IIA-USFQ
Instituto de Investigaciones Atmosféricas

Universidad San Francisco de Quito

Influence of the Andes on the Vertical Mixing of Ozone Above a tropical South American Site

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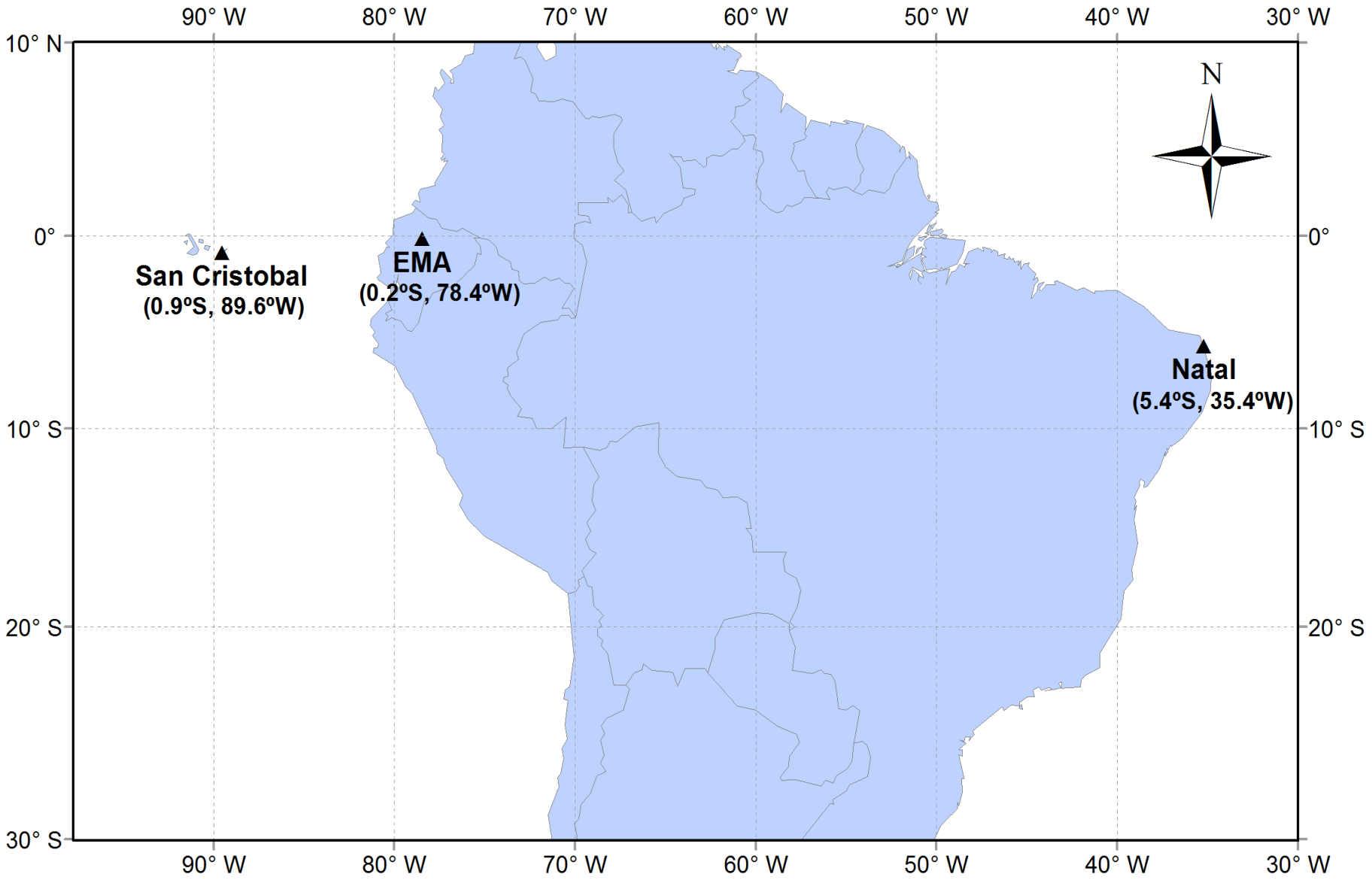
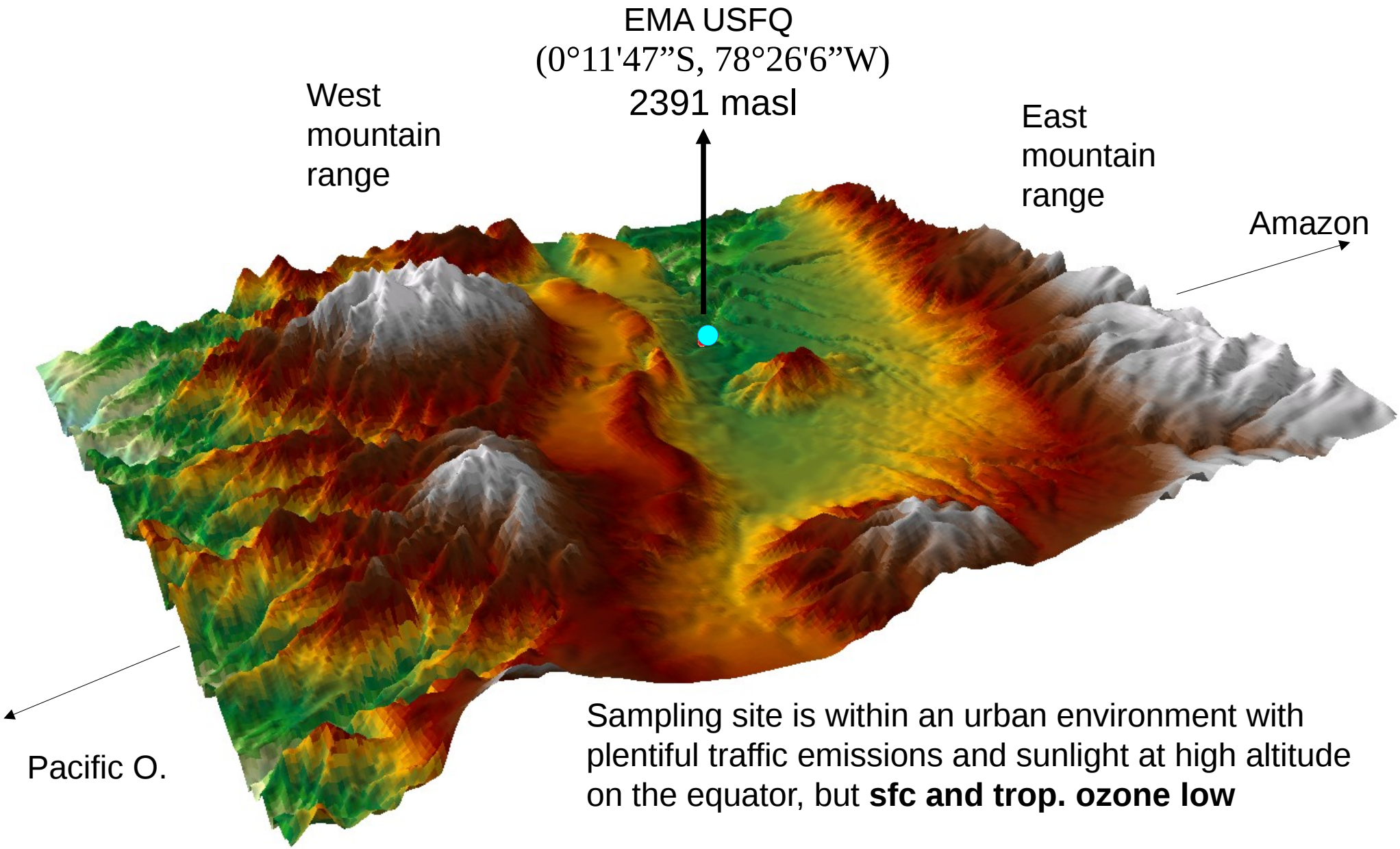
Ozonesonde campaign in Ecuador
June 2014 - Sep 2015
EMA USFQ, Spanish acronym for Atmospheric Measurement Station at Universidad San Francisco de Quito
Roof-top lab at coordinates:
(0°11'47” S, 78°26'6” O) 2391 masl
Met, AQ & upper-air measurements
Operating since 2014

http://www.usfq.edu.ec/programas_academicos/colegios/politecnico/institutos/iia



Ozone sounding stations in South America along the equator: SHADOZ San Cristobal (Ecuador), Natal (Brazil). **EMA USFQ is the only ozone sounding station on the tropical Andes.**

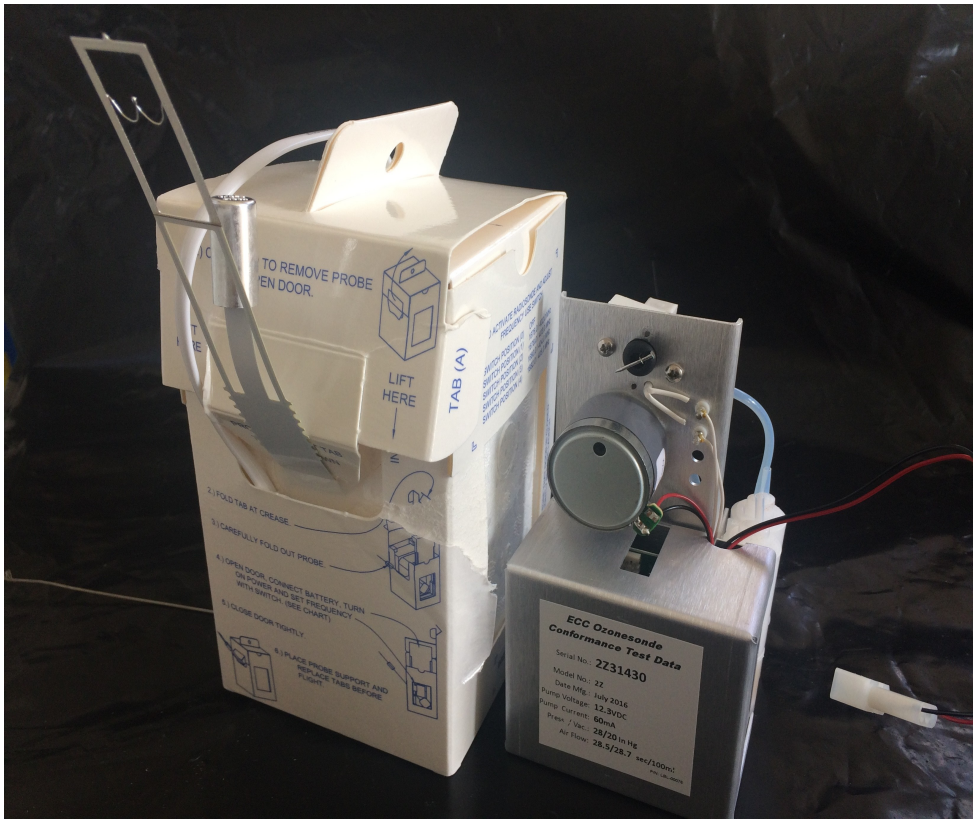


Sampling site is within an urban environment with plentiful traffic emissions and sunlight at high altitude on the equator, but **sfc and trop. ozone low**

Cazorla, M. Air quality over a populated Andean region: insights from measurements of ozone, NO, and boundary layer depths, *Atmos. Pollut. Res.*, 7, 66-.74, 2016.

Balloon campaign details

P-T-U observations: radio sondes iMet-1-RSB
Ozone measurements: DMT now ENSCI Electrochemical Concentration Cell (ECC) ozonesondes
Ozonesonde preparation, launching protocols, and data collection: NOAA guidelines – launching capability installed in collaboration with NOAA.



Cazorla, M., Ozone structure over the equatorial Andes from balloon-borne observations and zonal connection with two tropical sea level sites. *J. Atmos. Chem.*, 2016 doi:10.1007/s10874-016-9348-2

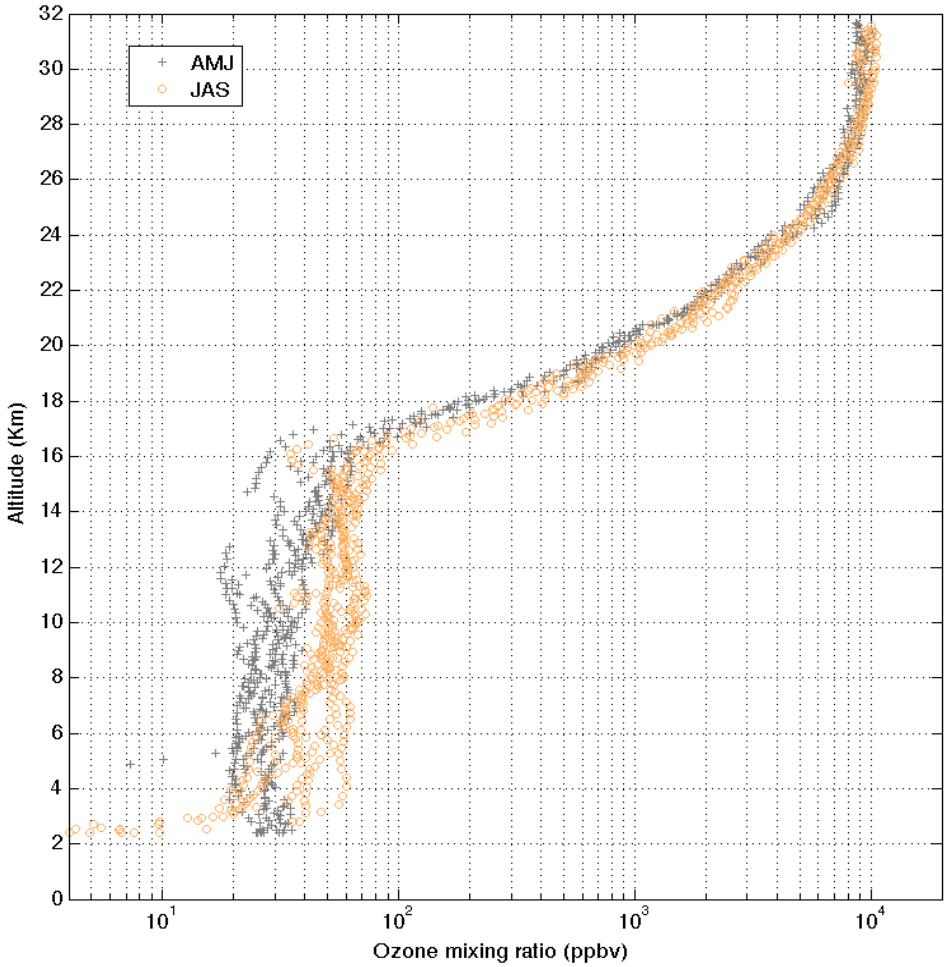
Balloon campaign dates and flight details

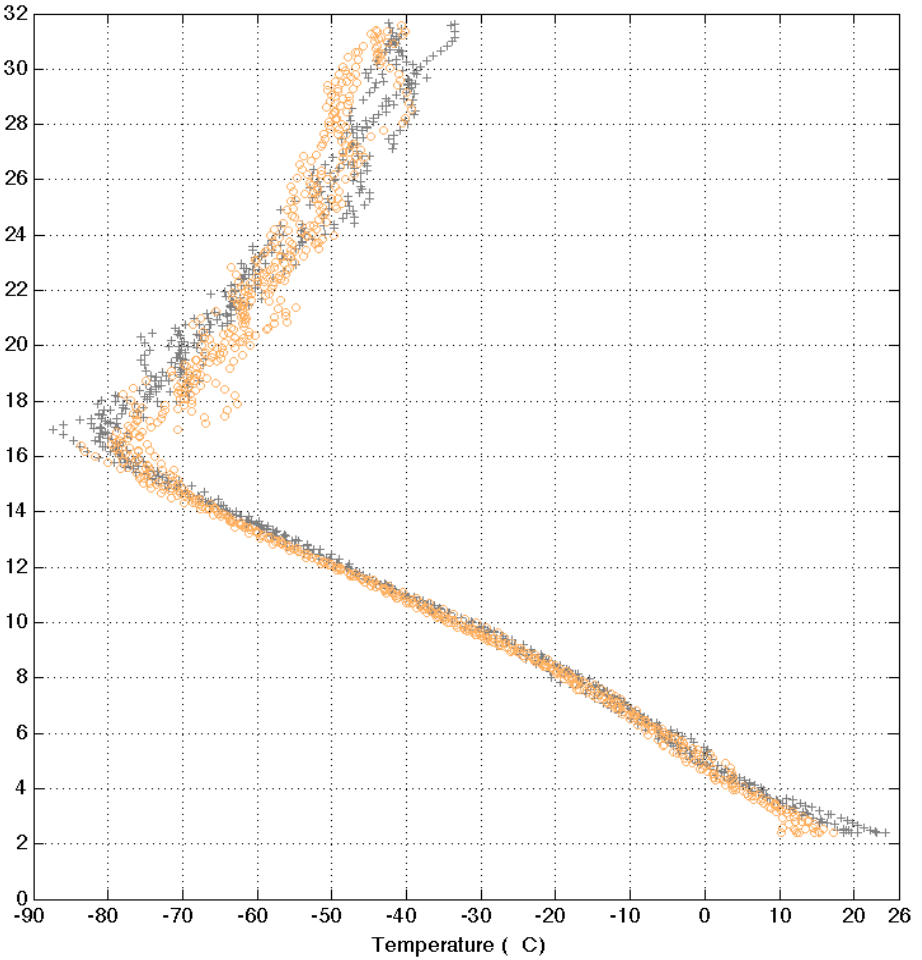
Flight	Date	Launch time	Duration (h)	Balloon burst altitude (km)
1	2 June 2014	13:15:05	2.14	31.98
2	4 June 2014	12:11:35	2.74	32.05
3	12 June 2014	12:12:35	2.40	24.71
4	15 July 2014	07:54:37	2.39	32.27
5	21 July 2014	06:58:55	1.77	30.73
6	29 April 2015	12:23:50	2.61	31.61
7	26 May 2015	13:21:50	2.23	32.27
8	30 June 2015	13:41:42	2.50	32.11
9	4 Aug 2015	07:17:44	1.99	31.55
10	27 Aug 2015	09:02:34	2.03	33.21
11	11 Sep 2015	09:06:00	1.70	31.10
12	30 Sep 2015	07:44:00	1.46	29.57

6 soundings in AMJ (cooler months), 6 in JAS (summer months)

Results

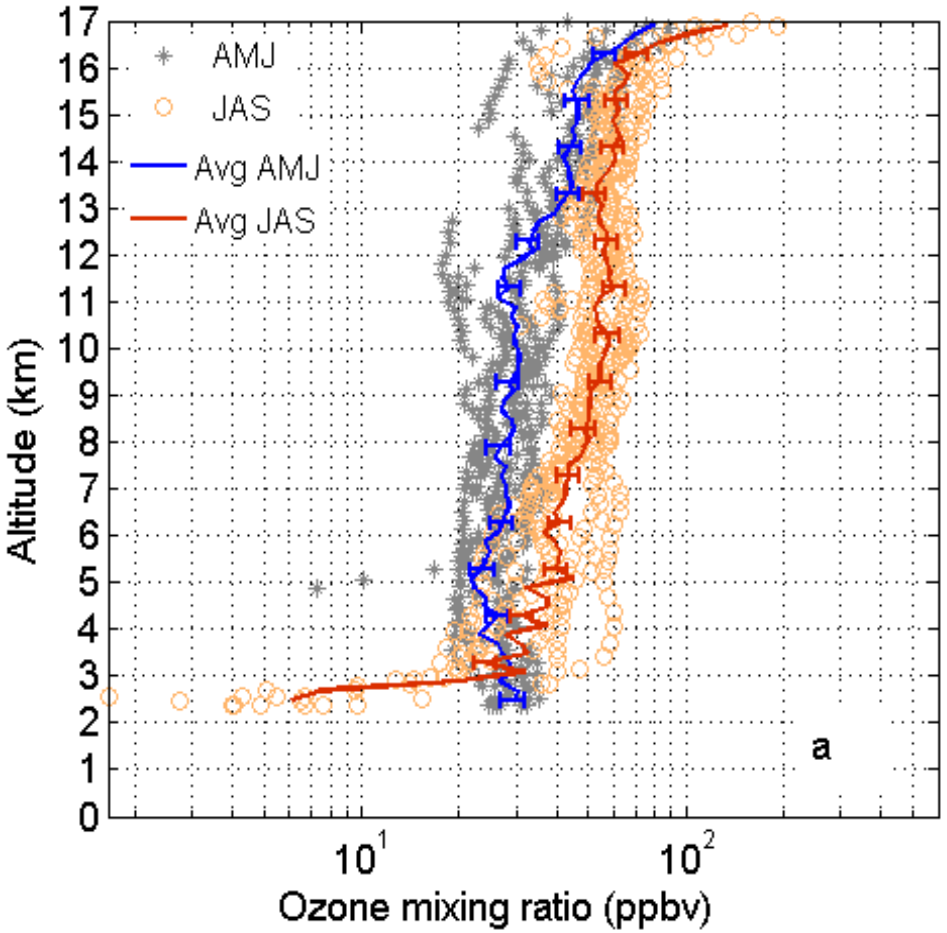
Ozone profiles above the Andes are well mixed up to CPT level – different from what has been observed at other tropical (sea level) stations.

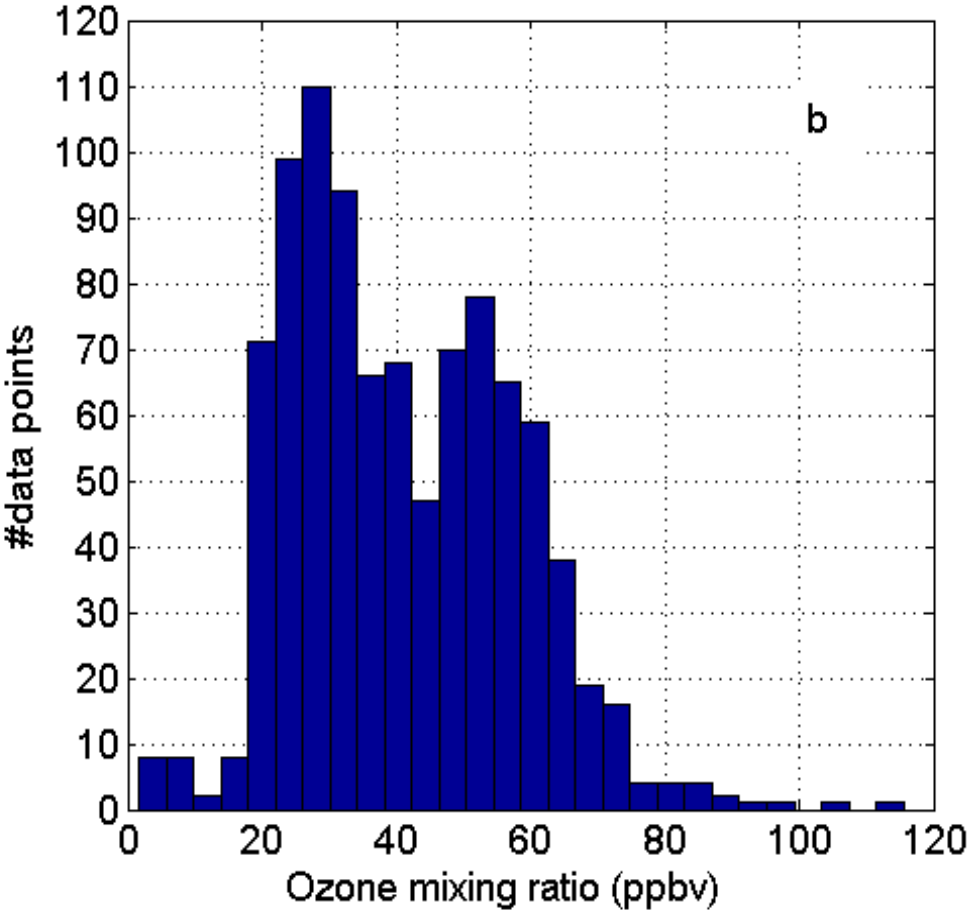




Results

Tropospheric ozone low, bimodal seasonal distribution
Low contribution from the PBL
Horizontal transport possibly reduced – Andes barrier effect
Enhanced vertical mixing – Andes mechanical effect



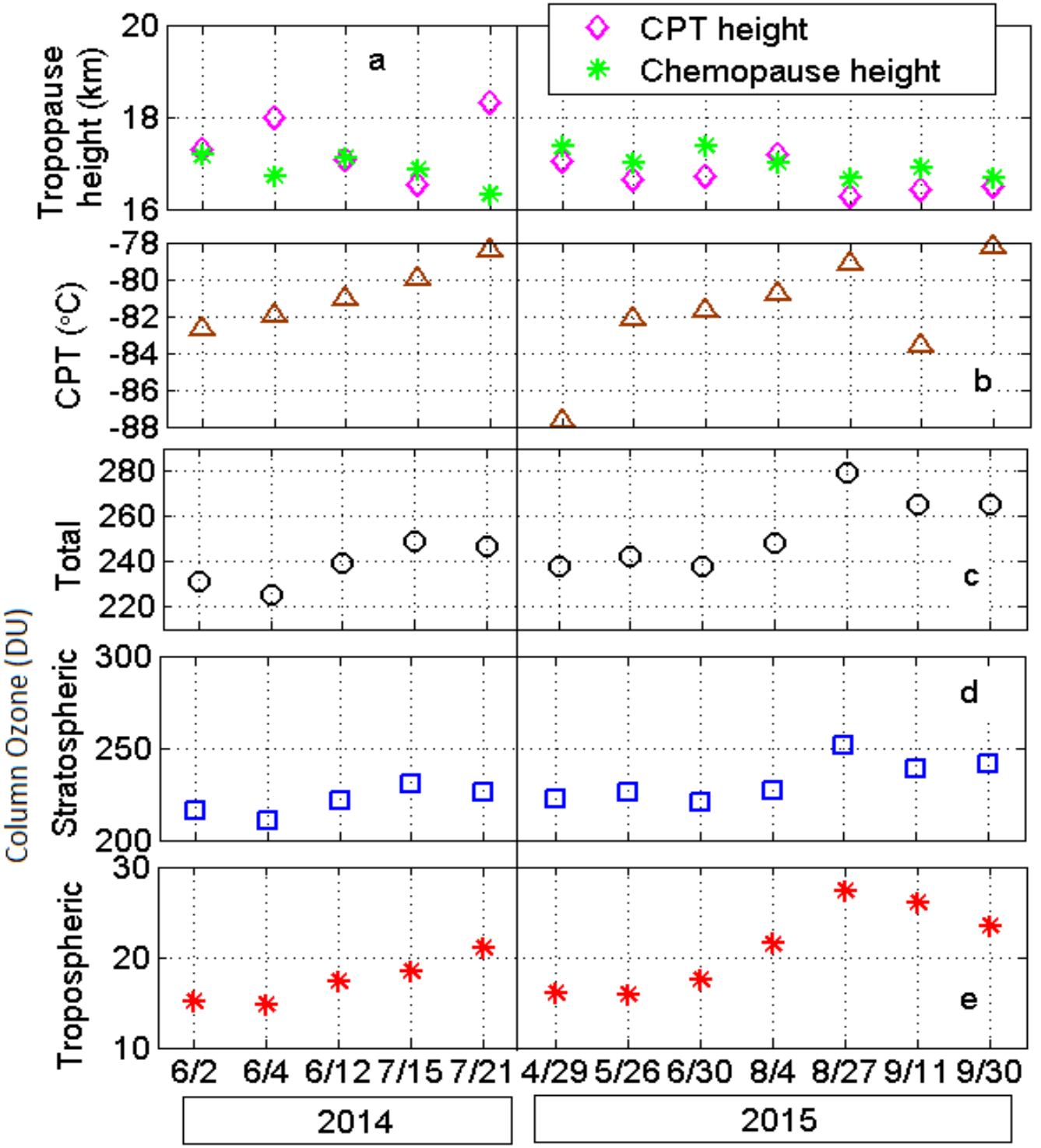


Results

*Tropopause height with chemical and thermal definitions not signifficantly different for majority of data. TTL thin.

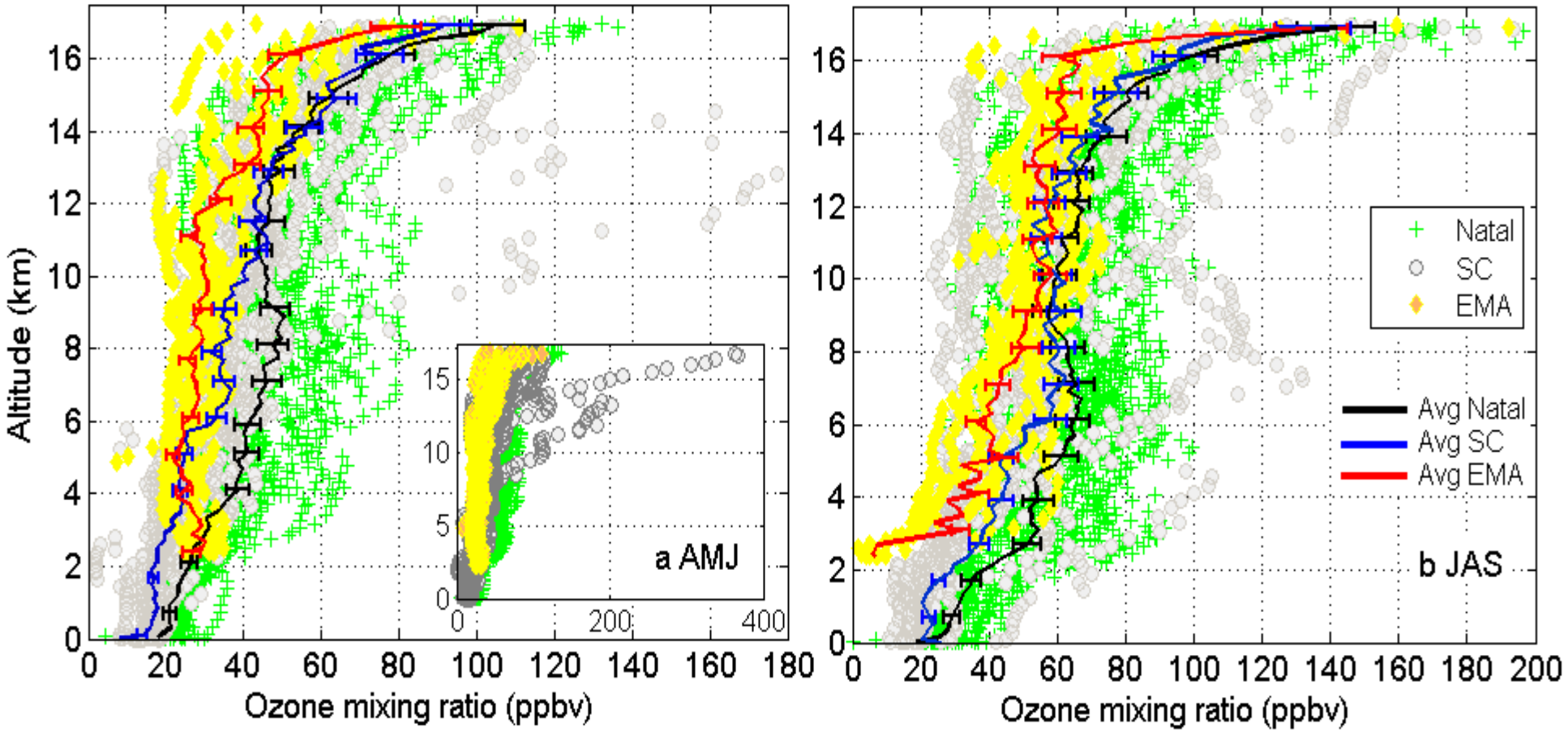
*Seasonal variability over the Andes induces up to 11 DU difference in trop. col. ozone.
Insight additional to Kirchhoff and Guarnieri (2002) in regard to what trop. column ozone is over tropical Andes.

*EMA total col. has larger contribution from strat. col when compared against SC and Natal.



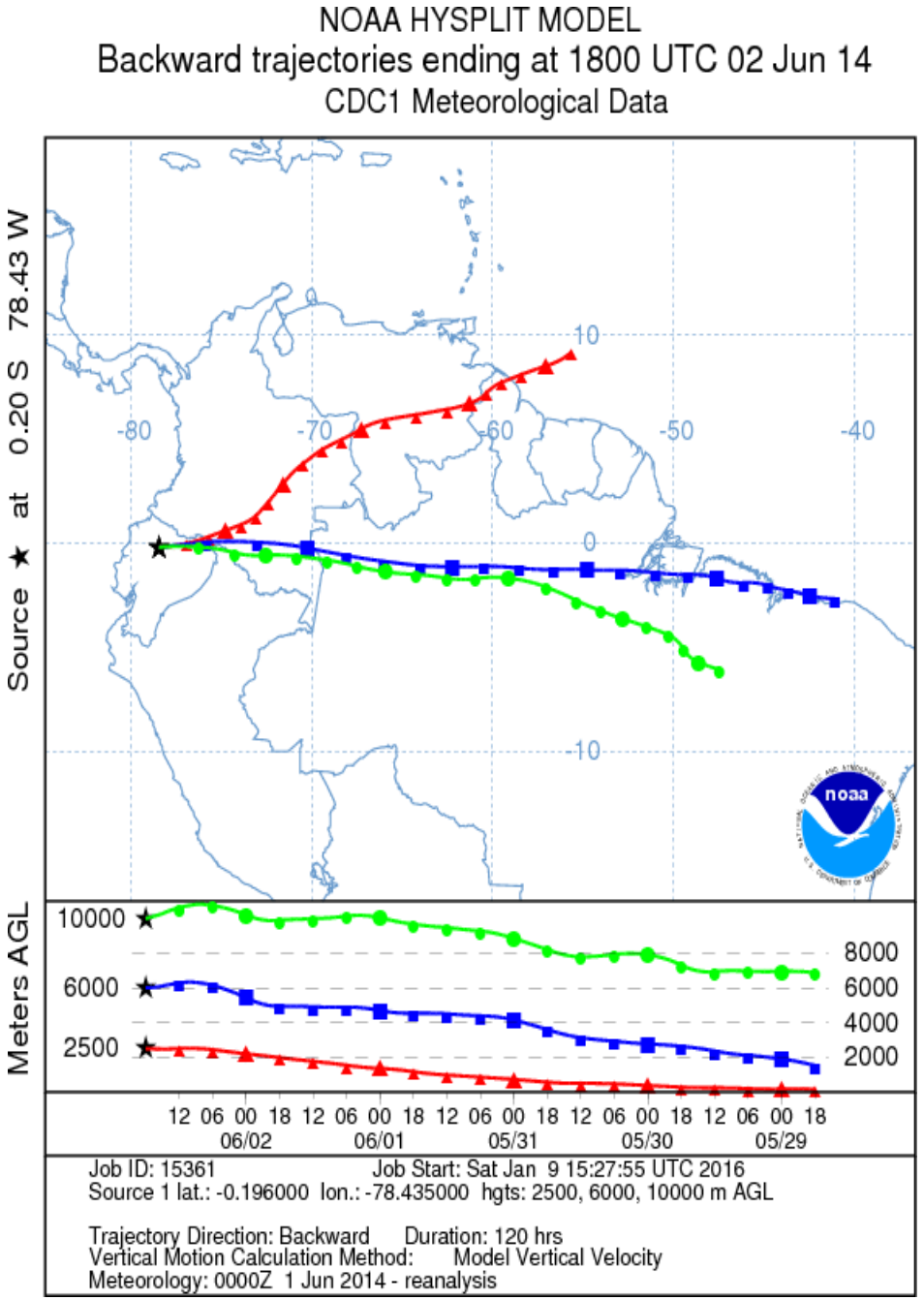
Results

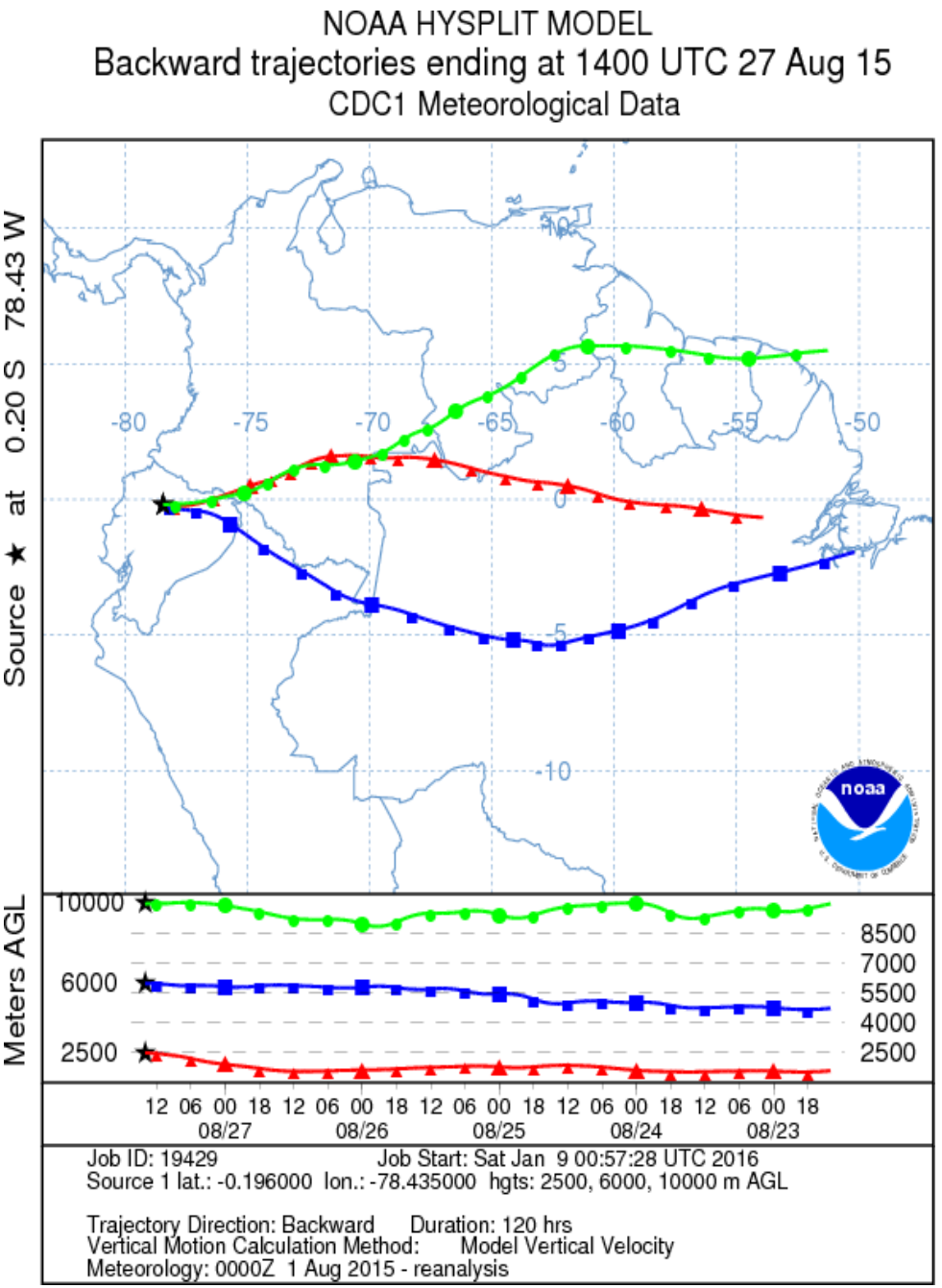
Trop. ozone over Andes low when compared to observations at SC and Natal in similar time periods. Mid-trop enhancement (S-shape) absent.



SC: 14 profiles AMJ, 14 profiles JAS for years 2008, 2012, 2013, 2014, 2015
Natal: 25 profiles AMJ, 34 profiles JAS for years 2008, 2010, 2015

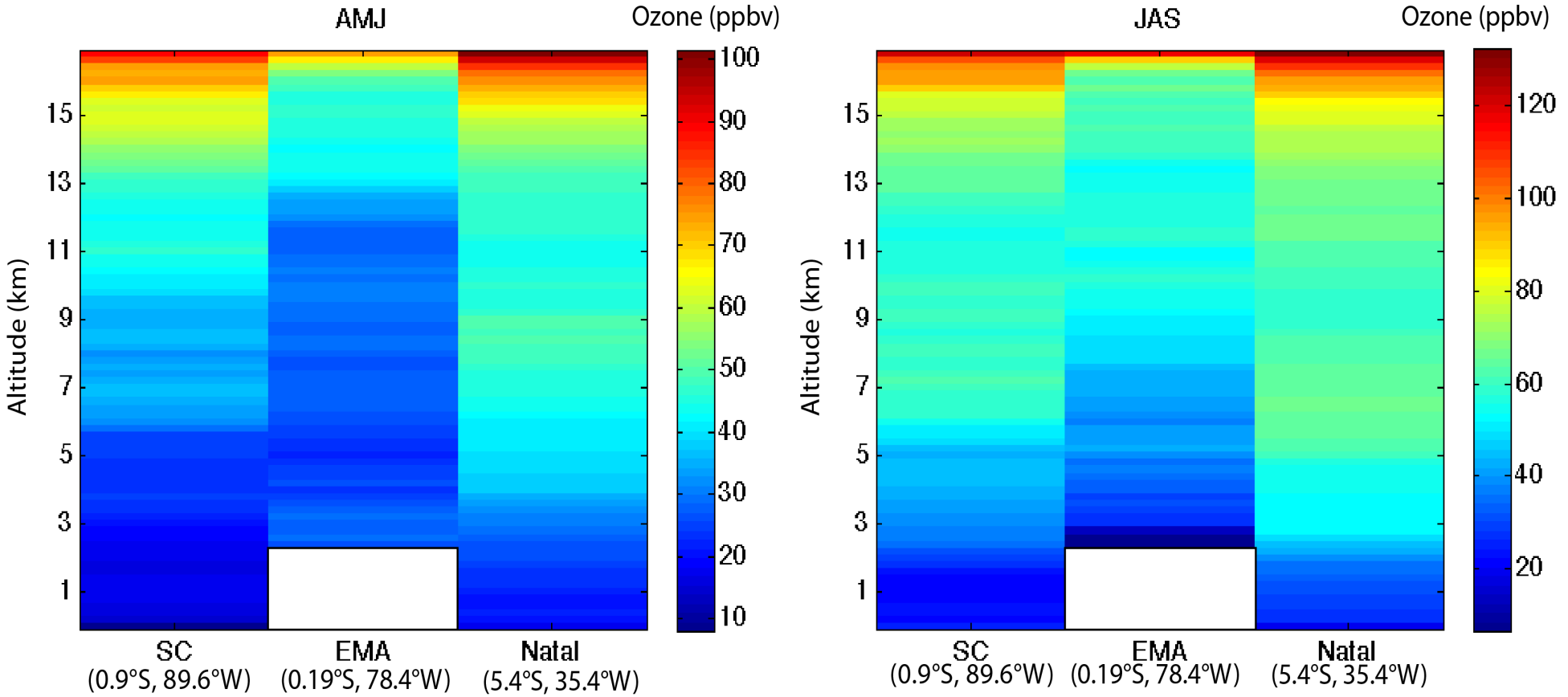
Typical parcel history at EMA during the campaign dates





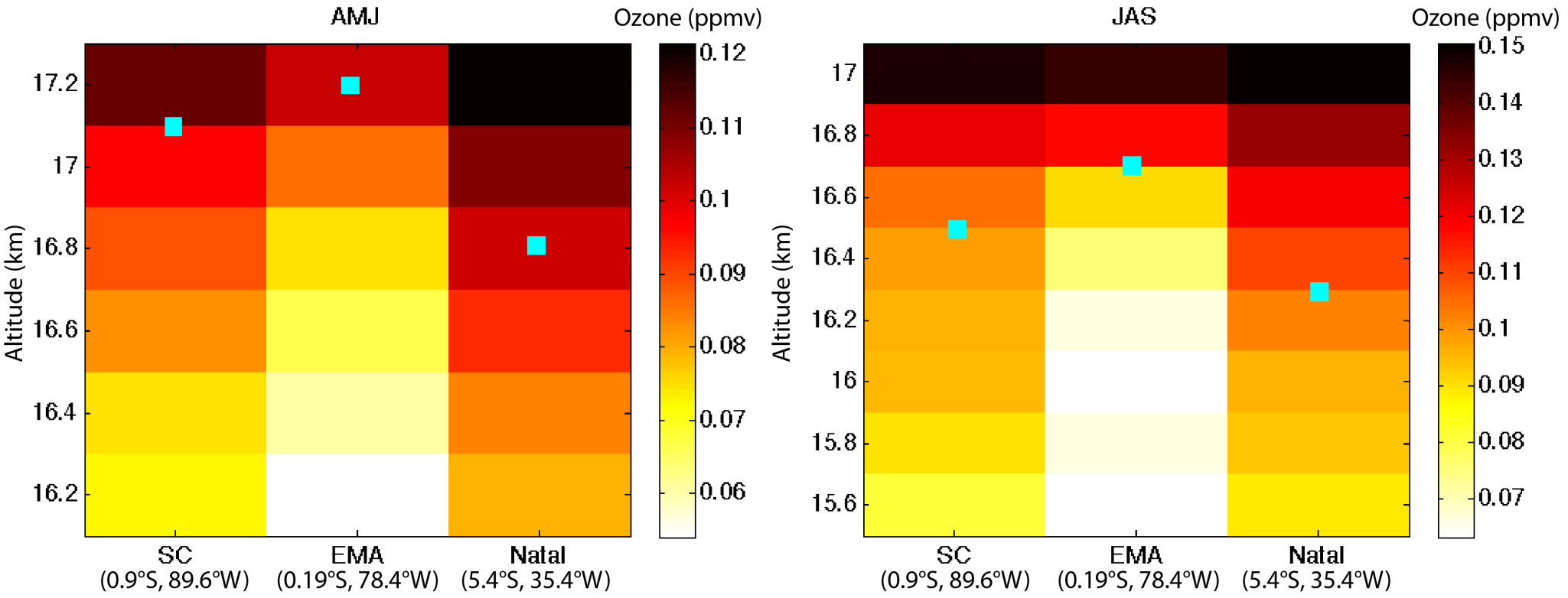
Results

Mean ozone vertical distribution accross SC, EMA, and Natal in similar time periods: tall low-ozone trop. Col. at EMA and sharp trop/strat transition



Results

Mean chemopause height approx. similar at three sites, but ozone distribution in the tropopause vecinity above Andes not gradual when compared to SC and Natal.



Andes feature mechanical effect in vertical mixing: lower boundary of TTL is pushed near its upper boundary.

Results

Total column ozone comparison against OMI:

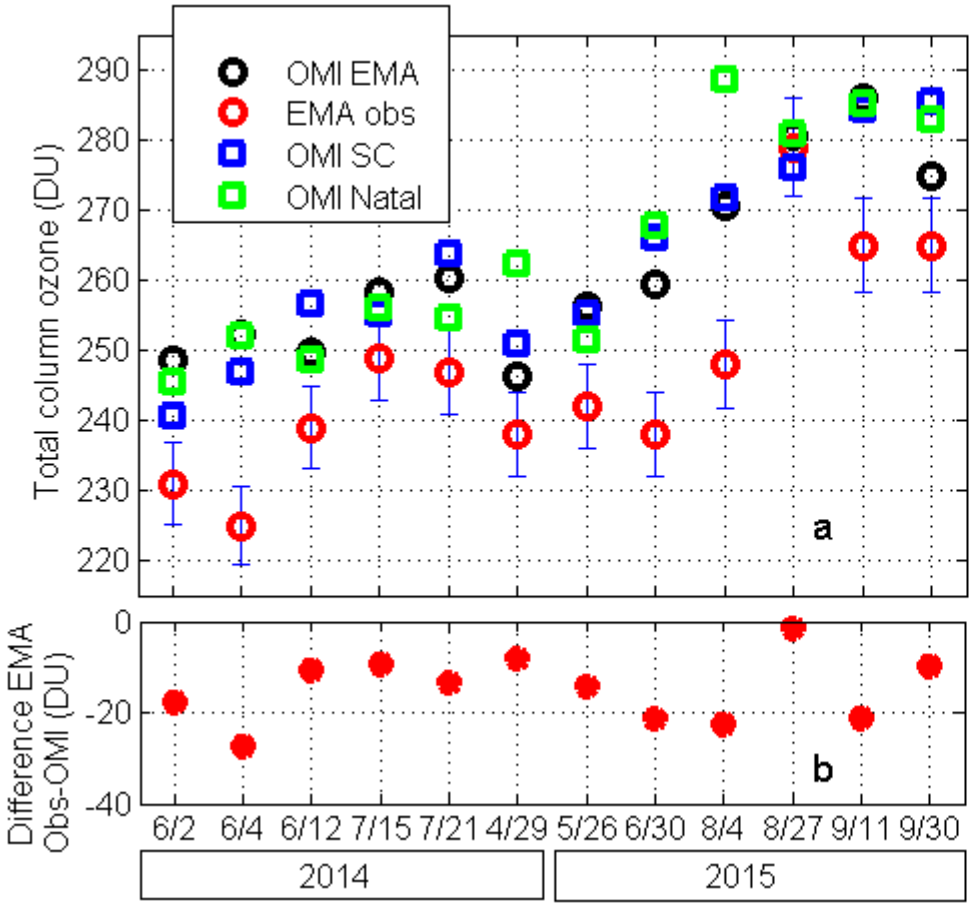
Observed (DU) < OMI (DU) – gridded data interpolated to EMA's coord.

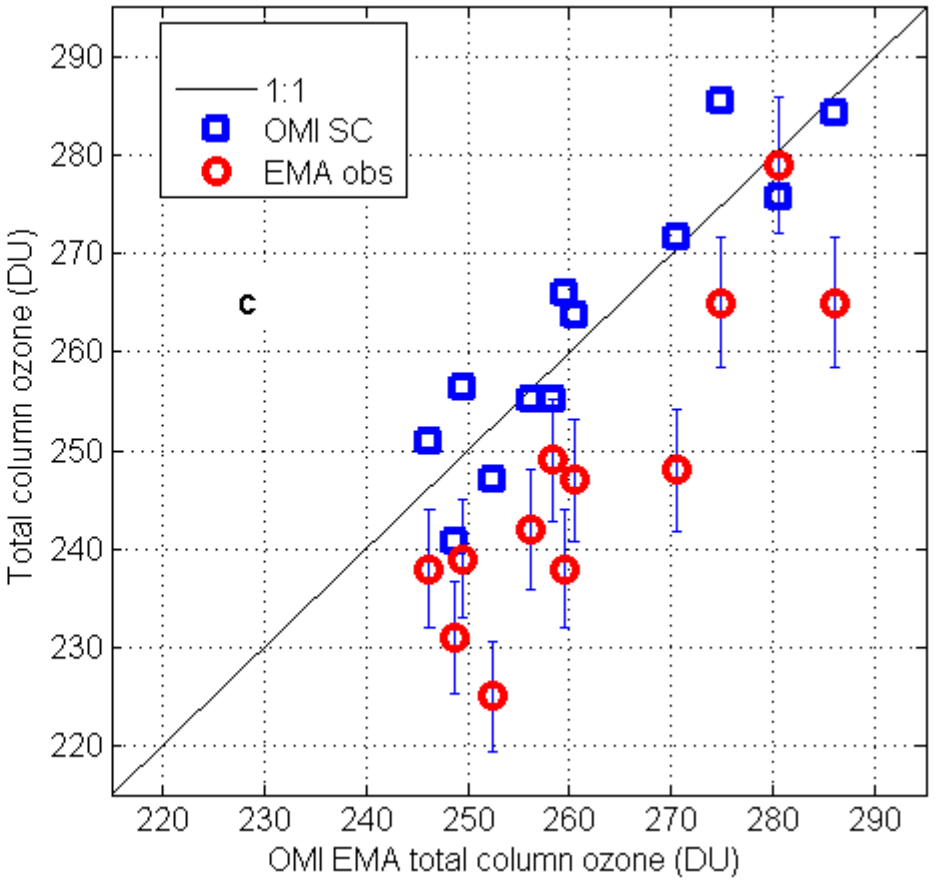
OMI (DU) for EMA ~ OMI overpass (DU) for SC

OMI data over Andes closely interpolated to OMI data over the Pacific O.

Residuals Obs-OMI ~ seasonal differences in measured trop. col.

Andes observations could help correct satellite data for Andes region.





Work in progress:

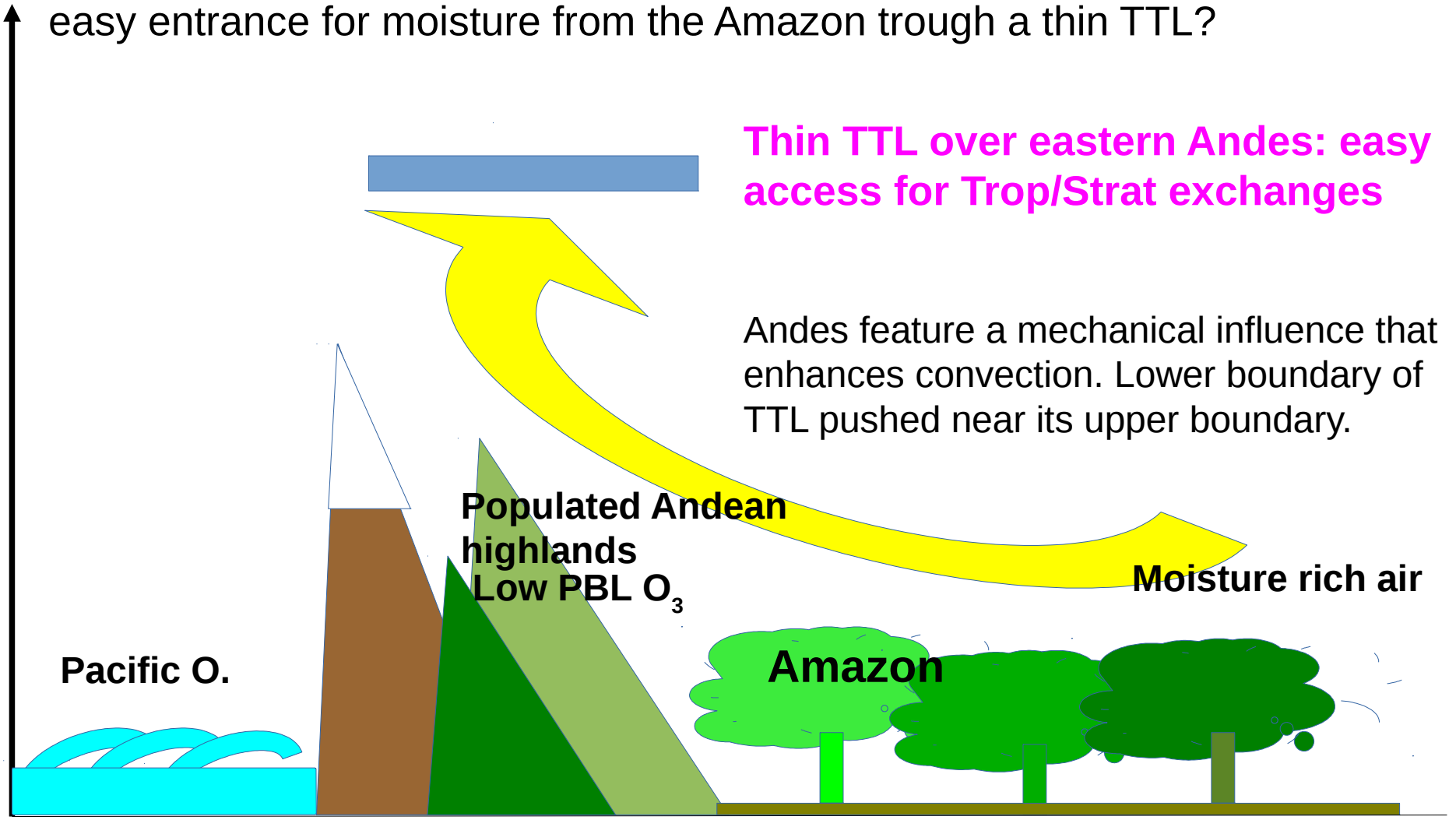
Currently collecting more profiles over EMA to explore:

Further comparisons obs vs. Satellite data

Low and well mixed tropospheric ozone - permanent features?

Is TTL permanentrly thin? How do water vapor profiles look like?

Is the region East to the Andes an “easy gate” for Trop/Strat exchanges: easy entrance for moisture from the Amazon trough a thin TTL?



2017 AMS theme
"Observations Lead the Way"

Observational needs:

- Upper air observations/ozone soundings – EMA USFQ is the only permanent station in the tropical Andes, but need funding to keep launching. Funding sources are very limited. Elegibility for international funding is very restricted.
- Calibration gases for AQ measurements, and cal. methods for met measurements (we have full met obs., but struggle when it is time for cal.)
- AQ sensors: SO_2, CO, VOCs, particles (we only have O_3 and NO_x)
- Need to integrate measurements from other stations. Information from other stations in the region is scattered.
- Really need access to science papers – more open science. Journal subscriptions are too expensive, Universities/Agencies in the Southern Hemisphere cannot afford full suscriptions. Big limitation that holds science back in SE.

Aknowledgements:

The EMA campaign was funded by USFQ Collaboration Grant CG2014.

Thanks to Bryan Johnson and Patrick Cullis from NOAA for their help implementing the sounding capability at EMA.

Thanks to Anne Thompson and team for data production at SHADOZ stations and for her wonderful mentoring.

Thanks to Nelson Herrera, Julieta Juncosa, and Miguel Bravo for operational help at EMA USFQ.

Thanks!