Intercomparison of Surface Albedo products from Various Optical sensors

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in collaboration with

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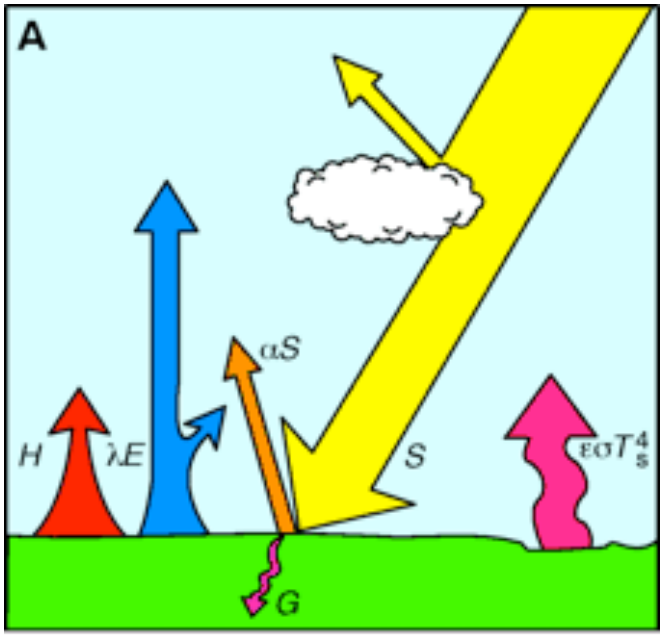
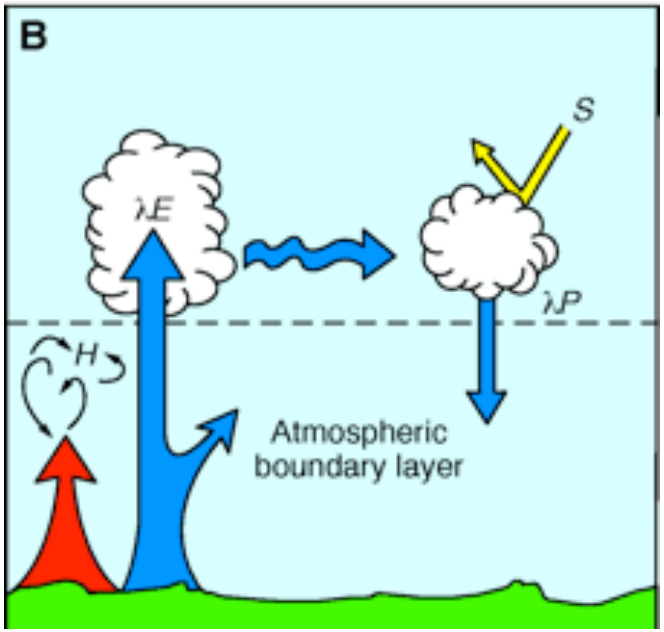
(4) SEAC, Georgia Tech., Georgia, USA
(5) EUMESAT, Darmstadt, Germany
(6) Boston University, USA
(7) University of Maryland, USA

Land-surface interactions



Surface radiation budget



Atmospheric heat fluxes

Definition of Surface albedo ?

Surface Albedo has come to assume a wide range of meanings:

BHR : Bi-Hemispherical Reflectance is the ratio between the upward and the downward radiant fluxes, that is, accounting for the downwelling diffuse intensities from the sky.

Depends on both surface and atmospheric radiative properties and …the Sun angle.

DHR: Directional Hemispherical Reflectance is the ratio between the upward flux and the downward collimated flux coming thus from one single direction.

Depends on surface radiative properties and …the Sun angle.

Surface albedo: some caveats!

• If the downwelling diffuse intensities from the sky is assumed fully **isotropic** then the BHR is equal to the integral of the DHR over all incoming directions and,

the BHR becomes a BHRiso called White Sky albedo by the MODIS team and depends on surface radiative properties only and …the Sun angle.

• The DHR boils down to a single integral of BRF on all the outgoing directions, called Black Sky albedo by the MODIS team where,

the BRF, a Bidirectional Reflectance Factor expressing the probability for radiation coming from one particular direction to be scattered in a specific outgoing direction

Surface albedo products from space agencies

- MISR delivers DHRs and BHRs as flux ratios but under ambient conditions and for the Sun illumination conditions at time of observations

  and all information needed to reconstruct the DHRs at any other Sun angle as well as the BHRiso

- EUMETSAT delivers DHRs for a fixed Sun angle

  and all information needed to reconstruct the DHRs at any other Sun angle as well as the BHRiso

- MODIS delivers DHRs and BHR_{iso}

  to reconstruct the BHRs may require substantial investments or some level of assumption

The albedo products may also differ wrt the spectral bands of integration they refer to.

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Needs of AGCMs wrt Surface albedo products

Atmospheric General Circulation/Climate Models (AGCMs) need to represent the ratios of upward to downward radiant fluxes, i.e., BHRs:

- For any given Sun position that is, any model grid cell at any time of the day and season

- For any arbitrary state and composition of the overlying atmosphere that is, any particular irradiance field resulting from the distribution of clouds and aerosols generated by the model

None of the products delivered, as such, by the main space agencies correspond to these needs!

Parameterizing the surface-atmosphere radiative coupling

Assuming that the field of downwelling diffuse intensity reaching the surface is PERFECTLY isotropic yields a *BLUE SKY ALBEDO*

Surface level

Sun angle

ratio of direct to total downward flux

$$BHR^{*}(z_0,\mu_0;\tau,\rho_{sfc}) = DHR(z_0,\mu_0;\rho_{sfc}) \times f^{\downarrow dir}(z_0,\mu_0;\tau)$$

$$+ BHR_{iso}(z_0,\mu_0;\rho_{sfc}) \times f^{\downarrow diff}(z_0,\mu_0;\tau,\rho_{sfc})$$

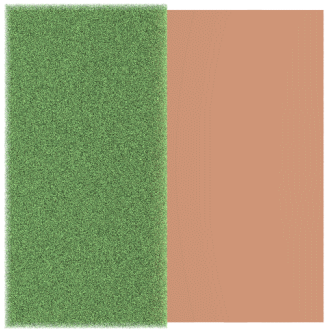
Atmospheric optical depth (type of atmosphere)

Surface BRF (amplitude and shape)

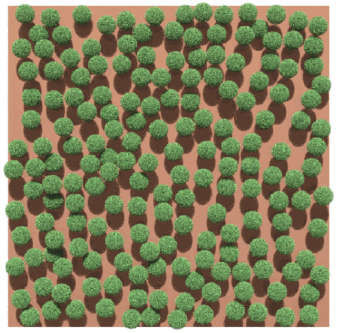
ratio of diffuse to total downward flux

with $f^{\downarrow dir}(z_0,\mu_0;\tau) + f^{\downarrow diff}(z_0,\mu_0;\tau,\rho_{sfc}) = 1$

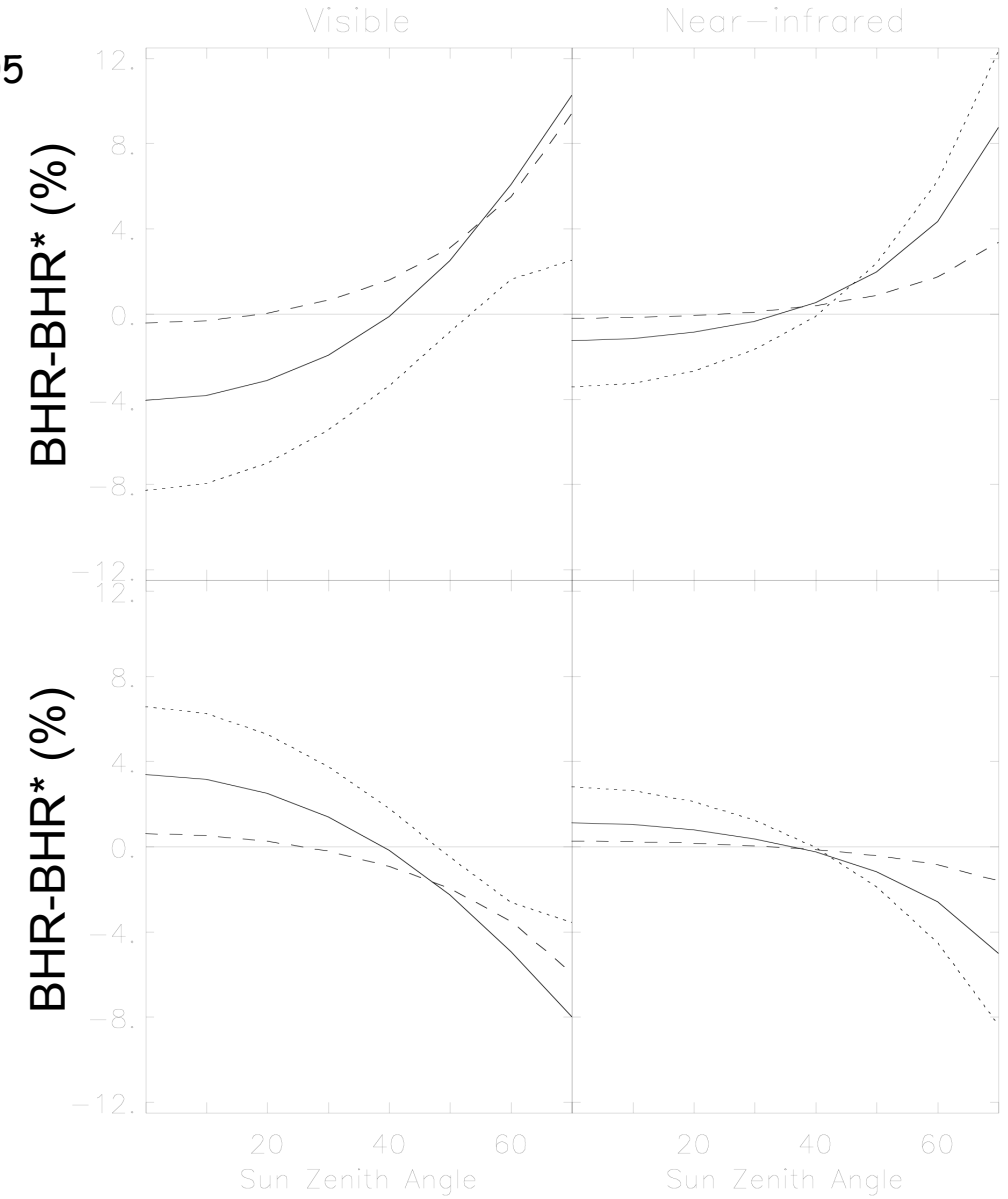
Pinty et al., JAS, 2005



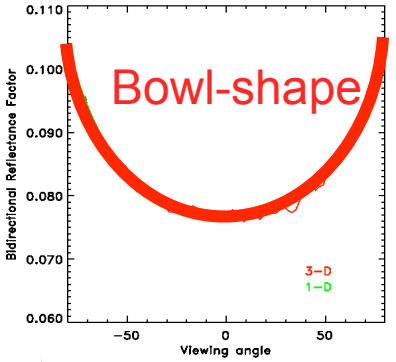
1-D'



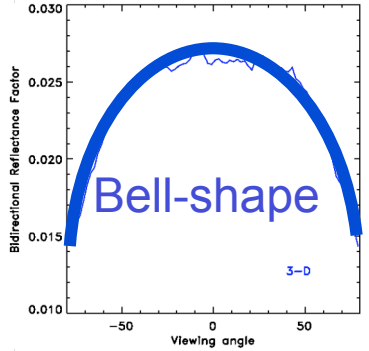
3-D

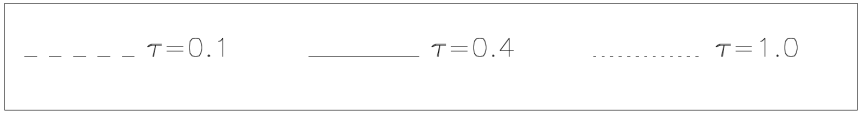


BRF



BRF





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Intercomparison of Surface *BHRiso* Products from MISR/MODIS/Meteosat

- Select the same period of time and identical geographical regions

- Identify the product values showing appropriate QA

- Achieve the needed transformations (e.g., BHRs, spectral conversions) to ensure intercomparison of physical quantities having same meaning

MODIS versus Meteosat Broadband (0.3-3.0) *BHRiso*

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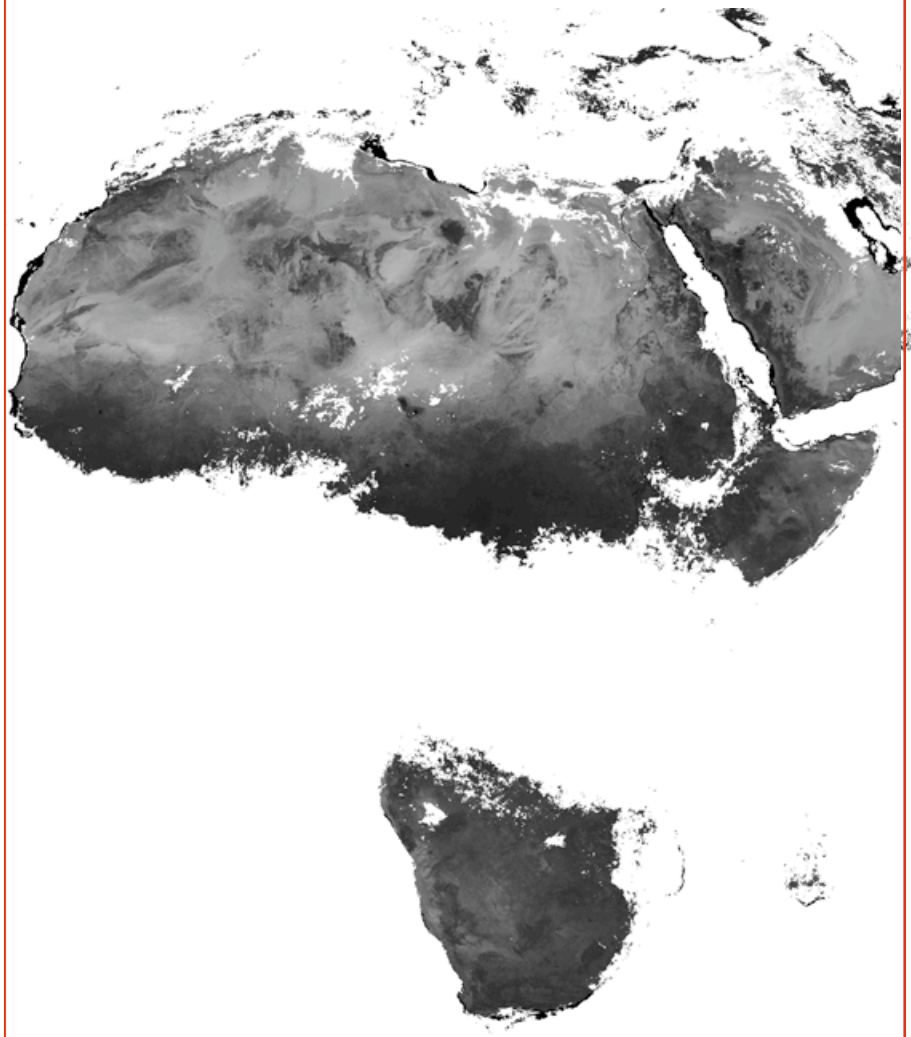
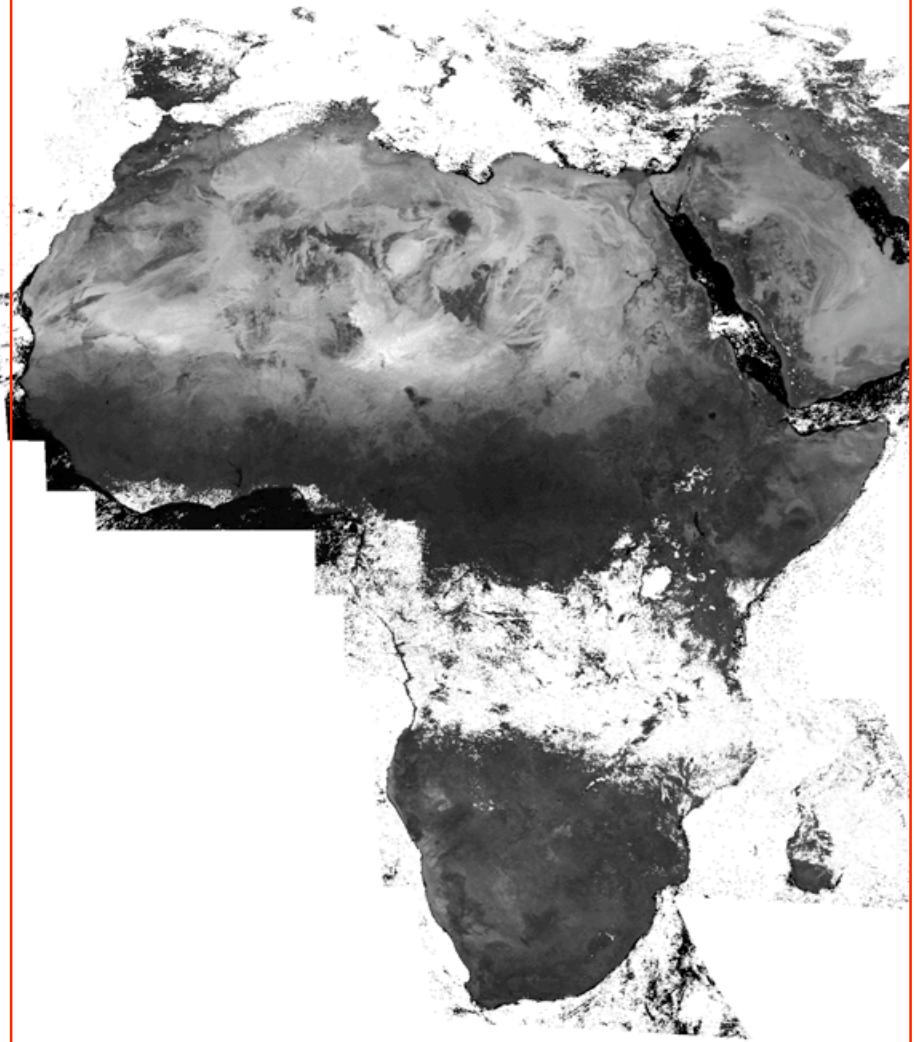
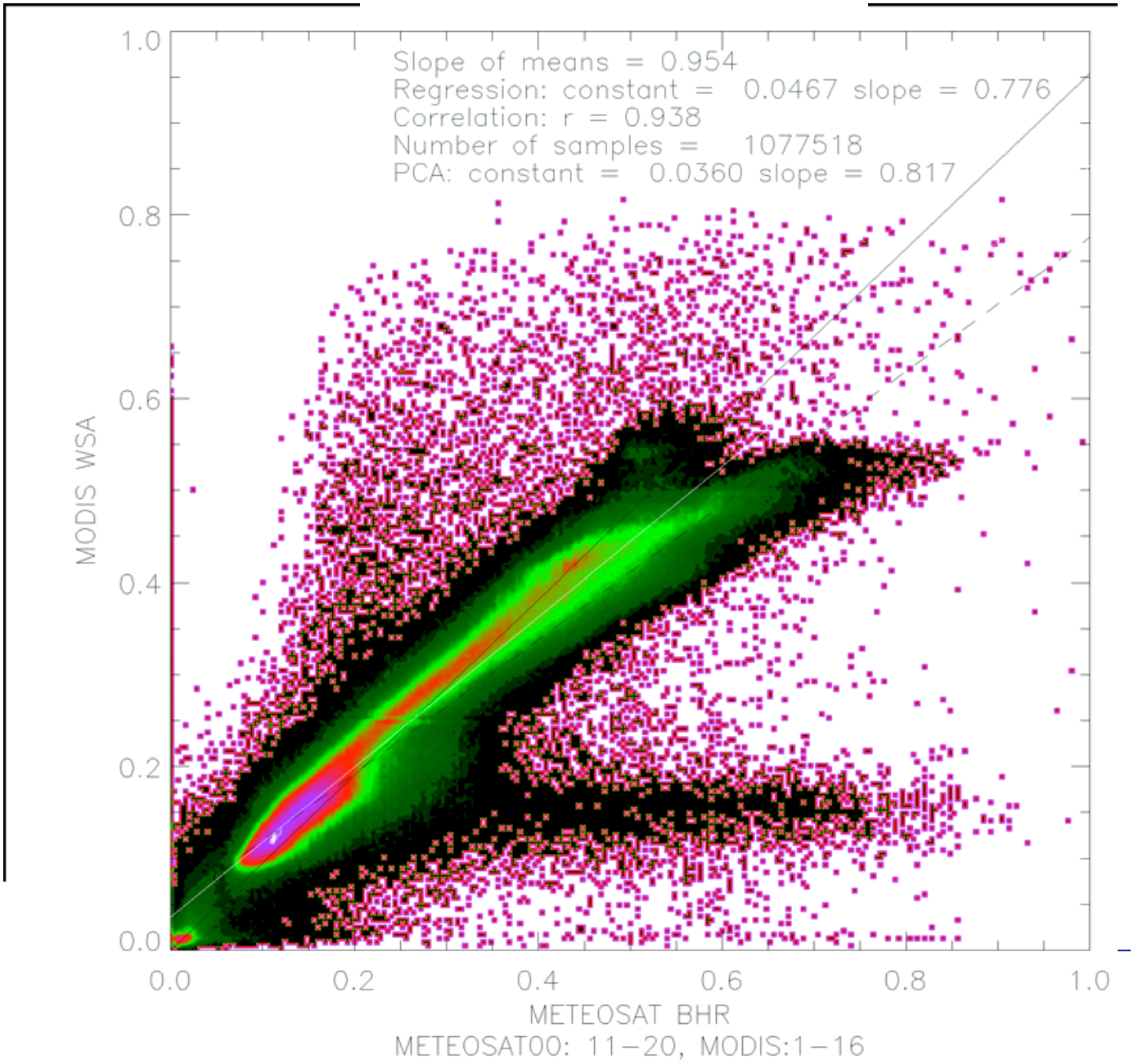
MODIS product year 2001, 1-16



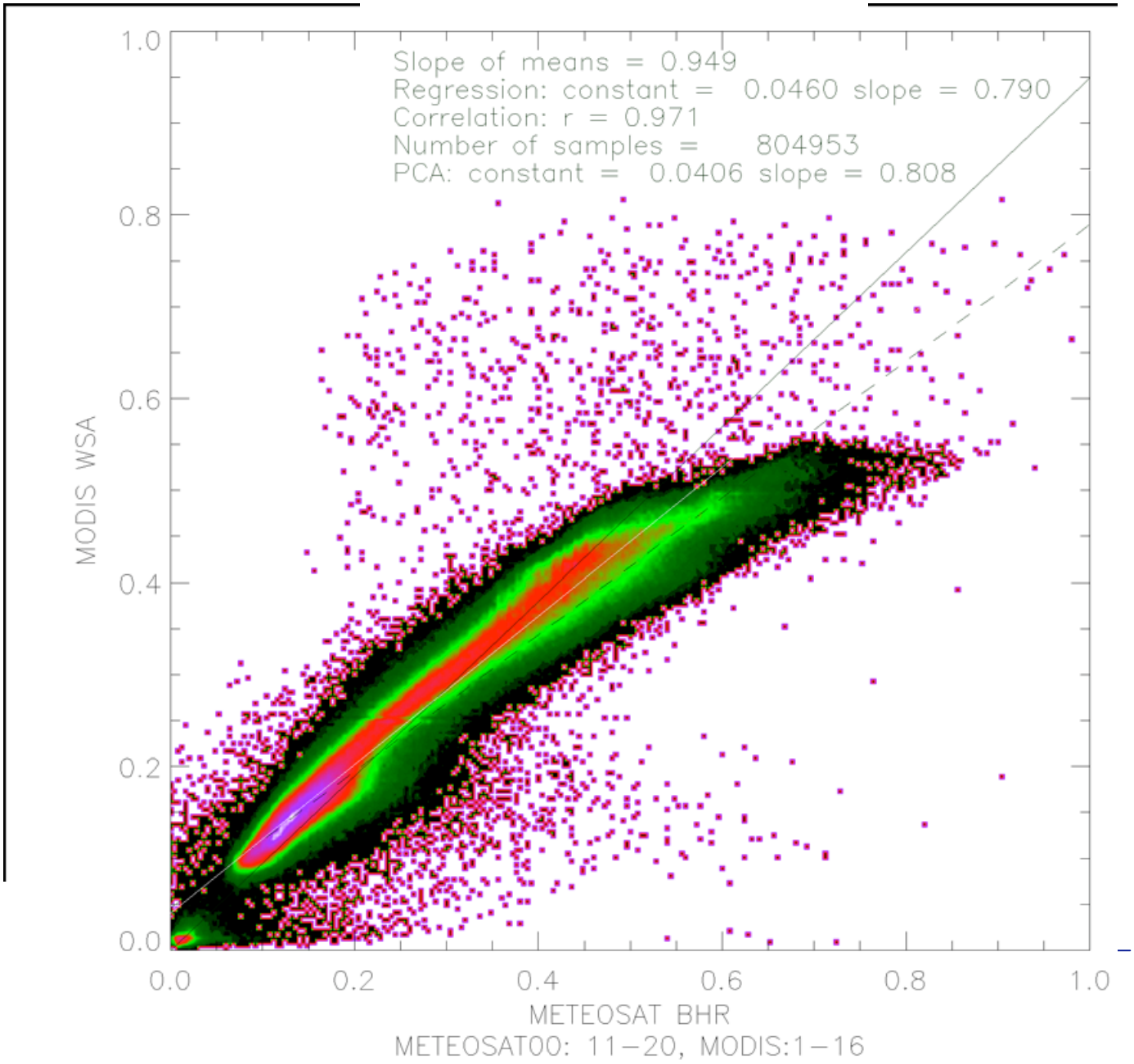
MSA product year 2001, 11-20

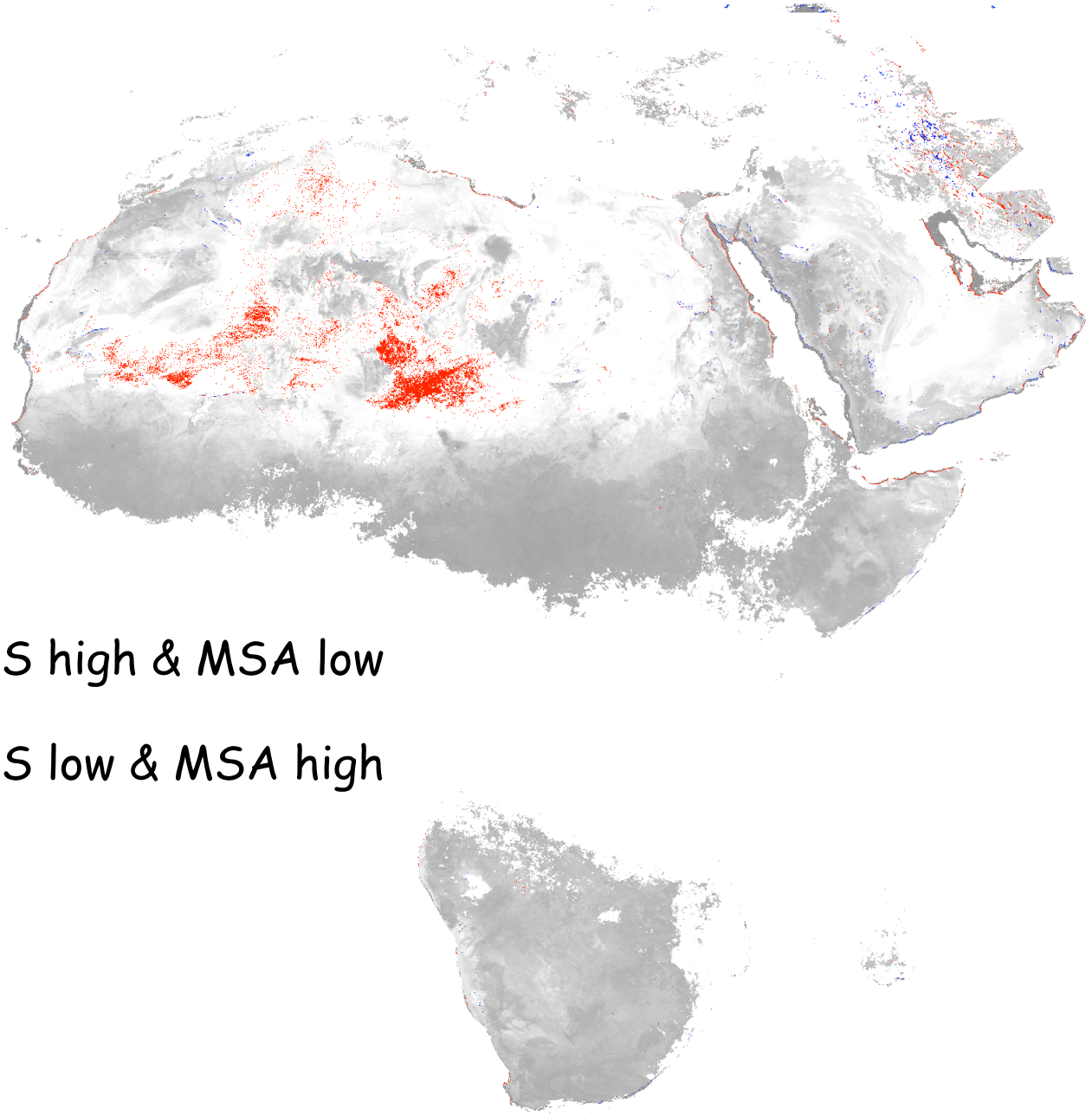


ALL QA values



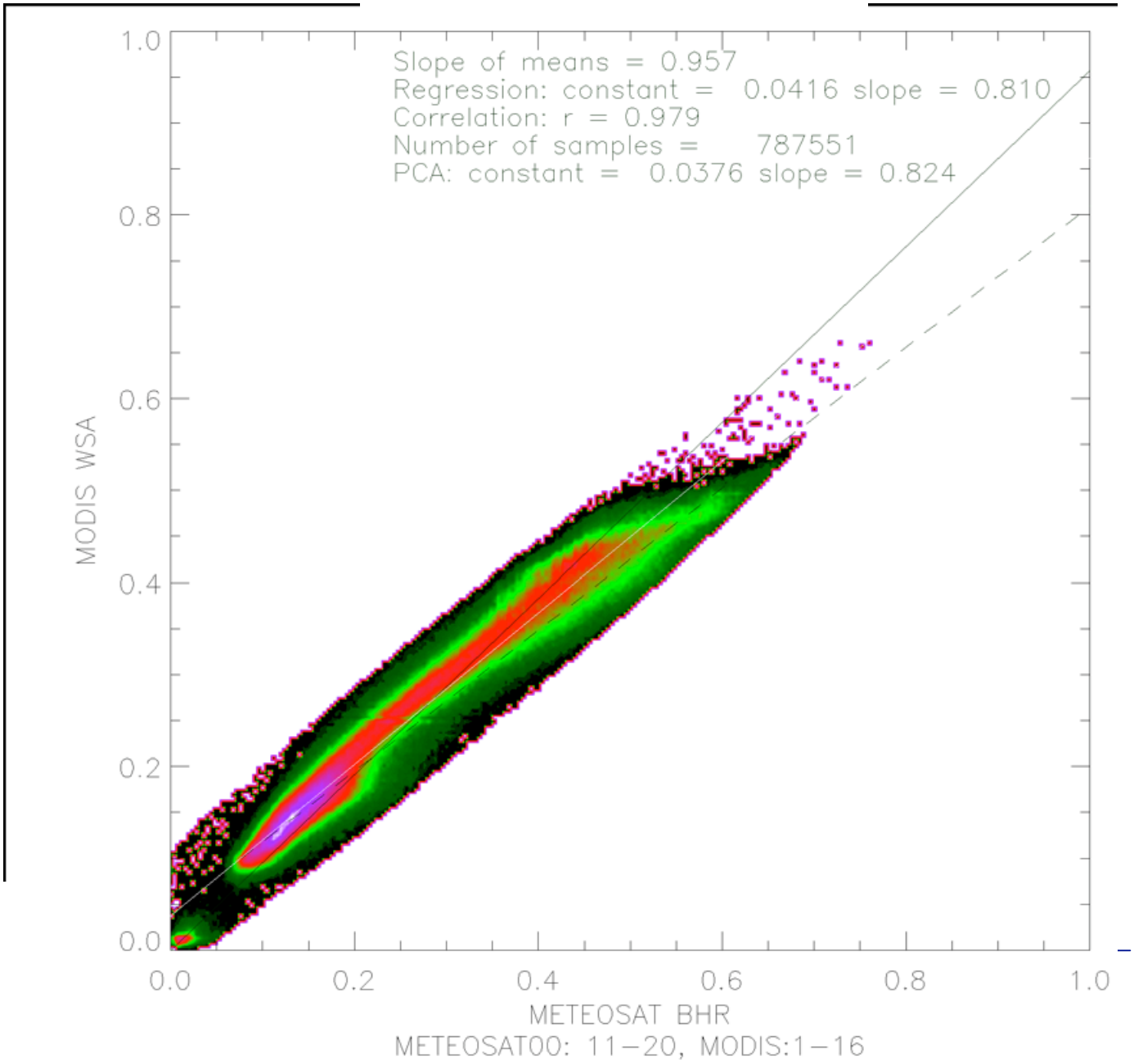
High QA values only



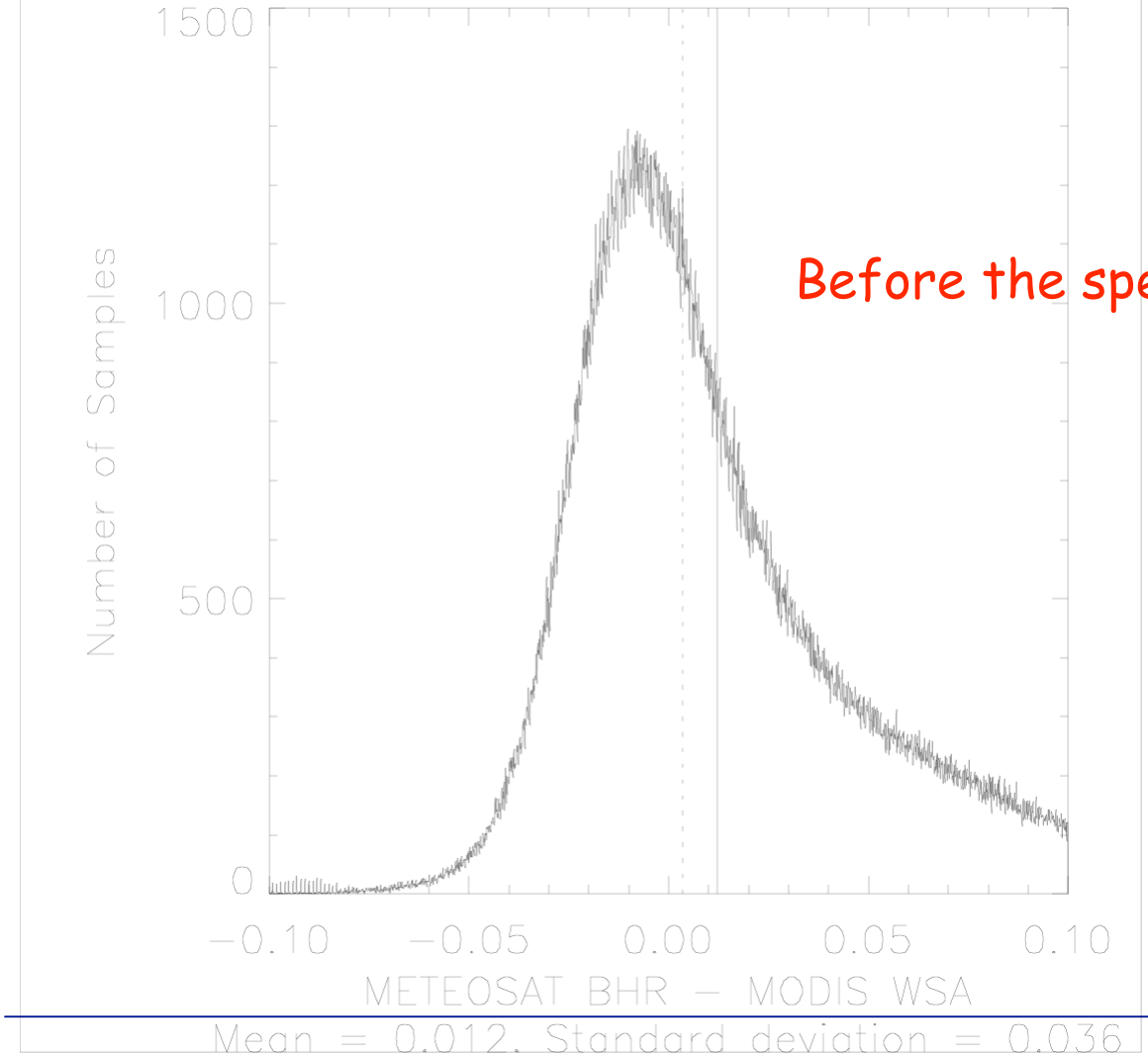


- MODIS high & MSA low
- MODIS low & MSA high

High QA values only



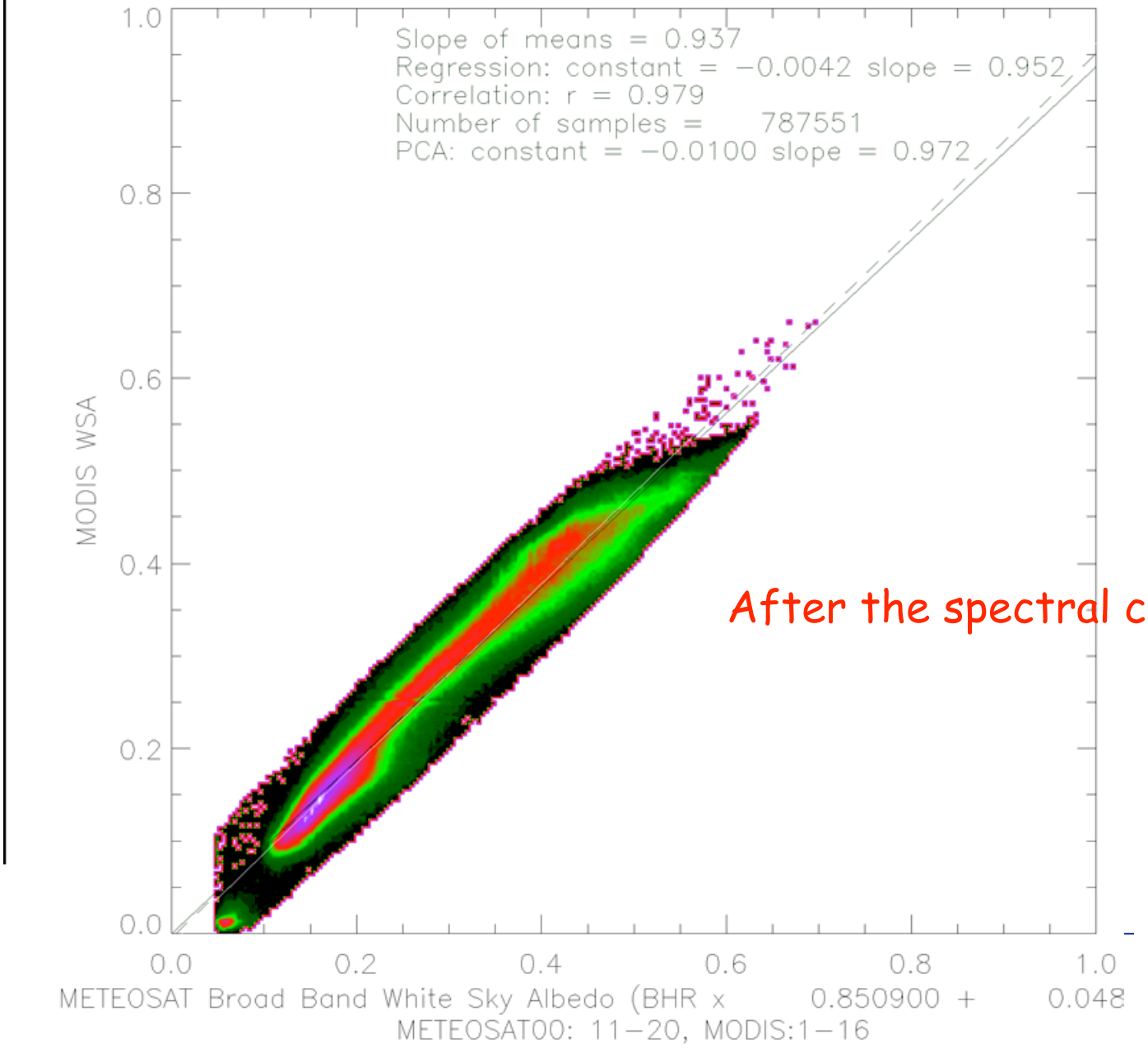
Histogram of BHR differences



Before the spectral conversion

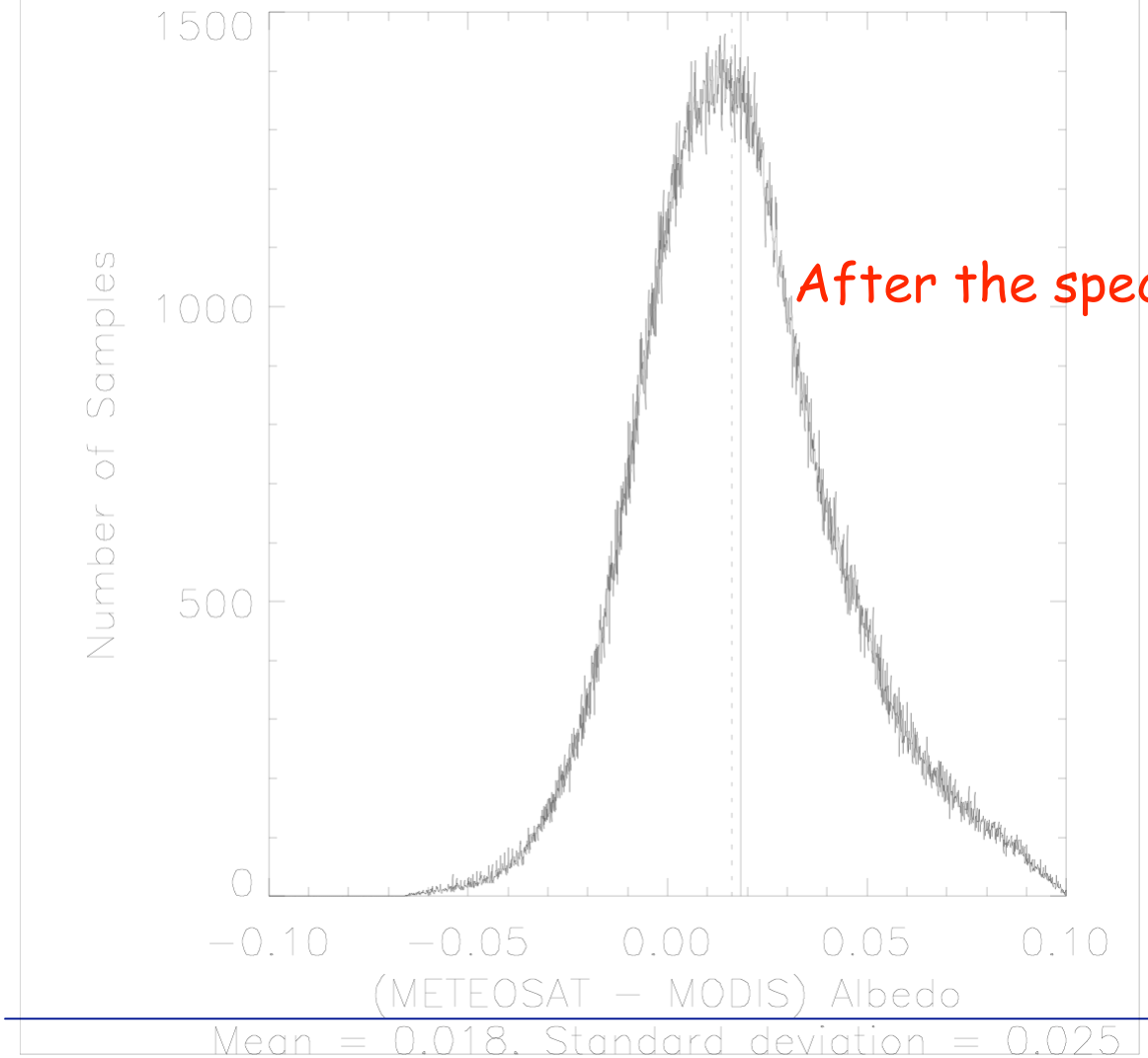
January 2001

High QA values only



After the spectral conversion

Histogram of BHR differences



After the spectral conversion

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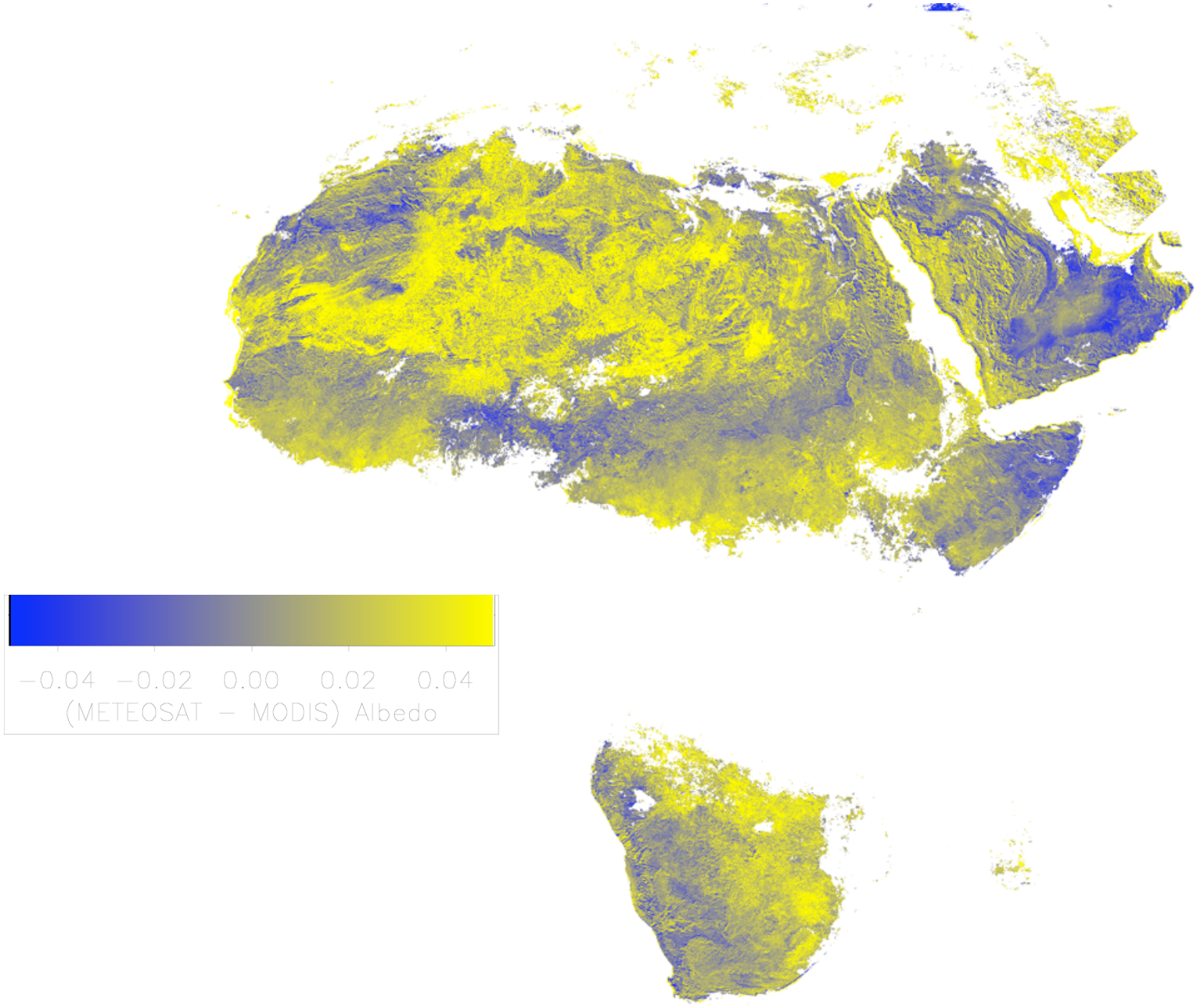
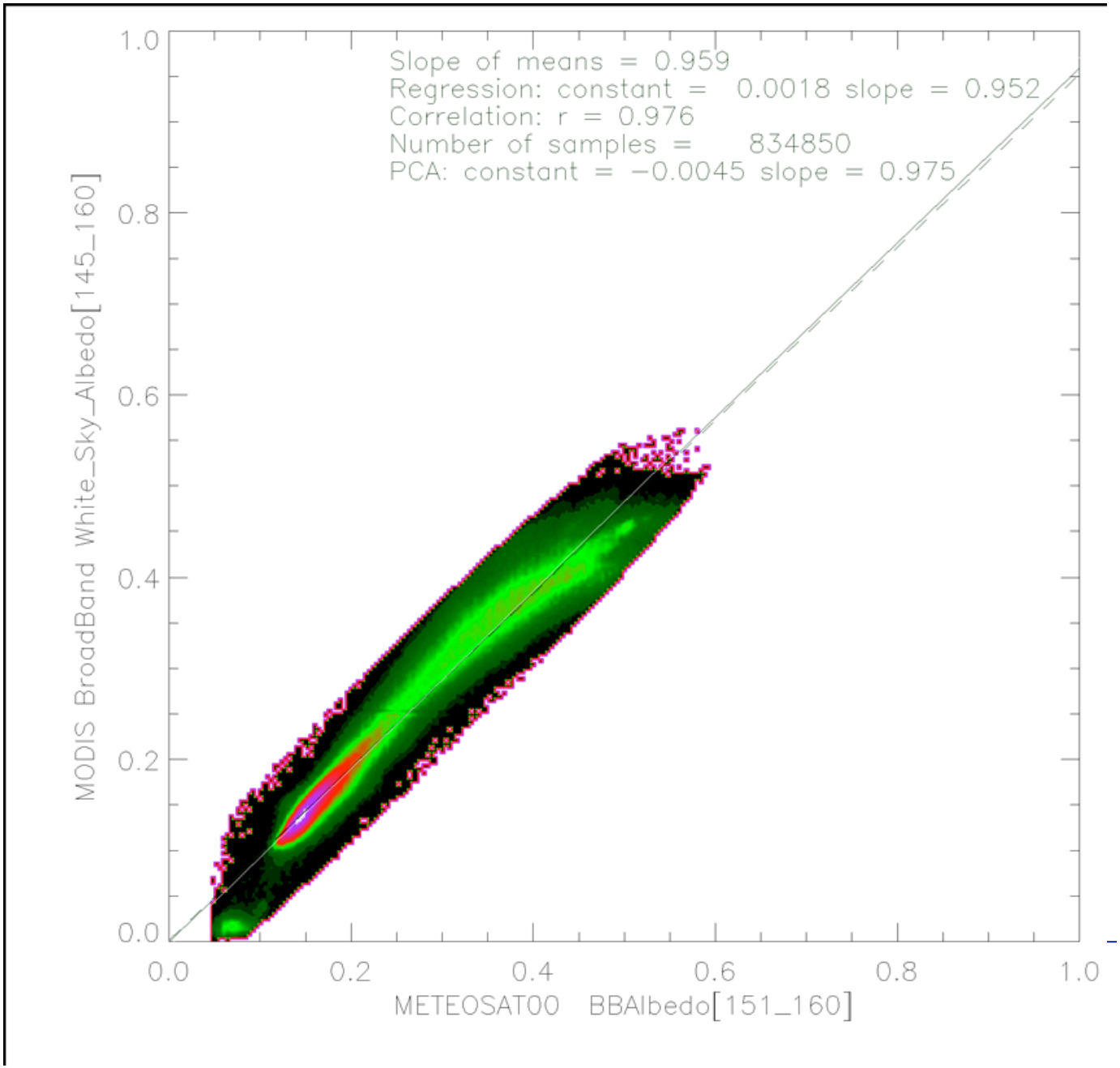

−0.04 −0.02 0.00 0.02 0.04
(METEOSAT − MODIS) Albedo

June 2001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Correlation: r = 0.976
Number of samples = 834850
PCA: constant = −0.0045 slope = 0.975
MODIS BroadBand White_Sky_Albedo[145_160]
METEOSAT00 BBAlbedo[151_160]
0.0
0.2
0.4
0.6
0.8
1.0

MISR versus Meteosat Broadband (0.3-3.0)
BHRiso

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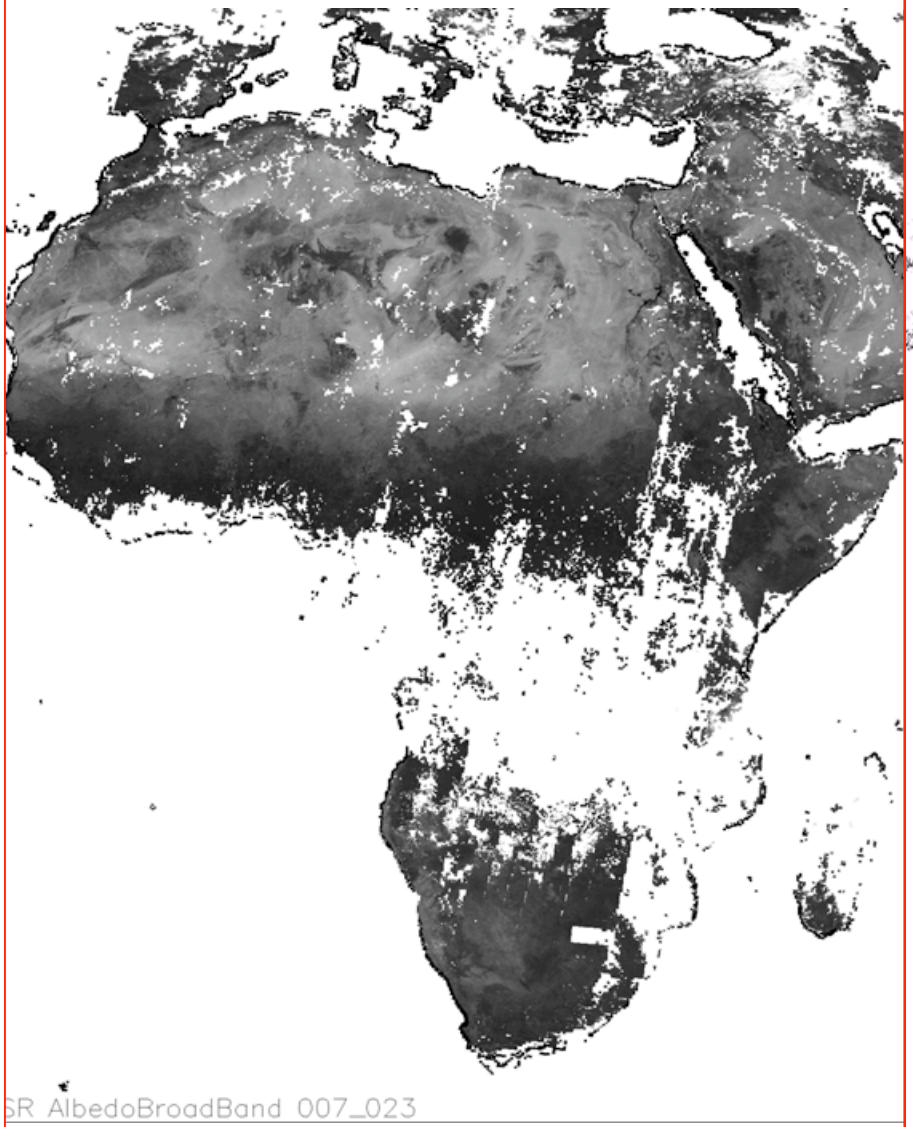
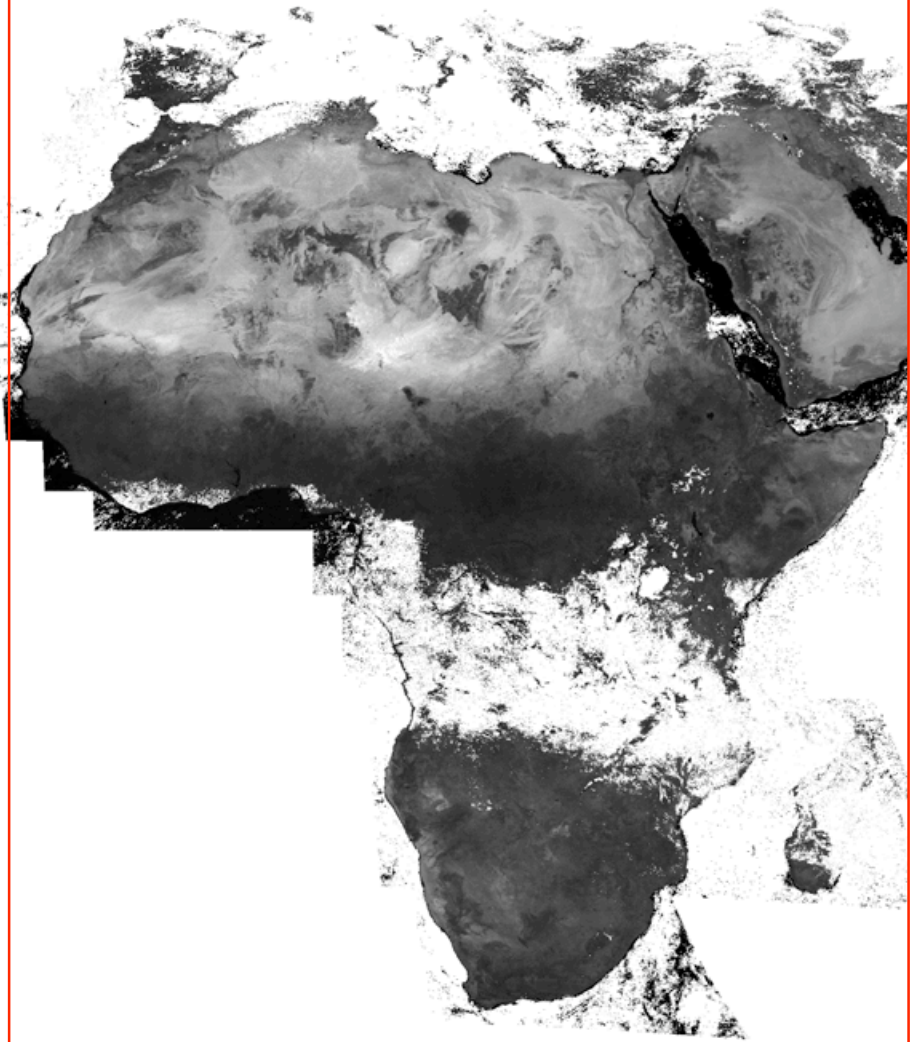
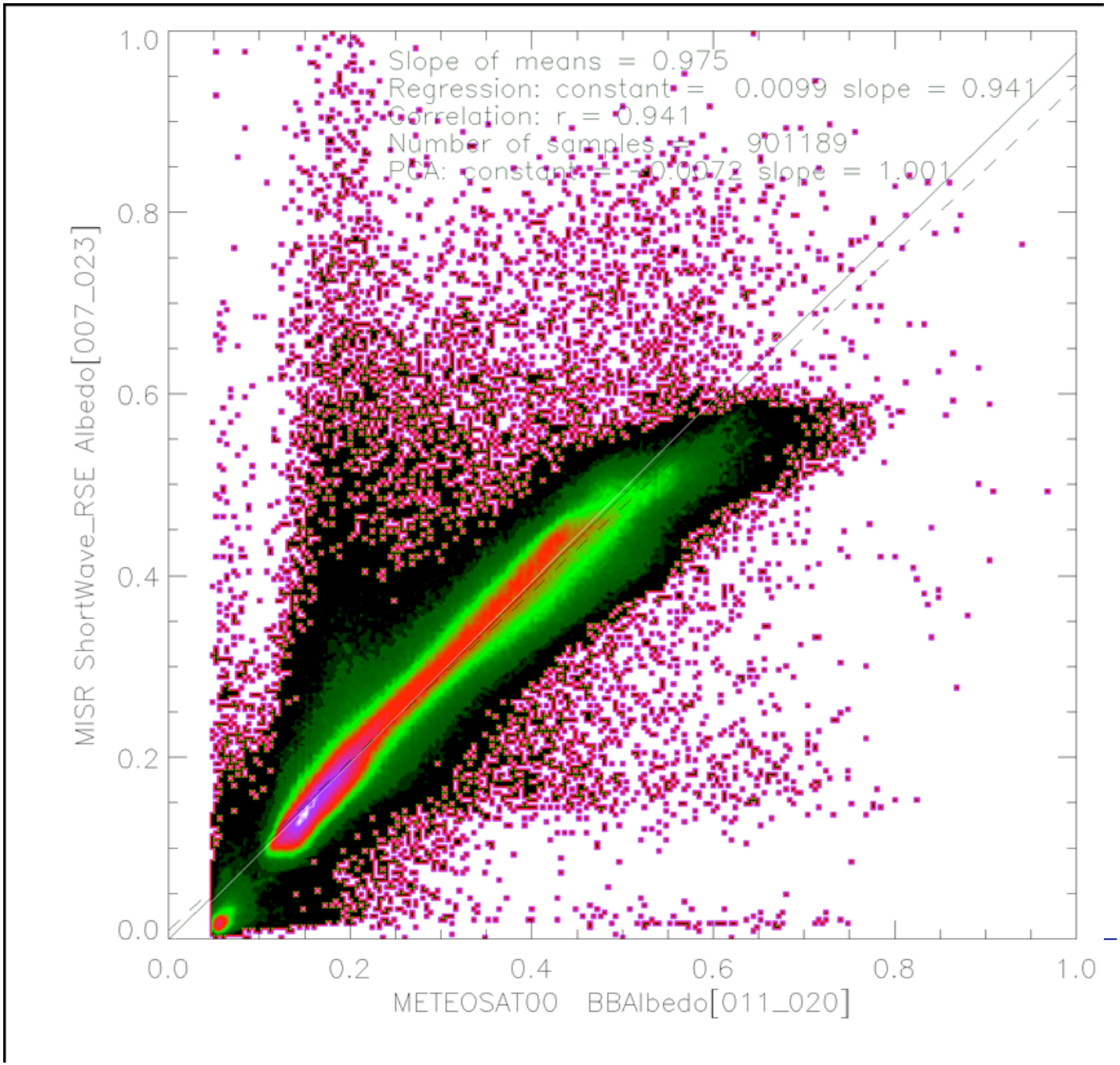
MISR product year 2001, 7-23



MSA product year 2001, 11-20

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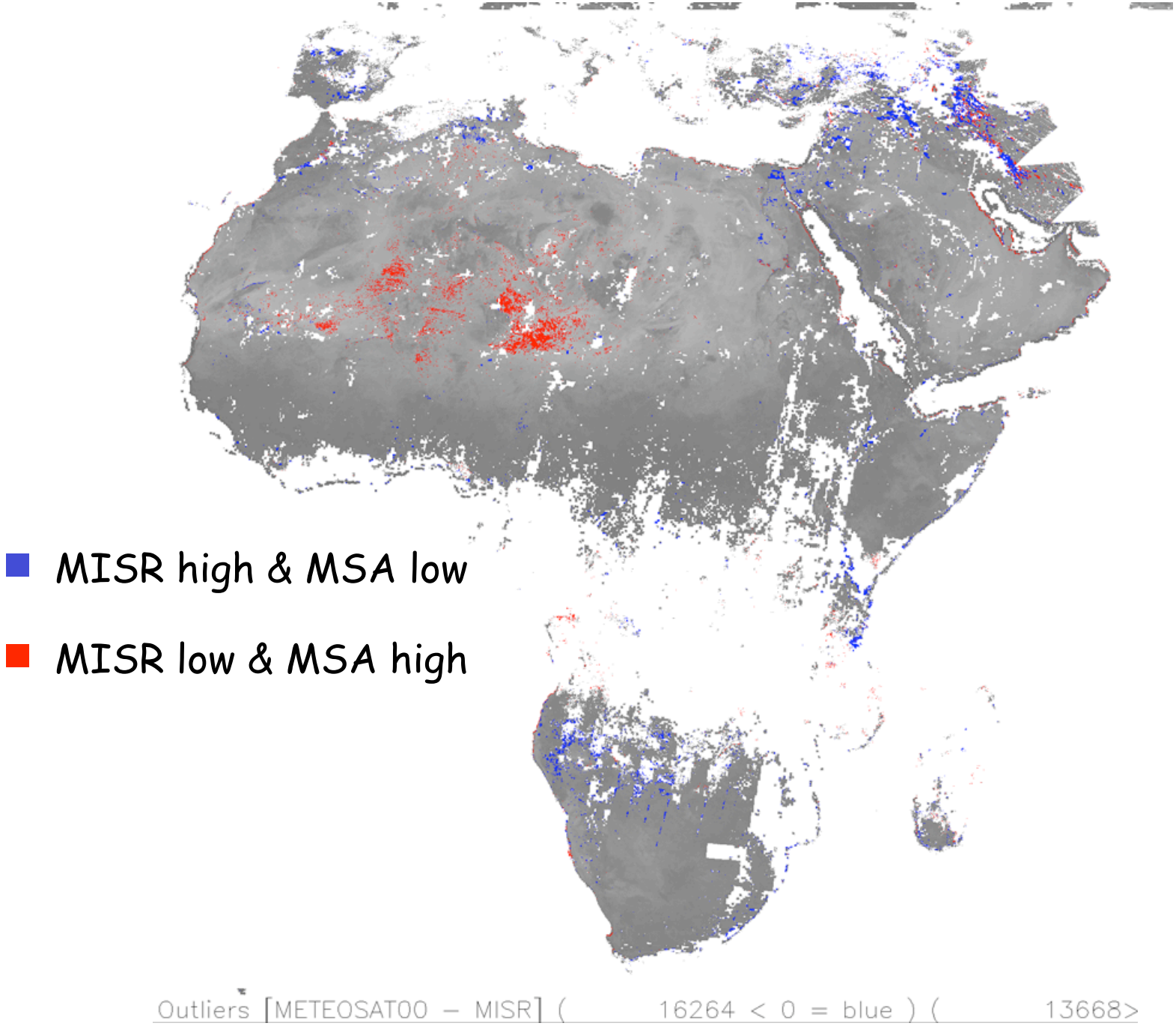
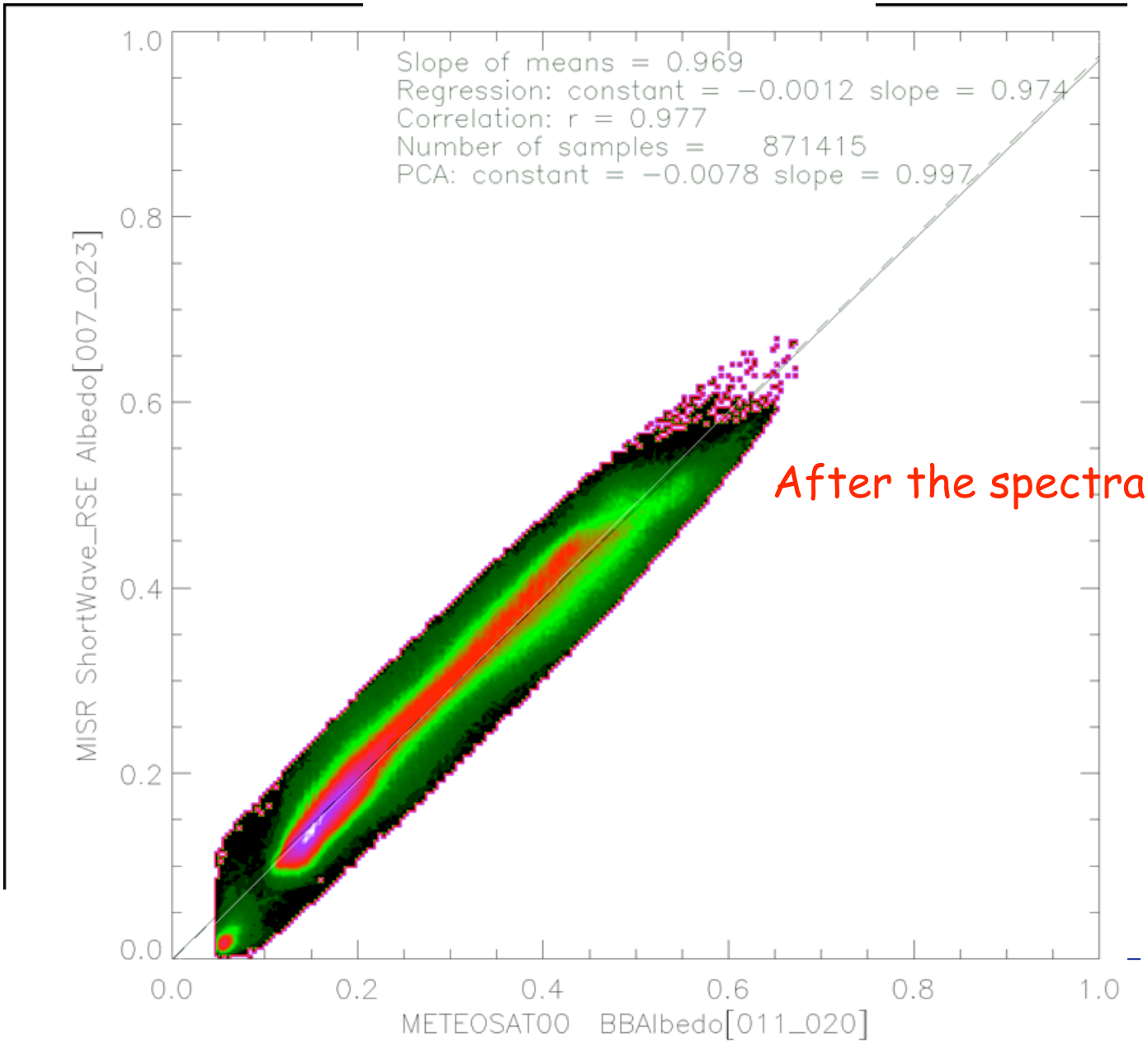
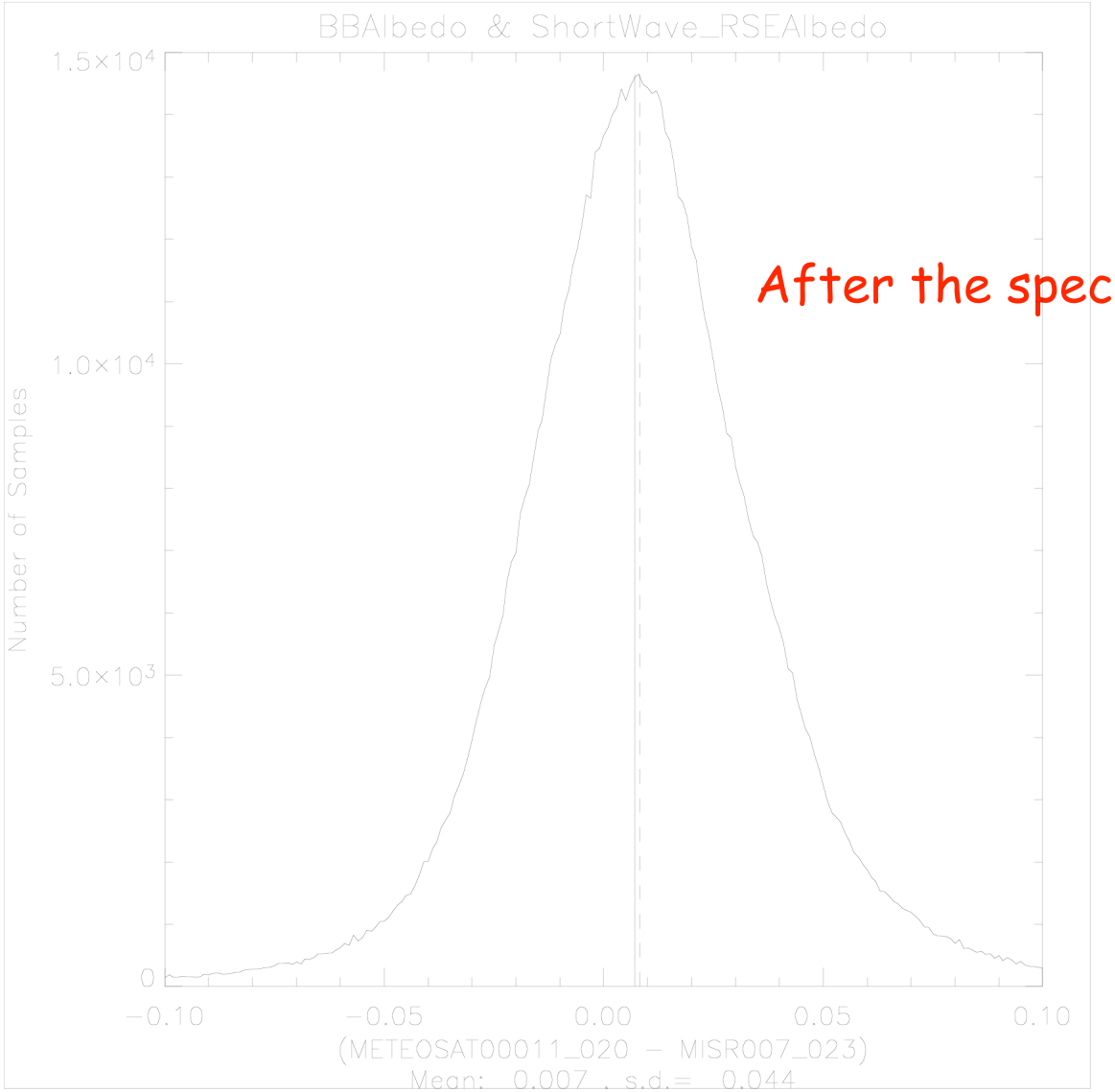
Correlation: r = 0.941
Number of samples = 901189
PCA: constant = -0.0072 slope = 1.001
MISR ShortWave_RSE Albedo[007_023]
METEOSAT00 BBAlbedo[011_020]
0.0
0.2
0.4
0.6
0.8
1.0


MISR high & MSA low
MISR low & MSA high
Outliers [METEOSAT00 – MISR] (16264 < 0 = blue) (13668>



After the spectral conversion

Histogram of BHR differences



After the spectral conversion

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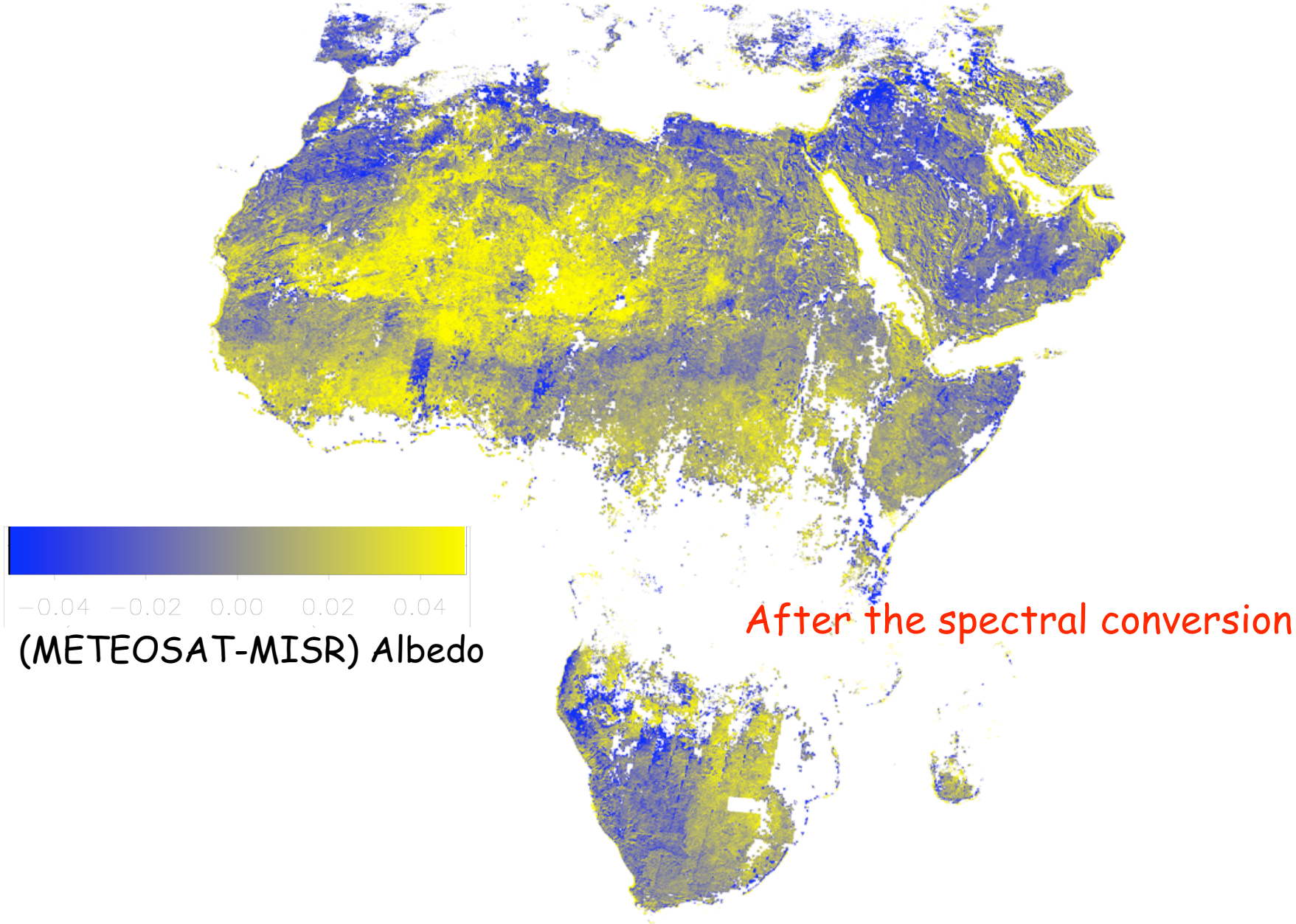
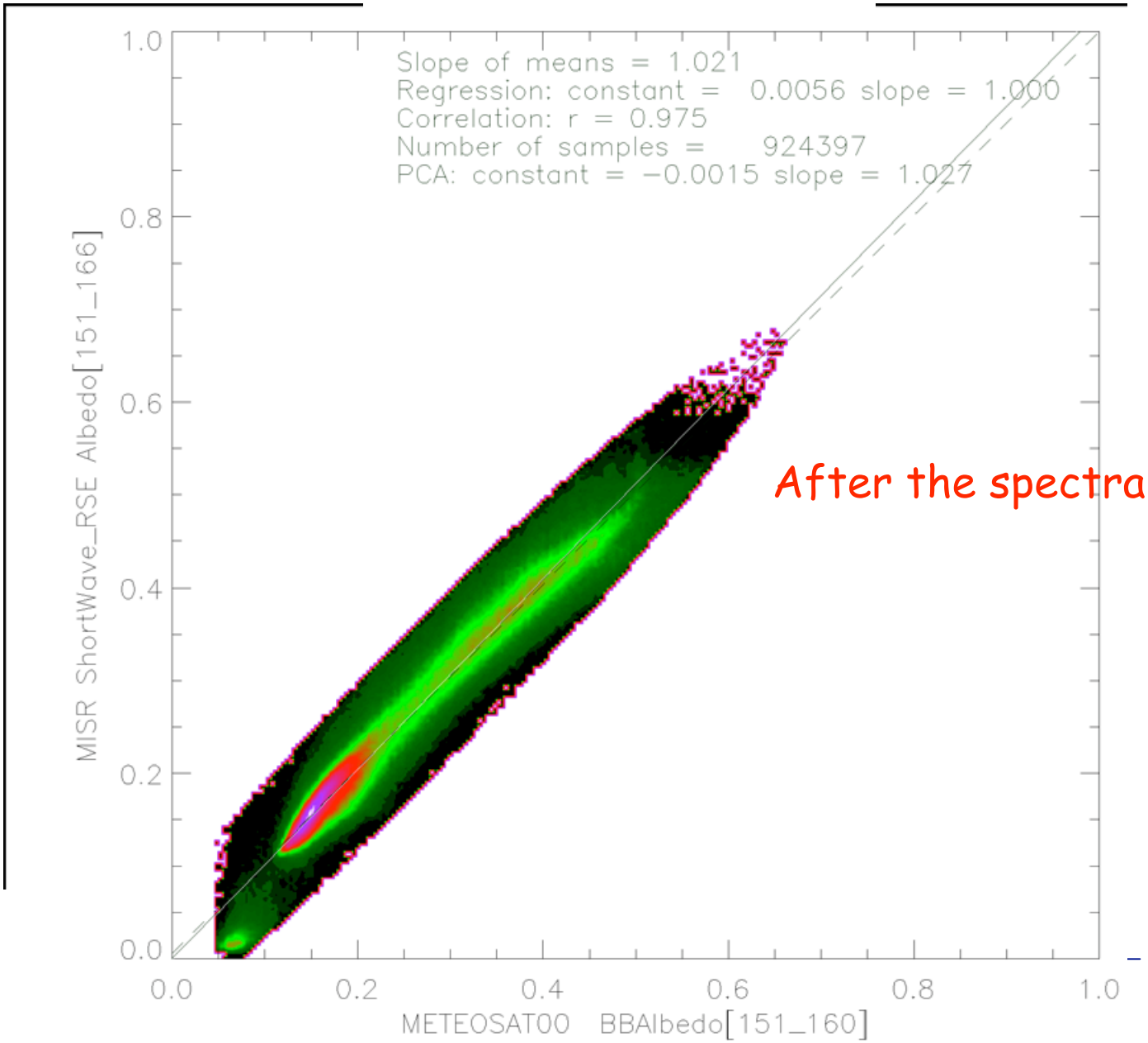

−0.04 −0.02 0.00 0.02 0.04
(METEOSAT-MISR) Albedo
After the spectral conversion
BBAlbedo & ShortWave_RSEAlbedo (METEOSAT00011_020 – MISR007_023)



After the spectral conversion

MISR versus MODIS Broadband (0.3-3.0) *BHRiso*

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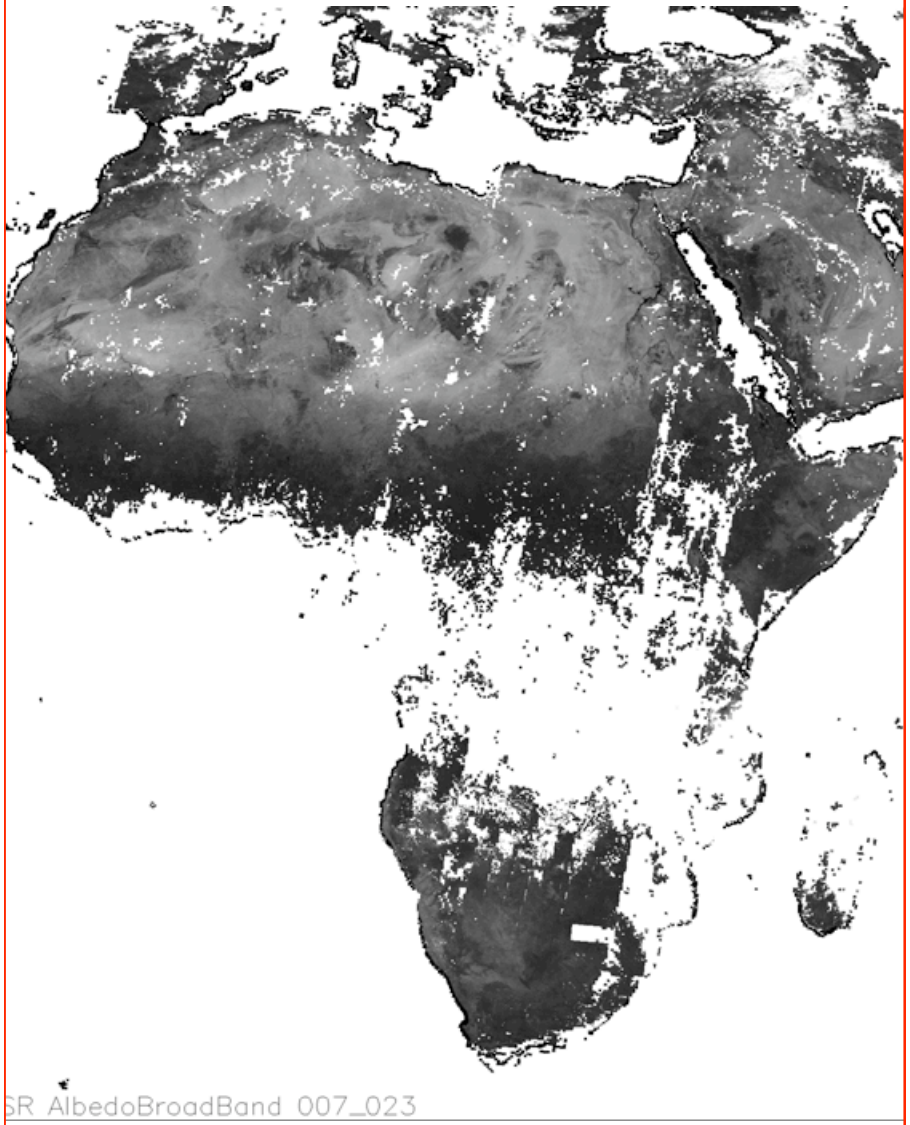
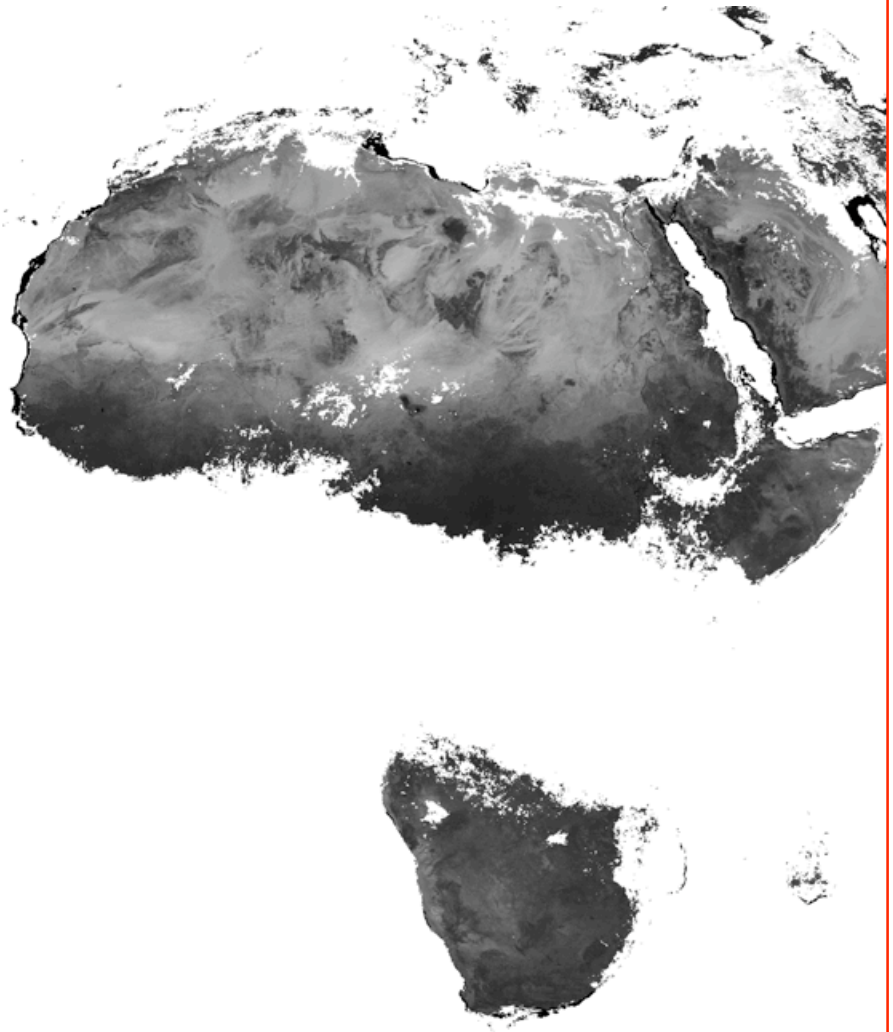
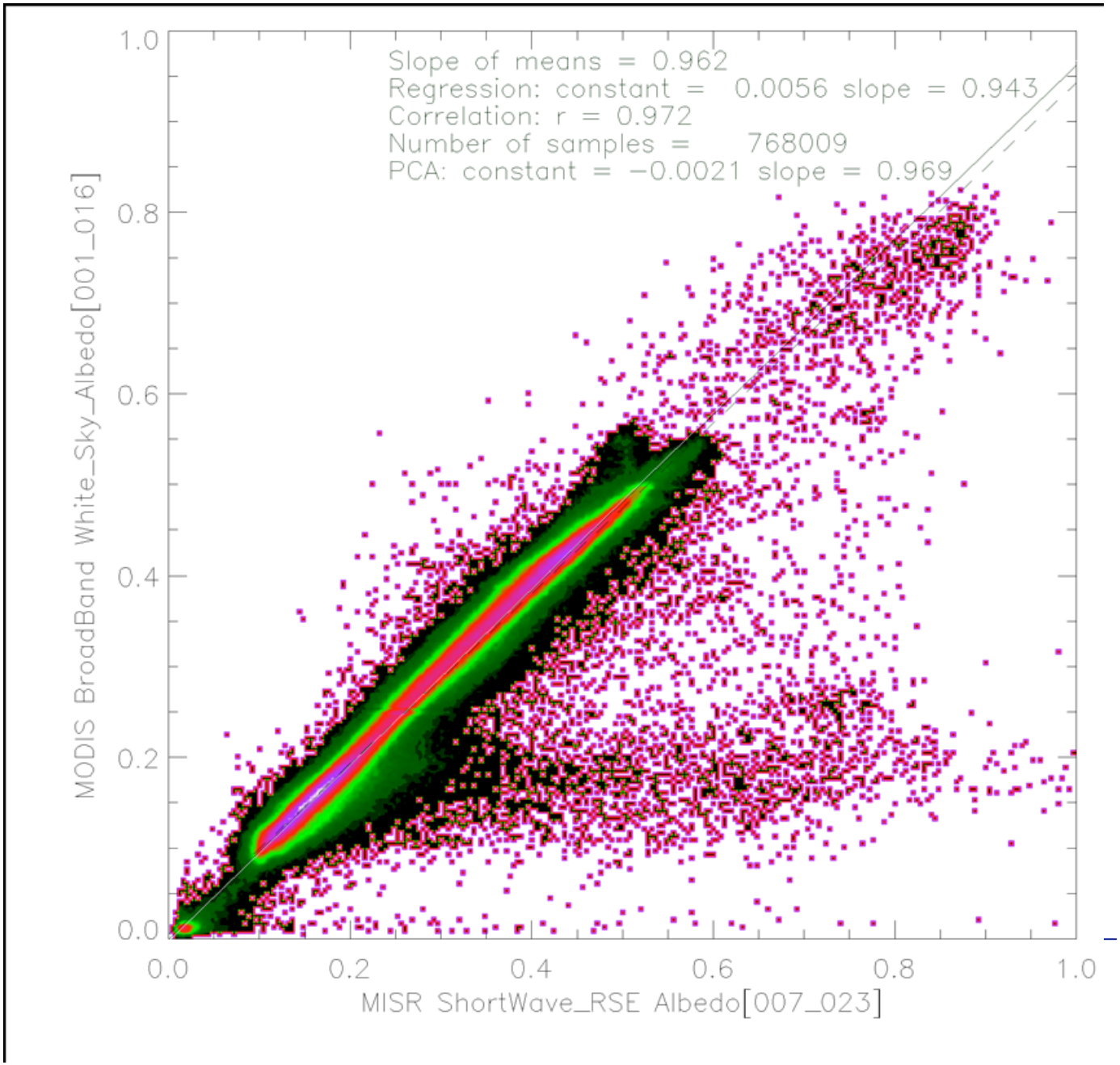
MISR product year 2001, 7-23



MODIS product year 2001, 1-16

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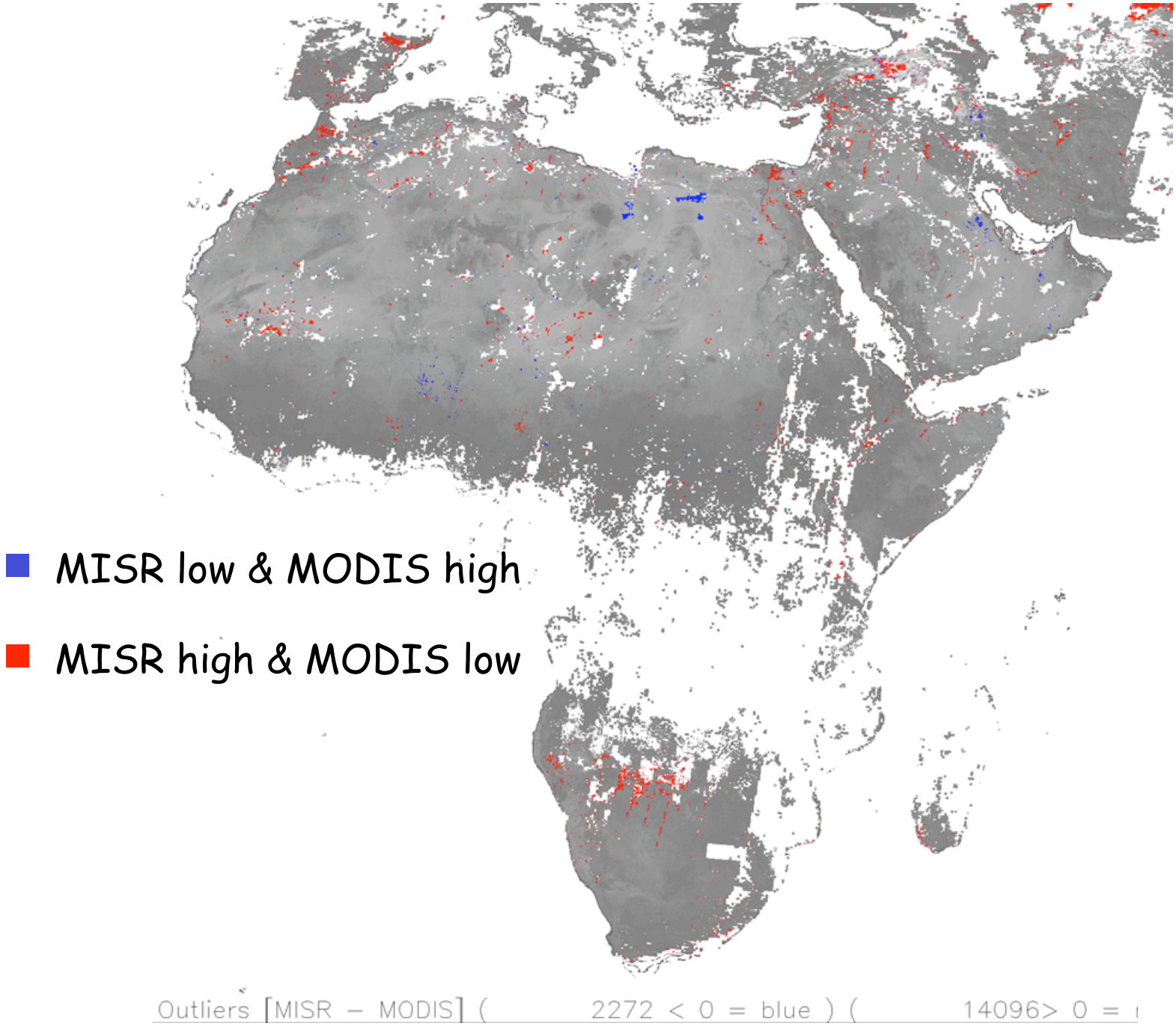
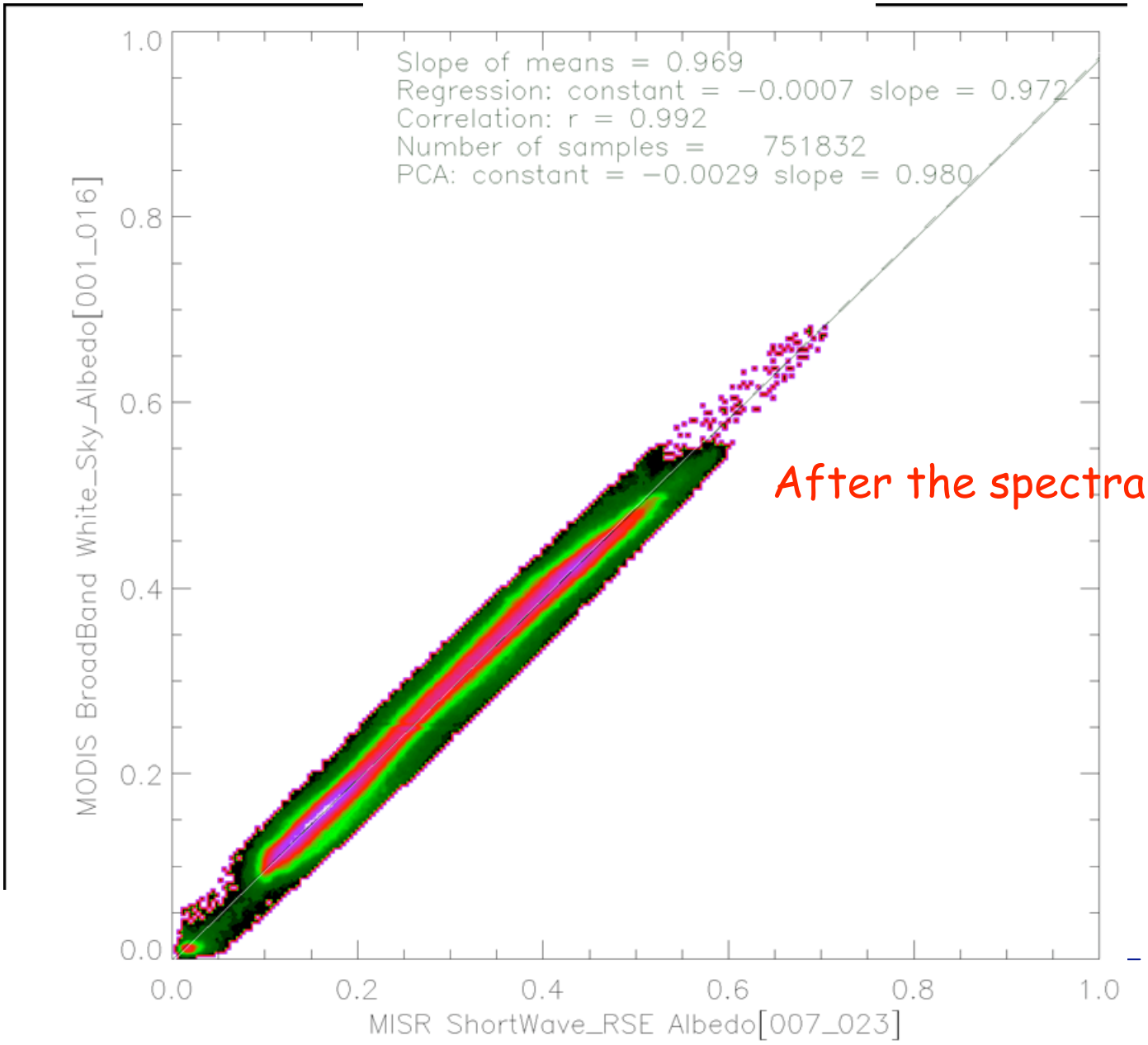
Correlation: r = 0.972
Number of samples = 768009
PCA: constant = −0.0021 slope = 0.969
MODIS BroadBand White_Sky_Albedo[001_016]
MISR ShortWave_RSE Albedo[007_023]
0.0
0.2
0.4
0.6
0.8
1.0

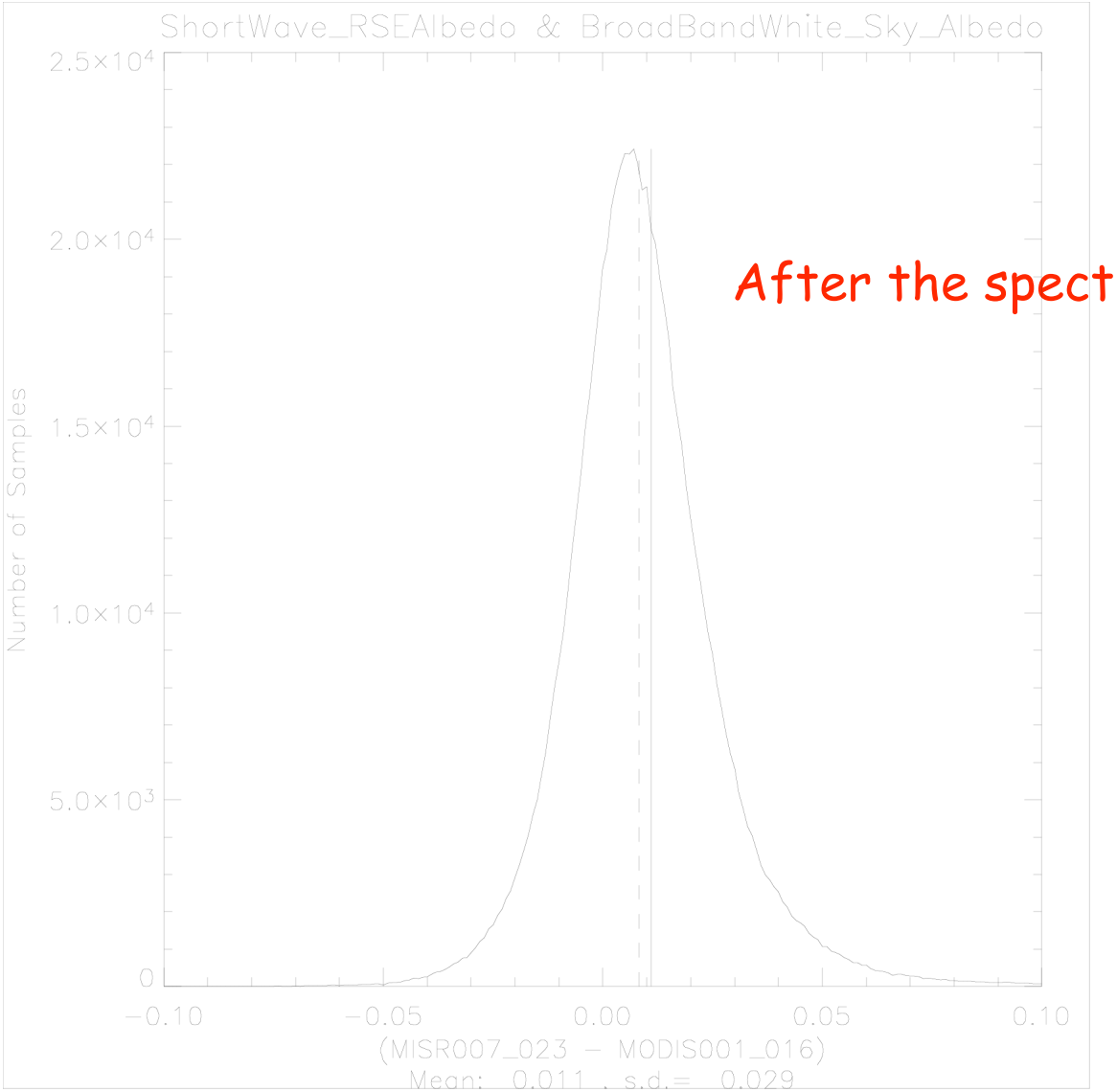

MISR low & MODIS high
MISR high & MODIS low
Outliers [MISR – MODIS] (2272 < 0 = blue) (14096> 0 =

January 2001



After the spectral conversion

Histogram of BHR differences



After the spectral conversion

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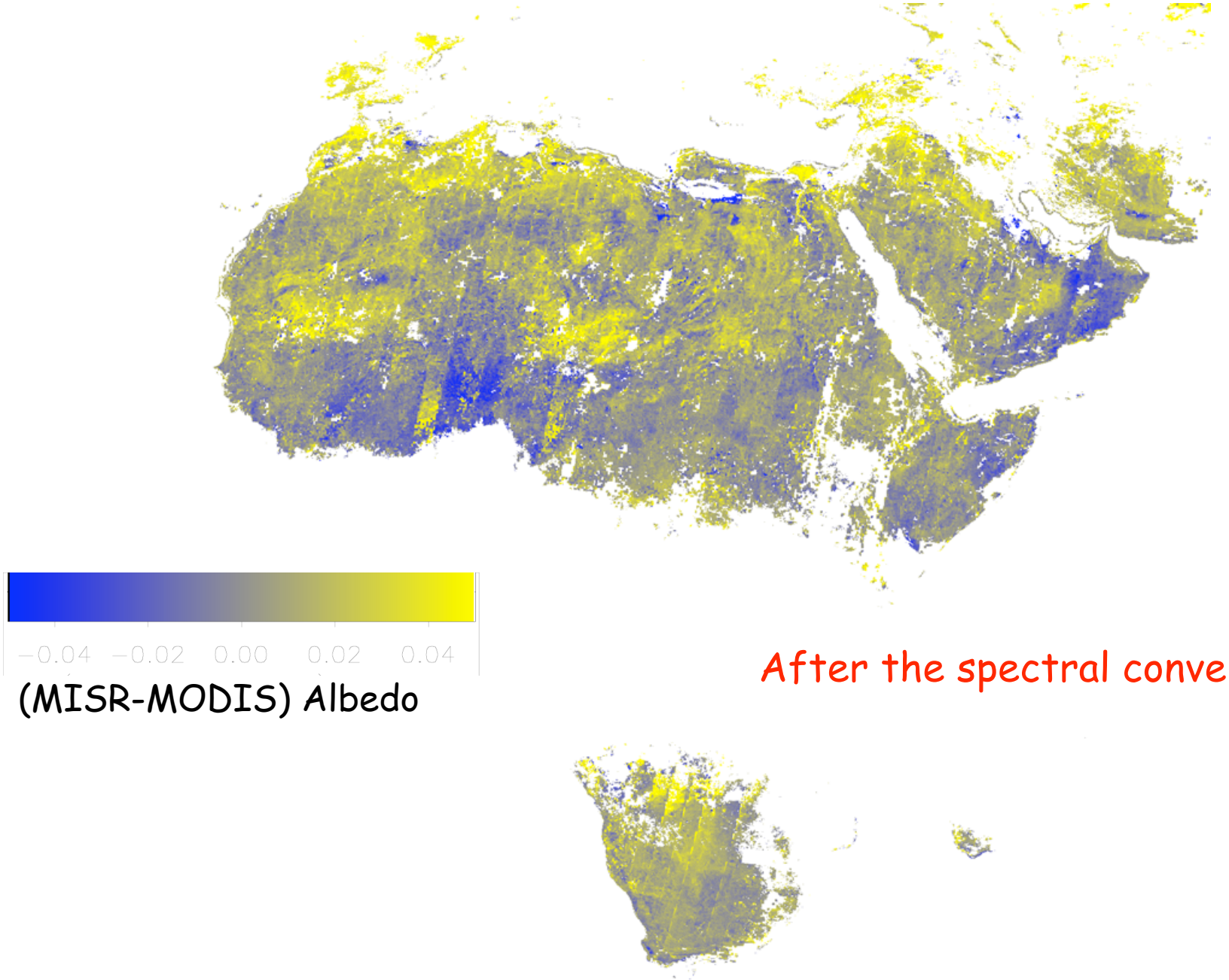
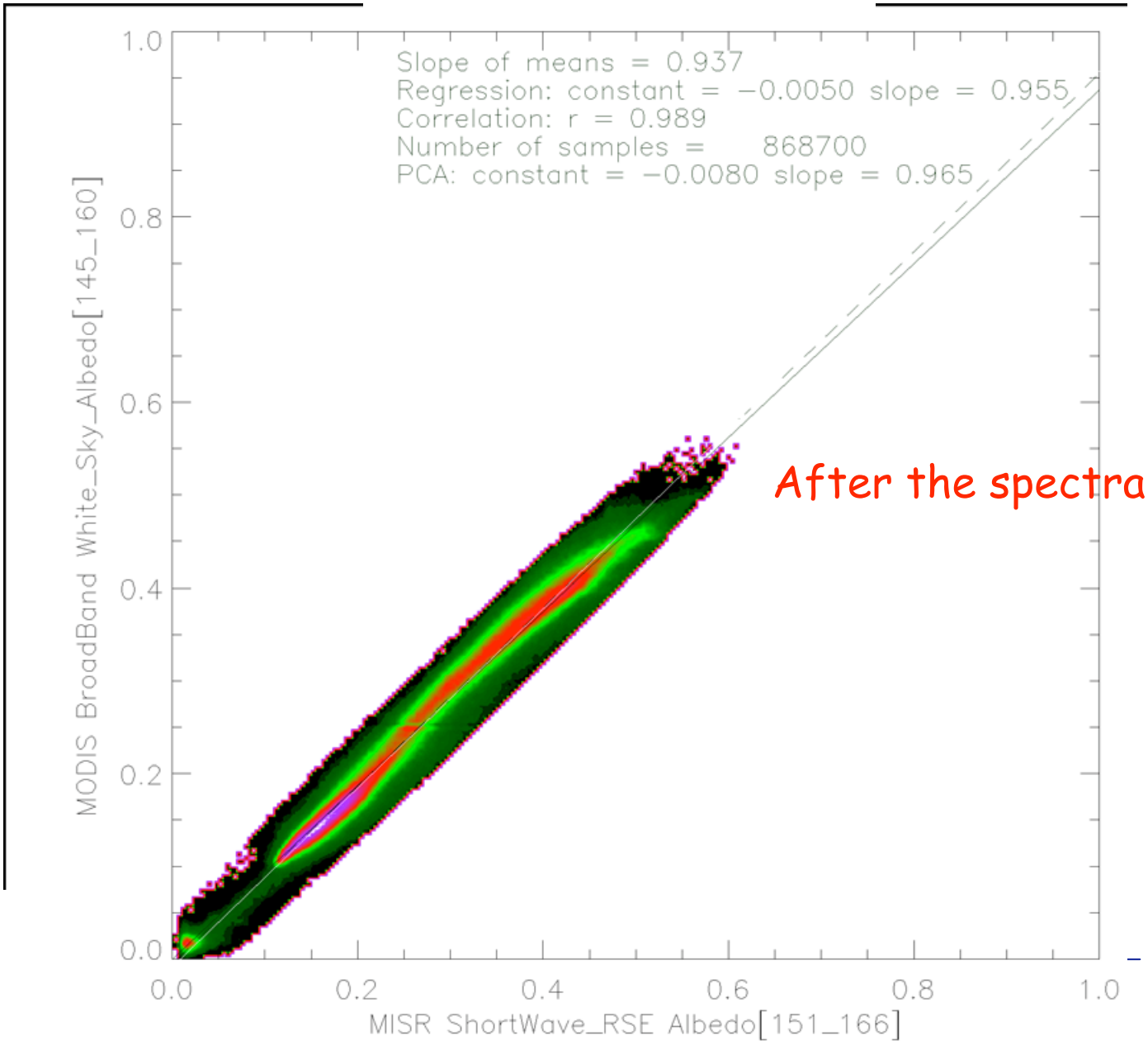

−0.04 −0.02 0.00 0.02 0.04
(MISR-MODIS) Albedo
After the spectral conversion
ShortWave_RSEAlbedo & BroadBandWhite_Sky_Albedo (MISR007_023 – MODIS00

June 2001

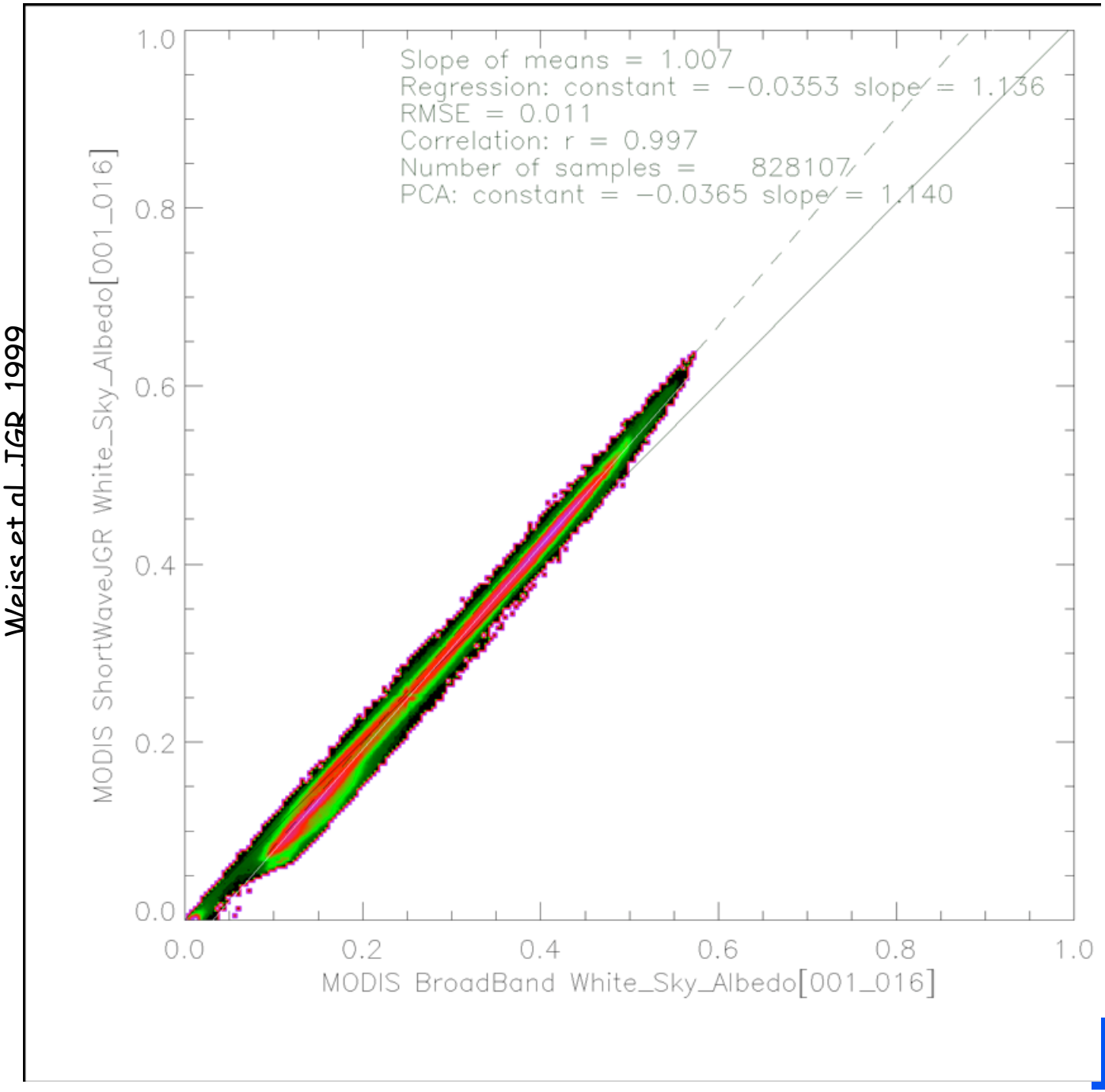


After the spectral conversion

BUT!!!

Significant 'errors/uncertainties' can be introduced when performing the spectral conversions !

Weiss et al. JGR 1999



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