CAST - Coordinated Airborne Studies in the Tropics

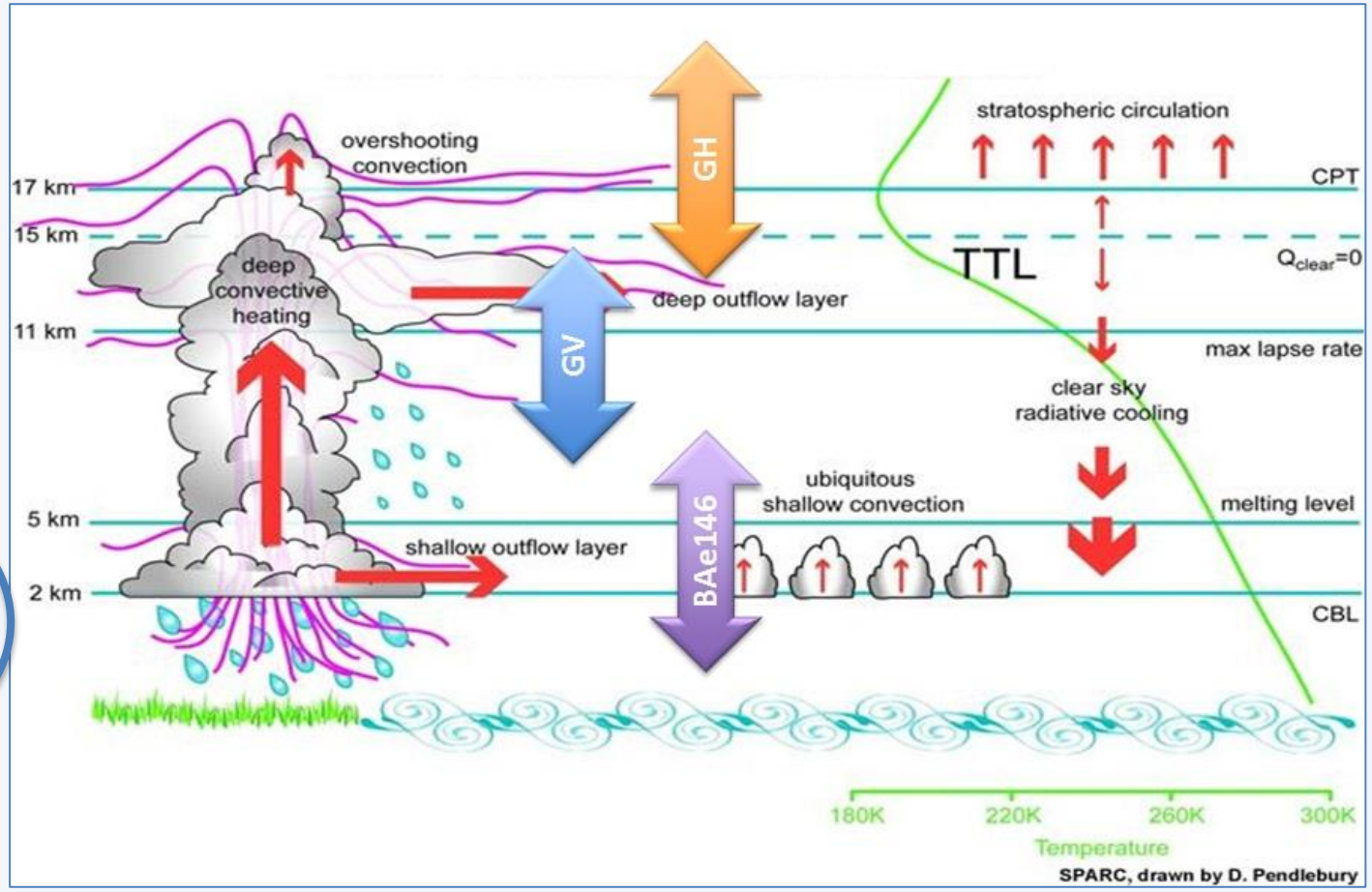
- Field measurements in Jan/Feb 2014
  - FAAM 146 flight plans
  - FAAM 146 instruments
  - Flight planning tools
  - Ground deployment
- Modelling (mainly post-campaign)
- Instrument development

Neil Harris

Boulder, Oct 21-25 2013

CAST - Coordinated Airborne Studies in the Tropics

Field measurements in Jan/Feb 2014



CAST flight plans - Jan-Feb 2014

AIMS

1. Provide comprehensive observations in lower troposphere over W. Pacific
   Z < 6 km; 135-160°E; 0-15°N

2. Measure halocarbon abundances in boundary layer in shallow regions

2. Concentrate on atmospheric tracers and halogen compounds

3. Use these measurements as representative of air in in-flow to convection measured at higher altitudes by GV and GH

BAe-146 Operational Structure

CAST scientists:

PI –	Neil Harris
Mission scientists –	**James Lee**, Lucy Carpenter, Mat Evans, John Pyle, Paul Palmer, Grant Allen

FAAM – campaign operations:

Campaign manager – **Maureen Smith**

DirectFlight – aircraft operations:

Project manager –	**Peter Chappell**
Chief Pilot -	**Finbarre Brennan**

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 / Baugitte + Manchester / Gallagher	GH, GV
N_2O, H_2O	Aerodyne QCLAS	Manchester / Gallagher	GH
VSL halocarbons[1]	Agilent GC-MS / Markes Dual TD	York / Carpenter	GH, GV
NMHC, small OVOC, DMS[2]	WAS	York / Carpenter	GH, GV
NO, NO_2	Air Quality Designs	FAAM + York / Lee	BAe
BrO, other[3] (in situ)	CIMS	Manchester / Percival	GV
IO, I_2, OIO (In situ)	BBCEAS	Cambridge / Jones	None
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

1. $CHBr_3$, CH_2Br_2, $CHBr_2Cl$, CH_3I, CH_2BrCl, $CHBrCl_2$, C_2H_5I, CH_2ICl, CH_2IBr, CH_2I_2, CH_2Cl_2, $CHCl_3$

1. C1-C6, ????

2. HCOOH (formic acid), HCN, $ClNO_2$, HNO_3, N_2O_5, CH_3COOH (Acetic Acid), CH_3CH_2COOH (propanoic acid), $CH_3CH_2CH_2COOH$ (butanoic acid)

Aircraft dates

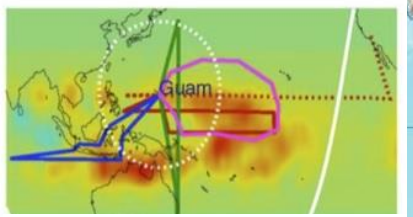
Jan 8:	depart UK
Jan 11:	arrive Guam
Jan 13 – Feb 7:	operational
Feb 9:	depart Guam
Feb 12:	arrive UK

FAAM Bae-146 Flights options (a), (b) – 1 night

Guam 13.5° N,
145° E
Chuuk 7.5° N,
152° E

Sample at < 20 kft (6 km)

Equator



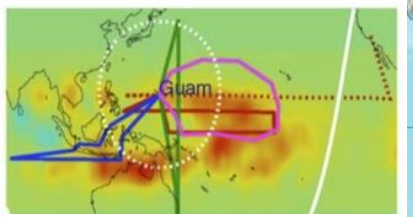
Nominal Global Hawk flights

FAAM Bae-146 Flights option (c) – 2 nights

Guam 13.5° N,
145° E
Chuuk 7.5° N,
152° E

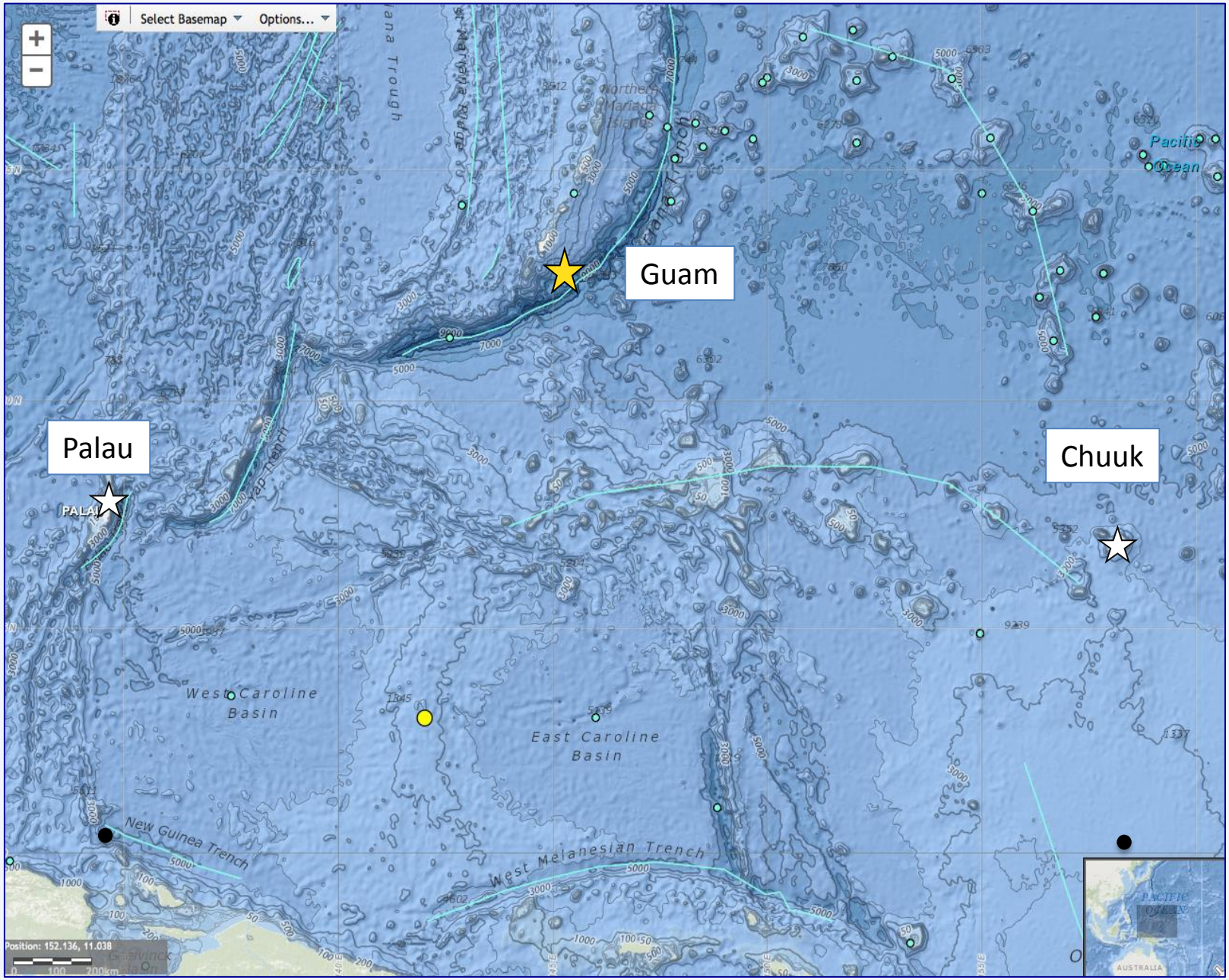
Sample at < 20 kft (6 km)

Equator



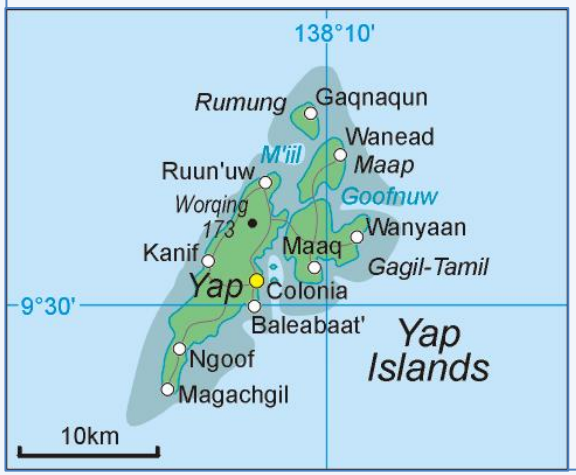
Nominal Global Hawk flights

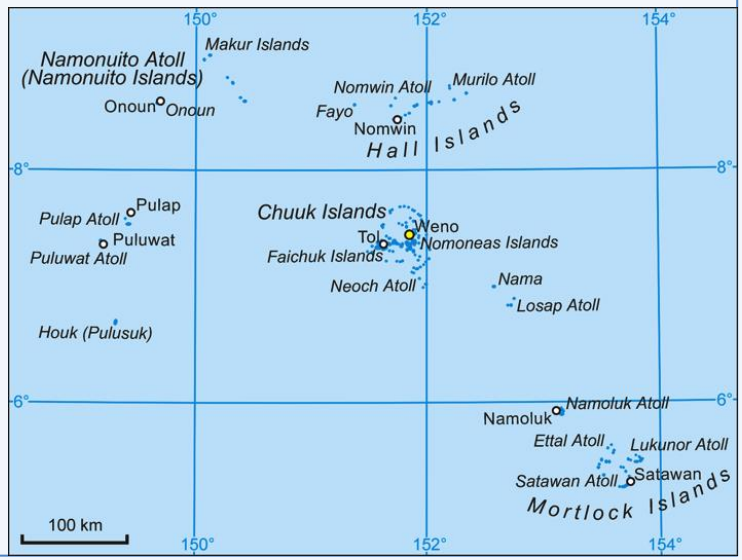
Ocean depth as predictor for VSLS emission - overview



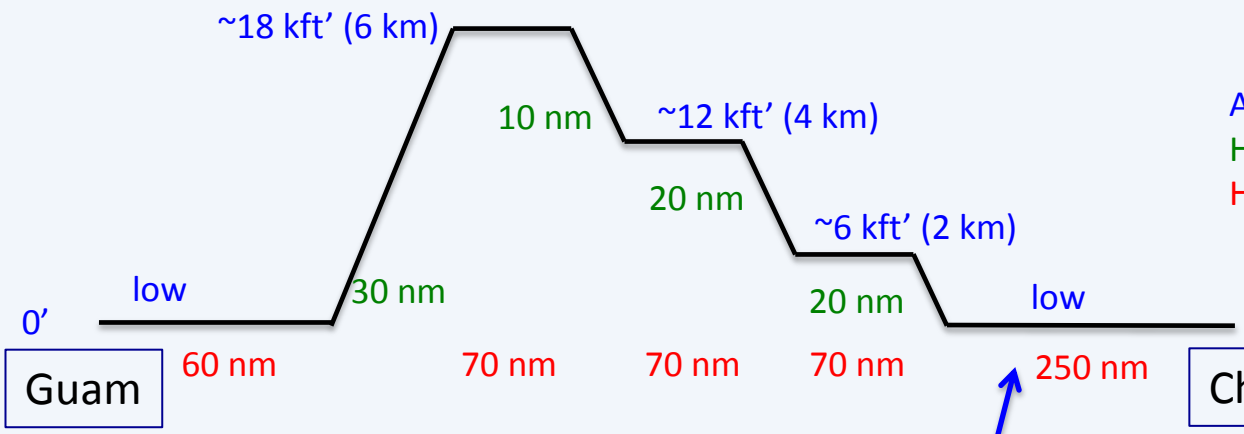
Ocean depth summary

- Guam: drops off steeply all round island
- Chuuk: 40 mile lagoon with max depth 300 ft; many little islands
- Palau: sharp drop off to E, shallower region to W
- Yap: several islands together between Palau and Guam
- Saipan/Tinian: similar except for one bay on NW side
- More islands/atolls on direct line from Chuuk to Palau (could be an option to S)

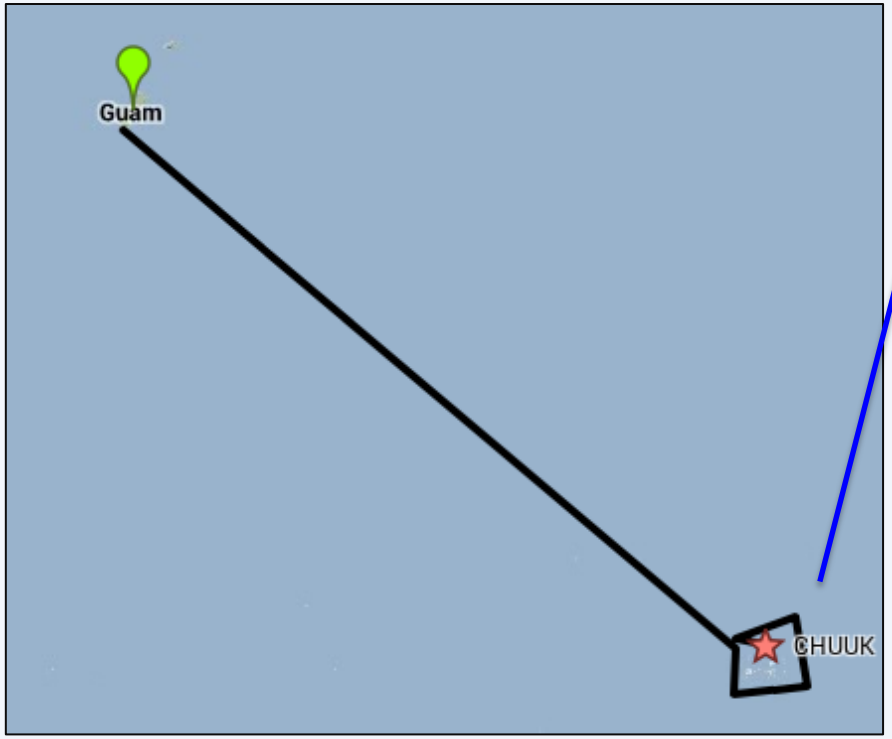




Guam ➔ Chuuk



Altitude
Horizontal distance travelled during climb
Horizontal leg

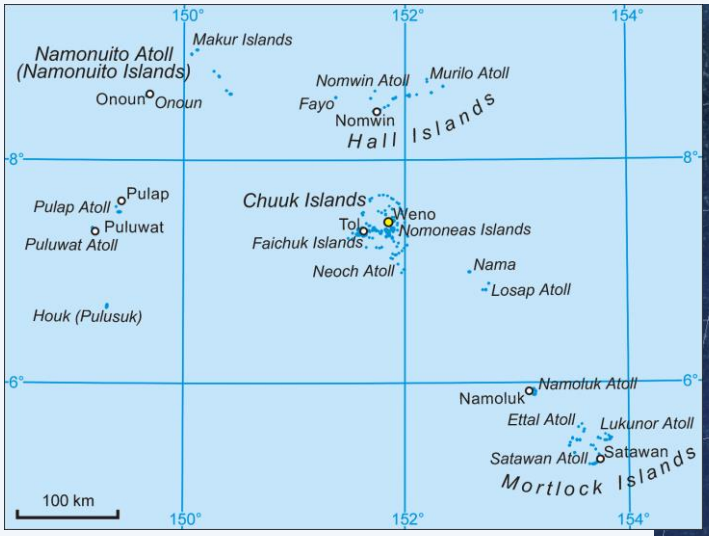


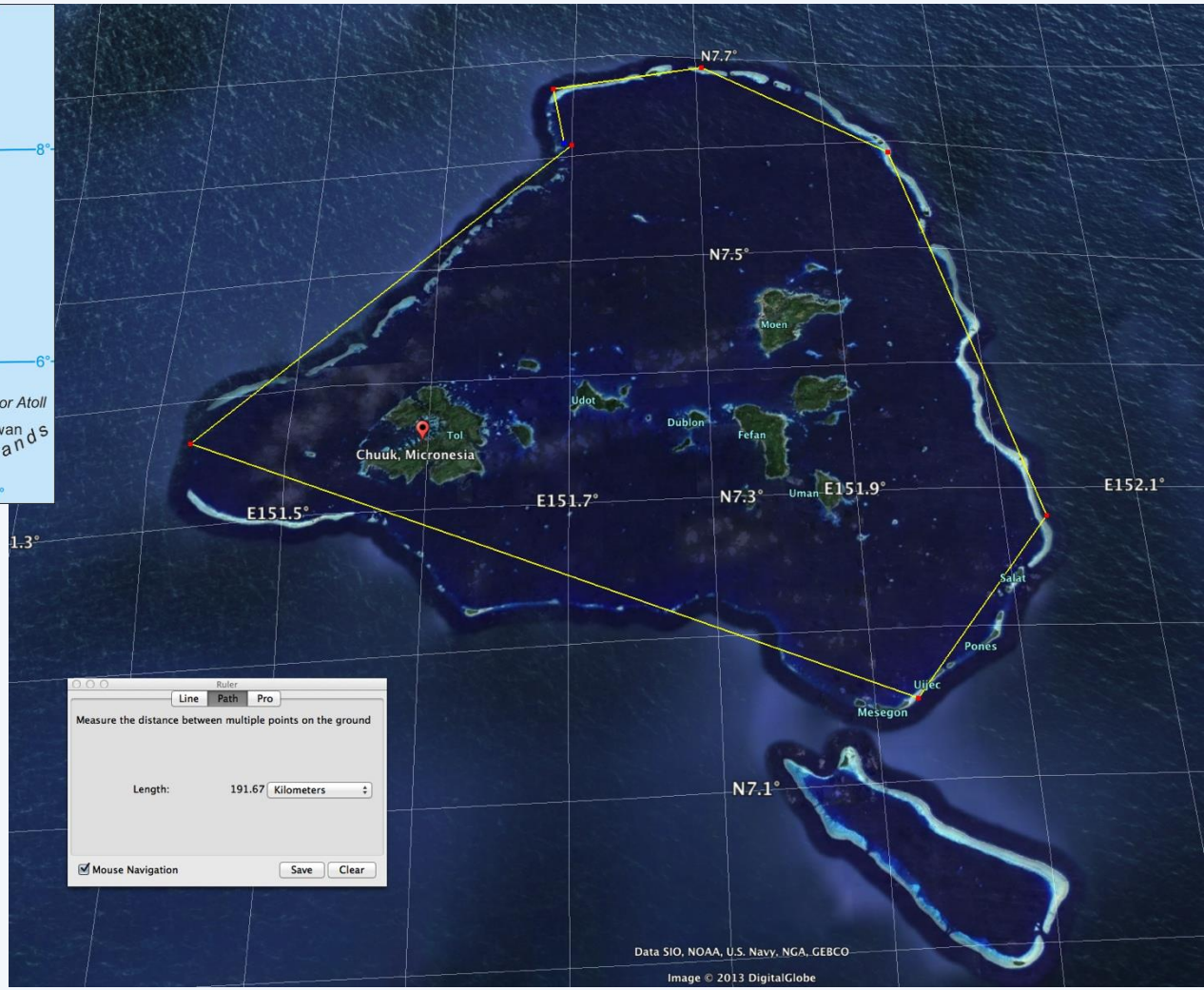
Science aims

- Survey: 13.5 to 7.5N
- Atoll emission estimates

- Total miles: 600 nm
- Leaves some time around Chuuk
- All 70 nm legs take ~20 mins so 5 GCMS samples + WAS

Guam ➔ Chuuk





Circular route round whole atoll system would be ~200km or 105 nautical miles

What is optimal route? This plus a line through the centre?

Flight planning

Option	Z	Flights	Flight hours
(a) Guam/Chuuk/south:	equator	4	16
(b) Guam/Palau/south:	equator	4	16
(c) Guam/Chuuk/Palau/Guam:	2x 0°, 2°N	5	20

NB NRPH guesses for flight hours (all 4 hrs)

80 flight hours for Guam

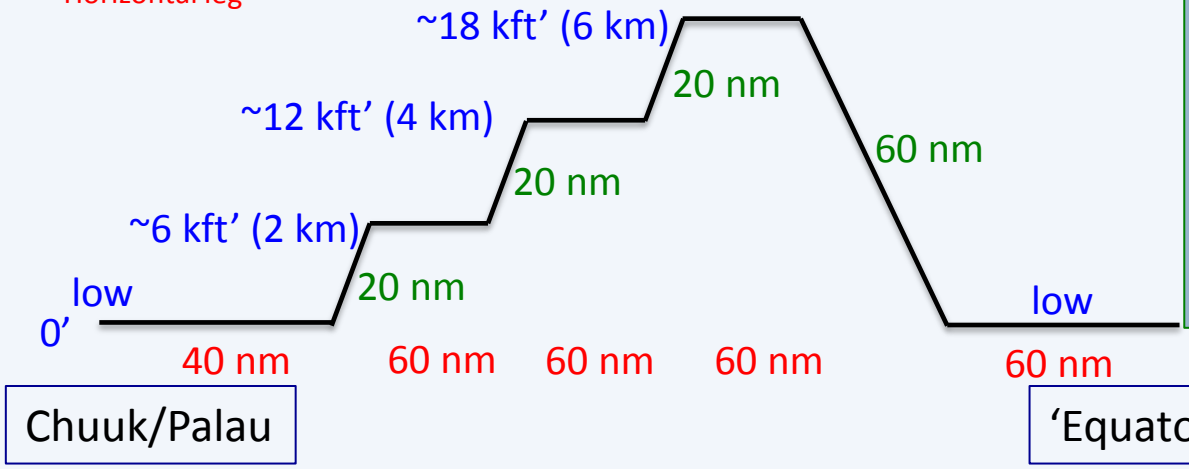
- ➔ **3 x (a) + 2 x (b)** **(totalling 5)**
- ➔ **4 x (c)**
- ➔ **a mixture**

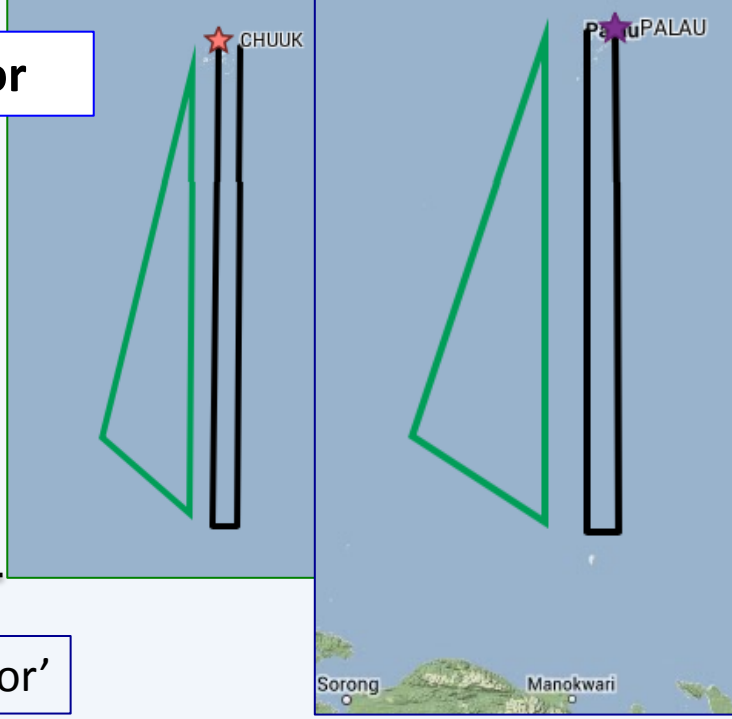
am initiating request for 20 additional flight hours to allow one more sortie

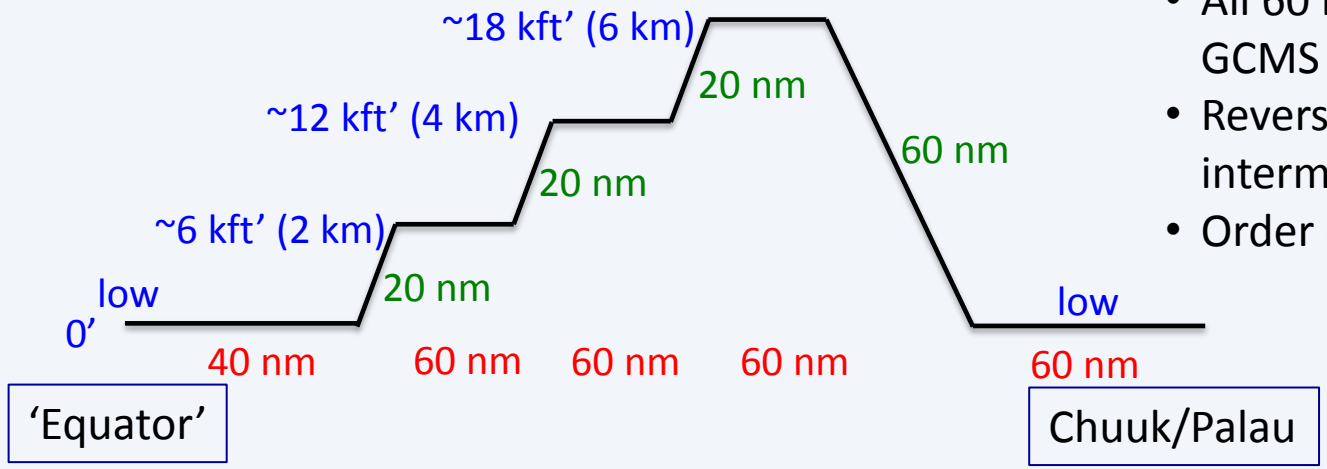
Science aim
Survey: 7.5N to equator

Chuuk/Palau ↔ equator

Altitude
Horizontal distance travelled during climb
Horizontal leg

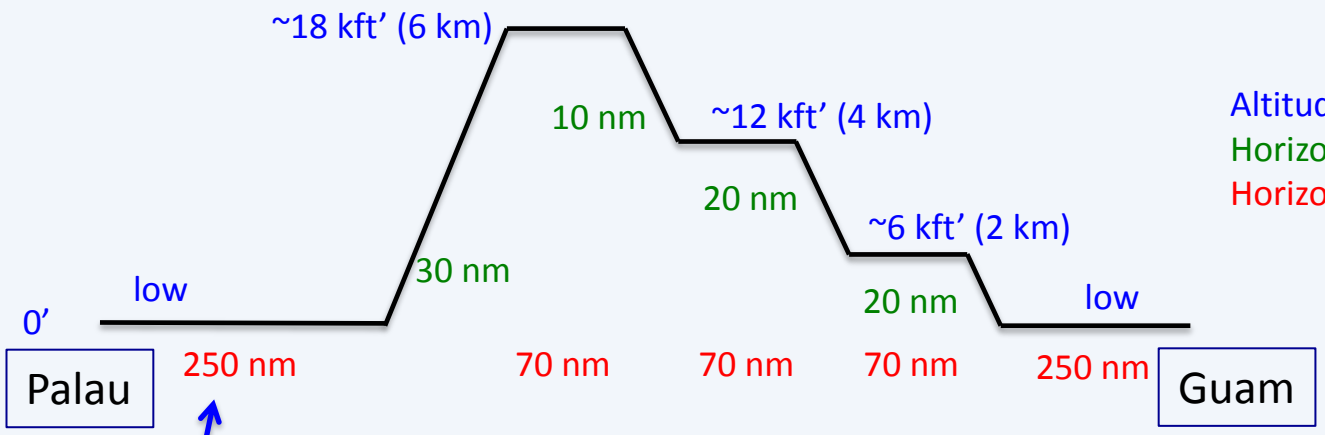




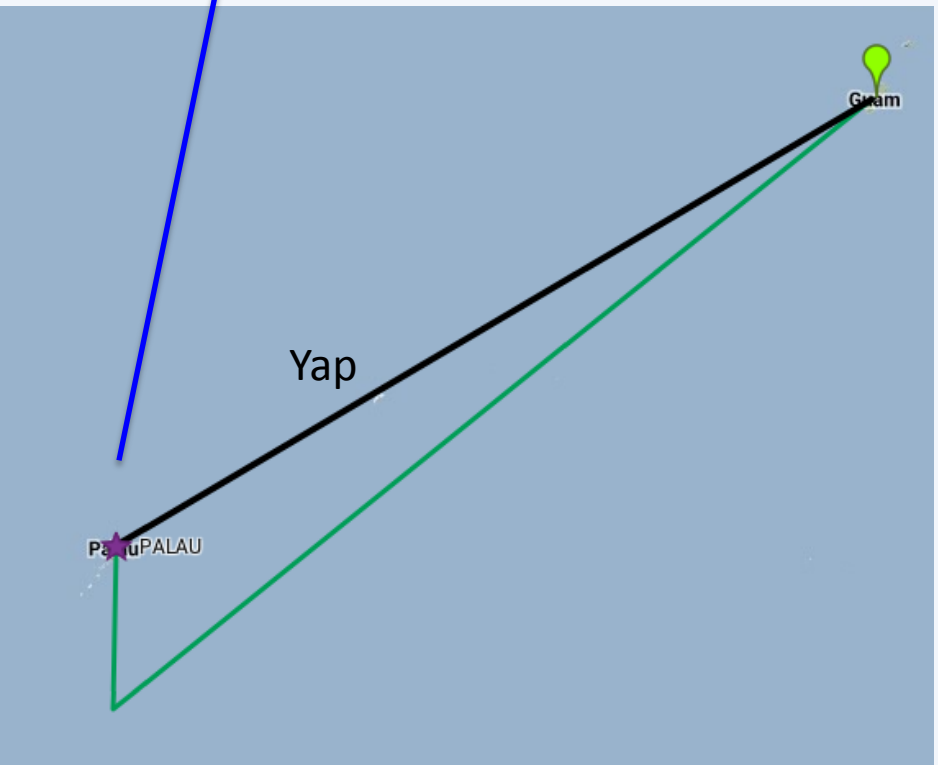


- Total miles out: 400 nm
- All 60 nm legs take ~20 mins so 5 GCMS samples + WAS
- Reverse on way back, perhaps at intermediate heights (1, 3, 5 km)
- Order of altitude legs not critical

Palau ➔ Guam



Altitude
Horizontal distance travelled during climb
Horizontal leg



Science aims

- Survey: 13.5 to 7.5N

- Total miles: 600 nm
- Leaves some time near Palau
- Could look at W side or go south
- Look at Yap?
- All 70 nm legs take ~20 mins so 5 GCMS samples + WAS

CAST flight operations

BAE 146 operation – nominal flight times

Flights (a or b)

Day 1:

- 09:00 T/O Guam, 13:00 Land Chuuk or Palau
- 14:30 T/O Chuuk or Palau for flight to equator, 18:30 land Chuuk or Palau and overnight there

Day 2:

- 09:00 T/O Chuuk or Palau for flight to equator, 13:00 land Chuuk or Palau
- 14:30 T/O Chuuk or Palau, 18:30 land Guam

Dusk ~18:00. Flight times can be shifted to hit or miss dusk accordingly

Flight (c)

Day 1:

- 09:00 T/O Guam, 13:00 Land Chuuk or Palau
- 14:30 T/O Chuuk for flight to equator, 18:30 land Chuuk and overnight there

Day 2:

- 09:00 T/O Chuuk, 13:00 land Palau
- 14:30 T/O Palau for flight to Equator, 18:30 Land Palau

Day 3:

- 11:00 T/O Palau, 15:00 land Guam

BAe 146 operation - day before flight (from Guam)

- 09:00: Scientists meeting
  - Instrument updates
  - Met, chemical forecasting
  - Flight planning, joint discussions with CONTRAST / ATTREX
- Instrument operators chance to go to aircraft for maintenance, calibrations etc.
- 11:00: Mission scientists meet pilots / ops
- 12:00: File flight plan

BAe 146 operation - day of flight

- T/O -4 hours: Power to aircraft, instrument pre flight
- T/O -3 hours: Pilots and missions scientists meet in ops centre to finalize flightplan
- T/O -2hours: Pilots and missions scientists to airport
- T/O -1hours: Pre flight briefing at airport
- T/O -45mins: Cabin security sweep

- Land +30 mins: Debrief on aircraft
- Land + 2hours: **Possible** quick look data sent to ops centre

BAe 146 operation – while aircraft away

- 09:00: Scientists meeting
  - Examine quicklook data sent from flight
  - Met, chemical forecasting
  - Flight planning for future flights, joint flight planning discussions with CONTRAST / ATTREX
- 11:00: Mission scientists meet pilots / ops for initial flight discussion
- 12:00: Further data analysis, forecasting, model runs

CAST ground measurements

CAST : Manus (tbc)

Observation	Instrument	Investigator	Operation
O_3 profile	ECC sonde	Manchester / Vaughan	Daily for 4 weeks
Surface O_3	TE49C	Manchester / Vaughan	Continuous
Aerosol lidar[2]	*Leosphere ALS300*	*Manchester / Vaughan*	*Night-time*
CO_2, CH_4, CO	Picarro	Cambridge / Harris	Continuous
VSL halocarbons[1]	Dirac GC	Cambridge / Harris	Continuous

1. $CHBr_3$, CH_2Br_2, $CHBr_2Cl$, CH_3I, CH_2BrCl, $CHBrCl_2$, C_2Cl_4 (depending on operating conditions)
2. We are still evaluating whether it is worth taking this instrument

Bureaucratic problems on going to Palau

Provisionally accepted by ARM to be based at their site on Manus (2S)

Need to sort logistics out

CAST : Manus (tbc)

Observation	Instrument
O_3 profile	ECC sonde
Surface O_3	TE49C
Aerosol lidar[2]	*Leosphere ALS300*
CO_2, CH_4, CO	Picarro
VSL halocarbons[1]	Dirac GC

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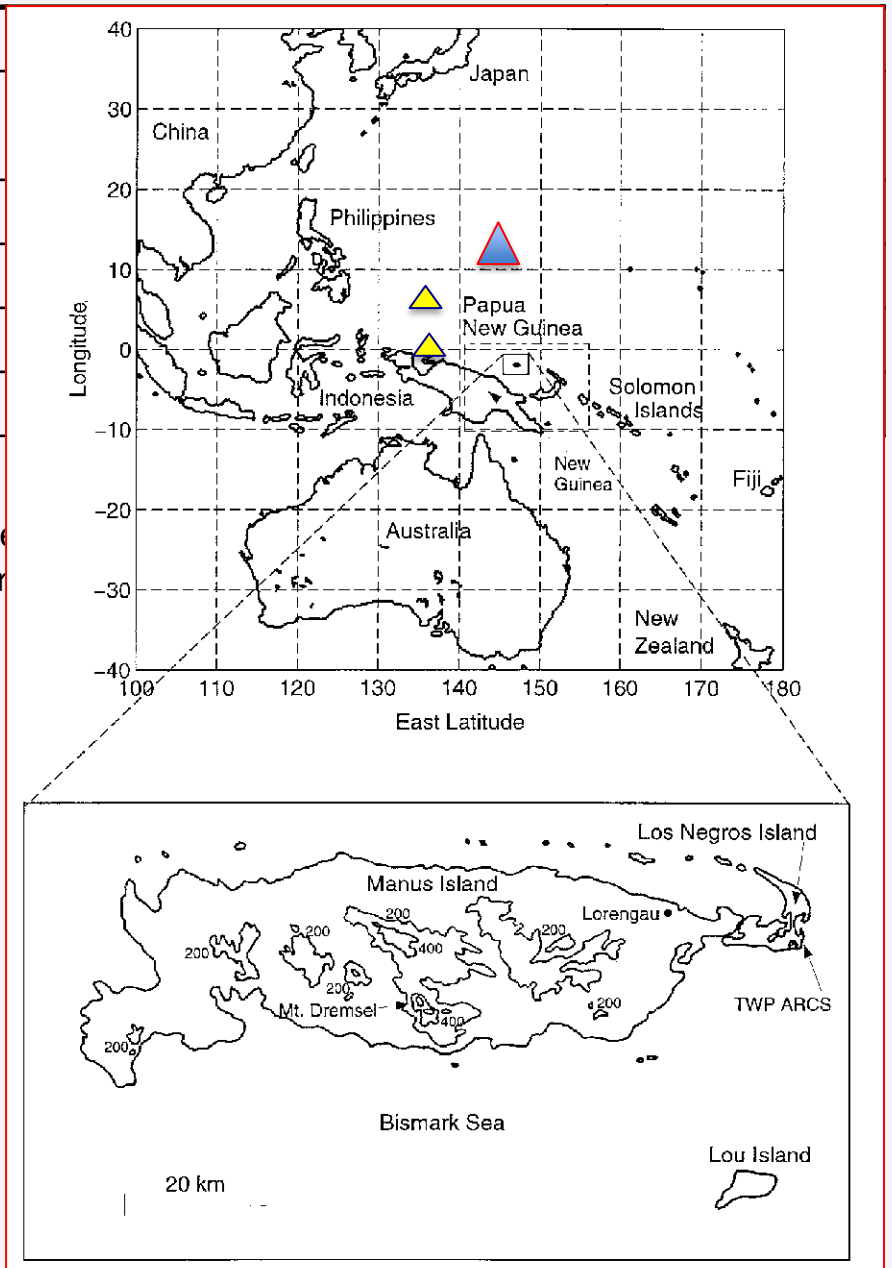
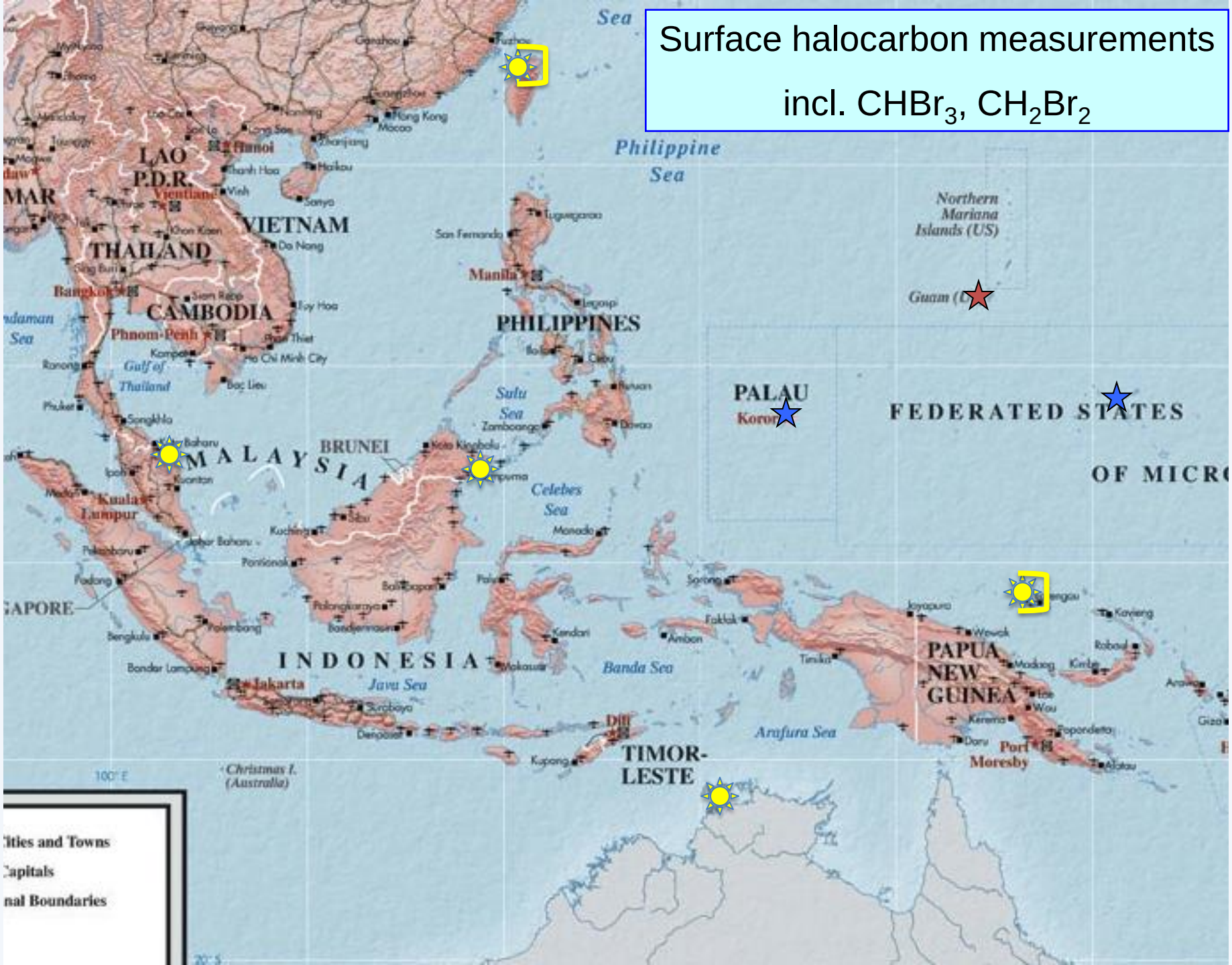
△ SOWER+ ozonesondes




Surface halocarbon measurements
incl. $CHBr_3$, CH_2Br_2
Philippine Sea
Sea
LAO P.D.R.
VIETNAM
THAILAND
CAMBODIA
Phnom-Penh
Bangkok
Hanoi
Vientiane
Manila
PHILIPPINES
Northern Mariana Islands (US)
Guam
PALAU
FEDERATED STATES
OF MICR
Sulu Sea
Celebes Sea
Gulf of Thailand
BRUNEI
MALAYSIA
Kuala Lumpur
INDONESIA
Jakarta
Java Sea
Banda Sea
Arafura Sea
PAPUA NEW GUINEA
Port Moresby
TIMOR-LESTE
Dili
Christmas I. (Australia)
Cities and Towns
Capitals
nal Boundaries

CAST – the rest

CAST - Coordinated Airborne Studies in the Tropics

Modelling

- Ocean emissions model - Lucy Carpenter
- VSLS transport in GEOS-CHEM – Paul Palmer
- Spatial scale analysis – Mat Evans
- VSLS in UKCA and TTL structure – John Pyle
- Cirrus modelling – Rob MacKenzie
- Real-time data analysis (development) – Plamen Angelov

Real-time

Halogen modelling in SLIMCAT – Martyn Chipperfield

Discussed later

AIITS to be developed for Global Hawk under CAST project (Harris, Cambs)

CAST – Co-ordinated Airborne Studies in the Tropics

Aerosol-Ice Interface Transition Spectrometer

- A new instrument that will quantify the size distribution of sub and super-micron particles as a function of their phase (liquid, "glassy/solid" or ice) and surface morphology in the Tropical Tropopause Layer.

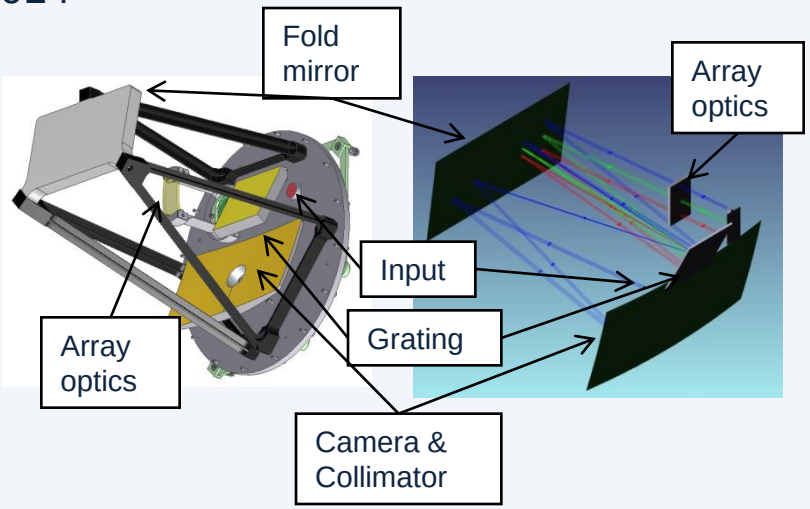
- The instrument will be designed to provide diagnostically rich measurements of small aerosol and ice particles in the TTL, probing the critical aerosol-ice transition size regime (0.3-20 µm), as well as the small ice particle size range (1-100 µm).

- **Aimed at key scientific questions:**
  - Cirrus particle nucleation processes in the TTL
  - Consequences of ice nucleation rates for cirrus persistence and lifetime
  - Cirrus radiative scattering properties.

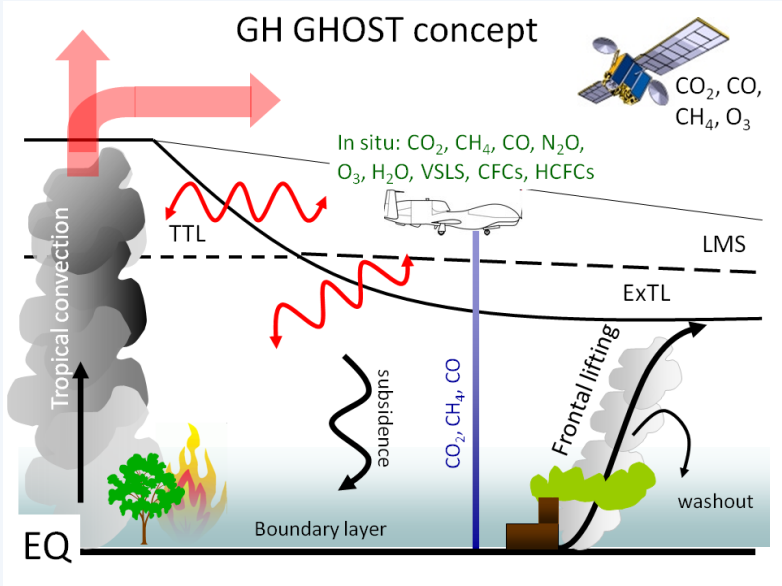
A new instrument for the Global Hawk UAV : The GreenHouse Observations of the Stratosphere and Troposphere (GHOST) instrument

University of Leicester , University of Edinburgh and the UK Astronomy Technology Centre

- Novel, compact short-wave IR spectrometer that is developed for Global Hawk UAV
- GHOST will acquire simultaneous GHG (CO_2, CH_4, CO) column data with high precision during large-scale surveys over ocean
- GHOST should be ready by for test flights end 2014



Subsystem	Band 1	Band 2	Band 3	Band 4
Function	Cloud/aerosol, surface pressure	CH_4 and CO_2 columns	Cloud/aerosol, CO_2 columns	CO, CH_4, H_2O, HDO columns
Spectral band	1.25 - 1.29 µm	1.59 – 1.68 µm	2.04 - 2.09 µm	2.31 – 2.39 µm
Spectral resolution (FWHM)	<0.1 nm	<0.25 nm	<0.15 nm	<0.25 nm



Primary science objectives of GHOST are to collect data to

- test atmospheric transport models (e.g., transition zone between tropics and subtropics)
- validate satellite GHG column observations over oceans thereby filling a critical gap of current validation networks
- complement in situ TTL tracer observations from the Global Hawk to help link upper troposphere with lower troposphere measurements

University of Leicester

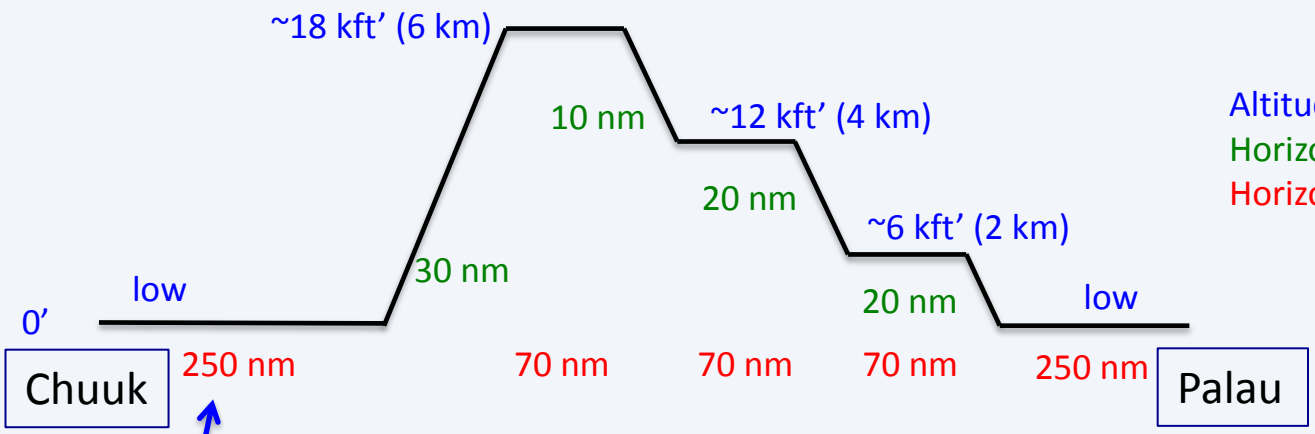
Science & Technology Facilities Council
UK Astronomy Technology Centre

Thank you

Chuuk ➔ Palau

Science aims

- Survey: 7.5 to X to 7.5N



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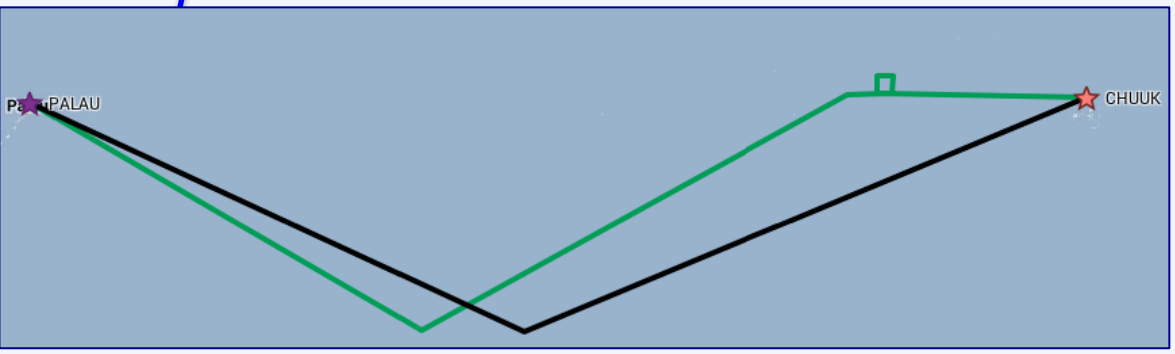
Horizontal leg



Not clear how far S we can go if we do profiles