Can Aerosols from mid-latitudes inhibit the liquid to ice transition in Arctic Clouds?


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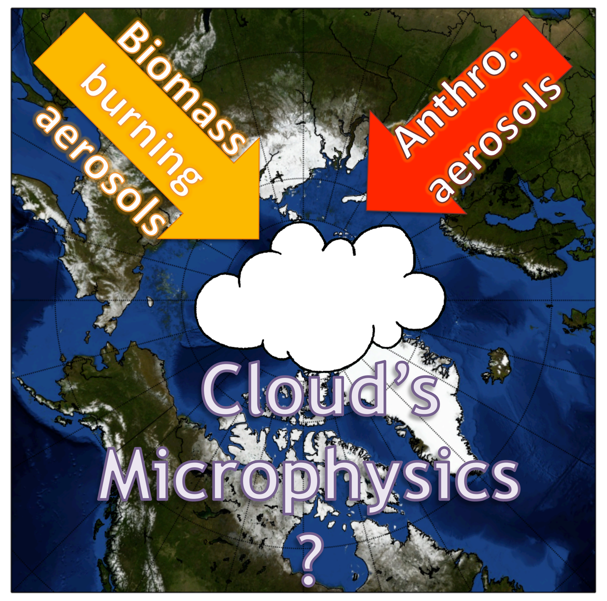
Introduction:

Even if the Arctic region is remote from mid-latitude aerosol sources, each winter and spring **the Arctic's atmosphere** has a **non-negligible aerosol concentration**.



This unexpected presence is mainly due to a decrease in wet scavenging **during winter** time and to a surface temperature inversion that inhibits vertical mixing and aerosol deposition.

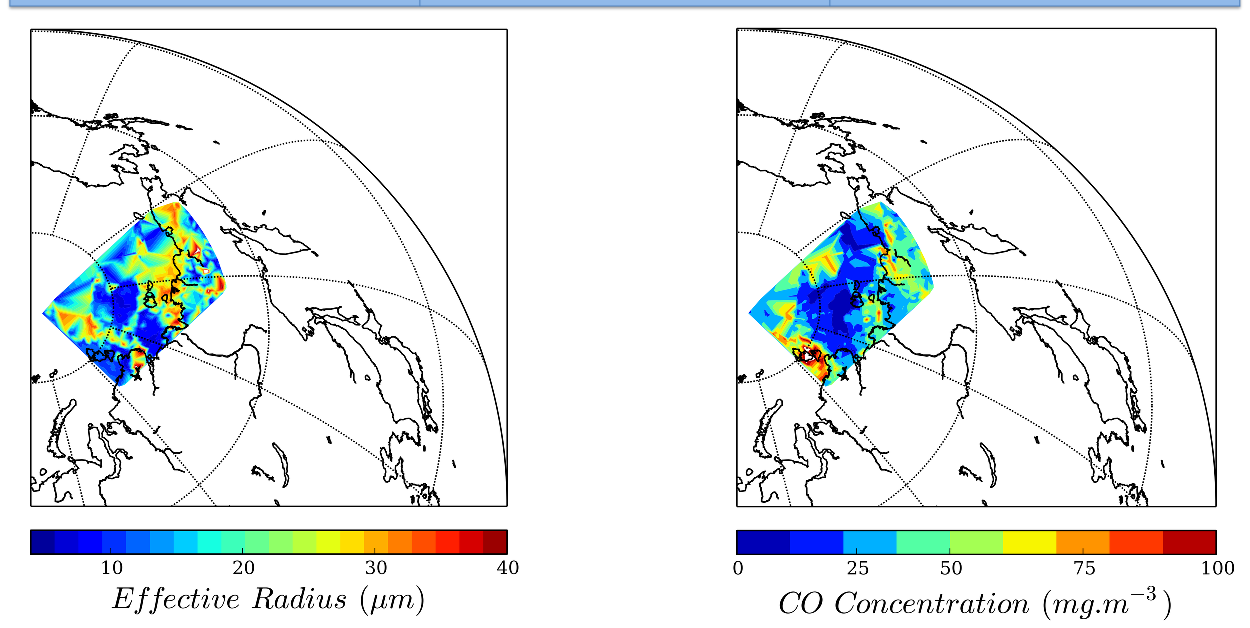
Reference: Tietze, K., Riedi, J., Stohl, A., Garrett, T. J.: Space-based evaluation of interactions between aerosols and ow-level Arctic clouds during the Spring and Summer of 2008, Atmos. Chem. Phys, 2011

1. Data Used:

The approach used in this study is a **co-location between satellite and tracer transport model data** to obtain simultaneous information on cloud properties, atmospheric state and tracers of aerosol content.

- The satellites **POLDER-3** (POLarization and Directionality of the Earth's Reflectance) and **MODIS** (Moderate Resolution Imaging Spectroradiometer).
- **FLEXPART** (FLEXible PARTicle model dispersion) is a Lagrangian transport and dispersion tracer transport model.
- **ECMWF** (European Centre for Medium-Range Weather Forecasts).

Parameter(s)	From	Resolution(s)
Cloud's parameters (T, r_{eff}, τ…)	MODIS & POLDER	Spatial resolution: 6x6km²
Anthropogenic and Biomass burning CO concentration	FLEXPART	Spatial resolution: 0.5°x0.5° Temporal resolution: 3 h
Specific humidity, wind velocity, temperature profiles…	ECMWF	Spatial resolution: 1.5°x1.5° Temporal resolution: 6 h

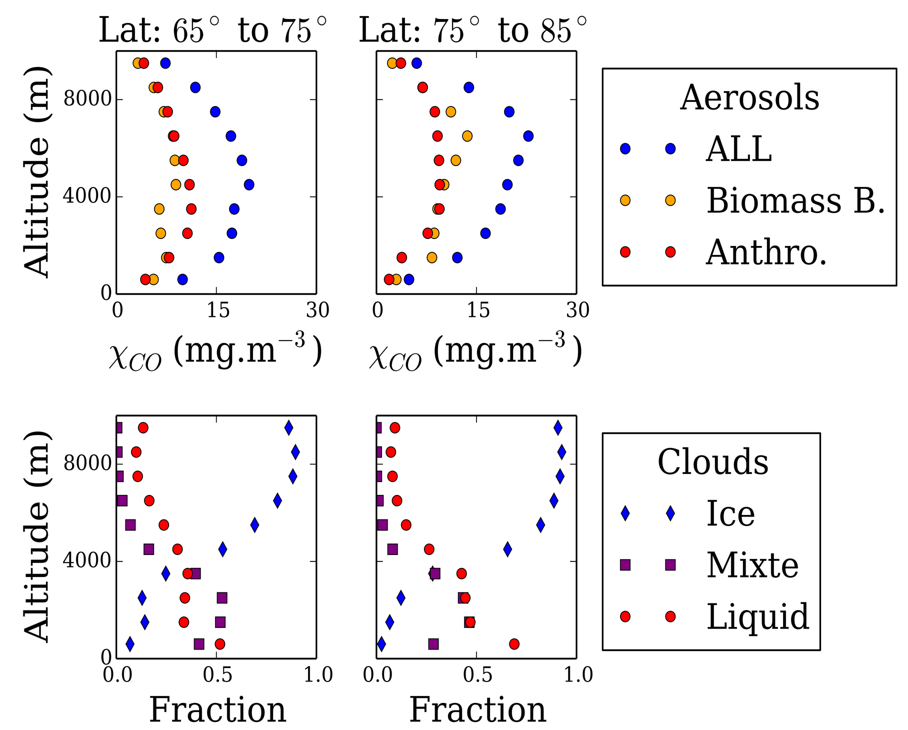


Orthographic projection of the Effective radius retrieval by MODIS (right) and the co-located Carbon Monoxide (CO) concentration (left) retrievals by FLEXPART on the 1st of May.

2. We focus on:

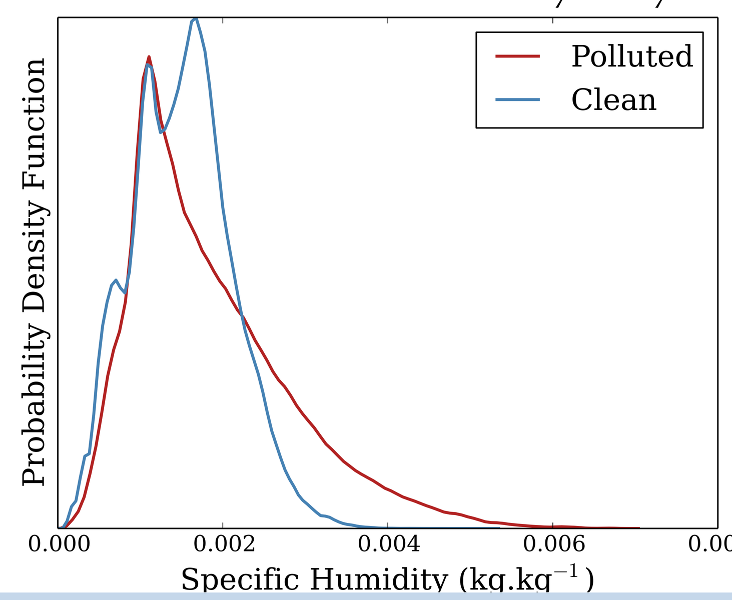
- **Aerosol impact on cloud microphysics.**
- **Ice-liquid cloud phase transition and cloud microphysics** over the Arctic region (latitude greater than 65°) during 2008.
- **Understanding the factors** that influence the phase transition temperature.

3. Methodology:



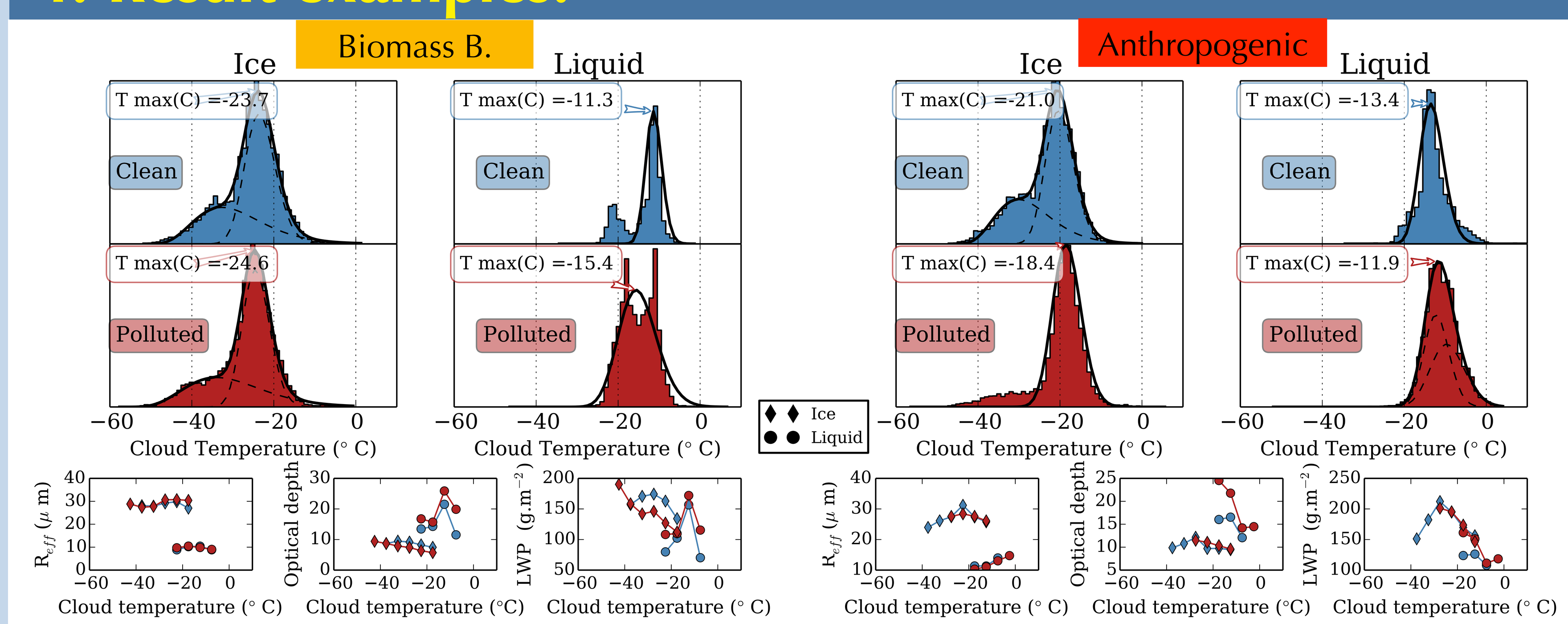
- Two types of aerosols: From **biomass burning** and **anthropogenic** sources.
- Define two categories: **polluted and clean** (respectively the highest and lowest 25th percentiles of their concentration).

(left): Vertical distribution of CO concentration (upper) and fraction of clouds for each thermodynamic phase.
(Bottom): Probability Density Function of the Specific humidity between March and May, between 0 and 2000 m reanalysis by ECMWF.



- Constrain our data on **atmospheric parameters and cloud parameters** to ensure as much as possible that observable differences can be attributed to aerosols.
- Look at different latitudes, altitudes, specific humidity, liquid water path (LWP), effective radius, and aerosol concentrations.

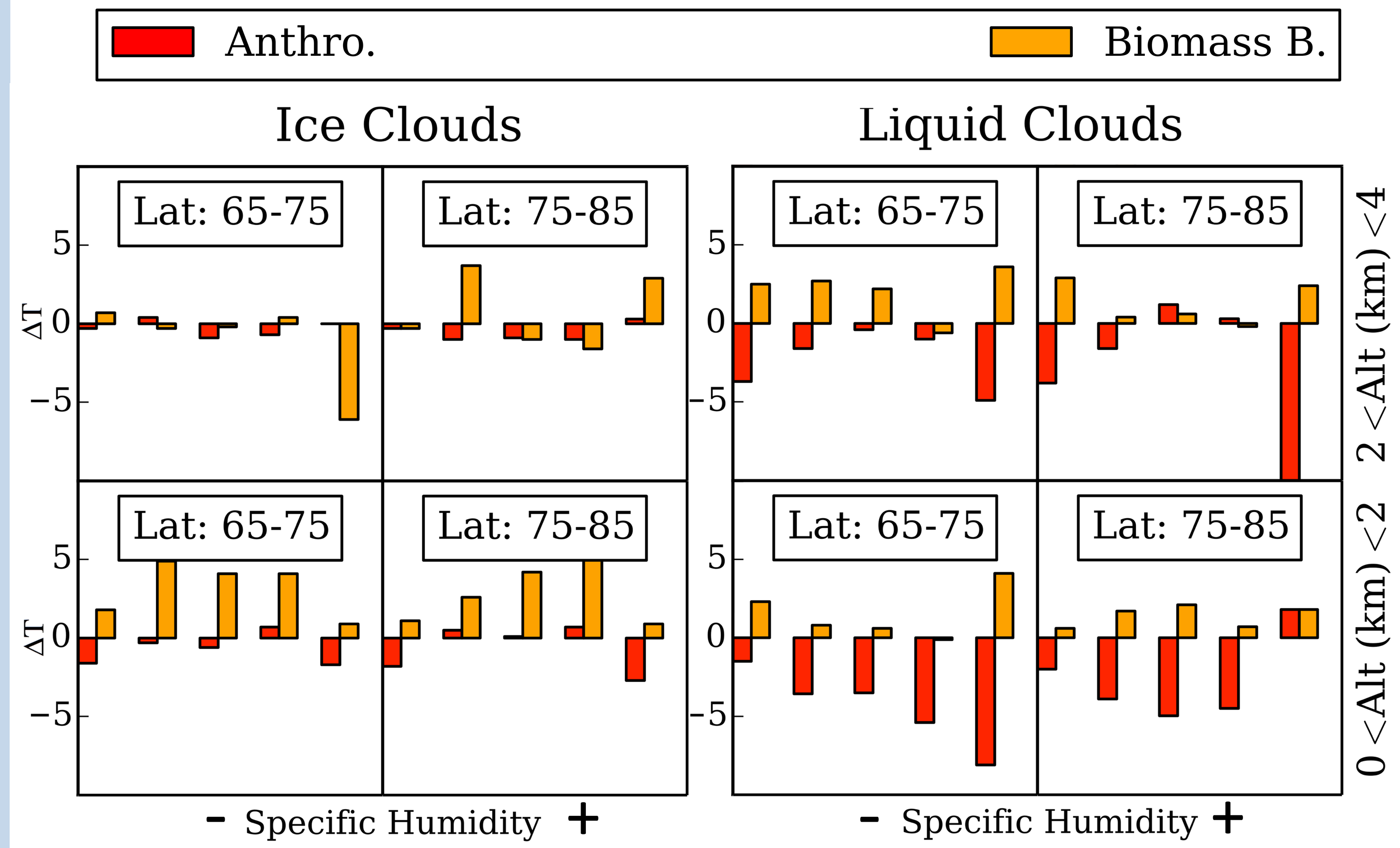
4. Result examples:



(Right): Histogram of cloud top temperature during high and low events of anthropogenic aerosols fitted by a mixture of gamma distributions for the liquid and ice case. Values of effective radius, LWP and optical depth are plotted for categories representing at least 5% of the total samples. (Left): Same but considering aerosols from biomass burning events.

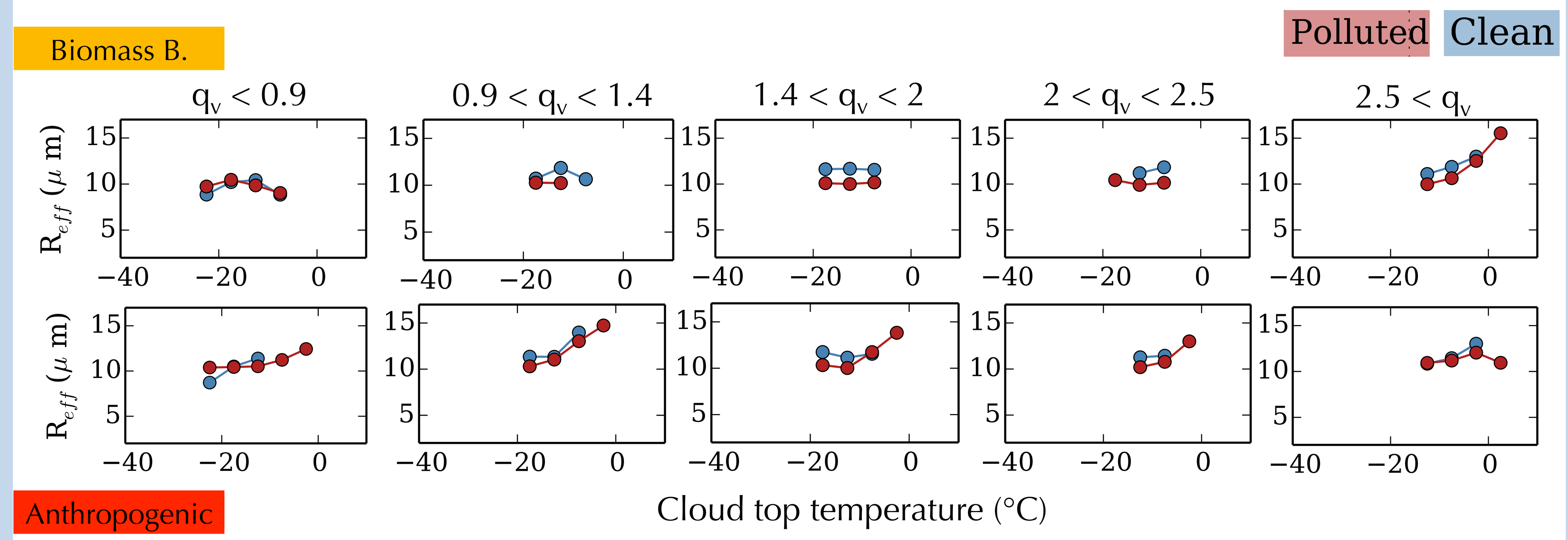
- We look up the maximum of the distribution for each cases (polluted, clean for each latitude, altitude, specific humidity…) and then we analyze the difference Clean – Polluted.

5. Result summary for low levels:



Differences between clean and polluted distribution maxima for different specific humidity, for different types of clouds: Liquid (right), Ice (left), Latitudes (Lat), and Altitudes (Alt), according to types of aerosols sources: biomass burning and anthropogenic. The LWP is greater than 40g.m^{-2}.

- Concerning liquid clouds, Biomass burning aerosols in polluted air masses tend to shift the distribution maximum to colder temperatures. The reverse is observed for anthropogenic aerosols.
- Regarding ice clouds, the same behaviors are observed, except the effect of Biomass aerosols exceeds that of anthropogenic aerosols.
- As altitude increases correlation between the phase transition and the aerosols tracer concentration tend to decrease.



The effective radius at latitude between 65° and 75° for liquid cloud for each bin of specific humidity (q_v in g.kg^{-1}) for biomass burning on the top and anthropogenic aerosols on the bottom for clean and polluted cases (dark red for polluted, dark blue for clean situations).

6. Conclusions & Future Work:

- Aerosols from biomass burning seem to inhibit the liquid-ice transition at low altitudes.
- Aerosols from anthropogenic sources accelerate the phase transition.

- Add **2 more years** of data to the analysis, with **new types of aerosol** (Flaring, Industrial…).
- **Study the indirect effect** on effective radius, optical depth, liquid water path.

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