The Transport of Formaldehyde in Thunderstorms in SEAC4RS and DC3

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Motivation

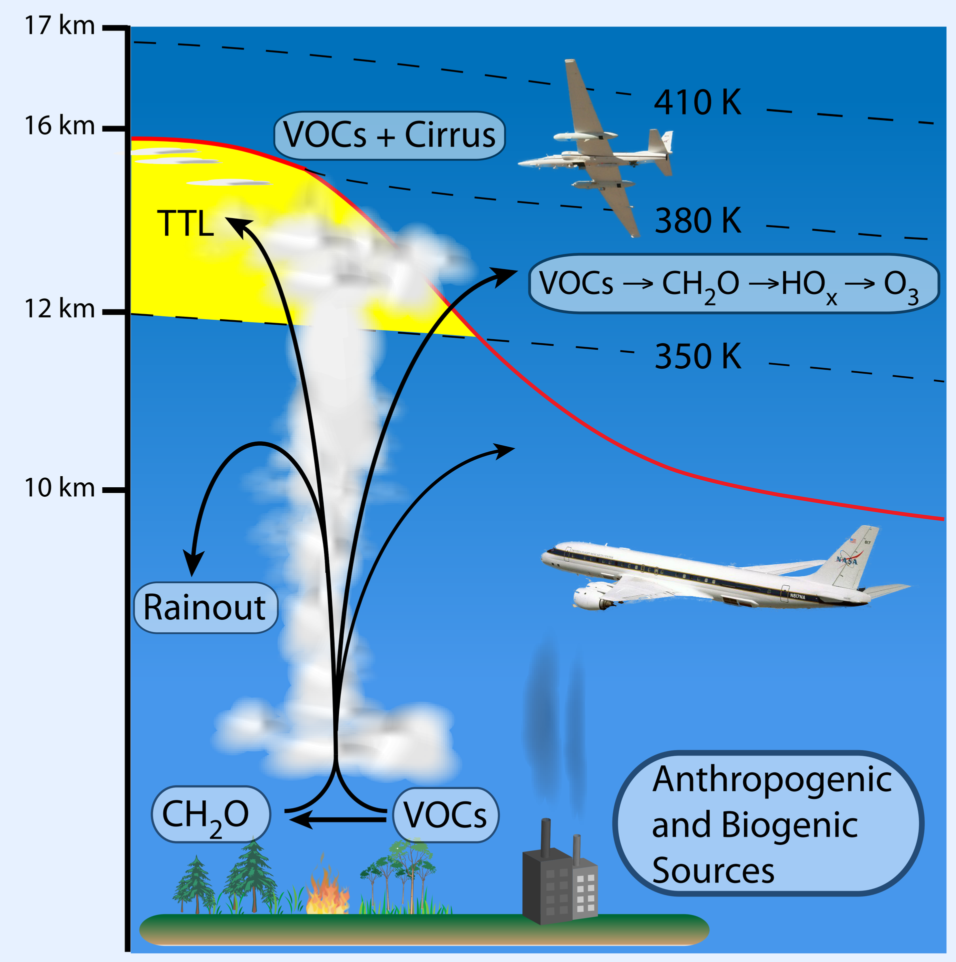

Figure 1. Measurements of formaldehyde can be used to help quantify:

- Convective transport
- The abundance of volatile organic compounds (VOCs)
- Pollution effects on cirrus formation
- HOx and Ozone production

Objective: Quantify the processes that control the transport of formaldehyde.

Experiment

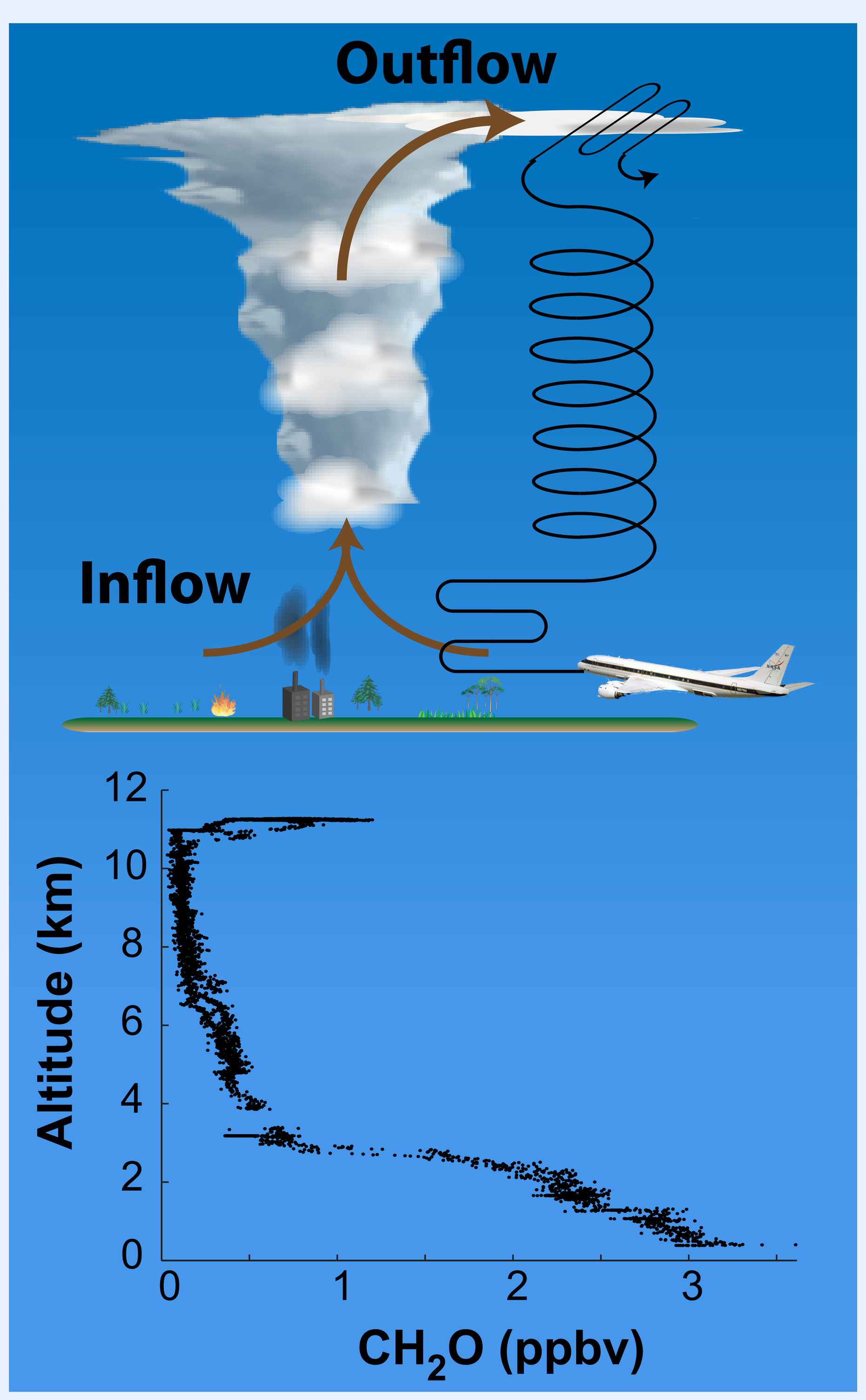

Figure 2. Measurements of HCHO with NASA's in situ airborne formaldehyde (ISAF) instrument are used to determine the transport efficiency of formaldehyde. The flight profile of the DC8 samples the boundary layer, entrainment level, and anvil outflow. In situ measurements and photolysis rates are used to constrain this analysis.

DC3

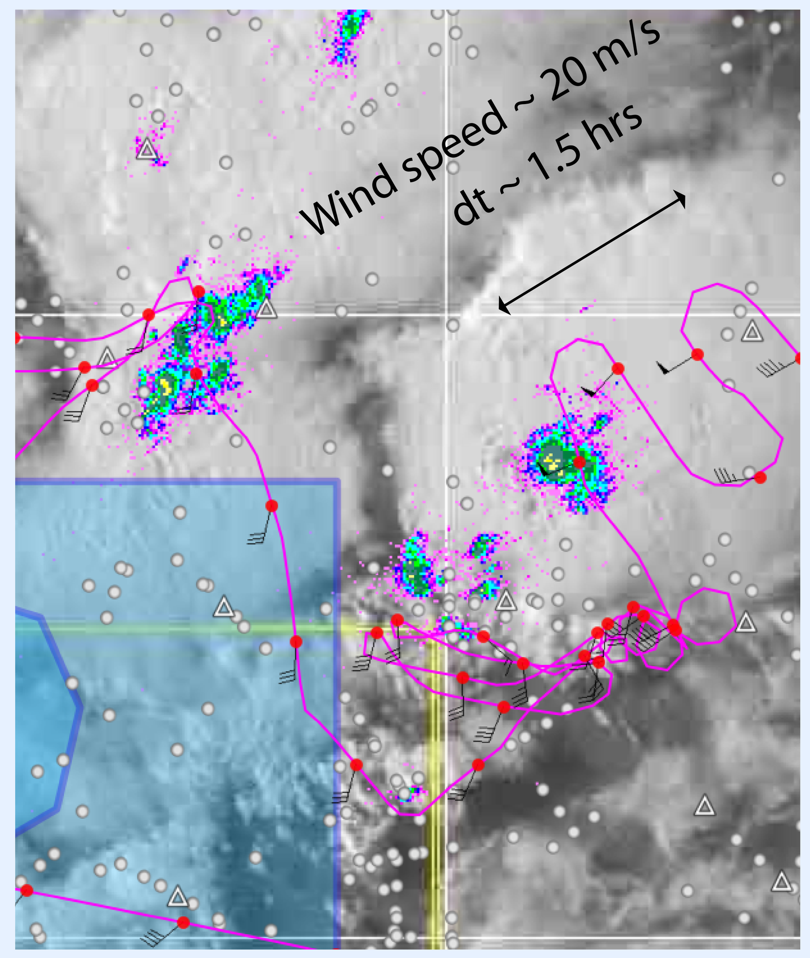

Figure 3. Measurements along the outflow of the anvil on 20120518 are used to constrain a time dependent photocemical model of HCHO. Photolysis rates and in situ measurements are used to initialize the model.

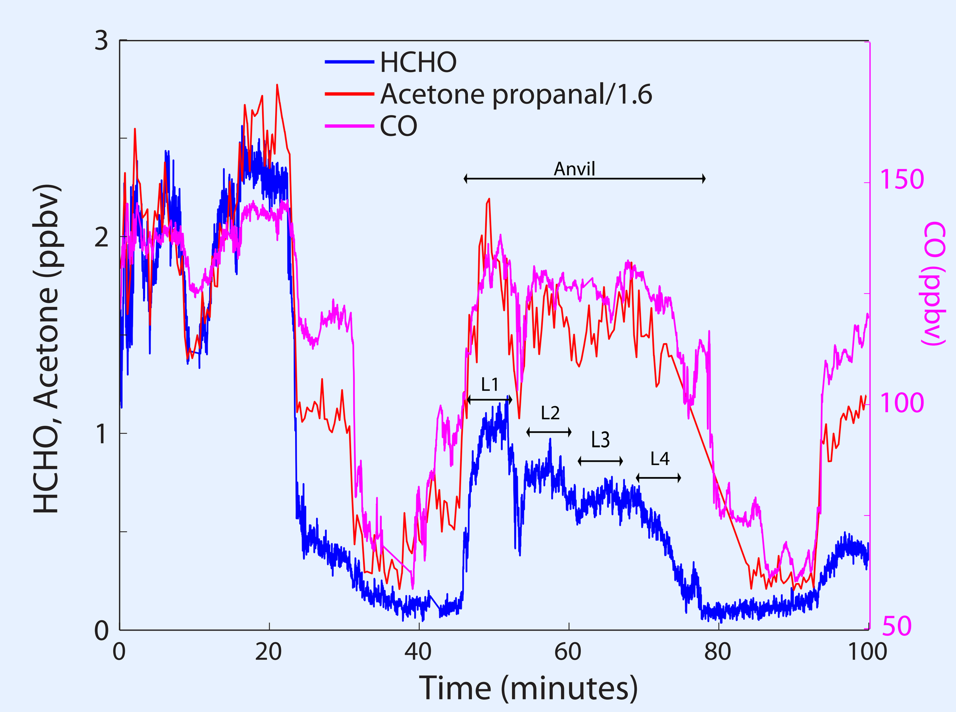

Figure 4. Measurements in the boundary layer to the outflow region of the storm of Acetone and CO are used to estimate the entrainment rate. There is uncertainty, especially with CO, in estimating the abundance in the entrainment level (6 - 8 km altitude). Notice the photochemical removal of HCHO.

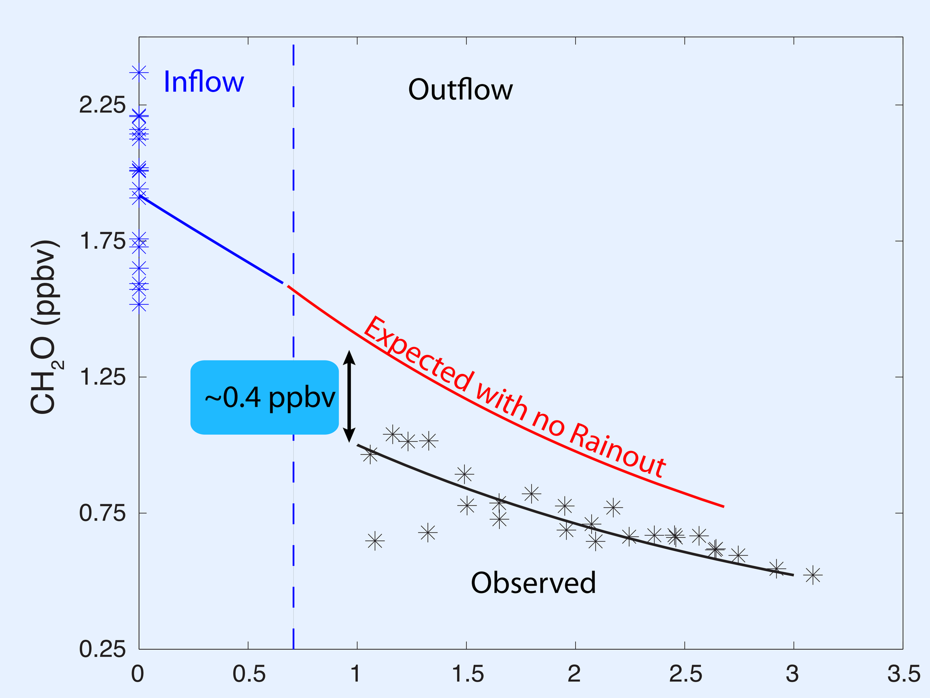

Figure 5. The time dependent photochemical model uses the measurements in the boundary layer, the dilution rate, and loss rate to estimate what we would see in the absence of wet removal of HCHO. We attribute all of the deficit between the expected and observed HCHO to wet removal. The line through the observed HCHO shows that the photochemical model adequately describes the time-dependence of HCHO.

SEAC4RS

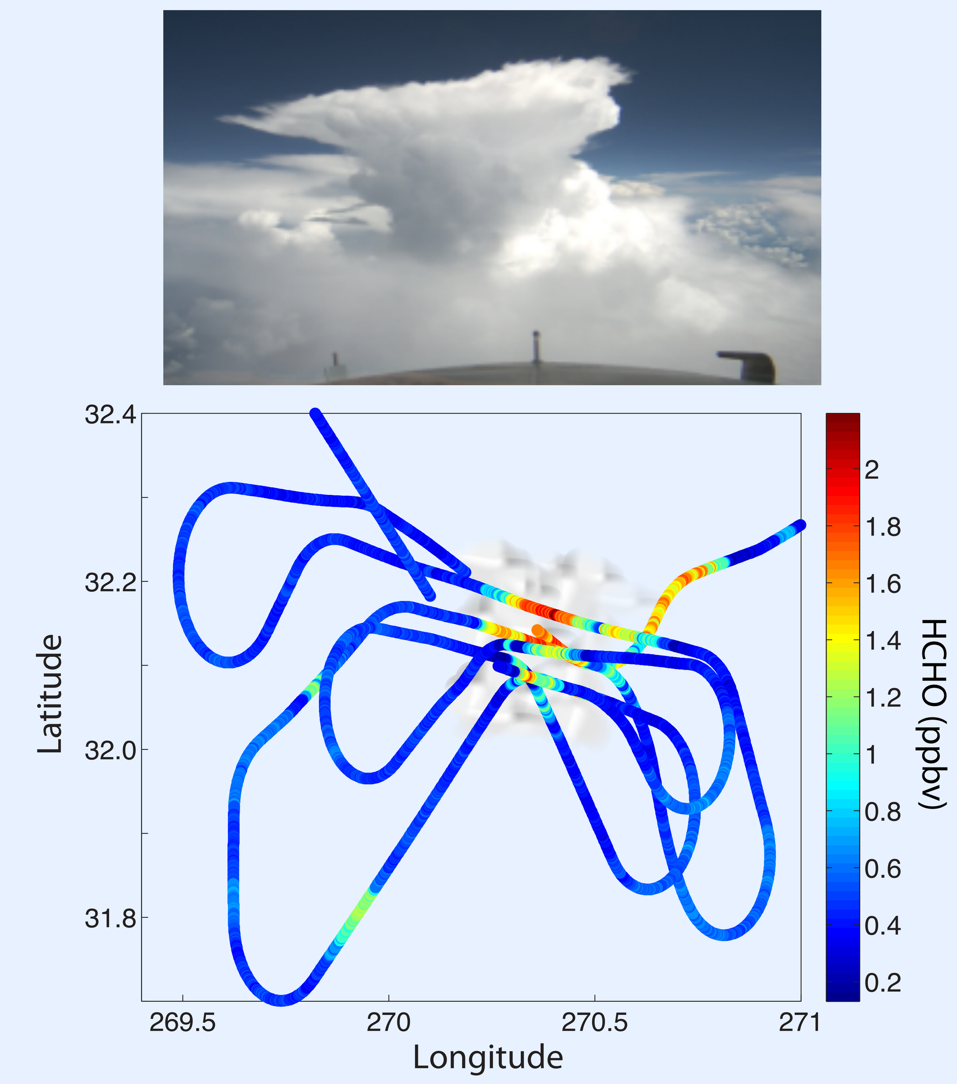

Figure 6. Repeated measurements in "Tammi" during the formation of an anvil show the time-dependence of HCHO at the top of the turret.

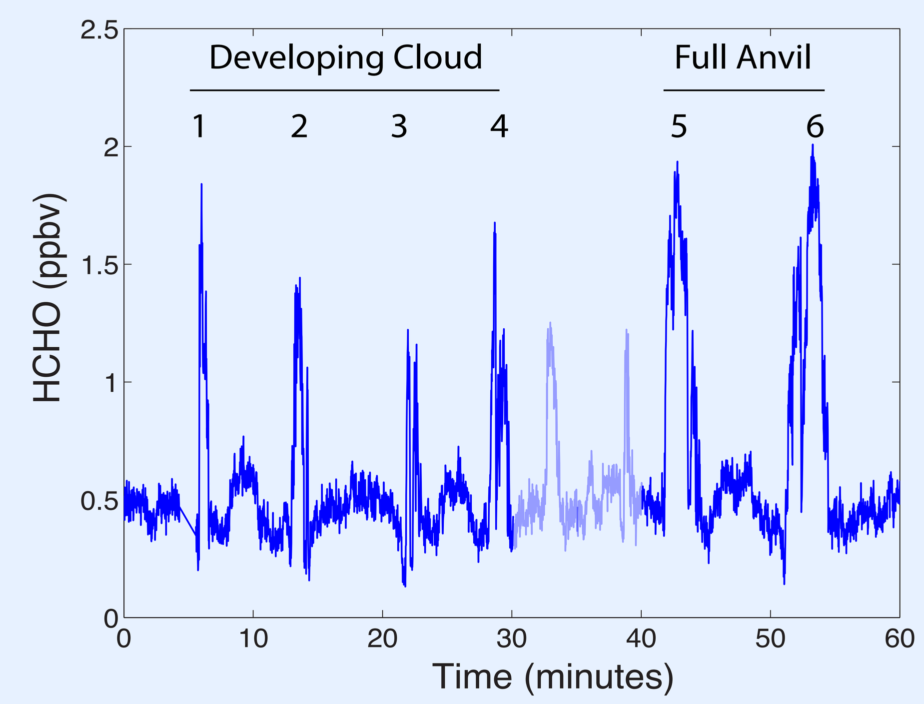

Figure 7. The abundance of HCHO increases only slightly as the anvil develops and increases in width. The presence of HCHO at the top of the turret is consistent with transport of HCHO. Photochemical production of HCHO from VOCs (CH_3OOH, Isoprene, etc.) cannot explain HCHO in the nascent anvil. (HCHO lifetime ~ 1- 2 hrs)

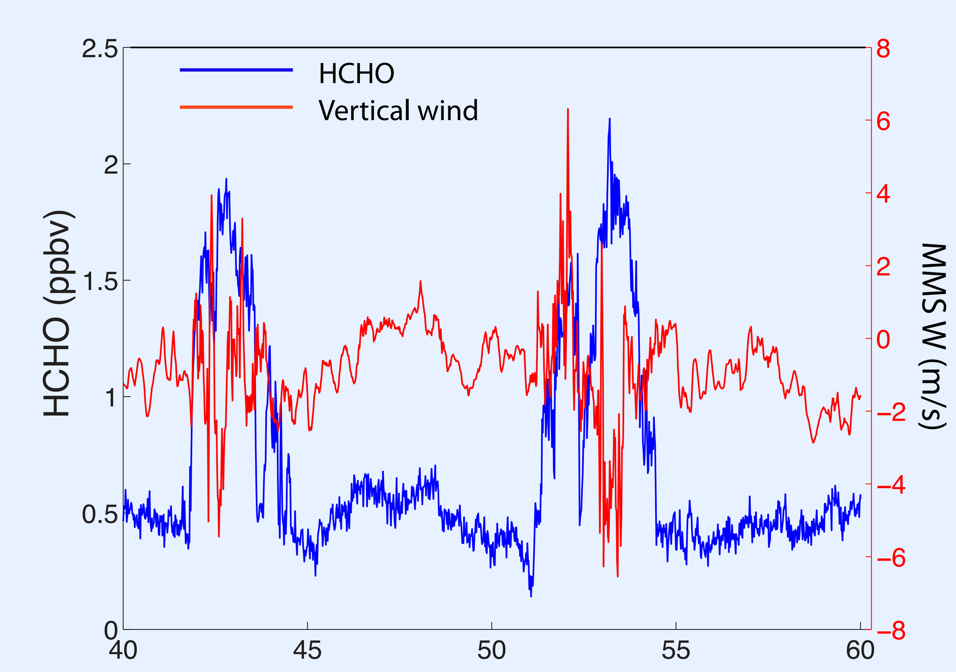

Figure 8. The coincident measurements of vertical winds and HCHO show that the decrease in HCHO at the edge of the cloud at each pass is not due to descending air. The decrease is likely due to entrainment from low HCHO air at 6 - 8 km.

Summary

Table 1. Measurements of multiple storms in DC3 show consistently low wet removal rates of HCHO.

Date	Location	Entrainment	Rainout	Ratio UT/BL
20120518	41N 258W (NE)	18%	22%	45%
20120519	37N 262W (OK)	40%	9%	40%
20120602	41N 256W (CO)	28%	10%	53%
20120606	41N 256W (NE)	33%	22%	38%

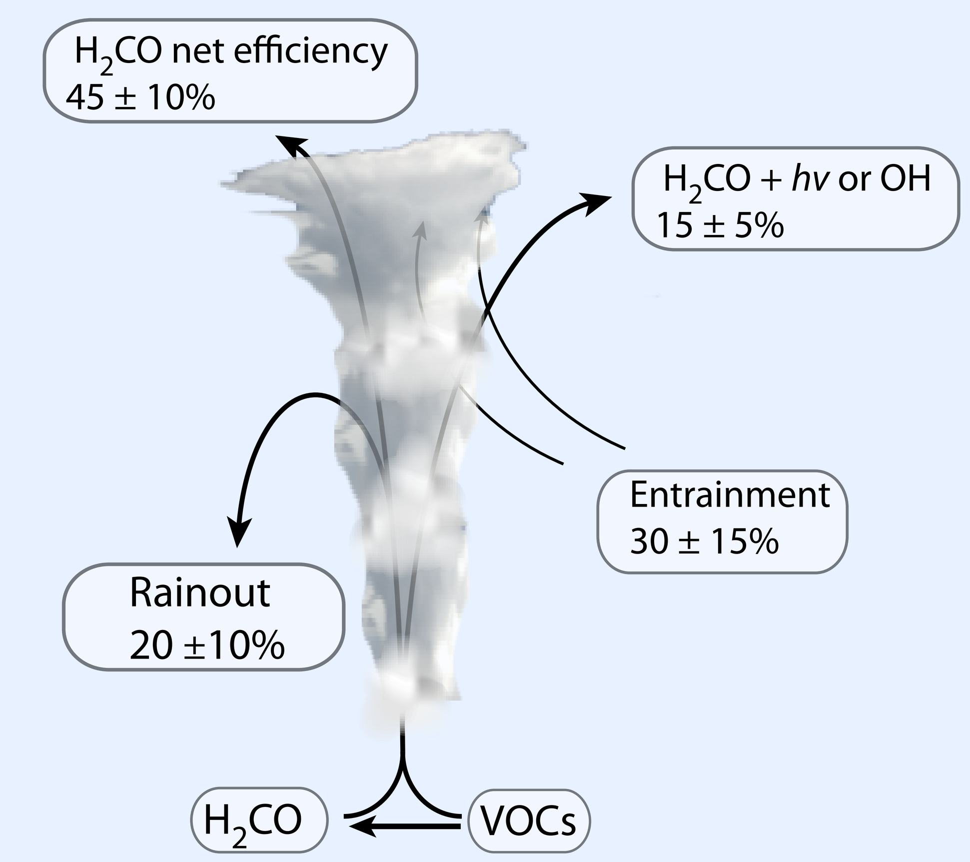

Figure 9. Summary of the contributions to HCHO transport in storms. The ranges shown are the variability in the observations. The uncertainties from model assumptions are not included.

Mechanism

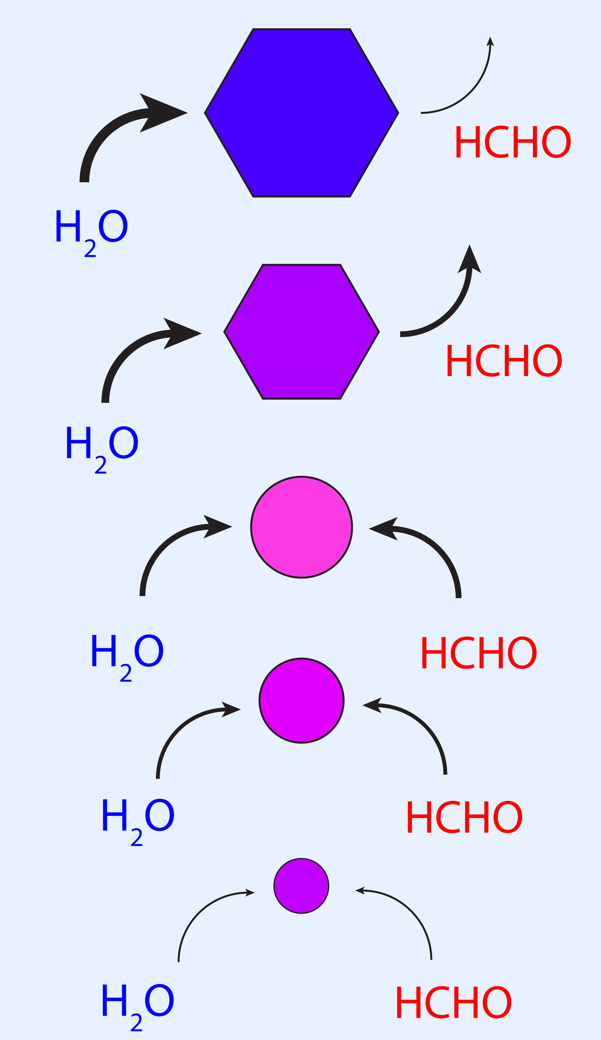

Figure 10. The solubility of HCHO is high enough that it should incorporate into liquid droplets during ascent in the turret. One possibility is that HCHO is transported to the top of the turret in liquid droplets and ejected during the formation of ice.

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