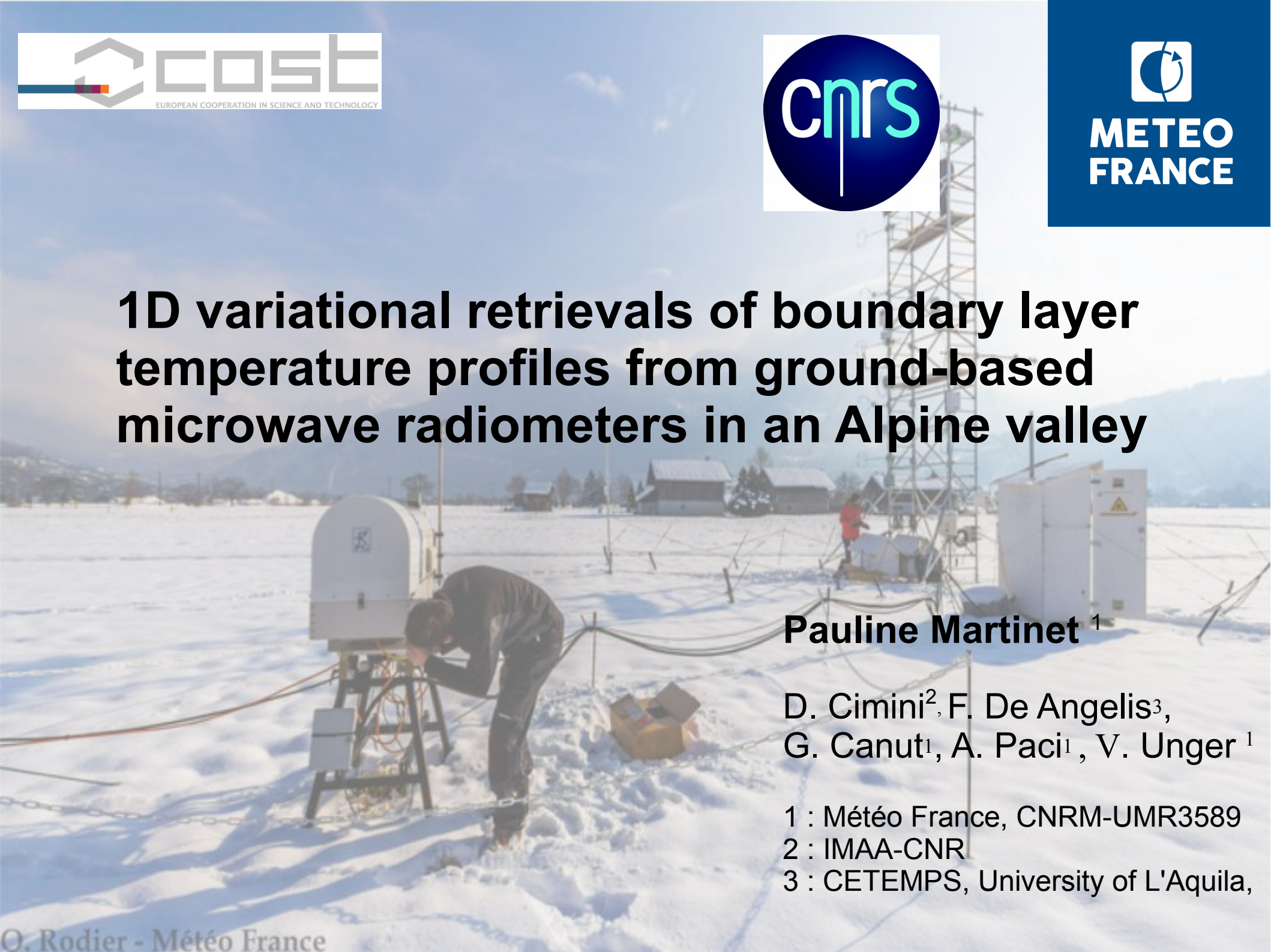


1D variational retrievals of boundary layer temperature profiles from ground-based microwave radiometers in an Alpine valley

Pauline Martinet [1]

D. Cimini[2], F. De Angelis[3],
G. Canut[1], A. Paci[1] , V. Unger [1]

1 : Météo France, CNRM-UMR3589
2 : IMAA-CNR
3 : CETEMPS, University of L'Aquila,

Content

- Motivation
- Overview of the Passy-2015 field experiment
- AROME forecast errors in stable conditions
- 1D assimilation of MWR data into AROME

METEO FRANCE

Motivation of the study

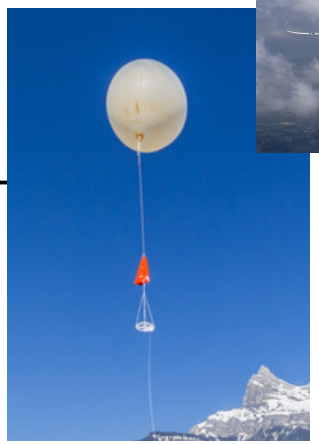
400 km

Satellite

Aircraft

Balloon

10 km



2 km

Weather station

10 m

Remote sensing :
-radar
- lidar
- sodar

Motivation of the study

Satellite

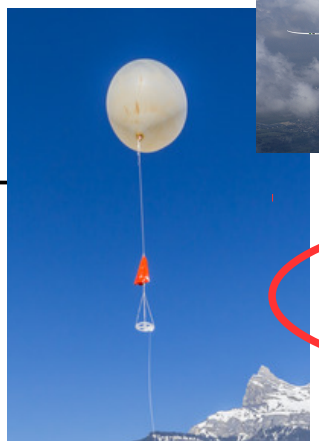
Pollution

400 km

Aircraft

Balloon

10 km



Fog

2 km

PBL : very few data of temperature and humidity

Remote sensing :
-radar
- lidar
- sodar

Weather station

10 m

Storms

Motivation of the study : benefit from ground-based microwave radiometer

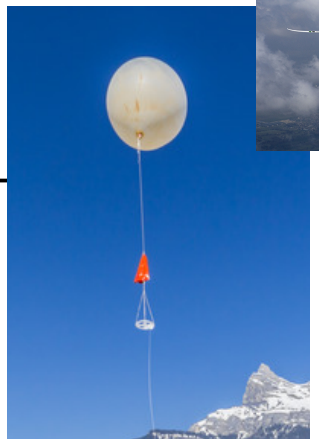
400 km

Satellite

Aircraft

Balloon

10 km



2 km

Add ground-based microwave radiometer

- Continuous measurements
- Clear-sky and cloudy-sky
- Information content mainly residing in the boundary layer

Weather station

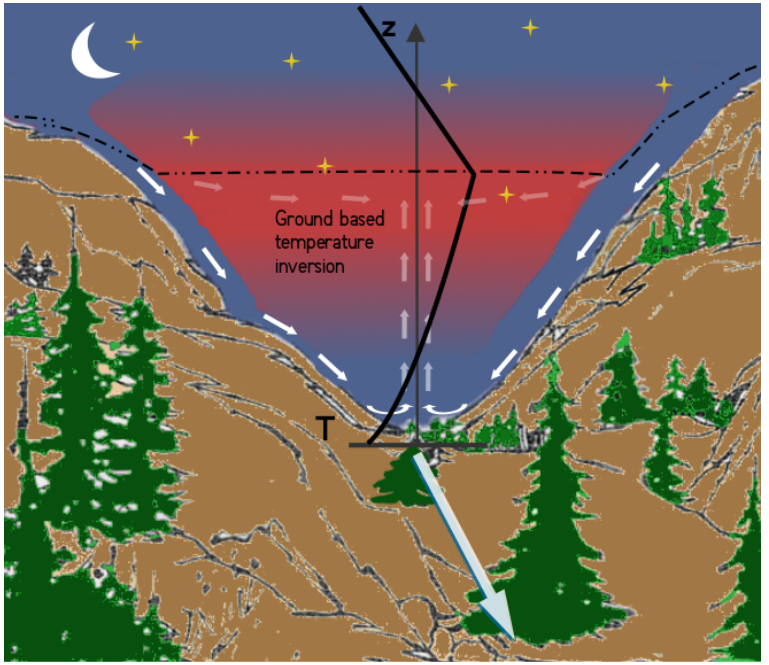
10 m

Remote sensing :
-radar
- lidar
- sodar

The Passy-2015 field experiment

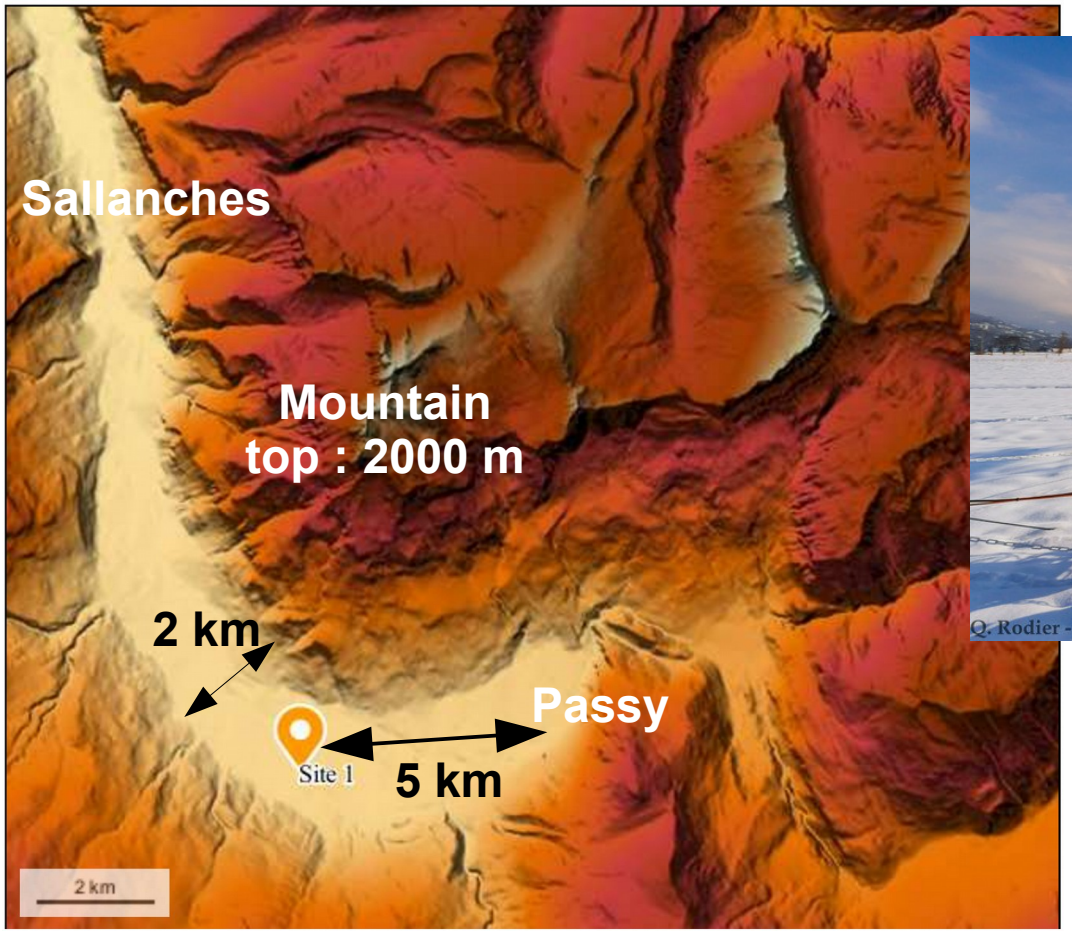
- **Mountainous regions** are known for complex atmospheric situations : anabatic and katabatic winds, strong temperature inversions
- The Arve river valley near Chamonix suffers from high **pollution** events during wintertime anticyclonic conditions
- **NWP models** suffer from large **forecast errors** during very **stable** boundary layer

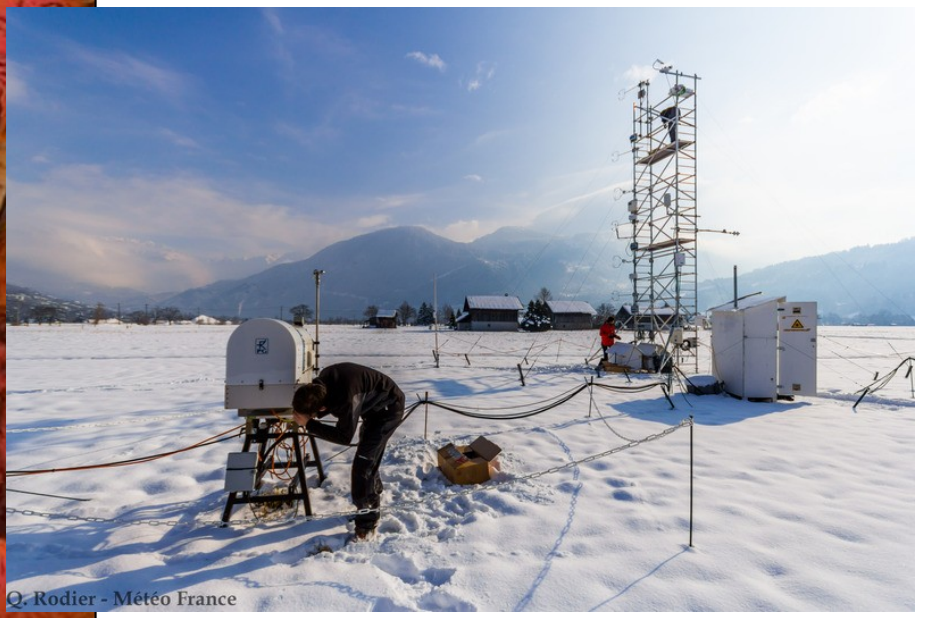
View of the Arve River Valley on 11 February 2015 from Paci et al 2016



Conceptual scheme of wind circulation in moutainous region Courtesy T. Sabatier

The Passy-2015 field campaign



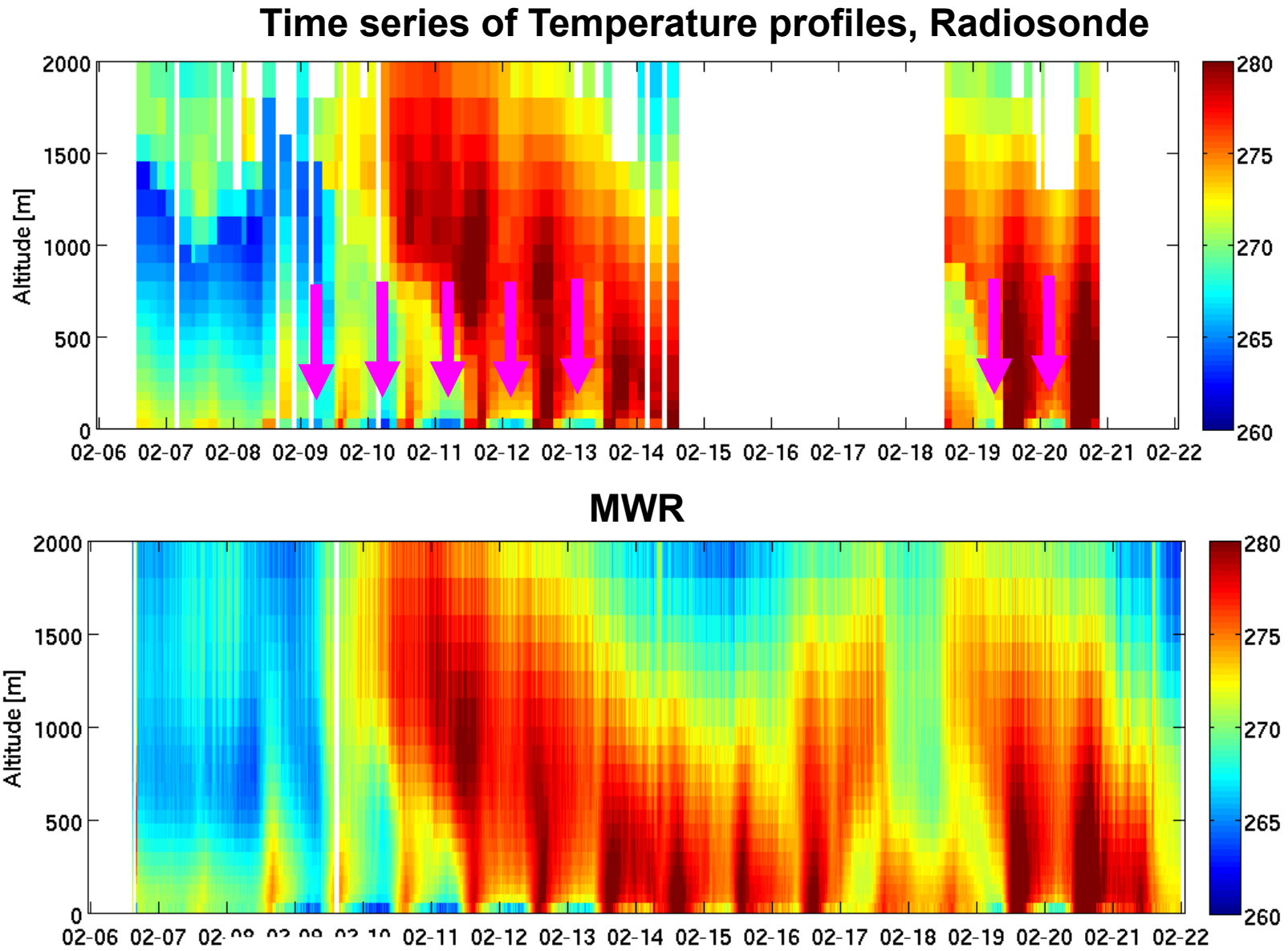


http://passy.sedoo.fr/

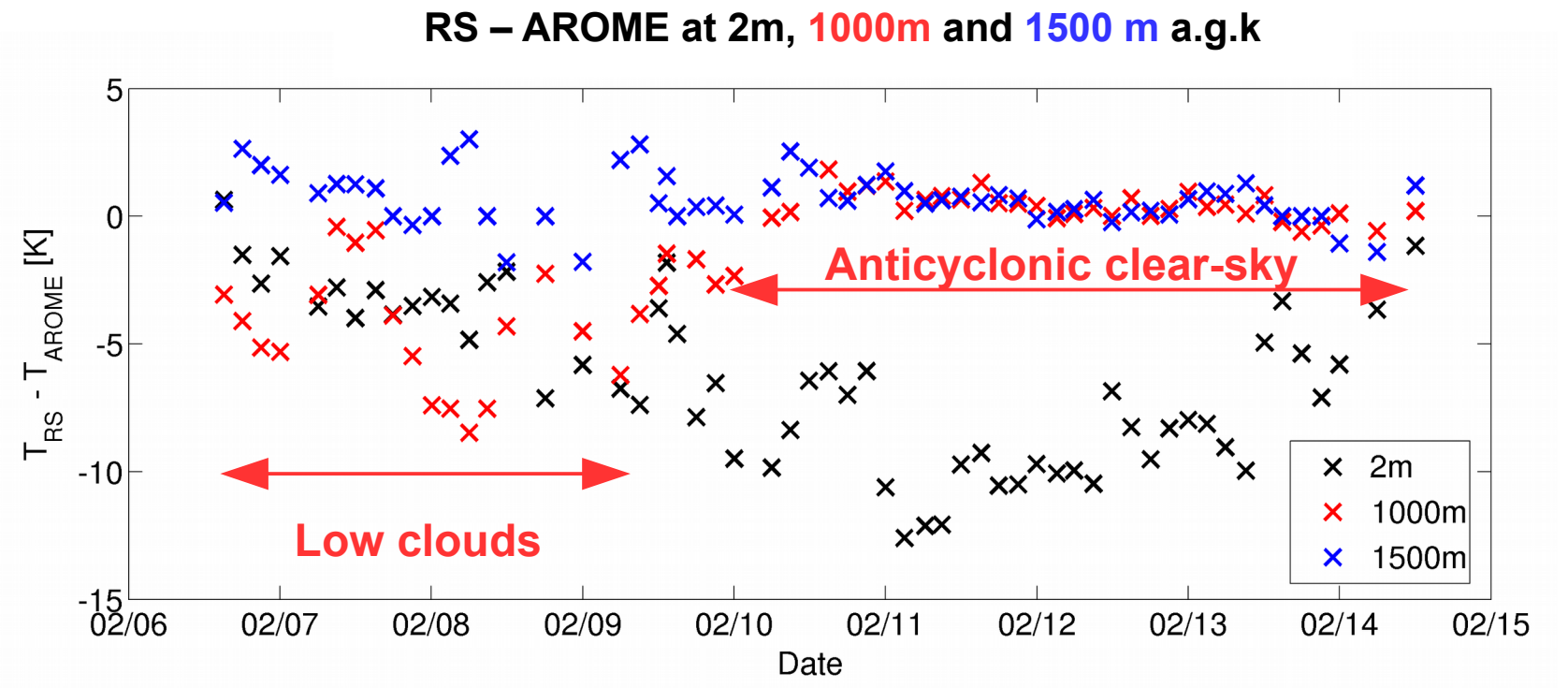
- A **HATPRO** ground-based microwave radiometers has been deployed down the valley
- Collocated with **radiosondes** launched every **3 hours** during **13 days of IOP** in February 2015
- Many instruments : ceilometers, wind profilers, aerosol lidars, tower measurements ...

Overview of the Passy 2015 experiment

- Persistent temperature inversions
- Destruction of the stability only between noon and 3 to 5 pm
- Temperature cooling up to -10°C at the surface well described by the MWR



AROME forecast errors during the Passy-2015 experiment



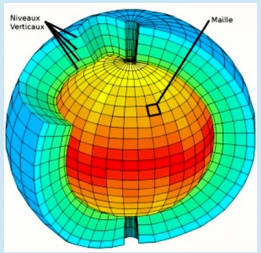
- Small errors (within 2 K) at 1500m stable during the IOP : **synoptic circulation** decoupled from the valley circulation

- High correlation between **surface temperature** error and atmospheric **stability**

METEO FRANCE

From brightness temperatures (BT) to atmospheric profiles: 1D-Var retrievals

Model Space: T, Q, LWC

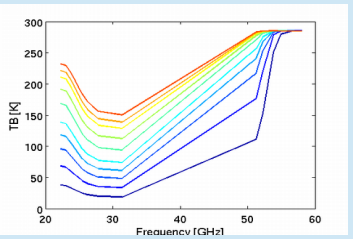


x_b= Background

1h AROME forecast

Radiative Transfer (F)
ARTS

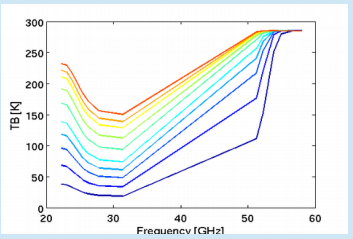
BT simulation (F(x))



Minimization of the cost function J:

$$J(x) = (x - x_b)^T B^{-1} (x - x_b) + (y - F(x))^T R^{-1} (y - F(x))$$

Observation : y



Iterative minimization
Adjustment of the background profile

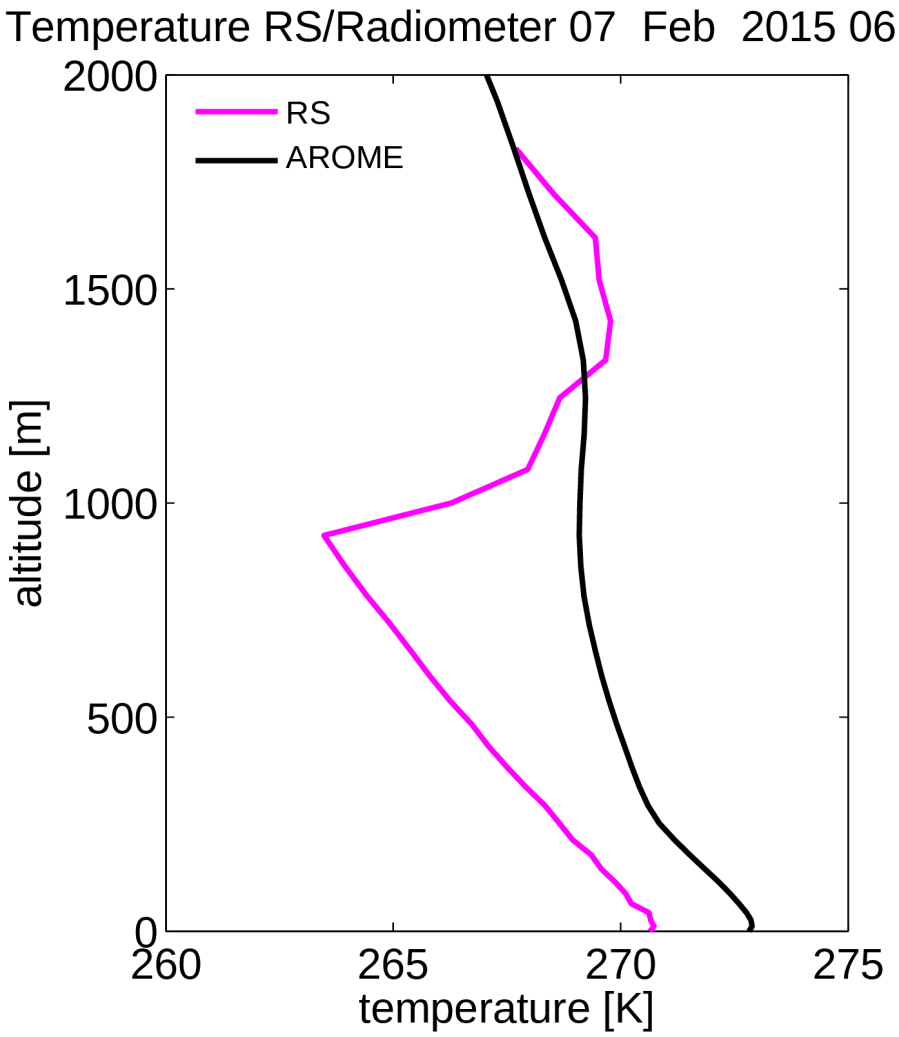
\+ **Can be run everywhere, evaluation of NWP analysis improvement**

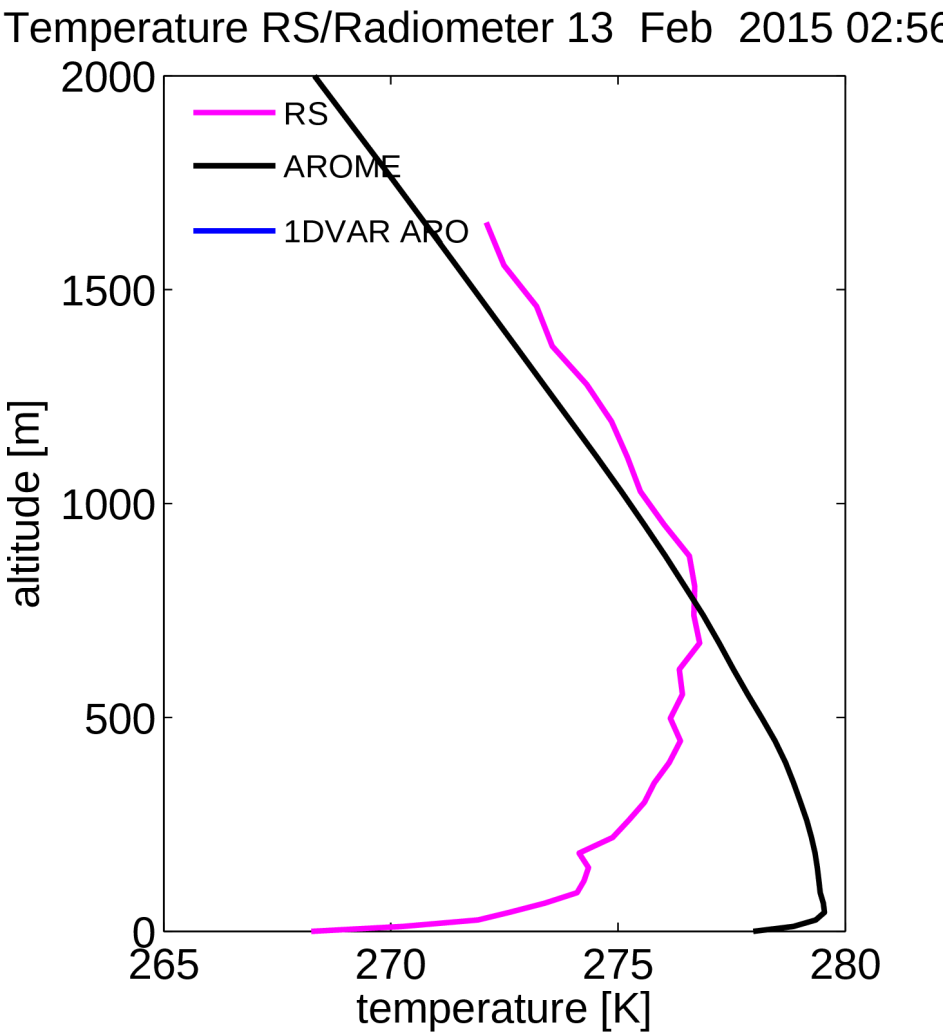
\- **Convergence, slow (with ARTS), specification B matrix, R matrix**

** Eriksson, P., Jimnez, C. and Buehler, S. A. 2005. Qpack, a general tool for instrument simulation and retrieval work. J. Quan. Spectrosc. Radiat. Transf. 91(1), 47-64.*

1D assimilation in the AROME model

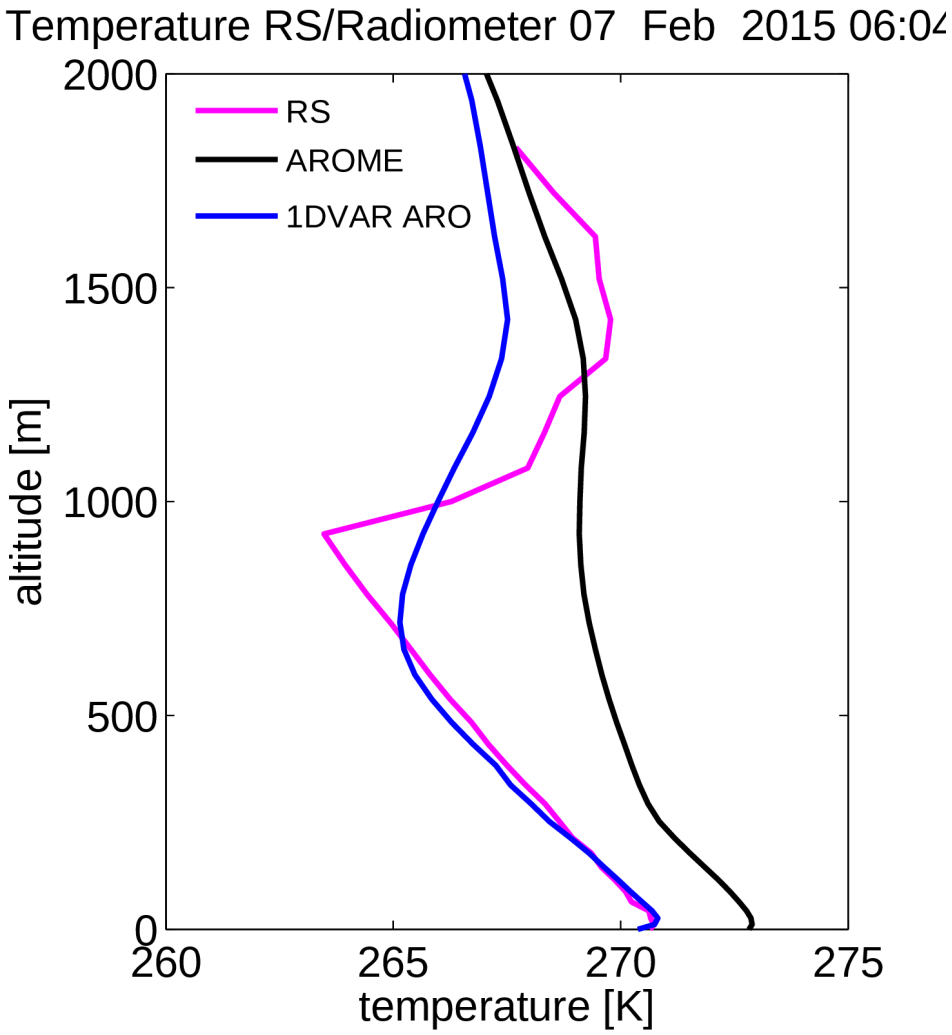
RS
AROME

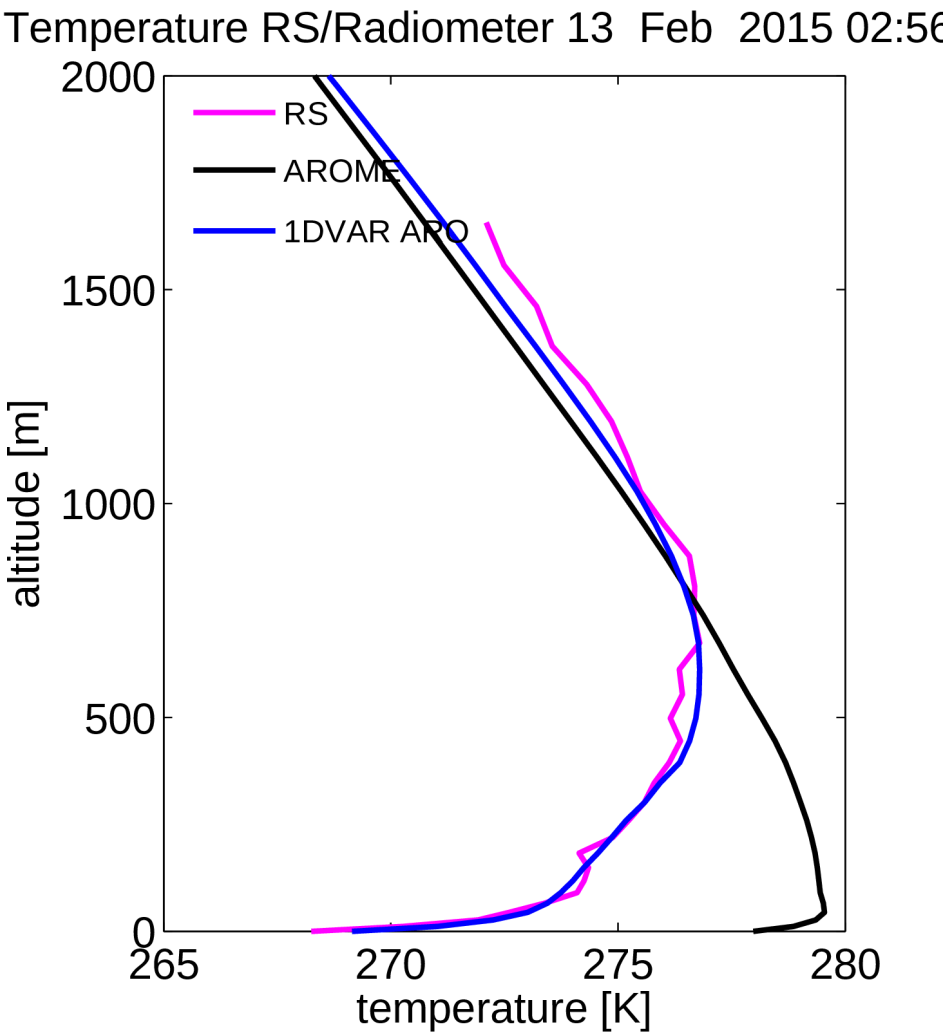




1D assimilation in the AROME model

RS
AROME
1DVAR Arome

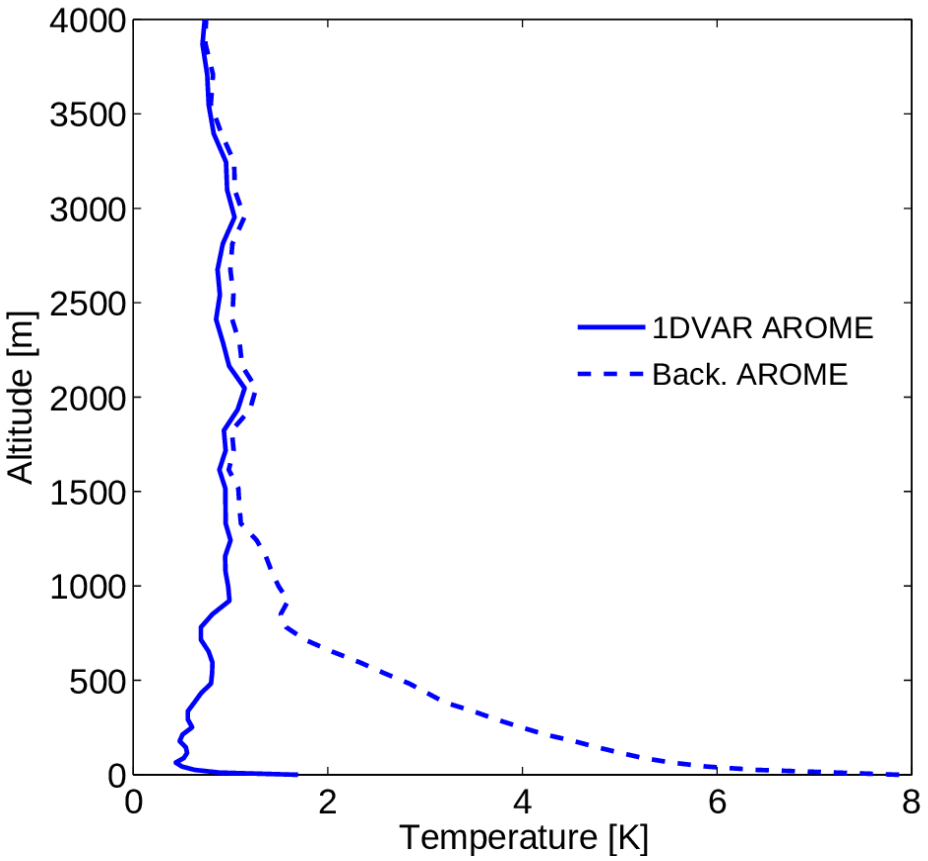




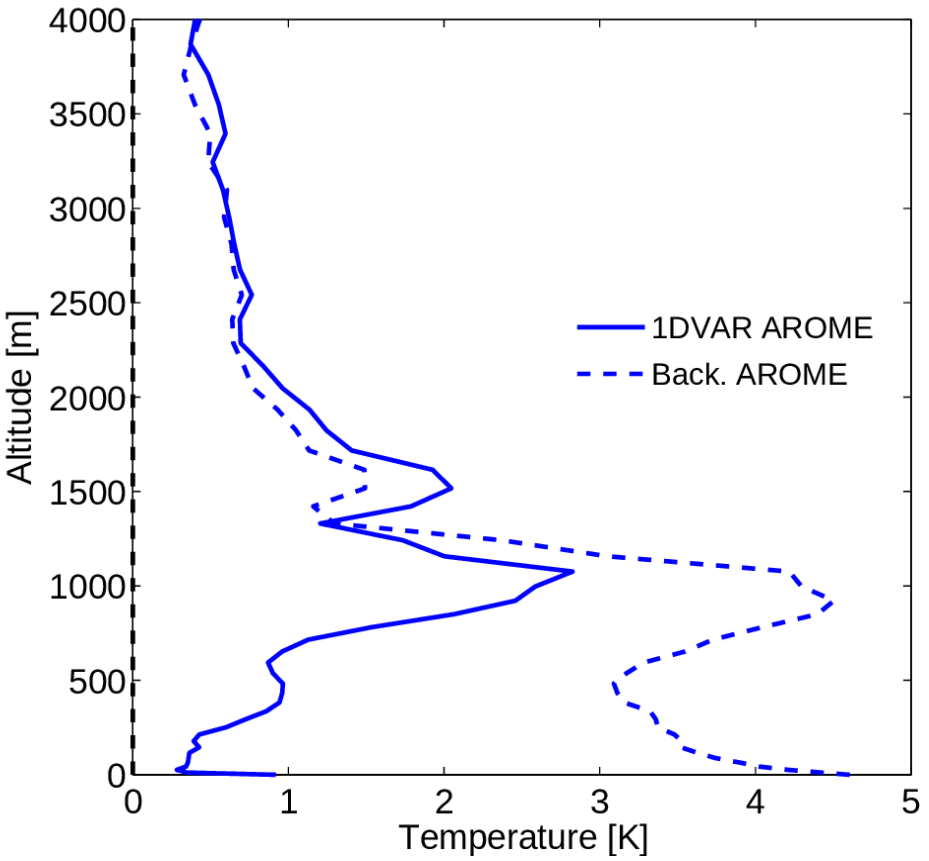
1D assimilation in the AROME model : RMSE with respect to radiosondes

1DVAR Arome
AROME 1h forecast

Clear-sky (56 cases)

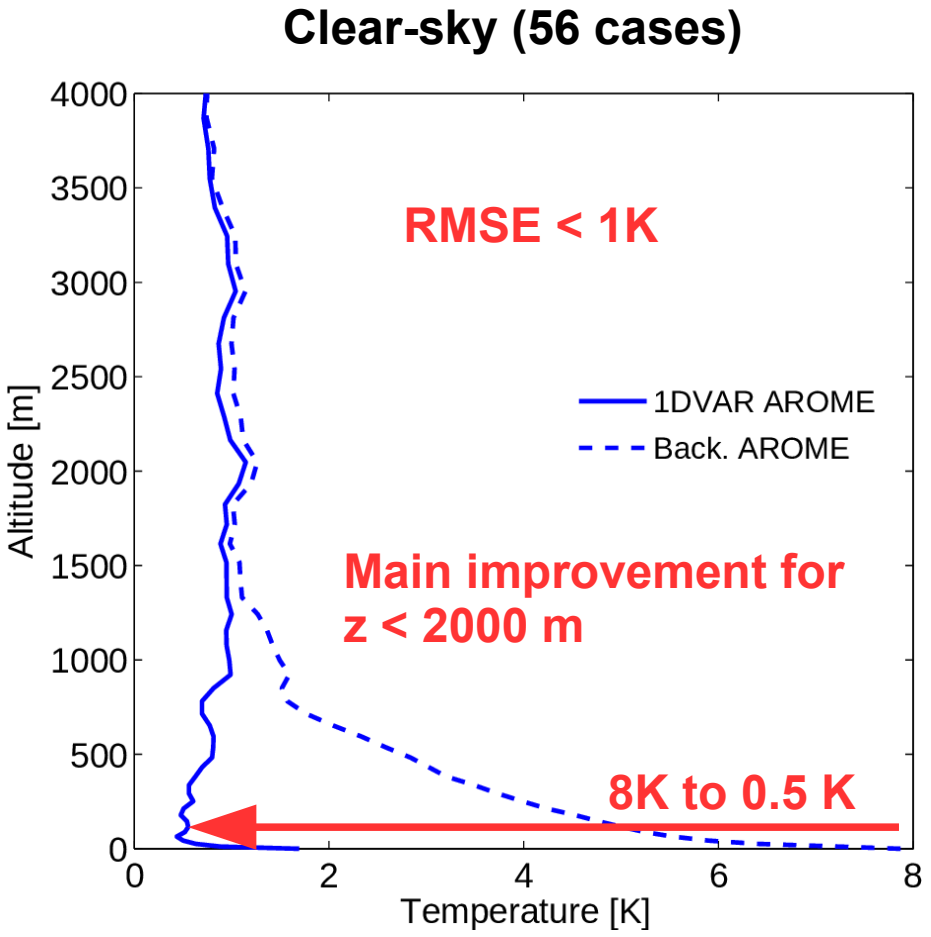


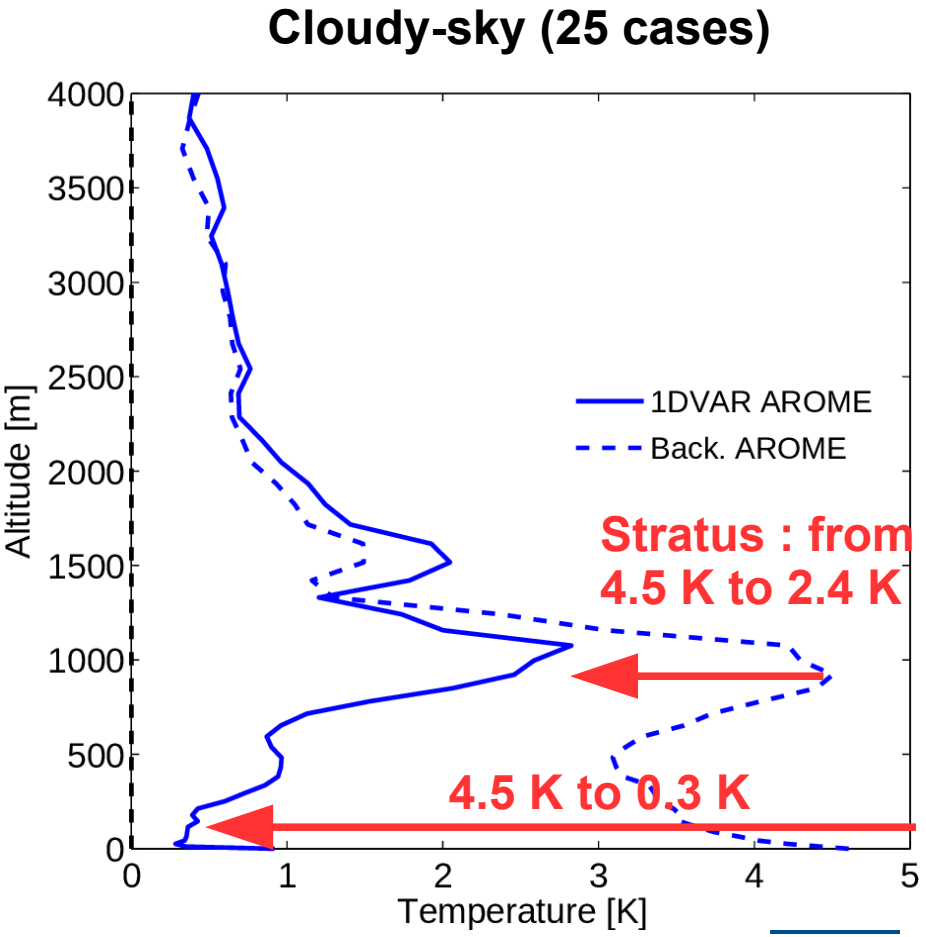
Cloudy-sky (25 cases)



1D assimilation in the AROME model : RMSE with respect to radiosondes

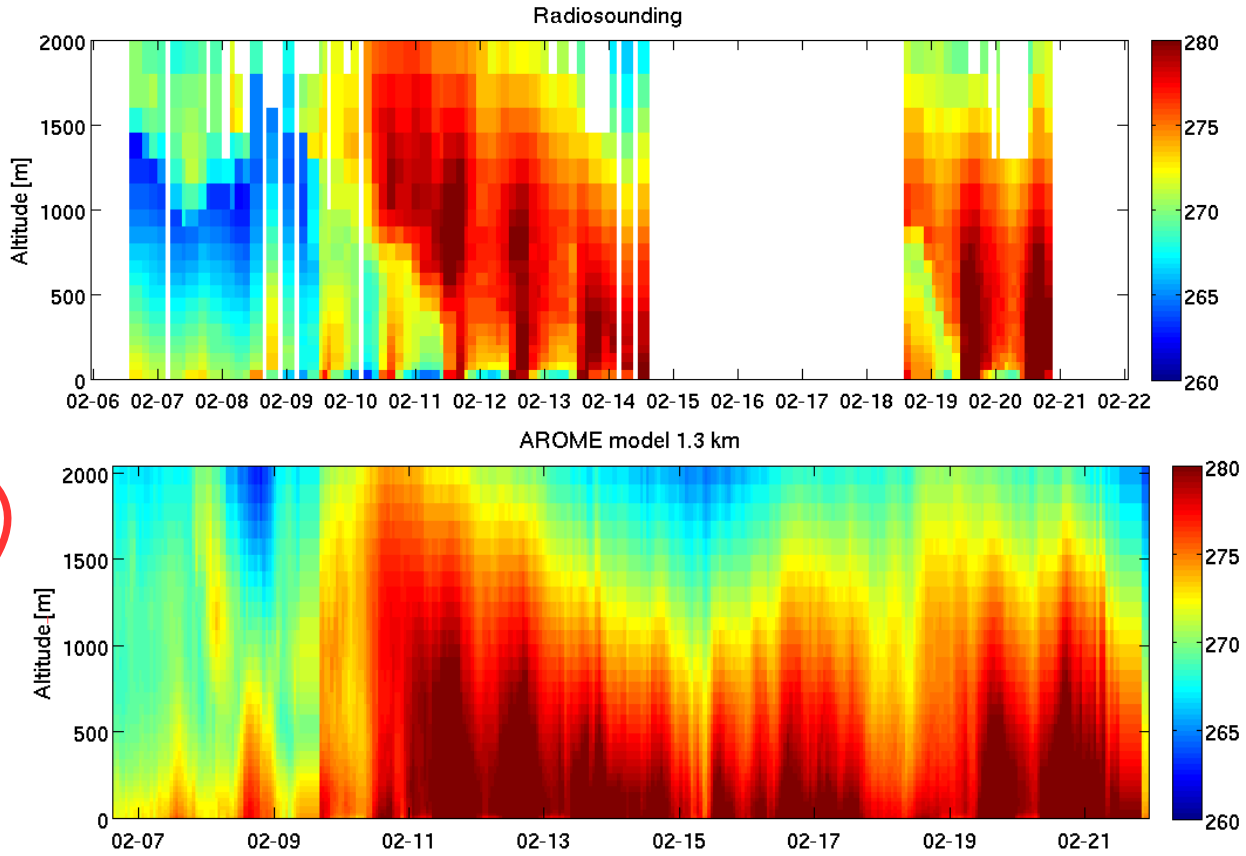
1DVAR Arome
AROME 1h forecast





What benefit from MWR can we expect in NWP models ?

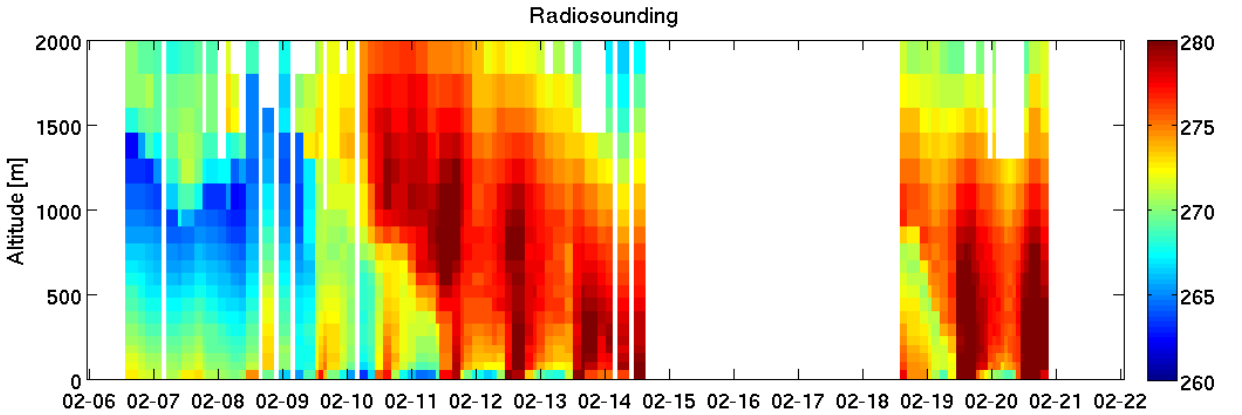
Radiosonde



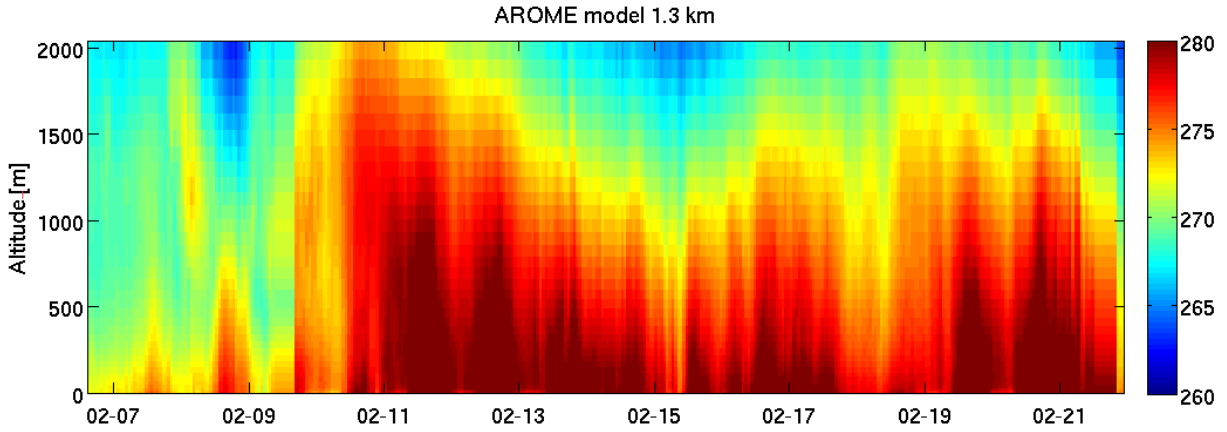
1h AROME forecasts
Before assimilation

What benefit from MWR can we expect in NWP models ?

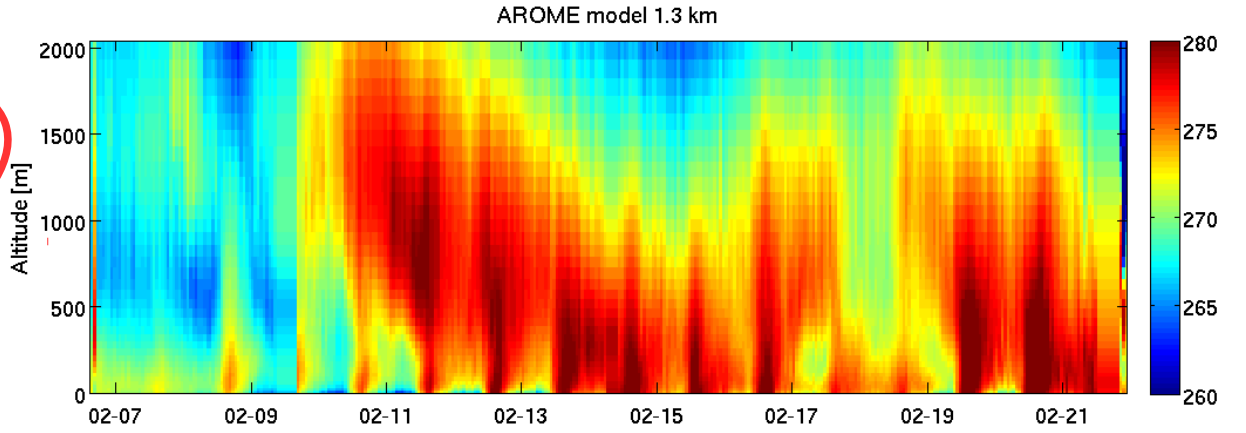
Radiosonde



1h AROME forecasts
Before assimilation

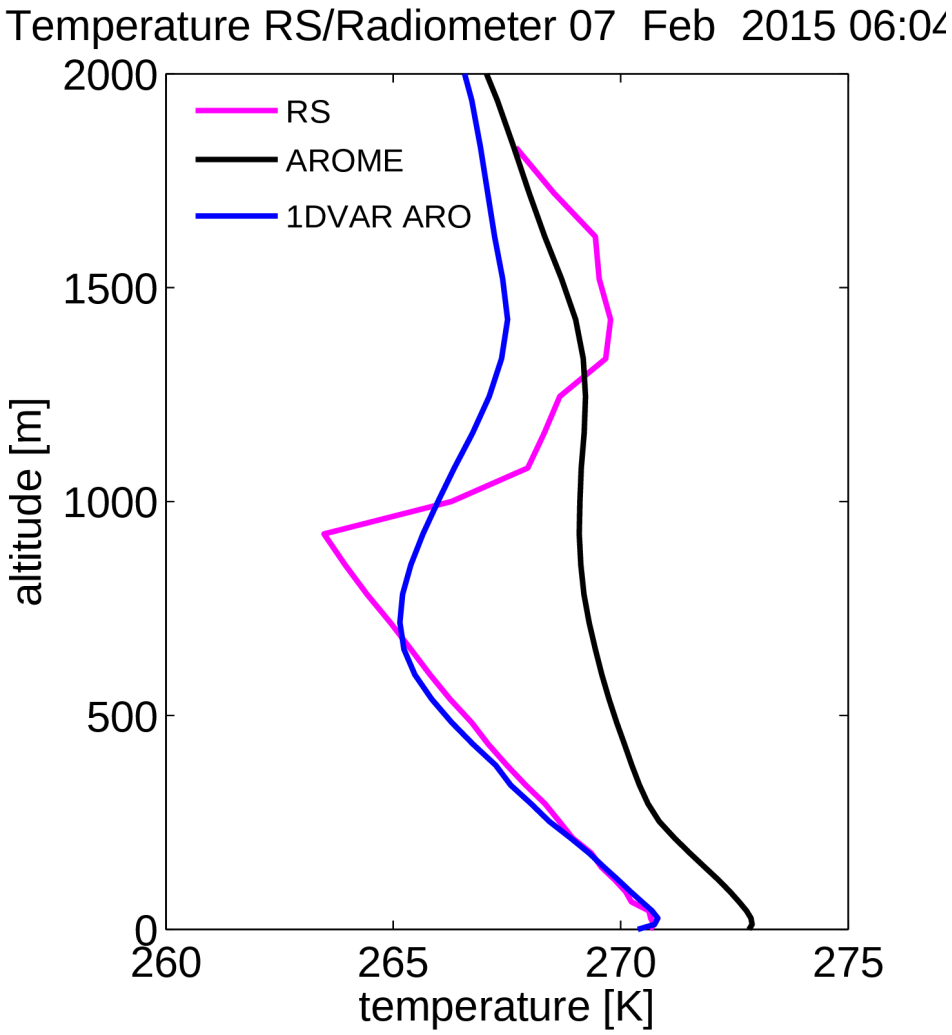


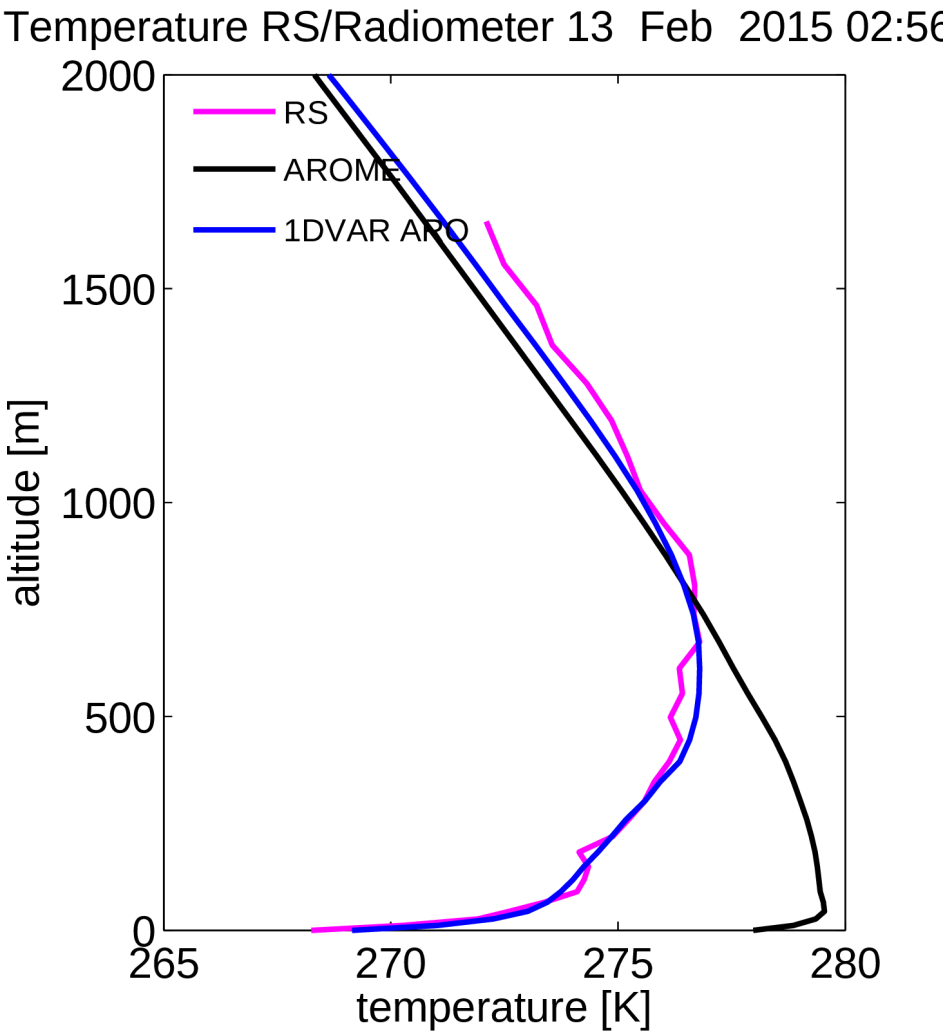
1D AROME analysis
After assimilation



The 1DVAR can also be adapted for BL processes studies

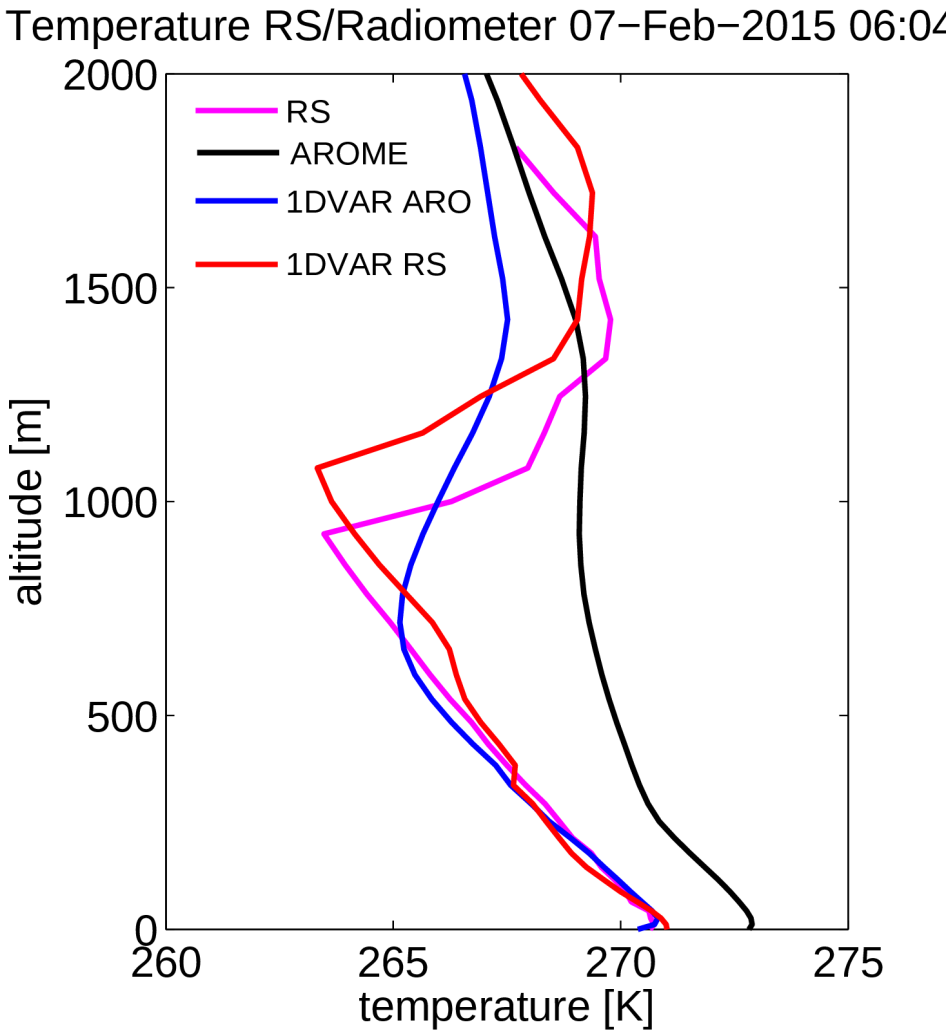
RS
AROME
1DVAR Arome

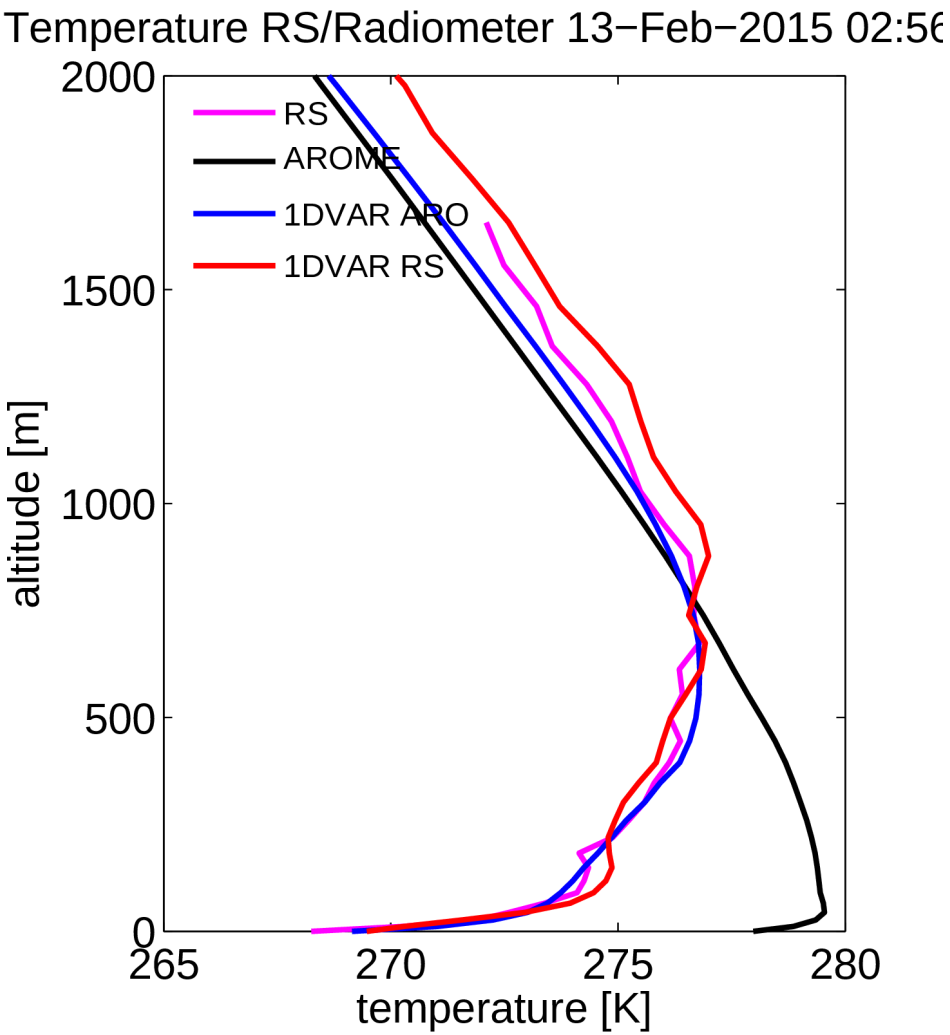




The 1DVAR can also be adapted for BL processes studies

RS
AROME
1DVAR Arome
1DVAR RS





Conclusions

Main Results

- Temperature retrievals with an **accuracy of 0.5 to 1 K** with highest information content in the boundary layer **below 2 km**
- Large **improvement** of **AROME** forecasts through 1D assimilation of MWR data : from **8 K to 0.5 K** RMSE
- Significant benefit can be expected in NWP models by the assimilation of MWR brightness temperatures
- **High temporal resolution** for a fine description of atmospheric processes in the boundary layer and future 4DVAR assimilation

Conclusions

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Future Prospects

- Use of the fast radiative transfer model **RTTOV-gb** on an extensive dataset (1 year of data, six instrumented sites)
- **Data assimilation** (1D-Var + 3D-Var or direct 3D-Var) and **reanalysis of experimental campaigns** to evaluate the improvement in NWP forecasts especially during fog conditions.

THANKS FOR YOUR ATTENTION

References :

Passy campaign website : http://passy.sedoo.fr/

Martinet et al, 2017, AMT, submitted : 1D variational retrievals of boundary layer temperature profiles from ground-based microwave radiometers in an Alpine Valley

Martinet et al, 2015, Tellus : 1D-Var temperature retrievals from microwave radiometer and convective scale model

Paci et al, 2016, Pollution Atmosphérique : The Passy-2015 field experiment: atmospheric dynamics and air quality in the Arve River Valley, http://lodel.irevues.inist.fr/pollution-atmospherique/index.php?id=5903