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Session MO3.L12 - International Spaceborne Imaging Spectroscopy Missions: Updates and News I

QUANTITATIVE GLOBAL MAPPING OF TERRESTRIAL VEGETATION PHOTOSYNTHESIS: THE FLUORESCENCE EXPLORER (FLEX) MISSION

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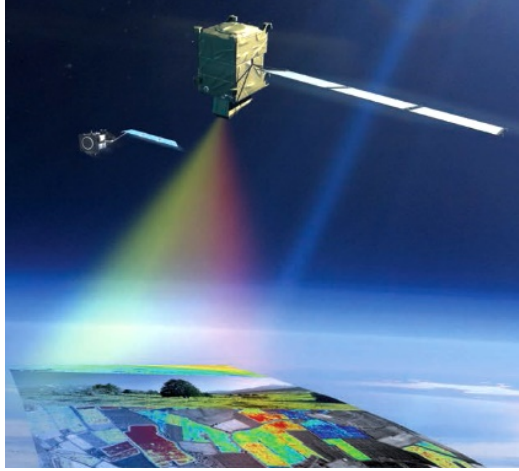
on behalf of the FLEX team

Presentation outline

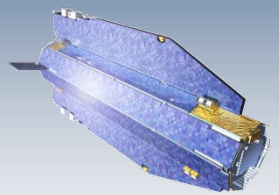


- Introduction: mission objectives and mission implementation
- Retrieval aspects: link between scientific requirements and technical solutions
- News and updates about mission status and developments
- Mission products
- FLEX in the context of international Imaging Spectroscopy Missions

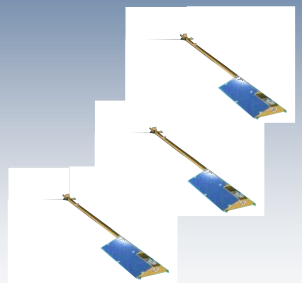
ESA Earth Explorer Missions

- Addressing high level science topics
- Advanced innovative techniques

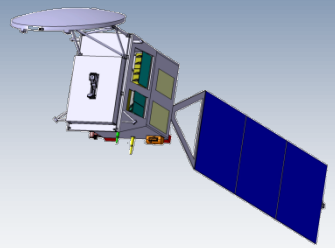
GOCE
Gravity Field and Steady-State Ocean Circulation Explorer



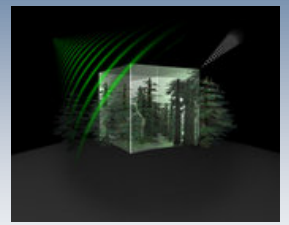
SWARM
The Earth Magnetic Field And Environment Explorer

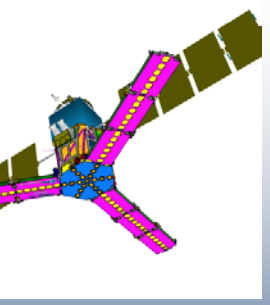


EarthCARE
Earth Clouds and Radiation Explorer

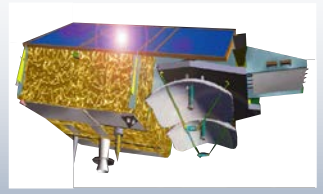


BIOMASS
Biomass Establishment

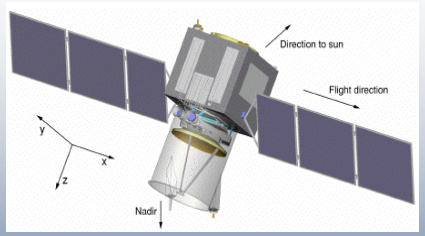




SMOS
Soil Moisture and Ocean Salinity

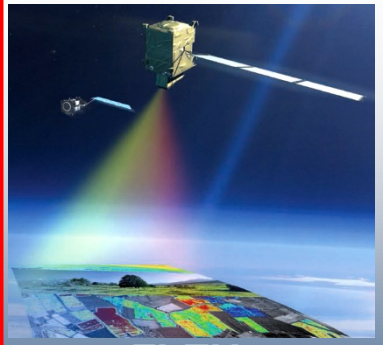


CryoSat-2
Polar Ice Monitoring



ADM-Aeolus
Atmospheric Dynamics Mission

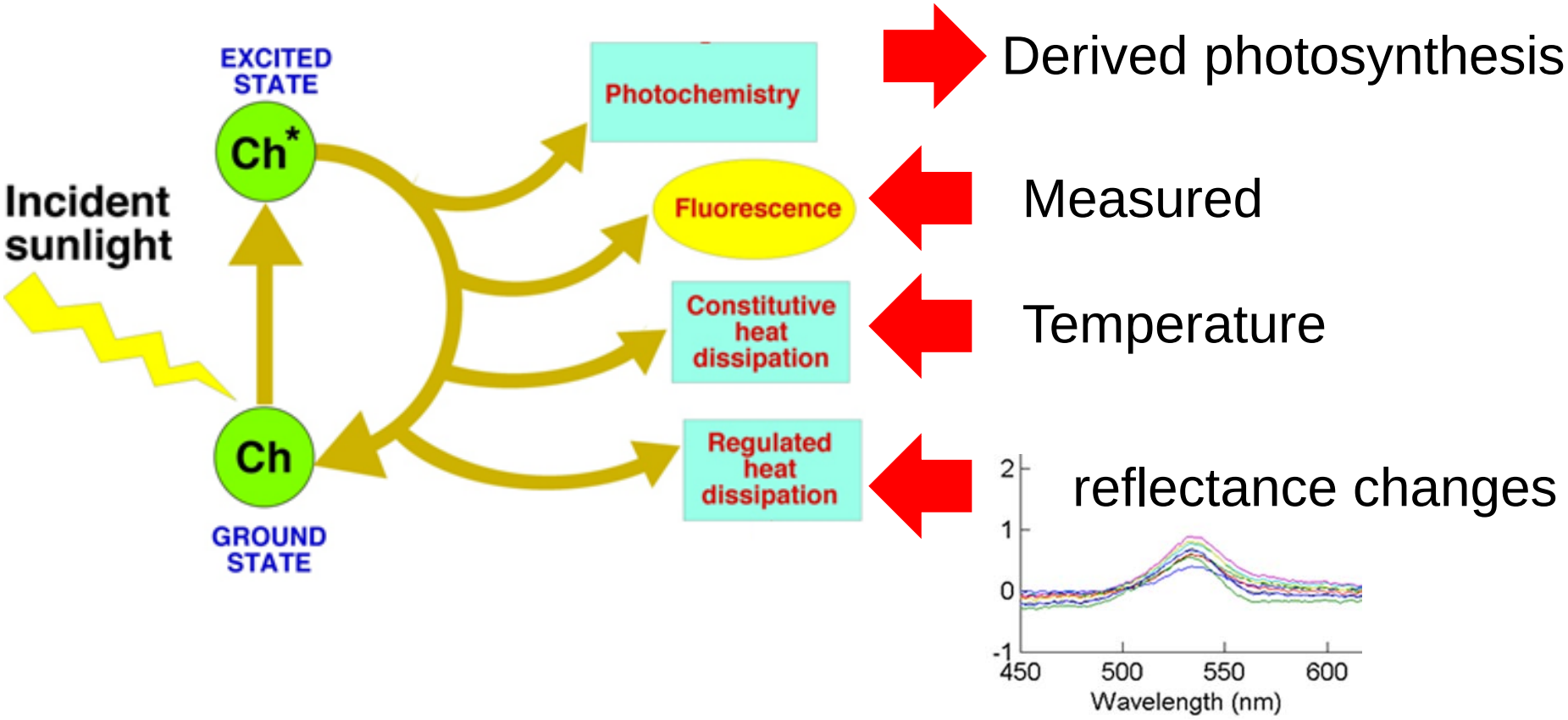
2022



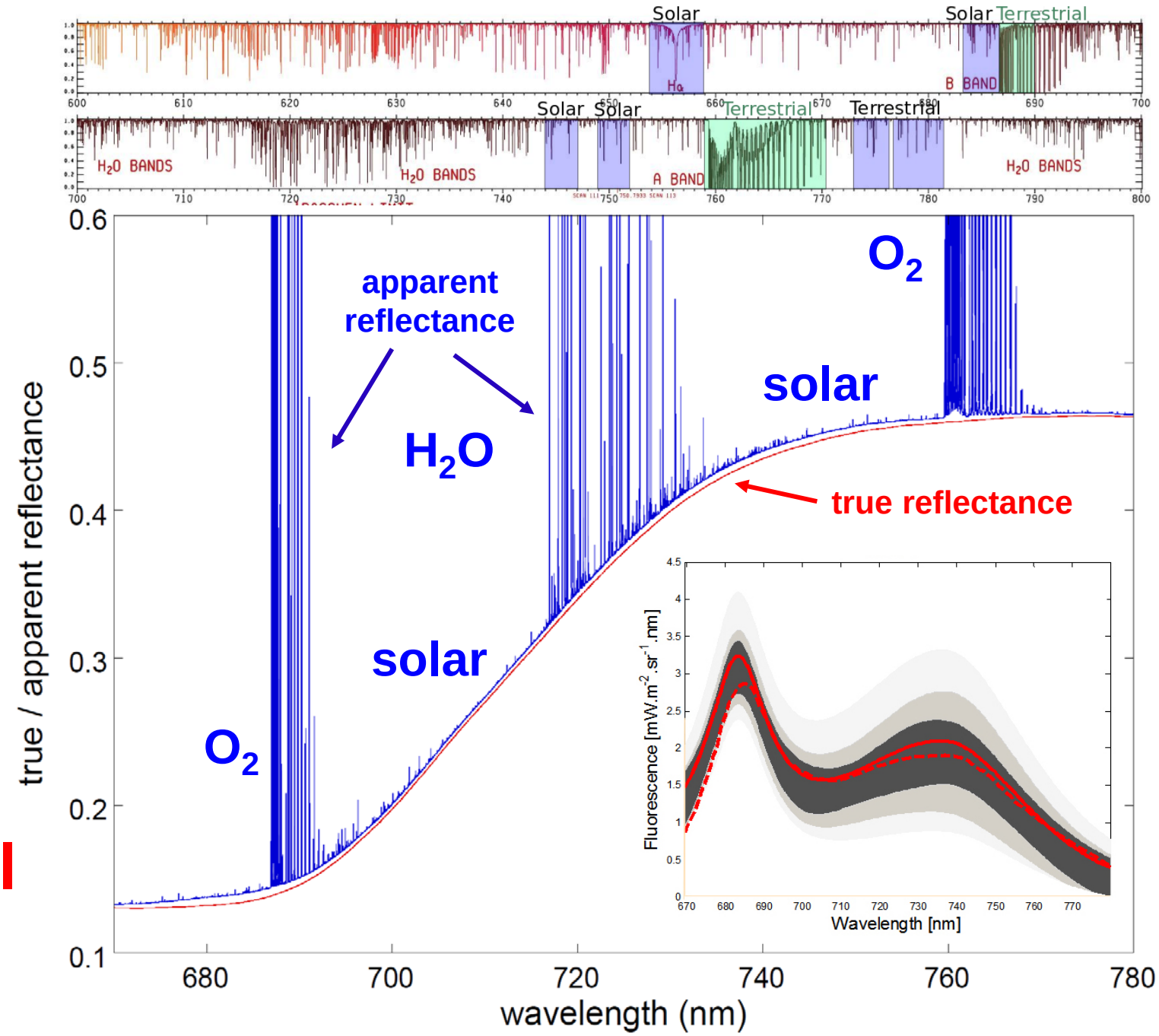
FLEX
Vegetation fluorescence

FLEX objectives

Quantitative global mapping of actual photosynthetic activity of terrestrial ecosystems, as a function of variable vegetation health status and environmental stress conditions

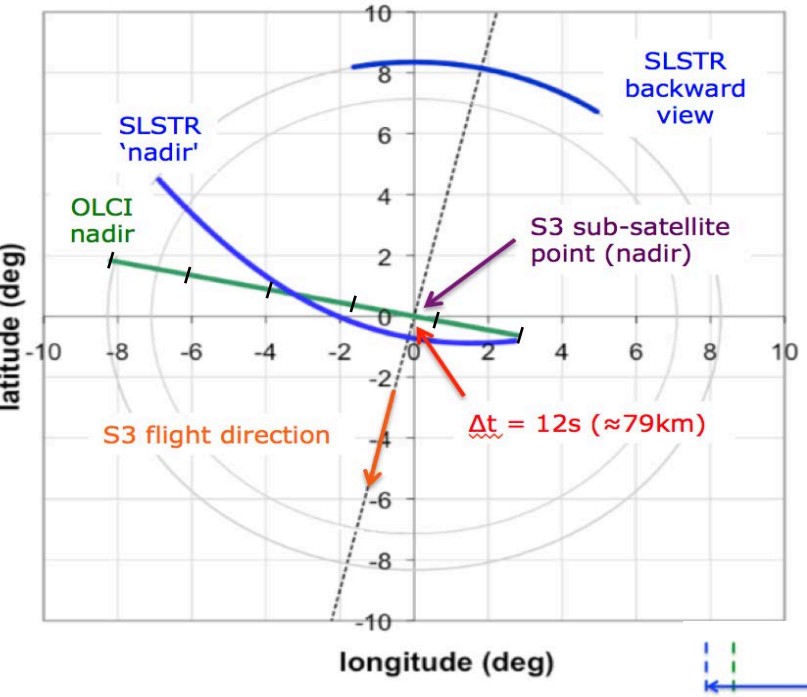


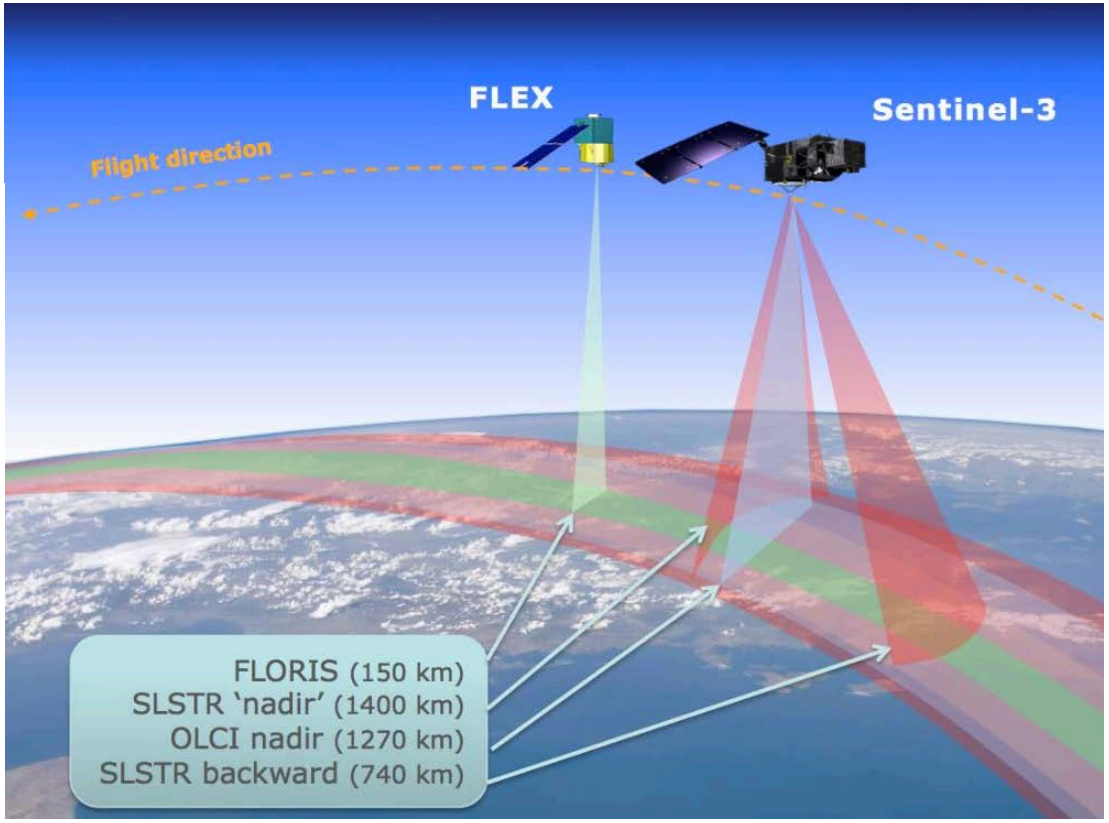
Very high spectral resolution absolutely needed

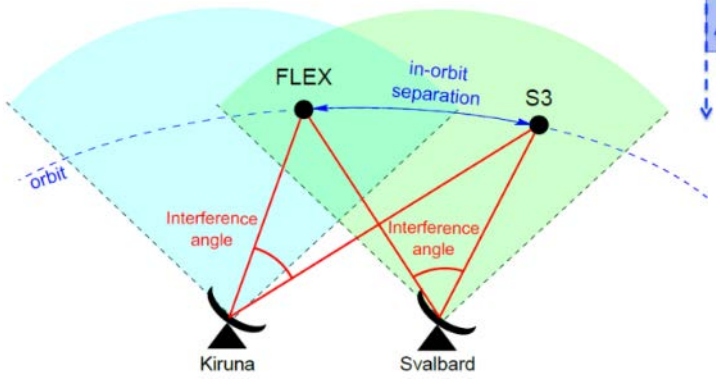


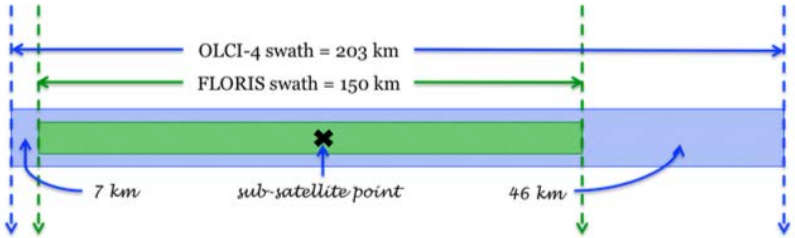
Retrieval concept

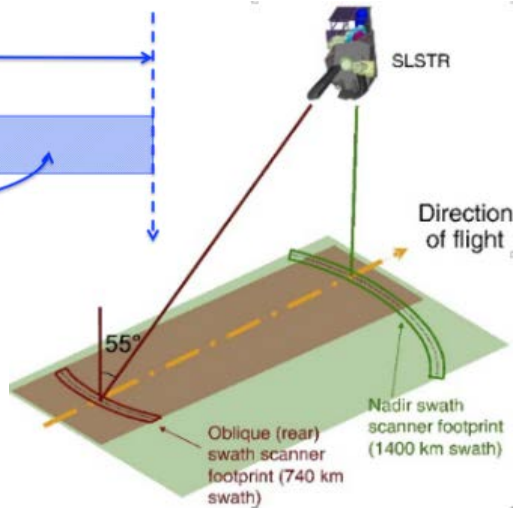
FLEX/Sentinel-3 Tandem Mission



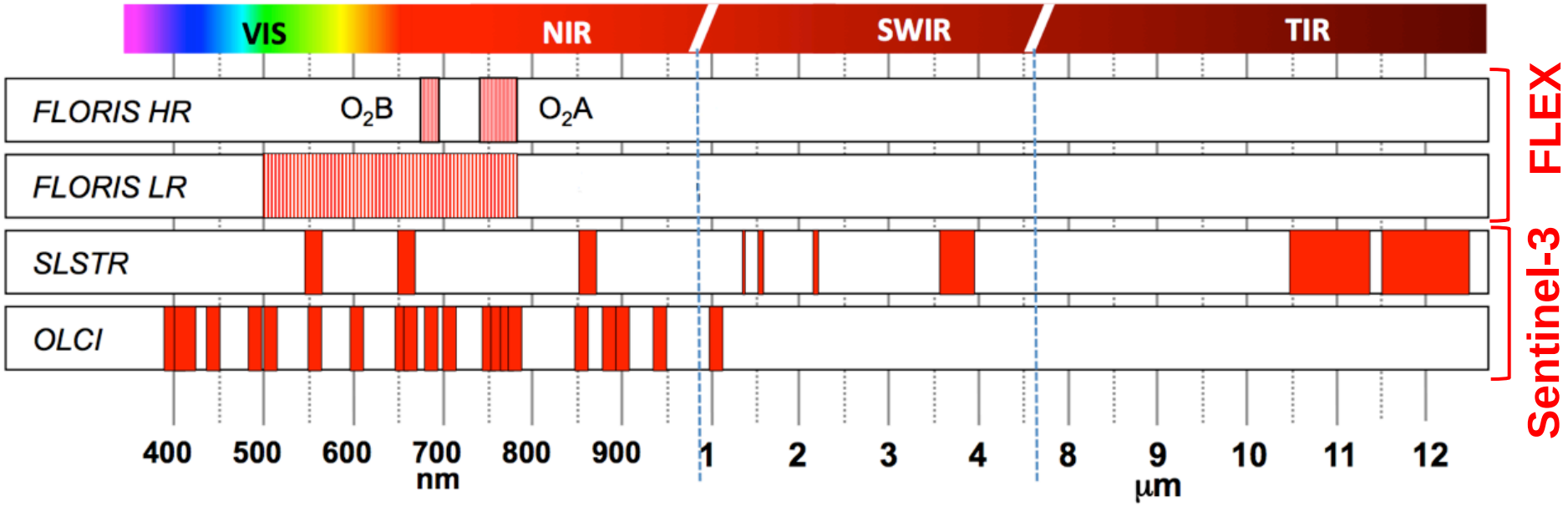


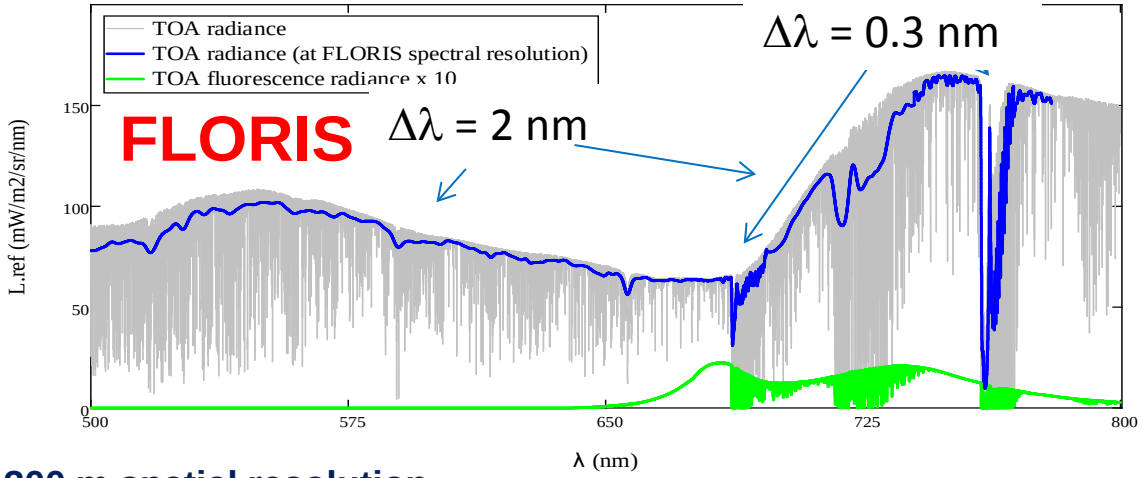






FLEX / Sentinel-3 spectral information

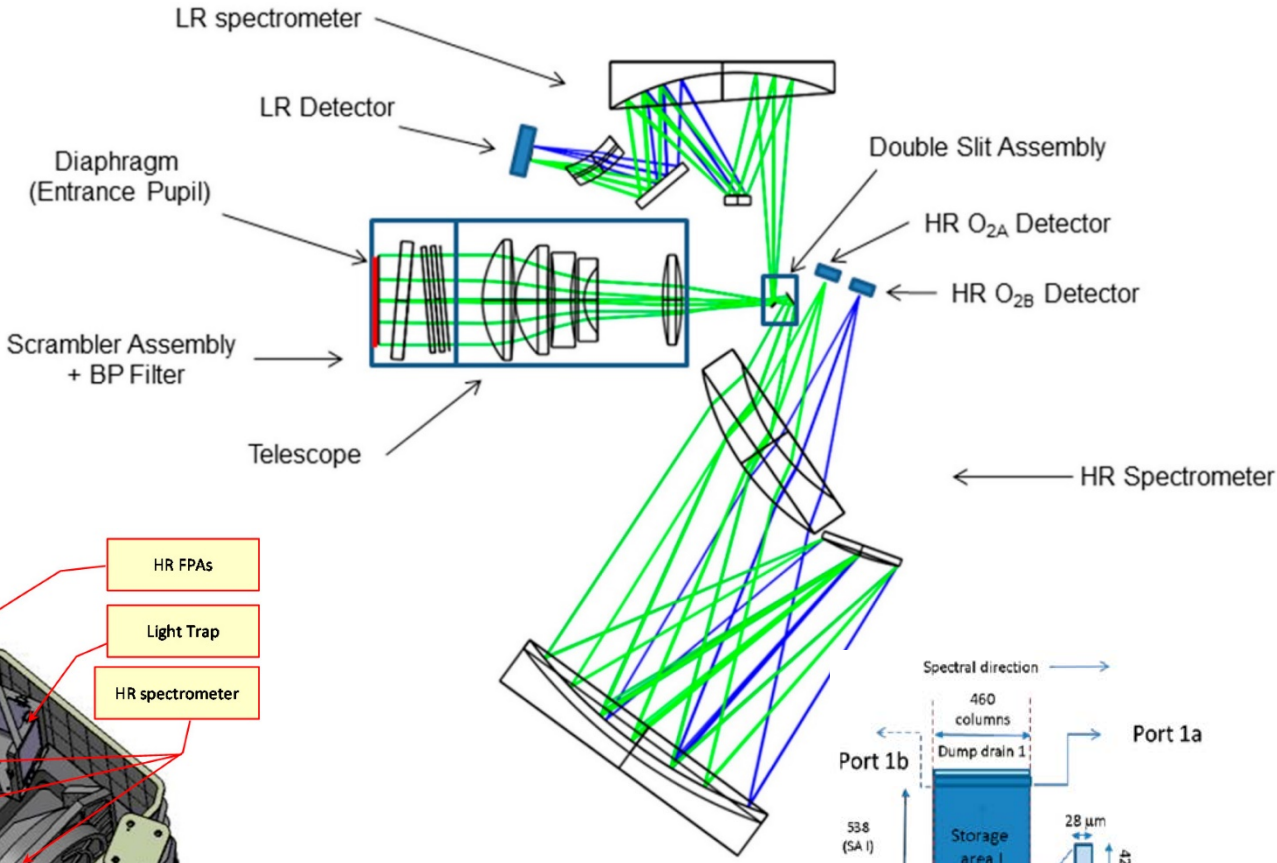


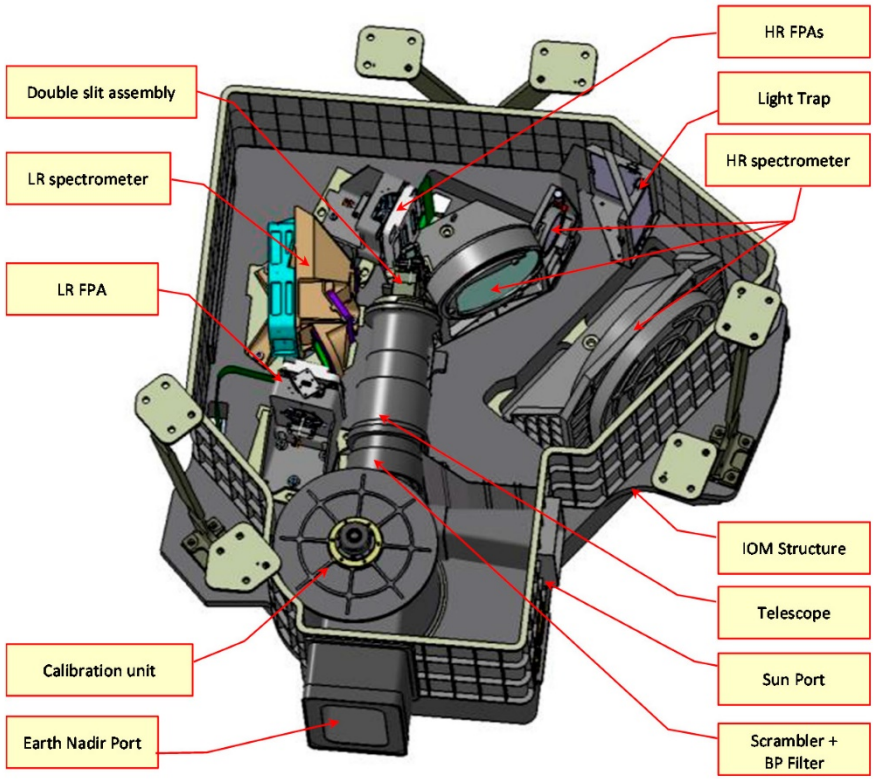


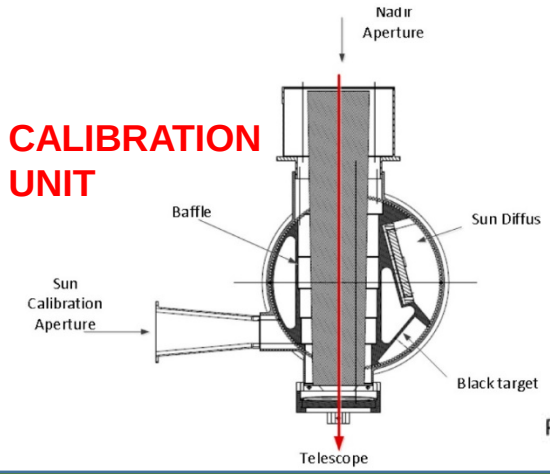
300 m spatial resolution

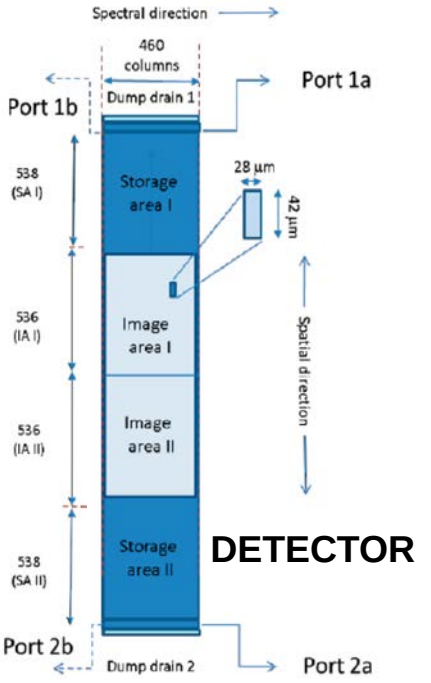
Spectral region	Central Wavelength [nm]	FWHM [nm]	Spectral Sampling [nm]
PRI	500 – 600	3	2
Chl	600 – 677	3	2
O_2-B	677 – 686	0,7	0,5
	686 – 697	0,3	0,1
Red-edge	697 – 740	2	1
	740 – 755	0,7	0,5
O2-A	755 – 759	0,7	0,5
	759 – 762	0,3	0,1
	762 – 769	0,3	0,1
	769 – 780	0,7	0,5

FLORIS instrument

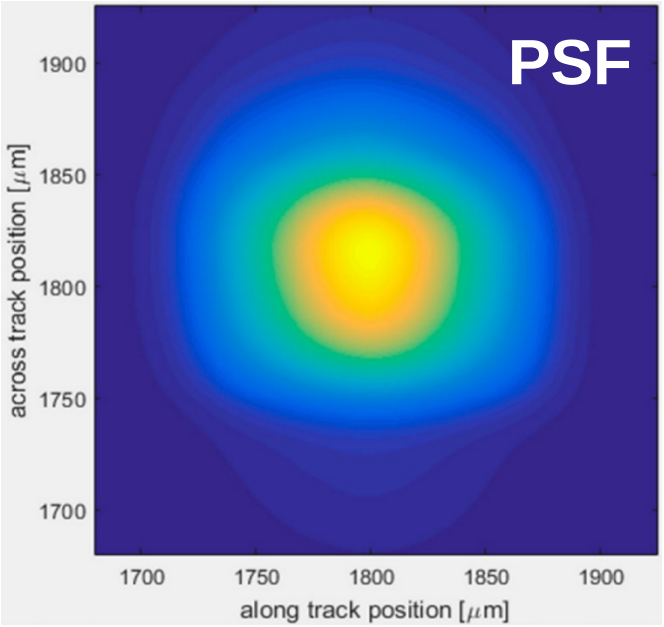


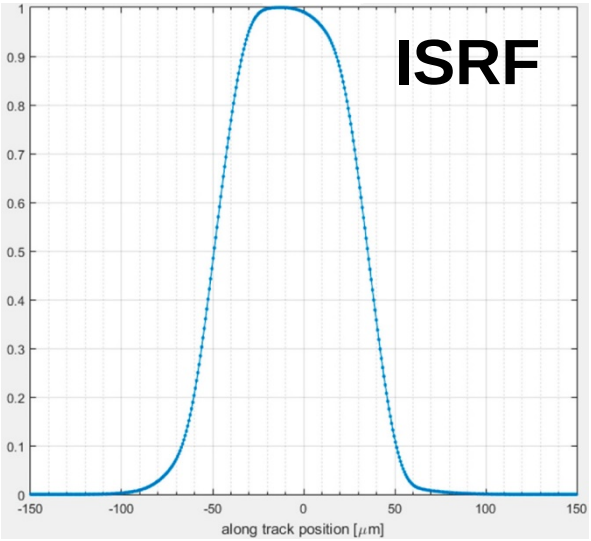






300 m spatial sampling





0.3 nm resolution / 0.1 nm sampling

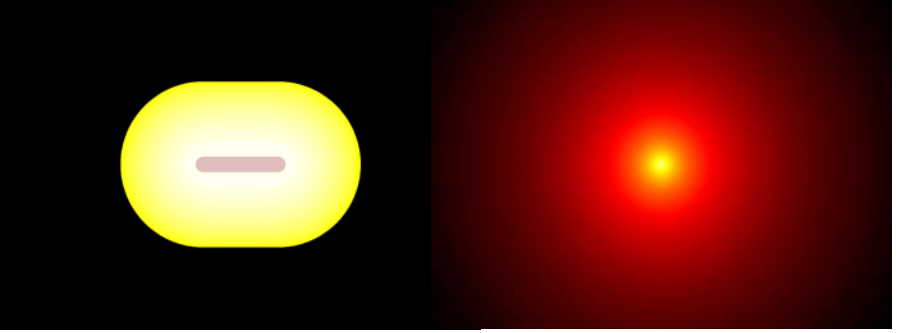
DEMANDING INSTRUMENT

- High spectral resolution
- High spatial resolution
- High SNR
- Very good calibration
- Spectral stability

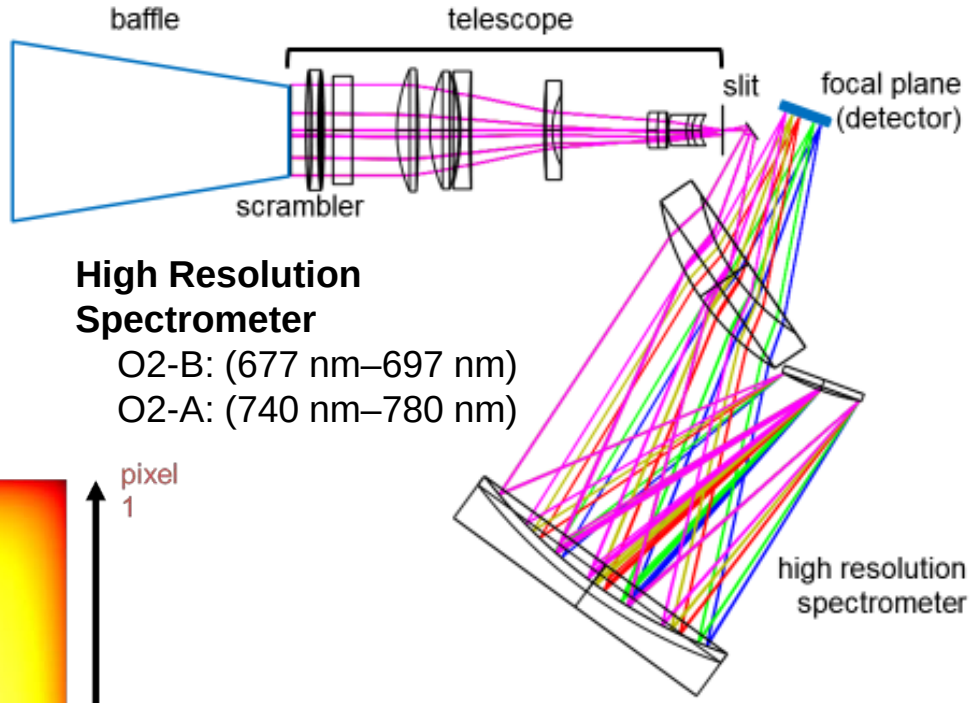
INSTRUMENTAL EFFECTS PERTURBING THE SIGNAL

- Polarization effects
- Spectral / radiometric calibration strategy
- Straylight effects:
  - Optical element roughness
  - Contamination effects
  - Ghost

  for each optical element (baffle, telescope, grating,…)



Baffle effects Straylight kernels

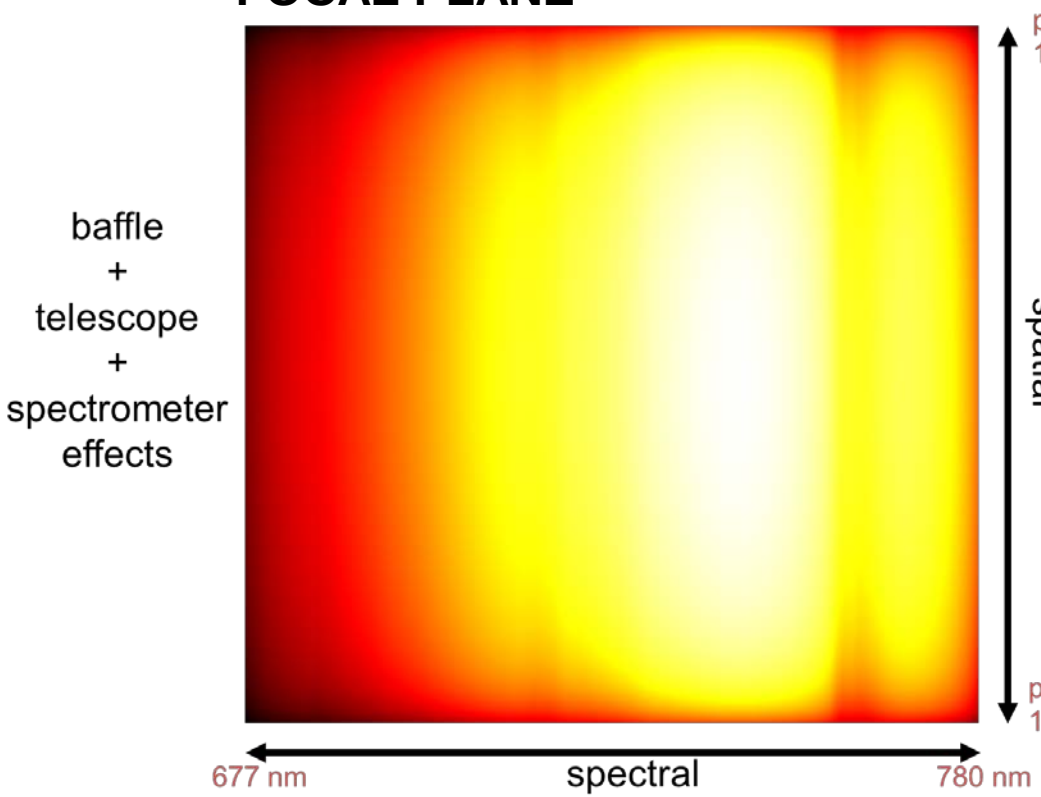


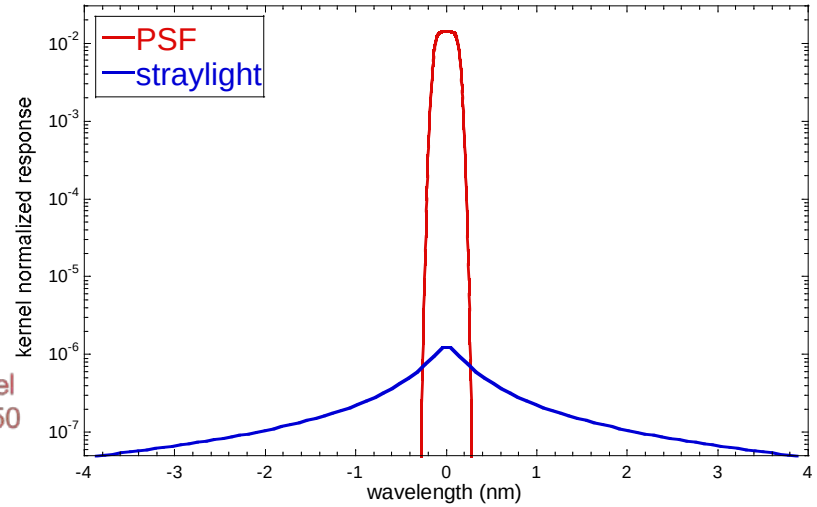
High Resolution Spectrometer

O2-B: (677 nm–697 nm)

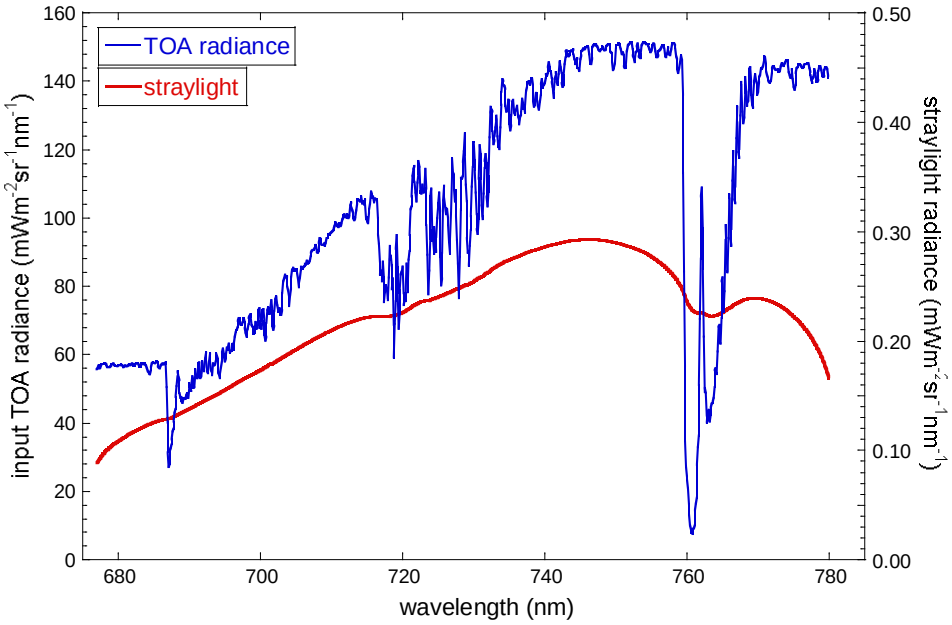
O2-A: (740 nm–780 nm)

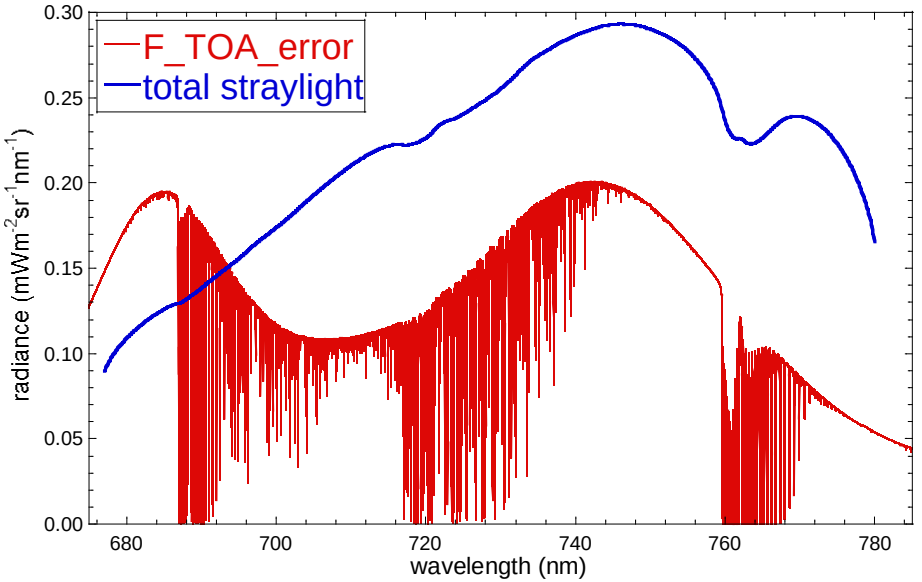
FOCAL PLANE

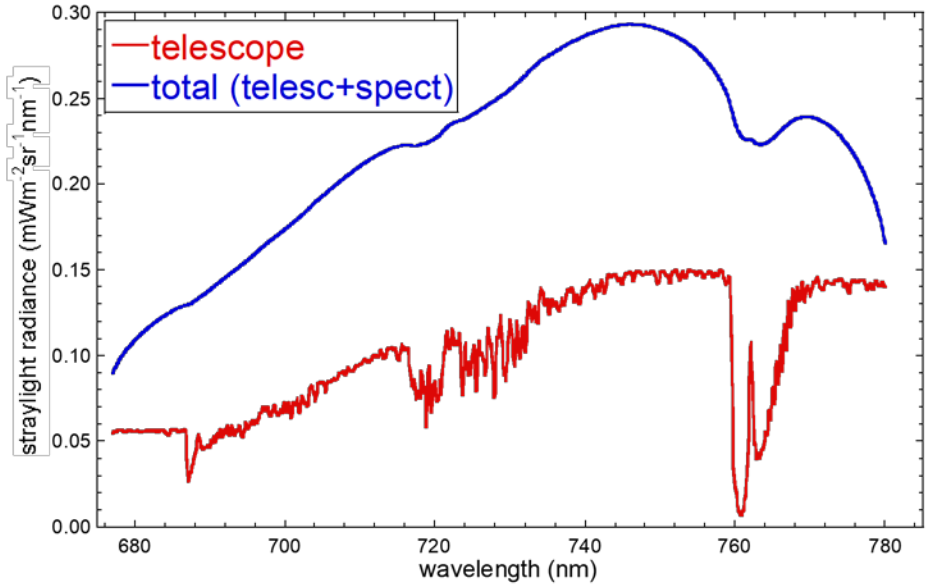


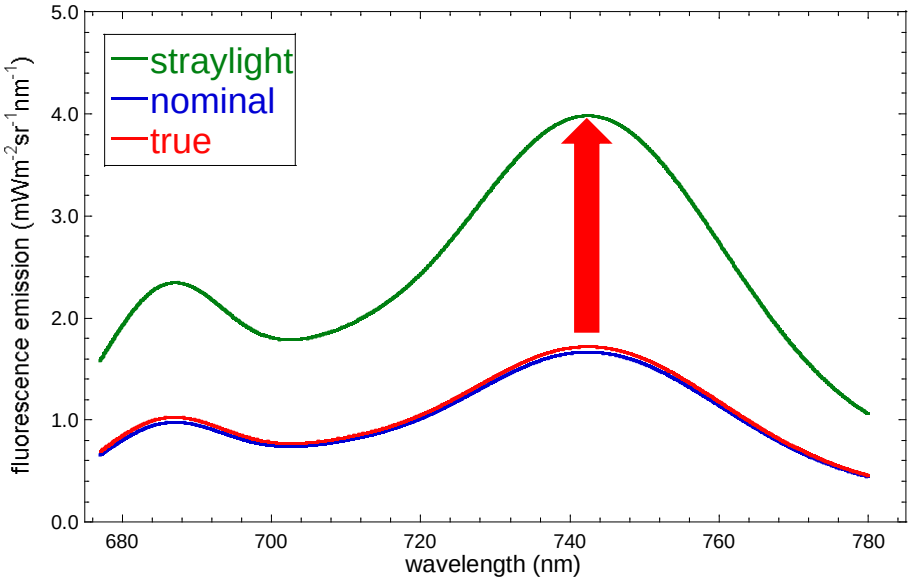


STRAYLIGHT EFFECTS

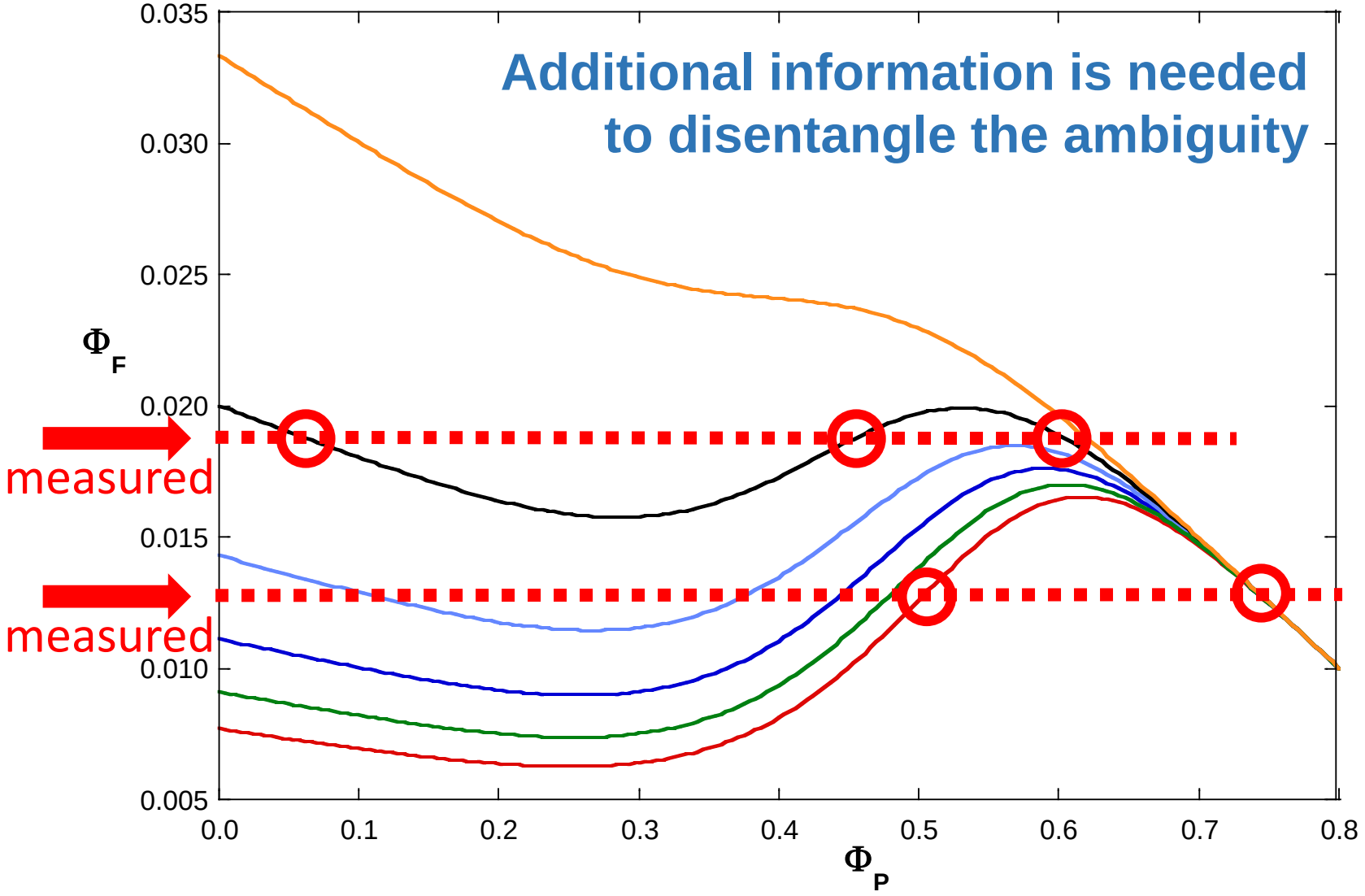






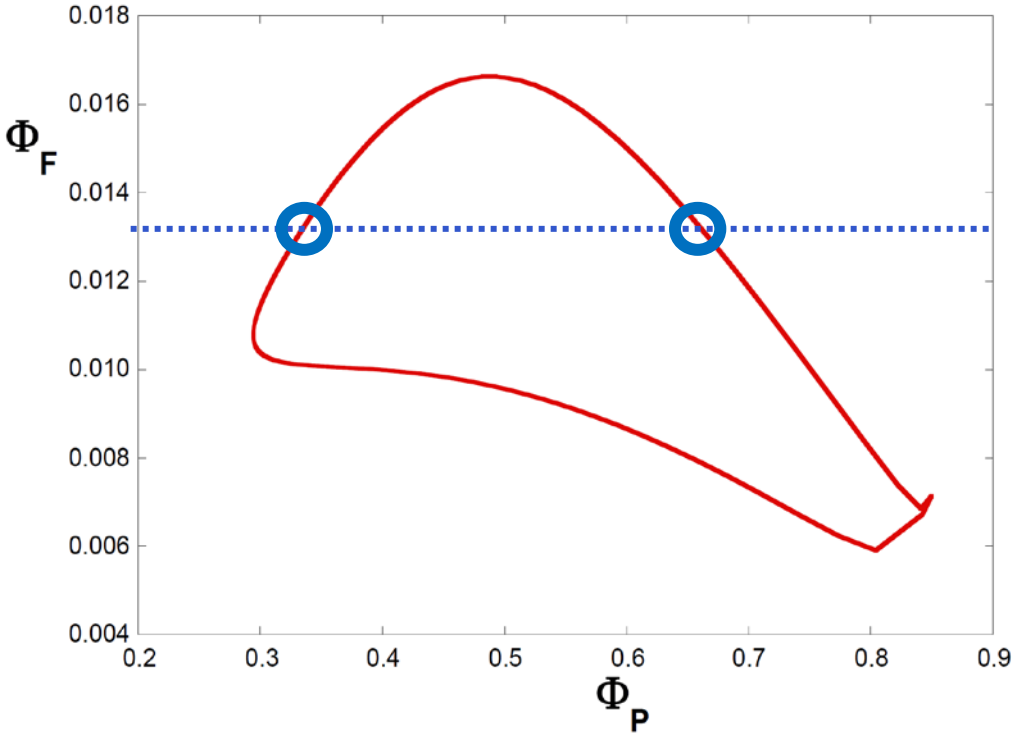


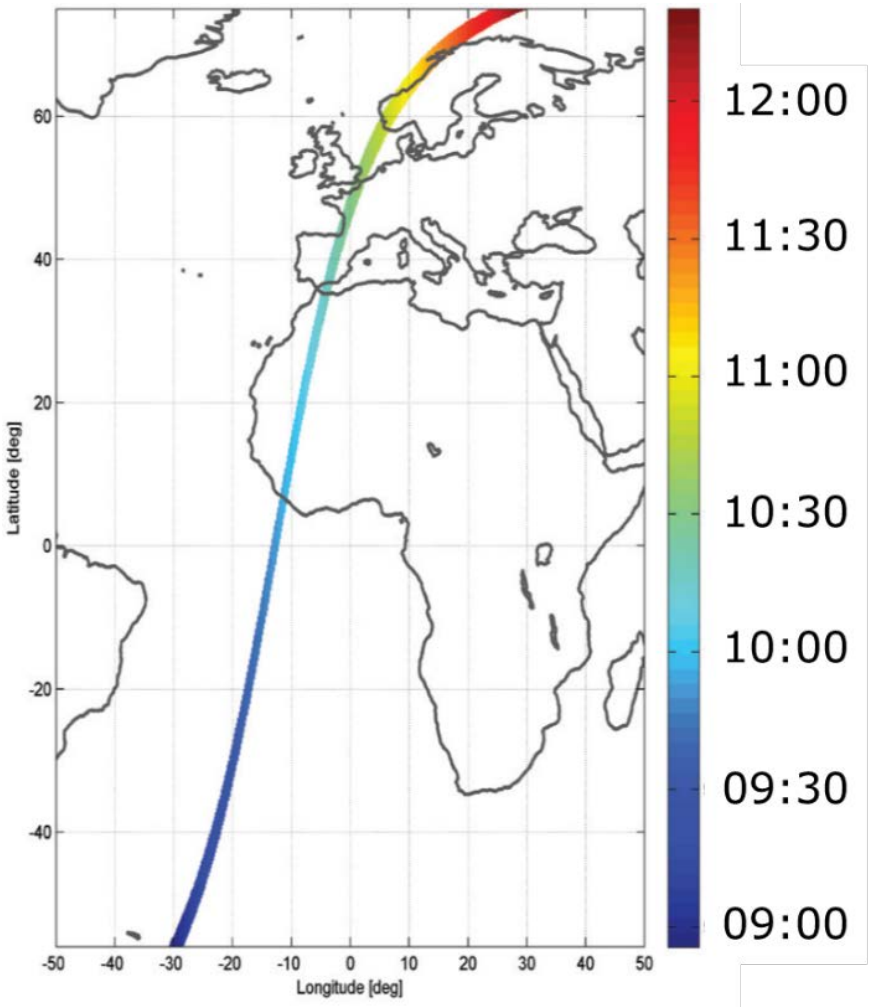
Relationship between fluorescence and photosynthesis



Impact of local time of observation in the retrieval of dynamical variables

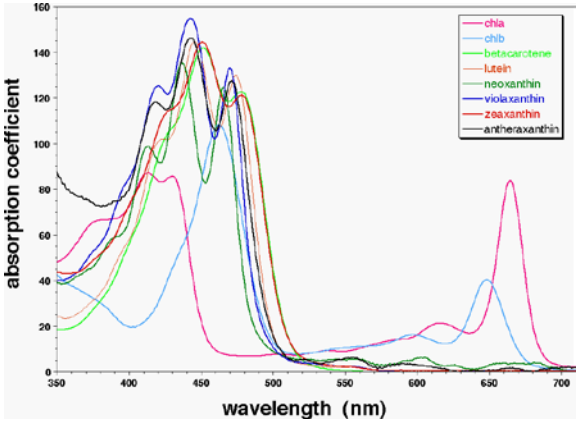
Diurnal cycle of Φ_P , Φ_F

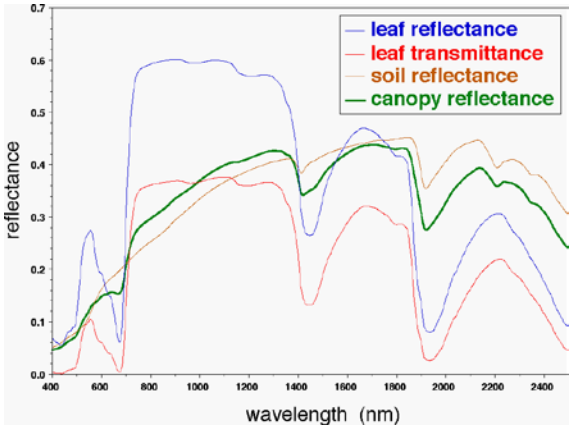


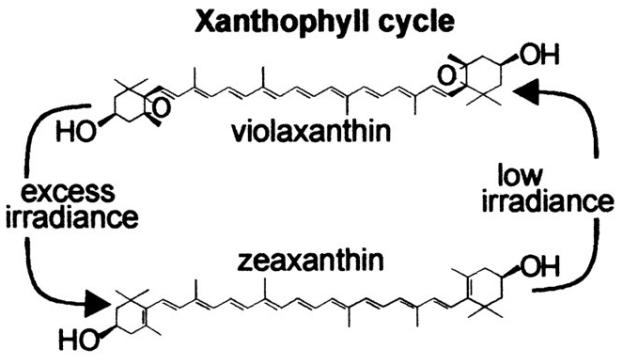


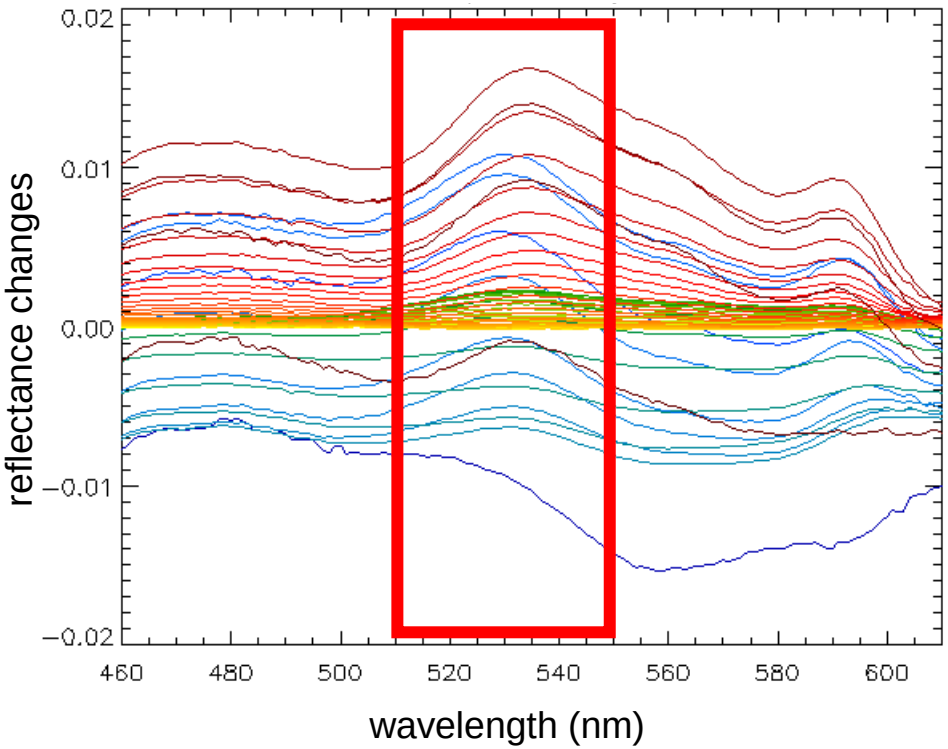
Changes in instantaneous illumination conditions and previous history of illumination hours at the time of overpass

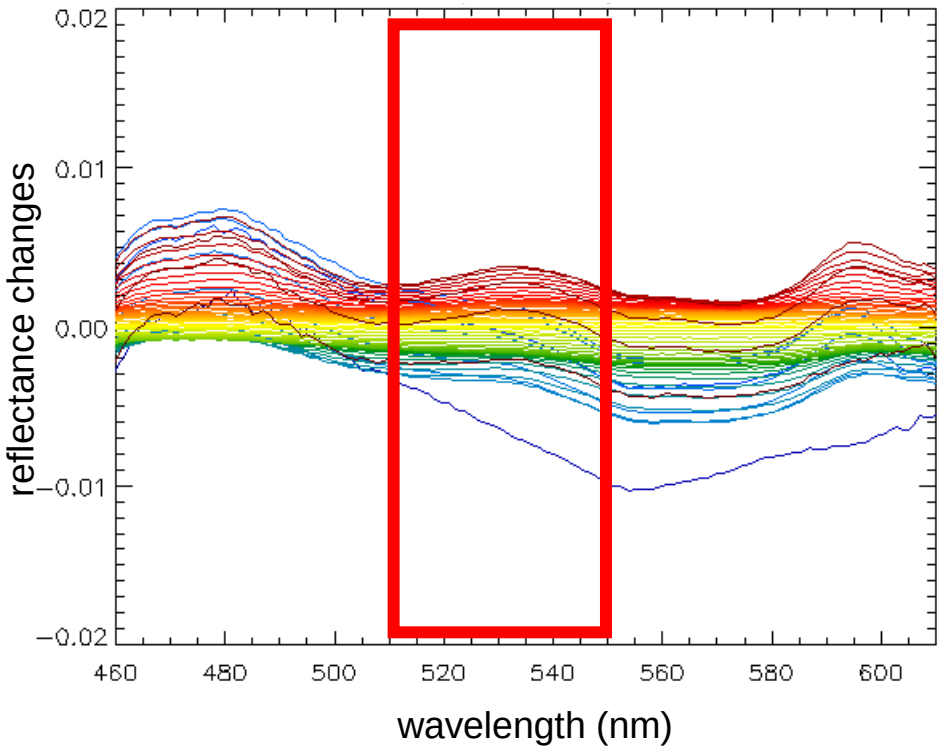
Dynamical reflectance changes associated to vegetation adaptation to stress conditions











FLEX products

LEVEL-2 PRODUCTS	COMMENTS
• **Total fluorescence emission (spectrally integrated value)** • **Peak values (F680 and F740)** • **PSI – PSII contributions**	Integrated values at canopy level are the ones required by models. $\varepsilon(F_s) \leq 0.2$ mW m^{-2} sr^{-1} nm^{-1} for instantaneous observations.at 300 m original spatial resolution.
• **Non-photochemical energy dissipation**	Regulated energy dissipation, accounts for the fraction of light absorbed by non-photochemical pigments (carotenoids / chlorophyll ratio and violaxanthin / zeaxanthin ratio, anthocyanin).
• **Fluorescence quantum efficiency**	Ratio between energy emitted as fluorescence versus actual chlorophyll specific absorption.
• **Photosynthesis rate**	Effective charge separation at PSII, interpreted as actual electron current.
• **Vegetation stress**	Defined as “actual photosynthesis / potential photosynthesis”

LEVEL-3 PRODUCTS	COMMENTS
• **Spatial mosaics**	Regional / continental / global maps
• **Temporal composites**	Monthy / seasonal / annual composites
• **Activation / deactivation of photosynthetic machinery**	Determines length of the growing season

LEVEL-4 PRODUCTS	COMMENTS
• **Gross Primary Productivity (GPP)**	Carbon uptake, derived by data assimilation with usage of external inputs (meteo data, land cover maps)
• **Dynamical vegetation stress**	Decoupling between different stresses through dynamical model

CONCLUDING REMARKS

FLEX IN THE CONTEXT OF IMAGING SPECTROSCOPY MISSIONS

I. State-of-the-art technology for very high spectral resolution measurements, with relatively high spatial resolution and very high SNR to detect changes in an small signal like fluorescence and subtle changes in reflectance.

II. Data processing aspects: atmospheric correction, spectral calibrations, straylight corrections, retrievals taking full advantage of all the spectral information, going from raw data to high-level products.

III. Optimal specific exploitation of spectral information: fluorescence derived from spectral changes in apparent reflectance, small reflectance changes used for sensitivity to stress conditions and plant adaptations: link between dynamical reflectance changes and dynamics of leaf pigments.

IV. Modelling aspects: sophisticate modelling of the radiometric signal, coupled with physiological processes, into dynamical vegetation models.

Thank you.

Questions?