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CLIMATE CHANGE RESEARCH

PAGES Solar-Climate Meeting

Solar imprint in climate reconstructions and reanalyses

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Outline

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- Introduction
- Data: Proxies, reconstructions, reanalyses, assimilation
- Imprint of the 200-yr De Vries cycle in tree rings during the past 2000 yrs
- Imprint of the 11-yr solar cycle on upper-level circulation and ozone during the past 100-150 yrs
- Conclusions and outlook

Low-frequency solar variabiity and temperature

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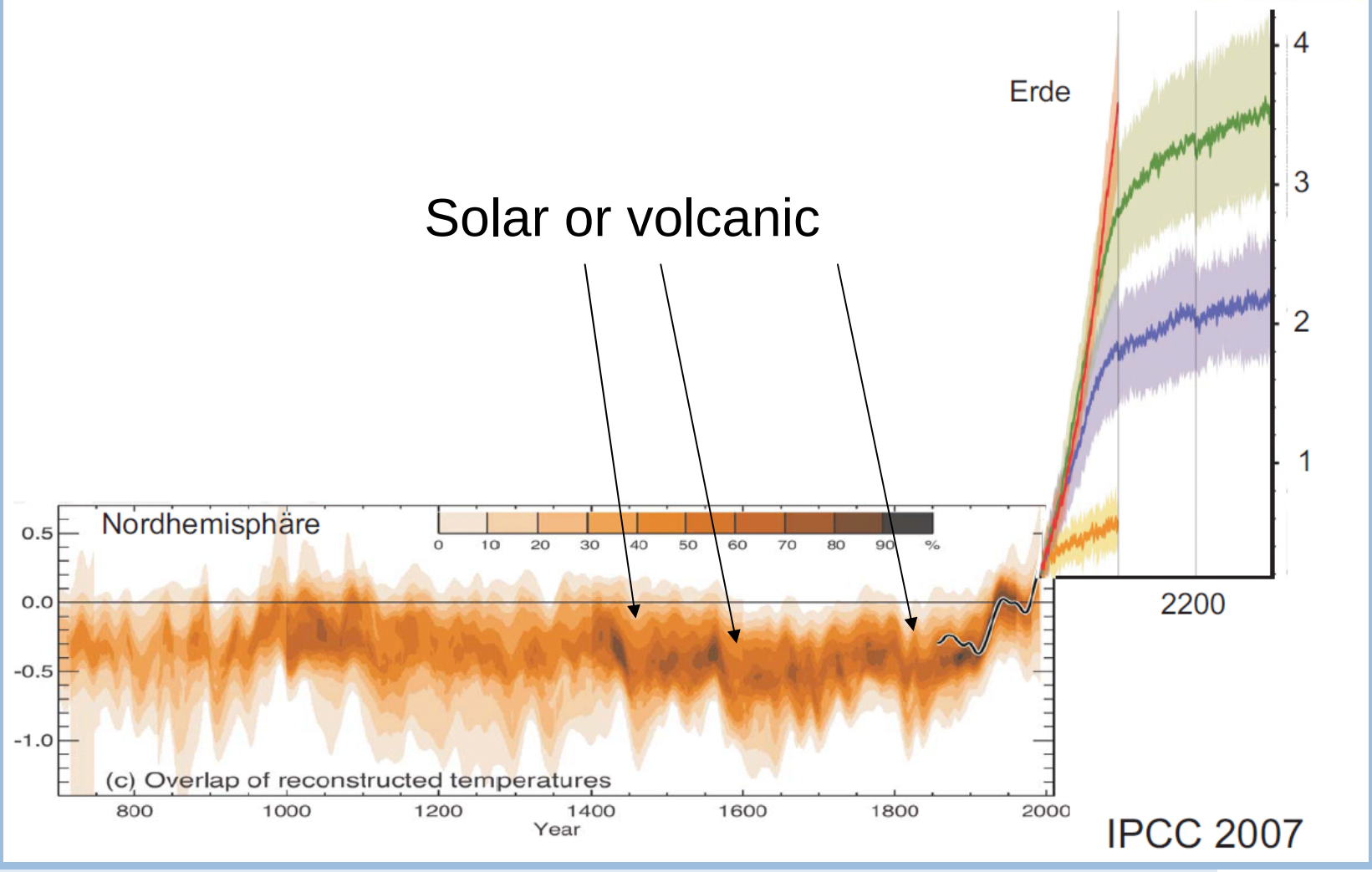

Solar cycle imprint in 3-D fields

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Mechanisms unknown

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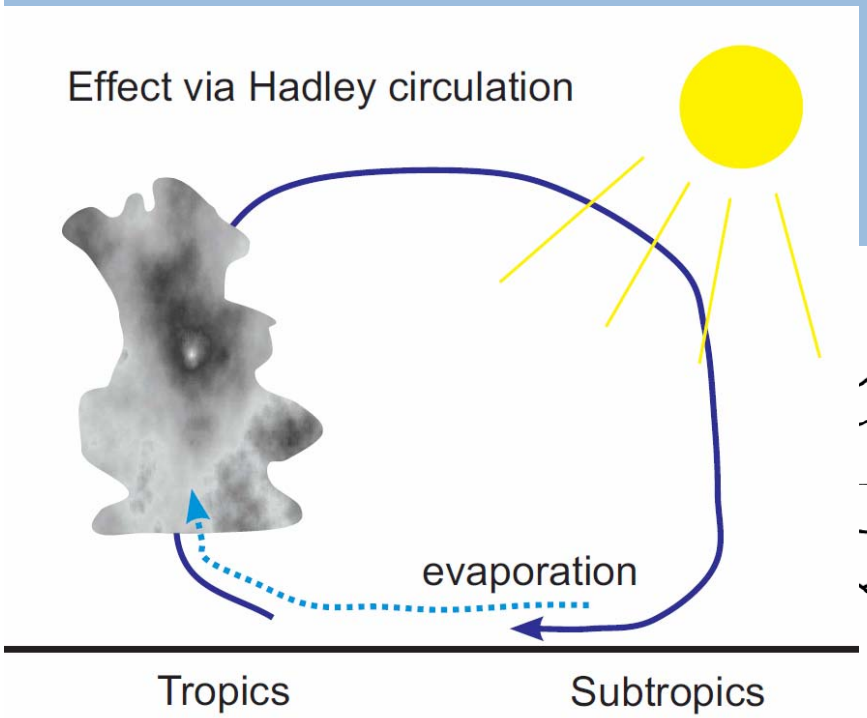

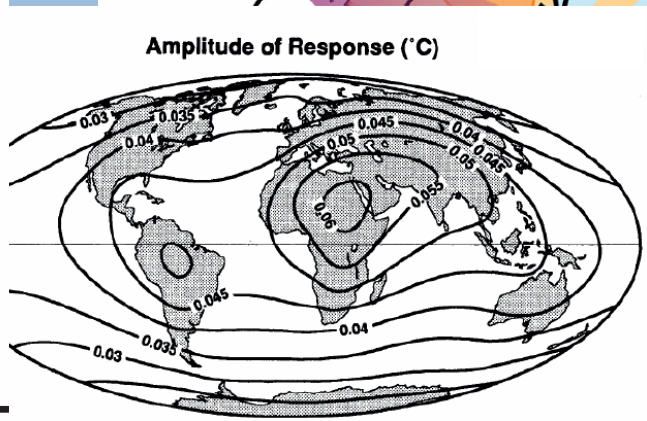

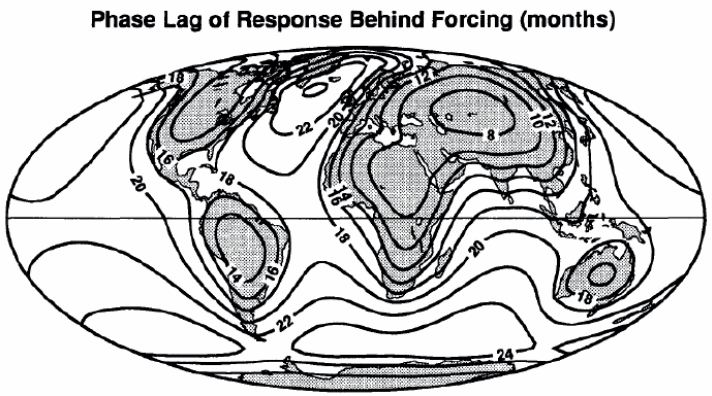

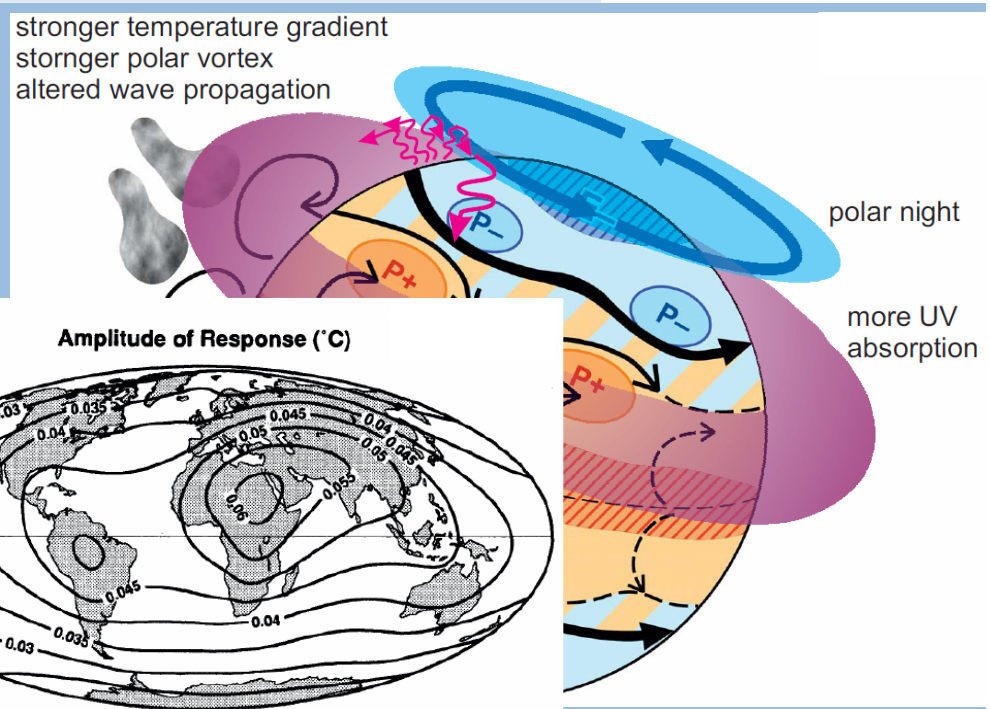

Data

- Proxies: Tree rings
- Reanalyes
- Upper-level reconstructions
- Ozone assimilation

Network of 2K tree ring chronologies

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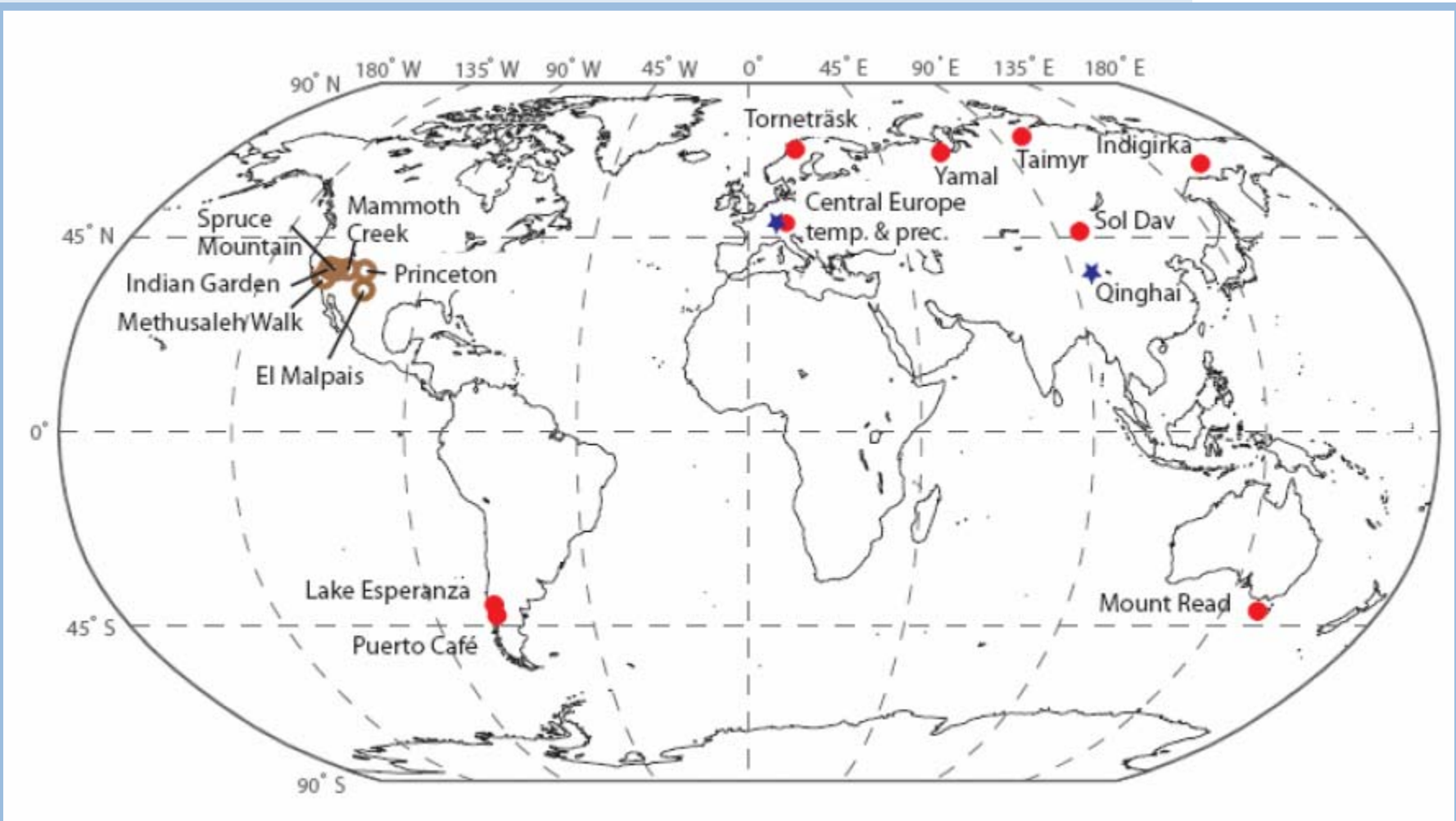

Breitenmoser et al. 2012

The Twentieth Century Reanalyses

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Global 6-hourly 3-d data set back to 1871 based on Ensemble Kalman Filter assimilation of surface and sea-level pressure plus SST/sea ice as boundary condition (Compo et al. 2011)

Comparison with radiosonde data

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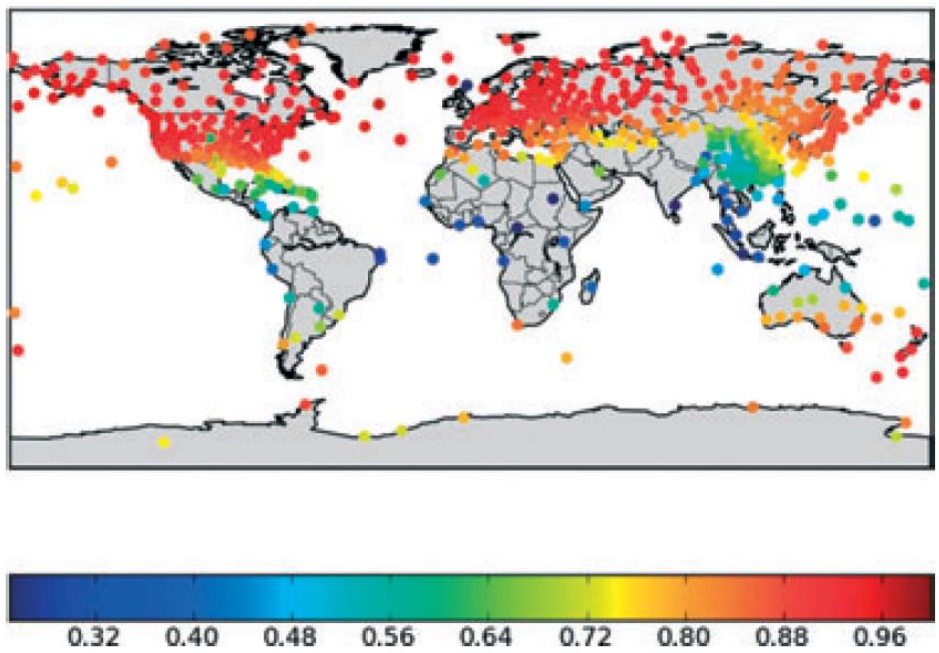
> Correlation with 300 hPa GPH (Compo et al. 2011)



Upper-level reconstructions

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> REC1: Statistical reconstruction (large-scale PCs), back to 1880, monthly, global, GPH/Temp, 6 levels, uses SLP, temperature, upper-air data

> REC2: Statistical reconstruction (grid columns; „cone of influence“), back to 1920s, monthly, global (with many gaps), 6 levels, Temp, GPH, wind, uses SLP, temperature and upper-air data

REC2 and 20CR are quasi-independent

Reconstructions

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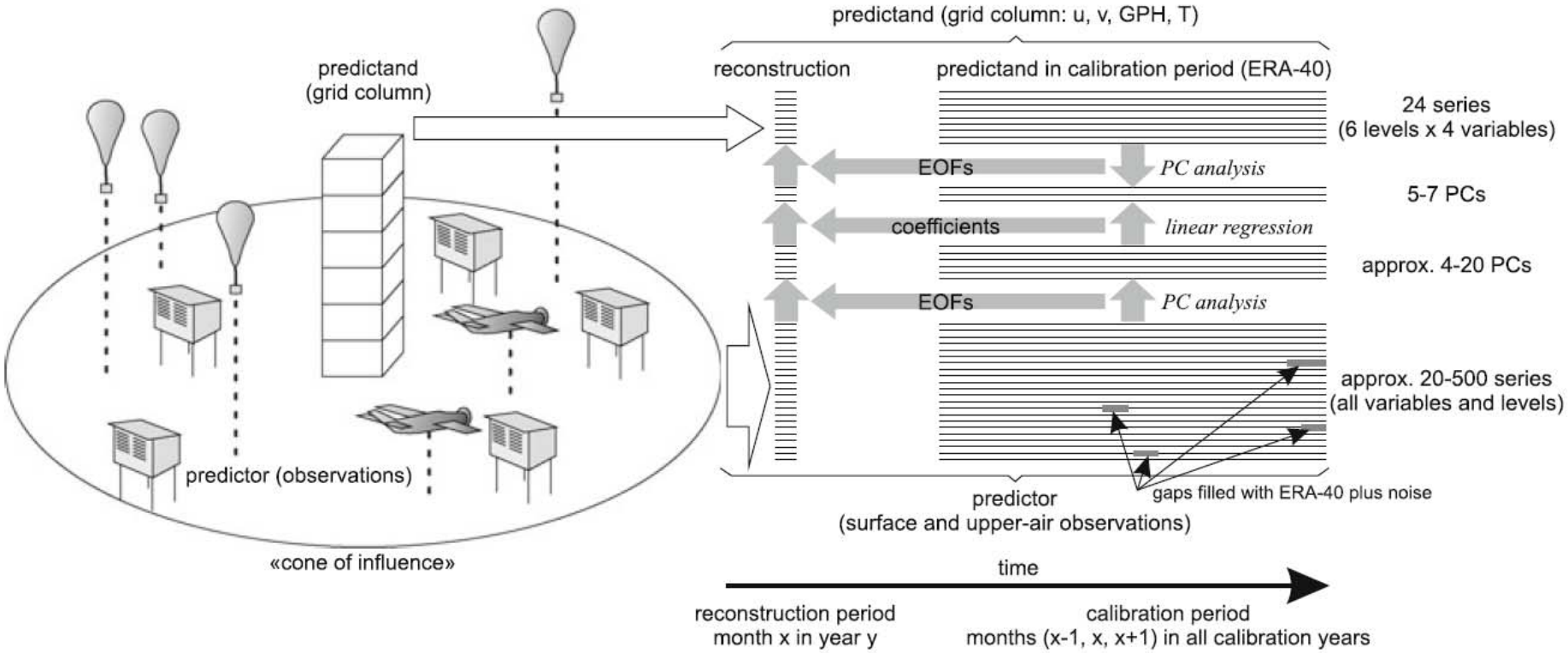
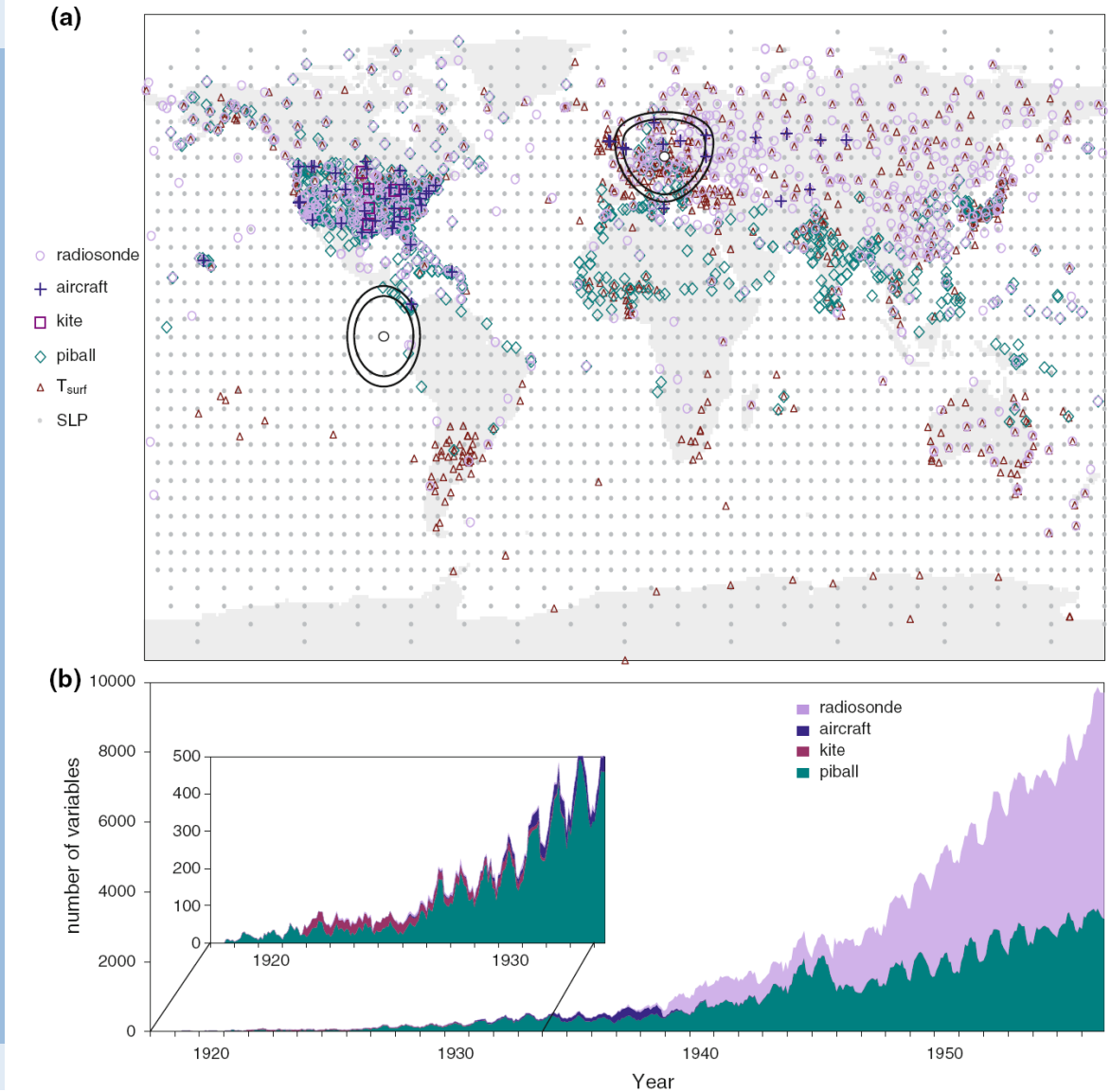


Predictor data



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Performance: Winter in European Arctic

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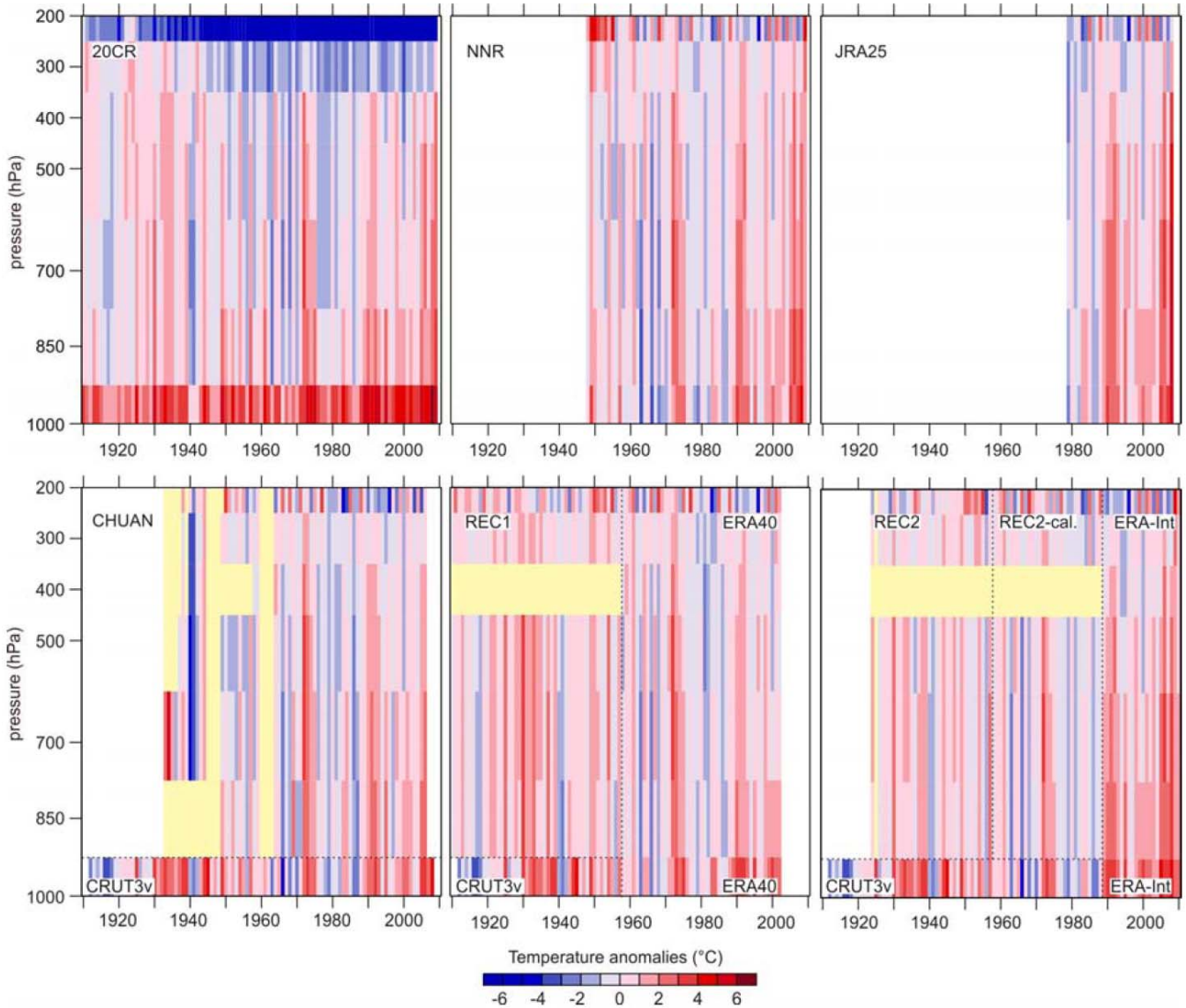

Ozone assimilation

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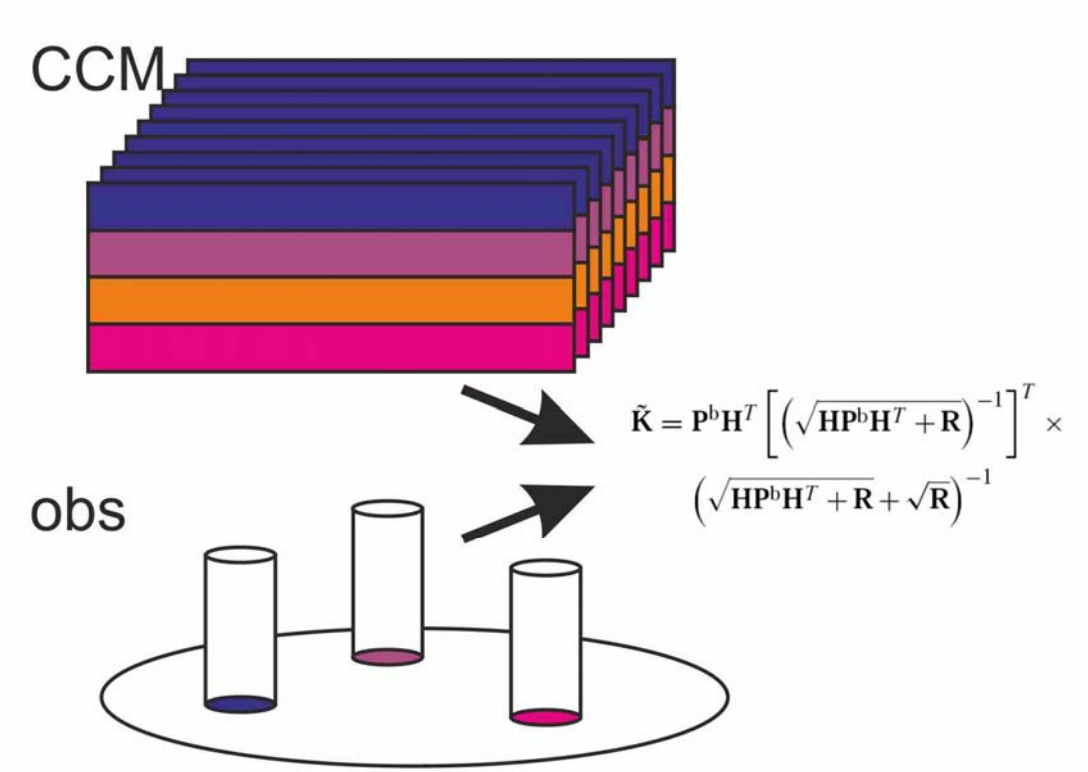
- „Off-line“ assimilation of historical total ozone data in Ensemble of Chemistry-Climate Model simulation
- Monthly, 2D (lat-alt), back to 1900 (but no observations assimilated before 1920s



Historical observations

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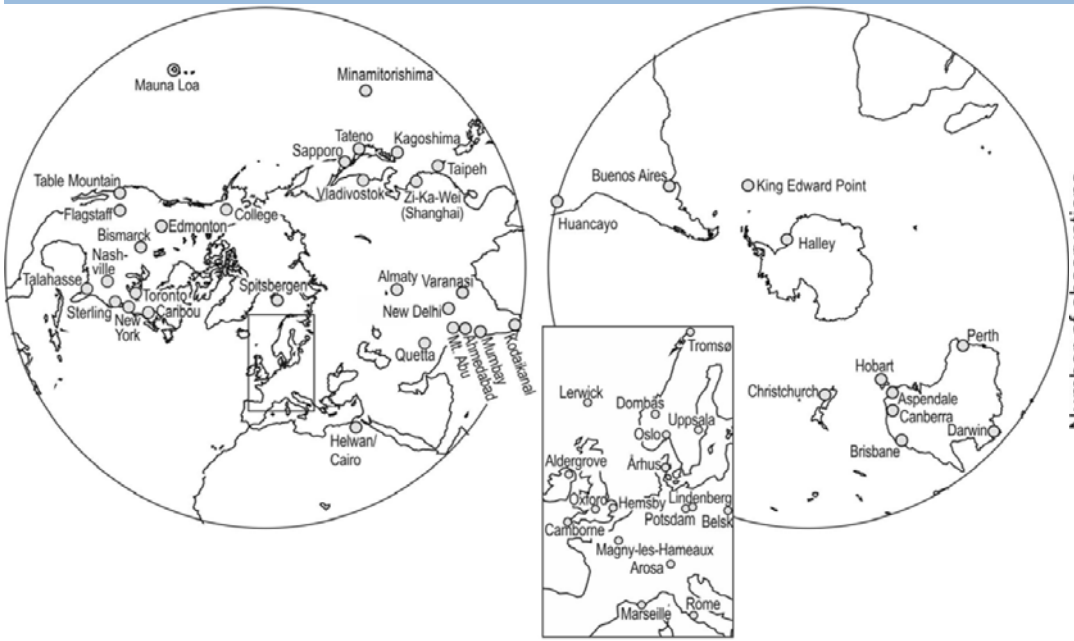
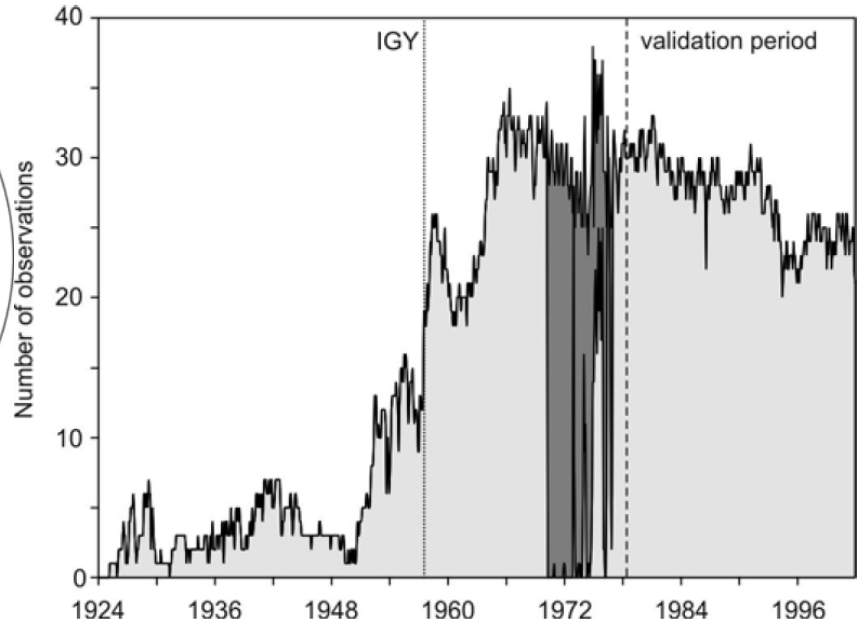
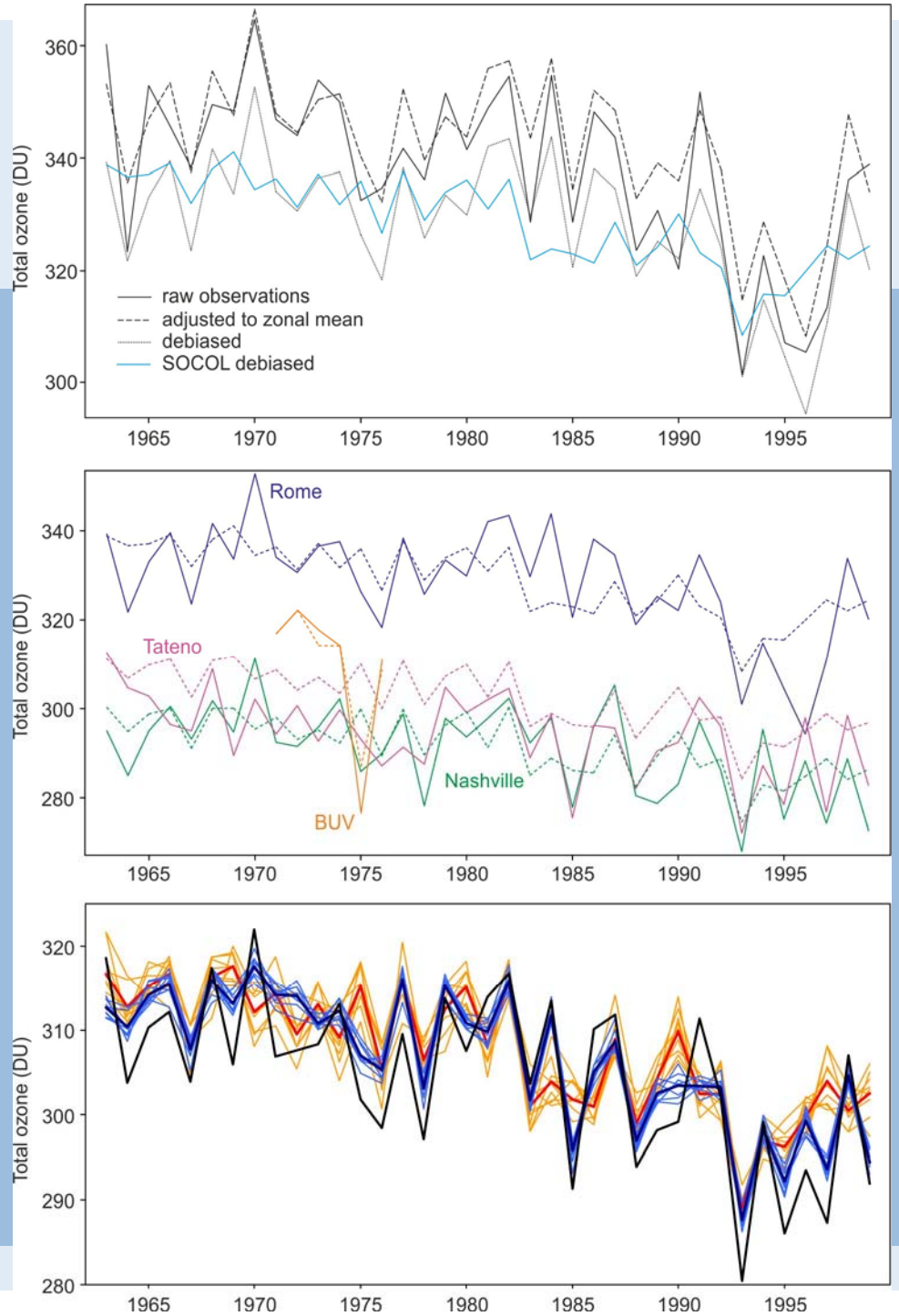




Ozone Assimilation



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Solar data

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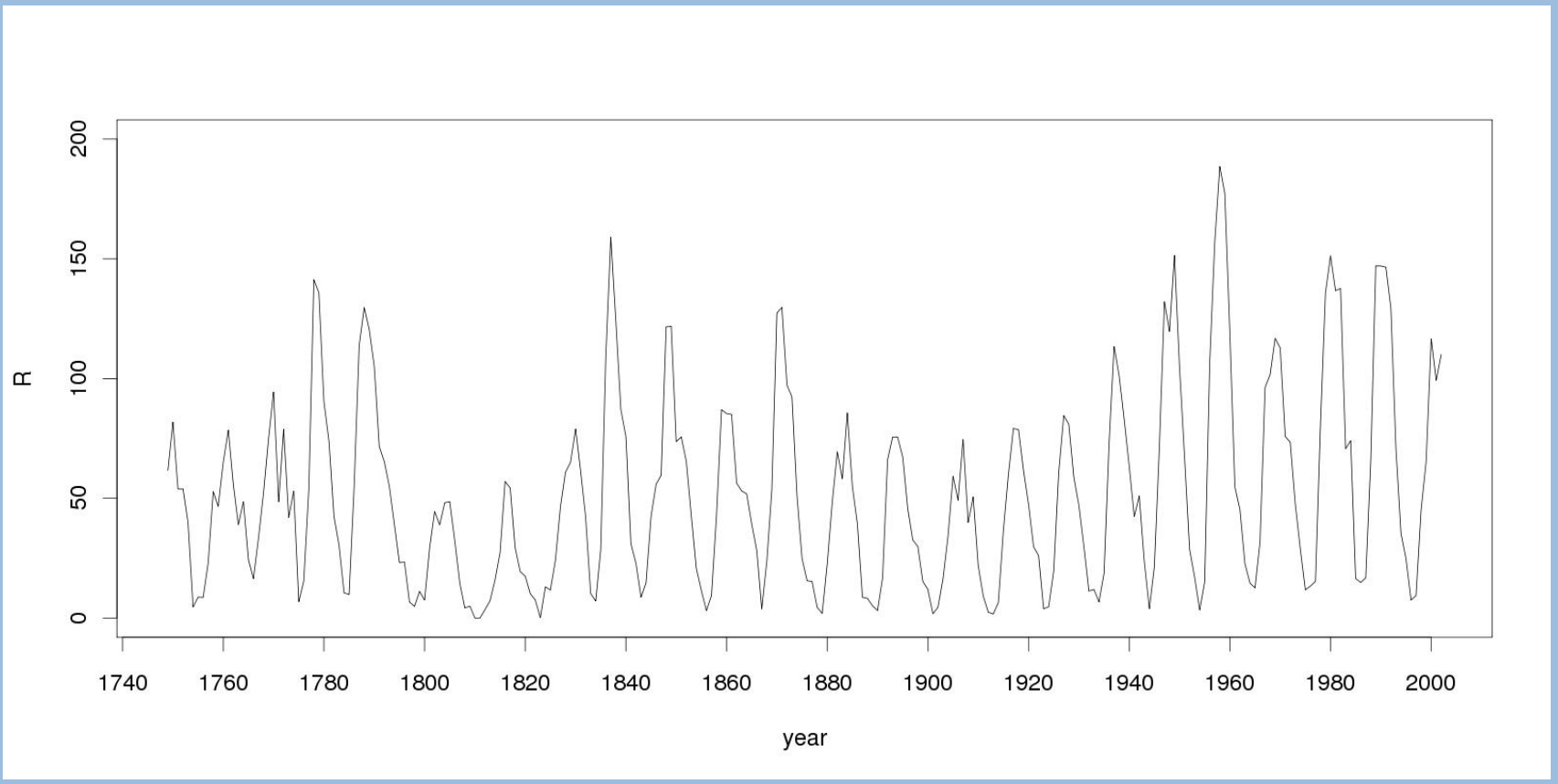
> Sunspot number



Results

- Imprint of the 200-yr De Vires cycle in tree ring chronologies
- Imprint of the 11-yr sunspot cycle in atmospheric circulation
- Imprint of the 11-yr sunspot cycle in ozone

Spectral analysis of raw chronologies

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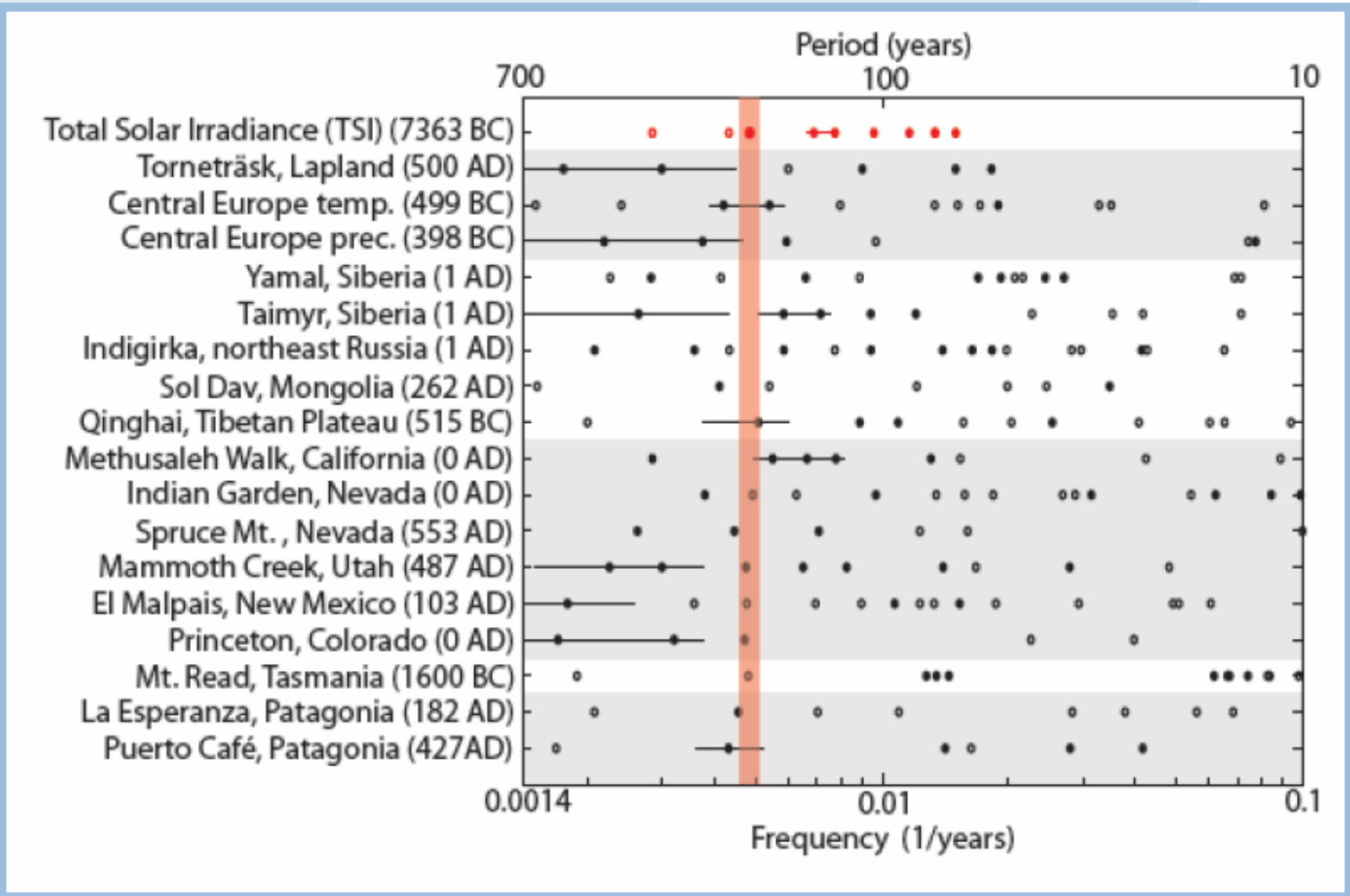

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Phase relations of raw chronologies

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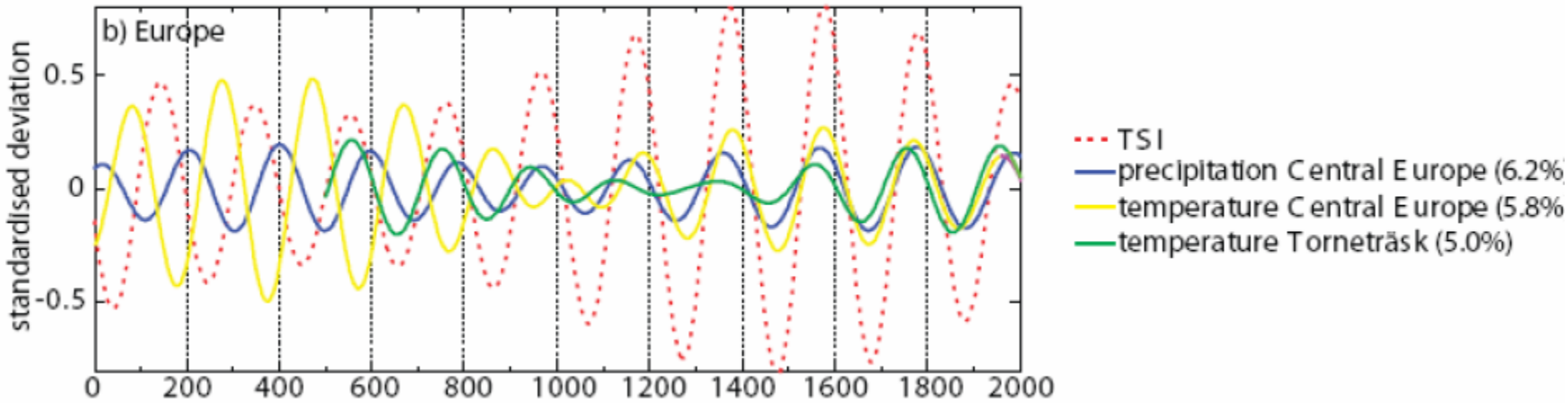

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Removal of volcanic influence

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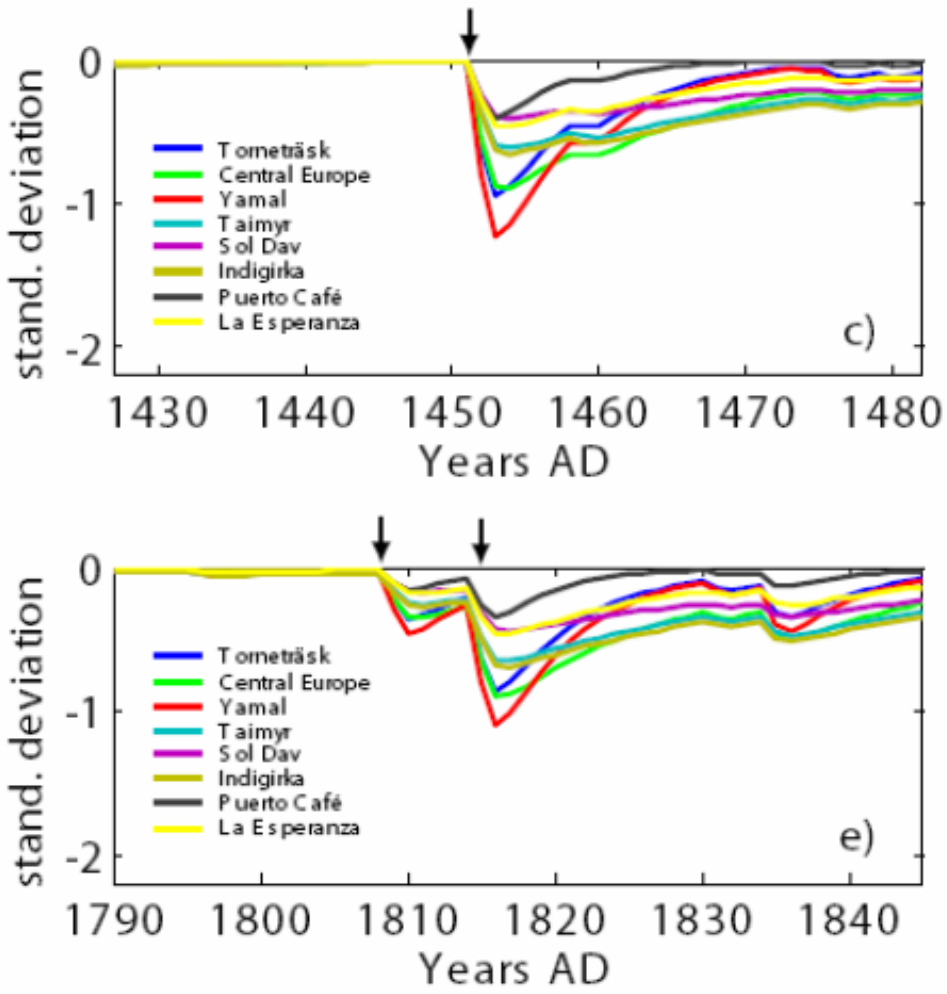
$$T(t) = T(t-1)*e^{-a\Delta t} - b*AOD$$



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„Volcanic“ and „residual“ spectra

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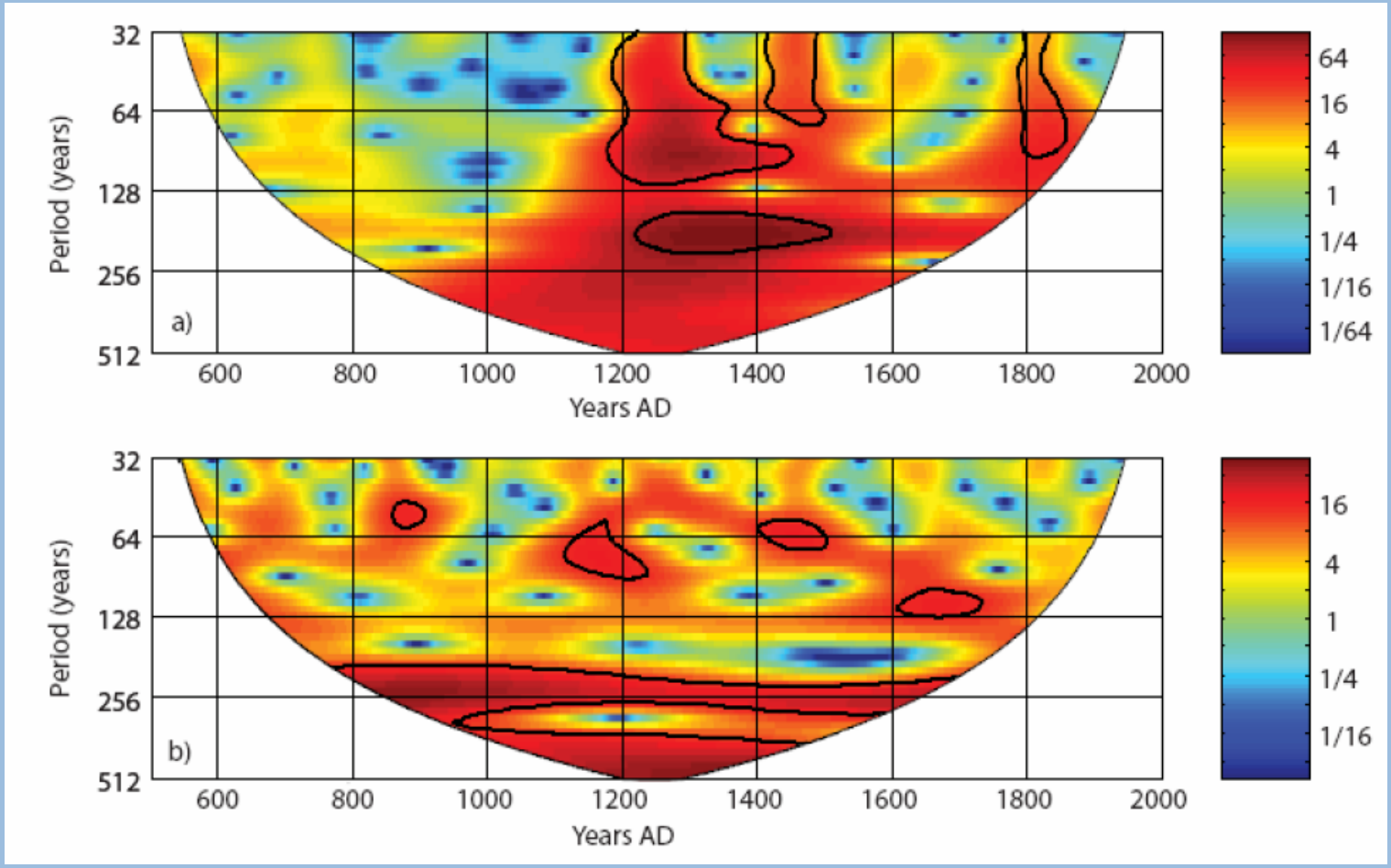

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Imprint of the 11-yr cycle

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- Compositing (max-min)
- Multiple linear regression
- Multiple data sets
- Multiple time periods

Jürg Luterbacher‘s SLP reconstructions

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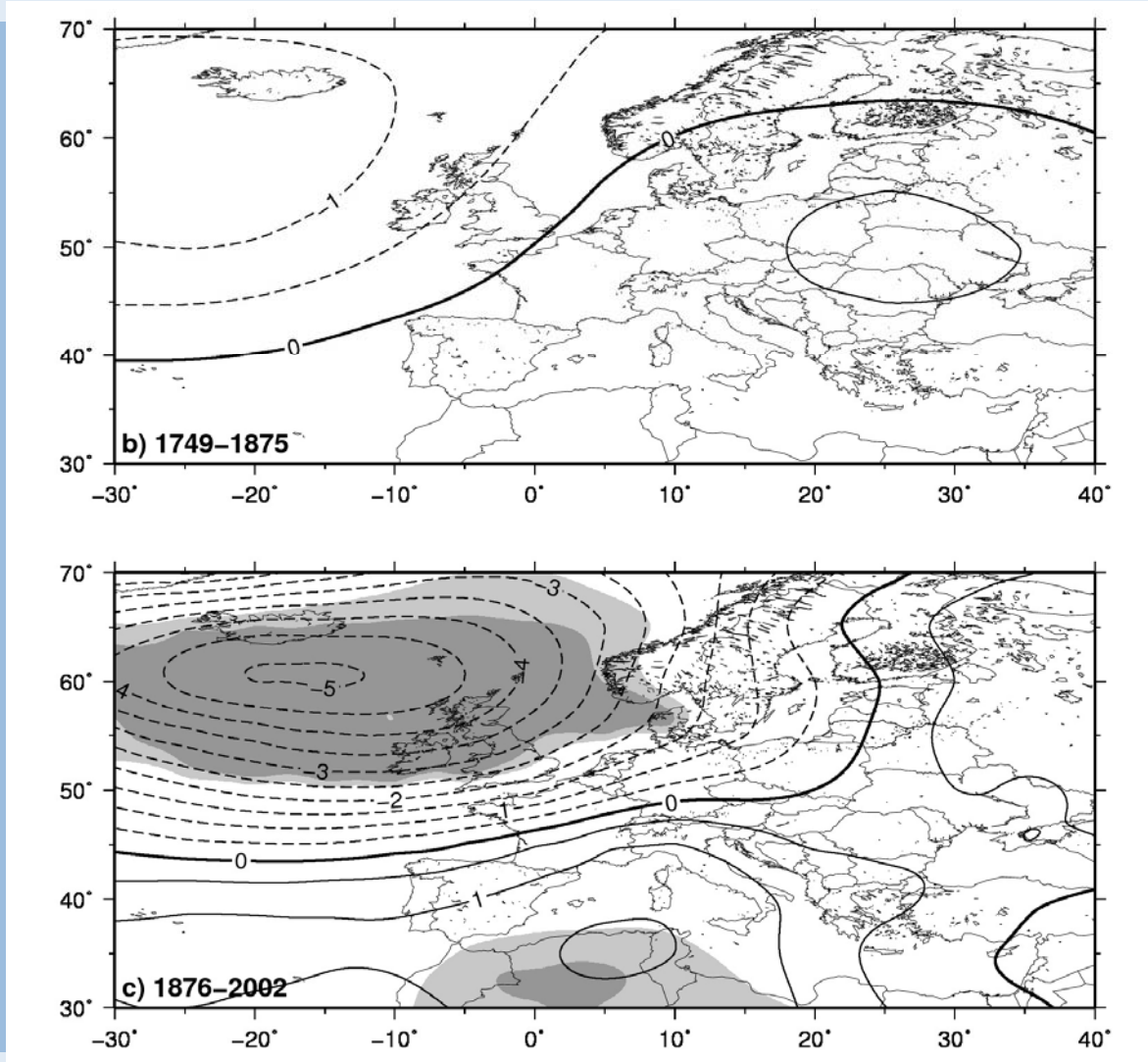

Brugnara et al. 2012

Jürg Luterbacher‘s index reconstructions

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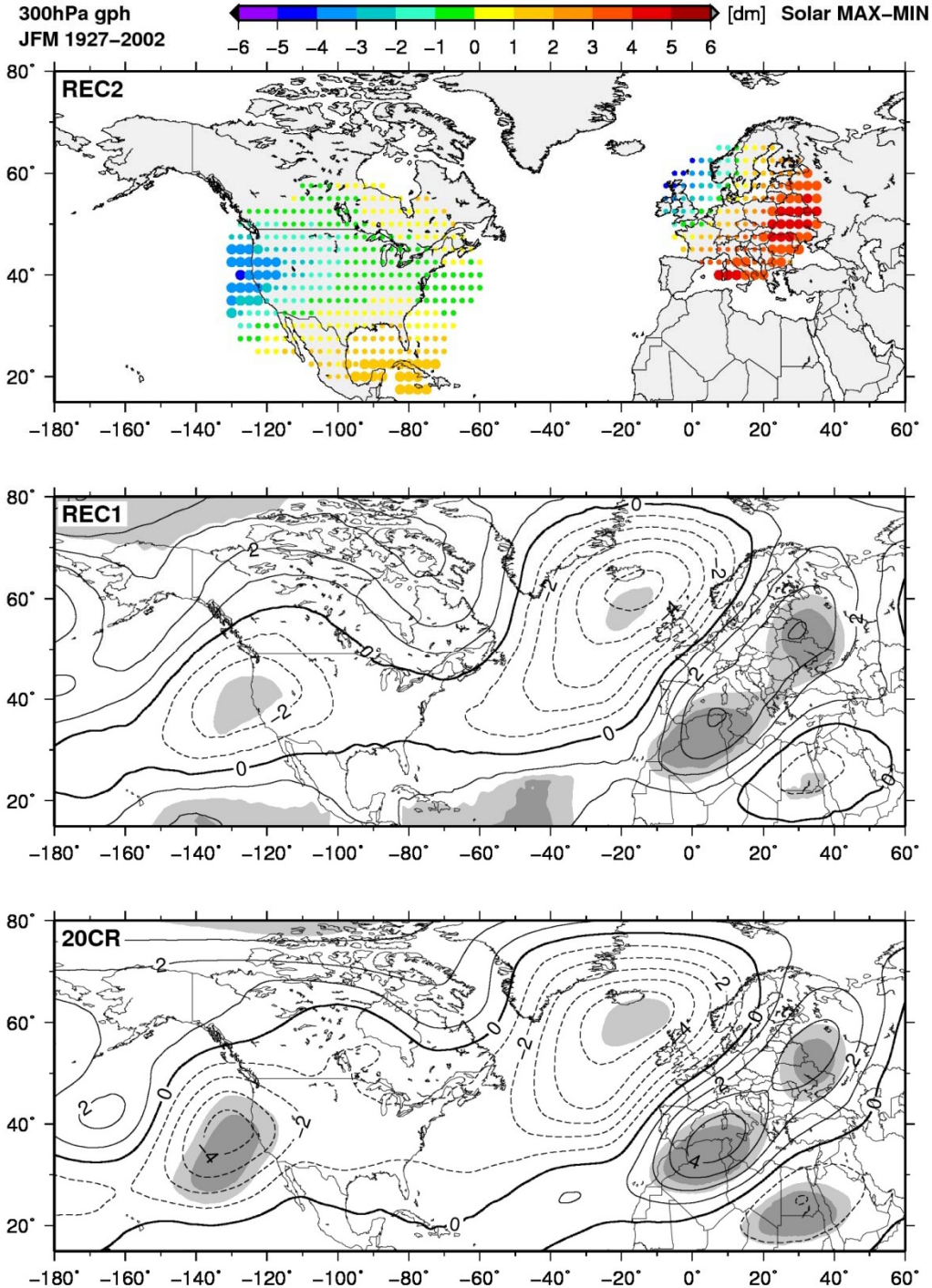
	1751-1990	1751-1870	1871-1990
NAO1	0.10	0.03	0.15
NAO2	0.09	0.03	0.11
EU1	**-0.26**	-0.06	**-0.37**
EU2	*-0.16*	-0.02	*-0.25*

Brugnara et al. 2012

300 hPa GPH composite



Brugnara et al. 2012

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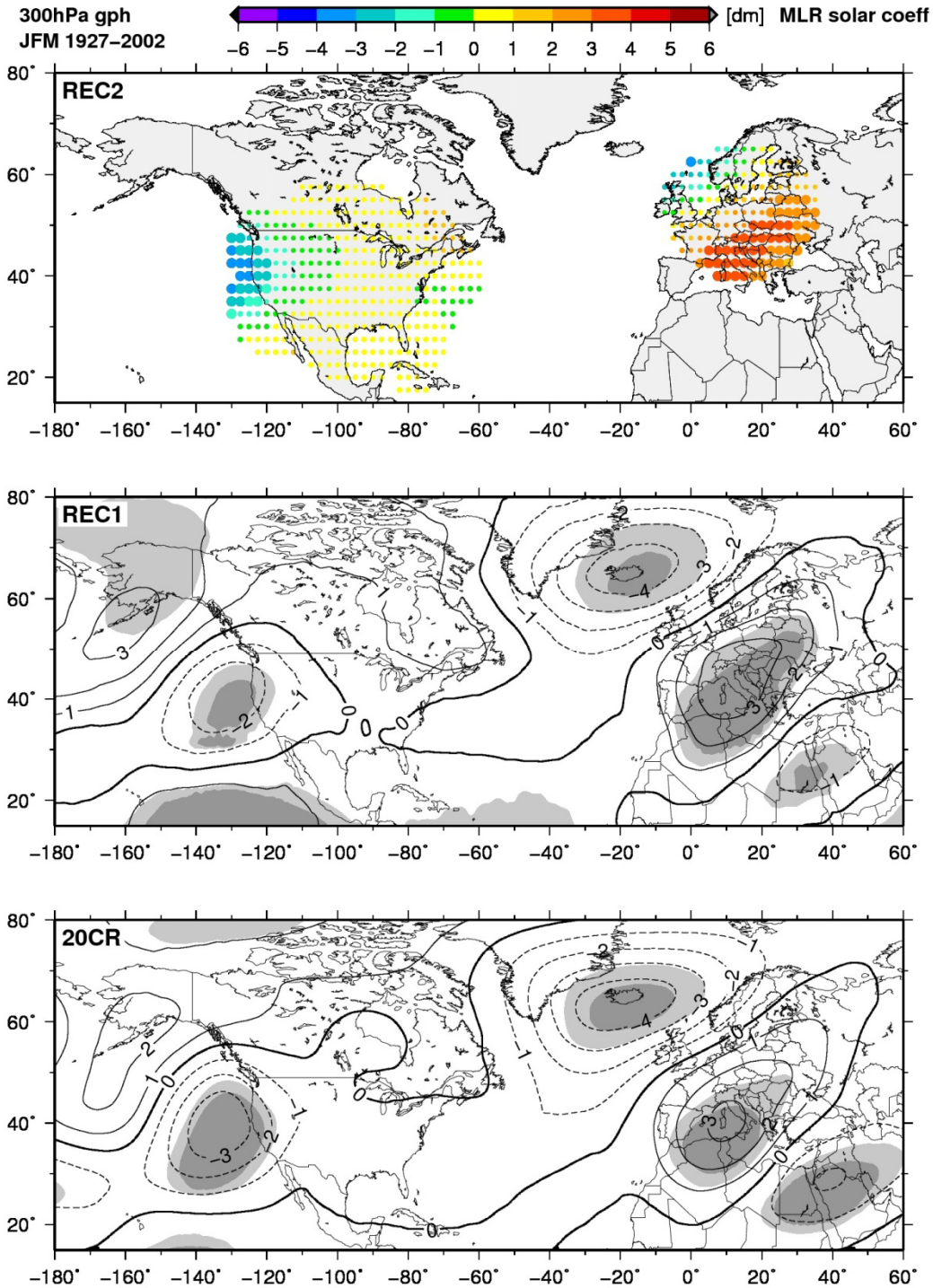
PAGES Solar Workshop

300 hPa GPH regression



Brugnara et al. 2012

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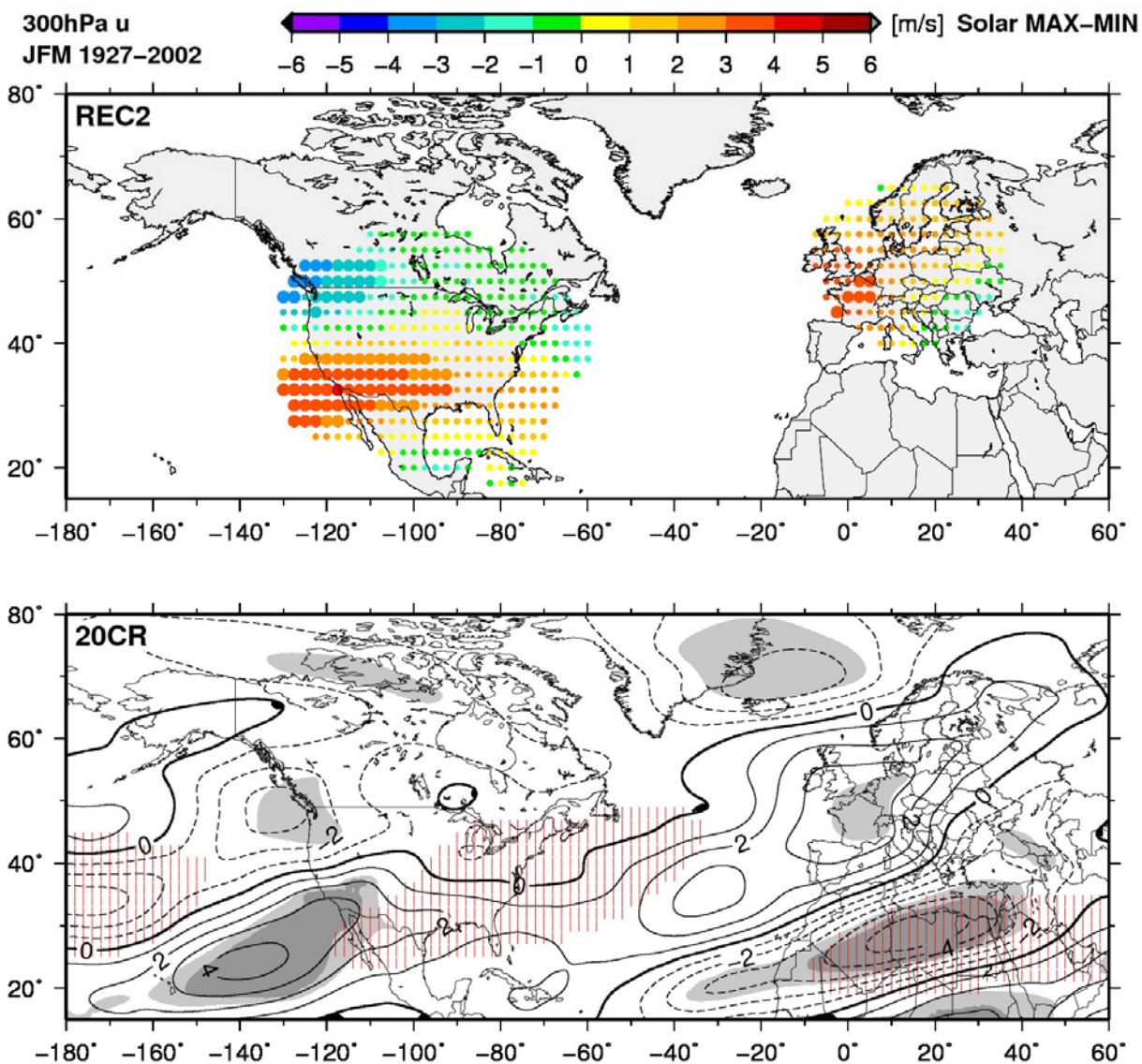
300 hPa zonal wind



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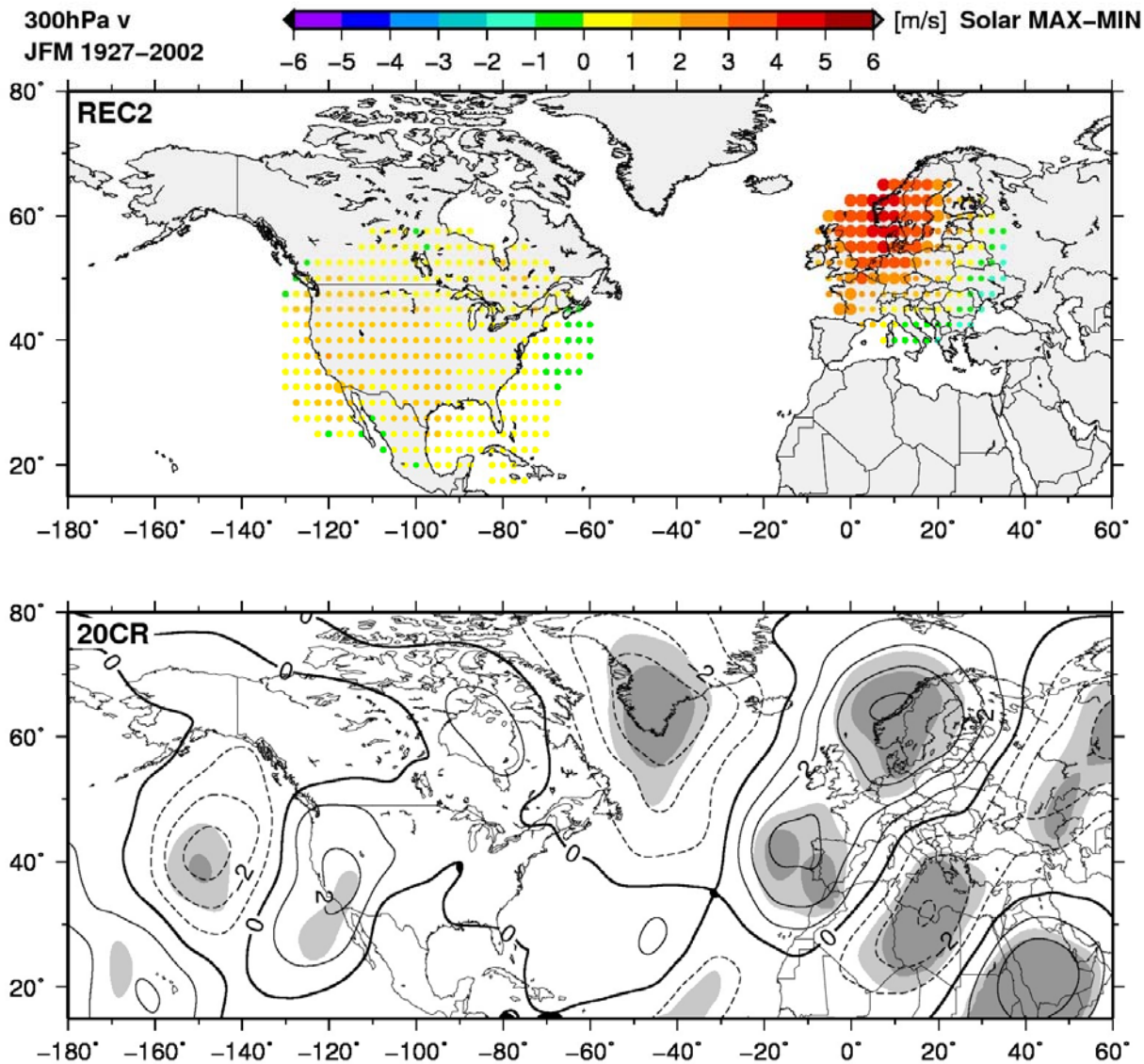
300 hPa meridional wind



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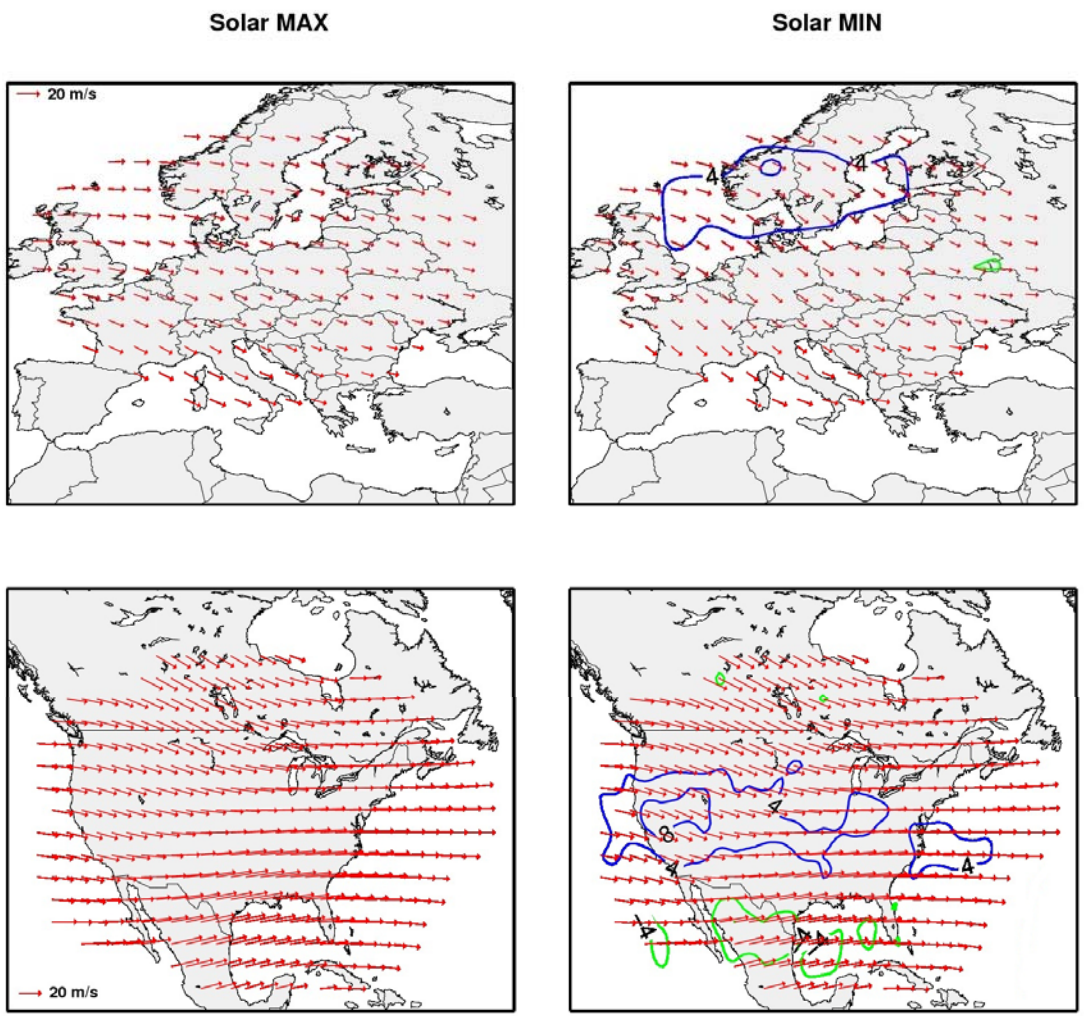
300 hPa wind vectors



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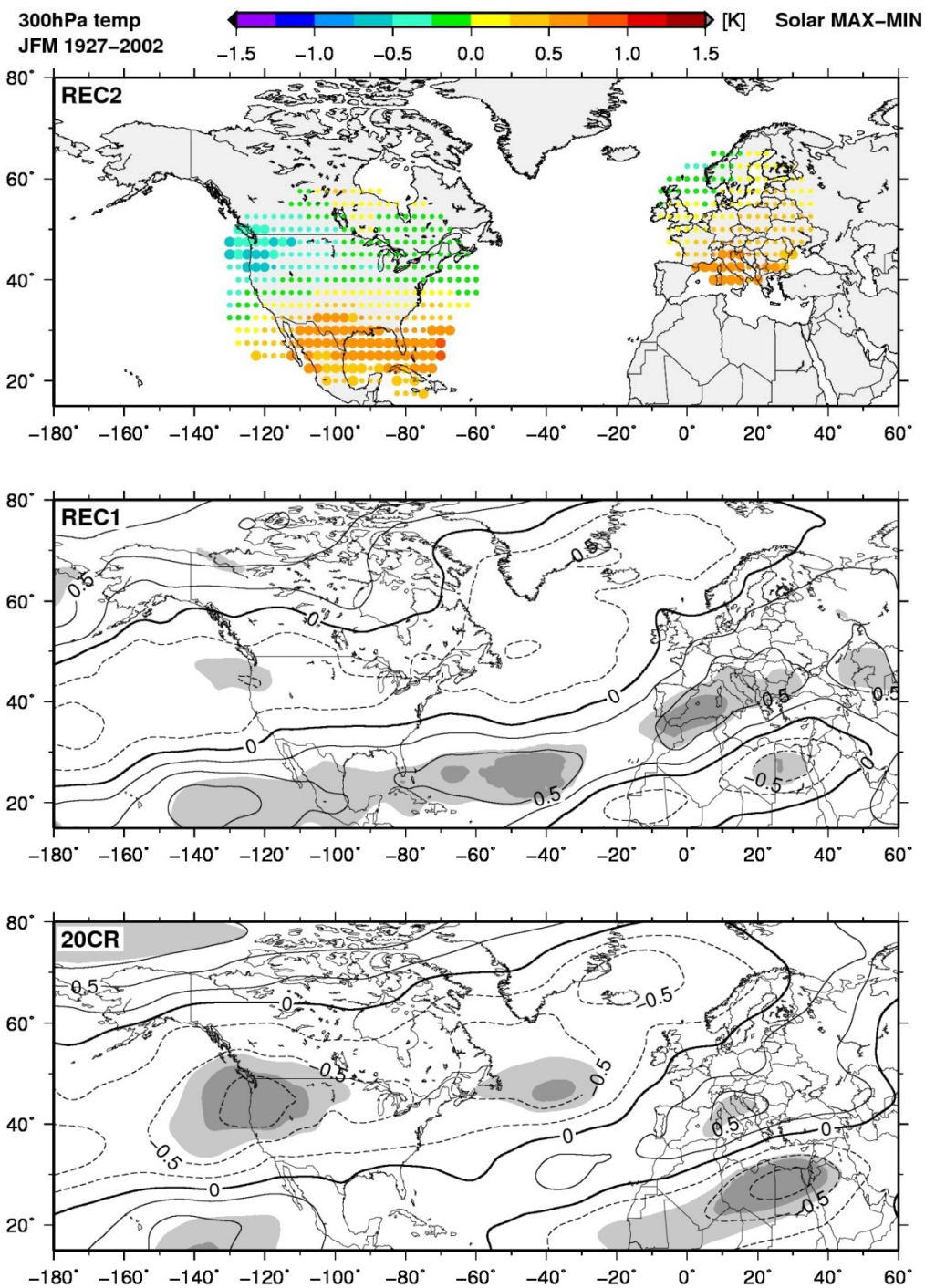
300 hPa Temperature



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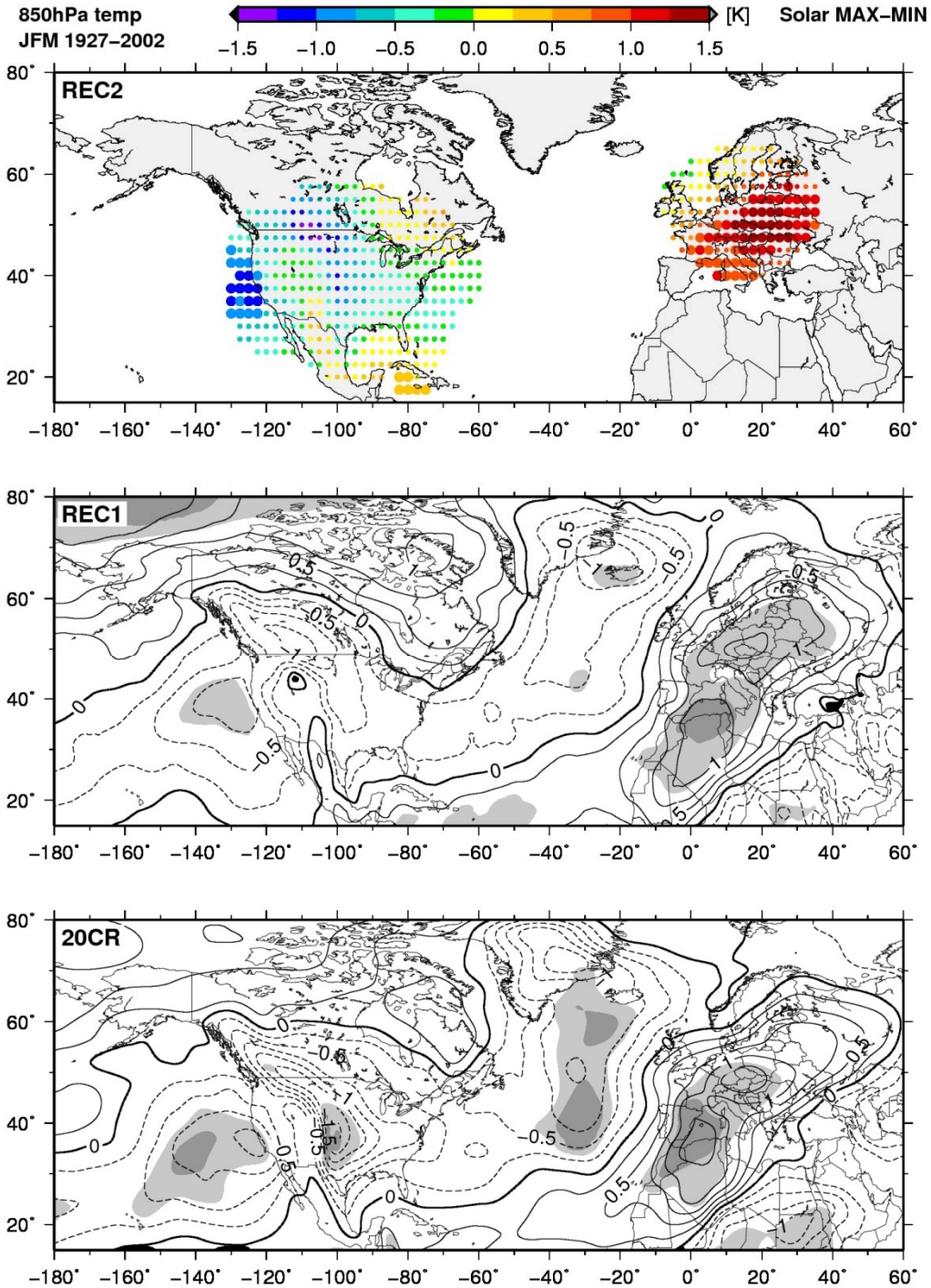
850 hPa Temperature



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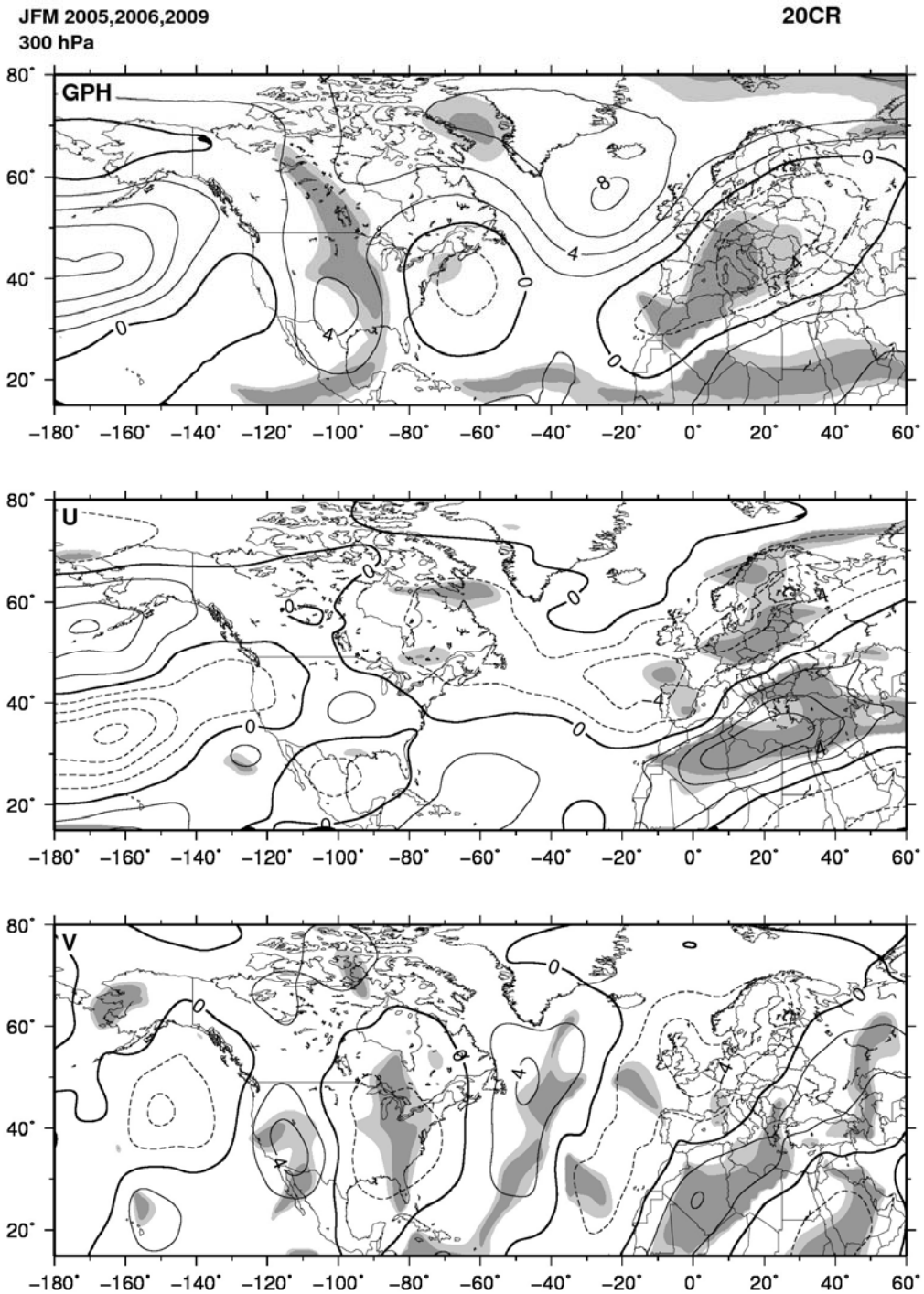
300 hPa GPH recent minimum



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Ozone

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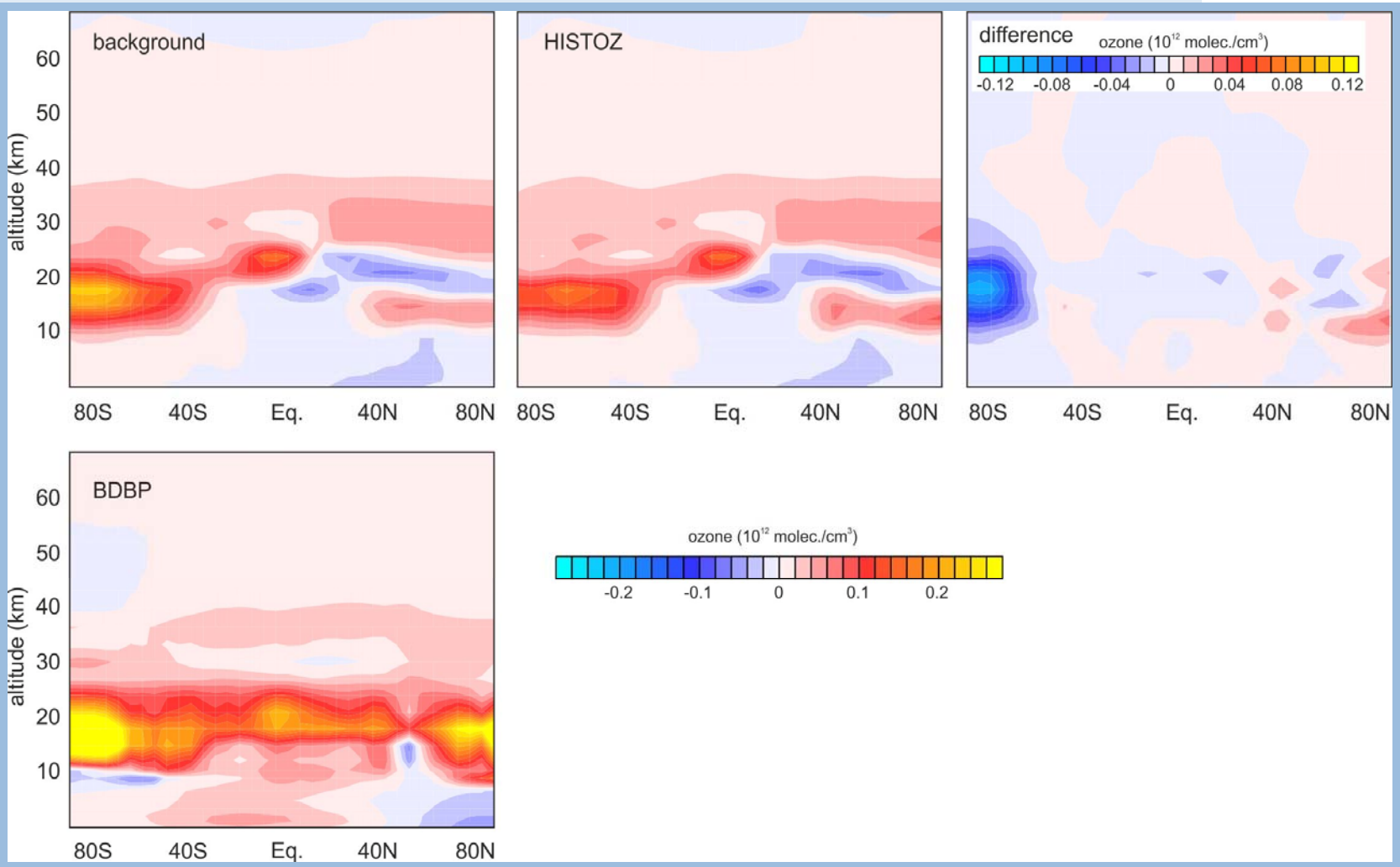

Conclusions

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- Imprint of De Vries cycle in tree rings: Spectral signature found
- Imprint of 11-yr sunspot cycle on reconstructions + reanalyses: Changes in jets, meridional flow over Europe
- Imprint of 11-yr sunspot cycle on ozone: Global increase lower and upper stratosphere

- Longer time periods confirm what was known from shorter periods
- Mechanisms?
- Early Twentieth Century warming?