

# Weather generator parameters for precipitation in Sweden and Norway – relation to atmospheric circulation

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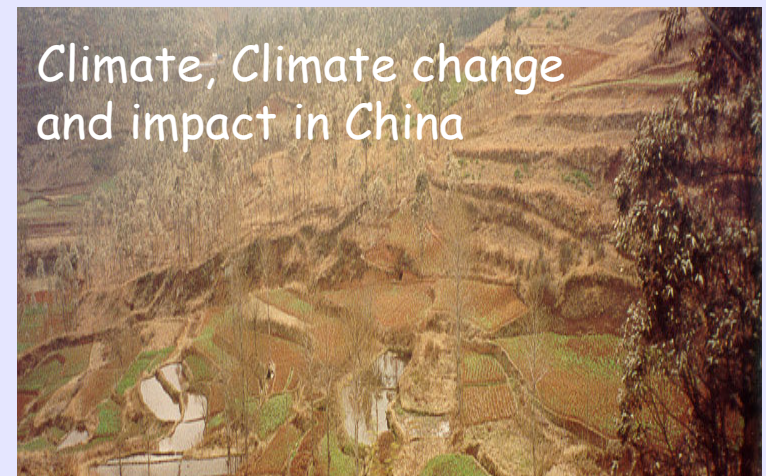
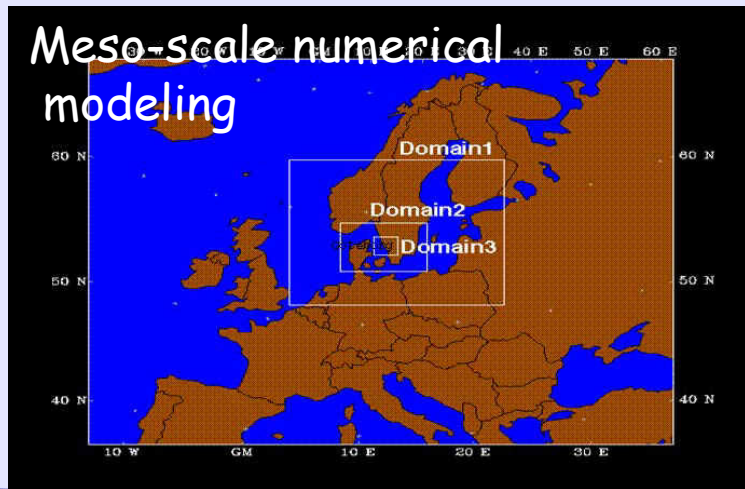
Expert workshop on statistical downscaling in Oslo, 3-4  
october 2005





## About the Regional Climate Group

Established 1995 by Prof. Deliang Chen, 4 PostDocs, 6 PhD-students



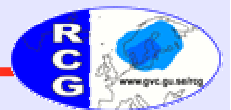
# Projects related to this study

**Extreme rainfall events in Sweden and their importance for local planning**, supported by Swedish Rescue Services Agency (SRSA) (2005-2007)

- past frequency and extend of extreme precipitation events in Sweden
- development of tools to estimate possible future changes

**European and North Atlantic daily to MULTidecadal climATE variability (EMULATE)**, Coordinated by Prof. Phil Jones and supported by EUs FP5 (2002-2005)

- extend daily air pressure records over the N Atlantic and Europe 1850-present
- relate atmospheric circulation patterns to the surface climate across Europe
- comparisons with model simulations
- future occurrence of extreme weather in Europe



# RCG's downscaling activities – Selected studies

Predictant	Predictor	Region	Method	Reference
Monthly temp	NAO-index	Sweden	Linear regression	Chen and Hellström, 1999
Winter temp	Atmospheric circulation	Sweden	weather typing, linear regression	Chen, 2000
Winter temp	Upper air circulation	China	Canonical correlation	Chen and Chen, 2003
Seasonal/Monthly prec	Atmospheric circulation	Sweden	Canonical correlation	Busuioc et al. 2001a) Busuioc et al. 2001b)
Monthly prec	Atm. circulation large-scale humidity	Sweden	Weather typing, Mult. linear regression	Hellström et al. 2001
Monthly prec	Atm. circulation large-scale humidity	Sweden	Weather typing using dyn. downscaled predictors, Mult. linear regression	Hellström and Chen, 2003
Monthly prec	Atm. circulation, large-scale prec.	Southern Sweden	Weather typing, Mult. linear regression	Linderson et al. 2004
Monthly prec	Atm. circulation,, large-scale prec.	Sweden	Weather typing, Mult. linear regression	Chen et al., 2005
Maximum ice extend	Atm. circulation	Baltic Sea	Weather typing, Mult. linear regression	Omstedt and Chen, 2001 Chen and Li, 2004
Aquatic ecosystem	Atmospheric circulation	Sweden	NAO-index, Weather typing, Mult. linear regression	Bleckner and Chen, 2003



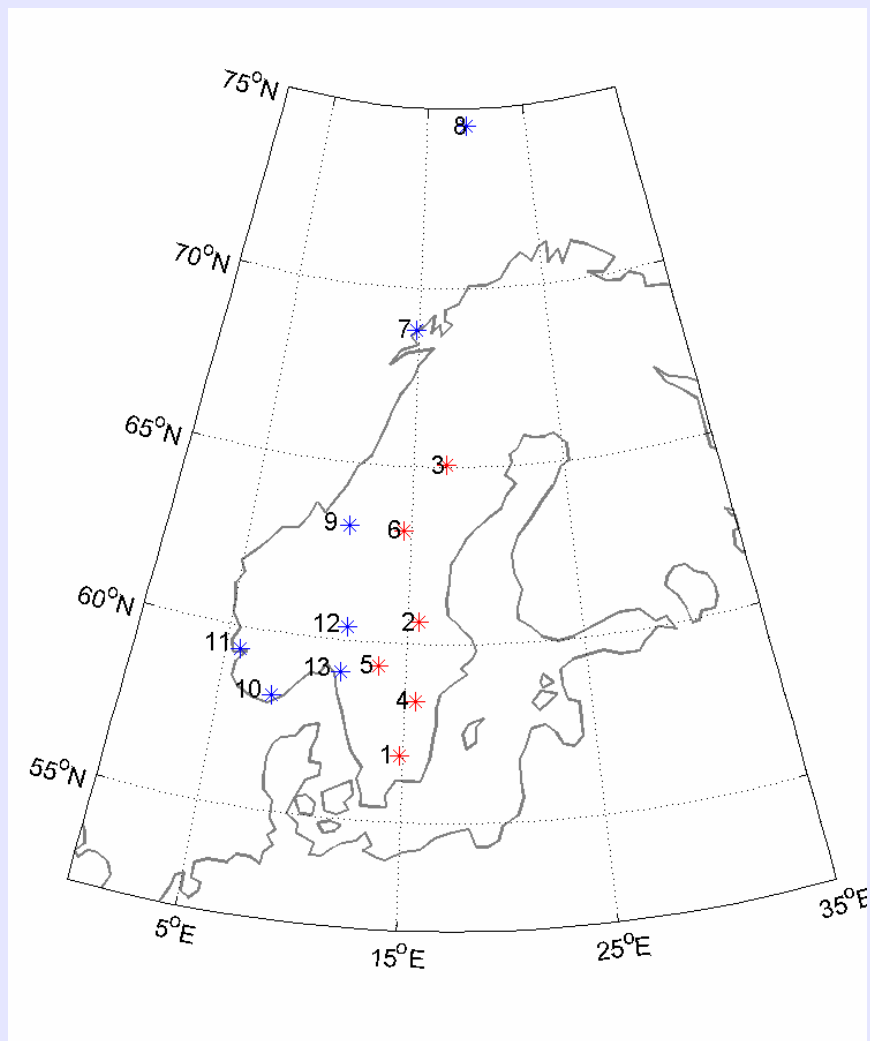
## Aim of this study

- derive parameters needed to develop a weather generator for daily precipitation in Sweden and Norway
- study and quantify the relation of these parameters to the large-scale atmospheric circulation over the region



# Data sets

## 1) Daily precipitation from ECA (European Climate Assessment)



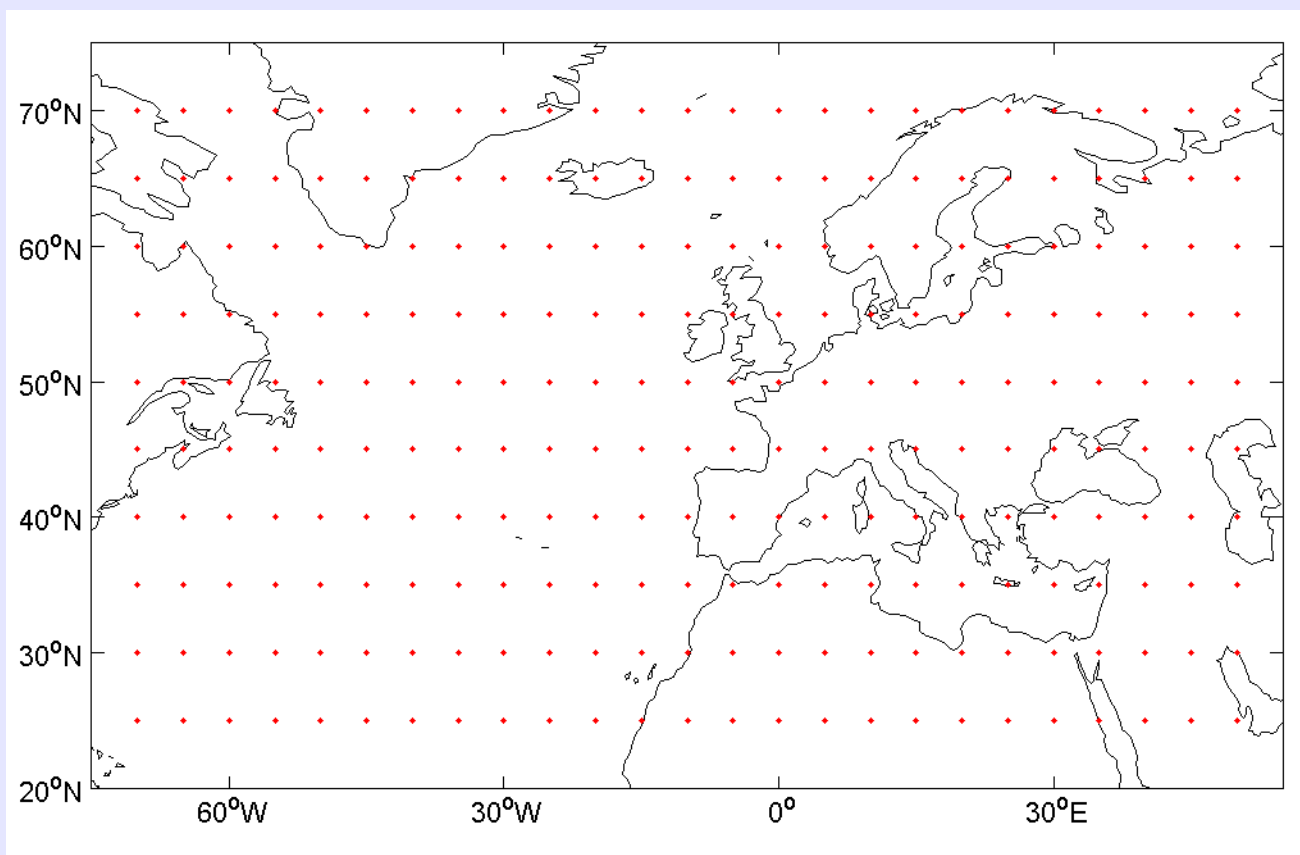
1 Växjö	1918-2004
2 Falun	1918-2004
3 Stensele	1918-2004
4 Linköping	1931-2004
5 Karlstad	1918-2004
6 Östersund	1918-2004

7 Barkestad	1900-2004
8 Bjørnøya	1921-2004
9 Lien i Selbu	1900-2004
10 Mestad	1900-2004
11 Nestrand	1957-2004
12 Nord i Odal	1900-2004
13 Halden	1901-2004





## 2) Daily air pressure grid from EMULATE



5°lat x 5°lon, 1850-2003



# Approach

## 1) Weather generator (WG)

Most weather generators treat precipitation *occurrence* and *intensity* separately.

Fully defined by two conditional probabilities:

$$p_{01} = \Pr\{\text{prec day } t \mid \text{no prec day } t-1\}$$

$$p_{11} = \Pr\{\text{prec day } t \mid \text{prec day } t-1\}$$

*Transition probabilities* are derived from station precipitation.

Precipitation amount on a wet day may be derived from the probability density function of daily precipitation,

e.g., the Gamma-function with parameter  $\alpha$  and  $\beta$ .

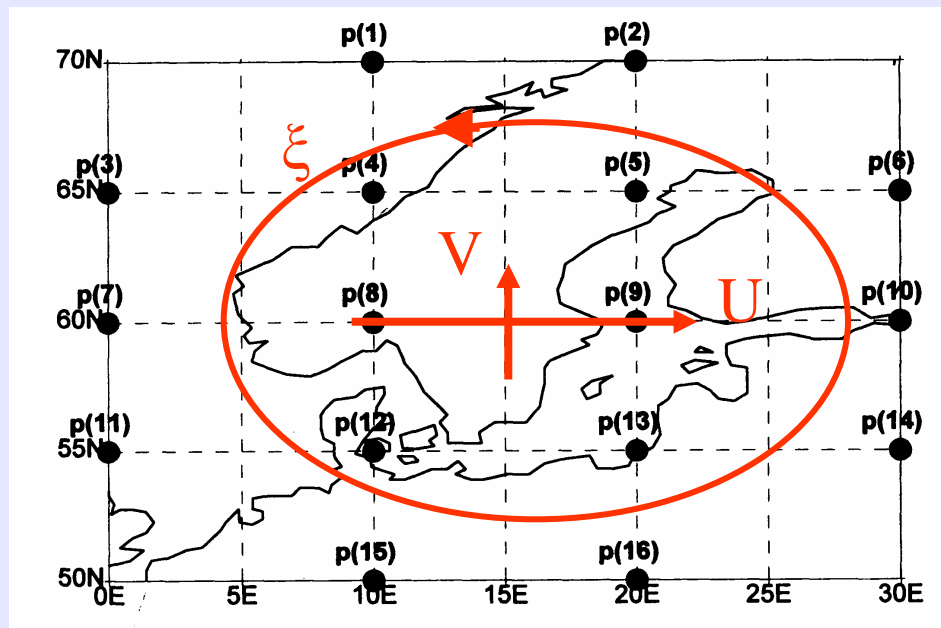
$\alpha$  and  $\beta$  are derived from station precipitation.





## 2) Quantification of atmospheric circulation

Objective classification based on the manual system by Lamb



(after Chen and Li, 2003)

6 circulation indices:

U: west-east geostr. wind  
V: north-south geostr. wind  
W: total geostr. wind  
 $\xi_u$ : westerly shear vorticity  
 $\xi_v$ : southerly shear vorticity  
 $\xi$ : total vorticity



26 weather types:

- 8 directional types  
(NW, W, SW, ..., N)
- 2 "rotational" types  
(A, C)
- 16 hybrid types  
(ANW, AW, ASW, ..., AN  
CNW, CW, CSW, ..., CN)



### 3) Linking WG-parameters and precipitation statistics to atmospheric circulation

So far:

correlation of gamma parameters, number of rain days and mean precipitation at the Swedish and Norwegian station with:

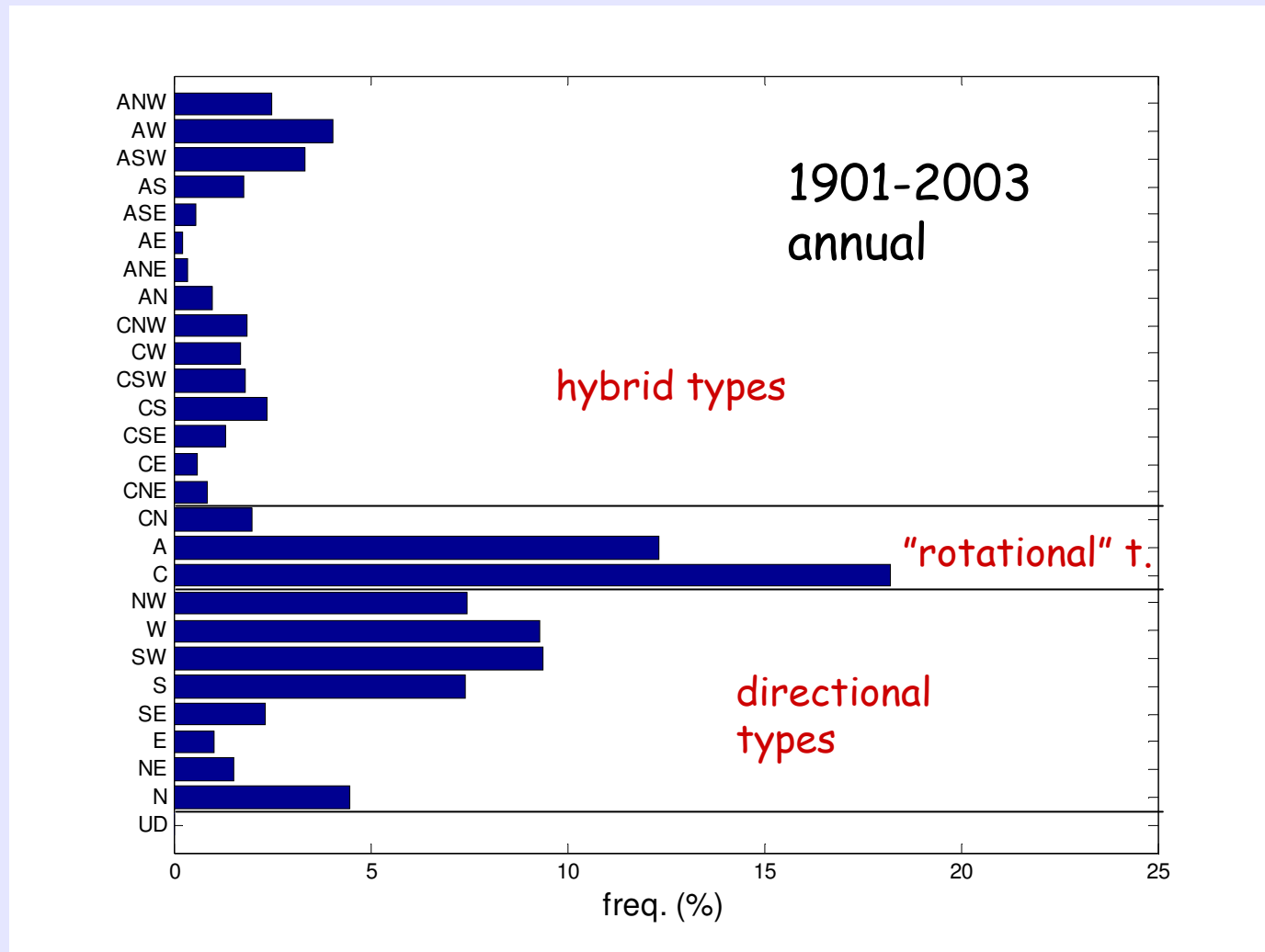
- frequency of all weather types

Divide total period (1900-2004) into four sub-periods:

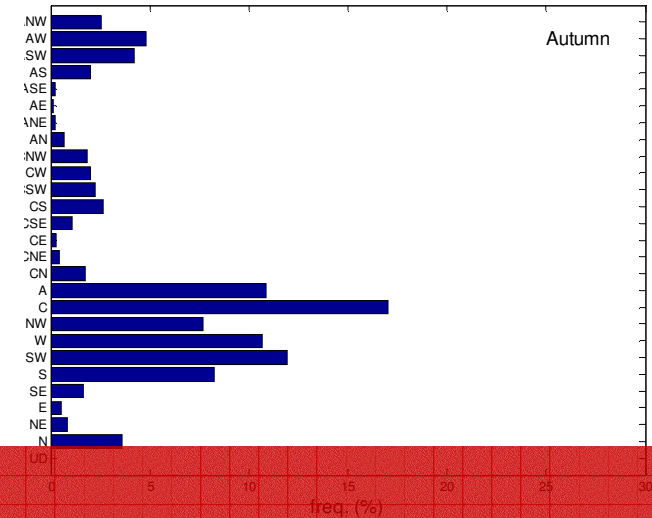
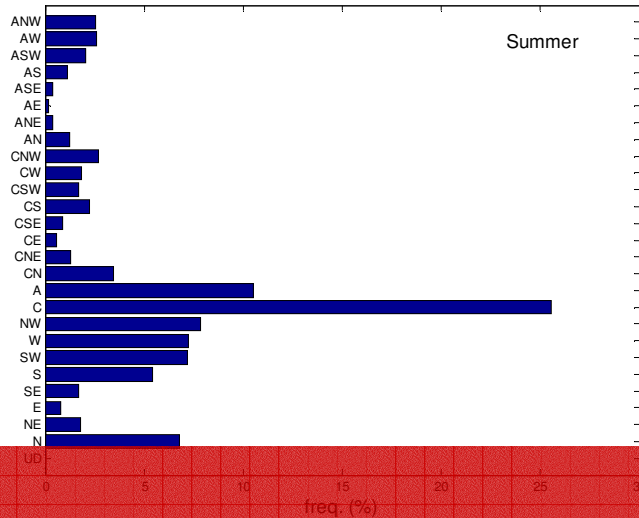
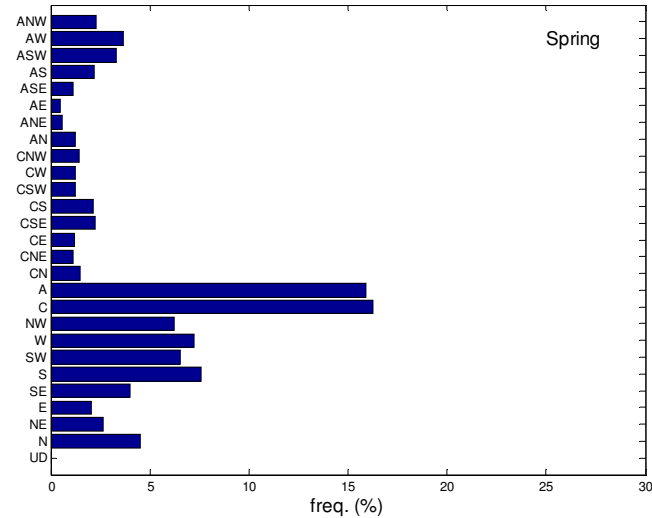
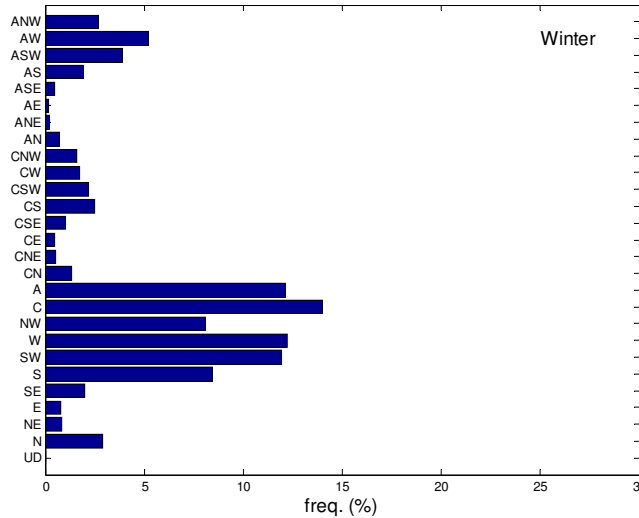
- 1901-1930, 1931-1960, 1961-1990, 1991-2003
- calculate precipitation and circulation statistics separately for each month and sub-period
- correlation separately for each season



# Applying the Lamb weather types to the EMULATE pressure data



# 1901-2003 seasonal frequencies



Frequency of weather types changes with season



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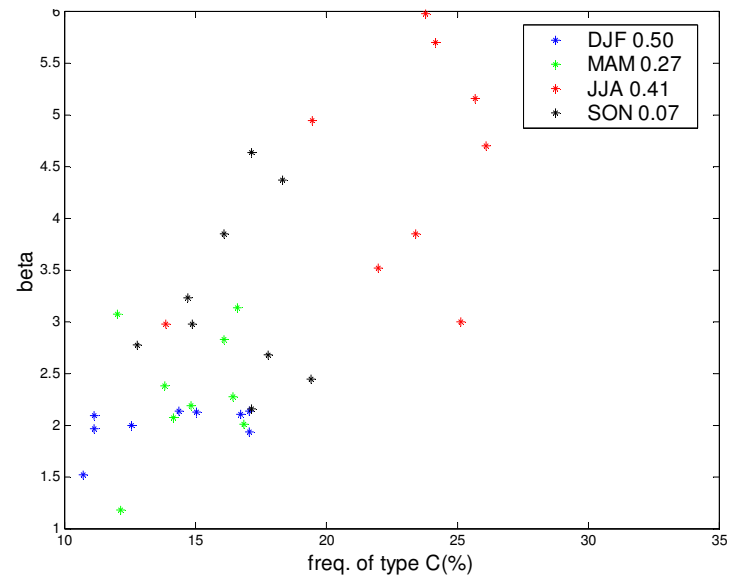
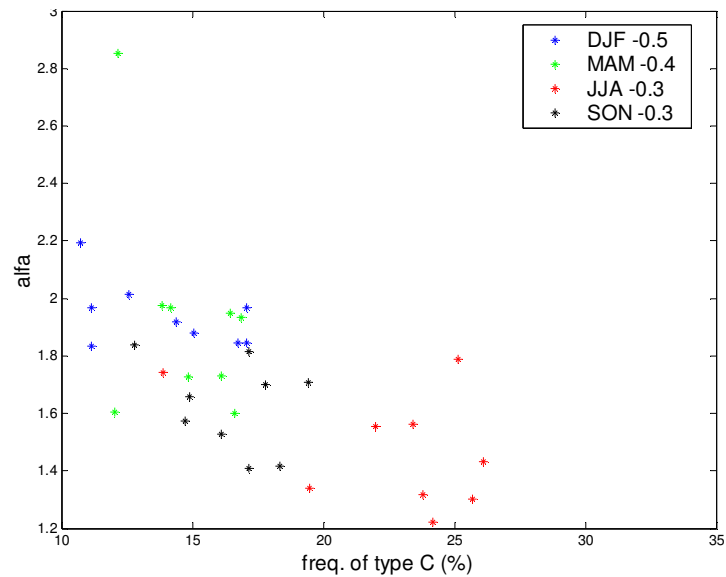
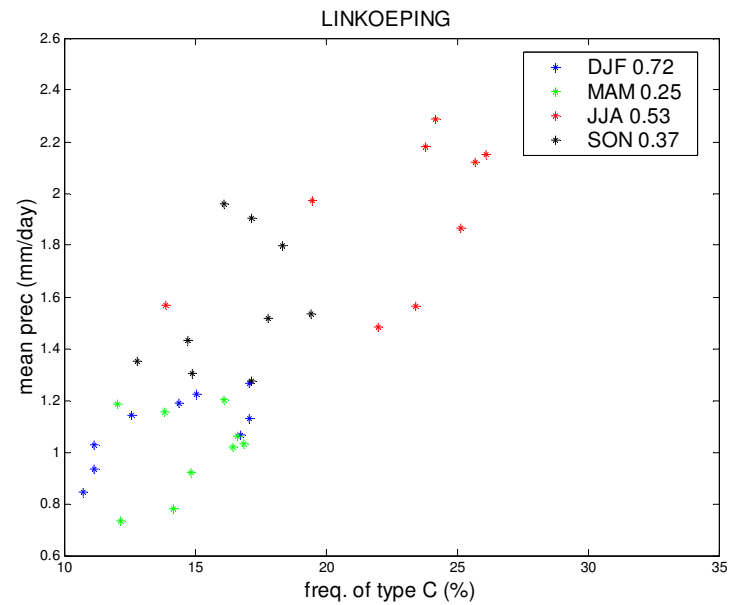
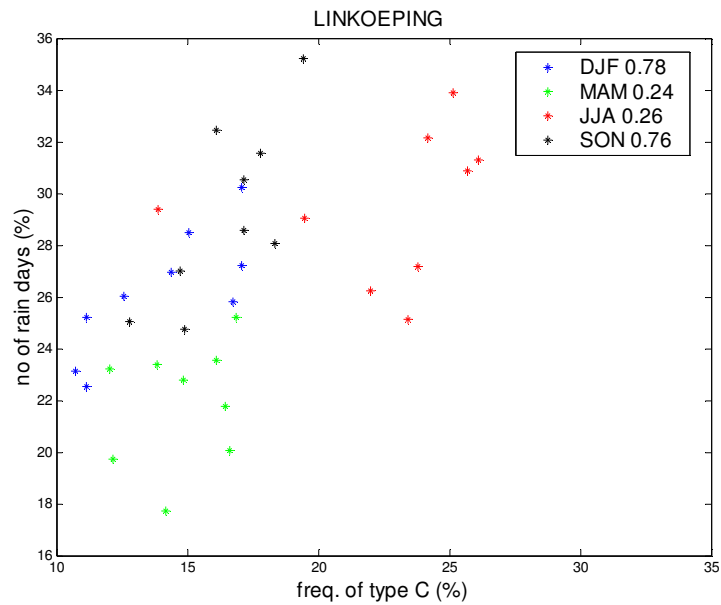
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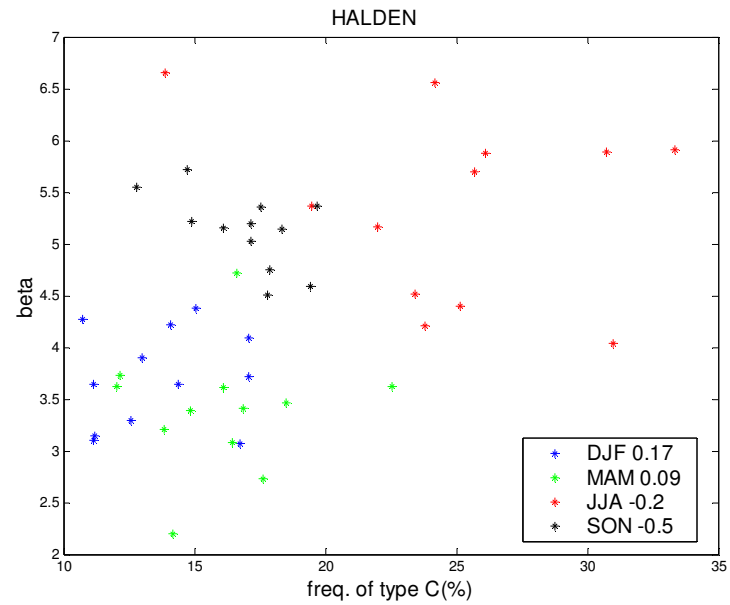
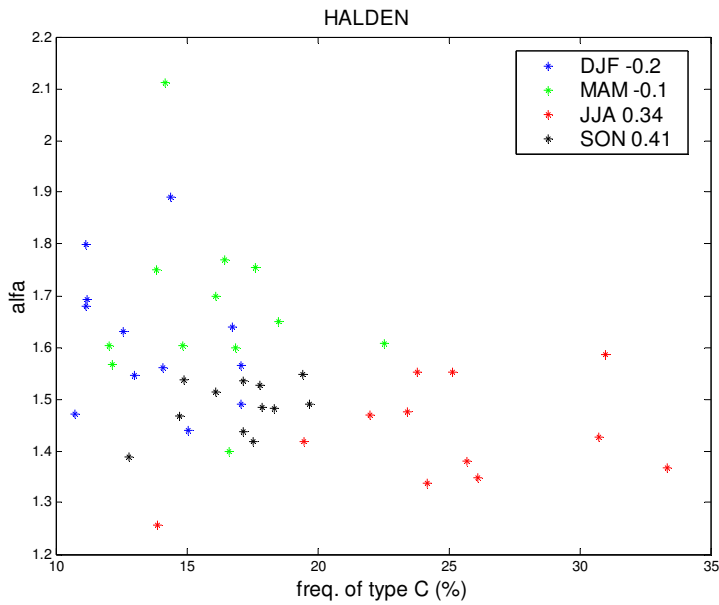
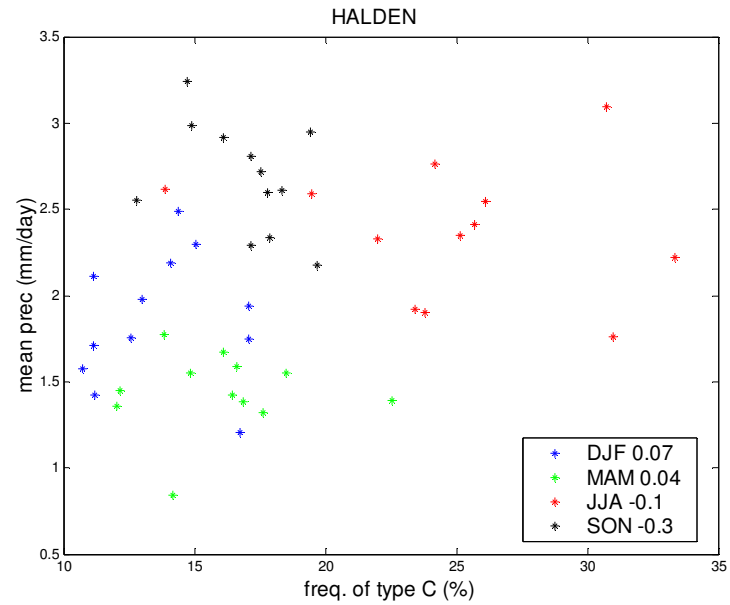
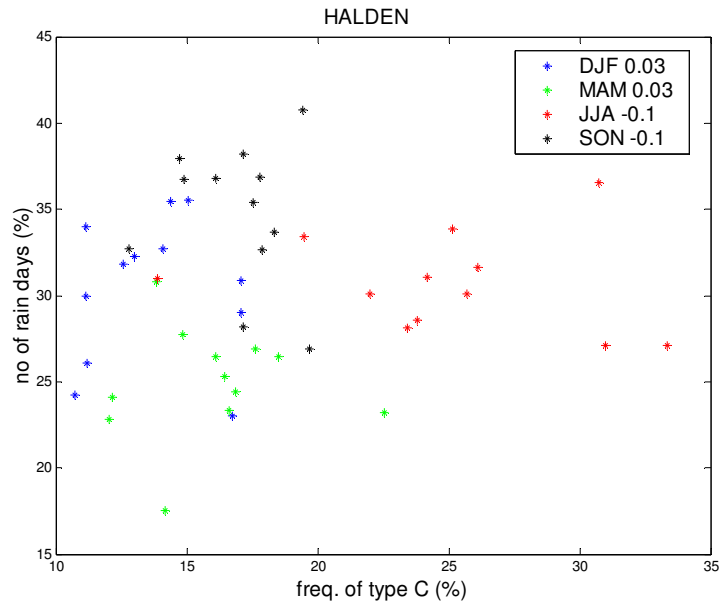
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# Some first results (1)

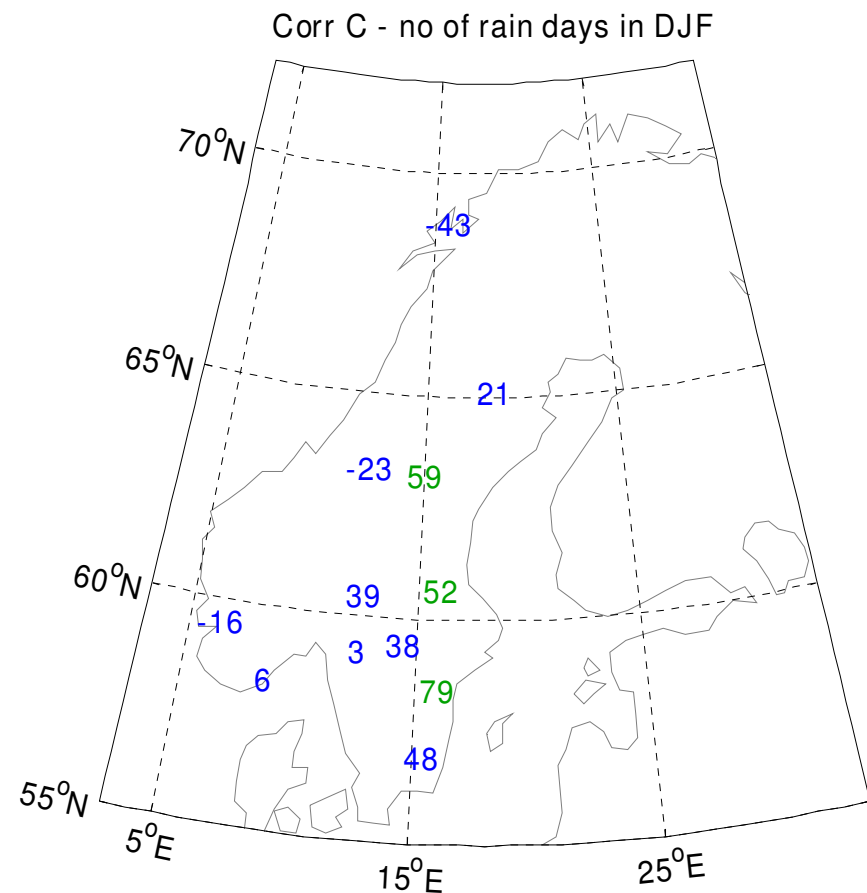
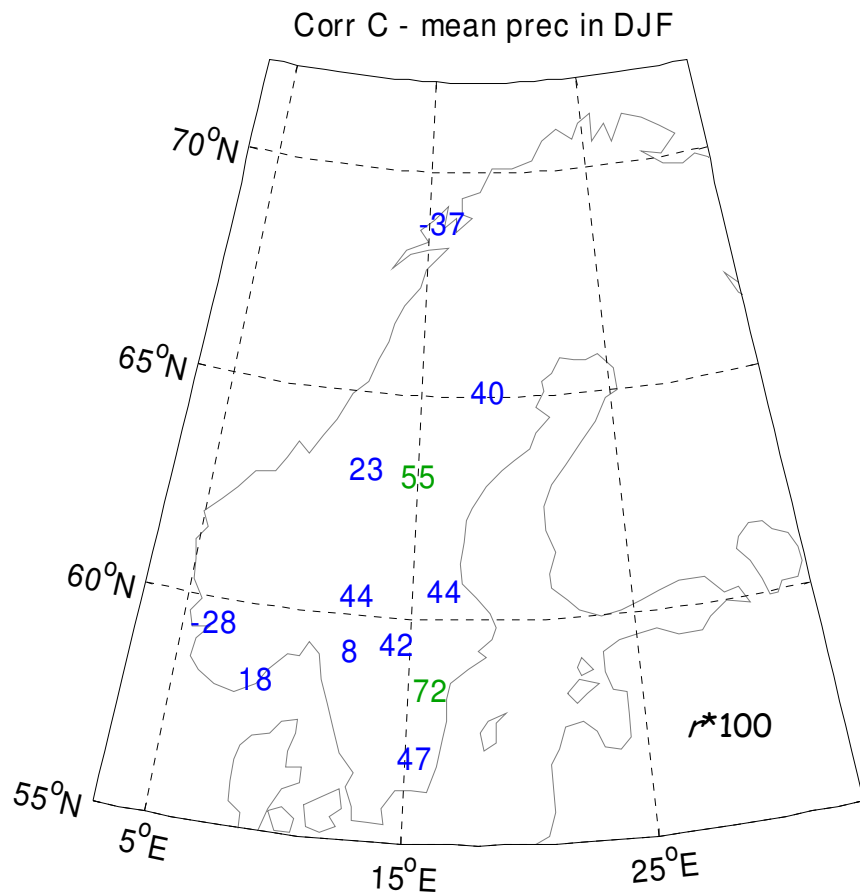


# Some first results (2)



# Spatial variability of correlation (1)

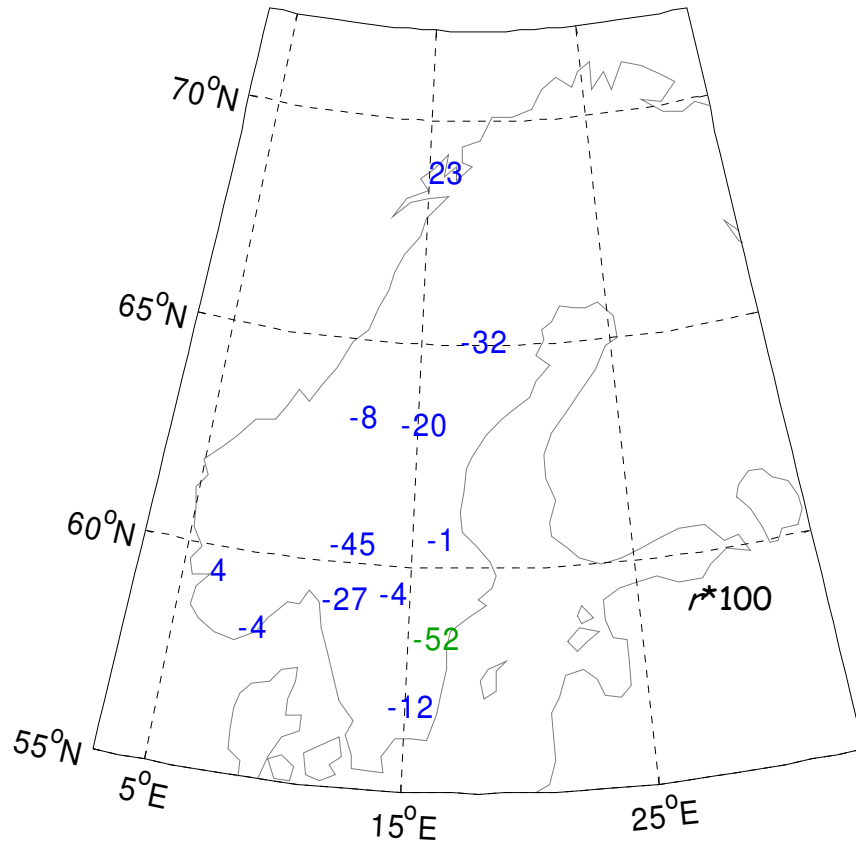
Frequency of  $C$  correlated with mean precipitation and no of rain days





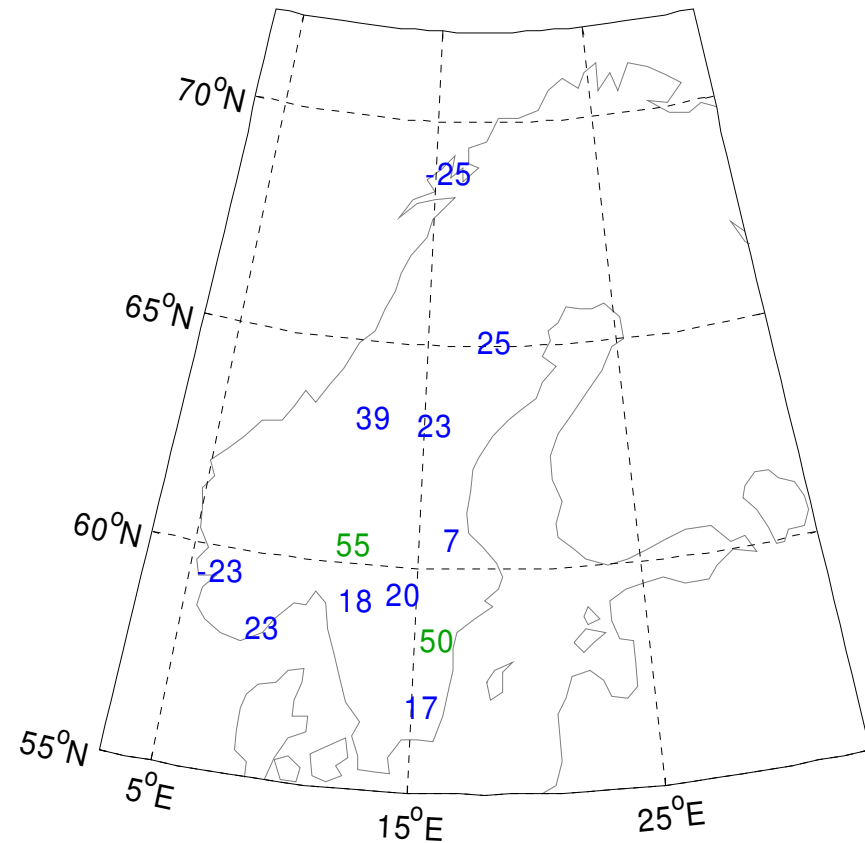
# Spatial distribution ... (2)

Corr C - alpha in DJF



Frequency of C correlated with alpha and beta.

Corr C - beta in DJF

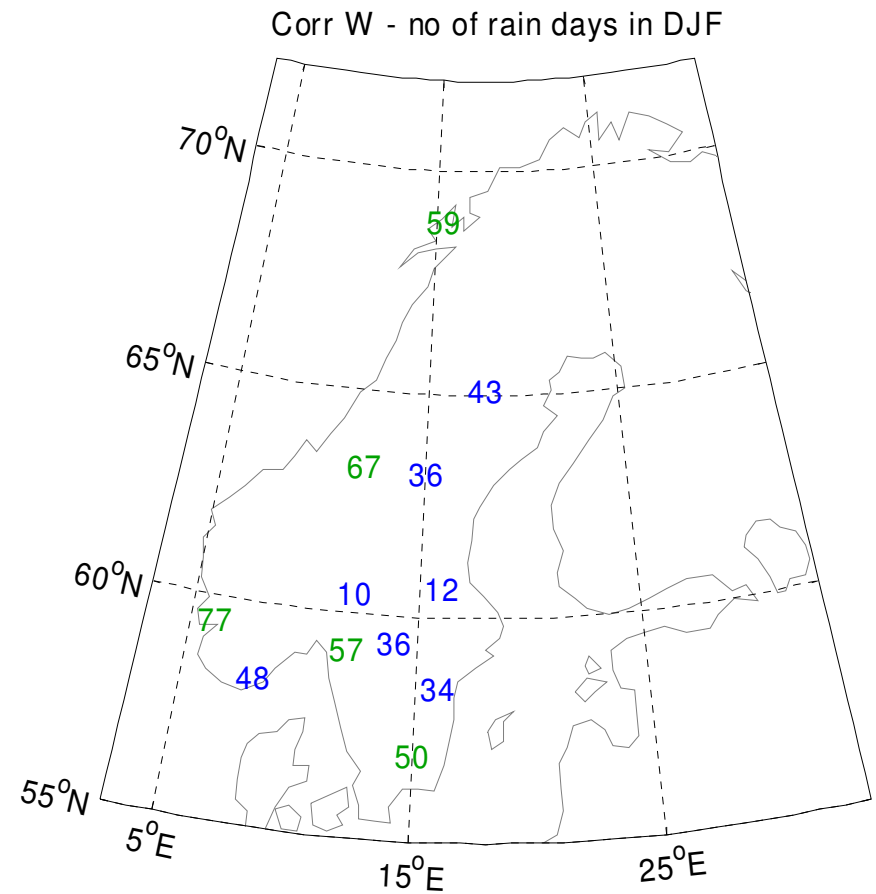
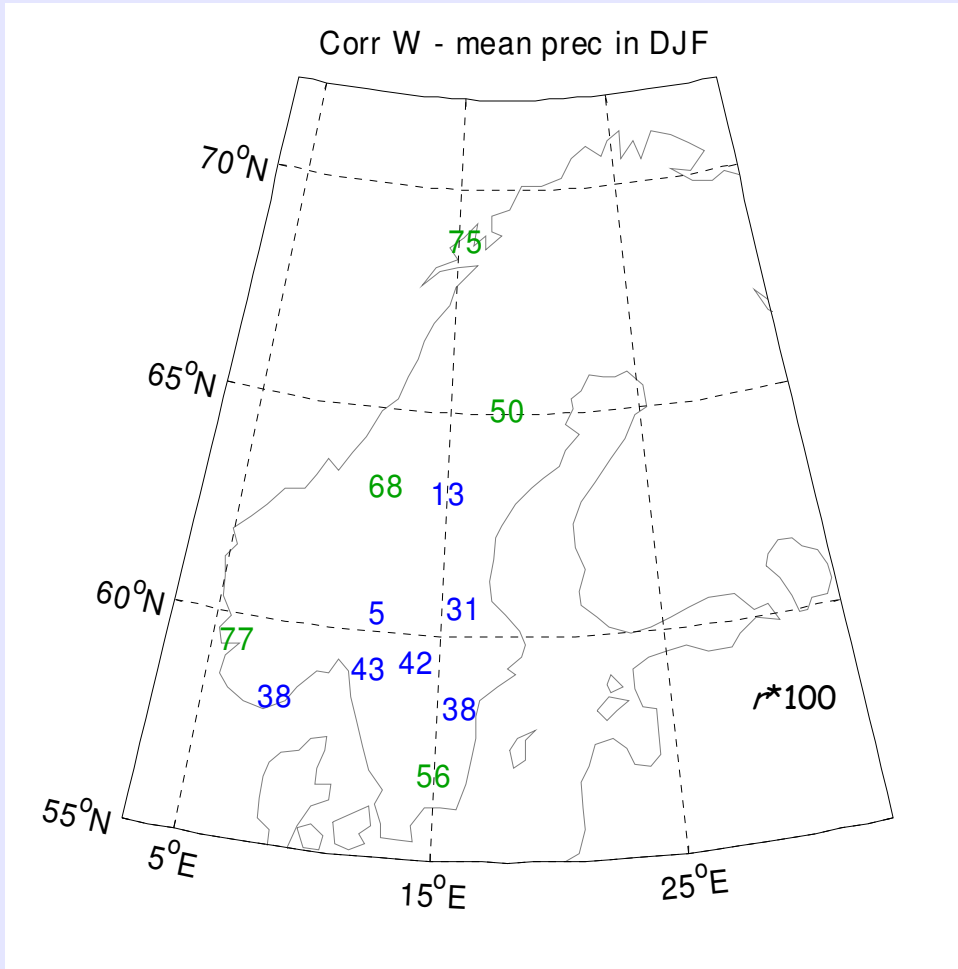


Correlation varies with site and parameter.



# Spatial distribution ... (3)

Frequency of W correlated with mean precipitation and no of rain days



High correlation in western Norway.



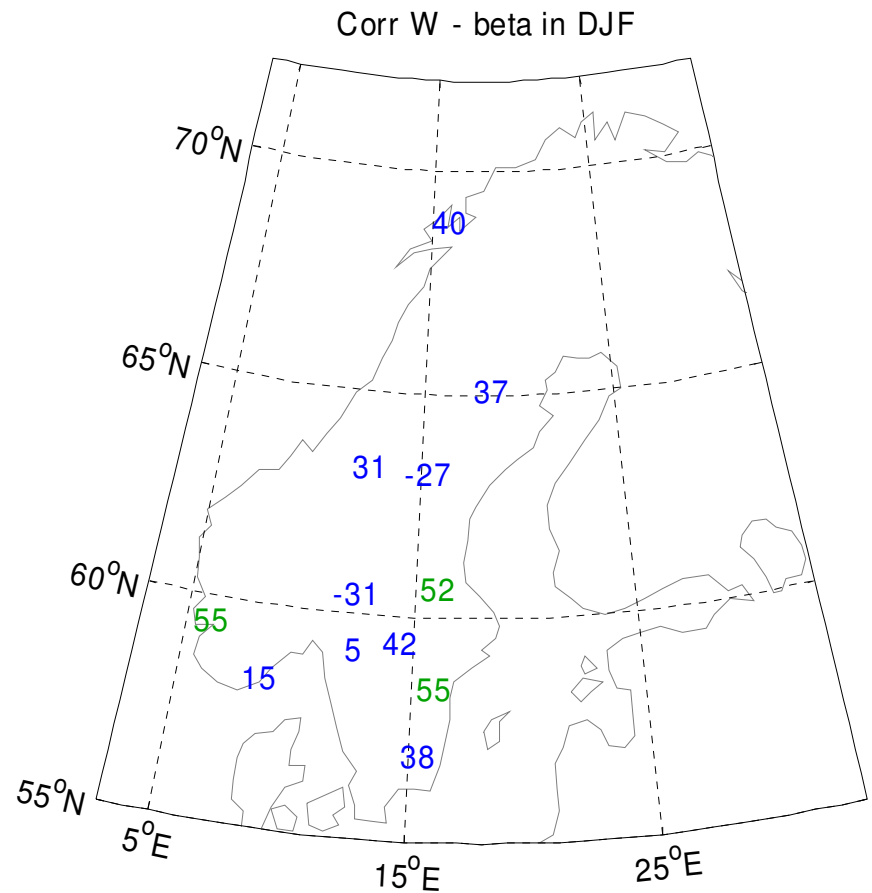
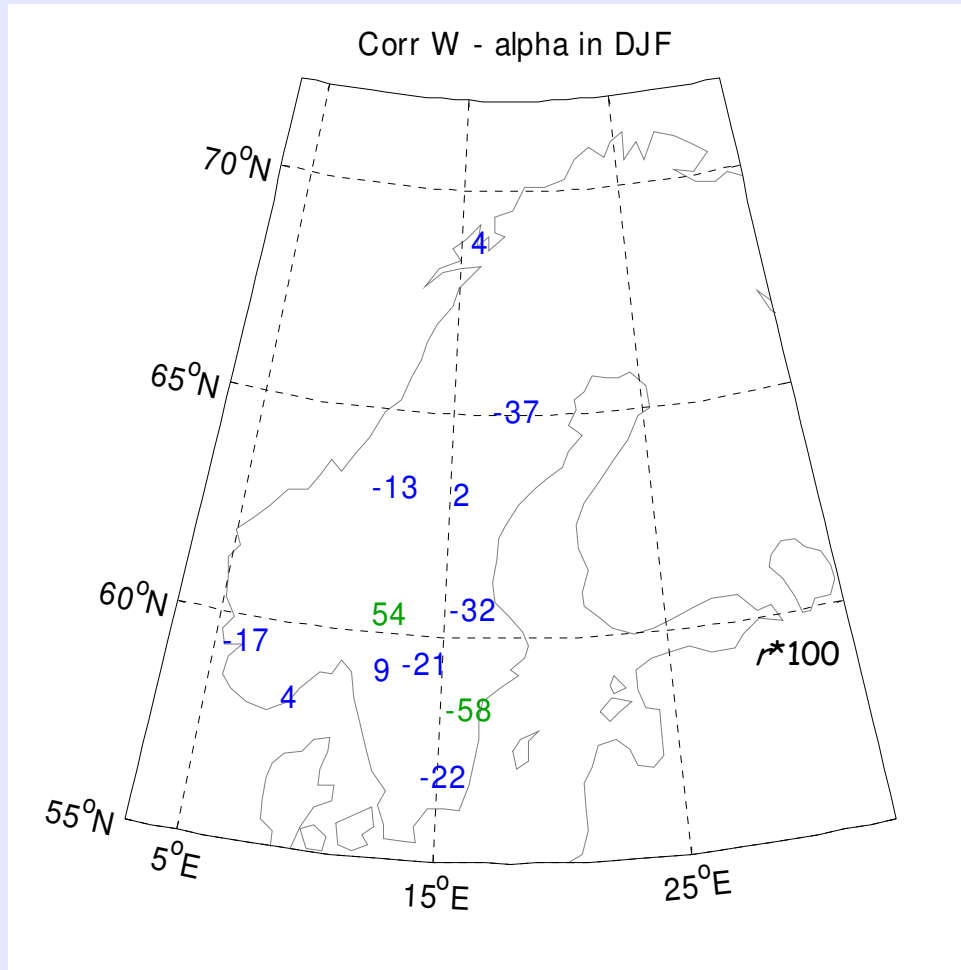
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# Spatial distribution ... (4)



**$\alpha$  and  $\beta$  tends to be less well correlated.**



# First conclusions

Correlation analysis shows that there exists relationships between daily precipitation statistics and the frequency of daily weather types.

... but strength of correlation varies very much depending on precipitation statistics, geographical location, predictor and season!



## Further steps

- relation transition probabilities to atmospheric circulation
- repeat correlation analysis with circulation indices instead of weather types
- try stepwise regression including more than one variable as predictor
- include other predictor variables in correlation analysis like temperature, precipitation or humidity

## In addition

- test other distribution functions than gamma distribution
- sensitivity of relationship to domain of weather types/index
- ...

