VIEsion: Assimilation of Mode-S Data

Aircraft Observations in High Resolution AROME Simulations

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Overview

- The VIEsion Project
- Mode-S data – Quick Look
- Assimilation Process
- First Results

Overview

- **The VIEsion Project**
- **Mode-S data – Quick Look**
- **Assimilation Process**
- **First Results**

Goals and Challenges of the VIEsion project:

- Focus on **high accuracy nowcasting** for air traffic control
  - 1.2 km model with a one hour update cycle
  - focus on nowcasting and up to 12 hours
  - extended model diagnostics (e.g. visibility, ceiling, wind variability, ...)
  - sensitivity tests with sub-km horizontal grid spacing

- Such a model requires **good initial conditions** based on up-to-date data assimilation

- Incorporation of additional data sources such as mode-S and radar as well as combination with other techniques like latent heat nudging

- Challenge: air traffic control needs high precision forecasts

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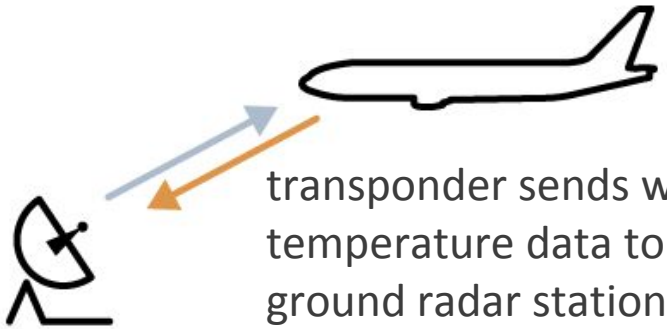
Mode-S Data



transponder sends wind and temperature data to the ground radar stations

image source:
www.skybrary.aero

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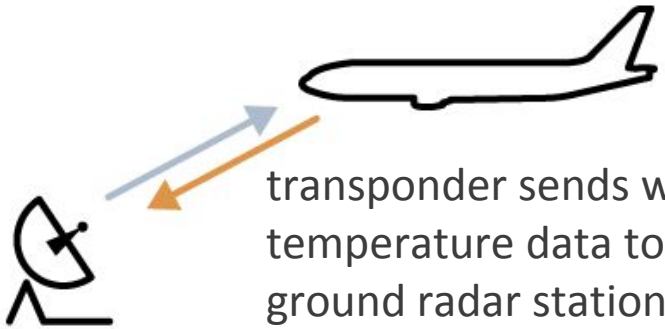

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- Secondary surveillance radar (SSR) receives temperature and wind data from aircraft (Mode-S data)
- 3D real-time data is available for use in weather models
- mostly on flight levels (cruise) with fewer observations during climb and approach

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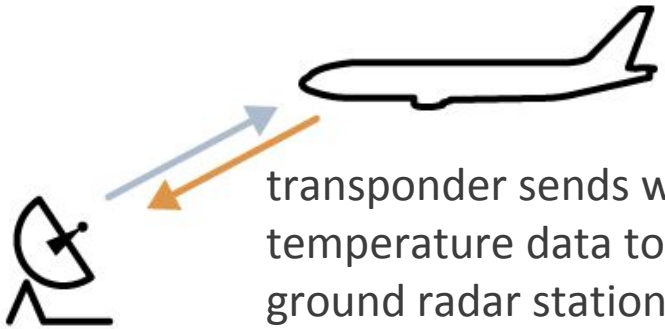

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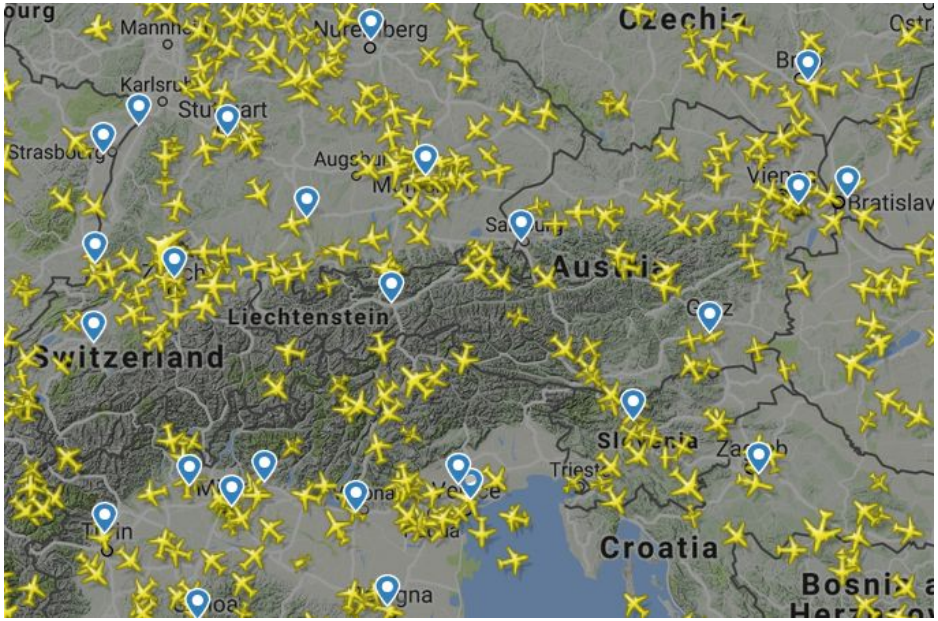

image source: www.flightradar24.com

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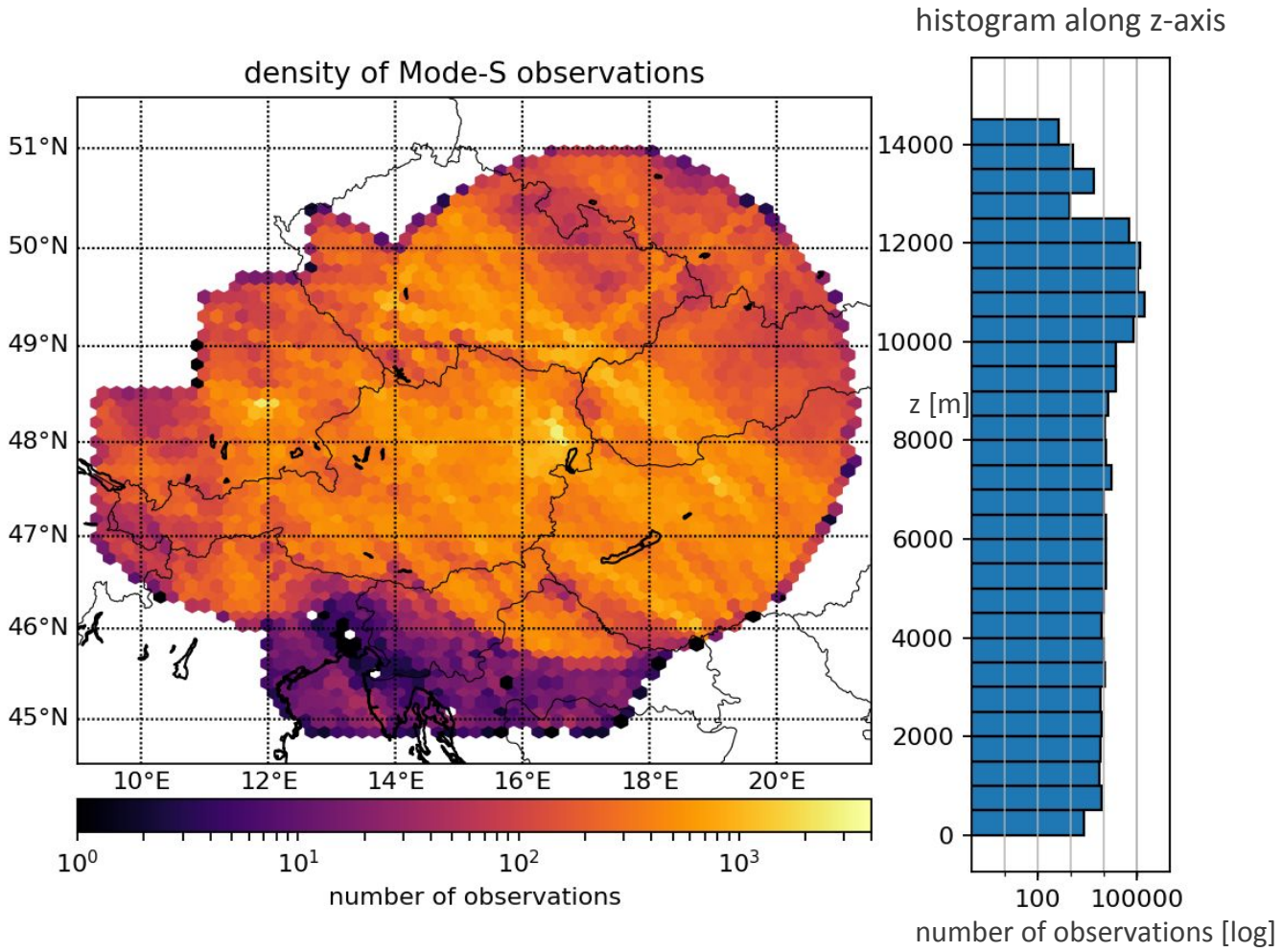
Distribution of Mode-S Data



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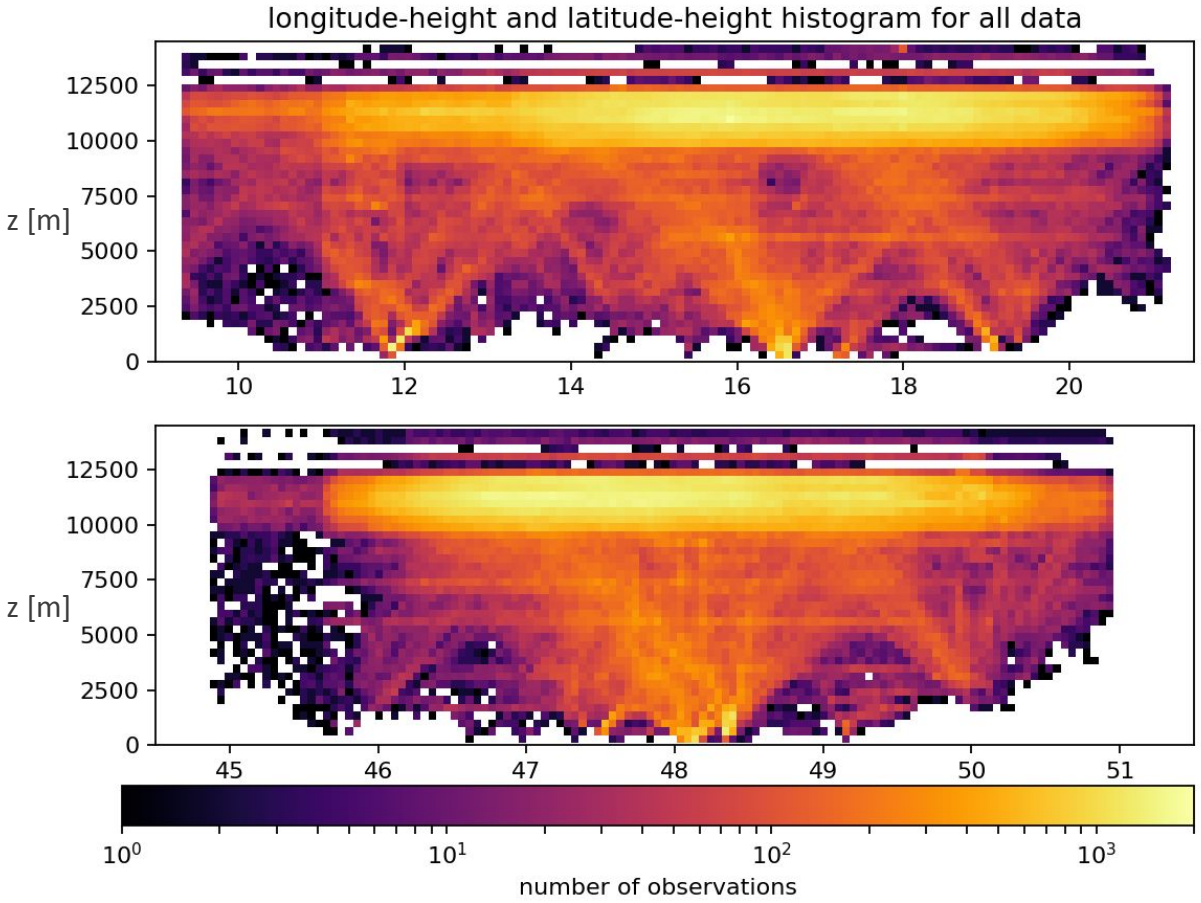

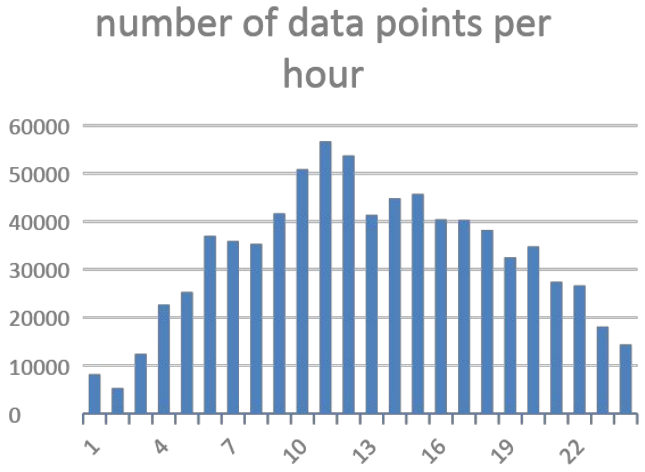

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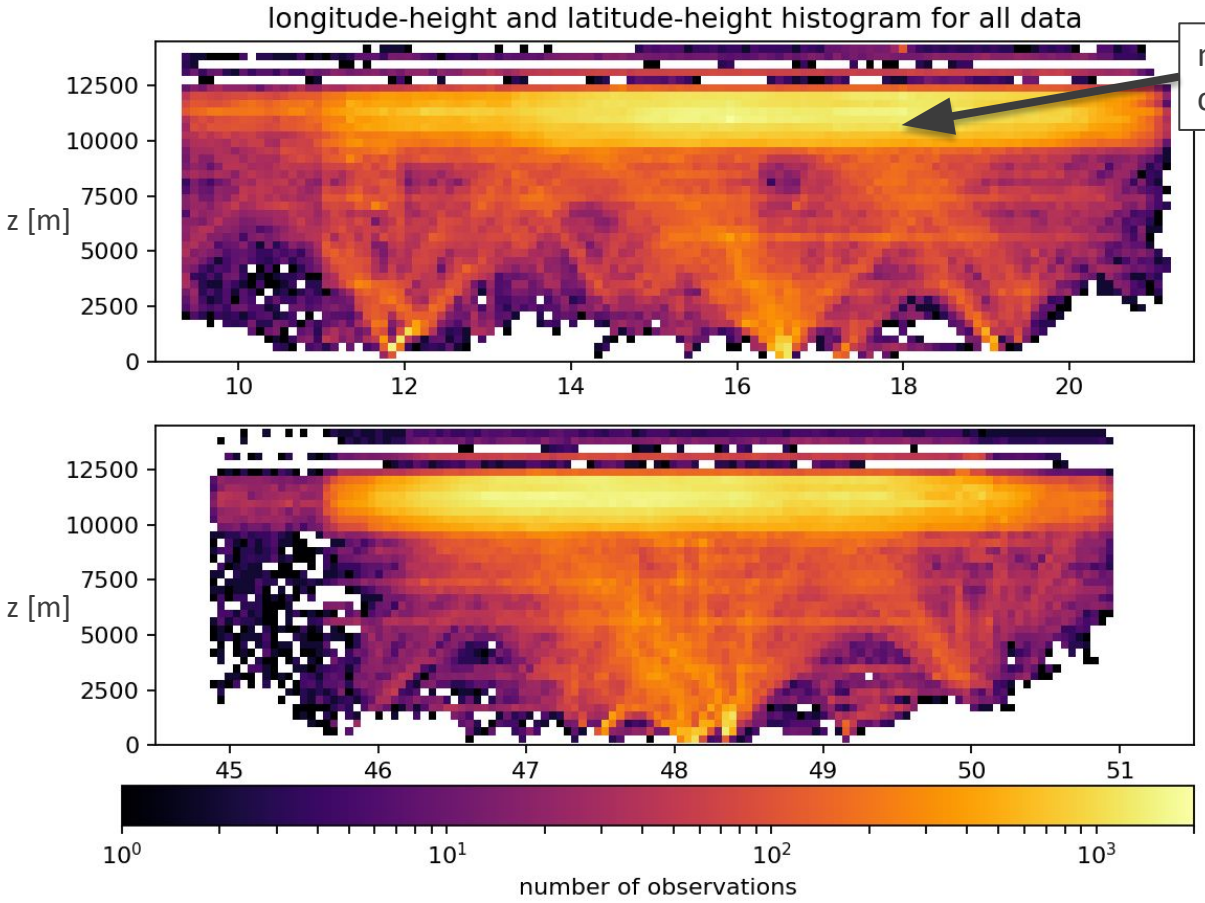
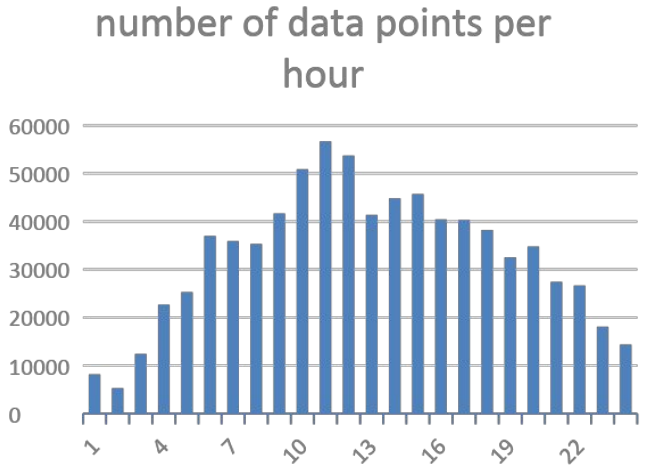


most measurements at cruise flight levels



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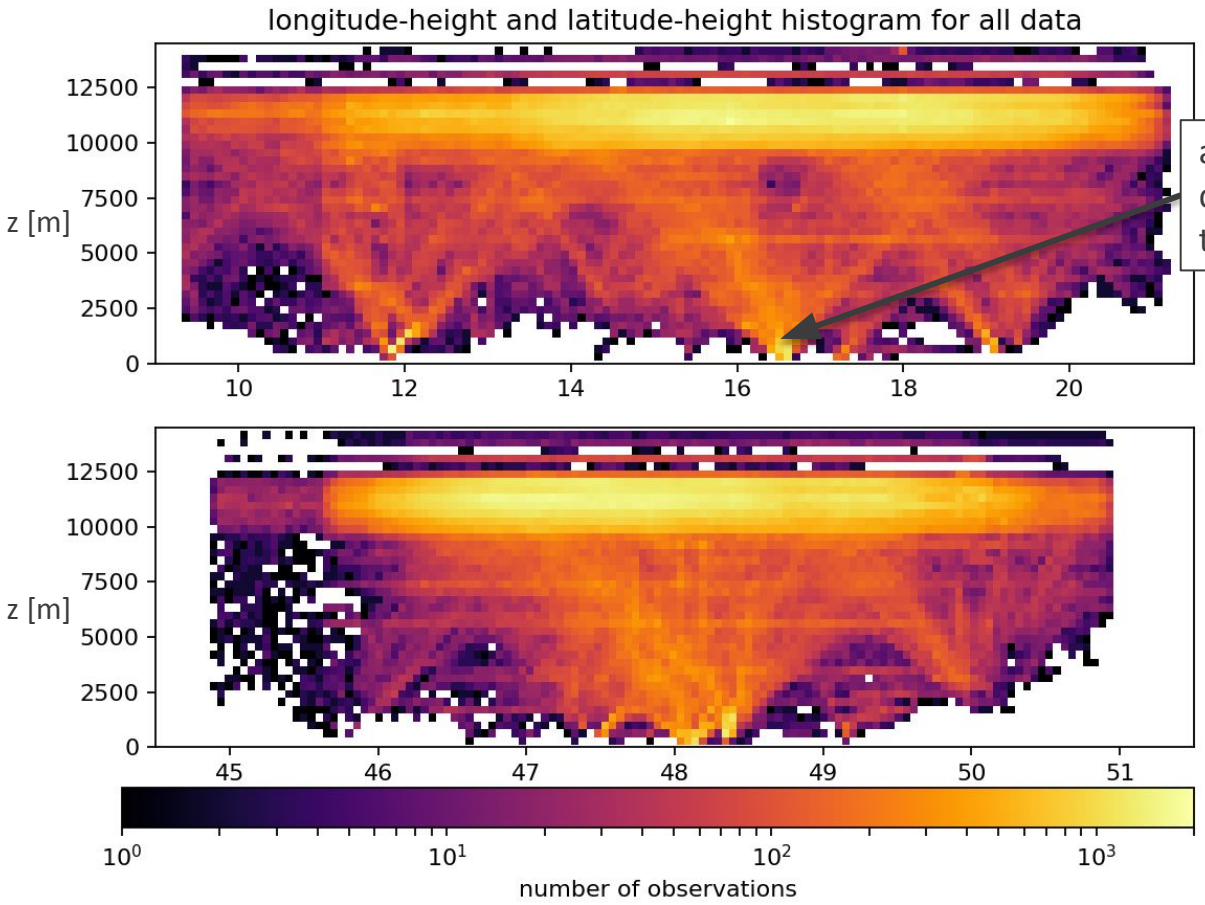
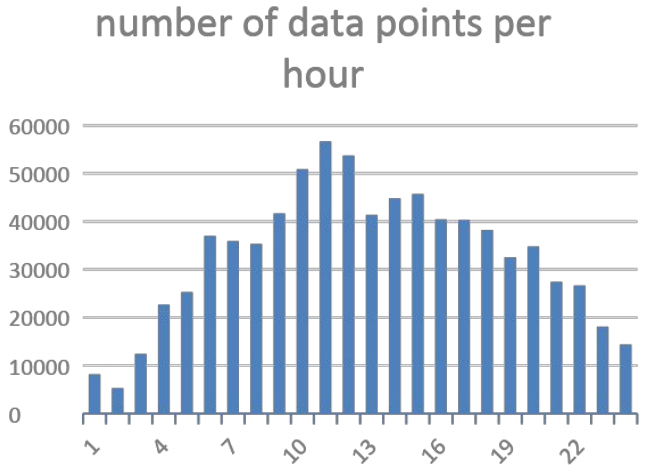


approach and climb provide data in the mid and lower troposphere close to airports



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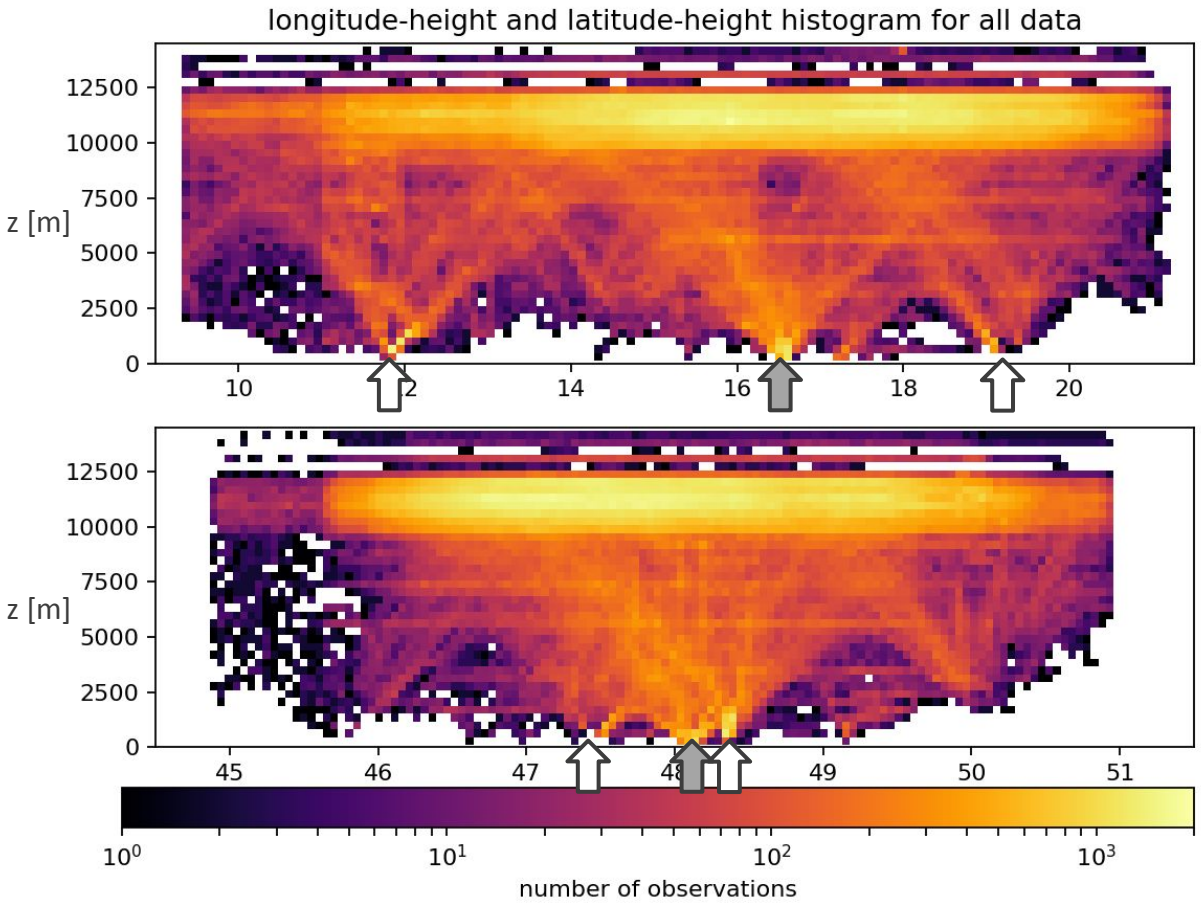

Airports show as higher density data density in the lower troposphere

⇒ ideal for nowcasting and shortest range forecasting over the airport

location of Vienna International Airport shown by the gray arrows

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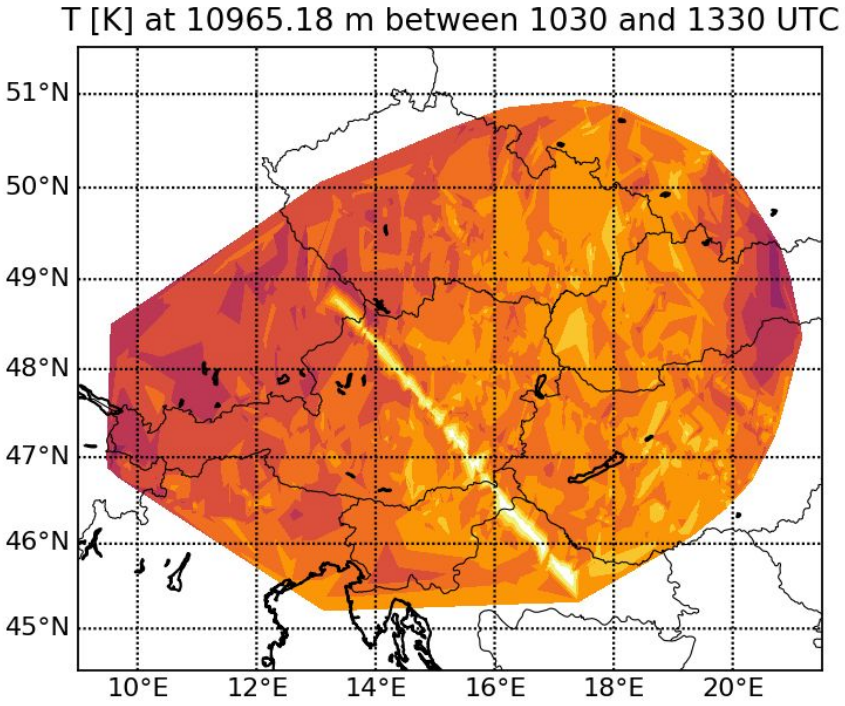
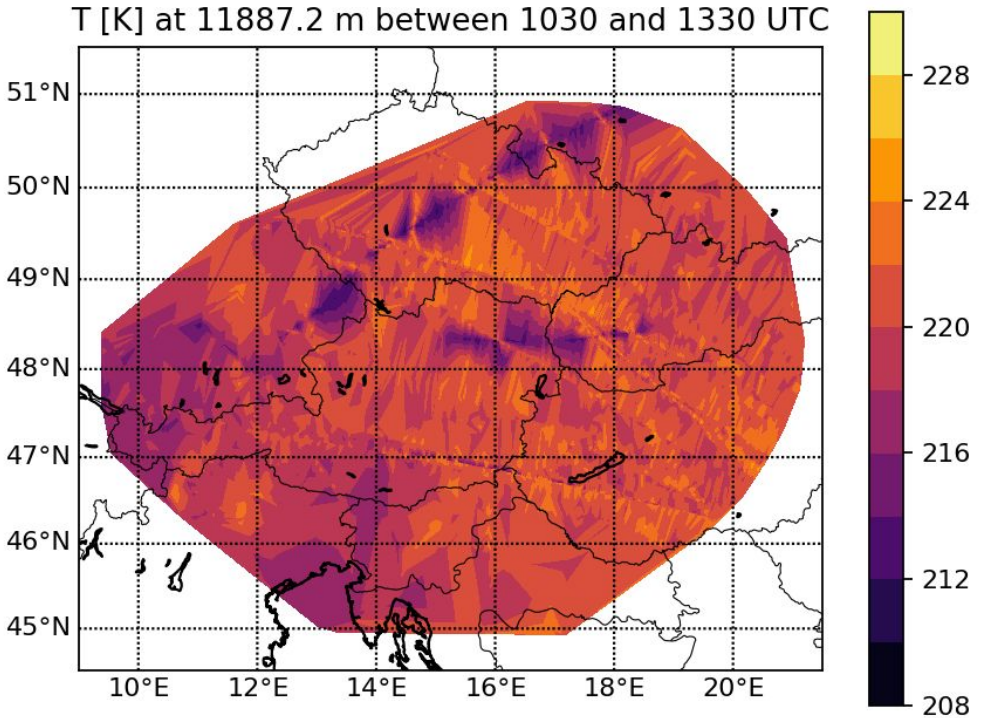
A Closer Look at the Data

Mode-S temperature data visualized at two different flight levels

Data used for the simulation presented above (3 hour assimilation window)





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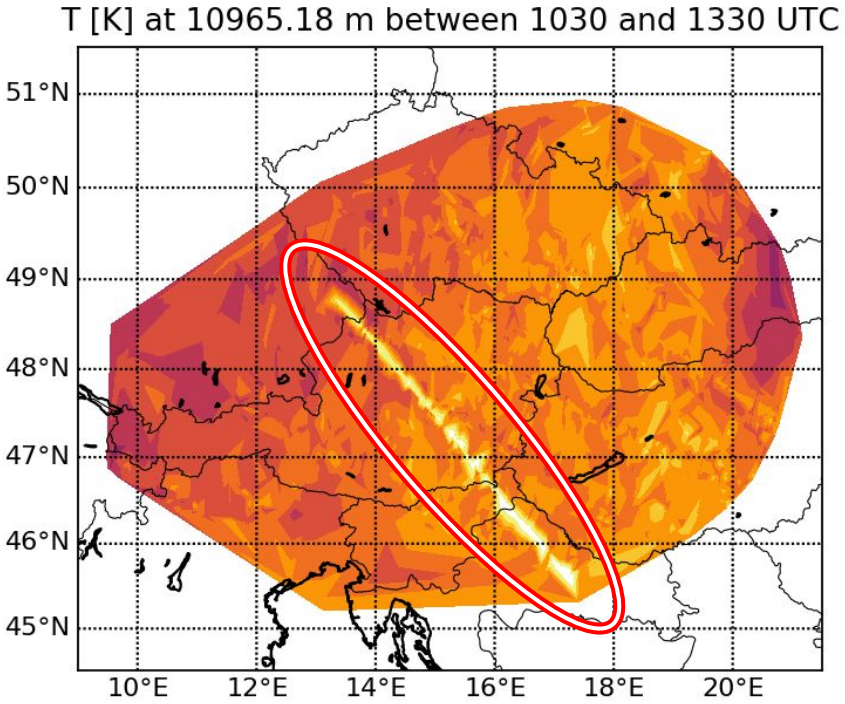

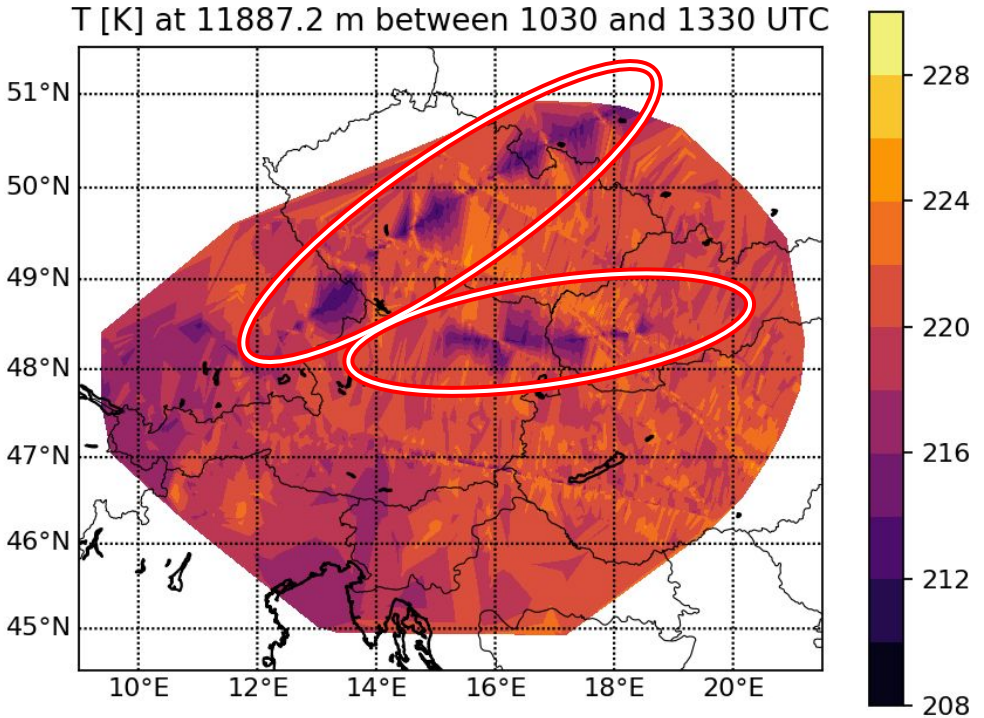

data shows clearly visible traces of some flights with high bias

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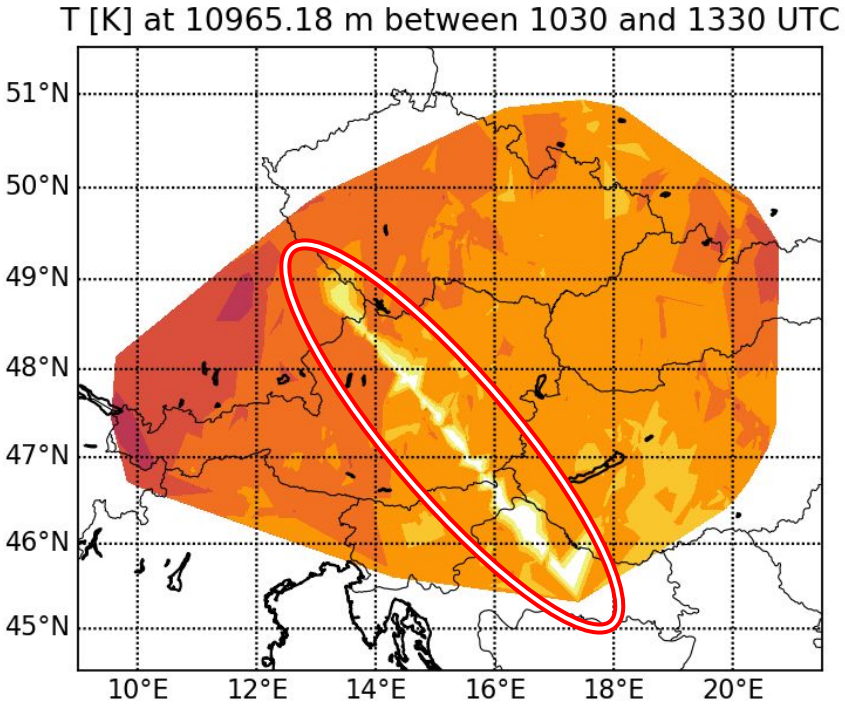

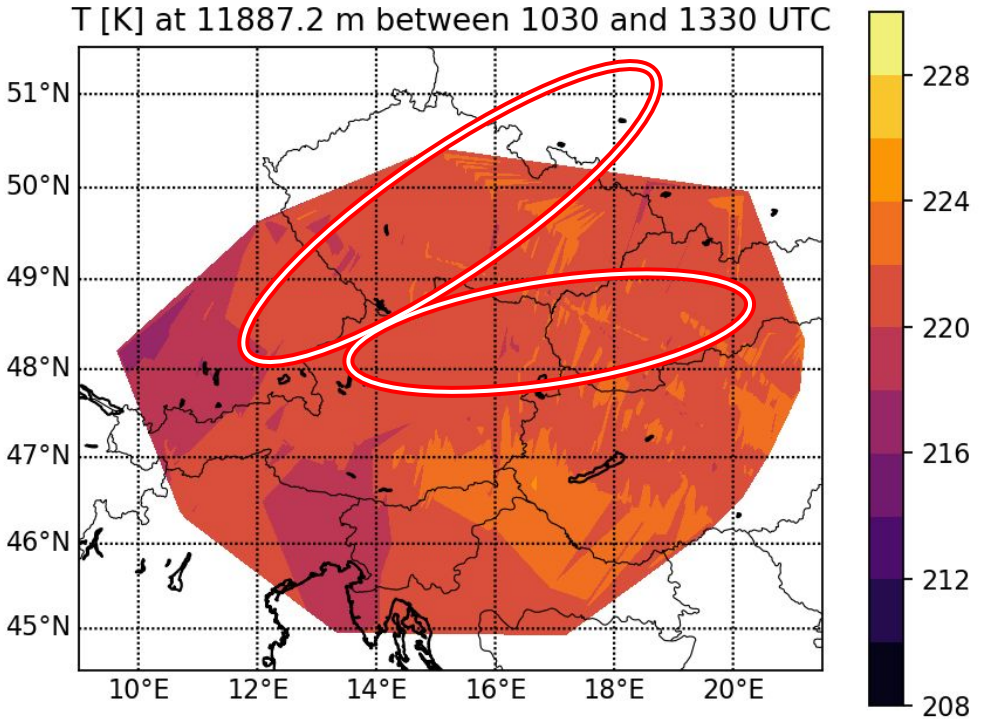

quality control is able to eliminate some of the artifacts, but there is still room for improvement

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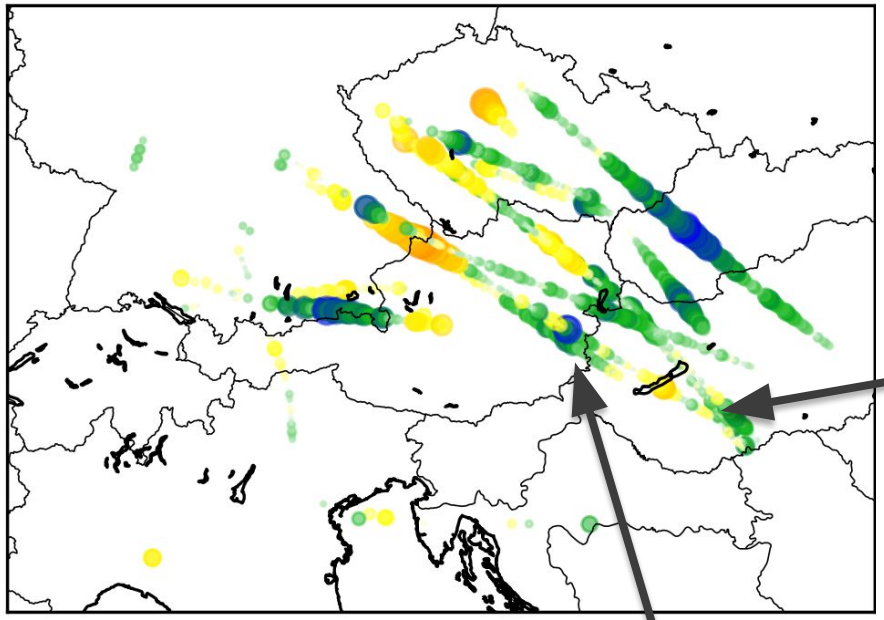
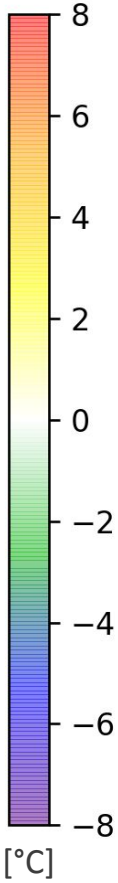
Analysis and First Guess Departures – 1 January 2018 06 UTC

FG departure [°C] for obs between 200 and 220 hPa



when looking at all observations, each flight shows a track of observations

some flights show large variations over short distances



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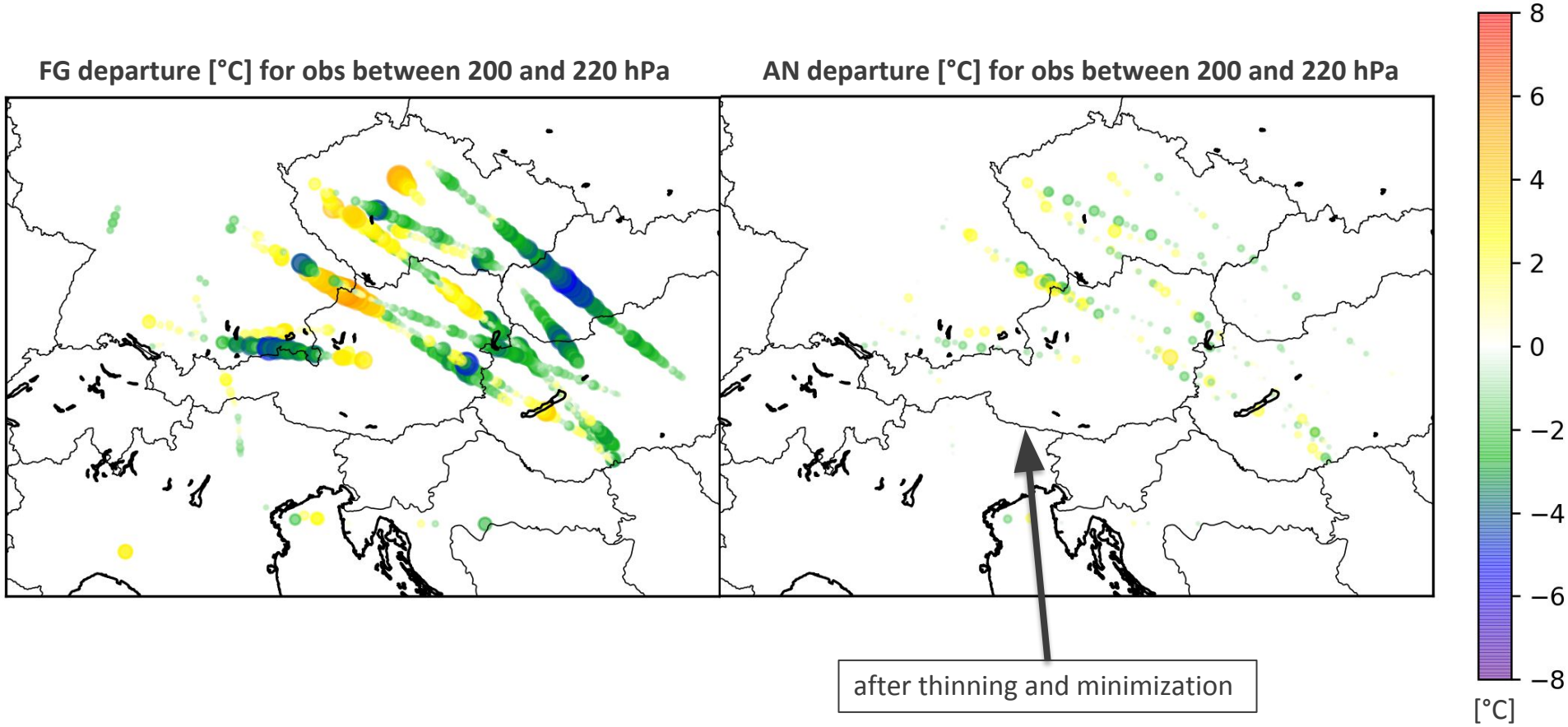

The assimilation does a reasonably good job at thinning the observations and dealing with the large variability

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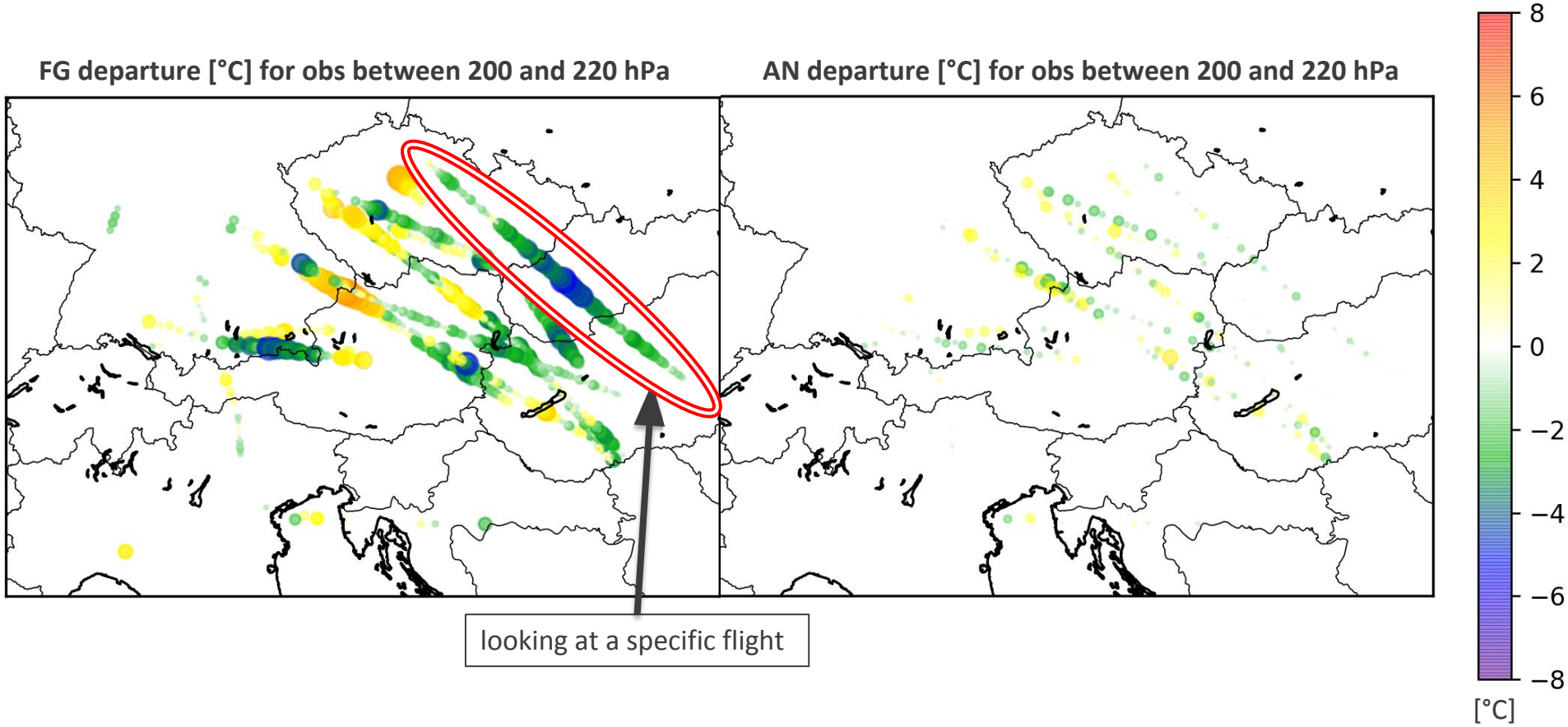

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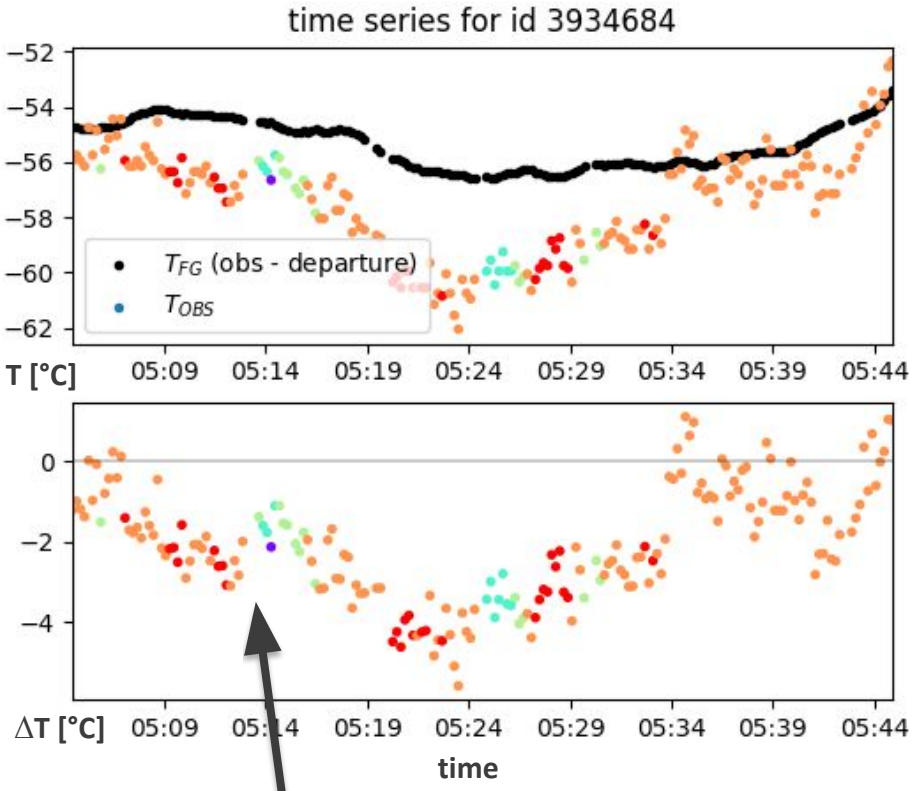
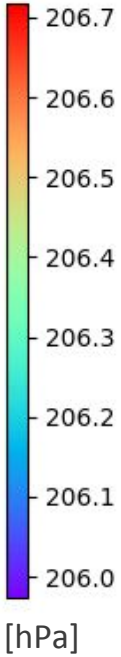
Analysis and First Guess Departure – Singe Flight



colors indicate the pressure level where the observation was made



departure is mostly negative, variability along the flight path appears too low in the first guess

NOTE: we do not know which plane this ID belongs to!

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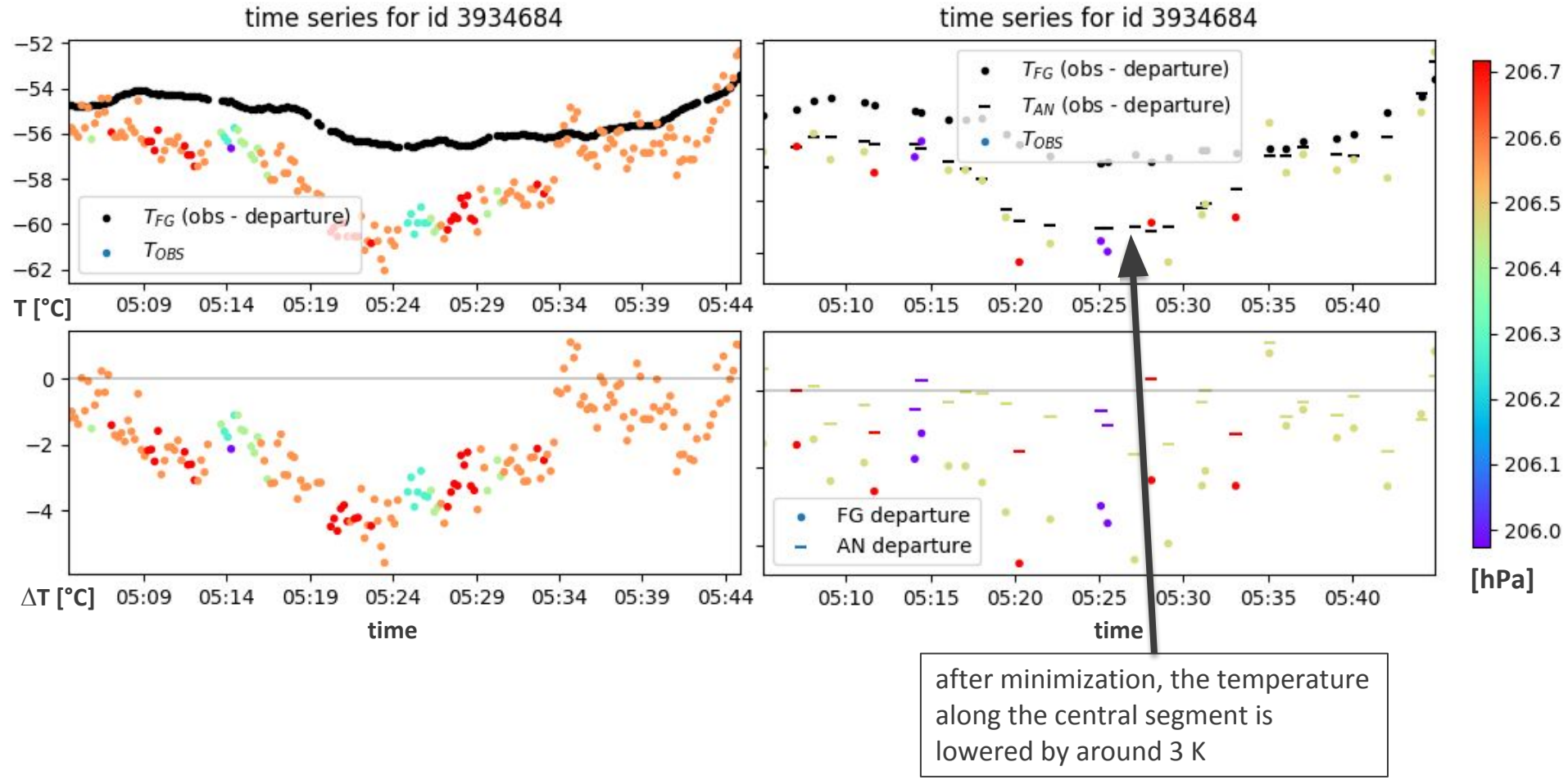

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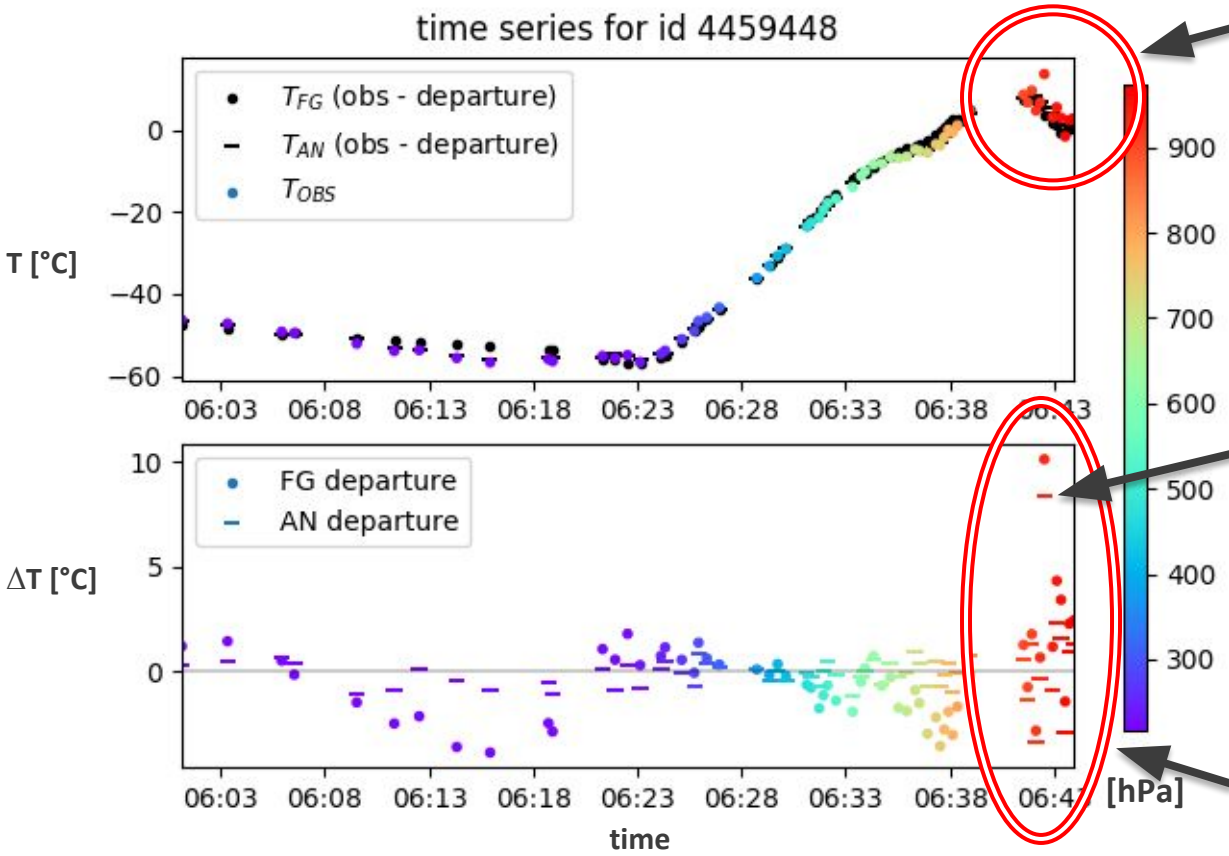
However, some Problems remain…



data from lower altitudes is relatively noisy compared to higher altitude measurements

analysis departure remains close to the first guess departure, indicating little adjustment toward this particular observation

the assimilation software has a hard time incorporating the data at these levels, as shown here by the wildly varying analysis departure

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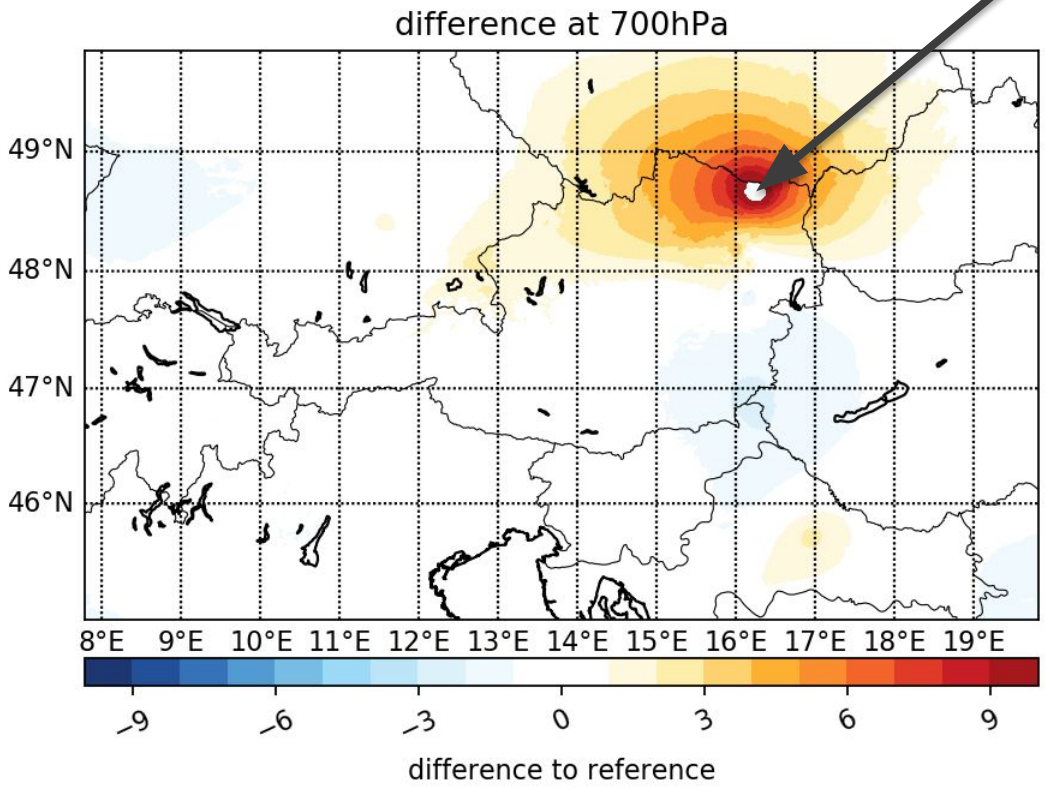
700 hPa temperature difference between two analyses, one with and one without Mode-S



Some tests show large anomalies which are not prevented by the assimilation software

More tweaking is needed!

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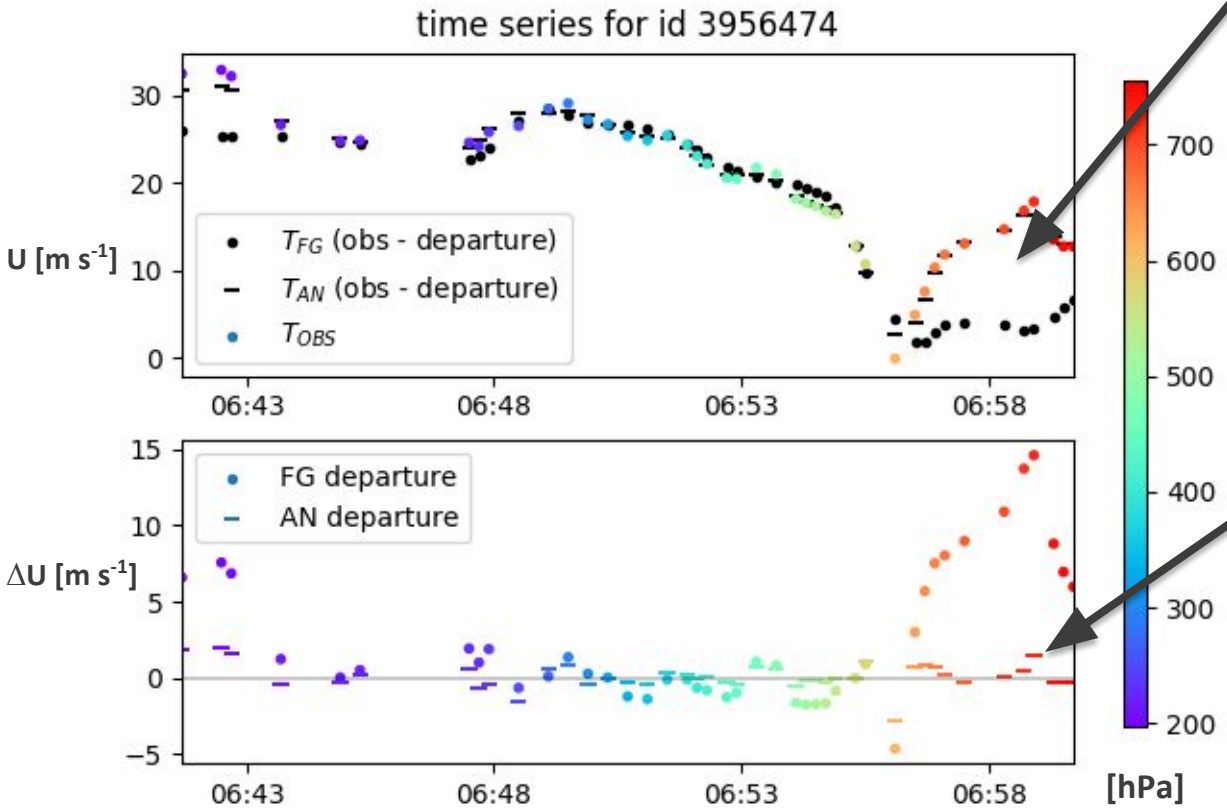
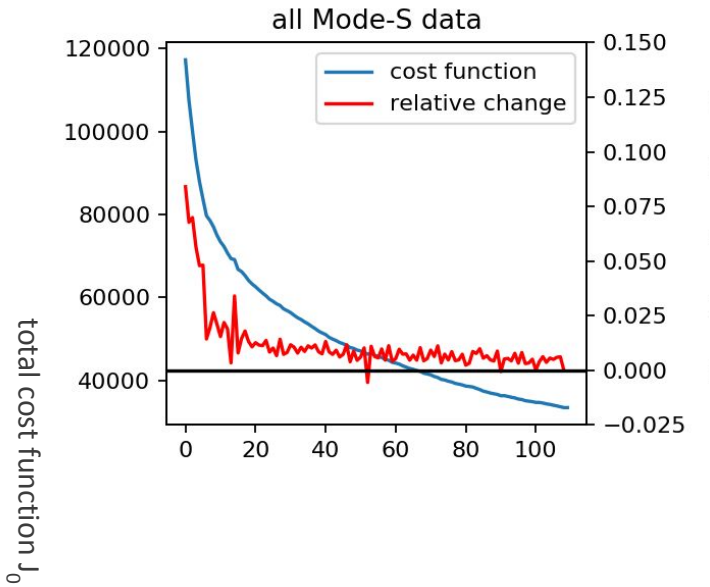


Flight shows large FG departure at lower altitudes

Assimilation adjusts the first guess by around 15 m s^{-1}.

Convergence Issues with Mode-S Data

Feeding the data into the model results in convergence problems of the cost function during minimization



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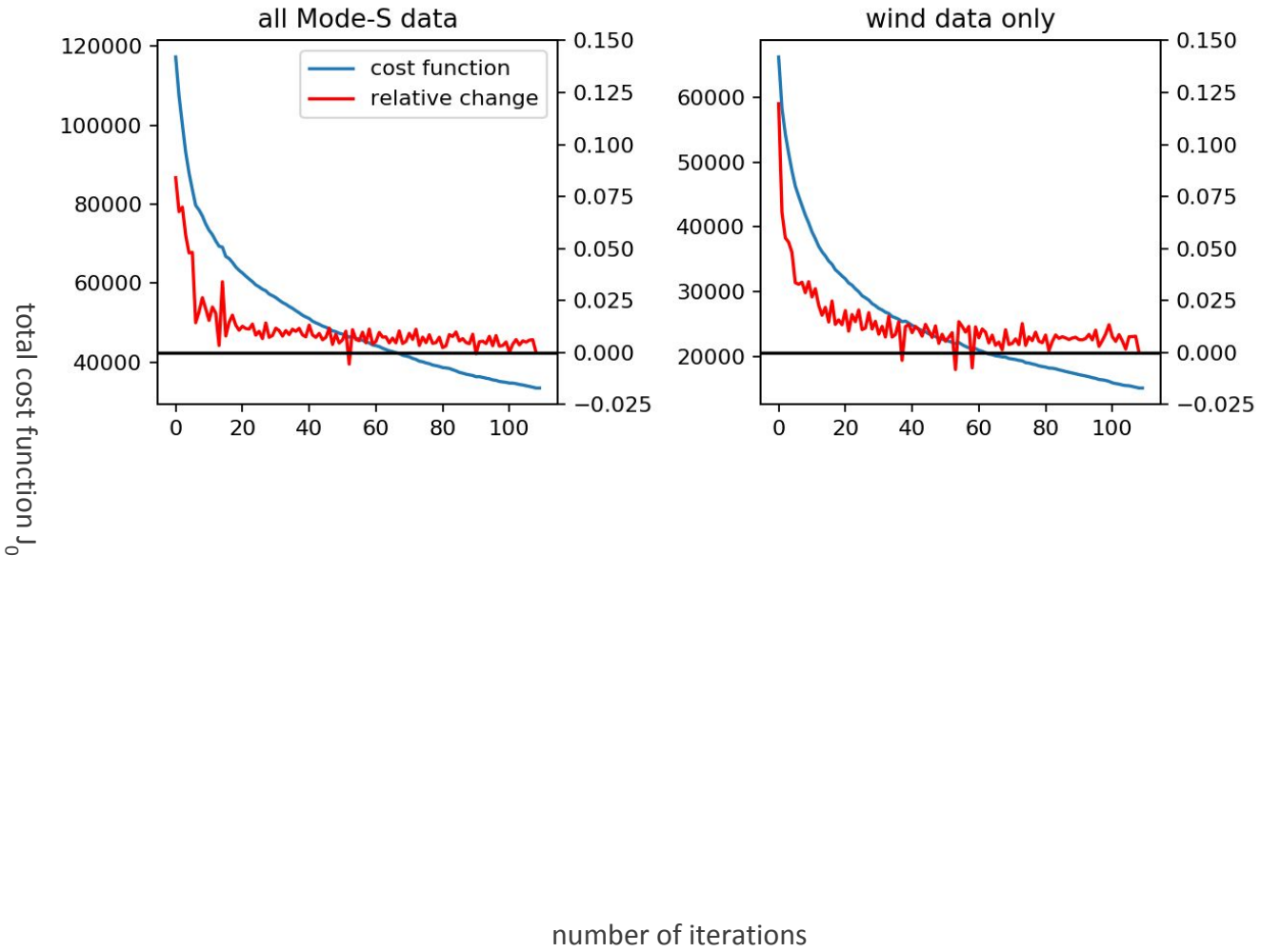

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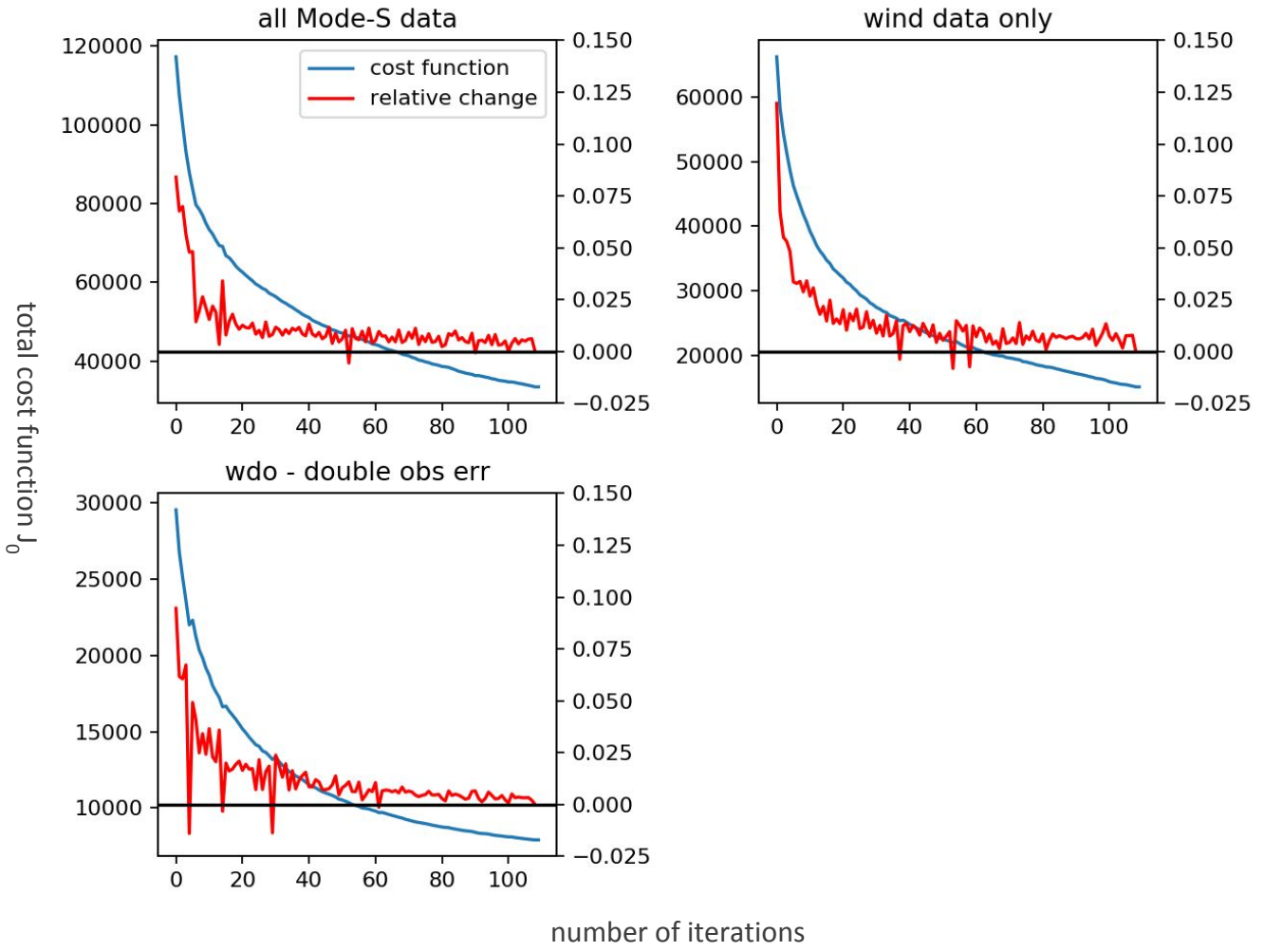

* obs error modified by implementing a custom BATOR namelist switch which multiplies the observation error for AIREP temperature measurements by a scalar factor

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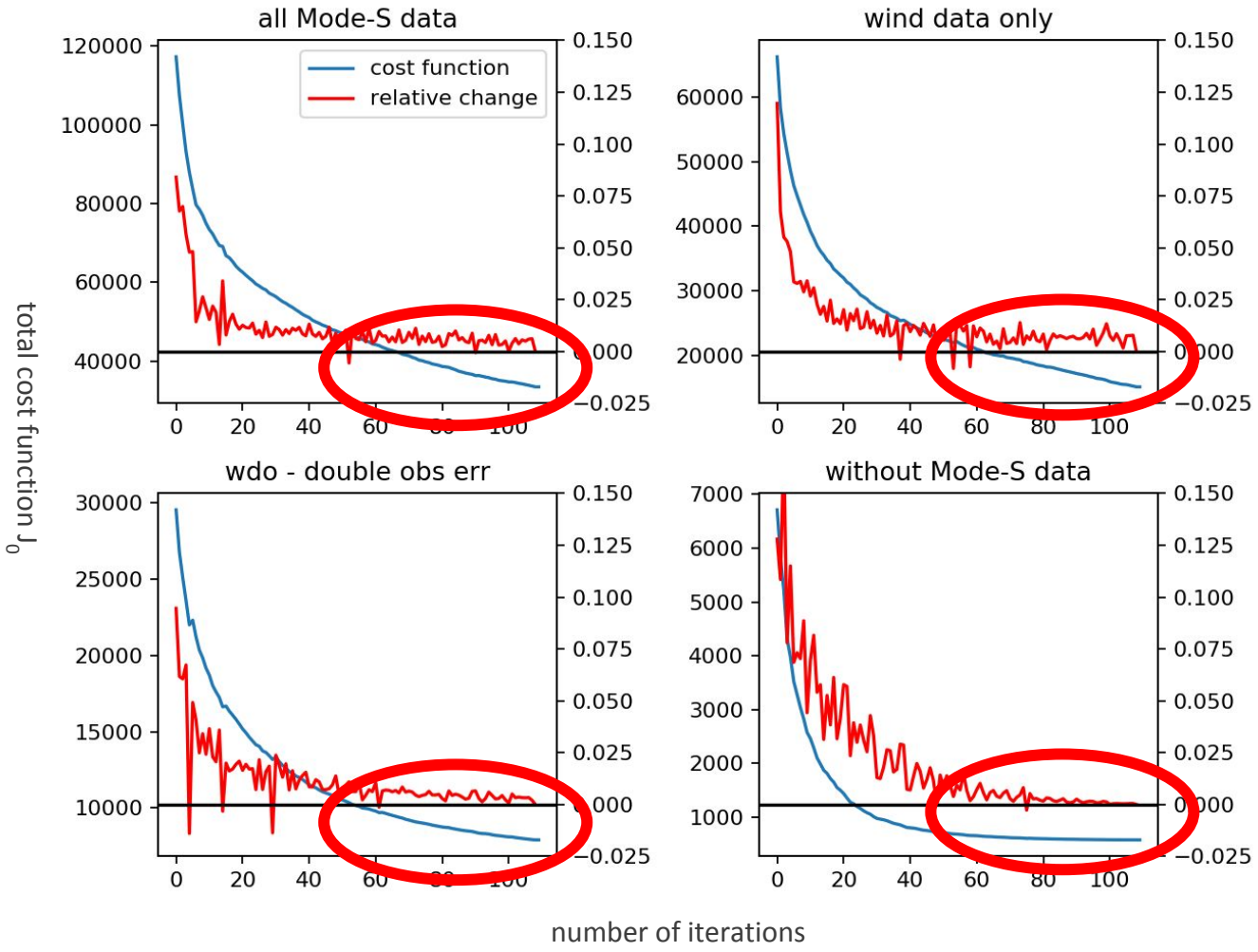

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Impact of Mode-S data on a 1.2 km Simulation

- Tornado case of 10 July 2017 at Vienna International Airport
- a supercell formed southwest of Vienna and moved east just south of the city with a tornado touching down in the fields close to the airport
- cell moved into zone sampled densely by climbing and approaching aircraft

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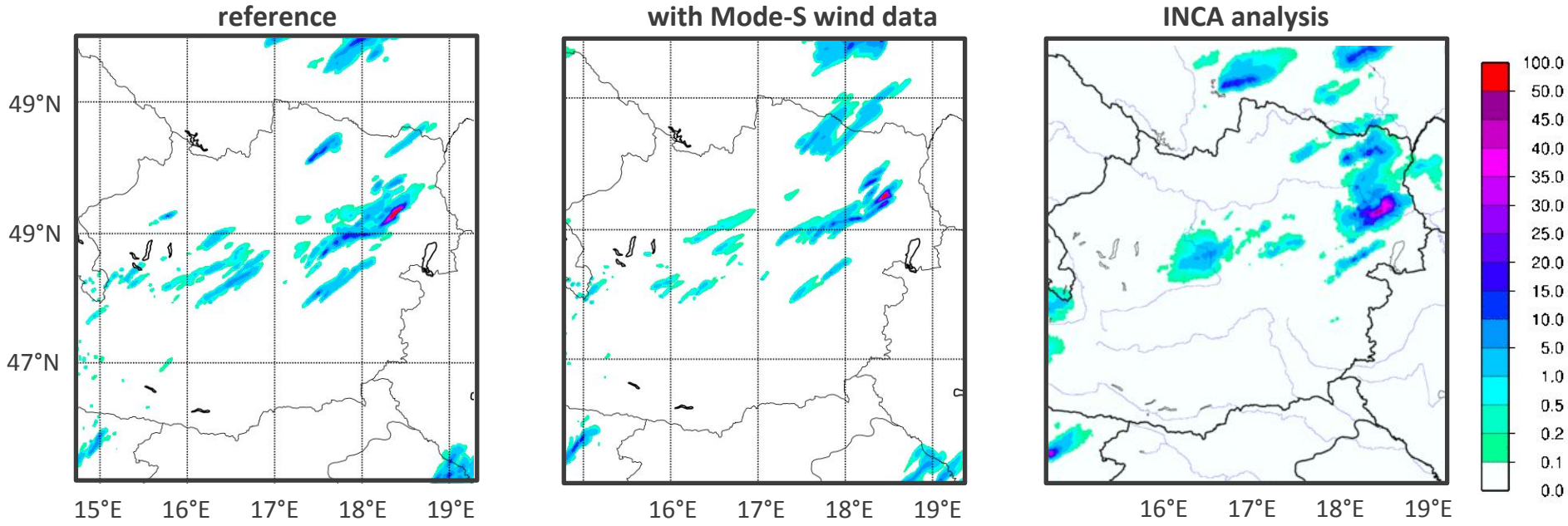
Test Case – 10 July 2017 (init at 12 UTC)

14 to 15 UTC accumulated precipitation



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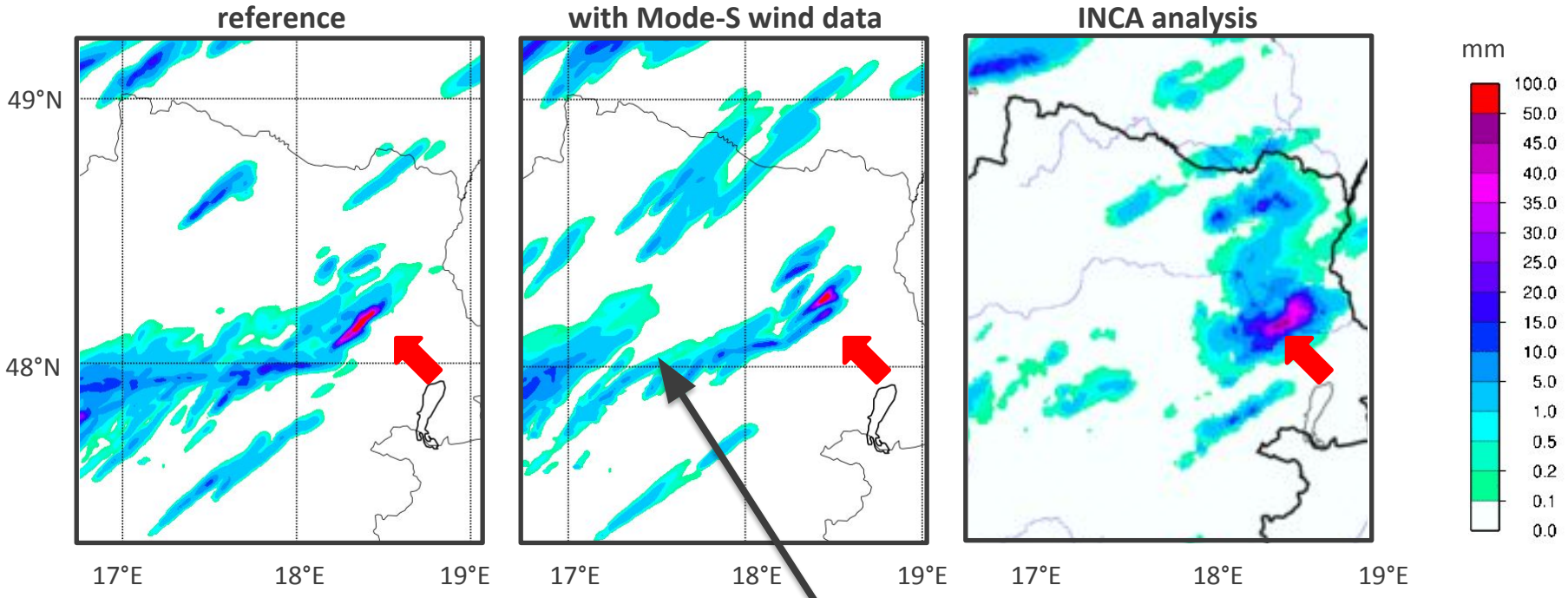

slight reduction in precipitation along the overestimated path of the supercell, but some degradation in other places, overall effect is minor for this case

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Conclusions and Discussion

- the assimilation of Mode-S data has **the potential to provide valuable and dense 3D data in a highly relevant area** for the VIEsion project

- initial tests show a **notable impact** of Mode-S data on simulations, but better tweaking of the assimilation is required to fully benefit from this new data

- specifically, bad observations need to be detected and eliminated more rigorously

- **convergence** of minimization can be a **problem** if the amount of observations is high

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