



# Overview of Canadian Convair-580 program and accomplishments

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HIWC/HACI Science team meeting, 9-12 November, 2015





- EC and NRC partnered to support the HAIC-HIWC program using the NRC Convair580 during the Cayenne flight campaign in May, 2015.
- The NRC Convair580 flight operations in Cayenne were funded by EC and NRC.
- Flight operation objectives: coordinated flight with the SAFIRE Falcon-20 with focus on the temperature level  $-15^{\circ}\text{C} < T < -5^{\circ}\text{C}$ .
- Regulatory objectives: enhance statistics of TWC and particle size distributions for the temperature range  $-15^{\circ}\text{C} < T < -5^{\circ}\text{C}$  for Appendix D.
- Science objectives: as described in the HIWC Science Plan (FAA in press)





# Timeline

- September 2014 – Paris HAIC-HIWC Meeting
- October 2014 – December 2014:
  - Feasibility study – Can the Convair operate in HIWC?
  - Review of Darwin environment by NRC airworthiness and chief pilot
  - Funding and authorization by NRC and EC management
    - Phased approach – System integration plan and funding  
January – March 2015:
  - Developing detailed plan, agreements
  - Partial system installations
- April – Final system integrations and local test



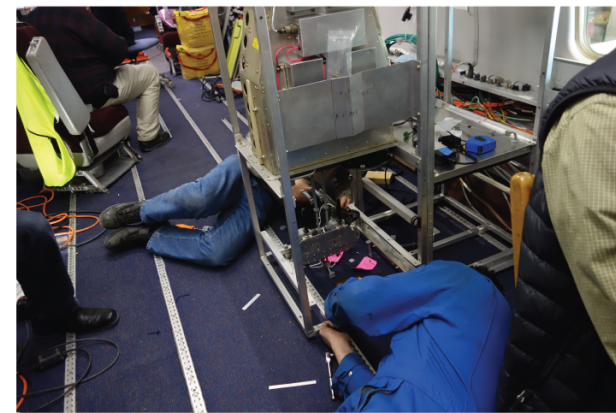
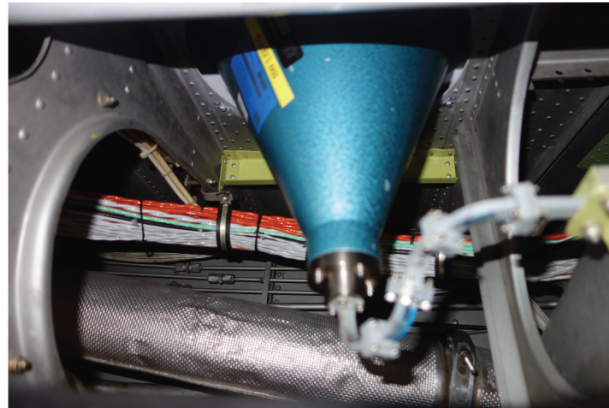
# 4-Feb



# 27-Feb



# 7-Mar



# NRC Convair-580 Schedule (Jan-May 2015)

2015	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
Jan																																
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June																																

- 8 March - ~ 10 April – Aircraft in Memphis; complete rack work
- 11 – 25 (29) April – Systems’ integration, ground and flight test
- 05-May - Aircraft depart for Cayenne
- 09-May – 1<sup>st</sup> flight
- 50 project flight hours (~ 11 flights)
- 30 May – Transit back to Ottawa



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## Schedule

- January-April 2015 instrumentation integration on the Convair580 (total integration time 1.5 months)
- 22-27 March 2015 reconnaissance trip to Cayenne
- 1-30 May 2015 EC/NRC team deployment in Cayenne
- 6-29 May 2015 Convair580 deployment in Cayenne
- 10-27 May 2015 research flight operations out of Cayenne

## Personnel

- 4 EC team (scientist, tech support)
- 14 NRC team (pilots, scientists, tech & maintenance)





## NRC Convair580 instrumentation during the HIWC field campaign in Cayenne, May 2015

### Cloud Microphysics

- 1.DMT UHSAS
- 2.PMS FSSP-100
- 3.DMT CDP
- 4.PMS OAP-2DC
- 5.PMS OAP-2DP
- 6.DMT CIP
- 7.DMT PIP
- 8.SPEC 2DS
- 9.SPEC CPI
- 10.Artium HSI
- 11.SEA IKP
- 12.SEA Robust Probe
- 13.SPT Nevzorov probe
- 14.Rosemount Icing Detector
- 15.EC Cloud Extinction Probe

### Remote sensing

- 16.ProSensing GVR
- 17.Alpenglow Elastic Lidar Zenith
- 18.Alpenglow Elastic Lidar Nadir
- 19.SEA Ka-band radar
- 20.ProSensing W-band radar (NAWX)
- 21.ProSensing X-band radar (NAWX)
- 22.Pilot's Radar
- 23.Storm Scope

### State parameters & thermodynamics

24. Aventech AIMMS-20
25. Rosemount 858
26. Licor 6262
27. Licor 6262
28. Licor 840A
29. Chilled Mirror CR-2
30. Reverse flow T
31. Rosemount Temperature sensor (x2)
32. Pressure sensors (2)

### Aircraft state & Navigation

34. Radioaltimeter
- 35-38. Honeywell IMU (x2), Litton, AIMMS-20
- 39-40. NovAtel GPS (x2)

GoPro camera

Purging system

Planet

Communication





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## NRC Convair580 cloud microphysical instrumentation







## Convair-580 Data Acquisition Systems

1. Convair-580 NRC DAS (state parameters, navigation, flight dynamics, etc.)
2. NAW DAS (W-band radar)
3. NAX DAS (X-band radar)
4. SEA M300 (Ka-band radar)
5. SEA M300 (IKP, Robust probe, Extinction)
6. SEA M300 (CDP, FSSP, 2DC, Nevzorov, Licor, DewPoint, etc.)
7. DMT PADS (CIP, PIP)
8. 2DS DAS
9. CPI DAS
10. UHSAS DAS
11. Lidar Zenith DAS
12. Lidar Nadir DAS
13. GVR DAS



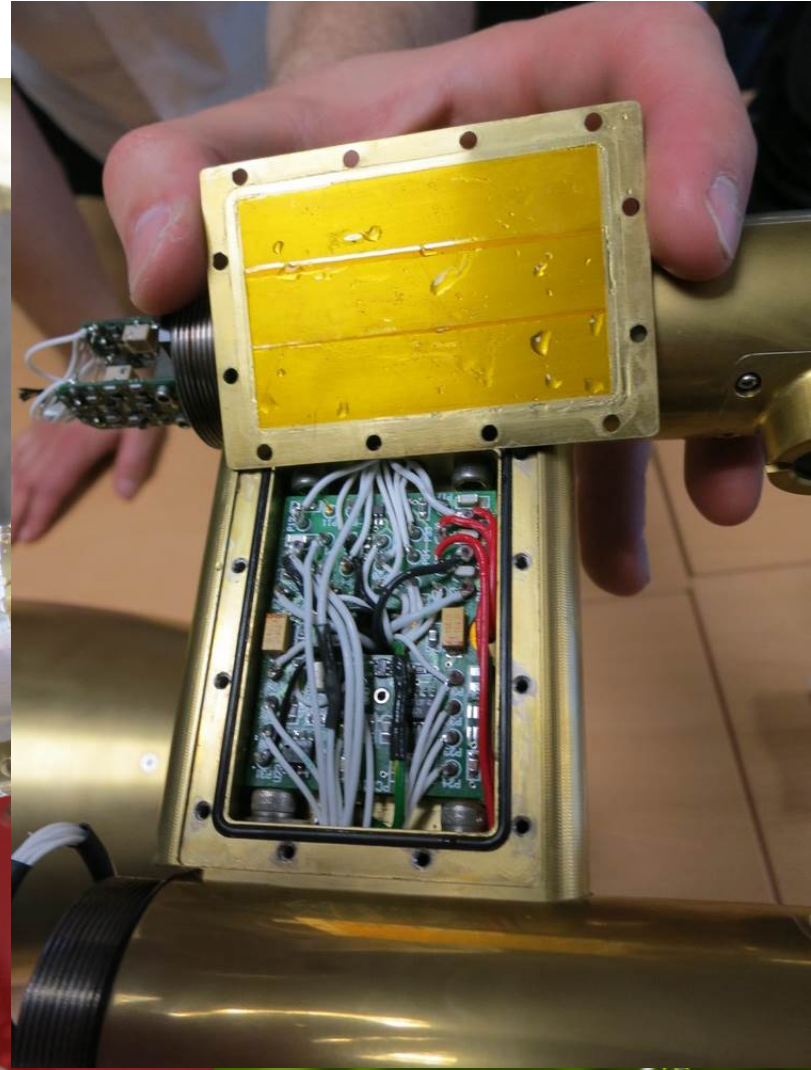
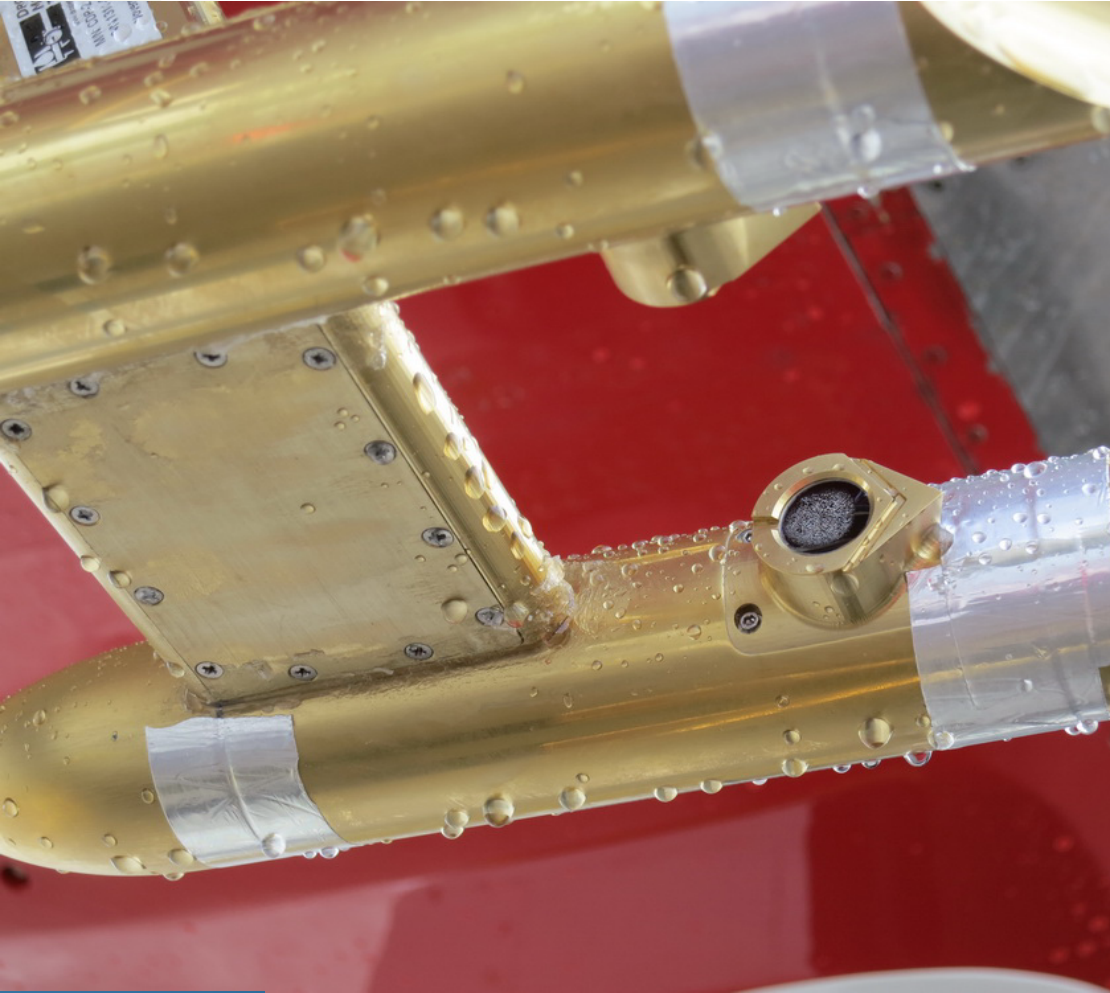
## Challenges of the Convair580 flight operations during the HAIC-HIWC Cayenne flight campaign

- no hangar was available for the Convair580
- parking outside under open sky
- instruments were exposed to the open air moisture and wind



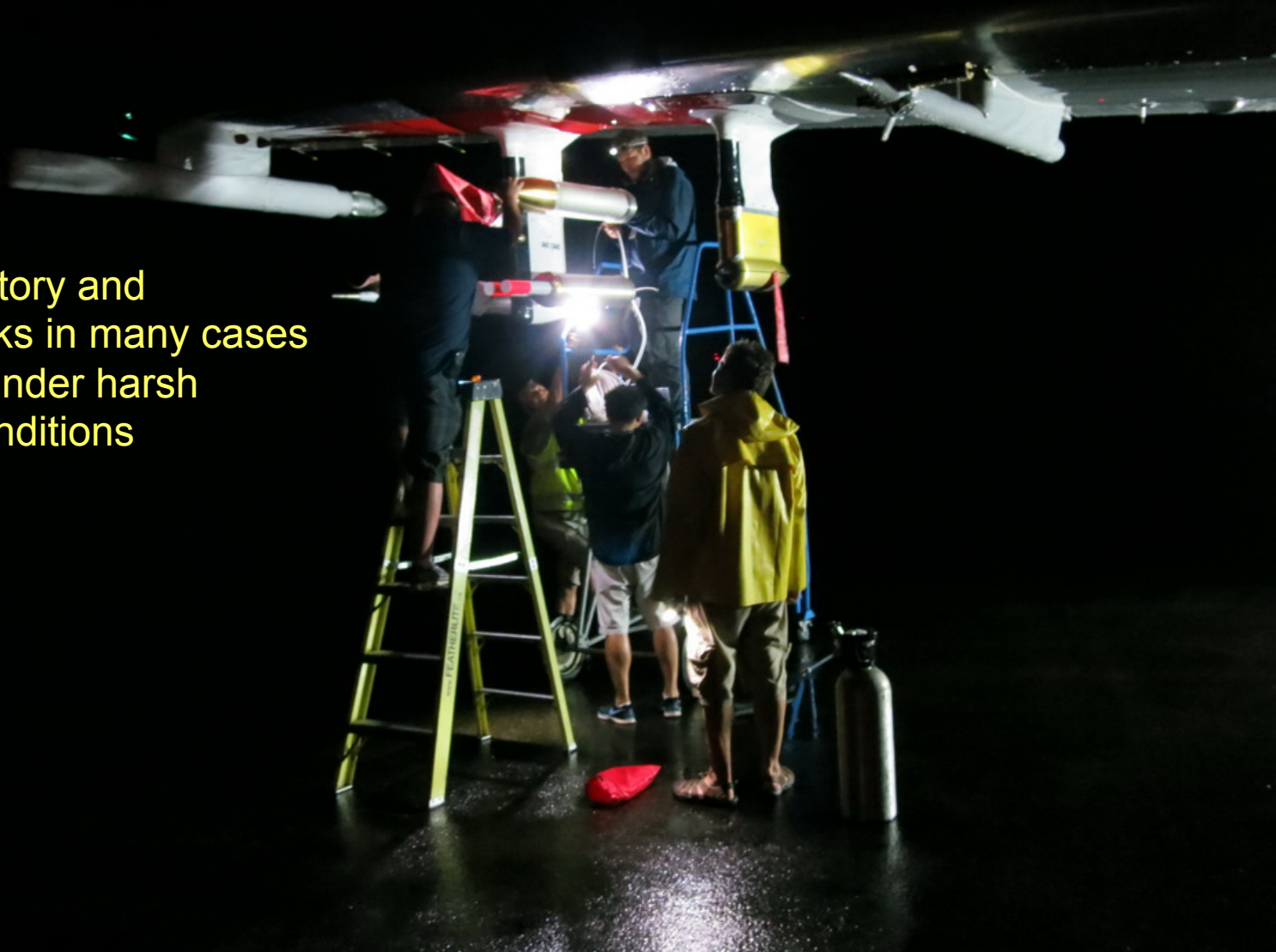
# Challenges of the Convair580 flight operations during the HAIC-HIWC Cayenne flight campaign

Enhanced maintenance efforts to keep the instruments operable



# Challenges of the Convair580 flight operations during the HAIC-HIWC Cayenne flight campaign

Pre-flight preparatory and maintenance works in many cases were performed under harsh environmental conditions



# Challenges of the Convair580 flight operations during the HAIC-HIWC Cayenne flight campaign



Airport Fire Station  
Convair580 instrumentation  
maintenance office



# Challenges of the Convair580 flight operations during the HAIC-HIWC Cayenne flight campaign

Inflight icing at  $-5^{\circ}\text{C} > -15^{\circ}\text{C}$ : light to moderate, occurred occasionally



## Challenges of the Convair580 flight operations during the HAIC-HIWC Cayenne flight campaign

- Thread of the radome erosion by graupel and hailstones.
- Occurred only once the Convair580 flight operations





## Summary of the NRC Convair580 flight operations out of Cayenne

<b>Flight#</b>	<b>Date</b>	<b>flight type</b>	<b>Convection type</b>	<b>Falcon-20 coordination</b>
7	10-May-15	test/research	Oceanic	no
8	12-May-15	research	Oceanic	no
9	14-May-15	research	Mixed	yes
10	15-May-15	research	Oceanic	yes
11	16-May-15	research	Oceanic	yes
12	16-May-15	research	Land	yes
13	20-May-15	research	Land	no
14	23-May-15	research	Oceanic	yes
15	23-May-15	research	Mixed	yes
16	25-May-15	research	Land	yes
17	26-May-15	research	Oceanic	yes
18	26-May-15	research	Oceanic	yes
19	27-May-15	research	Oceanic	yes
20	27-May-15	transit	Clear	no





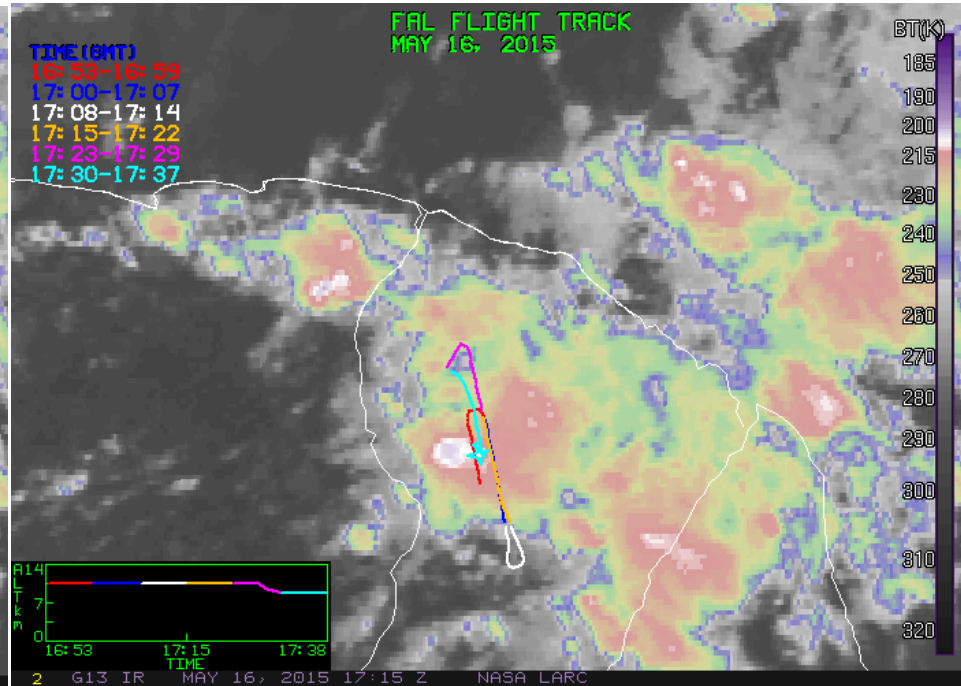
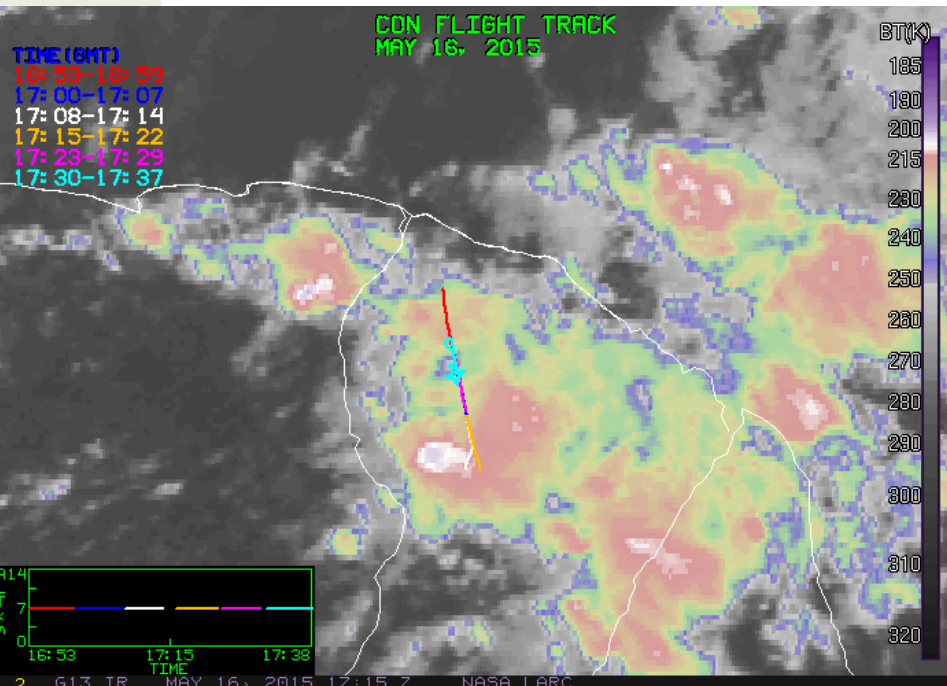


# Coordinated Convair580-Falcon20 flights

CloudSat overpass, 16 May 2015

NRC Convair580

SAFIRE Falcon-20





# Endurance of the flight operations of the NRC Convair580 at different temperature intervals

## In-cloud (TWC>0.1g/m<sup>3</sup>)

### *SEA Robust Probe*

Temperature interval	time (hrs)	Length (km)
-5 <T< 0C:	2.29	910.65
-10 <T< -5C:	11.73	4791.66
-15 <T< -10C:	8.19	3373.19
-20 <T< -15C:	0.03	14.15
total	22.24	9089.65

## In-cloud + clear sky

Temperature interval	time (hrs)	Length (km)
T> 0C:	6.29	2307.64
-5 <T< 0C:	4.61	1868.24
-10 <T< -5C:	17.42	7145.56
-15 <T< -10C:	11.46	4776.88
-20 <T< -15C:	0.06	25.54
total	39.84	16123.86

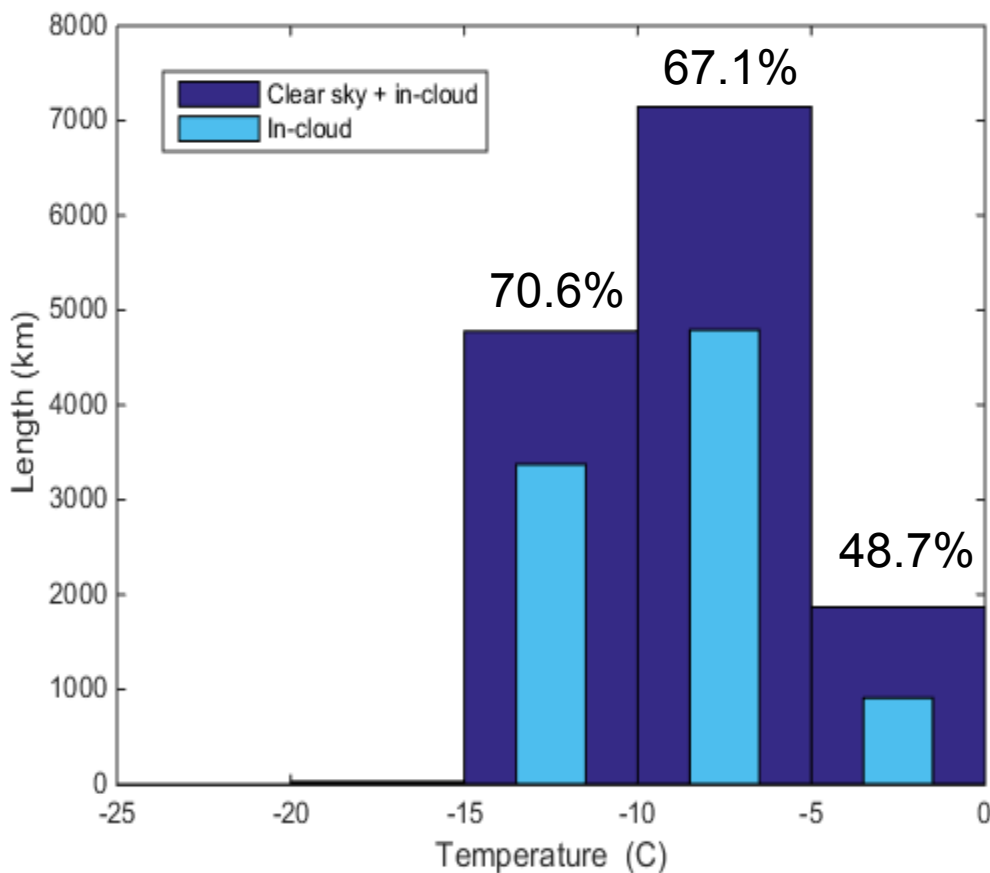
### *SPT Nevzorov Probe*

Temperature interval	time (hrs)	Length (km)
-5 <T< 0C:	2.19	876.82
-10 <T< -5C:	11.82	4830.73
-15 <T< -10C:	7.91	3259.16
-20 <T< -15C:	0.05	19.63
total	21.97	8986.34





# Statistics of the NRC Convair580 flight operations versus temperature



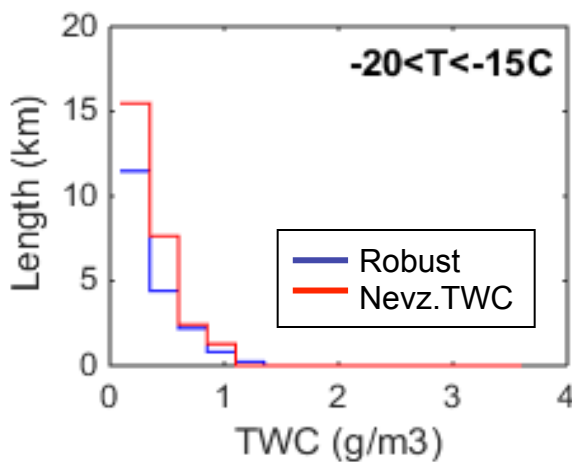
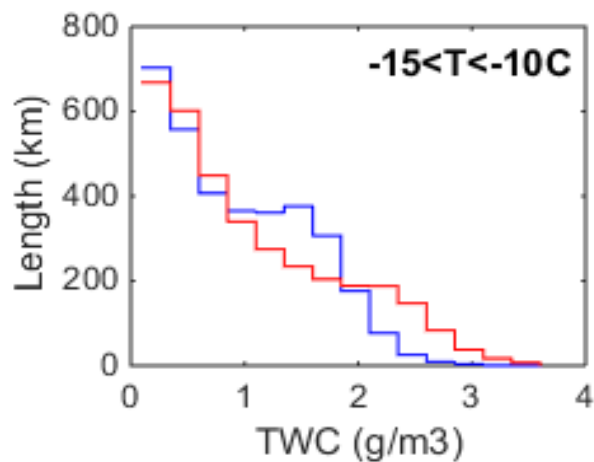
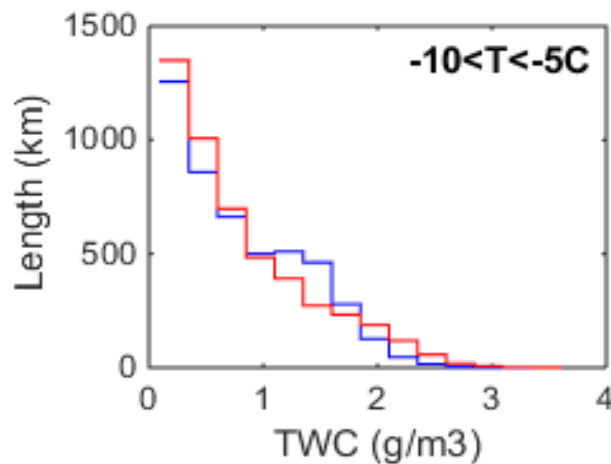
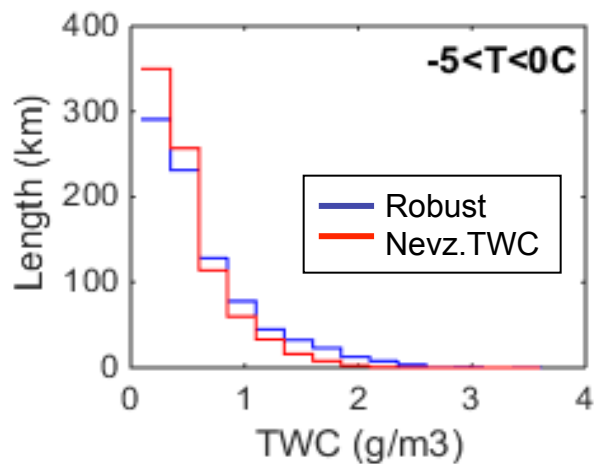
Sampling efficiency	
0C > T > -5C	48.7%
-5C > T > -10C	67.1%
-10C > T > -15C	70.6%

- Depends on:**
- Characteristic spatial scale of MCSs
  - Regional specifics (distance to targets)
  - Type of aircraft (ceiling, endurance, TAS)
  - Ground base navigation





## Preliminary IWC sampling statistics estimated from the Robust\*2 and Nevzorov TWC\*2 measurements



### Disclaimer:

- zero offsets from the Robust and Nevzorov probes were not completely removed
- Robust and Nevzorov IWC scaling coefficients are subject of further clarification
- the final result after applying all corrections may be different from shown here



## Accomplishments

- Convair580 conducted in total 14 flights out of which 12 were research flights (~40h)
- Sampled approximately 8100 km of clouds at  $-5^{\circ}\text{C} > T > -15^{\circ}\text{C}$ .
- Overall assessment of the probe performance: good
- Collected rich in-situ and remote sensing data sets on cloud microphysics and dynamics in MCSs
- Assessment of the HIWC Convair580 operations: successful





## Way forward

1. Finalize assessment of the data quality
2. Accomplish probe calibrations
3. Continue development of the data processing algorithms
4. Perform complete data processing
5. Development of the data archive
6. Work on development of the Appendix D envelop
7. Work on the science objectives specified in the HIWC Science Plan (to be published by FAA)





- Over 30 NRC and EC staff (DFS, Airworthiness, Flight ops. tech support): System integration and test flights
- SEA: M300 and Ka-band
- Wasey Inc.: Instrumentation integration + HSI
- NASA GRC: IKP
- SAFIRE & Airbus: Logistics and deployment in Cayenne

**THANKS TO ALL!**





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## High Ice Water Content (HIWC) Program

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