Assimilating visible satellite reflectances at ECMWF

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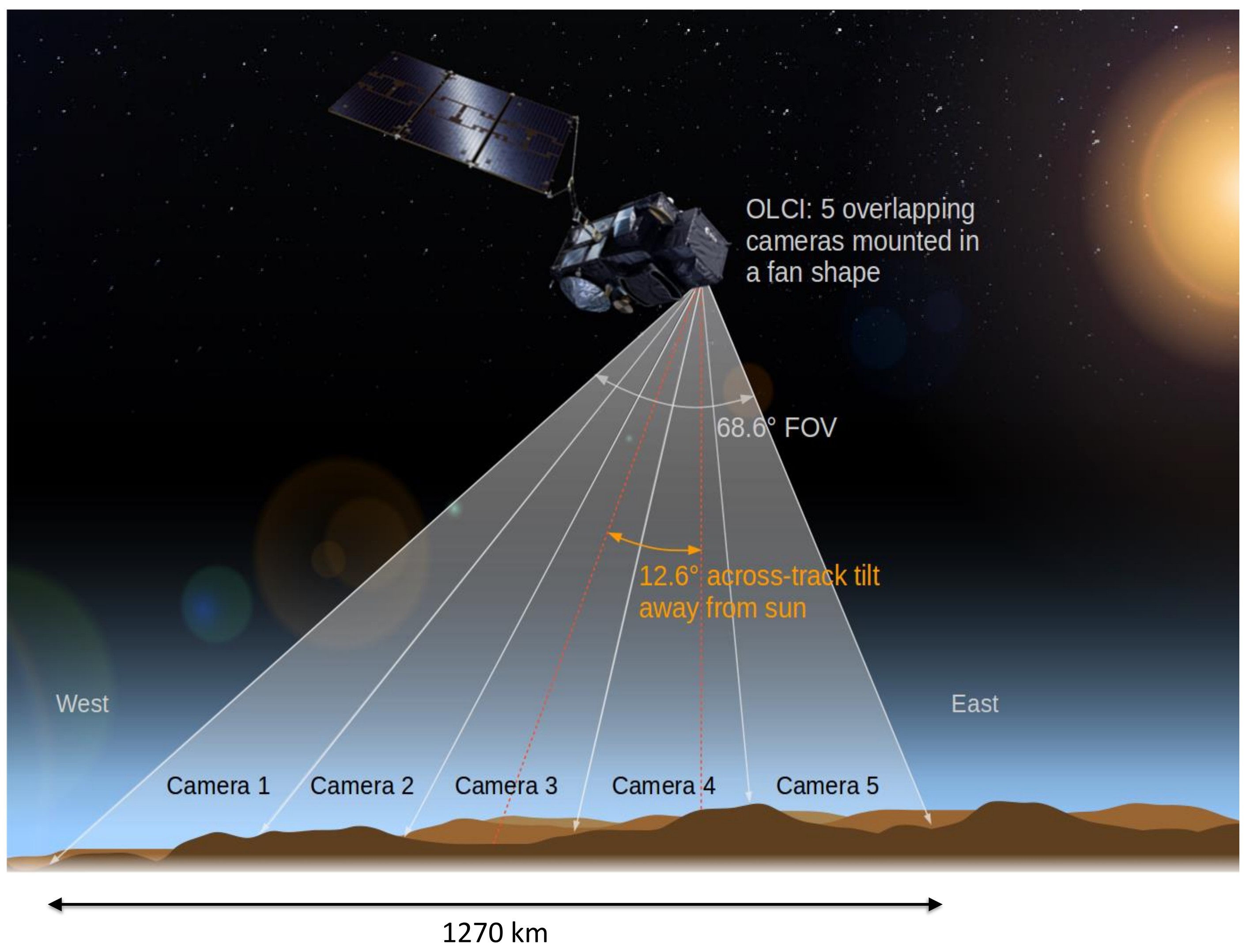
Why assimilate visible data?

- Cloud-affected microwave radiances are assimilated at ECMWF. These provide information at a resolution of tens of kilometres, mainly on the rain and liquid cloud distribution (Geer et al., 2014).
- Visible radiances contain a wealth of information on clouds. They are available at much higher horizontal resolution than microwave data, and are sensitive to the full depth of clouds in the atmosphere.
- Visible radiances have not yet been assimilated in global NWP models (Scheck et al., 2019) as they are much more sensitive to scattering, which adds significantly to the computational cost.
- Here we present an overview of the initial stages of assimilating visible satellite radiances at ECMWF.

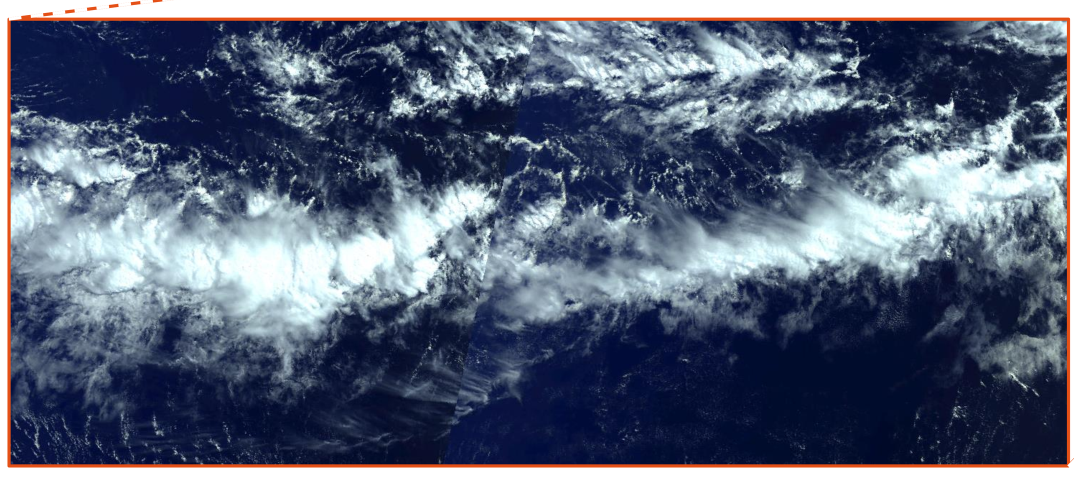
The OLCI instrument

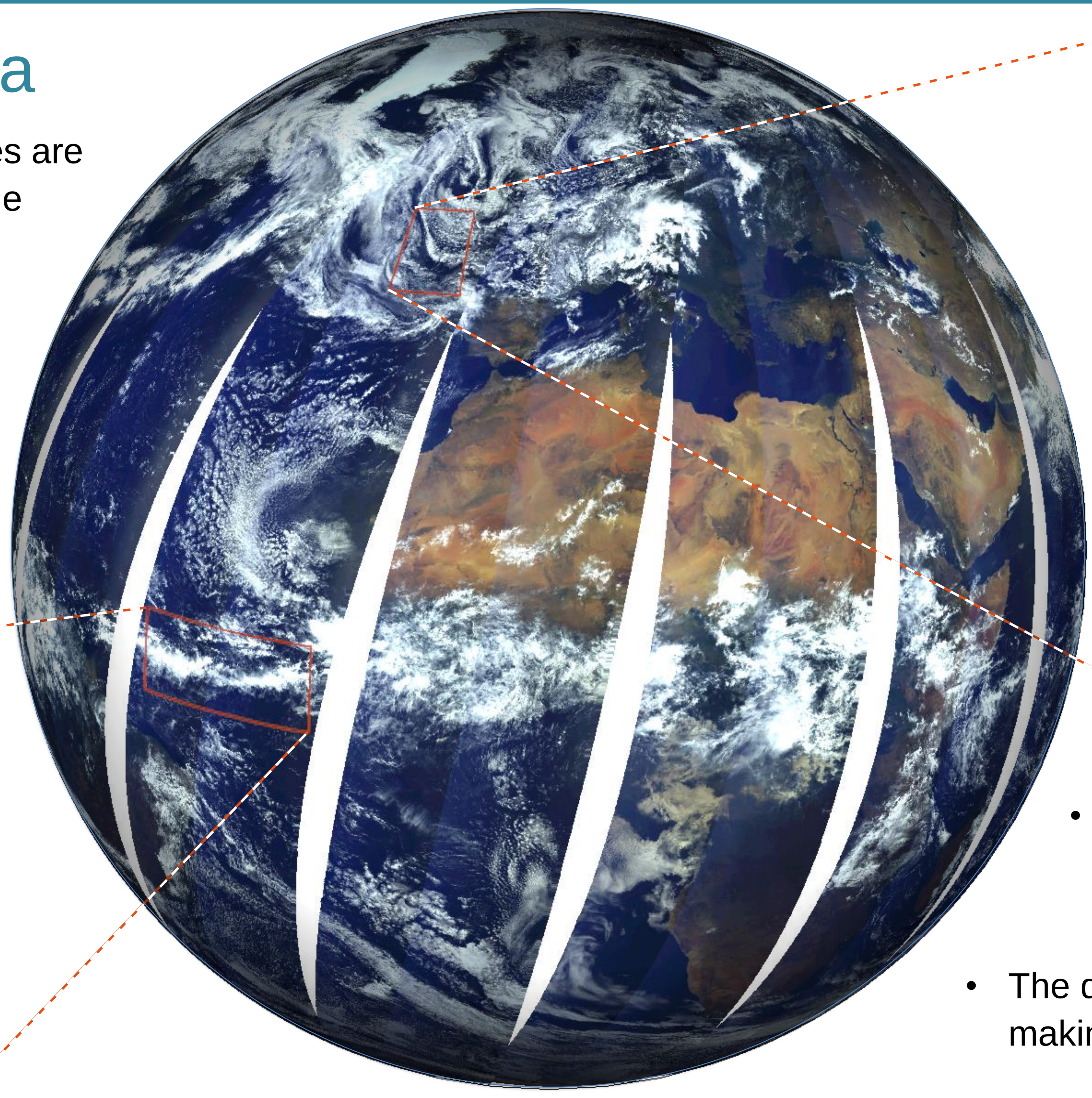
- The Ocean and Land Colour Instrument (OLCI) is aboard Sentinel 3A and 3B. It is a push-broom imaging spectrometer, based on the design of MERIS.
- Five cameras are arranged in a fan shape, and measure the solar radiation reflected by the Earth in the 0.4-1.02 µm range.
- The field-of-view is shifted 12.6° across track away from the sun, to minimize the impact of sun glint.
- The ground spatial resolution is approximately 300 m.

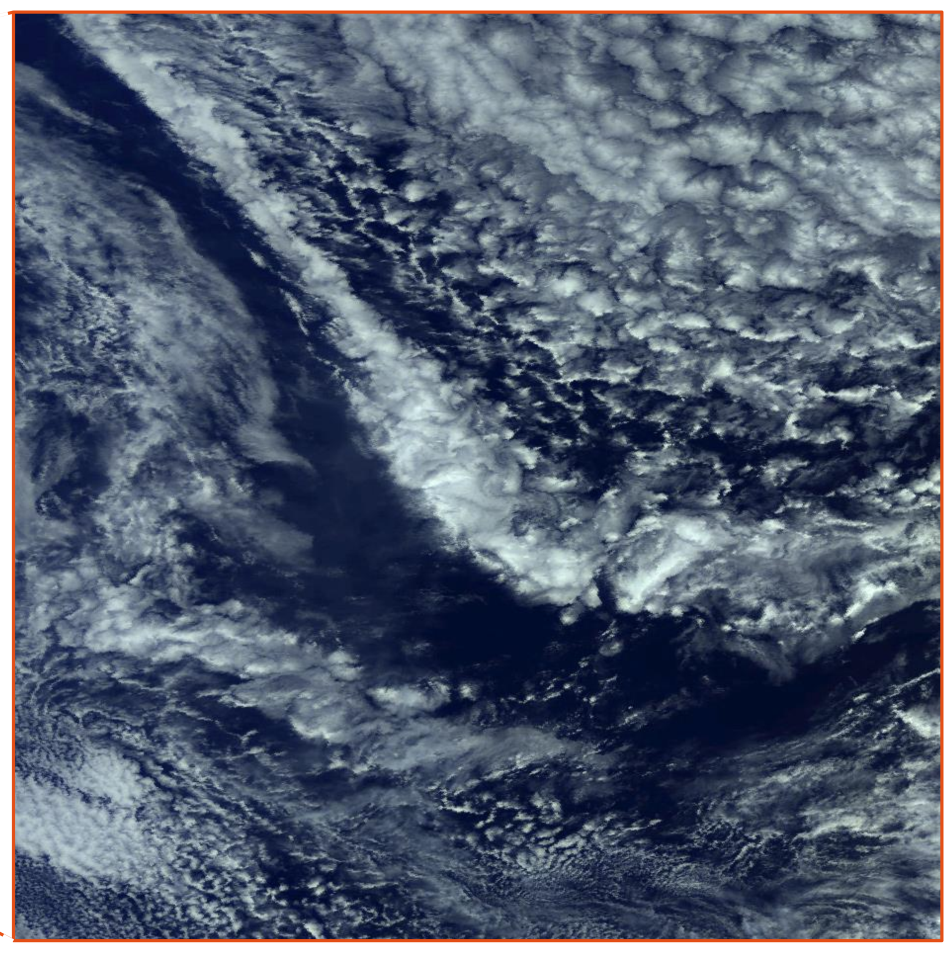


OLCI visible reflectance data

- We are using the 665 nm channel, and radiances are converted to reflectances for comparison with the output of the forward model.
- Initially we are only focusing on data over the oceans, due to the added complexities of accounting for surface reflectance over land.
- Data are superobbed to 9.6 km, for better comparison with the model resolution. The cloud fraction and reflectance variance are also recorded each superob.

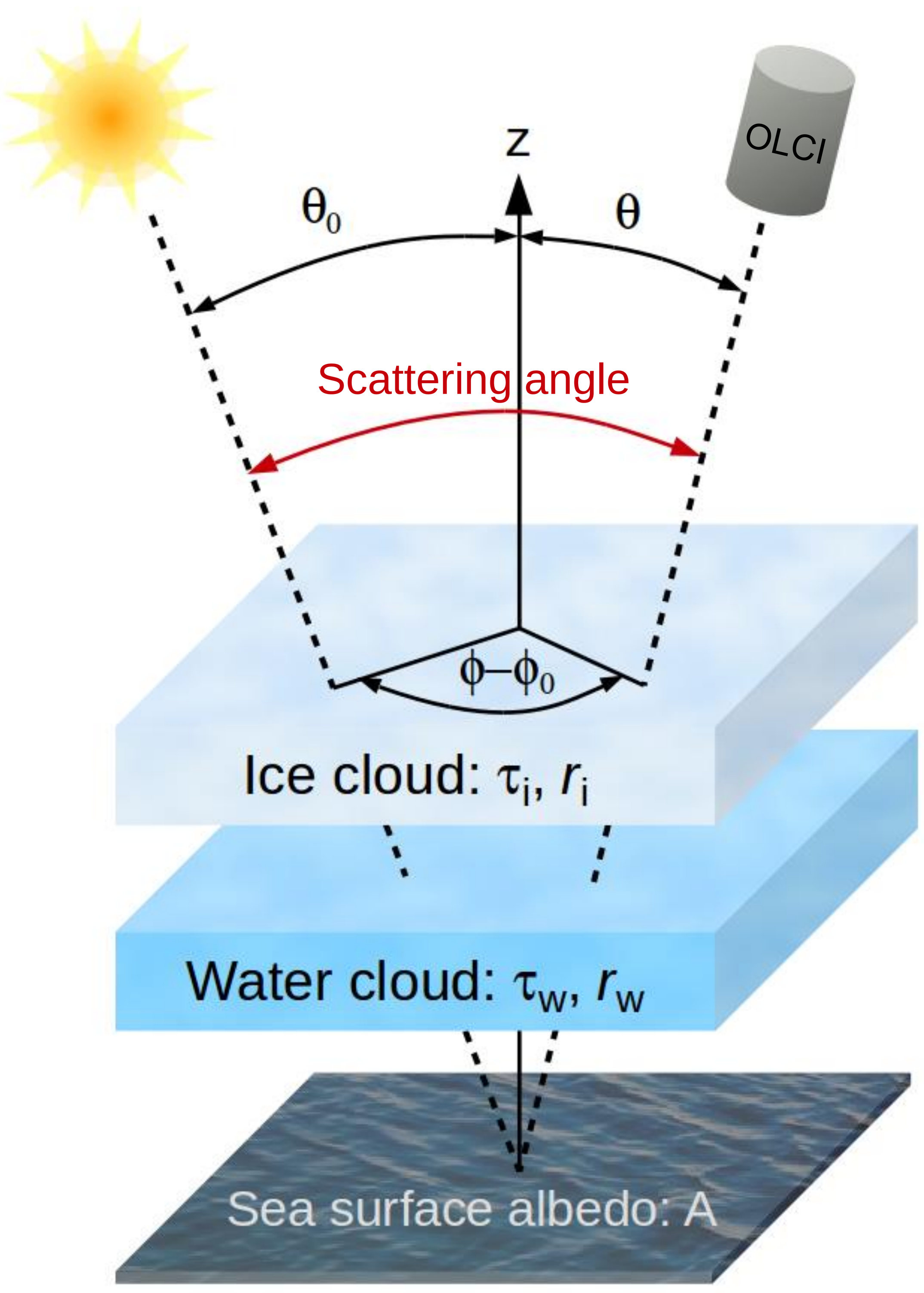






- Figures show visible images composed of OLCI-A and OLCI-B radiances at 665, 560 and 412.5 nm (RGB). Data are from 1 Aug 2021.
- The data are available within 3 hours of sensing, making them suitable for operational implementation.

MFASIS forward model



- Discrete Ordinates Radiative Transfer (DISORT) allows for highly accurate simulation of satellite radiances, but is too computationally expensive for NWP. Thus, we are using the Method for Fast Satellite Image Synthesis (MFASIS; Scheck et al., 2016) forward model.
- MFASIS is based on a reflectance look-up table computed with DISORT. It assumes ice clouds exist above water clouds, with the atmosphere described by only a few parameters: the total optical depths, τ, and effective radii, r, of water and ice.
- These parameters are calculated from vertical profiles of pressure, temperature, water vapour, cloud water/ice content, cloud water/ice effective radii and cloud fractional cover, provided by ECMWF's Integrated Forecasting System (IFS).
- Along with the surface albedo, A, the solar and satellite zenith angles, θ_0 and θ, and the difference between the solar and satellite azimuth angles, $\phi - \phi_0$, the look-up table finds the appropriate reflectance.

Progress and future work

- We are currently developing a cloud monitoring system as a first step towards implementing the assimilation of visible reflectances at ECMWF.
- Month-long simulations will be performed, and first guess and analysis departures (the differences between the OLCI observations and the IFS equivalent) will be recorded.
- The departures contain information regarding the performance of the model with respect to the observations, and can also reveal potential biases in the observations themselves.
- Benchmarking experiments will also be run, comparing the results of both the MFASIS and DISORT forward models against the OLCI observations.

References

Geer, A., Baordo, F., Bormann, N. & English, S. (2014). All-Sky Assimilation of Microwave Humidity Sounders, Technical Memorandum 741. ECMWF: Reading, UK.

Scheck, L., Frèrebeau, P., Buras-Schnell, R. & Mayer, B. (2016) A fast radiative transfer method for the simulation of visible satellite imagery, J. Quant. Spectrosc. Radiat. Transfer, 175, 54–67.

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