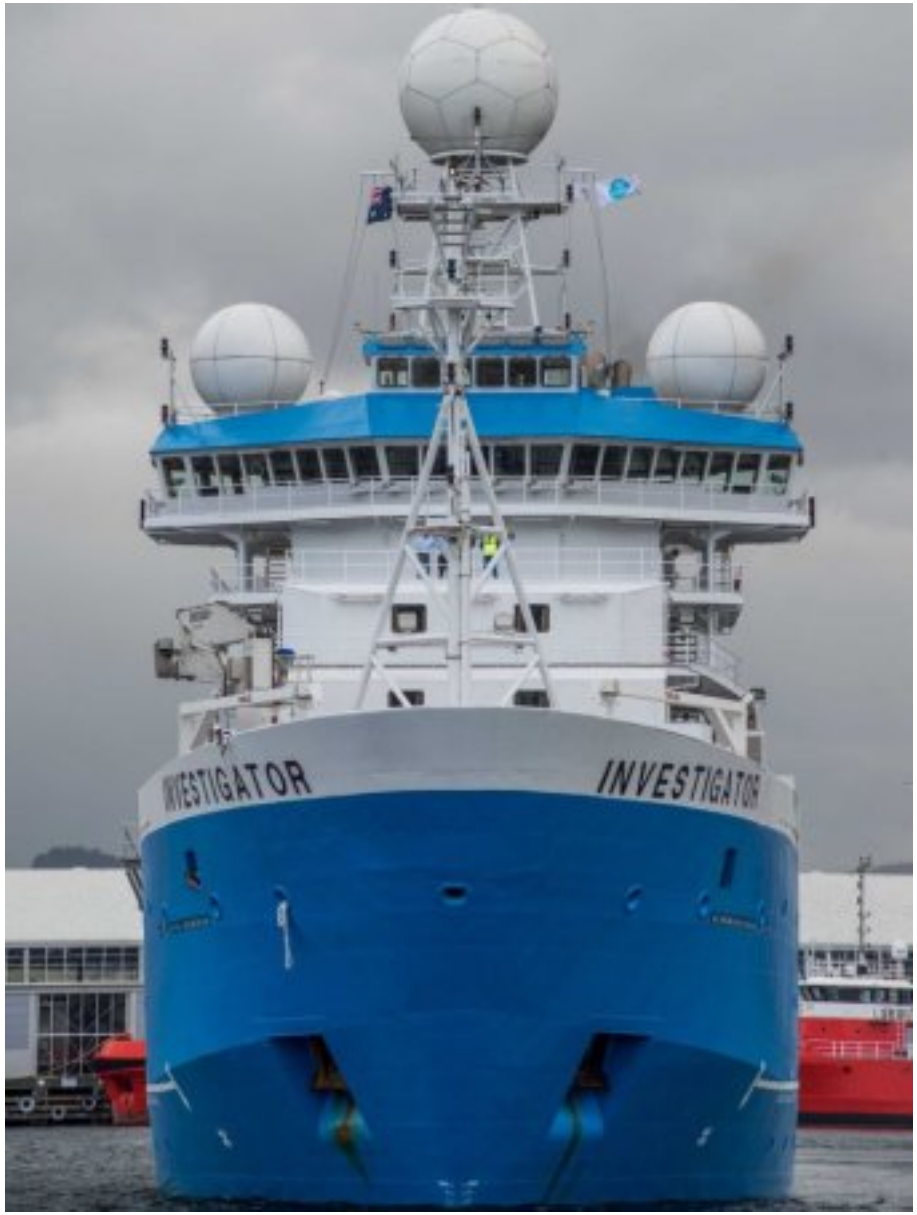
RV Investigator sea-time proposal for the Australian Monsoon period 2017/2018 - Understanding biogenic emissions in the Maritime Continent

R. Schofield, R. Robinson, M. Keywood, A. Protat, A. Johnson, D. Callahan, Z. Ristovski, N. Harris, J. Monty, M. Hamilton, C. Murphy (Paton-Walsh), M. Brown, T. Lane, Y. Huang, S. Tegtmeier, B. Quack, K. Krüger

Overview

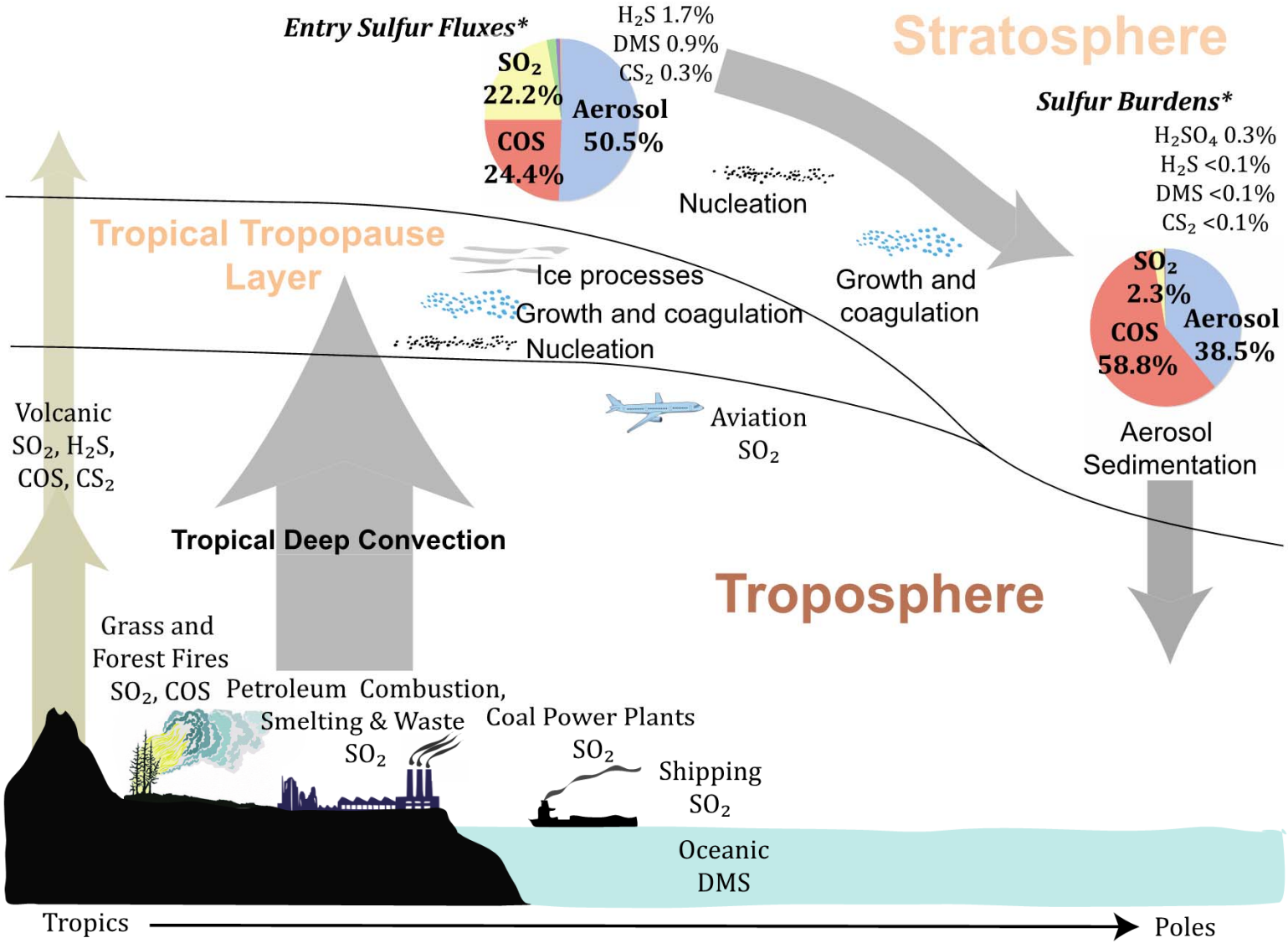
- Motivation
- Science plan
- Science objectives
- Sampling methodology
- Summary



Motivation

- Biogenic production of short-lived gases
- Air-sea fluxes
- Oxidative capacities (Rex et al., 2011)
- Bromine budget: stratospheric ozone
- Sulfur budget: aerosols / clouds
- Convective process delivery to the stratosphere
- Validation

Ocean – Air-sea flux – Convection



*** Sulfur fluxes and burdens from AER model (SPARC report). The total annual flux of sulfur to the stratosphere is 128.9 x 10^9 g, balanced almost exclusively by polar aerosol removal via sedimentation. The total stratospheric burden of sulfur is 485.9 x 10^9 g of sulfur.**

Sea-time proposal Nov/Dec 2017

Ocean objectives

- Collect micro-structure, current, nutrient concentration, and hydrographic data throughout the water column
- Conduct oceanic observations of halocarbons, trace gases and algal community
- Collect data for verification and improvement of mixing parameterizations for ocean models

Algal production in the Monsoon

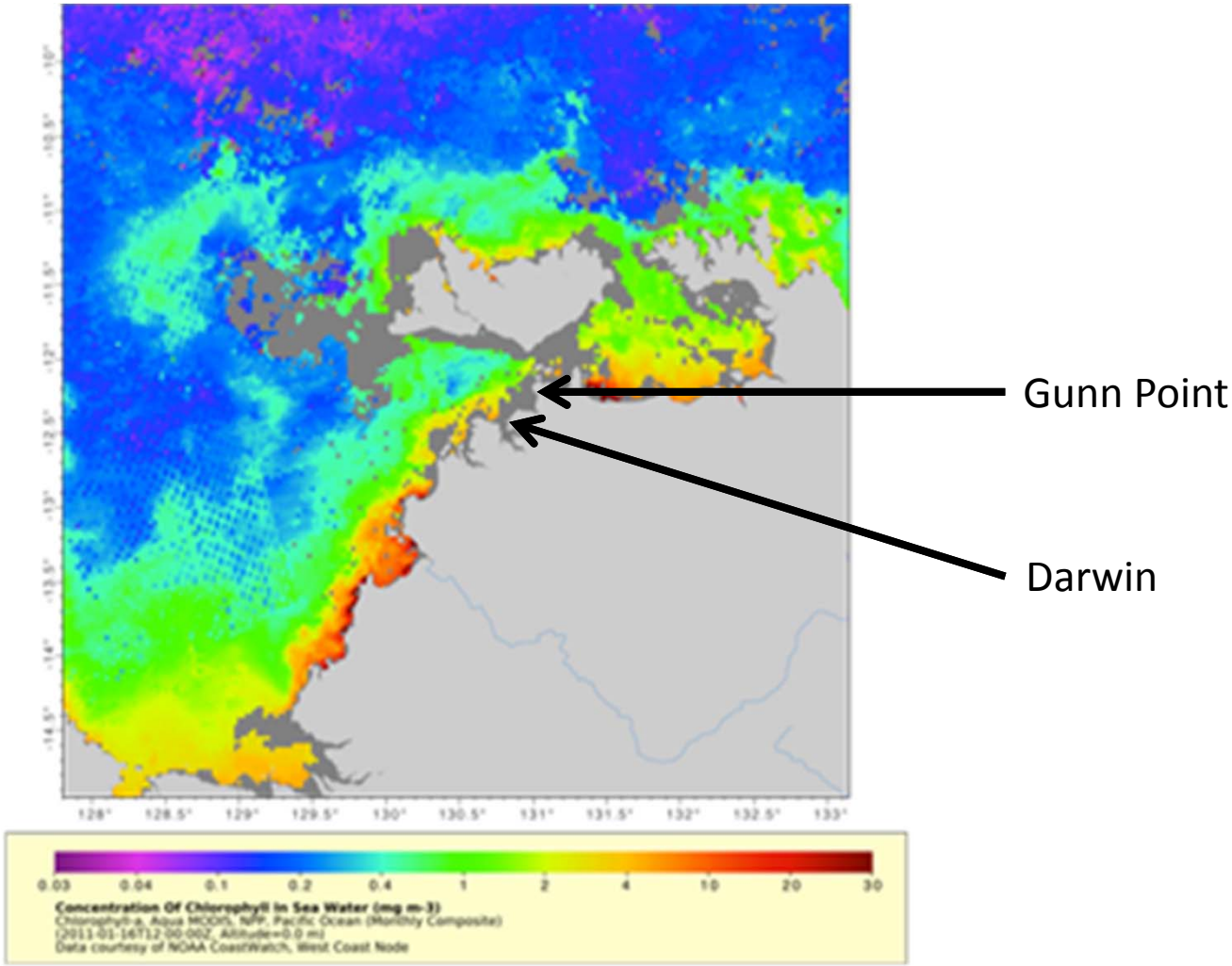


Figure 13: Aqua MODIS images of Chlorophyll distribution off the coast of Darwin during the wet (2011-01-16) season.

Atmospheric objectives

- Establish the sea-air fluxes, boundary layer ventilation and convection for trace gas delivery from the ocean to the stratosphere
- Conduct atmospheric halocarbon, sulfur, aerosol and greenhouse gas observations
- Quantify the biogenic contribution to cloud condensation nuclei in the region

Methyl iodide diurnal cycle

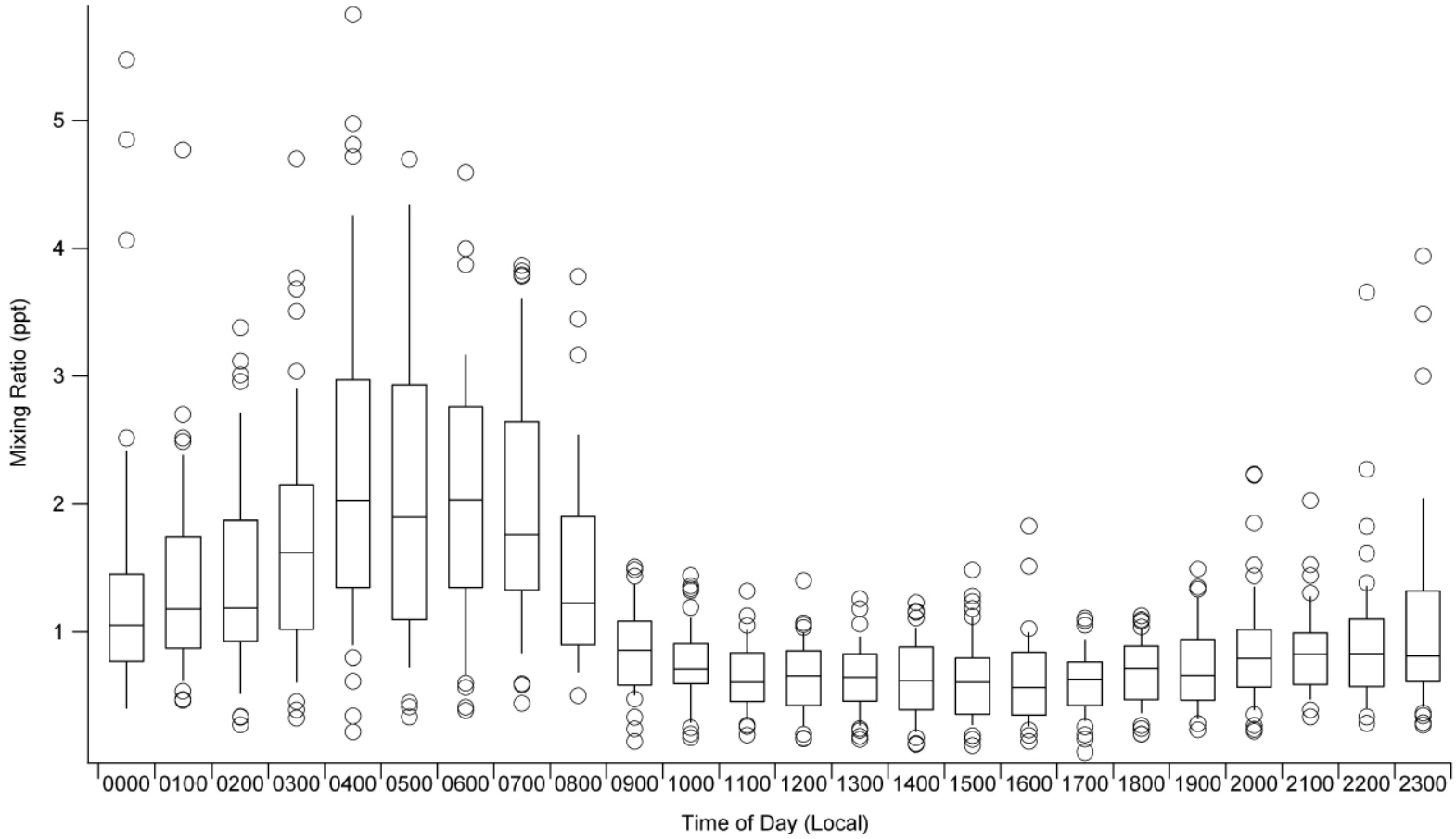


Figure 4: Diurnal behaviour of the CH_3I mixing ratios in Gunn Point between 12th August and 20th November 2013.

Evelyn Heather Holland, Cambridge University, Masters thesis, 2015

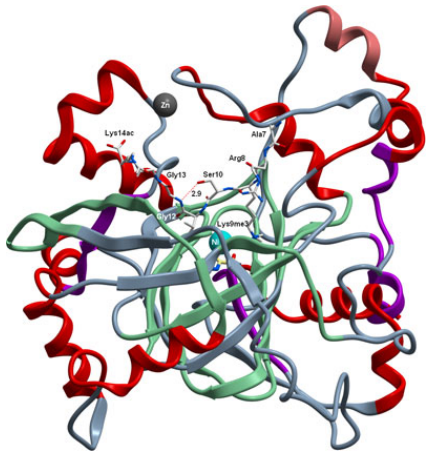
Validation / Modeling objectives

- Characterize tropical deep convection and validate the MNF radar against land based operational weather radars and Gunn Point CPOL research radar
- Validate MNF atmospheric chemistry observations against Gunn Point Tropical atmospheric research station
- Provide biogenic emissions for coupled chemistry climate models and test convective parameterizations and stratospheric ozone implications

RV Investigator

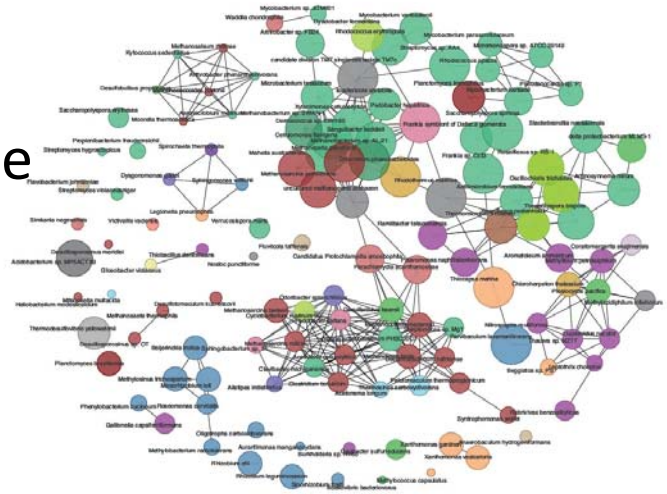
Ocean sampling

Instrument	Observations
Lowered Acoustic Doppler Current Profiler (LADCP)	Vertical shear in the horizontal velocities and dissipation
CTD – 24-bottle rosette	Water samples at 24 depths for halocarbon, DMS, Radon and GHG concentrations and biology for microbial analysis
Microstructure vertical profiler	Mixing in various wind stress conditions



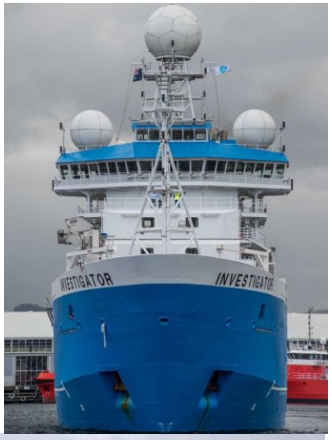
Metagenomic and molecular analysis to identify gene-function

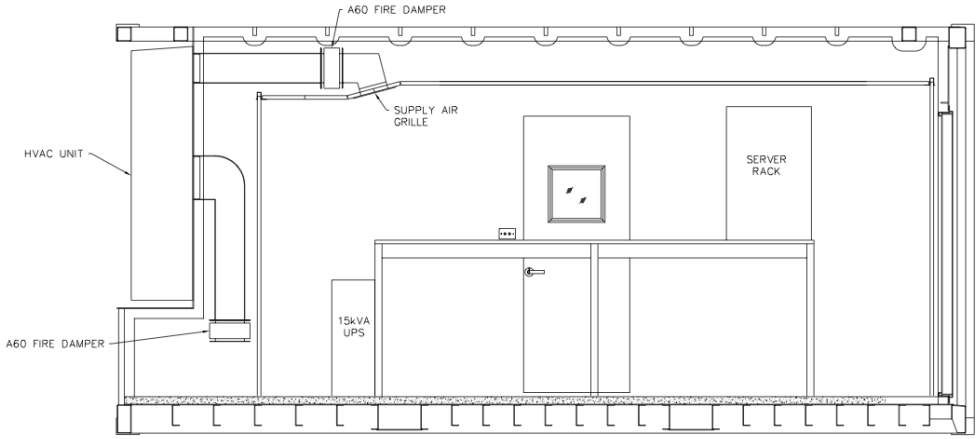
Culturing - environmental stresses that enhance gaseous production (parameterizations)



Atmospheric composition and dynamics

- Shipboard suite of composition observations
- AIR-BOX – Mobile atmospheric chemistry laboratory
- Radar, Lidar, precipitation, soundings





AIR-BOX Instruments

Instrument	Observations	Contact(s)
Chemical Ionization Mass Spectrometer - CIMS	Ions in aerosol phase: sulfuric acid derivatives, ammonia, and organic ions and aerosol precursor gases. OH/HO2	Zoran Ristovski, Peter Nelson
FTIR in situ trace gas analyser	In-situ continuous measurement of CO_2, CH_4, CO, N2O, δ13C in CO_2, δD-H_2O, δ18O in H_2O	Dave Griffith, Clare Murphy
UV/Vis Spectrometer MAX-DOAS including Direct-sun	Solar Spectra in UV/Vis (daytime only): many oxidants and oxidation products BrO,IO, NO_2, O_3, HCHO, CHOCHO, OClO, SO_2, H_2O, O_4, aerosol	Robyn Schofield, Steve Wilson
Meteorological – HOBO U30 Weather Station	Meteorological data	Steve Siems
Mini Micro Pulse Lidar System (532 nm)	Continuous aerosol and cloud profiles up to 10km. Boundary layer height defined continuously.	Robyn Schofield, Simon Alexander
In-situ Radon detector	Radon - a radioactive reliable tracer of land contact	Alastair Williams
Aurora 4000 Nephelometer with PM2.5 Inlet	Measures the concentration of particulates within aerosols using the reflective properties (in-situ)	Melita Keywood
Multi-Angle Absorption Photometer	Aerosol optical absorption properties of PM2.5 and PM10 particles	Melita Keywood
HIVOL particulate sampler and rain gauge	PM2.5, PM10 or TSP particles on filters. Subsequent ICPMS analysis for iron (weekly)	Andy Bowie

Identified guest instruments

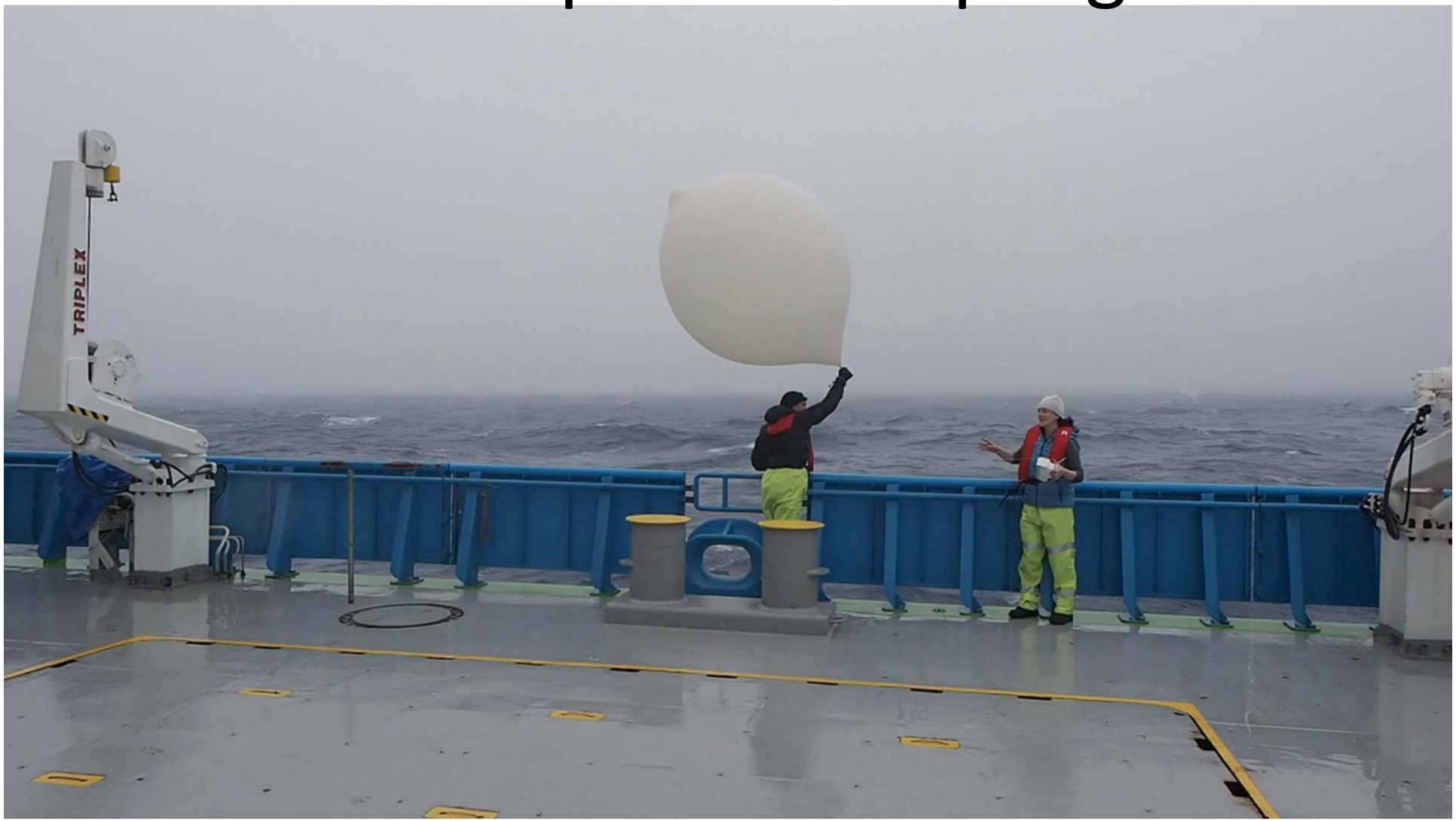
Instrument	Observations	Contact(s)
NOx	In-situ NOx	Clare Murphy
Ozone	In-situ Ozone	Clare Murphy
Mercury suite	Elemental, reactive and particulate mercury	Peter Nelson
FTS - direct sun	CO_2, CH_4, HDO, HCl etc total column measurements	Dave Griffith
Time-of-Flight Aerosol Mass Spectrometer (ToF-AMS)	Aerosol composition	Branka Miljevic
NAIS	Aerosol composition - particles: ~2 to 40 nm, ions: 3.2 to 0.0013 $cm^2/V/s$, (equivalent size range: 0.8 to 40 nm)	Zoran Ristovski
Ultrasonic 3D anemometer	High resolution winds resolving turbulent processes and surface heat fluxes	Jason Monty
Custom built humidity sensor	High resolution	Jason Monty
Sodar	Vertical profiles of wind and temperature	Melita Keywood

Summary

- Decision January

- Plan B – participate in 2018/2019 RV Investigator cruise

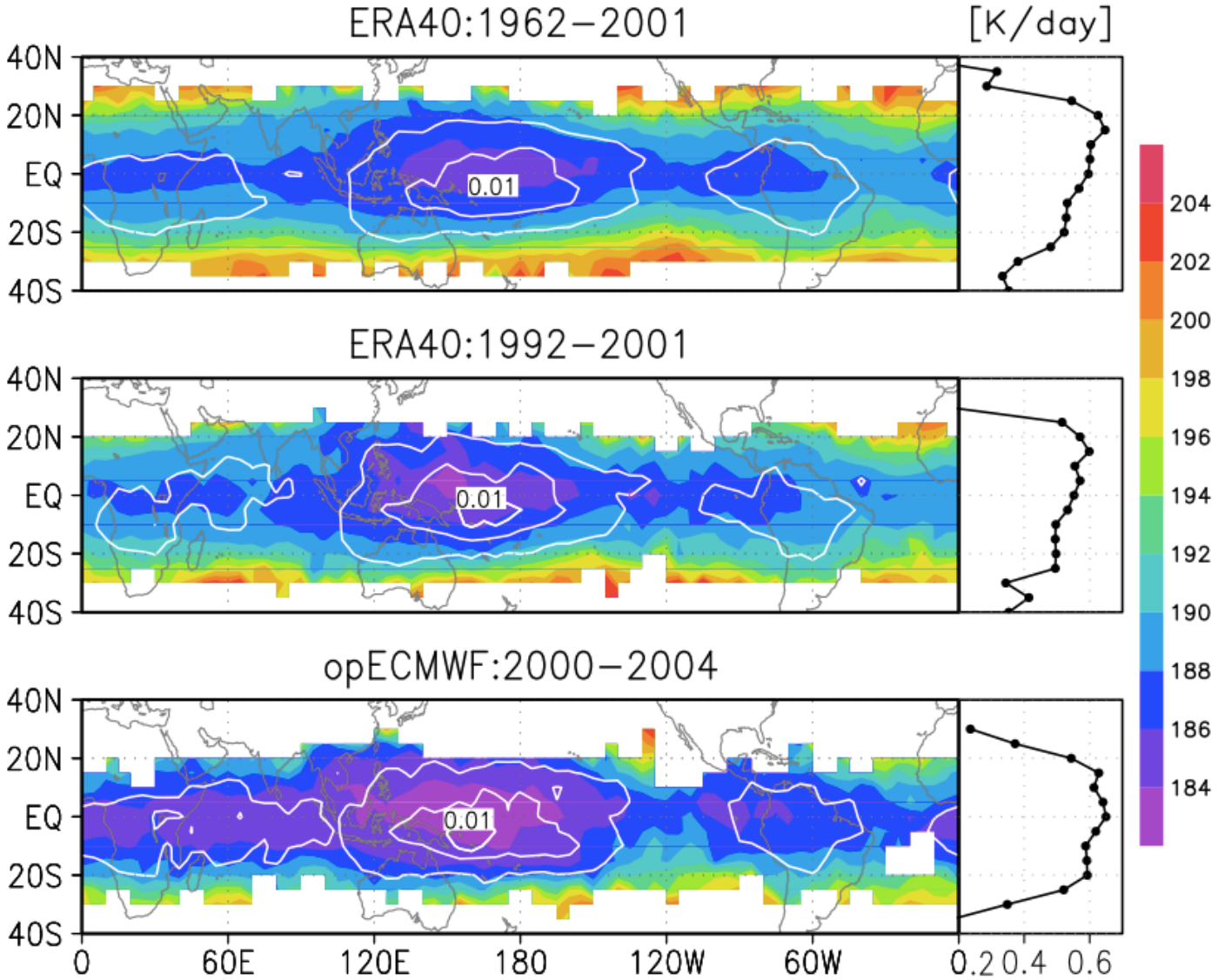
Atmospheric sampling



Item name	Supporting information
Cloud condensation Nuclei counter	Aerosol lab –successfully deployed on two voyages- requires remote desktop access to instrument
Particle counter	Aerosol lab- successfully deployed on two voyages- requires remote desktop access to instrument- will have butanol as working liquid
Aerosol Chemical Speciation Monitor	Air Chemistry Lab- successfully deployed on two voyages
Proton transfer mass spectrometer	Air Chemistry Lab- successfully deployed on two voyages, requires 3 gas cylinders (standards)
Scanning Mobility Particle Sizer	Air Chemistry lab successfully deployed on two voyages- uses sealed radioactive source
Nano scanning mobility particle sizer	Aerosol lab successfully deployed on two voyages- uses sealed radioactive source- requires remote desktop access to instrument
Cascade Impactor Aerosol sampler	Secured to a rail deck outside (observation deck); requires sample conditioning switch
95 GHz cloud radar	In the fore deck container with a stabilized platform (BOM)
Lidar	In the fore deck container (BOM)
OceanRAIN disdrometer	Main mast, second highest platform preferred (OceanRAIN project manager, Christian Klepp). Three instruments (disdrometer, detector and anemometer) along with data logger in dry lab. 40 m single-cable length.
AIRBOX	In left-hand foredeck container space: Atmospheric composition mobile container containing: - Chemical Ionization Mass Spectrometer (NO carrier gas, Po-210 radiation source) - Ecotech-UoW FTIR “Spectronus” (carrier and standard gas cylinders) - MAX-DOAS (passive remote sensor optics located on rail of deck 3) - Mini micropulse lidar (class 2 laser) (BOM container) - Nephelometer - Radon detector (Ra-226 source) - Multi-Angle Absorption Photometer - HIVOL 3000 particulate sampler (observation deck)

Sonic anemometer and custom built humidity sensor	Main mast or one of the bow arms
microDirac GC-ECD	Air chemistry lab using MNF aerosol inlet sampling line, clean from local effects. Low power, space needs. Will require internet connection and space for gas cylinders (carrier and standards).
iDirac	Air Chemistry Lab using MNF aerosol inlet sampling line, clean from local effects. Low power, space needs. Will require internet connection.
Radiosonde / polarsonde atmospheric soundings	Telemetry in observation deck room. Balloon filling in sheltered science space. Helium stored in external gas locker / 1-2 D bottles in sheltered science space for balloon filling.
Thermo Scientific Delta V isotope ratio mass spectrometer	Clean wet lab, deckboard incubators, Radvan (15N-N_2 gas (99 % pure))
DMS Oceanic gas chromograph with cryotrap	Air Chemistry laboratory (air, helium and hydrogen gas cylinders, liquid nitrogen). Hazardous chemicals (1% H_2SO_4).
Microstructure Profiler	Profiler that measures temperature, salinity, and velocity shears at high resolution. Profiler is small version that only goes to 200 m (Robertson and Lemckert)
Halocarbon - purge-and trap system	Clean wet lab. Purge and trap system, gas chromatograph with mass spectrometer, required are water samples (requiring a surface water pump, bottle rosette sampler) in the clean wet lab (1.5 x 3 m bench space required). Liquid nitrogen, helium, nitrogen gas cylinders are required). Standard oceanographic data such as SST, SSS, chlorophyll are also required.
Greenhouse gas high-precision cavity ring down spectrometers	Clean wet lab. (Picarro G2308 and PcarroG2201-I) for CO_2, CH_4 and N_2O analysis of seawater through a shower head gas equilibration device sampling a 3L/min. Requires gas standards – 3 compressed gas cylinders.
^{222}Rn RAD-7 detector	Clean wet lab. Radiation standard contained within instrument. Requires seawater supply through a shower head gas equilibration device sampling a 3L/min.

DJF climatologies



Krüger, K., S. Tegtmeier, and M. Rex (2008), Long-term climatology of air mass transport through the Tropical Tropopause Layer (TTL) during NH winter, Atmos Chem Phys, 8(4), 813–823.