SORAS and SWARA radiometer in Seoul, Korea

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Sookmyung Women's University

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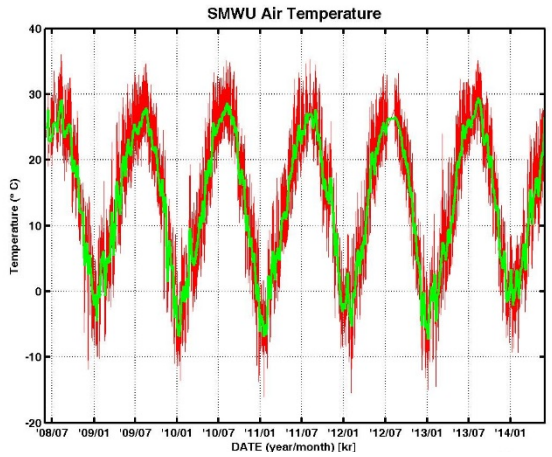
Contents

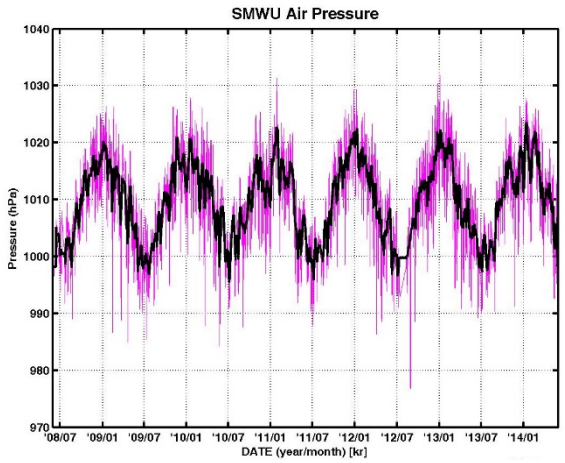
1. Institute, RIGE

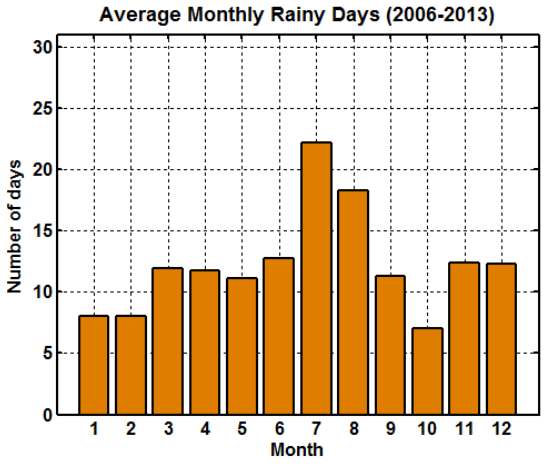
- RIGE, Research Institute of Global Environment
  - Sookmyung Women's University in Seoul, Korea
  - 37.32 °N, 126.57 °E, 52m a.s.l.

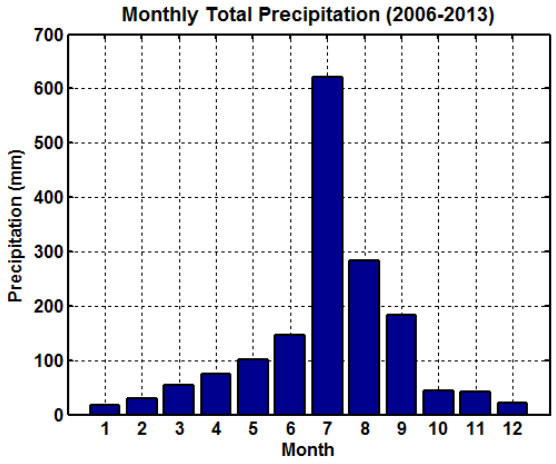
- Main Instruments for the Observation
  - 110.836 GHz Ozone Radiometer
  - 22.235 GHz Water Vapor Radiometer
  - 3rd Instrument : Observation or Chemistry?

1. Weather Condition of Seoul





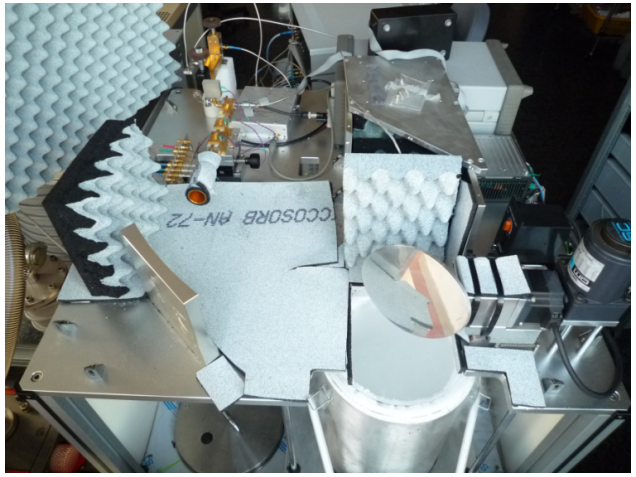




- Summer
  - Higher than 30 ℃ (Jul ~Aug)
  - Rainy Season(July)
  - 2 or 3 typhoons/year (Aug~Sep)
- Winter
  - Dry
  - Good condition for t he ground-based M W measurement

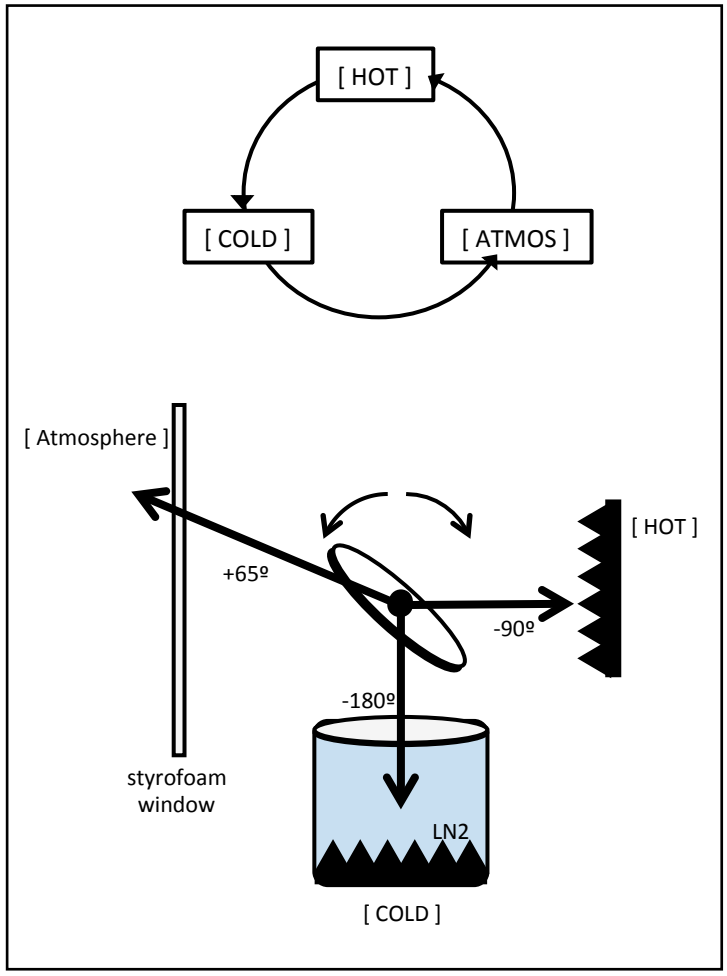
2. SORAS

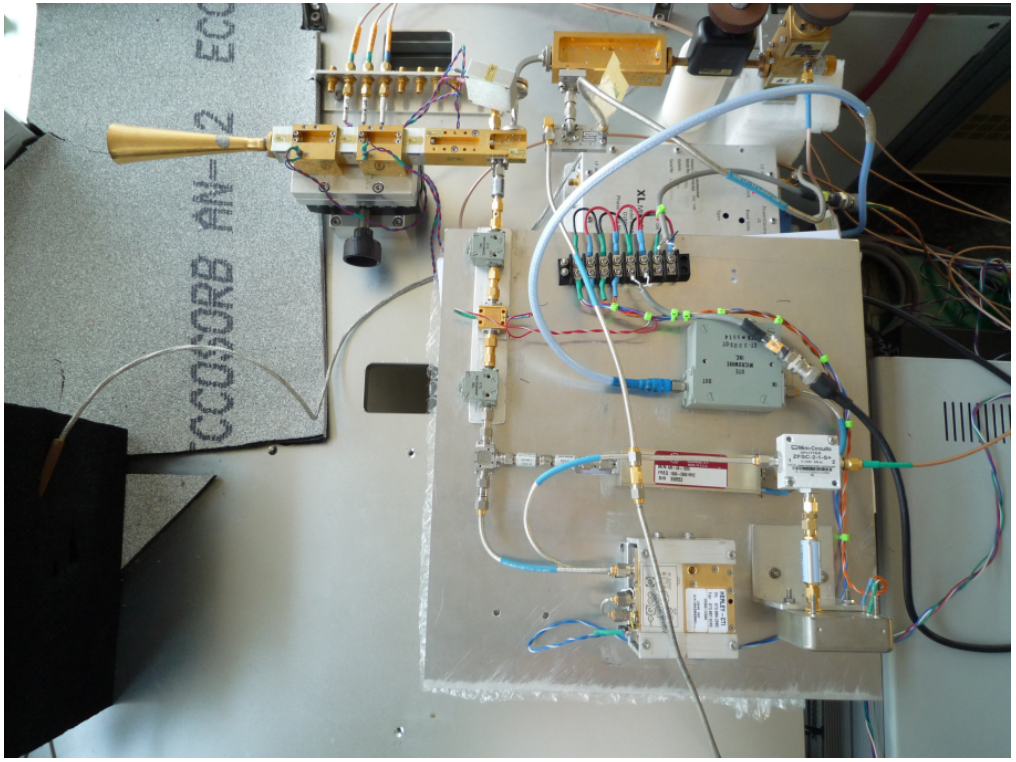
- SORAS
  - Stratospheric Ozone RAdiometer in Seoul
  - Located inside of the ozone observatory in Sookmyung Women's University
  - Receiving 110.836 GHz signal from the atmosphere thru a Styrofoam window
  - Acqiris FFT spectrometer of 1 GHz bandwidth
  - Continuous 24 hours measurement

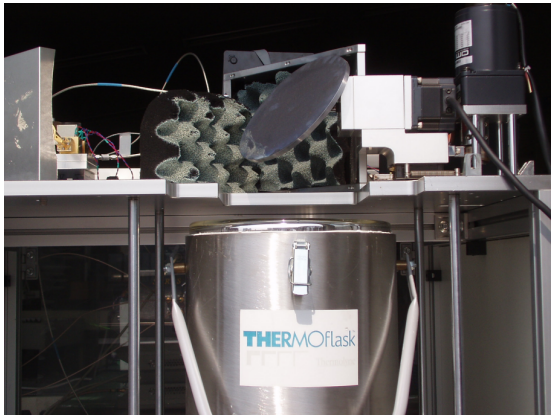


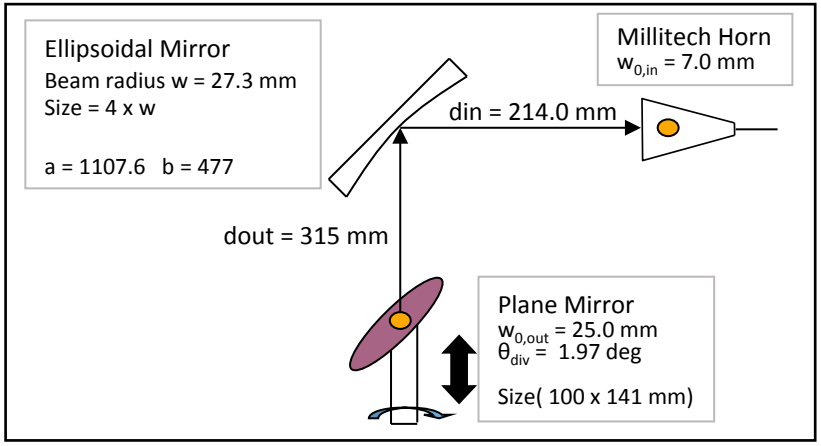
2-1. SORAS Instrument

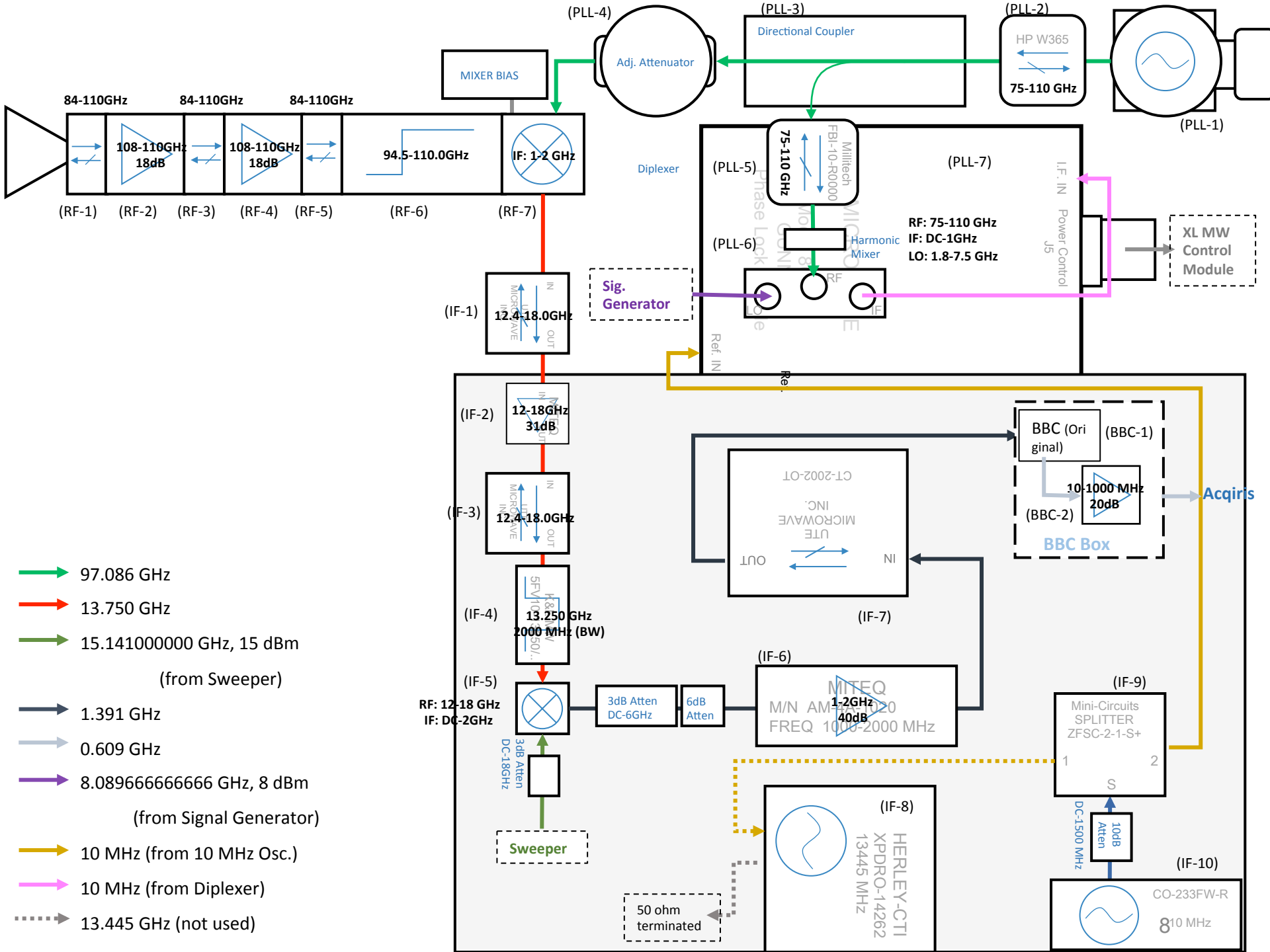
- Total power system with 2 reference loads plus Sky
- Hot - Cold - Sky - Hot - Cold - Sky - …
  - Hot - Eccosorb CV3 absorber in 30 ℃
  - Cold - CV3 absorber in liquid nitrogen
    - Refill LN_2 once a day (at PM 5:00)
  - Sky - 65 degrees direction in zenith
    - Penetrating the styrofoam window of 2 cm width





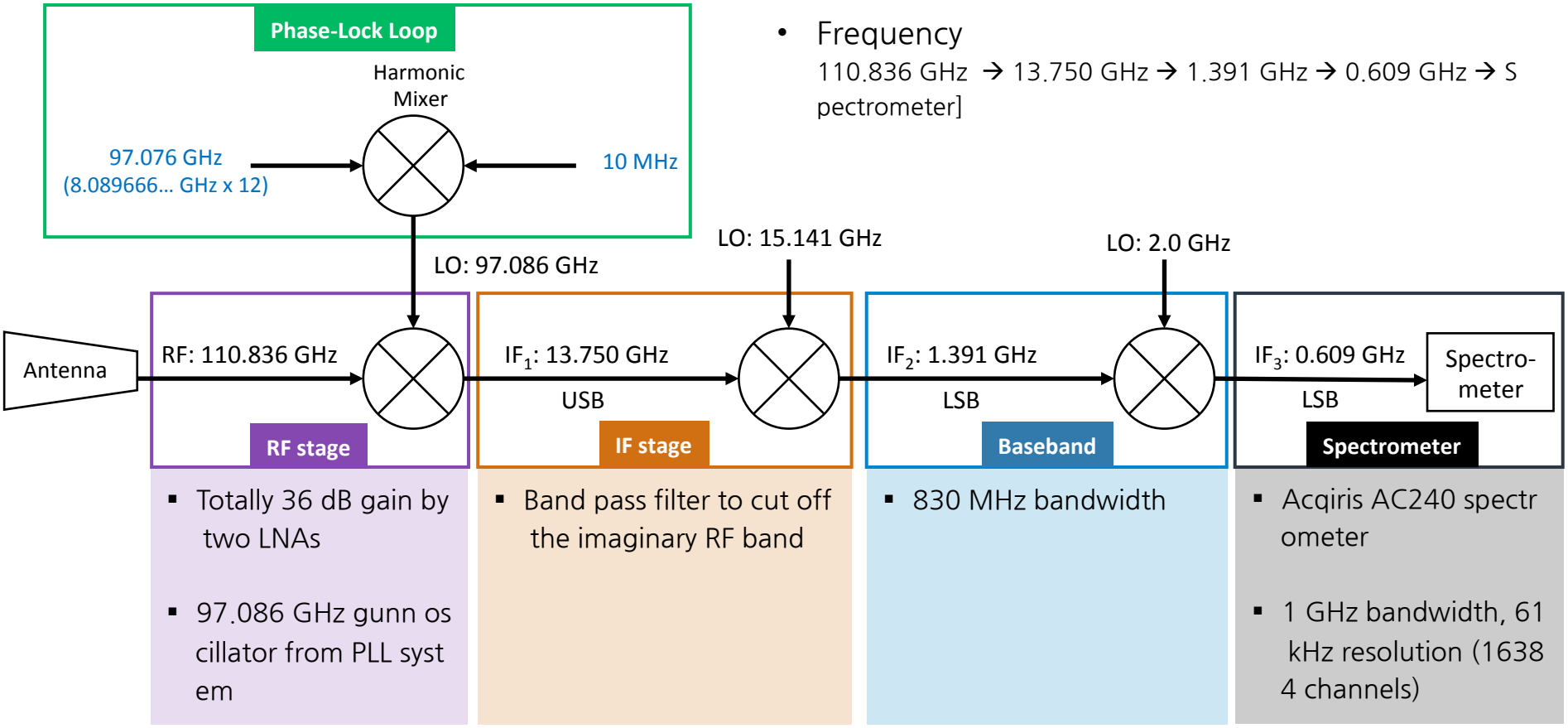

THERMOflask


Ellipsoidal Mirror
Beam radius w = 27.3 mm
Size = 4 x w
a = 1107.6 b = 477
Millitech Horn
$w_{0,in}$ = 7.0 mm
din = 214.0 mm
dout = 315 mm
Plane Mirror
$w_{0,out}$ = 25.0 mm
θ_{div} = 1.97 deg
Size(100 x 141 mm)


(PLL-4)
(PLL-3)
(PLL-2)
Directional Coupler
HP W365
75-110 GHz
Adj. Attenuator
MIXER BIAS
(PLL-1)
84-110GHz
84-110GHz
84-110GHz
108-110GHz 18dB
108-110GHz 18dB
94.5-110.0GHz
IF: 1-2 GHz
Diplexer
(PLL-5)
75-110 GHz
Millitech FBI-10-R0000
(PLL-7)
I.F. IN
Power Control J5
RF: 75-110 GHz
IF: DC-1GHz
LO: 1.8-7.5 GHz
(PLL-6)
Harmonic Mixer
XL MW Control Module
Sig. Generator
(RF-1)
(RF-2)
(RF-3)
(RF-4)
(RF-5)
(RF-6)
(RF-7)
(IF-1)
12.4-18.0GHz
Ref. IN
(IF-2)
12-18GHz 31dB
(IF-3)
12.4-18.0GHz
BBC (Original)
(BBC-1)
(BBC-2)
10-1000 MHz 20dB
Acqiris
BBC Box
(IF-7)
(IF-4)
13.250 GHz
2000 MHz (BW)
(IF-6)
(IF-5)
RF: 12-18 GHz
IF: DC-2GHz
3dB Atten DC-6GHz
6dB Atten
MITEQ
1-2GHz 40dB
(IF-9)
Mini-Circuits SPLITTER ZFSC-2-1-S+
3dB Atten DC-18GHz
Sweeper
(IF-8)
HERLEY-CTI XPDRO-14262
13445 MHz
50 ohm terminated
10dB Atten
DC-1500 MHz
(IF-10)
CO-233FW-R
10 MHz
97.086 GHz
13.750 GHz
15.141000000 GHz, 15 dBm
(from Sweeper)
1.391 GHz
0.609 GHz
8.089666666666 GHz, 8 dBm
(from Signal Generator)
10 MHz (from 10 MHz Osc.)
10 MHz (from Diplexer)
13.445 GHz (not used)

2-1. SORAS instrument

- Heterodyne System



- Frequency
  110.836 GHz → 13.750 GHz → 1.391 GHz → 0.609 GHz → S pectrometer]

- Totally 36 dB gain by two LNAs
- 97.086 GHz gunn os cillator from PLL syst em

- Band pass filter to cut off the imaginary RF band

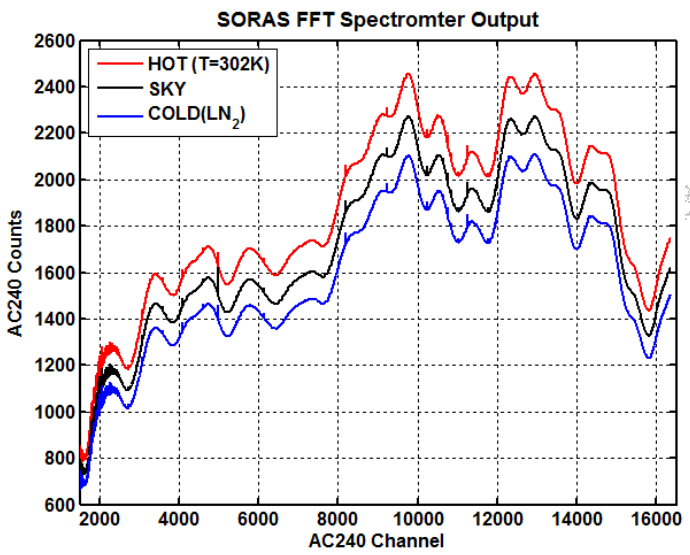
- 830 MHz bandwidth

- Acqiris AC240 spectr ometer
- 1 GHz bandwidth, 61 kHz resolution (1638 4 channels)

- Receiver Temperature : ~ 1250 K

2-2. SORAS spectrum

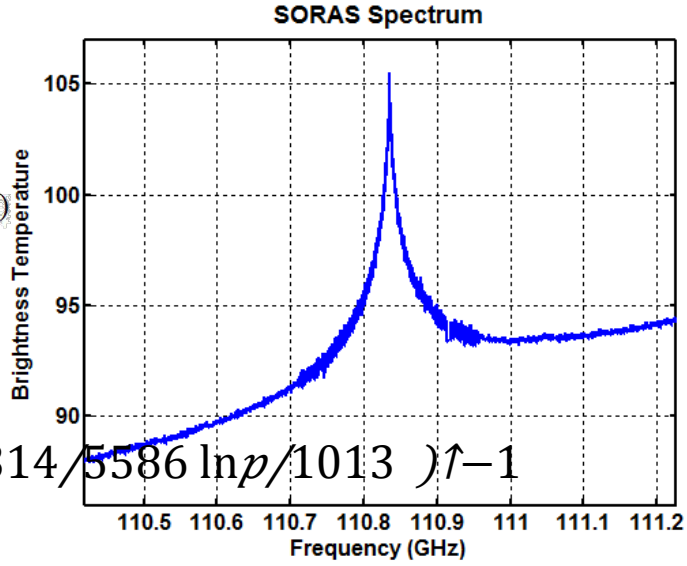
- Spectrum
  - Ozone frequency = 110.836 GHz
  - Channel average to reduce data size
    - 16384 data points → 6178 points
    - Center - 61 kHz resolution (110.836 GHz ∓ 122 MHz)
    - Wing - 305 kHz resolution (110.318~110.714 GHz, 110.958~111.226 GHz)



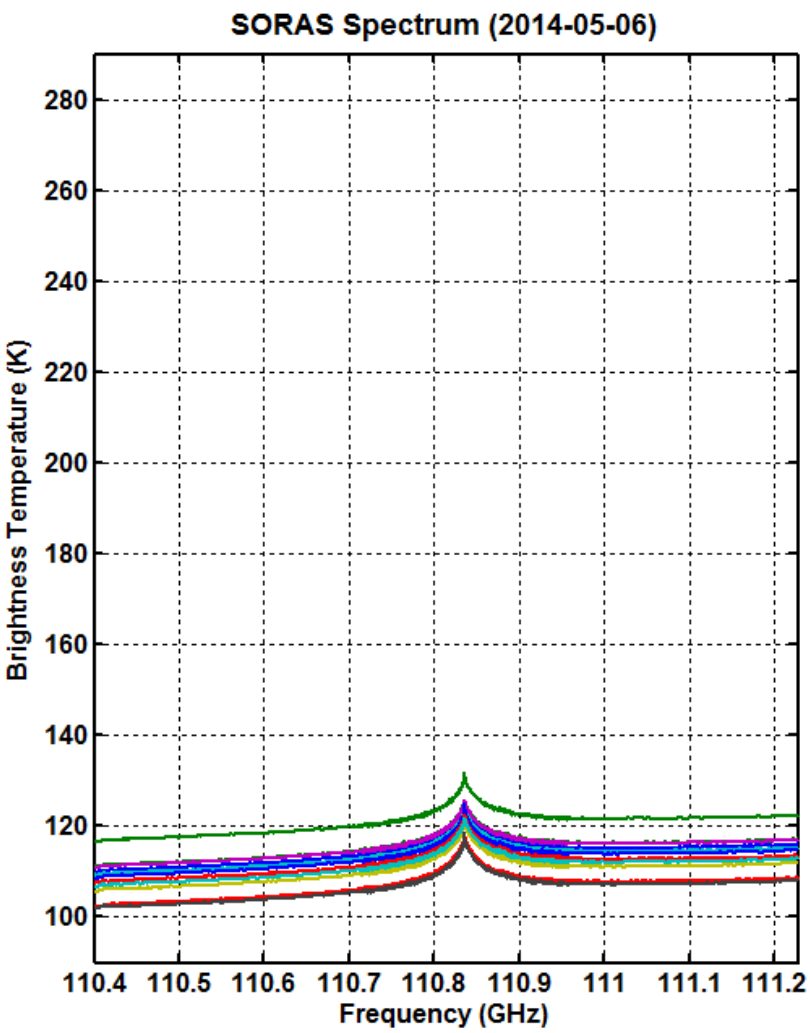
$$T_{B,atm} = T_{B,cold} + \frac{T_{B,hot} - T_{B,cold}}{P_{hot} - P_{cold}}(P_{atm} - P_{cold})$$

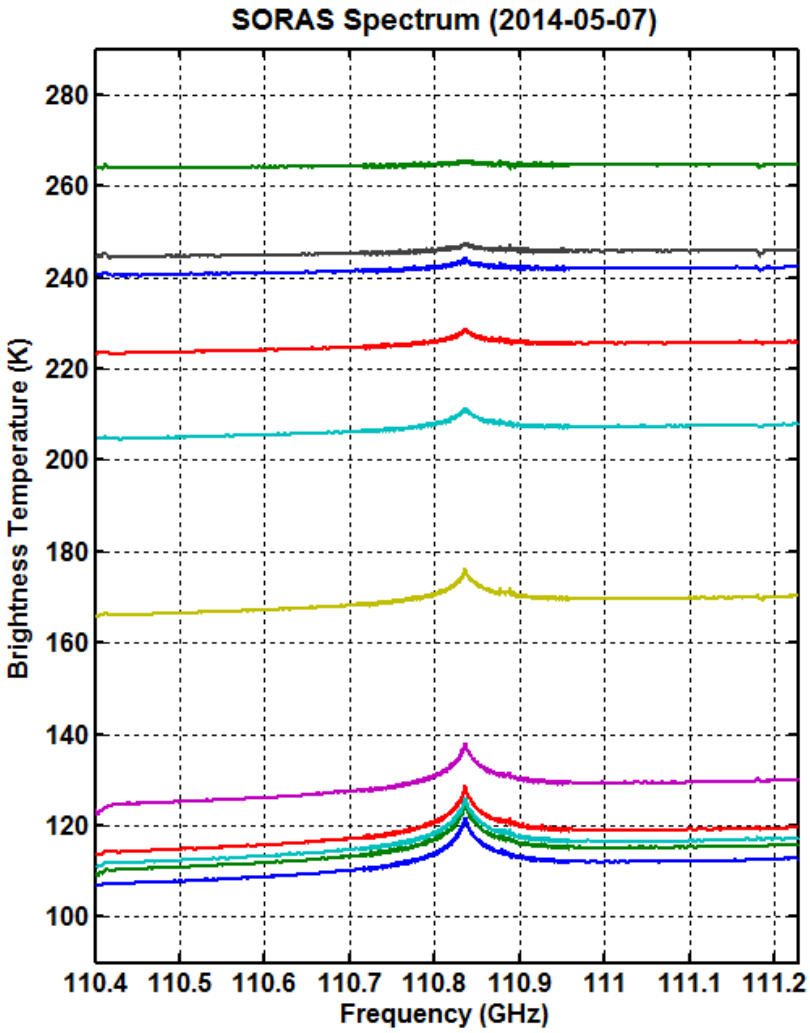
$T_{B,hot}$ from PT100 sensor
$T_{B,cold}$ derived by Clausius-Clapeyron equation with P and T

$$T\downarrow LN2 = (1/77.4 - 8.314/5586 \ln p/1013\ )\uparrow -1$$



2-2. SORAS Spectrum





2-3. SORAS Retrieval

- Spectrum
  - Bandwidth = 800 MHz
  - Allowed noise level = 0.2 K (Normal integration time for 1 ~ 1.5 hours)

- Platform
  - **Platform altitude = 52 m**
  - Zenith angle = 65 degrees

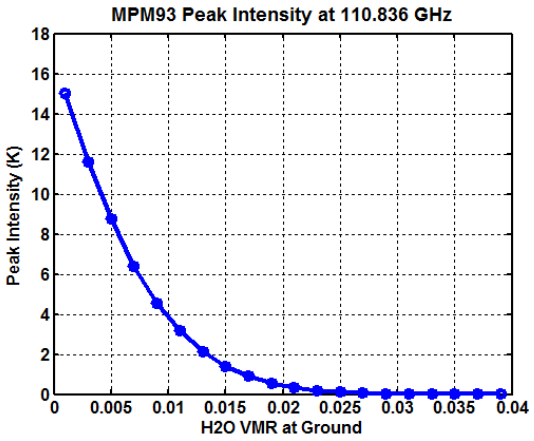
- Temperature information
  - AURA MLS v3.3 climate data + Sonde(~1000 Pa, @Pohang) + Meteo Sensor data at Sookmyung Univ.

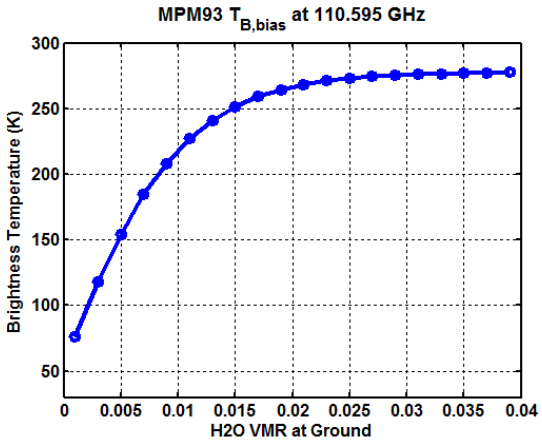
- *a priori* profile
  - [Ozone] : AURA MLS v3.3 climate profile (825~2.1 Pa) + Pohang Sonde(~1000 Pa)
  - [Water vapor] : AURA MLS v3.3 climate profile (6800 ~ 0.42 Pa) + FASCOD + **Estimated $[H_2O]_{ground}$**
  - [N2],[O2] and [CO2] : FASCOD

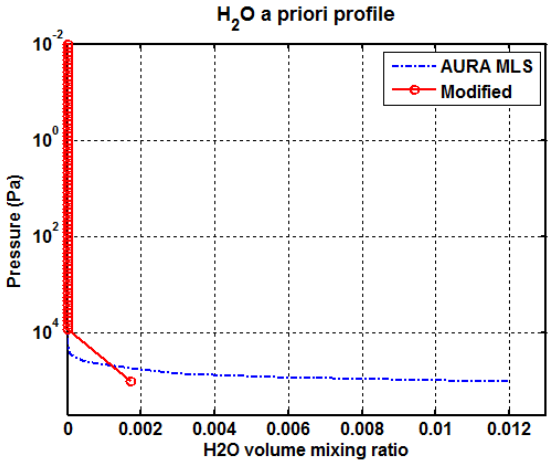
- 1st order of polynomial baseline fitting

2-4. SORAS Retrieval

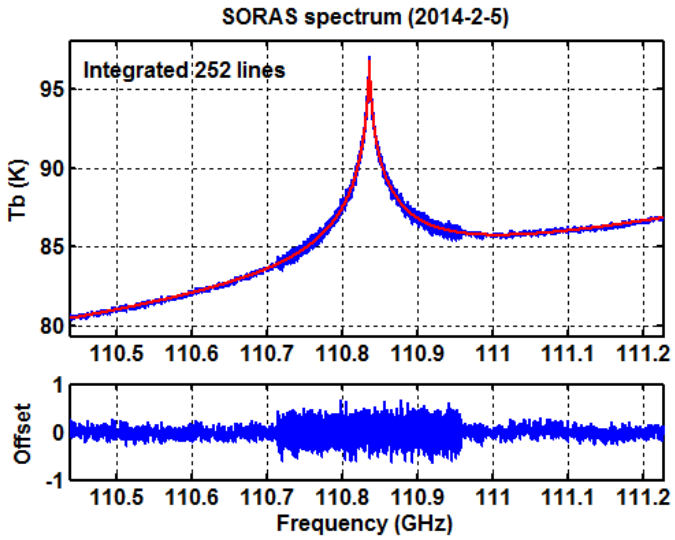
- Estimation for the ground H_2O volume mixing ratio
  - ① Get SORAS peak intensity and bias temperature
  - ② Estimate the ground H_2O volume mixing ratio corresponding ① SORAS values from MPM93 model
  - ③ Replace H_2O a priori data below 16 km by the estimated one

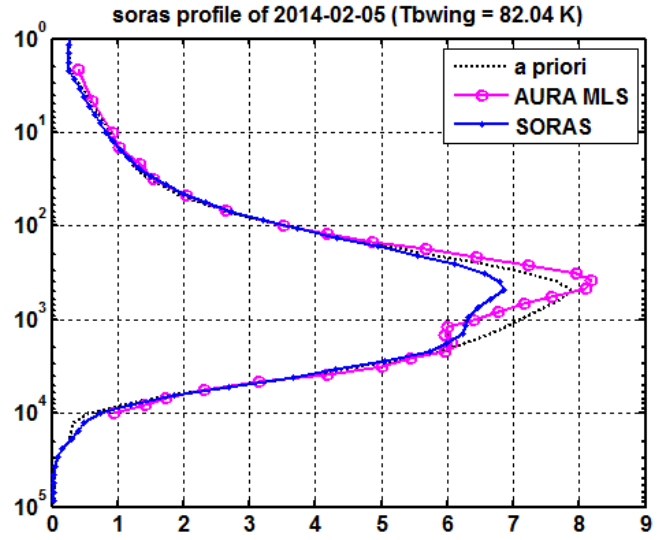


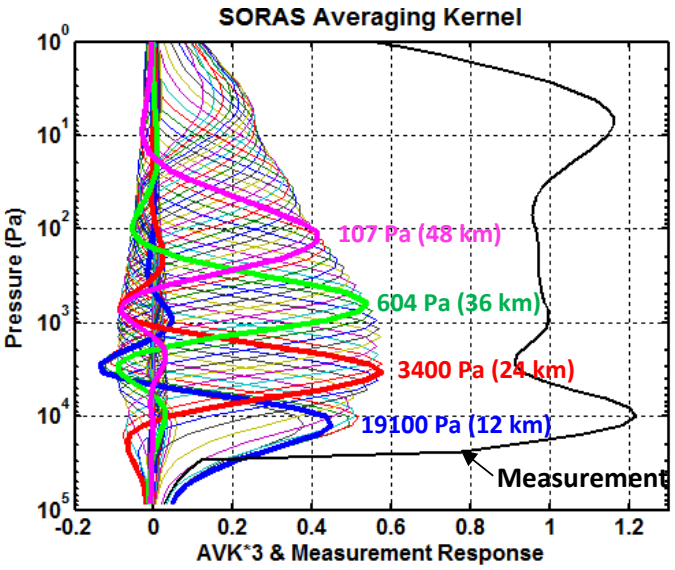


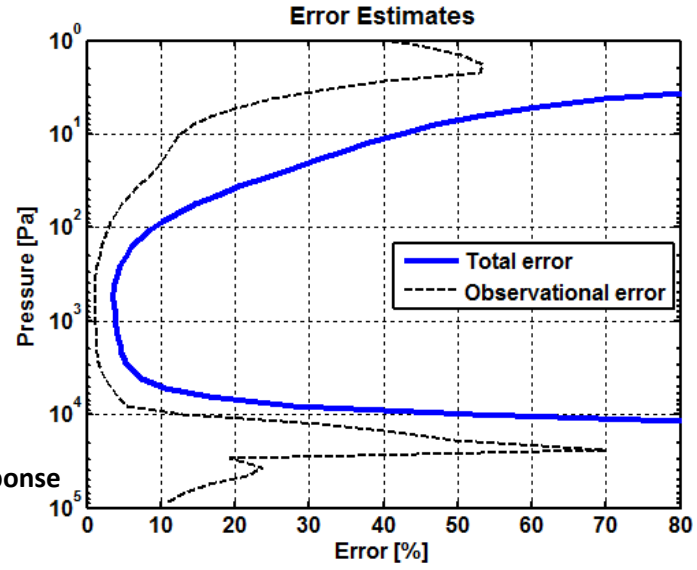


2-4. SORAS Retrieval (2014-02-05, 82 K)

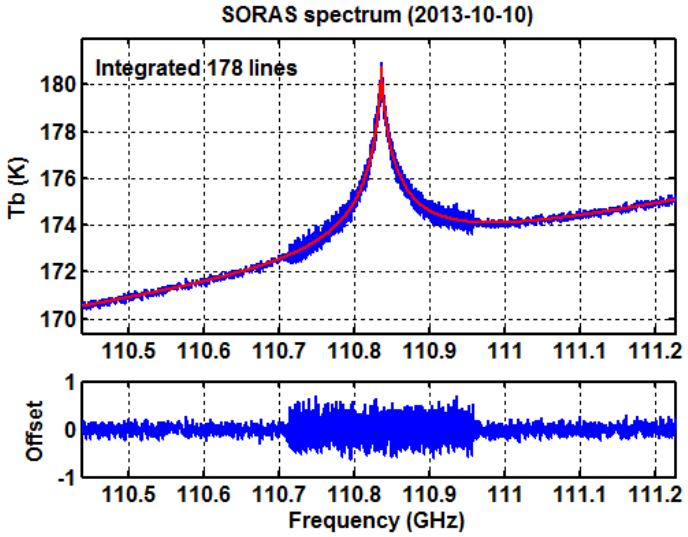


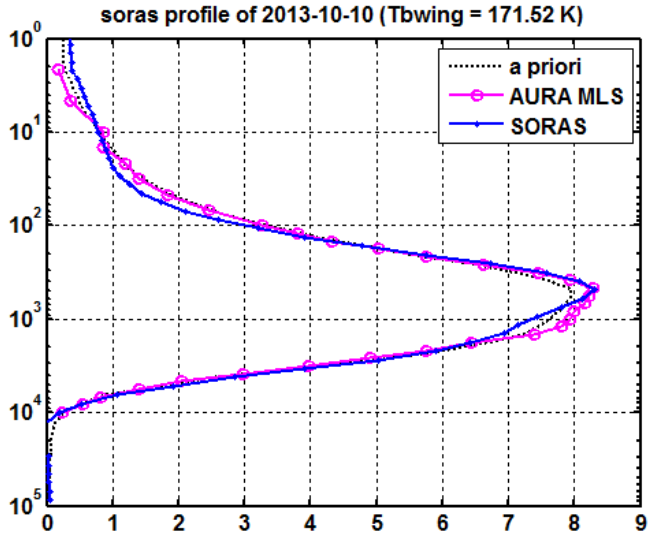


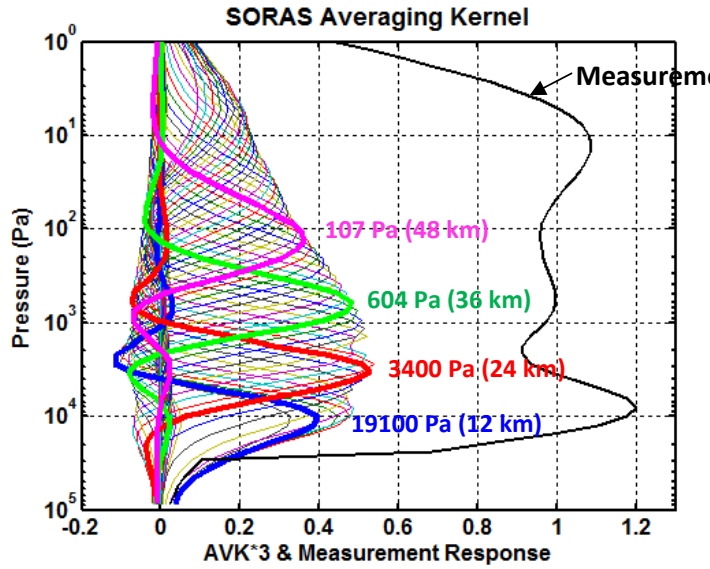


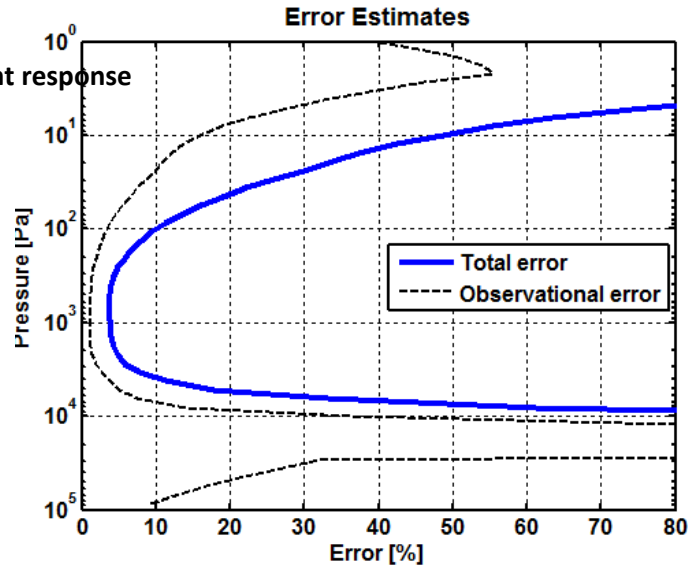


2-4. SORAS Retrieval (2013-10-10, 171 K)

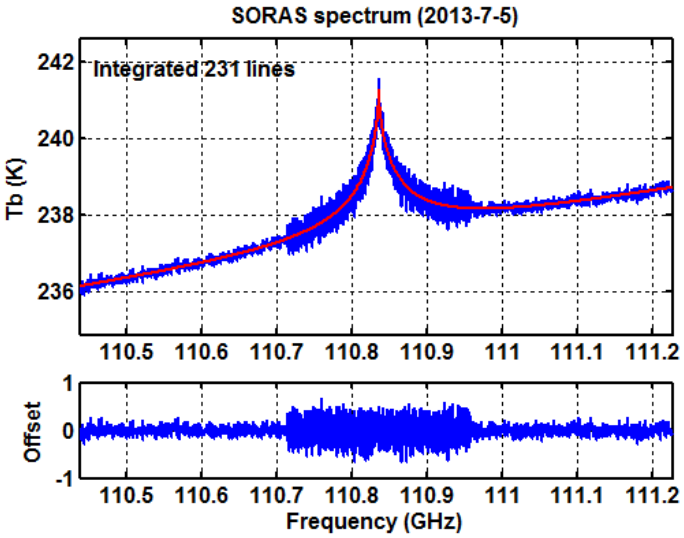


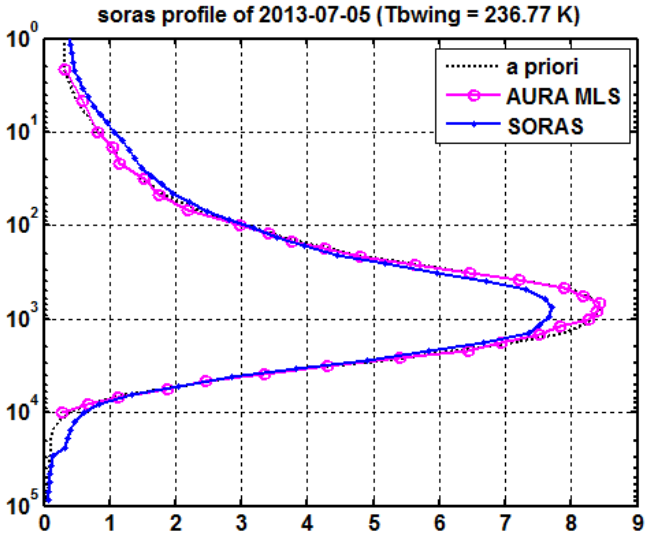


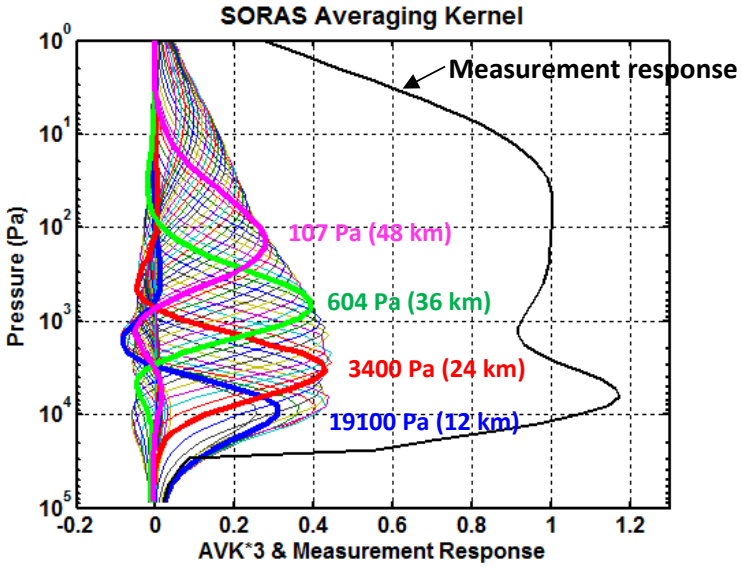


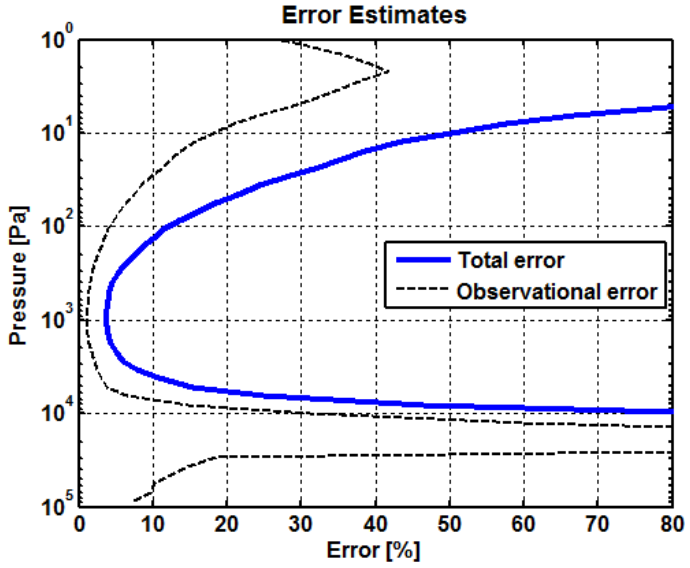


2-4. SORAS Retrieval (2013-07-05, 236 K)









3. SWARA

- SWARA : Seoul Water Vapor Radiometer
  - 22.235 GHz radiometer located on the roof of Science building
  - Developed by the joint project with IAP in Univ. of Bern, Switzerland (Prof. Niklaus K™mpfer)
  - NDACC Instrument (Accepted on Sep. 2012)
  - 1 GHz bandwidth with Acqiris AC240 FFT spectrometer
  - Continuous 24 hours measurement
  - Balancing and Tipping curve calibration
  - 140 K receiver temperature

3-1. SWARA Calibration

Tipping curve c alibration

(~17”, 3 or 4 events/hr)

- To calculate the tropospheric opacity
- Run the calibration every ~17 minutes
- Calibration Step
  - ① Line – sky signal at 7 direction between 44 degrees and 70 degrees
  - ② Coldsky – Sky signal at 30 degrees in zenith
  - ③ Hot – Eccosorb CV3 absorber

Balancing calibration

- To minimize the device nonlinearity
- Insert a noise material(CV3) in the sky zenith direction
- Calibration Step
  - ① Reference – Sky signal between 0 and 10 deg in zenith dire ction (automatically adjusted by Sky signal level)
  - ② LineSky – Sky signal between 65 degrees and 72 degrees in zenith direction (depending on the reference signal)

3-1. SWARA Calibration

- Tipping Curve Calibration

τ=0.3

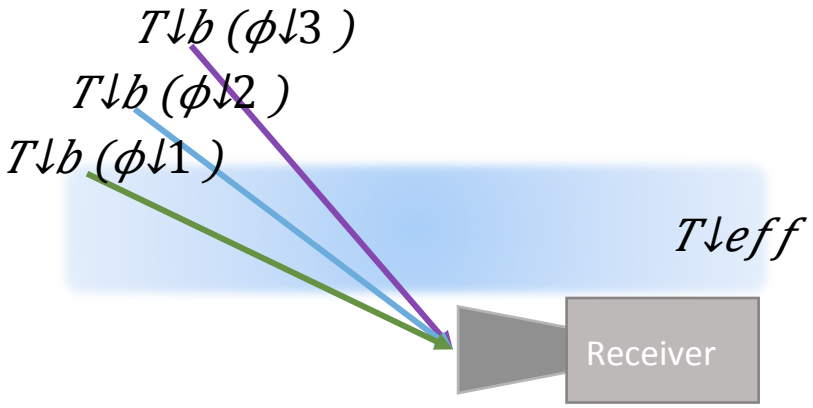
$$T\downarrow b\,(\phi)=T\downarrow 0\; e\uparrow-\tau A\downarrow\phi\; +T\downarrow eff\,(1-e\uparrow-\tau A\downarrow\phi\;)$$

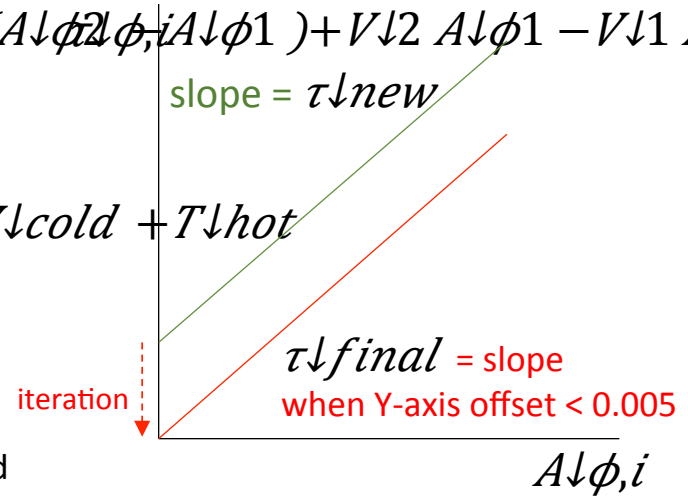
$$A\downarrow\phi\;\tau=\tau\downarrow\phi=\ln(T\downarrow eff-T\downarrow 0\;/T\downarrow eff-T\downarrow b\,(\phi))$$

$$\tau=(T\downarrow hot-T\downarrow 0\;)(V\downarrow 2-V\downarrow 1\;)/(T\downarrow eff-T\downarrow 0\;)\{V\downarrow hot\,(A\downarrow\phi 2\phi,iA\downarrow\phi 1\;)+V\downarrow 2\;A\downarrow\phi 1-V\downarrow 1\;A\downarrow$$

$$T\downarrow b,i=(V\downarrow i-V\downarrow hot\;)T\downarrow hot-T\downarrow b\,(\phi\downarrow cold\,)/V\downarrow hot-V\downarrow cold\;+T\downarrow hot$$

$$A\downarrow\phi,i\;\tau\downarrow new=\tau\downarrow\phi,i=\ln(T\downarrow eff-T\downarrow 0\;/T\downarrow eff-T\downarrow b,i\;)$$





$T\downarrow 0$: Cosmic background

$T\downarrow eff$: Effective Temperature of Troposphere

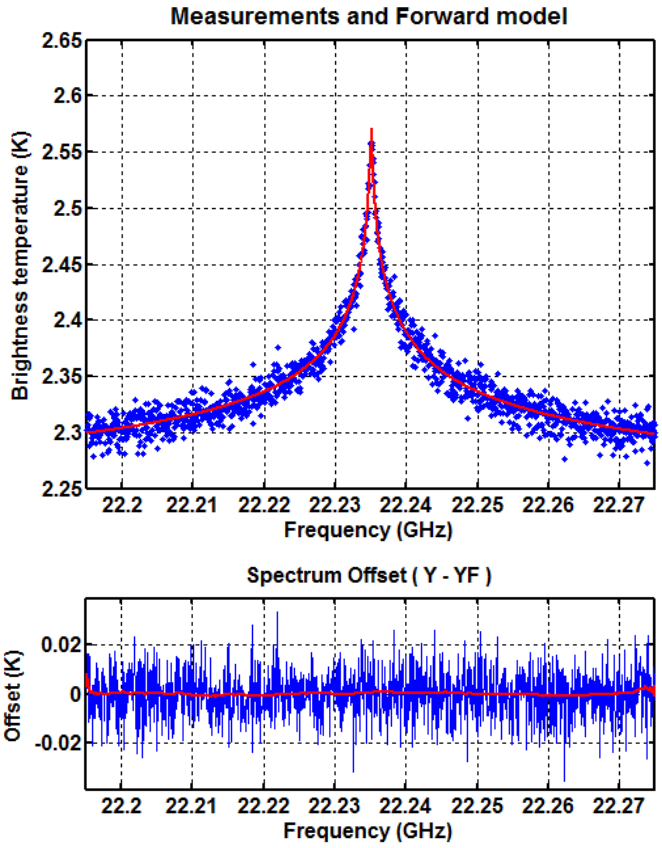
$A\downarrow\phi$: Air mass factor ($\approx 1/\sin(\phi)$)

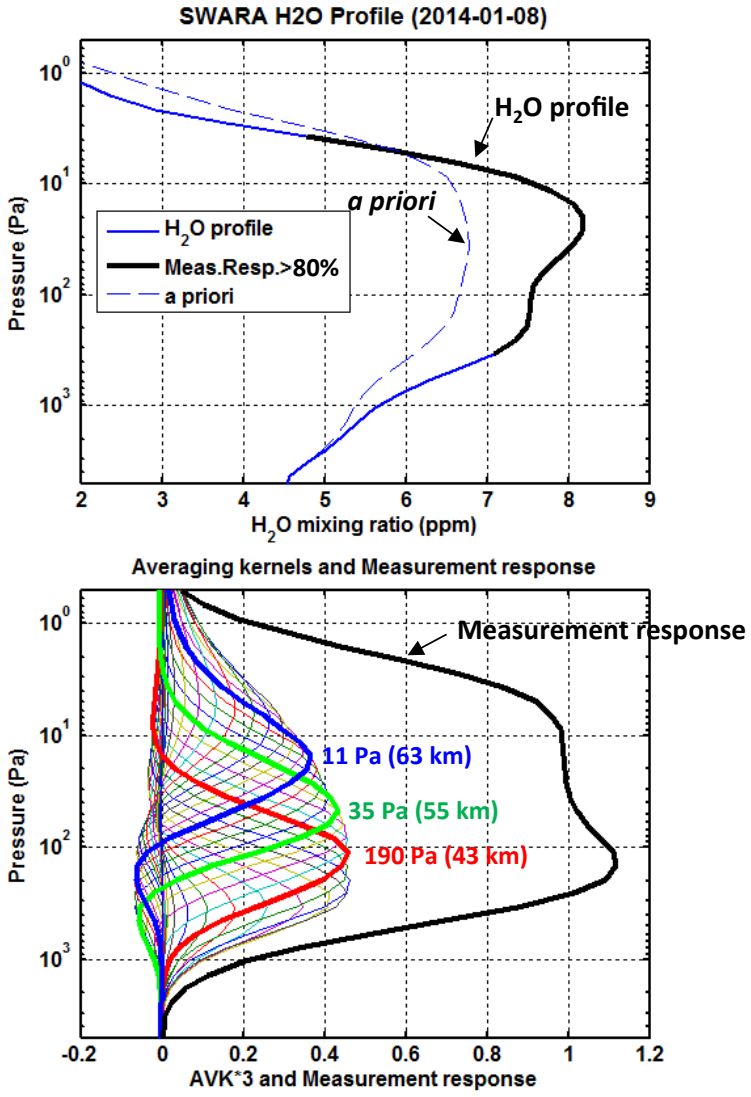
3-2. SWARA Retrieval

- Spectrum
  - Limit noise level = 0.01 K
  - Bandwidth = 80 MHz
- Platform
  - Altitude = 16000 m
  - Zenith angle = 0 degrees
- Temperature information
  - AURA MLS v3.3 recent profile
- *a priori* profile
  - AURA MLS v2.2 climate profile
- Baseline fitting
  - 3rd order of polynomial and 8th order of sinusoidal fit. (by FFT method)

3-2. SWARA Retrieval (2014-01-08, Winter)

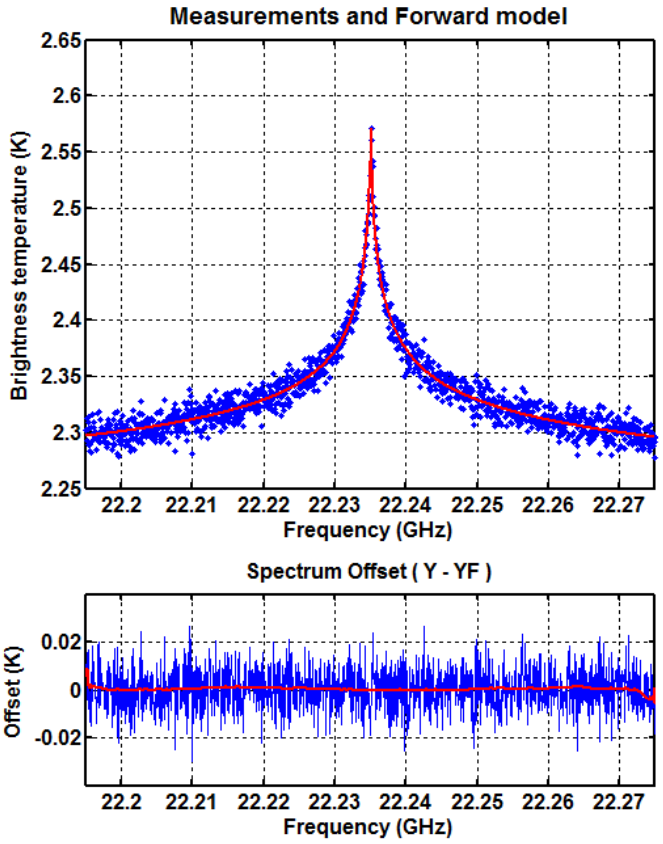
- 0.0346 tropospheric opacity
- 199 lines for 1.6 hours

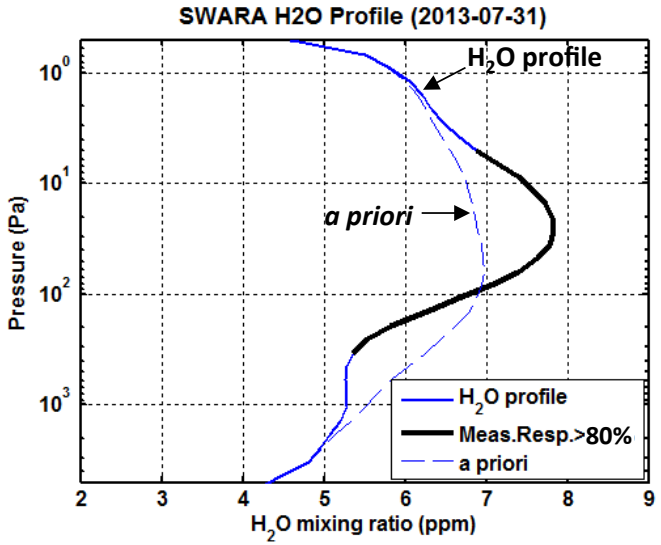


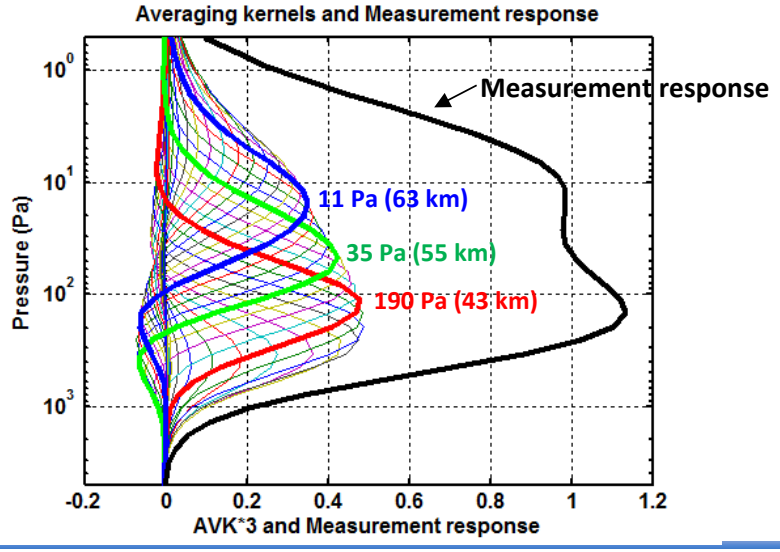


3-2. SWARA Retrieval (2013-07-31, Summer)

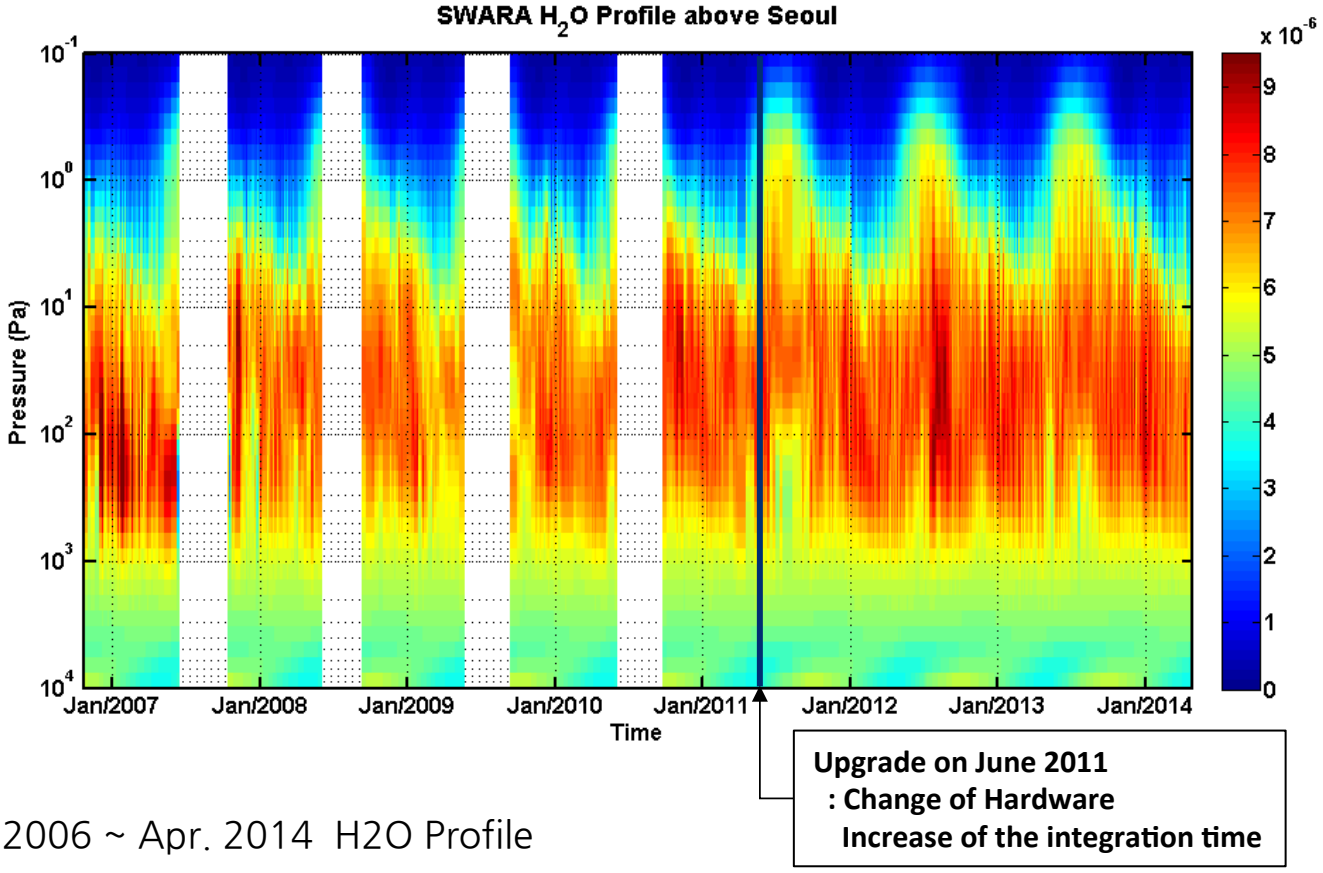
- 0.355 tropospheric opacity
- 5276 lines for 107.7 hours





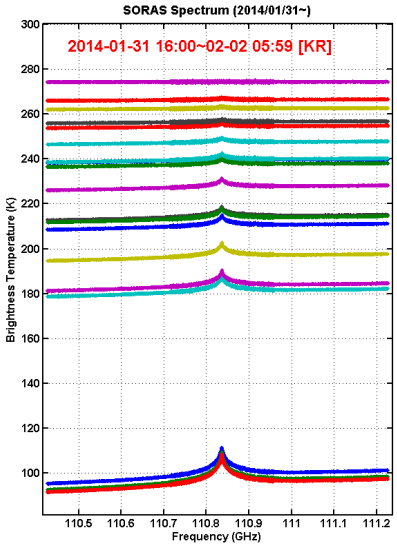


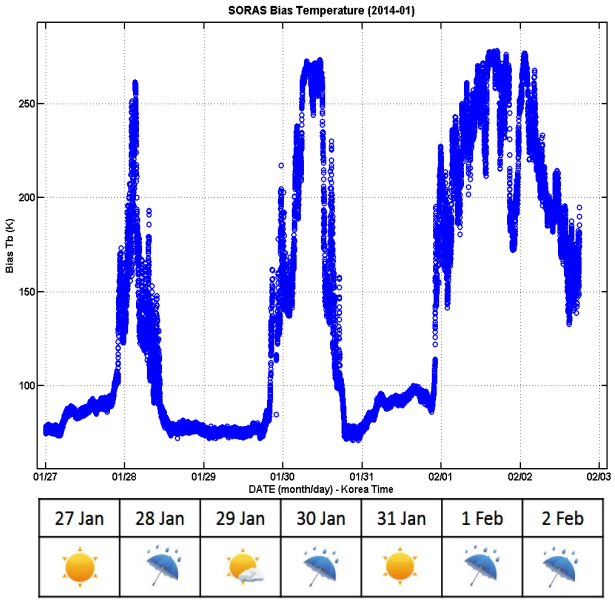
3-3. SWARA Profile

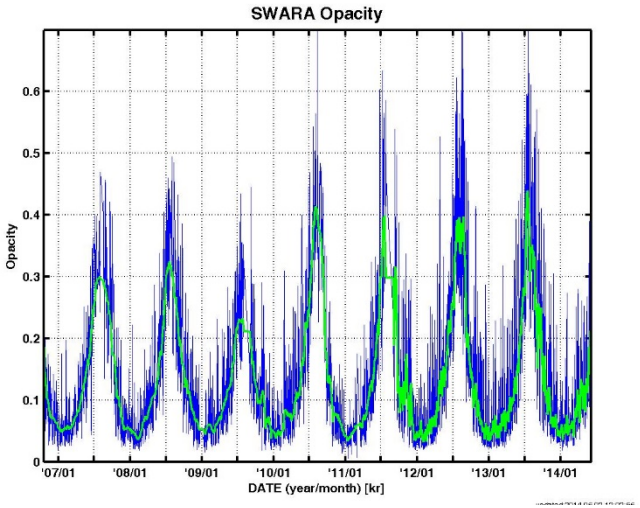


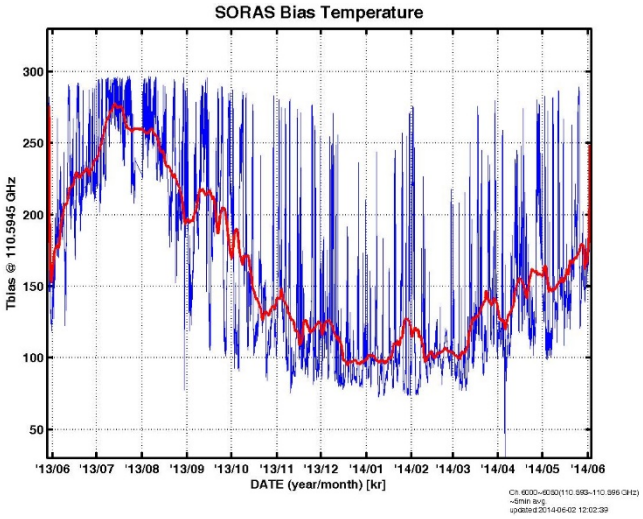
- Oct. 2006 ~ Apr. 2014 H2O Profile
- The blanks in summer result from too long integration time due to too high opacity.
- Measurement response 〉80% : 338 Pa ~ 4.11 Pa (39 km ~ 70 km)
- Measurement response 〉60% : 450 Pa ~ 2.57 Pa (37 km ~ 73 km)

4. Future Work - Tropospheric Water



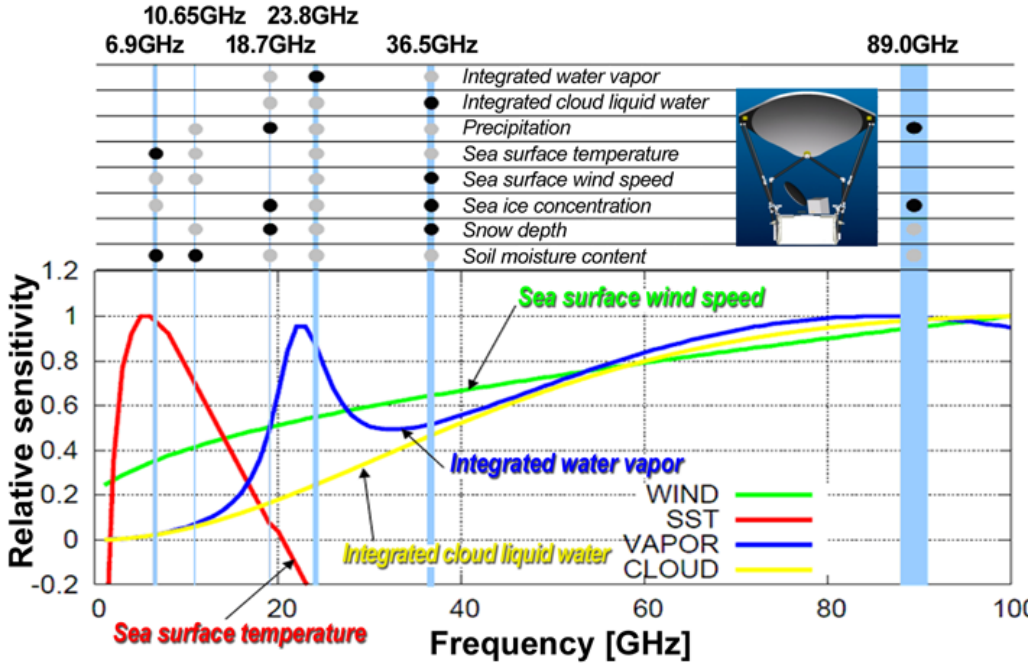


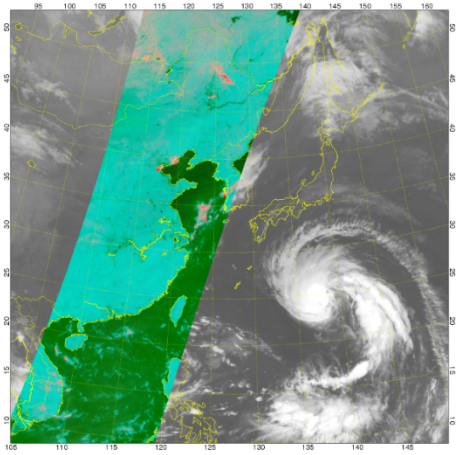




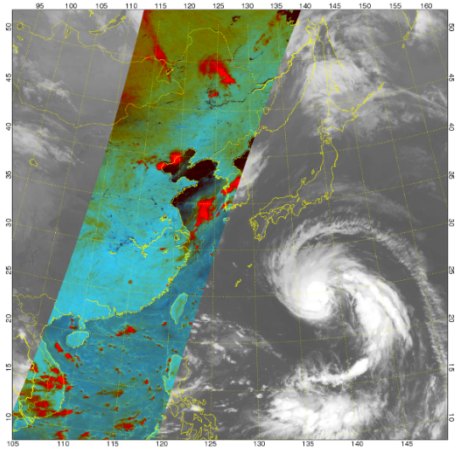
4. Future Work - Tropospheric Water

- GCOM-W1 Satellite AMSR2 Microwave Sensor (JAXA)
  - Launch on May 2012
  - 7 frequencies with 16 channels





◀ AMSR2
Convective Cloud
36.5 GHz
Synthetic color image
(2013.09.14.02:46KST)



◀ AMSR2
Convective Cloud
89.0 GHz
Synthetic color image
(2013.09.14.02:46KST)

Thank you for your attention