Aerosol effects on ice, liquid, and mixed phase clouds during ISDAC flights

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ISDAC special session, DOE ARM Meeting, Boulder, CO, October 1, 2009.

Abstract:

- Clouds formed in polluted and clean environmental conditions are studied.
- Cloud and aerosol physical and chemical properties are used for understanding the formation of ice, liquid, and mixed phase clouds.

Science Question:

2 *To what extent do the different properties of the arctic aerosol during April produce differences in clouds?*

2A Do the more polluted conditions during April in the Arctic enhance droplet number, crystal number, droplet dispersion, cloud optical depth, and longwave emissivity? How do these cloud properties depend on the degree of pollution?

2B How do numbers of arctic IN vary as function of temperature and supersaturation, and how does this compare against parameterizations used in models?

2C Does glaciation enhancement by increased IN dominate glaciation suppression by droplet size reduction associated with increased CCN?

2D What is the relationship between IN and ice crystal number and what role does ice multiplication play in determining ice crystal number concentration?

2E What are the spatial and temporal scales over which water and ice mix in mixed-phase clouds, and how does this depend on aerosol concentrations?

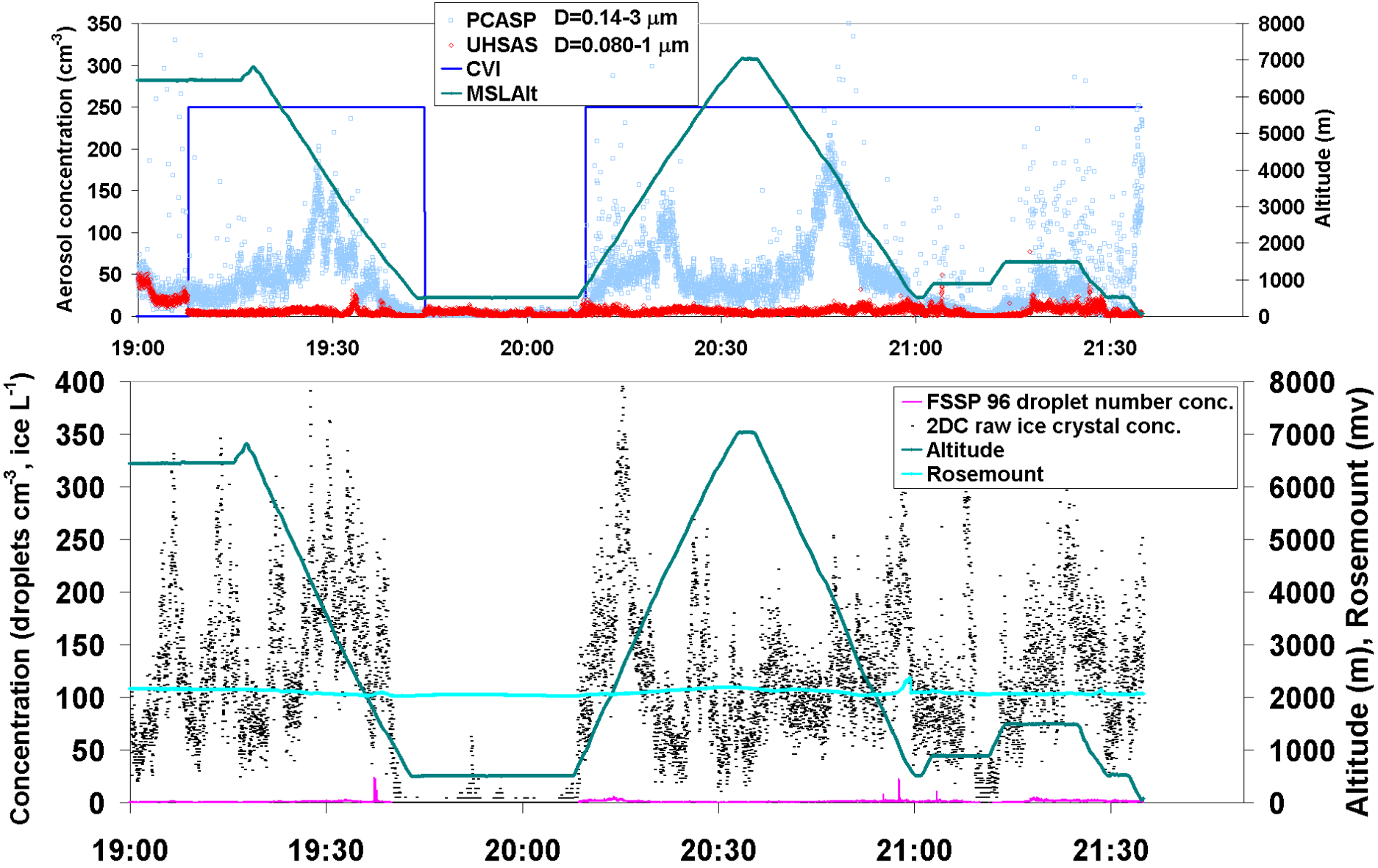
2F How do differences in large-scale meteorological forcing and surface conditions affect how cloud properties differ in the polluted April compared with October?

2G What role do aerosols play in explaining why springtime clouds observed during SHEBA persist so long, even though surface fluxes were weak and the ice precipitated?

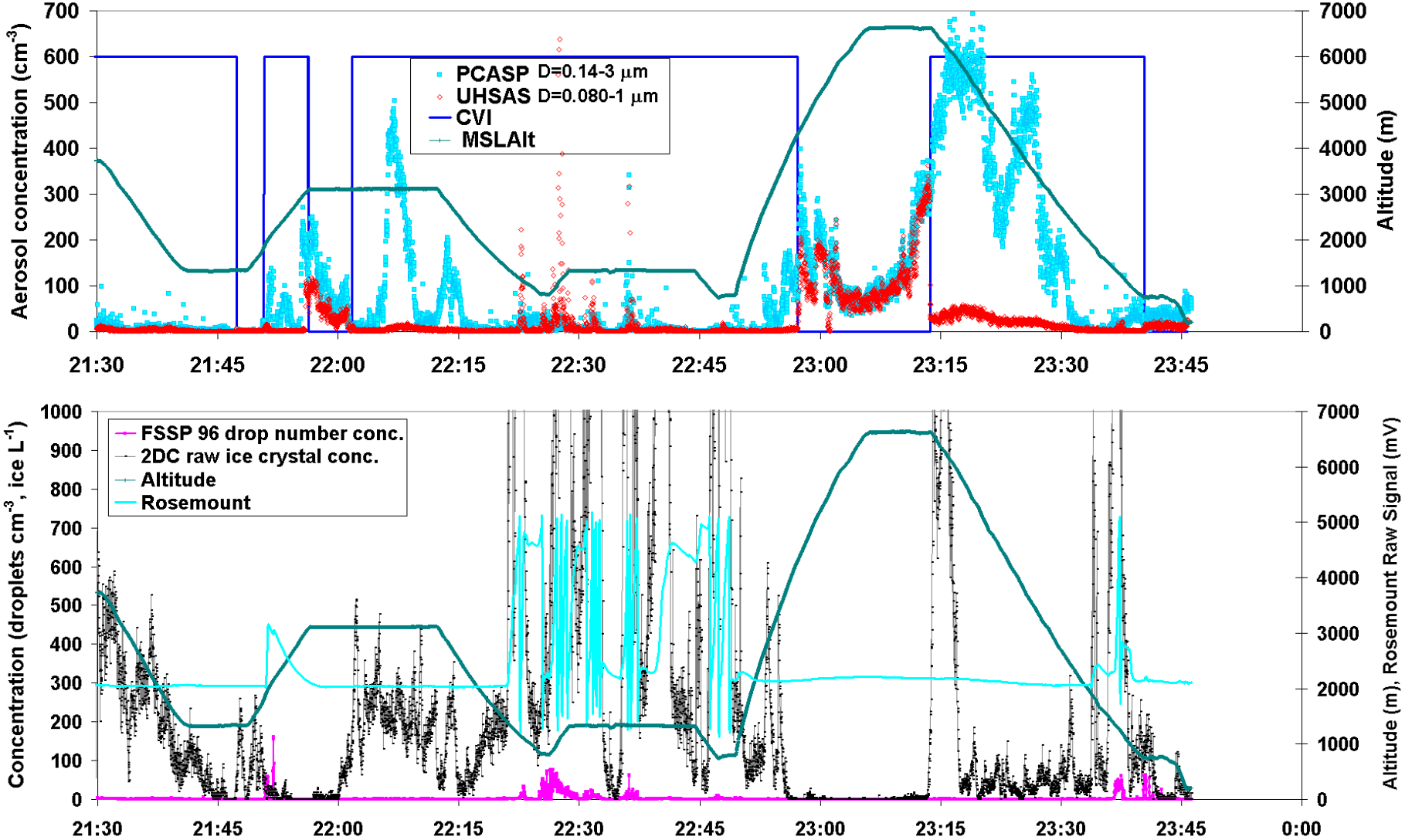
2H What role does aerosol absorption of sunlight play in the dissipation of springtime arctic clouds?

2I Which processes contribute to the scavenging of arctic aerosol during spring?

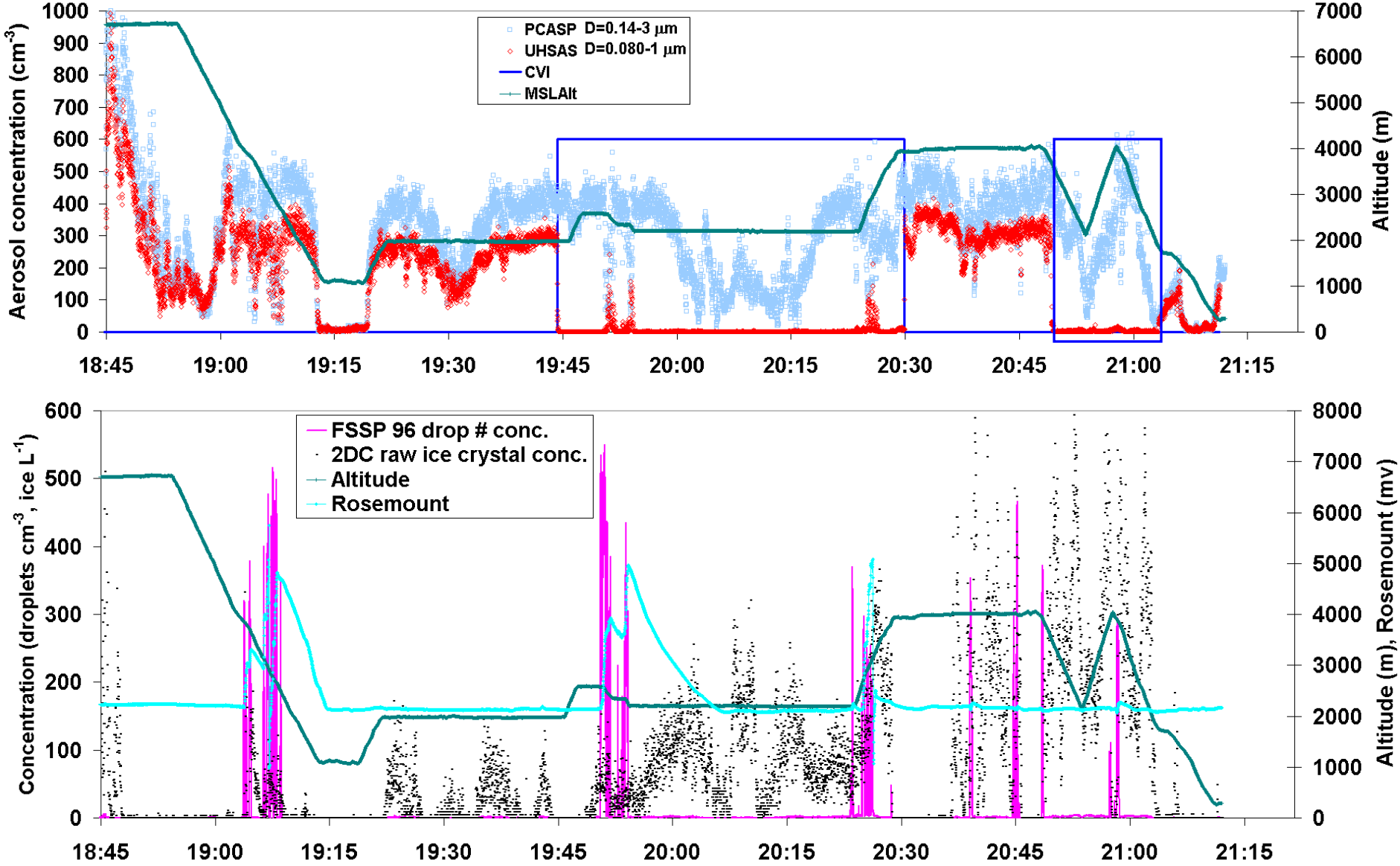
Flight 13 April 5th (clean, ice)



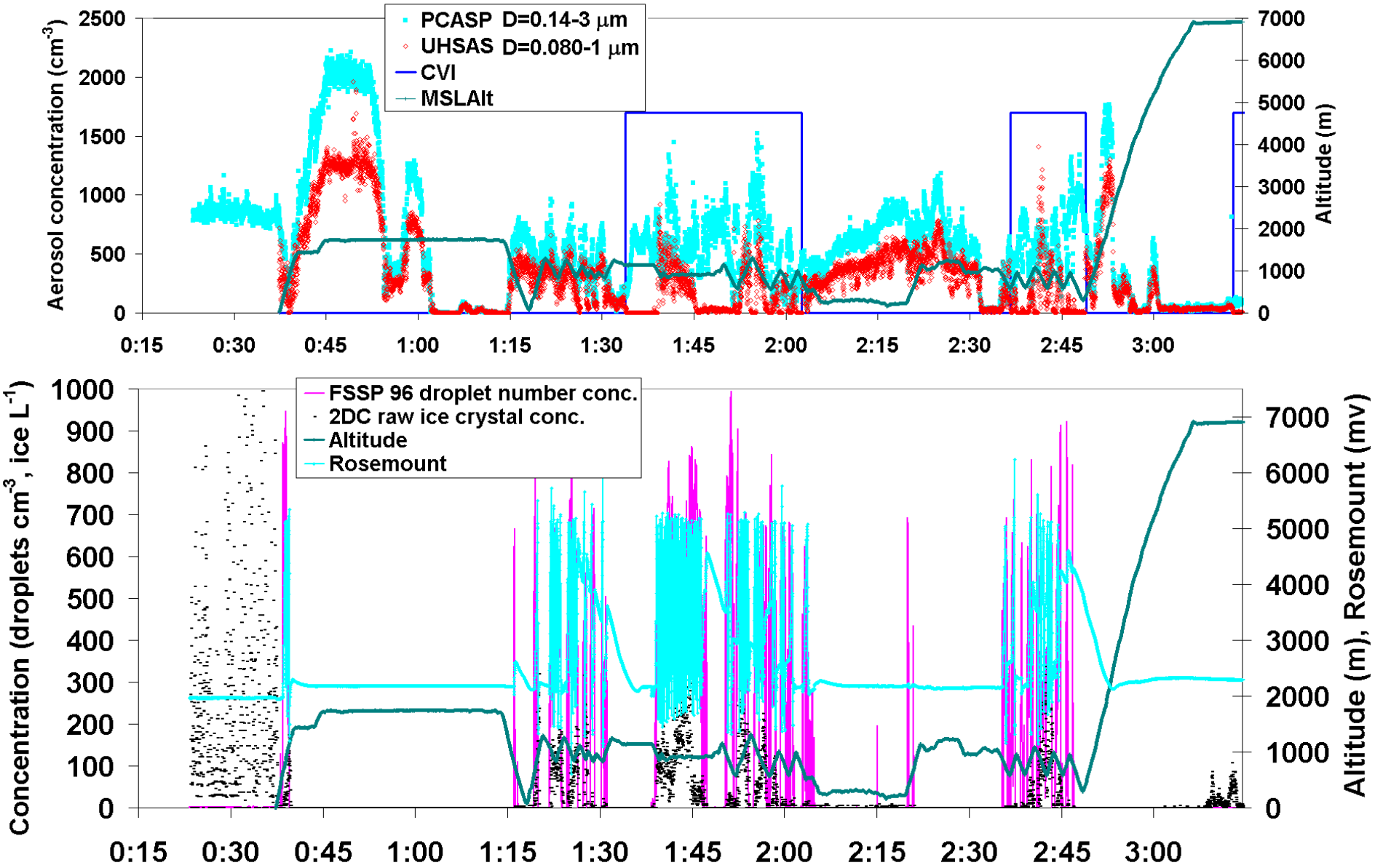
Flight 9 (Clean, polluted @ 23:15-23:30, mixed phase but with more ice)



Flight 27 (semi-polluted, mixed phase, ice only at times)



Flight 26 April 19 (polluted, mixed phase with more liquid)

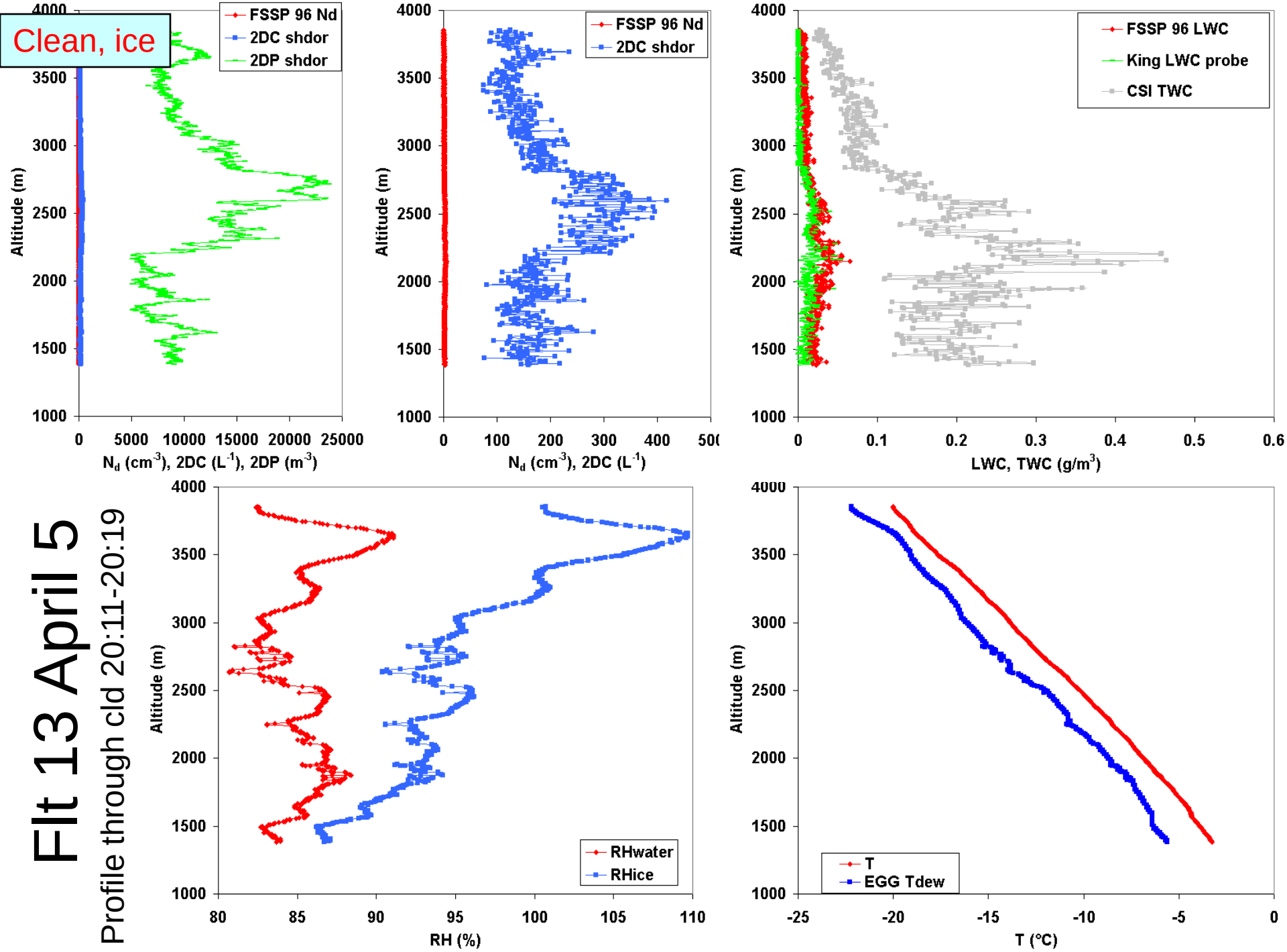


2 cases: clean/ice, polluted/liquid

Flight #		**Aerosol condition, phase**	**Flight patterns, temperatures**	
Flight 13	April 5, 2008	Clean (N_a < 200 cm^{-3}), mainly ice (very little liquid)	Profiles, horizontal leg below ice, T= +5 to -40°C	Photo: W. Strapp
Flight 26	April 19, 2008	Polluted (N_a > 500 cm^{-3}), mixed phase with more liquid relative to other cases	Porpoise, horizontal legs above and below cloud, T= 0 to -40°C	Photo: A. Korolev

Flt 13 April 5

Profile through cld 20:11-20:19

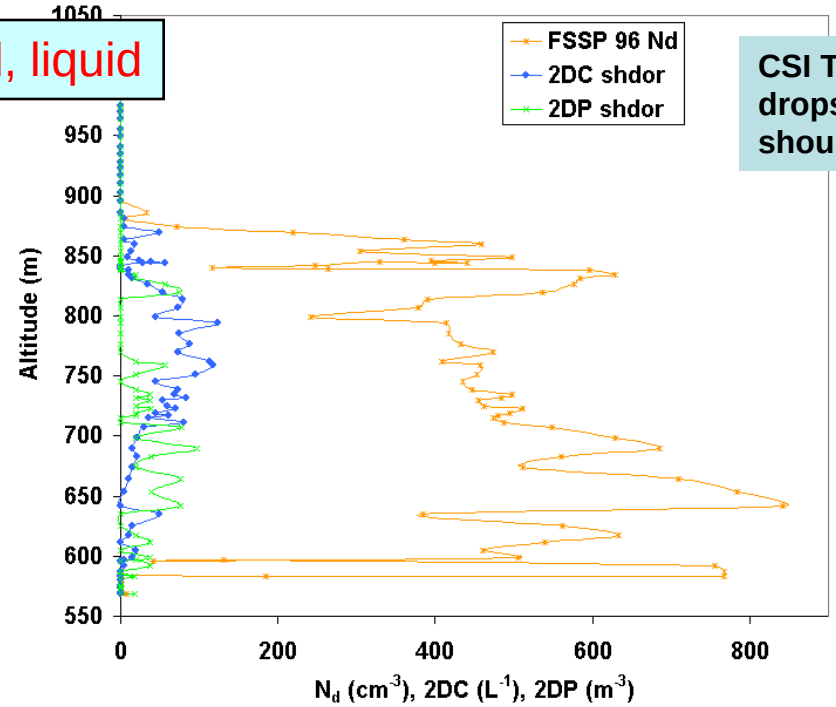


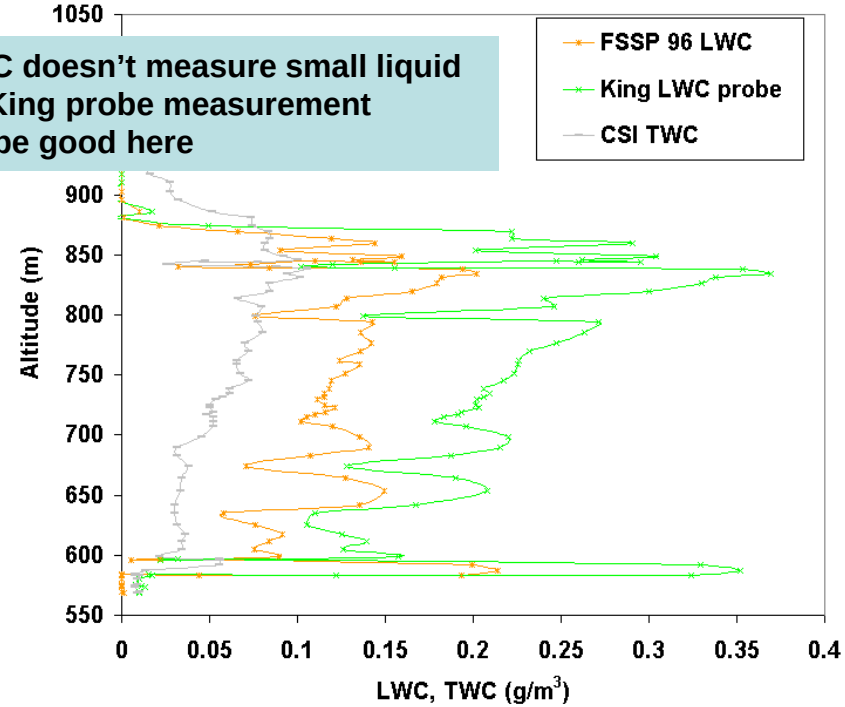
Polluted, liquid

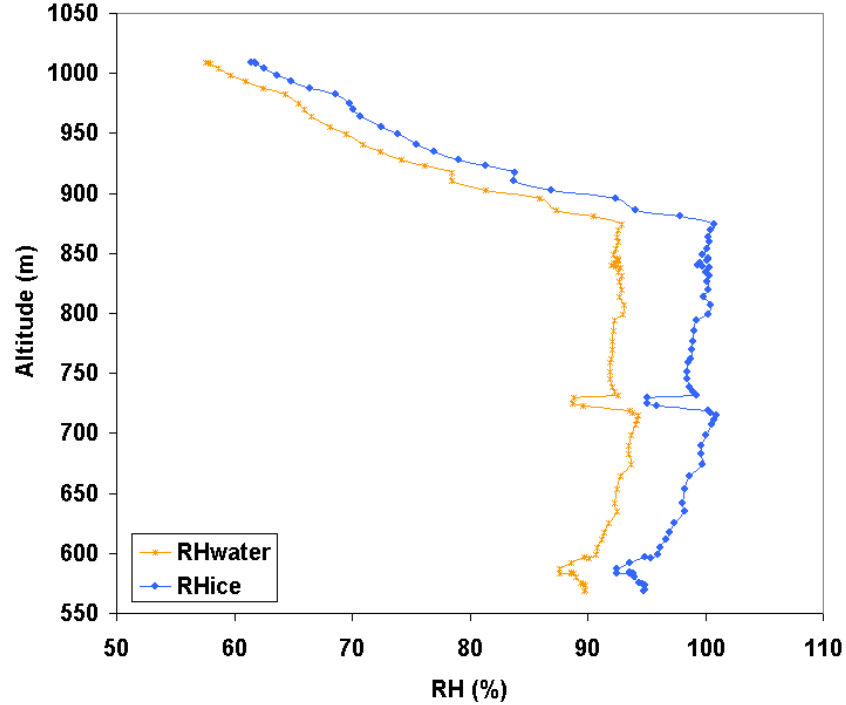
Flt 26 April 19

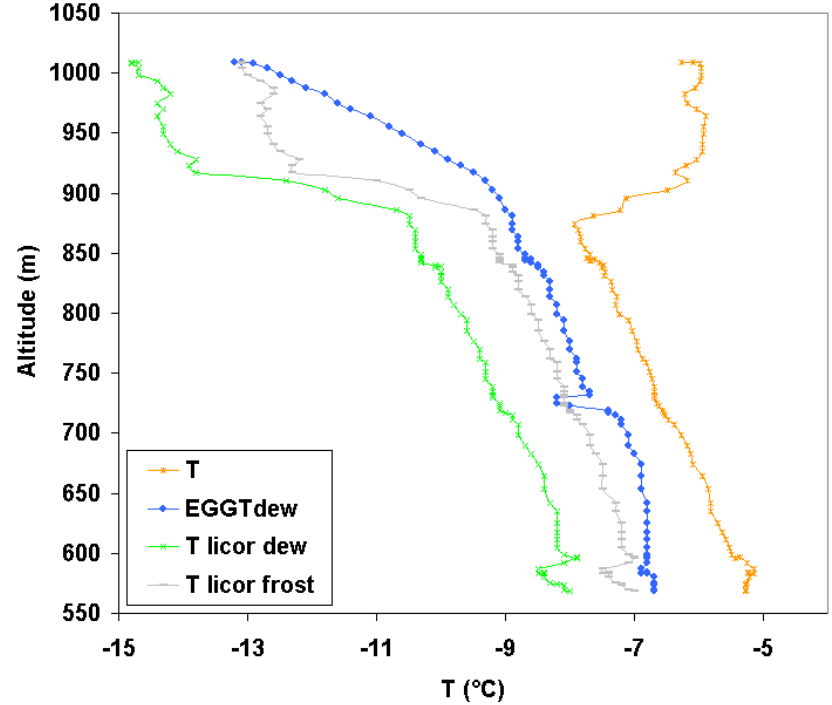
Profile through cloud
1:57-1:59

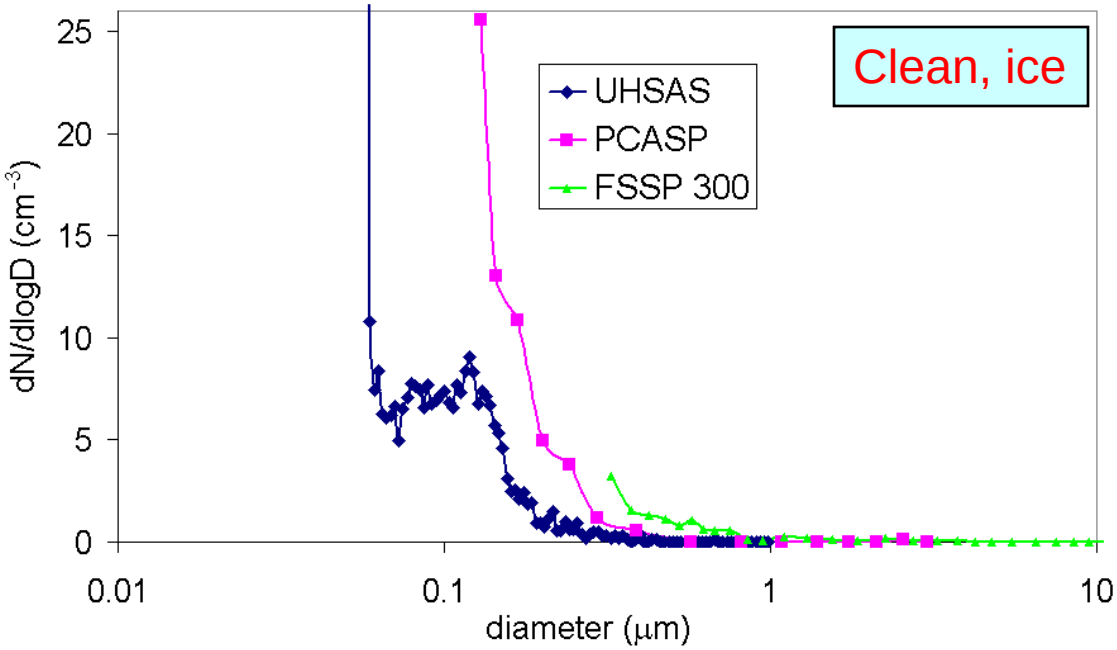
CSI TWC doesn't measure small liquid drops. King probe measurement should be good here

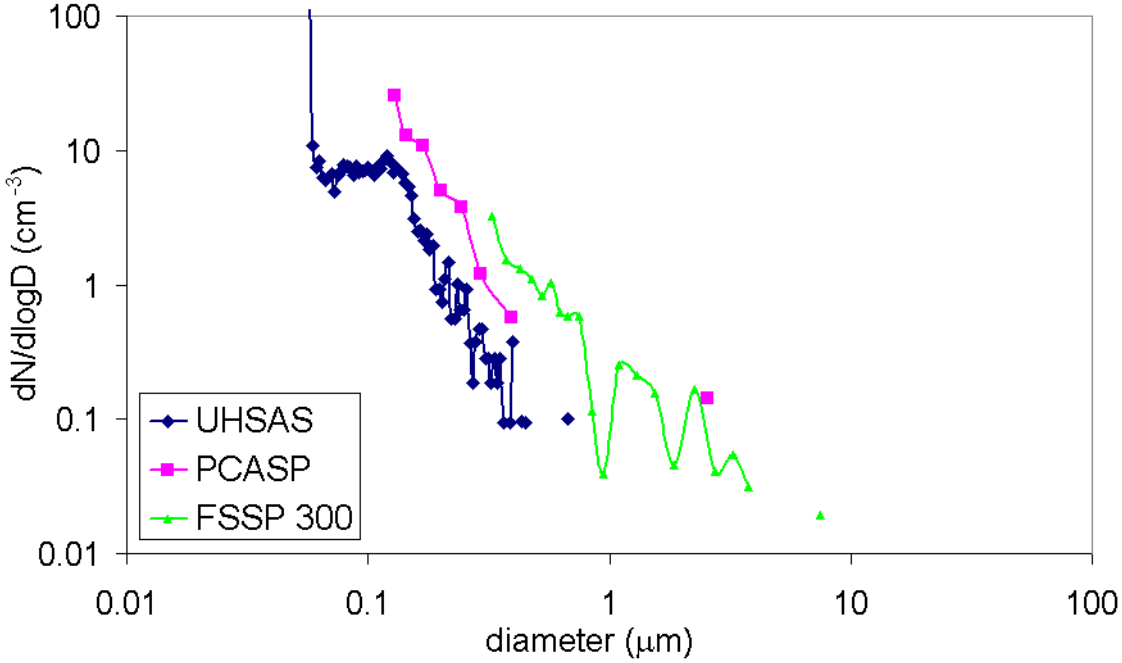












Flt 13 April 5

Below ice cloud, aerosol run

19:57-20:05 incl.

Averages:

Altitude: 516 m

Latitude: 71.5°

Longitude: 157.4°

N_d: 0.002 cm^{-3} (FSSP 96)

N_{ice}: 0.118 L^{-1} (2DC raw)

LWC: 0 g m^{-3}

TWC: 0.006 g m^{-3} (CSI)

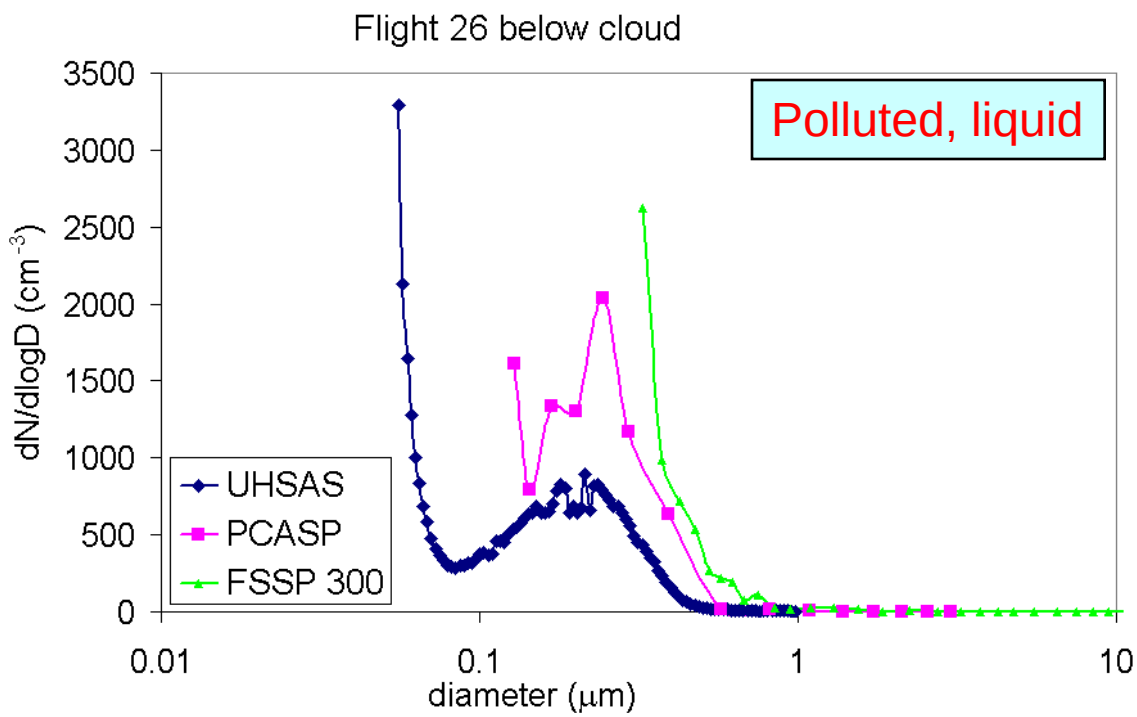
RH_w: 64.5%

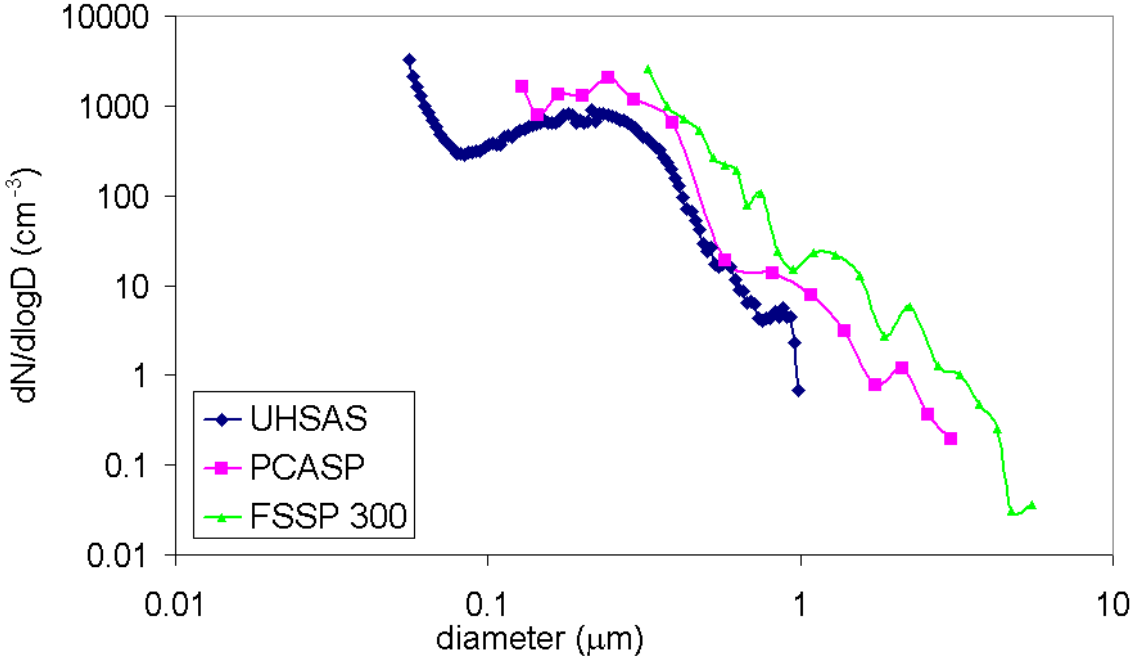
Rh_i: 63.3%

T: 2.28°C

T_{dew}: -3.673°C (EG&G)

Flt 26 April 19





Below cloud, aerosol run

2:08-2:14 incl.

Averages:

Altitude: 296 m

Latitude: 71.4°

Longitude: 155.6°

N_d: 0.25 cm^{-3} (FSSP 96)

N_{ice}: 0.223 L^{-1} (2DC raw)

LWC: 0 g m^{-3}

TWC: 0.003 g m^{-3} (CSI)

RH_w: 78.9%

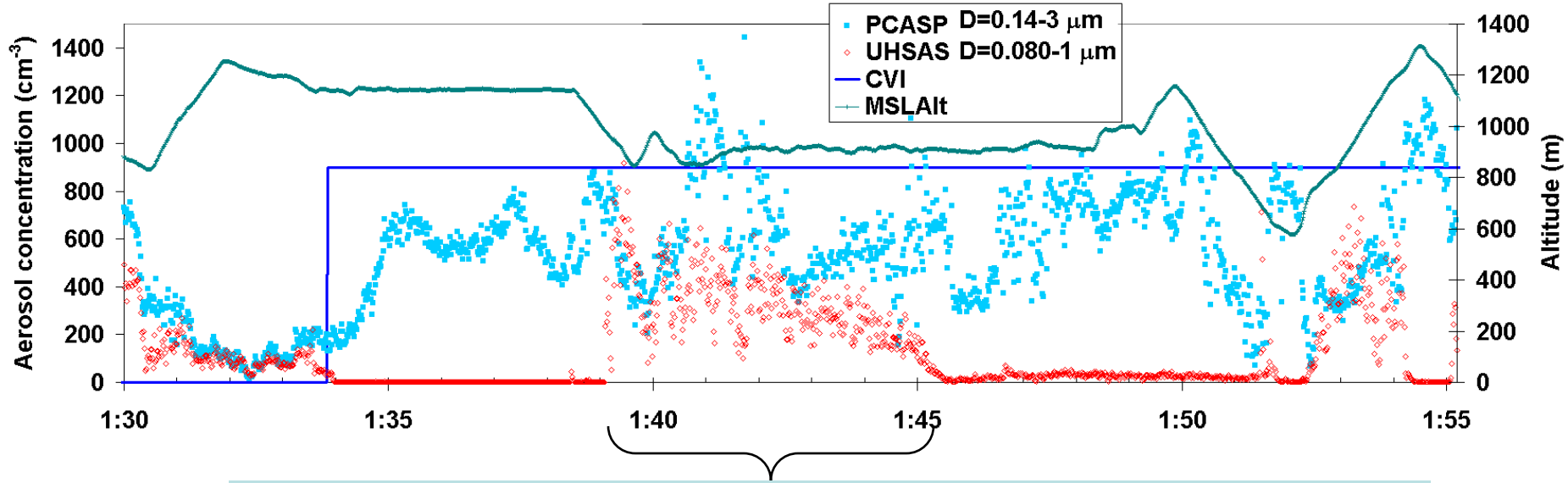
Rh_i: 81.4%

T: -3.2°C

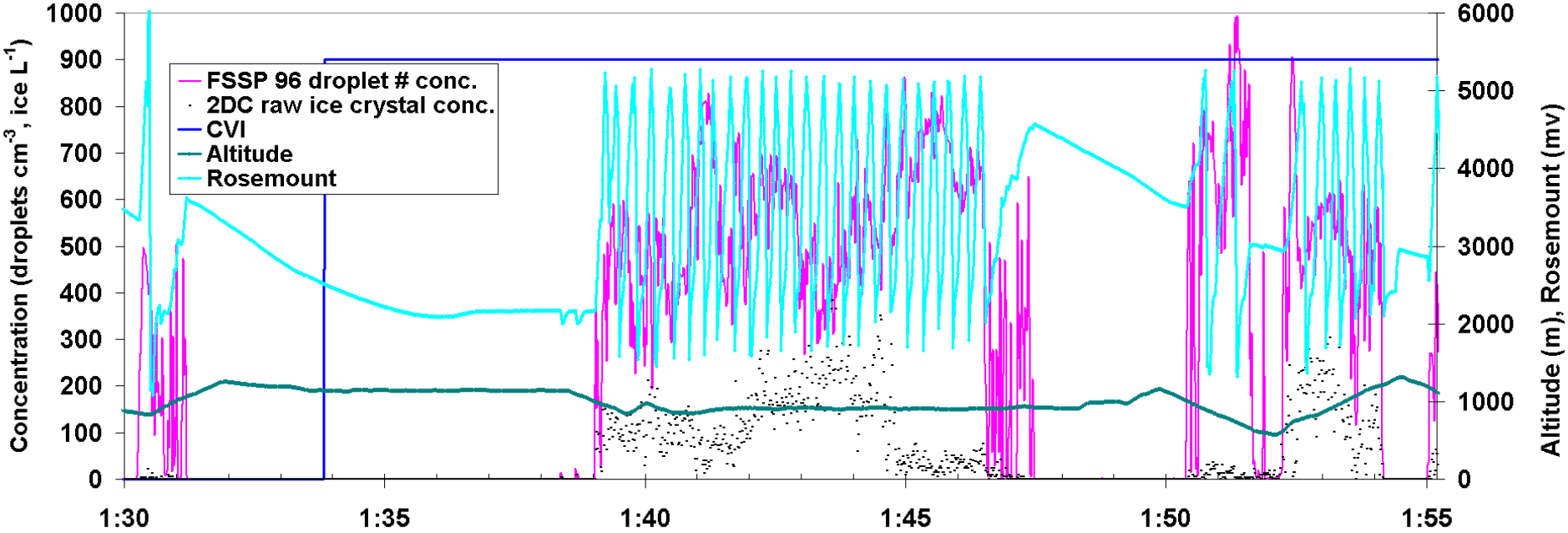
T_{dew}: -7.7°C, T_{frost}: -6.8°C (Licor)

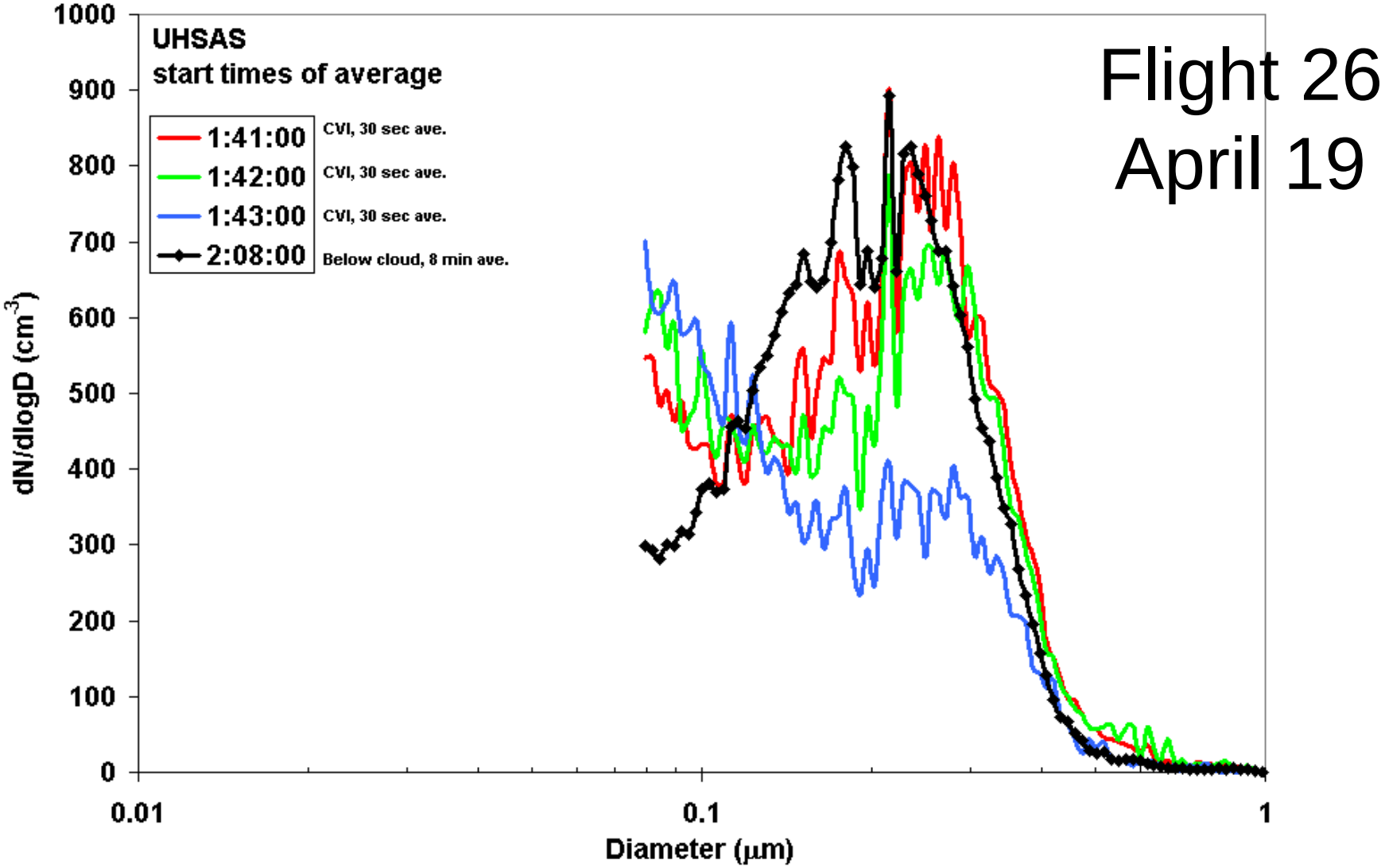
T_{dew}: -6.4°C (EG&G)

Flight 26, April 19



During this time, aerosol is sampled through the CVI, we see a lot of residuals with UHSAS





averages	N_d (cm^{-3} , FSSP96)	N_{ice} (L^{-1}, 2DC raw)	LWC (g m^{-3})	RH_w (%)	Rh_i (%)	T (°C)
1:41	678	68	0.60	94	101	-6.8
1:42	595	180	0.54	93	101	-7.0
1:43	410	197	0.40	93	100	-7.1

Future work

- Compare CSI TWC with Nevzorov probe TWC measurements to understand mixed phase cloud conditions
- Compare aerosol chemical composition from SPLAT for clean/polluted cases and liquid/mixed/ice phase cases
- Further processing of ice crystal number concentration
- Find cases to compare to ground measurements
- Simulations using
  - WRF model (Boybeyi)
  - Canadian GEM-Regional model (Girard)