# Topographic correction of radiation – relevance for snow cover

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# Introduction

**Snow cover evaluation (on European scale)**

- 12/2.2 km 10-year COSMO simulation (ERA-Interim)
- Comparison of snow cover extent with MODIS snow product

**Topographic effects on surface radiation in complex terrain**

- COSMO scheme that considers (subgrid) effect of topography on radiation
- First sensitivity experiments with SNOWPACK

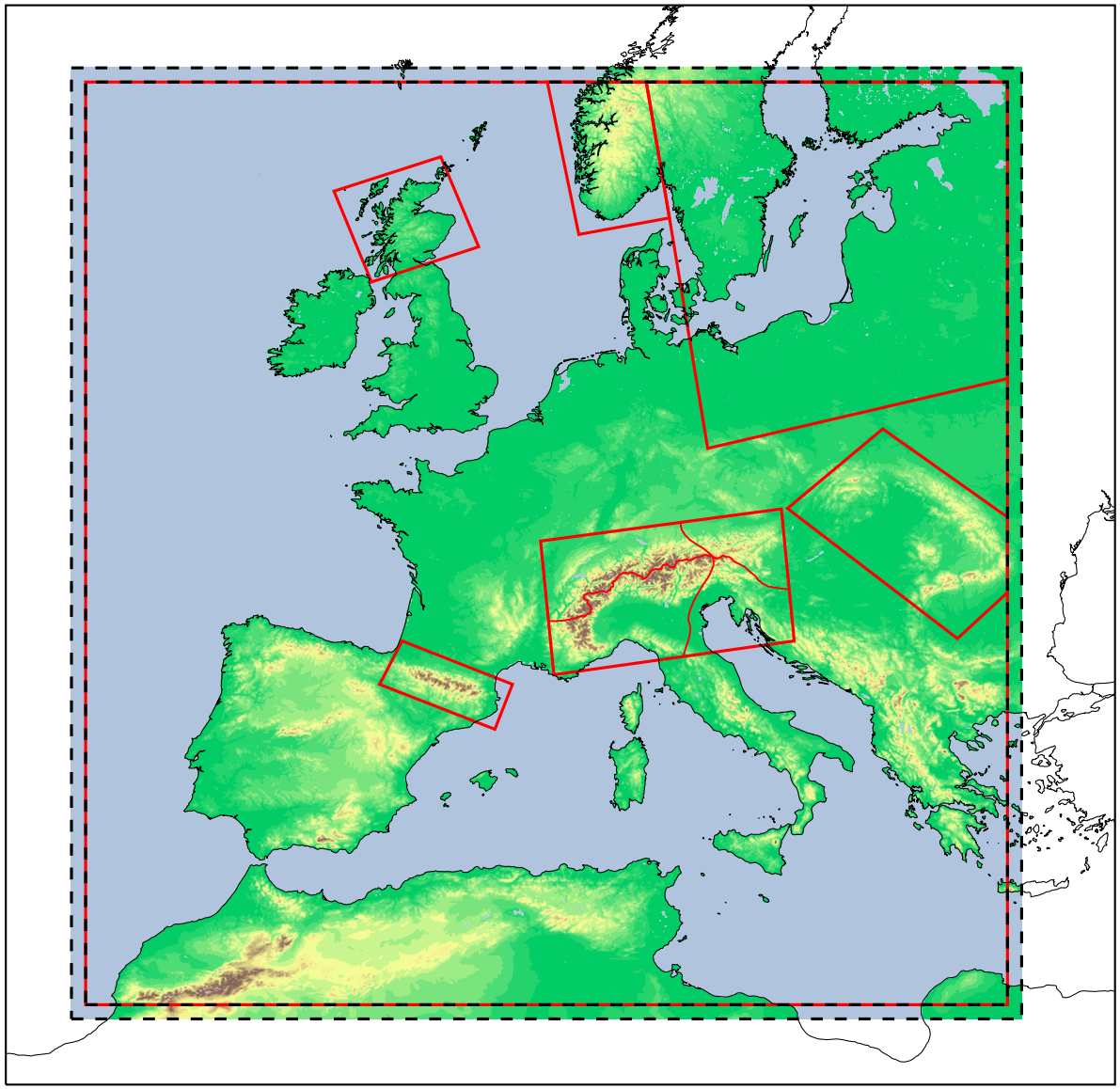
**Conclusions & outlook**

- Preliminary conclusions
- Outlook, open questions and technical details

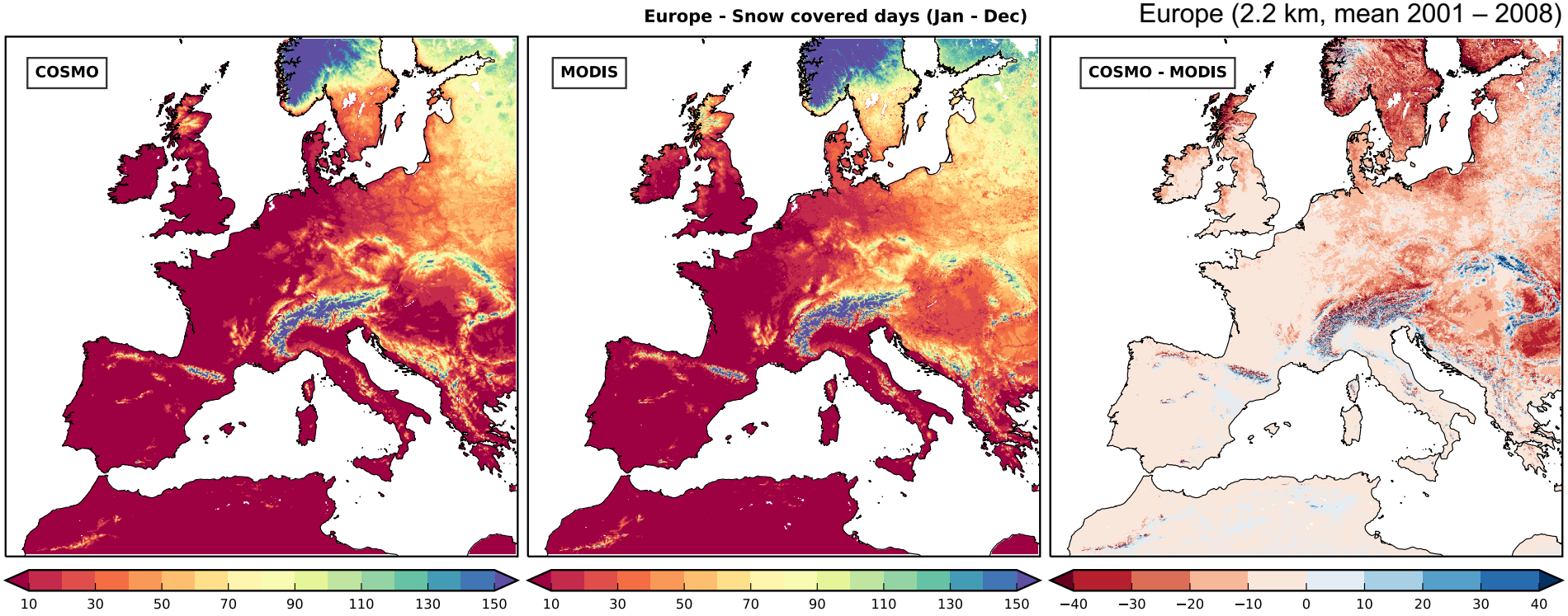
# COSMO European-scale 12/2.2 km climate simulations

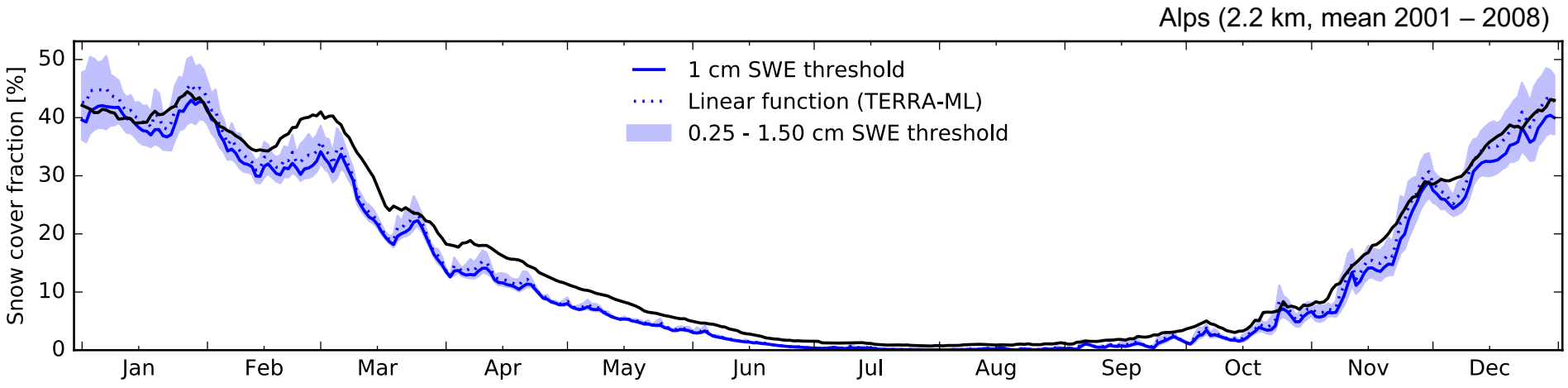
**Details**

- Simulation: 1999 - 2008
- ERA-Interim driven
- 2.2 km nested in 12 km
- Red boxes: analysis domains



# Snow cover duration bias (COSMO – MODIS)



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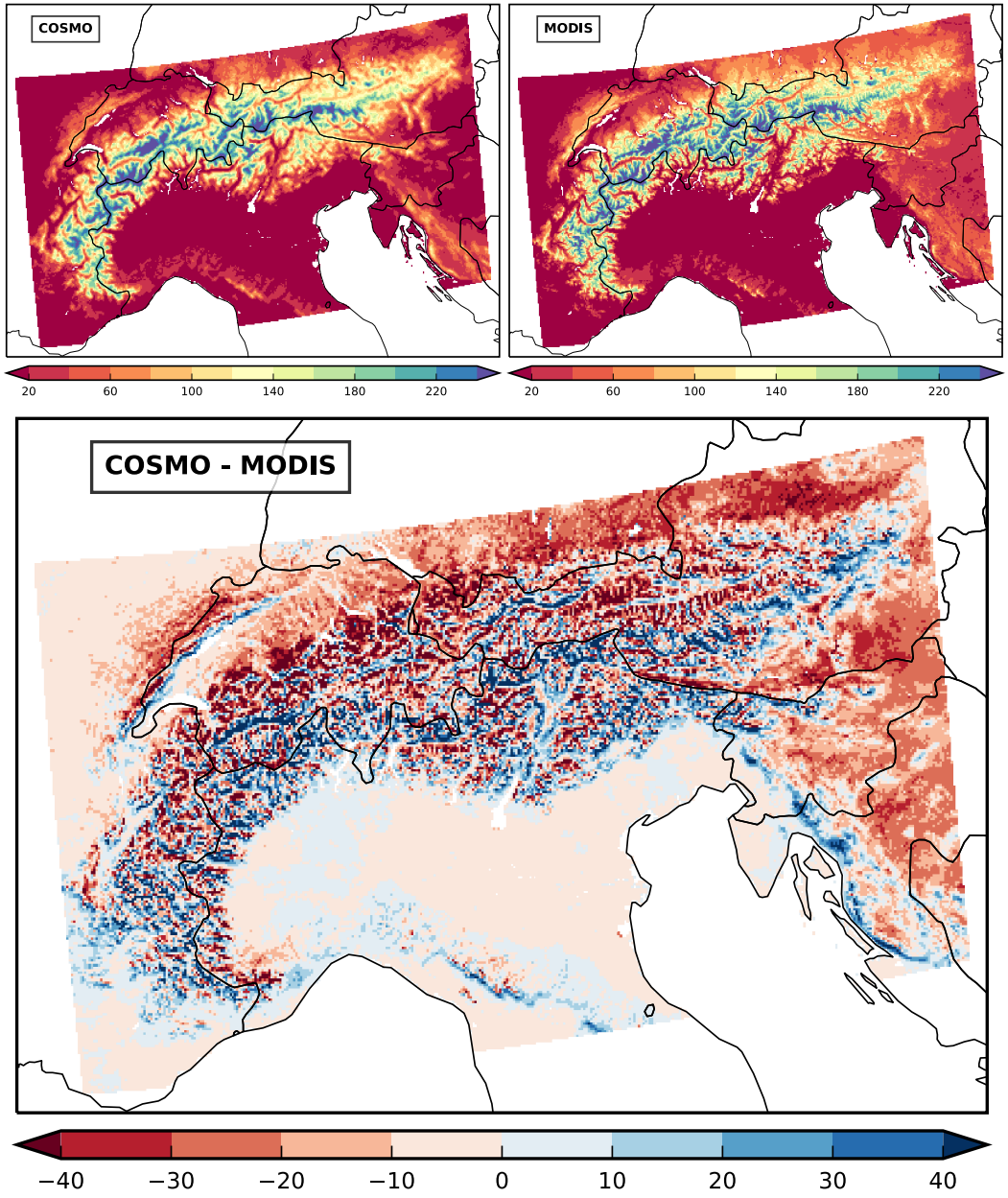


Alps (2.2 km,
mean 2001 – 2008)

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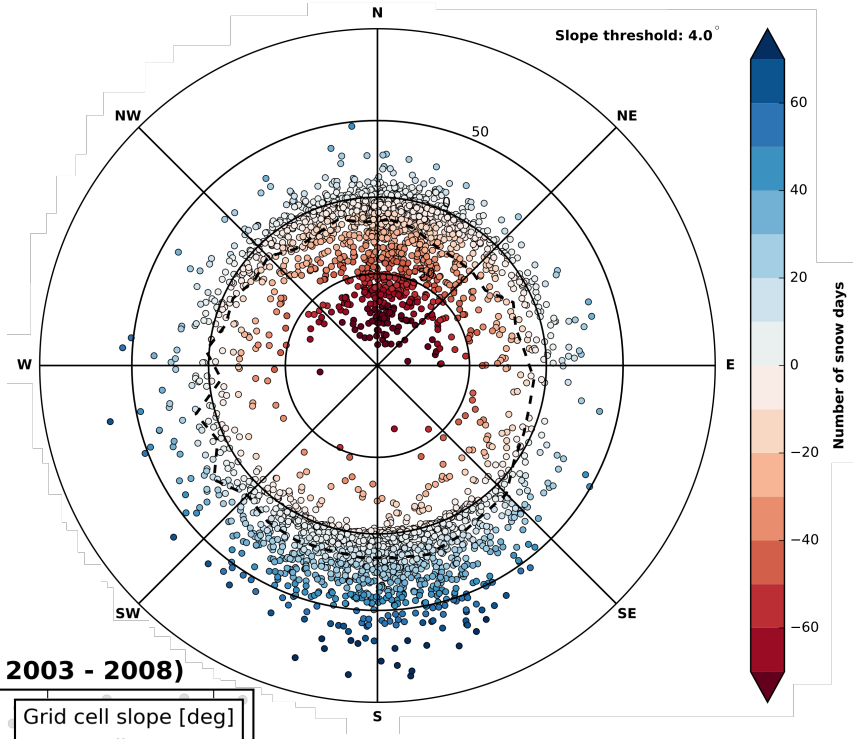
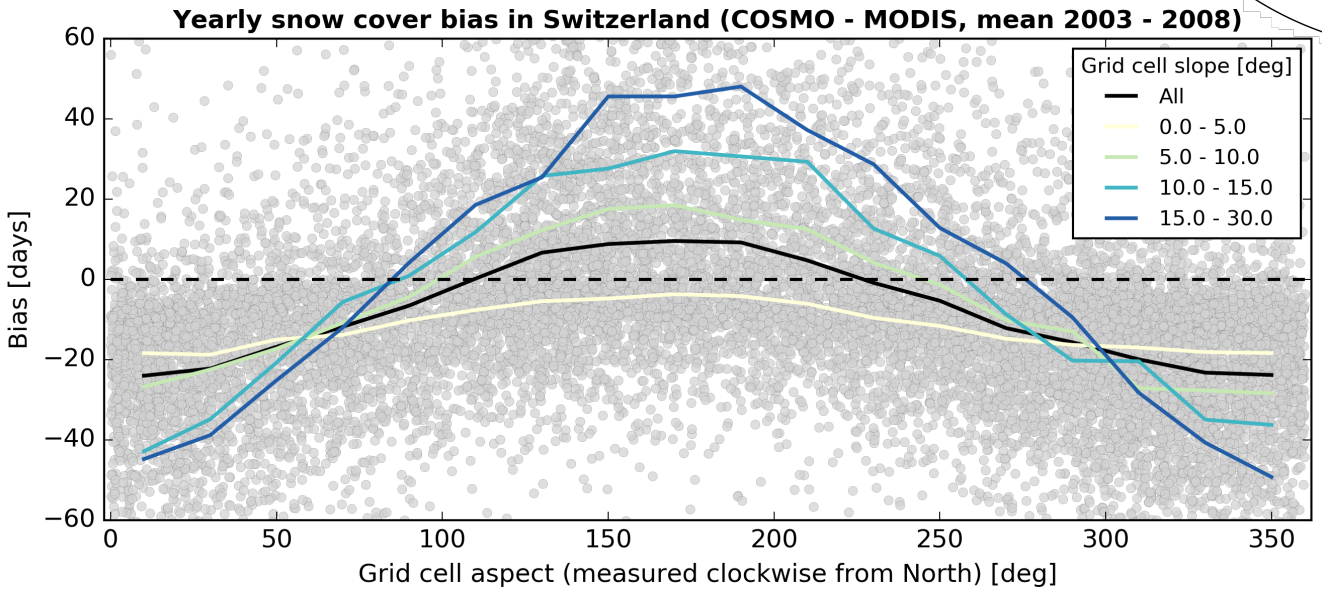



Pyrenees (2.2 km, mean 2001 – 2008)



# Topographical correction of incoming surface radiation

**Motivation**

- Feedbacks to atmosphere (e.g. snow-albedo)
- Improve representation of near-surface variables (e.g. $T_s$, $T_a$) for downstream applications & models

**Introduction**

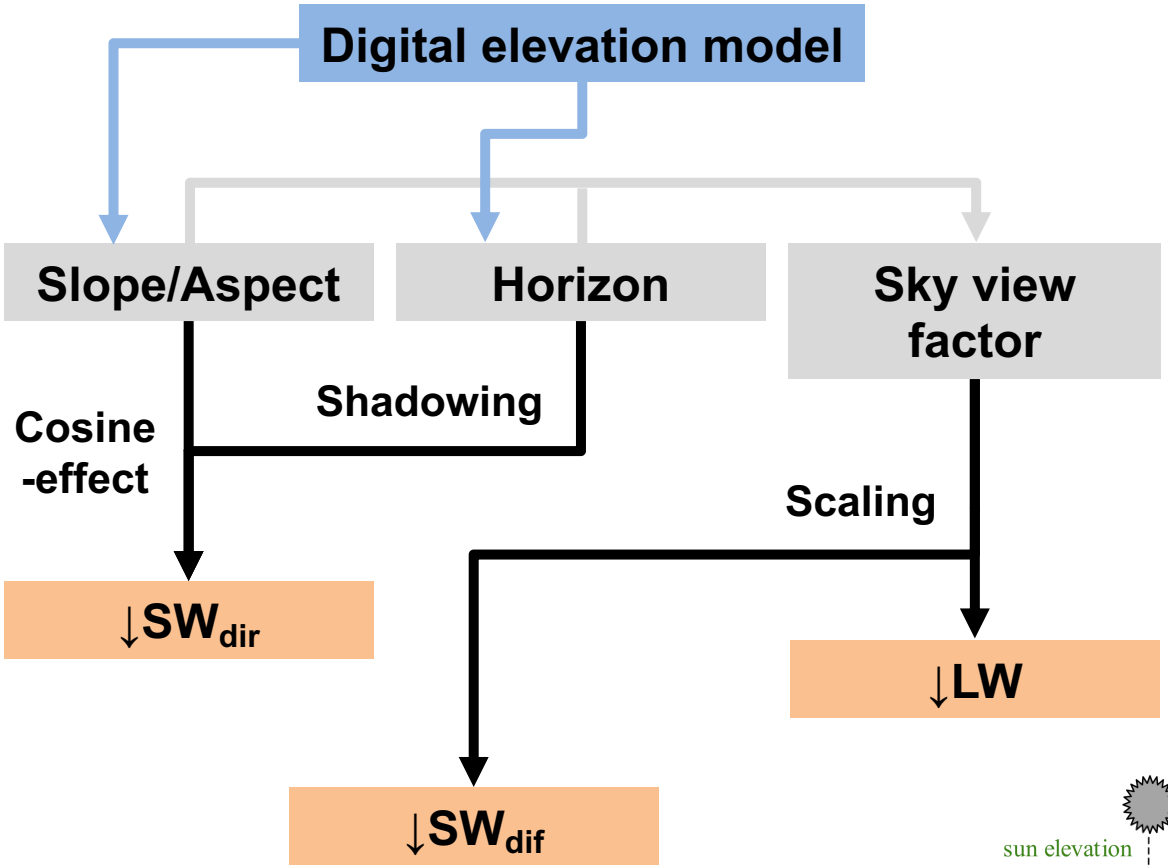
- Issue of (vertically) 1-dimensional radiation treatment → no lateral interaction with e.g. topography
- Only a few RCM consider topographic effects on radiation → e.g. WRF (Arthur et al., 2018)

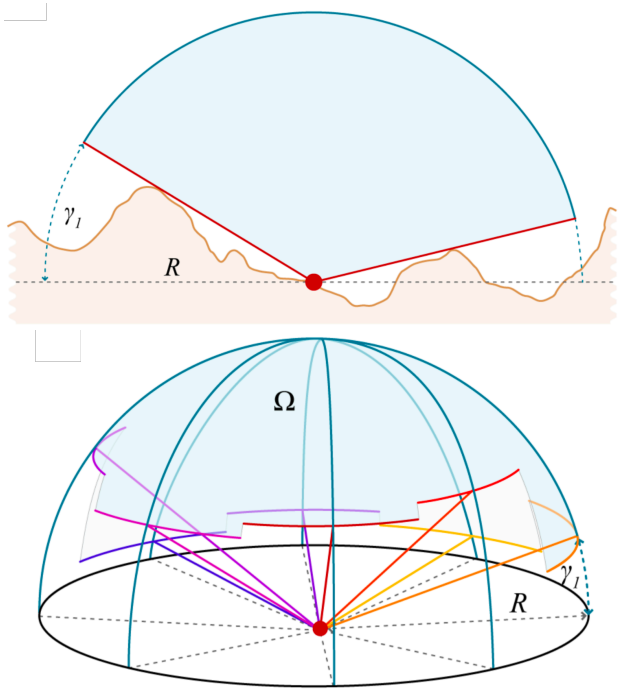
**Disadvantages**

- Scheme is not energy conservative

Tschierv, Val Müstair, 30th March 2019

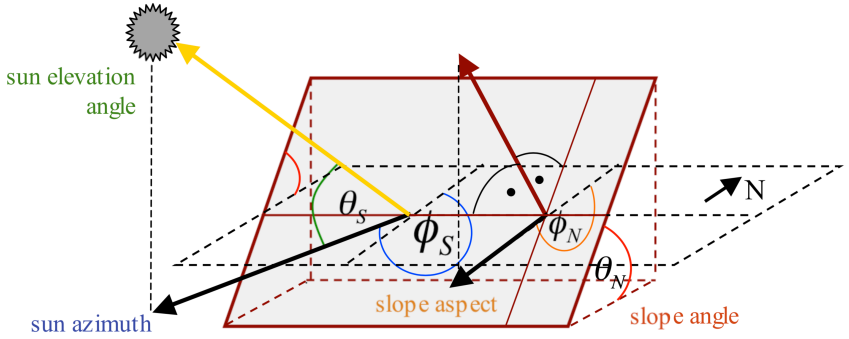
# Overview of radiation correction scheme



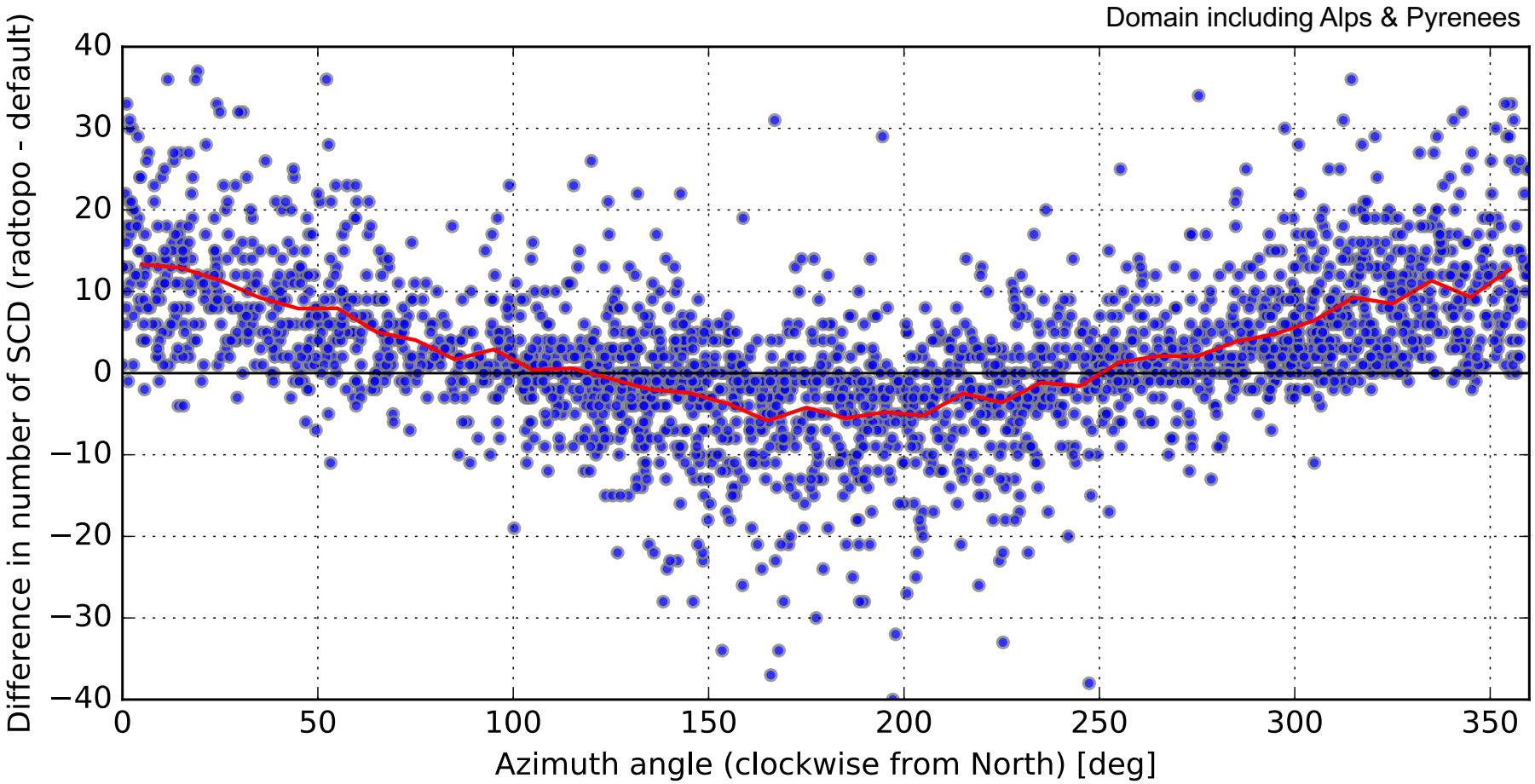

Zakšek et al. (2011)

- ↓$Sw_{dif}$ / ↓LW from environmental terrain
  → assumed to be equal to
  (uncorrected) local ↑SW and ↑ LW

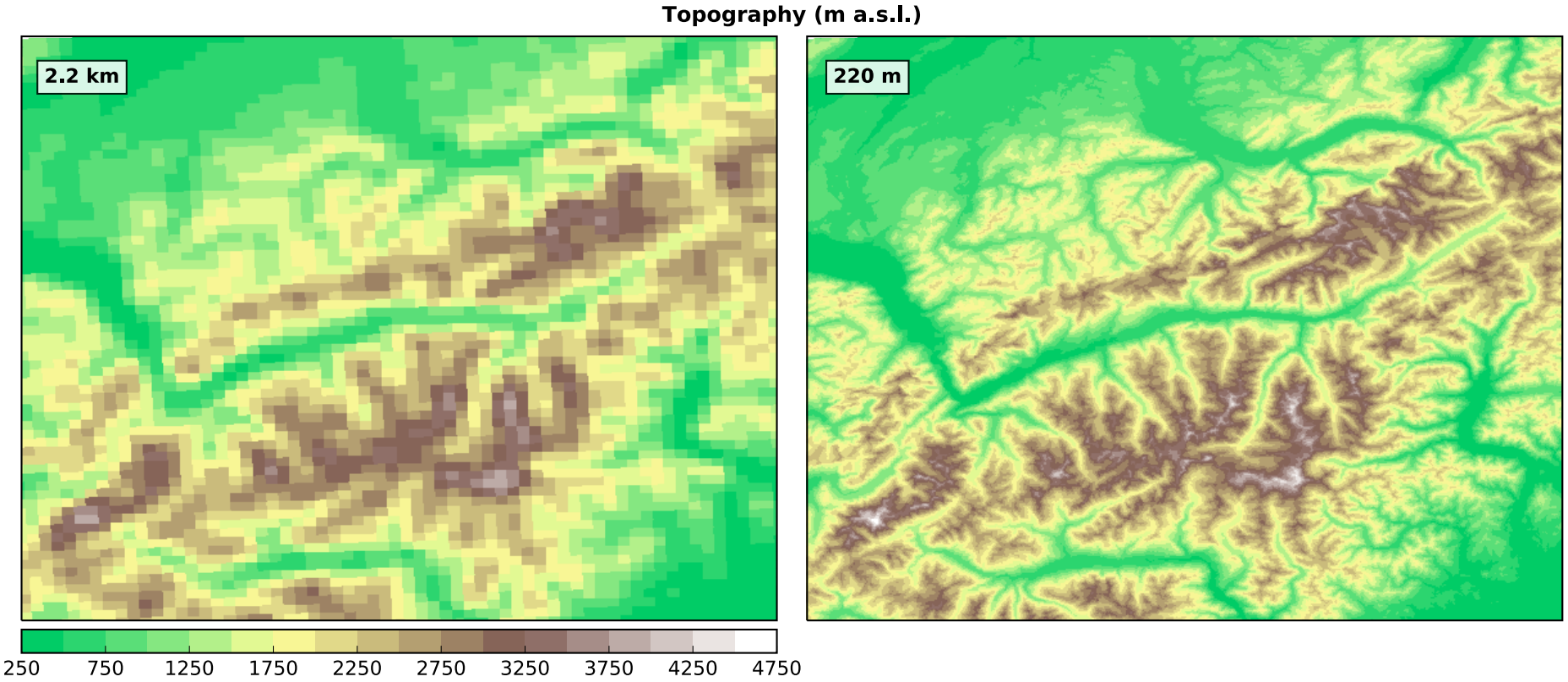



Buzzi (2008)

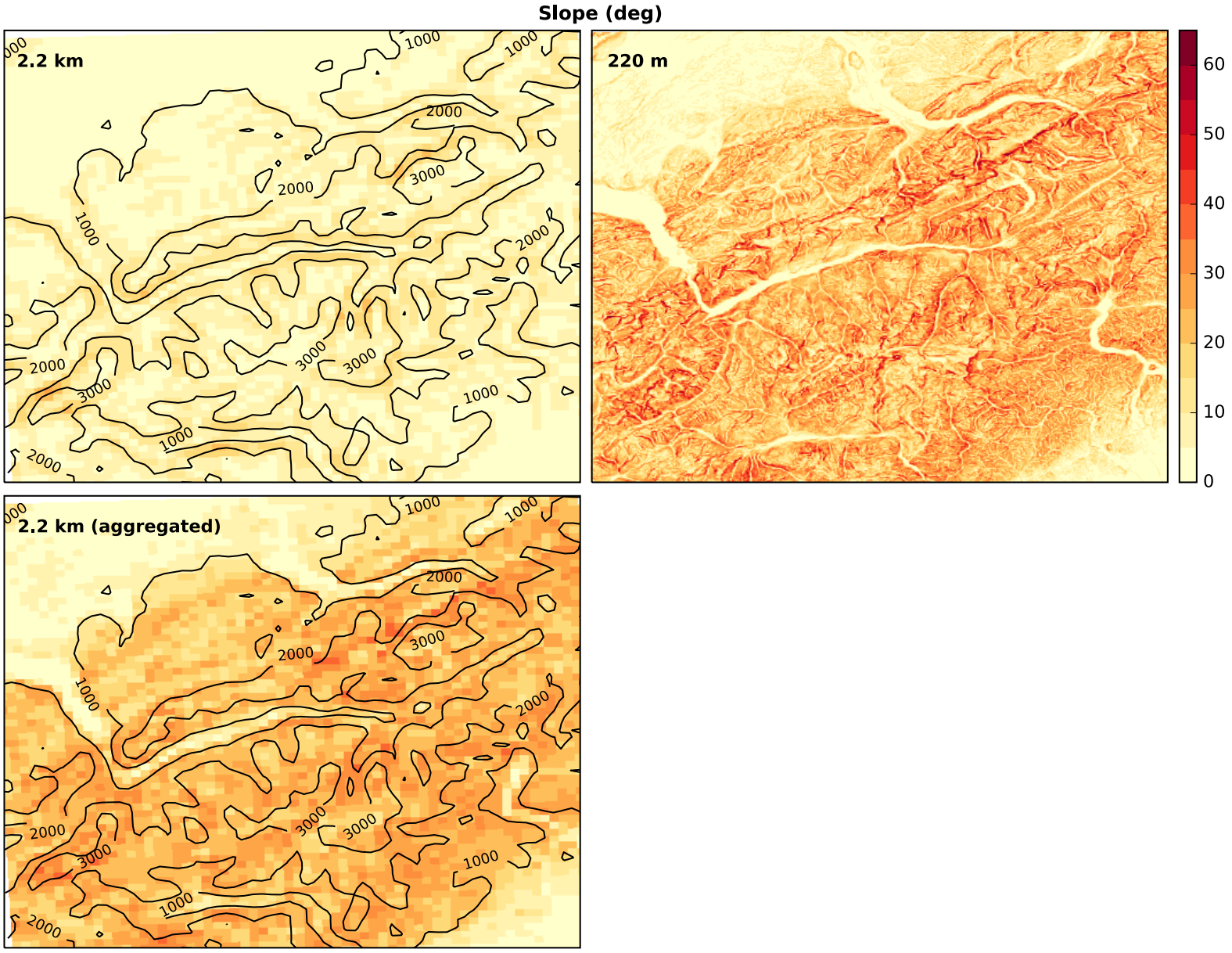
# Test of scheme in 1-year COSMO simulation



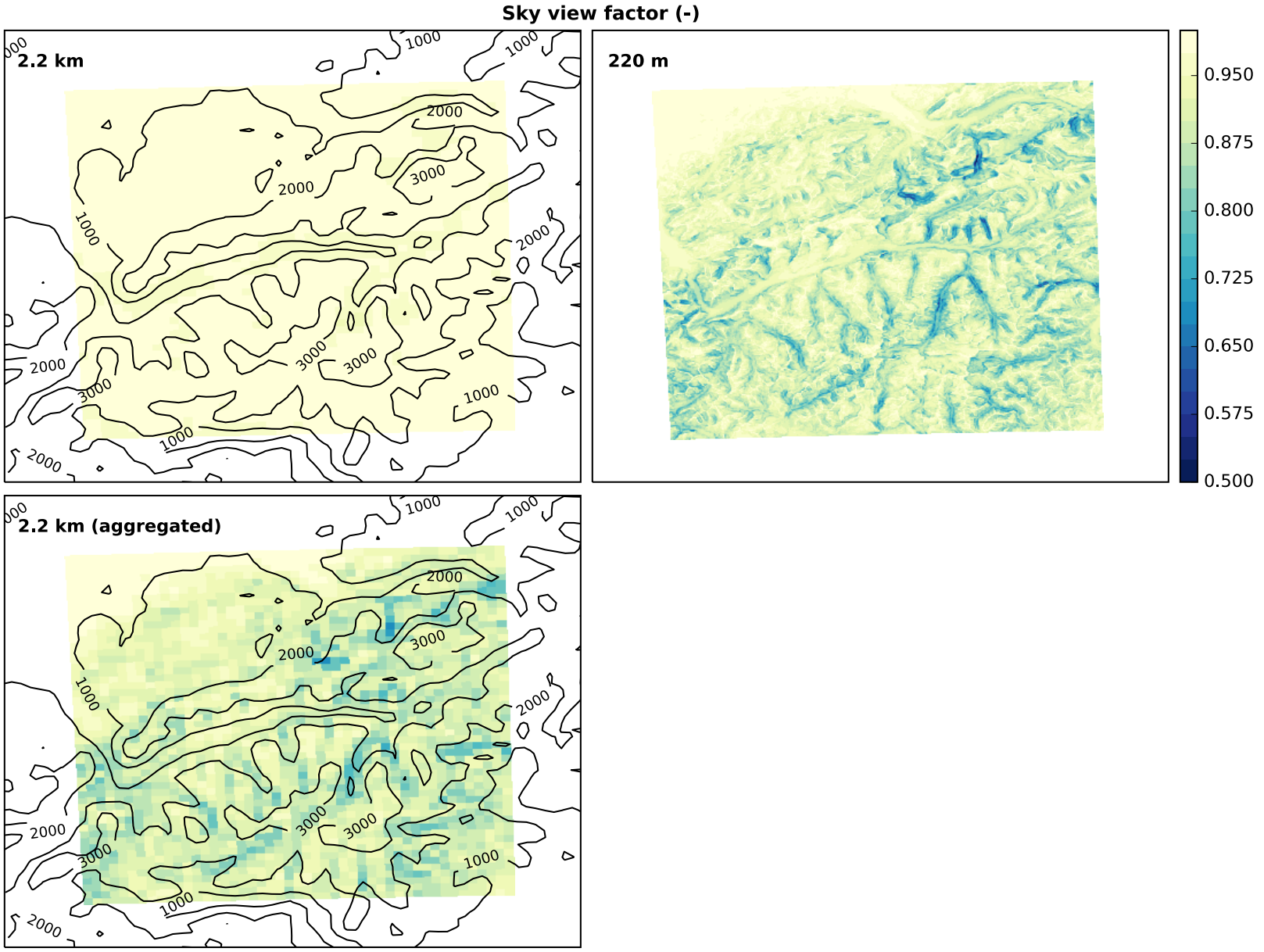
# Relevance of sub-grid topography



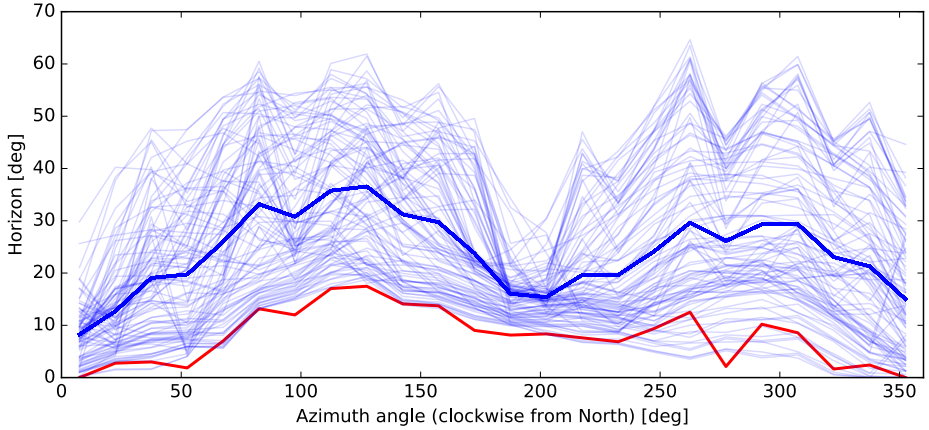
# Topographic parameters – slope

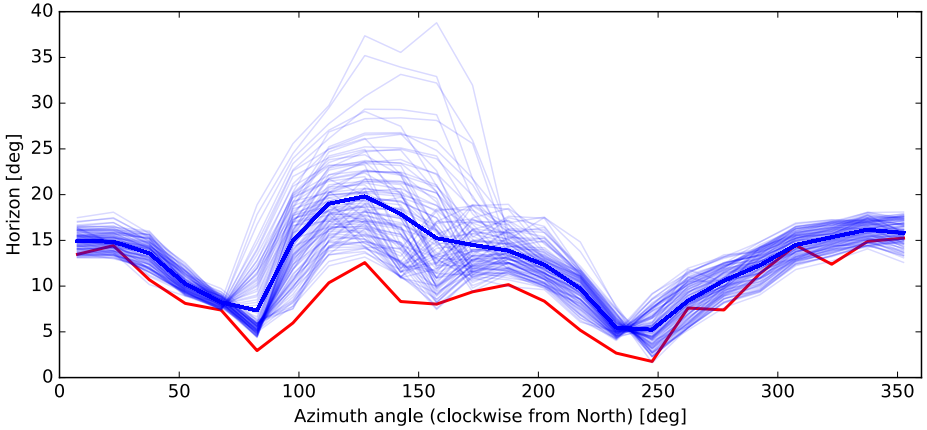


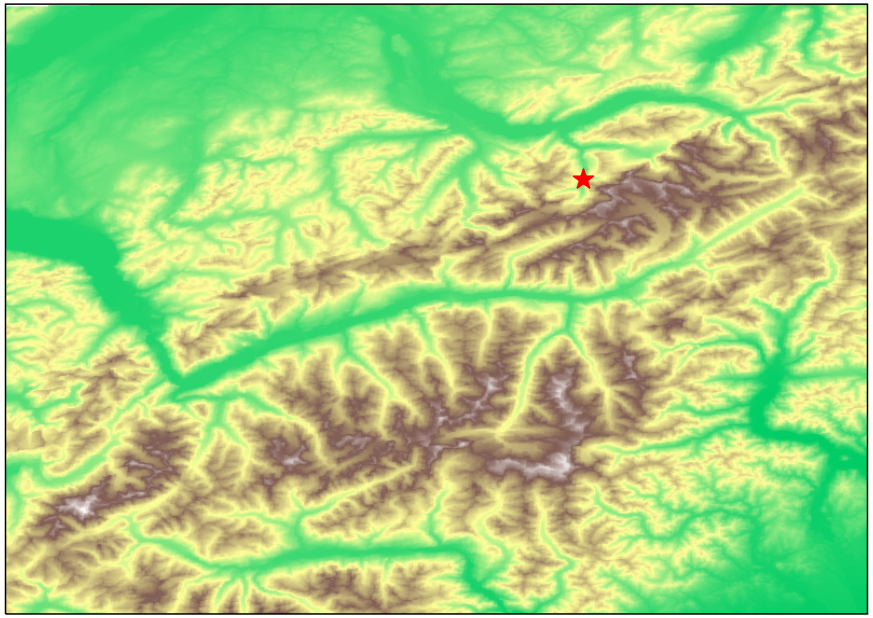
# Topographic parameters – sky view factor

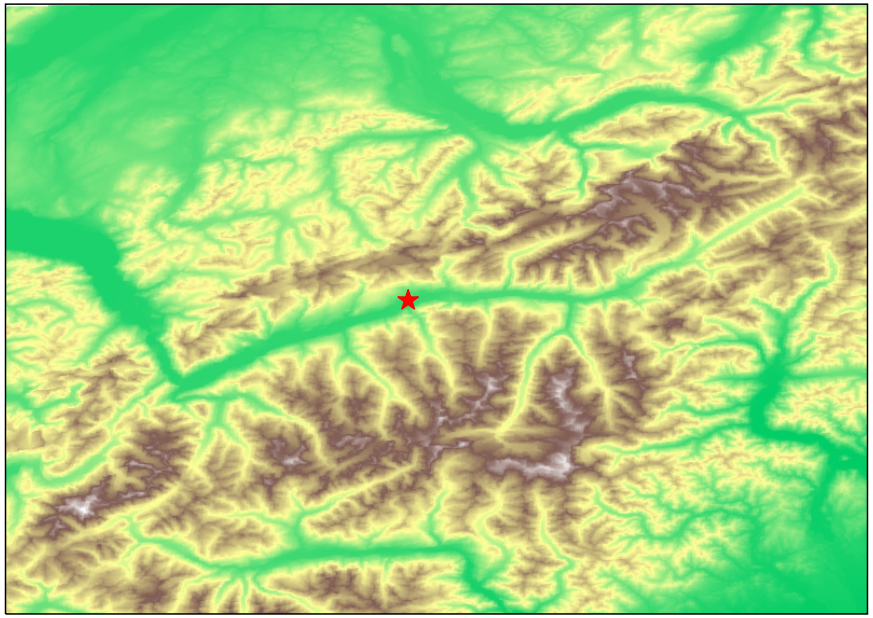


# Topographic parameters – horizon

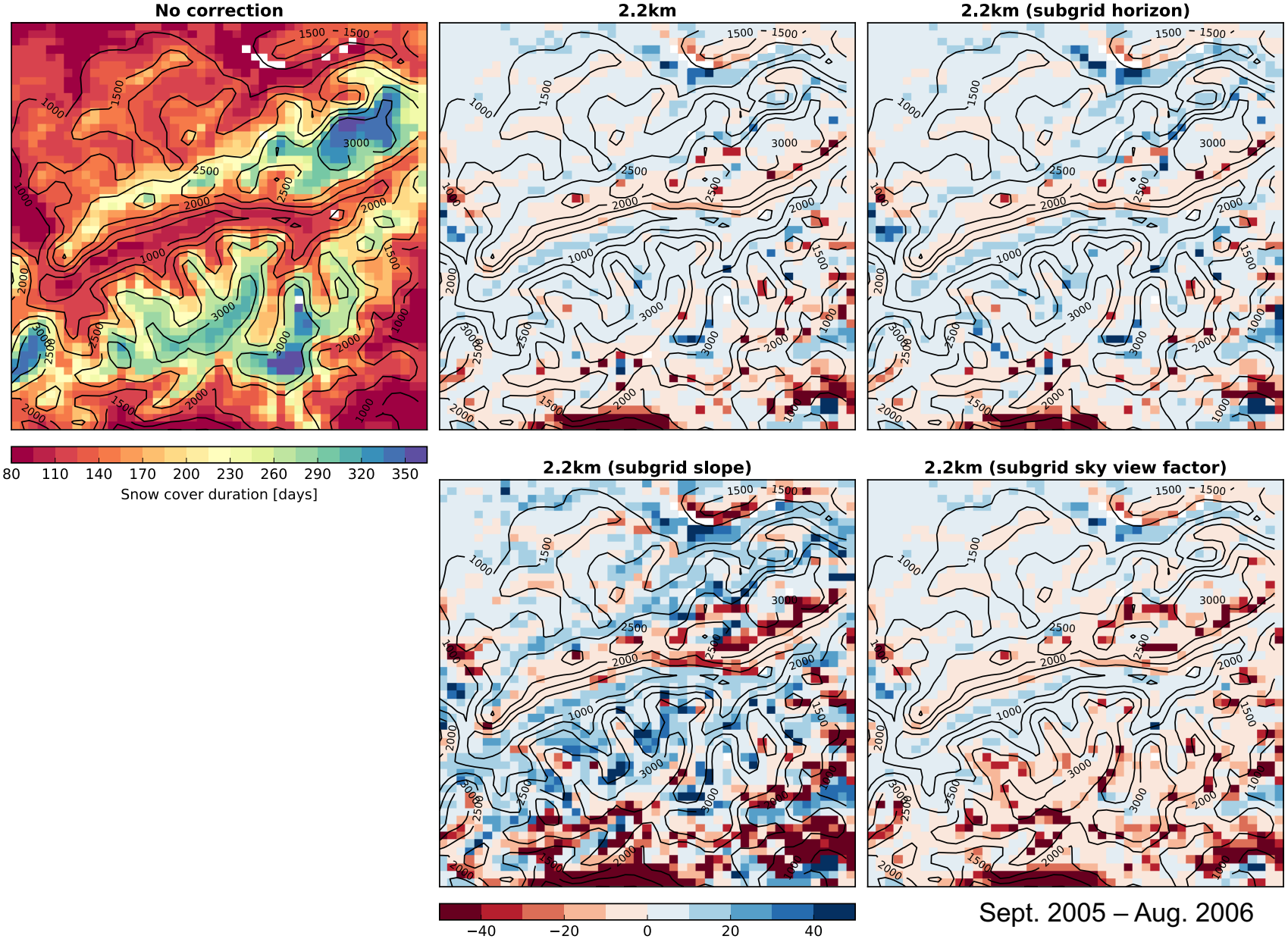




# First sensitivity experiment with SNOWPACK



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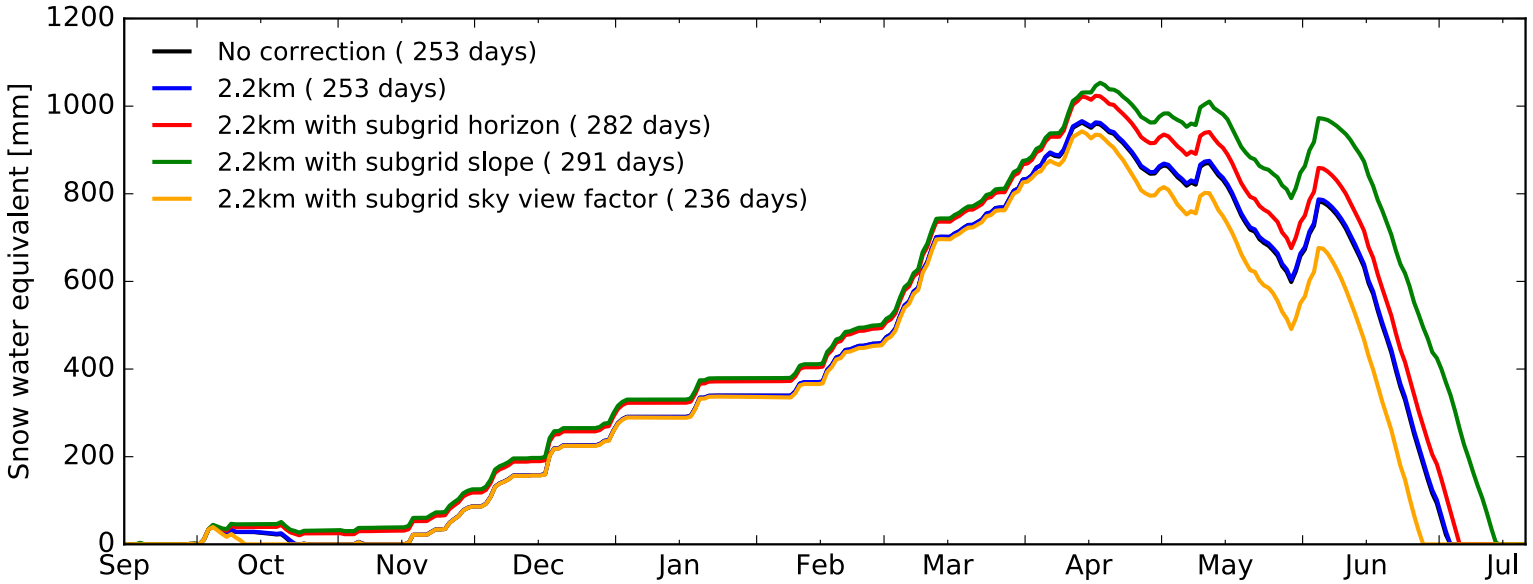
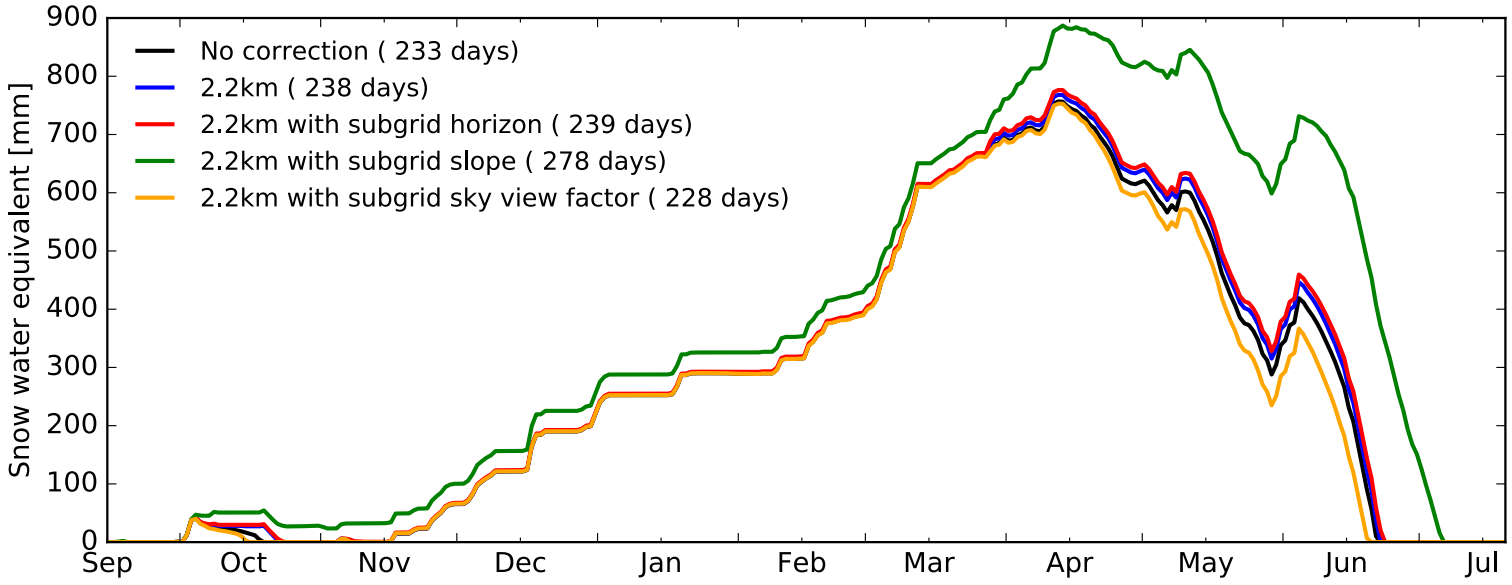


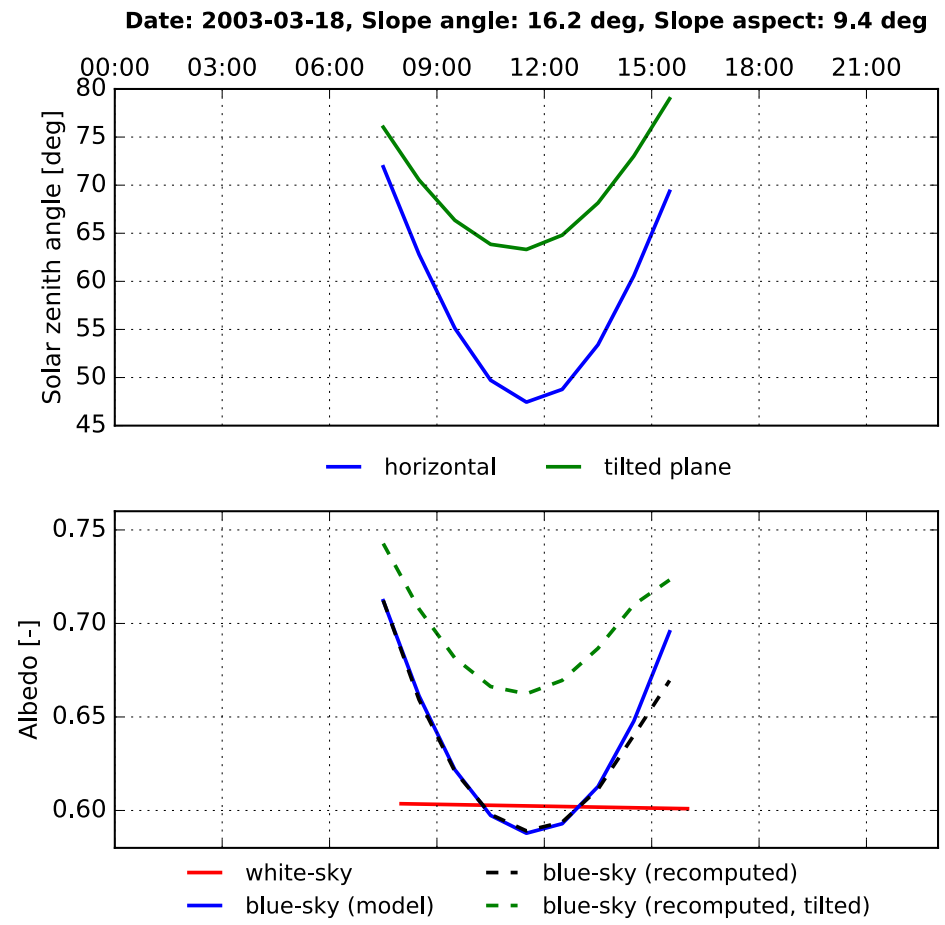

Aspect: ~300°
Sub-grid SVF: 0.78
Slope: ~1°
Sub-grid slope: ~32°



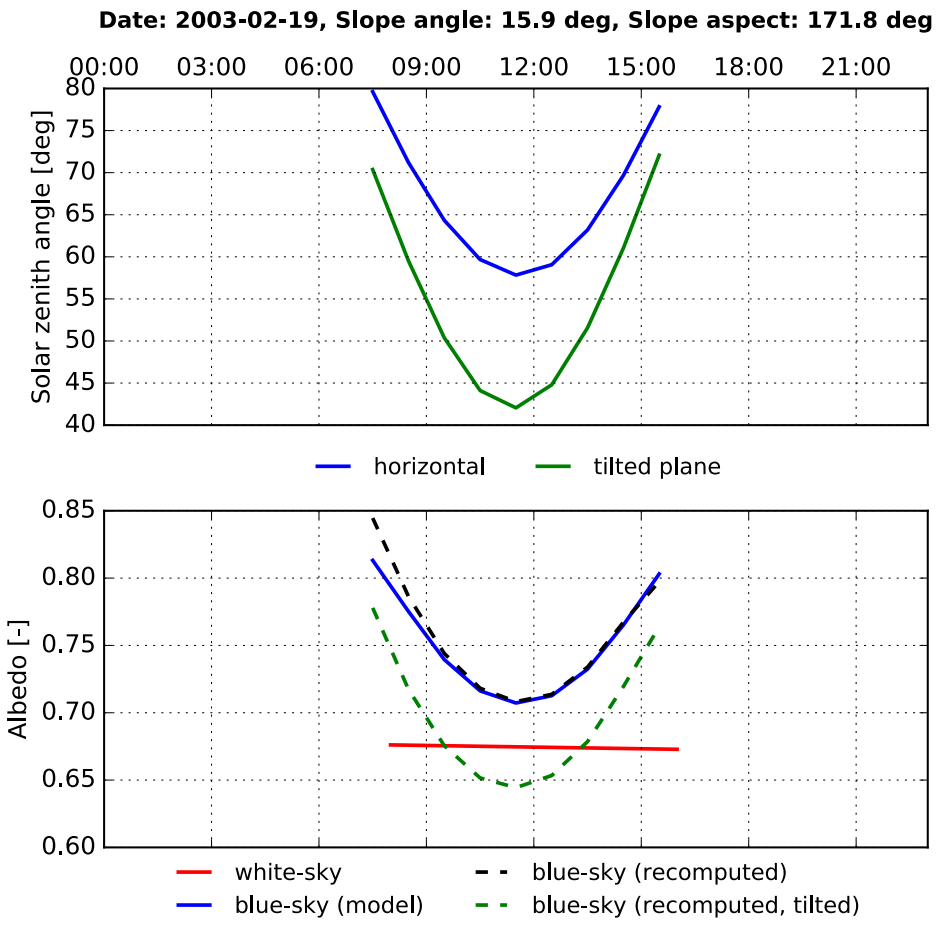

Aspect: ~11°
Sub-grid SVF: 0.84
Slope: ~4°
Sub-grid slope: ~34°

# Solar zenith angle dependency of (snow) albedo

## North-facing slope




## South-facing slope




$$\alpha = \alpha_b(\theta_s)\left(1.0 - f_{dif}\right) + \alpha_w\, f_{dif}$$

- $\alpha_b(\theta_s)$: Black-sky albedo; Solar zenith angle
- $\alpha_w$: White-sky albedo
- $f_{dif}$: Fraction of diffuse incoming shortwave radiation

# Conclusions & Outlook

**Main conclusions**

- SCD highly sensitive to incoming radiation → SCD benefits from improved representation of radiation fluxes in complex terrain
- Subgrid-scale radiation-correction required to reduce biases in SCD

**Outlook**

- Use Terra-ML stand-alone model for sensitivity experiments
- Use updated Terra-ML stand-alone model with multilayer snow model (as soon as available)
- Relevance of topography-radiation-scheme not only limited to winter conditions

# Open questions & technical details

**Open questions**

- Subgrid-scale → spatial aggregation of topographic parameters (slope, aspect and horizon) or aggregation of $f_{cor}$ (→ *see technical details & issues*)
- Violation of energy conservation in climate mode
  - Considerer modified SW-fluxes in albedo (→ compute “effective albedo” → issue: enhancement of ↓ SW limited by total incoming ↓ SW )
  - Terrain-reflected longwave radiation → remove ”terrain-intercepted” part from ↑ LW
- Consider solar-zenith angle dependency of albedo?
- Application of high-resolution DEM → SRTM (empirically corrected → Buzzi 2008) or ASTER?

**Technical details**

- Subgrid-scale part of scheme is not implemented in GPU-accelerated version of COSMO
- Further issues or challenges?

# COSMO - Black-sky albedo as a function of solar elevation angle