Oslo 2022: Snow-Reliability

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BOĞAZİÇİ ÜNİVERSİTESİ
1863

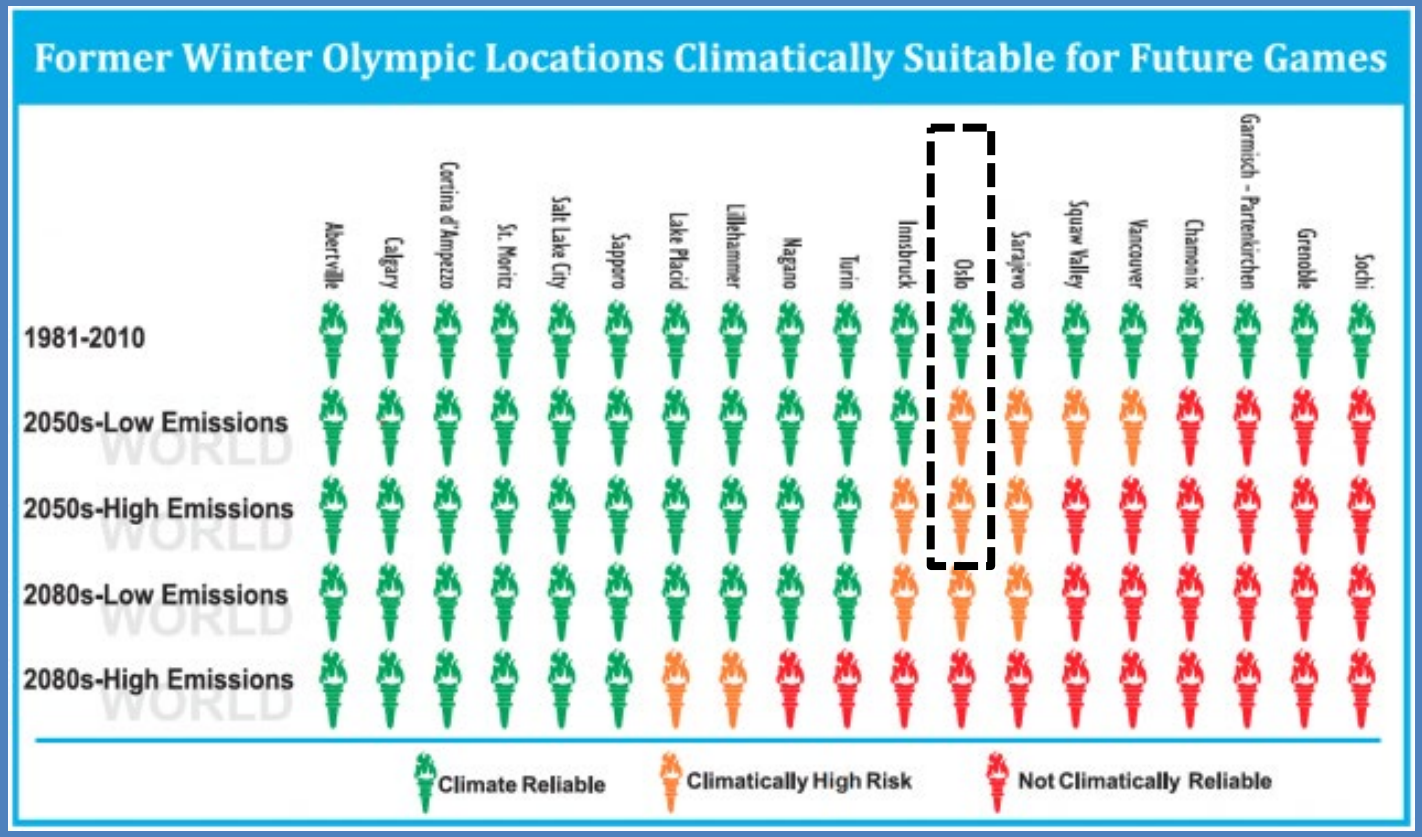
Introductory comments

- Yes or No to the Winter Olympics in Oslo 2022?
  - Our mission is not to present arguments against or in support of arranging the Winter Olympics in Oslo in 2022!
- Yes or No to analyzing climate change vulnerability?
  - Our mission is to advocate the need for doing systematic climate change vulnerability analysis in the case of major private or public investments, using the plans for arranging the Winter Olympics 2022 in Oslo as an illustrative case

Research background at Western Norway Research institute (WNRI)

- Research on climate change adaptation
  - Several projects financed by NORKLIMA
- Research on climate change adaptation in winter tourism
  - Aall, C., Høyer, K.G. (2005): Tourism and climate change adaptation - the Norwegian case. In Hall, C.M., Higham, J. 2005. *Tourism, Recreation and Climate Change*. London: Channelview Press: 209-223.
  - Demiroglu, O. C., Dannevig, H., Aall, C. (2013): The multidisciplinary literature of ski tourism and climate change, In Nazmi K., Metin, K. (ed) (2013): Tourism Research: *An Interdisciplinary Perspective*. Newcastle upon Tyne : Cambridge Scholars Press, 2013. p. 223-237.
  - A guest researcher scholarship at WNRI to Cenk Demiroglu in 2011 and 2012 resulting among other things in developing a method for calculating the past and future snowmaking capacities based on wet bulb temperatures.
- Research on the impacts of Olympic Games
  - Teigland, J. (1996): Impacts on tourism from mega-events: The case of Winter Oplympic Games. VF-rapport 13/96. Sogndal: Vestlandsforsking
  - Teigland, J. (2000): Impact Assessments as Policy and Learning Instrument. Why Effect Predictions Fail, and how Relevance and Reliability can be Improved. Doktorgradsavhandling ved Roskilde Universitet, Danmark. VF-rapport 13/00. Sogndal: Vestlandsforsking

Recent study on winter reliability and Winter Olympics



Oslo in general is regarded as a high climate risk destination to host the olympics in the later period of 2050s, according to a recent studyby Scott et al (2014)

An emerging public debate on snow reliability and the Oslo 2020 Winter Olympic Games (WO22)

DN AKTIV

INGEN SNØGARANTI: Petter Northug og hans konkurrenter hadde gode forhold under VM på ski i Holmenkollen i 2011. Klimaforsker Oskar landgren kan ikke love det samme hvis Oslo får lov til å arrangere OL i 2022. Foto: Jo Straube

Færre snødøgn i Oslo gir OL-bekymring

Klimaforsker Oskar Landgren savner snødebatt rundt Oslo-OL. Færre og færre snødøgn gir grunn til bekymring, mener han.

Oskar Landgren (researcher at the Norwegian Meteorological Institute):

"Climate data show that it can easily become problematic to carry out the Winter Olympics in Oslo in 2022…Although winters in Scandinavia are more robust than winters in southern Europe when it comes to climate change, I find it strange that snow reliability and climate change so far has not been part of the debate".

Eli Grimsby (director of WO22):

«We have made a thorough analysis and projections of weather conditions for the relevant time period. This is part of the preliminary work we have done and we are committed towards IOC to investigate these matters".

..but...

15. januar 2014 kl. 10.08 skrev Stian Gundersen <stian.gundersen@o22.oslo.kommune.no>:

Hei igjen,

Det er ikke gjort noen analyser ang. fremtidig klima, kun fremstilling av registrerte historiske data. Det er imidlertid tatt høyde for høye temperaturer i budsjettet. Et mulig senario vil være produksjon av kunstsnø i kalde område og transport til konkurransearenaene.

Med vennlig hilsen

Stian Gundersen
rådgiver
Oslo2022
Oslo kommune

Telefon dir.:
Mobil: 934 59 933
Sentralbord: 02 180

www.oslo2022.oslo.kommune.no

And some follow-up comments in the media

SØRKEDALEN 7. JANUAR: Skiføret passer best for hardbarkede entusiaster. Foto: Gisle Bjørå/TV 2

Katastrofeføret: Hvordan skal dette gå under Oslo-OL?

Mild vinter skaper ingen uro blant de som jobber for å få Oslo som OL-by.

Lars Barth-Heyerdahl

Onsdag 08. januar 2014, kl. 16:43 (Oppdatert: Onsdag 08. januar 2014, kl. 17:07)

Godt varmt nyttår

Vinteren i Norge har gått markant tilbake. Dette er klimaendringer vi må forholde oss til enten vi vil det eller ei.

Viten

Hans Olav Hygen, Seksjonsleder for klimainformasjon ved Meteorologisk institutt

Publisert: 03.jan. 2014 12:41 Oppdatert: 03.jan. 2014 12:41

Del Tweet E-post Lagre artikkelen i leselisten

I julen søker vi alle varme, og Oslo har vi fått det; en varm jul. Faktisk viser målingene på Blindern at vi akkurat gjennomført den varmeste julen siden målingene startet i 1937.

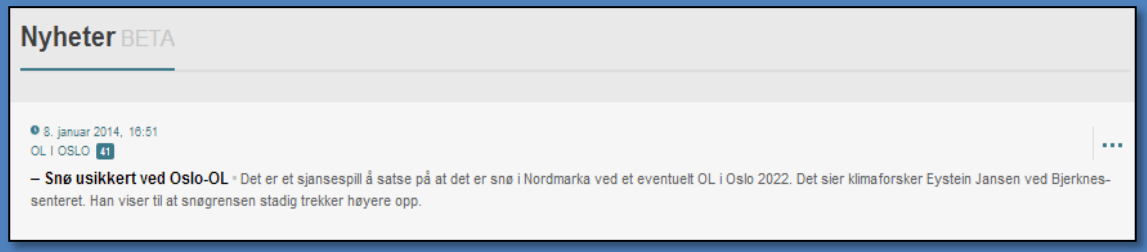
Hans Olav Hygen

Nå er det kanskje to ulike former for varme det er snakk om, og hvilken varme en opplevde i jula vil nok være individuelt, men det som er sikkert er at i måleserien fra Oslo-Blindern har feiret juleuken (her definert som 24.12 – 31.12) med et gjennomsnitt på 4,2 °C i 2013. Om gjennomsnittet av juleuken for ti og ti år legges til grunn er det siste tiåret det varmeste, selv med de kalde juleukene i 2009 og 2010.

Drømmen om en hvit jul ble nettopp det på Østlandet i 2013, en drøm. I Oslo kunne vi se langt etter snøen, faktisk er det bare 2006, 1974 og 1957 vi måtte se like langt etter snø på julaften.

Sjansen for å ha snø på julaften i Oslo har også gått ned fra åtte av ti julaftener på 1980-tallet til fem av ti nå. En annen

Hans Olav Hygen (researcher at the Norwegian Meteorological Institute) "Even if the chances of too little snow have increased, nothing indicates that the vicinities of Oslo will be without snow in the near future….Natural variation within the present climate is still much stronger than the possible effects of climate change"



Nyheter BETA

8. januar 2014, 16:51
OL I OSLO 41

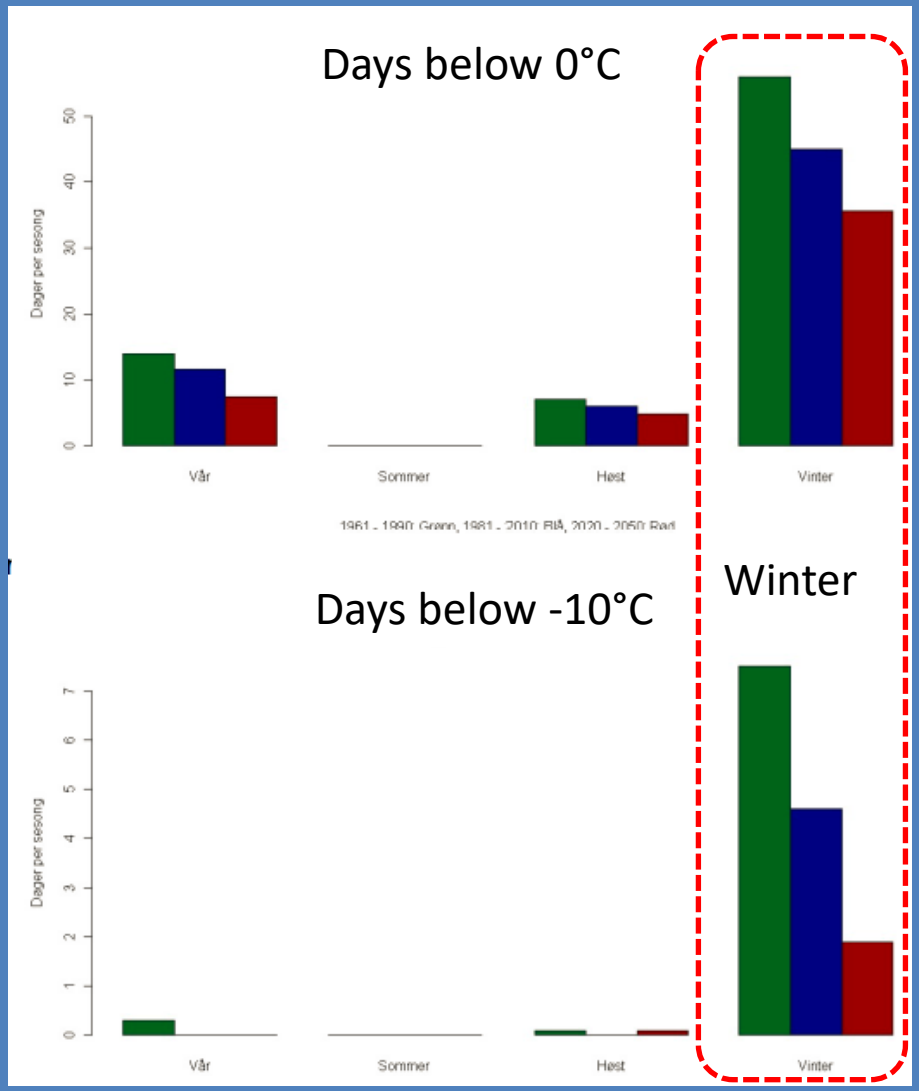
– Snø usikkert ved Oslo-OL - Det er et sjansespill å satse på at det er snø i Nordmarka ved et eventuelt OL i Oslo 2022. Det sier klimaforsker Eystein Jansen ved Bjerknessenteret. Han viser til at snøgrensen stadig trekker høyere opp.

Eystein Jansen (former director of Bjerknessenteret; lead author of the IPCCC): "It is a gamble to bet that there is enough snow at Winter Olympics in Oslo in 2022".

Oslo 2022 – Oslo Venues

Oslo 2022 – Lillehammer Venues

Oslo region: winter temperature in past, present and future



Represented by Fredrikstad

High risk of a reduction in the number of days below zero during winter

= 1961-1980

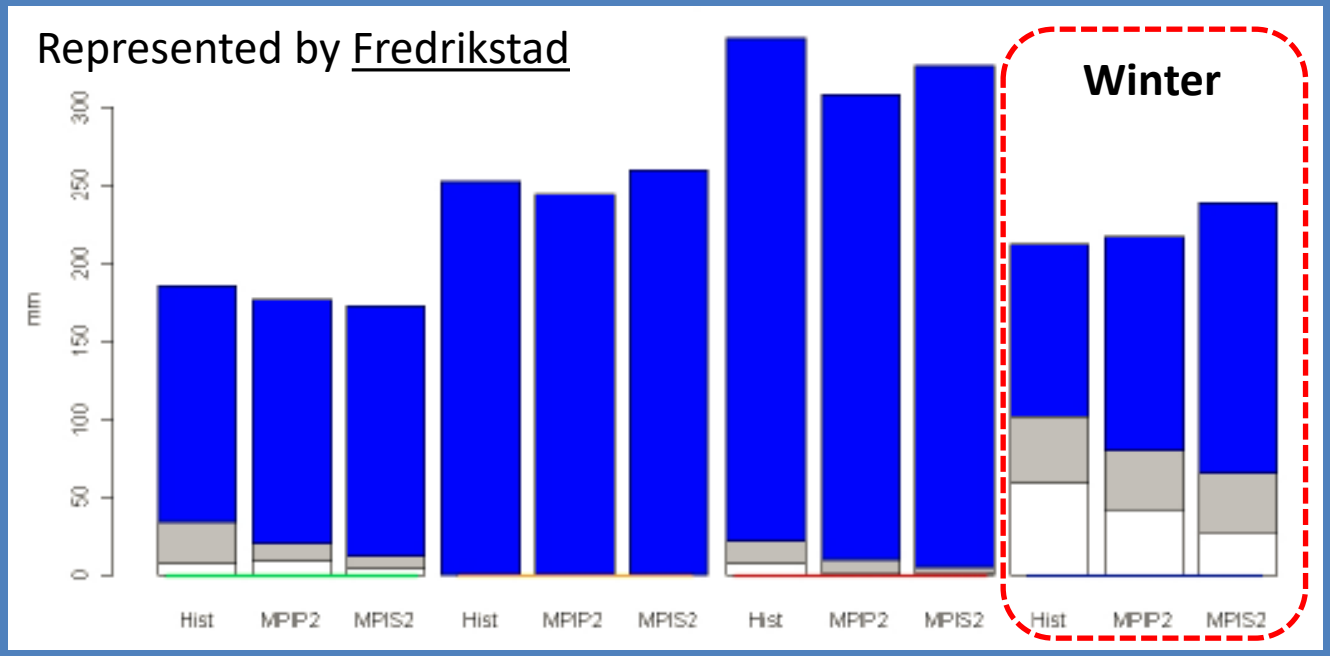
= 1981-2010

= 2020-2050

http://cicero.uio.no/publications/detail.aspx?publication_id=9556&lang=no

Oslo region: winter precipitation in past, present and future

More precipitation during winter, but high risk of an increased share of rainfall



Hist = 1960-1990 MPIP2 = 1990-2010 MPIS2 = 2025-2050

http://cicero.uio.no/publications/detail.aspx?publication_id=9556&lang=no

Oslo and Lillehammer region: climate in 2020-2050

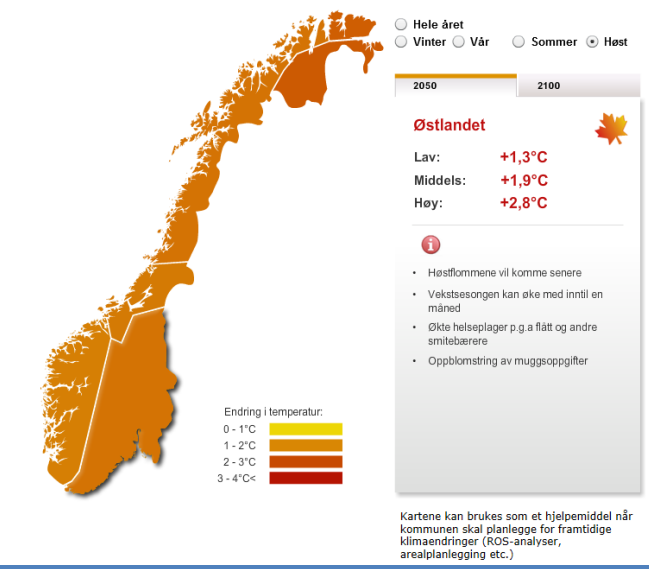
Warming

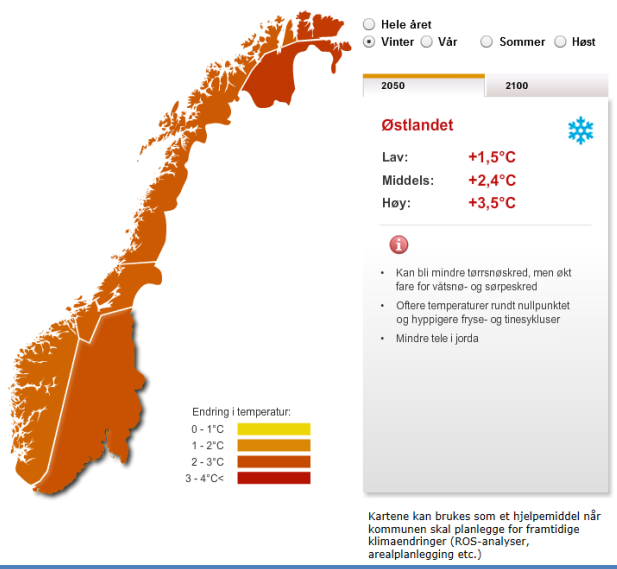
+ 1.3° C to 3.5° C temperature increase from the 1961-1990 period

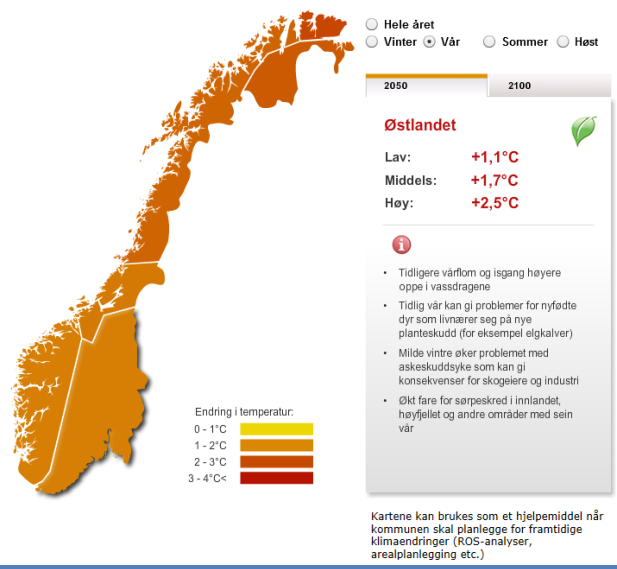
Winter

Less dry but more wet and slushy snow

Frequent freeze-thaw cycles

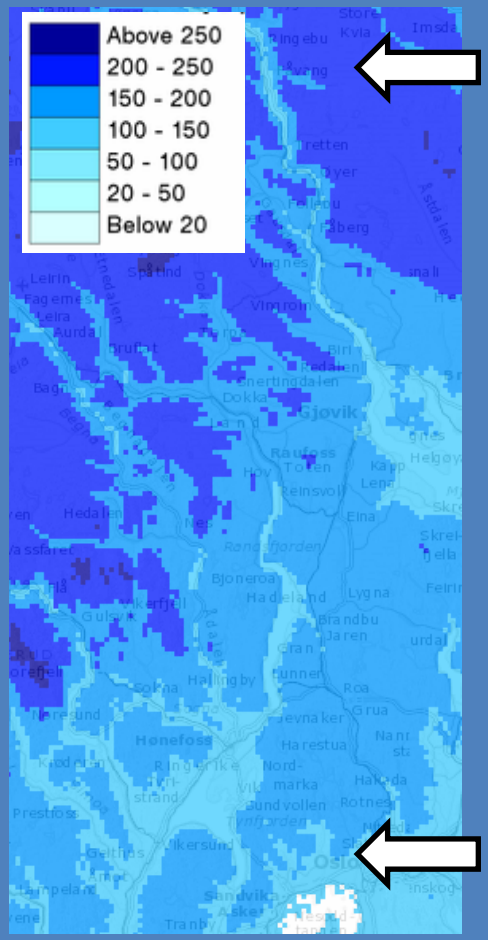






Oslo and Lillehammer region: snow

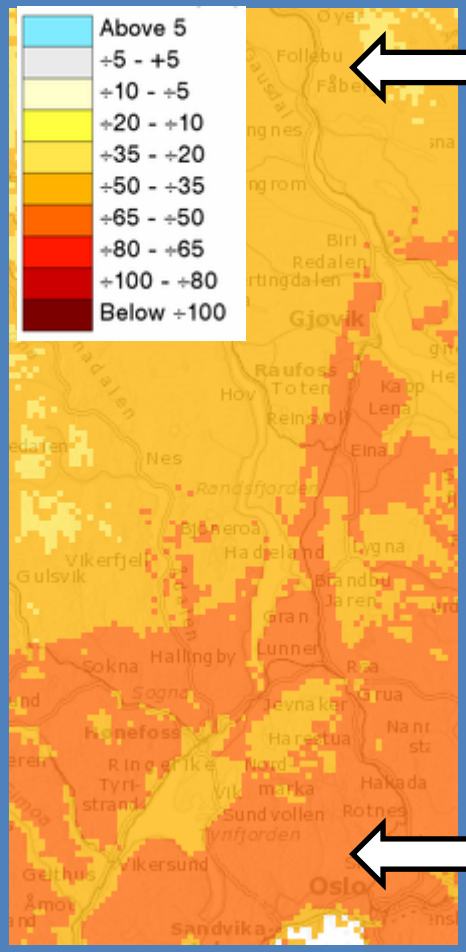
1961-1990
Average number of days with snow cover



Lillehammer
(150 to 250)

Oslo
(20 to 100)

2071-2100
Loss in number of days with snow cover



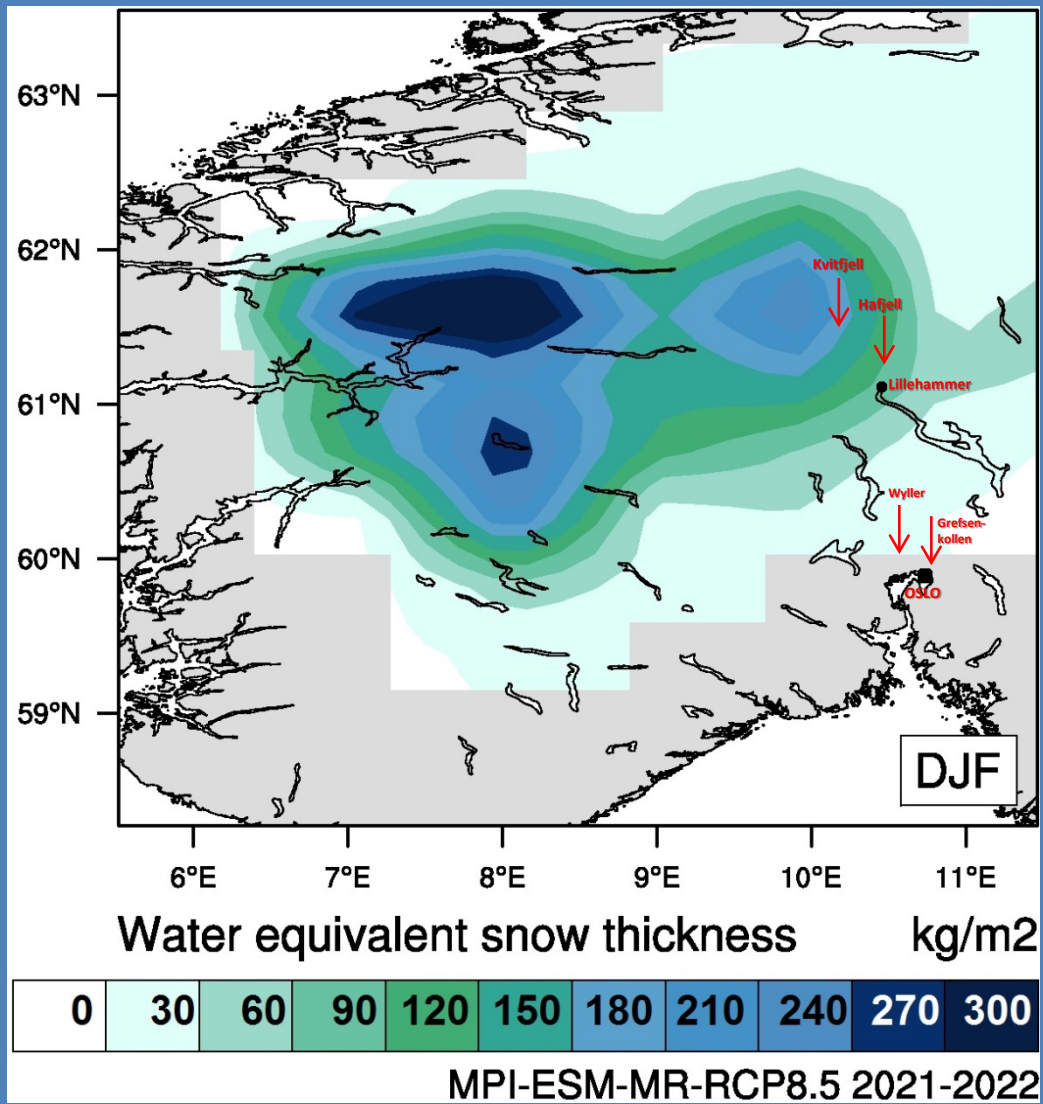
Lillehammer
(- 35 to - 20)

Oslo
(- 50 to -35)

Natural Snow Reliability Projections 2022 (1)

The results here were obtained by running the regional climate model RegCM4.3.5 for the input from the RCP 8.5 emission scenario (pessimistic, IPCC 2013) of the MPI-ESM-MR global dataset at a spatial resolution of 50 km for the winter of 2021-2022 (DJF).

Our preliminary projections based on model outputs, defined as Snow Water Equivalent (SWE) in kg/m^2, indicate a very weak reliability for the venues of Alpine events in the vicinity of Oslo for the winter of 2021-2022.

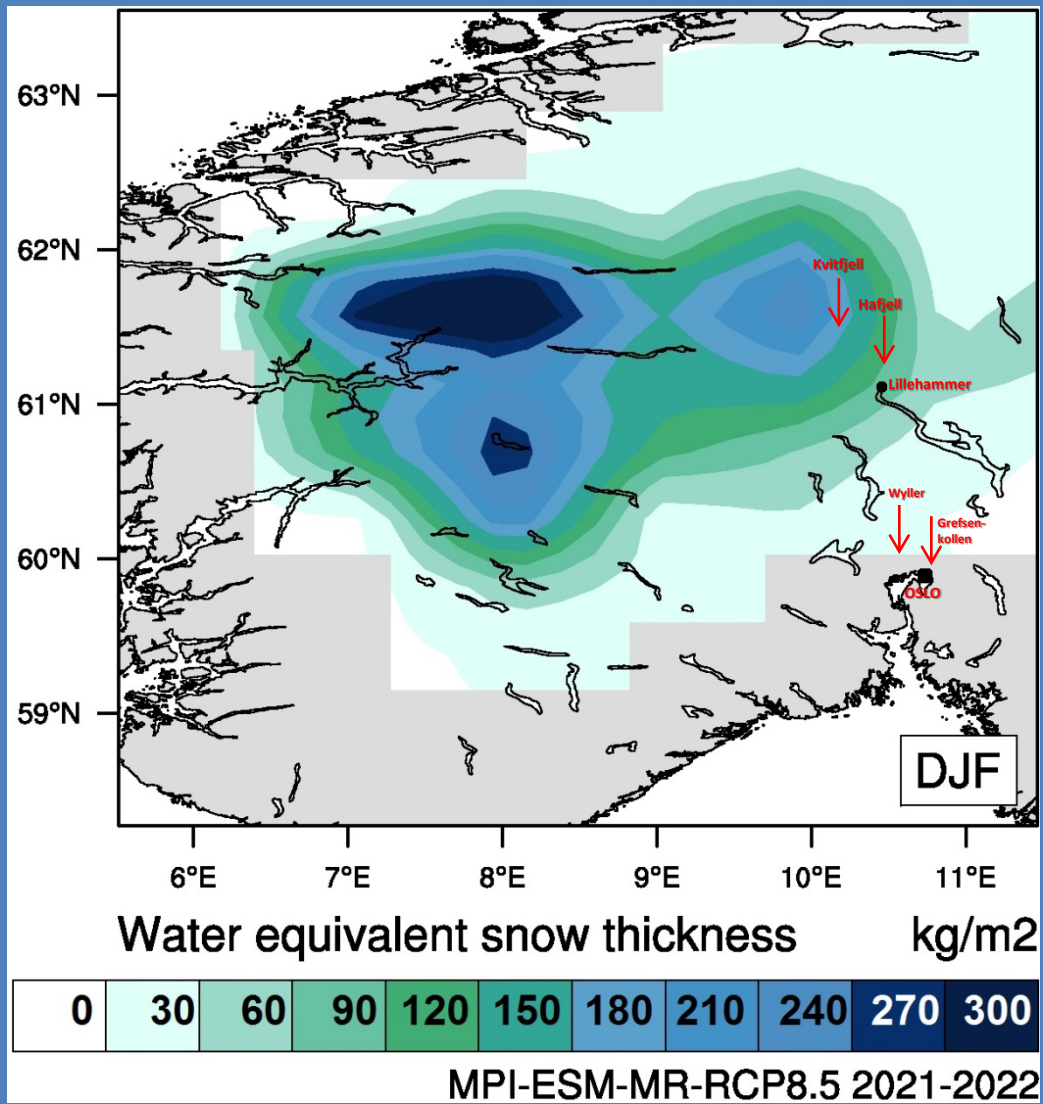


Natural Snow Reliability Projections 2022 (2)

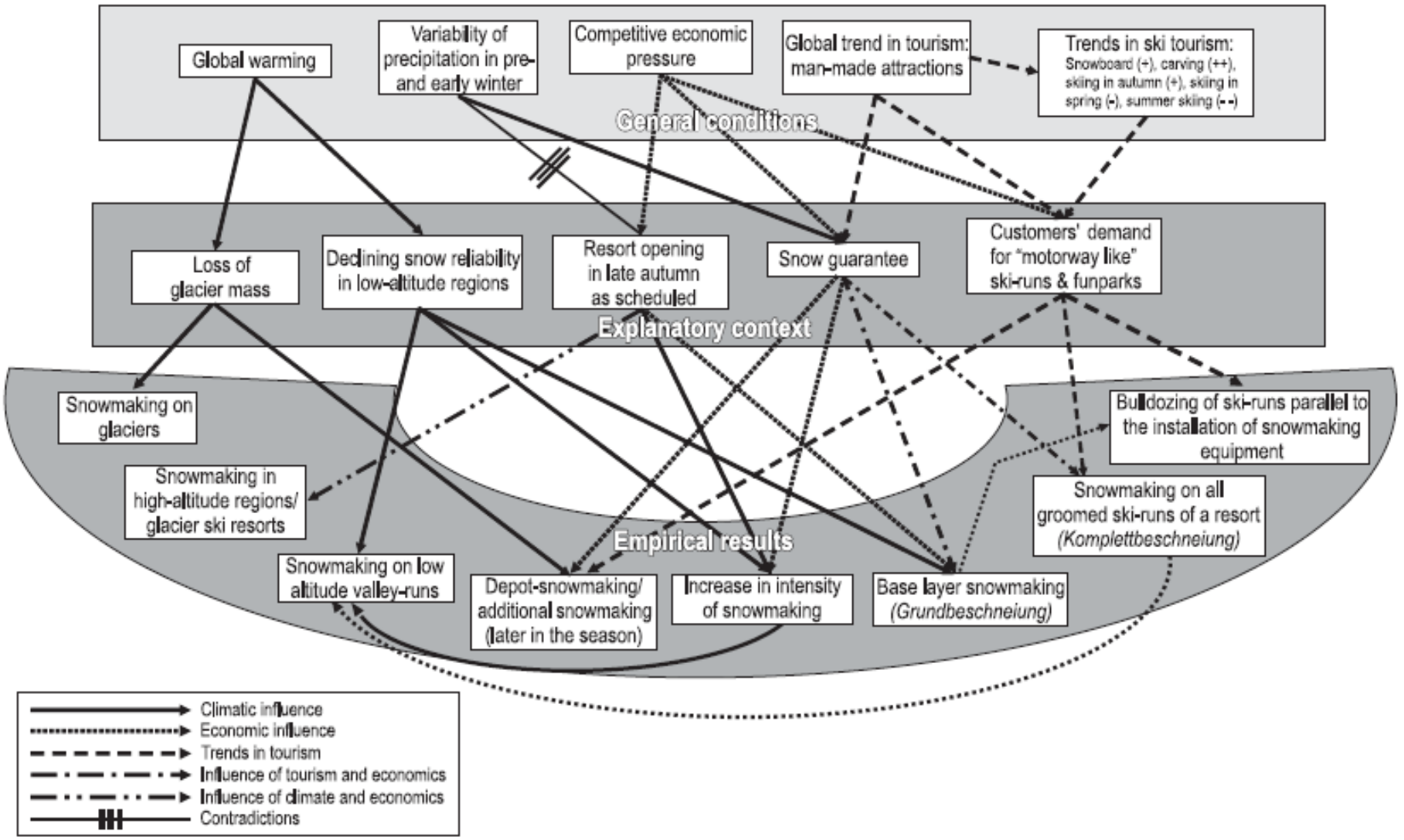
As the snowpack is subject to a snow density of 102 to 408 kg/m^3, depending on the period (with the later season generally containing a higher value), the expected Snow Depth values are:

Grefsenkollen:	0 cm
Wyller:	7-29 cm
Hafjell:	22-88/29-118 cm
Kvitfell:	44-177/52-205 cm

The lower values are more probable since the Games are planned to be scheduled for late February-March.



Why snowmaking?



Who needs snowmaking and/or snow transportation? (1)

Who needs snowmaking and/or snow transportation? (2)

Methods

$$T_w = T\,\mathrm{atan}[0.151\,977(\mathrm{RH\%} + 8.313\,659)^{1/2}] + \mathrm{atan}(T + \mathrm{RH\%}) - \mathrm{atan}(\mathrm{RH\%} - 1.676\,331) + 0.003\,918\,38(\mathrm{RH\%})^{3/2}\,\mathrm{atan}(0.023\,101\mathrm{RH\%}) - 4.686\,035.$$

Wet-Bulb Temperature Chart
Celsius

Good Snow Quality | Poor Snow Quality | No Snowmaking

Temp C \ Humidity	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%
-9	-12	-12	-12	-12	-12	-12	-12	-11	-11	-11	-11	-11	-11	-10	-10	-10	-10	-9	-9
-8	-12	-11	-11	-11	-11	-11	-11	-10	-10	-10	-10	-9	-9	-9	-9	-9	-9	-8	-8
-7	-10	-10	-10	-9	-9	-9	-9	-9	-9	-8	-8	-8	-8	-8	-7	-7	-7	-7	-7
-6	-10	-9	-9	-9	-9	-9	-8	-8	-8	-8	-8	-8	-7	-7	-7	-7	-7	-6	-6
-5	-9	-9	-8	-8	-8	-8	-8	-7	-7	-7	-7	-7	-6	-6	-6	-6	-6	-6	-5
-4	-8	-8	-8	-8	-8	-7	-7	-7	-7	-7	-6	-6	-6	-6	-6	-5	-5	-5	-4
-3	-7	-7	-7	-7	-6	-6	-6	-6	-5	-5	-5	-4	-4	-4	-4	-3	-3	-3	-3
-2	-7	-7	-6	-6	-6	-6	-5	-5	-5	-4	-4	-4	-4	-3	-3	-3	-3	-3	-2
-1	-6	-6	-5	-5	-4	-4	-4	-3	-3	-3	-3	-2	-2	-2	-2	-2	-1	-1	-1
0	-5	-5	-4	-4	-4	-4	-3	-3	-3	-3	-2	-2	-2	-2	-1	-1	-1	-1	0
1	-5	-4	-4	-4	-3	-3	-3	-3	-2	-2	-2	-2	-1	-1	-1	-1	0	0	1
2	-4	-3	-3	-3	-2	-2	-2	-1	-1	-1	-1	0	1	1	1	1	2	2	2
3	-3	-3	-3	-2	-2	-2	-1	-1	-1	0	0	1	1	1	2	2	2	3	3
4	-2	-2	-1	-1	-1	0	0	1	1	1	2	2	2	3	3	3	4	4	4

Wet bulb temperature is the lowest temperature that can be obtained by evaporating water into the air at a constant pressure. The term comes from the technique of wrapping a wet cloth around a mercury bulb thermometer and blowing air over the cloth until the water evaporates. The wet bulb temperature is always lower than the dry bulb temperature, but will be identical with 100% relative humidity.
This wet bulb temperature is what snowmakers use to know when they can make snow. You can see it is possible to make snow when the temperatures are above freezing but only with very low humidity

Plot your current temperature (red numbers on the left) to the % of humidity (blue numbers on the top) and where they meet the (black numbers) is your current wet bulb temp.
Any time the wet bulb number is below -7 degrees Celsius (blue shaded area) snowmaking is at its best… nice dry snow. You can make snow from -6 degrees to -3 degrees wet bulb (purple shaded area) but the snow will be wet.

Who has data (T & RH) on eKlima? (1)

Who has data (T & RH) on eKlima? (2)

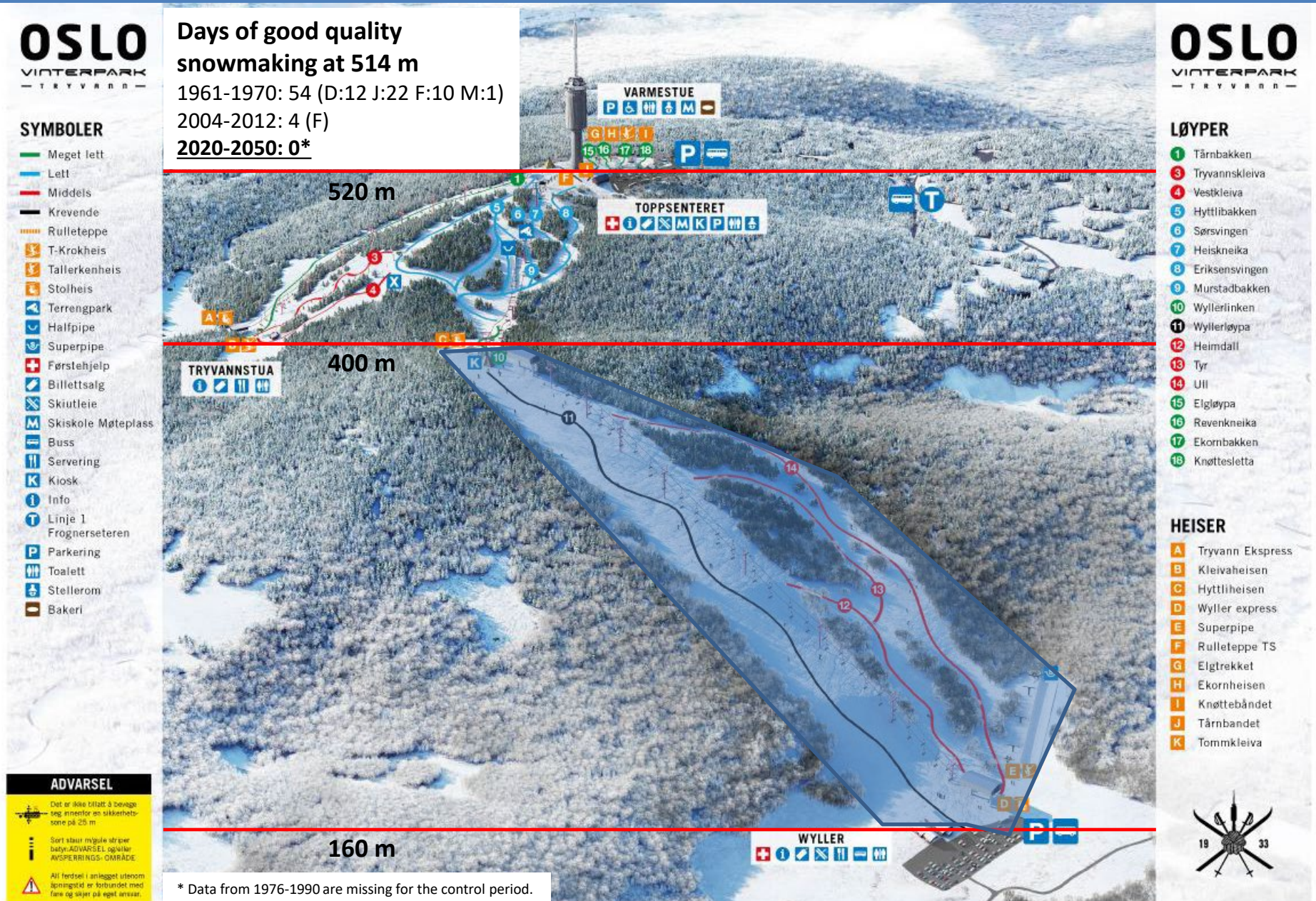
Wyller: Future Snowmaking

Days of good quality snowmaking at 514 m

1961-1970: 54 (D:12 J:22 F:10 M:1)

2004-2012: 4 (F)

2020-2050: 0*

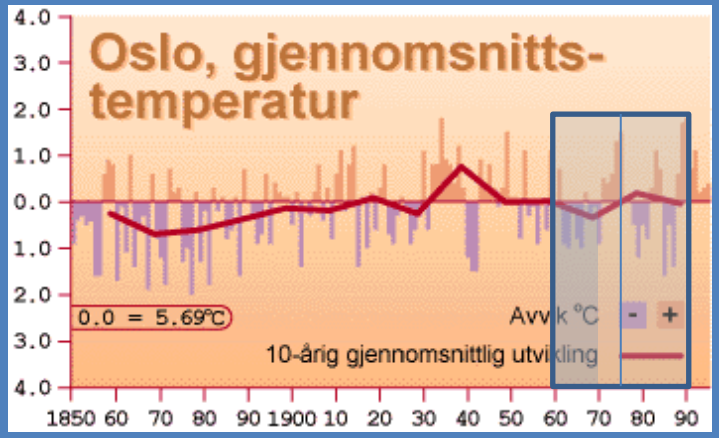


* Data from 1976-1990 are missing for the control period.

Conclusion & Recommendations (1)

Wyller:

Historically, Wyller had a strong snowmaking capacity, especially during the cold decade of 1961-1970, with the coldest days mostly falling into the winter months and peaking in January. However, this characteristic has recently been lost to warming with only 4 February days left on average for snowmaking during 2004-2012 and no more capacity projected* for the future period of 2020-2050, given the specifications of the commonly available technology at use.



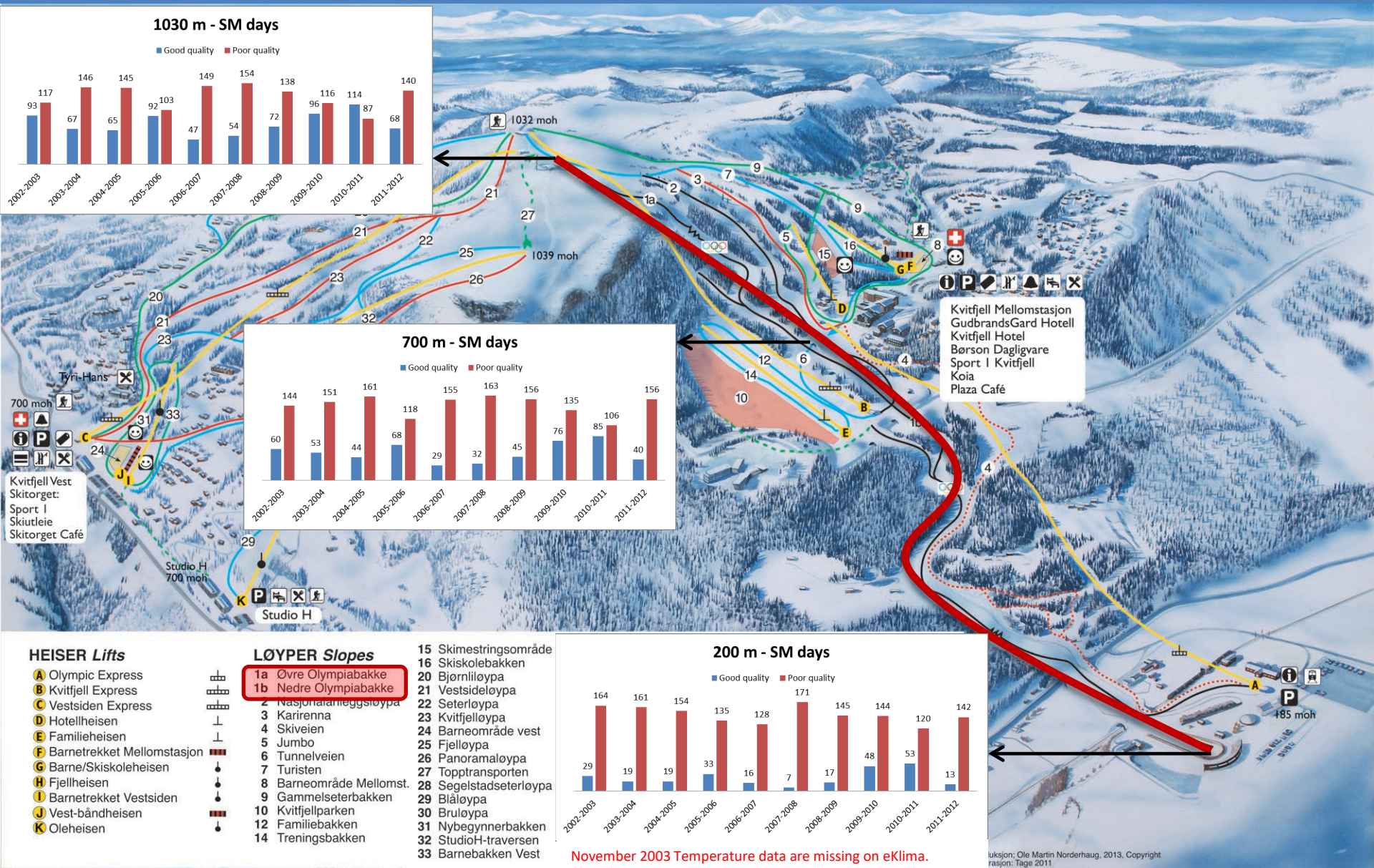
* The projections are made by adding the temperature increase predictions specified in Klima 2100 with respect to the control period of 1960-1990. However, we have taken the period of 1960-1975 as the normal reference, since the data for the rest of the period were missing on eKlima. Nonetheless, this weakness would not imply much change on the results since both the 15-year halves of the 1960-1990 period are quite identical (see Fig. above).

Conclusion & Recommendations (2)

Wyller:

It is advised that the events at this venue be scheduled for February, but not later in March. The newly planned slopestyle run, as well as the existing cross and slalom (snowboard) runs and the halfpipes, could be supported by dry material on the base, such as Snowflex®, if the FIS permits. Moreover, the organisers could consider making use of the state-of-the-art VIM technology, which claims to allow snowmaking at any ambient temperature , yet with a likely considerable requirement for financial and environmental resources.

Kvitfjell: Past Snowmaking Analogue for 2022



November 2003 Temperature data are missing on eKlima.

Conclusion & Recommendations (3)

Kvitfjell:

The resort has had a strong snowmaking capacity, especially on the upper runs during the 2004-2012 period. The period, mostly falling into the warmest decade recorded (2001-2010) is to some extent analogously indicative of the conditions for 2022.

The current Olympic Alpine run (1a+1b) is located on the southeast facet of the mountain. In order to take preventive measures, it is advised that the newly planned slope be located on the northern faucets to improve snowmaking capacity, at the expense of losing some of the sunshine. Moreover, the immediate west of the venue would be a potential area to provide additional snow for transferring, if needed.

Credits

«Why Snowmaking?» in Steiger, R. and M. Mayer (2008). Snowmaking and climate change: future options for snow production in Tyrolean ski resorts. Mountain Research and Development, 28(3/4): 292-298.

Venue maps and info @ http://www.ol22.no/en/venues-and-facilities/

Climate change maps @ http://www.regjeringen.no/nb/dep/kld/kampanjer/klimatilpasning-norge-2/temperatur--og-nedborendringer-2050-og-2.html?id=609105

Meteorological stations @ http://eklima.met.no/Help/Stations/toDay/all/en_Stations.html

Lapse rates in Linacre, E. (2003). Climate Data and Resources: A Reference and Guide. Routledge.

Wet bulb temperature formula in Stull, R. (2011). Wet-bulb temperature from relative humidity and air temperature. Journal of Applied Meteorology & Climatology, 50: 2267-2269.

Wet bulb temperature chart @ http://www.snowathome.com/snowmaking_weather_tools.php

Kvitfell map @ http://www.skiinfo.no/ostlandet/kvitfjell/skikart.html

Oslo Vinterpark map @ http://www.skiinfo.no/ostlandet/tryvann-vinterpark/skikart.html

Oslo average temperature chart @ http://wgbis.ces.iisc.ernet.in/energy/HC270799/SOE/nor/soeno97/climate/oslotemp.jpg

Olympic locations' climate risk @ https://uwaterloo.ca/news/sites/ca.news/files/uploads/files/oly_winter_games_warmer_world_2014.pdf

IDE All-weather snowmaker @ http://www.youtube.com/watch?v=IynipZwLjPY

Dry ski slope @ http://media-cdn.tripadvisor.com/media/photo-s/03/62/c1/c5/malta-ski.jpg

SkiKlima: A Geo-Bibliography of Climate Change and Ski Tourism Research, @http://www.skiklima.com/