Representing the Ice Fall Speed in Climate Models: Results from SPARTICUS

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Motivation

- Global Climate Models (GCMs) are highly sensitive to the representation of clouds and their feedbacks. According to a study by Sanderson et al. (2008), the ice fall velocity (V_i) is the second most important factor affecting the global feedback parameter in GCMs.

- In spite of its importance, V_i in climate models is highly uncertain due in part to its dependence on the ice particle size distribution (PSD), which has been plagued with measurement uncertainties from small ice particles produced by shattering. However, data processing techniques used in conjunction with new probes in recent field campaigns appear to have significantly reduced the artifact concentration of small ice particles.

Selected Case Studies

Synoptic Cirrus (117 segments)

- Jan 19th
- Jan 20th
- March 23rd
- March 26th
- April 1st
- June 17th

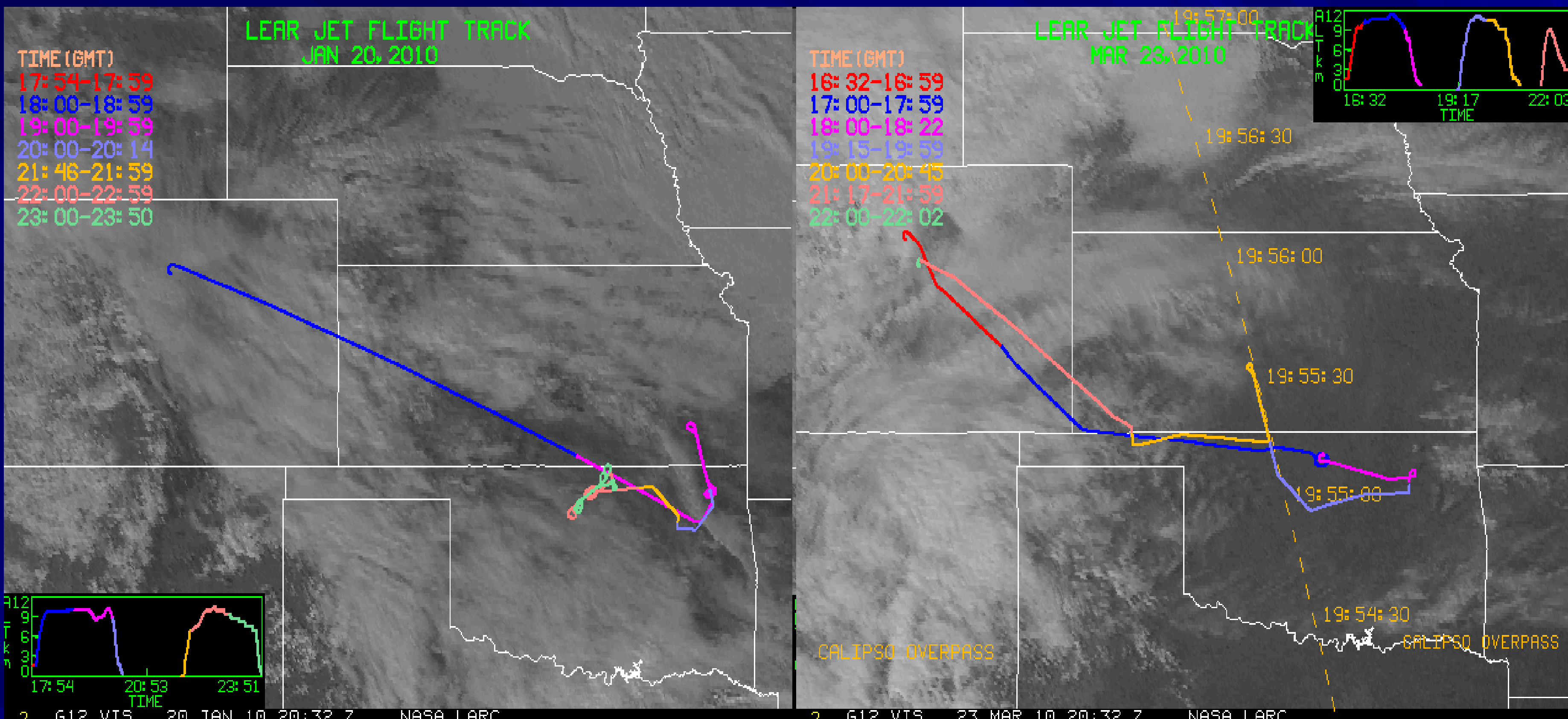
Anvil Cirrus (122 segments)

- April 22nd
- April 28th
- June 12th
- June 14th
- June 15th
- June 24th

Cloud segments are identified for each case by making sure that

- they contain no liquid water,
- they have good sampling statistics and utilize a good fraction of the data
- they are sampled under relatively steady microphysical conditions

Satellite Images Help Determine Cloud Type (Anvil/Synoptic Cirrus)



Source: P. Minnis (NASA Langley)

http://www-angler.larc.nasa.gov/cgi-bin/site/showdoc?mnemonic=ARM-SPARTICUS

General Approach

- The size resolved 2D-S measurements of number, projected area and mass concentration appear reasonable.
  - Ice artifacts from shattering greatly reduced
  - Good agreement between 2D-S and CVI IWC during TC4

- This study uses 2D-S data from SPARTICUS, a recent field campaign sampling mid-latitude cirrus. The treatment of D_e (effective diameter) is general for liquid, mixed phase and ice clouds and is expressed as:

$$D_e = 3/2(IWC/\rho_i A_t)$$

- V_i (ice particle fall speed) is calculated by using two different methods, namely the Mitchell-Heymsfield (2005) method (MH) and the Heymsfield-Westbrook (2010) method (HW). V_i is generally expressed as:

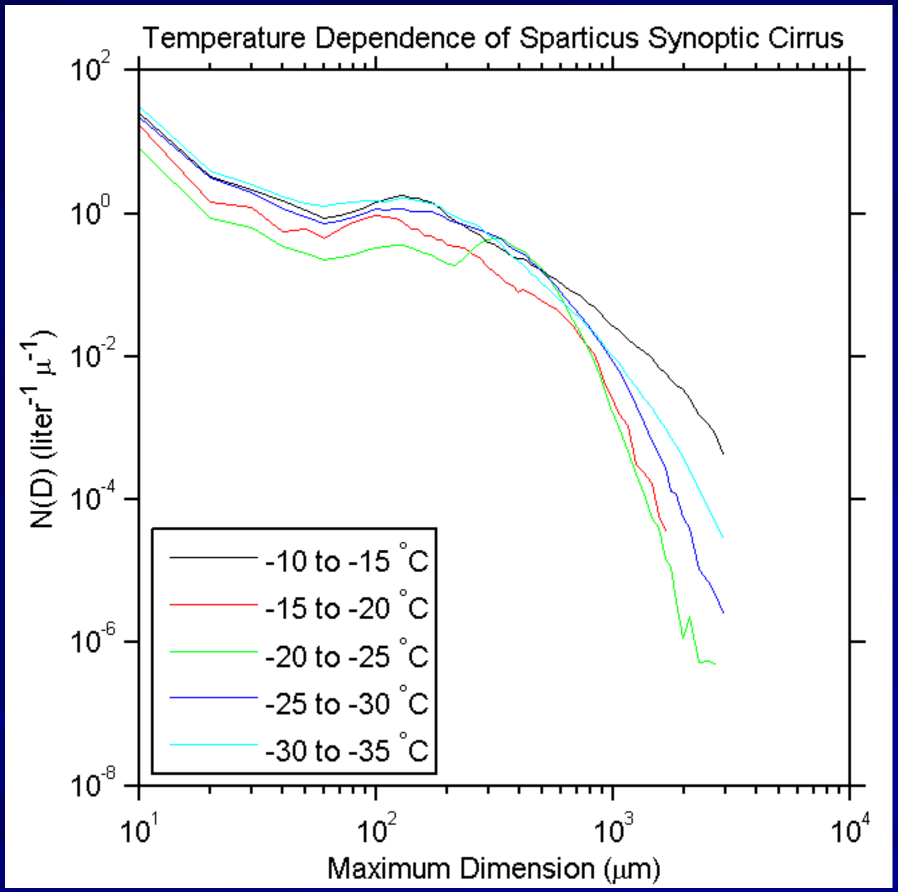
$$V_i = \alpha D^{\beta}$$

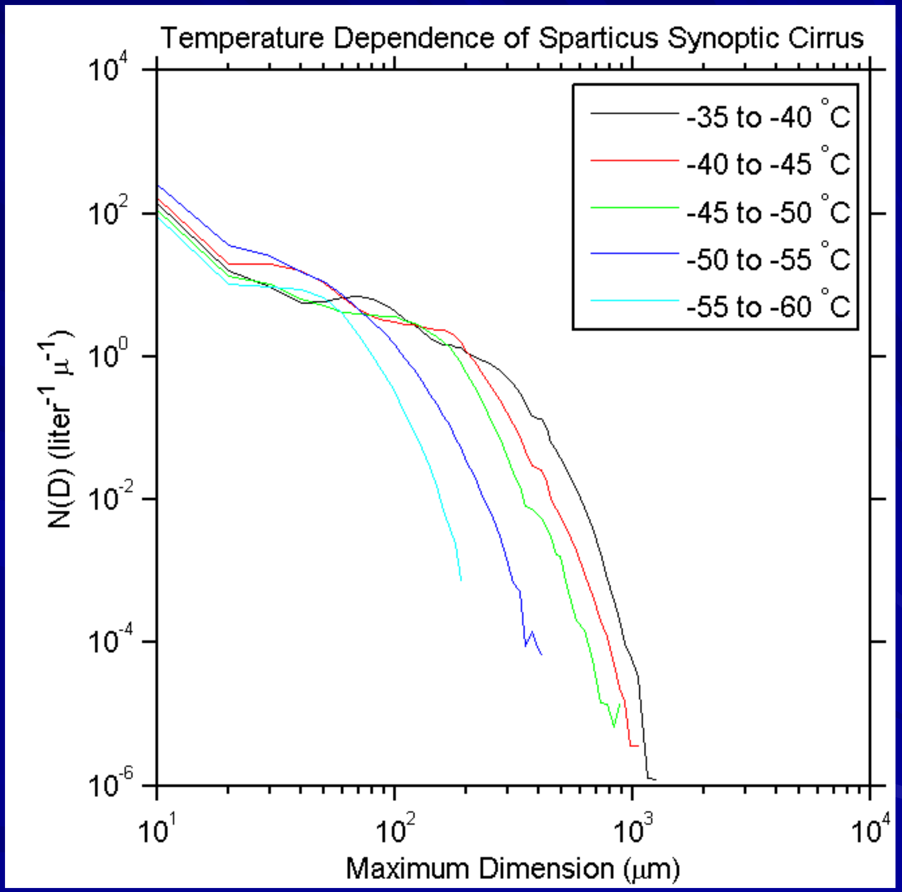
- Applying this definition to 2DS measurements, D_e and V_m (the PSD mass weighted fall-speed) were expressed as:

$$V_m = \Sigma\, V_i(D)\, m(D)\, N(D)\, \Delta D \,/\, \Sigma\, m(D)\, N(D)\, \Delta D$$

$$D_e = (3/2)\, \Sigma\, m(D)\, N(D)\, \Delta D \,/\, (\rho_i\, \Sigma\, A(D)\, N(D)\, \Delta D)$$

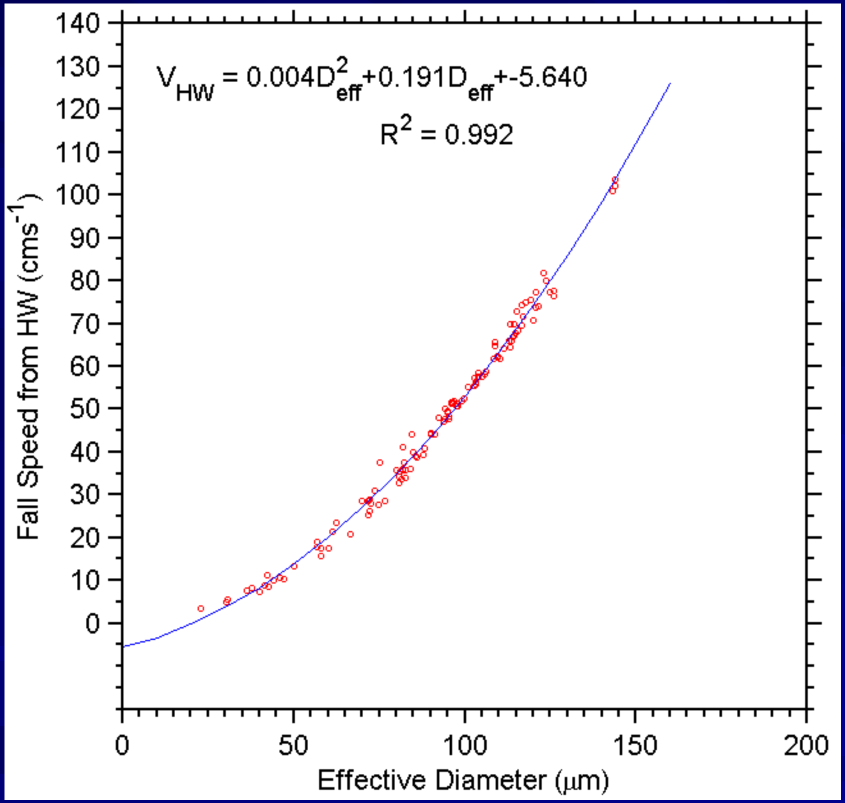
Synoptic Cirrus PSDs from 2DS

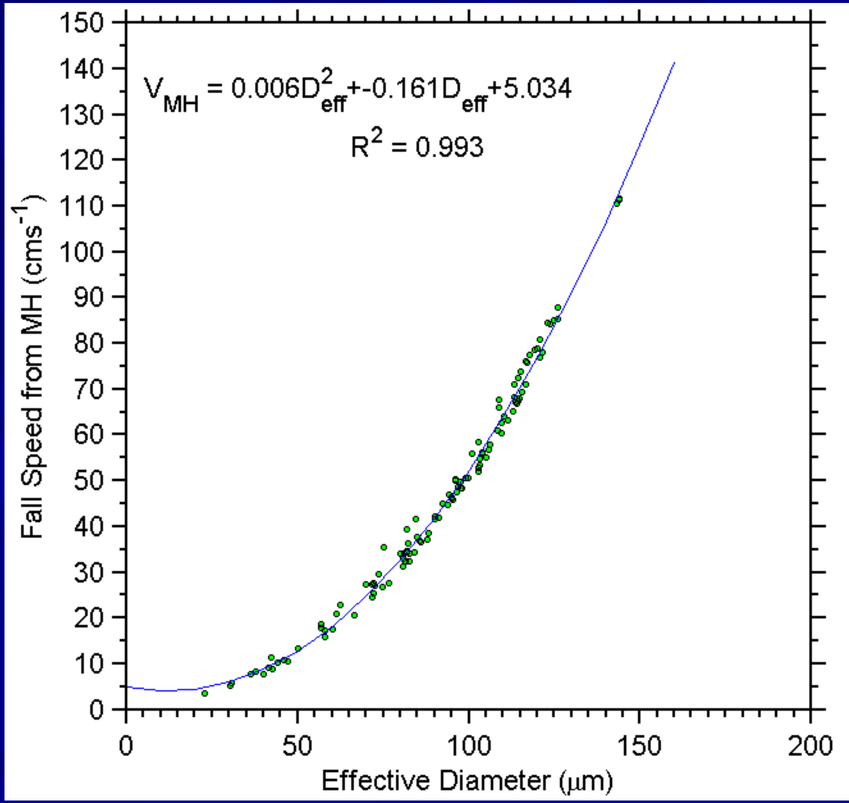




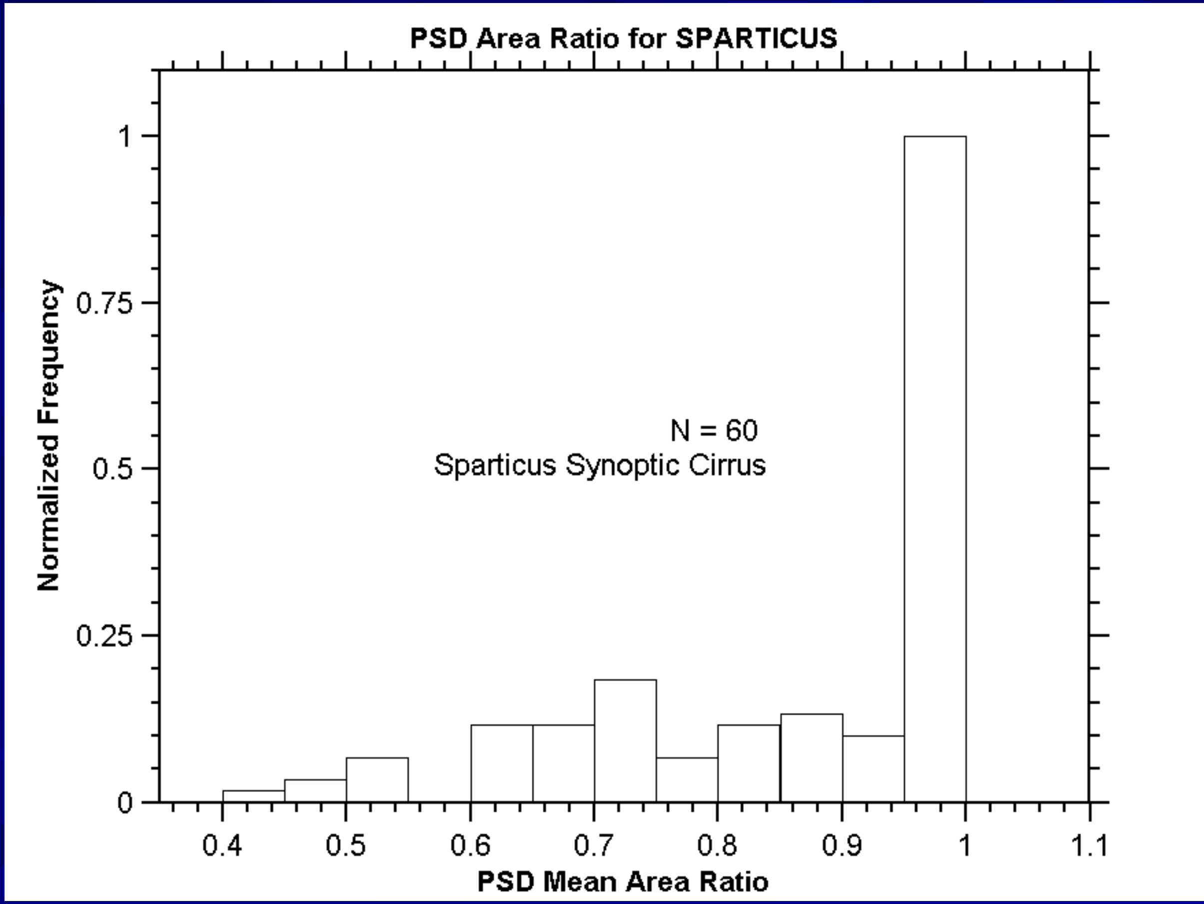
Fall Speed Related To D_e Using:

Mitchell Heymsfield (2005) & Heymsfield Westbrook (2010)

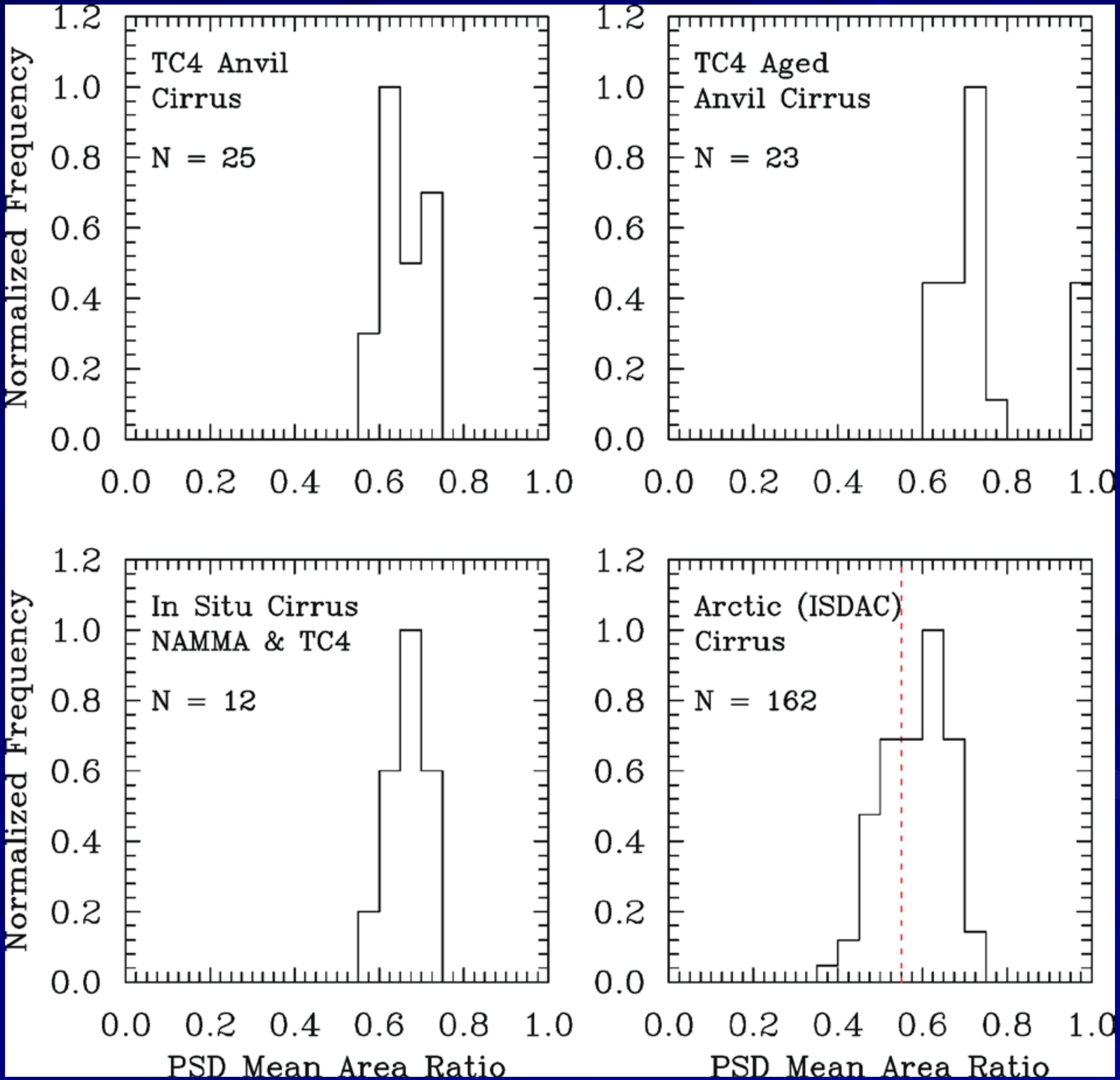




Area Ratios of SPARTICUS Synoptic Cirrus

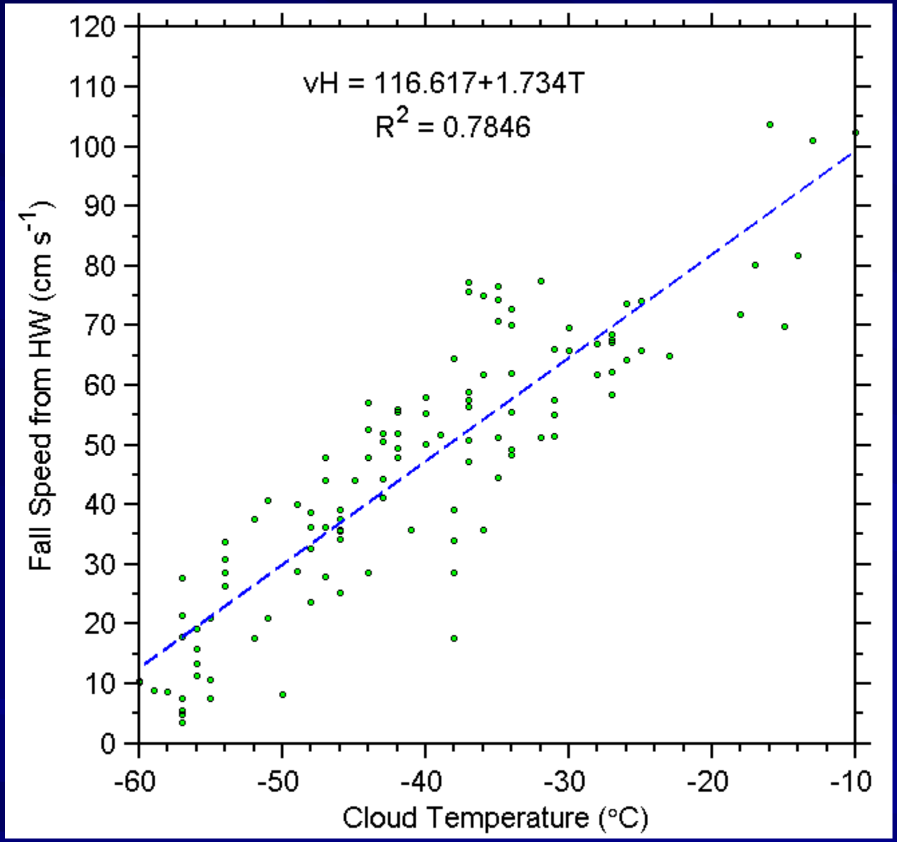


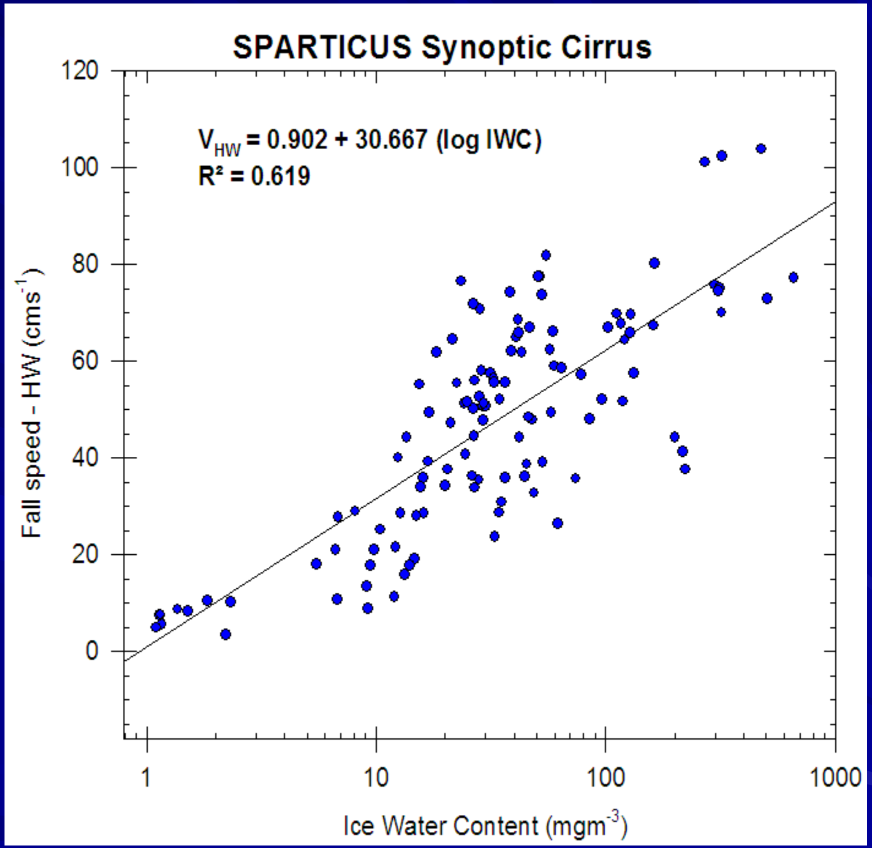
Area Ratios From Other Field Campaigns



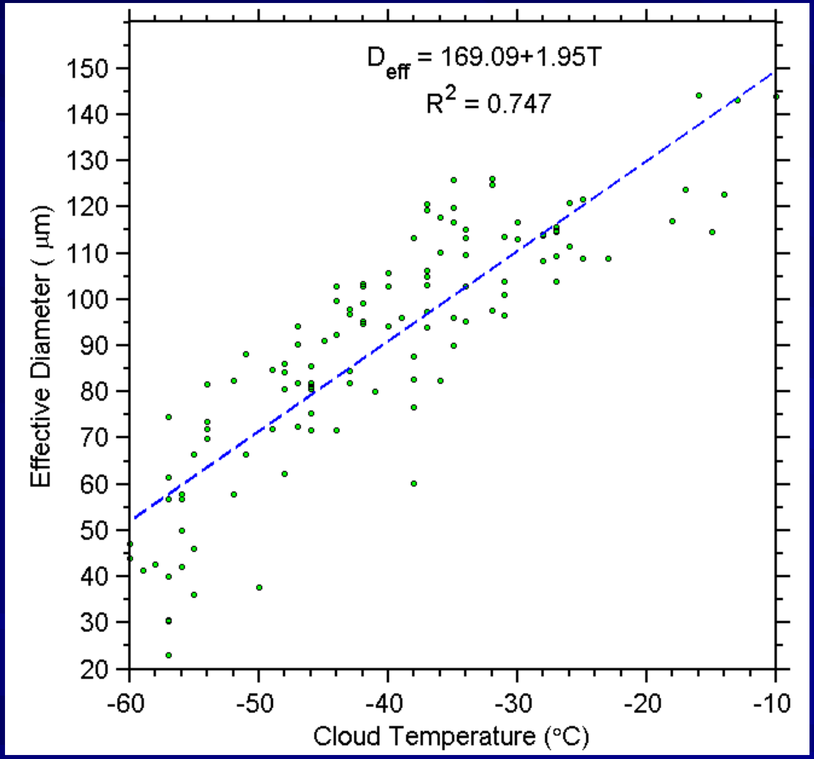
SPARTICUS SYNOPTIC CIRRUS:

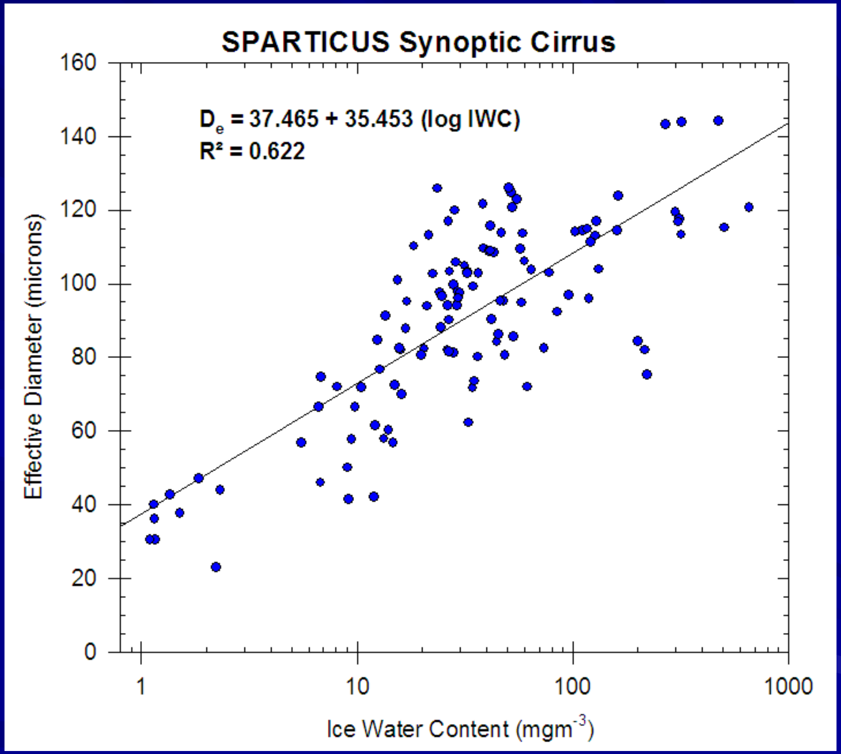
V_m vs. T and V_m vs. IWC



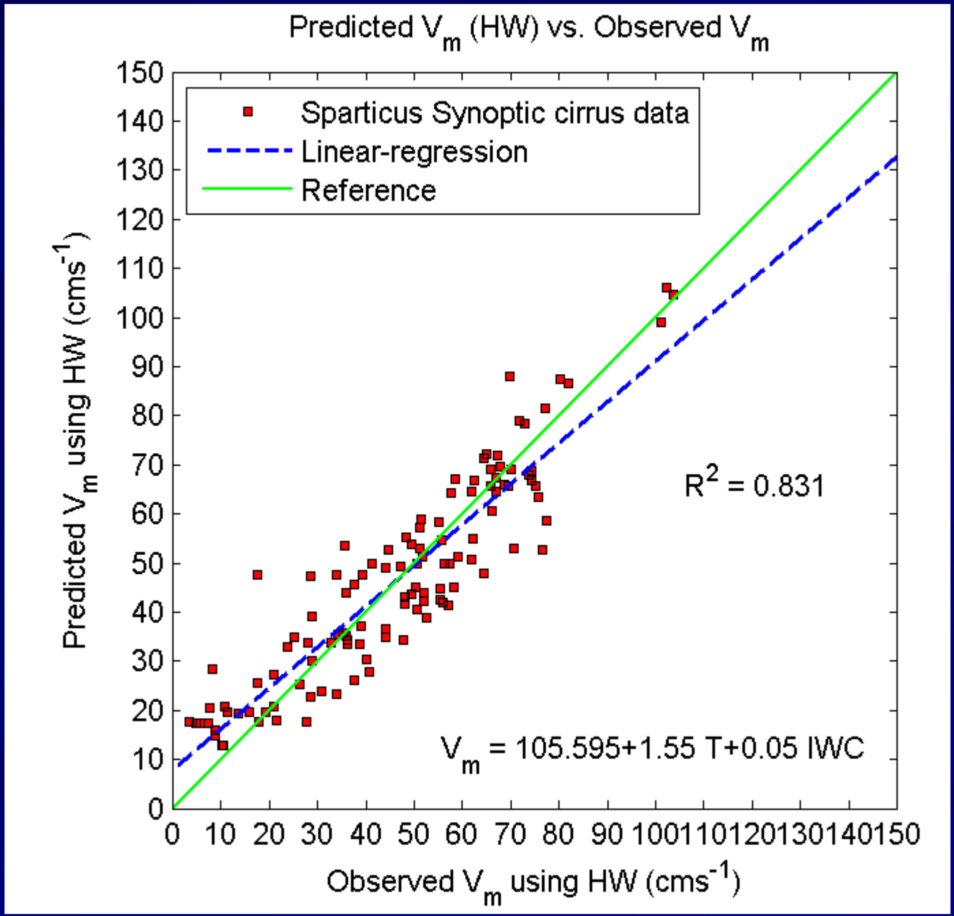


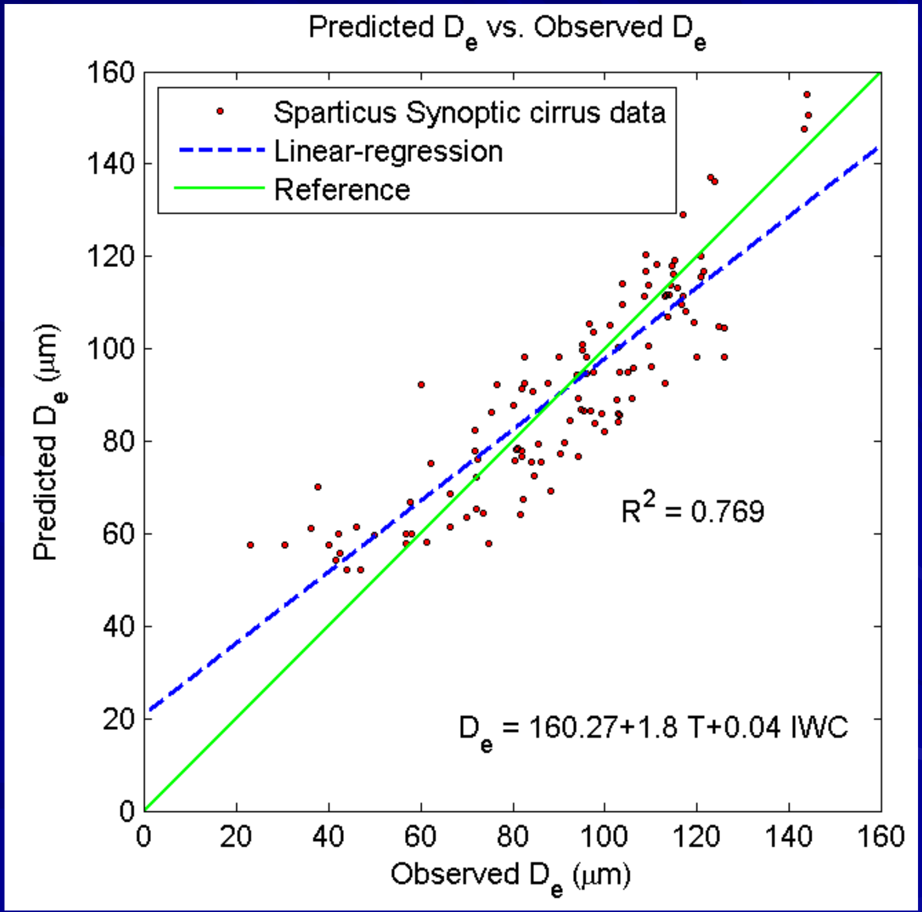
SPARTICUS SYNOPTIC CIRRUS:
D_e vs. T and D_e vs. IWC

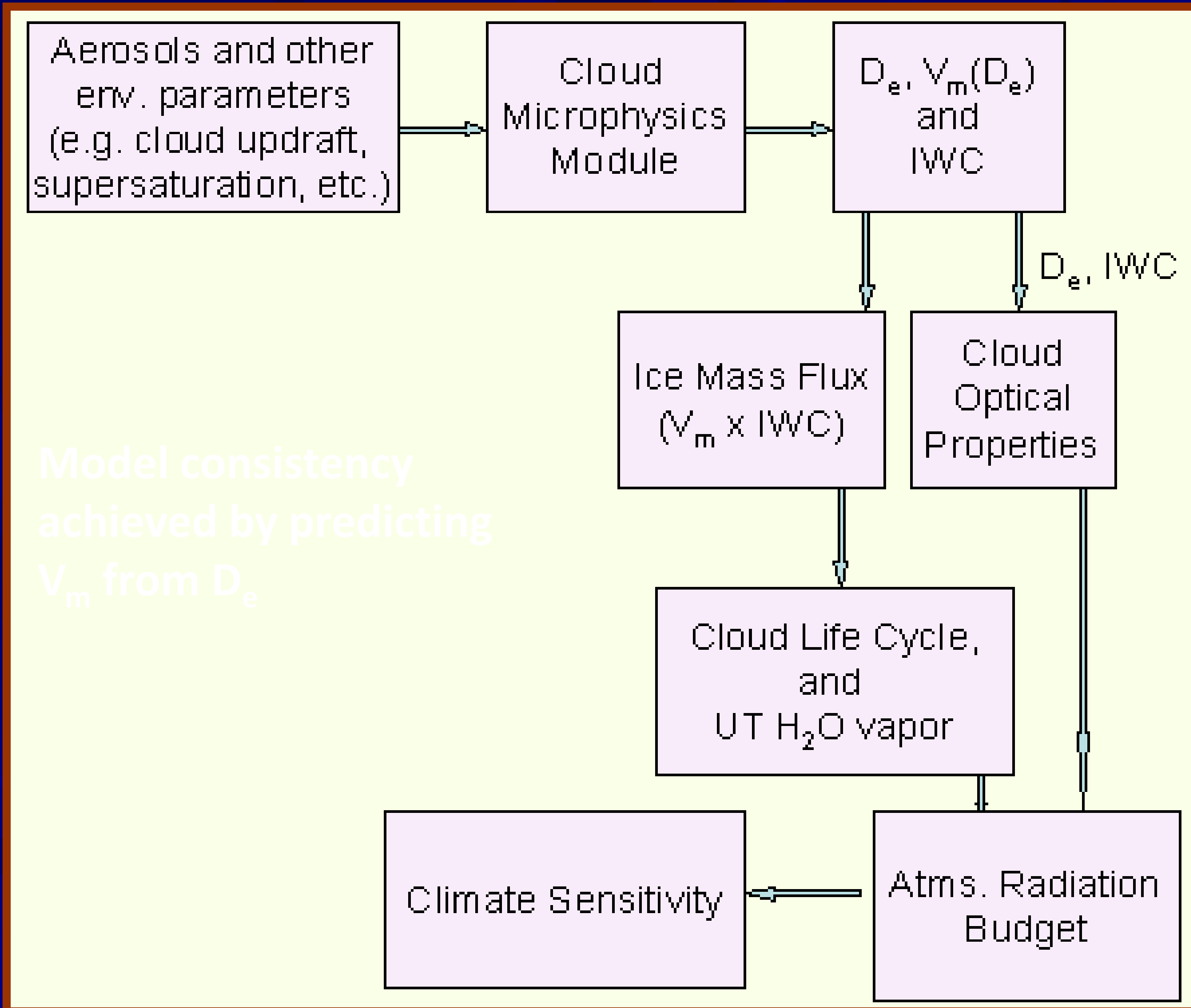




V_m And D_e Related To IWC And T







Model consistency achieved by predicting V_m from D_e

THANK YOU!

INPUTS AND

COMMENTS ?