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The Diurnal Cycles of Cloud Profiles and Water Vapor over Land and Ocean seen by the CATS Spaceborne Lidar and Megha-Tropiques Sensors

Vincent Noël, Hélène Chepfer, Marjolaine Chiriaco, Hélène Brogniez, John Yorks, Patrick Raberanto

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Diurnal Cycles of Cloud Profiles and Water Vapor seen by the CATS Lidar and Megha-Tropiques Spaceborne Sensors

- V. Noel - LA, CNRS
- H. Chepfer - LMD, UPMC
- M. Chiriaco - LATMOS, UVSQ
- H. Brogniez - LATMOS, UVSQ
- J. Yorks - NASA Goddard
- P. Raberanto - LMD, CNRS

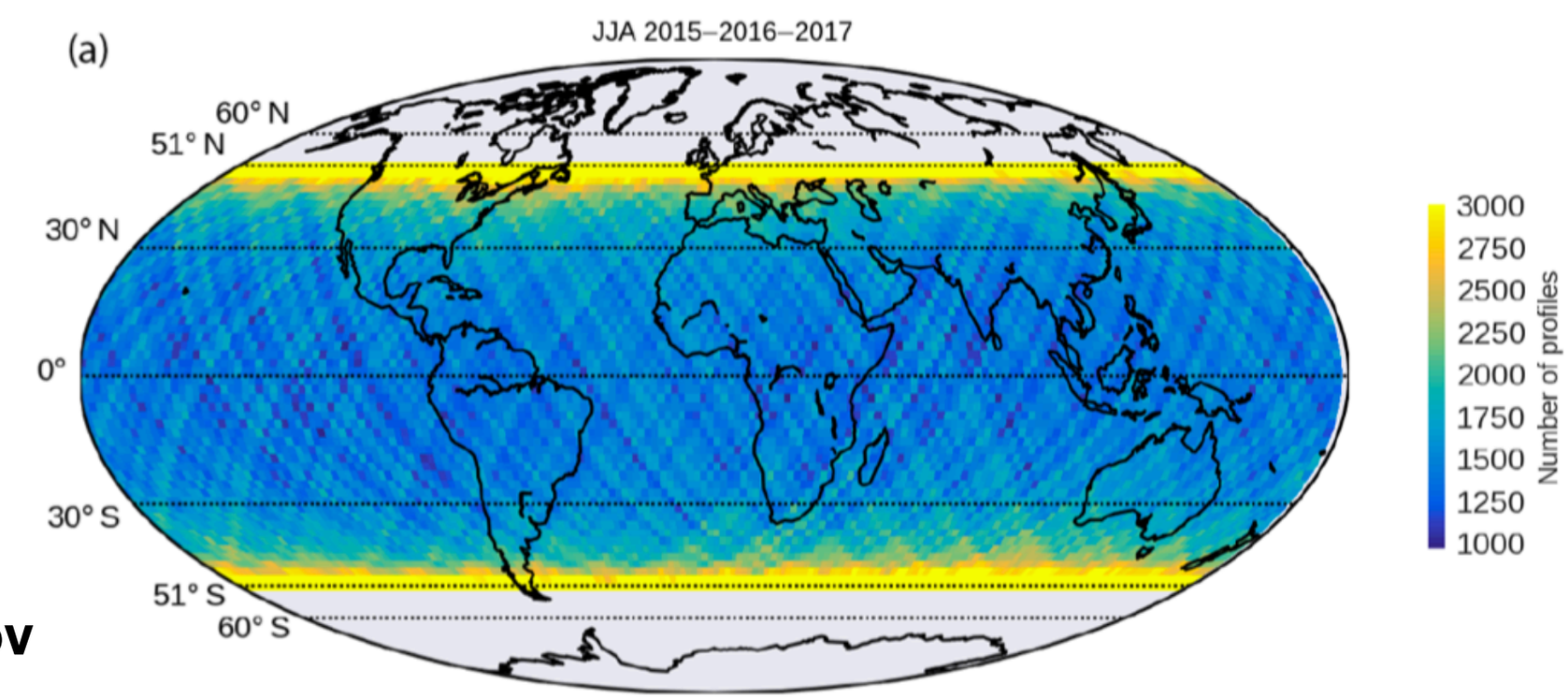
Spaceborne lidars and clouds

- Since 2006 the spaceborne lidar CALIPSO maps the 3D distribution of clouds on a near-global scale with a high vertical resolution
- Many important and useful results
- CALIPSO and almost all spaceborne lidars - ADM-Aeolus, IceSAT 1 and 2, Earth-CARE…
  - follow a sun-synchronous orbit
  - always sample a given location at the same local time
  - capture a single moment of the diurnal cycle
- CATS is an exception

CATS
The Cloud-Aerosol Transport System

- The CATS lidar operated on the ISS
  from Feb 2015 to Oct 2017 (NASA mission)
- ISS orbits ±51° latitudes = samples 78% of the Earth
- data :mostly 1064nm
- 350m between profiles, 60m vertical resolution, 5kHz

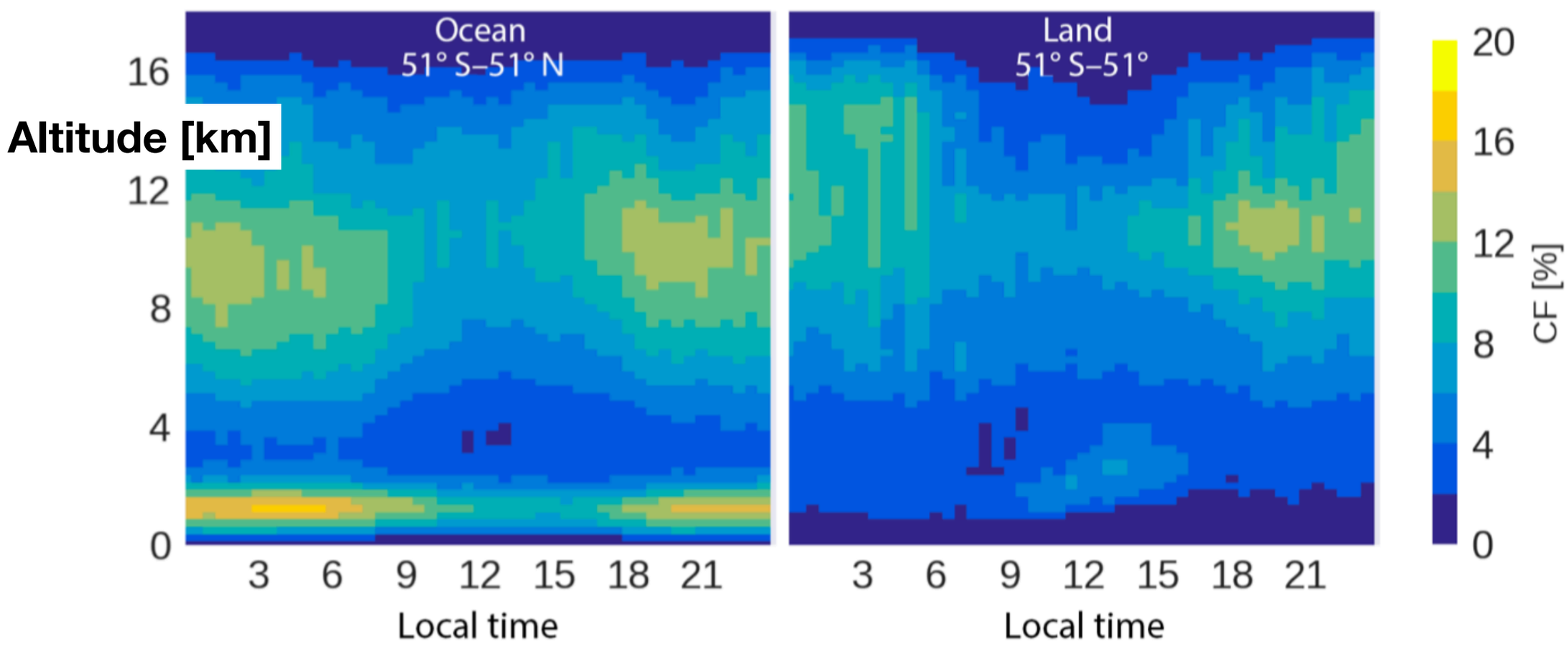
https://cats.gsfc.nasa.gov



From single overpasses to the diurnal cycle

By aggregating overpasses along local time, we can reconstruct the diurnal cycle with vertical variability

JJA 2015-2017 ±51°



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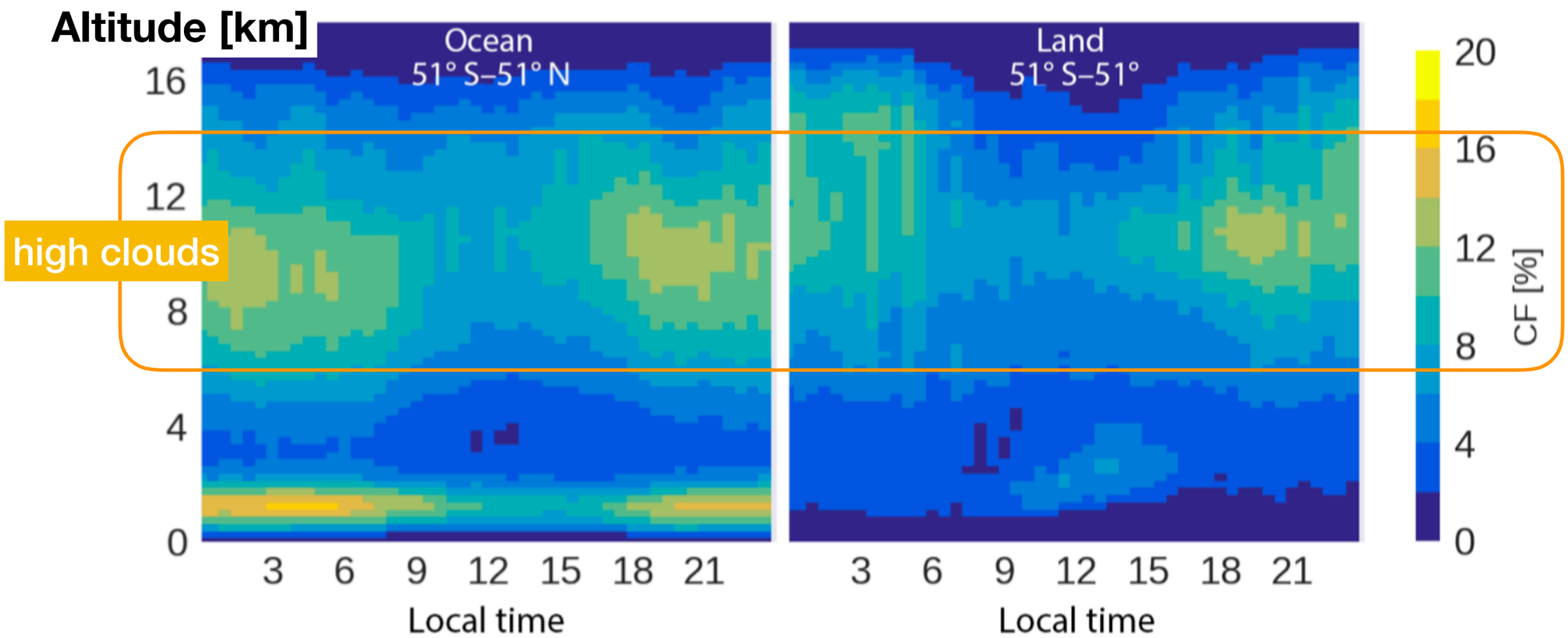

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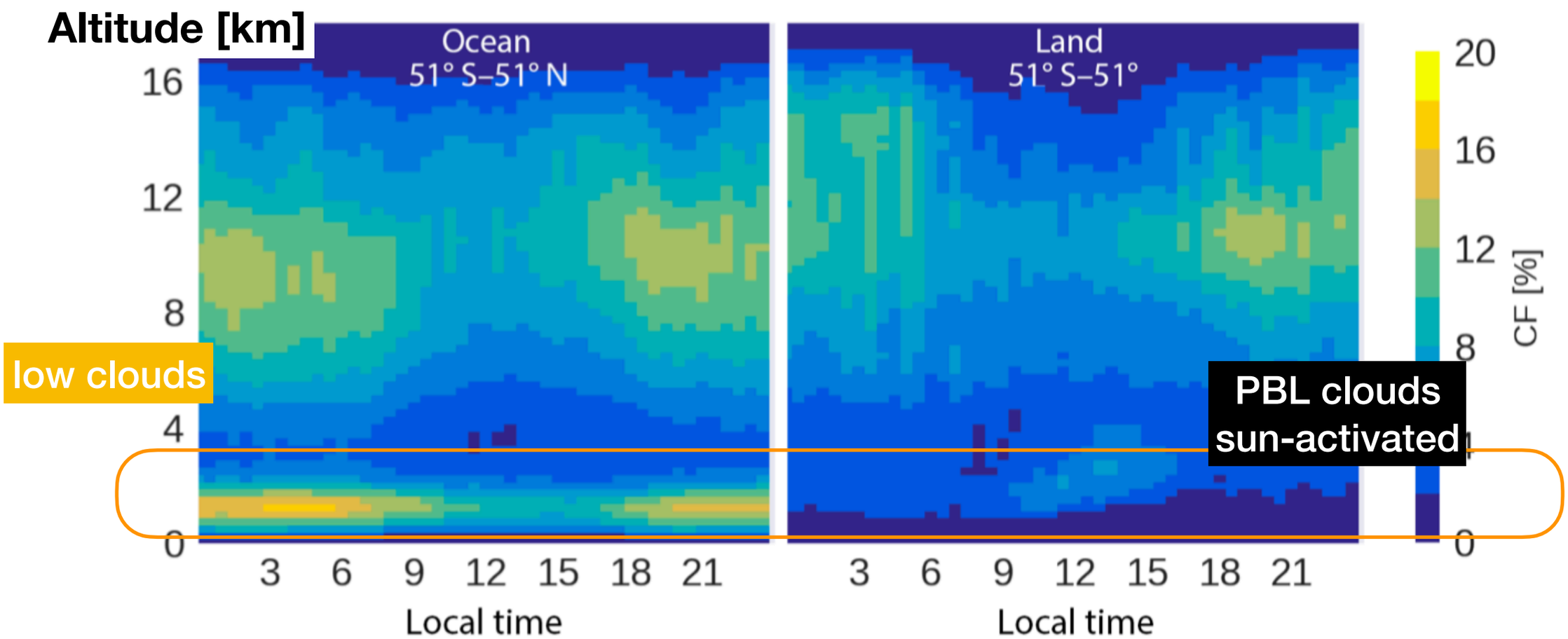
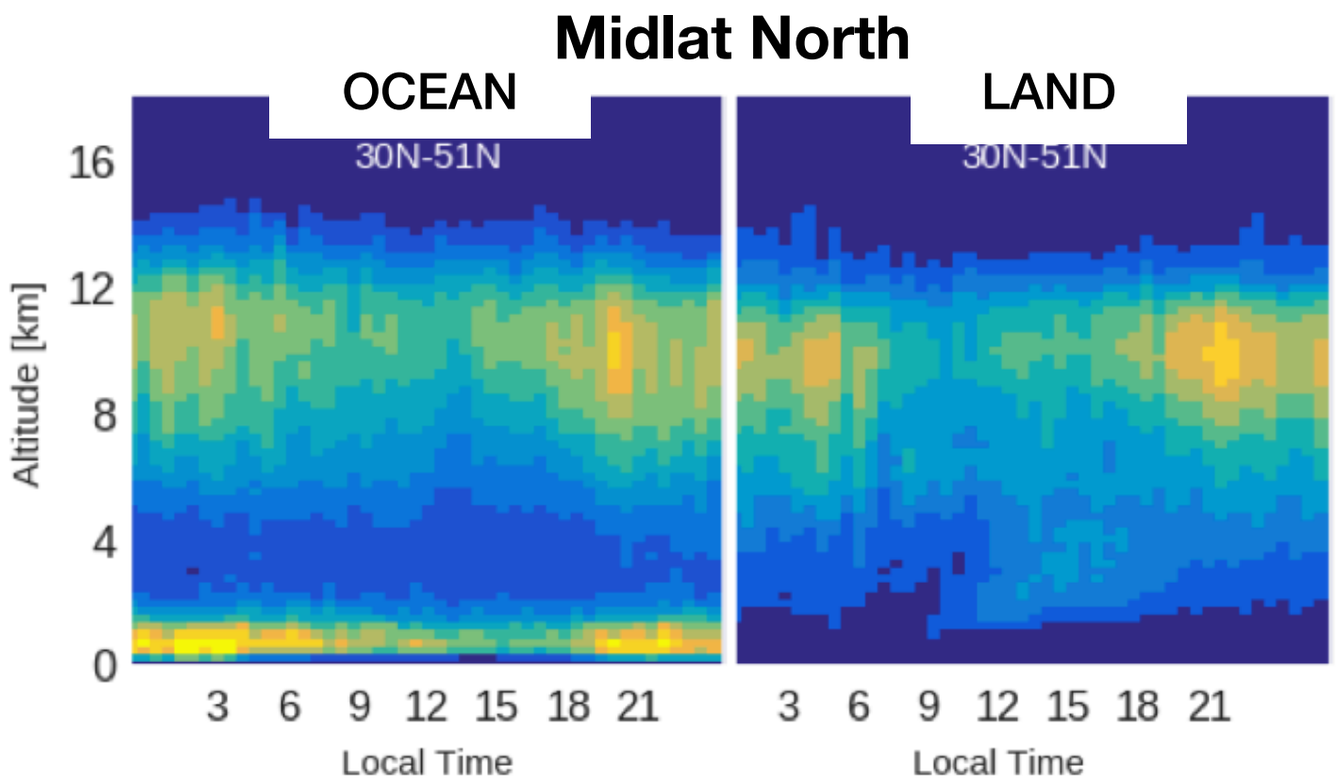
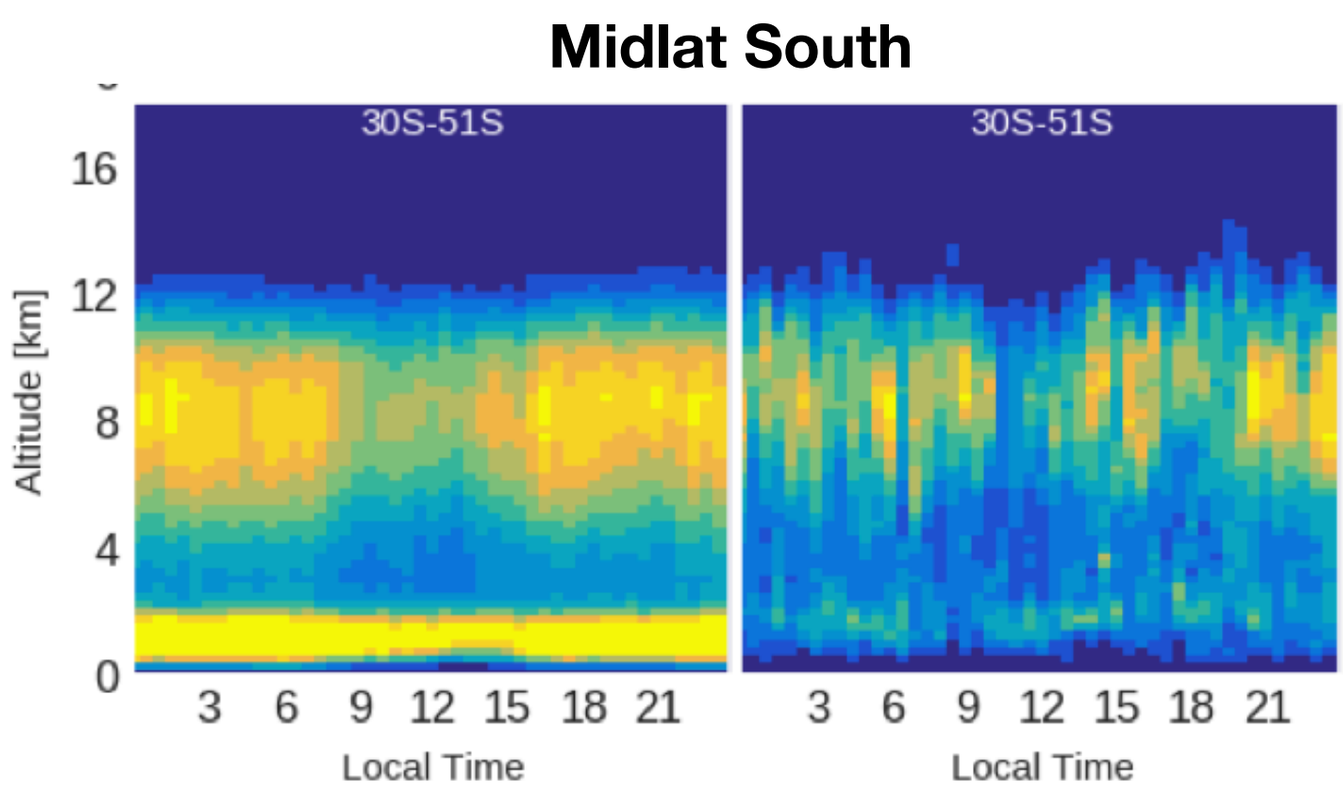
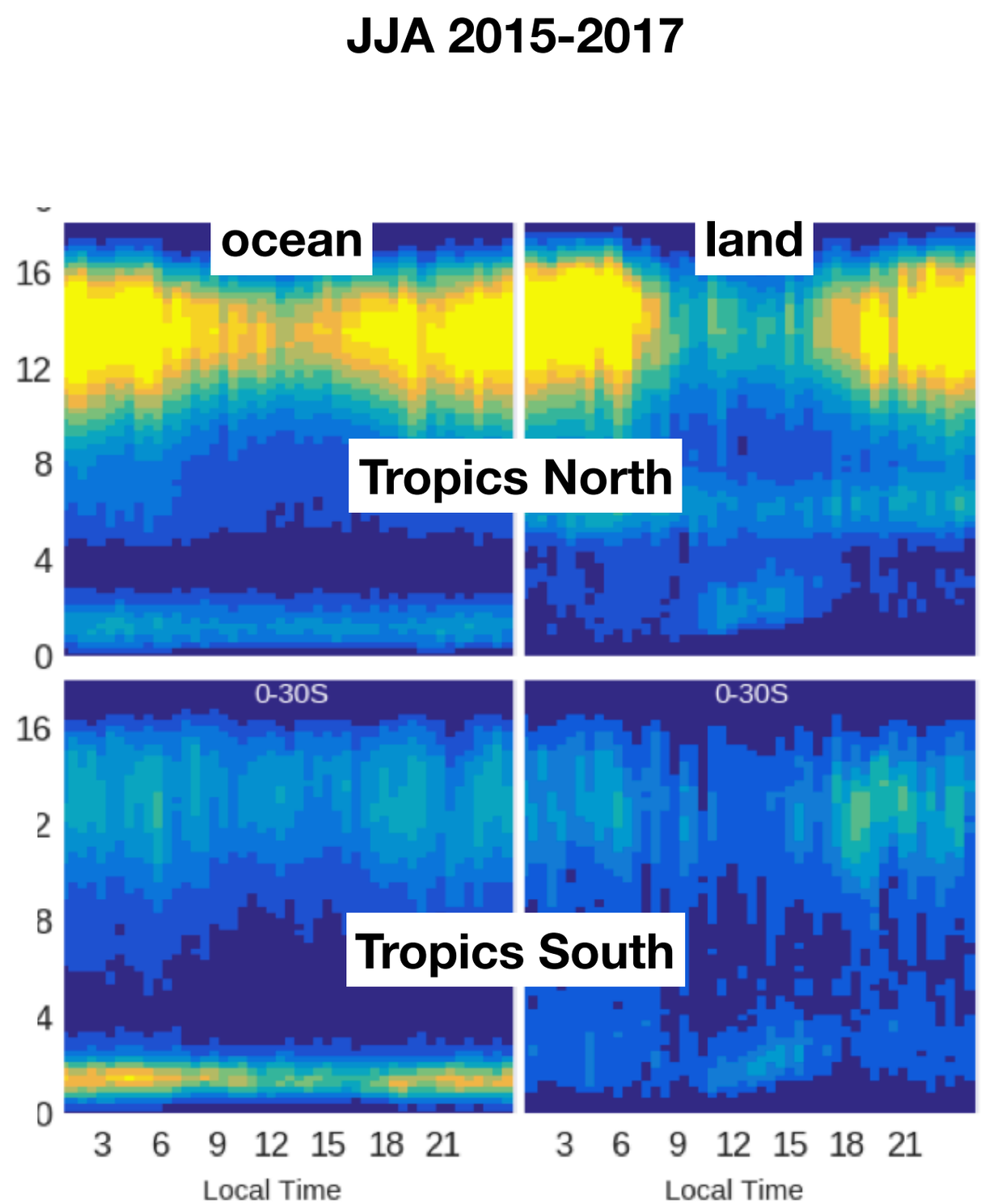


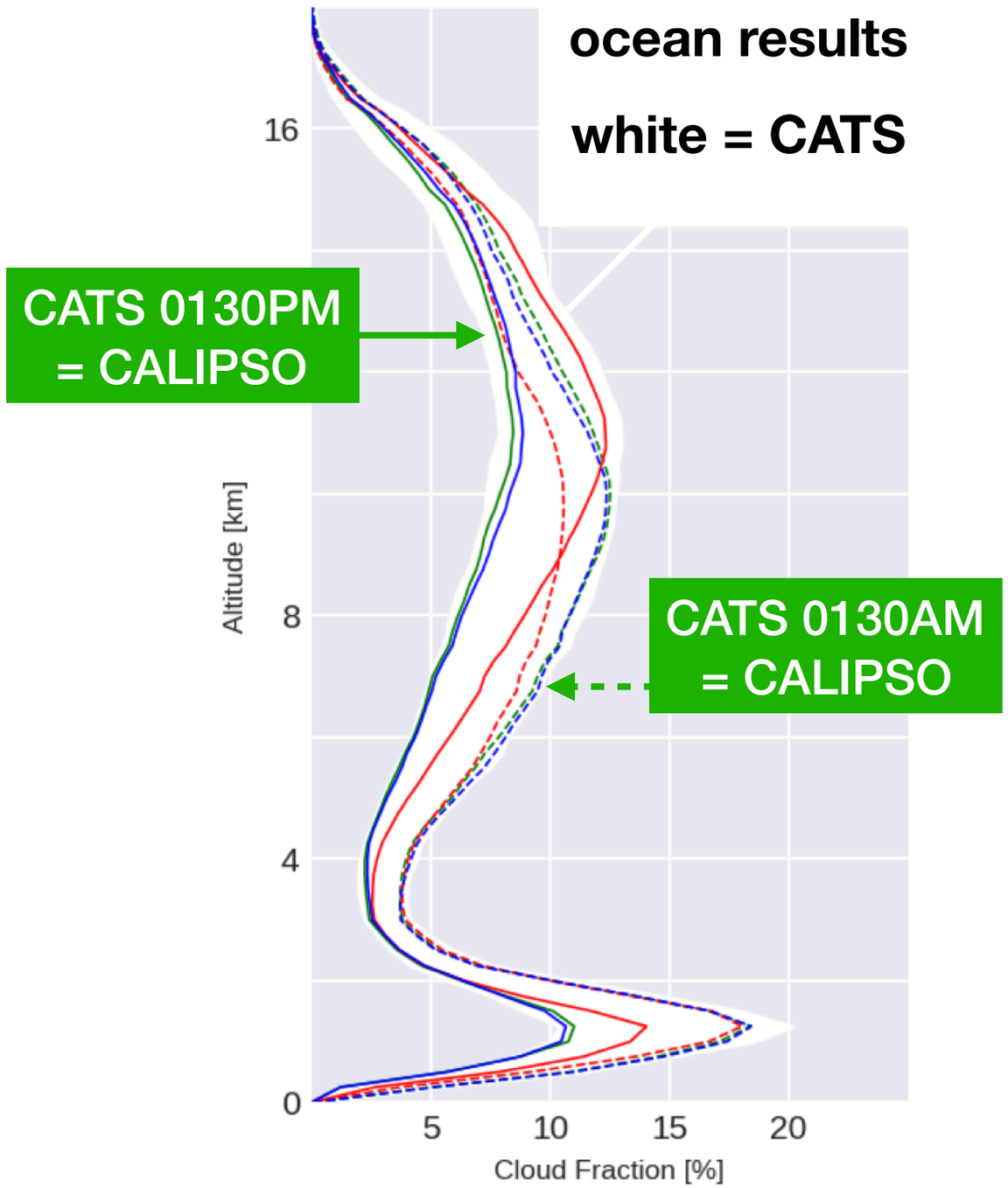
Diurnal cycles in smaller regions





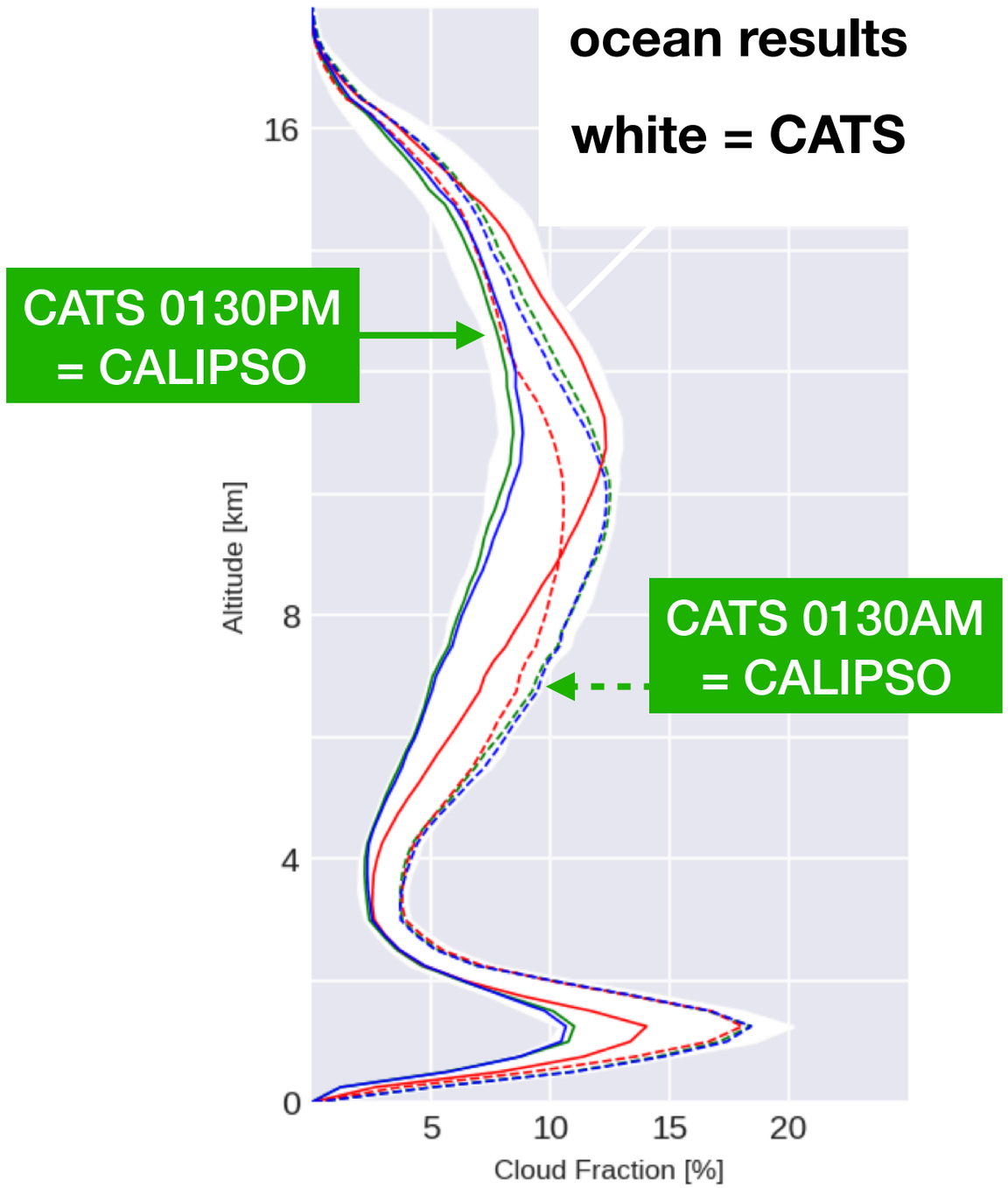


Implications of CATS results for CALIPSO & sun-synchronous missions



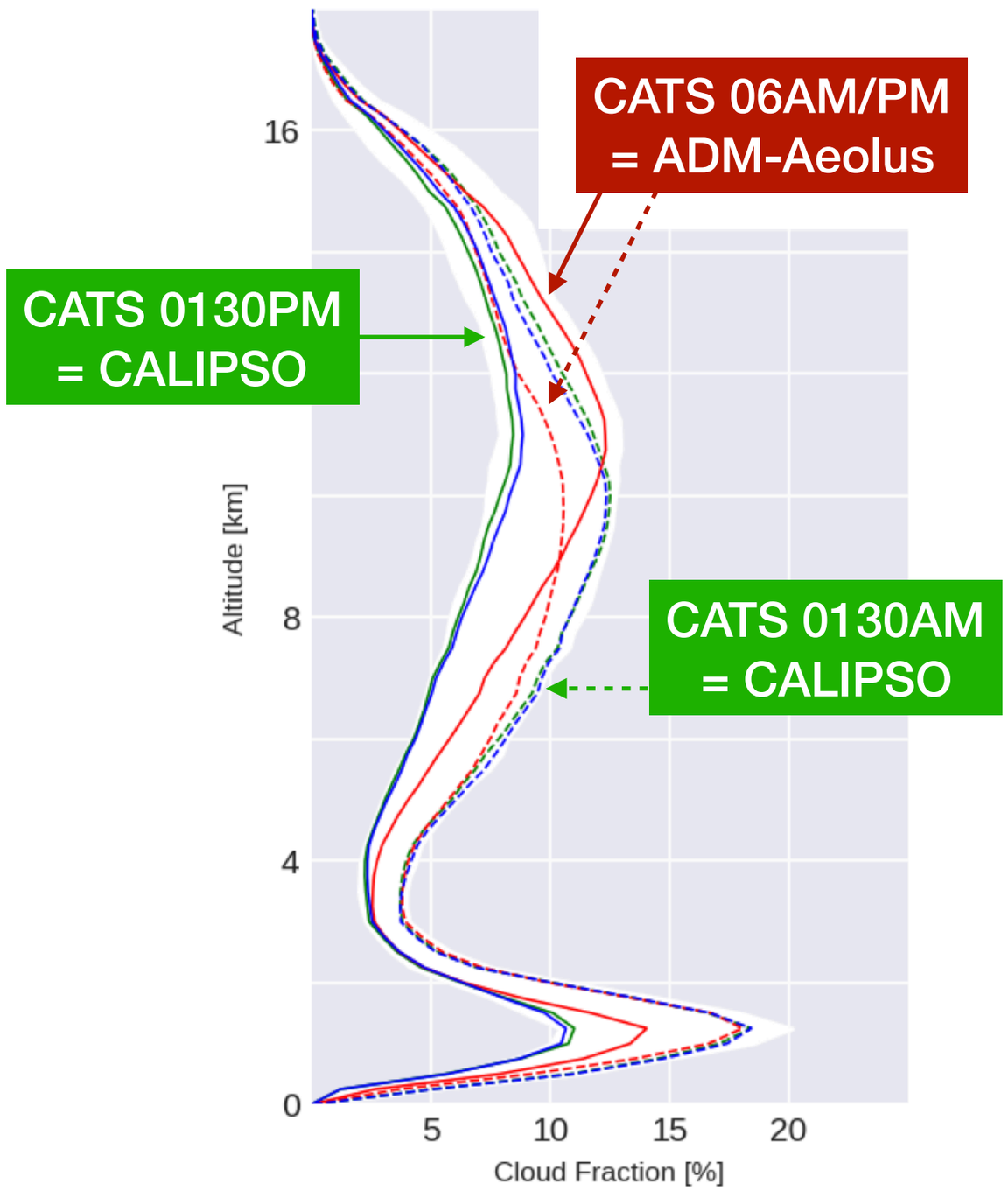
- CATS at 0130PM ~ CF daily min = CALIPSO daytime overpass
- CATS at 0130AM ~ CF daily max = CALIPSO nighttime overpass
- **CALIPSO = daily extremes of the cloud fraction** profiles **over ocean, especially below 10km ASL**

Implications of CATS results for CALIPSO & sun-synchronous missions



- CATS at 0130PM ~ CF daily min
  = CALIPSO daytime overpass
- CATS at 0130AM ~ CF daily max
  = CALIPSO nighttime overpass
- **CALIPSO = daily extremes of the cloud fraction** profiles **over ocean, especially below 10km ASL**
- **Also works for Earth-CARE (0200LT) & A-Train instruments**

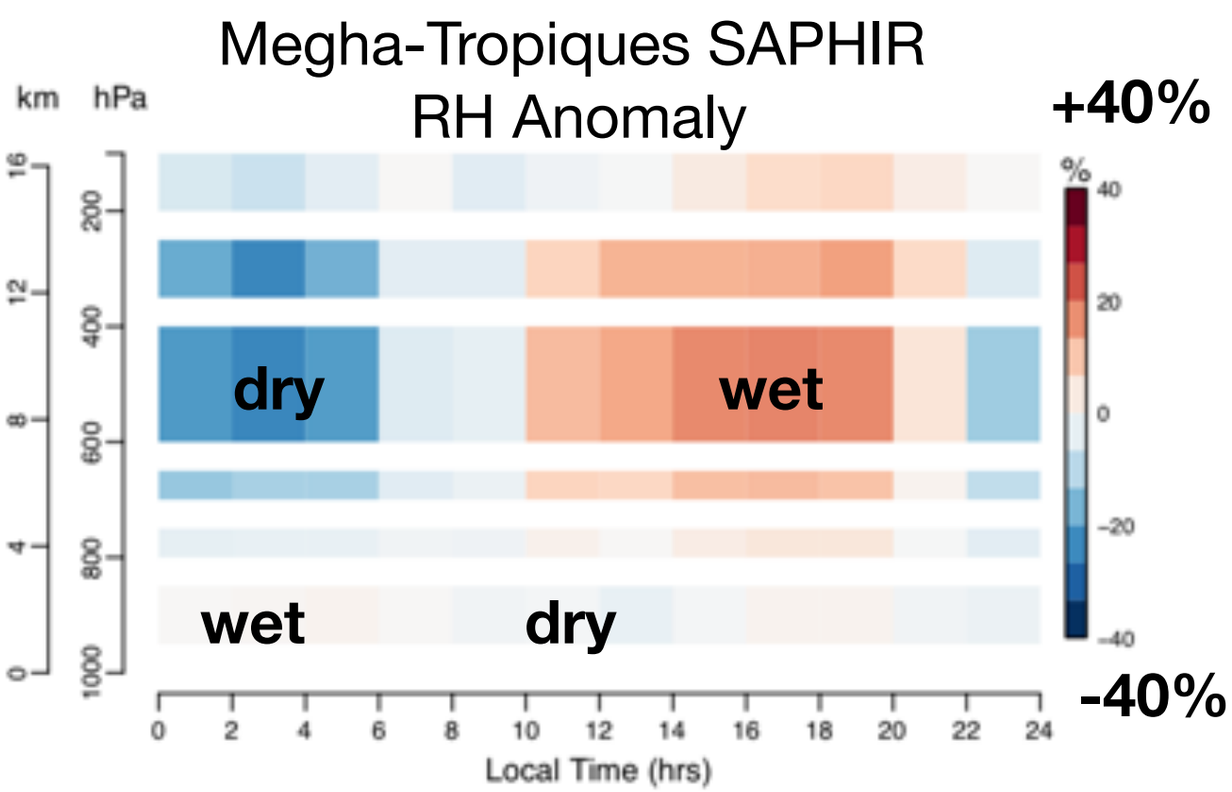
Implications of CATS results for CALIPSO & sun-synchronous missions

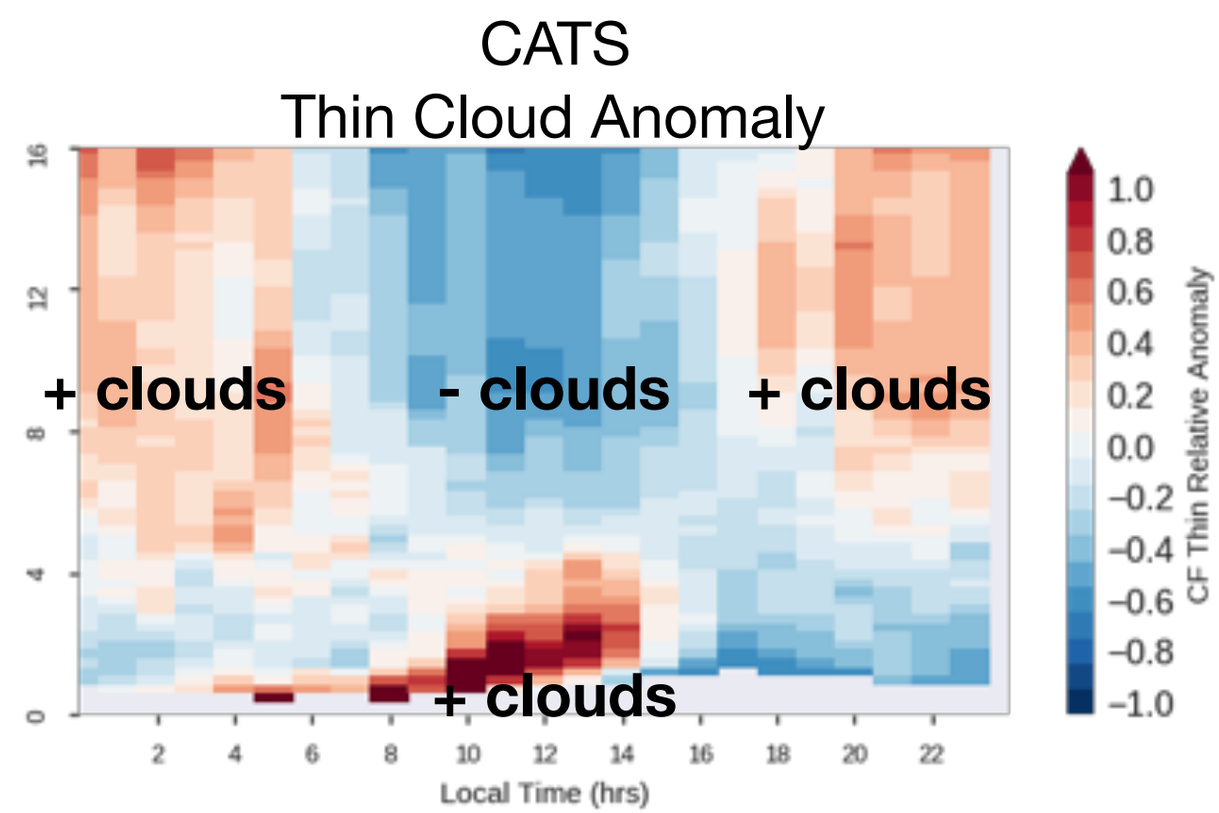


- CATS at 06AM/PM : intermediate CF profiles = ADM-Aeolus overpasses

diurnal cycles: clouds and water vapour

LAND - w500 < 0 (convection) - JJA 2015-2017





Takeaway Points

- CATS and Megha-Tropiques can describe **the diurnal cycle of vertical profiles of clouds and water vapor** in the Tropics
- CATS data shows CALIPSO, Earth-CARE data **document extremes of Cloud Fraction** profiles over ocean

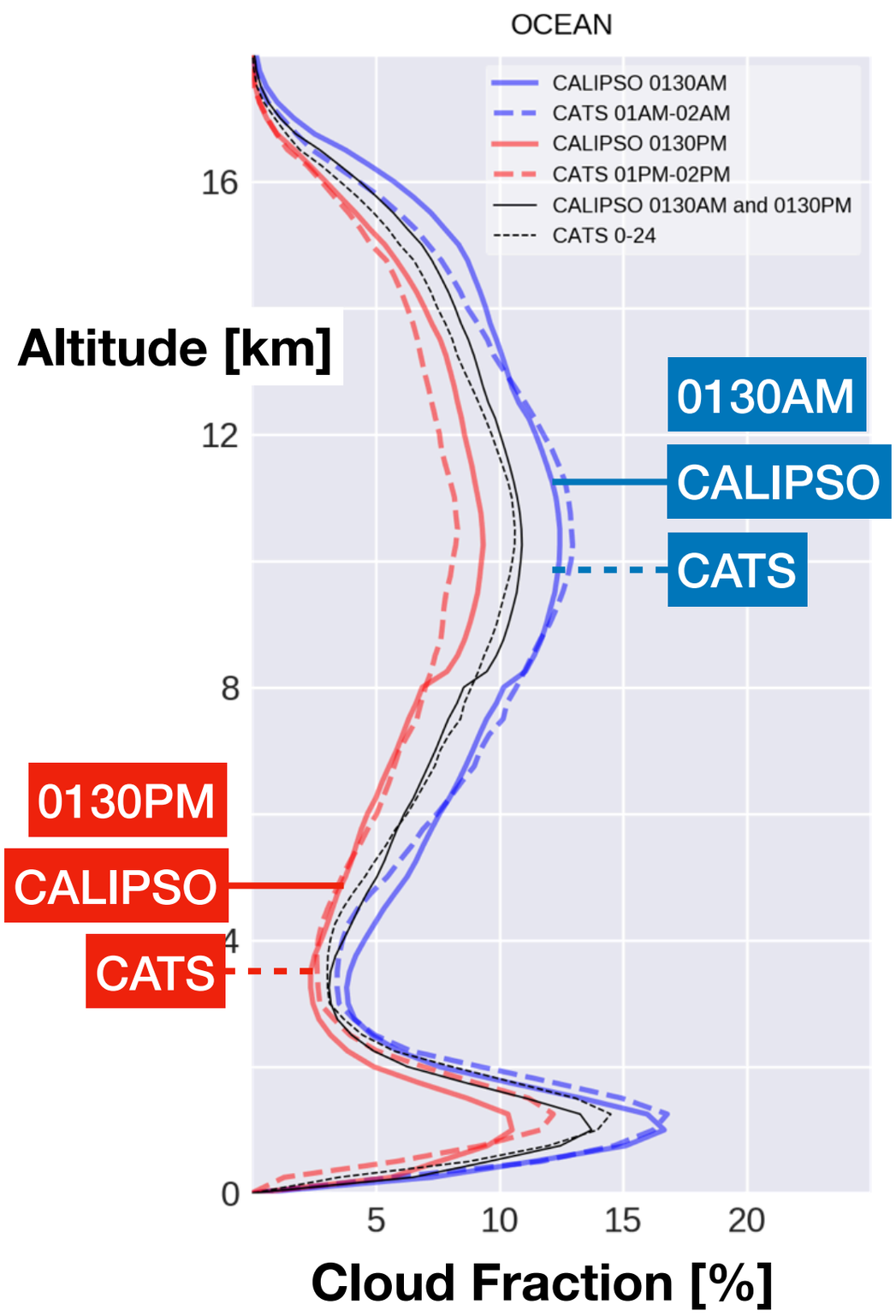
- Other factors will impact agreement between instruments, eg wavelength — cf. talk from M. Chiriaco, next

Noel, V., H. Chepfer, M. Chiriaco, and J. Yorks, 2018: The diurnal cycle of cloud profiles over land and ocean between 51°S and 51°N, seen by the CATS spaceborne lidar from the International Space Station, **Atmos. Chem. Phys. 18**, 9457–9473

Chepfer, H., H. Brogniez, V. Noel, P. Raberanto, 2018: Influence of water vapor and cloud profiles on temperature diurnal variation across the tropics. submitted.

backup slides

CATS at CALIOP local times



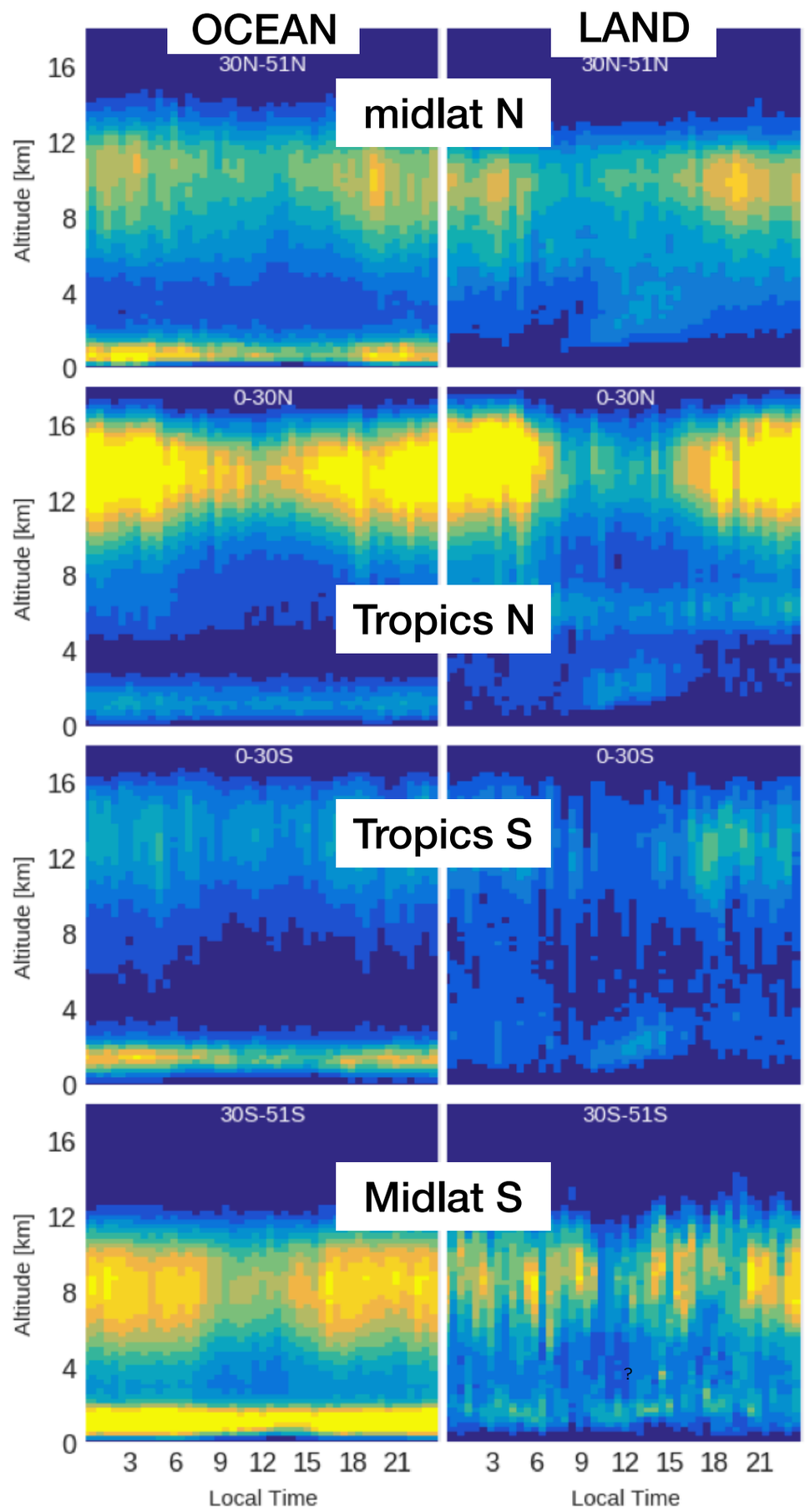
CALIOP overpasses any location at 0130AM or 0130PM local times

CATS overpasses at those local times are **consistent with those derived from CALIPSO**

Comparisons of CATS with ground-based lidar/radar data and ISCCP are also consistent (cf. Noel et al. 2018)

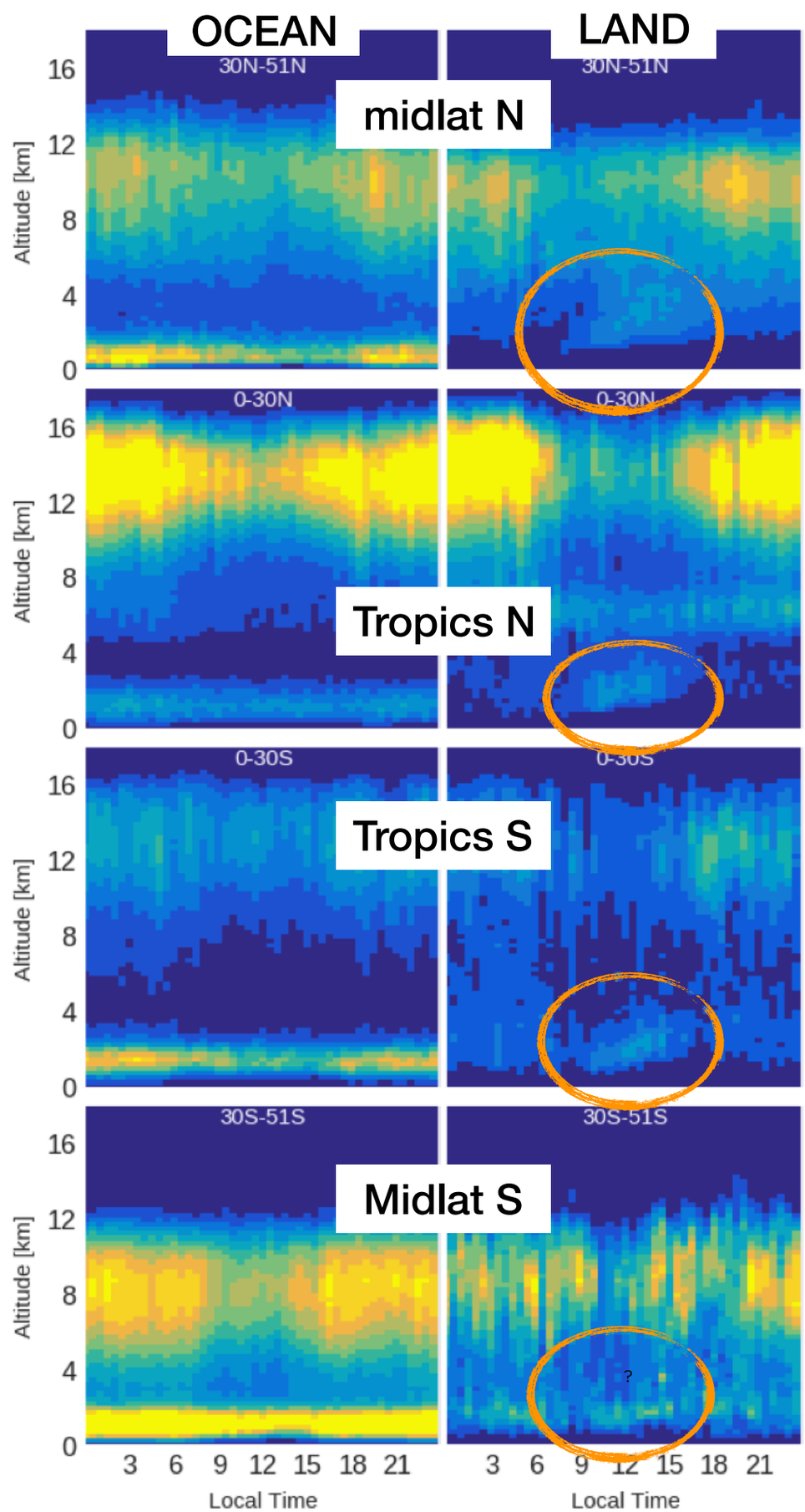
CATS clouds are reliable

JJA Results
by latitude band



- **low/high separation everywhere**
- **different cycles at different latitudes**

JJA Results
by latitude band

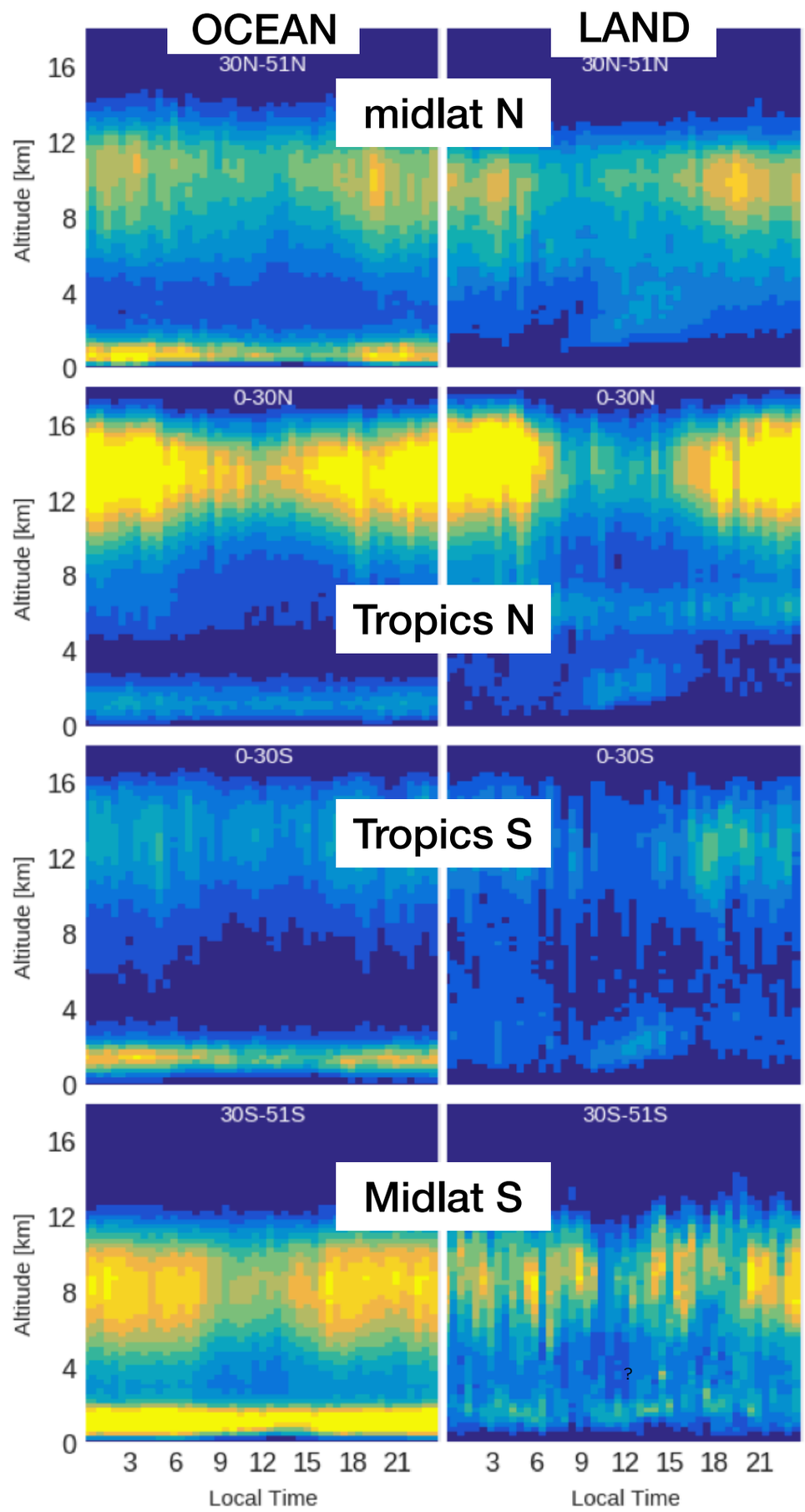


PBL clouds
sun-activated

JJA Results
by latitude band

Summer Tropics

Winter Tropics



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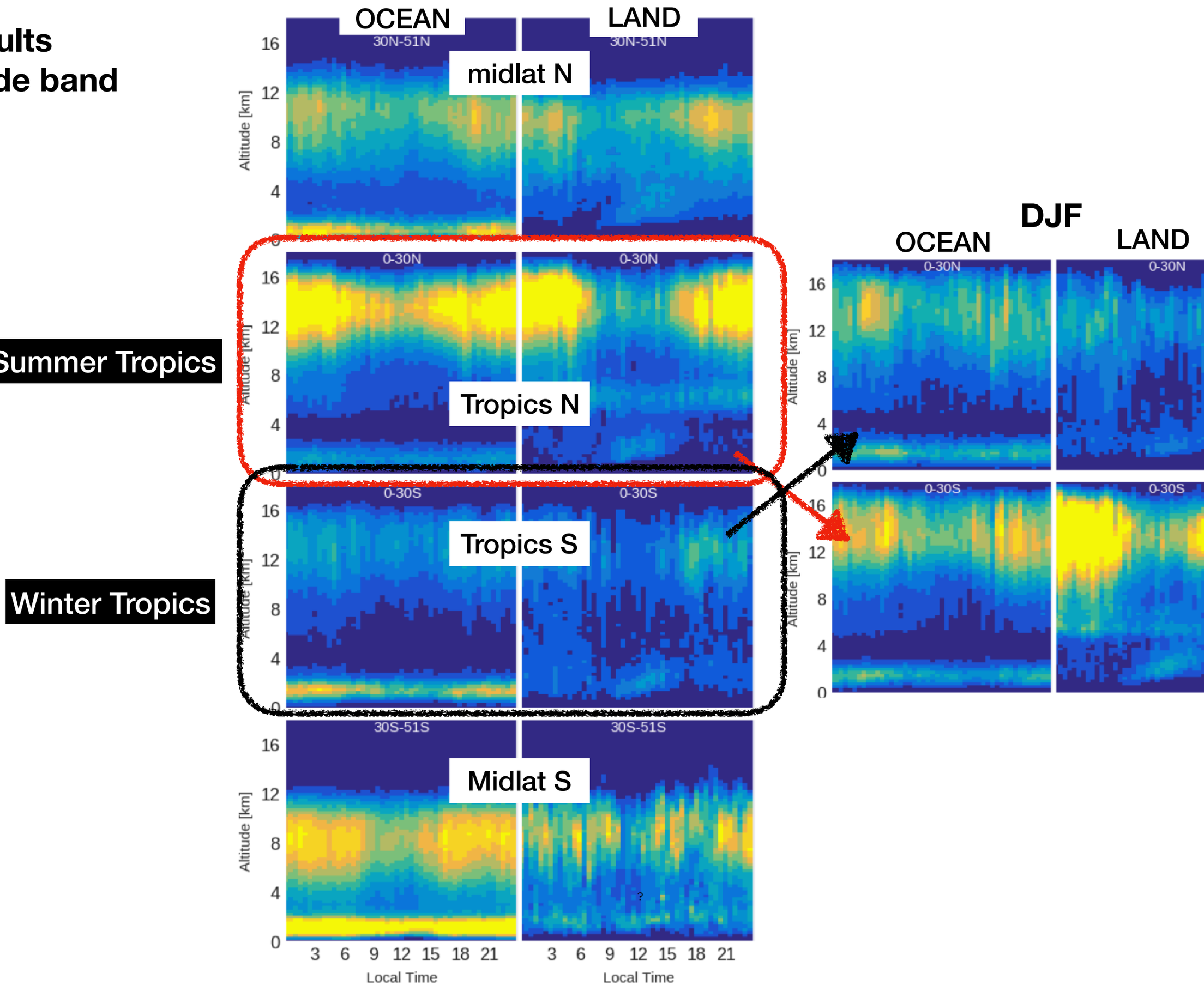

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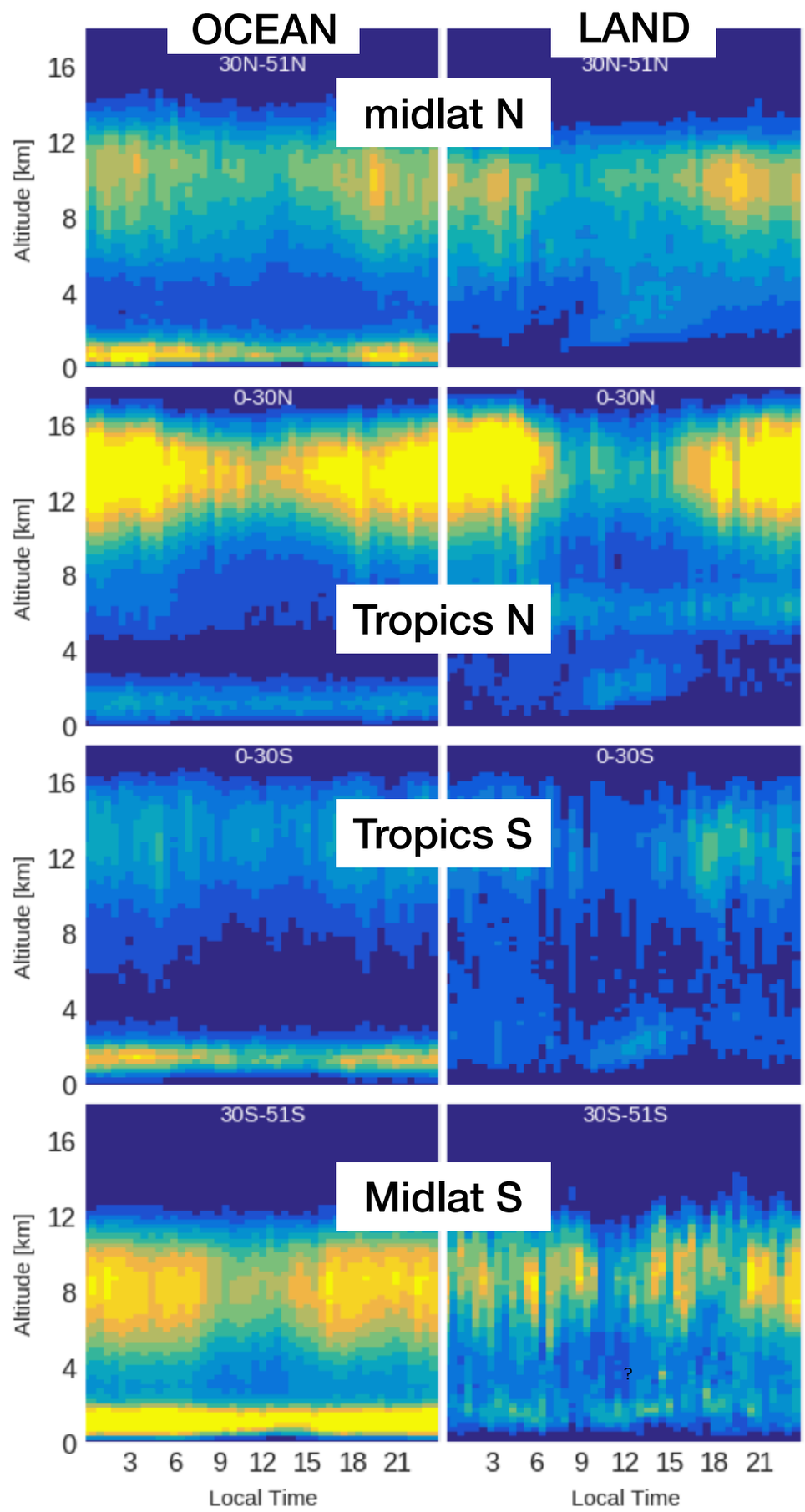
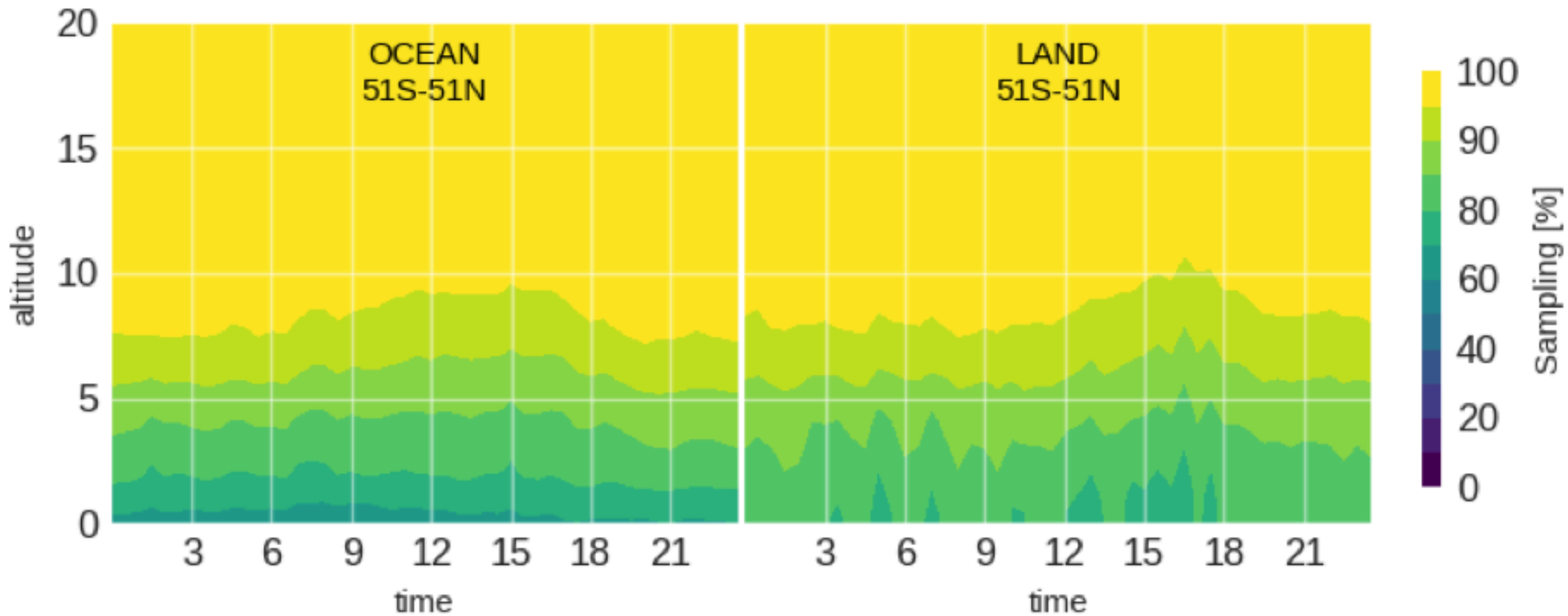
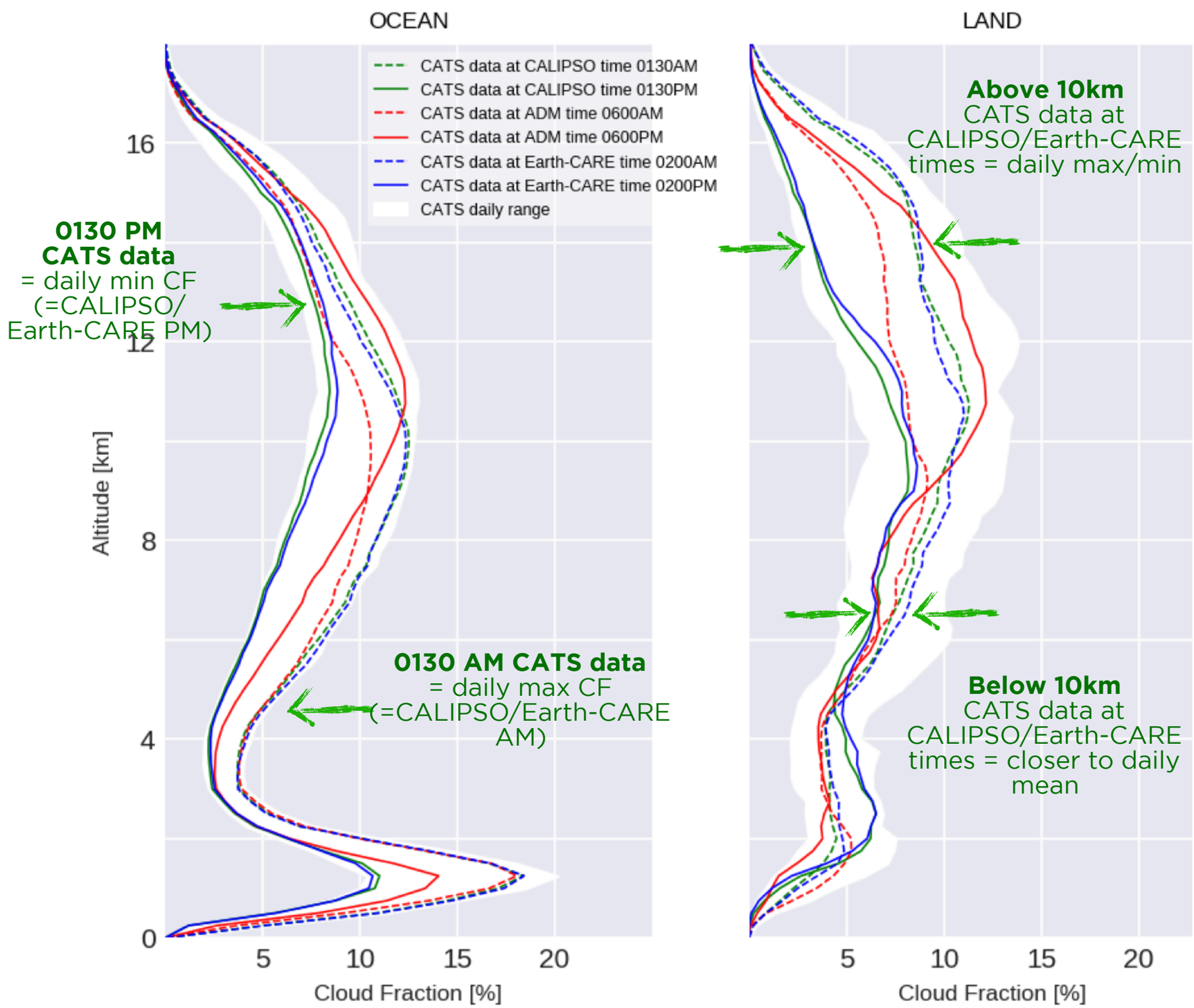


Southern Ocean



Even though some profiles get fully attenuated by atmospheric components, sampling is better than 80% at most altitudes, and ~100% above 7km except late in the afternoon


OCEAN
LAND
CATS data at CALIPSO time 0130AM
CATS data at CALIPSO time 0130PM
CATS data at ADM time 0600AM
CATS data at ADM time 0600PM
CATS data at Earth-CARE time 0200AM
CATS data at Earth-CARE time 0200PM
CATS daily range
Altitude [km]
Cloud Fraction [%]
0130 PM CATS data = daily min CF (=CALIPSO/ Earth-CARE PM)
0130 AM CATS data = daily max CF (=CALIPSO/Earth-CARE AM)
Above 10km CATS data at CALIPSO/Earth-CARE times = daily max/min
Below 10km CATS data at CALIPSO/Earth-CARE times = closer to daily mean