IAA 1.9: Atmosphere aerosol remote sensing in the Aerosol-UA project: experimental payload and processing algorithm

Status report for Paris IAA meeting, March 2019

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Ukrainian satellite mission Aerosol-UA: atmospheric aerosol polarimetric investigations

Three segments of the project:

Satellite:

ScanPol + MSIP

Data processing:

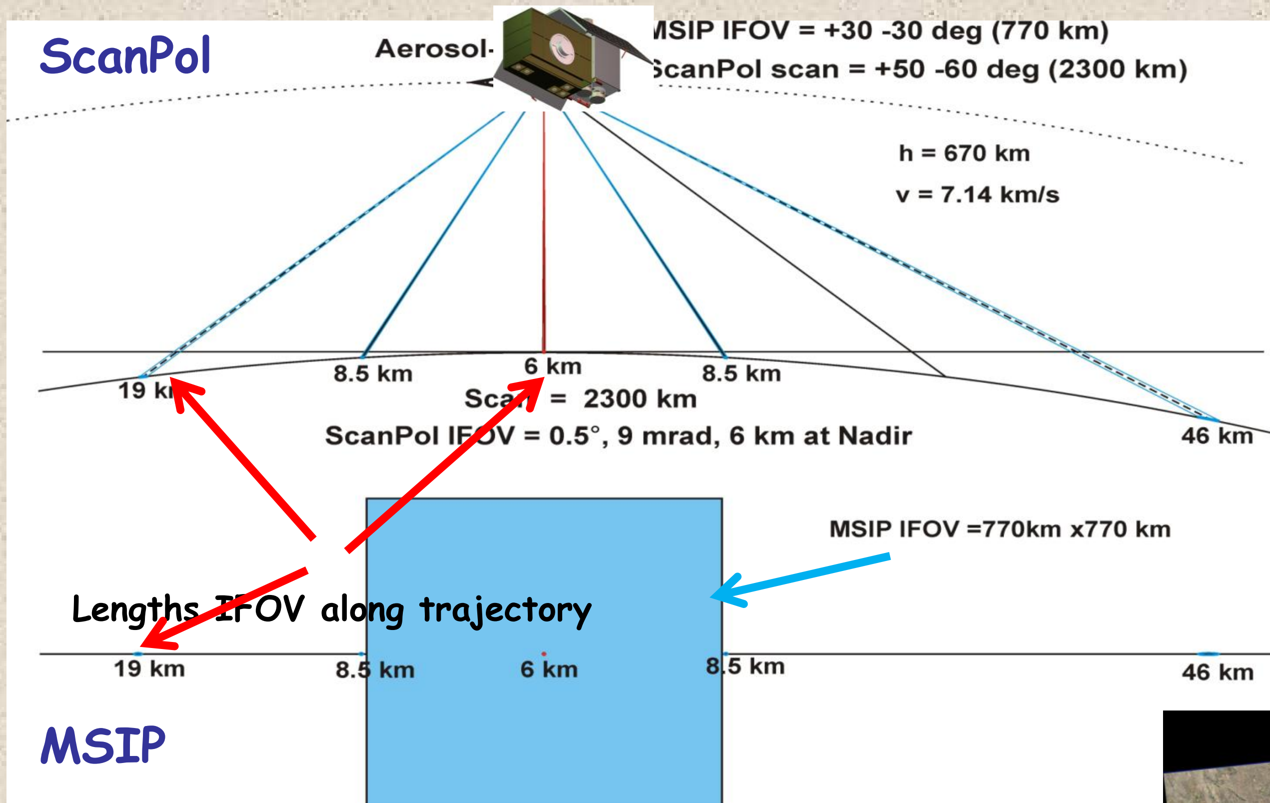
Mission products

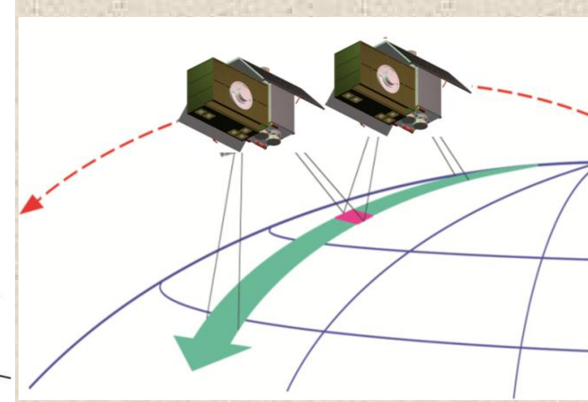
AERONET:

Validation

Idea for Aerosol-UA project come from Glory experiment and APS instrument

Aerosol-UA measurements geometry

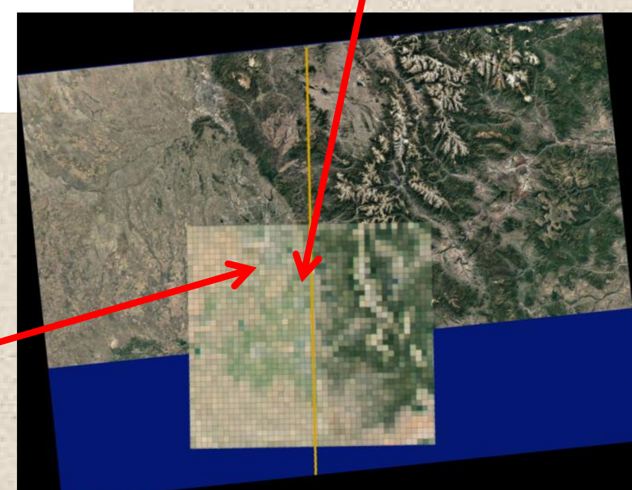




ScanPol track

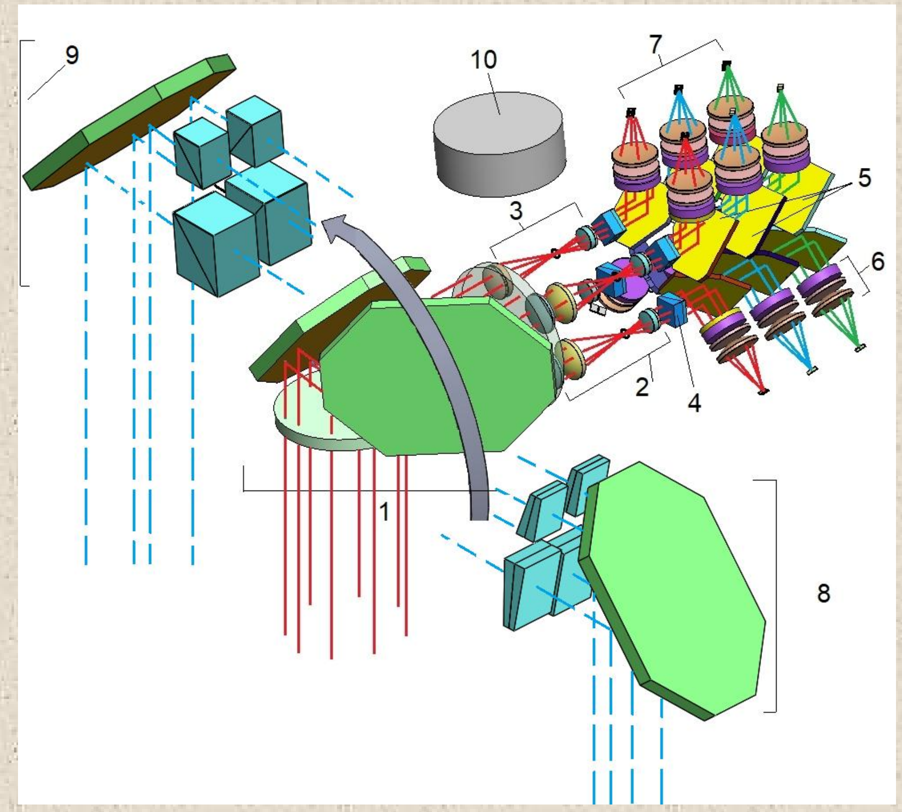
Field-Of-View
MSIP and ScanPol

MSIP



ScanPol polarimeter final optical design, updated in 2019

Spectral band: 370-1610 nm, six spectral channels:



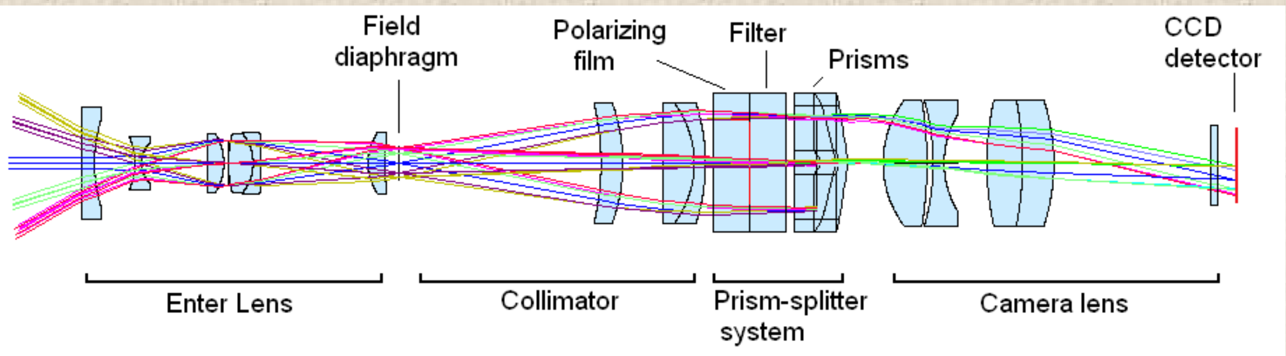
370 nm – tropospheric aerosol and top of clouds
410 nm – aerosol over ocean and surface
555 нм – aerosol over ocean and surface, ocean color
865 nm – aerosol over ocean and surface
1378 nm – separate cirrus clouds, stratosphere aerosol, separation of troposphere and stratosphere aerosol in case of volcanic eruption
1610 nm – separation surface signal from aerosol over Earth' surface

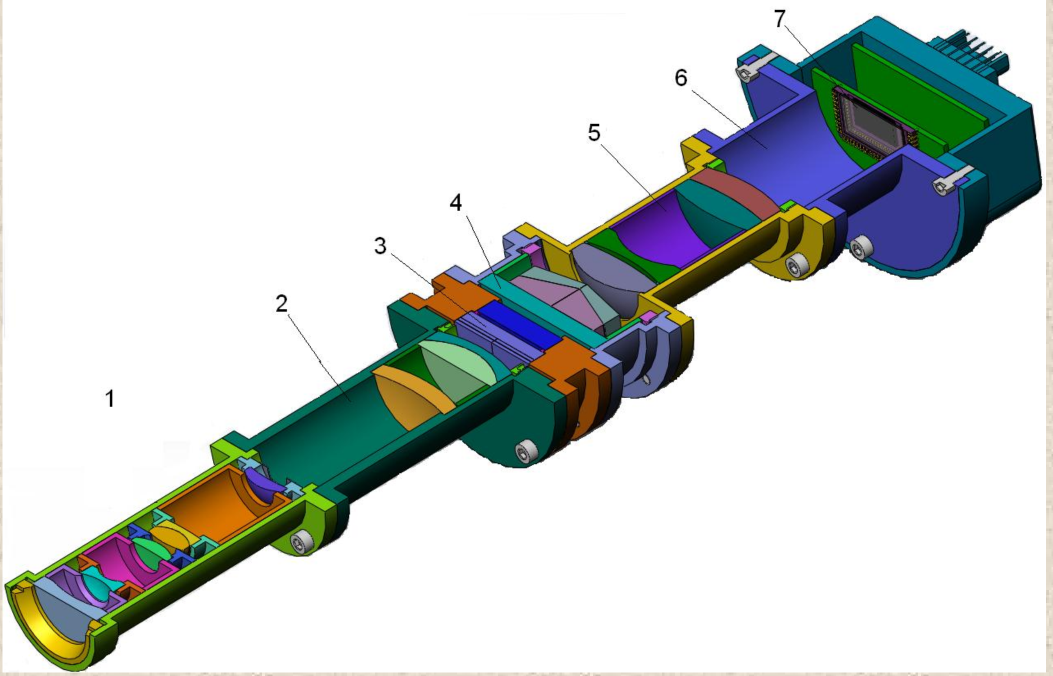
Filter ½ width 20 - 60 nm

Observable Stokes parameters: I, Q, U (0,90,45,135°)
Photometric accuracy: 4%
Polarimetric accuracy: 0.15%
On-board calibration: all three Stokes parameters

ScanPol is similar to APS Glory

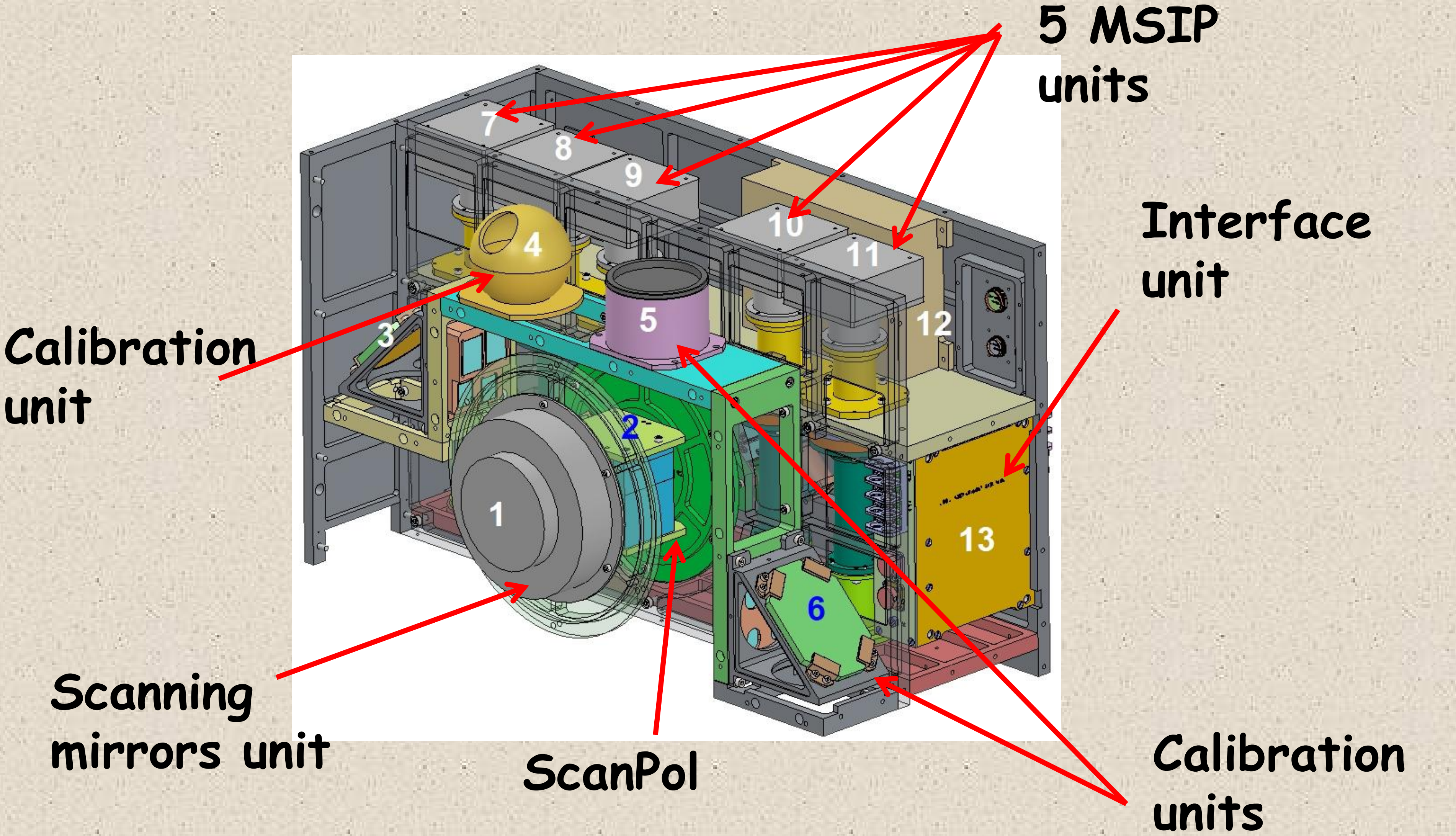
MSIP optic modeling



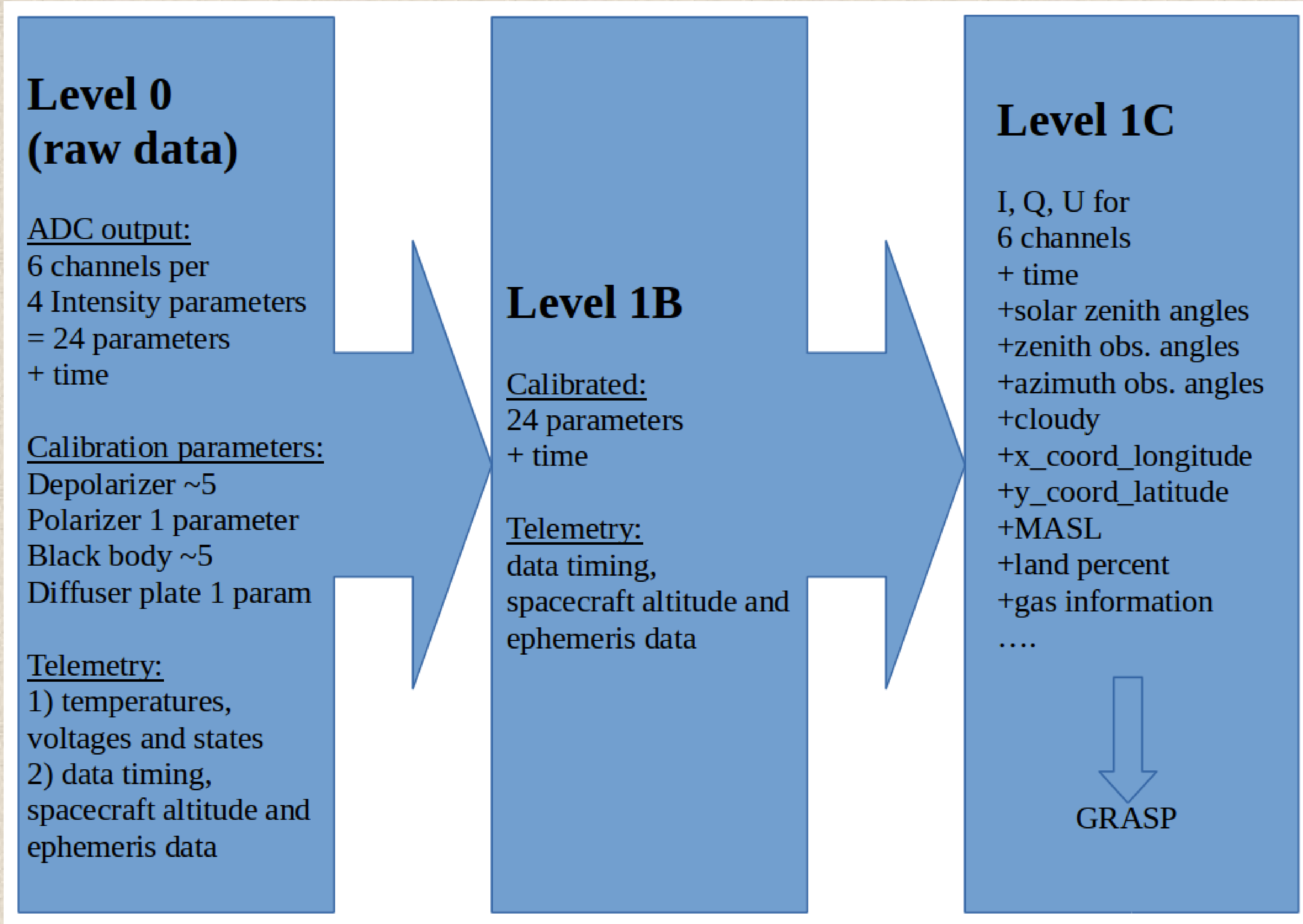


1- input lens;
2- collimator;
3- polarizer and filter;
4- prism image splitting system;
5- camera lens;
6- junction;
7- CMOS sensor

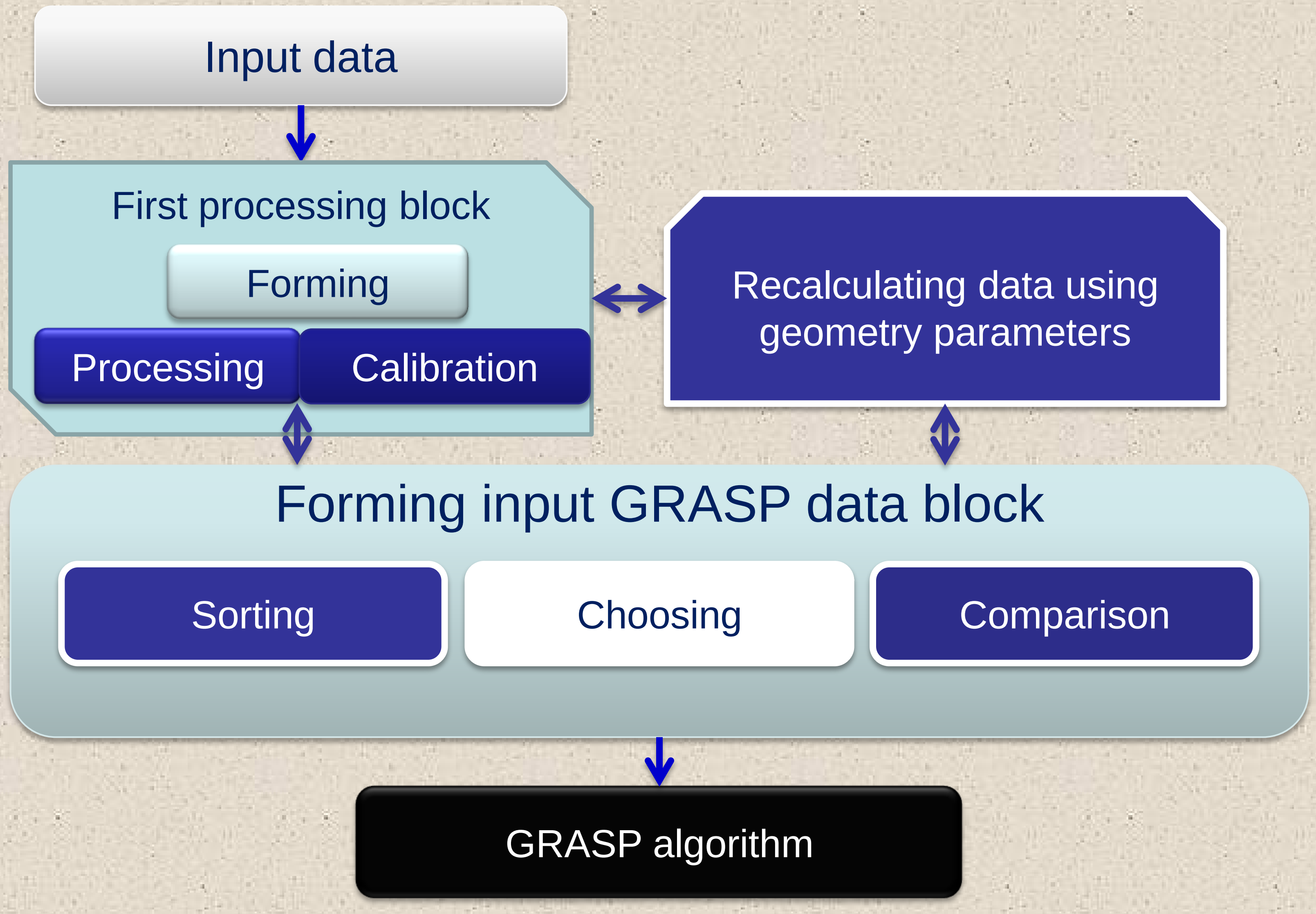
ScanPol and MSIP polarimeters: corrected final design for YuzhSat platform



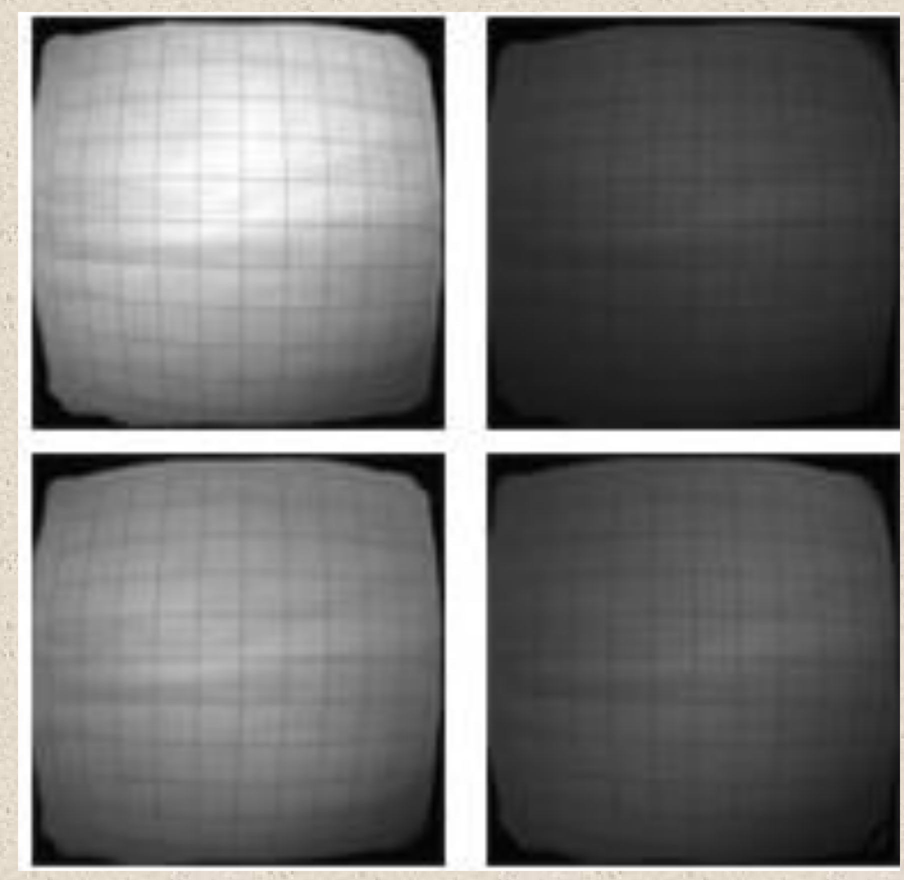
ScanPol data processing structure



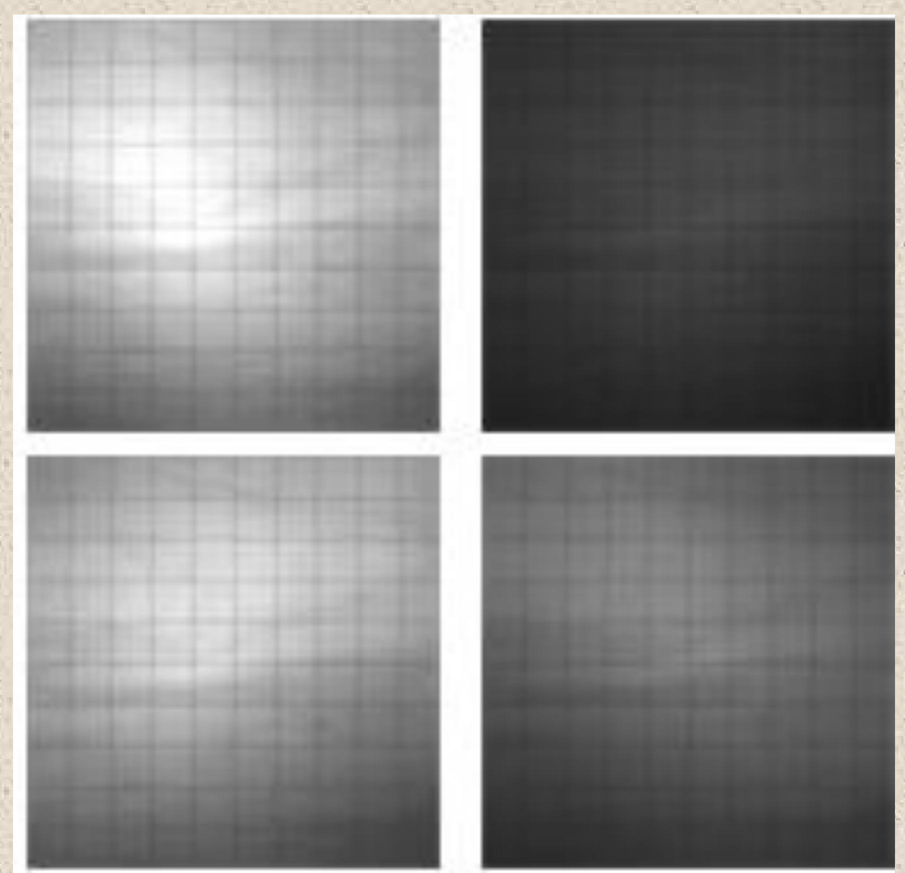
MSIP data processing scheme



MSIP image distortion compensation

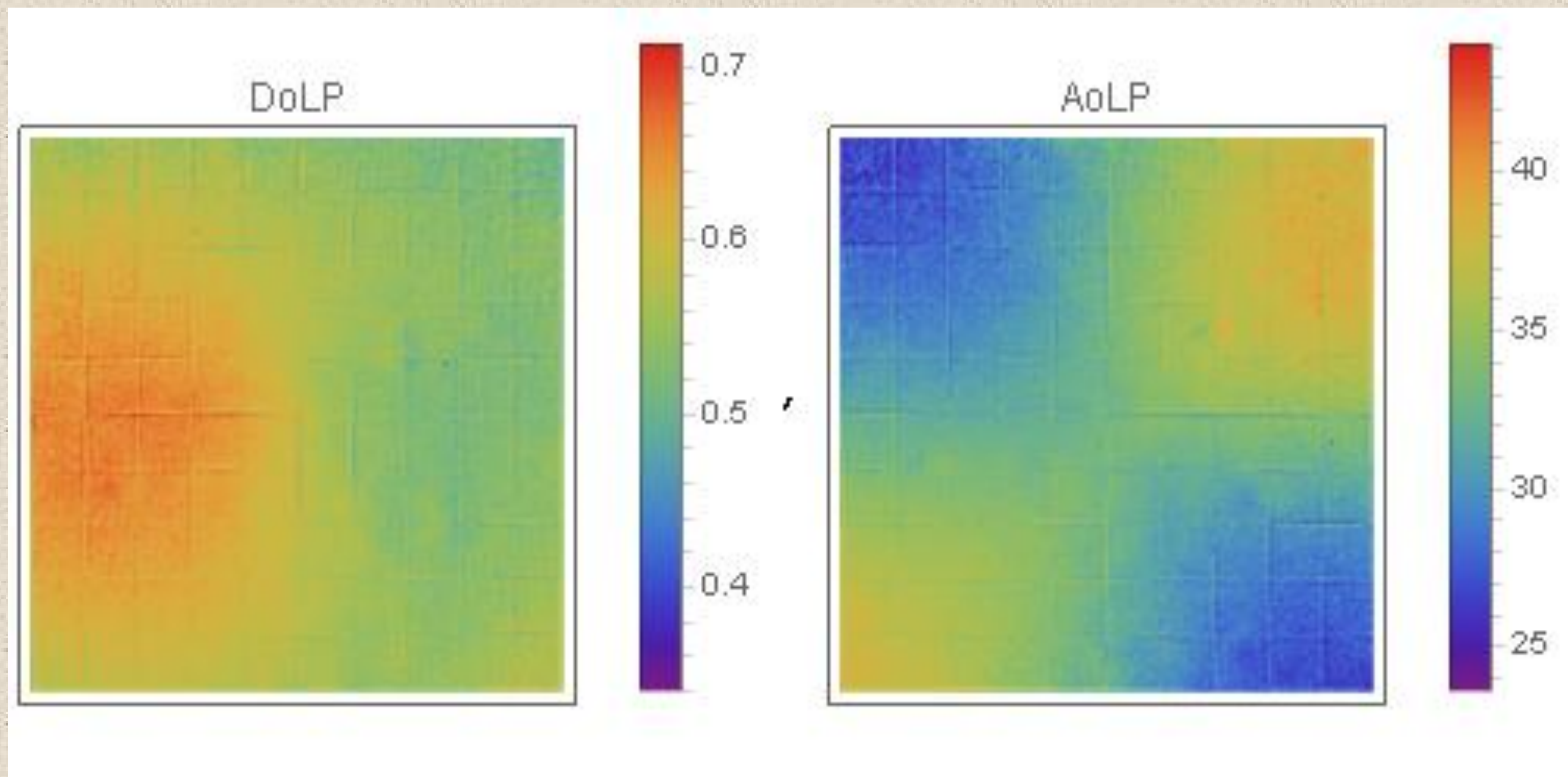


Use of gauge grids (view in polarized light)



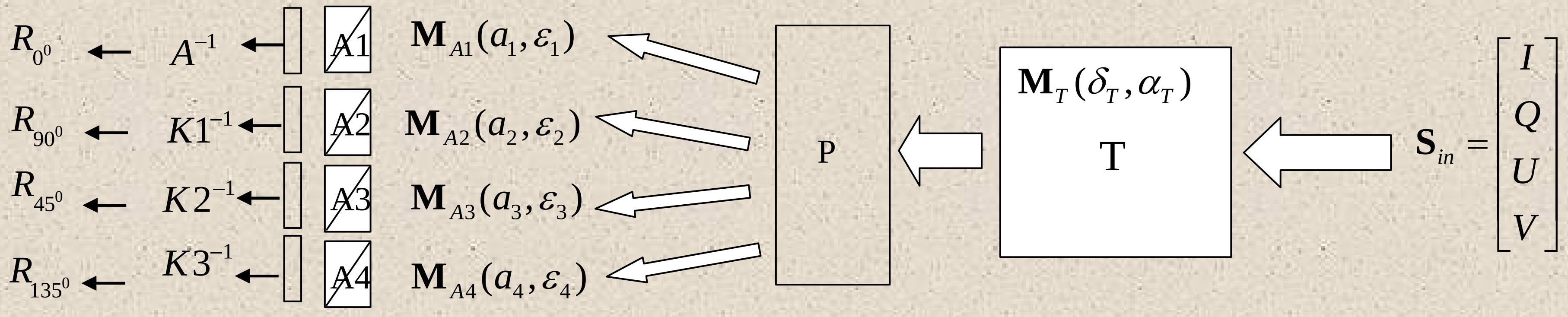
After applying the distortion compensation algorithm

Polarization calibration of MSIP



Determination of degree (DoLP) and angle (AoLP) polarization of linearly polarized input light in an uncalibrated MSIP channel

MSIP data processing model



Muller matrix method is used.

The model takes into account:

polarization distortion of lenses and film polarizers

the difference of the polarization-independent light intensity transfer coefficients in the conjugate polarization sub channels (A, K)

Distortion compensation algorithm

MSIP polarization light calibration

General analytic expression for a signal detected in a pixel

$$RD_{\alpha_A} = K^{-1} \times \left[M_A(a,\varepsilon) \times M_T(\delta,\alpha) \times \left[I \quad Q \quad U \quad 0 \right]^T \right]_0 =$$

$$= \left[Q \left[\cos\left(2\alpha_A + \varepsilon\right) \left[\left(\cos(\delta) - 1\right) \sin^2(2\alpha) + 1 \right] - \tfrac{1}{2} \sin\left(2\alpha_A + \varepsilon\right) \sin(4a) \left(\cos(\delta) - 1\right) \right] + \right.$$

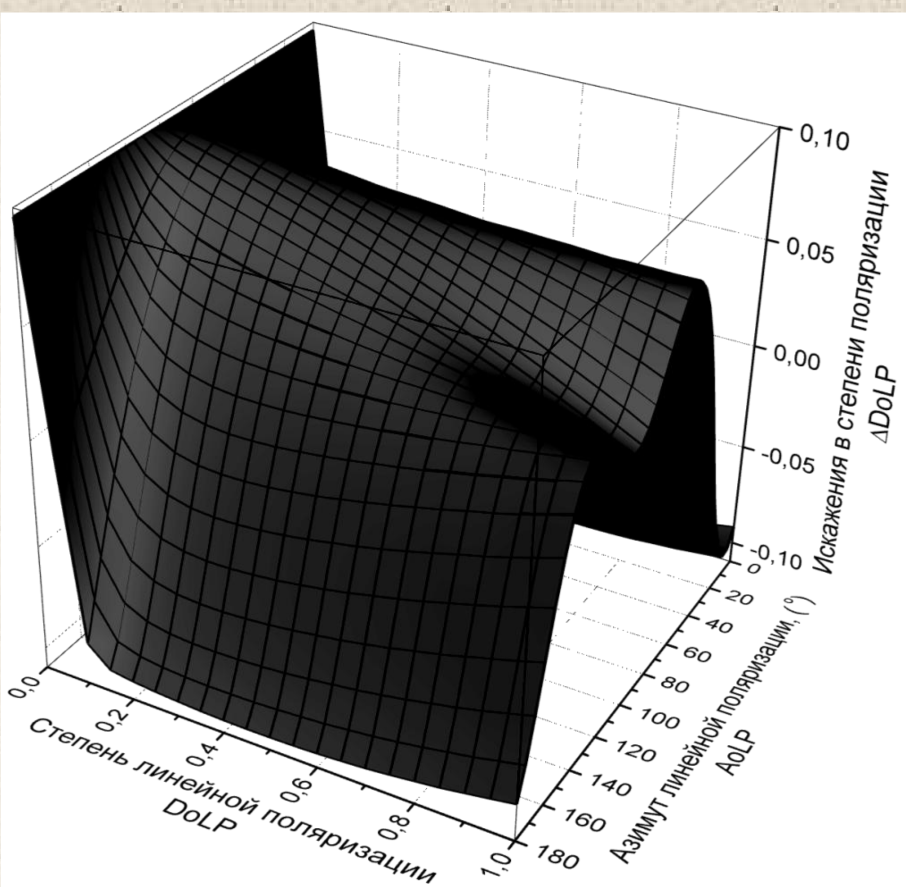
$$\left. + U \left[\sin\left(2\alpha_A + \varepsilon\right) \left[\left(\cos(\delta) - 1\right) \cos^2(2\alpha) + 1 \right] - \tfrac{1}{2} \cos\left(2\alpha_A + \varepsilon\right) \sin(4a) \left(\cos(\delta) - 1\right) \right] \right] K^{-1} a^{-1} +$$

$$+ I K^{-1}$$

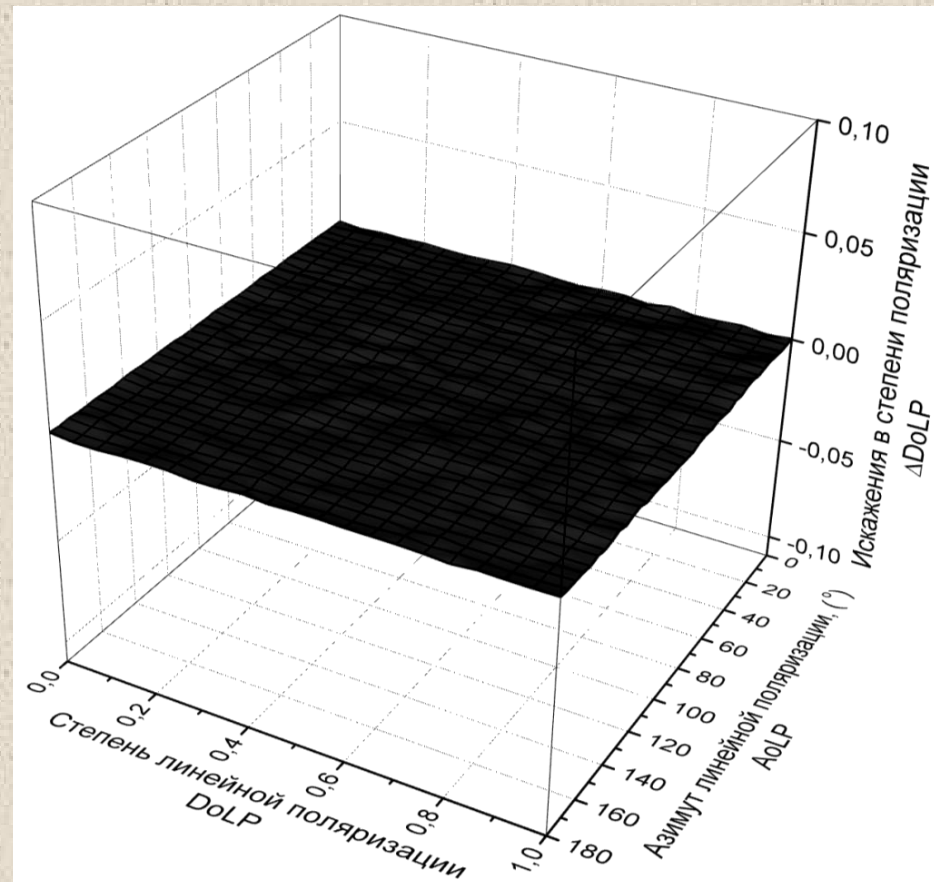
To estimate the calibration parameters and compensate for polarization distortion, it is planned to use reference sources with linearly polarized light.

MultiSpectral Imaging Polarimeter test measurements

DoLP corrections



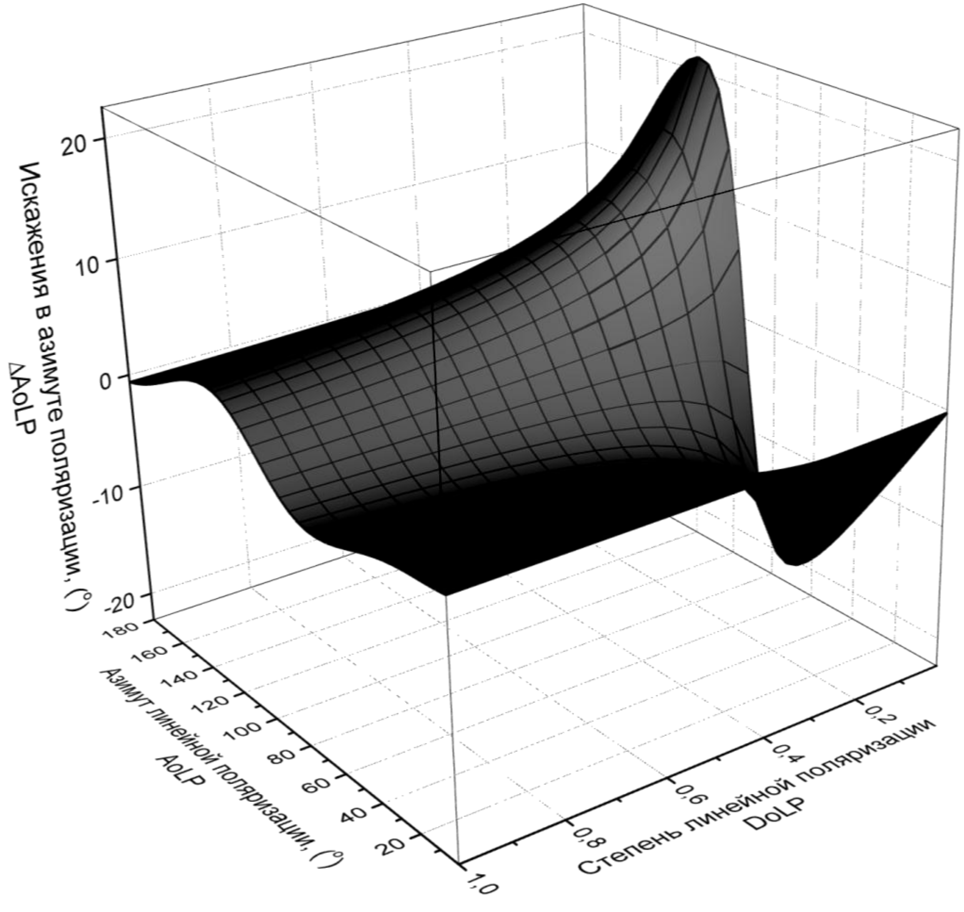
Before calibration



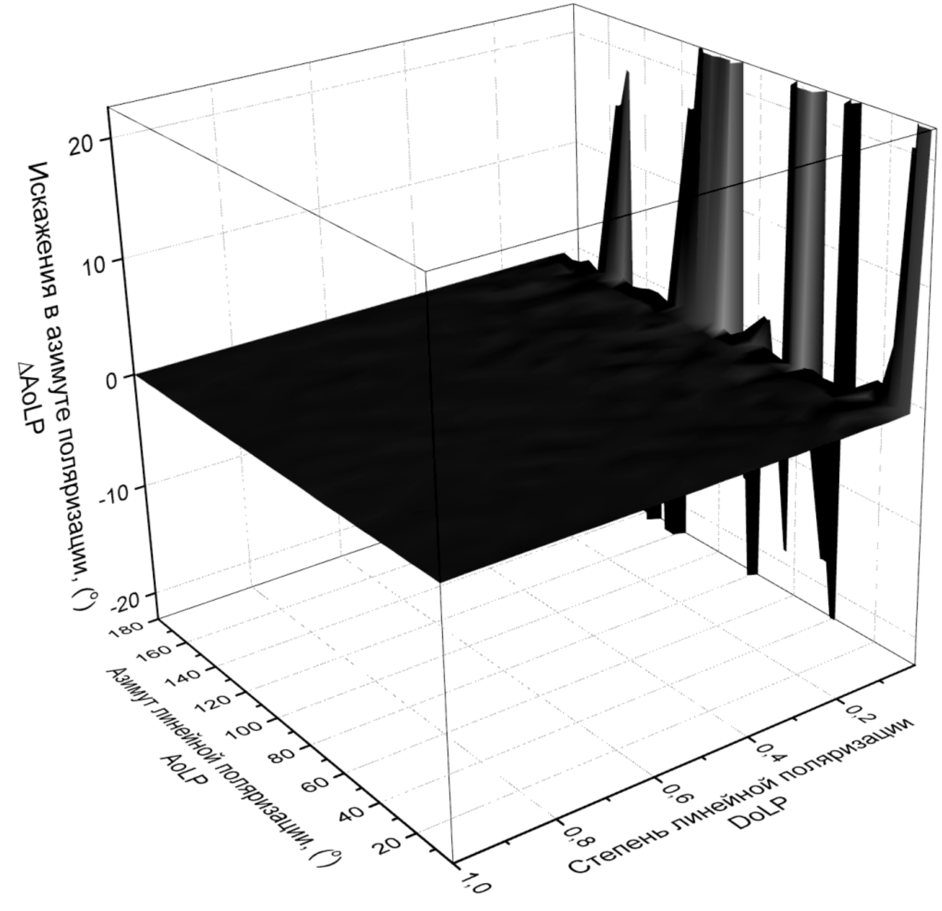
After calibration

MultiSpectral Imaging Polarimeter model calibration

AoLP



Before calibration



After calibration

ScanPol and MSIP polarimeters onboard of YuzhSat platform

Satellite platform YuzhSat designed by State Design Office "Yuzhnoe"

Characteristics of payload

Orbit

Type: sun-synchronous

Inclination: ~98°

Altitude: ~705 km

YuzhSat platform:

Pointing accuracy: ~0.1°

Total mass of scientific payload estimated: ~22 kg

Power for payload: ≤ 25 W

Design life: >3 years

Updated Timeline

Aerosol-UA mission has been included into State Space Program – 2018

State Space Program to be adopted – 2019

Aerosol-UA payload experimental model - 2019

Aerosol-UA flight payload ready – 2020

Aerosol-UA flight payload testing – 2021

Aerosol-UA launch (planned) – 2022