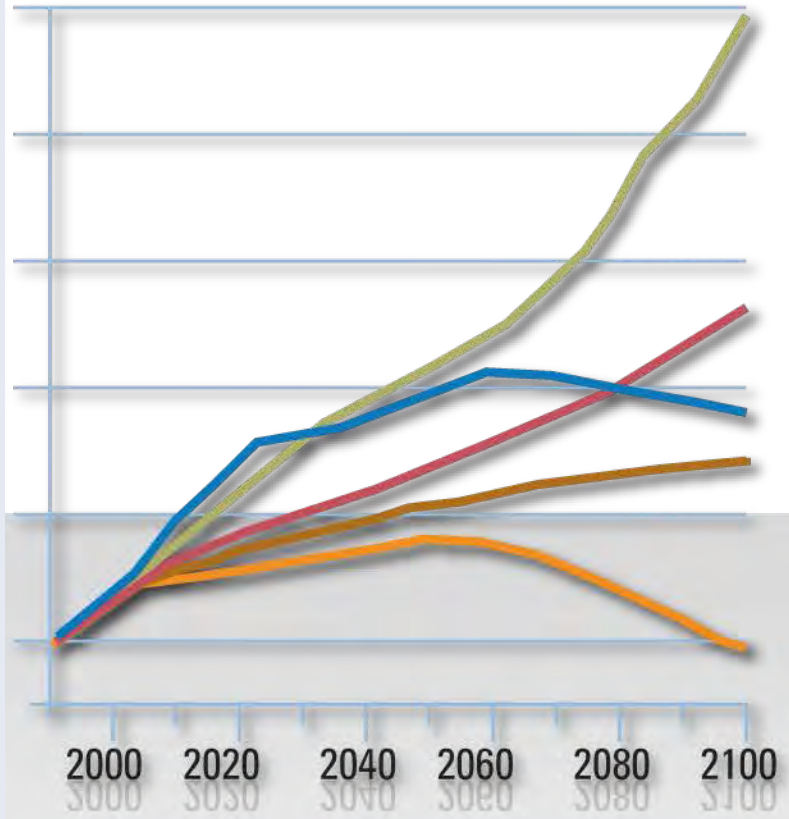


Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Developing the Scientific Basis for Climate Services

Lydia Dümenil Gates and colleagues in Klima und Umwelt

1 **Climate Services**

2 Assets: Observations and Models

3 Research Gaps

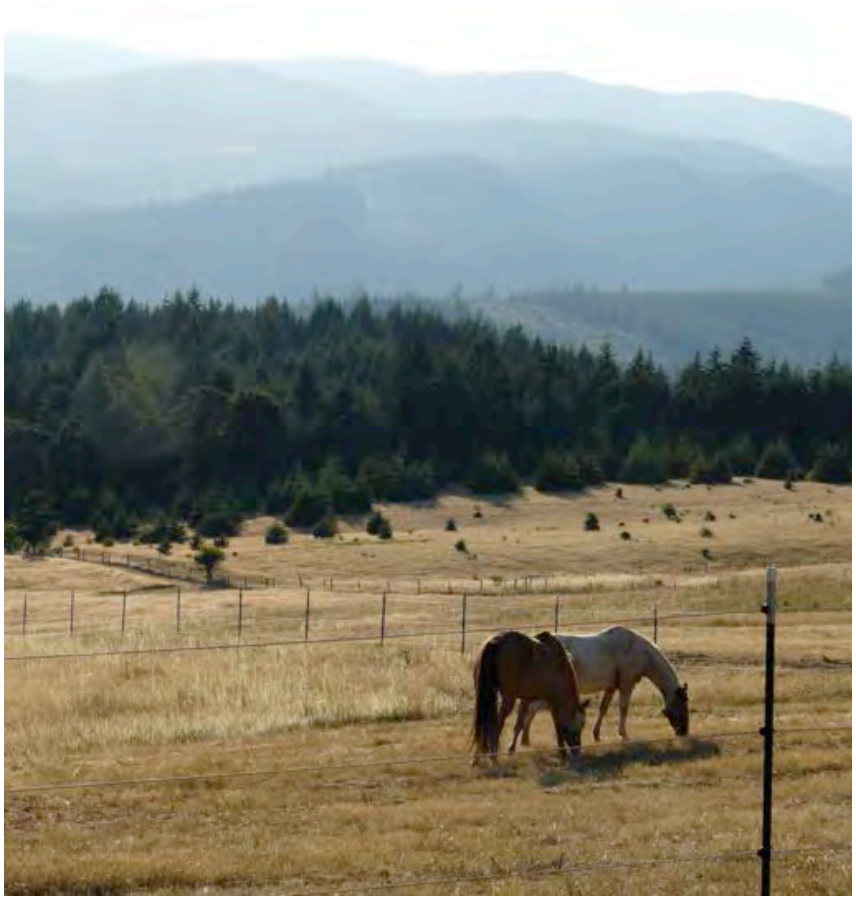
Climate Services

- Nationally mandated Climate Services and international responsibilities
- Global Framework for Climate Services as a UN-wide initiative of partners of WMO member states
  - Goal: provide science-based climate information in order to enable better climate risk management

GFCS Priorities

➔Health

GFCS Priorities



➔ Agriculture, Forestry and Food Security

GFCS Priorities

➔Water

GFCS Priorities

➔ Disaster Risk Reduction

GFCS Overview

- Users
- User Interface Platform
- Climate Services Information System
- Observations and Monitoring
- Research, Modelling and Prediction
- Capacity Development

Implementation at the National Level

- German Federal Strategy for Adaptation to Climate Change - Action Plan mandates DWD to provide climate services and mandates interdisciplinary collaboration
- DWD Climate Data Center: Easy access and climate data free-of-charge
- Dialogue with users – Strategic Alliance of Public Authorities on Adaptation to Climate Change
- Users are from Business, Federal Ministeries, Regional Governments (16 German States, cities), Public Authorities, Emergency Response Agencies
- Provide tailor-made products (i.e. regional focus, sector-oriented)
- Strong science base including socio-economic
- Dissemination strategy, education and capacity building (Annual DWD Climate Conference; German Climate Portal - Deutsches Klimaportal)
- Intensified collaboration within a region: Germany, Switzerland, etc.

International Implementation

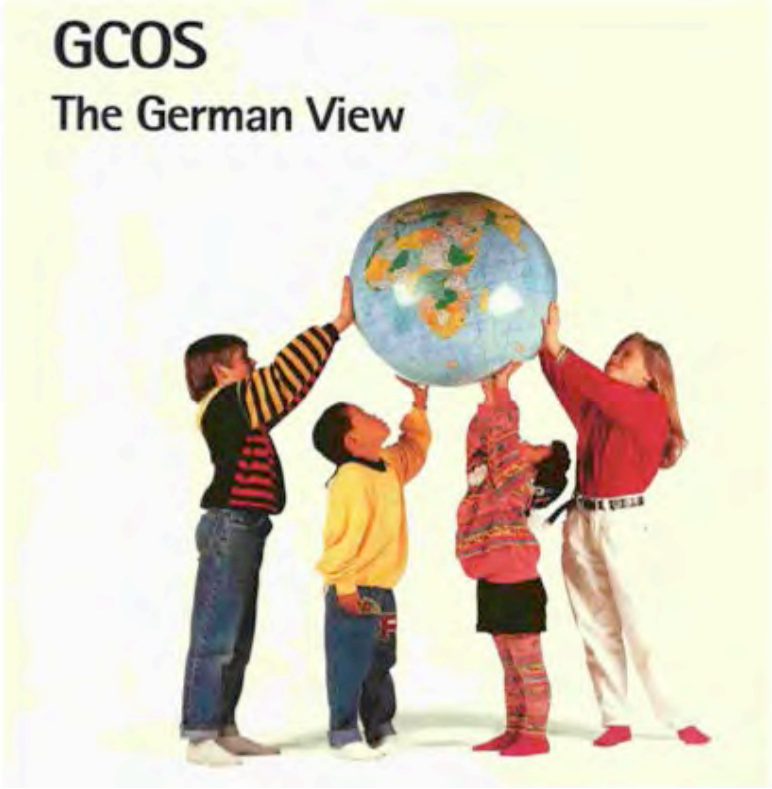
- International network
- Data rescue
- Contributions to international datasets and initiatives (ICOADS; IPCC)
- Science agenda

1 **Climate Services**

2 Assets: Observations and Models

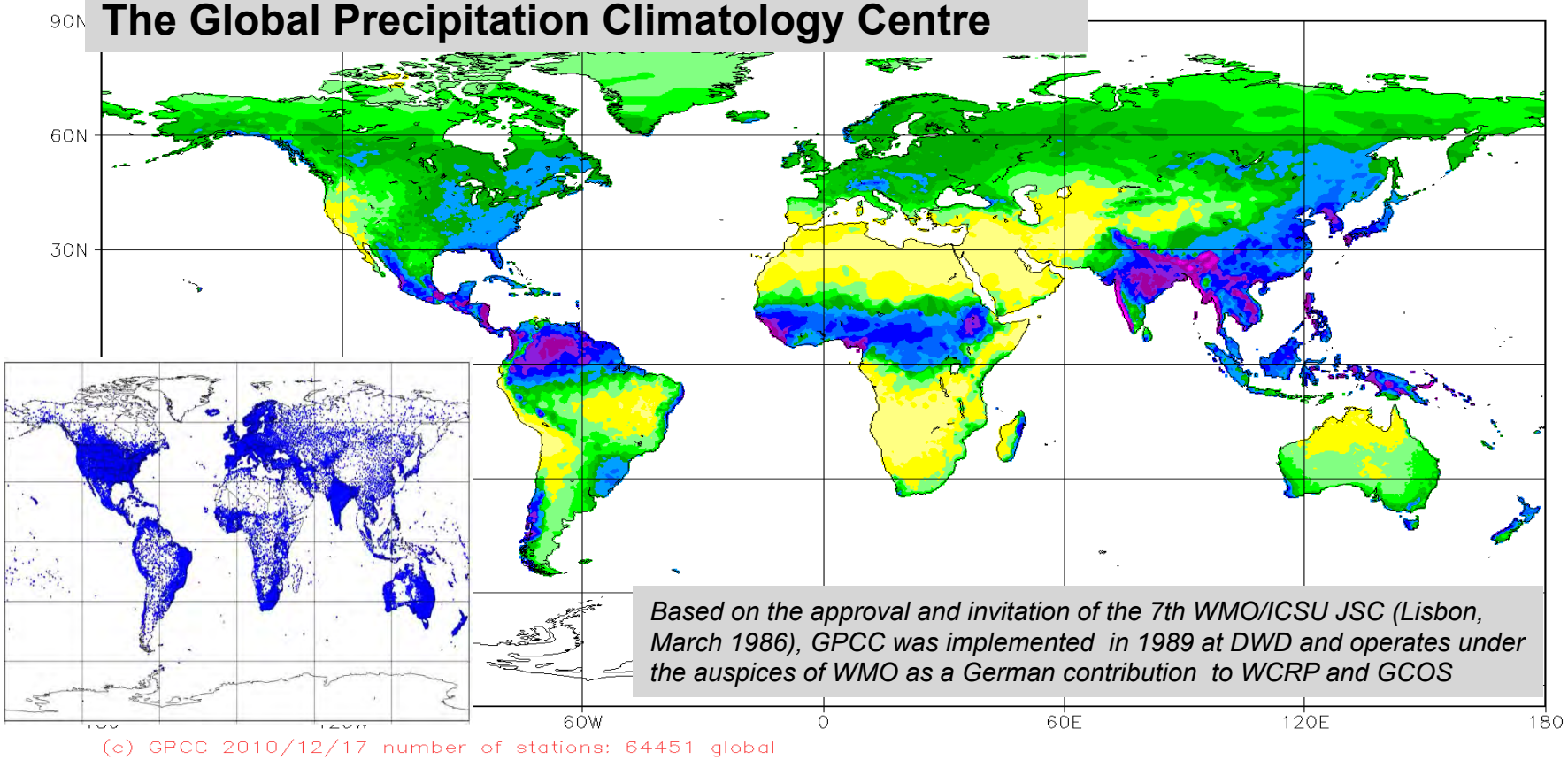
3 Research Gaps

Observations and Monitoring



- Satellite applications on climate monitoring CM-SAF
- Global Precipitation Climatology Centre (GPCC)
- Global Atmosphere Watch (GAW) global station
- Maritime Data Center (GCC)
- Baseline Surface Radiation Network (BSRN) reference station
- GCOS Reference Upper Air Network Lead Center
- Reanalysis of data

The Global Precipitation Climatology Centre



Based on the approval and invitation of the 7th WMO/ICSU JSC (Lisbon, March 1986), GPCC was implemented in 1989 at DWD and operates under the auspices of WMO as a German contribution to WCRP and GCOS

Precipitation July 1951-2000 (mm/month)

ICOADS

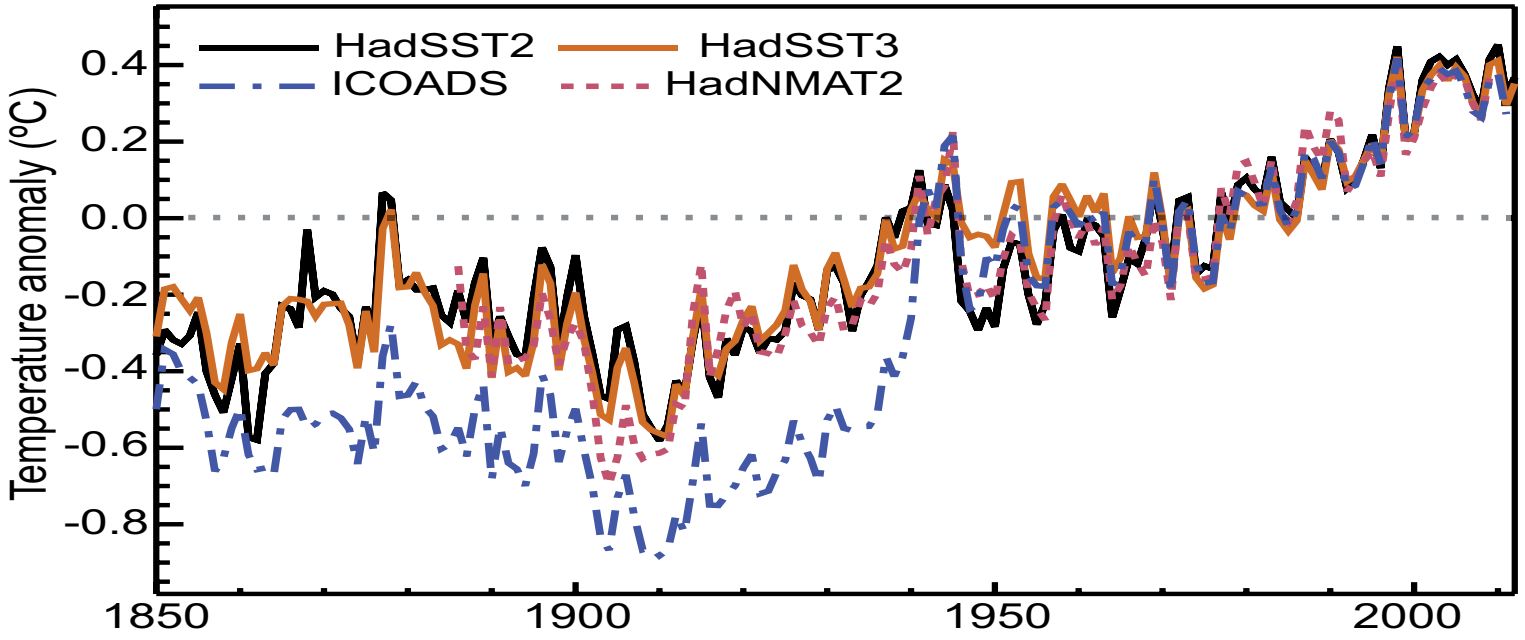
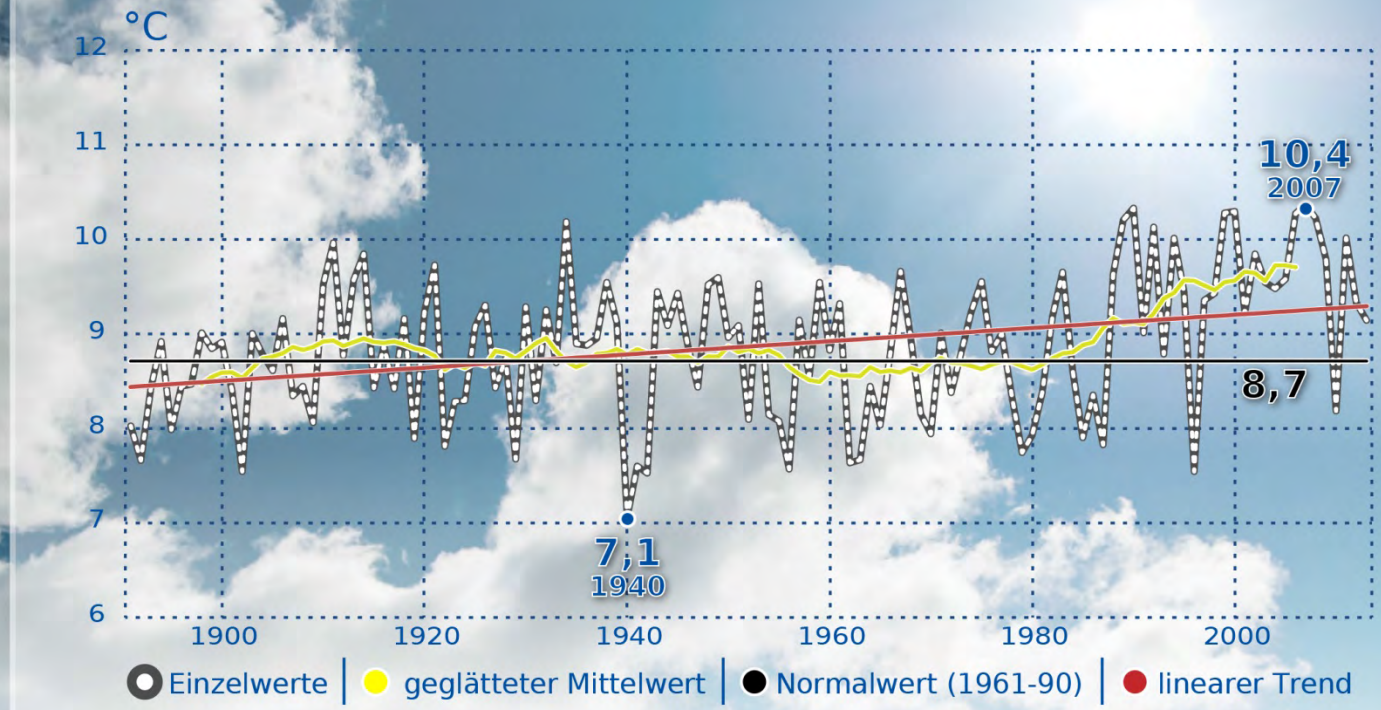


Figure IPCC14. WG1.2.16 | Global annual average sea surface temperature (SST) and Night Marine Air Temperature (NMAT) relative to a 1961–1990 climatology from gridded data sets of SST observations (HadSST2 and its successor HadSST3), the raw SST measurement archive (ICOADS, v2.5) and night marine air temperatures data set HadNMAT2 (Kent et al., 2013). HadSST2 and HadSST3 both are based on SST observations from versions of the ICOADS data set, but differ in degree of measurement bias correction.

REGIONAL CLIMATE INFORMATION

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Near surface temperature Hamburg 1891 – 2013



Quelle: Deutscher Wetterdienst, Abteilung Klimaüberwachung

Linear trends:

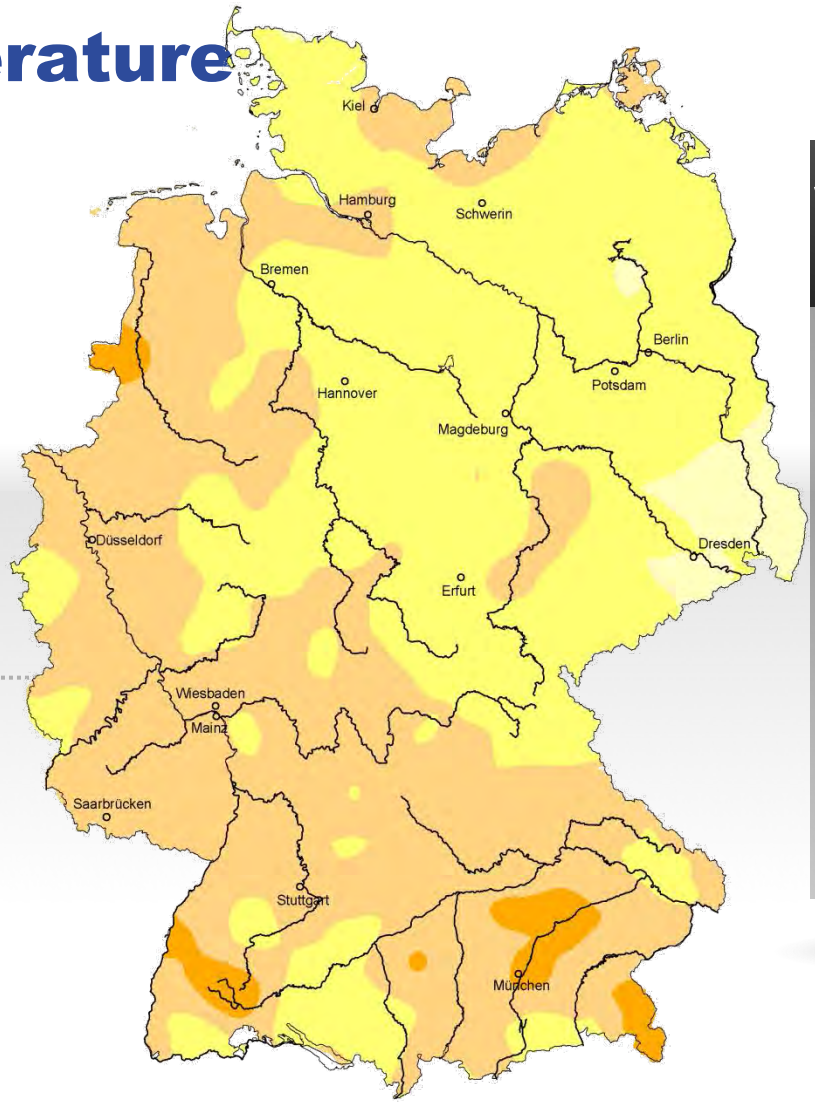
- record of 123 years: +0.07°C per decade
- last 30 years: +0.3°C per decade

Near surface temperature
winter

- linear trend (smoothed)
  1881 - 2011

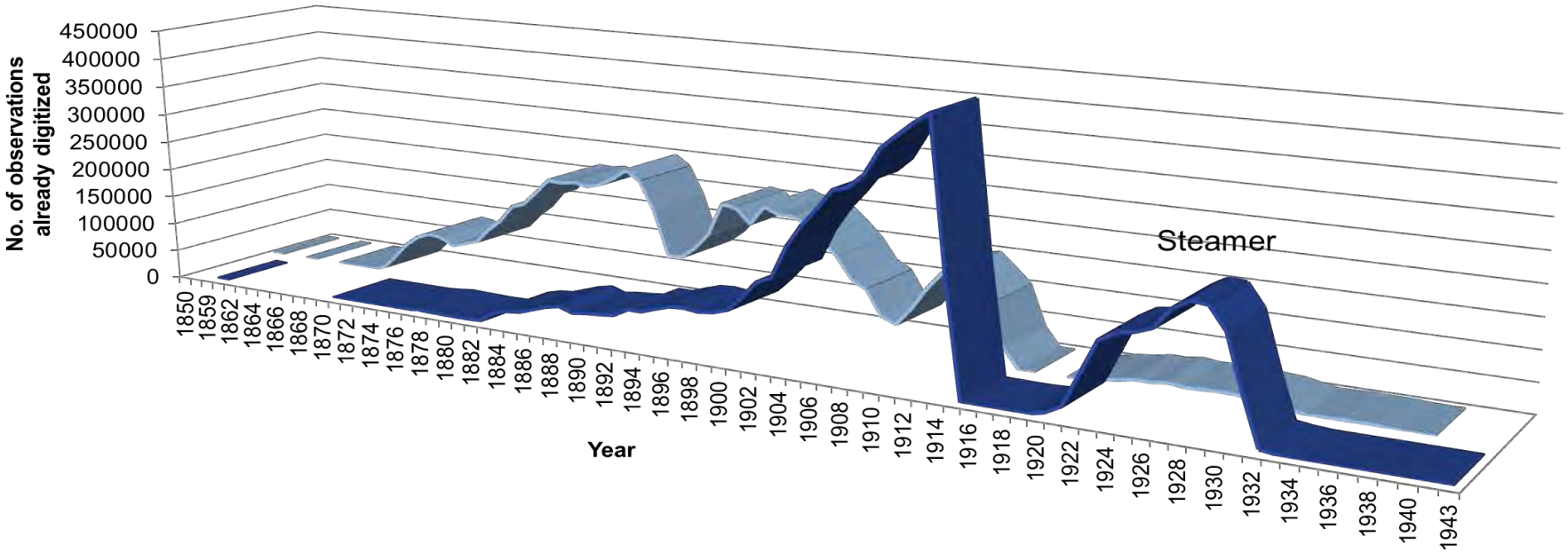
increase in winter

similar magnitude in summer and winter

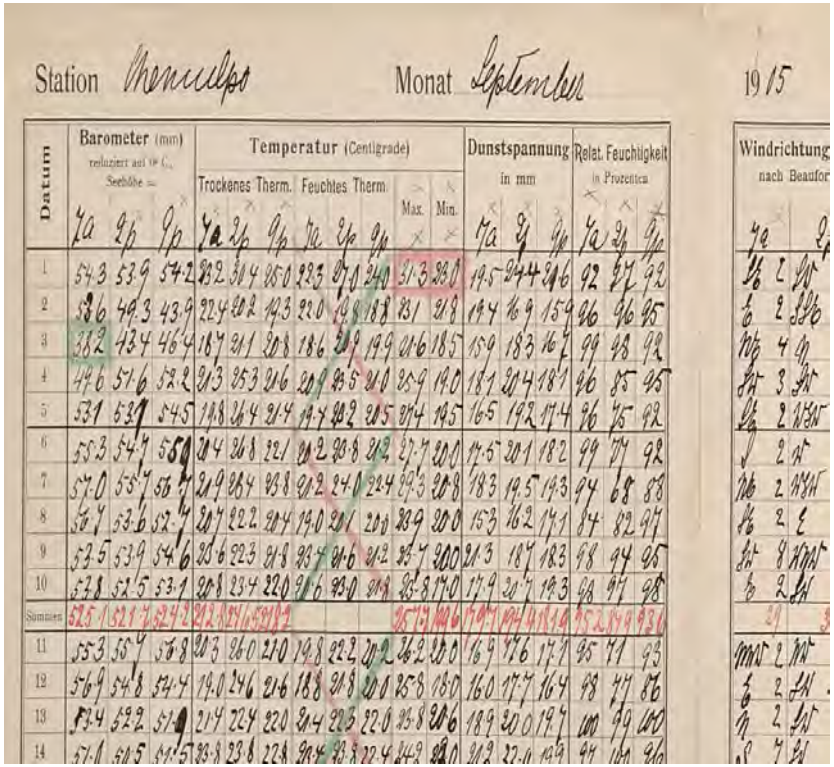


Quelle: Deutscher Wetterdienst, Abteilung Klimaüberwachung

Meteorological Station Kizunguzi (East-Afrika, 06°40' S, 37°11' E, 01/1934 - 02/1939)



Number of digitized observations from sailing ships and steamships (in total 15.1 million out of approx. 21 million until now)



FOCUS ON SUSTAINED OBSERVING SYSTEMS

DATA ASSIMILATION AND REANALYSIS

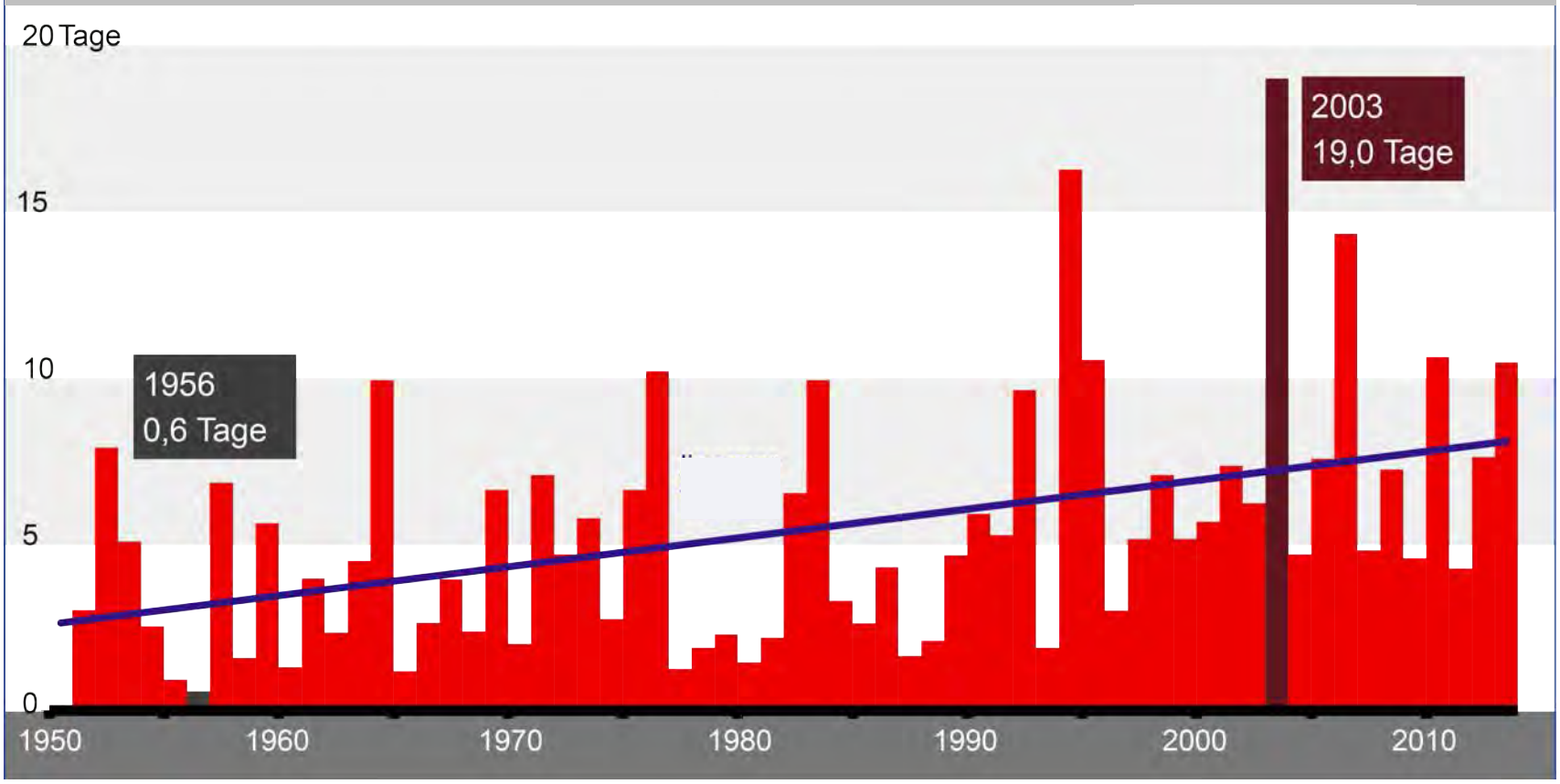
HIGH RESOLUTION DATA IN TIME AND SPACE

INTERNATIONAL DATA RESCUE

INTER-OPERABILITY OF DATA SETS

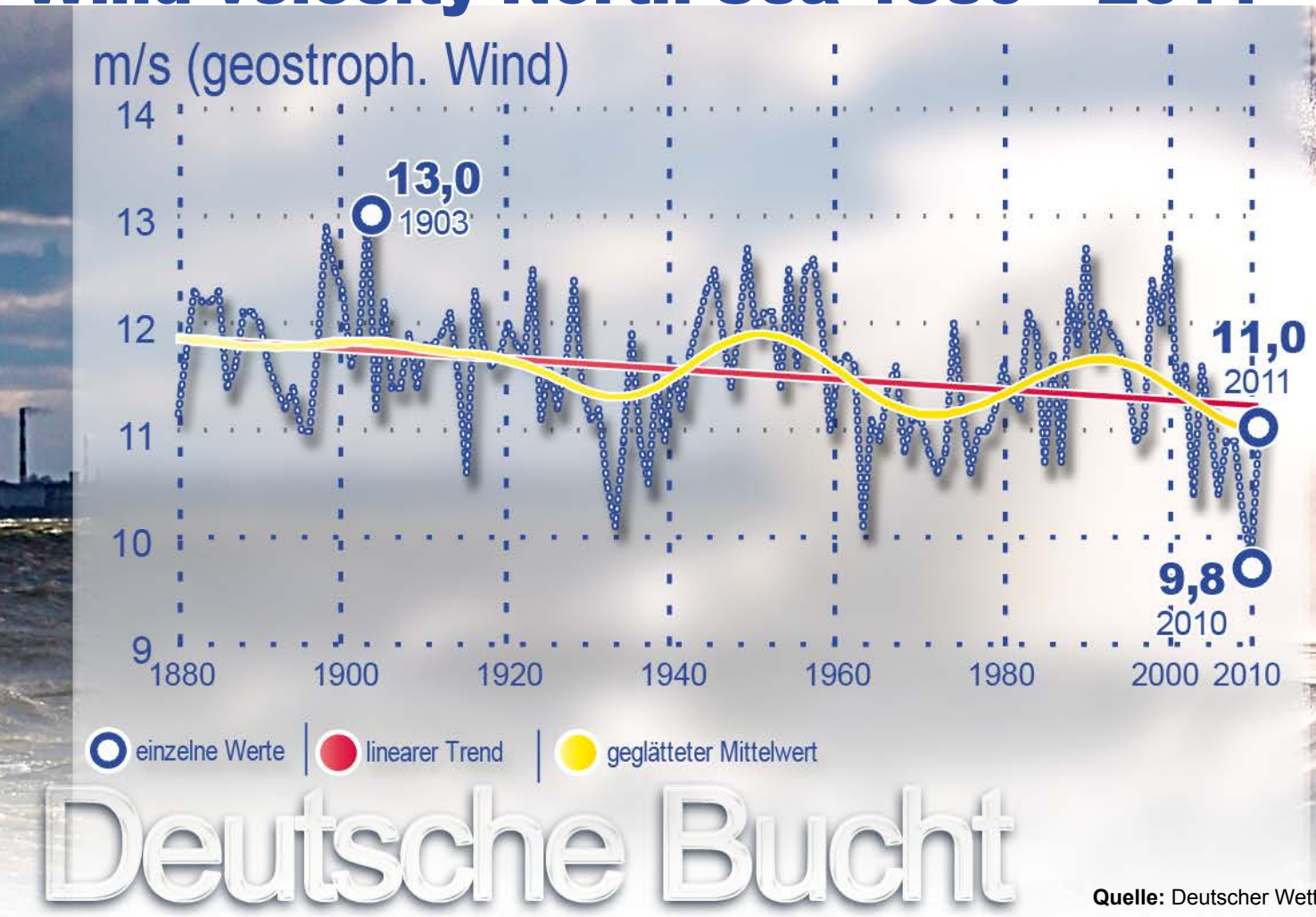
CLIMATE EXTREMES

Average number of days with temperatures above 30 C
Increased from 3 to 8 days per year



Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Wind velocity North Sea 1880 – 2011



Linear trends:

- last 100 years: **-0.043 m/s** per decade
- last 50 years: **+0.017 m/s** per decade

Quelle: Deutscher Wetterdienst, Abteilung Klimaüberwachung

1 **Climate Services**

2 Assets: Observations and Models

3 Research Gaps

WCRP Grand Challenges

- Clouds, Circulation, Climate Sensitivity
- Changes in the Cryosphere
- Regional Climate Information
- Climate Extremes
- Regional Sea Level Rise
- Water Availability

Key SPM Messages

19 Headlines

on less than 2 Pages

Summary for Policymakers
ca. 14,000 Words

14 Chapters
Atlas of Regional Projections

54,677 Review Comments
by 1089 Experts

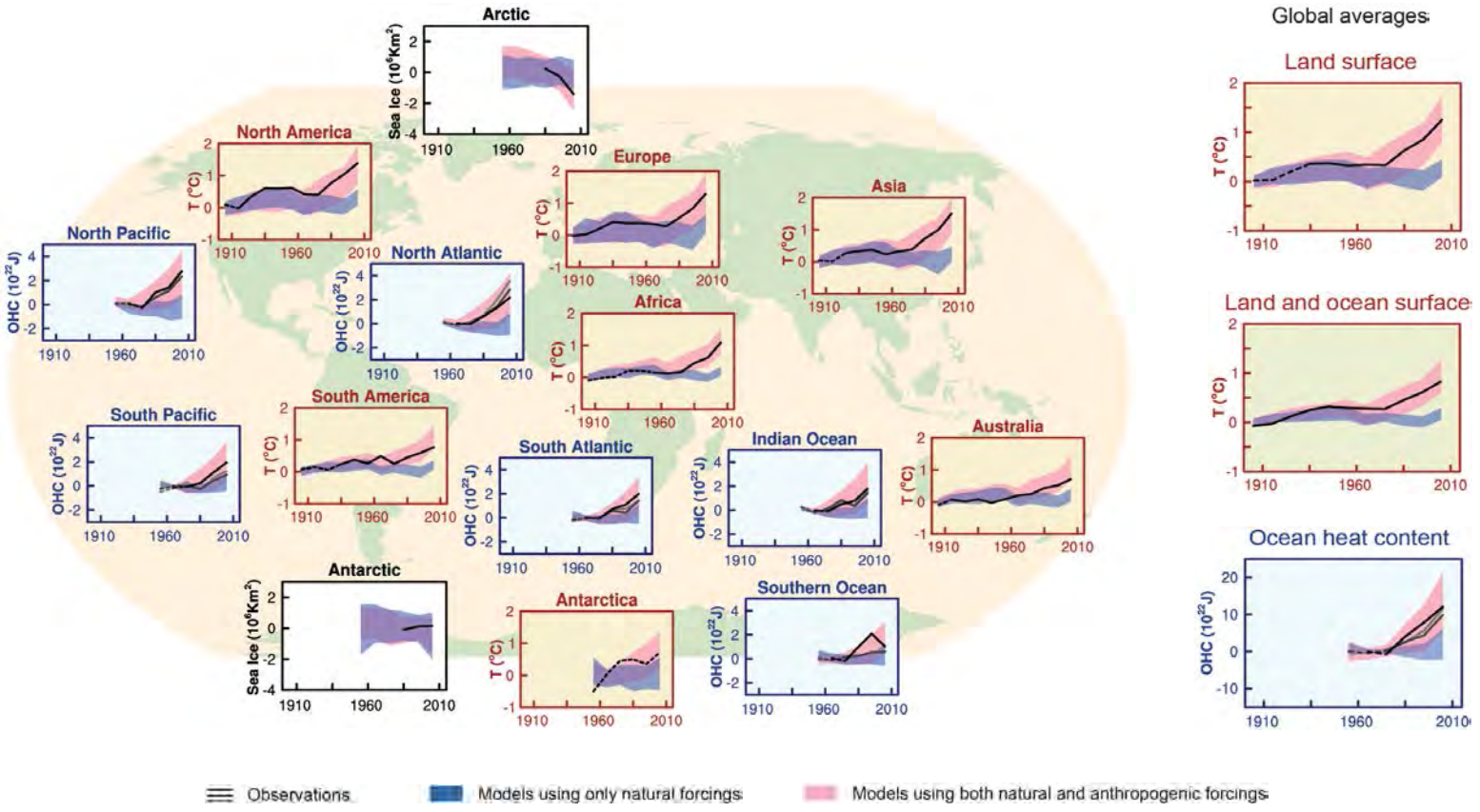
2010: 259 Authors Selected

2009: WGI Outline Approved

IPCC 3rd Lead Author Meeting, Marrakech, Morocco, April 2012

Figure IPCC14.SPM.6

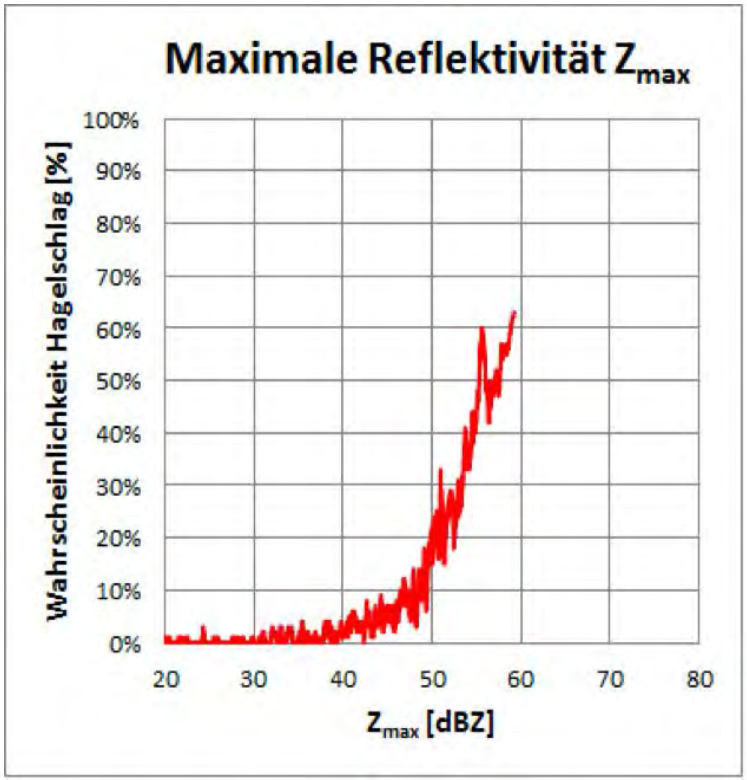
Comparison of observed and simulated climate change



USER DIALOGUE

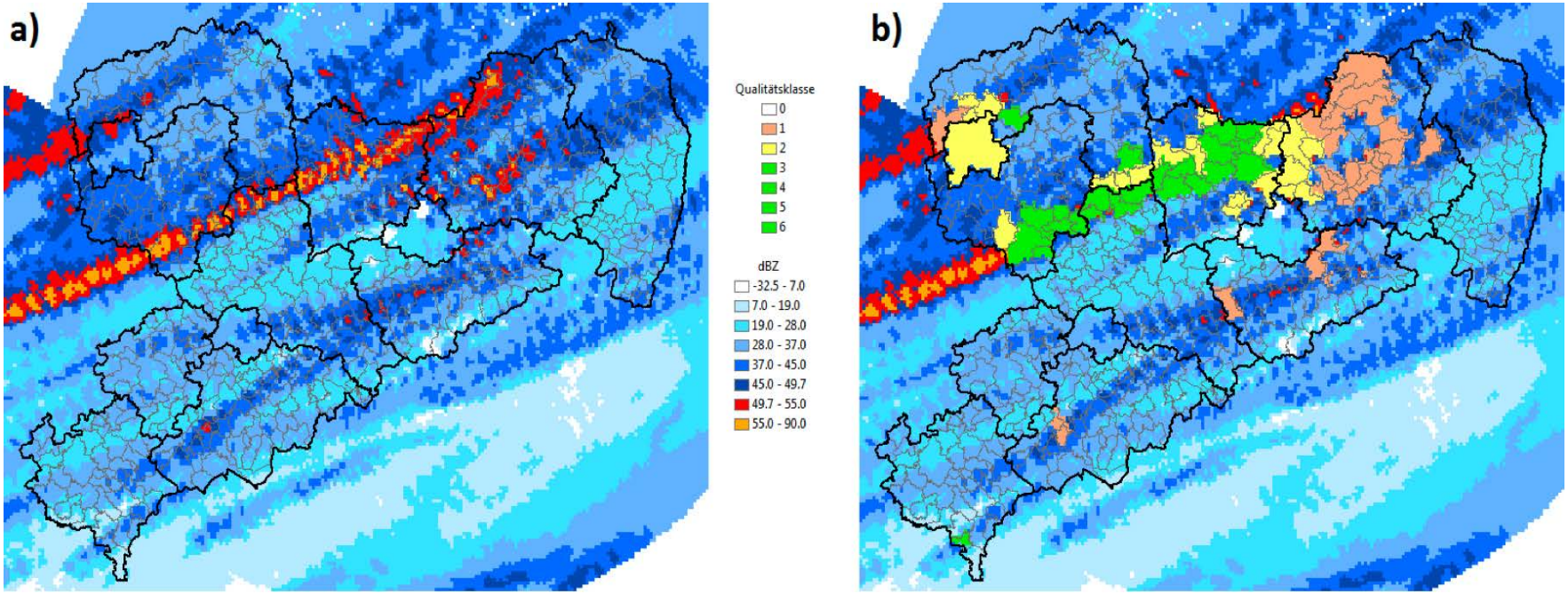
TAILOR-MADE PRODUCTS

A CLIMATOLOGY OF HAIL EVENTS



Wahrscheinlichkeit	max. Reflektivität
10%	(47.68 ±0.91) dBZ
15%	(49.65 ±0.16) dBZ
20%	(50.80 ±0.61) dBZ
25%	(51.83 ±0.83) dBZ
30%	(53.24 ±0.24) dBZ
35%	(53.84 ±0.23) dBZ
40%	(54.40 ±0.13) dBZ
45%	(54.88 ±0.43) dBZ
50%	(55.98 ±0.40) dBZ
55%	(58.01 ±1.33) dBZ
60%	(58.92 ±0.89) dBZ

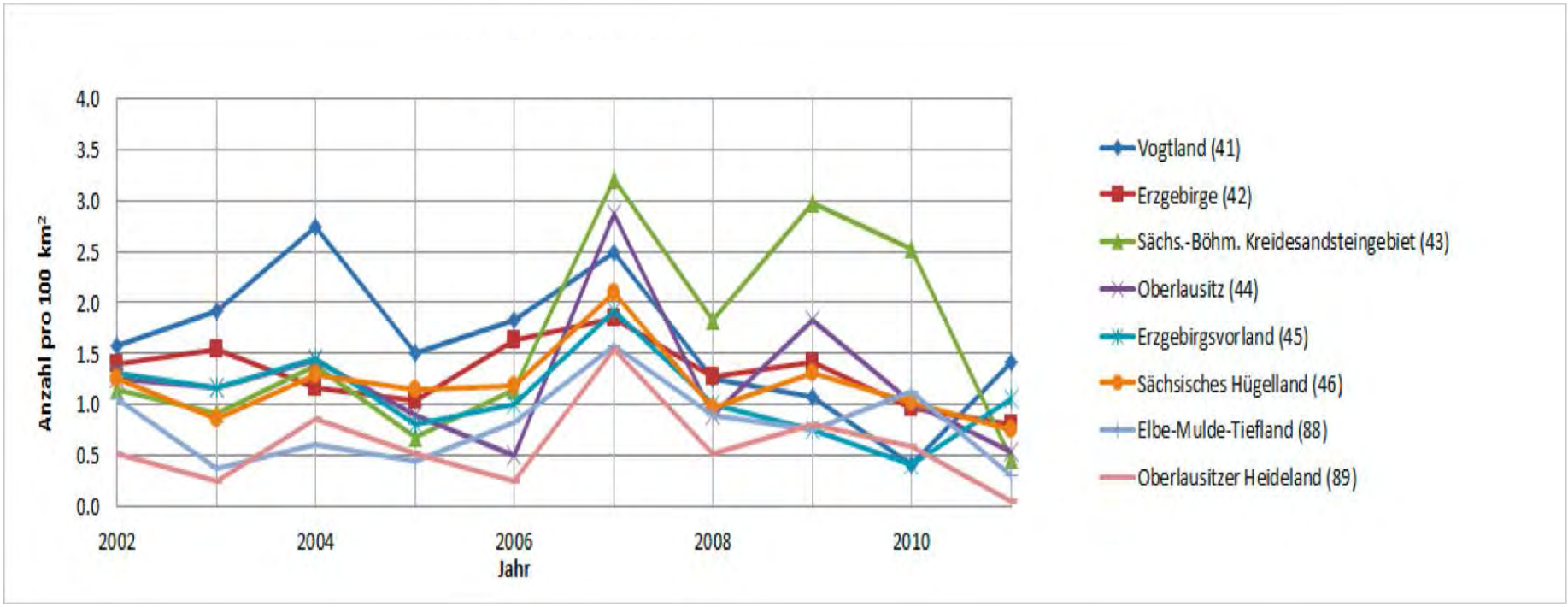
Occurrence of hail as a function of maximum RADAR reflectivity (Boettcher et al. 2013)



Hail on June 23, 2004.

a) reconstruction of maximum reflectivity,

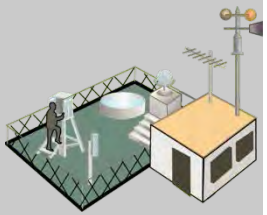
b) basic information (green) and algorithm of Boettcher et al., 2013 (yellow and pink)

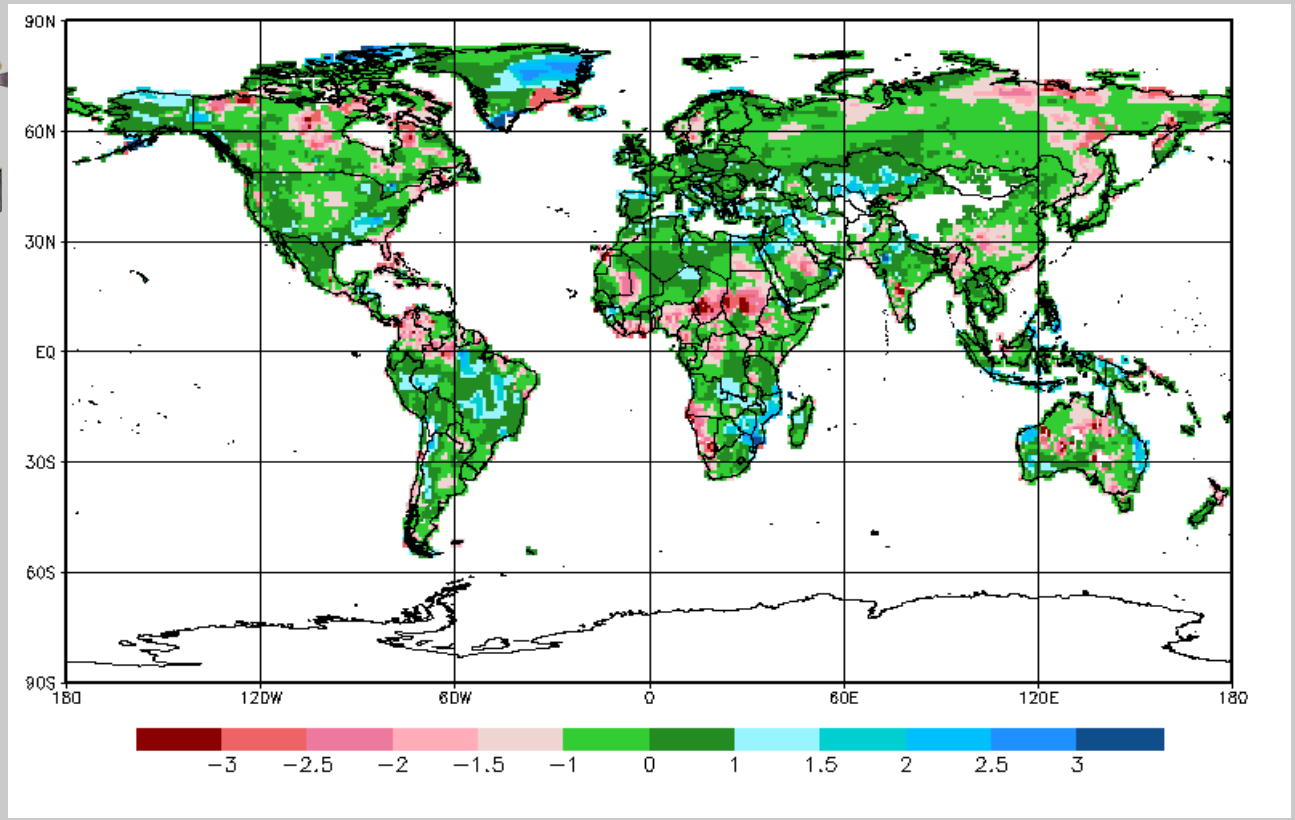


Interannual variation of hail events in Saxonia from Boettcher et. al., 2013, number of events per 100 km2

FLOODS AND DROUGHTS

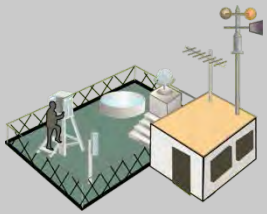
- New GPCC Drought Index Product allows for drought risk assessment

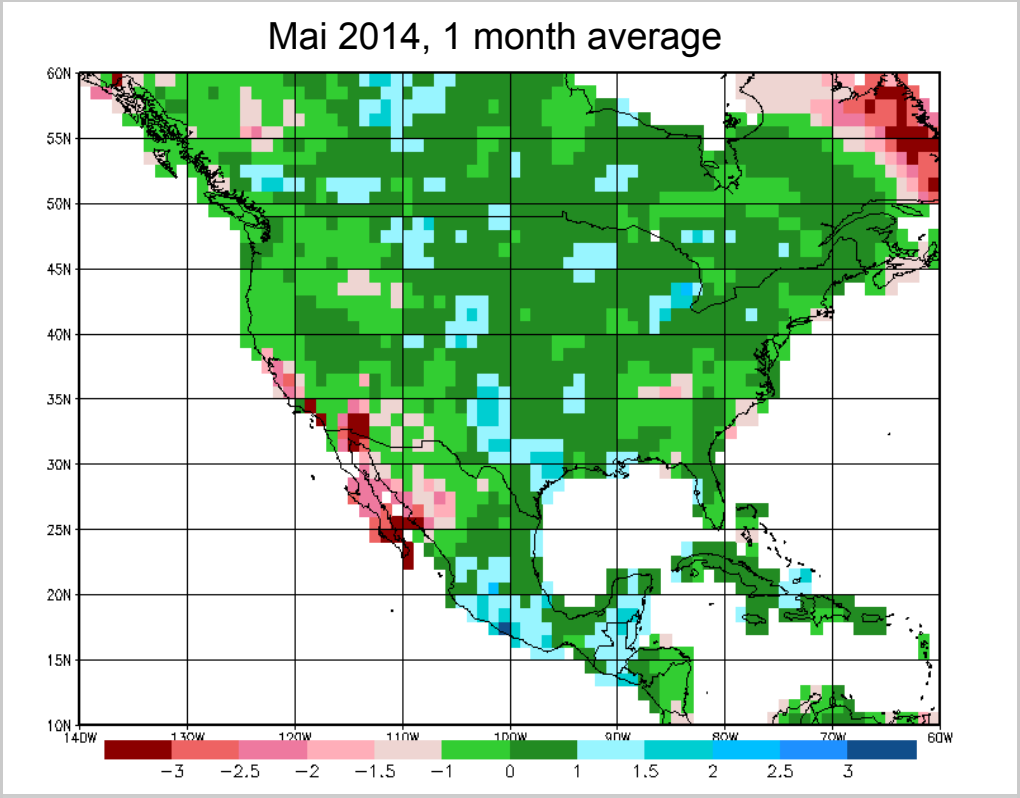




GPCC Drought Index Product

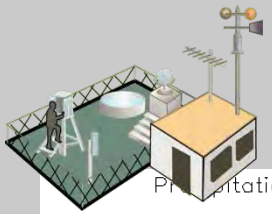
- New global GPCC Drought Index Product allows for drought risk assessment

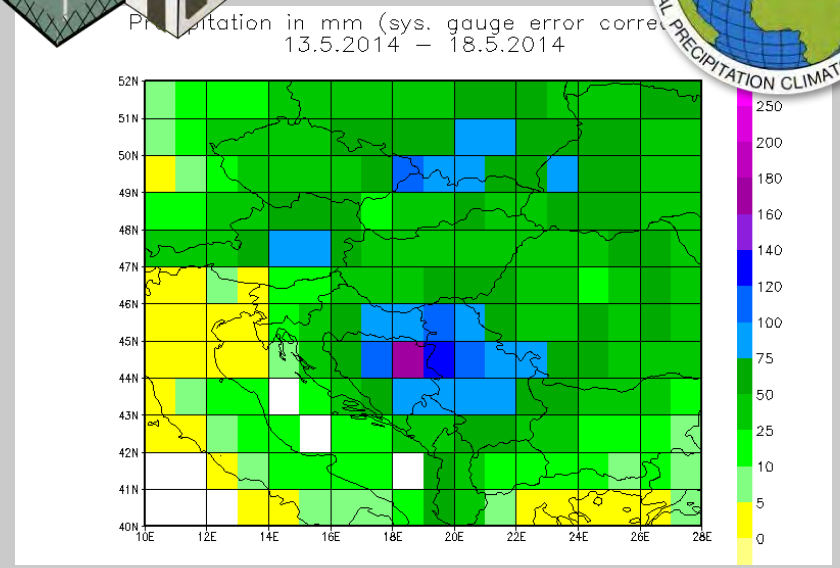




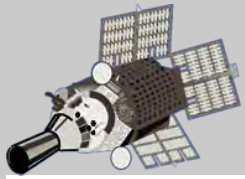
GPCC Drought Index Product

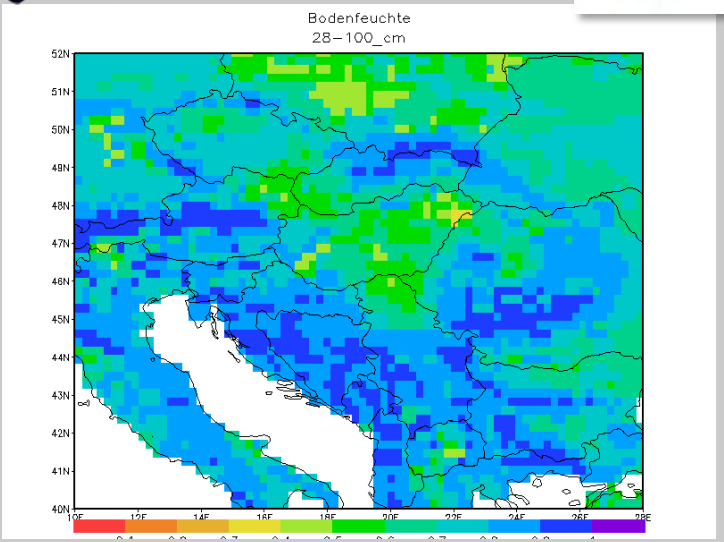
- New GPCC Daily Analysis Products allow for quick assessments of extreme events
- Integration with soil moisture products from H-SAF is key to diagnosing the flood risk of a region using a load concept





GPCC: Land Precipitation





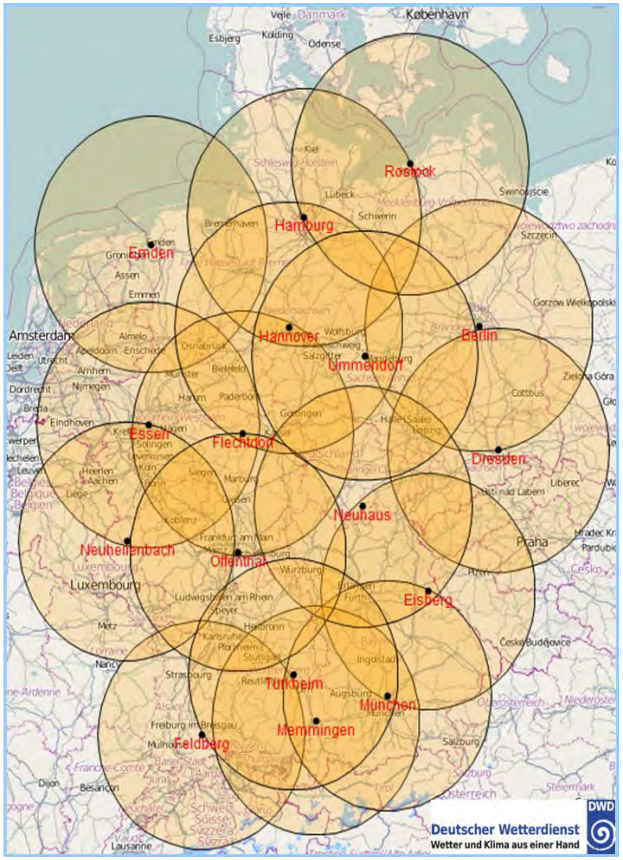
H-SAF Soil Moisture

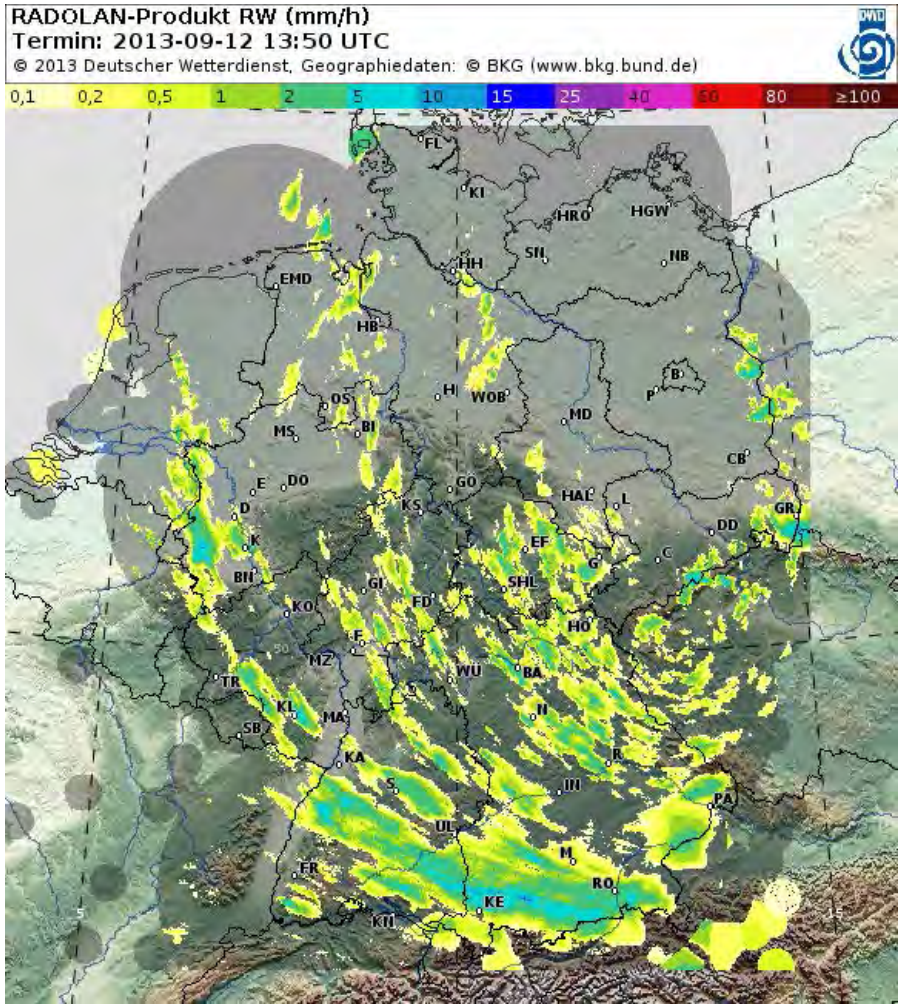
SUB-DAILY DATA

RADAR CLIMATOLOGY

1300 Automatic Rain Gauges operated by DWD

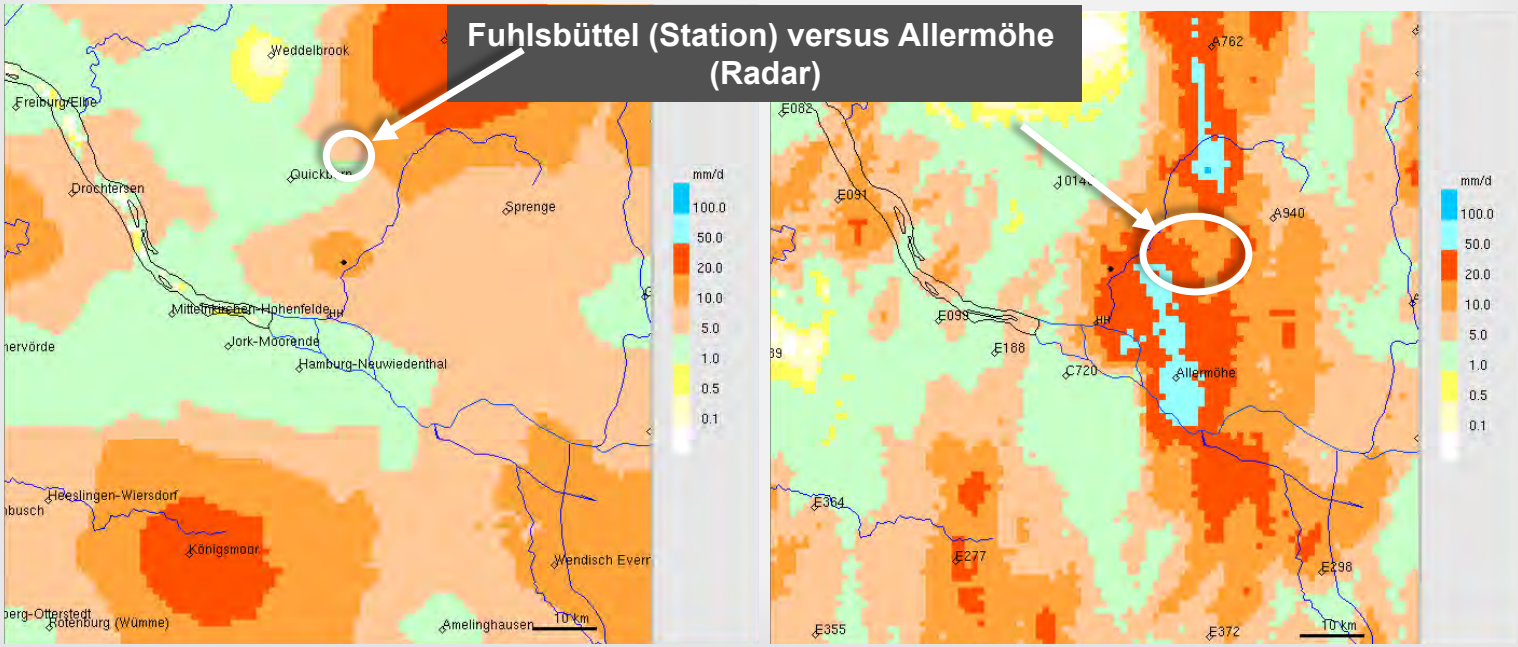
17 C-Band Doppler-Radars



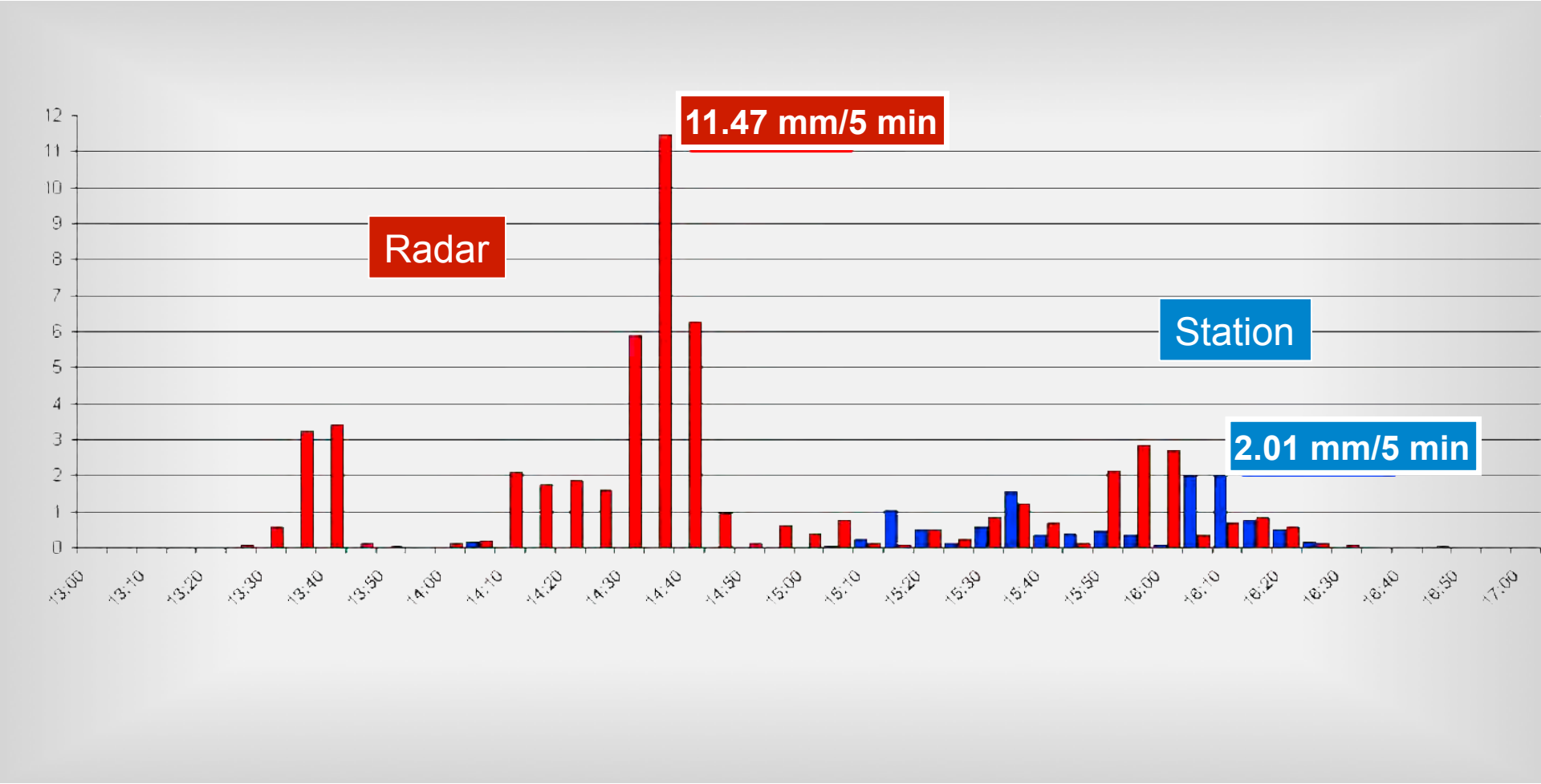


Extreme Events Precipitation

Precipitation on June 6, 2011 (06 to 06 UTC on the following day) from REGNIE (left) and RADOLAN analysis (right) for Hamburg Metropolitan area

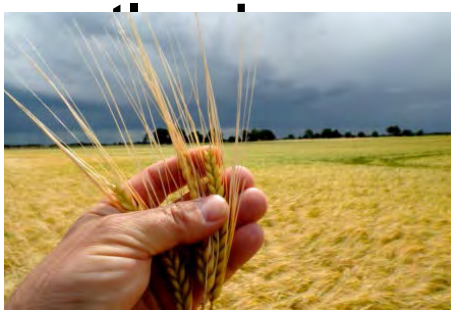


Extreme Events Precipitation



AGRICULTURE

German Climate Atlas

General

- air temperature
- ice days
- frost days
- summer days
- hot days
- tropical nights
- precipitation
- start of vegetation period
- forest fire index

Agriculture

- soil moisture under winter grain / sugar beet
- start of vegetation period
- days with changing frost
- start of flowering oil seed rape
- maize (yield and ripeness)
- pasture (yield 1st cut)
- plant haediness zones and plant heat zones
- Huglin-index (heat index for grape varieties)
- depth of frost penetration
- maximum of soil surface temperature
- air temperature
- precipitation

Forestry

- forest fire index
- bark-beetle development (start of infestation + end of 1st brood)
- plant haediness zones and plant heat zones
- start of vegetation period
- air temperature
- precipitation

Soil conservation

- soil moisture under winter grain / sugar beet
- depth of frost penetration
- maximum of soil surface temperature
- air temperature
- precipitation

new: **Energy industry** and **Transport**

Agro-meteorological Models

Agrometeorological model equations

Evapotranspiration: PENMAN-MONTEITH equation

Soil hydraulics: RICHARDS equation

Tracer modelling: Diffusion equation

Current measurement data of DWD and regional networks

1

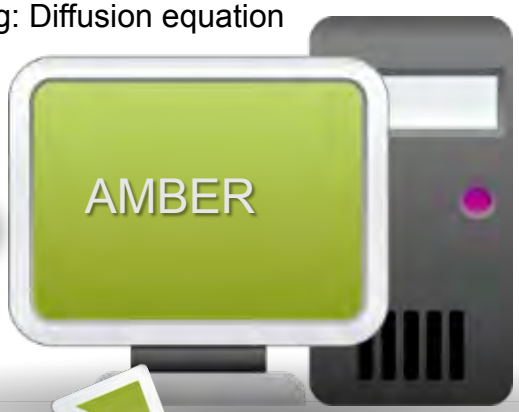
Numerical weather forecast data

Cultivation data–crop/soil
(phenological measurement network, special observers, contact via phone)

Corrections by meteorologists

2

3



4

Product generation

- headquarters
- branch offices

The advisory tool AMBER …

includes more than 200 agrometeorological parameters relevant for farming

- Timing of agricultural actions
- Hay drying
- Yield forecast
- Plant protection (pests and diseases)
- Crop and soil microclimate
- Phenological prediction
- EU Fertilizer Directive
- Irrigation advisory, …

Wind Erosion Modelling

March 5, 2014, A20 motorway, Bad Doberan

Wind Erosion Modelling: Case study

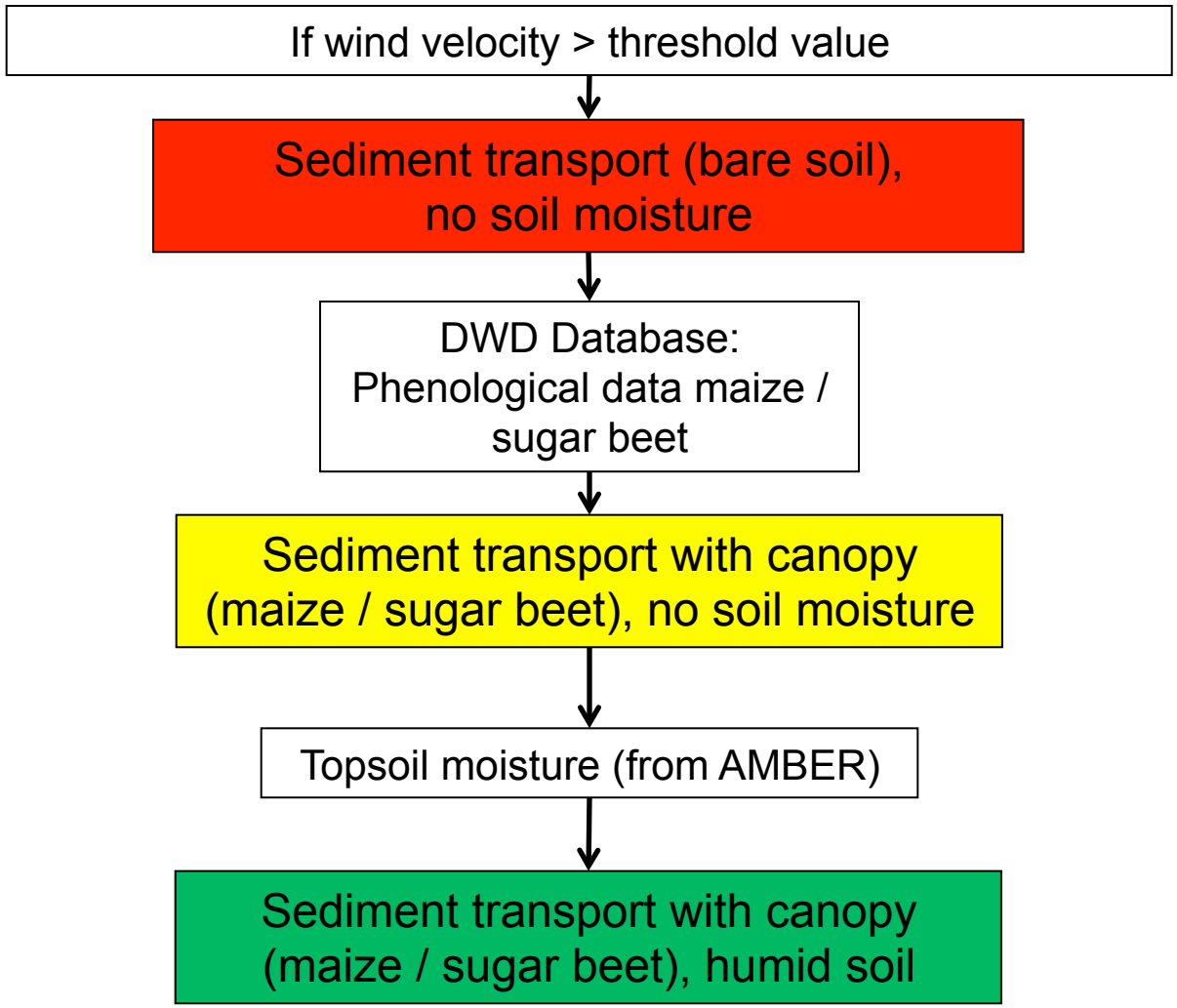
Motorway pileup in Northeastern Germany (April 8, 2011) due to unusually deep tillage and high winds

Model input:

- Sandy soil (40.5 % erodible material), no vegetation
- Wind velocity (average): 9.4 m/s
- Tillage depth: 20 cm (exceptional!)
- Top soil moisture: 23% (not extremely dry)

All erodible topsoil material depleted during one erosion event!

Source: www.merkur-online.de, April 9, 2011


If wind velocity > threshold value
Sediment transport (bare soil), no soil moisture
DWD Database: Phenological data maize / sugar beet
Sediment transport with canopy (maize / sugar beet), no soil moisture
Topsoil moisture (from AMBER)
Sediment transport with canopy (maize / sugar beet), humid soil

AMBER and climate prediction

21 regional models

observations	hindcasts	climate change projections
1961 - 1990	1961 - 1990	2011 - 2040 2071 - 2100

AMBER - application

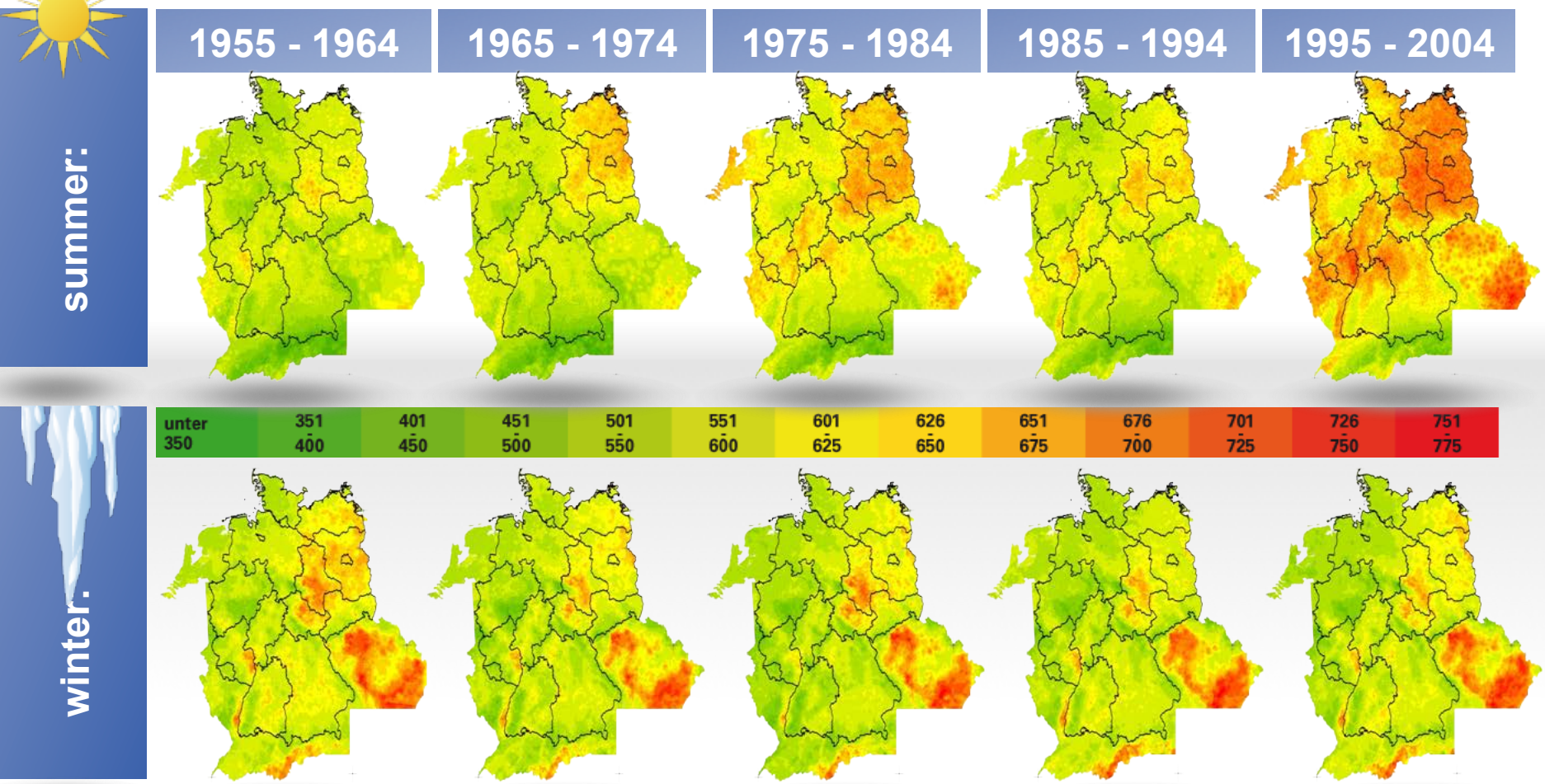
- comparison AMBER-results 1961 – 1990
  (input data: observations and modelling)
- assessment of future conditions

German Climate Atlas: www.deutscher-klimaatlas.de

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Dry Spells

(Days with less than 1 mm precipitation) – **Increase in summer**



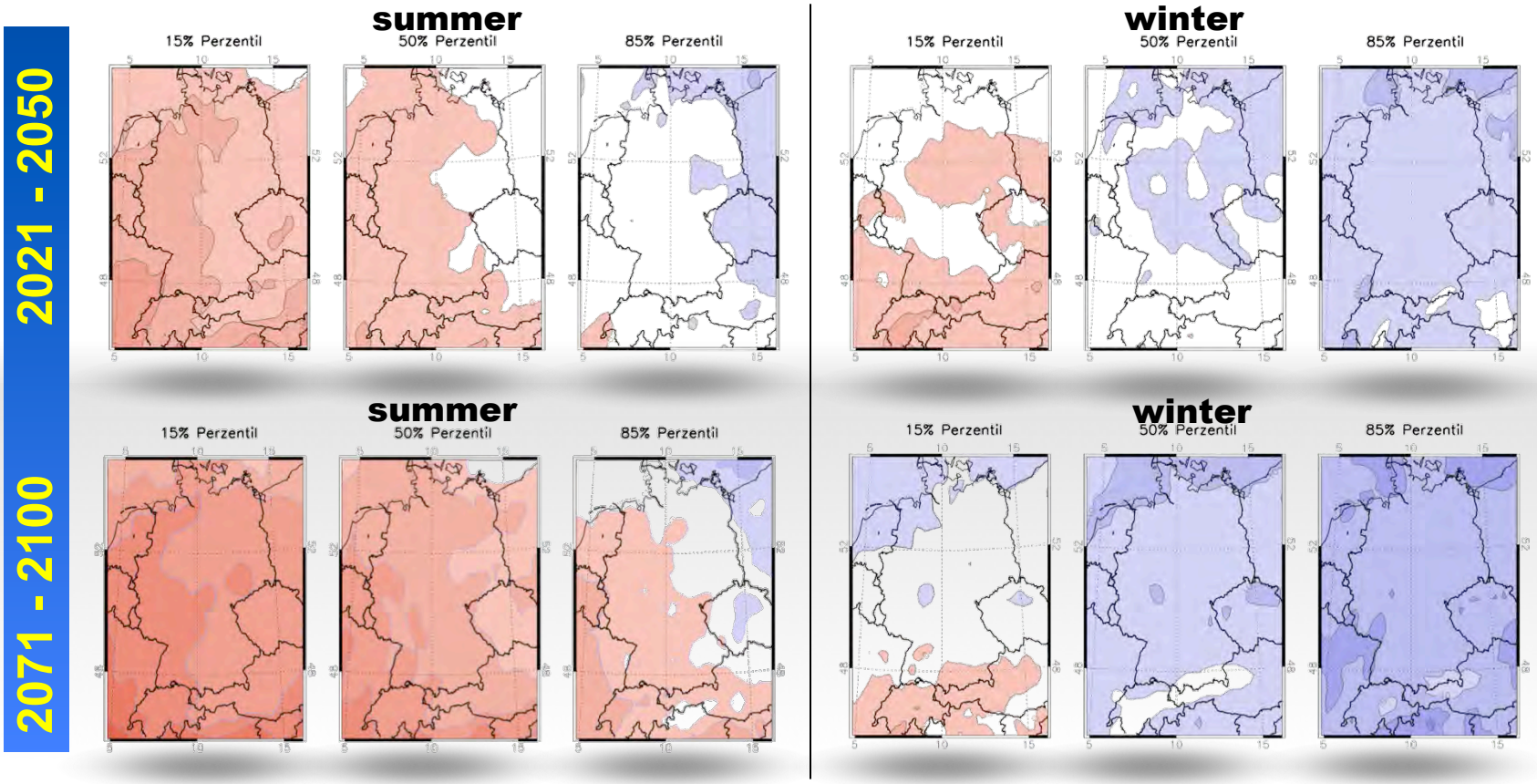
Quelle:: Deutscher Wetterdienst, Abteilung Hydrometeorologie

Modelling, Prediction and Projection

- ➔ Climate Services require *Seamless Prediction* capabilites
- ➔ Science:
  - Model development (ICON dynamical core)
  - Develop an international seasonal prediction system (EUROSIP EUROpean Seasonal to Interannual Prediction; DWD in collaboration with Max-Planck Institute)
  - Develop a decadal prediction system (BMBF project MIKLIP)
  - Inter-annual and multi-decadal variability
  - Attribution
  - Laboratory to check adaptation options
  - Regional focus on coupled ocean-atmosphere modelling and cryosphere
  - Hydrology, soil processes mainstreaming and facilitate land use change scenarios and permafrost dynamics

Ensemble Projections (19 Members)

Precipitation Probabilities (Reference 1971 – 2000)



Quelle: Deutscher Wetterdienst

Limited Area Climate Ensemble Prediction System LACEPS
Mittelfristige Klimaprognosen MIKLIP

COSMO-CLM :

Atmosphere, COSMO4.8-clm17, Euro-CORDEX model domain, resolution of 0.22°

Simulations

COSMO-CLM run from 1959 using ERA-40 as driving data and extended by ERA-Interim, i.e. 1959 – 2010

Hindcast Simulations

Driving data:

MPI-ESM-LR coupled model decadal simulations

Initialization for temperature/humidity in/at soil surface:

from evaluation runs

Deacadal Forecasts
Limited Area Climate Ensemble Prediction System LACEPS
Mittelfristige Klimaprognosen MIKLIP

COSMO-CLM

COSMO4.8-clm17, Euro-CORDEX model domain,

resolution of 0.22°

Evaluation Runs

COSMO-CLM run from 1959 using ERA-40 as driving data and extended by ERA-Interim to 2010

Hindcast Simulations

Driving data:

MPI-ESM-LR coupled model decadal runs

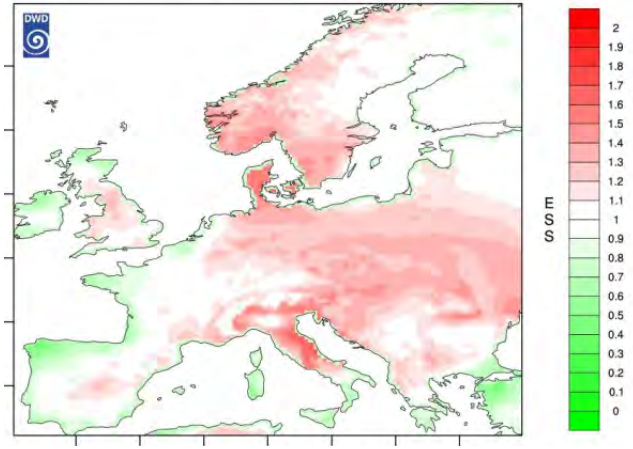
Initialization for temperature/humidity in/at soil surface:

from evaluation runs

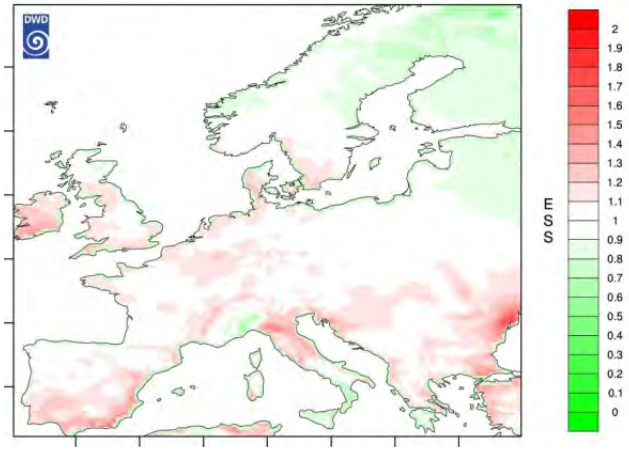
2m temperature, 2006-2009, DJF

Ensemble Spread Score

MPI-ESM-LR

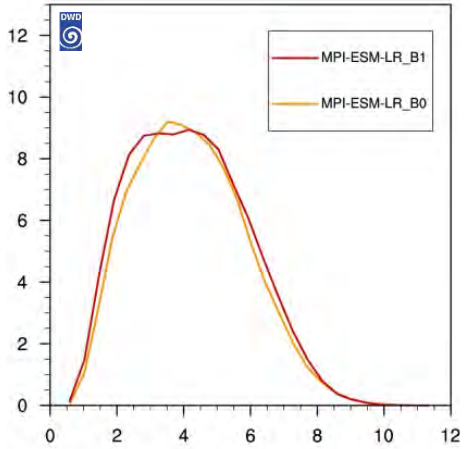


COSMO-CLM

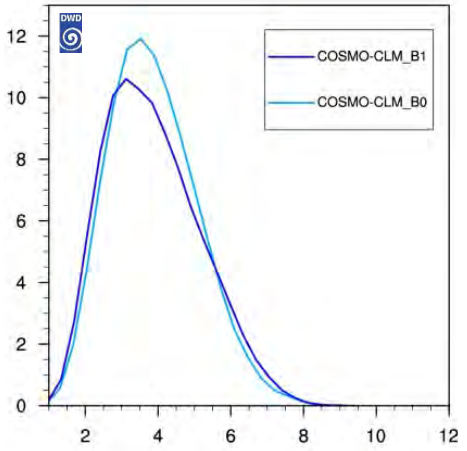


PDF of Spread

MPI-ESM-LR



COSMO-CLM



Baltic and Mediterranean as Hot Spots of Climate Change (Giorgi, 2006)

Regional and Seasonal Modelling

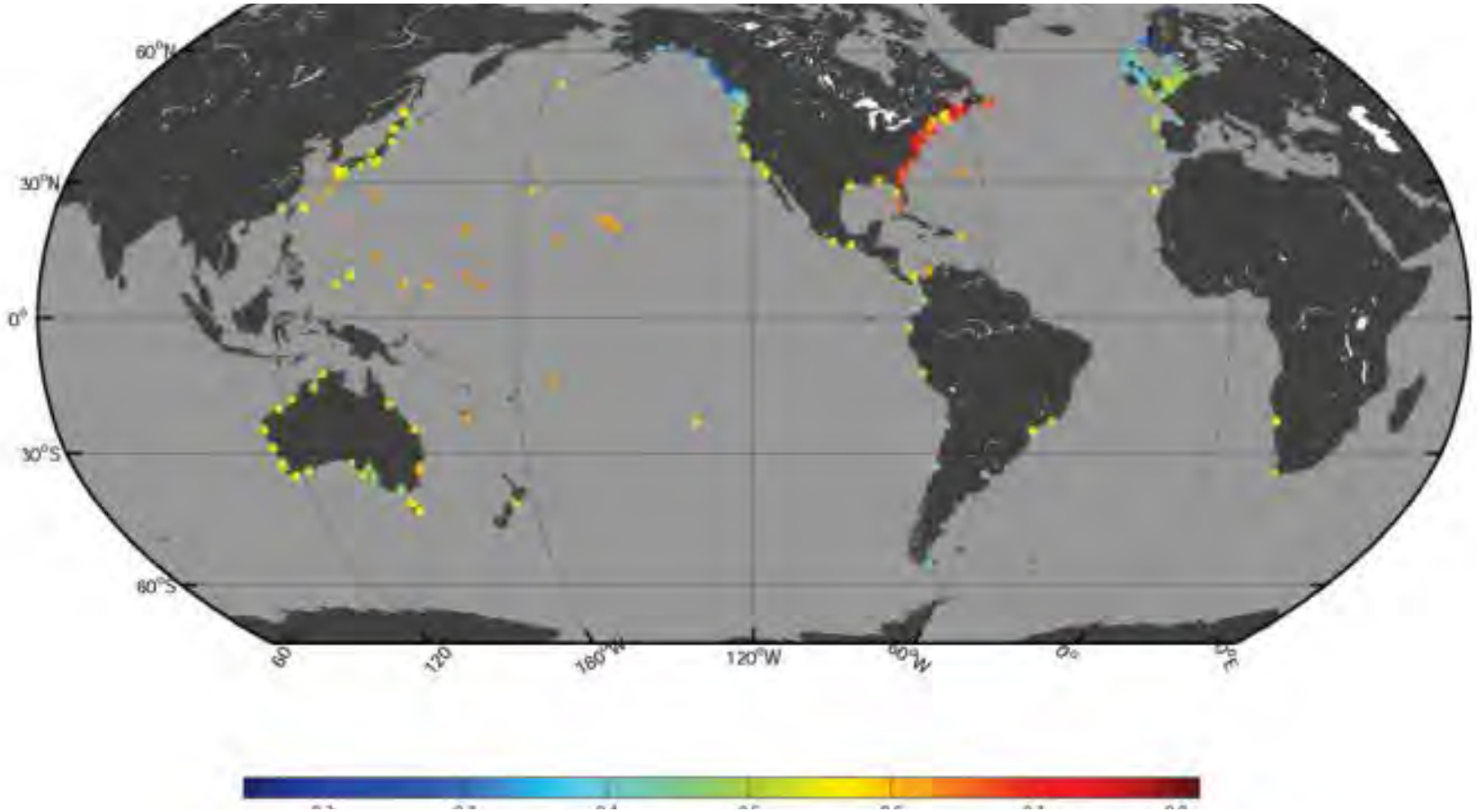
Coupling of COSMO-CLM and ocean model NEMO

- Improved description of
- … consistent physics of ocean-atmosphere fluxes
- … interaction of ocean and sea ice
- … transport of climate signals from the North Atlantic to the North Sea
- … the effect of the ocean on the local climate

Climate Limited-area Modelling Community

SEA LEVEL RISE

Fig. IPCC. : Hunter et al. 2013

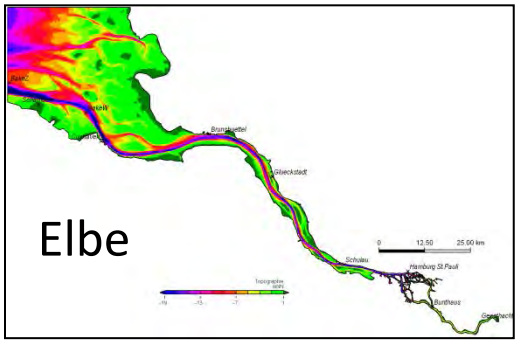


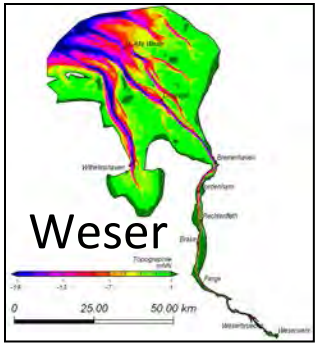
KLIWAS Project

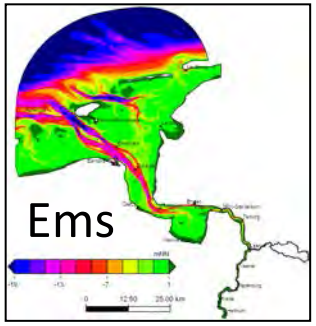
- Basic research and applied science
- Sector-specific example and regional focus area of socio-economic relevance – Transferable?
- Federal Agencies as users (transport and shipping, hydrography, hydrology, maritime meteorology, engineering)
- Protection of vulnerable coastal assets and shipping, risk reduction and protection of infrastructure
- Complexity issues in coastal areas, interest in extremes, low water levels as important as floods
- Highly interdisciplinary, natural and anthropogenic
- Ocean-atmosphere coupled regional modelling, wave model, storm surge data, sea level rise, sedimentation
- New climatologies at high resolution

Vulnerability and Adaptation in Estuaries

KLIWAS
Klima · Wasser · Schifffahrt

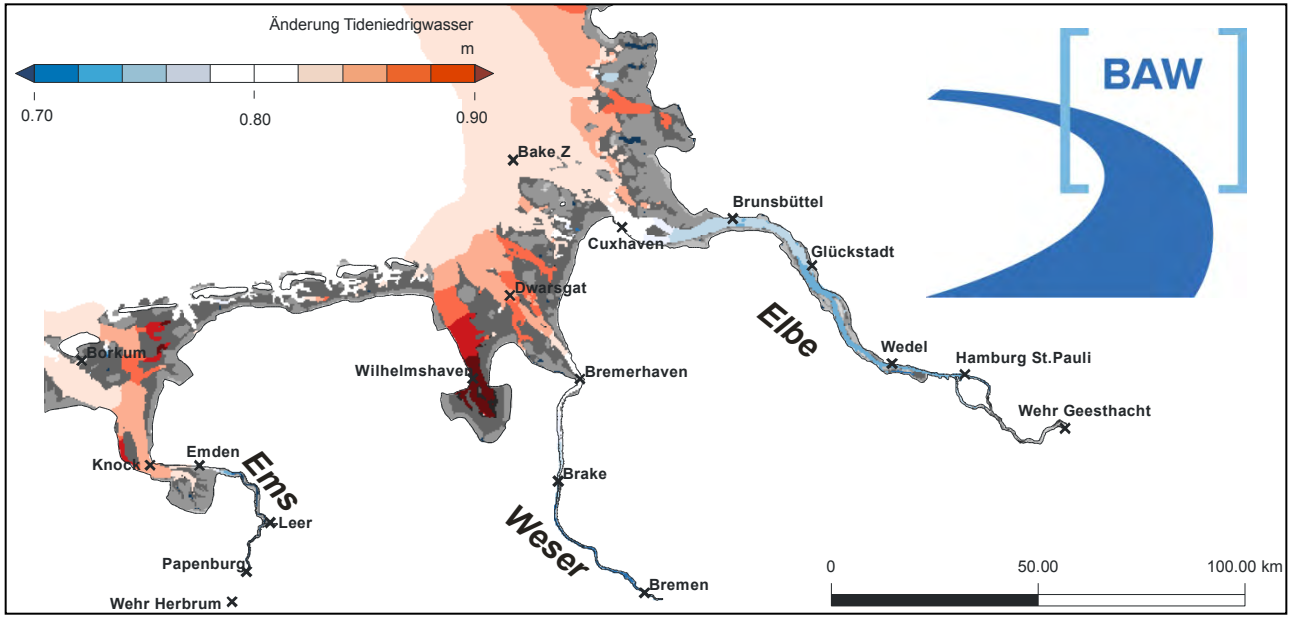






Sensitivity studies:
Sea level rise
Salinity in the estuary
Storm surges
Transport of pollutants

Winkel et al., 2014



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North Sea Salinity: Projection 2070-2099

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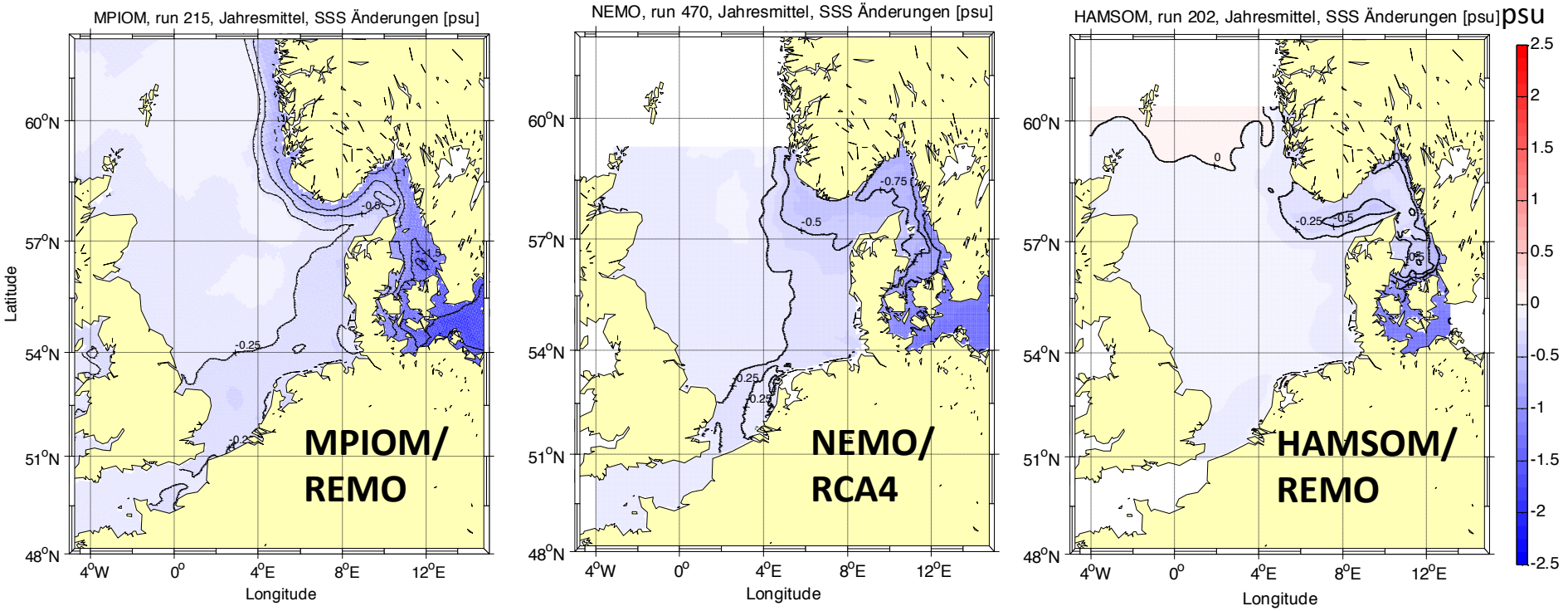
Difference to 1970 - 1999



Moderate decrease of salinity in the North Sea, strong decrease in the Baltic outflow

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North Sea Waves: Projection 2070-2099

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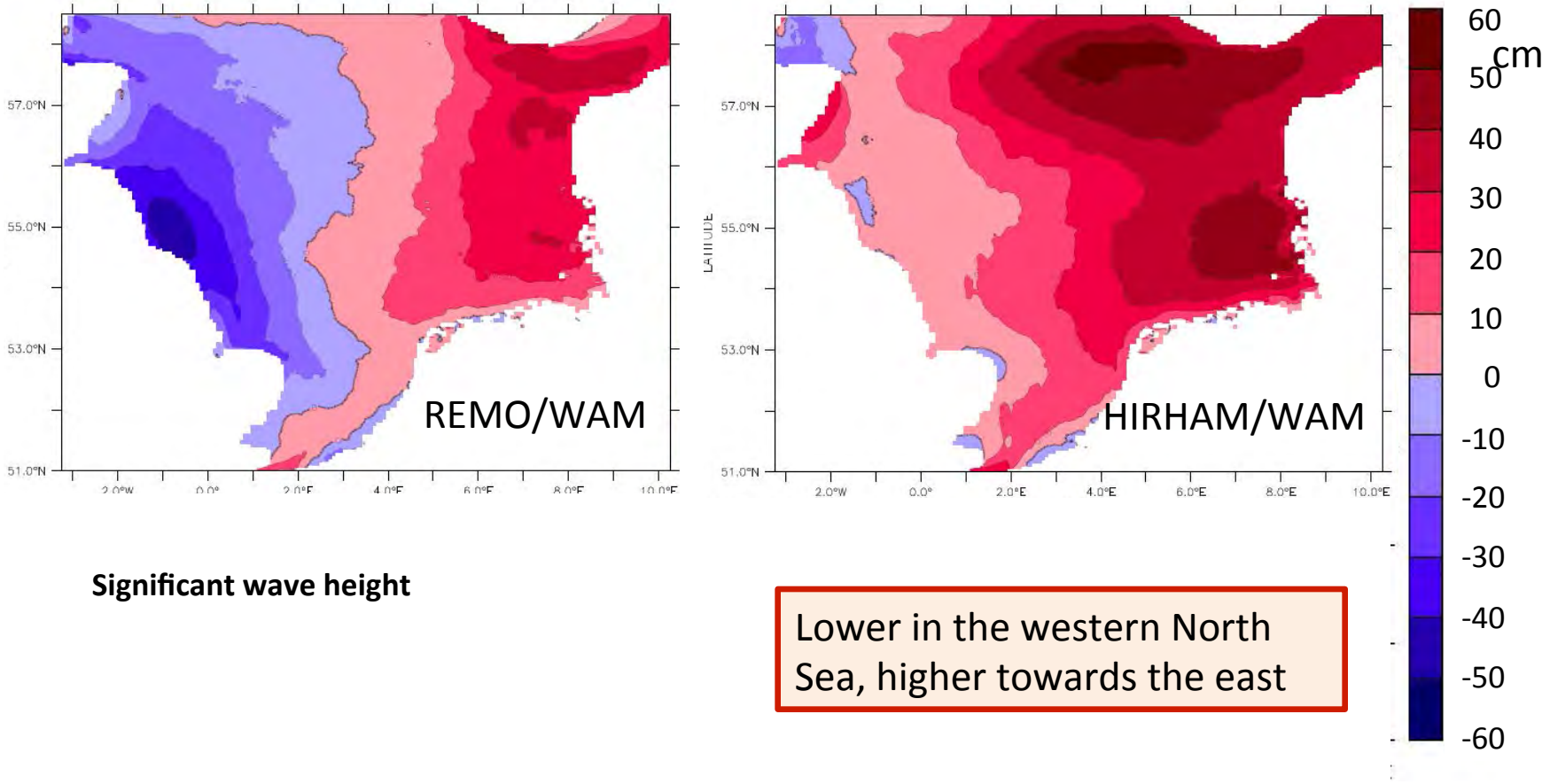
Difference to 1961 – 1990



Significant wave height

Lower in the western North Sea, higher towards the east

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Sea Level: Projection 2070-2099

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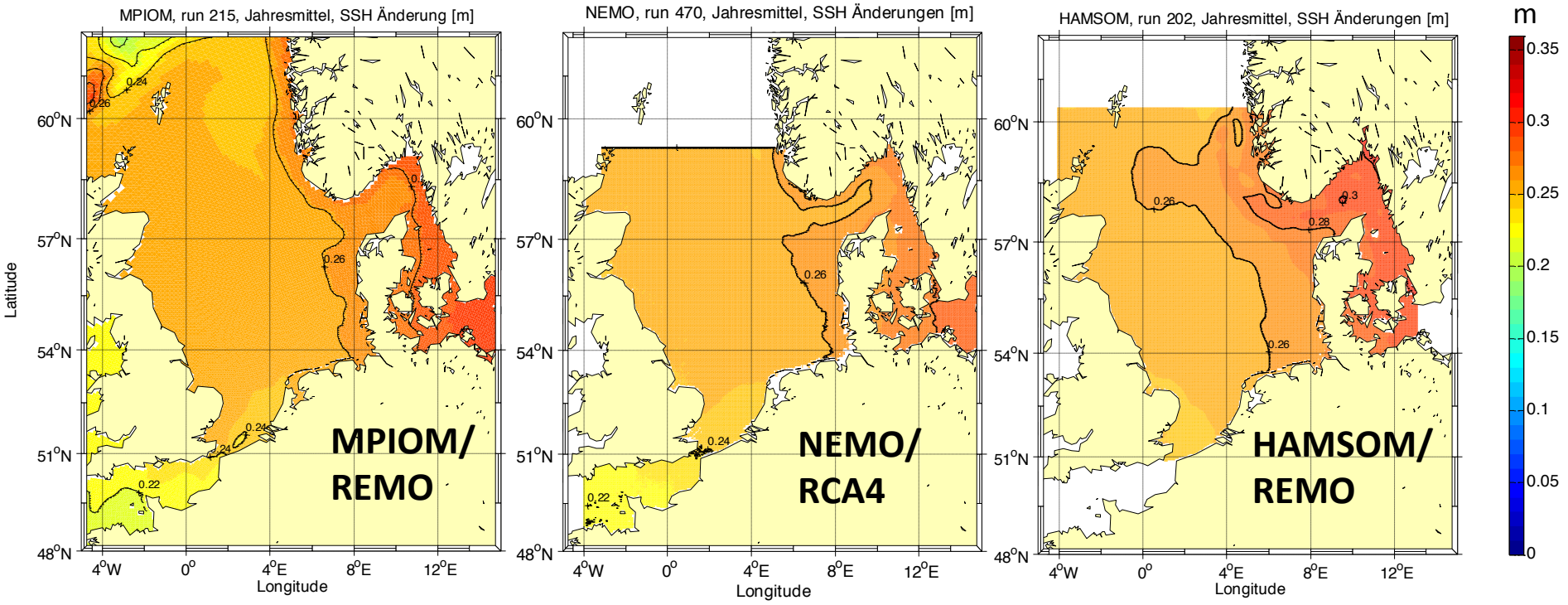

25-28 cm plus 31 cm from glaciers and ice shields

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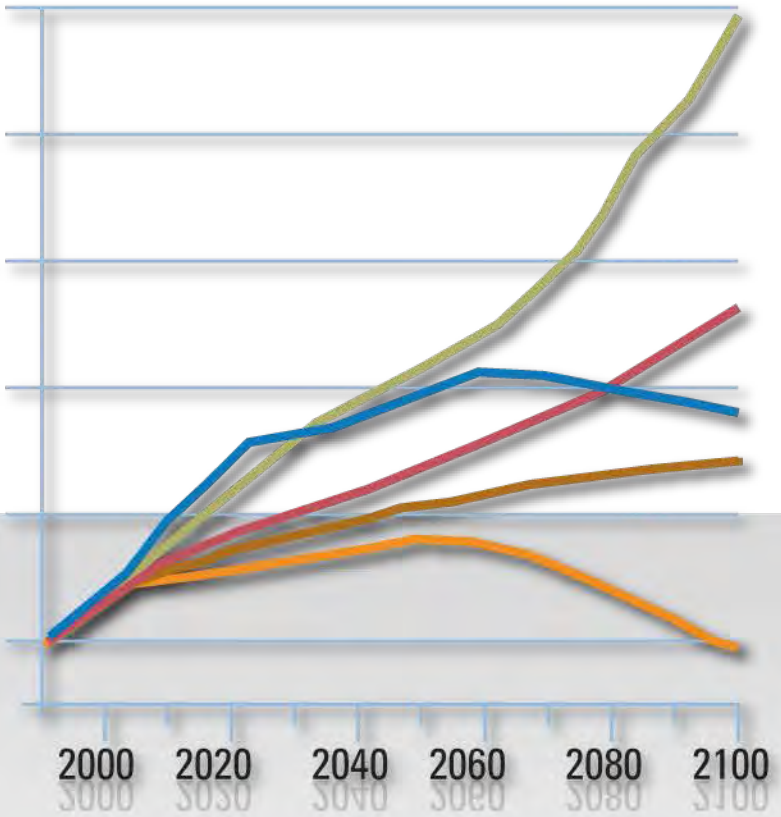
Conclusions

Provision of Climate Services requires new skills:

- User dialogue, create networks of practitioners and climate researchers
- Dialogue on high quality products, best practices, guidance on what to expect from a product, metrics of value
- Develop a new research agenda
- Global long-term records, inter-operability of diverse data holdings
- Regional applications, higher resolution, interdisciplinary competence
- Operations and near real-time
- Information systems: cutting-edge information technology
- Communication strategy, education, collaboration and capacity building



Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Thank you for your attention