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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**

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- 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

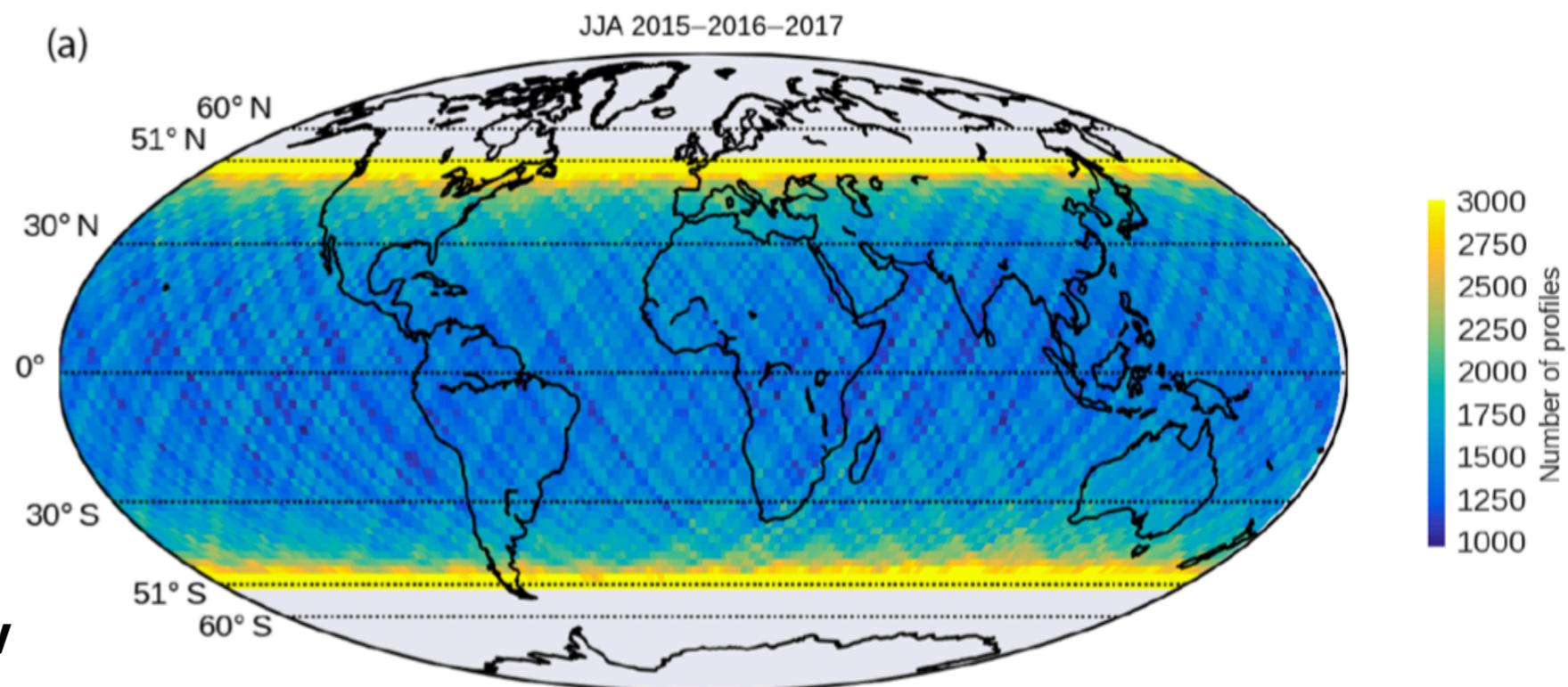
# CATS

## The Cloud-Aerosol Transport System

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



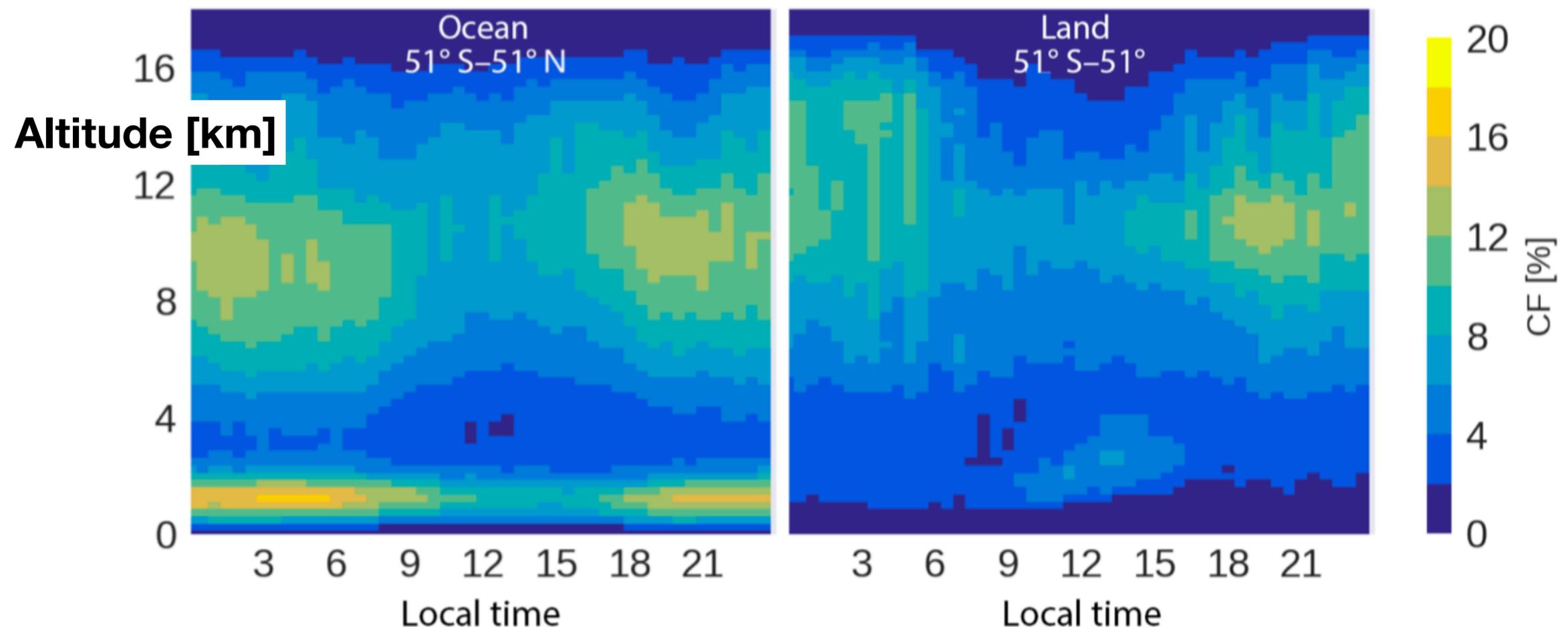
<https://cats.gsfc.nasa.gov>



# From single overpasses to the diurnal cycle

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

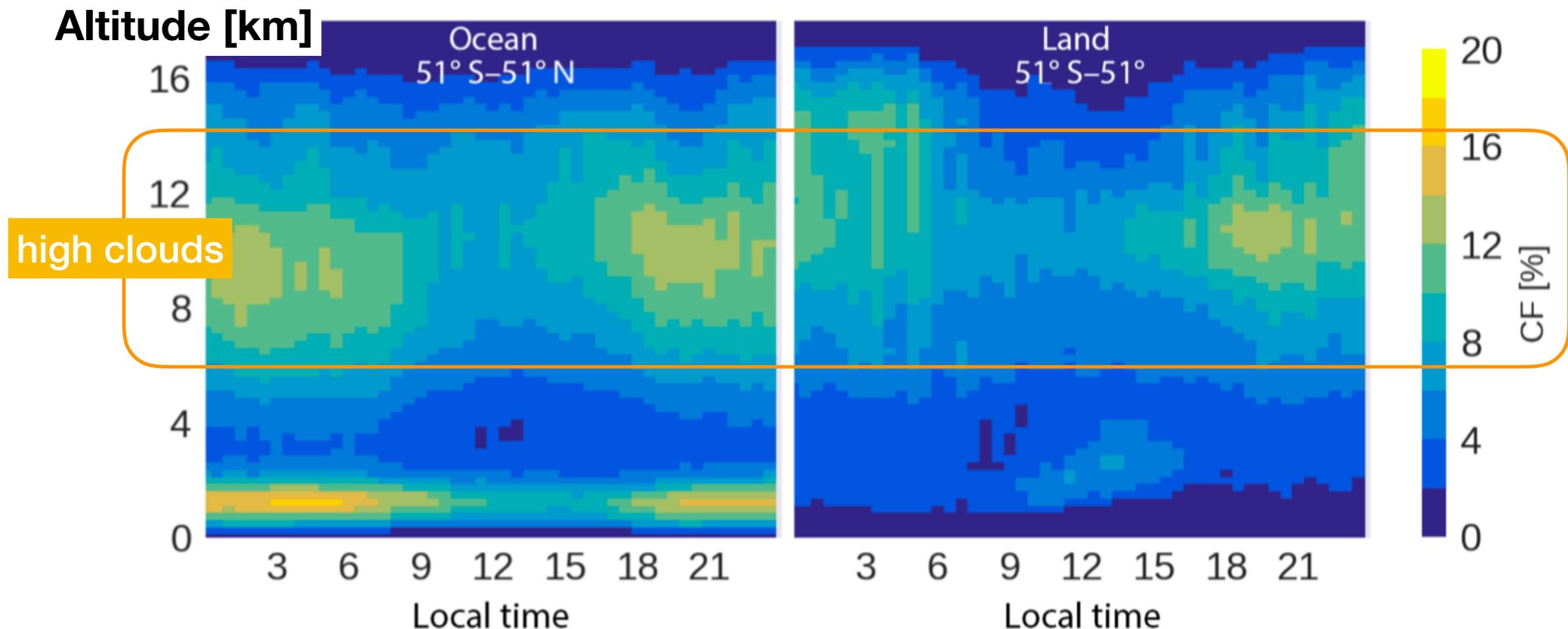
## JJA 2015-2017 $\pm 51^\circ$



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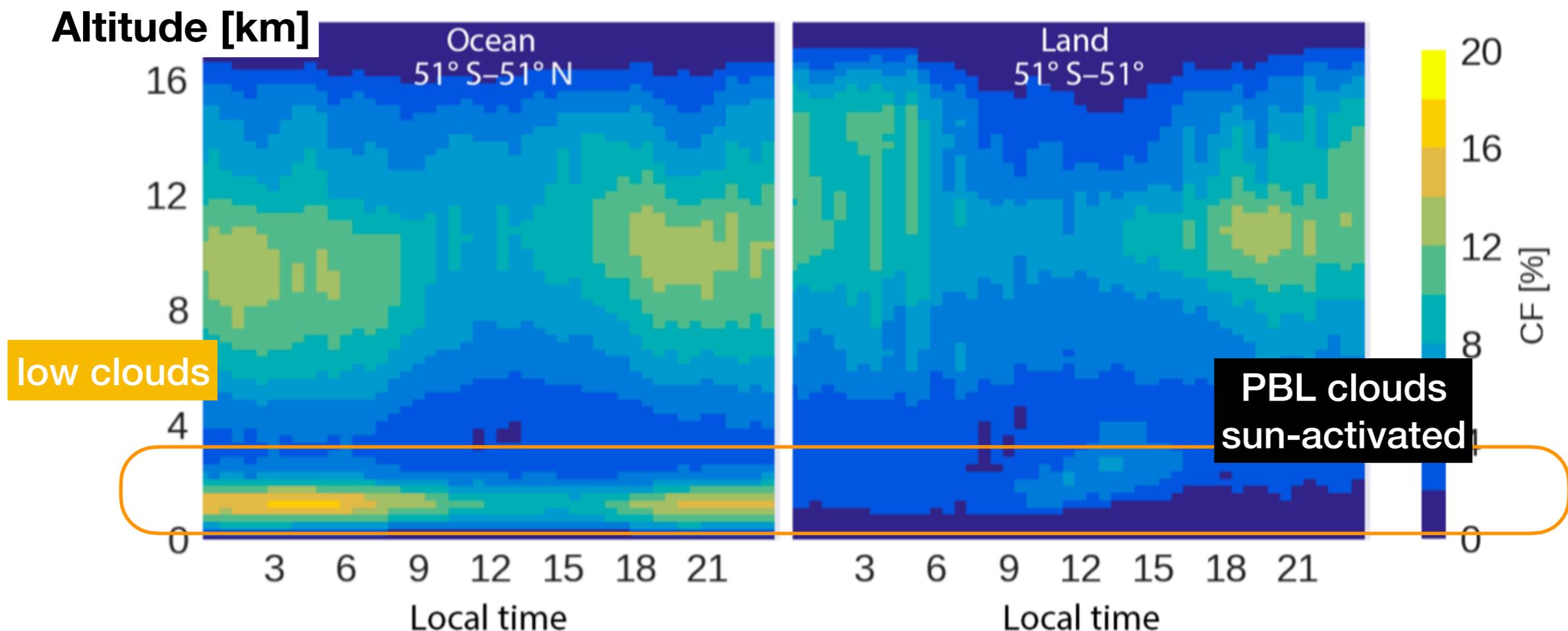
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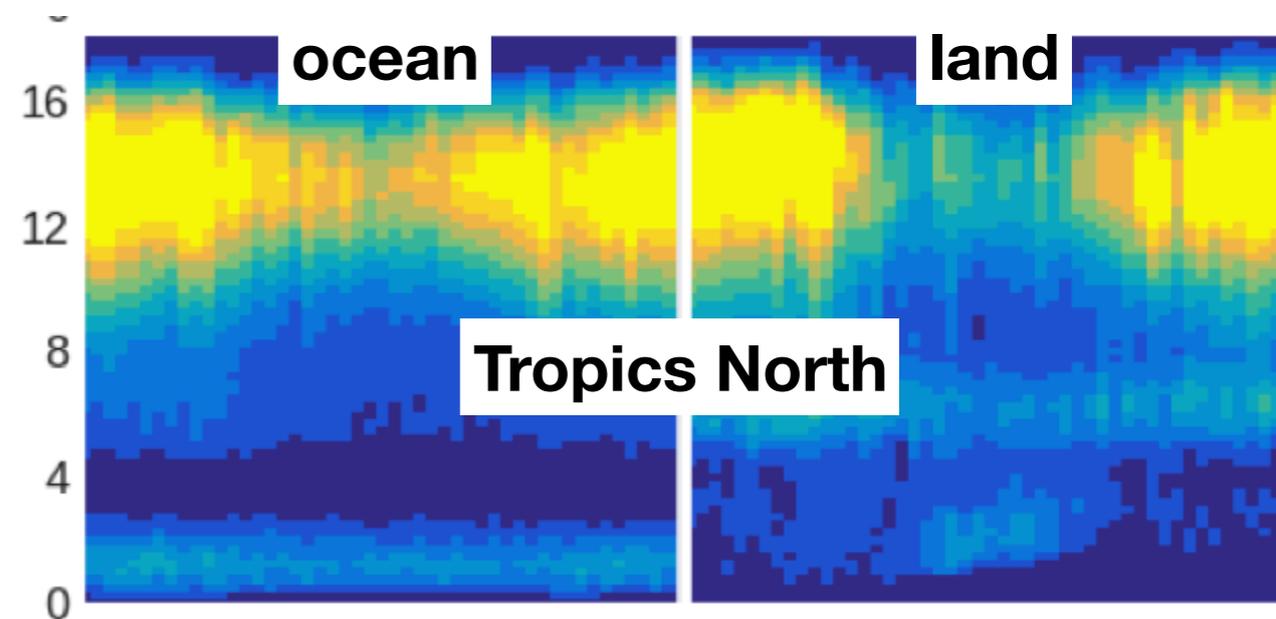
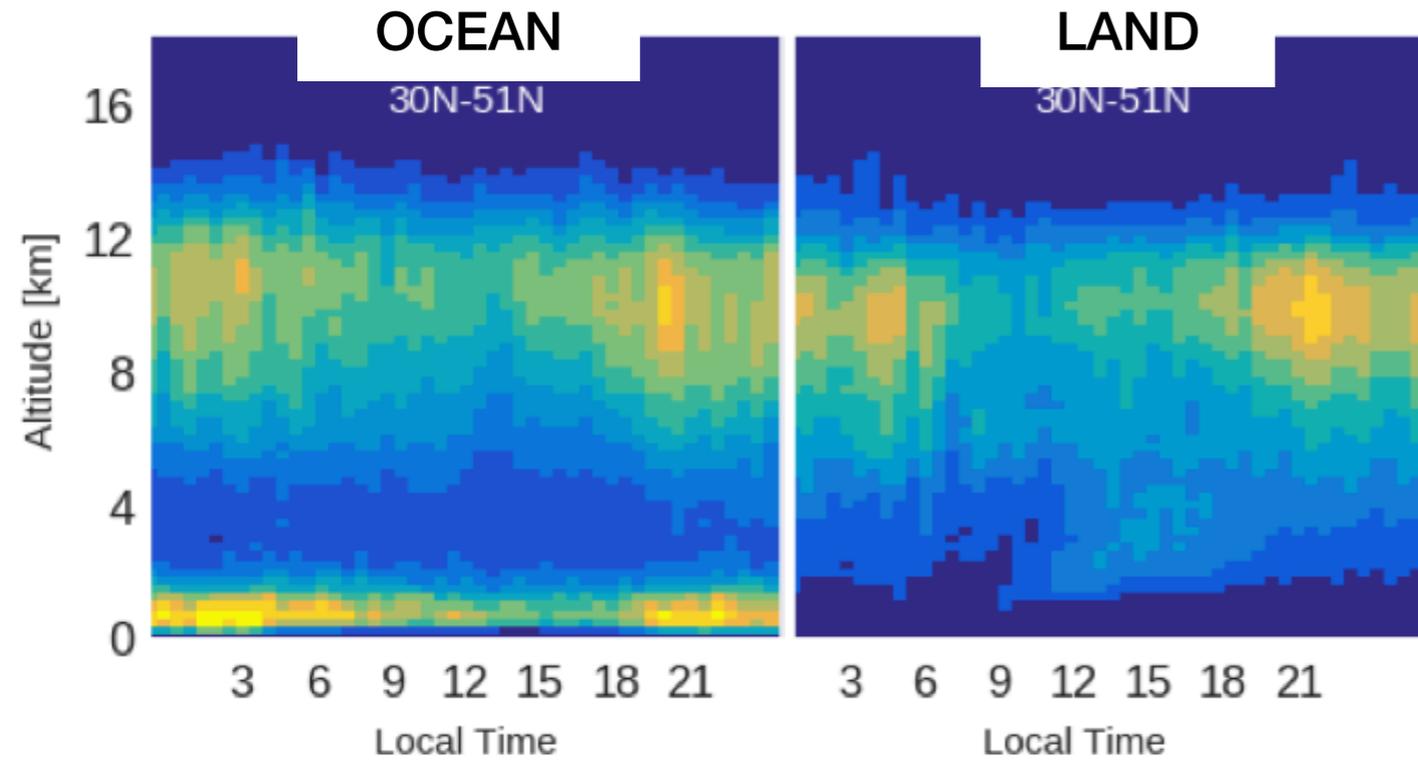
## JJA 2015-2017 $\pm 51^\circ$



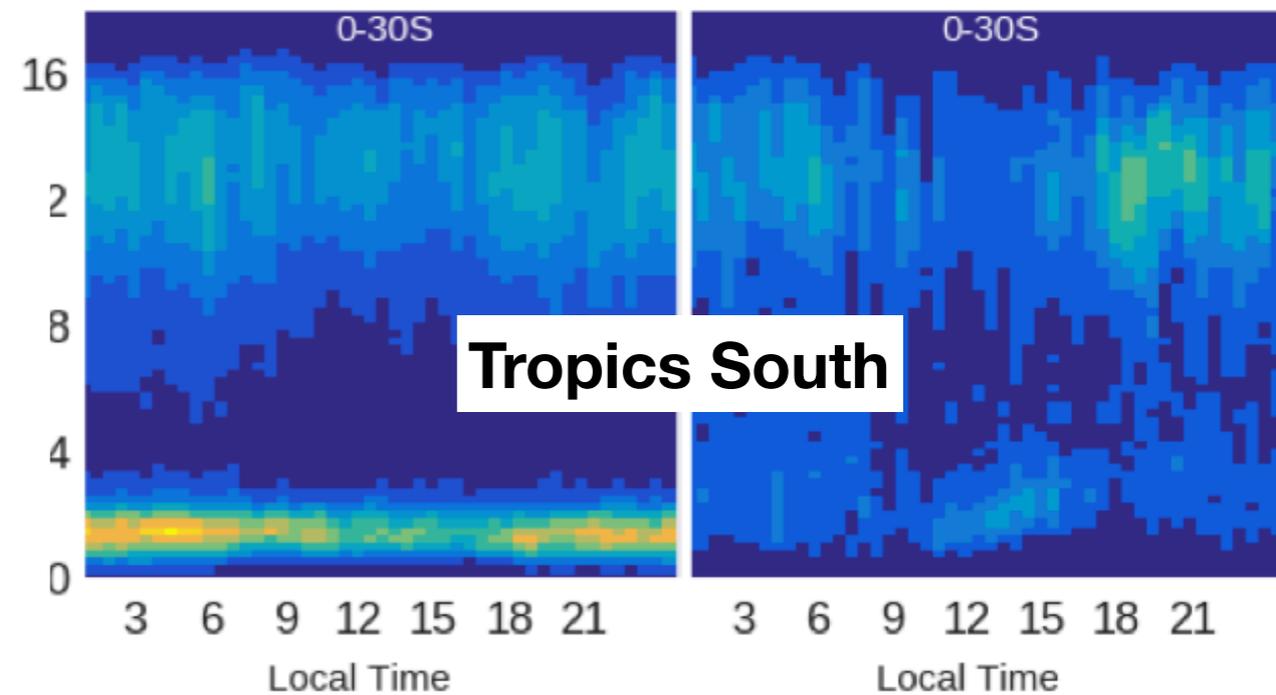
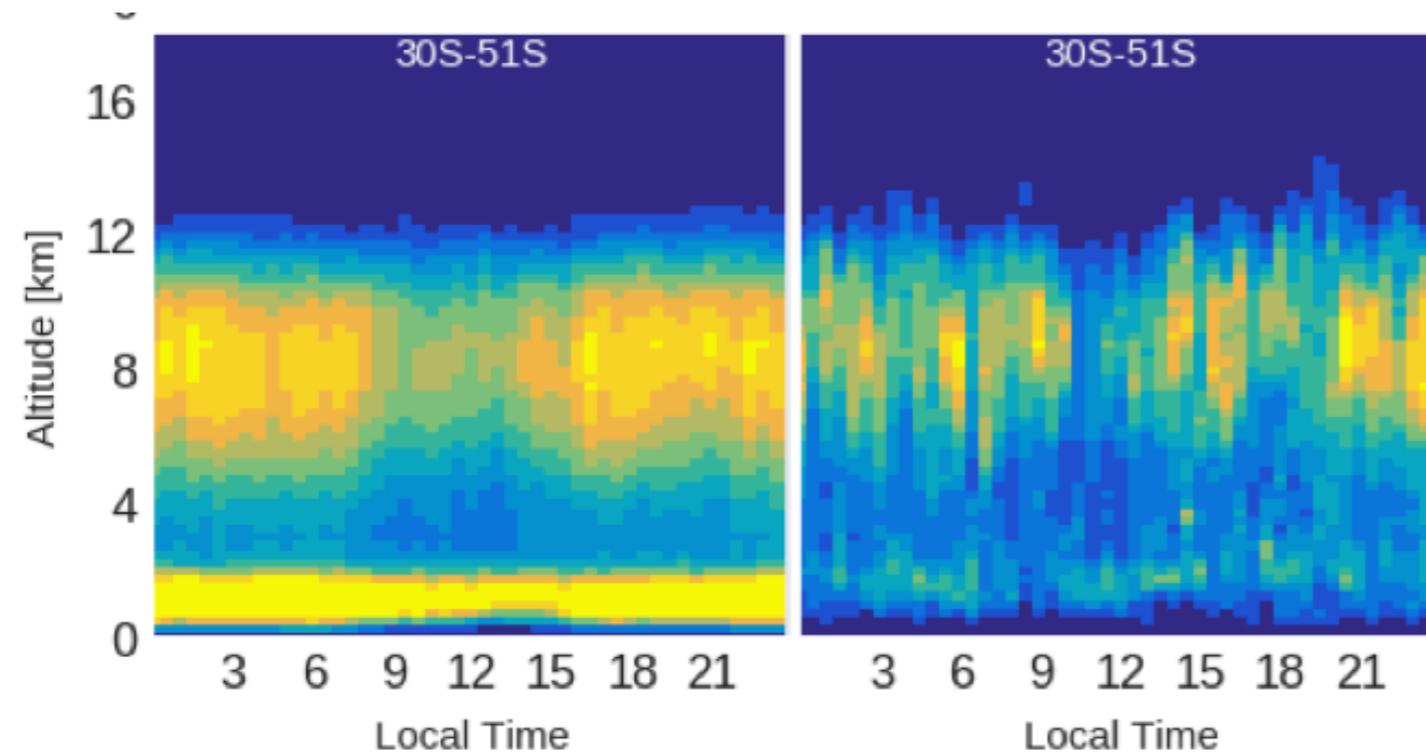
# Diurnal cycles in smaller regions

## Midlat North

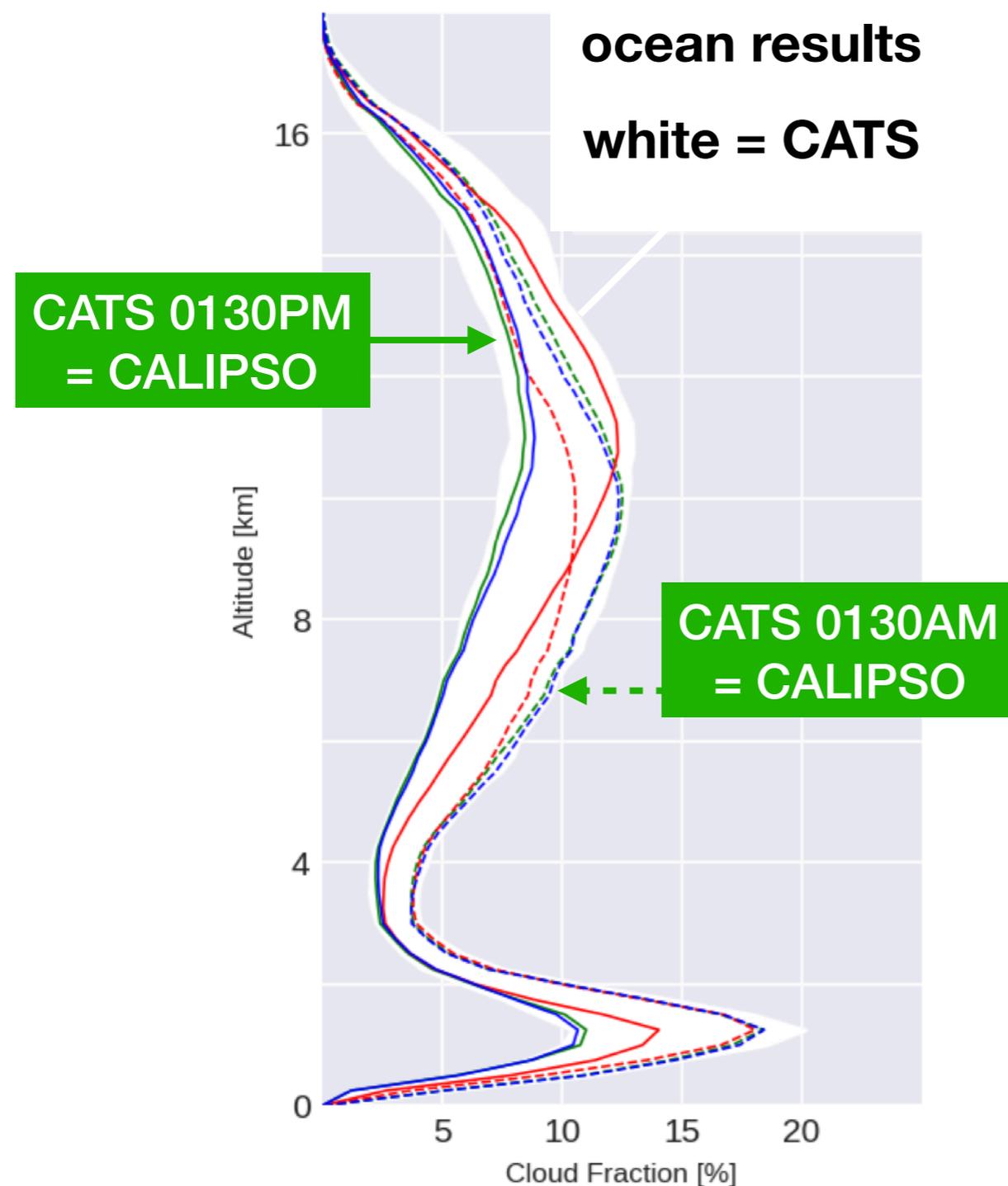
JJA 2015-2017



## Midlat South

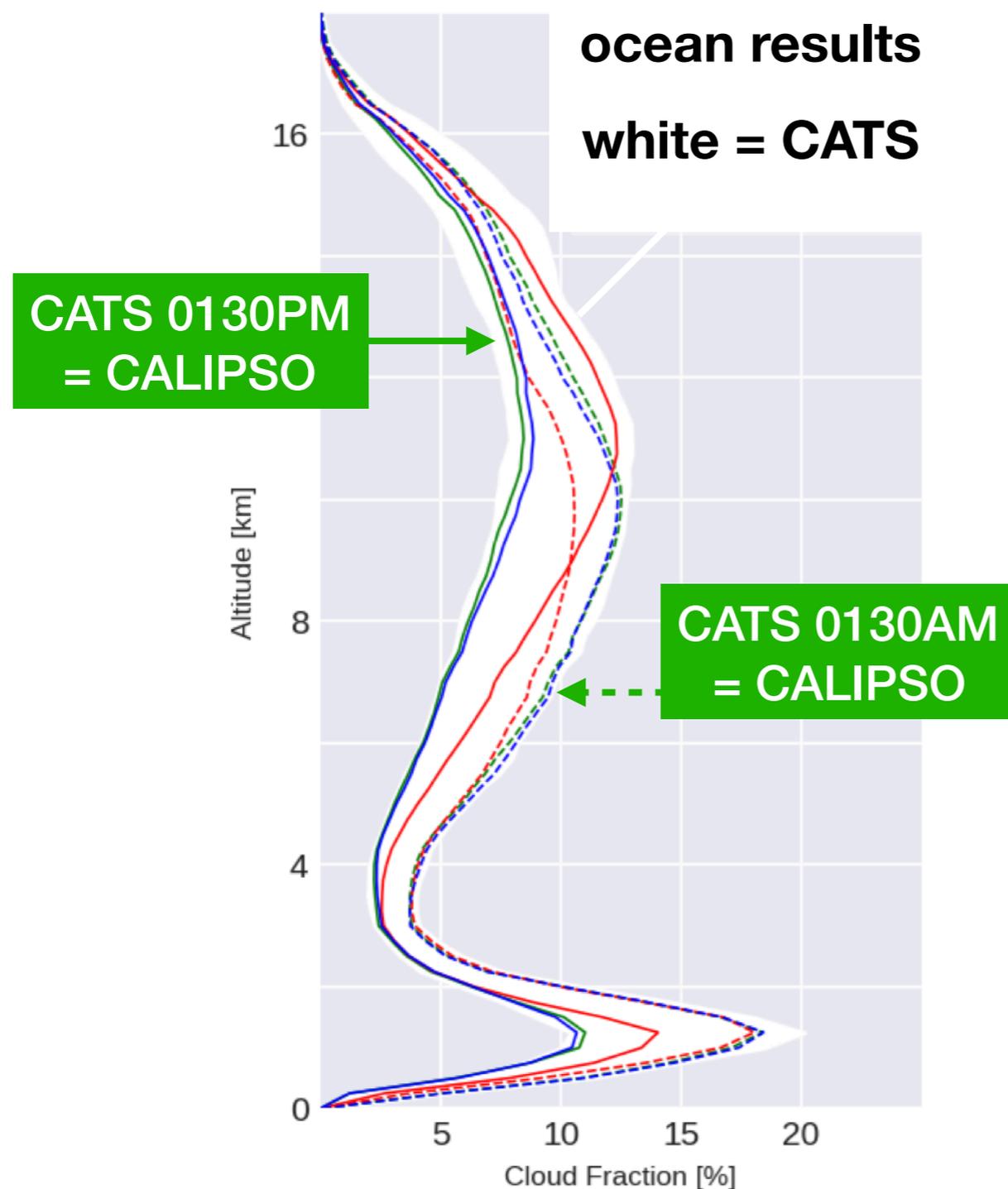


# Implications of CATS results for CALIPSO & sun-synchronous missions



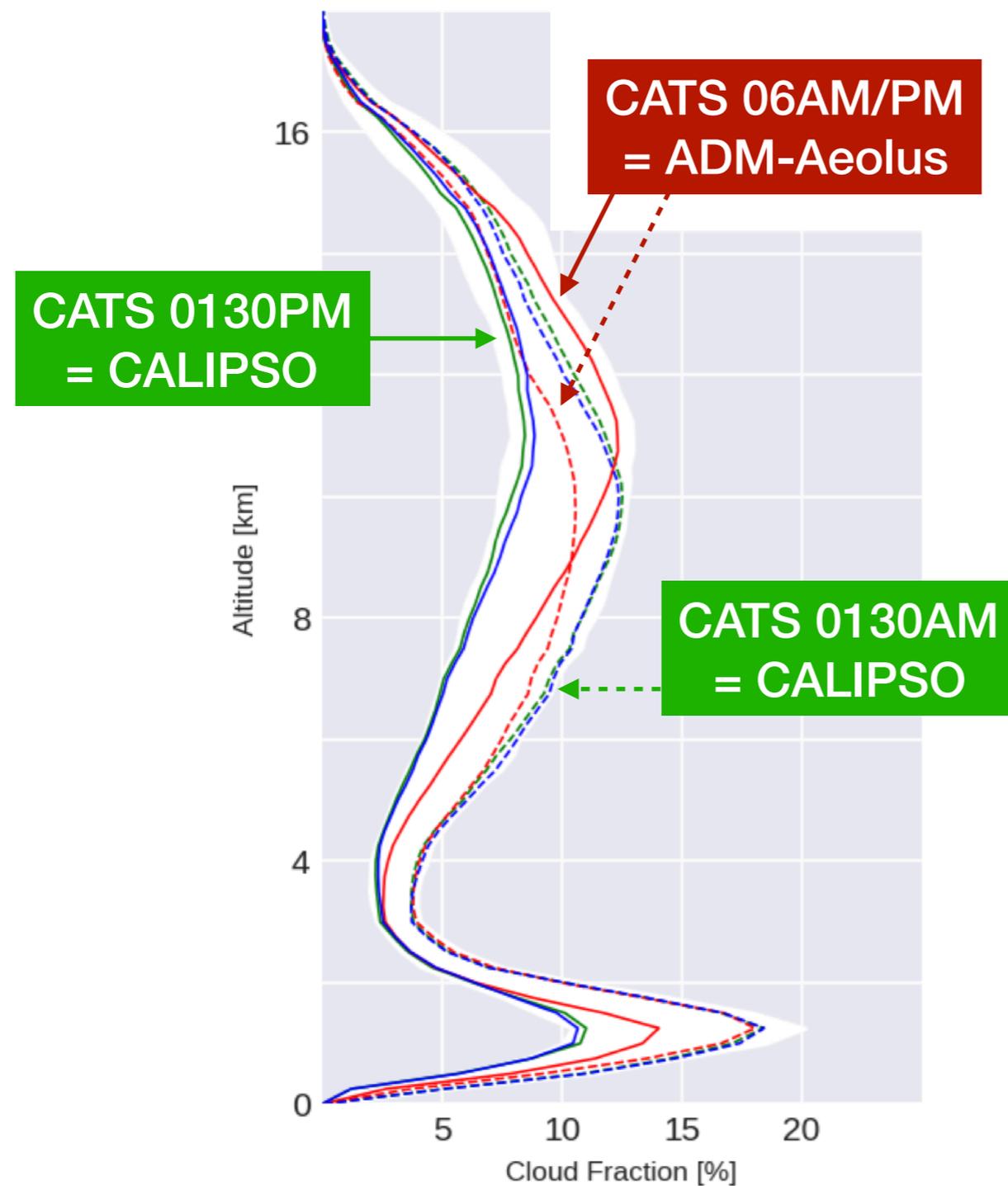
- CATS at 0130PM ~ CF daily min = CALIPSO daytime overpass
- CATS at 0130AM ~ CF daily max = CALIPSO nighttime overpass
- **CALIPSO = daily extremes of the cloud fraction profiles over ocean, especially below 10km ASL**

# 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**

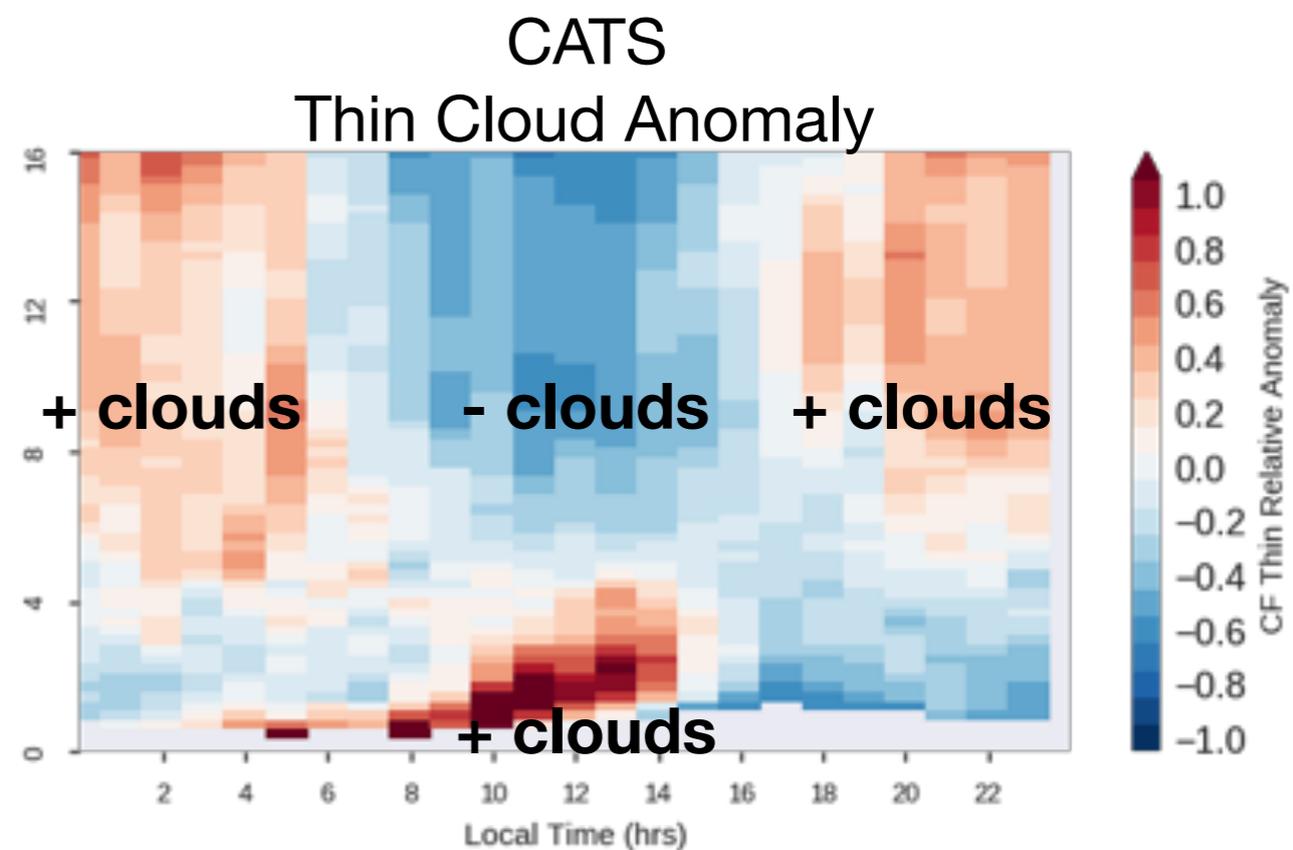
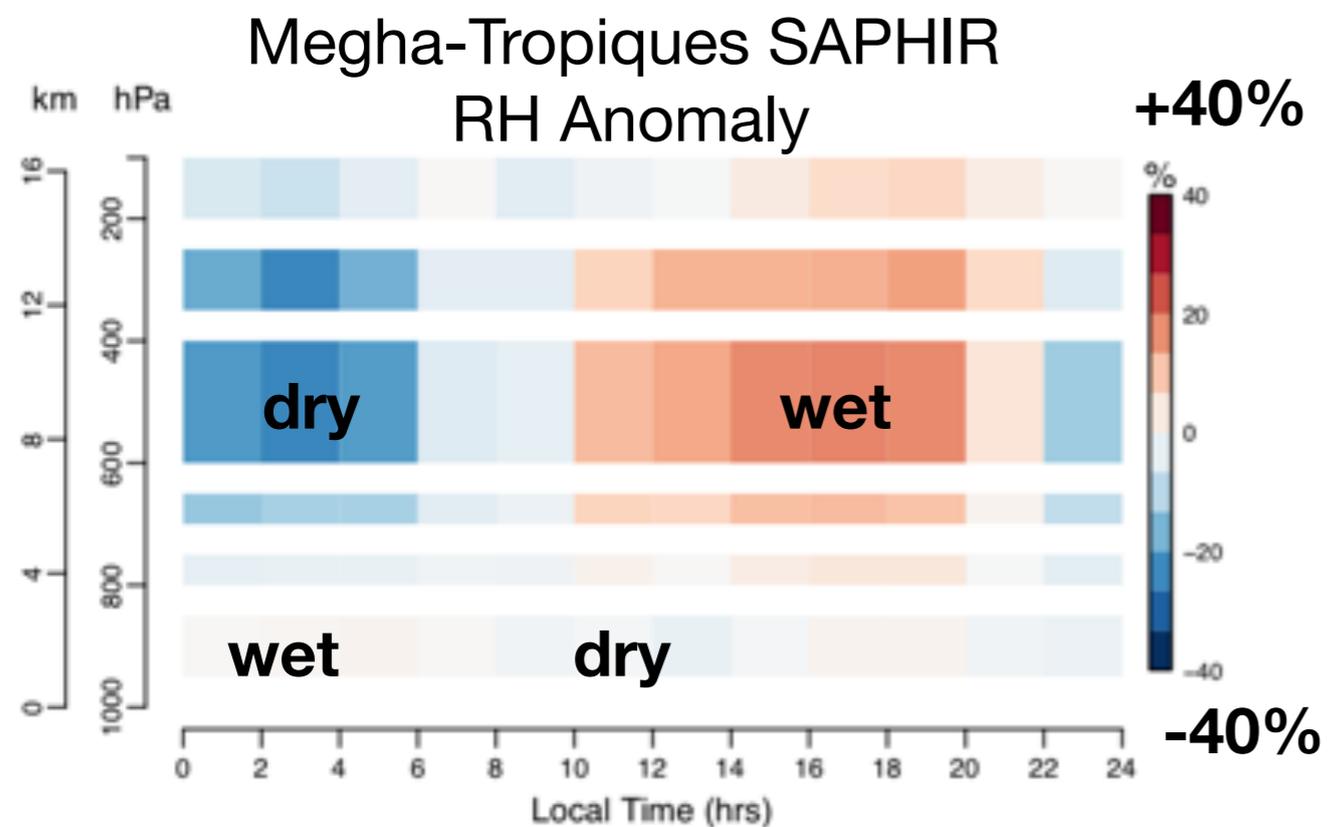
# Implications of CATS results for CALIPSO & sun-synchronous missions



- 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

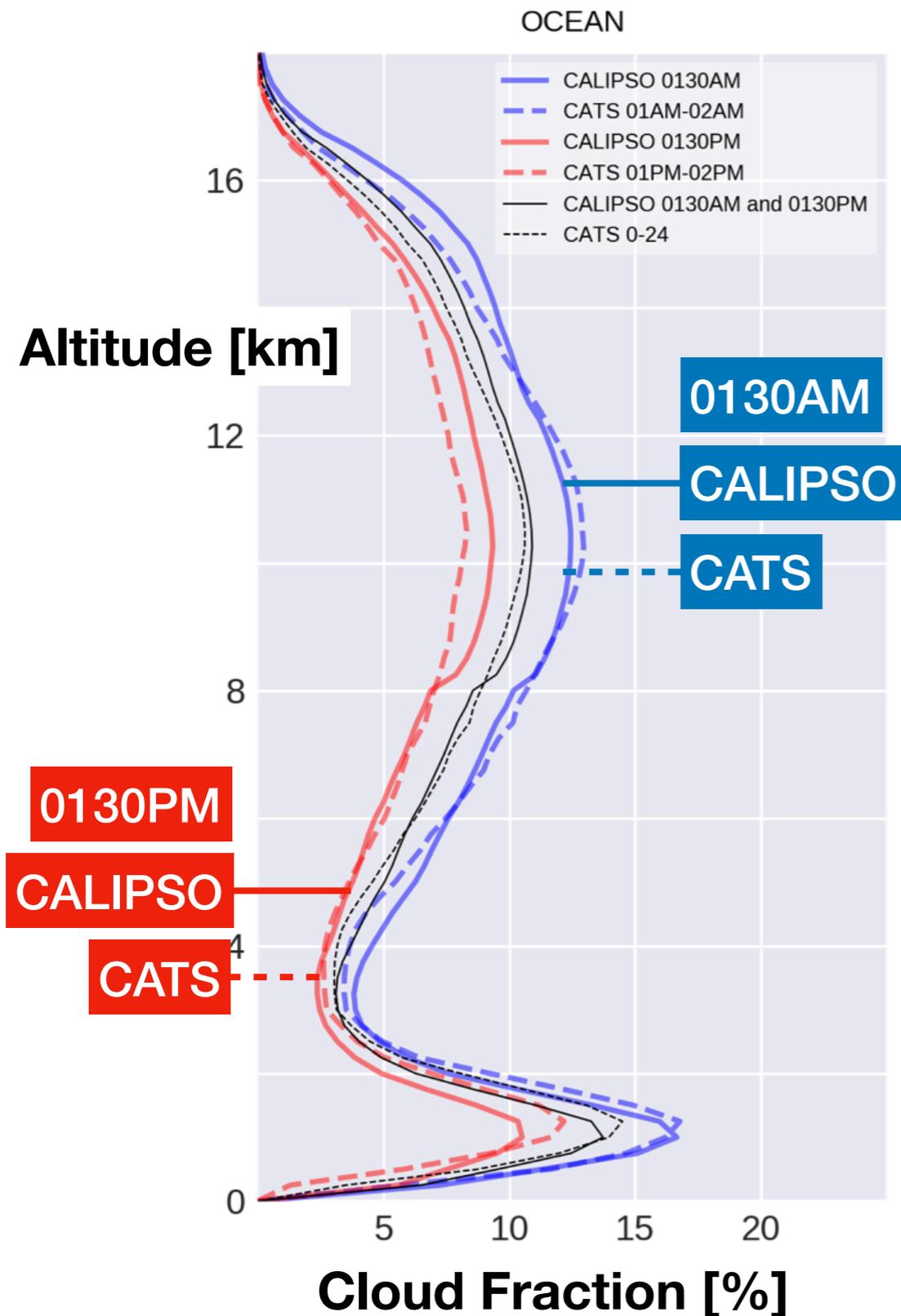
- CATS and Megha-Tropiques can describe **the diurnal cycle of vertical profiles of clouds and water vapor** in the Tropics
  - CATS data shows CALIPSO, Earth-CARE data **document extremes of Cloud Fraction** profiles over ocean
- 
- Other factors will impact agreement between instruments, eg wavelength — 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



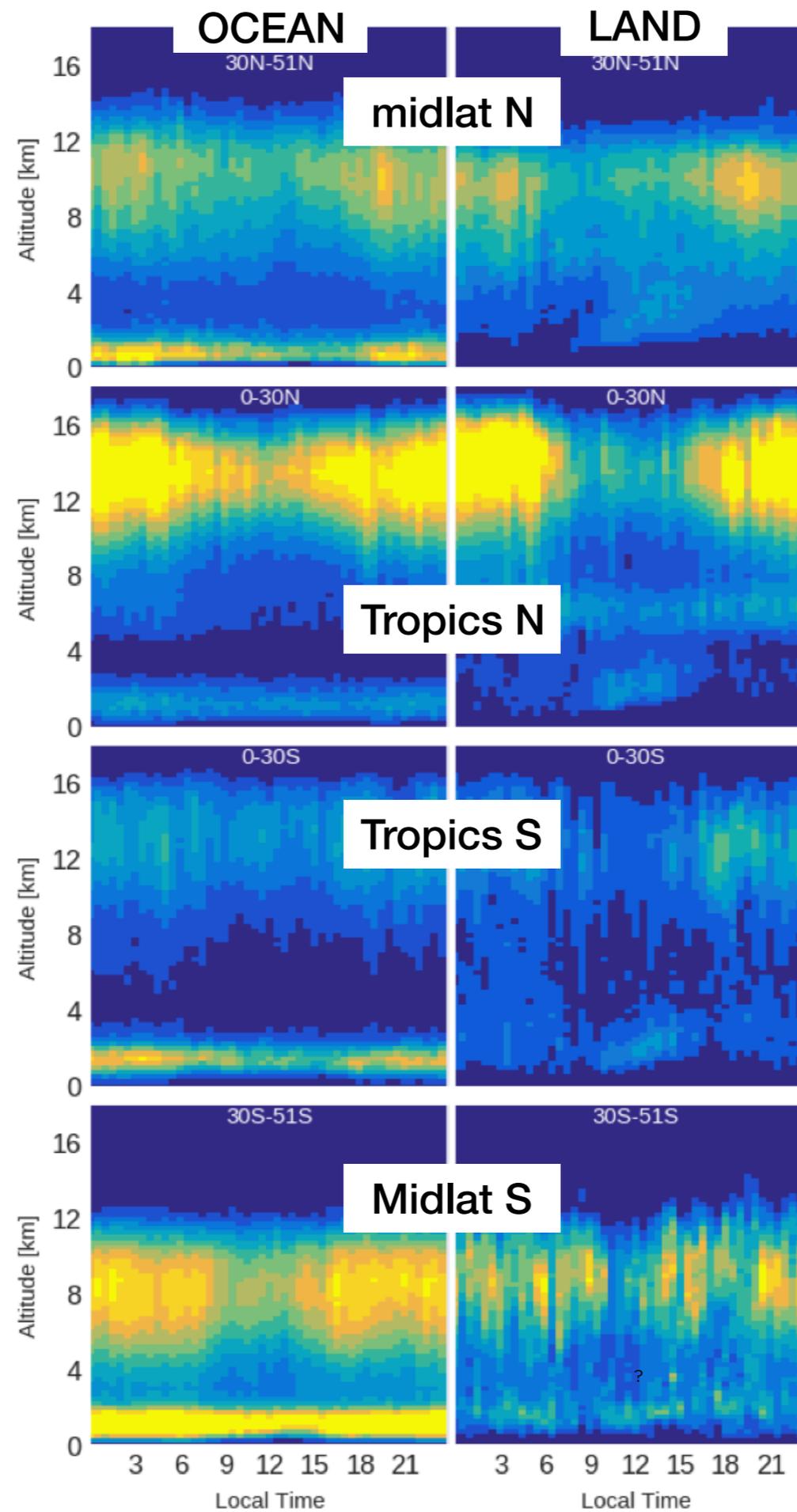
CALIOP overpasses any location at 0130AM or 0130PM local times

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](#))

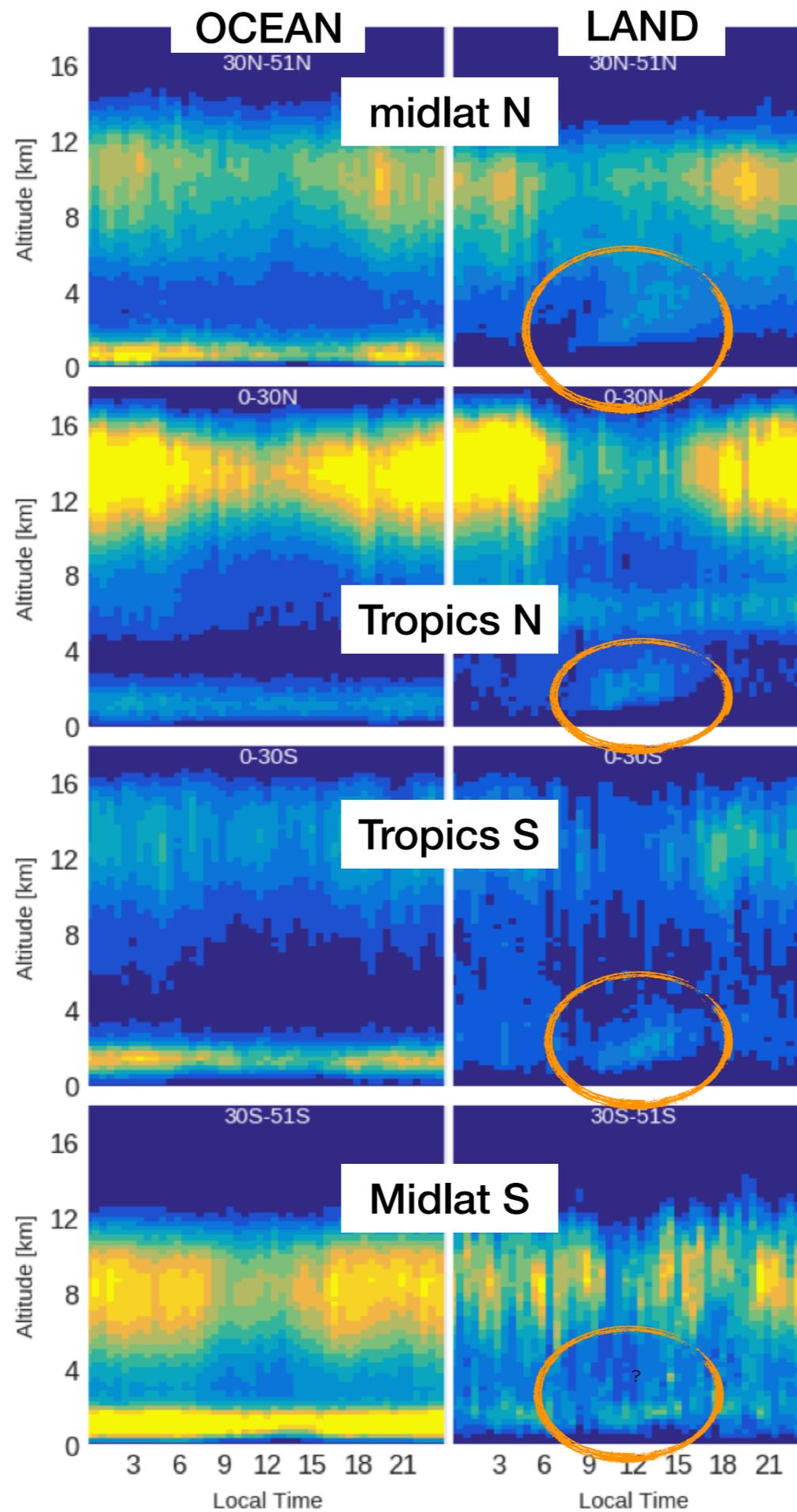
**CATS clouds are reliable**

# JJA Results by latitude band



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

# JJA Results by latitude band

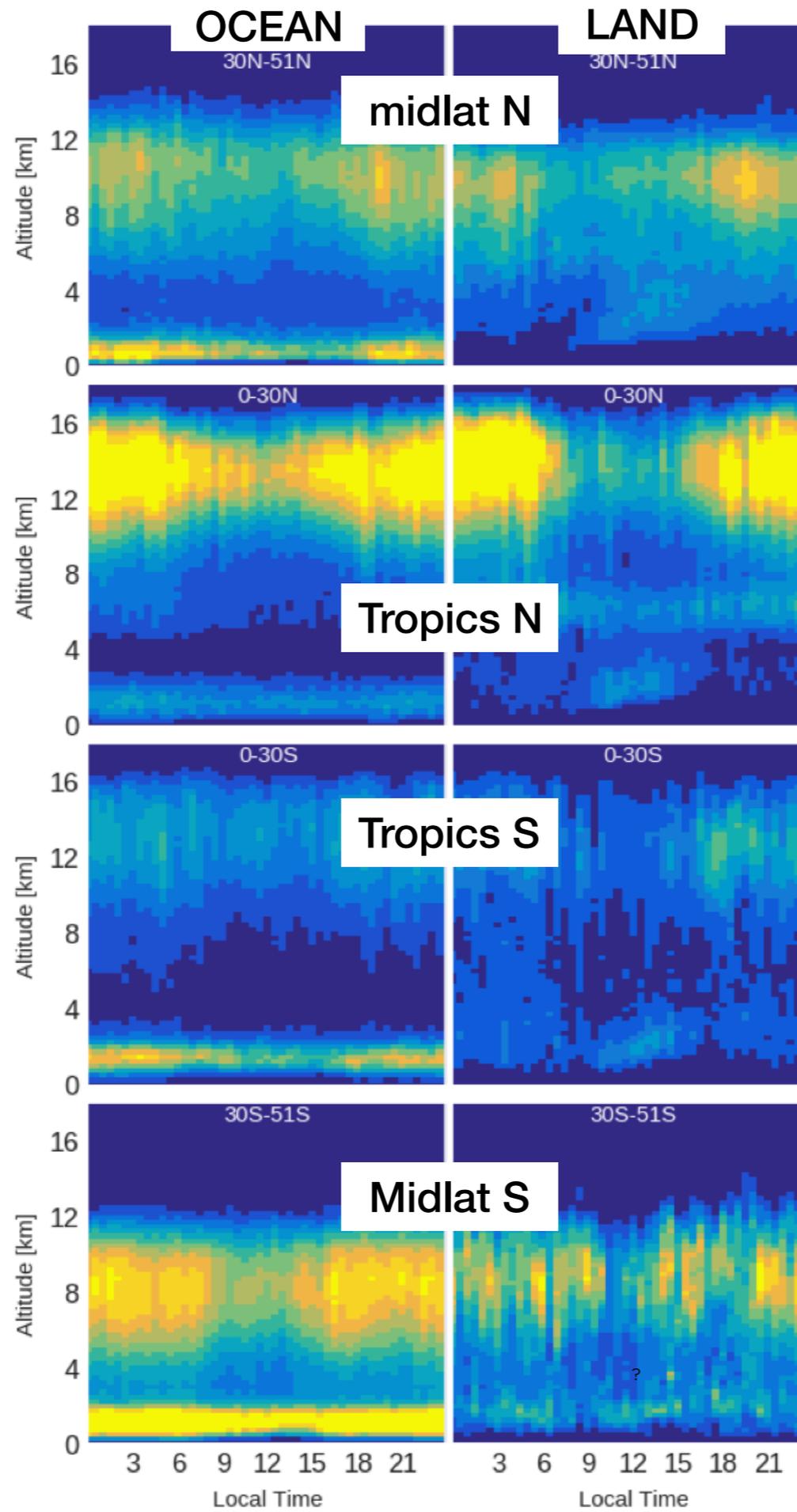


PBL clouds  
sun-activated

# JJA Results by latitude band

Summer Tropics

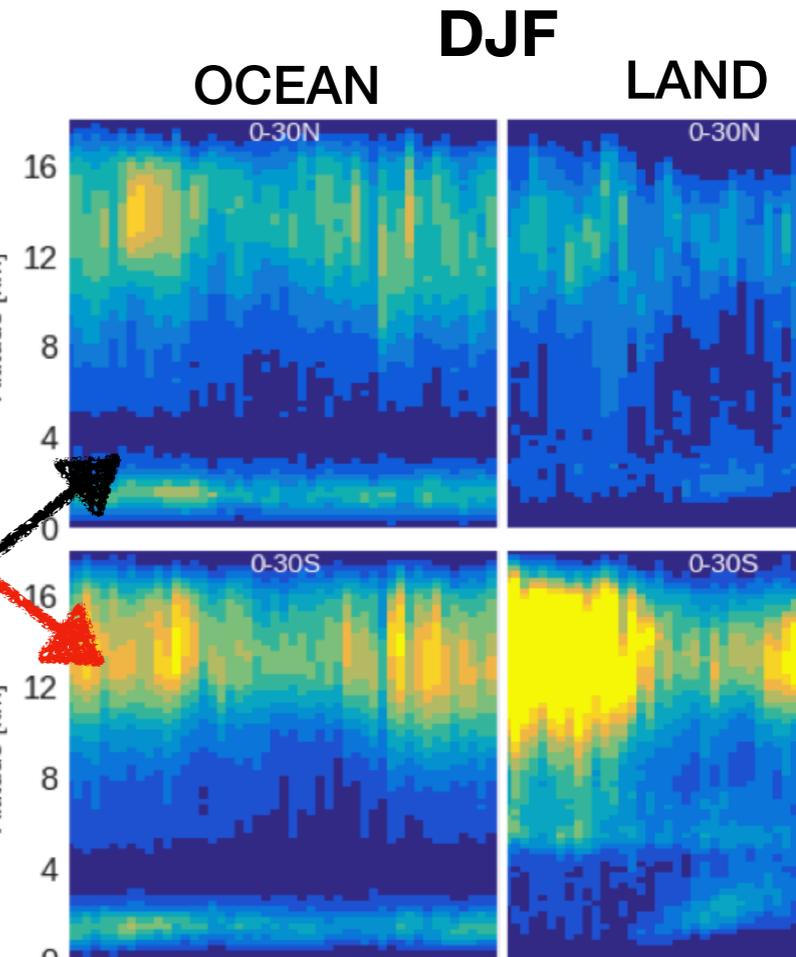
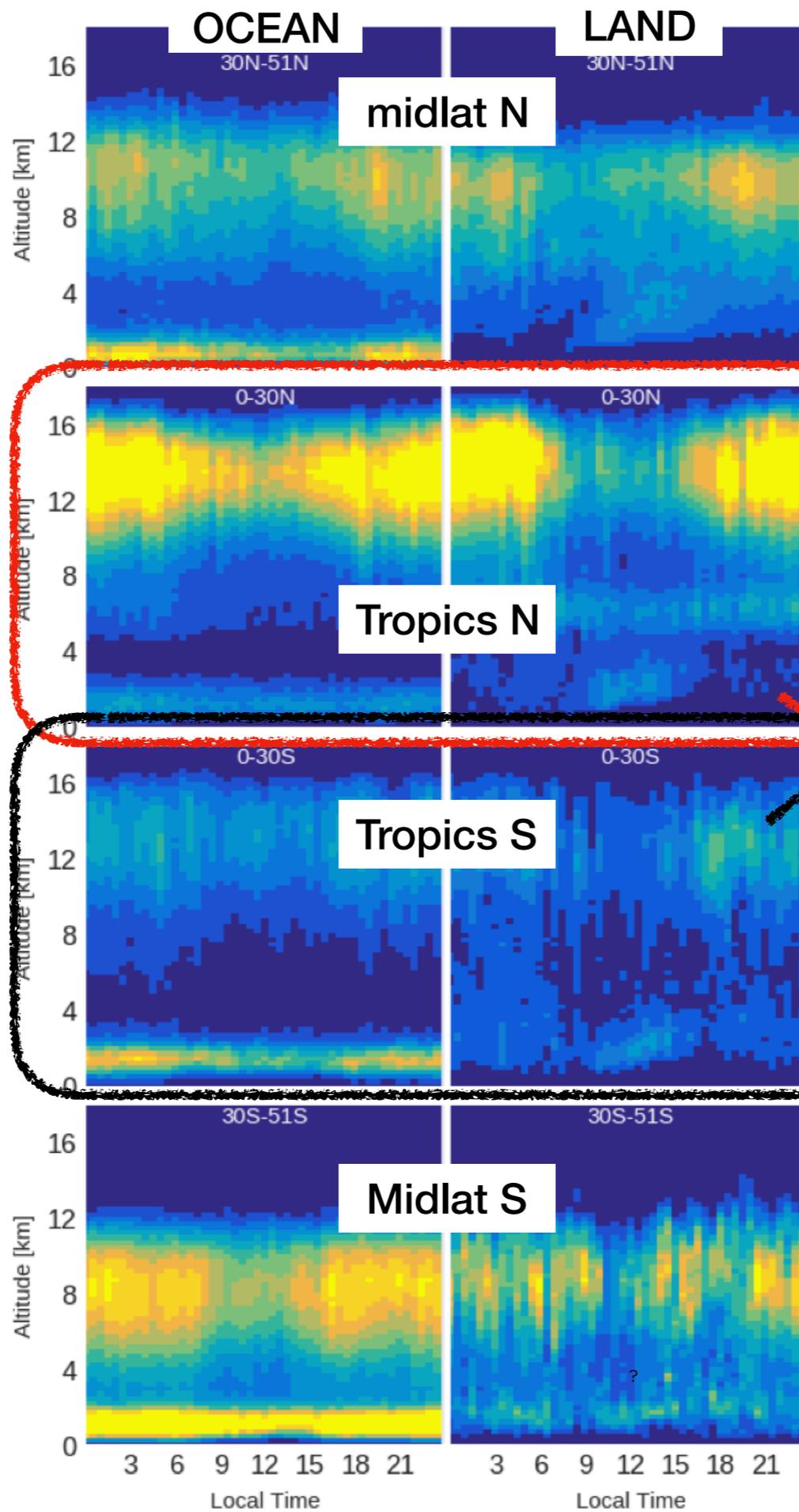
Winter Tropics



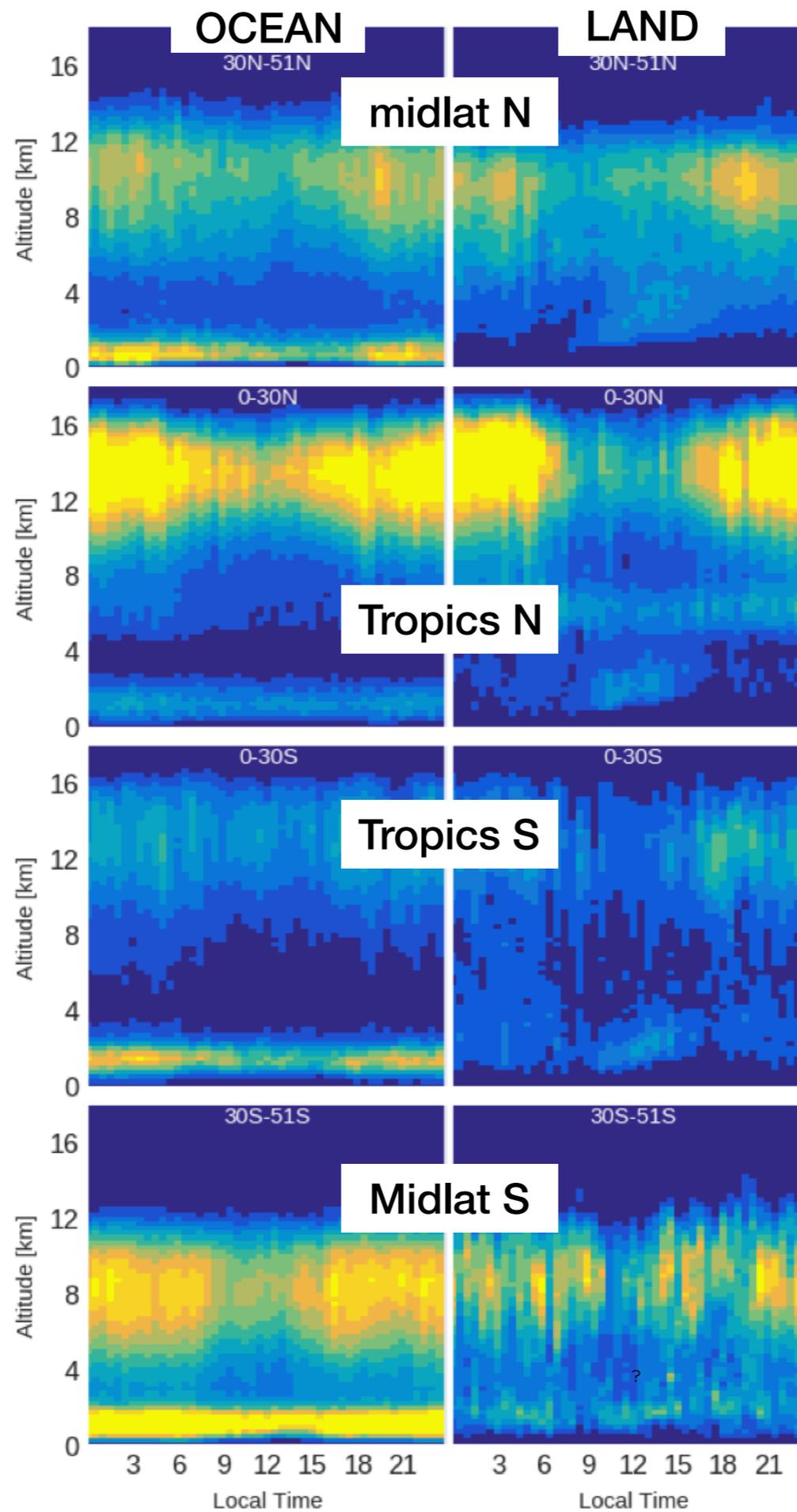
# JJA Results by latitude band

Summer Tropics

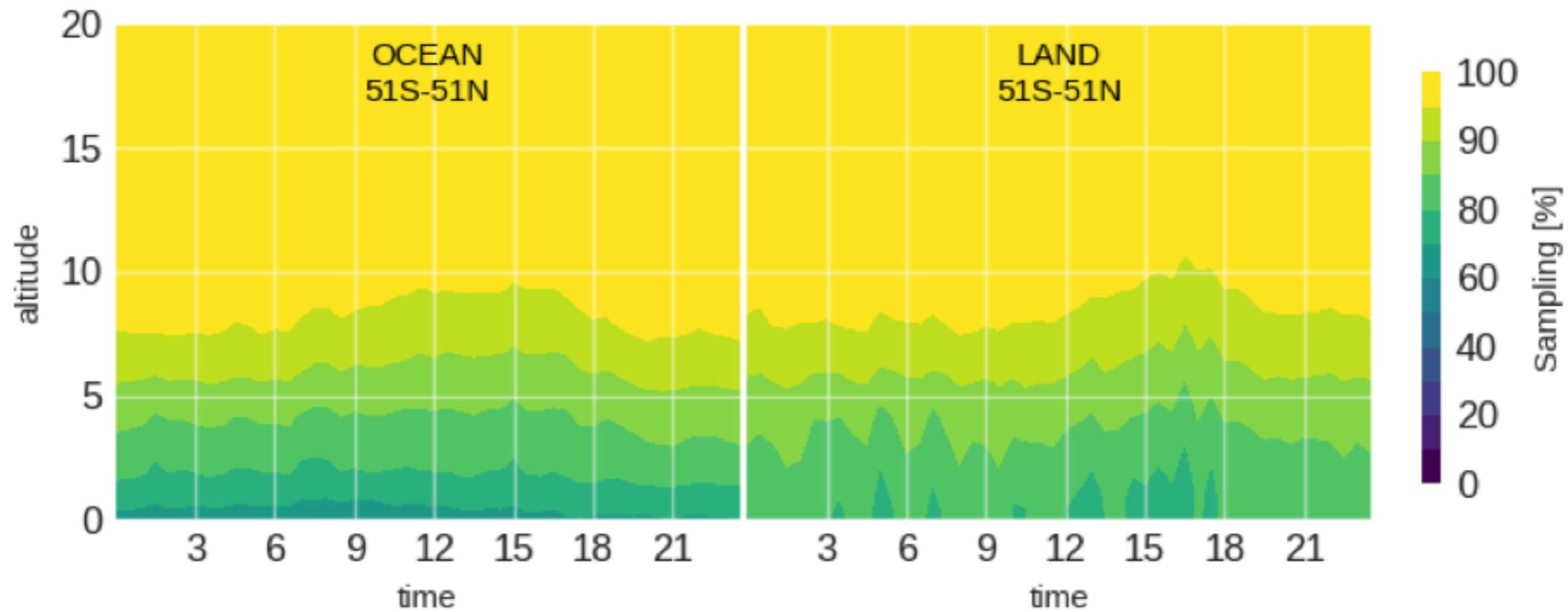
Winter Tropics



# JJA Results by latitude band



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

