Spatial Variability of Tropical Cirrus from 2006 TWP-ICE

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1. Introduction

In-situ cloud data acquired during the 2006 Tropical Warm Pool – International Cloud Experiment (TWP-ICE) are used to determine if the microphysical properties of tropical cirrus formed under differing conditions can be characterized in terms of prognostic variables in large-scale models such as temperature and ice water content (IWC)

To accomplish this, the spatial variability (horizontal and vertical) of microphysical properties (IWC, habit distribution, size distribution, median mass diameter D_{mm}) is examined and contrasted for different types of cirrus (convective vs. non-convective; aged vs. fresh),

2. In-situ Measurements

Data acquired by the Cloud Particle Imager (CPI) on the Scaled Composites Proteus in aged cirrus on 27 Jan. (Fig. 1) and 29 Jan. (Fig. 2) and in fresh anvils on 2 Feb. (Fig. 3) are examined in this study.

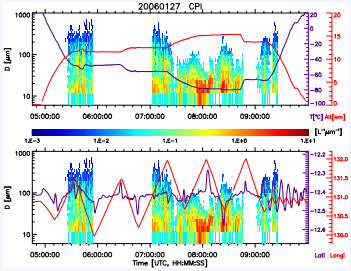

Fig.1. CPI number distribution function N(D), temperature (T), altitude (Alti), latitude (Lati), and longitude (Longi) for 27 Jan.. This flight represents horizontal E-W legs through aged cirrus of varying lifetime.

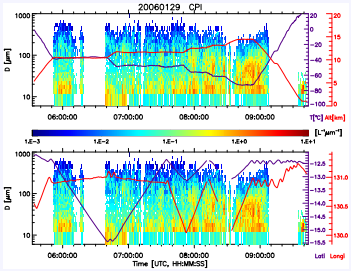

Fig.2. As in Fig. 1 except for 29 Jan. flight that looked at transition of anvil cirrus to more generic cirrus; N-S legs to look at cirrus bands of varying age.

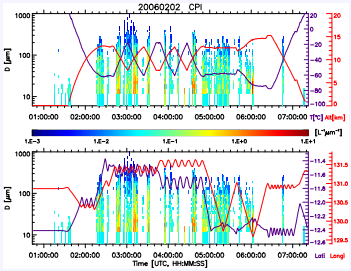

Fig.3. As in Fig. 2 except for 2 Feb. flight through rapidly dissipating fresh anvils behind convective line over Tiwi Islands. Spiral descents/ascents allowed determination of time evolution of vertical profile.

3. Ice Crystal Habits

Ice crystal habits are classified into 11 shapes (Fig. 4). Quasi-spheres dominate number concentration on all days. Bullet rosette and aggregates of bullet rosettes dominate large crystal (D>200 μm) concentration for 27 and 29 Jan., while aggregates of plates dominate D > 200 μm concentration on 2 Feb. (Fig. 5, 6).

Fig.4. Example CPI images of (a) small quasi-sphere, (b) medium quasi-sphere, (c) large quasi-sphere, (d) column, (e) plate, (f) bullet rosette, (g) aggregates of bullet rosettes, (h) aggregates of columns, (i) aggregates of plate, and (j) capped column

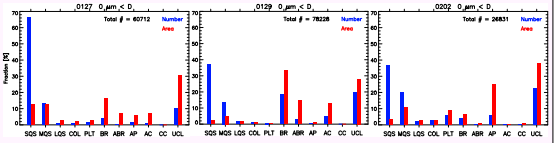

Fig.5. Frequency of ice crystal habit for 27 and 29 Jan. and 2 Feb.

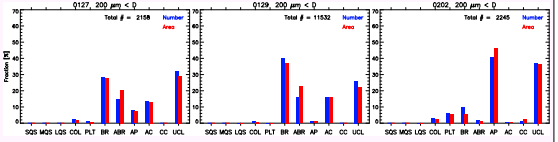

Fig.6. As in Fig. 5 except for ice crystals with D > 200 μm

4. Horizontal Variability

For a constant altitude horizontal leg (N-S leg, 64800-75000 UTC on 29 Jan., 12 km) the dependence of variables of a gamma fit to the observed size distributions, $N(D)=N_oD^{\mu}\exp(-\lambda D)$, D_{mm}, IWC, and habit distribution on latitude are determined. The habit and D_{mm} varied with latitude, but no distinct characteristics in gamma variables are revealed.

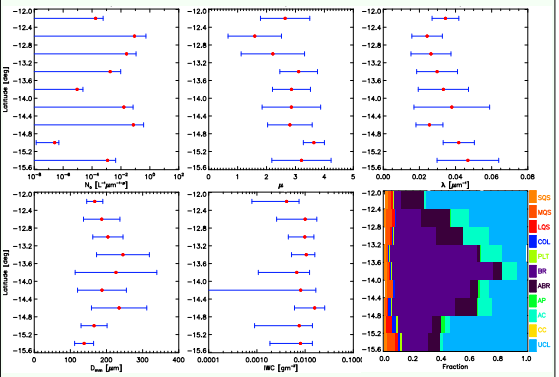

Fig.7. Mean (red) and standard deviation (blue) of N_o, λ, μ, D_{mm}, and IWC as function of latitude. A Habit distribution as a function of latitude is shown.

5. Vertical Variability

The vertical dependence of N_o, λ, μ, D_{mm}, IWC, and habit distributions are examined. The smallest D_{mm} and IWC are seen on 2 Feb. in the rapidly dissipating fresh anvils and the largest D_{mm} and IWC on 29 Jan. in the aged cirrus bands. The habit distributions for 2 Feb. are distinct from other days as the aggregates of plates and capped columns are not seen on 27 and 29 Jan.. D_{mm} decreases with altitude and habits change from quasi-spheres to either aggregates of plates/bullet rosettes for all days. However, N_o, λ, and μ are not strong functions of altitude for either the fresh anvils or aged cirrus—this suggests there is a possibility of diagnosing size distributions in terms of large-scale model prognostic variables.

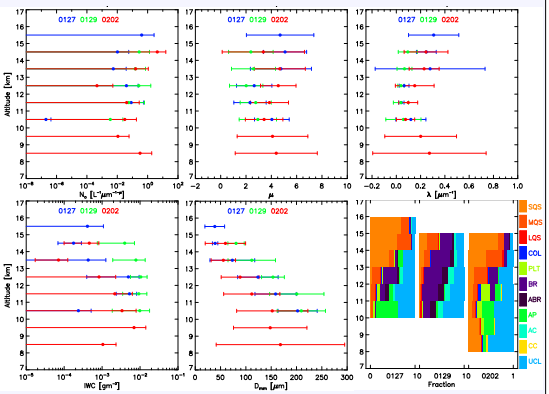

Fig.8. Mean and standard deviation of N_o, λ, μ, D_{mm}, and IWC for 27 (blue) and 29 Jan. (green) and 2 Feb. (red) as a function of altitude. Vertical habit distributions for three days are compared.

6. Summary

- There is a difference in ice crystal habits between fresh anvils (2 Feb) and generic and aged cirrus (27 and 29 Jan.).
- The fit parameters of gamma size distributions (N_o, λ, and μ) do not show systematic variations between fresh anvils and aged cirrus
- There is significant variability in N_o, λ and μ within the same temperature range and no discernible dependence on T, showing their dependence on IWC and other variables must be considered in parameterization development.
- A habit change in a constant altitude leg associated with variation in D_{mm} and IWC is shown.

Acknowledgements

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