Creating a cloud-free MODIS snow cover product using spatial and temporal interpolation and temperature thresholds

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Motivation and objectives

Motivation:

- Ground snow observation network is scarce and can not provide detail information on regional snow cover variations.
- Satellite-based snow products (VIS/NIR) can provide good spatial overview, but application of these products is limited by the cloud cover.
- Daily cloud free snow cover product is desired for hydrological and climatological applications.

Objectives:

- Use spatial and temporal interpolation to create the cloud free MODIS snow cover product.
- Apply temperature thresholds to reduce overestimarion errors of generated product.
- Asses accuracy of the cloud-free MODIS snow cover product using insitu data.

Data

- Study period: 1st October 2012 to 30th April 2017.
- MODIS Terra and Aqua Snow Cover Daily L3 Global 500m Grid, Version 6 (MOD10A1, MYD10A1) *(Hall & Rigs, 2018)*.
- Daily minimum temperature (Tmin), E-OBS 0.25° grided data, v17.0 (provided by ECA&D).
- In situ snow measurements (depth and coverage) from Lithuanian Hydrometeorological Service. Daily observations from 18 meteorological station.

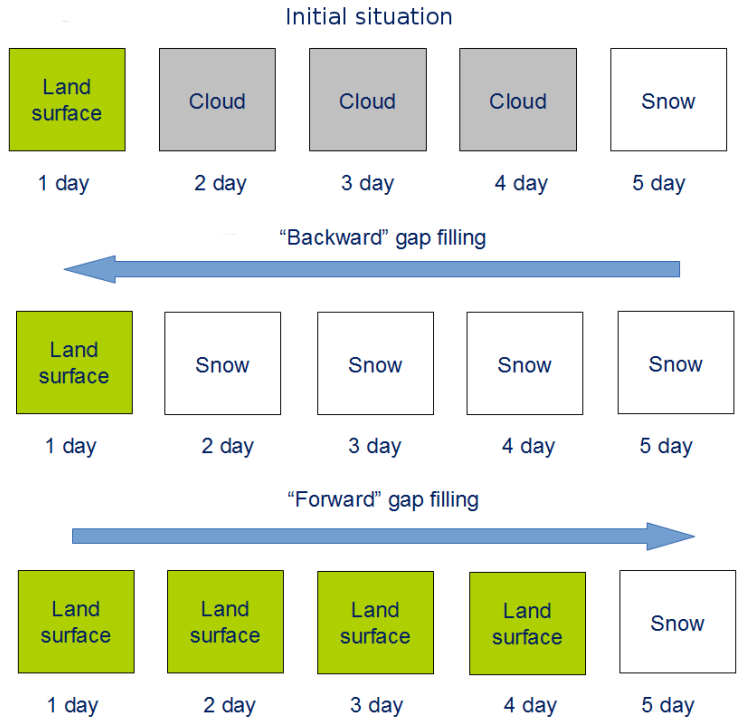
NSIDC
National Snow and Ice Data Center

ECA&D

Lietuvos hidrometeorologijos tarnyba

Methodology (1)

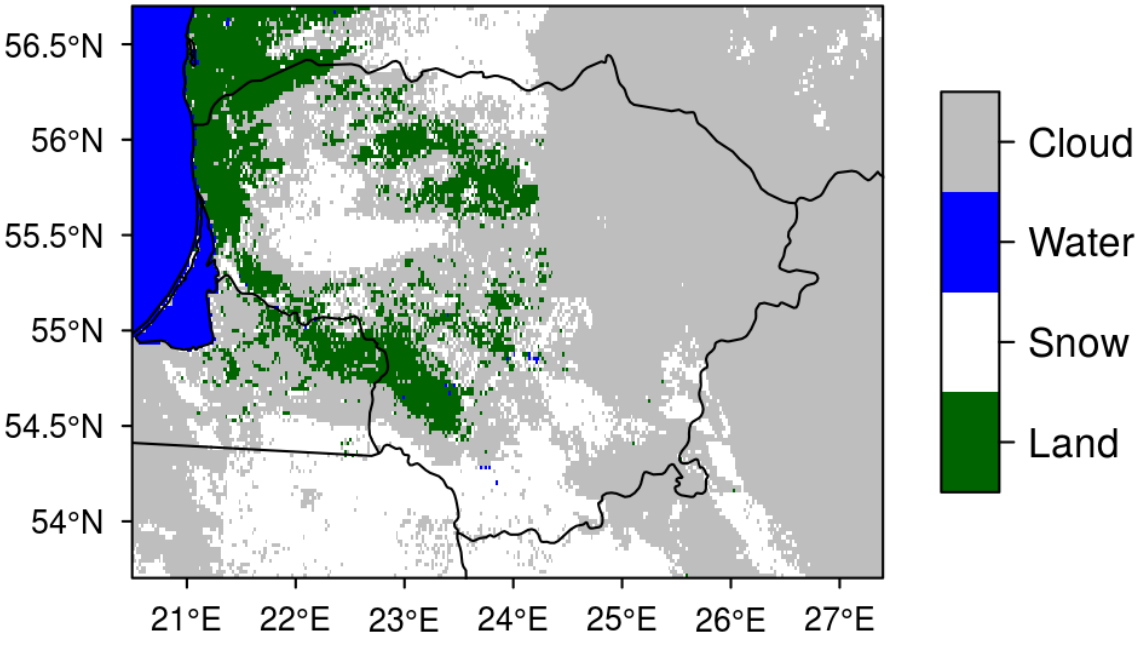
- Transformation of MOD10A1 and MYD10A1 products from sinusoidal to geographical WGS-84 projection (MODIS Reprojection Tool).
- Combining Terra and Aqua satellite snow cover products to one.
- Spatial filtering of cloudy values using 8 neighboring grid cells *(Parajka & Blöschl, 2008)*.
- Temporal filtering of cloudy grid cells, using forward and backward filling from the last cloud free value *(Foppa & Seiz, 2012)*.



Methodology (2)

- Applying Tmin threshold to filter the false snow grid cells. During accumulation of snow cover (October - February) Tmin < 1.0 °C, during ablation period (March-April) Tmin < 3.0 °C *(Dong & Menzel, 2016).*
- Calculating mean from the backward and forward temporal filtering with Tmin control.
- Validation with insitu data (contingency table statistics).

Results: cloud gap filling step 1

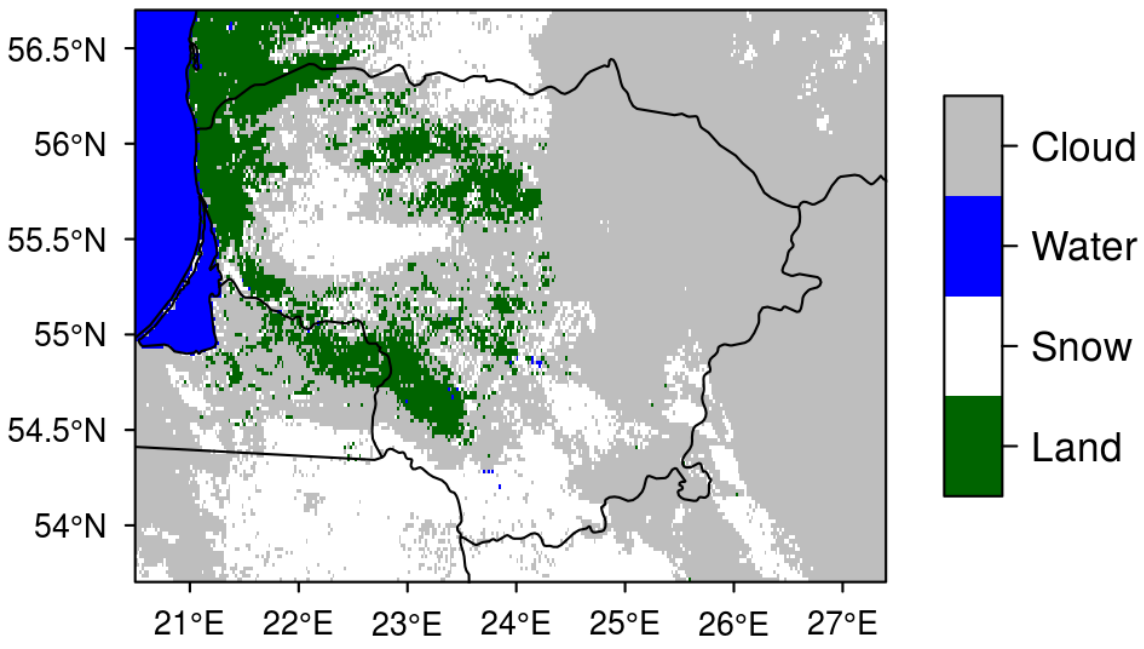


10th February 2017

MYD10A1 (Aqua)

60,1% of area is clouds,
10,4% of area is land,
24,1% of area is snow,
5,4% of area is water.

Results: cloud gap filling step 2



10th February 2017

Combination of MYD10A1 (Terra) and MOD10A1 (Aqua).

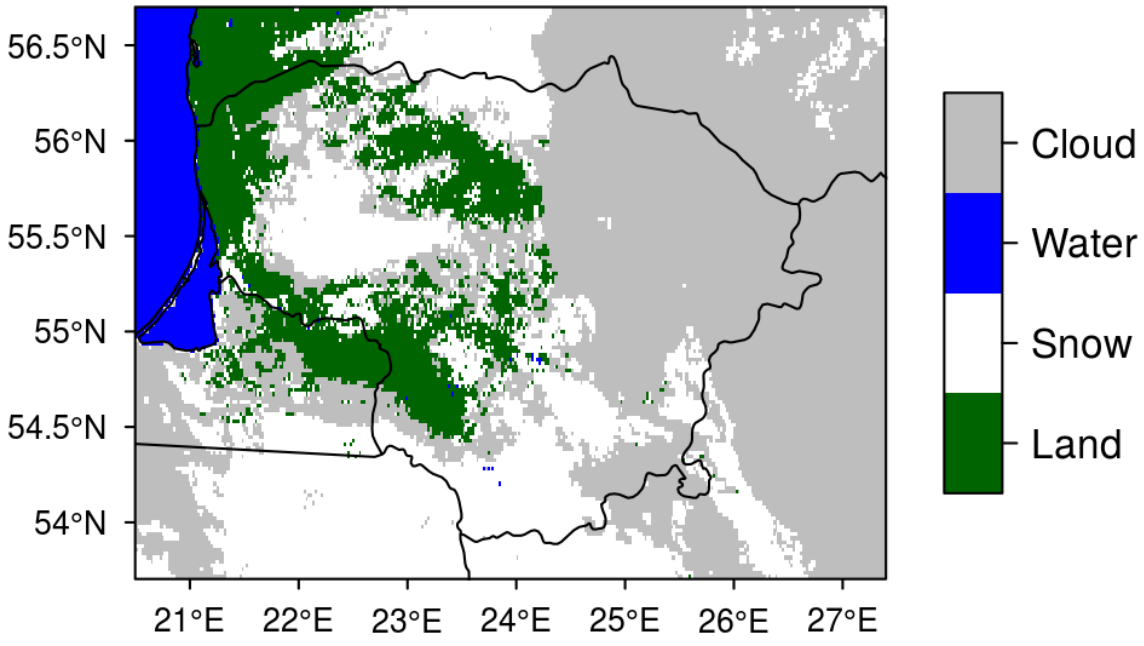
60,1% of area is clouds,

10,4% of area is land,

24,1% of area is snow,

5,4% of area is water.

Results: cloud gap filling step 3



10th February 2017

Spatial filtering by 8 neighboring pixels.

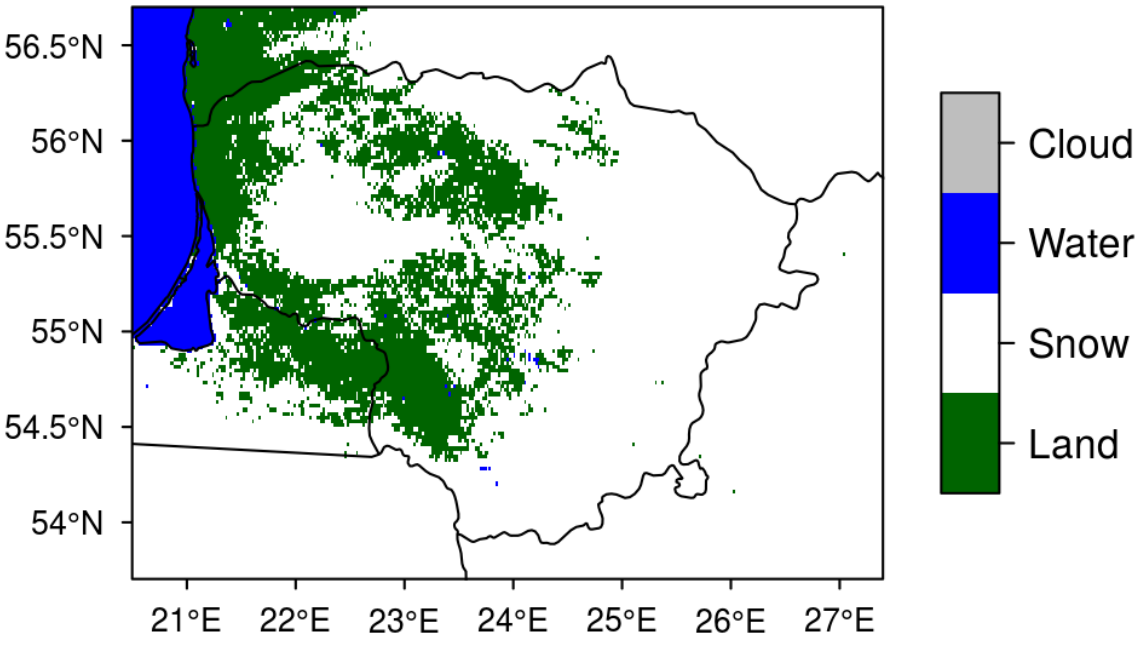
49,2% of area is clouds,

13,7% of area is land,

31,7% of area is snow,

5,4% of area is water.

Results: cloud gap filling steps 4-5



10th February 2017

Average of forward and backward temporal gap filling with Tmin control.

0,0% of area is clouds,

17,0% of area is land,

77,6% of area is snow,

5,4% of area is water.

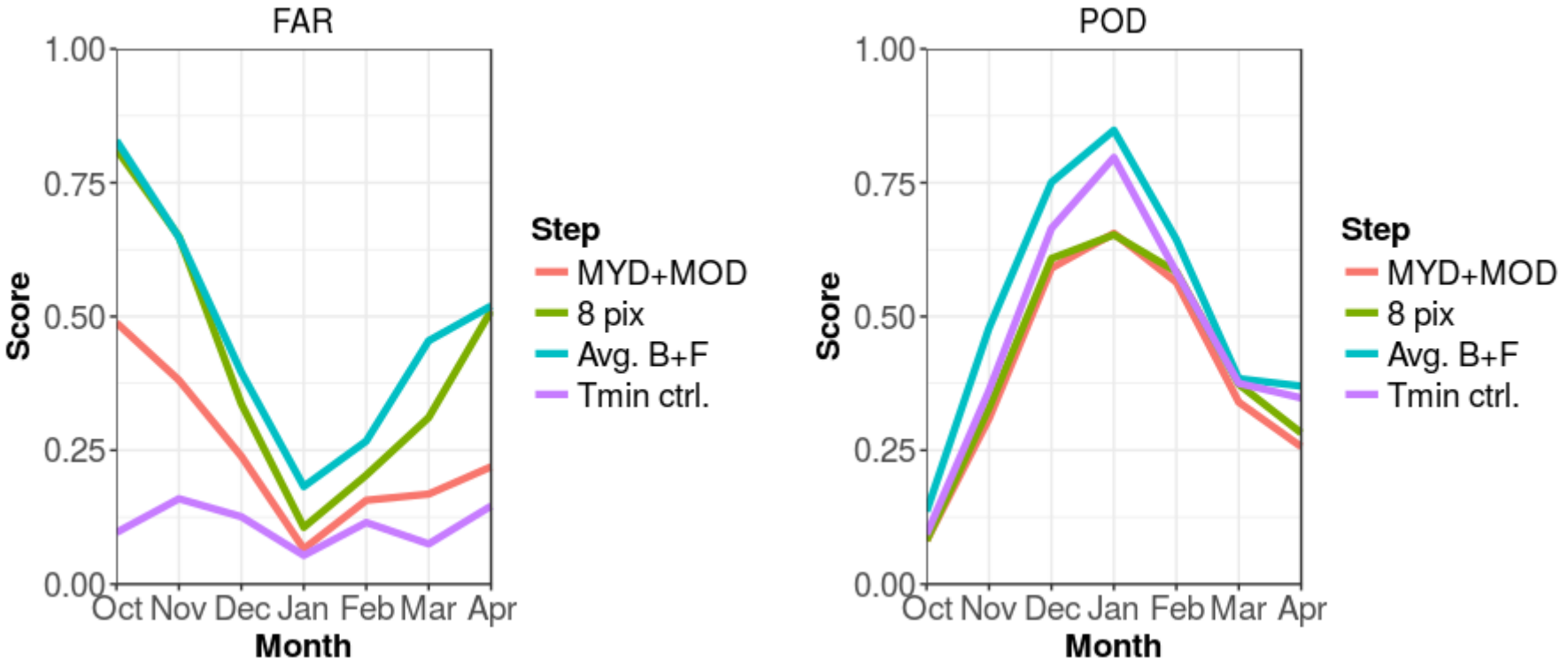
Validation results

Step	N	Hits	Miss	FalseA	CorrN	ACC	CSI	FAR	FBI	POD
MYD+MOD	5459	1345	111	431	3572	0.88	0.44	0.24	0.60	0.45
8px	6468	1635	128	670	4035	0.86	0.47	0.40	0.72	0.46
Backward	19098	4955	1070	3164	9909	0.78	0.35	0.48	1.49	0.54
Forward	19098	5166	859	2855	10218	0.81	0.39	0.45	1.44	0.58
Avg. B+F	19098	5212	813	2855	10218	0.81	0.39	0.45	1.45	0.58
Tmin ctrl.	19098	4839	1186	932	12141	0.89	0.46	0.11	0.76	0.52

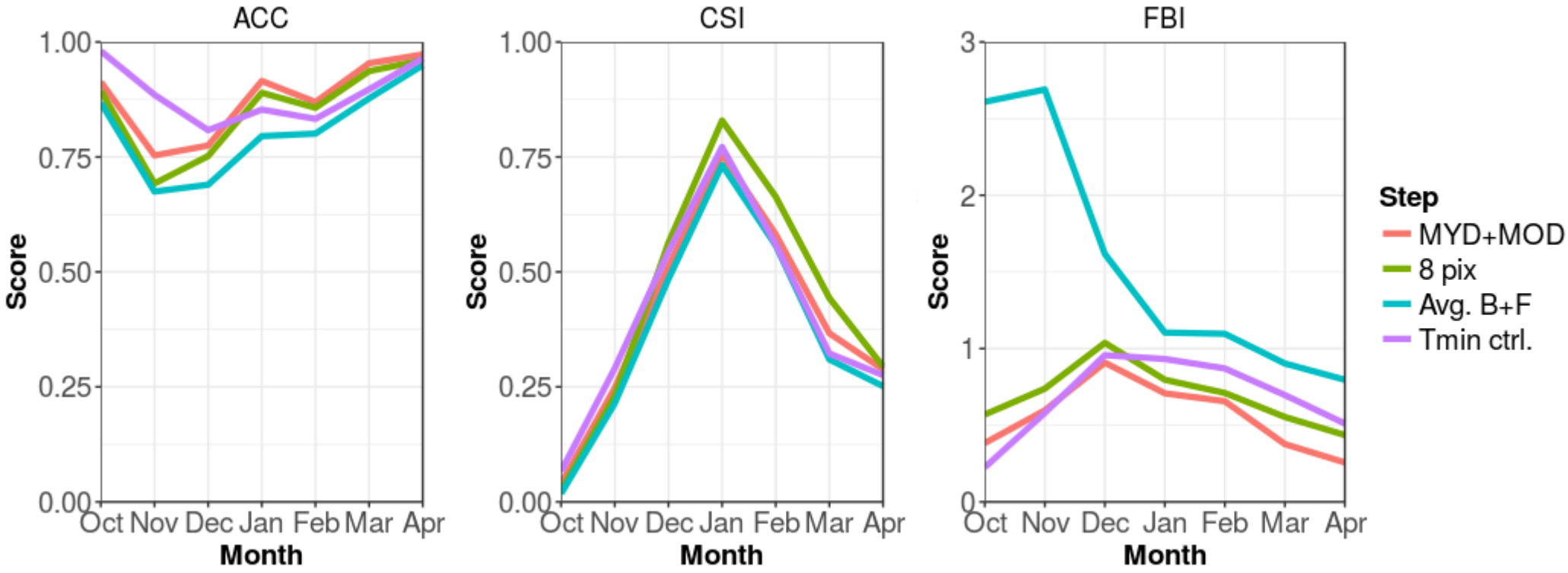
ACC – Accuracy (rate of agreement);
CSI – Critical Success Index (Threat Score);
FAR – False Alarm Rate.

FBI – Frequency Bias;
POD – Probability of Detection;

Validation results on different months



Validation results on different months



Summary

- In 2012-2017 on average 72 % of original MODIS snow cover products are cloud covered in cold period.
- Spatial filtering by 8 neighboring grid cells reduces the cloud cover on average by 8 %.
- Backward and forward filling can remove all cloudy values, but this method can be used only for re-processing with intention to derive monthly or seasonal snow cover characteristics.
- Temperature thresholds reduce false alarm rate by 4 times. Temperature filter is not universal and should be adapted to the the study area.
- Final cloud-free MODIS snow cover product has accuracy (ACC) of 0.89, probability of detection (POD) 0.52 and Critical Success Index (CSI) 0.46.

Reference

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