Does shrubs expansion in the high-Arctic lead to permafrost warming?

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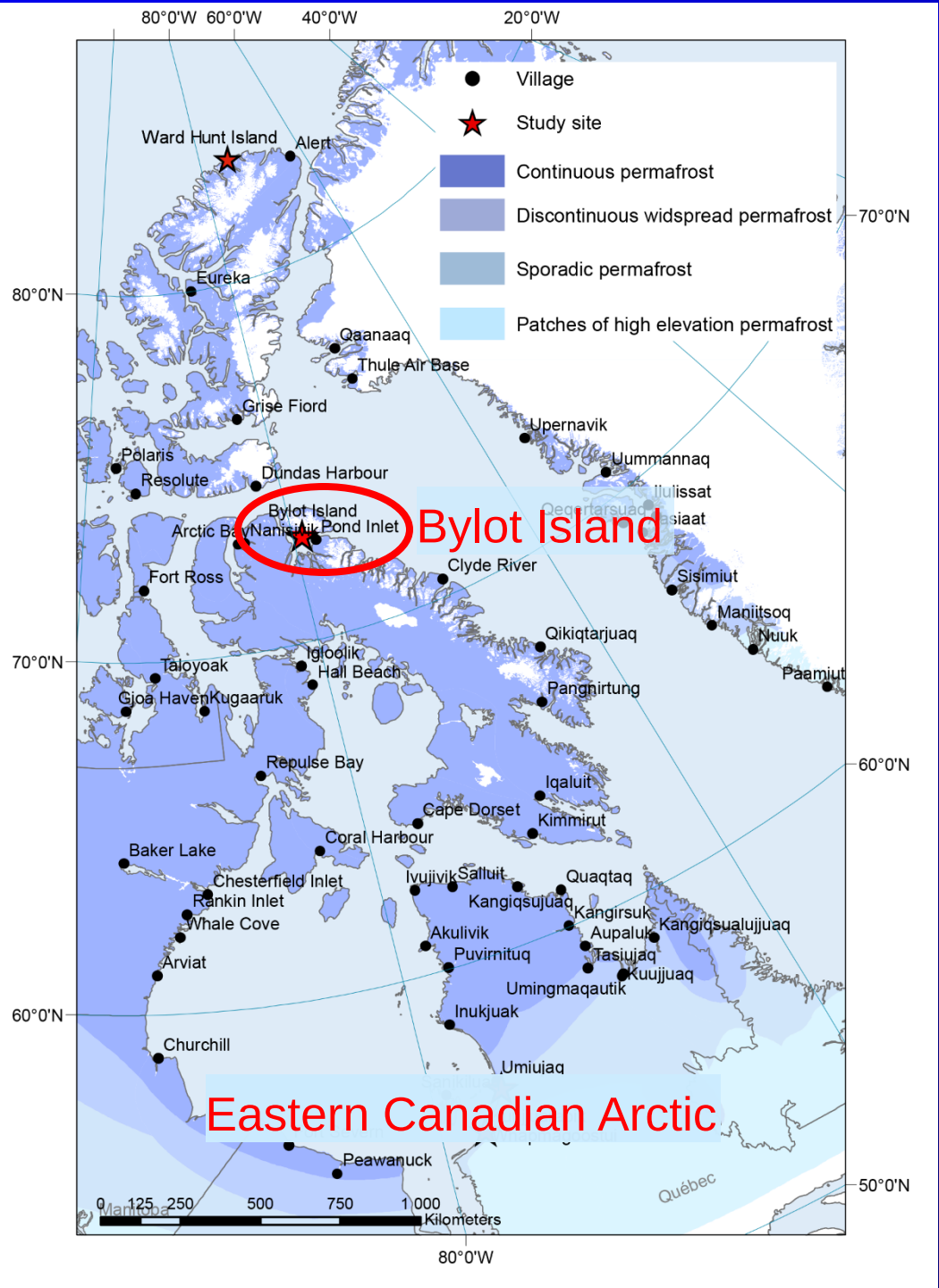
Shrubs are expanding on Arctic tundra

Salix richardsonii on Bylot Island, 73°N 80°W



Impact of shrubs on permafrost thermal regime ?

Summary of conventional wisdom

In winter shrubs **trap snow** and limits heat loss.

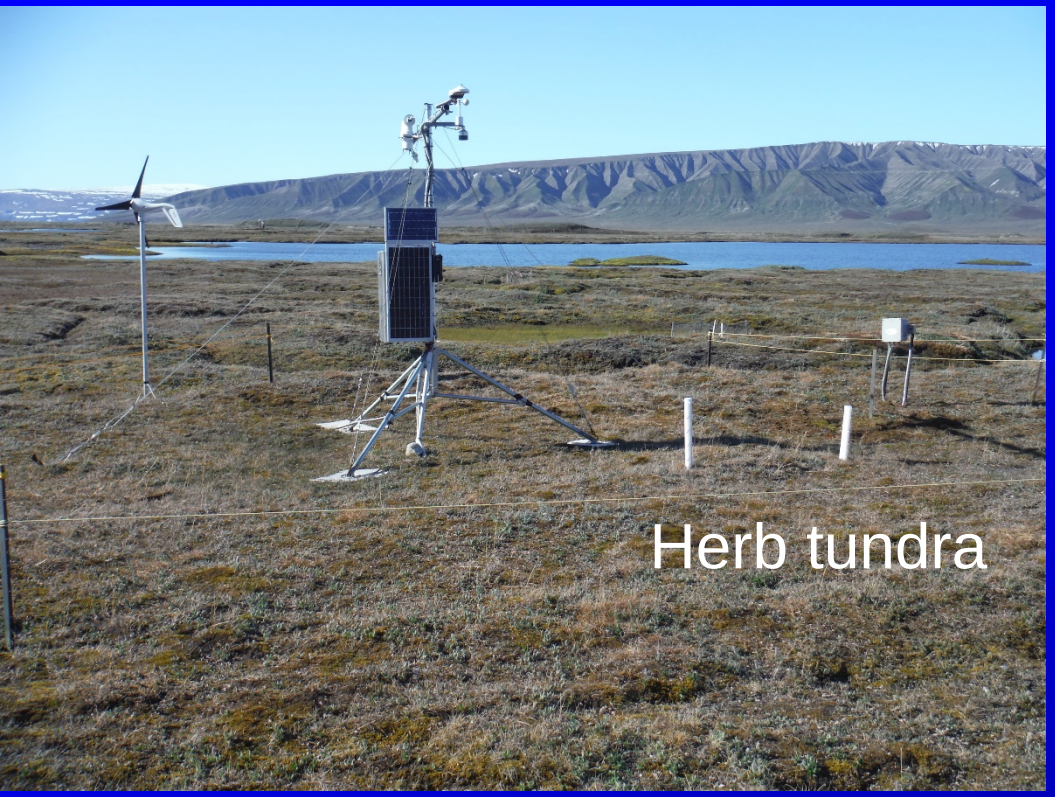
Permafrost T ↑

In summer shrubs **shade ground** and limit heat gain

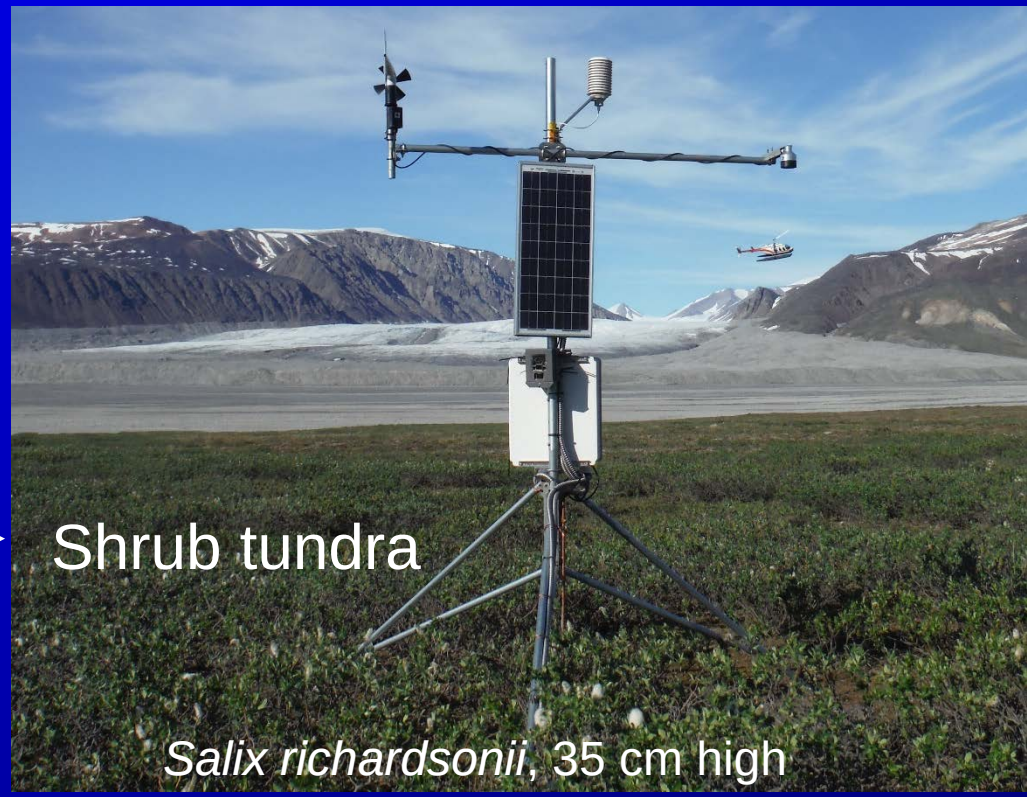
Permafrost T ↓

We compare 2 nearby sites without any manipulation

Sites in Qarlikturvik valley, Bylot Island



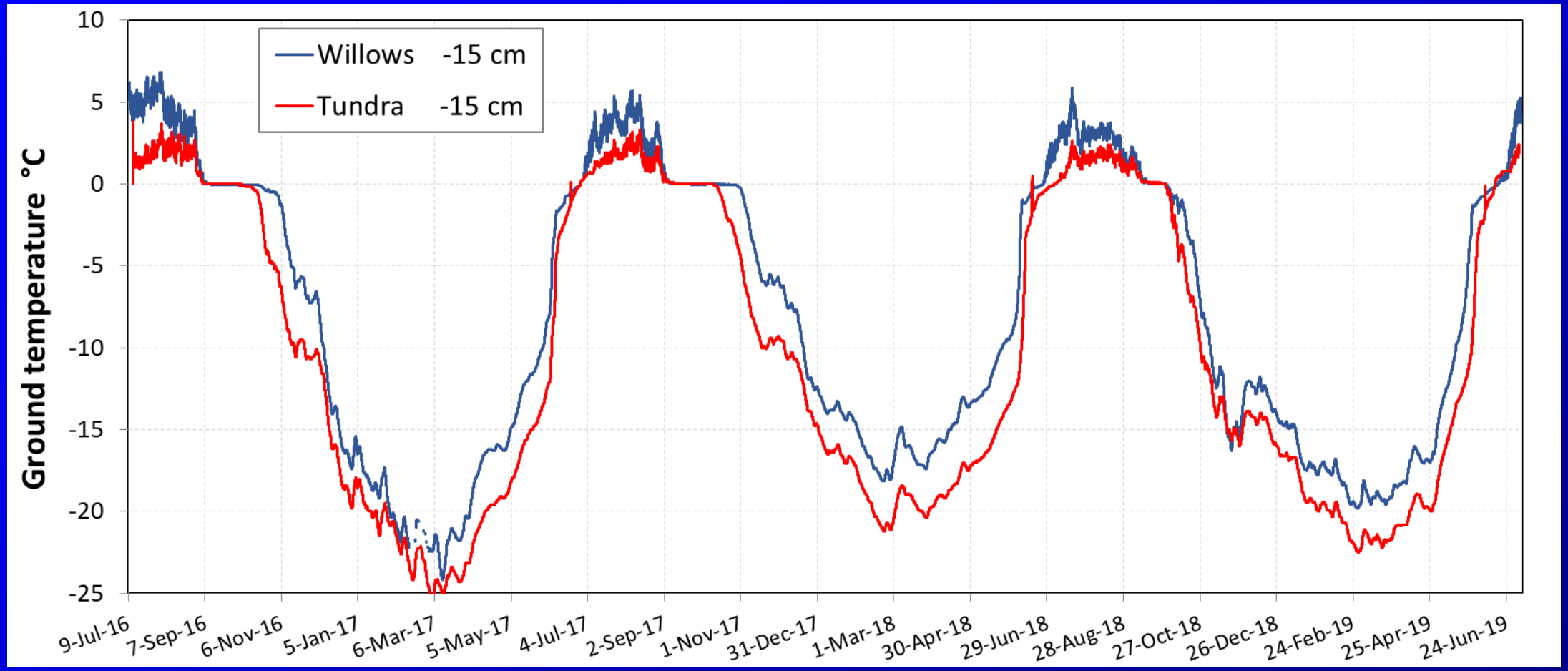
9 km



Monitor for 3 years

Air T and RH	Snow depth	Soil T
Wind speed	Snow T	Soil water fraction
Radiation	Snow thermal conductivity	Soil thermal conductivity

Ground temperature at 15 cm depth: comparison



Year round $T_{willow} - T_{tundra} = +2.3°C$

July-August: $T_{willow} - T_{tundra} = +1.6°C$

Air T: $T_{willow} - T_{tundra} = +0.6°C$

Simulations to quantify terms of energy budget

Use **Surfex V8** LSM with Crocus snow scheme, Arctic version

1- Test model on tundra data

2- Investigate effects of :

- Differences in air T
- Differences in surface roughness
- Differences in surface albedo

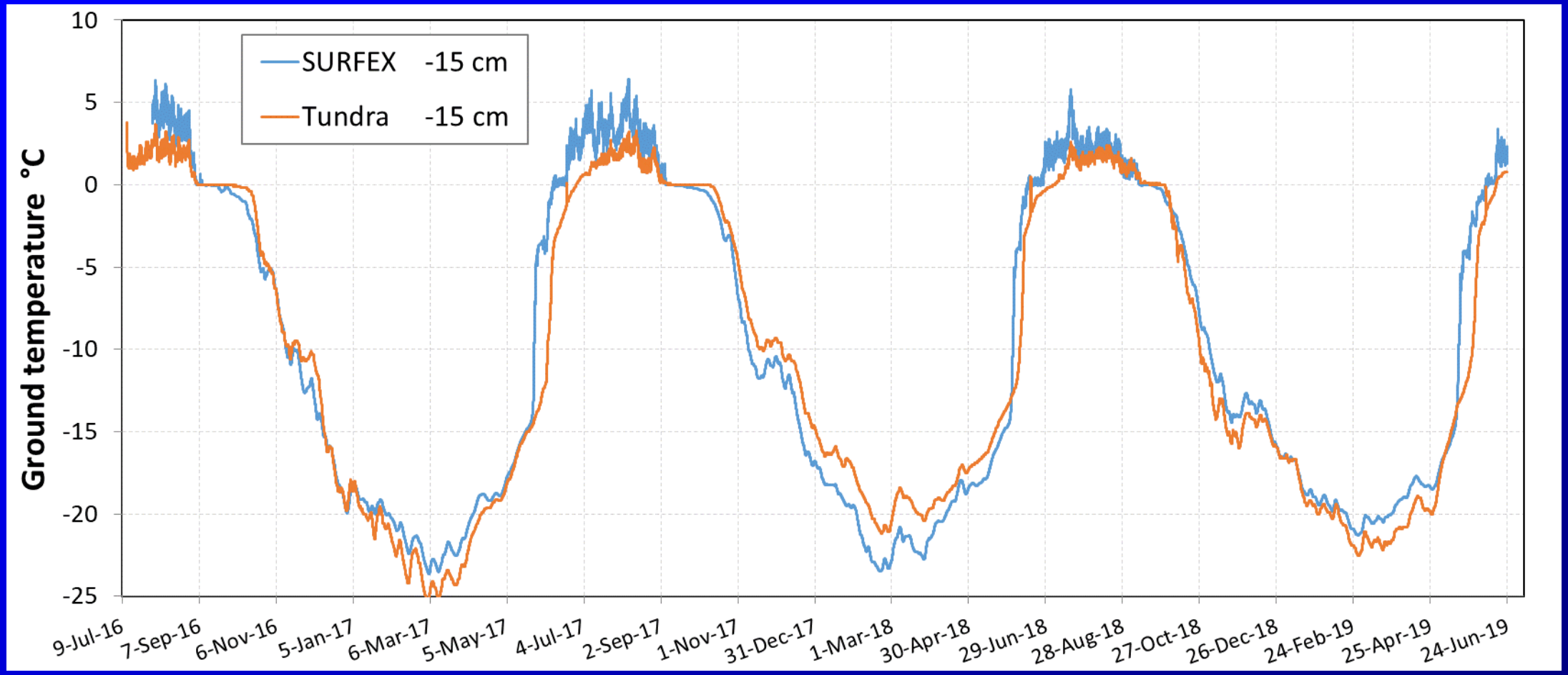
} a- Non-snow effects

- Differences in wind speed*
- Differences in snow compaction

} b- Snow effects

*lower at willlows⇒less snow compaction

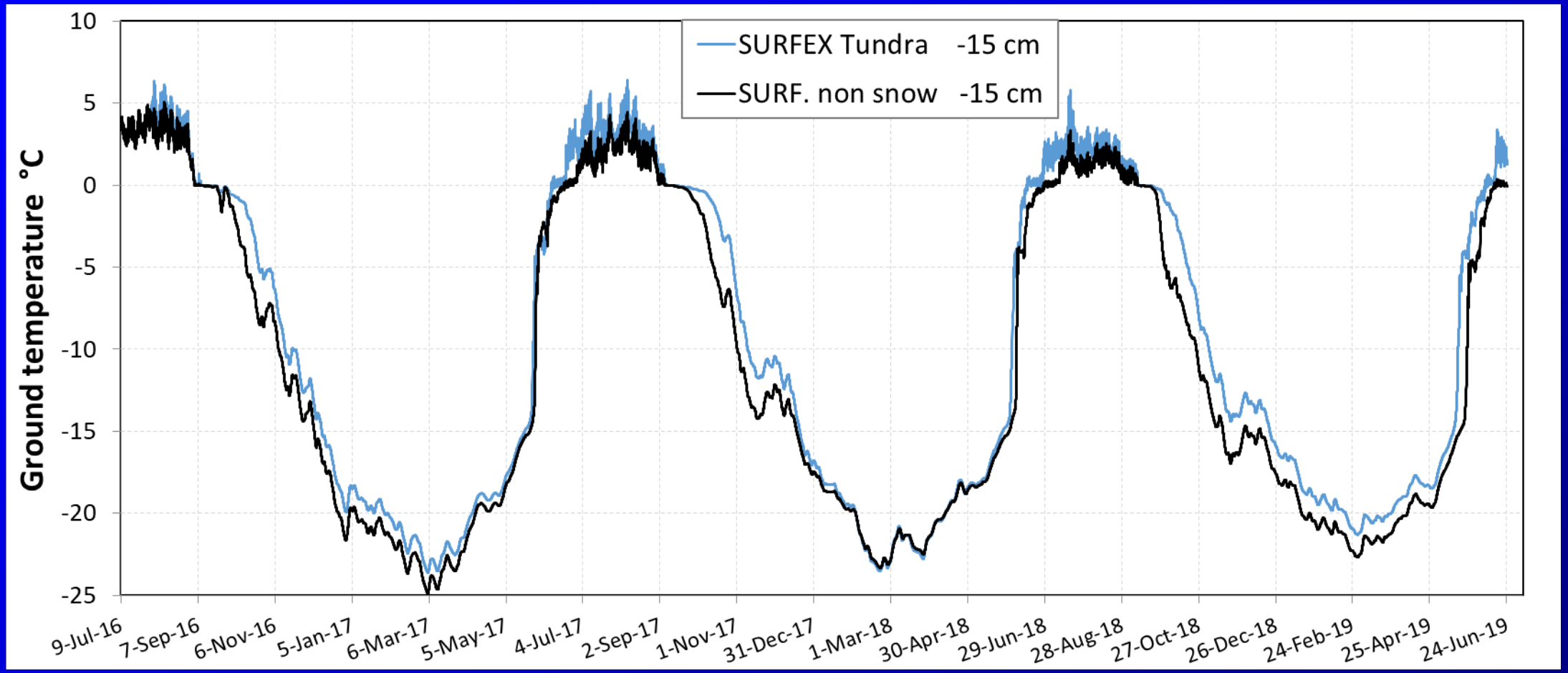
1- Test model on tundra data



RMSE = 2.00°C

Bias (Surfex-Tundra) = +0.46°C

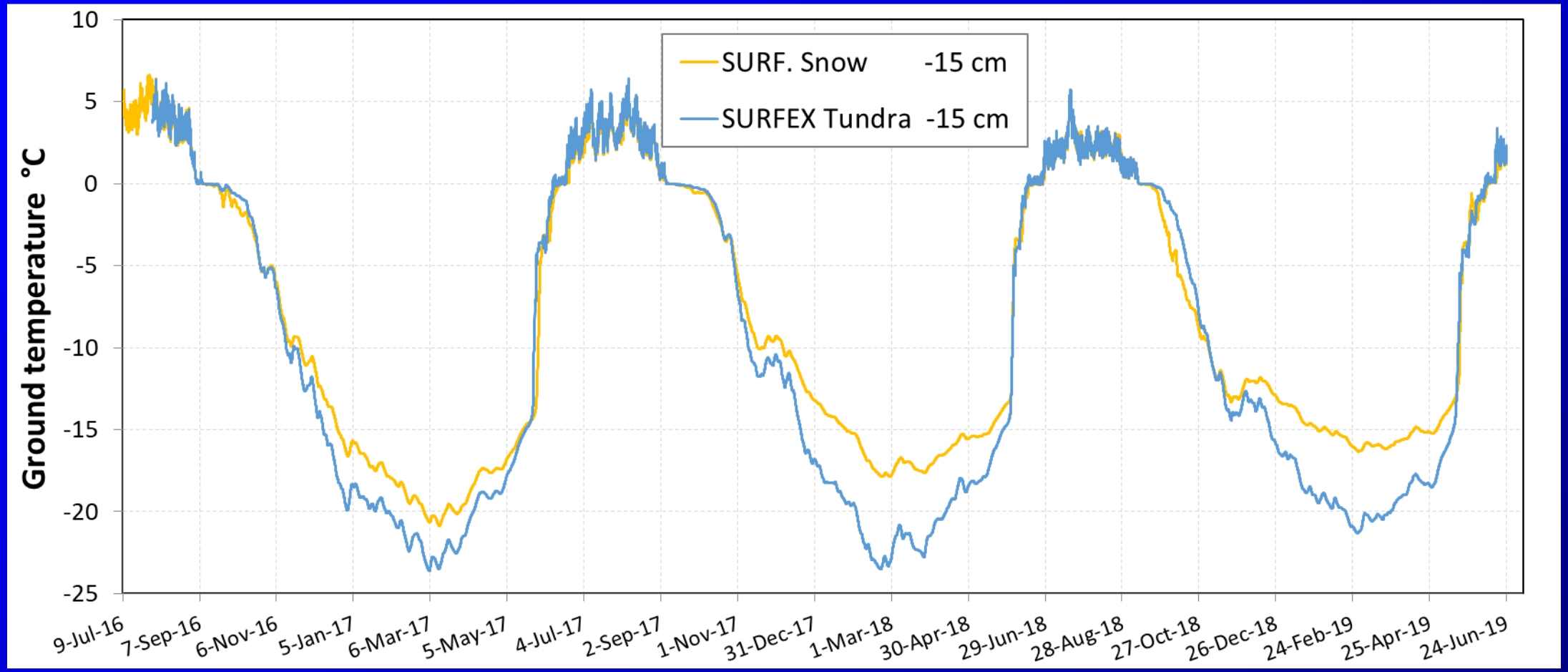
2- Investigate effects of: (a) non-snow effects: Temperature, **roughness**, albedo



Essentially, increased surface roughness leads to ground cooling

T change= -1.32°C

2- Investigate effects of: (b) snow effects: Wind speed, snow compaction*

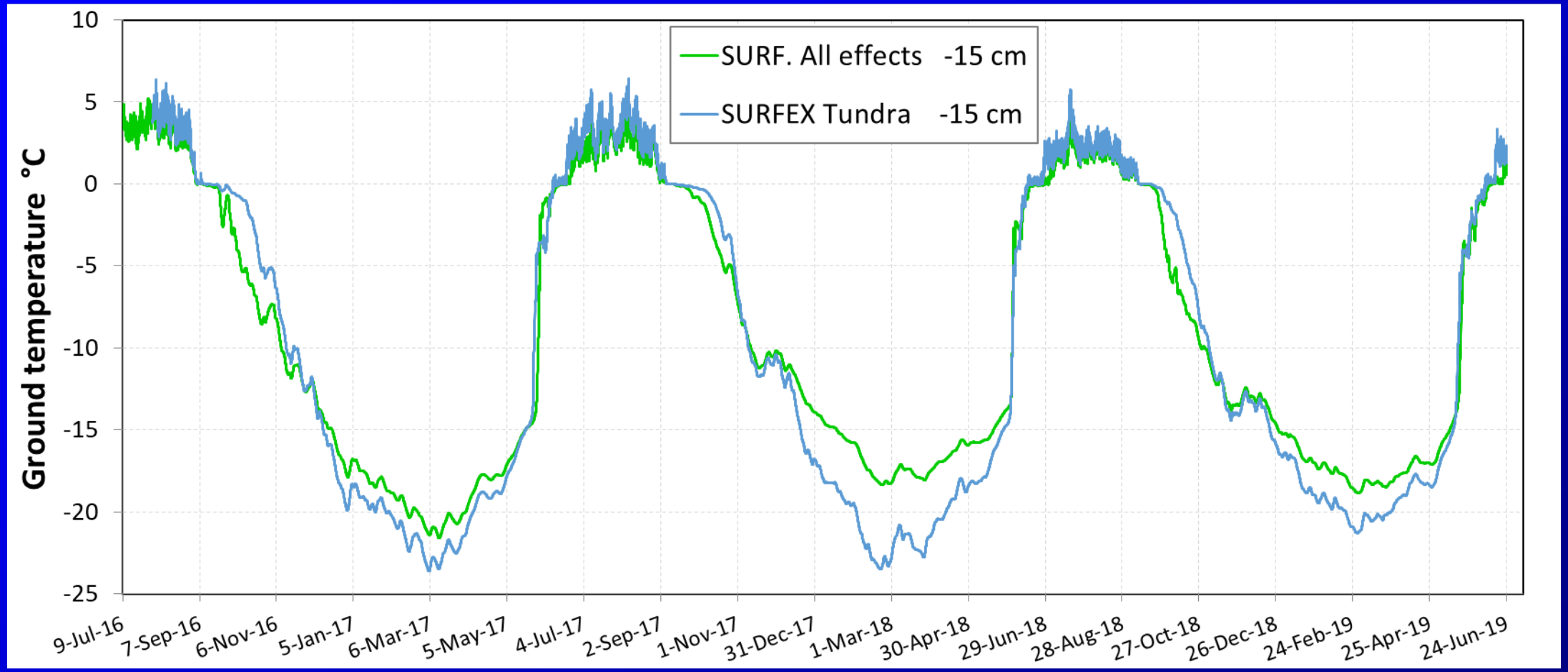


Essentially, decreased snow compaction leads to ground warming

T change= +1.43°C

*reduced in shrubs

2- ALL EFFECTS



SURFEX simulates winter warming but not summer warming

T change, sim= +0.55°C

T change, measure= +2.30°C

Conclusions

At Bylot Island, ground at -15 cm under willows is 2.3°C warmer than under herb tundra

Warming is observed in both summer and winter

Simulations with SURFEX indicate that:

Increased surface roughness due to shrubs produce cooling

Decreased snow compaction in shrubs produce warming

Remaining issues:

Summer warming under shrubs not simulated. Work on soil properties

Simulated zero curtain too short