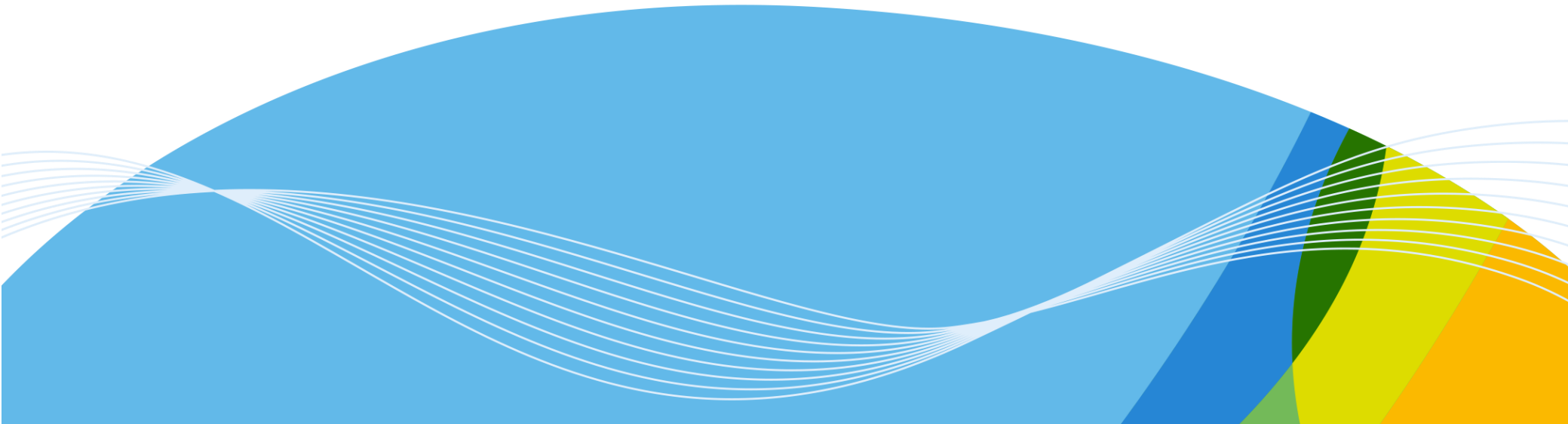
FINNISH METEOROLOGICAL INSTITUTE

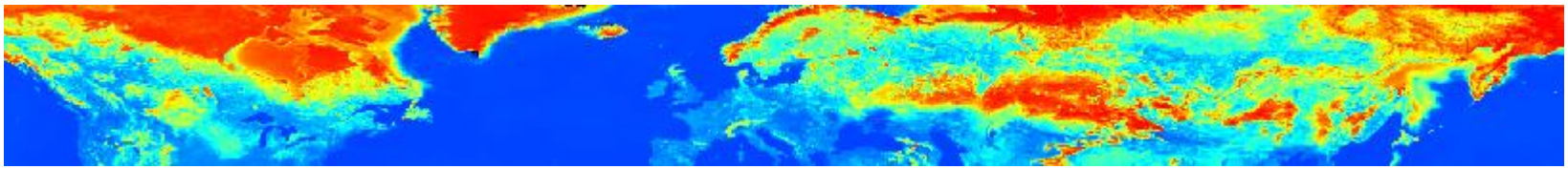
Darkening of snow covered season in Finland

Terhikki Manninen



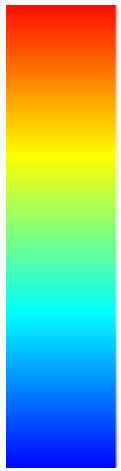
Surface albedo

- Surface albedo = the fraction of incoming solar radiation reflected hemispherically by the surface
- The surface albedo is an essential climate variable (ECV)
  - it is an indicator of climate change
  - changes in albedo will affect the climate



Surface albedo CLARA-A2-SAL, March 2010, (Anttila et al., 2017)

Surface albedo CLARA-A2-SAL, June 2010, (Anttila et al., 2017)



Effect of snow on boreal forest albedo

- In snow free conditions the coniferous forest albedo is ~12 %
- The pure snow albedo is in midwinter ~85%
- In snow covered conditions the albedo of forested area varies with the density of the forest and the snow properties (albedo)
- In a case of crown snow-load (’tykky’) even the structure of the canopy changes and snow dominates completely

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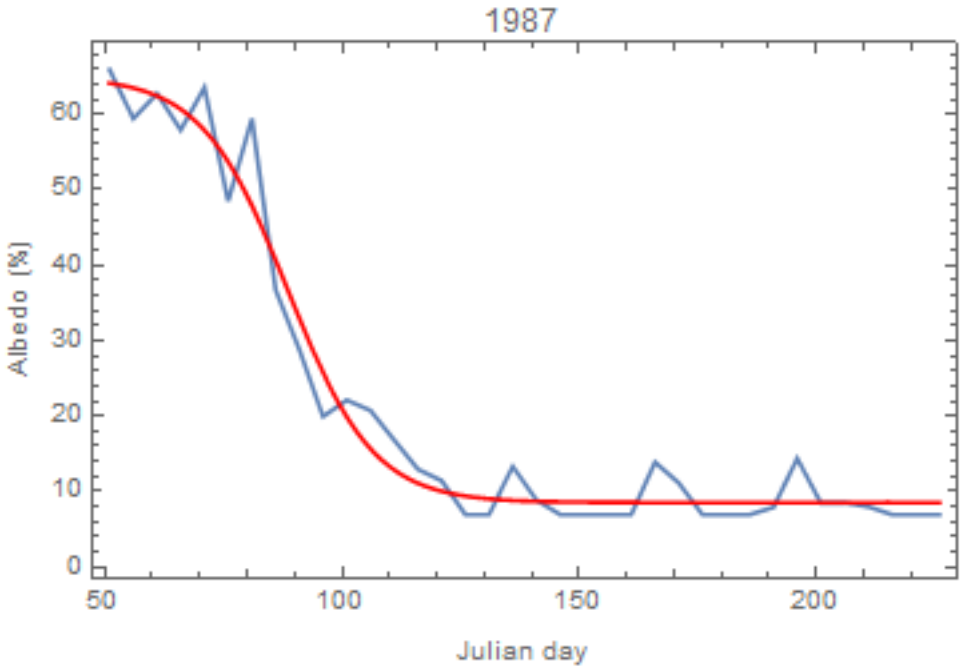
Importance of snow/forest albedo

- The snow cover has a marked effect on the albedo also in coniferous forests: 12 % -> 22 % (LAI ~2.5)
- If the length of the snow covered season decreases and snow melts earlier due to climate change, the albedo of forested areas becomes lower earlier in spring, which enhances the climate change.

- The coniferous canopy has a marked effect on the snow covered area albedo: 85 % -> 22 % (LAI: 0 -> 2.5)
- If the northern forest edge moves further north due to the climate change, the winter time albedo will decrease markedly, which will enhance the climate change.

Melt onset and end days estimated from albedo

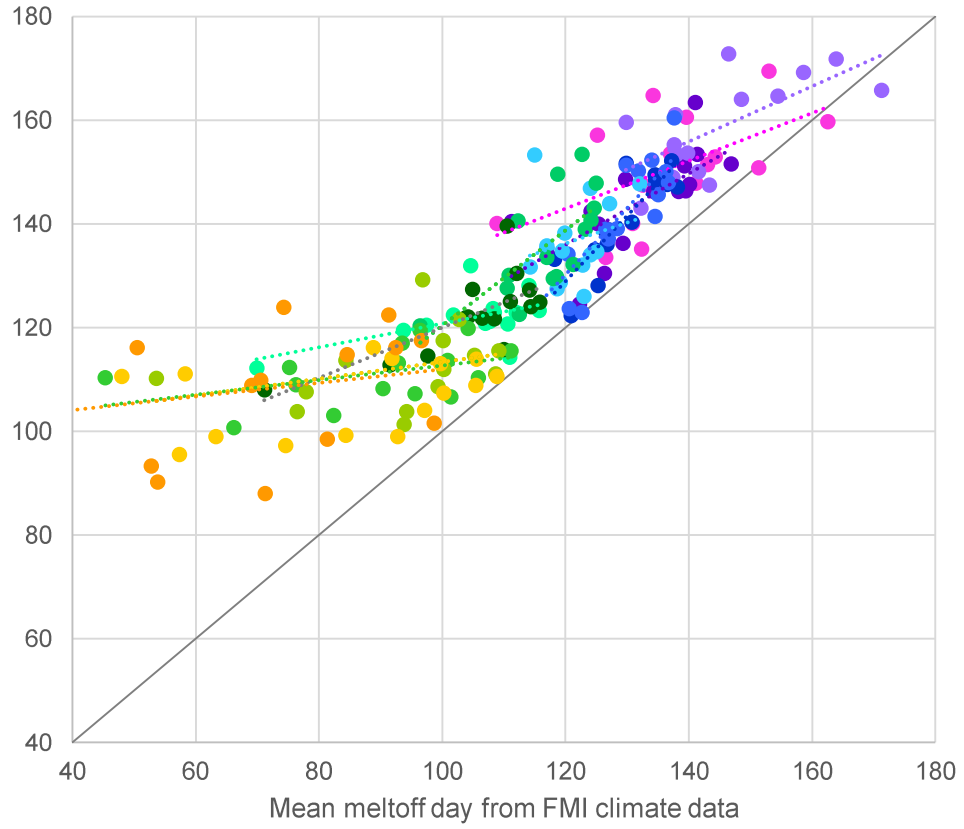


Melt onset: Albedo 99% from higher sigmoid level

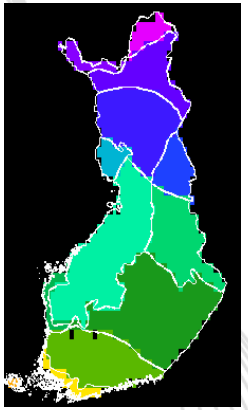
Melt end: Albedo 1 % from lower sigmoid level

Method similar as used for other data in SYKE by Kristin Böttcher

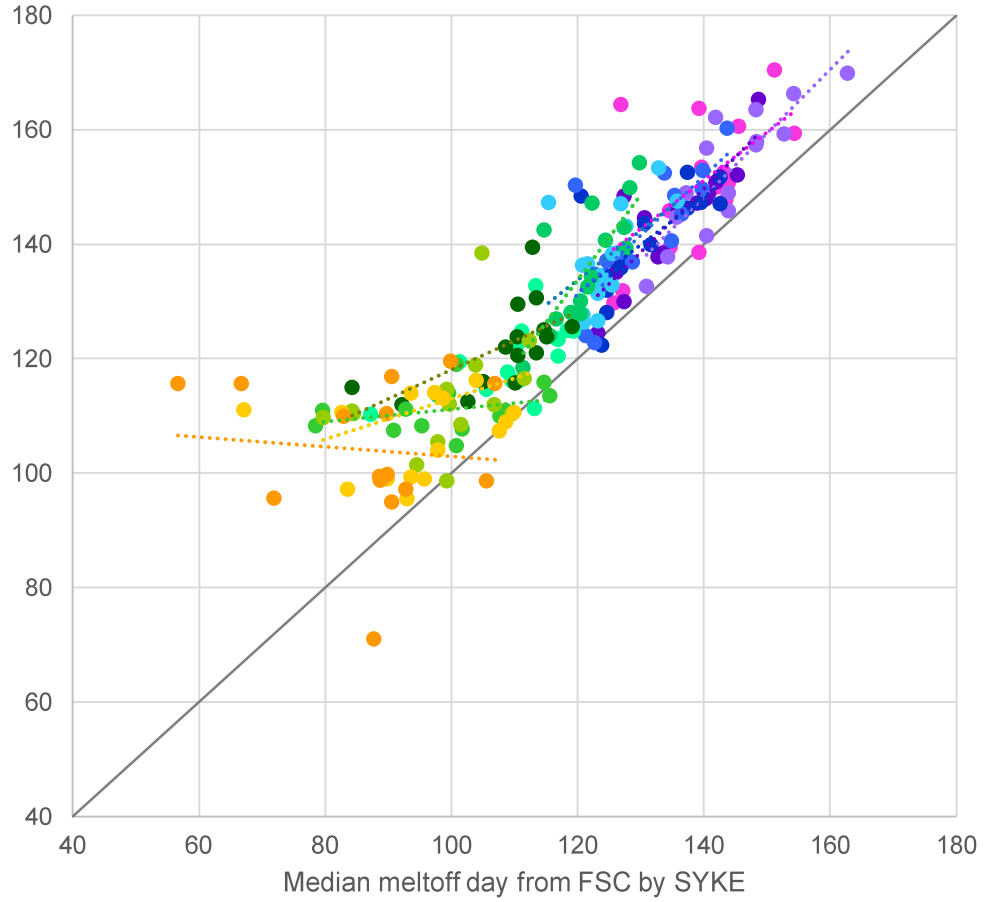
End of melt from in situ snow depth and albedo



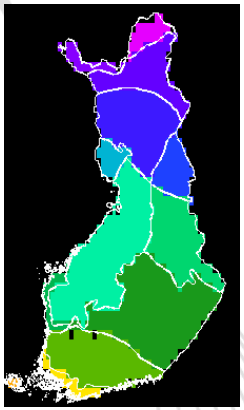
Utsjoki	y = 0.46x + 88.02 R² = 0.32
Inari	y = 0.69x + 53.52 R² = 0.47
Käsivarsi	y = 0.53x + 81.69 R² = 0.46
Metsä-Lappi	y = 1.26x - 21.67 R² = 0.72
Kainuu	y = 1.29x - 24.22 R² = 0.67
Perä-Pohjanmaa	y = 0.41x + 87.52 R² = 0.06
Pohjanmaa	y = 0.23x + 98.12 R² = 0.30
Pohjois-Karjala	y = 0.92x + 28.95 R² = 0.50
Järvi-Suomi	y = 0.49x + 71.34 R² = 0.52
Pohjanmaan rannikko	y = 0.14x + 98.70 R² = 0.19
Eteläisin Suomi	y = 0.16x + 97.21 R² = 0.11
Lounaisrannikko	y = 0.16x + 97.21 R² = 0.11
Ahvenanmaa	y = 0.13x + 98.78 R² = 0.07



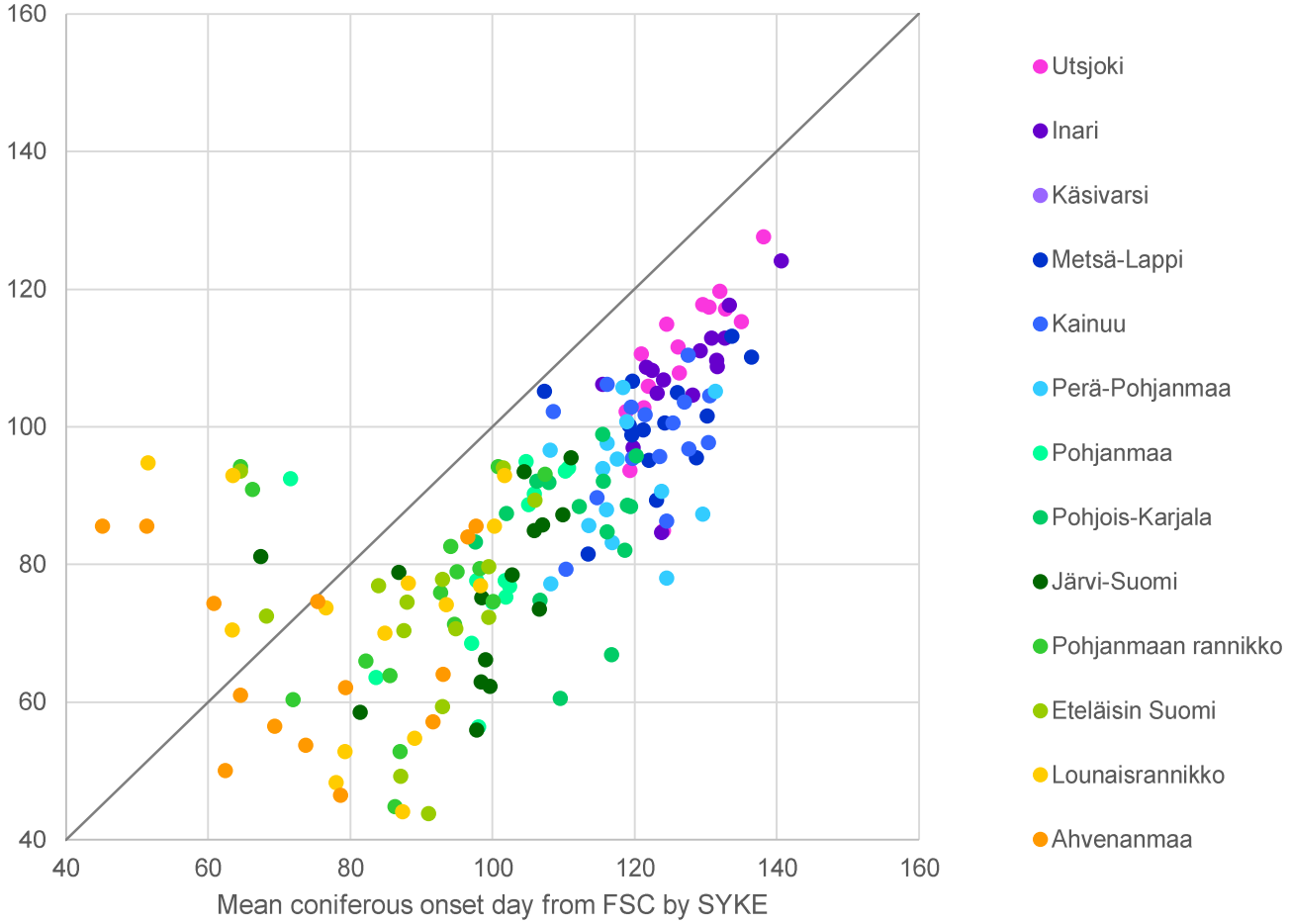
End of melt from fractional snow cover and albedo

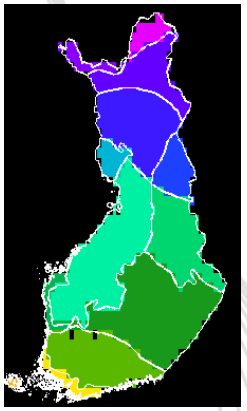


Utsjoki	y = 0.84x + 32.98 R² = 0.35
Inari	y = 1.11x - 5.29 R² = 0.74
Käsivarsi	y = 1.11x - 7.77 R² = 0.74
Metsä-Lappi	y = 0.84x + 30.52 R² = 0.49
Kainuu	y = 1.03x + 7.24 R² = 0.56
Perä-Pohjanmaa	y = 0.87x + 29.45 R² = 0.27
Pohjanmaa	y = 0.87x + 29.45 R² = 0.27
Pohjois-Karjala	y = 1.48x - 44.22 R² = 0.61
Järvi-Suomi	y = 0.51x + 67.11 R² = 0.39
Pohjanmaan rannikko	y = 0.11x + 100.10 R² = 0.11
Eteläisin Suomi	y = 0.36x + 77.18 R² = 0.14
Lounaisrannikko	y = 0.36x + 77.18 R² = 0.14
Ahvenanmaa	y = -0.08x + 111.39 R² = 0.01

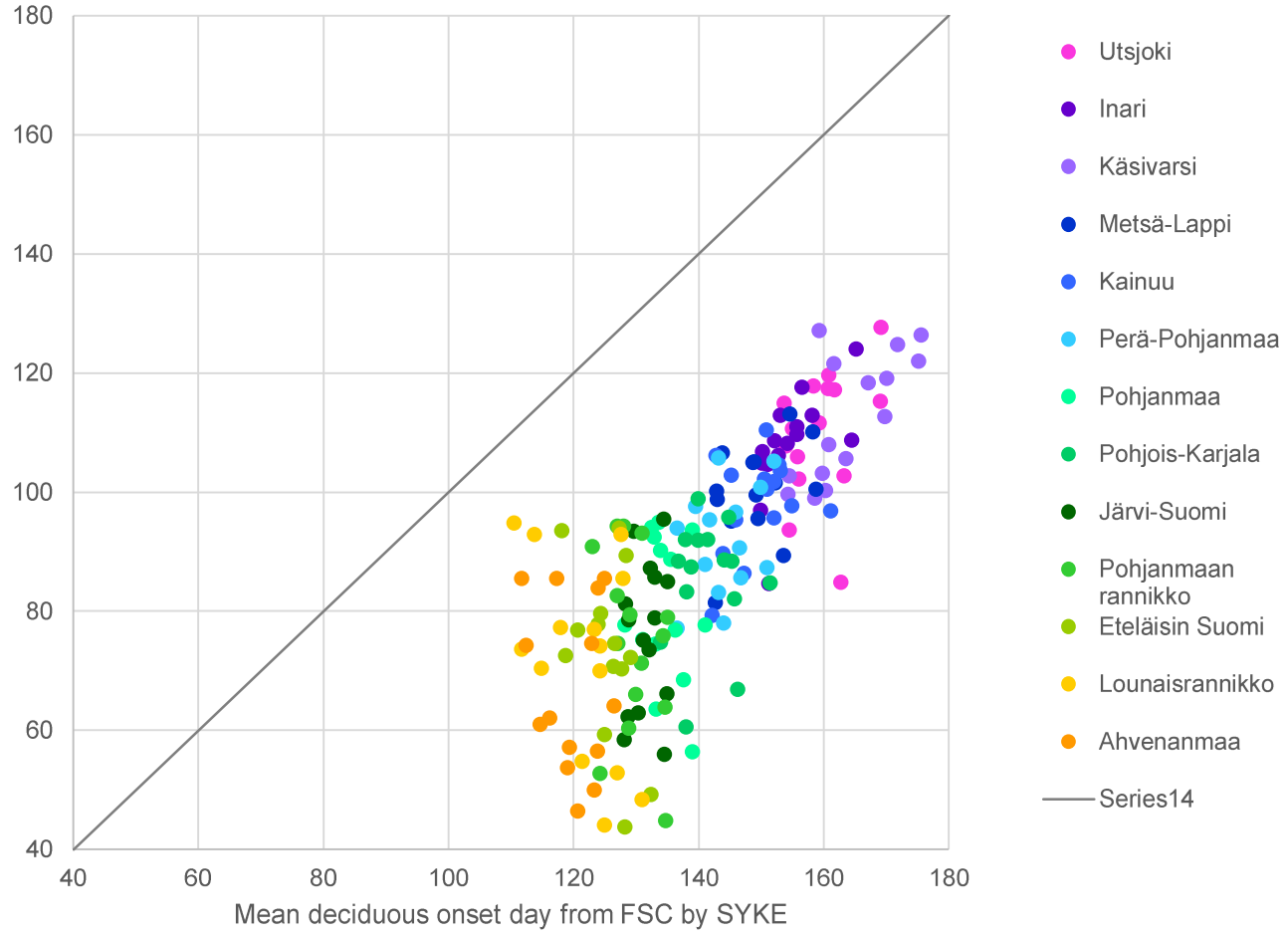


Melt onset day from surface albedo and growth onset of coniferous species

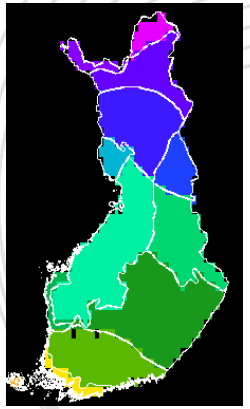




Melt onset day from surface albedo and growth onset of deciduous species

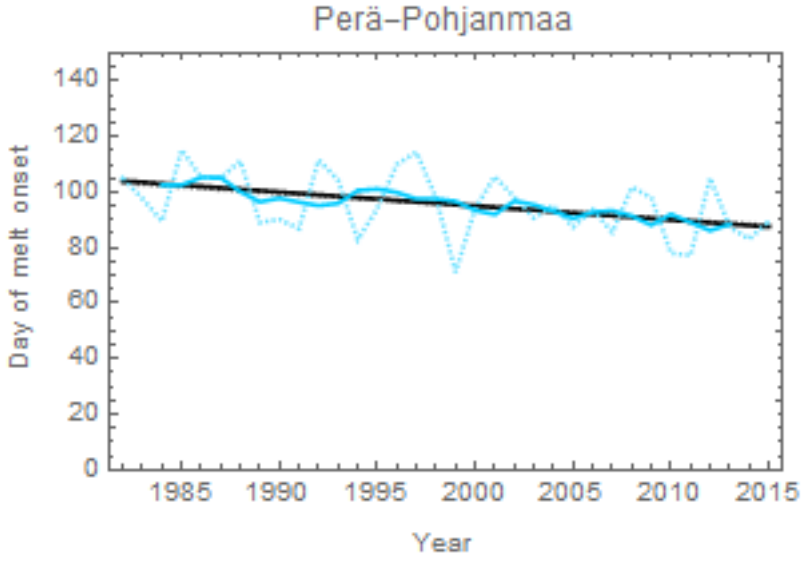


Melt onset day based on albedo

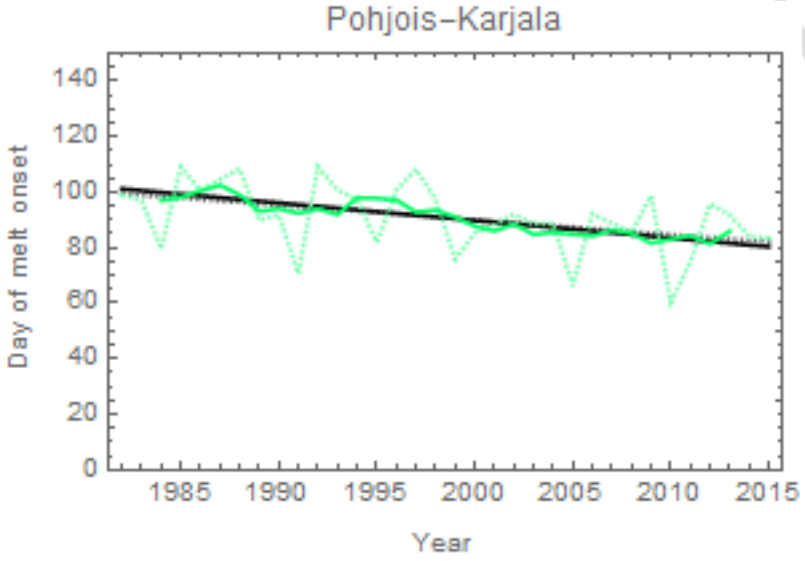


- Clear decreasing trend in two regions, slight decrease in Pohjanmaa, Kainuu and Järvi-Suomi

solid curves are 5 year moving averages, dashes annual values



$R^2 = 0.78$

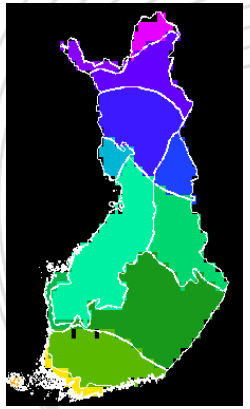


$R^2 = 0.81$

End day of melting season based on albedo

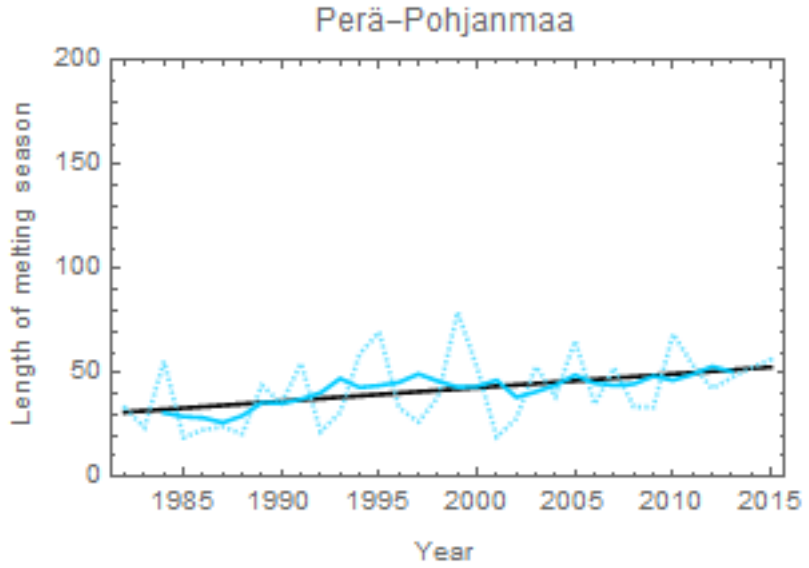
- In general no marked increase or decrease
- Slight decrease in Utsjoki
- The trends of the melting season length follow the trends of the melt onset day

Length of melt season based on albedo

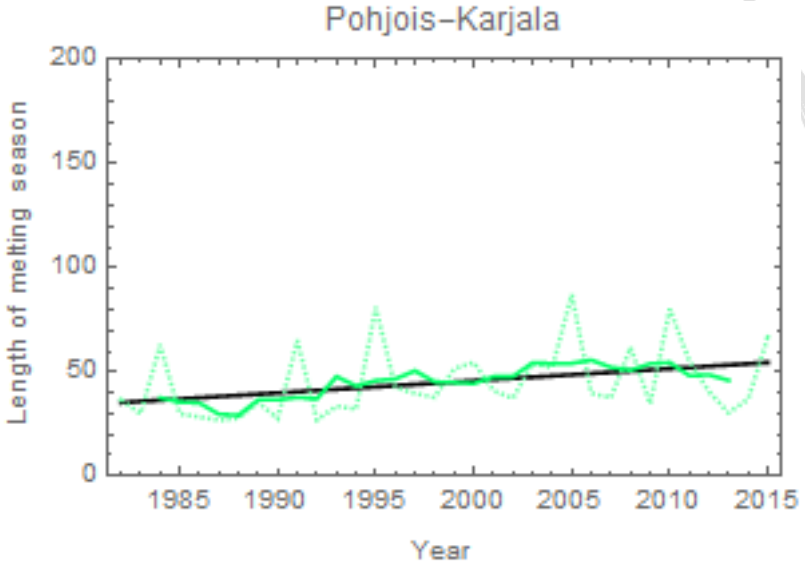


- Clear increasing trend in two regions, slight increase in Metsä-Lappi and Kainuu, slight decrease in Utsjoki

solid curves are 5 year moving averages, dashes annual values

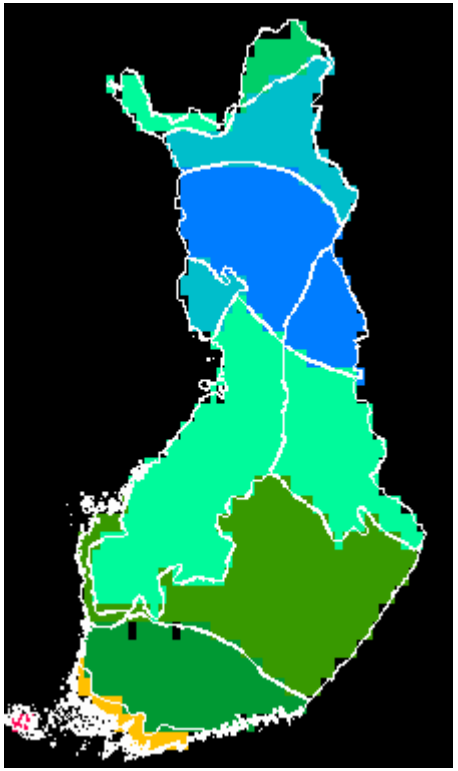


$R^2 = 0.67$

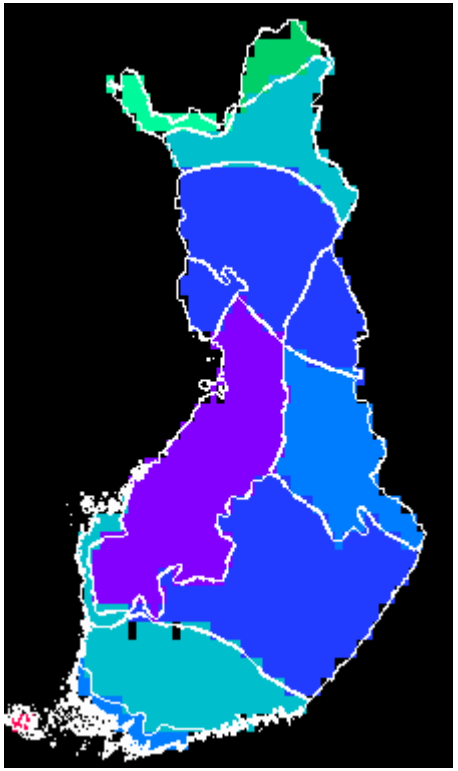


$R^2 = 0.68$

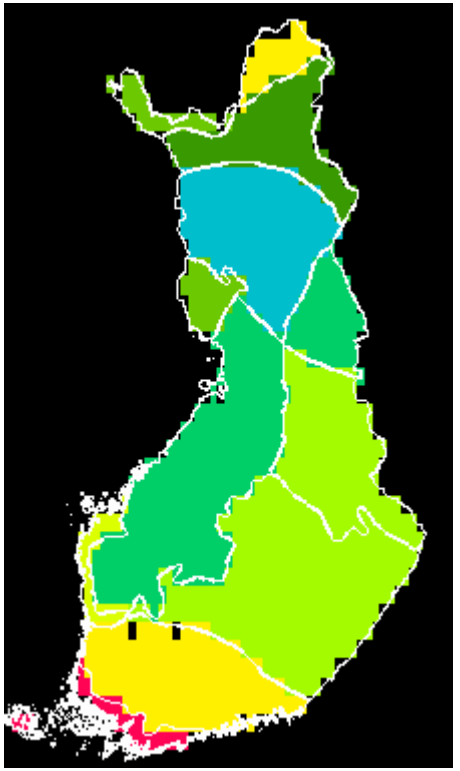
Variation of melting season onset, end and length



Standard deviation of melt onset day 1982 - 2015

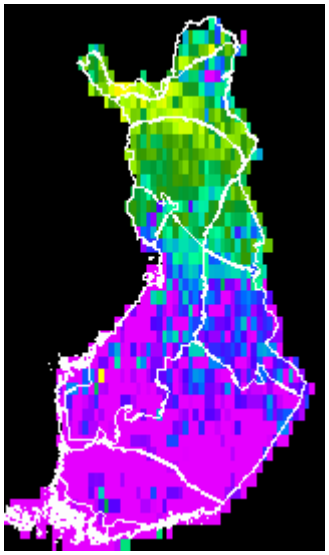


Standard deviation of end of melt day 1982 - 2015

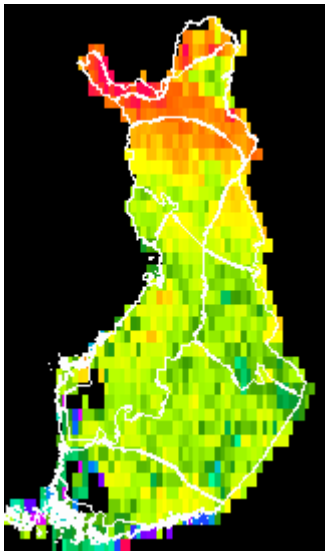


Standard deviation of melting season length 1982 - 2015

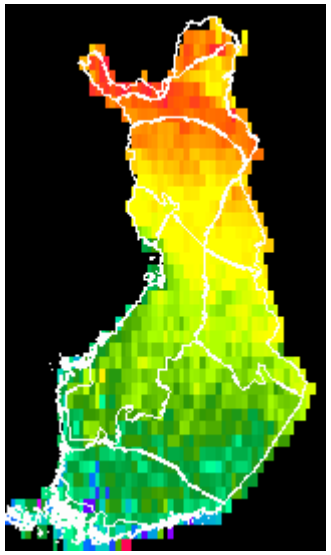
Melt onset 1982-2015



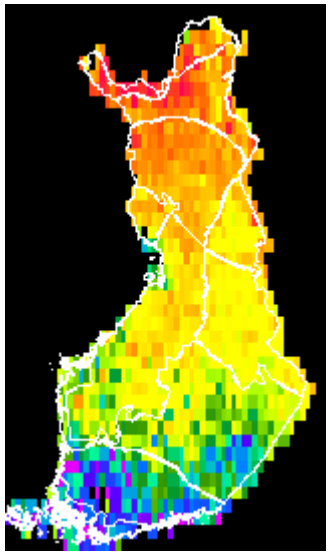
Min 1982-2015



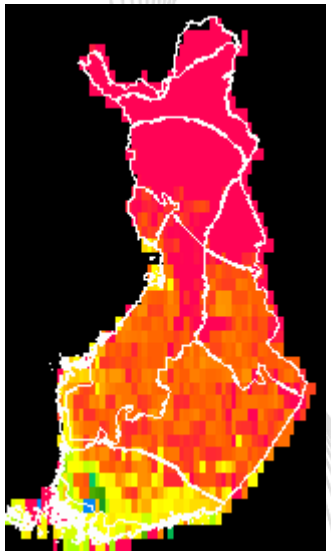
Mean 2011-2015



Mean 1982-2015



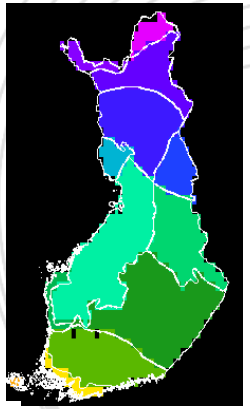
Mean 1982-1986



Max 1982-2015

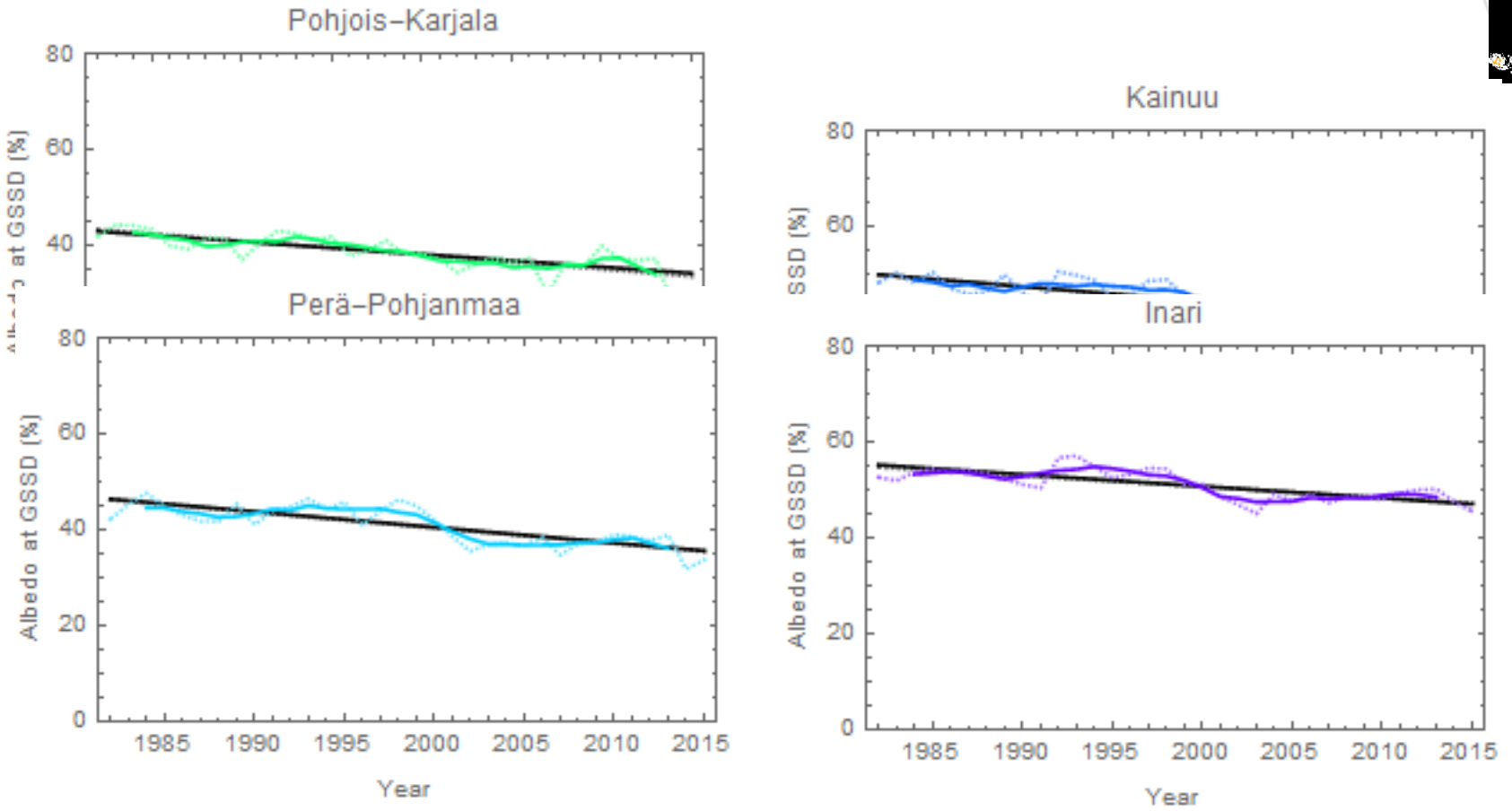
40 120

Albedo before melt onset



- Decreasing trend in several regions

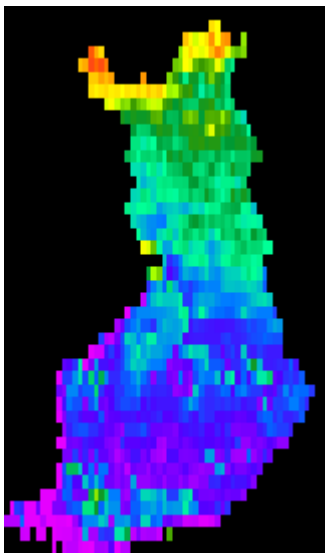
  solid curves are 5 year moving averages, dashes annual values



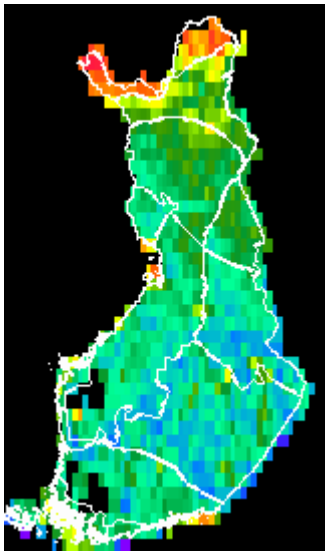
$R^2 = 0.82$

$R^2 = 0.69$

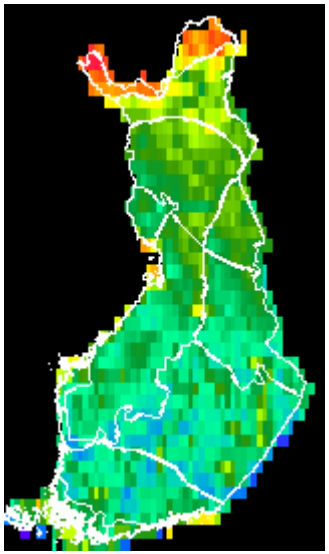
Albedo before melt onset 1982-2015



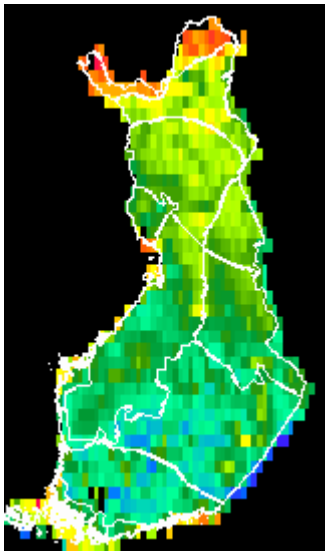
Min 1982-2015



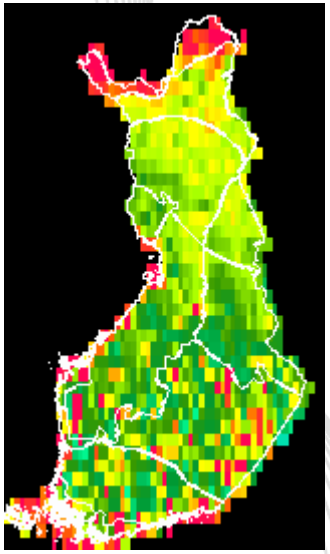
Mean 2011-2015



Mean 1982-2015



Mean 1982-1986



Max 1982-2015

10 % 80 %

Conclusions

- Albedo value preceding the melting season has decreasing trend in several areas of Northern Finland

  => Northern Finland becomes darker in midwinter
- The snow melt onset and end dates estimated using the surface albedo change are correlated with other methods, but the albedo reacts more quickly to the start of the snow melt and converges more slowly to the snow free period albedo.
- The growth season start dates of coniferous and deciduous species are about 20 and 50 day later than the day of onset of melt derived from the albedo
- Onset of snow melt decreases in Pohjois-Karjala and Perä-Pohjanmaa, also slightly in Pohjanmaa, Kainuu and Järvi-Suomi
- End of snow melt does not show any distinct trend, but a slight decrease is seen in Utsjoki
- Length of melting season has an increasing trend in Pohjois-Karjala and Perä-Pohjanmaa, and a slight increasing trend in Metsä-Lappi and Kainuu and a slight decreasing trend in Utsjoki

Thank you for your attention!