Investigating Wintertime Atmosphere Boundary Layer Evolution in Chia-Yi from High Temporal Passive Microwave Radiometer Observation

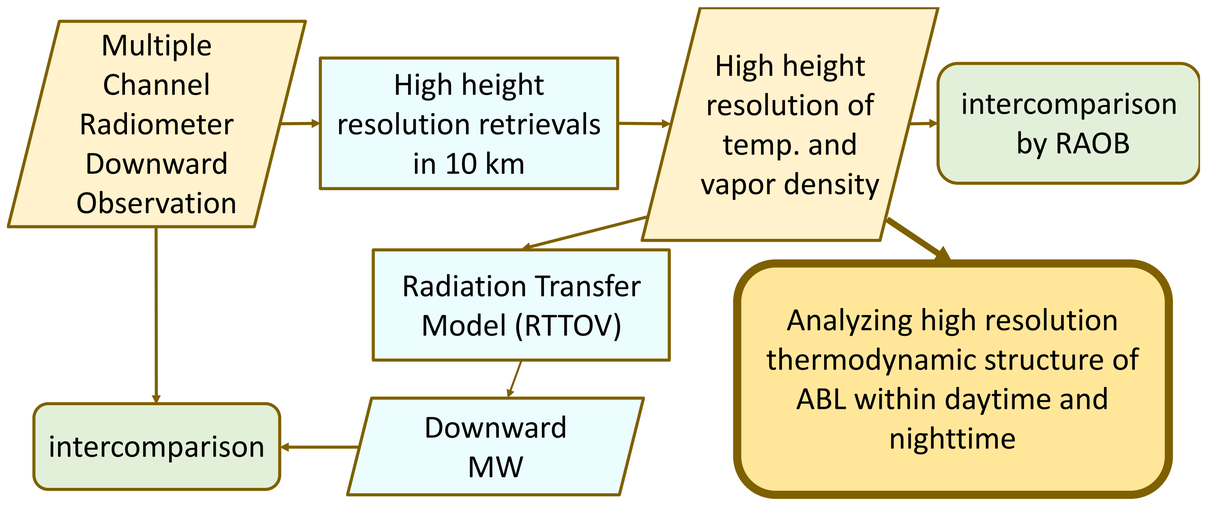
Sheng-Chia Chang[1], Chian-Yi Liu[2], Sheng-Cha Hsu[1], Meng-Yue Lin[1], Hung Lin[2], Charles CK Chou[2]

[1] Atmospheric science, National Central University, Taoyuan, Taiwan
[2]Research Center for Environmental Changes, Academia Sinica, Taipei, Taiwan

Motivation

The atmosphere boundary layer (ABL), especially in southern plains of Taiwan wintertime, has significant diurnal variation, and thus influences the stability and air quality. This study aims to investigate the thermal and stability structure of ABL through high temporal resolution passive microwave(PMW) radiometer observation.

Research Flow & Dataset



✧2023/12/20 to 2024/03/31 Chia-Yi radiometer observation data
✧2024/03/15 to 17 Chia-Yi (46748) IOP RAOB data

*Data are accessed in the clear sky and nonprecipiration scene.

Machine Learning based T/Q Profile Retrieval Model

NN_1001_SD_gaussian: Gaussian noise included, w/ normalization
NN_1001_MM_gaussian: Gaussian noise included, w/ maximum/minimum adjustments before normalization.
NN_1001_MM_natural: Data from 20 minutes before and after RAOB launch time, with max/min adjustments before normalization.
NN_58: Data from the vendor, uneven interval in 58 altitude levels.

*training dataset: 2023 Sep. to Dec. Xin-Pei (46692) radiosonde observation (RAOB) and radiometer observation data

RAOB intercomparison

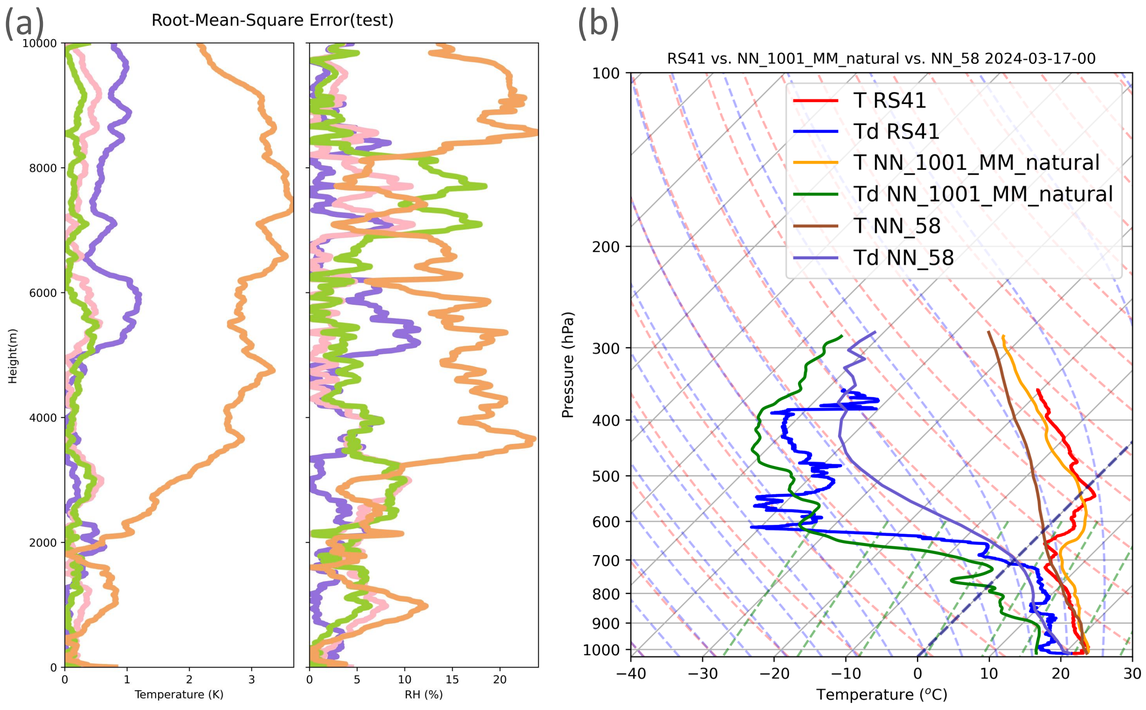


Fig 1. (a) compare each model with RAOB data Temp. and RH root-mean-square error (RMSE). (b) Chia-Yi RAOB 2024-03-17-00 skew-T log-P diagram.

Correlation Coefficient	3km (near surface)		10km	
	Temp.	RH	Temp.	RH
NN_1001_SD_gaussian	0.94	-0.26	0.98	0.26
NN_1001_MM_gaussian	0.98	0.47	0.99	0.76
NN_1001_MM_natural	0.99	0.99	0.99	0.99
NN_58	0.99	0.90	0.99	0.81

Table 1. Correlation Coefficient (CC) of the 3km and 10km of total profile comparing models and RAOB

Simulated Brightness Temperature (BT) from RTM

✧Due to wider bandwidth of the radiometer, which represents a thicker layer of the atmosphere, there exists relative larger RMSE when compare the observation against the simulated BT from RTM forward calculation.

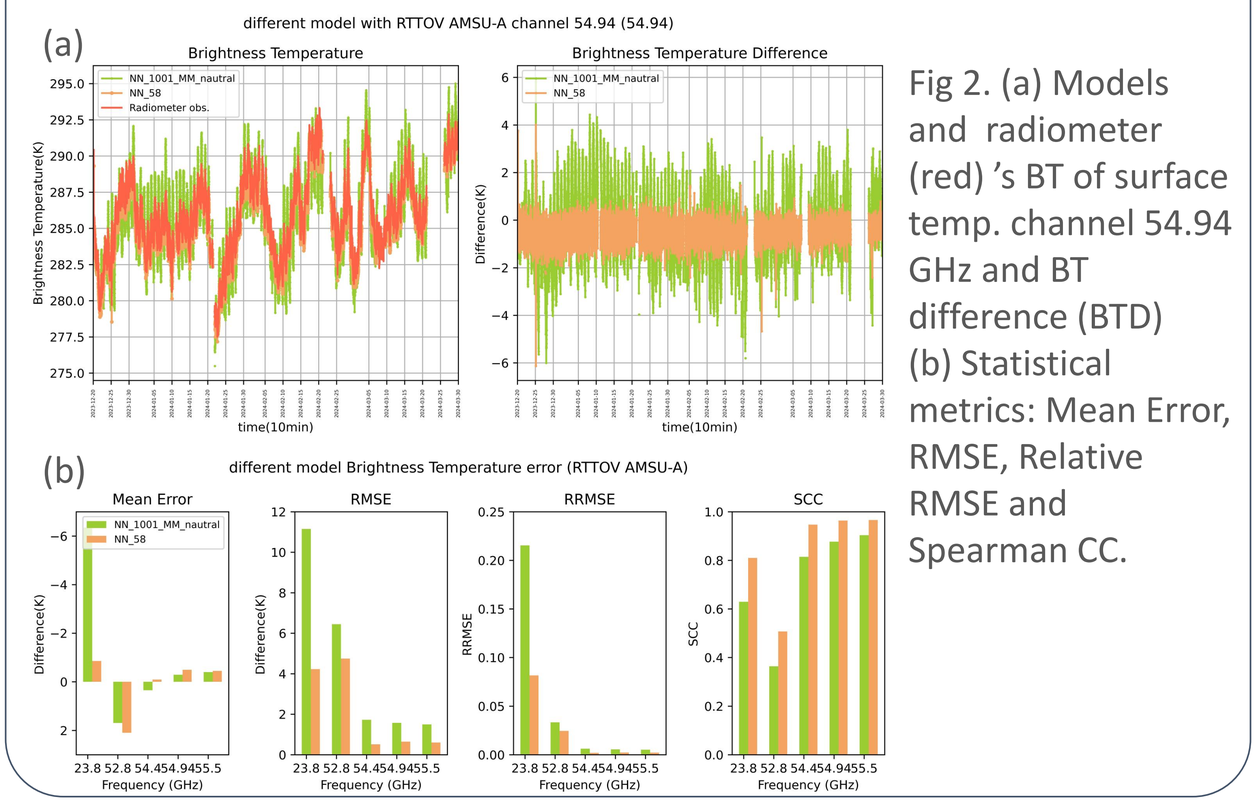


Fig 2. (a) Models and radiometer (red) 's BT of surface temp. channel 54.94 GHz and BT difference (BTD) (b) Statistical metrics: Mean Error, RMSE, Relative RMSE and Spearman CC.

Daytime vs. Nighttime

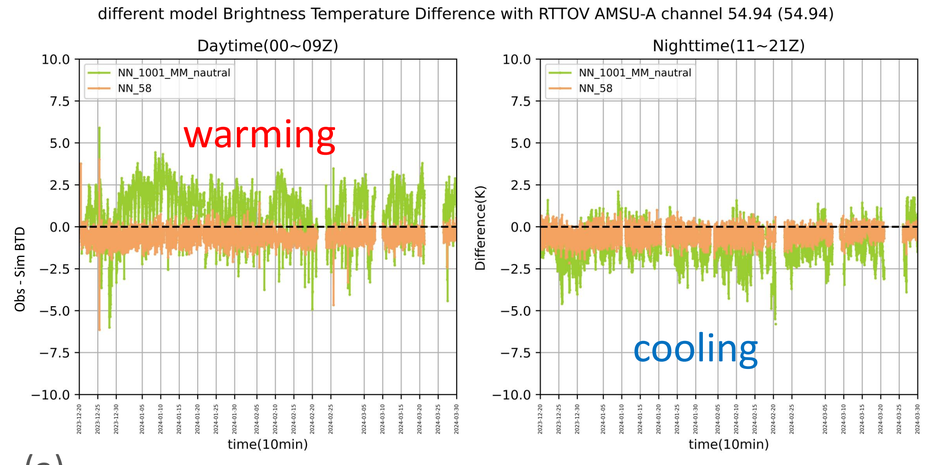


Fig 4. Separating BTD into daytime (00Z to 09Z) and nighttime (11Z to 21Z), dashed black line is 0.

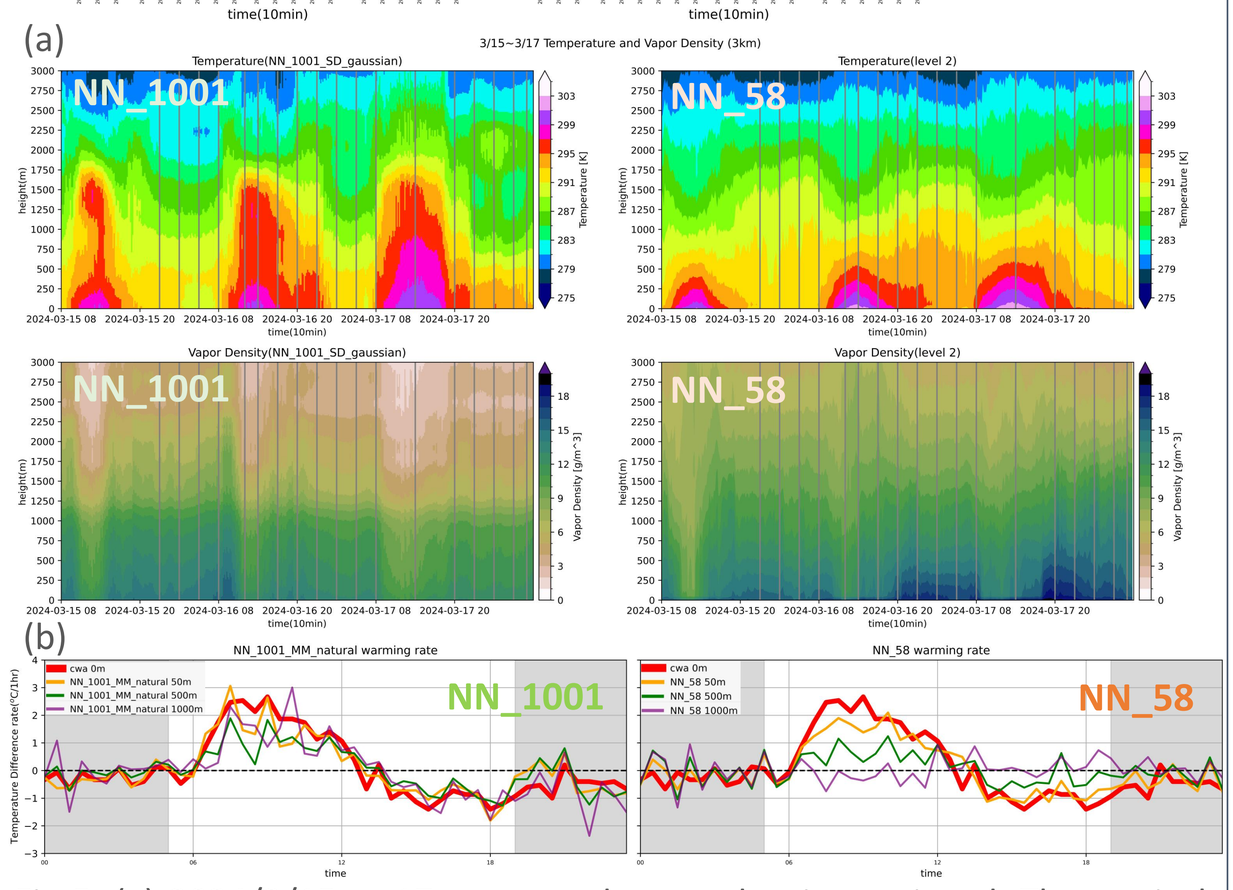


Fig 5. (a) 2024/3/15 to 17 temp. and vapor density retrieved. The vertical gray line is the launch time of radiosonde (b) Mean heating and cooling rate in 3/15 to 3/17. Red curve is CWA surface temperature (2m), 50m/500m/1000 m are in orange/green/purple, respectively.

✧NN_1001 shows a sharper temp. profile with higher heating heights below 1km, and suggests proper description of ABL structure in time.
✧After sunrise, temperature increases sharply close to the surface.
✧Lower heating in the higher altitudes.

Conclusions & Future work

✧NN_1001_MM_natural has the features of high-vertical and high-temporal resolutions atmospheric T/Q profile retrievals, with improved low uncertainties when compare against radiosonde observation.
✧Nighttime retrieval has higher accuracy. It may due to RAOB has heat-up effect from the sun.
✧Solar radiation leads surface 2m temperature increases sharply. The influences has stronger impact in the lowest atmosphere than higher levels.
✧We need to improve radiation transfer model forward calculation so that the higher vertical resolution BT could be simulated.
✧The lidar wind data need to be included so that the dynamic structure, and heat fluxes in vertical/horizontal directions could be investigated.