Guam, January & February 2014

- ATTREX Airborne Tropical TRopopause EXperiment
  - NASA Global Hawk (GH)
  - PI: Eric Jensen
  - Remotely piloted GH will sample below and above the tropical Cold Point Tropopause (CPT) and can stay aloft for 24 hours
  - GH will take off and land at Andersen Air Force Base in Guam
- CONTRAST CONvective TRansport of Active Species in the Tropics
  - NCAR Gulfstream V (GV)
  - coPIs: Elliot Atlas, Laura Pan, Ross Salawitch
  - GV sample to max altitude of ~14.5 km (above Q=0) via a series of 6 to 8 hr flights taking off and landing at A.B. Won Pat Airport, Guam
- CAST Coordinated Airborne Studies in the Tropics
  - BAe-146
  - PI: Neil Harris
  - BAe-146 will characterize composition of marine boundary layer (MBL) and lower troposphere via takeoffs and landing at Guam (13.5°N), Chuuk (7.5°N), Palau (7.3°N)

Guam, January & February 2014

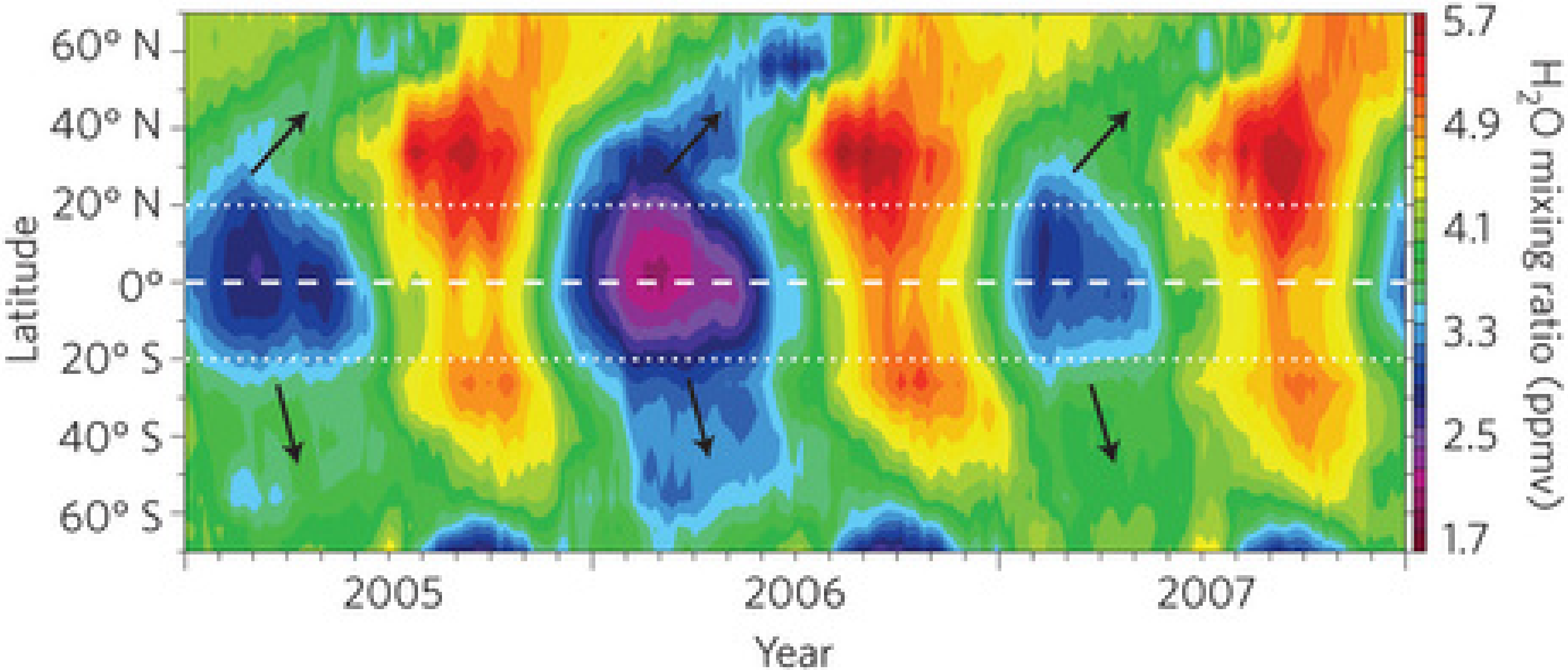
Motivations

- Tropopause Transition Layer (TTL)/Tropical Western Pacific (TWP) during boreal winter:
  - Most extensive deep clouds in climate system
  - Stratospheric humidity controlled by processes in TWP cold point tropopause
  - Chemical environment not well characterized
- Stratospheric transport of very short lived (VSL) species
  - Low O_3 / NO_x environment of this regions should be associated with low OH
  - Warm, nutrient rich, prevalent coastal waters should be active source of DMS and biogenic halocarbons
  - Energetic convection can place DMS & halocarbons near (or above) Q = 0
  - Low OH could extend lifetime of DMS & VSL halocarbons
- Tropospheric fate of very short lived (VSL) species
  - Halogen chemistry could play:

    a) dominant role for the oxidation of DMS

    b) important roe for photochemistry of tropospheric O_3

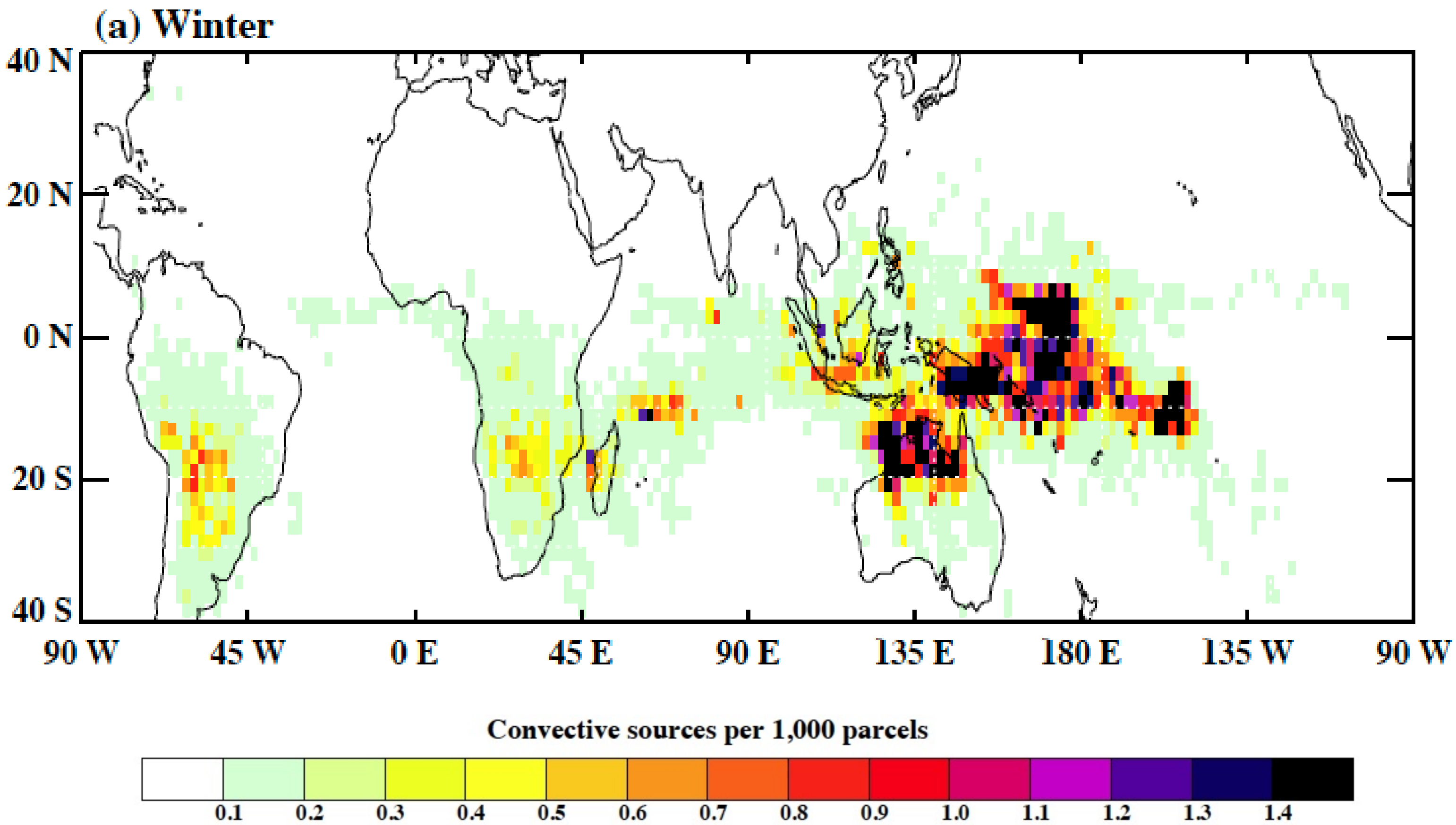
Lower Stratospheric Water



Strong annual cycle of lower stratospheric H_2O related to minimum tropical tropopause temperatures during the boreal winter

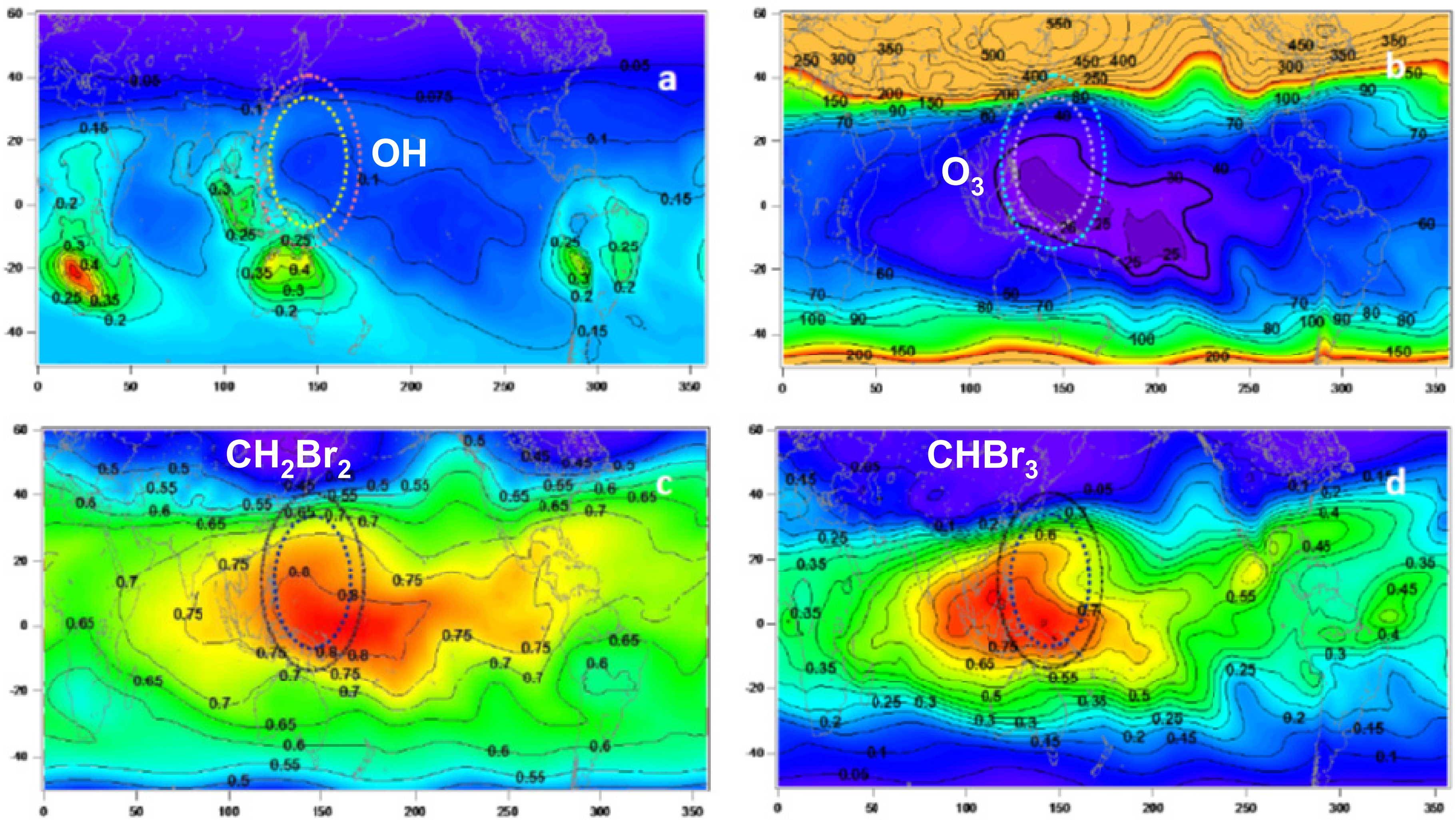
Randel and Jensen, Nature Geoscience, 2013

Geographic Origin of Convective Detrainment at 380 K



Bergman et al., JGR, 2012

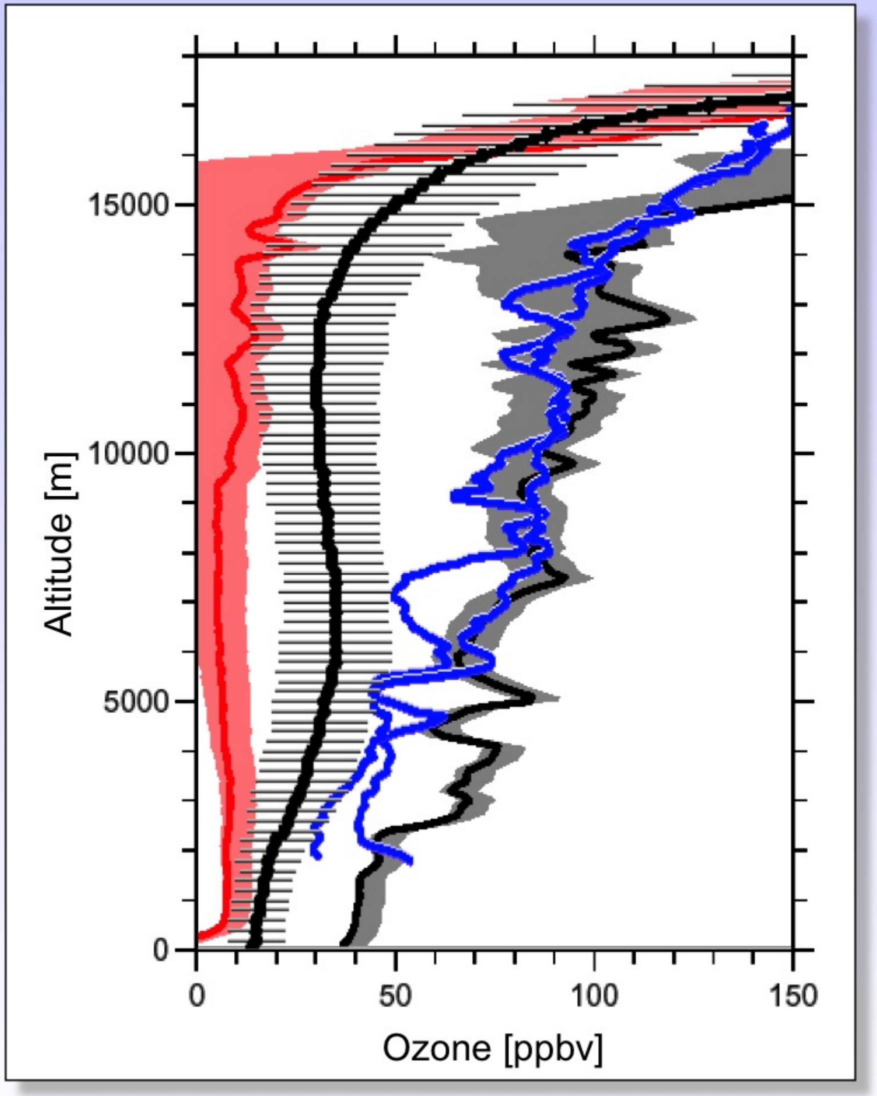
CCM Fields, January, 200 hPa



Calculated distributions, **CAM-CHEM**, for January at 200 hPa.
Concentric ovals indicate range of GV aircraft for a 6 hr flight and 8 hr flight, respectively.

Kinnison and Lamarque, CONTRAST Proposal

Ozonesonde Measurements, Oct 2009



Ozone profile measurements in the West Pacific

Extratropical West Pacific ~30°

Tropical Atlantic

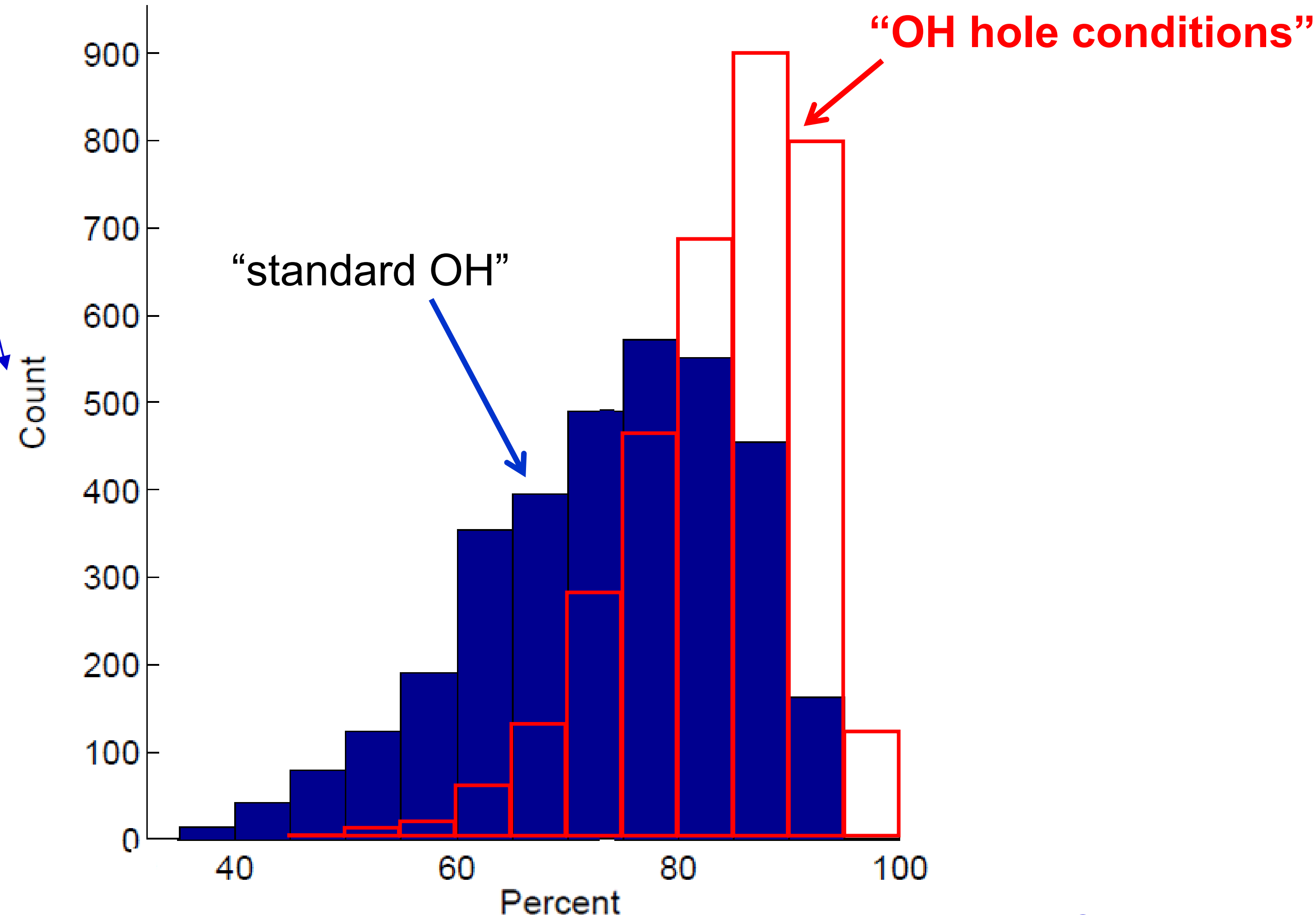
Tropical West Pacific

Samoa

Rex et al., ACPD, 2013

Consequence of low OH associated w/ low O_3, NO_x

Fraction of surface CH_2Br_2 reaching cold point tropopause



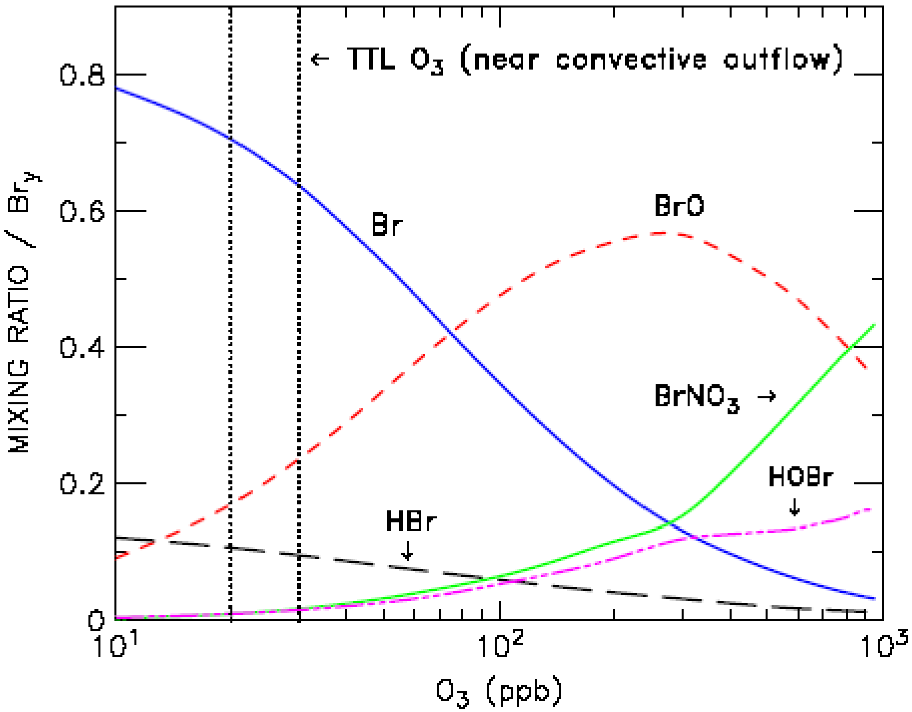
Rex et al., ACPD, 2013

Low Ozone affects Chemical Partitioning

Prior obs & modeling: SGI (source gas injection) of stratos Br_y is probably 5 to 7 ppt

Prior obs & modeling: PGI (product gas injection) of stratos Br_y highly uncertain: depends on efficiency of aerosol uptake and washout versus het chem release of labile bromine and strength of convection

Huge challenge: Br_y partitions to Br under low O_3 during daytime

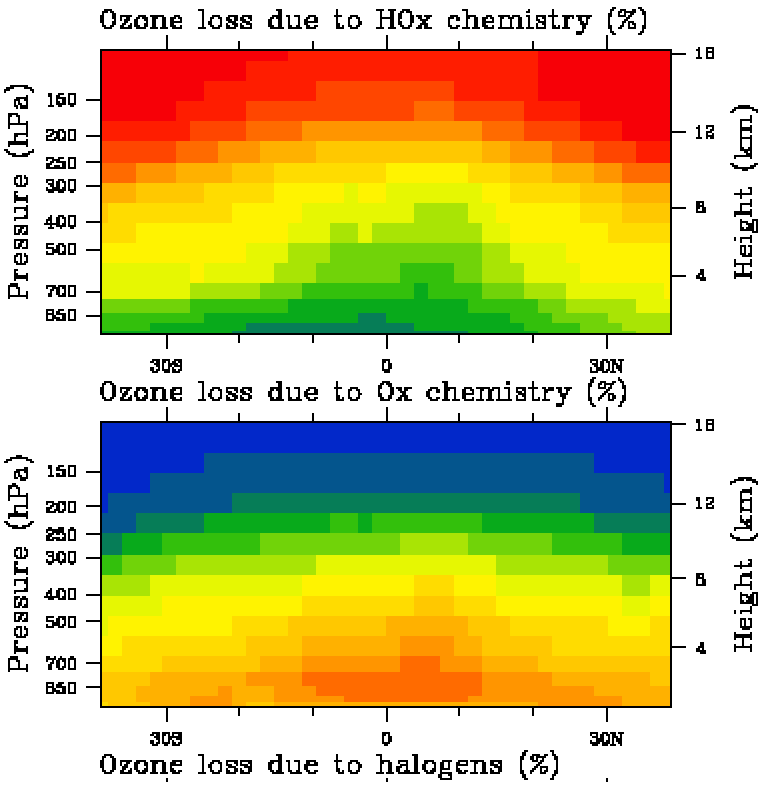


Br*: experimental method for quantifying atomic Br by exposing air to propene (C_3H_6) and NO, which produces stable bromine compounds that can be analyzed by Whole Air Sampler

e.g., Impey et al., JGR, 1997

Salawitch, CONTRAST Proposal

Halogens may be factor driving Low Ozone



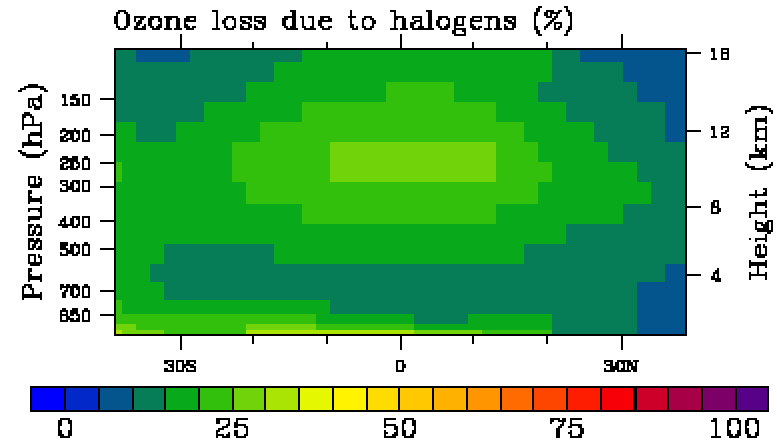
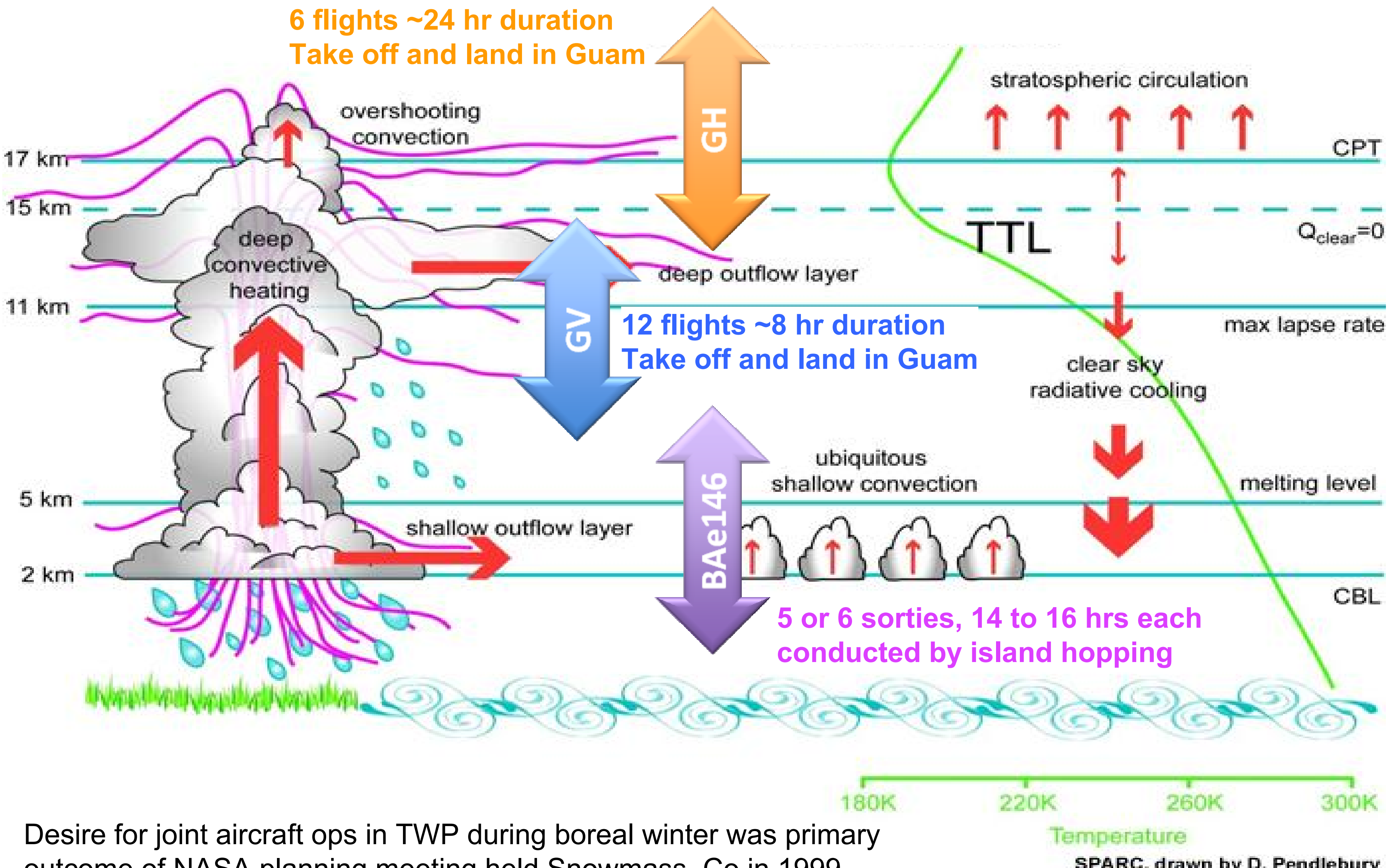


Fig. 6. Percentage of the annually integrated chemical ozone loss from HO_X, O_X and halogen photochemistry as simulated by CAM-Chem.

The integrated contribution of iodine-mediated reactions to the total rate of surface ozone loss is three times larger than that of bromine chemistry alone. When both chemistries are combined via the reaction of IO + BrO to Br + OIO (75 %) and Br + I (25 %), the ozone loss rate is fourfold that of bromine chemistry alone.

Saiz-Lopez et al., ACP, 2012

Coordinated flights of ATTREX, CONTRAST, & CAST aircraft key component of observing strategy



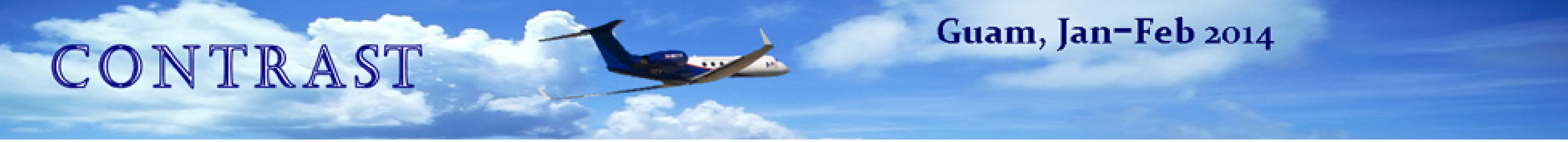
Desire for joint aircraft ops in TWP during boreal winter was primary outcome of NASA planning meeting held Snowmass, Co in 1999

ATTREX GH Payload

Acronym	Weight (lb)	Power (W)	Measurement	Sampling Rate	Precision	Accuracy
CPL	366		Aerosol/Cloud Backscatter	1 Hz	10-15% backscatter	15-25% extinction
O_3	40	200	O_3	2 Hz	1.5 x 10^{10} molecules cm^{-3}	5% + precision
AWAS	200	300	~60 tracers with lifetimes of 1 week to years	80 samples per flight	Various, typically 1-10%	Various, typically 2-20%
UCATS	60	250 (450)[a]	O_3	10 s	> 1 ppb or 2%	> 2 ppb or 3%
			H_2O	1 s	2-3%	3-5%
			CH_4	140 s	0.4-0.8%	1%
			N_2O	70 s	0.2-0.5%	1%
			CO	140 s	2-5%	1%
			H_2	140 s	2-3%	1%
			CFC-11*	70 s	0.3-0.6%	1%
			CFC-12*	70 s	0.3-0.6%	1%
			Halon-1211*	70 s	0.5-0.8%	1%
			SF_6	70 s	0.2-0.5%	1%
PCRS	45	370	CO_2	5 s	200 ppbv	150 ppbv
			CO	5 min	3 ppbv	15 ppbv
			CH_4	5 s	2 ppbv	1 ppbv
ULH	24	260	H_2O vapor	1-40 Hz	> 0.05 ppmv or 1%	10%
DLH	50	280	H_2O vapor	100 Hz	1% or 50 ppbv	10%
Hawkeye	135	3200	Ice crystal size distributions, habits	1 Hz	20%	50%
SSFR	40		Radiative Fluxes	20 Hz	0.1%	3%
MMS	65	135	Temperature	20 Hz	0.01 K	0.3 K
			Pressure	20 Hz	0.1 mbar	0.3 mbar
			Horizontal wind	20 Hz	0.01 m/s	1 m/s
			Vertical wind	20 Hz	0.01 m/s	0.1 m/s
MTP	24	51	Temperature Profile	1 prof/15 s	<1 K	<0.05 K
Mini-DOAS	33	28	BrO	50 s	0.9 pptv	8%
			O_3		80 ppbv	2%
			NO_2		20 pptv	5%
			OClO		4.5 pptv	12%
			IO		0.4 pptv	25%
			OIO		0.4 pptv	55%

⇨Downward looking lidar

⇨OCS



CONTRAST GV Payload

Observation	Instrument	Investigator	Meas. Synergy
O_3	Fast O_3	Weinheimer, Campos, Flocke	GH, BAe
H_2O Vapor	VCSEL	RAF	GH, BAe
CO	ACD (VUV)	Campos	GH, BAe
CH_4	ACD (Picarro)	Flocke	GH, BAe
CO_2	ACD (Picarro)	Flocke	GH, BAe
NO, NO_2	ACD (Chemiluminescence)	Weinheimer, Campos, Flocke	BAe
BrO, HOBr, BrCl, Br_2 (in situ)	CIMS	Huey	BAe
BrO, IO, H_2CO (remote)	CU-AMAX (DOAS)	Volkamer	GH
Σ Br+BrO	Br*	Atlas, Flocke, Orlando	None
H_2CO (in situ)	ISAF	Hanisco, Wolfe	None
OCS, Halocarbons, NMHC, short lived tracers	AWAS	Atlas	GH, BAe
DMS, CH_3CN, VOCs, NMHCs, OVOCs, halocarbons	TOGA	Apel, Riemer	GH, BAe
Aerosol (number, size, distribution)	UHSAS	Jensen	BAe
Cloud detection (in situ)	CDP, 2D-C	Jensen	GH
Radiation (UV/VIS)	HARP	Hall	GH, BAe

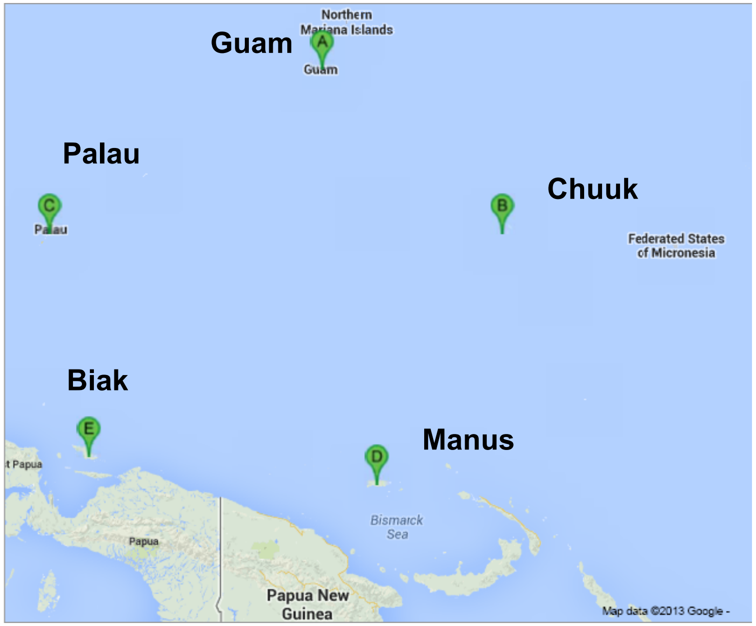
CAST : BAe-146 Payload

Observation	Instrument	Investigator	Meas. Synergy
O_3	TE49C	FAAM	GH, GV
H_2O Vapor	General Eastern 1011 / Buck CR2	FAAM	GH, GV
CO	Aerolaser 5002	FAAM	GH, GV
CO_2, CH_4	Los Gatos	FAAM / Bauguitte + Manchester / Gallagher	GH, GV
N_2O, H_2O	Aerodyne QCLAS	Manchester / Gallagher	GH
VSL halocarbons	Agilent GC-MS / Markes Dual TD *(in situ and WAS)*	York / Carpenter	GH, GV
DMS, NMHC, small OVOC	GC-FID *(WAS)*	York / Carpenter	GH, GV
NO, NO_2	Air Quality Design	FAAM / Bauguitte + York / Lee	GV
BrO, other (in situ)	CIMS	Manchester / Percival	GV
IO, I_2, OIO (In situ)	BBCEAS	Cambridge / Jones	GV (IO remote)
Black carbon	SP-2	Manchester / Gallagher	None
Aerosol	PCASP (Core FAAM)	Manchester/All	GH, GV
Winds/Turbulence/Met	AIMMS-20 (Core FAAM)	Manchester/Vaughan	GH, GV

Ancillary Observations

- **SOWER** Soundings of Ozone & Water in the Equatorial Region
  Hasebe, Inai, Oltmans, et al.
  Biak: 10 sets of CFH + ECC sondes launched Jan-Feb 2014
  Palau: 4 sets of CFH + ECC sondes launched Jan-Feb 2014
  Mie lidar active 20 Jan to 12 Feb 2014
- **CAST**
  Ground-based observations under consideration, possibly from Manus (2°S) ARM Site

O_3 profile	ECC sonde	Manchester / Vaughan
Surface O_3	TE49C	Manchester / Vaughan
CO_2, CH_4, CO	Picarro	Cambridge / Harris
VSL halocarbons	Dirac GC	Cambridge / Harris
Aerosol lidar (tentative)	Leosphere ALS300	Manchester / Vaughan



Websites and Theory Teams

- **ATTREX**

  https://espo.nasa.gov/missions/attrex

  Alexander, Bardeen, Bergman, Kim, Gettelman, Lait, Pan, Pfister, Randel, Rosenlof, Schoeberl, Selkirk, Singh, Ueyama

- **CONTRAST**

  http://www.eol.ucar.edu/field_projects/contrast

  Bergman, Bresch, Canty, Homeyer, Honomichl, Kinnison, Lamarque, Liang, Liu, Luo, Nicely, Orlando, Randel, Robinson, Saiz-Lopez, Shieh, Tilmes, Waugh

- **CAST**

  http://www.faam.ac.uk/index.php/current-future-campaigns/384-cast-2014-co-ordinated-airborne-studies-in-the-tropics

  Angelov, Carpenter, Chipperfield, Evans, MacKenzie, Palmer, Pyle