ACCORD

A Consortium for COnvection-scale modelling Research and Development

T2m bias in mountains: first results

Danaé Préaux, Ingrid Etchevers, Isabelle Gouttevin

CNRM cnrs METEO FRANCE

Outline

- Arome's temperature bias in the mountains
- Cold bias - possible causes
  - Valley station assimilation
  - Use of the 2 m increment
  - Temperature gradient above the snow
  - Height of the sensor above the snow: Nivôse station
  - Diagnostic of 2 m temperature
  - Interactions with the surface
- Summary of perspectives

Arome's temperature bias in the mountains

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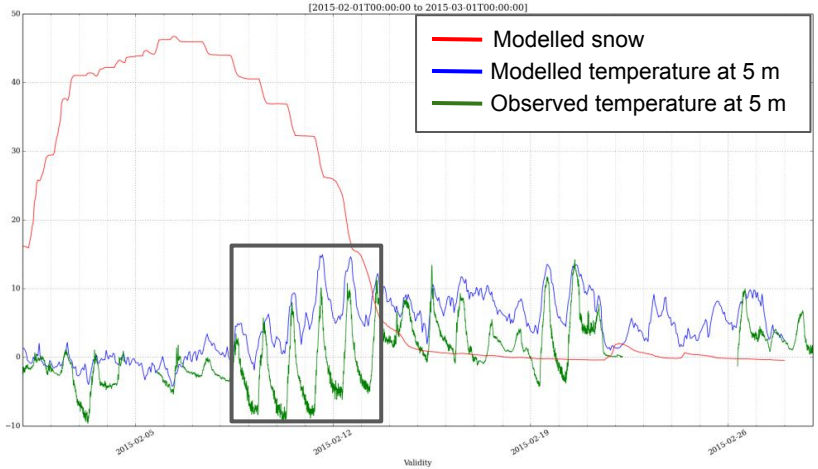
Warm bias in anticyclonic situation



Campaign at Passy (close to Mont Blanc) from 5 to 26 February 2015 (Paci et al. 2016)

Pollution

Arome's temperature bias in the mountains

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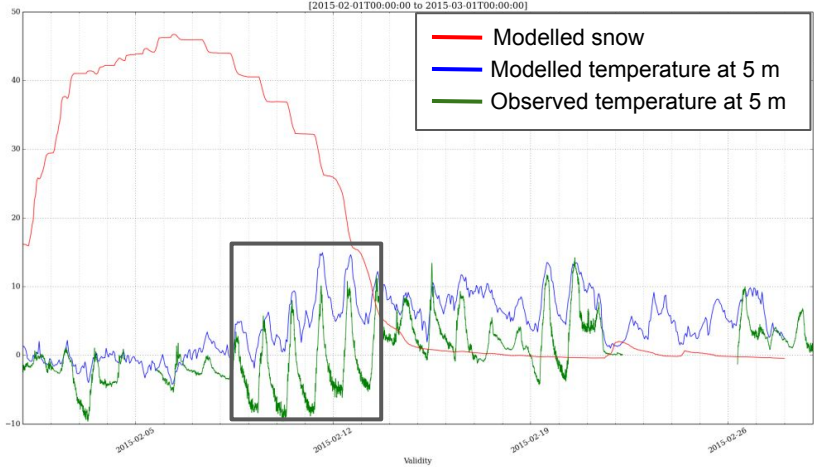
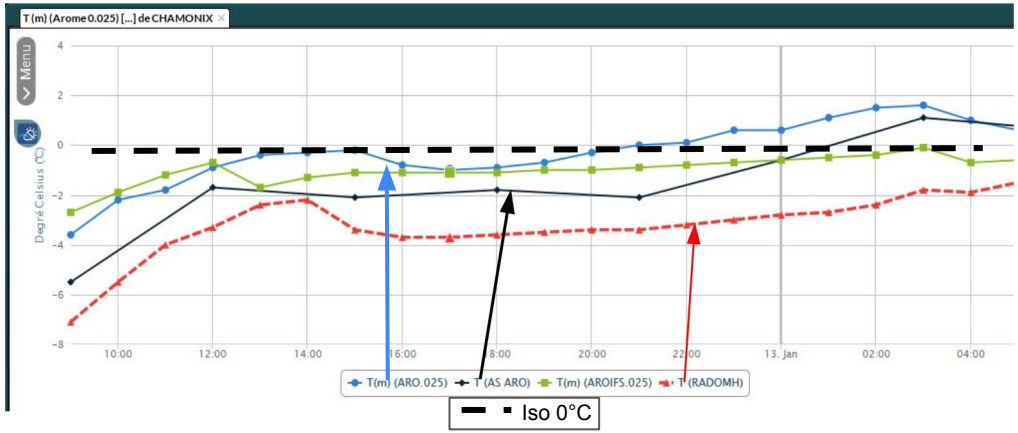


Campaign at Passy (close to Mont Blanc) from 5 to 26 February 2015 (Paci et al. 2016)

Warm bias in during snow events



Forecast and observed temperatures in Chamonix Mont Blanc on 12/01/2021 (J. Marceau, DIRCE)

Pollution

Road traffic

Arome's temperature bias in the mountains

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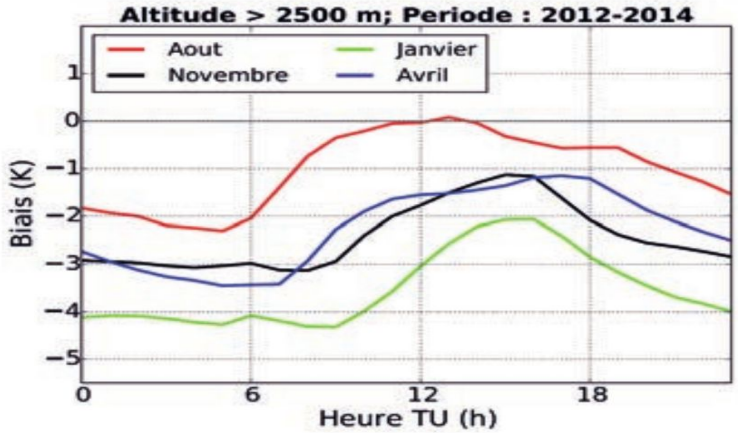
Cold bias in high altitude



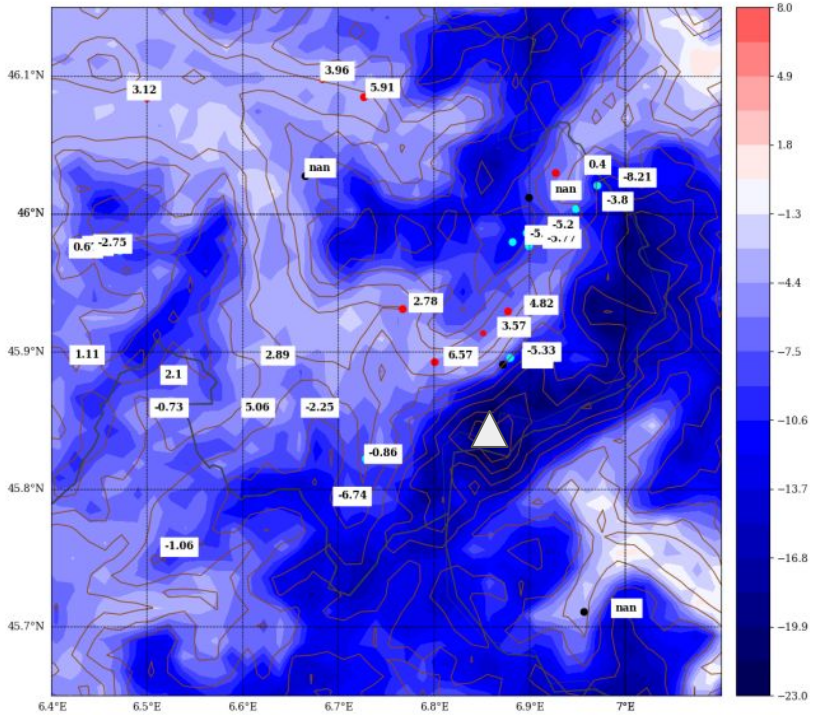
Vionnet et al, 2016

- T2m bias > - 4°C during the night in January
- Detrimental for avalanche and snowmelt forecasting
- Leads to spurious snow accumulation (*Monteiro et al. 2022*) while using Arome for climate

Snowpack and Climate

Cold bias - possible causes

Temperature and bias at 2m at 6am on 12/01/2021



Warm bias Cold bias Mont Blanc

Samoëns (749 m) : + 5.9°C
Les Houches (1005 m) : + 6.6°C
Chamonix Mont Blanc (1042 m): + 4.8°C

Plan de l'Aiguille (2250 m): - 5.3°C
Le Tour Balme (2196 m): - 8.2°C

Mean absolute error of 2 m temperature over the Chamonix Valley (0-10h the 12/01/2021)

Simulation	MAE (°C)		
	$z < 1100$ m	1100 m $\leq z < 2000$ m	2000 m $\leq z$
Reference	3.7	2.0	6.0
Surface	4.5	1.7	4.9
Analysis	3.3	2.4	6.9
3DVar 1.3km	4.5	2.1	5.7
156 levels	4.2	2.6	1.9

Cold bias - possible causes

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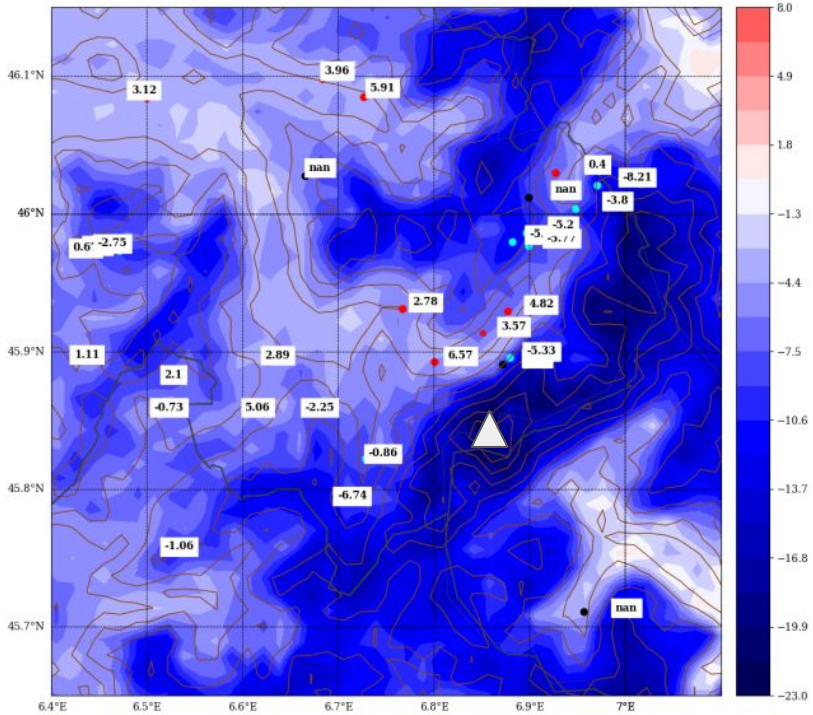

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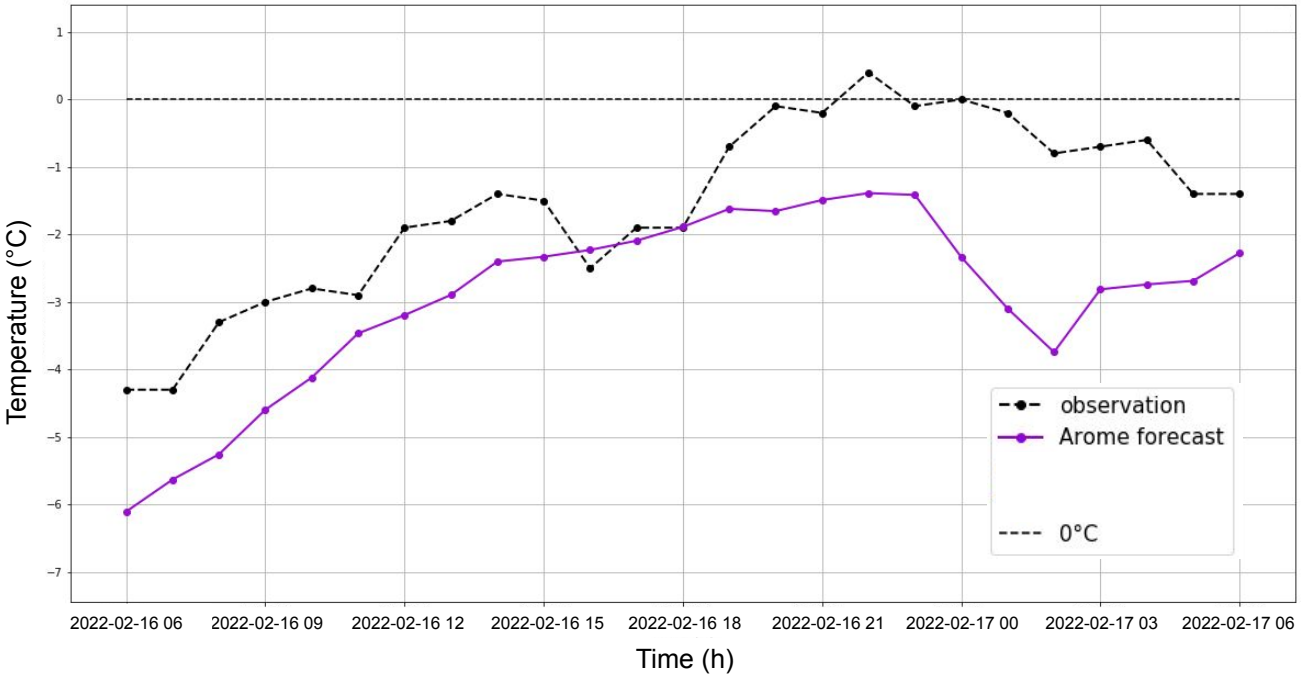
Cold bias - possible causes

Assimilation of data mainly in the valleys

Evolution of 2 m temperature the 16/02/2022, Aiguilles Rouges (Nivôse station at 2365 m)



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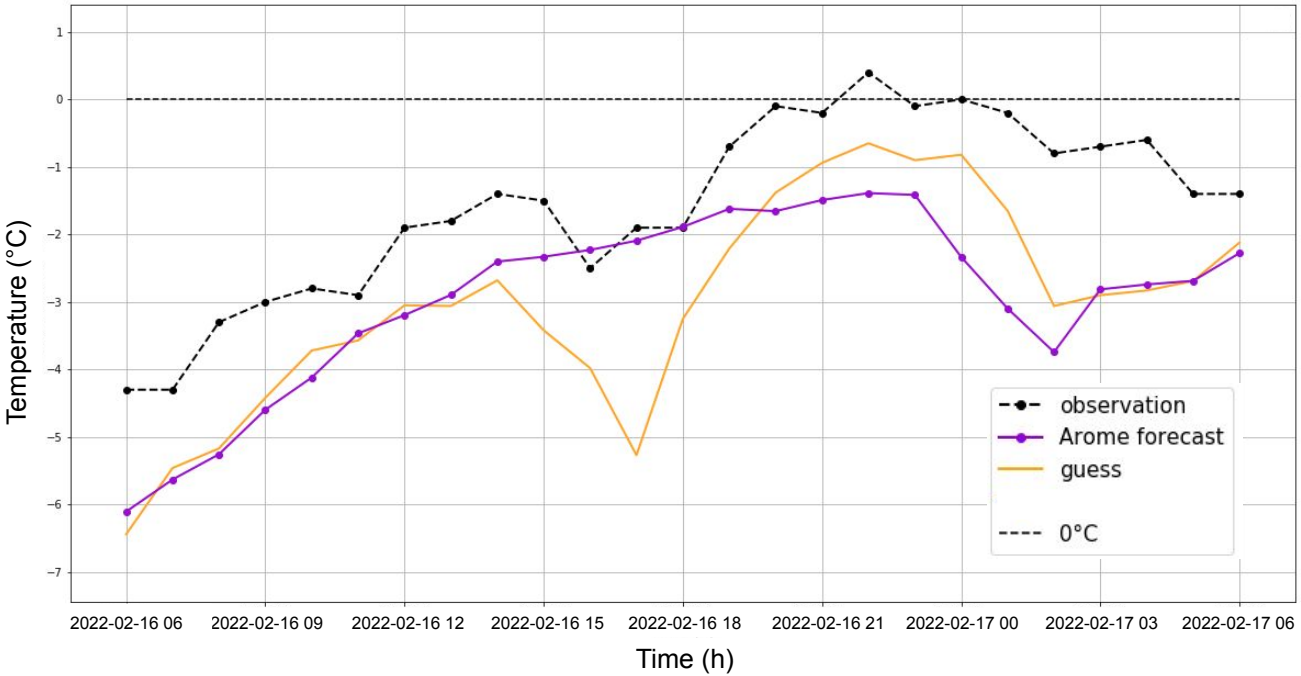

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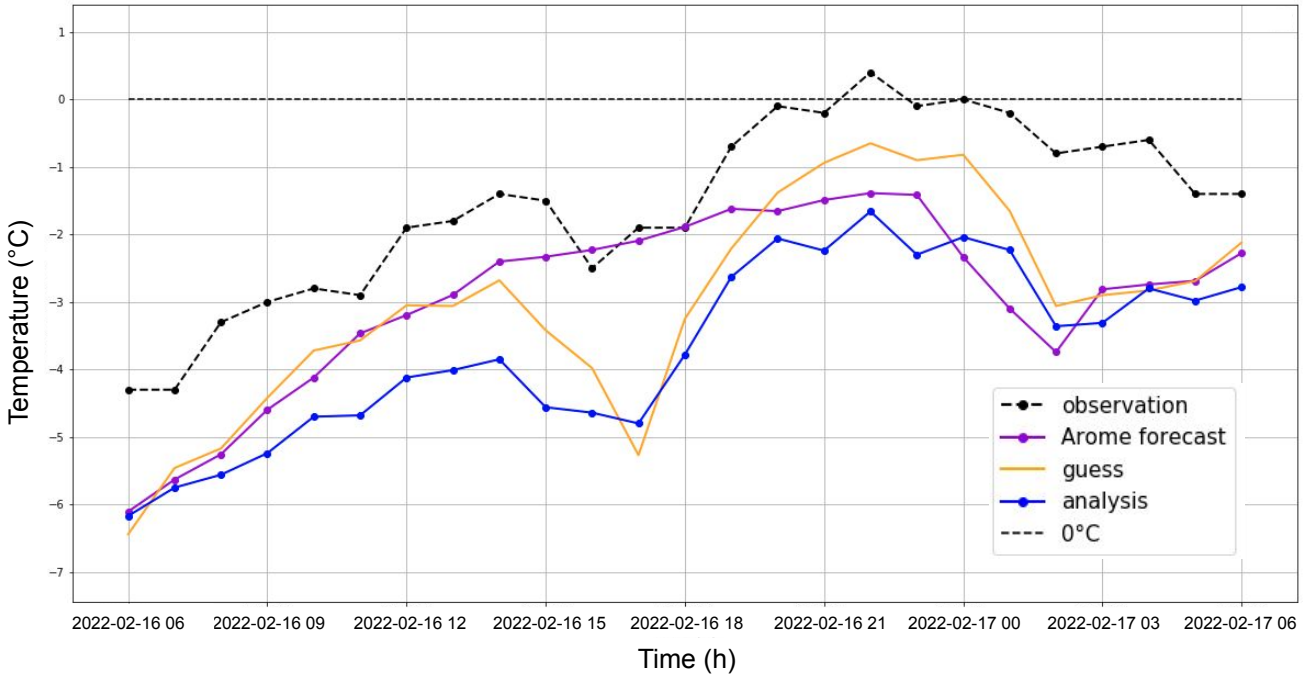

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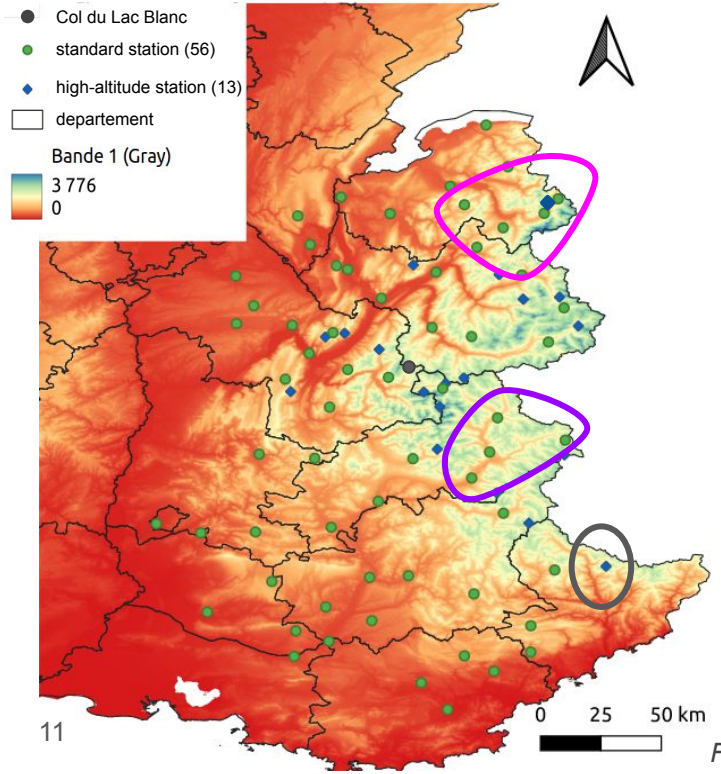
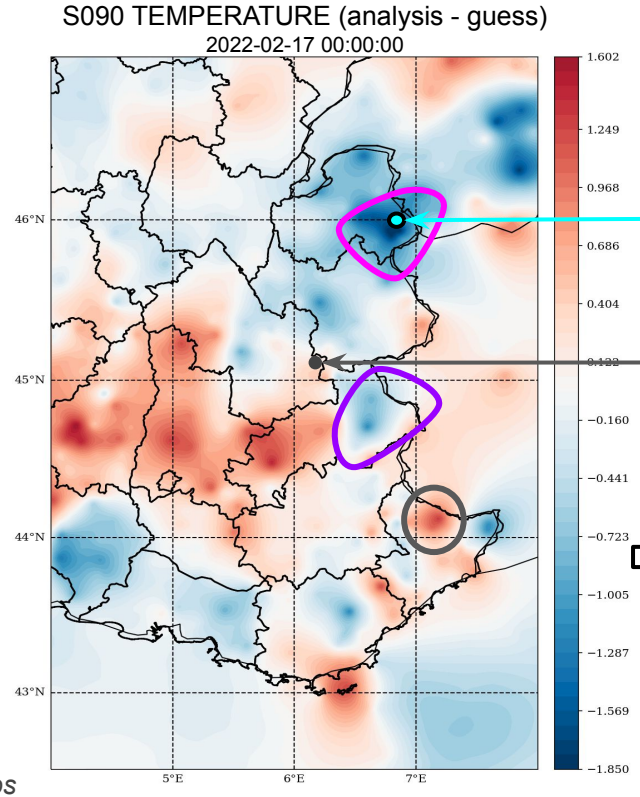


French Alps



Aiguilles Rouges:
guess = - 0.82
analysis = - 2.04

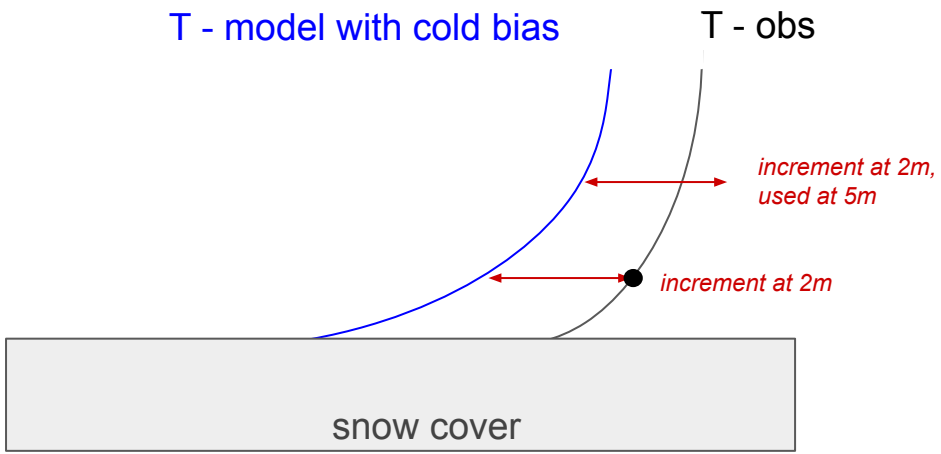
Col du Lac Blanc

The spatial influence of the assimilated data does not consider the topography

Cold bias - possible causes

Use of the 2m increment

standard station measuring at 2m (stable conditions over snow)

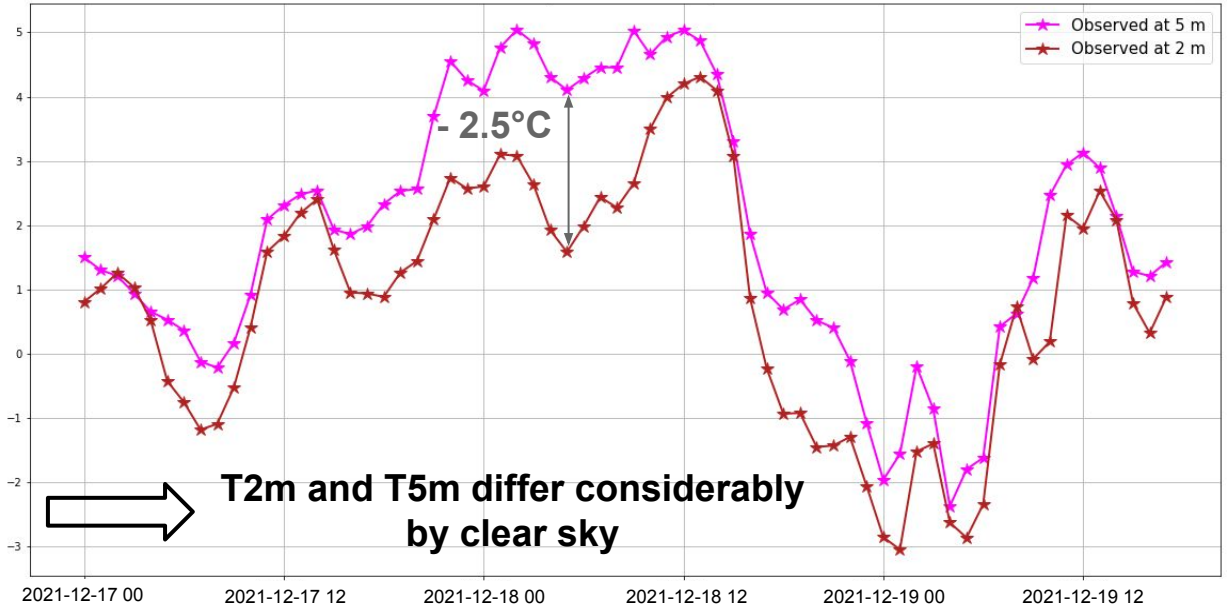


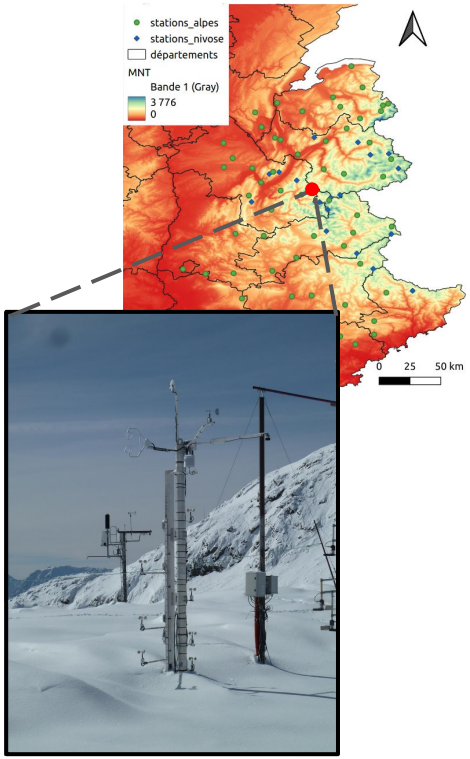
The analysis scheme considers the increment at 2 m as an increment at 5 m

Cold bias - possible causes

Temperature gradient above the snow

Col du Lac Blanc series, 2720 a.s.l, Grandes Rousses massif, Oisans



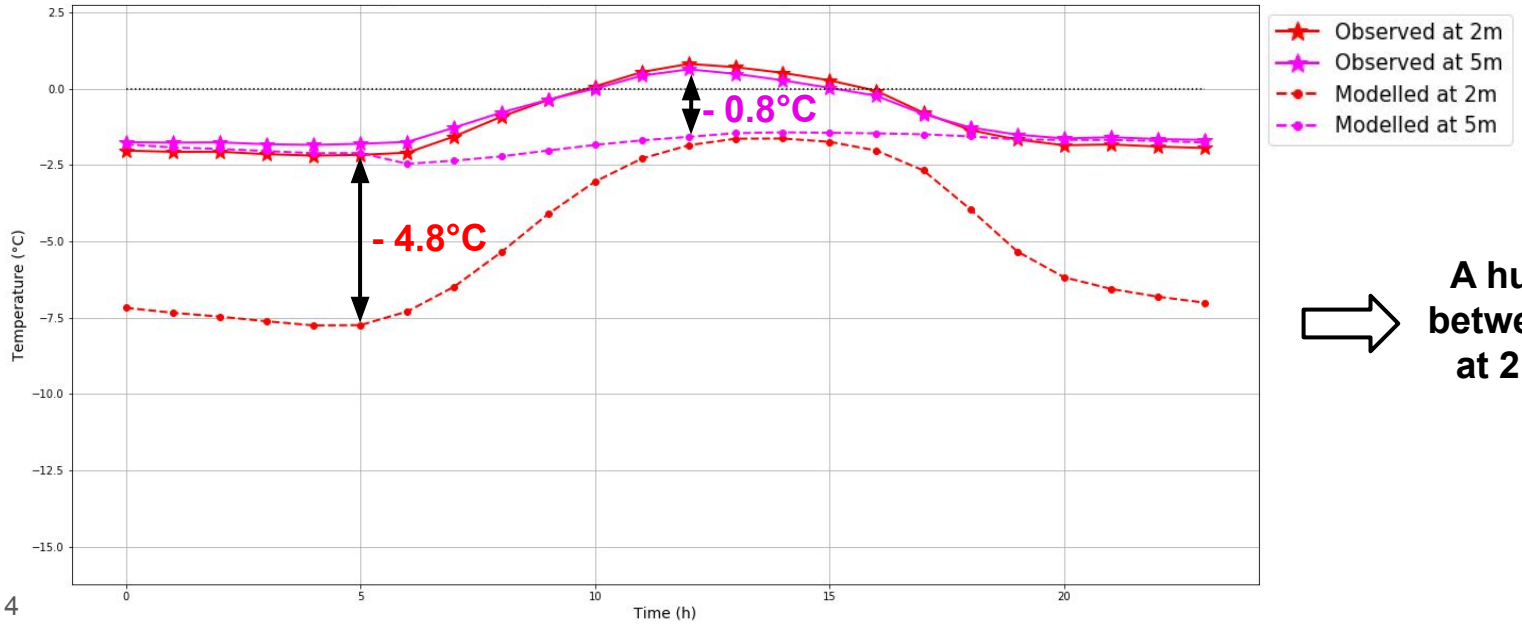


Col du Lac Blanc (snow research center): Mast measuring temperature at different heights

Cold bias - possible causes

Temperature gradient above the snow

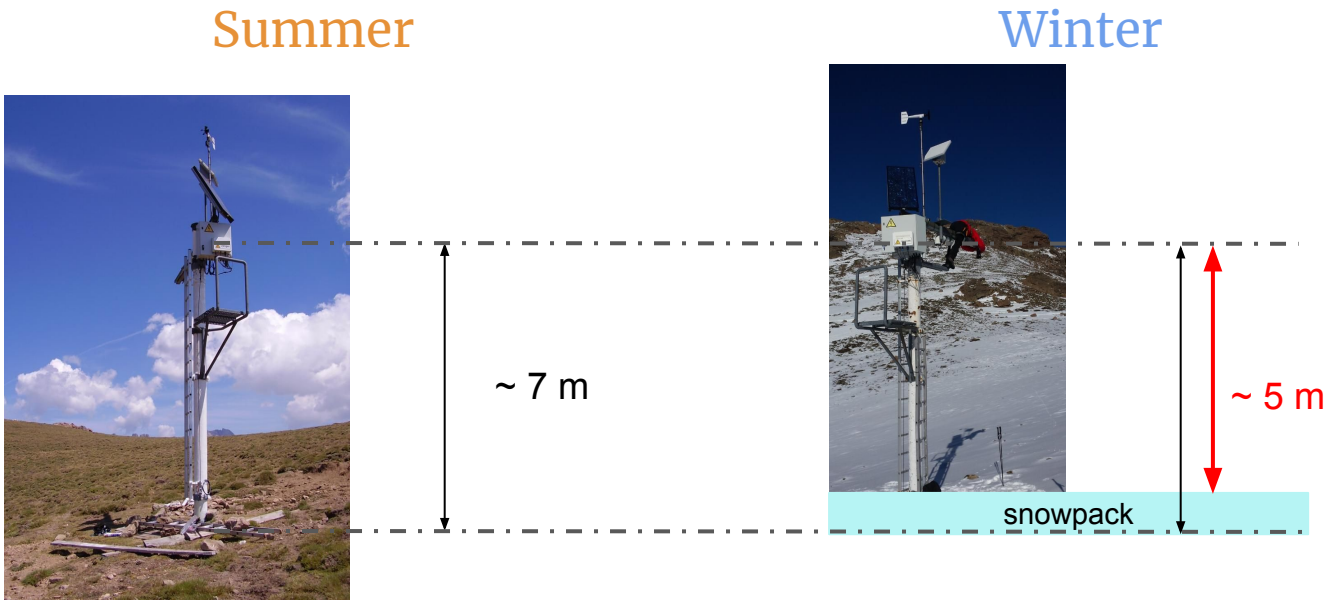
Diurnal temperature cycle averaged over 2020-2022 at the Col du Lac Blanc (2720 m) during wintertime



A huge difference between increments at 2 m and at 5 m

Cold bias - possible causes

Height of the sensor above the snow : Nivôse station



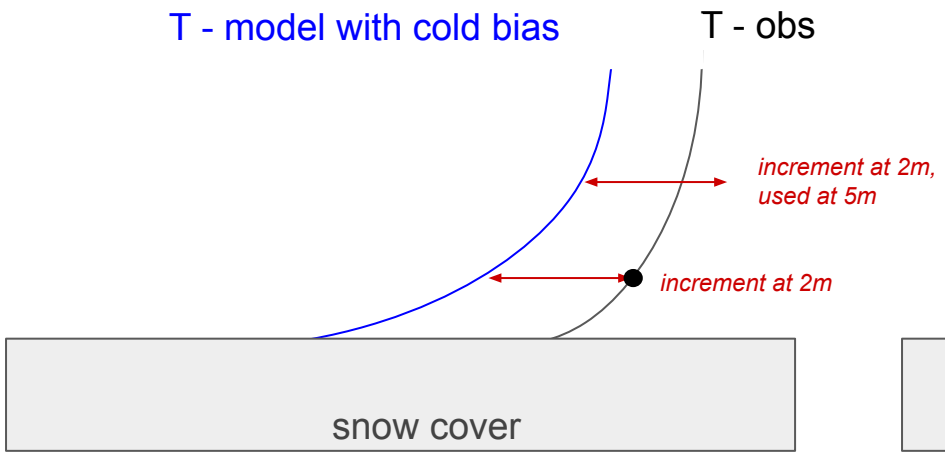
Sponde Nivôse, Albertacce (Corsica) (left and right photos)

Nivôse stations are part of a network of automatic weather stations in the high mountains, created by Météo-France.

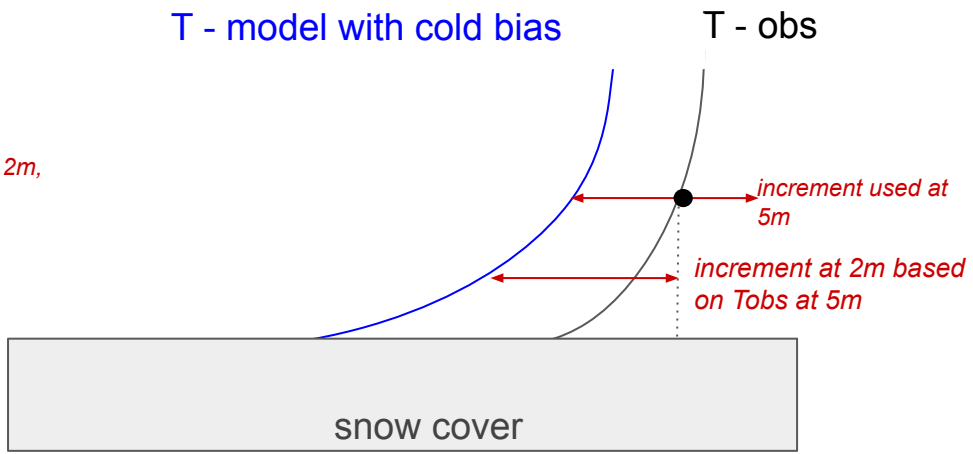
Cold bias - possible causes

Height of the sensor above the snow : Nivôse station

standard station measuring at 2m (stable conditions over snow)



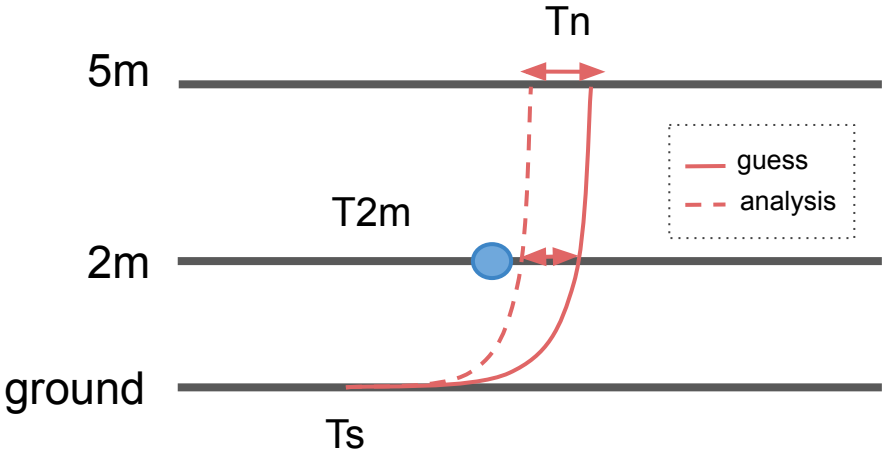
Nivôse station measuring at 5m (stable conditions over snow)



Cold bias - possible causes

2 m temperature diagnostic

- a calculation certainly obsolete in Surfex ⇒ for example: *Meier et al.*, 1st Newsletter Accord
- New diagnostics are available: *Dian et al. 2016*, Canopy, etc.
- To have a correct T2m, unbiased T5m and Tsurface are also required

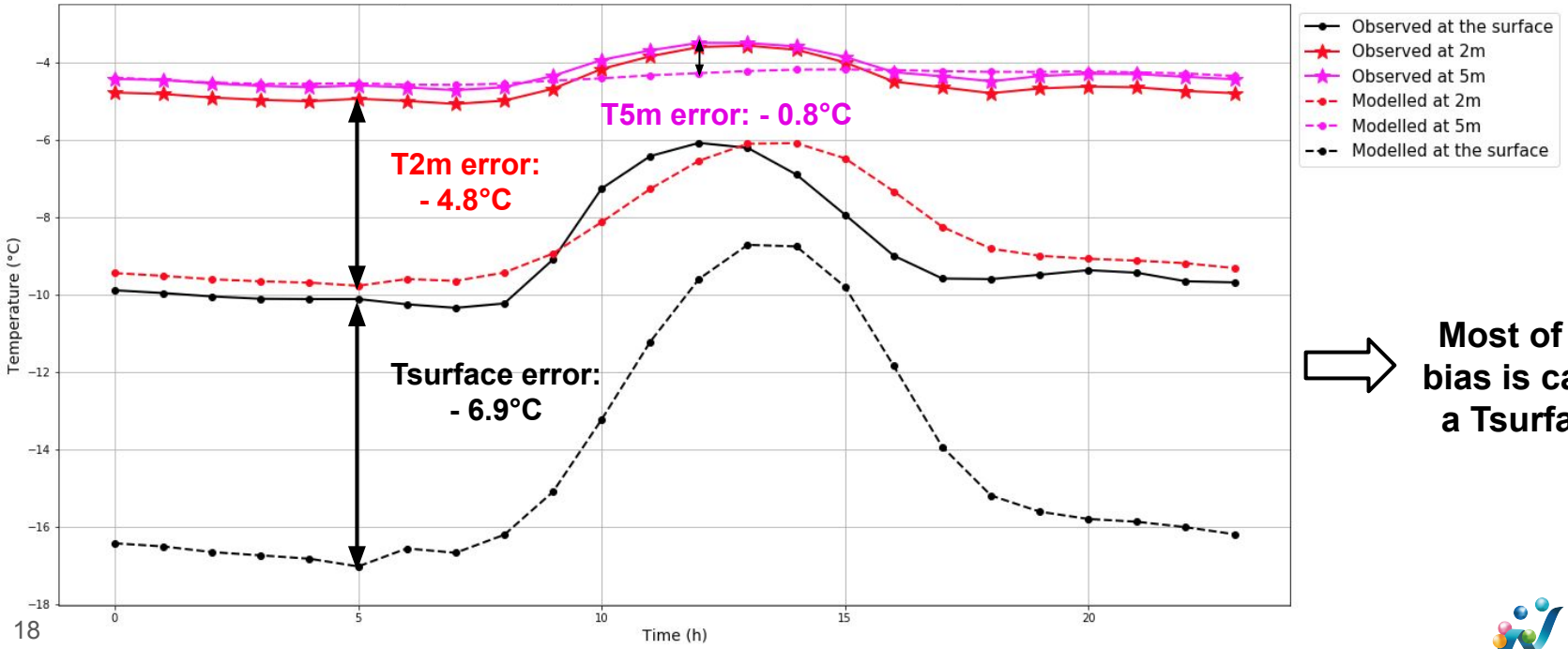


Scheme by Pierre Brousseau

Cold bias - possible causes

Interactions with the surface

Diurnal temperature cycle averaged over 2020-2022 at the Col du Lac Blanc (2720 m) during wintertime



Most of the t2m bias is caused by a Tsurface bias

Cold bias - possible causes

Interactions with the surface

- surface energy balance
  - radiation
  - wind
  - turbulence
- complexity of the snow model

Correcting both vw10m and lwin

⇒ contribute at 69% of the reduction of the original Tsurface bias at Col du Lac Blanc (*Gouttevin et al. 2022*)

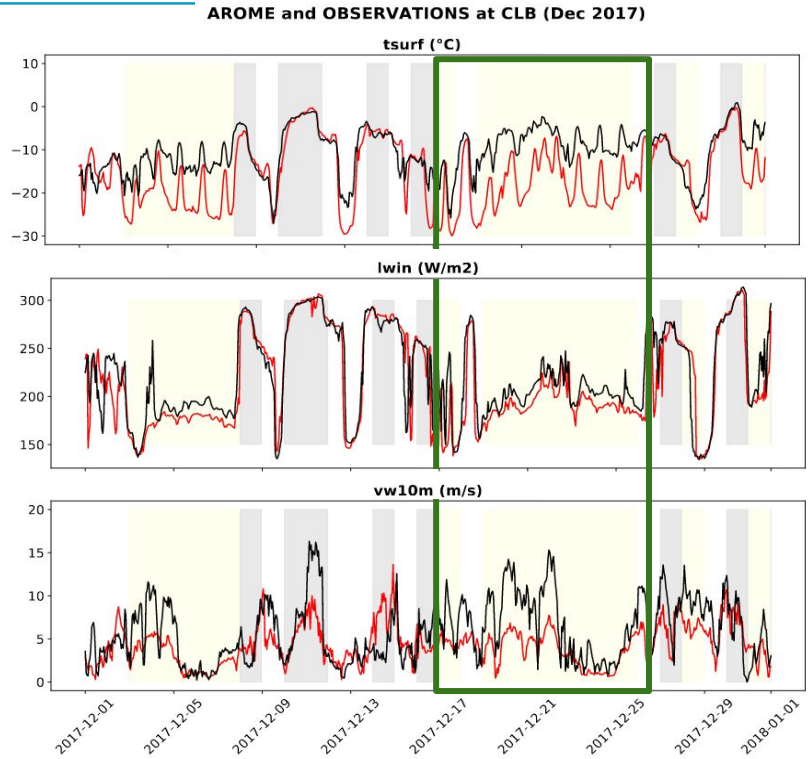
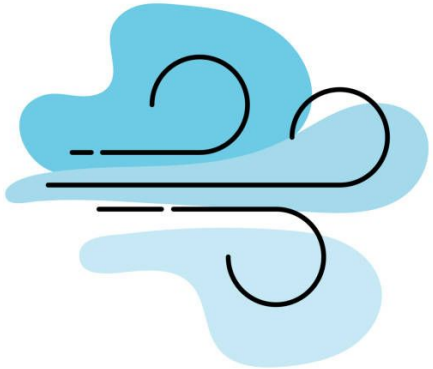


Figure by Gouttevin et al. (2022) : Comparison between AROME and observations at CLB in terms of temperatures (left) and radiation and wind (right) for Dec. 2017. Clear sky and cloudy sky conditions are highlighted with yellow and grey backgrounds, respectively, while white backgrounds denote conditions in-between.

Cold bias - possible causes

Interactions with the surface

- surface energy balance
  - radiation
  - wind
  - turbulence
- complexity of the snow model



⇒ **Reduction of the critical Richardson number**

⇒ Tsurface bias reduced by an additional 13% (*Gouttevin et al. 2022*)

Cold bias - possible causes

Interactions with the surface

- surface energy balance
  - radiation
  - wind
  - turbulence
- complexity of the snow model

⇒ **From D95 (Douville et al. 1995) to ISBA_ES (Interaction Soil-Biosphere-Atmosphere Explicit Snow) in SURFEX (work in progress)**

Perspectives

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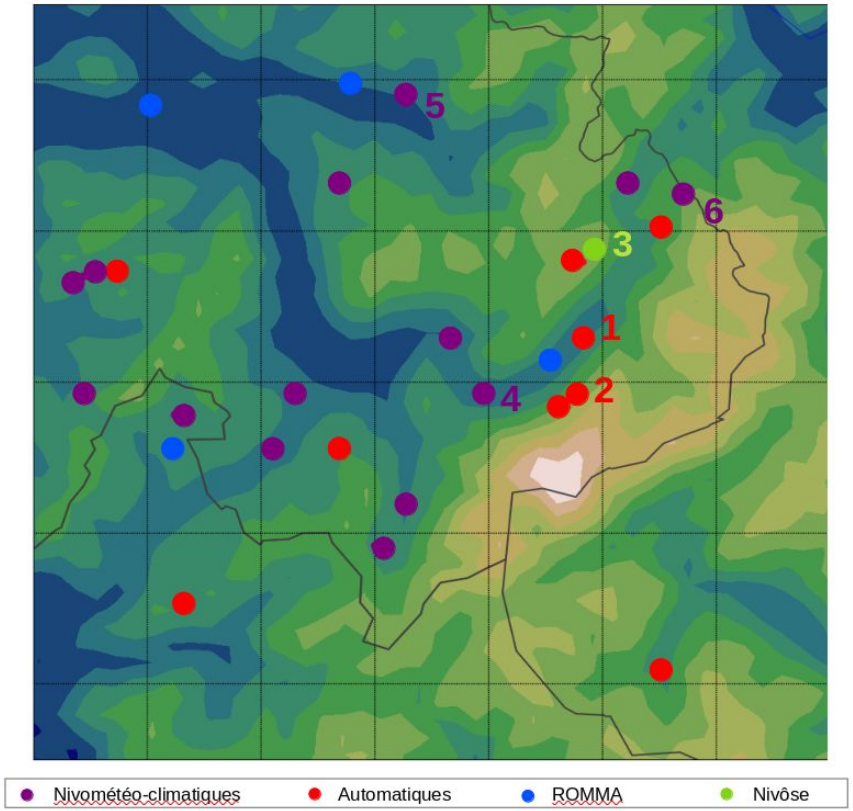
- Quantify the impact of the analysis ⇒ remove valley stations
- Nivôse stations ⇒ use the same methods than measures on ship masts
- Diagnostic of T2m ⇒ scientific visit to GeoSphere Austria (Thanks!)
- Surface temperature
  - ISBA_ES
  - Parameterisation of thermal radiation from slopes

Annexe: Calculation of the MAE

Study area



Scores calculated over the period 6h - 10h

$$Bias = \frac{1}{N}\sum_{n=1}^{N}(X_n - X_{obs})$$

$$MAE = \frac{1}{N}\sum_{n=1}^{N}|X_n - X_{obs}|$$

Simulation	Altitude (z)		
	$z < 1100$ m	1100 m $\leq z < 2000$ m	2000 m $\leq z$
Number of stations	8	13	7

Number	Station name	Altitude (m)
1	Chamonix	1042
2	Plan de l'Aiguille	2250
3	Aiguilles Rouges-Nivôse	2365
4	Les Houches	1005
5	Samoëns	749
6	Le Tour Balme	2196