Improving Short-Term Precipitation Forecasts through Machine Learning Inference of Latent Heating Profiles Based on Radar Observations

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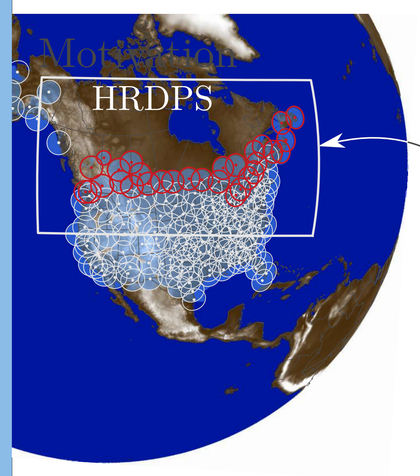
Context



The purpose of this work is to improve the forecasts made with the High Resolution Deterministic Prediction System (HRDPS)

- Cycled 4D-EnVar assimilation system
- @2.5km
- 6h window
- 4 x 48h forecasts per day

Since 2021, radar-inferred precipitation rates are assimilated using Latent Heat Nudging (LHN).

https://doi.org/10.1175/MWR-D-22-0028.1

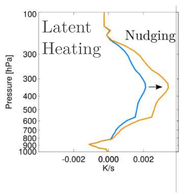
The Idealized profiles are responsible for ~80% of the improvements that are brought by LHN.

Working hypothesis: improving these profiles should also improve HRDPS forecasts.

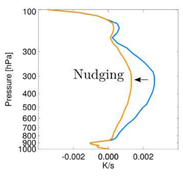
LHN operates in four different modes

1- Do nothing

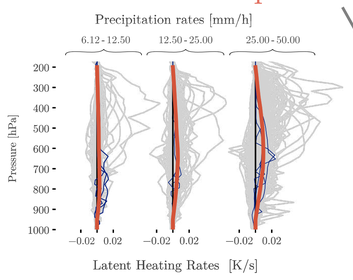
2- Precip-Precip Scale profiles

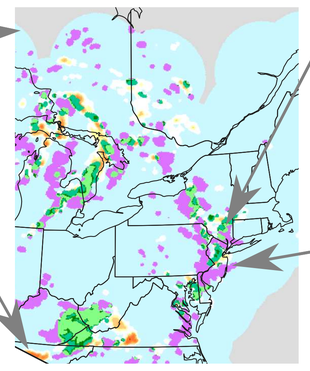


3- No Observed Precip Reduce profiles



4- No Simulated Precip Idealized profiles

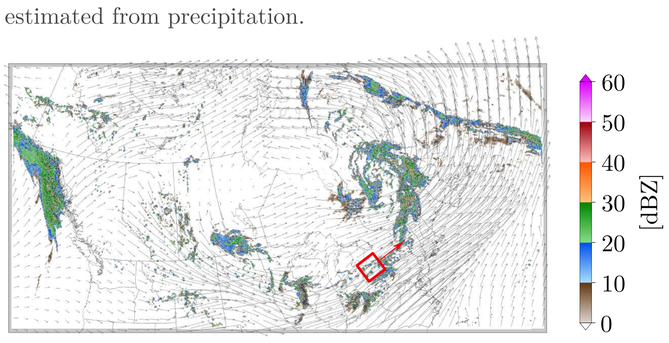




3D latent heating field as multitude of 1D profiles

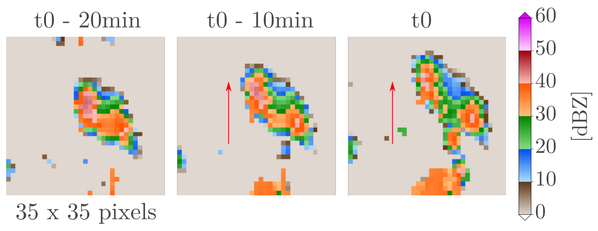
For both training and inference, 1D profiles of latent heating are inferred from 2D precipitation in a local neighborhood.

Precipitation is rotated such that the sampling windows are always aligned with the motion vectors estimated from precipitation.



Input:

Reflectivity at three time steps



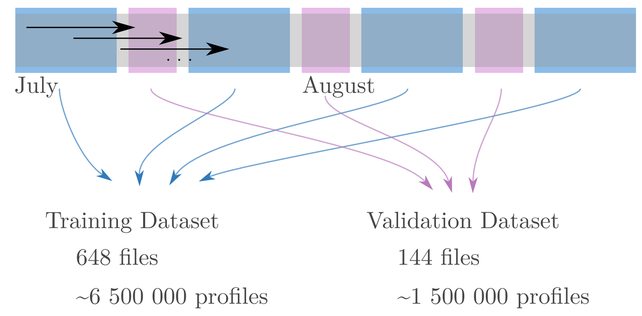
Output:

Profiles of latent heating

Best result so far obtained with a 152 layer RESNET, L1 loss function with the Adam minimizer.

Data is divided into training and validation datasets

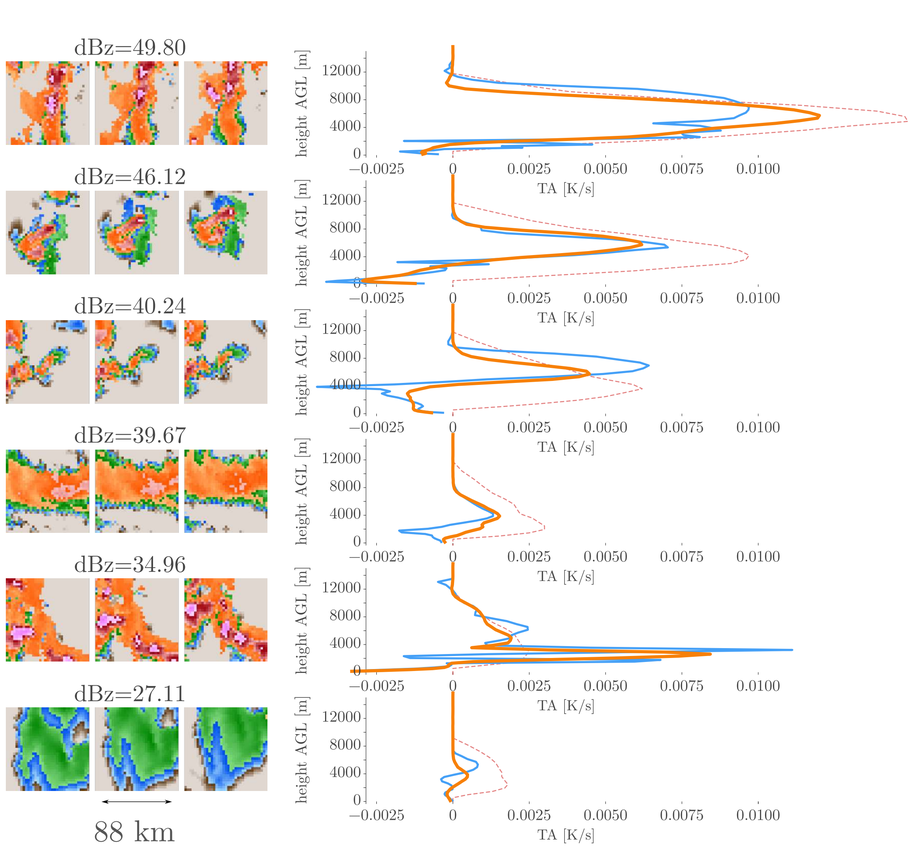
HRDPS forecasts every 12h during two months -> ~120 forecasts



Inference of 1D latent heating from simulated precipitation

Machine learning inference
HRDPS latent heating
Idealized profiles

HRDPS precip input



Machine learning inference
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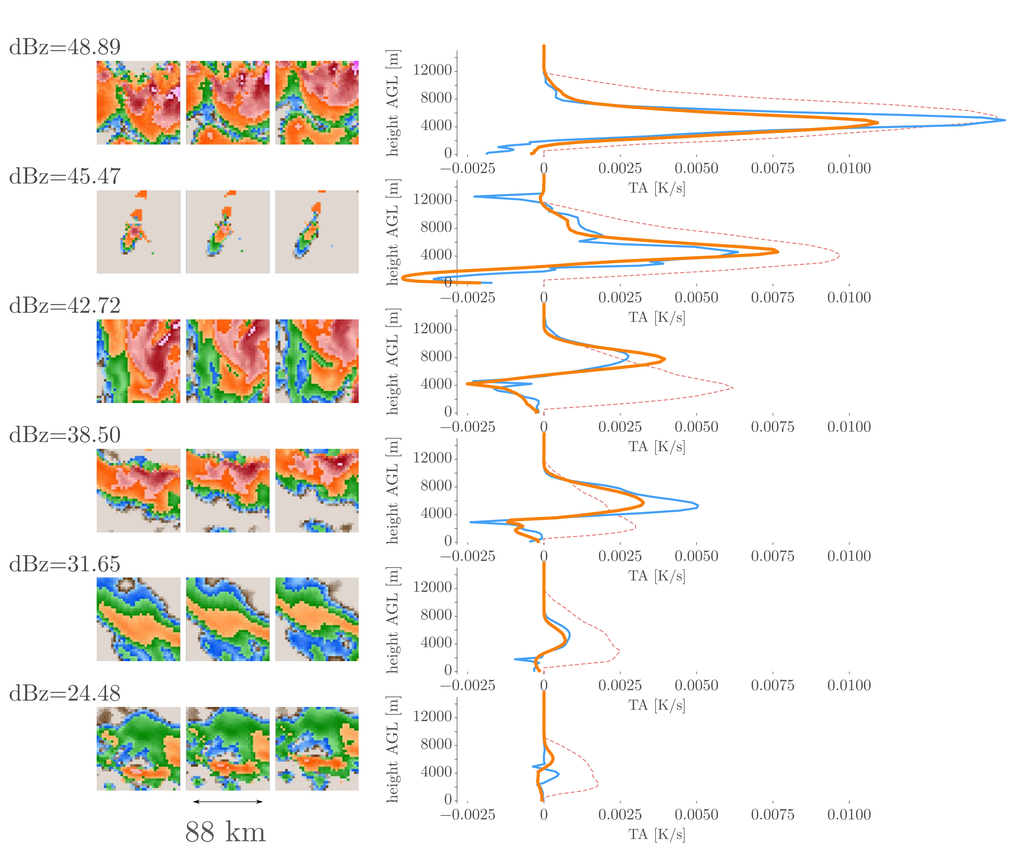
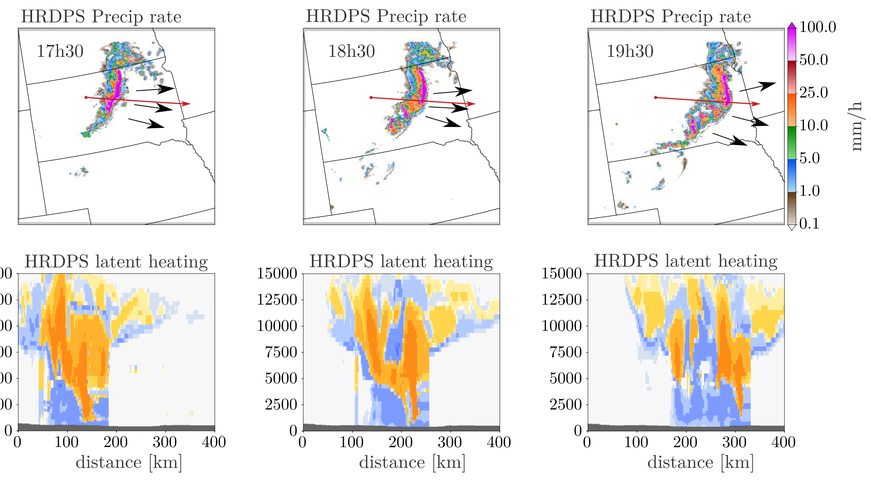
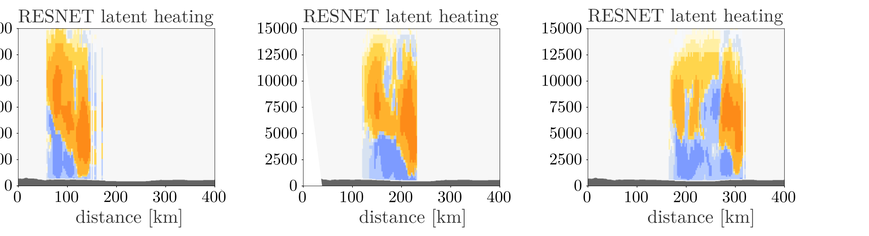


Spatial and temporal coherence

Precipitation rates of an advancing squall line are closely related to the latent heating "ahead" and "above."



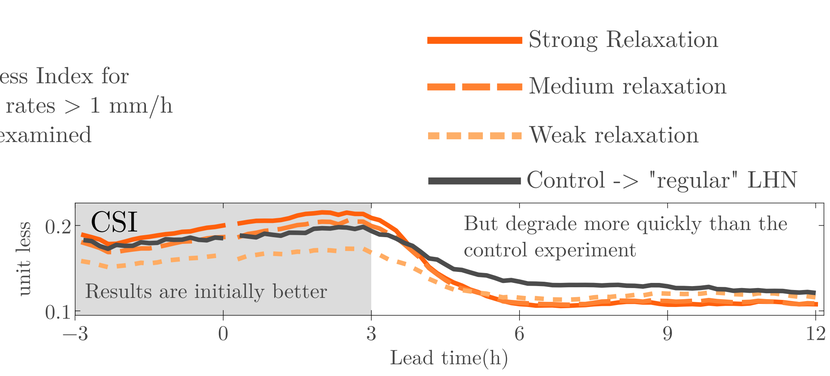
Independent inference profiles are coherent in space and time.



Verification results

Unfortunately, experiments conducted with the improved latent heating profiles do not perform as well as the control experiment without.

Critical Success Index for precipitation rates > 1 mm/h
61 forecasts examined



Verifications against other types of observations also show deterioration.