

2nd Open Energy Modelling Workshop

Re-analysis climate data as an important input for energy system modeling

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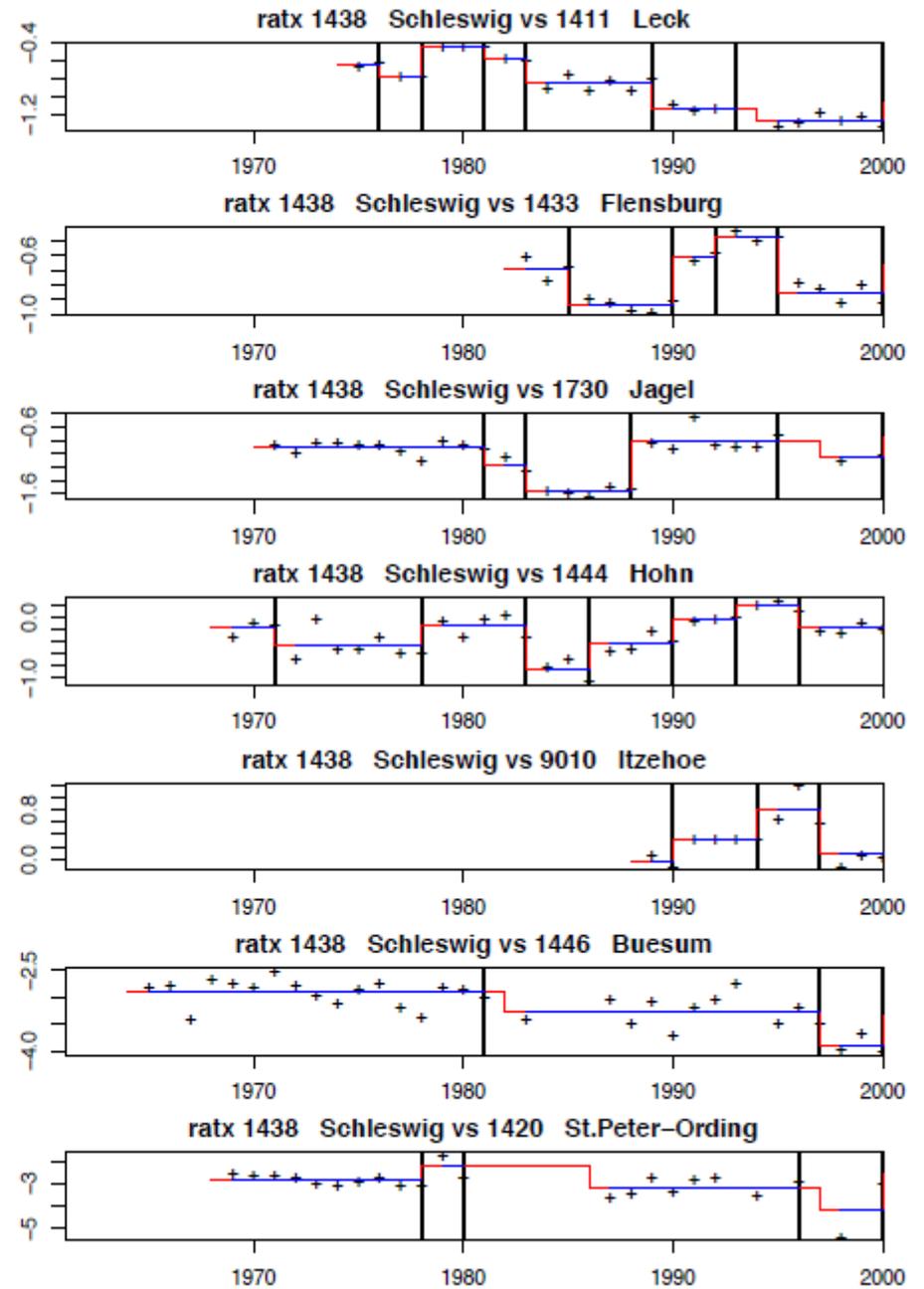
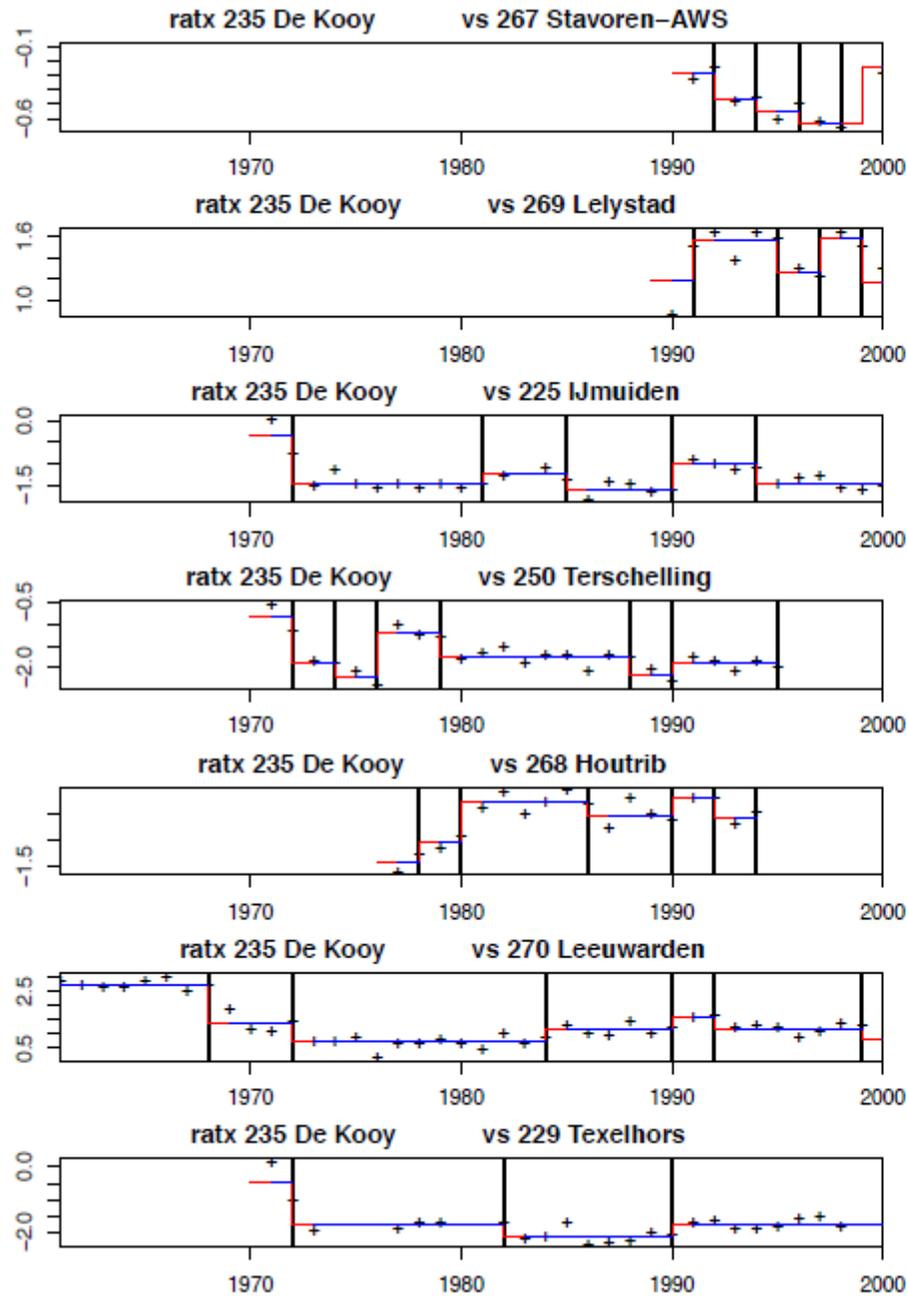
Objectives

- overview on climate data sets for wind and solar time series
- the challenge of wind data on different heights
- (handling of the license problem for coastDat II data)

Meteorological data

You need climate/meteorological data sets for wind and radiation -

but why using Reanalyses or hindcasts for calculation of energy potentials?



Gidded measurements

Cross-Calibrated Multi-Platform Ocean Surface Wind Vector Analyses 1987 to 2011

CCMP

gap-free, 6-hourly gridded database of global ocean surface wind vector 0.25°

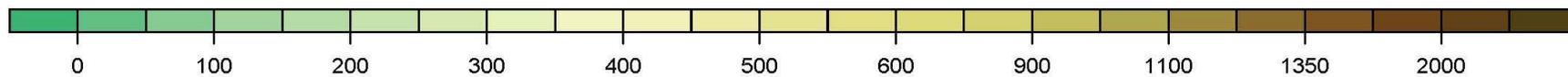
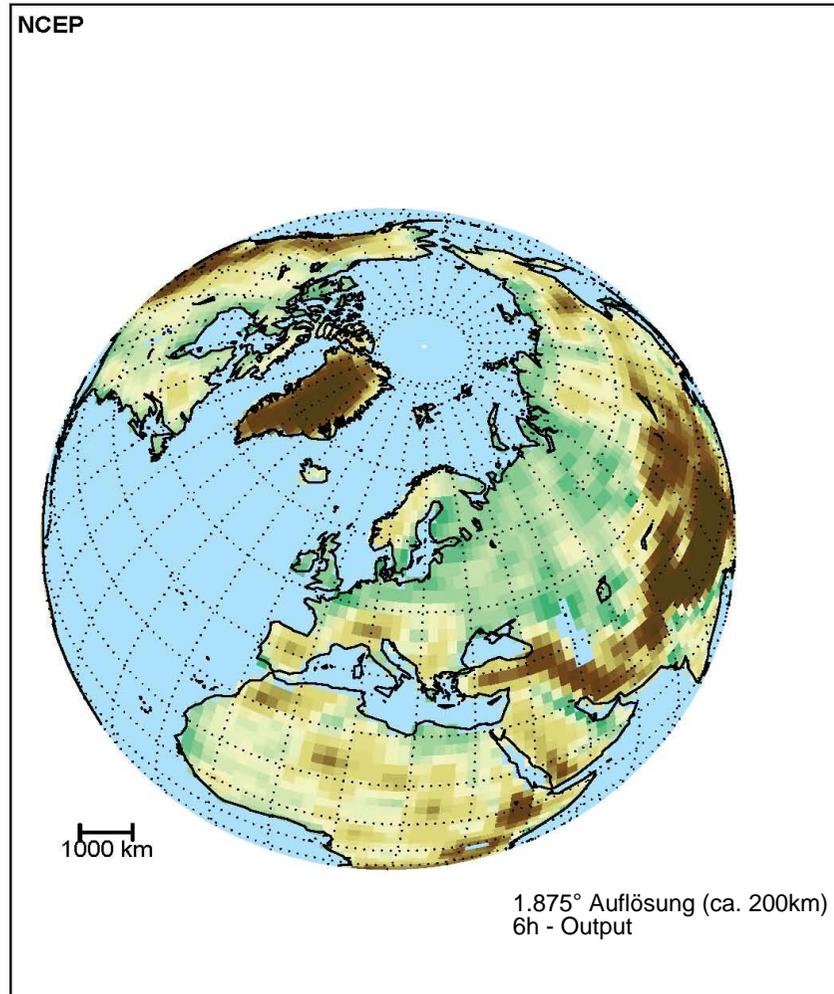
basis: ERA-40 (1987-1998) and ECMWF operational since 1999

CCMP assimilates measurements

TRMM-TMI, QuikSCAT, WindSat, SSM/I, SSMIS, AMSR-E and other satellites, and also data from in situ measurements (ships, buoys, etc.).

→ **not homogenous**

Reanalysis



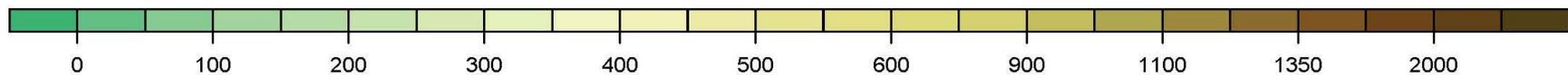
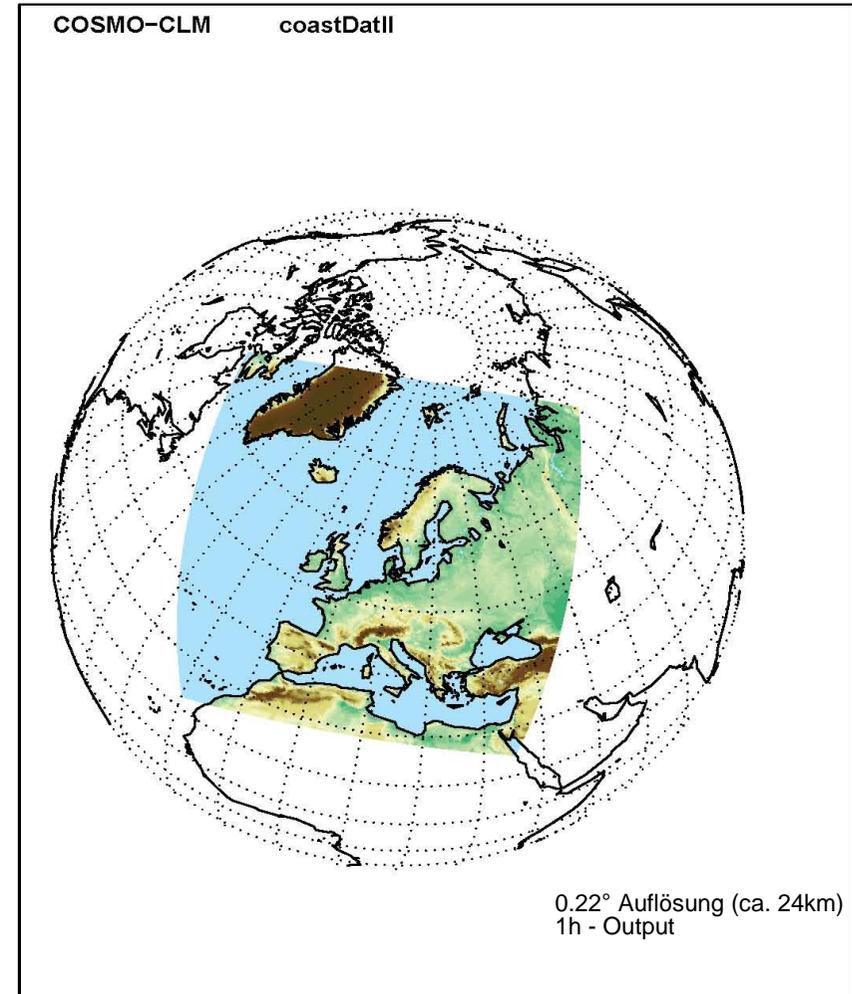
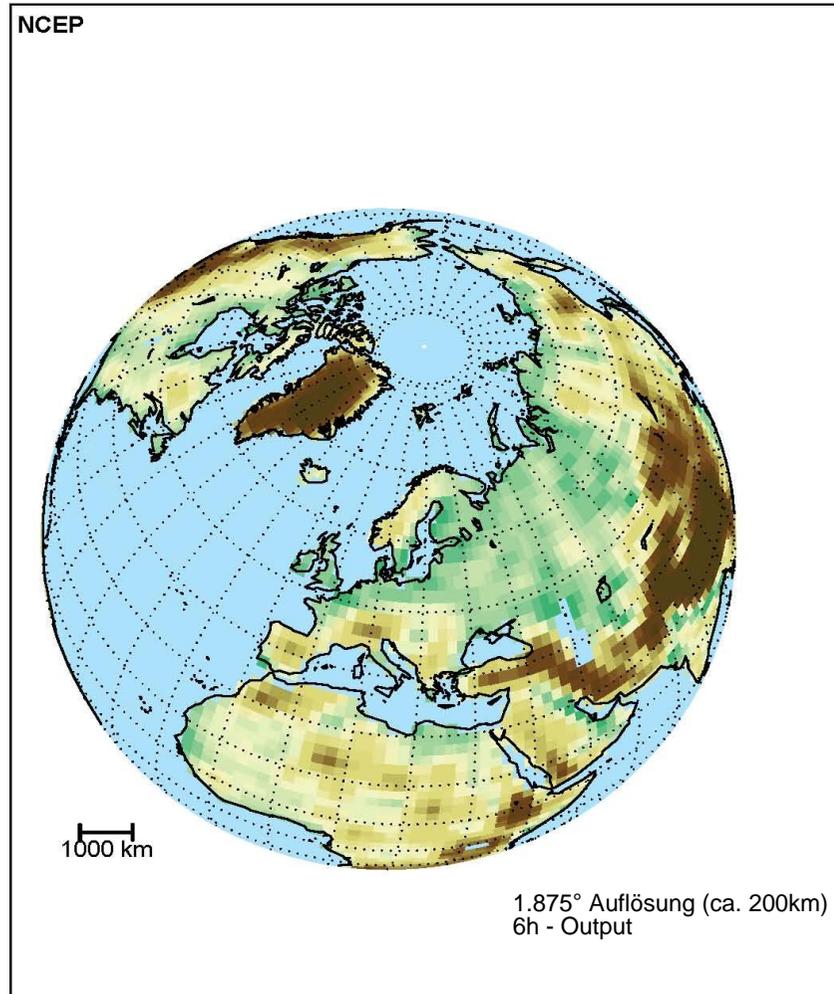
Globale Reanalyses

NCEP/NCAR			
NCEP1	1948 – ongoing	6h: 1.875°	Kalnay et al., The NCEP/NCAR 40-year reanalysis project, <i>Bull. Amer. Meteor. Soc.</i> , 77, 437-470, 1996
NCEPII	1979 – 2014	6h: 1.875°	Kanamitsu M, Ebisuzaki W, Woollen J, Yang SK, Hnilo JJ, Fiorino M, Potter GL. 2002. NCEP-DOE AMIP-II reanalysis (R-2). <i>Bulletin of the American Meteorological Society</i> 83 (11): 1631–1643.
NCEP-CFSR	1979 – 03/2011	6h: 0.3°	Saha, S., S. Moorthi, H.-L. Pan, X. Wu, J. Wang, S. Nadiga, P. Tripp, R. Kistler, J. Woollen, D. Behringer, et al., 2010: The NCEP climate forecast system reanalysis. <i>Bull. Amer. Meteor. Soc.</i> , 91 (8), 1015–1057.
ECMWF			
ERA40	1958 – 08/2002	6h: 1.125°	Uppala, S.; Kallberg, P.; Simmons, A.; Andrae, U.; et al. The ERA-40 re-analysis <i>Quart. J. Roy. Meteor. Soc.</i> , 2005 , 131, 2961-3012
ERAint	1979 – ongoing	6h: 0.7°	Dee, D.P., et al., 2011: The ERA-Interim reanalysis: configuration and performance of the data assimilation system, <i>Q. J. R. Meteorol. Soc.</i> 137: 553–597. DOI:10.1002/qj.828
ERA-20C	1900-2010	3h: 1.125°	-
NASA			
MERRA	1979 – ongoing	0.66°x0.5° 2D-diagn. fields: 1h	Rienecker, M.M., M.J. Suarez, R. Gelaro, R. Todling, et al. (2011), MERRA: NASA's Modern-Era Retrospective Analysis for Research and Applications . <i>J. Climate</i> , 24, 3624-3648, doi:10.1175/JCLI-D-11-00015.1.
JMA			
JRA-25	1979 – 02/2014	6h: 1.125°	Onogi, K., J. Tsutsui, H. Koide, M. Sakamoto, S. Kobayashi, H. Hatsushika, T. Matsumoto, N. Yamazaki, H. Kamahori, K. Takahashi, S. Kadokura, K. Wada, K. Kato, R. Oyama, T. Ose, N. Mannoji, and R. Taira, 2007: The JRA-25 Reanalysis. <i>J. Met. Soc. Jap.</i> , 85 (3), 369-432.
JRA-55	1958-2012	3h/6h: 0.5°	Kobayashi et al., 2015: The JRA-55 Reanalysis: General Specifications and Basic Characteristics, <i>Journal of the Meteorological Society of Japan</i> . Ser. II, Vol. 93, No. 1 p. 5-48
NOAA-CIRES			
20th Century Reanalysis 20CR version 2	1871-2012	6h: 1.875°	Compo, G.P. et al., 2011: The Twentieth Century Reanalysis Project. <i>Quart. J. Roy. Meteor. Soc.</i> , 137, 1-28. DOI:10.1002/qj.776.

Regional Reanalyses

NCEP/NCAR				
North American Regional Reanalysis (NARR)	1979-2014	North America	3h: 0.3°	<u>NORTH AMERICAN REGIONAL REANALYSIS</u> : A long-term, consistent, high-resolution climate dataset for the North American domain, as a major improvement upon the earlier global reanalysis datasets in both resolution and accuracy, Fedor Mesinger et. al, submitted to BAMS 2004.
PMG				
Arctic System Reanalysis (ASR)	2000-2012	Arctic	3h: 30 km	Byrd Polar Research Center, T. O. S. U. Arctic System Reanalysis (ASR) Project <i>Research Data Archive at the National Center for Atmospheric Research, Computational and Information Systems Laboratory, 2012</i>
DWD				
COSMO-REA6 and COSMO-REA2	2007–2011 Sel. month	Europe Germany	2D: 15min;6.2km 2D: 15min;2km	Bollmeyer, Ch. et al.: A high-resolution regional reanalysis for the European CORDEX region, Vol. 17, EGU2015-11209, 2015
KIK Estonian Environmental Investment Centre				
BaltAn65+ HIRLAM (ERA-40 forcing)	1965-2005	Baltic Sea region	6h: 0.1°	
MetOffice				
UKMO		Europe, NA	3h: 0.18°	Bush 2006: Development of the North Atlantic European Model (NAE) into an operational model

Reanalysis and Regional Hindcast

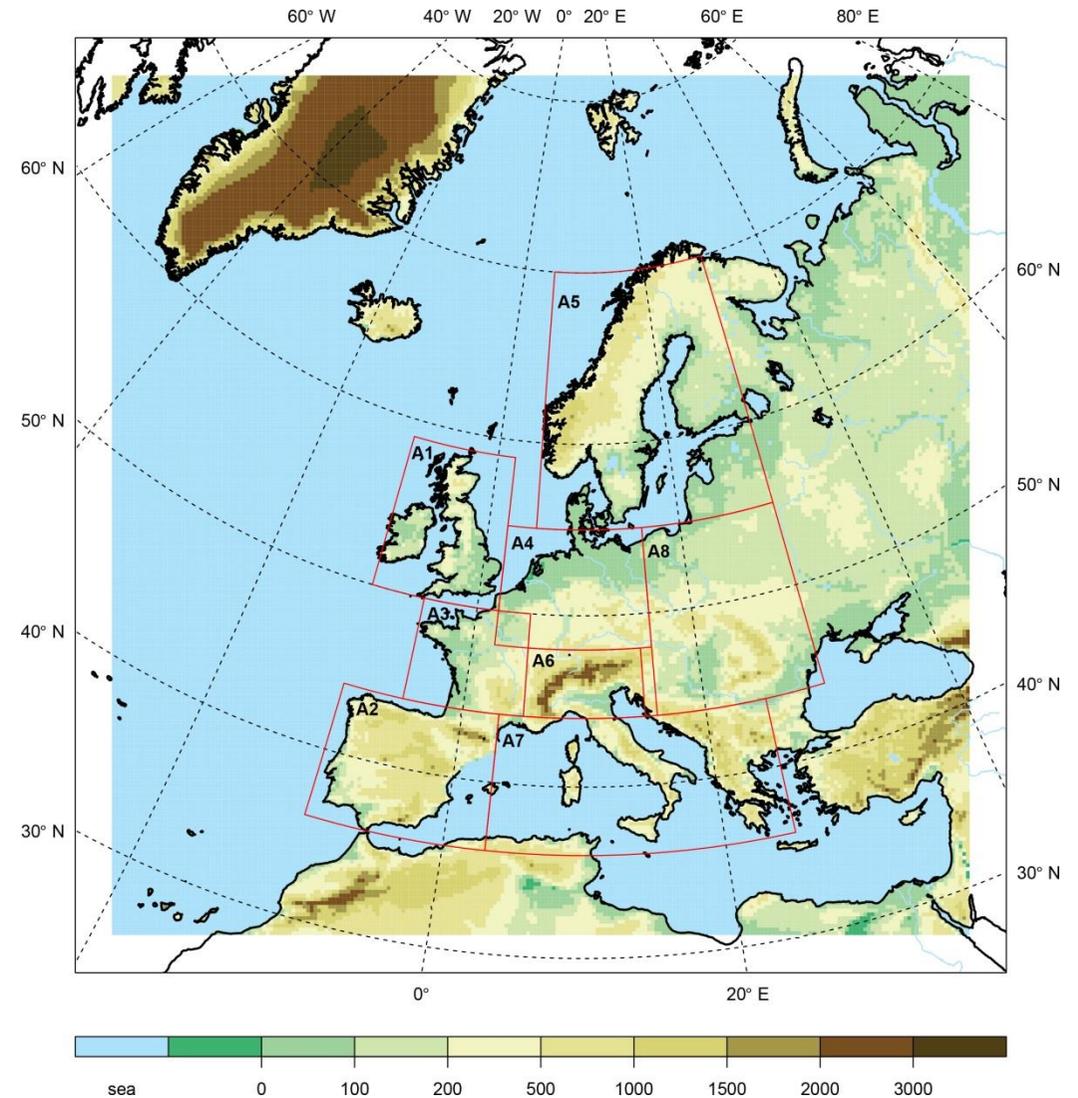


coastDat 2 – Atmospheric part

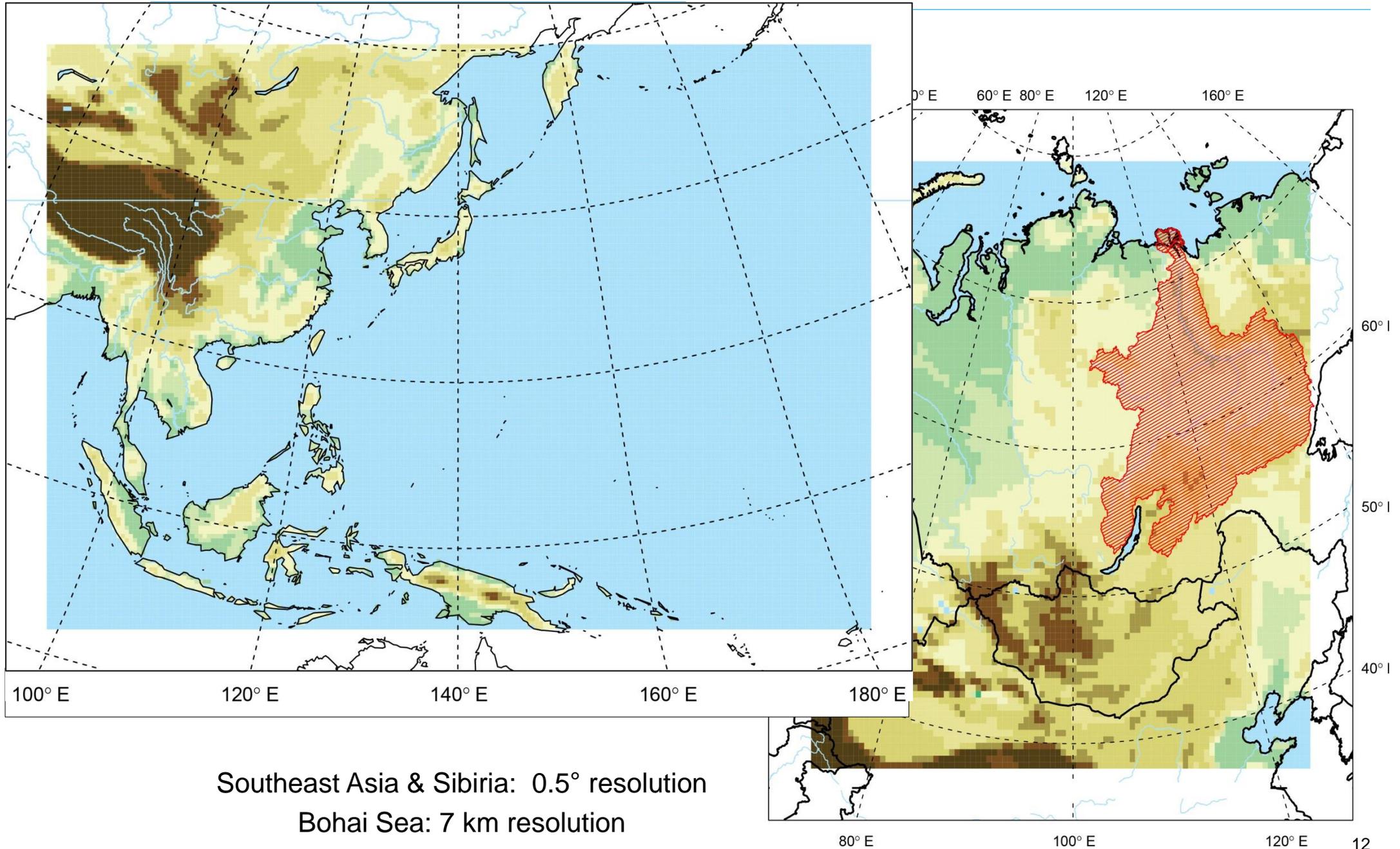
1948-2014

COSMO-CLM Version 4.8

- horizontal resolution 0.22°
- 40 vertical layers
- hourly output
- rotated coordinates
- for good representation of the general circulation: spectral nudging for the upper windfields
- Number of grid points: 254×248
(~6000x6000km)



Other Hindcasts by HZG



more regional data

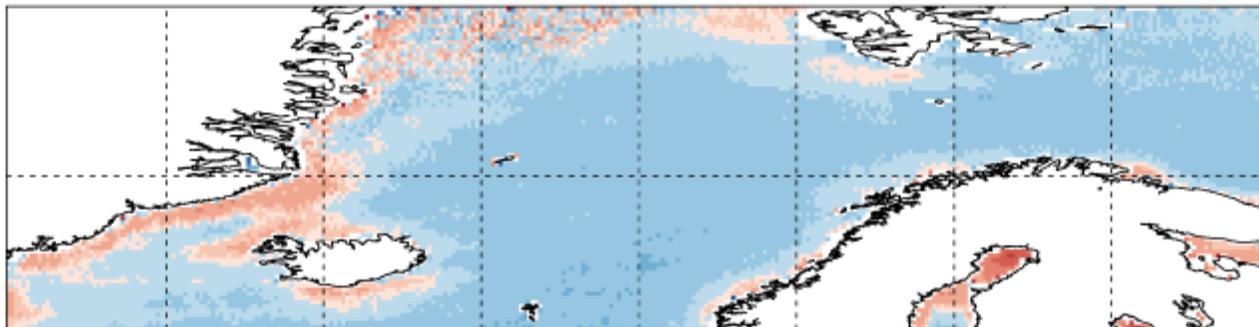
Other institutions do hindcasts as well, e.g.

CORDEX – EU funded projects, but output is stored 3hly

Added value of the regional hindcast

Windgeschwindigkeit in 10m Höhe für 2000-2009

Wertebereich: 3-25 m/s entspricht 3-9 Bf



Quantitative Erfassung des Mehrwertes durch modifizierten Brier skill score:

Maßstab sind Satellitenmessungen v. QuikSCAT2.0 L2B12, Referenz ist die globale Reanalyse

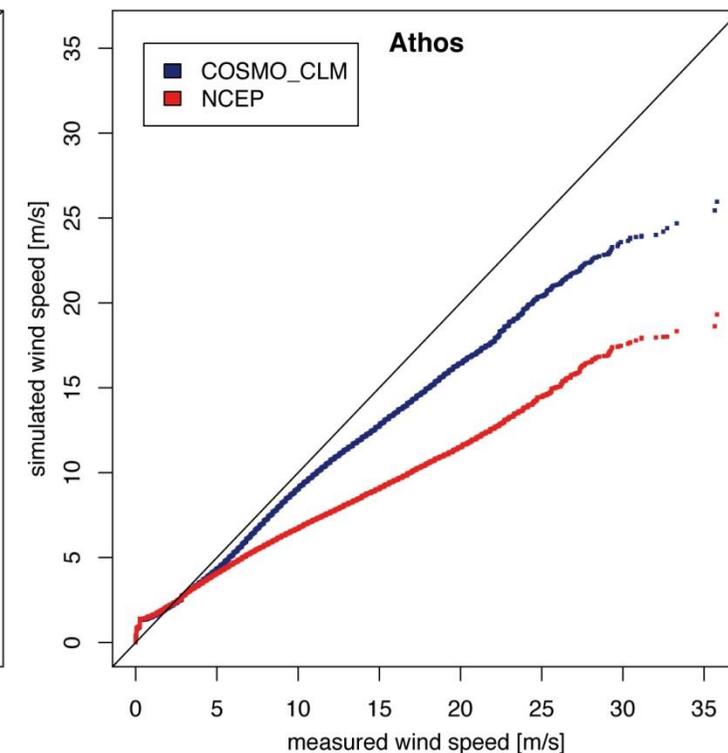
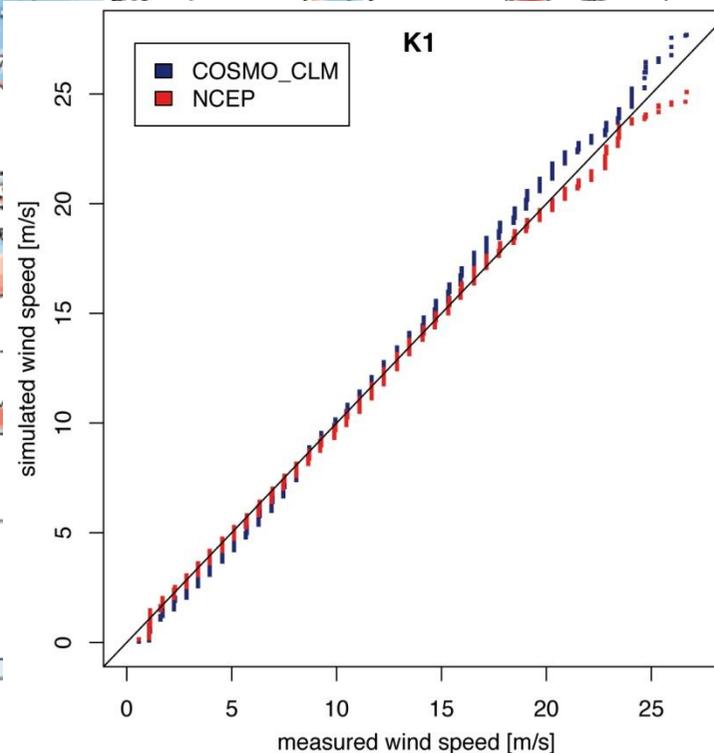
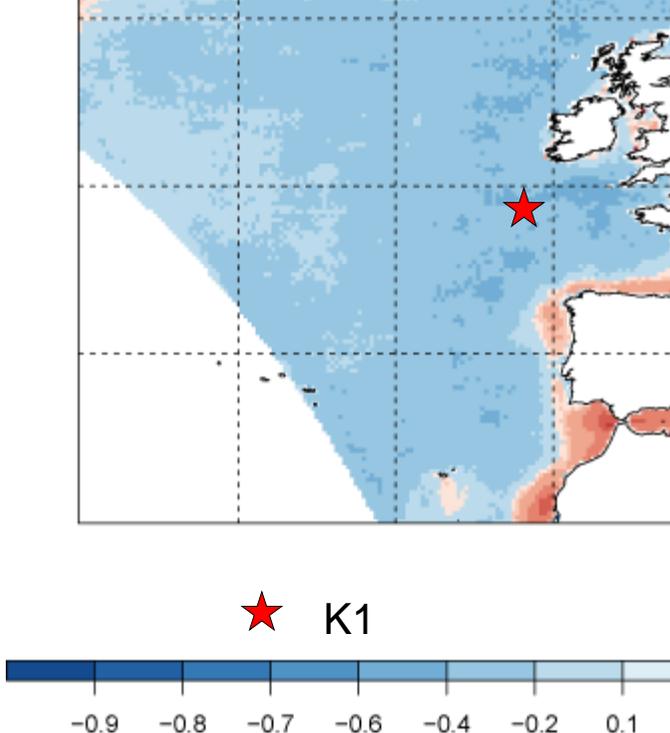
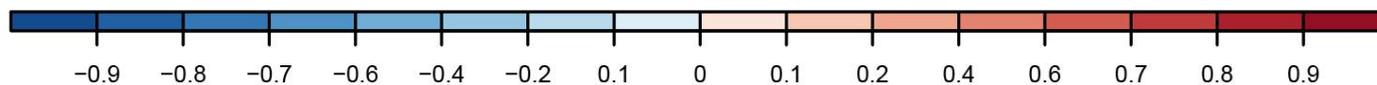
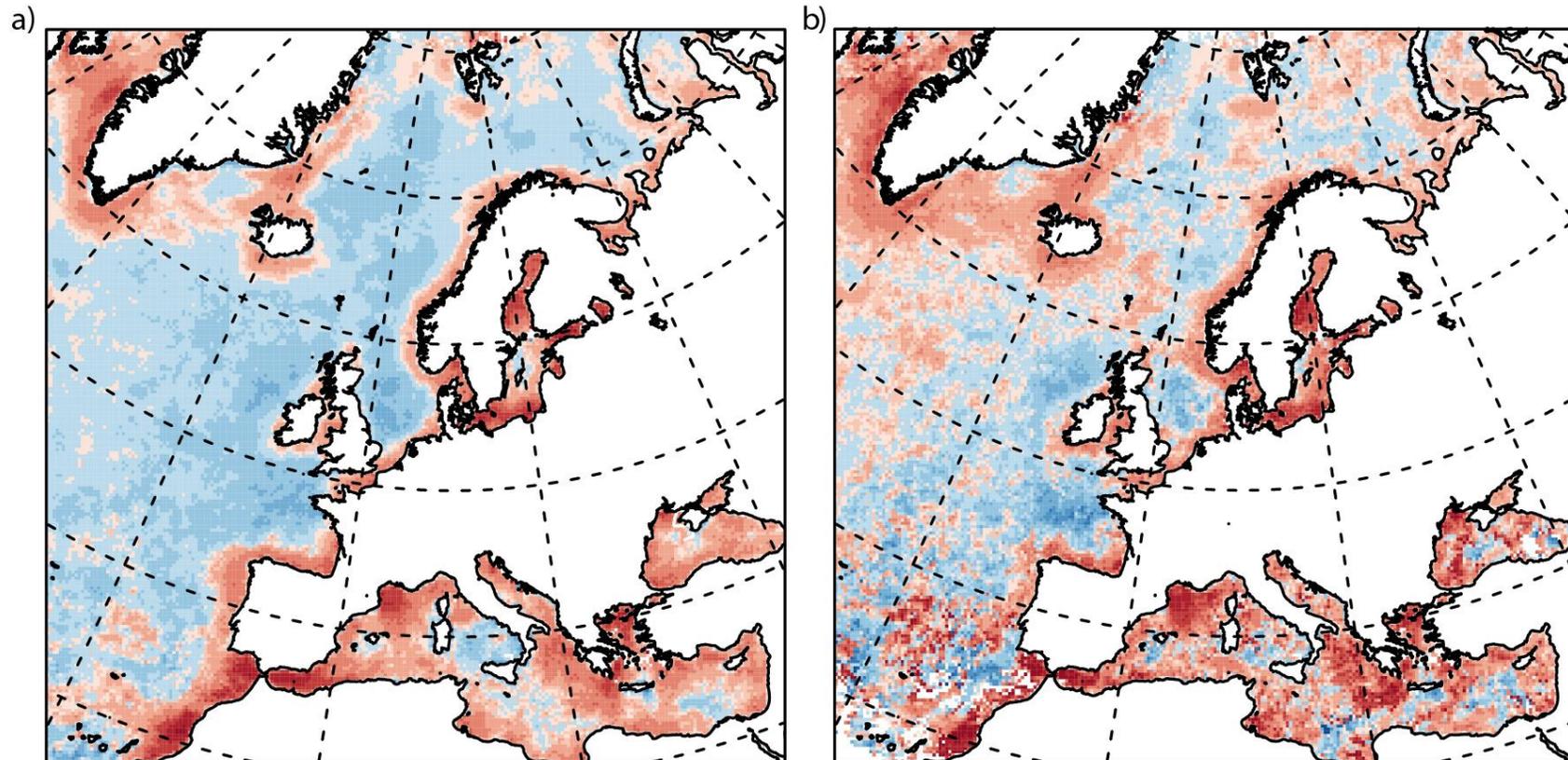


Abb. wie Sotillo et al. 2005 für coatsDat1

Added value of the regional hindcast

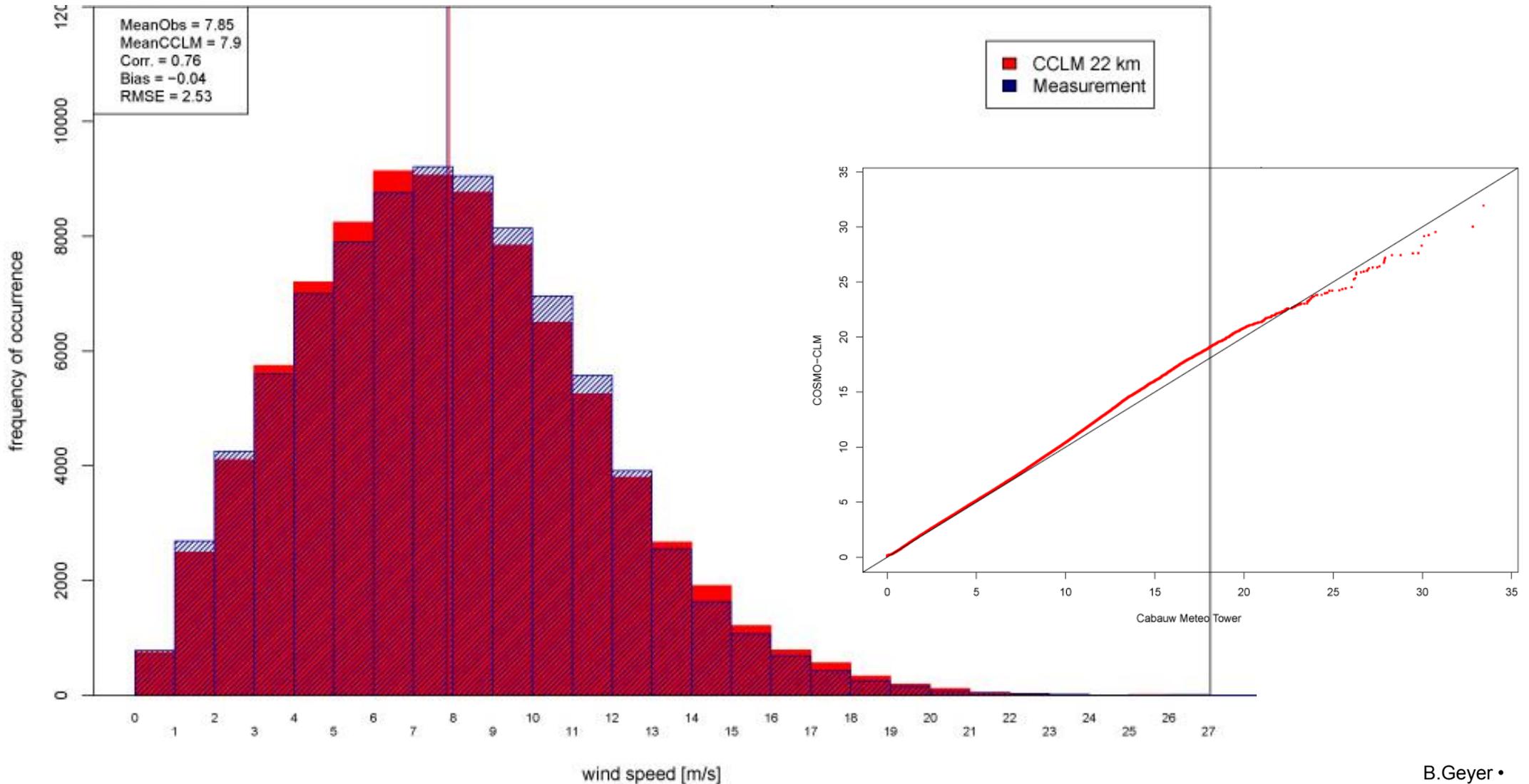
Windgeschwindigkeit in 10m Höhe für 2000-2009

Wertebereich: a) **12-25 m/s** (6-9 Bft) und b) **17-25 m/s** (7-9 Bft)



coastDatII – Validierung: Wind

Häufigkeitsverteilung: Cabauw in 140m Höhe; 2001-2010



Wind data on different heights

Interpolation is necessary:

- measurements in the network of WMO: in 10 m height in an open area
- measurements on platforms/ship (20-50m)
- measurements on buoys (3m)

- height of interest 80m to 200m

Different strategies are possible:

Engineers take the power law which is comparable to the logarithmic wind profile used by the meteorologists.

Figure 3.7 (Emeis, 2012): Three normalised non-neutral windprofiles extrapolated from the 50 m wind speed for increasing stability (from left to right)

Full lines: logarithmic profiles

Dashed lines: power law (exponent given in the middle)

Middle: roughness length: 0.023 m ($z/z_0=2174$)

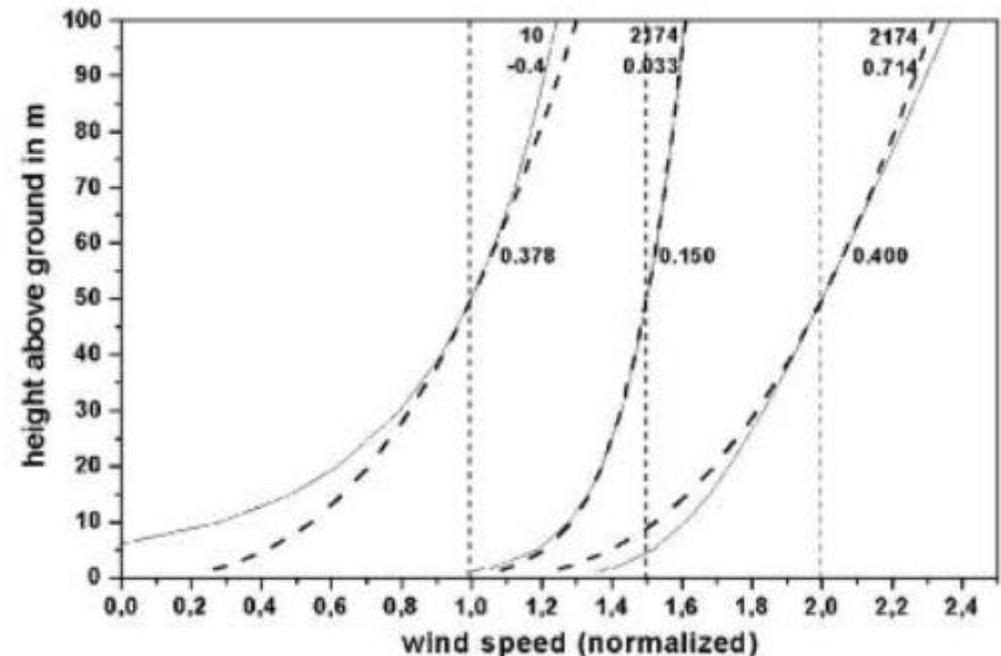
Obukhov Length: 1500m ($z/L = 0.033$) -> power law and logarithmic wind profile deliver the nearly the same curve: in 100 m the difference is 0.1% in 10m 0.9%

Left (unstable)

in 100 m the difference is 4.5% in 10m 90%

Right (very stable)

in 100 m the difference is -3.5% in 10m -14%



Reference:

Interpolation of simulated data: 3D – model grid

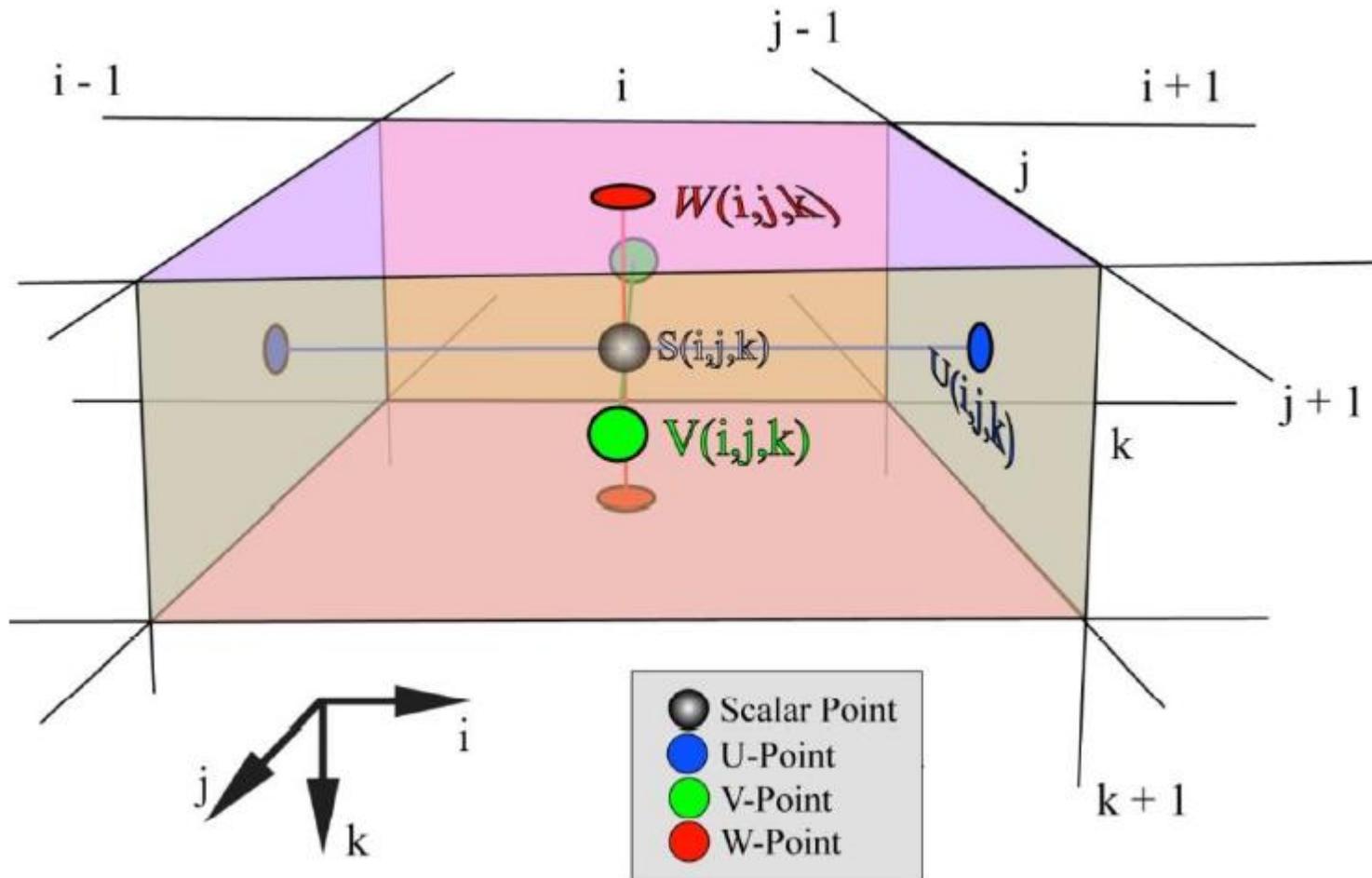
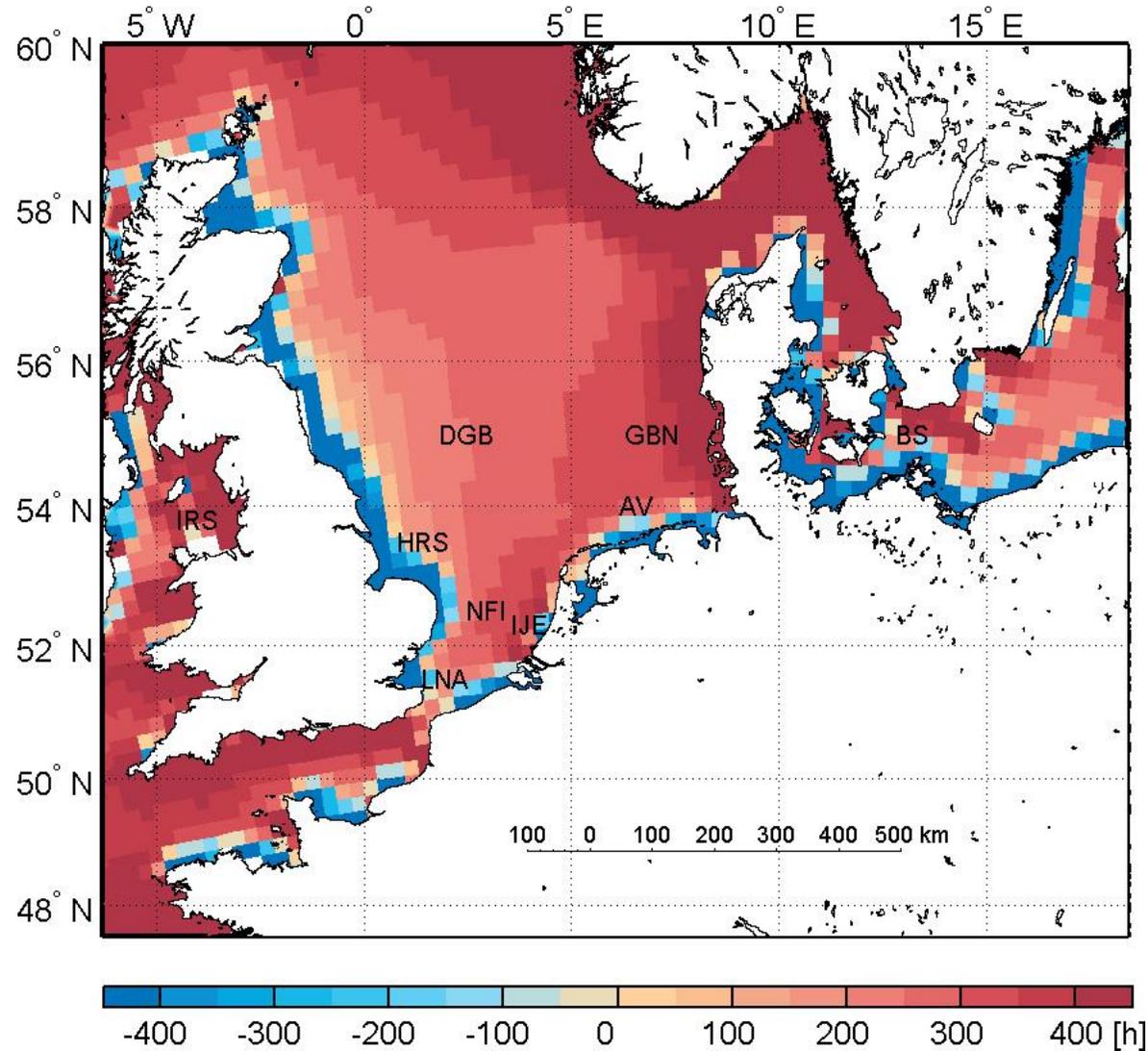
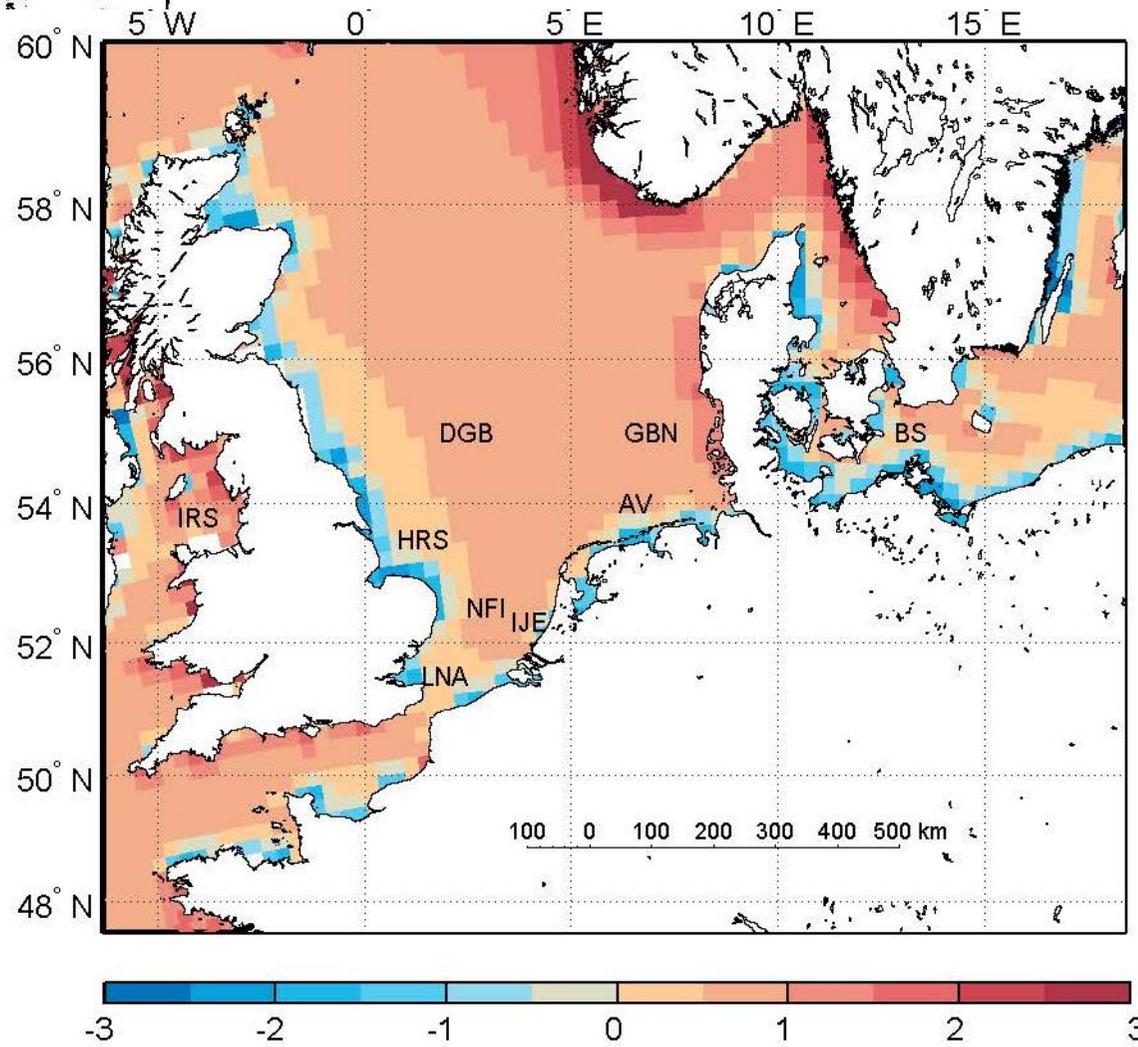
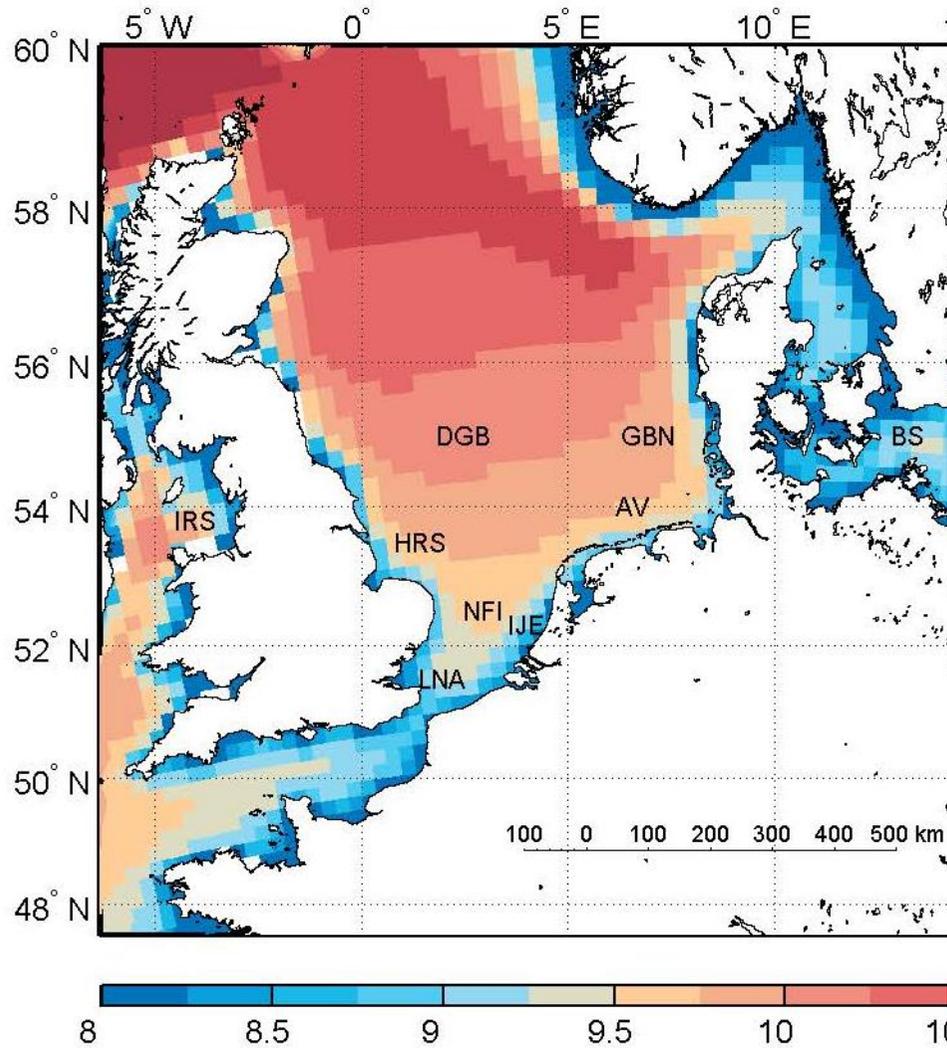


Abb.: Michael Böttinger, DKRZ

Errors due to interpolation



Long-term average difference between EFLH based on wind speeds at a height of 10 m extrapolated using a power law and the direct model output at a height of 100 m for the period of 1958-2012.



longterm mean of 100m wind speed (1958-2012)

difference ,power law' - modeled

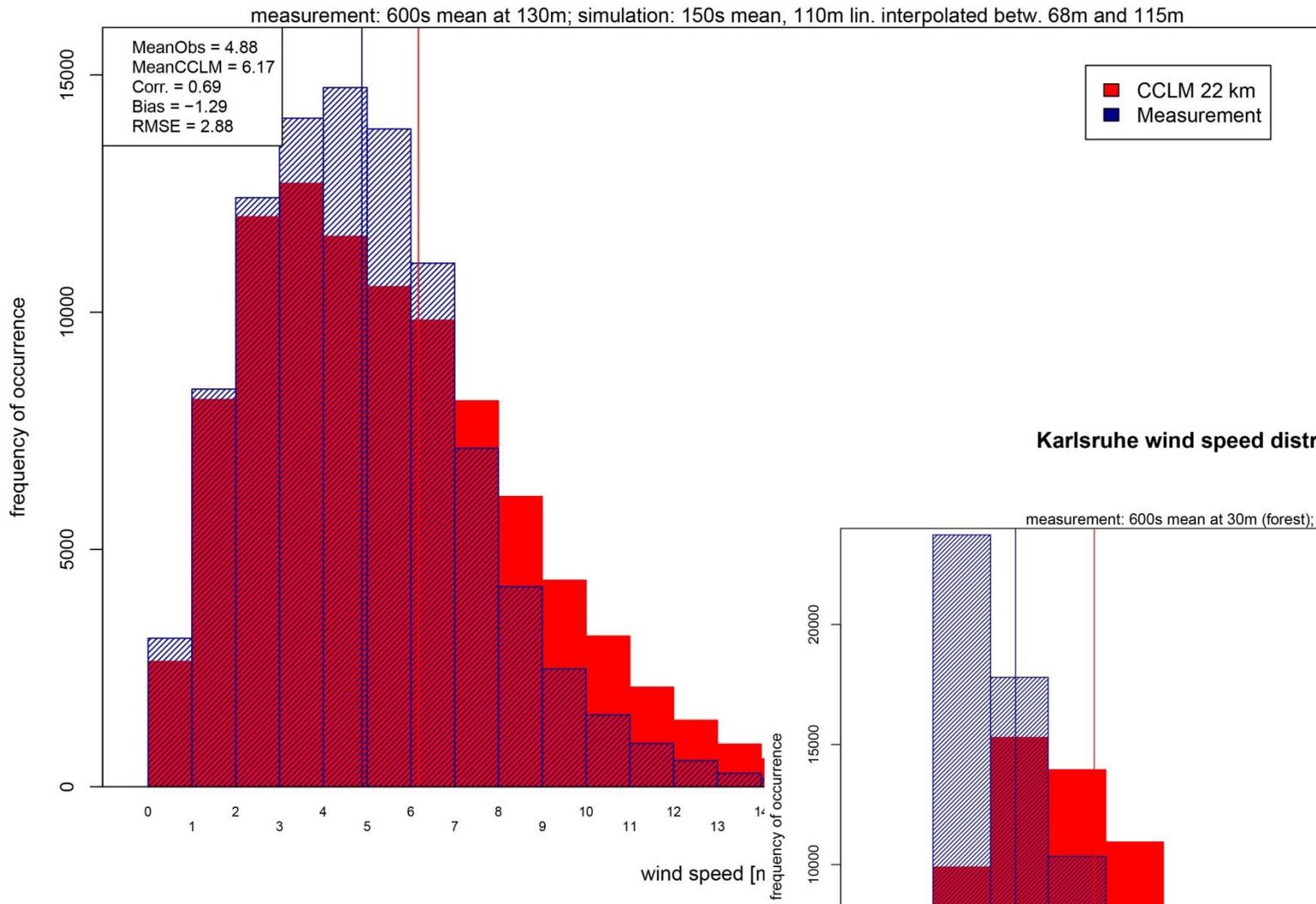
Radiation

In the literature (e.g., Daryl Ronald Myers ,Solar Radiation: Practical Modeling for Renewable Energy Applications (Energy and the Environment)' you can find how to calculate the incoming radiation (clear sky and all sky - parametrized).

ALHFL_S	W m-2	averaged surface latent heat flux
ALWD_S	W m-2	downward lw radiation at the surface
ALWU_S	W m-2	upward lw radiation at the surface
APAB_S	W m-2	averaged surface photosynthetic active radiation
ASHFL_S	W m-2	averaged surface sensible heat flux
ASOB_S	W m-2	averaged surface net downward shortwave radiation
ASOB_T	W m-2	averaged TOA net downward shortwave radiation
ASOD_T	W m-2	averaged solar downward radiation at top
ASWDIFD_S	W m-2	diffuse downward sw radiation at the surface
ASWDIFU_S	W m-2	diffuse upwward sw radiation at the surface
ASWDIR_S	W m-2	direct downward sw radiation at the surface
ATHB_S	W m-2	averaged surface net downward longwave radiation

Thanks for listening!

Karlsruhe wind speed distribution for 2000–2010



Karlsruhe wind speed distribution for 2000–2007

