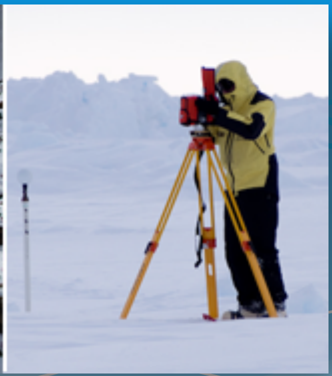

Erneuerbare Energien und die Rolle des Schnees

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ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

SCCER SoE
SWISS COMPETENCE CENTER for ENERGY RESEARCH
SUPPLY of ELECTRICITY

Motivation

* We are in the mountains
* We are in the snow
* The mountains have traditionally contributed the majority of Swiss electricity

Let’s see what the mountains can contribute in a Future Renewable Switzerland

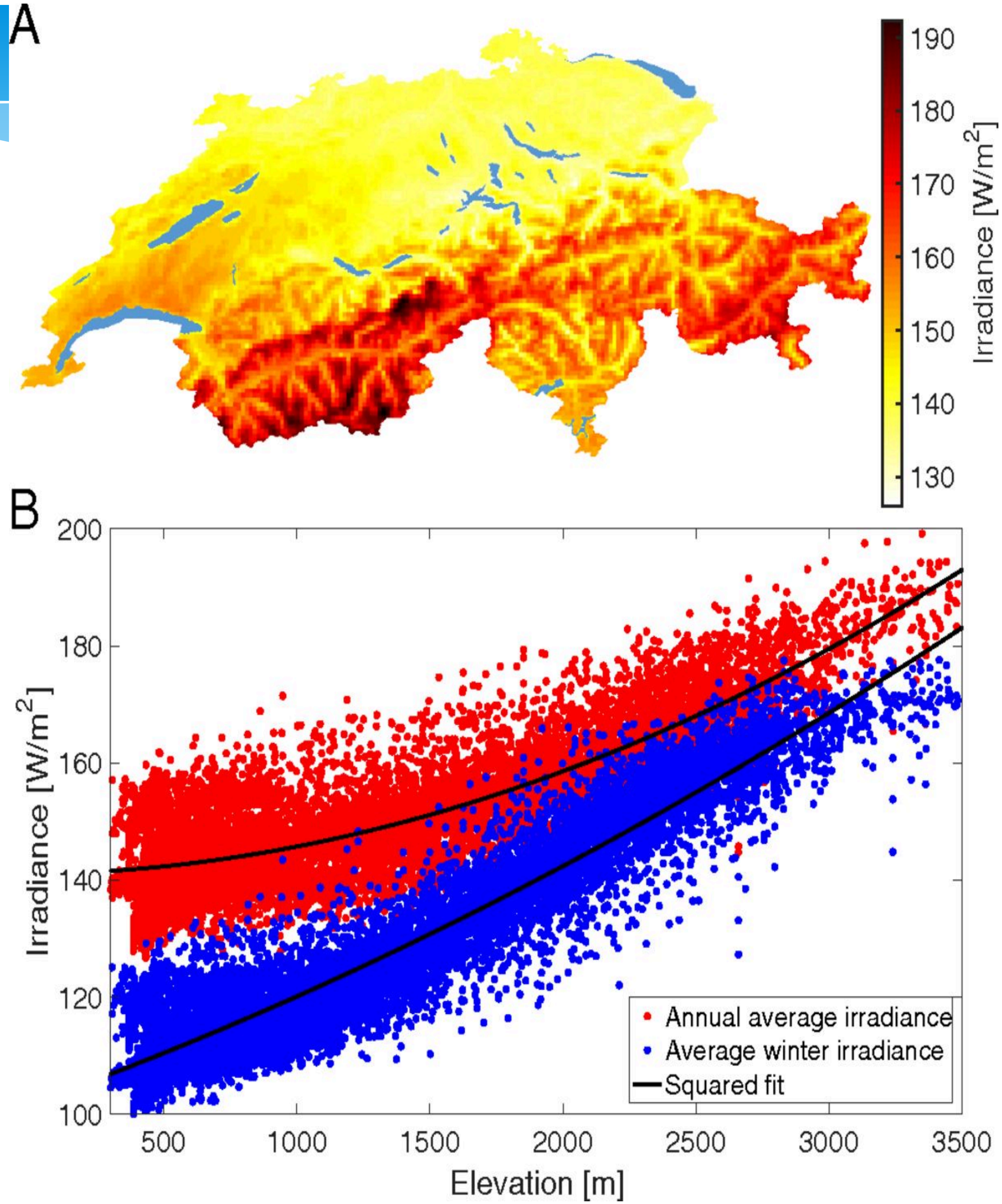
Content

* Influence of Elevation and Snow on PV Production
* PV and Wind in a Fully Renewable Switzerland
* Future Snow

Situation for PV

Distribution of incoming global irradiance (Heliomont product by MeteoSwiss) in Switzerland (2011 – 2016).

Winter shows an even stronger increase with elevation



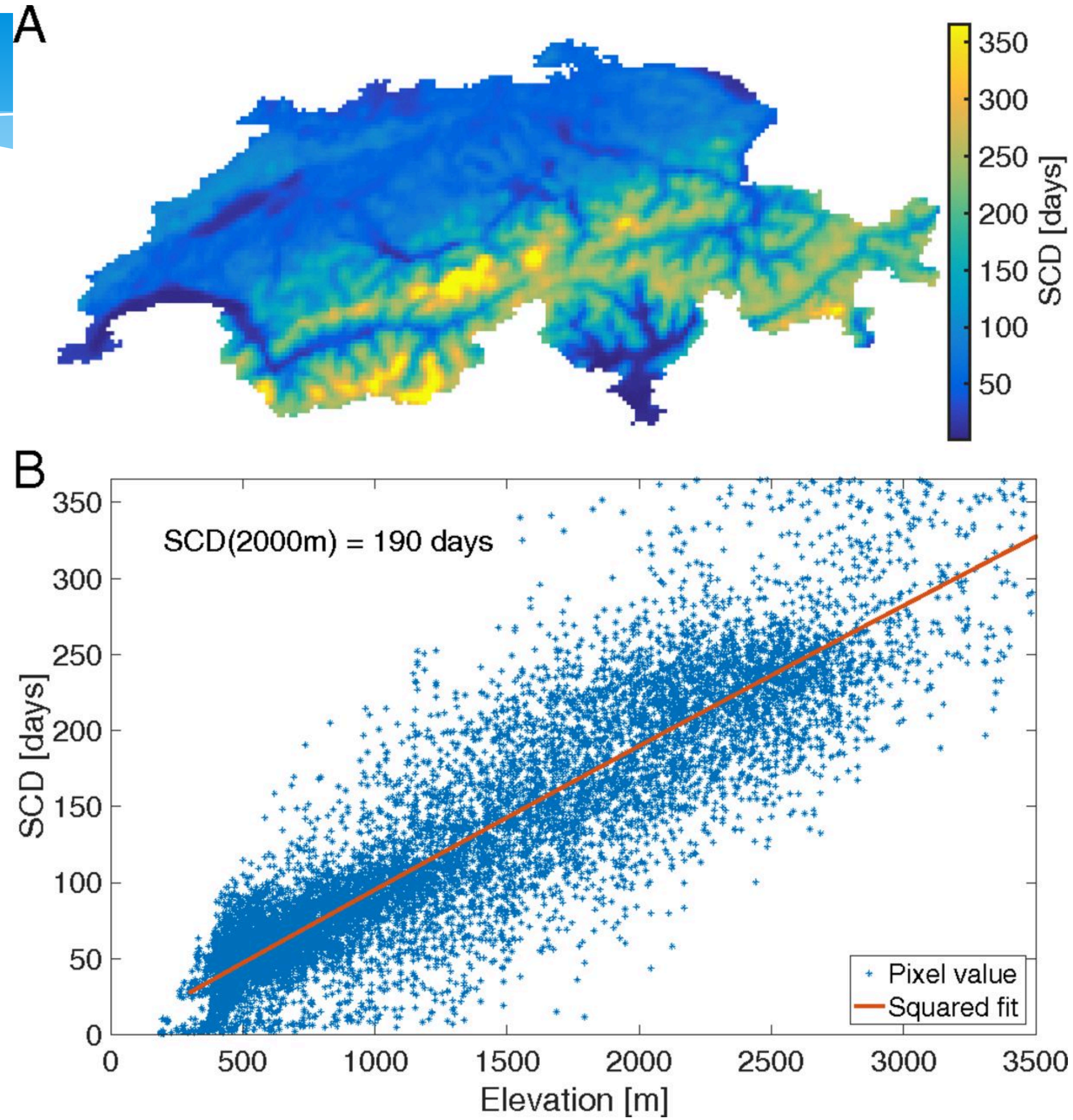
Annelen Kahl et al. PNAS 2019;116:4:1162-1167

CRYOS, EPFL laboratory of the WSL/SLF

Situation for PV

Snow cover duration also increases strongly with elevation.

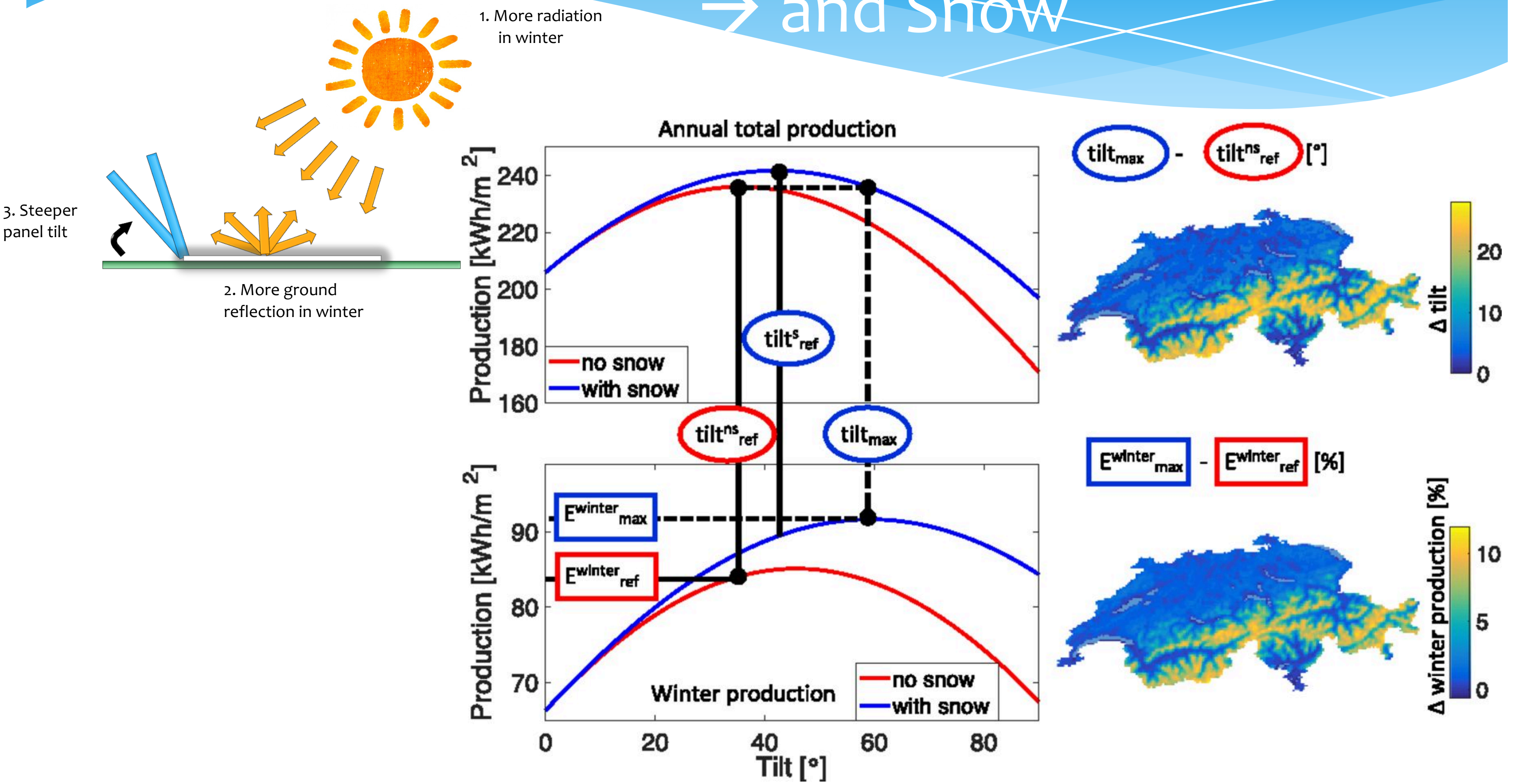
At 2000 m a.s.l. ground coverage by snow is 190 days.



Annelen Kahl et al. PNAS 2019;116:4:1162-1167

CRYOS, EPFL laboratory of the WSL/SLF

An important parameter is panel tilt → and Snow



Annelen Kahl, Jérôme Dujardin, Michael Lehning, PNAS 2019;116:4:1162-1167

Arbitrary mountain location at 2500 m a.s.l.

Define two scenarios to look at real world impact

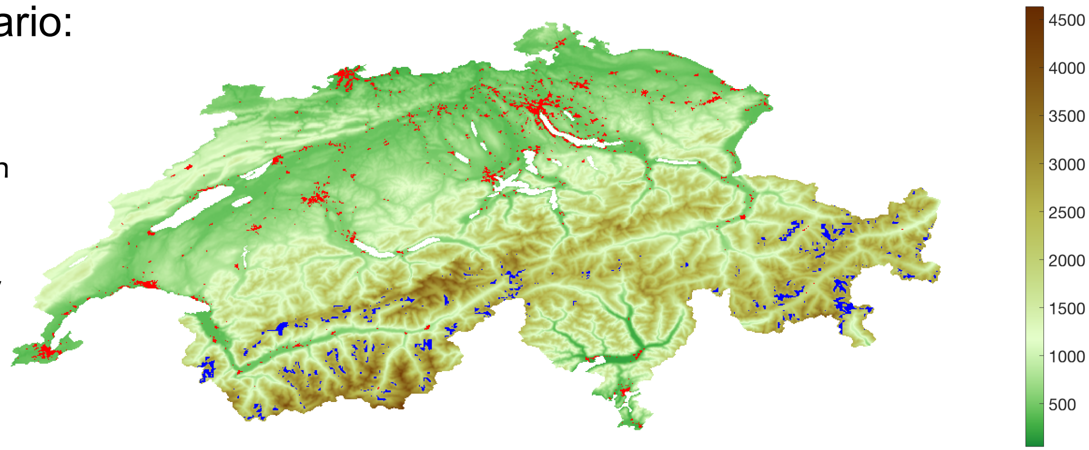
Urban scenario:

Conventional

Roof-top installation

Close to demand

Lowest productivity



Mountain scenario:

Innovative

PV farms/mountain infrastructure

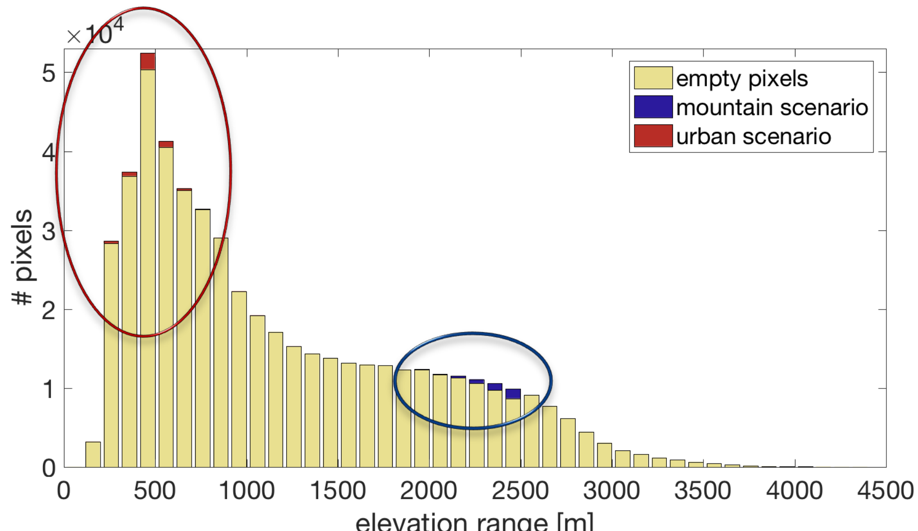
Far from demand

Highest productivity

Pixel Selection:

With population

Max. cover fraction (0-8%) per pixel



Pixel Selection:

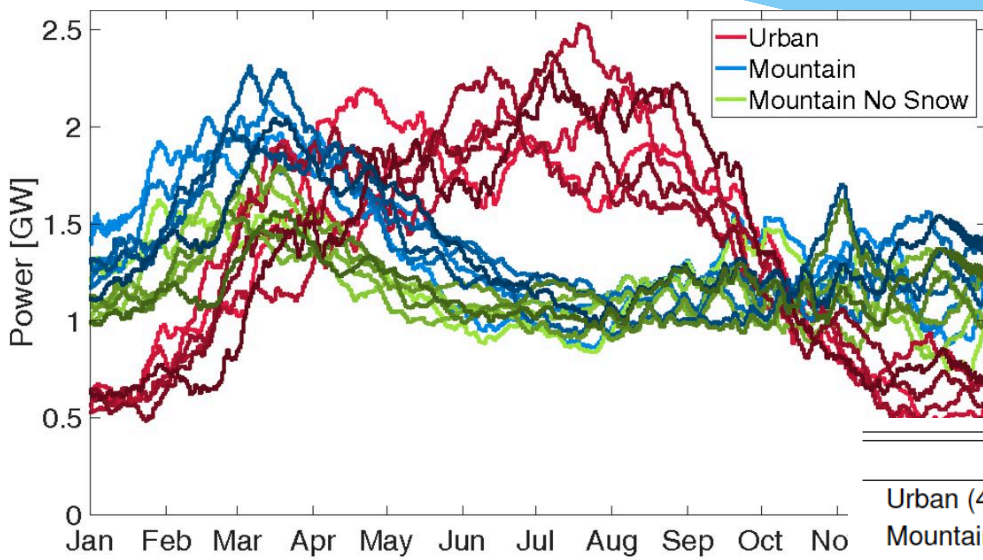
Below 2500m

Max. cover fraction (0-8%) per pixel

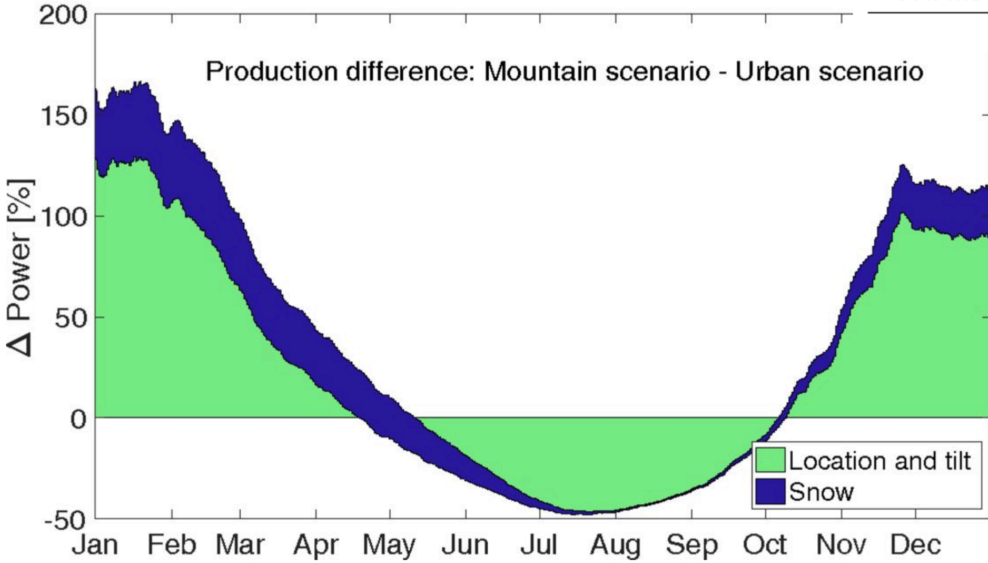
Mountain No Snow:

Re-run at constant surface reflectance of r=0.2

Seasonal profile of PV production for Scenarios

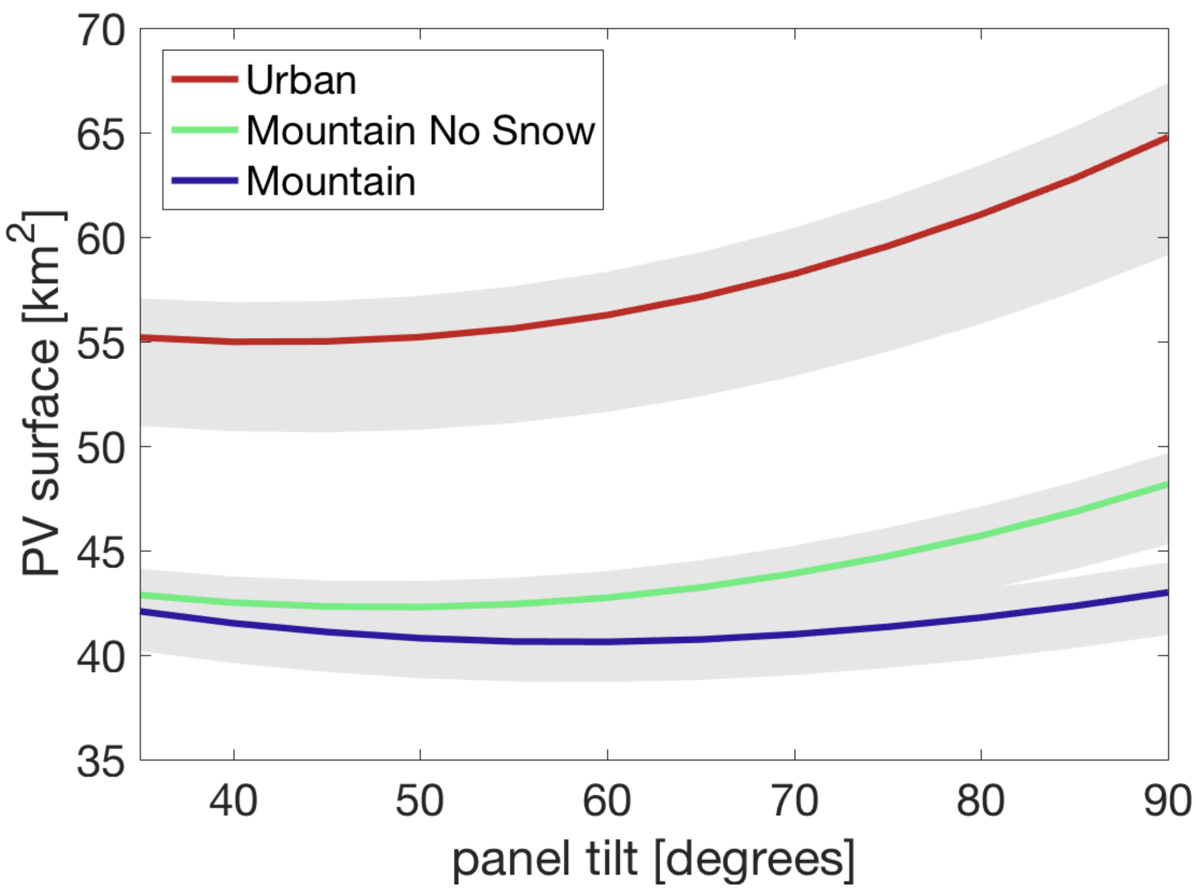


	2011	2012	2013	2014	2015	2016
Urban (40° tilt)	53	55.9	60.4	57.8	54.3	59.5
Mountain (90° tilt)	54.5	54.9	54.1	59	54.4	54.9
OR: Mountain (65° tilt)	45.6	46.2	46.2	50	45.8	46.4



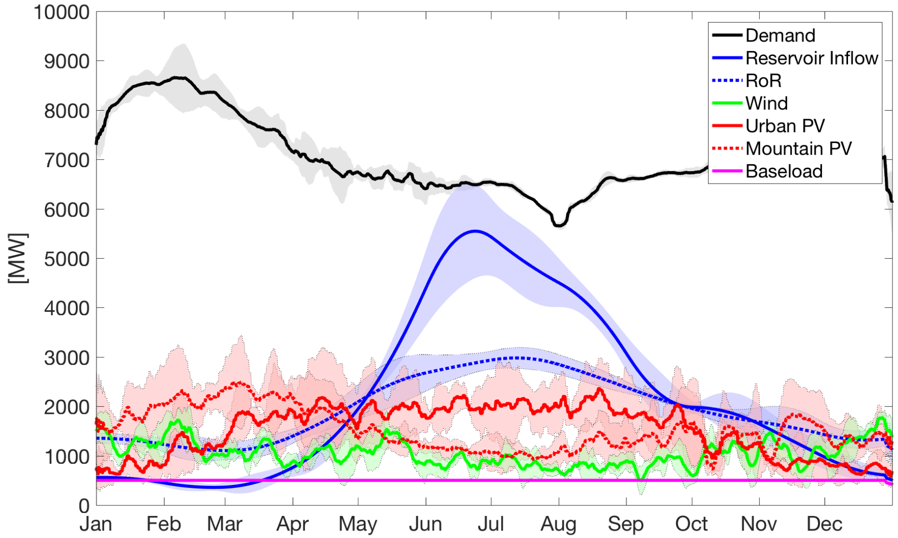
The combined effect of location, tilt and snow enormously boosts winter production

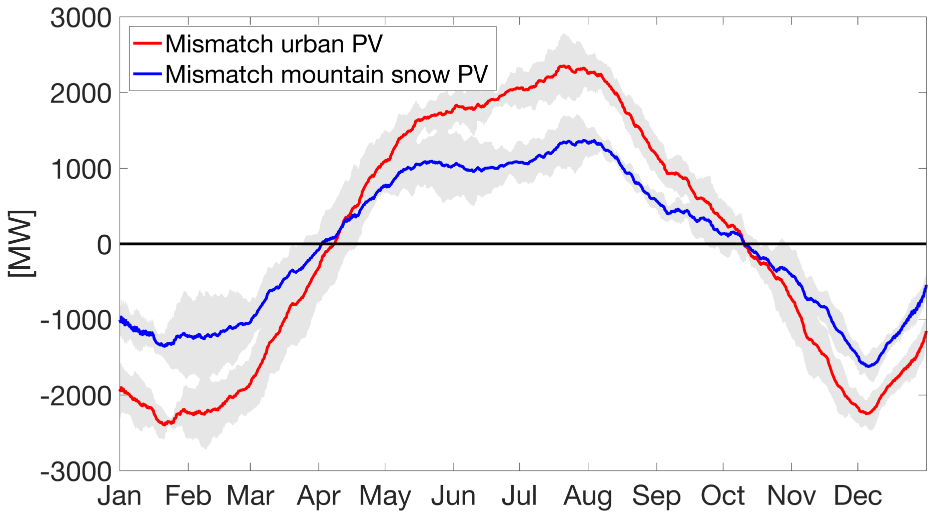
Mountain Installations require less Surface



We need to install much less PV surface to produce 12 TWh per year!

Significant seasonal mismatch reduction

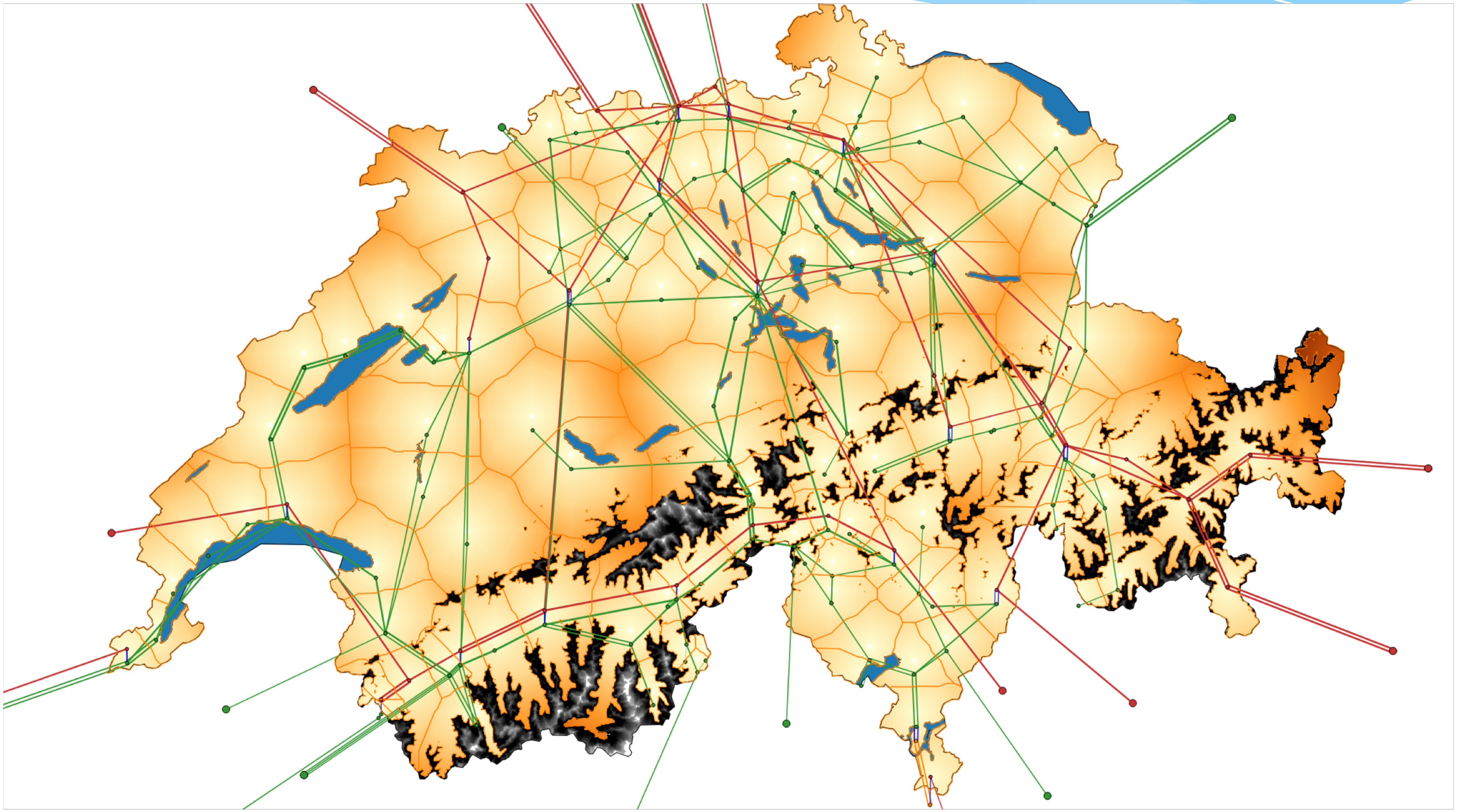




This mismatch reduction also reduces the required import of energy

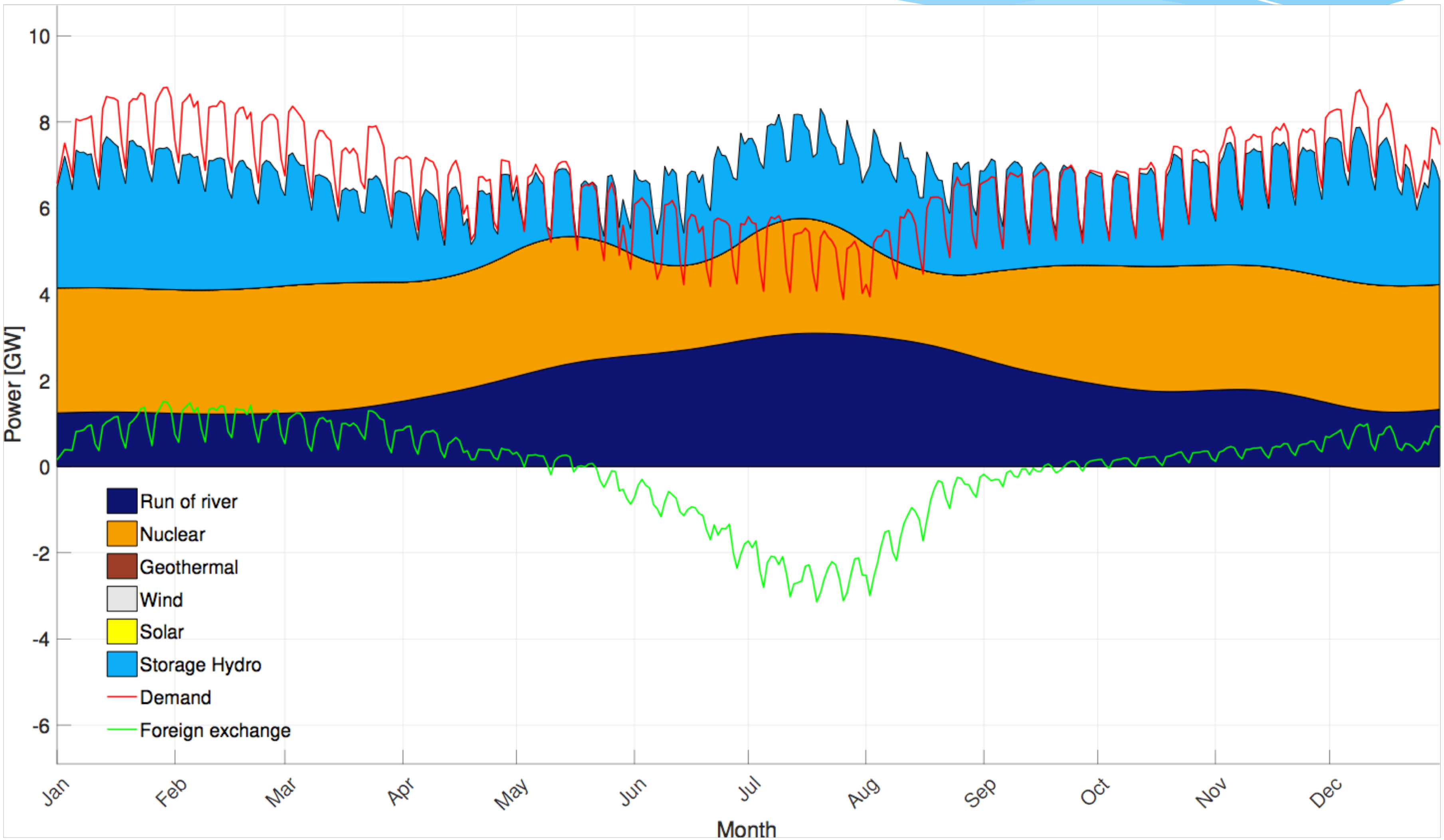
	Panel tilt	PV area
urban	40°	$53km^2$
mountain	90°	$42km^2$

Renewables in the Context of the Swiss Energy System

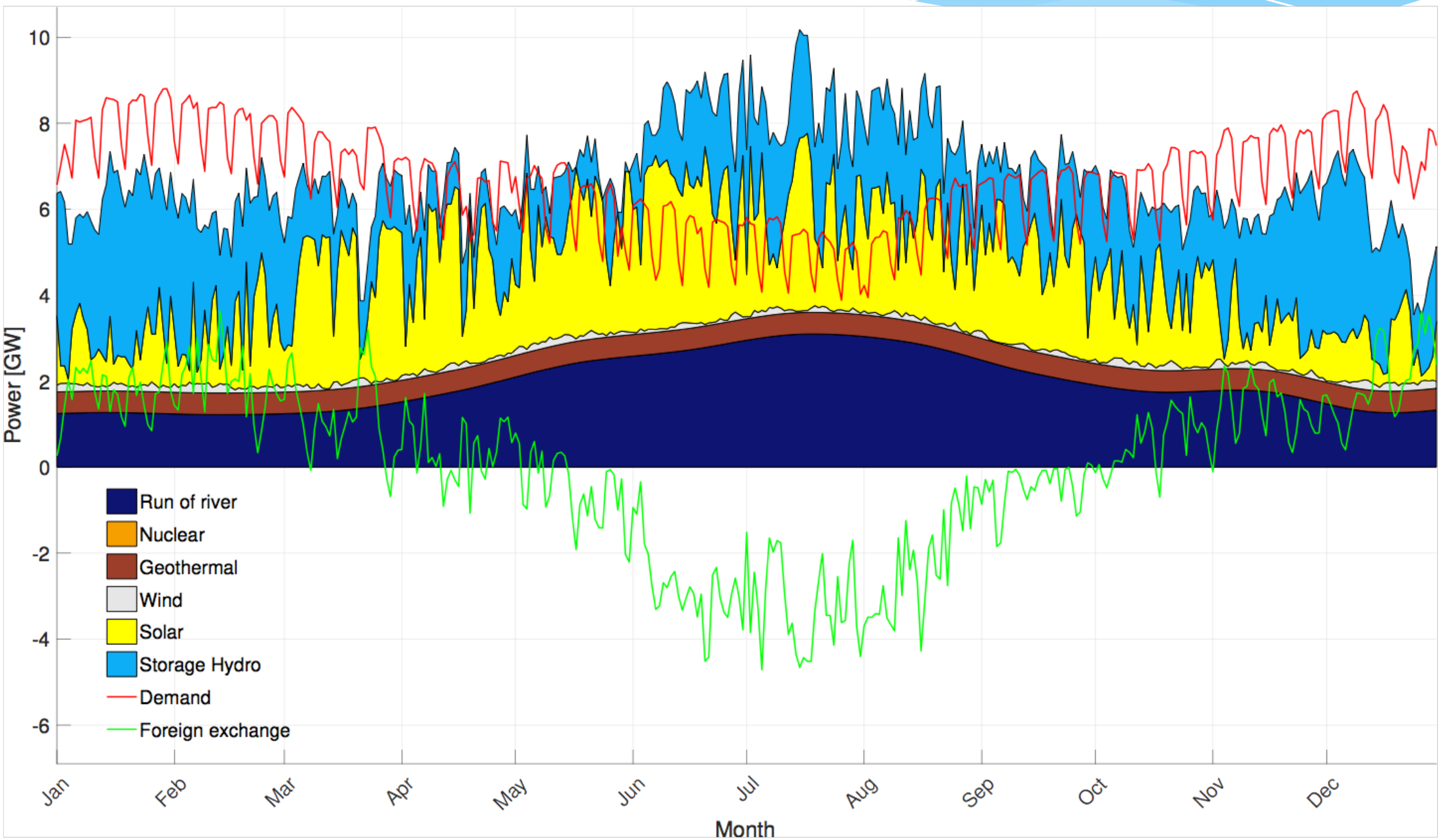


Bartlett, S. et al., 2018. Charting the Course : A Possible Route to a Fully Renewable Swiss Power System. , A Possible Route to a Fully Renewable Swiss Power System. , Energy, 163, pp. 942–955.

Current Situation with Nuclear



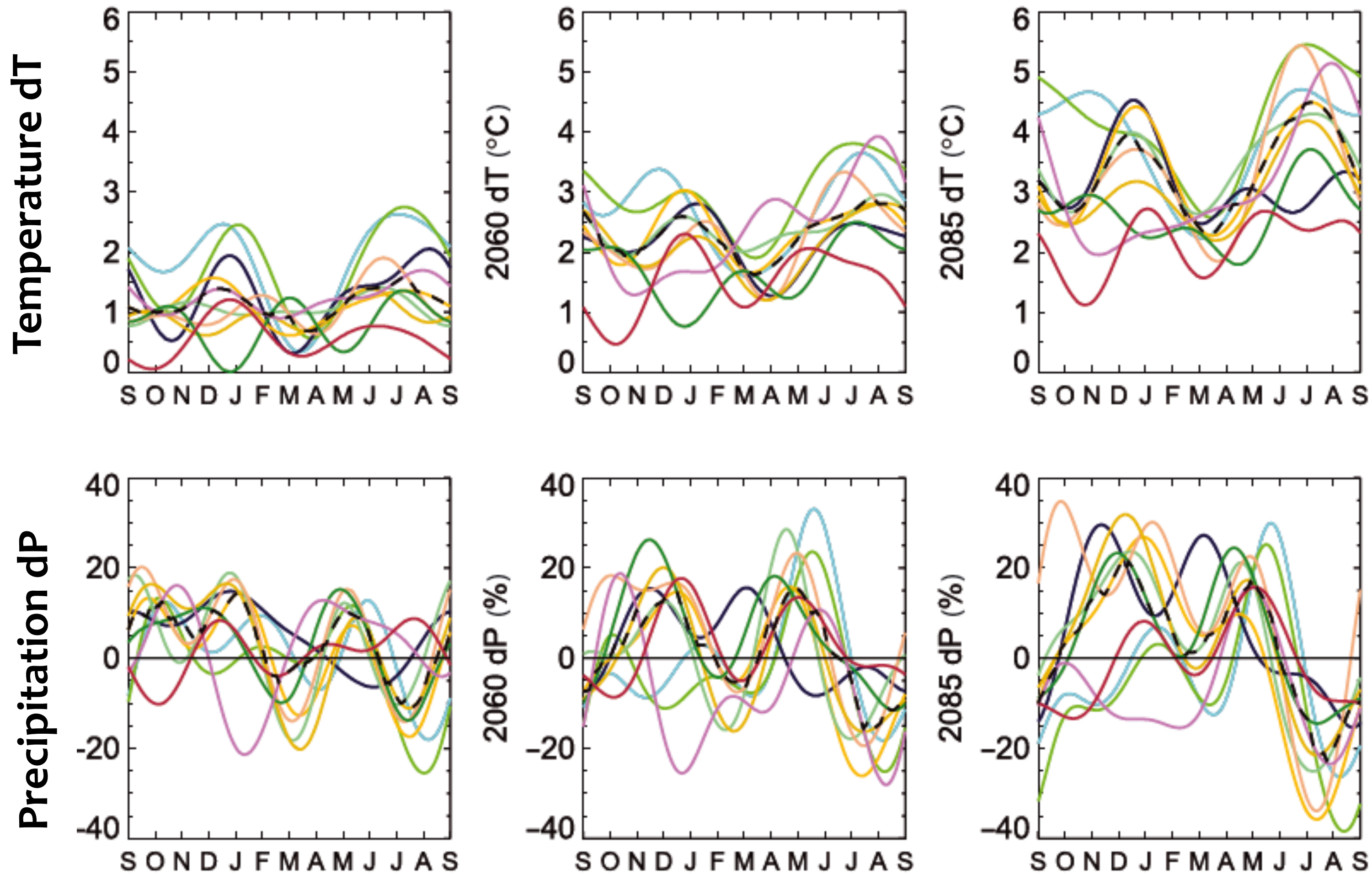
Scenario with a large fraction of solar production



Foreign exchange increases (not net import), grid is less or equally stressed

Climate Change Scenarios for Switzerland (CH2011)

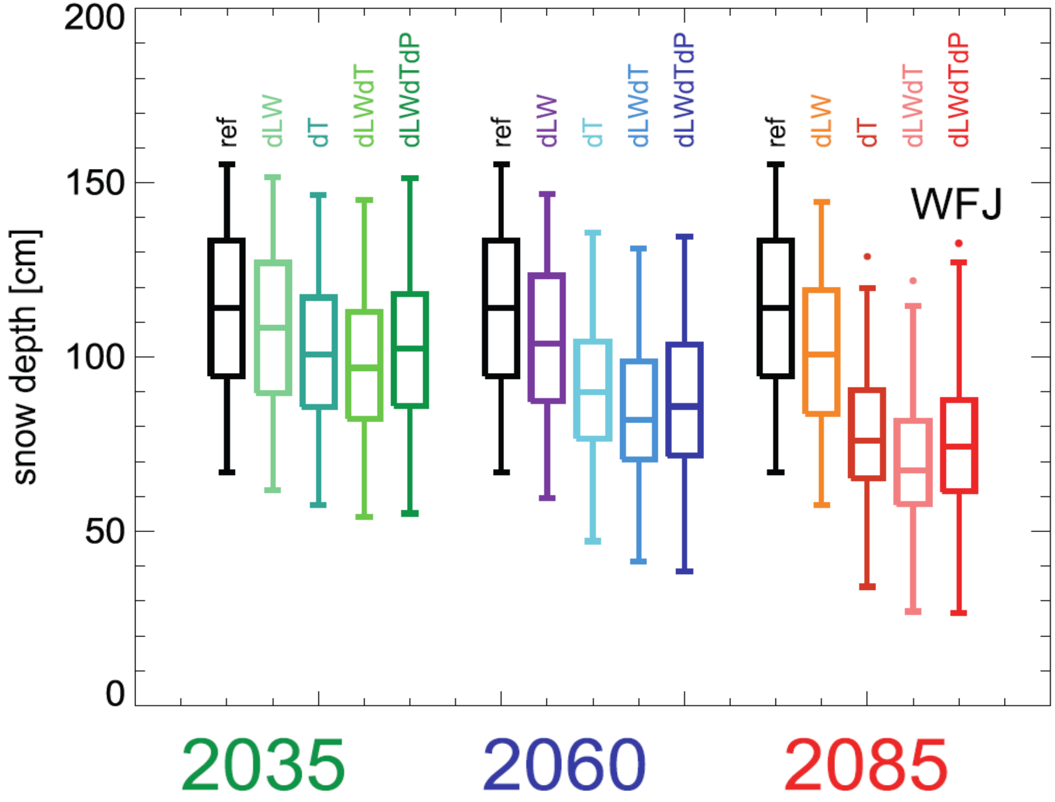
Large spread of predictions on Warming and Precipitation Change



2035 2060 2085

Decrease of mean snow depth at WFJ

dLWdTdP: - 10 % - 25 % - 35 %



2085 dLW: - 12 %

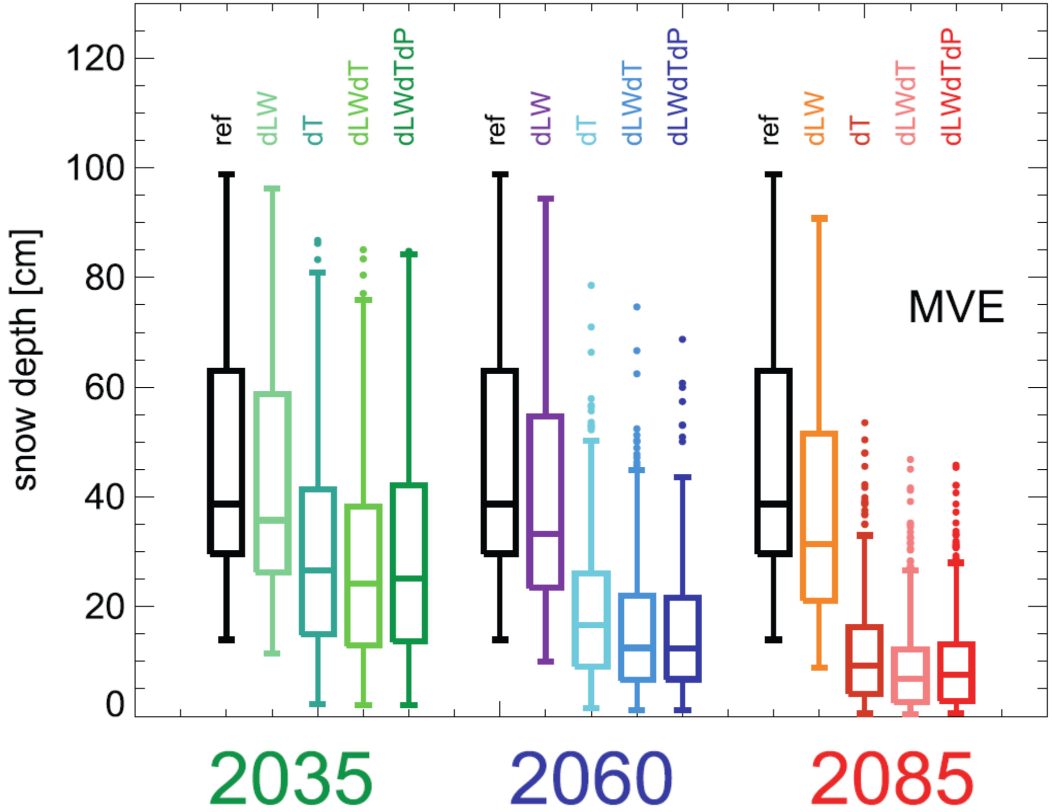
2085 dT: - 34 %

2085 dLWdT: - 41 %

Schmucki et al., Int. J. Climatology, 2014

Decrease of mean snow depth at Montana

dLWdTdP: - 35 % - 68 % - 81 %



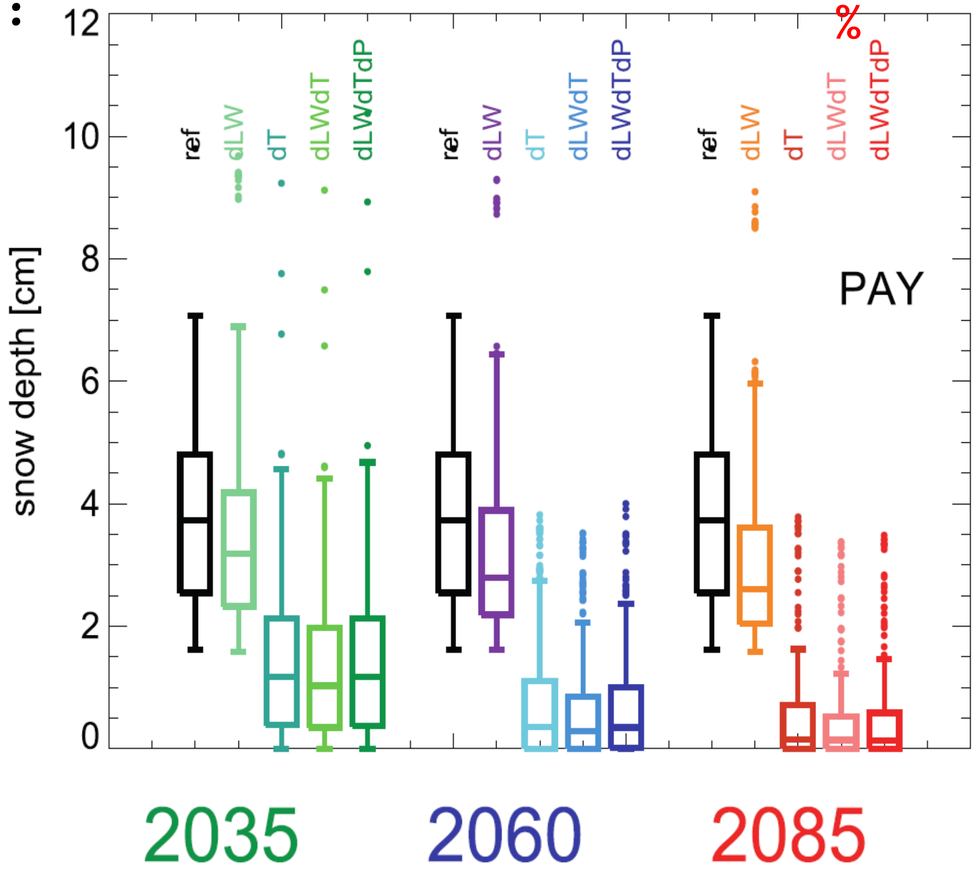
2085 dT: - 76 %

2085 dLWdT: - 83 %

Schmucki et al., Int. J. Climatology, 2014

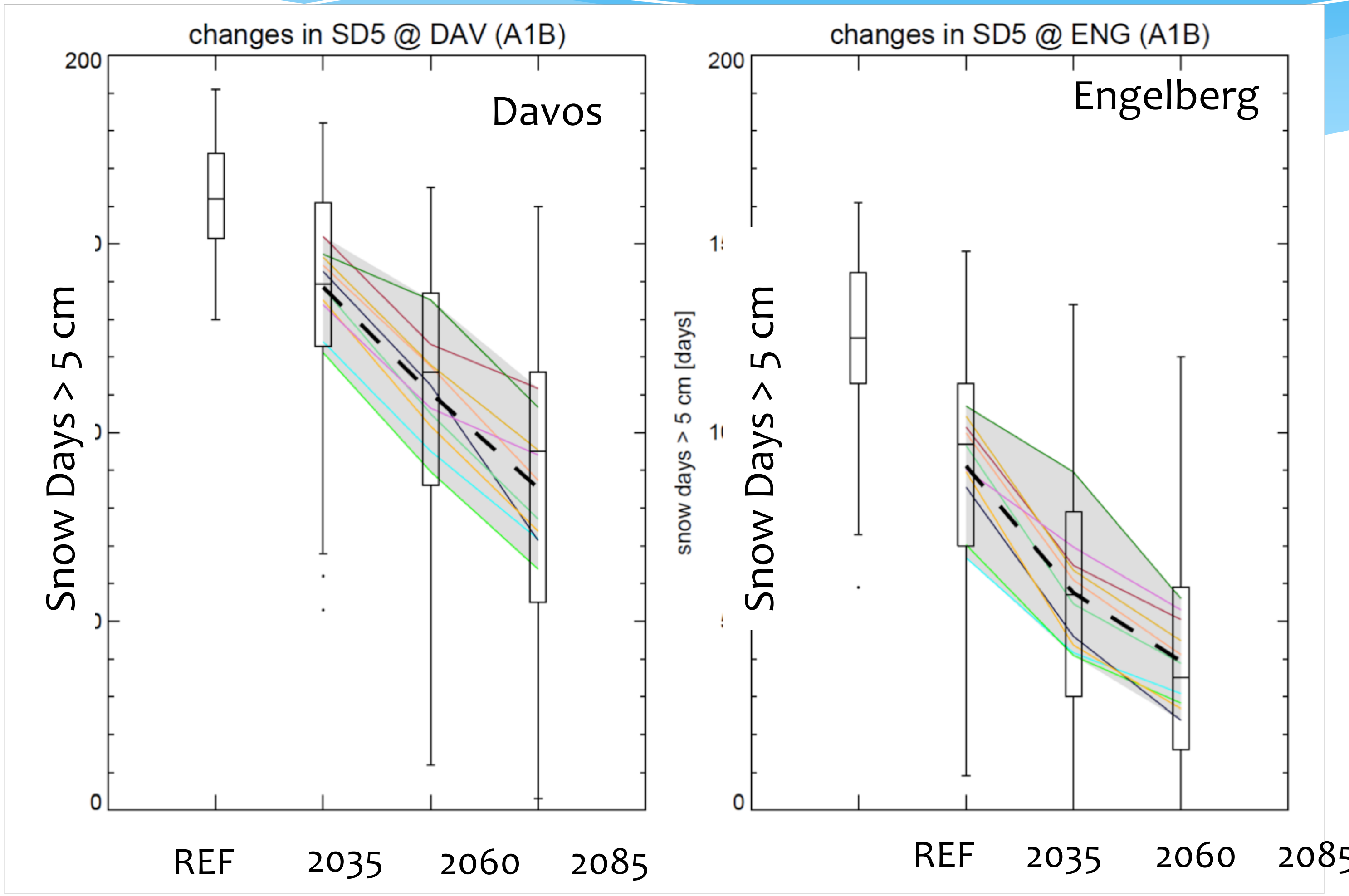
Decrease of mean snow depth at Payerne

dLWdTdP: - 69 %   - 91 %   - 96 %



Schmucki et al., Int. J. Climatology, 2014

Comparative Analysis of Uncertainties in Socio-Economic Snow Indices



Schmucki et al., Theoret. App. Climatology, 2015

A real world example from my house (Davos Laret)

Conclusions

* Existing Infrastructure in the Alps should be used for PV installations
  * Reduces the Winter Energy Gap
  * Reduces Dependency from Import
  * Reduces total required capacity to replace nuclear
* Renewable installations are largely compatible with grid 2025
* Snow will be less in the future but at high elevations snow reduction will be acceptable in the next 30 years

Let’s produce even more energy in our mountains