GCOS Upper Air Workshop, 22 May 2006

Water vapor observations in the upper troposphere and lower stratosphere

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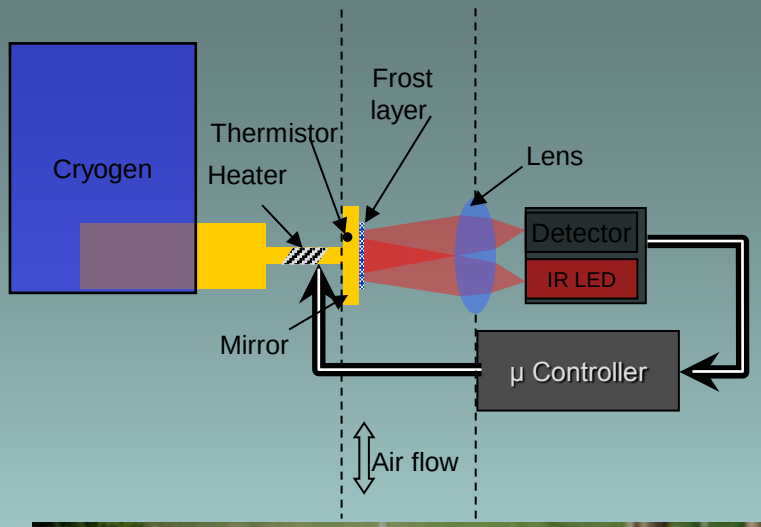
Overview

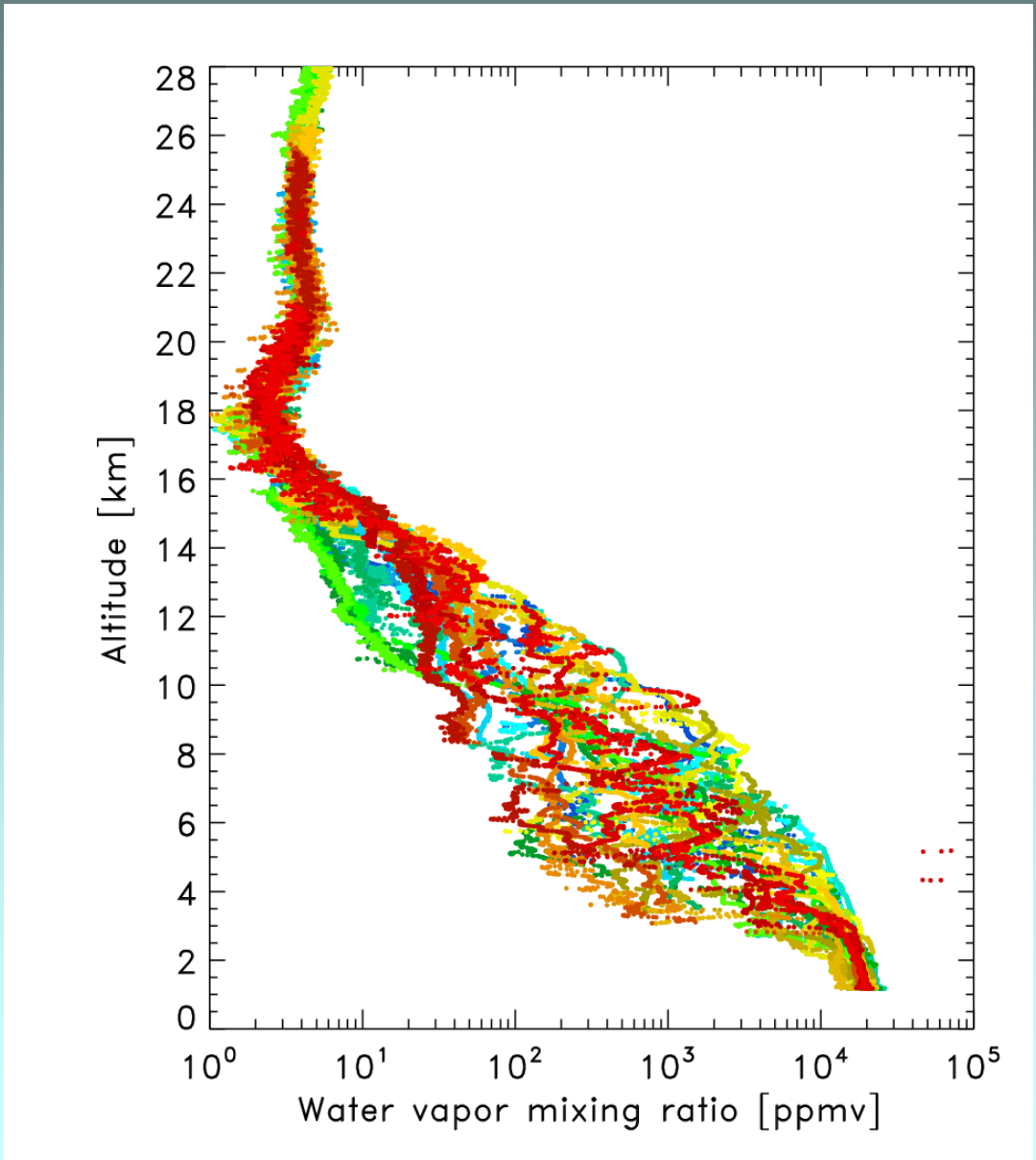
- Frost point
- Lyman-α
- TDL
- Polymer (Vaisala RS92)
- Summary

Cryogenic Frostpoint Hygrometer (CFH)

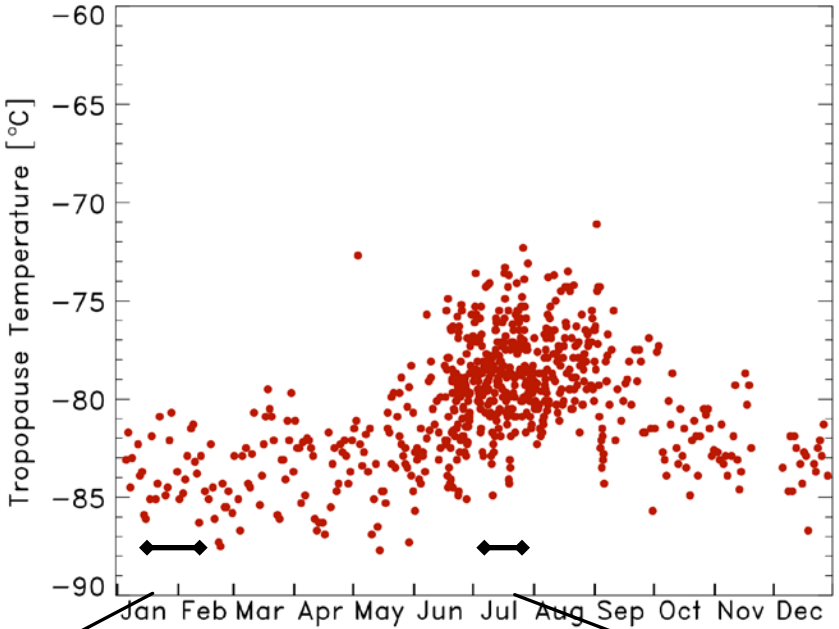
- Microprocessor control
- Vertical Range: surface to ~28 km
  (surface to ~25 km on ascent)
- Uncertainty: troposphere: > 4% MR
  stratosphere: ~ 9 %
- Phase sensitive detector:
  electronic sunlight filter
- No liquid/ice ambiguity
- Weight: ~ 400 gr
- Currently interfaced with ECC ozone sonde and Vaisala RS80
- Based on NOAA/CMDL frost point hygrometer
- 162 soundings



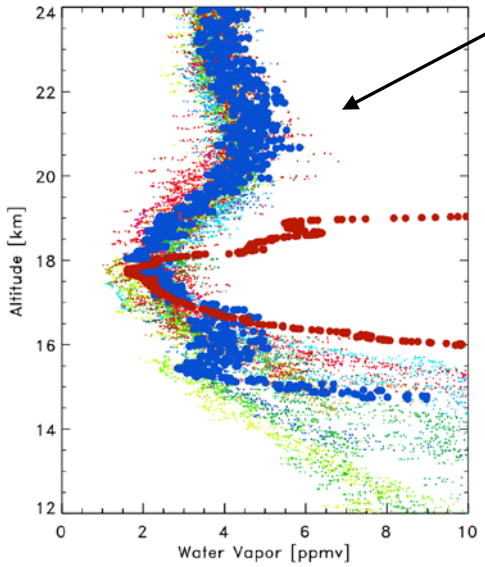
Water vapor mixing ratio
Ticosonde 2006, Jan 4 – Mar 4, 2006



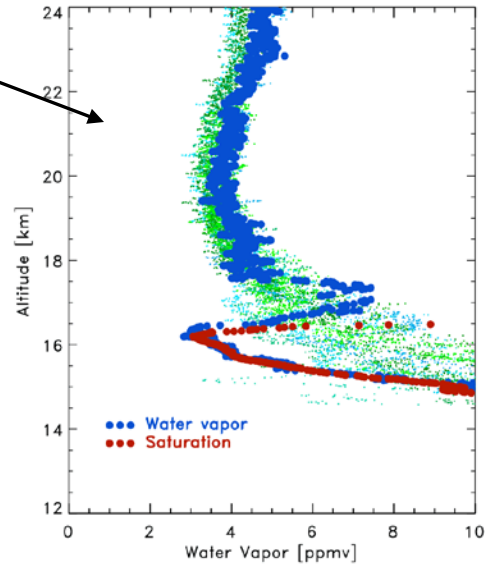
Tropical tropopause dehydration



Ticosonde 2006
Jan 4 - Mar 4, 2006



Ticosonde 2005
July 8-24, 2005



CFH Advantages

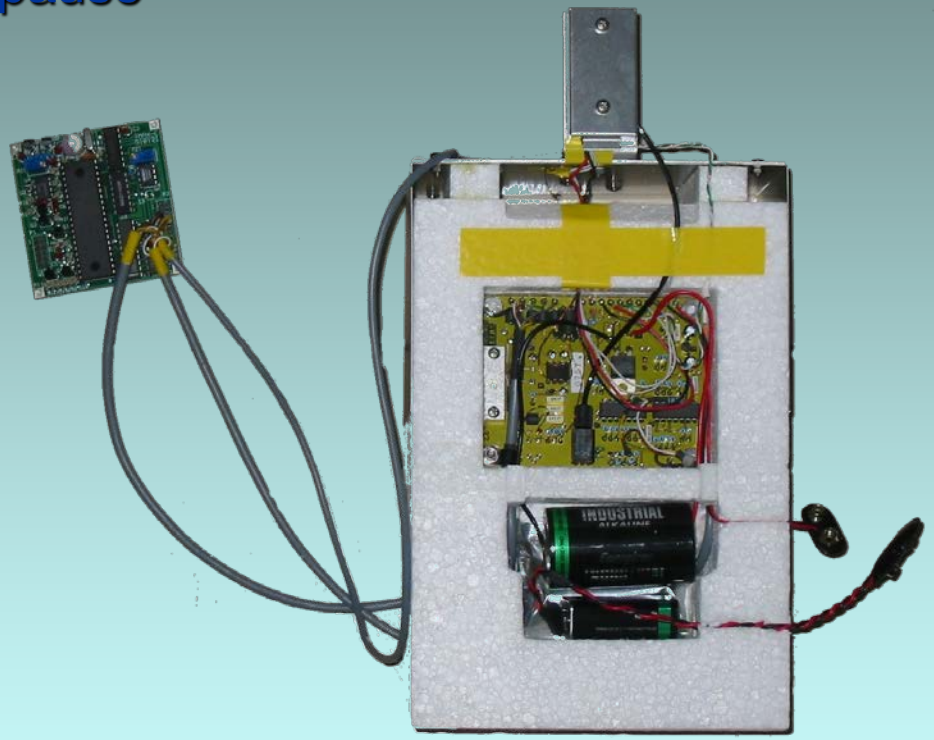
- Measurement based on simple physics
- Measurement not calibrated for water vapor, but rather for temperature (assume vapor pressure equation is correct)
- Extremely large dynamic range
- Long history for technology

CFH Limitations

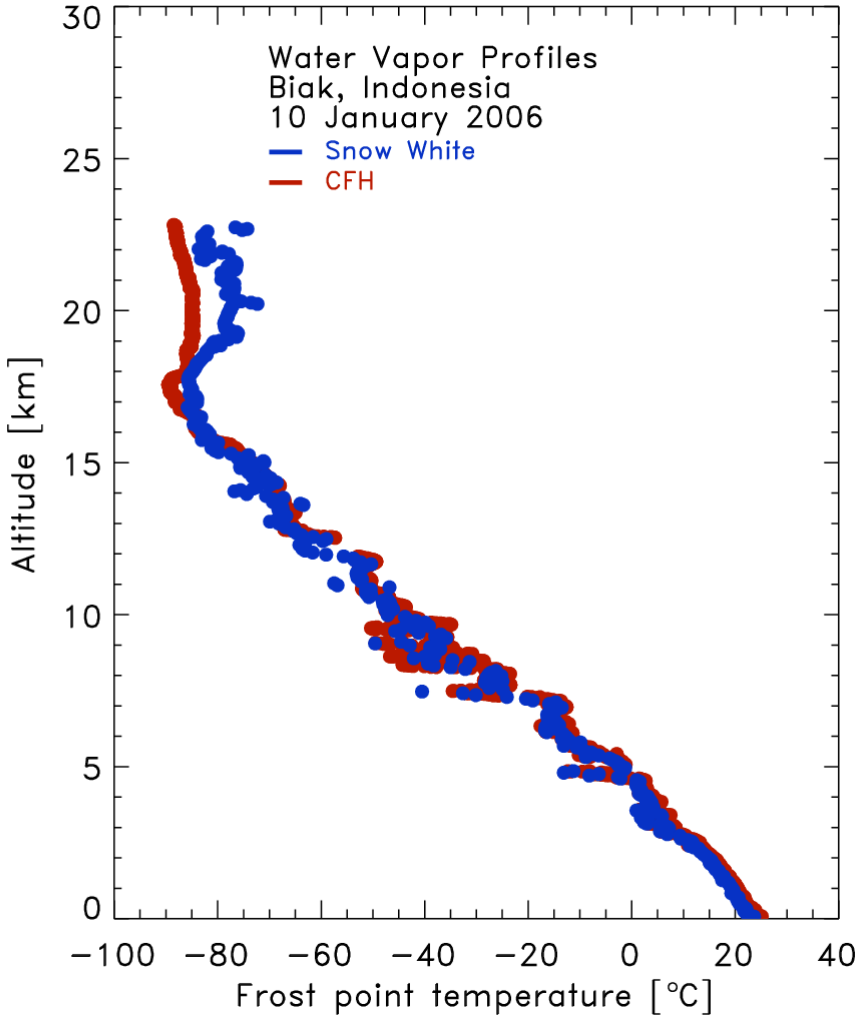
- Instrument may fail completely in “thick” liquid clouds or highly ice-supersaturated air
- High cost
- Availability of cryogen
- Instrument needs minor preparation
- Data product needs understanding of instrument

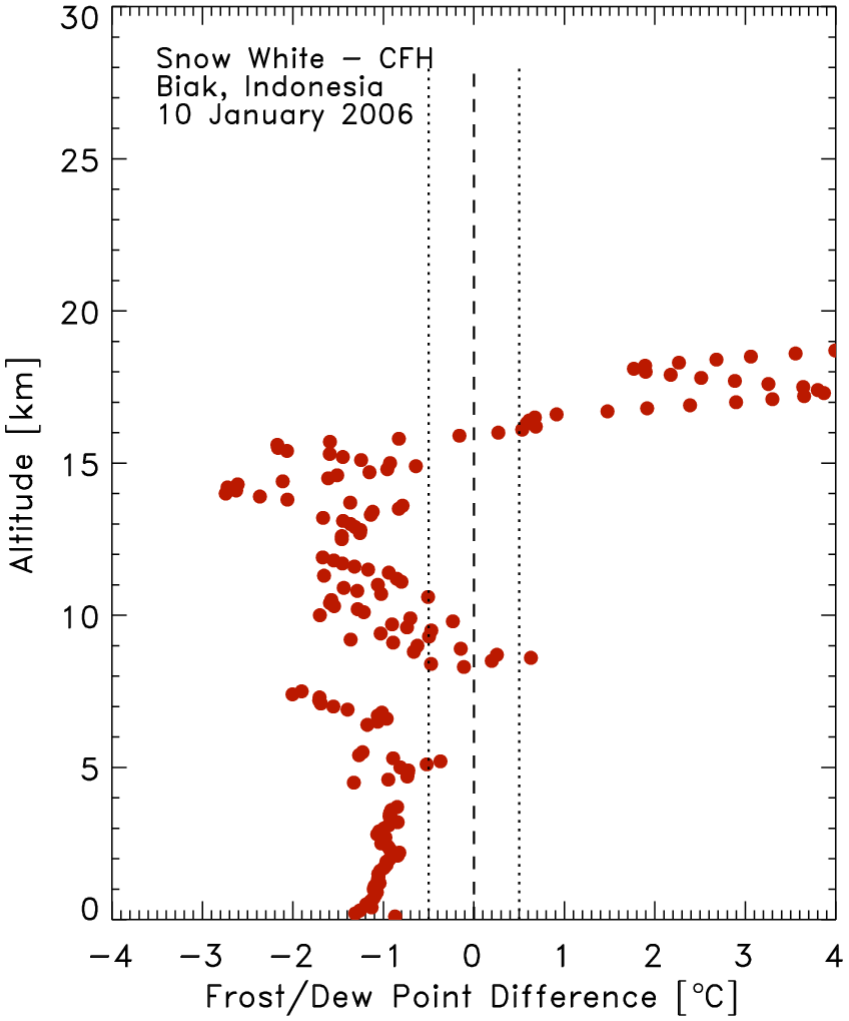
Snow White frostpoint hygrometer

- Peltier cooling
- Vertical Range: surface to < tropopause
- Uncertainty: 0.1°C DP/FP
  realistic 0.5°C DP
- Sunlight sensitive detector
- Liquid/ice ambiguity
- Weight: ~ 400 gr
- Currently interfaced with SRS34, Sippican or Tmax/Vaisala RS80

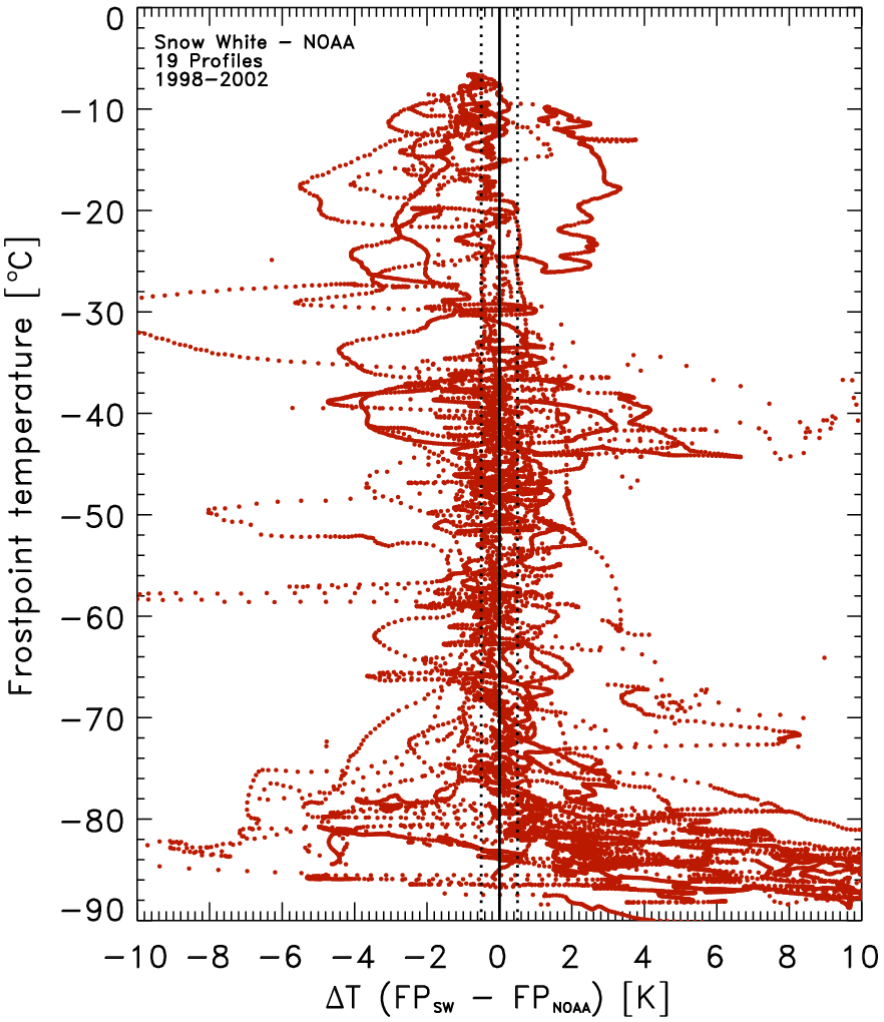


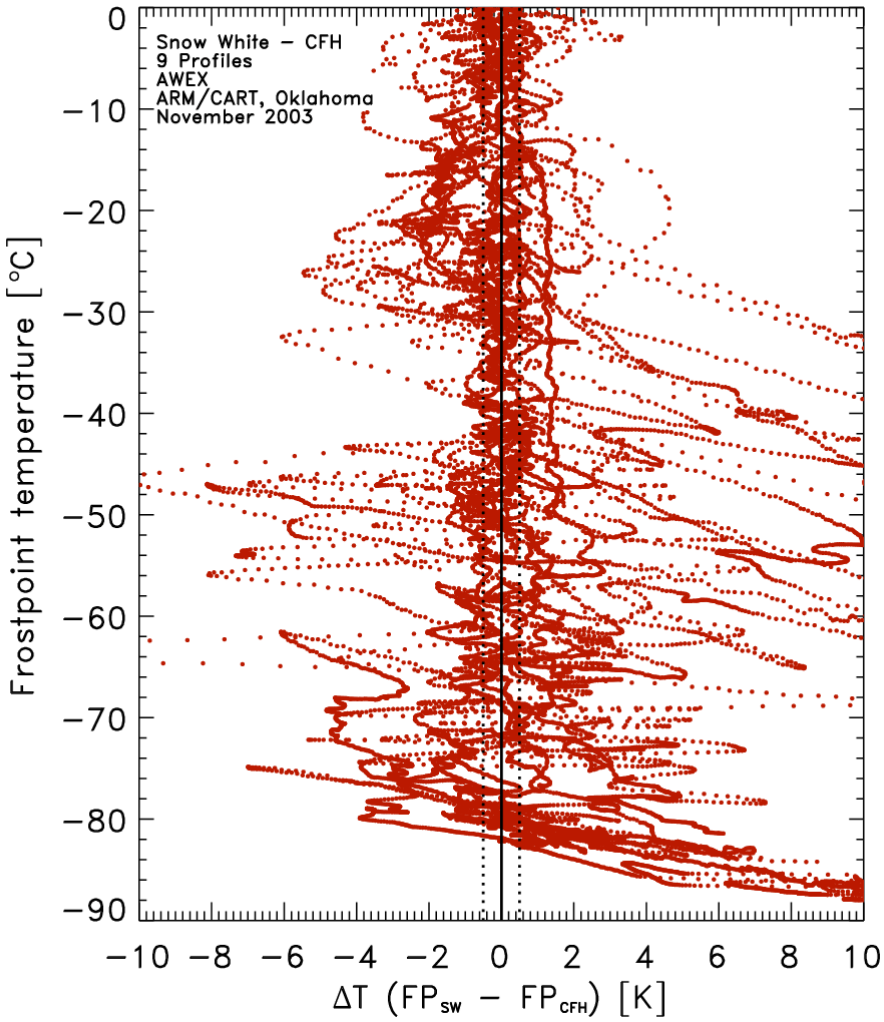
Snow White frostpoint hygrometer





Snow White comparisons





NOAA/CMDL

Galapagos/Huntsville/Boulder/Watuskosek

CFH

AWEX Oklahoma

Snow White Advantages

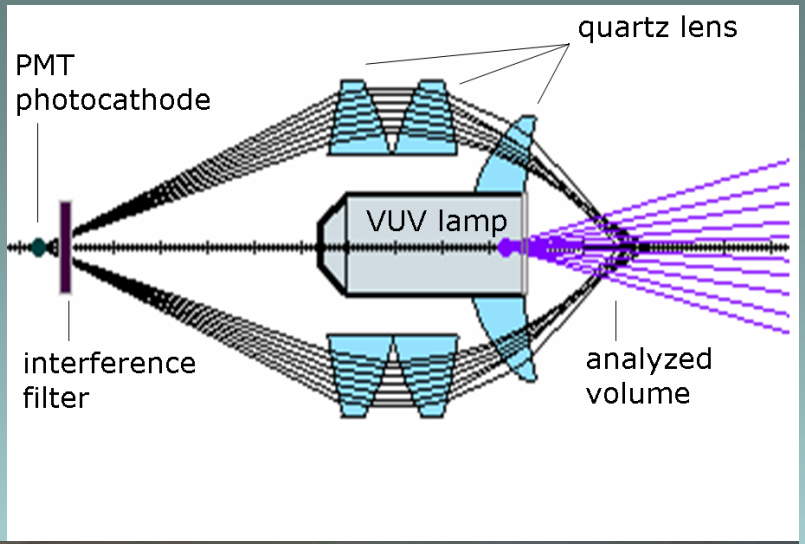
- Measurement based on simple physics
- Measurement not calibrated for water vapor, but rather for temperature
- Large dynamic range
- Simple operation

Snow White Limitations

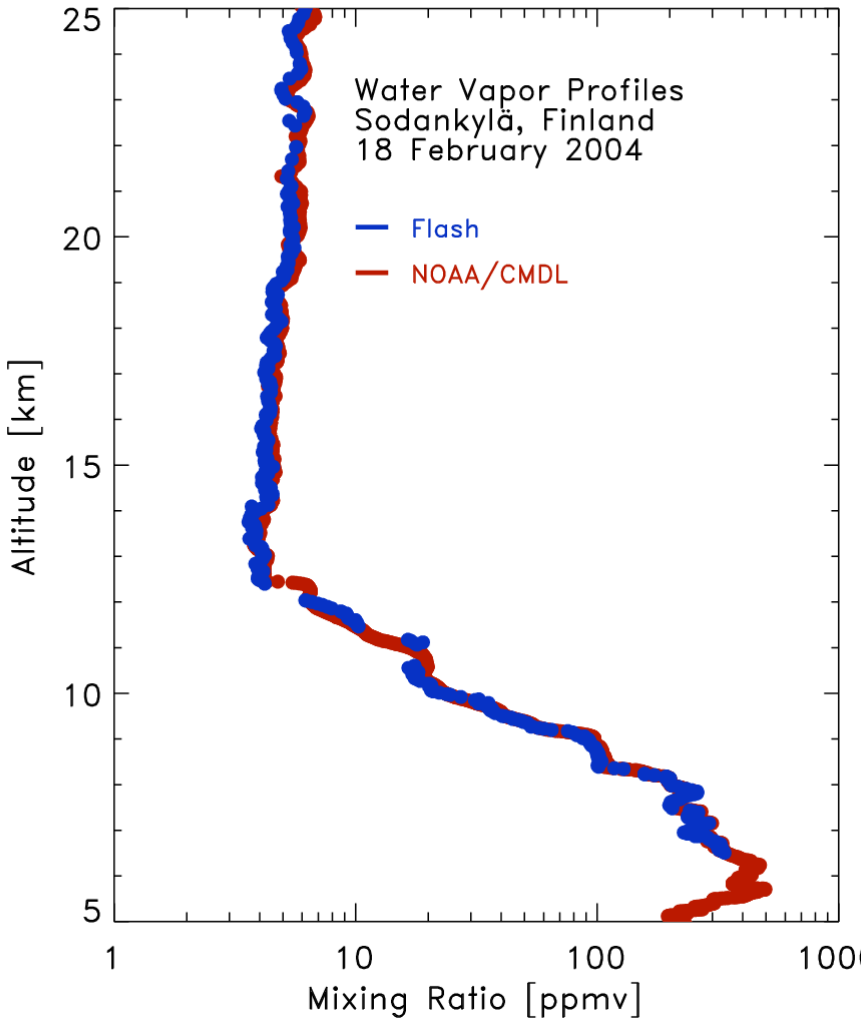
- Highly sensitive to cloud contamination
- Occasional unexplained failure
- Moderate cost
- Limited to below tropopause
- Limited to RH ≥ 3-6%
- Data product needs understanding of instrument

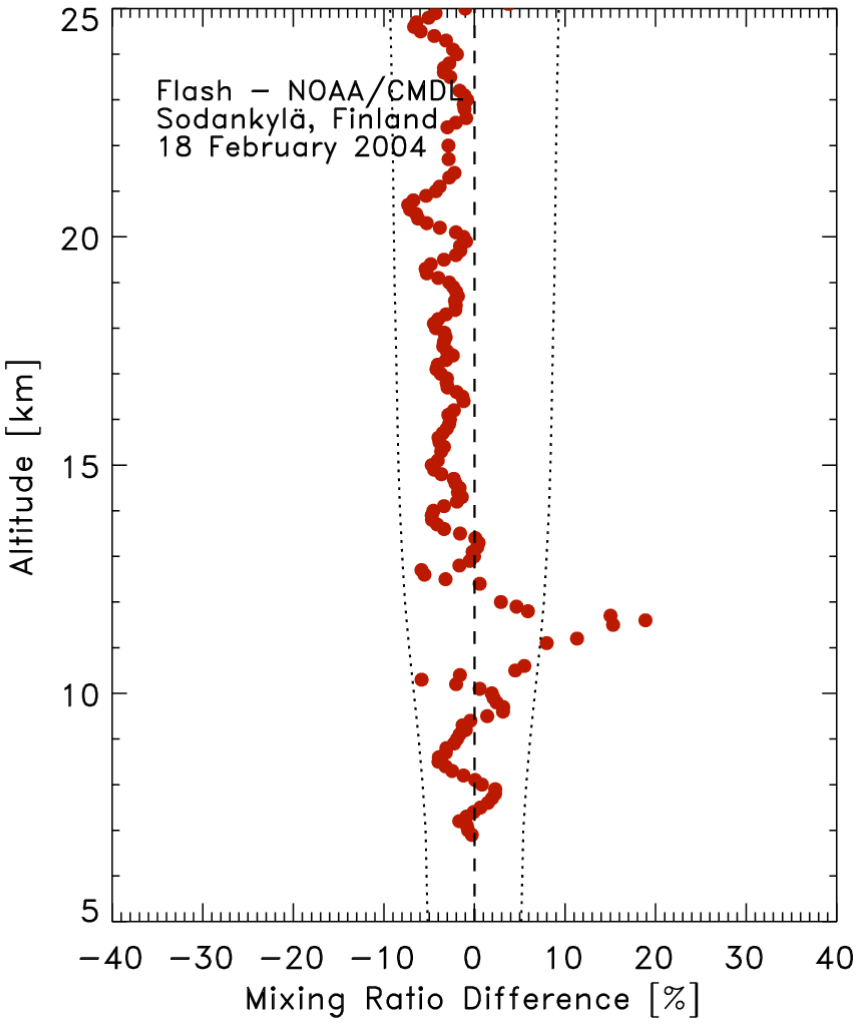
FLASH - Lyman-α

- Fluorescent Lyman Alpha Stratospheric Hygrometer (FLASH)
- Vertical Range: upper troposphere to stratosphere (0.5 to 500 ppmv)
- Calibrated against reference frost point
- Uncertainty: 9% MR
- Night time (descent) only
- Weight: ~ 1 kg
- Currently interfaced Vaisala RS80
- 45 soundings

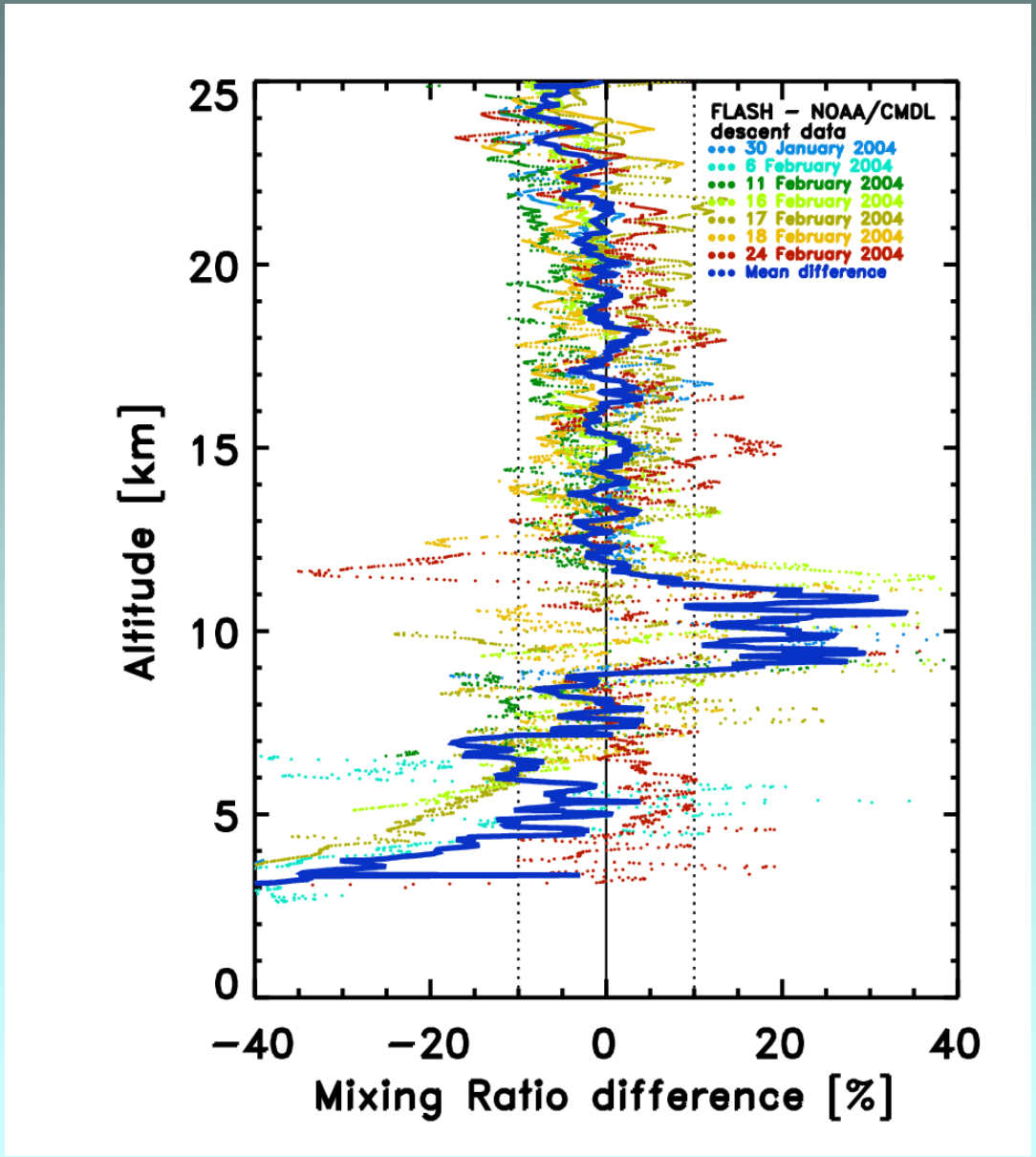


FLASH - Lyman-α





FLASH - Lyman-α



FLASH Advantages

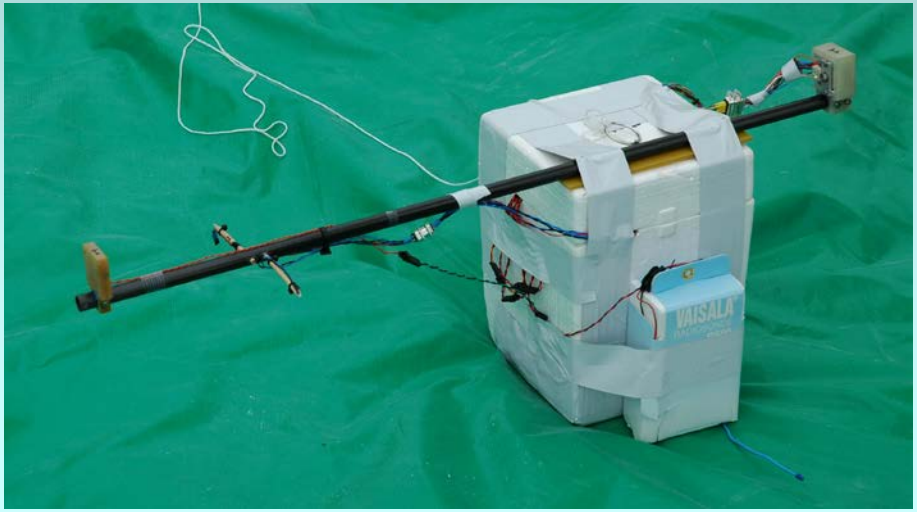
- Calibrated against frost point standard
- High measurement precision
- Very fast sensor
- Largely insensitive to clouds
- Large dynamic range (low mixing ratios)

FLASH Limitations

- Instrument measures properly on descent
- Can only measure during night time
- Full moon limits data range
- High cost
- Measurement range : 0.5 to 500 ppmv
- Currently can’t check calibration in the field

MayComm TDL

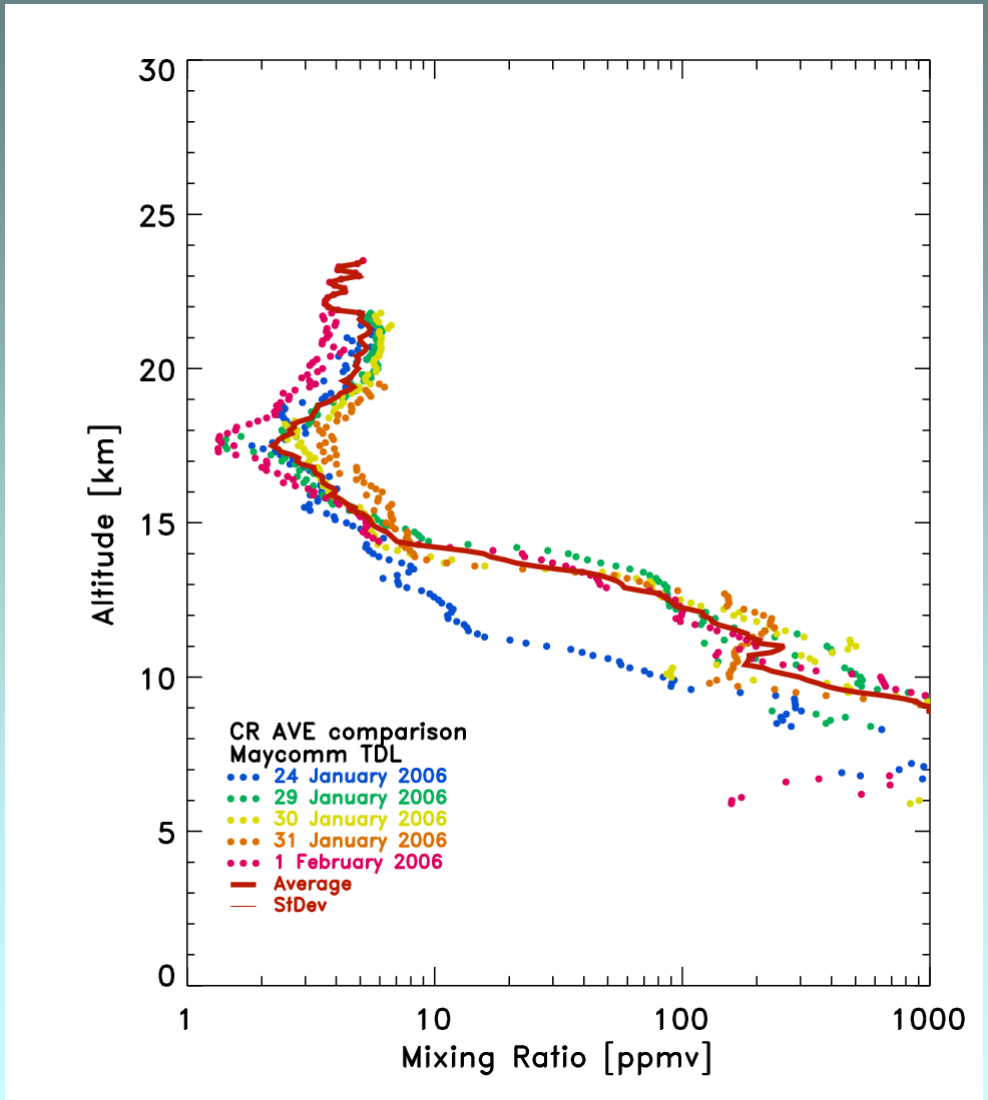
- Tunable Diode Laser
- Vertical Range: mid troposphere to stratosphere
- Calibrated against reference frost point
- Uncertainty: 5% MR or 0.5 ppmv
- Payload weight: ~ 1 kg



MayComm TDL

Costa Rica
January/February 2006

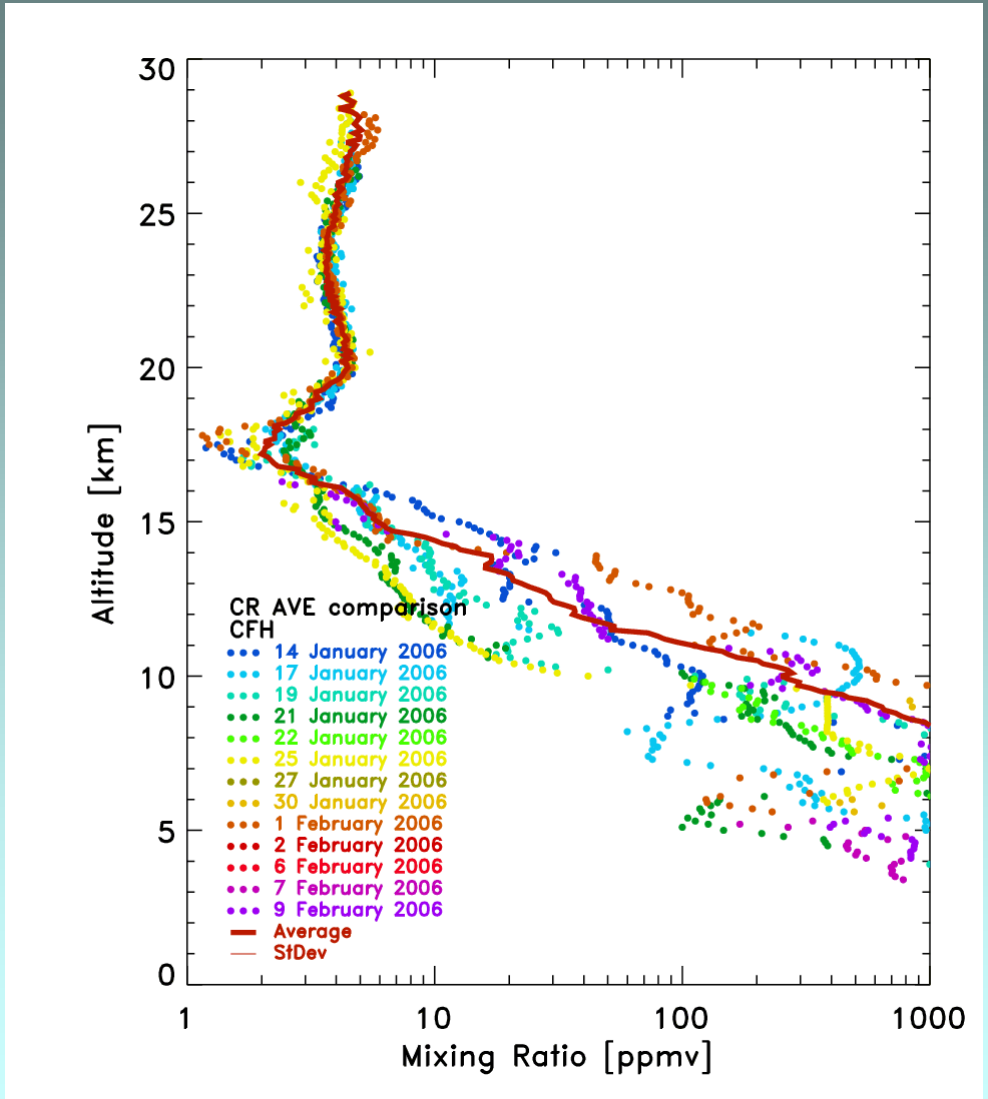
5 TDL soundings



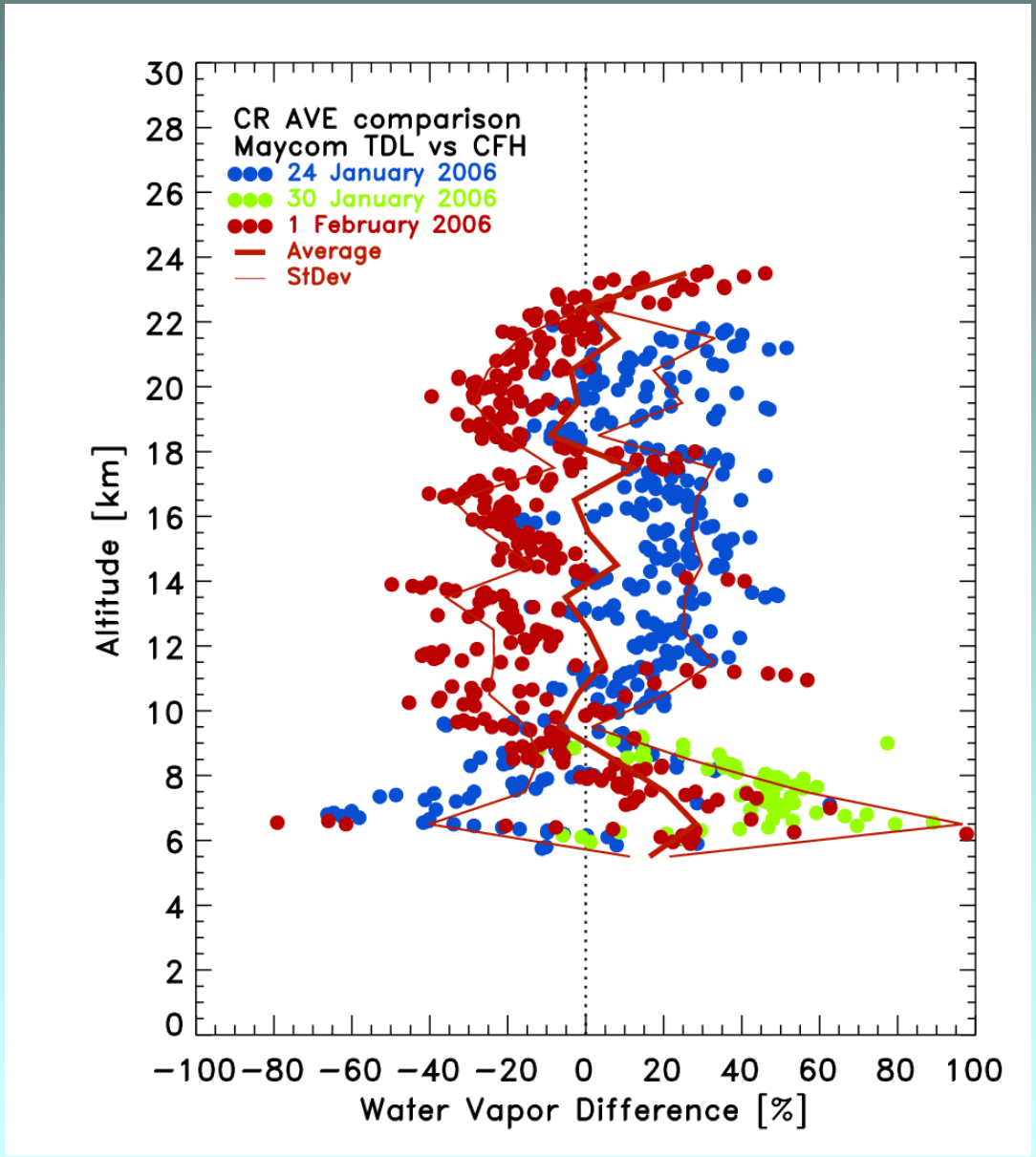
MayComm TDL vs CFH

Costa Rica
January/February 2006

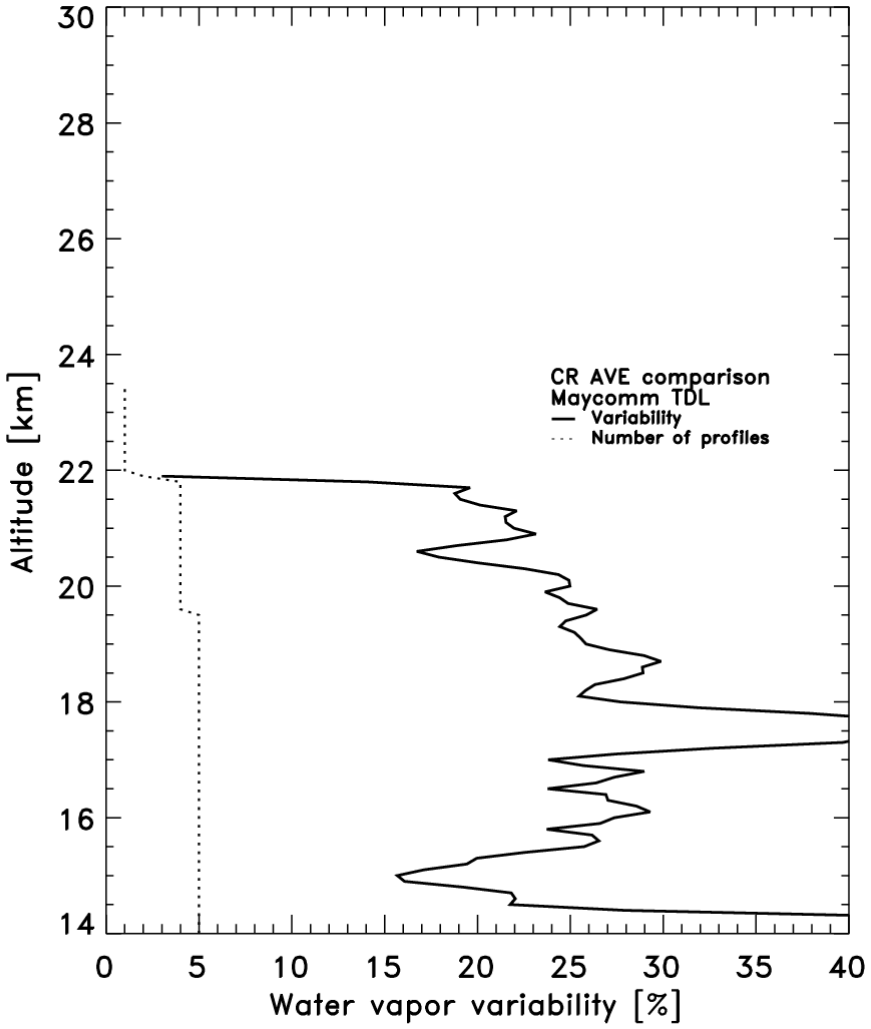
13 CFH soundings



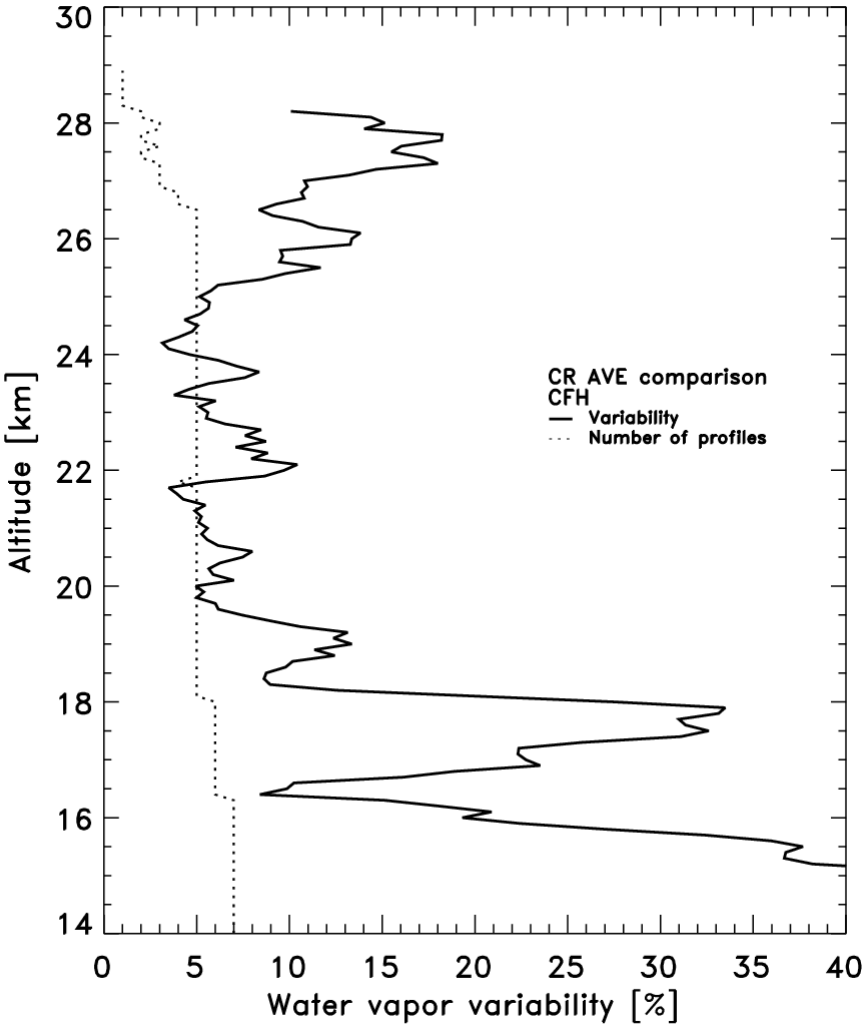
MayComm TDL – CFH comparison



MayComm TDL Variability



TDL



CFH

MayComm TDL Advantages

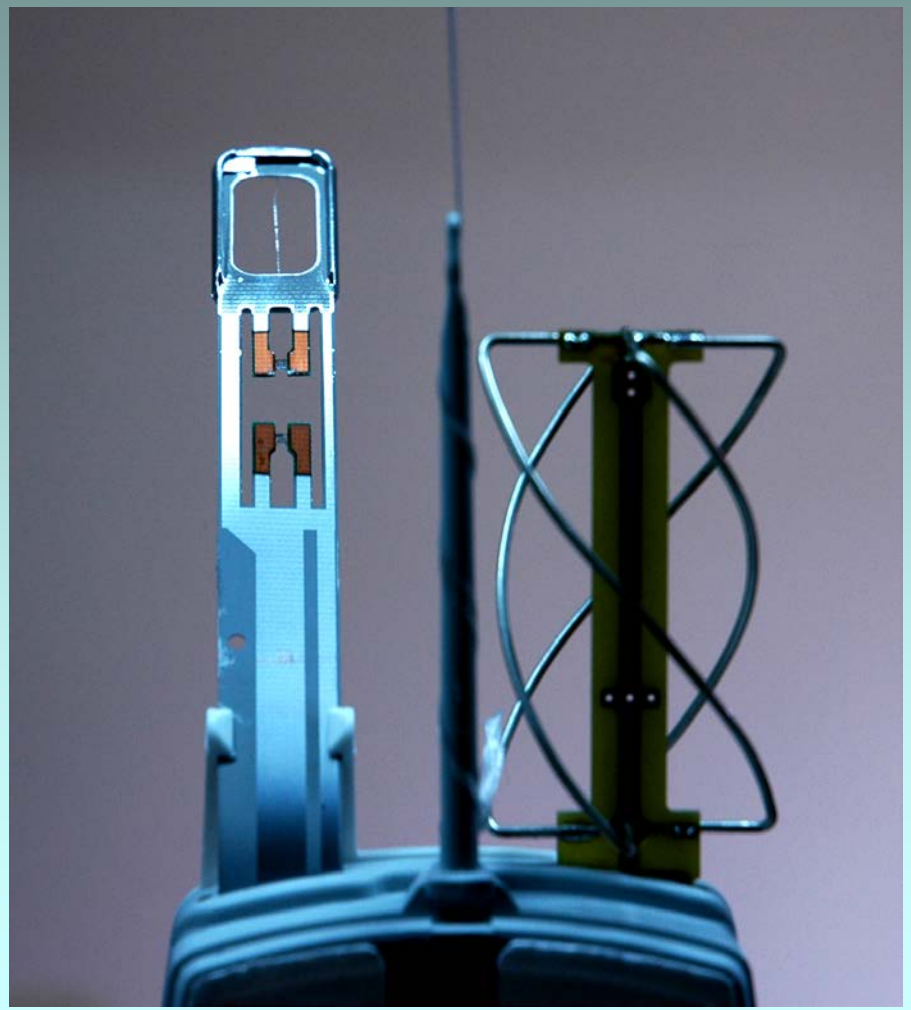
- High measurement precision
- Very fast sensor
- Insensitive to clouds
- Large dynamic range (low mixing ratios)
- Easy to use

MayComm TDL Limitations

- Prototype only
- High cost
- No lower troposphere
  (Can extend to surface with second path)
- No stable interface/telemetry system yet

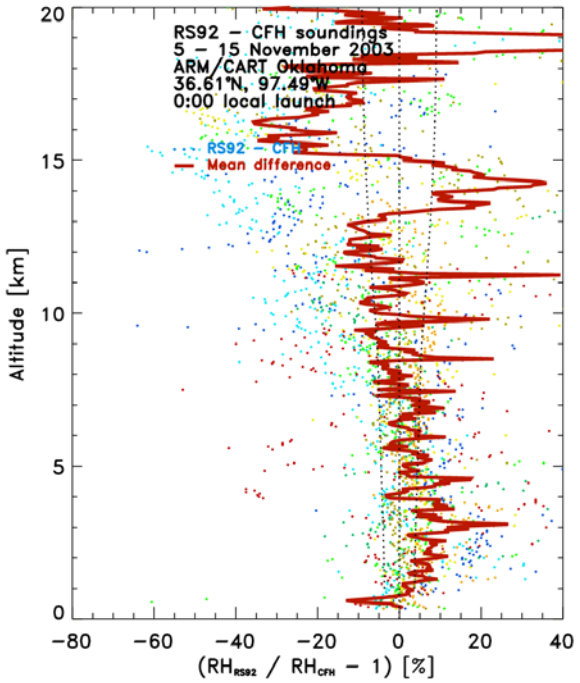
Polymer sensor (Vaisala RS92)

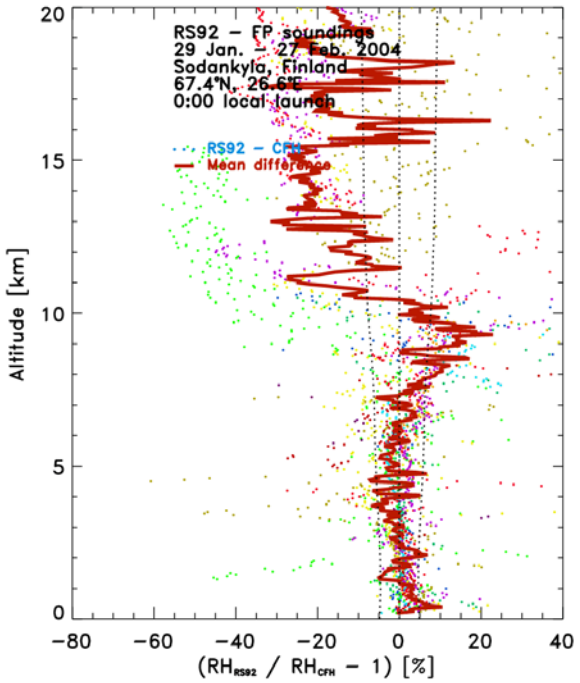
- Capacitive polymer sensor
- Vertical Range: lower to upper troposphere (?)
- Uncertainty: 2-5% RH
- Payload weight: ~ 250 g
- Sensors go through undocumented changes

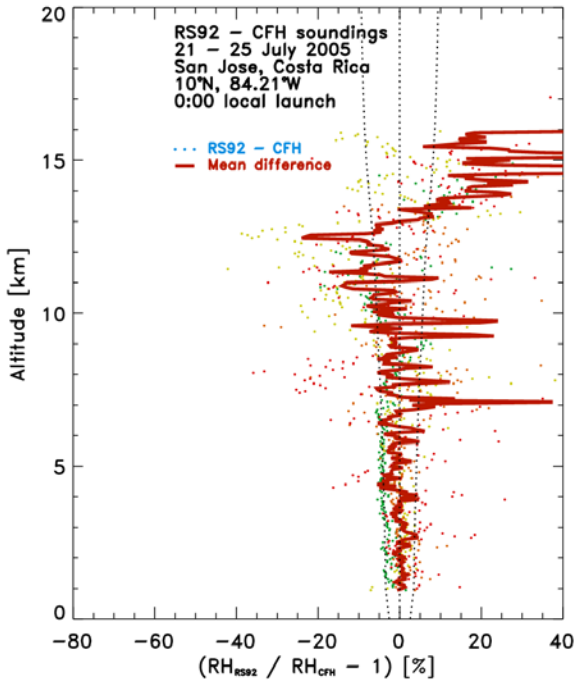


Polymer sensor (Vaisala RS92)

Night time comparisons RS92 vs CFH







AWEX, Oklahoma

Nov 2003

Lautlos, Finland

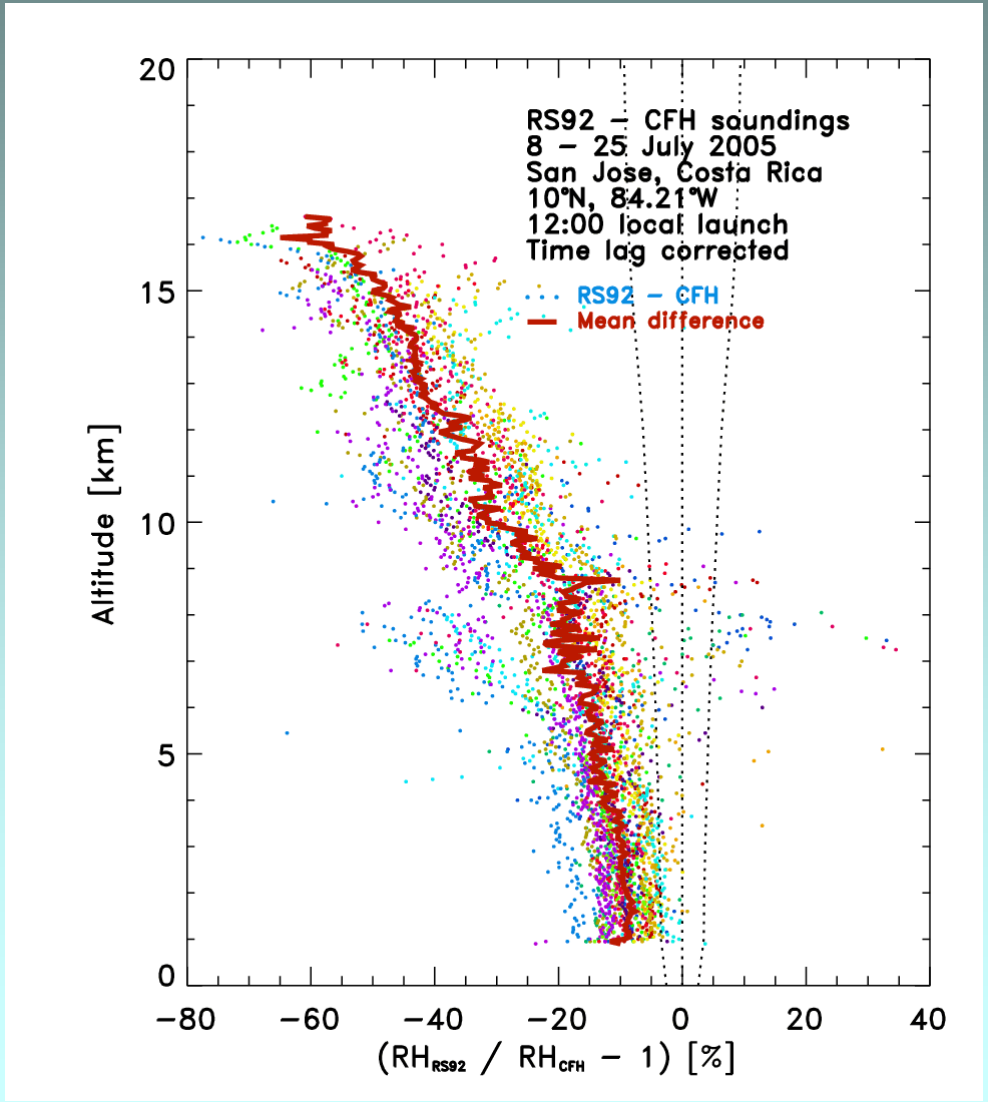
Feb 2004

TCSP, Costa Rica

Jul 2005

Polymer sensor (Vaisala RS92)

Day time comparison RS92 vs CFH



TCSP, Costa Rica

Jul 2005

Polymer sensor (Vaisala RS92) Advantages

- Very low cost
- Largely insensitive to clouds
- Easy to use
- Vaisala RS92: One of the best of the polymer sensors

Polymer sensor (Vaisala RS92) Limitations

- Very large solar radiation sensitivity
- Good measurements need third party corrections
- Very hard to trace calibration changes
- Very hard to trace sensor changes

	Claimed accuracy	Calibration	Limitations	Dynamic range	History	Cost	Ease of use	Engineering status
CFH	0.5°C DP/FP 4-9%	++	No "wet" clouds	++	+	- (o)	o	research / small series
Snow White	0.1°C DP/FP	+	Some clouds RH > 3-6% No stratosphere	o	+	o	++	production small series
Lyman-alpha (FLASH)	9% (20% below 2 ppmv)	+	Night time only Descent only No lower troposphere	+	o	--	+	research / small series
TDL (MayComm)	5% 0.5 ppmv	o	?	+	-	--	(++)	Proof of concept
Polymer (Vaisala RS92)	2-5% RH	-	No stratosphere Large radiation error Chemical contamination Very hard to trace sensor/calibration changes	-	+	++	+ (++)	Large scale production

Questions?