

# Ubercal update

Lyon, 02/03/26

[https://me.lsst.eu/bracine/ZTF/  
20260227\\_repopulated\\_catalogs\\_control\\_plots/  
test\\_output\\_test\\_multiplots.html](https://me.lsst.eu/bracine/ZTF/20260227_repopulated_catalogs_control_plots/test_output_test_multiplots.html)

# What's new

- New merging of yearly repopulated catalogs:
  - Star  $\chi^2$  used to be max of yearly  $\chi^2$
  - Now we **recompute the star  $\chi^2$  properly**, including between year  $\chi^2$
- Cuts now based on p-values, not  $\chi^2$ 
  - **p-values makes more sense**, takes into account number of dof
  - made it clear that our **noise model is not good enough**
- Comparison with Gaia
  - **Looks good-ish**, **large scale residuals** appear, some are obviously gaia, but some are probably PS1 related. We also see some ZTF looking residuals
  - Also: remember that we provide **ubercal out of atmosphere**
- More digging on the money plot of map of repeatability
  - **Looks good to great (for bright stars)**, **strong dependence on coating**

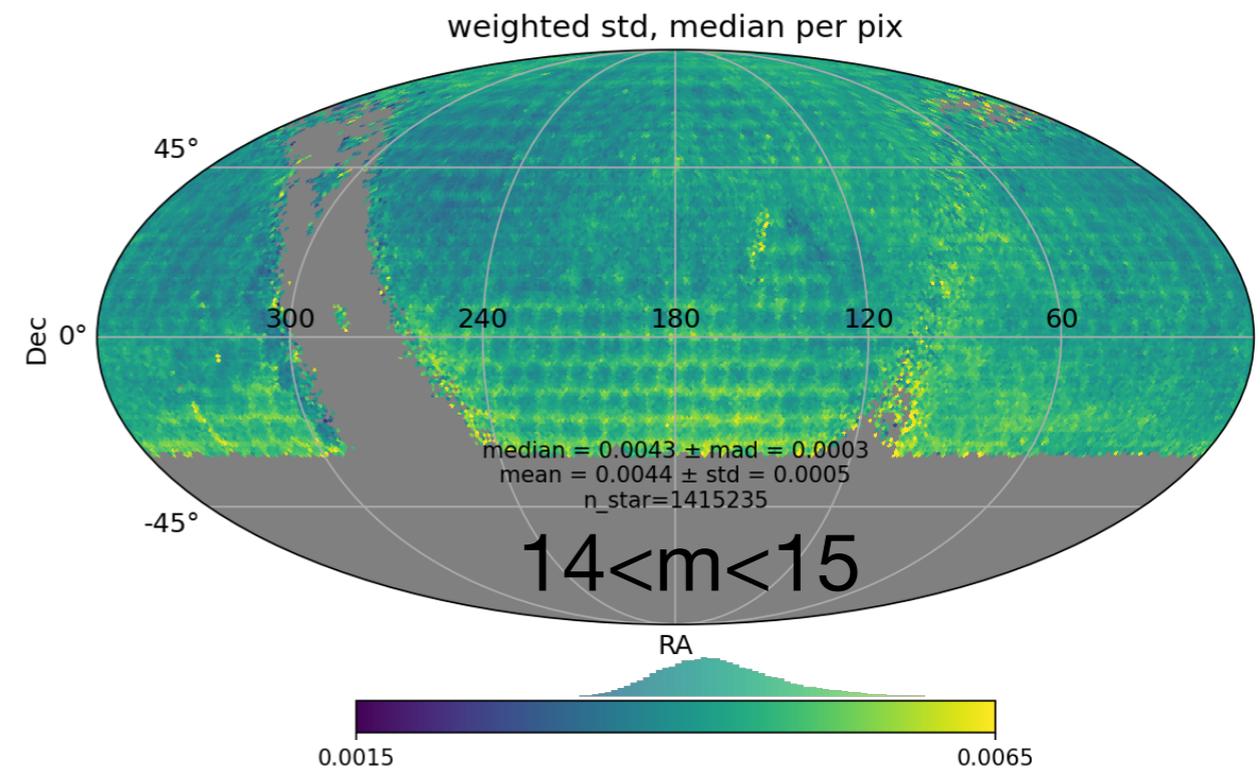
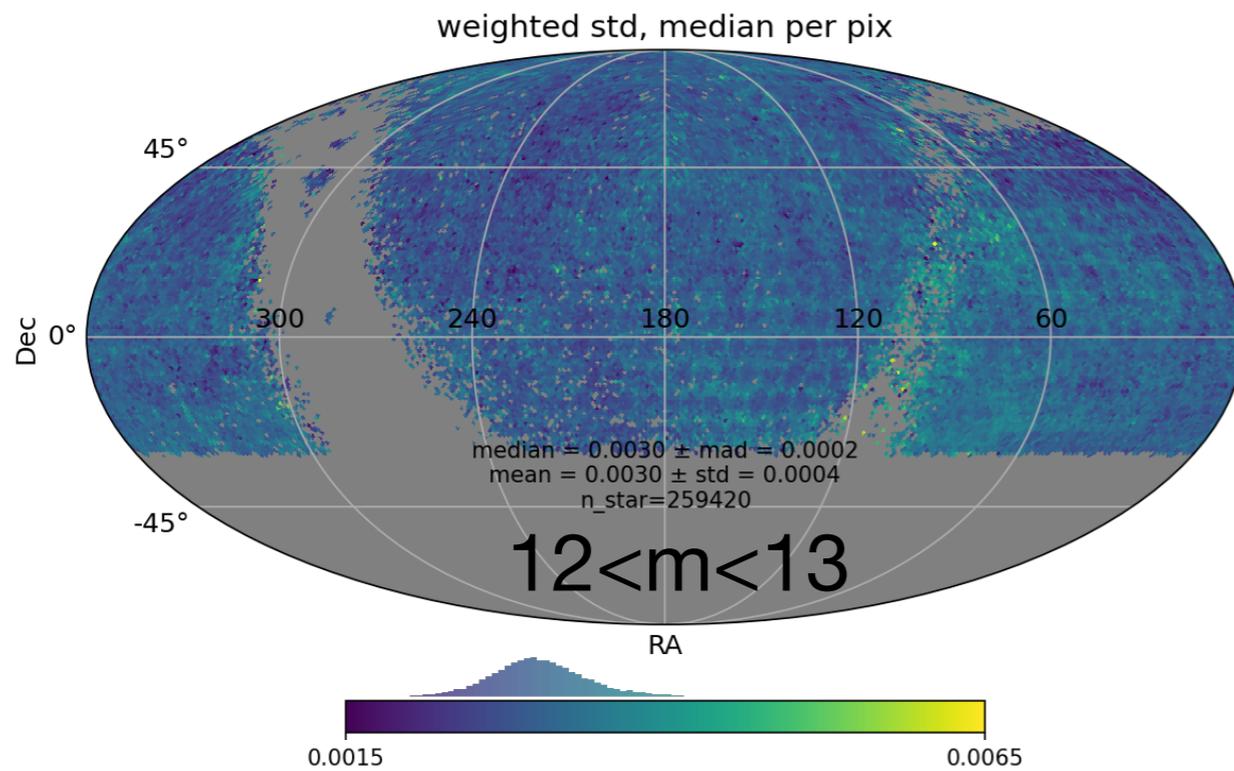
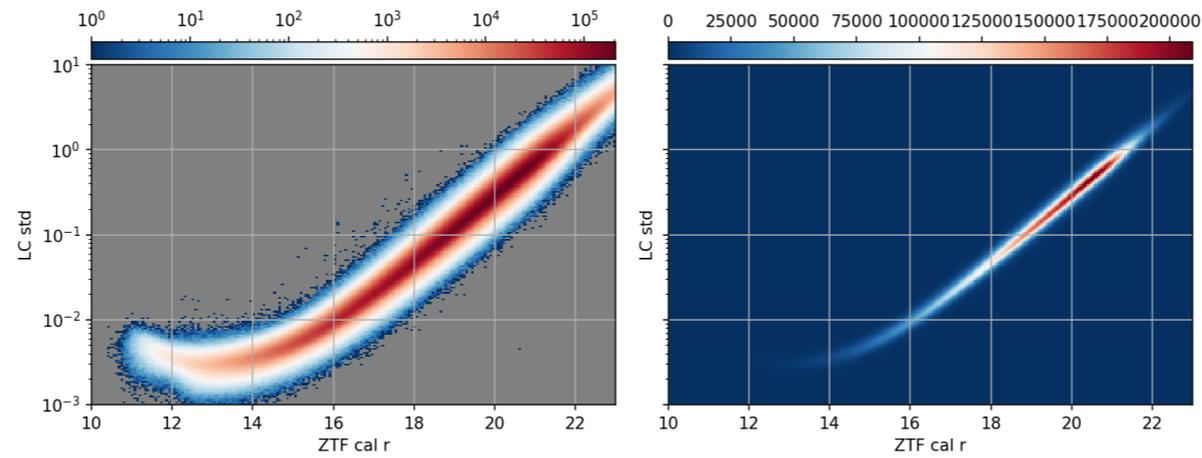
# Repeatability money plot?

ZTF-g

2019-2023

at least 10 obs per LC

p-value <  $10^{-3}$



All coatings

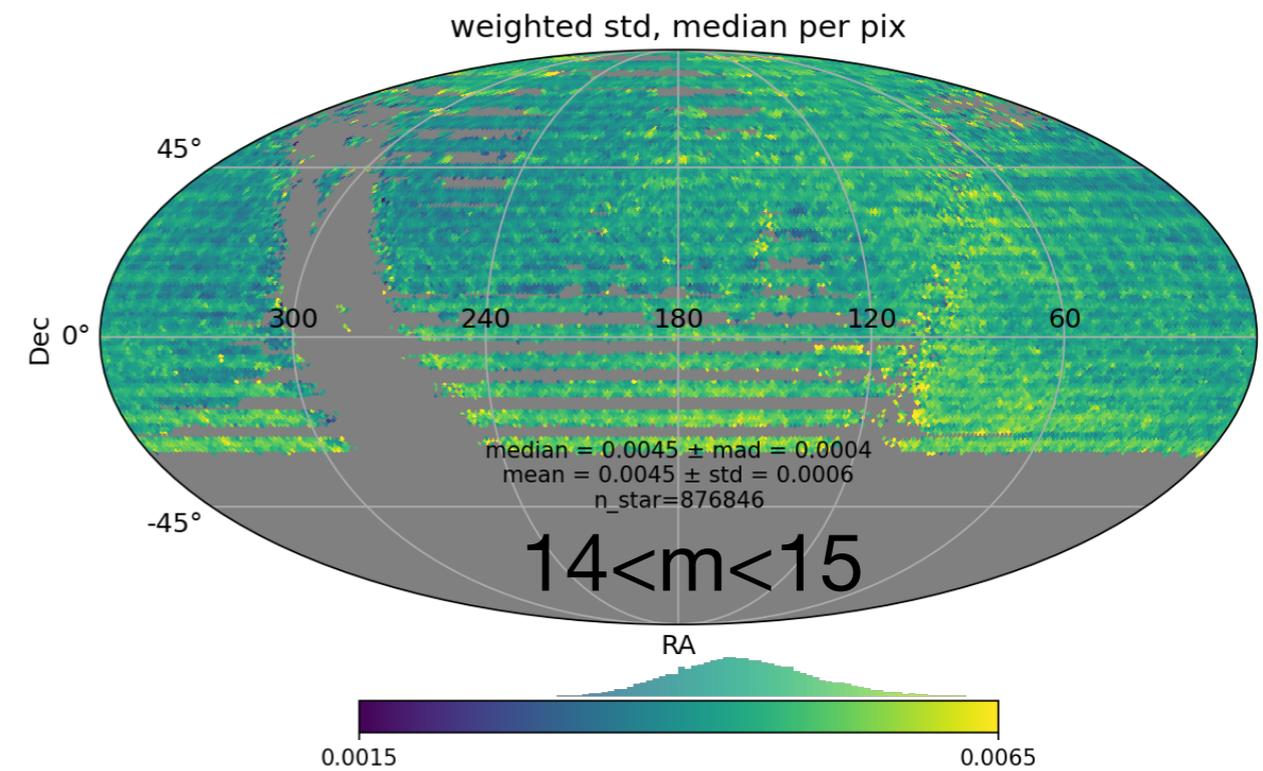
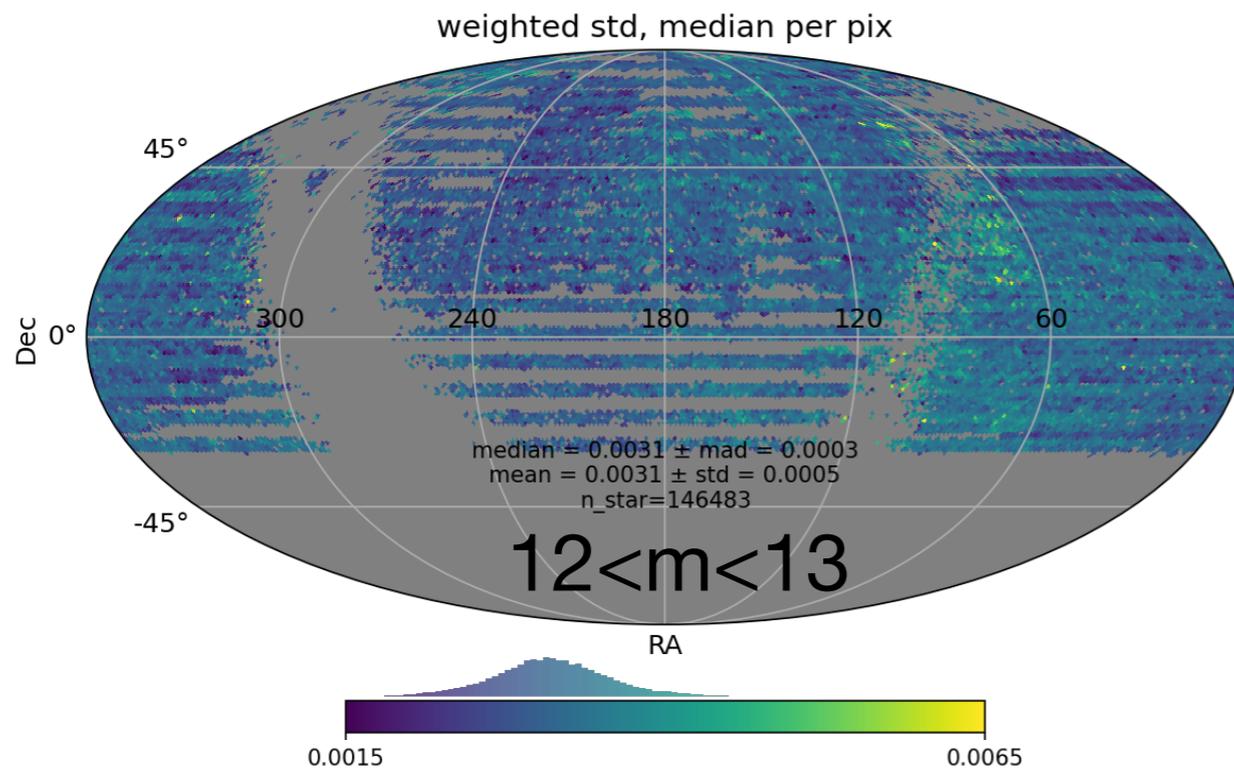
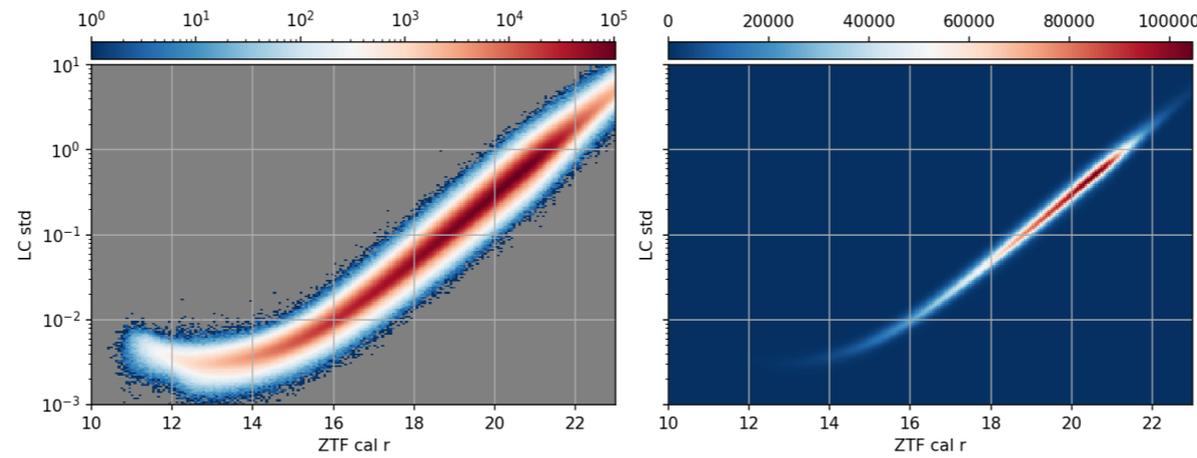
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Single coatings

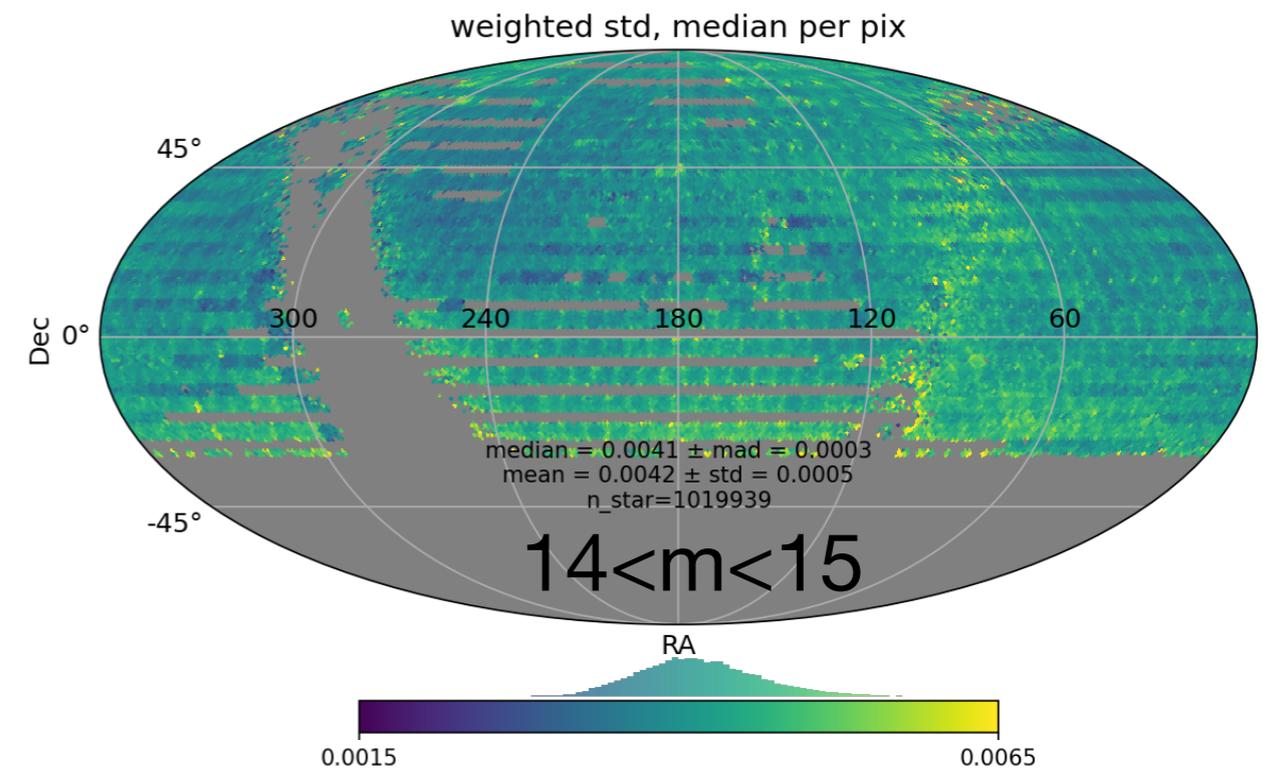
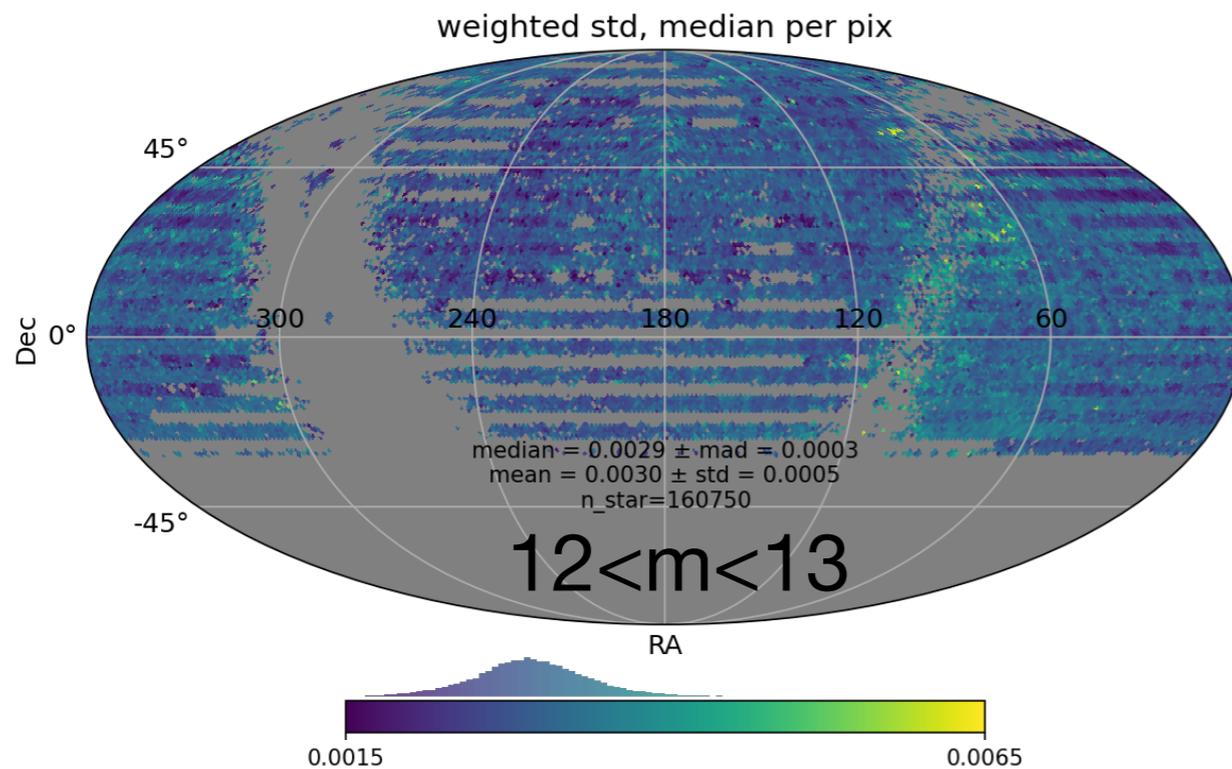
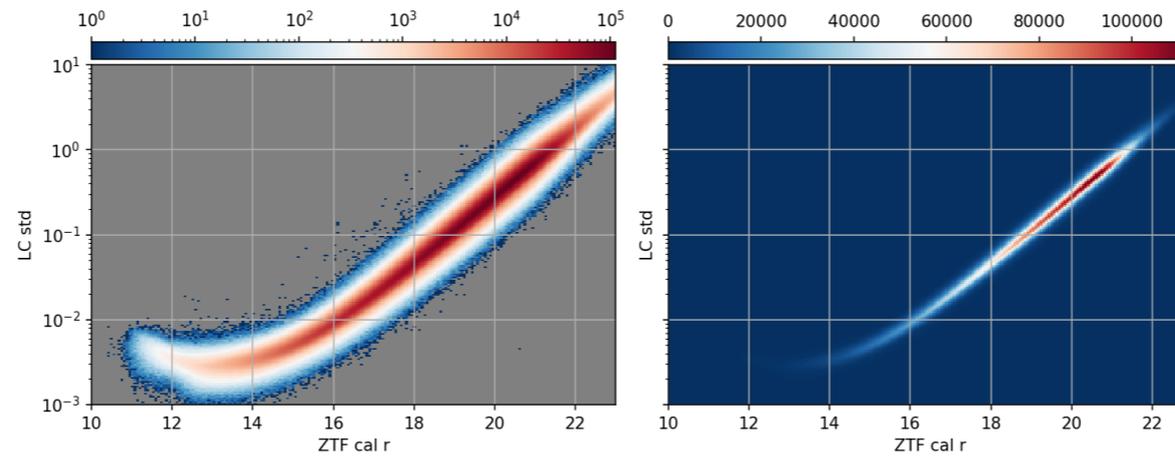
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Double coatings

# Repeatability money plot?

ZTF-g

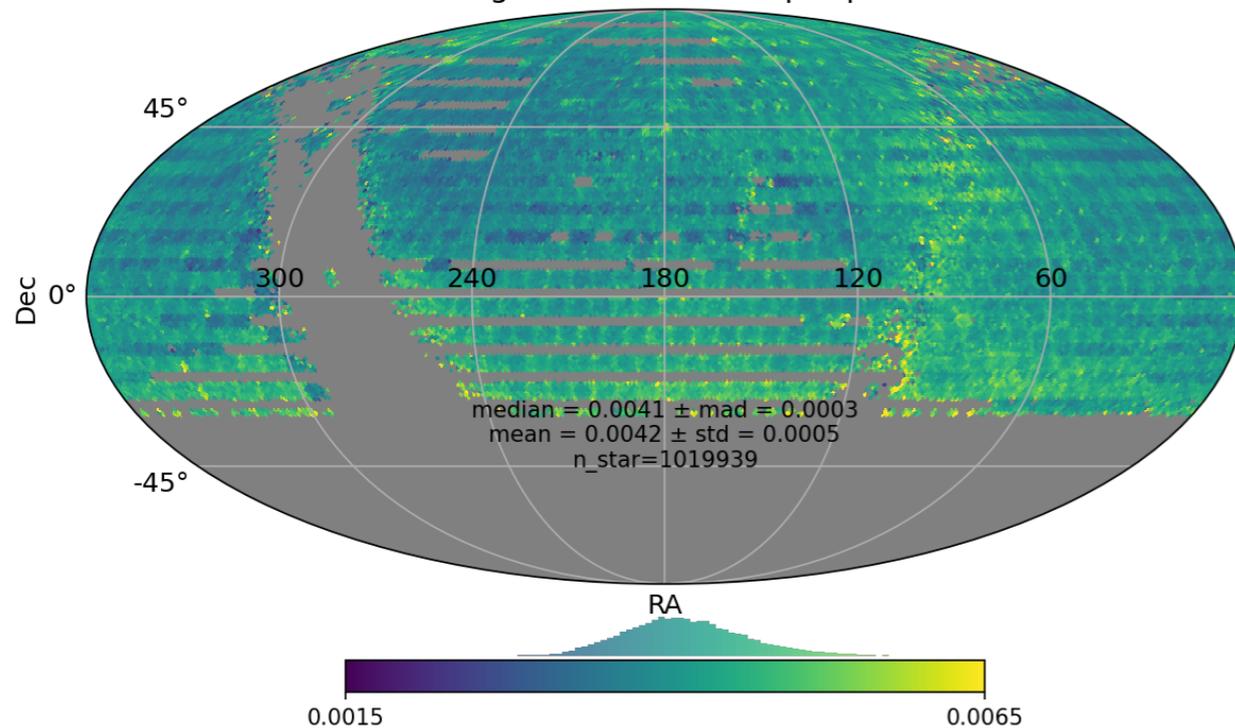
2019-2023

at least 10 obs per LC

p-value  $< 10^{-3}$

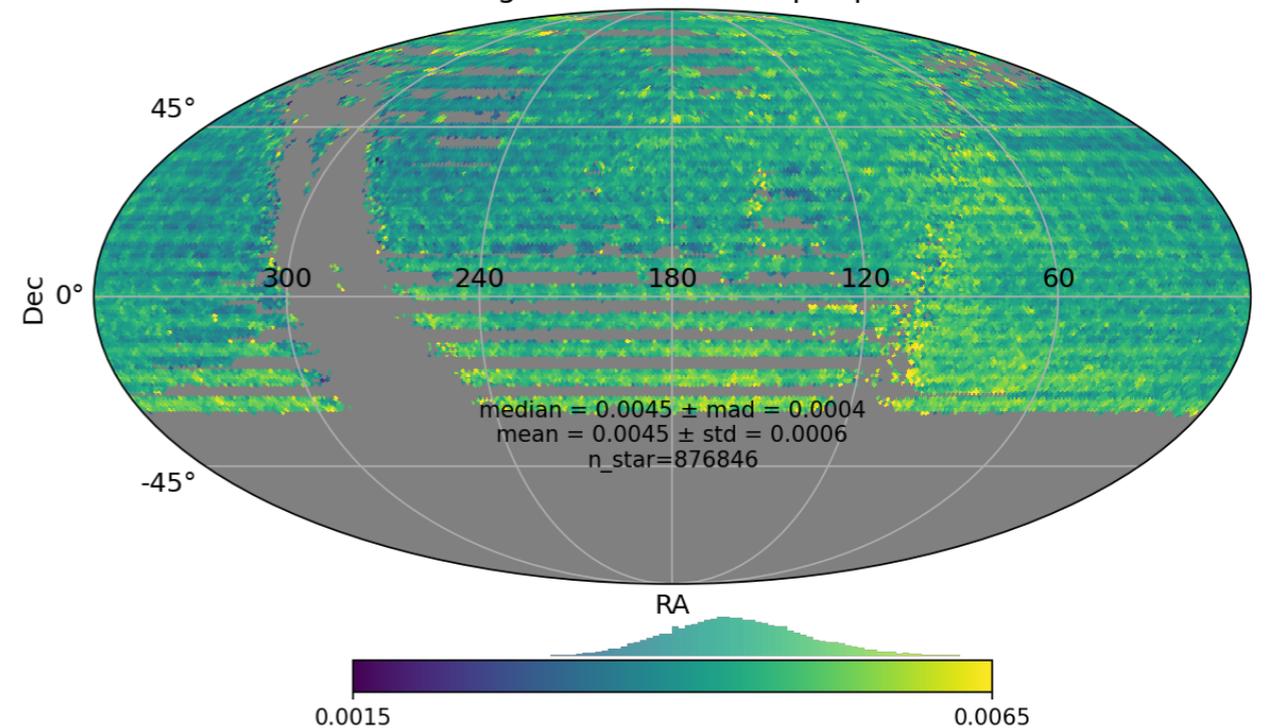
## Double coatings

weighted std, median per pix



## Single coatings

weighted std, median per pix



Light curve repeatability depends on coating level:  
better in double coating

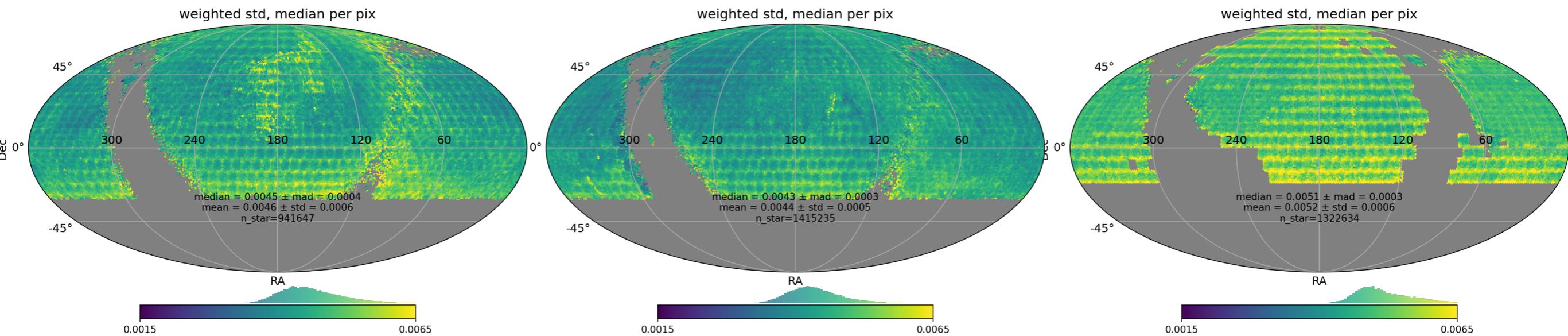
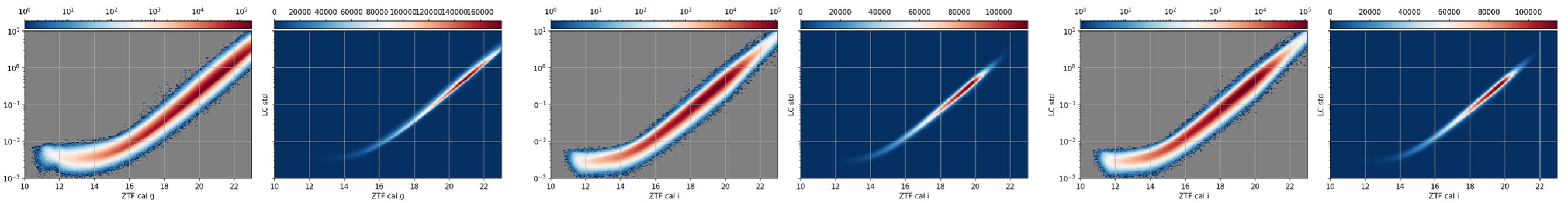
Makes sense probably?, but less easy to represent.  
Maybe show full map and a table with numbers per coating?

**2019-2023**  
**at least 10 obs per LC**  
**p-value <  $10^{-3}$**

**ZTF-g**

**ZTF-r**

**ZTF-i**



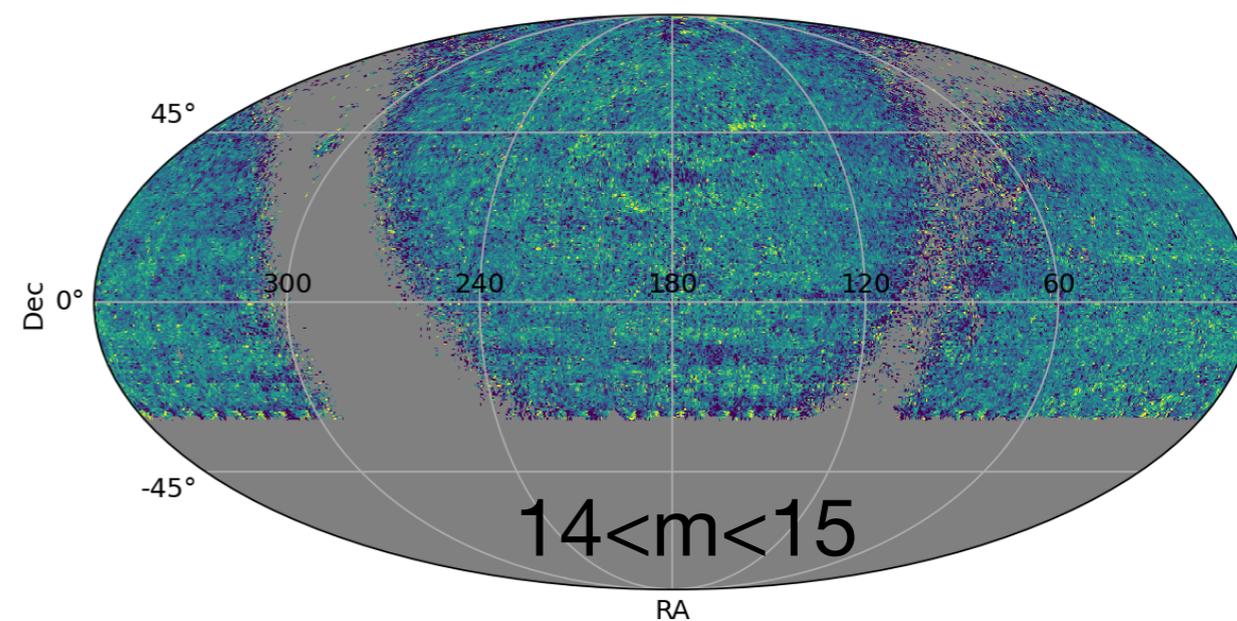
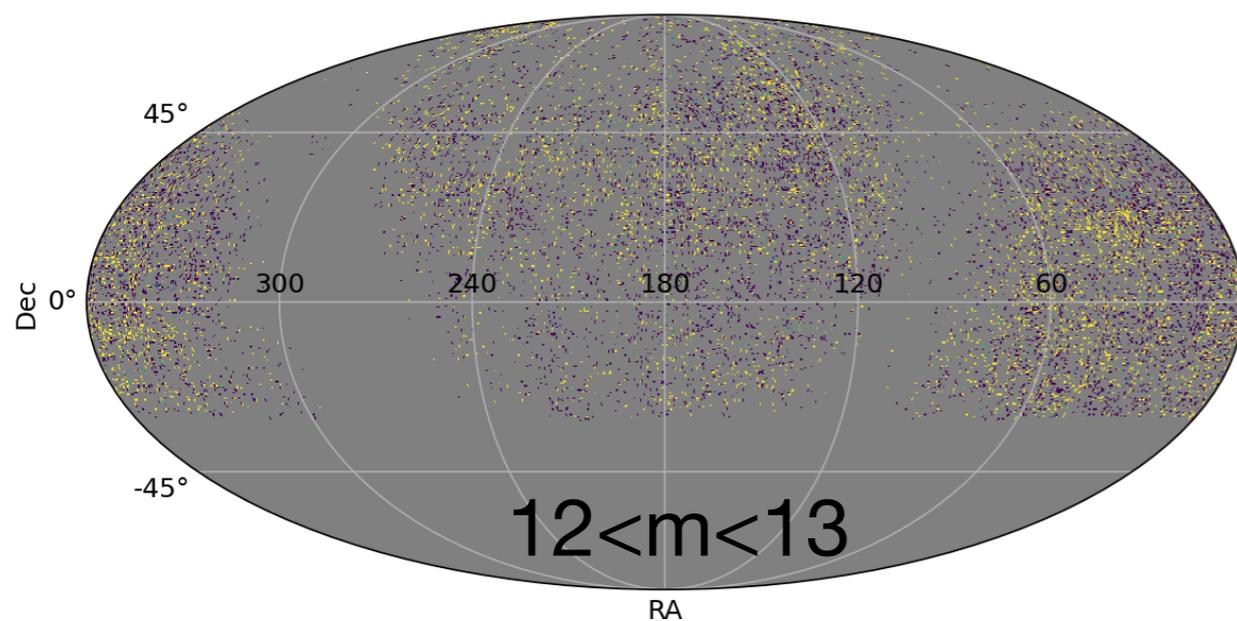
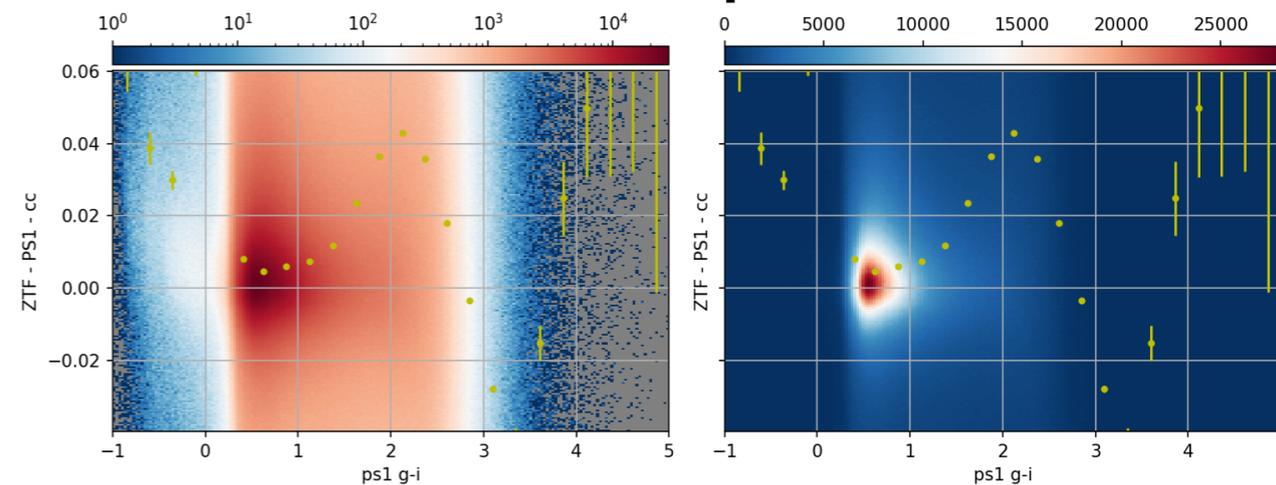
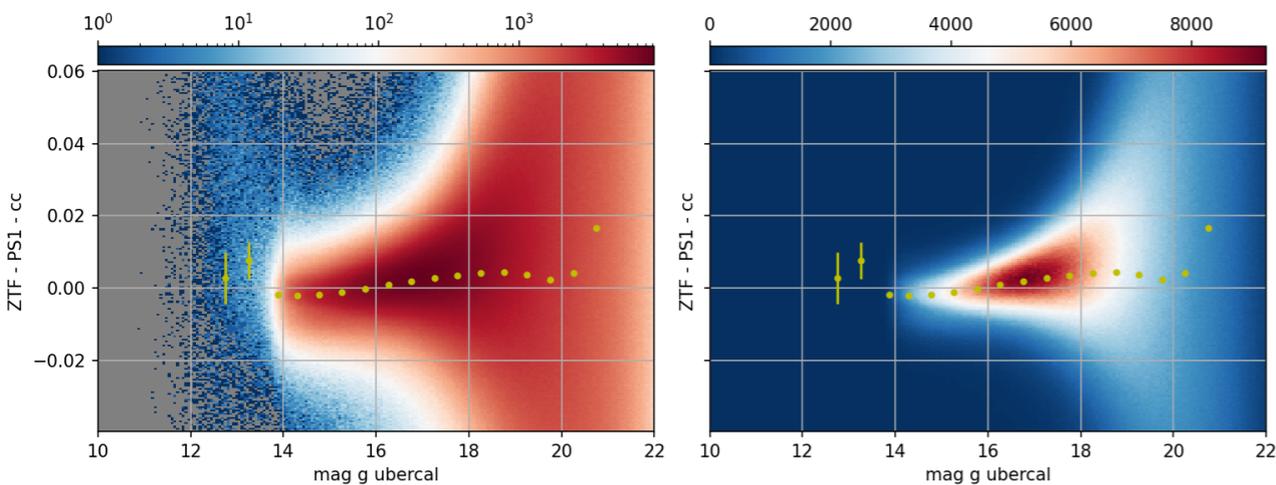
# ZTF-PS1 money plot?

ZTF-g

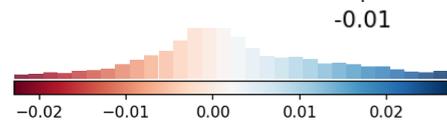
2019-2023

at least 10 obs per LC

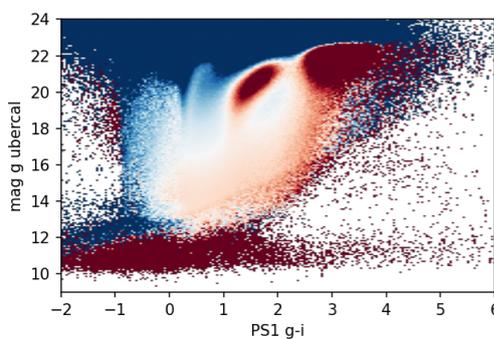
p-value <  $10^{-3}$



median of diff



All coatings



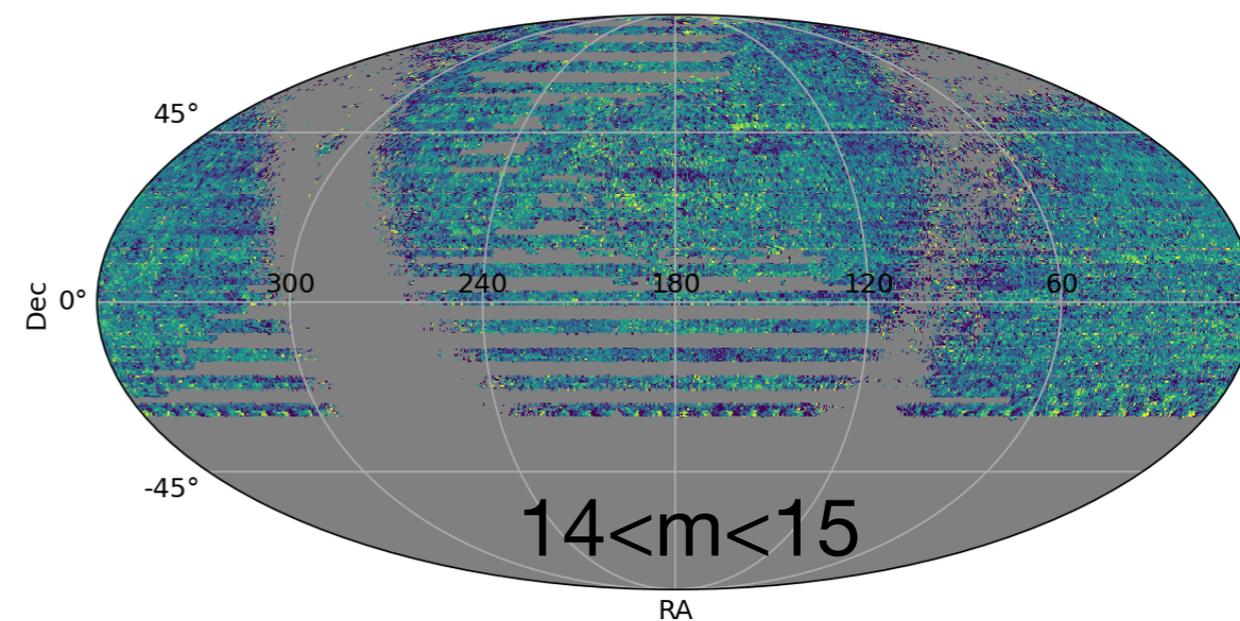
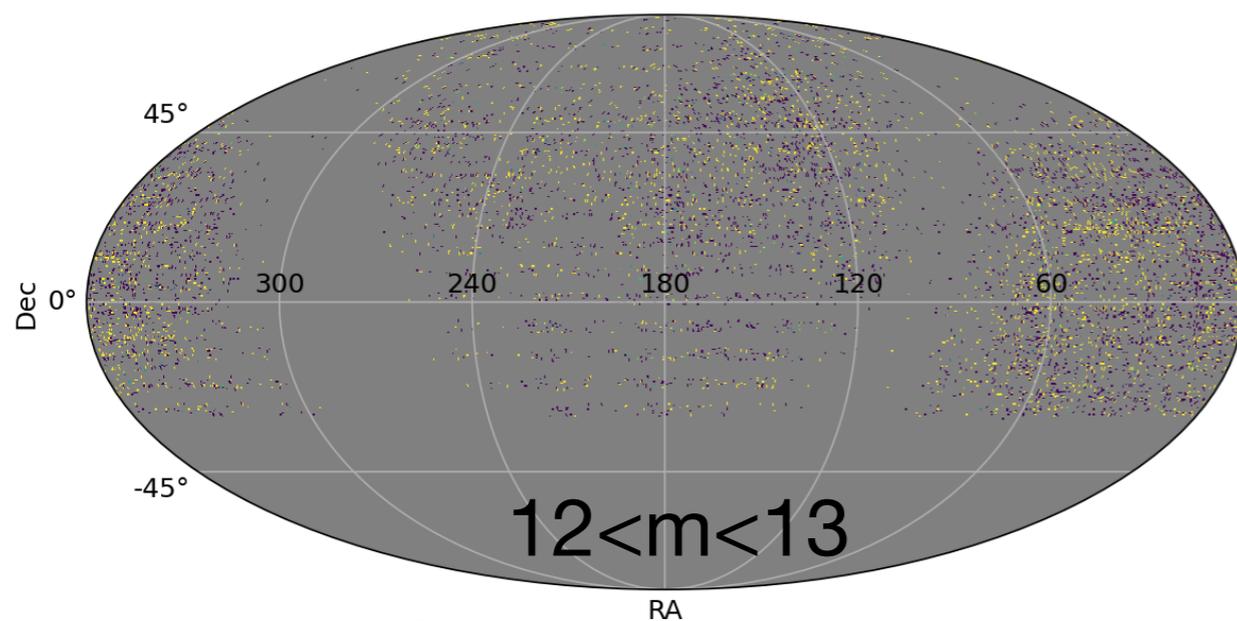
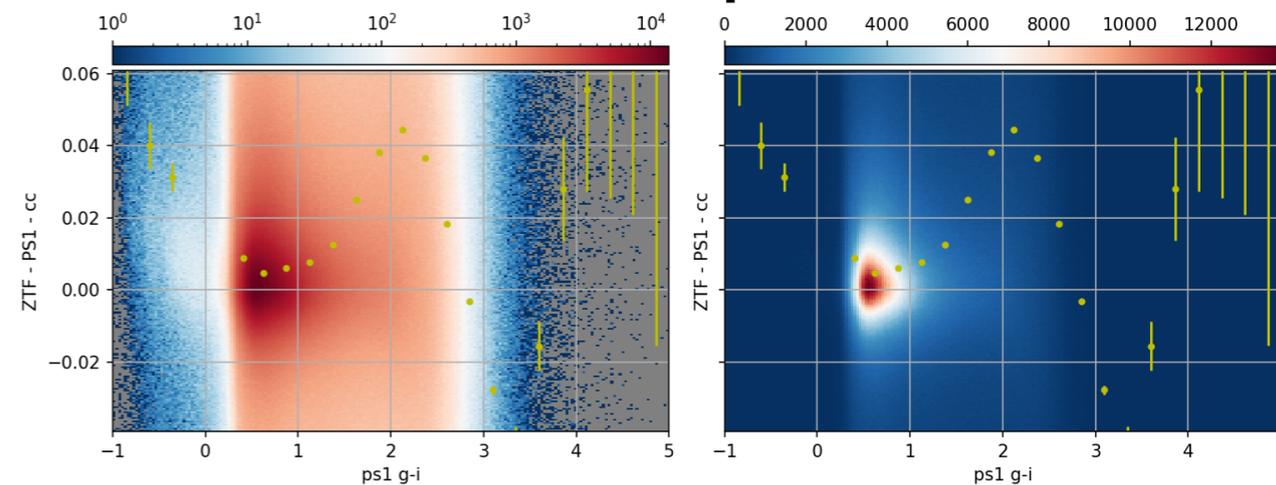
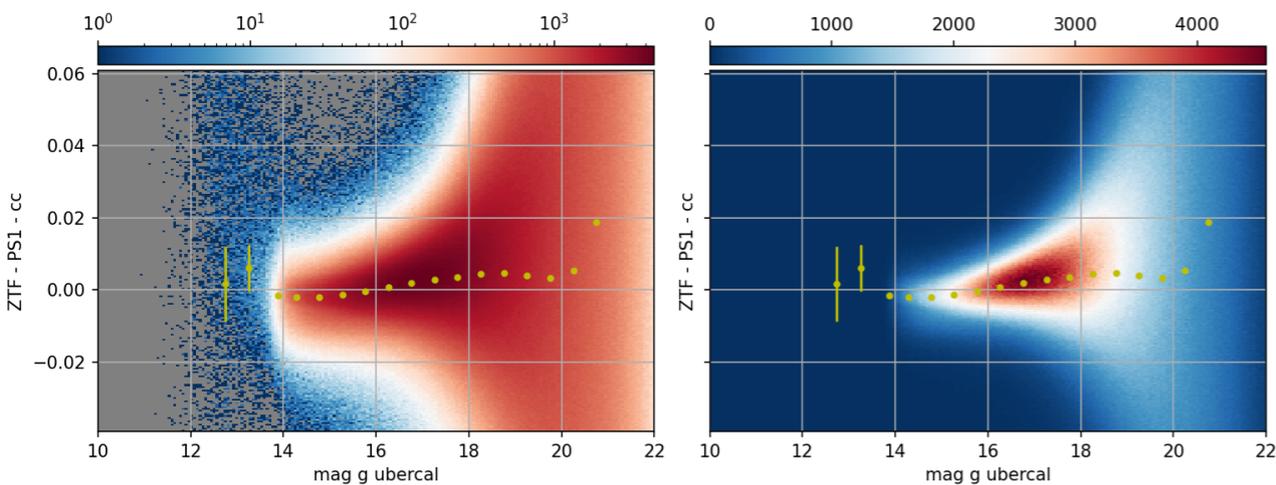
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2019-2023

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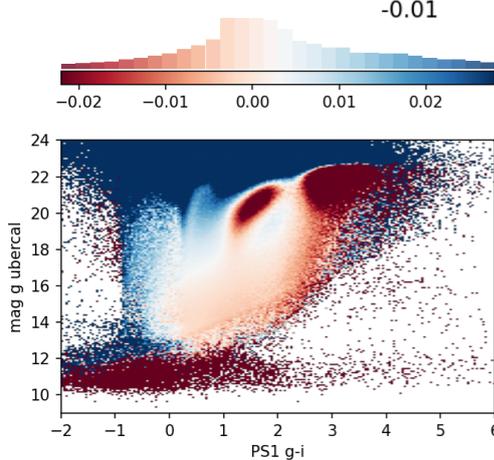
p-value <  $10^{-3}$



median of diff



single coatings



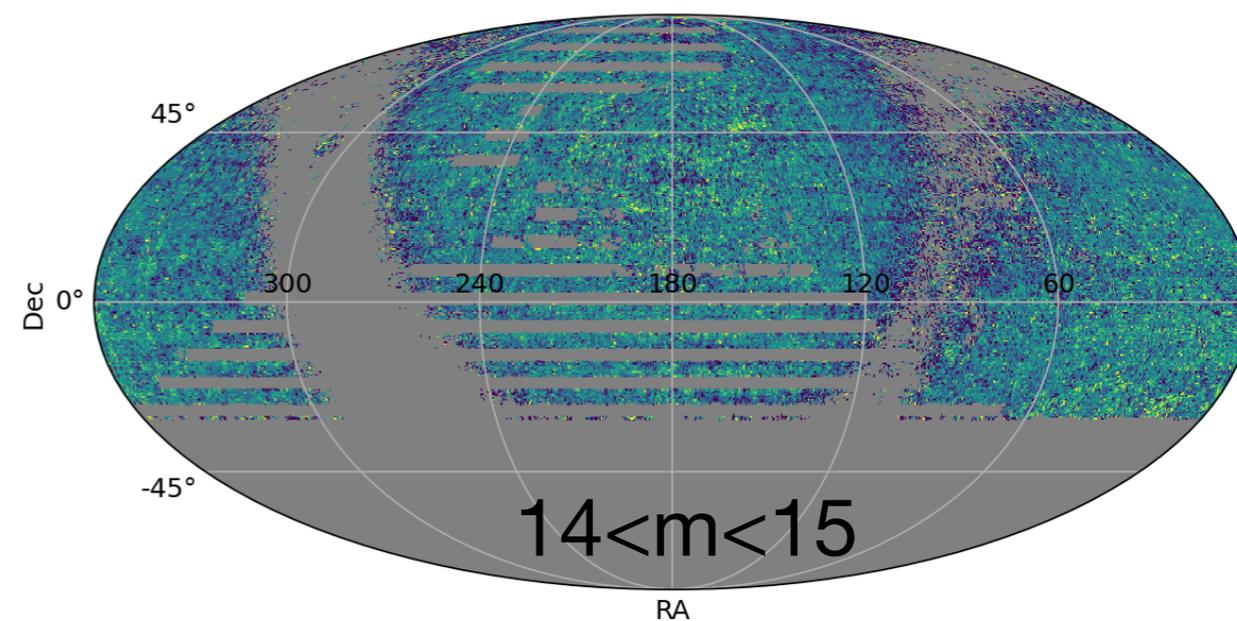
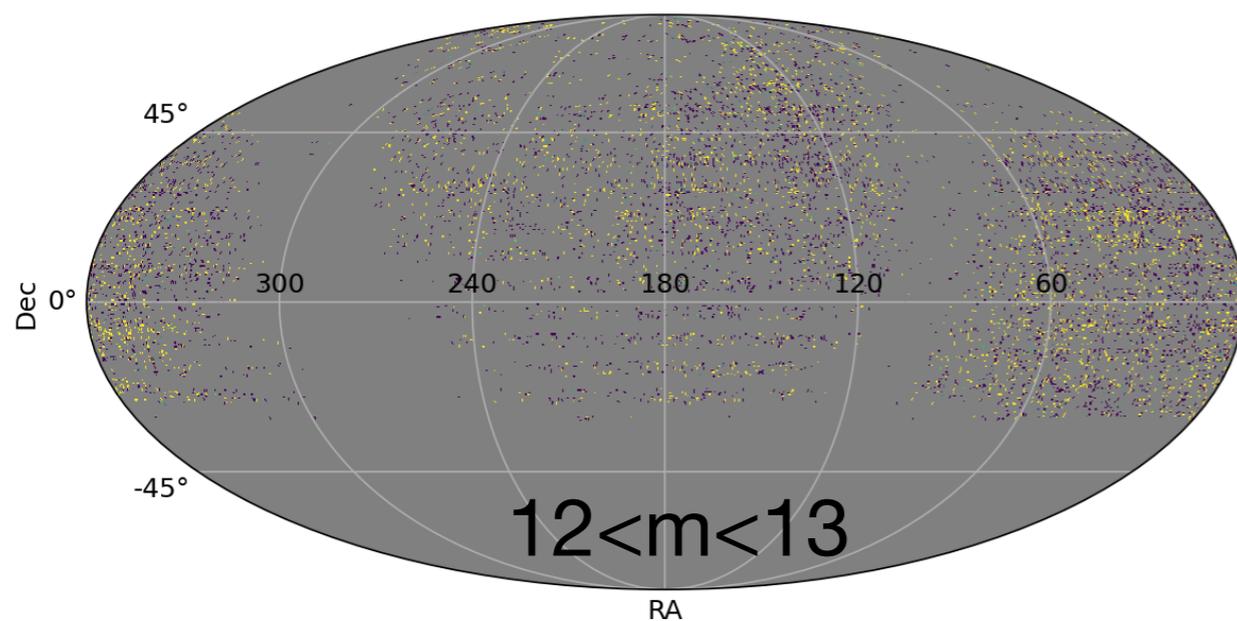
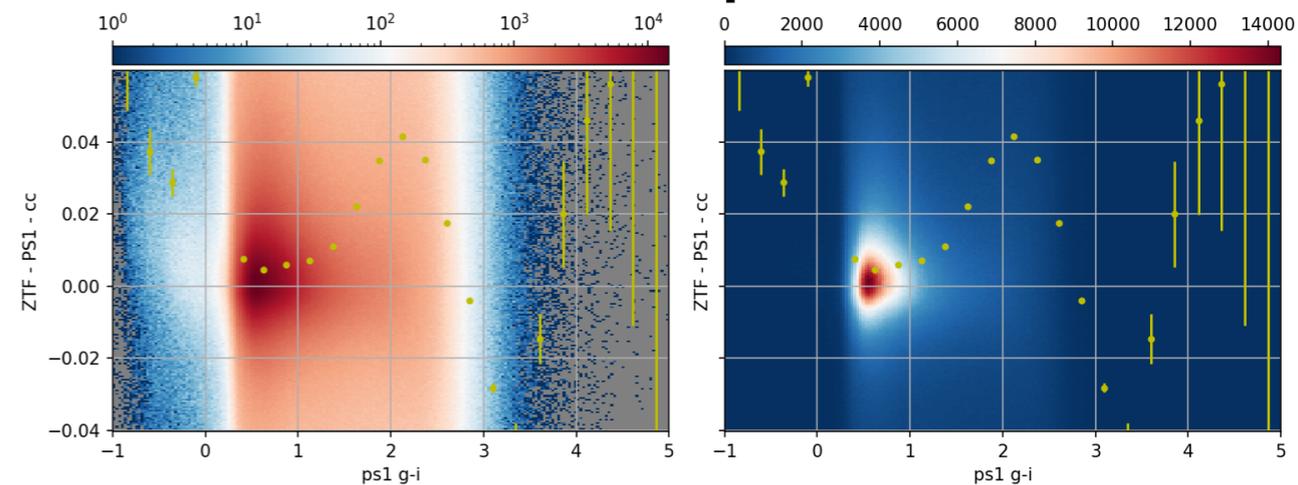
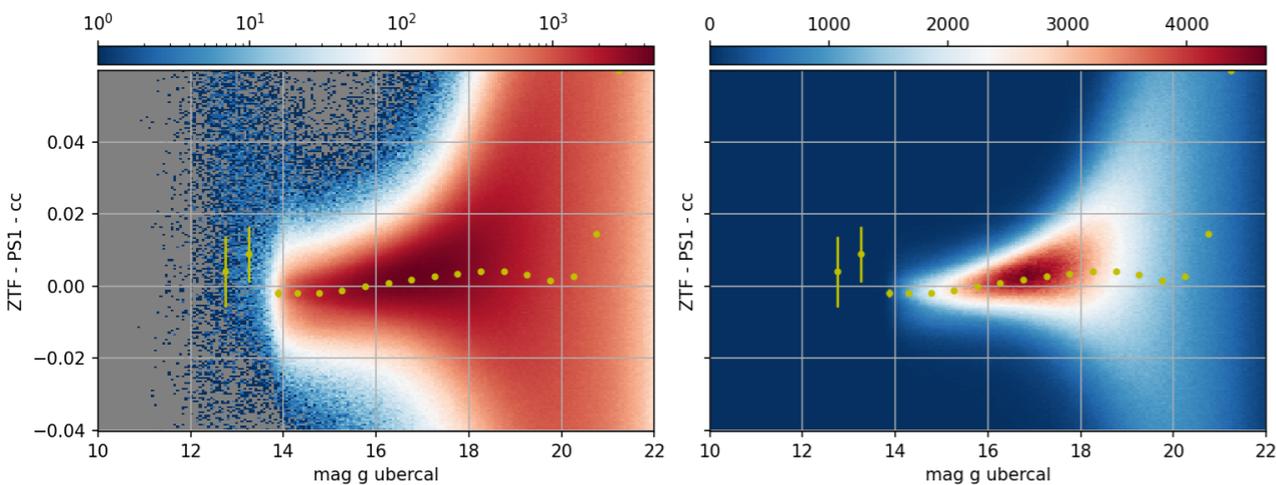
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ZTF-g

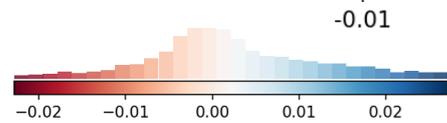
2019-2023

at least 10 obs per LC

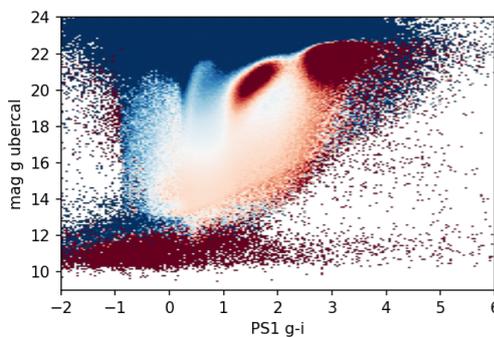
p-value <  $10^{-3}$



median of diff



double coatings



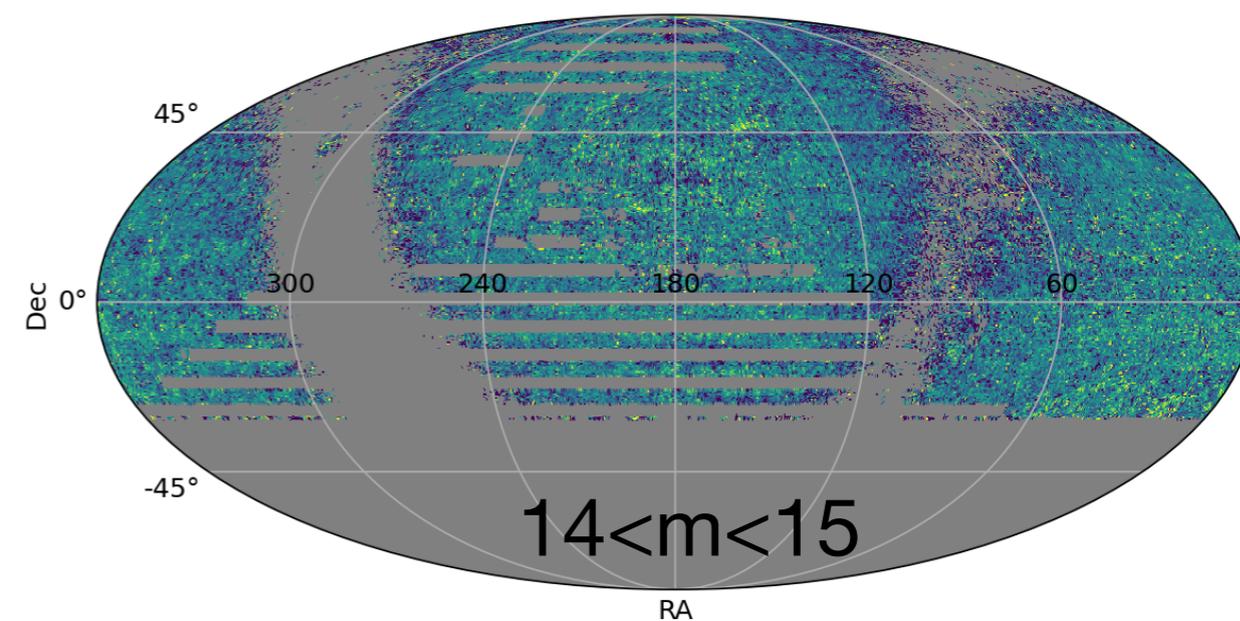
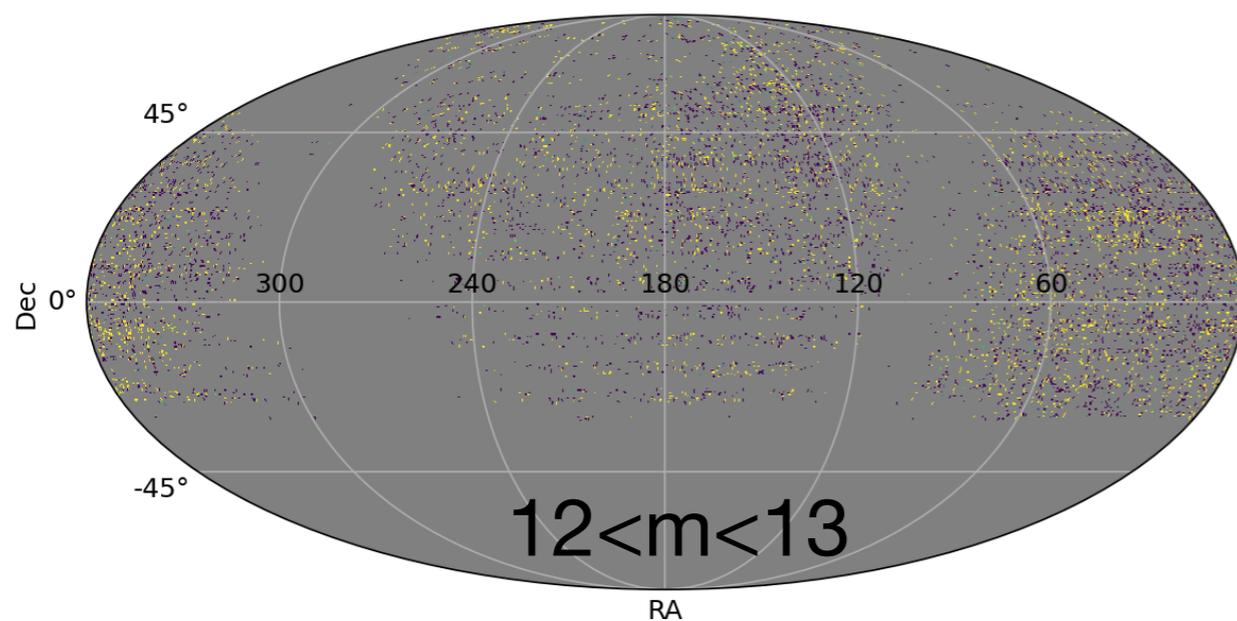
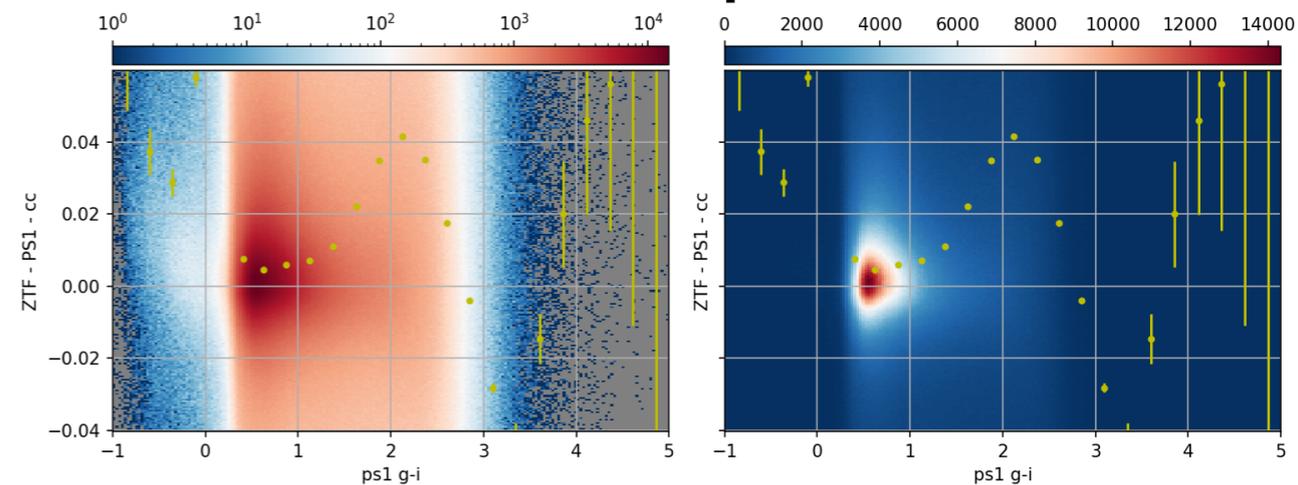
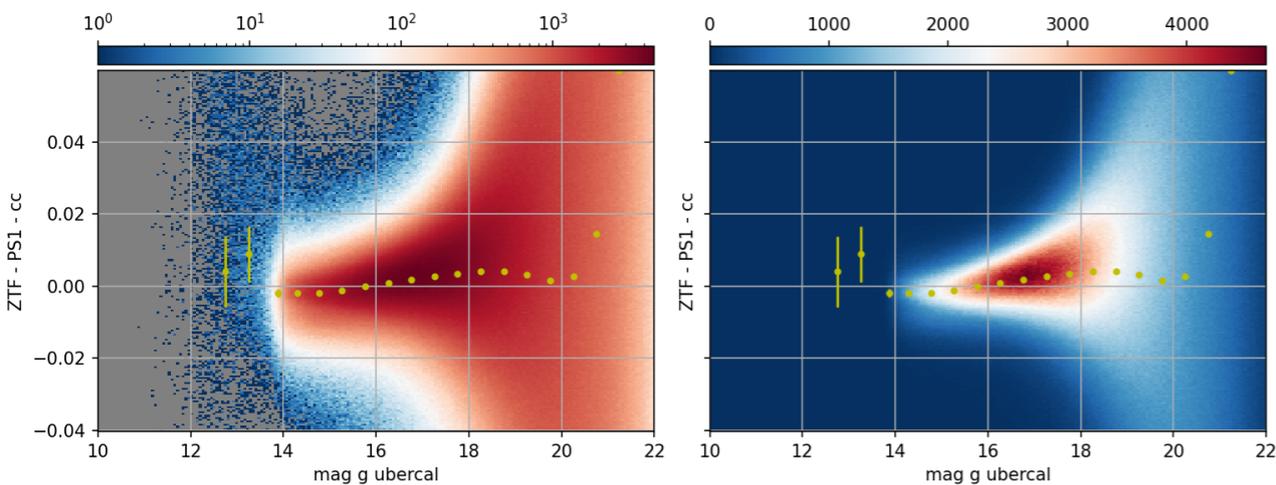
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ZTF-g

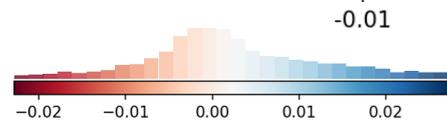
2019-2023

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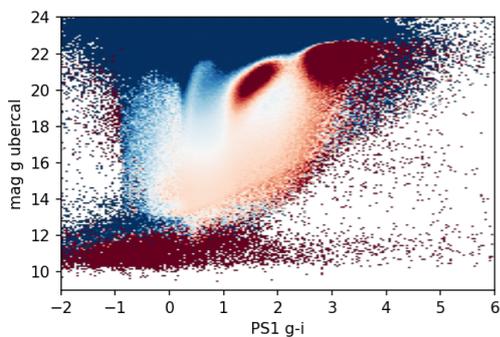
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median of diff



double coatings

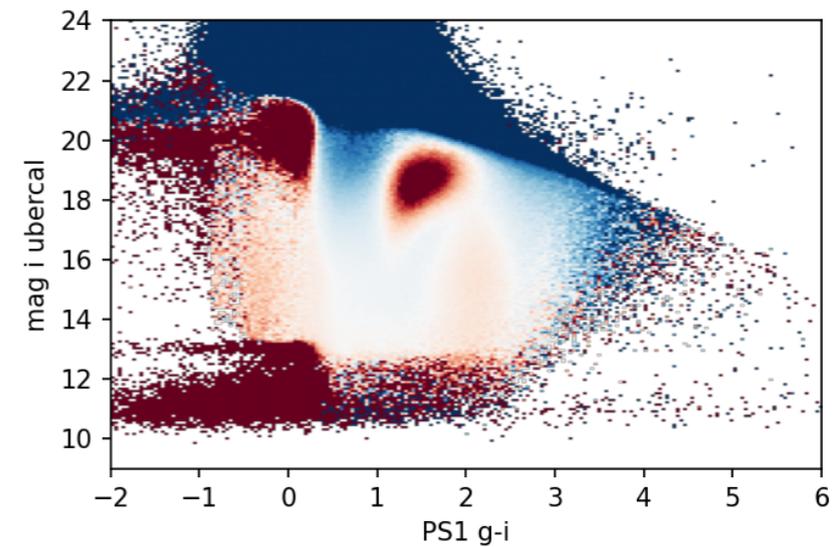
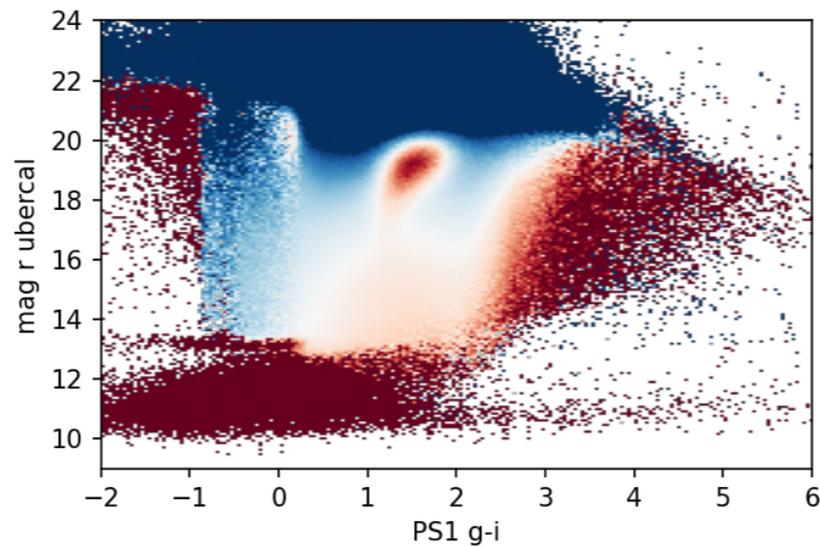
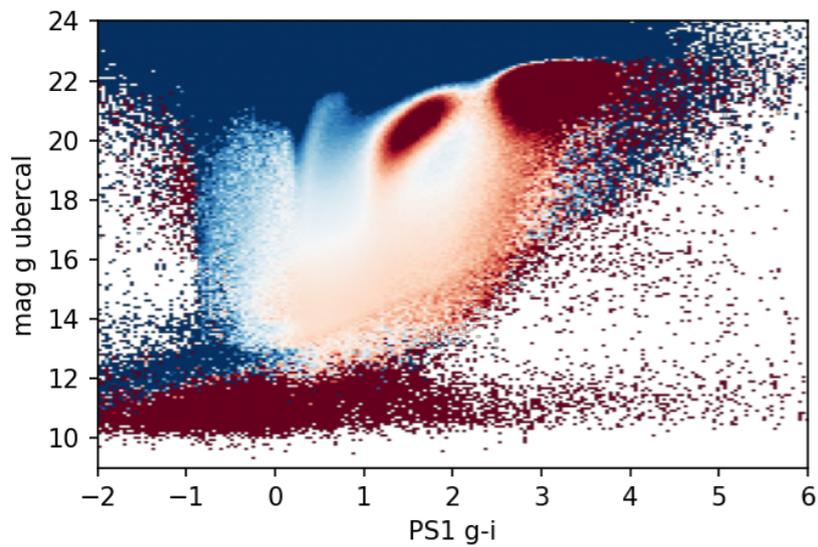
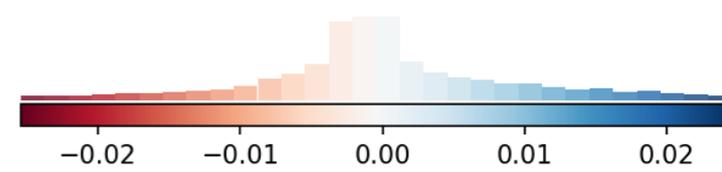
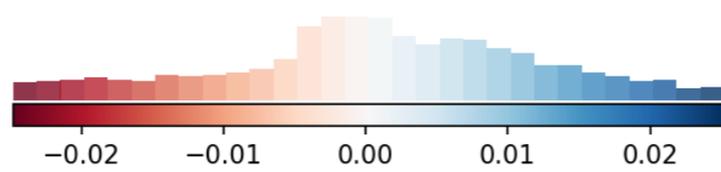
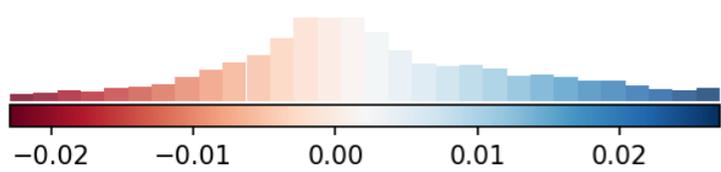
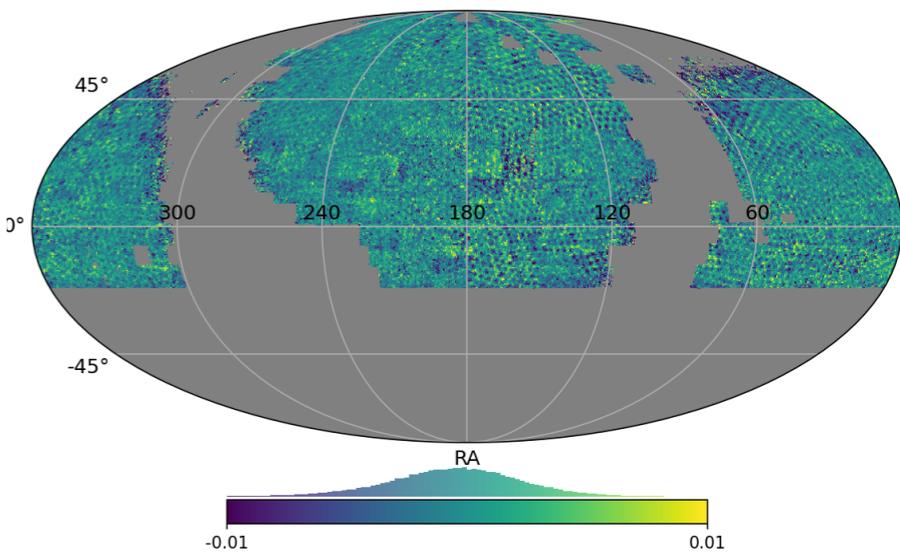
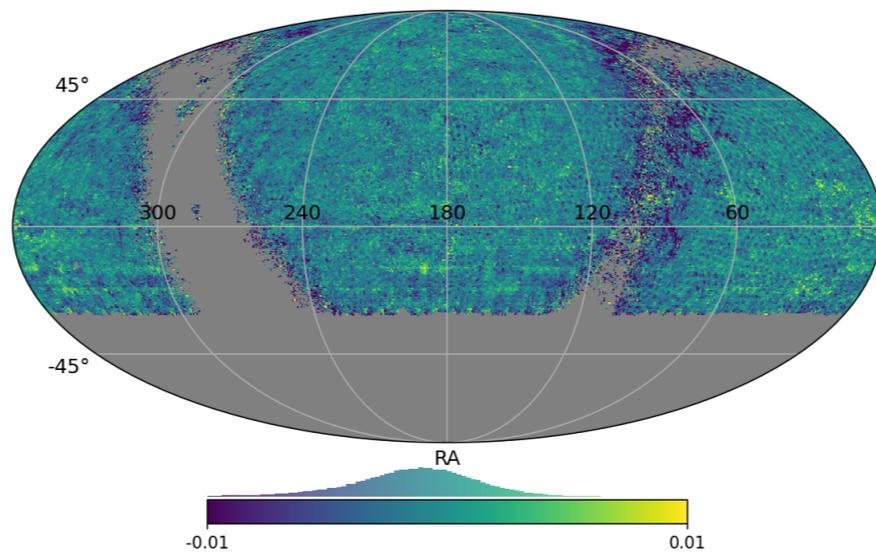
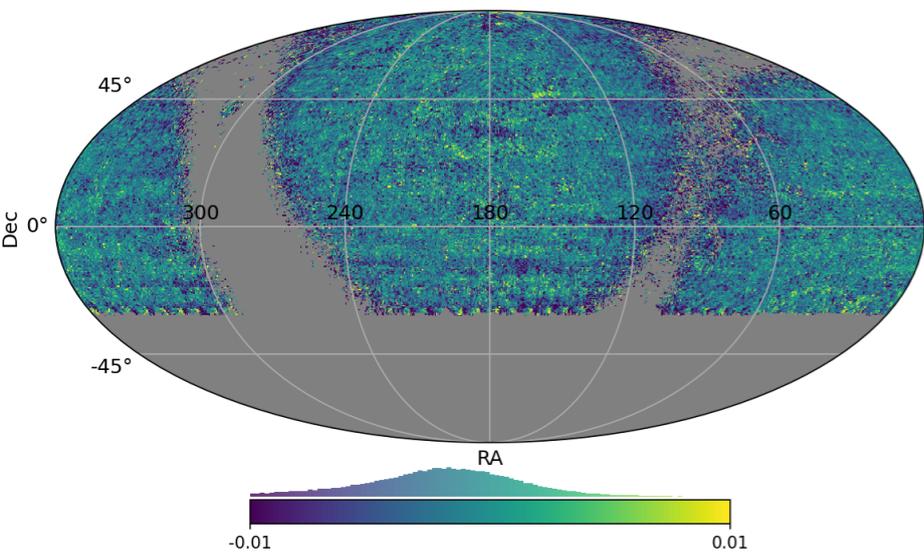


2019-2023  
at least 10 obs per LC  
 $p\text{-value} < 10^{-3}$

ZTF-g

ZTF-r

ZTF-i



# New $\chi^2$ , new weighted std

- Star  $\chi^2$  used to be max of yearly  $\chi^2$
- Now we **recompute the star  $\chi^2$  properly**, including between year  $\chi^2$

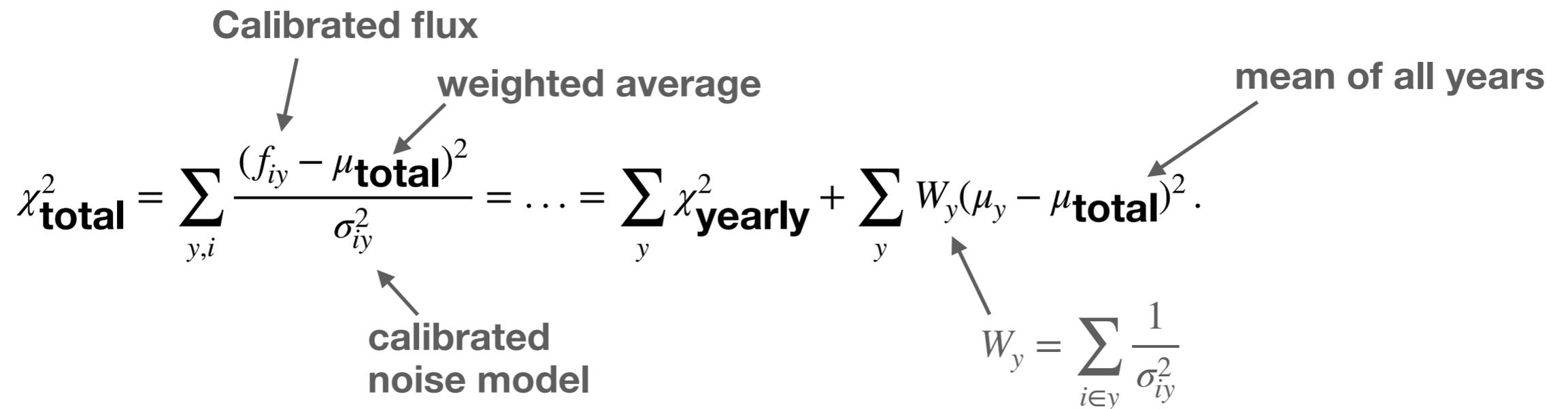
Calibrated flux

weighted average

mean of all years

$$\chi_{\text{total}}^2 = \sum_{y,i} \frac{(f_{iy} - \mu_{\text{total}})^2}{\sigma_{iy}^2} = \dots = \sum_y \chi_{\text{yearly}}^2 + \sum_y W_y (\mu_y - \mu_{\text{total}})^2.$$

calibrated noise model

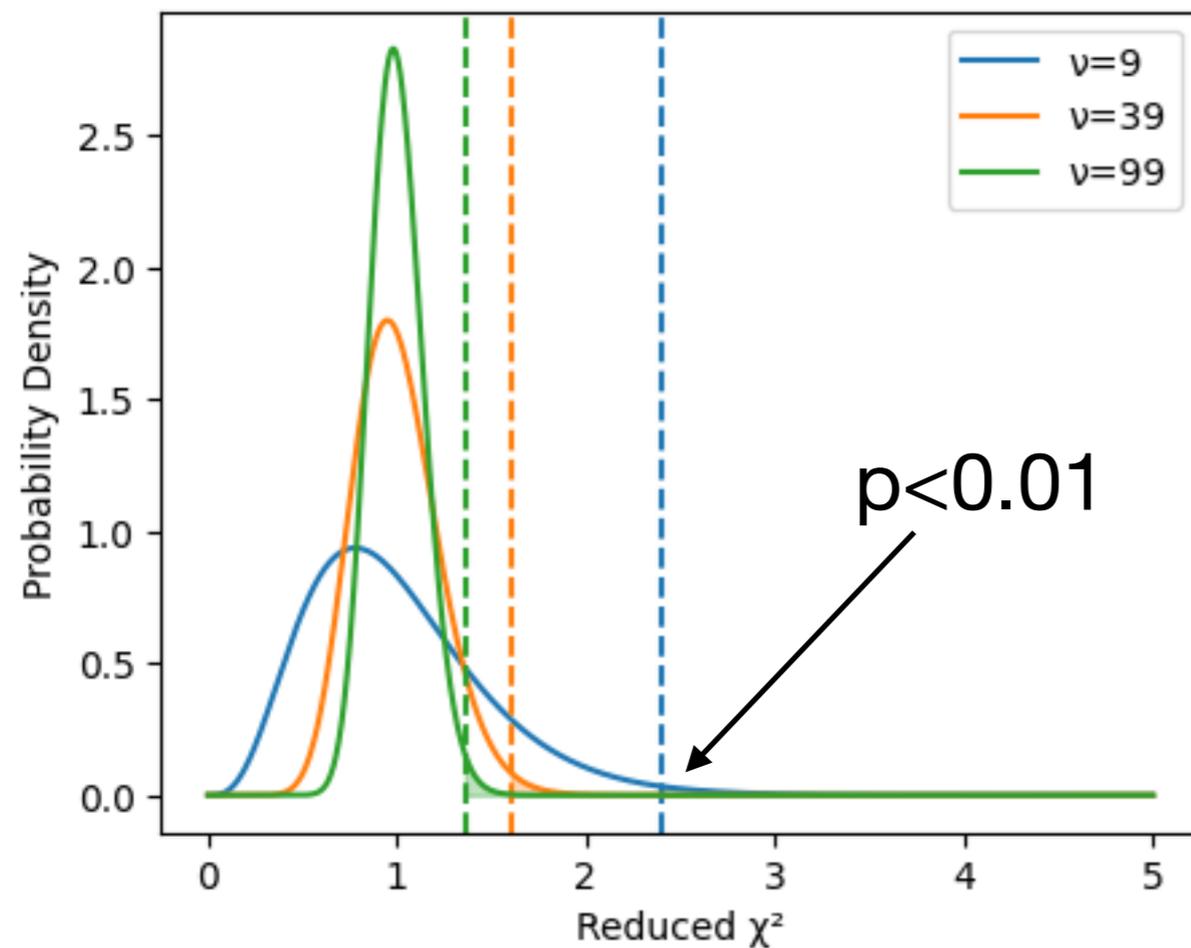
$$W_y = \sum_{i \in y} \frac{1}{\sigma_{iy}^2}$$


# p-value cuts

Until now, selection was based on reduced chi2

This had a very different meaning depending on the number of dof instead:

p-value computed from  $\chi^2$  and dof



This is used to remove "bad years for a given star" when combining the catalogs

This is also used to remove "bad stars" in the final catalog

For now we removed when p-value < 0.001

# p-value cuts

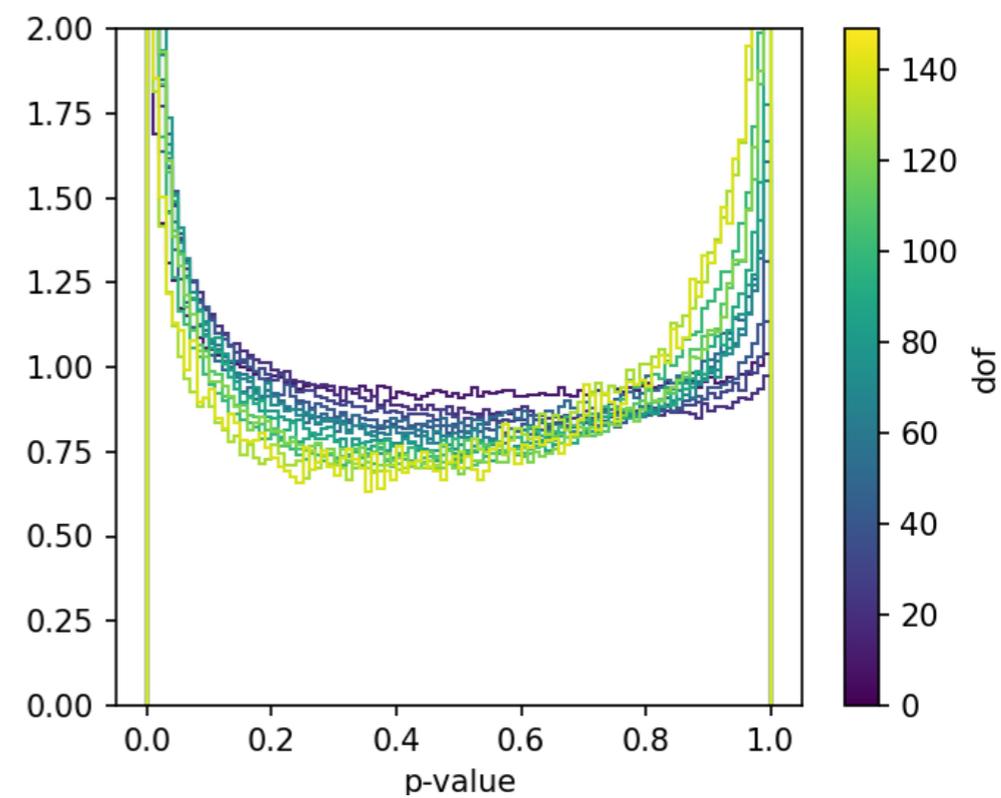
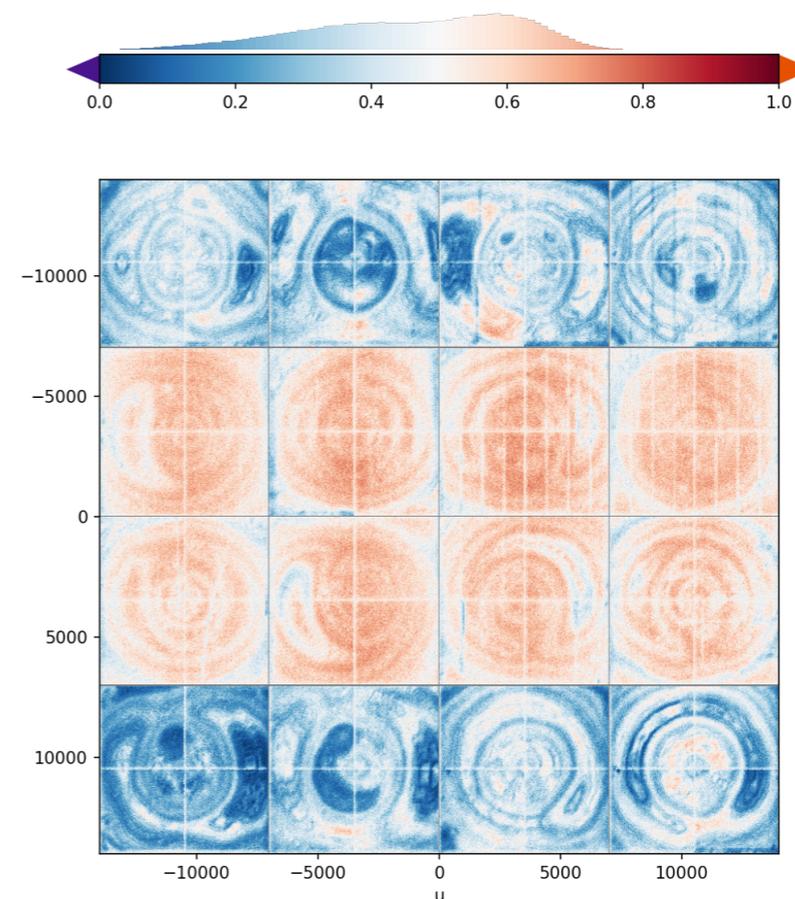
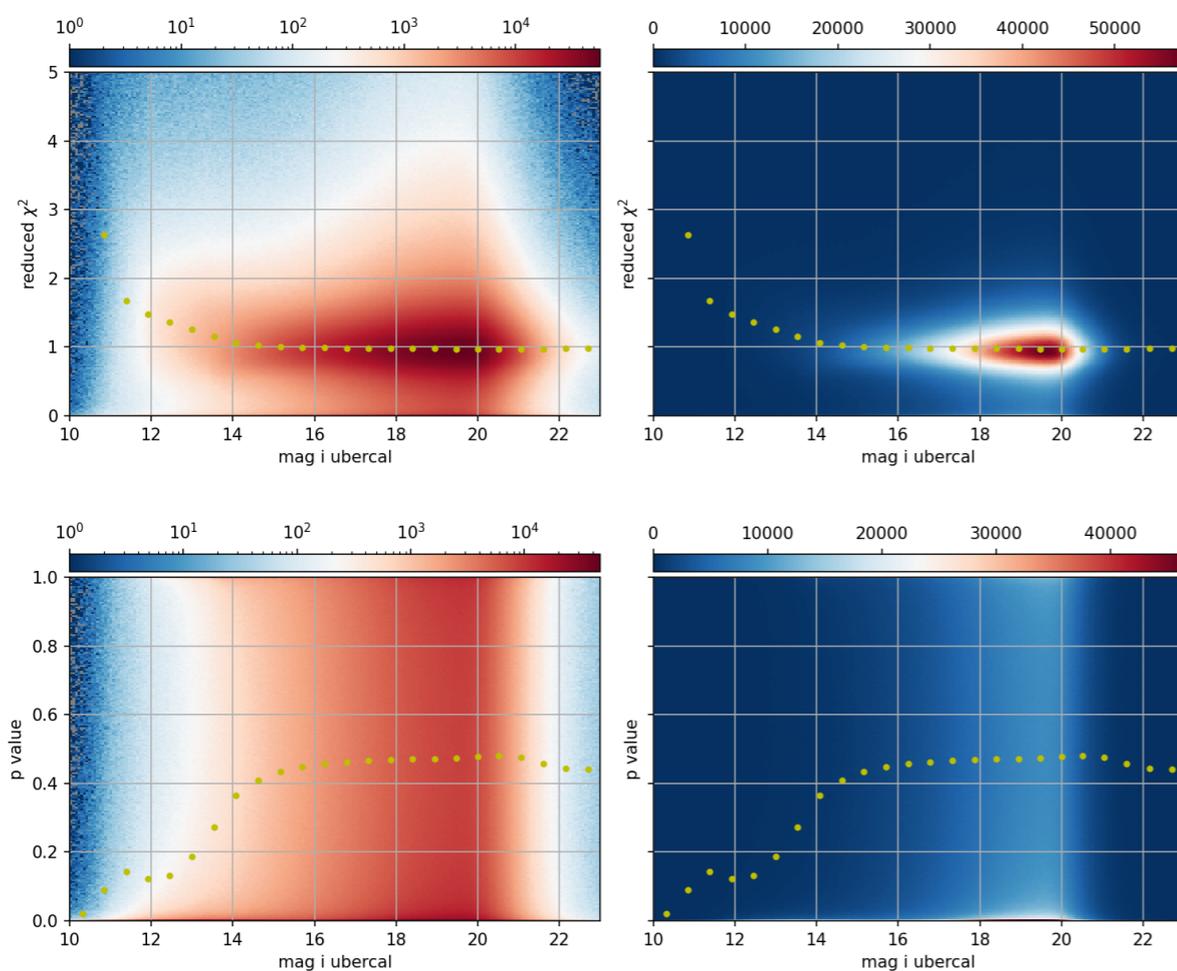
p-value computed from  $\chi^2$  and dof

peak at low p-value:

- variable stars?
- noise under-estimated?

peak at high value:

- noise over-estimated?



# p-value cuts

p-value computed from  $\chi^2$  and dof

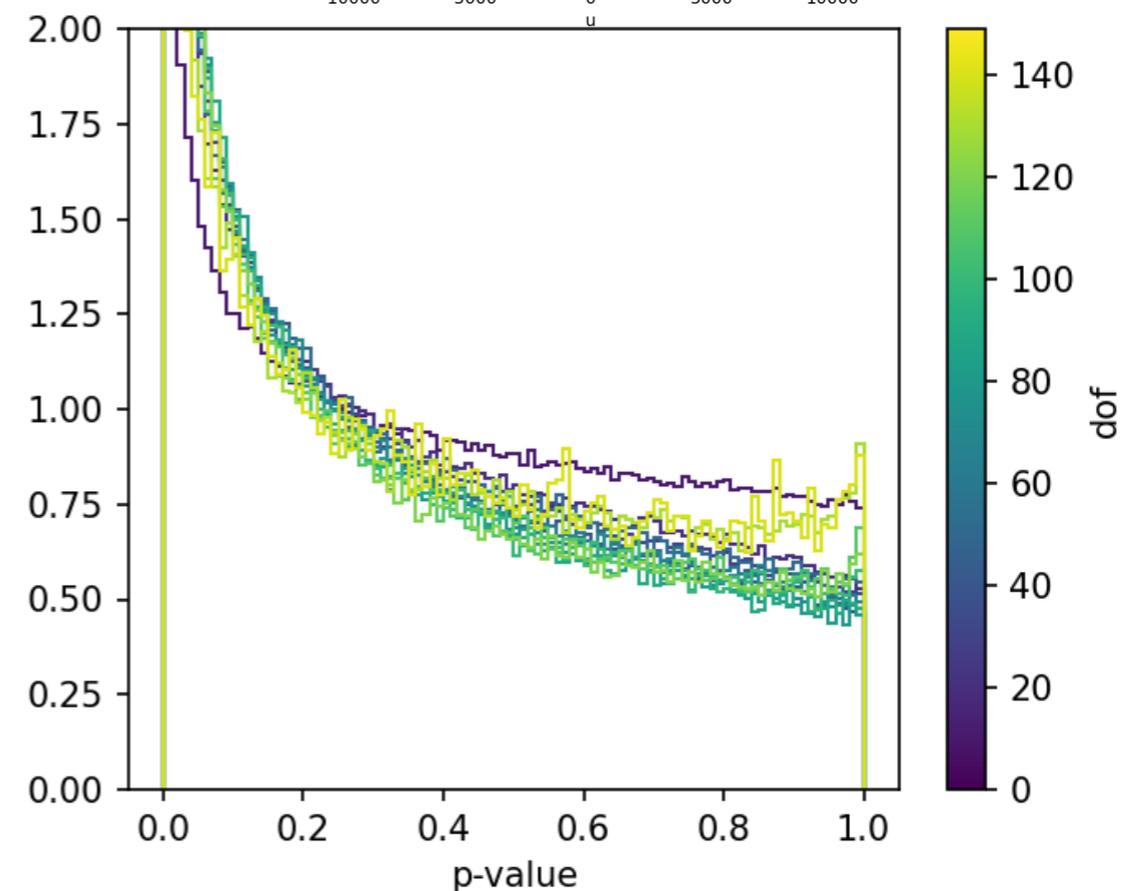
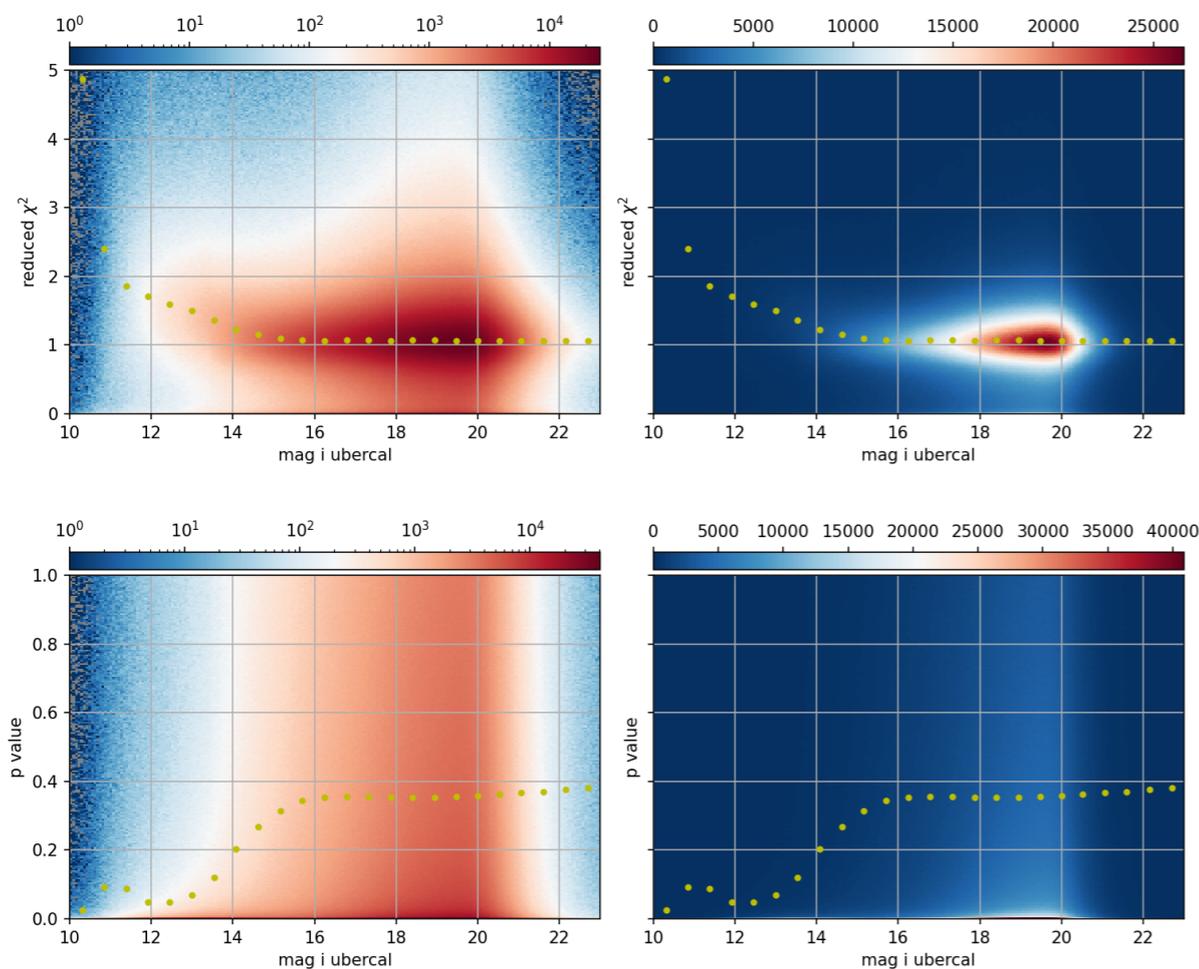
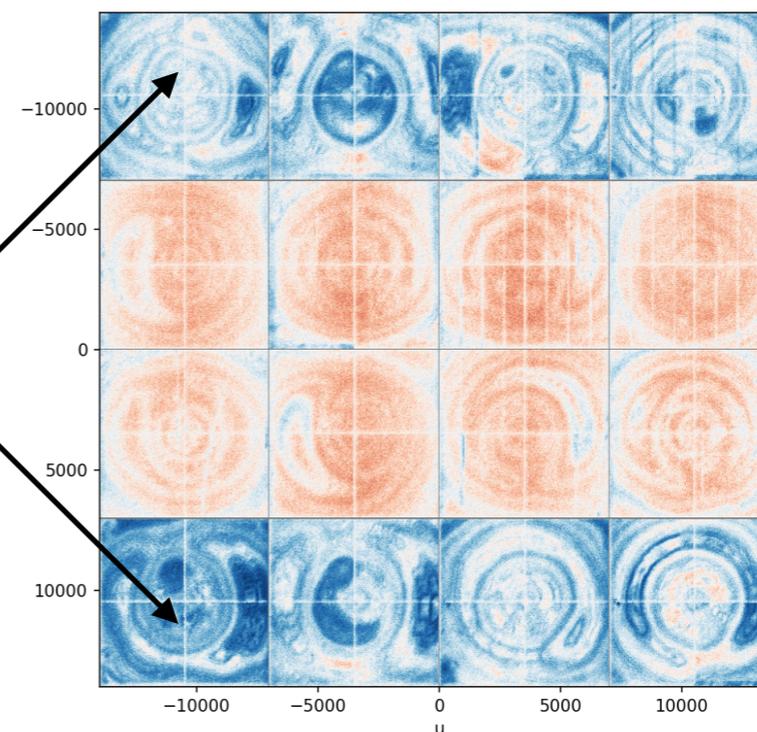
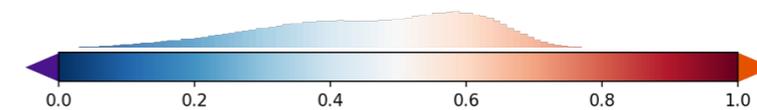
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peak at high value:

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Single coatings



# p-value cuts

p-value computed from  $\chi^2$  and dof

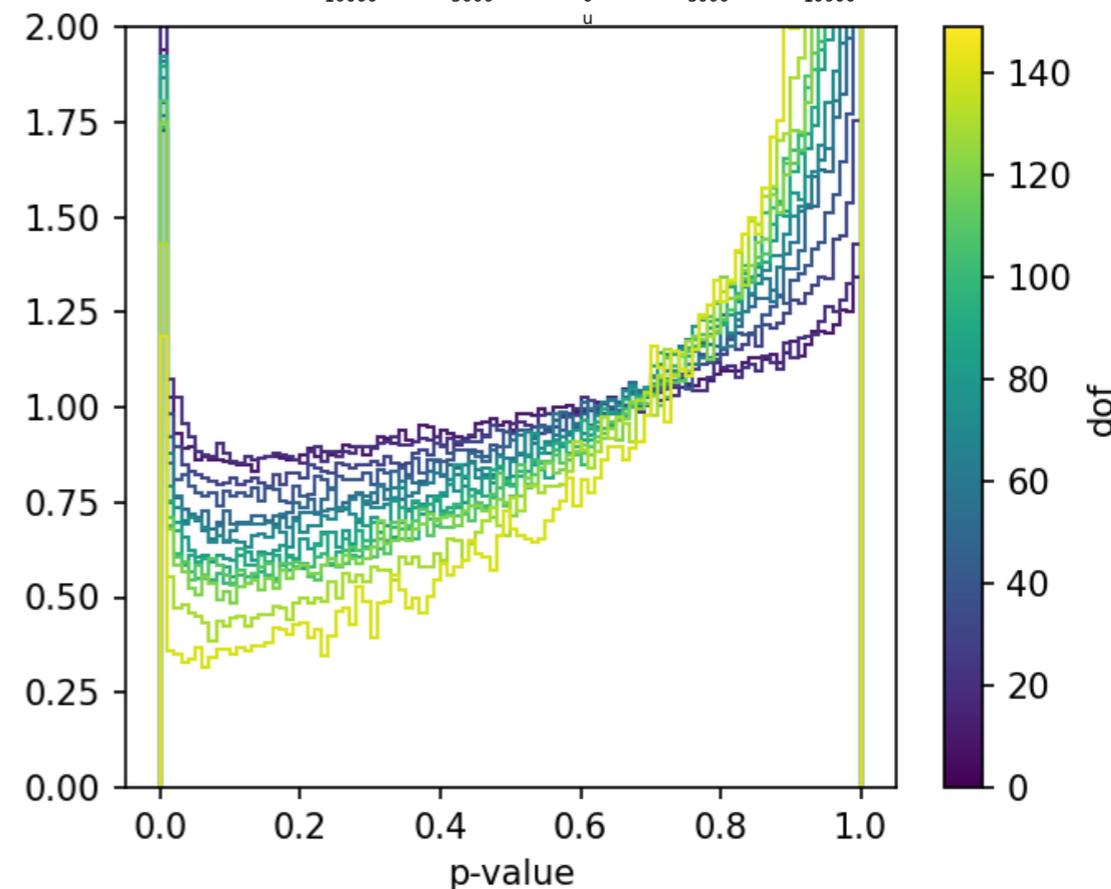
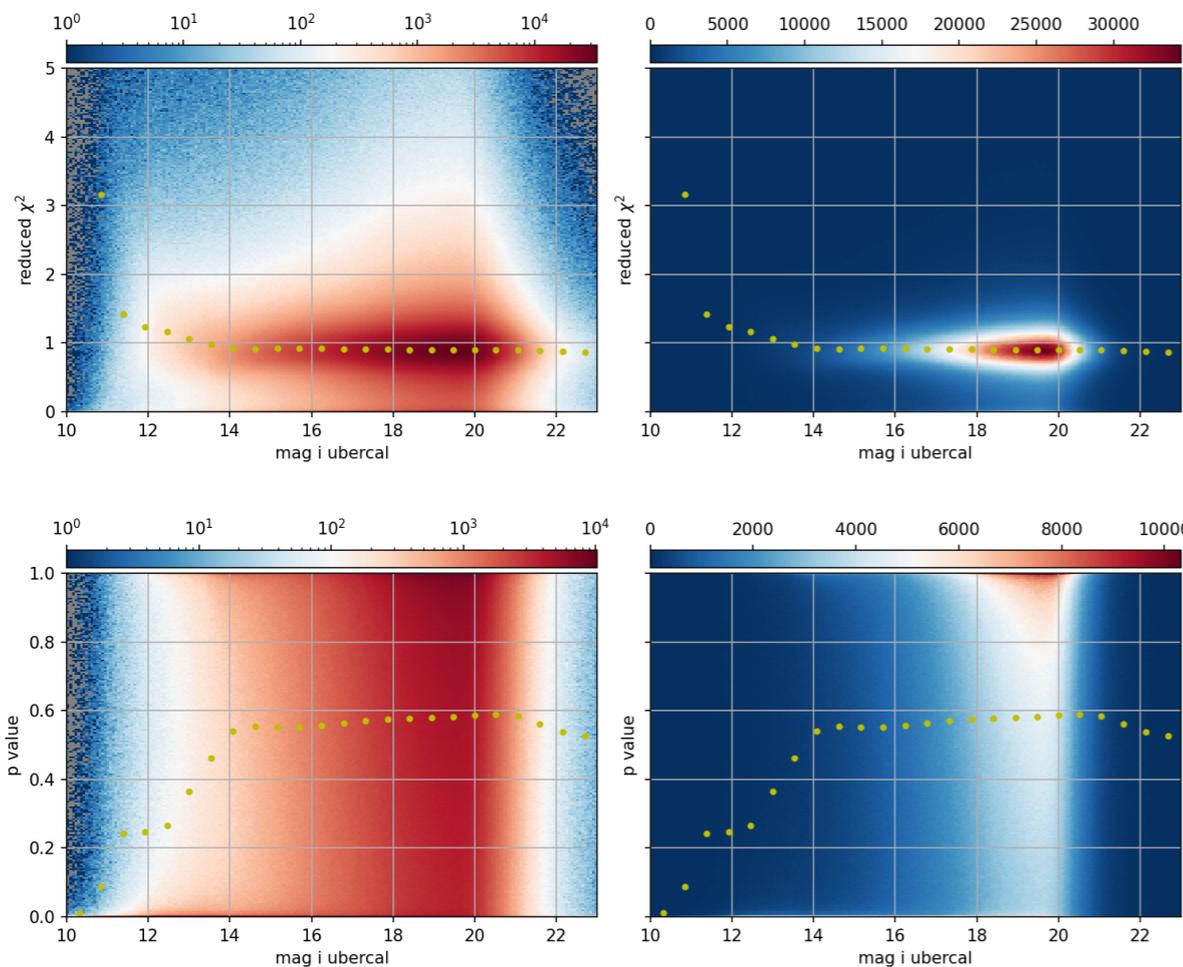
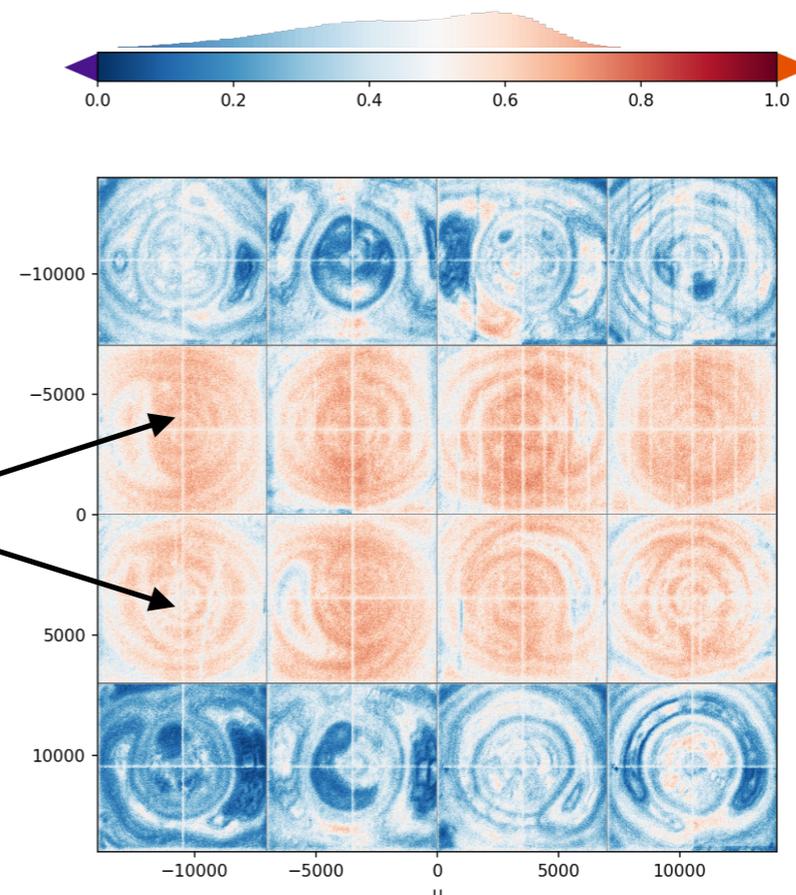
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**Double coatings**



# p-value cuts

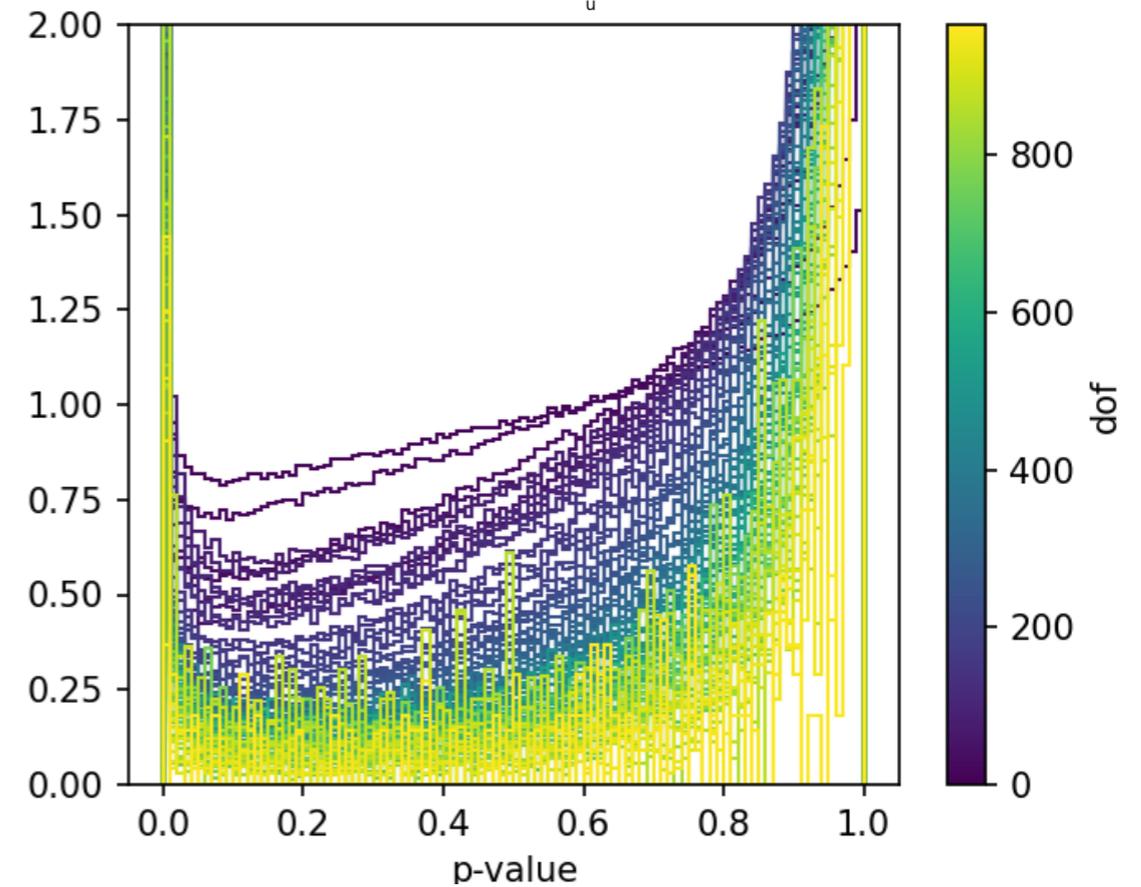
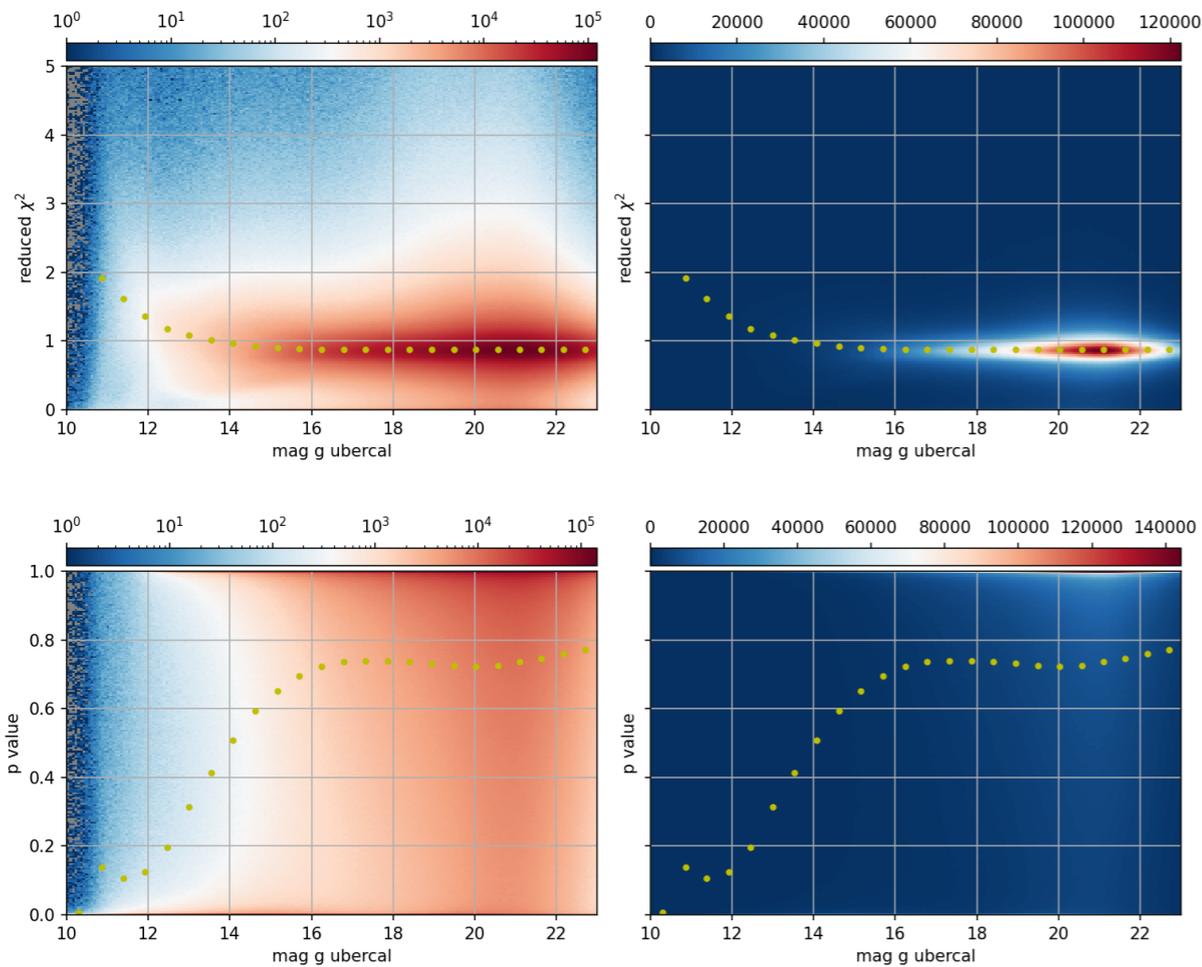
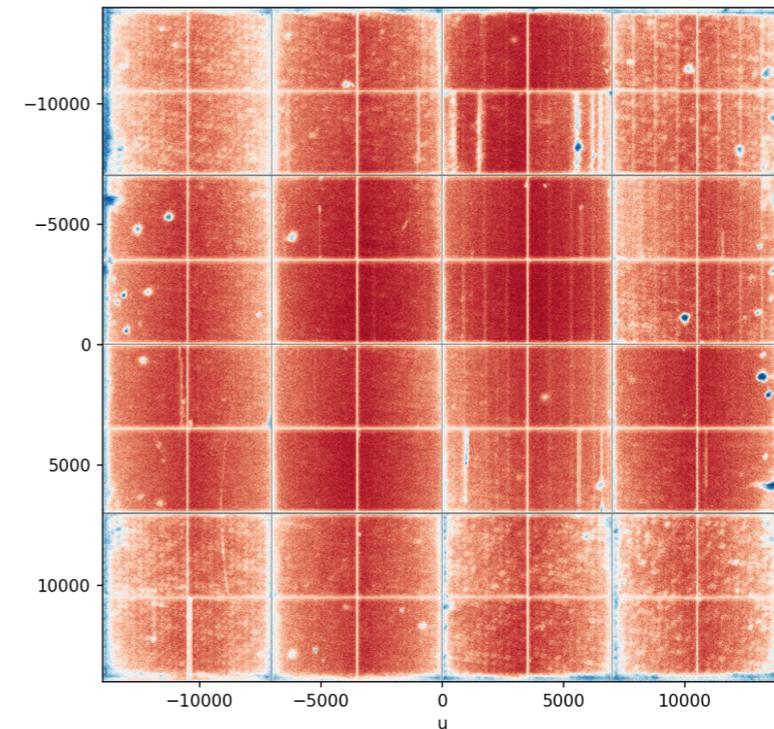
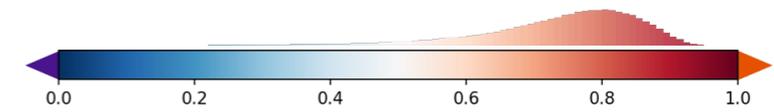
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peak at low p-value:

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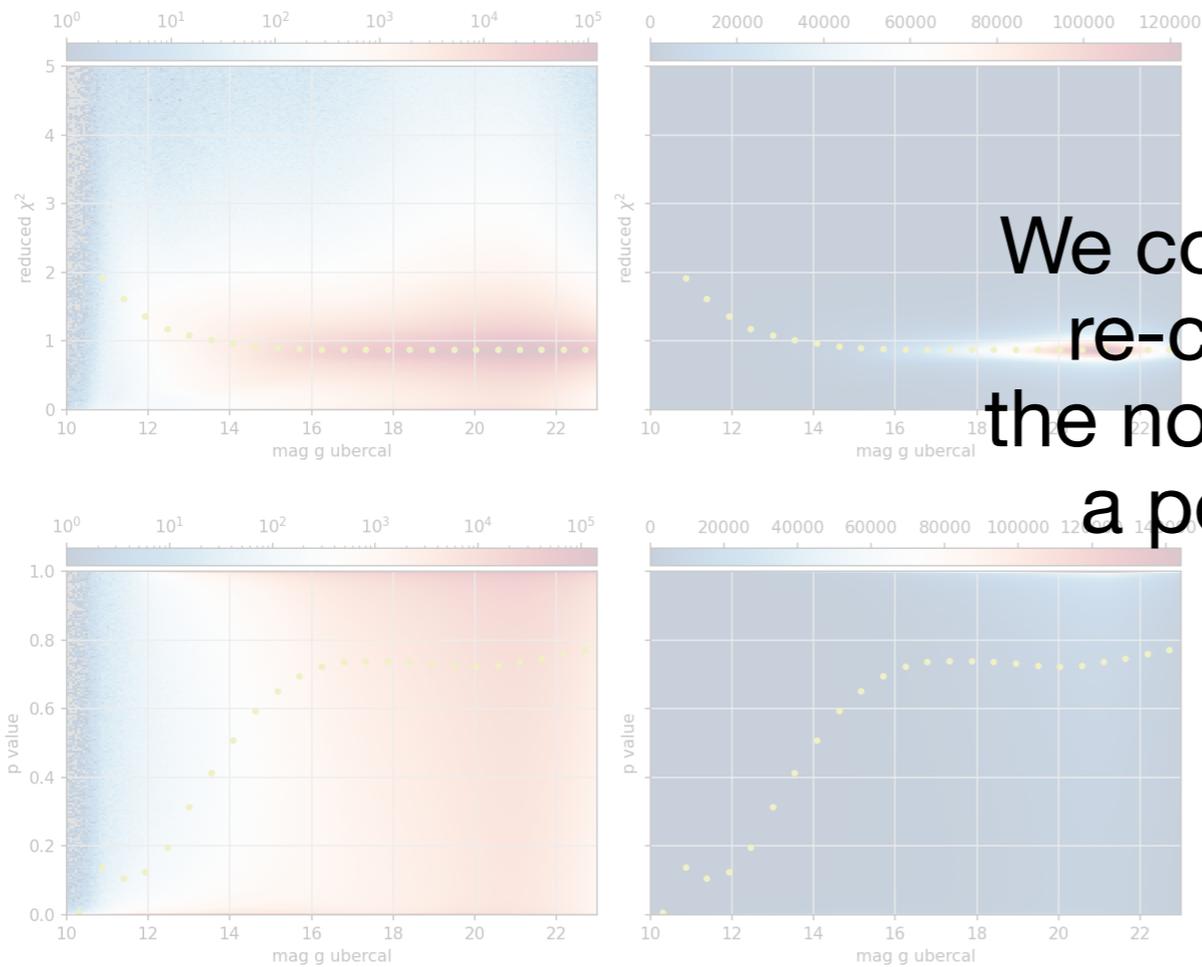
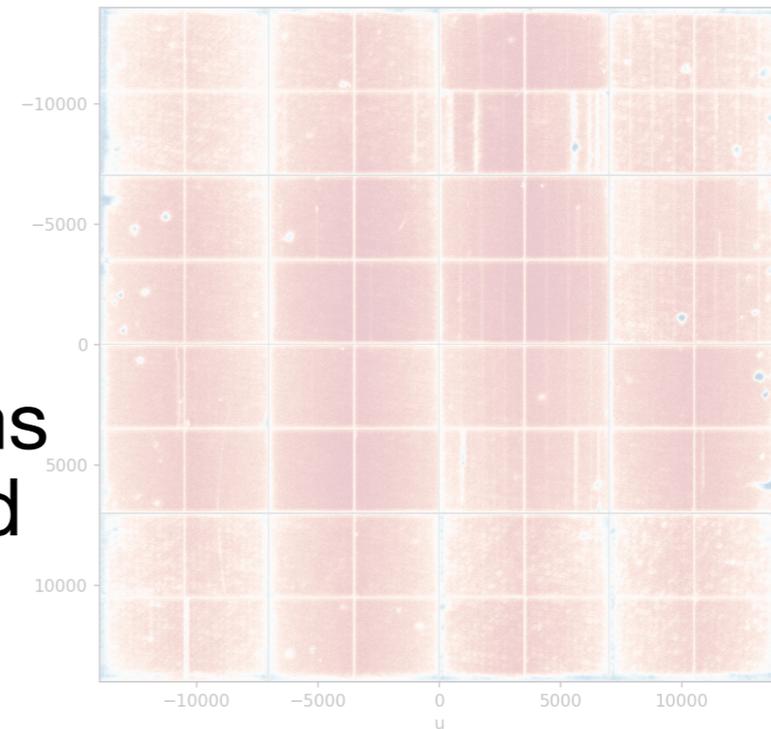
peak at low p-value:

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- noise under-estimated?

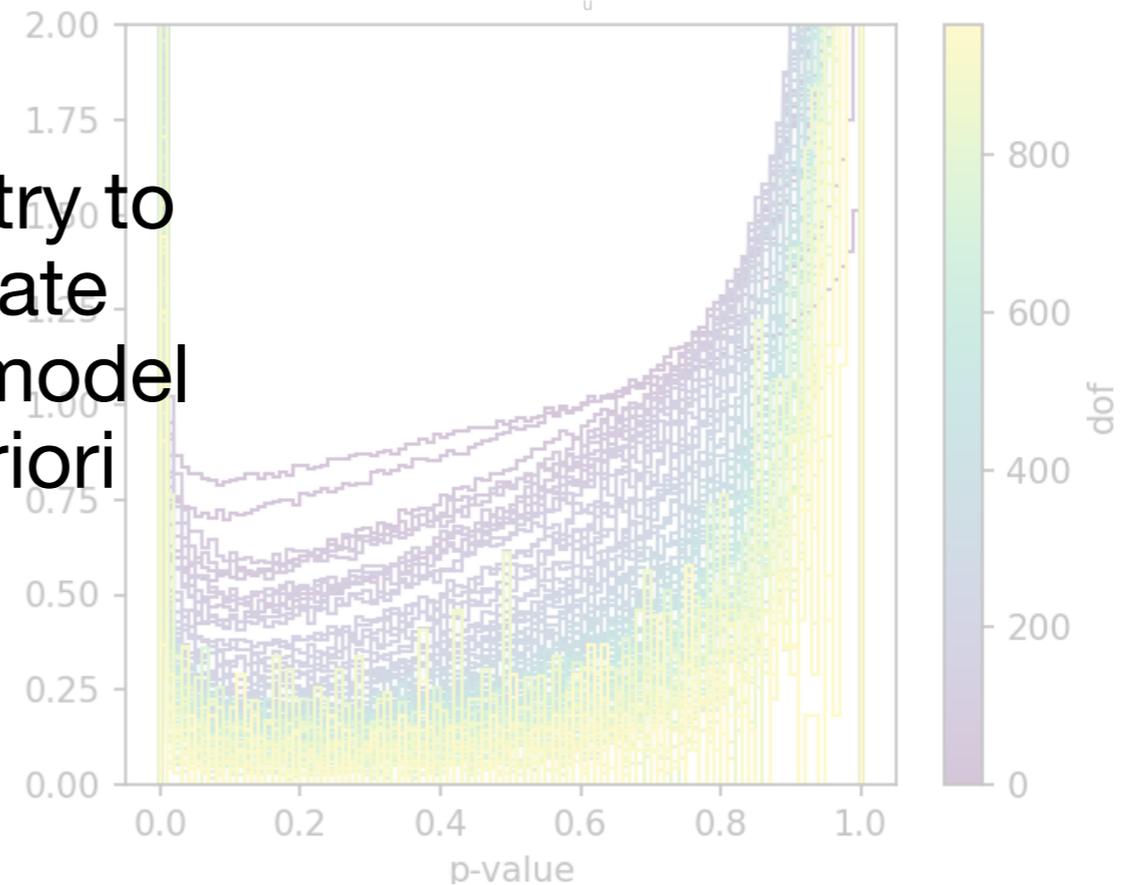
peak at high value:

- noise over-estimated?

in g and r,  
the noise seems  
over estimated

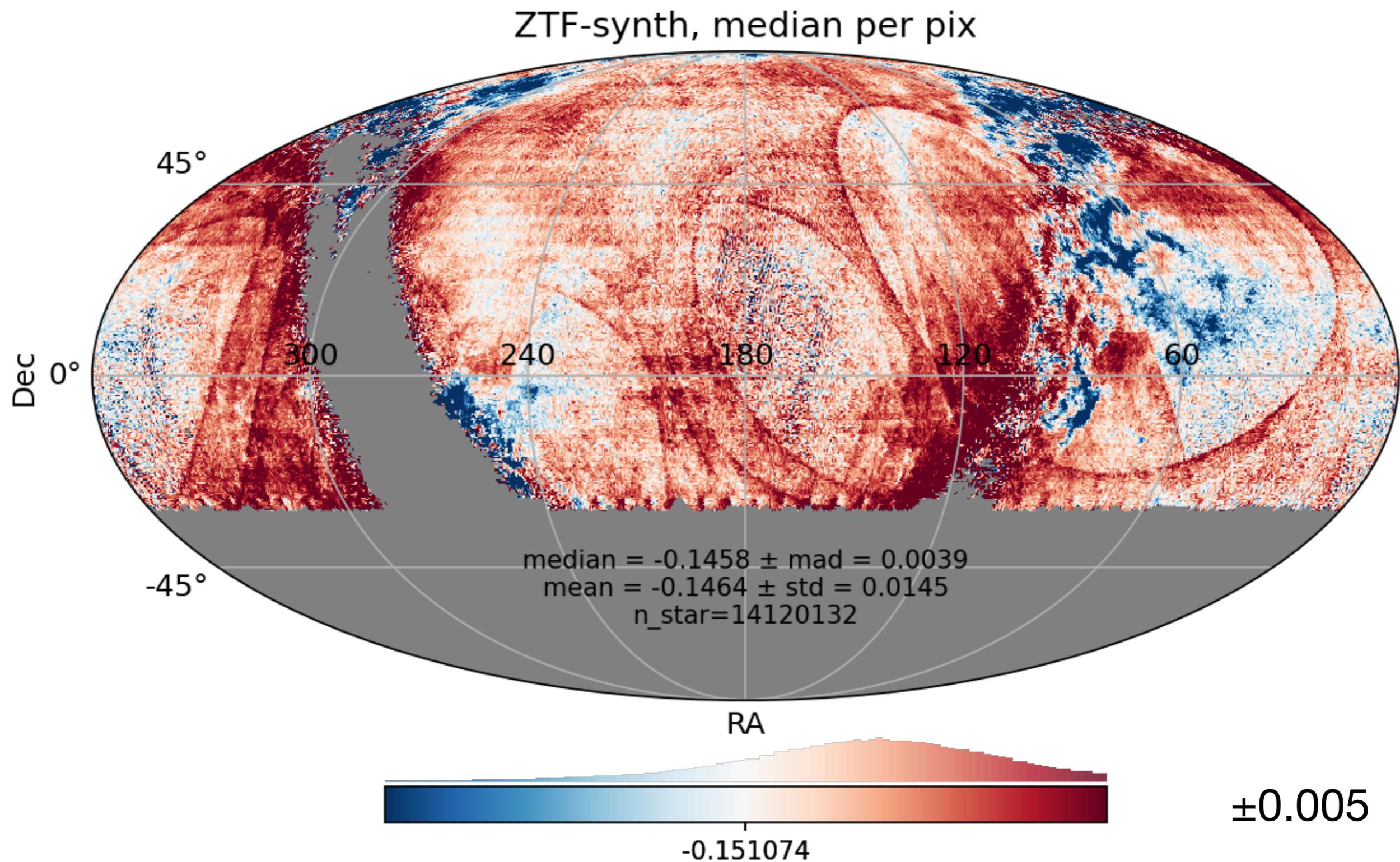


We could try to  
re-calibrate  
the noise model  
a posteriori  
??



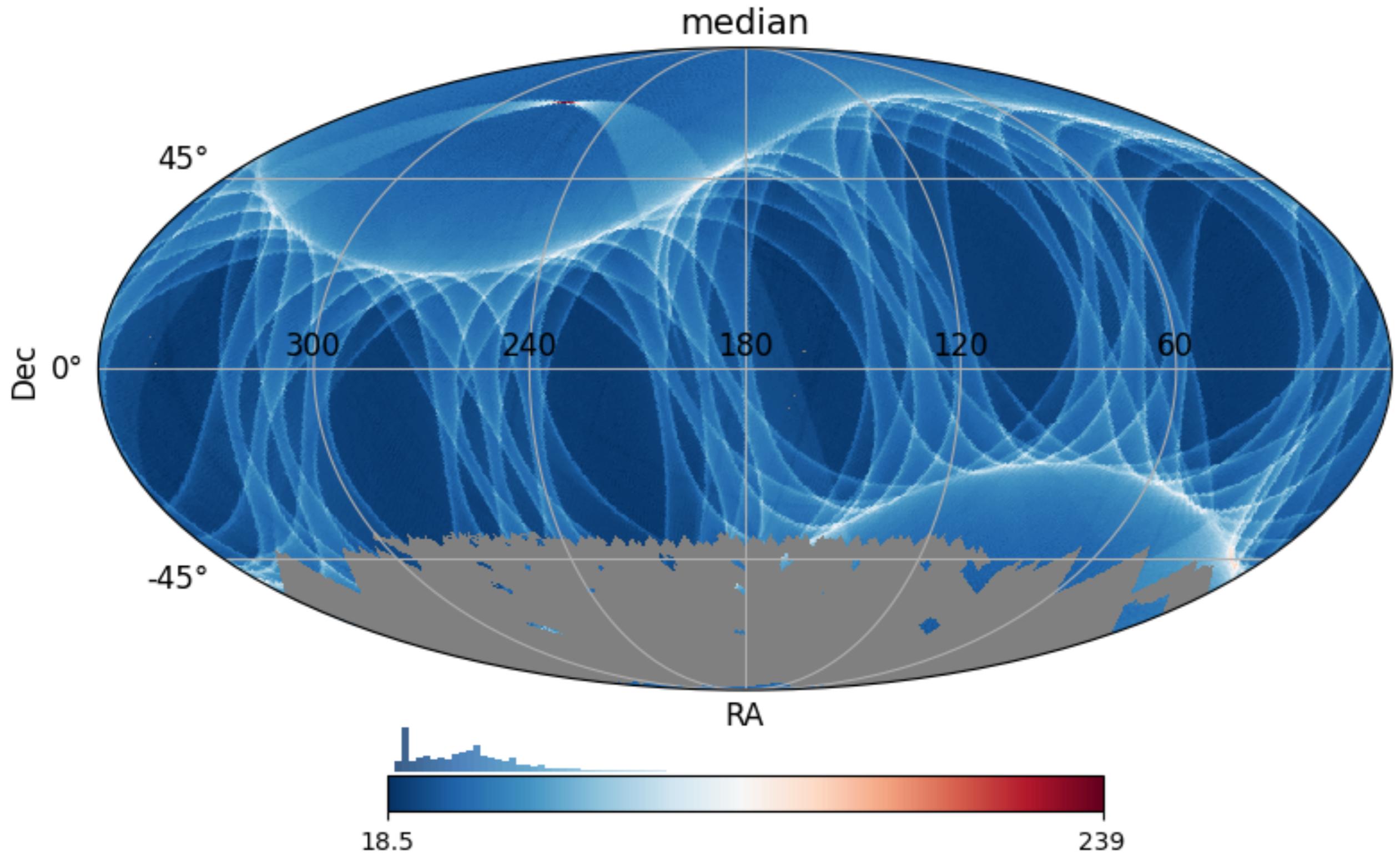
# Comparison to Gaia Synth

- used bbf using for now "ztf2" filters



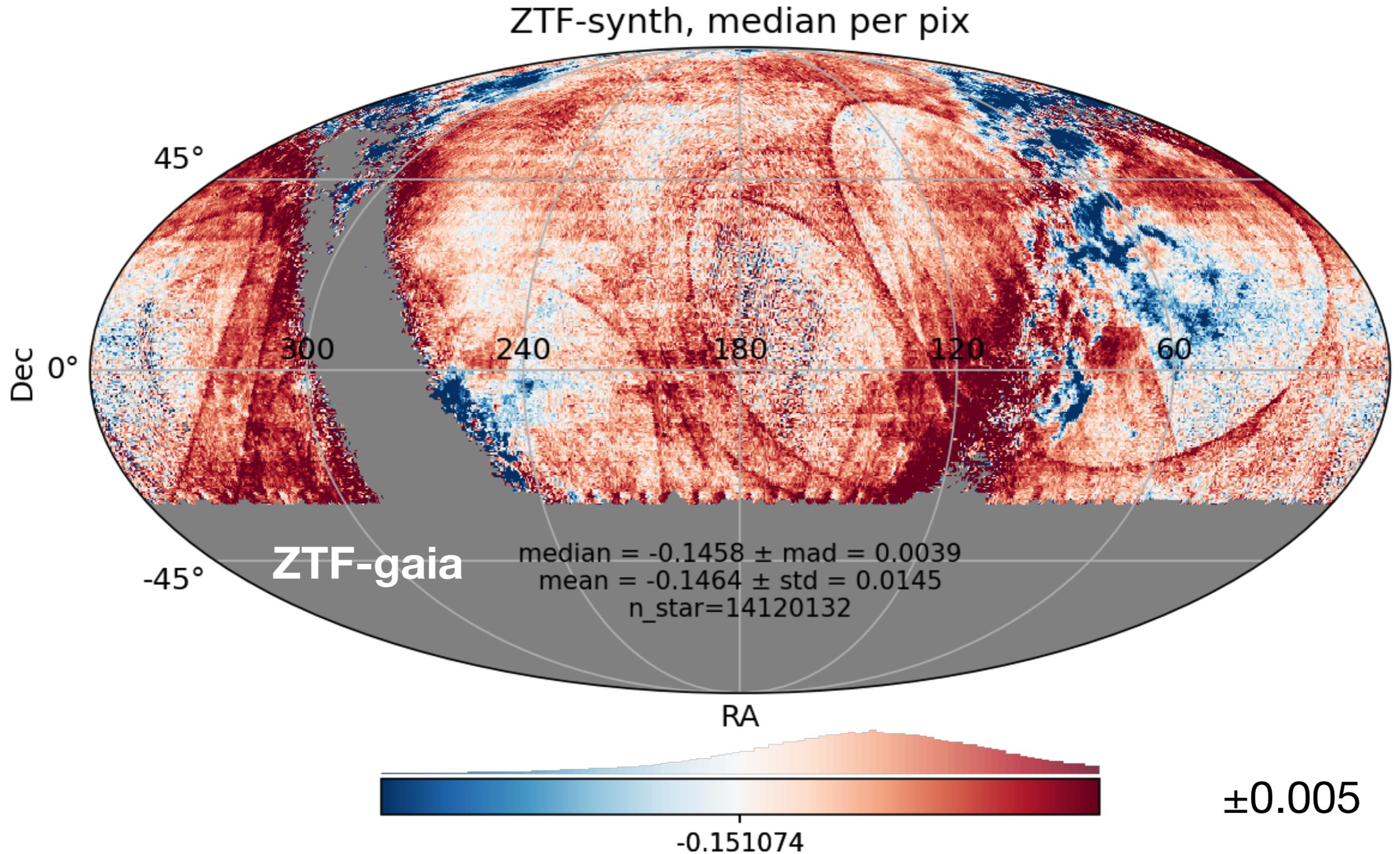
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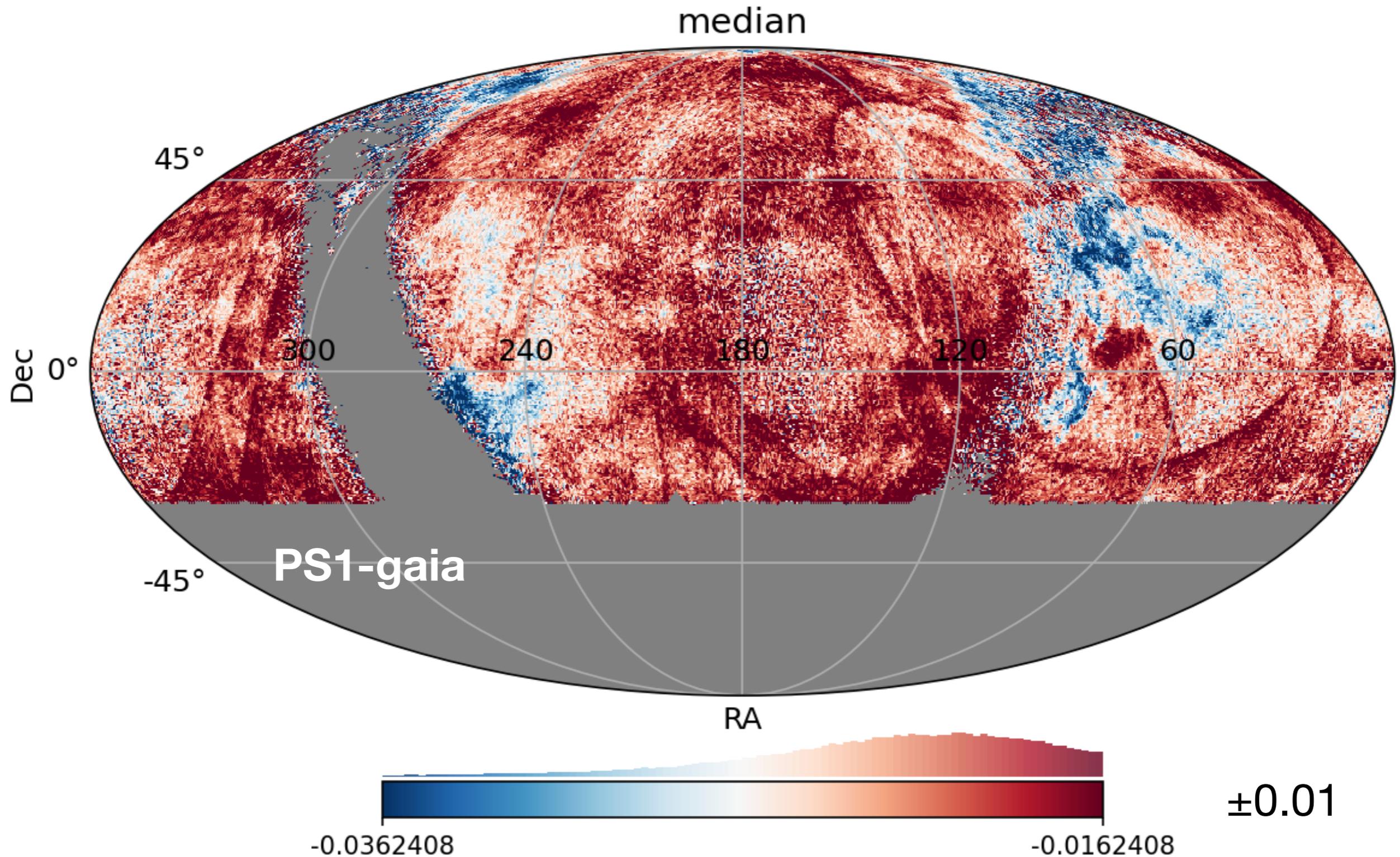
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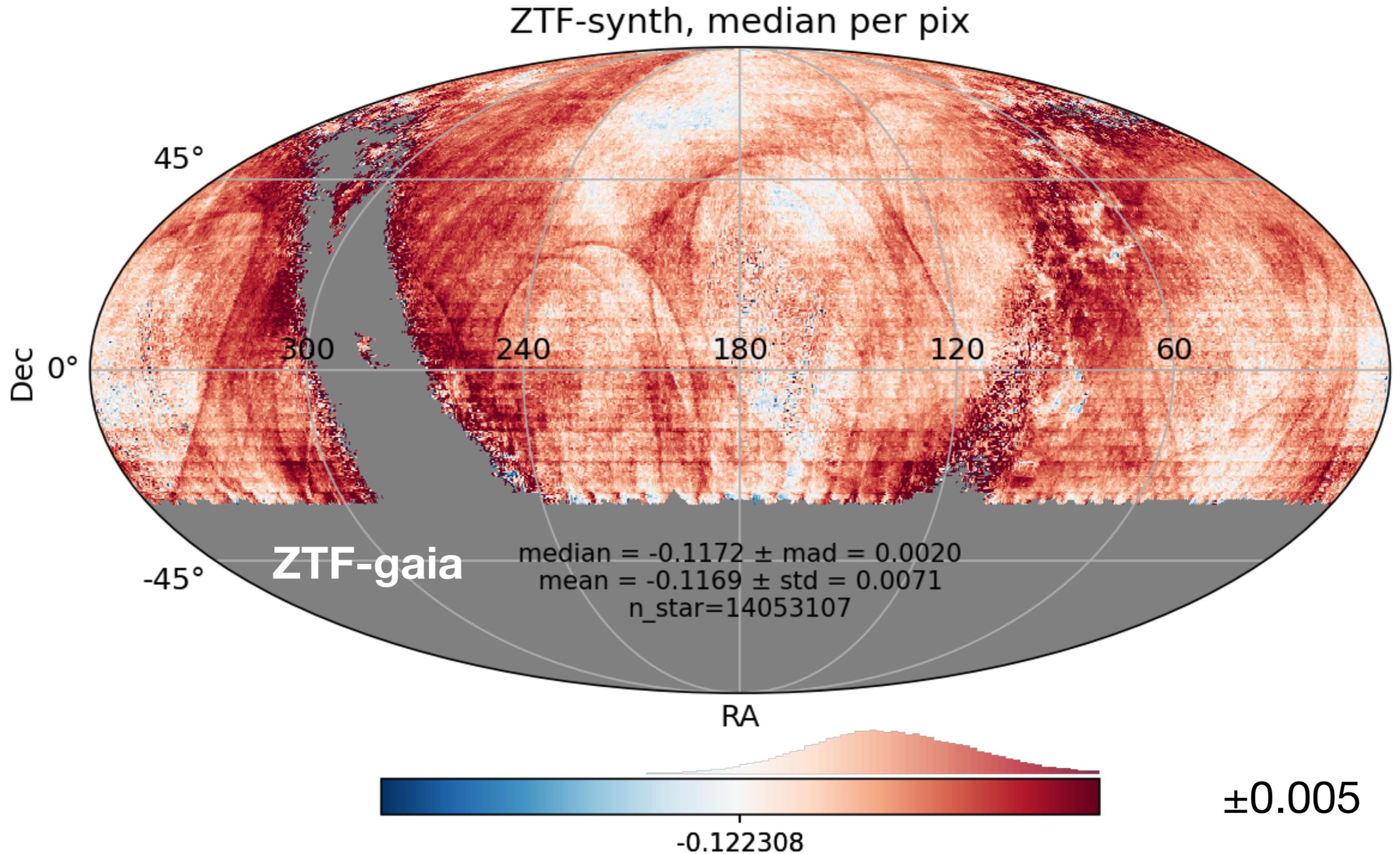
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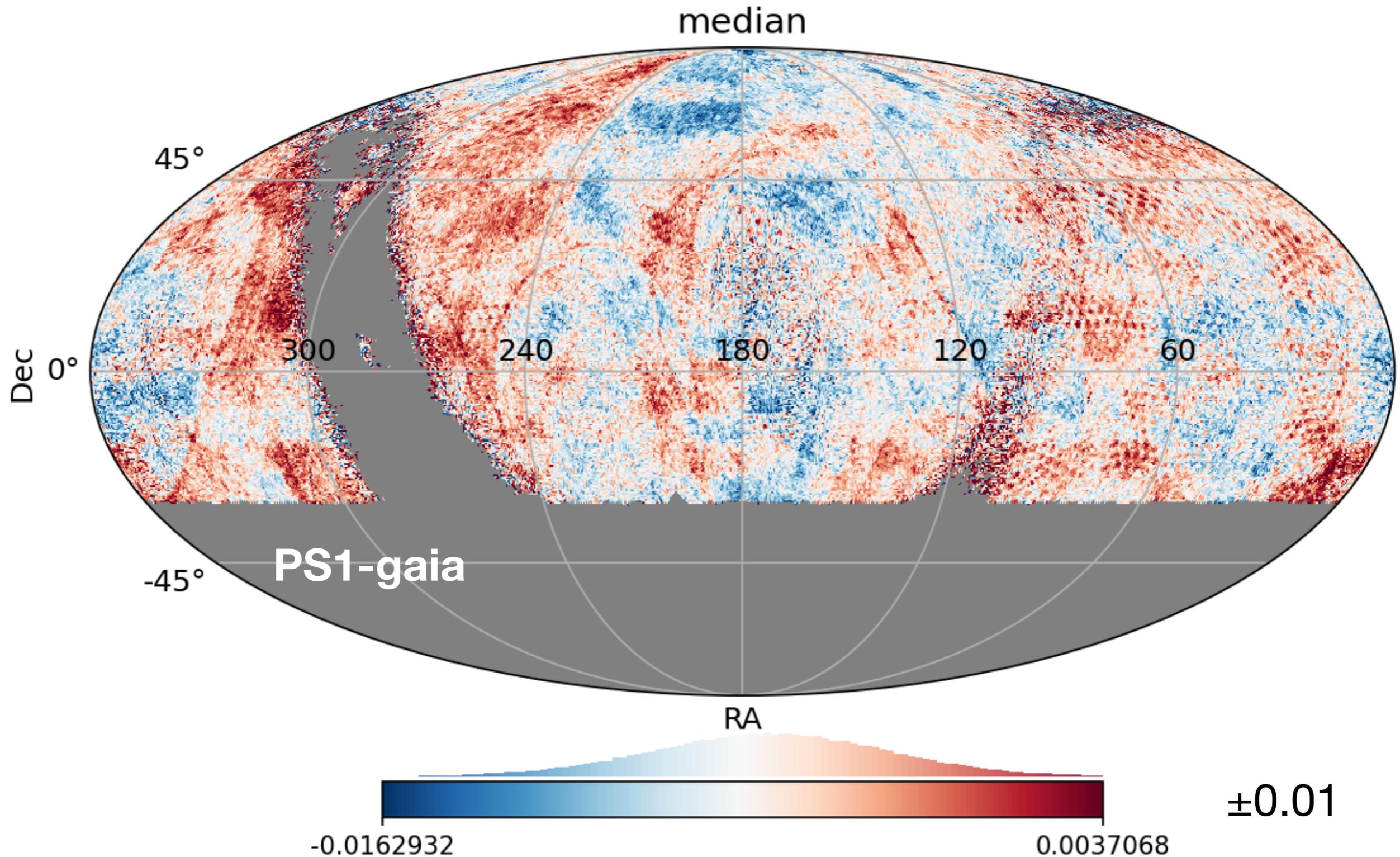
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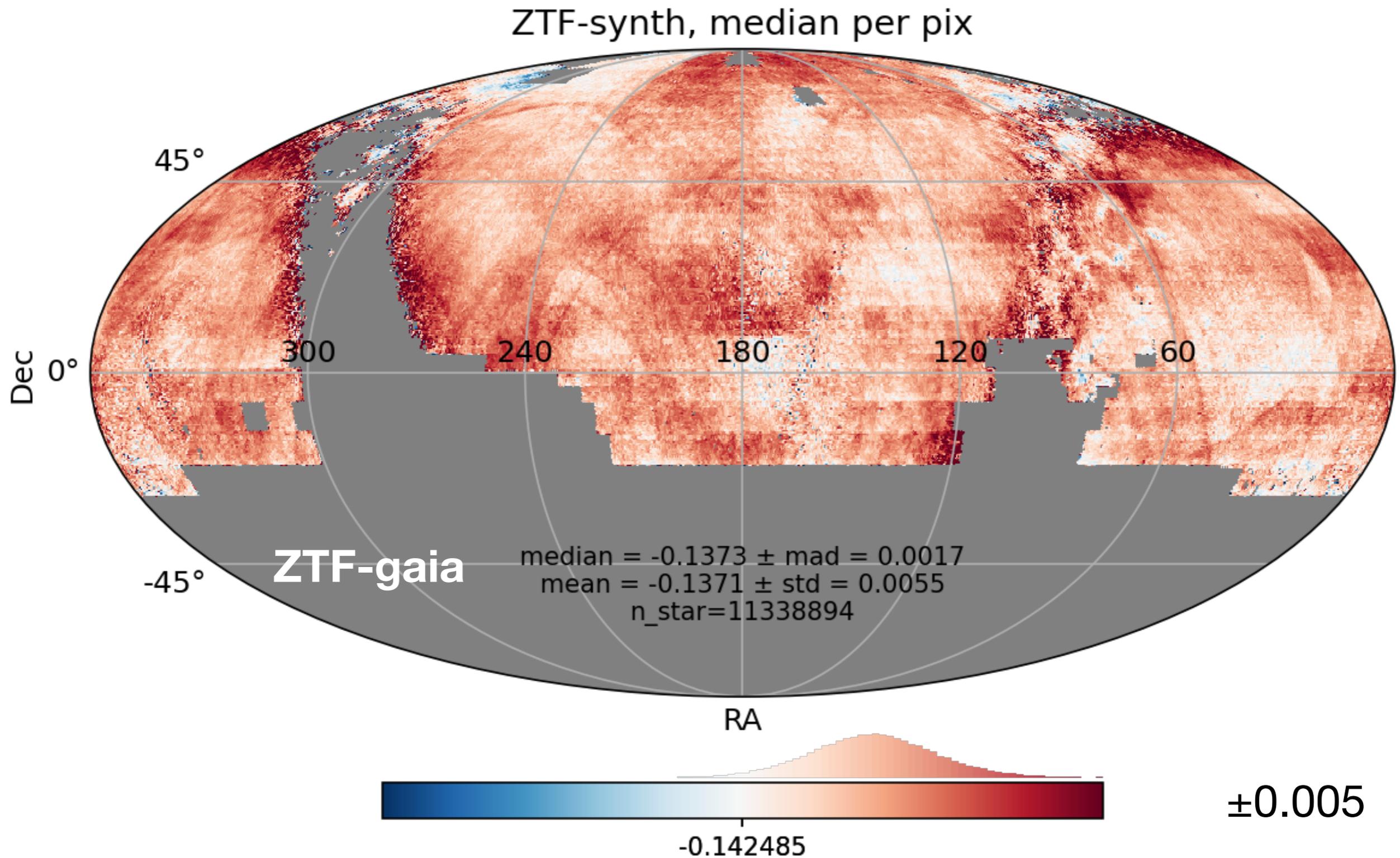
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- used bbf using for now "ztf2" filters



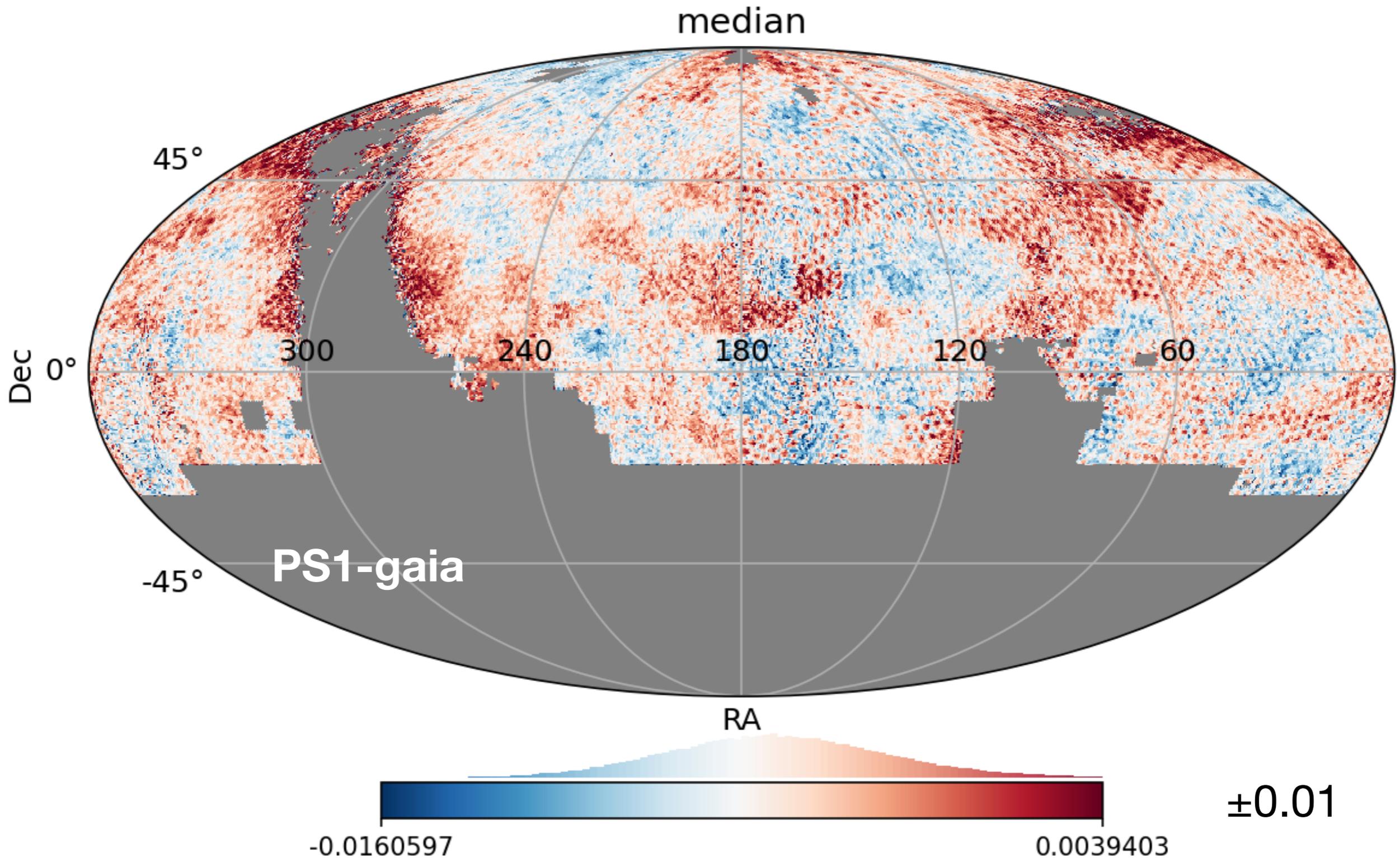
# Comparison to Gaia Synth

- used bbf using for now "ztf2" filters



# Comparison to Gaia Synth

- used bbf using for now "ztf2" filters



# ZTF-g

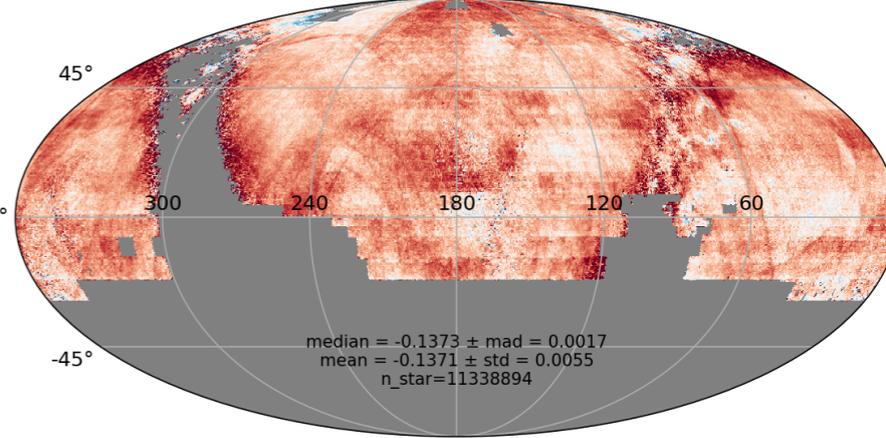
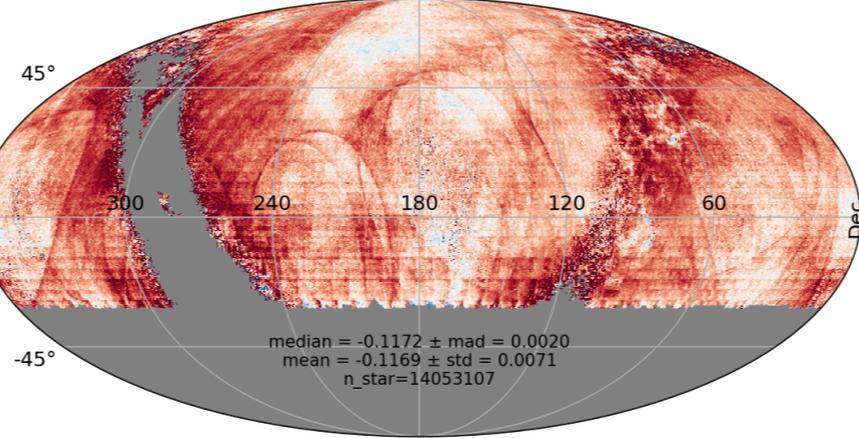
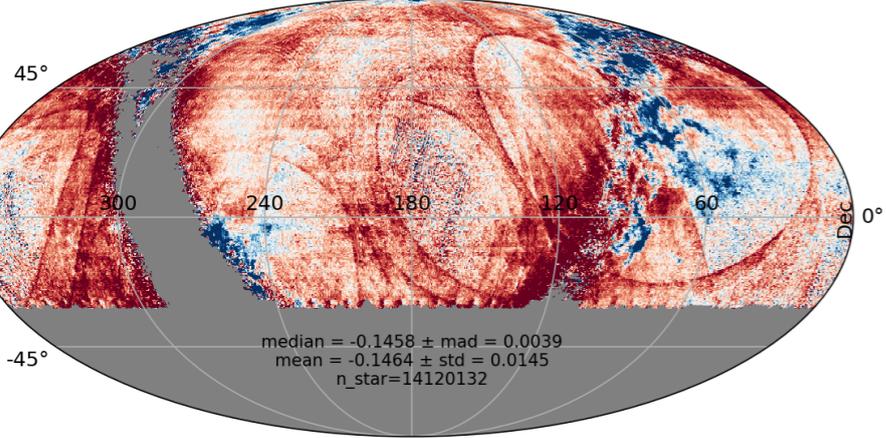
# ZTF-r

# ZTF-i

ZTF-synth, median per pix

ZTF-synth, median per pix

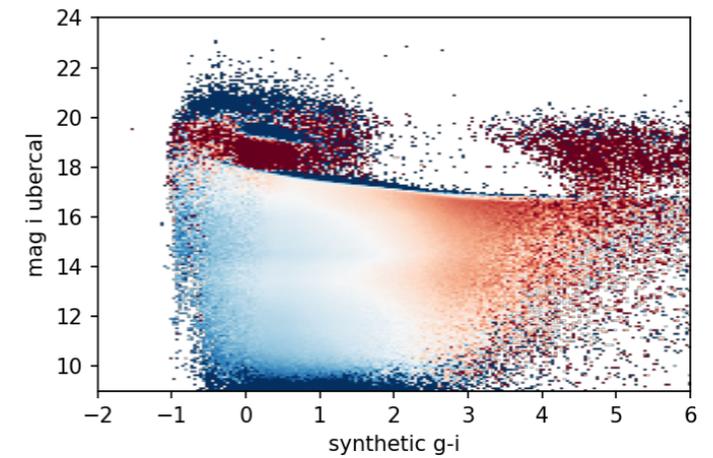
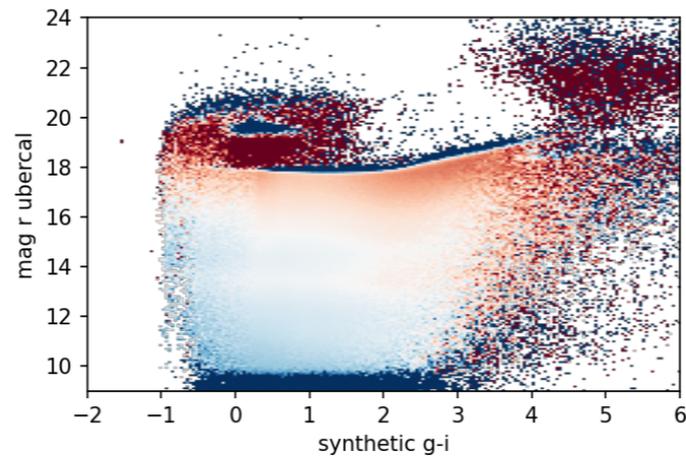
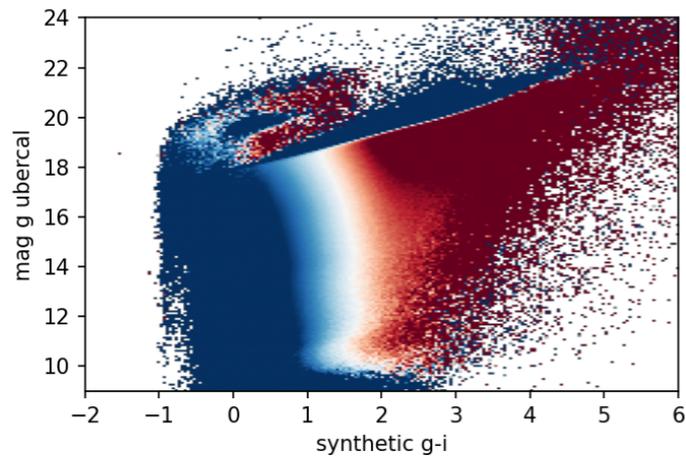
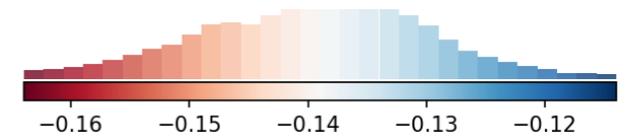
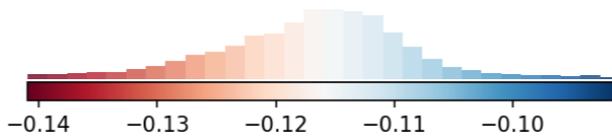
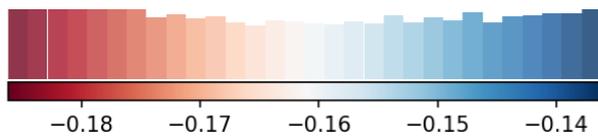
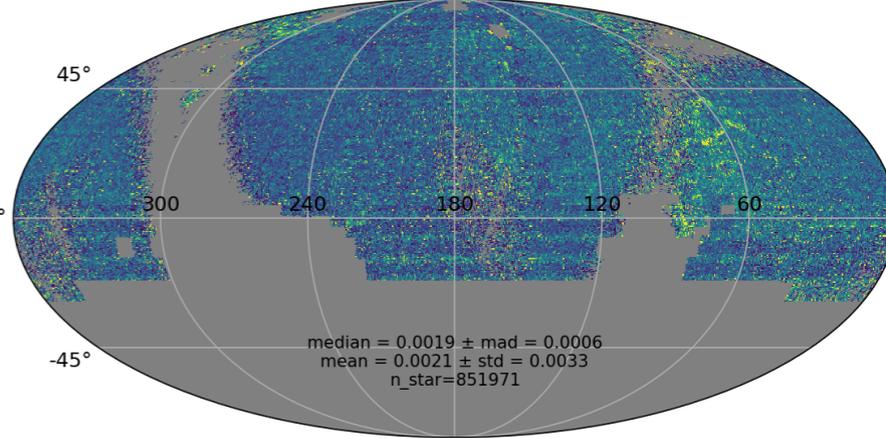
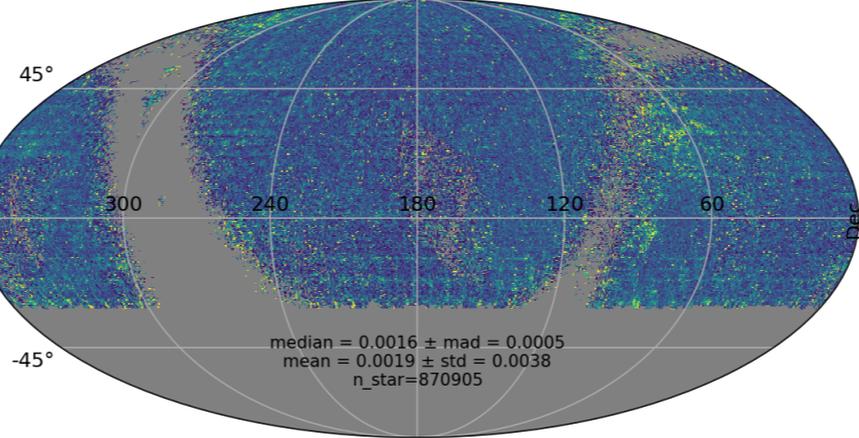
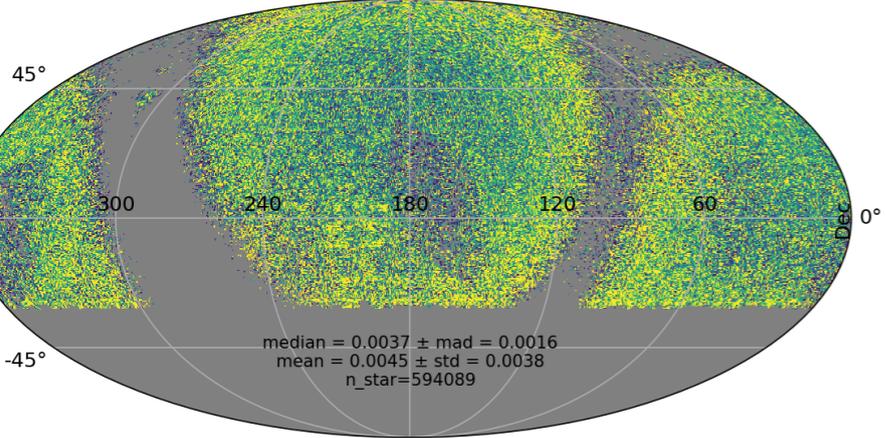
ZTF-synth, median per pix



ZTF-synth, mad per pix

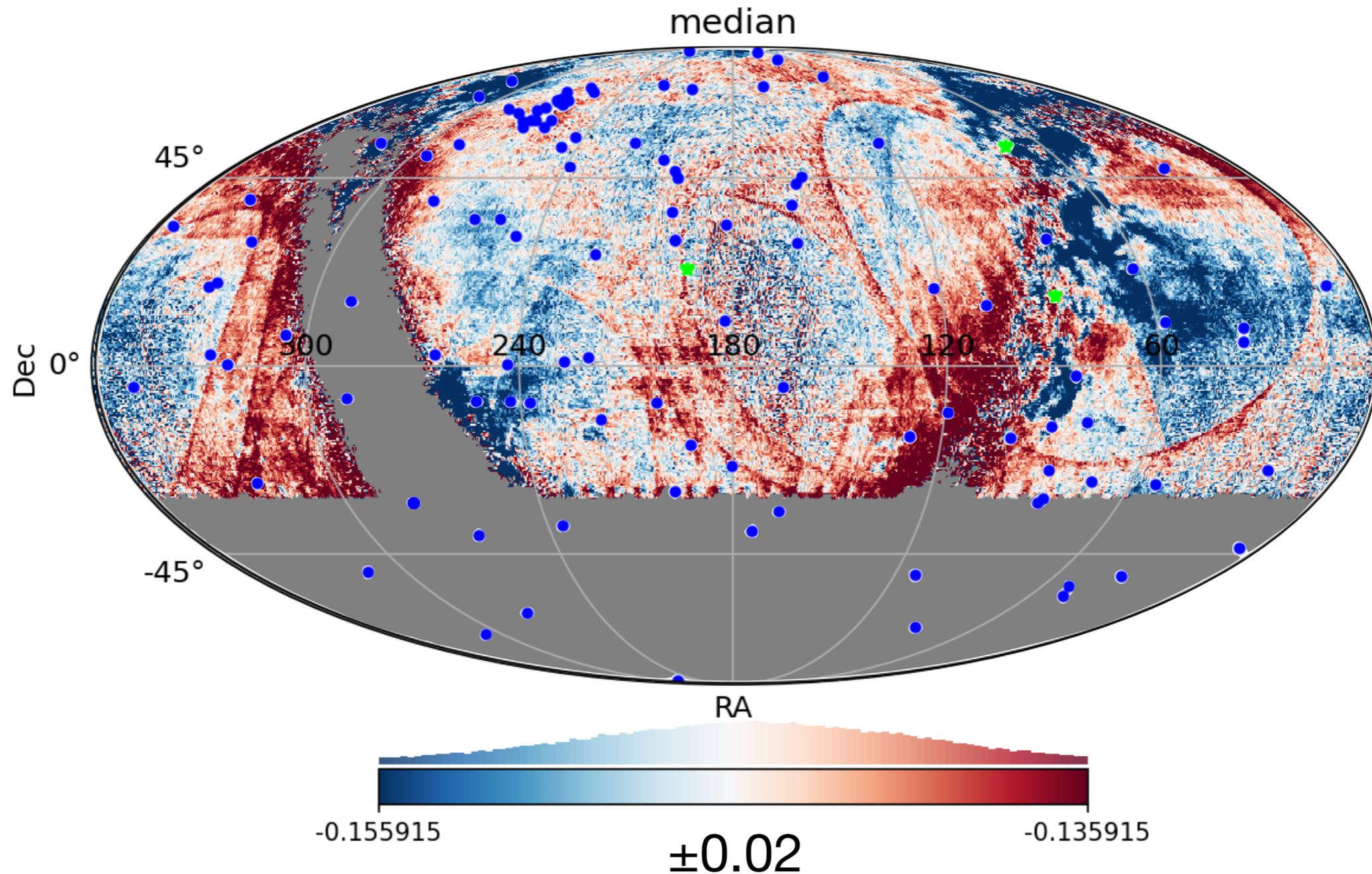
ZTF-synth, mad per pix

ZTF-synth, mad per pix



# Comparison to Gaia Synth

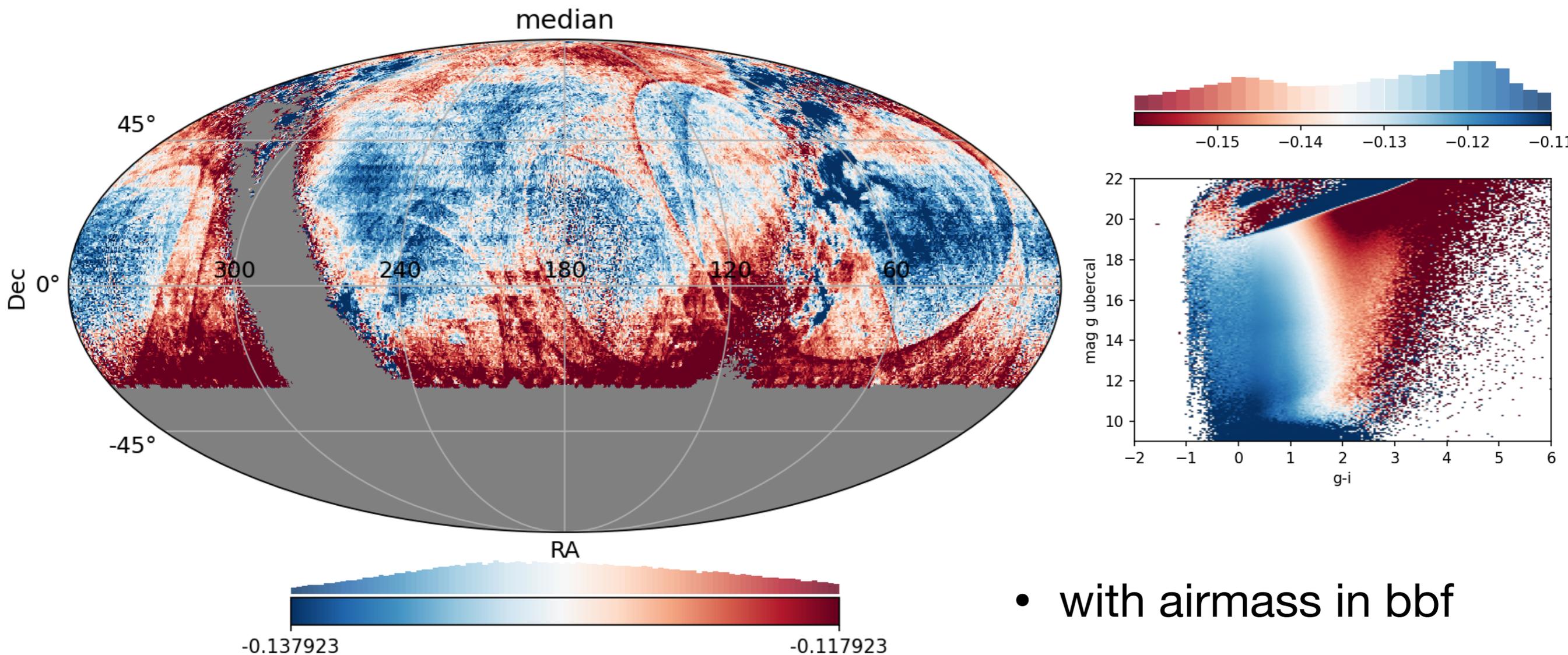
- used bbf using for now "ztf2" filters



# Comparison to Gaia Synth

- used bbf using for now "ztf2" filters
- Option to add airmass in bbf, but here, we give ubercal at "no airmass", i.e. out of atmosphere.

$$m_{obs} - m_{ps_g} = \alpha_{r,i} * (m_{ps_g} - m_{ps_{r,i}}) + ZP(t_{exposure}) + k(t_{night}) * \text{airmass} + \delta ZP(u, v)$$



- with airmass in bbf

# Comparison to Gaia Synth

- used bbf using for now "ztf2" filters
- Option to add airmass in bbf, but here, we give ubercal at "no airmass", i.e. out of atmosphere.

$$m_{obs} - m_{ps_g} = \alpha_{r,i} * (m_{ps_g} - m_{ps_{r,i}}) + ZP(t_{exposure}) + k(t_{night}) * \text{airmass} + \delta ZP(u, v)$$

