Grid scale and subgrid scale parameterization of topographic effects on radiation

Matteo Buzzi
Mathias W. Rotach

MeteoSwiss

LM-User Seminar
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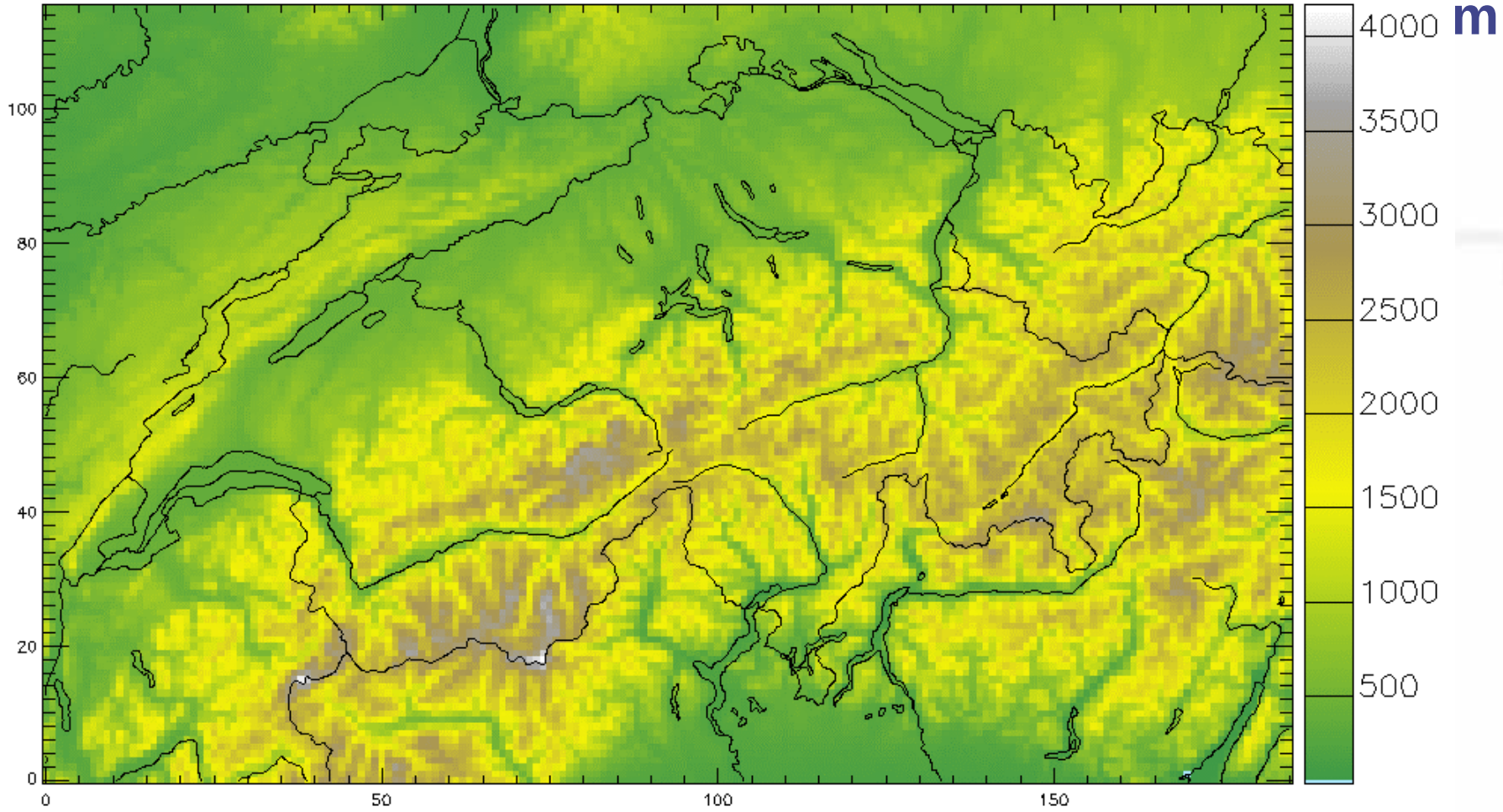
Topography aLMo 2.2 km



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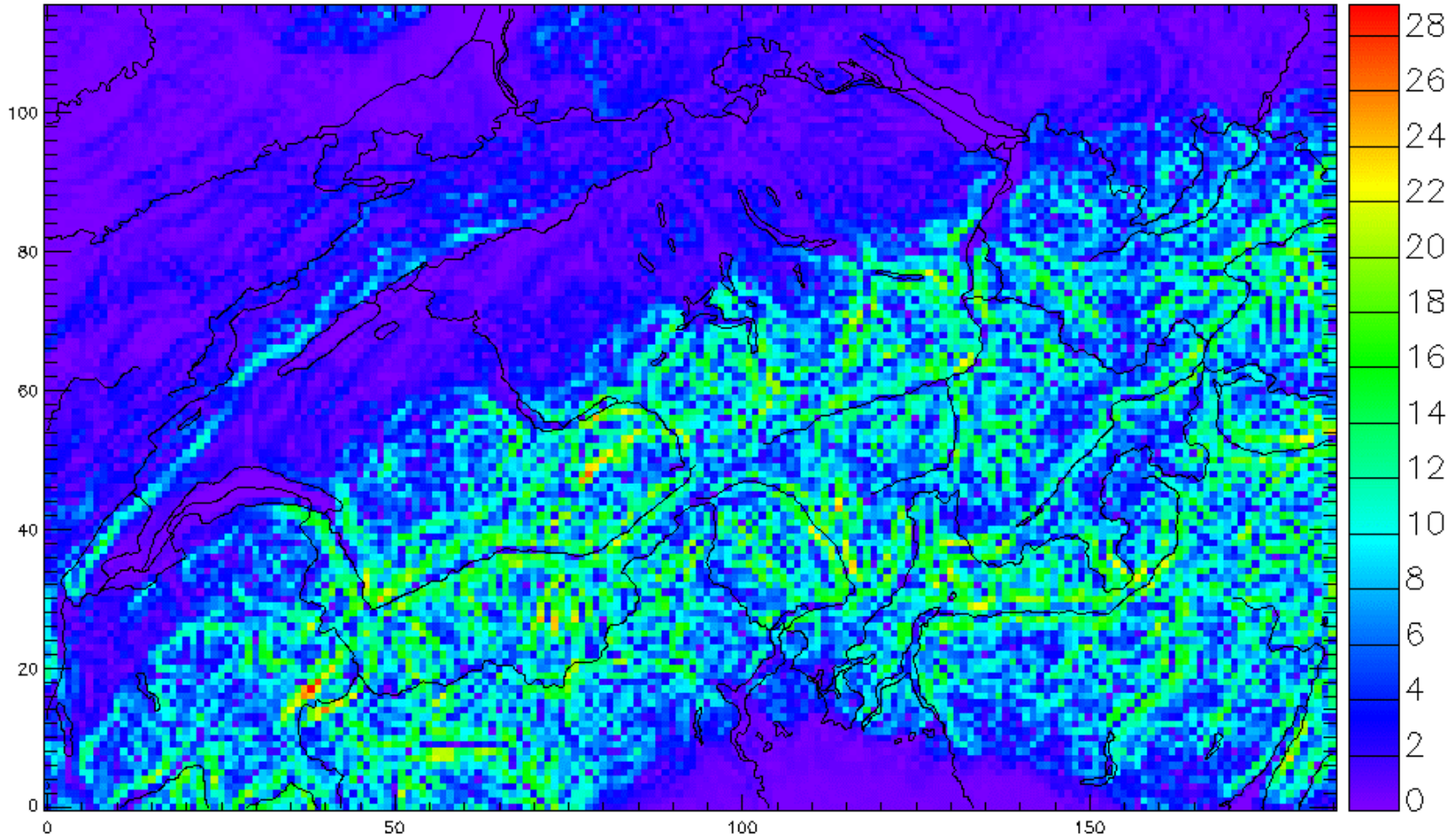
Slope angle aLMo 2.2 km



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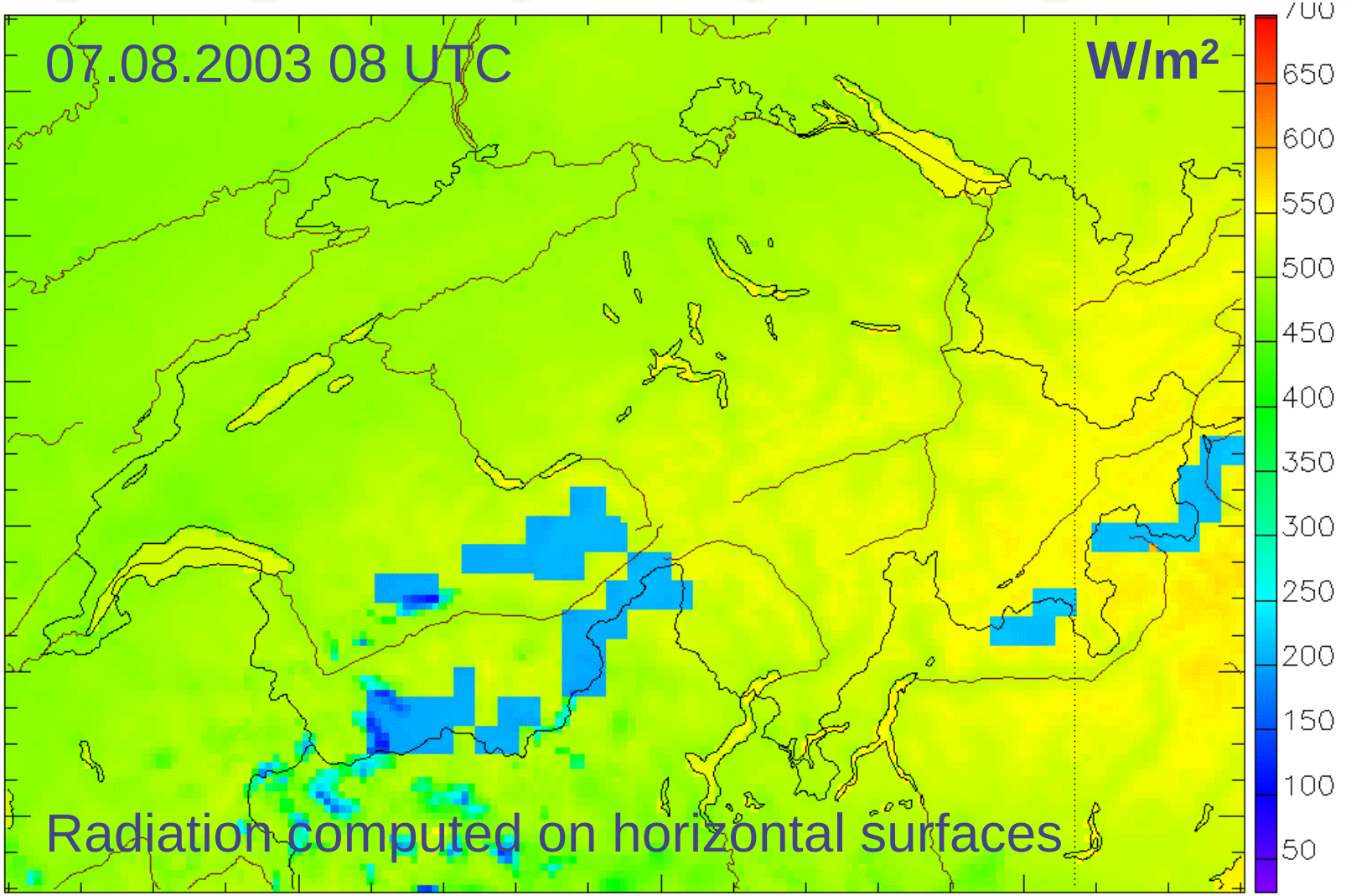
aLMo: surface shortwave radiation balance



Radiation scheme: Ritter and Geleyn (1992)

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Overview

- Introduction: the radiation problem in complex topography
- The parameterization scheme
  - Correction factors for surface radiation components
    - Grid scale scheme
    - Subgrid scale scheme
- aLMo 2.2 km test case
  - Impact of the correction
  - Differences between grid scale and subgrid scale scheme
- 7 km test case
- Summary and outlook

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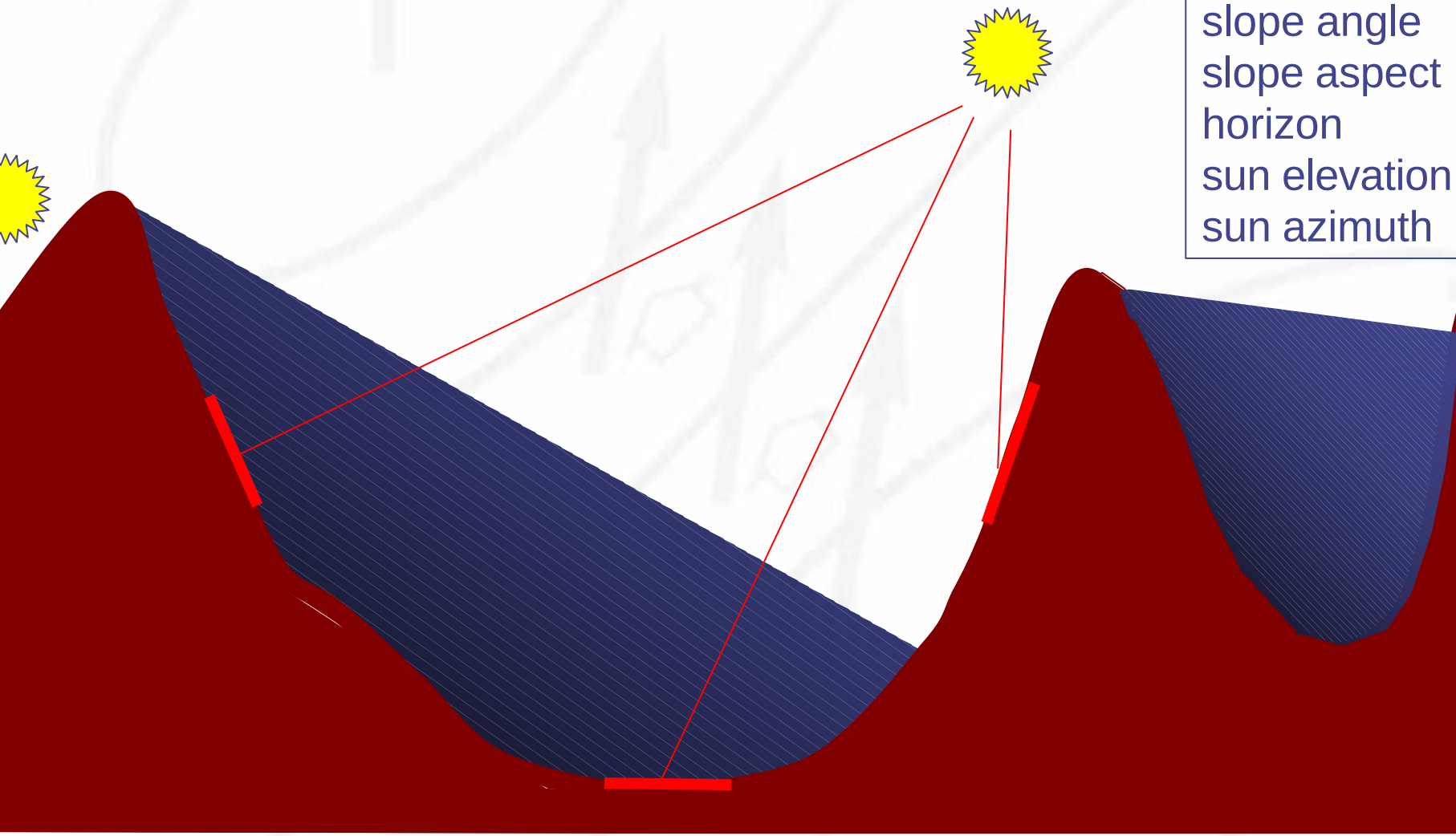
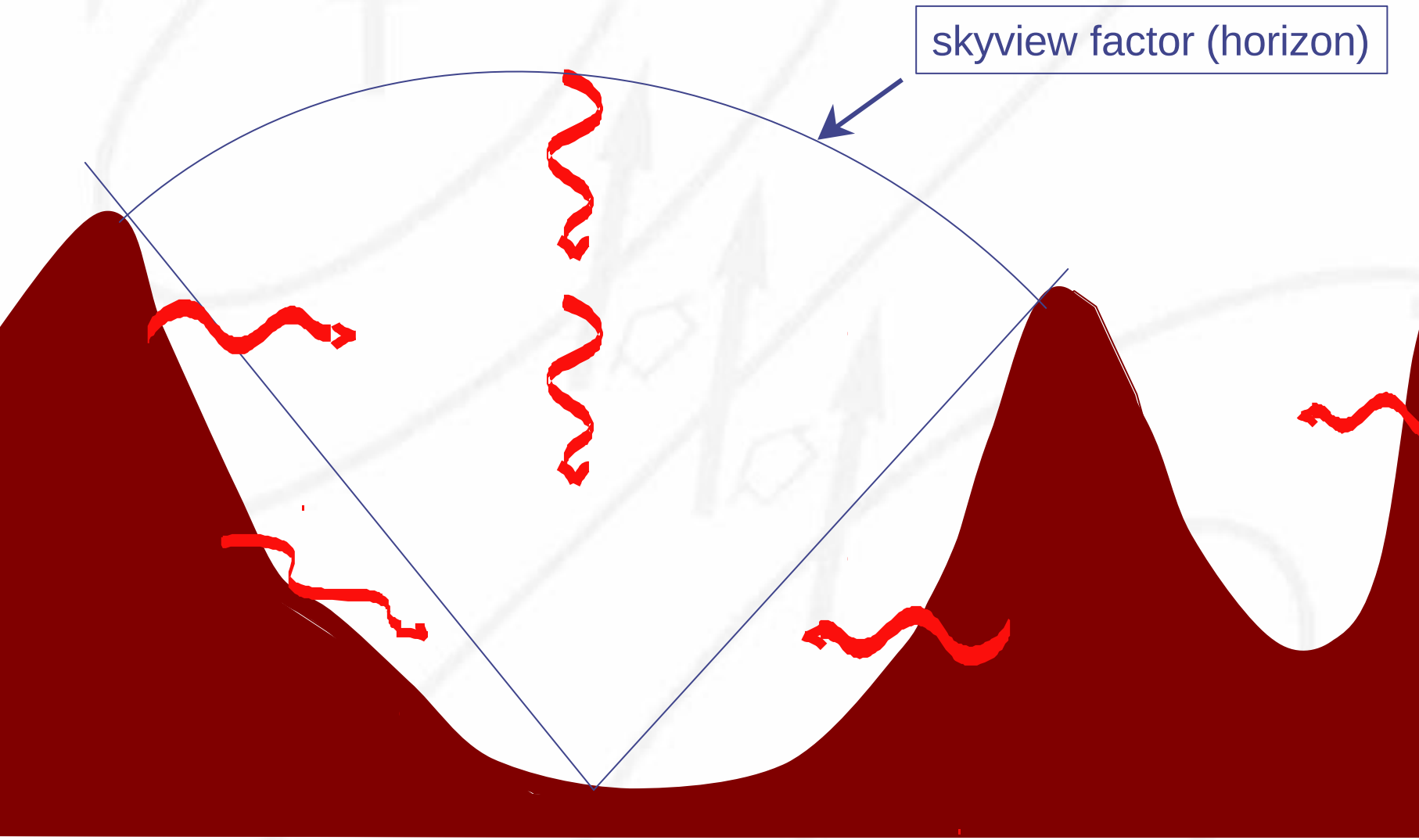
Downward shortwave radiation

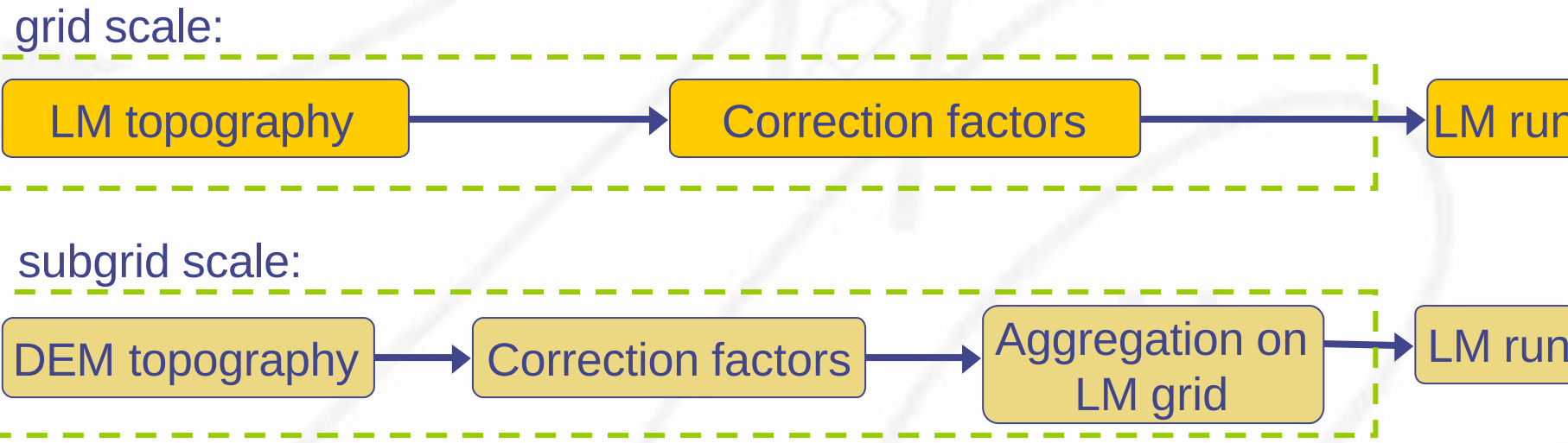


Downward longwave radiation



How to solve the problem?

- Complex solution: 3D radiation scheme
  - the most accurate solution, 3D shadowing effects of clouds could also be included
  - Long developing time, expensive in terms of cpu
- Simple approach: correction factors for surface radiation components ✂ Müller and Scherrer (2005) scheme



Corrections of the surface radiation components

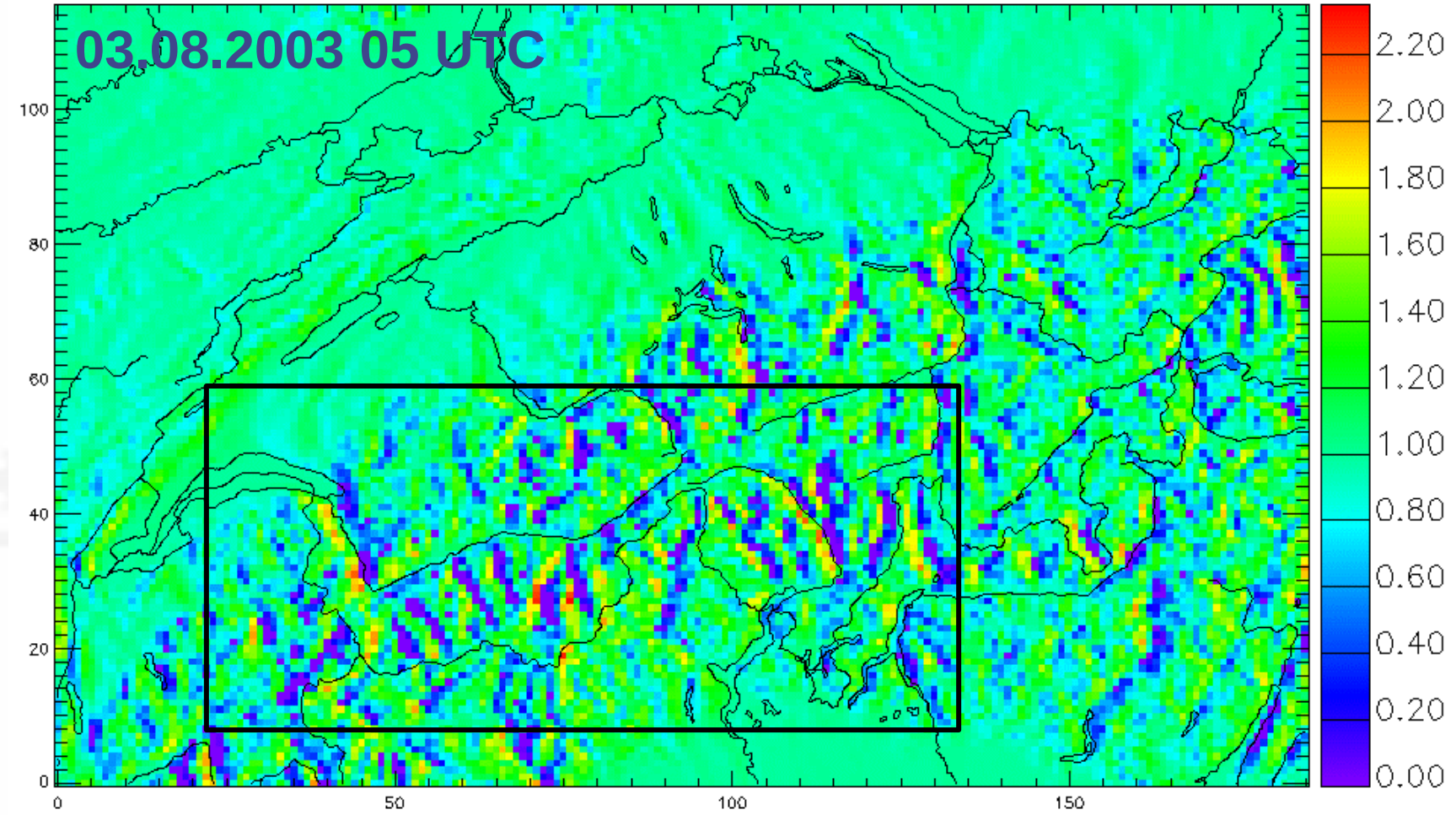
- Direct shortwave radiation

$$\downarrow SW^{*}_{dir} = fcor \cdot \downarrow SW_{dir}$$

sunshine conditions
slope angle
aspect angle
(correction factor for each grid point,
computed prior to model integration)

Müller and Scherrer (2005)

Correction factors for direct radiation, 2.2 km



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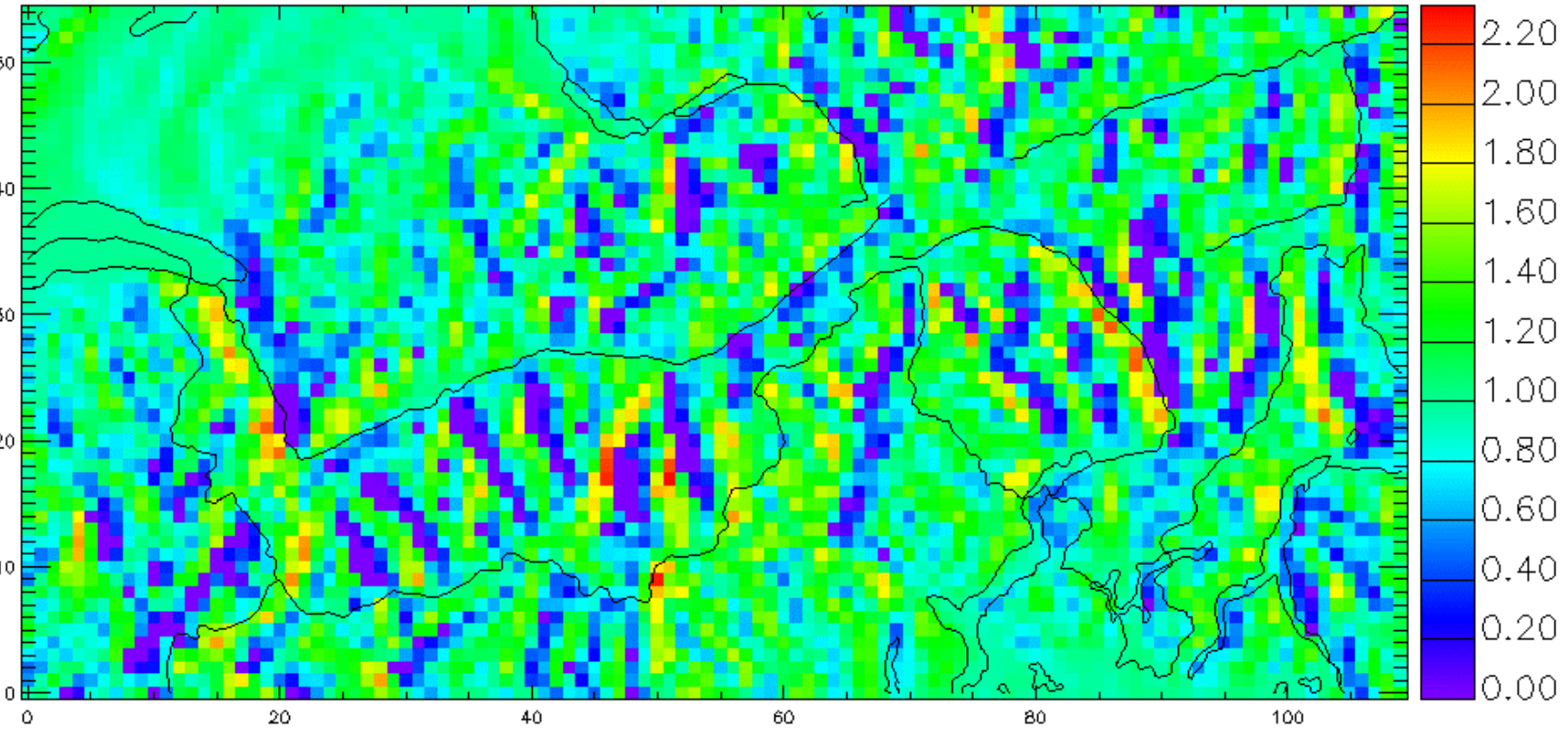
Correction factors for direct solar radiation

grid scale version

03.08.2003 05 UTC



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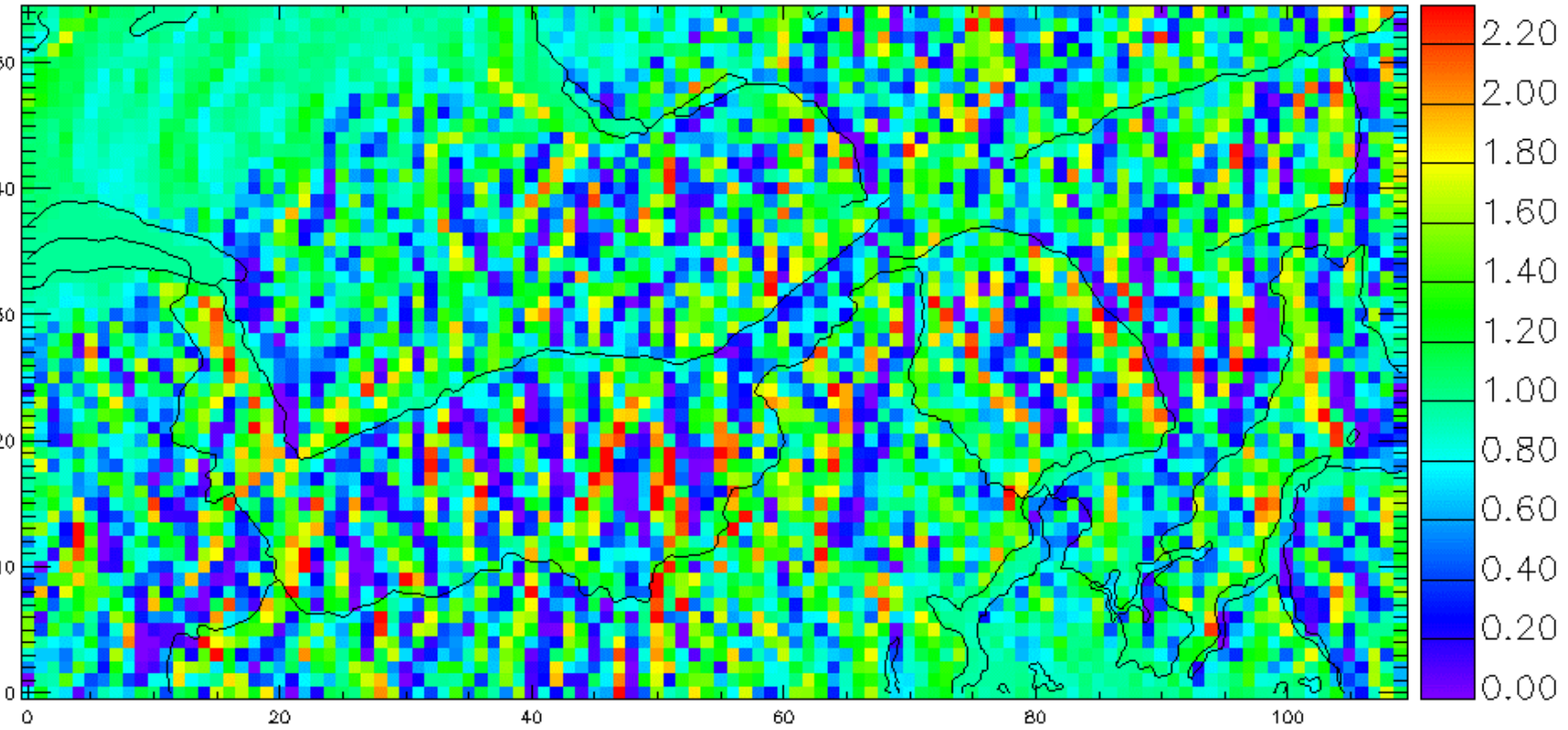
Correction factors for direct solar radiation

subgrid scale version

03.08.2003 05 UTC



DEM resolution 450 m ~ 24 subgrid points per LM grind point at 2.2 km

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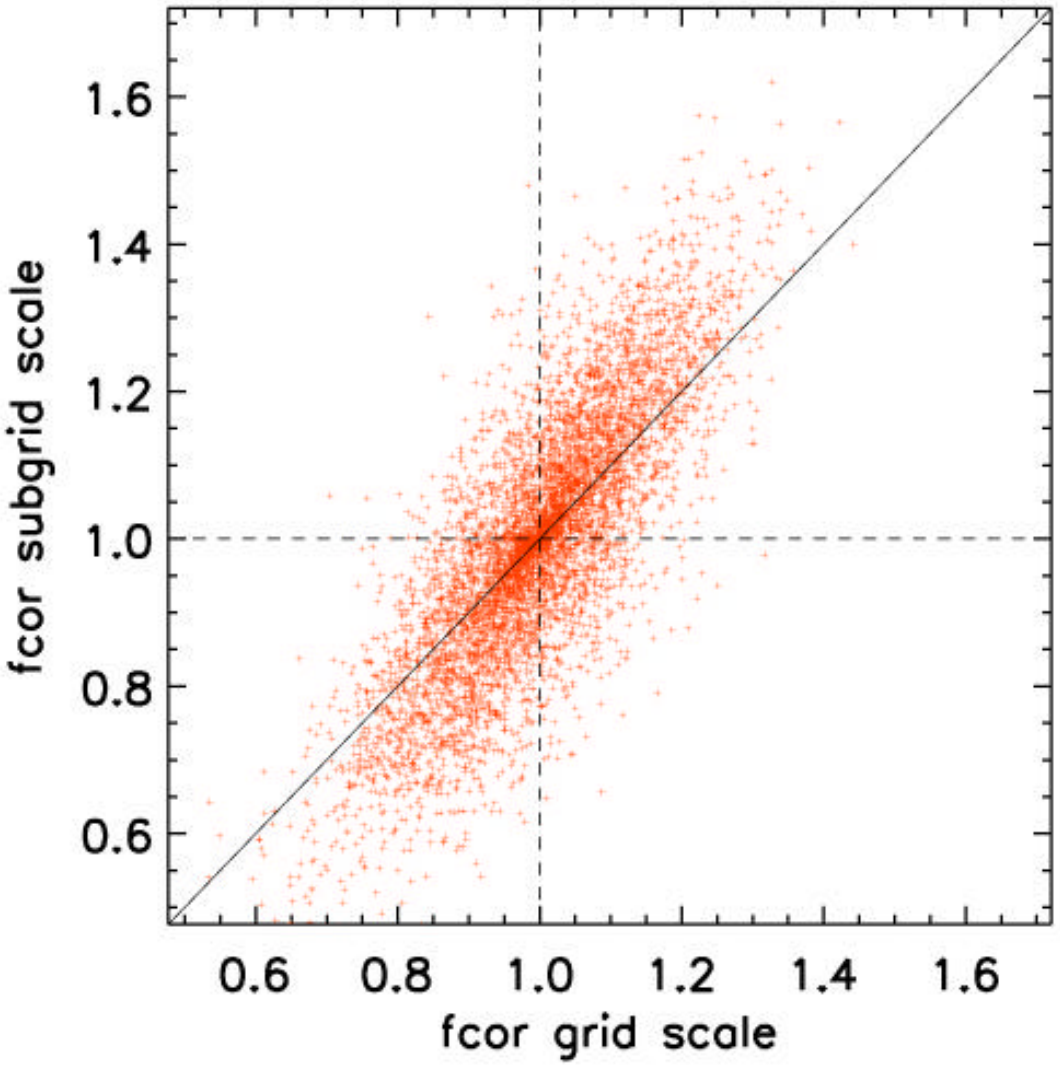
Correction factors for direct solar radiation



03.08.2003 08 UTC

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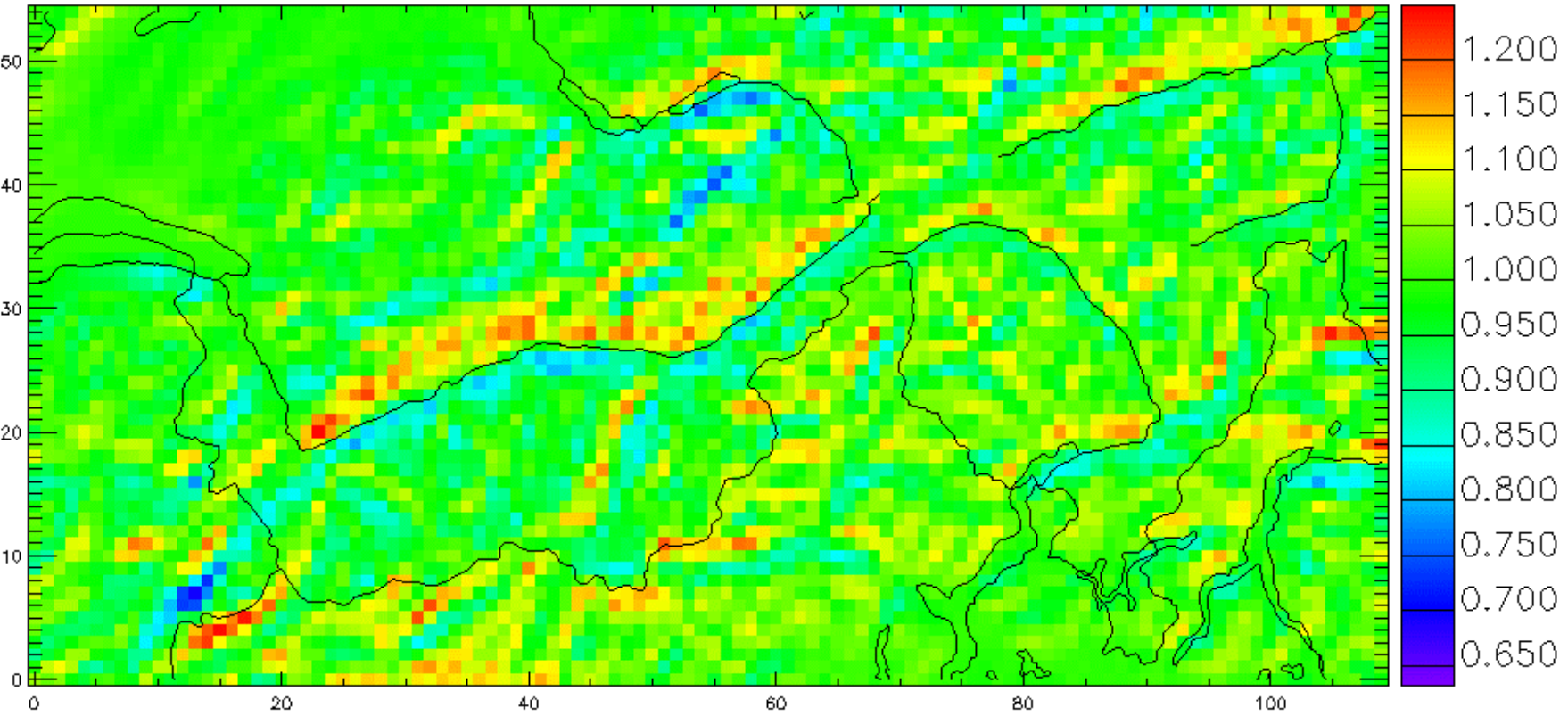
Correction factors for direct solar radiation

03.08.2003 11 UTC

grid scale version



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Corrections of the surface radiation components

- Downward shortwave diffuse radiation:

$$\downarrow SW^{*}_{diff} = \downarrow SW_{diff} \cdot f_{sky} + \uparrow SW_{diff} \cdot (1 - f_{sky})$$

$$f_{sky} : skyview\ \ factor$$

horizon, slope angle and slope aspect
for each grid point
computed prior to model integration

Müller and Scherrer (2005)
Zelenka (pers.com)

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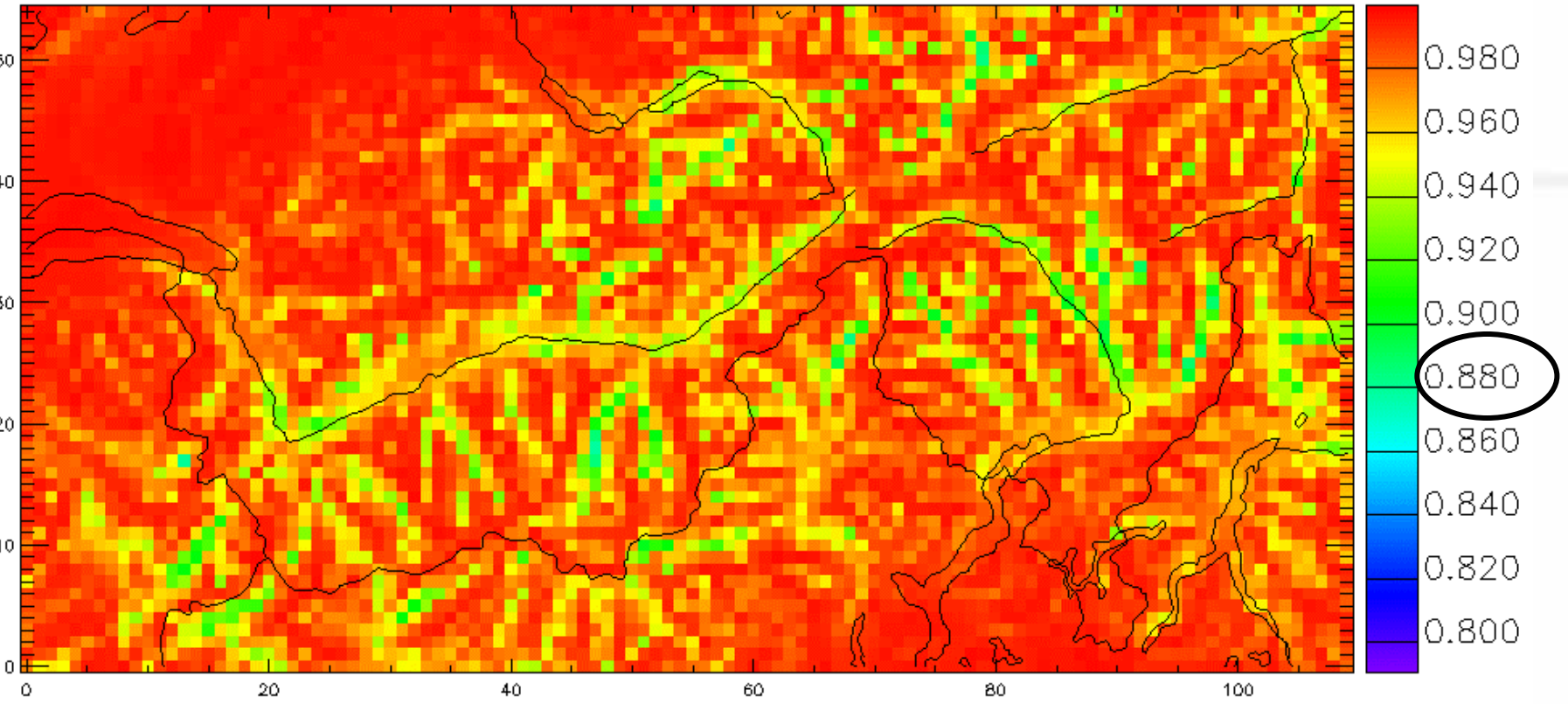
Sky view factor, 2.2 km

grid scale version



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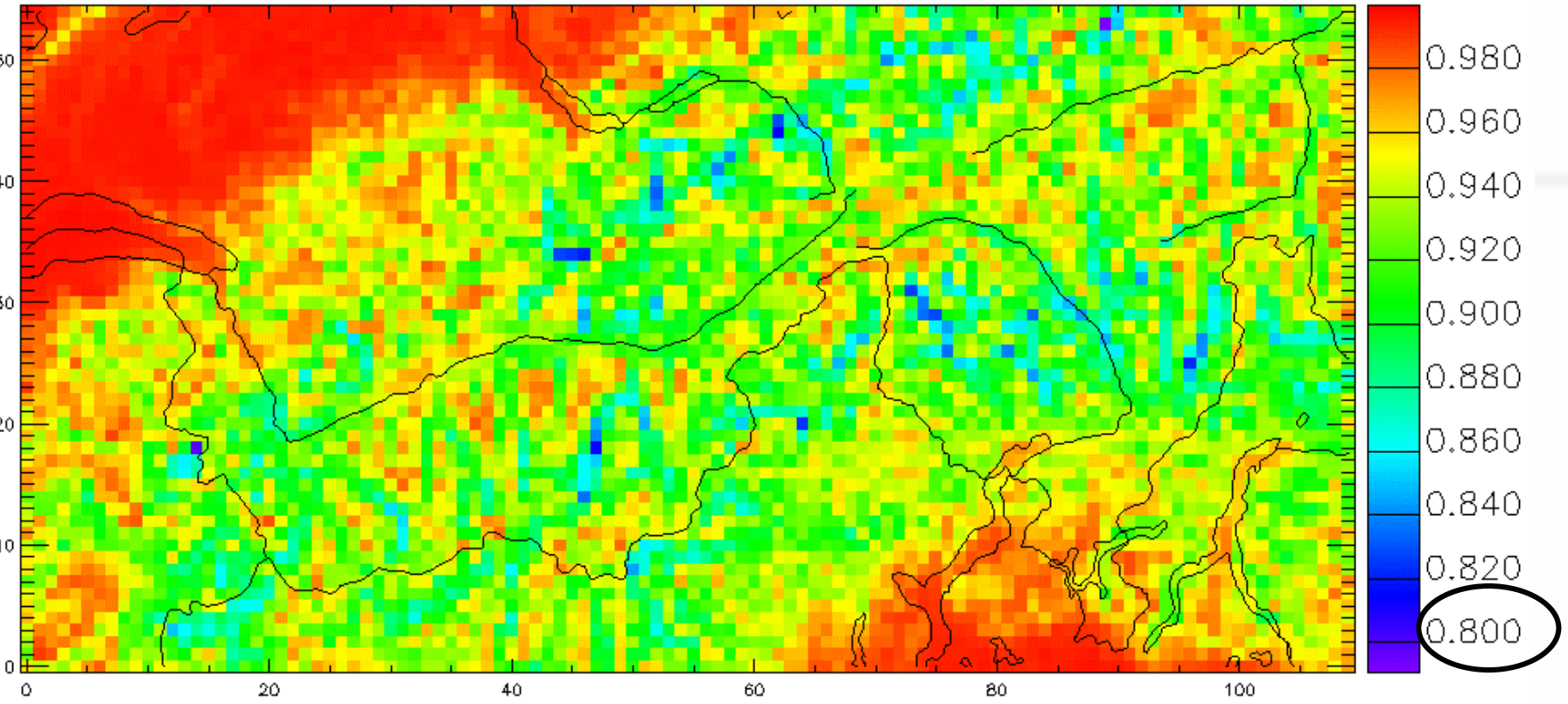
Skyview factor, 2.2 km

subgrid scale version



DEM **450 m** aggregation of ~24 subgrid points per aLMo grind point at 2.2 km

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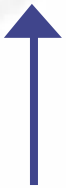
Corrections of the surface radiation components

- Downward thermal radiation:

$$^{\downarrow}LW^{*} = {}^{\downarrow}LW \cdot f_{sky} + {}^{\uparrow}LW \cdot (1 - f_{sky})$$

$$f_{sky} : skyview\ \ factor$$



horizon, slope angle and slope aspect
for each grid point
computed prior to model integration

Modified from Müller and Scherrer (2005)
Zelenka (pers.com)

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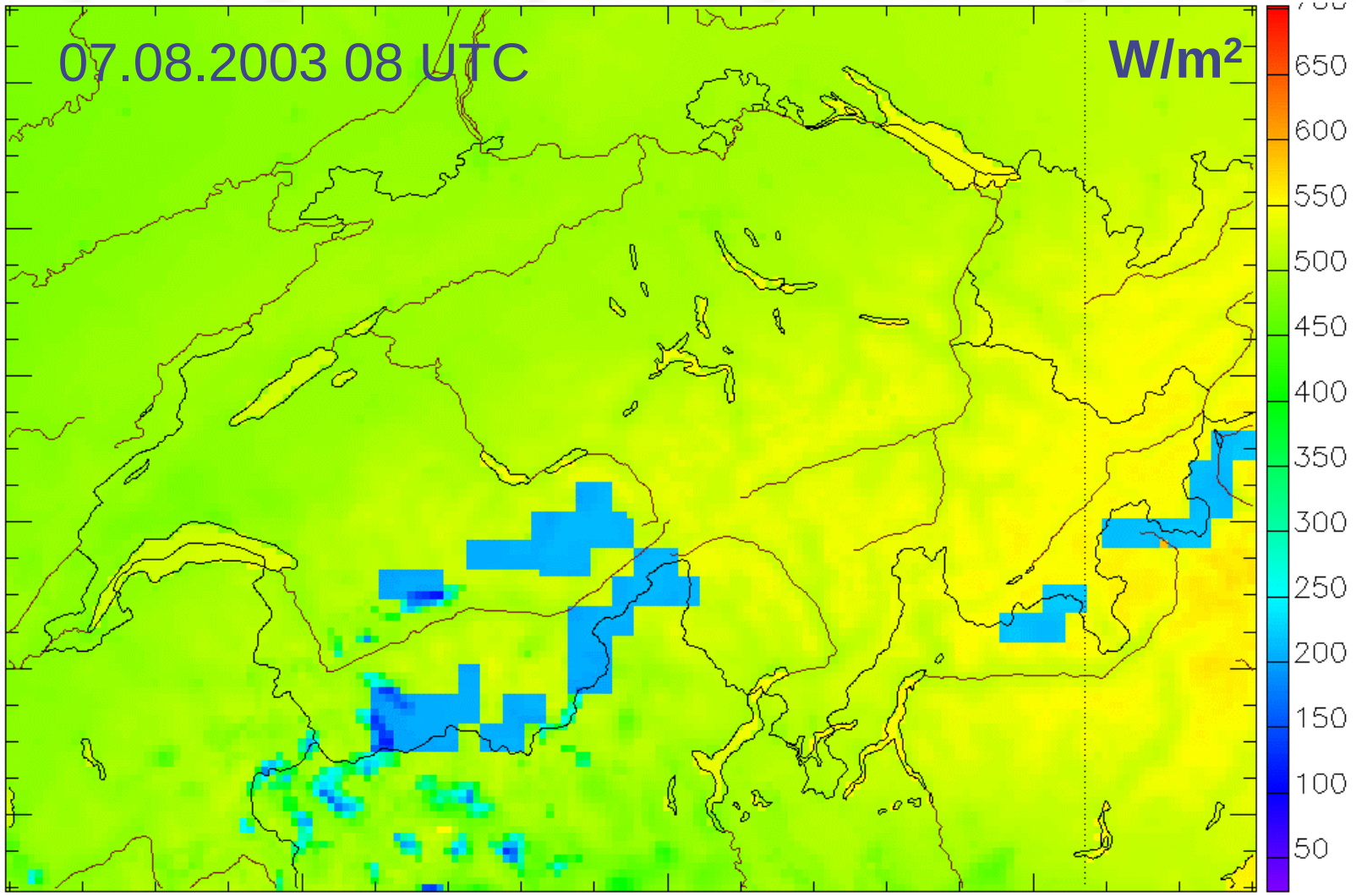
Shortwave radiation balance: aLMo



2.2 km

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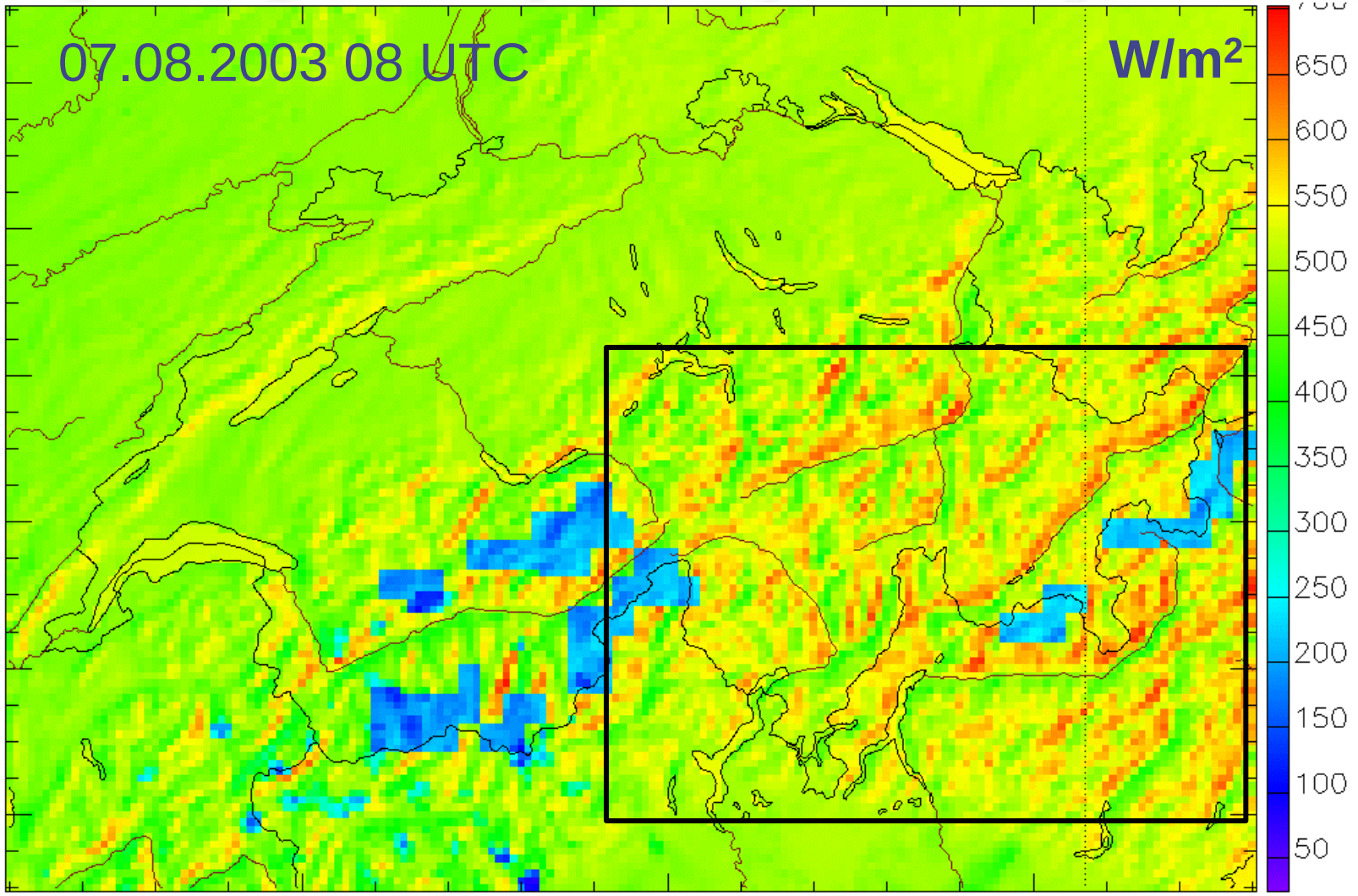
Shortwave radiation balance: aLMo corrected



2.2 km

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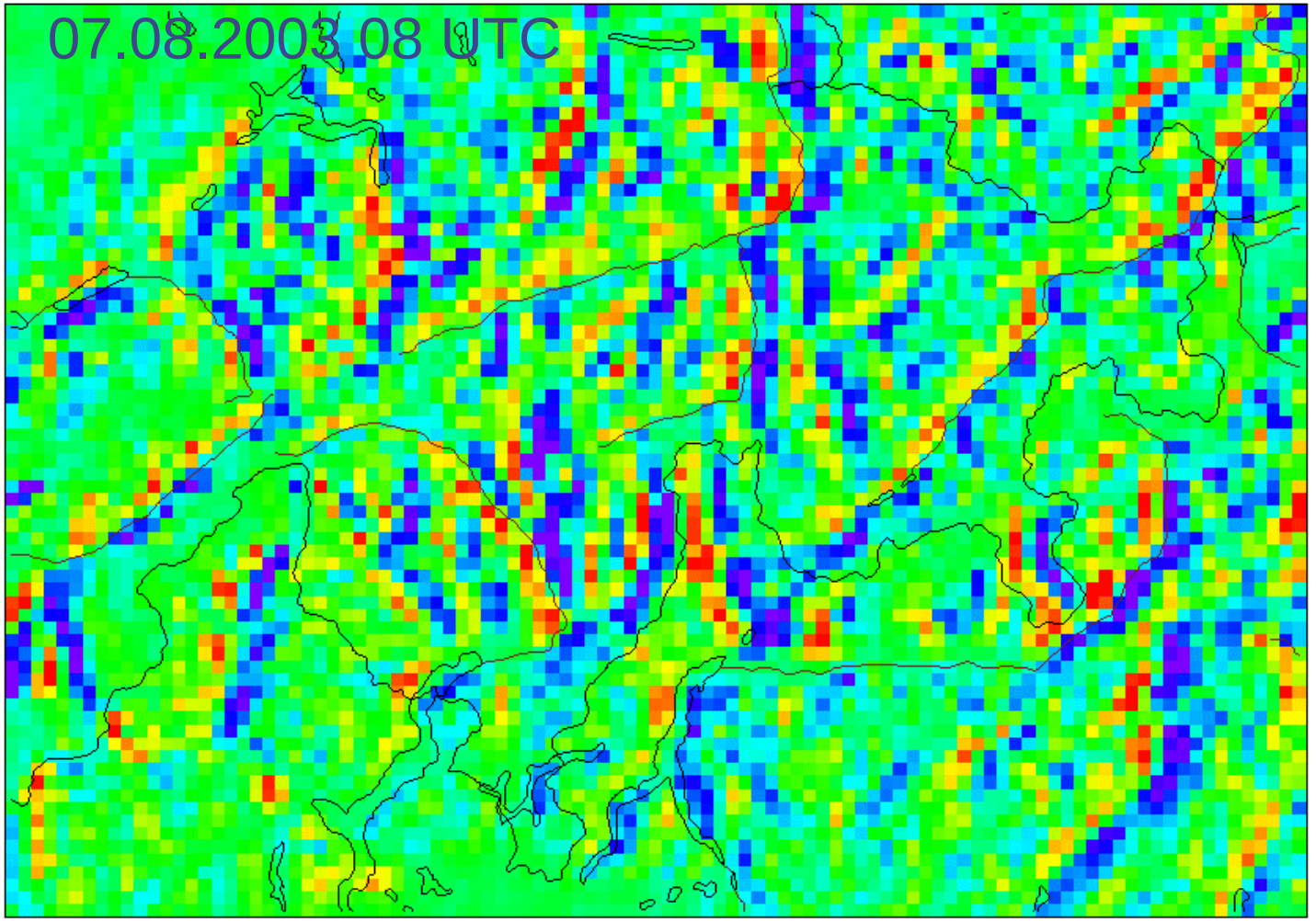
Shortwave radiation balance: aLMo difference



Difference = corrected - uncorrected

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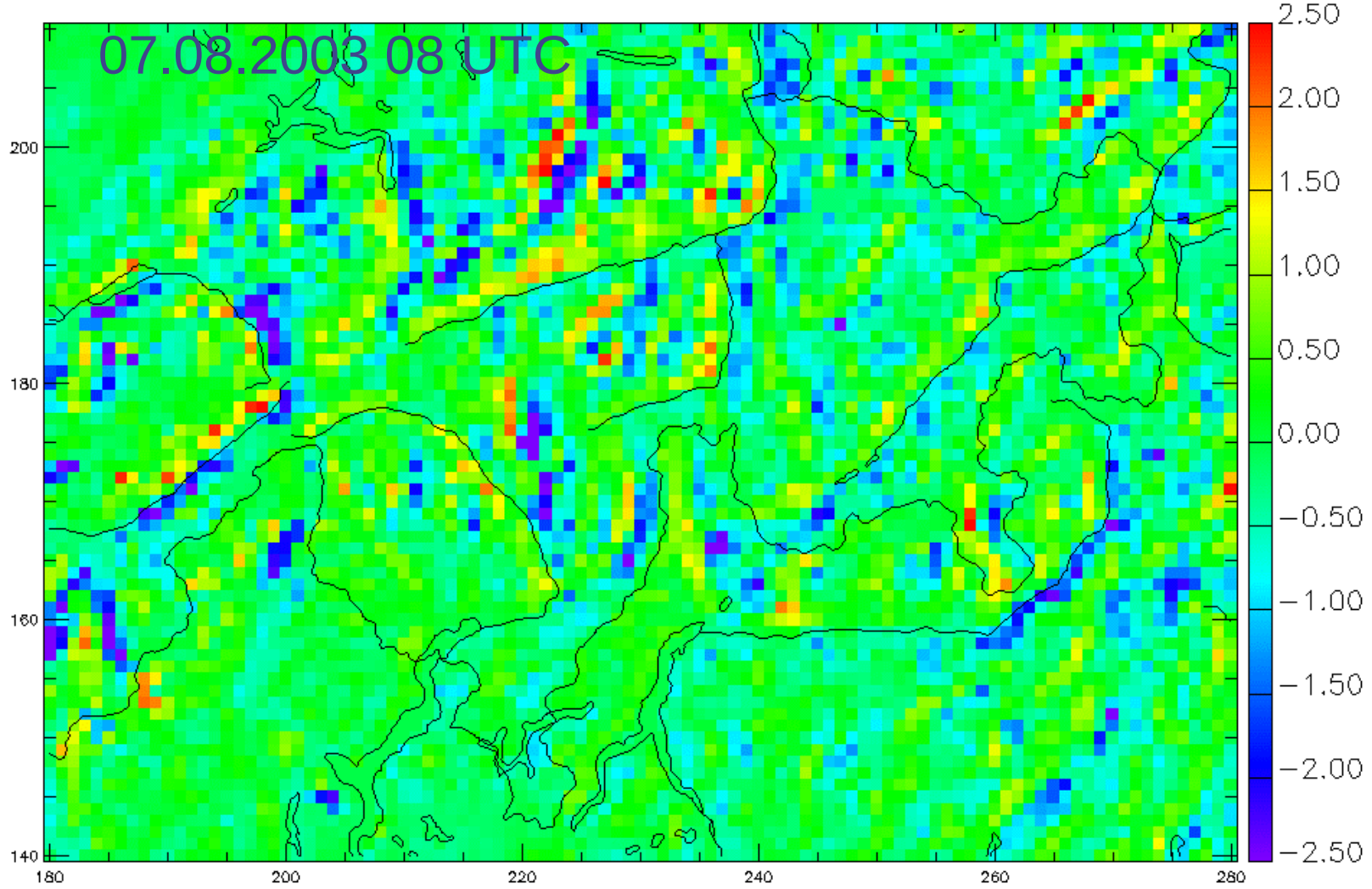
Surface temperature: aLMo difference 2.2 km



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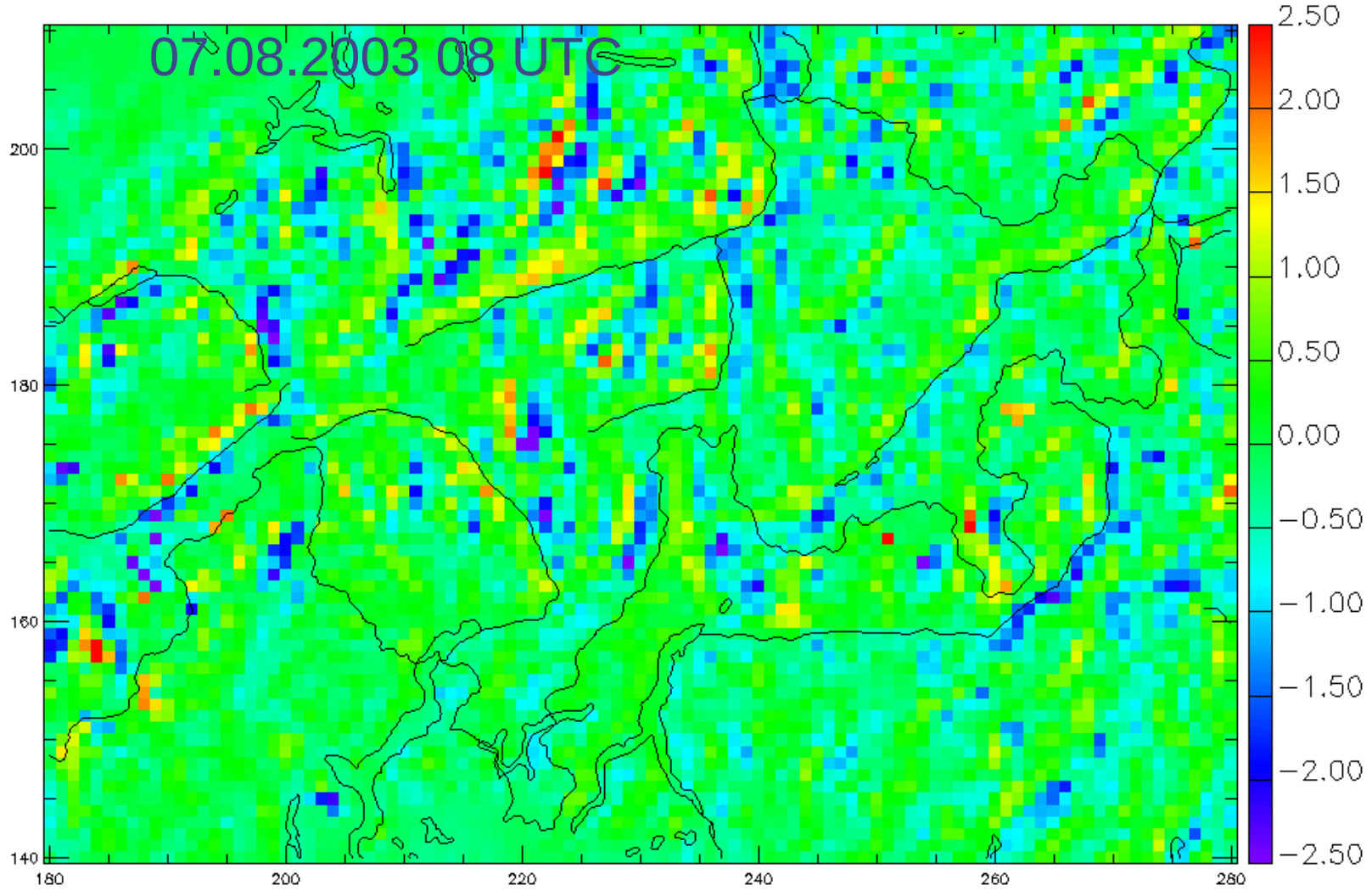
2 m temperature: aLMo difference 2.2 km



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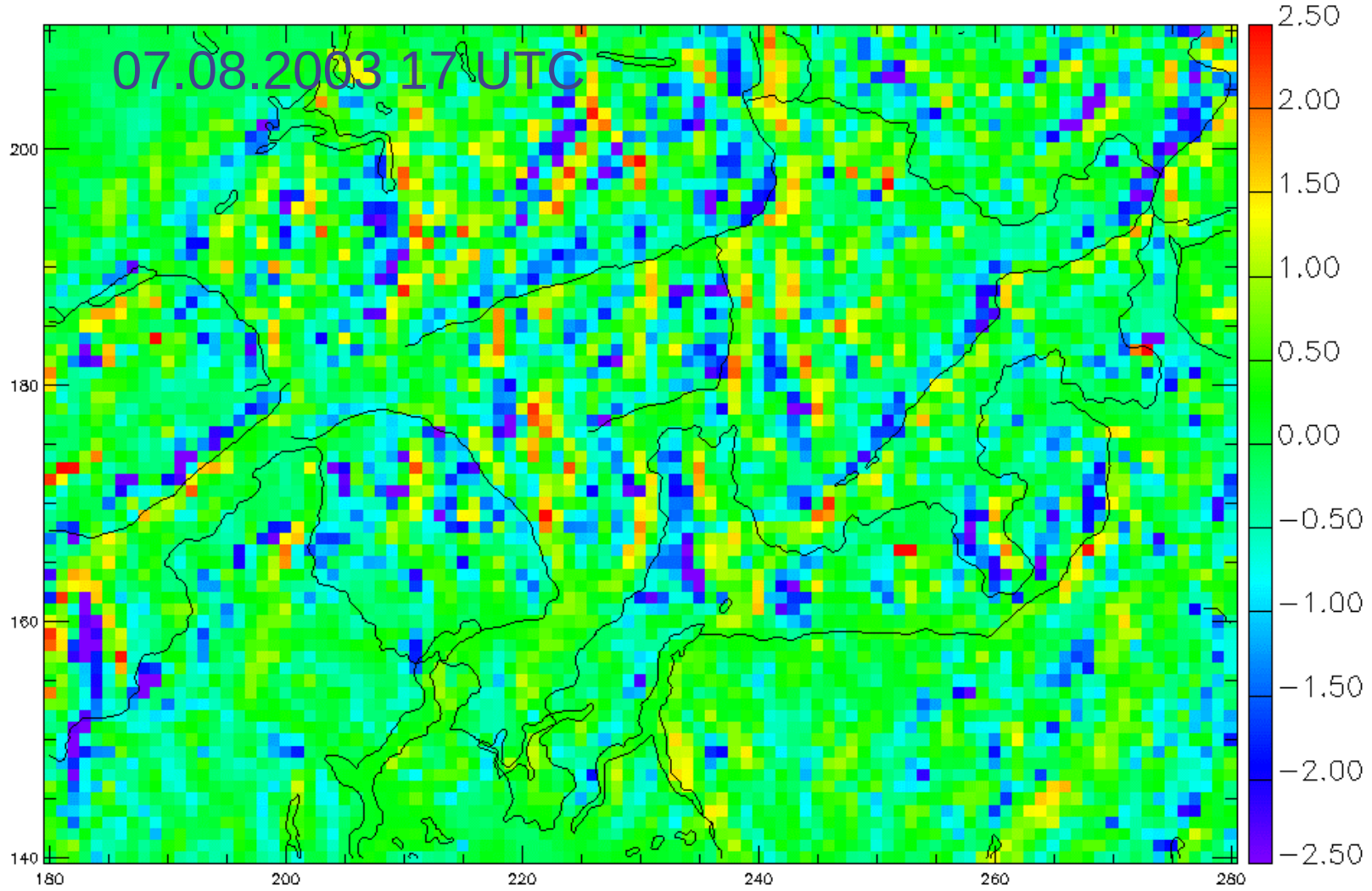
2 m temperature: aLMo difference 2.2 km



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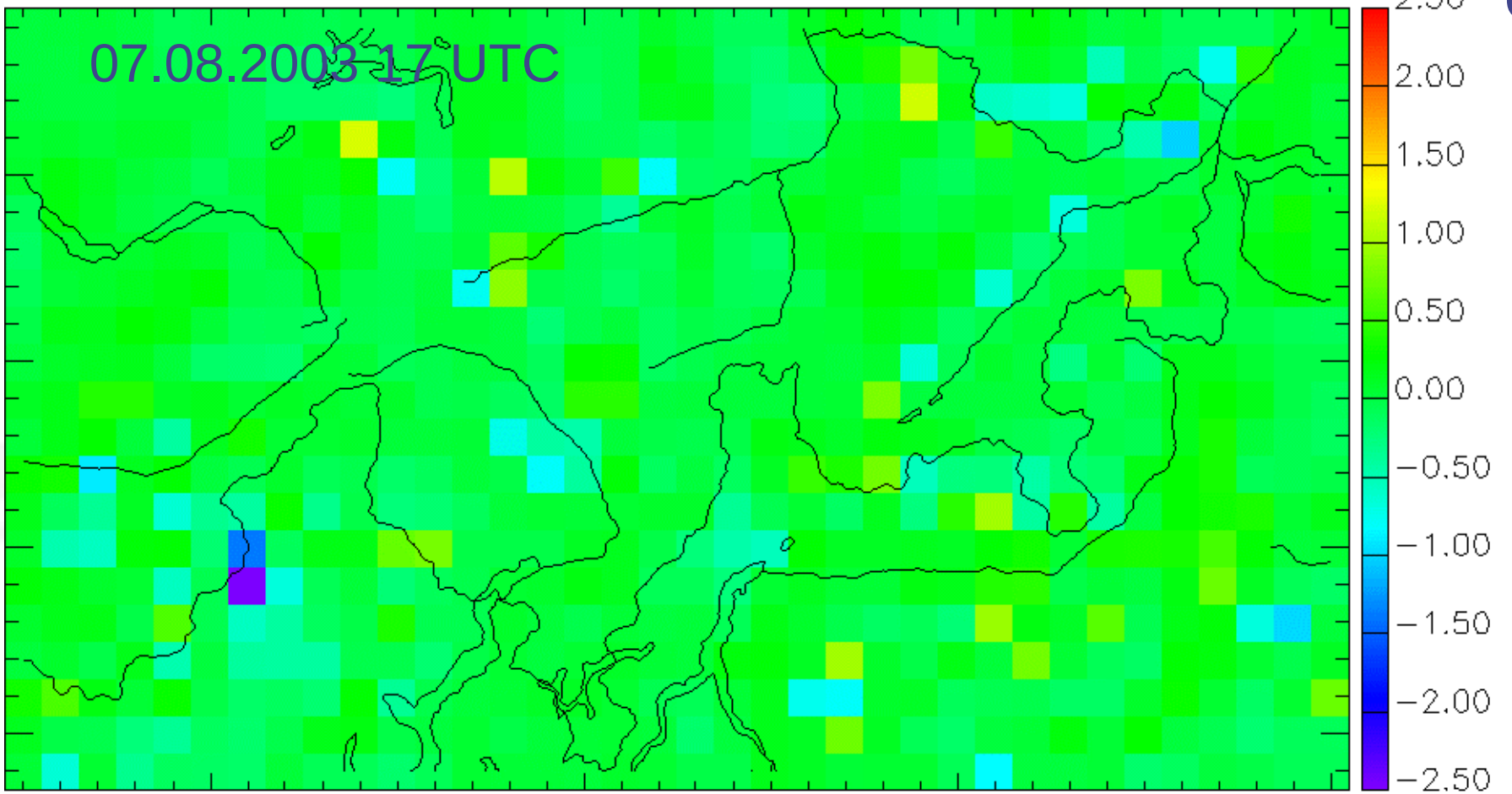
2 m temperature: aLMo difference 7 km



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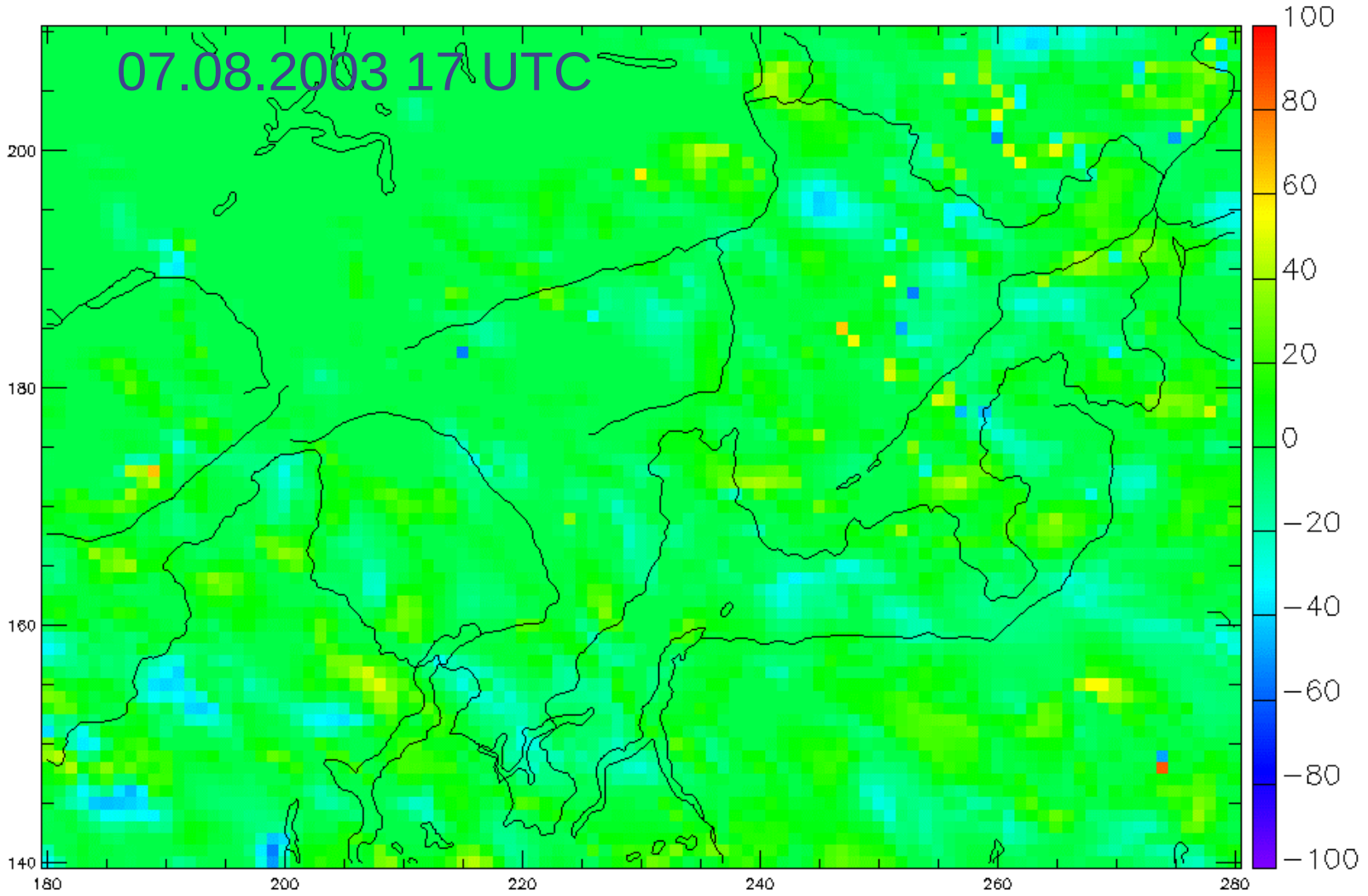
Total clouds cover: aLMo difference 2.2 km



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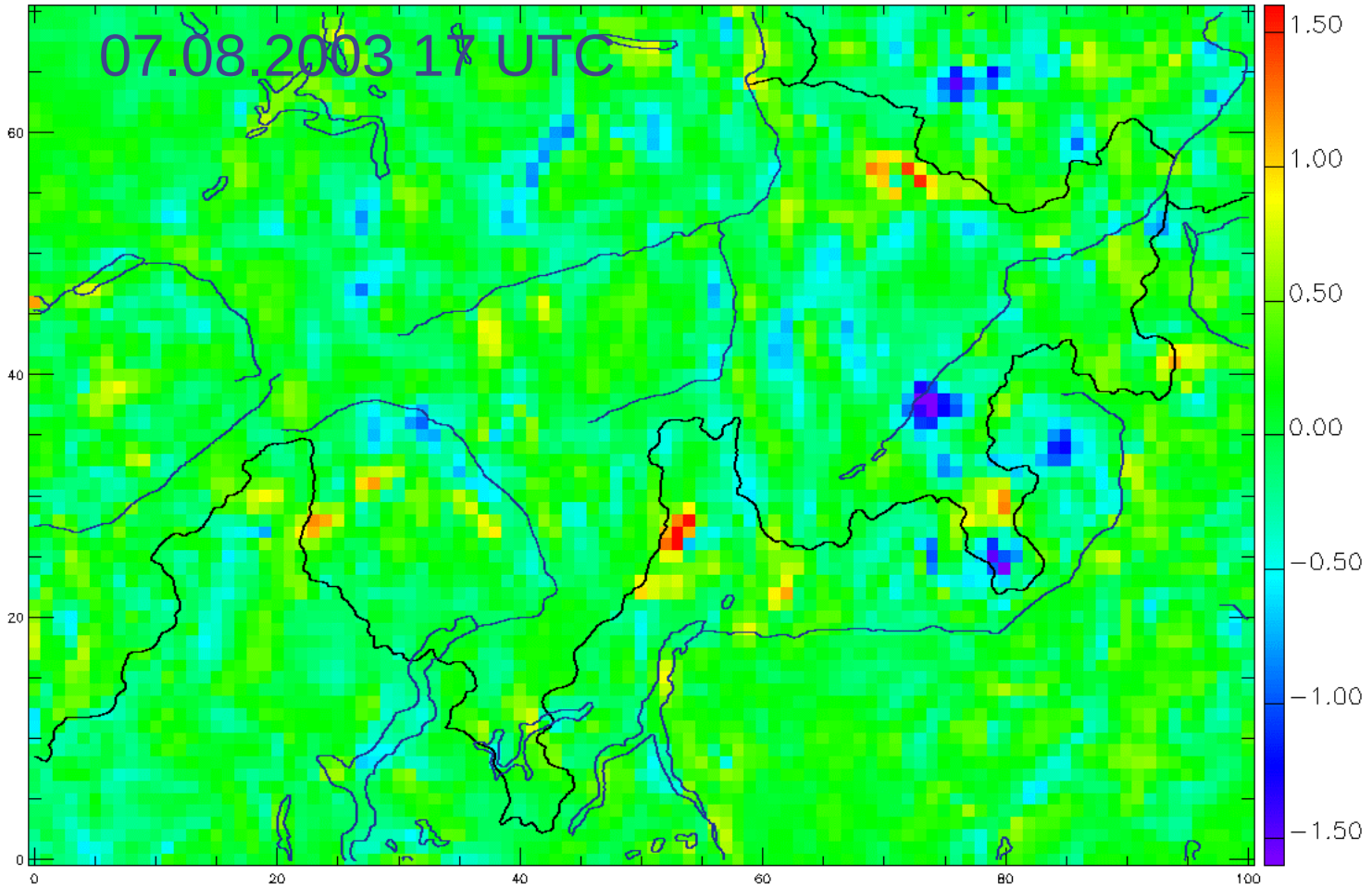
10 m horizontal wind speed: aLMo difference



2.2 km

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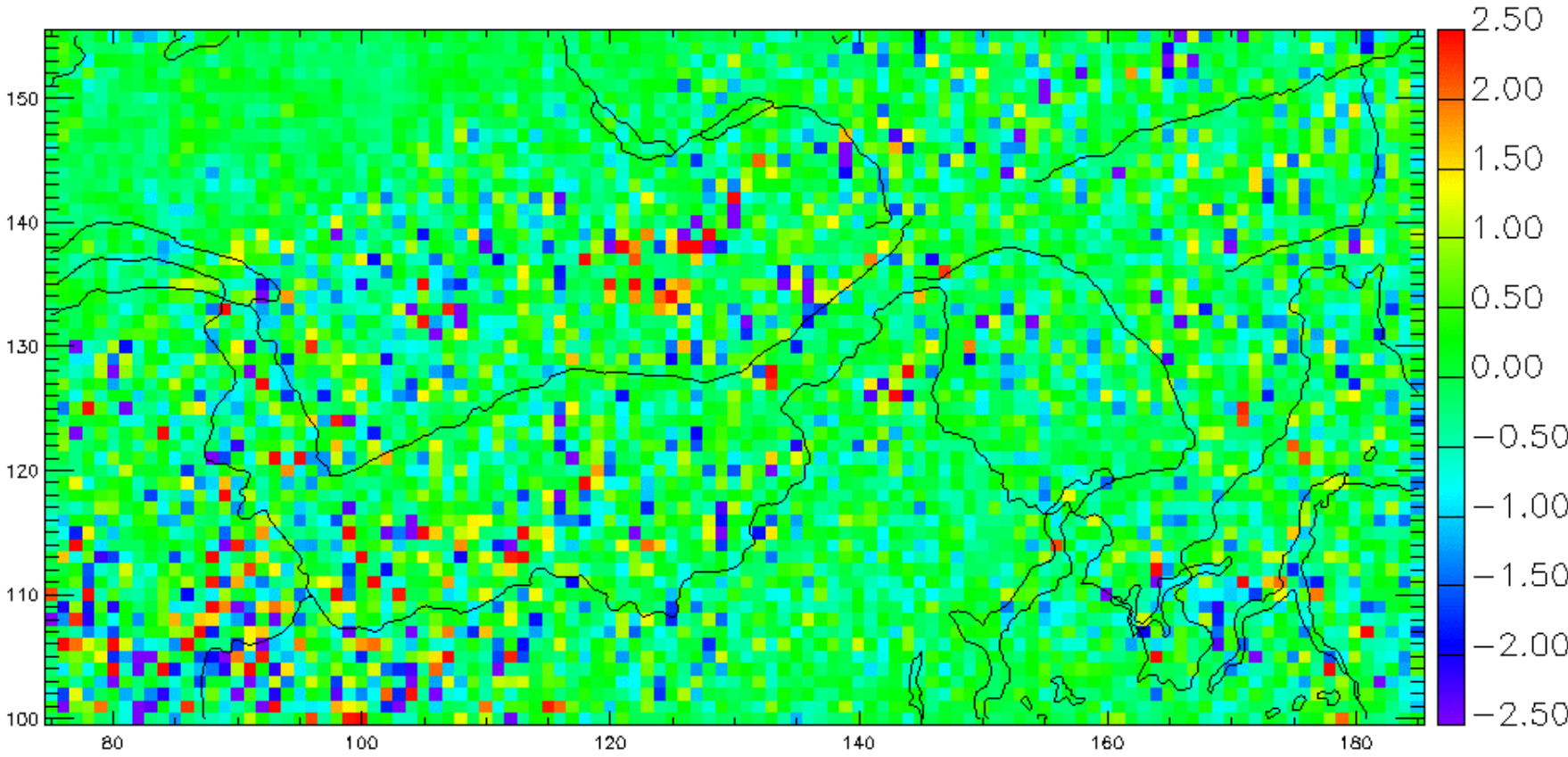
2 m temperature: aLMo difference grid - subgrid

07.08.2003 08 UTC



2.2 km

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Summary and outlook

- The adaptations of the radiation calculations at the surface have an important impact on the surface temperature
  - generally below 1.5°C, for several grid points up to 3-4°C
- We observe also changes in the cloud coverage. The effect on clouds has to be further investigated
  - Higher call frequency of the radiation scheme can help to resolve better clouds movements
- At 7km resolution there is a significant impact of the correction only in very few grid points

Summary and outlook

- Differences between subgrid scale and grid scale calculation of the correction factors are significant
  - further analysis is needed (possibly with a good DEM which covers the entire Alps)

- The radiation corrections will be introduced operationally at MeteoSwiss with the new model configuration aLMo 2 (2.2 km) after accurate verification

- The code changes (LM 3.16) are available

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Thank you very much for your attention!

matteo.buzzi@meteoswiss.ch

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