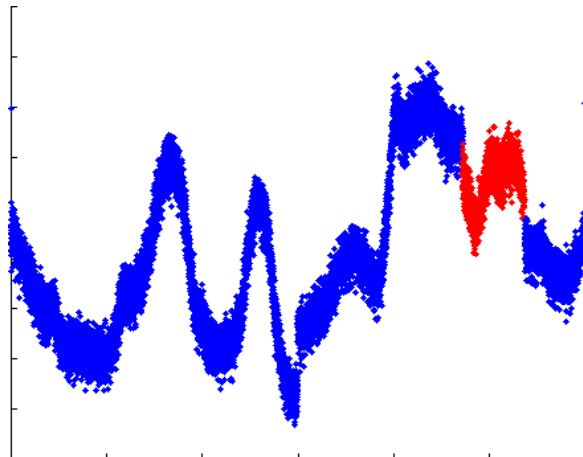
# PROCEDURE



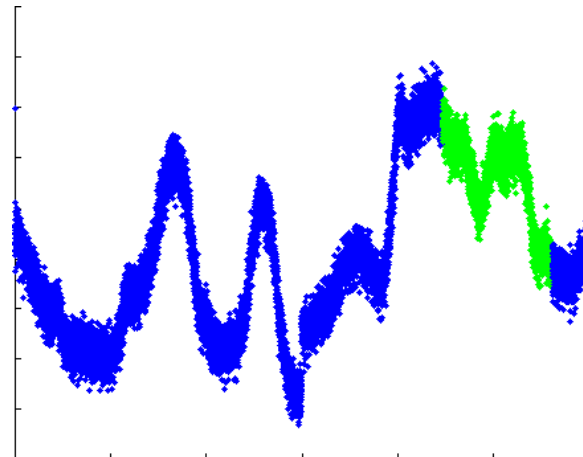
Collect **Image Means**



Compare to **Previous Side Slither**

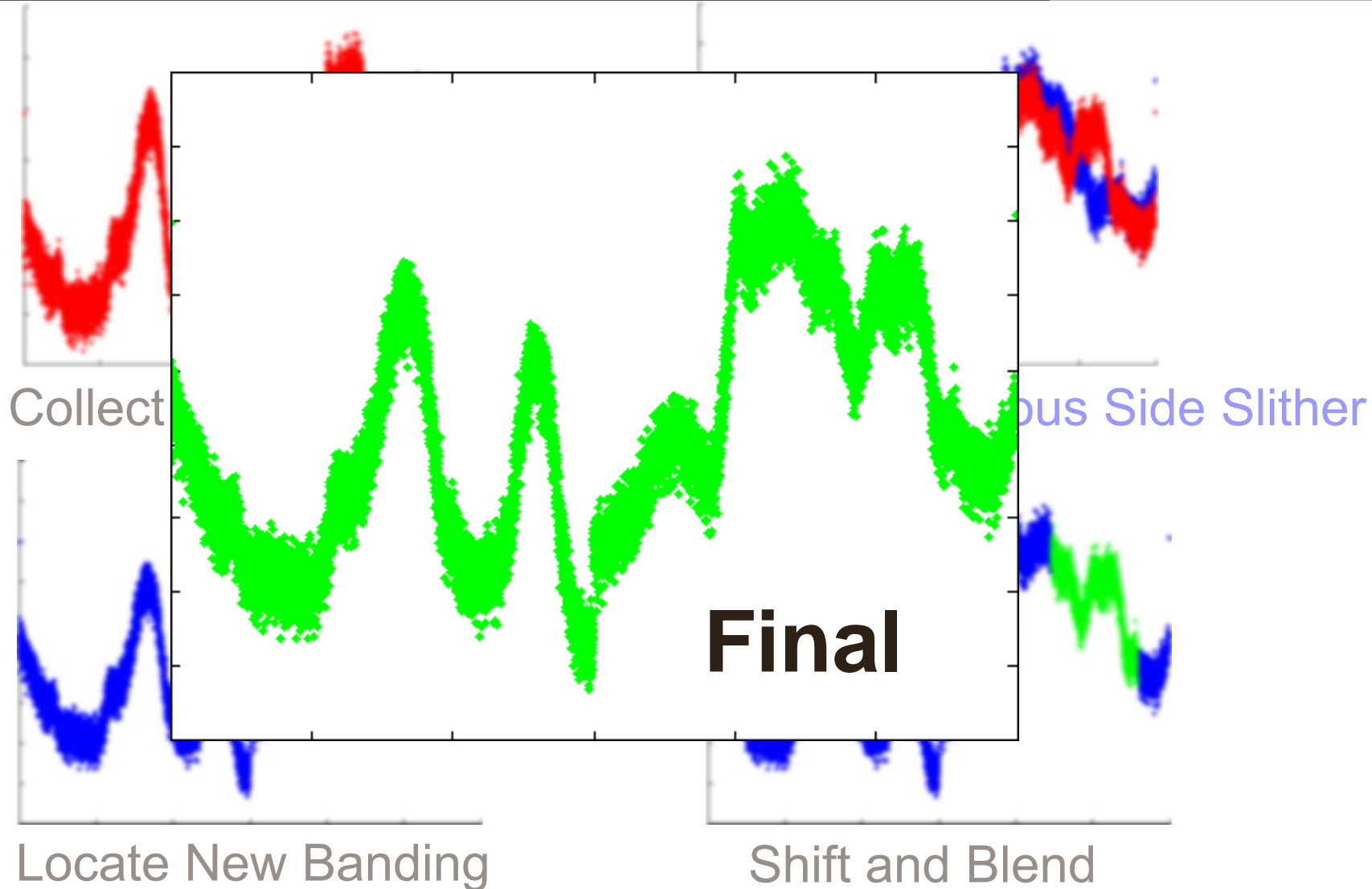


Locate **New Banding**



**Shift and Blend**

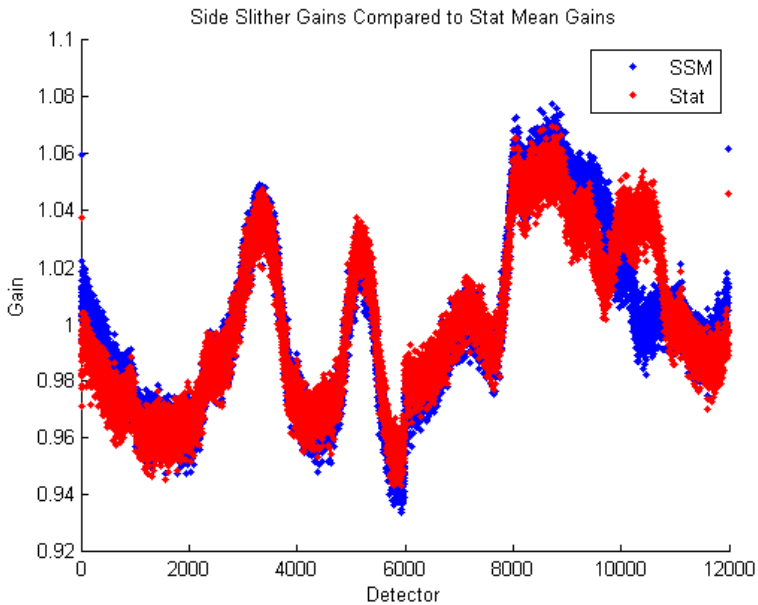
# PROCEDURE



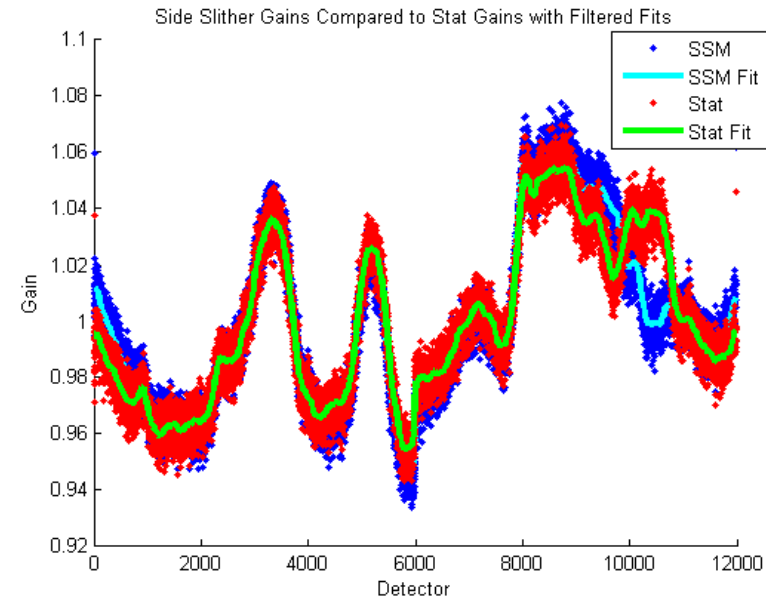
# PROCEDURE DETAIL

## LOCATE NEW BANDING

### MEDIAN/MEAN FILTER FIT



Median/Mean  
Fit



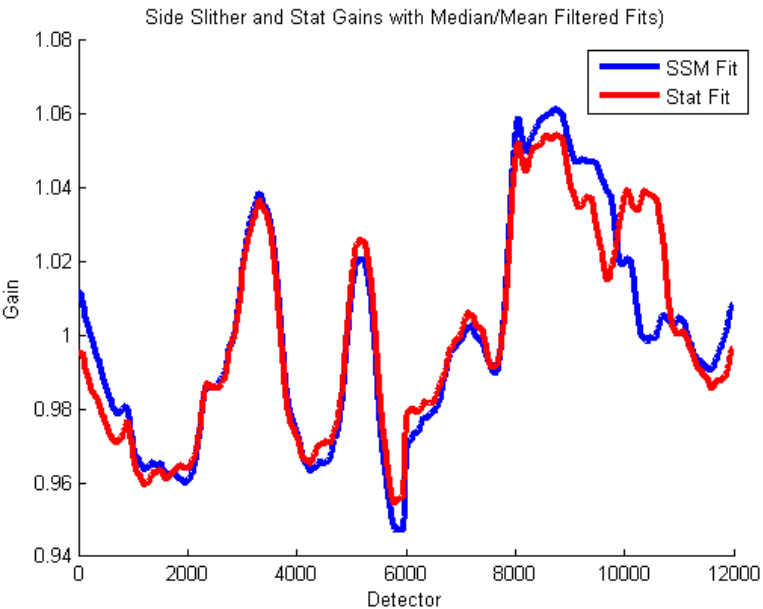
Previous Side Slither Gains  
Stat Mean Gains

Side Slither Gains Fit  
Stat Mean Gains Fit

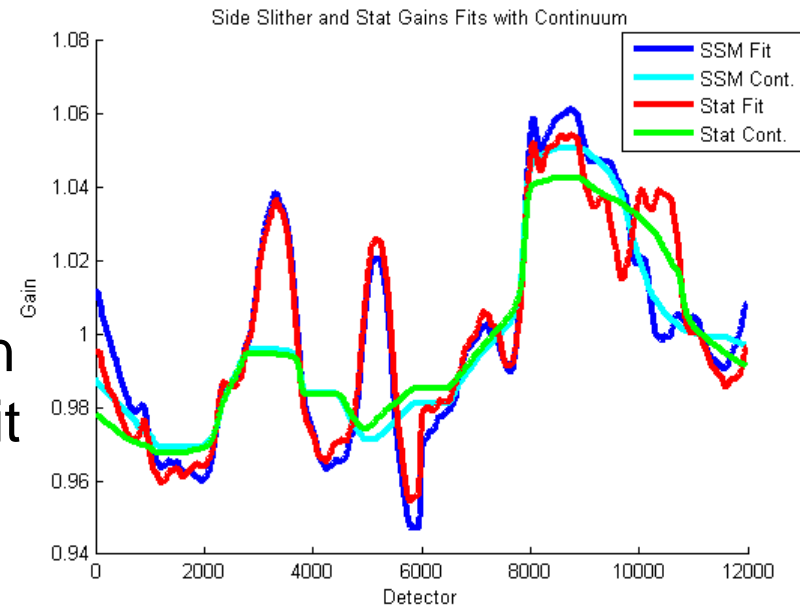
# PROCEDURE DETAIL

## LOCATE NEW BANDING

### CONTINUUM FIT



Median/Mean  
Continuum Fit



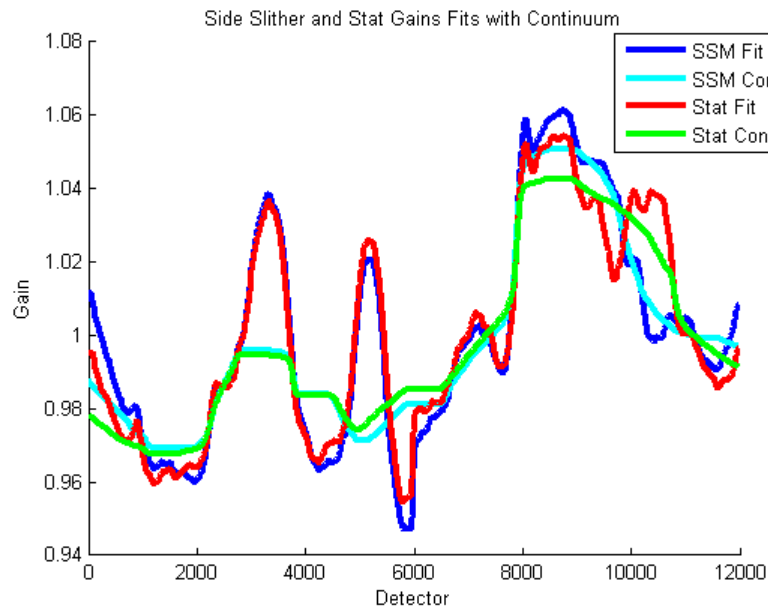
Side Slither Gains Fit  
Stat Mean Gains Fit

Side Slither Continuum Fit  
Stat Mean Continuum Fit

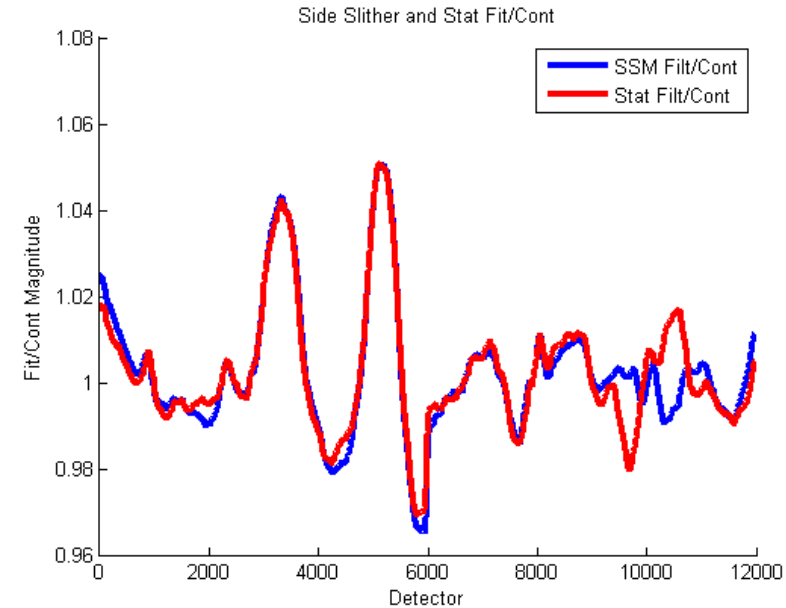
# PROCEDURE DETAIL

## LOCATE NEW BANDING

### CONTINUUM REMOVAL



➔  
Remove  
Continuum



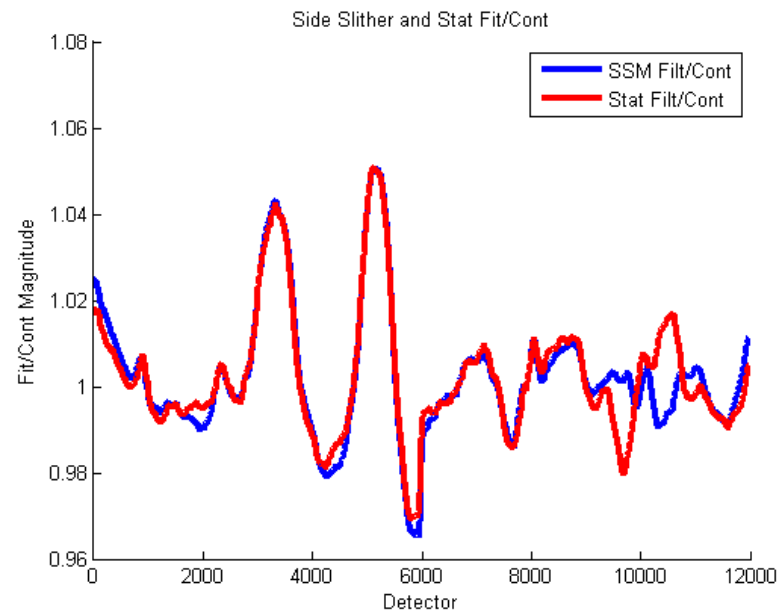
Side Slither Gains Fit  
Stat Mean Gains Fit  
Side Slither Continuum Fit  
Stat Mean Continuum Fit

Side Slither Gains Fit /  
Side Slither Continuum Fit  
Stat Mean Gains Fit /  
Stat Mean Continuum Fit

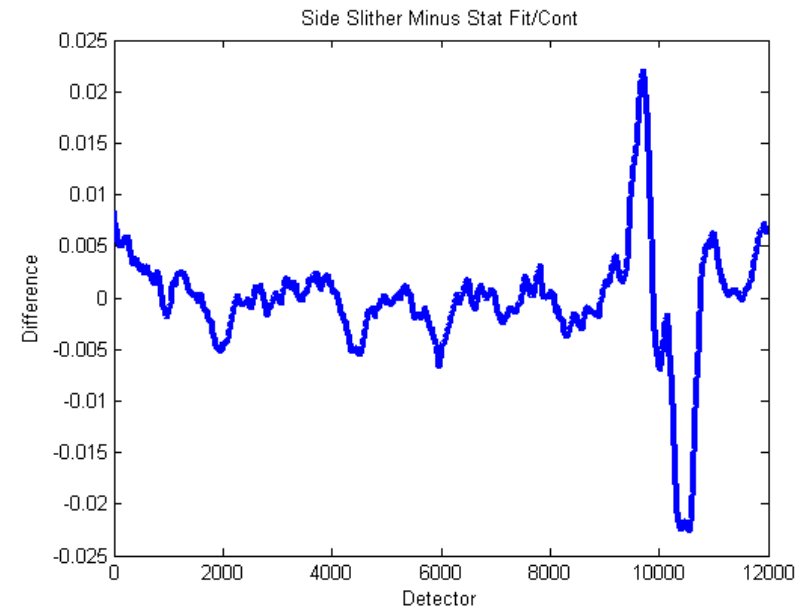
# PROCEDURE DETAIL

## LOCATE NEW BANDING

### DIFFERENCE BETWEEN SSM AND STAT



SSM-STAT



Continuum Removed Side  
Slither Gains Fit  
Continuum Removed Stat  
Gains Fit

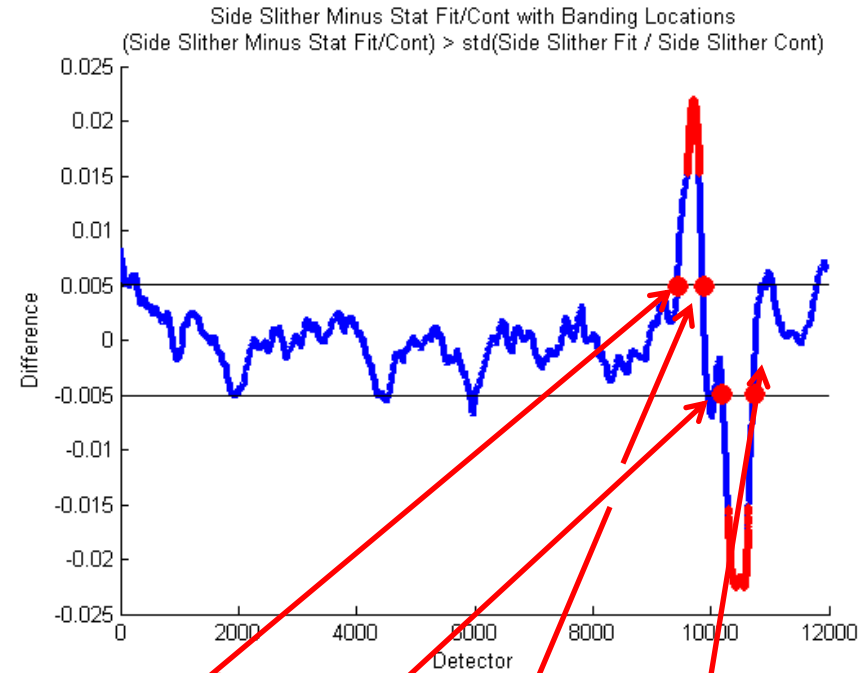
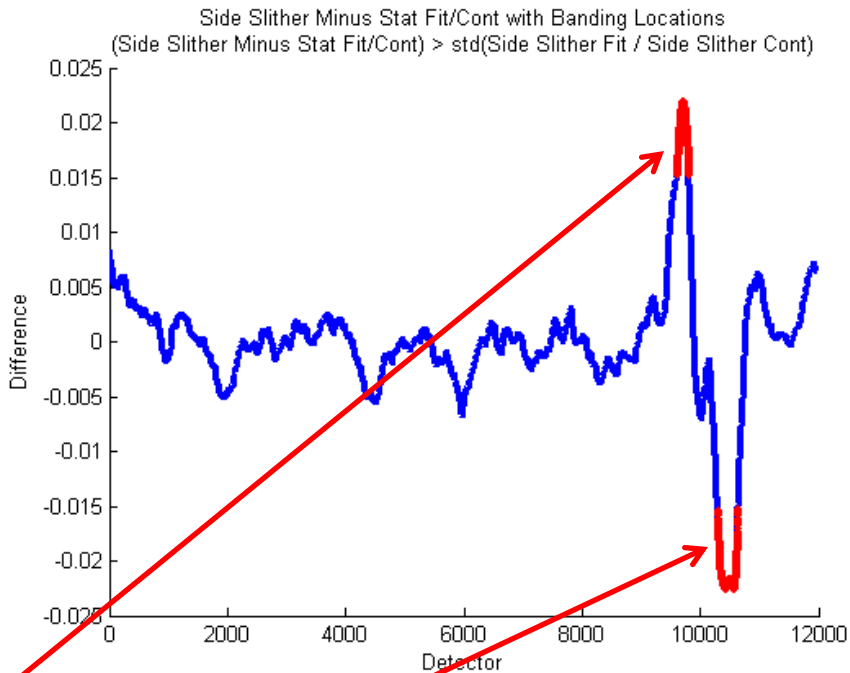
Continuum Removed Side  
Slither Gains Fit –  
Continuum Removed Stat  
Gains Fit



# PROCEDURE DETAIL

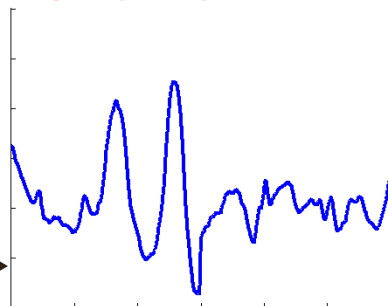
## LOCATE NEW BANDING

### BAND LOCATIONS



Band Locations are greater than 1 standard deviation of the Continuum  
 Removed Side Slither Gains Fit.

STD →

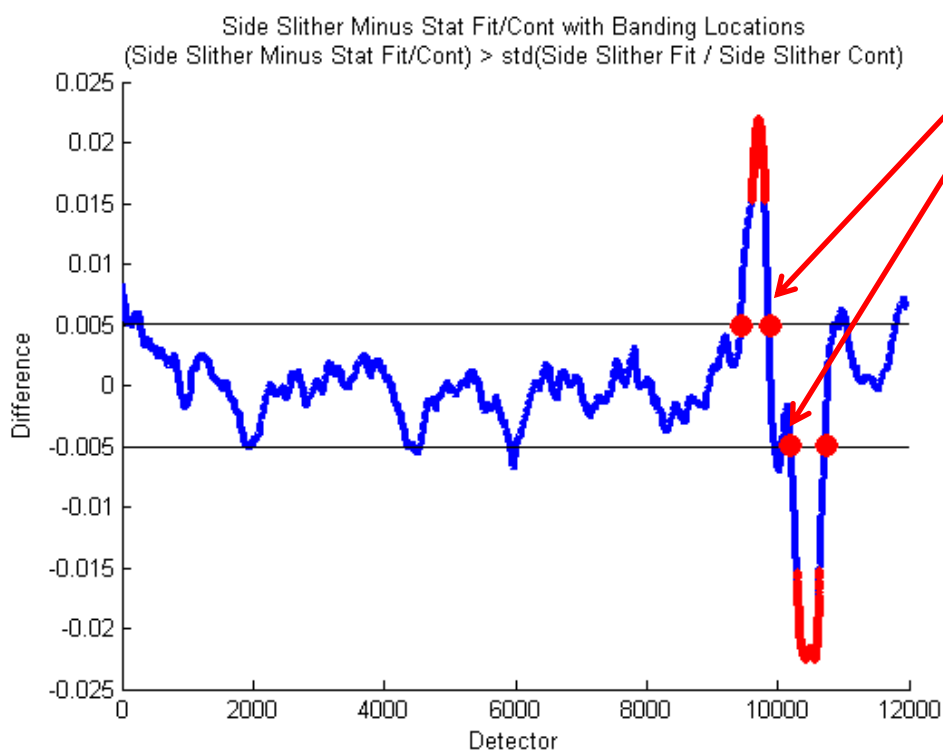


Band Starting and Ending Points are near (Threshold 0.005) a zero difference between the SSM and STAT continuum removed fits.

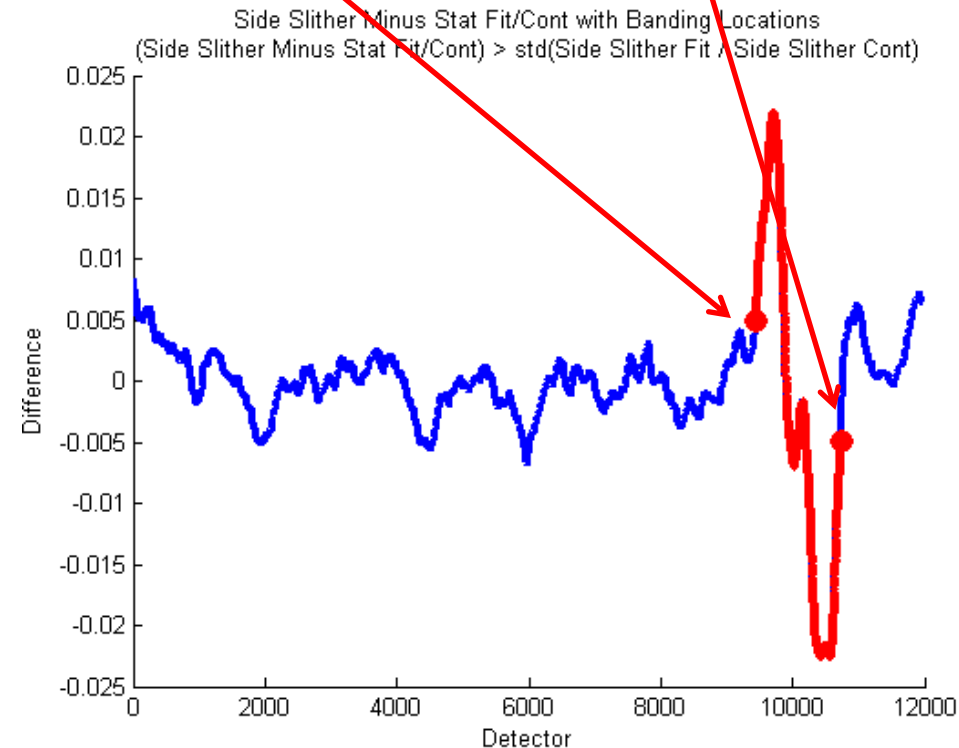
# PROCEDURE DETAIL

## LOCATE NEW BANDING

## COMBINING BANDING LOCATIONS



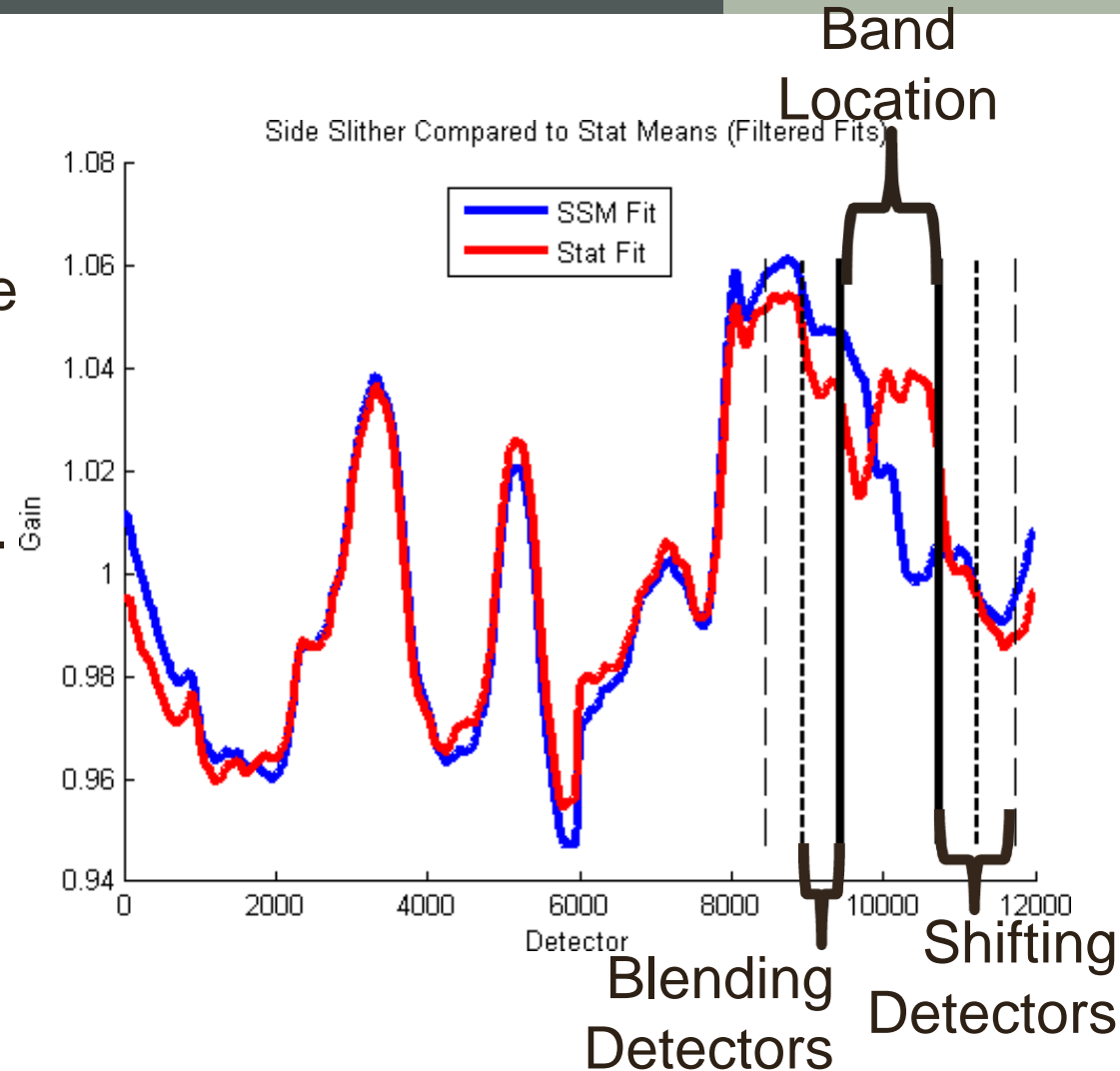
If an  
End and  
Start point are within 1000  
detectors of each other, it is  
considered one single band.



# PROCEDURE DETAIL

## SHIFTING AND BLENDING

- The the statistically derived relative gains at the new band location must be shifted and blended into the previous side slither gains.
- 500 detectors are used to blend the two sets of gains.
- 1000 detectors are used to shift the statistic relative gains.

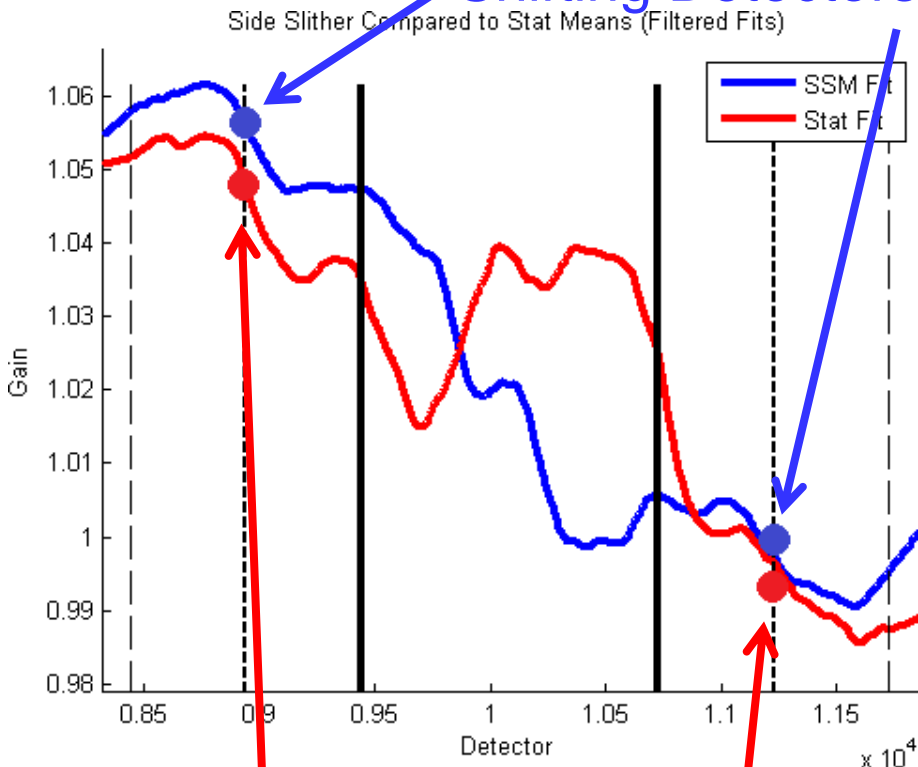


# PROCEDURE DETAIL

## SHIFTING AND BLENDING

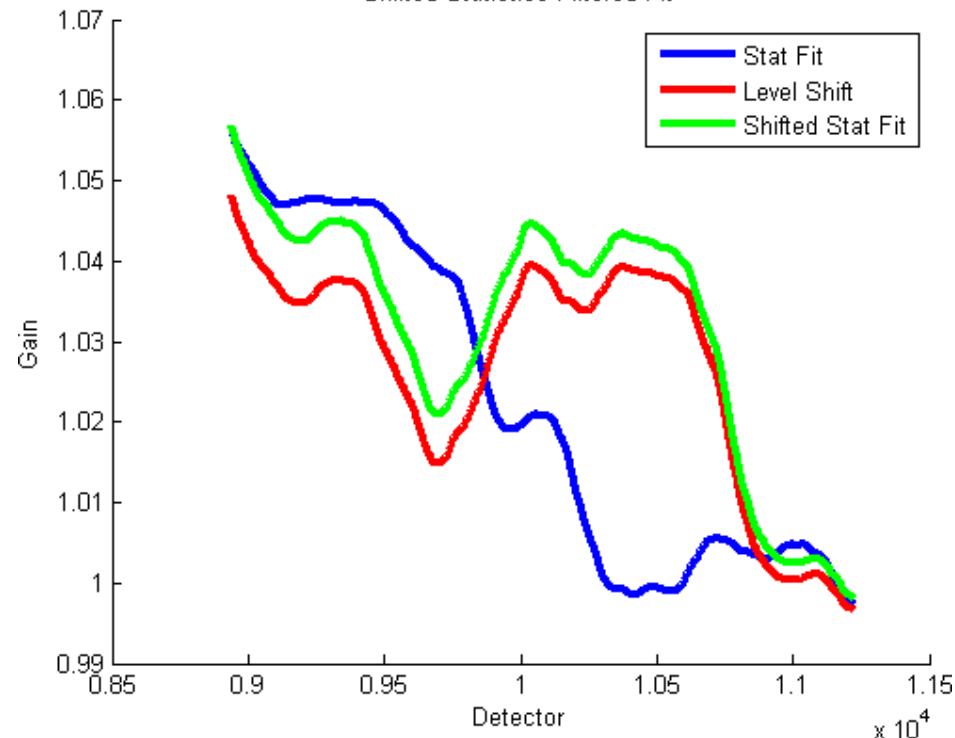
### SHIFTING

Mean of 1000 SSM  
Shifting Detectors



Mean of 1000 STAT  
Shifting Detectors

Shifted Statistics Filtered Fit



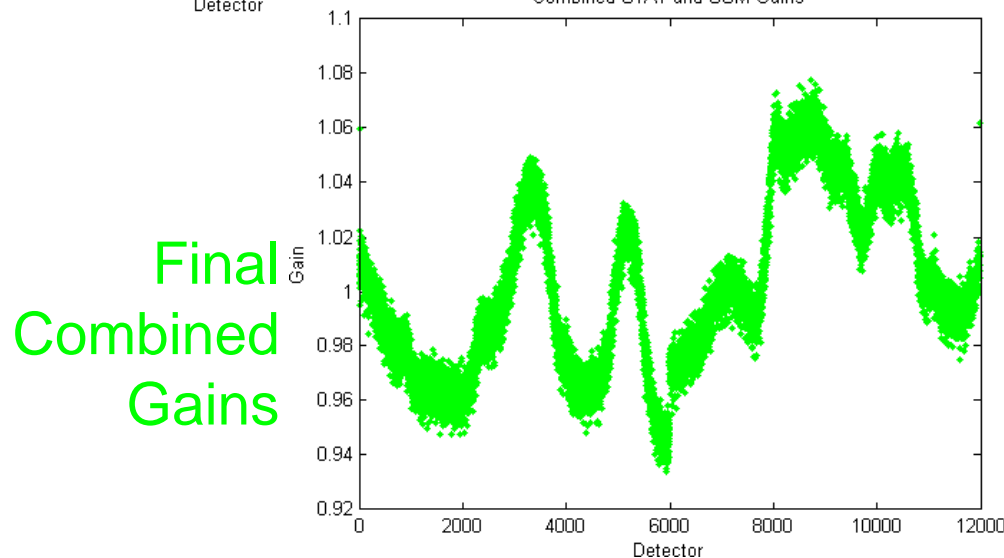
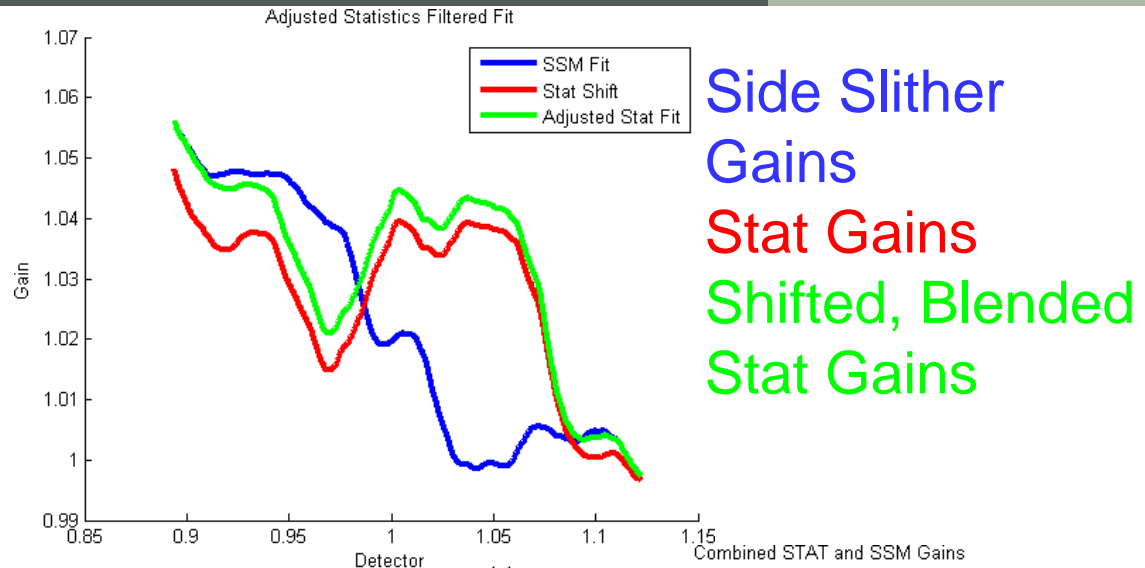
Side Slither Rel Gain Fit  
Statistic Rel Gain Fit  
Shifted Stat Rel Gain Fit

# PROCEDURE DETAIL

## SHIFTING AND BLENDING

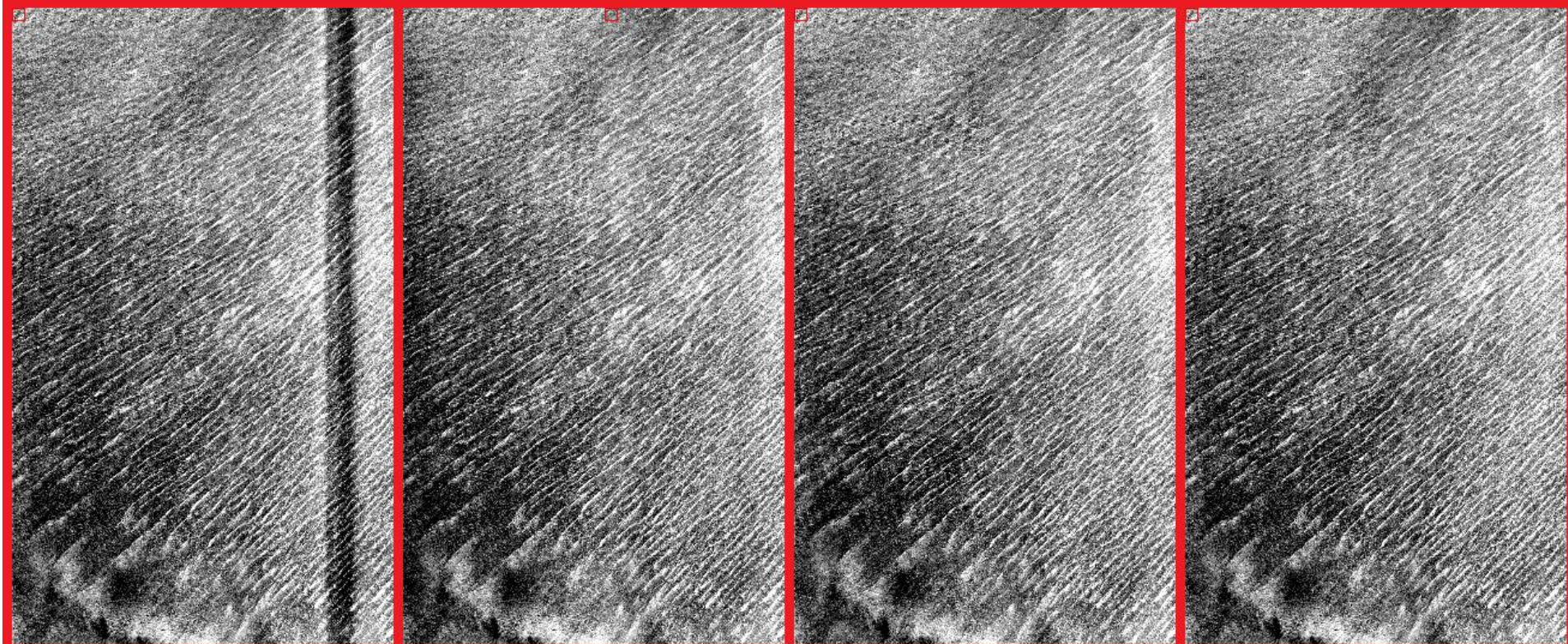
### BLENDING

- A weighted average between the statistic and side slither individual gains is used to blend to two sets of gains.
- The detector closest to the band location is 499 parts Stat and 1 part Side Slither, the next is 498 parts Stat and 2 parts Side Slither, and so on.
- Finally, the rest of the Side Slither Gains are used for all other detectors.



# RESULTS

# SAUDI ARABIA (02/20/2012)



**Previous SSM**  
Acquired on  
01/20/12

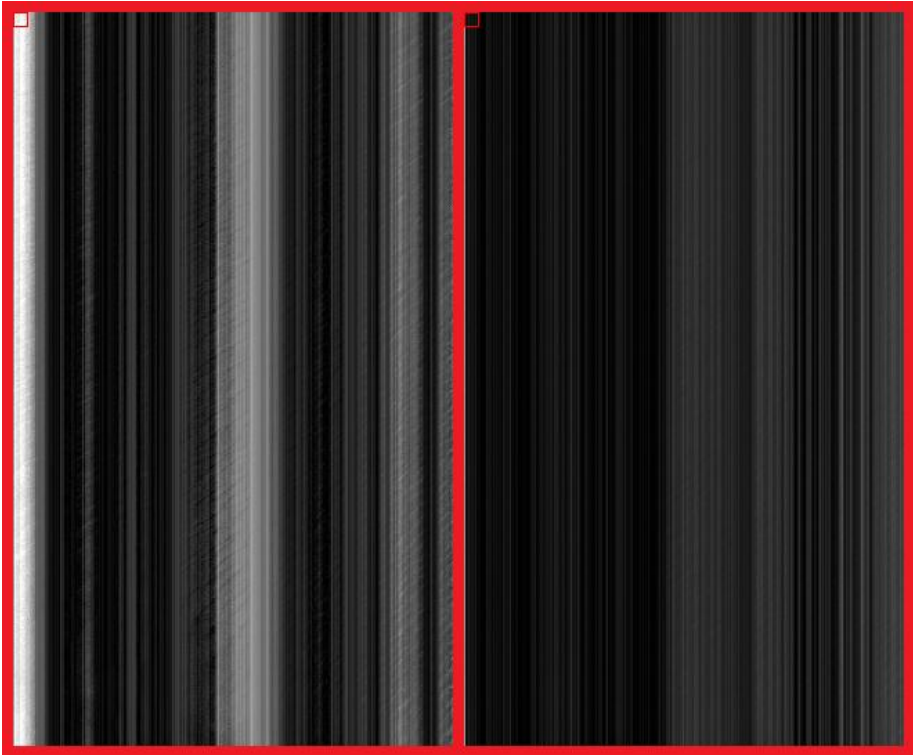
**Statistics**

**Combination of  
Stats and  
Previous SSM**

**New SSM**  
Acquired on  
03/08/12

Stats gathered between 02/16/12 - 03/08/12

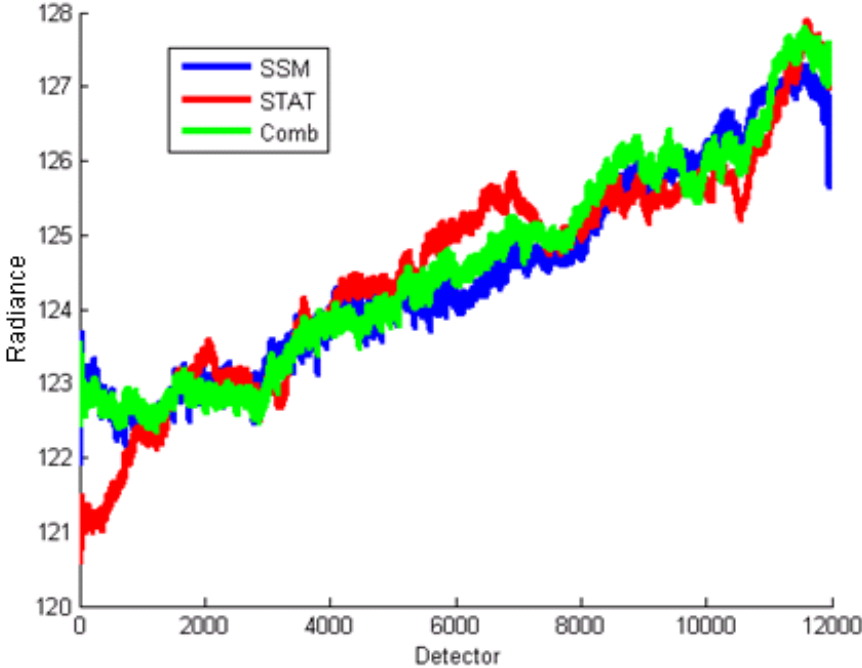
## Absolute Difference Images



SSM-Stat

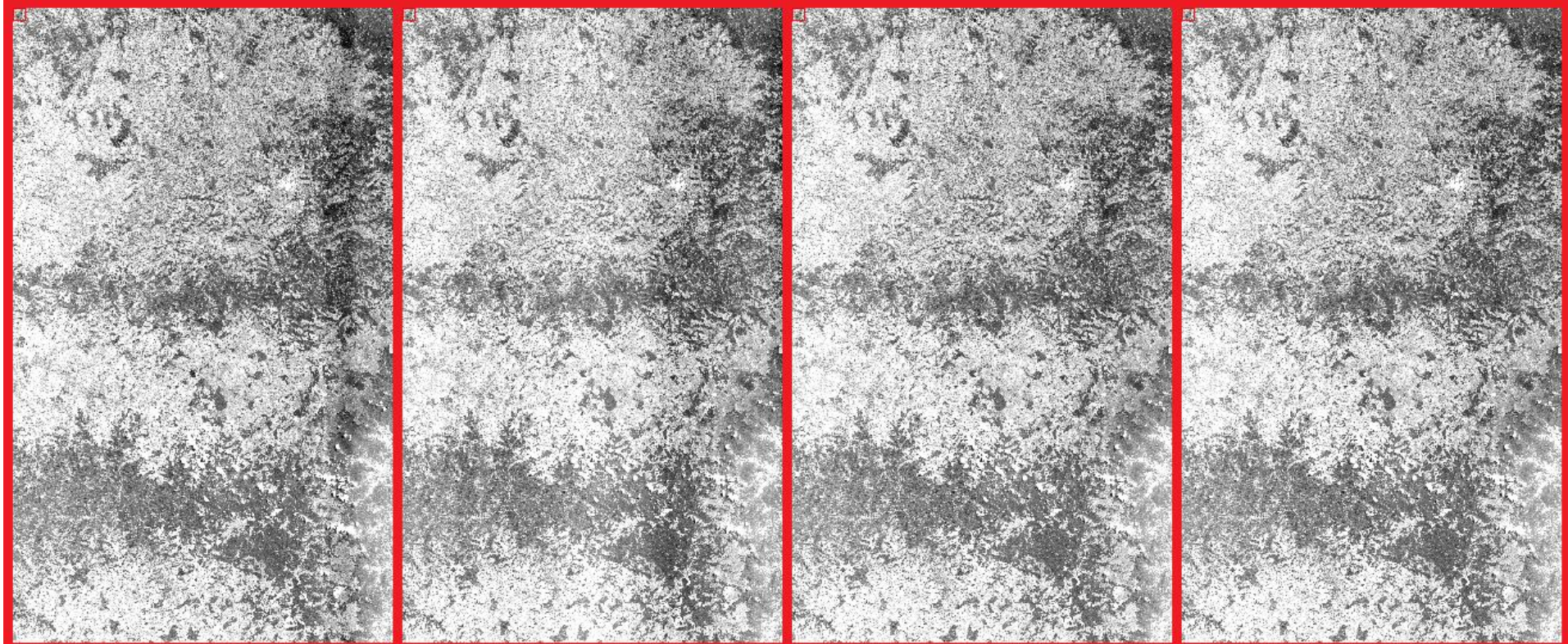
SSM-Comb

## Detector Means





# BRAZIL (02/18/2012)



**Previous SSM**

Acquired on  
01/20/12

**Statistics**

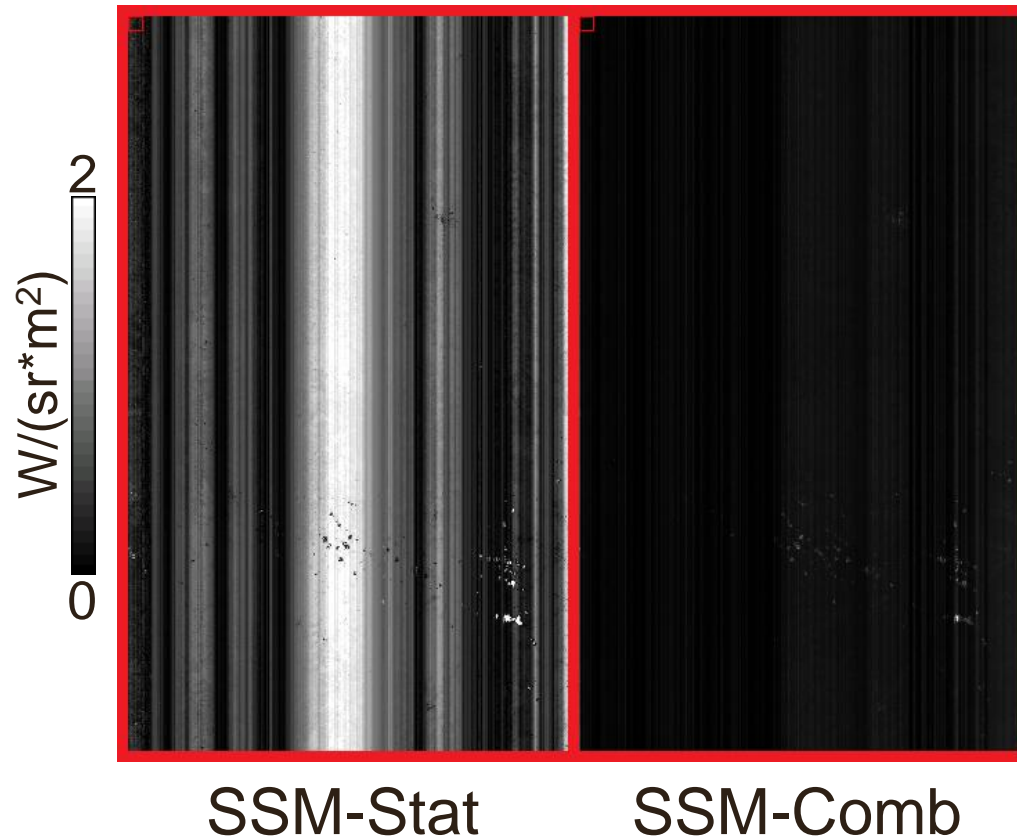
**Combination of  
Stats and  
Previous SSM**

**New SSM**

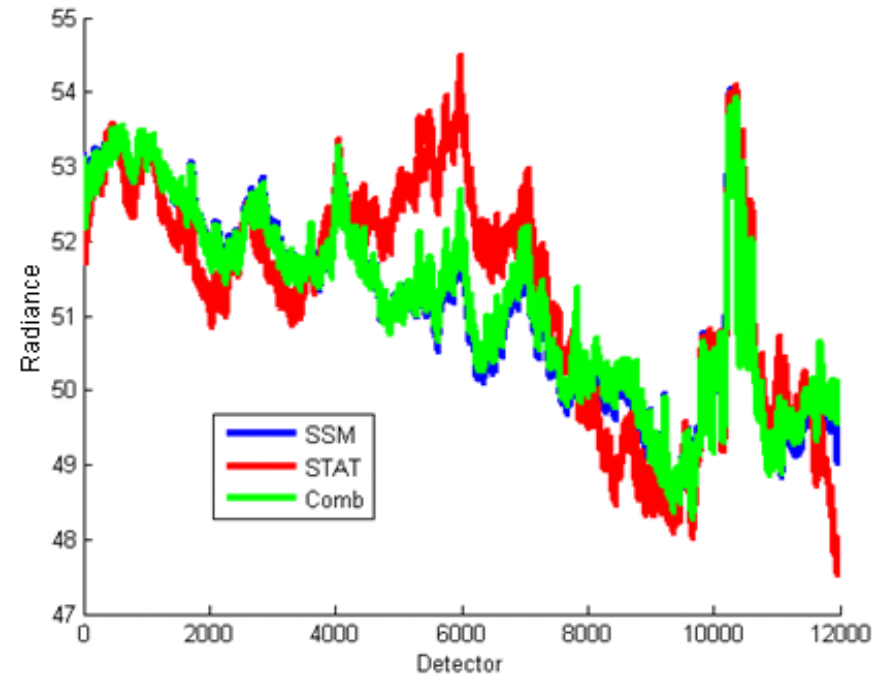
Acquired on  
03/08/12

Stats gathered between 02/16/12 - 03/08/12

## Absolute Difference Images



## Detector Means



- Clearly Side Slither is still the best method.
- The amount of visual banding in the Combination method is better than the STAT method.
- The main difference between the STAT and Combination methods is what happens to underlying gradient structure in the images.
  - The STAT method changes the gradient significantly while the Combination method preserves it.