Characteristics of Nearby Ice Particles in Winter Storms Sampled During NASA IMPACTS

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ENVIRONMENT ANALYTICS

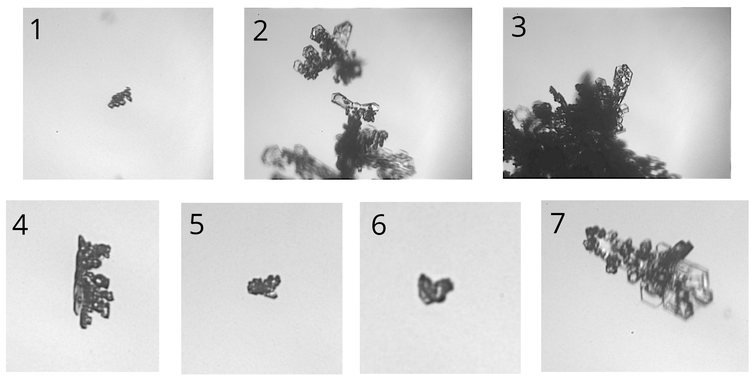
Motivation

Naturally-occurring precipitation-sized (> 2 mm diameter) ice particles typically have complex shapes that are a result of sequential growth in different environments as well as episodes of riming. We examine the validity of some underlying assumptions used in many remote sensing retrievals of ice -- that ice properties are relatively uniform for nearby particles and conform to growth forms for the local temperature and RH with respect to ice (RH_{ice}).

Data and Methods

We use *in situ* grey-scale image pairs (two camera angles) collected by the Particle Habit Imaging and Scattering Probe (PHIPS) along NASA P-3 flight legs during the NASA IMPACTS[1] field study. Ice particles in each image pair are categorized by their shape and degree of riming.

Example Subset: 26 Feb 2020 00:31 – 00:32



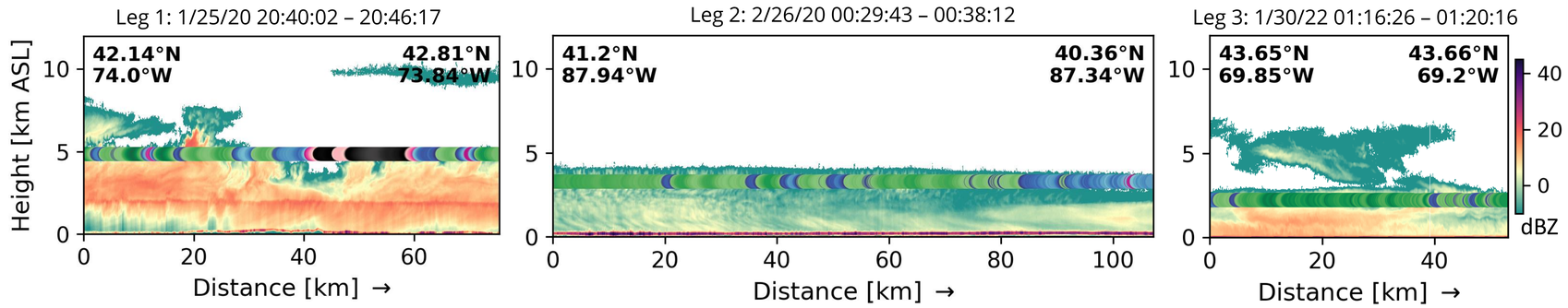
Example of seven classifiable PHIPS images (only Camera Angle 1 shown) over a 1 min interval (~8.5 km along flight track).

Shape (can occur in combination)	Images 1-7 With Characteristic
Monocrystalline	2
Tabular Polycrystalline	1, 2, 3, 4, 5, 6, 7
Columnar Polycrystalline	None
Tabular Growth	2, 3, 7
Columnar Growth	None
Branched Growth	2, 3, 7
Side Branched Growth	2
Degree of riming	**Images 1-7 With Characteristic**
Unrimed	None
Lightly Rimed (1-50%)	1, 2, 6
Moderately Rimed (51-99%)	2, 3, 4, 5, 7
Densely Rimed (100%)	None
Graupel	None

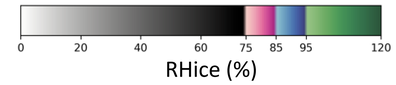
Multiple shapes can be present when an ice particle has traversed multiple environments and undergone sequential growth.

Multiple degrees of riming can occur for an image pair when more than one particle is present (e.g. image 2)

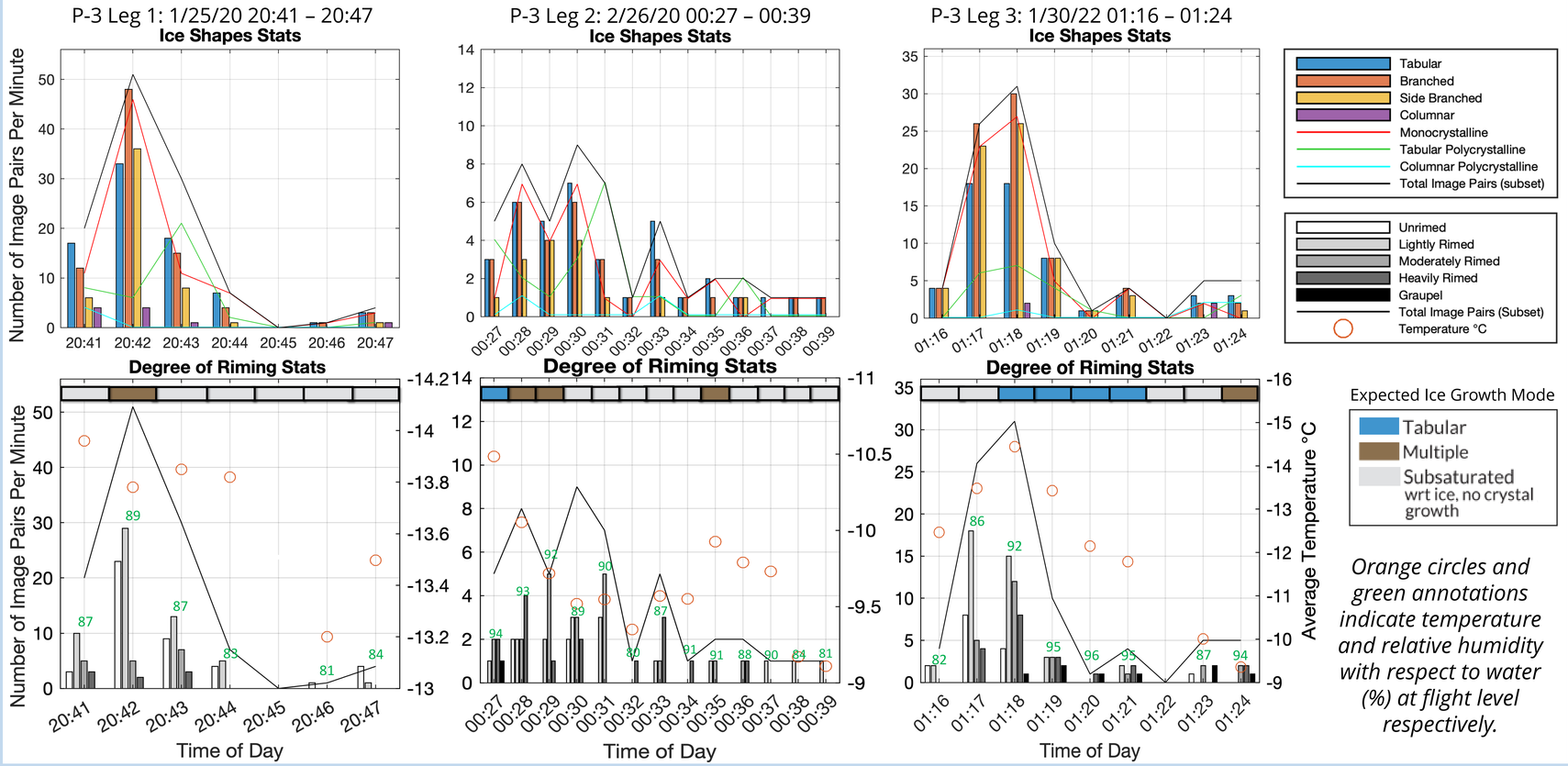
Analysis results for 26 min of observations when NASA P-3 aircraft was within 1 km of NASA ER-2 cloud radar echo top.



NASA ER-2 Cloud Radar radar reflectivity data overlaid with NASA P-3 tracks color-coded according to in situ RH_{ice} measurements.



All the PHIPS image pairs (245 samples) from the three P-3 flight legs are analyzed below. Expected ice growth modes[2] based upon local environmental conditions are noted for each minute at the top of the bottom row of graphs.



Orange circles and green annotations indicate temperature and relative humidity with respect to water (%) at flight level respectively.

Summary: The shapes and degrees of riming of precipitation-sized ice near cloud top are not determined solely by the local temperature and RH_{ice} where the ice is observed. Rather, the observed mixtures are a result of ice particles that are formed in different sequences of temperature and RH_{ice} growth environments and intermingled by a combination of horizontal and vertical air motions and ice fall speed.

Acknowledgements

References: [1]McMurdie et al. (2022, BAMS), [2]Hueholt et al. (2022, BAMS)

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