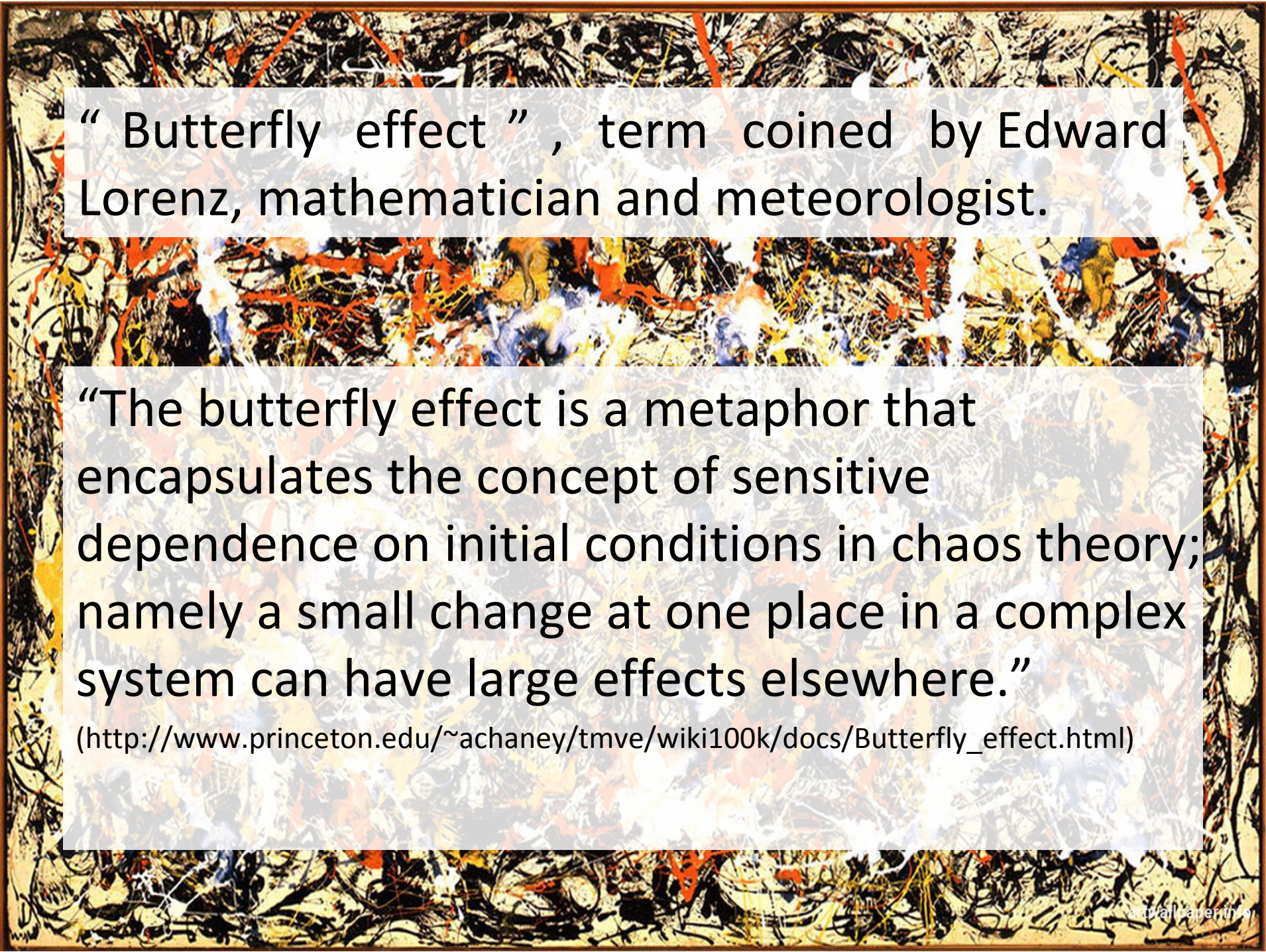


The "butterfly effect", herbivory and modelling the energy budget in Fennoscandia: Does the flap of a moth's wings in Norway set off a tornado in Texas?

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Tromsø



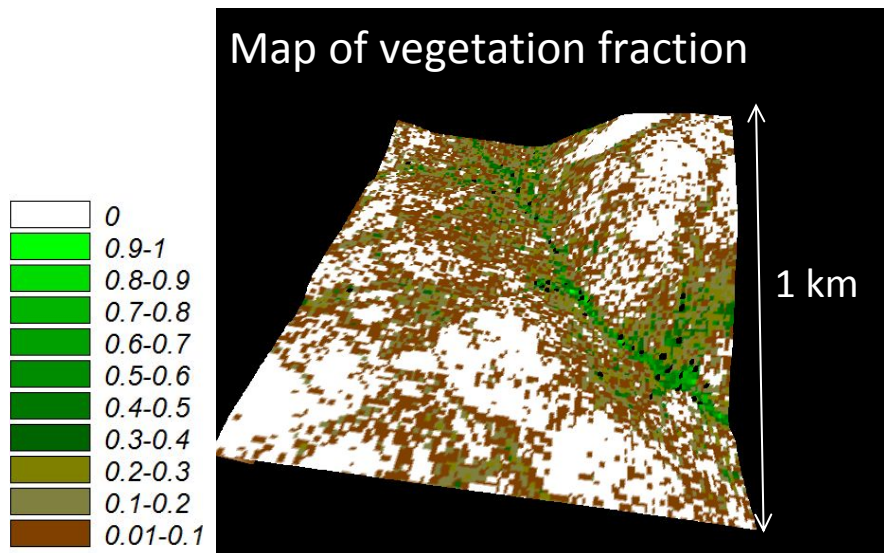
“ Butterfly effect ” , term coined by Edward Lorenz, mathematician and meteorologist.

“The butterfly effect is a metaphor that encapsulates the concept of sensitive dependence on initial conditions in chaos theory; namely a small change at one place in a complex system can have large effects elsewhere.”

(http://www.princeton.edu/~achaney/tmve/wiki100k/docs/Butterfly_effect.html)

Granger Basin, Wolf Creek, Yukon

Initial conditions: Topography, canopy height, vegetation density (i.e. % of woody vegetation covering the ground per gridbox)

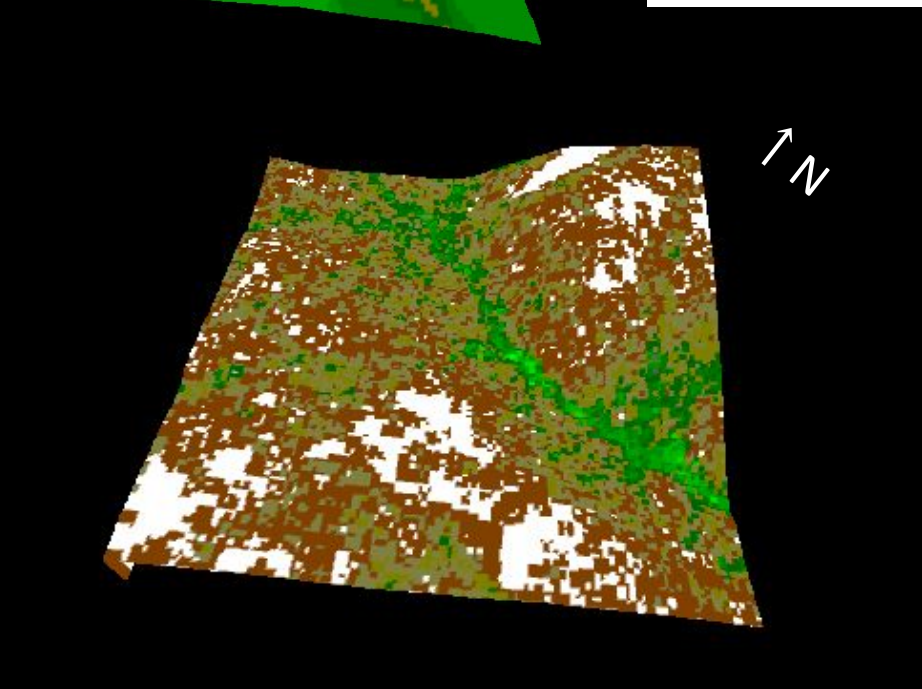
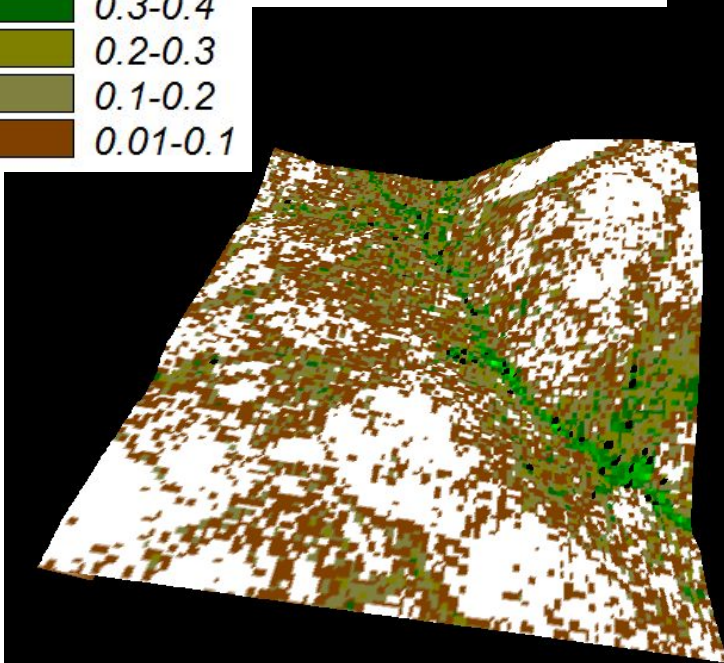
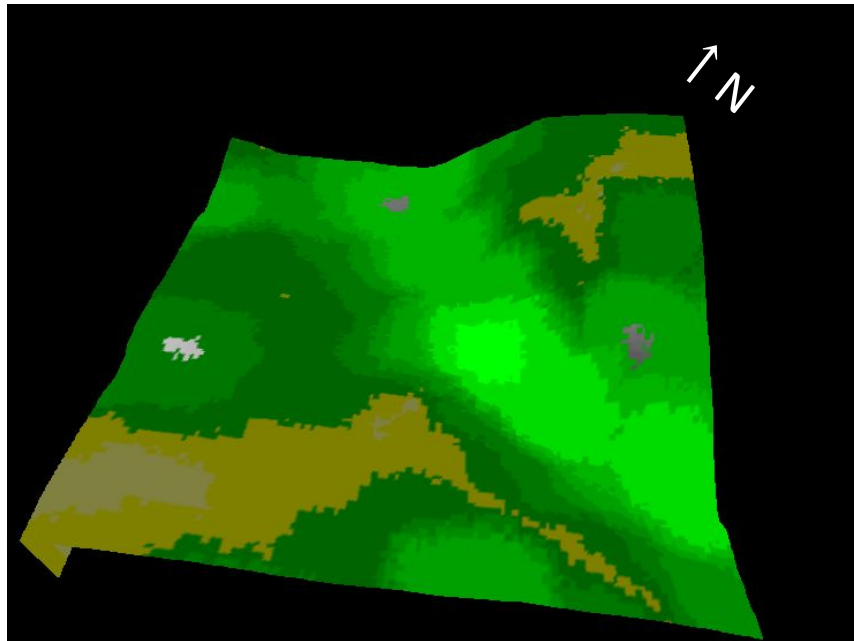
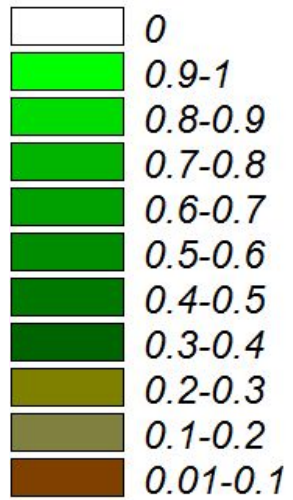


Model set-up:

- Distributed model (1km × 1km,
- 8m gridbox size)
- Coupling of blowing snow model (DBSM; Essery et al., 1998) + 3-source energy balance model (3SOM; Menard et al., 2014)

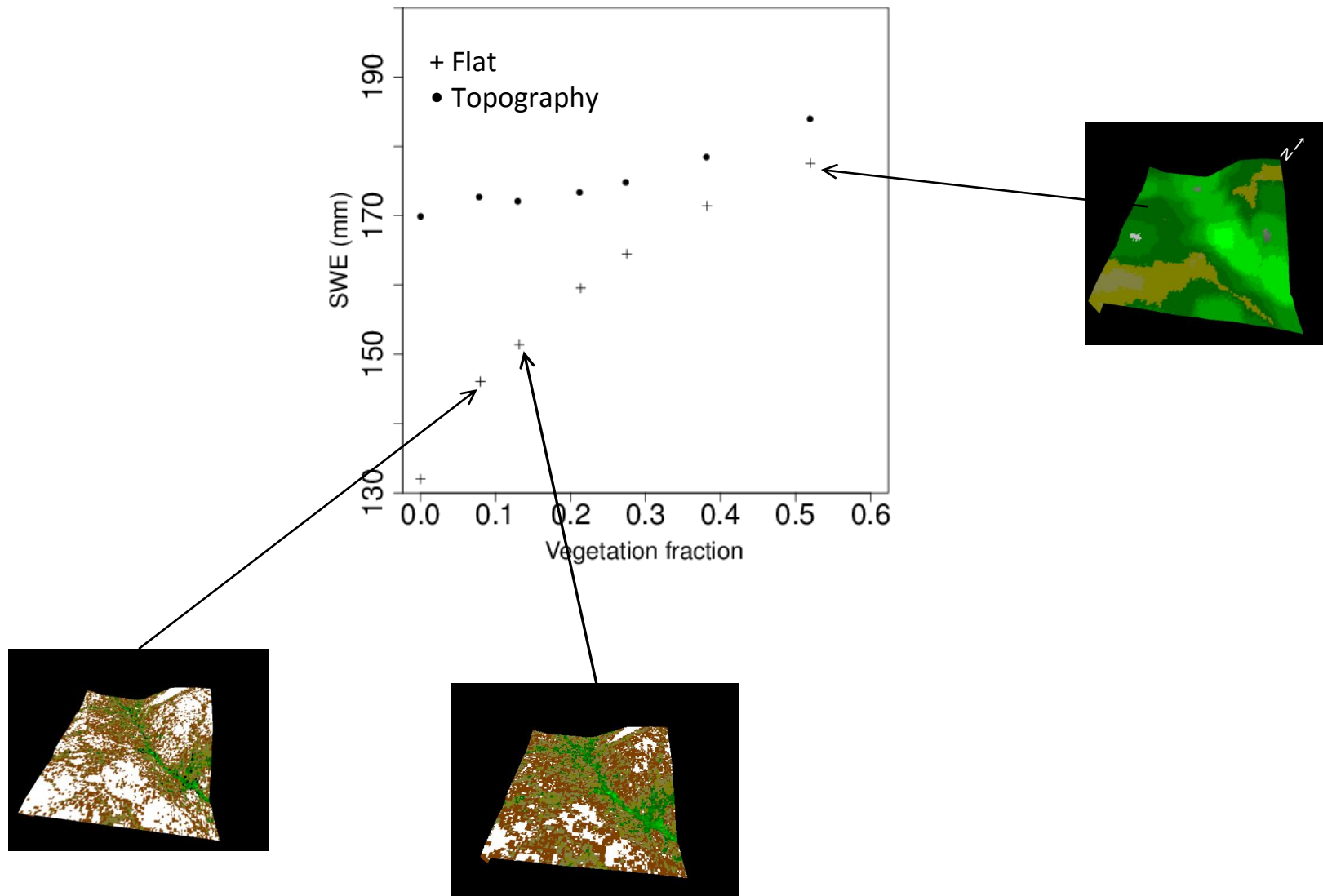
Shrub expansion scenarios

Vegetation fraction



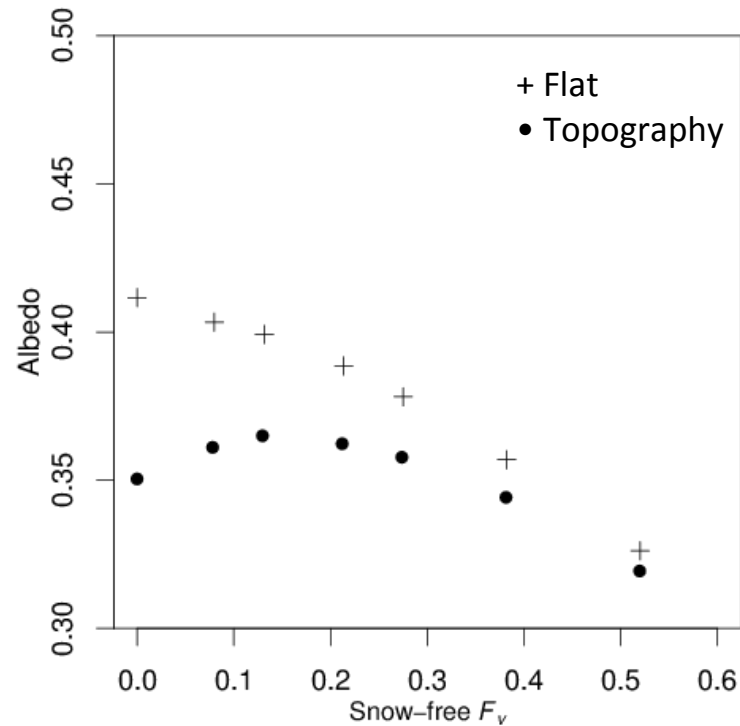
Ménard et al. (2014) *HESS*

Pre-melt snow amount in GB

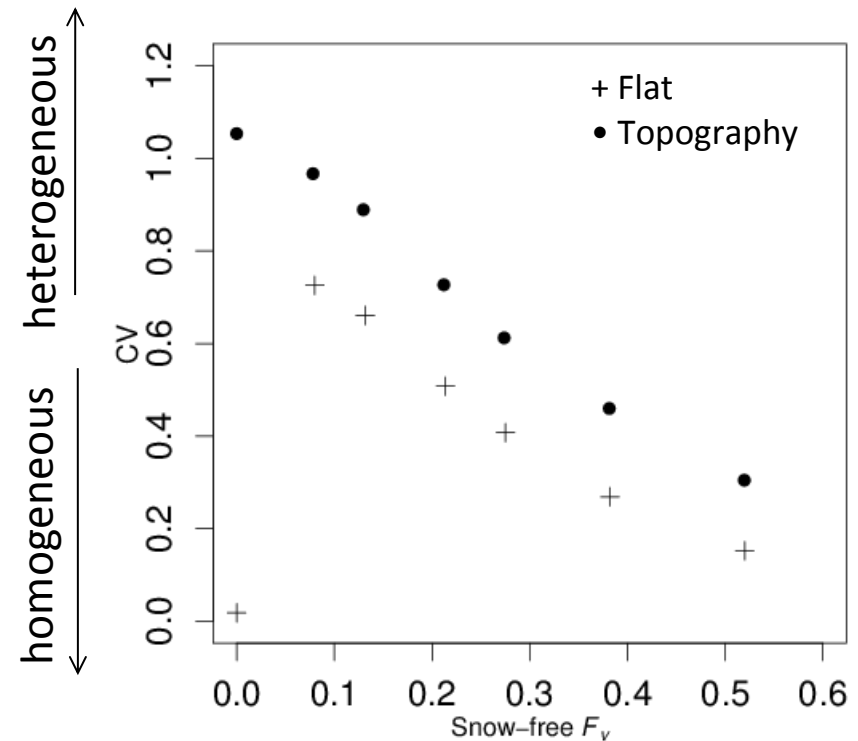


Ménard et al. (2014) *HESS*

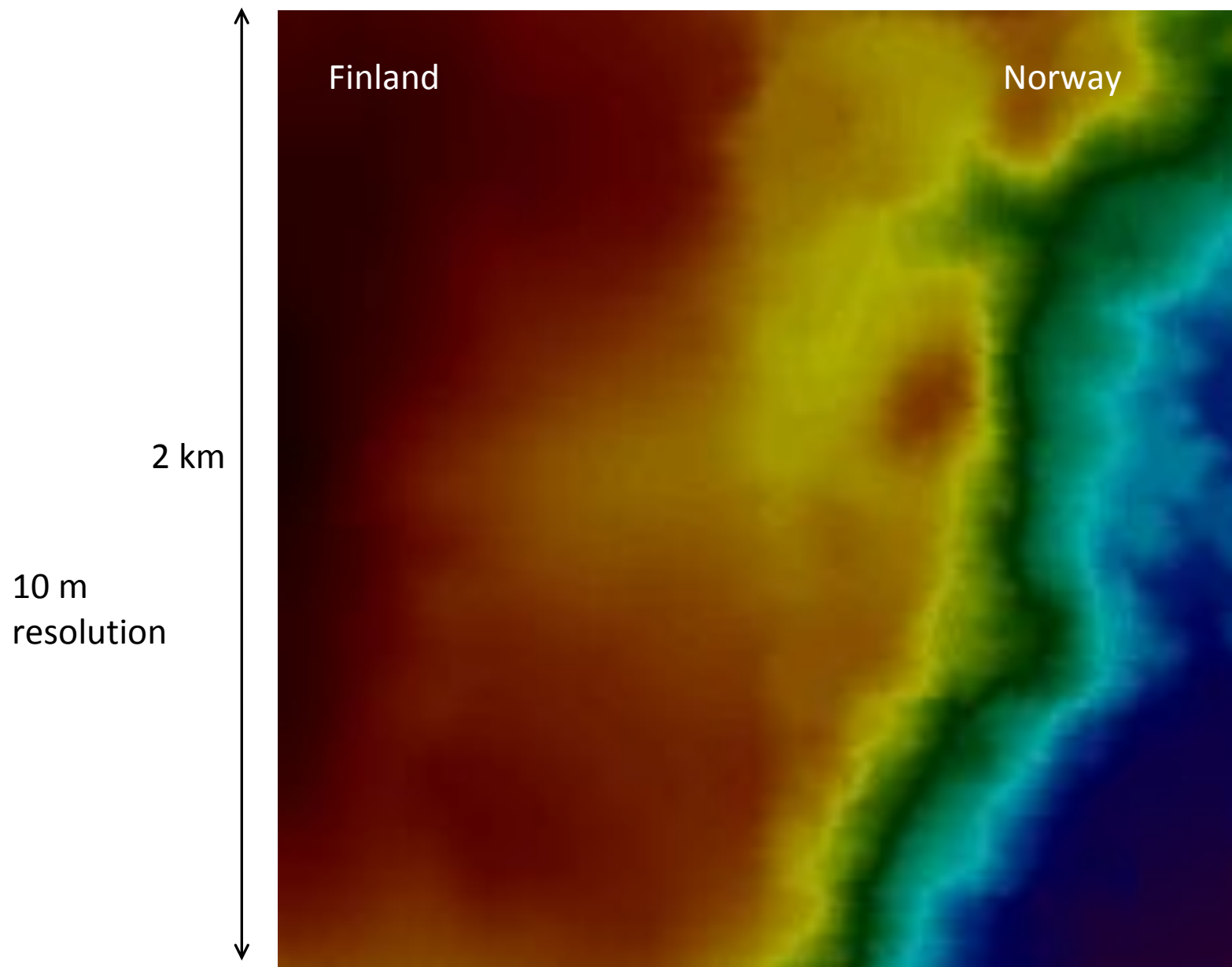
Albedo as proxy for
sensible heat fluxes and
net radiation



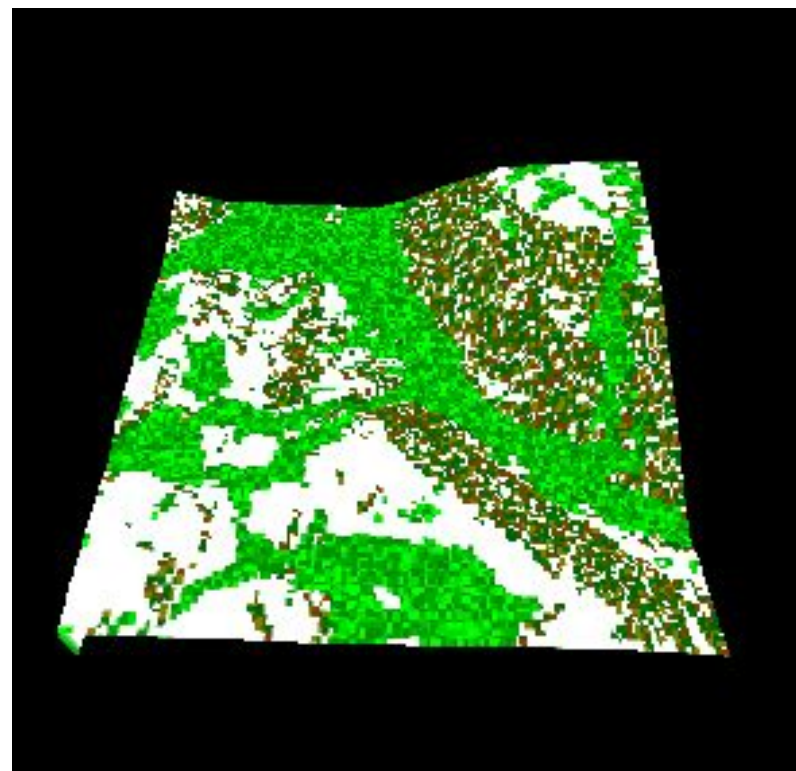
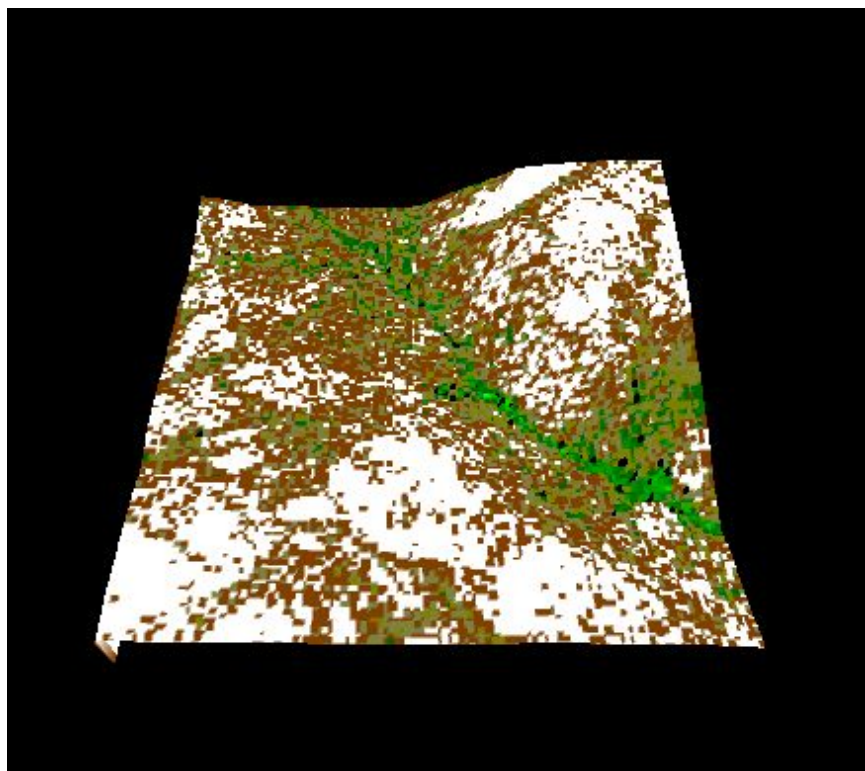
Covariance (stdev SWE /
mean SWE) as a
measure of **snow
heterogeneity**

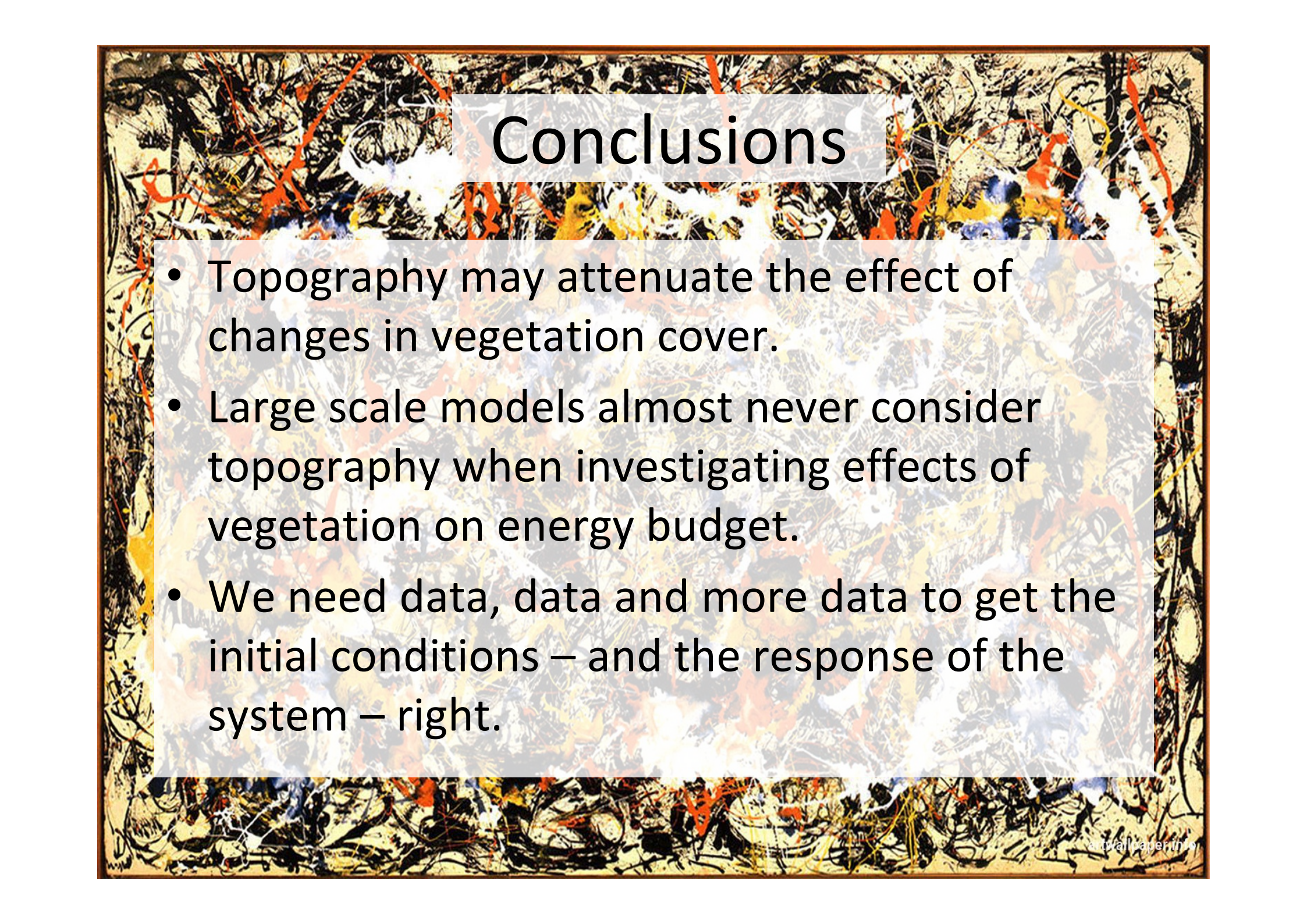


Polmak DEM



LiDAR vs. “guestimate” map of vegetation cover





Conclusions

- Topography may attenuate the effect of changes in vegetation cover.
- Large scale models almost never consider topography when investigating effects of vegetation on energy budget.
- We need data, data and more data to get the initial conditions – and the response of the system – right.

Background photo:

Jackson Pollock, Convergence, 1952. Pollock is believed to have used **chaotic motion and fractal geometry** (10 years before chaos theory was actually defined) in his paintings.

