Cirrus clouds and RH_i in the TTL above the Indian Ocean

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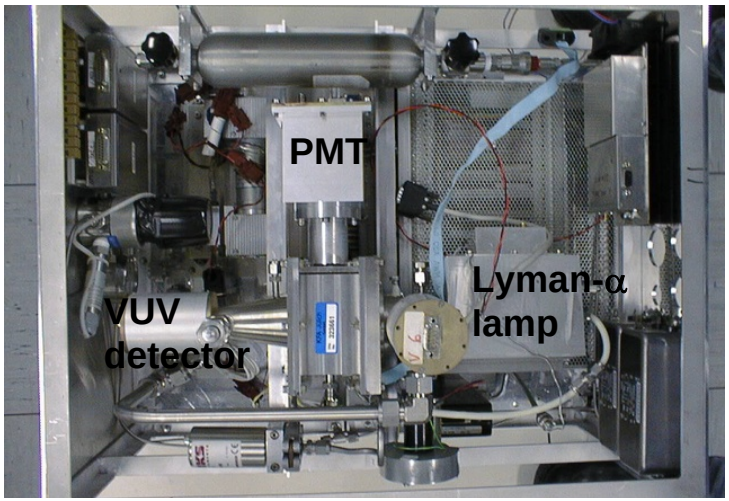
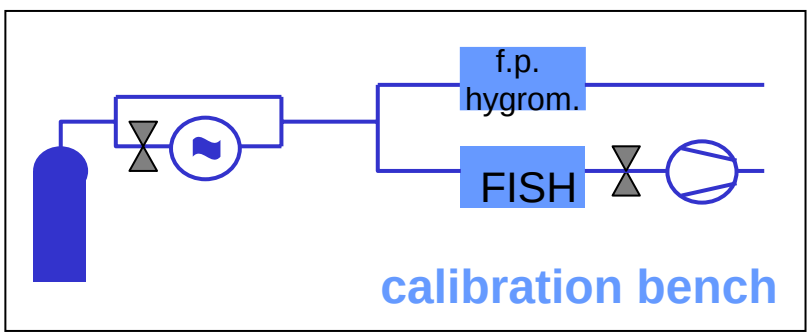
APE-THESEO: Indian Ocean, February-March 1999

total water: **FISH, FZ Jülich**

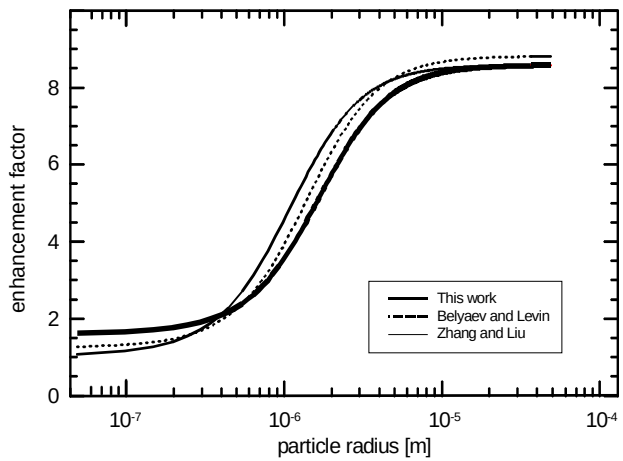
gas-phase H_2O: **FLASH, CAO Moscow**



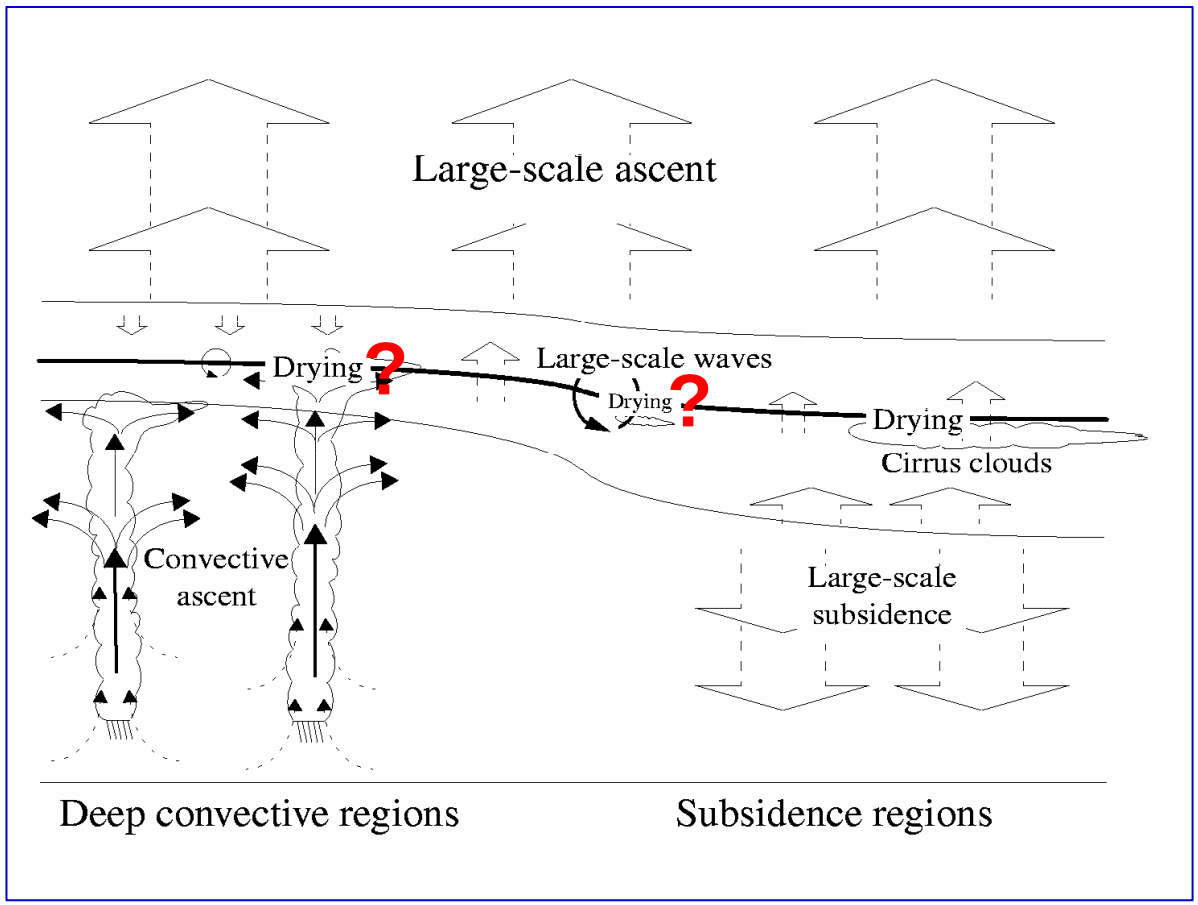
$$H_2O + h\nu_{121.6nm} \rightarrow OH^* + H$$
$$OH^* \rightarrow OH + h\nu_{308nm}$$



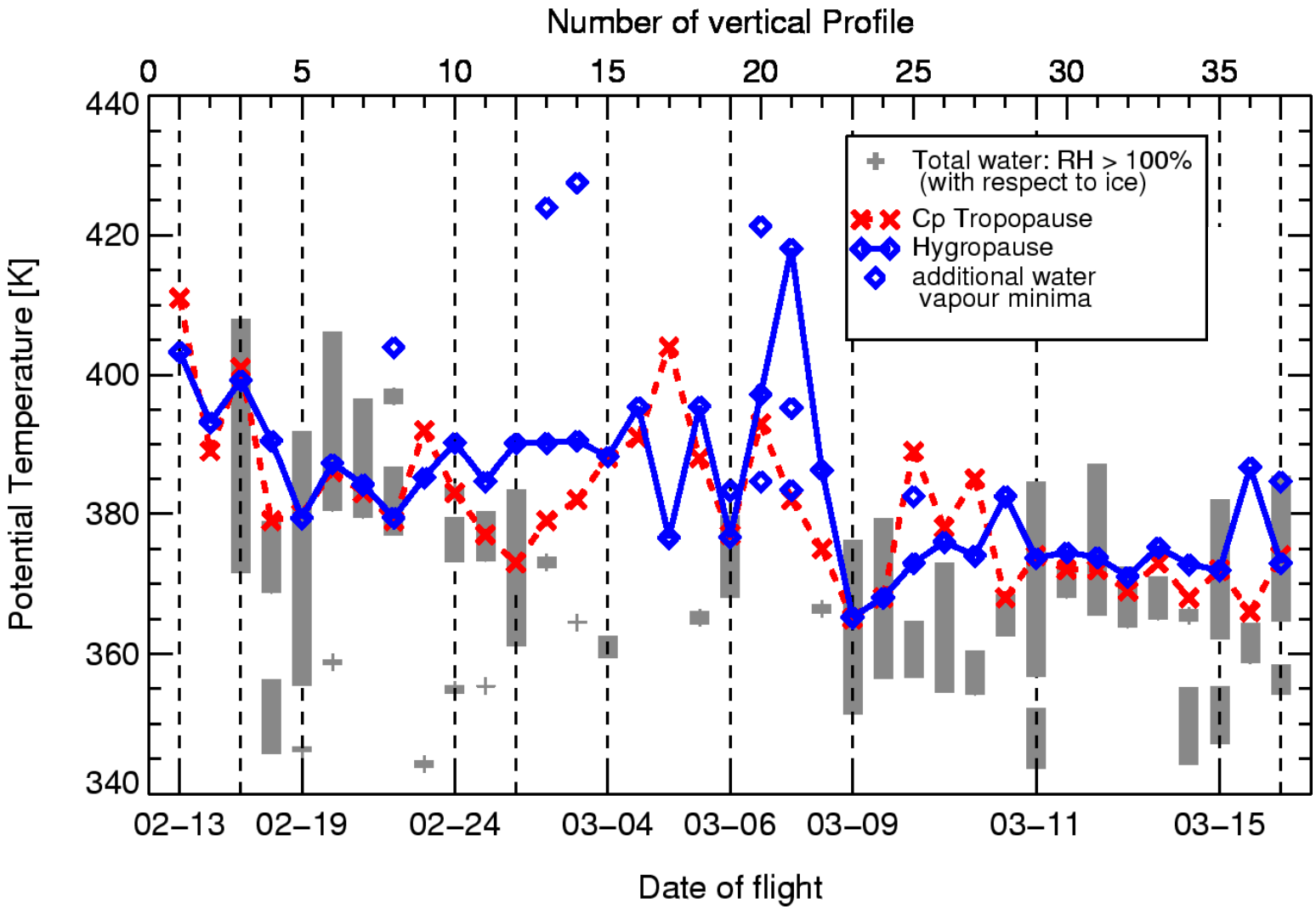
total water inlet



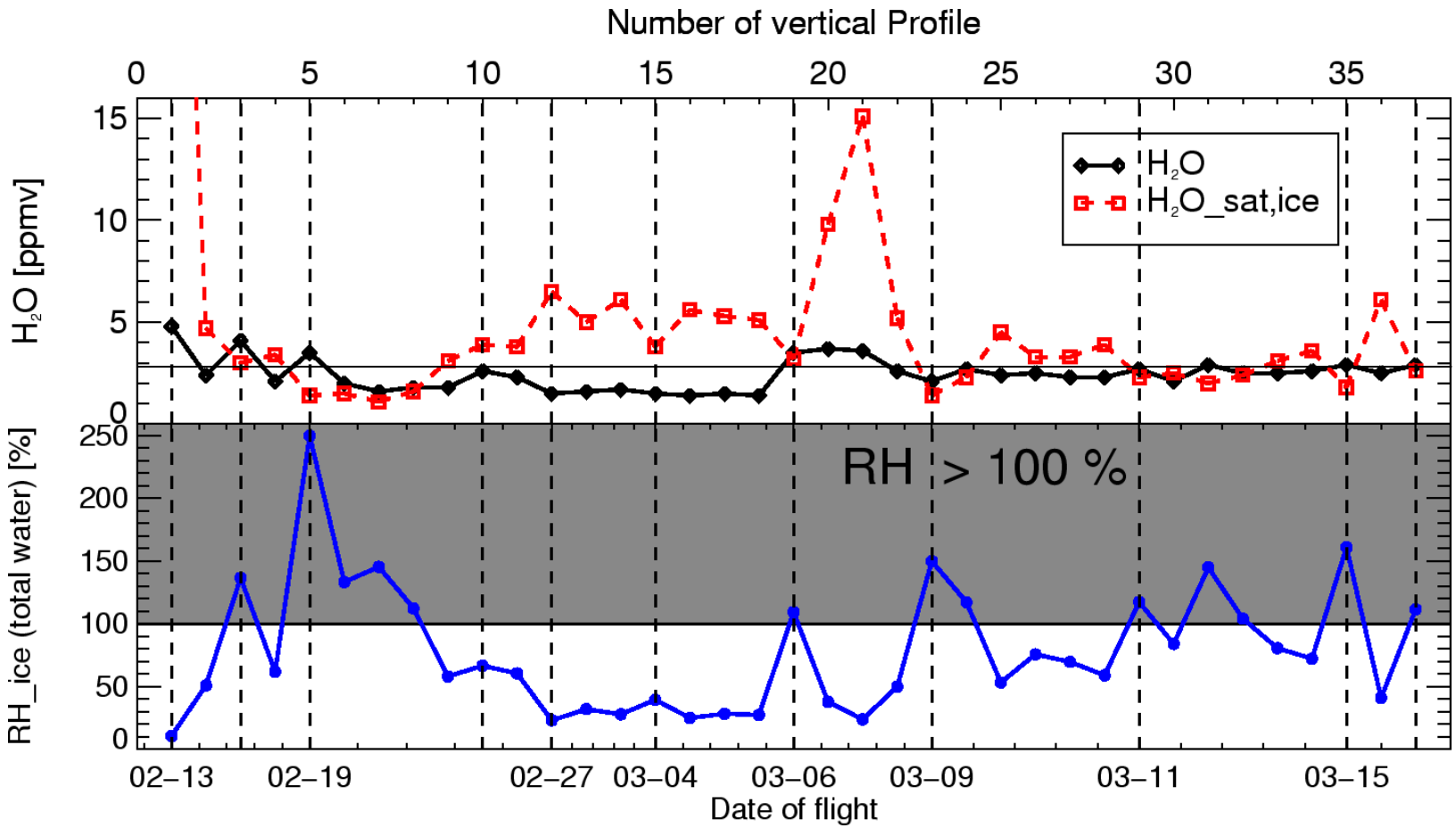
What is drying / moistening the TTL ?



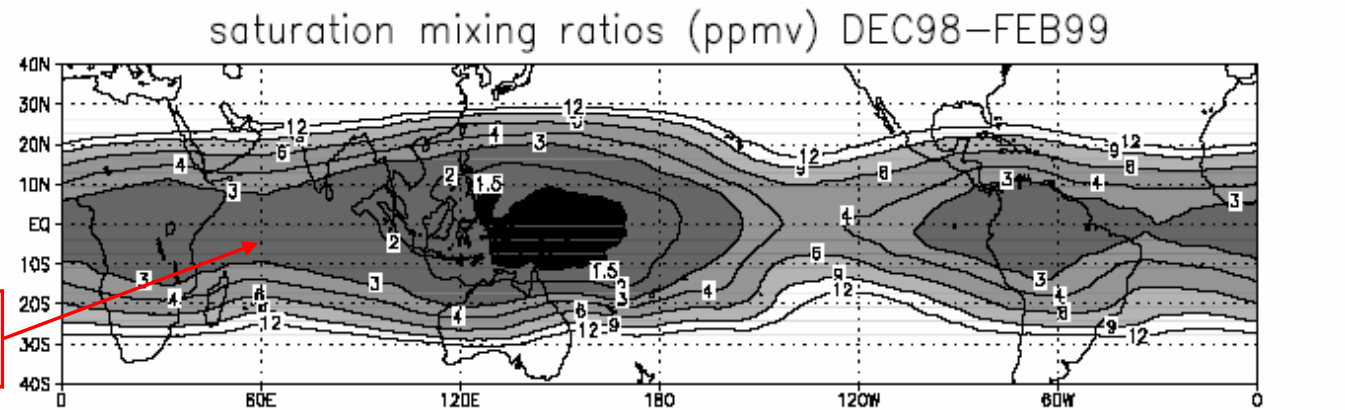
APE-THESEO: hygropause and saturation



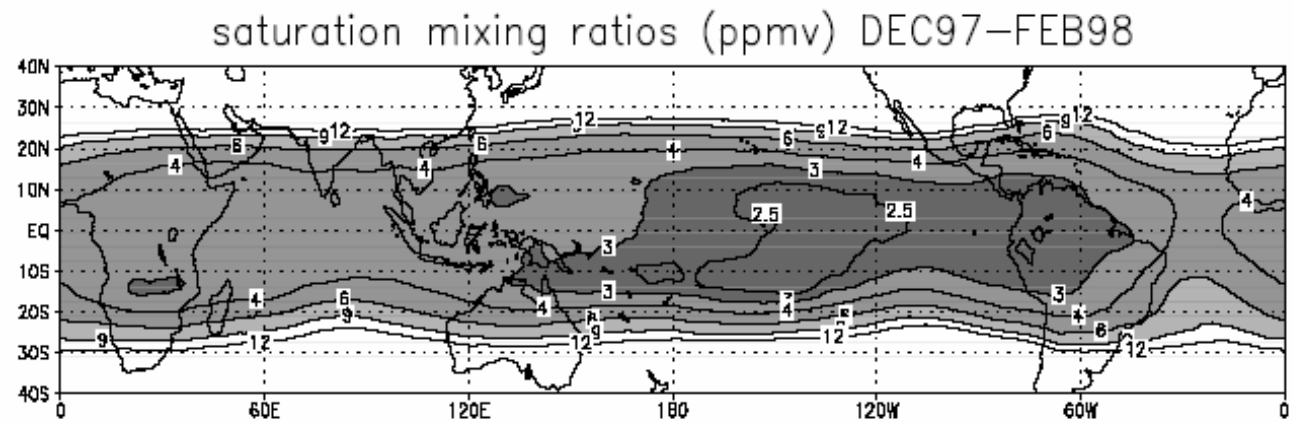
total water and saturation at the hygropause

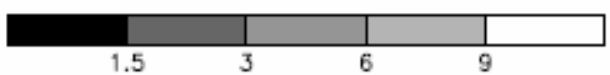


ECMWF-anlysis: saturation at the tropopause



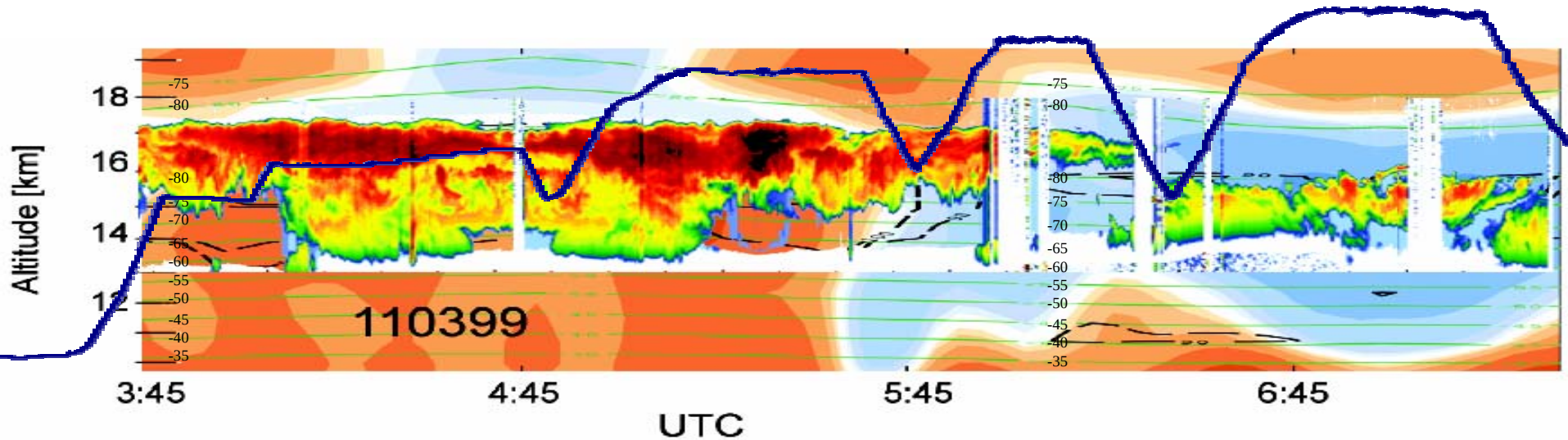
APE-THESEO

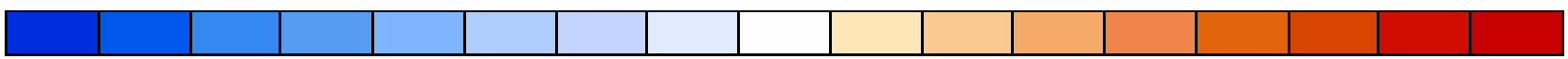




M. Bonazzola and P. H. Haynes, 2004

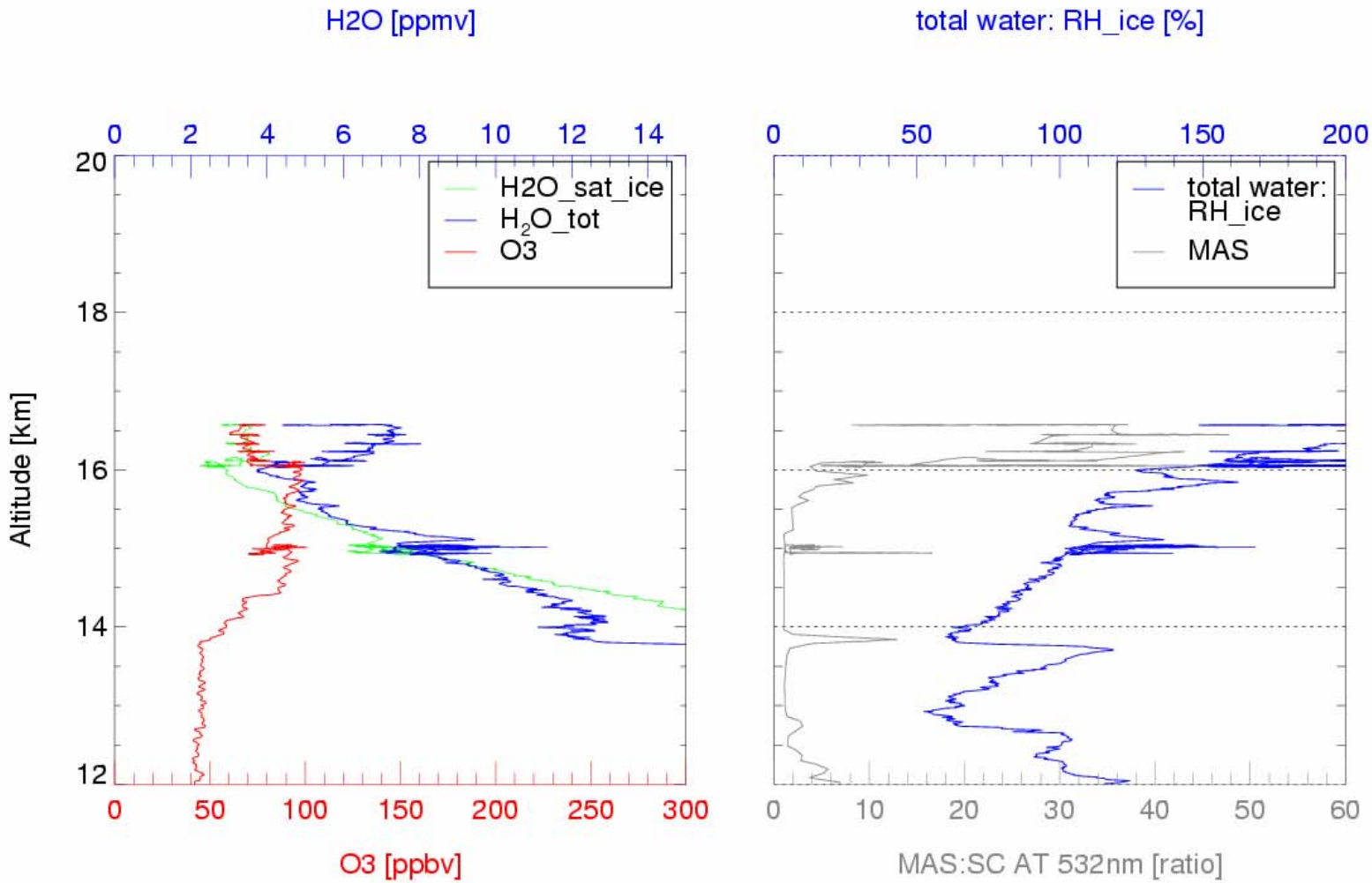
1999-03-11: barely visible cirrus

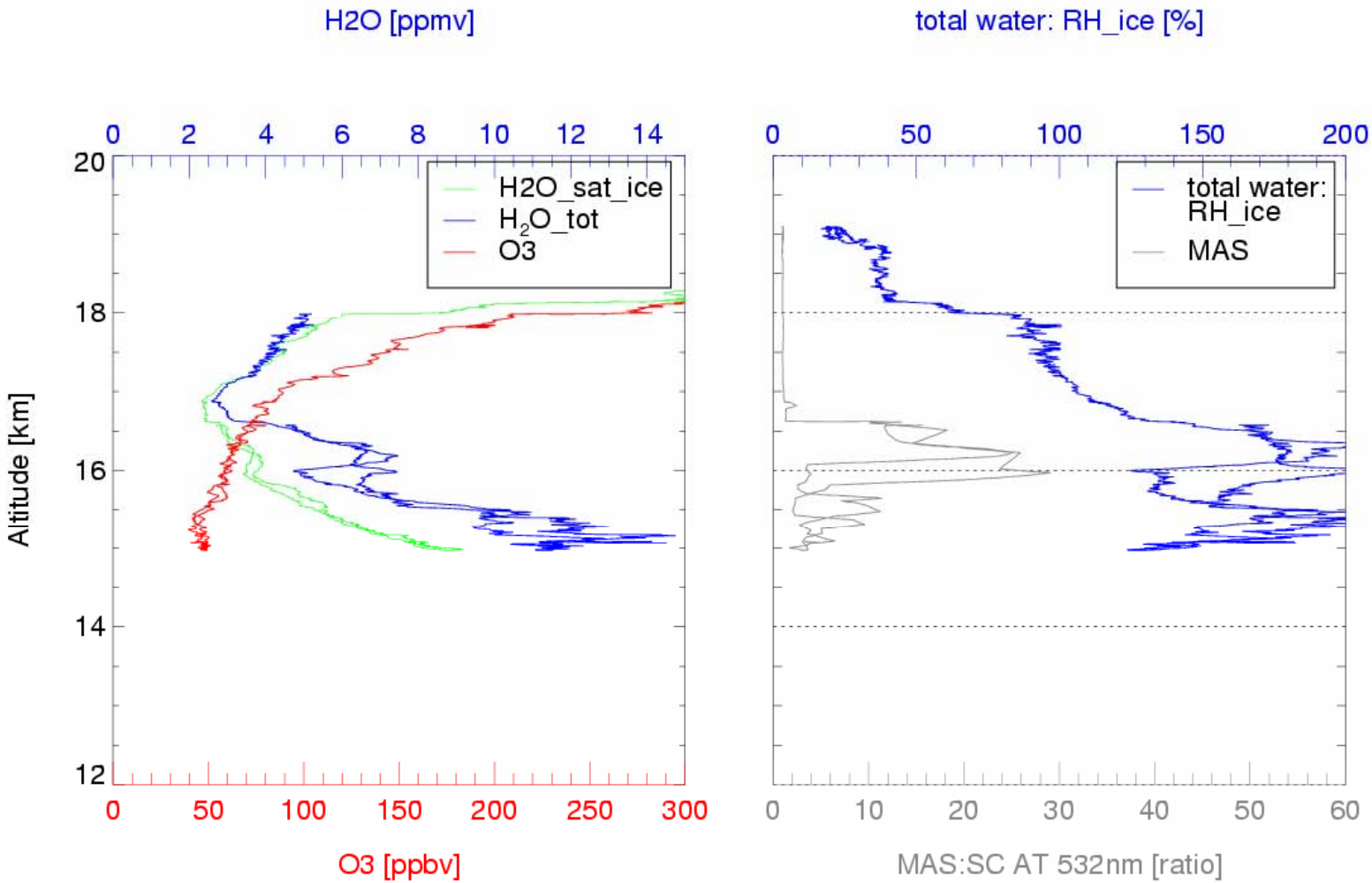




-15 -7 -2 -0.5 +0.5 +2 +7 +15

cm/s


H2O [ppmv]
total water: RH_ice [%]
Altitude [km]
H2O_sat_ice
H2O_tot
O3
total water: RH_ice
MAS
O3 [ppbv]
MAS:SC AT 532nm [ratio]



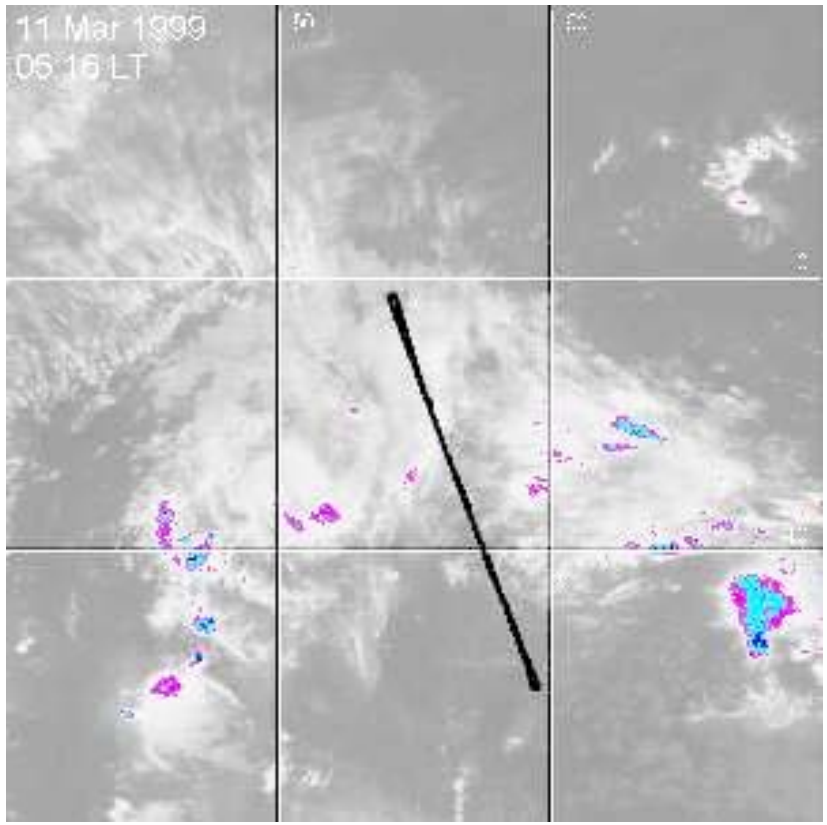
cp tropopause low (17 km)

cirrus up to the tropopause

ice water content 4-6 ppmv

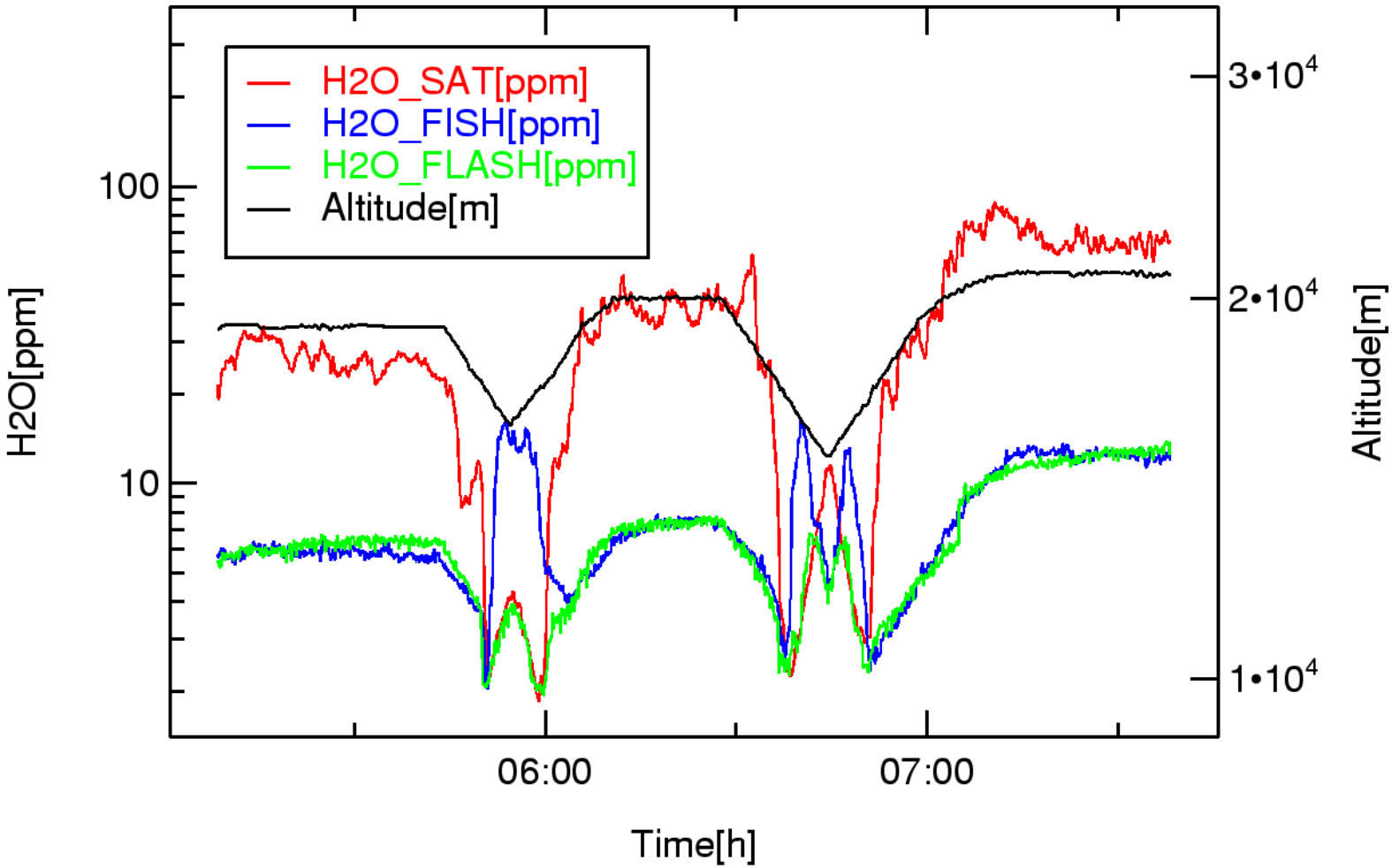
low ozone mixing ratios in cirrus layer

Cirrus clouds at 15-17 km a result of convective outflow?

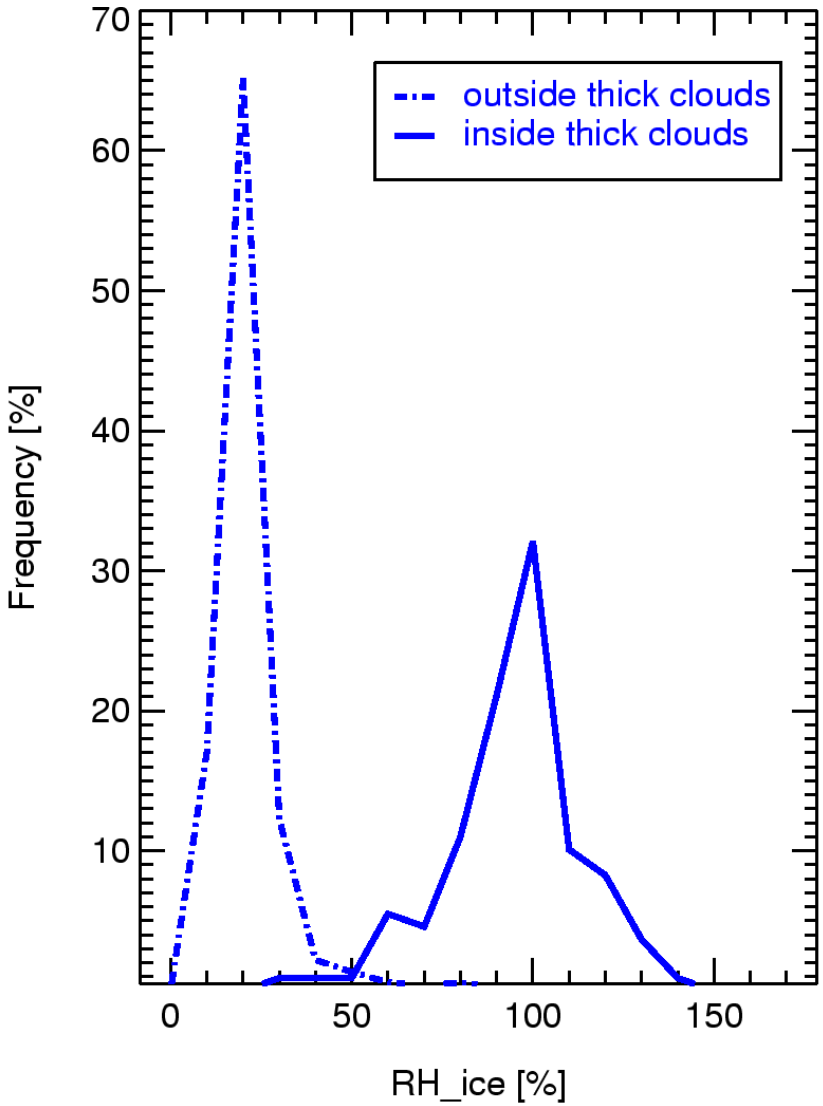


- deep convection observed, but only up to 15-16 km
- upward velocities in clouds allow lofting by 1 km within 1 d
- ozone mixing ratios are unusually low in cirrus clouds

total H_2O (FISH) and gas-phase H_2O (FLASH)



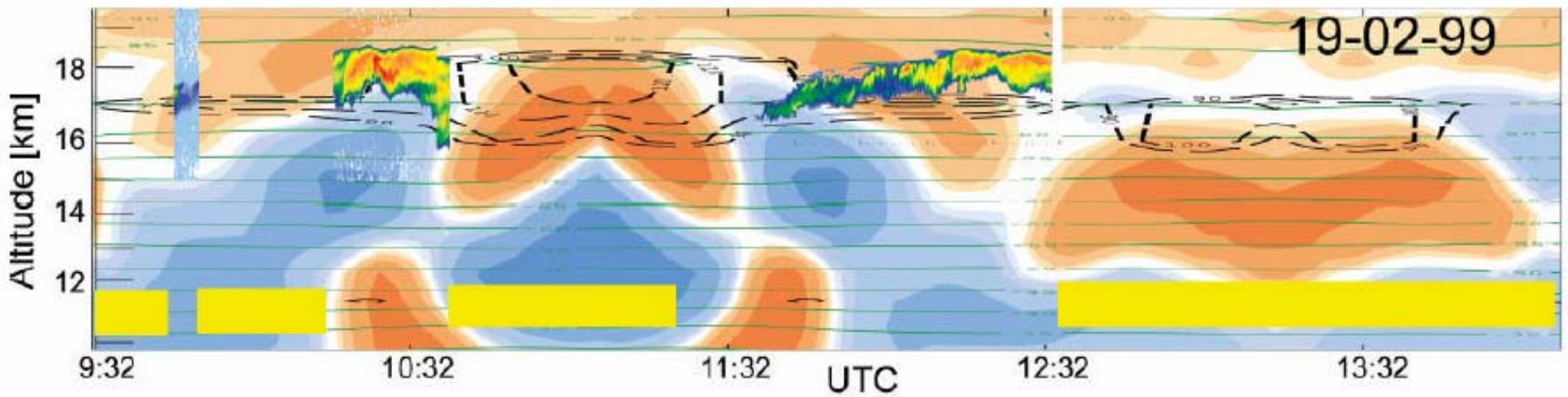
RH_i frequency distribution

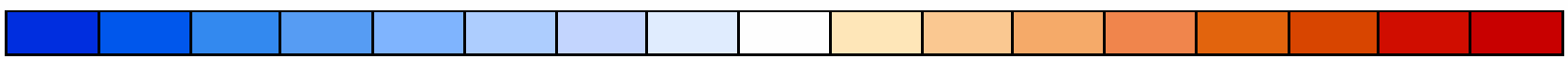


barely visible cirrus 1999-03-11

- RHi inside cirrus ≈ 100 % ⇒ aged cloud, equilibrium
- dry environment (RHi ≈ 20 %)
- hydration potential
- outflow from convection

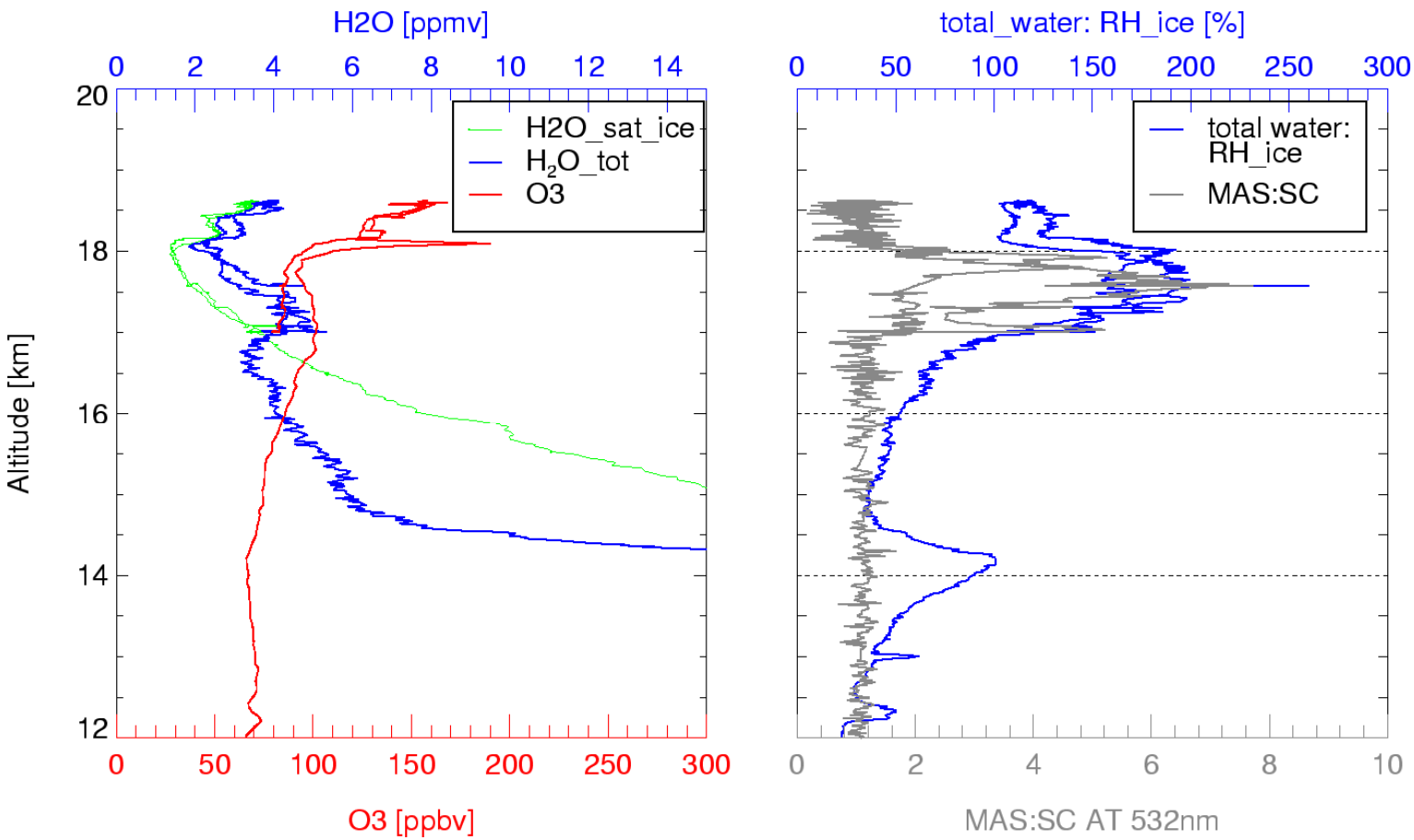
1999-02-19: thin cirrus (SVC)





-15 -7 -2 -0.5 +0.5 +2 +7 +15

cm/s

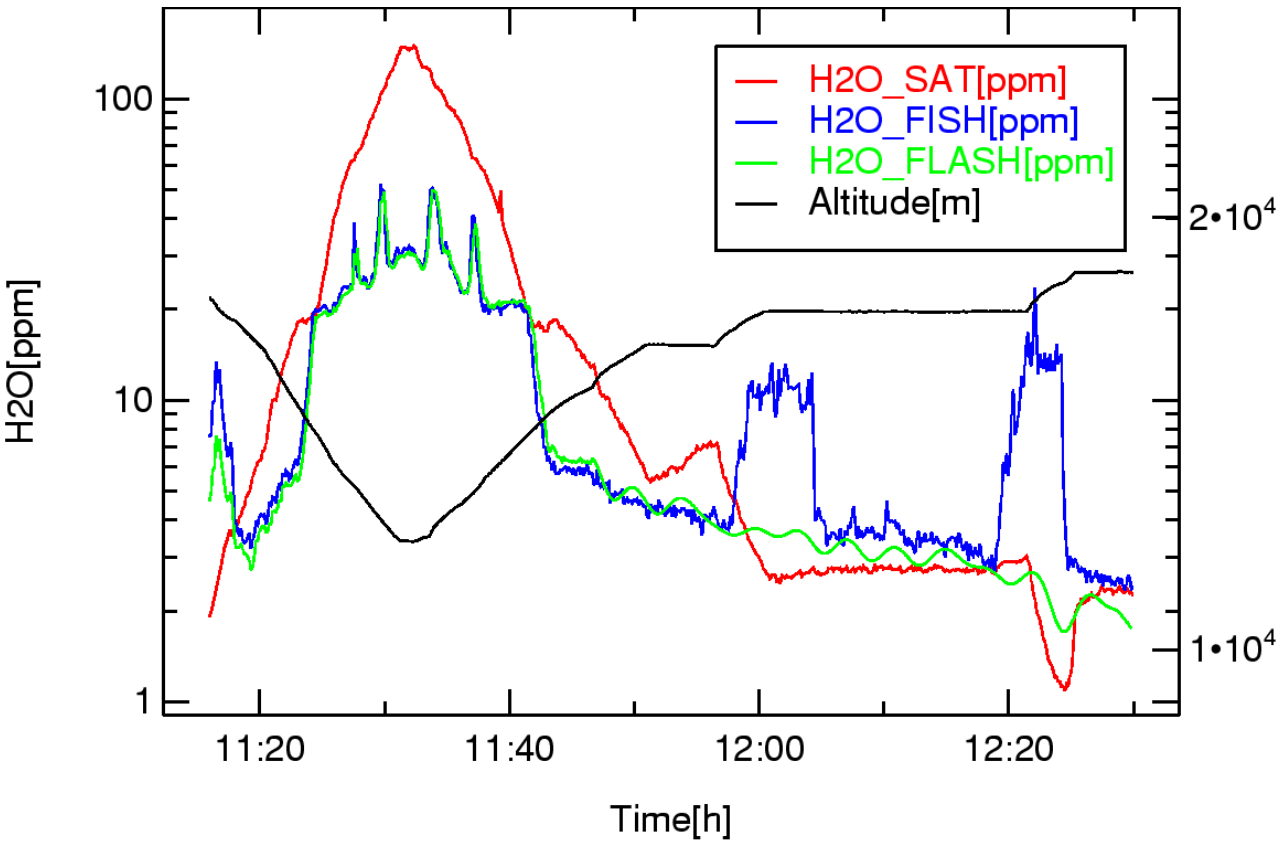


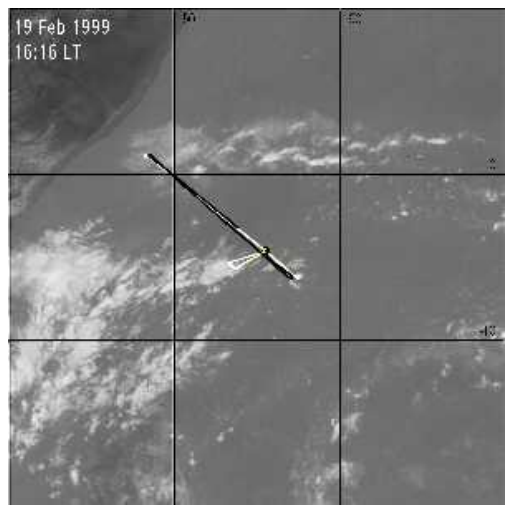
cp tropopause high (18 km)

cirrus at the tropopause

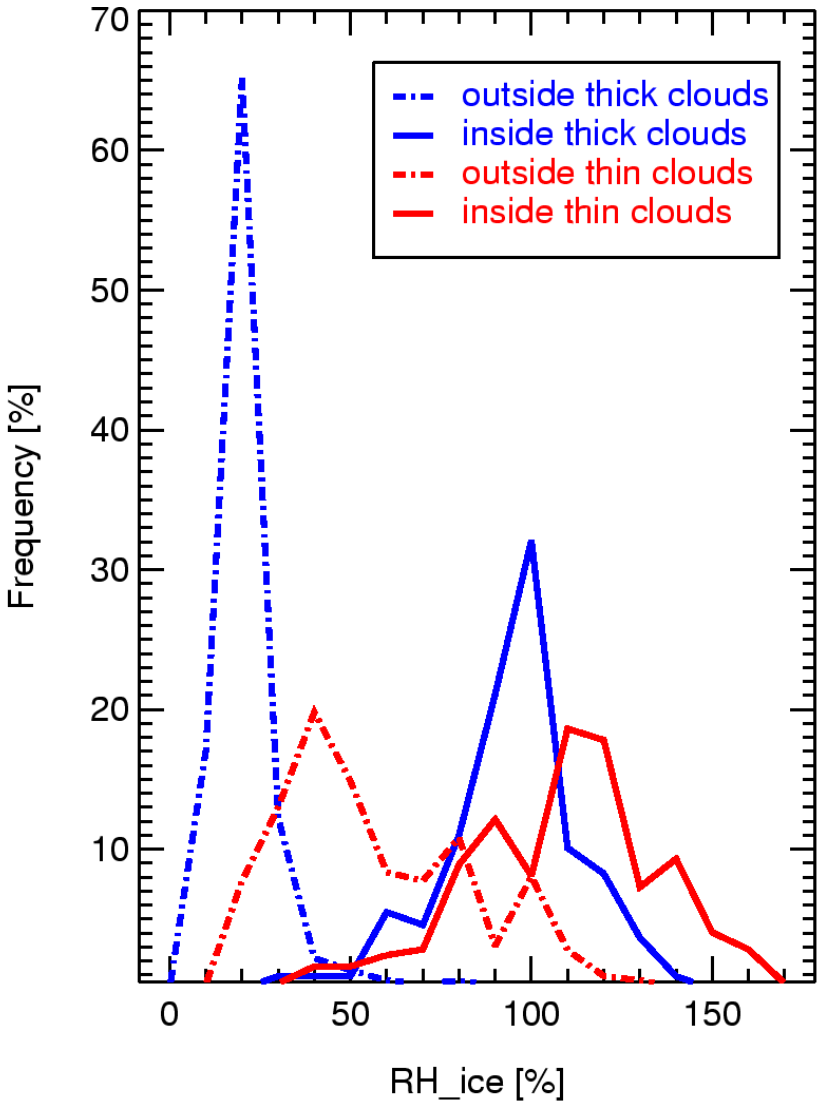
ice water content 1 ppmv

normal TTL ozone mixing ratios in cirrus layer


H2O_SAT[ppm]
H2O_FISH[ppm]
H2O_FLASH[ppm]
Altitude[m]
100
10
1
H2O[ppm]
2•10^4
1•10^4
Altitude[m]
11:20
11:40
12:00
12:20
Time[h]


19 Feb 1999
16:16 LT

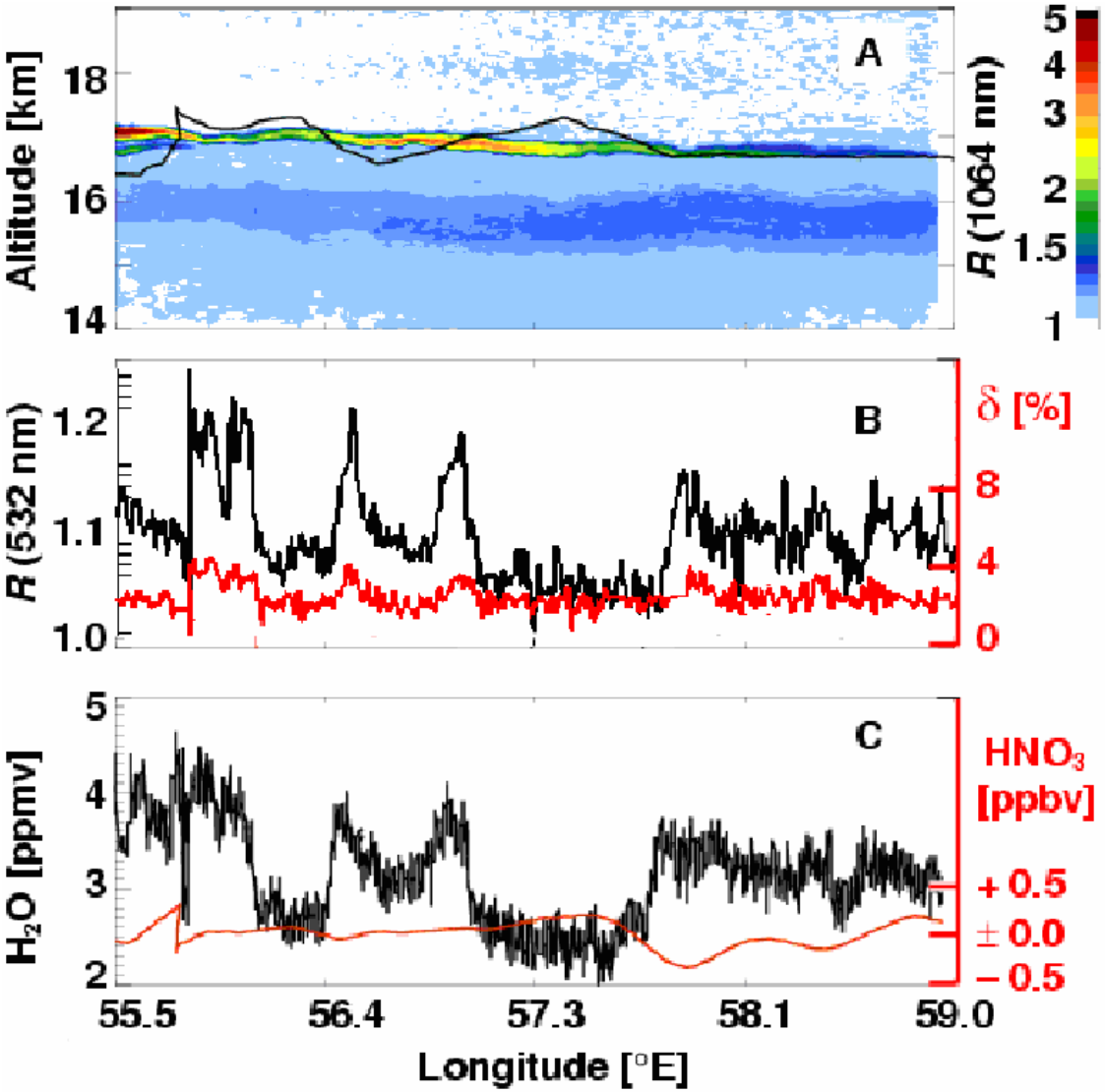
RH_i frequency distribution



thin cirrus (SVC) 1999-02-19

- RH_i inside cirrus up to 170 % ⇒ cirrus in process of cooling
- humid environment (RH_i up to 120%)
- dehydration potential
- origin: gravity wave

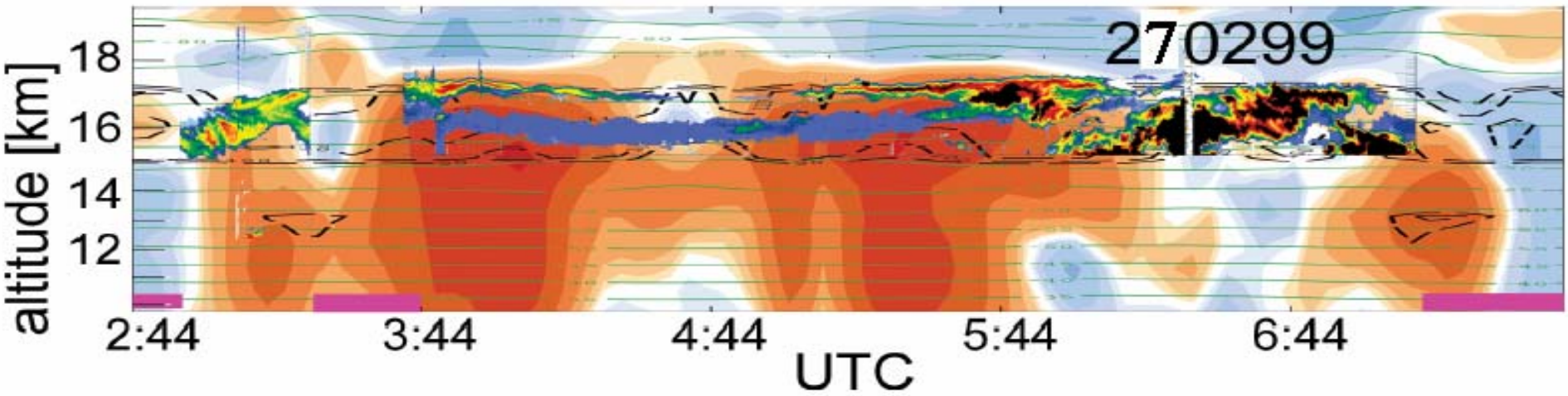
UTTC: Ultra-thin Tropical Tropopause Clouds

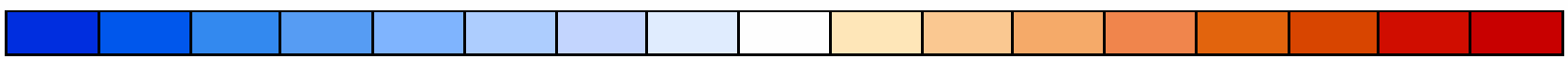


- remnants of gravity-wave-induced cirrus
- only 100 m thick
- ice clouds, only 50 pptv cloud water content
- environment (nearly) saturated
- few large particles: high dehydration potential

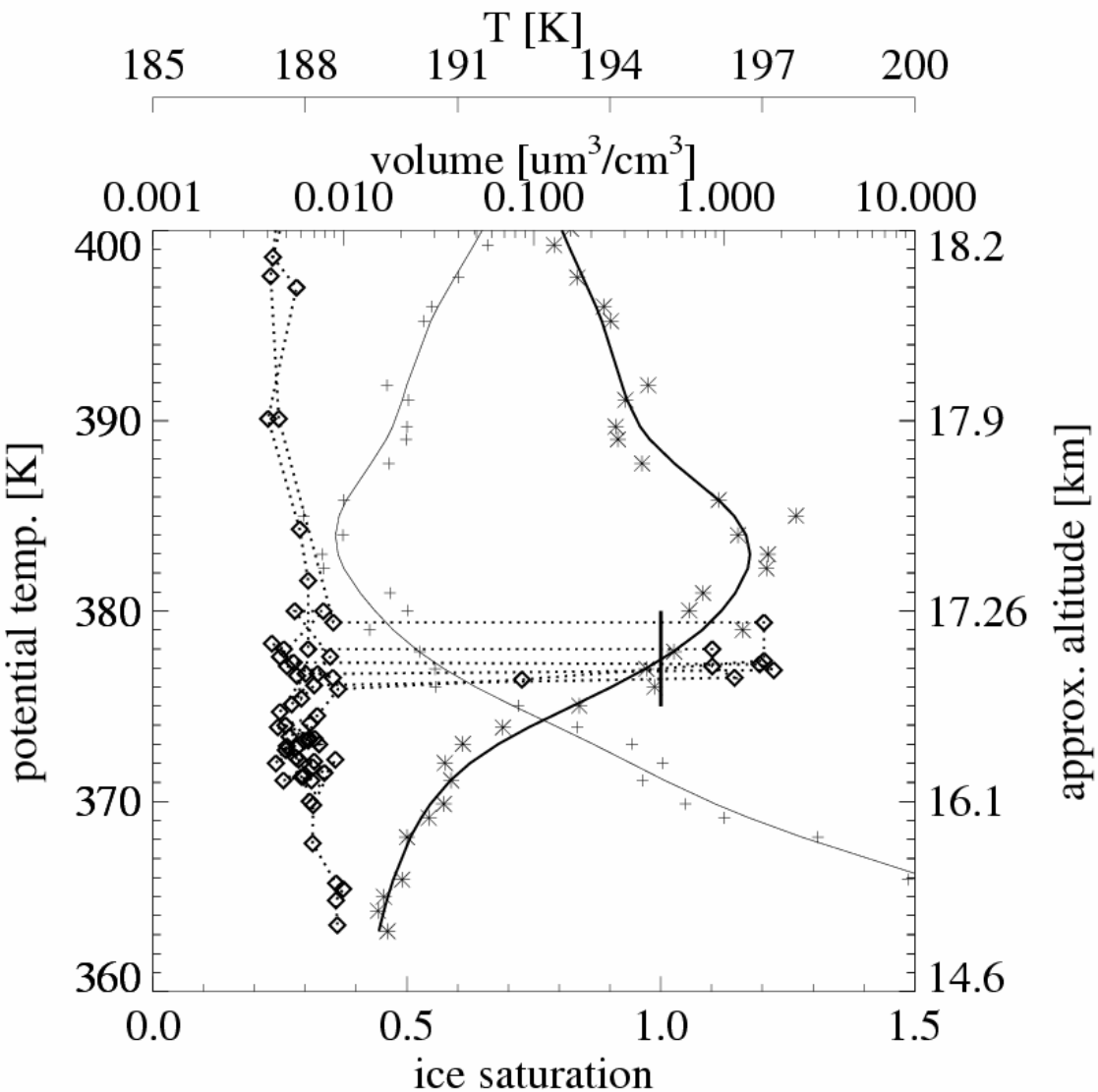
Luo et al., 2003; Peter et al., 2003

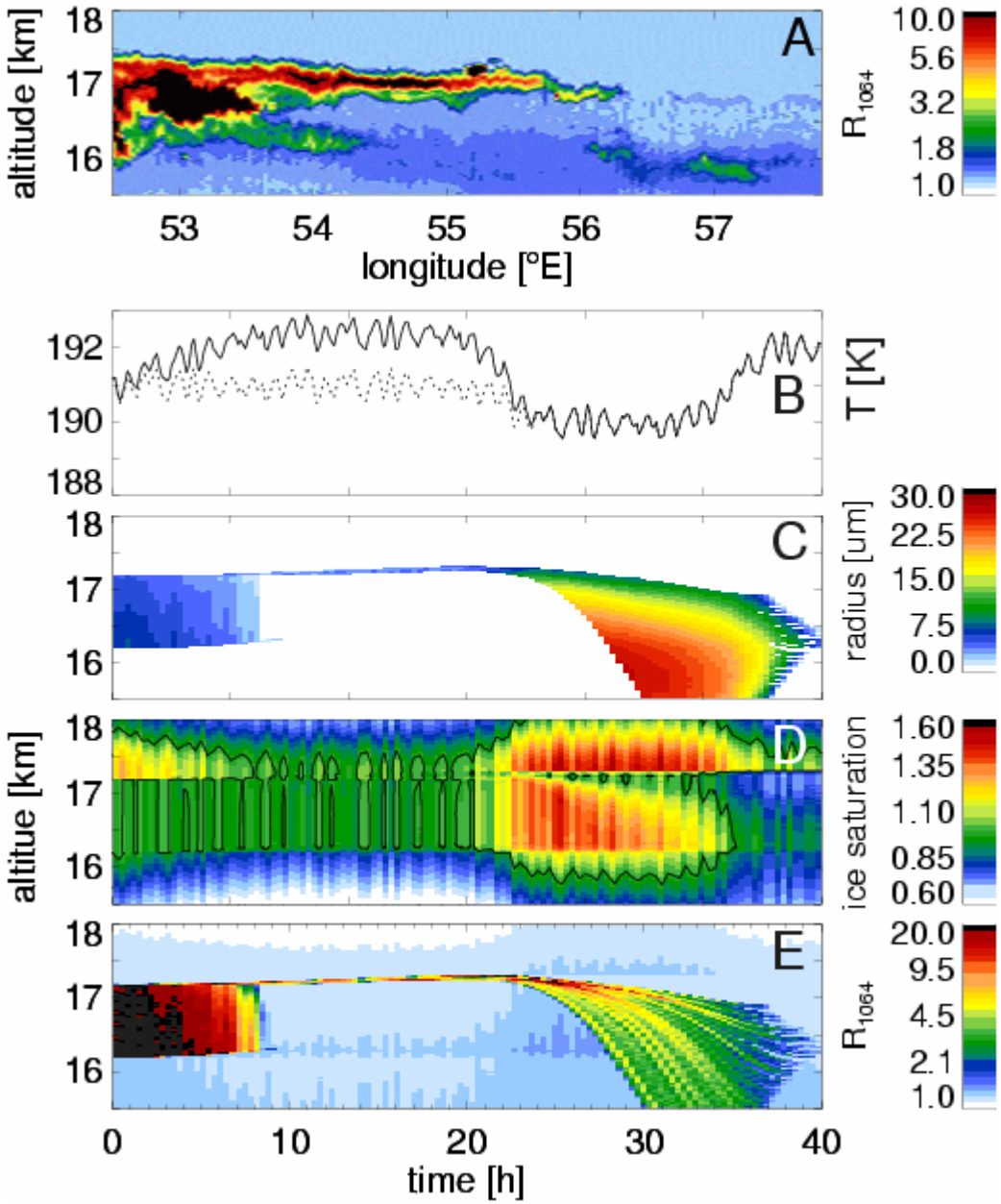
Upwelling + high RH → UTTC
dashed = ice supersaturation





mechanism for stabilisation of UTTC





Luo et al., 2003; Peter et al., 2003

Summary

APE-THESEO 1999:
dry and cold, ongoing dehydration

barely visible cirrus at 15-17 km
outflow of convection, lofted
RHi peaks at 100%, aged
dry environment
hydration potential

SVC at 17-18 km
gravity wave-induced
RH_i up to 170%, cooling
humid environment
de-hydration potential

UTTC
remnants of SVC
high de-hydration potential