

# VIesion: Assimilation of Mode-S Data

*Aircraft Observations in a High Resolution AROME Simulation*

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**austro**  
CONTROL



**ZAMG**  
Zentralanstalt für  
Meteorologie und  
Geodynamik

# Goals and Challenges of the VIEsion project:



12.10.2017  
Folie 2

- New 500 m model for Vienna International Airport (VIE) in development
  - 1 hour update cycle
  - focus on nowcasting and up to 12 hours
  - high accuracy requirements
- Such a model requires good initial conditions based on up-to-date data assimilation
- Challenge: dense data at the surface but scarce upper air measurements

# Mode-S data

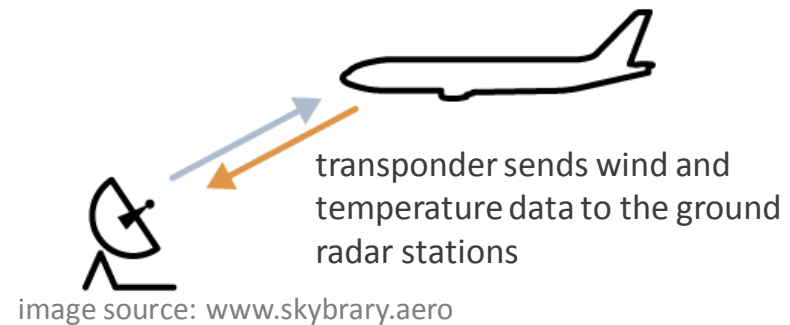
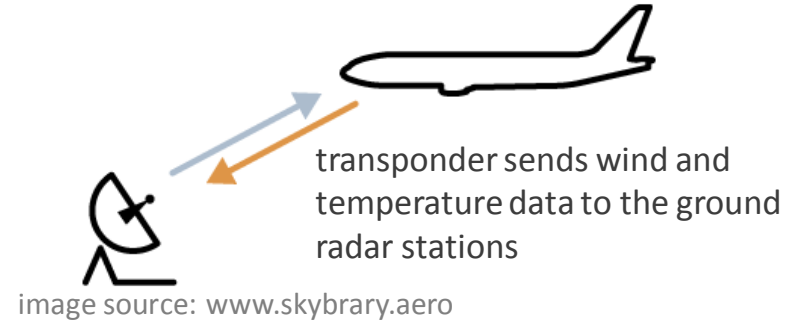


image source: [www.flightradar24.com](http://www.flightradar24.com)

# Mode-S data



- 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

# Mode-S data

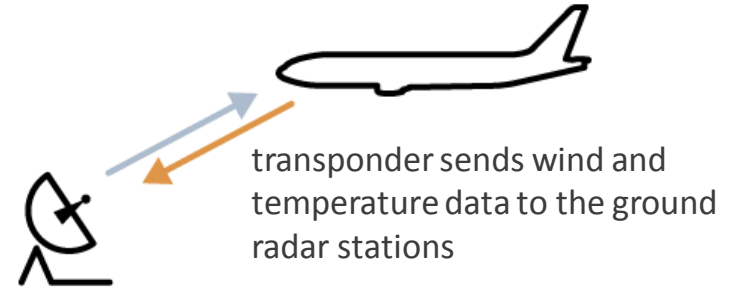


image source: [www.skybrary.aero](http://www.skybrary.aero)

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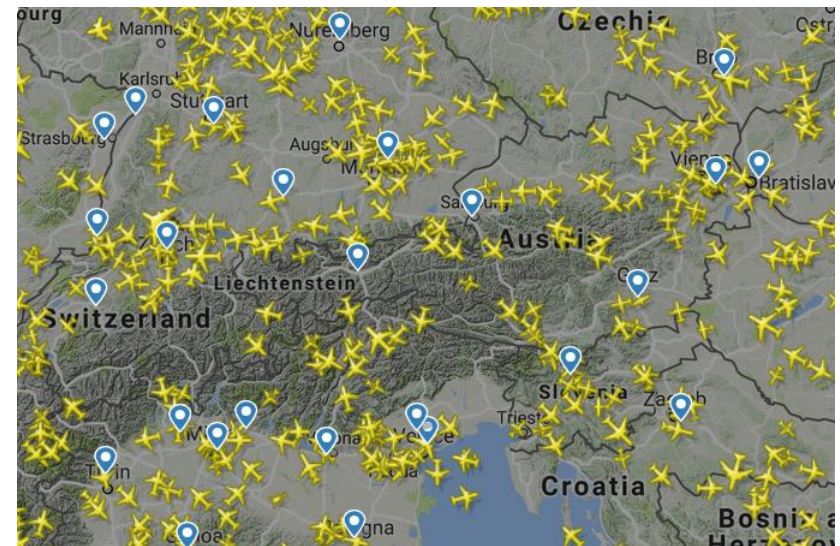
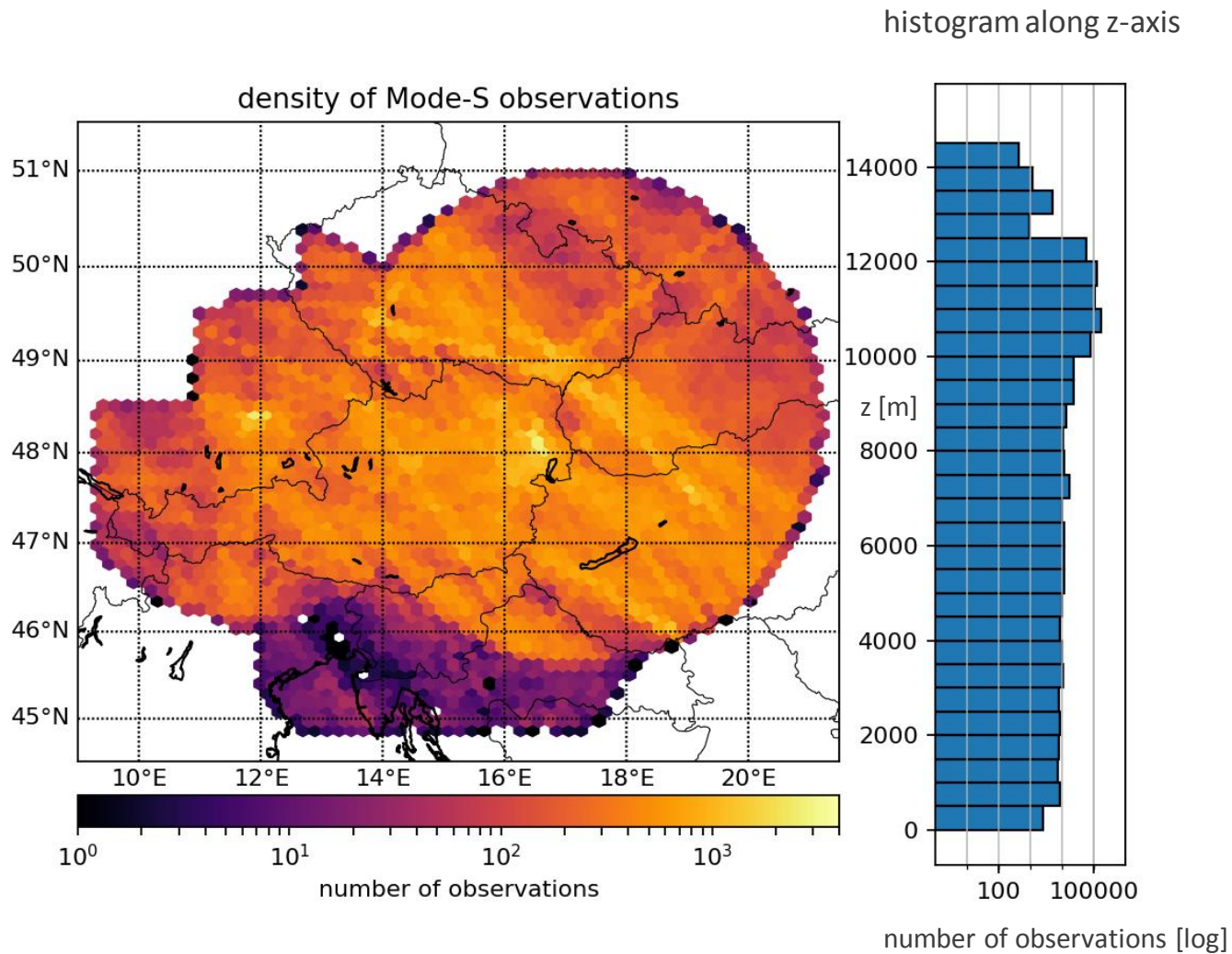


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# Distribution of Mode-S data

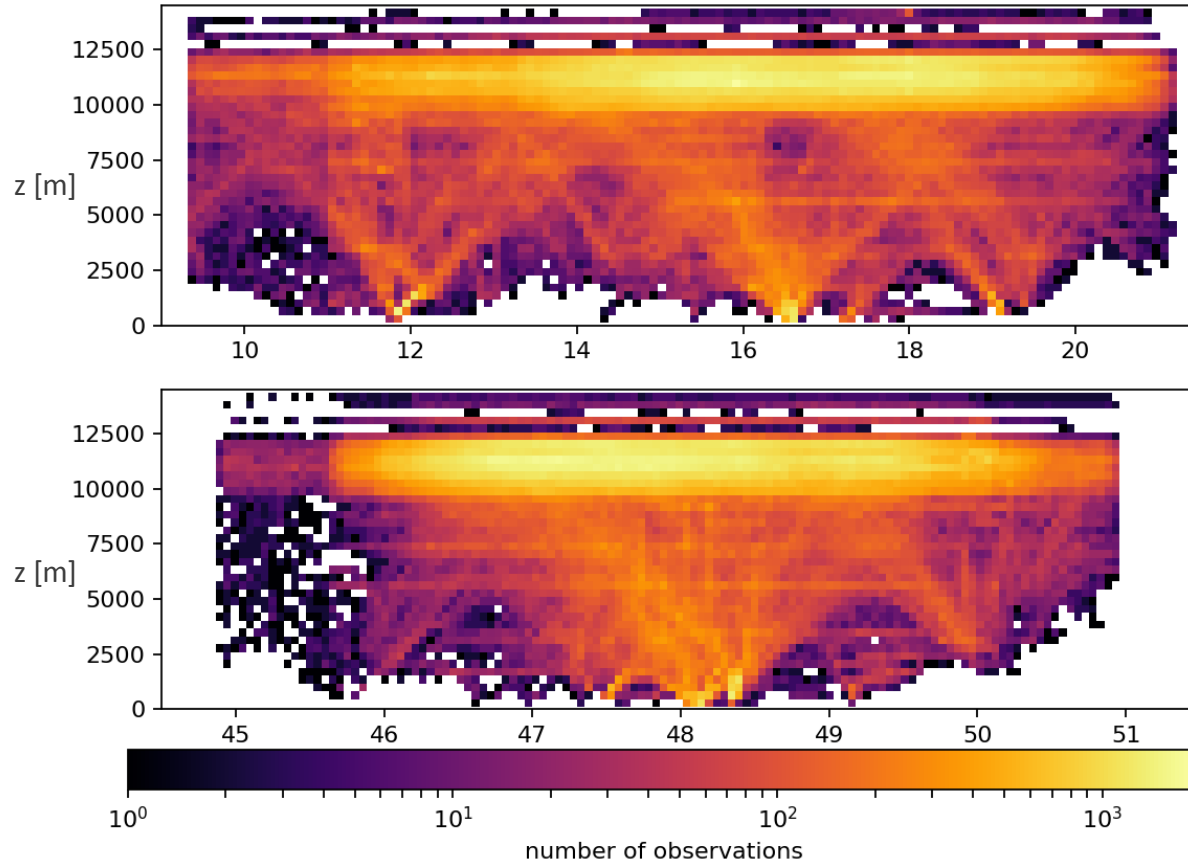


total number of observations: 792825

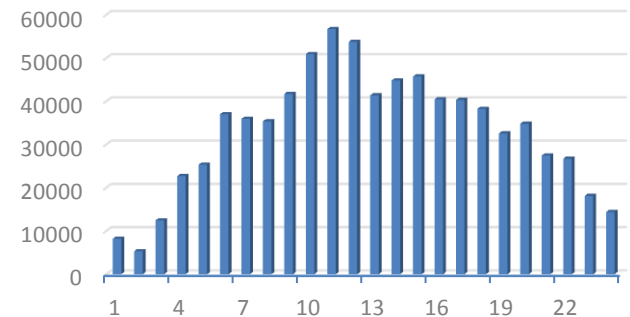
# Distribution of Mode-S data



longitude-height and latitude-height histogram for all data



number of data points per hour

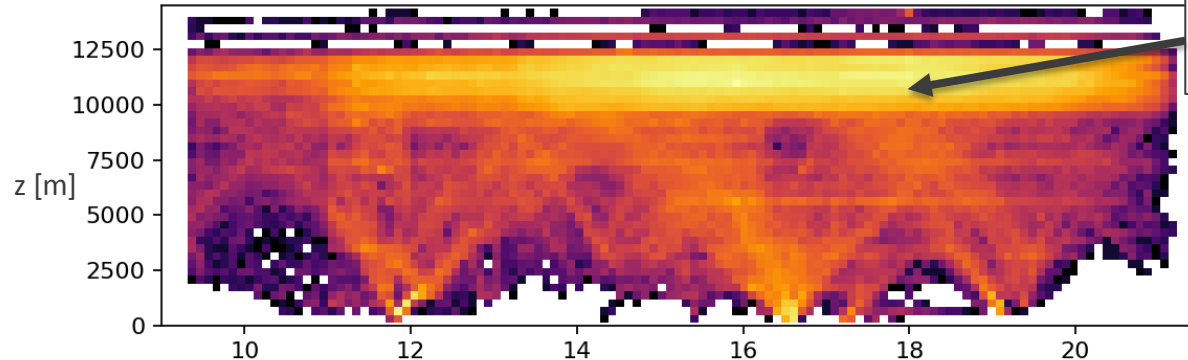


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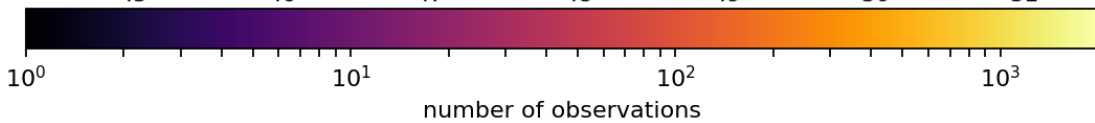
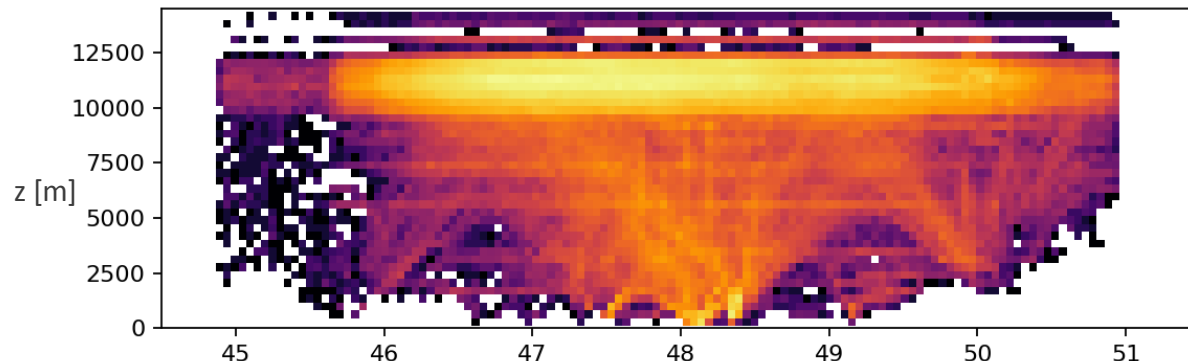
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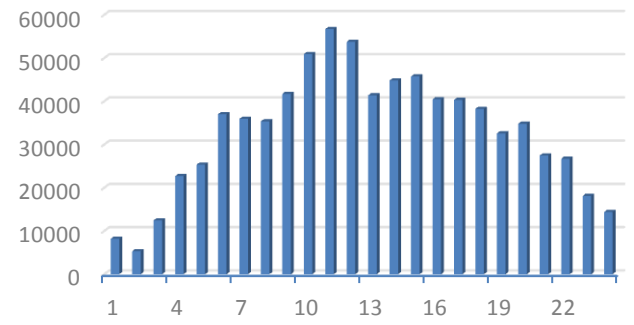
longitude-height and latitude-height histogram for all data



most measurements at cruise flight levels



number of data points per hour



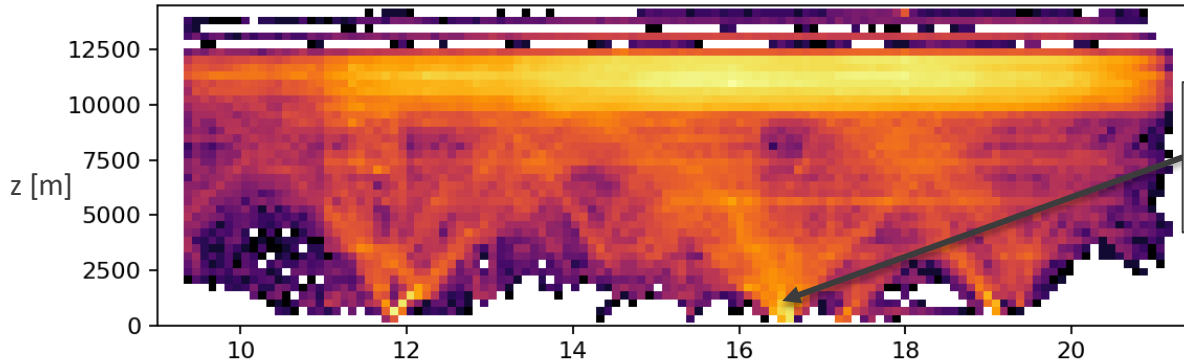
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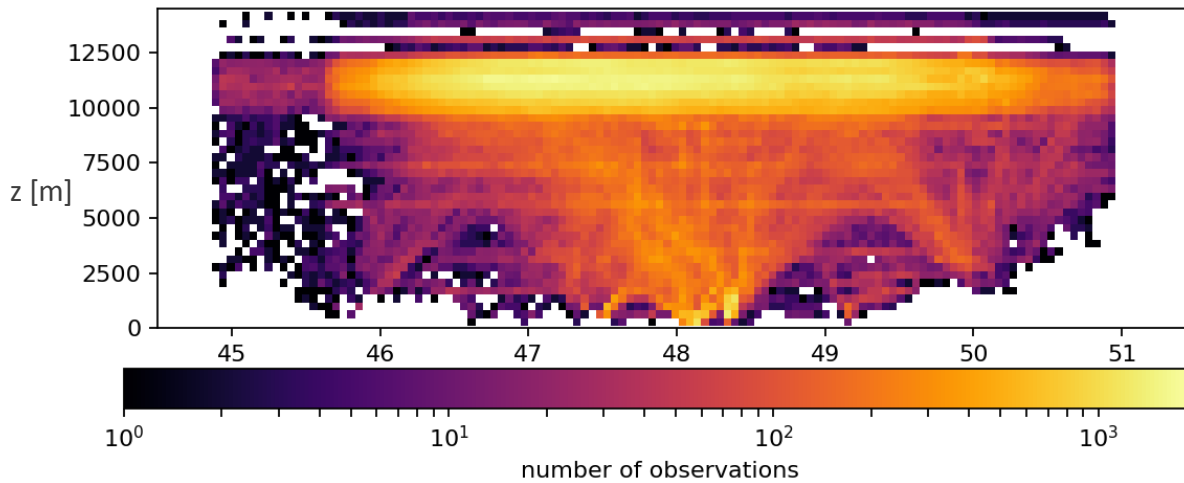
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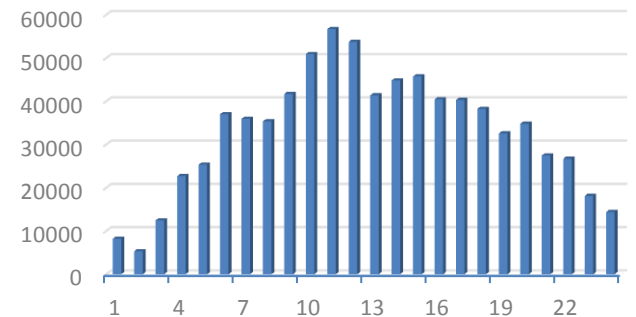
longitude-height and latitude-height histogram for all data



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



number of data points per hour

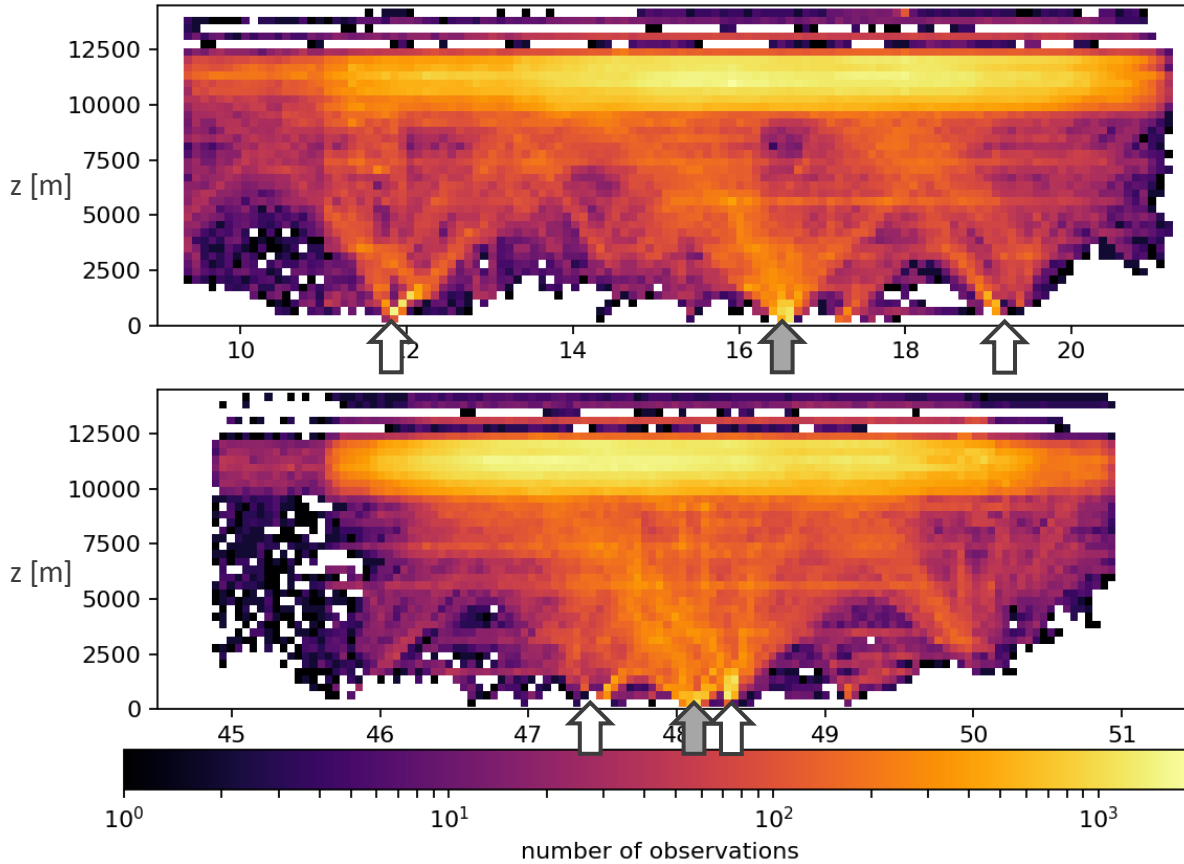


total number of observations: 792825

# Distribution of Mode-S data



Longitude-height and latitude-height histogram for all data



Airports show as higher data density in the lower troposphere

⇒ ideal for nowcasting and shortest range forecasting over the airport

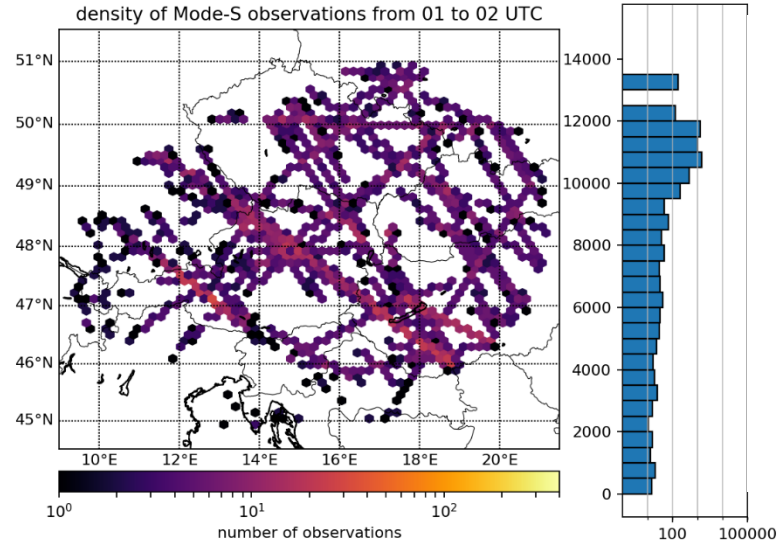
location of Vienna International Airport shown by the gray arrows

total number of observations: 792825

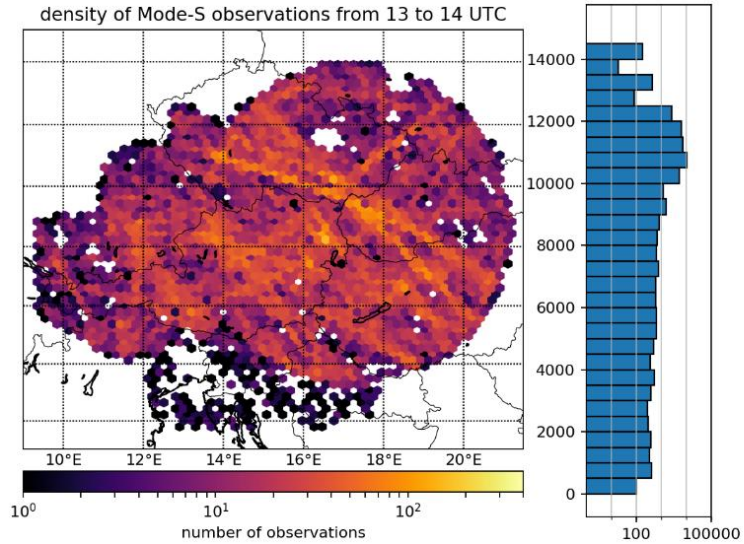
# Hourly Distribution of Mode-S Data (example)



density of Mode-S observations from 01 to 02 UTC

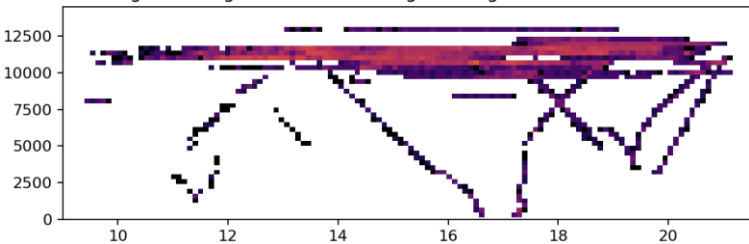


density of Mode-S observations from 13 to 14 UTC

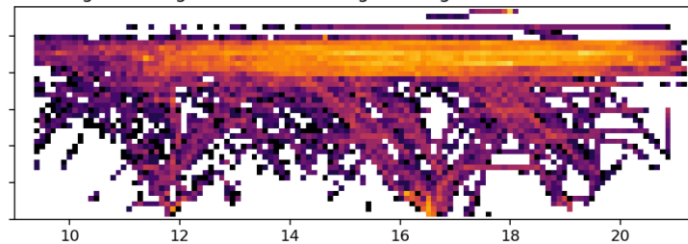


example for the distribution for one hour during the night (left) and day (right)

longitude-height and latitude-height histogram from 01 to 02 UTC

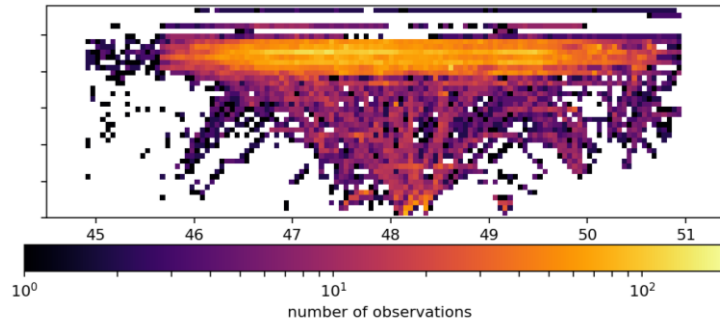
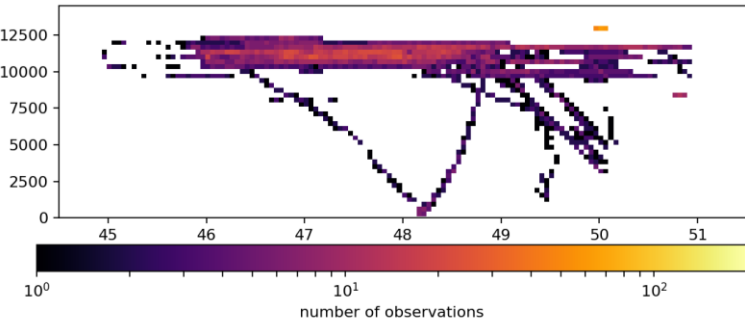


longitude-height and latitude-height histogram from 13 to 14 UTC



**obs count:**

night: 5310  
day: 44816



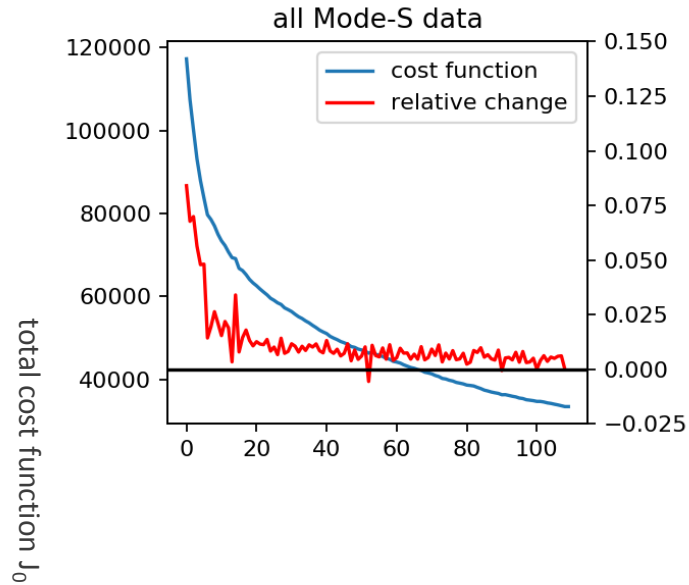
# Impact of Mode-S data on a 1.2 km simulation

- 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



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

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

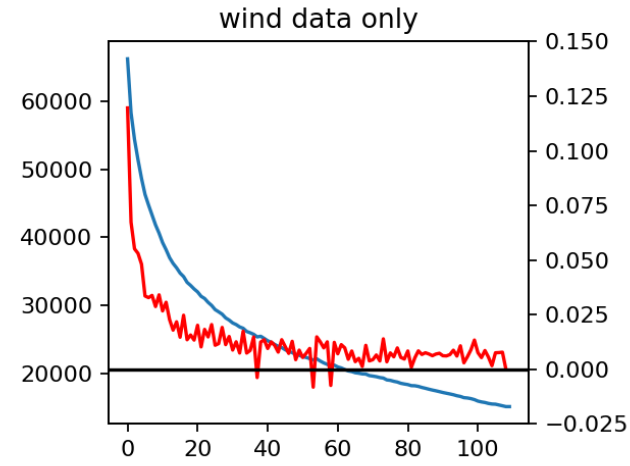
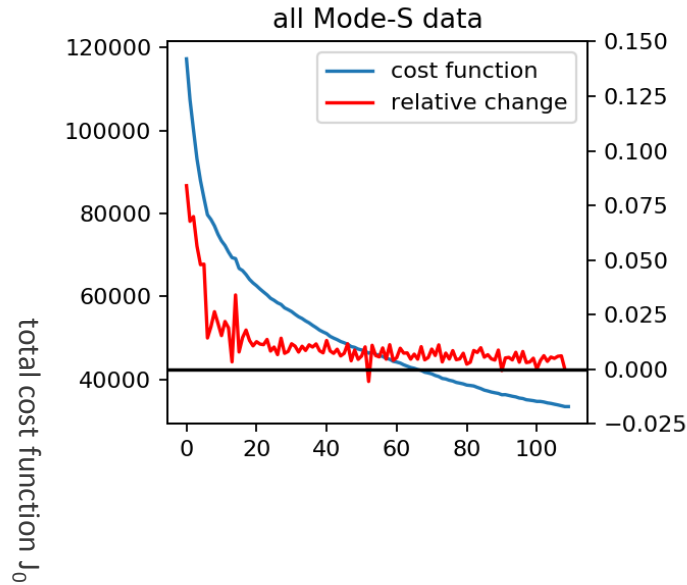


number of iterations

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only using the (slightly better) wind data does not solve the problem



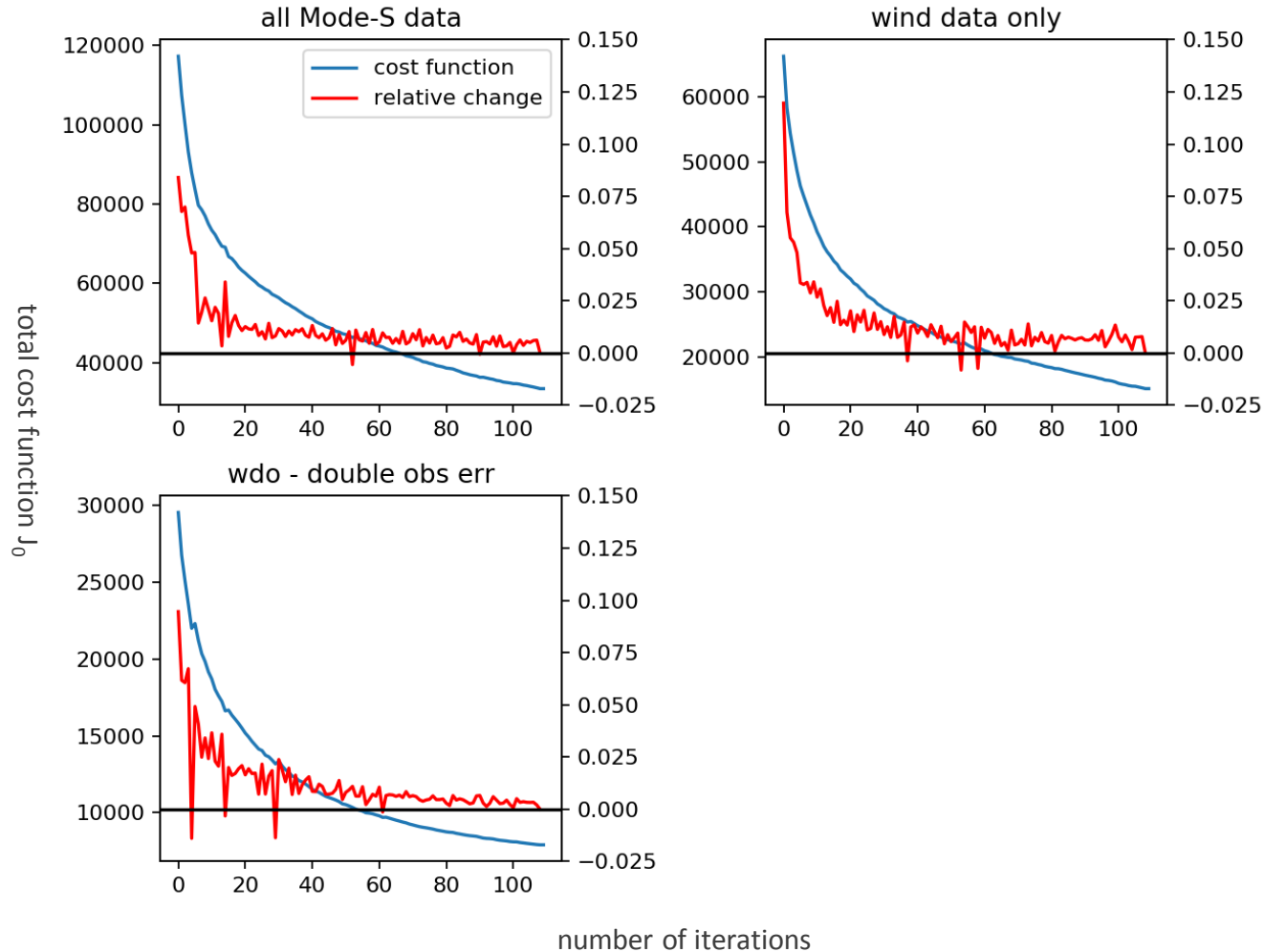
number of iterations

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doubling the observation error\* for the new wind data improves the result only slightly



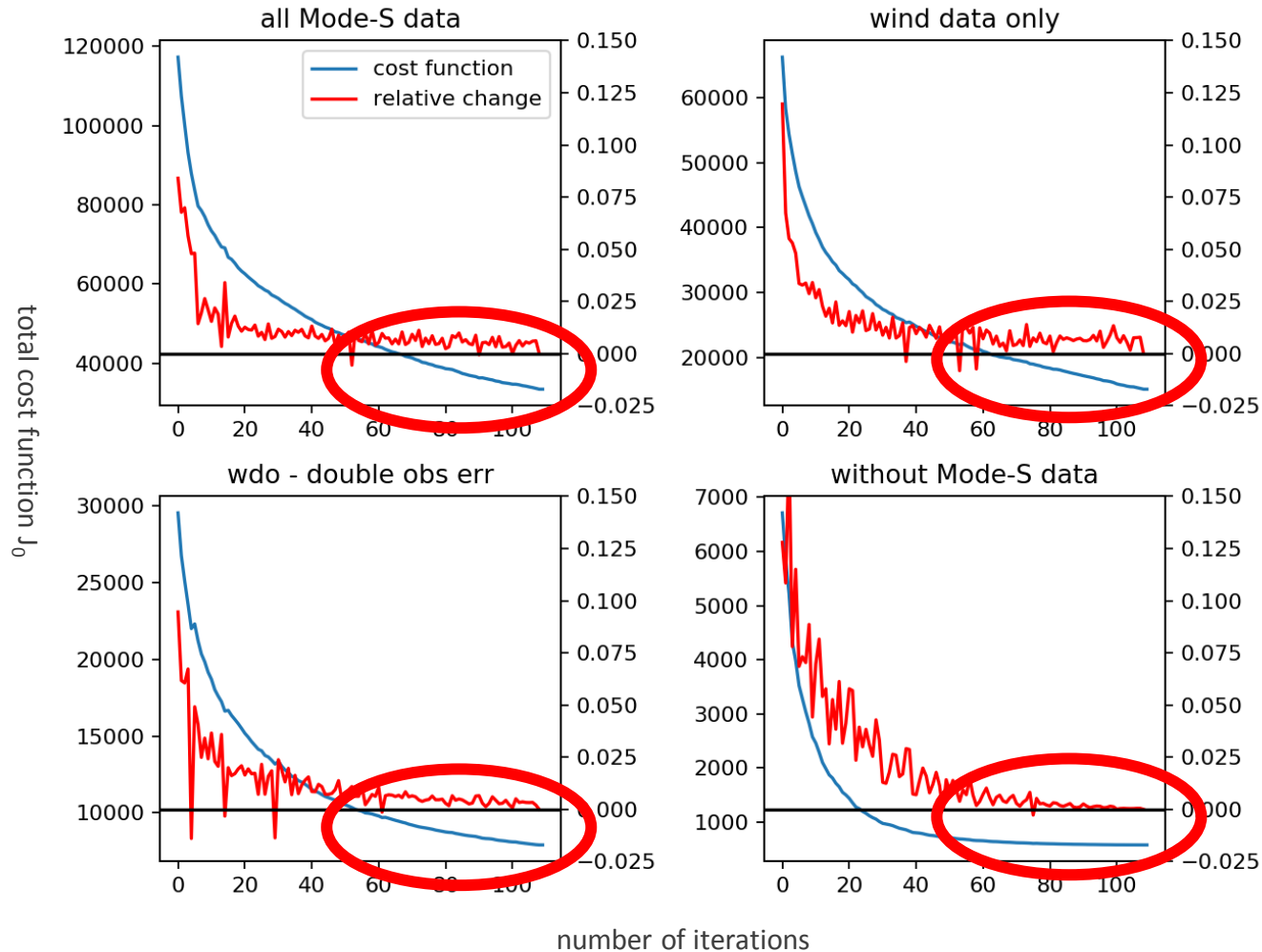
\* obs error modified by implementing a custom BATOR namelist switch which multiplies the observation error for AIREP temperature measurements by a scalar factor

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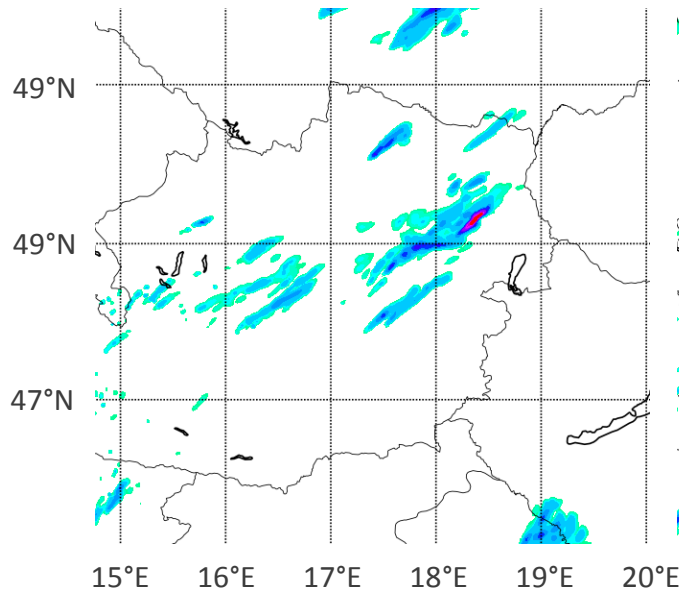


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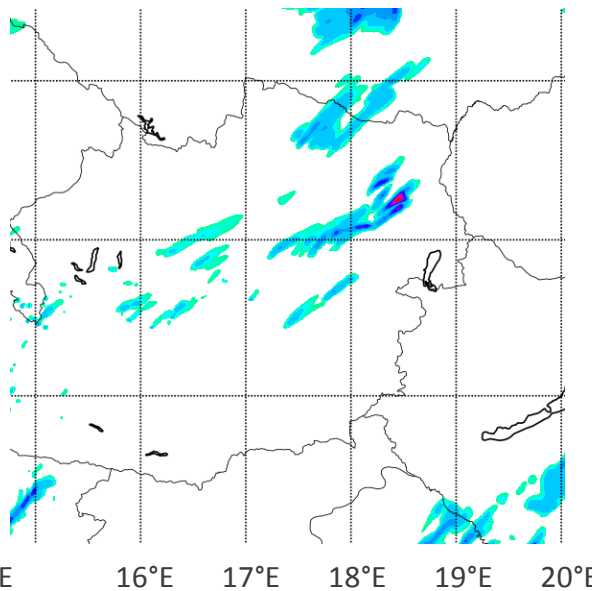


## 14 to 15 UTC accumulated precipitation

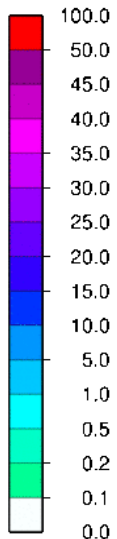
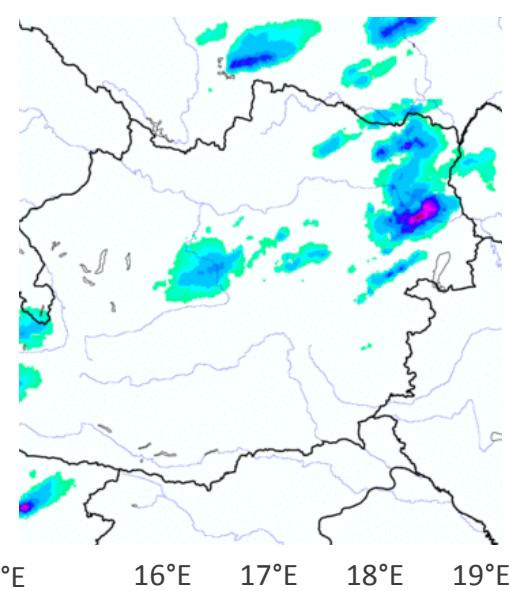
reference



with Mode-S wind data



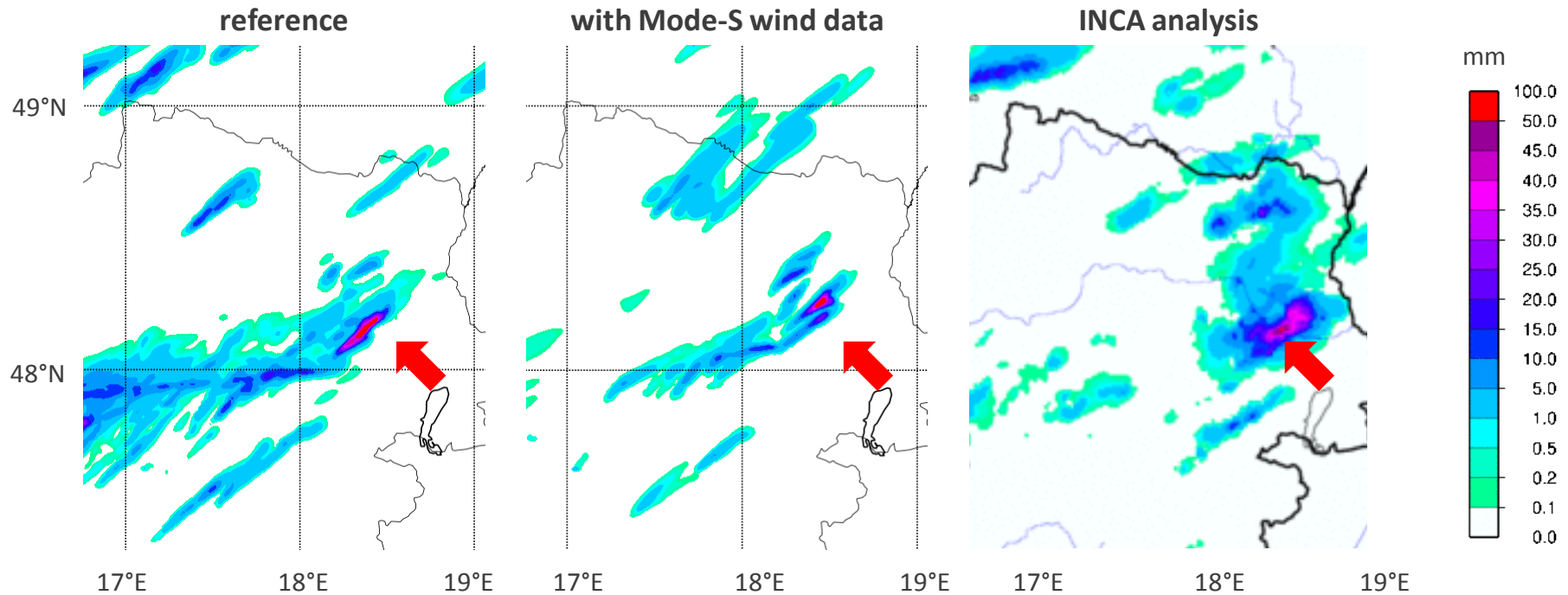
INCA analysis



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



## 12 to 15 UTC accumulated precipitation



# Conclusions and Discussion



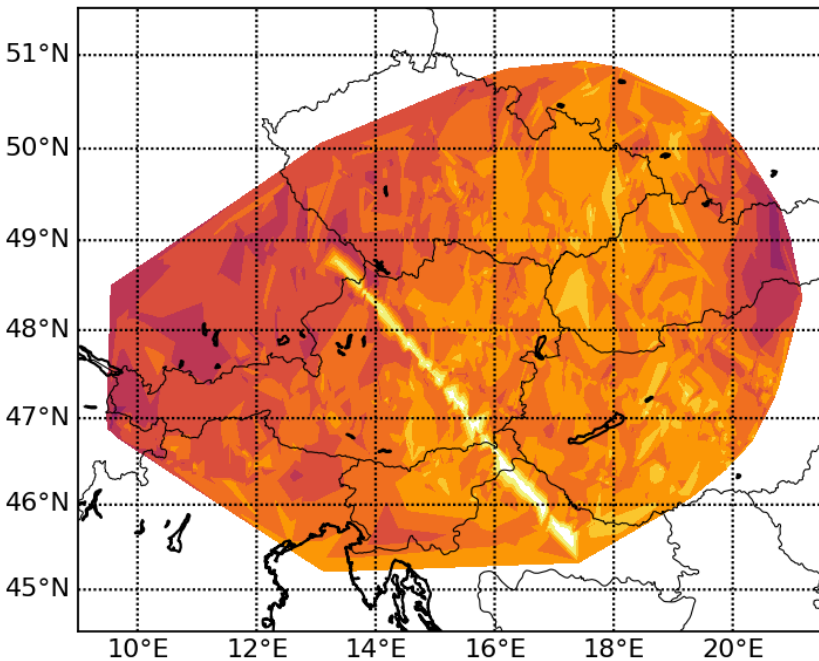
- the assimilation of Mode-S data has **the potential to provide dense 3D data in a highly relevant area** for the VIEsion project
- initial tests show a **notable impact** of Mode-S data on simulations
- **convergence** of minimization is still a **problem** (also found for EHS data)

# Supplementary Material

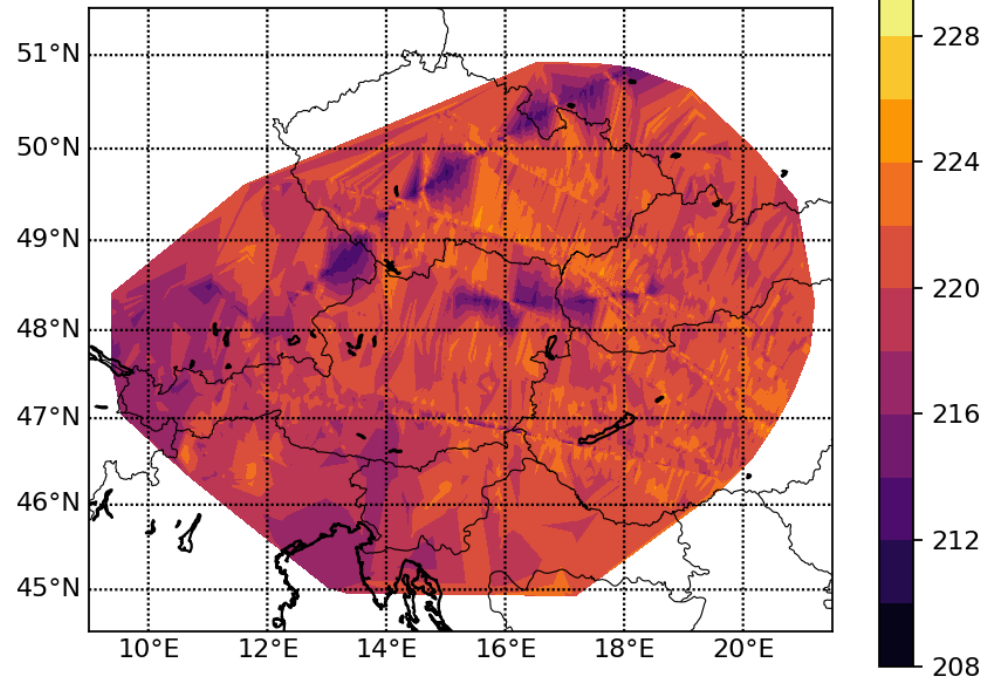
## Mode-S temperature data visualized at two different flight levels

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

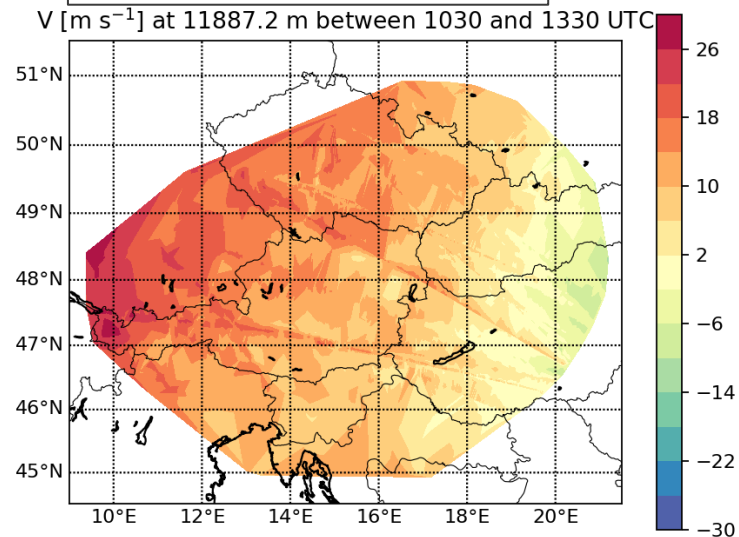
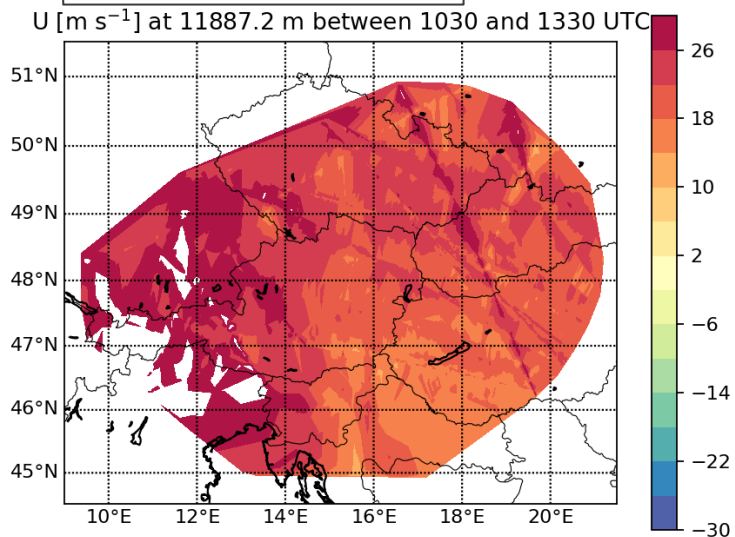
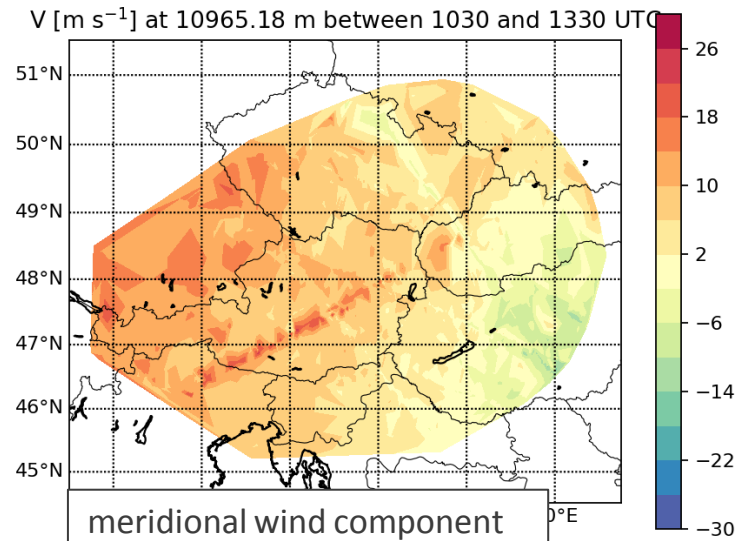
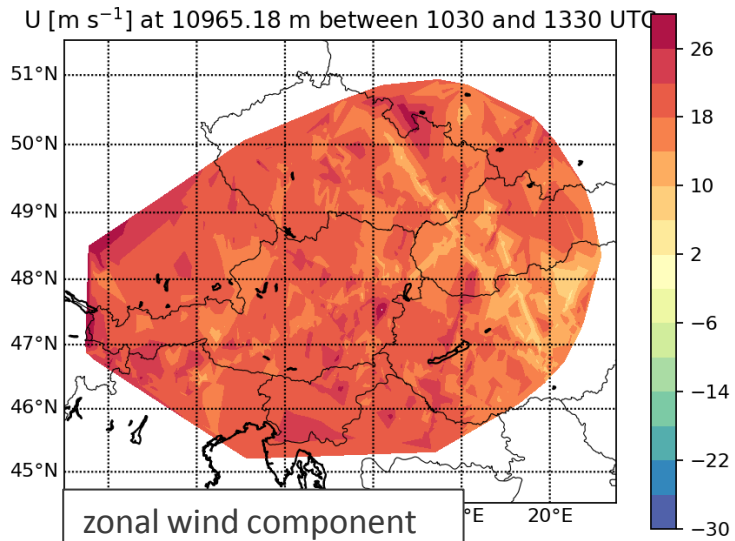
T [K] at 10965.18 m between 1030 and 1330 UTC



T [K] at 11887.2 m between 1030 and 1330 UTC



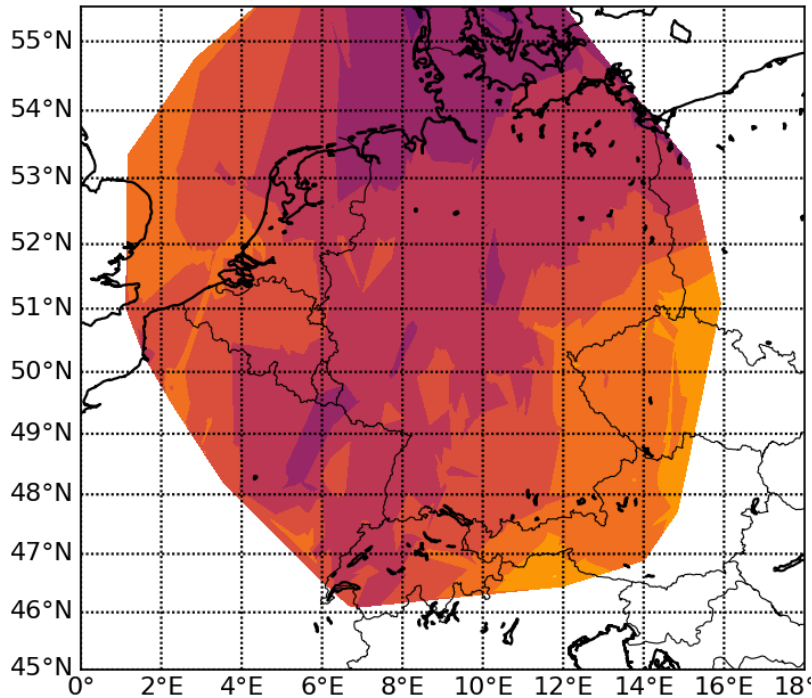
## Mode-S wind data visualized at two different flight levels



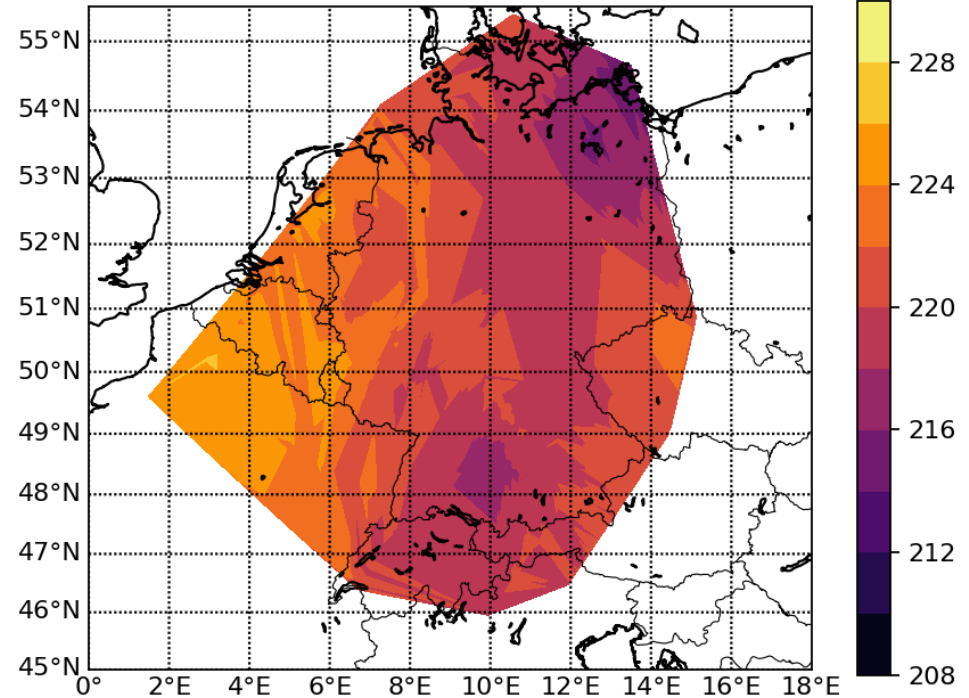
# Supplementary Material

## Mode-S temperature data visualized at two different flight levels (EHS)

T [K] at 10965.18 m between 11 and 12 UTC

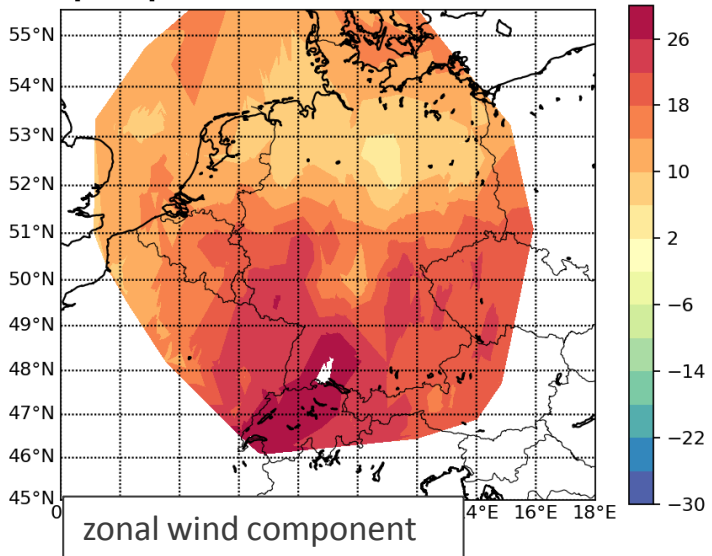


T [K] at 11887.2 m between 11 and 12 UTC

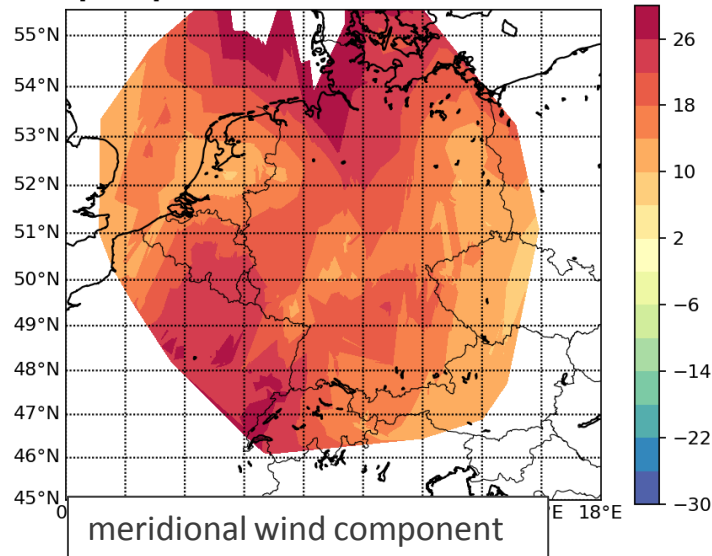


## Mode-S wind data visualized at two different flight levels (EHS)

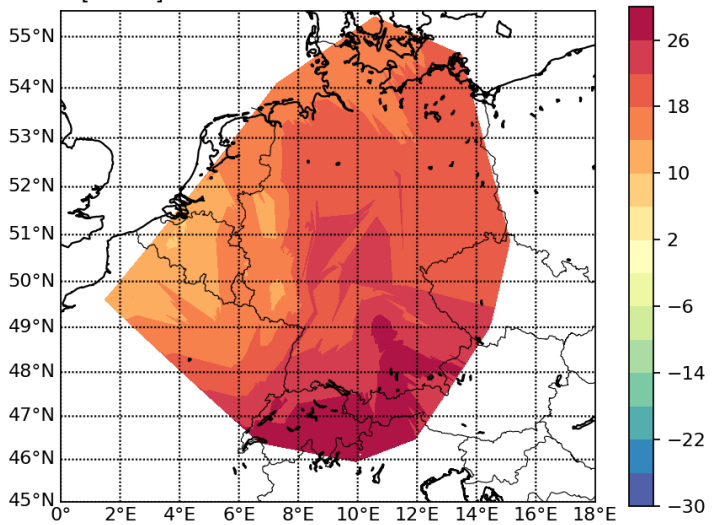
U [ $\text{m s}^{-1}$ ] at 10965.18 m between 11 and 12 UTC



V [ $\text{m s}^{-1}$ ] at 10965.18 m between 11 and 12 UTC



U [ $\text{m s}^{-1}$ ] at 11887.2 m between 11 and 12 UTC



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