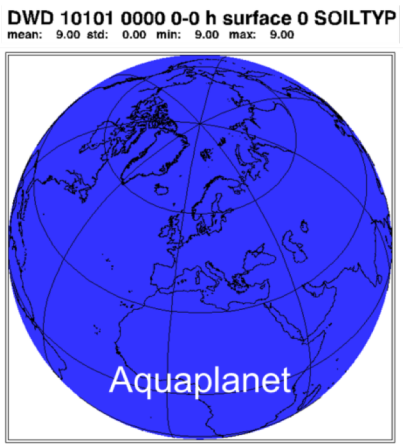
The COSMO software for processing geospatial data (EXTPAR)

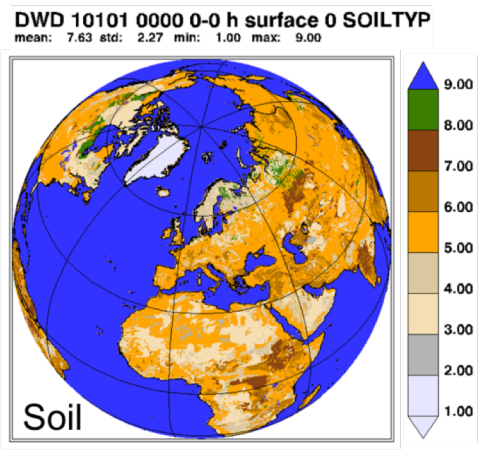
Status April 2020

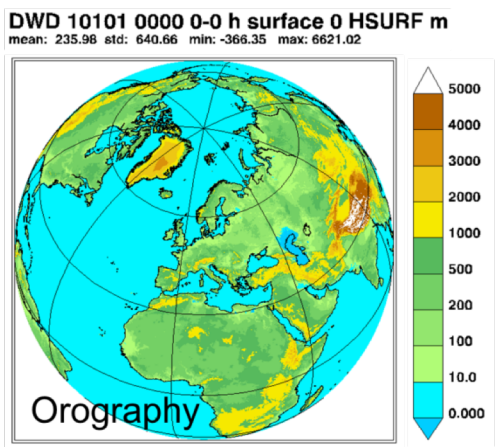
J. Helmert, K. Osterried, L. Kornblueh, Ch. Koziar, J.M. Bettems

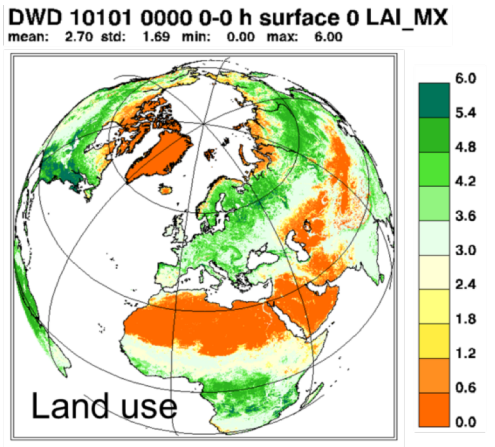
EXTPAR - Background

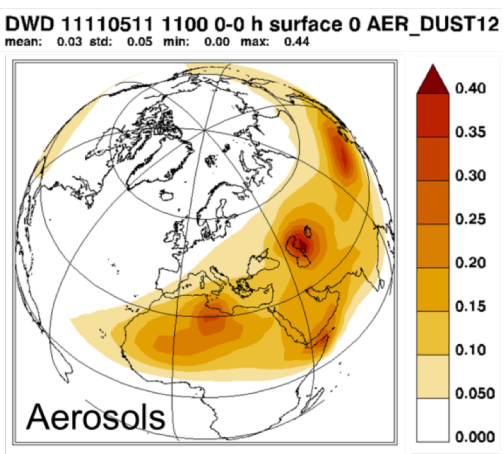
Deutscher Wetterdienst
Wetter und Klima aus einer Hand











- Geospatial data are retrieved from high-resolution satellite information or land registers and are aggregated to the model's global or limited-area grid.
- In a final processing step all available data are cross-checked for consistency (e.g., to exclude vegetation on glaciers).
- The required model parameters are very similar for NWP models, but the used data sources and the applied tools vary between different models – i.e. different mapping of geospatial information (Onvlee et al, 2014).

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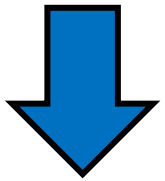
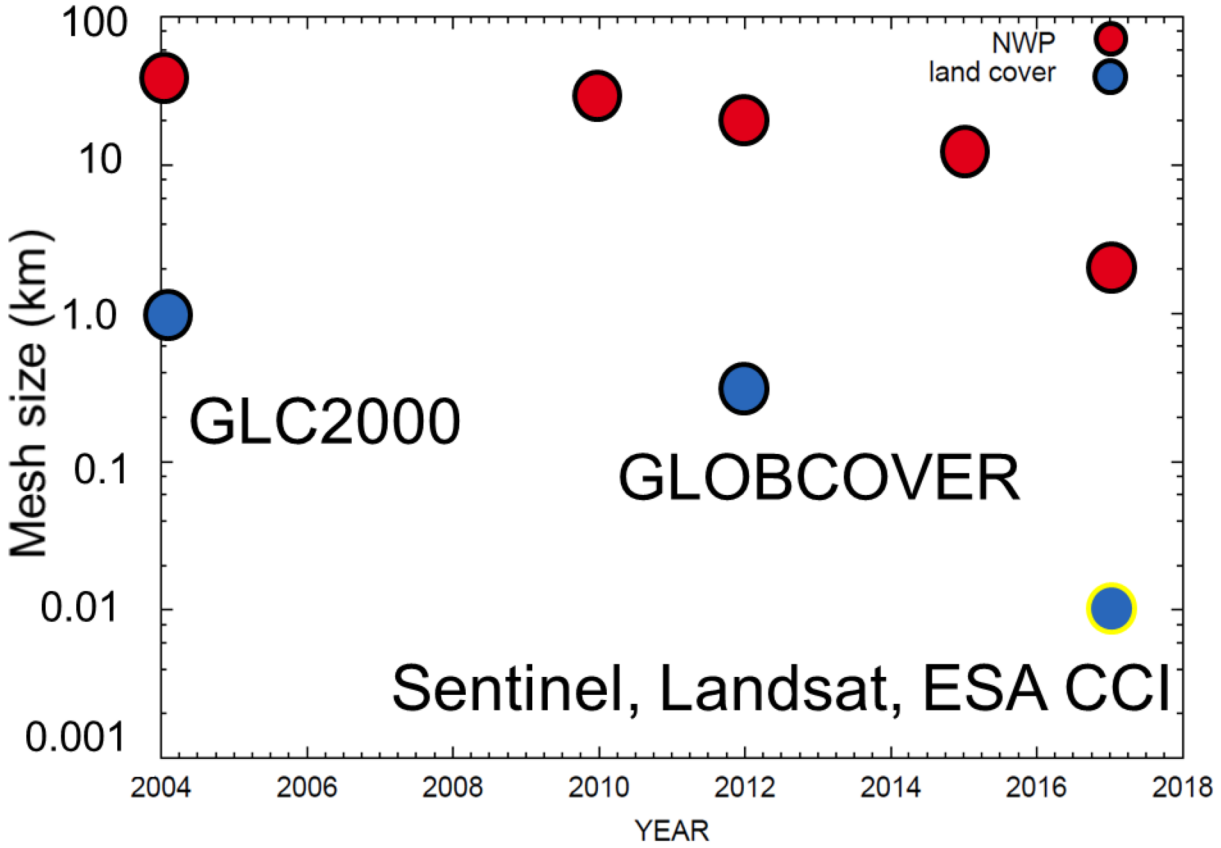
EXTPAR - Challenges

1. Demand for high-resolution remote sensing data to be used for:
2. convection permitting global NWP or LES-type limited-area models.
3. Increasing number of users for aggregated data on model's grid all over the world

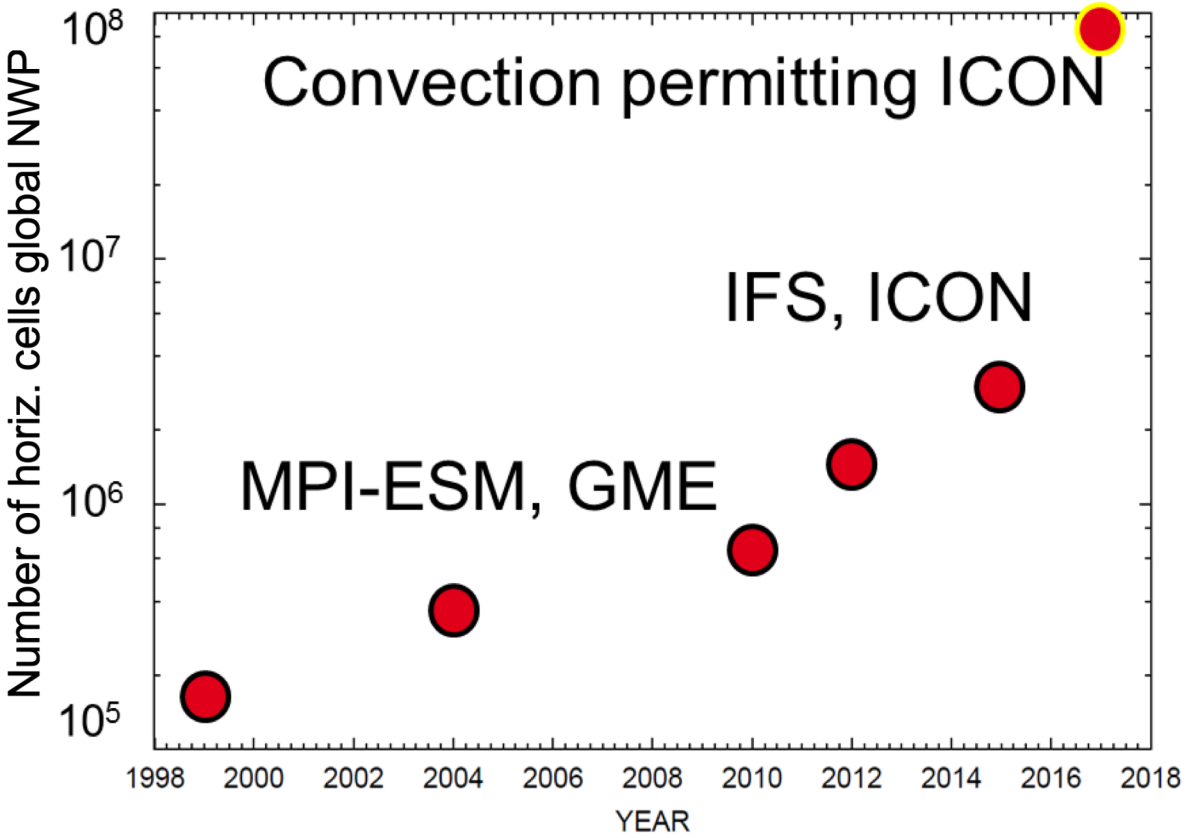


- Increase in storage costs
- Increase in I/O costs
- Demand for improved approaches for data aggregation
- Need for parallelization
- Need for user-friendly, low maintenance front ends

EXTPAR - Challenges



Evolution of the mesh size in global NWP models and land use remote sensing products



Evolution of number of grid points in global NWP models

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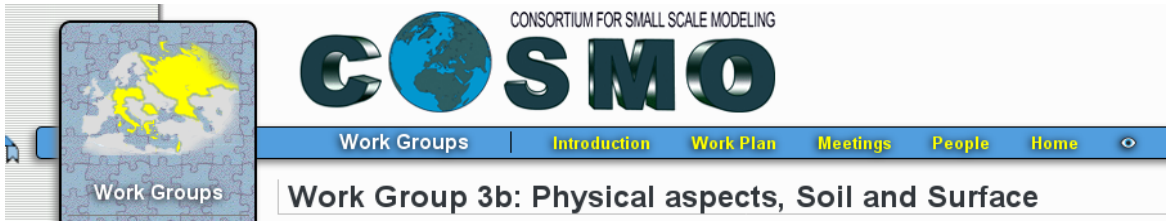
EXTPAR - 2017

- Different source code
- Different source code administration
- Different front ends
- No coordinated development

PAMOR

WebPE



- Limitations of the situation recognized in COSMO WG3b (J.M. Bettems)
- Ressources invested in COSMO-CH (D. Luethi, M. Messmer, A. Roches)
- Nomination of new COSMO SCA for EXTPAR
- Impetus for unified EXTPAR version
- Progress documented at COSMO WG3b website*

MPI

DWD

CLM
ETH
CCSM

*http://www.cosmo-model.org/content/tasks/workGroups/wg3b/default.htm#EXTPAR

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EXTPAR – Kick off 2107

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Events »

27 June 2017 ICON EXTPAR Meeting

Meeting

- **Offenbach**
- Time: **14:00-18:00 (ca.)**
- **Room: DWD, OF, F135, conference area GREE**

Participants

Jürgen Helmert	DWD
Marco Giorgetta	MPI-M
Reinhard Budich	MPI-M
Christian Steger	DWD
Luis Kornblueh	MPI-M
Reiner Schnur	MPI-M
Michael Weimer	KIT
Günther Zängl	DWD
Astrid Schöne	DWD
Katherine Osterried	ETH

Agenda

14:00 Welcome
14:15 - 14:45 J. Helmert et al.: COSMO/ICON physiogr
14:45 - 15:00 A. Schöne: Informationen zu Geodaten

15:15 - 15:45 Coffee Break

15:45 - 17:30 Discussion
17:30 Summary and closing

Notes from Luis:

extpar

Basic: github, test suite, fork - pull model, agreement on working together on the github account: expect some work initially to get a single version, Jenkins (get an account for Katherine Osterried on mistral)

Optimization: LAM data generation and date line handling

Usability: Pick-up the web-frontend for extpar from Florian later

Long-term project: Open-up license from COSMO institutional license

Till September (ICON meeting) target

Github handling, Jenkins, and merging of available modifications (without MPI version of consistency checking)

- Jürgen 1: merge DWD changes into **in preparation**
- Jürgen et al.: evaluation of MPI implemtion with respect to necessary man-power requirements to clean-up **in preparation**
- Luis 1: add the cmake build
- Luis 2: netcdf4 support
- Luis 3: add the additional SSO parameters
- Luis 4: the compile checks with NAG (assuming the bugs submitted to Jürgen are resolved)
- Michael: add some KIT extras
- Luis 5: send Katherine the 'versioning best practice of ICON'
- Jürgen 2: DLR/AIRBUS DEM request by ICON community to DLR for scientific/non-commercial **commissioned**

Features required

- DWD: Cleanup of code planning of necessary steps: Günther et al. (Reiner und Luis @MPI)
- MPI 1: slm, frland re-proccesing for the coupled model
- LES 1: Land data processing for JSBACH: Reiner-Luis
- DWD/MPI: SSO parameter problem (first solve DWD 1: it might support this); idea by Günther: Average the subgrid-scale slopes?, and more ... Target: ssotheta **solved**

Immediate action:

- Kathy: Pass around information to get access to ...

Topics for discussion:

- Status of EXTPAR
- Deficiencies of the current solution
- New developments - MPI parallelization
- New HiRes data (e.g. COPERNICUS-Sentinels) - challenges for EXTPAR
- Efficient code structure
- others?

Summary:

- Presentations by J. Helmert and A. Schöne: EXTPAR and ArcGIS
- ArcGIS not as production tool but offers features for preprocessing and validation
- Merging Code in github, managing feature requests, wiki - Sept. 2017
- MPI-Parallel version of EXTPAR after Sept. 2017, Evaluation of the code required
- Roadmap of future developments, Release plan
- Decision: COSMO STC, ICON-PI
- Legal issues for EXTPAR: GPL?
- Frequency of Meetings: Min. 2x per year
- Building a test-suite at CSCS and DWD, MPI (CLIM to HiRes HDCP2)
- Web-Interface: Evaluate existing versions, hosting a common interface
- New features from MPI (MIN, MAX of gridpoint values), Ocean related land-mask
- General module for reading new data as demand
- NetCDF-Issues (NetCDF-4)
- Solve SSO problems – background: orientation of mountains in high lat.

- *alternative data set from DLR/Airbus – area based, legal questions*
- *slope of the icon grid (averaging sso-slope)*

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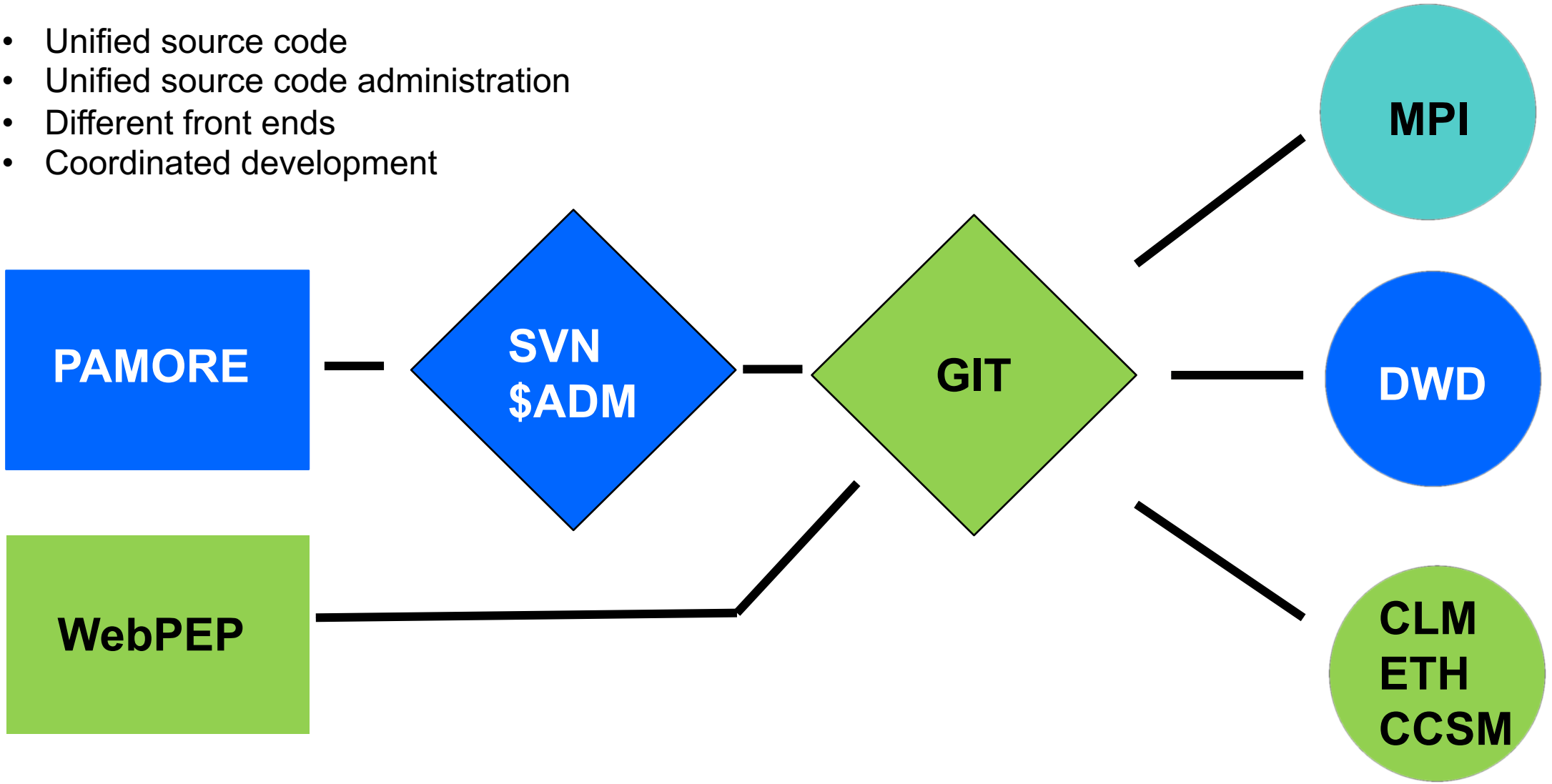
EXTPAR - 2020

- Unified source code
- Unified source code administration
- Different front ends
- Coordinated development



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EXTPAR – Results 2020

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Wetter und Klima aus einer Hand

Features	2017	2020	Results
Development requests	pers. communication, E-Mail	GitHub Issue List	Better overview, avoid work duplication
Source code handling	$ADM/workbench @DWD GitHub (CLM)	Github handling, Jenkins, and merging of available modifications	robust and stable environment Parallelization: fast CDO with OMP support
Software Test Suite	Own tests @ DWD, CSCS, MPI	TestSuite with Jenkins including ICON @GitHub	Improved Quality management
Web-Interface: Evaluate existing versions, hosting a common interface	PAMORE (DWD), WebPEP (CLM)	PAMORE (DWD), WebPEP (CLM)	Actually PAMORE and WebPEP
General module for reading new data as demand	Own F90 module for new data	Easy implementation by simple CDO scripts	Faster implementation of new data
Compiler support	Intel, Cray	Intel, Cray, NAG, PGI	More robust and clean code
Integration of developments for SSO, glacier points, emissivity	Available only @DWD, or MPI, ETH	Available for all users @GitHub EXTPAR	Share ressources for new developments

EXTPAR@DWD - PAMORE WebService

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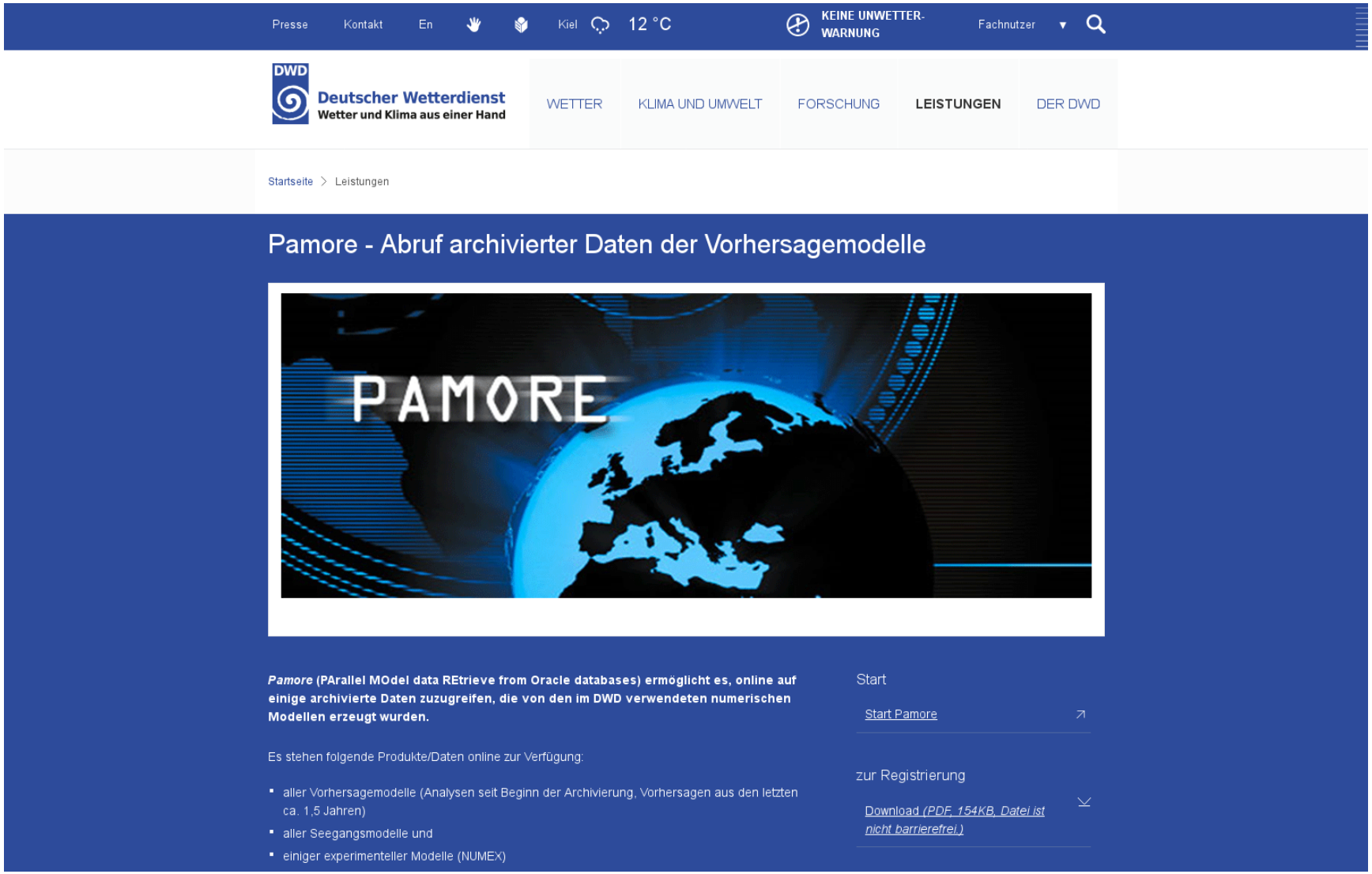

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EXTPAR@DWD

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Production (PAMORE)

- Web- Frontend
- Grid- Generator
- Namelist-Control
- ERA-I SST
- ERA-I T2M
- EXTPAR-F90
- OUTPUT, FTP, MAIL

SVN
$ADM

GIT

Development

- Namelist-Control
- ERA-I SST
- ERA-I T2M
- EXTPAR-F90

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EXTPAR@DWD - Results

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Feature	Result
GIT	• Exchange with GIT and DWD SVN svn://xceh.dwd.de ($ADM) • Version Tagging for head of GIT DWD branch
Scripts	• Uniform and complete job output • Clean error codes • Ex post modification of name lists
Orography	• Automatic determination of model resolution • Automatic determination of required ASTER files • Switch of orography in ASTER non-covered regions
Grid	• Improved compatibility with grids from MPI HH
Executables	• Implementation of CDO versions for improved performance (albedo, **SST, CLIM_T2M**) • Optional treatment of new fields (emissivity, soil)
GRIB	• Automatic detection of required value for **`generatingProcessIdentifier`** • ICON-GRIB2: grib_filter from NetCDF, libCDI and Fieldextra in future • COSMO-GRIB2: Fieldextra

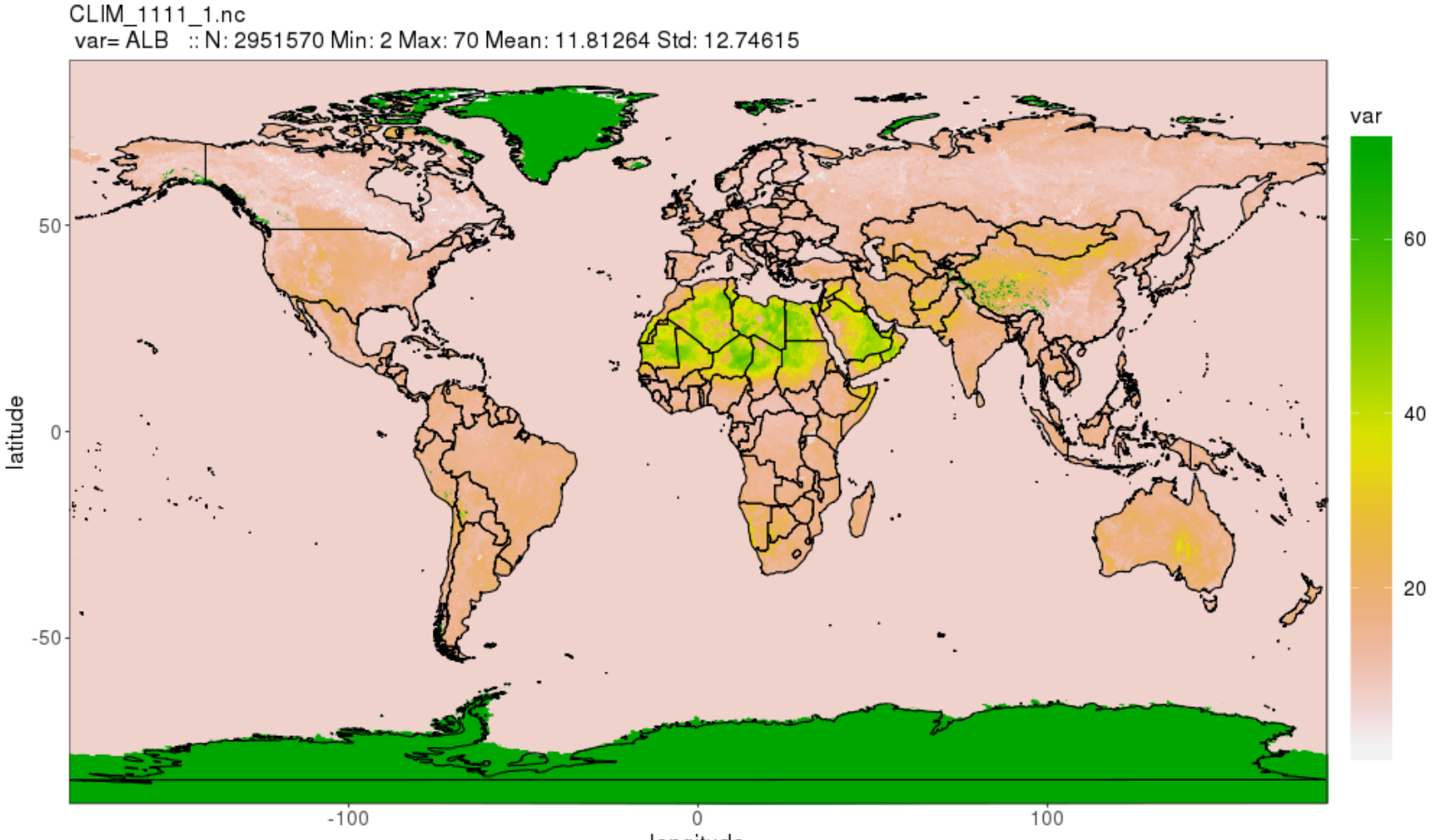
EXTPAR – Summary

- Joint project with COSMO-(CLM), MPI-HH, DWD
- Project partners with long experience in geospatial data for NWP and climate models
- Now unified, robust, and stable code of EXTPAR available for project partners
- Special adaptions for application in DWD (PAMORE)
- Possible to run EXTPAR on different platforms (compilers)
- Allow automatic tests of modified code (compilers and output)
- Benefit from developments in CLM/DWD/MPI, e.g. fast CDO with OpenMP support – easy implementation of new data
- Work share on open issues in GitHub (MERIT, TANDEM-X, technical issues, etc.) see later

EXTPAR – Outlook

- Further improve quality management – automatically provide figures for EXTPAR fields (see next slide)
- Replace F90 code with CDO for modules, which only interpolate to model grid (e.g., Albedo, CRU, NDVI) – further reduce of maintenance costs
- Pre-processing of hi-res satellite data for usage in EXTPAR will be an issue (support GIS solution?)
- Management of memory demanding grids – special attention to consistency check
- Common Web-Interface after COSMO expires for CLM - EXTPAR^{CLOUD}
- Intensify collaboration with NWP and climate consortia – formulate requests to ESA
- EXTPAR-HACKATHON End of March

EXTPAR – Outlook



Surface albedo – EXTPAR GlobCover/GLCC

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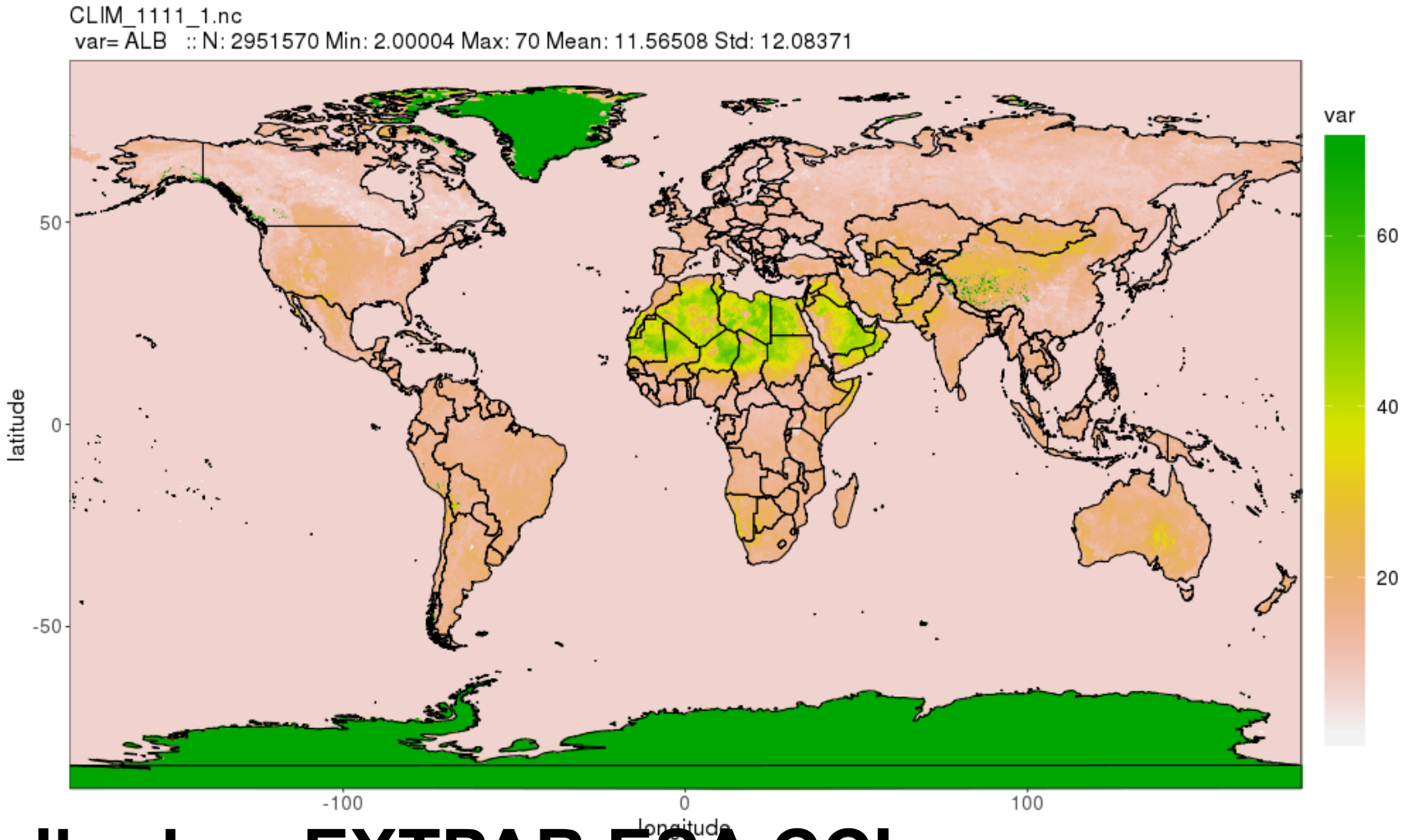
EXTPAR – Outlook



Surface albedo – EXTPAR ESA CCI

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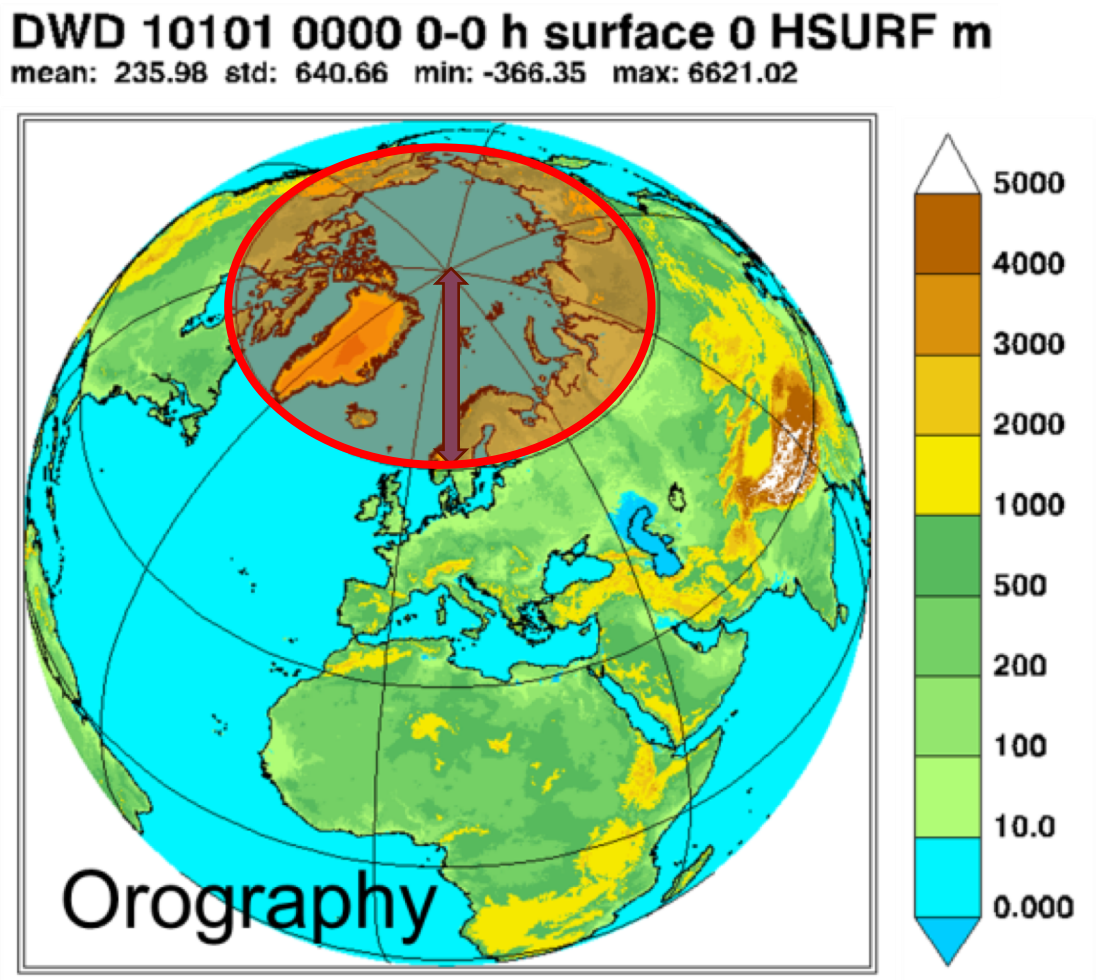
Future global HiRes Orography in EXTPAR

Orography issues



GLOBE-DEM (1km) global
ASTER-DEM (30m) +/- 60° lat
(available for DWD)

IGLO,ICON-EU: GLOBE
ICON-D2: ASTER

Automatic switch
for grid size < 3km to allow ICON-D2

SSO parameters adapted

Tandem-X or MERIT DEM to fill the gap?

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TANDEM-X

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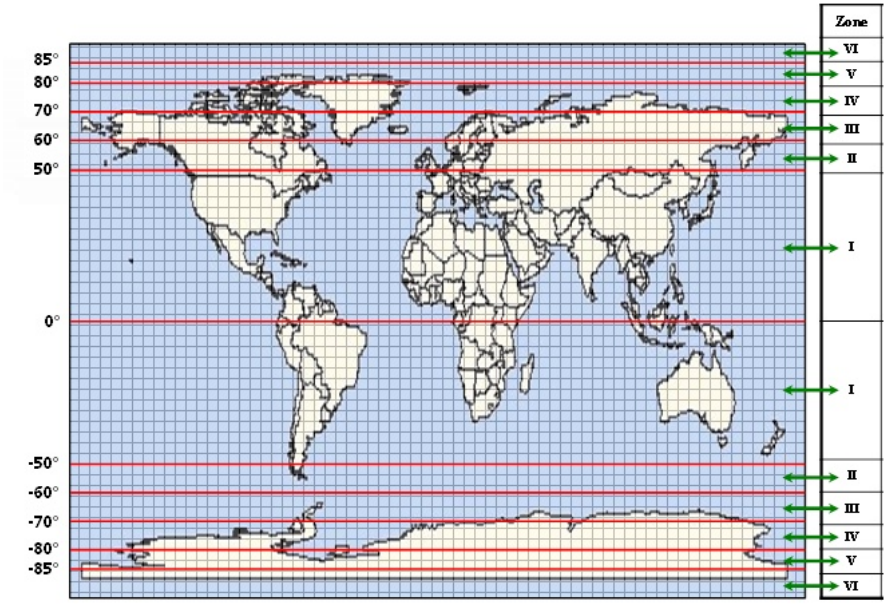

Zone	Latitude Zone Extension	Latitude Pixel Spacing [arsec]	Longitude Pixel Spacing [arsec]
V	80° - 85° N	3.0" (93m)	15.0" (81.0m...31m)
IV	70° - 80° N	3.0" (93m)	9.0" (94.5m...48m)
III	60° - 70° N	3.0" (93m)	6.0" (93.0m...63m)
II	50° - 60° N	3.0" (93m)	4.5" (90.0m...69m)
I	0° - 50° N	3.0" (93m)	3.0" (93.0m...60m)
		Equator	
I	0° - 50° S	3.0" (93m)	3.0" (93.0m...60m)
II	50° - 60° S	3.0" (93m)	4.5" (90.0m...69m)
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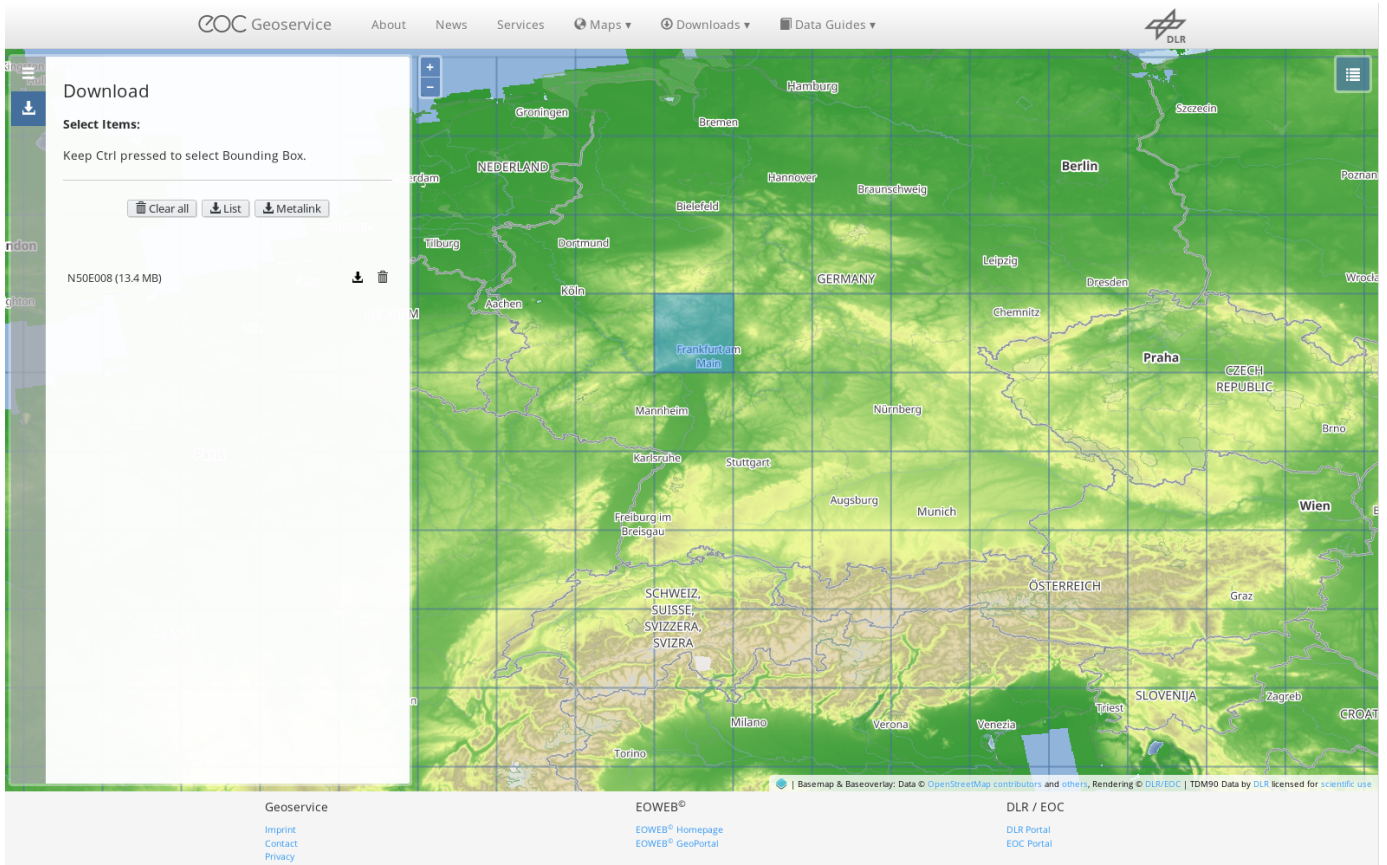
IV	70° - 80° S	3.0" (93m)	9.0" (94.5m...48m)
V	80° - 85° S	3.0" (93m)	15.0" (81.0m...31m)
	85° - 88° S	3.0" (93m)	30.0" (81.0m...24m)
VI	88° - 89° S	3.0" (93m)	30.0" (23.5m ... 8m)
	89° - 90° S	3.0" (93m)	30.0" (8.1m ... 0m)
		South Pole	



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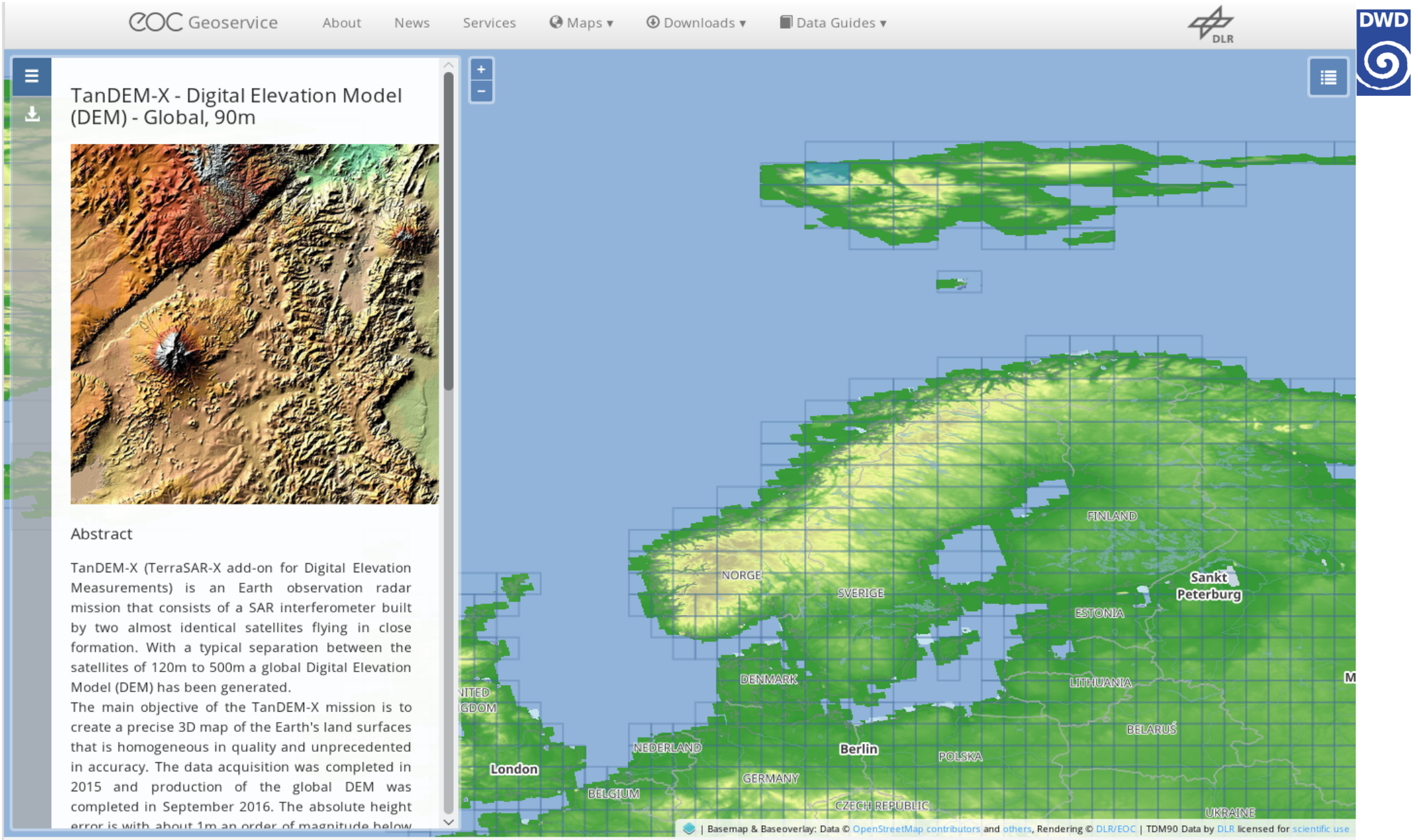
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TanDEM-X - Digital Elevation Model (DEM) - Global, 90m
Abstract
TanDEM-X (TerraSAR-X add-on for Digital Elevation Measurements) is an Earth observation radar mission that consists of a SAR interferometer built by two almost identical satellites flying in close formation. With a typical separation between the satellites of 120m to 500m a global Digital Elevation Model (DEM) has been generated.
The main objective of the TanDEM-X mission is to create a precise 3D map of the Earth's land surfaces that is homogeneous in quality and unprecedented in accuracy. The data acquisition was completed in 2015 and production of the global DEM was completed in September 2016. The absolute height
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LITHUANIA
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NEDERLAND
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London
GERMANY
BELGIUM
CZECH REPUBLIC
UKRAINE
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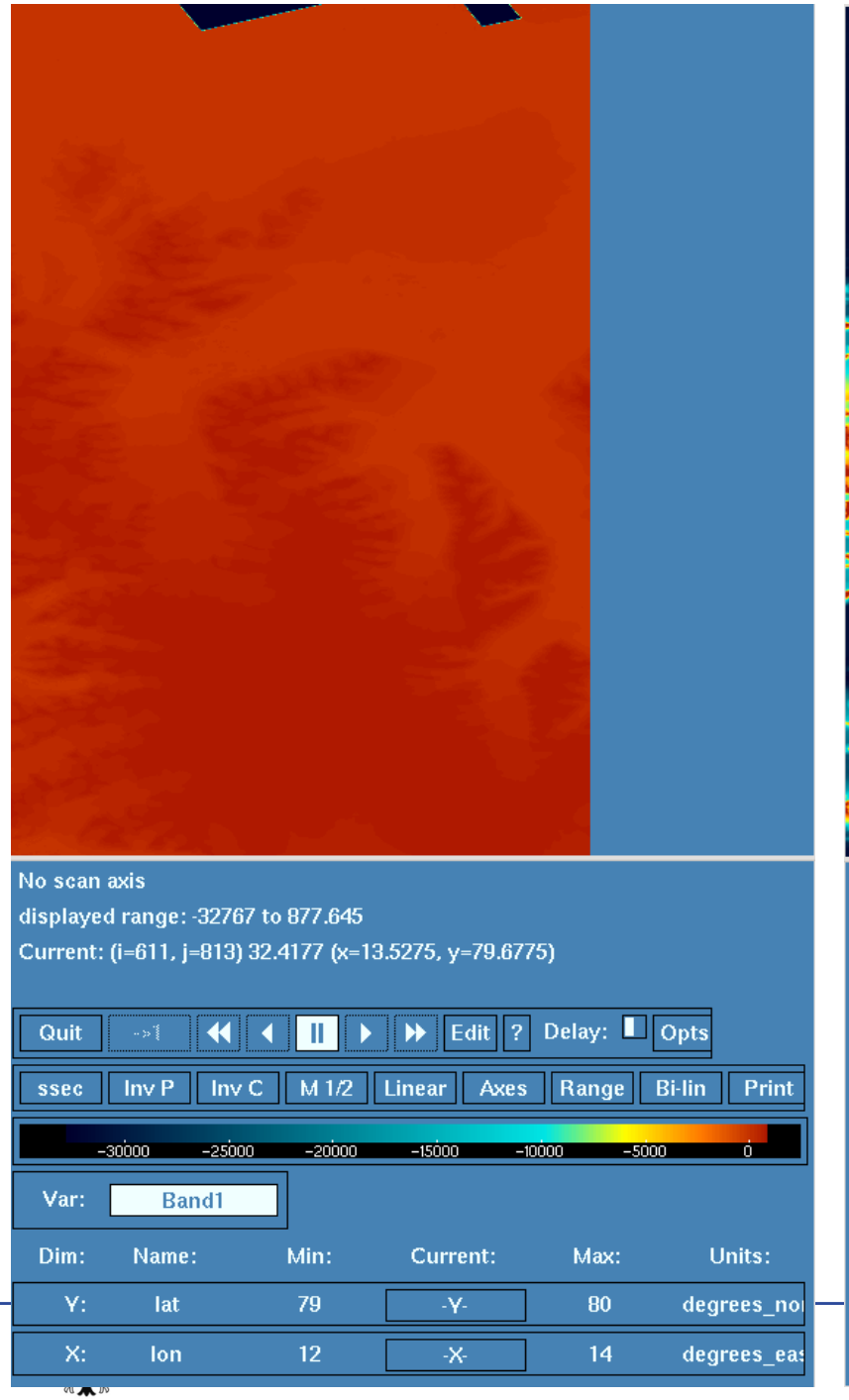

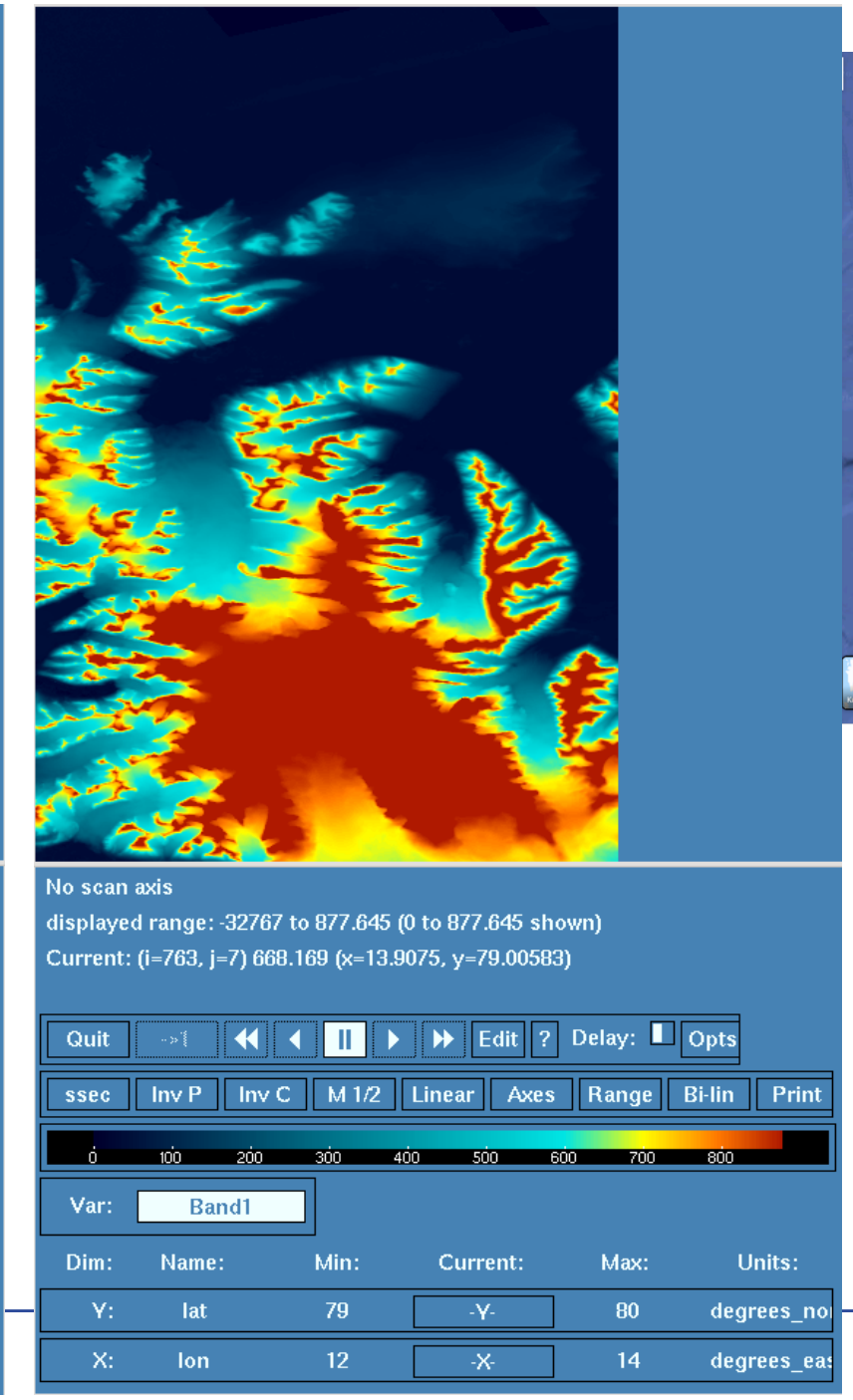

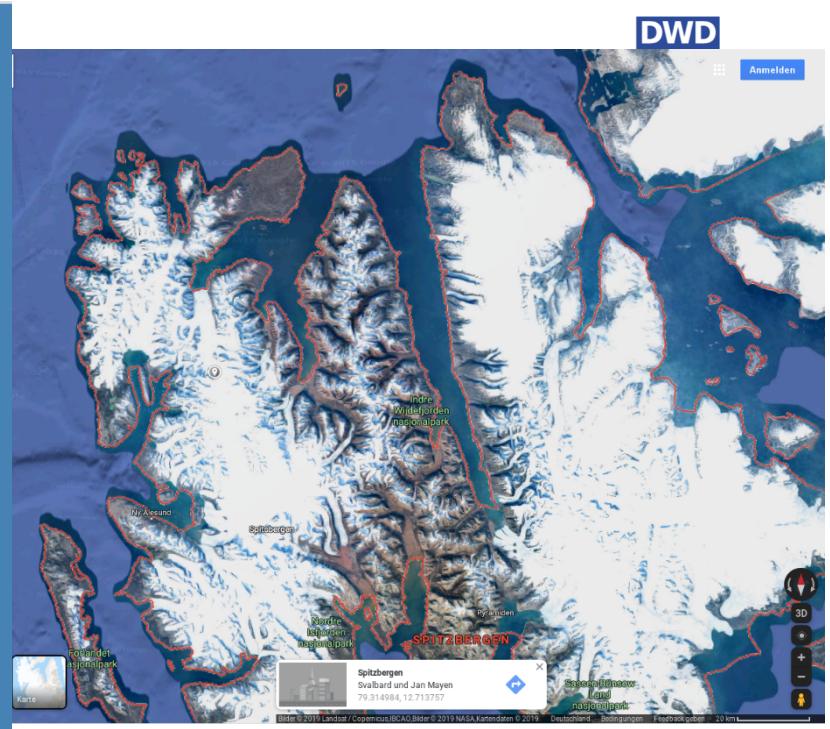

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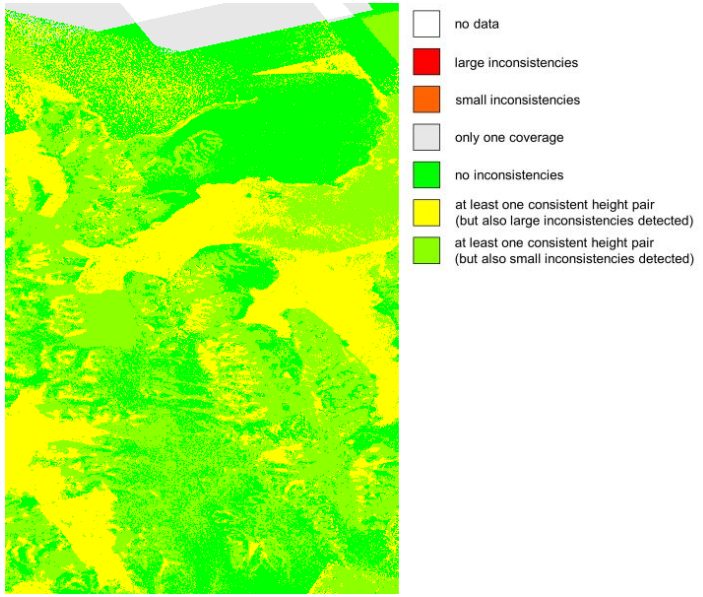
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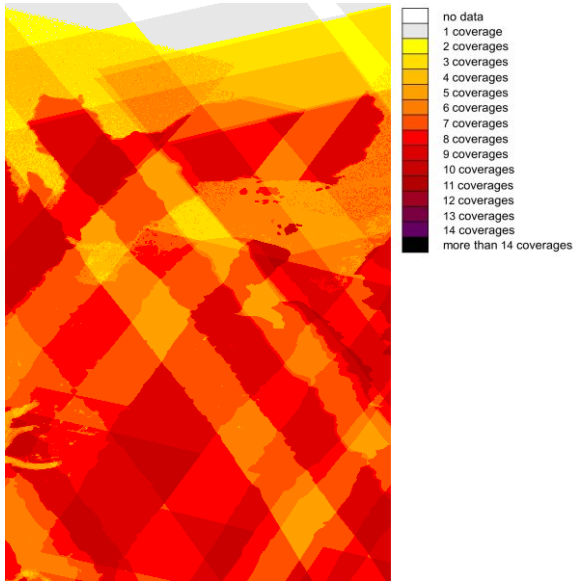
(but also large inconsistencies detected)
at least one consistent height pair
(but also small inconsistencies detected)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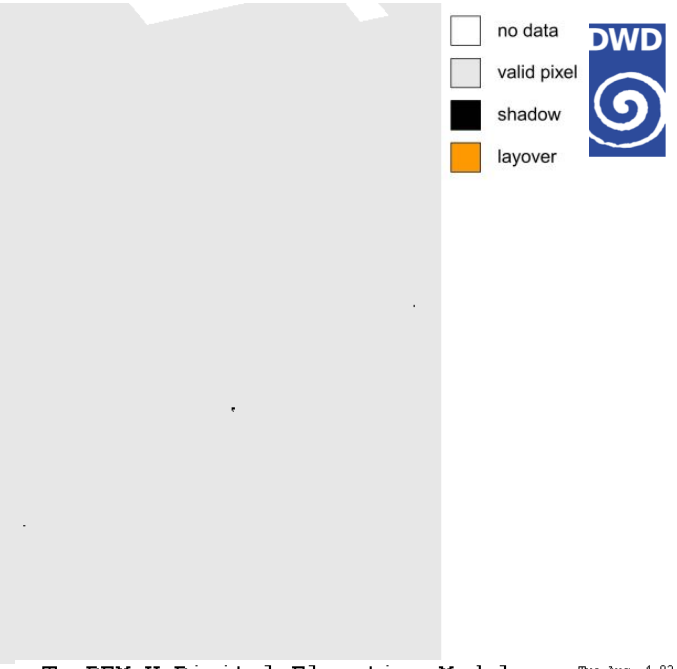
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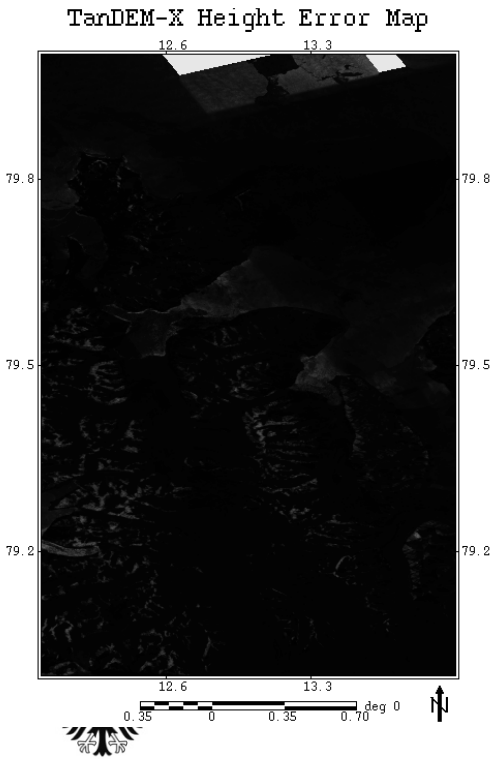
TanDEM-X Height Error Map
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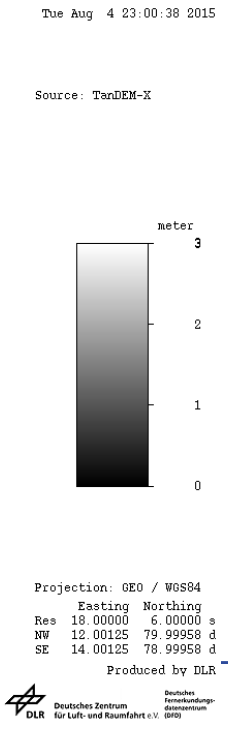
Tue Aug 4 23:00:38 2015
Source: TanDEM-X
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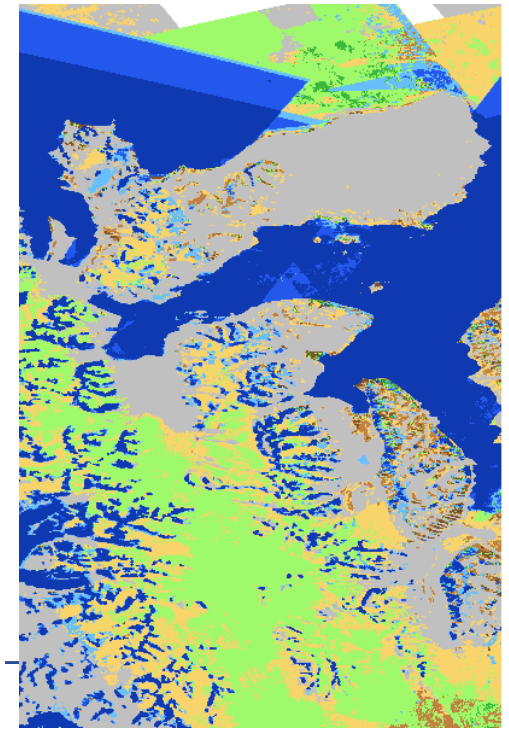
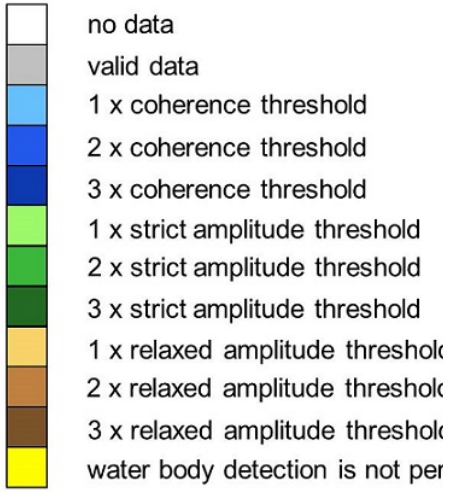
Produced by DLR
DLR Deutsches Zentrum für Luft- und Raumfahrt e.V.
Deutsches Fernerkundungs-datenzentrum (DFD)

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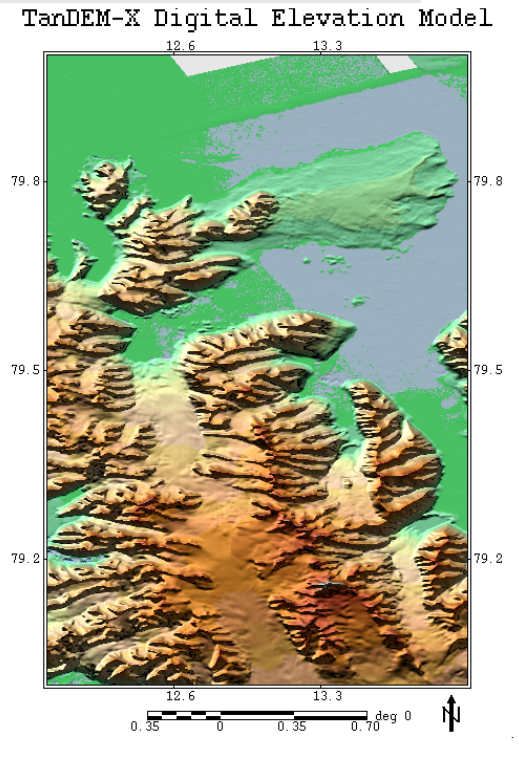
water body detection is not per


TanDEM-X Digital Elevation Model
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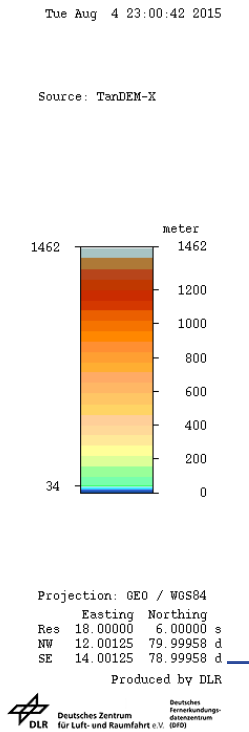
0.35
0.70


Tue Aug 4 23:00:42 2015
Source: TanDEM-X
meter
1462
1200
1000
800
600
400
200
0
34
Projection: GEO / WGS84
Easting Northing
Res 18.00000 6.00000 s
NW 12.00125 79.99958 d
SE 14.00125 78.99958 d
Produced by DLR
DLR Deutsches Zentrum für Luft- und Raumfahrt e.V.
Deutsches Fernerkundungs-datenzentrum (DFD)

MERIT DEM: Multi-Error-Removed Improved-Terrain DEM

Last Update: 15 Oct, 2018

MainPage
Main
--
CV
(En)Publication
(En)Presentation
--
Japanese-CV
(Jp)Publication
(Jp)Presentation
--
Old Posts
Model&Data
Developper Webpage
Dai Yamazaki
CaMa-Flood
Global Hydrodynamic Model
MERIT Hydro
Global hydrography map
MERIT DEM
Accurate DEM
GWD-LR
Global River Width
G3WBM
Global Water Map
OSM water layer
OpenStreetMap water layer
J-FlwDir
Japan Flow Dir
Links

FrontPage

General Information

Product Info

The MERIT DEM was developed by removing multiple error components (absolute bias, stripe noise, speckle noise, and tree height bias) from the existing spaceborne DEMs (SRTM3 v2.1 and AW3D-30m v1). It represents the terrain elevations at a 3sec resolution (~90m at the equator), and covers land areas between 90N-60S, referenced to EGM96 geoid.
Hydrologically adjusted DEM is now available as a component of MERIT Hydro datasets.
Please visit MERIT Hydro webpage to get an access.

Data Summary

Spaceborne Digital Elevation Models (DEMs) are a fundamental input for many geoscience studies, but they still include non-negligible height errors. Here we introduce a high accuracy global DEM at 3 arcsecond resolution (~90 m at the equator) by eliminating major error components from existing DEMs (NASA SRTM3 DEM, JAXA AW3D DEM, Viewfinder Panoramas' DEM). We separated absolute bias, stripe noise, speckle noise and tree height bias using multiple satellite datasets and filtering techniques. After the error removal, land areas mapped with 2 m or better vertical accuracy were increased from 39% to 58%. Significant improvements were found in flat regions where height errors larger than topography variability, and landscapes such as river networks and hill-valley structures became clearly represented. We found the topography slope of previous DEMs was largely distorted in most of world major floodplains (e.g. Ganges, Nile, Niger, Mekong) and swamp forests (e.g. Amazon, Congo, Vasyugan). The newly developed DEM will enhance many geoscience applications which are terrain-dependent.
-- Description Paper in GRL

Data Source

MERIT DEM was developed by processing the following products as baseline data (all are freely available from their web page).
- NASA SRTM3 DEM v2.1: link to the SRTM webpage
- JAXA AW3D-30m DEM v1: link to the AW3D-30m webpage
- Viewfinder Panoramas' DEM link to the ViewfinderPanoramas webpage

In addition to the above baseline DEMs, below products were used as supplementary data:
- NASA-NSIDC ICESat/GLAS GLA14 data link to the NSIDC webpage
- U-Maryland Landsat forest cover data link to the Global Forest Change webpage
- NASA Global Forest Height Data link to NASA webpage
- JAMSTEC/U-Tokyo G3WBM water body data link to G3WBM webpage

J. Helmert et al., 2020

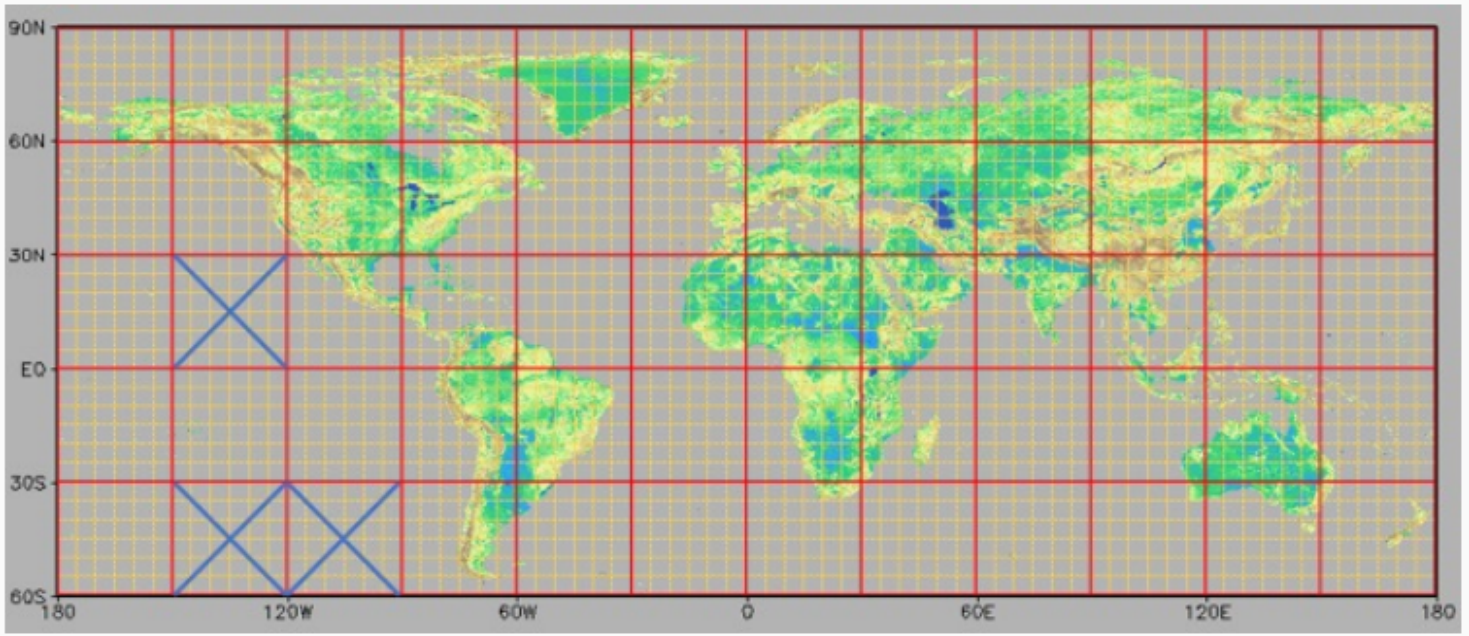
Data Description

Data Format

The MERIT DEM represents elevation in [meter] , referenced to WGS84 and EGM96.
The data is prepared as 5 degree x 5 degree tiles (6000 pixel x 6000 pixel).
Filename represents the center of the lower left pixel of the data domain; e.g. the file "n30w120_dem.tif" is for the DEM of the domain N30-N35, W120-W115. (more accurately, N29.99958333-N34.99958333,W120.0004167-W115.0004167)

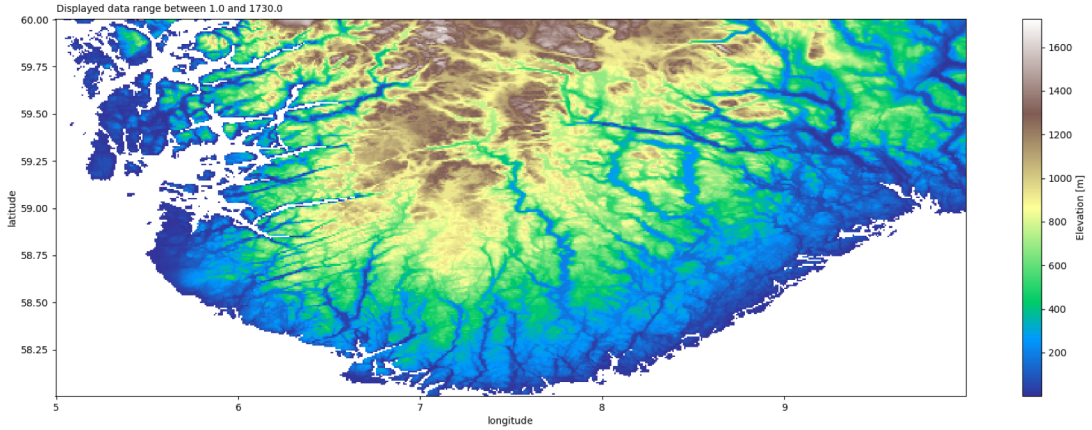
The 5 deg tiles are compressed into 30 degree (lat) by 30 degree (lon) package.
Package name represents the lower left corner of the package domain; e.g. the package "dem_tif_n30w120.tar" contains the files in the domain of N30-N60, W120-W090.

The data format is 'Fortran Direct Access Format' (i.e. ESRI 'FLT' raster format with the HDR file, GrADS binary with CTL file). Data is stored in 4-byte float, little endian.
GeoTiff file is also available

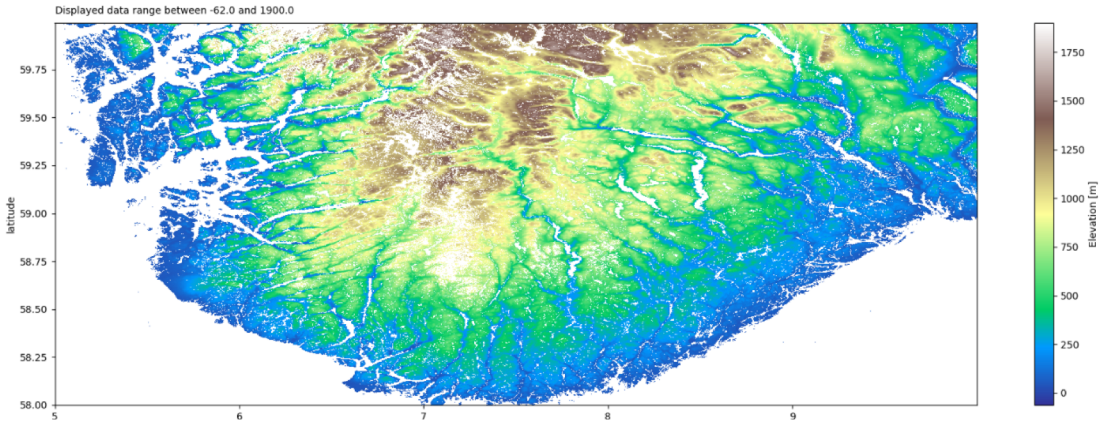


J. Helmert et al., 2020

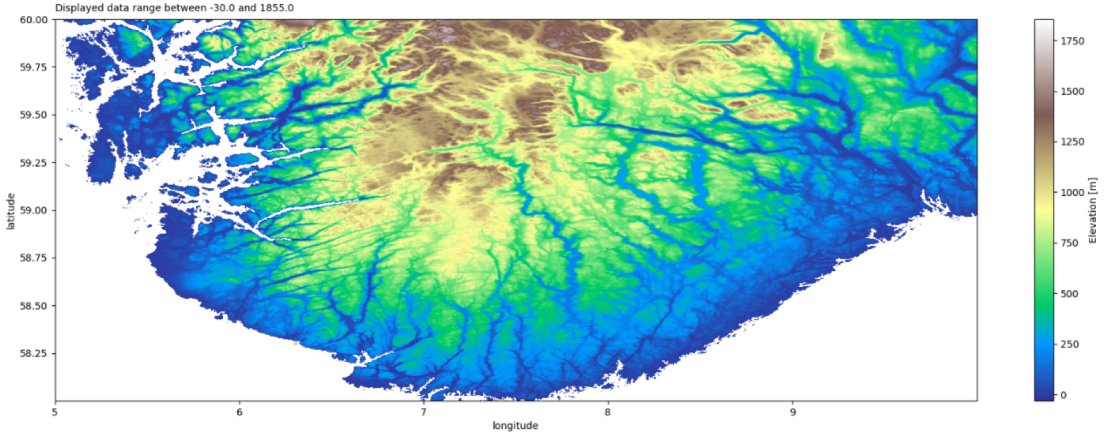
DEM Comparison South Norway (R. Redler)



GLOBE



TANDEM-X



MERIT

J. Helmert et al., 2020

DEM-90m Comparison - Summary:

MPI/DKRZ in favor for the MERIT data

pro: less preprocessing required

con: Antarctica is missing

TANDEM-X:

pro: product by DLR/Airbus (ca. 10m version also available), true global data

con: more preprocessing is required (20000 tiles, error checking)

Decision @DWD to implement first MERIT with filling Antarctica by other data

EXTPAR – Outlook

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

EXTPAR work packages

Code

- A1 Disk cache approach
- A2 fast topo processing
- A3 register raw, buffer, grib
- A4 code replacement- cdo

Content

- B1 ESA CCI LandCover
- B2 SoilGrids
- B3 Pollen
- B4 global hires orography

Infrastructure

- C1 raw data processing
- C2 cmake environment
- C3 Repository @DKRZ
- C4 Input data maintenance
- C5 Unified web interface

#	Work package	Start	End	Q2/20	Q3/20	Q4/20	Q1/21	Q2/21	Q3/21
A1	Disk cache approach	Q2/20	Q3/20						
A2	fast topo processing	Q2/20	Q3/20						
A3	register raw, buffer, grib	Q2/20	Q2/20						
A4	code replacement- cdo	Q2/20	Q2/20						
B1	ESA CCI LandCover	Q2/20	Q4/20						
B2	SoilGrids	Q2/20	Q4/20						
B3	Pollen	Q3/20	Q1/21						
B4	global hires orography	Q3/20	Q4/20						
C1	raw data processing	Q2/20	Q2/20						
C2	cmake environment	Q2/20	Q2/20						
C3	Repository @DKRZ	Q3/20	Q3/20						
C4	Input data maintanance ICDC	Q3/20	Q3/20						
C5	Unified web interface	Q1/21	Q3/21