Recent Regional Climate State and Change - Derived through Downscaling Homogeneous Large-scale Components of Re-analyses

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Downscaling re-analyses

Global re-analyses suffer from inhomogeneities, as they process data from networks under development.
However, the *large-scale component* of such re-analyses is mostly homogeneous; additional observational data add in most cases to a better description of regional details and less so on large-scale states. Therefore, the concept of downscaling may be applied to homogeneously complementing the large-scale state of the re-analyses *with regional detail* – wherever the condition of homogeneity of the large-scales is fulfilled.
Technically this can be done by using a regional or global climate model, which is constrained on the large scale by spectral nudging (von Storch et al., 2000)

It turns out that spatially detailed reconstructions of the state and change of climate in three to six decades is doable for any region of the world, independent of the availability of a good regional data coverage.

This approach has been developed and tested for the region of Europe, and a skillful representation of regional risks – in particular marine risks – was identified (Feser et al., 2011). While the data density in Europe is considerably better than in most other regions of the world, even here insufficient spatial and temporal coverage is limiting risk assessments. Therefore, downscaled data-sets are frequently used by off-shore industries.

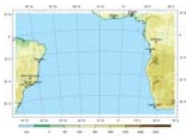
We have run this system also in regions with reduced or absent data coverage, namely
- the *Lena catchment* in Siberia
- the *Yellow Sea/Bo Hai region* in East Asia
- *Namibia* and the adjacent Atlantic Ocean.

Also a global (large scale constrained) simulation has been implemented.

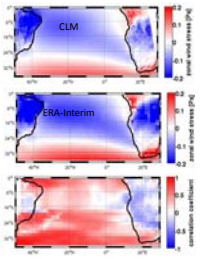
Region	Authors	Re-analysis	Grid resolution	Spectral nudging cut off
Western Africa and South Atlantic	Tim, Zorita	ERA-interim 1979-2012	7km	about 1000 km
Lena Delta	Klehmet, Rockel, Geyer	ERA40, NCEP-R1	50 km	about 1000 km
Yellow Sea	Li, von Storch, Geyer	ERA interim, 1979-2013	7 km	about 300 km

Regional: Western Africa and South Atlantic

Benguela Upwelling System
Tim et al.



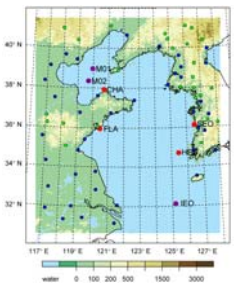
- climatologies of reconstruction (CCLM) and driving re-analysis (ERA interim) are very similar
- the correlation pattern shows that:
  - data sets differ especially over land
  - no or low correlations occur in the Benguela upwelling region off the southwest African coast as well as over the Angola Dome

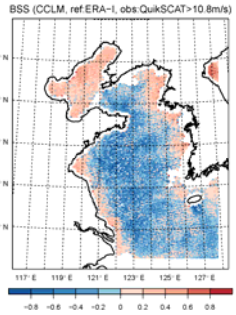


grid-cell correlation between the seasonal means of June-August) zonal wind stress in reconstruction and driving re-analysis

Regional: Yellow Sea

Surface winds
Li et al., 2016





In terms of Brier Skill score: added value (red) in reconstruction relative to ERA-I re-analysis, when comparing strong wind cases (>10.8 m/s). Reference: QuikScat wind data.

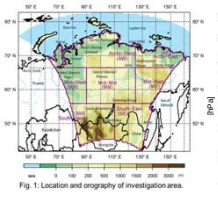
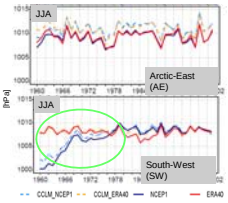


Fig. 1: Location and orography of investigation area.

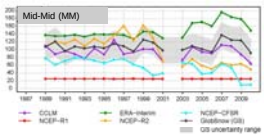
Regional: Lena Delta

Siberian snow conditions
(Klehmet et al., 2013)



Interannual variations of MSLP [hPa] for during JJA, in sub-regions

Temporal inconsistency of NCEP-R1 in July in the Southwest, affecting years before1979



Time series of mean January SWE (Snow Water Equivalent) [mm] (1987-2010) for sub-region Mid-Mid (MM).

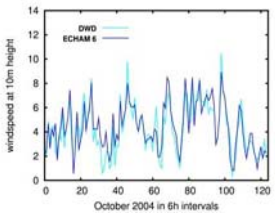
Reconstruction
- agrees well with observed snow conditions in January
- overestimates SWE in April
- adds value to reanalysis NCEP-R1

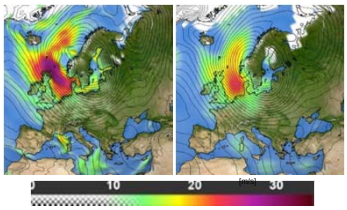
Global downscaling

Following Kanamaru and Kanamitsu (2007);
Schubert-Frisius et al.

- *Global reconstruction: January 1948 – April 2015*
- *ECHAM6 (T255L95) with NCEP1 (T62L28) as large-scale forcing data*

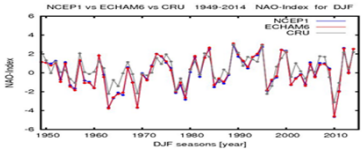
Small scale: The regional reconstructive skill is demonstrated by the close resemblance between simulated and observed data in Hamburg-Fuhlsbüttel, Germany





Meso scale: The Hamburg storm surge was an extreme event, triggered by a winter storm on 16.-17 February 1962. Snapshots of wind field at 10 m height and sea level pressure over Europe indicate more realistic details in the reconstruction (left) than in driving re-analysis NCEP1 (right).

Synoptic scale: NAO index follows closely the driving analysis (as it should)



The different data sets are archived and may freely by used for scientific purposes. Of course, before application, a careful analysis of the quality for the intended application is needed, as sometimes unexpected changes in the quality of the description of large-scale driving states emerge.

Feser, F., B. Rockel, H. von Storch, J. Winterfeldt, and M. Zahn, 2011: Regional climate models add value. *Bull. Amer. Meteor. Soc.* 92: 1181–1192
Kanamaru, H., and M. Kanamitsu, 2007: Scale-selective bias correction in a downscaling of global analysis using a regional model. *Mon Wea. Rev* 135: 334-350
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von Storch, H., H. Langenberg and F. Feser, 2000: A spectral nudging technique for dynamical downscaling purposes. *Mon. Wea. Rev.* 128: 3664-3673

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