CONTRASTING THE ICE NUCLEATION IN TWO LEE WAVE CLOUDS OBSERVED DURING THE ICE-L CAMPAIGN

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Ice in Clouds Experiment – Layer clouds

- The long term goal of the project is to show that the number of ice particles formed by nucleation mechanisms can be predicted if the aerosol feeding into the cloud is adequately characterised both physically and chemically.

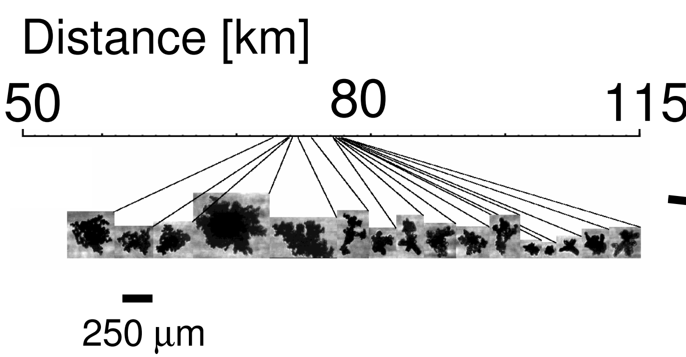
- Airborne observations made with the NCAR C-130 in two isolated lee wave clouds on separate days are compared and contrasted. One cloud contained relatively large amounts of ice while the other was relatively devoid of ice.

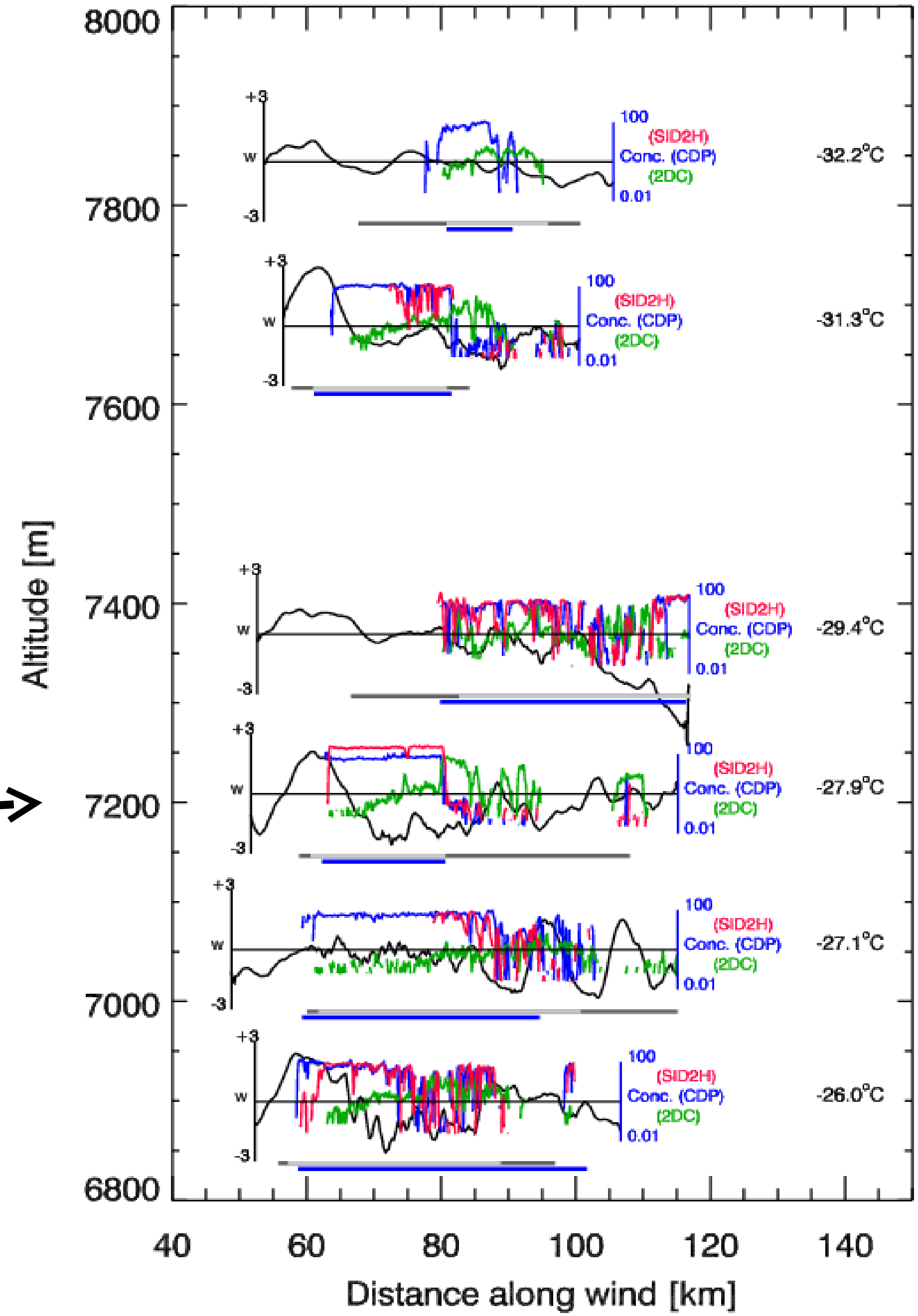
- Is the difference due to homogeneous versus heterogeneous freezing, dynamics, or are chemical and aerosol differences important?

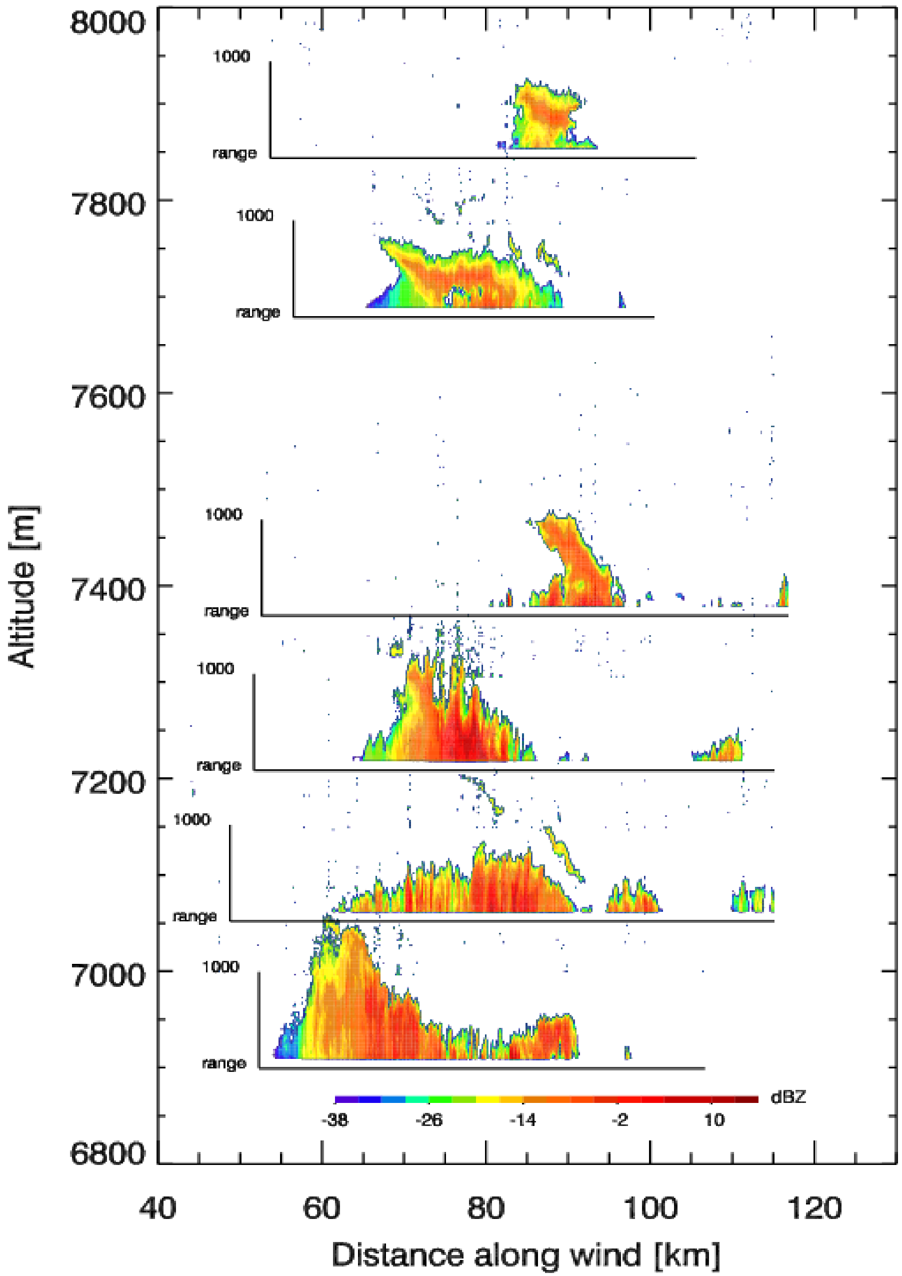
RF03

Vertical velocity, w [m s⁻¹]
Cloud droplet probe, CDP [cm⁻³]
Small Ice Detector, SID2H [cm⁻³]
Fast 2D-C (D>100mm), 2DC [L⁻¹]
Supersaturation w.r.t. ice: ▬ liquid: ▭
1Hz change in Rosemount icing probe >0.01mV/s ▬

RF03:
Droplet concs ~ 100 cm⁻³
Ice concs (D>100µm) up to 10-100 L⁻¹
Ice concs (CDP, SID2H) up to 0.1-1 cm⁻³



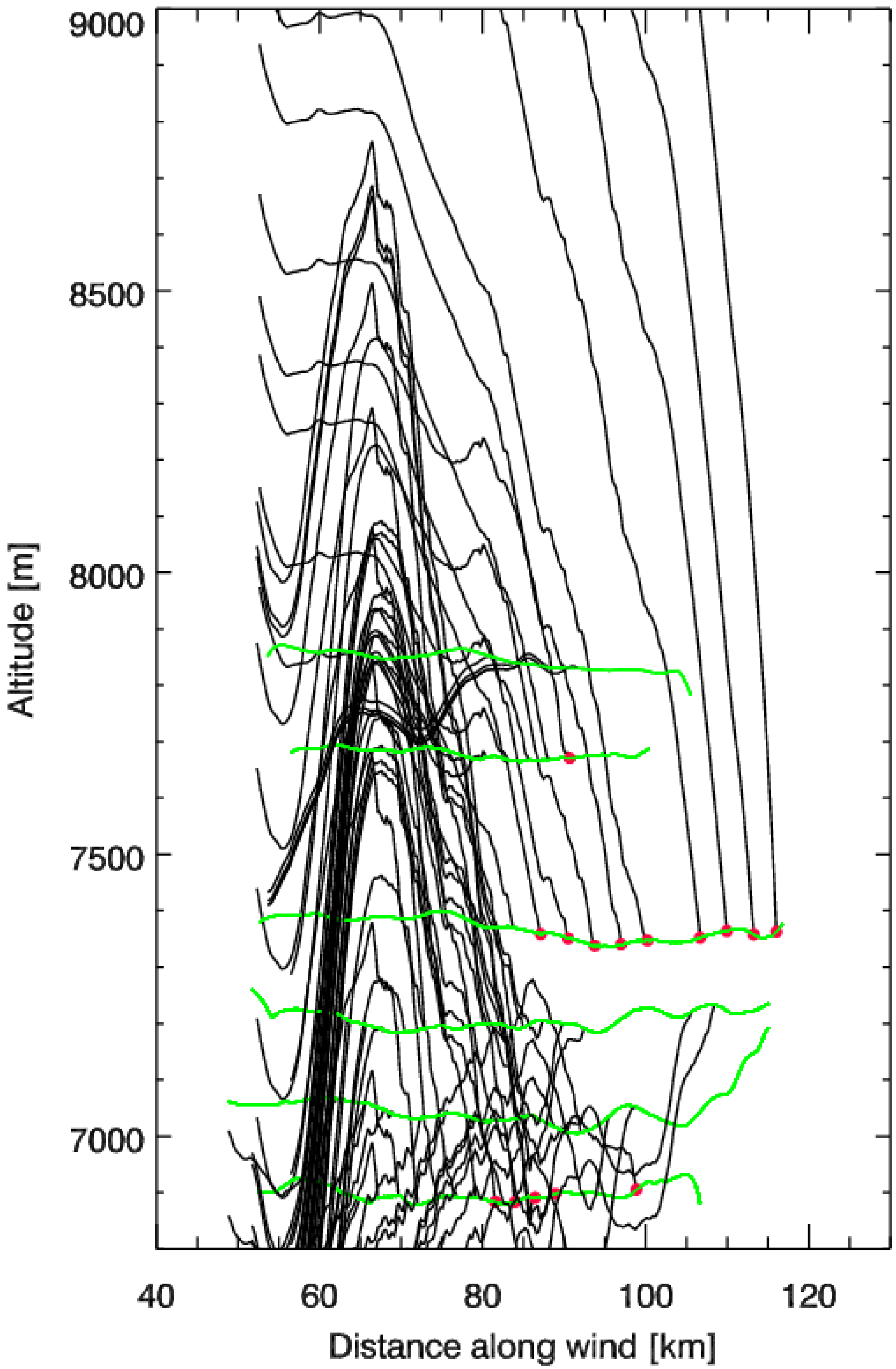




RF03

Wyoming Cloud Radar

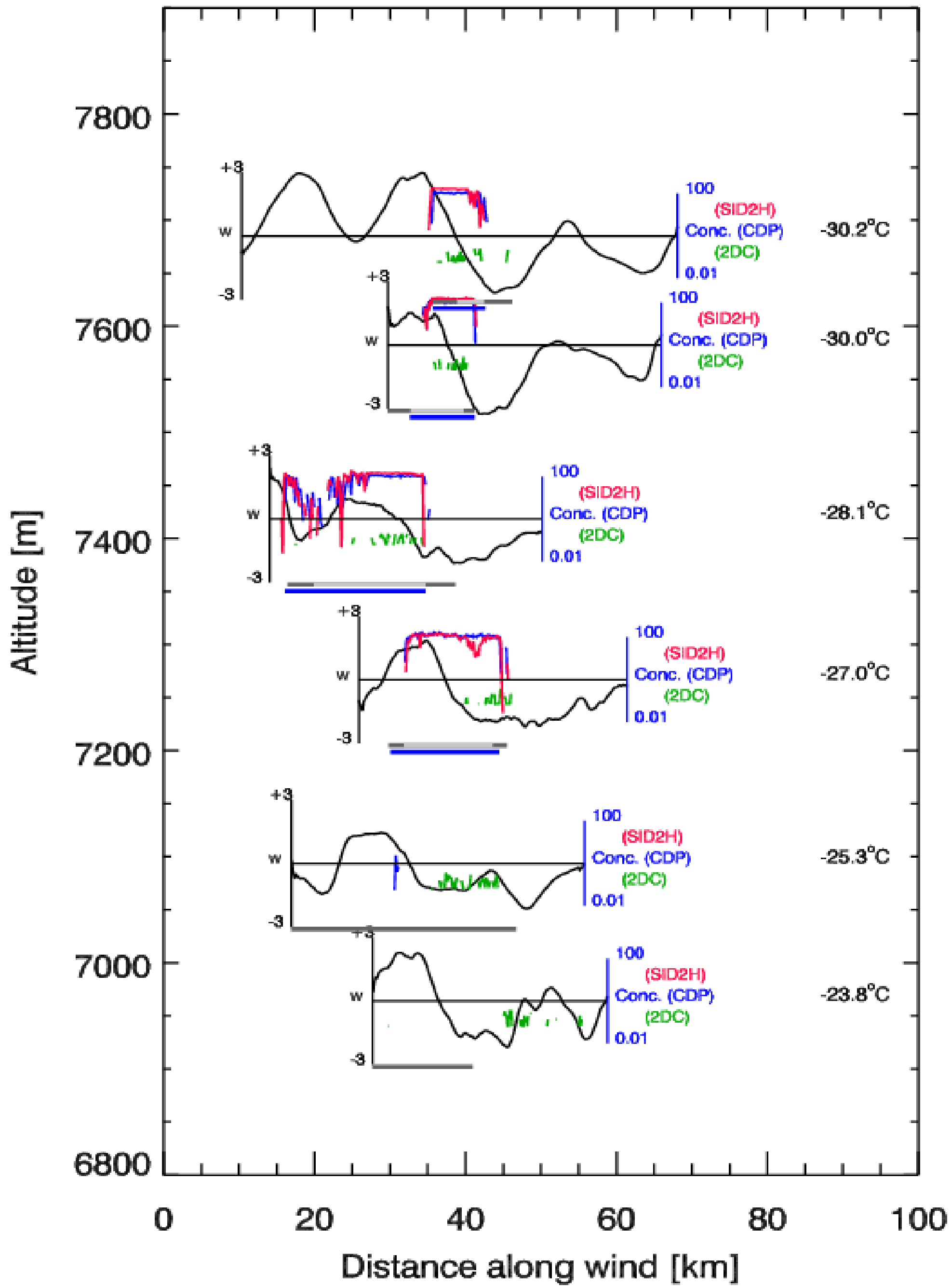
Cloud top ~ 8800m



RF03
Estimated parcel trajectories

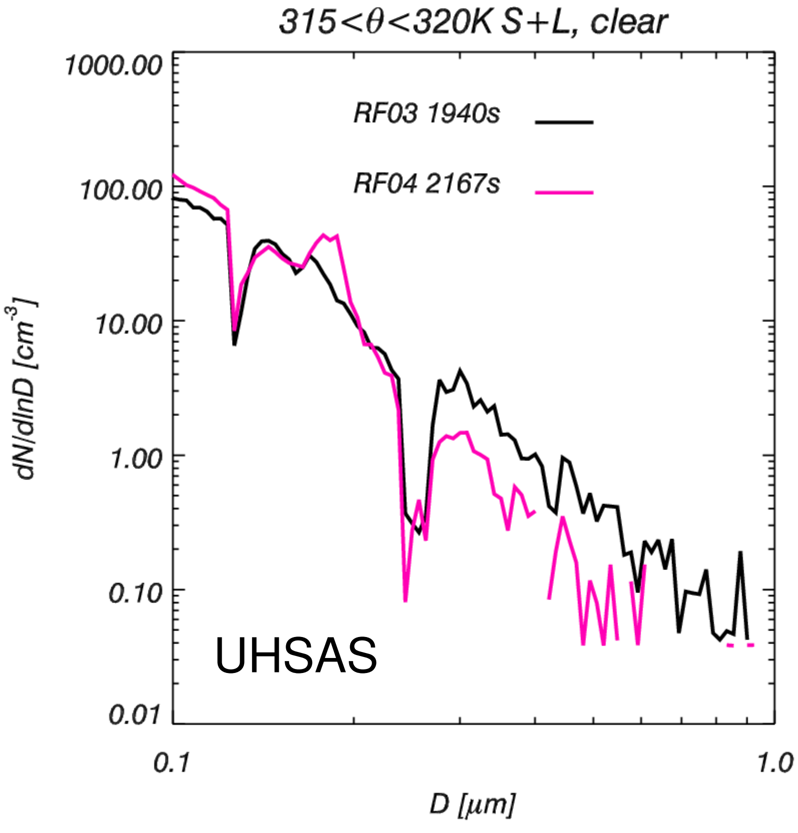
RF04

Vertical velocity, w [m s-1]
Cloud droplet probe, CDP [cm-3]
Small Ice Detector, SID2H [cm-3]
Fast 2D-C (D>100mm), 2DC [L-1]
Supersaturation w.r.t. ice: liquid:
1Hz change in Rosemount icing probe >0.01mV/s



RF04:
Droplet concs ~ 100 cm-3
Ice concs (D>100μm) up to 1 L-1

Aerosol



RF03 - more large aerosol

CVI residuals for RF03 show greater fractions of crustal/biomass/industrial material.

Summary

RF03 vs RF04

- RF03 has more ice, more large aerosol, and CVI residuals for RF03 show greater fractions of crustal/biomass/industrial material.

- RF03 parcel trajectories penetrate to colder temperatures than for RF04 and show some indication for a role for homogeneous freezing. However, homogeneous freezing does not appear to dominate the results. No homogeneous freezing for RF04.

- If homogeneous freezing is not important for RF03, the differences in ice amounts are likely to be related to the different aerosol characteristics between the two days.

Next steps

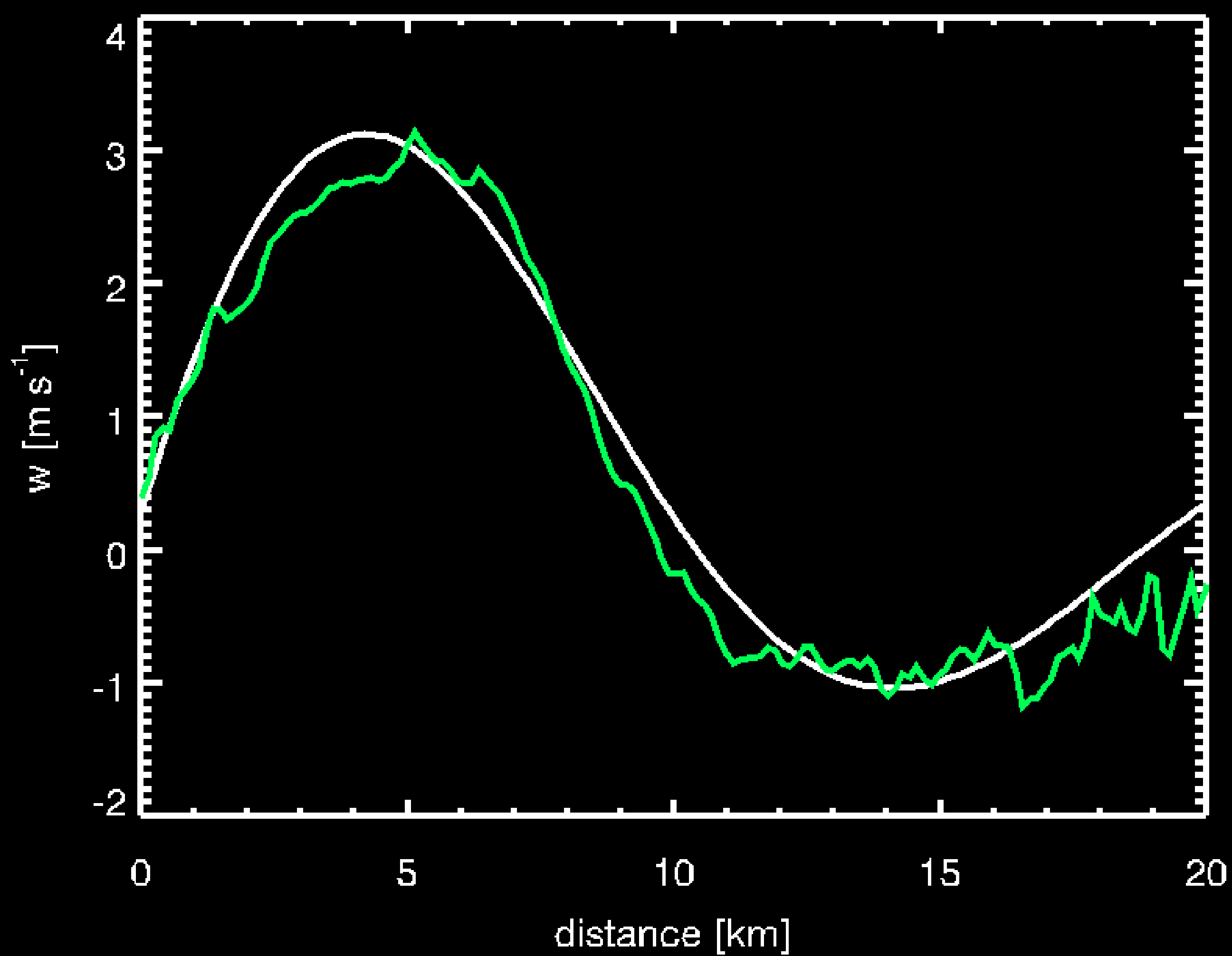
Test hypothesis that homogeneous freezing is not important in RF03.

Configure Met Office 1-D microphysics model with temperature, humidity, vertical velocity profiles, and aerosol physical and chemical characteristics.

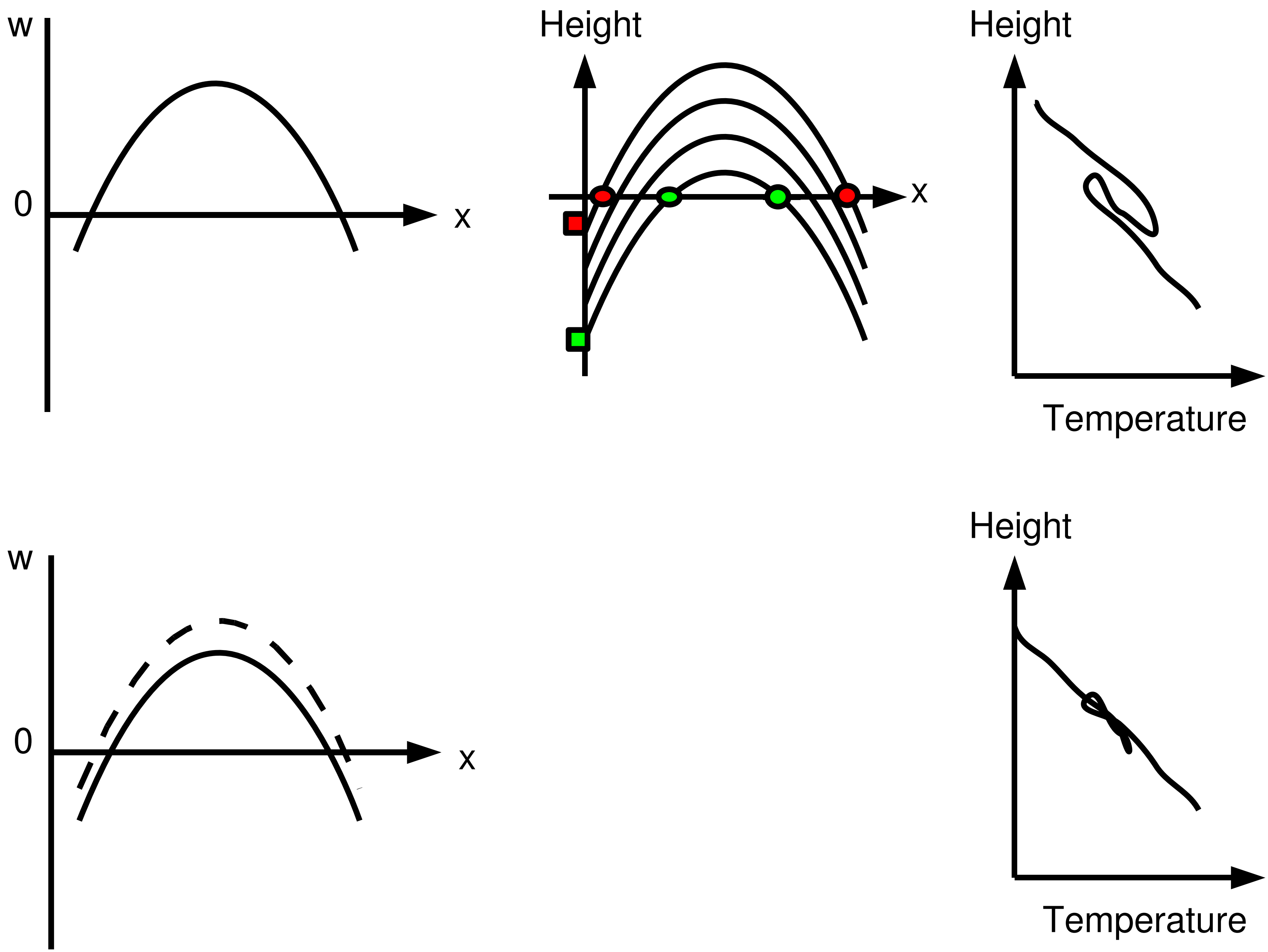
Trial different candidate ice nucleation schemes and compare pseudo aircraft sampling of the model output with observations.

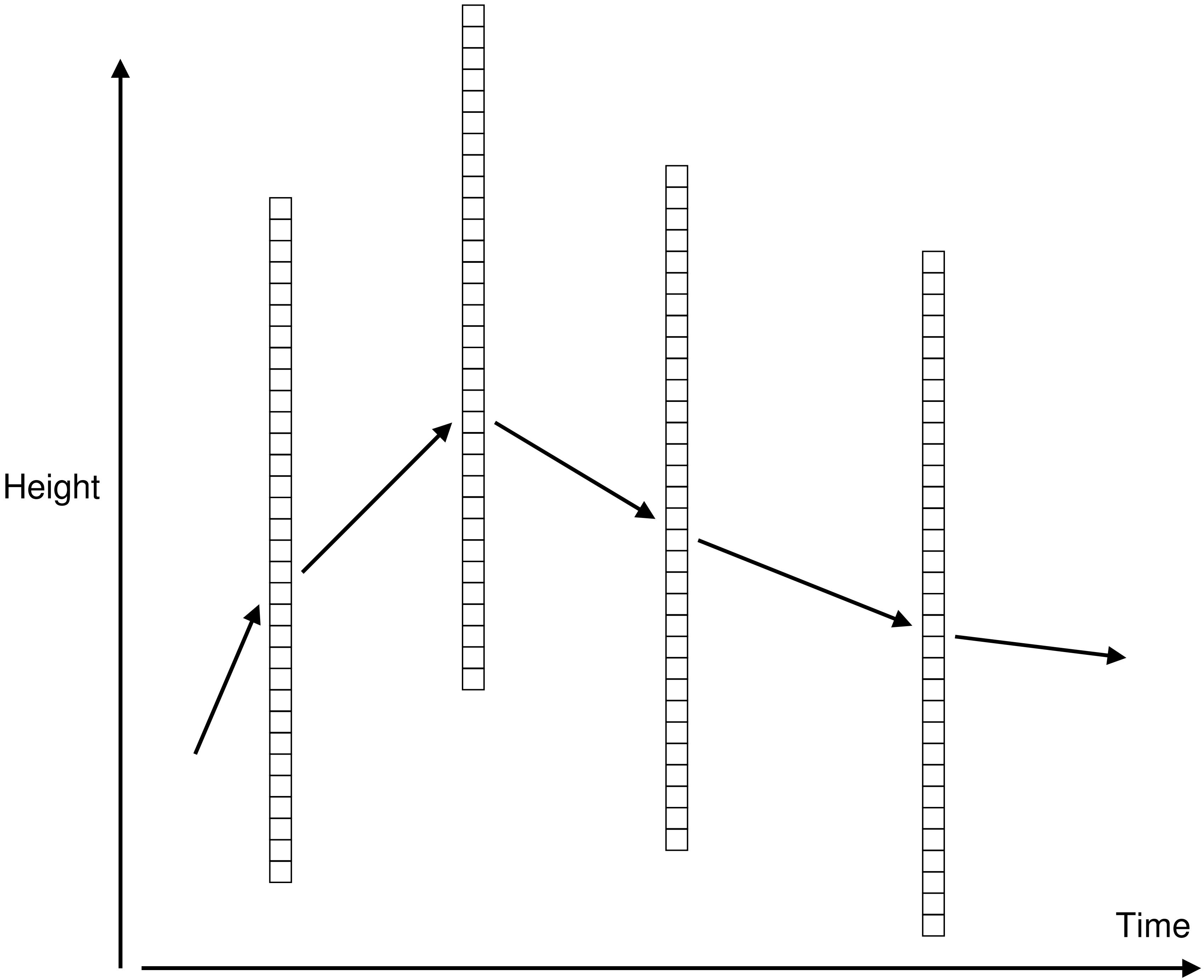
Running the UKMO LEM in 1-D

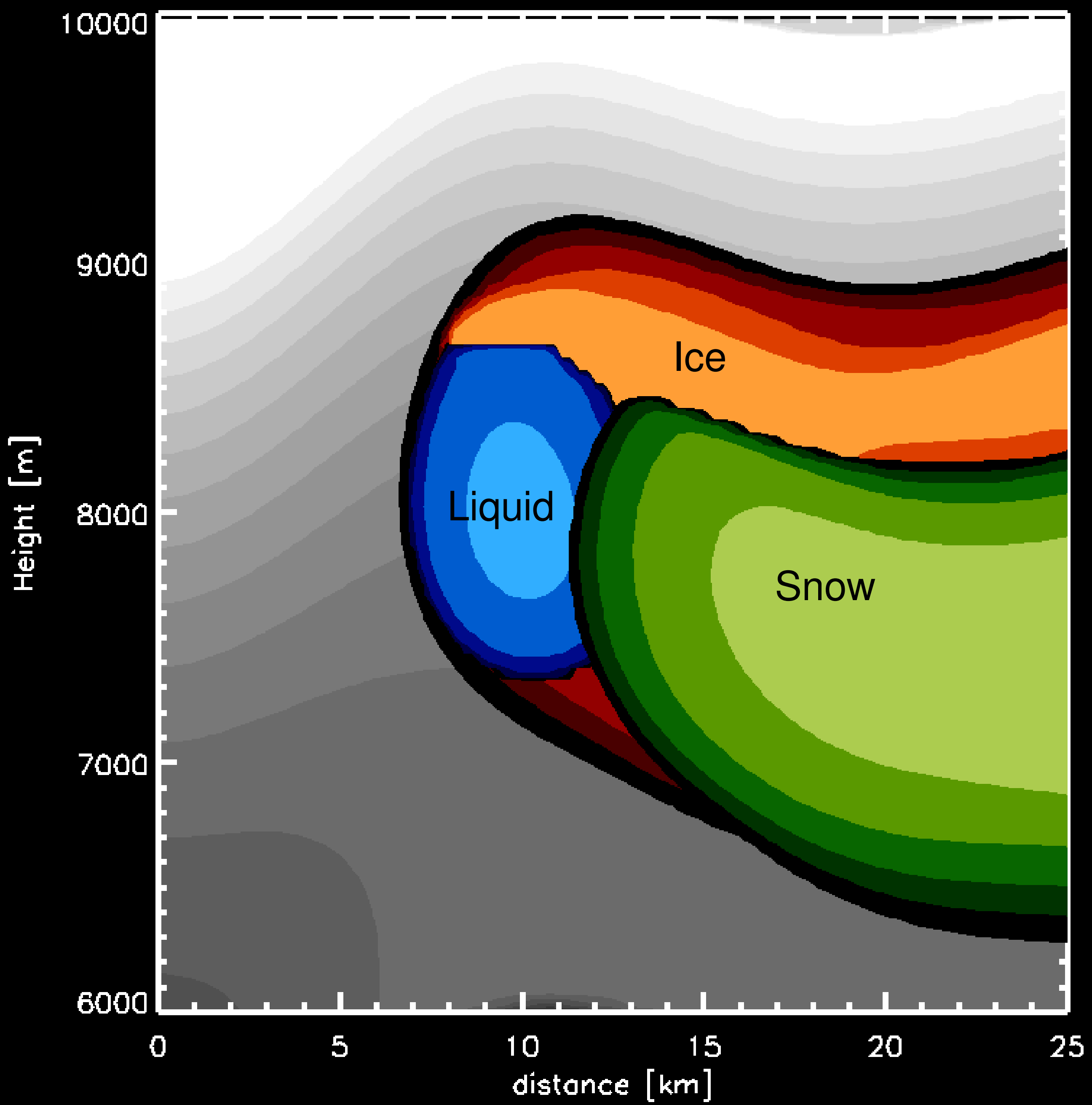
- Initialise vertical temperature and humidity structure
- Force a single vertical column with vertical velocity
- 3 phase microphysics – allows sedimentation.
- Primitive droplet activation and hom. fzg.



4
3
2
1
0
-1
-2
w [m s-1]
0
5
10
15
20
distance [km]


w
0
x
Height
x
Height
Temperature
w
0
x
Height
Temperature

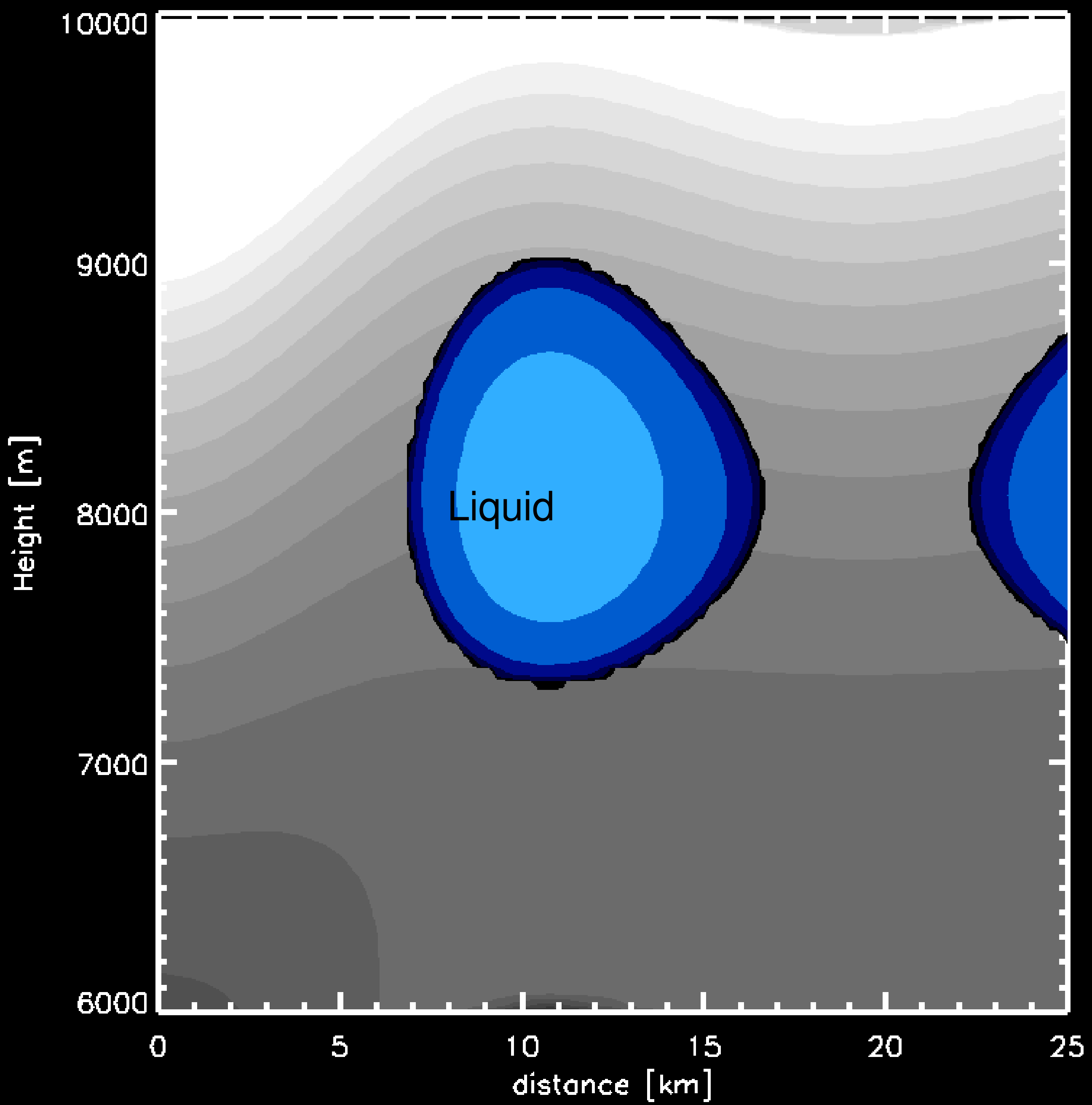

Height
Time



10000
9000
8000
7000
6000
Height [m]
0
5
10
15
20
25
distance [km]
Ice
Liquid
Snow

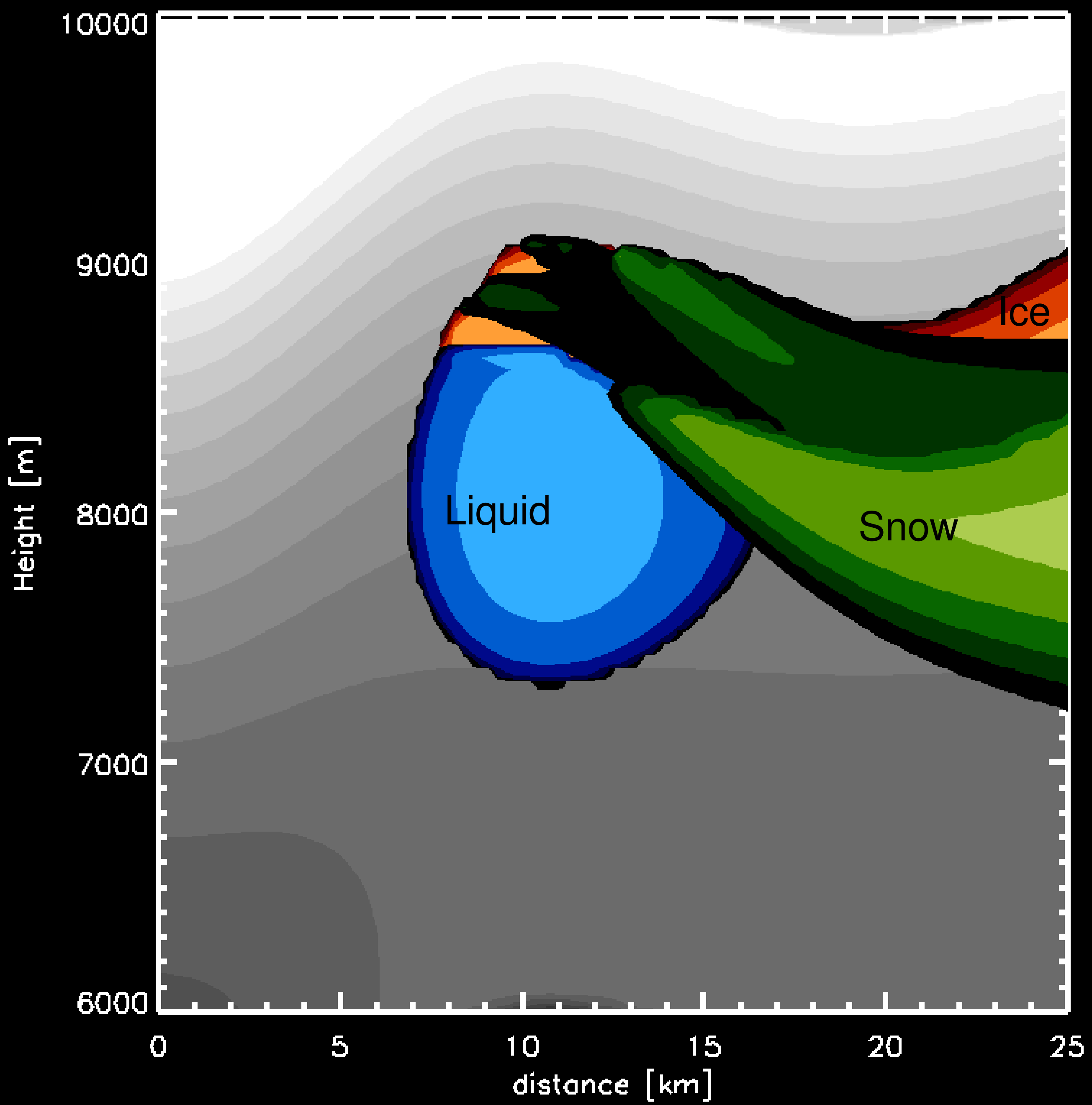
No homogeneous Freezing

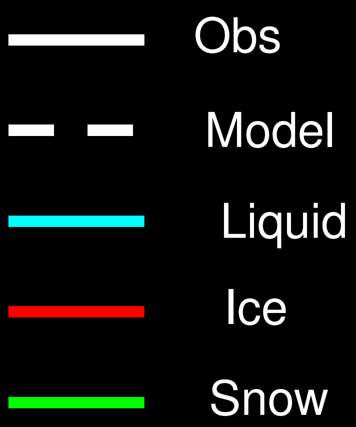
No primary ice nucleation

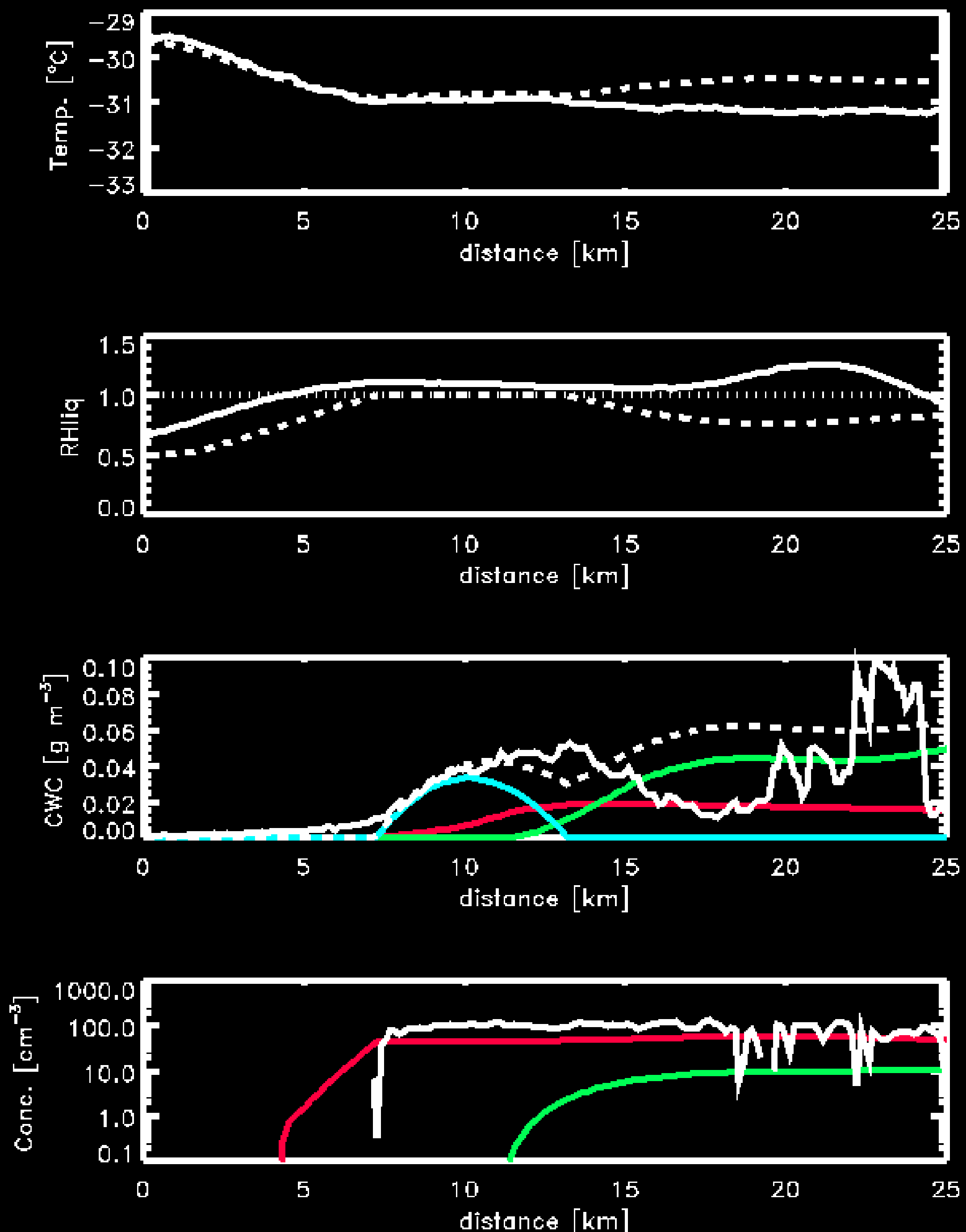


No primary ice nucleation

Allow homogeneous freezing







Cut through model output at altitude of aircraft penetration

Near Future Work

- Improved homogeneous freezing (T, w dependent haze freezing)
- Trial heterogeneous nucleation schemes
- Introduce new diagnostics:
  - ice conc. D>threshold size
  - radar reflectivity
- Incorporate more accurate humidity measurements
- Sensitivity analyses of initial conditions, microphysics assumptions (e.g. m-D, fallspeed, capacitance…)