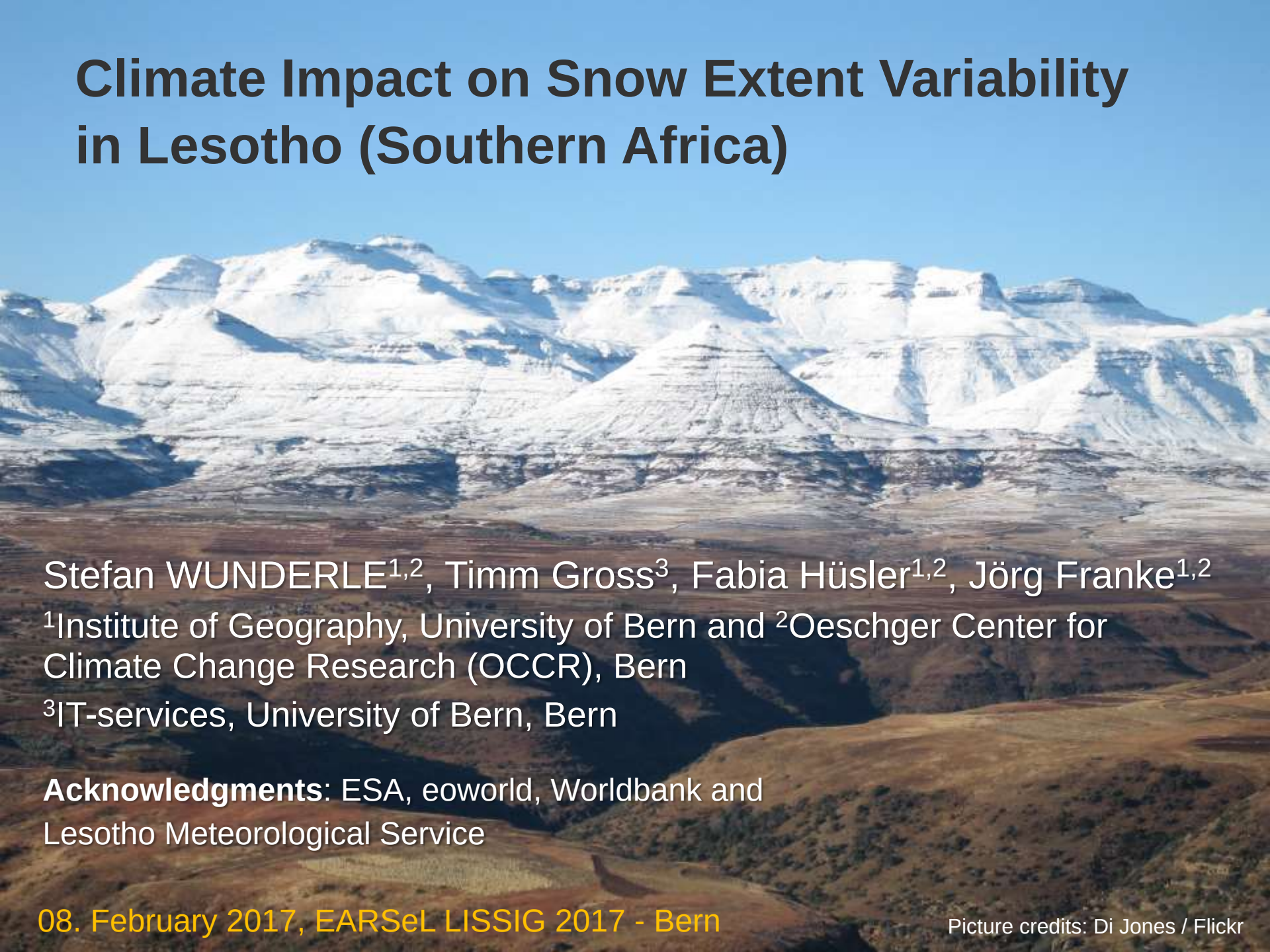
Climate Impact on Snow Extent Variability in Lesotho (Southern Africa)



Stefan WUNDERLE[1,2], Timm Gross[3], Fabia Hüsler[1,2], Jörg Franke[1,2]

[1]Institute of Geography, University of Bern and [2]Oeschger Center for Climate Change Research (OCCR), Bern

[3]IT-services, University of Bern, Bern

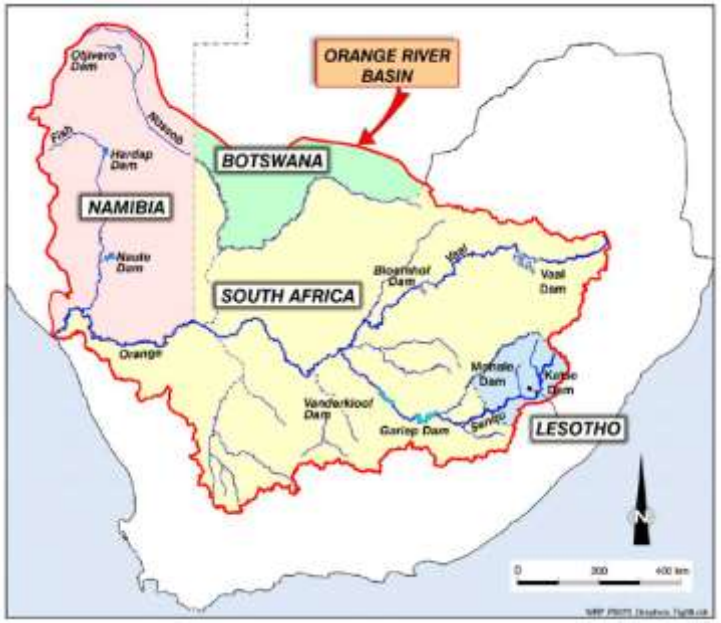
Acknowledgments: ESA, eoworld, Worldbank and Lesotho Meteorological Service

08. February 2017, EARSeL LISSIG 2017 - Bern

Picture credits: Di Jones / Flickr

Why we should care about snow in Lesotho: Water management

- Lesotho represents a water tower contributing approximately 40% of the water to the Orange River. Lesotho's economy relies on water export.
- Due to its high elevation, snow is an important contribution for runoff during winter time.

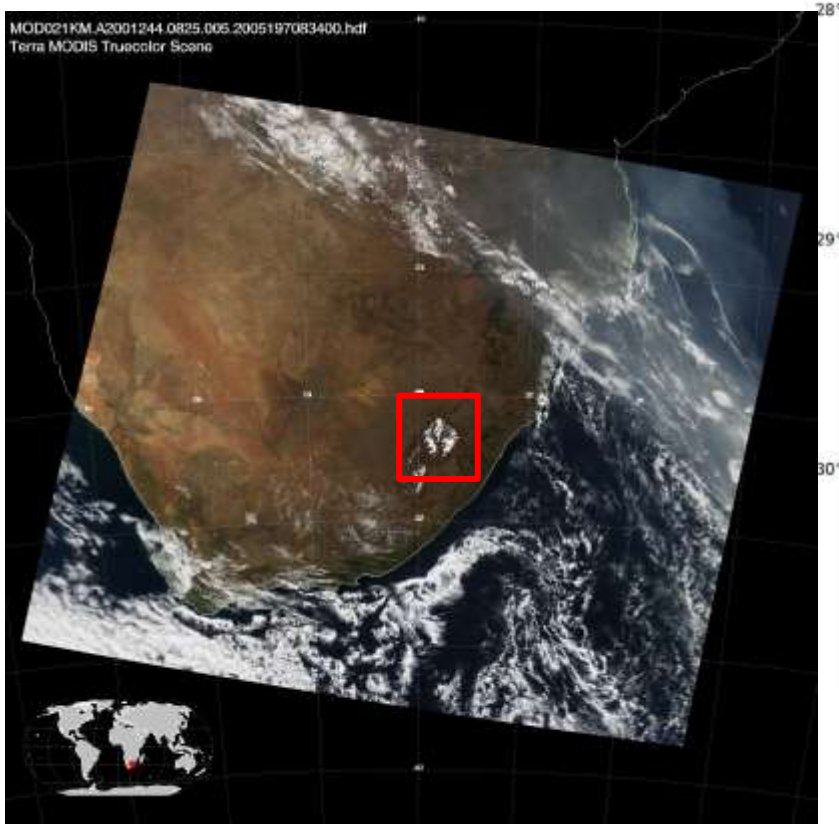


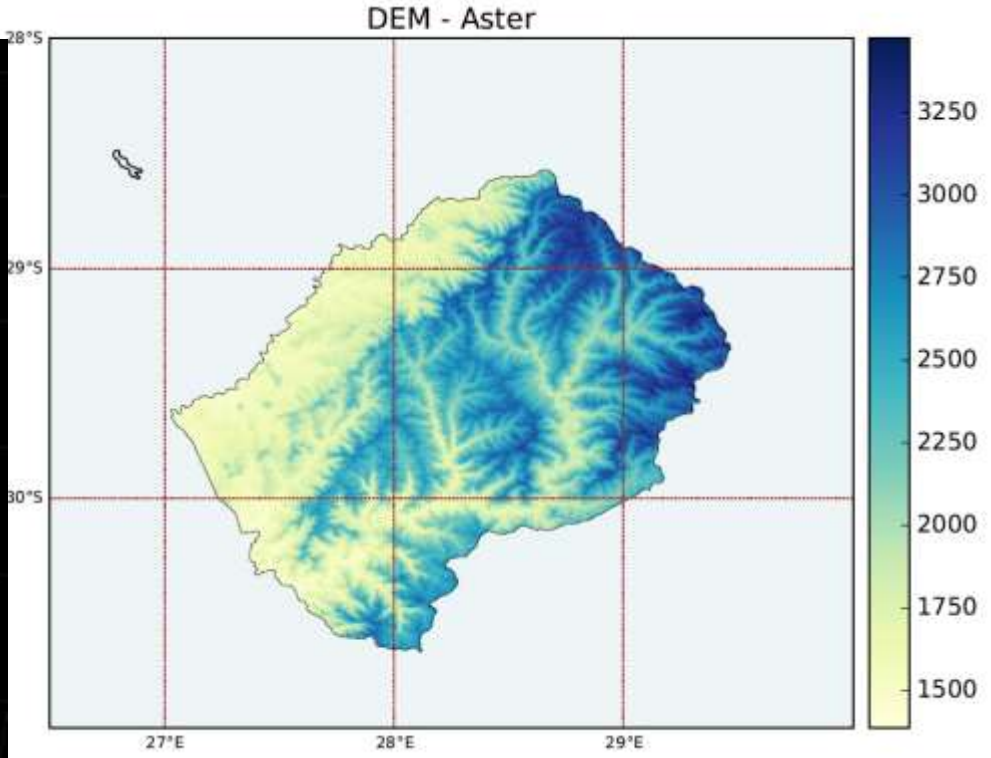


Lesotho – an remarkable topographic high in southern Africa

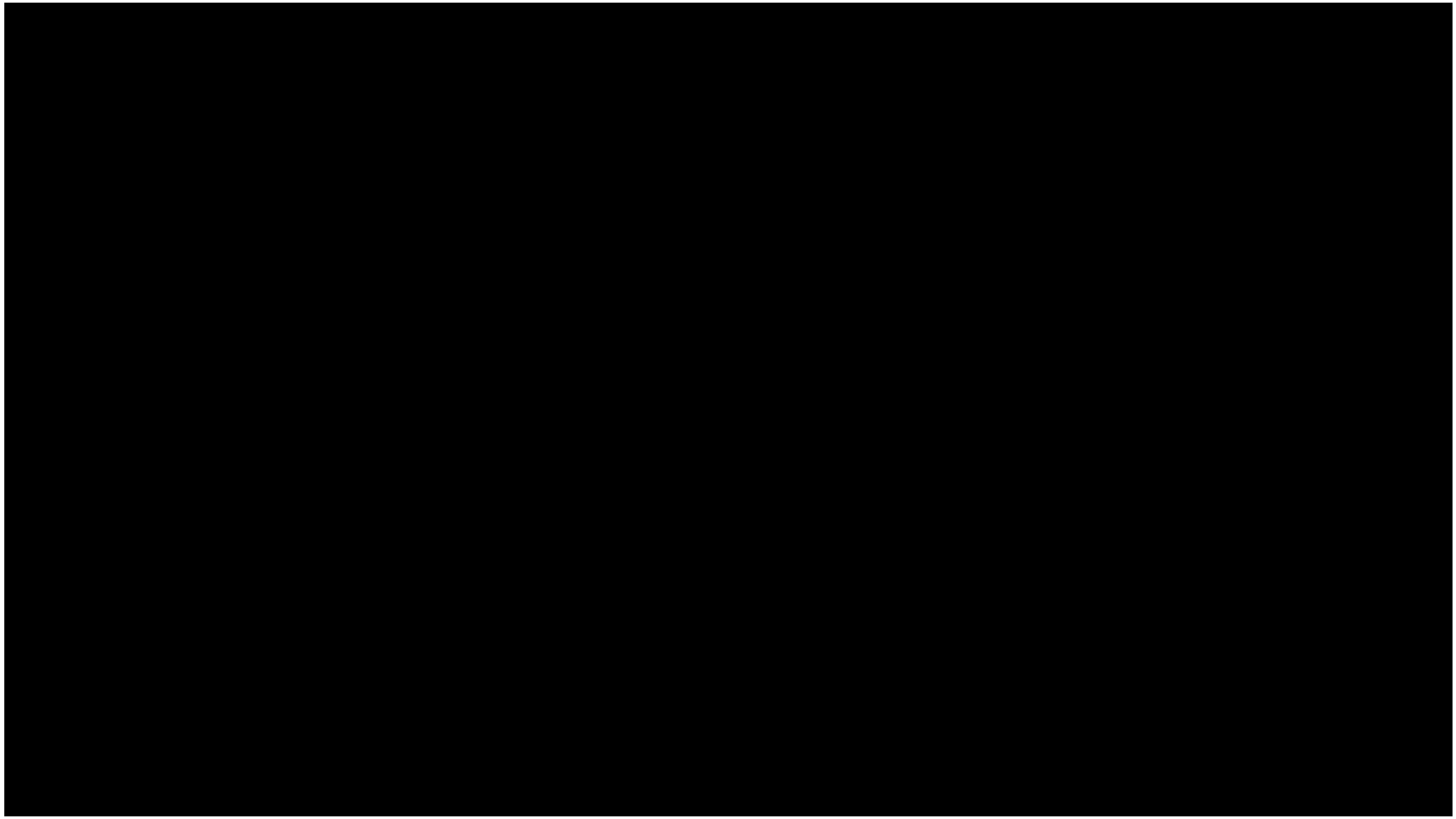
UNIVERSITÄT BERN

- MODIS image (2001,244) and ASTER elevation model

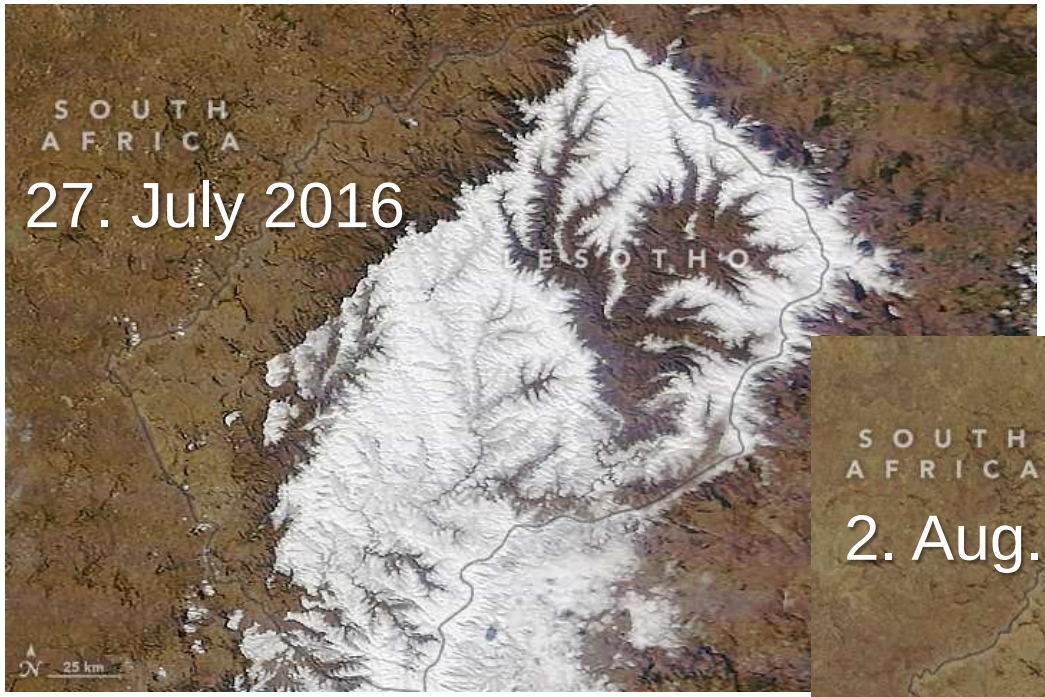




Lesotho snow fall August 2016



Lesotho snow fall 2016

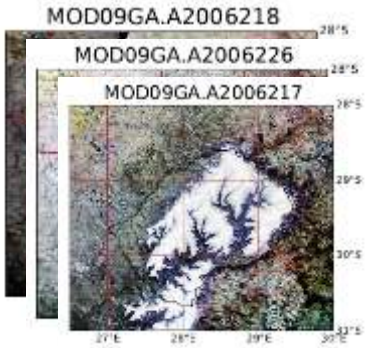


One of the heaviest snow-fall event since 10 years

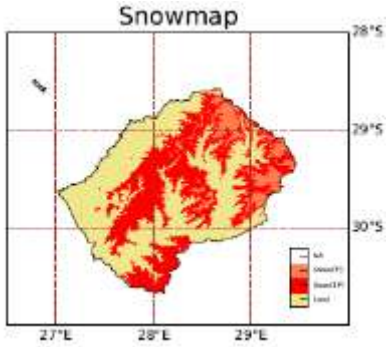


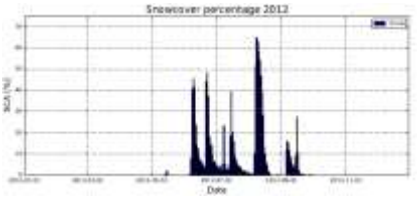
After 3-4 days most of the snow in the lowlands is melted.

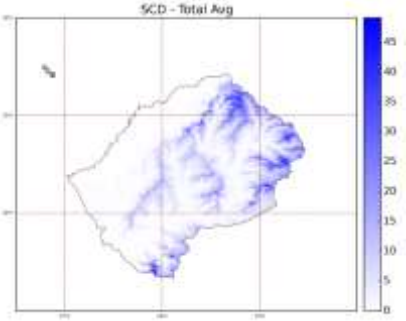
Product generation

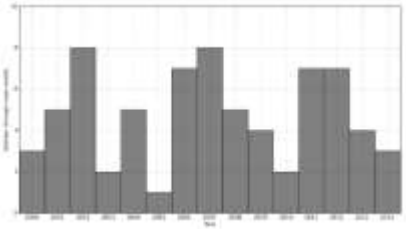


NDSI + post processing + validation



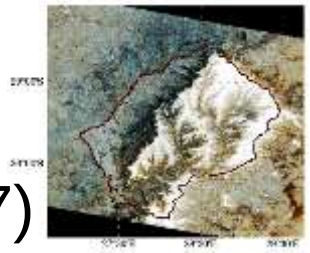






MODIS data
2000 - 2014

Reference images (cloud free)

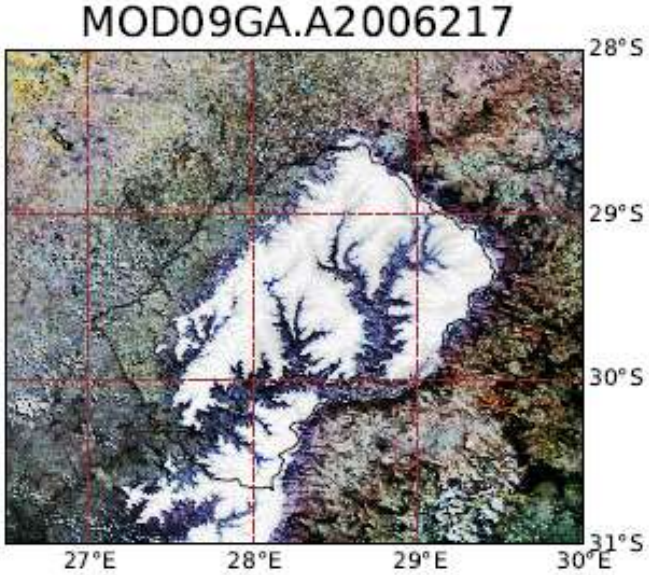


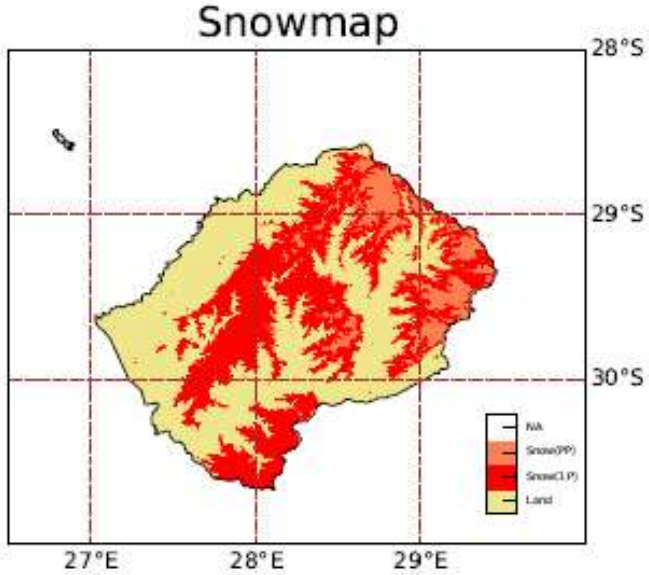


MERIS data (57)

TM data (17)

Snow retrieval





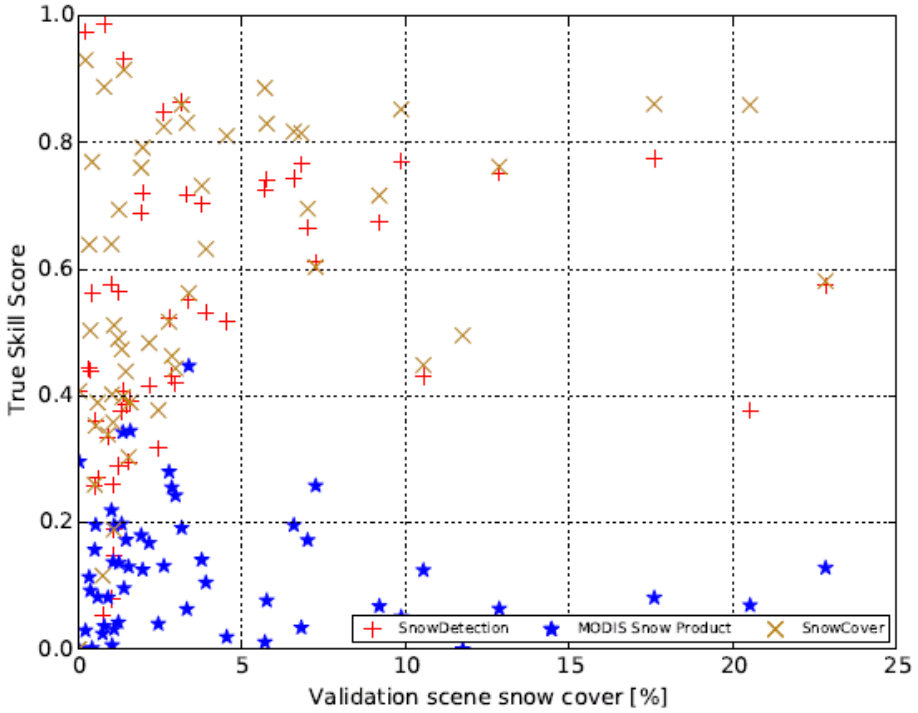
$$NDSI_{Terra} = \frac{B_4 - B_6}{B_4 + B_6} \qquad NDCI = \frac{B_{32} - B_{26}}{B_{32} + B_{26}}$$

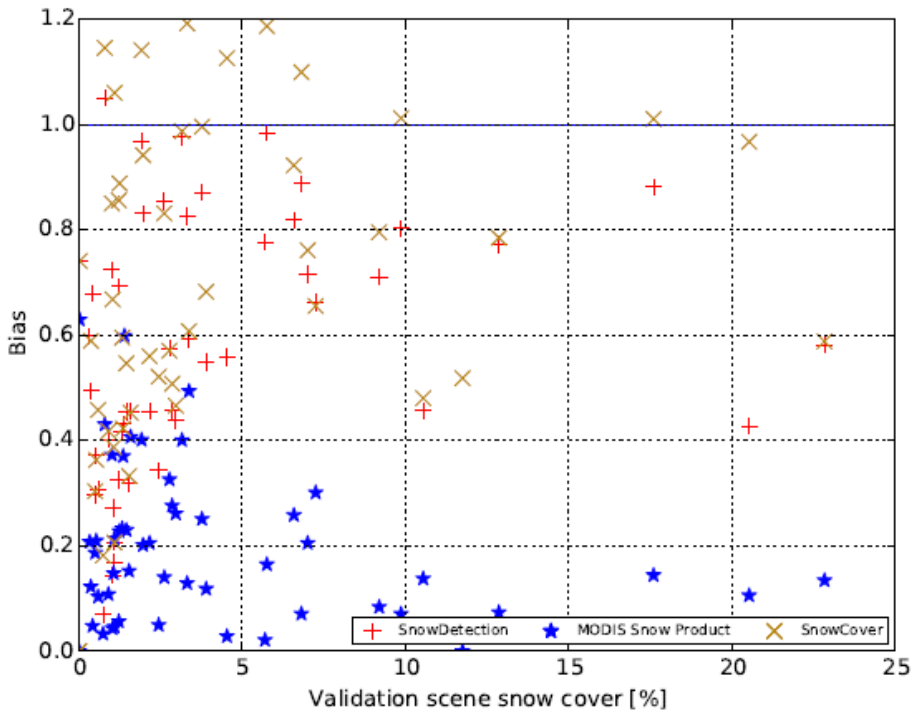
$$NDSI > 0.4 \wedge B_2 > 11\% \wedge B_4 > 10\% \wedge NDCI > 0.7$$

Comparison and validation I

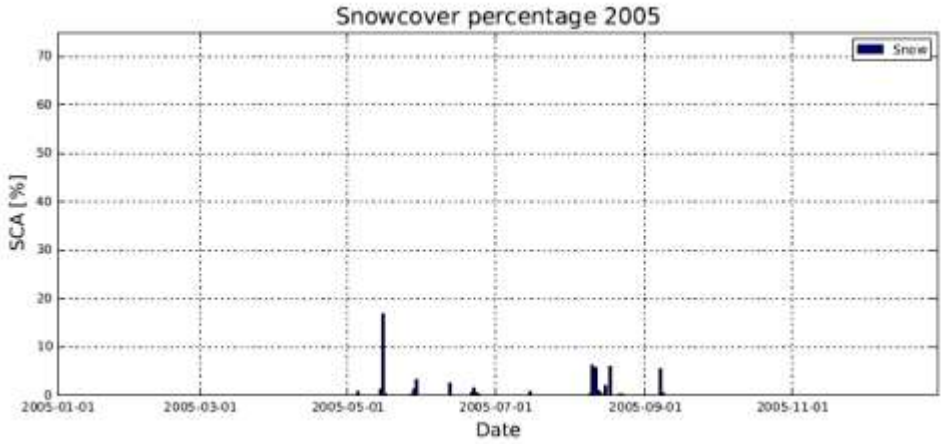
UNIVERSITÄT BERN

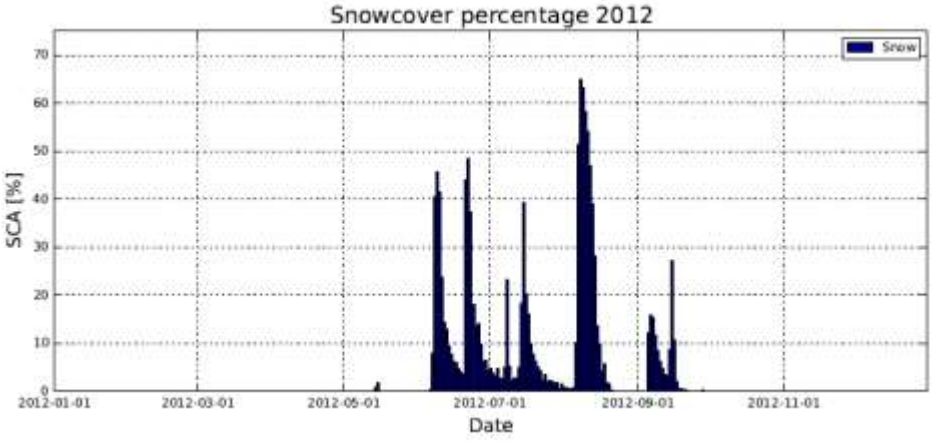
- Comparison with MERIS (270m) snow mask (True Skill Score and Bias)

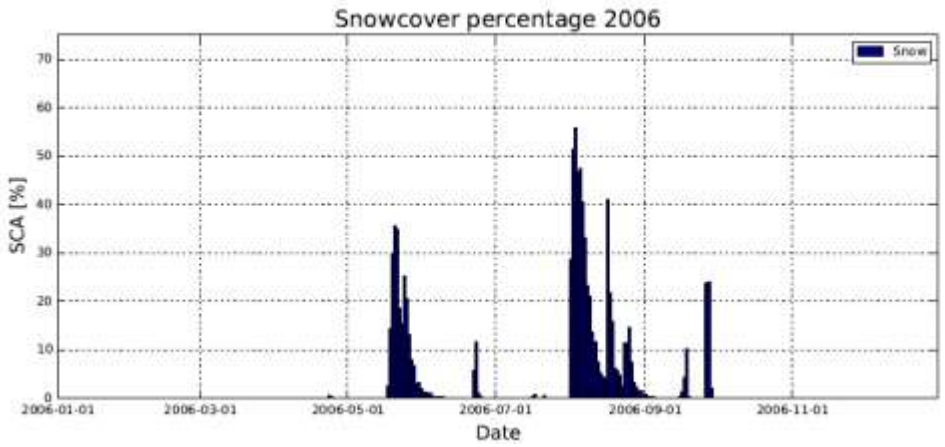


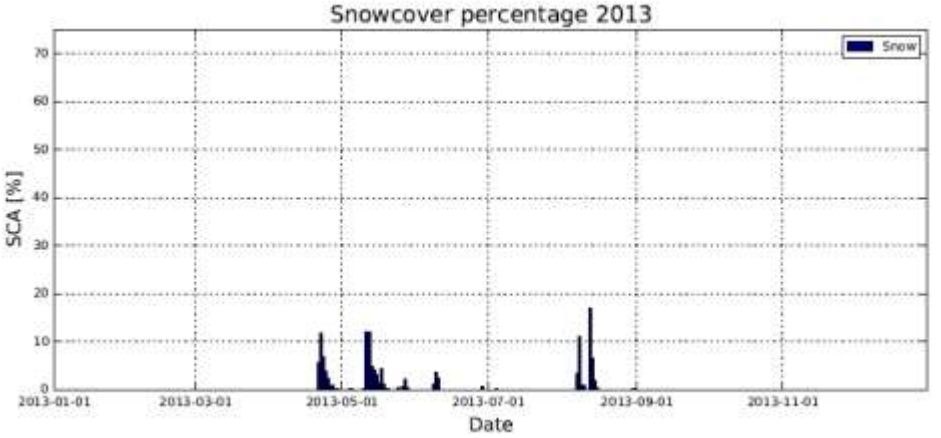


High variability of snow cover example: 2005/2006 and 2012/2013

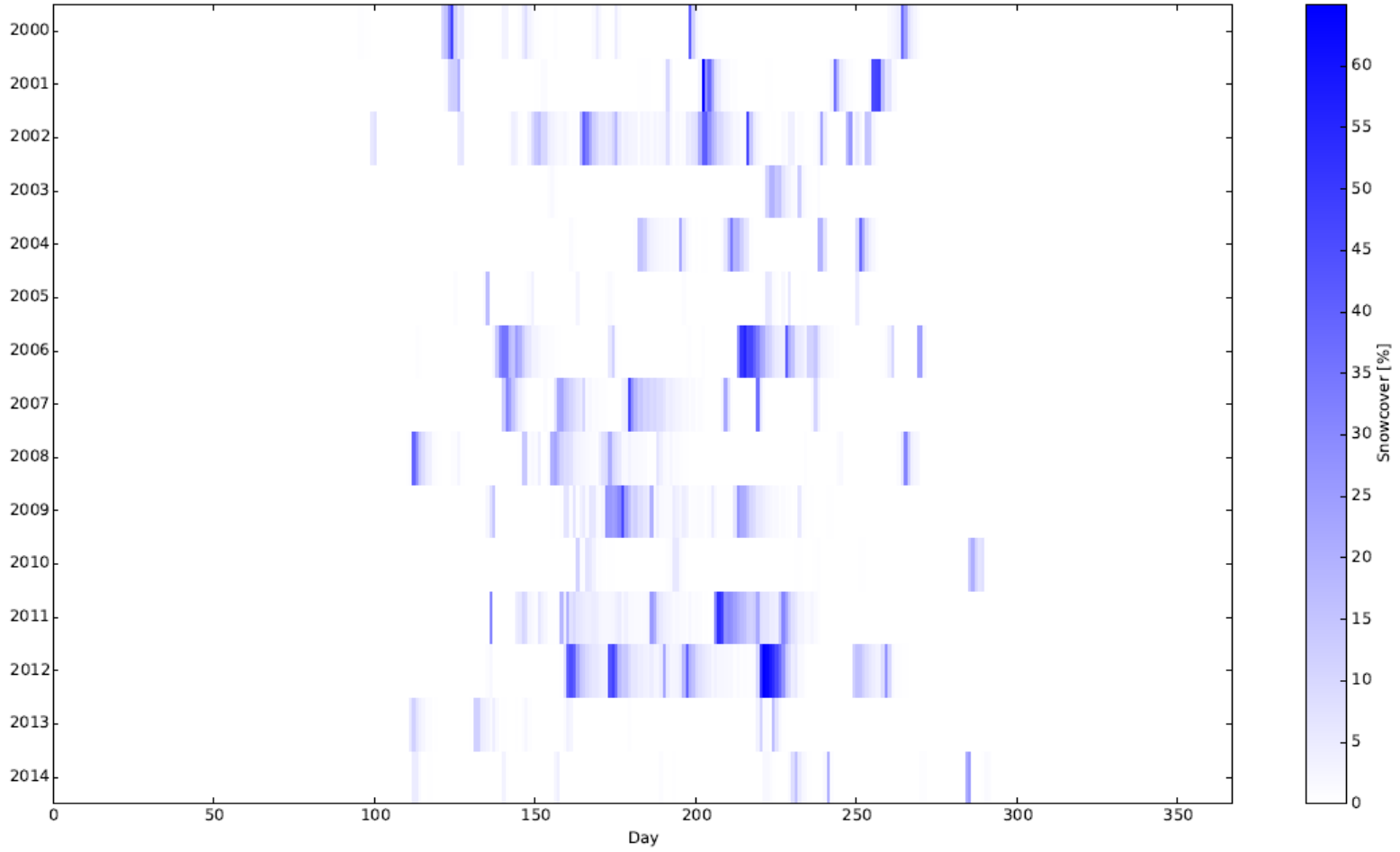








Snow cover in Lesotho (% of area) 2000 - 2014



Synoptic patters over Southern Africa Summer (Oct-Mar) – Winter (Apr-Sep)

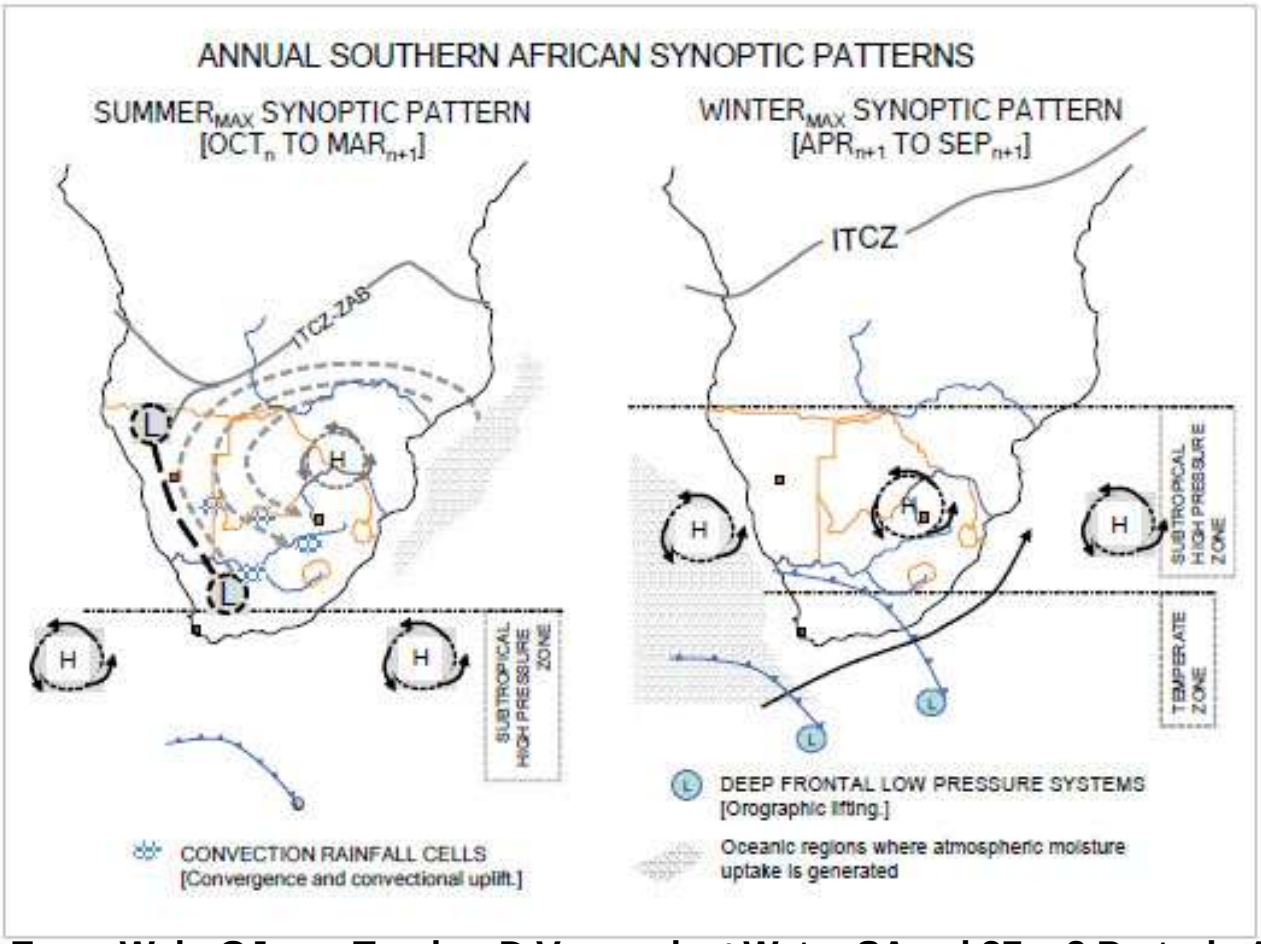
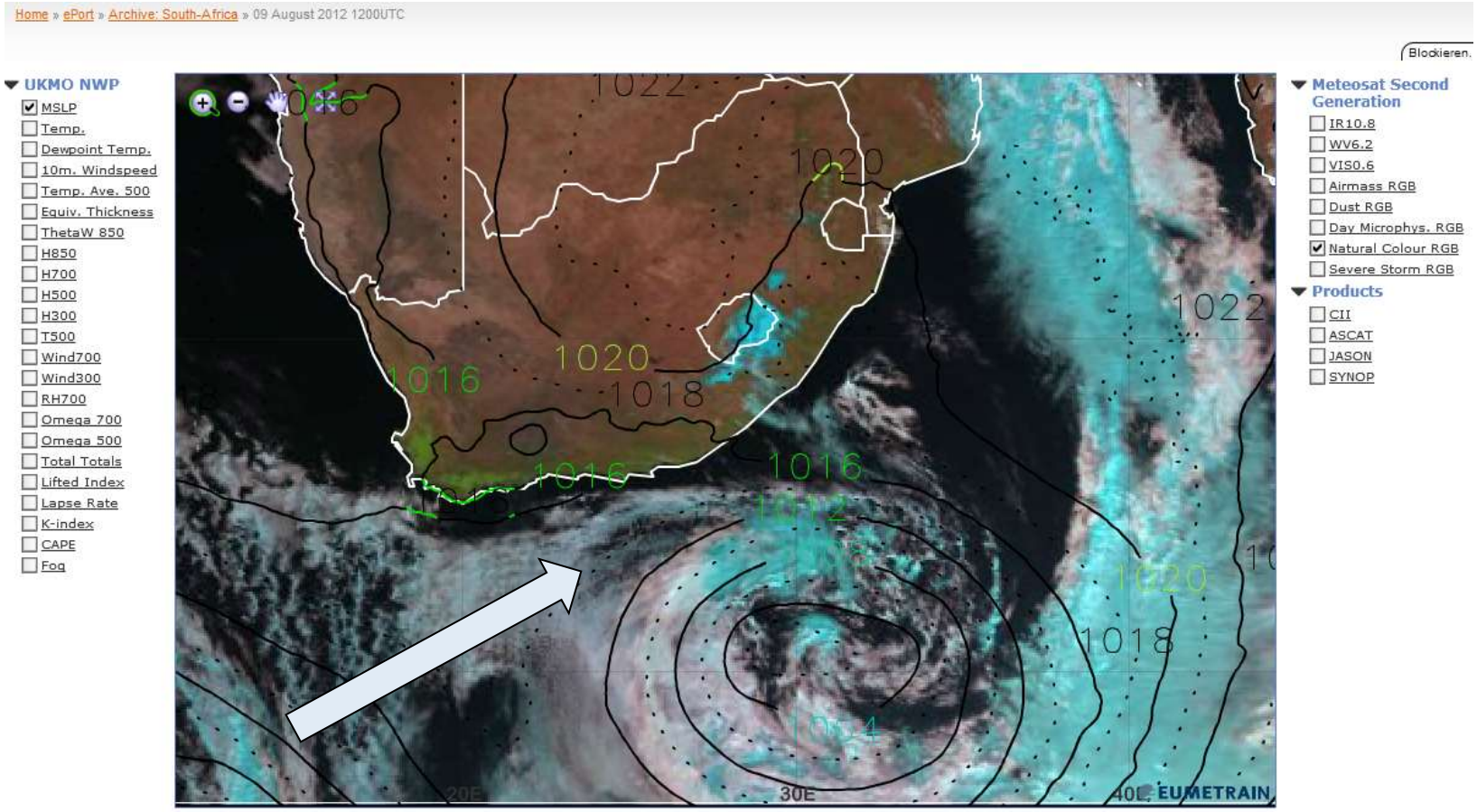


Figure 1
Synoptic patterns over Southern Africa during summer and winter seasons in relation to the generation of airborne moisture and the general migration pathways

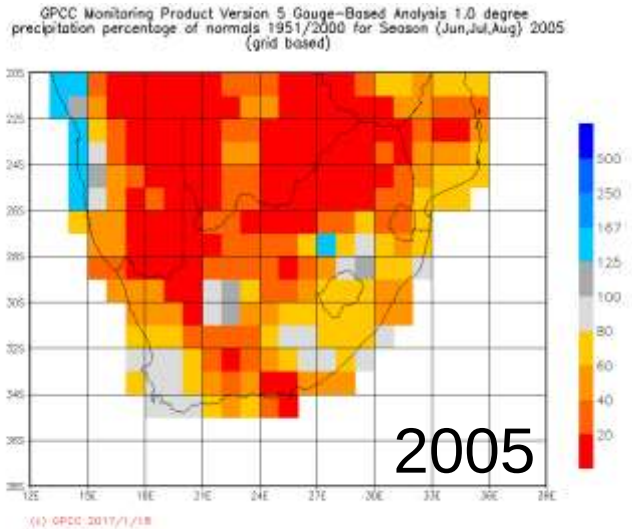
E van Wyk; GJ van Tonder; D Vermeulen; Water SA vol.37 n.2 Pretoria Apr. 2011

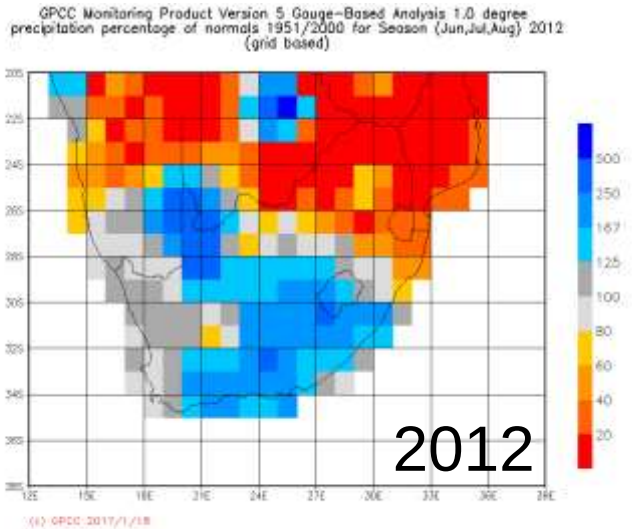
Meteosat image (RGB) with added pressure field.

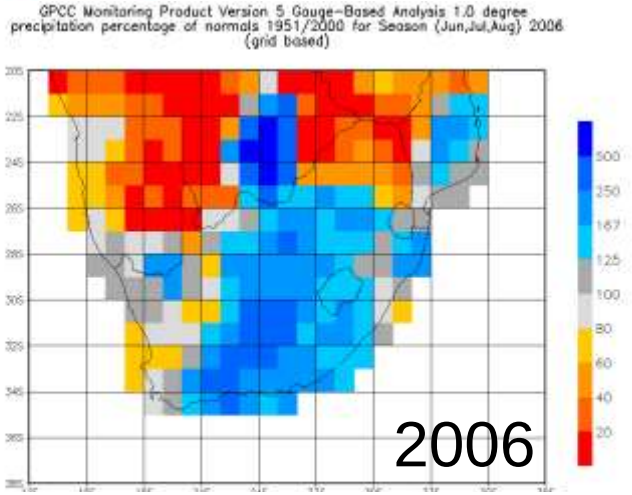


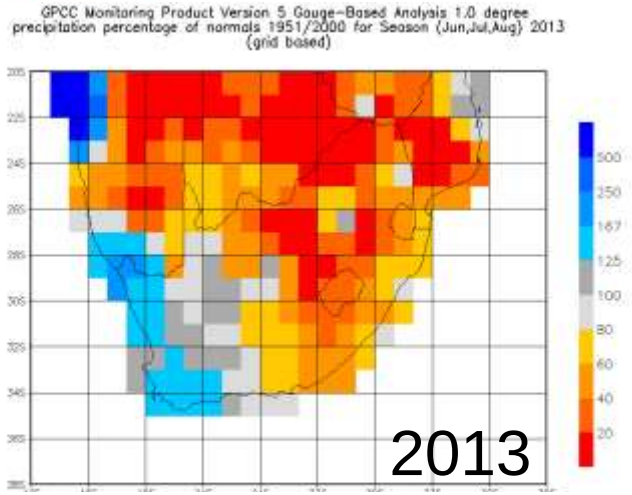
http://www.eumetrain.org/eport/archive_saws.html?width=1920&height=1200

Precipitation percentage of normals 1951-2000 for season June, July, August



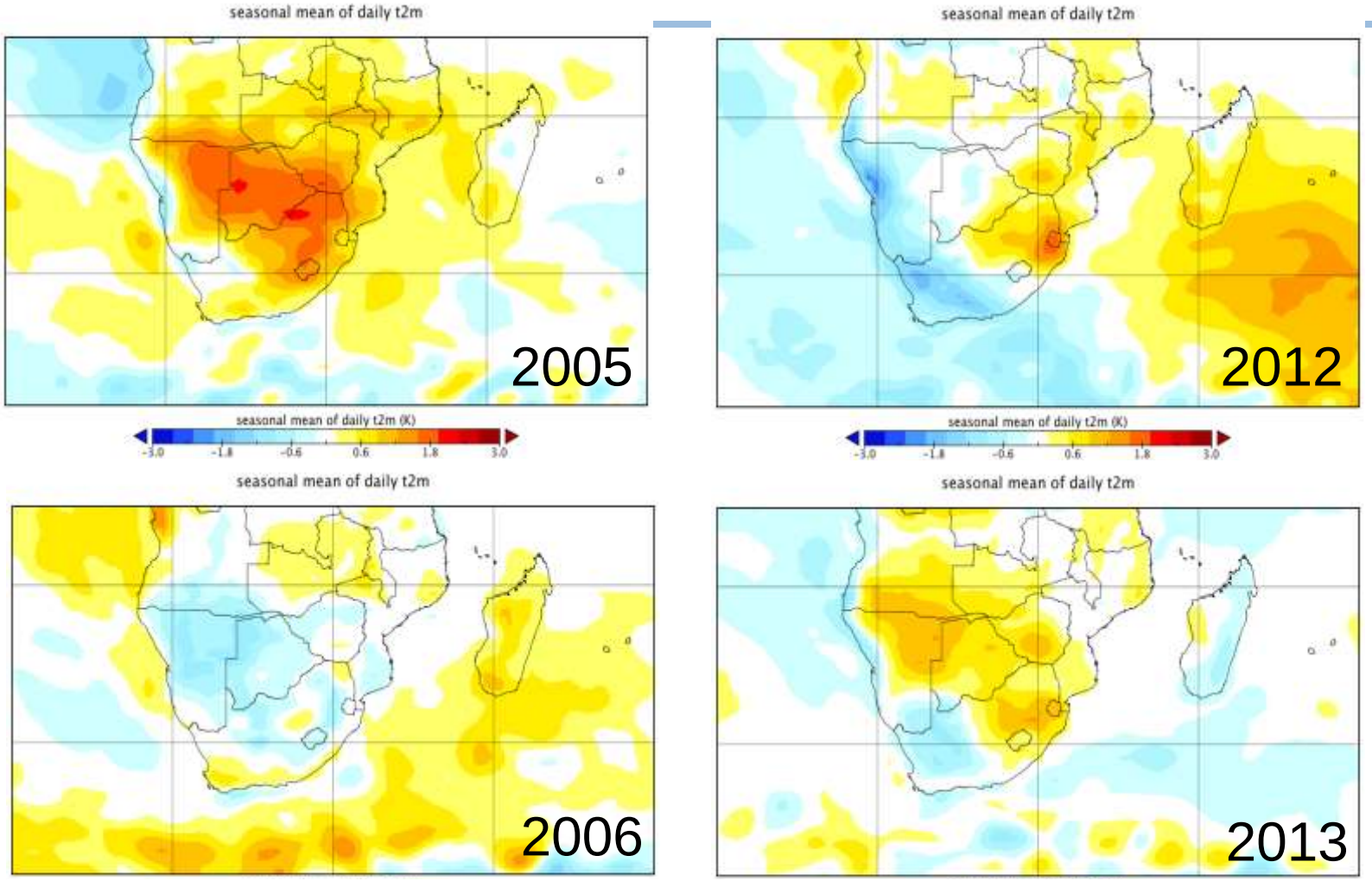




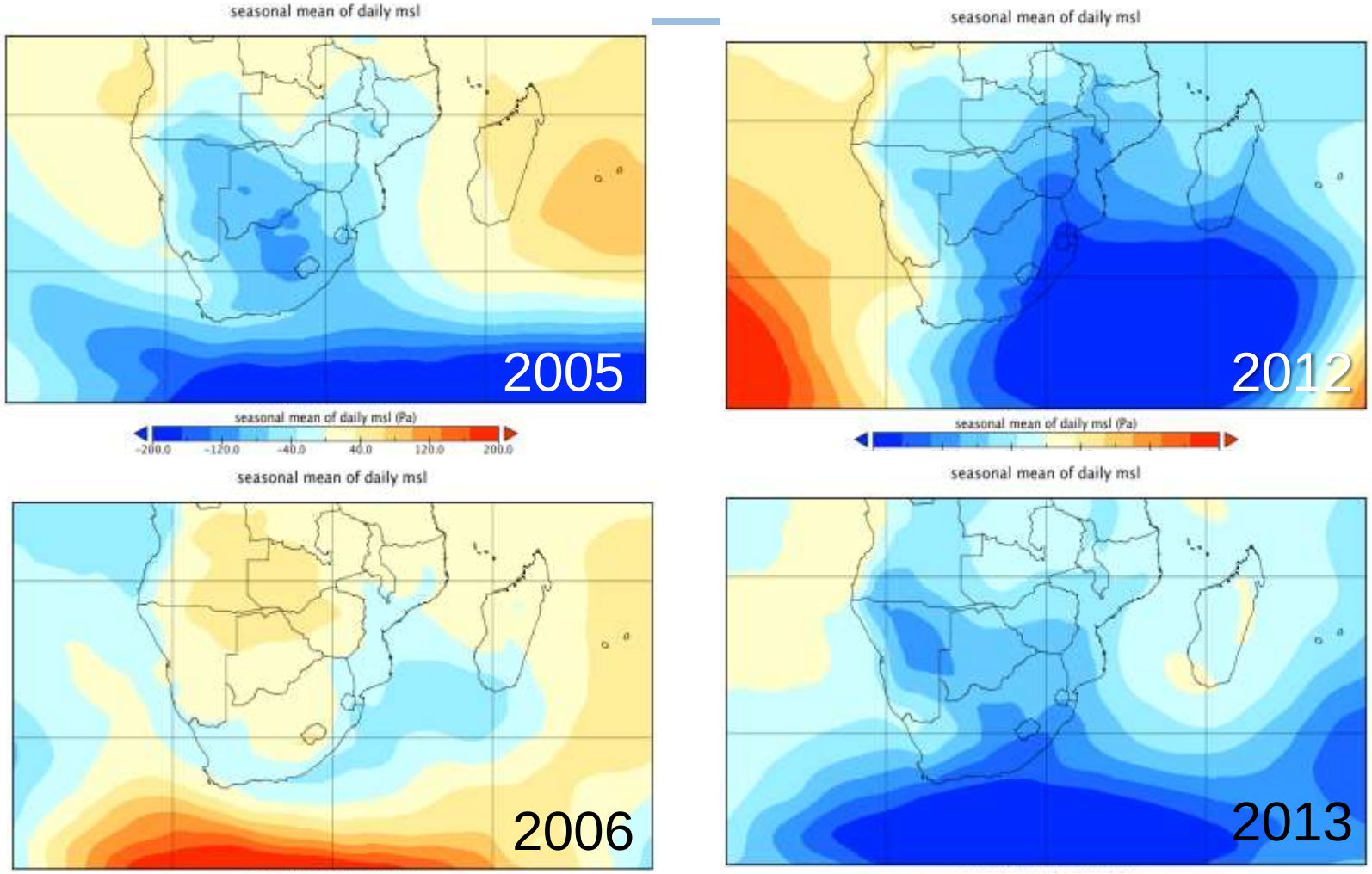


https://kunden.dwd.de/GPCC/Visualizer

ERA-interim: mean 2m temperature (JJA) anomaly (wrt 1979-2015)



ERA-interim: seasonal JJA average SLP anomaly (wrt 1979-2015)



ERA-interim: frost days at Lesotho grid box

UNIVERSITÄT BERN

> Number of frost days at Lesotho grid box

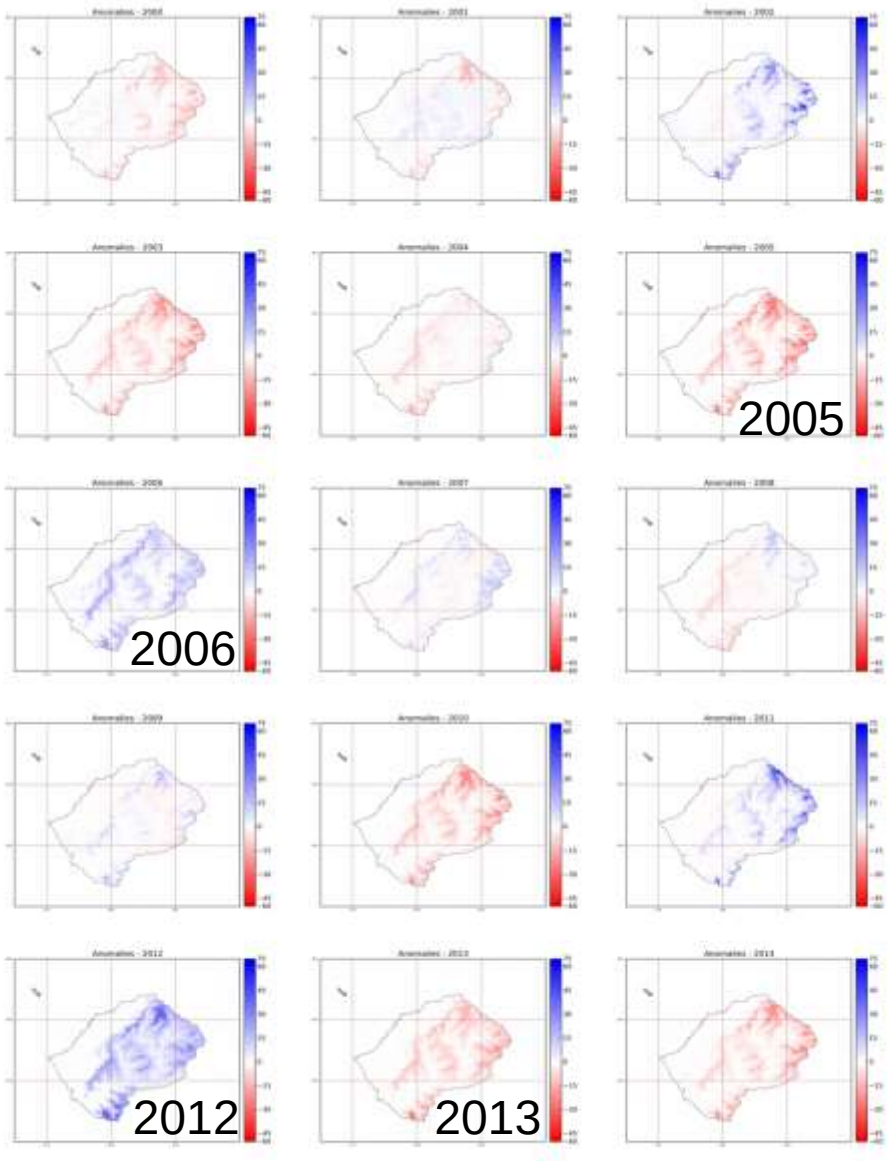
year	DJF	MAM	JJA	SON
2005	0	9	47	1
2006	0	19	66	7
2012	0	12	62	4
2013	0	9	59	7

> Maximum of consecutive frost days at Lesotho grid box

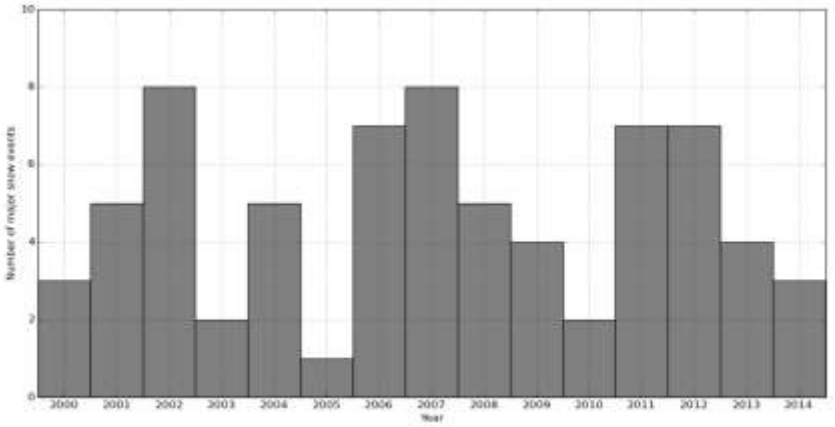
year	DJF	MAM	JJA	SON
2005	0	3	13	1
2006	0	11	22	5
2012	0	4	26	2
2013	0	5	16	2

Lesotho 2000 - 2014

UNIVERSITÄT BERN



- Left: Anomaly of SCD (days with snow cover)
- Number of major (>10% SCA) snow events per year.



eoworld Earth Observation for Development

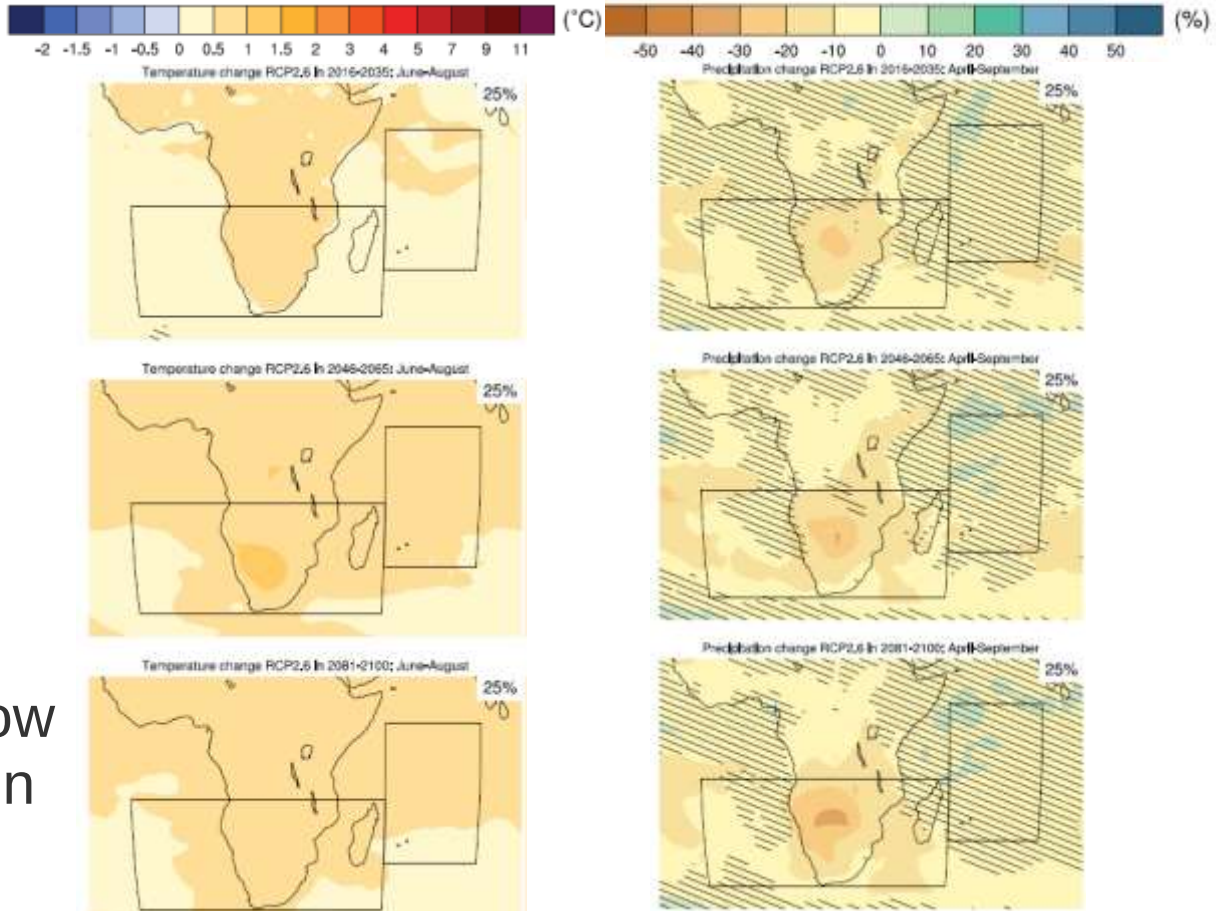
esa

THE WORLD BANK IBRD • IDA | WORLD BANK GROUP

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Snow cover in Lesotho is very sensitive to small changes in temperature

- IPCC RCP 2.6
- → decrease in precipitation
- → increase in temperature
- Interhemispheric teleconnection → asymmetry of the Hadley cells → change of frontal low pressure systems in Lesotho



IPCC, 2013: Annex I: Atlas of Global and Regional Climate Projections Supplementary Material RCP2.6 [van Oldenborgh, G.J., M. Collins, J. Arblaster, J.H. Christensen, J. Marotzke, S.B. Power, M. Rummukainen and T. Zhou (eds.)]. In:

Conclusion

- A homogenous, satellite based time series (2000 – 2014) of snow cover extent for Lesotho has been processed for the first time.
- Single snow fall events and short duration (2 – 10 days) of snow coverage characterize the snow dynamics in Lesotho, which requires daily monitoring.
- No strong seasonal cycle and high inter-annual variability has been found.
- The transport of cold air masses depends on the position of ITCZ and low pressure systems during winter season. Small changes result in high variability of precipitation and temperature.
- The projected climate is assumed to result in reduced snow events with increased variability of snow covered days effecting water management in the future.