

The Airborne Tropical Tropopause Experiment (ATTREX)

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Funded as a 5-yr NASA suborbital venture-class mission

Use measurements on board the NASA Global Hawk UAS and models (meteorological, transport and chemistry) to investigate:

- The role of stratospheric water vapor in Earth's energy budget and climate.
- Dehydration of tropospheric air entering the stratosphere.
- The physical processes and chemical composition of the Tropical Tropopause Layer (TTL) which is the region of the atmosphere that controls the composition of the stratosphere.


Schedule of TTL flights:

Jan-Feb 2013: Armstrong Flight Research Center, California

Jan-Mar 2014: Guam



ATTREX Global Hawk UAS Payload (Guam, 2014)

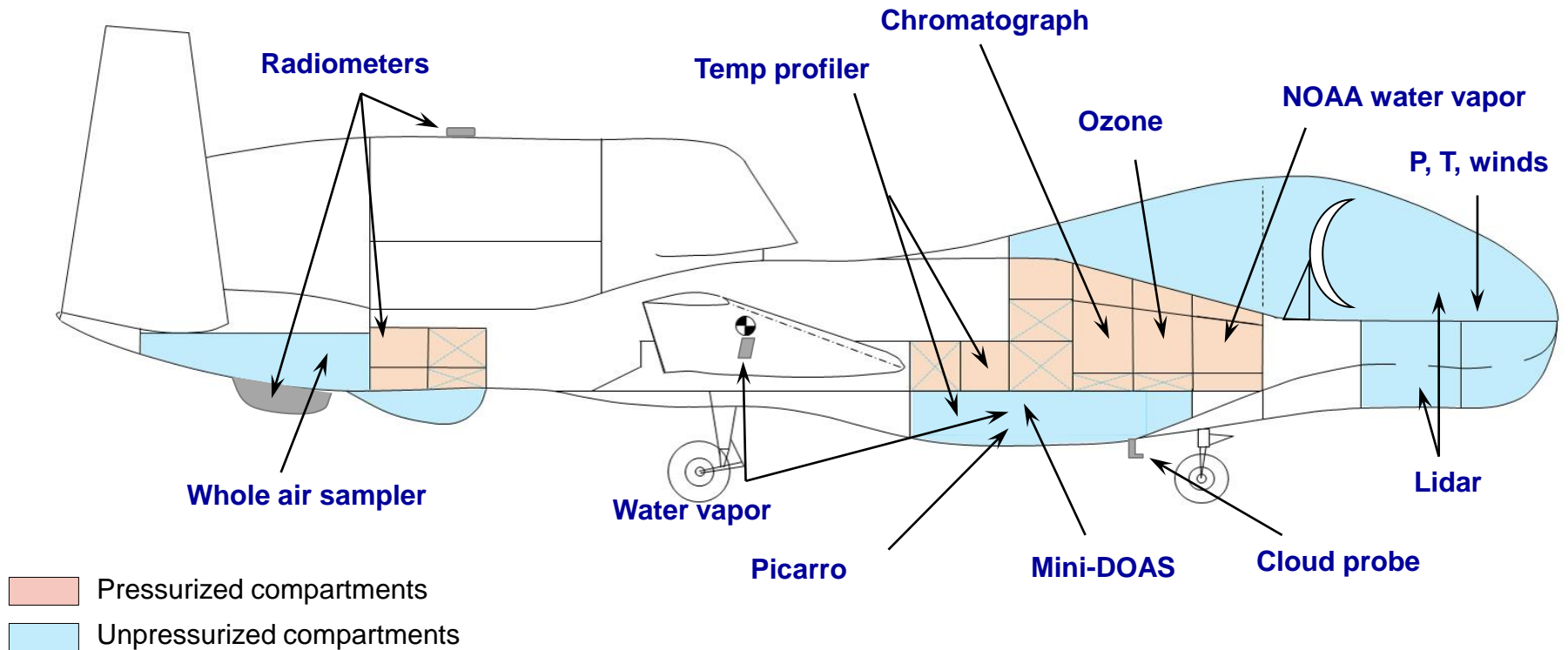
Instrument	Measurements	Investigator
INSITU		
Advanced whole air sampler (AWAS)	Laboratory analysis of 50 stable gases: anthropogenic, natural, biomass burning	Atlas/U of Miami/USA
UAS Chromatograph for Tracers (UCATS)	Columns + electron capture detectors CH ₄ , N ₂ O, SF ₆ , CO (O ₃ and H ₂ O)	Elkins/NOAA/ESRL/USA
NOAA Ozone	UV absorption for O₃	Gao/NOAA/ESRL/USA
Picarro Cavity Ringdown Spectrometer (PCRS)	IR absorption for CO ₂ , CO, CH ₄	Wofsy/Harvard U/USA
Diode Laser Hygrometer (DLH)	Tunable diode laser absorption. Water vapor only and cloud particle extinction	Diskin/NASA/Langley/USA
NOAA Water Vapor	Tunable diode laser absorption. Two channels: water vapor only and (water vapor + ice particles)	NOAA/ESRL/USA
 Hawkeye & FCDP	Ice crystal size distribution and habit	Lawson/SPEC/USA
REMOTE		
Cloud Physics Lidar (CPL)	Aerosol and cloud laser backscatter	McGill/NASA/Goddard/USA
Mini-DOAS	Absorption spectrometer for BrO, NO ₂ , OCIO, IO	Stutz/UCLA/USA Pfeilsticker/U of Heidelberg/Germany
Solar Spectral Flux Radiometer (SSFR)	Solar and infrared spectral flux	Pilewskie/U of Colorado/USA
Microwave Temperature Profiler (MTP)	Temperature profile	Mahoney/JPL/USA
Meteorological Measurement System (MMS)	Temperature, pressure, 3D winds	Bui/NASA/Ames/USA

**Removed
because of CG
problem**



ATTREX Payload Integration

NASA 872 (AV-6)



Instrument problems:

- O_3 removed to make CG
- CPL failure last two flights

ATTREX Guam calendar

January 2014

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
			1	2	3	4
5	6	7 Fiber optic Tx, UHF antenna & cable sent from DFRC	8	9	10	11
12	13	14	15	16	17	18
				Transit Flight: 20.5 hours		
				A/C Transit to Guam		
19 Down Day	20 Rain	21 Rain	22 Cancelled: Hawkeye mount, preload test kit hand carried from DFRC	23 Cancelled: rain	24 Cancelled: tail winds, postponed to 2/27	25
26 Cancelled: wind & rain	27 Cancelled: wind & rain	28 Cancelled: rain and strong winds, engine wash unit & tire gauge sent from DFRC	29 Cancelled: rain and strong winds, GHMOF computer, computer sent from DFRC	30 Postponed: GHMOF backup computer	31 Cancelled: A/C generator?	

ATTREX Guam calendar

February 2014

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
						1 Aborted: Navigation Issues
2 Ku and Omsistar testing	3 Consulting with L3 regarding Ku problem	4 Ku waveguide maintenance, troubleshooting identifies HPA as the problem	5 Ku HPA replaced, still not functioning	6 Cancelled: Navigation Issues, hydraulic fault, Omnistar unit and fuel density kit sent from DFRC	7 Cancelled: Navigation Issues, consultation with NGC & USAF, Omnistar receiver hand carried from DFRC	8 Outdoor navigation system work, Omnistar receiver arrives
9 Omnistar receiver replaced	10	11 Cancelled: Navigation Issues, AF GH take-off, hydraulic fault, Ku HVPS sent from DFRC	12 Omnistar receiver not the problem	13 1st Science Flight 17.5 hours	14	15 Down Day
16	2nd Science Flight 18 hours (35.5), INMARSAT issues, flight in UAZ east only	18 INMARSAT troubleshooting, problem thought to be modem, modem laptop sent from DFRC	19 Attempt to get modem from AF. No soap.	20 Cancelled: Bleed air valve (valve hand carried from DFRC), Ku HVPS replaced	21 Modem from DFRC arrives. DFRC grounds A/C pending resolution of INMARSAT issue	22 Cancelled flt for 2/23: INMARSAT modem not the problem, HPA/LNA, antenna & cable sent from DFRC
23	24 INMARSAT antenna arrives, flight cancelled: fuel quick disconnect fitting leaking (hand carried from DFRC)	25 INMARSAT and Ku both working	26 Quick disconnect fitting changed, problem fixed	27 Cancelled: wind, low cloud ceiling	28 Cancelled: wind, low cloud ceiling	

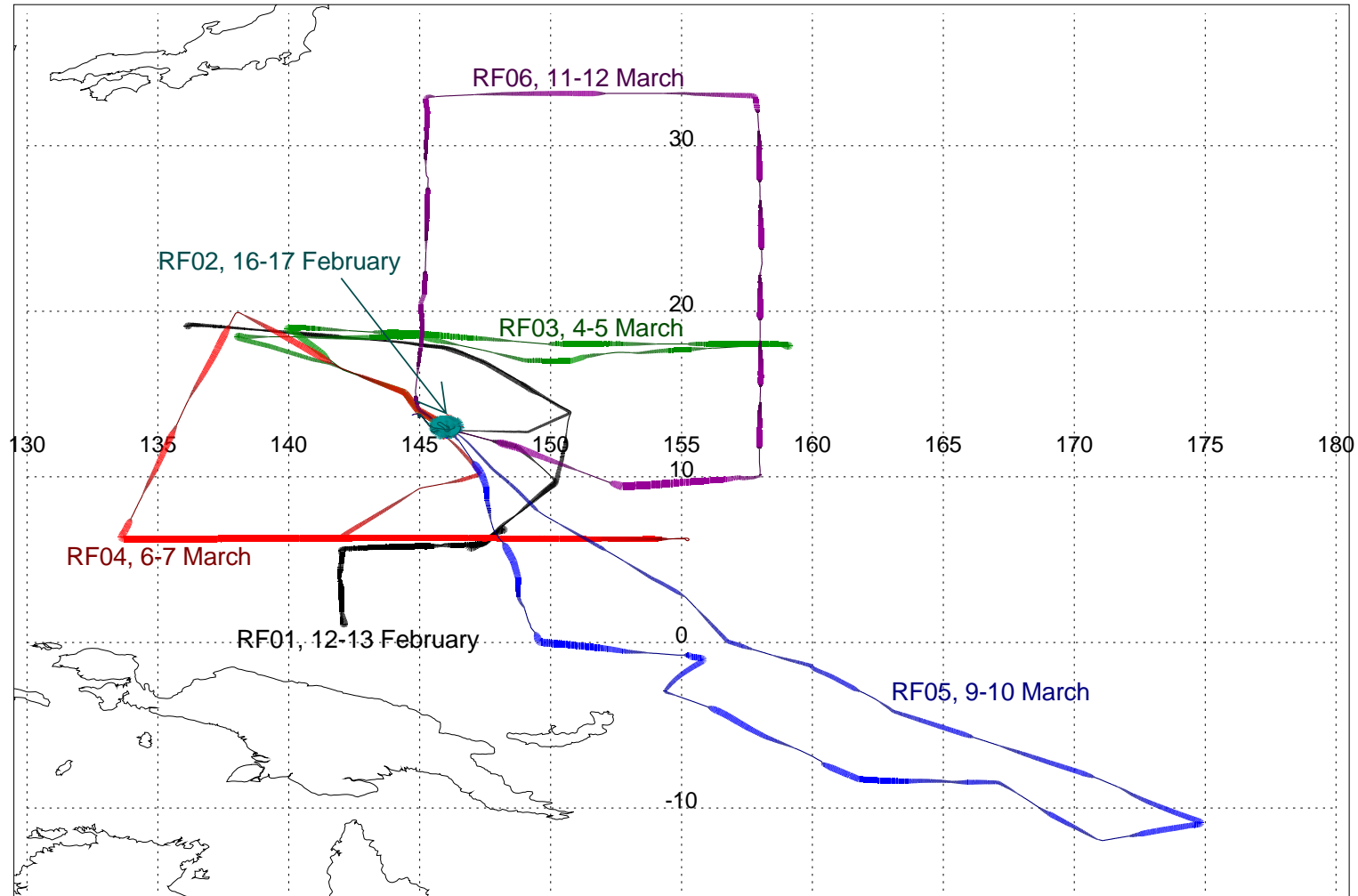
ATTREX Guam calendar

March 2014

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
						1 Possible flight cancelled - Down Day
2 Planning for 3/3 flight	3 Flight cancelled wind	4 Flight cancelled wind	5 3rd Science Flight 13 hours (48.5)	6	7 4th Science Flight 17 hours (61.5)	8 Down Day
9	10 5th Science Flight 20 hours (81.5)	11	12 6th Science Flight 15.3 hours (100.8)	13	14 7th Science Flight Transit Flight 19.3 hours (120.1)	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

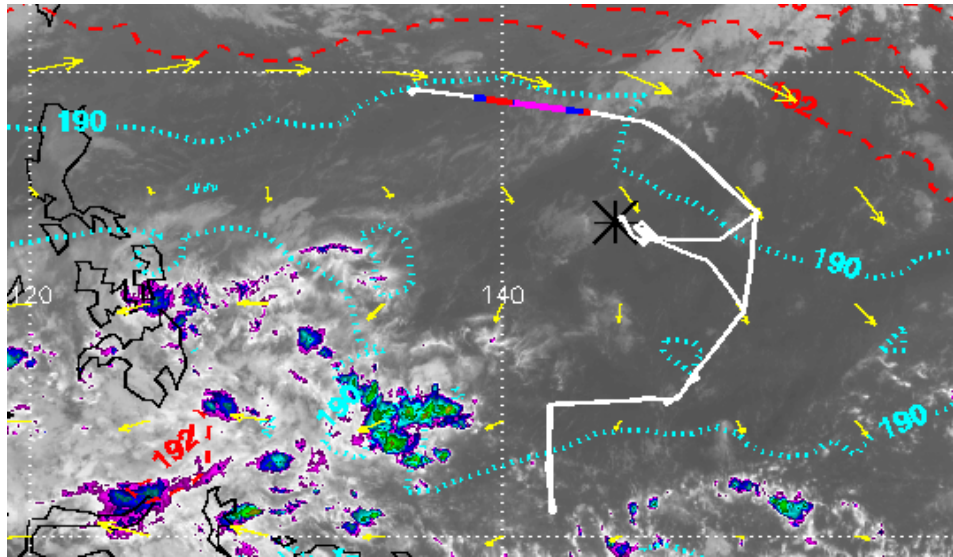
ATTREX-Guam science flights

2014 ATTREX science flights



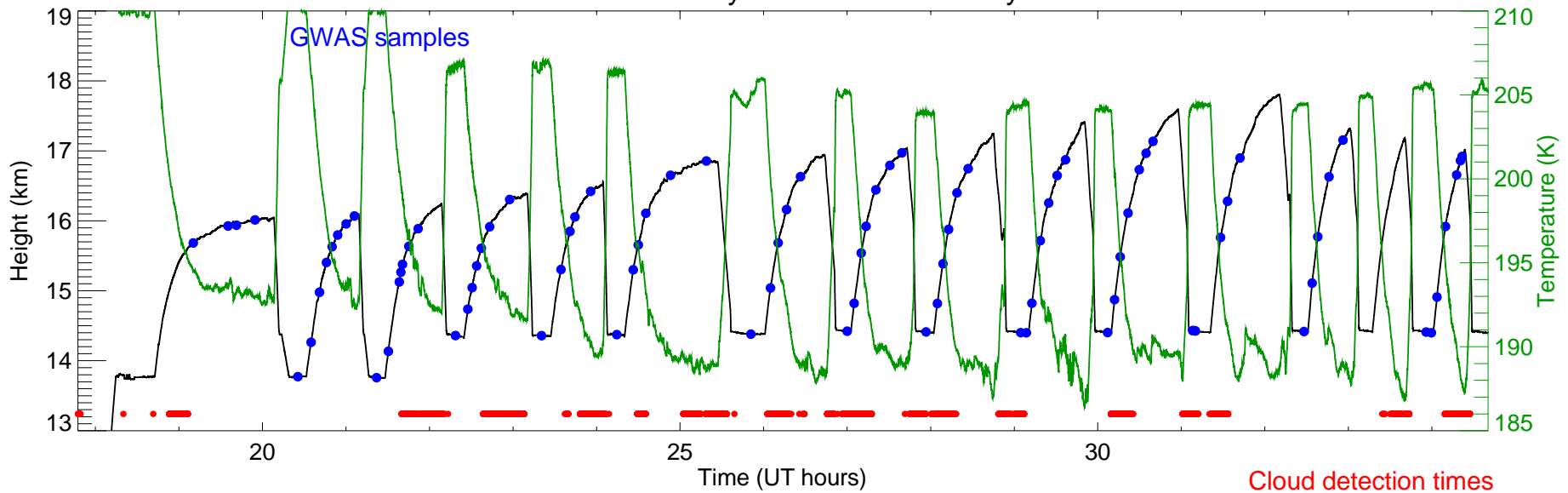
- 6 Guam local flights + 1.5 transits
- ~100 hours of TTL sampling
- ~180 TTL vertical profiles (GWAS samples on ascents)

RF01 February 12

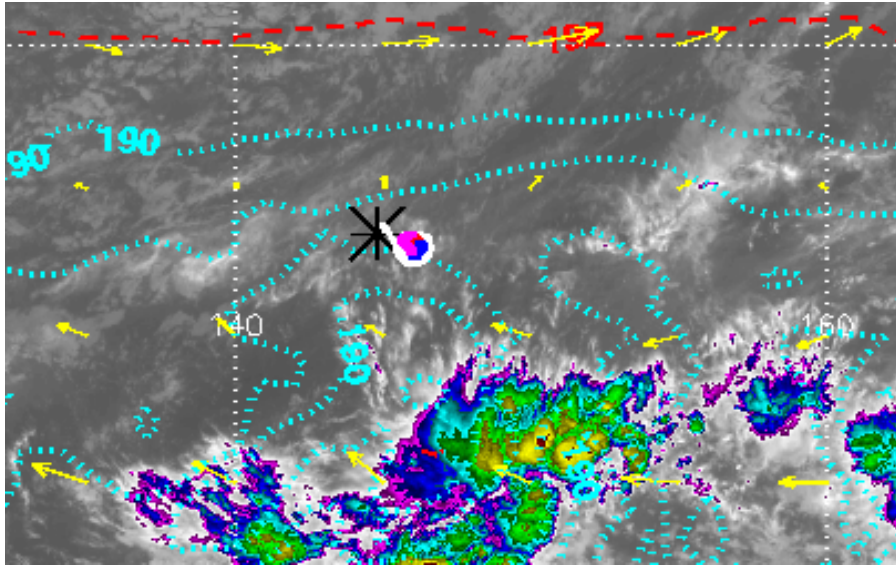


- Western Pacific TTL composition survey
- TTL cirrus sampling

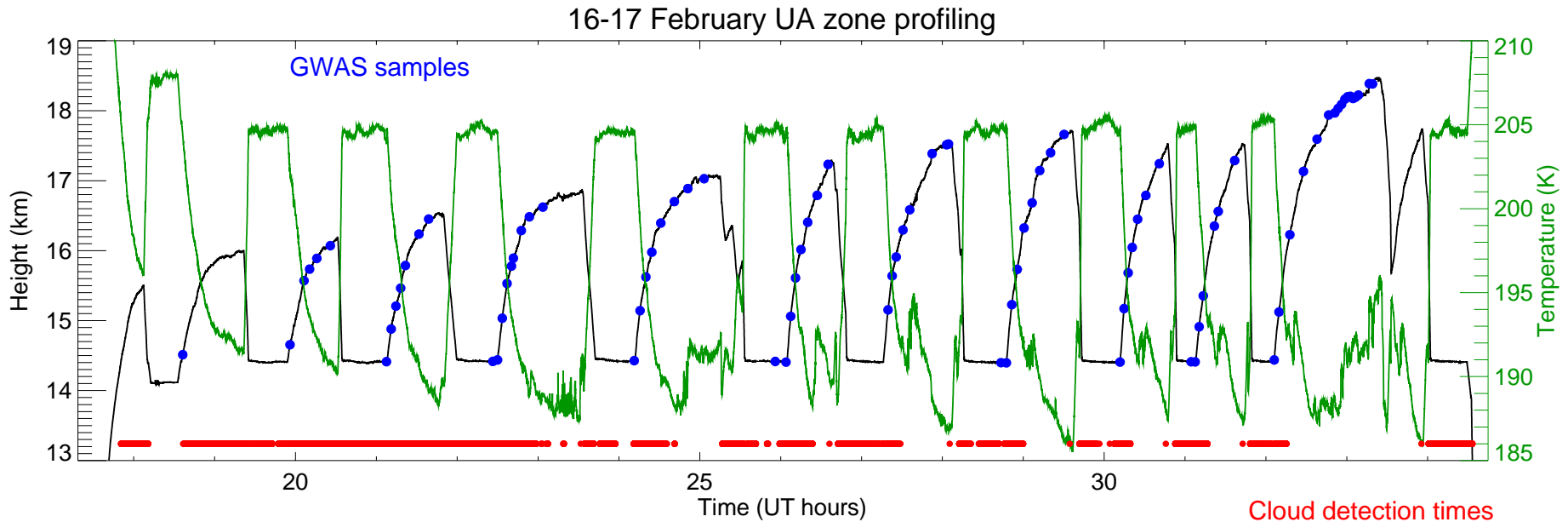
12-13 February WestPac TTL survey



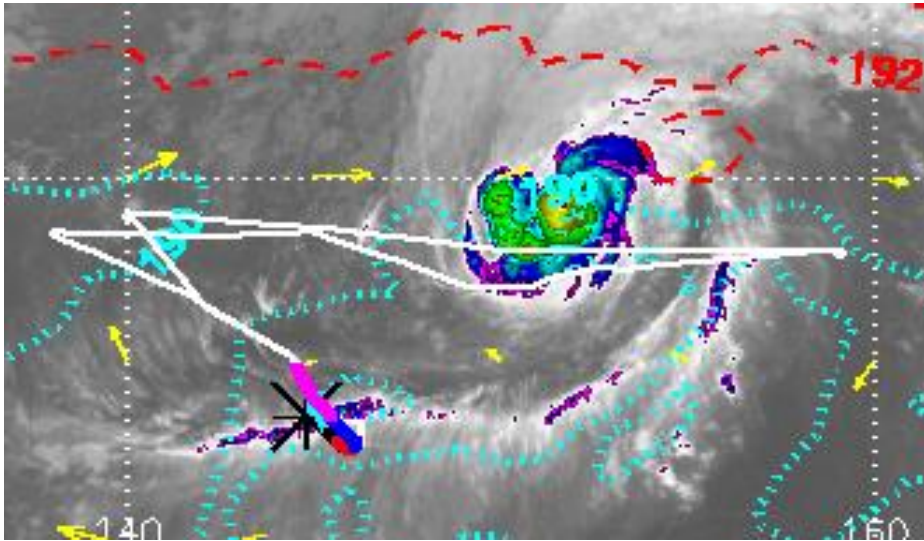
RF02 February 16



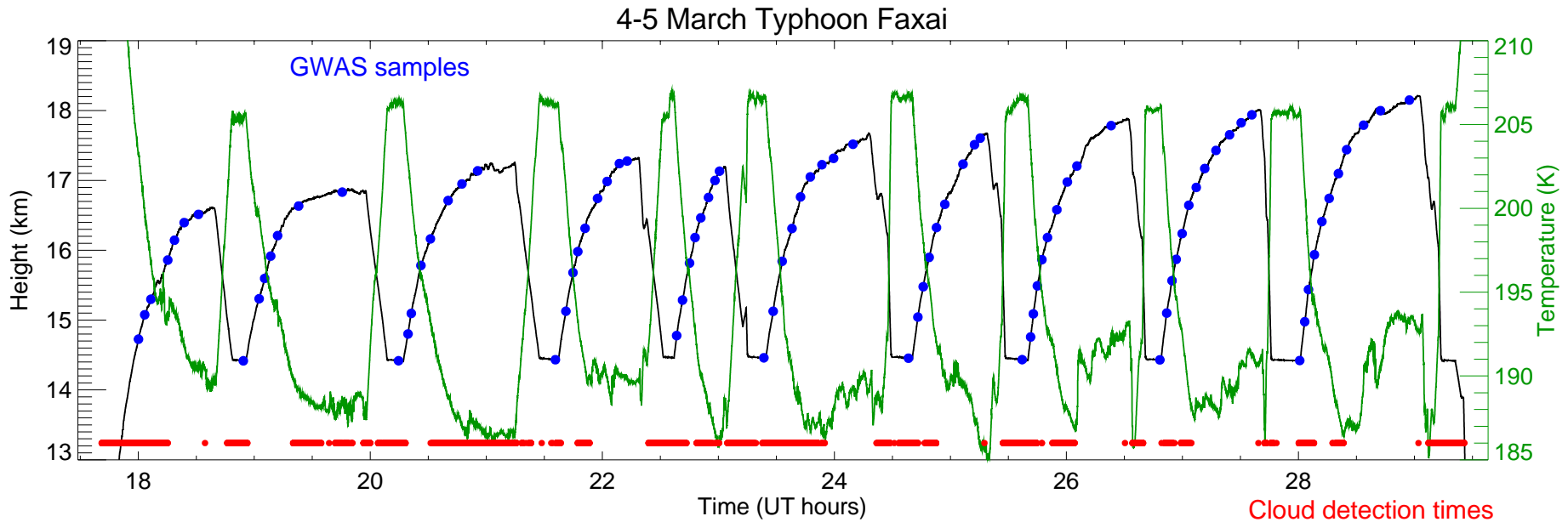
- UA zone vertical profiling
- Double-tropopause apparent in thermal structure and tracers



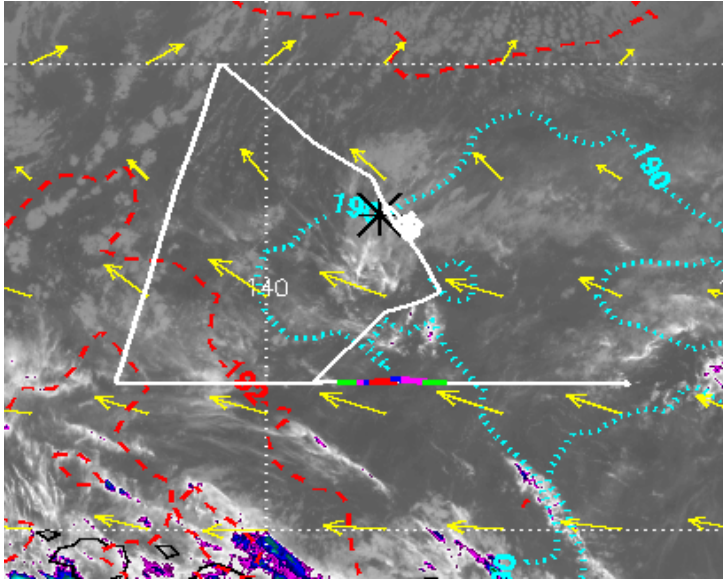
RF03 March 4



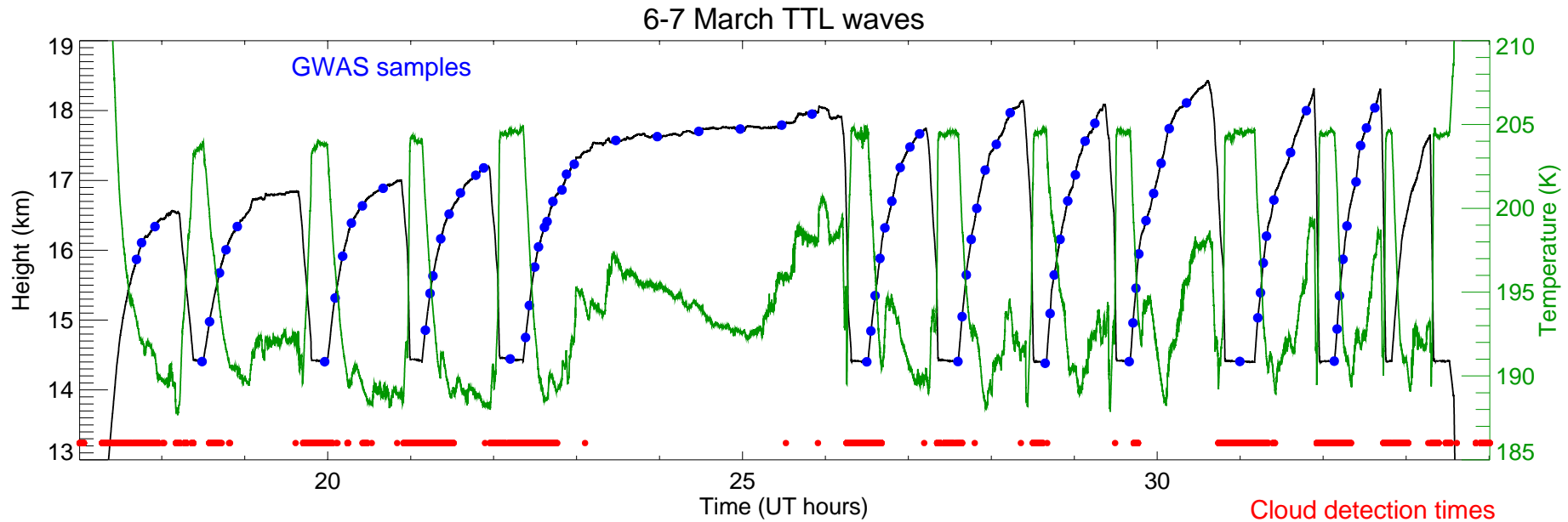
- Faxai-perturbed TTL sampling
- TTL cirrus produced by Faxai



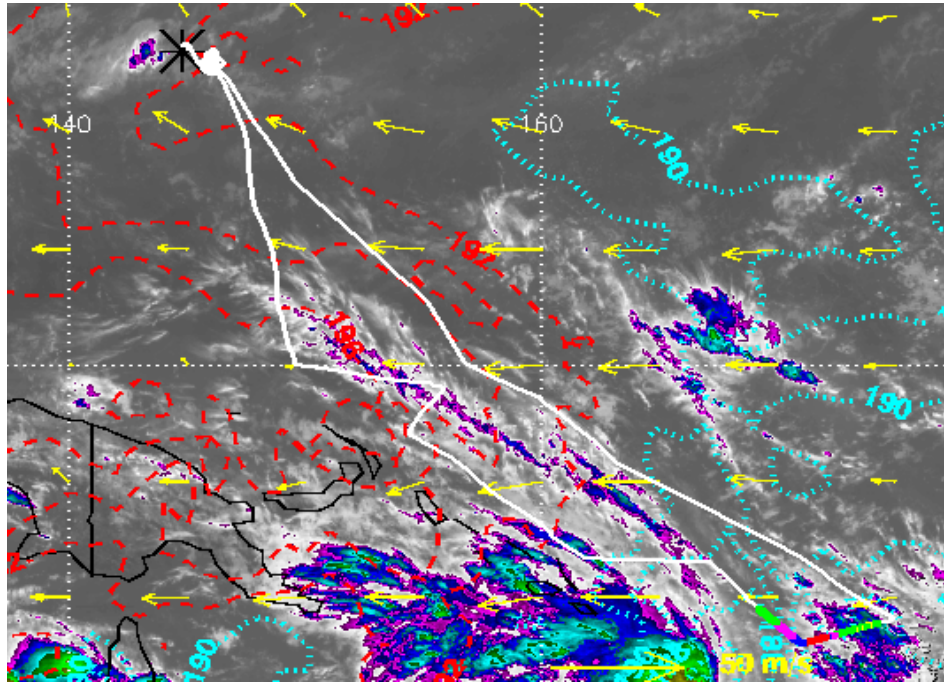
RF04 March 6



- TTL wave measurements
- TTL trace gas and cloud measurements

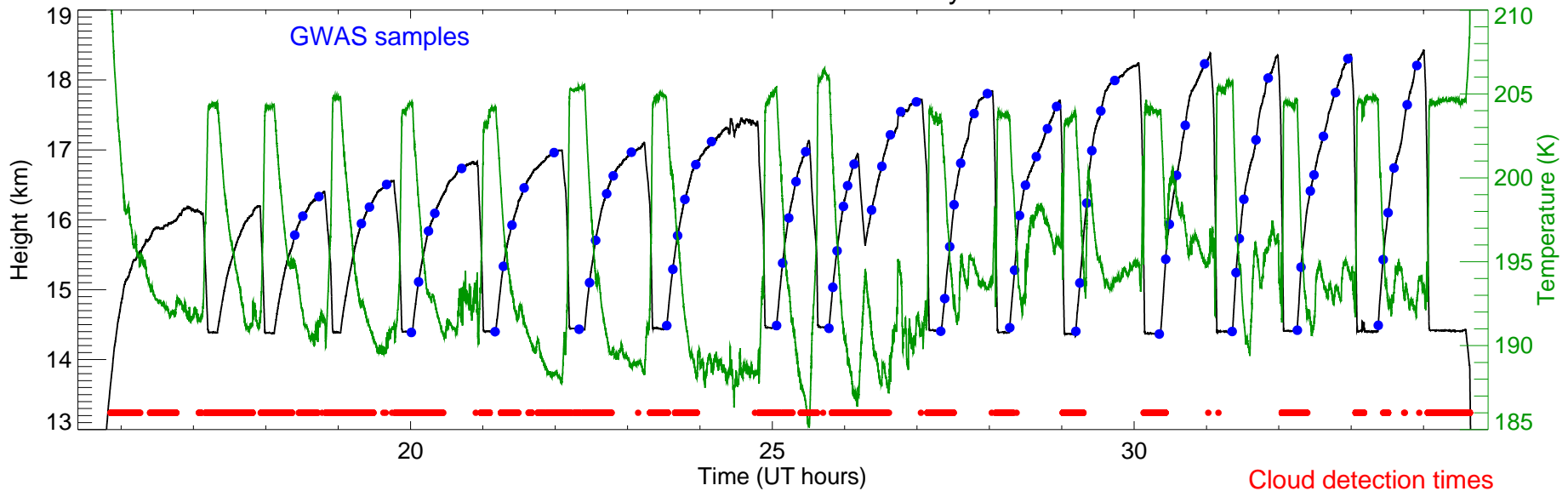


RF05 March 9

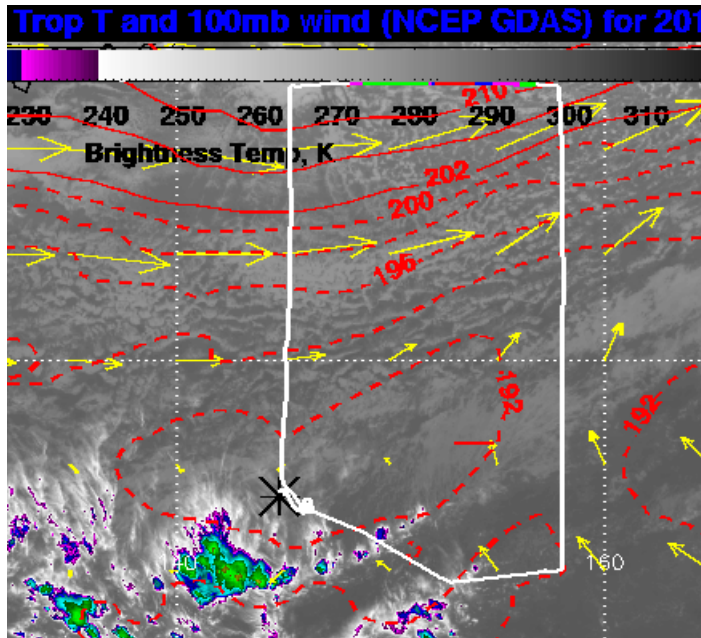


- Southern survey
- Fresh outflow from equatorial convection

9-10 March southern survey

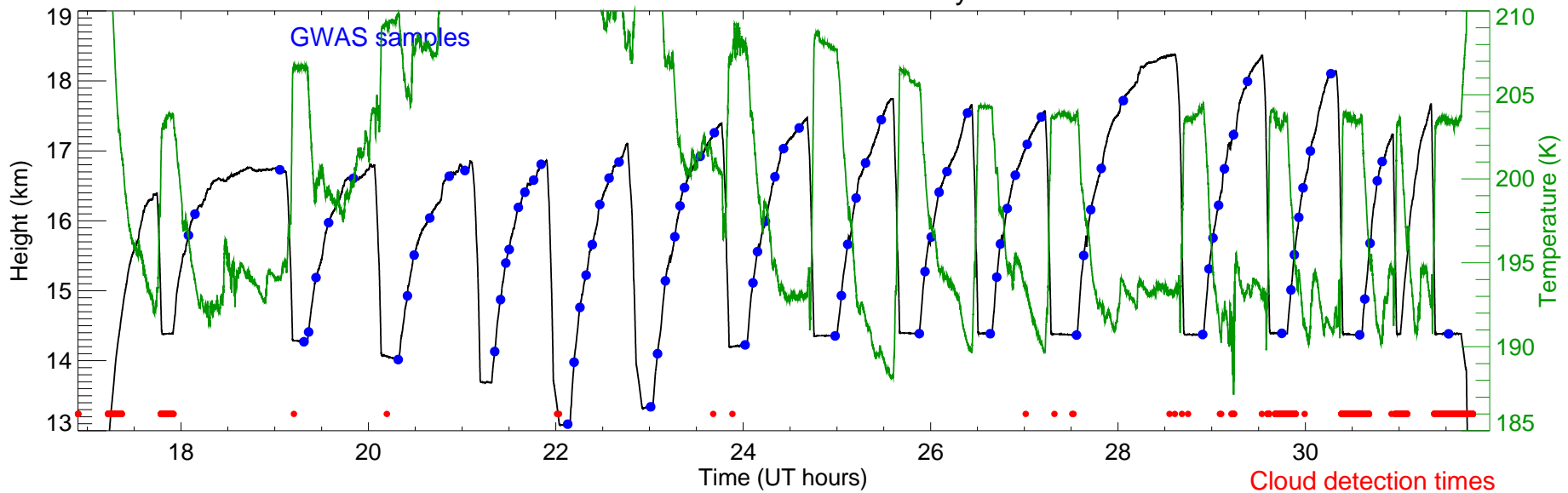


RF06 March 11

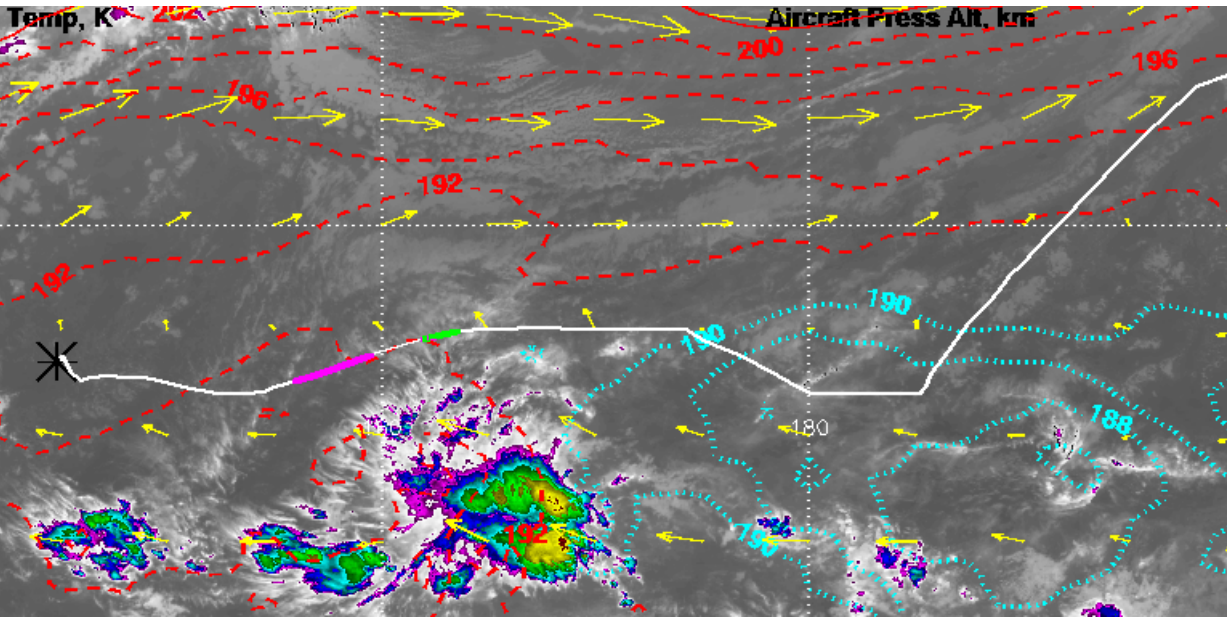


- Northern survey
- TTL/exTLS contrast measurements

11-12 March northern survey

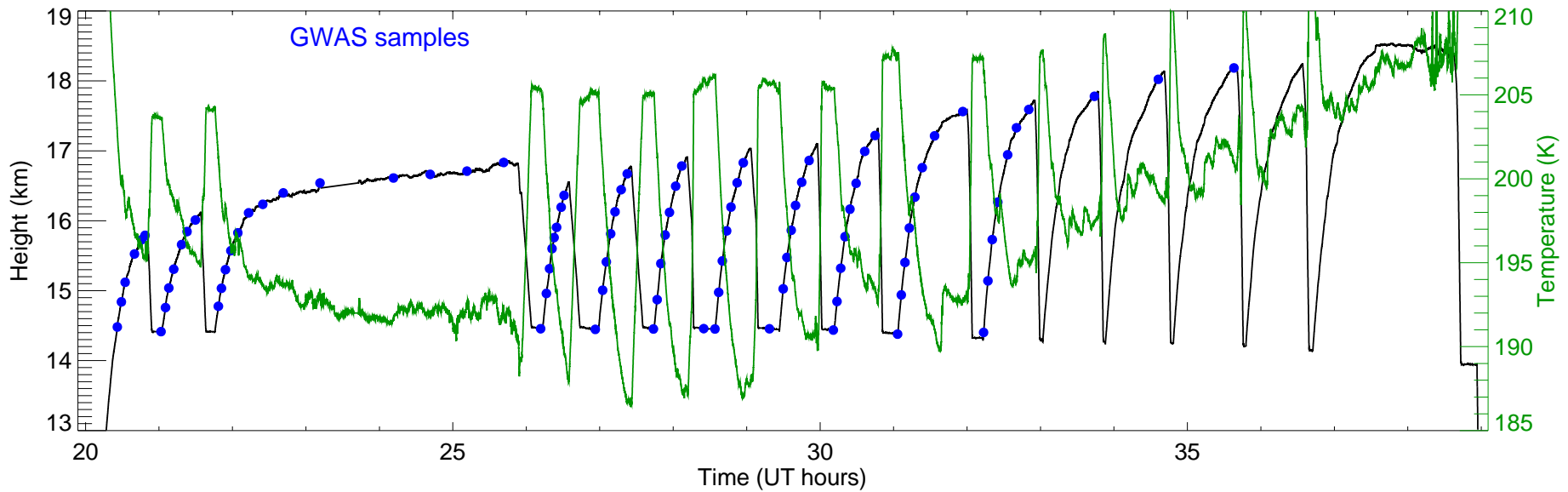


Transit back to Armstrong



- TTL profiling across central Pacific

13-14 March transit to AFRC



ATTREX future

- Flights from AFRC with CAST instruments and partial ATTREX payload are planned for early March, 2015.
- Modeling and analysis work ahead