



A new IASI channel selection method for the KIM DA system

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1 Background

- Hyperspectral infrared measurements have a significant impact on NWP forecasts, providing abundant information of atmospheric vertical structure.
- More than 150 (out of 8461) IASI channels over CO₂, water vapor, and window bands are used in the DA system at other operational NWP centers (e.g. ECMWF and MetOffice). However, only 91 IASI channels over CO₂ and water vapor bands are being used in the operational KIM DA system.
- In this work, we aim to increase the number of IASI channels used in the KIM DA system to make the most advantage of hyperspectral infrared observation.

2 Methodology

- For an efficient channel selection, **195 IASI channels** combining the channels used at ECMWF and those at MetOffice **were divided into 20 channel groups** by using **K-means clustering algorithm**.
- In order to consider both T and q Jacobians as the criteria, **3D normalized Jacobian PDF profile** having T Jacobian PDF as x-axis and q Jacobian PDF as y-axis was calculated for each channel.
- First, a channel group that makes **the smallest normalized RMSE against the ERA5 reanalysis** was selected, and the group that produced **the smallest error along with previously selected channels** among the other channel groups was added in turn.
- This process was performed until the normalized RMSE smaller than a certain threshold, comparing to the results using the 91 operational channels and 195 candidate channels, and IASI denial result.

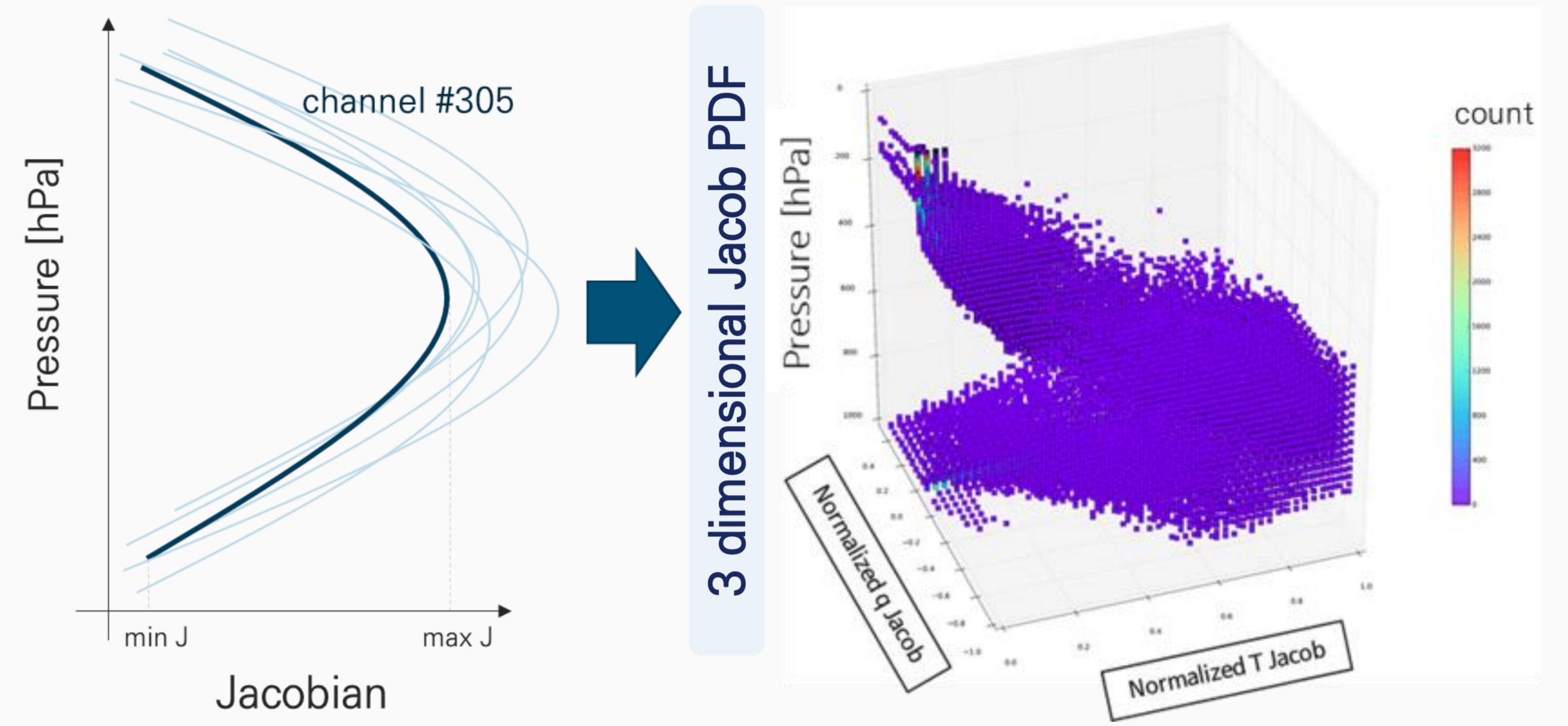


Fig 1. Schematic diagram of how to make three-dimensional normalized Jacobian PDF for each IASI channel for K-means clustering.

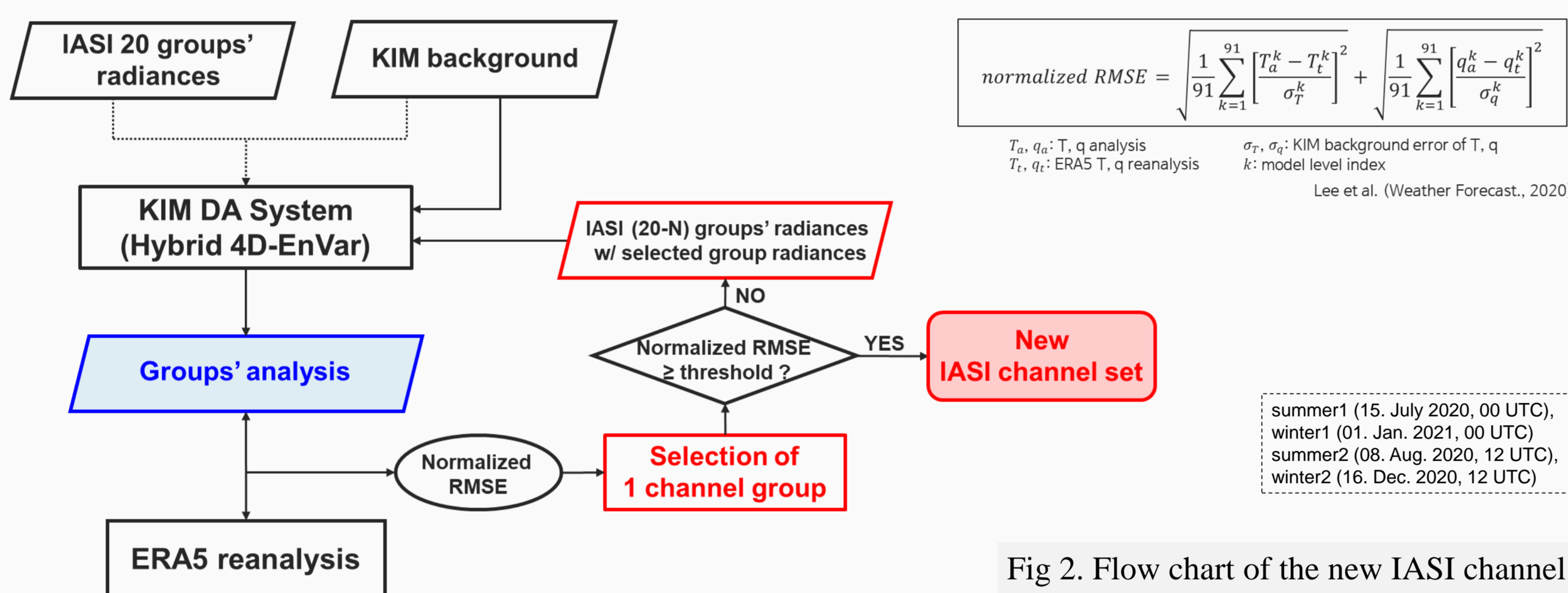


Fig 2. Flow chart of the new IASI channel selection method using normalized RMSE.

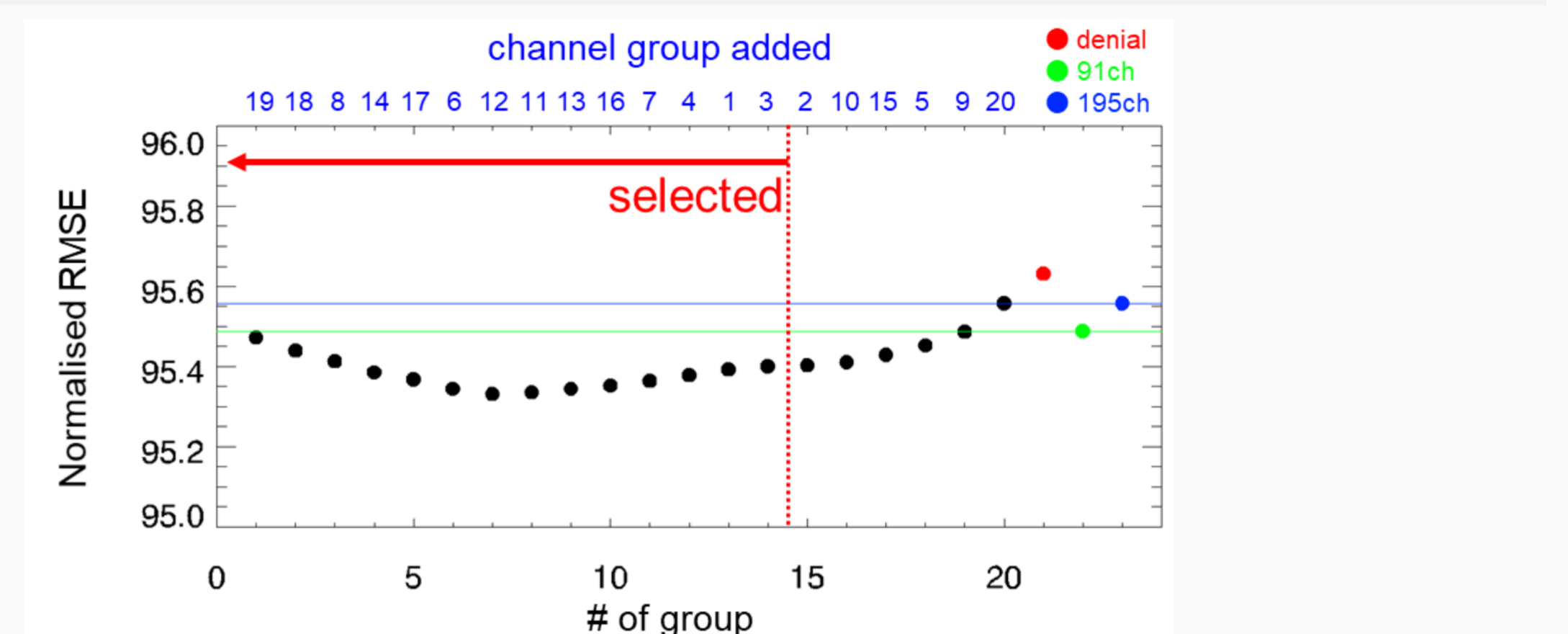


Fig 3. The change of normalized RMSE with respect to the number of used IASI channel groups. Blue top numbers indicate groups added at each process. Normalized RMSE of denial test (red) and that of using 91 (green) and 195 (blue) channels are also shown.

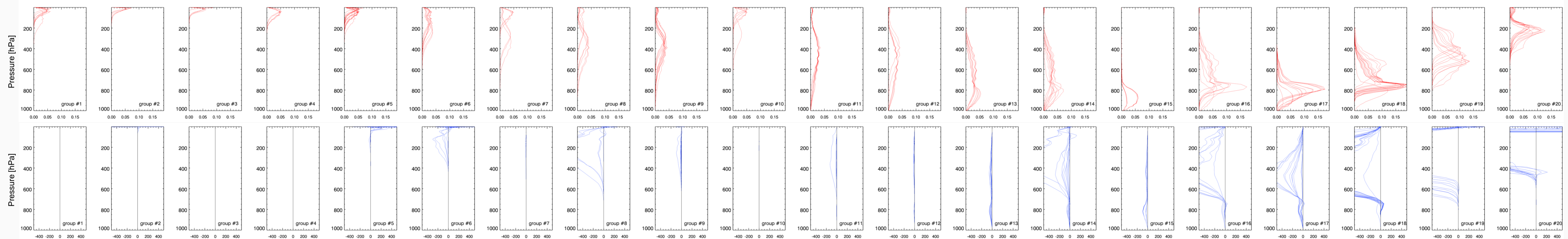


Fig 4. T (top) and q (bottom) Jacobians of each IASI channel group.

3 Results

- Including 83 CO₂ channels and 53 water vapor channels, **136 IASI channels (13 channel groups) were selected**.
- Comparing to the 91 operational IASI channel set (CTL), the use of new IASI channel set (EXP) shows **positive impact on the T/q analysis fields** in the middle and lower troposphere.
- Consistently, the new 136 IASI channels represent **a positive impact on the T, q, and GPH forecast fields** until 3-day forecast.

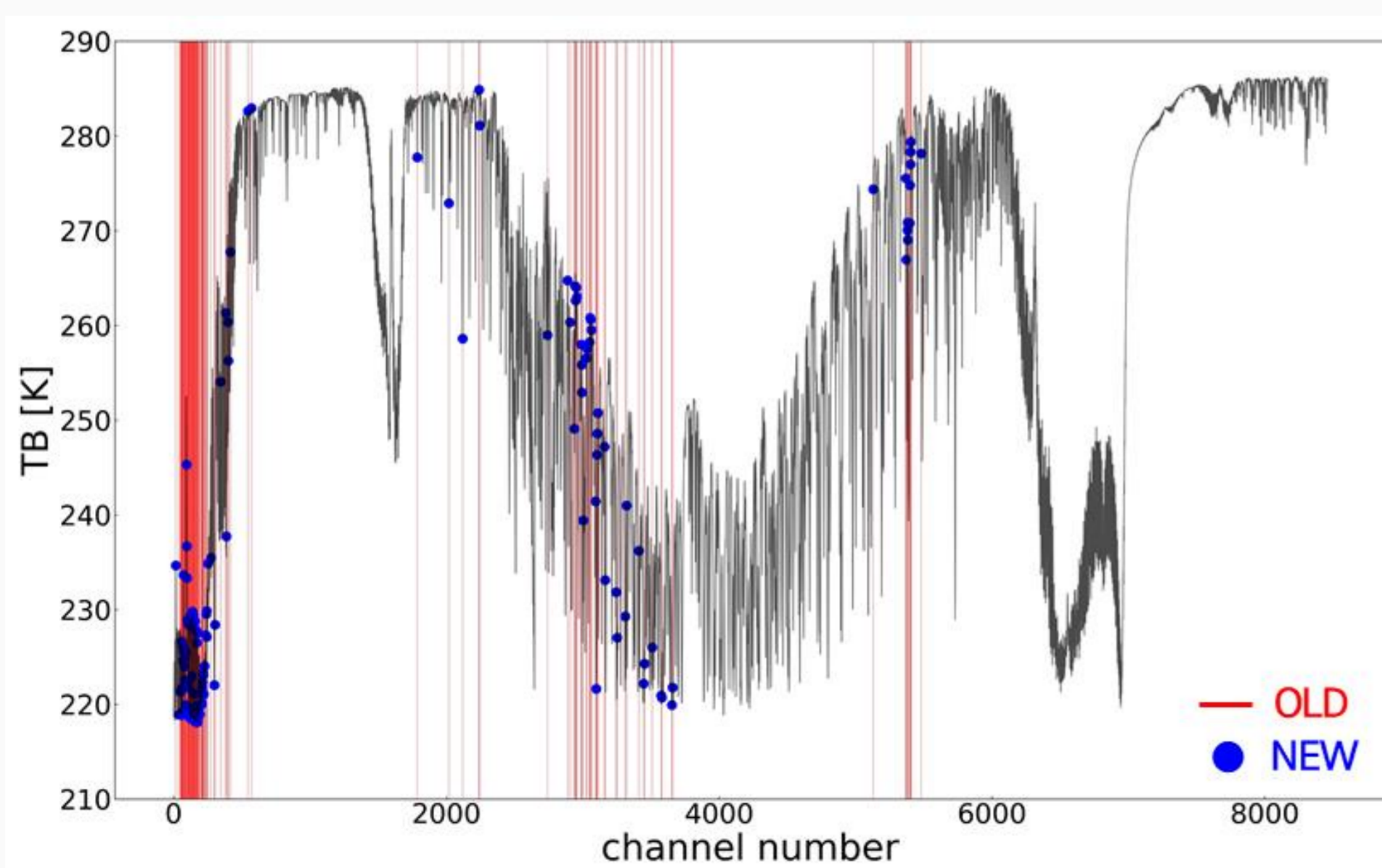


Fig 5. Spectral distribution of (red line) the 91 operational IASI channels and (blue dot) the newly selected 136 IASI channels.

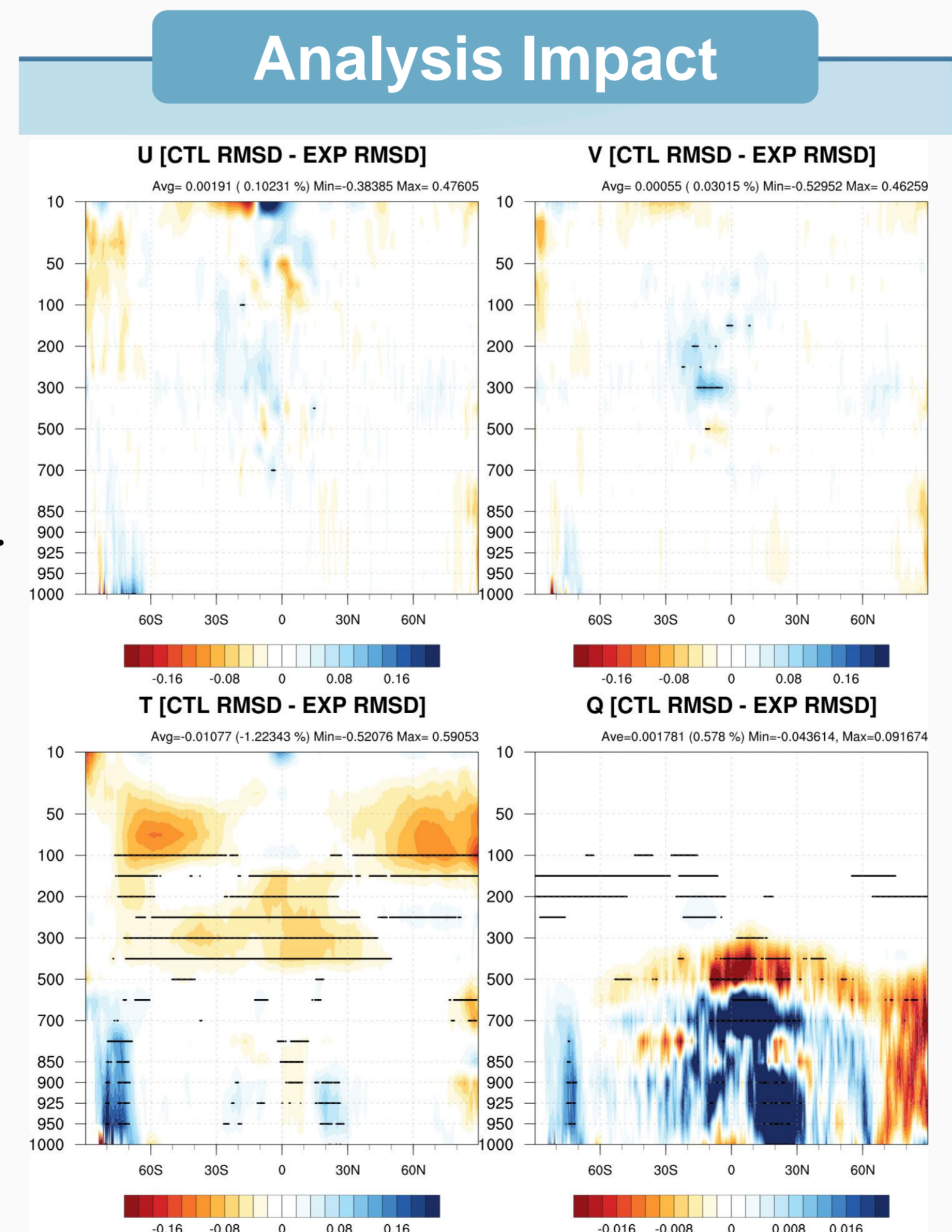


Fig 6. Zonal mean of RMSD of u, v, T, q analysis between CTL and EXP experiments (CTL minus EXP). Black dots represent the 95% significant difference, verified by a t-test.

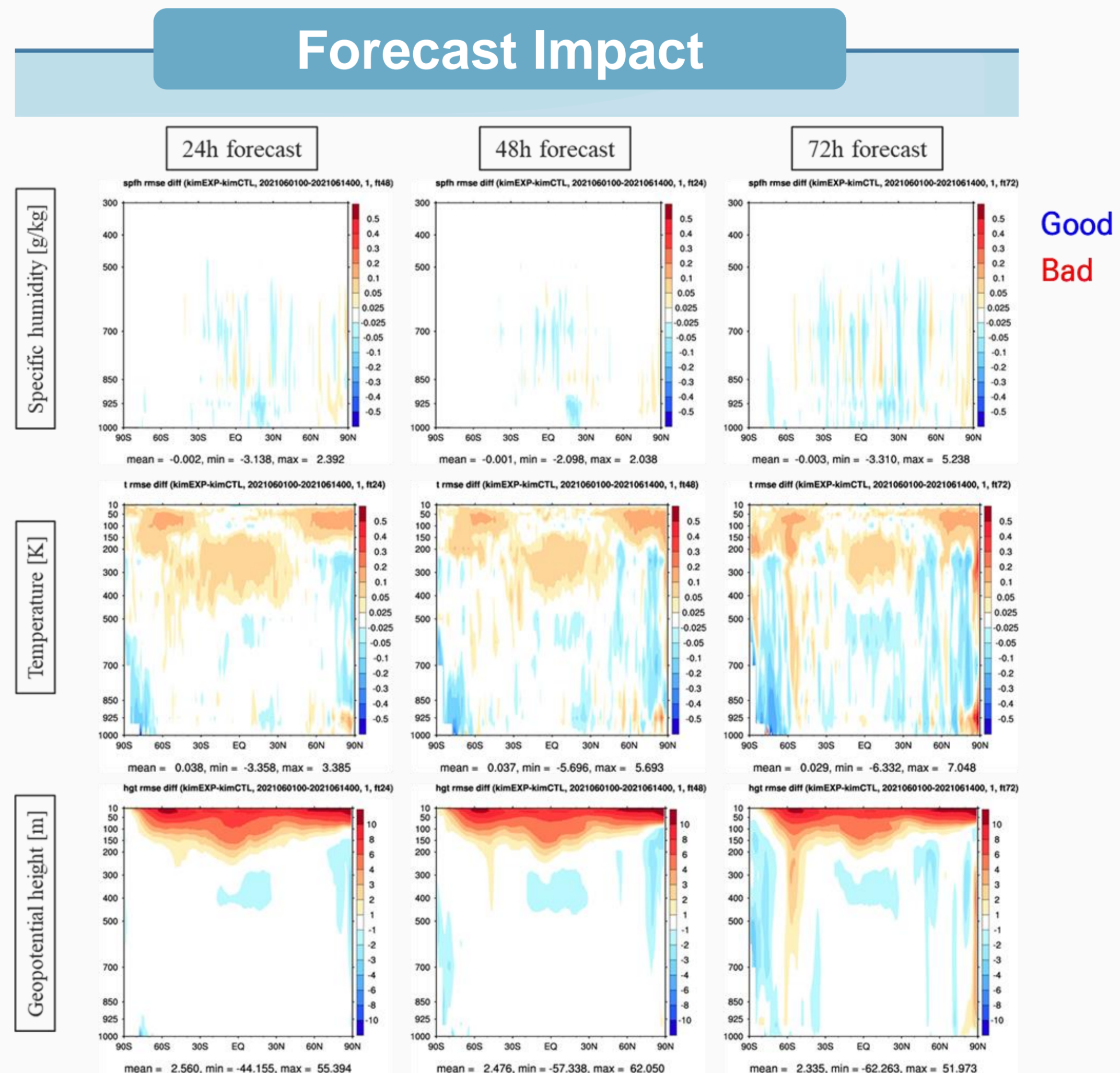


Fig 7. Zonal mean of RMSE of (upper) q, (middle) T, and (lower) GPH forecast fields between CTL and EXP experiments (EXP minus CTL). Shown are the (left) 24, (middle) 48, and (right) 72 hour forecast times.

4 Summary and future work

- In order to extend the number of used IASI channels in the KIM DA system, **a new channel selection method using T/q analysis fields was introduced**.
- For efficient experiments, 195 IASI channels were divided into 20 channel groups by using the **K-means clustering algorithm** based on their T/q Jacobians.
- A total of 136 IASI channels** were used by selecting channel groups that produce a small normalized RMSE compared to the ERA5 reanalysis.
- When we compare to the results using the operational 91 IASI channels, **T/q analysis and forecast fields show some positive impact**. But some **negative impact over the upper tropospheric temperature and lower tropospheric humidity** should still be considered.
- This new channel selection method will be applied to the channel selection for the other hyperspectral infrared sounders in the KIM DA system.