Detection of
IO and glyoxal in the FT –

implications for satellite retrievals

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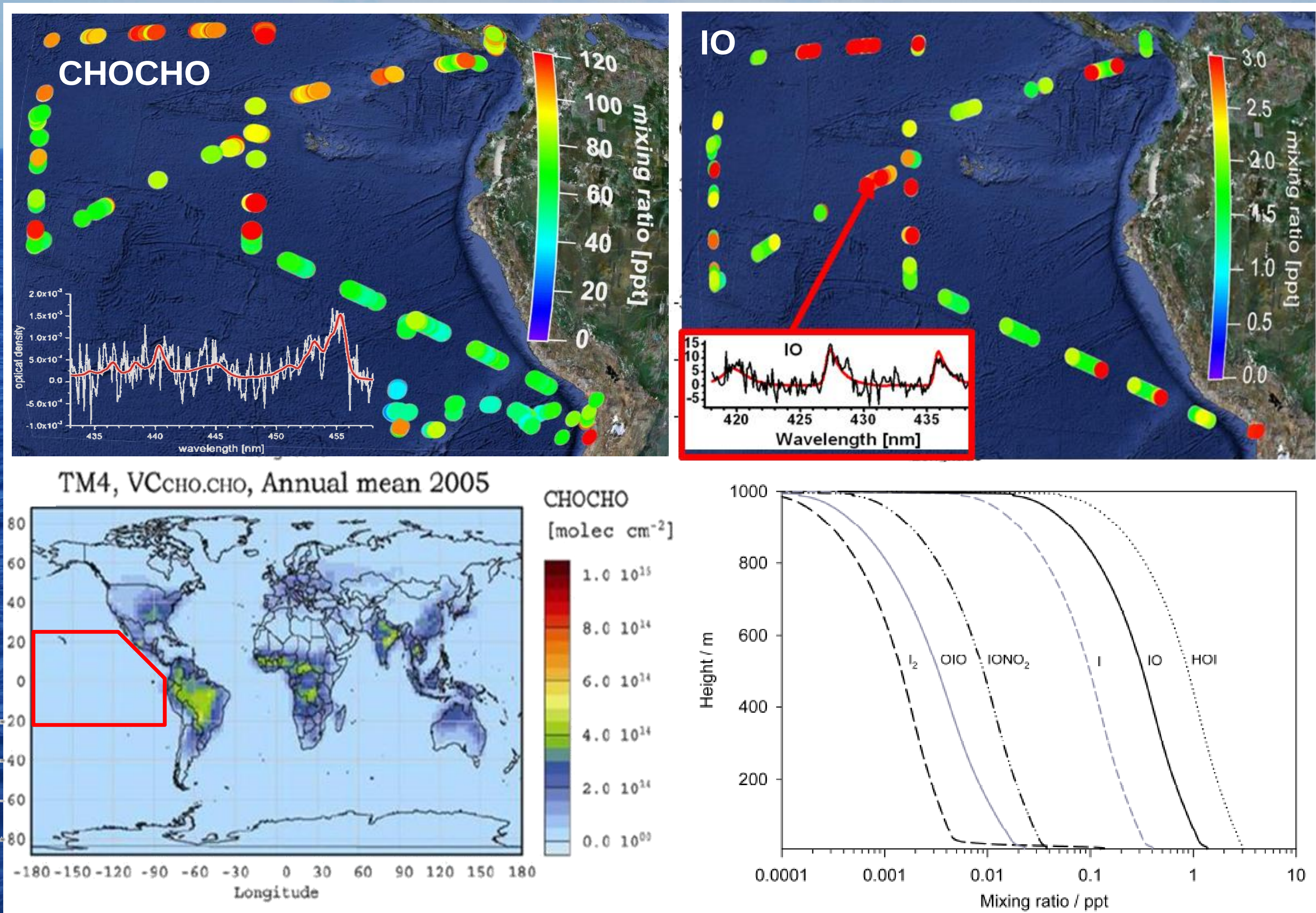
1 Motivation

Iodine monoxide (IO) and glyoxal (CHOCHO) impact atmospheric chemistry and potentially climate by:

- affecting atmospheric oxidation capacity
- formation by destroying ozone (IO)
- forming particles that could act as CCN (IO)
- leading to formation of SOA (CHOCHO)

→ Open questions on:

- source mechanisms
- global distribution

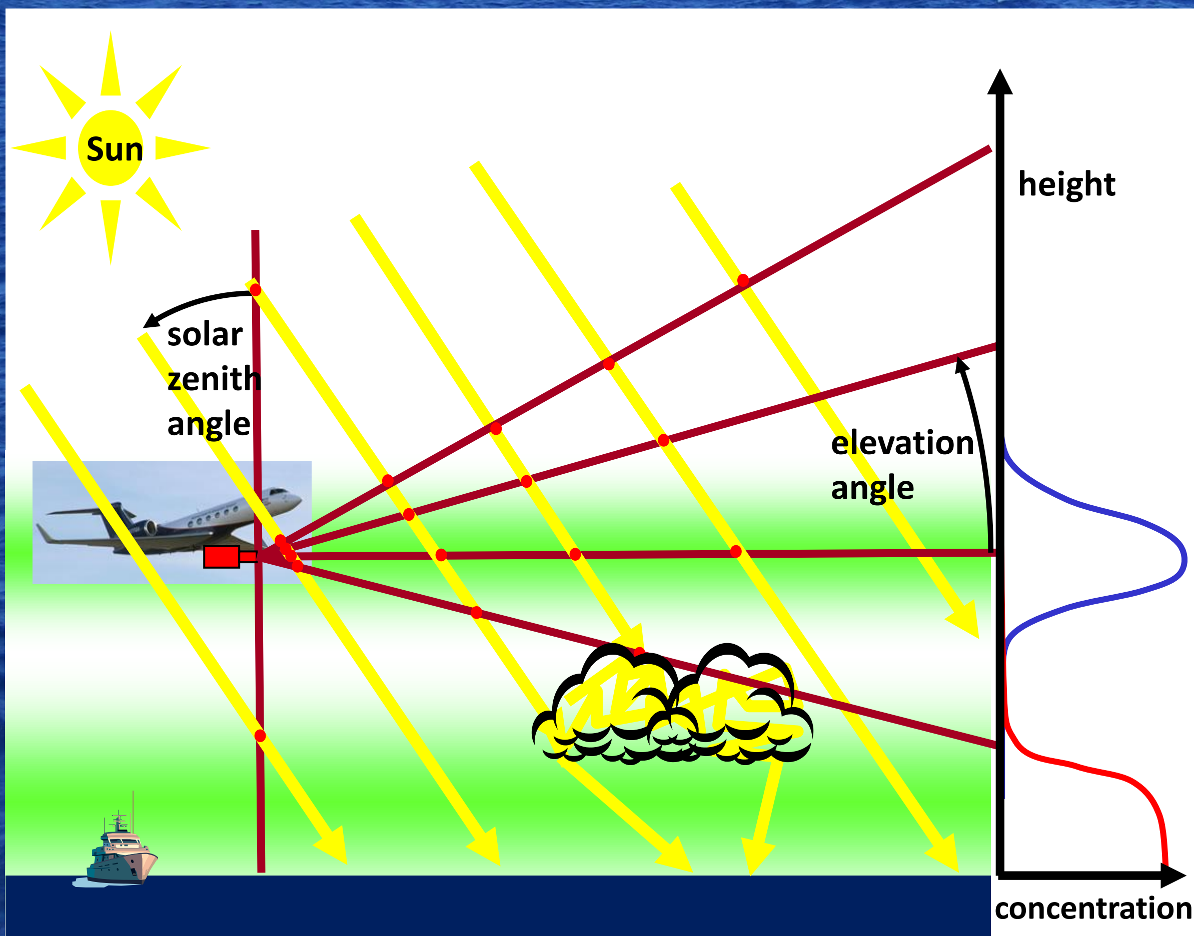


Myriokefalitakis et al., 2008, Schönhardt et al., 2008, Mahajan et al., 2010

Sinreich et al., 2010, Volkamer et al., 2010; recent confirmation: Mahajan et al., 2012, Puentedura et al., 2011)

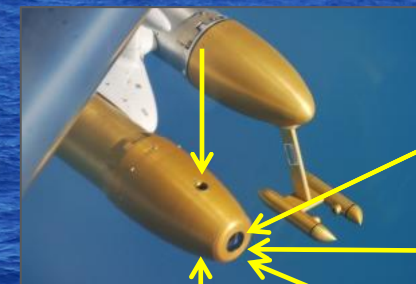
2 Instrumentation: CU-AMAX-DOAS

Colorado University-Airborne Multi-AXis
Differential Optical Absorption Spectroscopy



Volkamer et al., 2009

telescopes

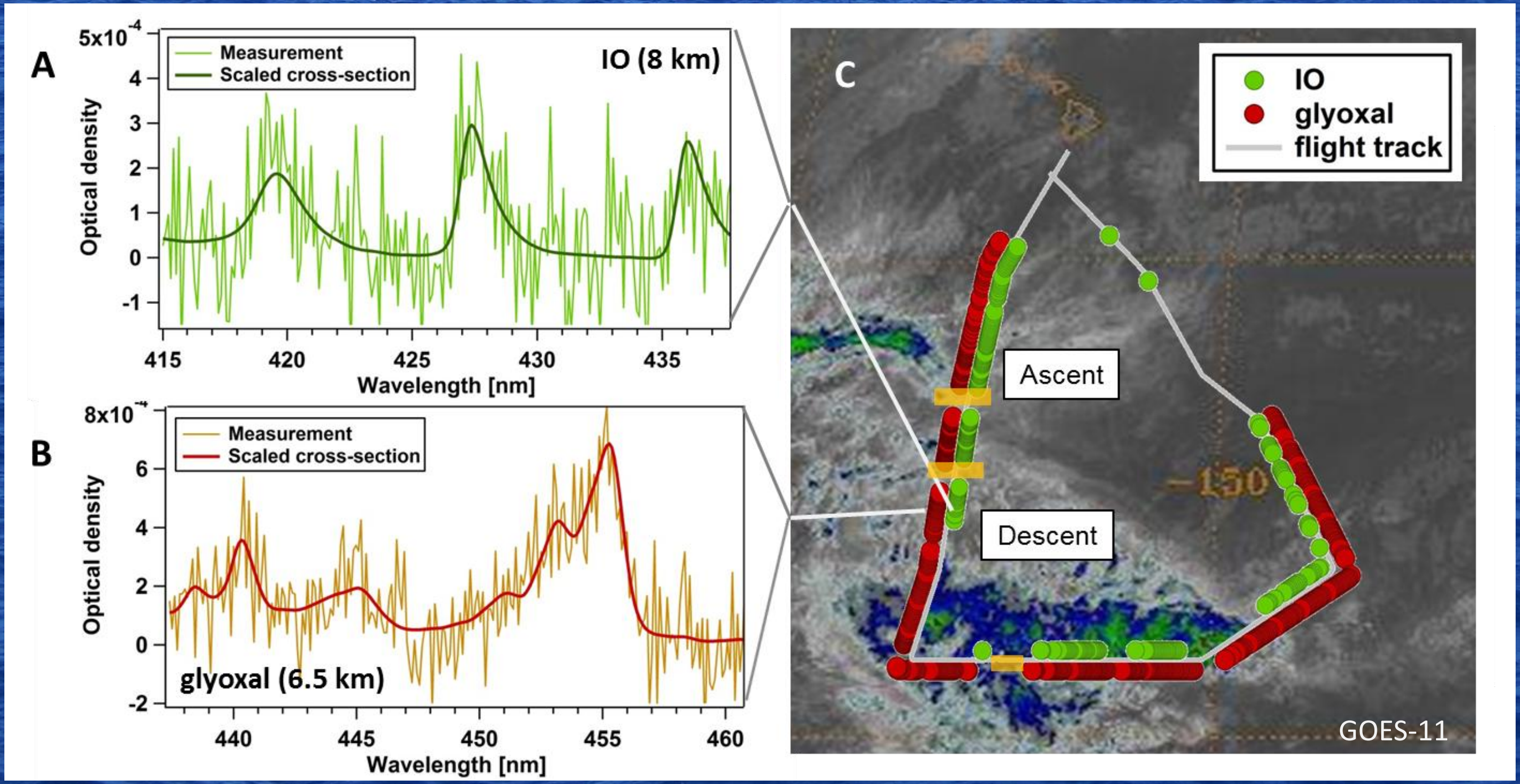


Motion stabilized

spectrographs/detectors
scientist accessories

3 Profile retrieval - 3.1 slant column densities

Slant Column Densities of IO and glyoxal in the FT during HEFT-10, 29 Jan 2010



$SCD = \int c(l) * dL$

SCD_{IO} = 1.1 ±0.2 × 10^{13} molec/cm^2 (RMS = 1.2 x 10^{-4})

$SCD_{glyoxal}$ = 1.3 ±0.2 × 10^{15} molec/cm^2 (RMS = 1.3 x 10^{-4})

3 Profile retrieval - 3.2 aerosol extinction

SCD O_4 → Radiative Transfer Modeling (RTM) → Aerosol Profile → RTM + trace gas SCD + Optimal Estimation → Trace Gas Profiles

RTM settings			
Parameter	**Settings**		
wavelength	428nm (IO), 455nm (glyoxal), 445nm (H_2O), 477nm (O_4)		
ground albedo	8%		
solar zenith angle	from measurements		
solar azimuth angle	from measurements		
viewing direction	from measurements		
field of view	0.17°		
Atmosphere		**Aerosol and clouds**	
pressure	in-situ	profile	t.b.d.
temp	in-situ	AOD/AOD	t.b.d.
O_4 profile	from p, T	SSA	0.99
O_3, NO_2 profile/VCD	in-situ/ sat.	g/g	0.75

- aircraft in-situ sensors
- microwave temperature profiler

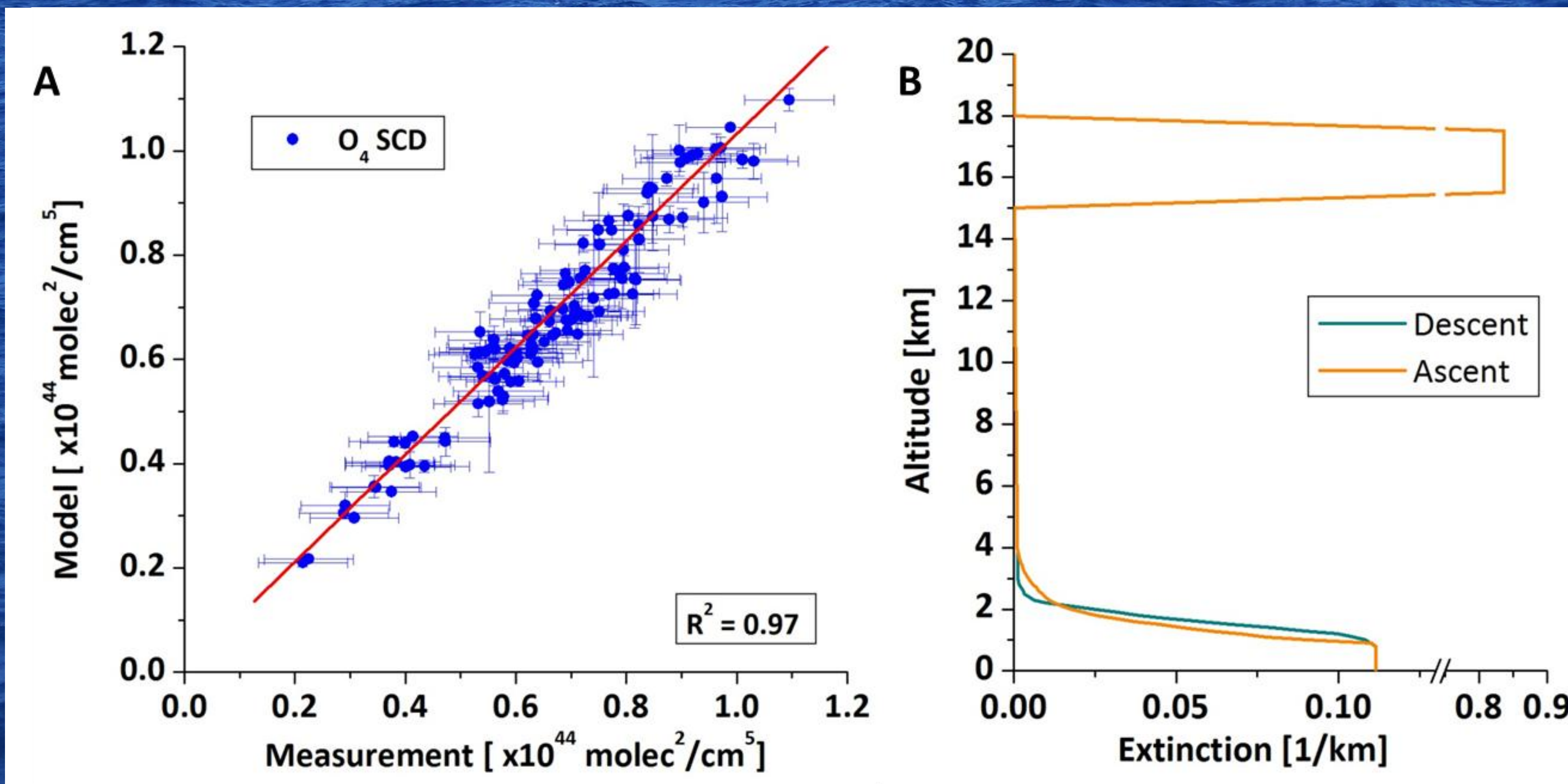
- HSRL

- inferred from HARP irradiance

- aerosol size distributions

3 Profile retrieval - 3.2 aerosol extinction

SCD O_4 → Radiative Transfer Modeling (RTM) → Aerosol Profile → RTM + trace gas SCD + Optimal Estimation → Trace Gas Profiles



3 Profile retrieval - 3.3 trace gas inversion

SCD O_4 ⇨ Radiative Transfer Modeling (RTM) ⇨ Aerosol Profile ⇨ RTM + trace gas SCD + Optimal Estimation ⇨ Trace Gas Profiles

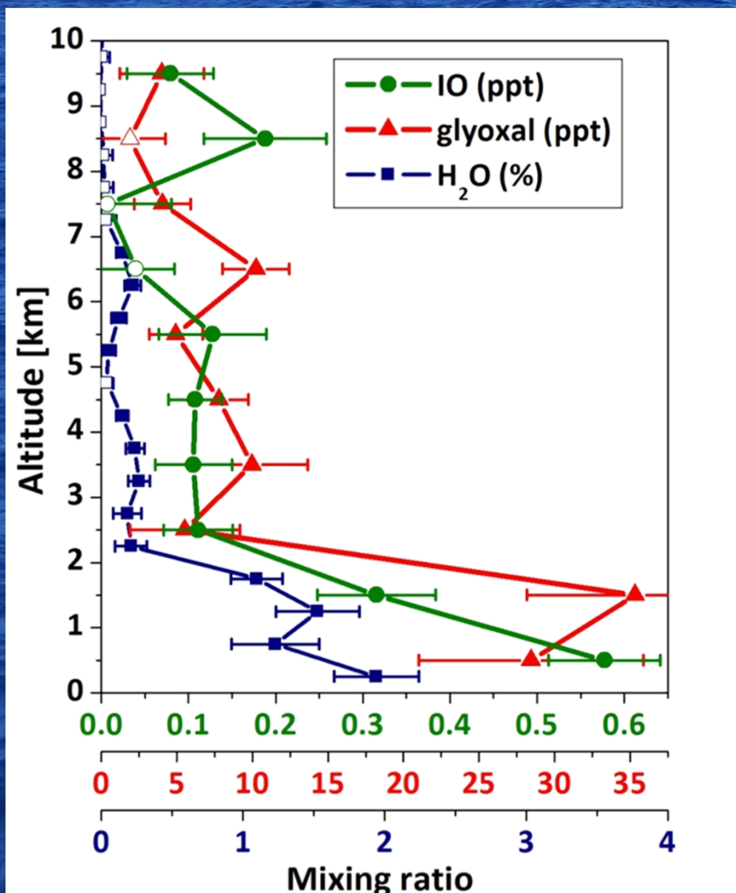
⇨ $$\mathbf{y} = \mathbf{F}(\mathbf{x}, \mathbf{b}) + \boldsymbol{\epsilon}$$

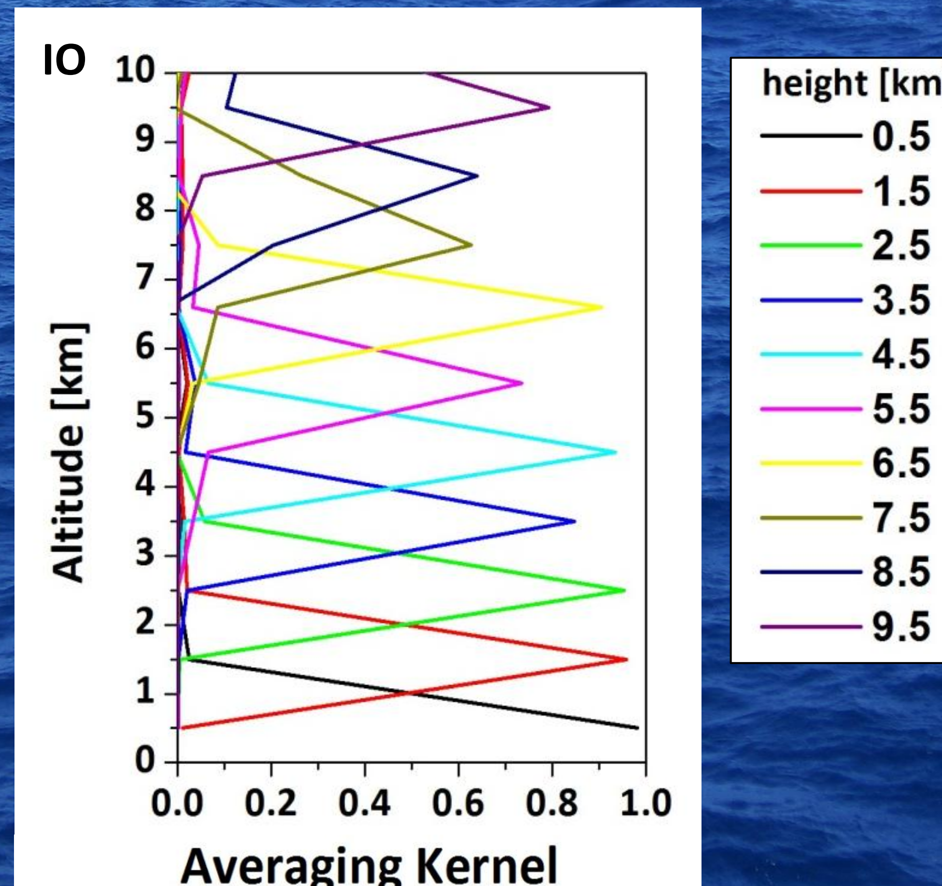
SCD = F (c, RTM param.) + ΔSCD

→ Baidar S. et al., *The CU Airborne MAX-DOAS instrument: ground based validation, and vertical profiling of aerosol extinction and trace gases*, in prep.

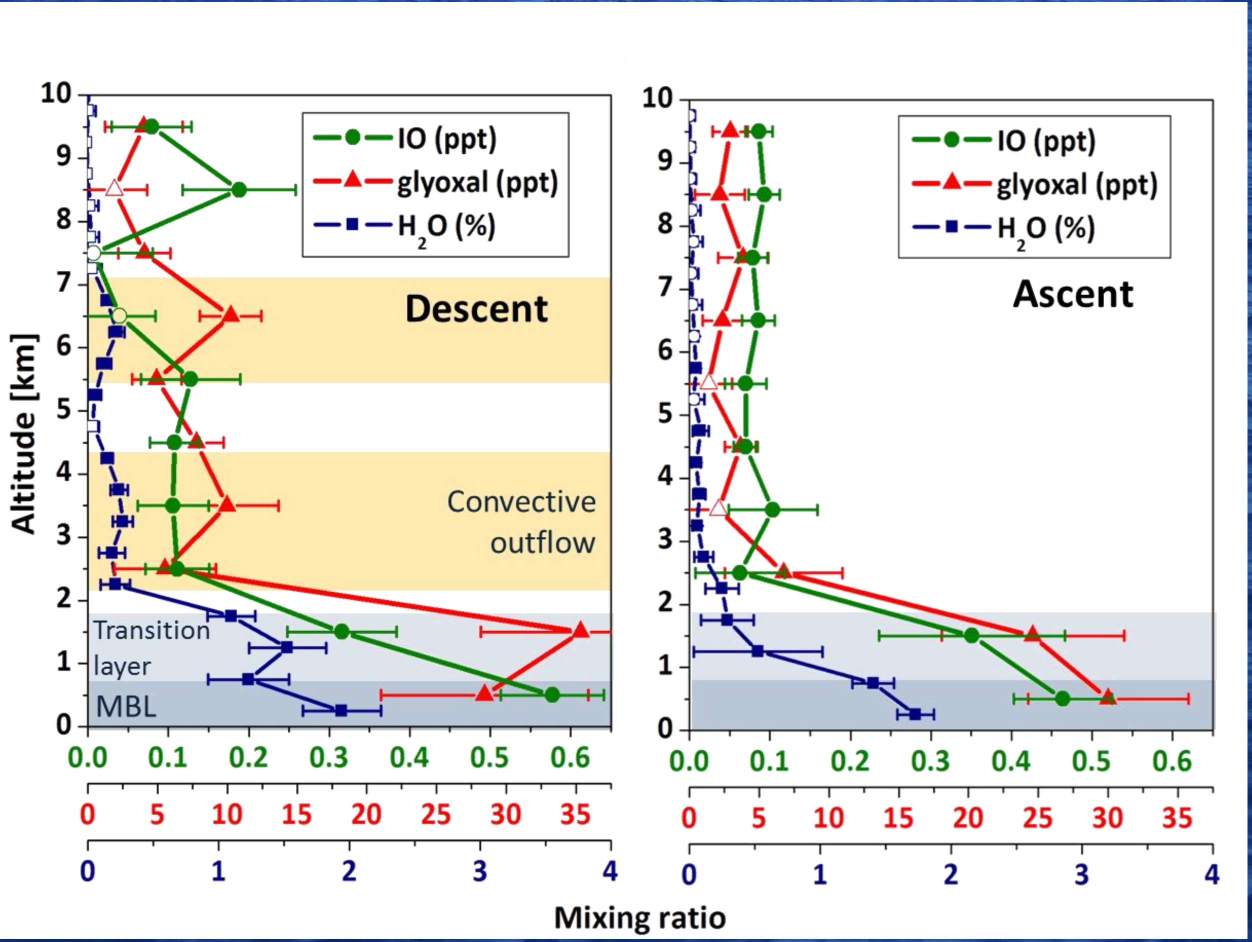
3 Profile retrieval - 3.3 trace gas inversion

SCD O_4 → Radiative Transfer Modeling (RTM) → Aerosol Profile → RTM + trace gas SCD + Optimal Estimation → Trace Gas Profiles



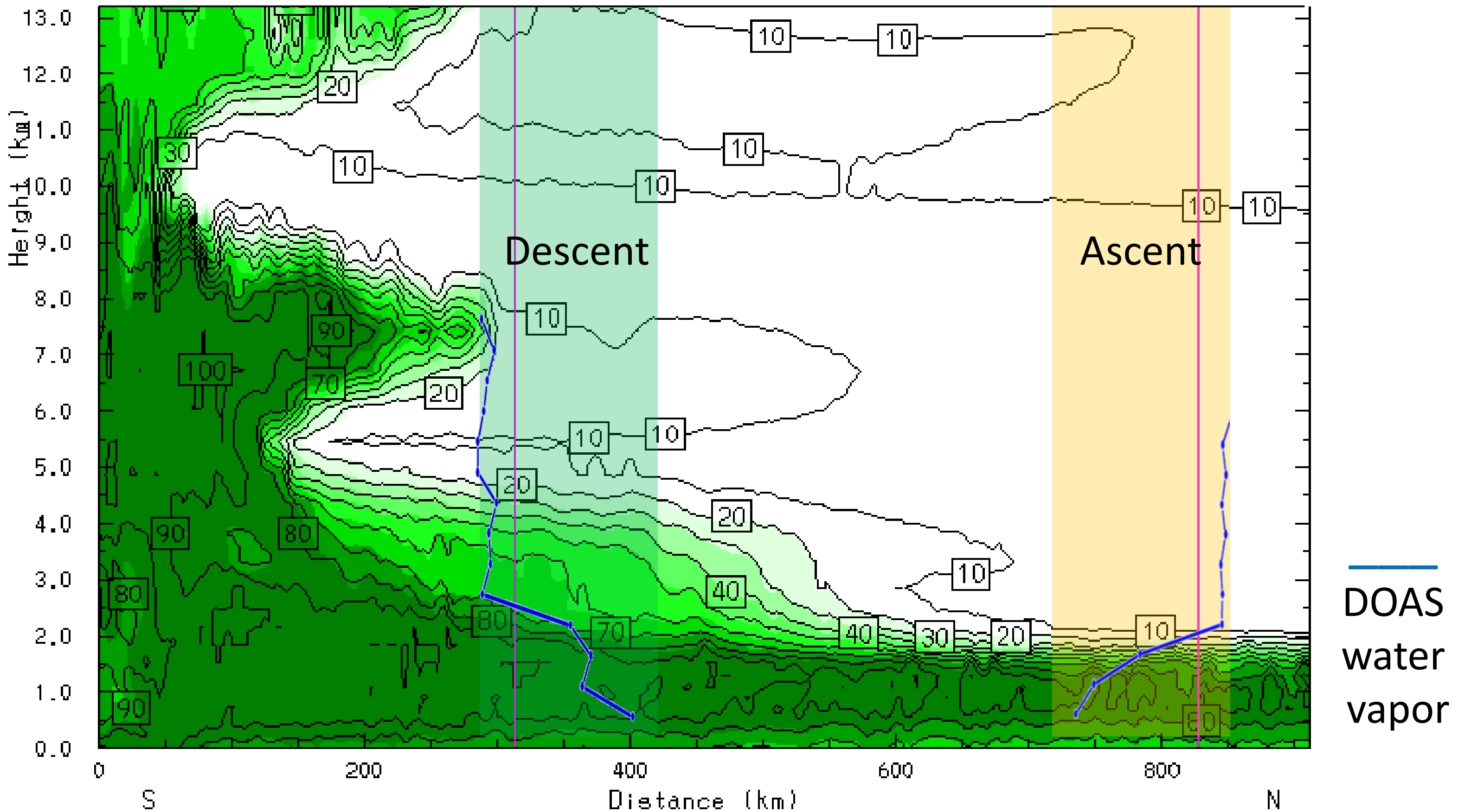


4 Results - 4.1 HEFT-10 IO, glyoxal and H_2O profiles



4 Results - 4.2 meteorological modeling

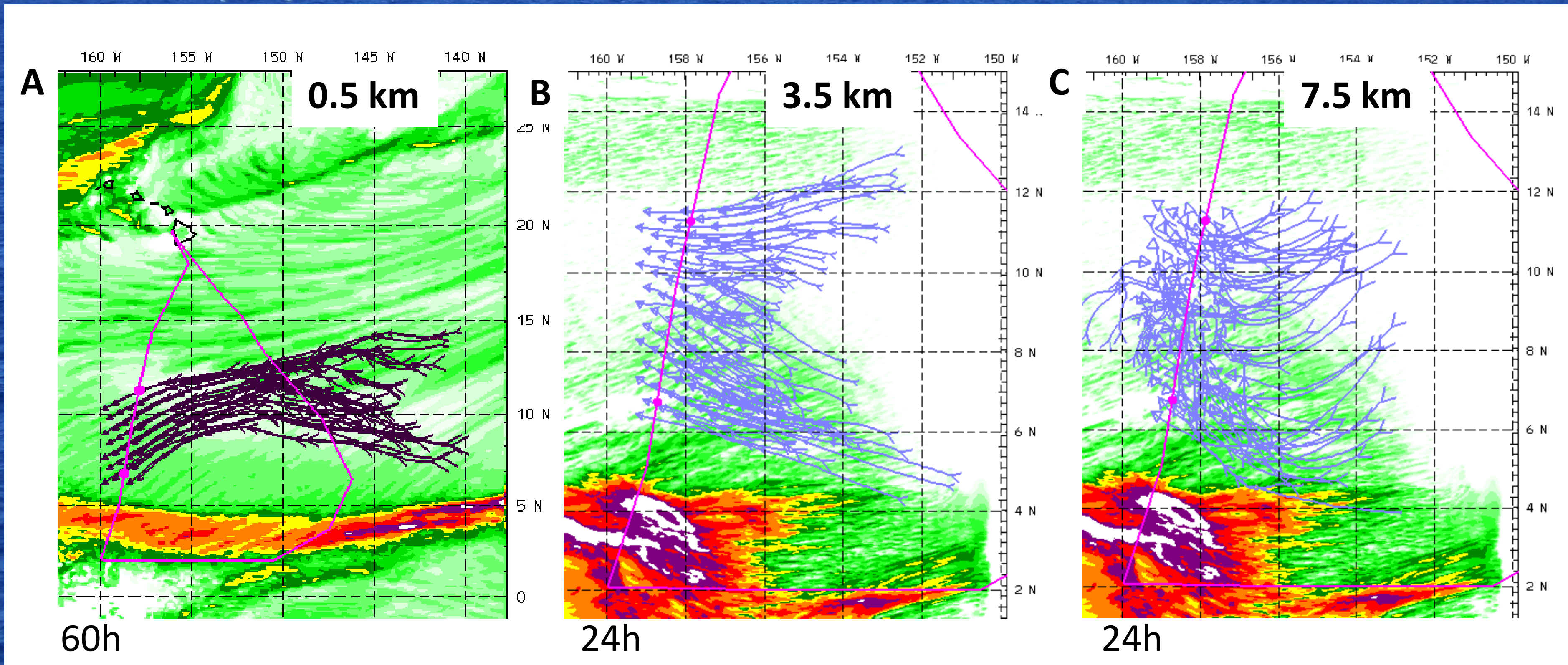
RH cross section along flight track (24h high resolution WRF analysis)



→ Role of deep convection/detrainment?

WRF analysis by Jim Bresch

4 Results - 4.2 meteorological modeling



IO and glyoxial in fresh and aged FT air

→ presence over large spatial scales

WRF analysis by Jim Bresch

Refreshed?

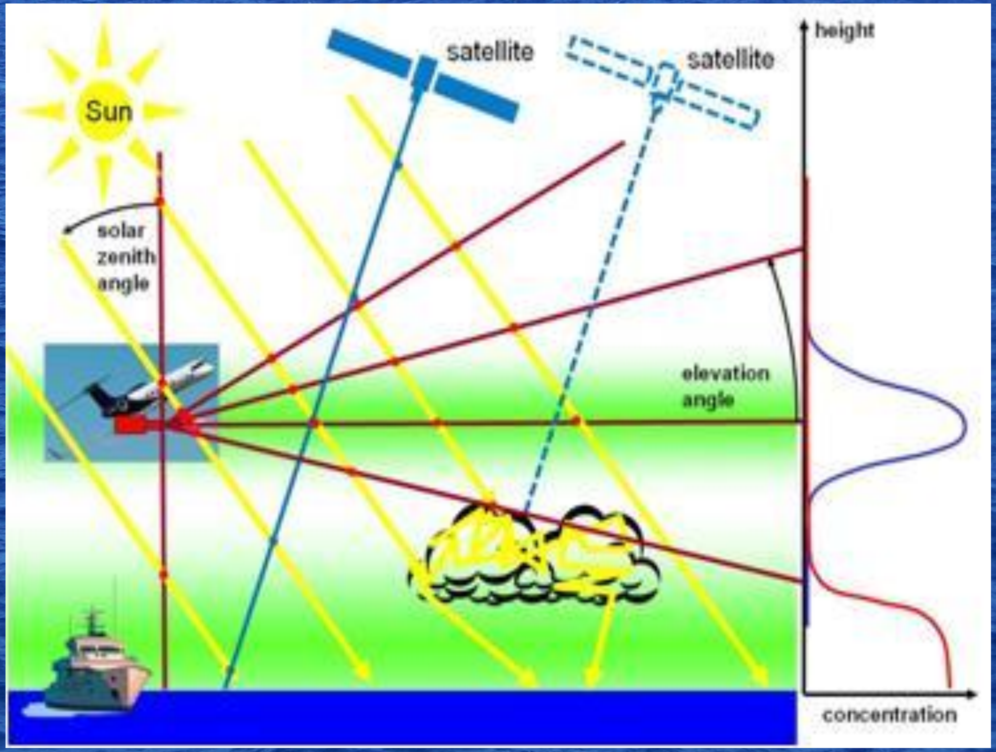
4 Results – 4.4 implications for satellite retrievals

Satellites provide:
- global view
- remote ocean access

Satellite maps are used:
- to constrain models
- to compare to meas. and models
- to scale sources

Quantification of satellite SCDs is complicated by:

- altitude dep. sensitivity
- need for a priori profiles
- changing cloud cover
- low ocean albedo



4 Results – 4.4 implications for satellite retrievals

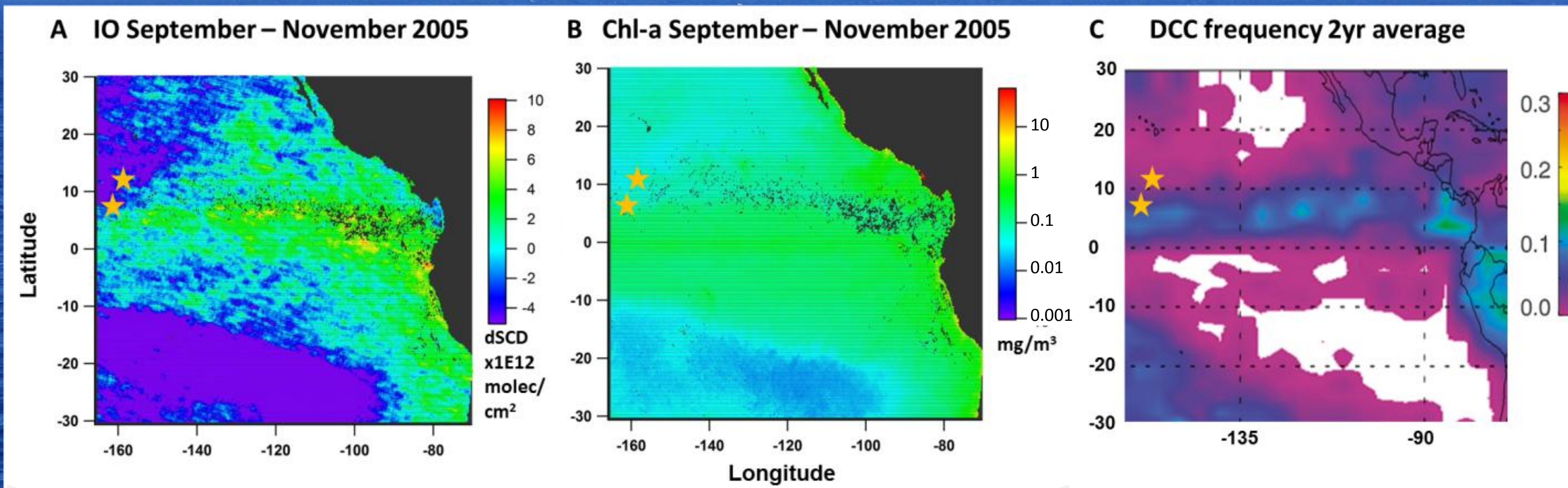
Simulation of satellite nadir view of retrieved IO and glyoxal profiles

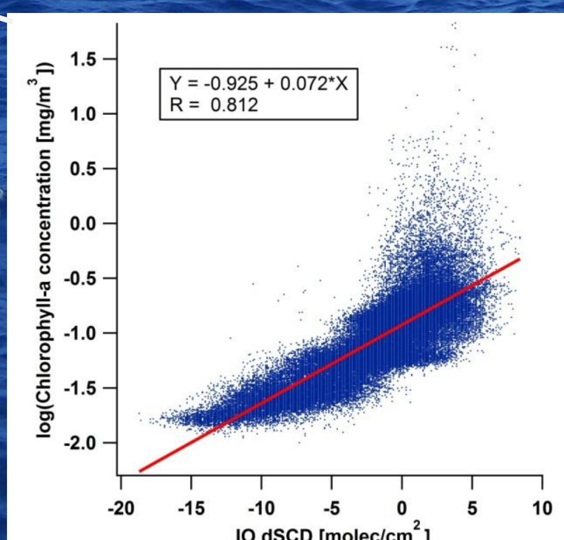
Comparison of averaged retrieved VCDs and modeled satellite SCDs

Trace Gas	VCD				Cloud Cover	SCD				VCD Bias*
	Total	MBL	Trans. Layer	FT		Total	MBL	Trans. Layer	FT	
IO x10^{12} molec/cm^2	2.71	0.94	0.76	1.01	0%	4.25	0.99 (23.3%)	1.17 (27.5%)	2.09 (49.2%)	1.5
					20%	4.34	0.60 (13.8%)	1.29 (29.7%)	2.45 (56.5%)	2.5
					40%	4.38	0.39 (8.9%)	1.36 (31.1%)	2.63 (60.0%)	3.8
glyoxal x10^{14} molec/cm^2	1.76	0.55	0.60	0.61	0%	2.74	0.57 (20.8%)	0.91 (33.2%)	1.26 (46.0%)	1.5
					20%	2.88	0.34 (11.8%)	1.04 (36.1%)	1.50 (52.1%)	2.6
					40%	2.96	0.23 (7.8%)	1.10 (37.1%)	1.63 (55.1%)	4.0

* Based on widely made assumption that satellites indicate BL processes

4 Results – 4.3 implications for satellite retrievals

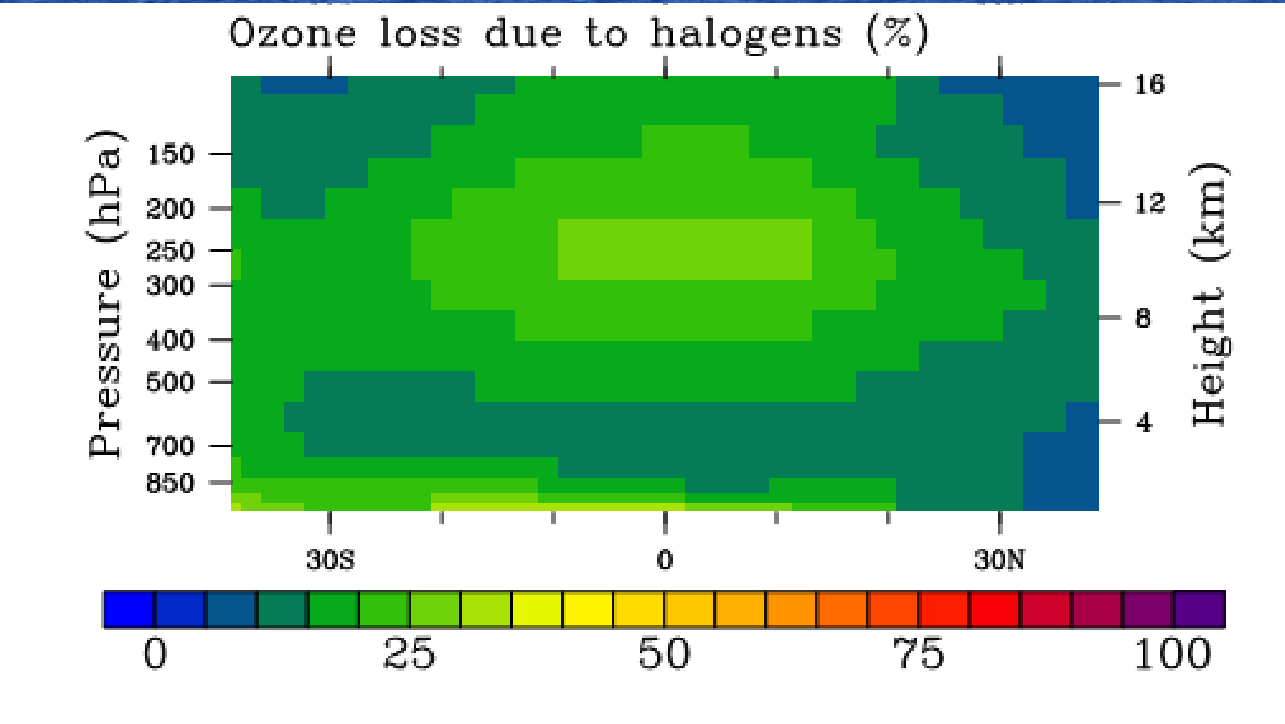




R = -0.7
MBL correlation
Mahajan AS et al. (2012)

Schönhardt A et al.(2008)
NASA Aqua/MODIS
Sassen K et al. (2009)

4 Results – potential atmospheric implications



oceanic iodine + bromine species: 10% depletion of tropical tropospehric ozone (annual average)

modeled IO mixing ratio UT: ~0.02 ppt

Saiz-Lopez et al. 2012

5 Summary and Conclusions

- HIAPER/TORERO flights well suited for FT trace gas profile retrievals:
  - distance and altitude range
  - auxiliary measurements and modeling (TORERO)

- First evidence for IO and CHOCHO in the tropical FT
- First IO detection from research aircraft
  $\rightarrow$ regular detection during TORERO

- IO and glyoxal in fresh and aged FT air
- ~ 2/3 of vertical columns are *above* MBL
  $\rightarrow$ potential for reactive halogen species and OVOCs in FT on global relevant scales

5 Summary and Conclusions

- Relevant to the interpretation/quantification of satellite maps:
  - altitude dependent satellite sensitivity
  - possible satellite VCD overestimation by ~ 1.5 – 4
  - spatial decoupling of MBL and FT processes
    - -> - first a priori constraint by our profiles

- Implications for:
  - perception of sources
  - current research focus on MBL
  - atmospheric chemistry (ozone, oxidation capacity, SOA)

B. Dix, S. Baidar, J. Bresch, S. Hall, S. Schmidt, R. Volkamer *Detection of Iodine Monoxide and Glyoxal in the Tropical Free Troposphere*, submitted

Thank You!

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