

A Microphysics Guide to Cirrus Clouds

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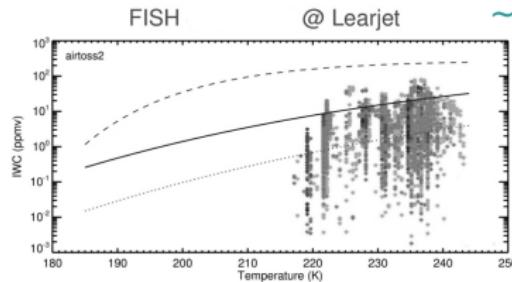
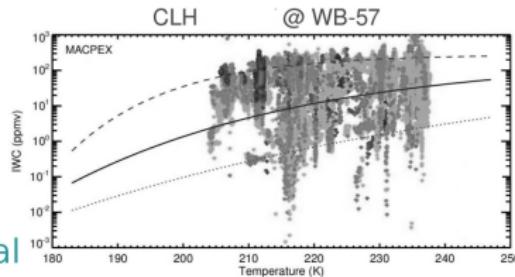
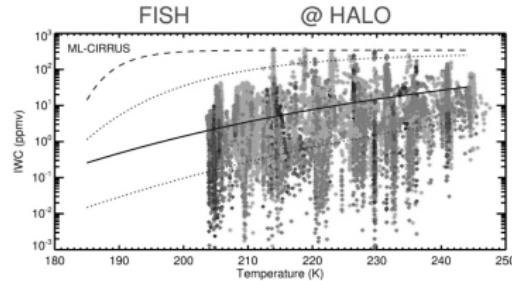
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(4) Harvard Univ. Cambridge, USA (5) JPL Pasadena, USA

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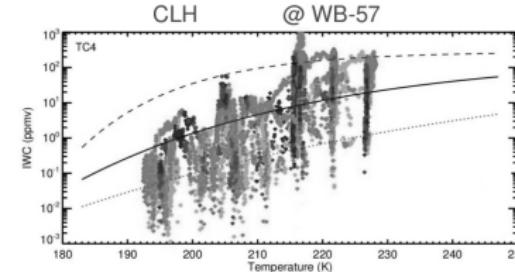
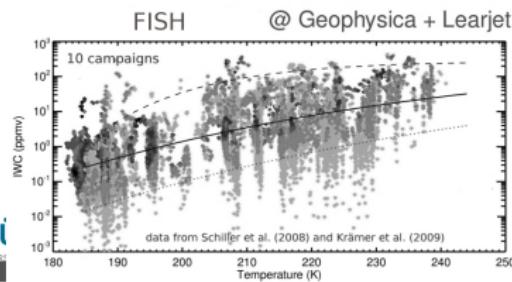
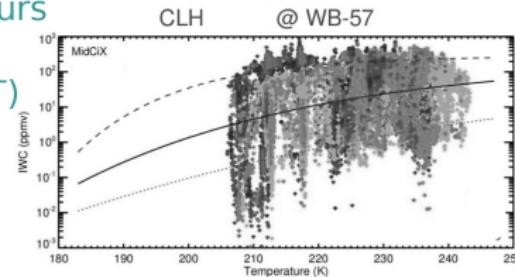
14th AMS Conference on Cloud Physics, Boston, July 2014

AIRCRAFT IN-SITU ICE WATER MEASUREMENTS



in total
~ 80 hours

of
IWC(T)



INTENTION

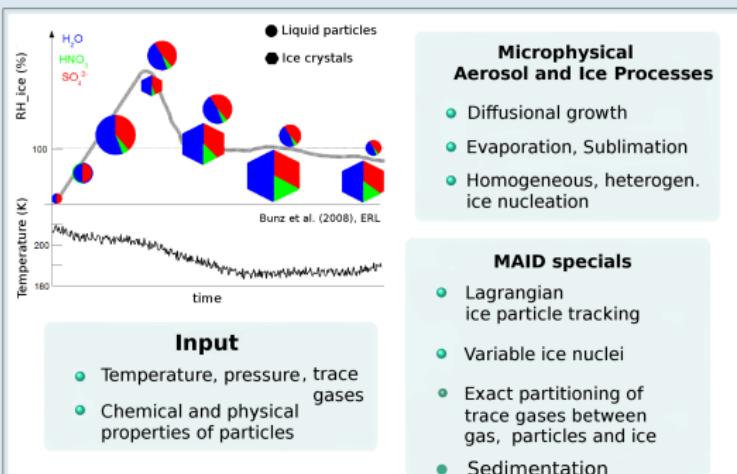
Track Ice Water Content (IWC) development with temperature

- by means of model simulations
- compare with observations

assign cirrus microphysics and formation mechanism
to observations

METHOD: MAID

Microphysical boxmodel MAID (Model for Aerosol and Ice Dynamics)

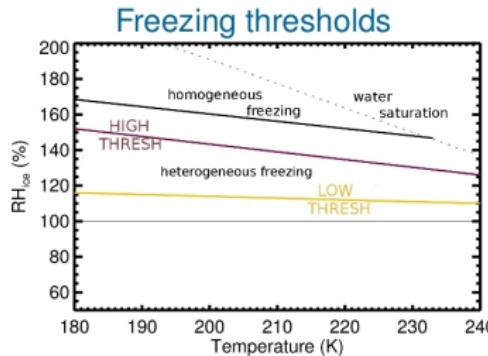


Bunz et al. (2008), ERL, Gensch et al. (2008), ERL

CIRRUS GUIDE - SCENARIOS

Air parcel trajectories:

- Temperature range 190 - 230 K in 10 K steps
- Vertical velocities: 0.0001, **0.01**, **0.1**, **0.5**, **1.0**, **3.0** m/s
- H₂O: 90% RH_{ice}
- each scenario contains 27 model runs



hom. freezing: Koop et al. (2000), Nature
het. freezing: Kärcher et al. (2006), JGR
freezing thresholds: Gensch et al. (2008), ERL

Initial conditions:

- HOM + HET:
Heterogeneous ice nuclei (IN): 0.001, 0.01, 0.1, 1.0 cm⁻³
- High/low freezing thresholds (MD: mineral dust, CS: coated soot)
- sedimentation parameter f = 0.9 / 0.5
- scenarios: 20 nofluct , 20 fluct
→ 1080 model runs

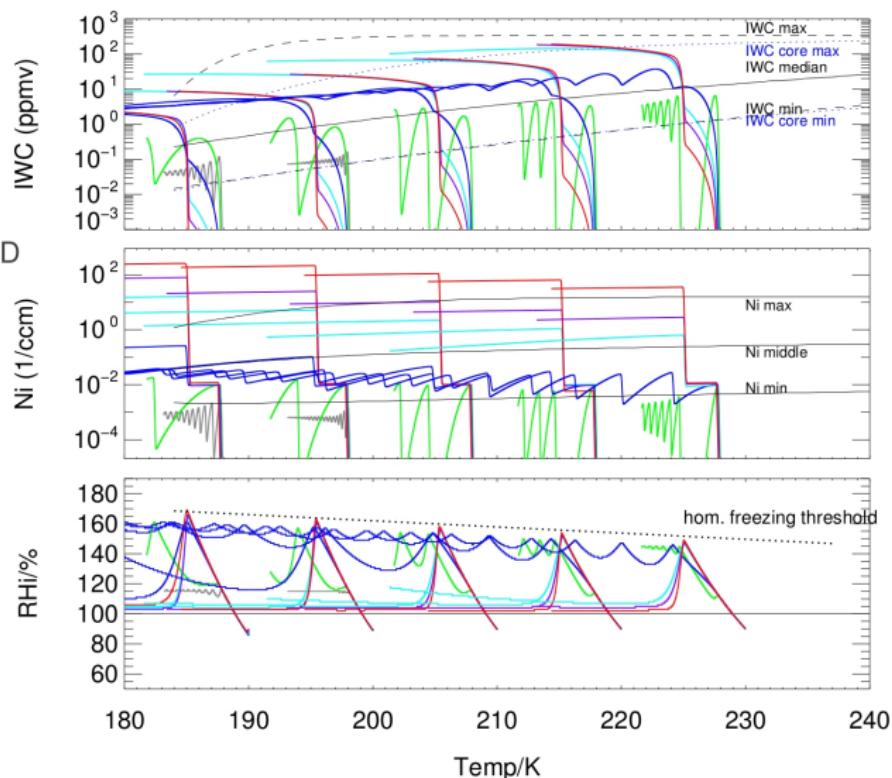
➤ the whole cirrus parameter range is covered by the simulations

➤ No evaporation

MAID SCENARIO EXAMPLE

sedi 0.9, IN=0.01 cm⁻³, MD

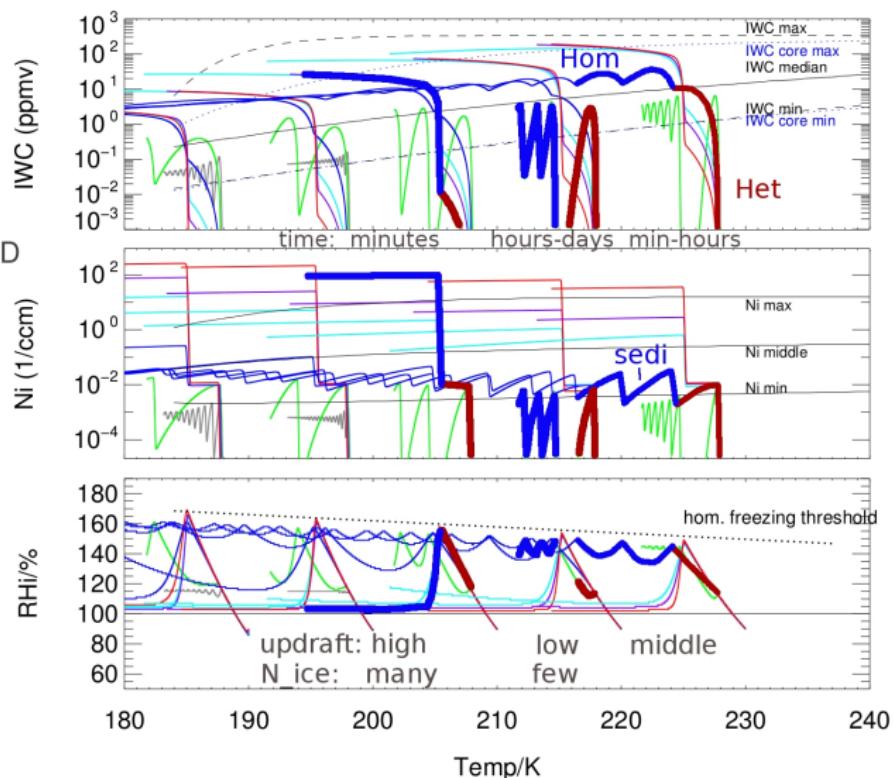
3.0 m/sec	≈	0.6 min/K
1.0 m/sec	≈	1.7 min/K
0.5 m/sec	≈	3.4 min/K
0.1 m/sec	≈	17 min/K
0.01 m/sec	≈	170 min/K
0.0001 m/sec	≈	28 h/K



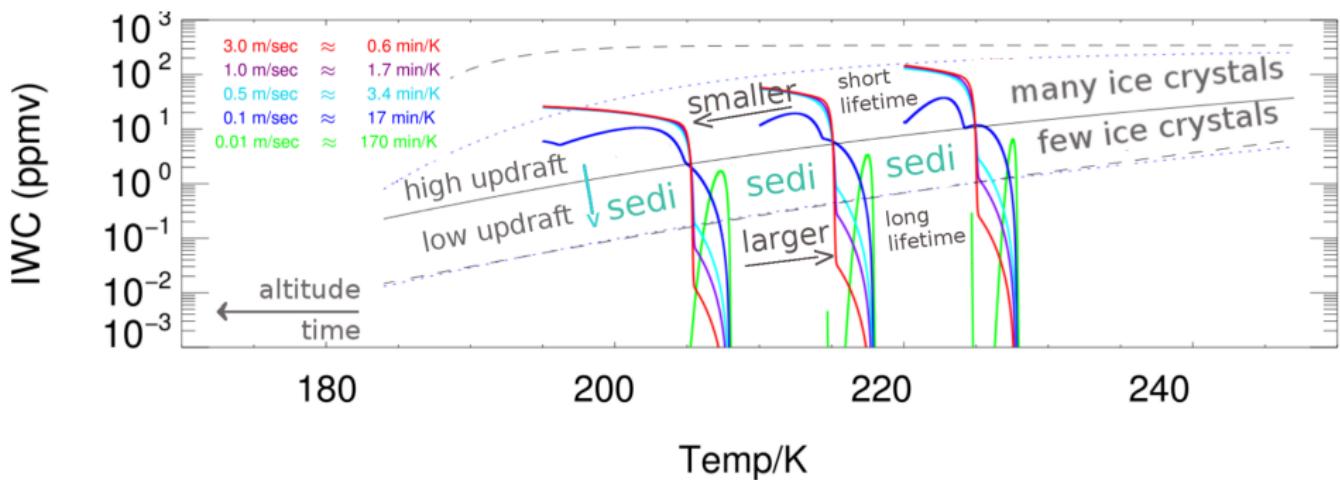
MAID SCENARIO EXAMPLE

sedi 0.9, IN=0.01 cm⁻³, MD

3.0 m/sec	\approx	0.6 min/K
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CIRRUS GUIDE

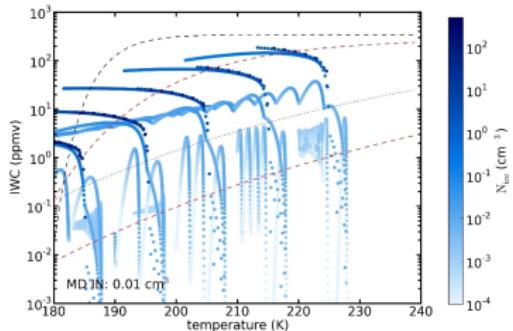


- Cirrus microphysics visible in the IWC - T parameter space !
 - Do we see the many/few ice crystals (IWC(N_{ice})) in the measurements?

IWC COLORED BY N_{ice}

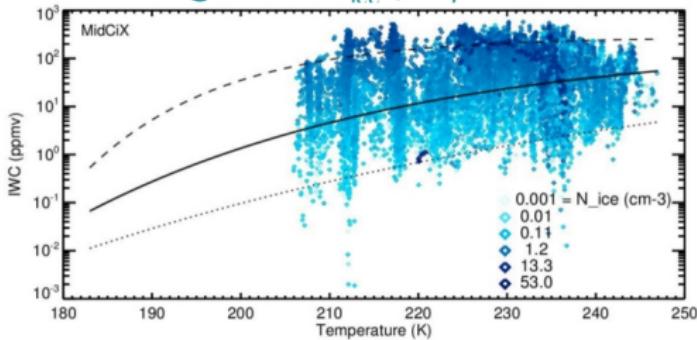
Simulations

sedi 0.9, IN=0.01 cm⁻³, MD



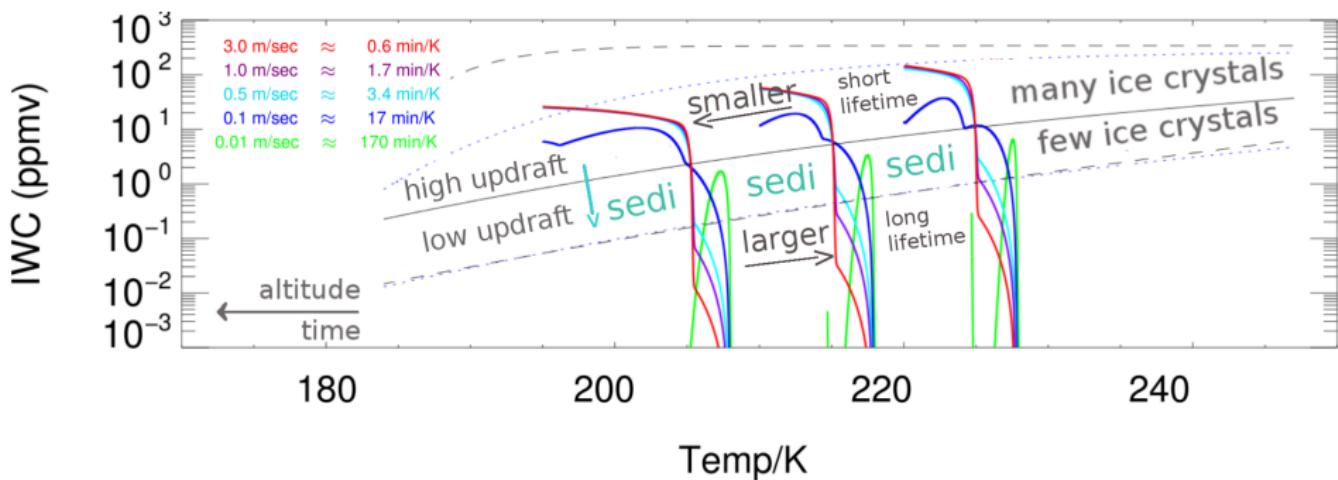
Observations - example

CAPS@WB-57: D_{ice} > 3 μm MidCix



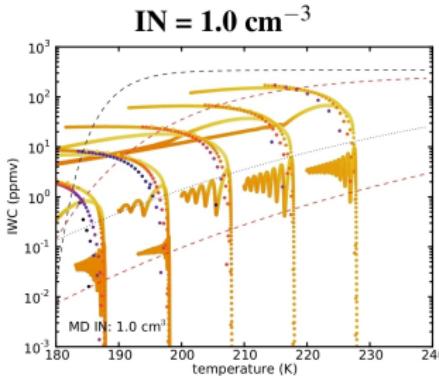
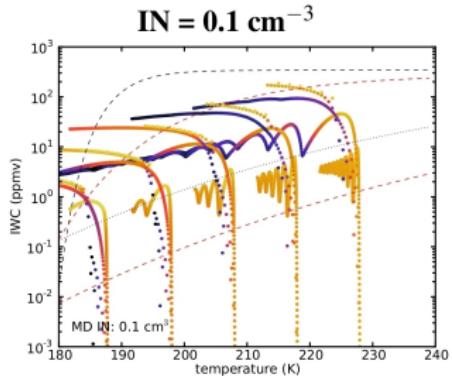
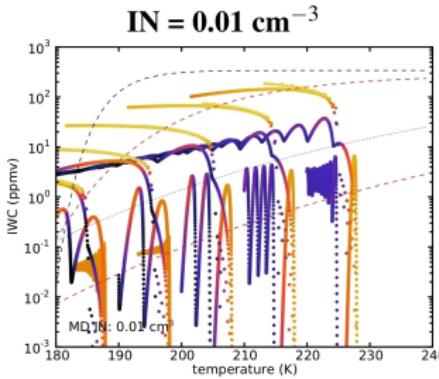
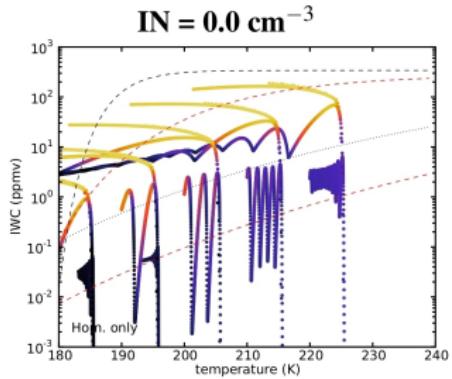
► We see the many/few ice crystals (IWC(N_{ice})) in the measurements !

CIRRUS GUIDE

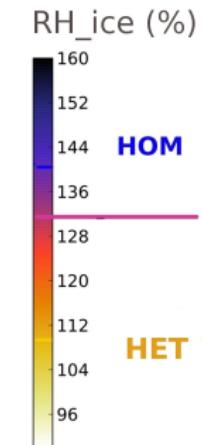


→ Can we assign the freezing mechanism in IWC - T parameter space?

IWC COLOURED BY RH_{ice} - SIMULATIONS



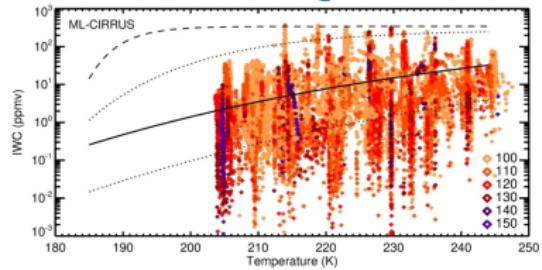
HET



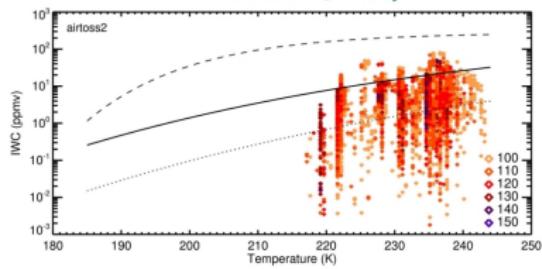
(sedi 09)

IWC COLOURED BY RH_{ice} - OBSERVATIONS

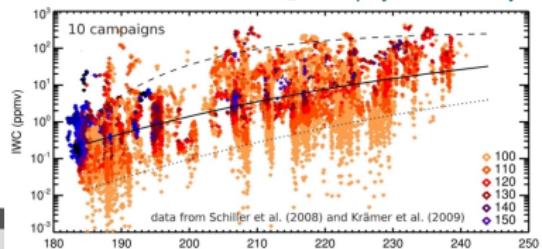
FISH + SHARC @ HALO



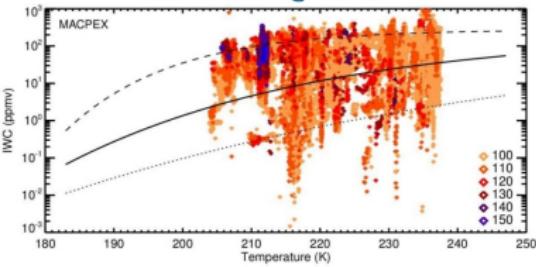
FISH + SEALDH @ Learjet



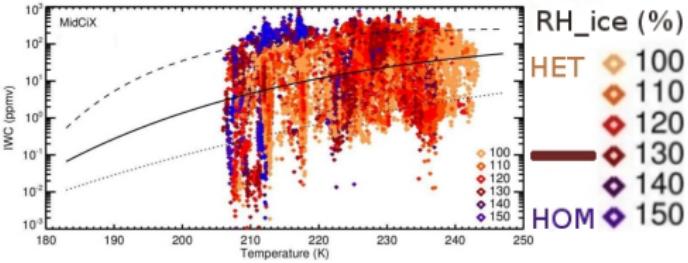
FISH + FLASH/OJSTER @ Geophysica + Learjet



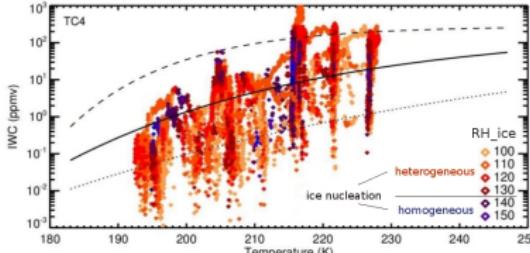
CLH + HWV @ WB-57



CLH + JLH @ WB-57



CLH + HW @ WB-57



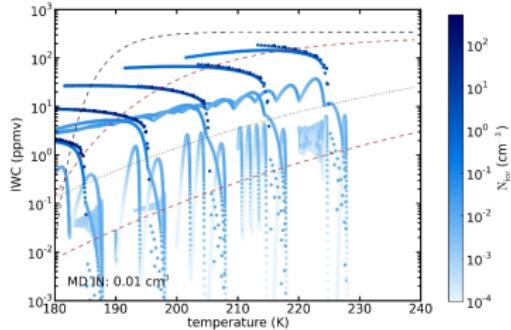
CIRRUS GUIDE

- We can assign the freezing mechanism in the IWC - T parameter space only from IWC - RH_{ice} measurements
- Heterogeneous freezing is dominant in all European / US field campaigns (from ~ 80 h in cirrus)
 - ➡ in accordance with Cziczo et al. (2013)
 - Cirrus from heterogeneous freezing represent about 90% of the cirrus population

IWC COLORED BY N_{ice}

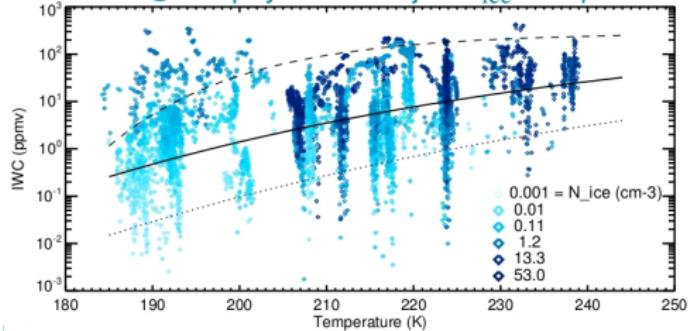
Simulations

sedi 0.9, IN=0.01 cm⁻³, MD



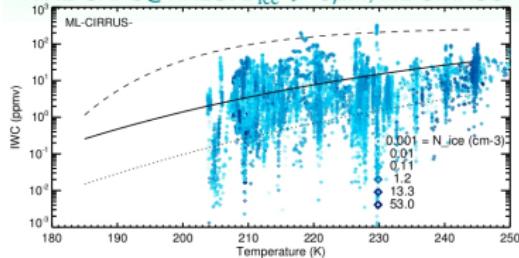
Observations

FSSP@Geophysica&Learjet: D_{ice} > 3 μm

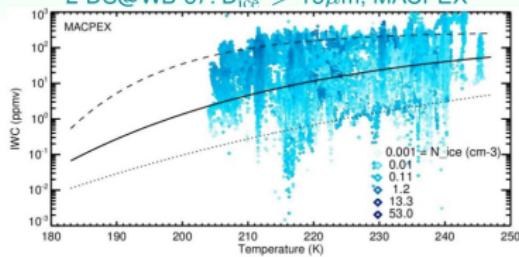


IWC COLORED BY N_{ice}

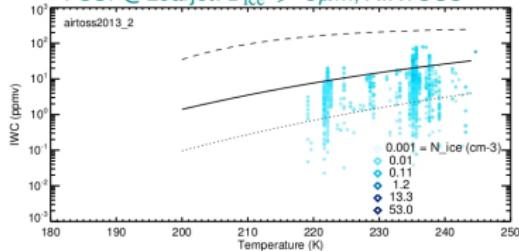
NIXE-CAPS@HALO: $D_{\text{ice}} > 3\mu\text{m}$, ML-CIRRUS



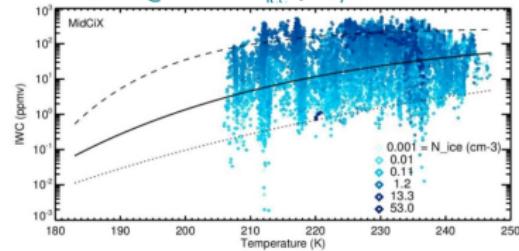
2-DS@WB-57: $D_{\text{ice}} > 15\mu\text{m}$, MACPEX



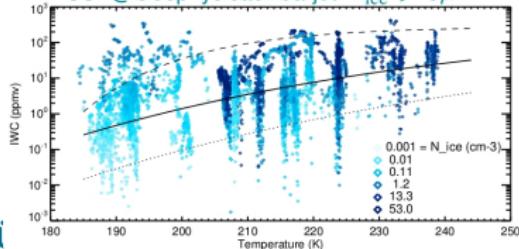
FSSP@Learjet: $D_{\text{ice}} > 3\mu\text{m}$, AIRTOSS



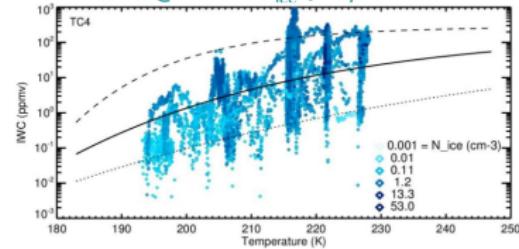
CAPS@WB-57: $D_{\text{ice}} > 3\mu\text{m}$ MidCix



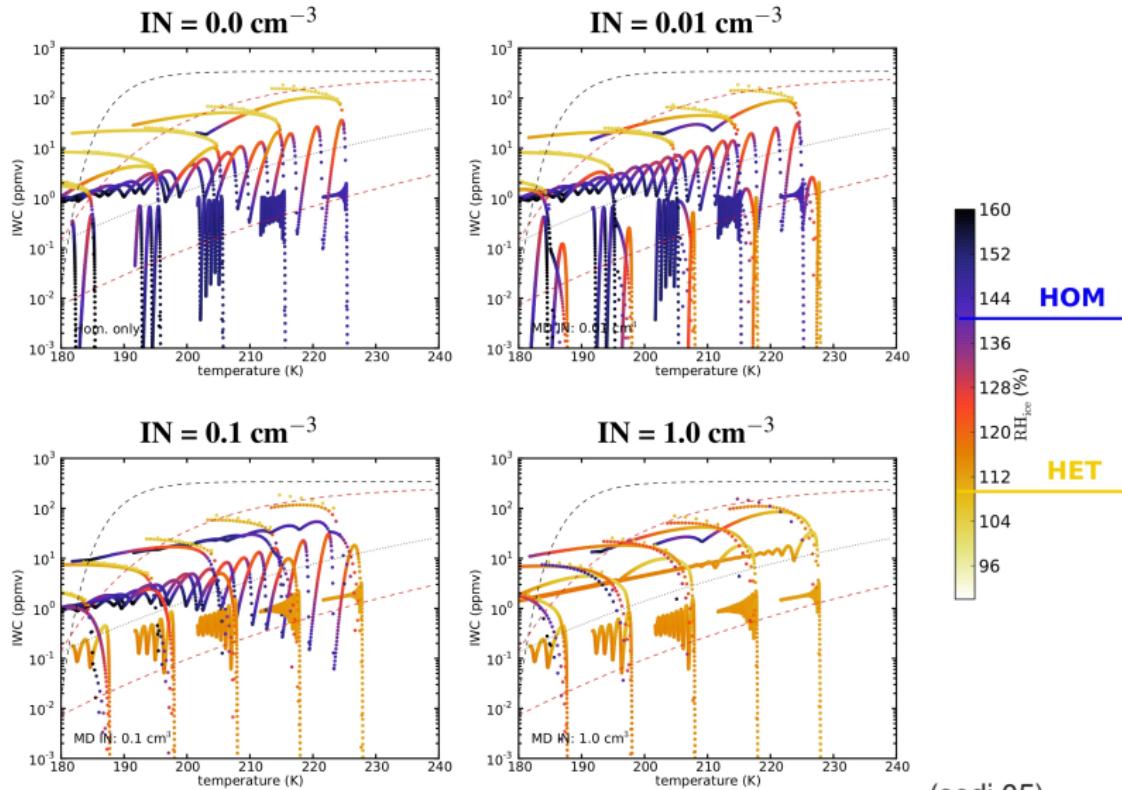
FSSP@Geophysica&Learjet: $D_{\text{ice}} > 3\mu\text{m}$



CAPS@WB-57: $D_{\text{ice}} > 3\mu\text{m}$ TC-4



IWC COLOURED BY RH_{ice} - SIMULATIONS



(sedi 05)