Impacts of Cloud Microphysical Properties and Meteorological Parameters on the Cloud Freezing Temperature

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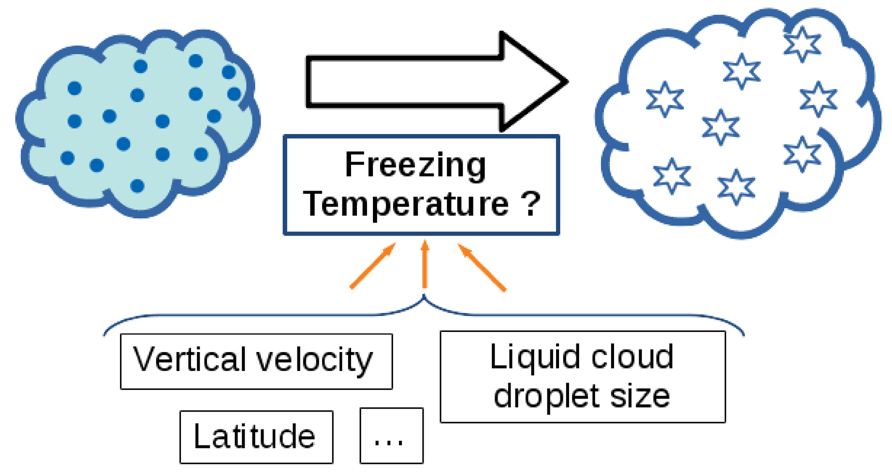
Introduction:

- The **thermodynamic phase** has an impact on cloud **radiative properties** and **precipitation**
- Our understanding of the cloud phase transition is incomplete: Which parameters **enhance or inhibit the phase transition?**



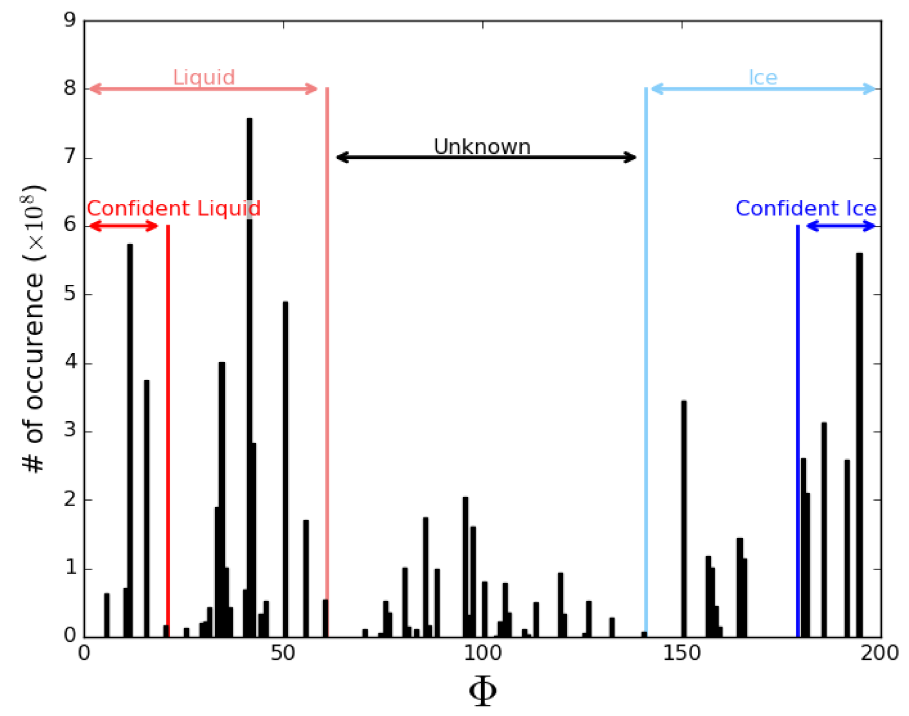
1. Data Used:

- The space-based instruments **POLDER-3** (Polarization and Directionality of the Earth's Reflectance) and **MODIS** (Moderate Resolution Imaging Spectroradiometer) on board of polar-orbiting satellites
- POLDER-3 and MODIS retrieve **cloud-top microphysical properties** (T, r_{eff}, τ…)
- Cloud **thermodynamic phase** are retrieved from a combination of **visible, infrared, and polarized measurements**. The algorithm retrieves an index between 0 (liquid) and 200 (ice) with different degrees of confidence
- **ERA-Interim** reanalysis from **ECMWF** (European Centre for Medium-Range Weather Forecasts). We use the vertical velocity at 700 hPa

2. We focus on:

- **Ice to liquid cloud phase transitions**
- **Understanding the factors** that influence the phase transition temperature
- Data from 2005 to 2010

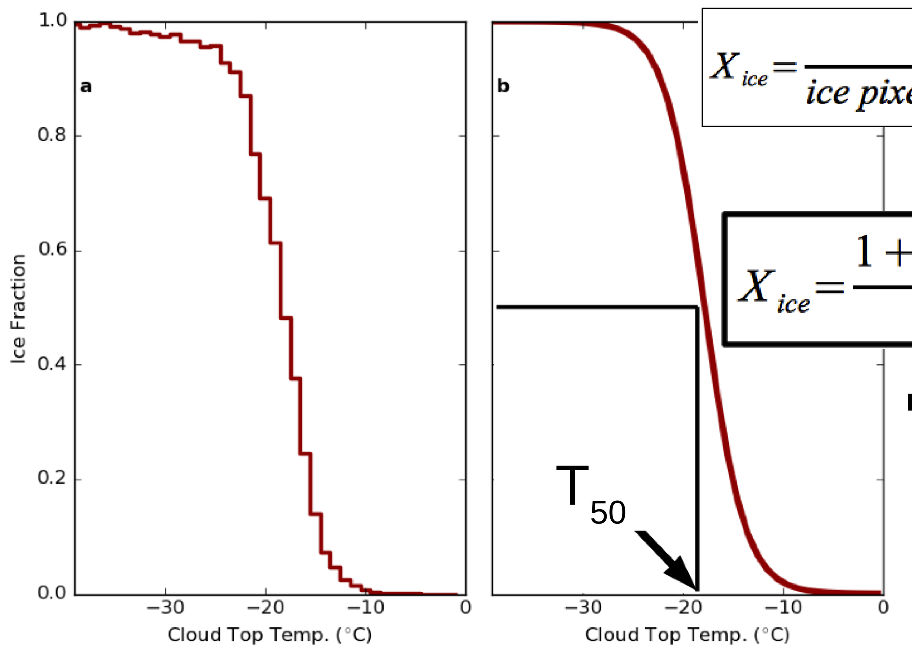
3. Methodology:



Cloud phase index (Φ) distribution retrieved from POLDER-3 and MODIS. The different thresholds used in the study are display and are associated with different degrees of confidence in the phase retrievals.

- We define **several degrees of confidence** to retrieve an uncertainty in our results

4. The freezing temperature from ice cloud fraction



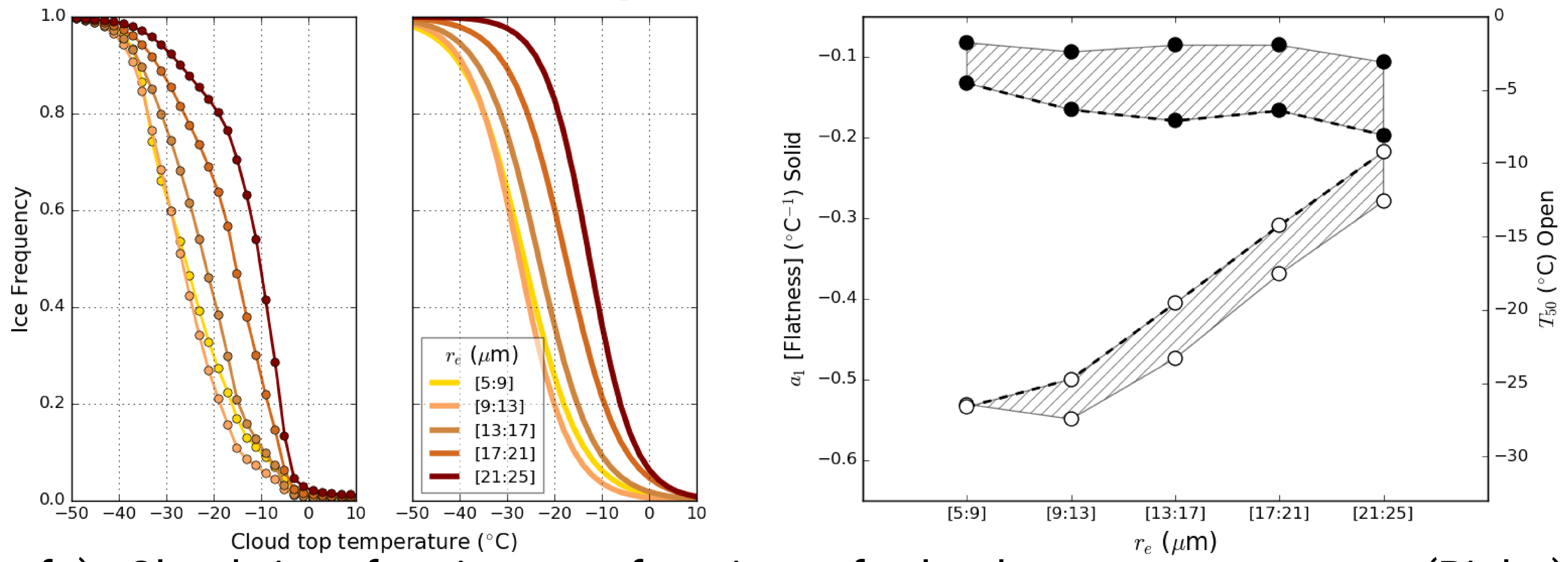
$$X_{ice} = \frac{\text{ice pixels Nb}}{\text{ice pixels Nb} + \text{liq pixels Nb}}$$

$$X_{ice} = \frac{1 + \tanh(a_1 \times T + a_2)}{2}$$

- a_1 controls the **flatness** of the curve
- a_2 controls the shift of the **freezing temperature** (T_{50})
- Use **hyperbolic fitting** function simplifies the study of liquid-solid water transitions as function of other **parameters**

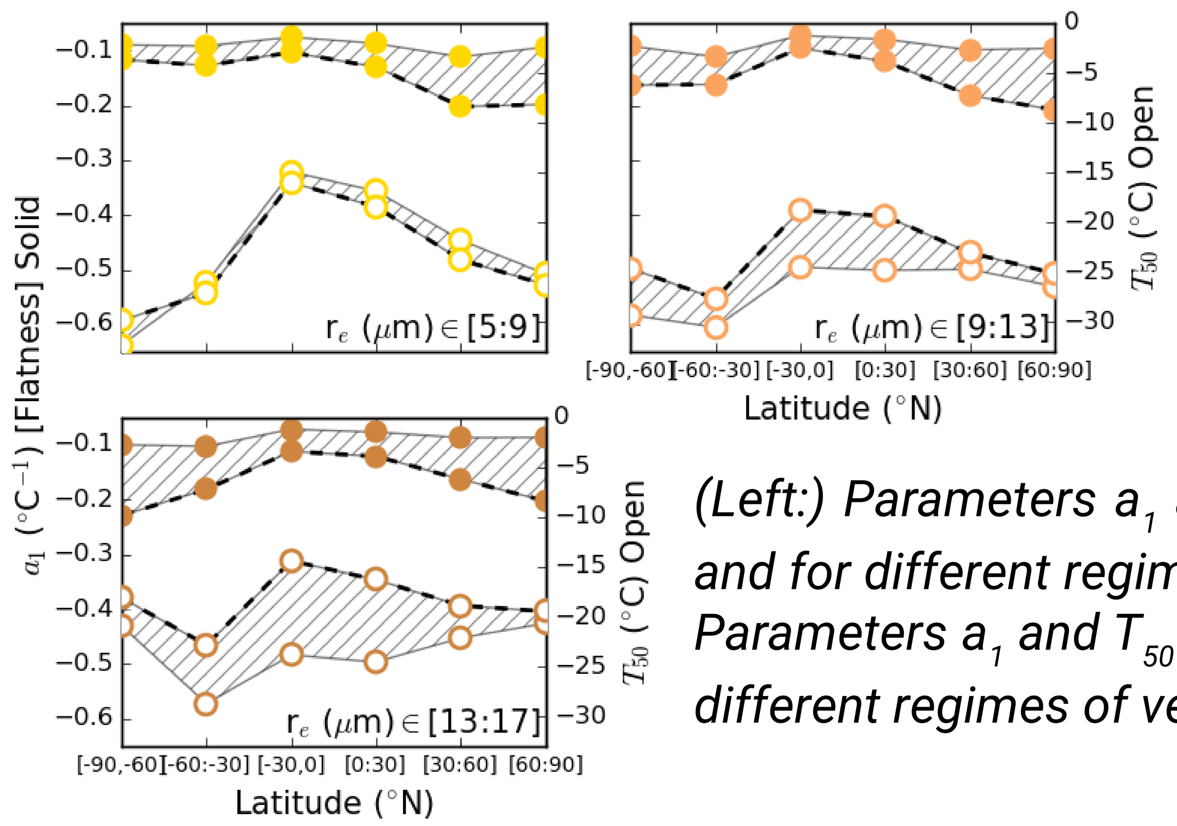
Cloud ice fraction as function of cloud top temperature (a). Hyperbolic tangential fit of the ice fraction as function of cloud top temperature (b).

5. The freezing temperature increases when liquid cloud droplet radius increase



(Left:) Cloud ice fraction as function of cloud top temperature. (Right:) Parameters a_1 and T_{50} for different regimes of r_e. The dashed line corresponds to retrievals when degree of confidence is high for liquid and ice phase retrievals.

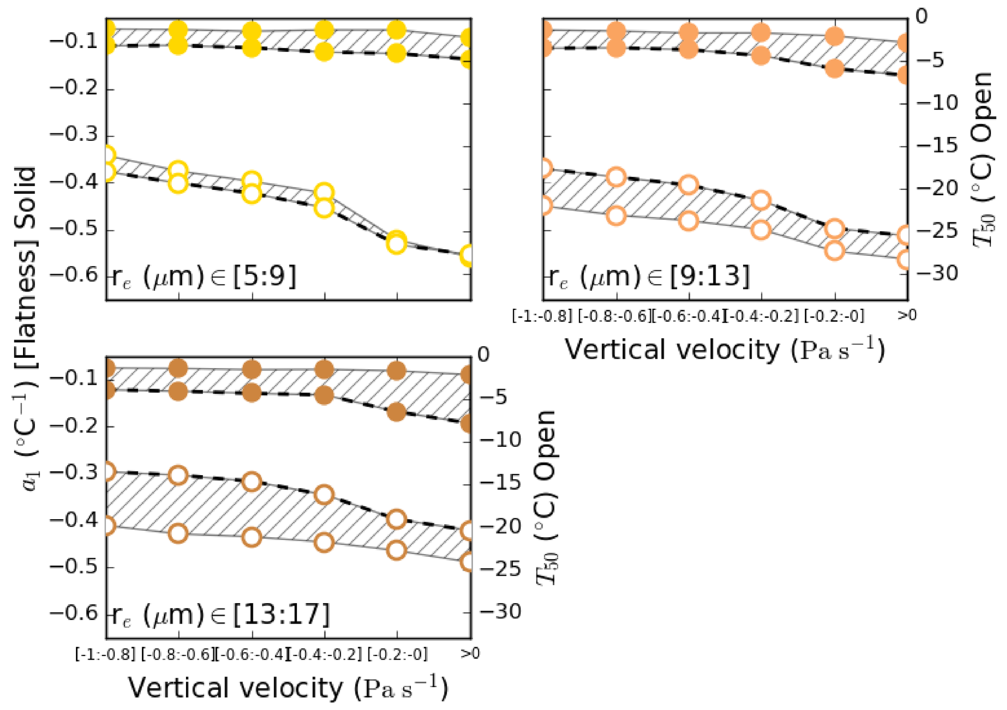
6. The freezing temperature decreases when updraft velocity weaken and depends on latitudes



- T_{50} differs up to 10°C for different latitude regimes

(Left:) Parameters a_1 and T_{50} constrained for r_e and for different regimes of latitudes. (Bottom:) Parameters a_1 and T_{50} constrained for r_e and for different regimes of vertical velocity.

- T_{50} is maximal when the updraft is strong
- The difference in T_{50} for different regimes of **latitude** can be **explained** by different **regimes of vertical velocity**



7. Conclusions & Future Work:

- **The larger the liquid cloud droplet** is, **the warmer the freezing temperature** is
- **The weaker the updraft velocity** is, **the lower the freezing temperature** is
- Difference in the freezing temperature for different latitudes
- We aim to find correlations between parameters to better understand which parameters influence T_{50}

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