Evaluation of thermally driven local winds in the Swiss Alps simulated by a high-resolution NWP model

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Background

- Thermally driven local winds are key feature of local mountain weather and climate.
- Along-valley winds in large Alpine valleys well simulated by COSMO model at 1 km resolution, except for station Sion in Rhone valley (Schmidli et al., 2018).

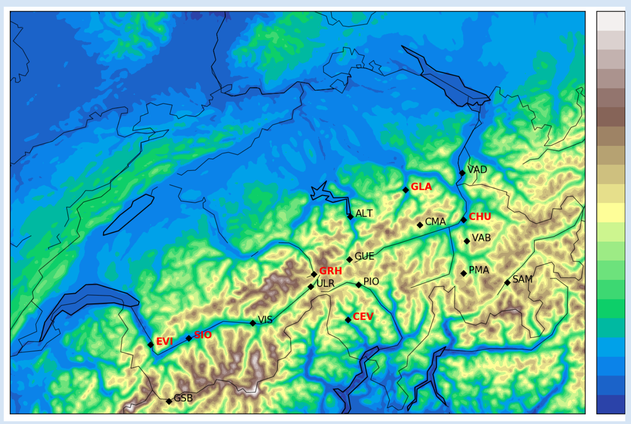
Objectives

- **Accuracy of simulated along-valley winds in typical NWP configurations?**
- **Most important factors influencing the accuracy?**
- **What is cause of poor skill for Sion?**

Experimental setup

Model setup

- Model: COSMO 5.06b; 80 levels
- Initial and BCs from MeteoSwiss analysis (1.1 km)
- Standard physics options, based on operational setup at MeteoSwiss (no shconv; $K_{\min} = 0.1$)
- Simulation period: September 2016 + 2 days spin-up
- ASTER topography (30 m), GC2009 land cover (300 m), HWSD soil (1 km)
- Integration domain: ca 830x830 km



The valley wind stations and topography [m].

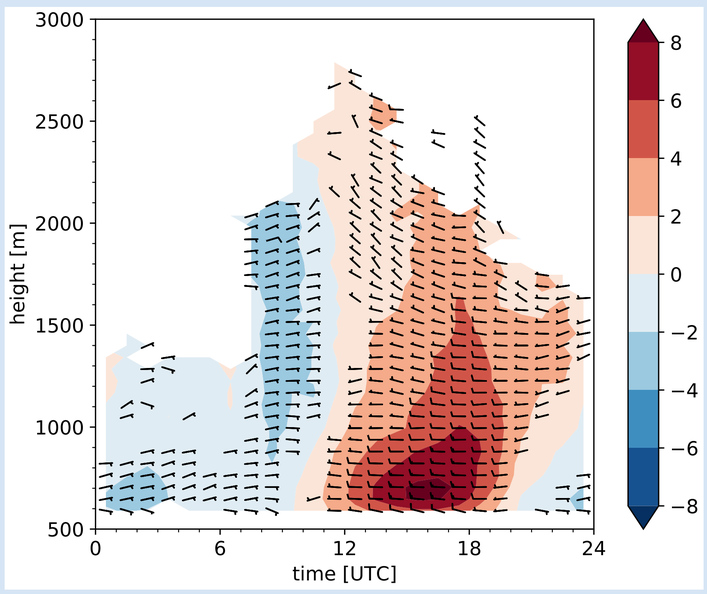
Experiments

Experiment	Δx [m]	initial soil moisture
c1ref	1100	COSMO-1 analysis
c1wet	1100	+30 %
c500r	550	COSMO-1 analysis
c500w	550	+30 %

Observations

- Hourly data from the SwissMetNet station network for September 2016
- Wind profiler data collected at Sion airport
- Sounding data collected at Payerne

Wind climatology in Sion



Mean diurnal cycle of the valley wind in September 2016, average over 19 days classified as valley wind days. Shown are along-valley wind speed (color shading) and wind direction with respect to valley axis (barbs).

Evaluation of valley winds in Swiss Alps

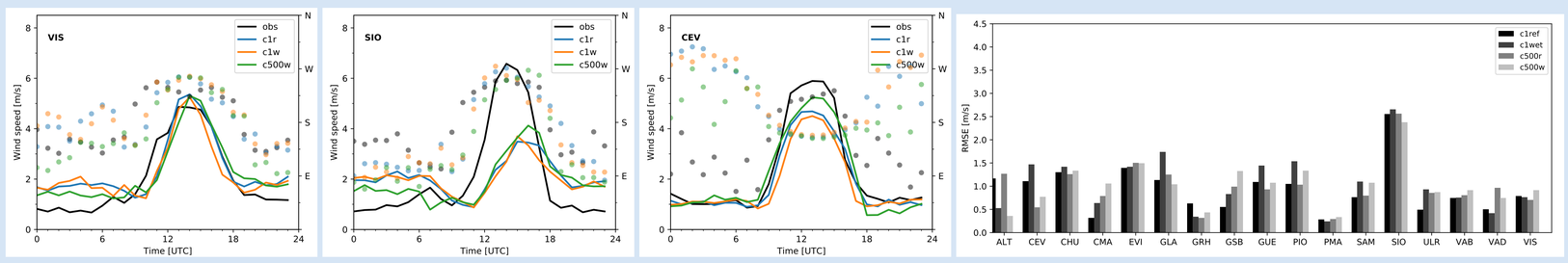
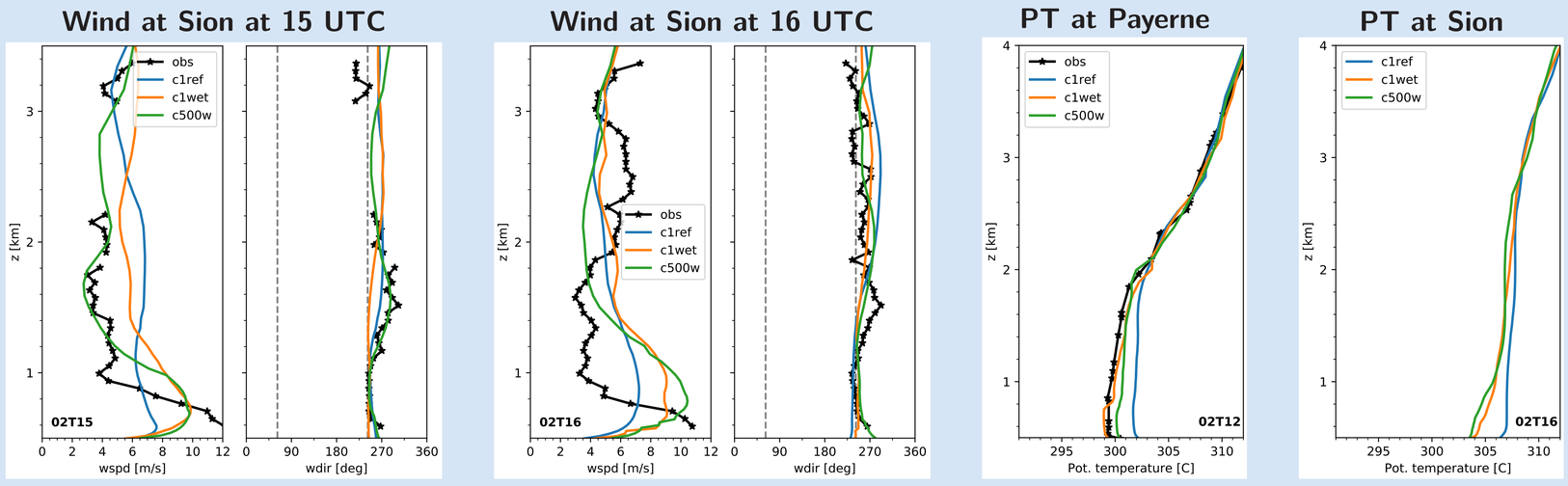


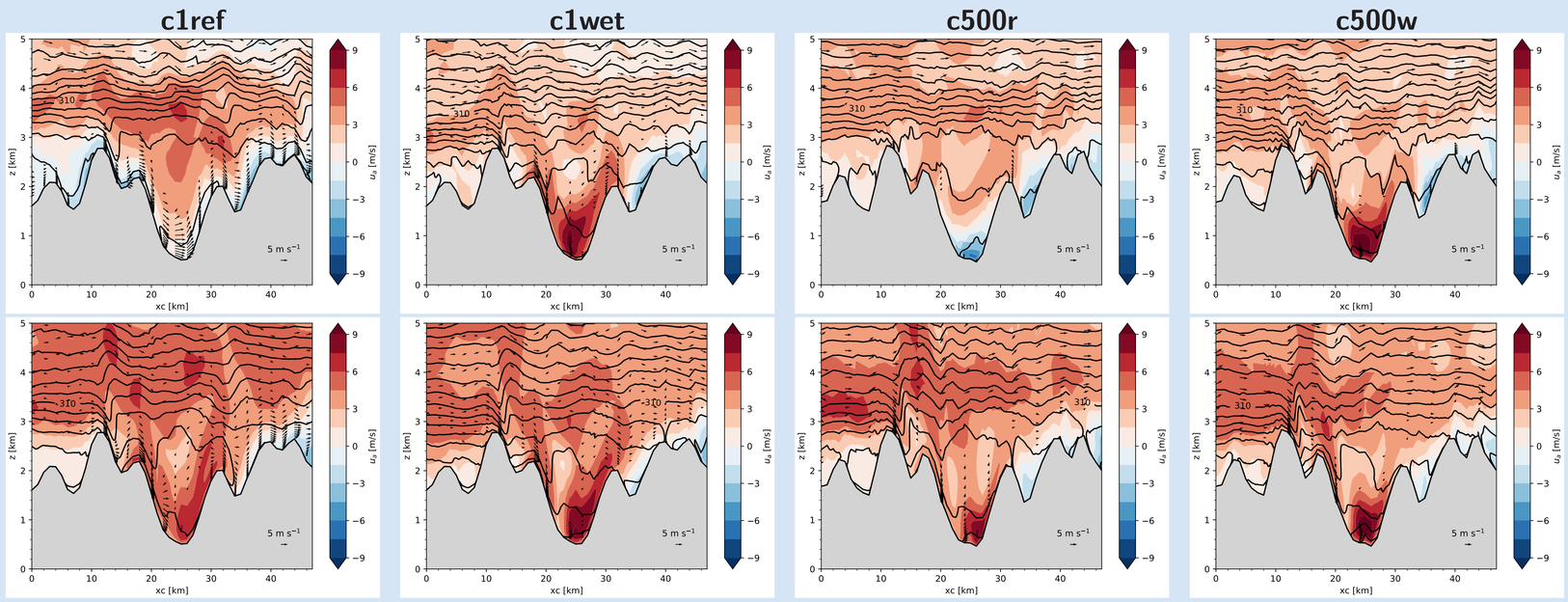
Illustration of mean diurnal cycle of the valley wind for valley wind days in Sep 2016 for three stations (Visp, Sion, Cevio). RMSE largest for Sion (right panel).

Vertical structure of valley wind at Sion

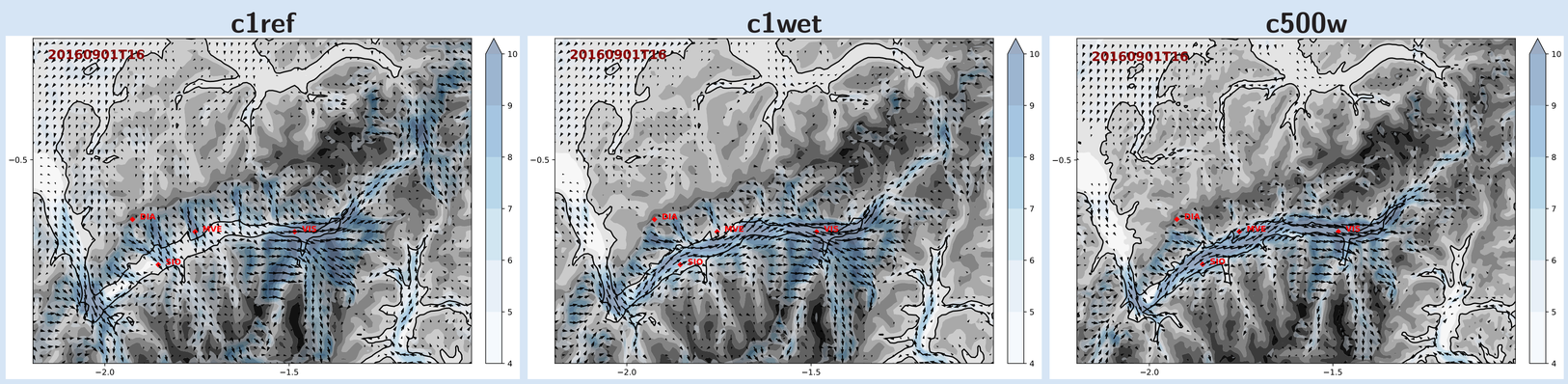


Observed and simulated wind and potential temperature profiles (PT) on 2 Sep 2016.

Impact of soil moisture and resolution on the valley wind

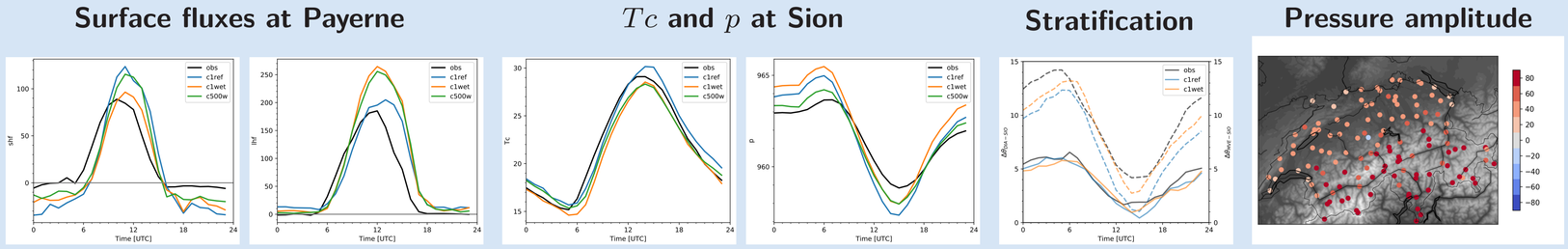


Cross section showing along-valley wind speed (color) and potential temperature (isolines) at 16:00 UTC for different model configurations for Sep 1 (top panels) and Sep 2 (bottom panels).



Horizontal wind direction (arrows) and wind speed (color, in m/s) at 200 m AGL for the different model configurations for 1 Sep 2016 at 16:00 UTC.

Analysis of surface forcings



Mean diurnal cycle of surface fluxes, temperature, pressure, valley stratification, and comparison of simulated (c1ref) and observed diurnal pressure amplitude.

References

Schmidli, J., S. Böing, and O. Fuhrer, 2018: Accuracy of simulated diurnal valley winds in the Swiss Alps: Influence of grid resolution, topography filtering, and land surface datasets. Atmosphere, 9, 196.

Schmid, F., J. Schmidli, M. Hervo, and A. Haefele, 2020: Diurnal valley winds in a deep alpine valley: Observations. Atmosphere, 11, 54.

Conclusions

- **Consistent underestimation of up-valley wind strength at Sion in COSMO-1 (Jul 2006 and Sep 2016)**
- **Simulated up-valley wind (c1ref) disturbed by katabatic cross-ridge flow penetrating to valley floor**
- **Cross-ridge flow too strong (c1ref), due to too deep upstream BL and too weak stratification in valley; simulated up-valley flow much improved for simulation with increased soil moisture (c1wet, c500w)**
- **Further cause of underestimation: core of simulated up-valley jet not over Sion, while in reality local valley geometry leads to an additional acceleration of the along-valley flow**