Eurasian snow in (long-term) climate reanalyses

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Question

Why bother looking at “inferior” reanalyses products?

Motivation

1. To know how much complexity we need to get to a reasonable result
2. To assess how valuable their information is for decadal and centennial studies
3. To investigate peculiar climate features which are beyond the range of other products

Question

Why bother looking at snow over northern Eurasia?

Motivation

1. Generally, snow is an important component of the climate system
2. Northern Eurasia is a key player in the "warm Arctic – cold continent" theory
3. Important dynamic links were found between sea ice reduction and Siberian snow fall /depth increase
4. Eurasian snow depth is important for the evolution of late winter / spring NH pressure patterns

How to validate

Validation of complex variables such as snow depth is challenging, especially beyond 1950

Typical challenges:
- length of timeseries
- missing values
- homogeneity
- spatial distribution of observations
- independency
- station relocation / metadata

Menu

1. Comparison of 4 long term and 2 short term reanalyses with in-situ snow depth over Russia -> ca. 1900 - 2010, daily

2. Comparison of 1 long term and 4 short term reanalyses with in-situ snow depth and in-situ albedo over Russia -> 2000 - 2013, daily

3. Quick summary of major findings

CHAPTER 01

Long-term: Snow depth

Wegmann, Orsolini, Dutra, Bulygina, Sterin, Brönnimann 2017: Eurasian snow depth in long-term climate reanalysis. *Cryosphere*

Dataset overview

Reanalysis	Assimilated data	Assimilation type	Time covered
ERA-Interim	*surface, upper air, satellite*	*4D-var*	*1979-present*
ERA-Interim land	Nudged to ERAI atmosphere		1979-present
ERA20C	Surface pressure and marine winds	4D-var	1900-2010
ERA20C land	Nudged to ERAI20C atmosphere		1900-2010
20CRv2	Surface pressure	Ens. Kalman filter	1871-2012
20CRv2c	Surface pressure	Ens. Kalman filter	1851-2014

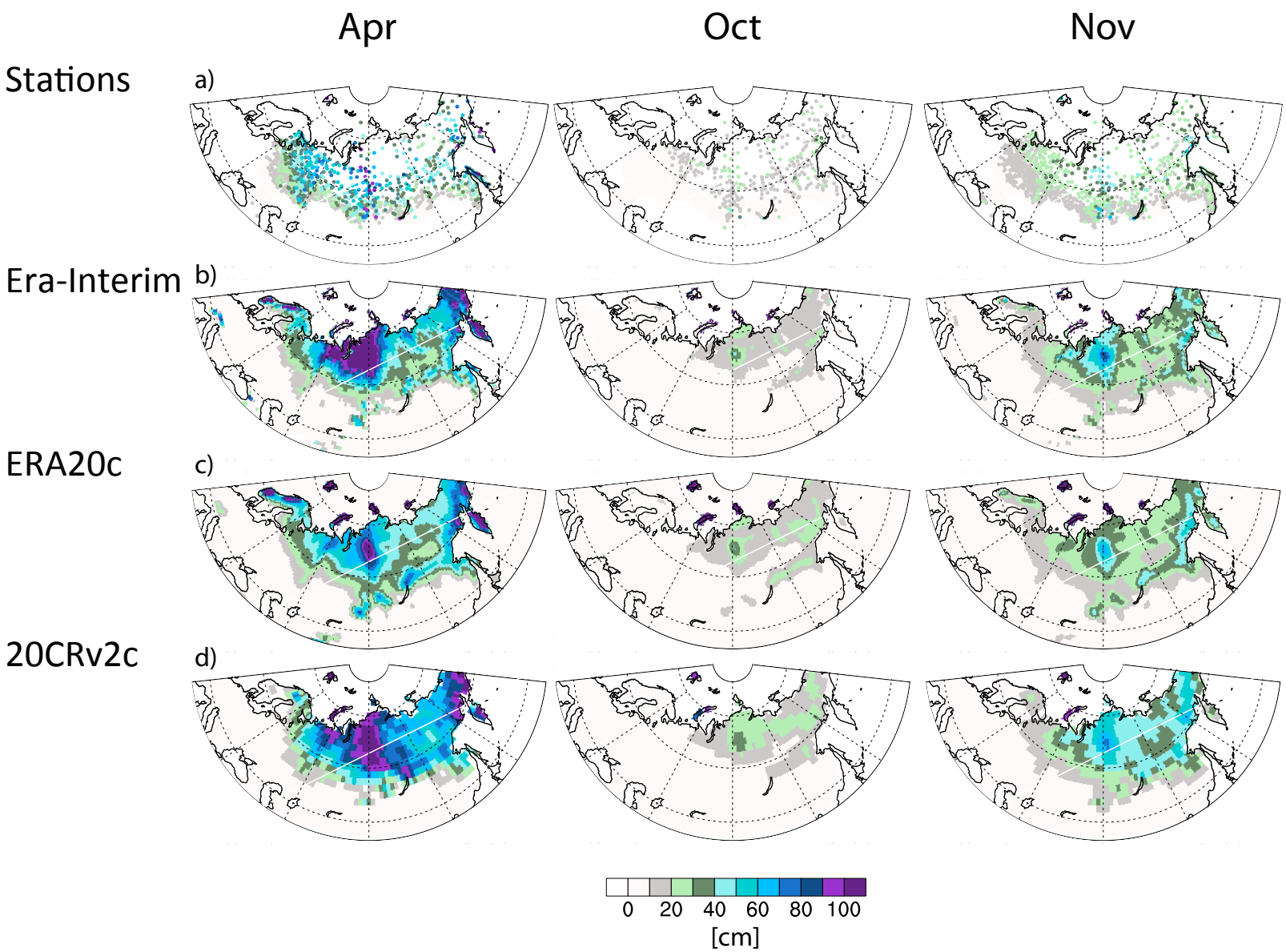
Dataset overview

1. Over 800 Russian meteorological stations with in-situ snow depth measurements (most complete ca. 1960 – 1990). 13 which cover (more or less) the 20th century. Daily resolution. Stake measurements

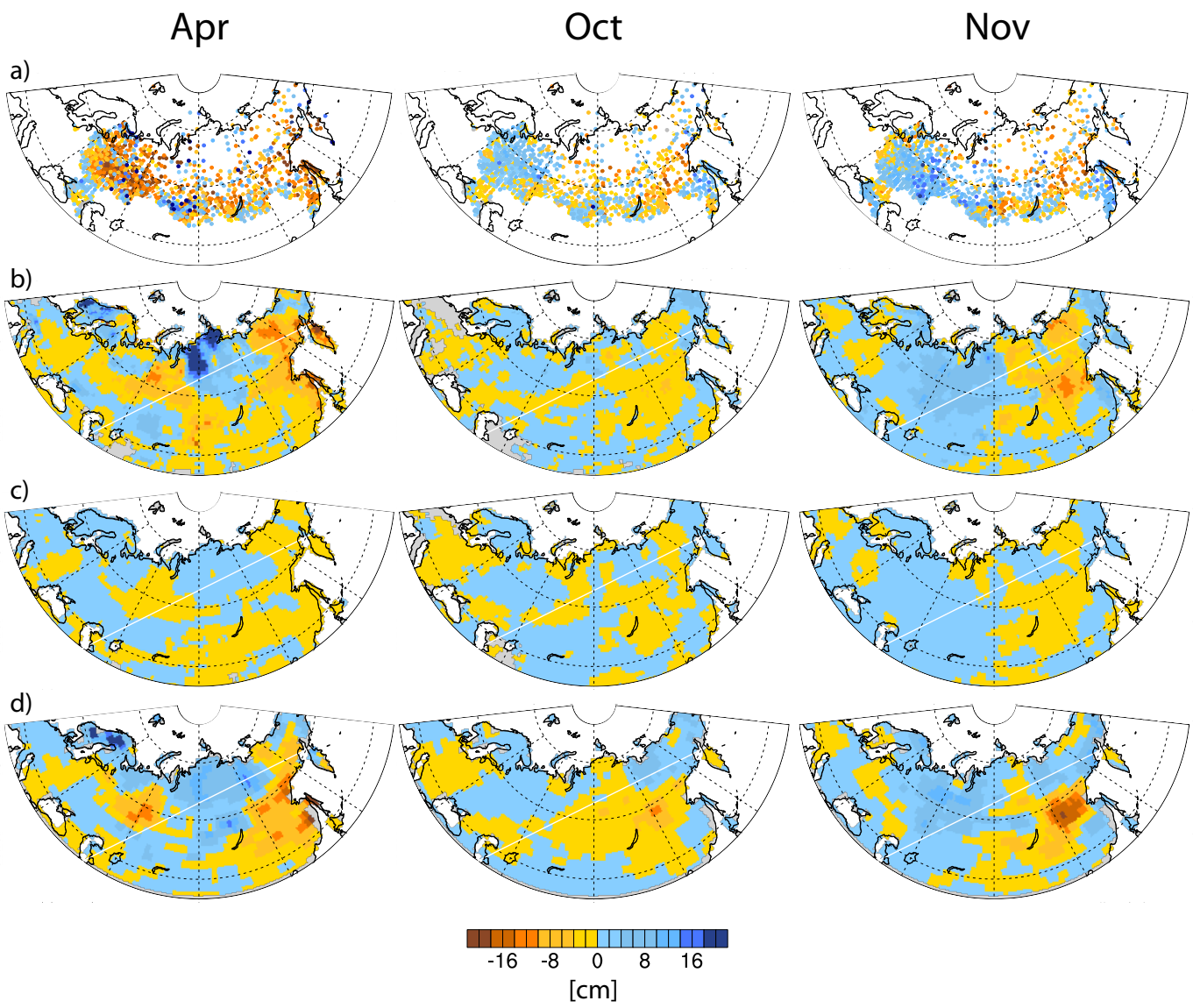
We decided to focus on autumn (ON, first snow fall) and spring (A, melt season) since both processes are probably most challenging for the reanalyses

Dataset overview

Climatology 1981 - 2010

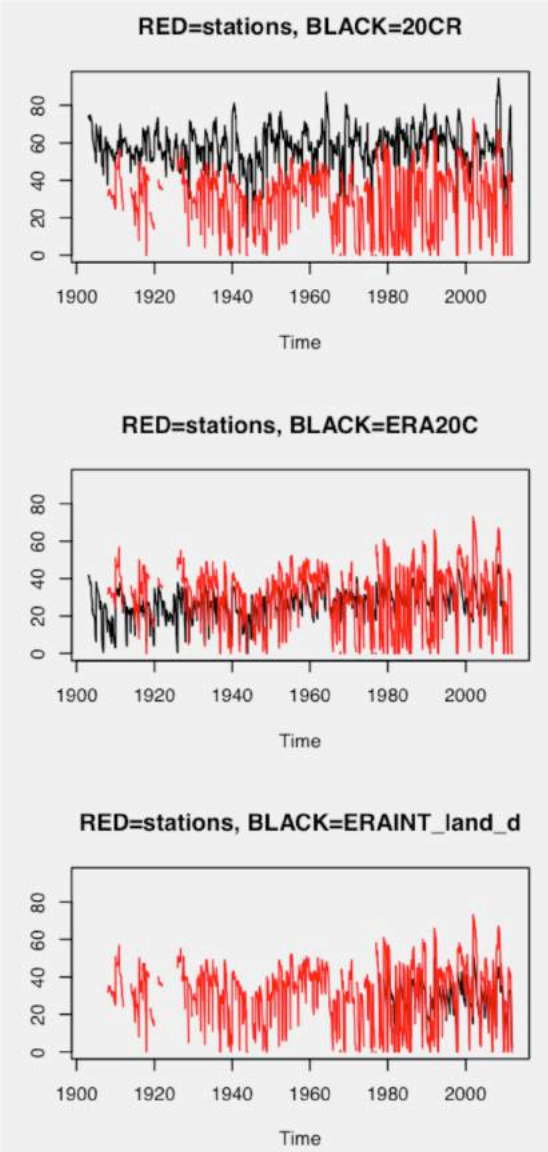


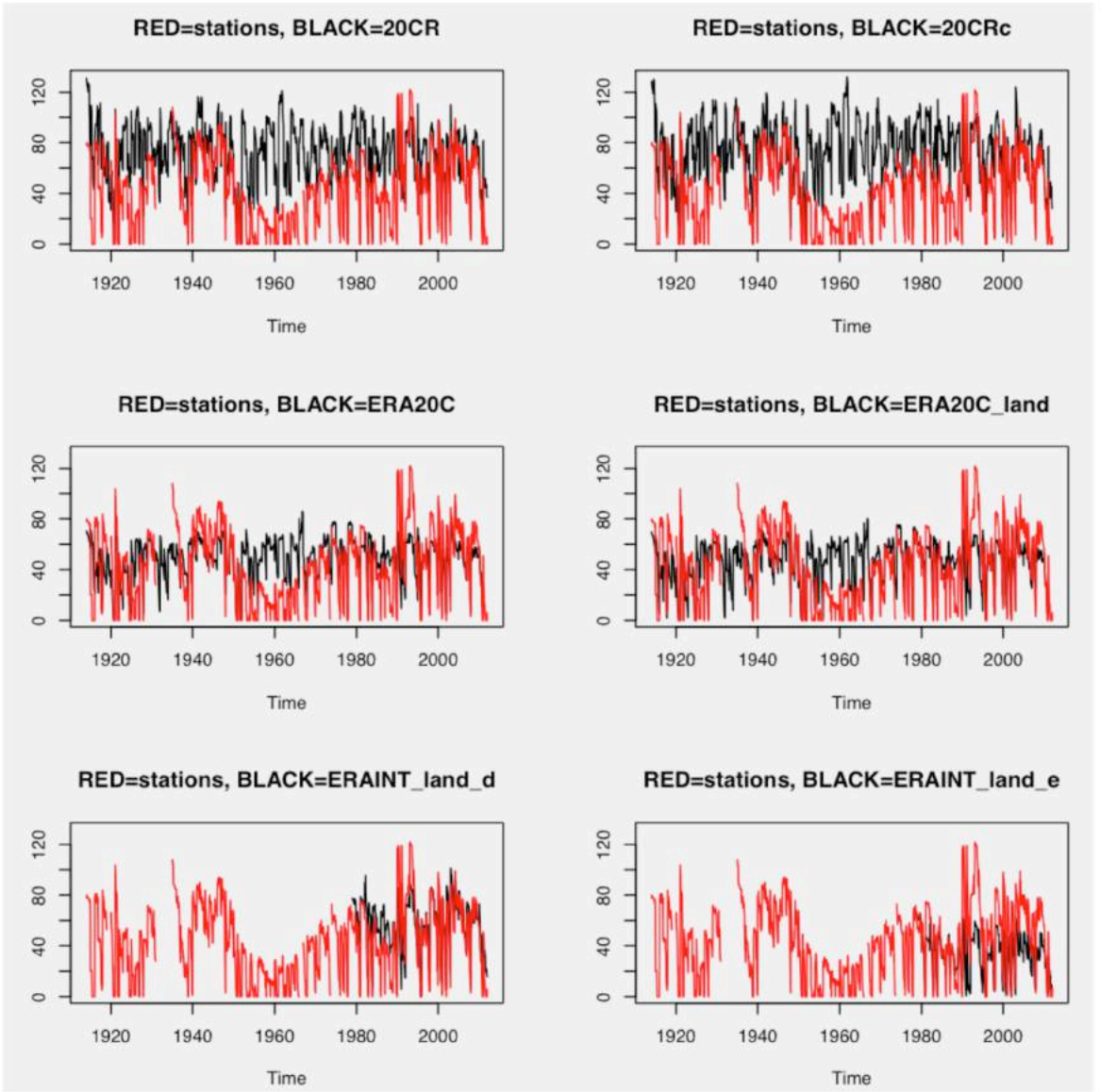
Anomalies 1996 – 2010 wrt 1981 - 1995



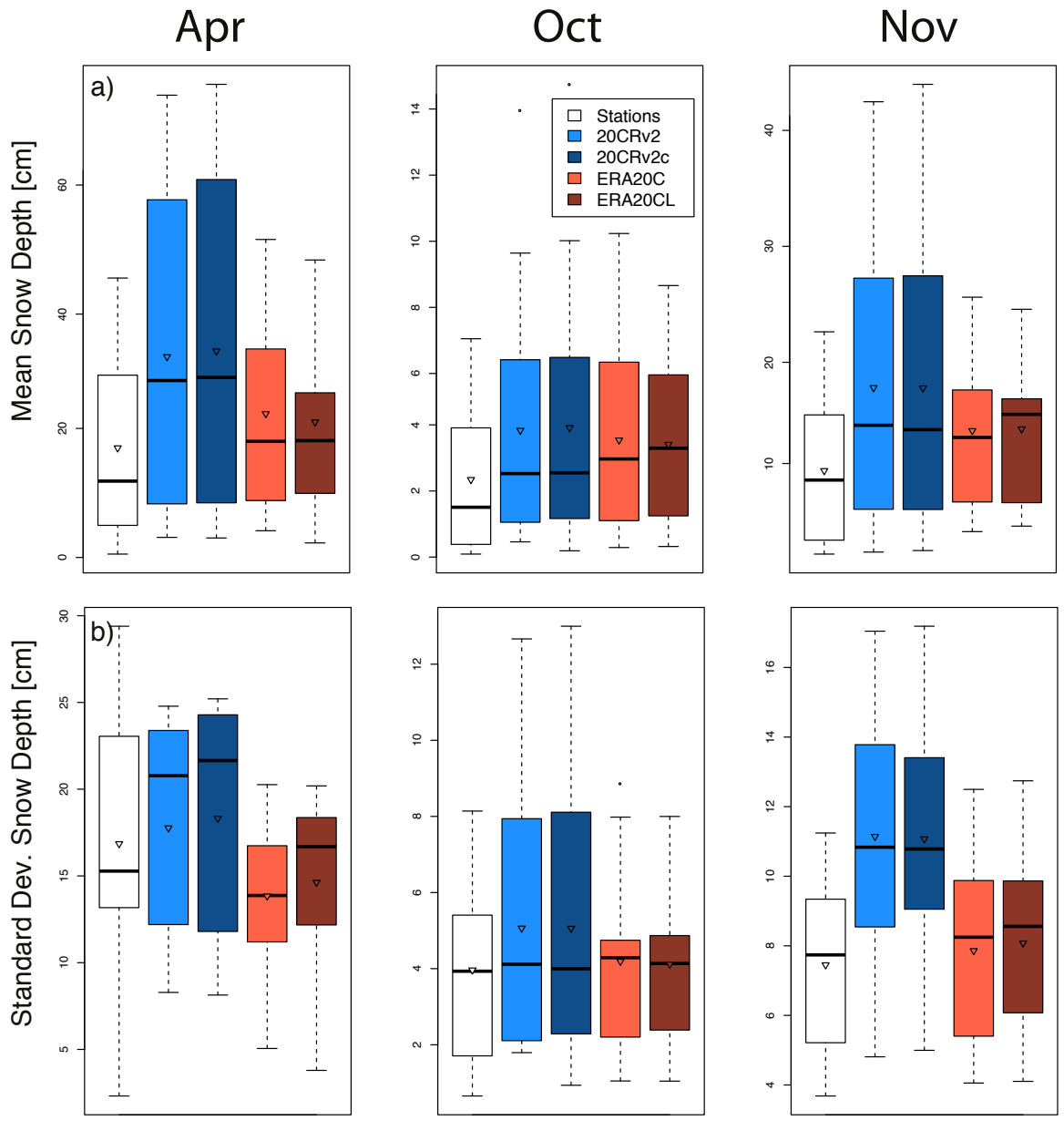
Dataset overview

Dataset overview

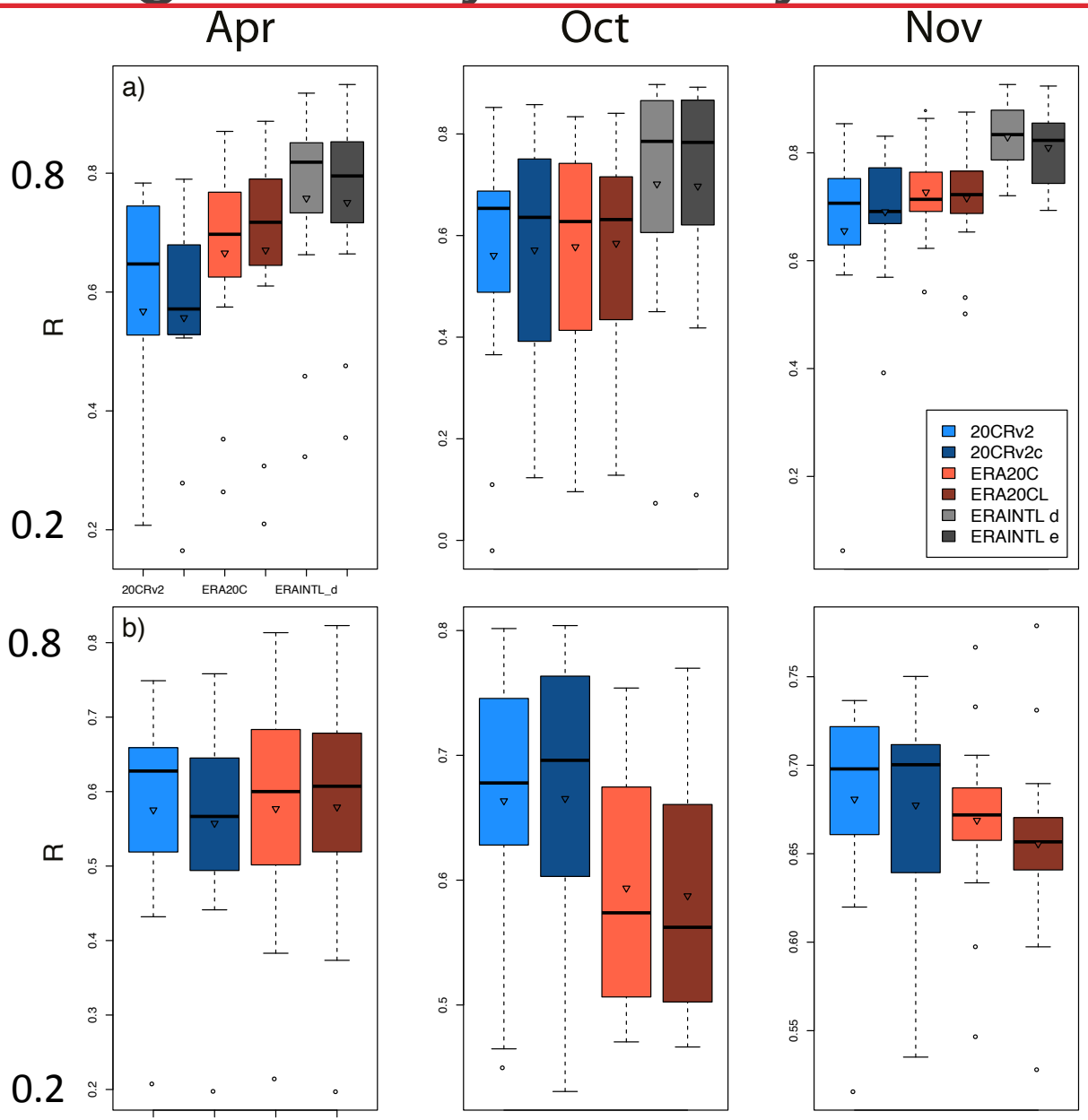




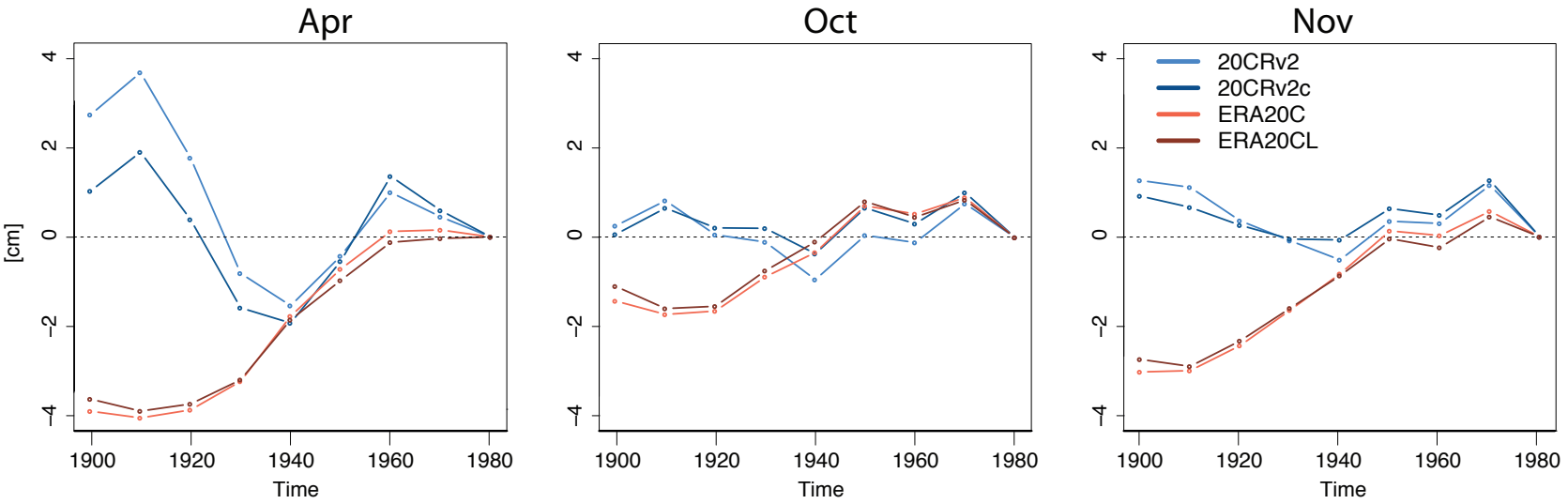
Nearest grid analysis, daily res.



Nearest grid analysis, daily res.

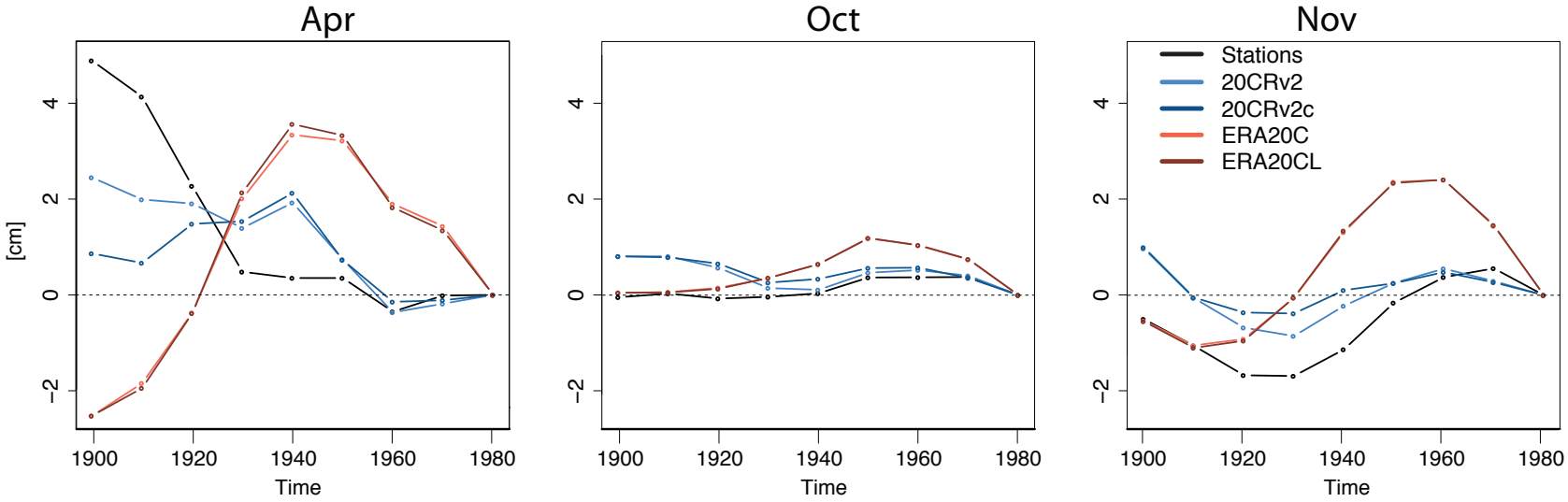


Centennial snow depth evolution



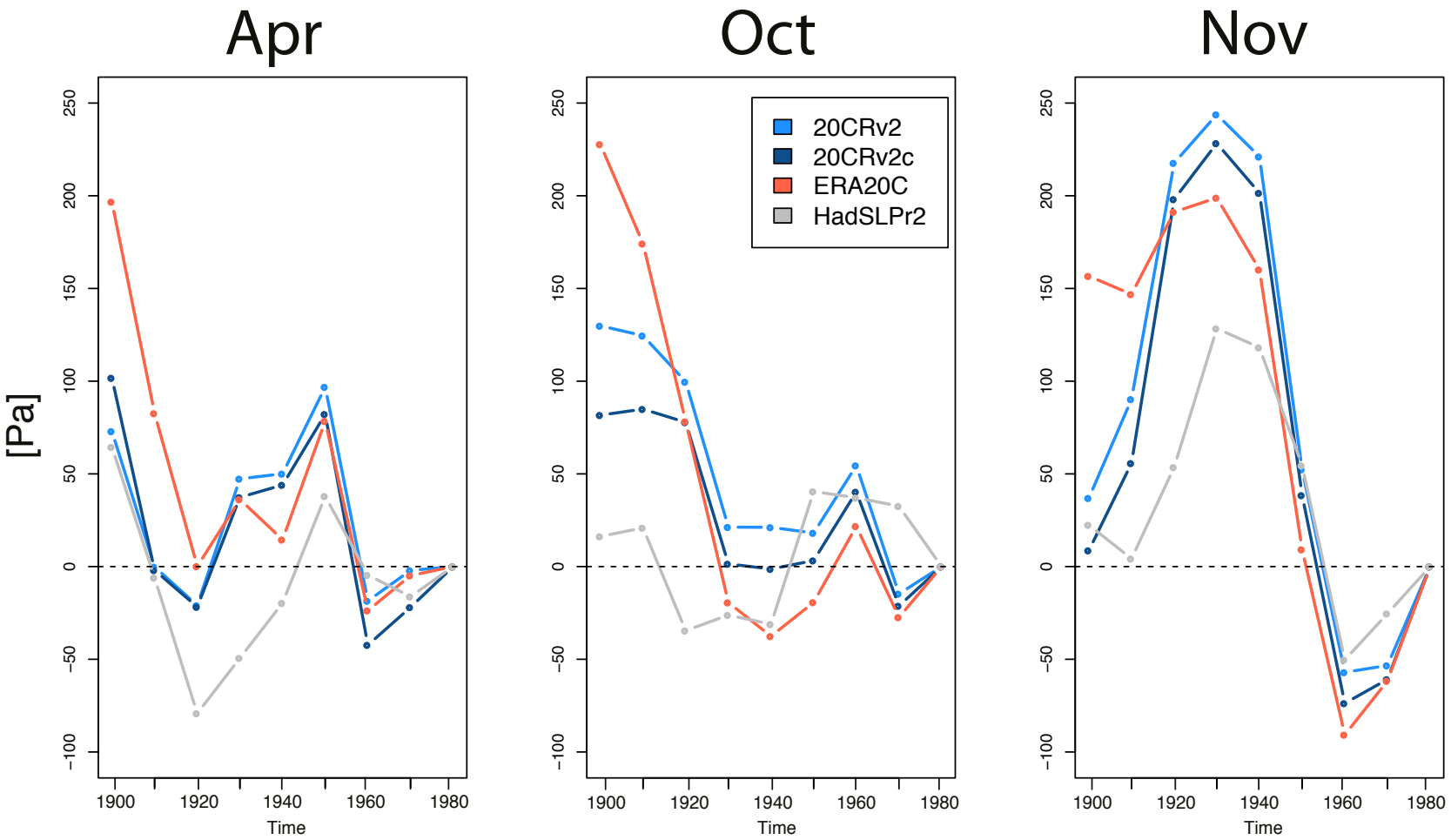
Field averaged snow depth over (50°-150° E, 60-75° N)
Each point is a 30 year climatology wrt 1981-2010

Centennial snow depth evolution



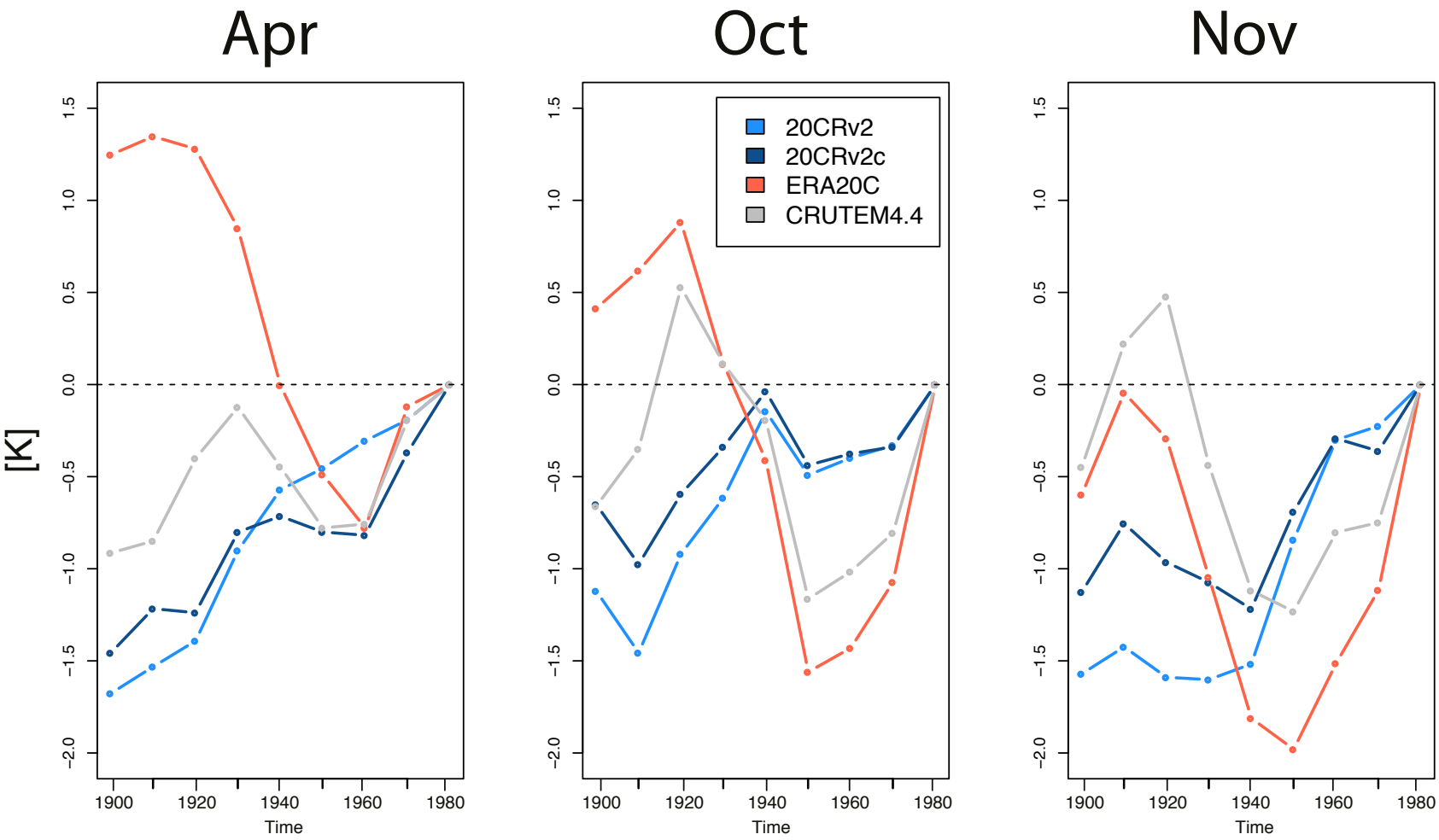
Field averaged snow depth over all station locations
Each point is a 30 year climatology wrt 1981-2010

Centennial snow depth evolution



Field averaged SLP over (50°-150° E, 60-75° N)
Each point is a 30 year climatology wrt 1981-2010

Centennial snow depth evolution



Field averaged t2m over (50°-150° E, 60-75° N)
Each point is a 30 year climatology wrt 1981-2010

CHAPTER 02

Short term: Snow depth and albedo

Dataset overview

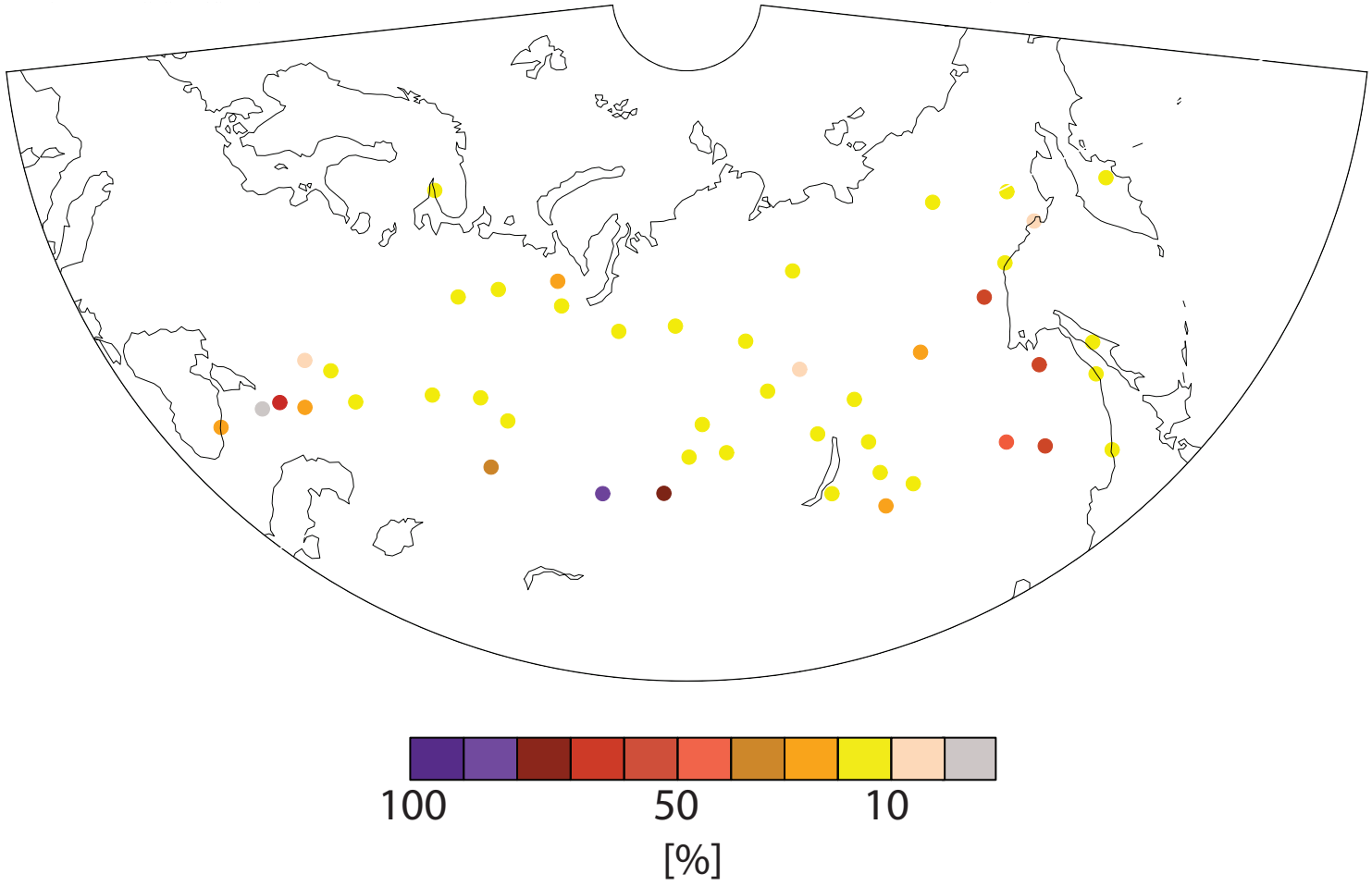
Reanalysis	Assimilated data	Assimilation type	Time covered
ERA-Interim	surface, upper air, satellite	4D-var	1979-present
JRA55	surface, upper air, satellite	4D-var	1955-present
MERRA	surface, upper air, satellite	3D-var + IAU	1979-present
MERRA2	surface, upper air, satellite	3D-var + IAU	1979-present
20CRv2c	Surface pressure	Ens. Kalman filter	1851-2014

Dataset overview

1. Over 800 Russian meteorological stations with in-situ snow depth measurements. 13 which cover (more or less) the 20th century. Daily resolution. Stake measurements
2. 65 Russian meteorological stations with in-situ radiation measurements for 2000-2013. Daily resolution.
3. 47 combined stations

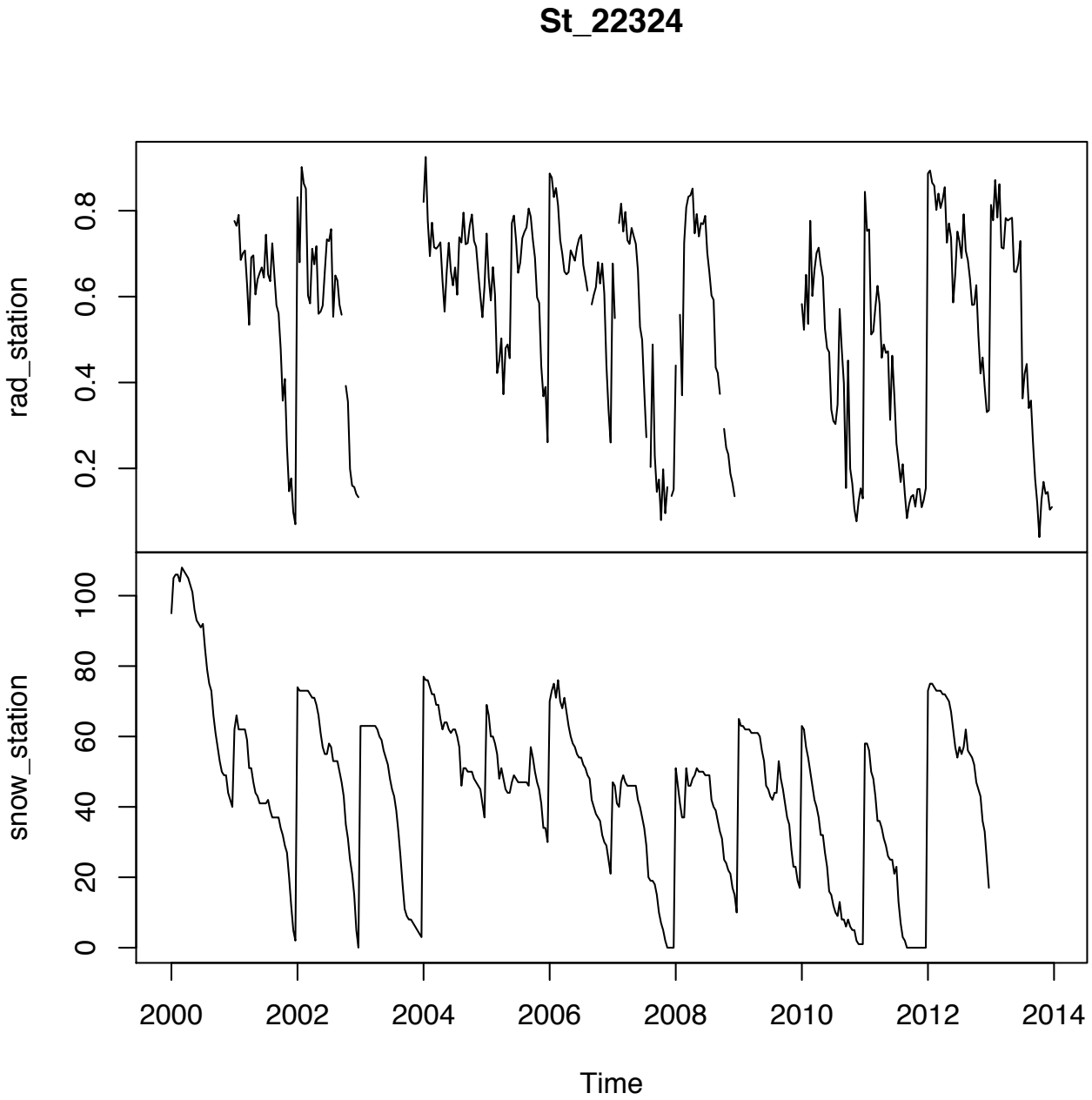
We decided to focus on spring (MAMJ) to investigate snow albedo feedbacks

Dataset overview

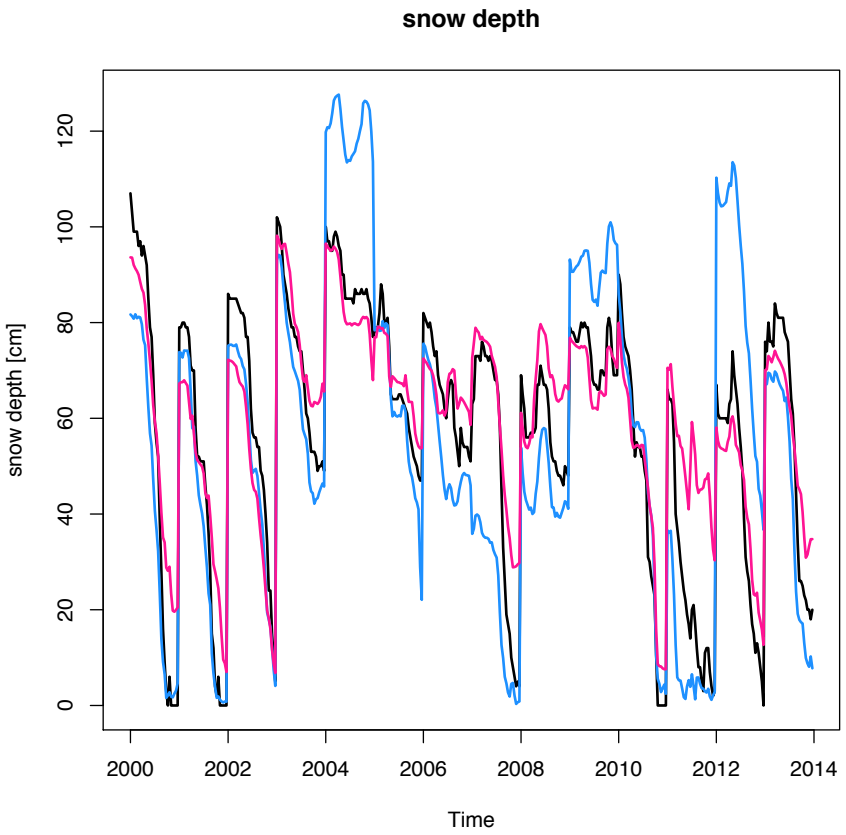


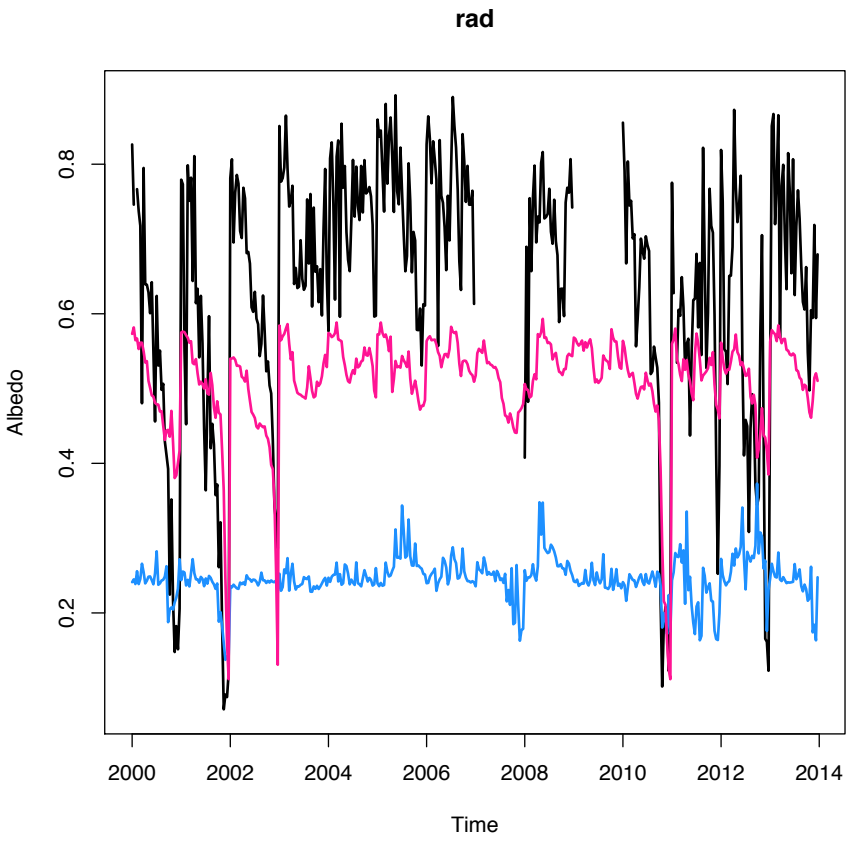
Averaged relative amount of missing values of daily albedo timeseries for MAMJ

Dataset overview



Dataset overview





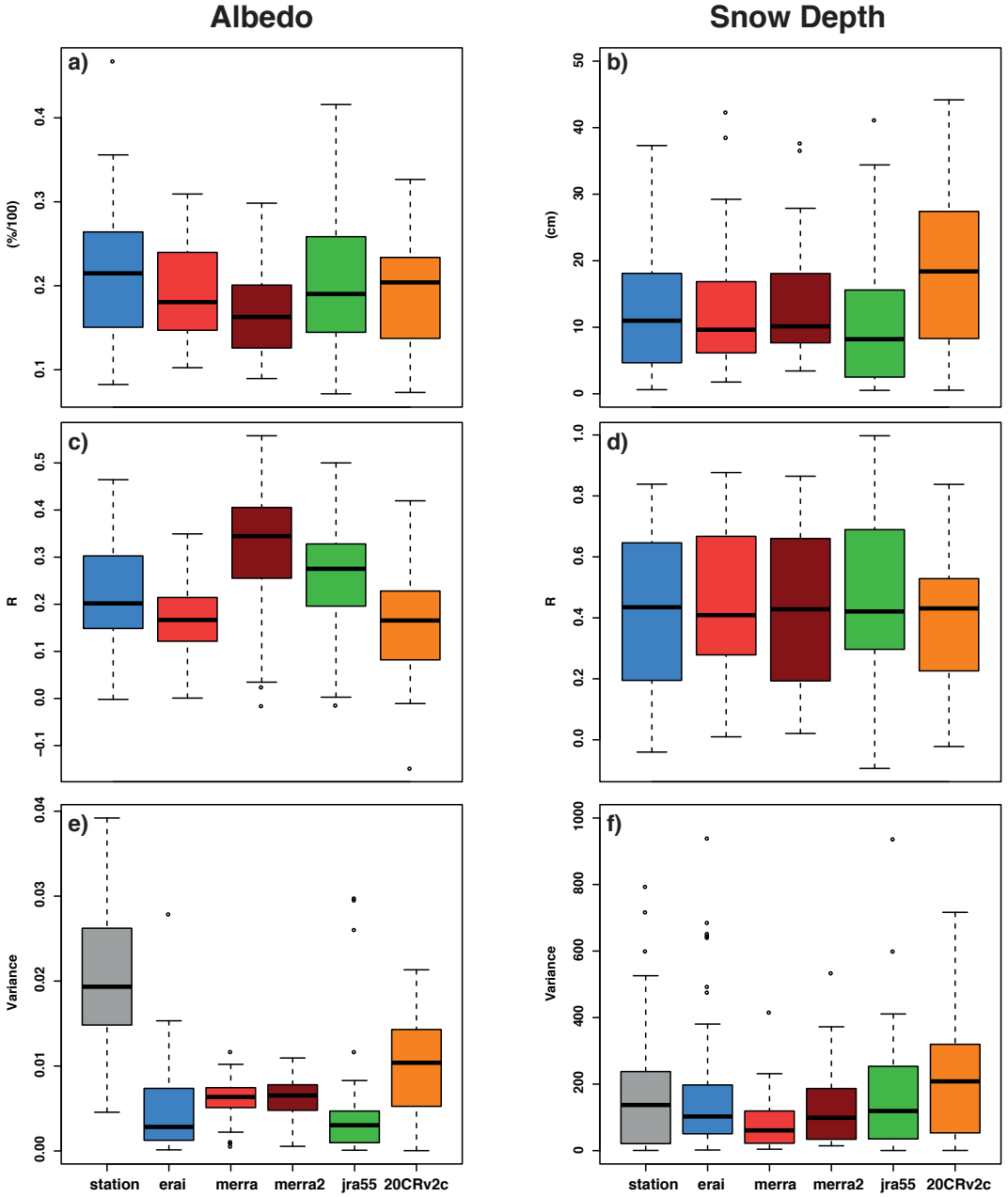
ERAI
MERRA
STATION

Nearest grid analysis, daily res., MAMJ

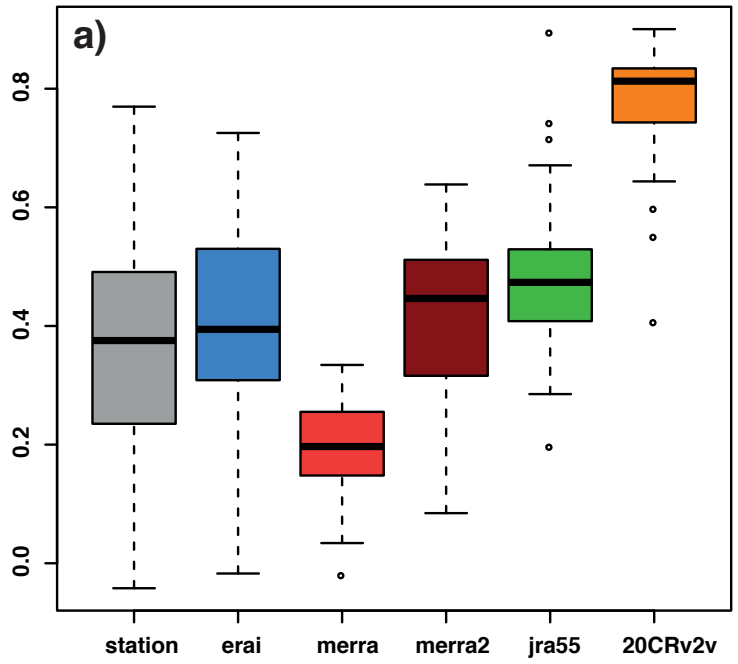
RMSE

Correlation

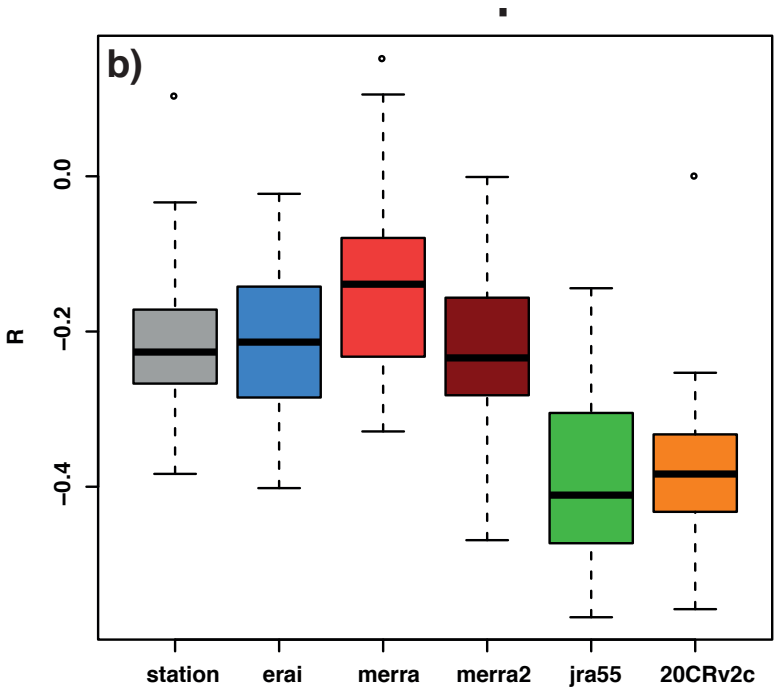
Variability



Nearest grid analysis, daily res., MAMJ

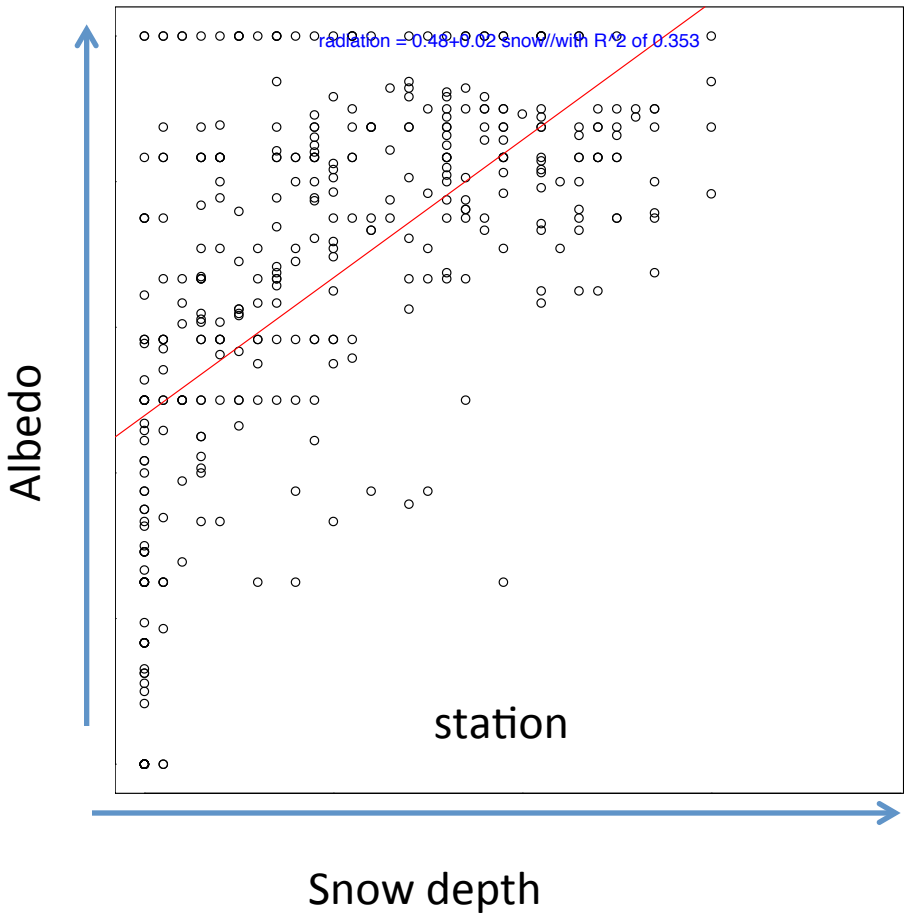


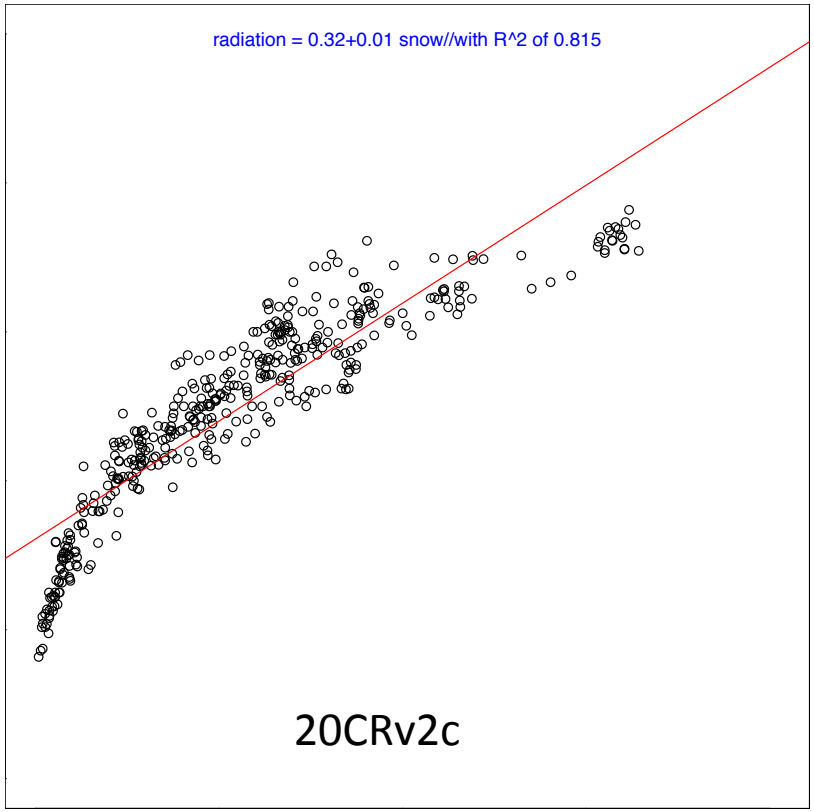
Simple linear correlation between snow depth and albedo



Simple linear correlation between albedo and temperature

Nearest grid analysis, daily res., MAMJ





Surface albedo feedback

	Station	ERA-Interim	MERRA	MERRA2	JRA55	20CRv2c
SAF	-2.05	-1.23	-1.54	-1.94	-1.43	-1.96
SNC	-1.56	-0.93	-0.85	-1.23	-0.88	-1.5
TEM	-0.49	-0.3	-0.69	-0.71	-0.55	-0.46
Snow melt sensitivity	-3.49	-3.88	-3.65	-3.92	-3.59	-2.77
albedo contrast	0.36	0.19	0.19	0.2	0.2	0.39
snow albedo	0.57	0.34	0.31	0.33	0.34	0.55
snow free albedo	0.2	0.15	0.12	0.13	0.14	0.16
snow depths	18.28	16.67	15.84	20.80	19.83	28.54
snow cover	39.34	54.21	57.3	59.75	46.20	59.87
2m temperature	276.96	277.07	277.06	275.81	277.02	275.16
albedo	0.37	0.25	0.27	0.28	0.25	0.39
delta snow	-0.08	-0.05	-0.09	-0.09	-0.09	-0.07

$$SNC = (\overline{\alpha_{snow}} - \alpha_{land})\,\Delta S_c/\Delta T_{2m}$$

CHAPTER 03

Summary

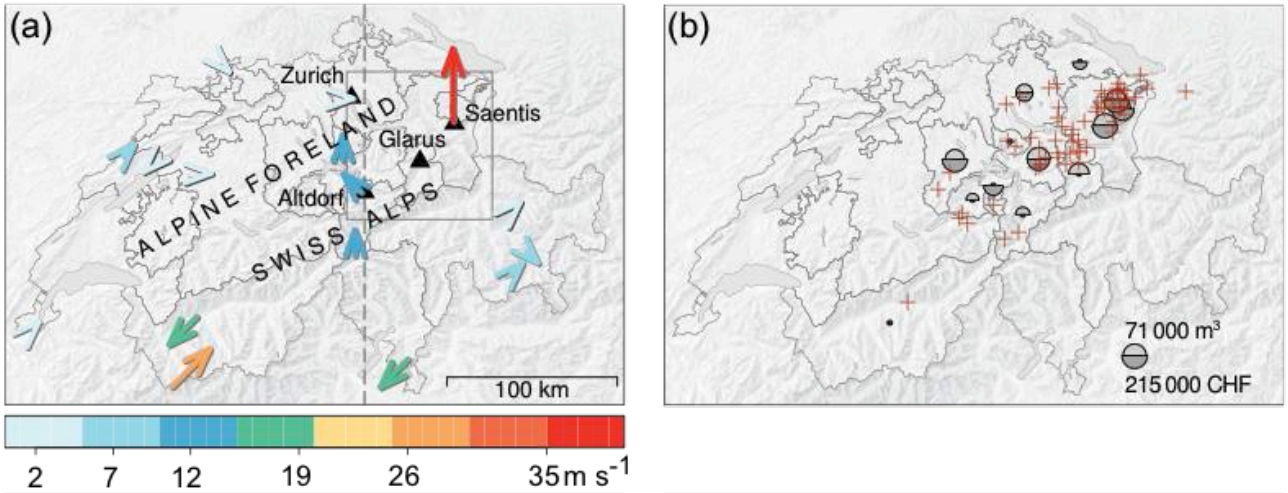
TAKE HOME MESSAGE

1. Snow in 20CR (much) too high
2. Snow depth correlation good
3. Diverging snow climates
4. Albedo variability bad
5. Relationship albedo snow bad in 20CR
6. Albedo over 100% snow prob. too low

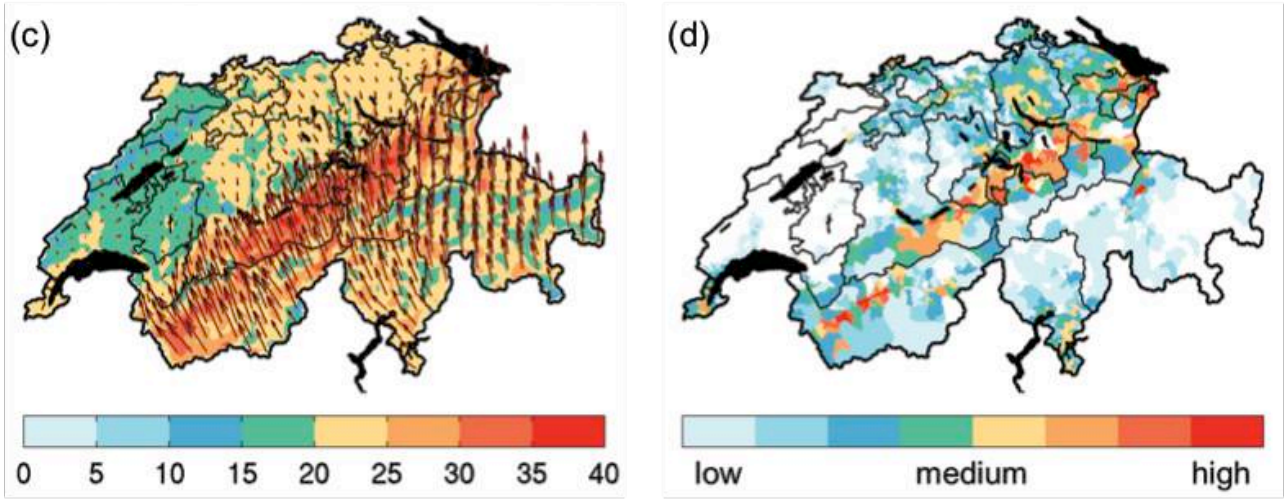
Topography and reanalyses

20CRv2 downscaled with WRF
to 2km over the Alpes

Stucki et al. 2015



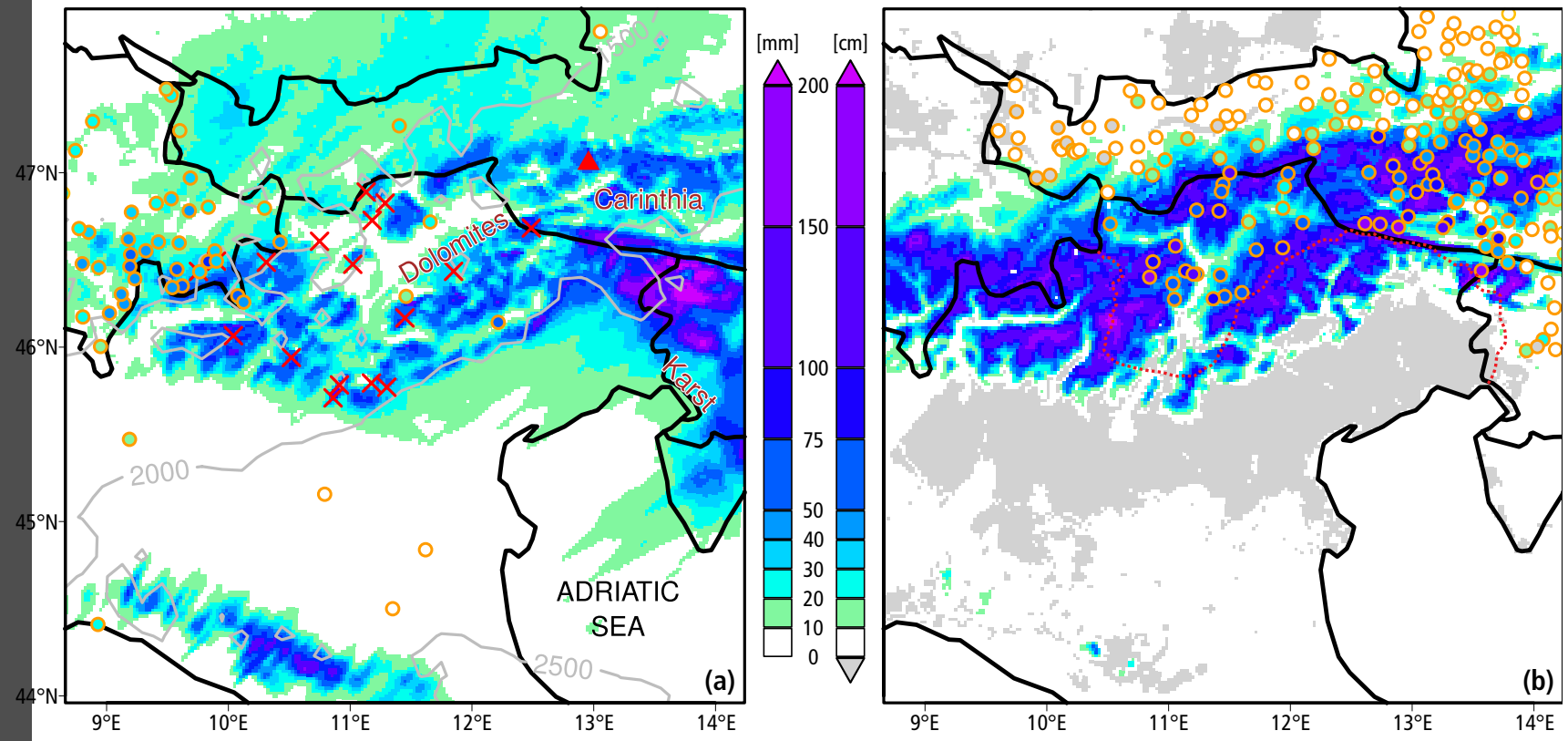
Foehn 15 Feb 1925



Topography and reanalyses

ERA20C downscaled with WRF
to 2km over the Alpes

Brugnara et al. 2016



Precip 13 Dec 1916

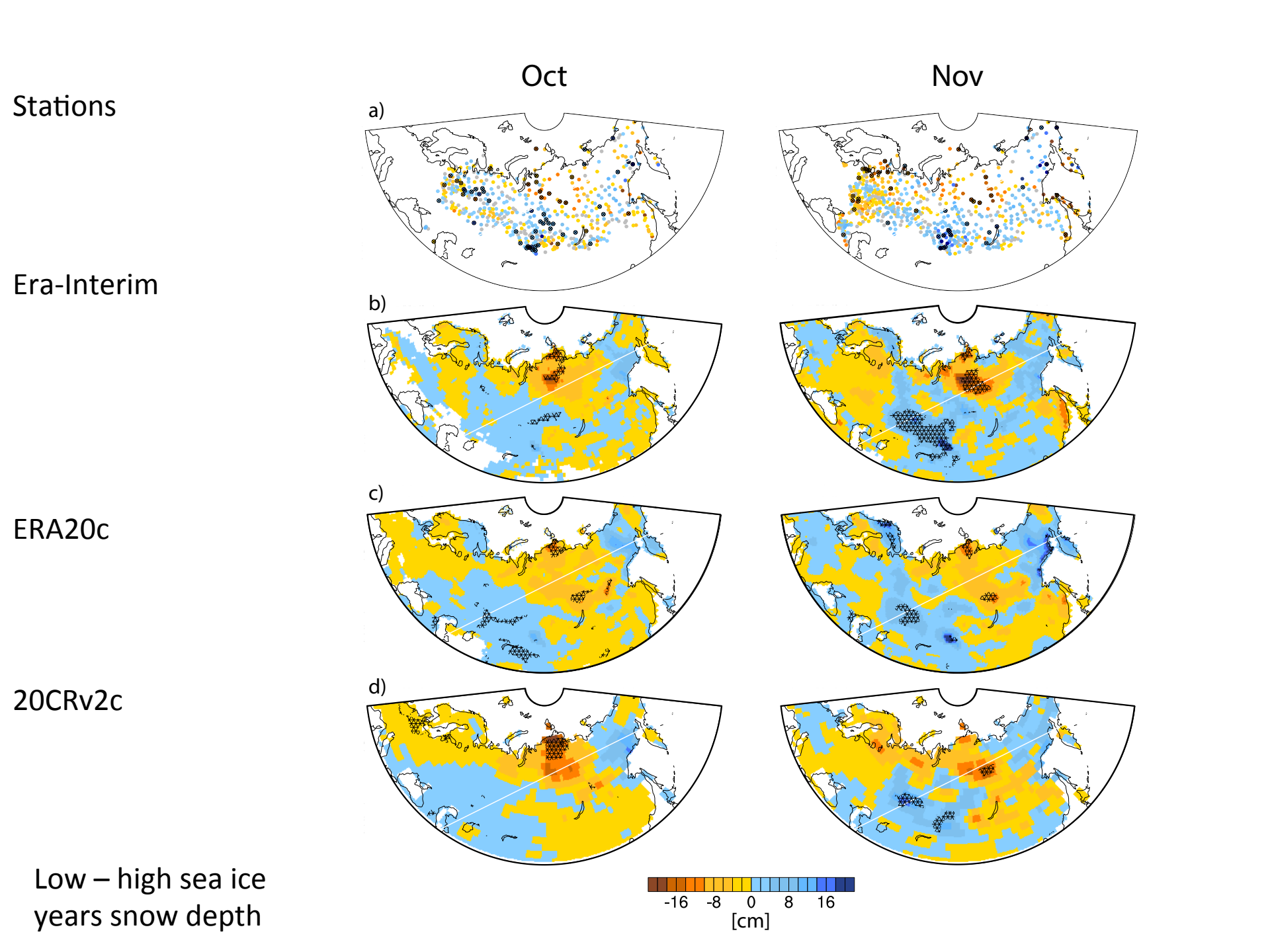
Snow depth 13 Dec 1916

PERSONAL MESSAGE

Apply for a Swiss NSF PostDoc (Feb. 2018)

- Money to go to non-swiss institutions
- Travel, work and living for ca. 2 years
- Just need a host (table, seat + internet)
- And a good research idea

ANNEX


Oct
Nov
Stations
Era-Interim
ERA20c
20CRv2c
a)
b)
c)
d)
-16
-8
0
8
16
[cm]
Low – high sea ice years snow depth

Feb

Feb

a)

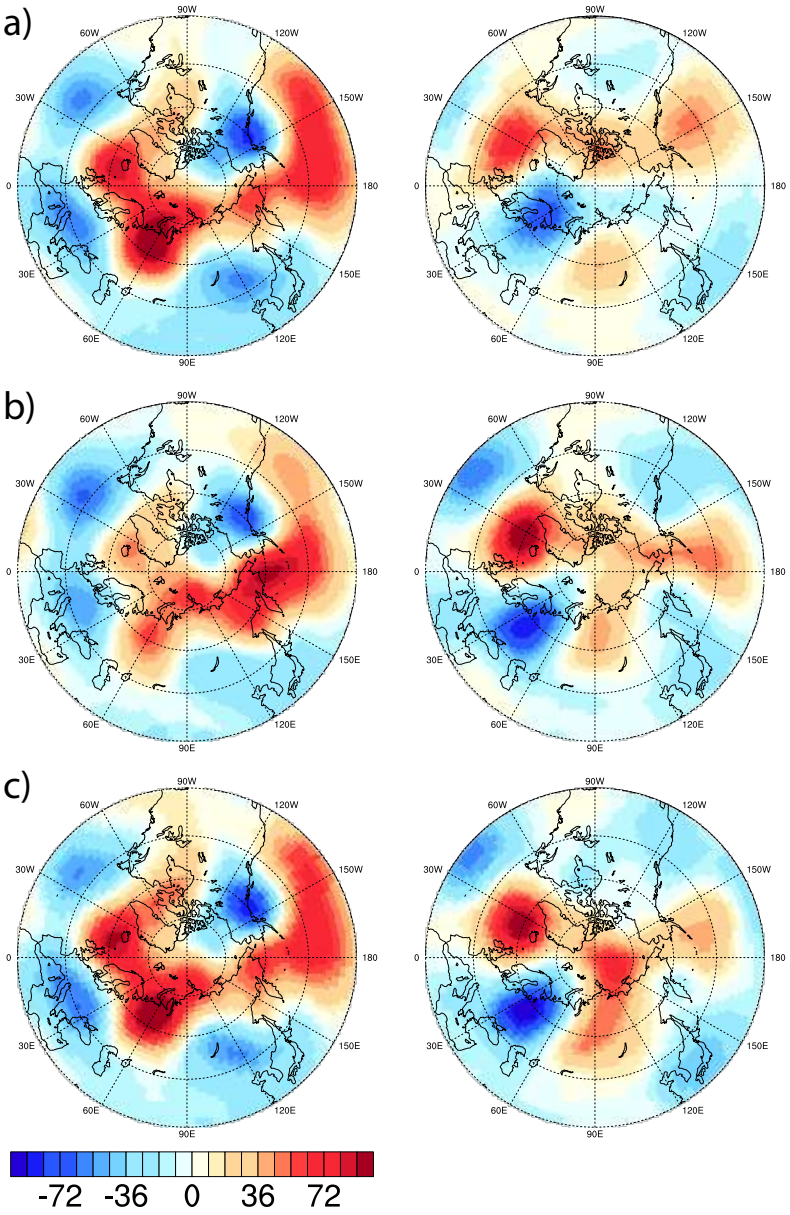
Era-Interim / REC

b)

ERA20c

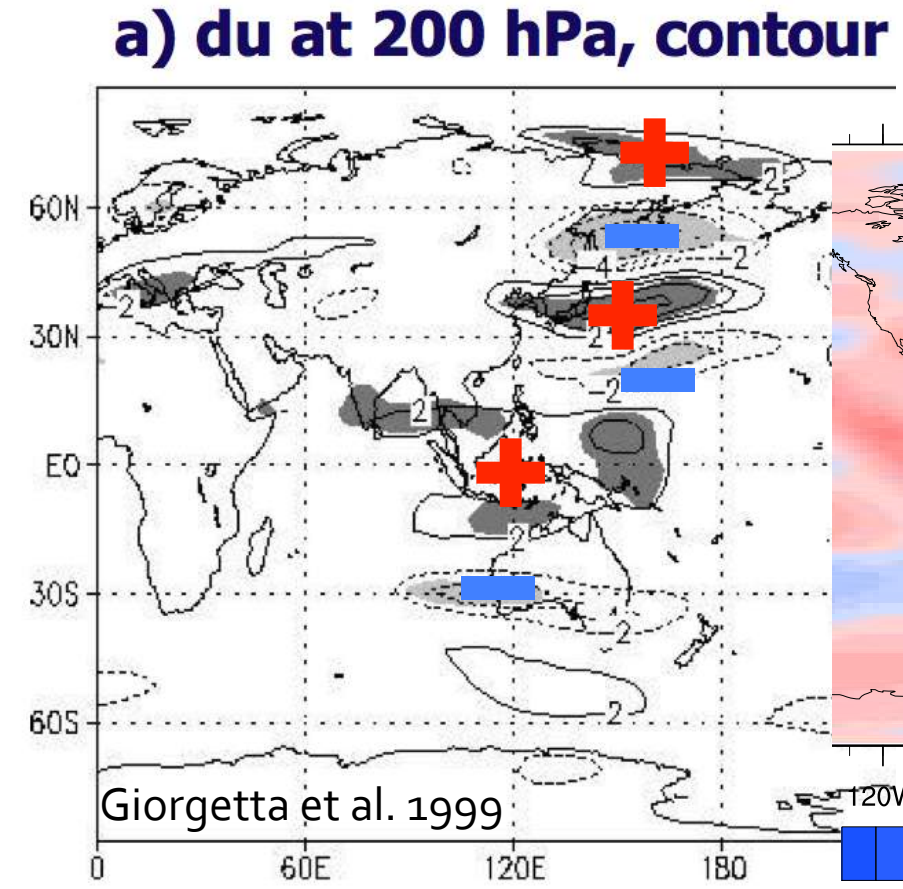
c)

20CRv2c



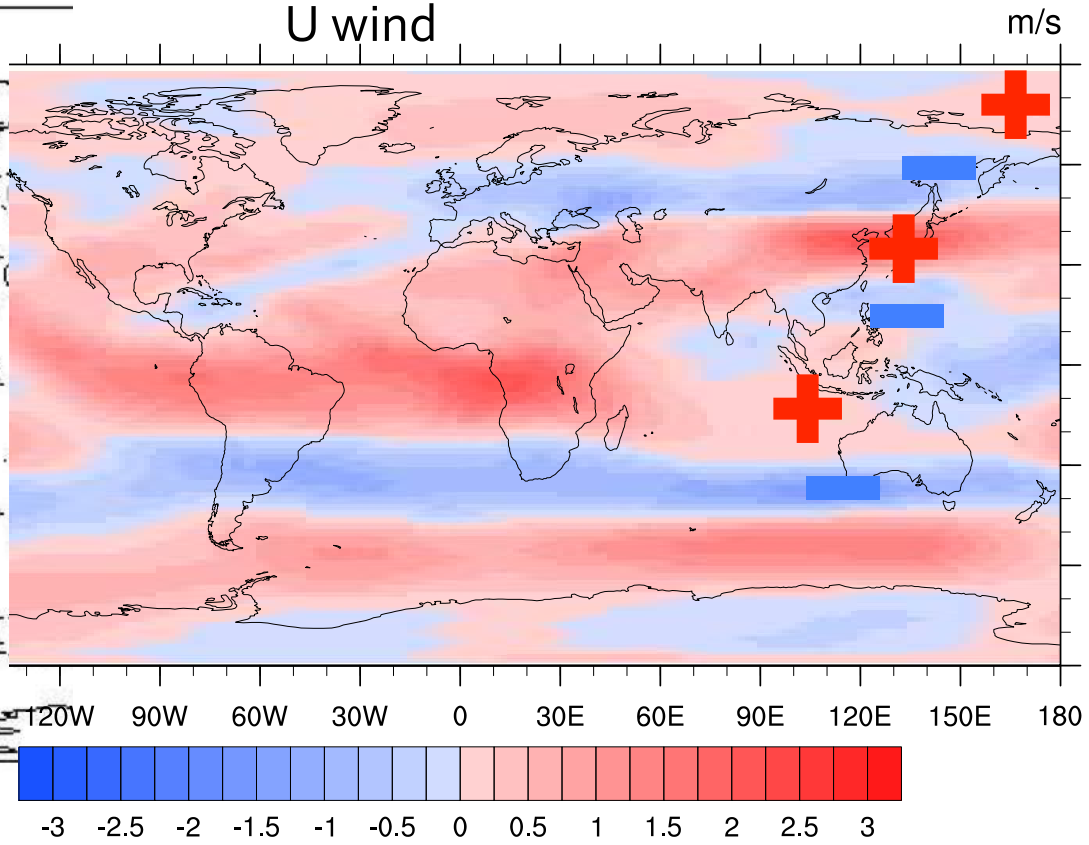
Low – high sea ice years 700 hPa

Discussion

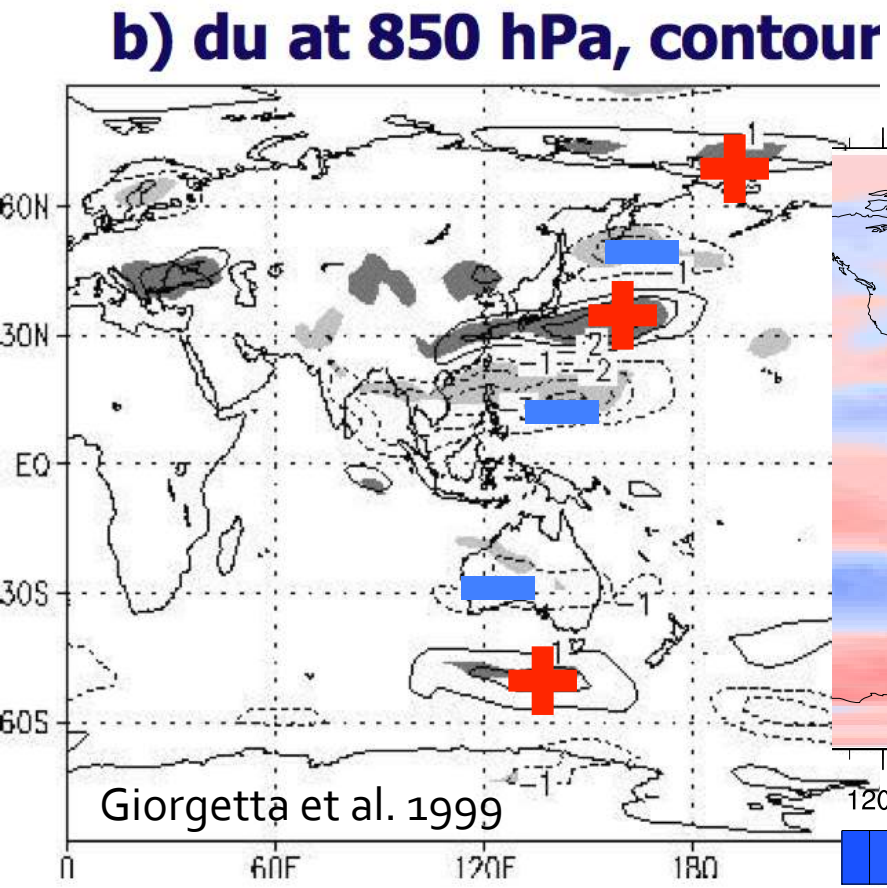


Westerly – easterly QBO in JJA U wind

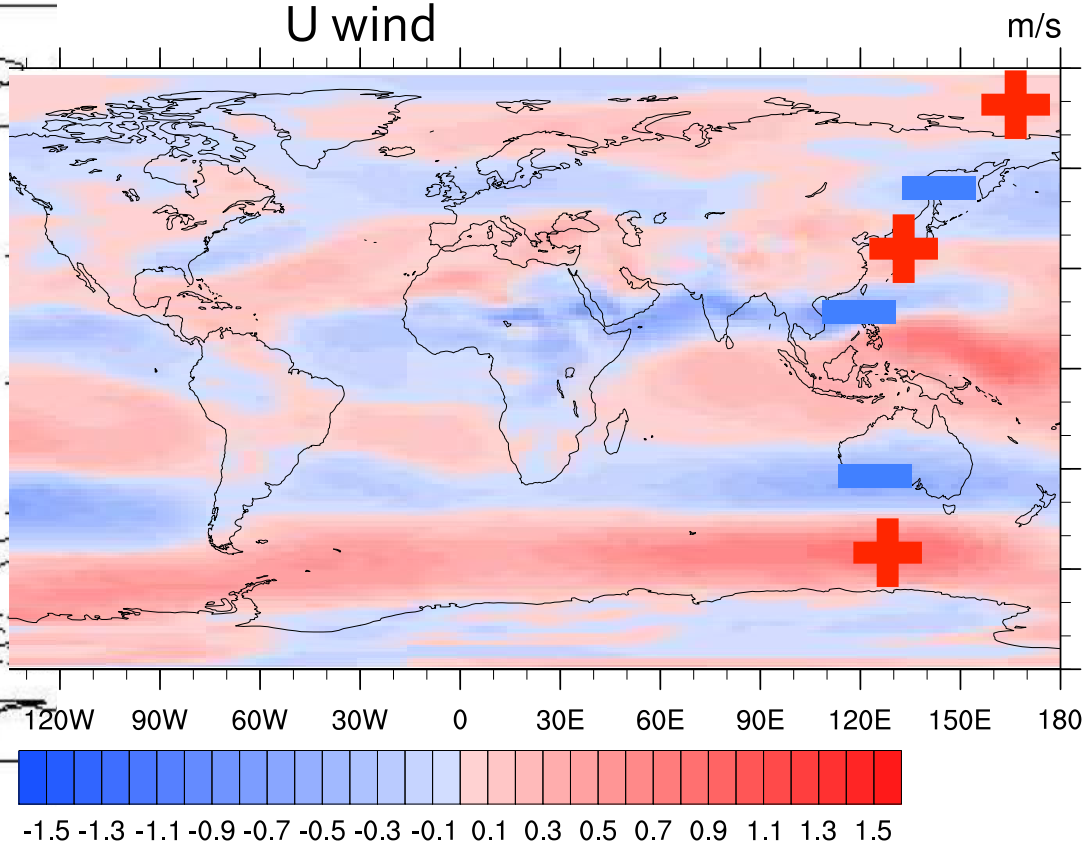
14 volcanic eruptions, JJA U wind



Discussion



14 volcanic eruptions, JJA
U wind



Westerly – easterly QBO in JJA
U wind