Simon Proud

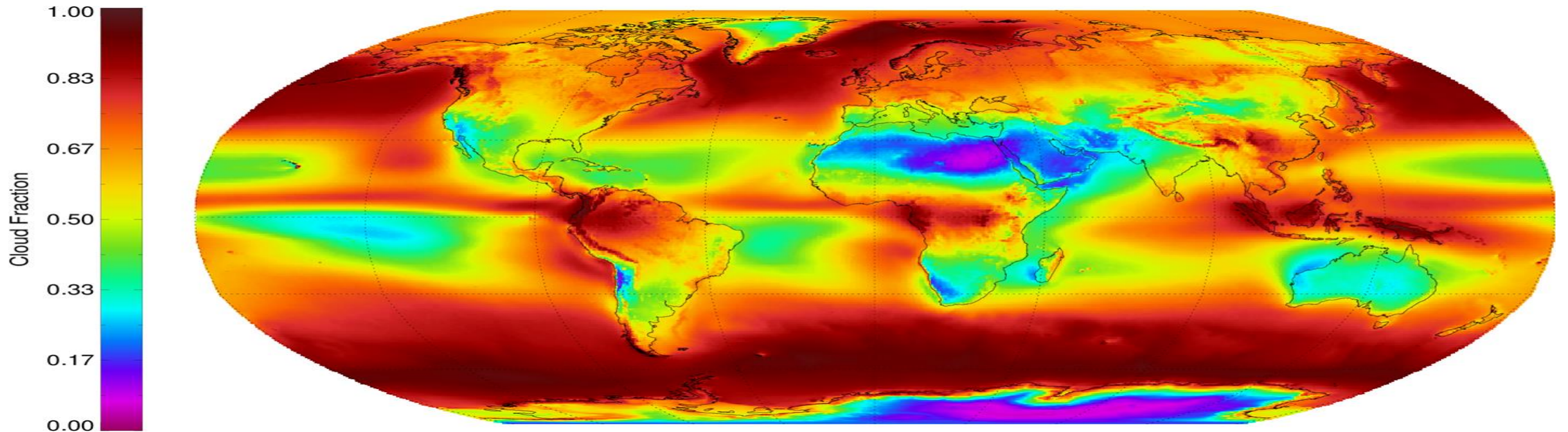# Multi-layer cloud properties, application to convection

@simon_sat
Simon.proud@physics.ox.ac.uk

Credit: Capt. Dan Hunn

Background

- Worked with GEOSats throughout my career, primarily MSG / SEVIRI
- 2015-2017: Part of the ESA's Cloud and Aerosol Climate Change Initiatives (CCIs)
- 2018-: Industrial fellowship to explore Convectively Induced Turbulence (CIT)

Cloud-CCI average cloud fraction, 1981 - 2014

Background

- Ongoing project with airlines to provide convection warnings to the flight deck
- Satellites provide a substantial operational benefit here: Rapid, long range, information about convection en-route.
- In operation with several major airlines, data sent directly to the cockpit.
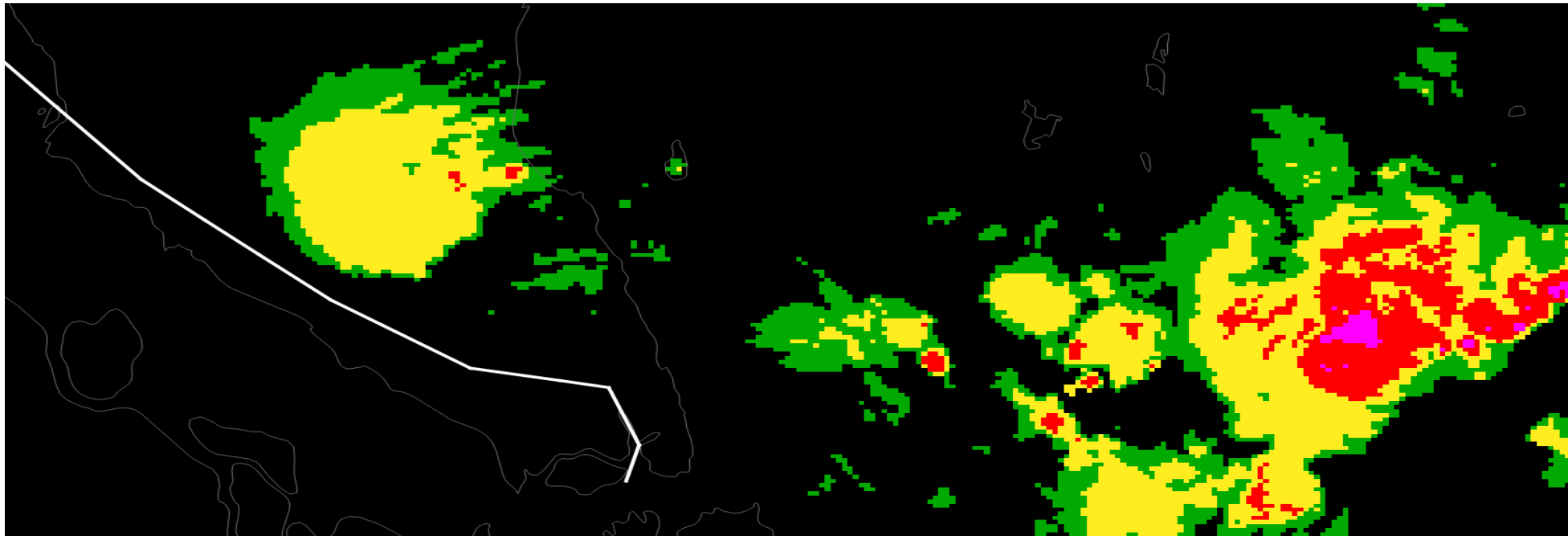
Recent convection research

- A five year dataset of overshooting tops (using Bedka's 2010 method) from SEVIRI
- Soon to be extended to full AVHRR and AATSR time series (30+ years) and updated to the 2016 detection method.

- Analysis of aircraft flights near convection over Europe
  - Around 2% of aircraft fly inadvisably close to cumulonimbus
  - Airspace congestion and poor awareness of the weather situation are main drivers of this.
  - Aircraft fly closer to Cbs at night than during day.
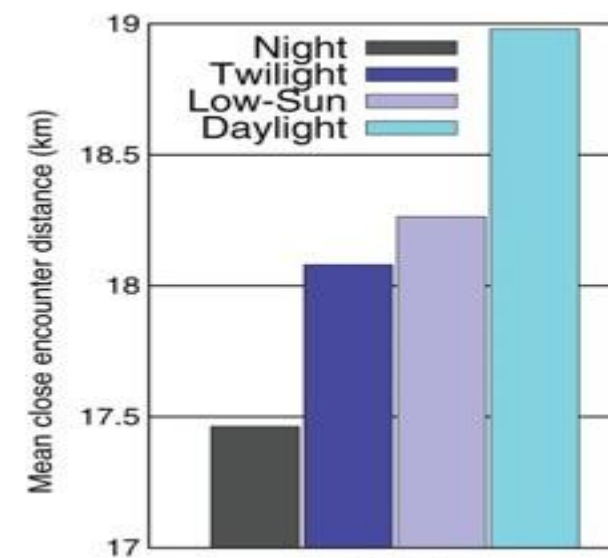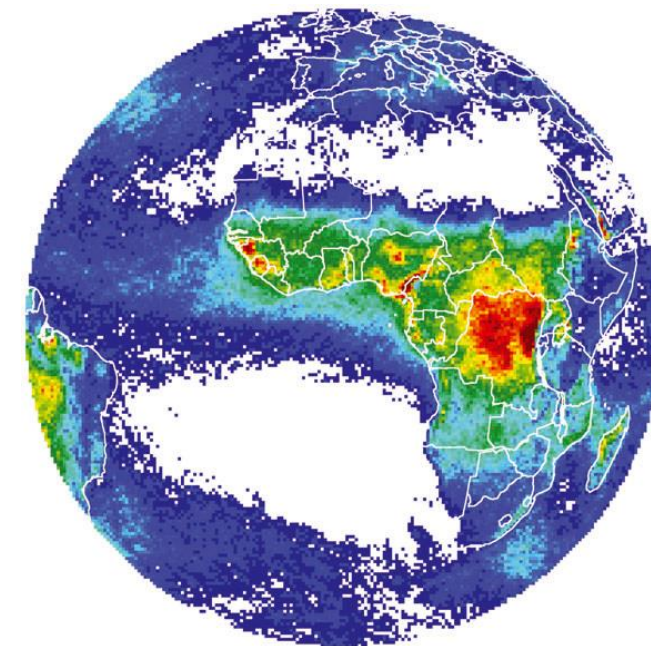
The ORAC Retrieval Framework

The Optimal Retrieval of Aerosol and Cloud (ORAC) algorithm retrieves cloud and/or aerosol properties from satellite imagers.

Wide range of sensors supported:

Polar:
AVHRR
ATSR2 / AATSR / SLSTR
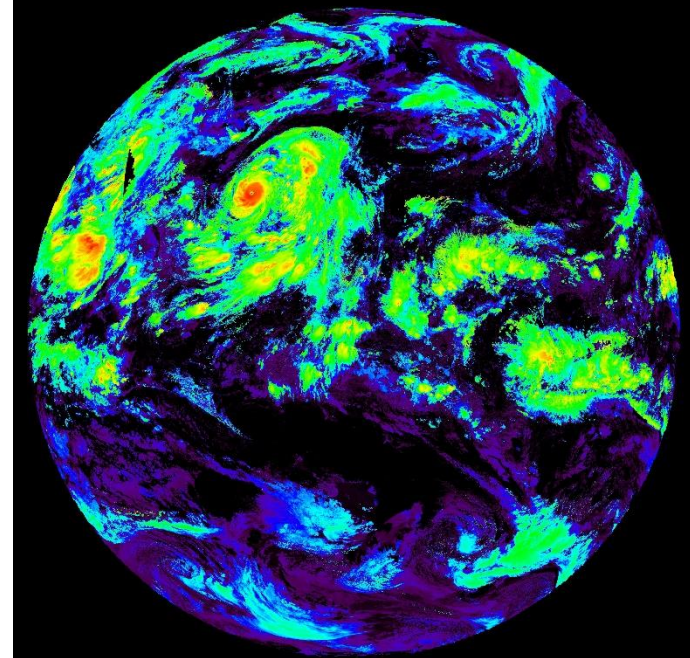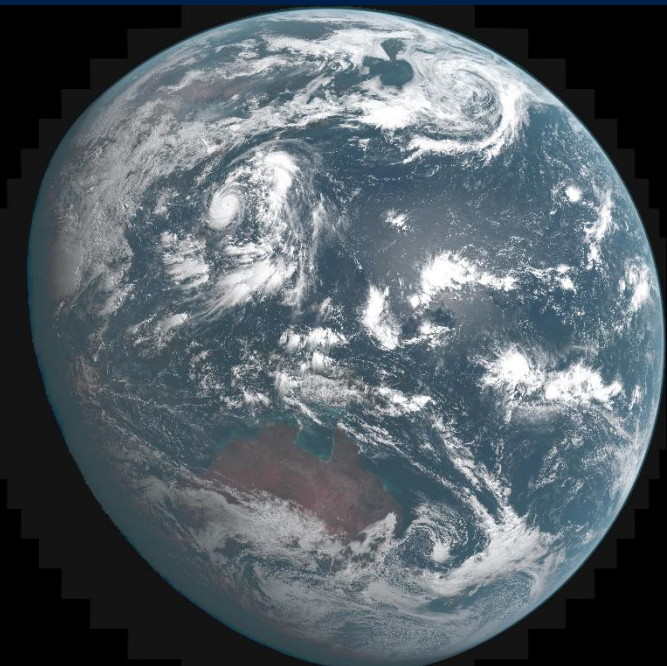MODIS (Aqua + Terra)
VIIRS

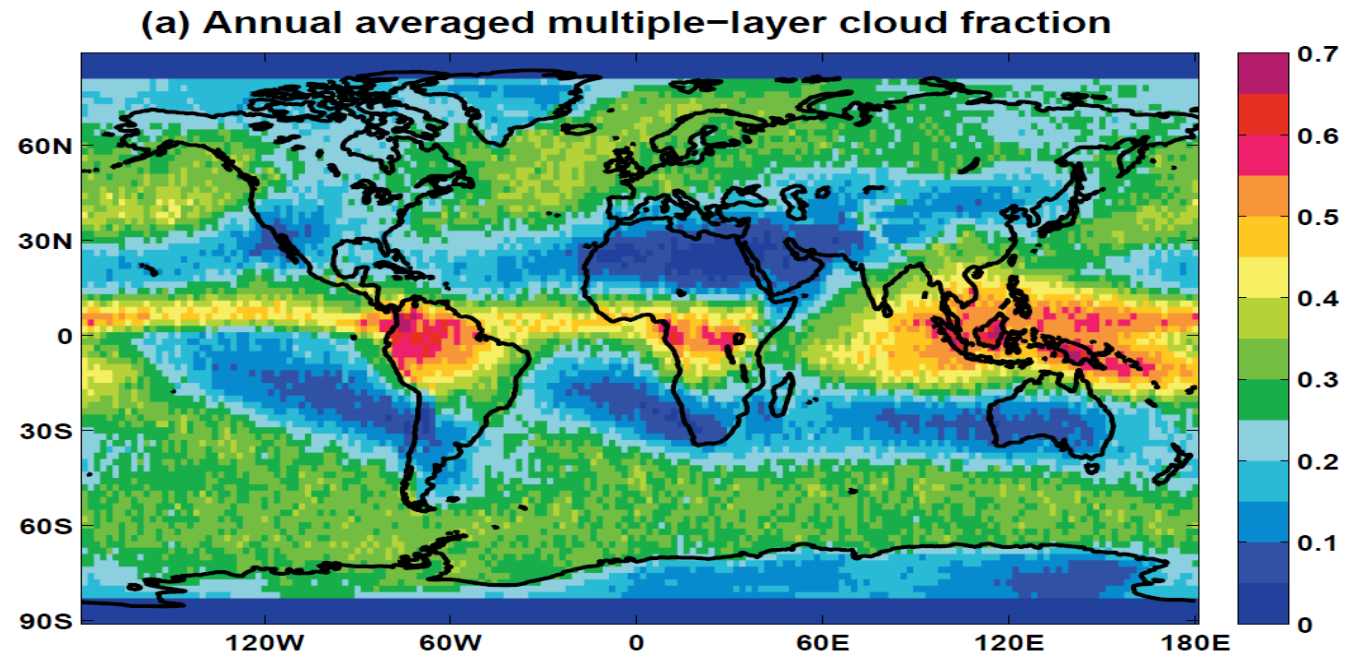**Geostationary:**
SEVIRI
ABI /GOES
AHI /Himawari

Plans to include Sentinel-3 OLCI and Meteosat Third Generation FCI as well as sensors on Chinese + Indian platforms.
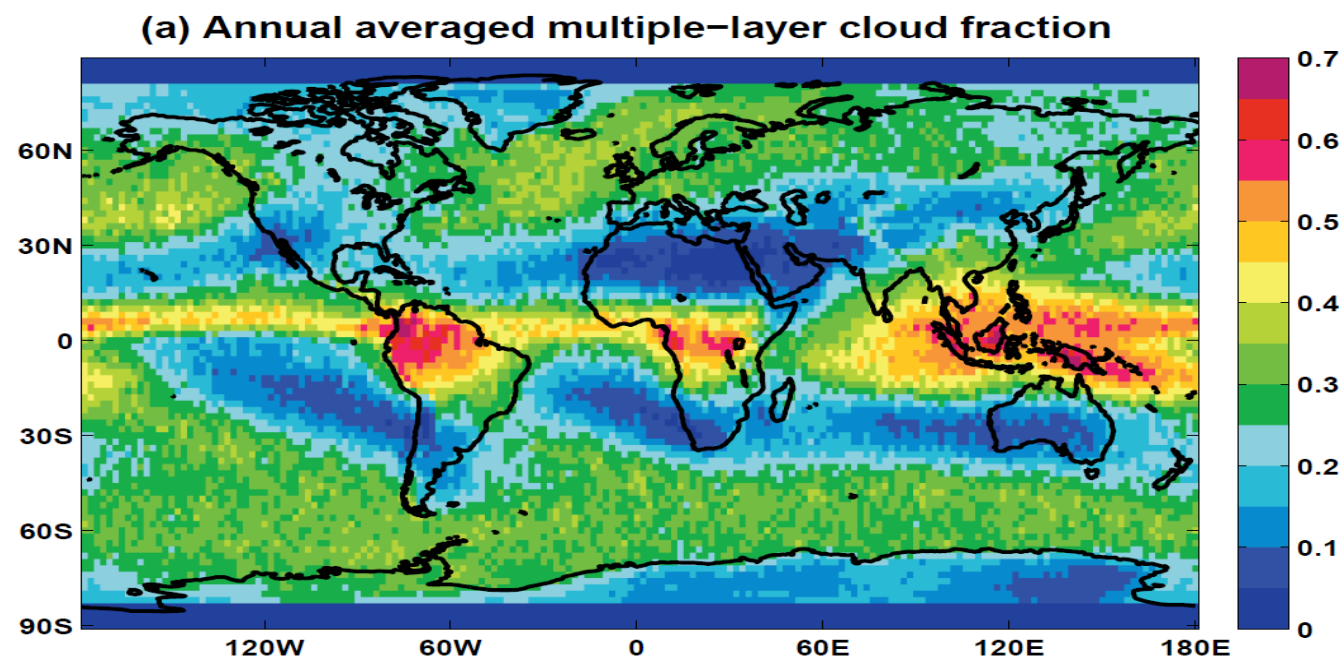
Multi-layer cloud property retrievals

- Multiple layers of cloud often present in one pixel, eg: high cirrus over a lower layer
- Retrievals of cloud properties that assume one layer will therefore be incorrect.

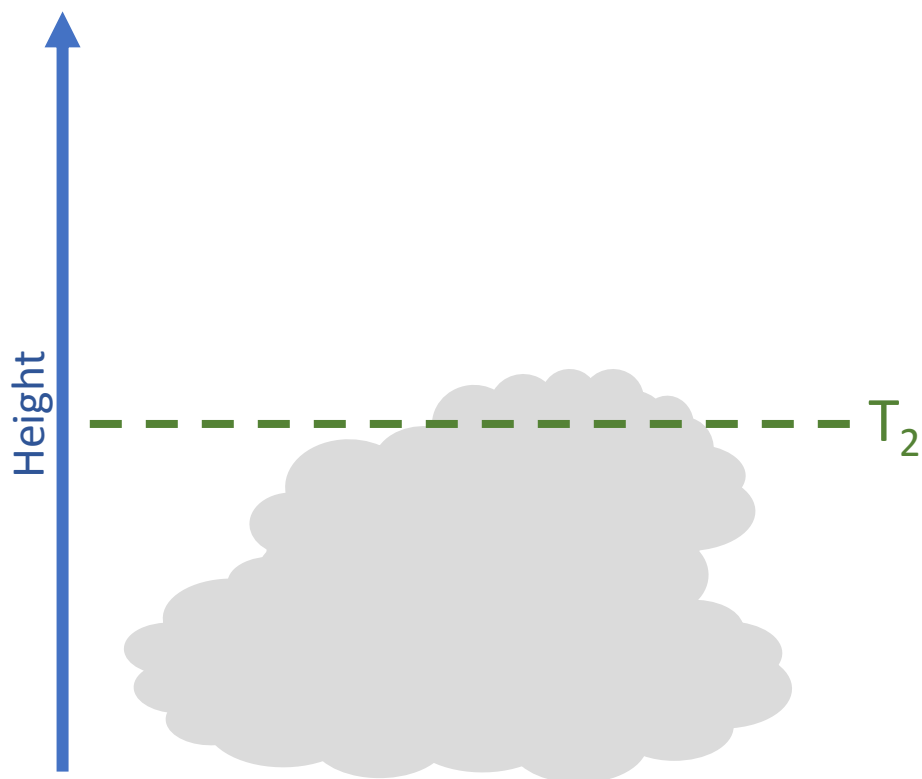(a) Annual averaged multiple-layer cloud fraction

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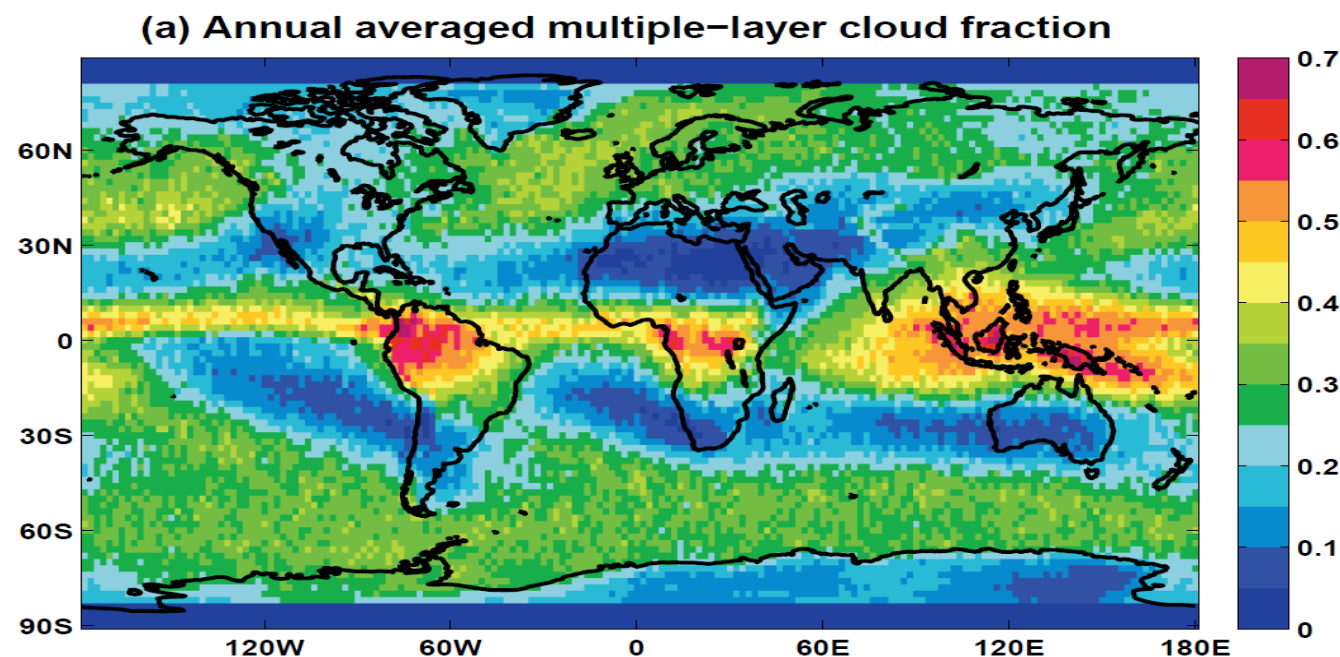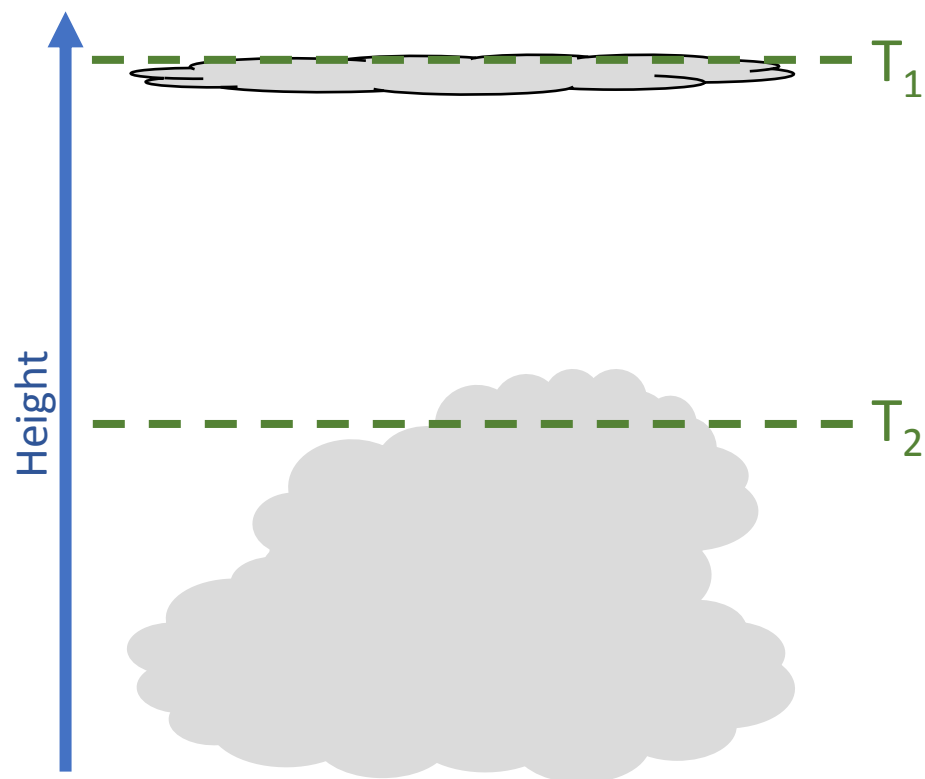(a) Annual averaged multiple-layer cloud fraction

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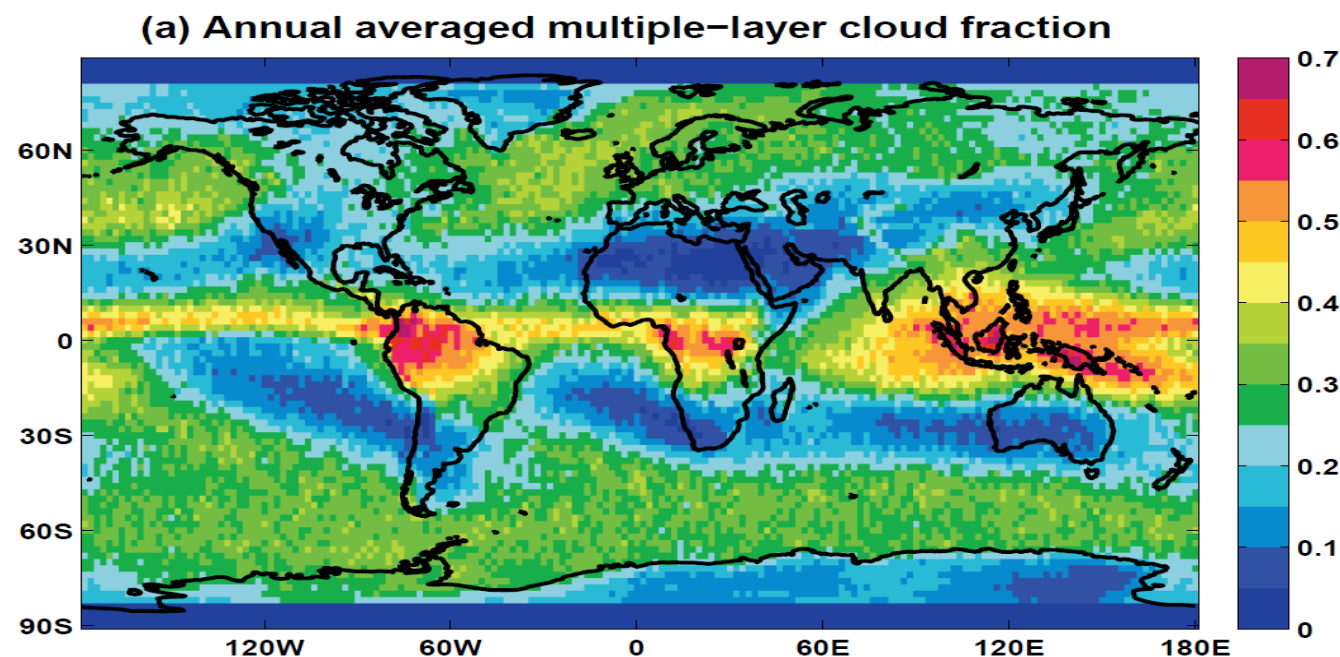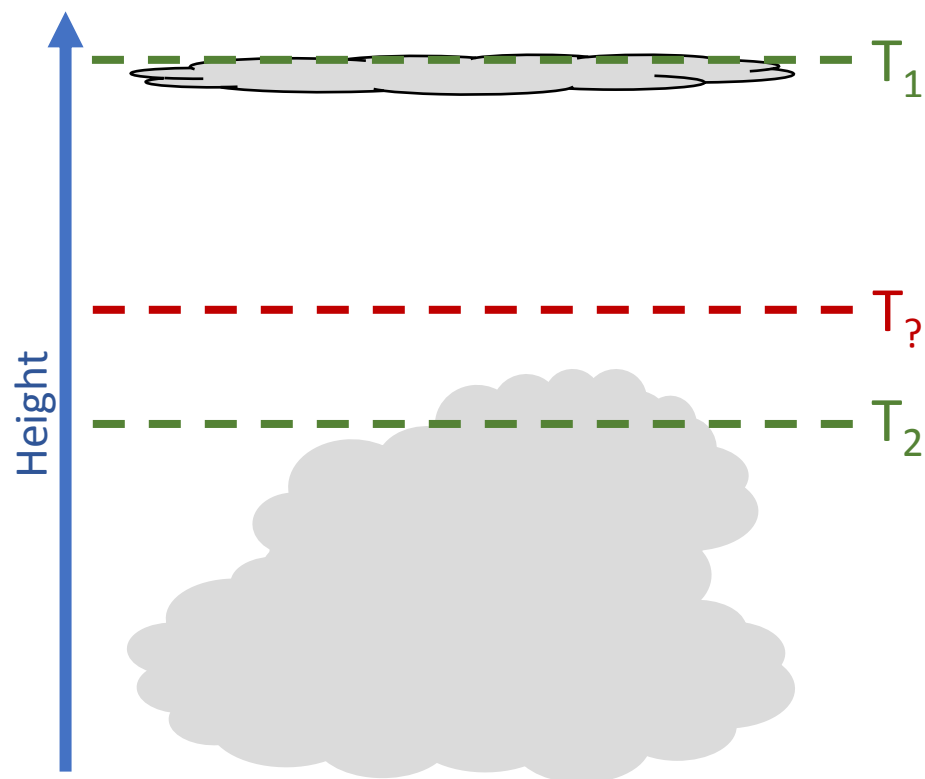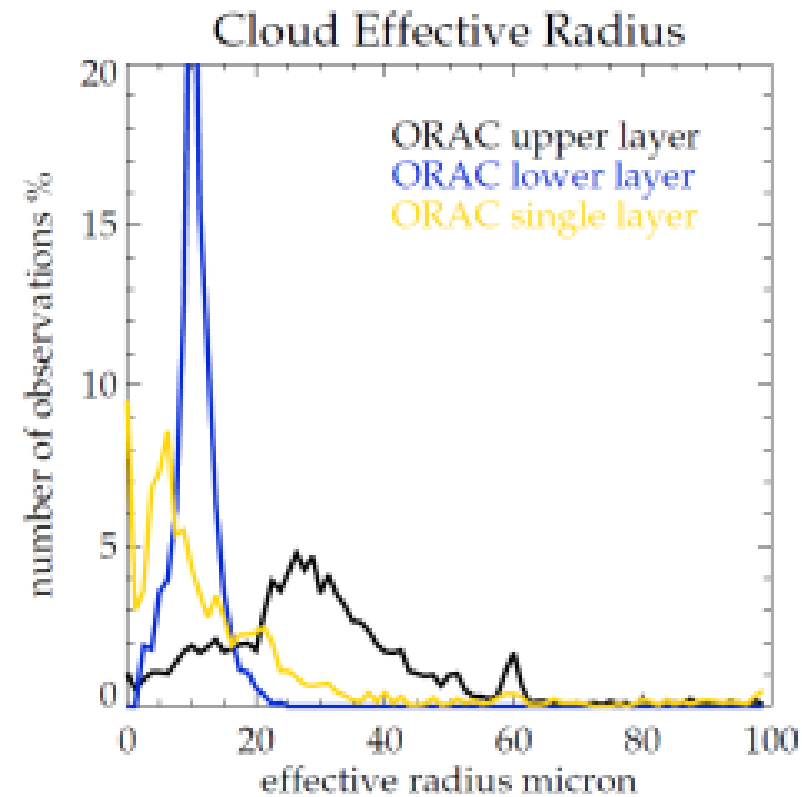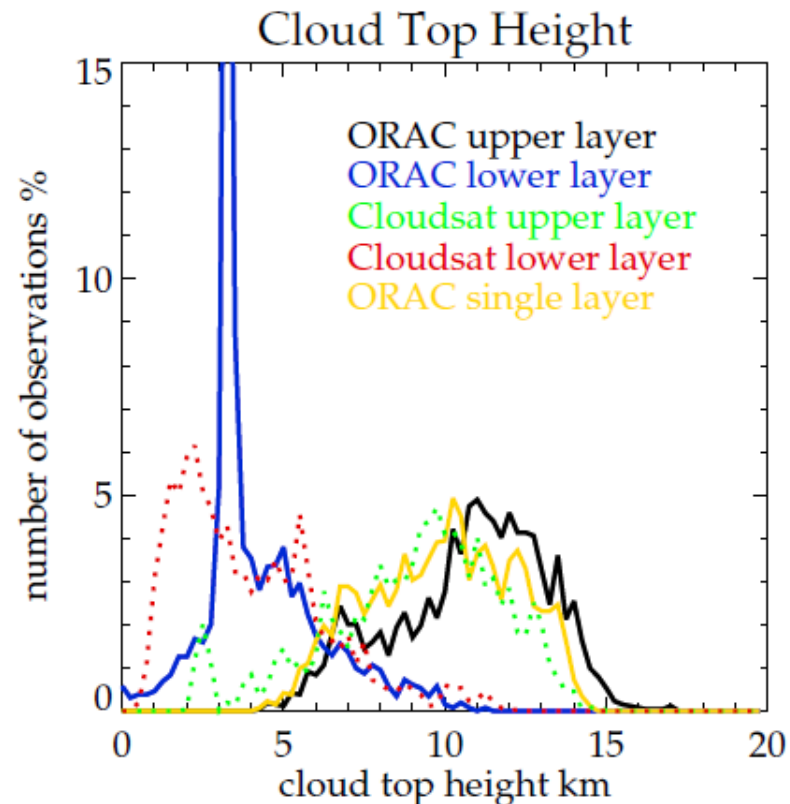(a) Annual averaged multiple-layer cloud fraction

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(a) Annual averaged multiple-layer cloud fraction

Multi-layer clouds, initial results

- Multi-layer results in more low cloud and more high cloud: Reduction in mid-level
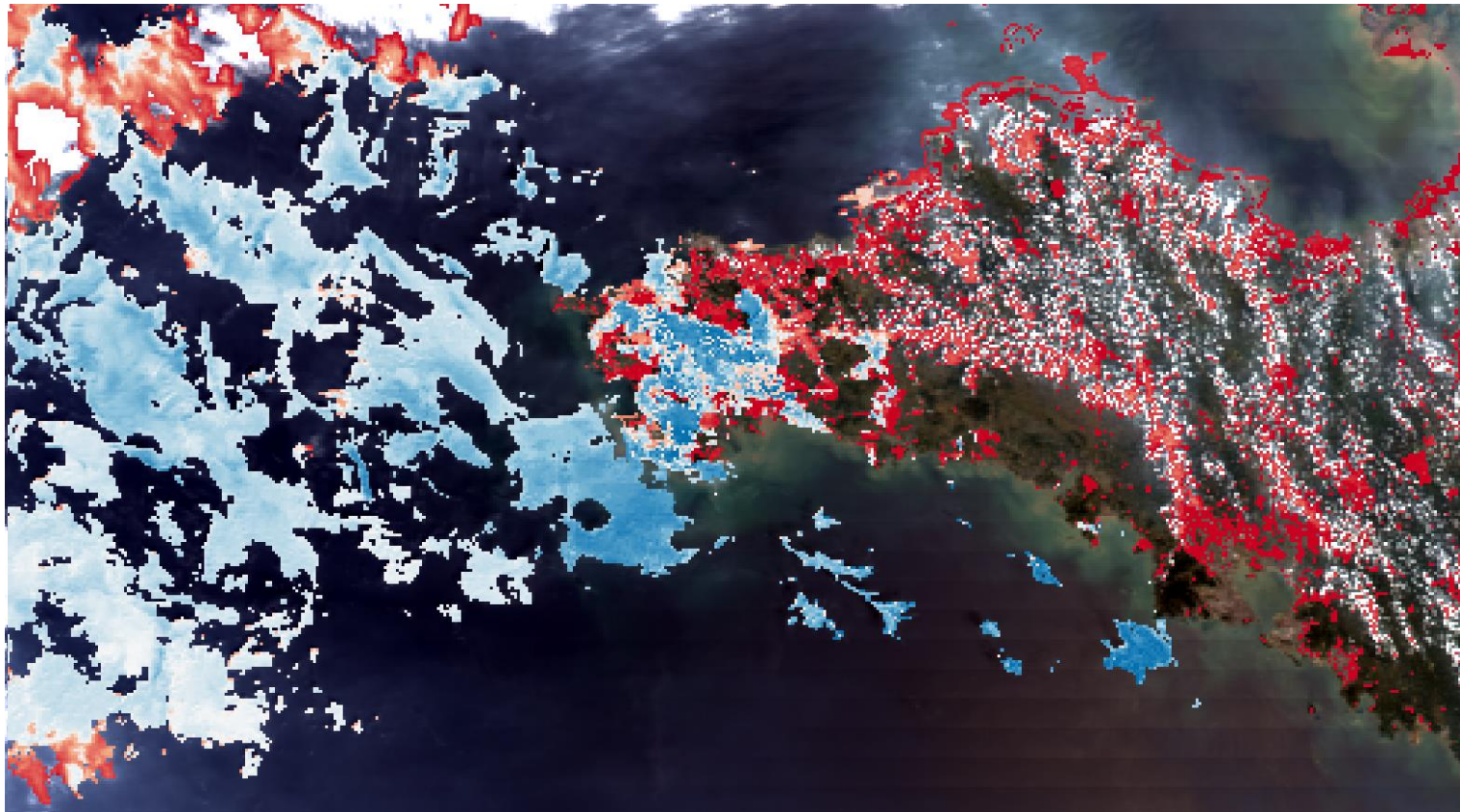- Slight CTH overestimate for high clouds

Multi-layer clouds, thin cirrus contamination

- Cirrus above initialising convection
- Pao's case: 29th Jul 2016 over E. China, contrail cirrus present as convection begins.

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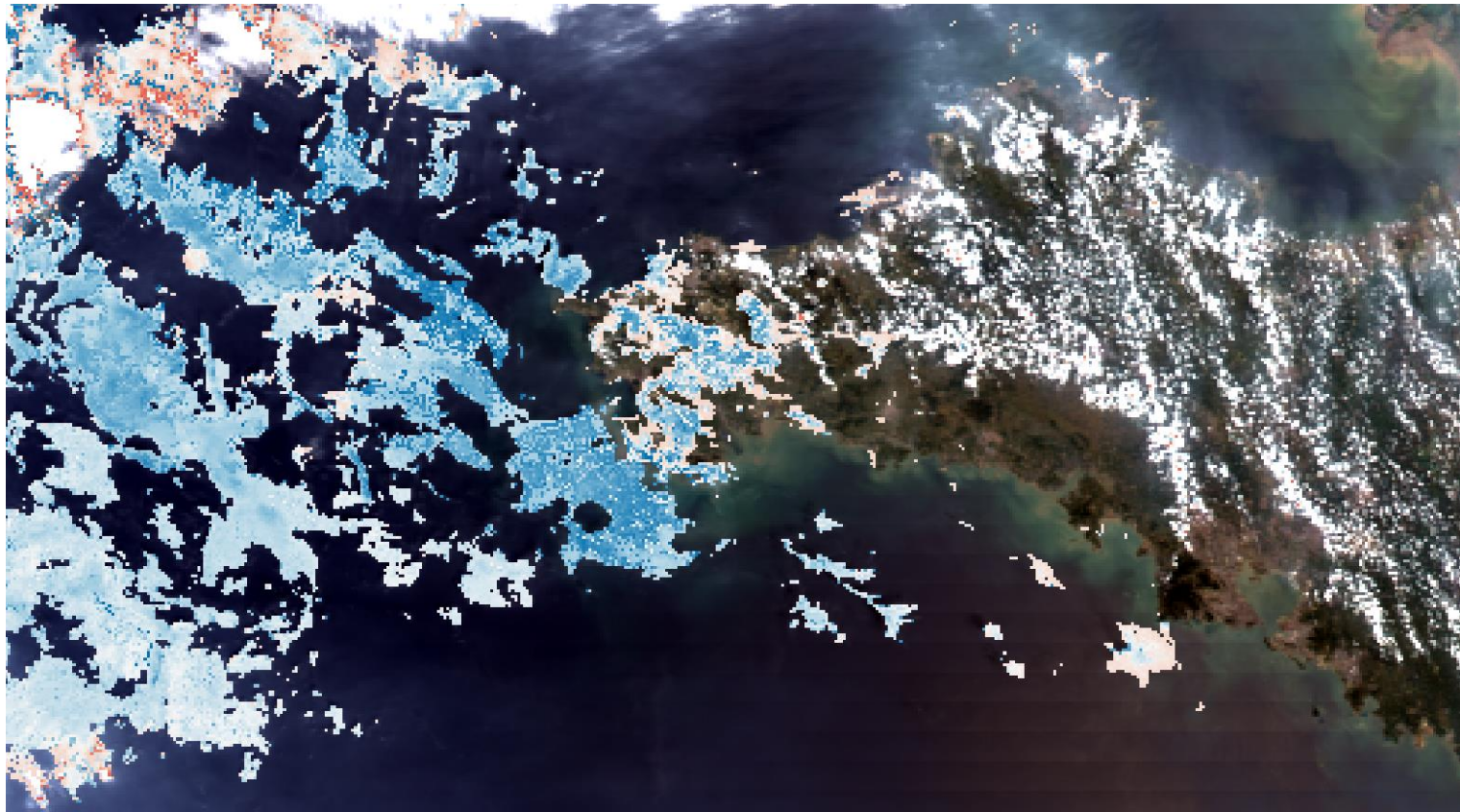
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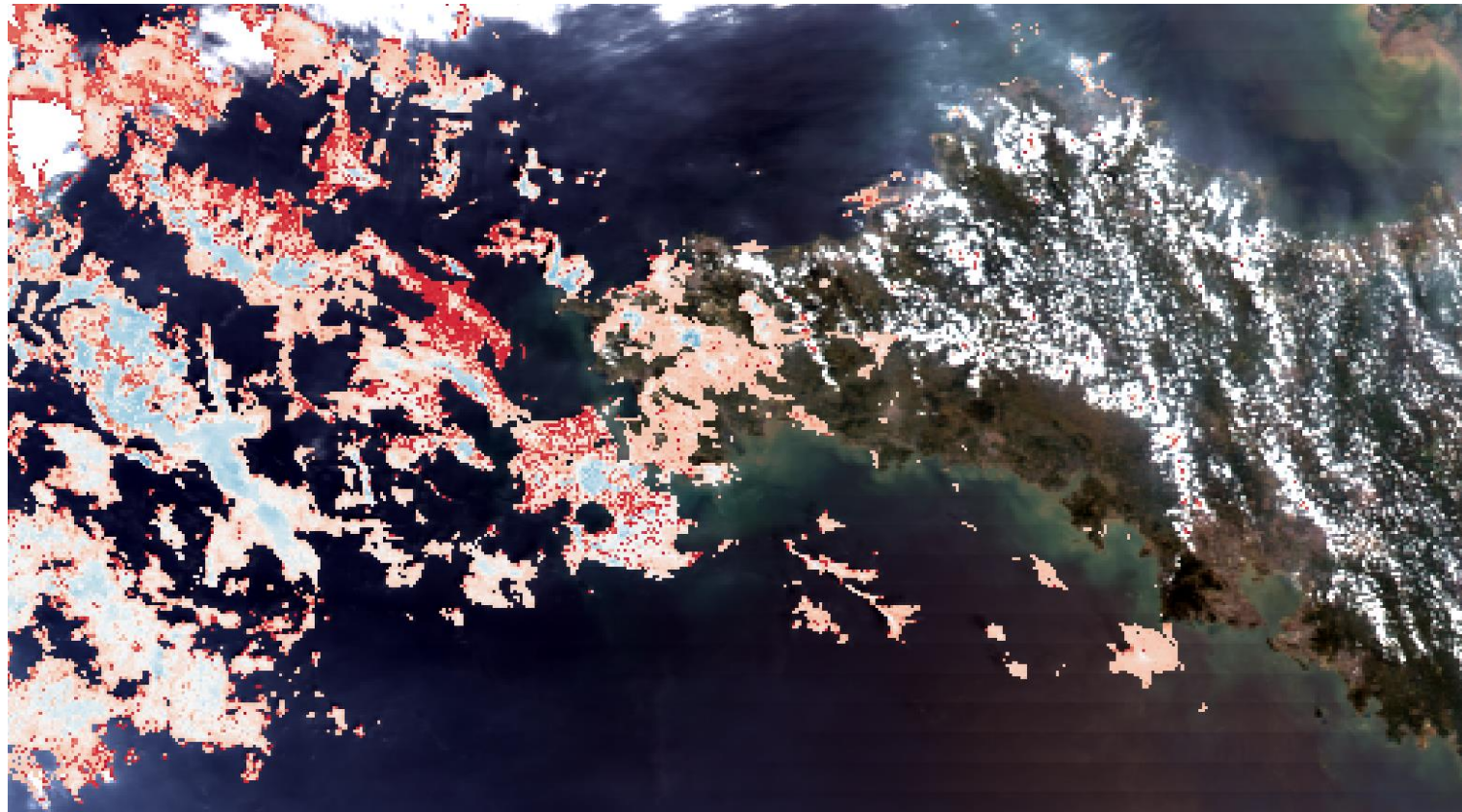
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Multi-layer clouds, above-anvil plumes

- Cirrus plumes: Very challenging as they can be warmer than the underlying anvil
- ORAC does detect the plumes, though – so some information is there to be exploited.
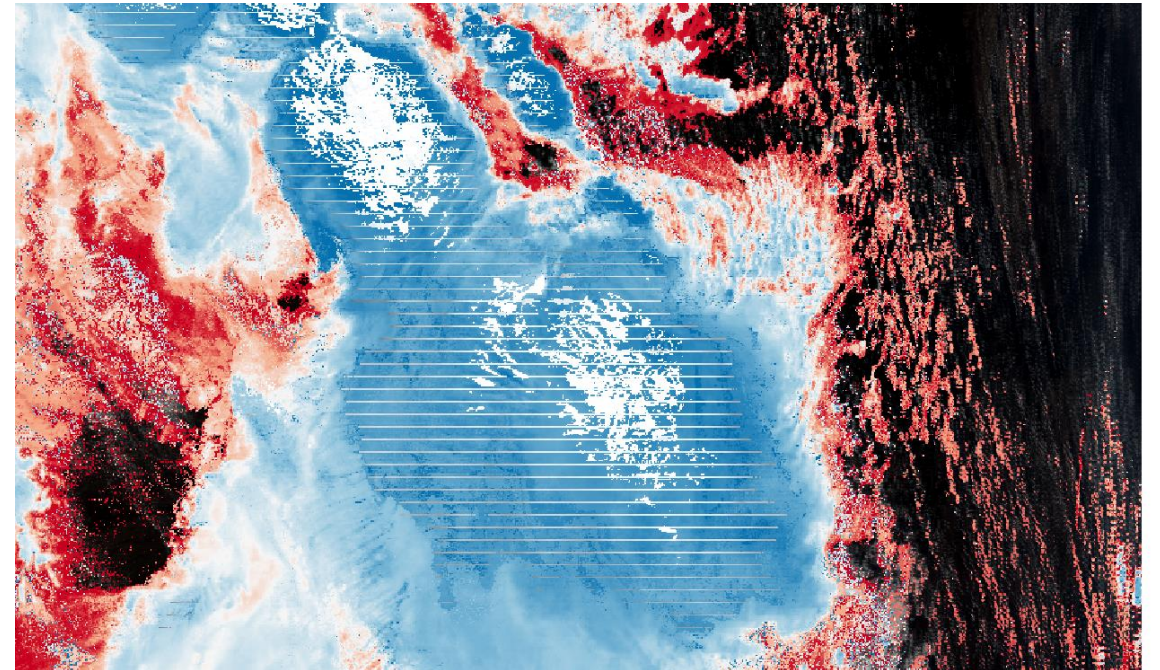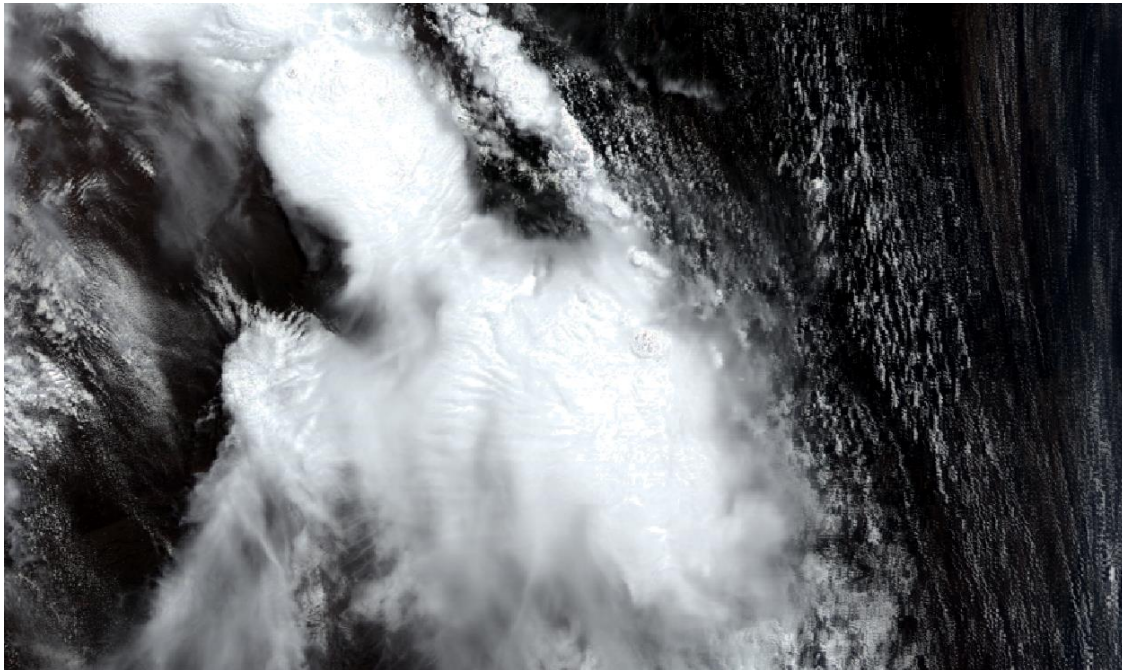
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Summary

- Instruments with multiple WV bands (+ideally a VIS cirrus band) can be used for multi-layer cloud properties retrieval.
- Method currently tuned for thick water cloud under thin ice cloud.
- Retrieving cloud properties on two layers enables better monitoring of young convection.
- Should be possible to retrieve cirrus plumes over an anvil, but challenging.

Some improvements needed:
- How to deal with warm plumes?
- Apply to GEO sensors for changes in cloud properties over time.
- How to choose sensible first guess values?