Iodine Oxide observations from AMAX-DOAS (HEFT-10, TORERO)

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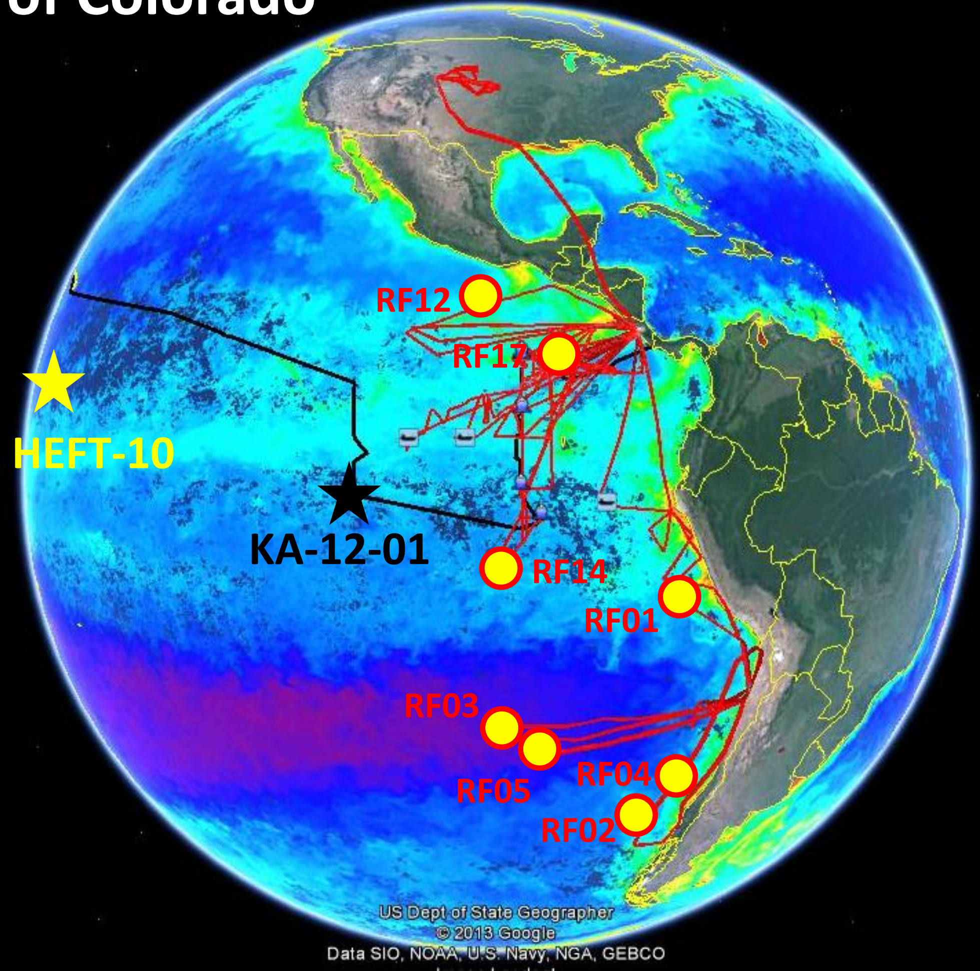
5 Summary and conclusions



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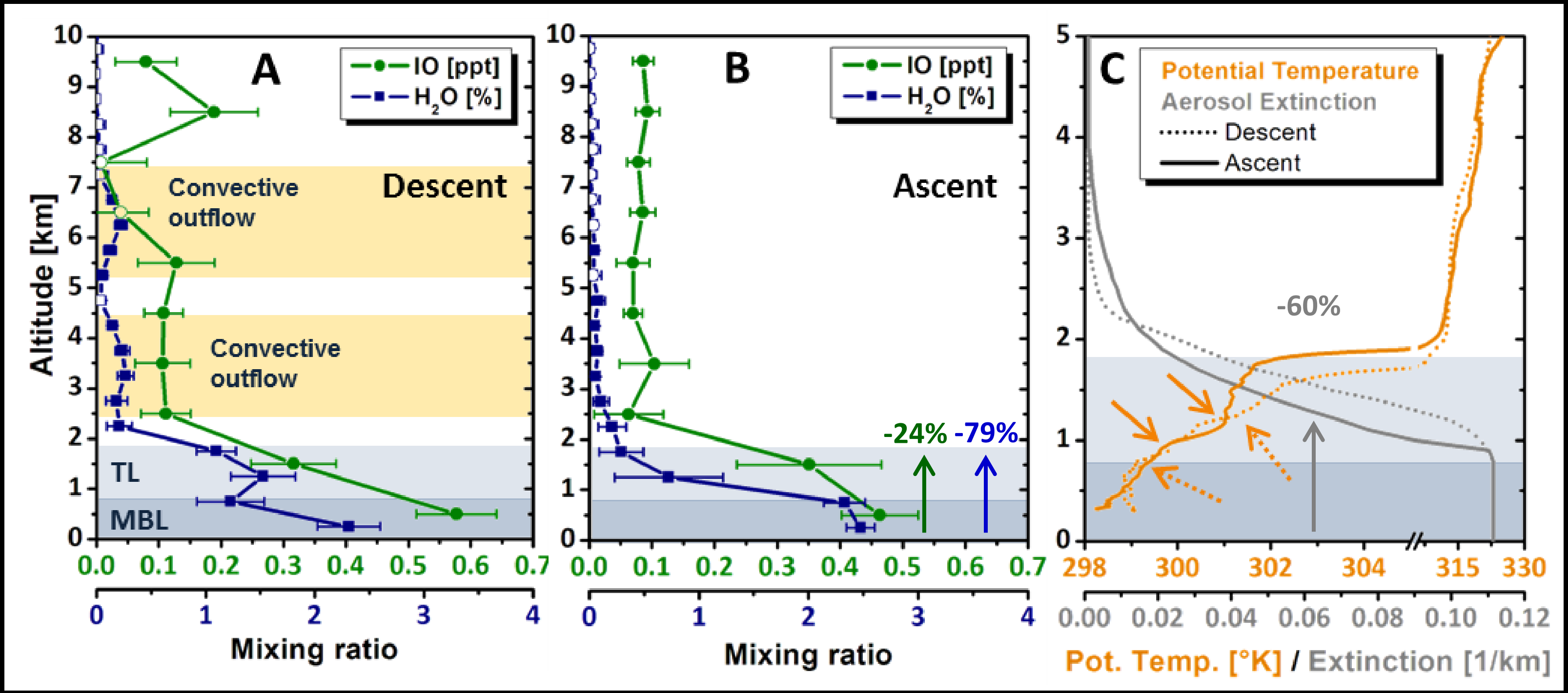
1 Motivation

- Why do we need to know about IO?
  - IO modifies the atmosphere’s oxidative capacity
  - IO catalytically destroys ozone
  - IO may impact the creation and growth of aerosol particles

- What don’t we know about IO?
  - Source chemistry and atmospheric lifetime
    - Organic biological/photochemical vs inorganic sources
    - Multiphase chemistry in aerosols
    - Aerosol loss vs Aerosol recycling
  - Vertical and global distribution
  - Only upper limits are known in the lower stratosphere
  - The magnitude of its importance for atmospheric chemistry and climate

1 Motivation – uncertainty in IO effective lifetime



HEFT-10

Transition Layer (TL)

- no contact with ocean surface for ~12h (WRF back trajectories)
- IO lifetime : ~1h if irreversibly lost to aerosol

→ IO observed suggest longer effective lifetime - aerosol recycling?

→ TORERO measures aerosol SA and iodine precursors

Dix et al., 2013 PNAS

1 Motivation – TORERO approach

Aircraft:

- CH_3I, C_2H_5I, CH_2I_2, CH_2ICl (TOGA)
- Aerosol size distribution (->surface area, UHSAS) and
- IO (AMAX-DOAS)

  Northern and Southern Hemisphere tropical and subtropical ocean

  SH Subtropical and Mid-Latitude remote oligotrophic ocean and coastal eutrophic upwelling

RV Ka'imimoana:

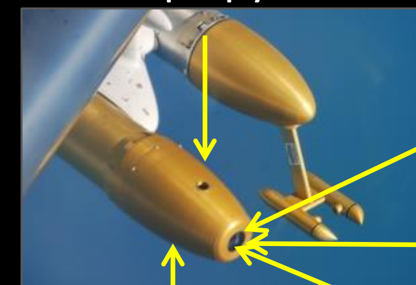
- Organoiodine fluxes from subsurface waters into MBL (GC-MS)
- IO (SMAX-DOAS)

  NH and SH gradient in the tropical MBL

2 Instrumentation - CU AMAX-DOAS

Colorado University-Airborne Multi-AXis
Differential Optical Absorption Spectroscopy

telescope pylon

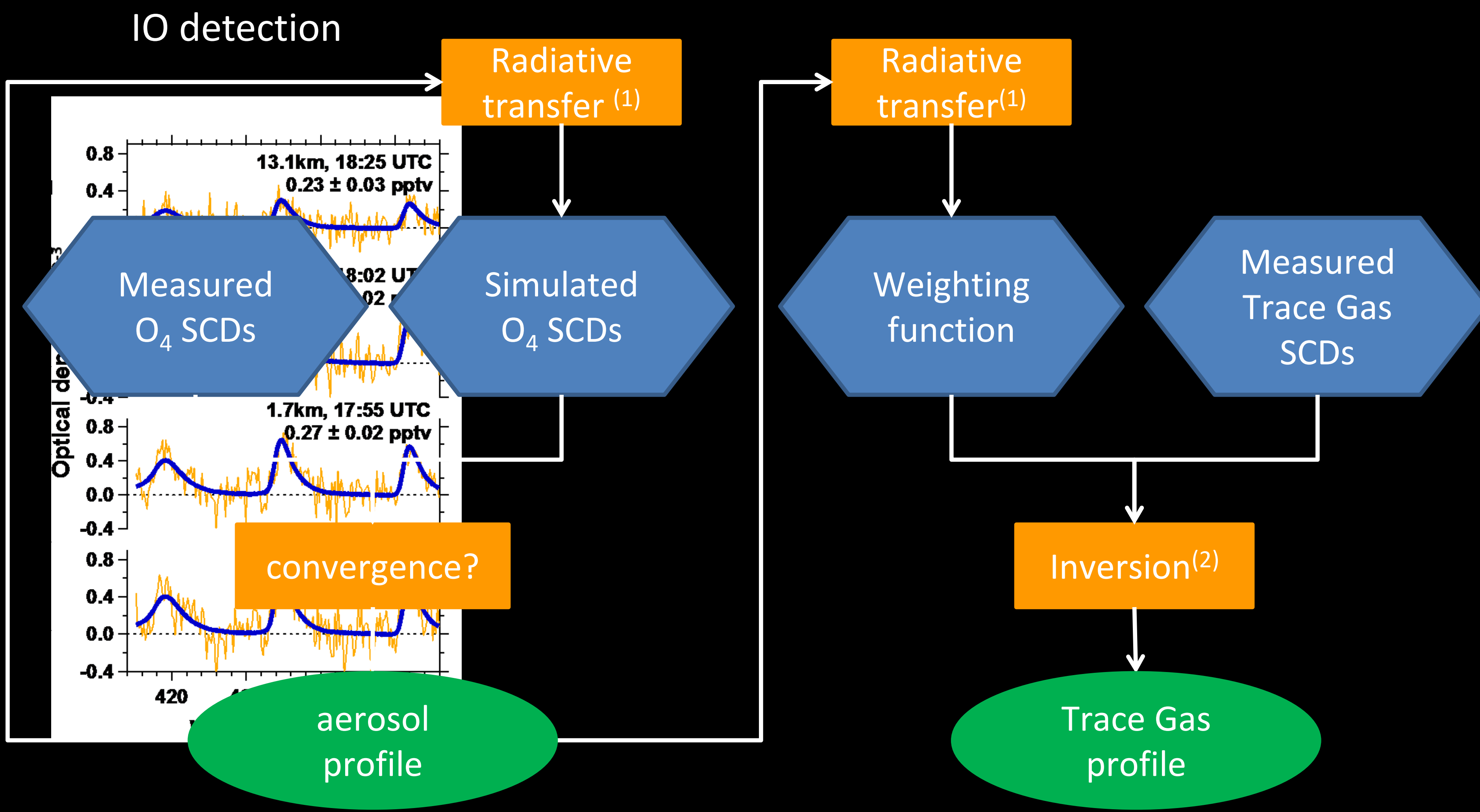


motion
stabilized

spectrographs/detectors

Volkamer et al., 2009, SPIE
Baidar et al., 2013, AMT

2 DOAS and Profile Retrieval

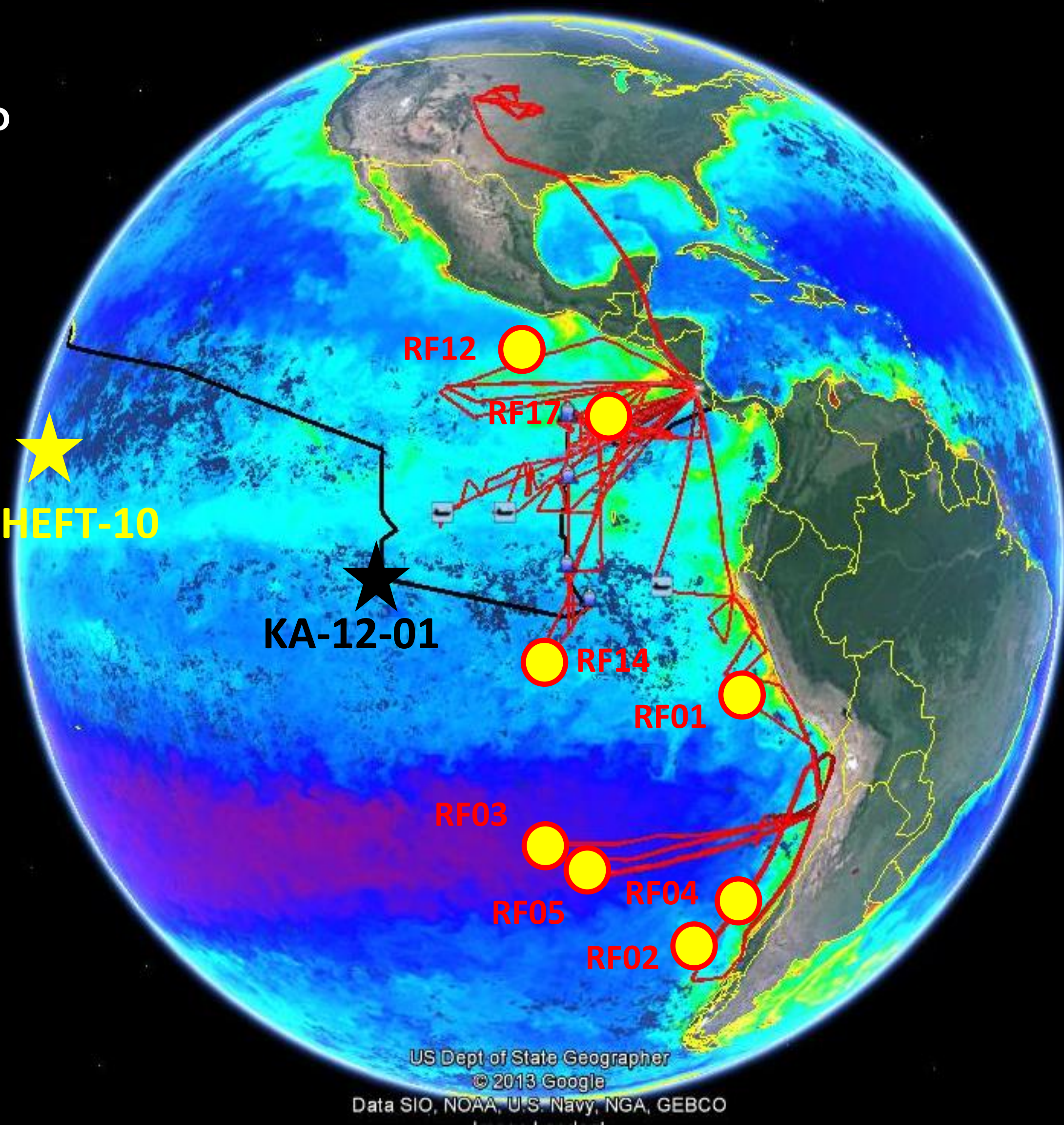


3 TORERO - regions of interest

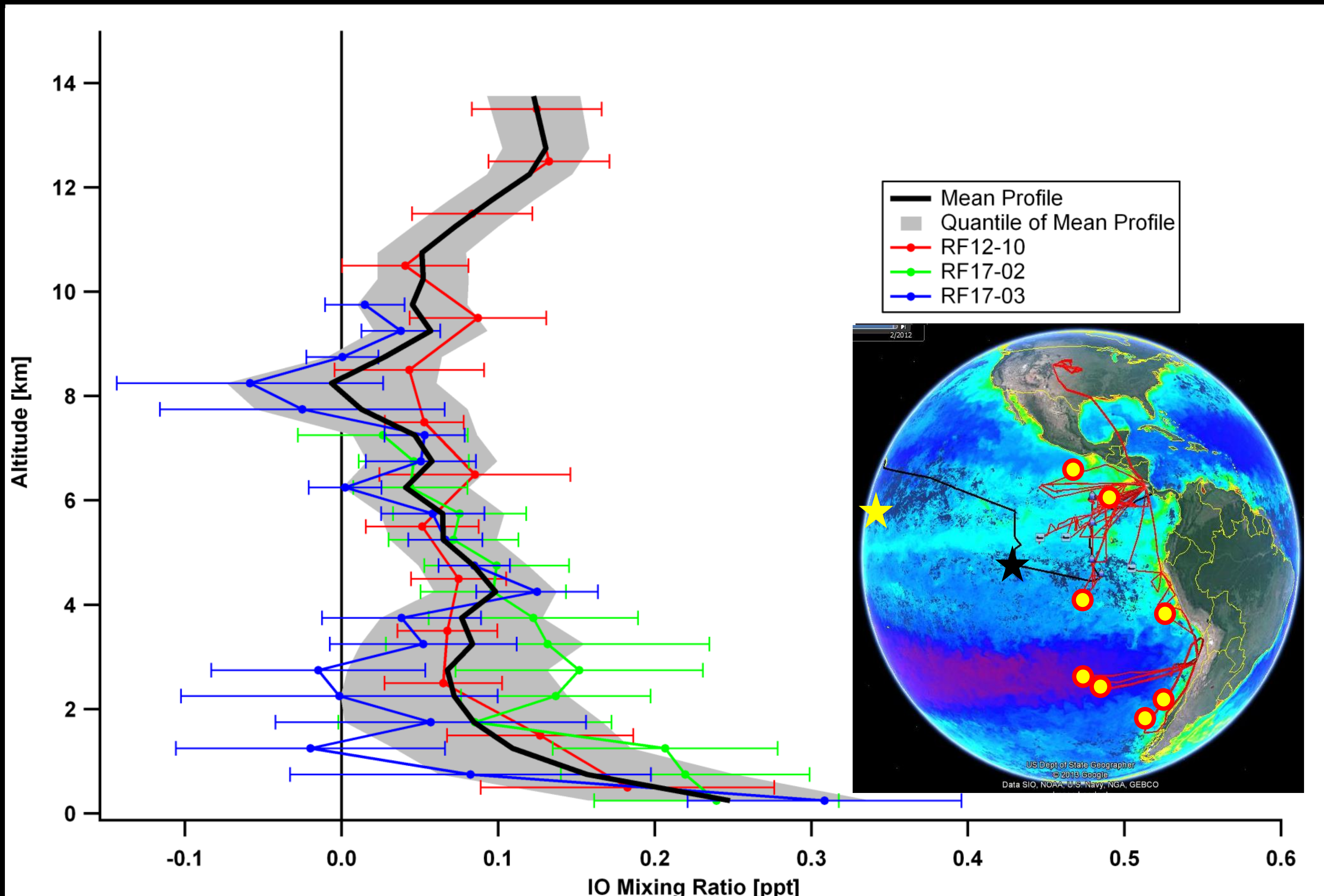
<u>Focus:</u>

- Regional gradients
- Transition layer:

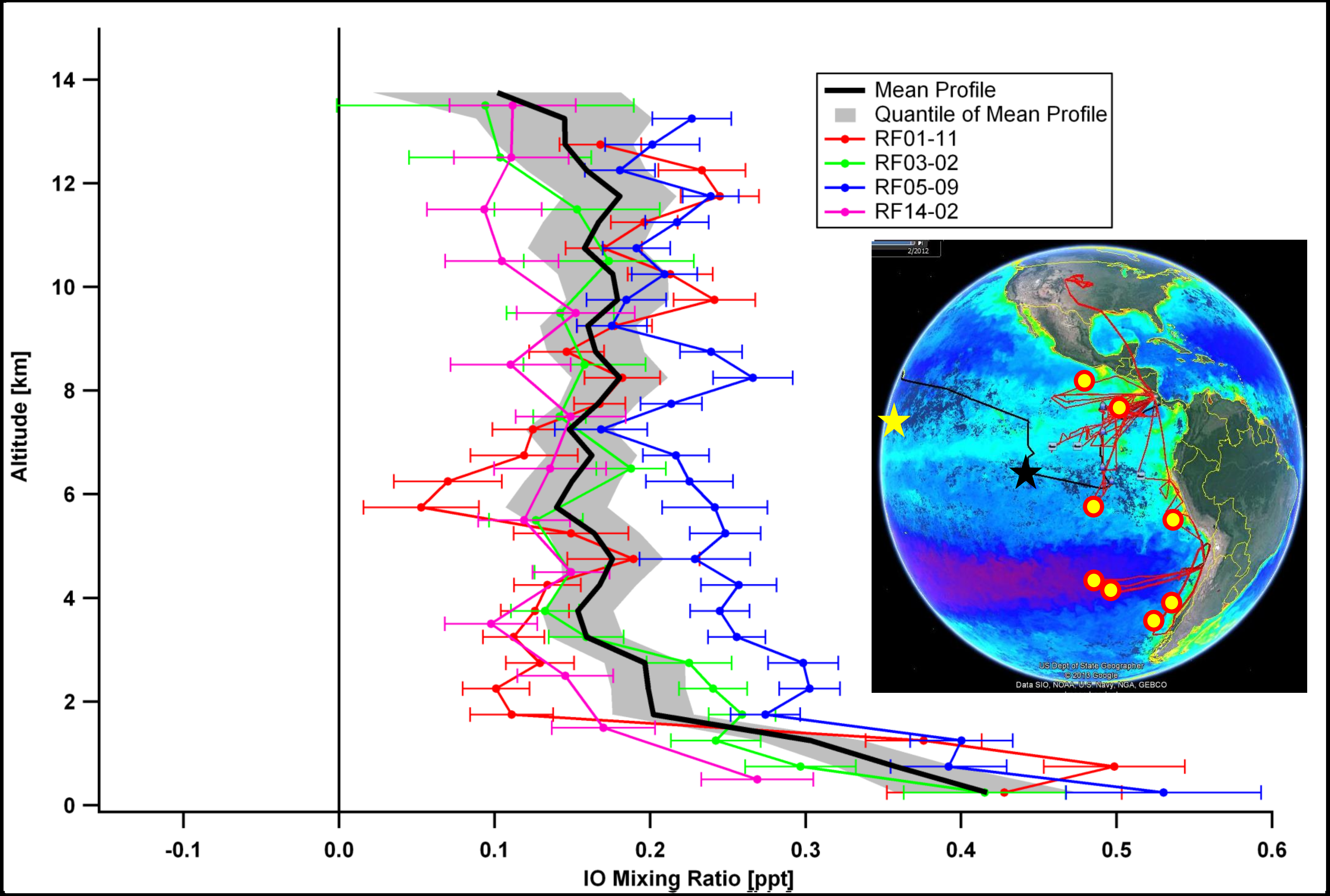
IO recycling vs organoiodine?



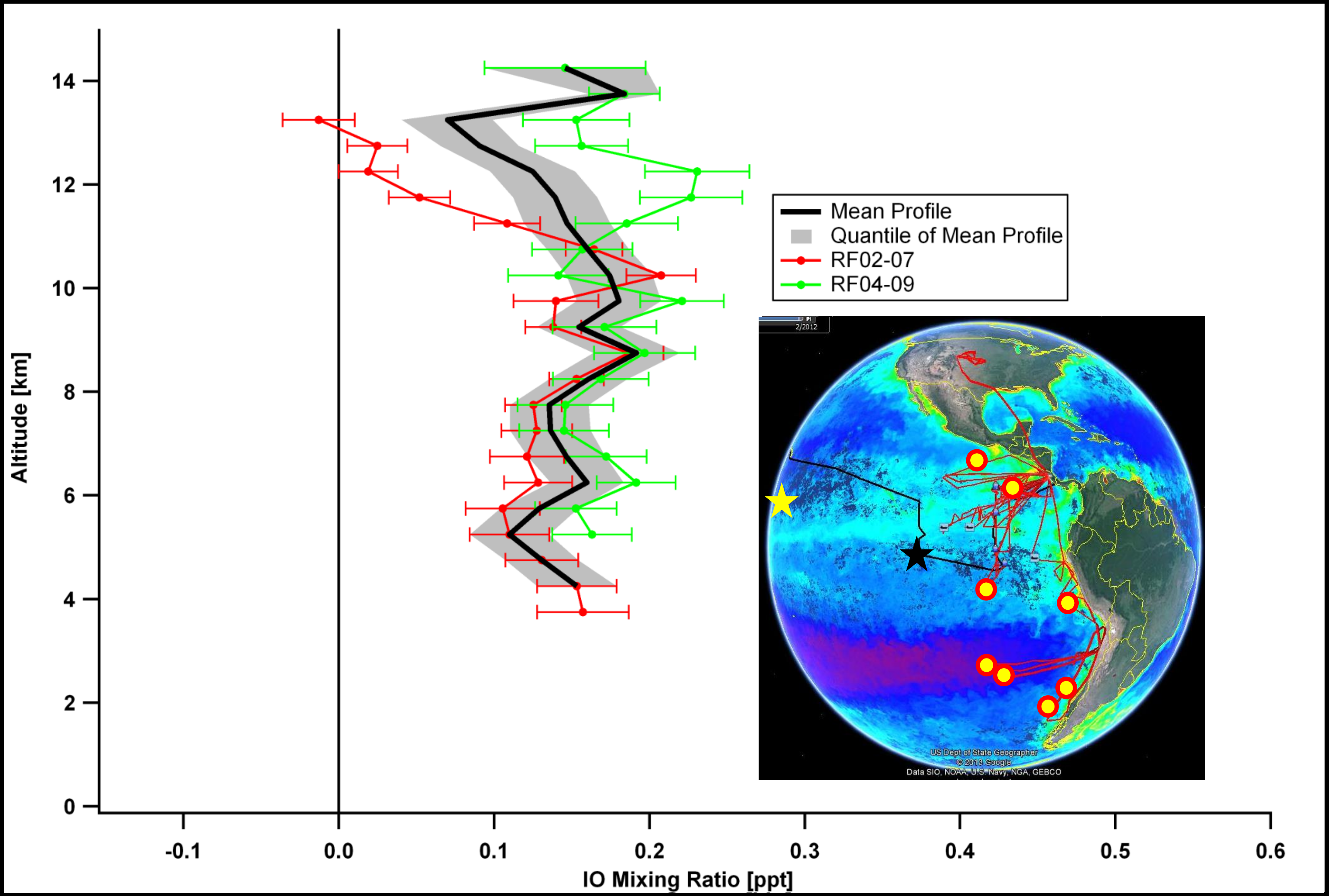
3 TORERO – NH Tropical Ocean



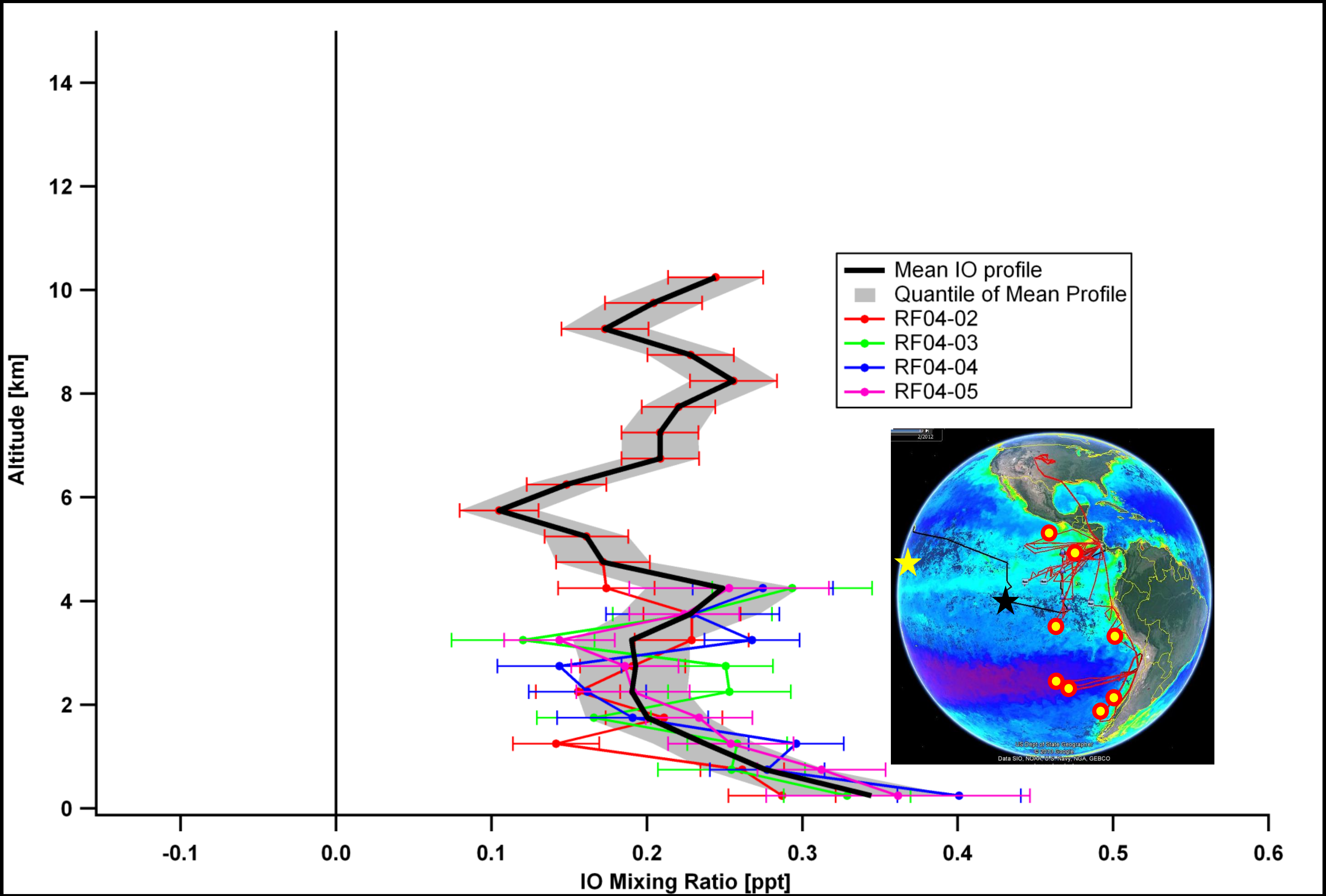
3 TORERO – SH Tropical and Subtropical Ocean



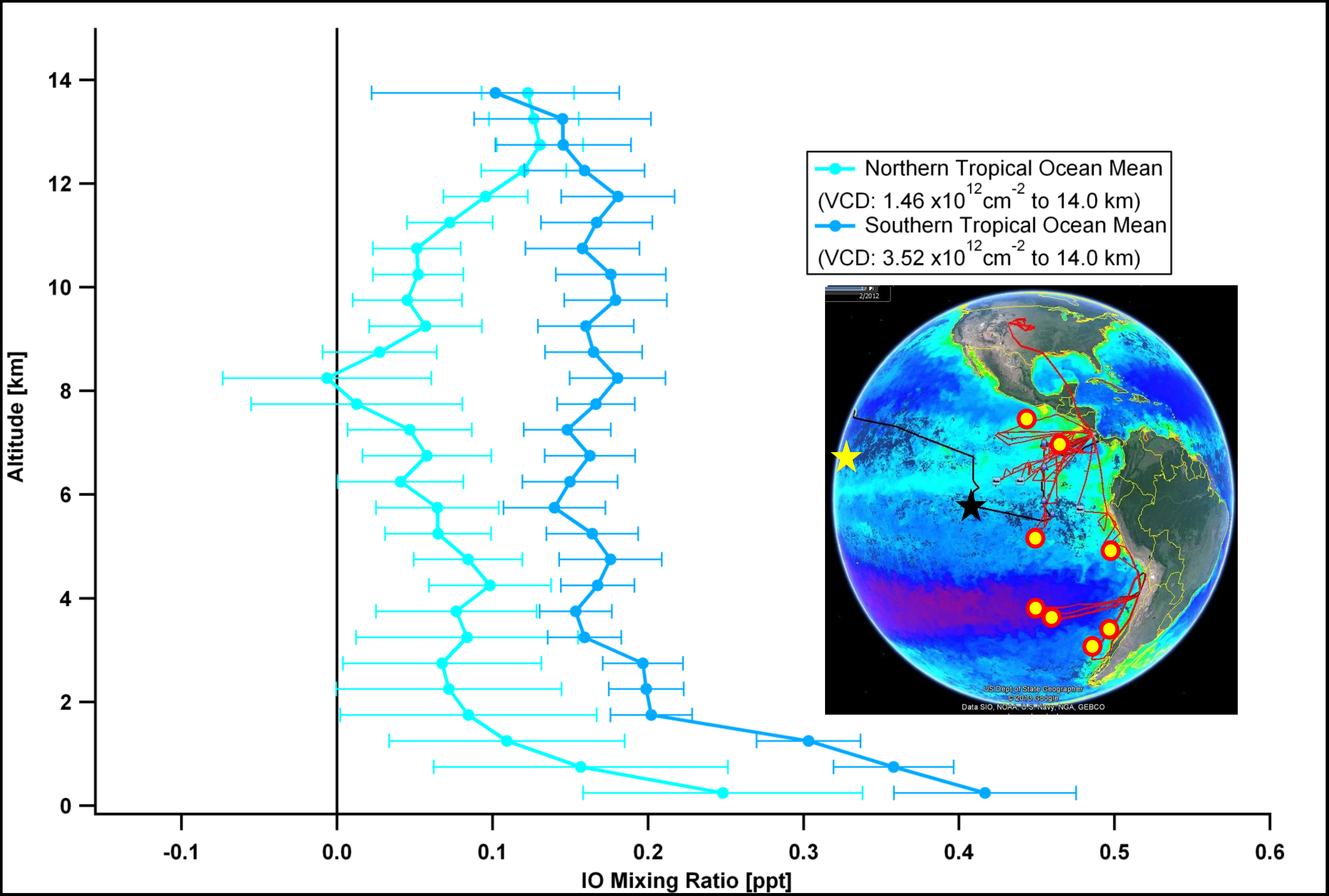
3 TORERO – SH Mid-latitude Ocean



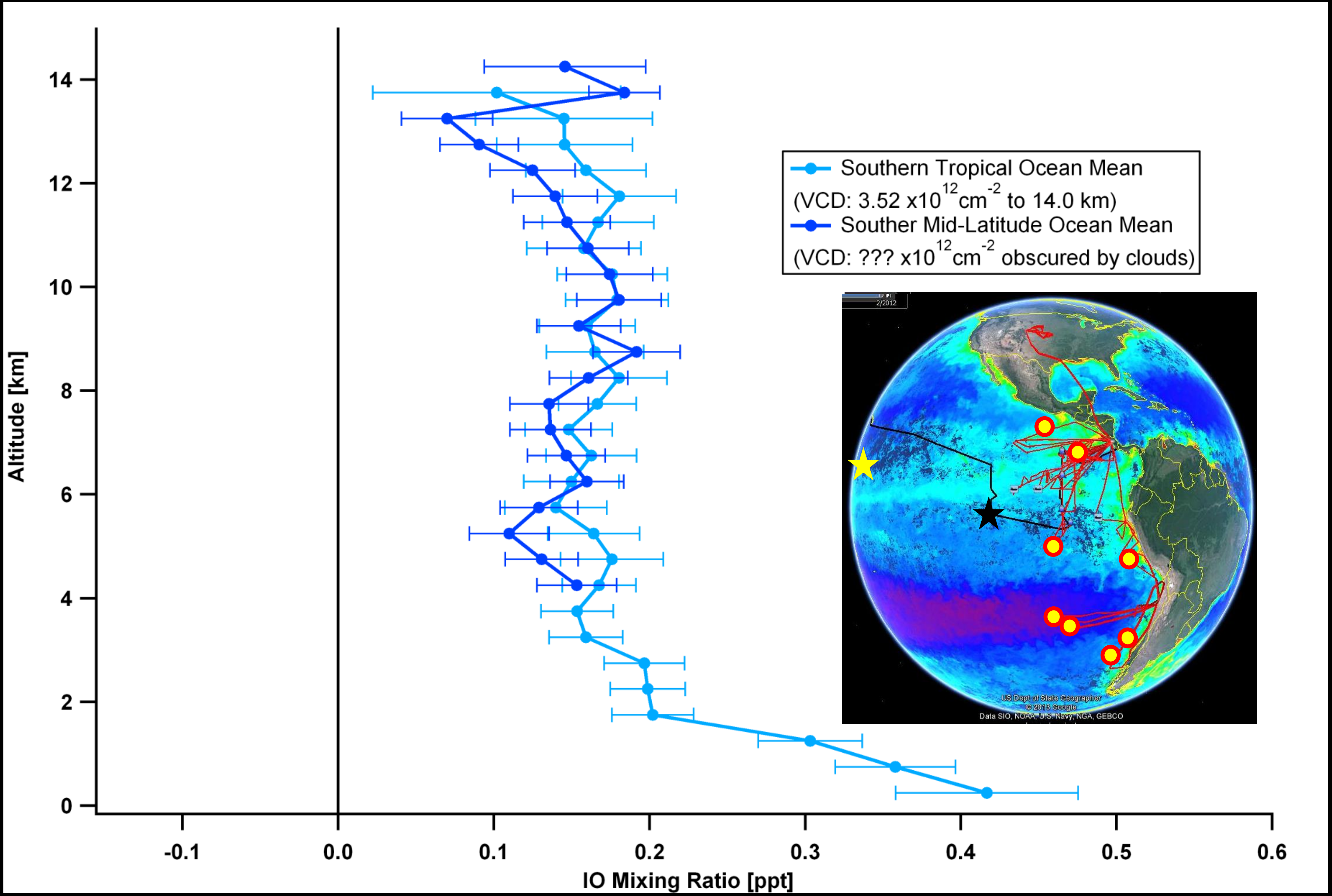
3 TORERO - SH Mid-latitude Coastal



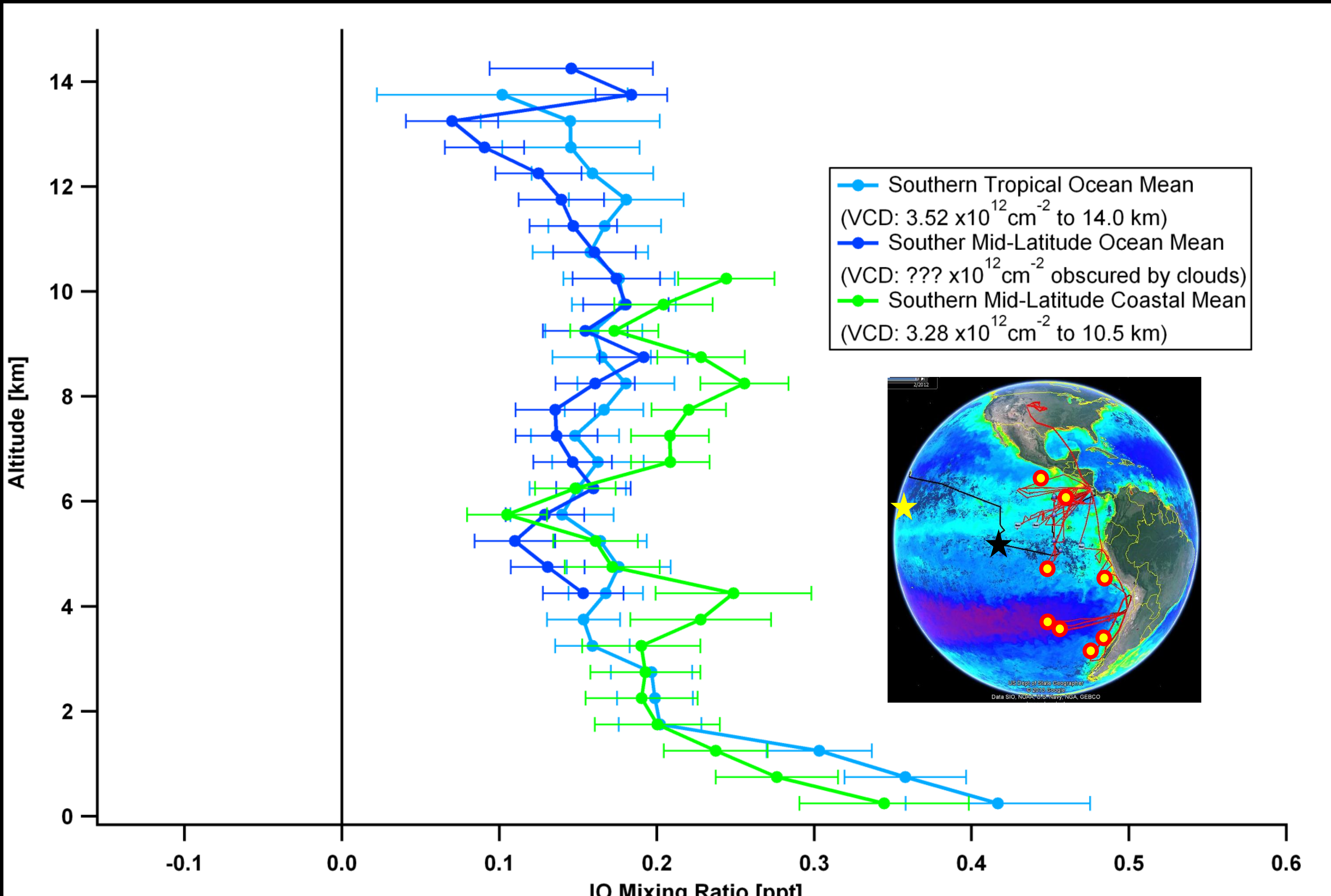
3 TORERO – NH vs SH Tropics and Subtropics



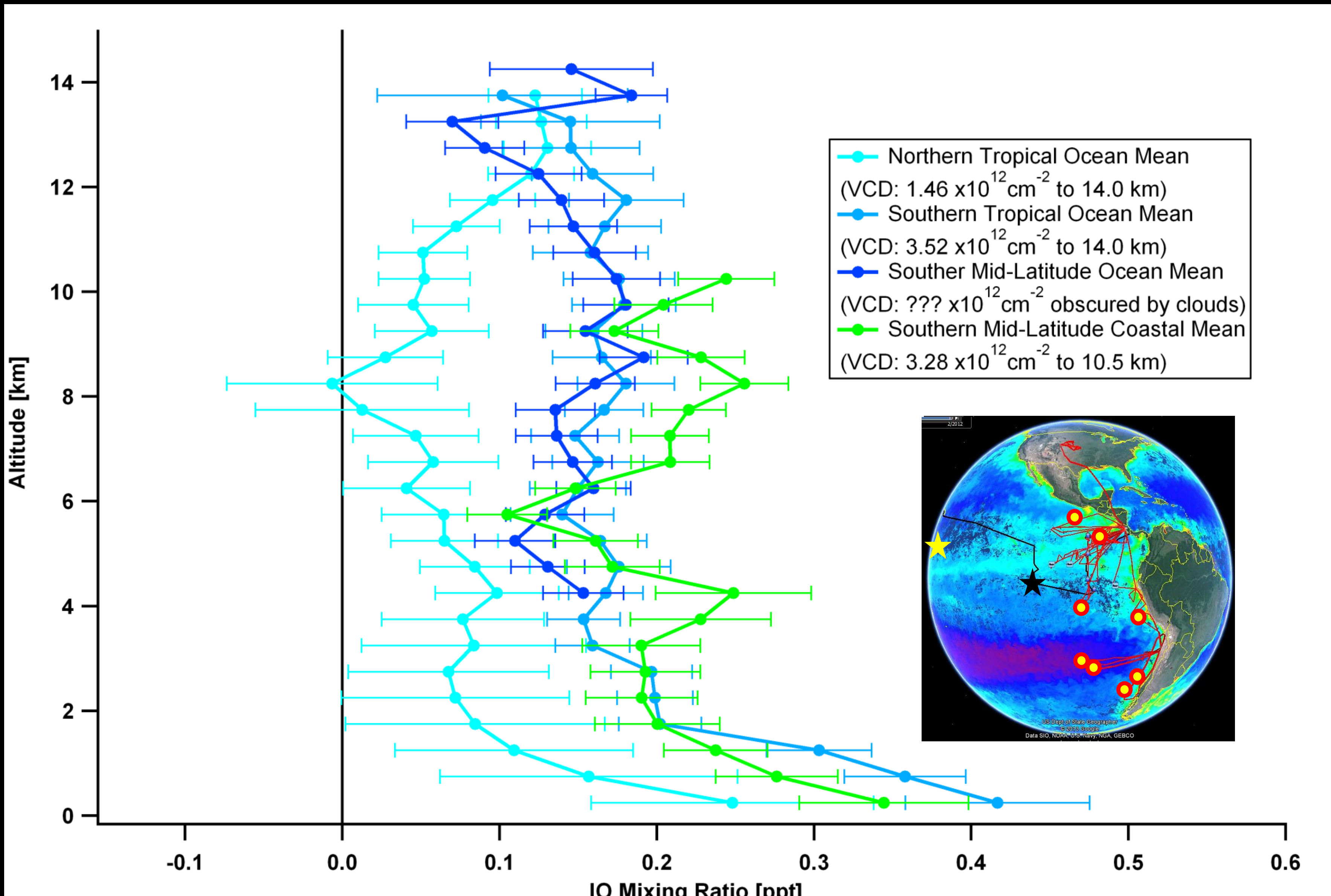
3 TORERO – Tropics and Subtropics vs Mid-Latitudes



3 TORERO – SH summary



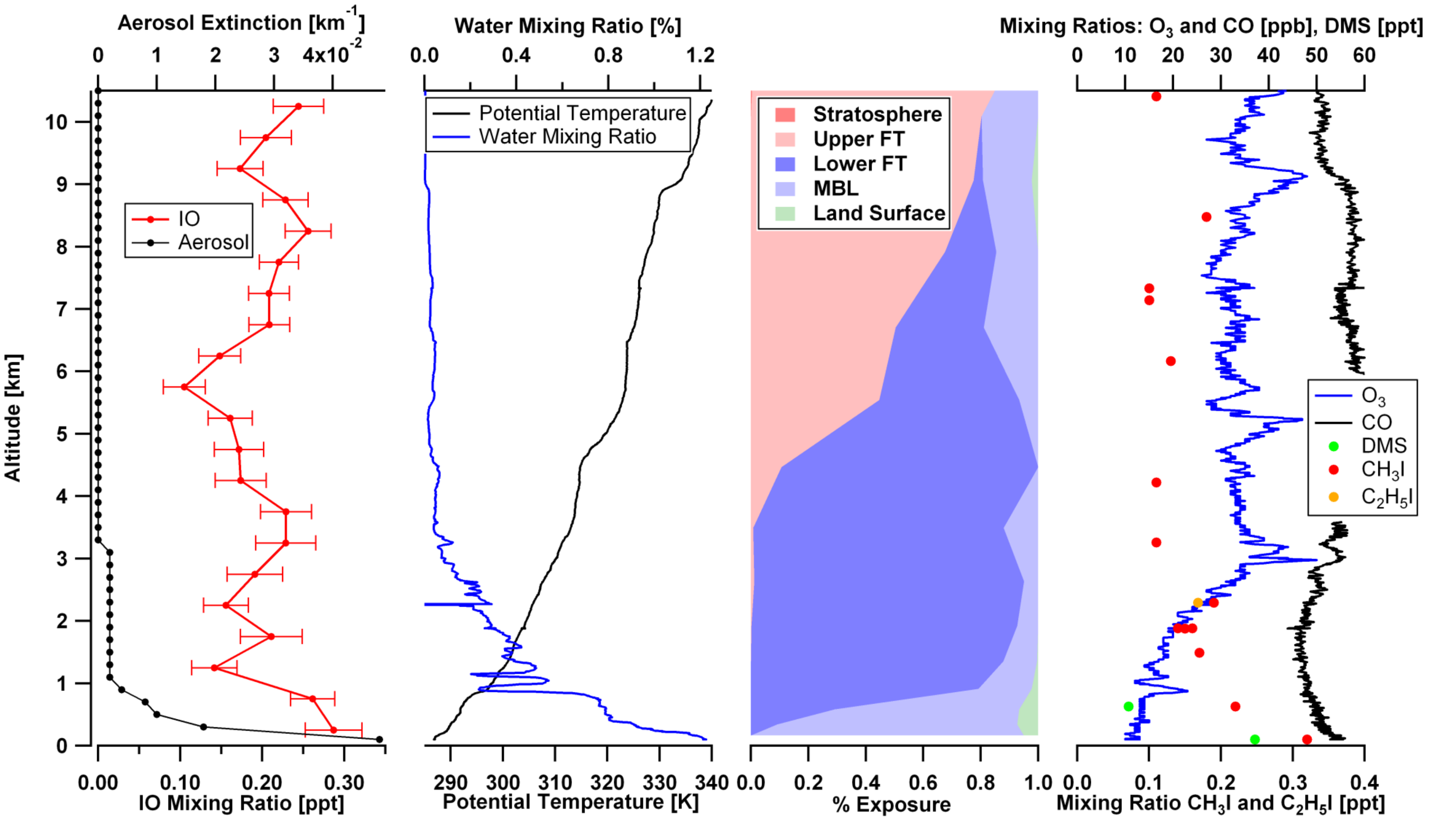
3 TORERO – Summary of IO by region



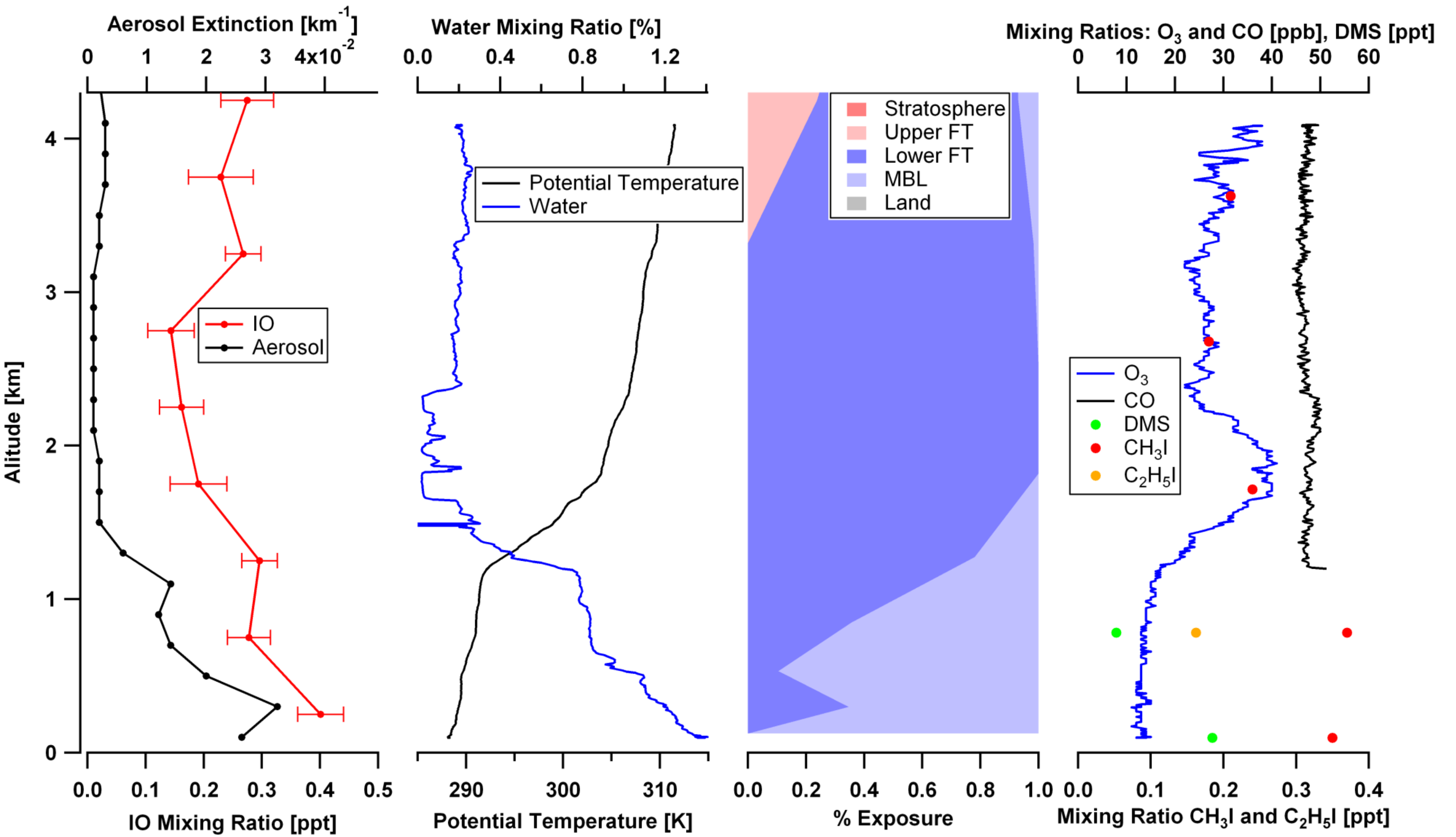
3 TORERO – Summary of regional IO

Region	Profile	Total IO VCD (10^{12} molecule/cm^2)	Max Altitude (km)
HEFT10	A	2.4±0.7	10.0
	B	2.1±0.7	10.0
Northern Hemisphere Tropical Ocean	RF12-10	1.4±0.8	14.0
	RF17-02	1.5±0.8	7.5
	RF17-03	0.7±0.9	10.0
	Average	**1.5±1.0**	**14.0**
Southern Hemisphere Tropical and Subtropical Ocean	RF01-11	3.2±0.5	13.0
	RF03-02	3.3±0.6	14.0
	RF05-09	4.7±0.5	13.5
	RF14-02	2.4±0.6	14.0
	Average	**3.5±0.6**	**14.0**
Southern Hemisphere Mid-Latitude Coast	RF04-02	3.0±0.4	10.5
	RF04-03	1.9±0.3	4.5
	RF04-04	2.0±0.3	4.5
	RF04-05	1.9±0.3	4.5
	Average	**3.3±0.5**	**10.5**

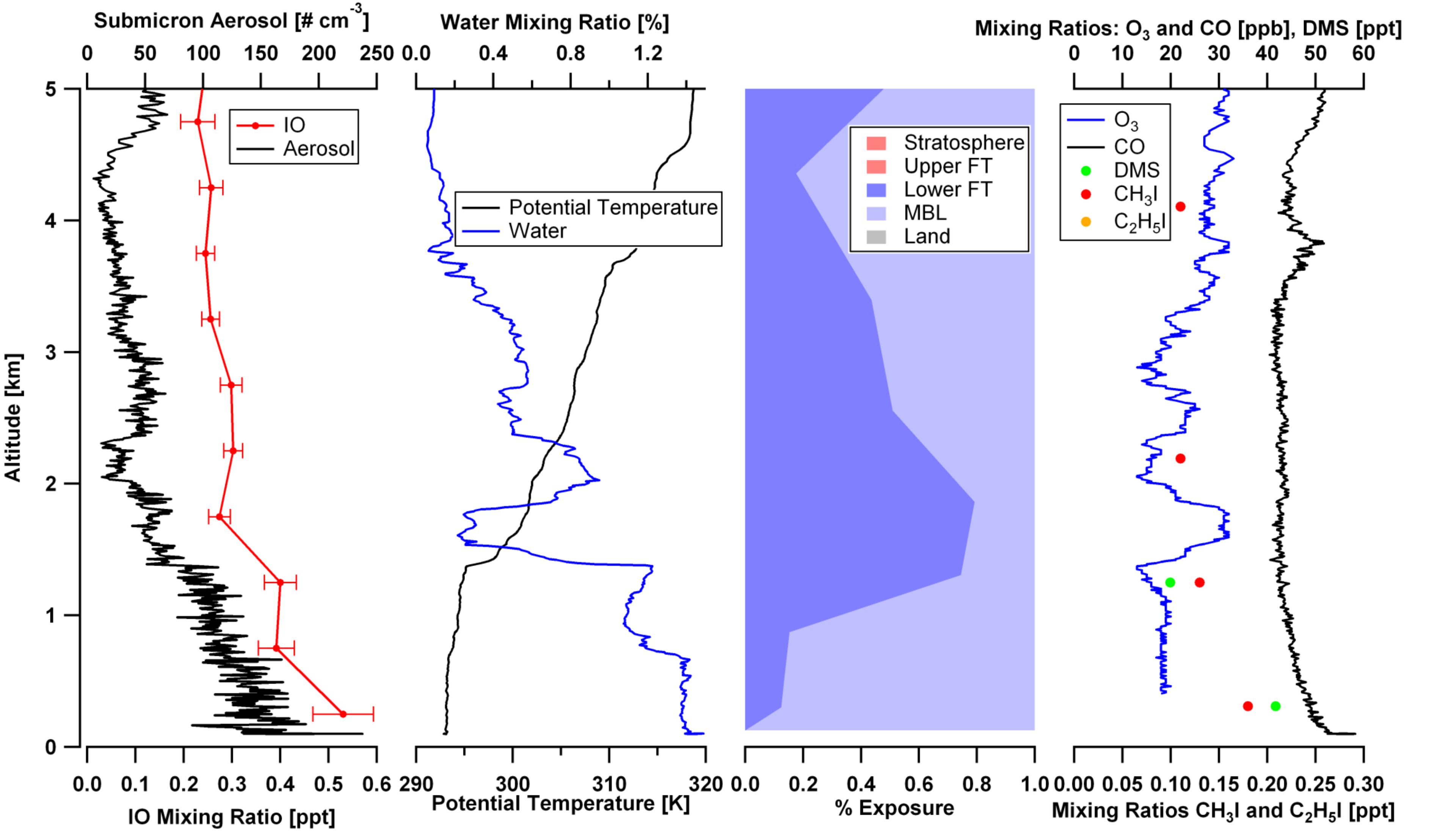
3 TORERO – Case Study RF04-02 (FT structure)



3 TORERO – Case Study RF04-04 (Pristine Low MBL)



3 TORERO – Case Study RF05-09 (TL enhancement)



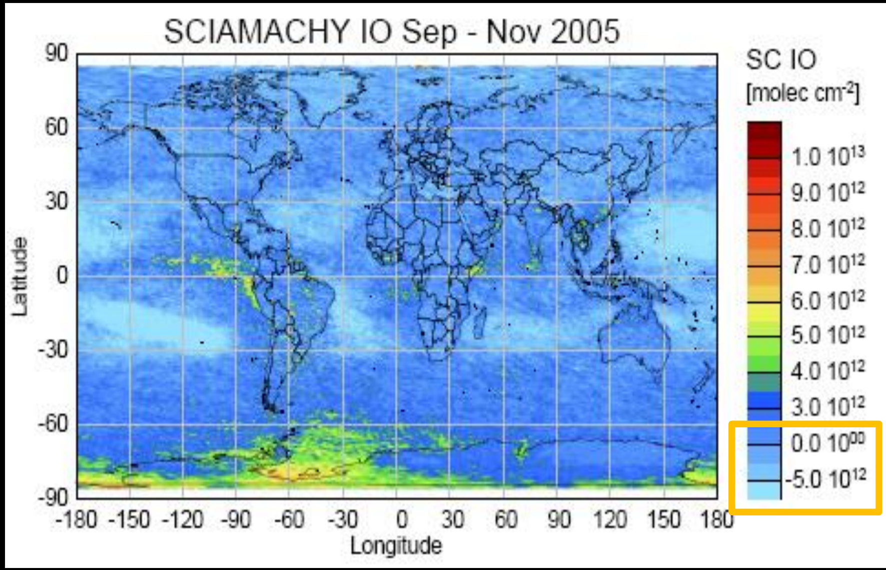
Implications for satellite retrievals - sensitivity

Averaged IO VCDs and simulated satellite SCDs (x10^{12} molec/ cm^2)

Layer	VCD	Cloud Cover	SCD / VCD Bias*
Total	2.71	0% 20% 40%	4.25 / 1.5 4.34 / 2.5 4.38 / 3.8
MBL	0.94	0% 20% 40%	0.99 (23.3%) 0.60 (13.8%) 0.39 (8.9%)
TL	0.76	0% 20% 40%	1.17 (27.5%) 1.29 (29.7%) 1.36 (31.1%)
FT	1.01	0% 20% 40%	2.09 (49.2%) 2.45 (56.5%) 2.63 (60.0%)

* Based on assuming MBL only profile

Schönhardt et al., ACP 2008



→ TORERO profiles suggest even greater sensitivity of satellite to the FT then had been suggested in Dix et al

Dix et al., 2013 PNAS

Summary and Conclusions

- Regular detection of IO also in the TORERO study area
  - Reactive iodine in FT on globally relevant scales
  - Factor 1.5-2 more IO in the SH than in the NH
  - Halogen driven ozone loss in FT might currently be underestimated
- Relevance for the interpretation/quantification of satellite maps:
  - Altitude dependent sensitivity and decoupling of MBL and FT
- Understanding IO sources:
  - Is an inorganic source necessary to explain AMAX observations of IO?
  - How do observations of aerosol and, CH_3I and C_2H_5I in the free troposphere in understanding IO at these altitudes?
- Quantifying and understanding the potential impacts of IO on climate.

Outlook & Possible future plans

- **Process level understanding:**
  → Organic biological/photochemical vs inorganic sources
  → Multiphase chemistry: aerosol loss vs recycling
  → IO lifetime
- **Box-model: MISTRA? York? CU box model?**
  → MBL focus: experimentally constrained by ship/aircraft observations of VSLH fluxes (Lucy), CH_3I & C_2H_5I profiles (TOGA), IO profiles (AMAX), aerosol SA, J-values
  → TL focus: can we understand variability of IO in TL?
- **Regional/global models: WRF-Chem/GEOS-Chem/CAM-Chem?**
  → Iodine emission inventories; IO constraints to I_y
  → Importance of iodine for chemistry and climate
- **IO in the lower stratosphere**
  → Experimental: TORERO (limited), CONTRAST (in progress)
  → Model: CAM-Chem (Saiz-Lopez/Lammarque)

Thank You!

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Thank you for your attention

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