Interfaces of Climate and Environment services of Deutscher Wetterdienst to the research in CESOC

Short overview

- Founded in 1952
- Governmental public authority under the Federal Ministry for Digital and Transport (BMDV)
- Headquarters in Offenbach am Main
- 6 branch offices in Hamburg, Potsdam, Leipzig, Essen, Stuttgart and Munich
- Around 2,200 staff members
- Provider of scientific and technical services and with a duty to undertake research
- Representation of Germany in international meteorological and climatological organisations (e.g. WMO, ECMWF, EUMETSAT)

Organisation Chart

Administrative Advisory Board

Scientific Advisory Board

Press Office

International Affairs

Prof Dr G. Adrian
President

Internal Audit

Strategy and Office of the President

Board of directors

N. Wetter
Personnel and Business Management

KJ. Schreiber
Technical Infrastructure and Operations

Prof Dr S. Jones
Research and Development

R. Hagedorn
Weather Forecasting Services

T. Fuchs
Climate and Environment Services

Data base for weather forecasts, weather warnings and climate monitoring

- In situ observation sites, some with long term time series going back more than 100 years
- Radiosondes
- Weather radar network (since 2001)
- Satellites
- Civil aircrafts
- Buoys
- Ships
- Data from co-operation partners

DWD's spatial data and spatial data services freely available via
www.dwd.de/opendata
https://maps.dwd.de/geoserver/web/

HPC for weather and climate modelling

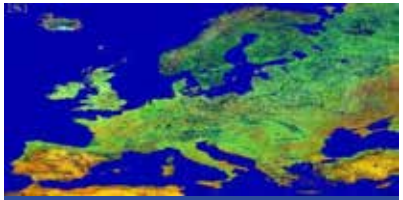
- All data are transmitted to the DWD's HPC for storage and further processing
- Computing systems deployed: two NEC SX-Aurora TSUBASA vector engines
- Peak performance of 4.3 and 5.6 petaFLOPS (achieved by over 4,100 vector processors)
- Eco-friendly due to innovative “green” hot water cooling

Seamless Prediction

Production and provision of seamless weather and climate services at all timescales in support of evidence-based policy decisions

Climate services: Global – EU – National

Global



EU

Germany

New initiative DestinE just started
→ first phase until mid 2024

GFCS GLOBAL FRAMEWORK FOR CLIMATE SERVICES

Copernicus Europas Blick auf die Erde

Global Framework for Climate Services

WMO + commissions + partners

Operational, free, European climate and atmosphere services of EU with trans-national dimension

Operational, free, national climate services of DWD and its partners

EU Initiative COPERNICUS thematic service areas

Land monitoring
(*Management: EEA*)

Ocean monitoring
(*Management: Mercator Ocean*)

Atmosphere monitoring
(*Management: ECMWF*)

Security
(*Management: EMSA/FRONTEX*)

Emergency management
(*Management: JRC*)

Climate Change
(Management: ECMWF)

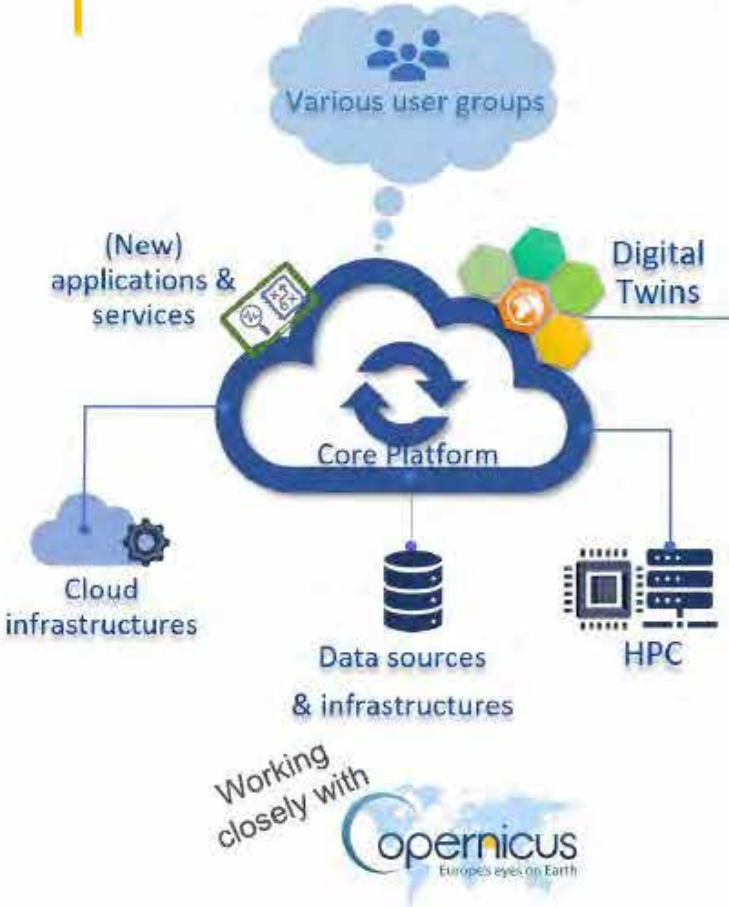
Destination Earth - Team Breton initiative

(*Management: ECMWF*)

Close cooperation: Copernicus will be major **data provider** and **part** of DestinE Data Lake federated data holdings

Commission co-lead by CNECT, DEFIS, RTD, JRC

Destination Earth - baseline architecture & DTs



Digital Twins

1. Weather-induced and Geophysical Extremes
Environmental extremes at very high spatial resolution and close to real-time decision-making support (e.g. floods, wild fires, hurricanes, earthquakes, volcano eruptions)

2. Climate Change Adaptation
Climate change adaptation policies and mitigation scenario testing at decadal timescales aiming at a real breakthrough at the level of reliability at regional and national levels, for understanding the causes and explaining the feedback mechanisms of change, predicting possible evolution trajectories and identifying irreversible tipping points

Oceans DT

AI-powered Urban DTs

Biodiversity DT

More DTs... (e.g. migration)

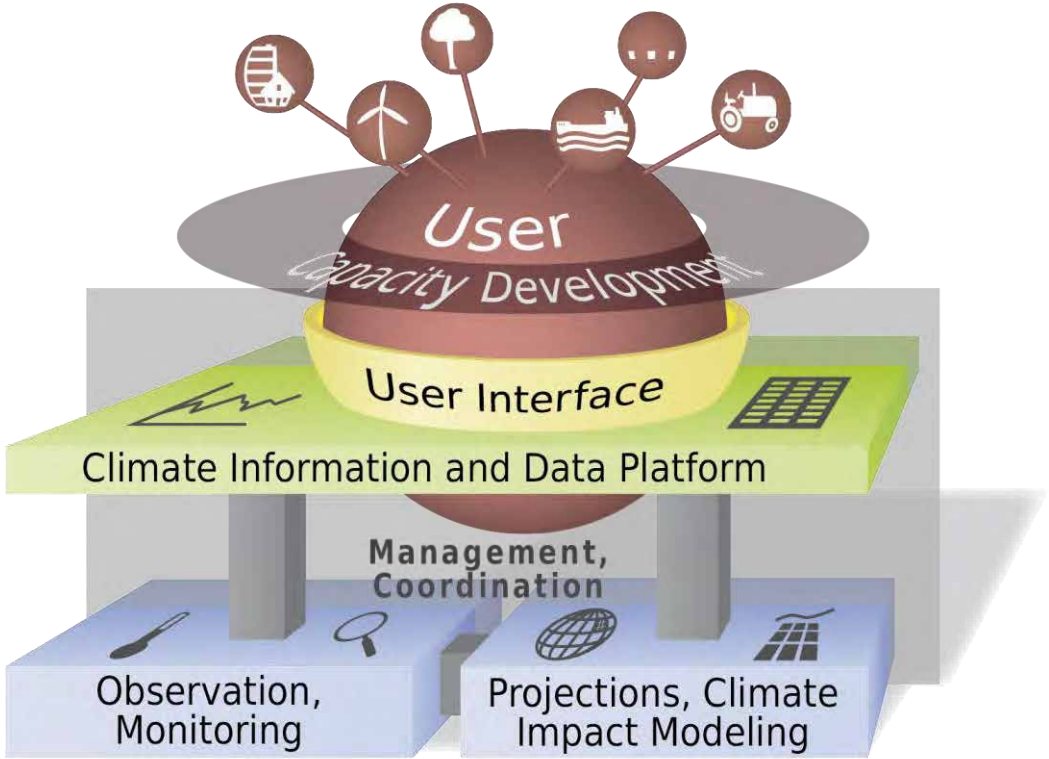
Horizon Europe calls to support the future DTs

European Commission

Strategic background

IPCC	• Climate science
GFCS	• Climate services
UNFCCC	• Climate mitigation and adaptation
DAS	• German adaptation strategy

Global / National Framework for Climate Services

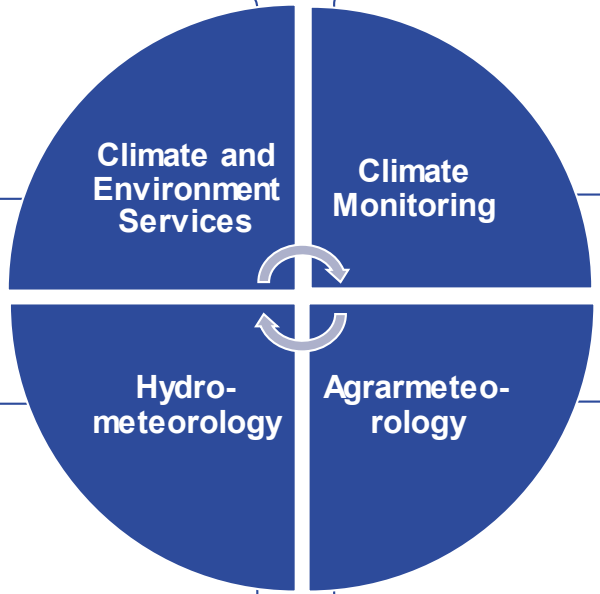


German Strategy for Adaption to Climate Change (DAS)

DWD Business Area Climate and Environment

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

- Climate modelling
- Human Biometeorology
- Urban Climate
- Attribution & Socio-Economy



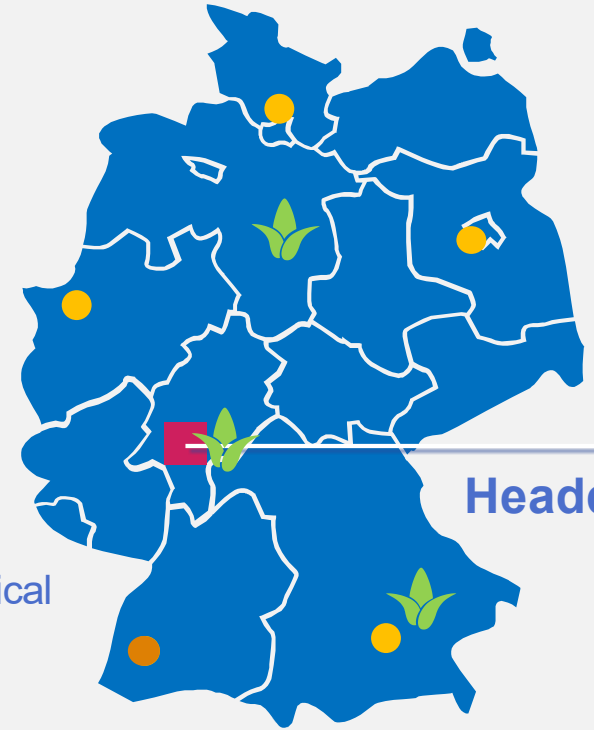
- Re-analyses
- Regional and global monitoring
- Emission verification of GHG

- In situ- and remote sensing-based precip analyses
- Heavy precipitation, snow & drought

- Impact modelling
- Soil moisture obs. + modelling
- Experimental studies

Where to find us?

Service centers climate and environment
- Hamburg
- Potsdam
- Essen
- München



Agrometeorological service centers
- Weihenstephan
- Braunschweig
- Offenbach

Headquarters Offenbach

Medicine-meteorological service center
- Freiburg

Climate and Environment Services: An overview

Measurements (additional to conventional DWD stations)
- Urban climate stations
- Mobile measurements
- Soil moisture
- ICOS

Data Centers
- WMO RCC RA VI
- CDC
- GPCC
- CM-SAF
- Marine data center
- …

Impact models
- MUKLIMO / PALM4U
- AMBER
- SNOW
- EPISODES
- …

Consulting services
- Predictions and warnings
- Statistics and evaluations
- Expert reports
- DAS core service
- RCC
- …

Sectors
- Agriculture and forestry
- Water management
- Urban and regional planning
- Energy sector
- Transportation
- Health
- …

DWD Climate Services – Earth System Monitoring

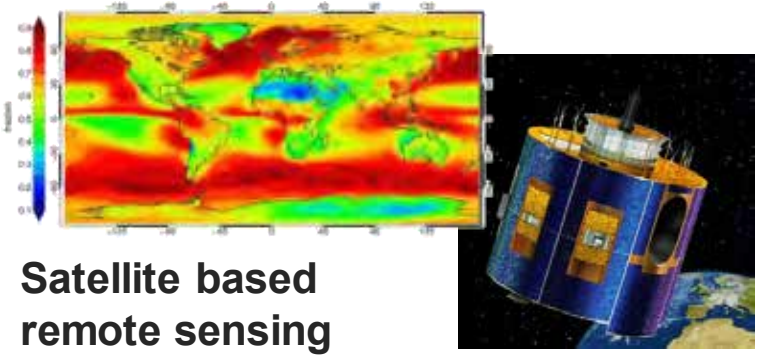
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

In situ observations

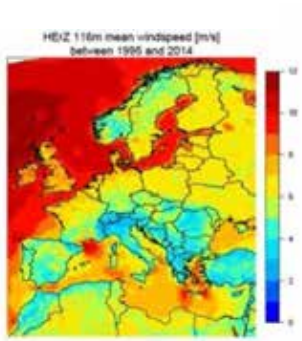
"Wetterschiff Polarfront" von Norwegen

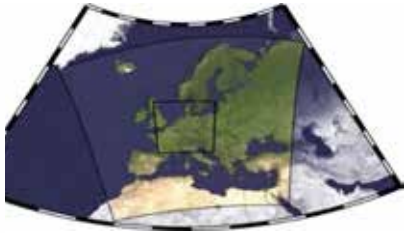
Ground based remote sensing

Satellite based remote sensing



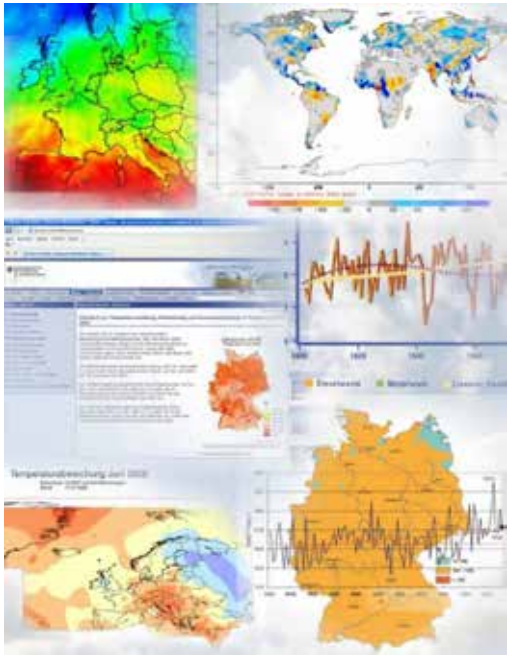
Modell based regional Re-analyses





International data and information centers hosted by DWD

- Global Precipitation Climatology Centre (GPCC) monthly global precipitation climatology and monthly/ daily precipitation analyses for the Earth's land surfaces
- WMO GCOS Reference Upper Air Network: GRUAN Lead Centre in Lindenberg
- WMO Global Atmosphere Watch (GAW): Station Zugspitze-Hohenpeißenberg
- WMO RCC on Climate Monitoring for RA VI
- EUMETSAT Satellite Application Facility – Climate Monitoring (CM-SAF)
- Global Collection Centre (GCC (new: VOS-GDAC)) for ship observations of JCOMM's Marine Climate Data System (MCDS)



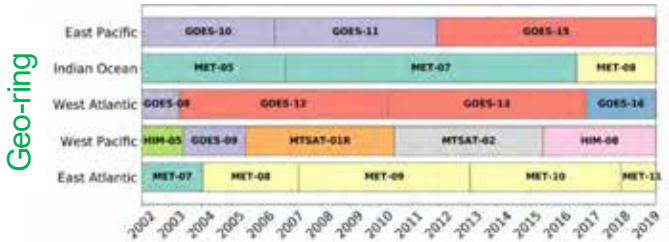
A global satellite-based precipitation product

Global Interpolated RAinFall Estimation (GIRAFE, http://www.cmsaf.eu/wui)

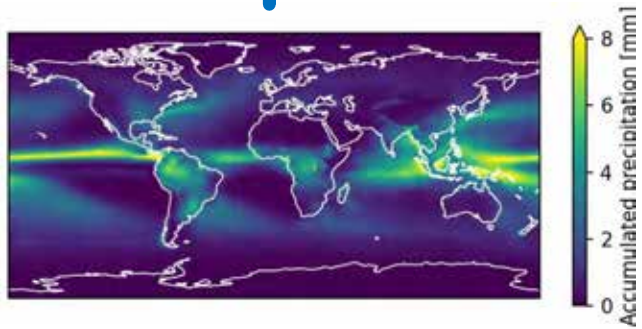
Key technical features:

- Global coverage at 1°,
- Daily accumulation,
- Uncertainty estimates (Roca et al., 2010; Juca Oliveira et al., 2021)
- Correlation length
- 2002-2020.

Release of v1.0 expected in early 2023



11 satellites with microwave imagers,
3 (11) in low Earth orbits
9 satellites with microwave sounders



Mean accumulated precipitation, 2006-2019

Potential topics for co-operation with CM-SAF

Precipitation Climate Data Record

- ➔ Precipitation retrieval development with focus on solid phase and extremes
- ➔ Analysis / validation of precipitation data using radar and other references
- ➔ Contribute to DWD/CM SAF led workshop series „Towards the generation of a satellite-based global precipitation product in a joint European effort“

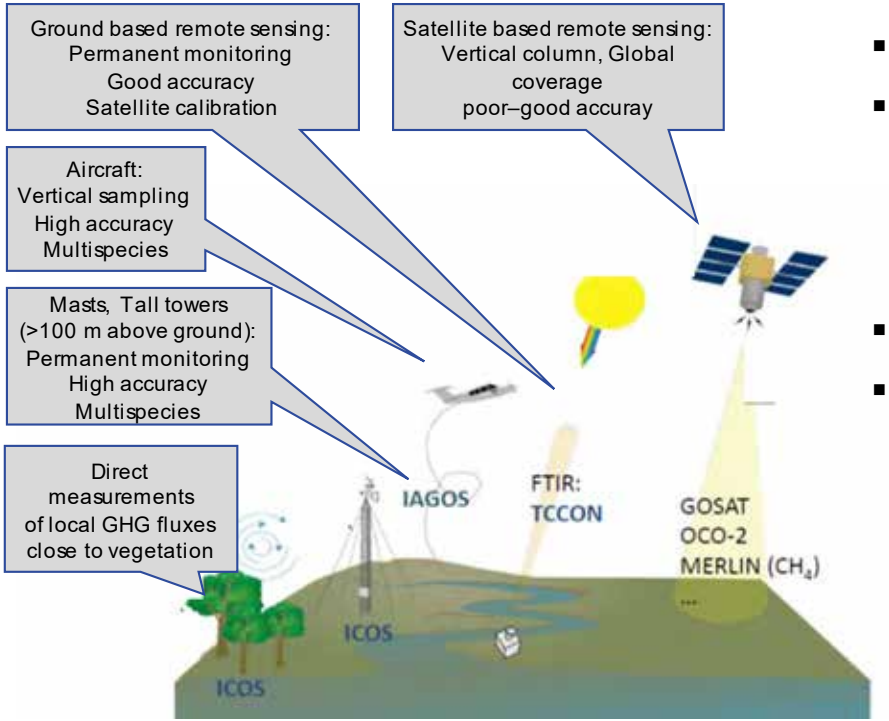
Satellite based climate data records

- ➔ Evaluation and quality control
- ➔ Machine learning for recognition of patterns and extremes in climate data records from satellite observations

Comb. of DWD precip products (GPCC/CM-SAF) with GRACE-based hydrol. Indices

- ➔ Assessment ground water recharge
- ➔ Drought monitoring and assessment

Integrated greenhouse gas (GHG) monitoring on national level



- Integration of all available GHG measurents
- Ground-based observations:
  - Contribution to better understanding of the processes of regional/national greenhouse gas sources and sinks
  - Enable separation of the impact of anthropogenic emission and natural carbon cycle
- Better quantification of national GHG emissions
- Improvement of regional transport models and inverse methods

→ development of an operational national integrated GHG monitoring system

(after J.D.Paris, LSCE, France)

BMBF project 'HoWa-innovativ' *(2018-2021)*

➔ Combining precipitation estimates by weather radars, gauges, and **CML**s for application in operational flood forecasting, especially for short-term prediction in small catchments

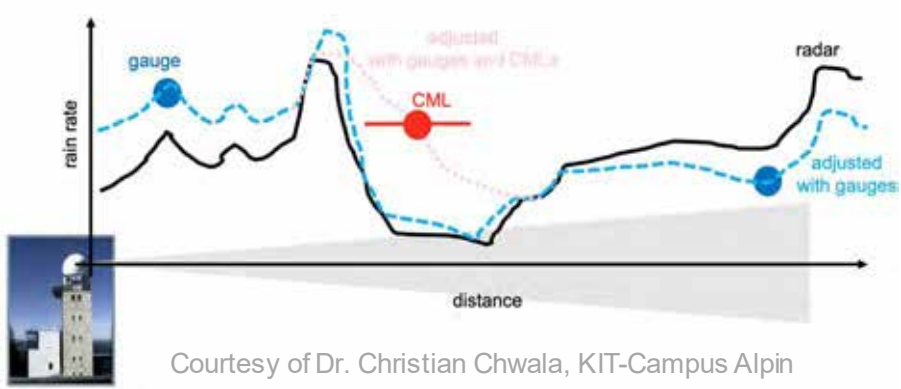
CML = Commercial microwave link

+

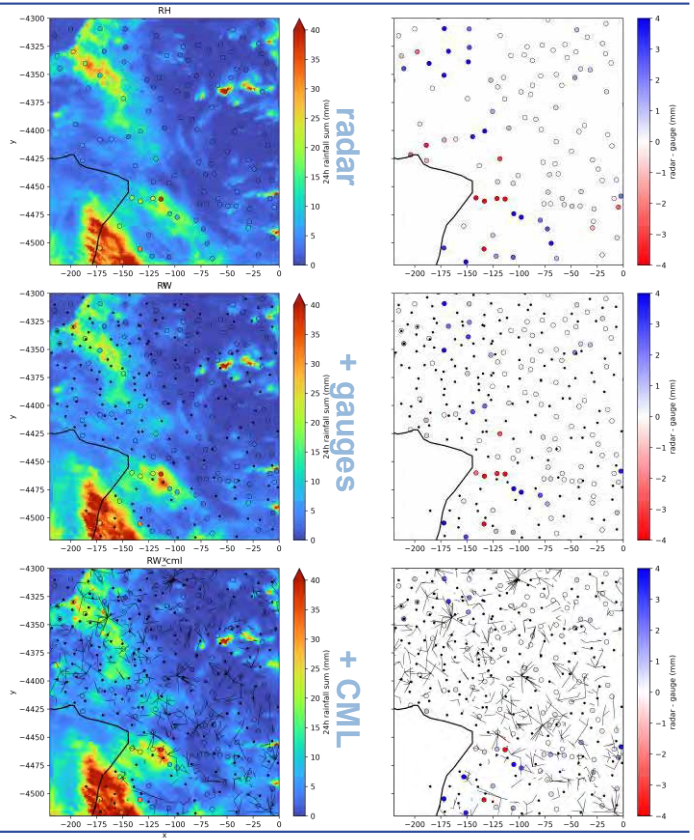
+

Integration of CML into precipitation analysis – case study

- Adjustment of radar-based estimates to gauges **and CML data** has potential to improve precipitation analysis
- Timeliness of CML data allows for acceleration of data provision to clients in flood forecasting



Courtesy of Dr. Christian Chwala, KIT-Campus Alpin



Regional Reanalysis - Background

➔ The regional reanalysis COSMO-REA6 was developed based on DWD's COSMO-NWP-model
(developed at the Hans-Ertel-Center for Weather Research (HErZ) at Universitîes of Bonn/Cologne)

ERA-Interim Reanalysis (T255)

COSMO-REA6 (6.2 km)
- COSMO-EU v4.25
- CORDEX EUR-11 Domain
- Period 1995-2019/09

Soil moisture analysis (SMA)

Continuous nudging
SYNOP, SHIP, PILOT, TEMP, AIREP, AMDAR, ACARS,…
SST analysis (daily)
Snow analysis (6-hourly)

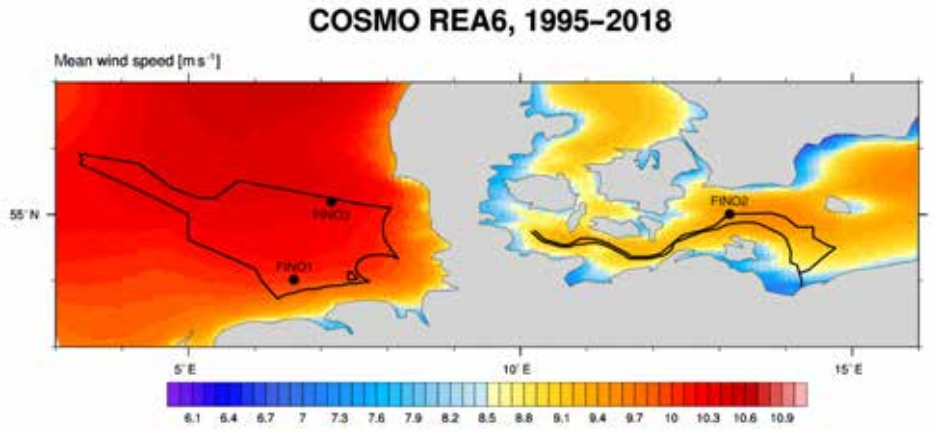
Data available at: https://opendata.dwd.de/climate_environment/REA/

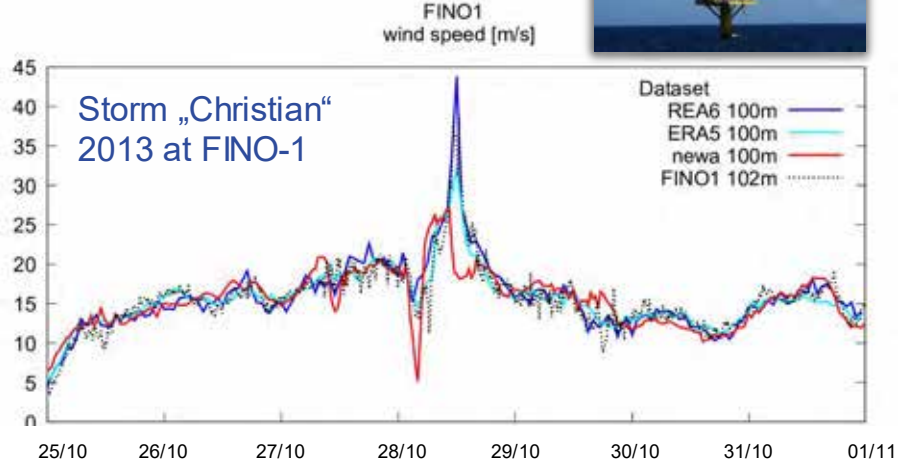
More details: http://reanalysis.meteo.uni-bonn.de/

Bollmeyer et al., 2015

Regional Reanalysis – Applications at DWD

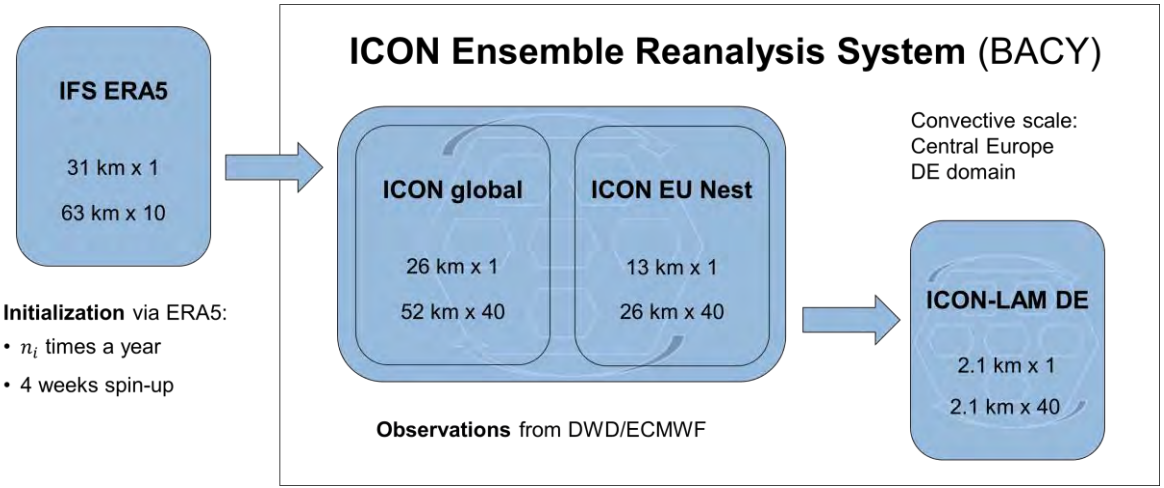
- The reanalysis dataset is now an element of DWD's climate services and also used in internal applications, e.g. offshore wind energy or extreme event analysis.





Regional Reanalysis – Outlook

- DWD continues to work on re analysis development (e.g. study with RIU cologne on aerosols)
- COSMO-REA6 will be upgraded:
  - Use of latest operational COSMO model version with nudging (v5.04d4)
  - Lateral boundary conditions of ERA-5
- Mid-term plan is to develop an ICON-EU and/or ICON-LAM reanalysis

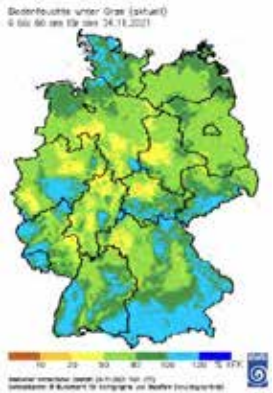


Soil moisture viewer

https://dwd.de/bodenfeuchteviewer

Available products:

Soil moisture



Bodenfeuchteanalyse

Deutschlandkarten zur Analyse der aktuellen Bodenfeuchtesituation

Soil water balance

Bodenwasser

Deutschlandkarten zum aktuellen pflanzenverfügbaren Wasser und zum freien Bodenwasserspeicher

Precipitation

Niederschlagsanalyse

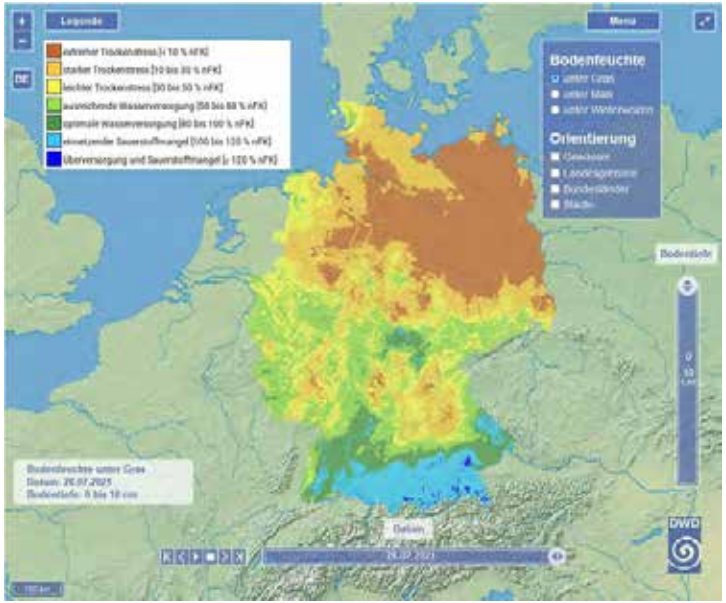
Deutschlandkarten zur Analyse der aktuellen Niederschlagssituation

Reports

Bodenfeuchtebericht

Bericht zur aktuellen Bodenfeuchtesituation

Interactive Mapviewer

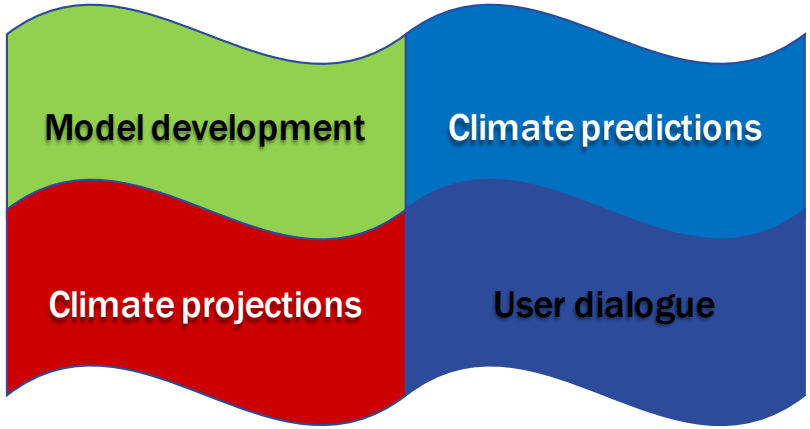


DWD Climate Services – Climate modelling

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Model development:
Improvement of simulation quality and migration to ICON (ICON-Seamless, ICON-CLM)

Evaluation:
Analysis of climate prediction quality and of plausibility of climate projections



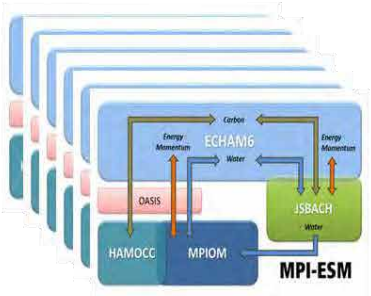
Provision of seasonal and decadal climate predictions

https://www.dwd.de/klimavorhersagen

Operationalisation:
Automatic production of simulations and derived products on all climate time scales

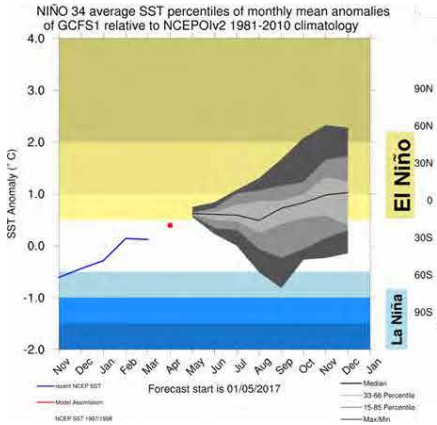
User dialogue:
Annual user workshop as well as continuous exchange with users in research and operational services

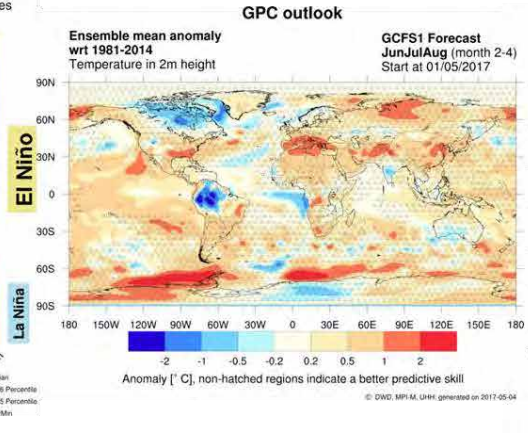
German Climate Forecast System

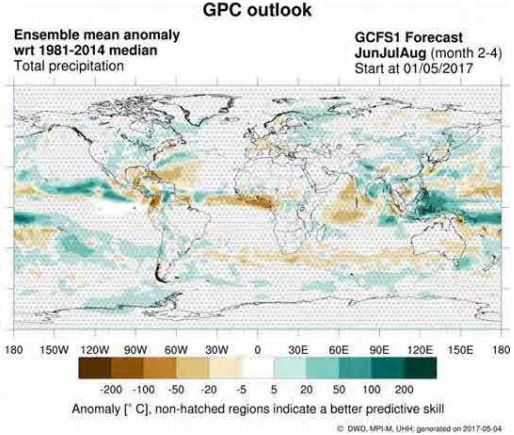


Ensemble member Hindcast	15
Ensemble member Forecast	30
Atmosphere Resolution	1.9°x1.9°
Ocean resolution	1.5° in tropics

www.dwd.de/jahreszeitenvorhersage







In development: One global model system for weather and climate

ICON-Seamless = Model and data assimilation for

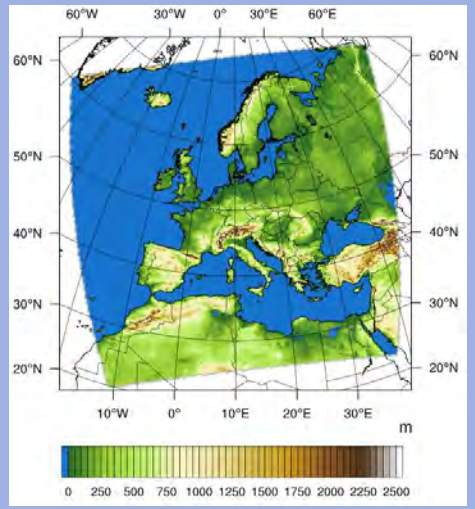
- ✓ Numerical weather prediction (NWP)
- ✓ Climate predictions (seasonal and decadal)
- ✓ Climate projections

- **consistent model** for atmosphere, ocean, land, air chemistry
- **configuration** for different weather and cimate applications
- Project start November 2020
- in cooperation with MPI-M, KIT, DKRZ

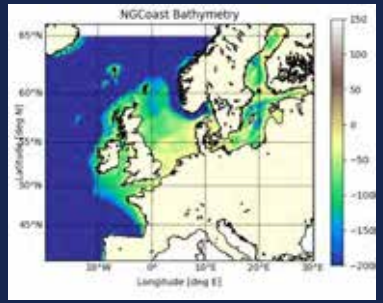
➔ *pre-operational* seasonal and decadal *climate predictions* in year 2024

Coupled regional climate modelling (COSMO-CLM -> ICON-CLM)

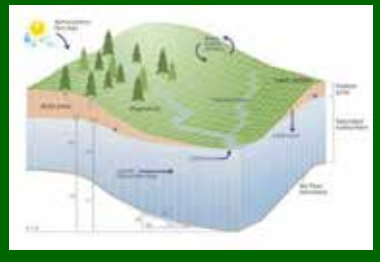
Atmosphere ICON-CLM



Ocean: NEMO-GCOAST



Land: PARFLOW



Climate Limited-area Modelling Community

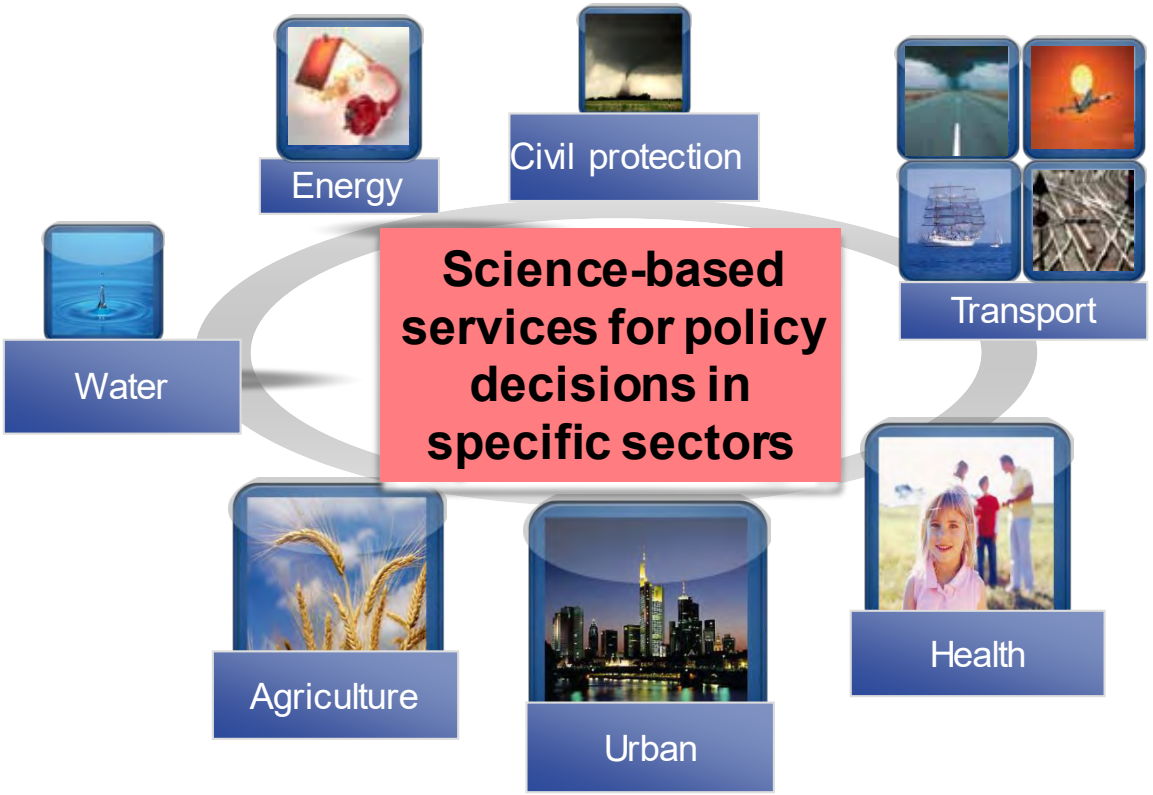
DAS Basisdienst Klima und Wasser

hereon

BSH BUNDESAMT FÜR SEESCHIFFFAHRT UND HYDROGRAPHIE

DWD Climate Services - Applications

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

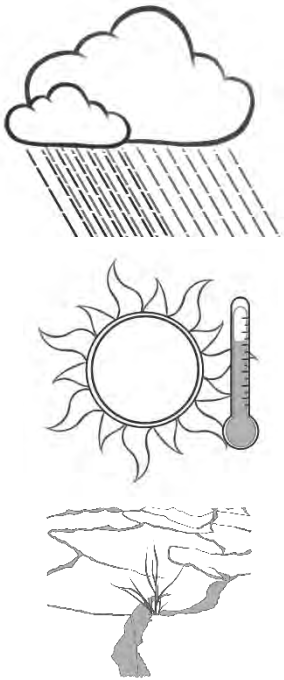


based on HPC and other ICT

and on cooperation with many research partners

DWD attribution services - Current developments

- The DWD is currently developing a largely-automated attribution system through its own contributions and within the BMBF ClimXtreme project.
  - Developments focused on heat waves, droughts and large-scale precipitation events.
- The development is carried out in close cooperation with the World Weather Attribution group.
  https://www.worldweatherattribution.org
- The DWD participated in a number of Attribution studies of the WorldWeatherAttribution group.
- In addition to the system currently under development, there are a number of further development possibilities.



Rain, heat and drought
© Hanna Luca

Possible topics for cooperation on attribution services

1. How to combine the results from different model simulations (multi-model multi-member ensemble) and from different methods in an attribution statement?
   → Development of a synthesis approach.
2. Attribution of regional-scale events such as convectively driven precipitation events.
   → Developments of methods to enhance the use of available data – including artificial intelligence-based approaches.

Flooding in Altenahr-Kreuzberg, 15.07.2021.
CC0: Martin Seifert

Climate Watch Advisories

- DWD provides **Climate Watch Advisories** (early warning advisories) for heat and cold waves, periods of heavy precipitation, drought events in the RA VI Region
- This is a mandatory product of the **WMO RAVI Regional Climate Centre (RCC),** which is led and coordinated by DWD
- For doing this, DWD uses various climate monitoring and forecast products, among them **ECMWF extended range forecasts** (scale of advisories is subseasonal, usually 2-4 weeks).
- Up to know the advisory is based on a mere **subjective assessment** (expert discussion of monitoring and forecast products.

Climate Watch Advisory

WMO RA VI RCC Network

Guidance on heat wave with drought
ID: 202113-u1

Area concerned: southern Italy, southern Croatia, Bosnia-Herzegovina, Montenegro, Albania, North Macedonia, Serbia, southern Romania, Bulgaria, Greece, western and southern Turkey, Cyprus, Lebanon, Israel, Syria, Jordan, southern European Russia, west Kazakhstan

Initial statement issued on 27 July 2021
First update issued on 30 July 2021

Valid:
Begin: 30 July 2021
End: 13 August 2021

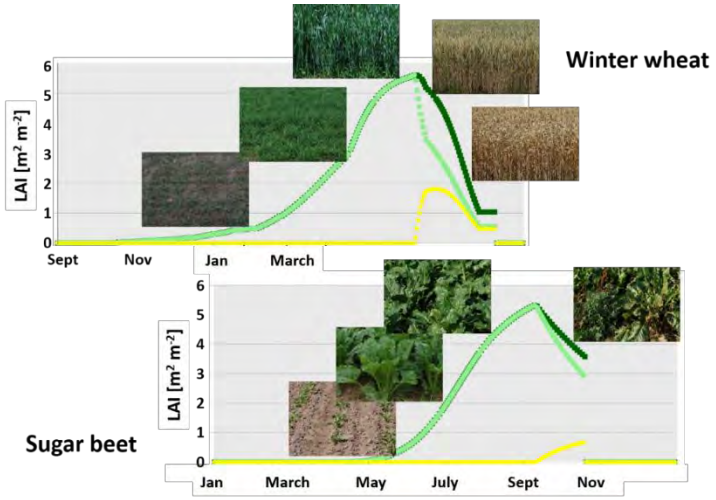
To: Climate Watch focal points of NMHS of Italy, Croatia, Bosnia-Herzegovina, Montenegro, Albania, North Macedonia, Serbia, Romania, Bulgaria, Greece, Turkey, Cyprus, Lebanon, Israel, Syria, Jordan, Russia, Kazakhstan

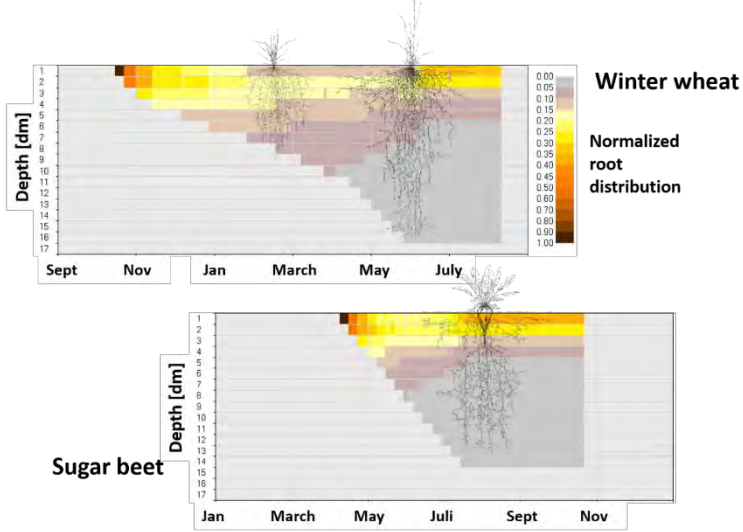
Planned activity for Climate Watch

- Develop an objective approach for Climate Watch Advisories (independent from individual expert assessment, but a reproducable (automatic) process)
- This includes
  - Formulation of relevant warning criteria,
  - Technical realisation as forecast maps (anomalies, probabilities) for these events
  - First approach could be the Extreme Forecast Index (EFI) provided by ECMF, to be refined/tuned for Climate Watch Advisories
  - Collaboration could be useful e.g. with University of Bonn (experience in evaluation of climate forecasts in terms of frequency/intensity of extreme events)

Development of agrometeorological impact models

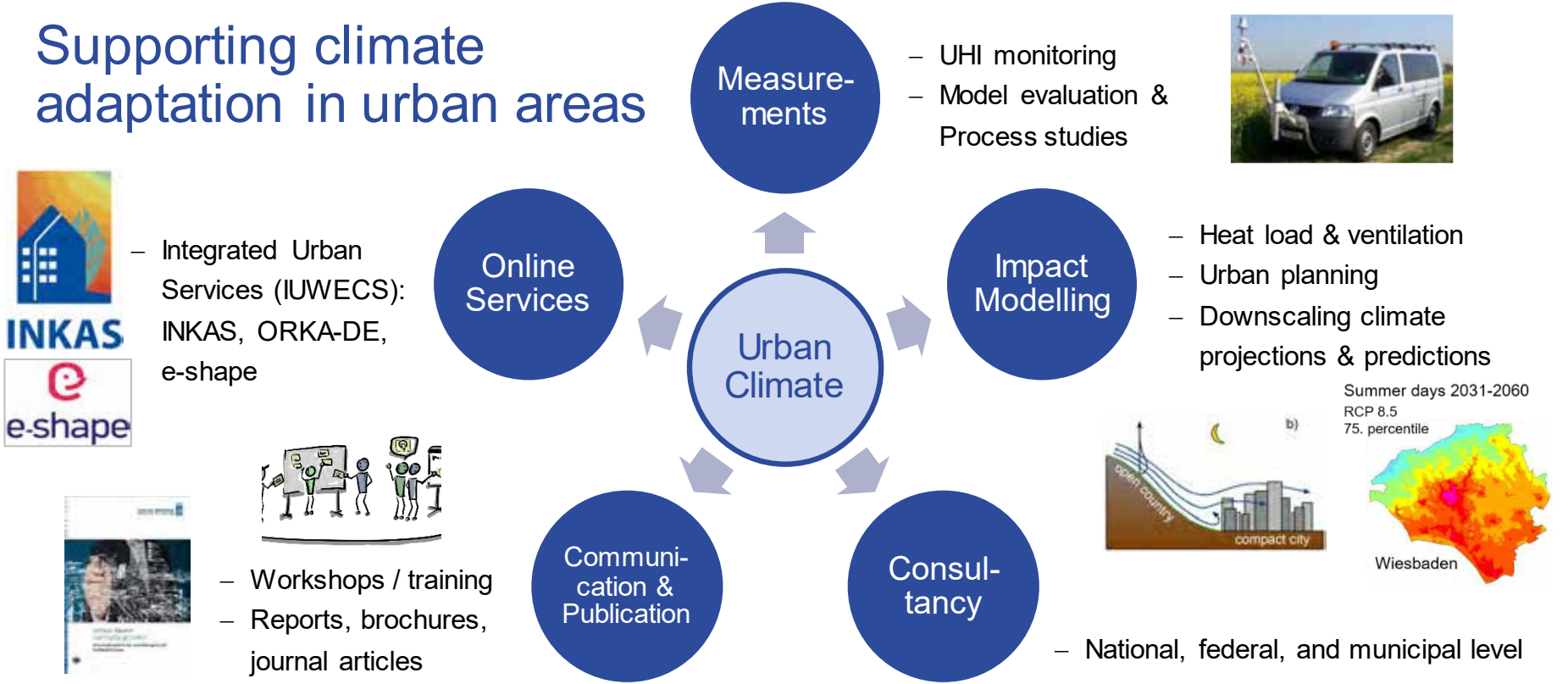
➔ Development of species-specific algorithms and parameterizations to describe the seasonal variability of aboveground and belowground biomass (e.g. leaf area index (LAI), root distribution) and their feedbacks to the atmosphere through energy and water exchange.





DWD Climate Services - Applications

Supporting climate adaptation in urban areas



- UHI monitoring
- Model evaluation & Process studies

- Integrated Urban Services (IUWECS): INKAS, ORKA-DE, e-shape

- Heat load & ventilation
- Urban planning
- Downscaling climate projections & predictions

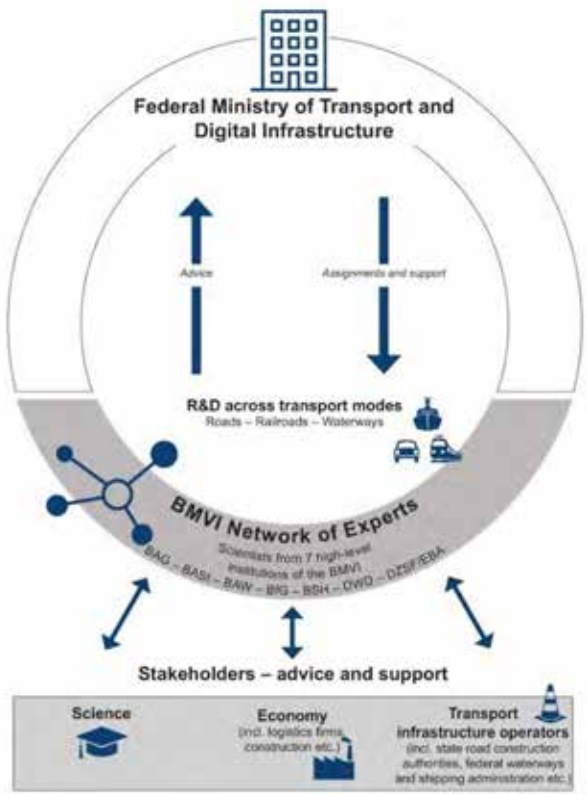
- Workshops / training
- Reports, brochures, journal articles

- National, federal, and municipal level

BMVI Network of Experts
Knowledge Ability Action

Applied governmental research: The BMVI network of experts

- Cross-institutional research and development of cross-modal approaches and solutions
- 6 topic areas (climate change, environment, reliability, digital technologies, renewable energies, transport economy)
- Topic area Climate change impacts and adaptation: **Increasing the climate resilience of the federal transport system** merging information on climate change with knowledge of the transport modes



Increasing the climate resilience of the federal transport system

BMVI Network of Experts
Knowledge Ability Action

Changes in climatic influences and impacts on the German transport infrastructure

Climate parameters
- Sea level rise
- Heat
- Heavy precip.
- Storm
- Drought

Climate Impacts
- (Flash) floods
- Embarkment fires
- Low water
- Wind throw
- Mass movements

Climate-induced disturbances and failures of traffic streams

- Criticality
- Stress tests

Climate Change and Adaptation

Examples of infrastructure properties:
- Outlets
- Safety fences
- Electrification of rails
- Stream bed

Identification of infrastructure properties that control the sensitivity across climatic influences and impacts

- Climate impact analysis
- User dialogue
- Resilience management
- Developing adaptation options

Integration of knowledge on climate change, infrastructure sensitivity and criticality to prioritize adaptation measures

From research to operational policy action → DAS core service "Climate and Water"

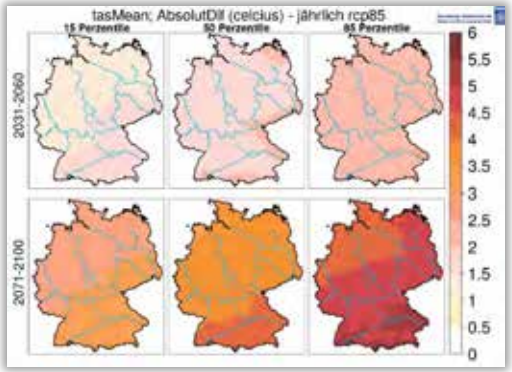
- **Background:** German adaption strategy to climate change (Deutsche Anpassungsstrategie an den Klimawandel „DAS")
- **Established:** 2020 with the action plan „low water" of BMVI
- **Objectives:**
  - Establishment of an operational service which provides ongoing quality checked climate data, evaluation and advisory service on the topics climate and water in Germany.
  - DAS core service addresses many decision-making and process chains associated with weather extremes, hydrological extremes and potential sea-level changes.

DAS related climate products @DWD

- climate reference data and climate projection data in high spatial resolution (5 km x 5 km)
- climate variables for many fields of policy action (→ DWD Klimaatlas)
- hydro-meteorological gridded dataset (HYRAS)
- Specific preparation of variables as input for impact models (regionalisation and bias correction)

Planned products

- Climate projection simulations with a coupled atmosphere-ocean model of the North and Baltic seas in cooperation with the BSH



Some DWD suggestions for research cooperation with CESOC

- Precip assessments from satellites (snow, hail, precip extremes)
- GRACE use for hydrological applications
- model-based regional re-analyses (aerosols, offshore wind)
- Coupling of PARFLOW with ICON-Seamless/ICON-CLM
- Analysis of weather-induced extremes (changes of weather patterns, energy applications, evaluation of climate predictions)
- Assessments of hydrological cycle based on the use of innovative precip data sets (CML, X-Band Radar)
- Use of further developed models for attribution studies
- Use of monthly climate predictions (extremes) for RCC climate watch advisories
- Analysis and prediction of air quality (high resolution)
- Development and operation of integrated GHG monitoring

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