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Improving the Quality of the NYS Mesonet Microwave Radiometer Data with a Novel Bias Correction Scheme

Chau Lam (Chris) Yu, Bhupal Shrestha, and Junhong Wang

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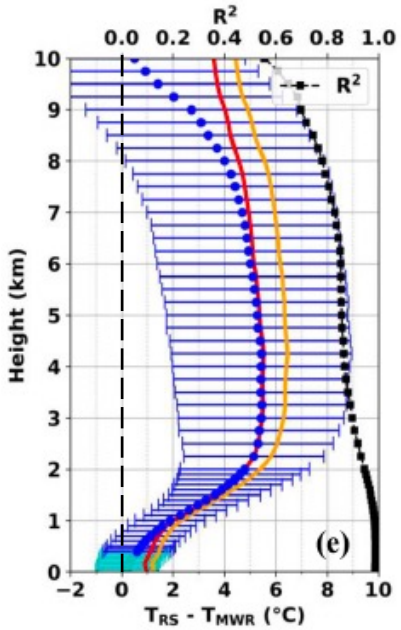
NROW XXV conference

Background

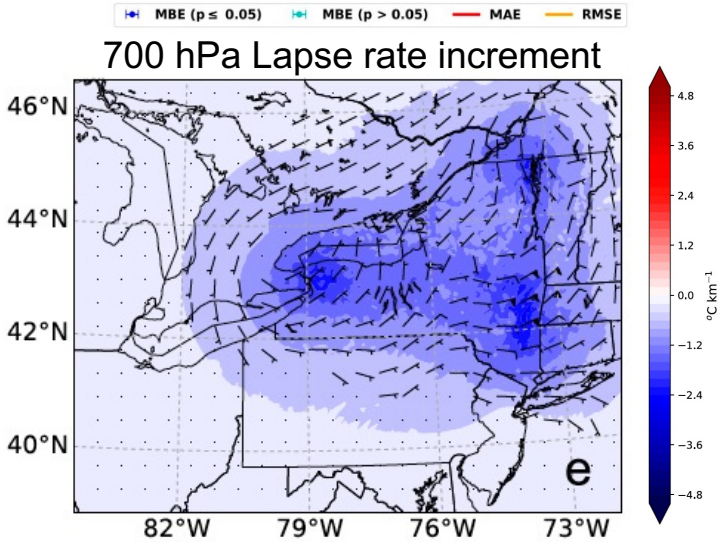
- Substantial cold bias in the retrieved MWR temperature (Shrestha et al. 2022) can lead to degrade of model forecasts (Lin et al. 2023)
- Lin et al. (2023) showed that assimilating MWR temperature led to erroneous increment in temperature lapse rate, causing to overly strong convective initiation.

- Source of Bias:

1. **Sensor calibration issues**
2. **Assumptions in the retrieval algorithm**



Shrestha et al. 2022



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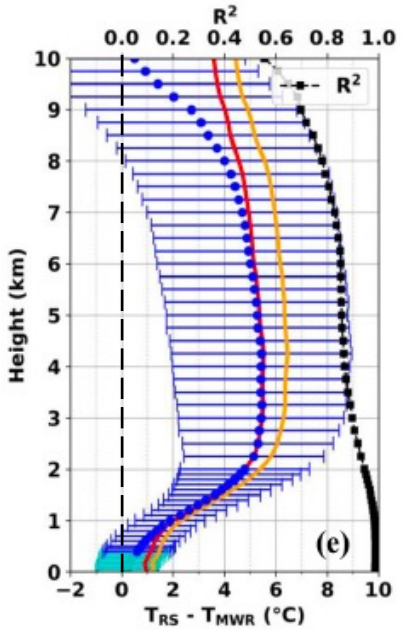


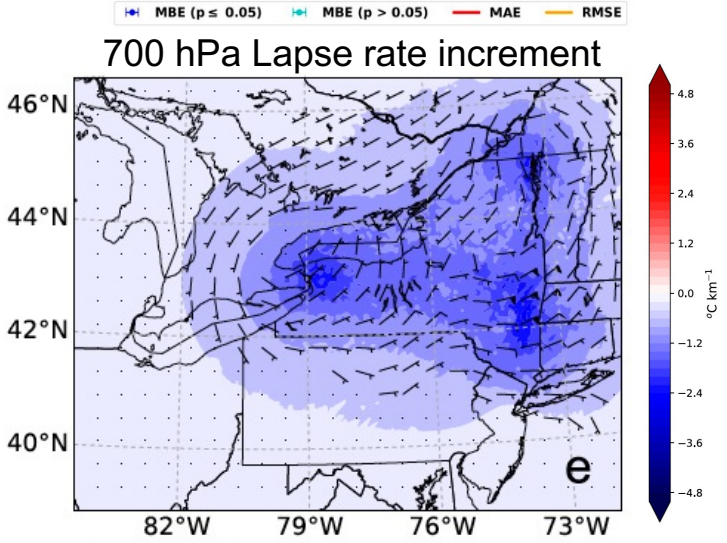
Shrestha et al. 2022

- Source of Bias:

1. **Sensor calibration issues**
2. **Assumptions in the retrieval algorithm**

- **Goals**:

1. Remove the systematic bias and improve the MWR data quality
2. Show the data impact by conducting DA experiments



Lin et al. 2023

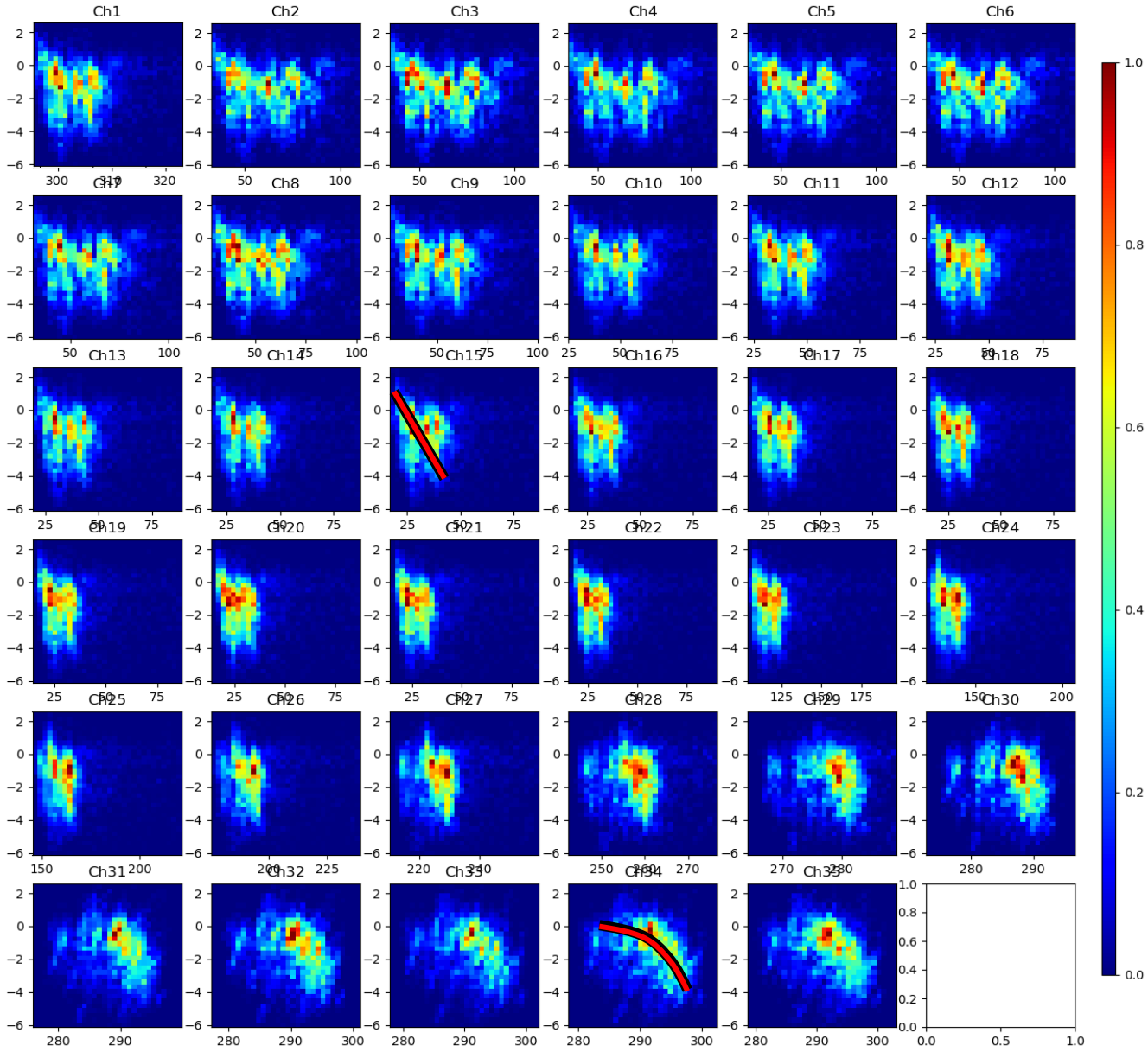
Trends in observational error

- Compute observational error based on High-Resolution Rapid Refresh (**HRRR**) analysis data

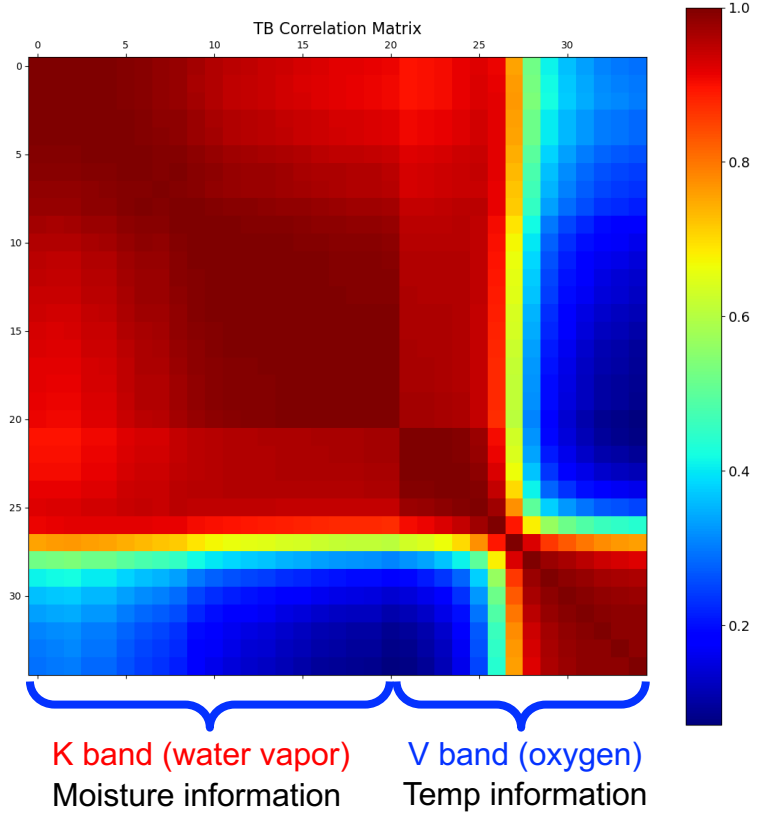
- Clear trend exists between the observed-minus-background (OmB) and the 35 channels of T_B

Challenges:

- Trend is also obscured by noise
- Which channels to pick?



MWR brightness temperature

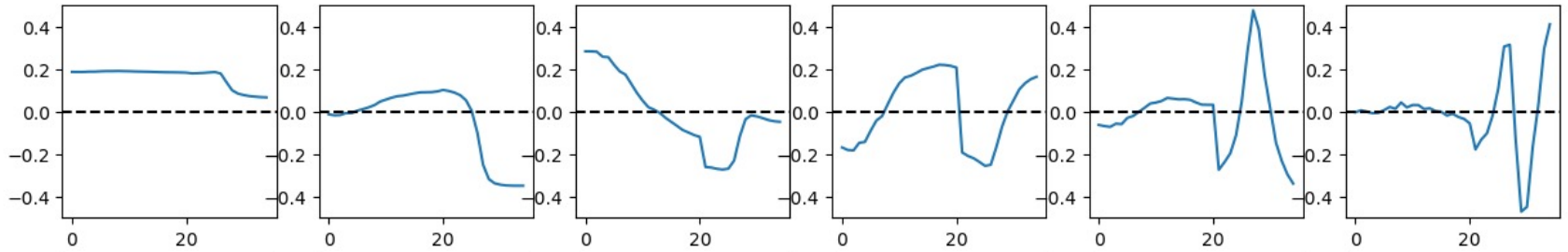


The 35 channels are highly correlated

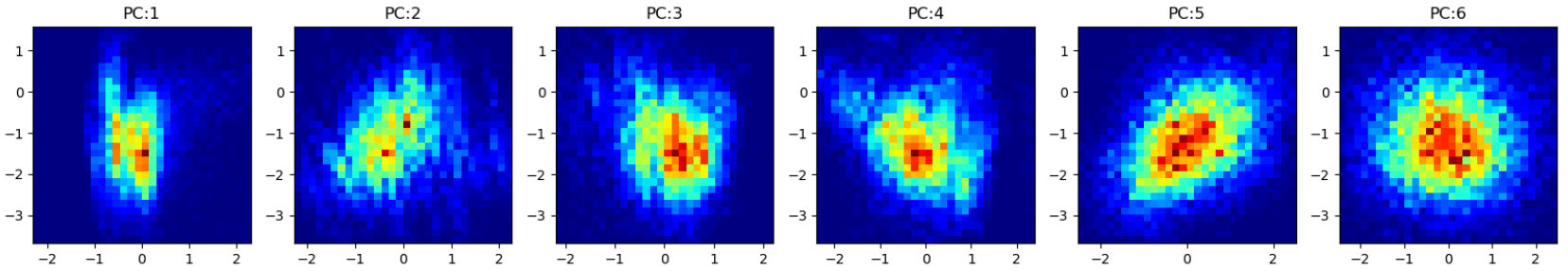
PCA allows us to identified combination of channels that can explain the largest variance of the observed T_B

→ Dominant information of the channels

First 6 principal components (PCs)

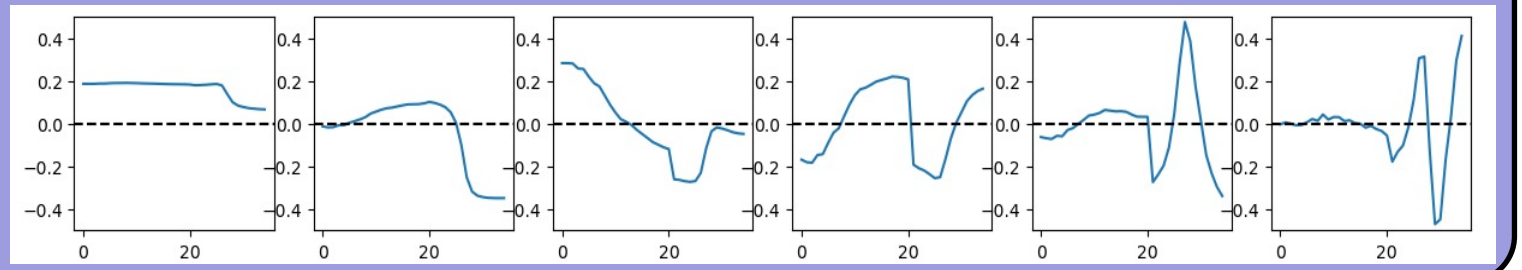


OmB against first 6 PCs



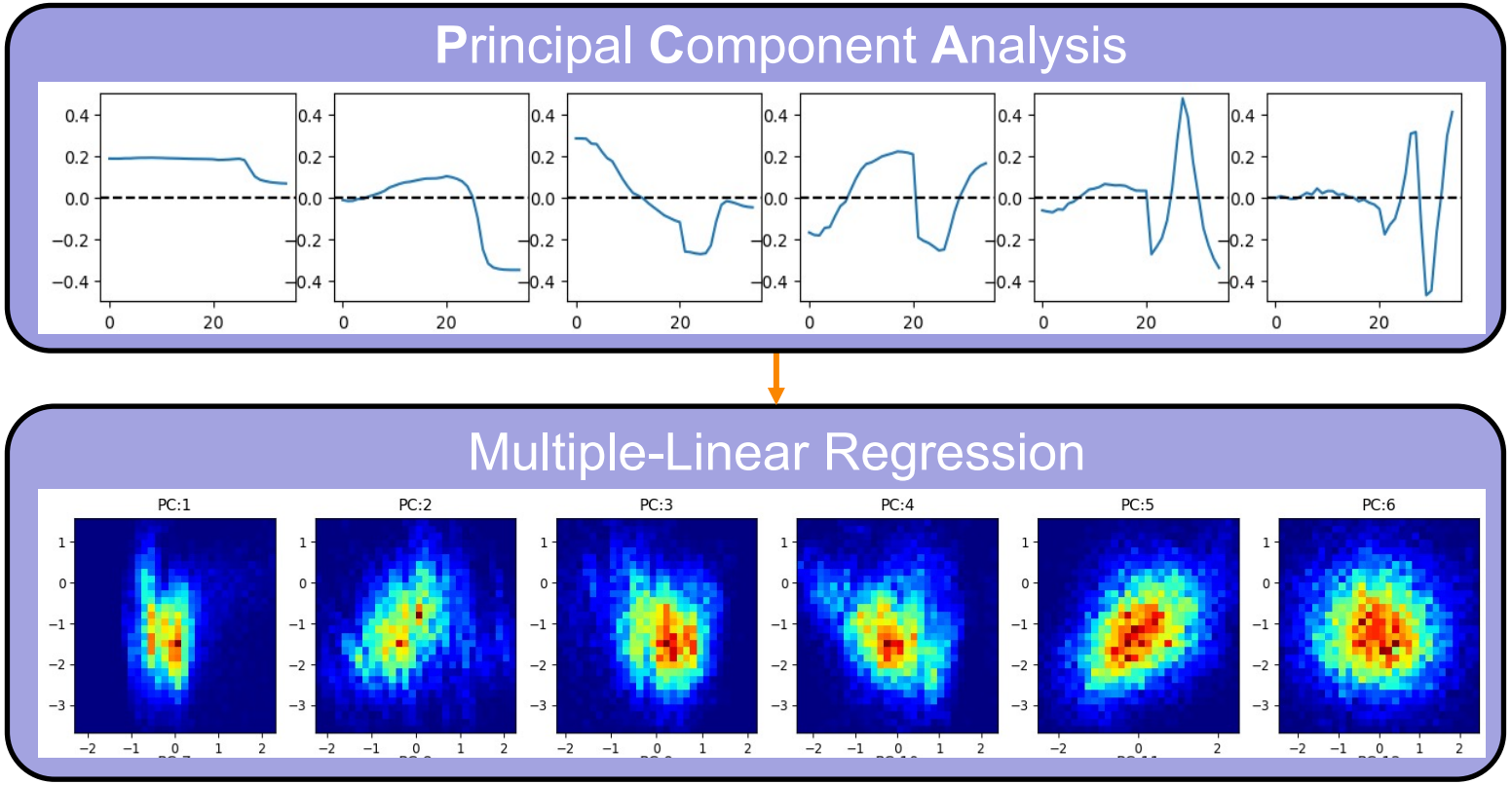
Bias correction procedure

Principal **C**omponent **A**nalysis



1. Collect 3 month of observation error statistics. Apply PCA to obtain the leading 6 PCs

Bias correction procedure



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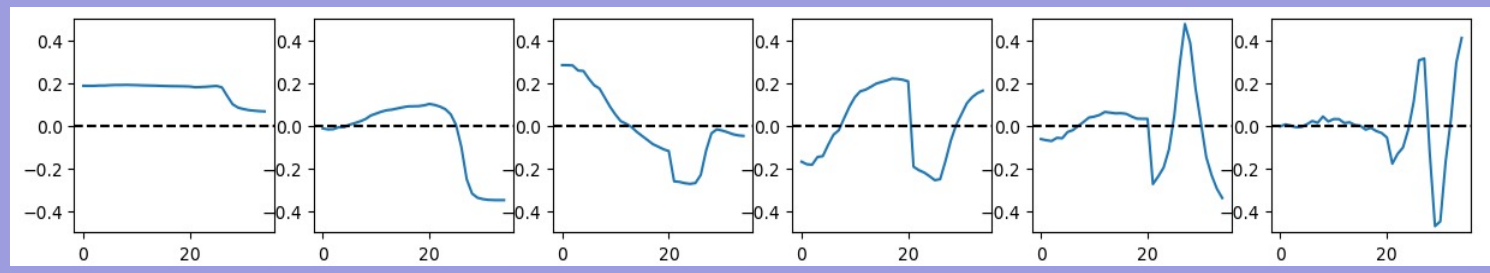
2. Regress the observational error onto the leading 6 PCs. The resulted multiple-linear regression model is the foundation of the BC scheme

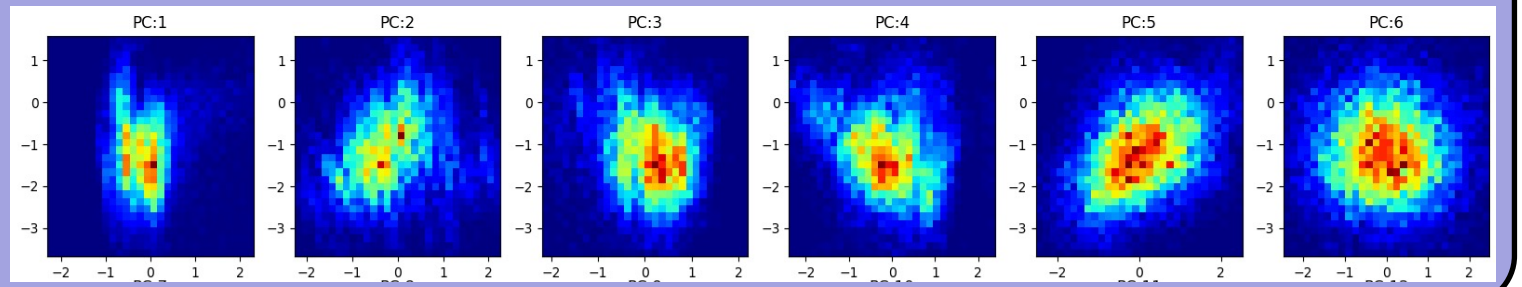
Bias correction procedure

Principal Component Analysis



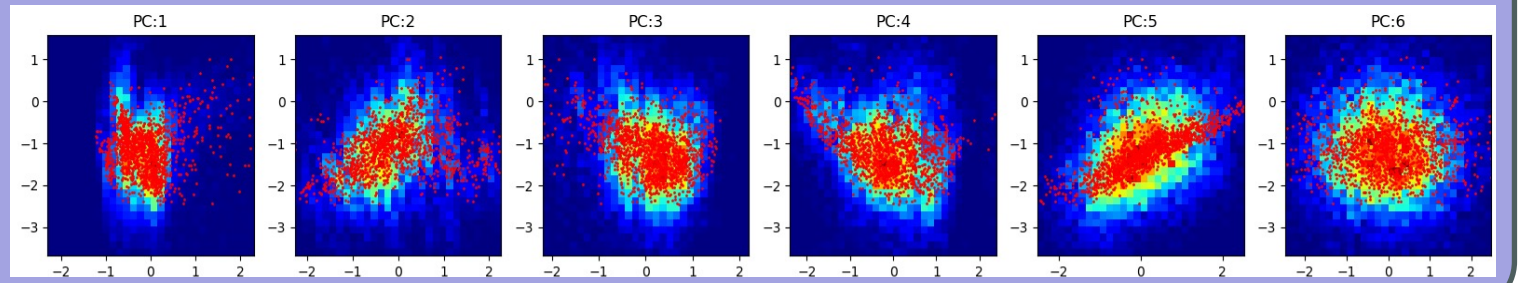
1. Collect 3 month of observation error statistics. Apply PCA to obtain the leading 6 PCs

Multiple-Linear Regression



2. Regress the observational error onto the leading 6 PCs. The resulted multiple-linear regression model is the foundation of the BC scheme

Predict and remove the Bias



3. Predict the bias using the BC scheme and remove the bias from the data

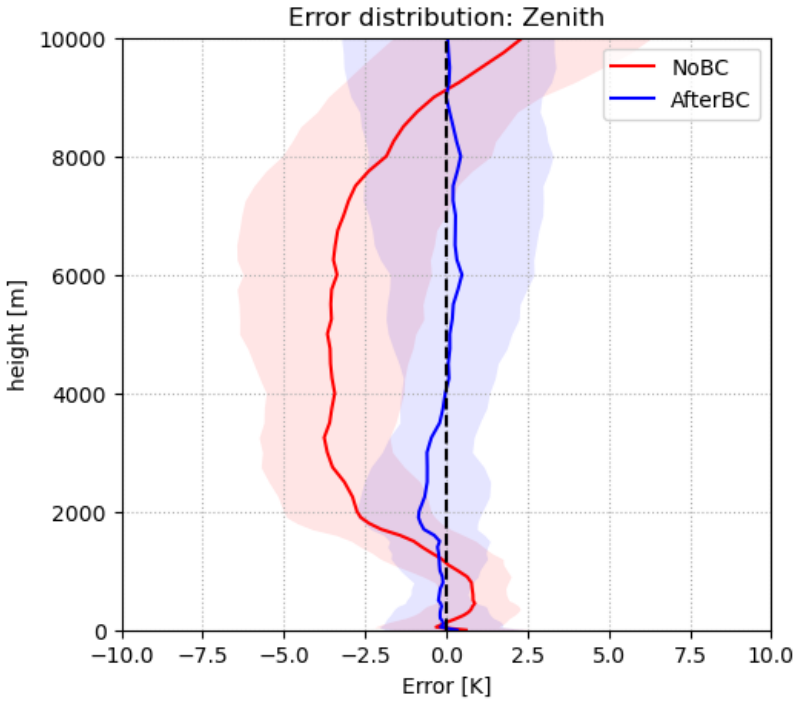
Verification using radiosonde sounding

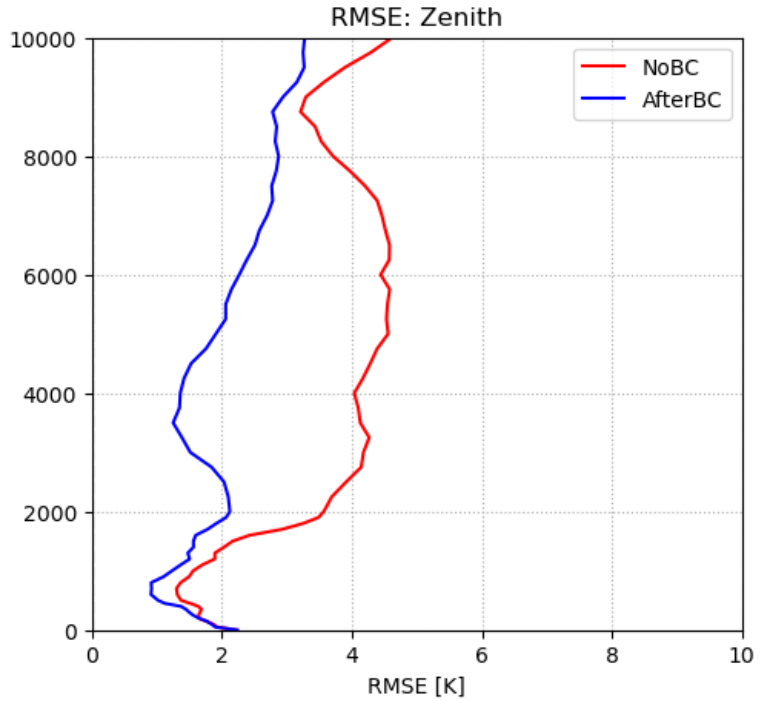
Independent soundings

We verify our bias-corrected MWR temperature profile against radiosonde sounding not assimilated into HRRR

Event	**Site**	**Time period**	**Sounding #**
Eclipse	ALB2 (ETEC)	04/01/2024 - 04/30/2024	36
Freezing Rain	CHAZ	02/02/2022 - 03/15/2022	24

Eclipse 2024
04/01/2024 - 04/30/2024
ALB2 site





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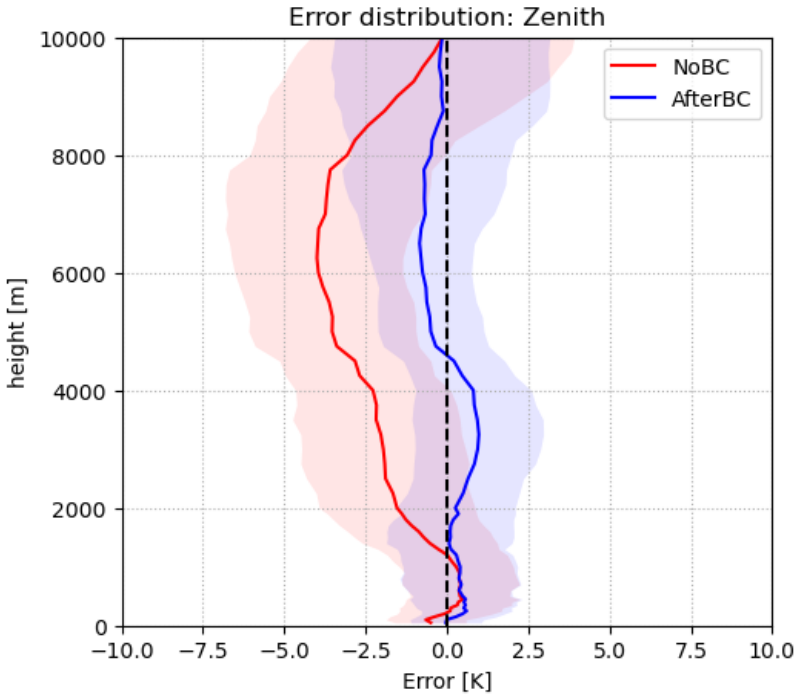
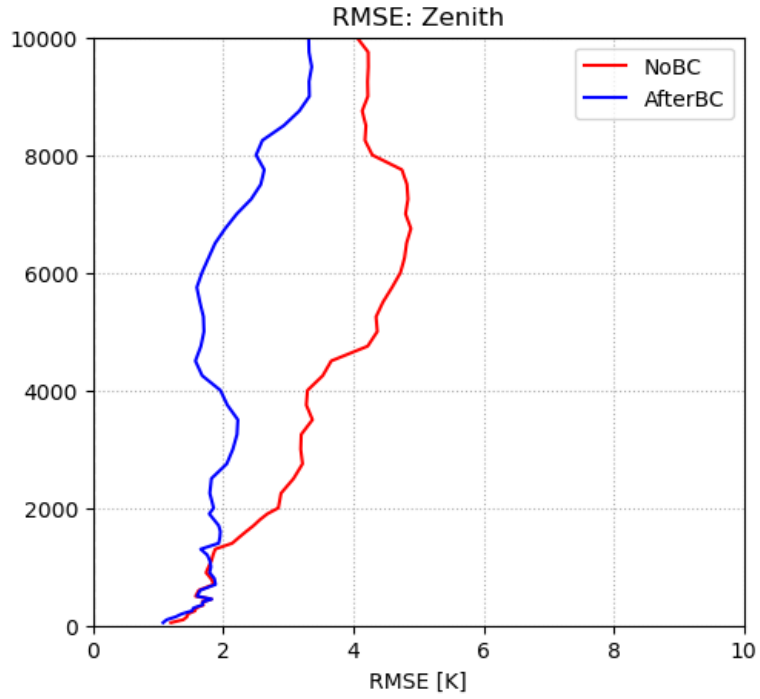


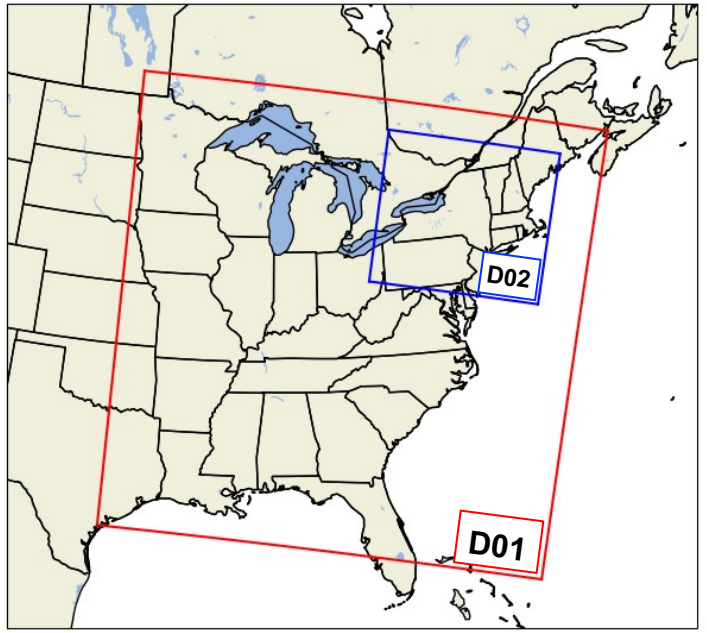


Data Assimilation Experiments

Data assimilation cycling experiments

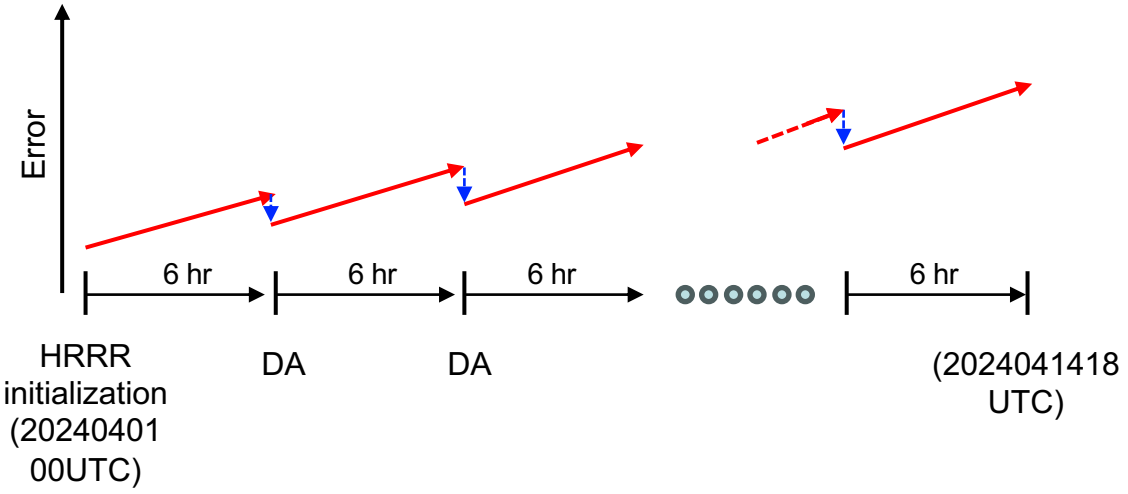
WRF-GSI data assimilation experiments:

- Inner domain cover the NYS (4 km resolution)
- GSI 3DVar DA system is utilized to perform 2 week-long DA cycling



Data assimilation strategy:

- Perform DA cycling experiment at every 6 hour
- Verify the d02 analysis error (domain averaged θ) using HRRR analysis as reference at the valid time of each cycle.



April 1 00UTC-30 06 UTC: Potential Temp Error

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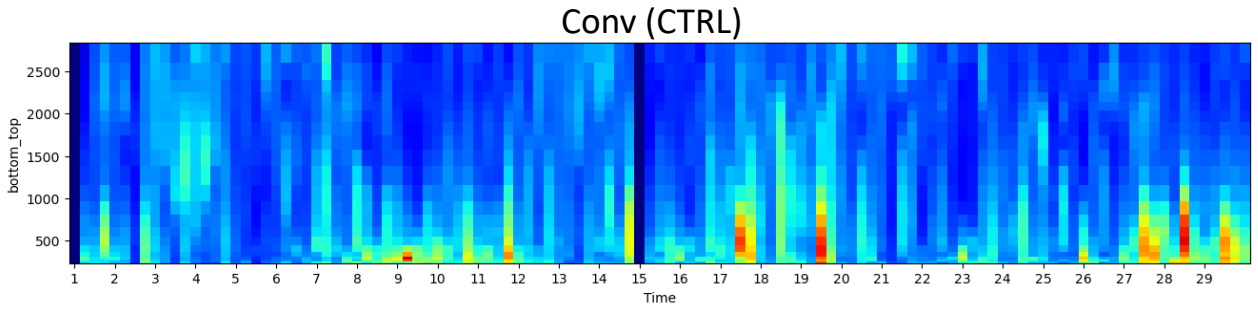

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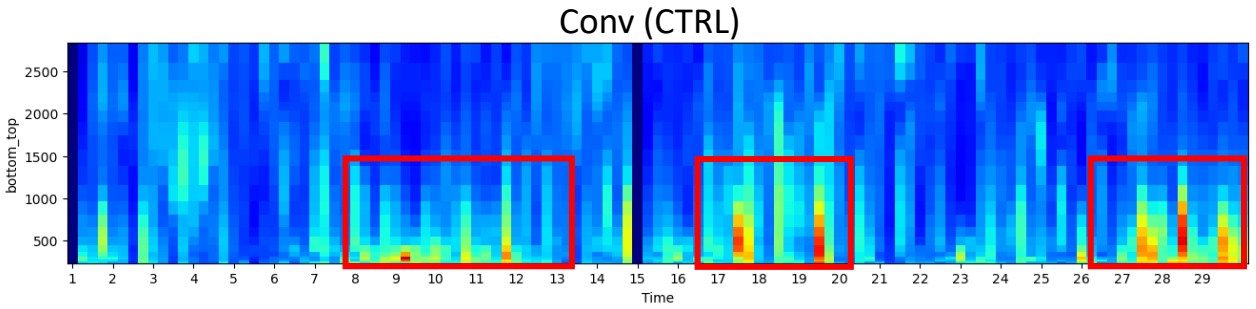

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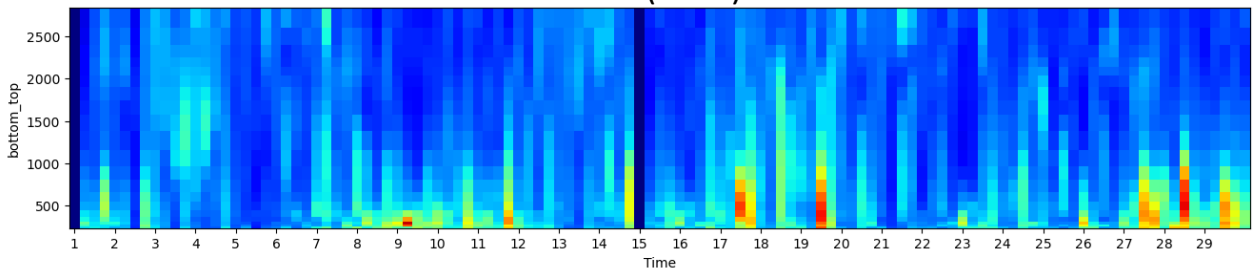
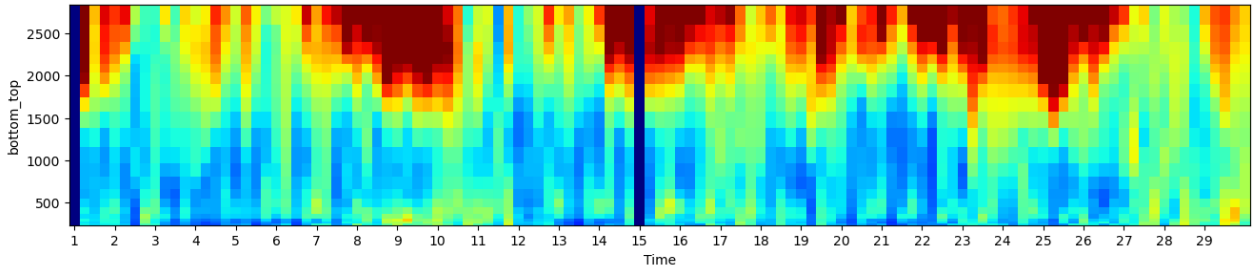
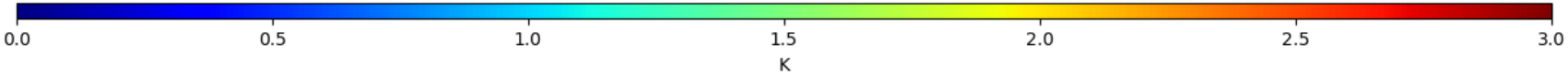


Conv + **surf** +**MWR3km** (**NoBC**)





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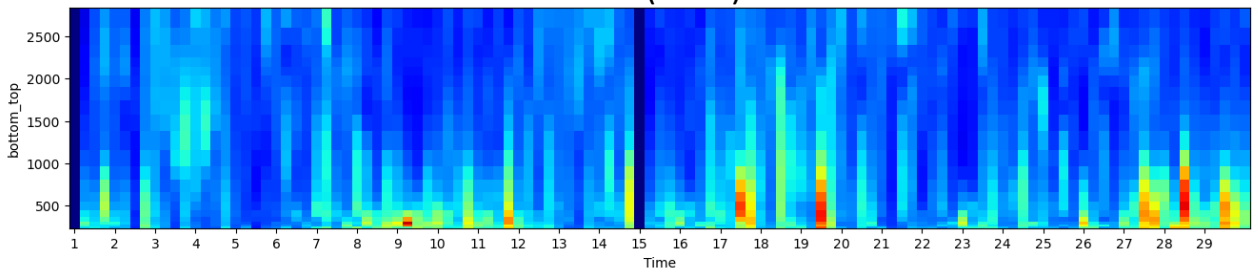

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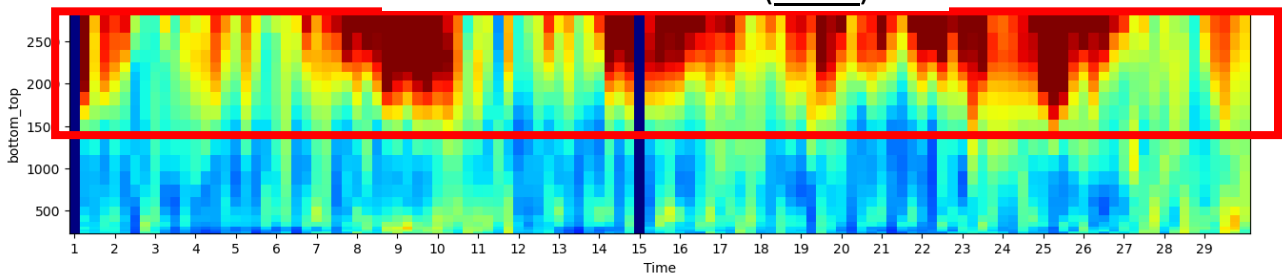

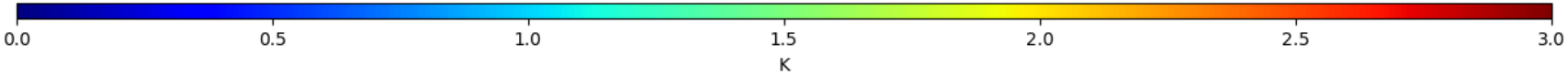

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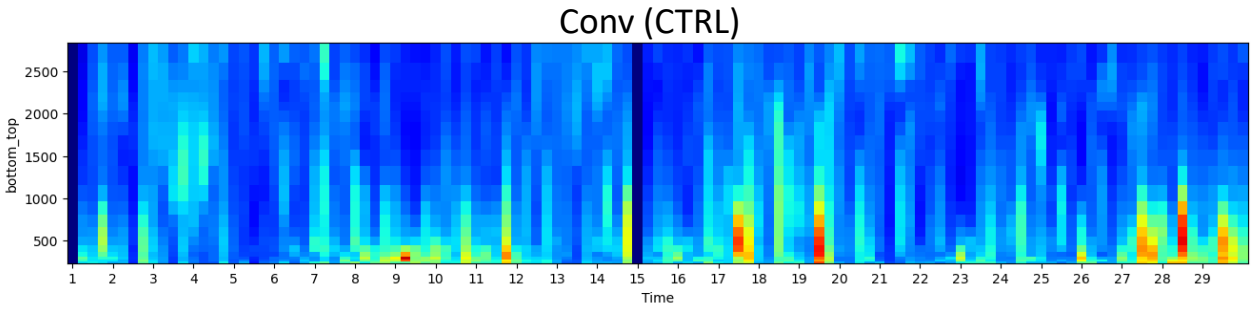

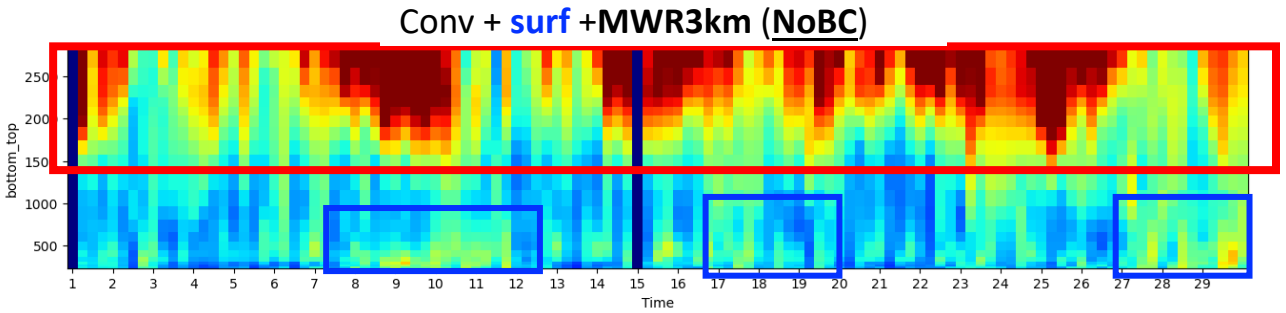

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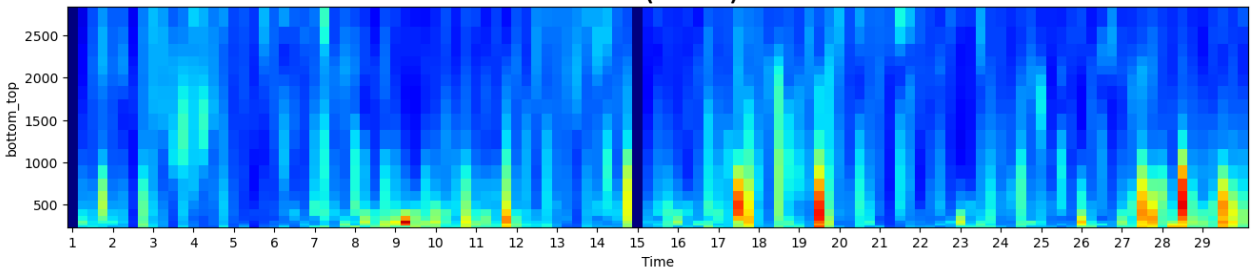

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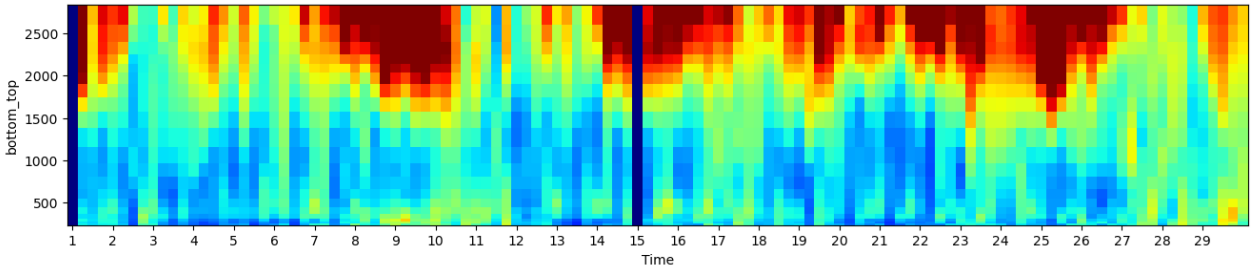

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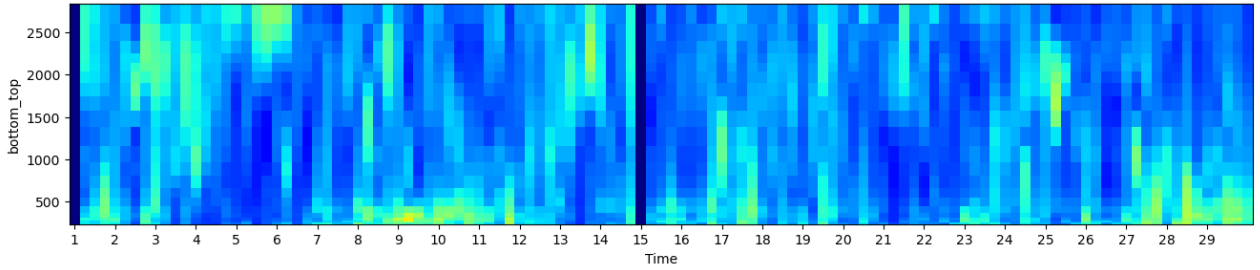

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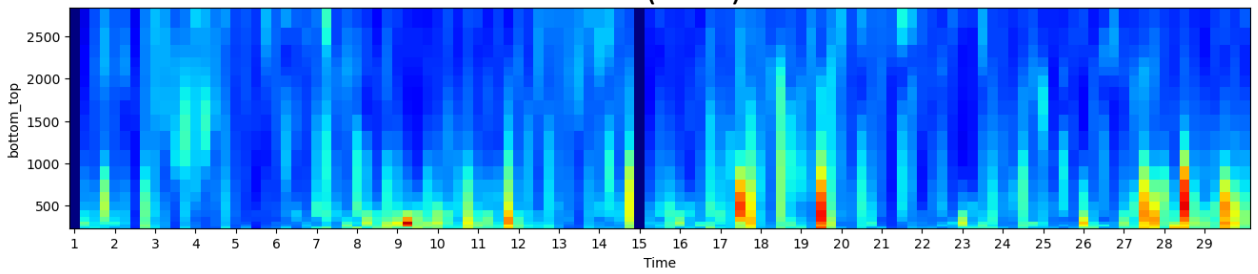

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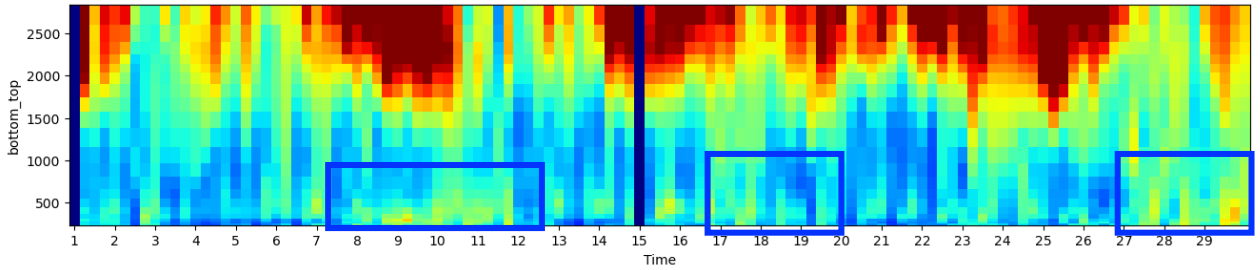

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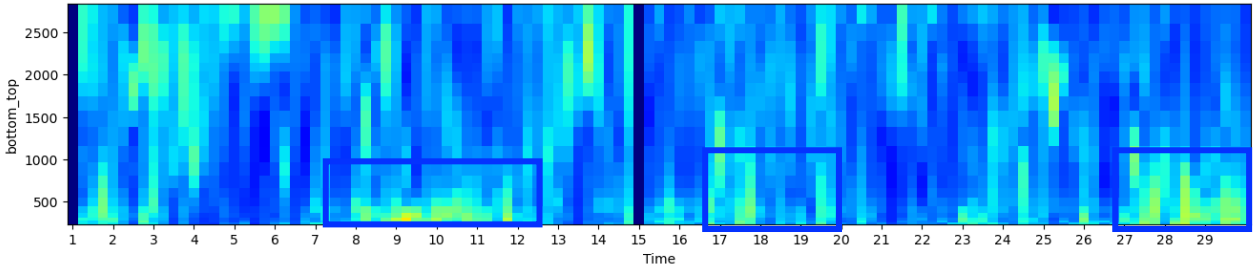

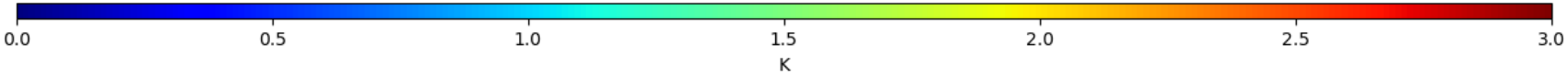

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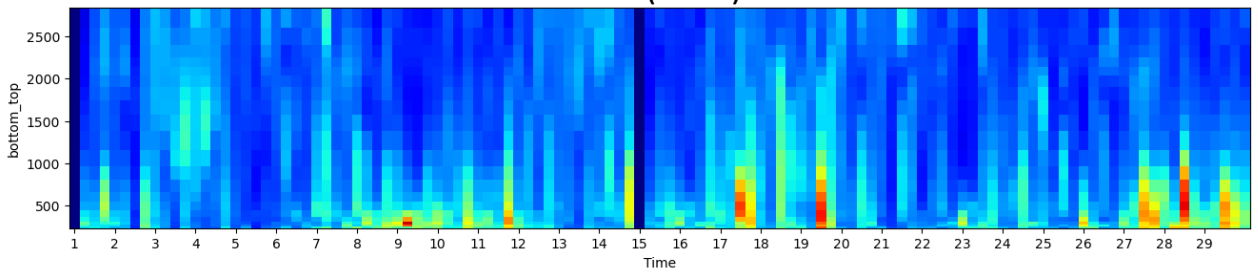

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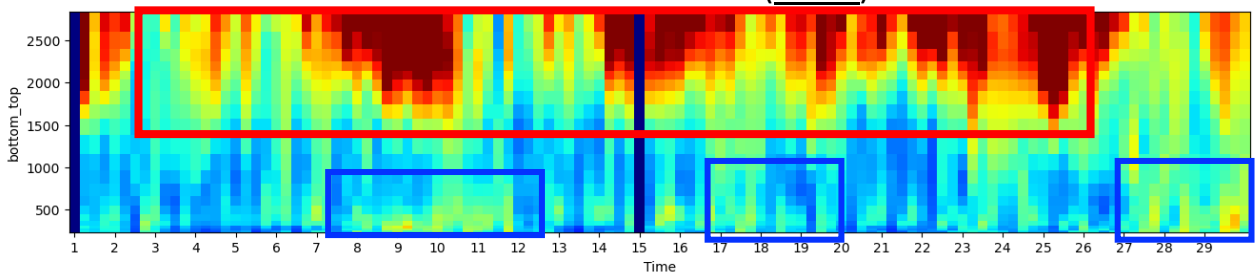

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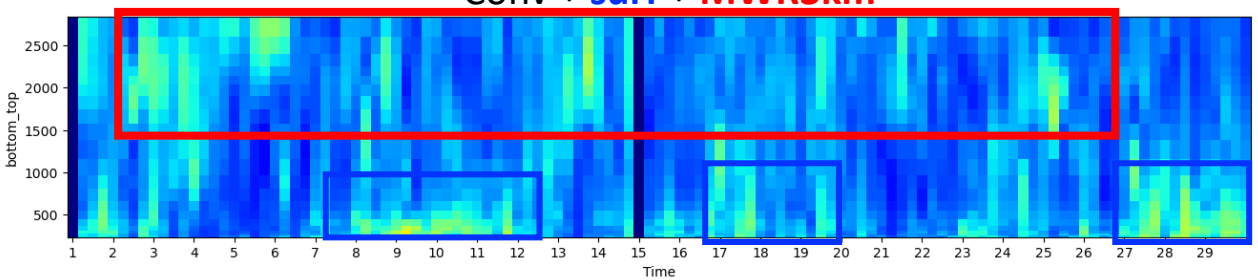

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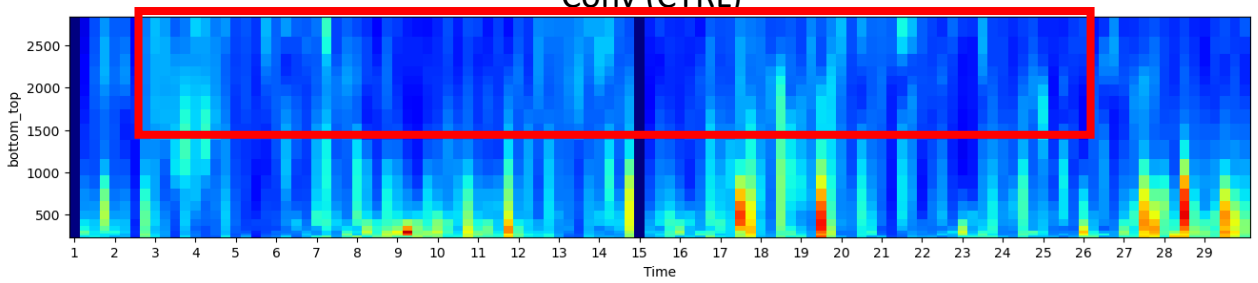

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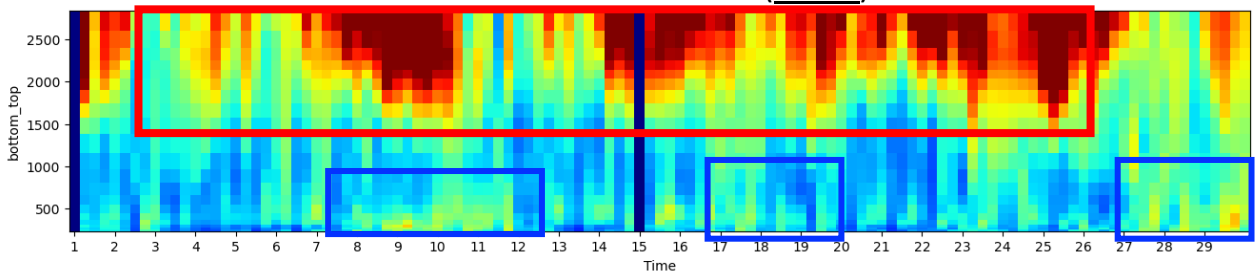

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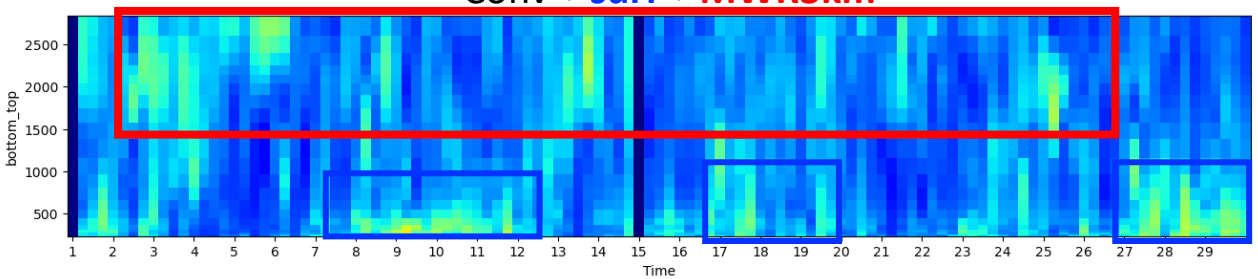

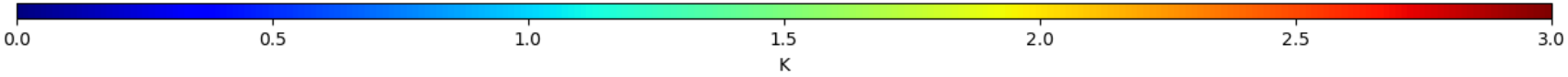

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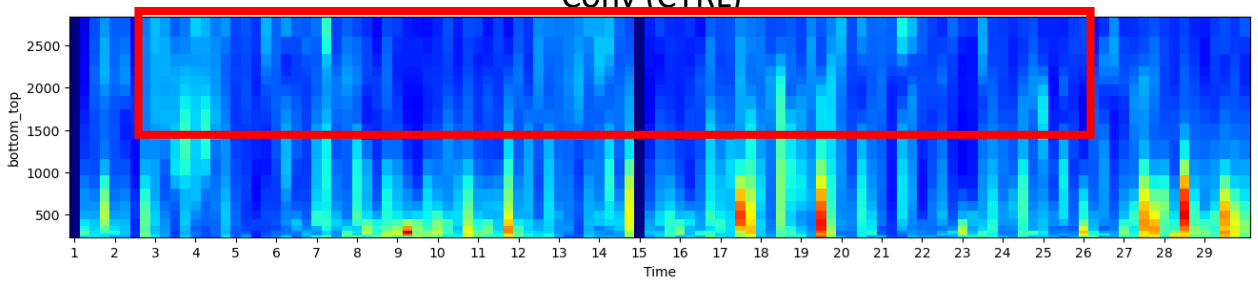
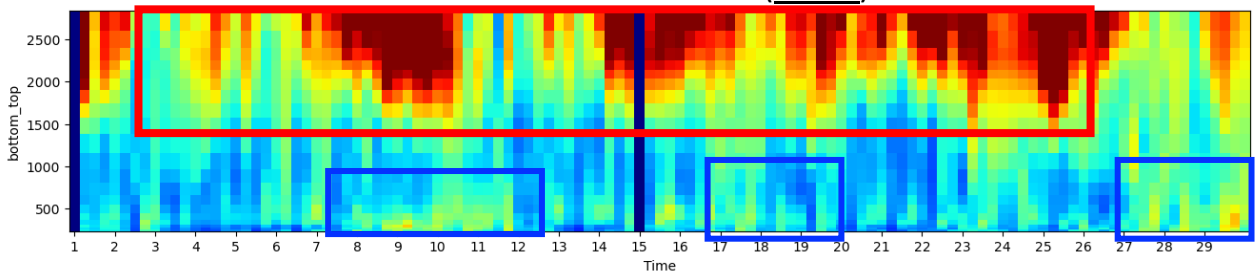
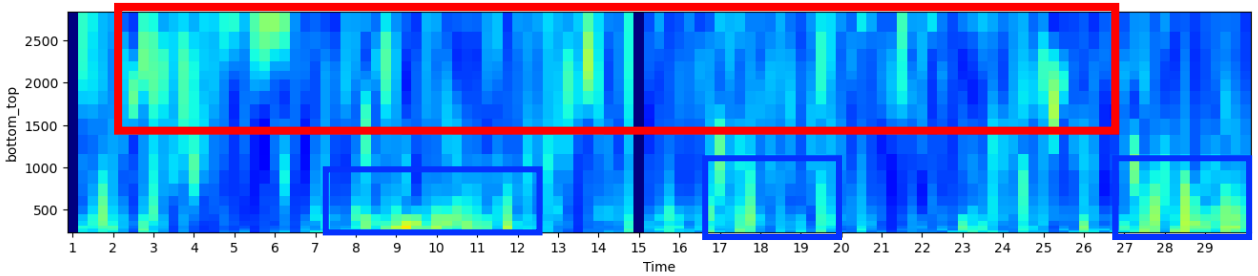


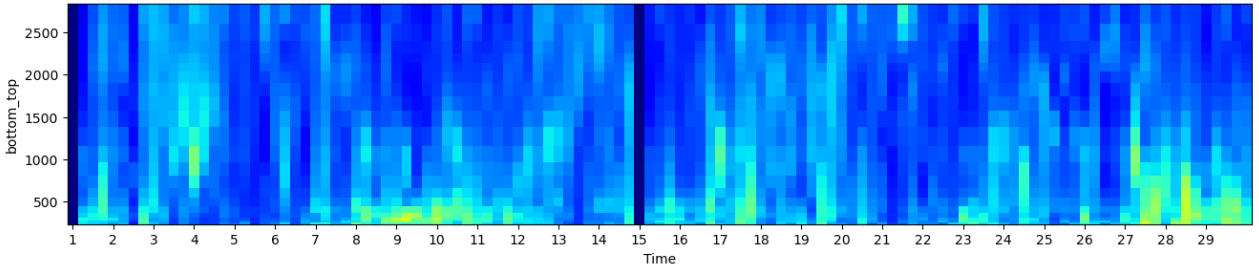
Conv + surf +MWR3km (NoBC)



Conv + surf + MWR3km



Conv + surf + MWR (1km)



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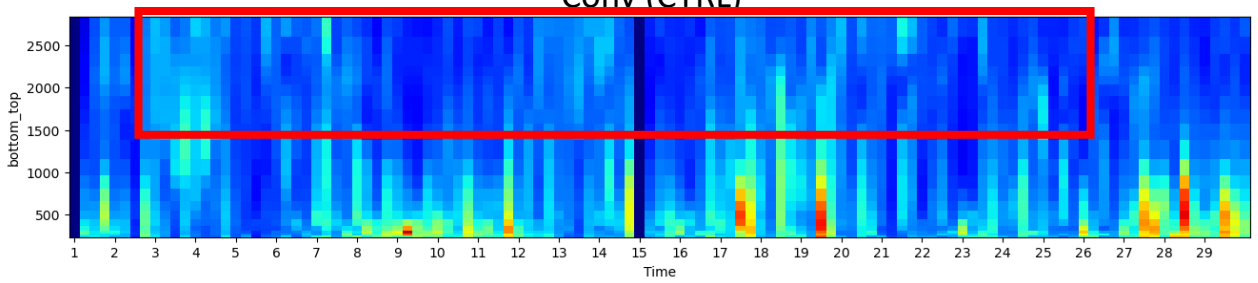
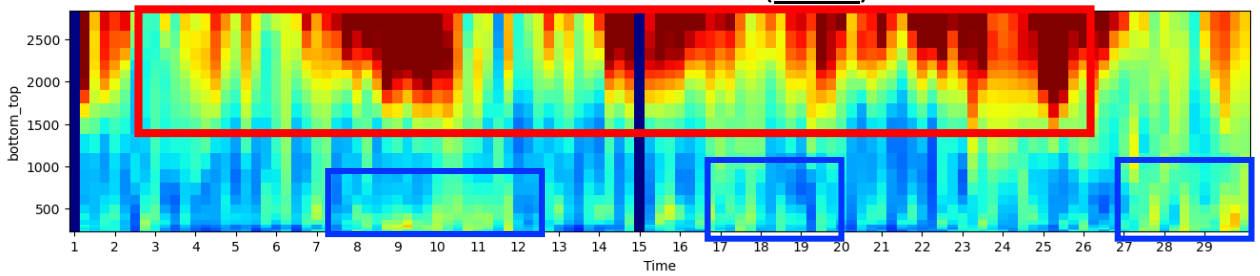
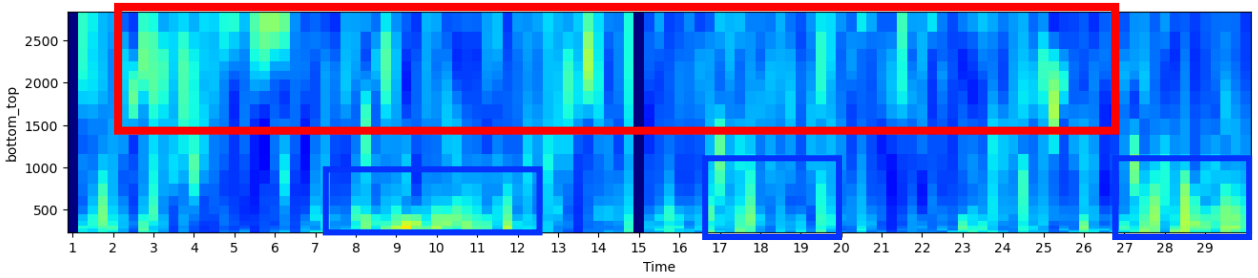


Conv + surf +MWR3km (NoBC)



Conv + surf + MWR3km



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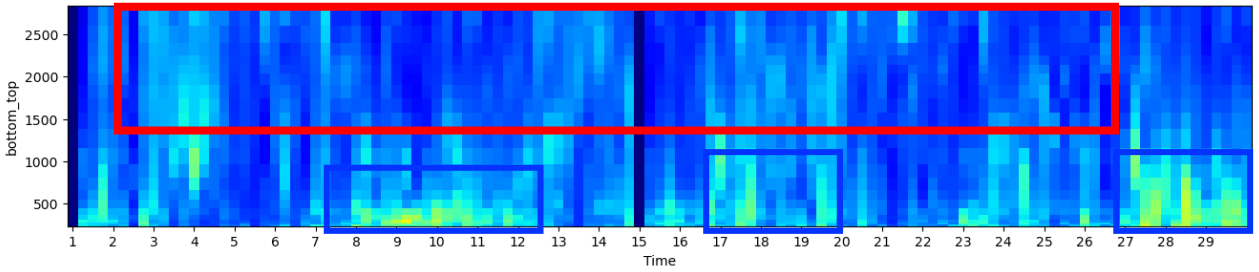
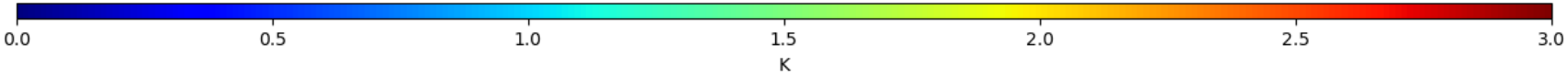
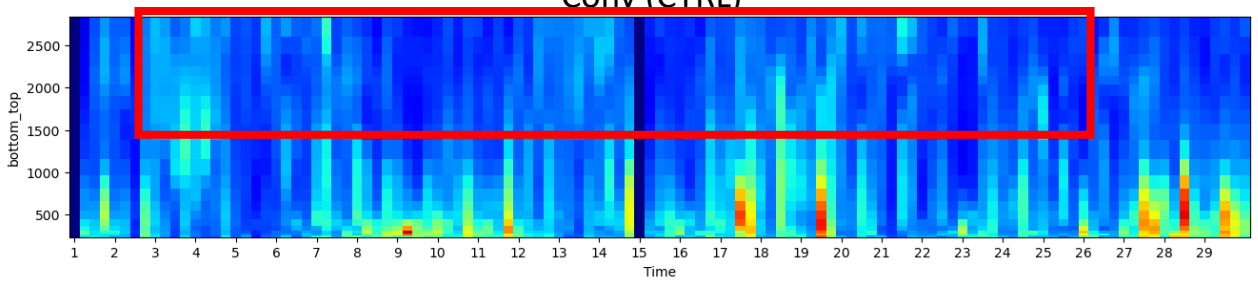


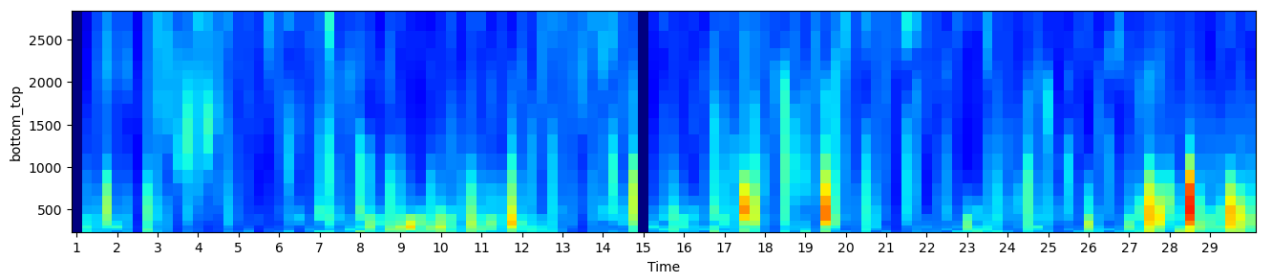


April 1 00UTC-30 06 UTC: Potential Temp Error

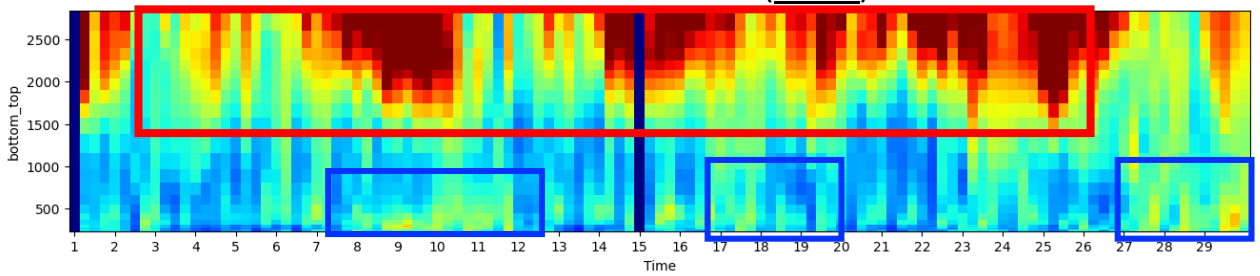
Conv (CTRL)



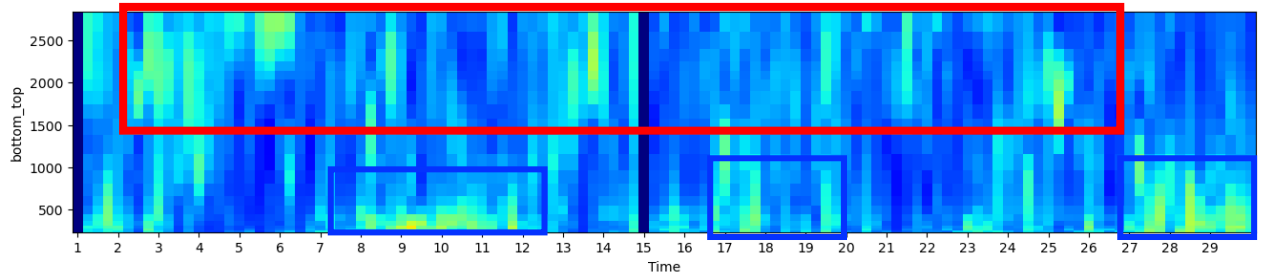
Conv + surf



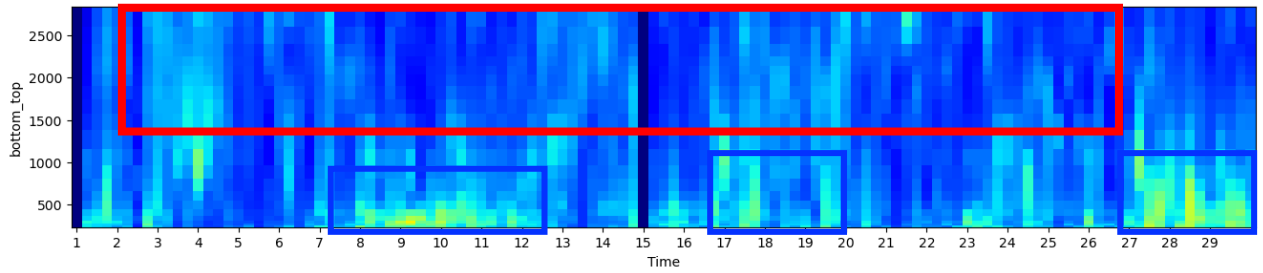
Conv + surf +MWR3km (NoBC)



Conv + surf + MWR3km

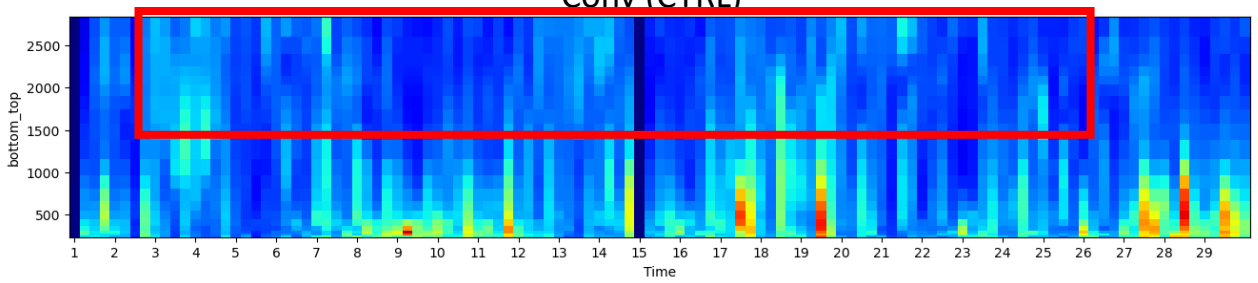


Conv + surf + MWR (1km)

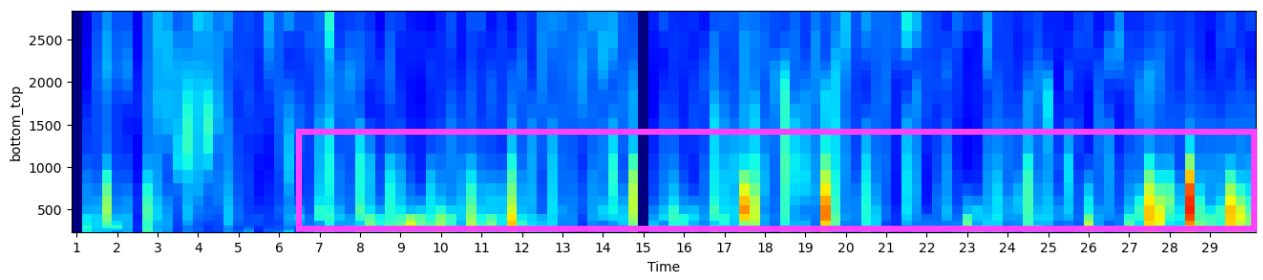


April 1 00UTC-30 06 UTC: Potential Temp Error

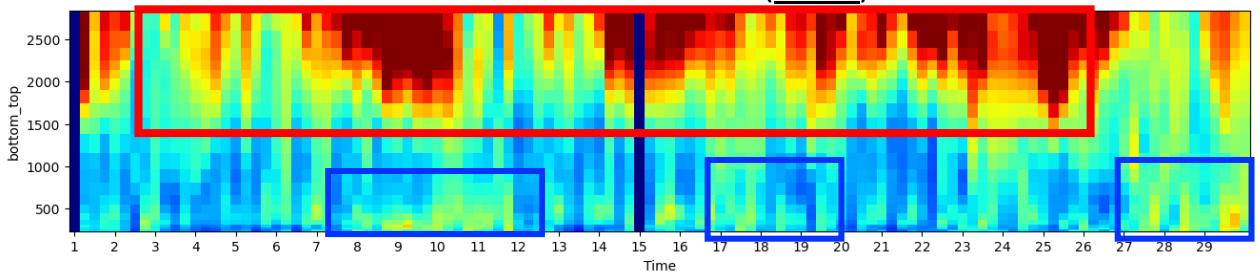
Conv (CTRL)



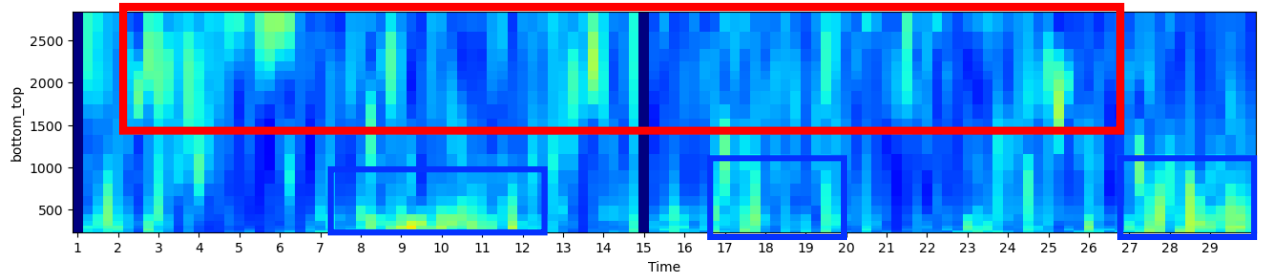
Conv + surf



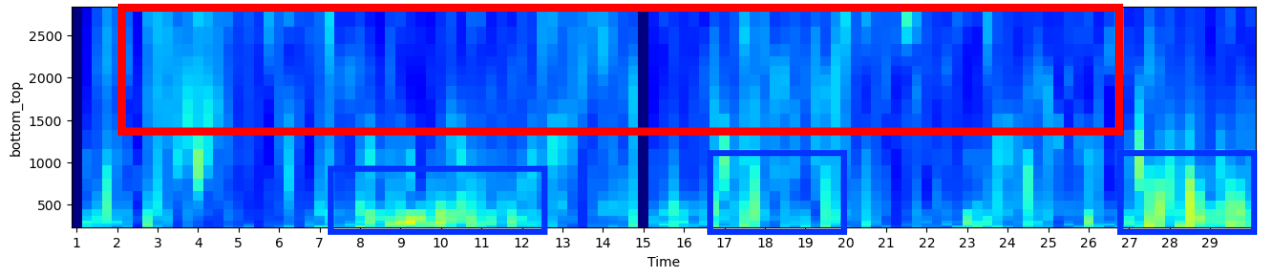
Conv + surf +MWR3km (NoBC)



Conv + surf + MWR3km

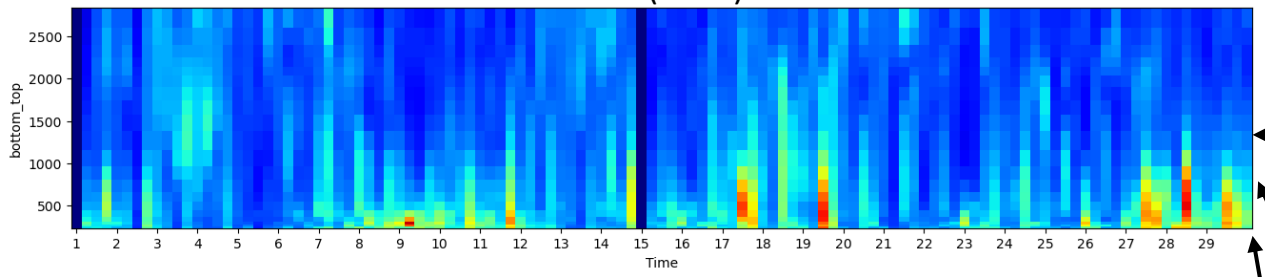


Conv + surf + MWR (1km)

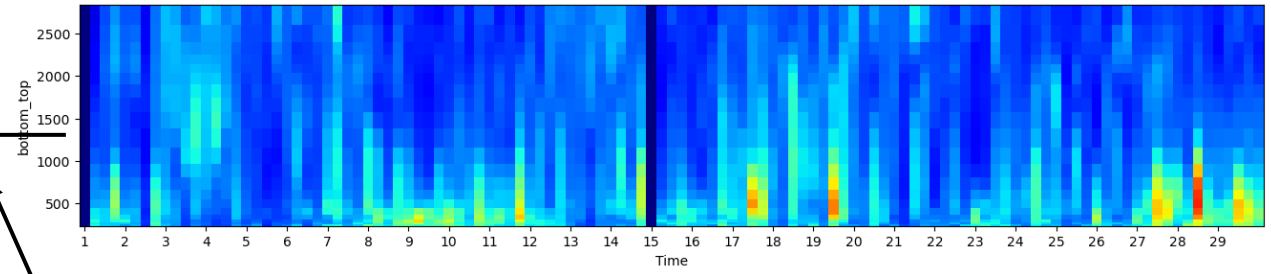


April 1 00UTC-30 06 UTC: Potential Temp Error

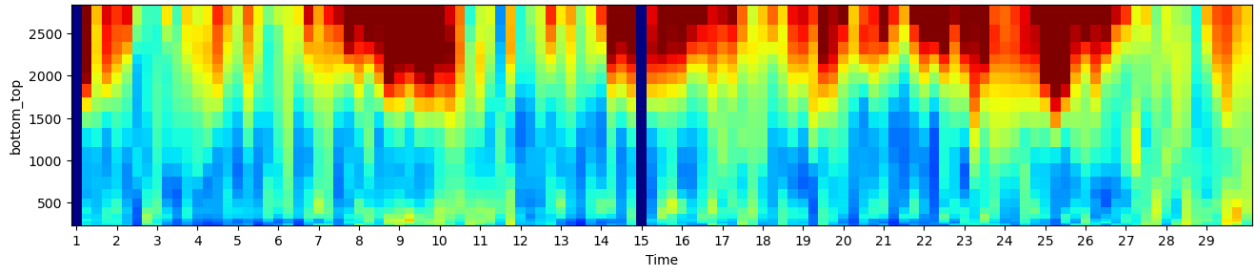
Conv (CTRL)



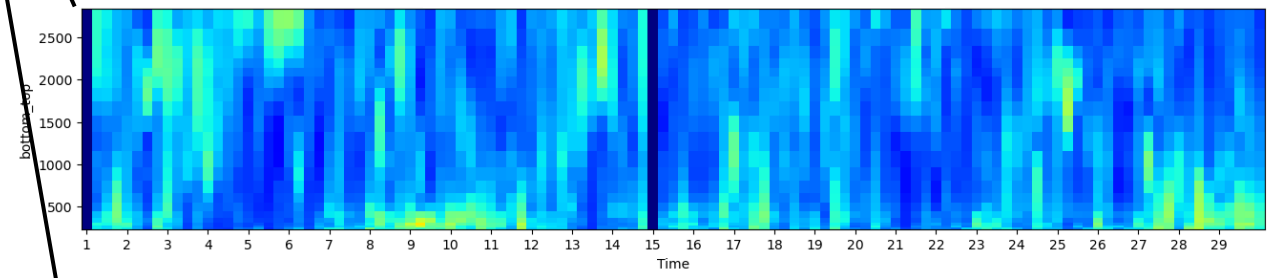
Conv + surf



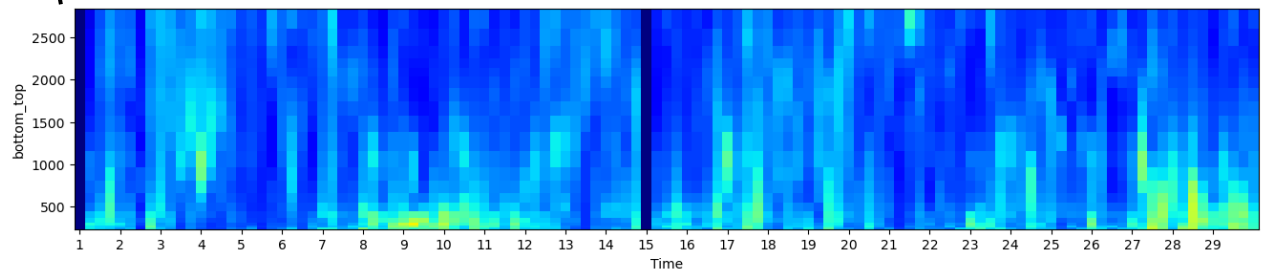
Conv + surf +MWR3km (NoBC)



Conv + surf + MWR3km

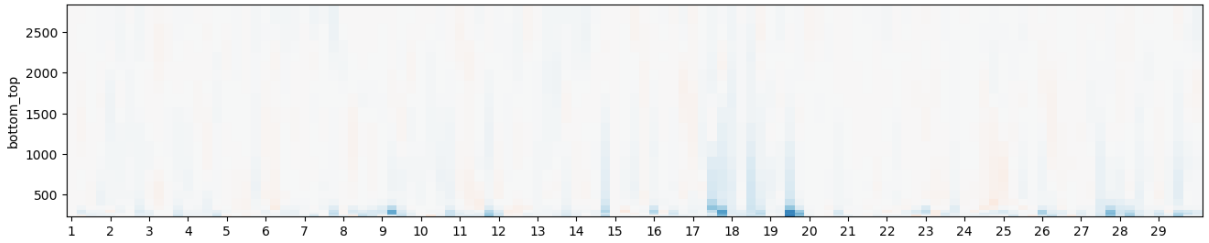


Conv + surf + MWR (1km)

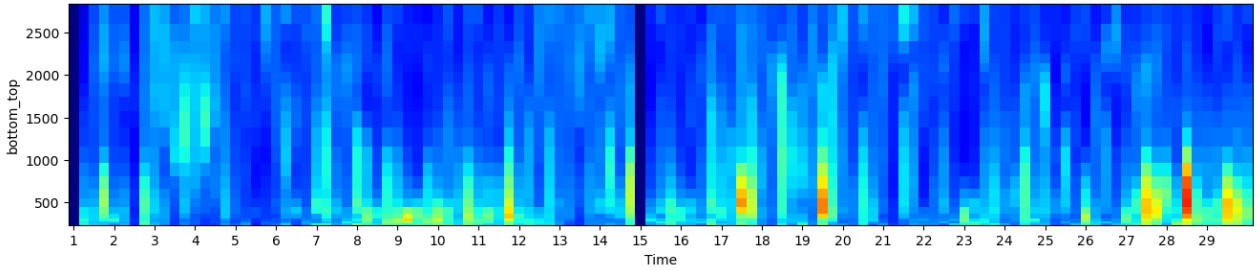


April 1 00UTC-30 06 UTC: Temperature Error

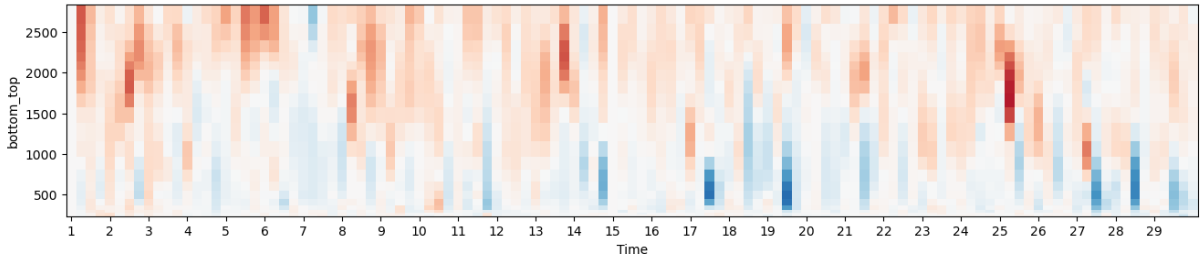
Conv + **surf** : Data impact



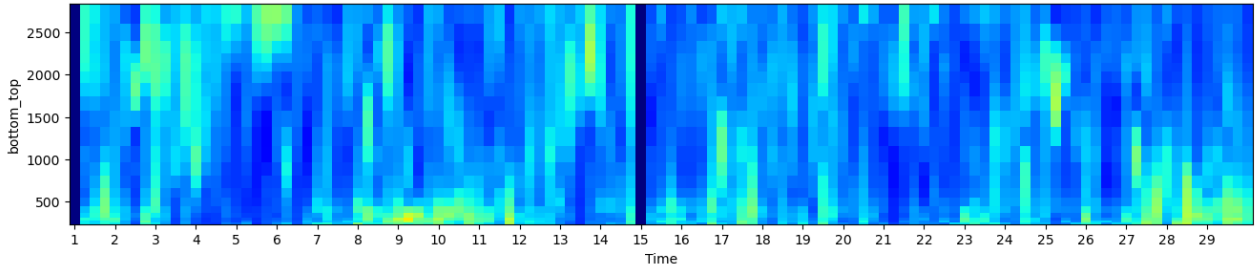
Conv + **surf**



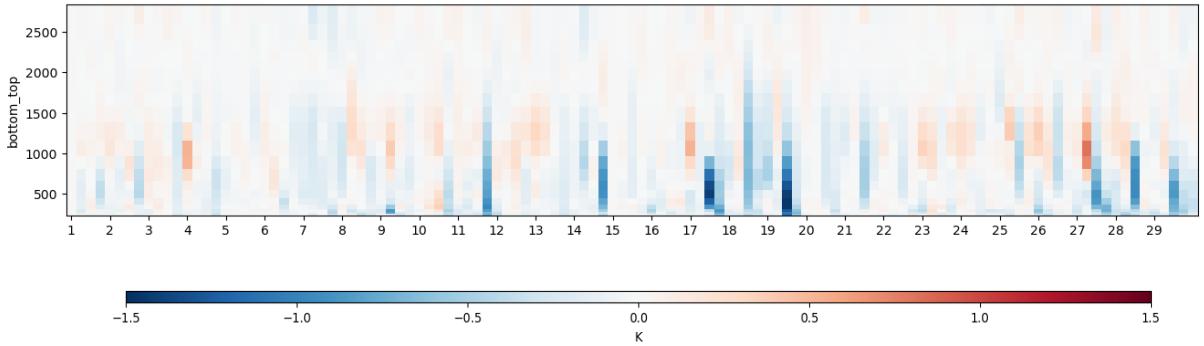
Conv + **surf** + **MWR3km**: Data impact



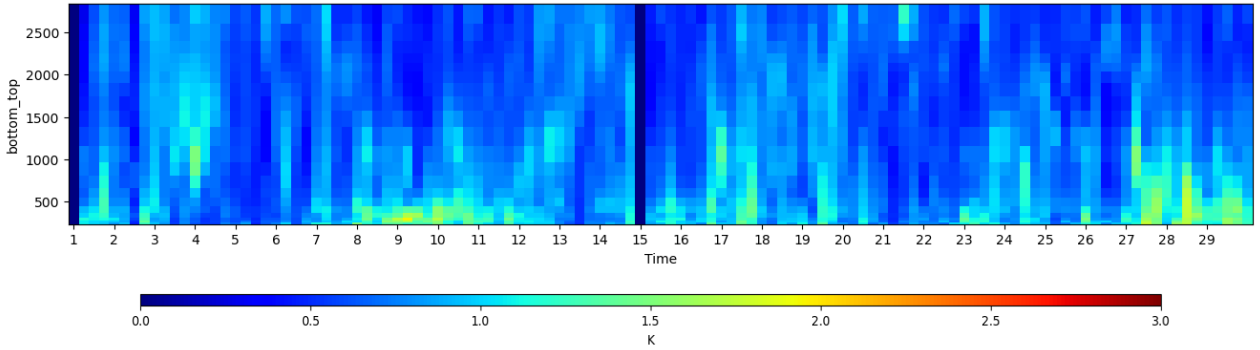
Conv + **surf** + **MWR3km**



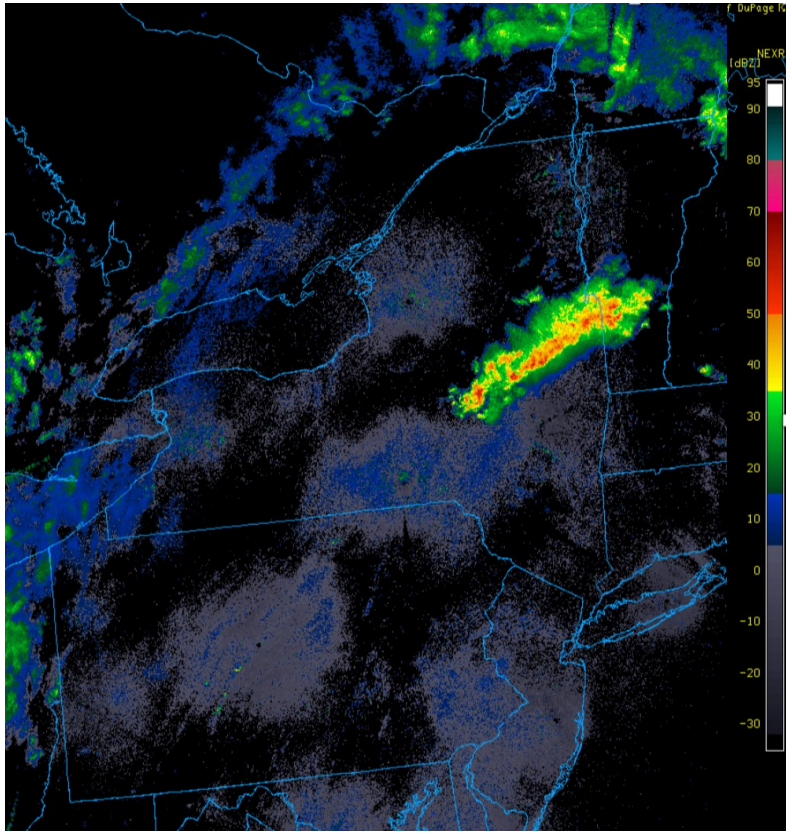
Conv + **surf** + **MWR (1km)** : Data impact



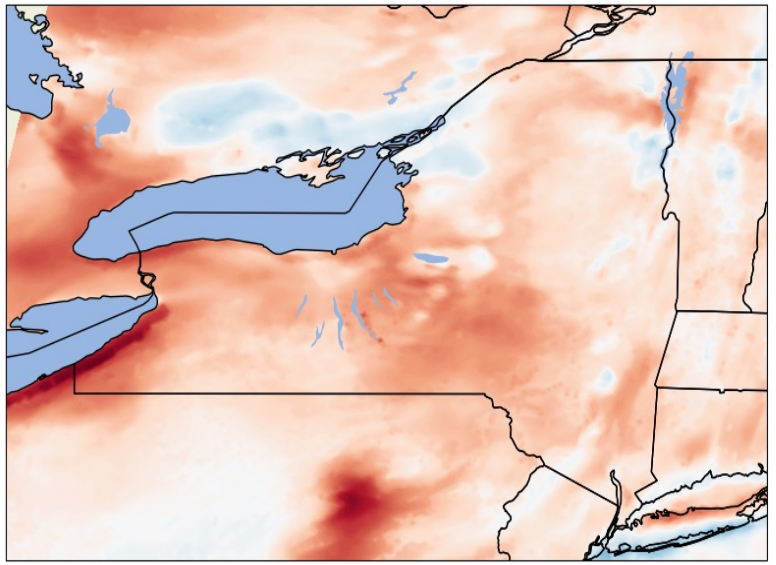
Conv + **surf** + **MWR (1km)**



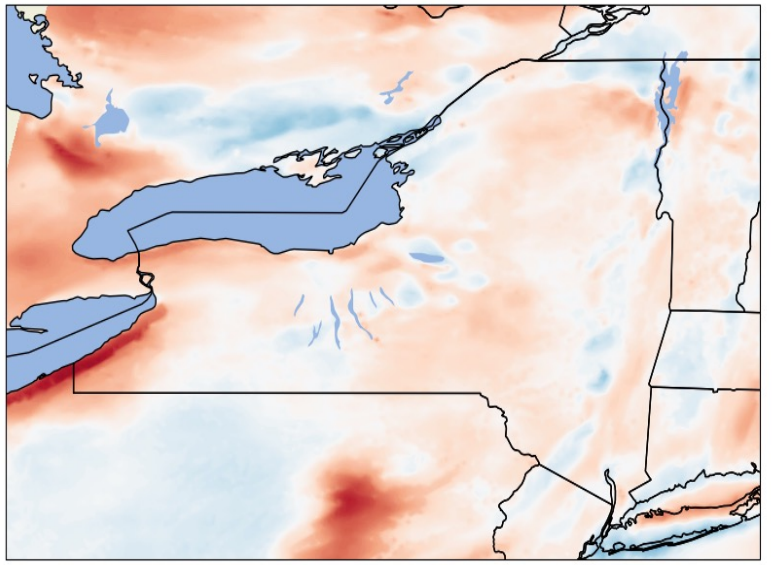
April 28 12 UTC



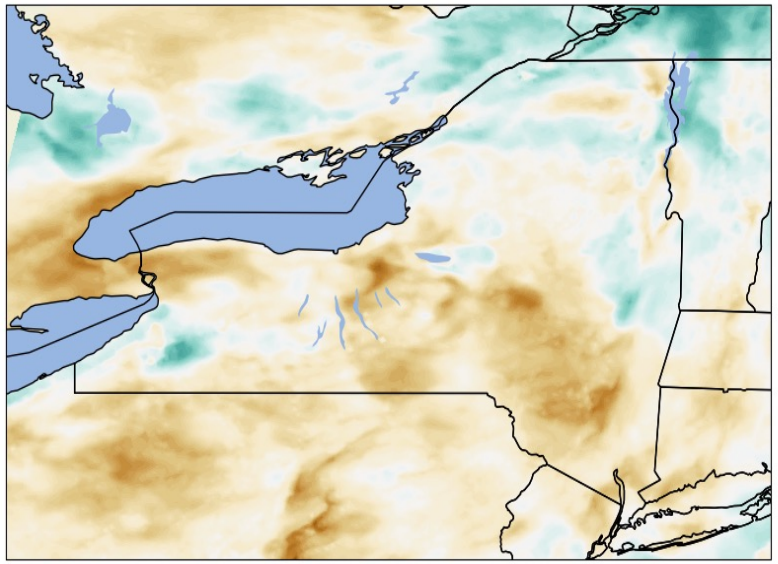
CTRL(Conv): θ error



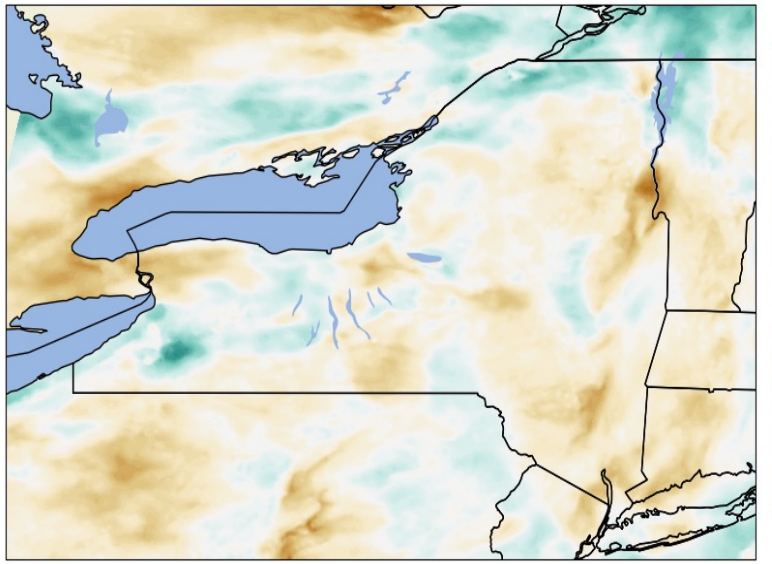
Conv + surf + MWR (1km) : θ error



CTRL(Conv): q_v error



Conv + surf + MWR (1km) : q_v error



Conclusions

- We developed a bias correction scheme based on raw brightness temperature of the MWR to remove the cold bias in the NYSM MWR temperature retrieval

- Verification using independent soundings showed the removal of the majority of the cold bias throughout the troposphere, as well as a reduction of standard deviation in the temperature uncertainty

- Data assimilation cycling experiments over April 2024 showed significant improvement in analysis quality within the lowest 1 km of the atmosphere

Ongoing research:

- Collaborating with NCAR team to investigate the optimal DA setting and strategy (data thinning, observational error covariance) for assimilating NYSM MWR radiometer data