

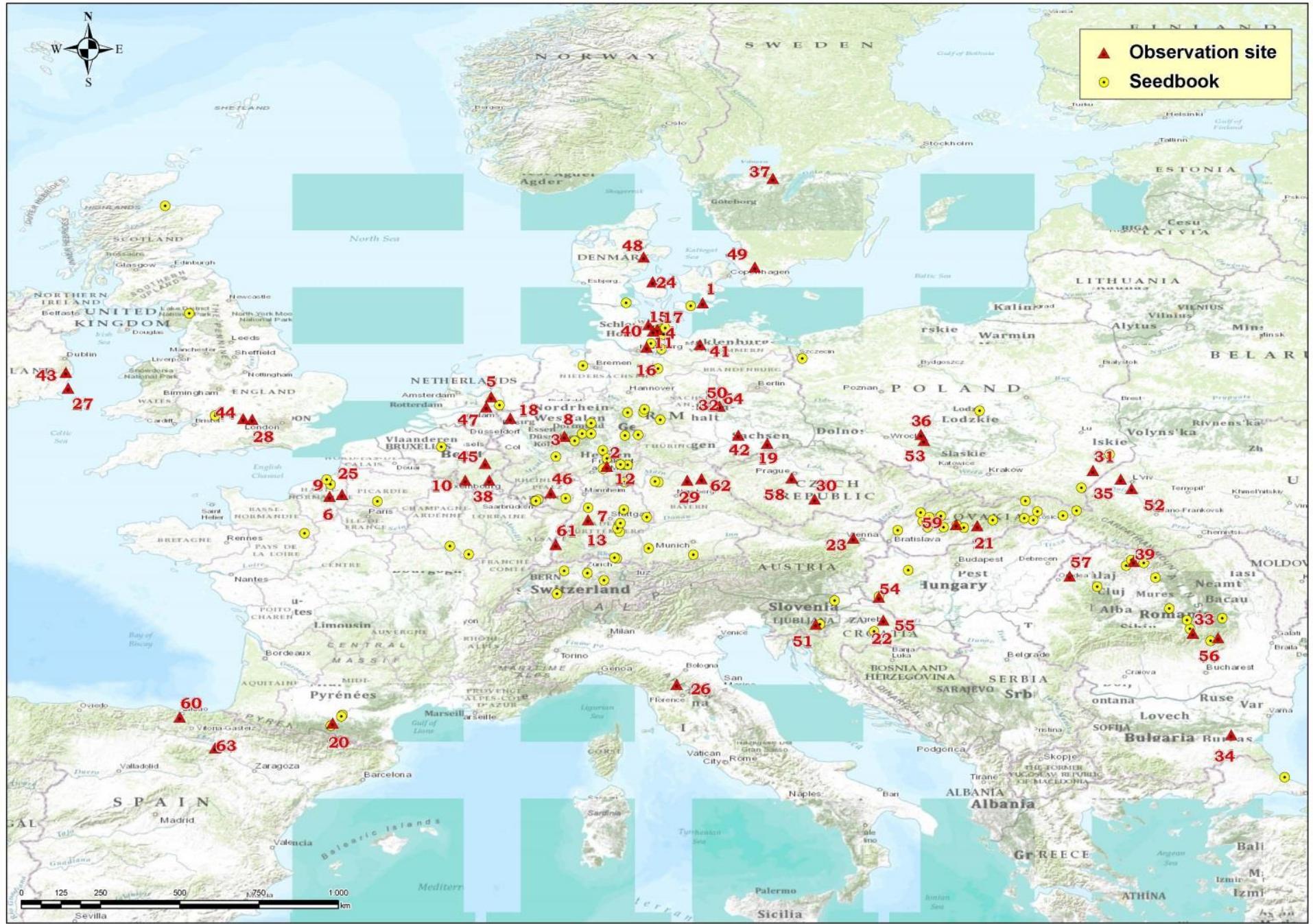
# Spatial analysis of provenance characteristics for future sites suitability matching: a case study on the phenology of beech

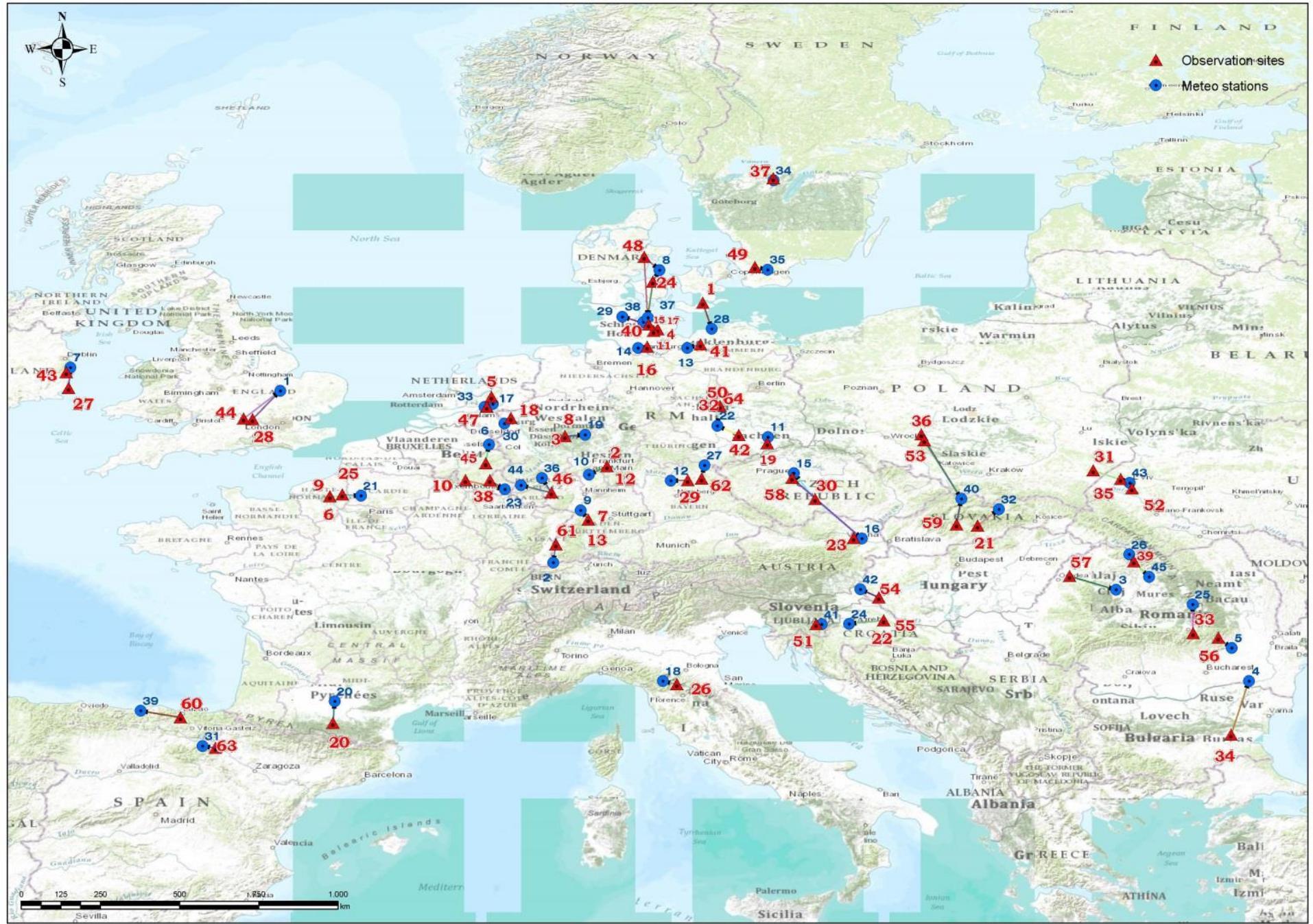
Koen Kramer, Mirko Liesebach, Adrian Lorent



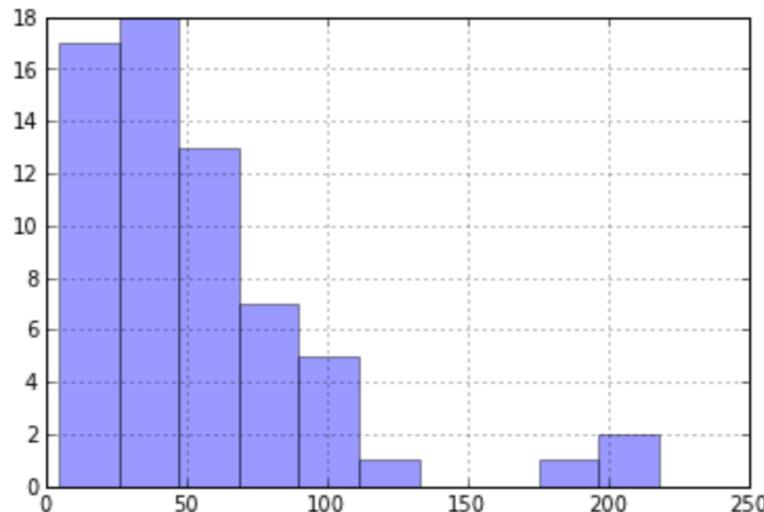
2<sup>nd</sup> Annual meeting Trees4Future, 21 November 2013, Doorwerth, Netherlands

Designing Trees for the Future

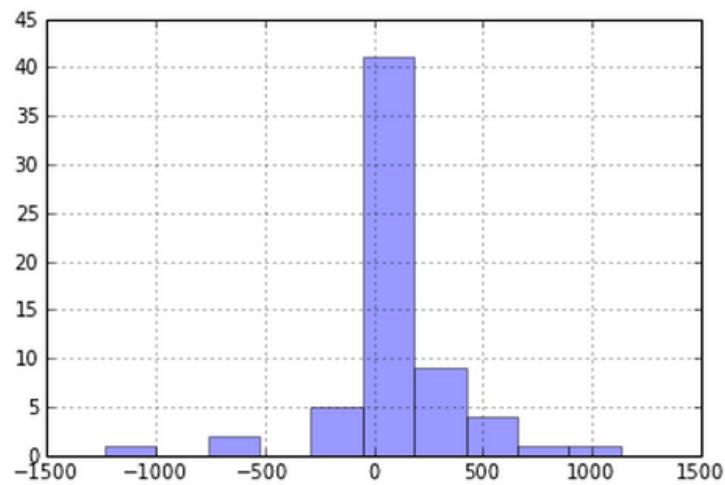




# Representativeness of meteorological stations for observation sites



Distance between observation site and meteorological station (km)



Difference in altitude between observation site and meteorological station (m)

# Some statistics

- seed book nrs.
  - 344
  - 325 with co-ordinates of origin
  - 291 non-synonymous
- 64 observation sites
- 41 meteorological stations
- 1763 observation site X seedbooknr X date combinations

# Phenological data: counts on a multinomial scale

3-step scale

site	date	SBN	a1	a2	a3
Bu8	05051998	2	61	40	6
Bu8	05051998	4	32	53	30
Bu8	05051998	6	55	42	8
Bu8	05051998	7	35	53	20
Bu8	05051998	8	53	44	15
Bu8	05051998	9	9	26	36
...					

6-step scale

site	date	SBN	a1	a2	a3	a4	a5	a6
BU2008	20042007	1	21	67	3	4	0	0
BU2008	20042007	2	36	59	19	7	2	0
BU2008	20042007	3	8	53	25	4	3	0
BU2008	20042007	6	20	34	13	1	0	0
BU2008	20042007	8	12	37	23	10	3	1
BU2008	20042007	12	5	66	25	5	4	0
...								

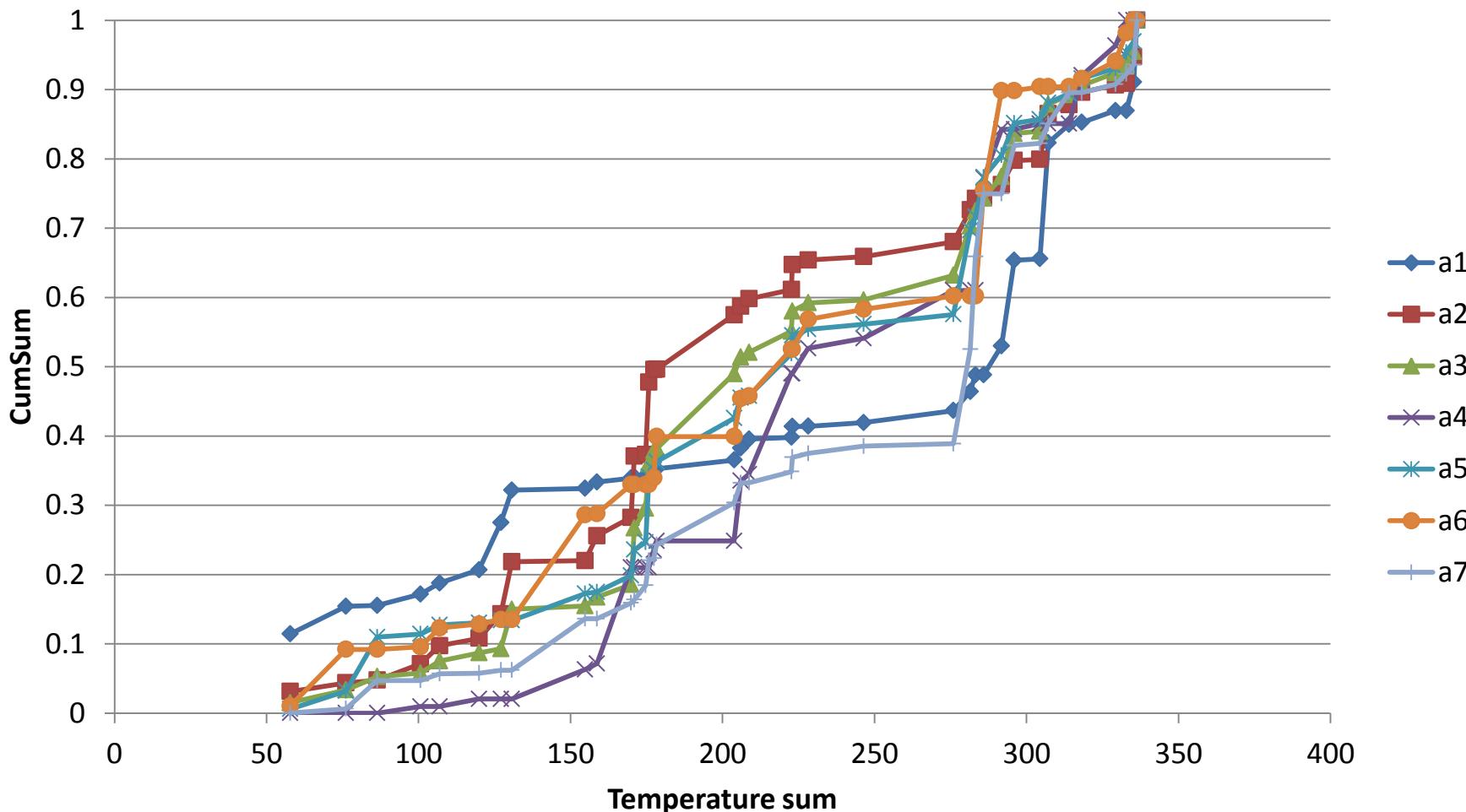
5-step scale

site	date	SBN	a1	a2	a3	a4	a5
Bu6	09051989	1	2	48	36	9	2
Bu6	09051989	2	7	152	64	10	2
Bu6	09051989	3	0	22	55	53	49
Bu6	09051989	4	3	105	83	44	18
Bu6	09051989	5	0	7	42	25	21
...							

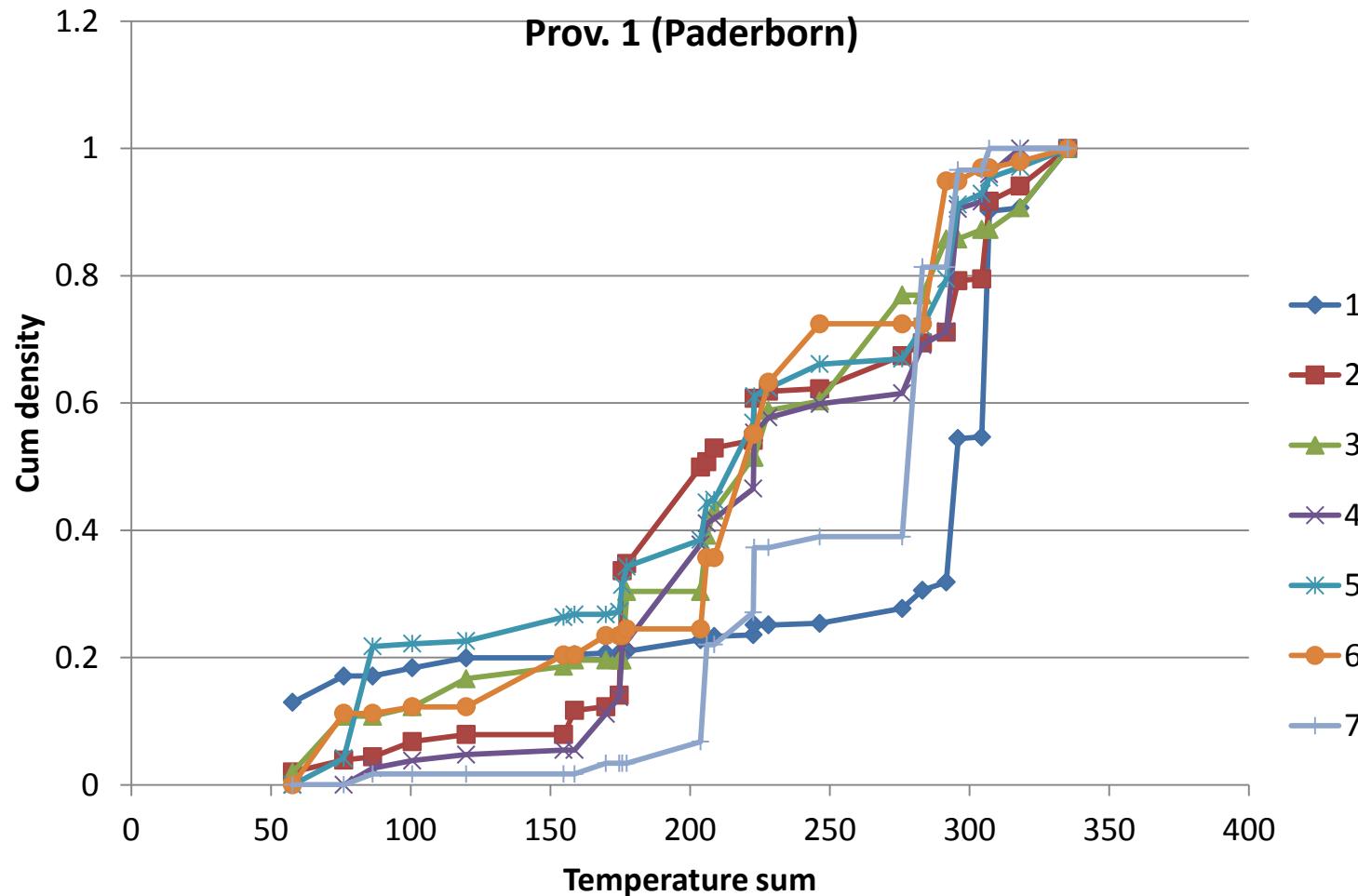
7-step scale

site	date	SBN	a1	a2	a3	a4	a5	a6	a7
Bu1901	13051997	2	1	6	0	24	0	3	1
Bu1901	13051997	5	1	14	10	18	2	0	0
Bu1901	13051997	7	0	6	13	12	6	5	1
Bu1901	13051997	8	0	18	7	8	1	1	0
Bu1901	13051997	9	0	25	10	7	3	1	0
...									

# Cumulative distribution of phenological scores at 7-steps scale. All provenances & Sites



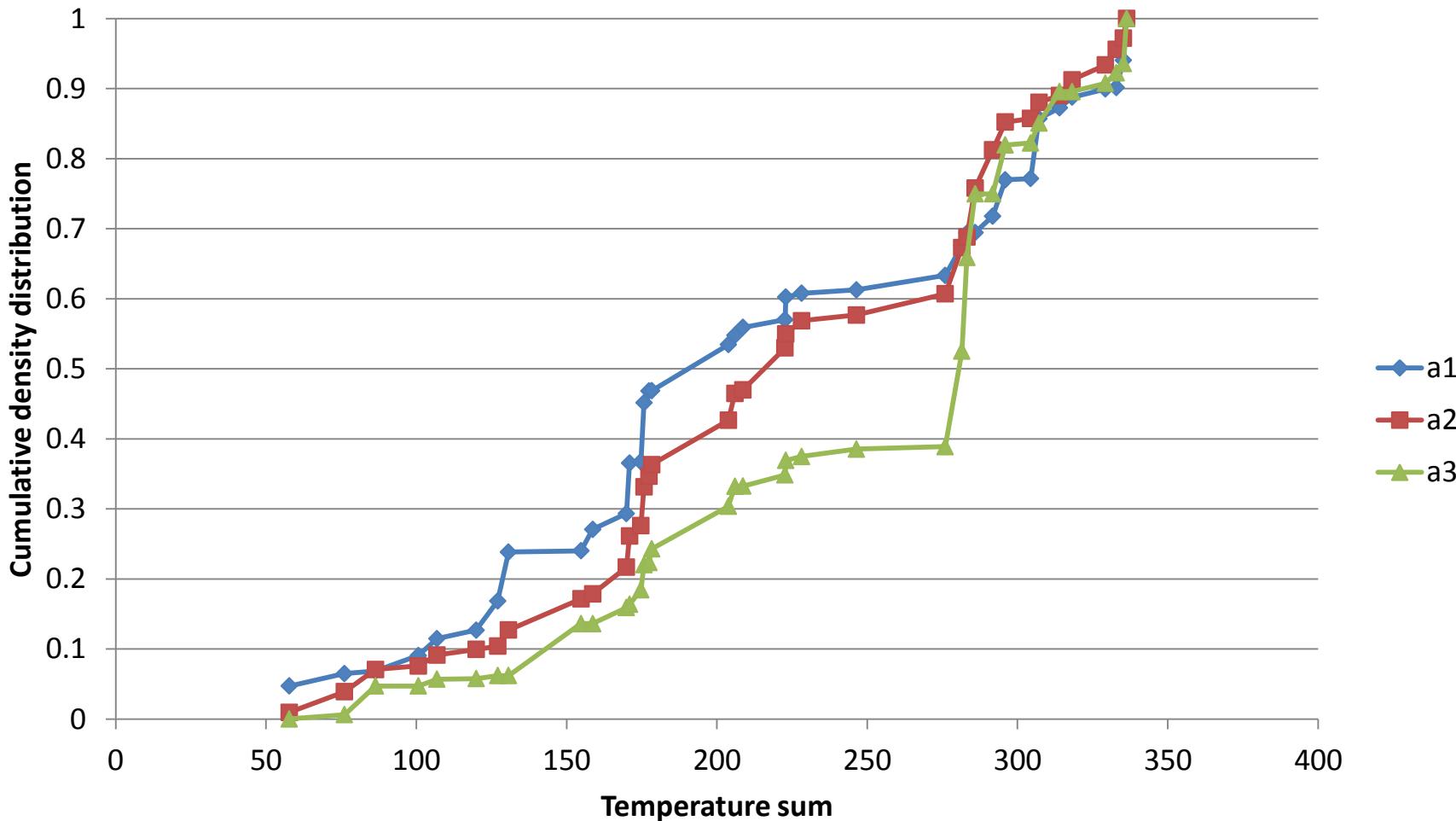
## Cumulative density function for 1 provenance, over sites (17 years of observation)



# Score conversion to 3-step scale

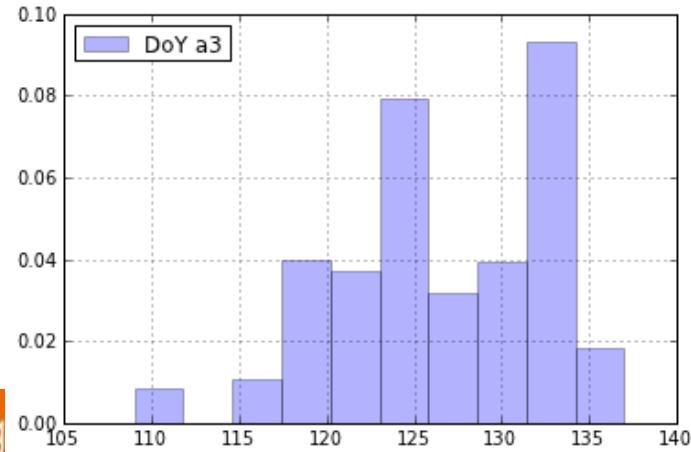
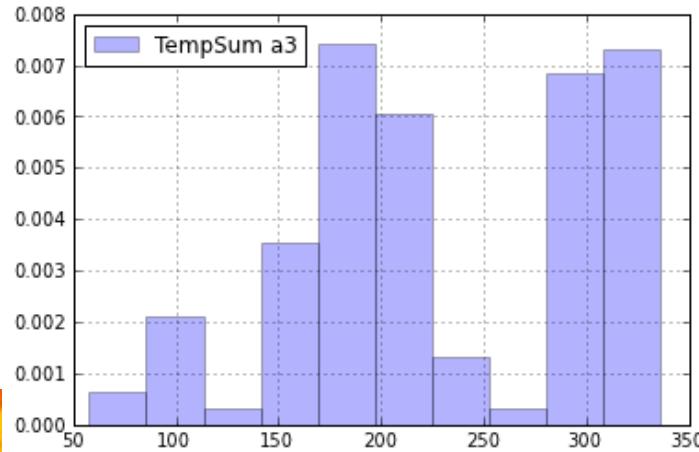
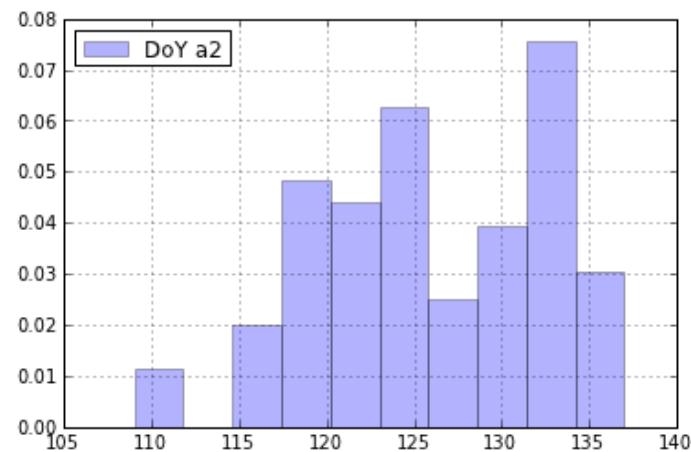
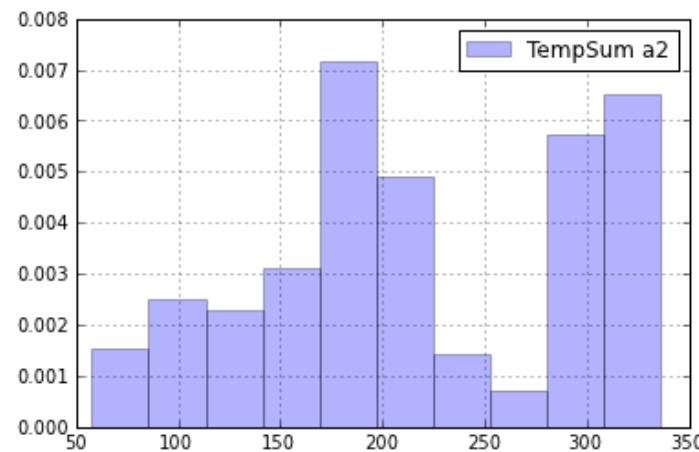
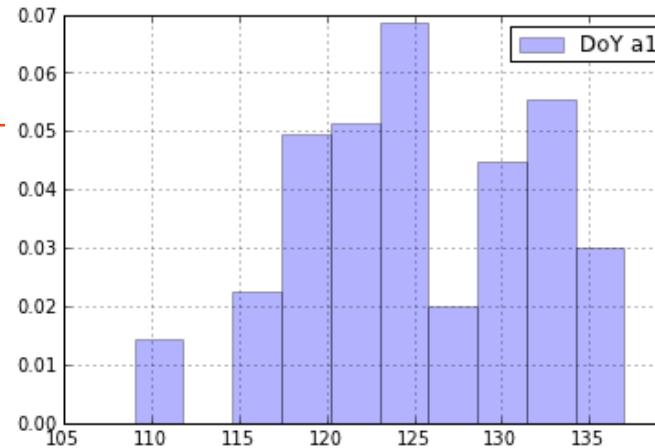
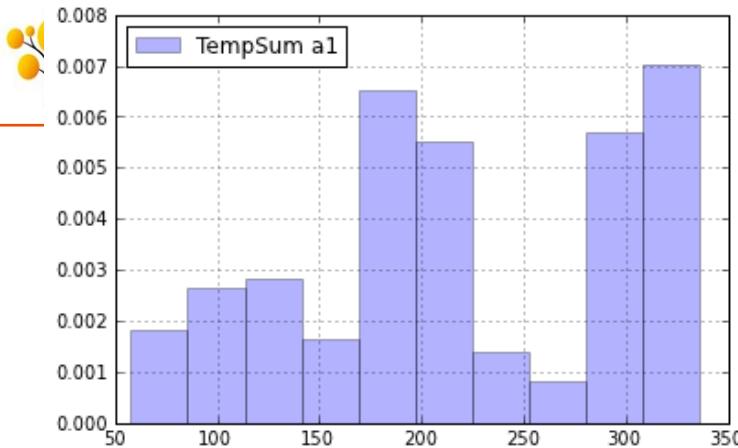
ScaleName	ScoreOriginalScale	Score3StepScale		
		a1	a2	a3
<b>5-step-scale</b>	a1	a1		
	a2	a1		
	a3		a2	
	a4		a2	
	a5			a3
<b>6-step-scale</b>	a1	a1		
	a2	a1		
	a3		a2	
	a4		a2	
	a5		a2	
	a6			a3
<b>7-step-scale</b>	a1	a1		
	a2	a1		
	a3		a2	
	a4		a2	
	a5		a2	
	a6		a2	
	a7			a3

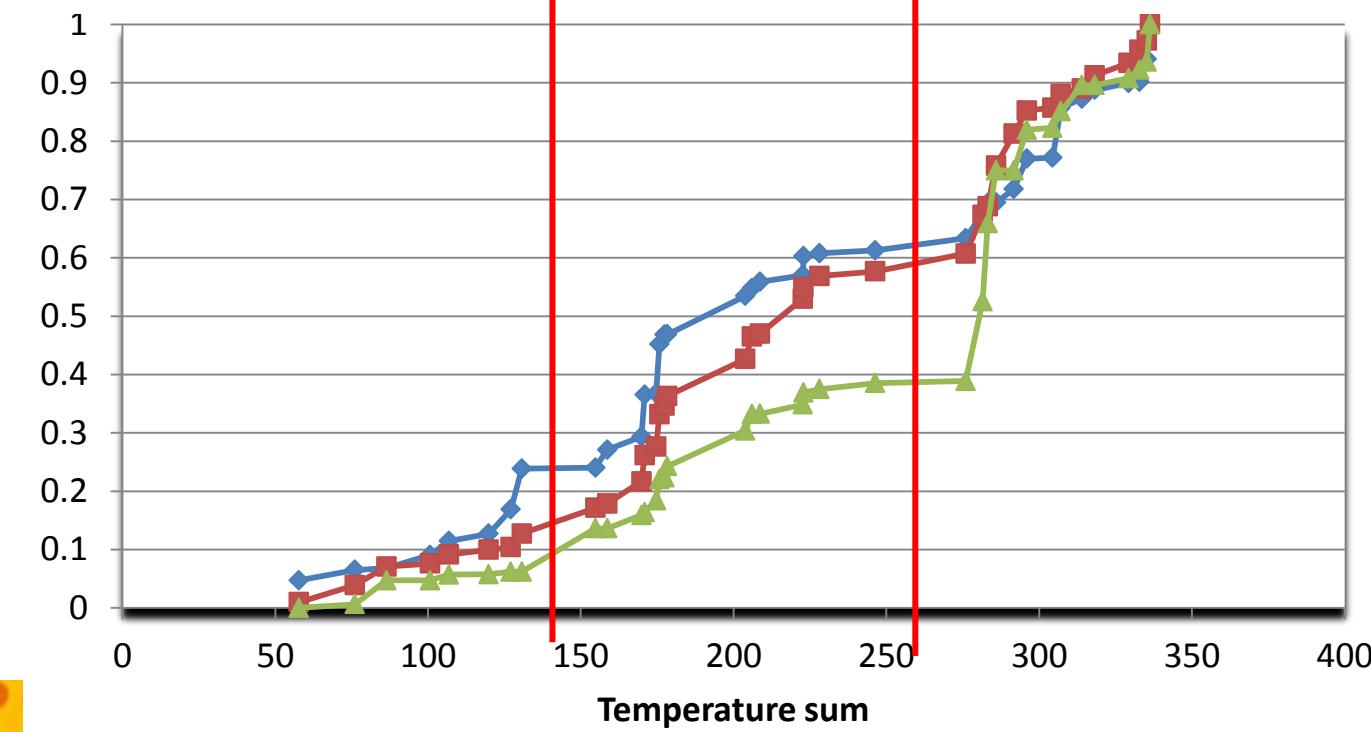
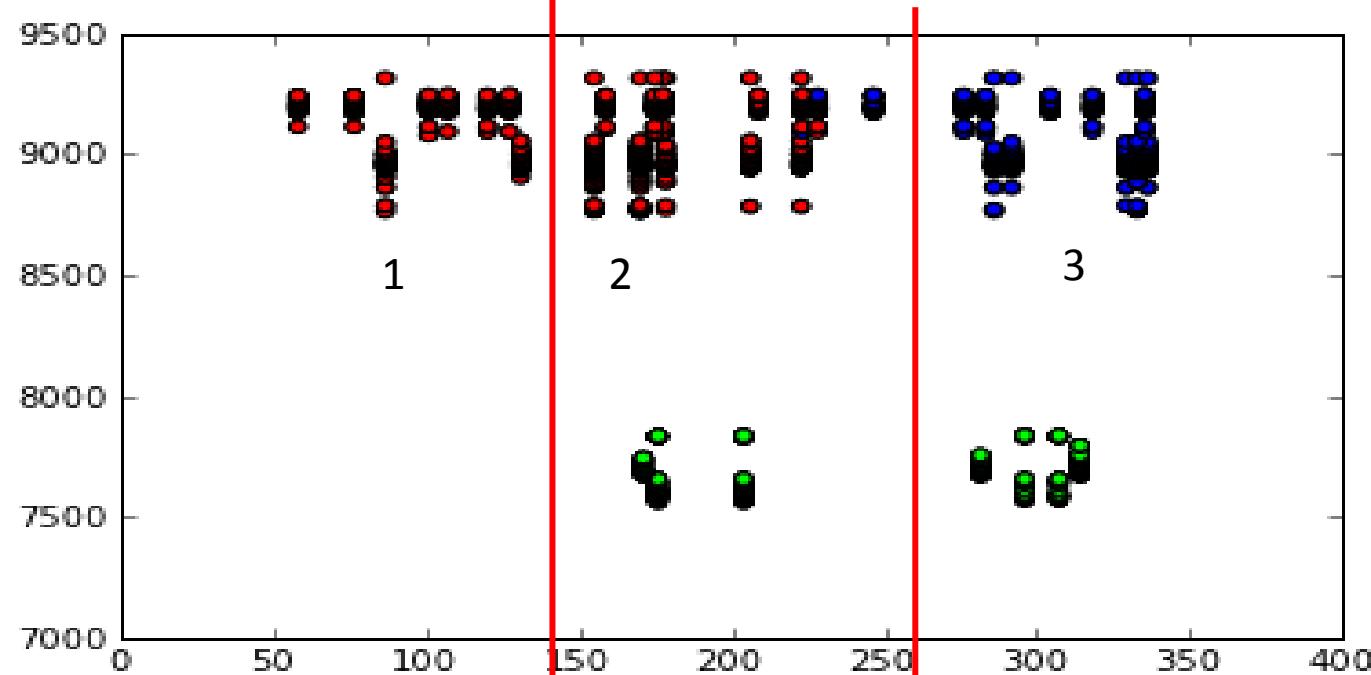
# Cumulative distribution of phenological scores at 3-steps scale. All provenances & Sites





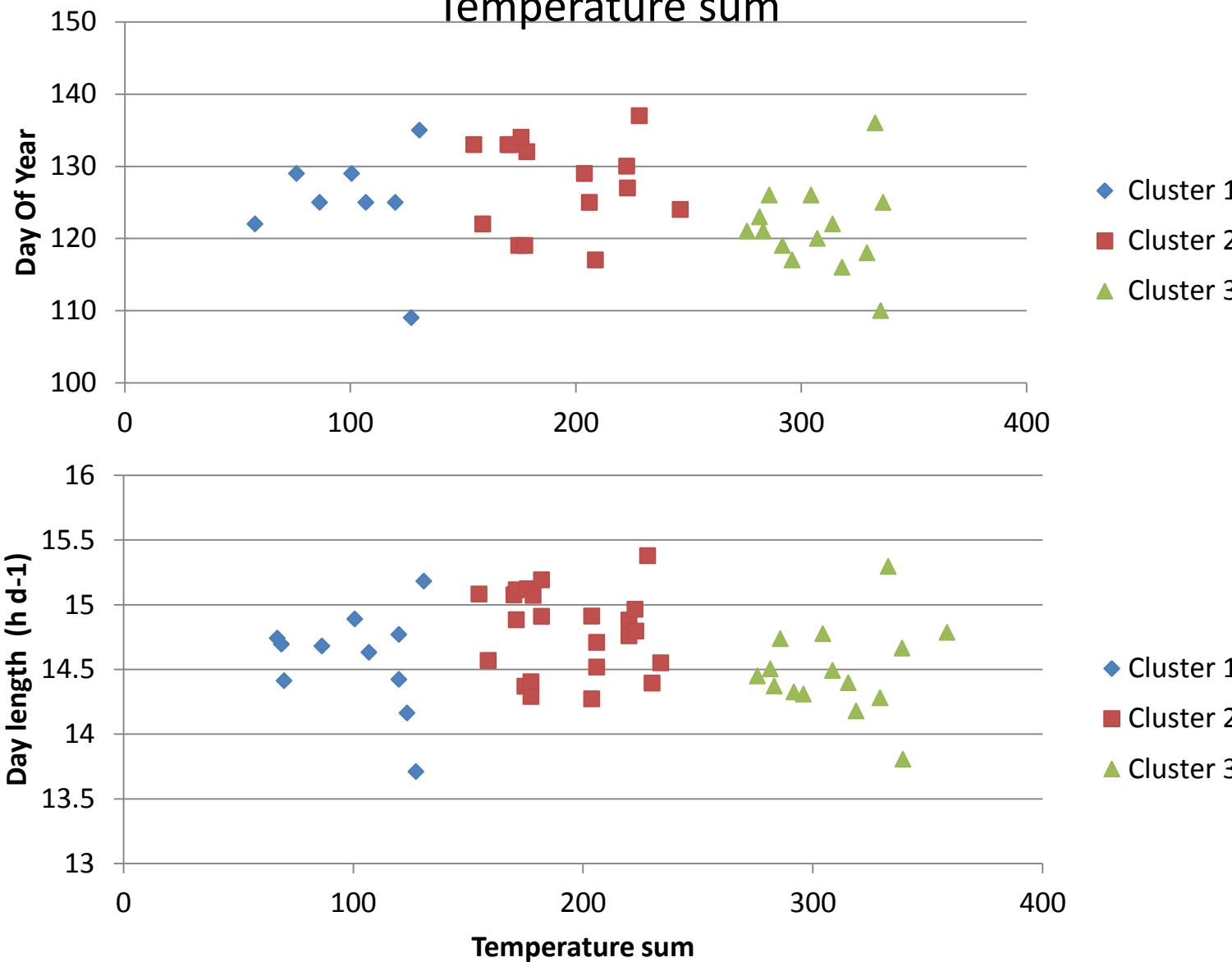
TempSum a1

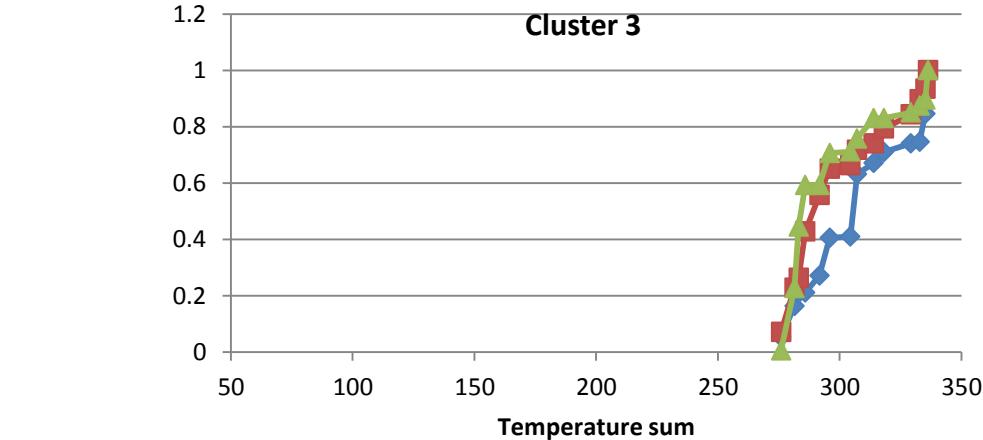
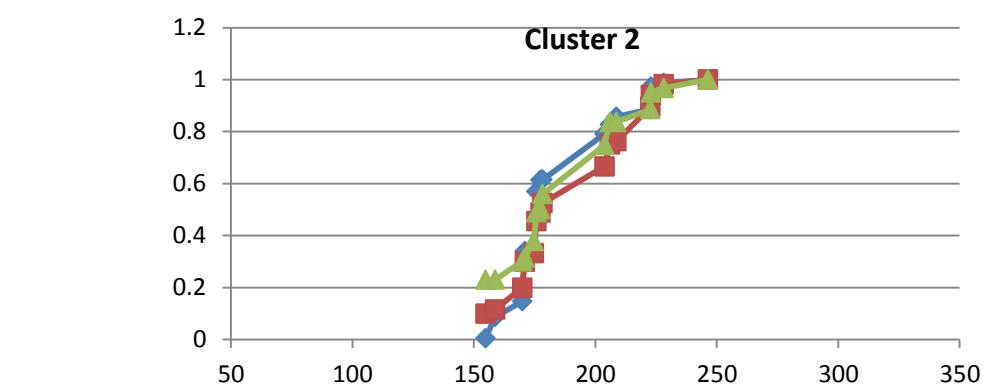
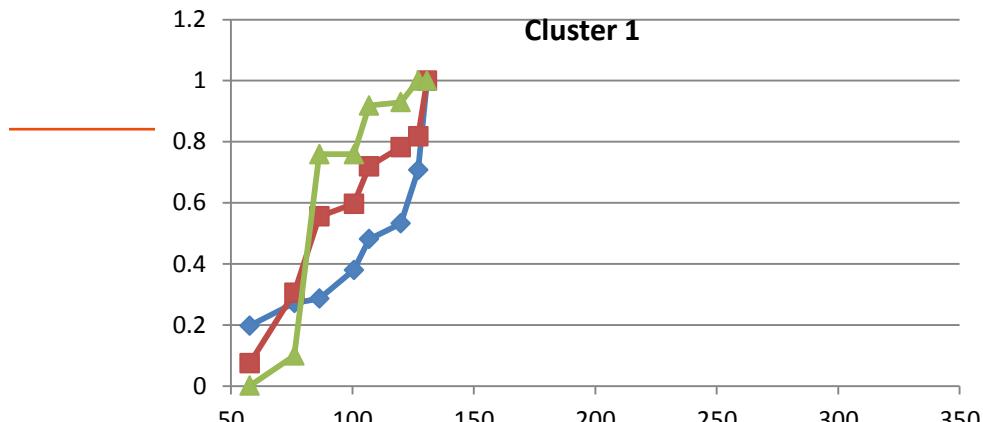
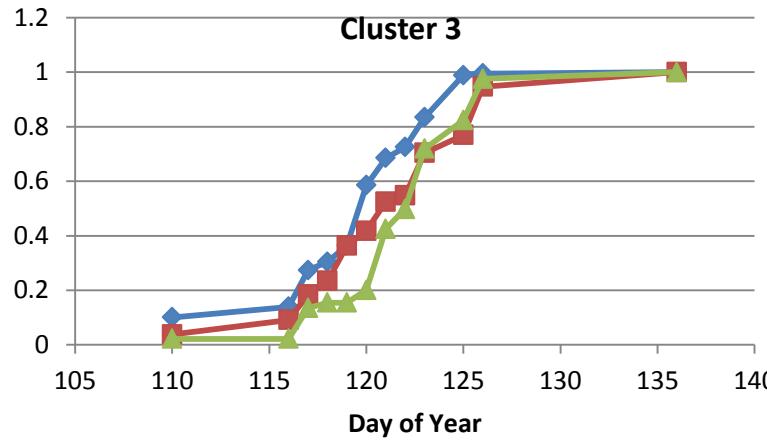
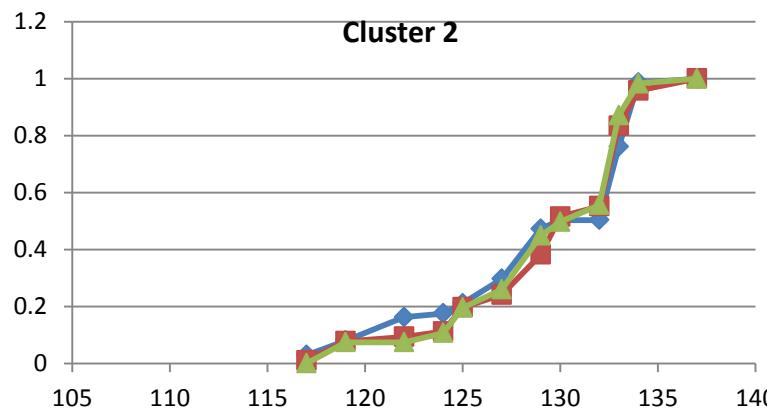




# Dependencies of DoY and Daylength on

## Temperature sum





— a1 ■ a2 ▲ a3

g Trees

— a1 ■ a2 ▲ a3

# DoY and TempSum per clusters.

## Weighted values over provenances, sites and years

**Day of Year**

		Weighted mean DoY	
Cluster	a1	a2	a3
1	125.2	127.1	124.3
2	129.5	129.9	129.8
3	119.7	121.8	122.3

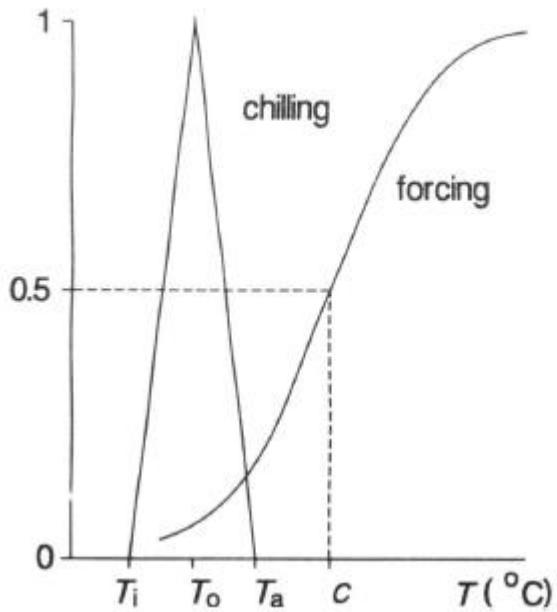
**Temperature Sum**

		Weighted mean temperature Sum	
Cluster	a1	a2	a3
1	105.2	96.6	91.9
2	187.2	191.3	187.1
3	307.9	299.7	296.8

		Deviate with score a2:	
Cluster	a1	a2	a3
1	1.9	0.0	2.8
2	0.4	0.0	0.1
3	2.1	0.0	-0.5

Deviate with score a2:

		Deviate with score a2:	
Cluster	a1	a2	a3
1	8.6	0.0	-4.8
2	-4.1	0.0	-4.2
3	8.2	0.0	-2.8



$$R_c = \begin{cases} 0 & T \leq T_i \\ \frac{T - T_i}{T_o - T_i} & T_i < T \leq T_o \\ \frac{T - T_a}{T_o - T_a} & T_o < T < T_a \\ 0 & T \geq T_a \end{cases}$$

$$R_f = \begin{cases} 0 & T \leq T_b \\ K \frac{1}{1 + e^{-b(T-c)}} & T > T_b \end{cases}$$

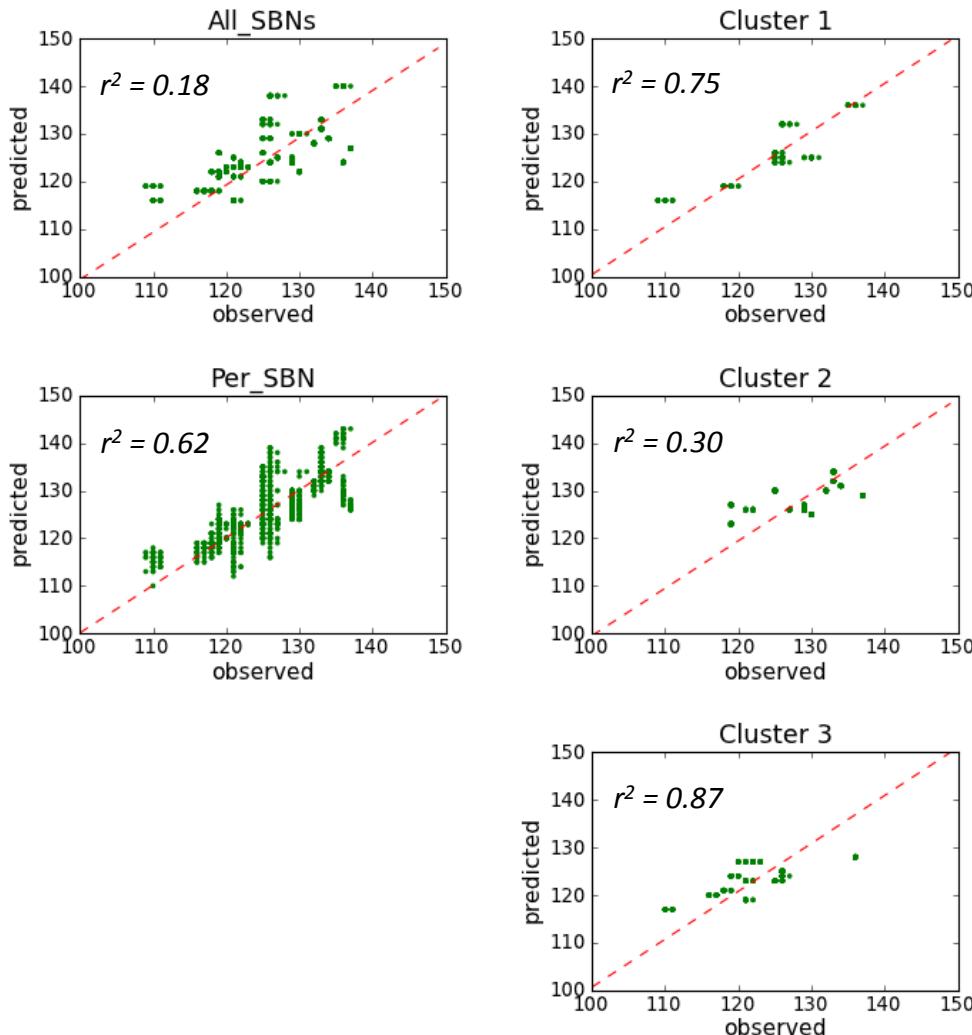
$$S_c = \sum_{t_1}^{t_2} R_c(T); \quad t_2 : S_c = S_c^*$$

$$S_f = \sum_{t_2}^{t_3} R_f(T); \quad t_3 : S_f = S_f^*$$

- Single estimate of model parameters over all data
  - Fit per cluster
  - Fit per seed book number (or non-synonymous SBN)
- analyse spatial structure of results with respect to origin of SBNs

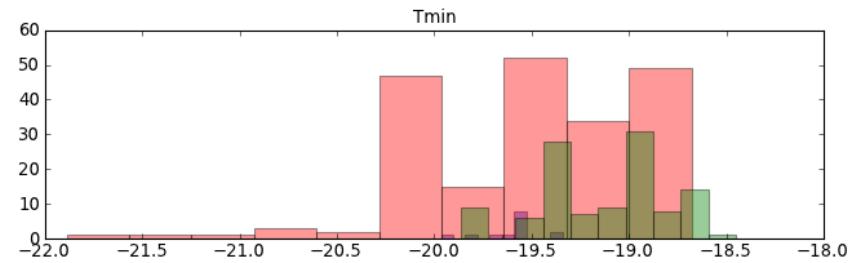
# Observed and fitted day of bud burst

observed x predicted day of budburst

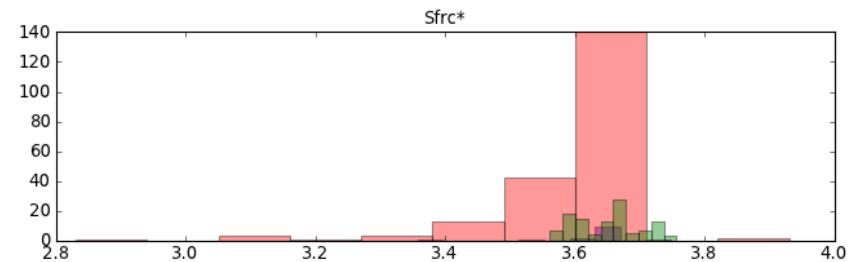
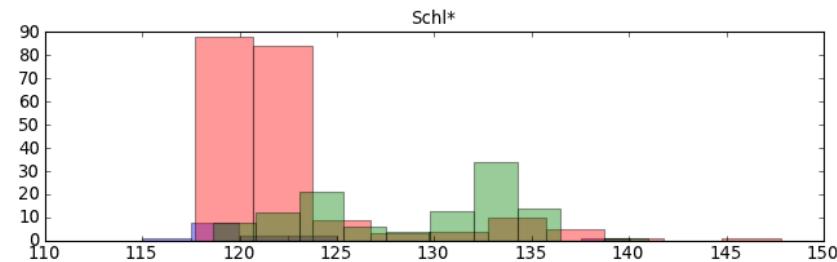
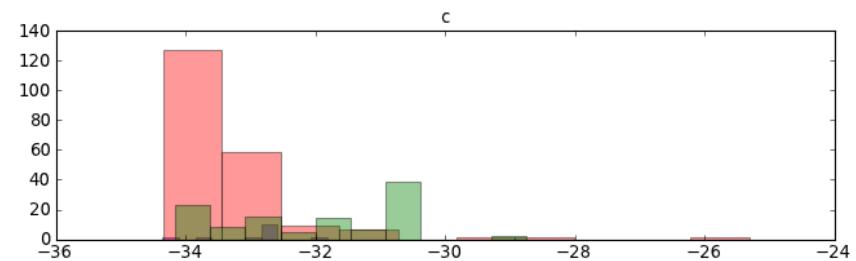
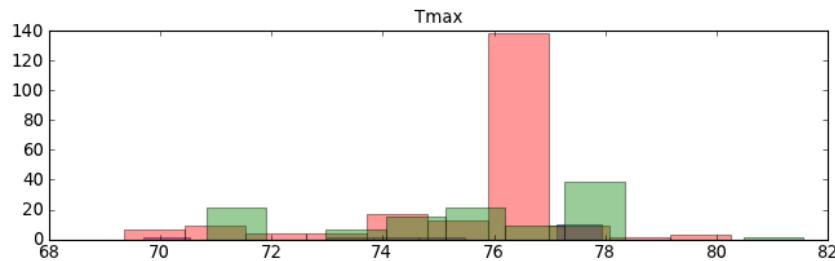
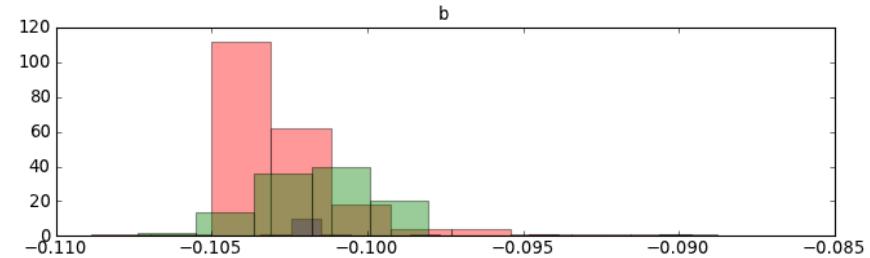
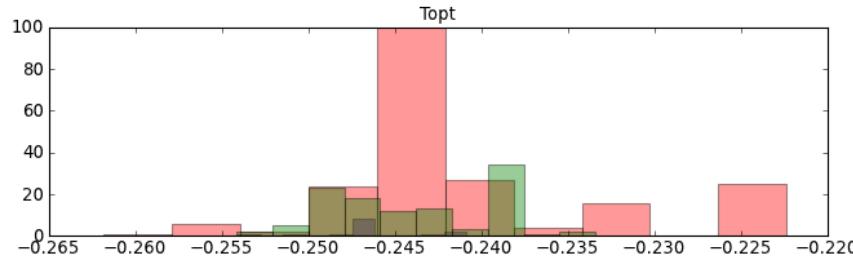


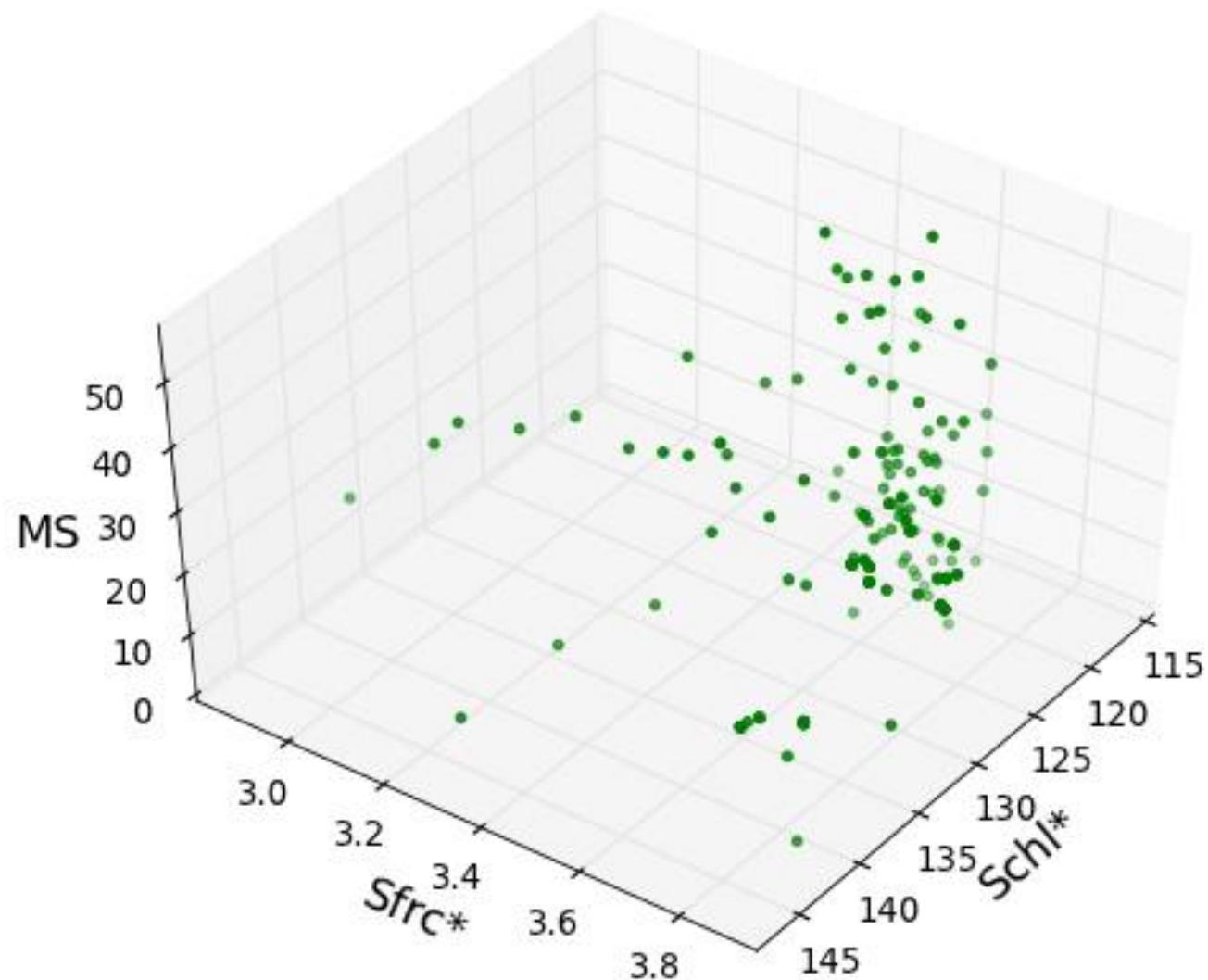
		Observed	Fit
<b>All SBNs</b>	mean	126.0	125.4
	std	6.4	5.5
	min	109	116
	max	137	140
<b>Per SBN</b>	mean	<b>126.0</b>	<b>126.0</b>
	std	<b>6.4</b>	<b>6.4</b>
	min	<b>109</b>	<b>110</b>
	max	<b>137</b>	<b>143</b>
<b>Cluster 1</b>	mean	124.8	125.4
	std	6.8	6.1
	min	109	116
	max	137	136
<b>Cluster 2</b>	mean	129	128.5
	std	4.9	3.3
	min	119	123
	max	137	134
<b>Cluster 3</b>	mean	122.3	123.3
	std	5.9	3.1
	min	110	117
	max	136	128

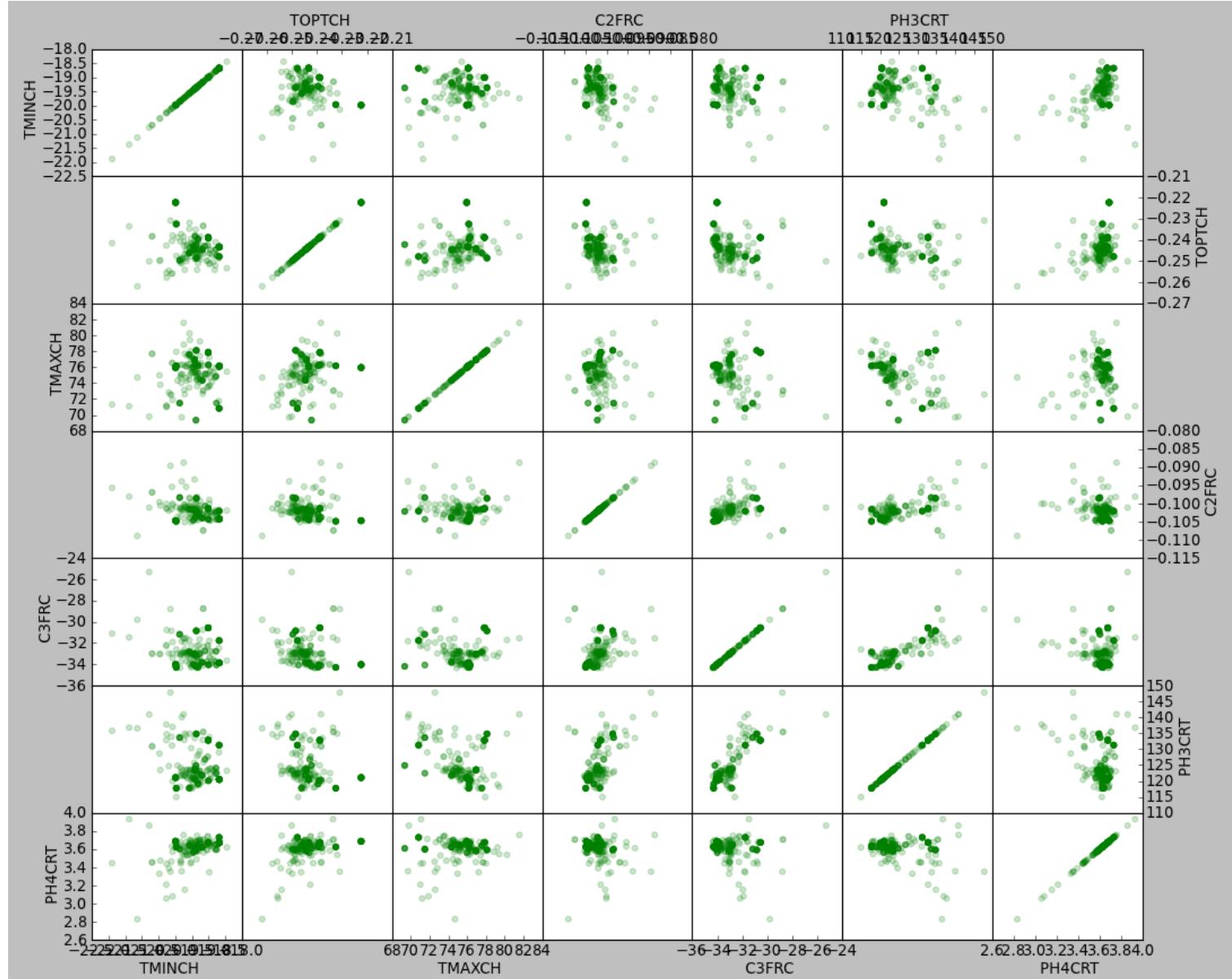
Scenario	$T_{\min}$	$T_{\text{opt}}$	$T_{\max}$	B	c	$S_{\text{chl}}^*$	$S_{\text{frc}}^*$
All SBNs	-20.02	-0.25	69.72	-0.10	-32.31	126.49	3.64
Cluster 1	-20.97	-0.25	69.79	-0.10	-29.43	138.14	3.52
Cluster 2	-19.77	-0.25	69.36	-0.10	-32.59	128.83	3.71
Cluster 3	-20.09	-0.25	69.95	-0.10	-32.36	129.67	3.65
Avg 'Per SBN' $\pm$ sd	-19.35 $\pm$ 0.51	-0.24 $\pm$ 0.007	<b>75.55</b> $\pm$ 2.14	-0.10 $\pm$ 0.002	-32.94 $\pm$ 1.32	<b>124.63</b> $\pm$ 5.81	3.63 $\pm$ 0.1



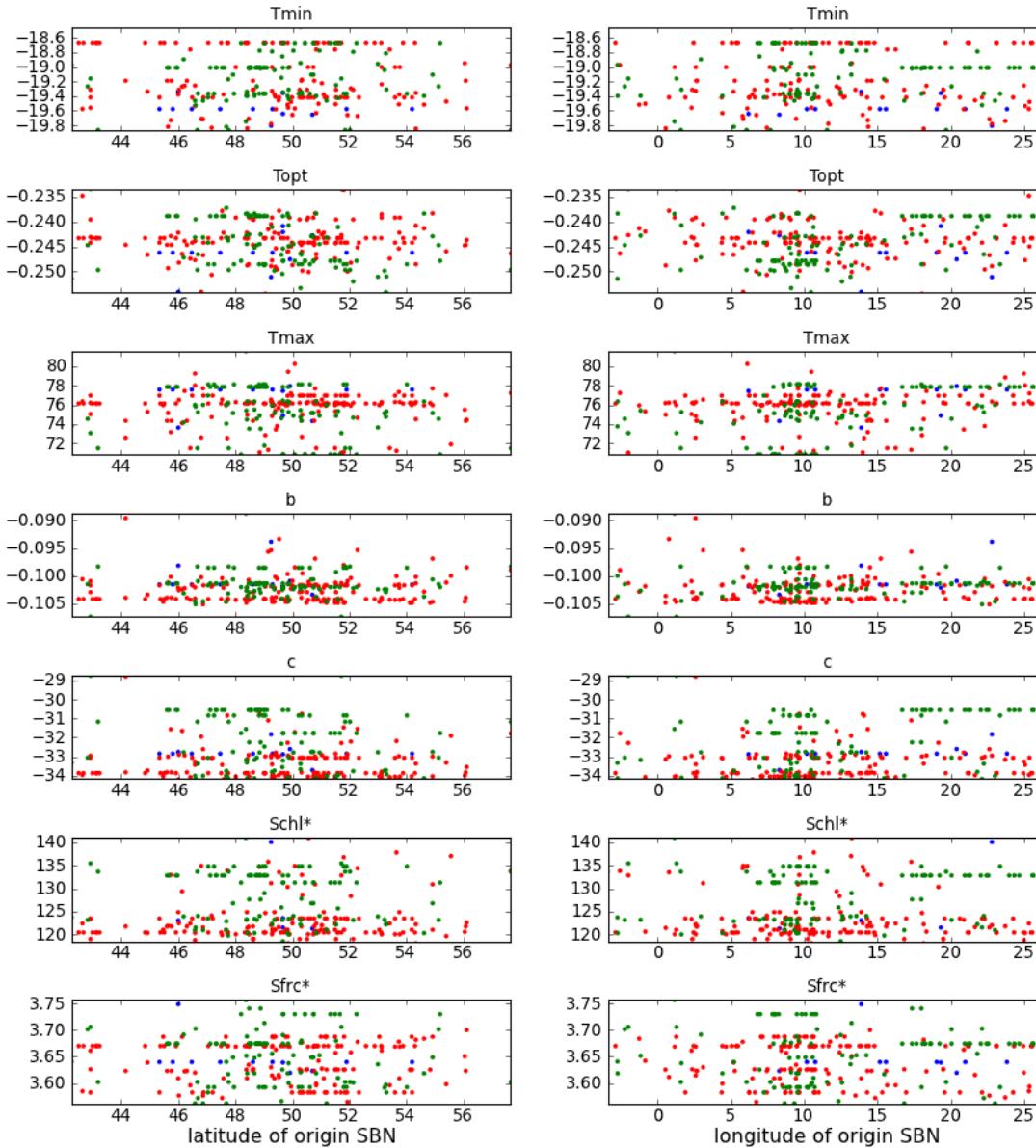
- Cluster 1
- Cluster 2
- Cluster 3



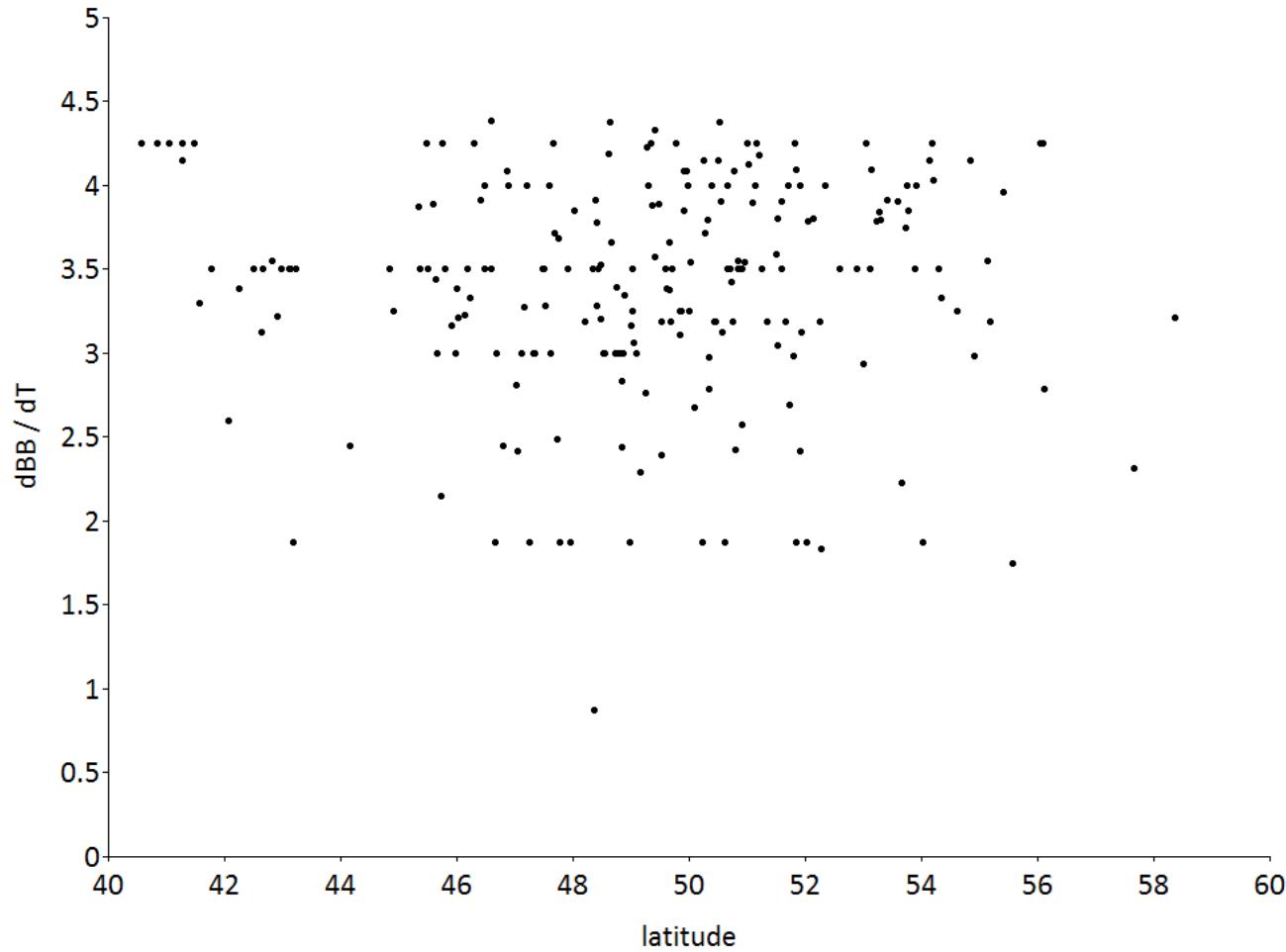




# Spatial structure parameters ‘Per SBN’



# Spatial structure of change in budburst per degree T change



# Conclusions

- Reasonably good fit is feasible when fitted per provenance, though with minor overestimation at the extreme early and late bud burst
- Fit can probably be improved with other methods
- Clustering of SBNs on temperature sum threshold is not reflected in model parameters
- Possibly two populations in terms of  $S_{chl}^*$
- No latitudinal or longitudinal trends in model parameter values of provenances