Cloud properties retrieved from OCO-2

Mark Richardson[1], Anthony Davis[1], Heather Cronk[2], Thomas Taylor[2], James McDuffie[1], Graeme Stephens[1,2,3]

A-train meeting, Pasadena, California, U.S.A. 2017-04

[1]Jet Propulsion Laboratory, California Institute of Technology, USA
[2]Cooperative Institute for Research in the Atmosphere, Colorado State University, USA
[3]Department of Meteorology, University of Reading, UK

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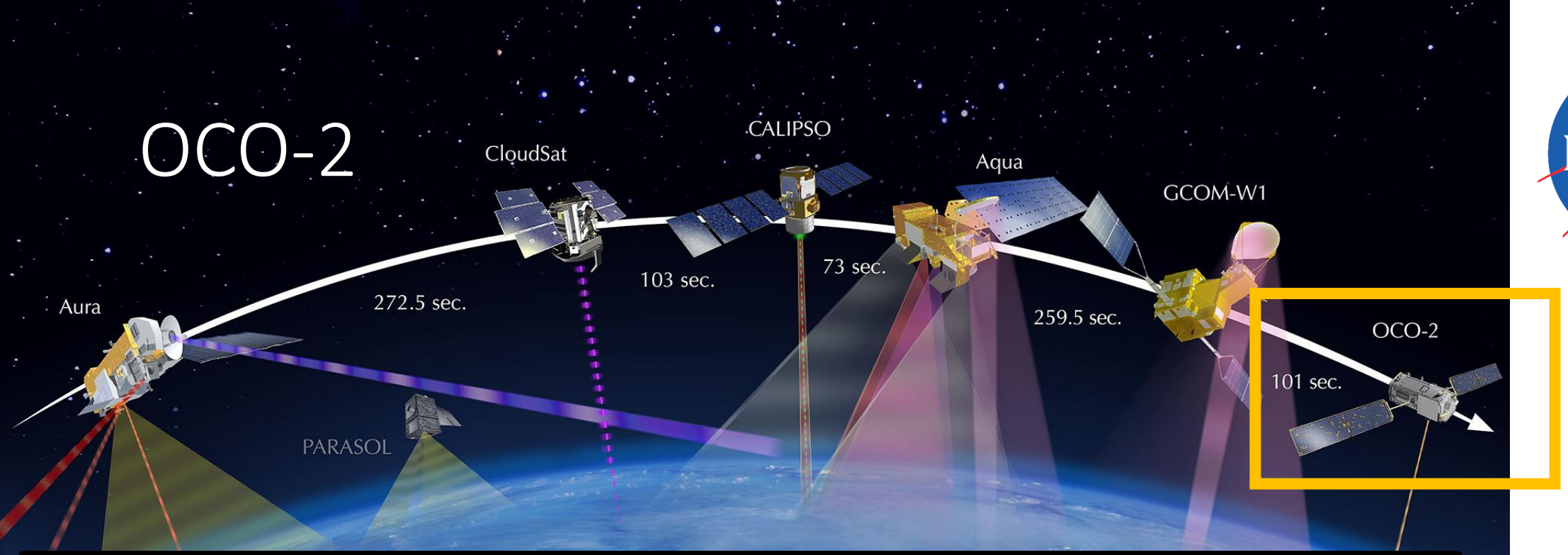
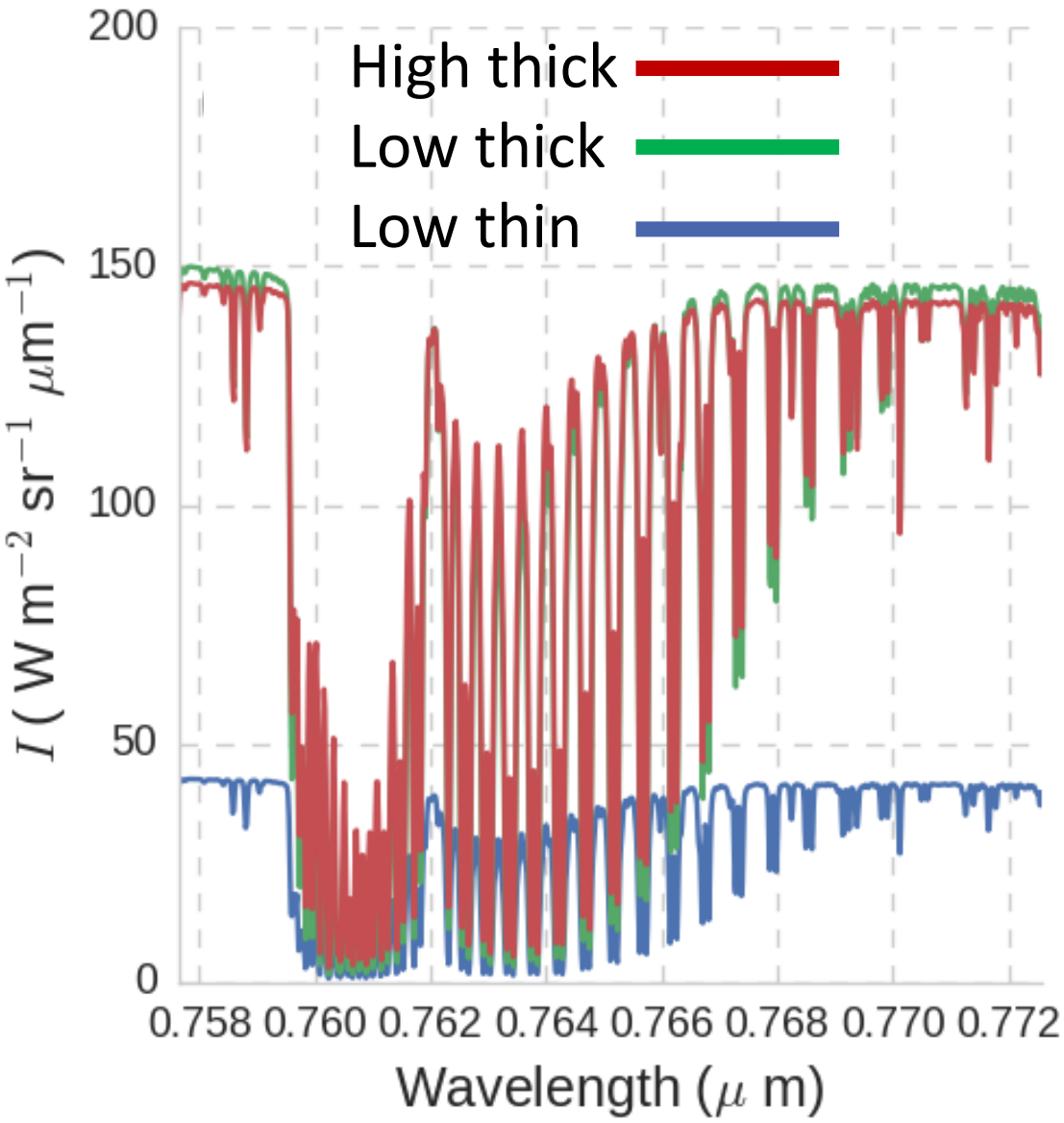
OCO-2



- **No other satellite gets pressure thickness of marine boundary layer clouds**
- We use (mainly) OCO-2 A-band measurements of reflected sunlight
- Retrieve: τ, P_{top}, cloud thickness

Image credit: NASA/JPL/Caltech

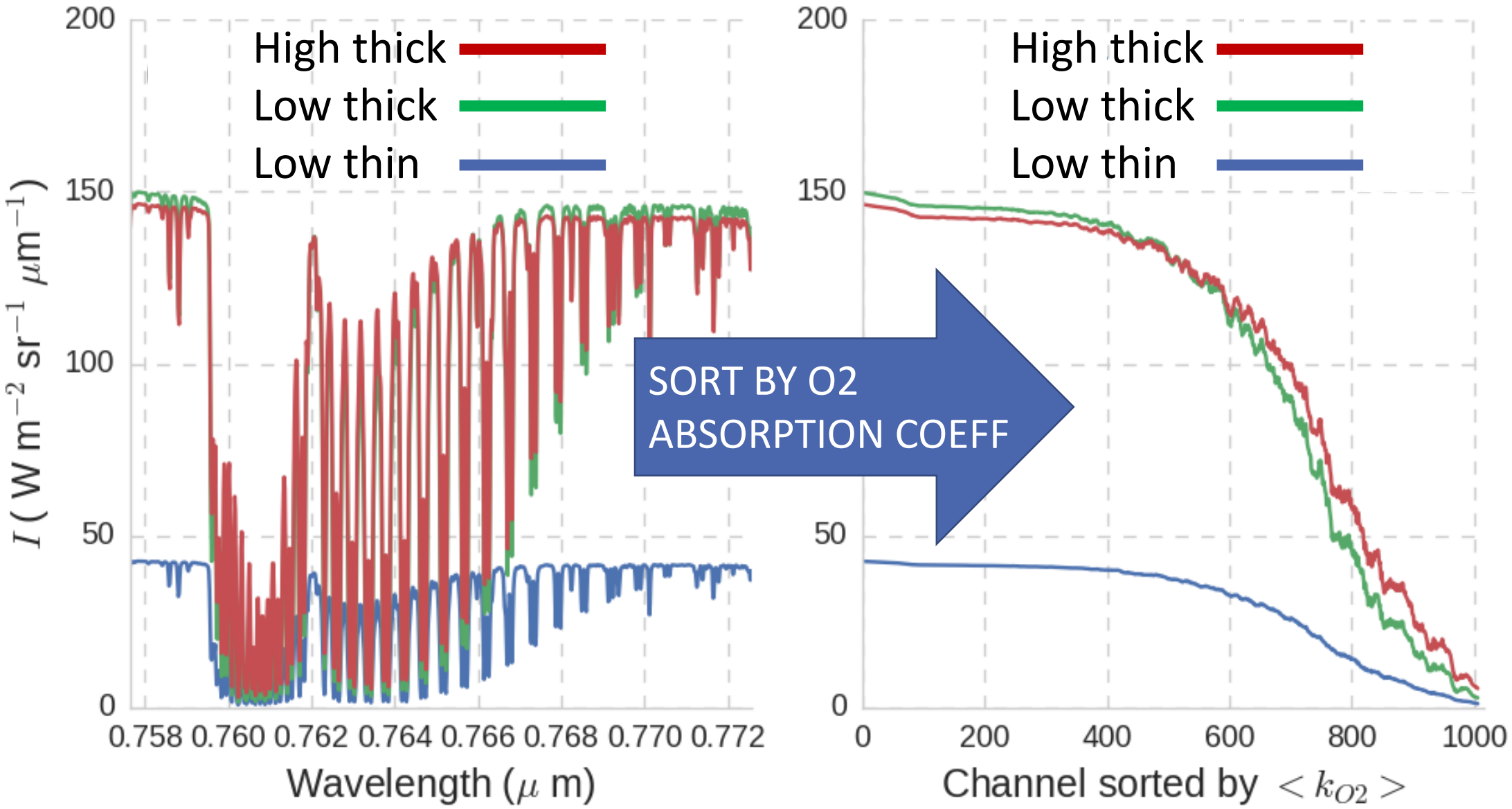
(2) OCO-2 A-band response to clouds



Optically thick clouds are more reflective (“brighter”)

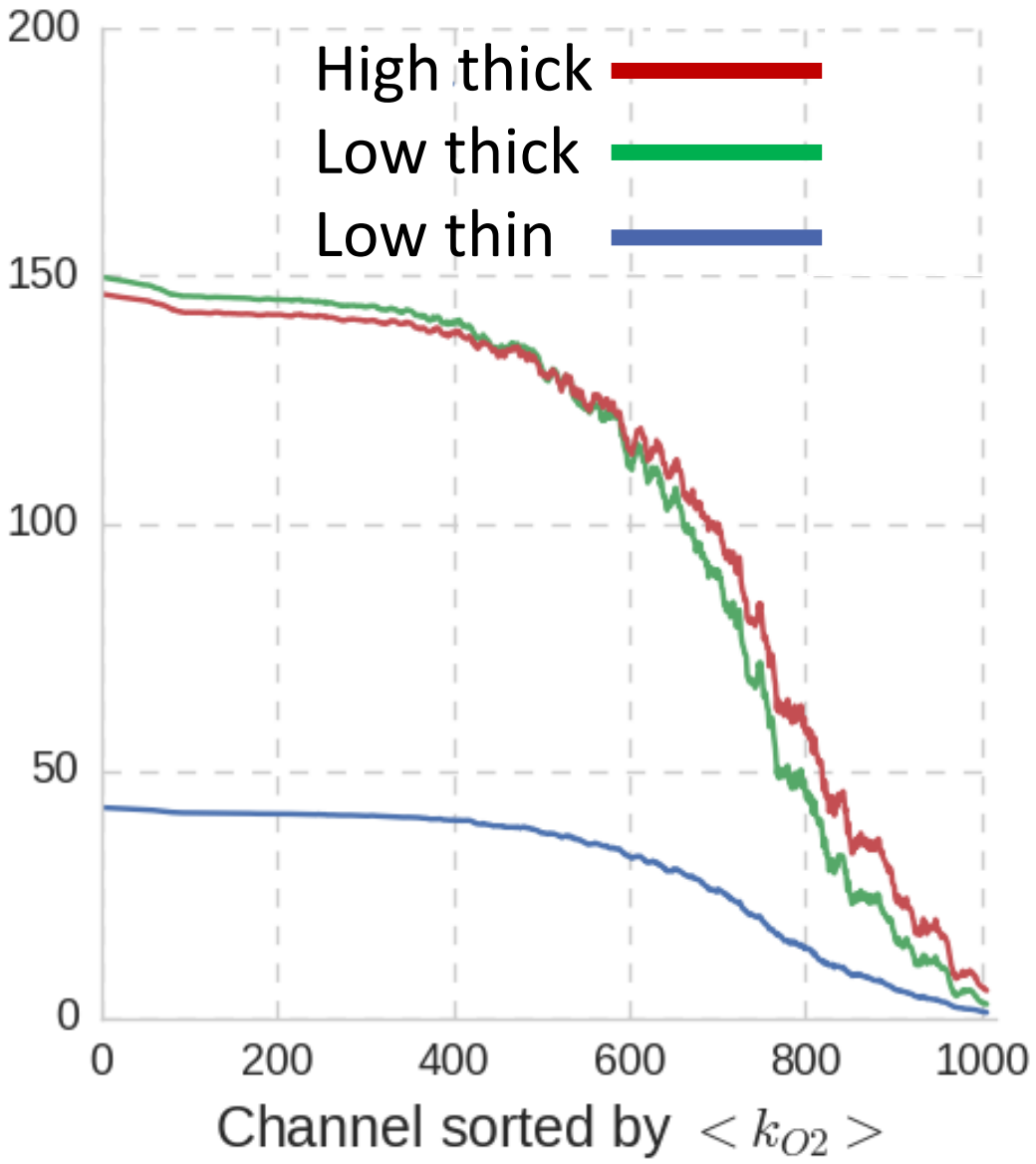
Optically thin clouds are less reflective (“darker”)

(3) A-band spectra sorted by oxygen absorption



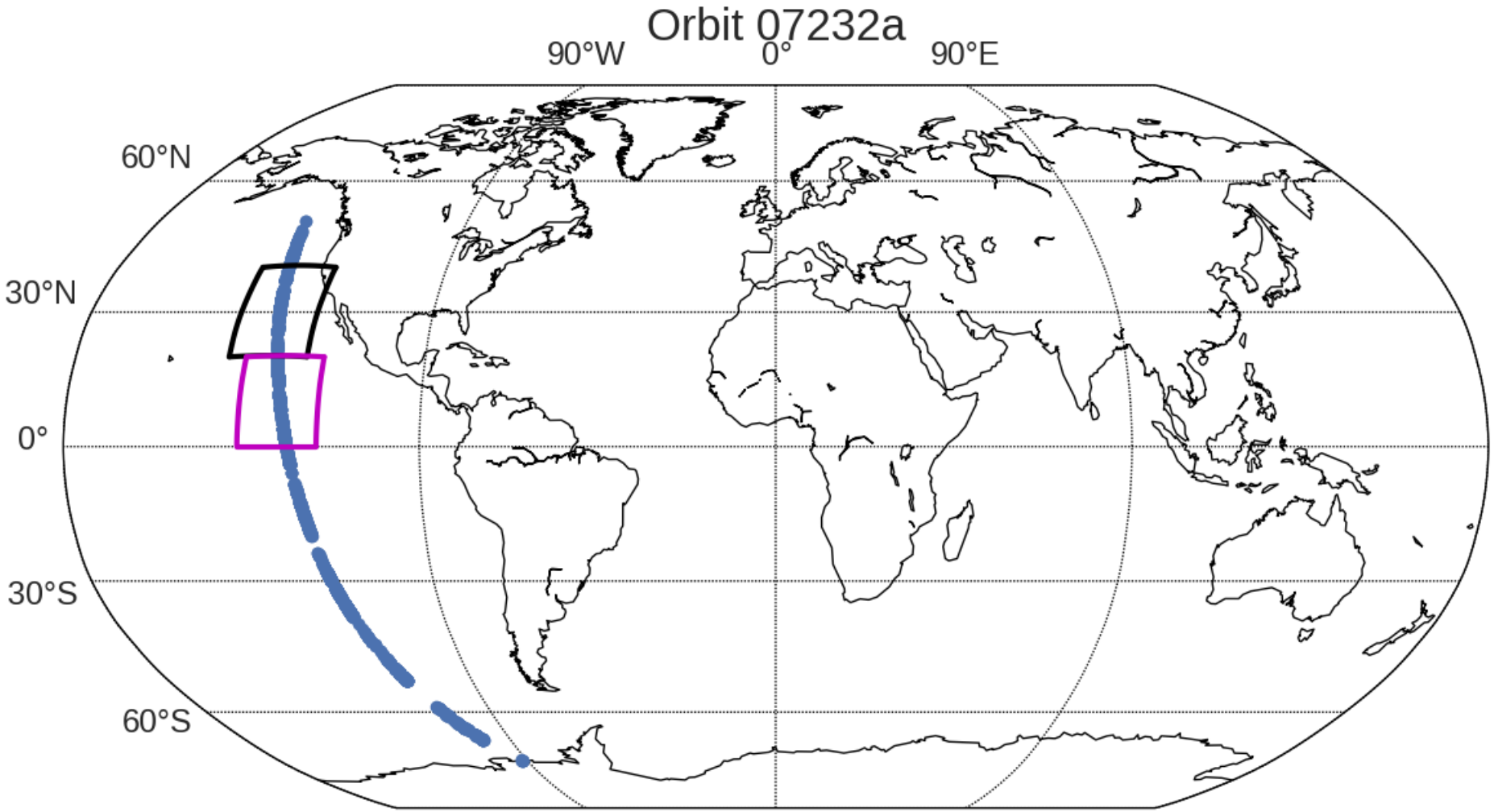
(4) A-band spectra response to photon path

- The green is “darker” in the absorption bands
- Photons have travelled further → more absorption → cloud is lower and/or thicker



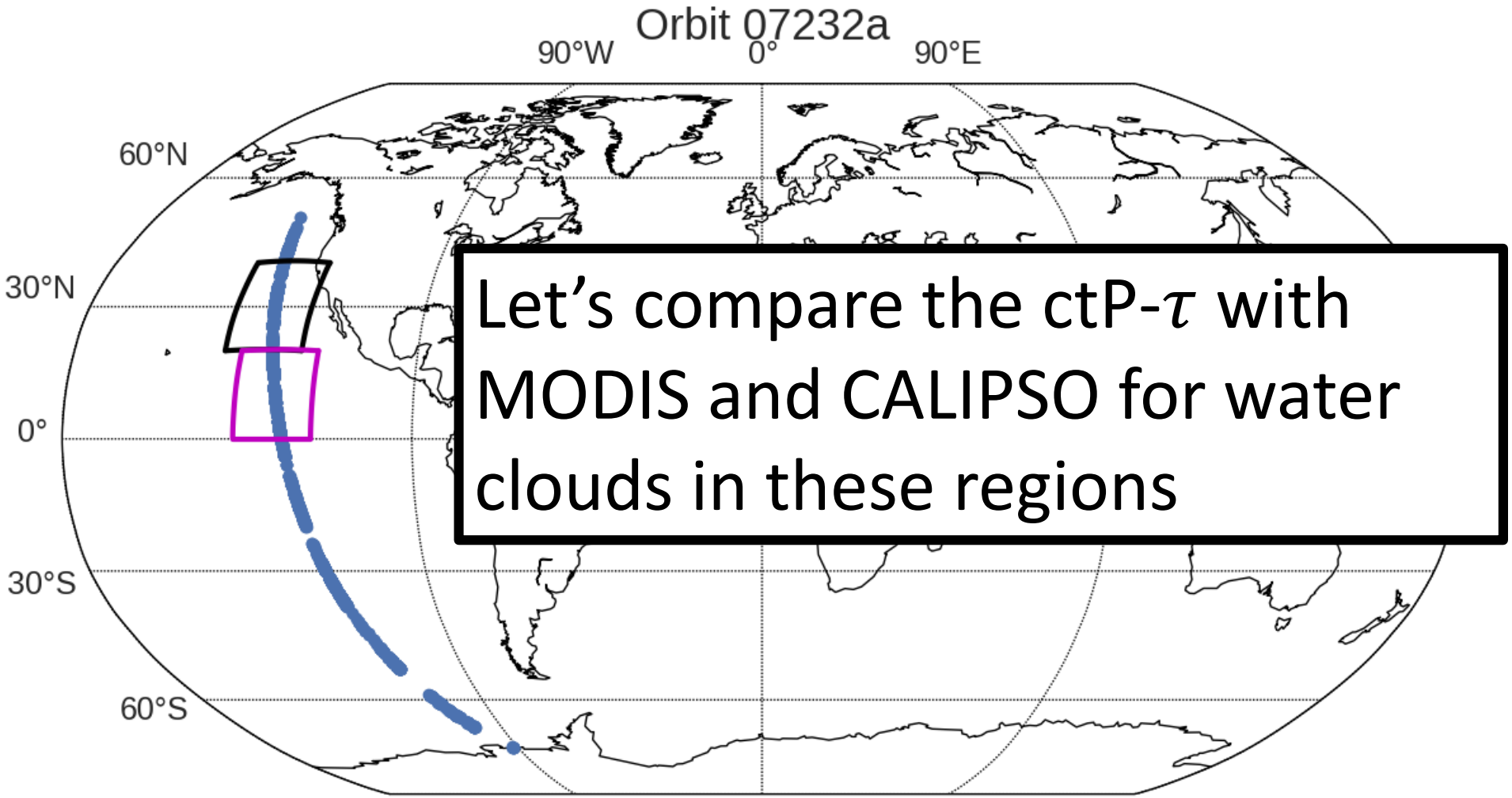
(5) One orbit example

November 2015



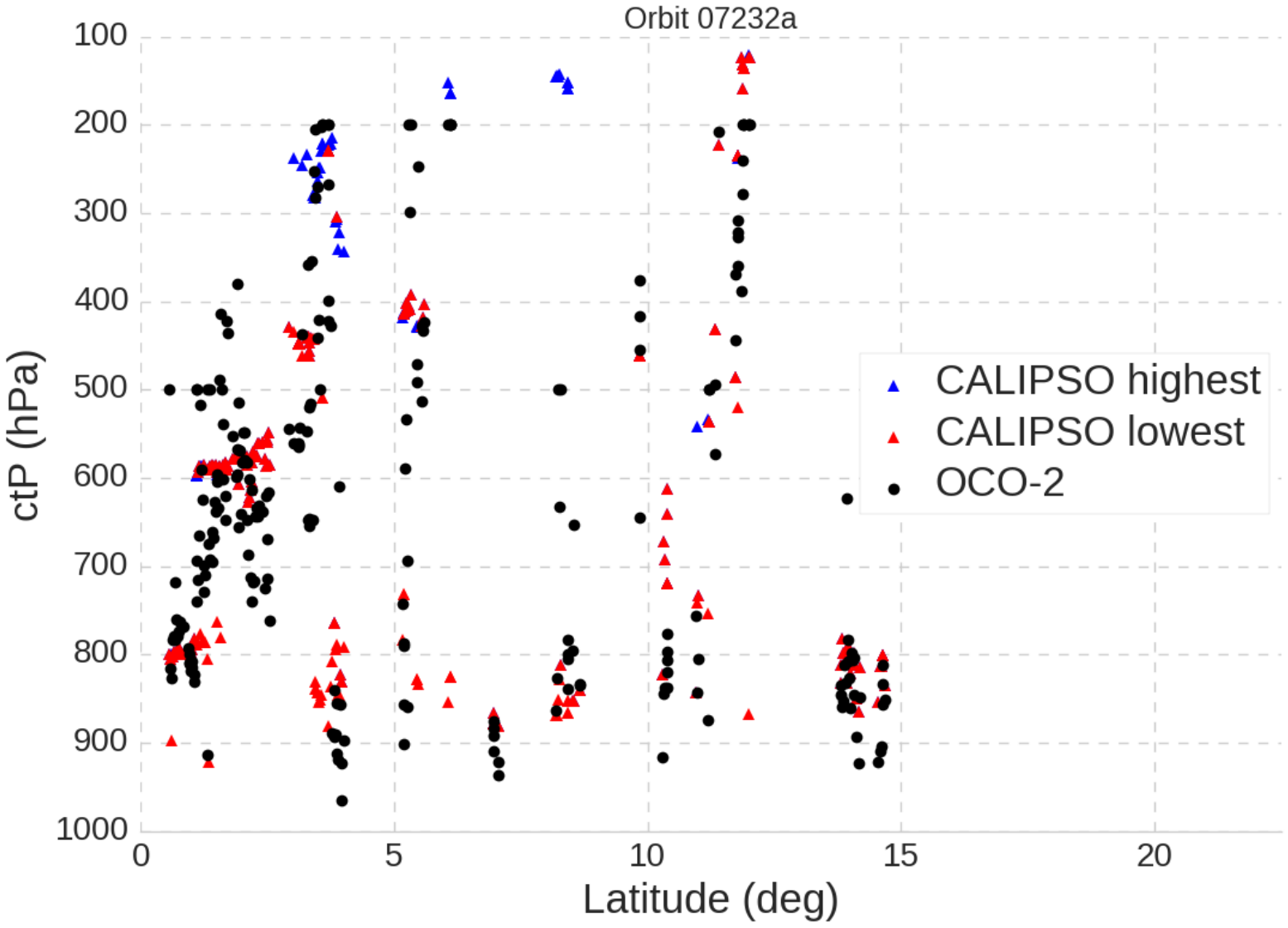
(6) Region selection

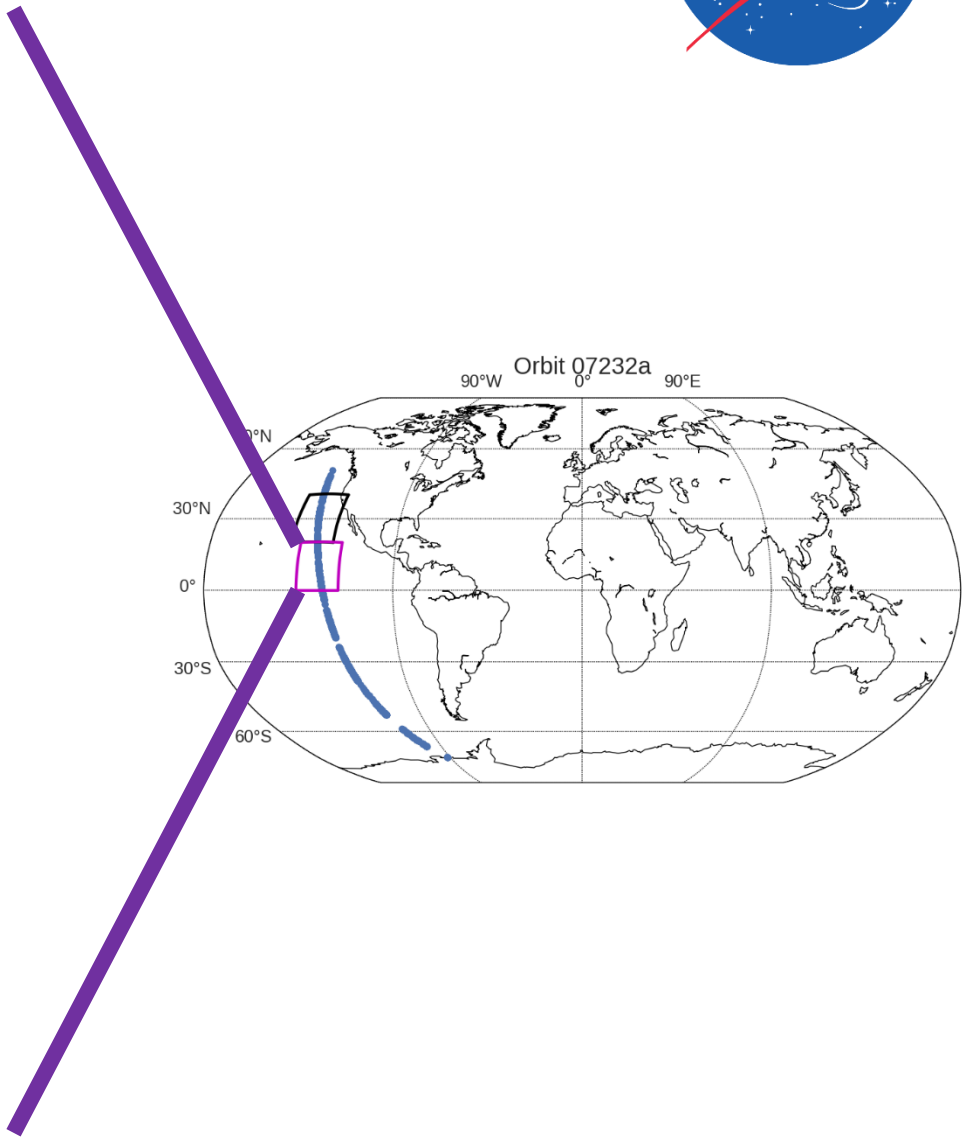
November 2015



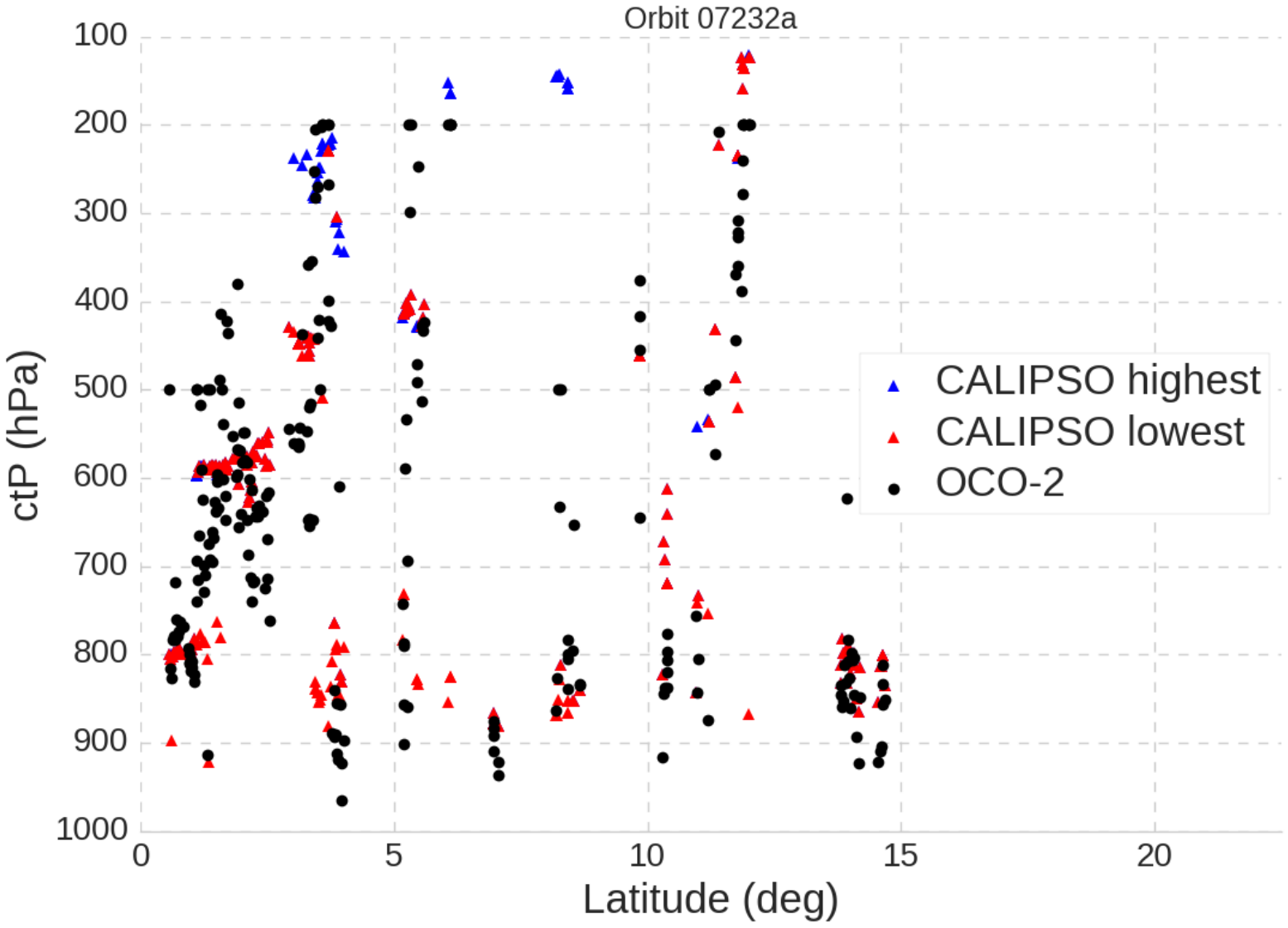
Let's compare the ctP-τ with MODIS and CALIPSO for water clouds in these regions

(6) Convective region



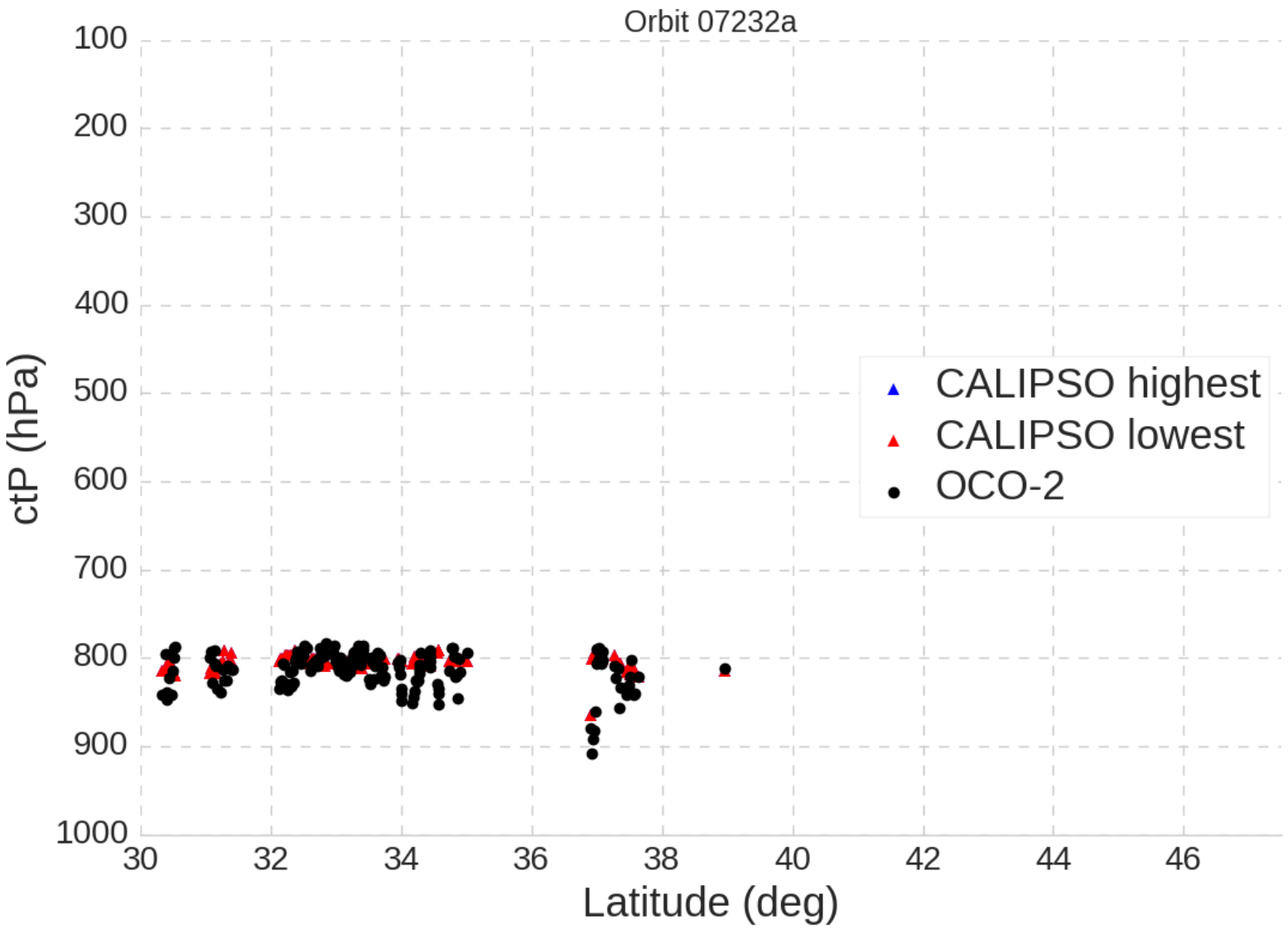


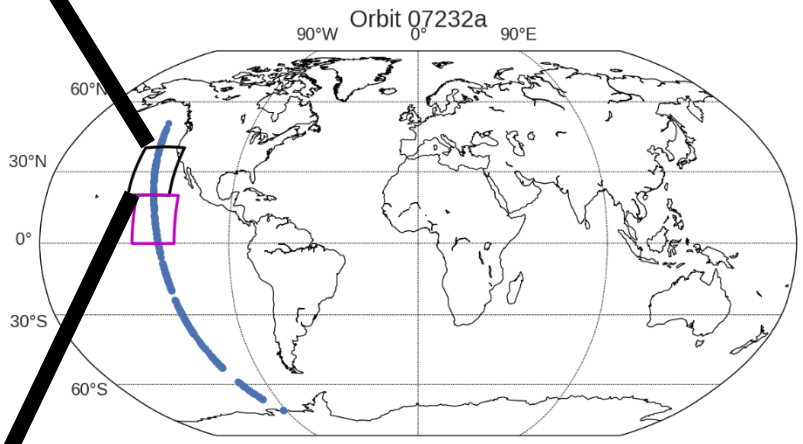
(7) Convective region



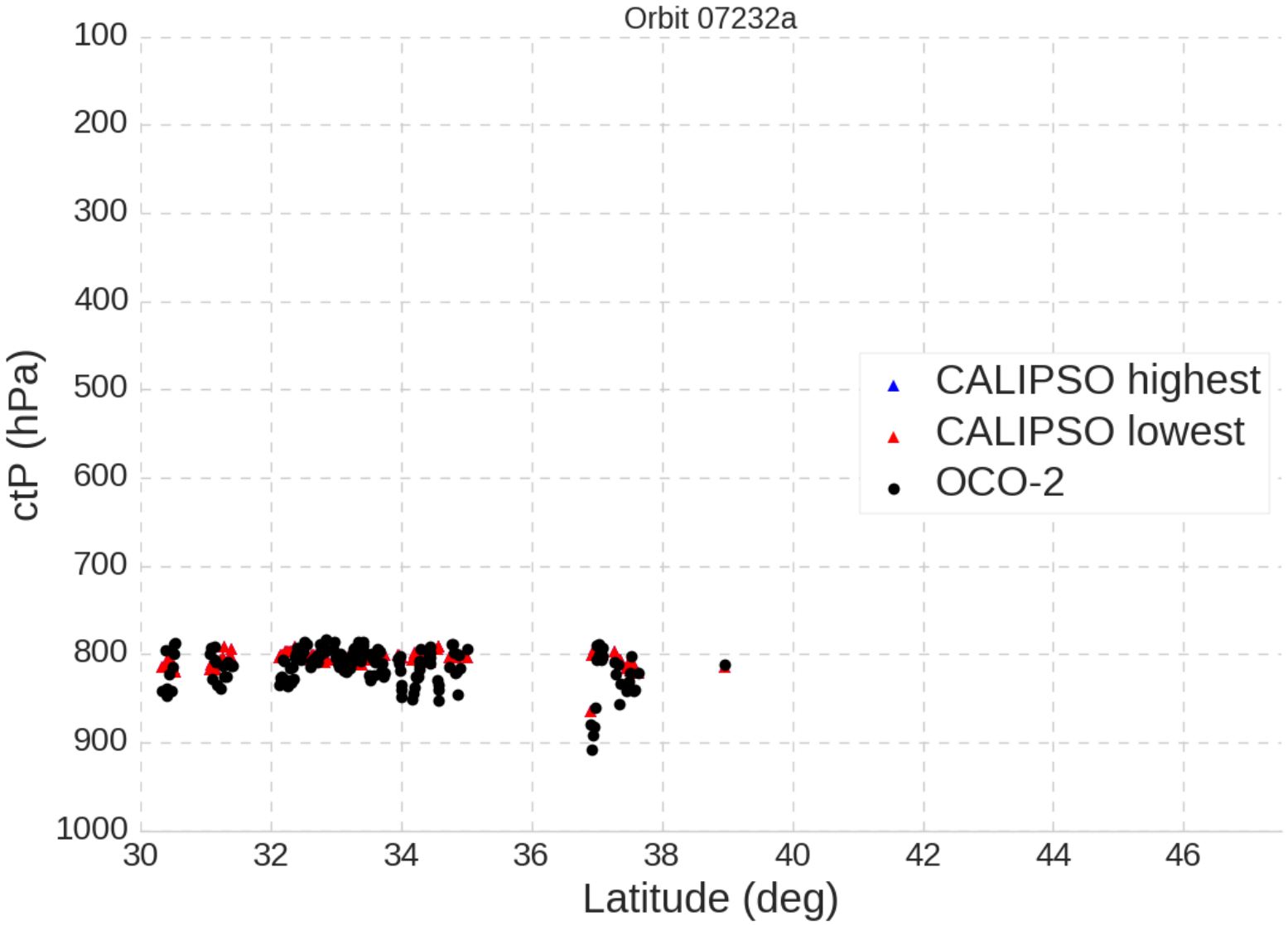
OCO-2 (black) and CALIPSO (colours) disagree when CALIPSO sees multiple layers

(8) Boundary layer cloud region





(9) Boundary layer cloud region



In stratocumulus region, much better agreement between OCO-2 (black) and CALIPSO ctP (colours)

(10) Implied results so far

Convective/multi-layer regimes:

- Poorer agreement. OCO-2 retrieval assumes single layer
- Commonly fails to converge for pressure thickness

Boundary layer regime

- Better agreement with MODIS/CALIPSO
- Converges more often for pressure thickness

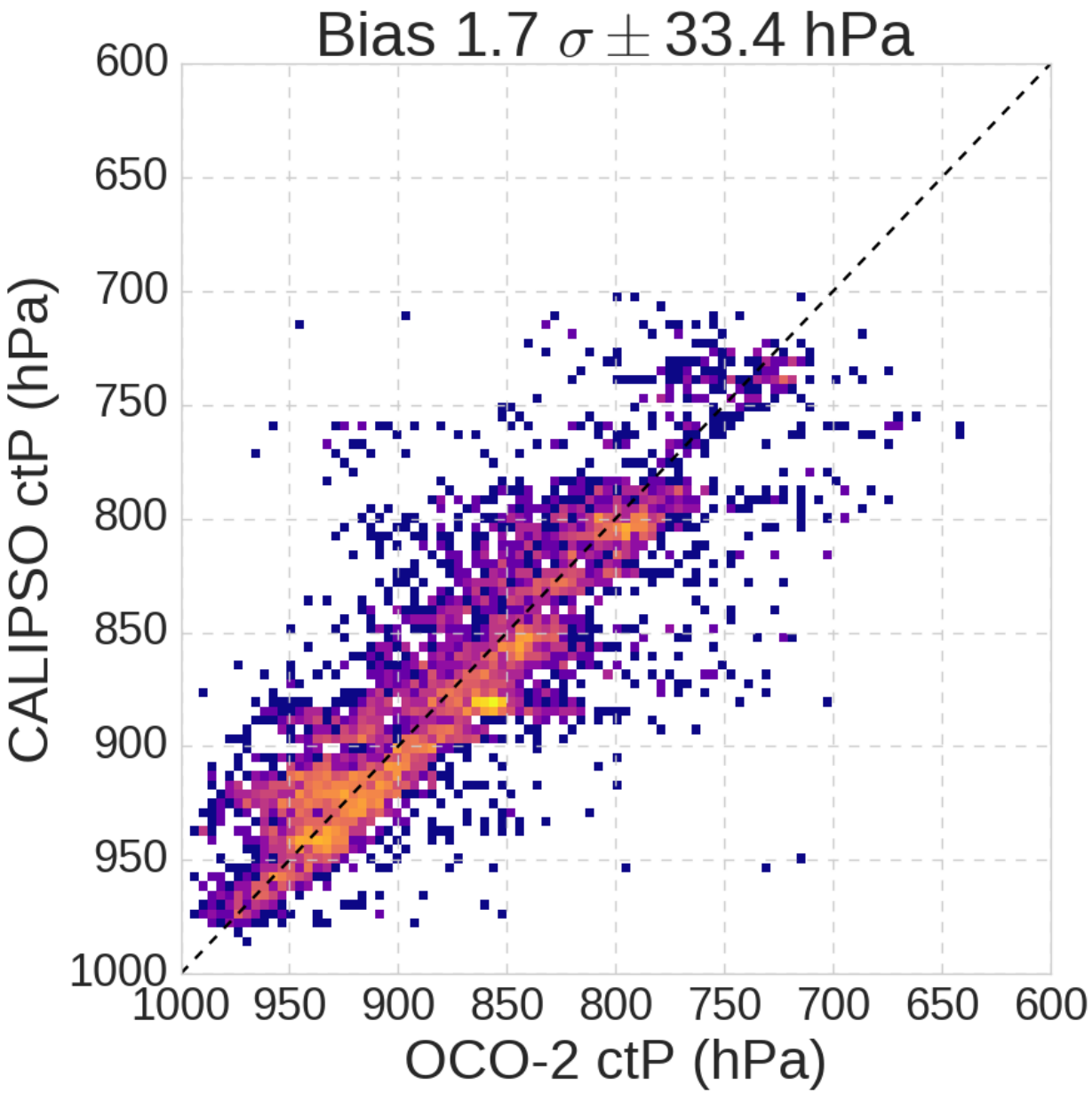
Let's look at statistics of marine "stratus" clouds

(11) Some statistics

Selected cases:

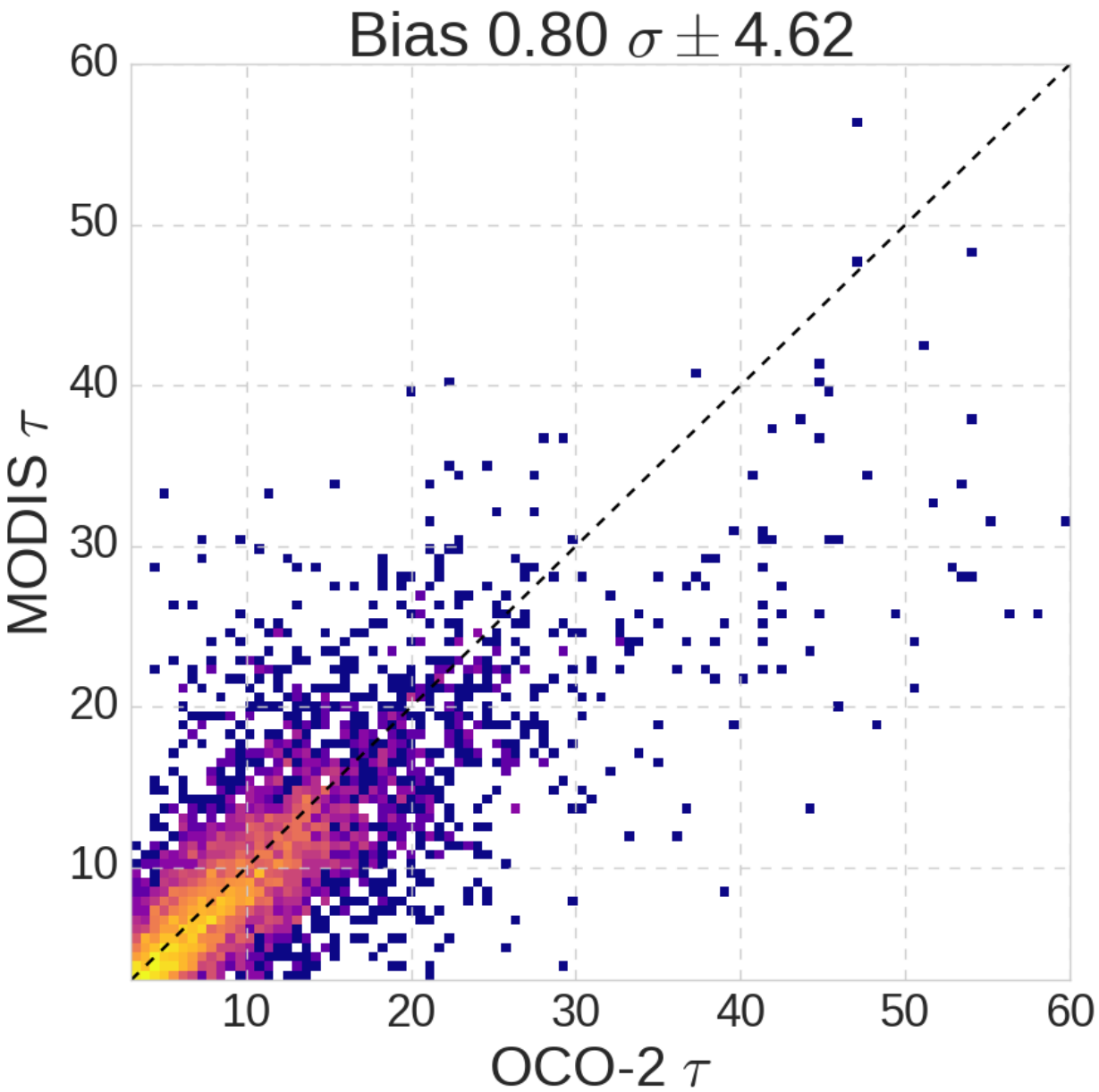
- 20 orbits from November 2015
- CALIPSO shows continuous cloud top over 10 km horizontally
- CALIPSO ctP > 700 hPa
- OCO-2 retrieval converges (χ^2 and "realistic" physical properties)

(12) Stratus cloud-top pressure, OCO-2 v CALIPSO



Converged "strato" cases, N = 5247 (70 % converge)

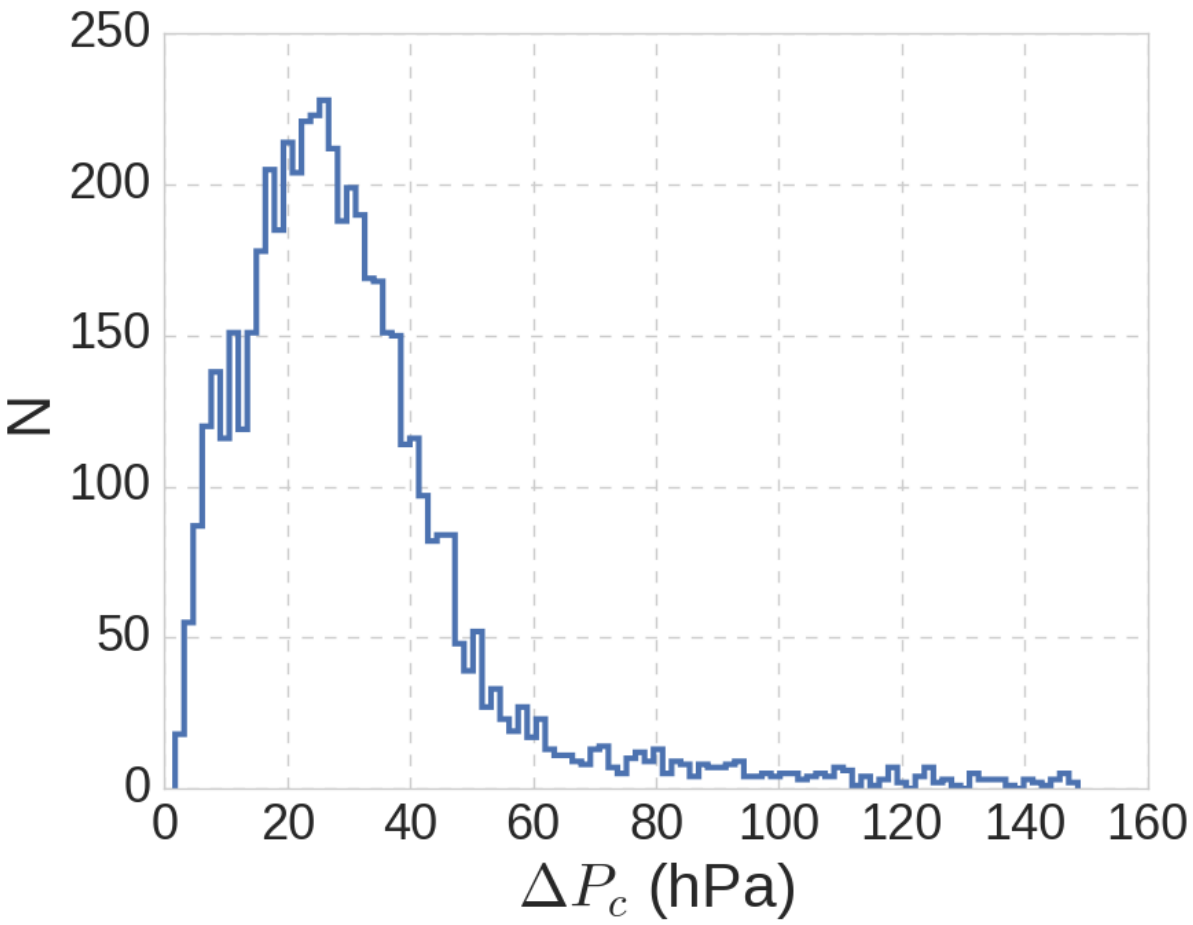
(13) Stratus optical depth, OCO-2 v MODIS



Converged "strato" cases, N = 5247 (70 % converge)

(14) First results of cloud pressure thickness

Histogram of cloud pressure thickness from converged stratus cases



Thickness:

Mean: 36 hPa

Stdev: ±16 hPa

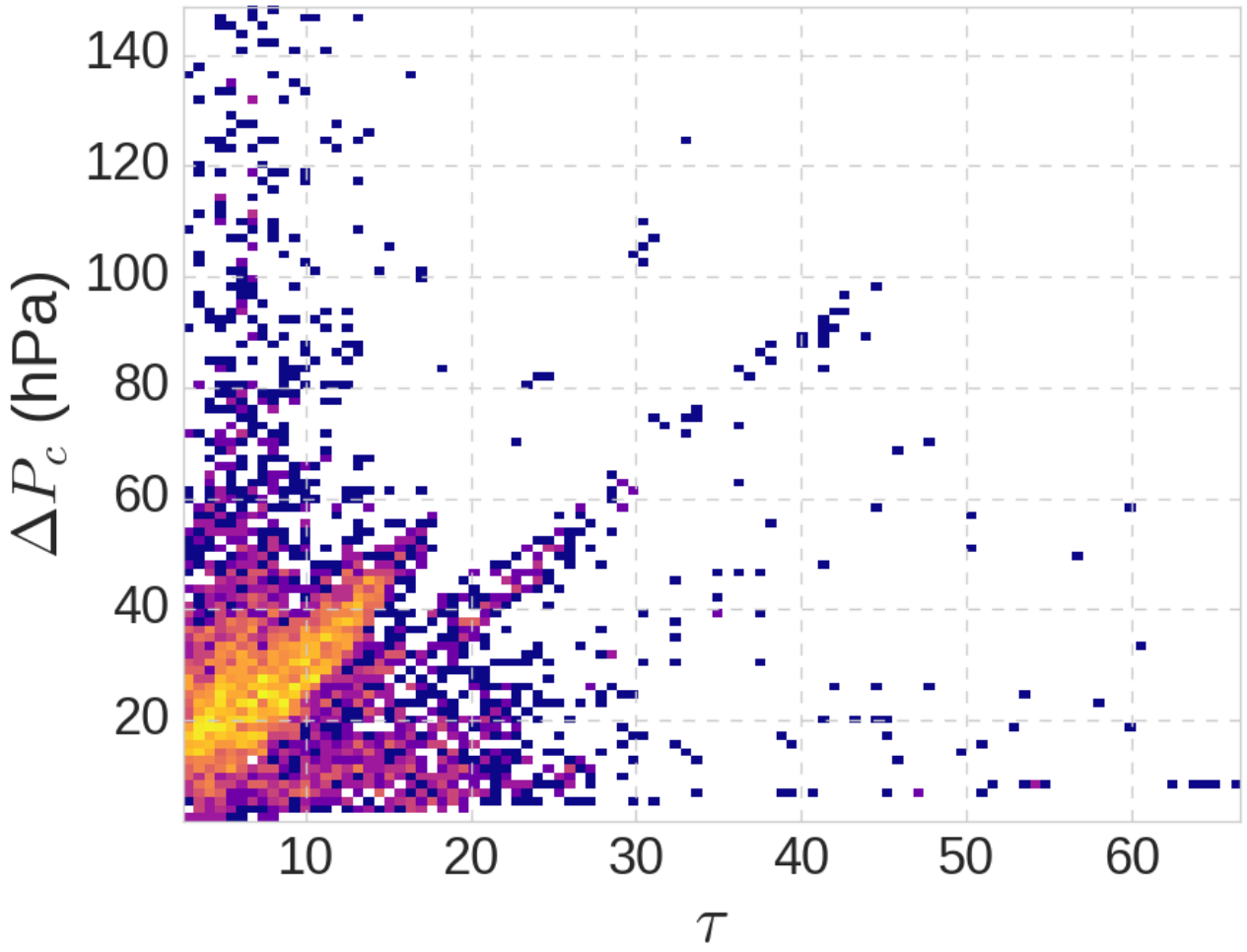
τ:

Mean: 11

Stdev: 6

(15) First results of cloud pressure thickness

Joint $\tau - \Delta P_c$ from converged OCO-2 marine stratus



Optical depth and pressure thickness should be related, but we see some outliers here.

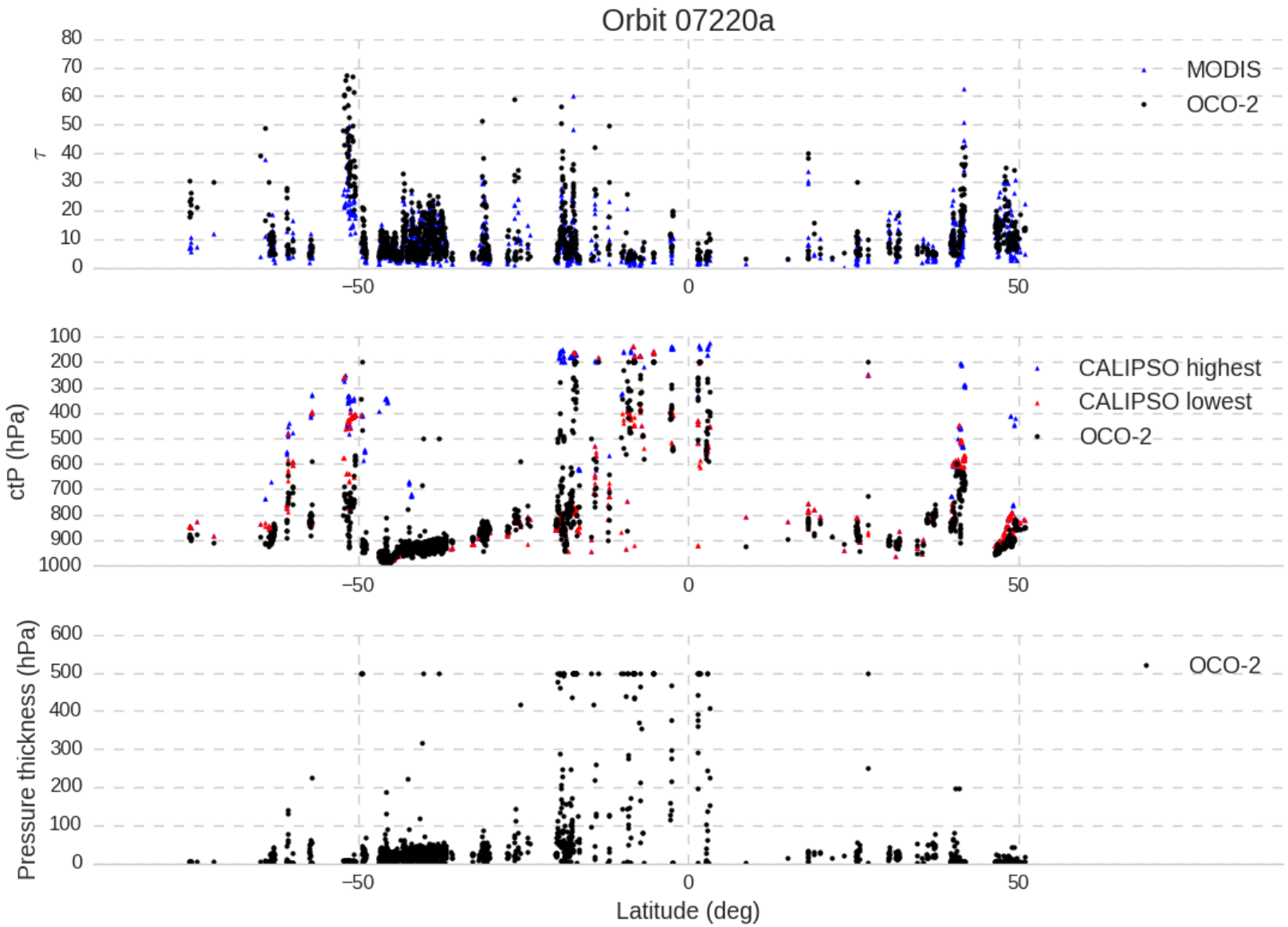
They passed convergence tests but are still unrealistic.

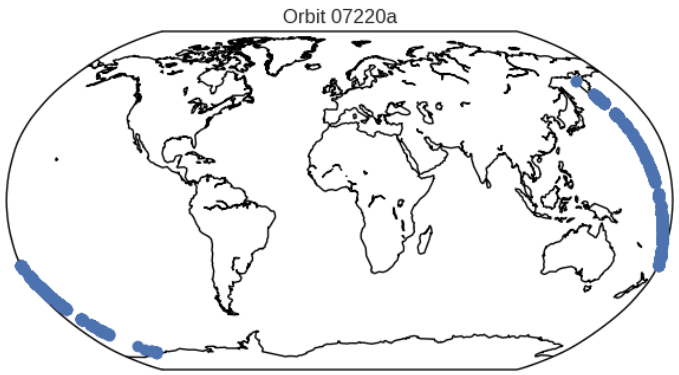
(16) Conclusions

- OCO-2 retrievals of marine boundary layer clouds will be collocated with CloudSat and put on CloudSat DPC website
- ctP-τ validation looks fine v MODIS/CALIPSO
- Now: speed retrieval & improve convergence
- Later: Extend to cloud layering, over land, ice clouds + validation of thickness

BLANK

BONUS SLIDES





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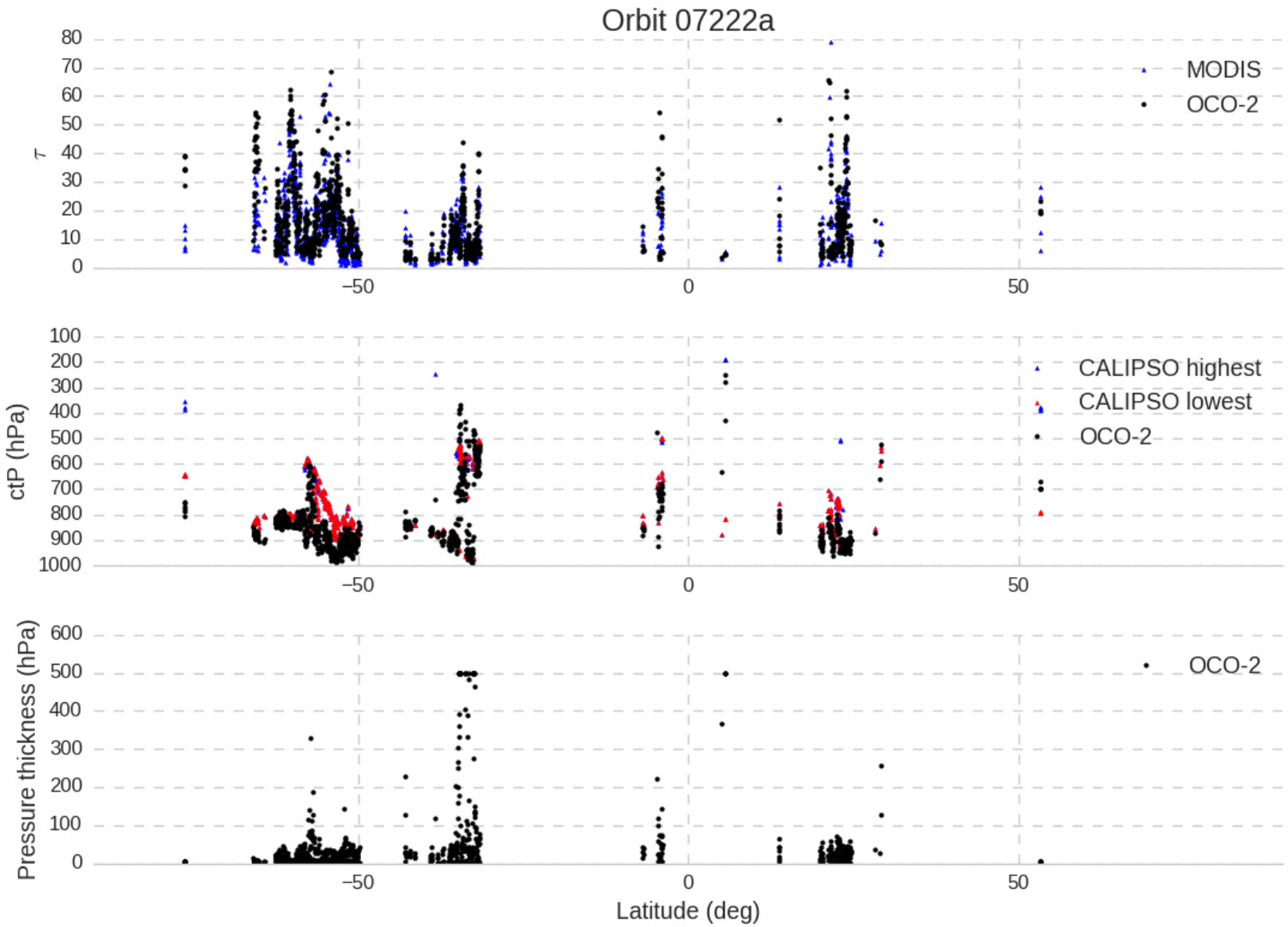

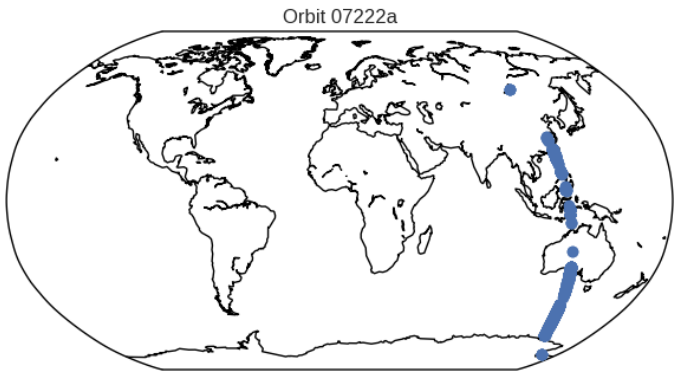

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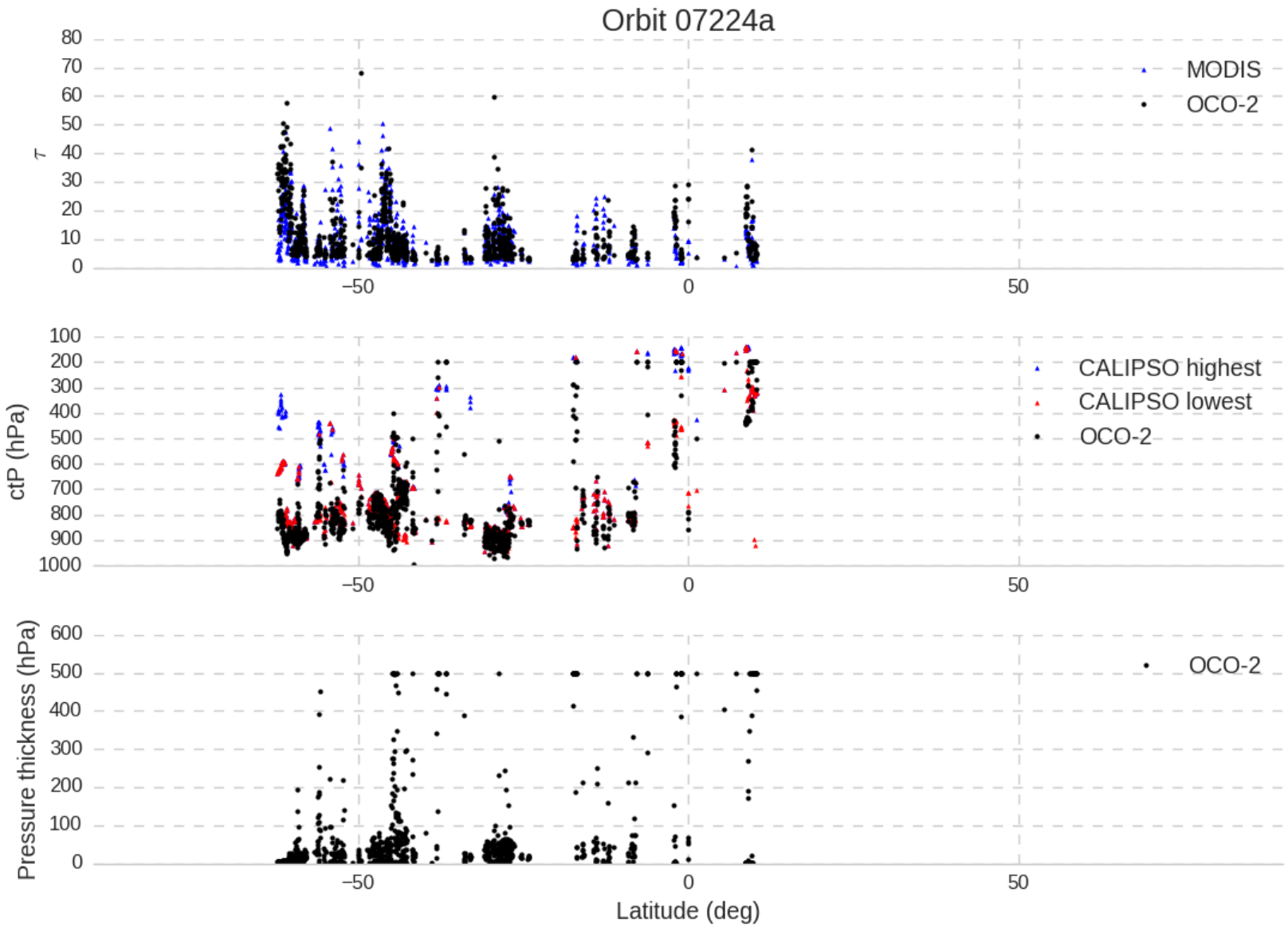

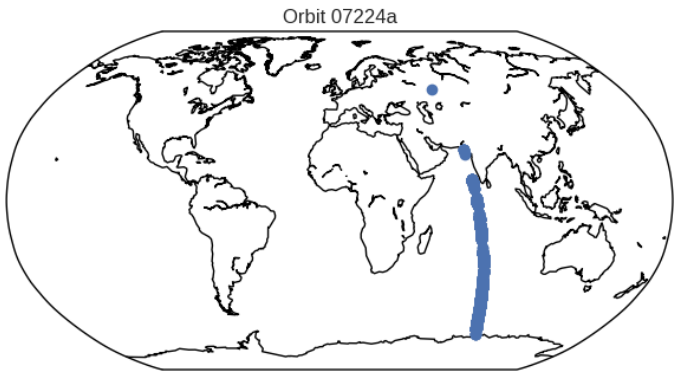

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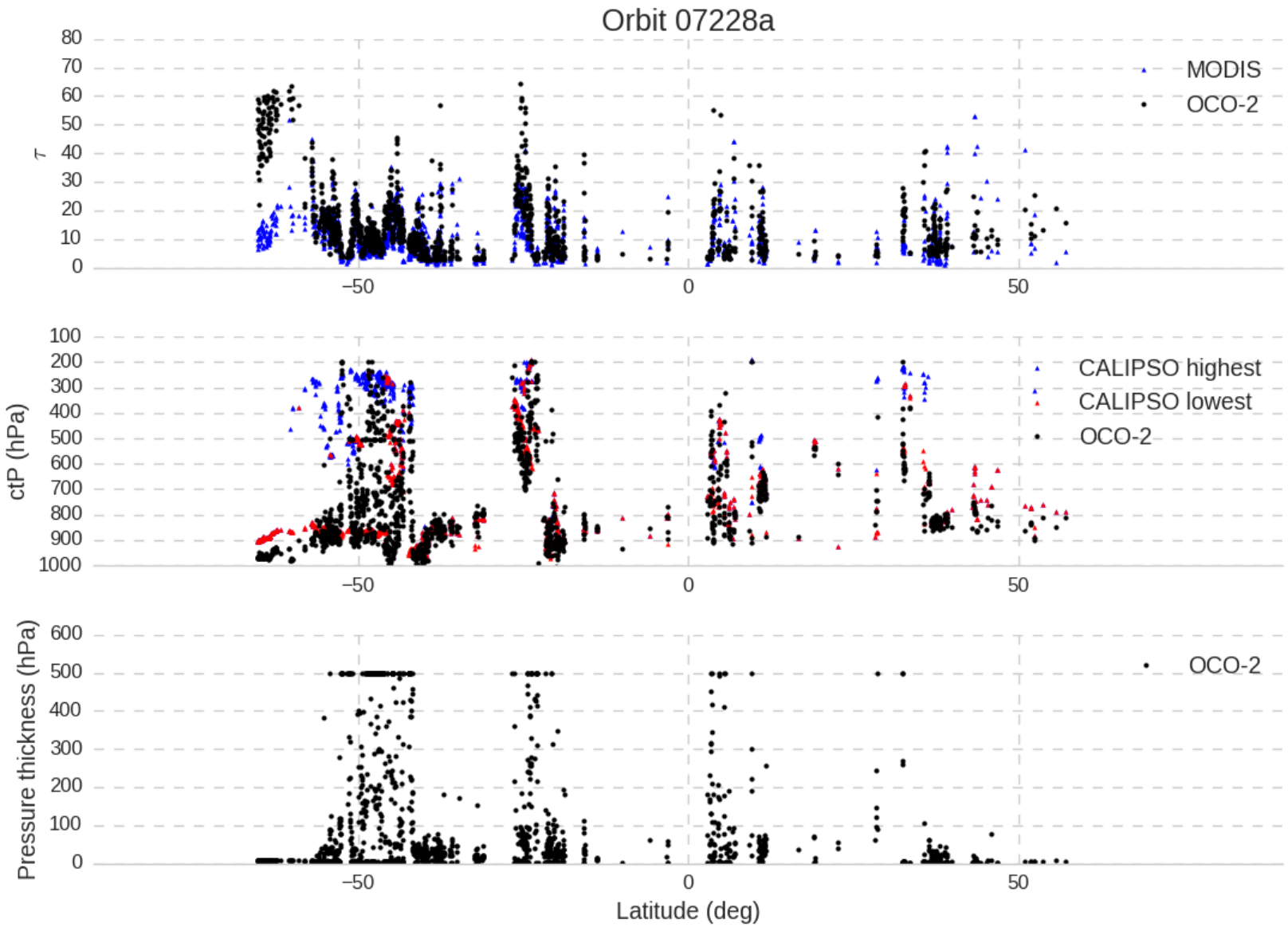

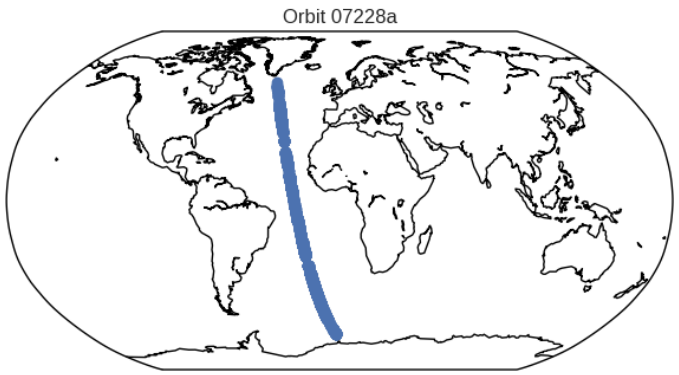

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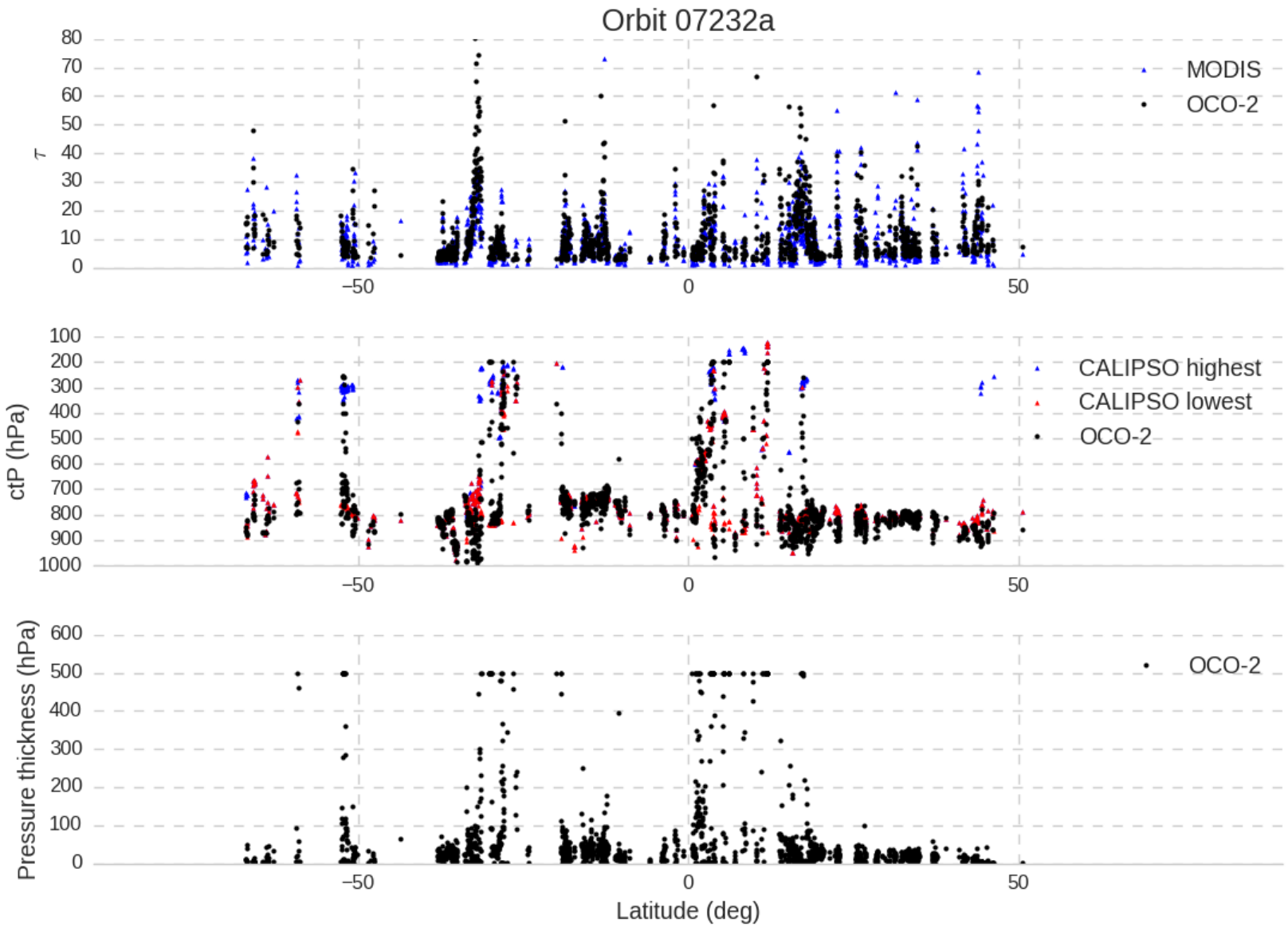

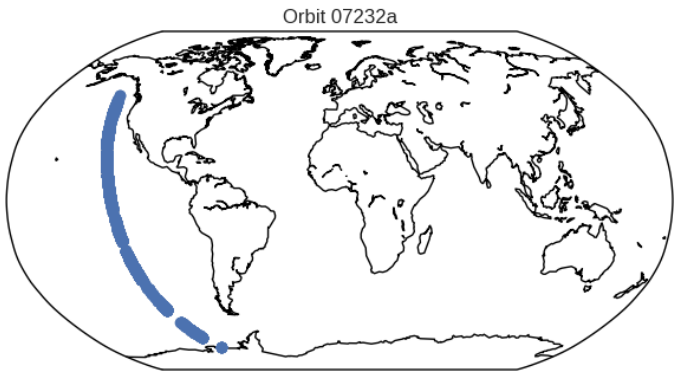
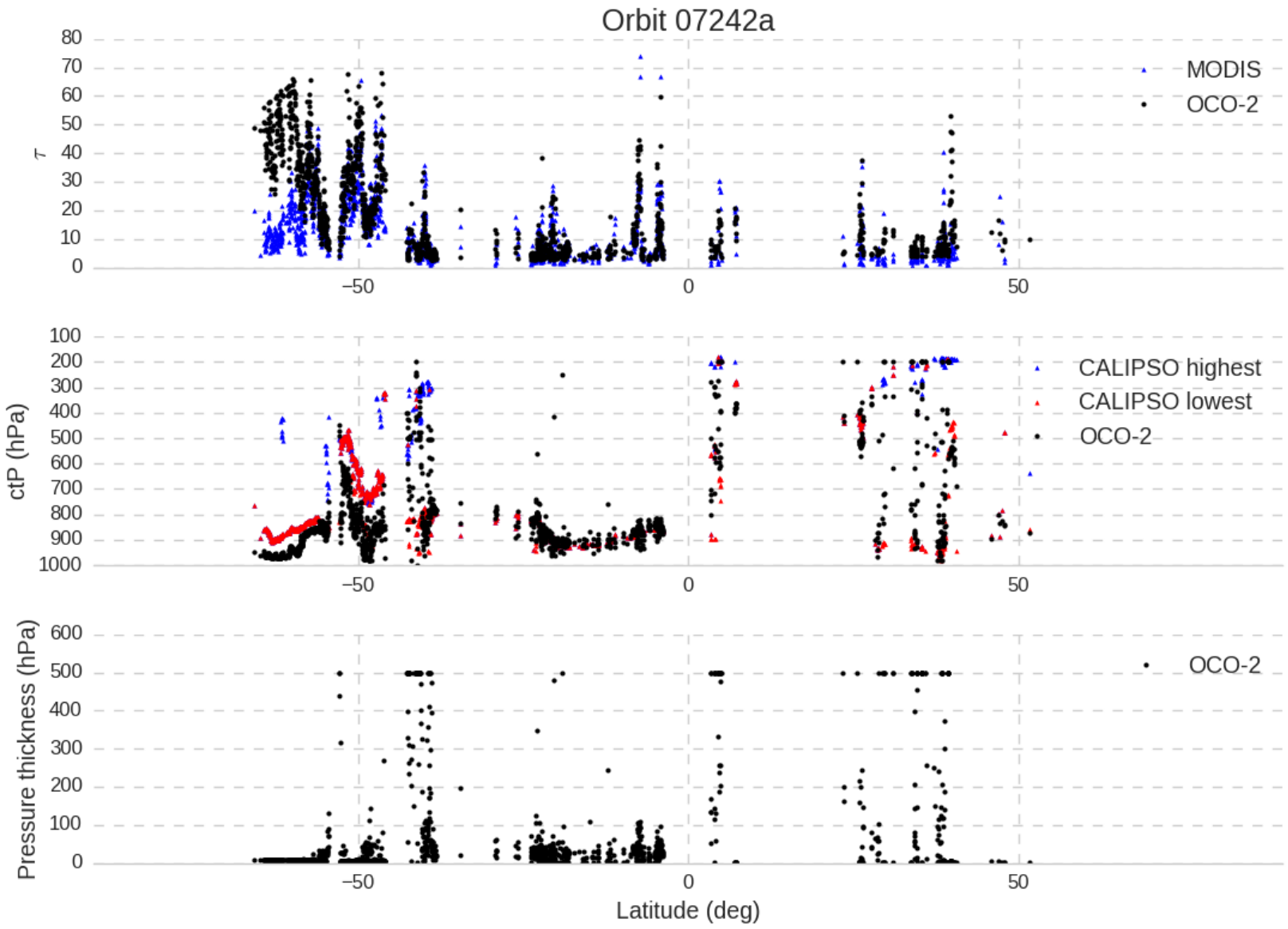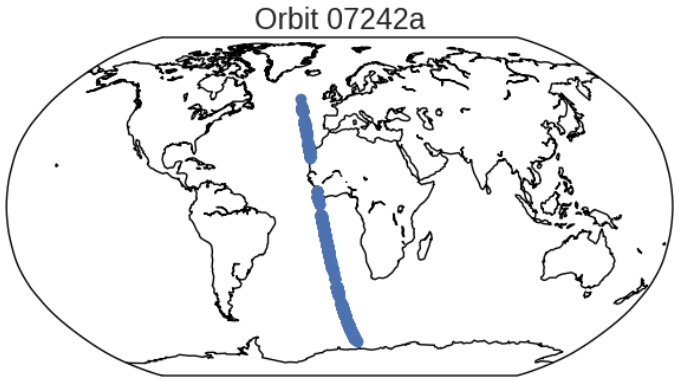
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