

PICO #1.14 – EGU, 21 Apr. 2016

Snow management practices in French ski resorts

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Say, you have:

A 60 years long meteorological forcing data over the whole French Alps

(Durand et al., 2009a, 2009b; SAFRAN)

+

A snowpack model able to account for snow management physical processes (grooming, snowmaking)

(PICO #1.10, Spandre et al., 2016; SURFEX/Crocus-Resort)

+

A method to cross geographical information on French Alps ski resorts with simulations of snow conditions

(PICO #1.15, François et al., 2014, observatoires-stations.fr)

Would you do something with it?

Following François et al. (2014), we intend to **adress detailed snow conditions in French Alps ski resorts** over the reference period (1961-2015), and in particular:

- **Differences** with natural conditions
- **Vulnerability** to the natural variability
- **Ability to mitigate** the lack of snow through snowmaking
- **Assessment** of the market **viability**

Something missing?

Following François et al. (2014), we intend to **address detailed snow conditions in French Alps ski resorts** over the reference period (1970-2050) and in particular:

- **Differences** with natural conditions
- **Vulnerability** to climate change
- **Ability to mitigate** through snowmaking
- **Assessment** of the market **viability**



What about the human factor ?

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**« Snow management practices
in French ski resorts »**

CONTENTS

- 👉 2-minutes-madness slides
- 👉 A few definitions
- 👉 Representation of the sample
- 👉 Priorities of operators
- 👉 Grooming equipment and habits
- 👉 Equipment in snowmaking facilities

#1.10

#1.14

More details on our research in PICOs #1.15

A few definitions...

Ski lift power (SLP, km pers h⁻¹)

= product of skiers flow x altitude difference of a ski lift

Then aggregated for a ski resort

Ski resort categories (defined by SLP)

Resorts categories	Small resorts (S)	Medium resorts (M)	Large resorts (L)	Very Large resorts (XL)
Ski Lift Power (SLP) (km pers h ⁻¹)	SLP < 2500	2500 < SLP < 5000	5000 < SLP < 15000	15000 < SLP

Survey among French ski resorts

Online survey in Autumn 2014

Contacts provided by



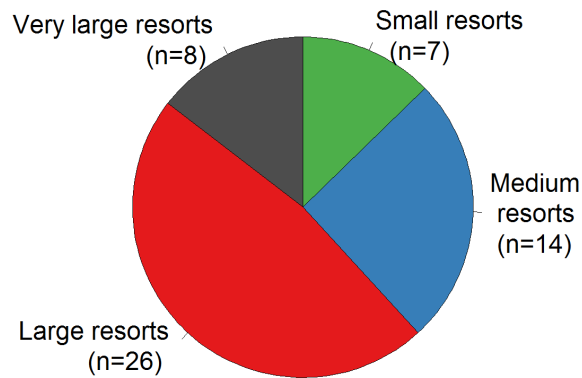
ASSOCIATION NATIONALE DES DIRECTEURS DE PISTES
ET DE LA SECURITE DE STATIONS DE SPORTS D'HIVER

56 participant ski resorts, splitted in:

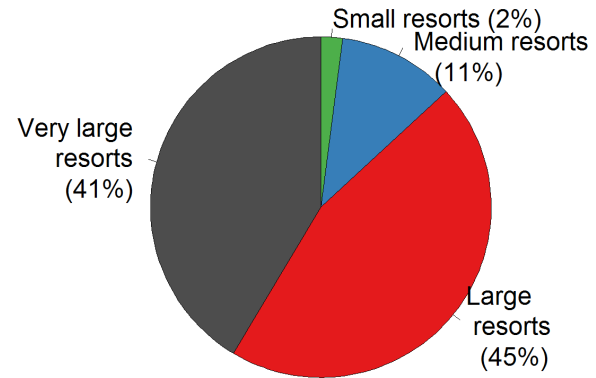
- 11 in Southern Alps
- 33 in Northern Alps
- 8 in the Pyrenees
- 2 in the French Jura
- 1 in Massif Central
- 1 in the Vosges

Representation of sample

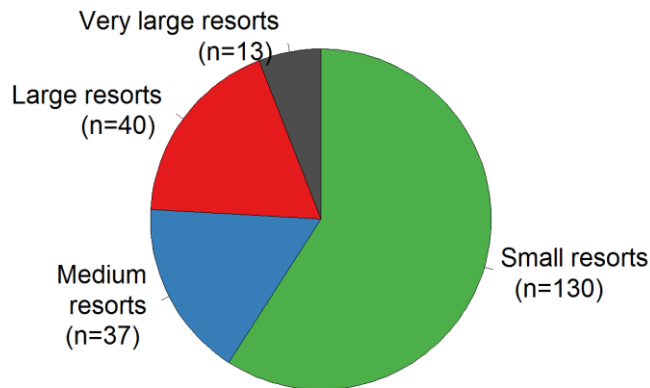
NUMBER OF SKI RESORTS (SAMPLE)



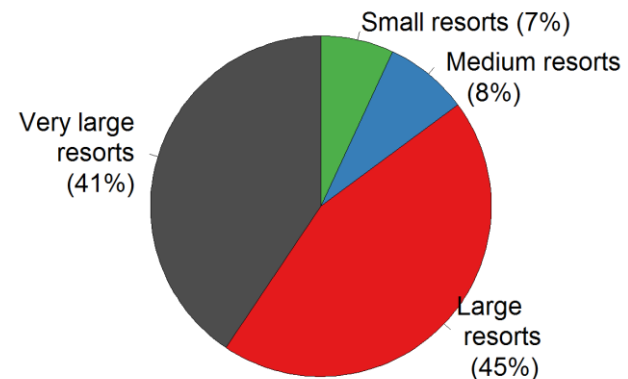
SHARE OF SLP OF SKI RESORTS (SAMPLE)



NUMBER OF SKI RESORTS (NATIONAL)

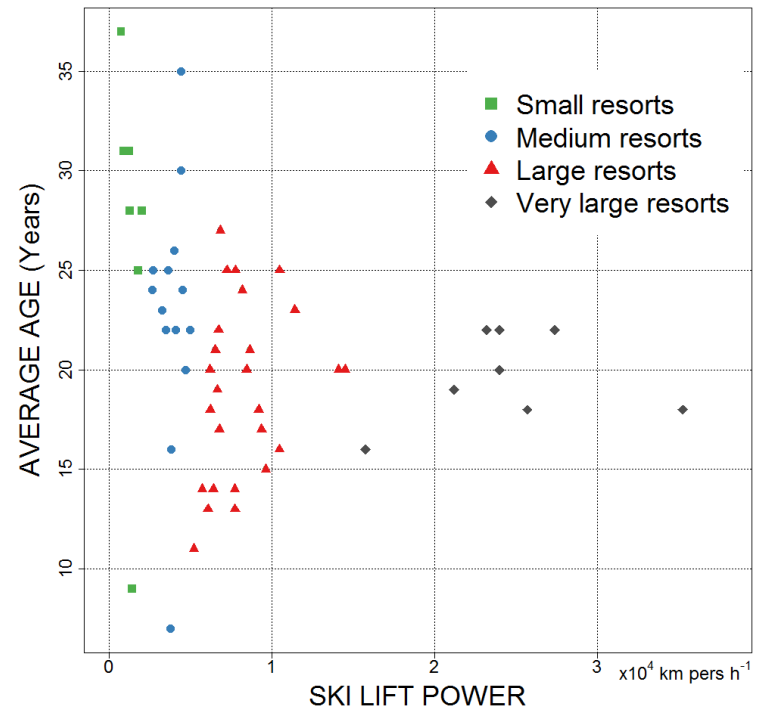
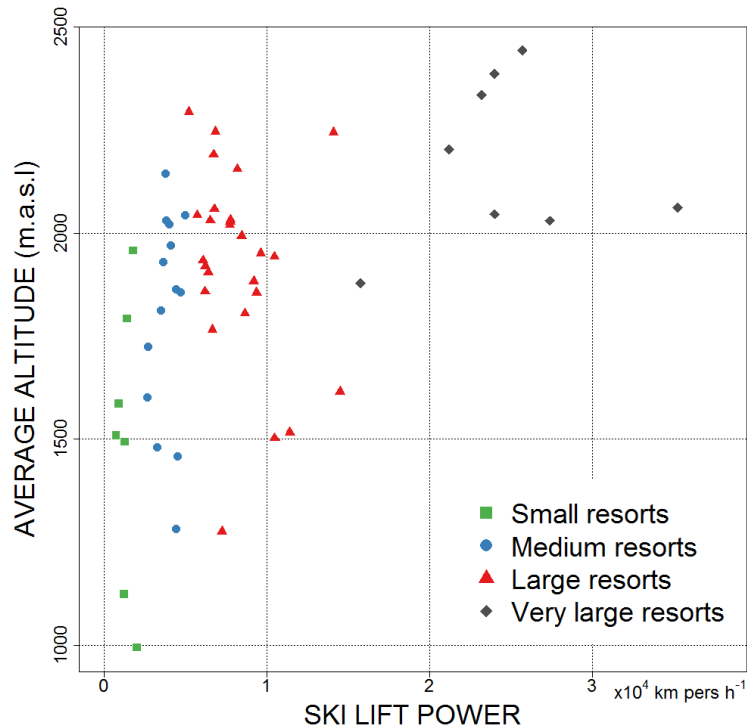


SHARE OF SLP OF SKI RESORTS (NATIONAL)



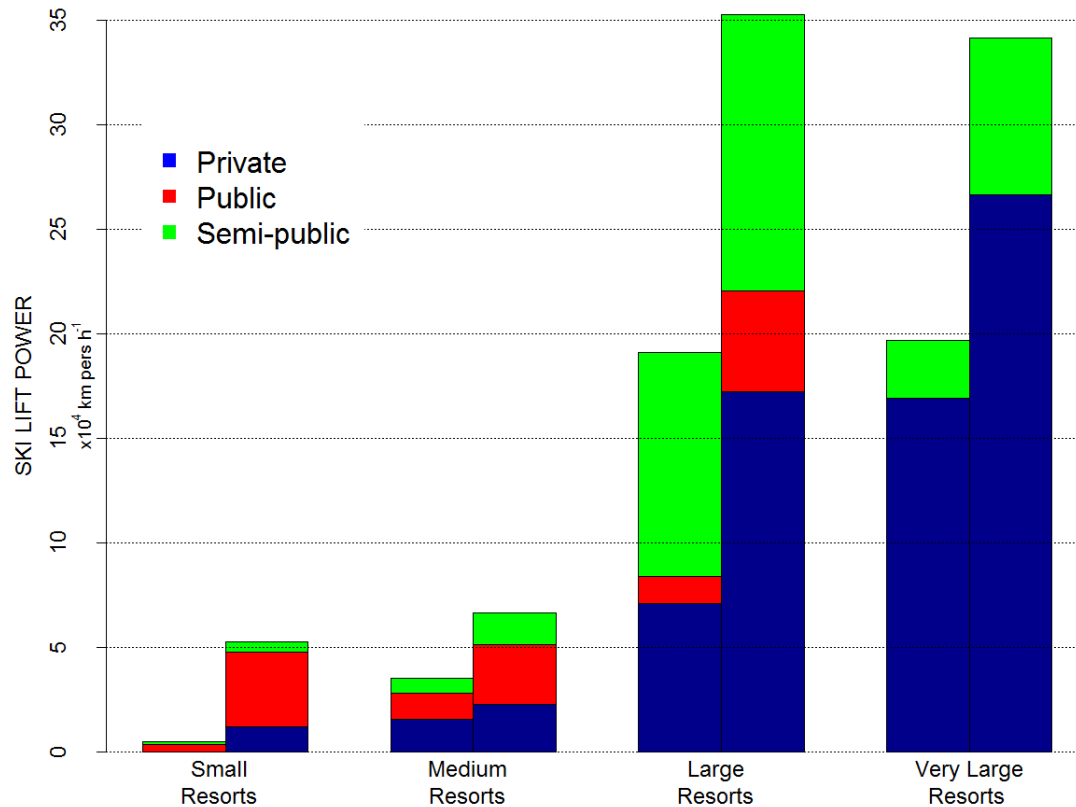
Representation of sample

Average altitude and age of ski lifts



Representation of sample

Management mode (left: sample, right:national)



=> A large diversity of resorts

Results: Priorities of operators

#1 Customer satisfaction

- Comfortable skiing conditions **9.0 /10**
- Skiing back down to the station **8.8 /10**
- Visual attractiveness of the resort **8.1 /10**

#2 Technical constraint

- Mechanical resistance of the snow **8.2 /10**
- Keep a minimum snow depth **8.1 /10**
[42 à 49 cm average snow depth]

Results: Priorities of operators

#3 Connecting neighbouring resorts

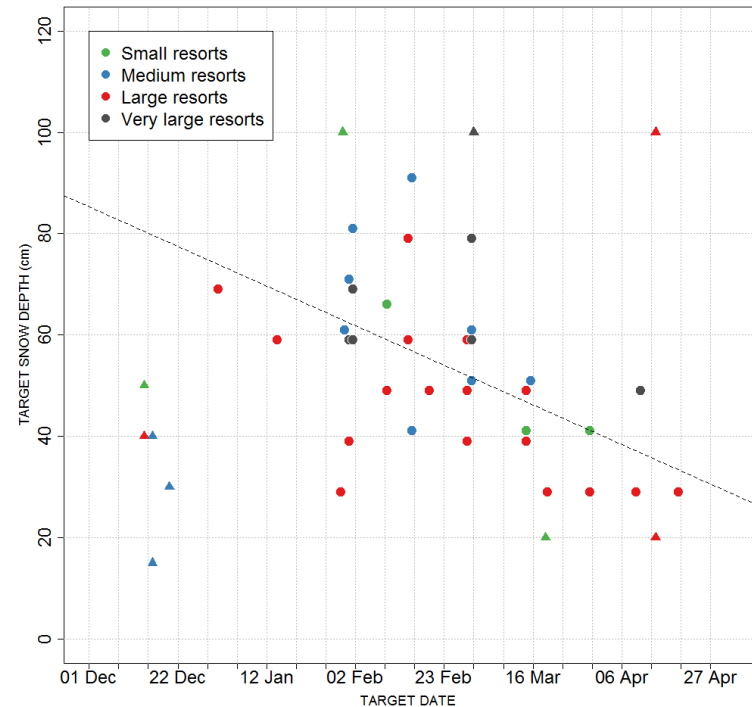
Small resorts	2.0 /10
Medium resorts	5.0 /10
Large resorts	7.0 /10
Very Large resorts	9.0 /10

Results: Priorities of operators

#4 Reaching a specific depth at a specific date

5.0 to 7.0 /10

Still, 49 out of 56 ski resorts indicated a (depth, date) couple, showing a decreasing pattern with time...



Spandre et al., under review

Results: Priorities of operators

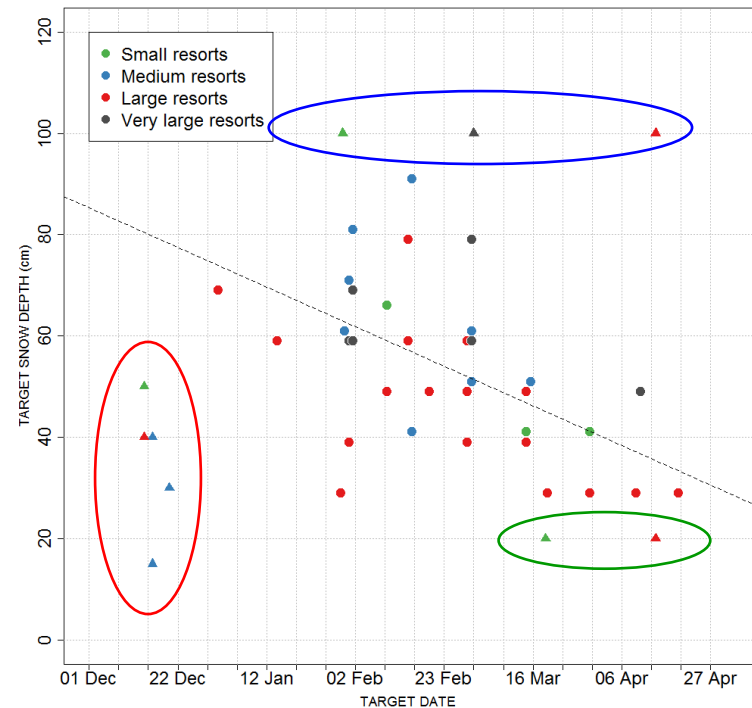
#4 Reaching a specific depth at a specific date

Still, 49 out of 56 ski resorts indicated a (depth, date) couple, showing a decreasing pattern with time...

If removing couples related to opening issue (red), the maximum (blue) and minimum values (green), **38 couples remain (●)**

=> **Significant decreasing trend**

Date	Average answers	Trend		
	Feb.	1 st Feb.	1 st Mar.	1 st Apr.
Snow depth (cm)	63	62	52	40



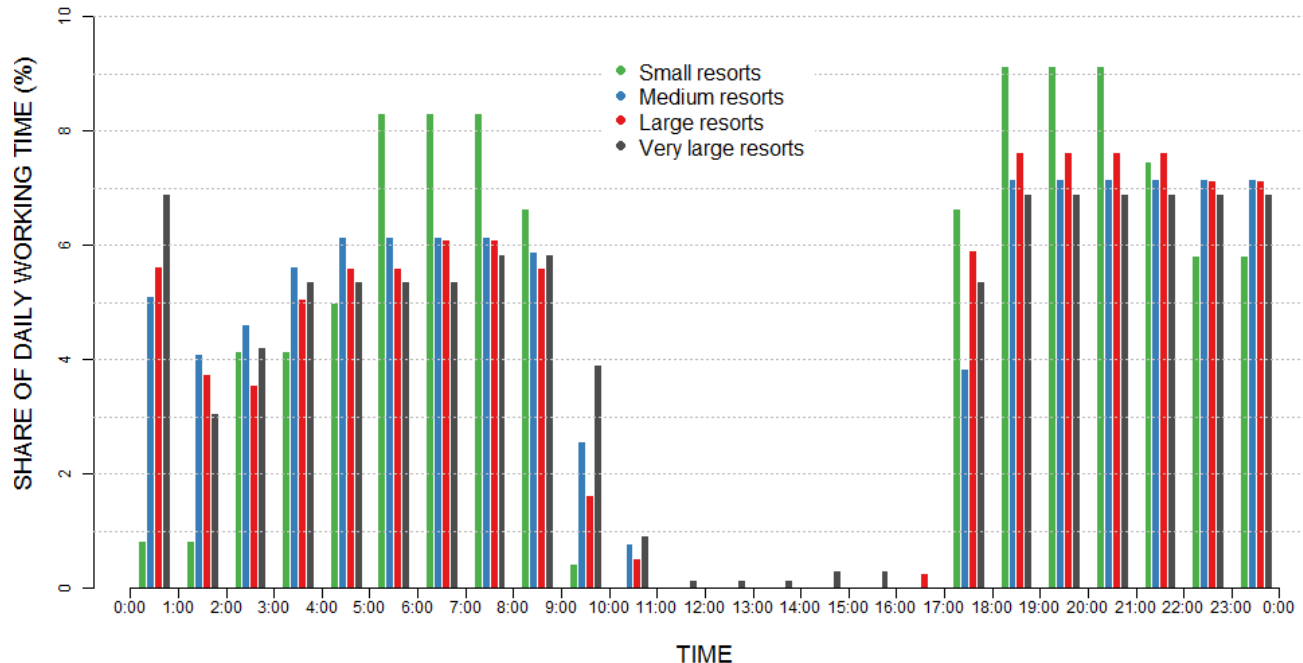
Grooming equipment and habits

All resorts groom their ski slopes

77% of ski slopes are groomed every day

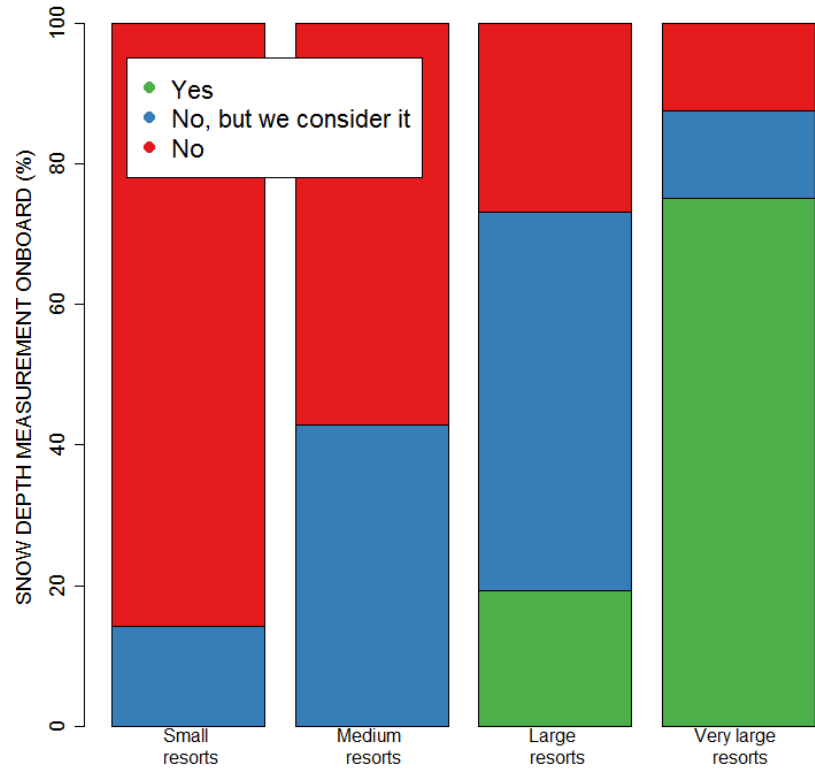
About 1 engine per 20 ha of ski slopes

Grooming
hours



Grooming equipment

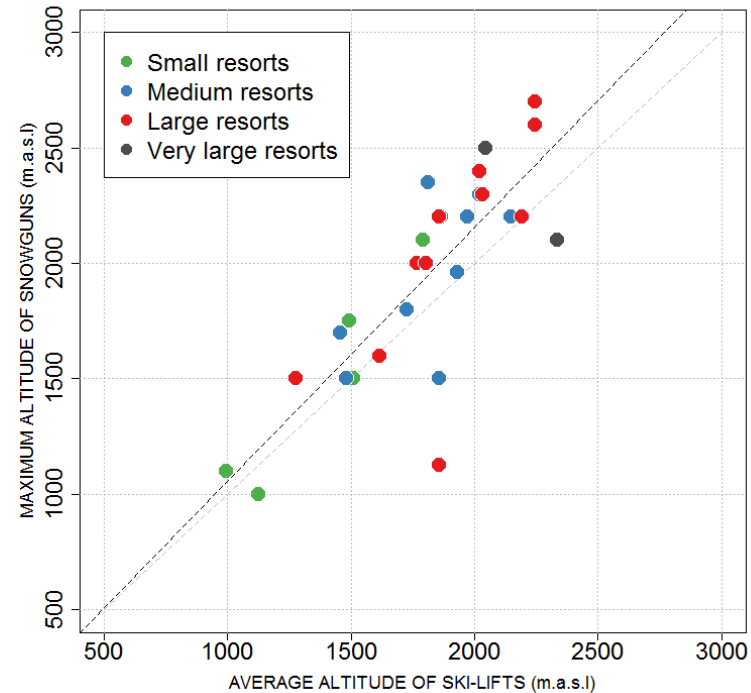
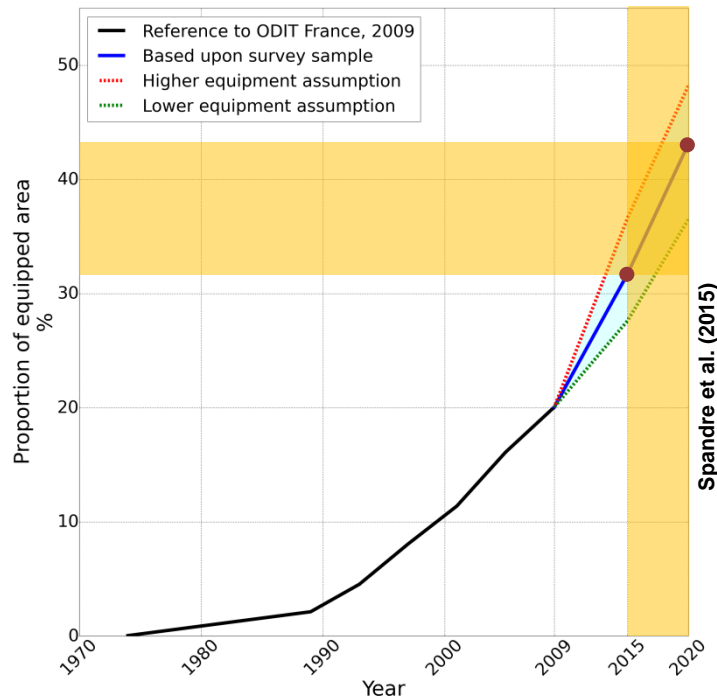
Is resort equipped with on-board snow depth measurement (GPS, Radar)?



Spandre et al., under review

Equipment in snowmaking facilities

Equipment ratio and maximum altitude of snowguns

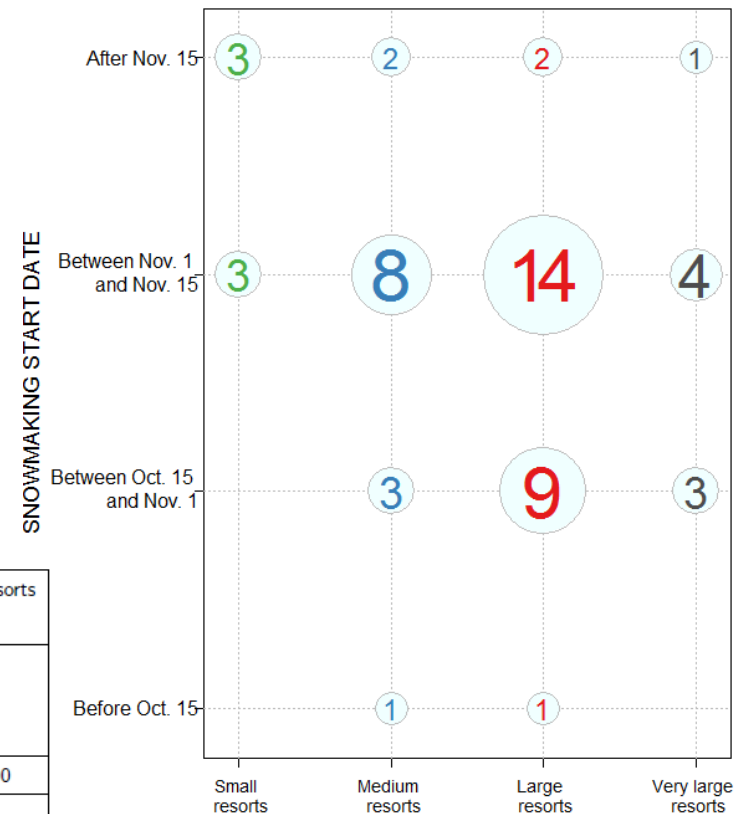


Equipment in snowmaking facilities

Date when facilities are ready to produce

Spatial distribution of snowguns within the resort

Resorts categories	Small resorts (S)	Medium resorts (M)	Large resorts (L)	Very Large resorts (XL)
Is priority given to low-altitude areas for the installation of snowmaking facilities? Replied "Yes" (%)	86	71	46	25
Maximum altitude of snowguns (m.a.s.l)	1450 ± 550	1950 ± 450	1850 ± 1100	2300 ± 300
Is priority given to specific slopes (aspect) for the installation of snowmaking facilities? Replied "Yes" (%)	57	36	31	25
Wet-bulb temperature threshold used for snowmaking (°C)	-3.2 ± 0.8	-3.8 ± 0.6	-3.7 ± 0.7	-4.0 ± 0.8



Equipment in snowmaking facilities

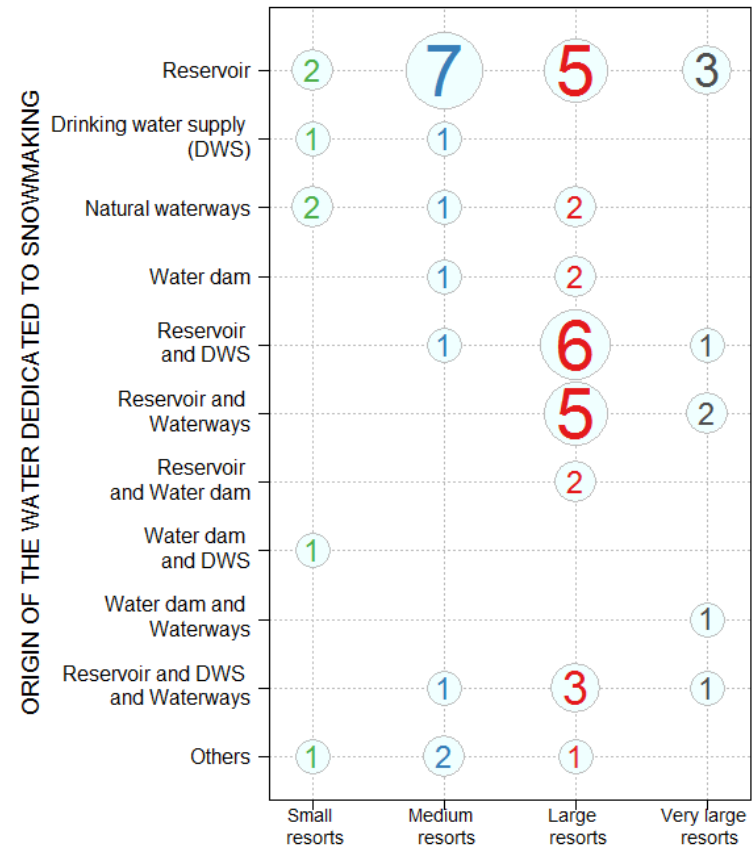
Resorts categories	Small resorts (S)	Medium resorts (M)	Large resorts (L)	Very Large resorts (XL)
Ski slopes surface equipped with snowmaking facilities (%)	18 ± 25	34 ± 16	35 ± 21	34 ± 24
Number of air/water guns per surface of equipped ski slopes (ha ⁻¹)	3.1 ± 2.5	2.5 ± 1.1	2.6 ± 1.7	3.0 ± 0.8
Number of fan guns per surface of equipped ski slopes (ha ⁻¹)	0.4 ± 0.3	0.2 ± 0.3	0.2 ± 0.2	0.1 ± 0.1
Total reservoirs capacity per surface of equipped ski slopes (m ³ ha ⁻¹)	1450 ± 2350	1800 ± 1650	1700 ± 1600	1500 ± 1300

Equipment in snowmaking facilities

Water supply: the main limit to MM snow production
 (ahead of cost and need)

Mostly ensured by
 dedicated reservoirs...

...which capacity is related
 to the surface equipped
 with facilities



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Spandre, P., François, H., Morin, S., George-Marcelpoil, E., 2015. **Snowmaking in the French Alps. Climatic context, existing facilities and outlook.** Journal of Alpine Research | Revue de géographie alpine doi :10.4000/rga.2913

#1.10

#1.11

More details on our research in PICO #1.15