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External parameters based on high resolution topography

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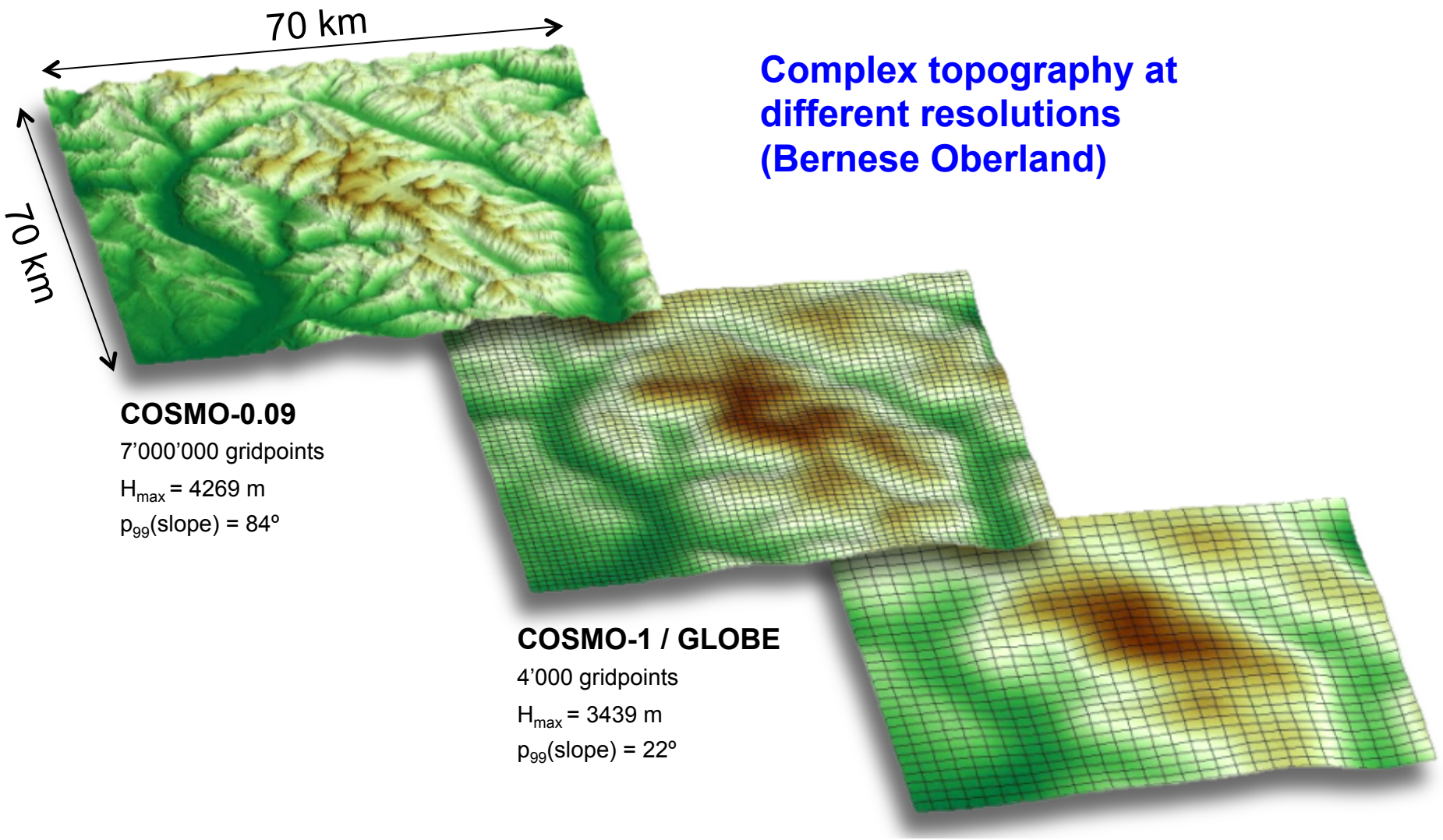
COSMO User Seminar
Offenbach, March 5 , 2013

Motivation



Complex topography at different resolutions (Bernese Oberland)

COSMO-0.09

7’000’000 gridpoints

H_{max} = 4269 m

p_{99}(slope) = 84°

COSMO-1 / GLOBE

4’000 gridpoints

H_{max} = 3439 m

p_{99}(slope) = 22°

COSMO-2

1’000 gridpoints, H_{max} = 3224 m, p_{99}(slope) = 13°

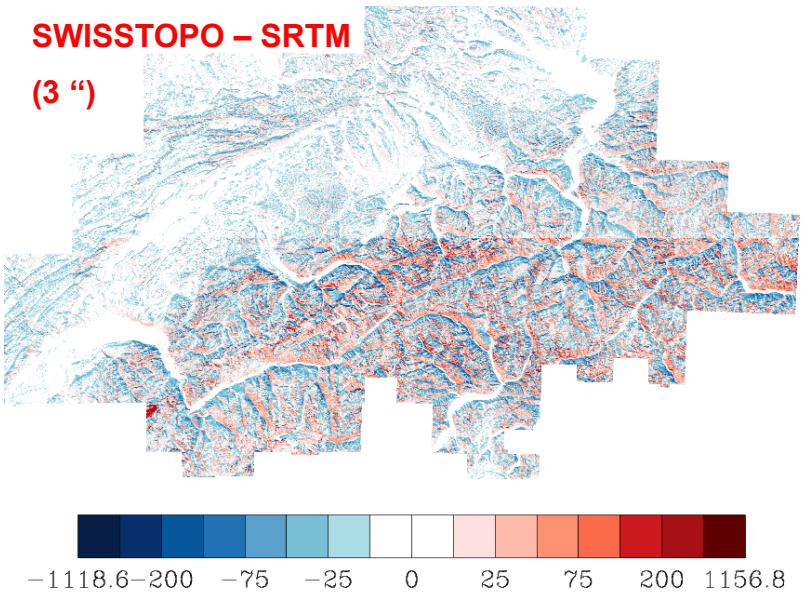
Motivation

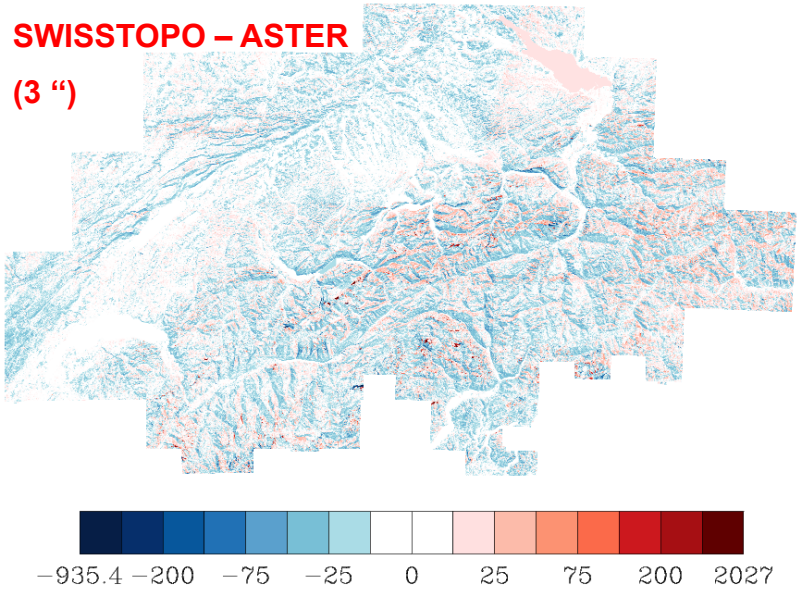
- 2 km resolution of COSMO-2 is still too coarse for Swiss topography
- Simulations with COSMO-1 are required for more precise forecasts
- BUT: resolution of GLOBE is similar to COSMO-1, meaning that **sub-grid scale topography is not visible**

⟹ A new high resolution digital elevation model (DEM) is needed to derive topography related external parameters. Both **SRTM** and **ASTER** are considered. **SWISSTOPO** data are used as reference over CH.

	GLOBE	SWISSTOPO	ASTER GDEM2	SRTM V4
Resolution	30 arc-sec	25 meters	1 arc-sec	3 arc-sec
Lat range	90° N – 90° S	whole CH	83° N – 83° S	60° N – 58° S
Projection	WGS84	CH-1903	WGS84	WGS84

SRTM and ASTER versus SWISSTOPO



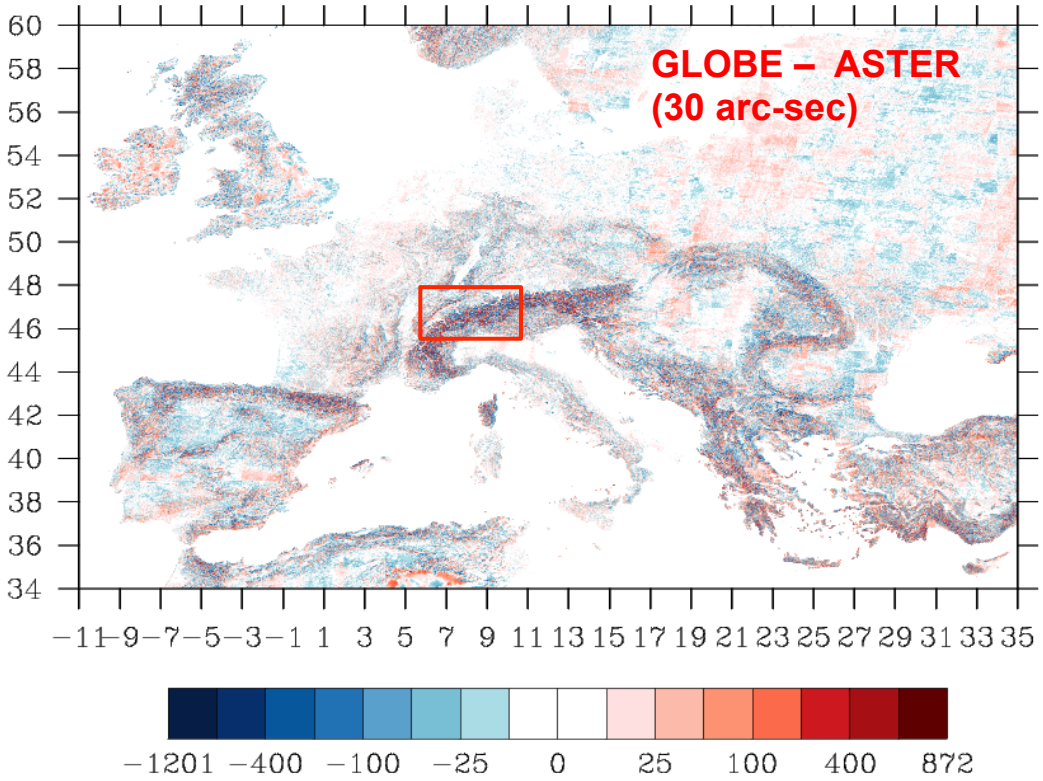


- Good match over flatlands
- Alps exhibit shift, visible as shading

- Overall good match
- Isolated spikes over Alps
- Artifacts of satellite flyover

⟹ **ASTER is more accurate than SRTM over CH Alps**

ASTER versus GLOBE (Europe)

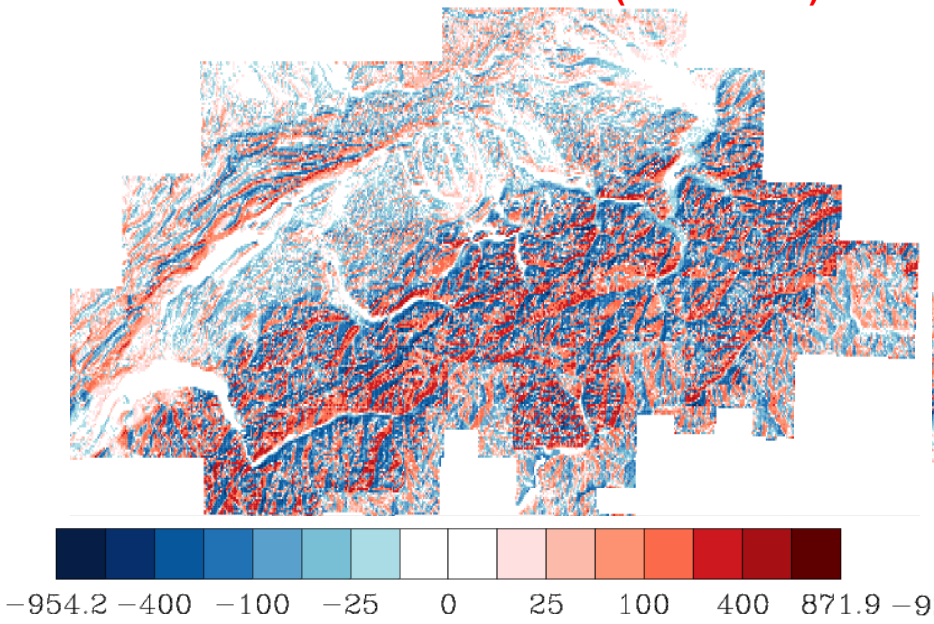


- Good match in **flat terrain** (the easy part!)
- Significant differences in **complex topography**
- **ASTER has been checked over CH Alps**

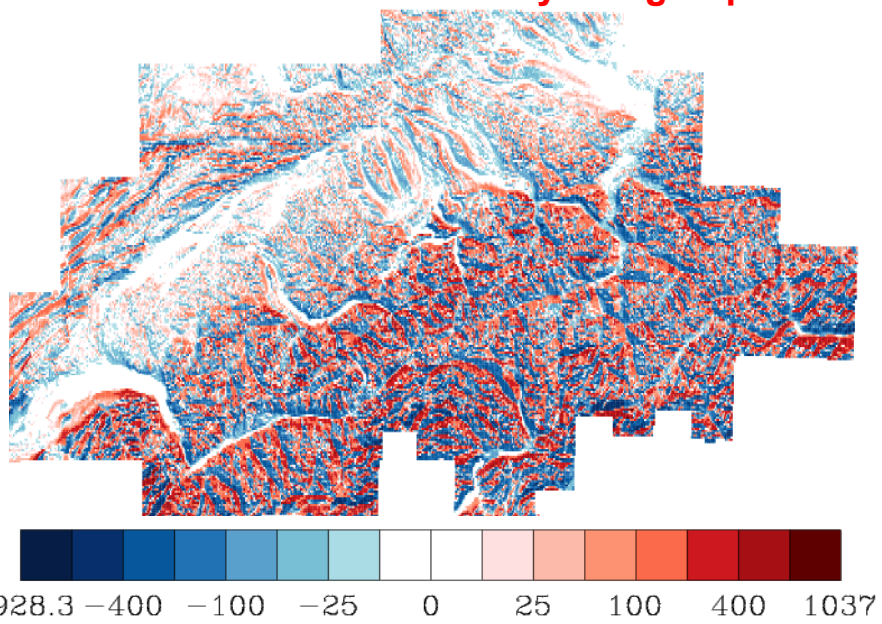
⟹ **GLOBE not as accurate in complex topography as ASTER**

GLOBE versus SWISSTOPO

GLOBE – SWISSTOPO (30 arc-sec)



GLOBE shifted to the S by one grid point

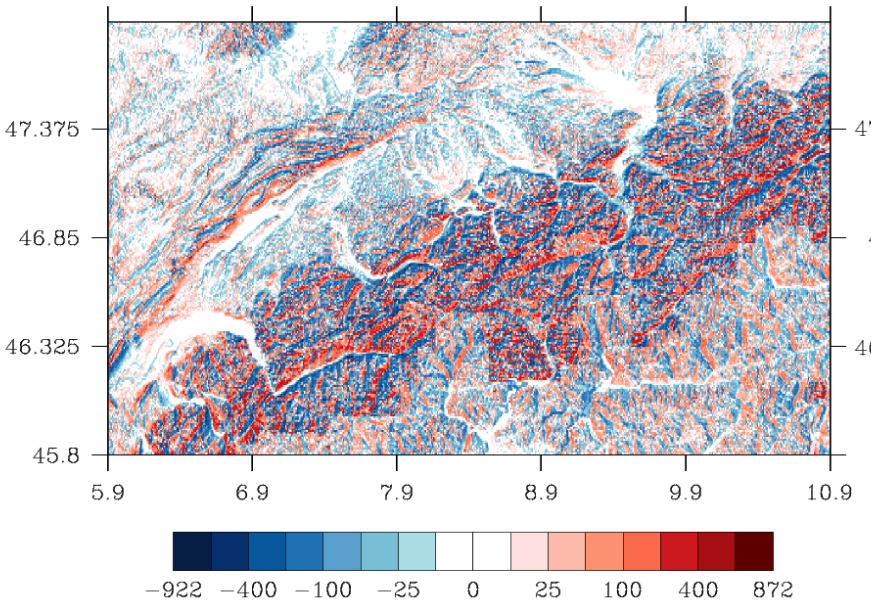


- Borders of lakes and shaded valleys imply a **shift** in the topography
- This is confirmed by artificially shifting GLOBE, which results in a slightly better match with SWISSTOPO over the Alps

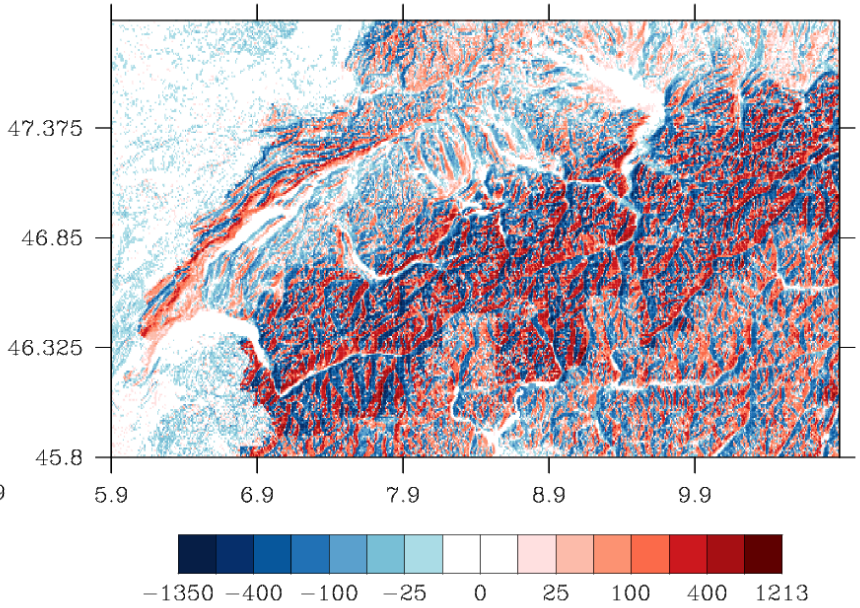
⟹ **GLOBE shifted over CH Alps, shift O(1km)**
Additional motivation to use a new DEM for complex topo

GLOBE versus ASTER (Switzerland)

GLOBE – ASTER (30 arc-sec)



GLOBE shifted to the S by one grid point



- Differences are much reduced over France when shifting the GLOBE data set by one grid point

⟹ **Unlike ASTER, GLOBE is a patchwork of different data sets**

Assets and Drawbacks of ASTER

Advantages

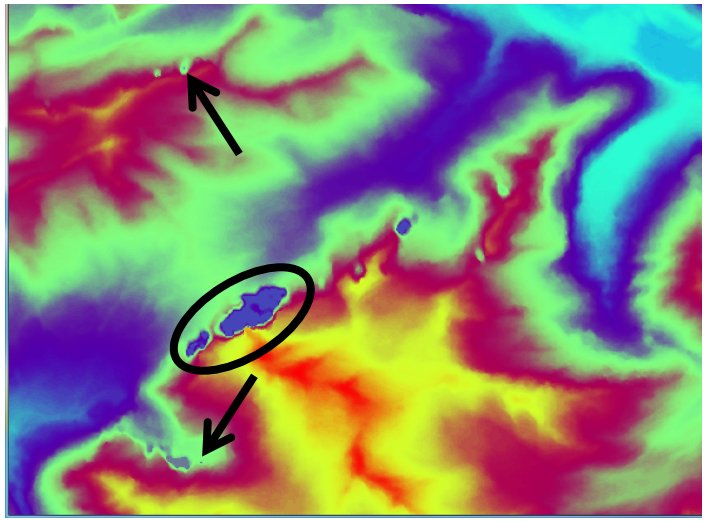
- The most **complete** very high resolution digital topography at the moment
- Better mapping of the **mountainous** regions than SRTM
- Reduces **the current shift** in the geolocation observed with GLOBE

Drawbacks

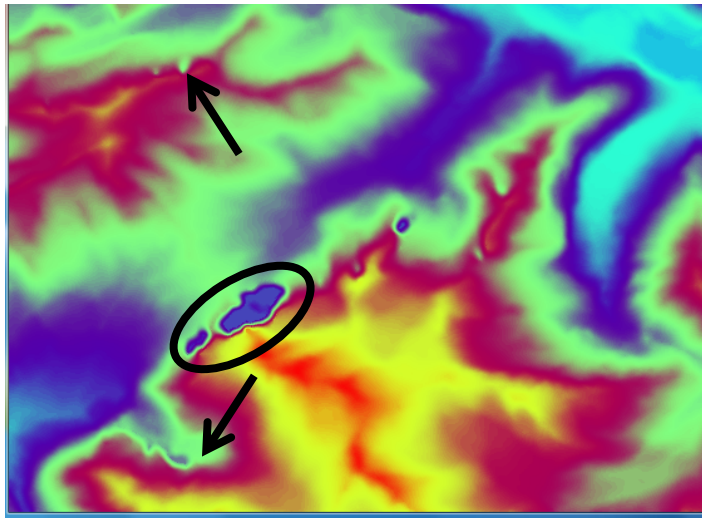
- Significant number of void data points in the **high latitudes** (not shown), correction only possible by using other DEMs
- Large **isolated spikes** in mountainous regions
- **Expensive** regarding computing time, as ASTER has 900 times more grid points than GLOBE

Spike Removal

raw ASTER data (1 arc-sec)
Region: around Grindelwald



spike removed ASTER data (1 arc-sec)



- **Spikes associated with a single point** can easily be removed
- **Extended bogus regions** cannot easily be automatically removed; they mainly appear in regions of **steep slope**

Adaptations in EXTPAR

- Support ASTER data (but currently **limited** to the tested region)
- A **new module** has been introduced
- There is a **new switch**, which allows user to choose between GLOBE and ASTER
- The new module can read the information of the raw input topography more dynamically (NetCDF meta-information)
- An additional DEM can be introduced more easily

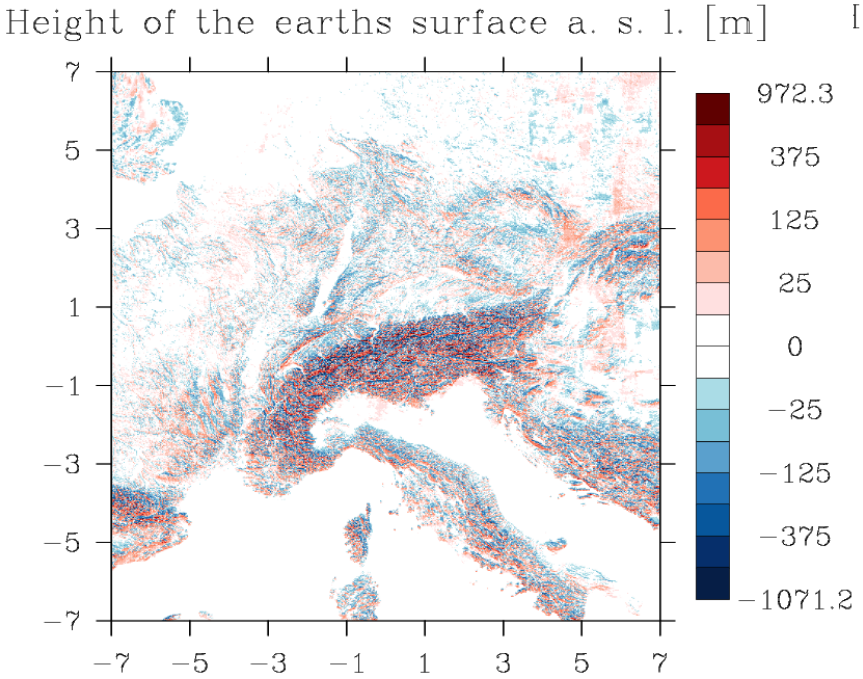
⟹ ASTER is **only recommended** for very high resolution applications and for a domain not extending to high latitudes:

- Increased computational time
- Lack of accuracy at high latitudes

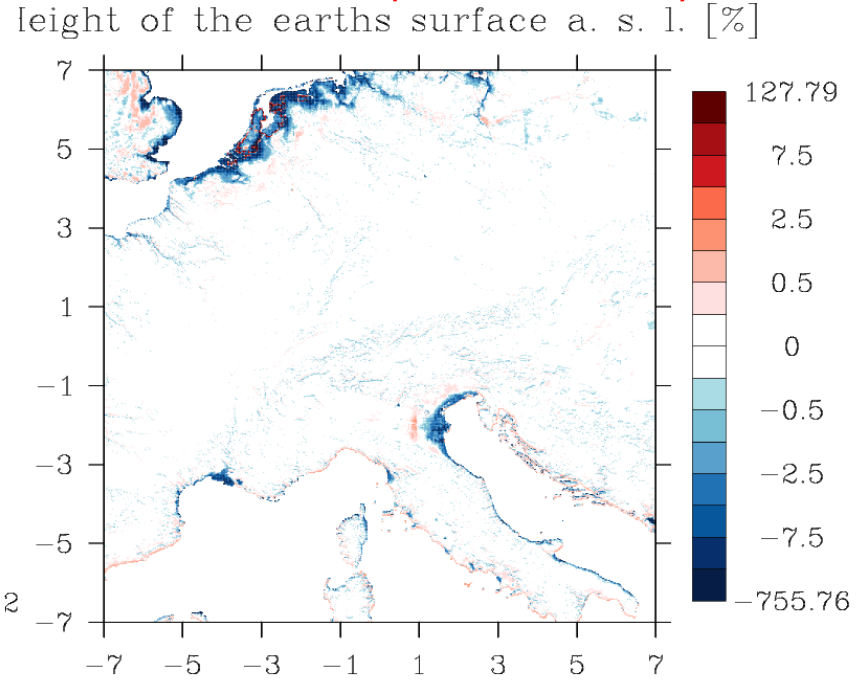
Validation of implementation

External Parameters for COSMO-2 : orography

Absolute differences: GLOBE - ASTER



Relative differences: (GLOBE - ASTER)/GLOBE



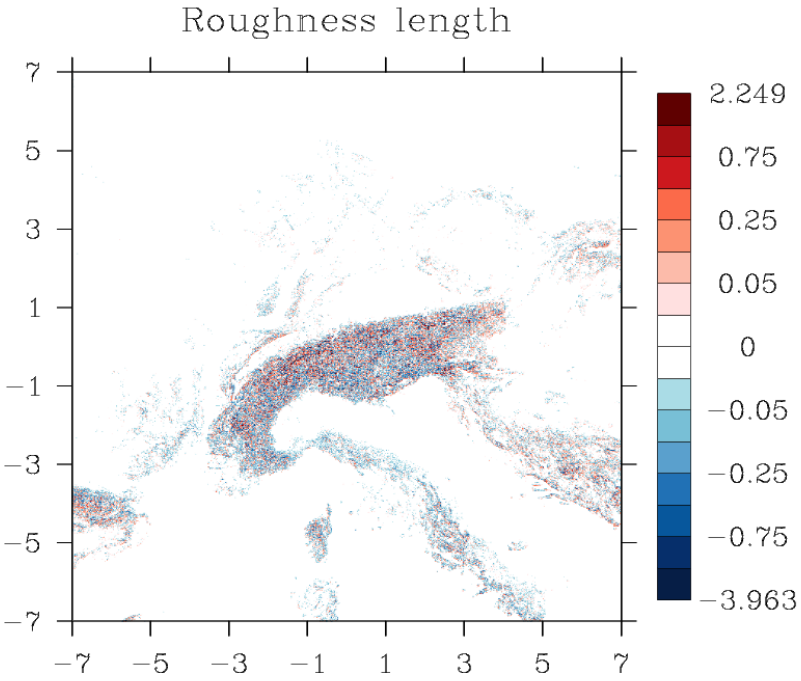
- Difference similar to raw data comparison

- Shift well visible
- Areas close to sea level show larger differences

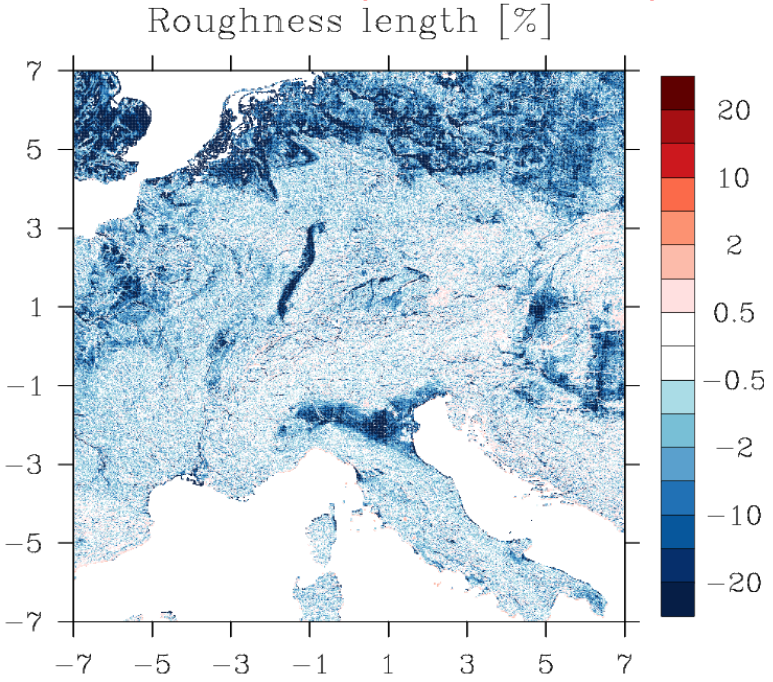
Validation of implementation

External Parameters for COSMO-2 : roughness length

Absolute differences: GLOBE - ASTER



Relative differences: (GLOBE - ASTER)/GLOBE

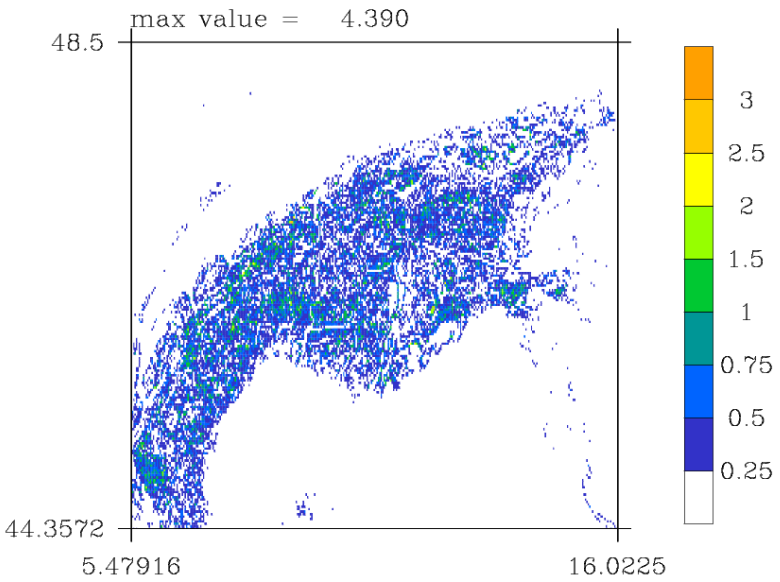


- Only contribution from **orography** is shown, as land-use component was not changed
- **Relative** differences small over Alps and larger in flatlands

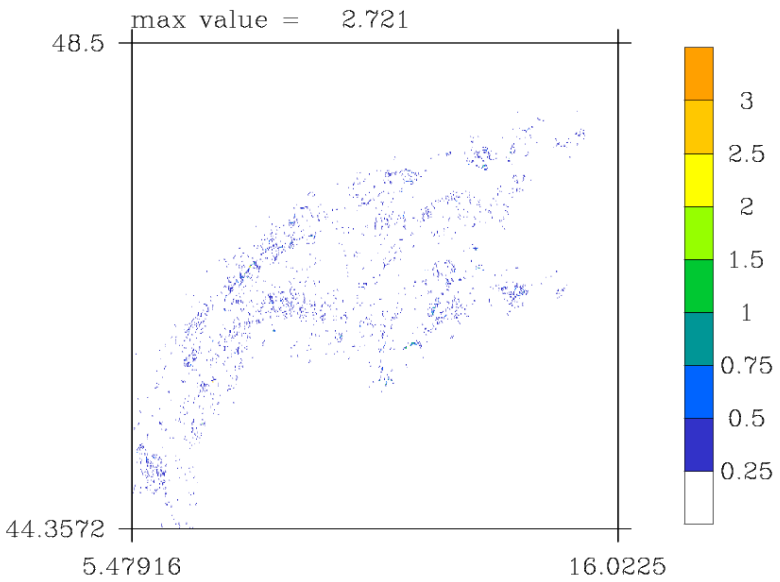
Validation of implementation

External Parameters : roughness length

z0 calculated with ASTER projected on the COSMO-2 grid



z0 calculated with ASTER projected on the COSMO-1 grid



- Roughness length is deduced from **ASTER** in both cases
- Roughness length is **reduced**, when using a finer grid, **as expected**

Summary

- Comparison of ASTER with GLOBE and SWISSTOPO is accomplished, **ASTER** is a good candidate for high resolution applications
- Attempt to remove **spikes** in ASTER data set has been performed, but some extended bogus regions cannot be automatically removed
- **Adaptation of EXTPAR** such that the user can choose between GLOBE and ASTER
- A first **validation** process of the external parameters on the COSMO-2 and COSMO-7 grid has been completed
  - *Reasonable differences between the two data sets suggests a correct implementation*

Outlook

- Implementation of **scale separation** to derive z0 and SSO parameters, using a 3 km filtered topography
- **Quality control** of code (4 eyes principle)
- **Sensitivity study**
  - COSMO-1 with GLOBE and ASTER
  - COSMO-7 with and without scale separation

- Implementation of parameters for **topo corrected radiation**

⟹ New EXTPAR release combining DWD release 1.7 (OpenMP), topo corrected radiation, ASTER extension planned for **mid April**

CONSORTIUM FOR SMALL SCALE MODELING

COSMO

Thank you for your attention!