

A monthly, three-dimensional data set of the global atmosphere, 1870-2005

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Thomas Griesser
Tracy Ewen
Andrea Grant
ETH Zürich



Ewden	Gleitwitz	Swinemünde	Brantberg	Kjeller	Oberkirch
10.05	10.05	10.05	10.05	10.06	10.08
-59	-50	-59	-49	-	-60
11800	10800	11300	10100	-	11800
phen					
(-52)	-51	-48	-48	-	-56
-60	-58	-57	-50	-	-60
-45	-48	-45	-45	-53	-41
-30	-32	-30	-33	-37	-25
1599.3	1596.4	1587.3	1592	-	1613.8
1165.6	1159.7	1155.5	1147	-	1180.1
909.5	904.8	900.6	886	879	922.5
715.0	709.9	706.5	694	691	725.3

Monthly global 3-D reconstructions, 1870-2005

Introduction

Historical data

Reconstruction

Some results

Conclusions

Overview

- Introduction
- Historical upper-air data
- Reconstruction method
- Some results
- Outlook: reconstructions of Arctic sea ice, QBO

Why 3-D recons for the past 130 years?

3-D data are only available for reanalysis period.

Prior to 1948 we can not directly address atmospheric circulation variability (Hadley and Walker circulation, monsoon, jet streams, polar vortex).
But would be very interesting!

Our group works on 20C climate variability with a special focus on the early decades.
-> Purpose of this data set

Monthly global 3-D reconstructions, 1870-2005

Introduction

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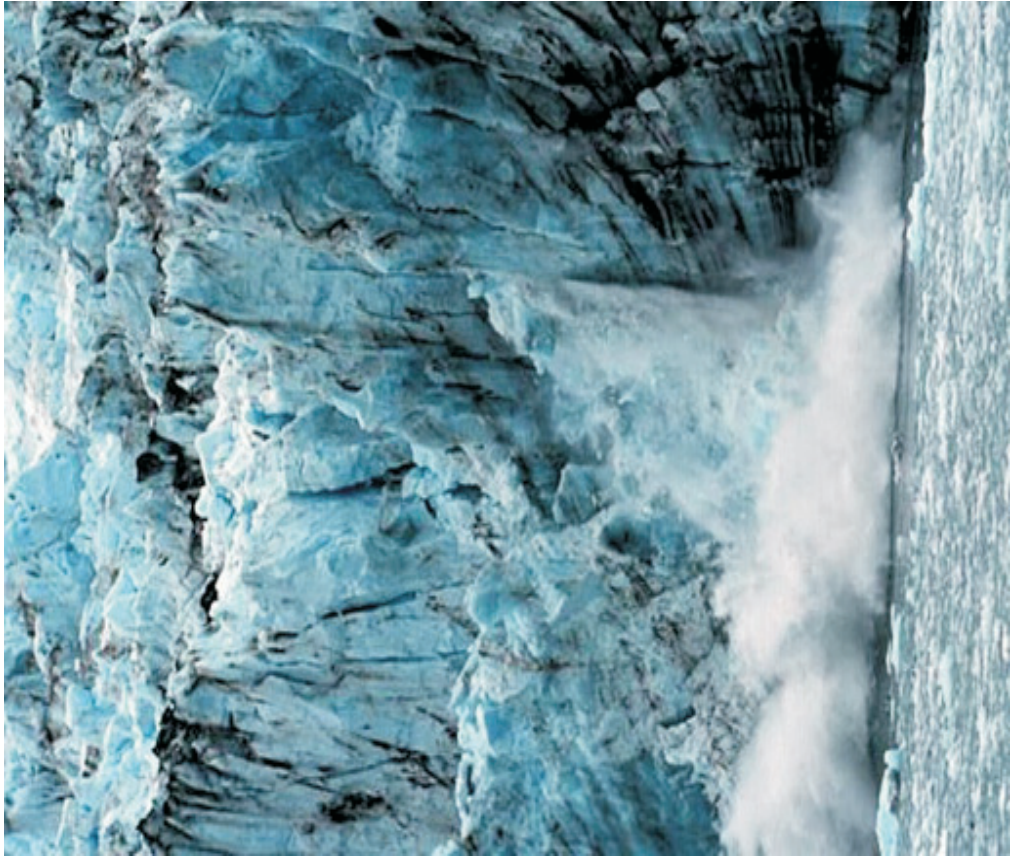
Some results

Conclusions

Arctic warming



1920-1945



1975 to present

Monthly global 3-D reconstructions, 1870-2005

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Droughts



The "Dust Bowl", USA, 1930s

Monthly global 3-D reconstructions, 1870-2005

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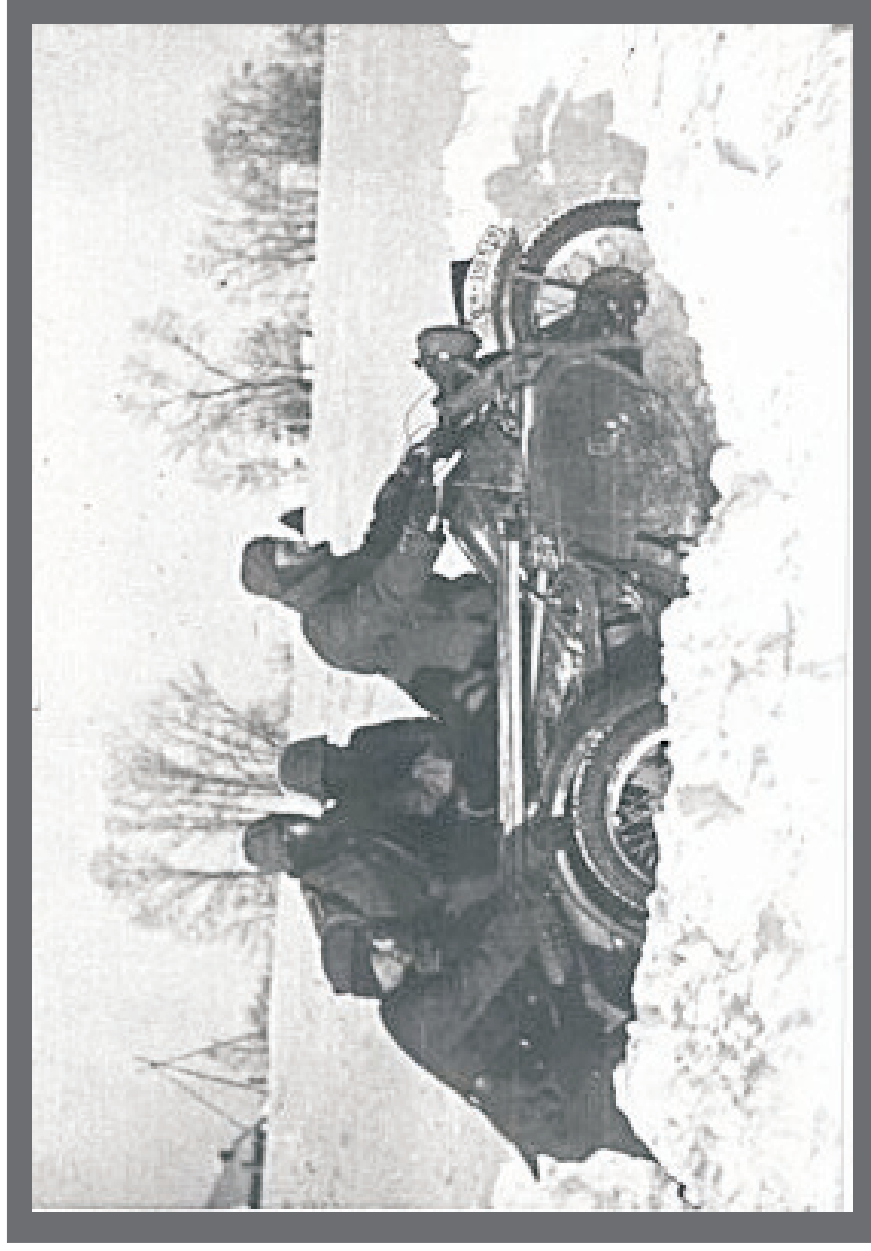
Historical data

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Severe winters



German soldiers in Russia, January 1942

Monthly global 3-D reconstructions, 1870-2005

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Volcanic effects



Katmai, Alaska, 1912



Pinatubo, Indonesia, 1991

Monthly global 3-D reconstructions, 1870-2005

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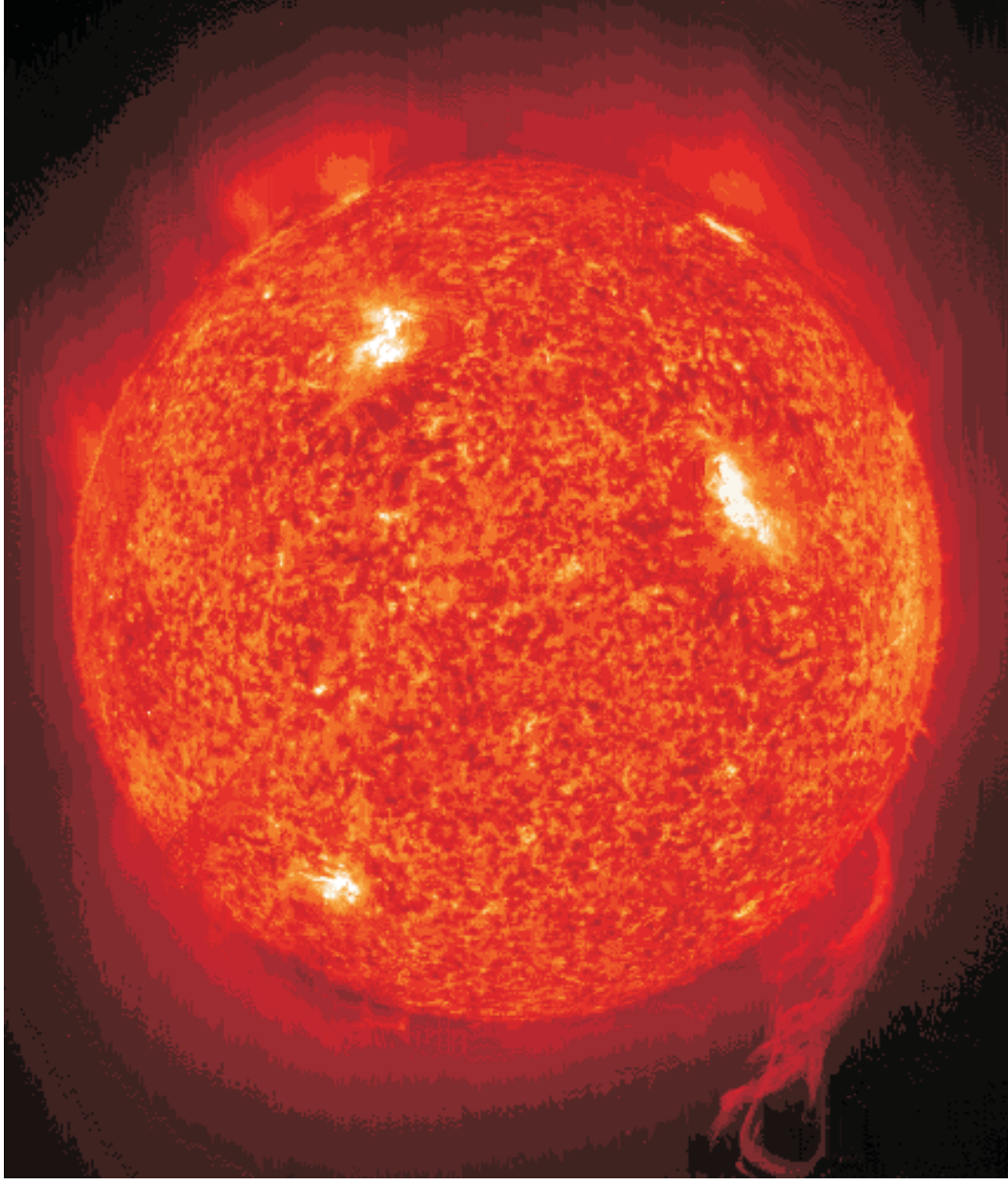
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Solar effects



Monthly global 3-D reconstructions, 1870-2005

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Historical upper-air data

Monthly global 3-D reconstructions, 1870-2005

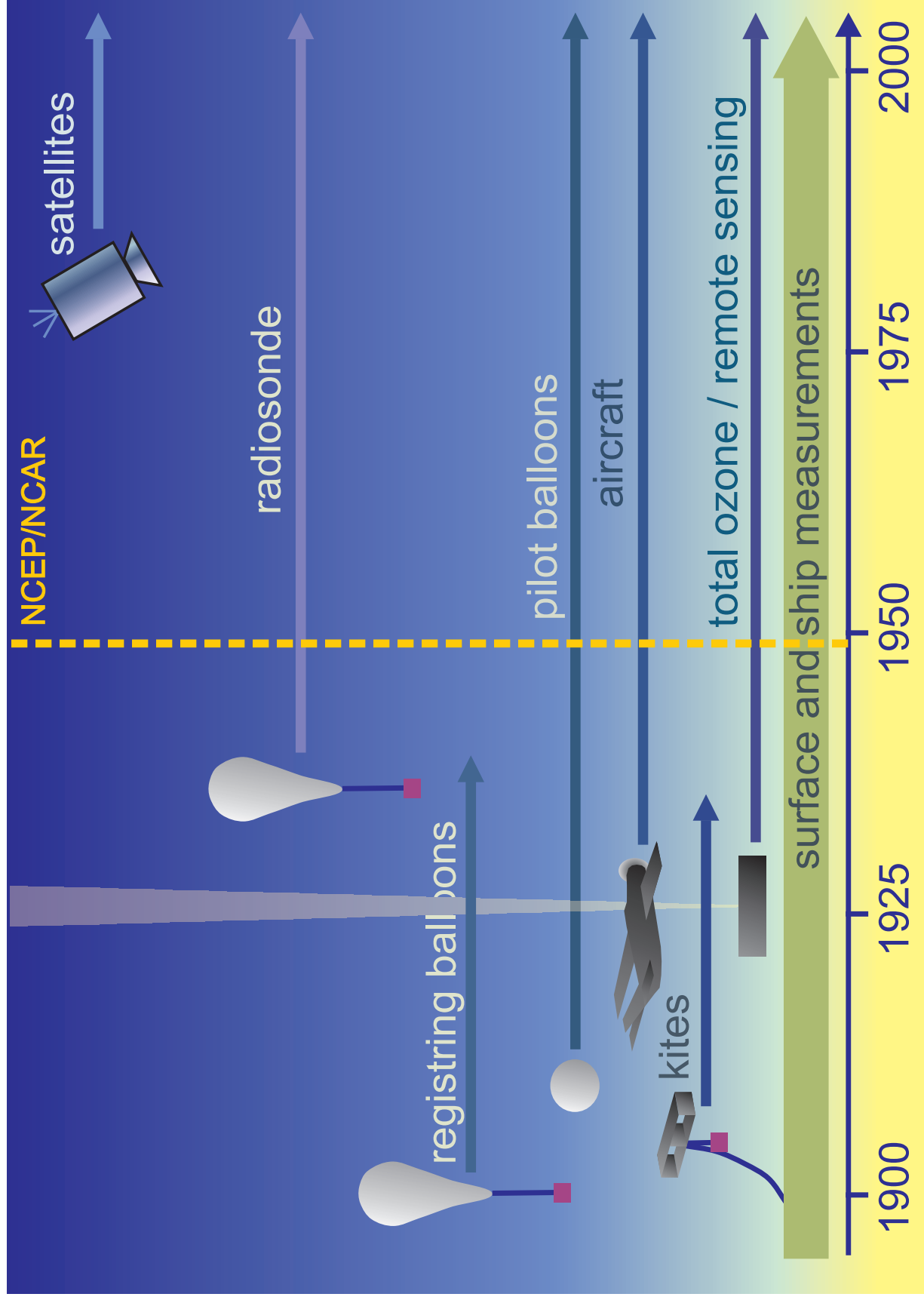
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Monthly global 3-D reconstructions, 1870-2005

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Radiosonde

Since 1930s

estimated 300,000 profiles
prior to 1948

(Photo: Library of Congress)



Monthly global 3-D reconstructions, 1870-2005

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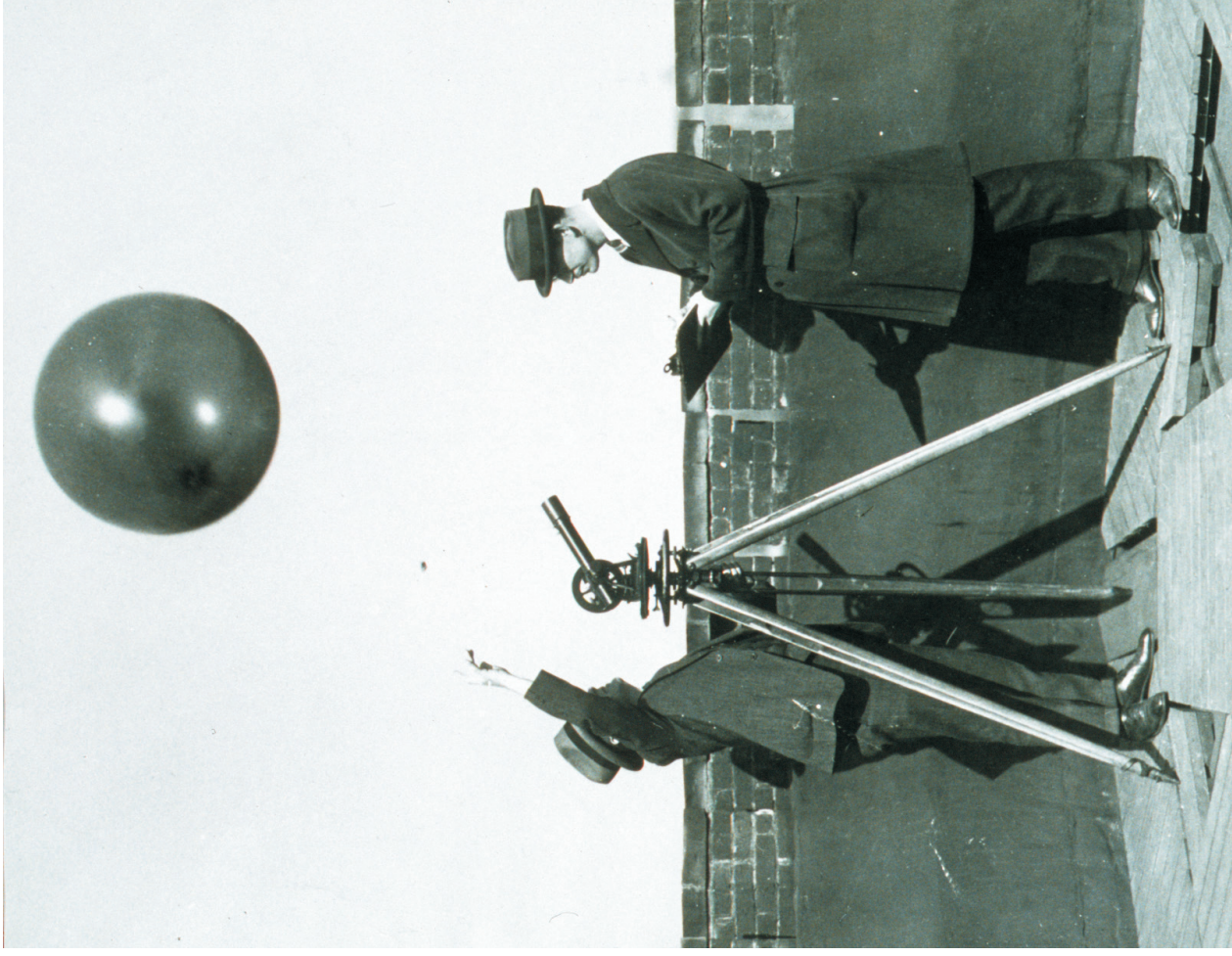
Some results

Conclusions

Pilot balloons

Since 1910s
several millions of profiles
prior to 1948

(Photo: NOAA)



Monthly global 3-D reconstructions, 1870-2005

Introduction

Historical data

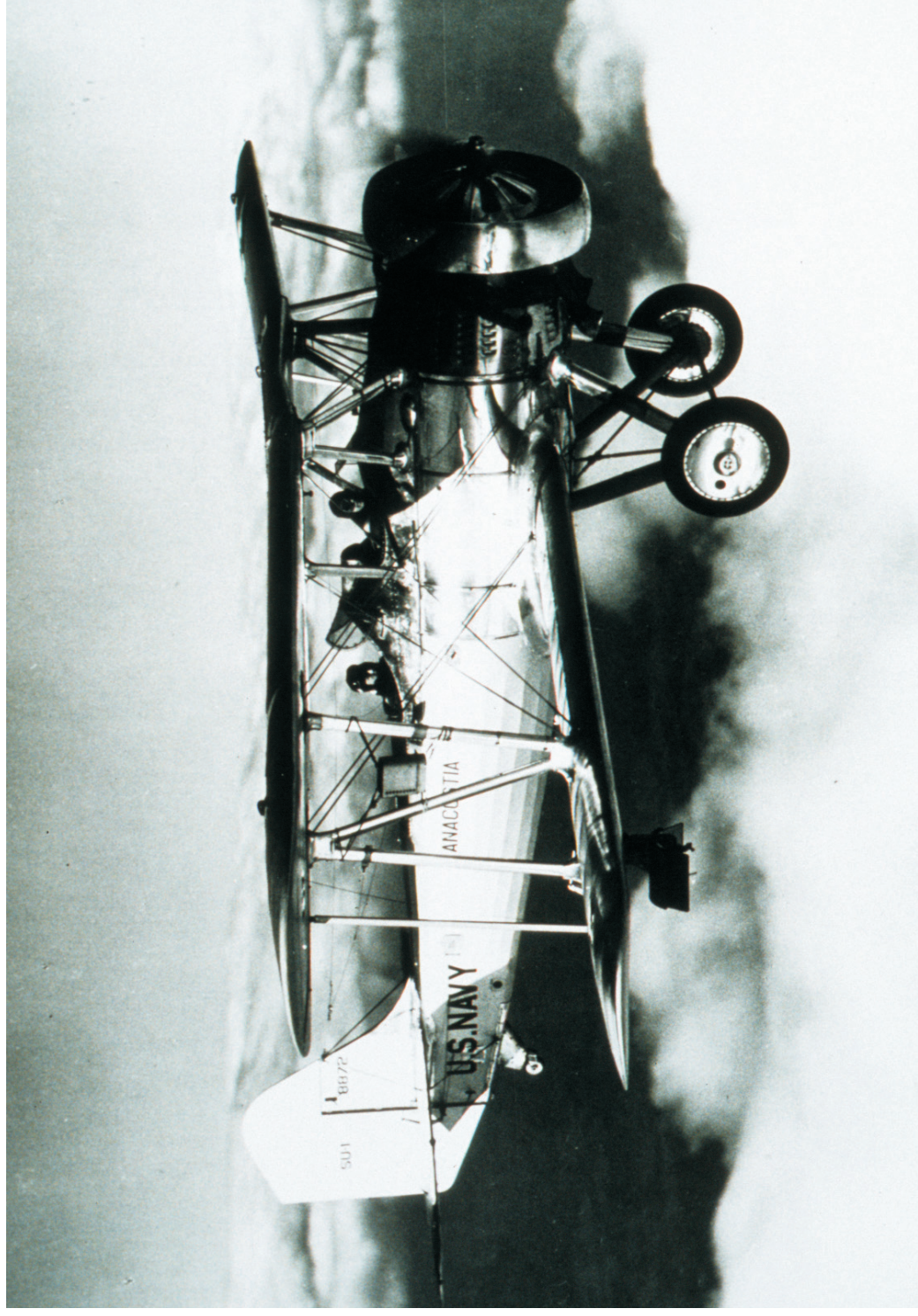
Reconstruction

Some results

Conclusions

Air craft

Since 1920s, estimated 150,000 flights prior to 1948 (Photo: NOAA)



Monthly global 3-D reconstructions, 1870-2005

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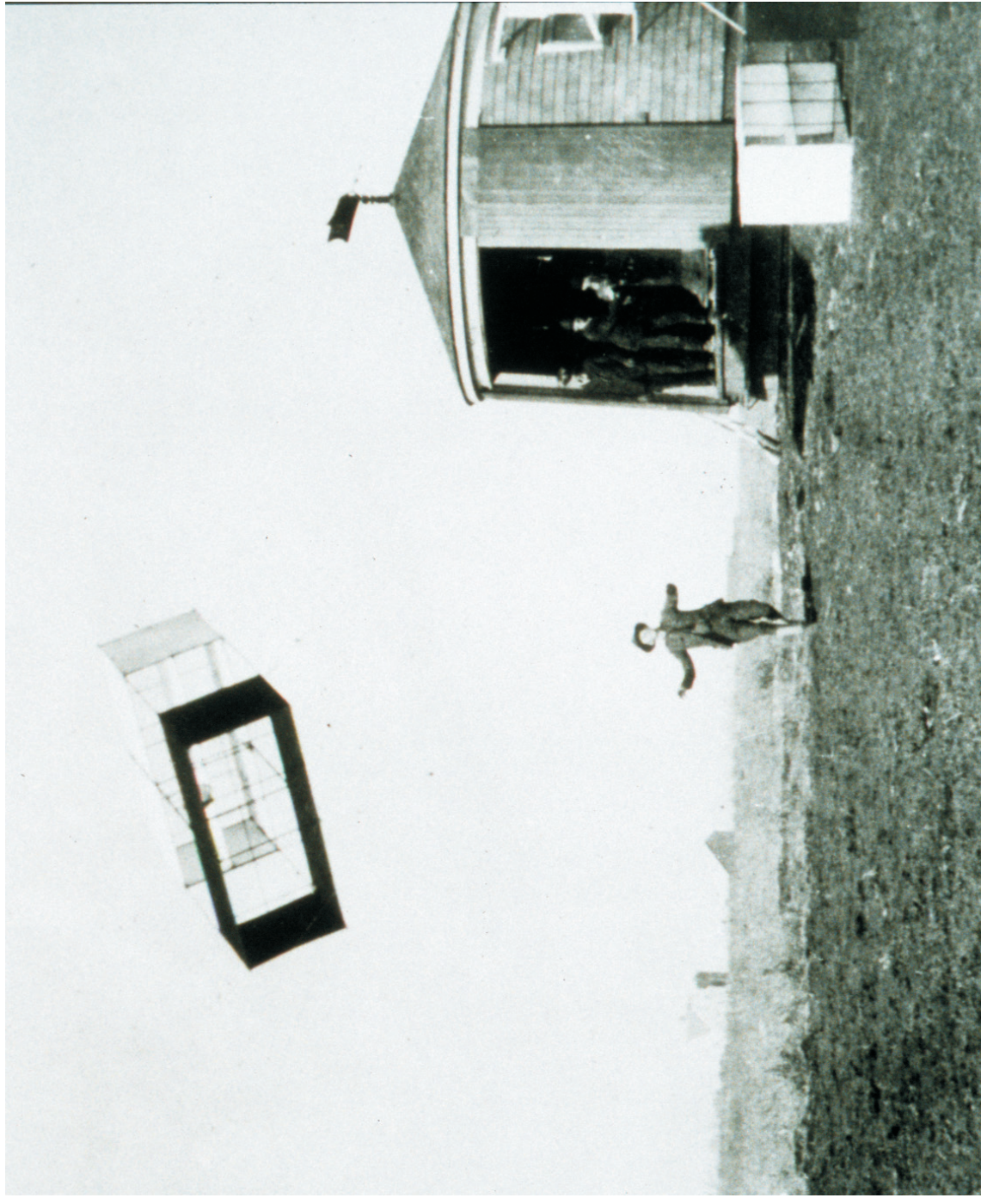
Some results

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Kites

ca. 1900-1930

(Photo: Glasgow
Digital Library)



Monthly global 3-D reconstructions, 1870-2005

Introduction

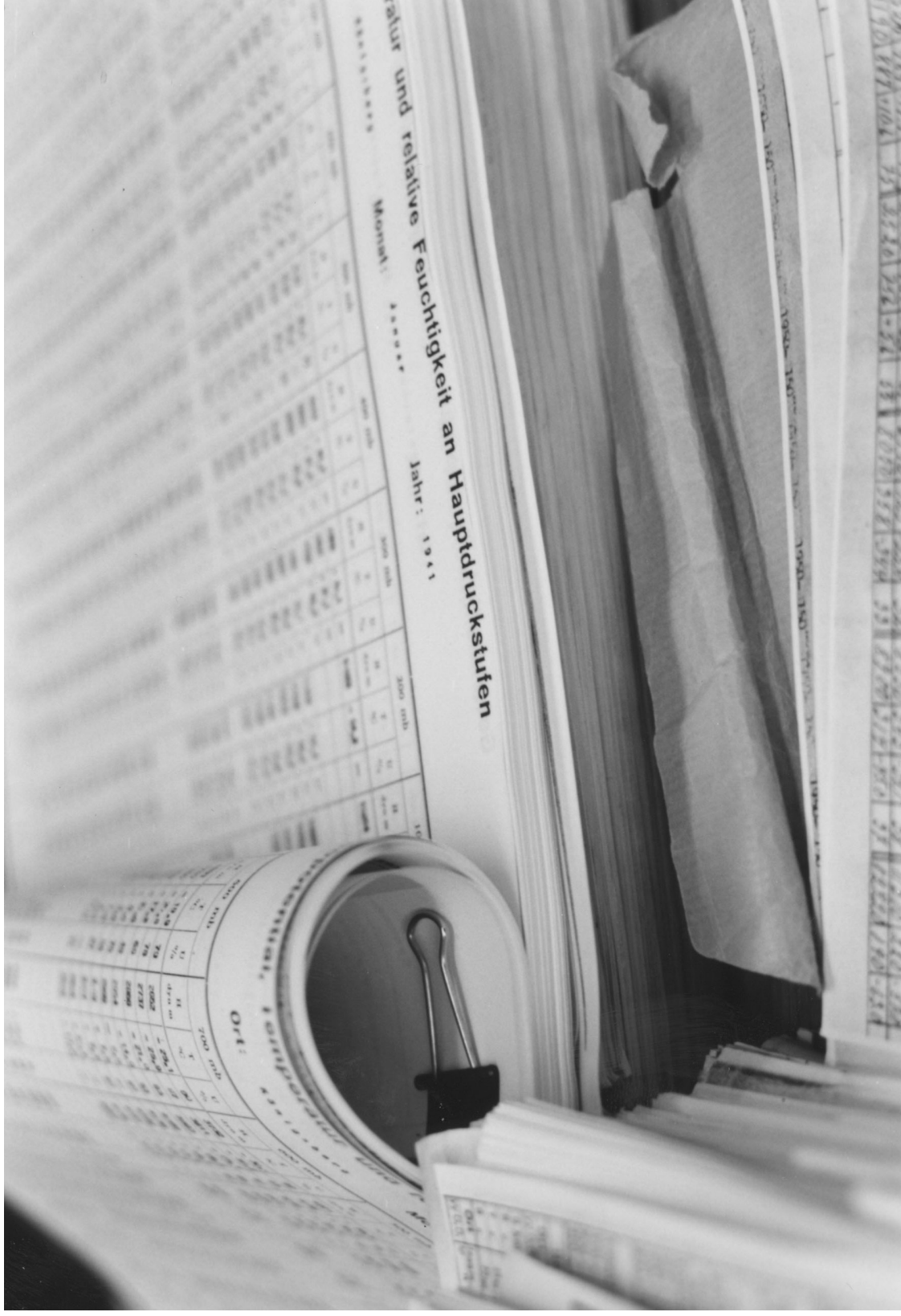
Historical data

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The raw data



Monthly global 3-D reconstructions, 1870-2005

Introduction

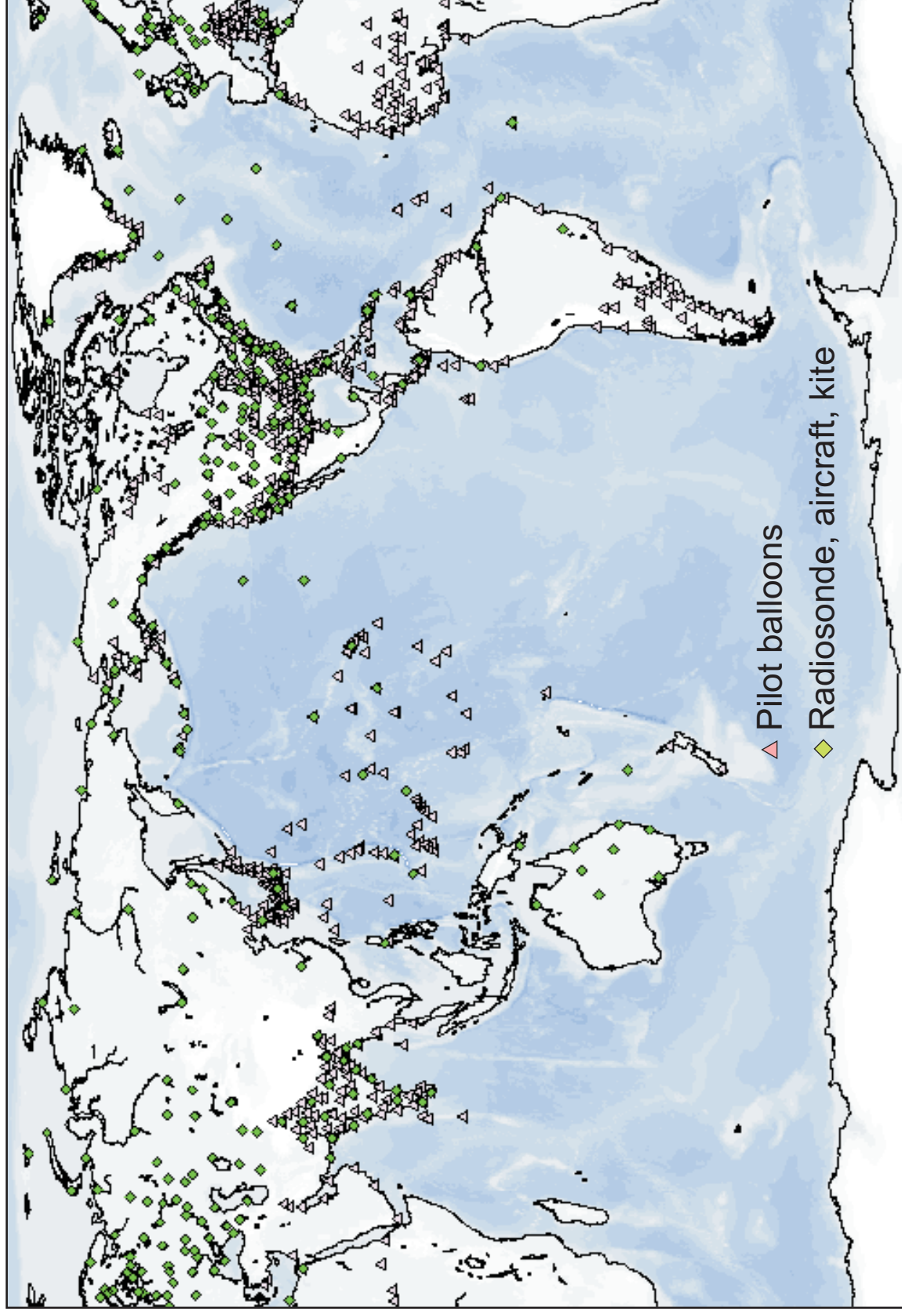
Historical data

Reconstruction

Some results

Conclusions

Electronically available upper-air data prior to 1948



Monthly global 3-D reconstructions, 1870-2005

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Next generation reanalysis? Hopefully!

We use statistical models on the scale of monthly fields.

UA data serve as predictors, supplemented with surface data (SAT, SLP)

Monthly global 3-D reconstructions, 1870-2005

Introduction

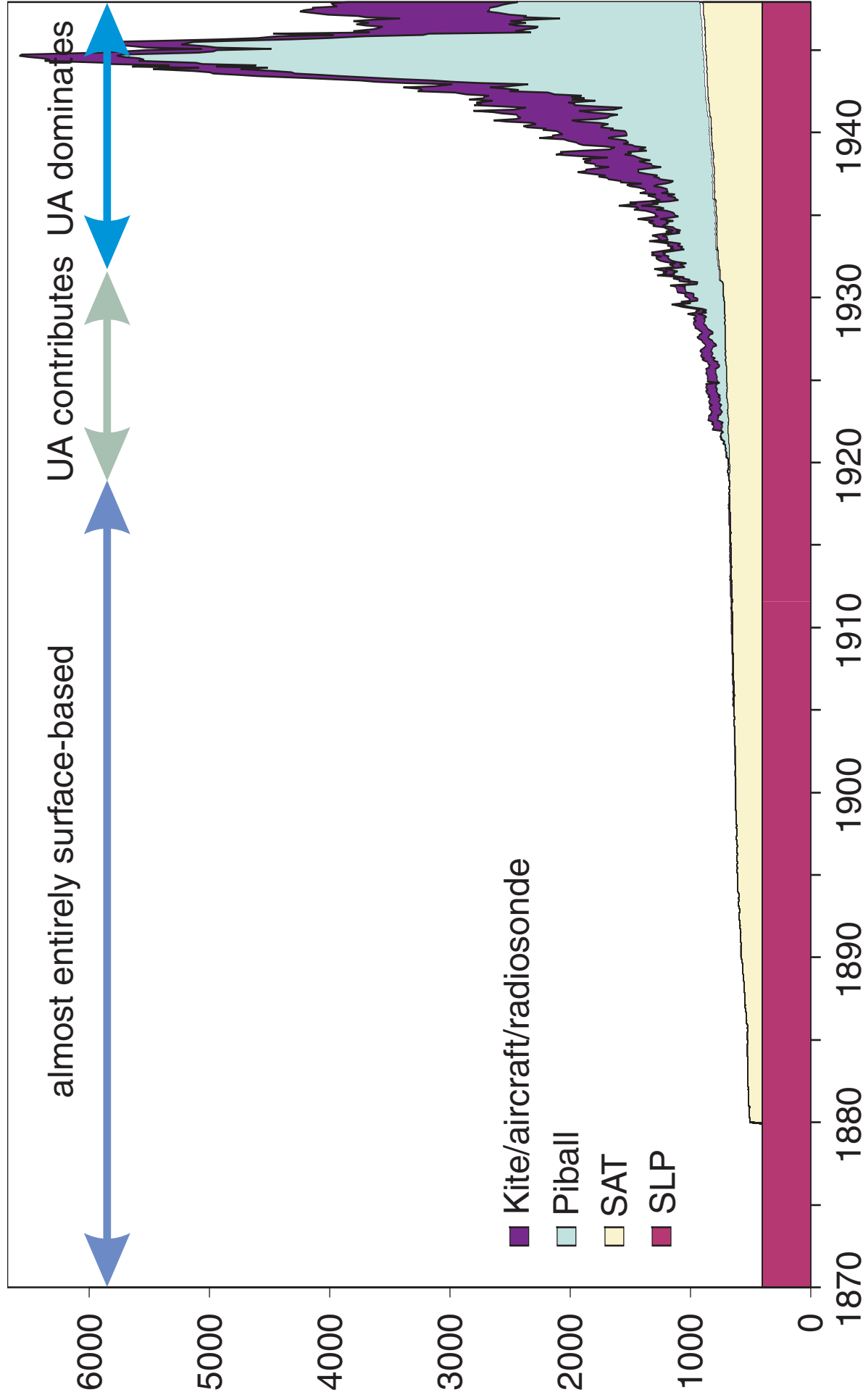
Historical data

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Number of predictor variables per month



Monthly global 3-D reconstructions, 1870-2005

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Reconstruction method:

Principal component regression
(GPH and T, up to 100 hPa, back to 1870)

Monthly global 3-D reconstructions, 1870-2005

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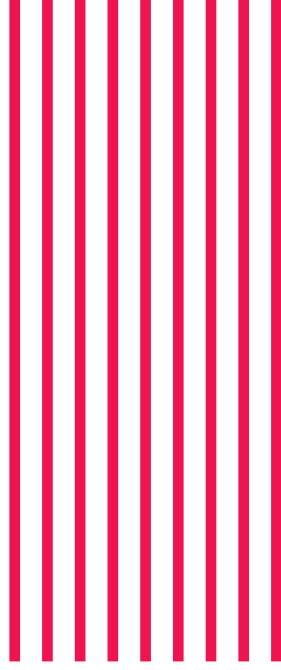
Historical data

Reconstruction

Some results

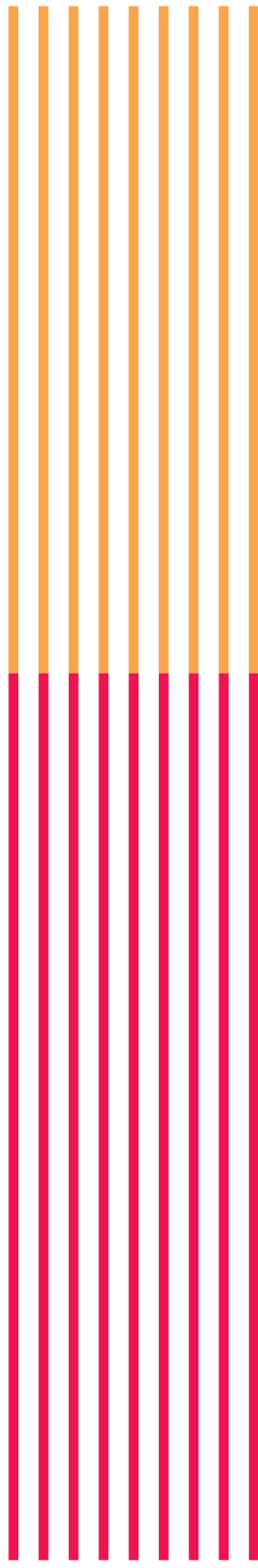
Conclusions

Predictor
Historical data



Predictand
Fields to be
reconstructed

Predictor
Recent data



Predictand
available fields

Monthly global 3-D reconstructions, 1870-2005

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Predictor
Historical data

Predictor
Recent data



Predictand
Fields to be
reconstructed

**NCEP or
ERA40?**

Monthly global 3-D reconstructions, 1870-2005

Introduction

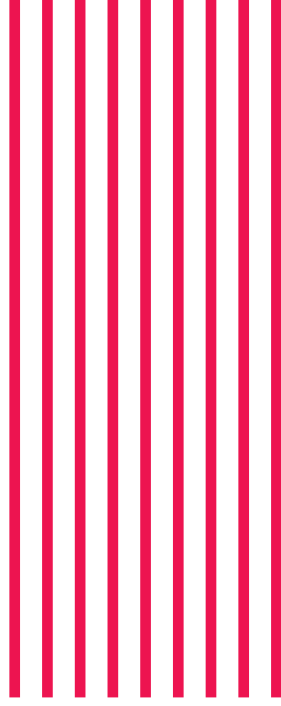
Historical data

Reconstruction

Some results

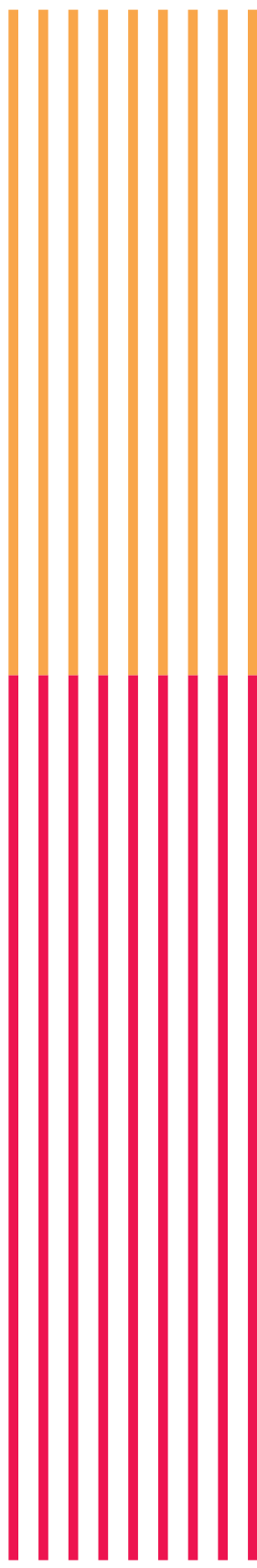
Conclusions

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Historical data



Predictand
Fields to be
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Predictor
Recent data



Individual fields or
everything together?

Monthly global 3-D reconstructions, 1870-2005

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Predictor
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Predictor
Recent data

**Use ERA40,
perturbed**



Predictand
Fields to be
reconstructed

Predictand
available fields

Monthly global 3-D reconstructions, 1870-2005

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Predictor
Historical data

Predictor
Recent data

Weigthing of predictors



Predictand
Fields to be
reconstructed

Predictand
available fields

Monthly global 3-D reconstructions, 1870-2005

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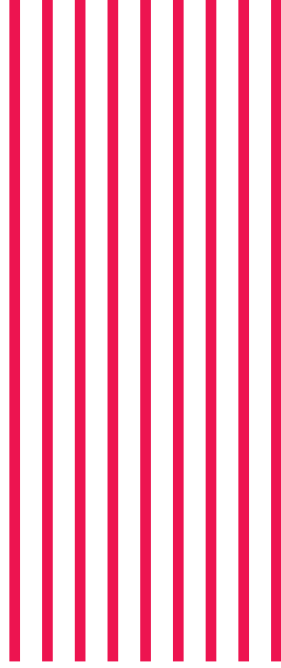
Historical data

Reconstruction

Some results

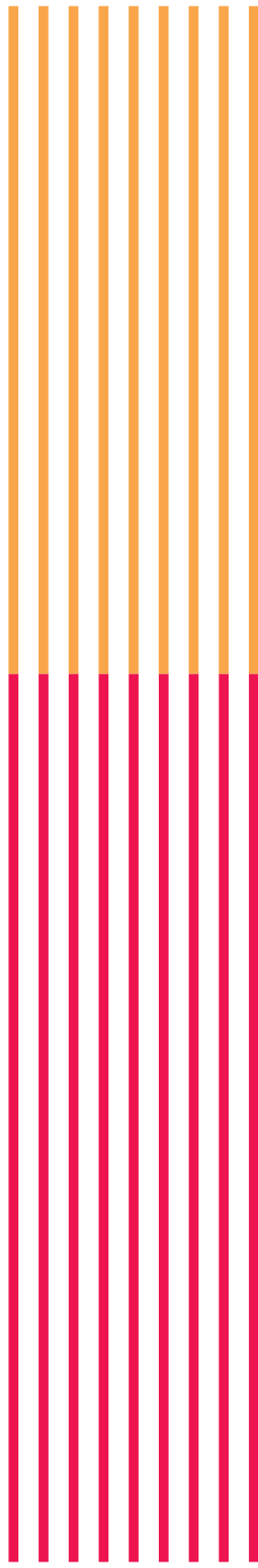
Conclusions

Predictor
Historical data



Predictand
Fields to be
reconstructed

Predictor
Recent data



Optimise

retained

variance



Predictand
available fields

Monthly global 3-D reconstructions, 1870-2005

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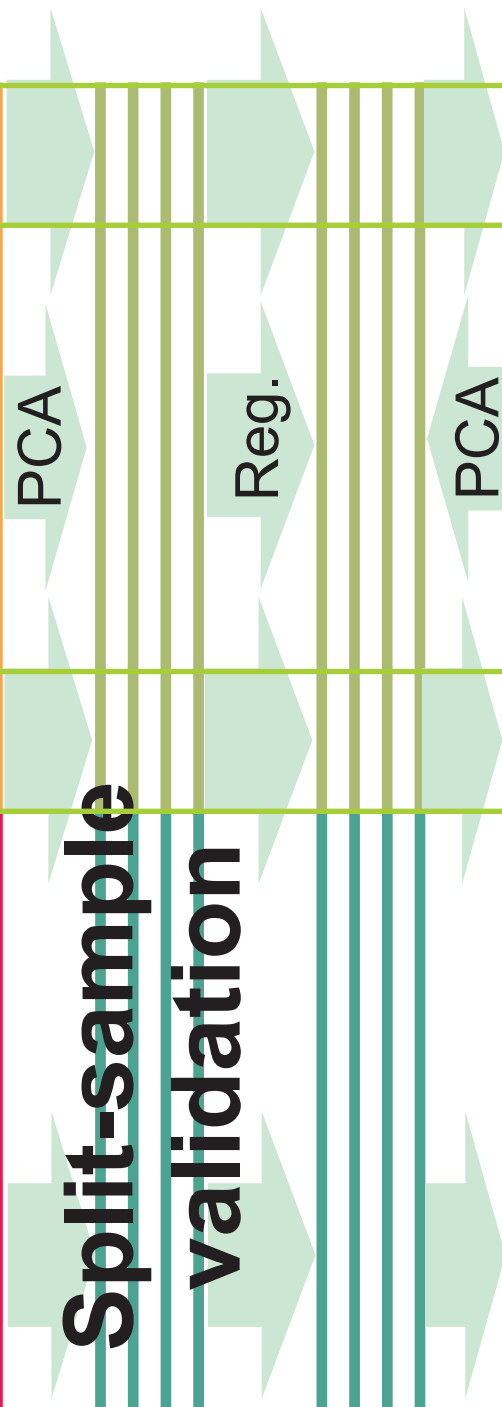
Conclusions

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Predictor

Recent data



Predictand
Fields to be
reconstructed

Predictand
available fields

Monthly global 3-D reconstructions, 1870-2005

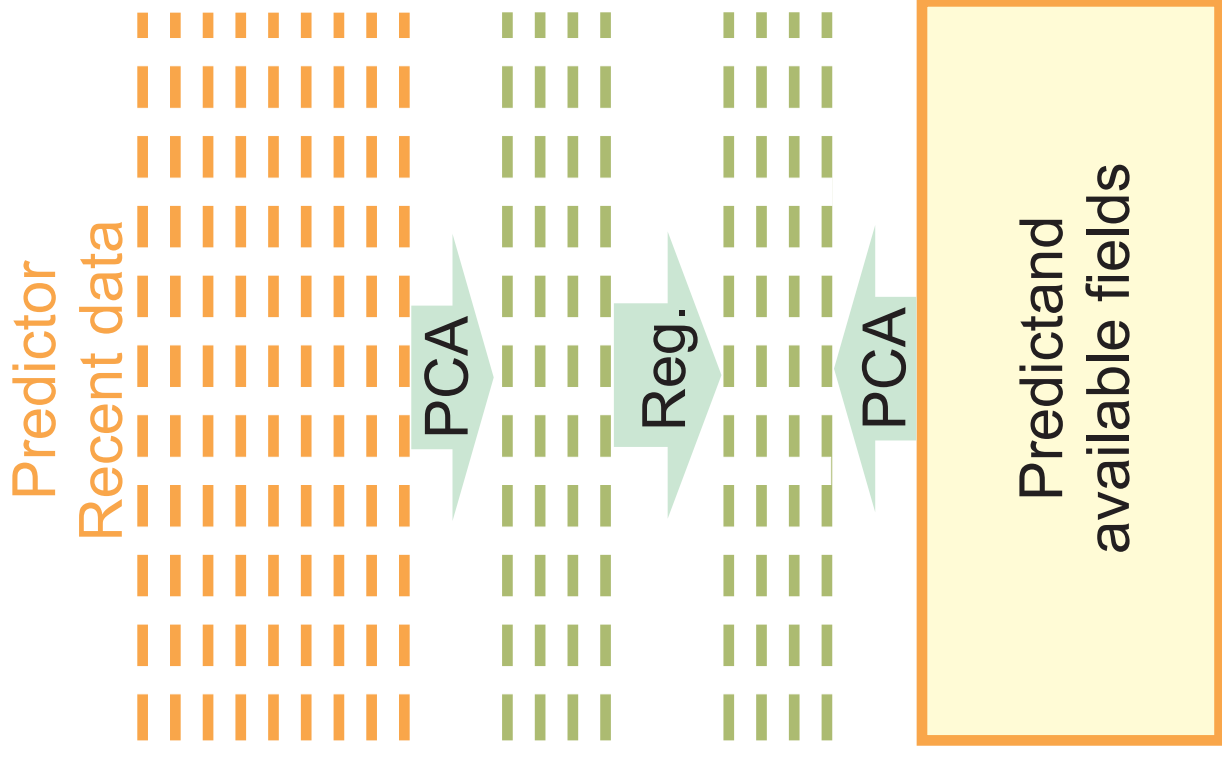
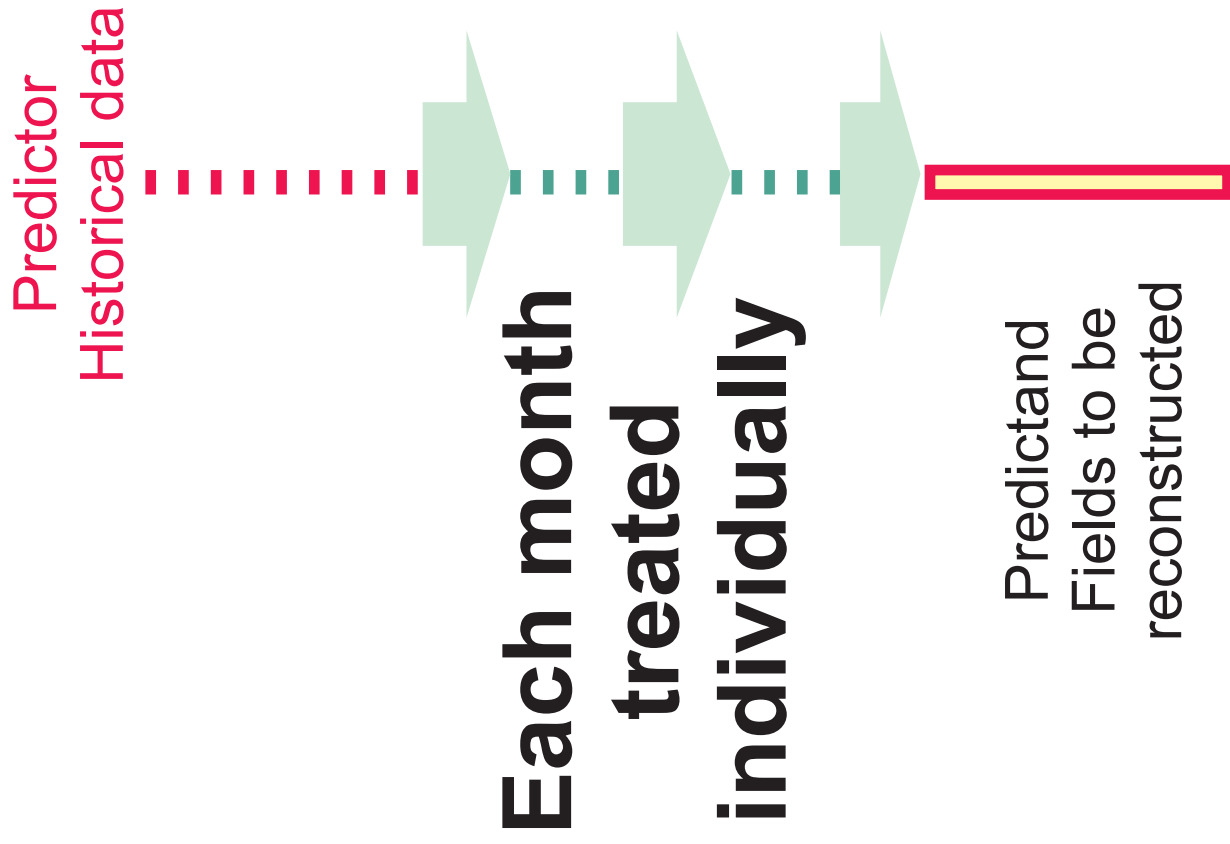
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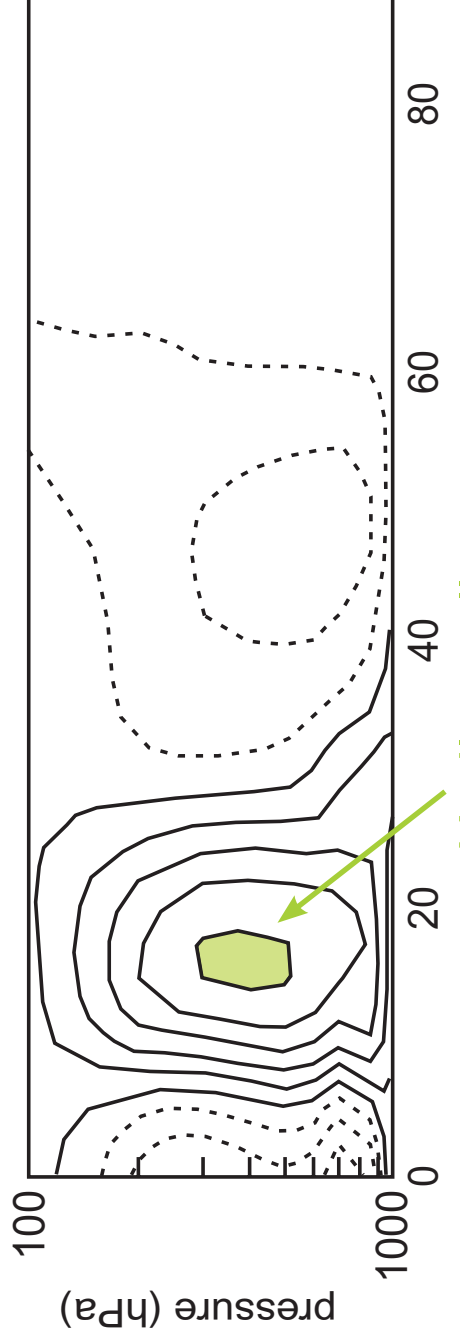
Some results

Conclusions



Directly reconstruct circulation indices

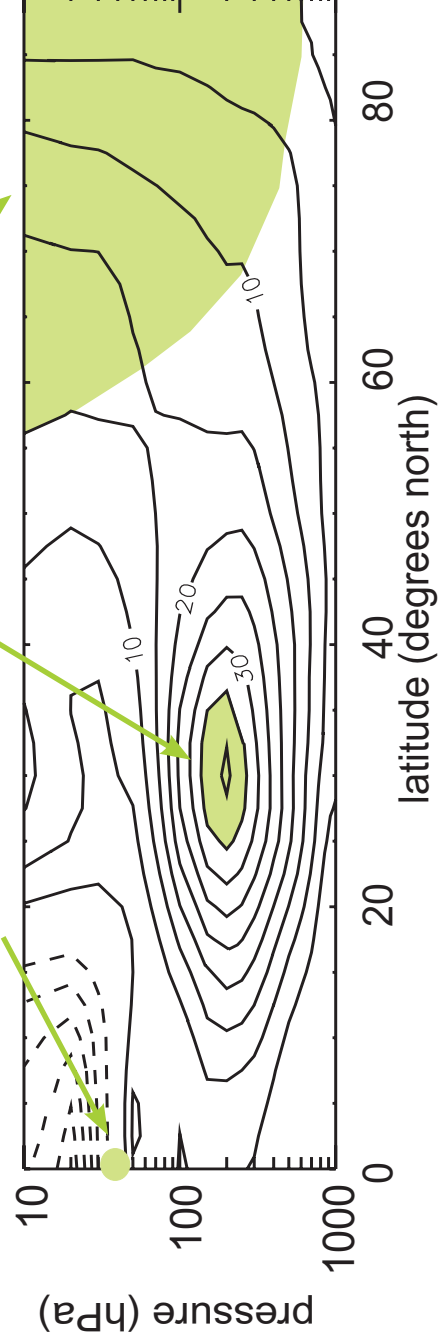
zonal mean meridional stream function



also: PNA

zonal mean zonal wind

QBO subtropical jet



Monthly global 3-D reconstructions, 1870-2005

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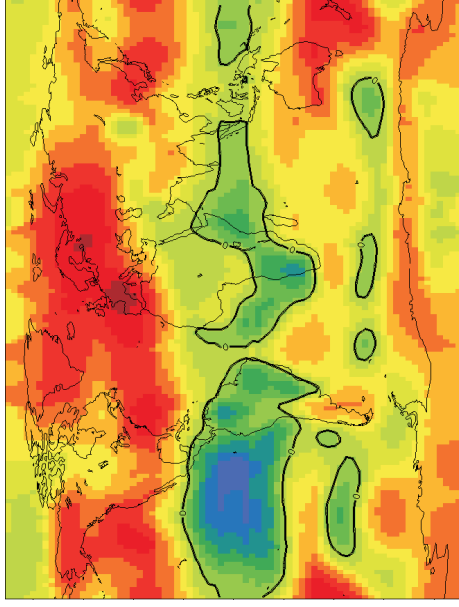
Reconstruction

Some results

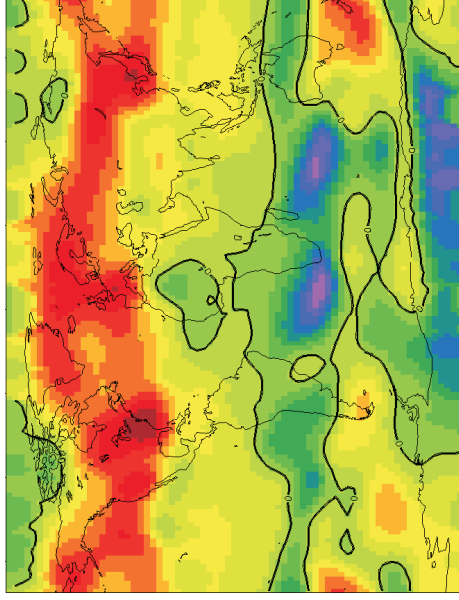
Conclusions

RE for geopotential height in 1905

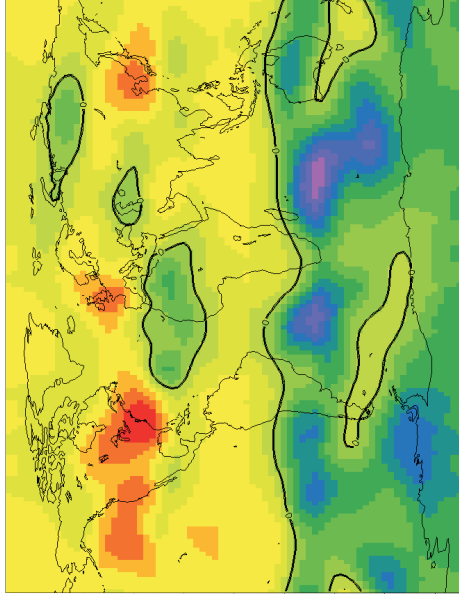
850 hPa



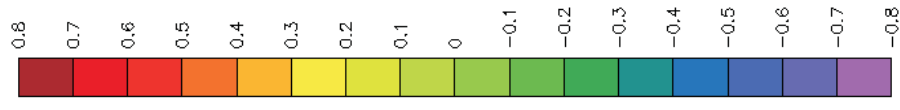
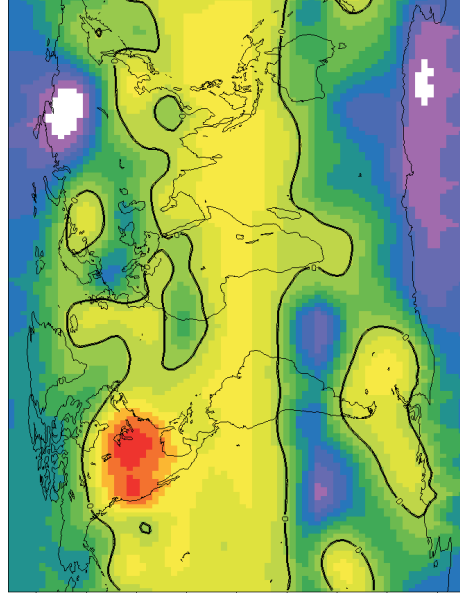
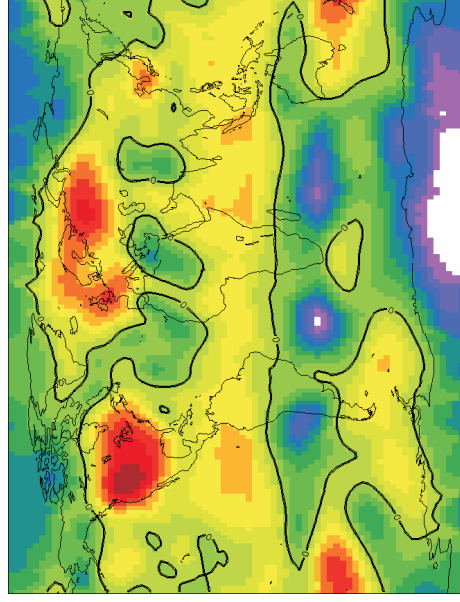
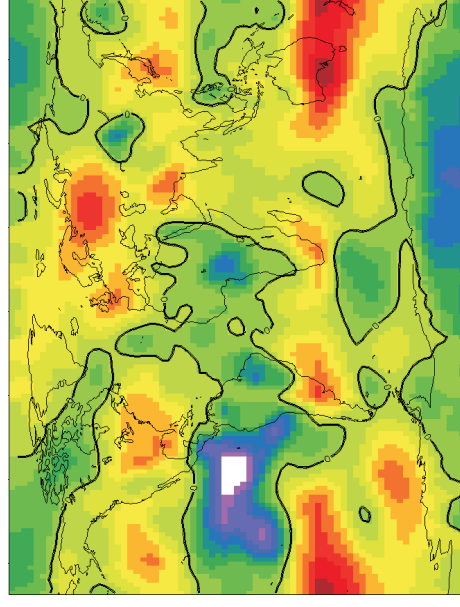
300 hPa



100 hPa



summer



Monthly global 3-D reconstructions, 1870-2005

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Historical data

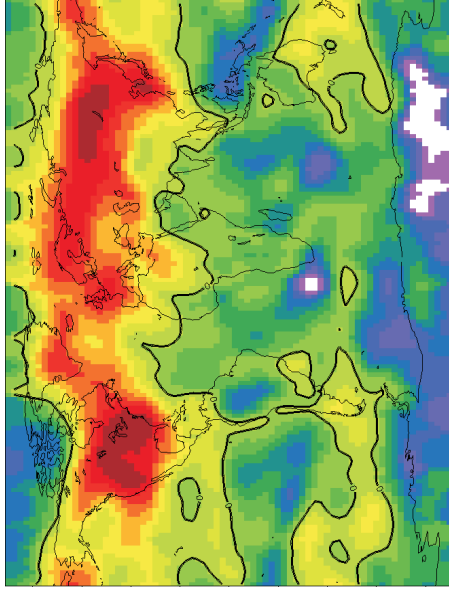
Reconstruction

Some results

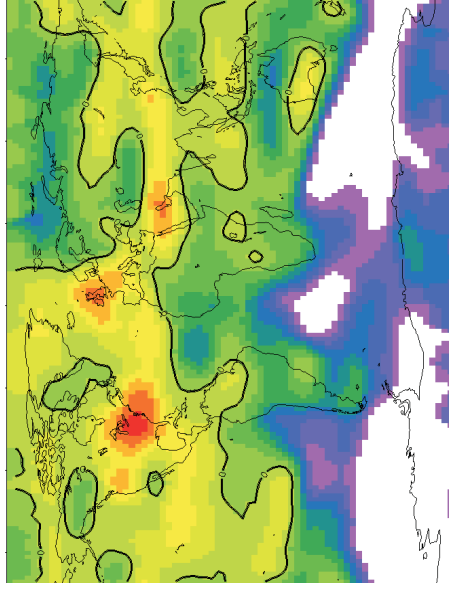
Conclusions

RE for temperature in 1905

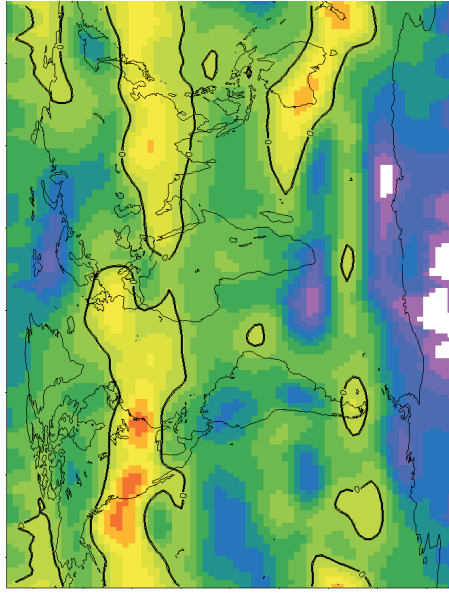
850 hPa



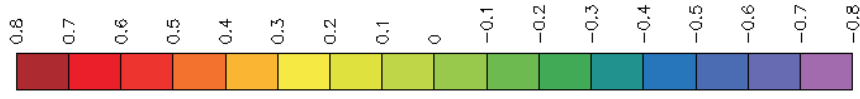
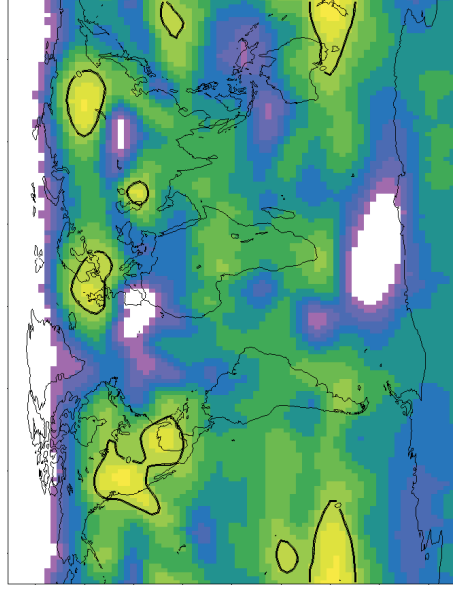
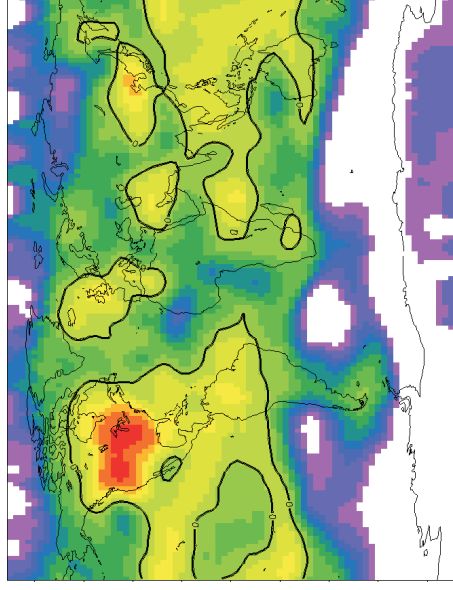
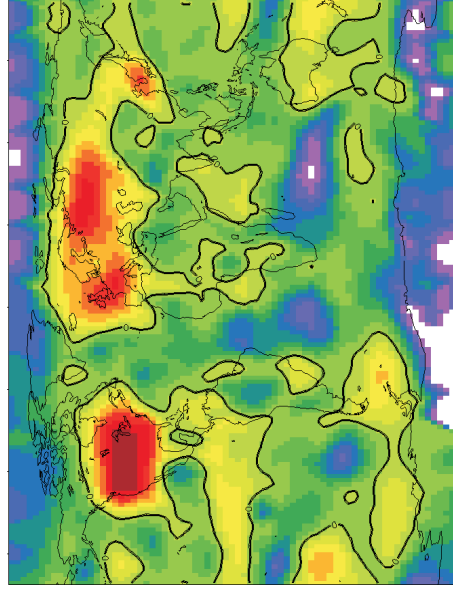
300 hPa



100 hPa



summer



Monthly global 3-D reconstructions, 1870-2005

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Some reconstructed fields will be presented
by Andreas Fischer (tomorrow, 9:55).

Monthly global 3-D reconstructions, 1870-2005

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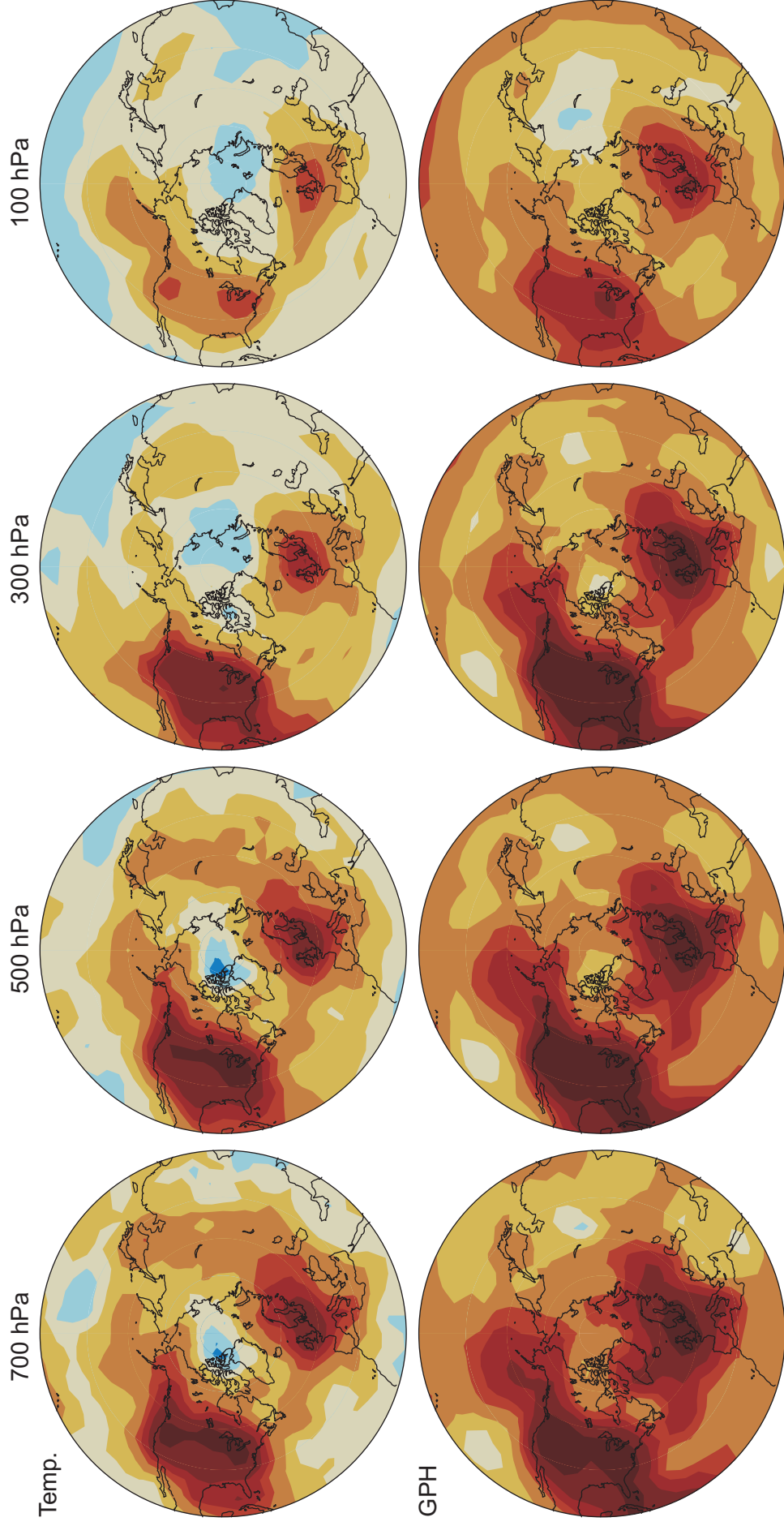
Historical data

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RE (year-round) in the 1940s



Monthly global 3-D reconstructions, 1870-2005

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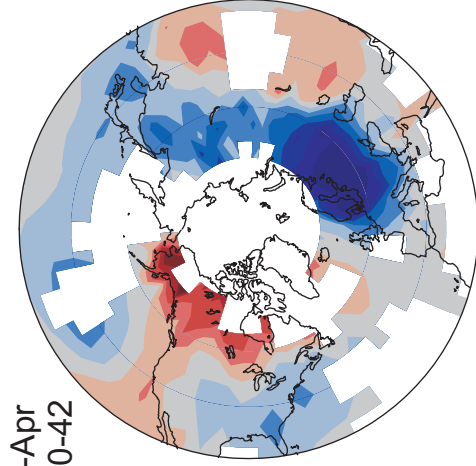
Reconstruction

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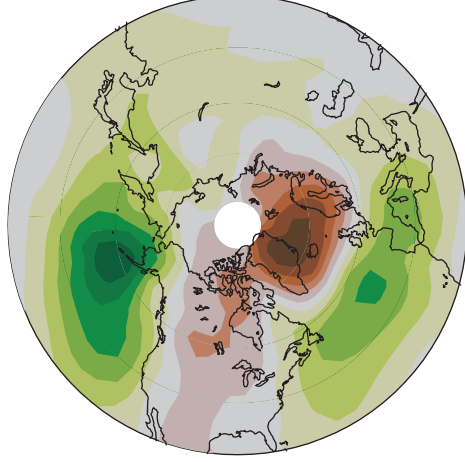
Winters 1940-1942, Reconstructions

Surface air temperature (K)

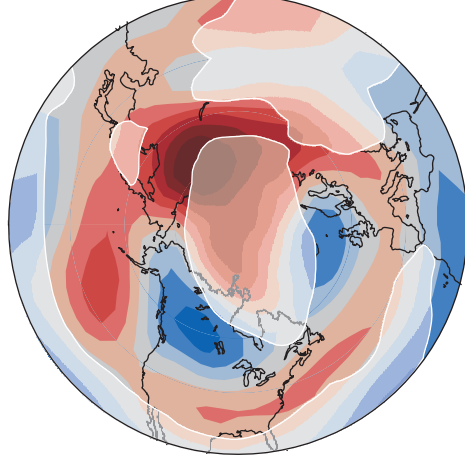


Jan-Apr
1940-42

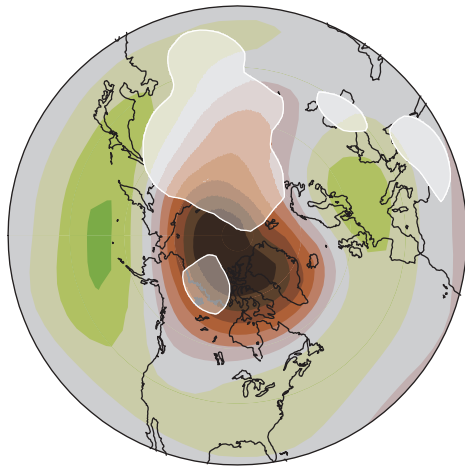
SLP (hPa)



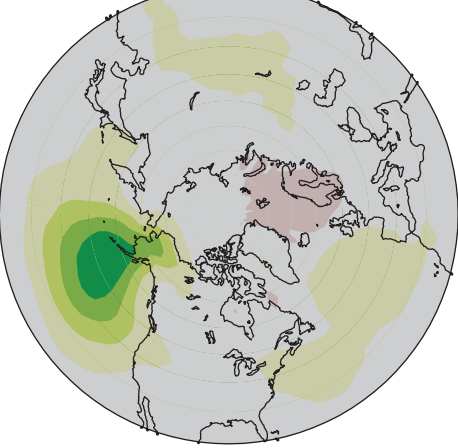
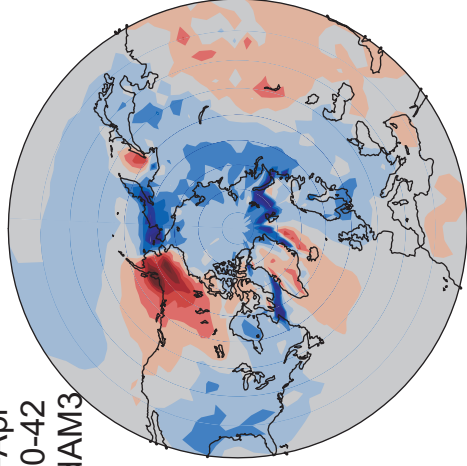
Temperature 100 hPa (K)



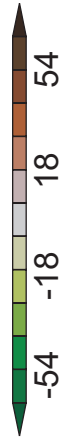
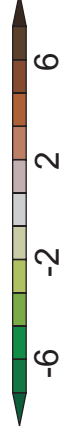
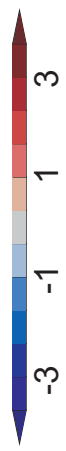
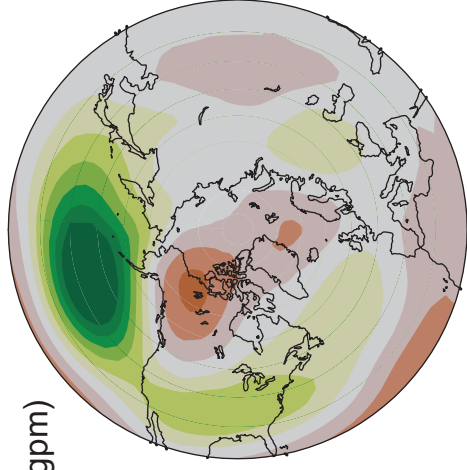
GPH 100 hPa (gpm)



Jan-Apr
1940-42
HadAM3



GPH 200 hPa (gpm)



Monthly global 3-D reconstructions, 1870-2005

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Historical data

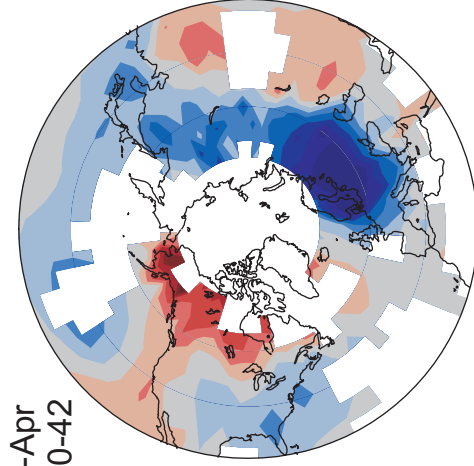
Reconstruction

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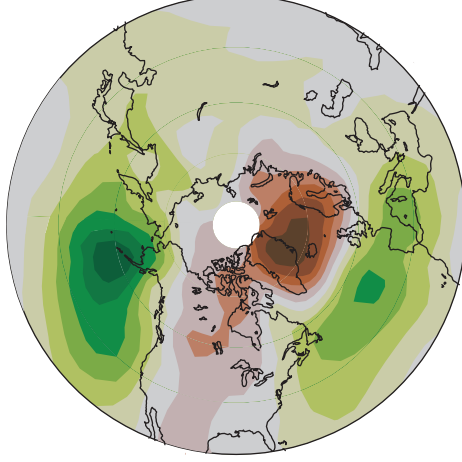
Winters 1940-1942, Reconstructions

Surface air temperature (K)

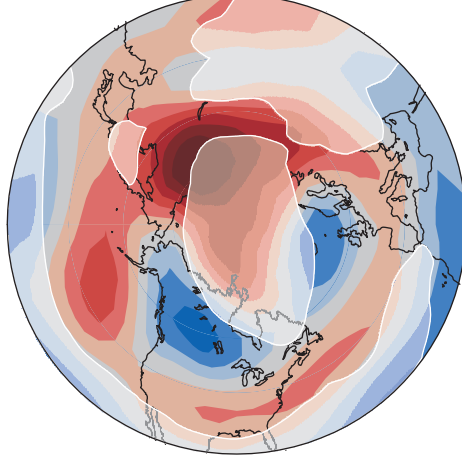


Jan-Apr
1940-42

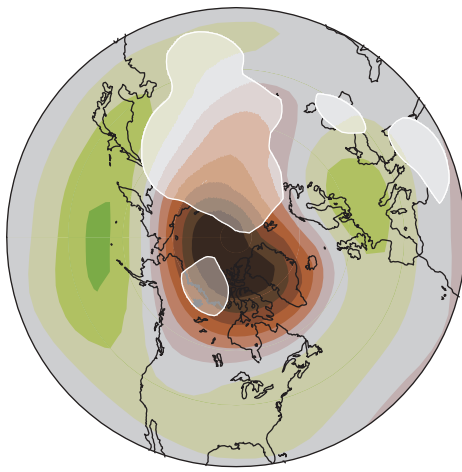
SLP (hPa)



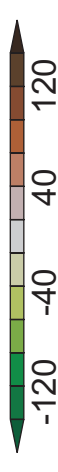
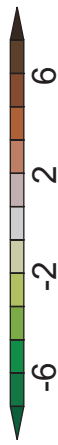
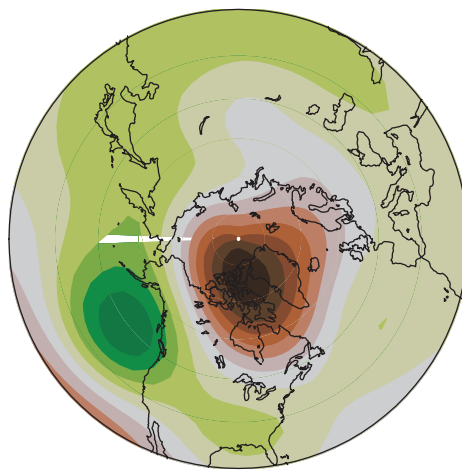
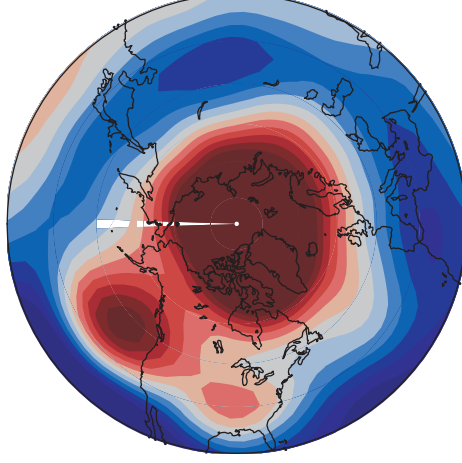
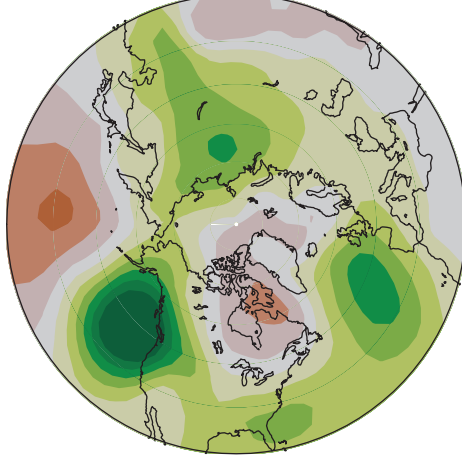
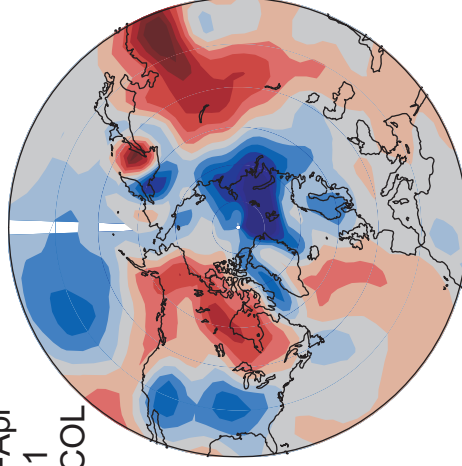
Temperature 100 hPa (K)



GPH 100 hPa (gpm)



Jan-Apr
1941
SOCOL



Monthly global 3-D reconstructions, 1870-2005

Introduction

Historical data

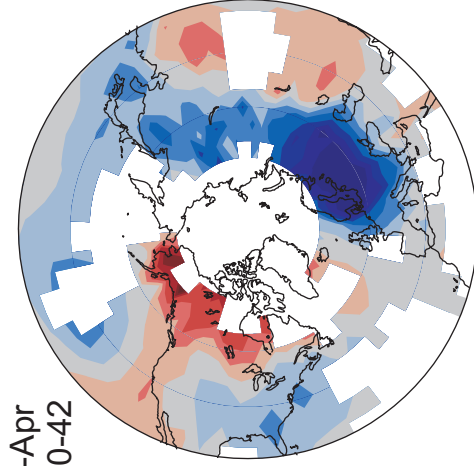
Reconstruction

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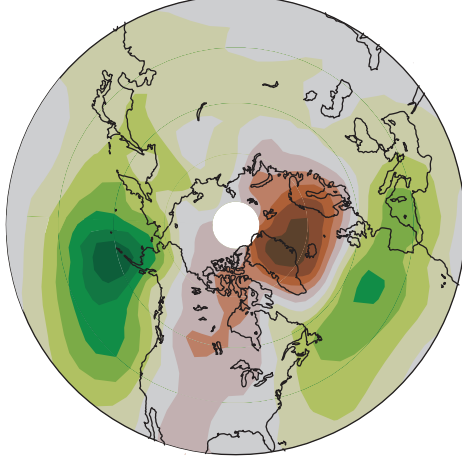
Winters 1940-1942, Reconstructions

Surface air temperature (K)

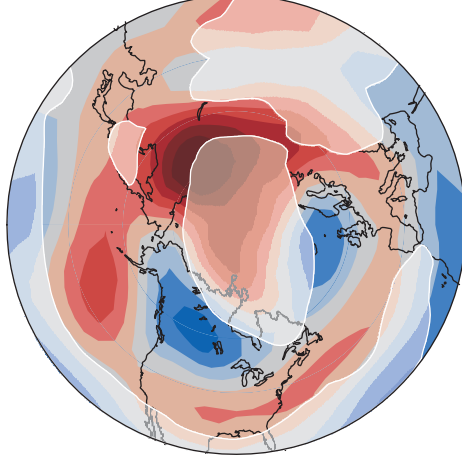


Jan-Apr
1940-42

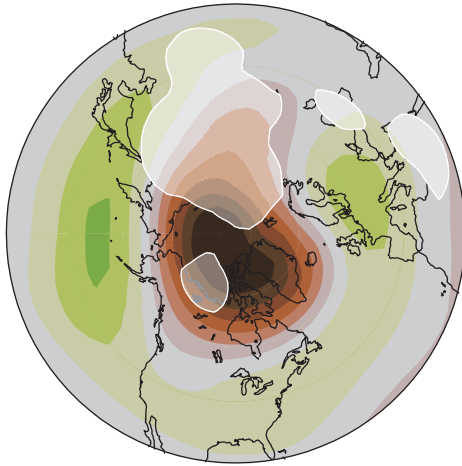
SLP (hPa)



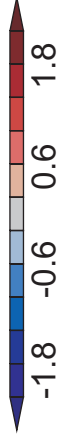
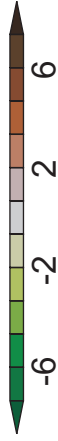
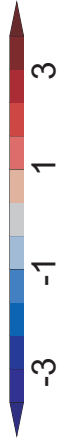
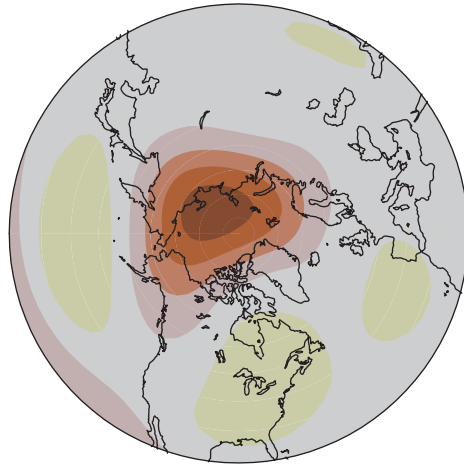
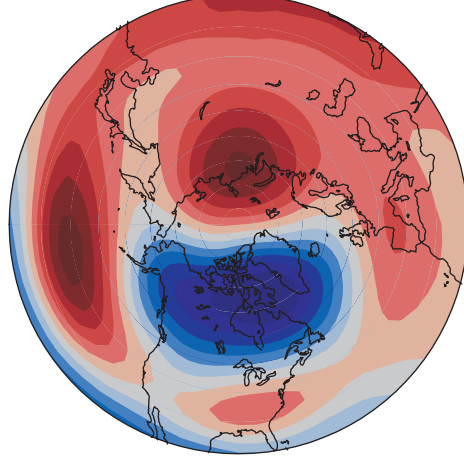
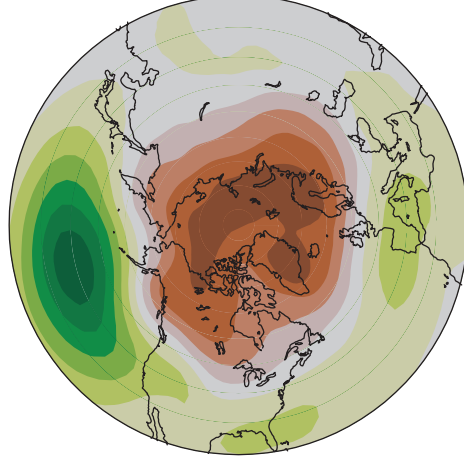
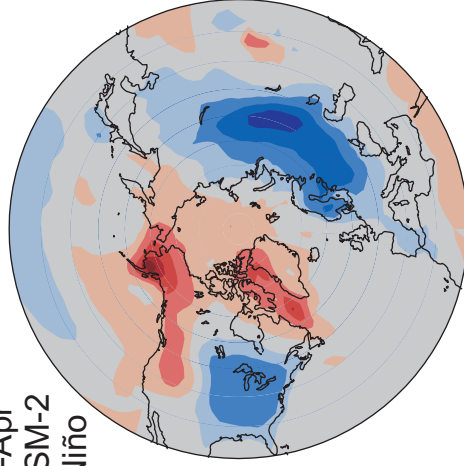
Temperature 100 hPa (K)



GPH 100 hPa (gpm)



Jan-Apr
CCSM-2
El Niño



Brönnimann et al., *Nature* 431, 971-974 (2004)

Conclusions and outlook

A global monthly 3-D data set back to 1870 (data until ~1920 are ready, rest is under construction)

Quality is sufficient for large signals, depends on

- variable (GPH better than T)
- level (lower levels better than upper levels)
- season (winter better than summer)
- time (later better than earlier years)

Reconstructions of QBO and Arctic sea ice back to 1900

Monthly global 3-D reconstructions, 1870-2005

Introduction

Historical data

Reconstruction

Some results

Conclusions

Thanks

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KLIMET research group (University of Bern),

Gil Compo (NOAA, Boulder), Roy Jenne (NCAR)

and all data providers!

Monthly global 3-D reconstructions, 1870-2005

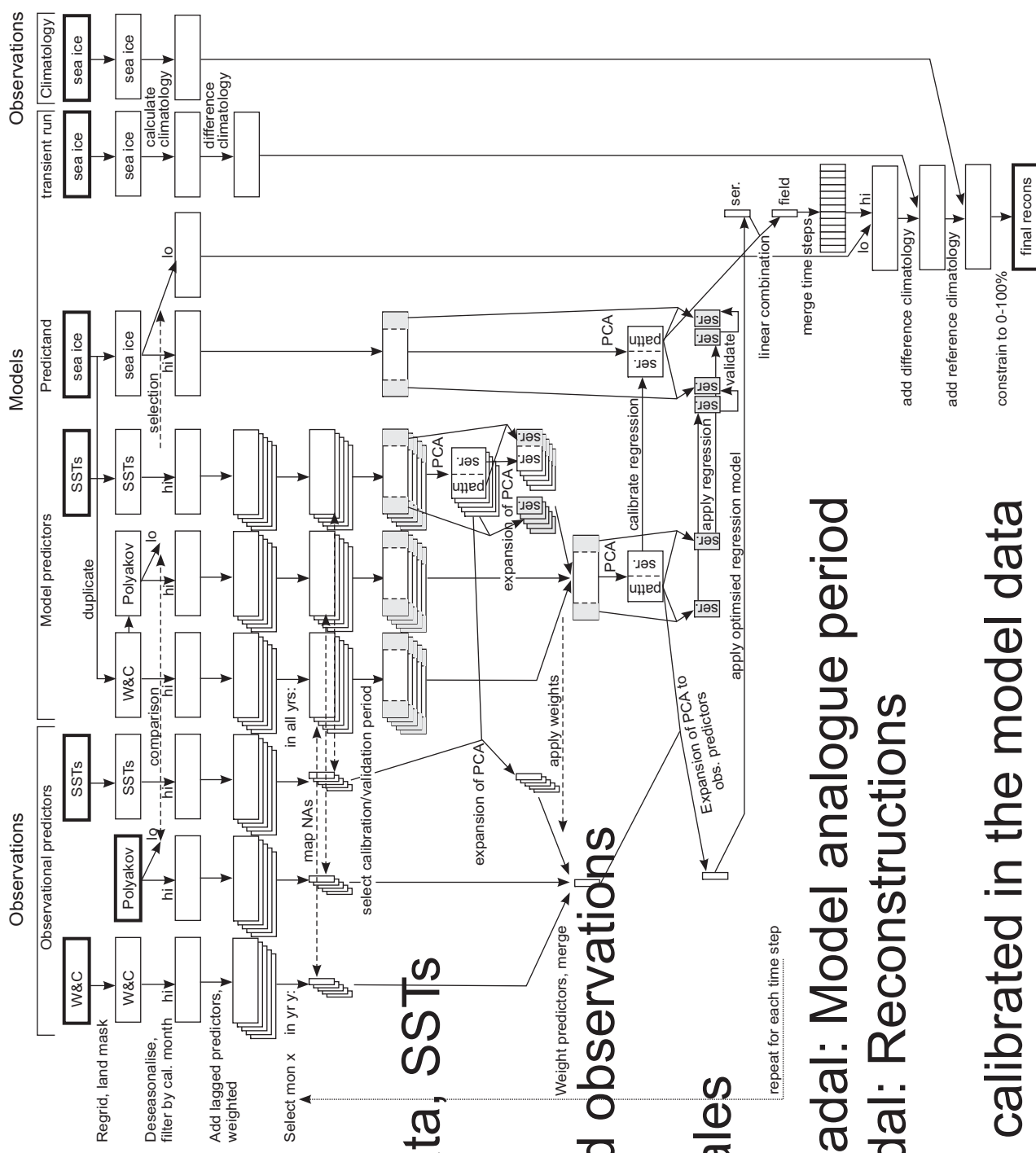
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Predictors
Historical sea ice data, SSTs

Hybrid approach:
combines model and observations

Separates times-scales

Focrcing: Model

Decadal-to-multidecadal: Model analogue period

Interannual-to-decadal: Reconstructions

Reconstructions are calibrated in the model data