GRASP updates:

aerosol- surface – gases joint retrievals

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- **GRASP-SAS, Remote sensing developments, Villeneuve d'Ascq, France.**

Rene Preusker and Jurgen Fischer
- **SpectralEarth, Berlin, Germany**

Remote Sensing of Surface Atmosphere System and inclusion of gases into consideration

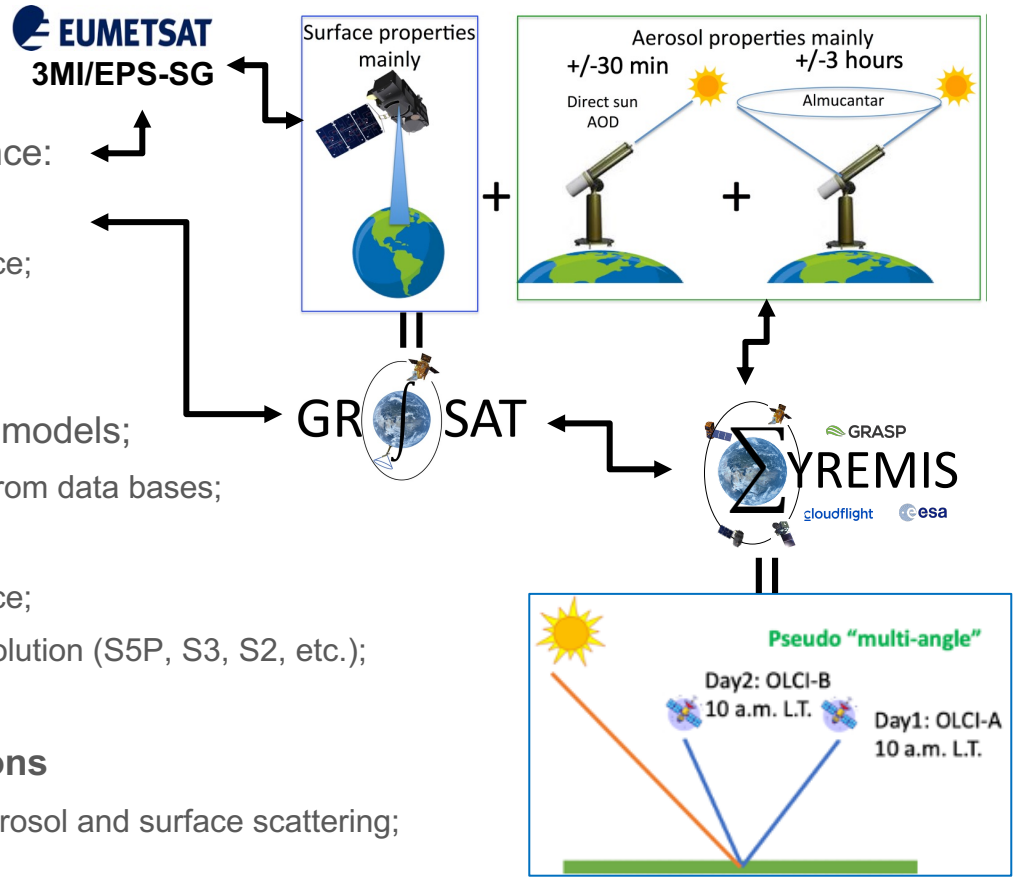
Objective: Developing methodologies for **validation** and **improving** of **aerosol** and **surface** reflectance (BRDF and BPDF) modeling in remote sensing

TASKS:

- ✓ **Joint retrieval aerosol** and **surface** reflectance; **WP-2130**
- ✓ **Optimizing aerosol** and **surface** reflectance models;
- ✓ **Inclusion of gas parameters in the GRASP retrieval** **WPs-2131-2132**

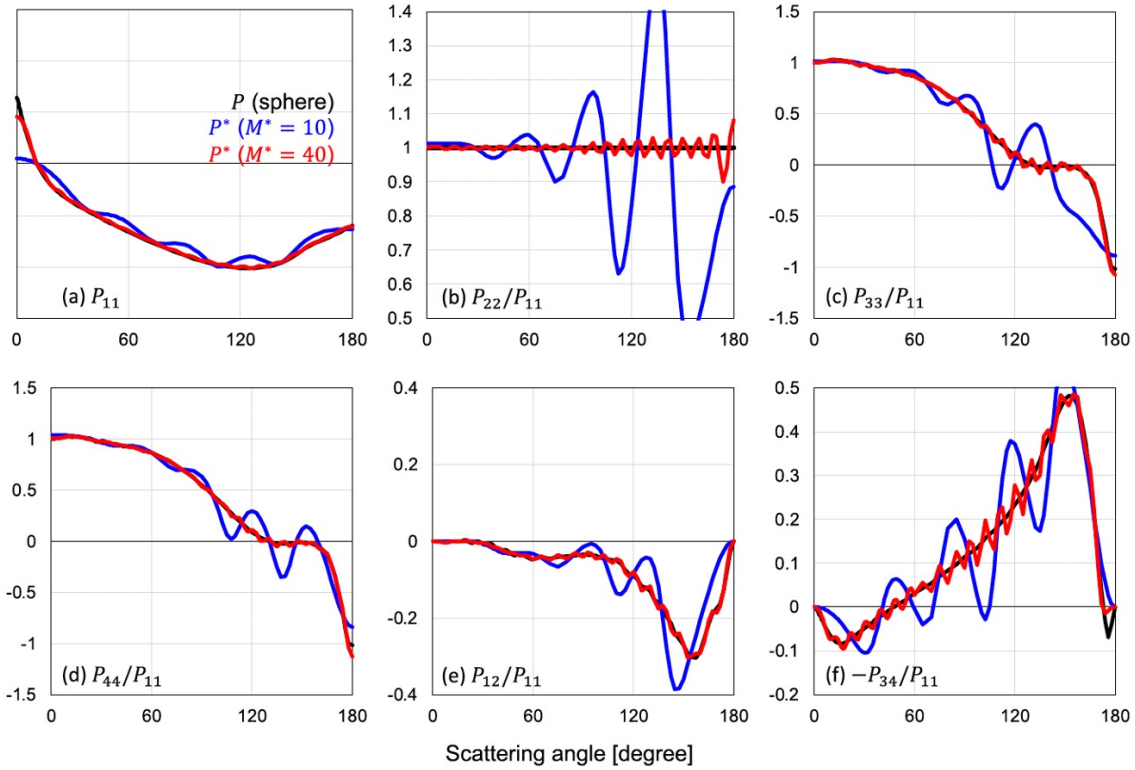
CCN ?

- ✓ **Joint retrieval aerosol and surface reflectance:**
  - AERONET + satellite inversions;
  - optimizing a priori constraints on aerosol and surface;
  - addressing BRDF modeling at different resolution;
  - etc.
- ✓ **Optimizing aerosol and surface reflectance models;**
  - "retrieving" optimized aerosol and surface models from data bases;
  - verifying modeling approaches;
  - optimizing a priori constraints on aerosol and surface;
  - addressing BRDF modeling at different spatial resolution (S5P, S3, S2, etc.);
  - etc.
- ✓ **Improving diverse aspects of RT calculations**
  - optimizing RT in situations with sharp features of aerosol and surface scattering;



RT in situations with sharp features of aerosol and surface scattering

- Accurate representation of phase matrix elements in RT requires large number of the expansion terms
- The sharper features in P_{ij} the larger number of terms required
- The effects of sharp features in P_{ij} the are mostly important in first orders of scattering



P3-IMS - Improved **M**ultiple and **S**ingle scattering (IMS) by **3rd** order multiple scattering correction of the forward lobe

Optimizing RT in situations with sharp features:
solar aureole, glory, and Sun-glint regions

IMS truncation & correction methods

Delta-M algorithm, Wiscombe 1977: $P = P^{\#} f + (1- f) P^{*}$

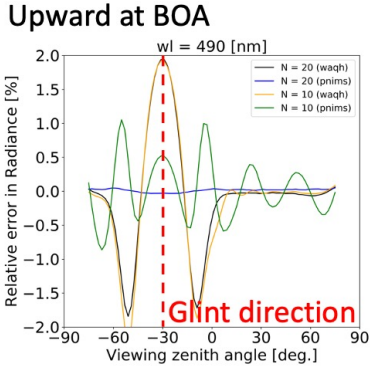
Nakajima and Tanaka, 1988: *1-st and 2-nd order scattering correction for P11*

Waquet-Herman 2010: 1-st, 2-nd and 3-rd corrections for P11, P12, P22 and P33
(no interactions between truncated fraction and rest of calculations)

Momoi et al. 2022a-b: 

1-st, 2-nd and 3-rd correction for P11,…, P33 and 1-st, 2-nd for glint
(full interactions between truncated fraction and rest of calculations)

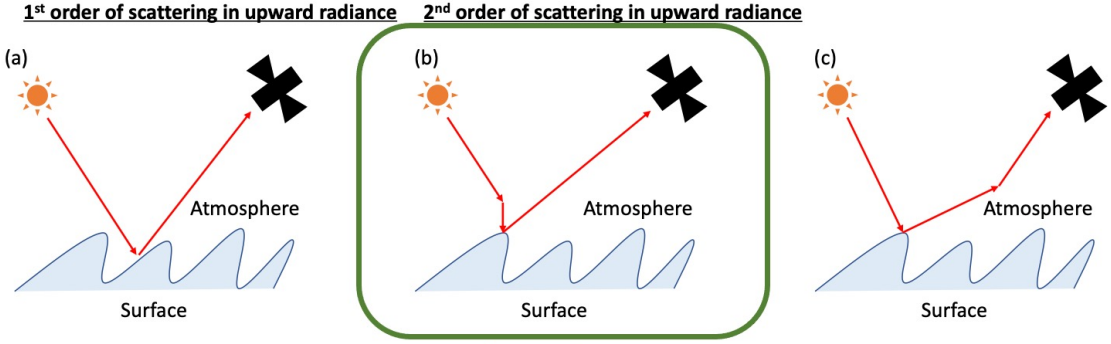
https://www.esa.int/



- The sharper features in P_{ii} the larger number of terms required

- The correction is helpful for glint too…

What about sun-glint over ocean surface?



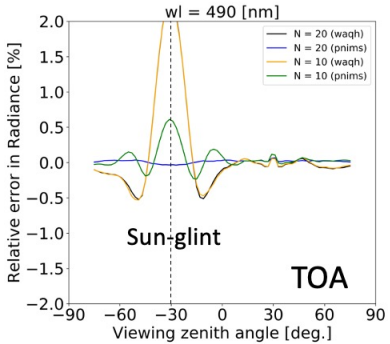
P^nIMS w/ sun-glint correction

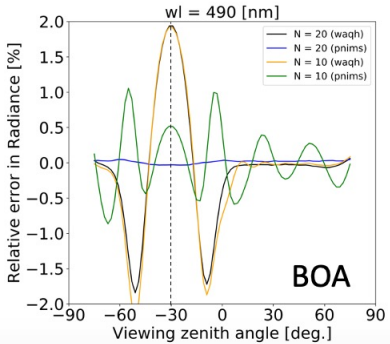
Sun-glint correction using P^{n}IMS method

- The sharper features in P_{ii} the larger number of terms required

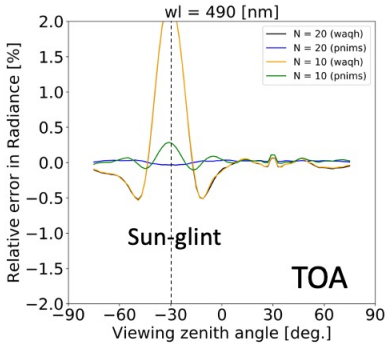
- The correction is helpful for glint too…

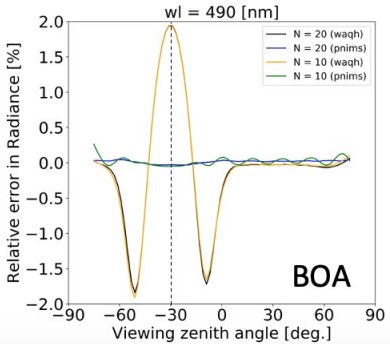
P^{n}IMS w/o sun-glint correction





P^{n}IMS w/ sun-glint correction





Waquet-Herman P^{n}IMS-method

GRASP OPEN

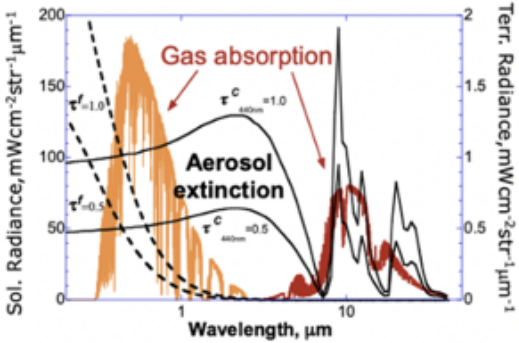
Integration of spectrometric observations into GRASP synergetic retrievals

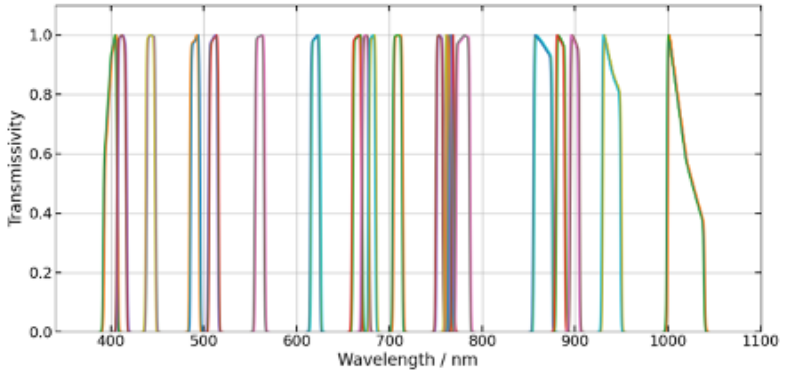
Marcos Herreras-Giralda[1], Oleg Dubovik[2], Rene Preusker[3], Tatsiana Lapionak[2], Jurgen Fischer[3] and David Fuertes[1].

(1) GRASP-SAS, Remote sensing developments, Villeneuve d'Ascq, France.
(2) Laboratoire d'Optique Atmosphérique, CNRS/Université Lille, Villeneuve d'Ascq, France.
(3) Institute for Space Science, Free University of Berlin, Berlin, Germany

The Concept

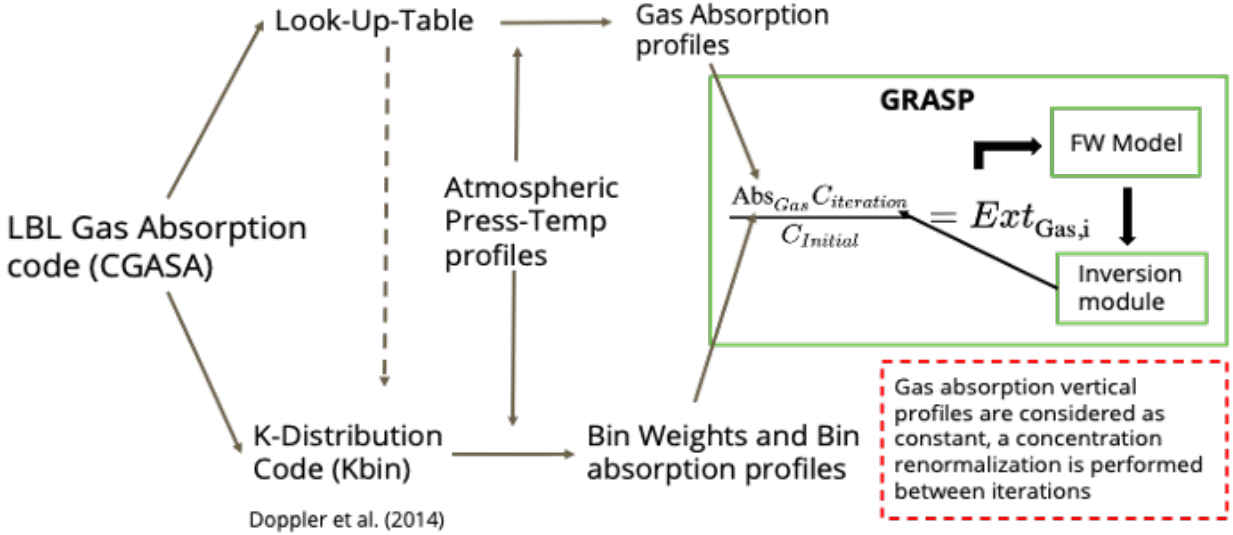
- GRASP was orientated to aerosol and surface retrievals which are **spectrally smooth**
- Missing information:
  - Physical: Gas absorption lines
  - Instrument related: Filter shape
    - Non square shape
    - Unknown or variable channel center (Ex.: smile effect)
- Compatible, intuitive and complementary with previous GRASP applications
- Following GRASP generalized philosophy non of the new developments are instrument related and can be applied to any instrument/channel with spectrometric characteristics





The Scheme

The main GRASP assumption is the constant vertical shape of gas absorption profiles



Any combination of channels with different spectral widths or filter shapes is allowed:

```
channels:
    filter[1]:
        measurement_type: tod
        index_of_wavelength_involved: [1,2,3,4,5]
        spectral_resolution: 0.0001
    filter[2]:
        measurement_type: tod
        index_of_wavelength_involved: [6,7,8,9]
        spectral_resolution: 0.01
```

Applications

- The integration of spectrometric measurements in GRASP enables the simultaneous and combined retrieval of aerosol properties and gas concentrations:

PSR direct sun measurements + **AERONET** -> Aerosol properties + NO_2 + less assumptions

- An accurate description of gas absorption lines can improve aerosol retrieval in certain conditions

AERONET + **Pandora NO_2** concentration -> 0.02 SSA difference at 440 nm for NO_2 > 0.9 DU

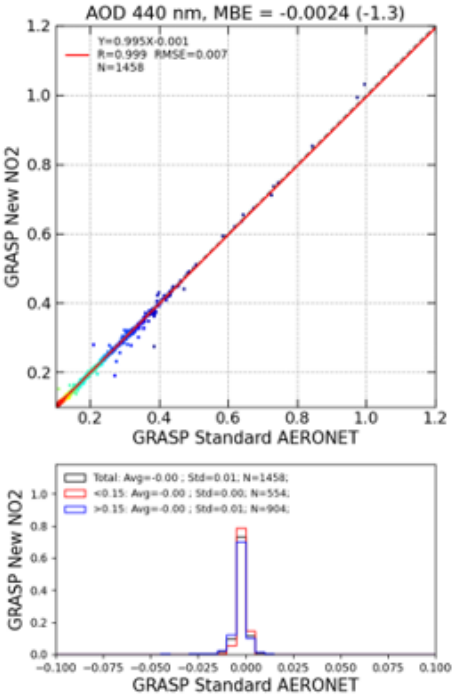
- Accurately accounting for aerosol and gas absorption properties brings additional sources of information to the GRASP retrieval:

Aerosol Height retrieval (**ALH**) from **OLCI** A-band -> surface BRDF + Aerosol + ALH

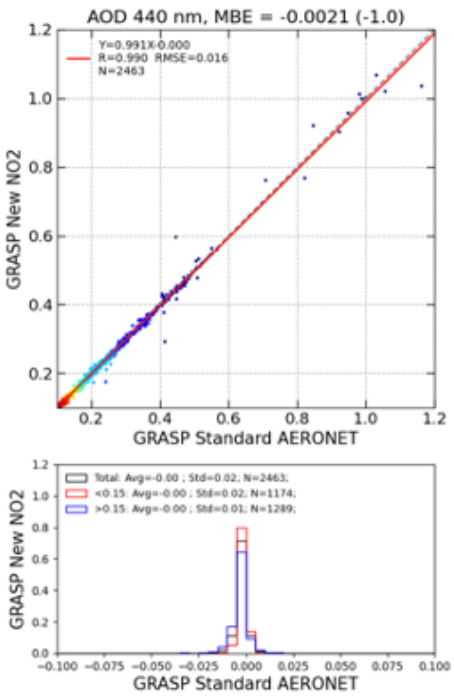
AERONET + Pandora NO2

The usual AERONET NO_2 climatology just providing total column NO_2 has been replace by Pandora NO_2 concentration values from collocated instruments in two Rome sites. Kbin code (Doppler et al., 2014) has been used to perform accurate gas absorption calculations.

ROME_TOR



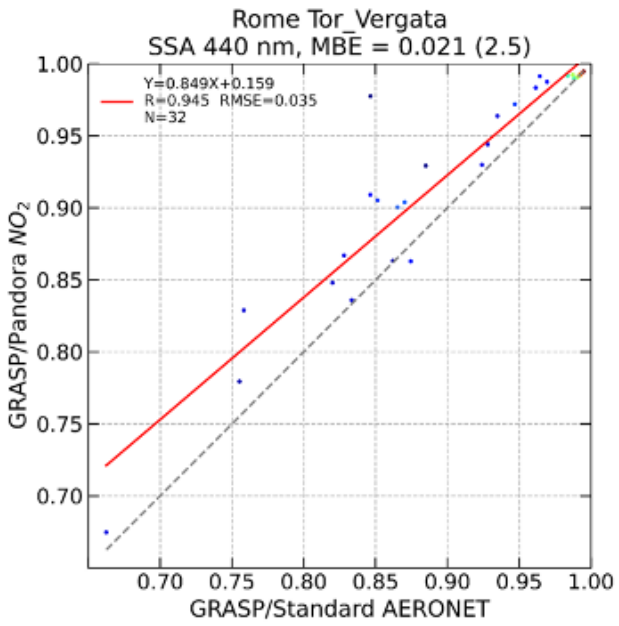
ROME_SAP

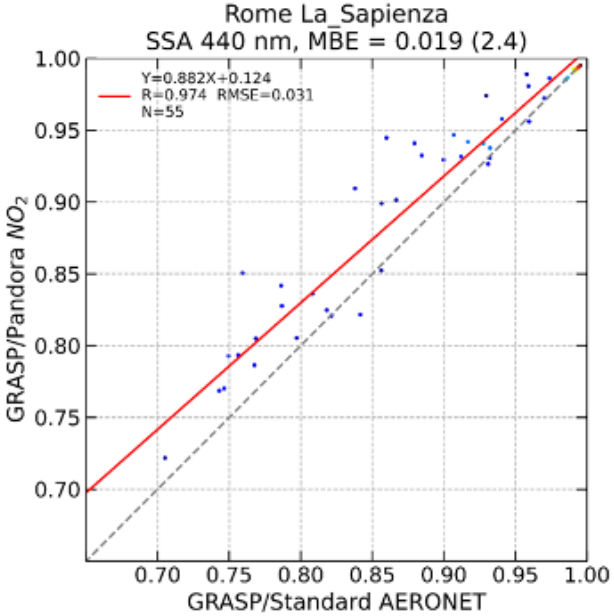


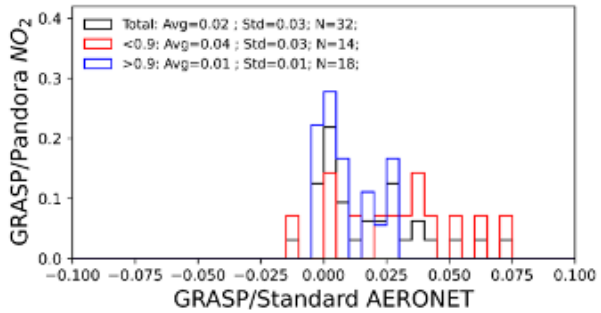
AOD at 440 nm does not seem to be affected by changes in NO_2 concentration. No matter the NO_2 conditions AOD does not experiment any significant bias or RMSE reduction.

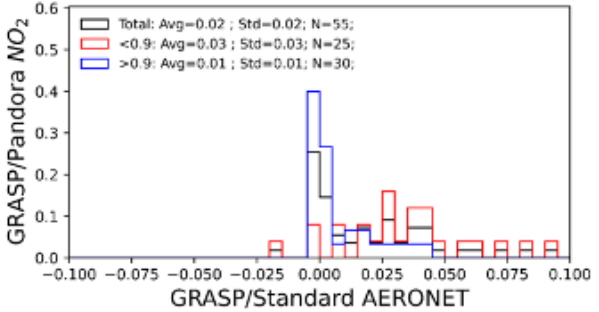
AERONET + Pandora NO2

However, the Single Scattering Albedo (SSA) at 440 nm presents a consistent bias of around 0.02 for both stations (Rome Tor Vergata and Rome La Sapienza) in conditions of elevated concentrations of NO2.

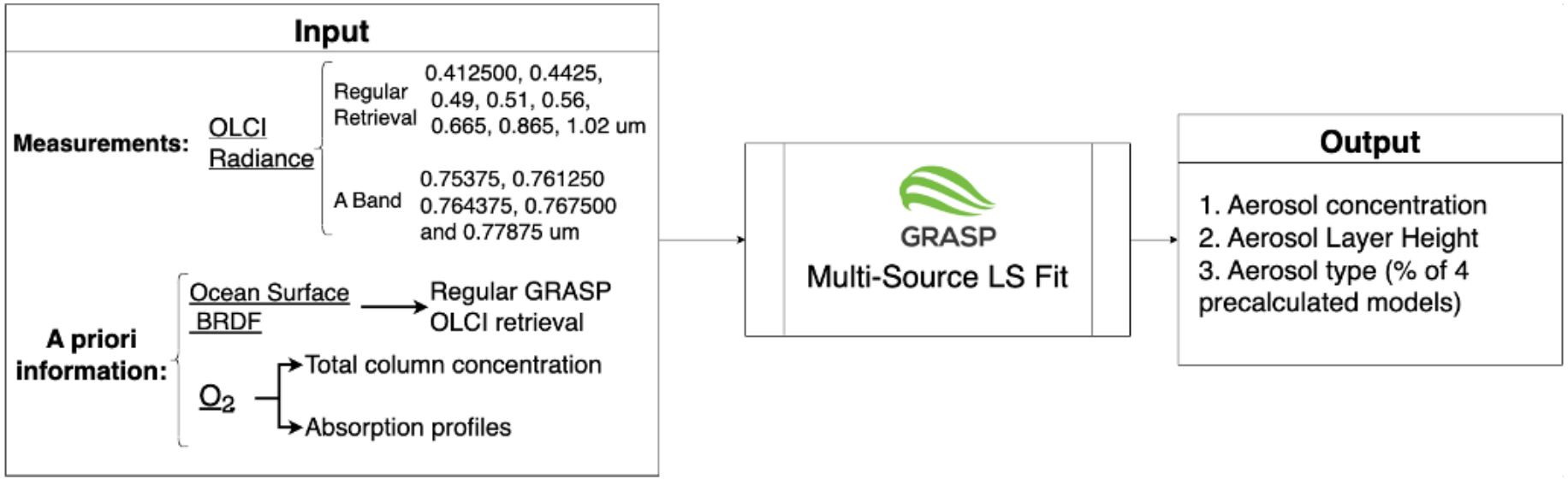








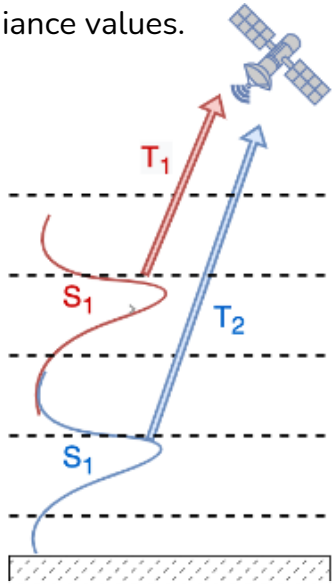
ALH OLCI A-band retrieval



ALH OLCI A-band retrieval

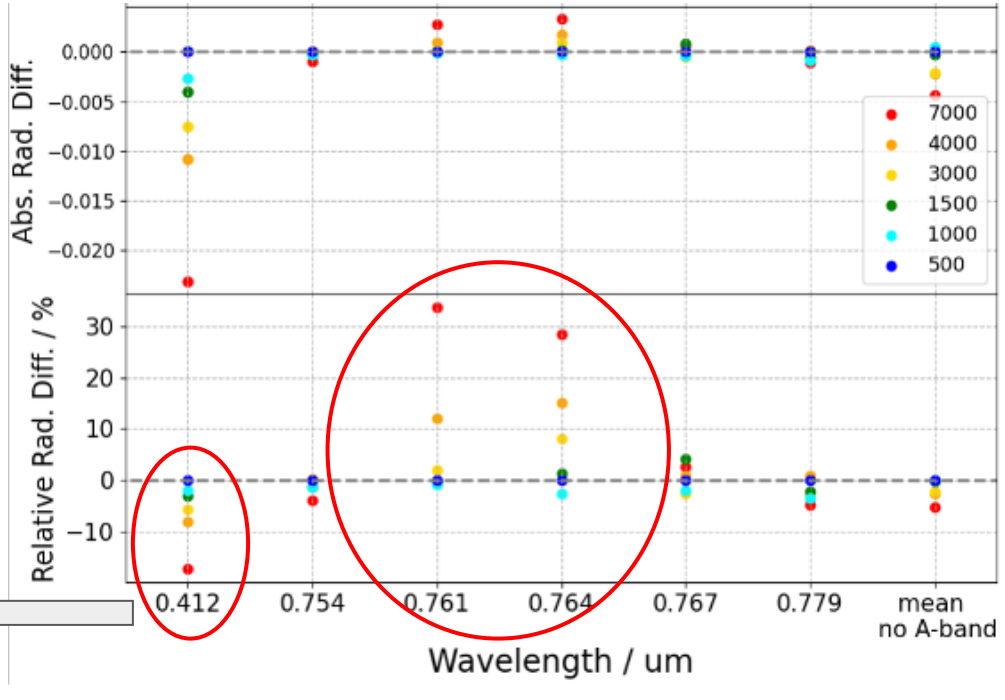
Sensitivity to ALH in O_2 A band

In conditions of equal source function (“same aerosol load”) changes in ALH lead to changes in transmissivity (different optical path) which is translated in different radiance values.



$S_1 = S_2$

$T_1 > T_2$



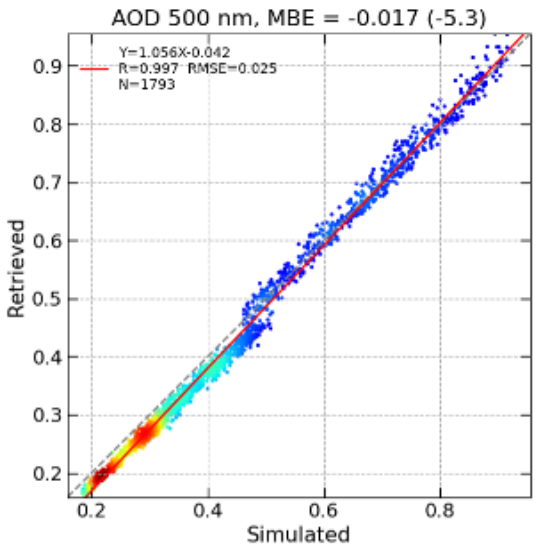
$$\mathbf{S}(\tau,\mu,\varphi) = \frac{\omega(\tau)}{4\pi}\mathbf{P}(\tau,\mu,\varphi,\mu_0,\varphi_0)\mathbf{E}_0 \exp\left(\frac{\tau}{\mu_0}\right) + \frac{\omega(\tau)}{4\pi}\int_0^{2\pi}\int_{-1}^{+1}\mathbf{P}(\tau,\mu,\varphi,\mu',\varphi')$$

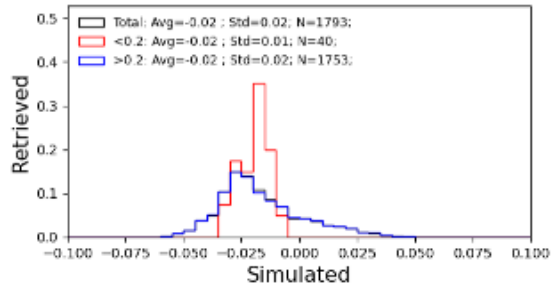
Rayleigh and mainly **O2 A band channels provide sensitivity to** changes in **Aerosol Layer Height**.

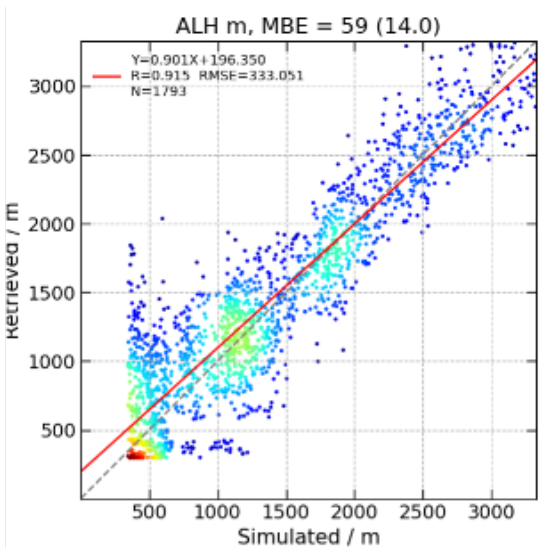
ALH OLCI A-band retrieval

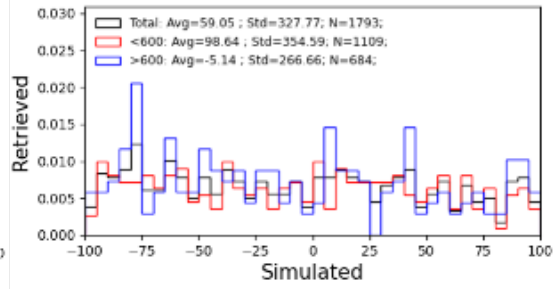
Synthetic Retrieval tests: Results

Dispersion (RMSE) and bias (MBE) are inversely proportional to ALH.

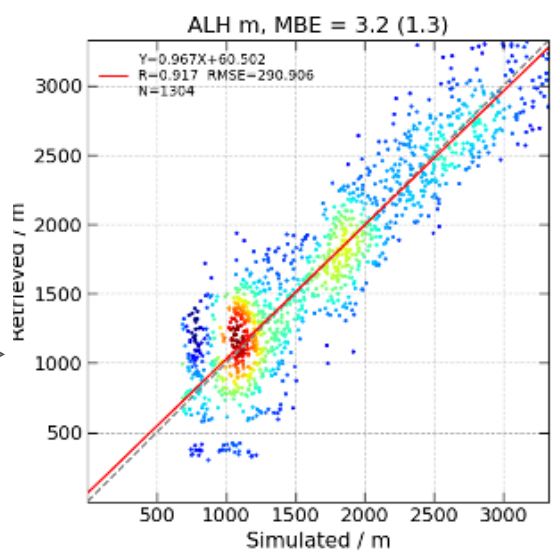


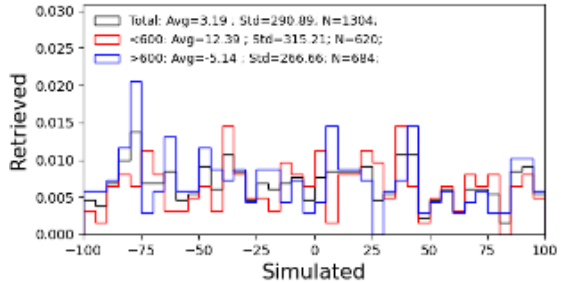






ALH > 750 m





Conclusions

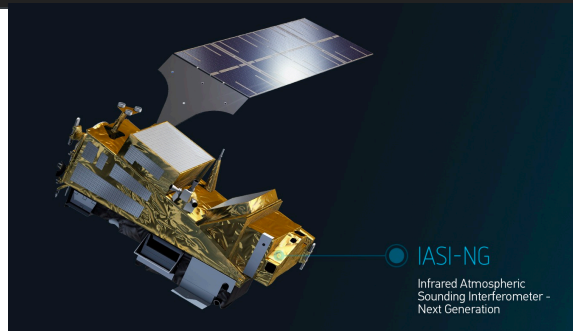
•**Spectrometric measurements and accurate gas absorption features have been implemented in GRASP** for a wide range of applications: ground-based, satellite, shortwave and longwave channels, non-fixed filter shapes…

•**Combined retrieval of gas concentrations and aerosol** properties has been performed for multiple configurations.

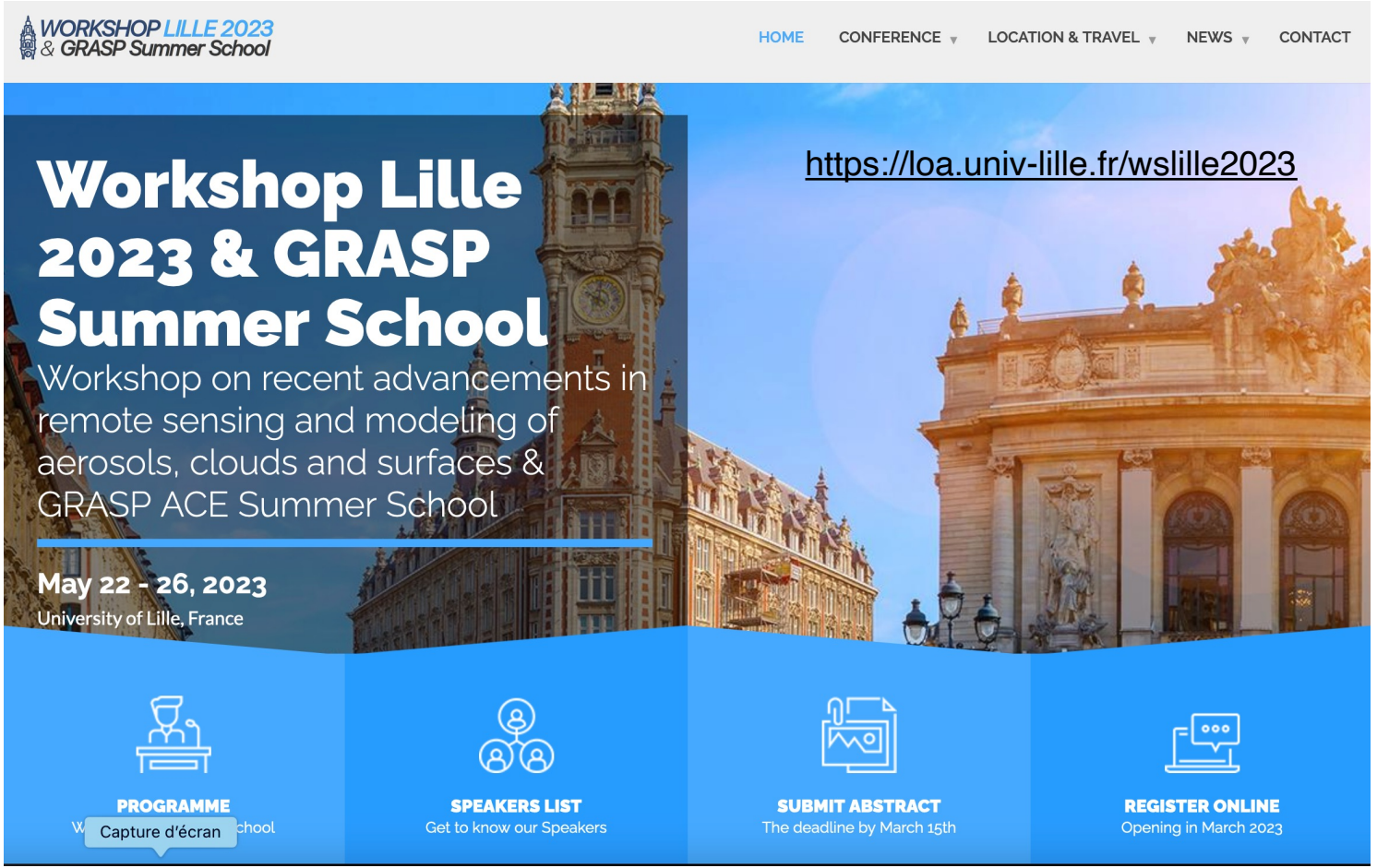
•The addition of gas absorption information **improves aerosol characterization**:

- AERONET SSA at 440 nm
- ALH retrieval from O_2 A-band

Future perspectives



- **Higher optimization** for very exigent applications.
  - Improving filter representation -> center channel retrieval
- **New application to other satellite platforms**
  - POLDER ALH improved retrieval: Polarization + A-band as sources of sensitivity
  - GRASP/IASI first prototype retrieval
- **More ground-base combined retrieval** of aerosol and gas concentrations
  - AERONET aerosol and Water vapor combined retrieval (940 nm channel)
  - Pandora (Luftblick)
  - PFR (PMOD)
  - PSR (PMOD)
  - …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