Tropical Ocean tRoposphere Exchange of Reactive halogen species and Oxygenated voc - TORERO

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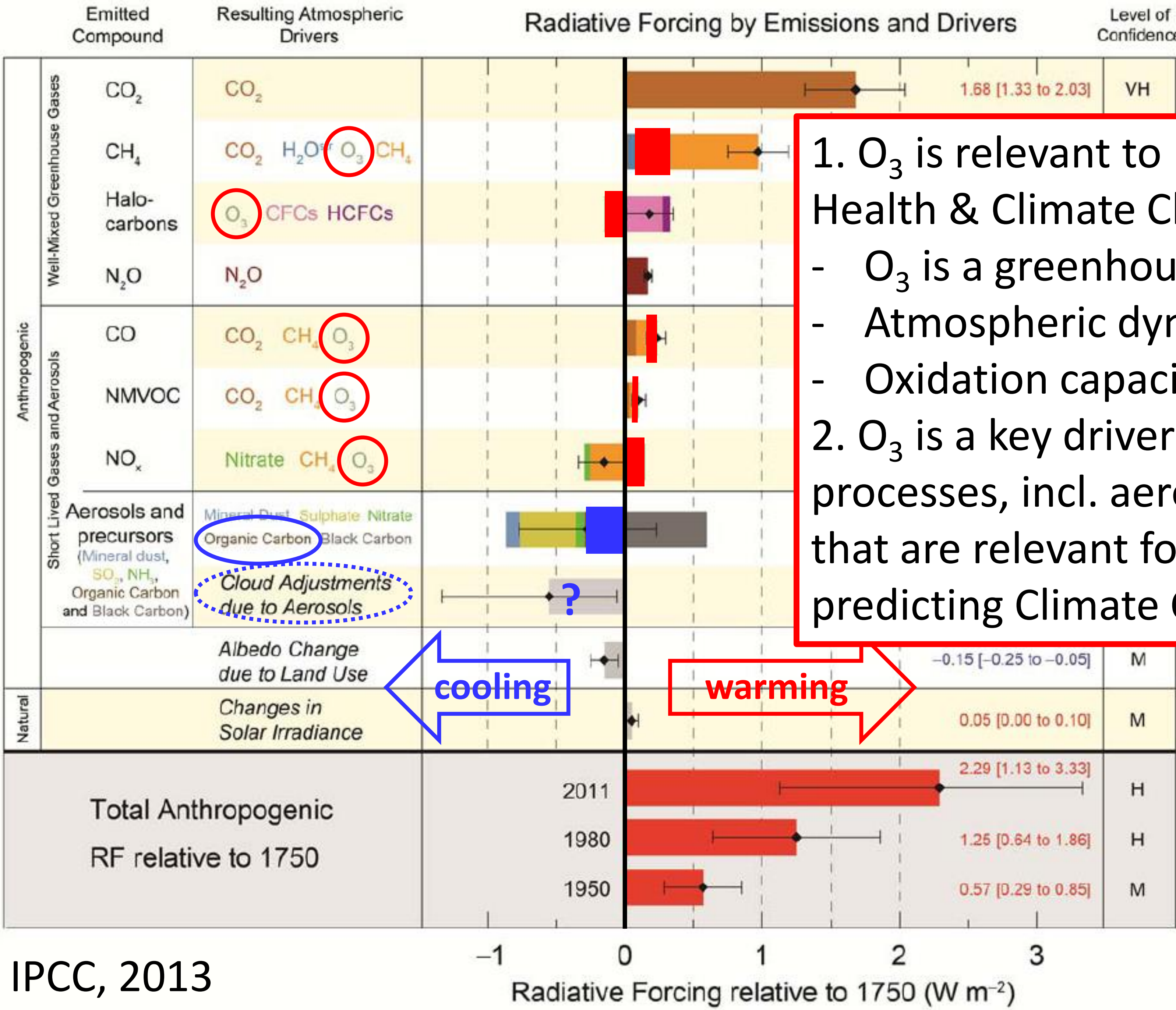
Ocean emissions impact the lifetime of climate active gases in the upper atmosphere

- Scientific questions
- Focus: Technology Innovation

A US contribution to IGBP-SOLAS 'Surface Ocean Lower Atmosphere Study'

CIRES
Cooperative Institute for Research in Environmental Sciences
University of Colorado Boulder

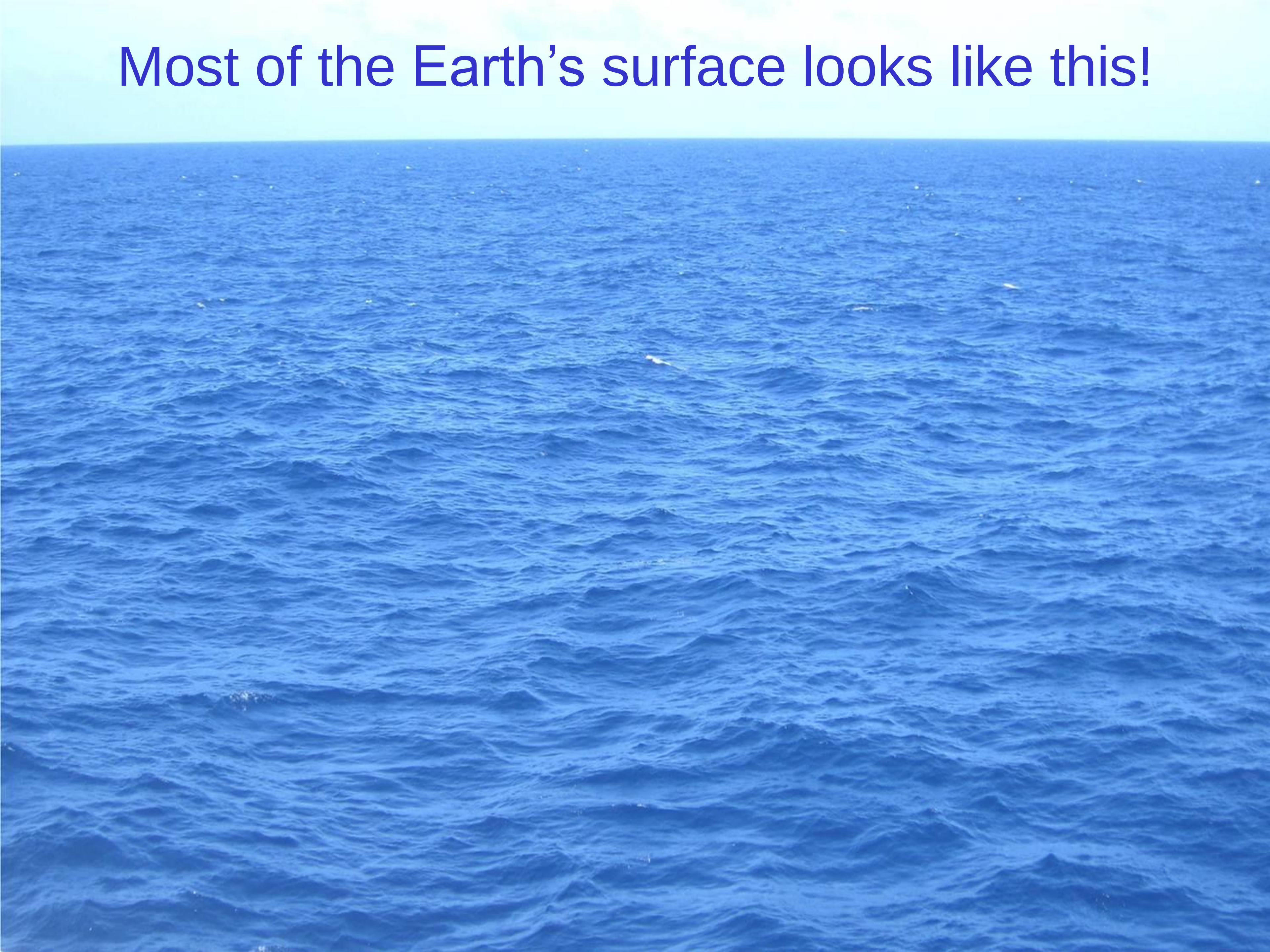


1. O_3 is relevant to Public Health & Climate Change:
- O_3 is a greenhouse gas
- Atmospheric dynamics
- Oxidation capacity

2. O_3 is a key driver to many processes, incl. aerosols, that are relevant for predicting Climate Change

IPCC, 2013

Most of the Earth’s surface looks like this!



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Hypothesis #1: Marine sources of halogens affect the lifetime of climate active gases (O_3, CH_4, DMS) and oxidize atmospheric mercury over much of the tropical air column.

How abundant are halogen oxide radicals (BrO, IO)?
Do we understand their sources?

Hypothesis #2: Glyoxal over oceans is a smoking gun for other oxygenated VOC and 'missing' sources from ocean biology.

Where does it come from, and what comes with it?
What do 4D measurements reveal about the source mechanism?

Myriokefalitakis et al., 2008; Sinreich et al., 2010; Coburn et al., 2011; Dix et al., 2013
Wang et al., 2014 submitted; Volkamer et al., 2014 in prep.

Most of the Earth's surface looks like this!

Hypothesis #3: Is atmospheric oxidation of elemental mercury by bromine in the tropical free troposphere a primary driver for the bioaccumulation of mercury in fish?

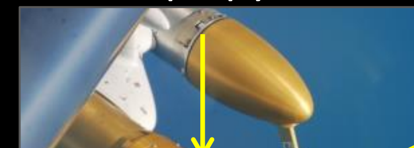
Where does mercury get oxidized in the atmosphere?
What is the lifetime of gaseous elementary mercury?
Do we understand vertical profiles of Gaseous Oxidized Mercury?

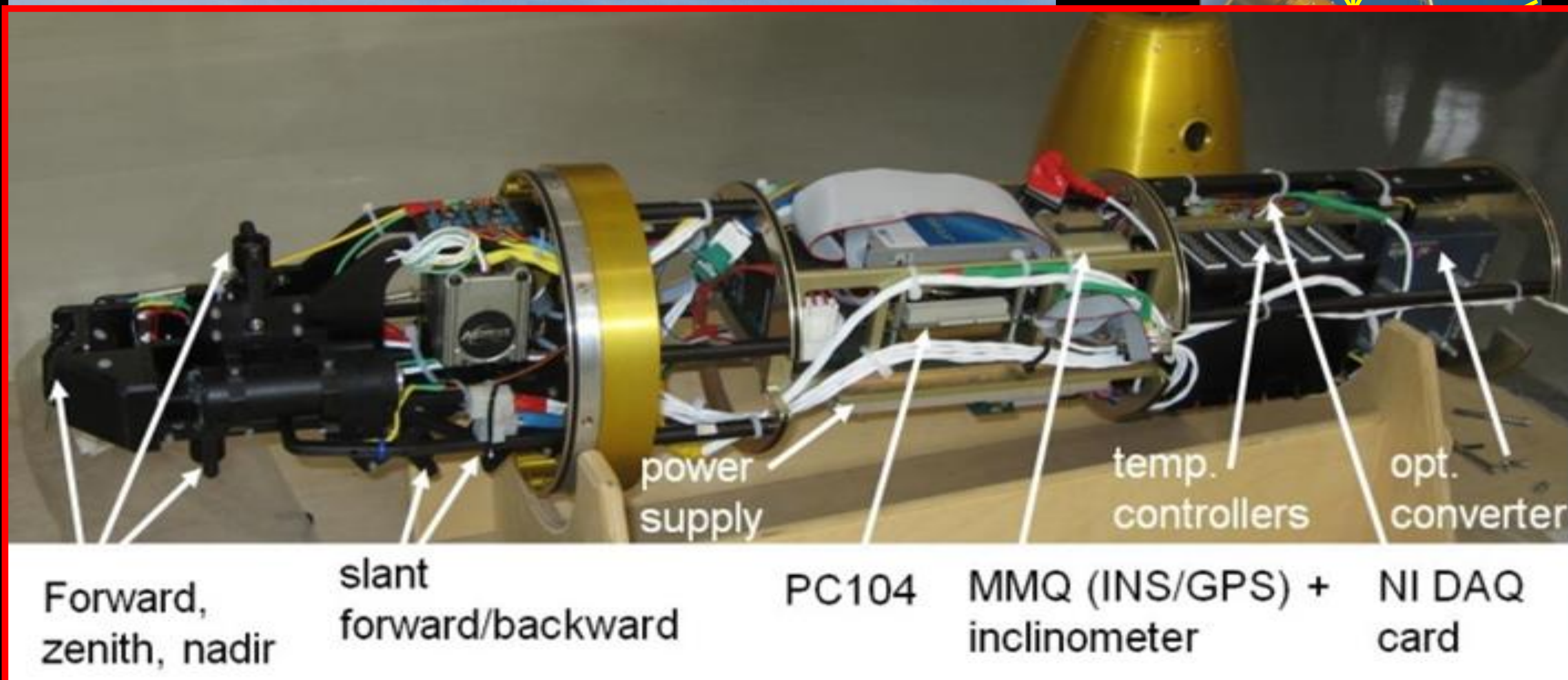
Topic #4: Gain a wider perspective on the chemistry and climate effects of O_3 and water vapor changes in the tropical FT (and lower stratosphere)

CU-AMAX-DOAS instrument aboard NSF/NCAR GV

University of Colorado Airborne Multi-AXis Differential Optical Absorption Spectroscopy

Telescope pylon





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

Trace Organic Gas Analyzer (TOGA)

VOCs: NMHCs (C3-C10), OVOCs (C2-C9), HVOCs

High selectivity GC/MS
2 minute continuous analyses of 50 VOCs
Semi-autonomous operation up to 50,000 ft
TORERO, DC3

TOGA on GV aircraft

Eric Apel
Alan Hills
Becky Hornbrook
Dan Riemer (U Miami)

Instrument designed to have very low limits of detection (low – sub pptv)

Remote Sensing

Instrument	Species / Parameters	Detection limit / Accuracy / Comment	Time / Space resolution	PI / Institution
CU AMAX-DOAS	IO BrO OClO NO_2 HCHO CHOCHO	0.1 ppt 1 ppt 0.7 ppt 10 ppt 120 ppt 3 ppt	Acquisition: 2-30 sec Profile scan: 1-5 mins Vertical resolution: ~ few 100 m– few km	Rainer Volkamer (CU Boulder)
HARP	Photon actinic flux: J_{O3}, J_{NO2}, J_{OVOC}, J_{RX}, J_{IxOy}, etc. Hyper spectral irradiance Surface albedo Cloud optical depth + Percent cloud cover Cloud/Aerosol eff. radius Single scattering albedo Asymmetry parameter	~ 9 % (280–680 nm) < 5 % (260–2217 nm) < 3 % ~ 3 % ~ 5 % ± 0.03 ~ 0.1	0.1 – 3 sec 1 sec inferred by difference from hyper spectral irradiance data	Sam Hall (NCAR/ACD) Sebastian Schmidt (CU Boulder)
GV-HSRL	Aerosol Backscatter, Depolarization, Extinction altitude profiles	$1x10^{-9}$ m^{-1} sr^{-1} ~ 1% $2x10^{-8}$ cm^{-1}	Acquisition: 0.5 sec Profile time: 3-5 mins Vertical res.: 7.5 m Range: 30 km	Ed Eloranta (U Wisconsin)
Microwave Temperature Profiler	Altitude temperature profile	1 K (near plane) < 2 K (within 6km from plane)	Profile scan: 18 sec Vertical resolution: ~150 m to few km	Julie Haggerty (NCAR/RAF)

In-situ instruments

TOGA-HIAPER	Alkylhalides (incl. CH_2X_2, CH_2XY, CH_3X, C_3H_7X) VOC (incl. DMS, C_5H_8, monoterpenes) OVOC (incl. CH_3CHO, DMSO, C_2H_5OH, acetone, MACR, MVK, acetonitrile)	0.1 - 1 ppt* 3 - 10 ppt* 3 - 10 ppt*	2 mins * Detection limits are a function of how many species are measured simultaneously. Upper limits: ~50 species	Eric Apel (NCAR/ACD)
O_3	O_3	$1.5x10^{10}$ molec cm^{-3}	1 sec	Ru-Shaun Gao (NOAA/ESRL)
VCSEL	Water vapor	< 1 ppm	0.04 sec	Stuart Beaton (NCAR/RAF)
Hygrometers	Water vapor	± 0.1°C	10 - 120 sec	EOL facility instrument
CO	CO	2 ppb	3 sec	Frank Flocke (NCAR/ACD)
CN / NMASS	Aerosol number (nucleation mode)	0.2 # cm^{-3} (integral # / 6 and 15 nm cutoff)	1 sec	Dave Rogers (NCAR/RAF) Chuck Brock (NOAA/ESRL)
UHSAS	Aerosol size distribution	1 cm^{-3} (60-1000 nm)	1 sec	EOL facility instrument
Cloud droplet probes	Cloud droplet size distribution	2-50 µm	1 sec	EOL facility instrument
Cloud 2-D imaging spectrometers	Distinguish ice and water droplets / Cloud droplet size distribution	18-640 µm 25-1600 µm	N/A	EOL facility instrument
DVR	Video stream	Forward view	1 sec	EOL facility instrument
Ozone/water vapor sonde launches from the surface (ship /Galapagos Island)	Water vapor O_3 GPS Position Temperature Pressure	< 0.8 ppm < 3 ppb ~ 25 m < 0.5 K	Vertical res.: ~50m	Rainer Volkamer (CU Boulder) Holger Voemel (CIRES/DWD)