IAA. 1.9: Aerosol-UA - Satellite remote sensing of aerosols in the Earth atmosphere

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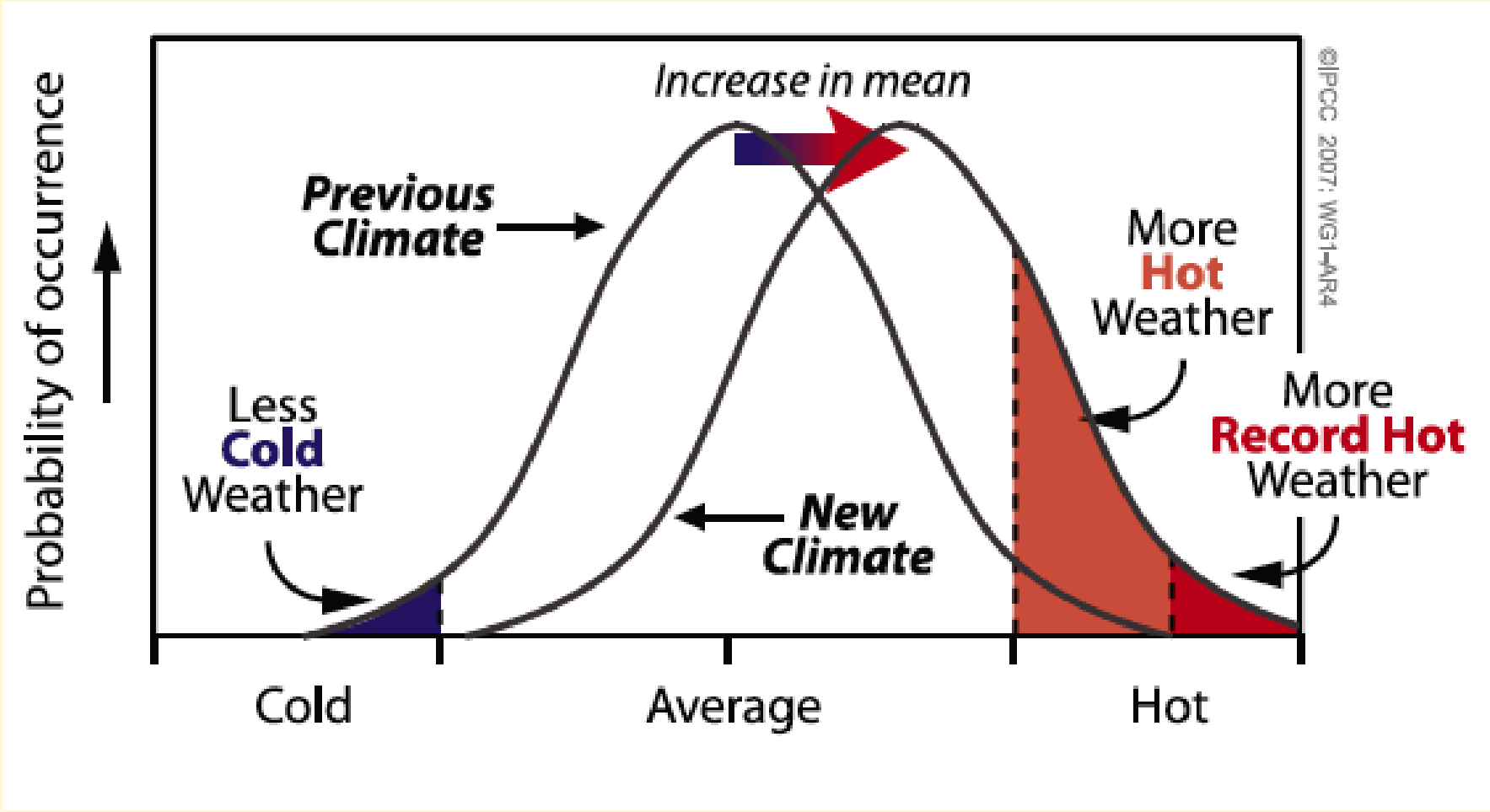
Forest fire near Kyiv (200 km) from 10km altitude, November 1, 2015

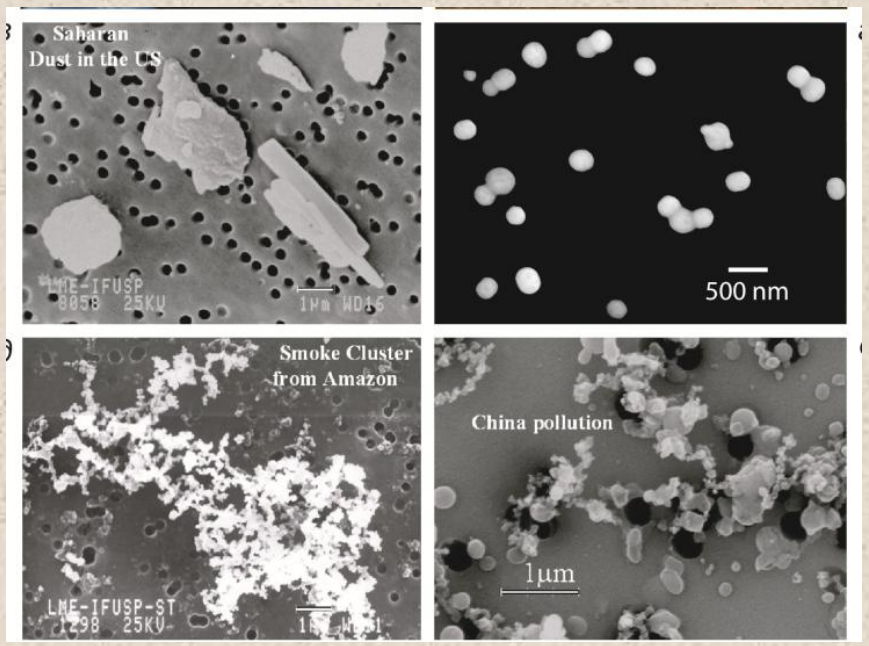
Climate system shift



Box TS.5, Figure 1. *Schematic showing the effect on extreme temperatures when the mean temperature increases, for a normal temperature distribution.*

Atmospheric aerosol, shape and size

Saharan dust



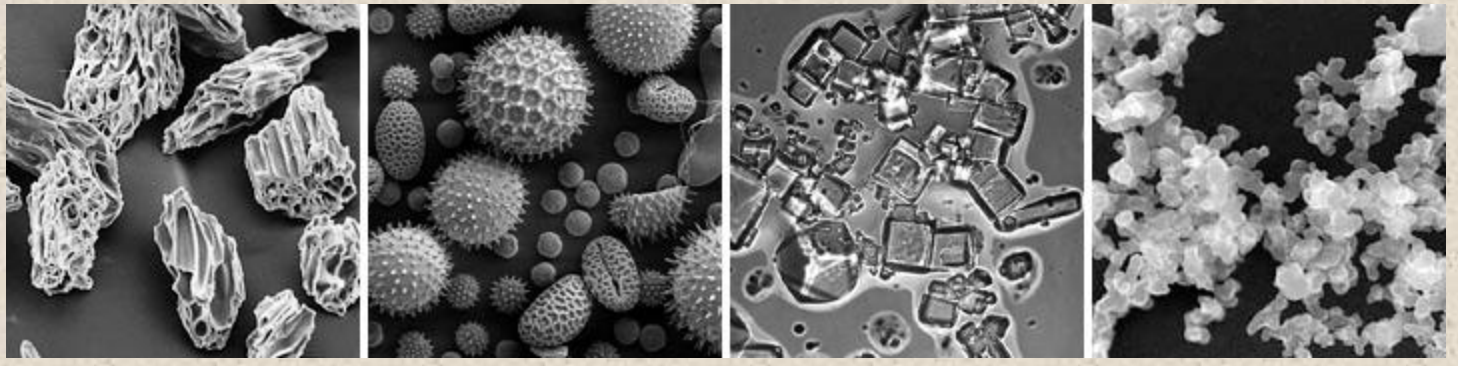
Pollen

China pollution

Smoke cluster

Typical size 0.001–20 µm

Lot of types natural and industrial/ anthropogenic aerosols

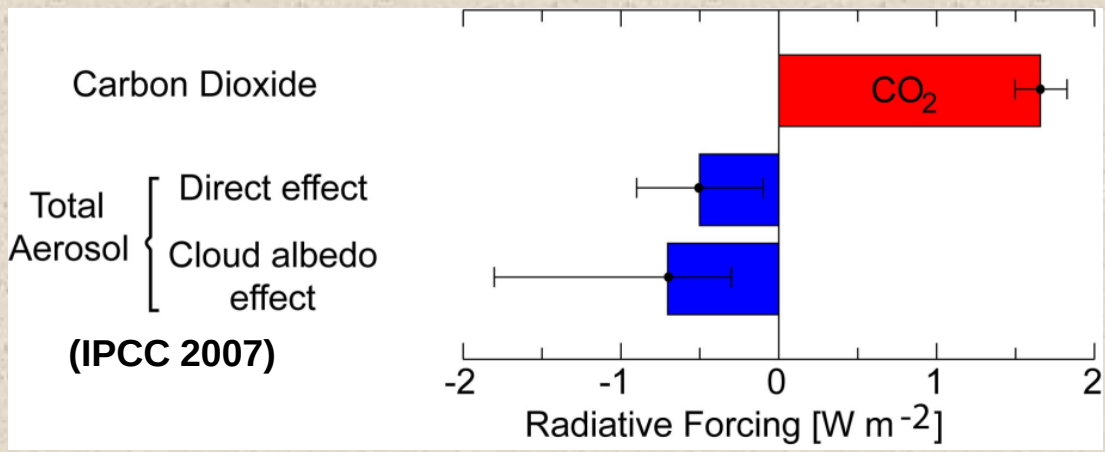


Volcanic ash | Pollen | Sea salt | Soot

Microphysics of aerosol for climate models

Atmospheric aerosols **direct climate impact** by absorbing and reflecting sunlight producing heating or cooling

Aerosols also cause **indirect cooling effect** by modulating cloud properties: increased numbers of aerosols lead to larger numbers of smaller cloud droplets

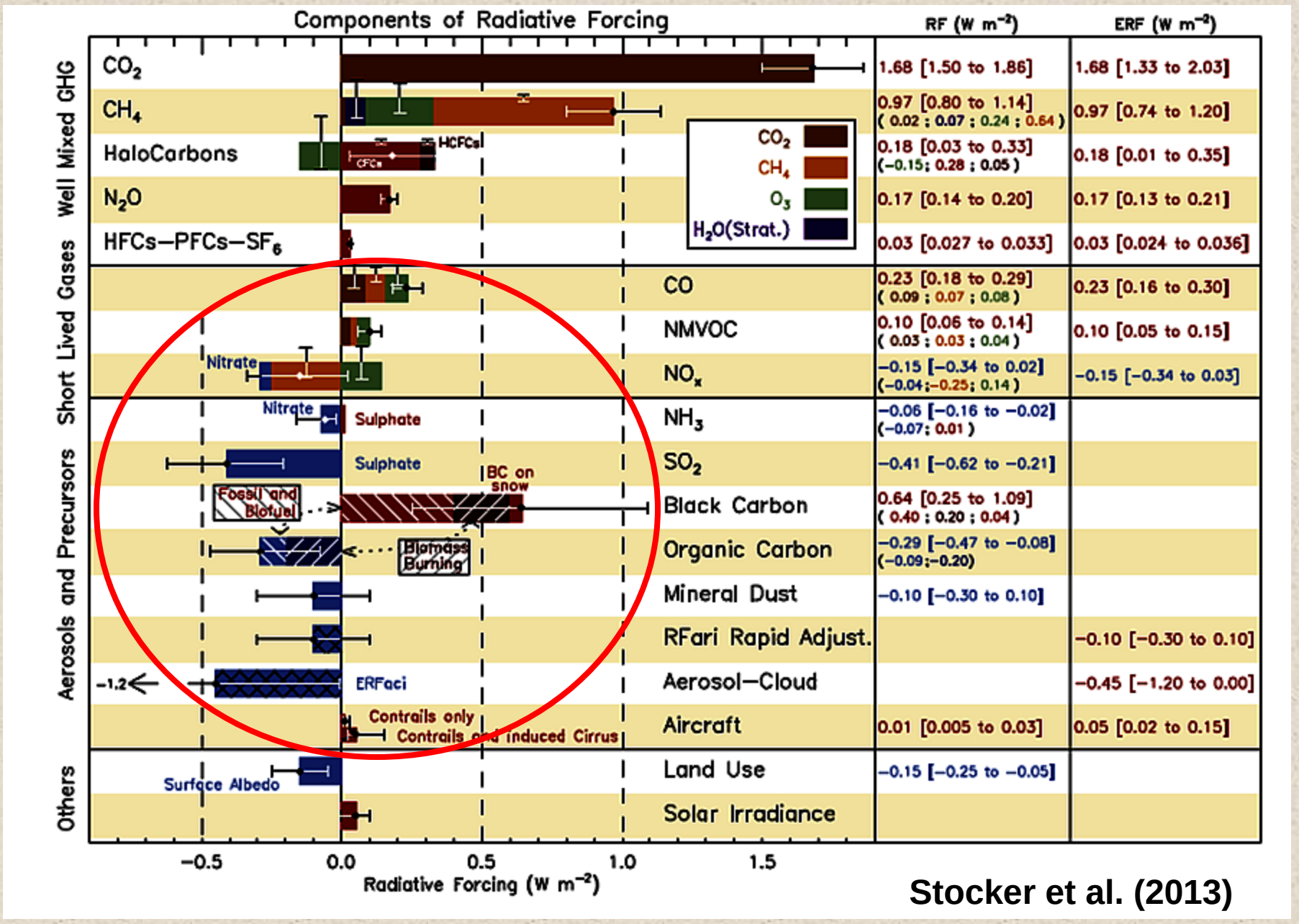


(IPCC 2007)

Climate effects of aerosols remain poorly quantified due to lack data for microphysics (refractive index, type, size)

1367 W/m^2 vs 341 W/m^2

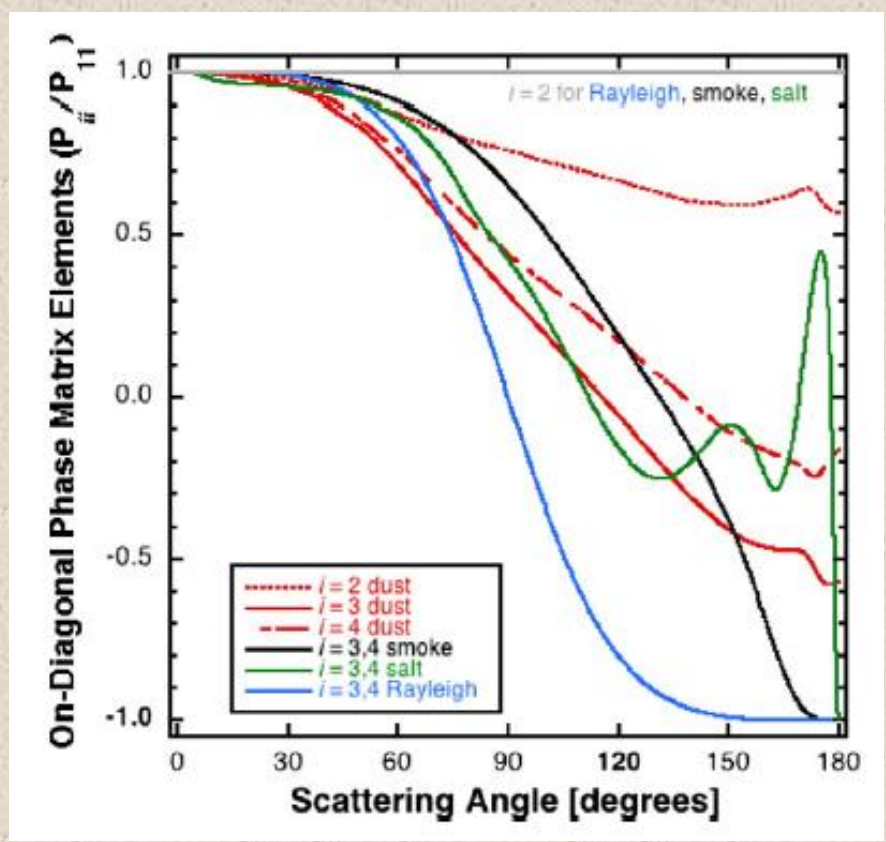
Why aerosol? Radiative forcing concept

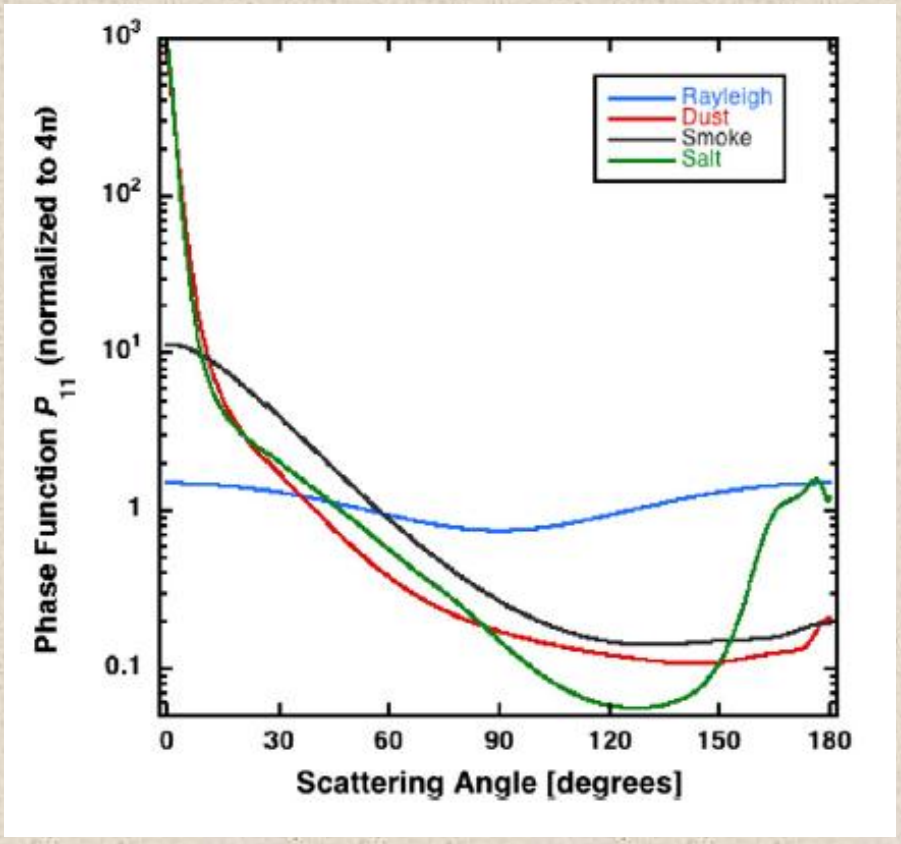


Stocker et al. (2013)

Why polarization? Why scanning?

Microphysics dependency in polarimetric data



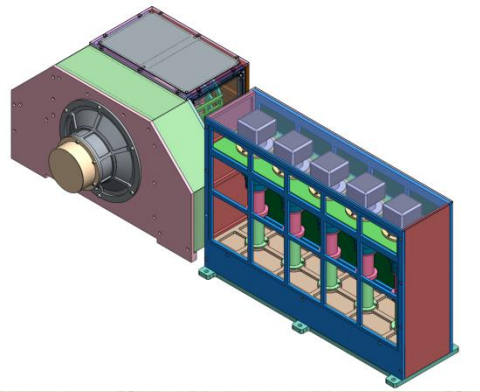


Needs in polarization and many scattering angles !

(Kokhanovsky et al., Earth-Science Reviews, 2015)

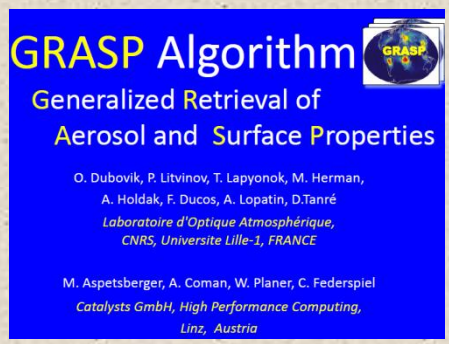
Structure Aerosol-UA project

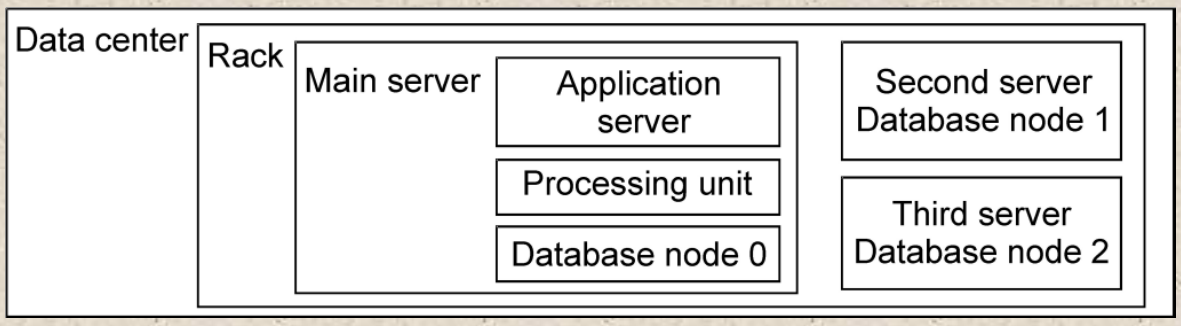
Instruments:
ScanPol + MSIP



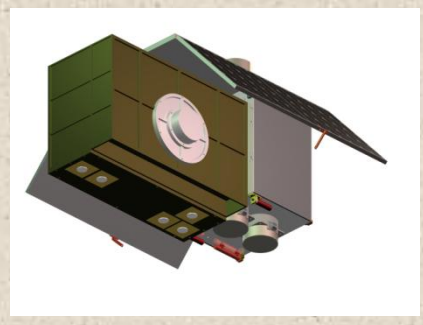
Data processing:

GRASP, Mission products





Platform:
YuzhSat?



Validation
AERONET, Lidar

Basic strategy: receive max information in the reflected sunlight

Aerosol-UA: ScanPol (*I, Q, U*) + MSIP (image, *I, Q, U*)

- Polarization is a **relative** measurement that can be made **accurately**.
- Polarimetric ScanPol measurements can stably **calibrated on the orbit**.
- Polarization change with scattering angle and wavelength gives **size, refractive index and shape of aerosol**.
- Synergy of **scanner** and **imager** will produce new quality of data different from similar aerosol missions.

Orbital platform characteristics needs

Orbit

Type: sun-synchronous

Inclination: ~98°

Altitude: ~670 km

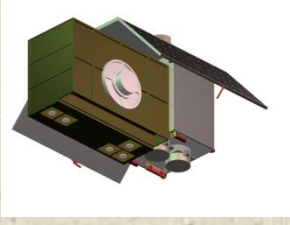
Platform needs

Pointing accuracy: ~0.1°

Total mass of scientific payload estimated: ~20 kg

Power for payload: ≤ 50 W

Design life: >3 years



ScanPol:

Scan: period 1.5 sec, exp. 1ms, along ground track, +50/-60°

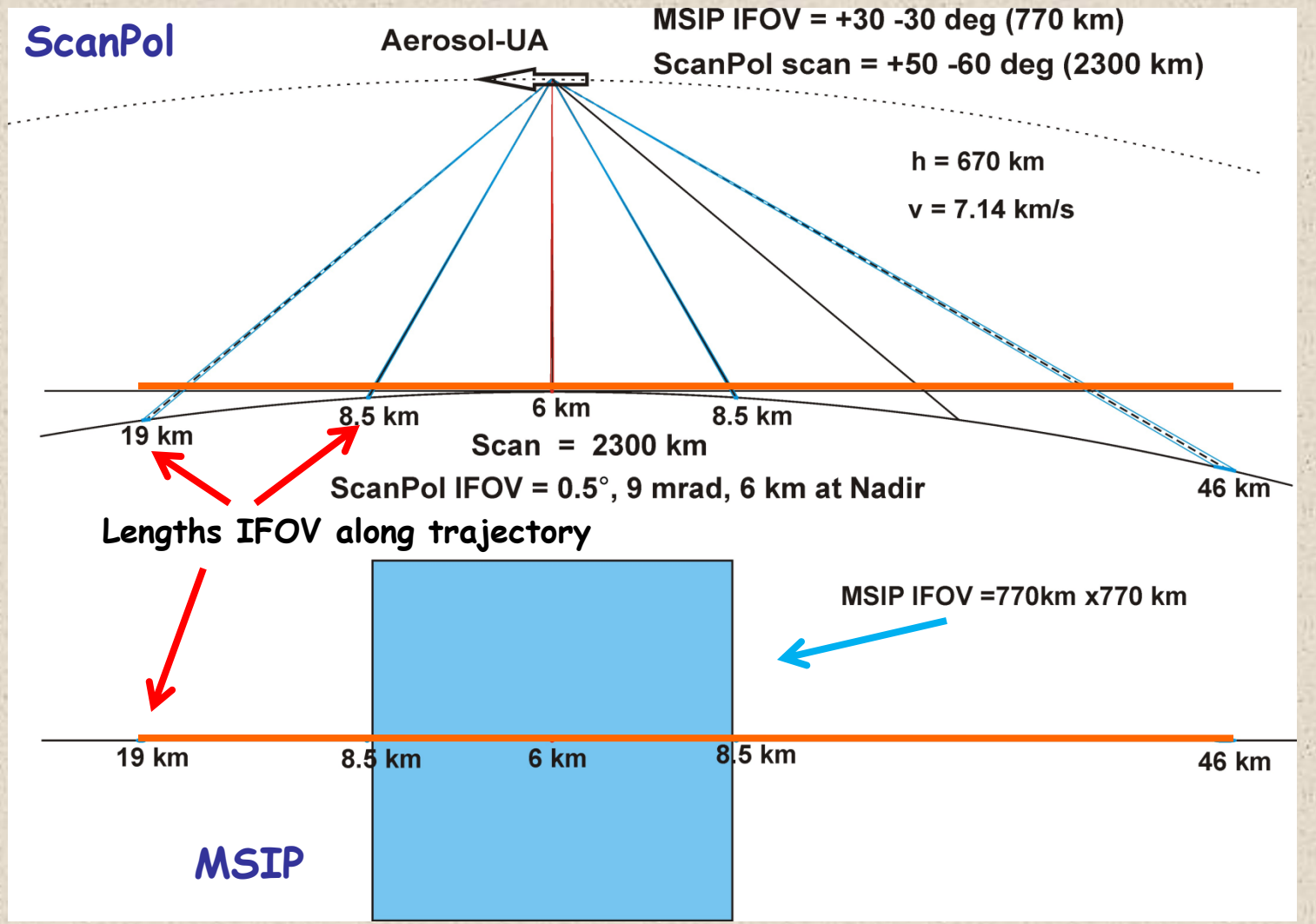
Spatial resolution: ~6 km at nadir

MSIP:

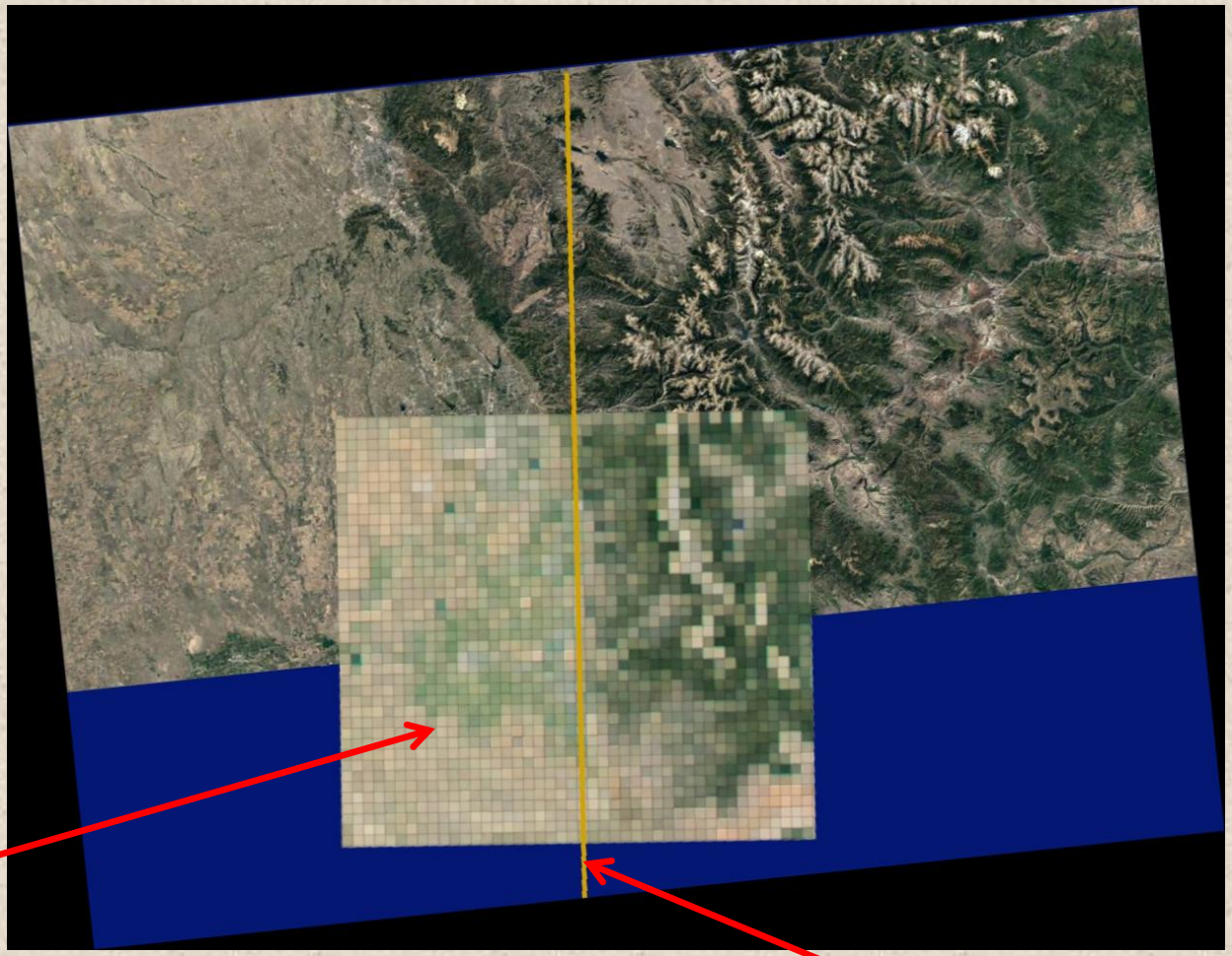
Image:+60/-60°, 770x770 km

Spatial resolution: ~3 km at nadir

Aerosol-UA scanning-imaging geometry

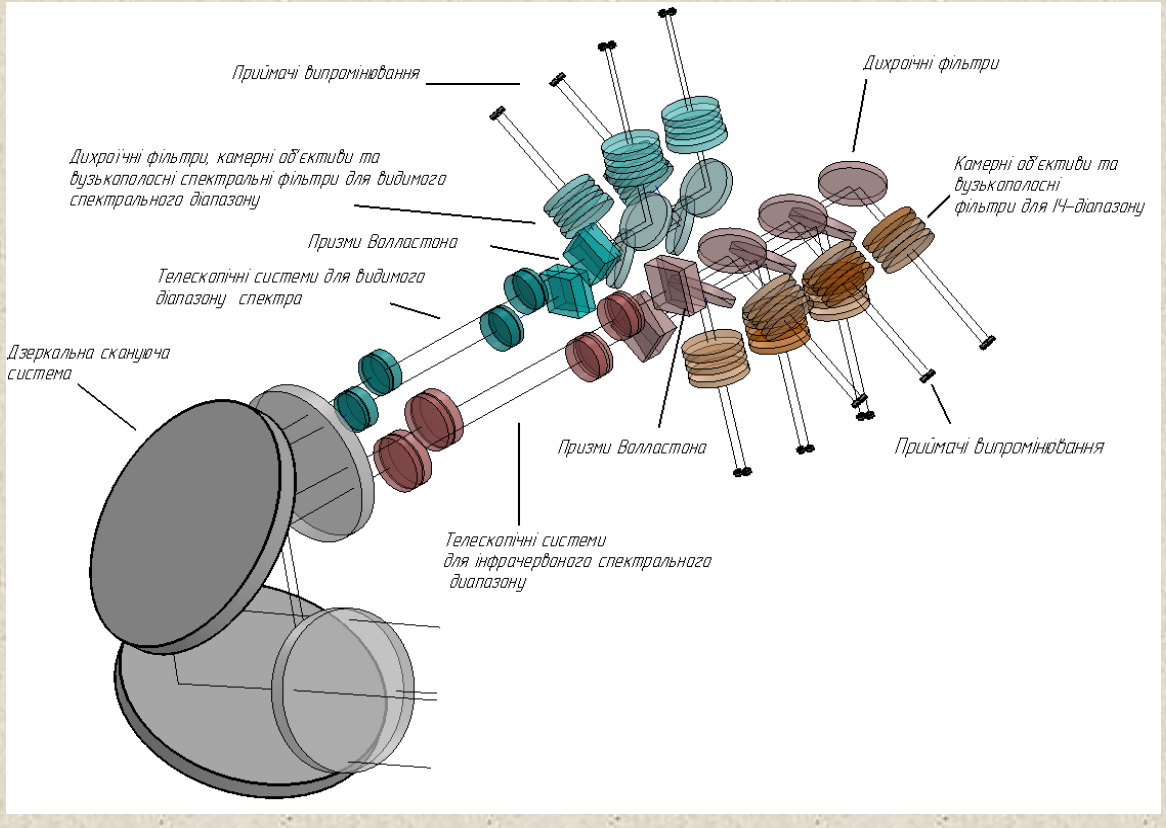


Field-Of-View MSIP and ScanPol



ScanPol polarimeter: optical alignment

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

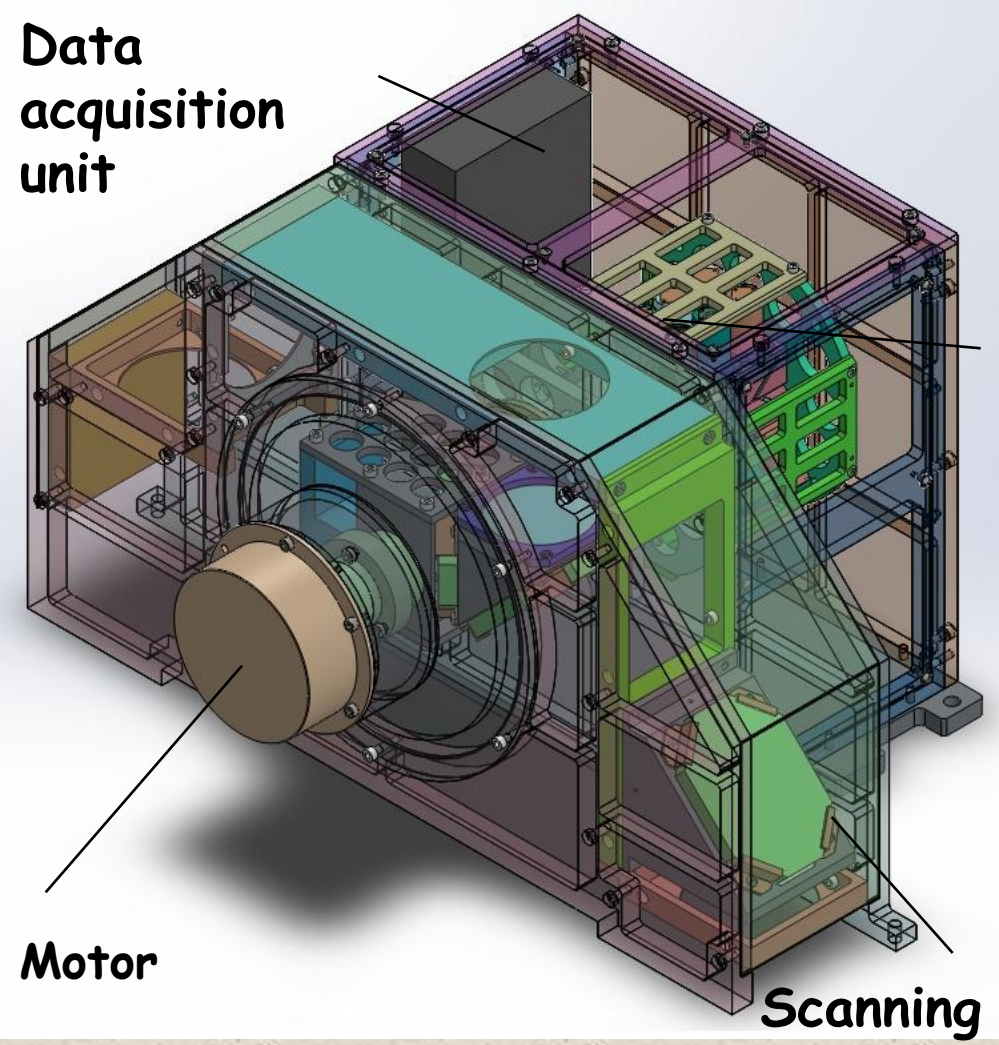
1378 nm – separate cirrus clouds, stratosphere aerosol, separation of troposphere and stratosphere aerosol in case of volcanic eruption

1610 nm – separation surface signal from aerosol over Earth' surface

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

Filter ½ width 20 - 60 nm

Optic-mechanical unit of ScanPol designed for test from aircraft in 2017

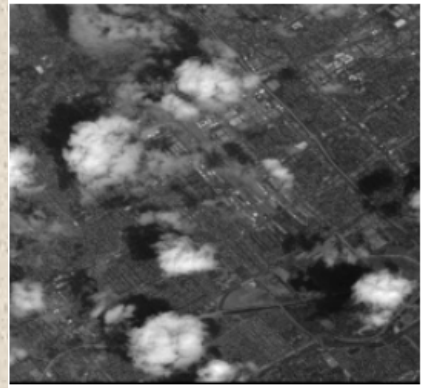


MultiSpectral Imager-Polarimeter (MSIP)

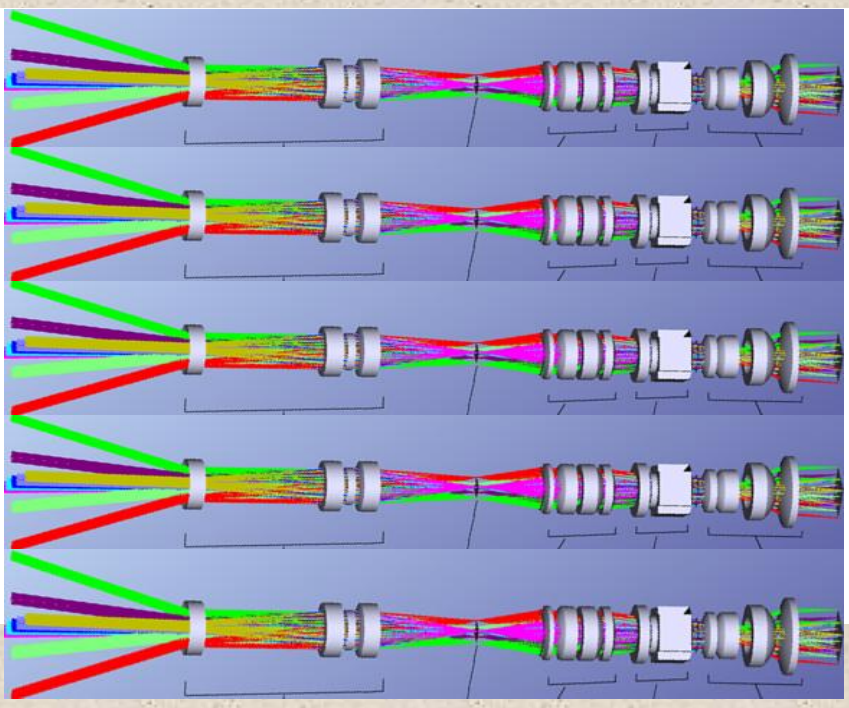
- MSIP main purposes: aerosol/clouds parameters measurements and aerosol - clouds separation
- Three spectral polarimetric channels: 410, 555, 865 nm 0°, 45°, 90°, 135° polarization each
- Two intensity channels: (1) 410, 443, 470, 490; (2) 555, 670, 865, 910 nm
- FOV: 60°x60°, 770x770 km, resolution 3 km
- Images rate 1.5 s^{-1} ÷ 6.0 s^{-1} (dependent on data rate transmission), exposure <0.5 s
- Calibration using ScanPol scans, <1% accuracy

MultiSpectral Imager-Polarimeter (MSIP)

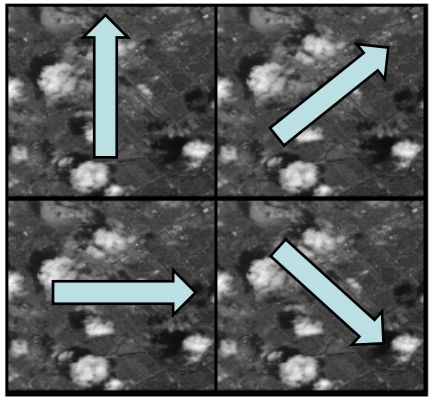
scene



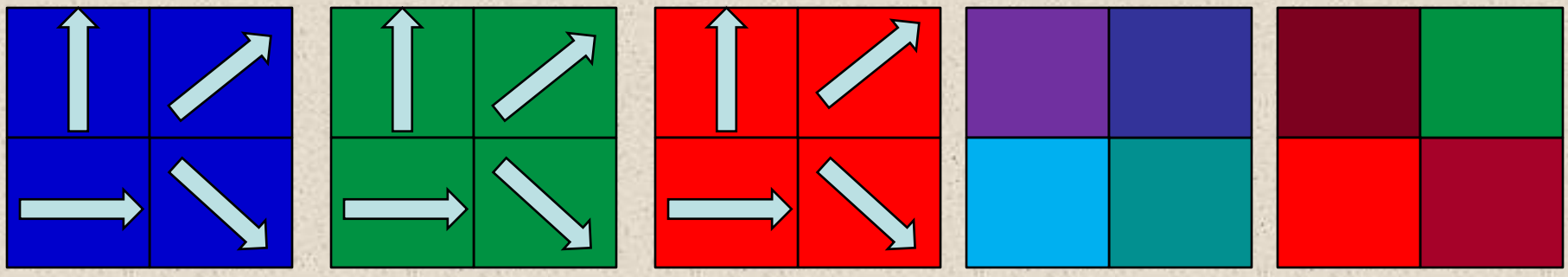
FOV = 350 x 350 km



4 images on the CCD detector
with polarization components
0° 45° 90° 135°



Detector
2K x 2K, size 20 x 20 mm



Polarization 0°, 45°, 90°, 135°

410 nm 555 nm 865 nm

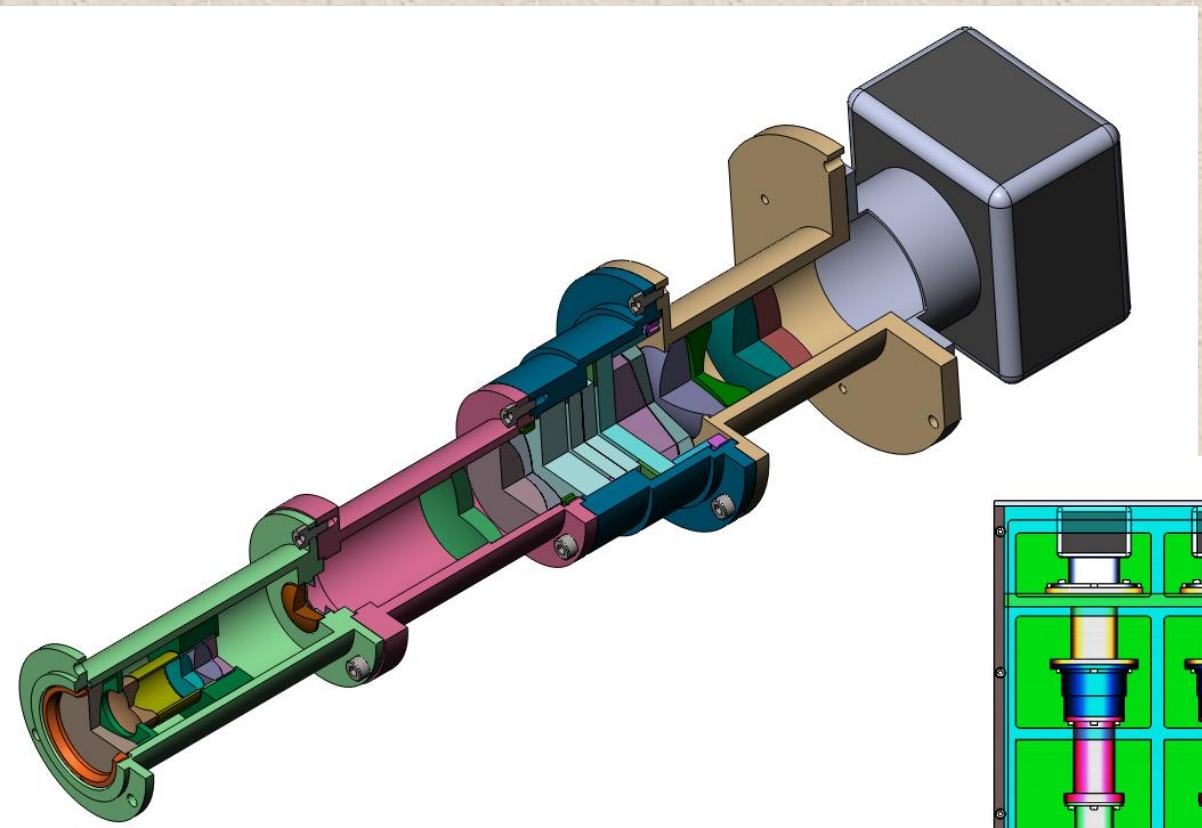
Overall 20 Sp/Pol channels

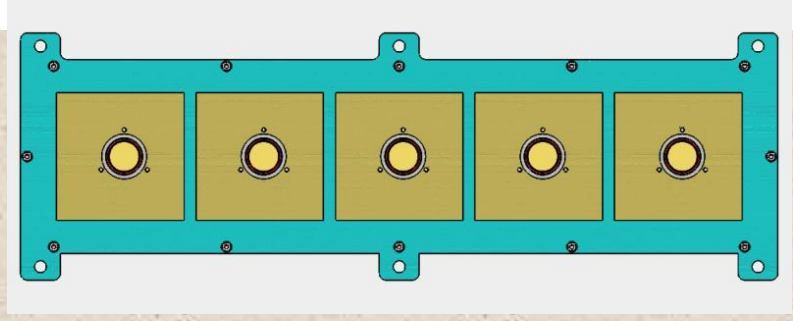
Intensity

410+443+ 555+670+

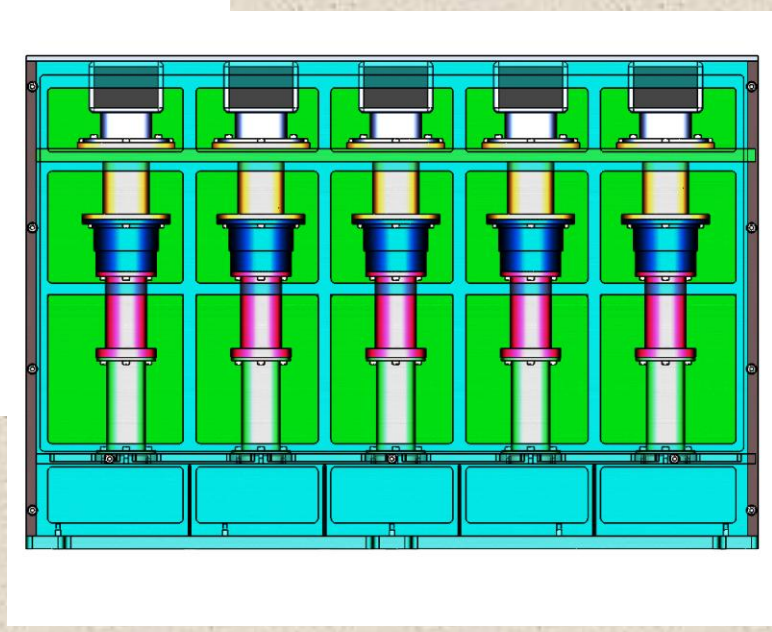
+470+490 nm +865+936 nm

MSIP optical channel design, 2016



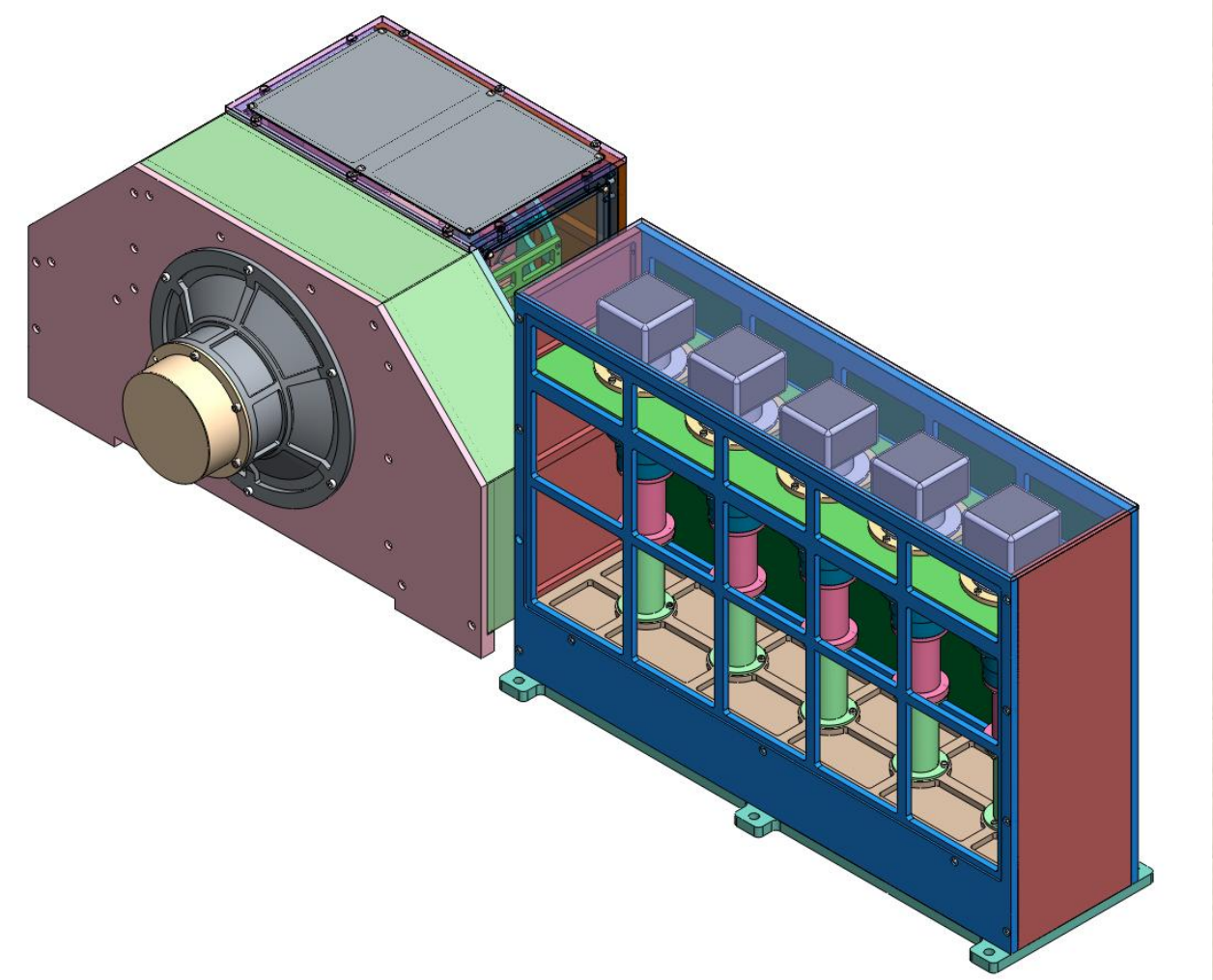


Input windows of MSIP

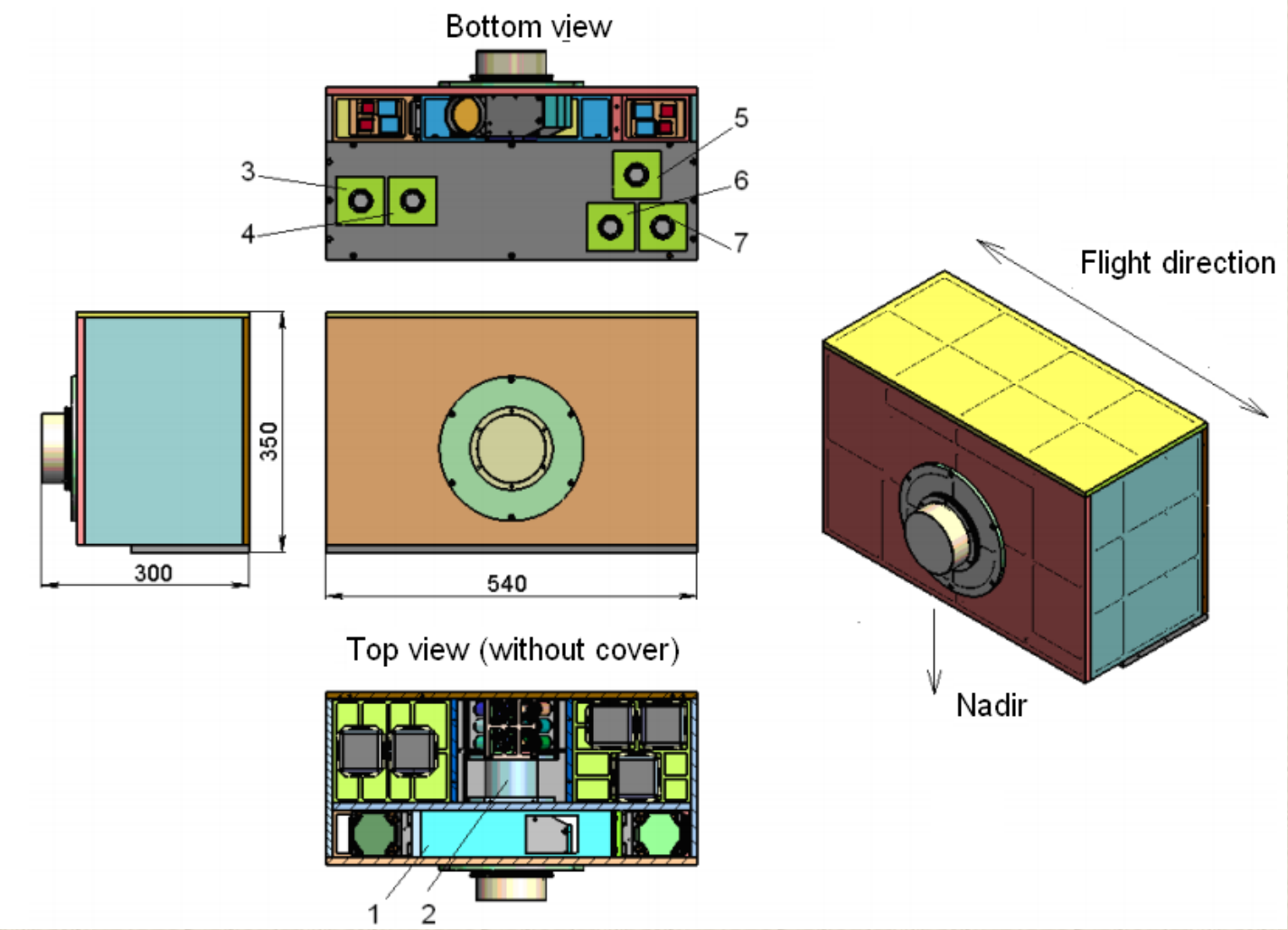


Five units of MSIP – linear design

ScanPol and MSIP polarimeters for space missions Aerosol-UA, August 2016



ScanPol and MSIP polarimeters for space missions Aerosol-UA, September 2016



Characteristics of payload

1. Total mass of scientific payload ~23 kg
2. Power for payload: ≤ 50 W approximate estimate
3. Data volume per 24 hours :

SkanPol 0.2 Gbyte

MSIP 24 Gbyte

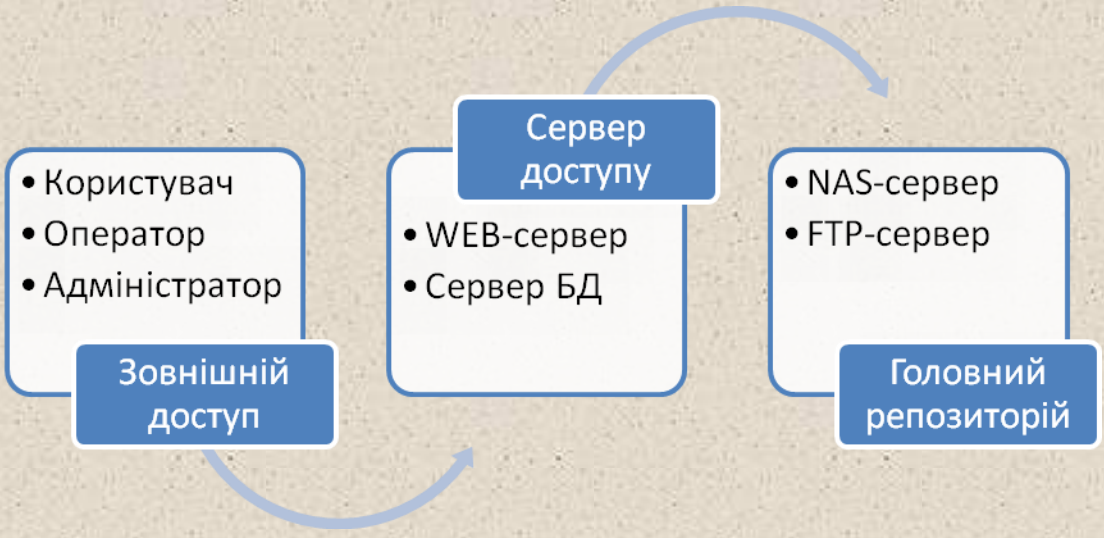
> approximate estimate and will be optimized for the capabilities of the platform

The experiment features

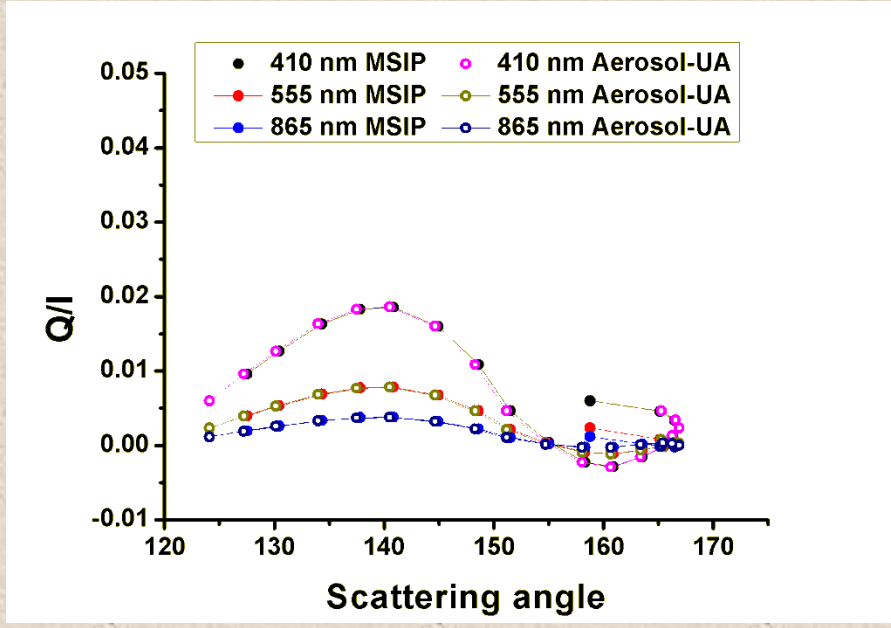
1. The need for measurements at each orbit round.
2. The ability to deploy the platform in the direction of the Moon (the Sun) for calibration.

Data processing

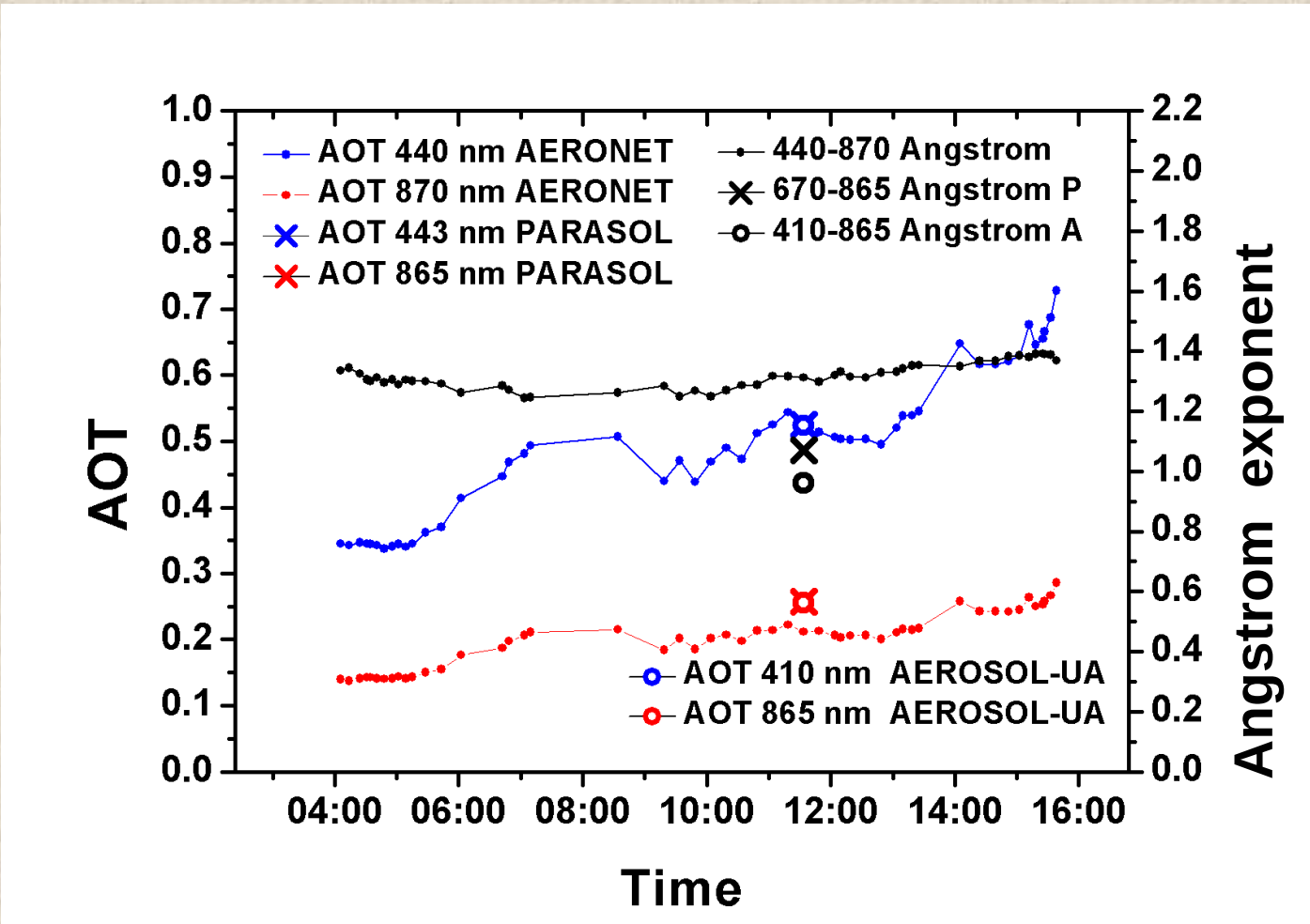
1. Data Center concept has been developed



2. Testing the GRASP software for synthetic data processing



Aerosol-UA performance analysis using synthetic observation



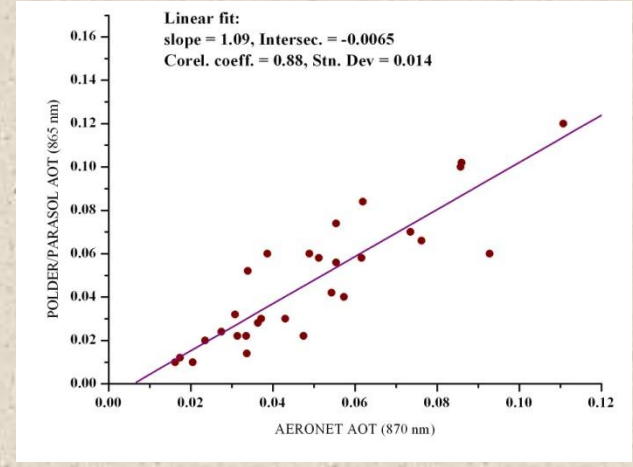
Aerosol optical thickness (AOT) calculations by GRASP for synthetic data and PARASOL data for August, 14, 2010

Ground-based support of Aerosol-UA: data validation in AERONET network

Direct simultaneous measurements

- Permanent AERONET sites
- mobile AERONET sites

POLDER/AERONET data comparison



Conclusions and Objectives

In comparison to the several aerosol polarimetric missions planned for 2017-2020 where Aerosol-UA instrument concept provides synergy of precision scanner-polarimeter and imager-polarimeter

1. Finalizing ScanPol model calibration – spring of 2017
2. Construction of MSIP one channel – spring of 2017
3. Data processing algorithm – mid 2017
4. On flight ScanPol testing – fall 2017
5. Platform choice – mid-2017
6. MSIP channel construction – end of 2017