The Contribution of the Swiss Mountains to the Energy Turnaround with New Renewables

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Menue

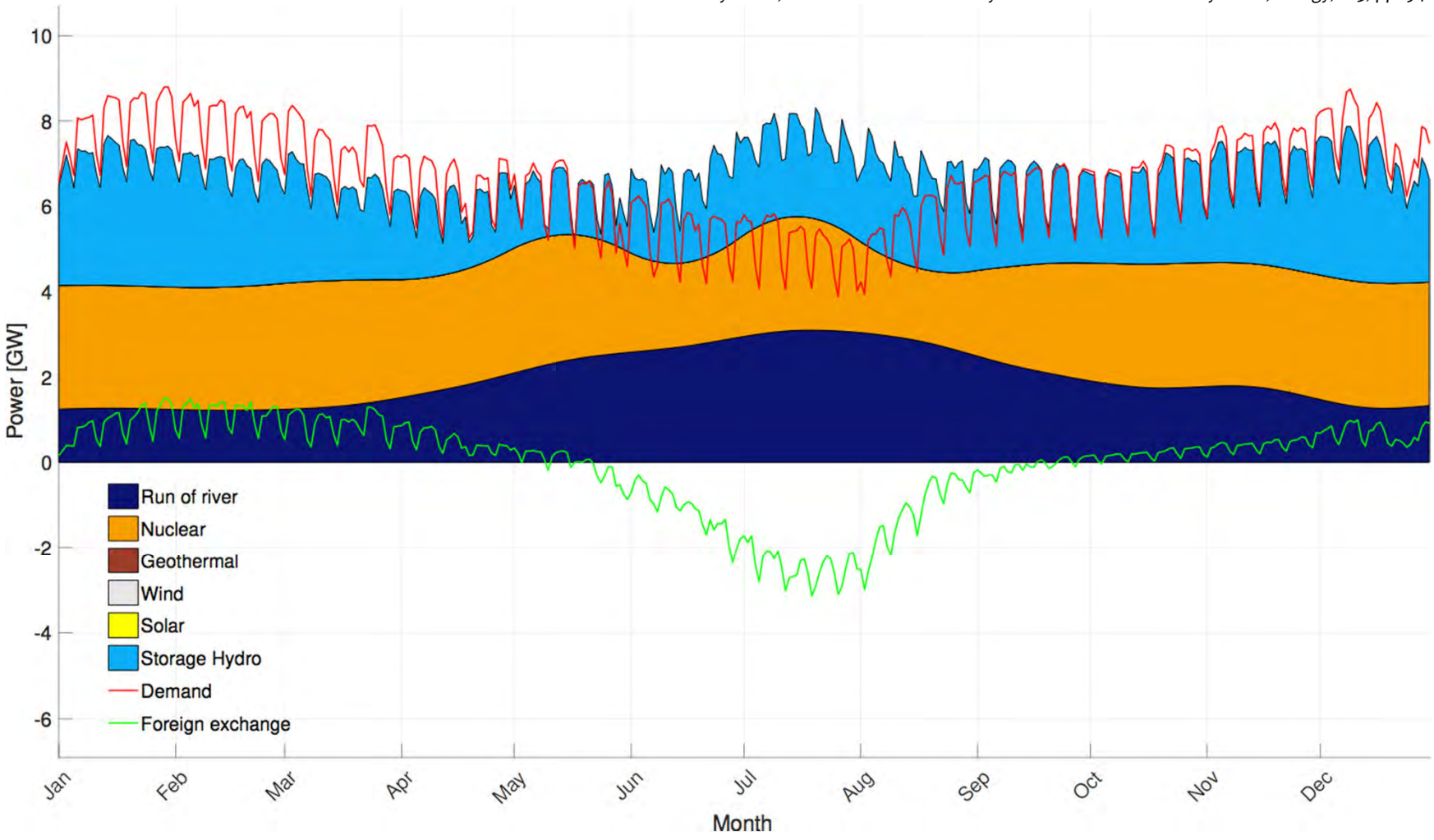
* The Swiss energy problem
* The renewable scenario with PV in the Swiss electricity world
* Cetero Censeo: Wind is good !!!
* The correct radiation energy balance in complex snowy terrain
* Future snow?
* Snow removal from roofs and research gaps

➞ Let's see what the mountains can contribute for a Future Renewable Switzerland

Current Average Production and Demand (CH)

- Overall good balance
- Winter Import
- Sommer Export

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.



Problemstellung

Neue Zürcher Zeitung

KOMMENTAR

Drohender Strommangel: Die Schweiz braucht einen Elektroschock

Ohne Strom geht nichts. Die Schweiz setzt ihre Versorgungssicherheit fahrlässig aufs Spiel. Ein Weckruf für ein Land, das sich in falscher Sicherheit wiegt.

Helmut Stalder 22.5.2019, 05:30 Uhr

* Versorgungssicherheit
* Importabhängigkeit
* Winterlücke auch im benachbarten Ausland
* Entwicklungen bei Kohle, Gas und Öl

Renewable Scenario with PV (CH)

- Overall good balance
- Winter Import
- Sommer Export

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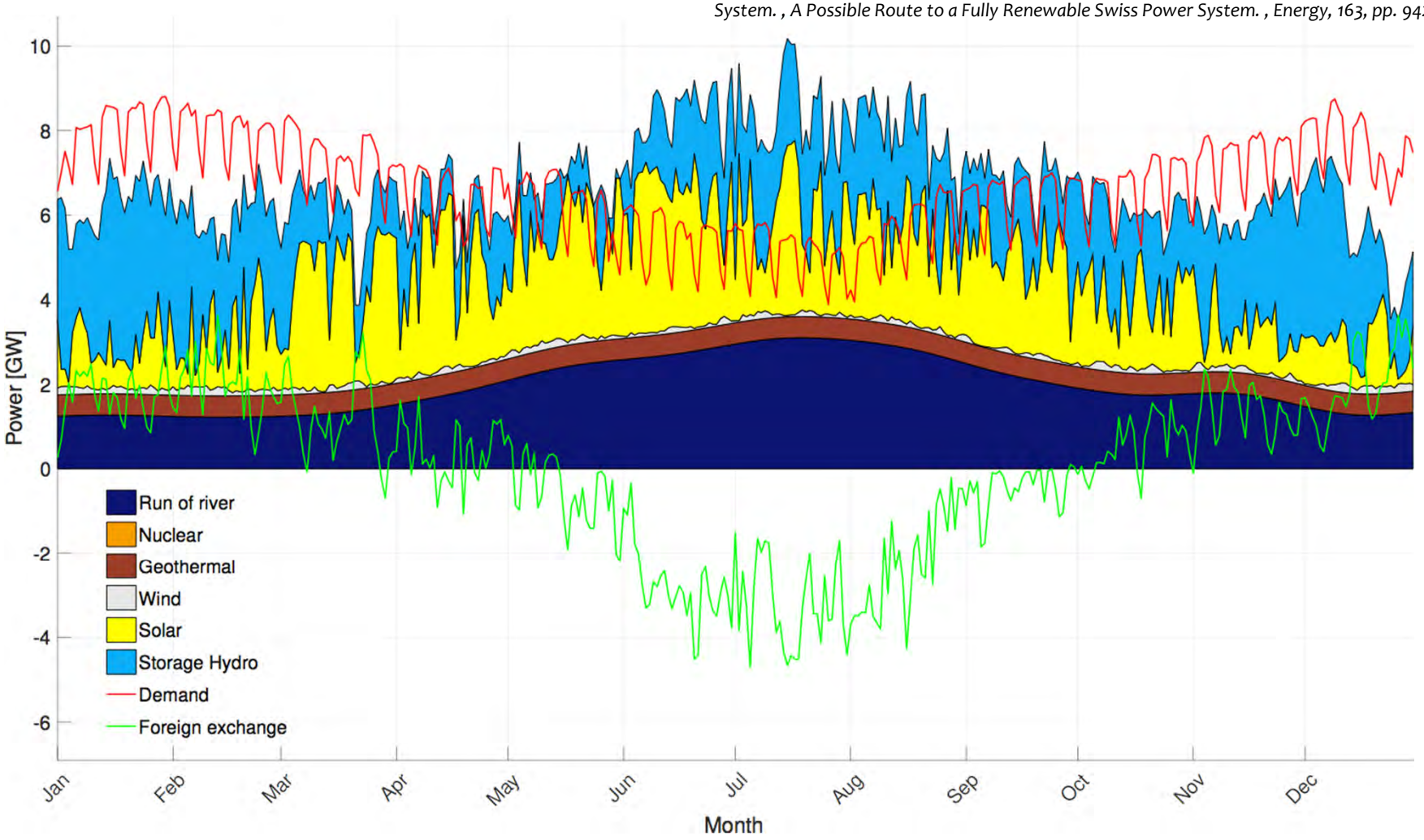
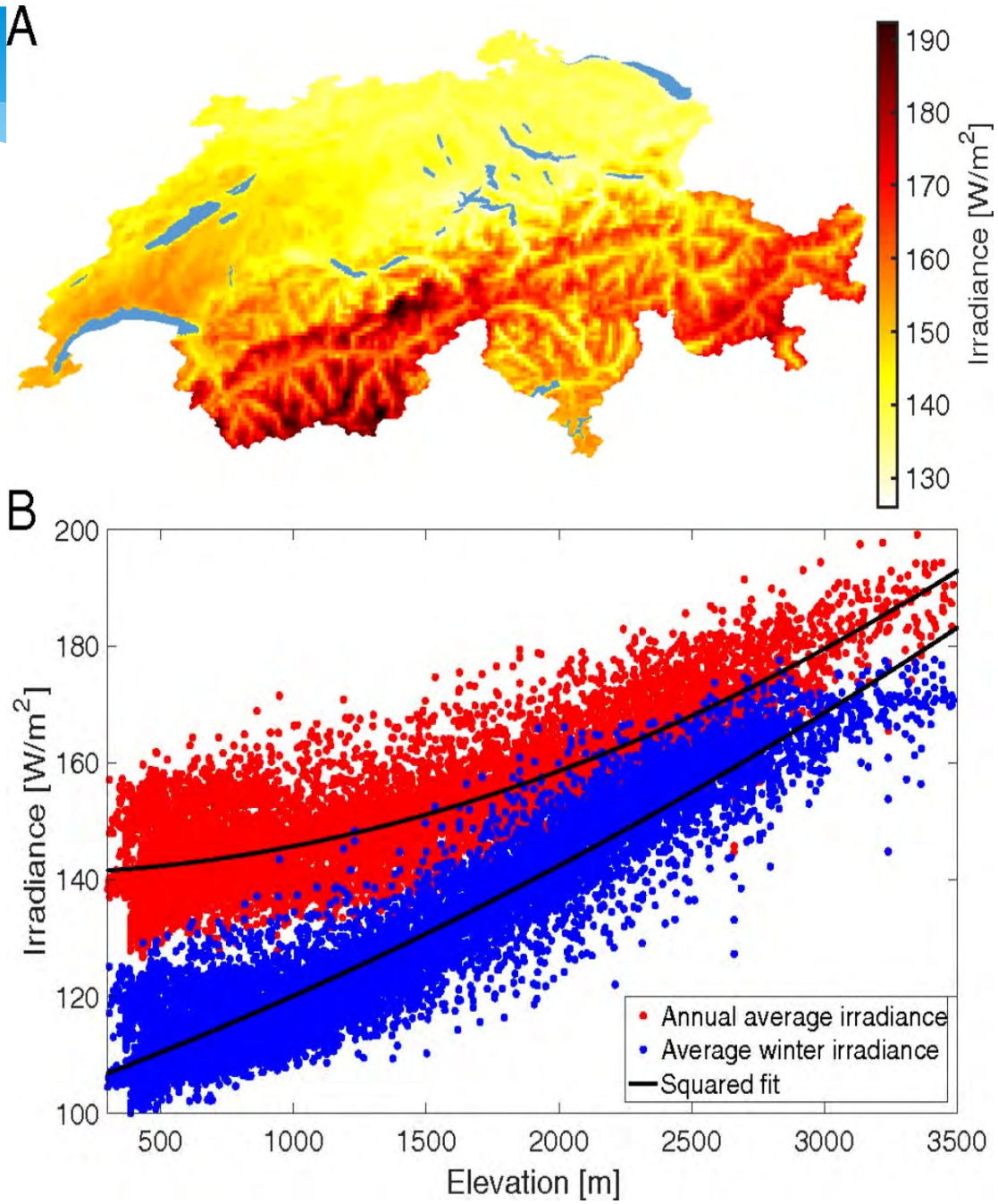


Situation for PV

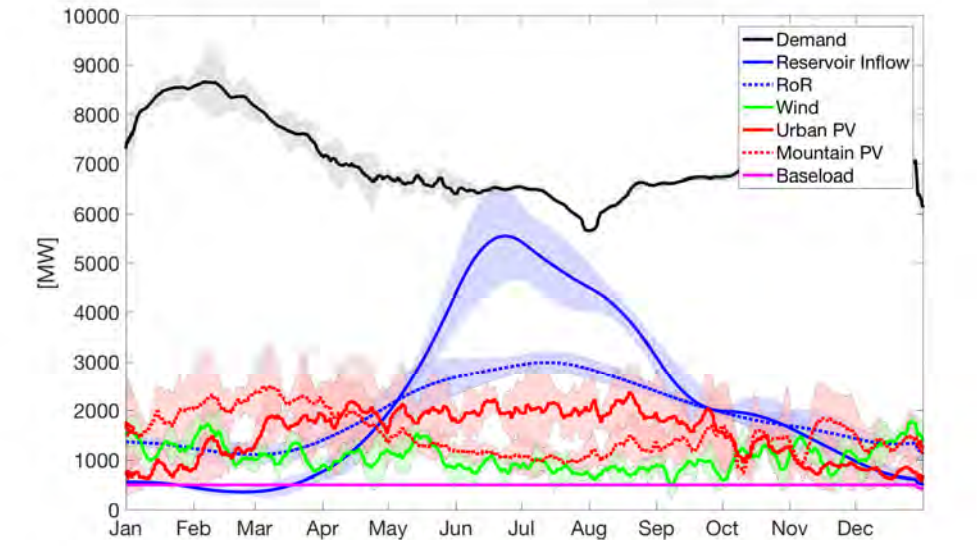
Distribution of incoming global irradiance (Heliomont product by MeteoSwiss) in Switzeland (2011 – 2016).

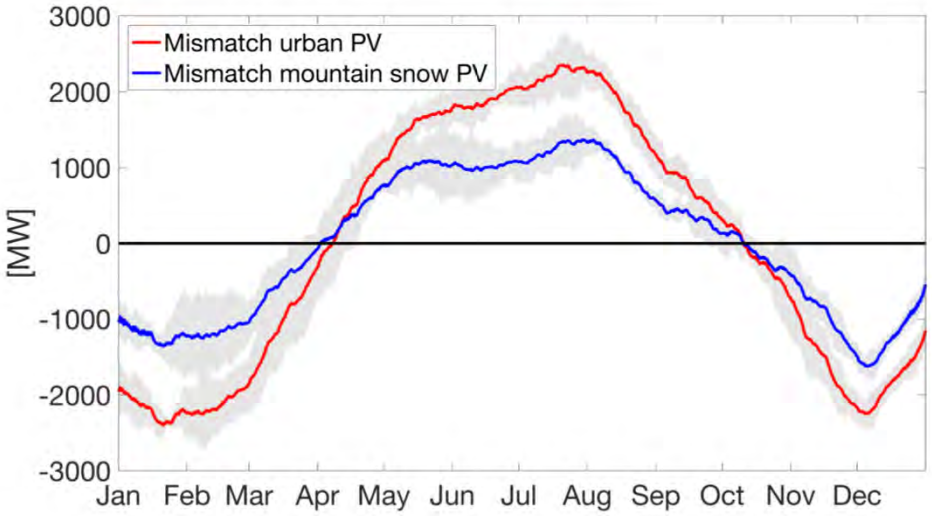
Winter shows an even stronger increase with elevation



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

Significant seasonal mismatch reduction





This mismatch reduction also reduces the required import of energy

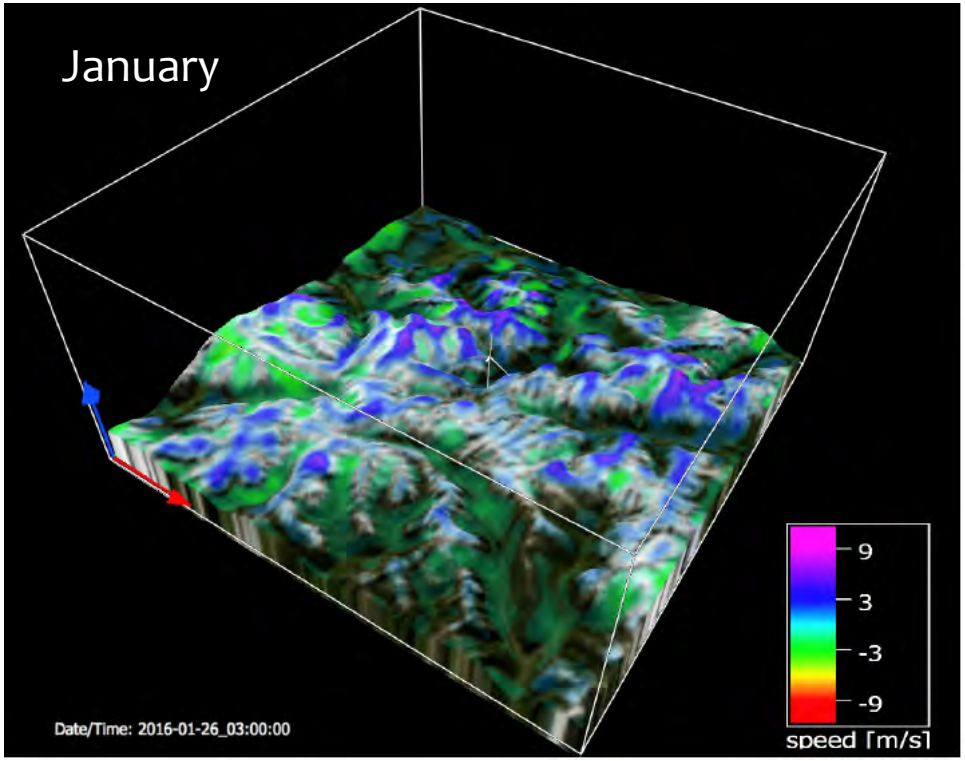
	Panel tilt	PV area
urban	40°	53km²
mountain	90°	42km²

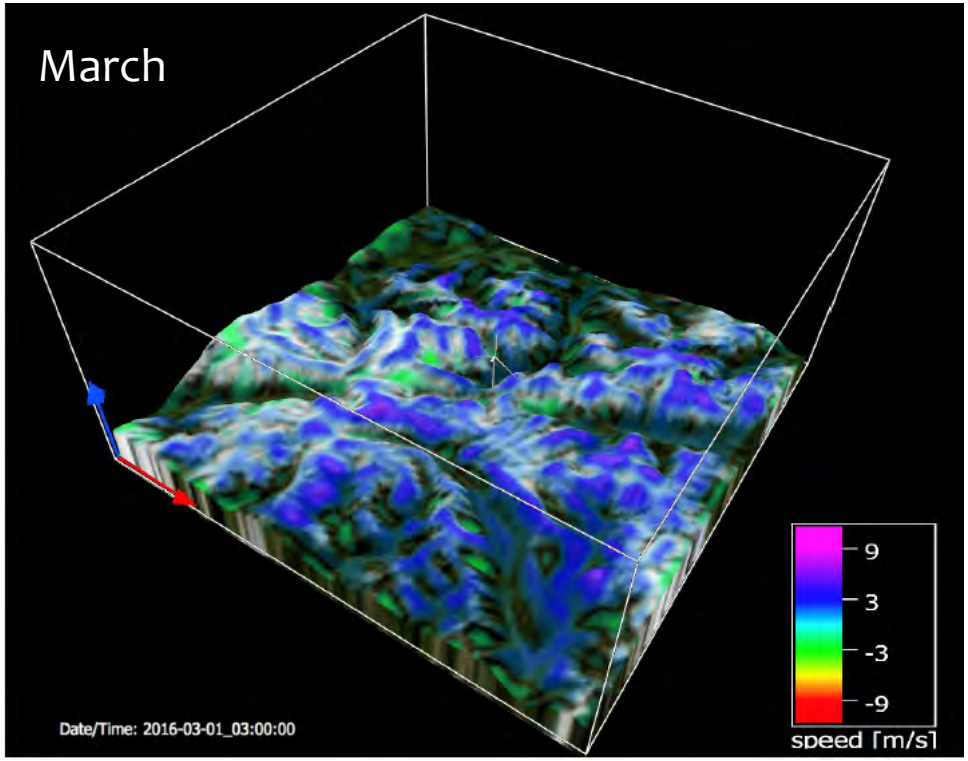
Annelen Kahl, Jérôme Dujardin, Michi Lehning, PNAS 2019;116:4:1162-1167

Cetero Censeo: WRF-HR simulations show untapped wind potential in complex terrain

- **Difference** in wind speed estimates between COSMO2 (2.2 km resolution) and WRF (450 m resolution)
- Two specific weather situations

Main Alpine passes around Andermatt (Gütsch). WRF provides more accurate results.





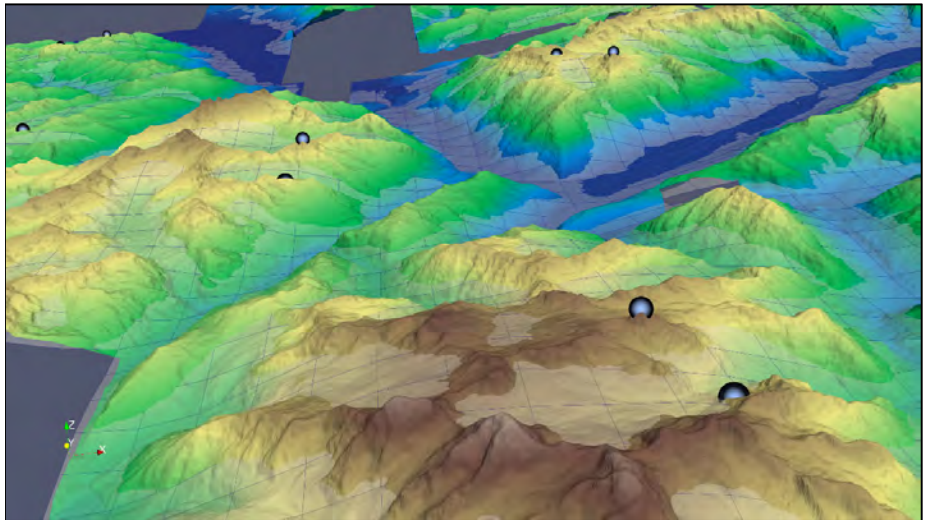
Cetero Censeo: How to better characterize wind potential using IMIS observatins?

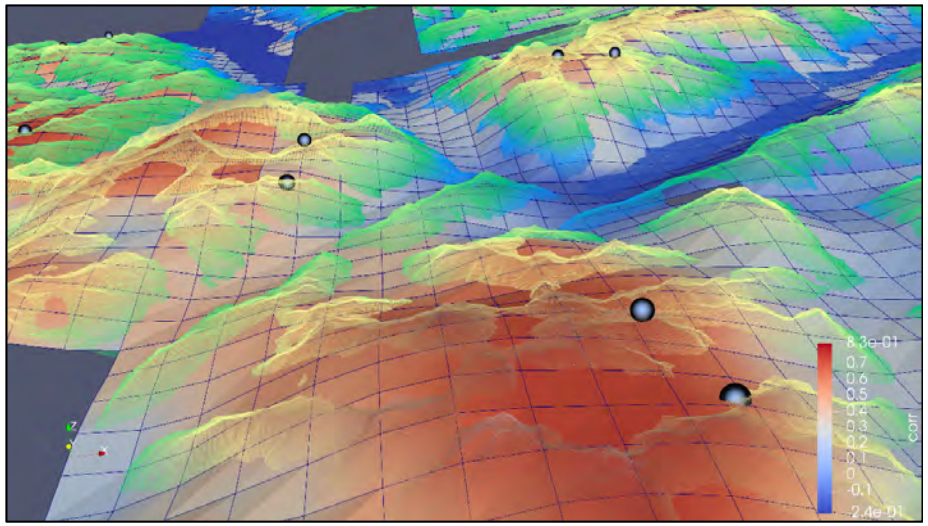
Difference in topography (25 m) to COSMO (1.1 km) grid

- Strong smoothing
- Wrong valley volumes and peak heights
- Incorrect IMIS microtopography

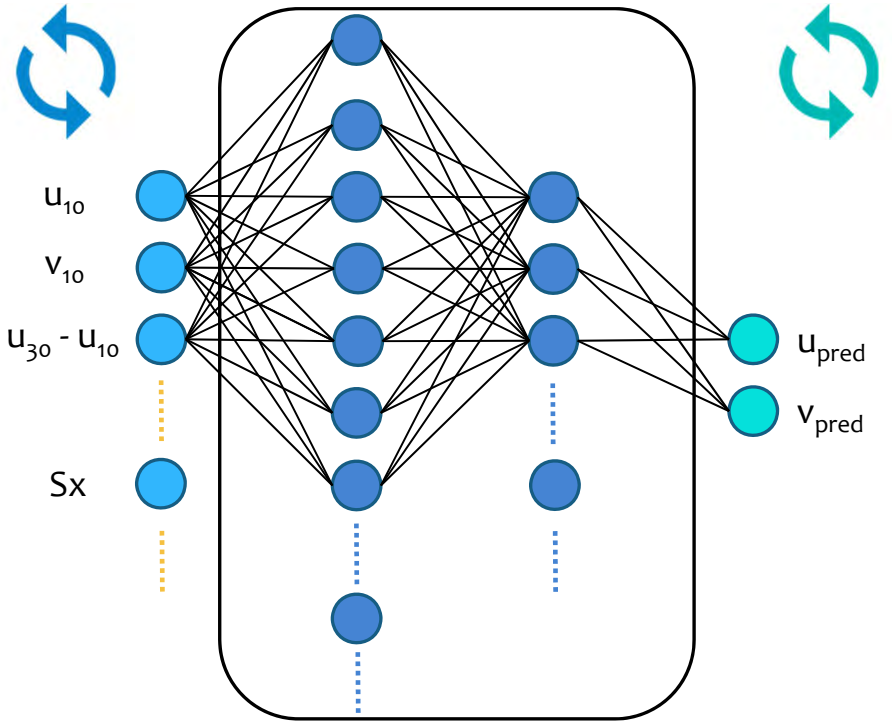
Correlation between COSMO and IMIS:

- Best correlation not at the nearest grid point
- Insufficient distinction between wind- and snow stations



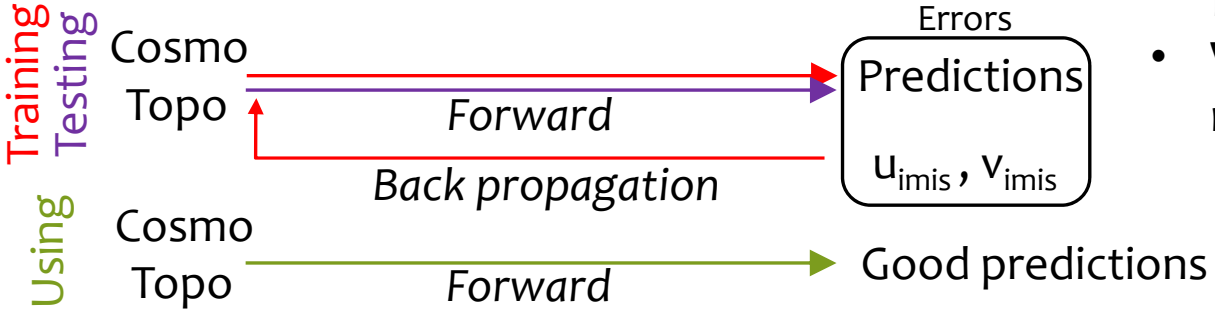


Combining ML approaches with measurements and topography-based flow footprints



→ **Mapping function** between:

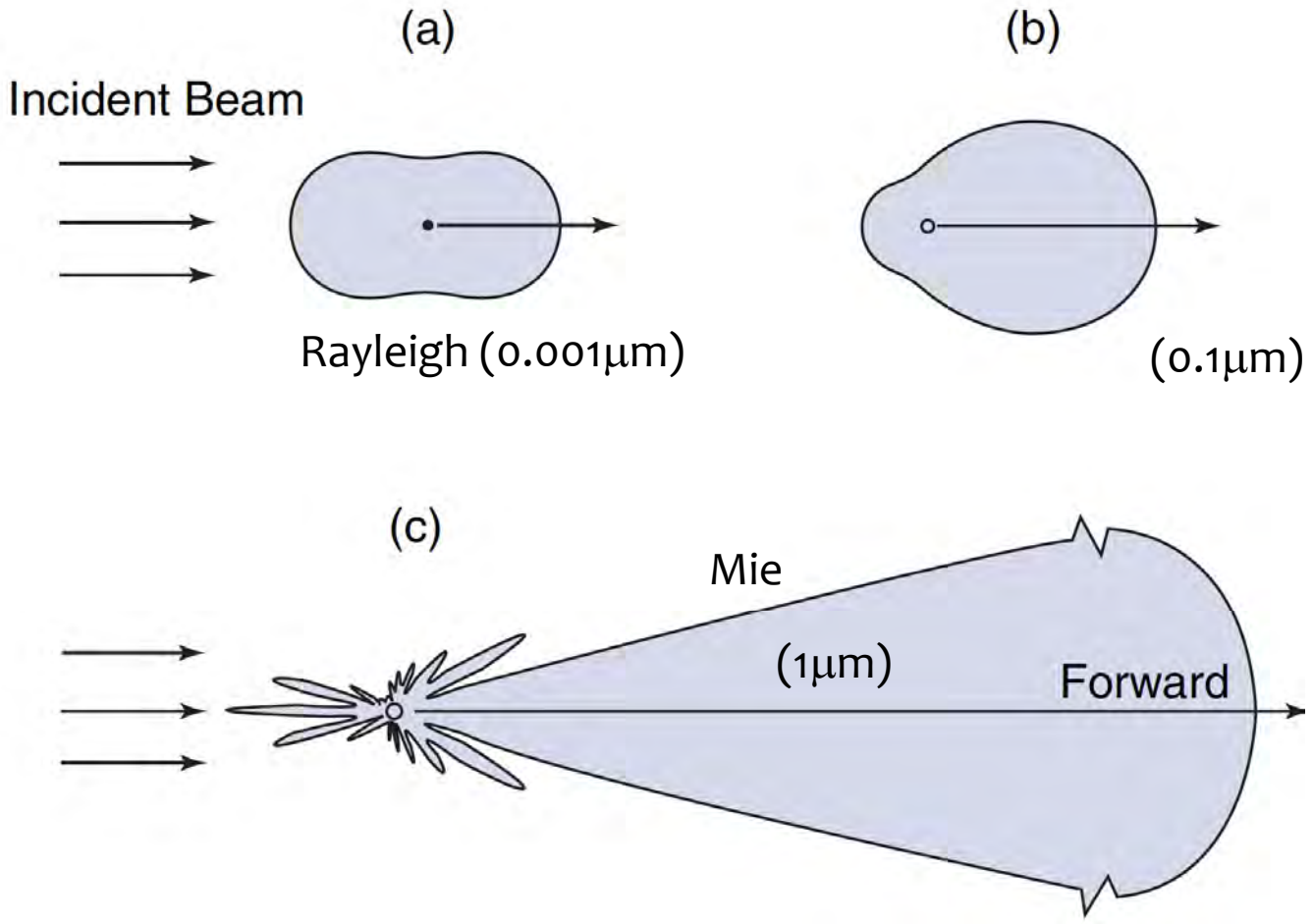
- Atmospheric state above the station (Cosmo data)
- Local topography VIA FLOW FOOTPRINTS
- True wind (IMIS)



- **Easy** to be good on training data
- **Not too hard** to do well at other times (test times or forecasts)
- **Very hard** to generalize well to new locations (test stations)

Back to radiation: The effect of snow

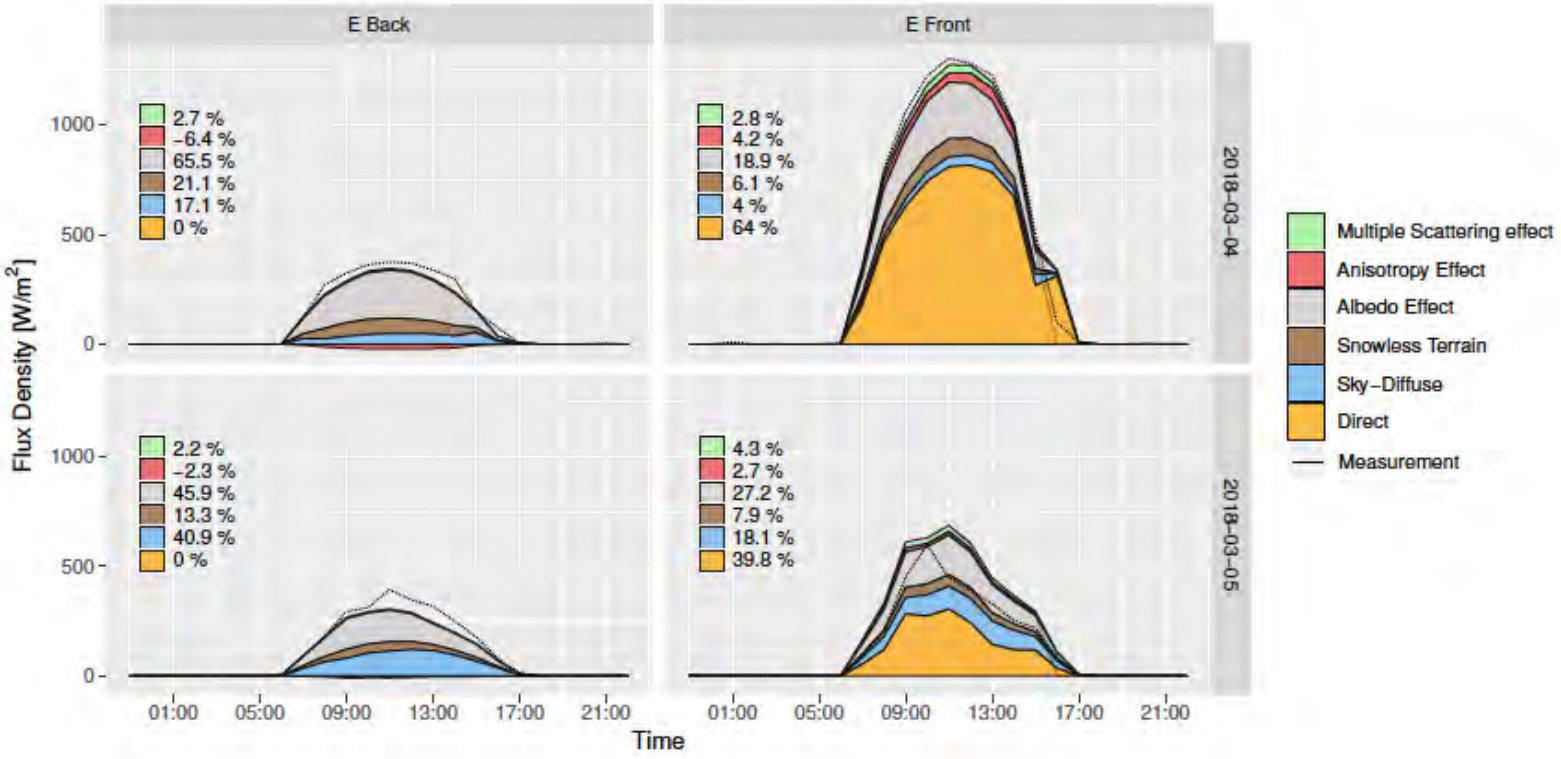
Snow is ”forward scattering”, multiple reflections from terrain and between clouds and snow covered surface



Directional probability distribution for scattered radiation.

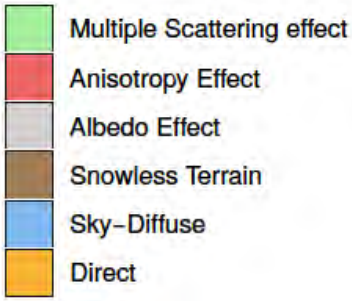
The effect of snow on solar panels

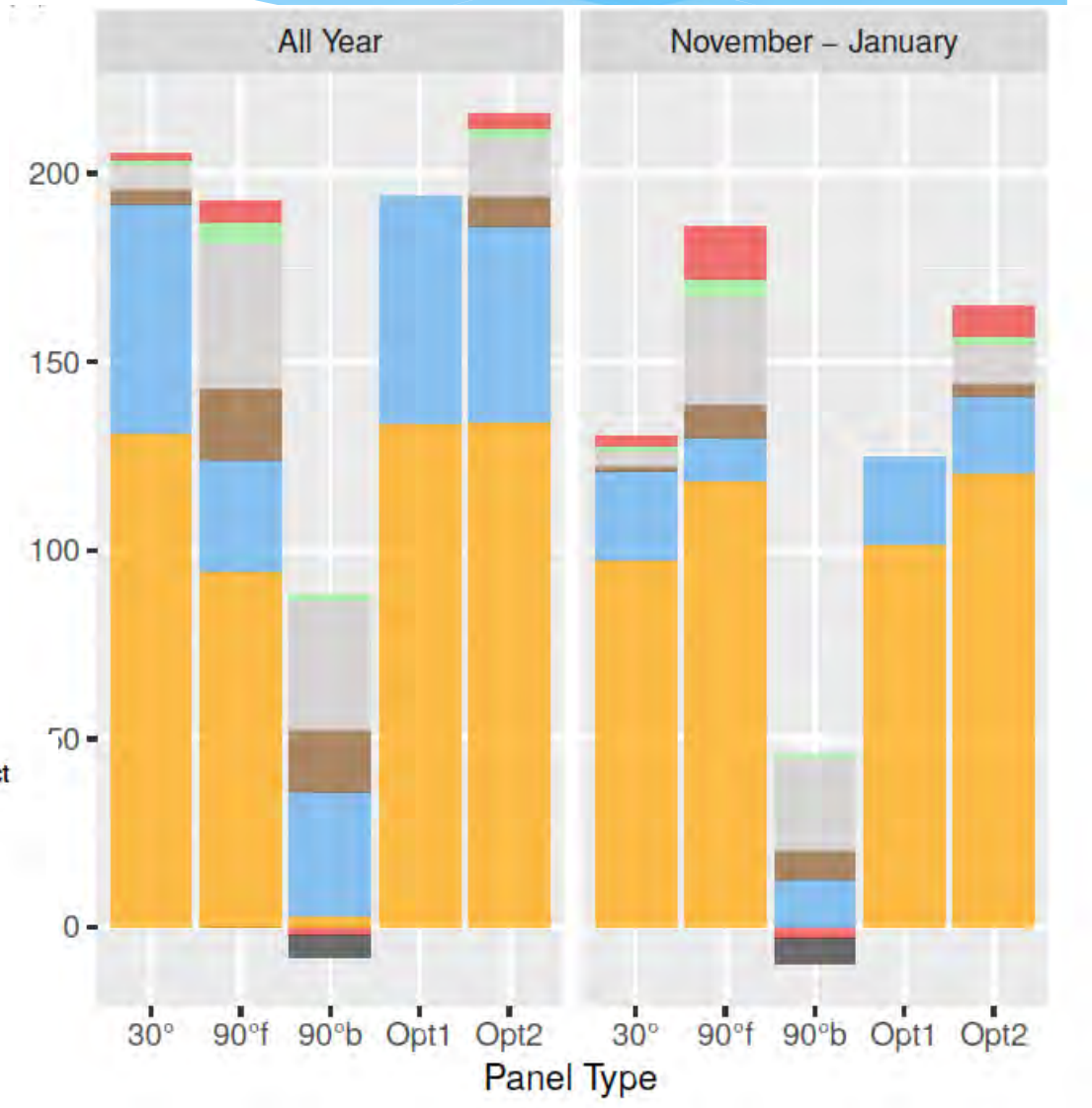
Totalp Installation (EKZ+ ZHAW)



The effect of snow on solar panels

- 30° South
- 90° South
- 90° North
- Optimal not considering terrain
- Optimal considering terrain





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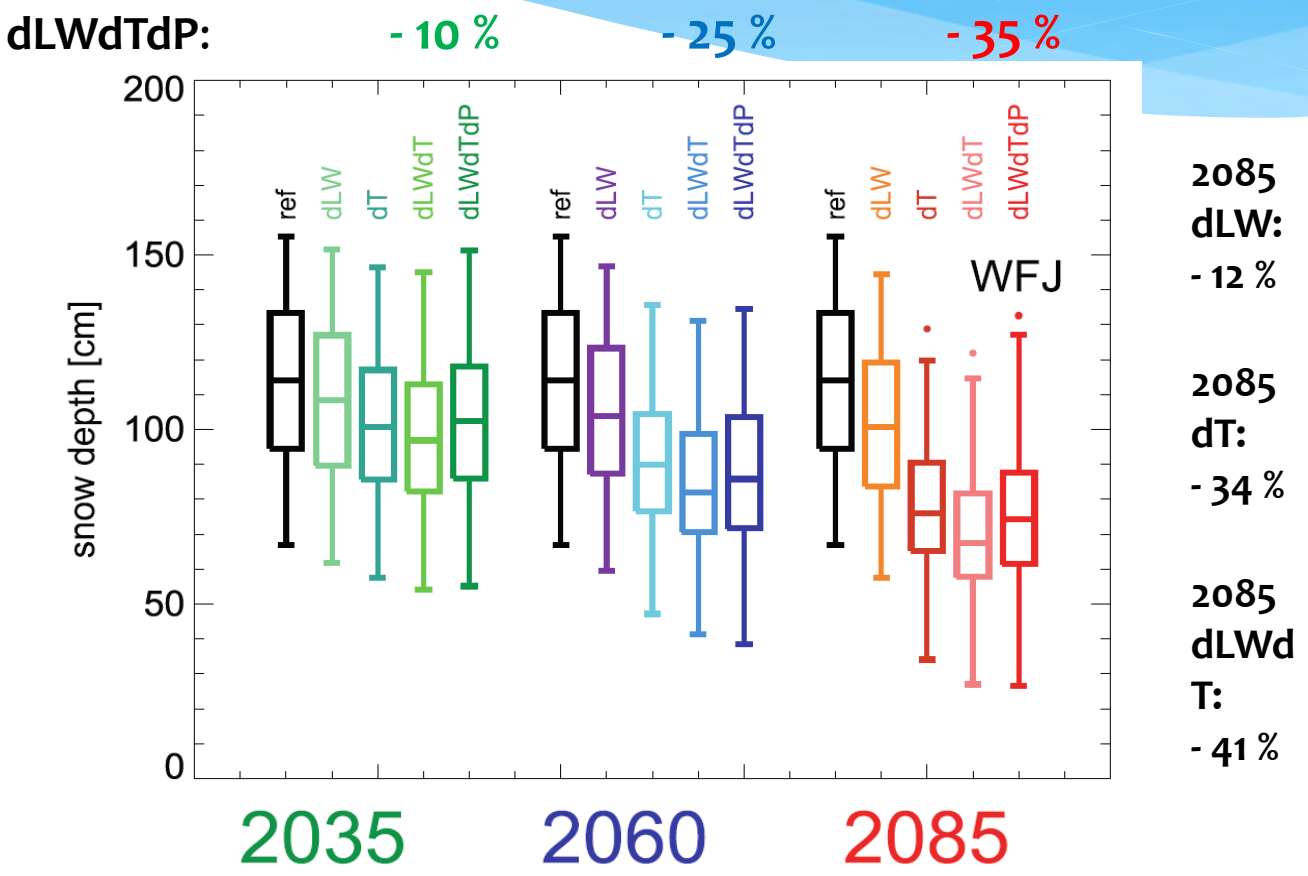
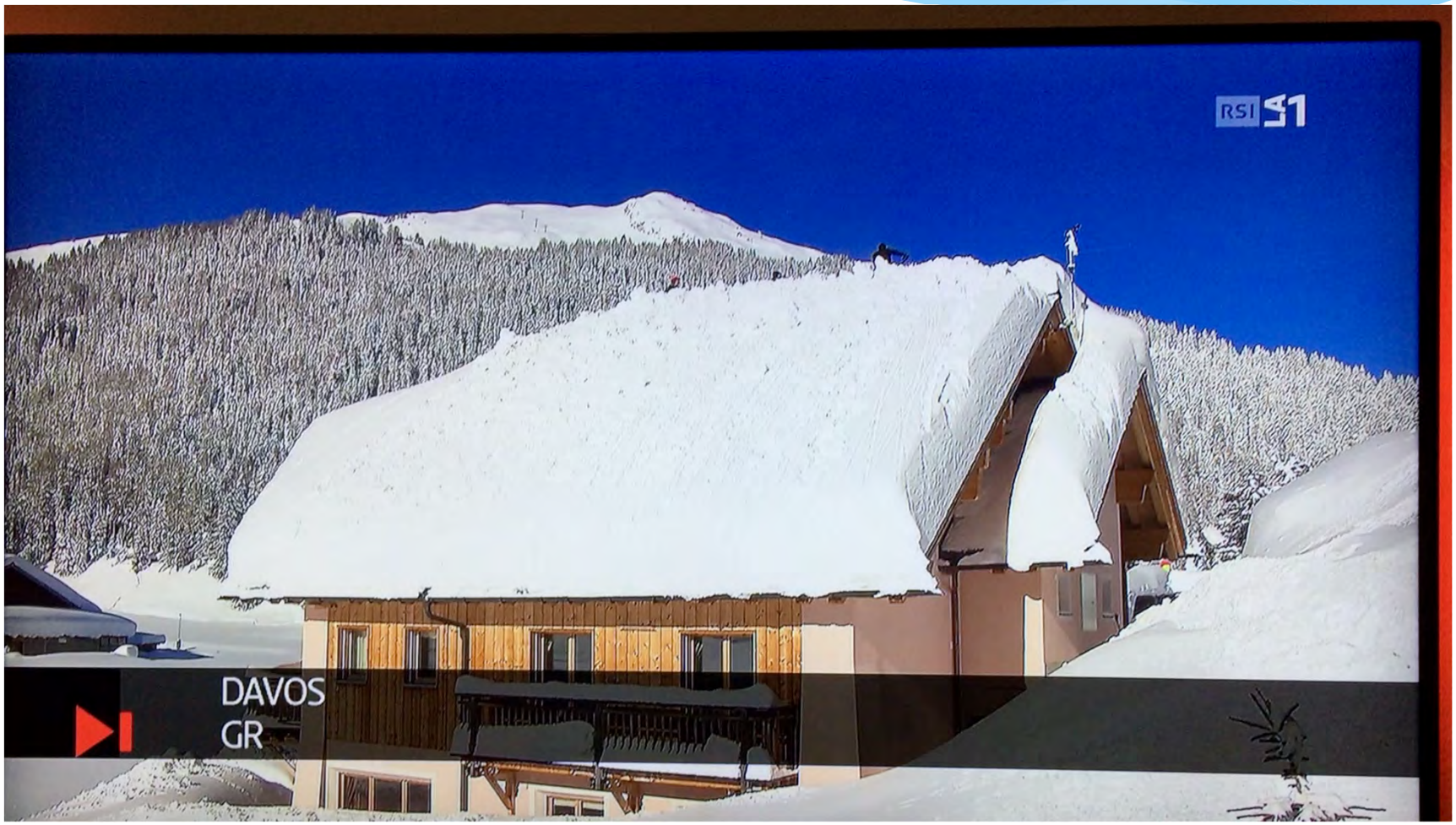
Future Snow: Decrease of mean snow depth at WFJ



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

A real world example from my house (Davos Laret)



What to do next

Two Suggestions:

- Develop Model “Search Engine for Maximum Yield Locations”
- Develop Control Module “Thermal Snow Removal from PV Panels”

→ Significant Contribution to the Swiss Energy Change

Conclusions

* Existing Infrastructure in the Alps should be used for PV and Wind installations
  * Reduces the Winter Energy Gap
  * Reduces Dependency from Import
  * Solutions for Snow Removal need to be developed
* 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