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Canada

Cloud Droplet Closure Study Using ISDAC Data

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Outline

- Objectives
- Background
- Overview of research method
- Example of case selected
- Summary

Objectives

- Perform aerosol-cloud droplet number concentration closure study based on the observations from the DOE-ISDAC field campaign
- Improve the representation of the vertical velocity for the parameterization of aerosol activation
- Evaluate the Abdul Razzak and Ghan activation parameterization

Background

- In order to establish confidence in climate models, activation of aerosol particles into cloud drops must be realistically represented
- Aerosol activation parameterizations will be tested by comparing predicted cloud droplets number concentrations with measured values
- Agreement between the two increases the confidence in model predictions

Uncertainties in parameterization

- Two poorly constrained parameters in the droplet growth equation:
  1) The application of updraft velocities to the determination of droplet number concentration
  2) Mass accommodation coefficient, α_c
- This study will focus on improving our knowledge and the representation of the updraft velocity
- With improved representation of updraft velocity, sensitivity tests to α_c can then be performed

Methodology

- ISDAC will be examined for cases appropriate for droplet closure study
  - Several cases identified already.
- Extract and contrast relevant observation data
- Evaluate CCN closure
- Use Large Eddy Simulation (LES) applied to a few cases to improve our knowledge of the role of gust velocity in cloud droplet nucleation
- Use adiabatic parcel model in combination with LES simulations to examine aerosol-cloud closure
- Evaluate Abdul-Razzak and Ghan aerosol-cloud parameterization

Relevant ISDAC Data

- Aerosol Particle size distribution from
  - SMPS (10-500nm)
  - UHSAS (60-1000nm)
  - PCASP100x (125-3000nm)
  - FSSP-300 (300-20000nm)
- Cloud droplet number concentration (CDNC)
  - CDP/FSSP100
- CCN concentration
  - DMT CCN counter
- Size resolved hygroscopicity of particles
  - Texas A&M HTDMA
- Aerosol chemical composition
  - PNNL SPLAT
- Vertical velocity
  - gust probe
- Other Supporting data
  - King LWC, CVI LWC and Nevzorov LWC
  - 2DC, 2DP
  - Rosemount icing probe
  - Temperature and pressure

CCN Closure

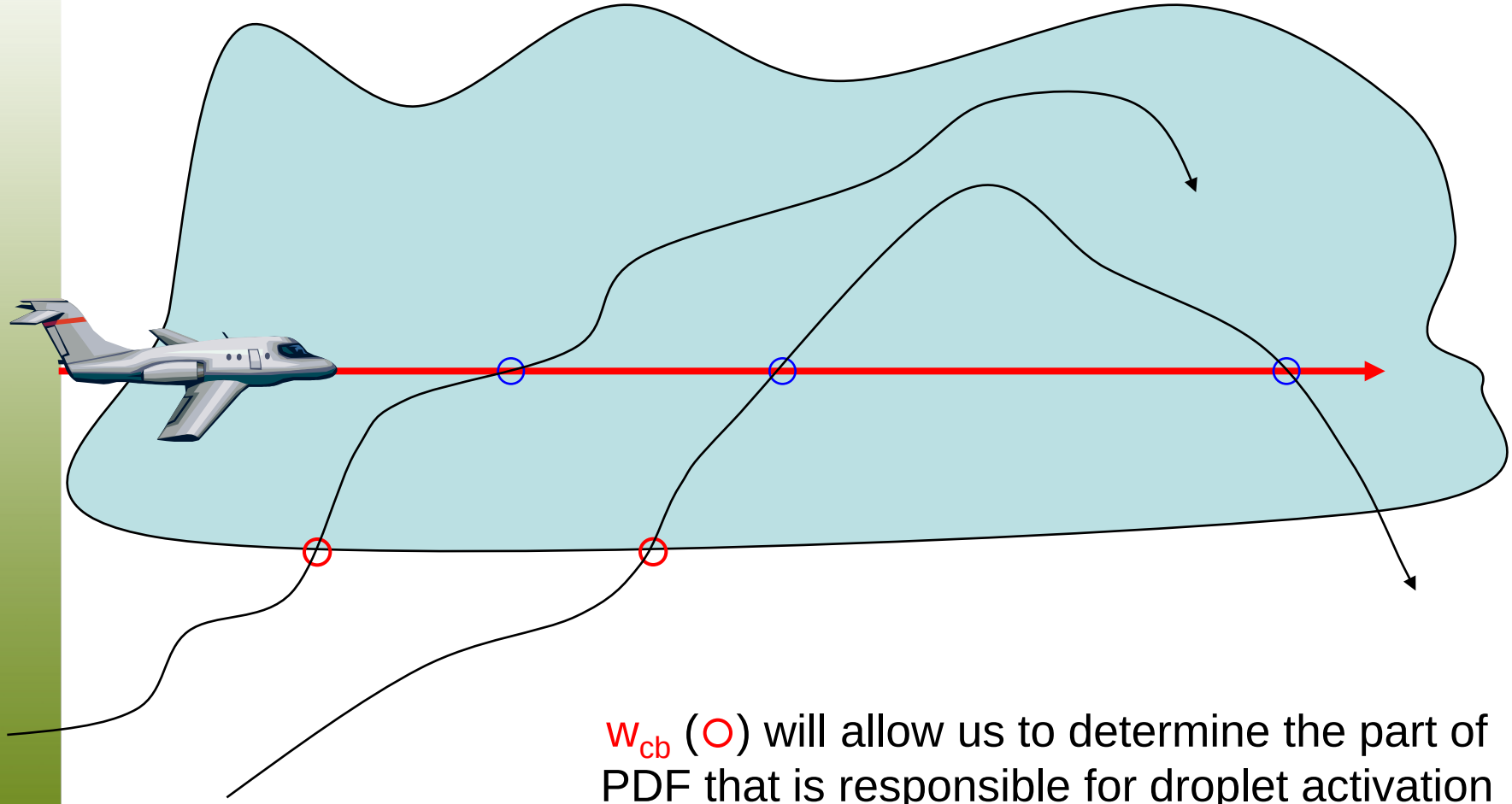
- To provide confidence in our ability represent the size distributed chemistry, CCN closure will be performed
- Predict CCN concentration using Köhler theory based on the measured aerosol size distribution and composition
- Compare with measured CCN concentration

- *CCN closure does not relate to growth rates or provide updraft information*

Large Eddy Simulation- (LES) (PNNL) and Adiabatic Parcel Model (EC)

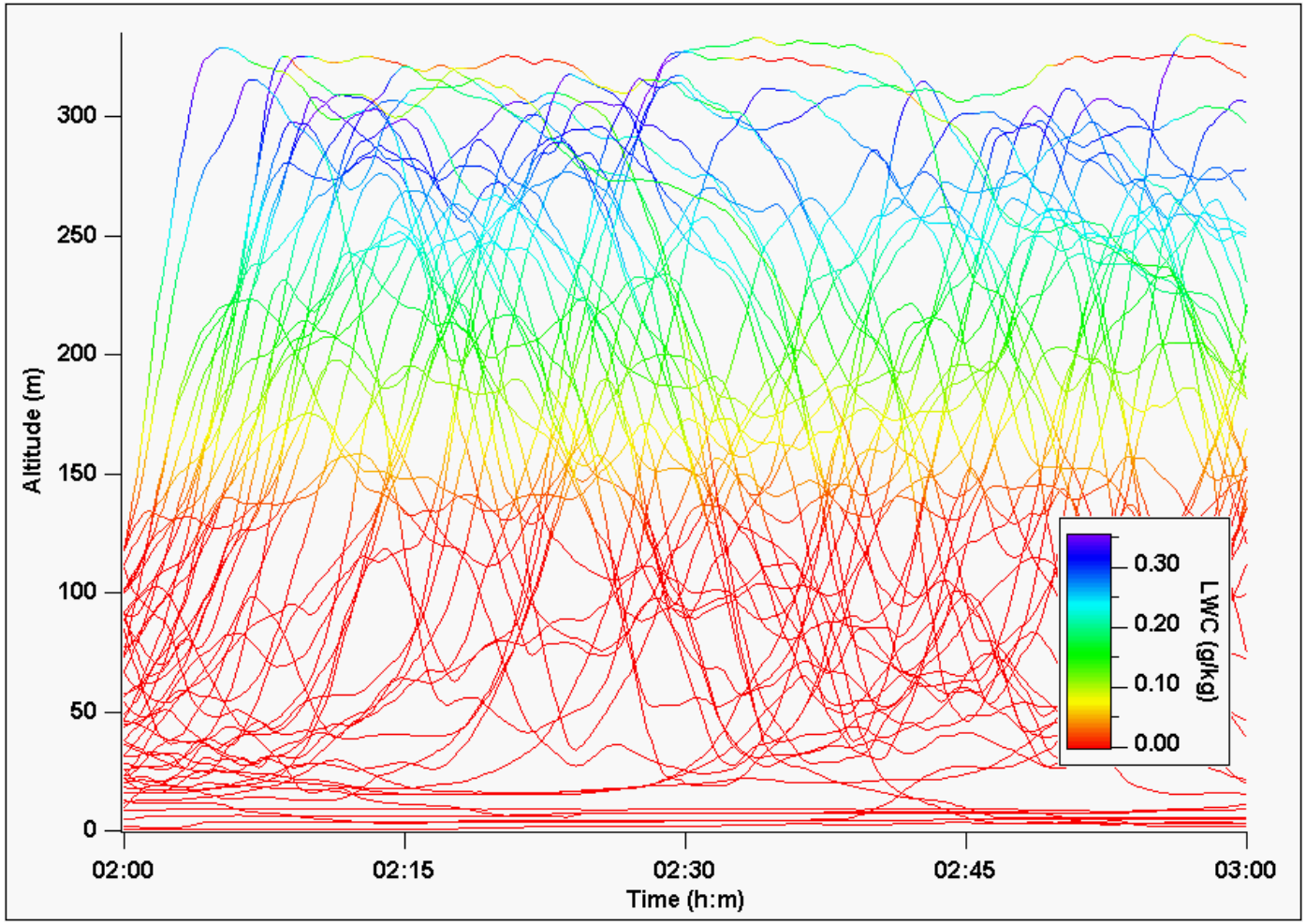
- Use LES to help with the interpretation of cloud dynamics, specifically gust velocity
- Compare simulated PDF with measured PDF gust velocity, LWC etc.
- Use the LES model trajectories to identify the appropriate gust velocity corresponding to Cloud Base (CB)
- Apply the Adiabatic Parcel Model for the corresponding CB gust velocity; compare simulated CDNC with measured values corresponding to near adiabatic LWC
- Repeat with Abdul-Razaak & Ghan parameterization

Use the LES model trajectories (in the hundreds) to identify the appropriate gust velocity corresponding to Cloud Base (w_{cb})

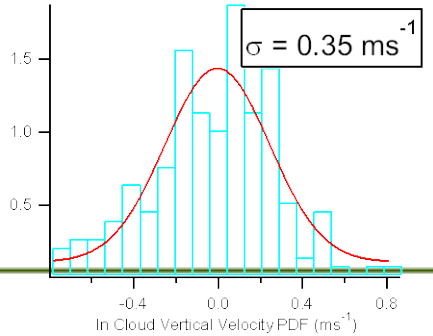


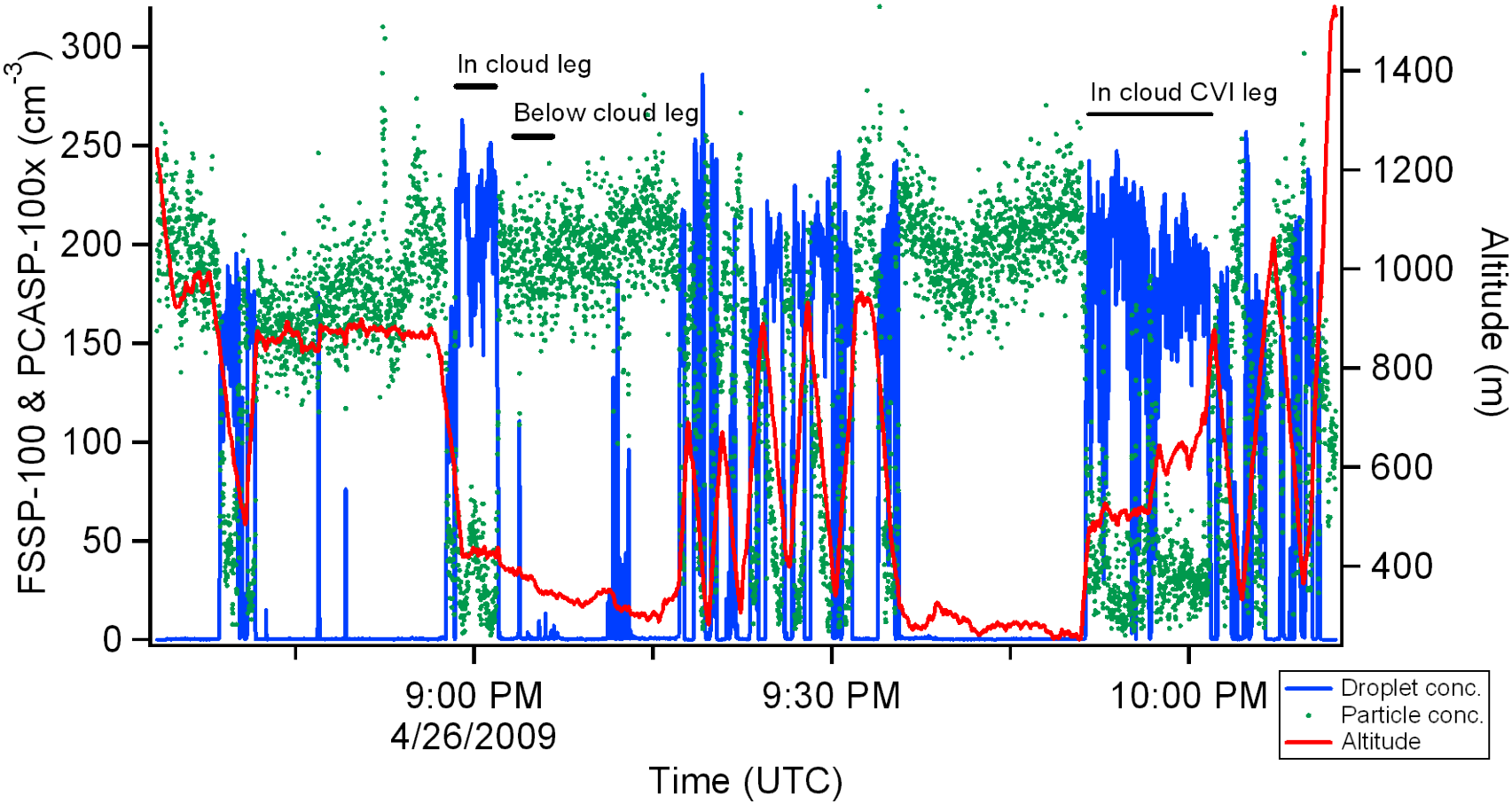
w_{cb} (O) will allow us to determine the part of PDF that is responsible for droplet activation

Example of LES trajectories



Example Flight 30





Some cases showing the range of data

Flight #	CDNC (cm^{-1})	CB PCASP Aerosol # (cm^{-1})	CDNC:PCASP ratio	1 σ gust velocity (ms^{-1})
30	210	190	1.1	0.35
28	300	450	0.67	0.44
26	550	800	0.69	0.71
23	250	400	0.63	0.38

Summary

- Perform aerosol-cloud droplet number closure
- Improve the representation of vertical gust velocity for the parameterization of aerosol activation
- Evaluate Abdul-Razaak & Ghan Parameterization

Thanks for your attention