The Dependence of Cloud Size Distributions and Bulk Parameters Measured during MC3E on Environmental Conditions

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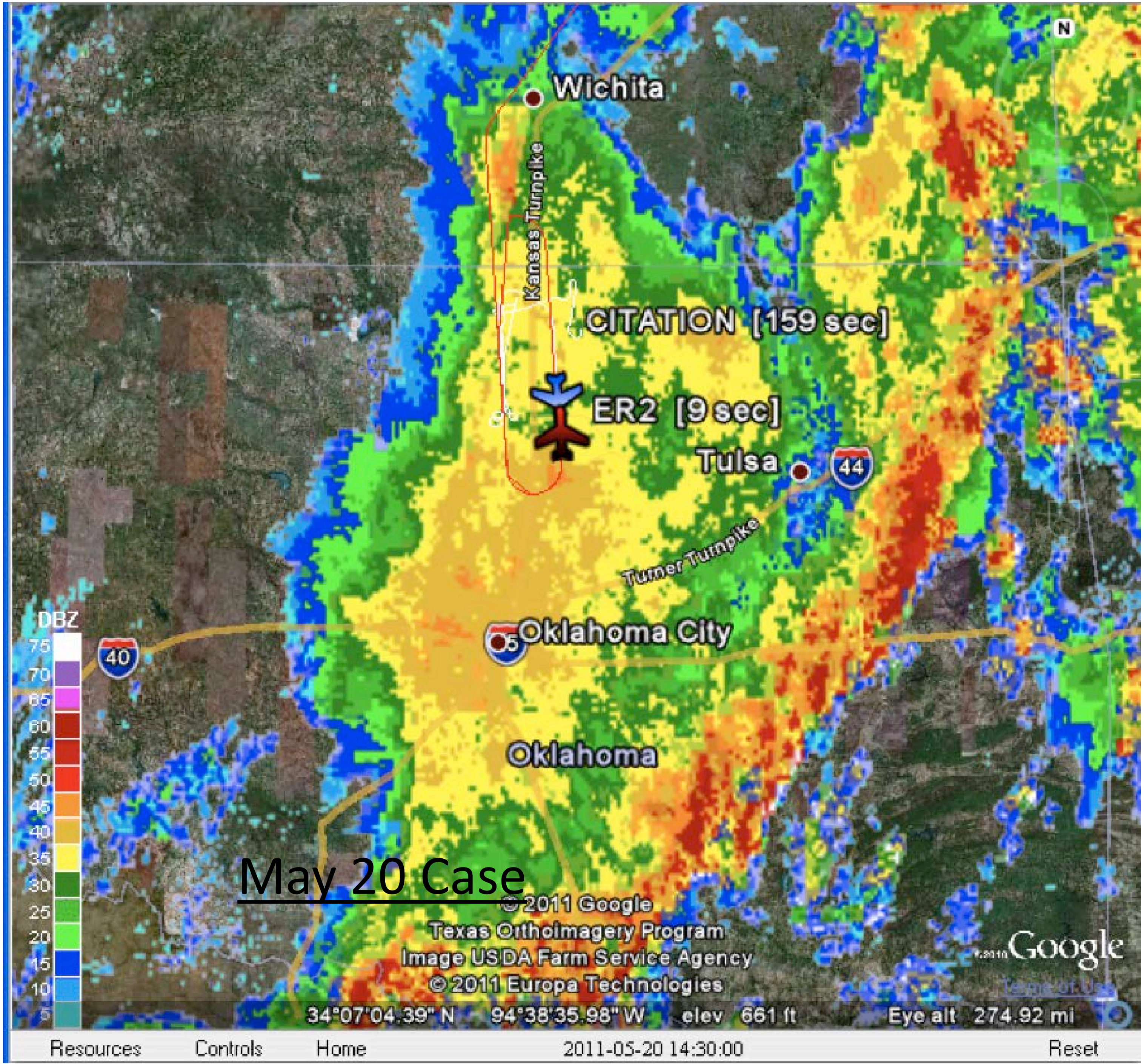
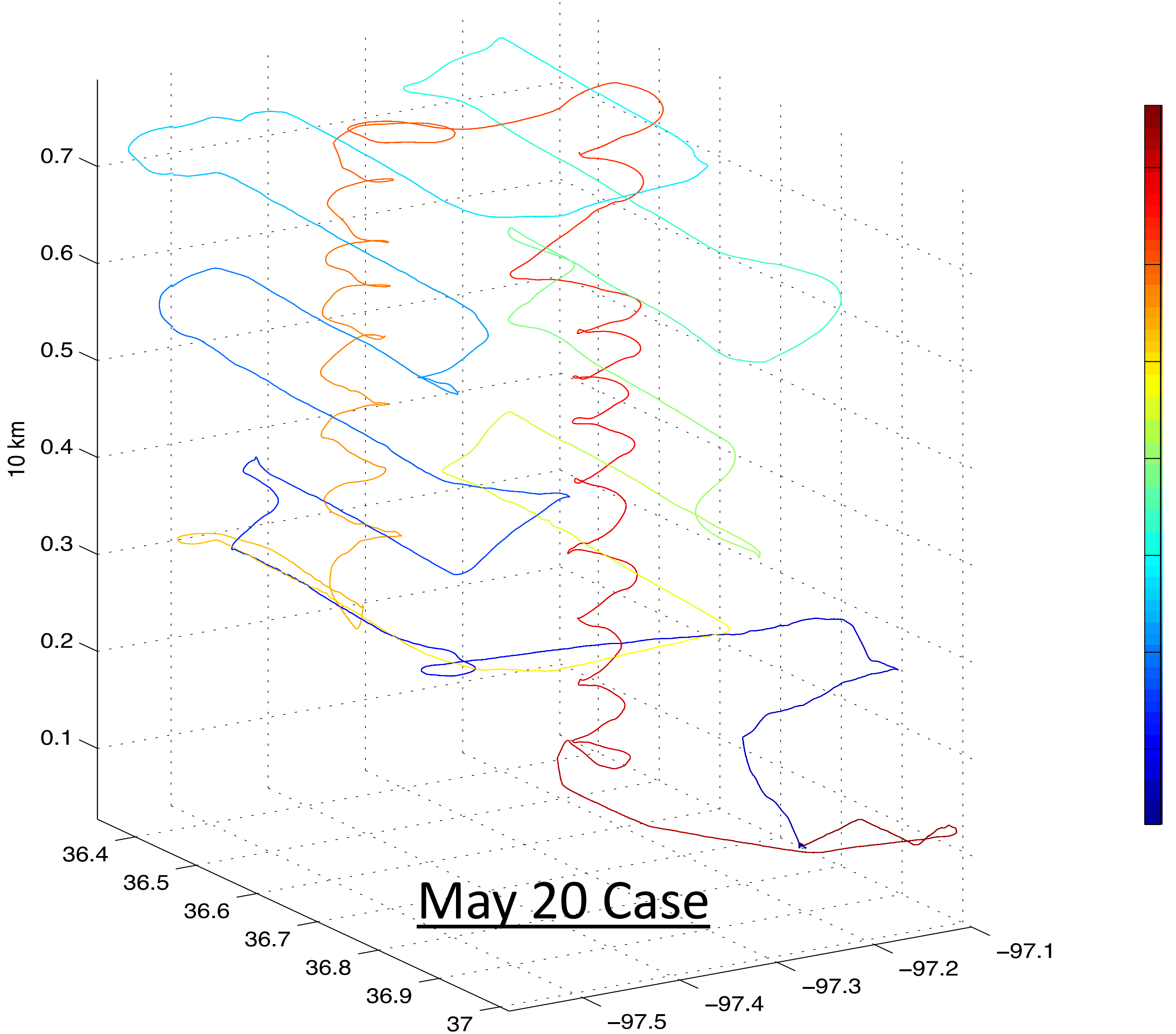
Outline

- Use ice cloud data to characterize variation of IWC and r_e with
  - Temperature
  - Supersaturation
  - Vertical velocity
  - Turbulence
- Here, show preliminary results from analysis of CIP data for flights on 18, 20, 23 and 24 May 2011


N
Wichita
Kansas Turnpike
CITATION [159 sec]
ER2 [9 sec]
Tulsa
44
Turner Turnpike
Oklahoma City
40
Oklahoma
DBZ
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
©2011 Google
Texas Orthoimagery Program
Image USDA Farm Service Agency
© 2011 Europa Technologies
Google
34°07'04.39" N 94°38'35.98" W elev 661 ft Eye alt 274.92 mi
Resources Controls Home 2011-05-20 14:30:00 Reset

May 20 Case

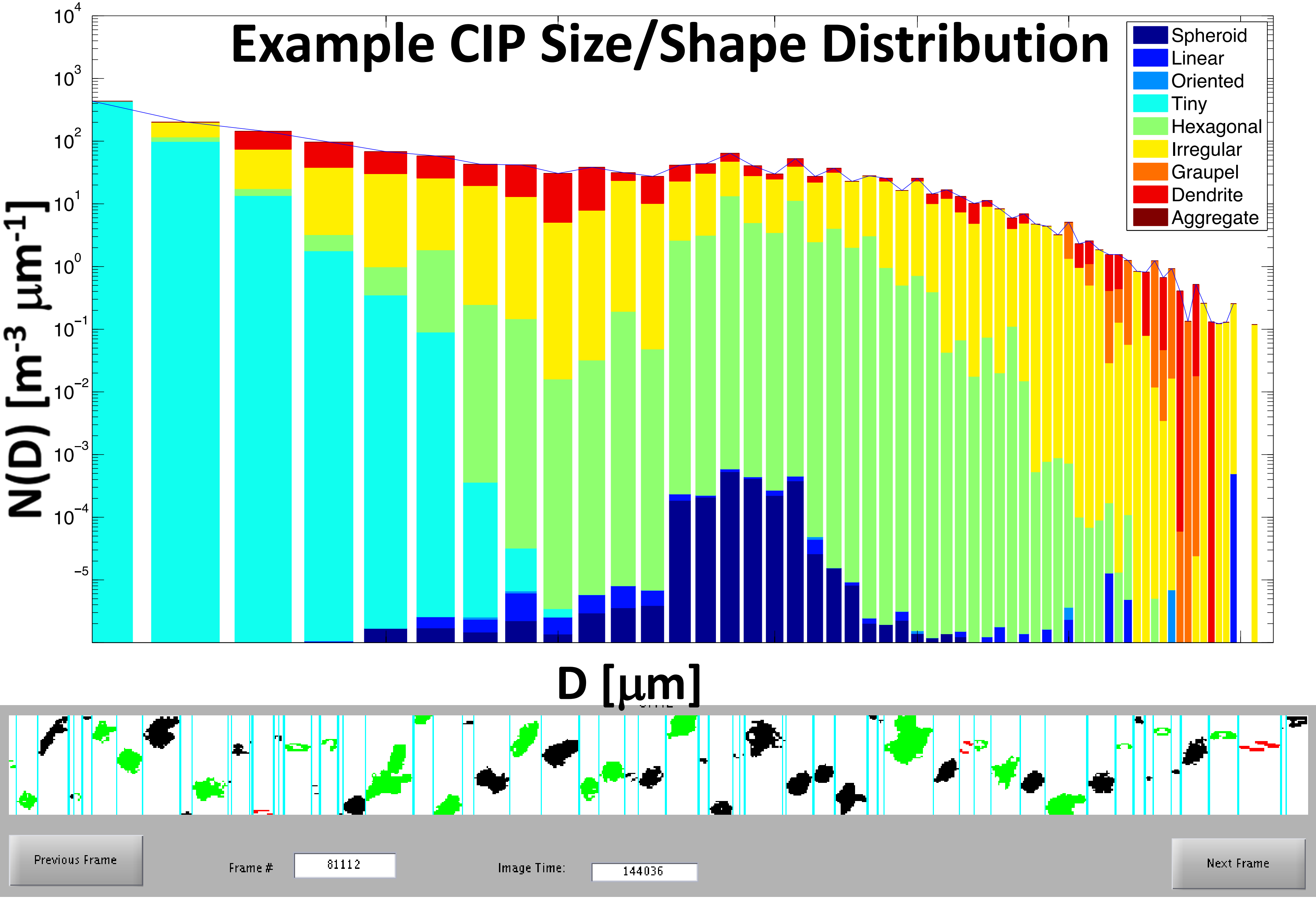

10 km
0.7
0.6
0.5
0.4
0.3
0.2
0.1
36.4
36.5
36.6
36.7
36.8
36.9
37
−97.5
−97.4
−97.3
−97.2
−97.1

May 20 Case

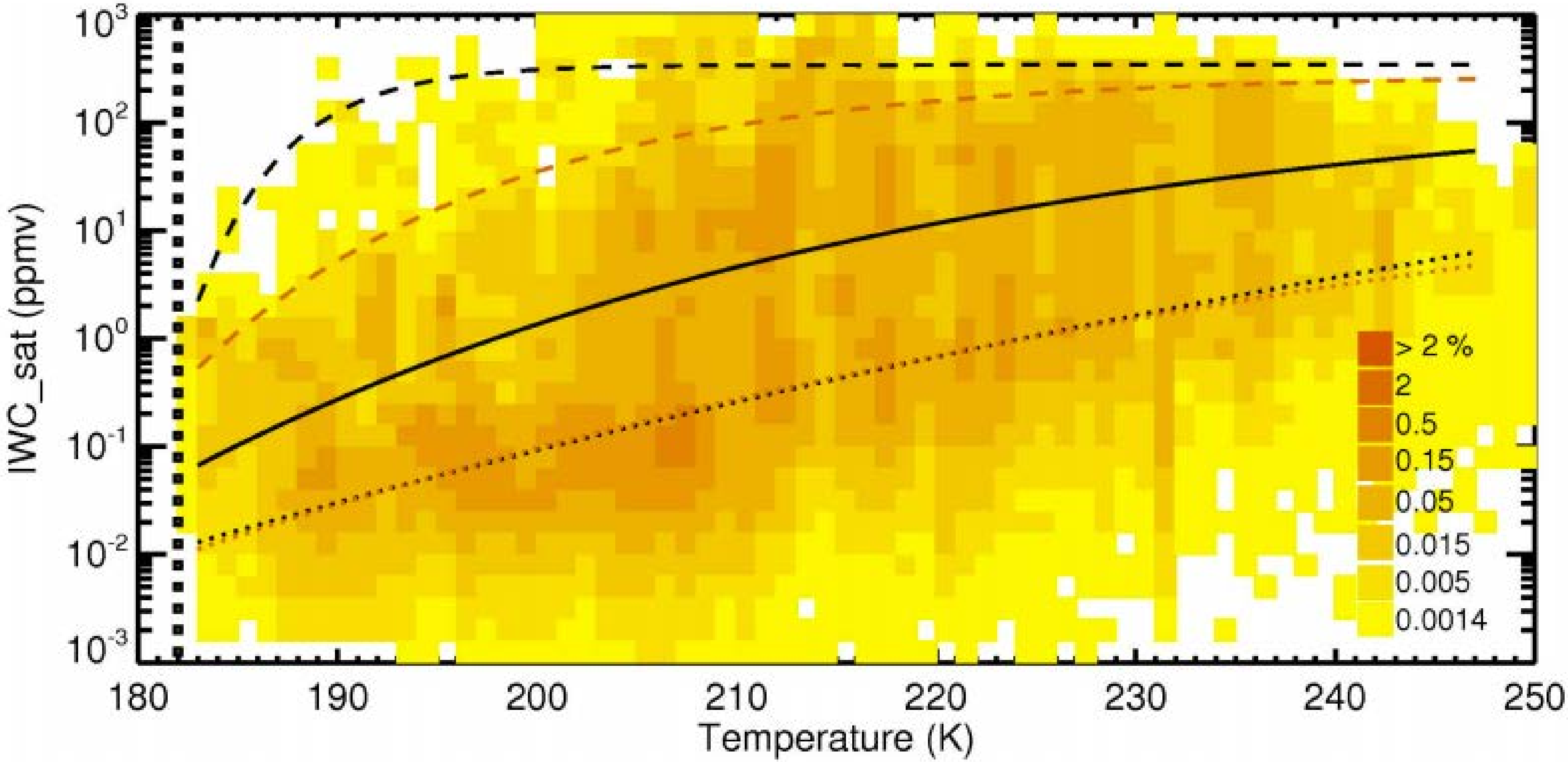
CIP Processing

- Corrected timing drift problem
- Holroyd habit classification and Jackson et al. (2012) m-D relationship for mass calculation (also computed m-D from Baker/Lawson 2006)
- Shattering effect removal using inter-arrival information
- Used particle reconstruction for images touching edges of photodiode array
- Output area ratio, aspect ratio and more single particle properties

Example CIP Size/Shape Distribution



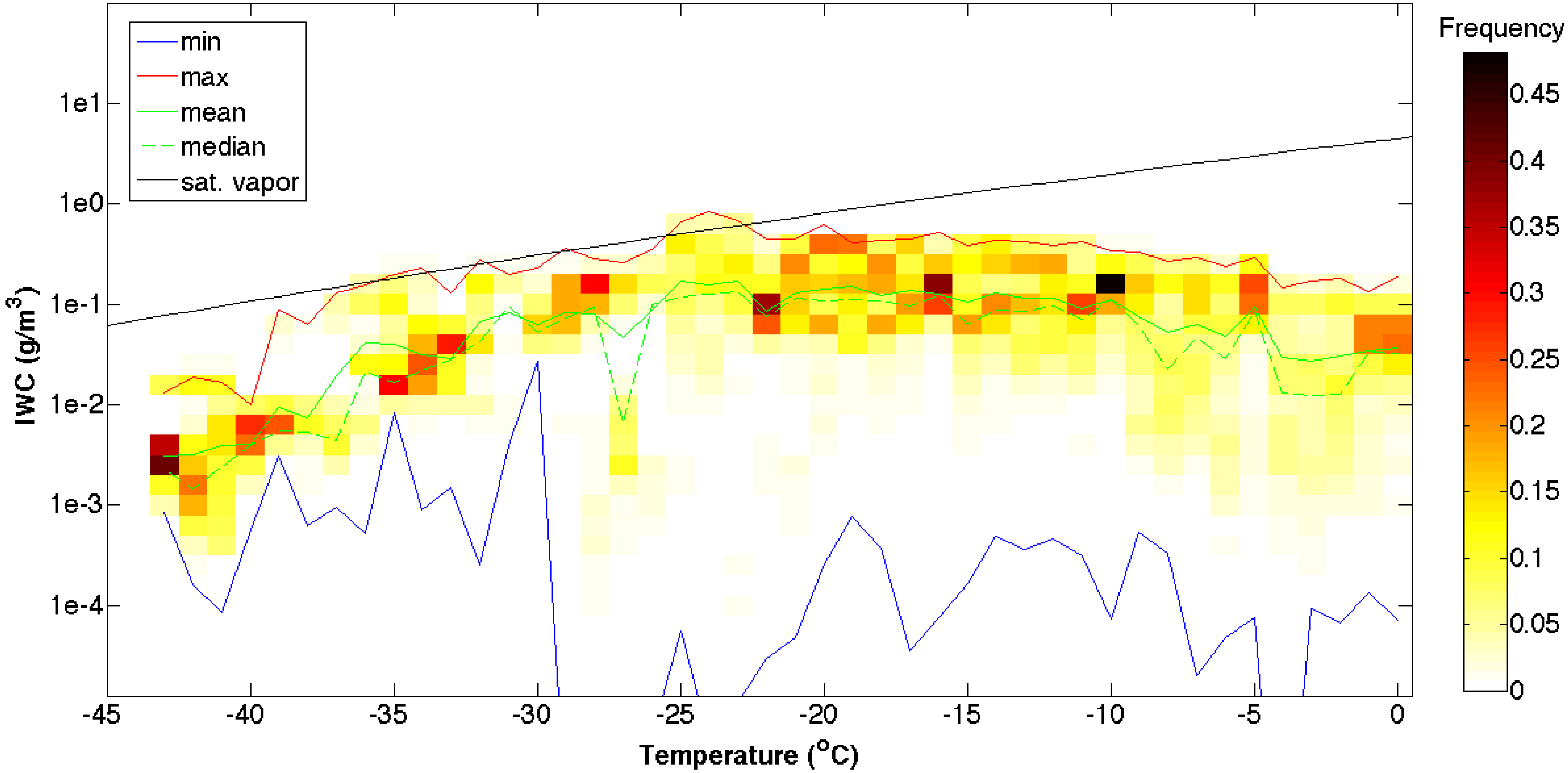
Luebke et al. (2013)



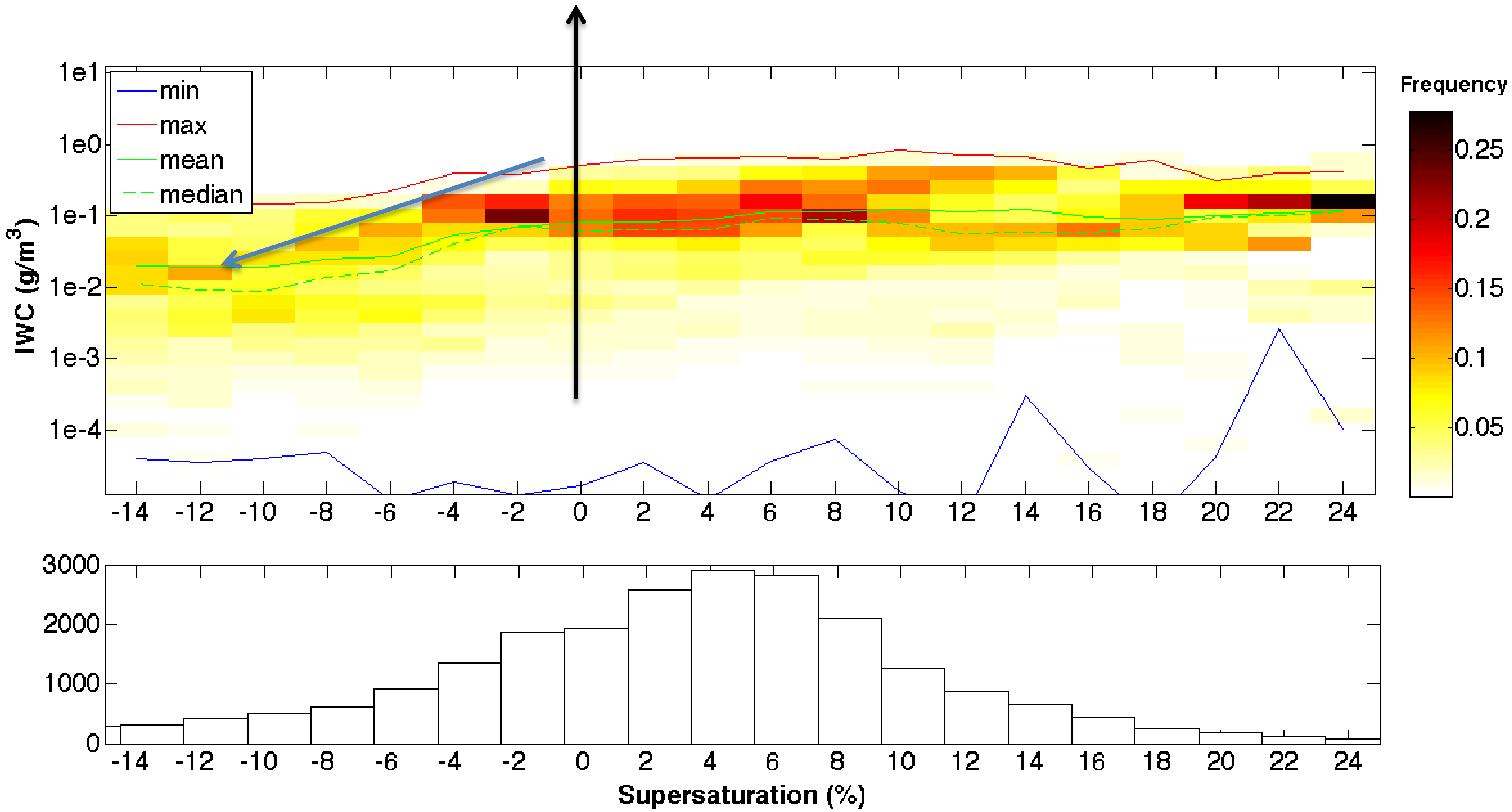
Data from FISH instrument in variety of mid-latitude (mainly European) campaigns

What types of relationships do we see with MC3E?

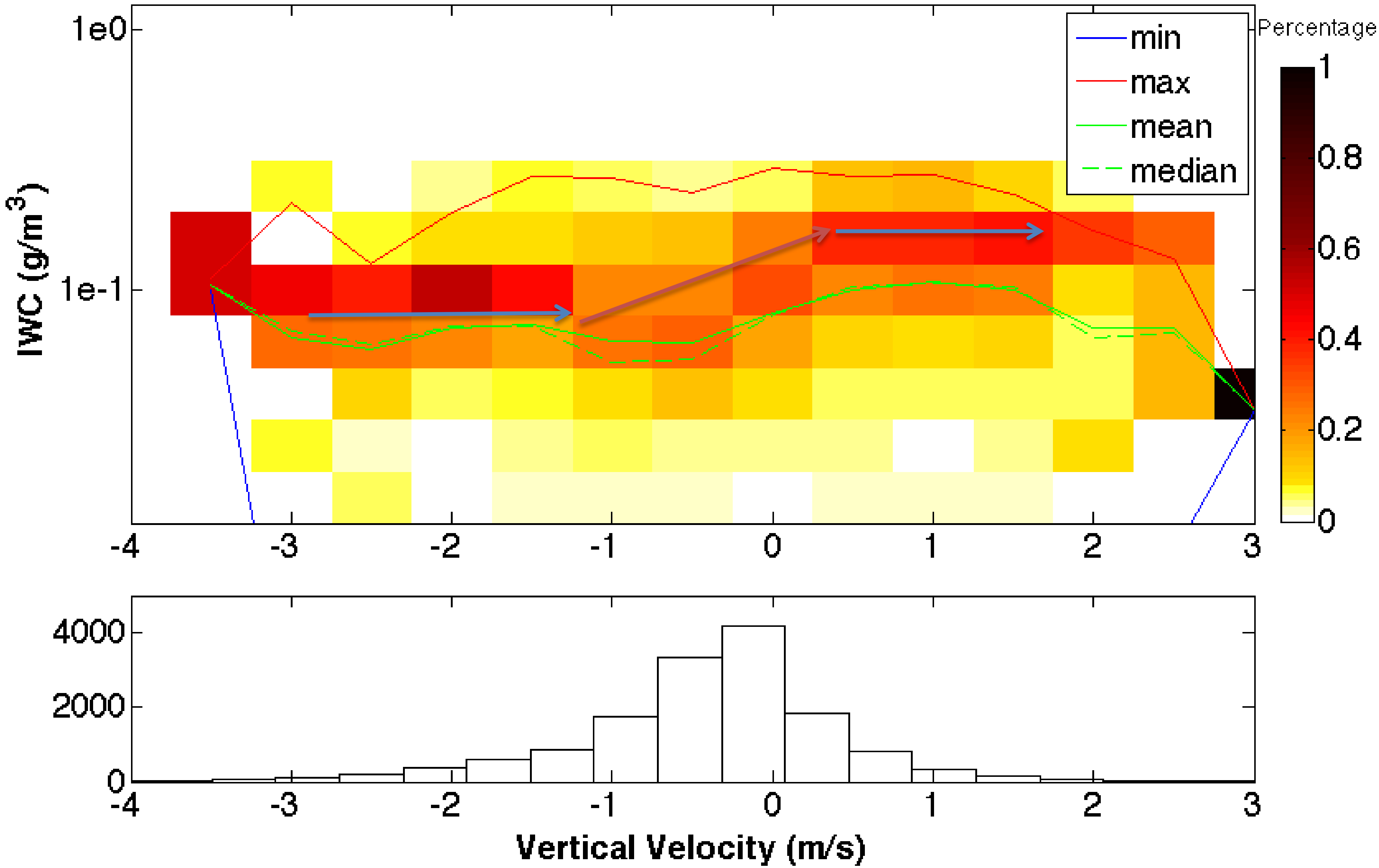
IWC: Temperature



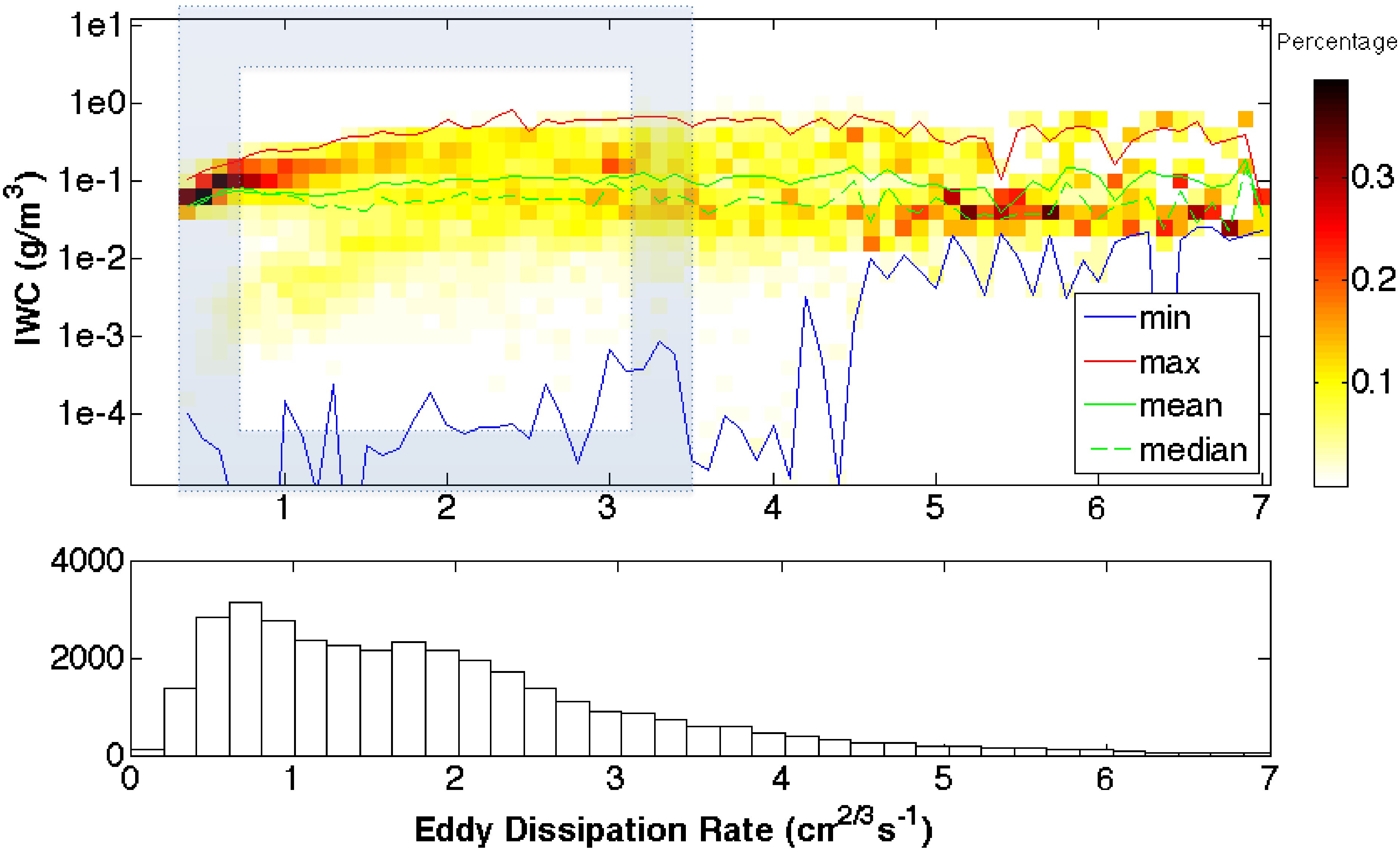
IWC: Supersaturation



IWC: Vertical Velocity



IWC: Turbulence

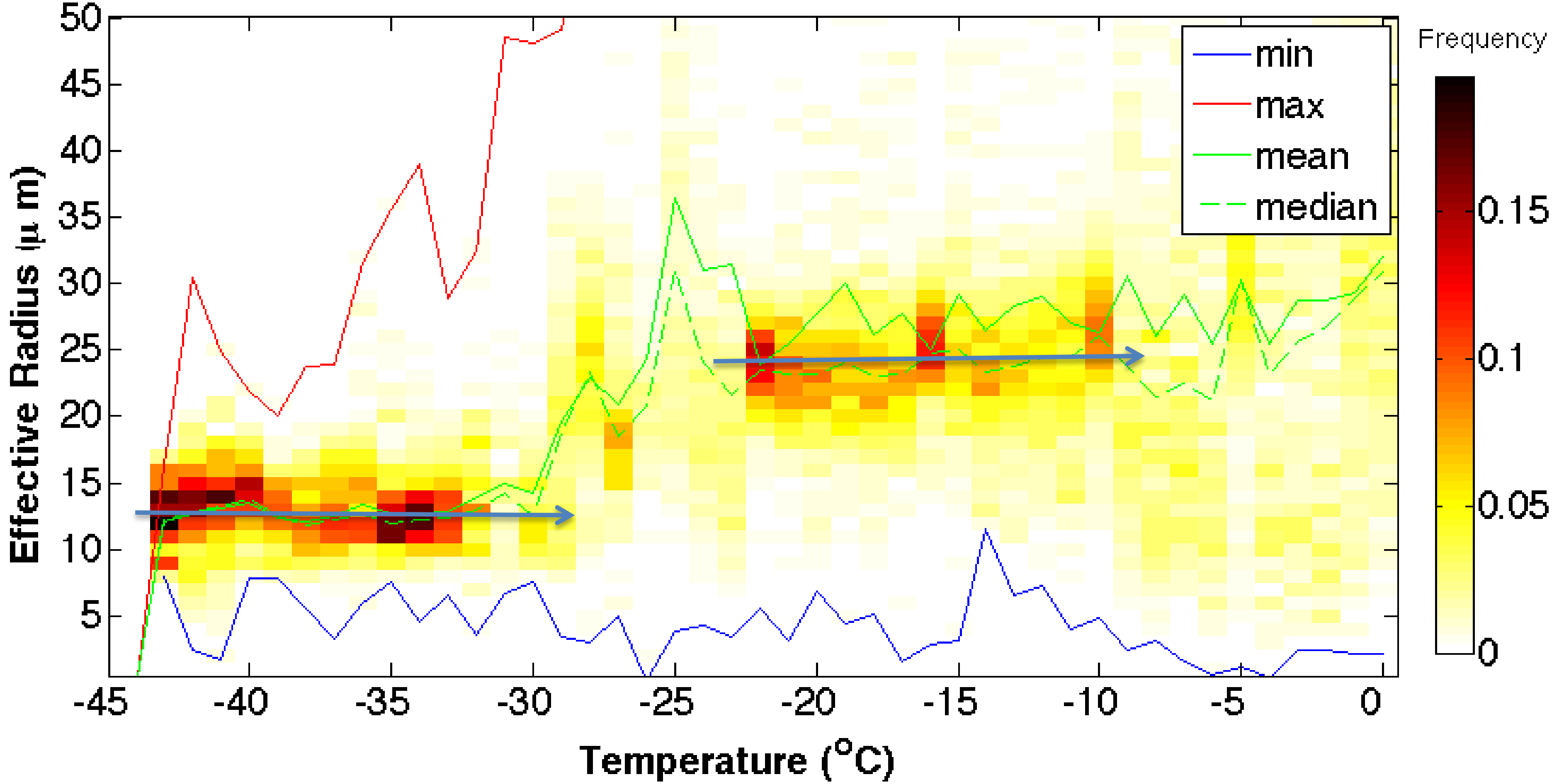


Effective Radius

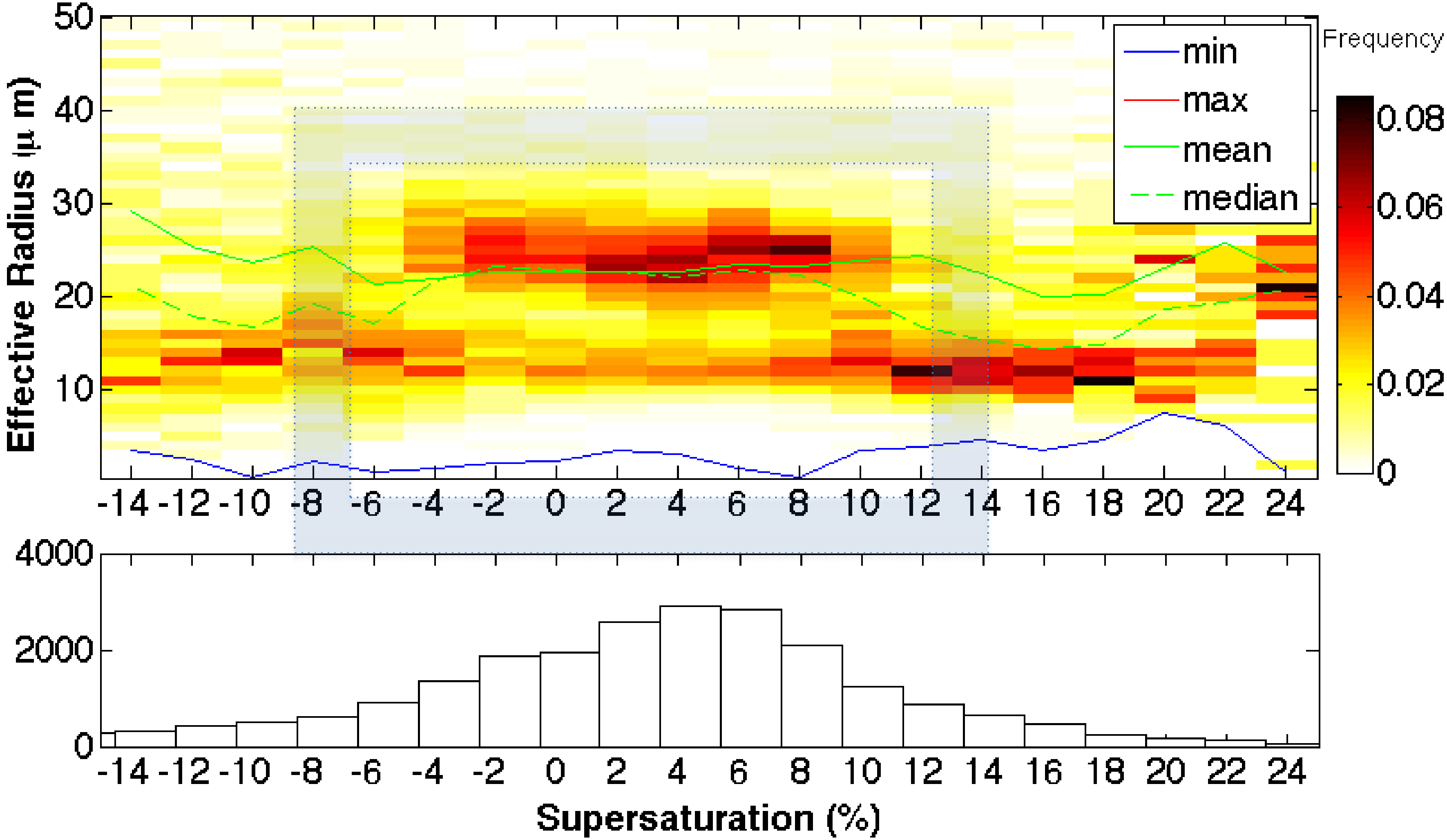
- $$R_e = \frac{\sqrt{3}}{3\rho_i}\frac{IWC}{A_c}$$, Fu (1996)

- Important for radiative transfer

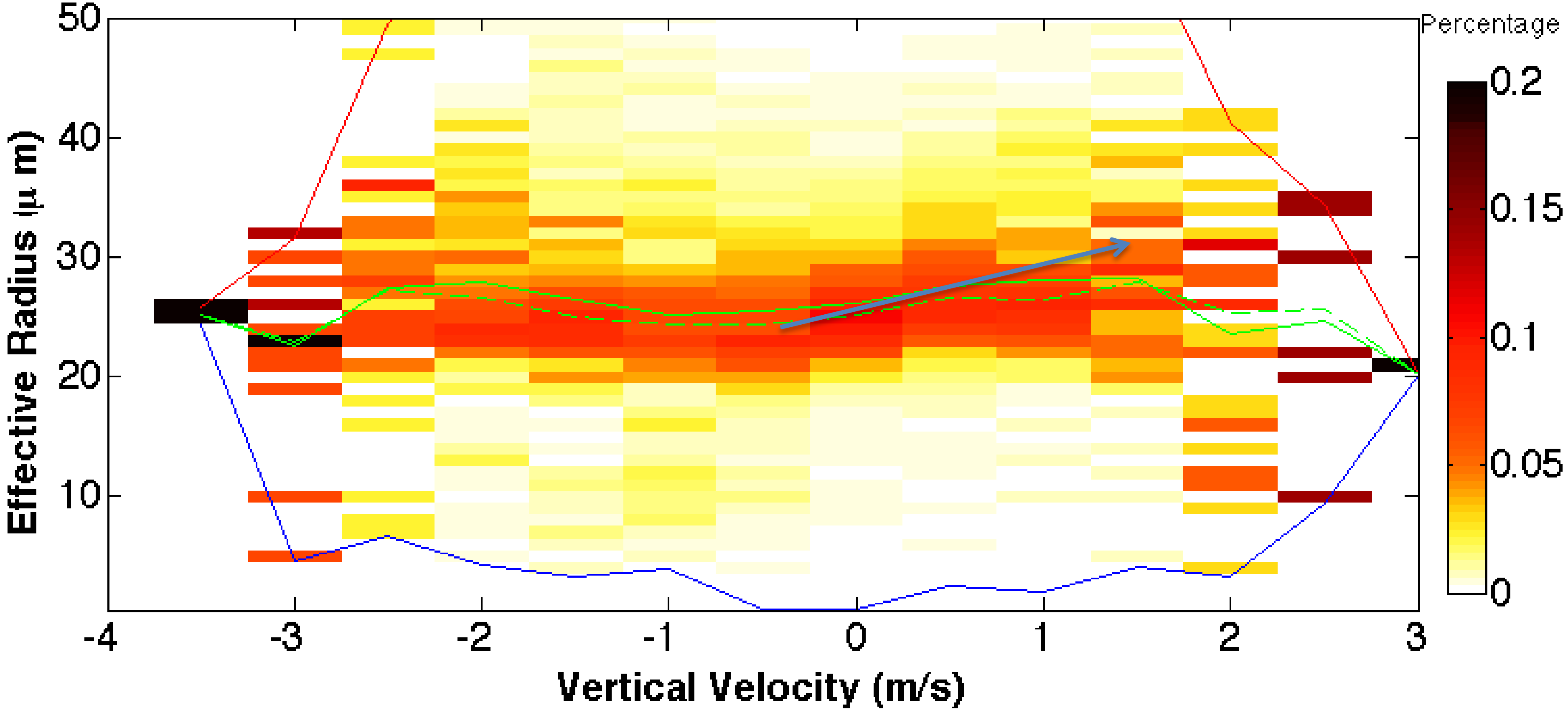
Re: Temperature



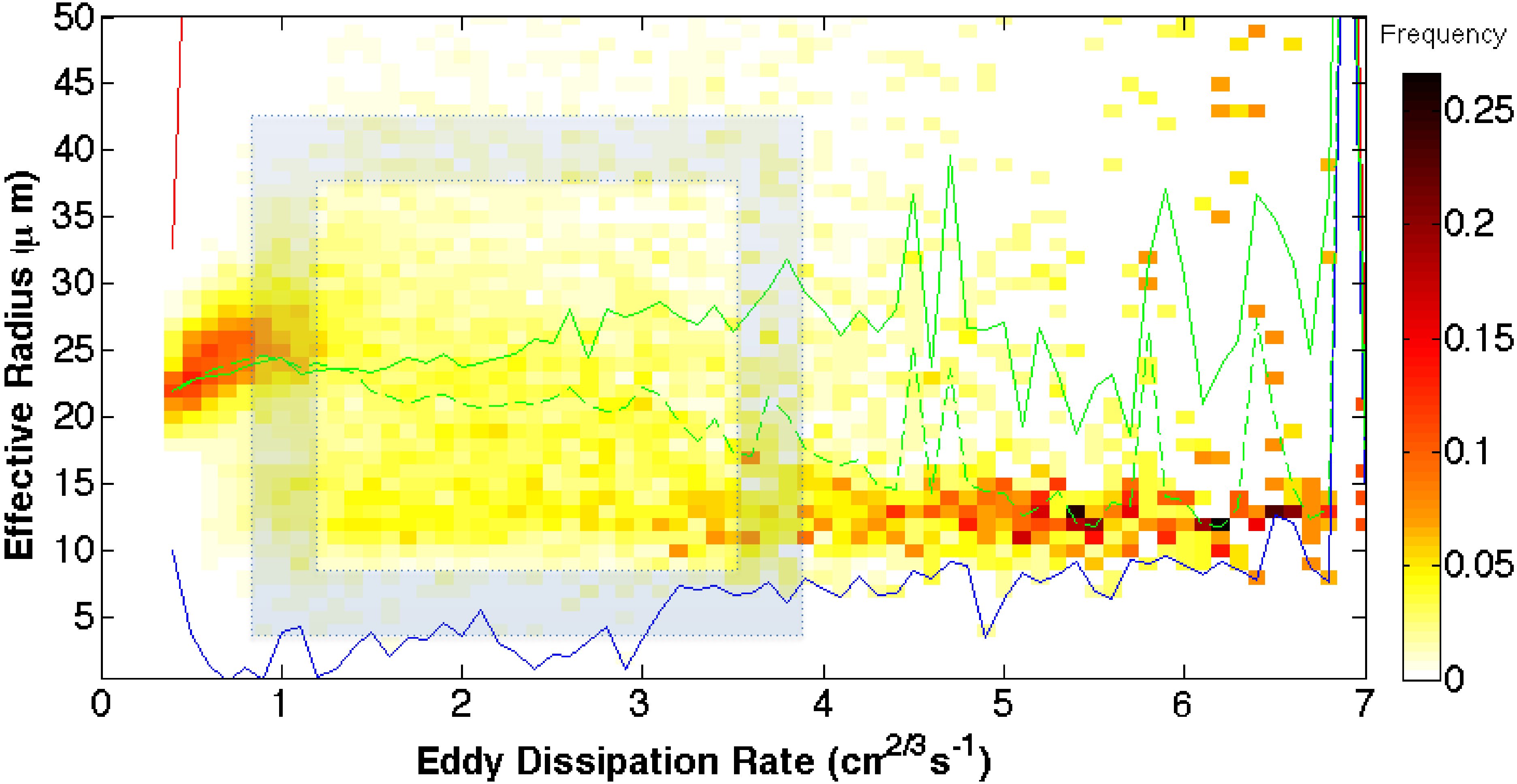
Re: Supersaturation



Re: Vertical Velocity



Re: Turbulence



Preliminary Findings

- IWC decreases with T for T < -25˚C, on dependence on T for T > -25˚C
- IWC decreases with S when sub-saturated, but no increase with amount of supersaturation
- IWC increases with w; little dependence on turbulence
- Big increase in r_e for T > -25˚C
- Bifurcation of r_e for supersaturated conditions
- r_e increases with w; little dependence on turbulence

Future Work

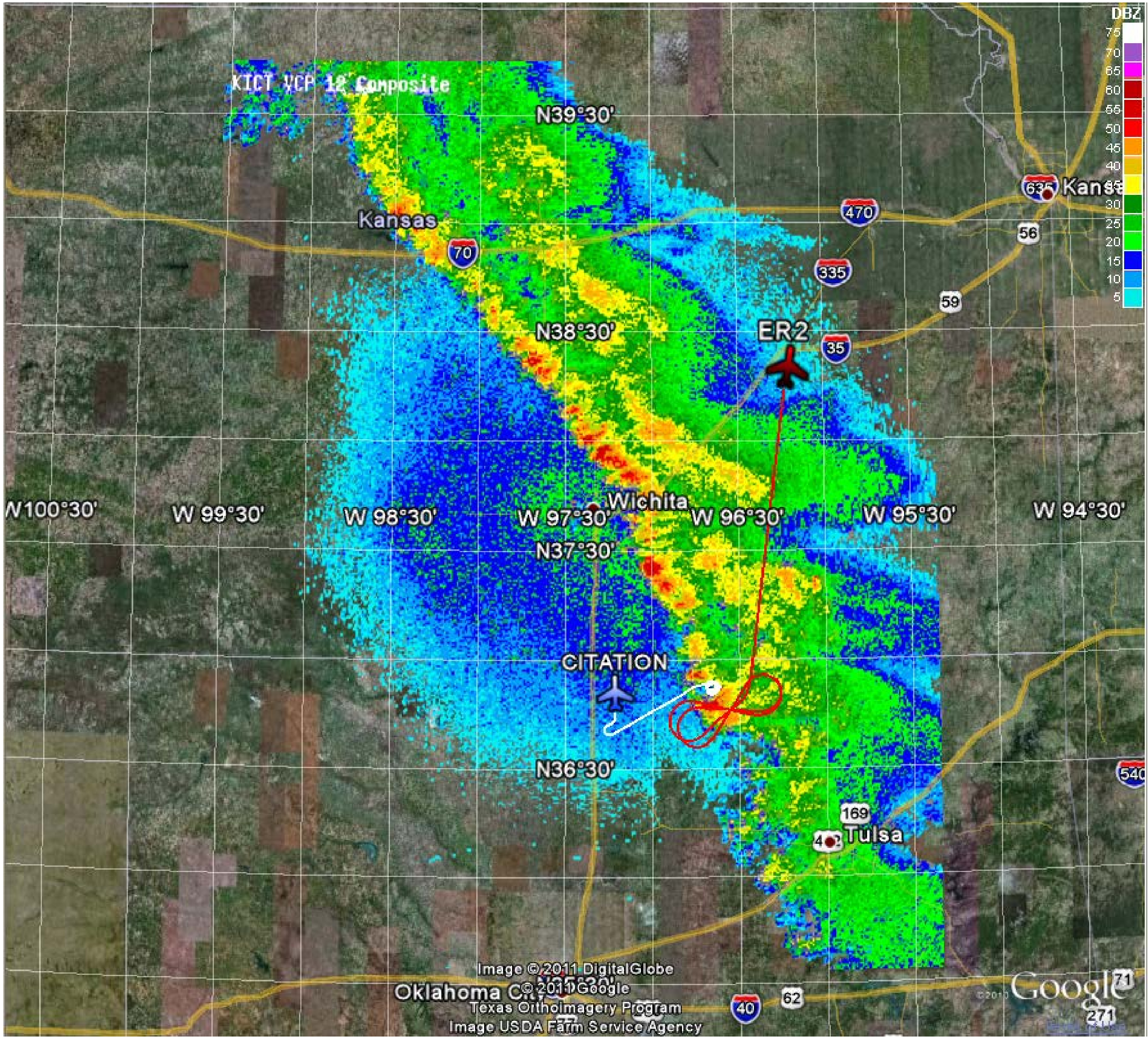
- Characterize variation of D_{mm}, β, N_t & derived V_m & scattering properties with T, S, w and turbulence
- Characterize variation of parameters with
  - meteorological conditions & geographic location
  - formation mechanism (synoptic vs. convective)
  - location within cloud
  - Intensity of and proximity to convection
- Compare to data in other campaigns (SPARTICUS, STORMVEX, TWP-ICE, etc.) & more flights
- Develop parameterizations describing above
- Determine how contributions of crystals with $D < 100$ μm to mass/radiative properties vary in above conditions

Integrate HVPS3 data into analysis

- 128 diodes
- 2DS electronics.
- 150 um resolution
- High sample volume
- Particles from 150 um-1.9 cm

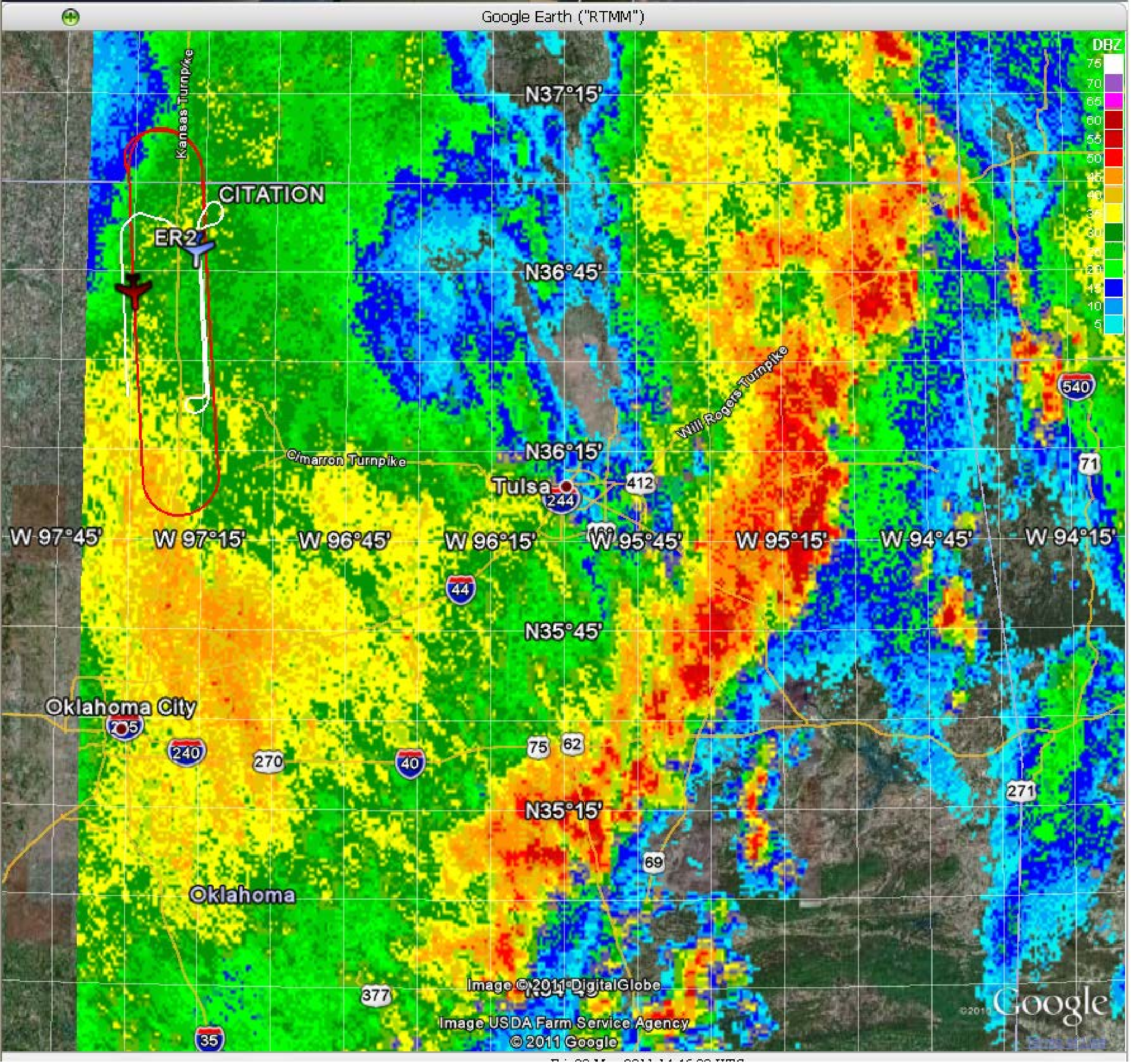
HVPS Processing

- Speeding up processing
- Ensuring consistently defined maximum dimension between codes
- Better ways of reconstructing particle images

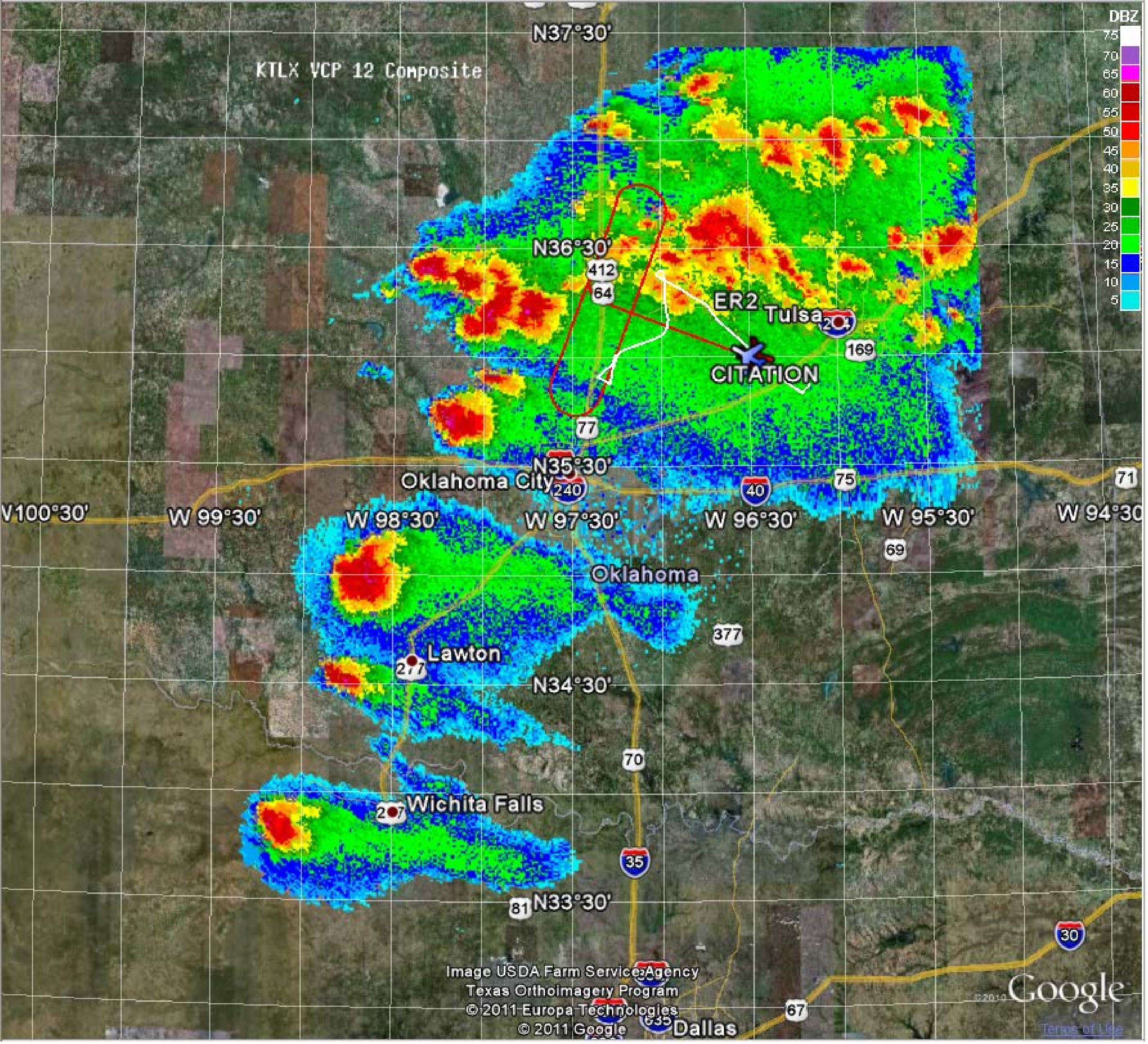


May 18:

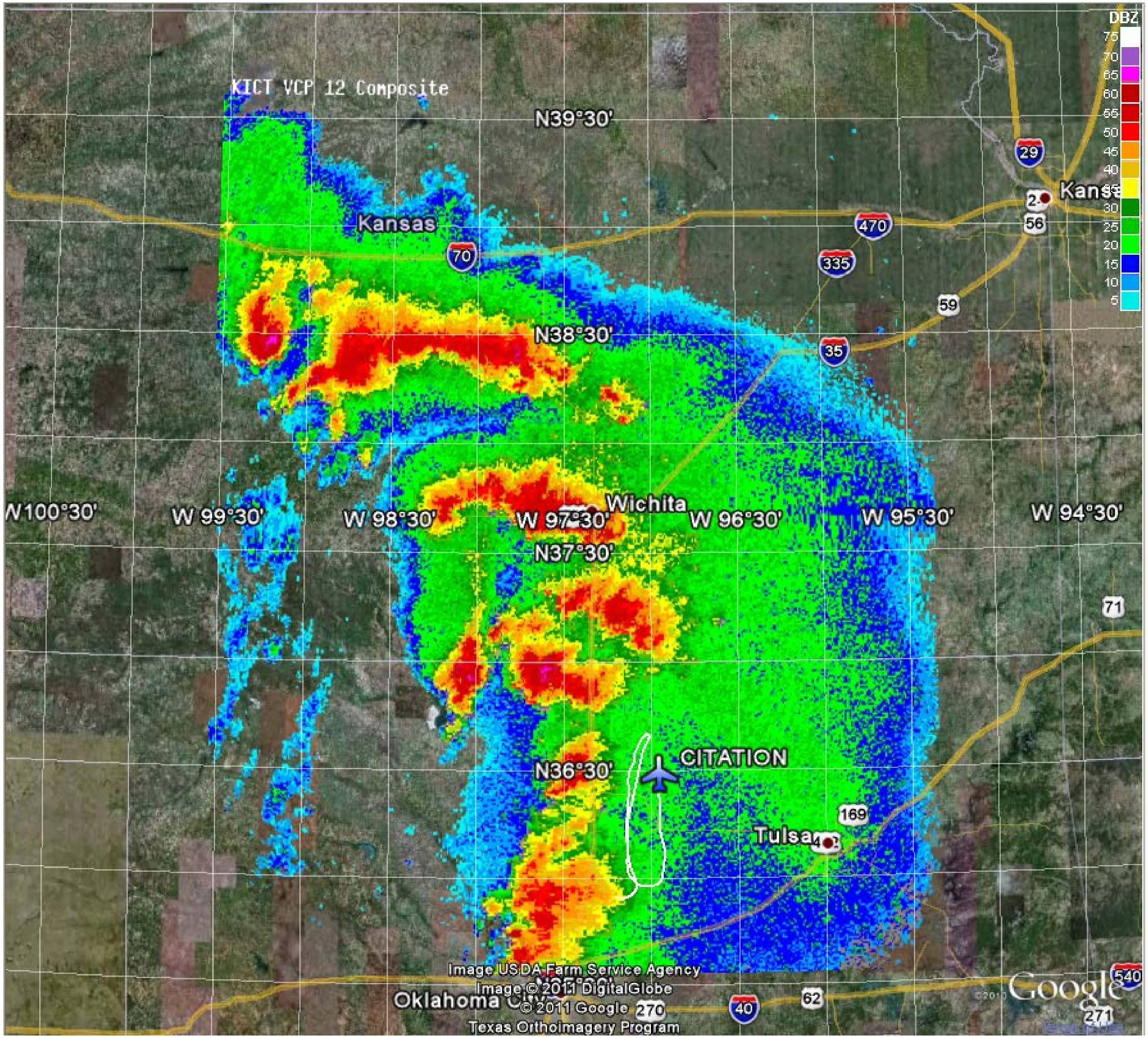
Squall line extending from low pressure system in Colorado, moisture from Gulf Stream



May 20:
Strong low-level jet pushed over OK in early morning as a deep trough moved through western US; large MCS formed just west of cold front



May 23:
Surface low pushed into OK panhandle, interacting with dry line and firing convection; several cells along dry line became supercells



May 24:

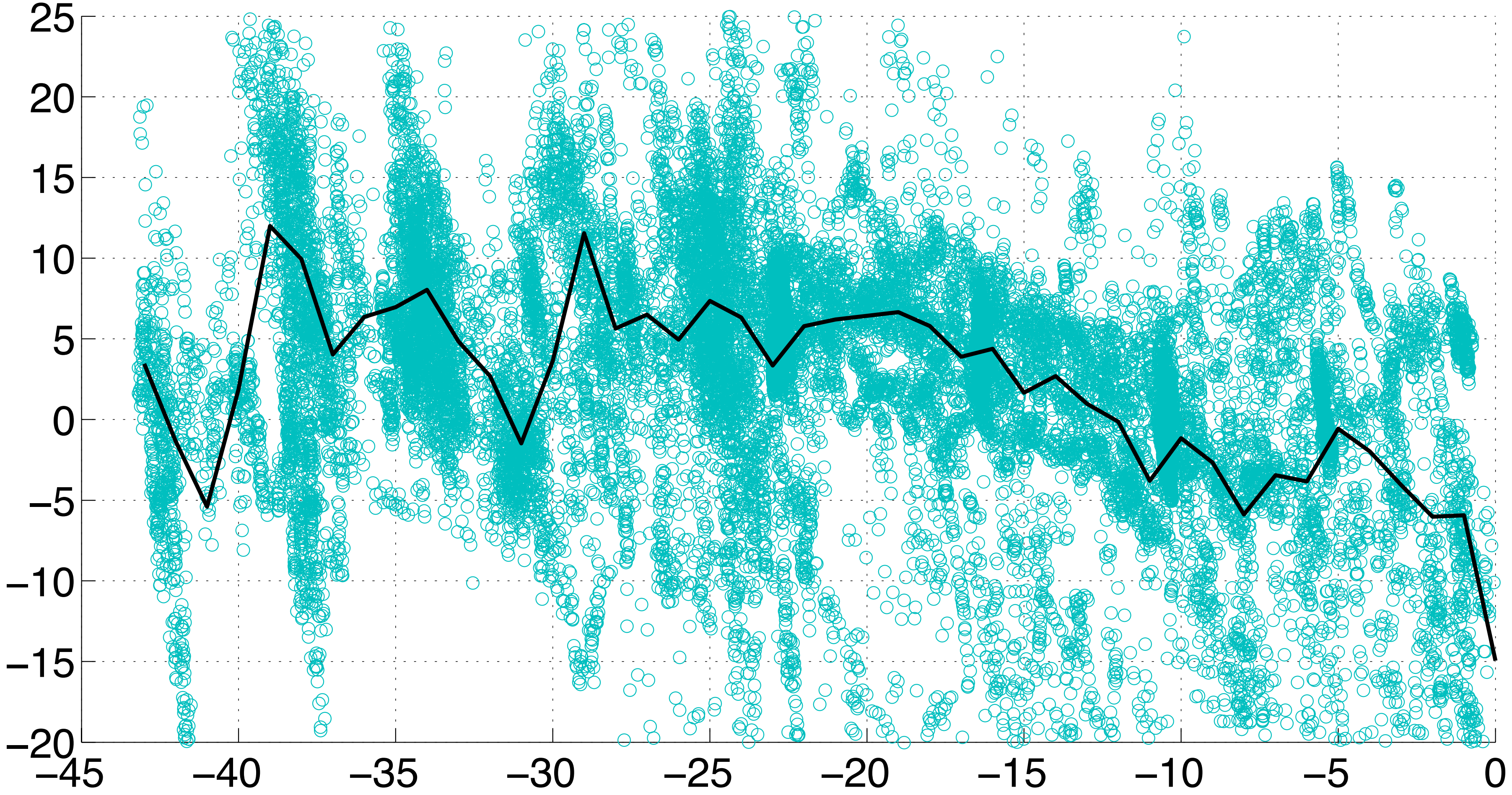
Upper level trough over Rockies and surface low over OK pushed dry line to western part of state, where cells firing in N-S line intensified into super cells generating some tornadoes

IWC

- Calculated using habit m(D) relationship
- Habit classification follows Holroyd
- m(D) follows Jackson et al. (2012)

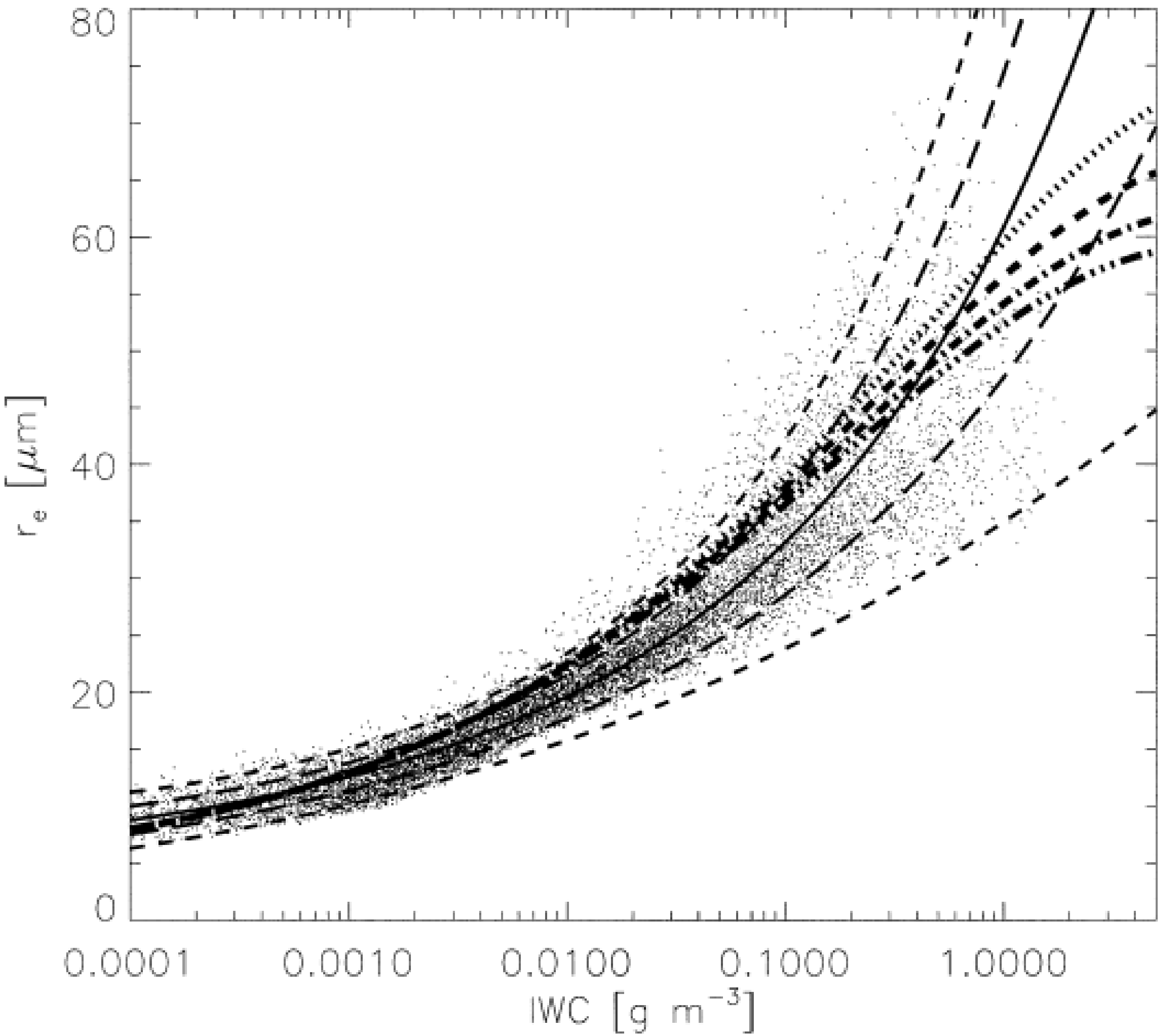
- IWC using m(A) also computed, systematically larger

Supersaturation vs Temperature



Almost independent, with higher supersaturation value on low temperature

Dependence of Re on IWC

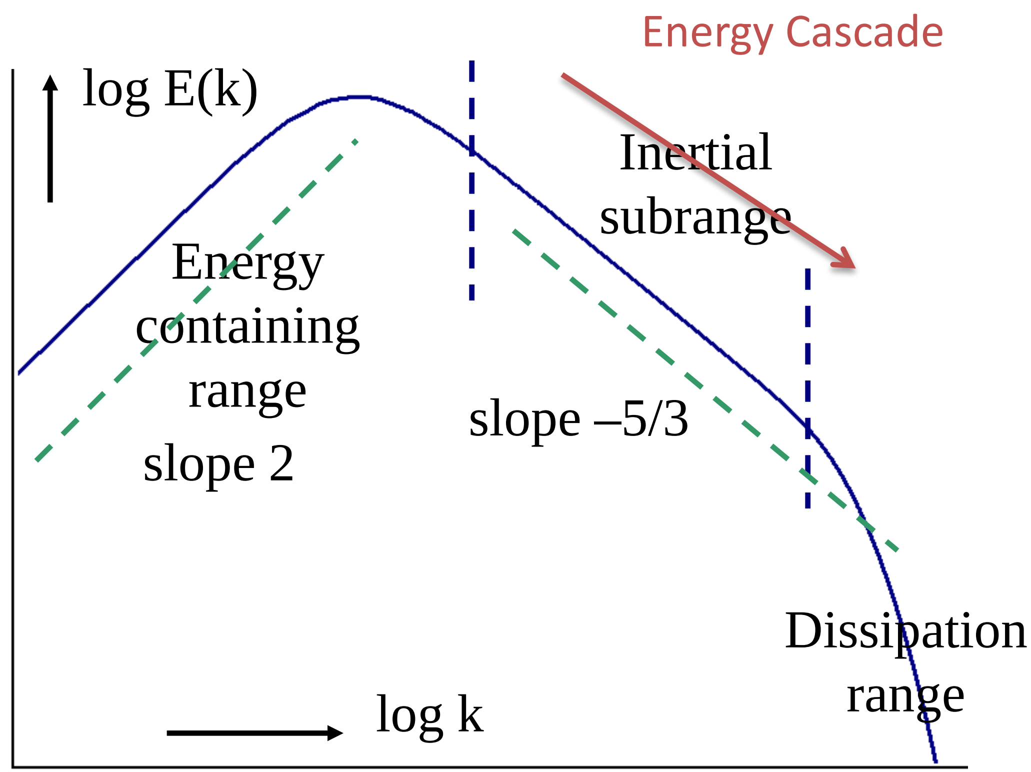


Turbulence

- Turbulent Kinetic Energy (TKE)=$(u'^2+v'^2+w'^2)/2$, $u'=u-u_{ave}$ and v', w'
- Expand:

$$TKE = \int_0^\infty E(\kappa)\,d\kappa$$

- k is wavenumber, k=2*pi/l, where l is eddy wavelength
- f_L and $f\eta$ are for production and dissipation range



$$E(\kappa) = C\varepsilon^{2/3}\kappa^{-5/3} f_L\, f_\eta$$

ε is eddy dissipation rate (EDR), usually represents turbulence intensity. Others measures include u'/u_{ave}...