



MeteoSwiss



Meteorological Service of Canada
Service météorologique du Canada



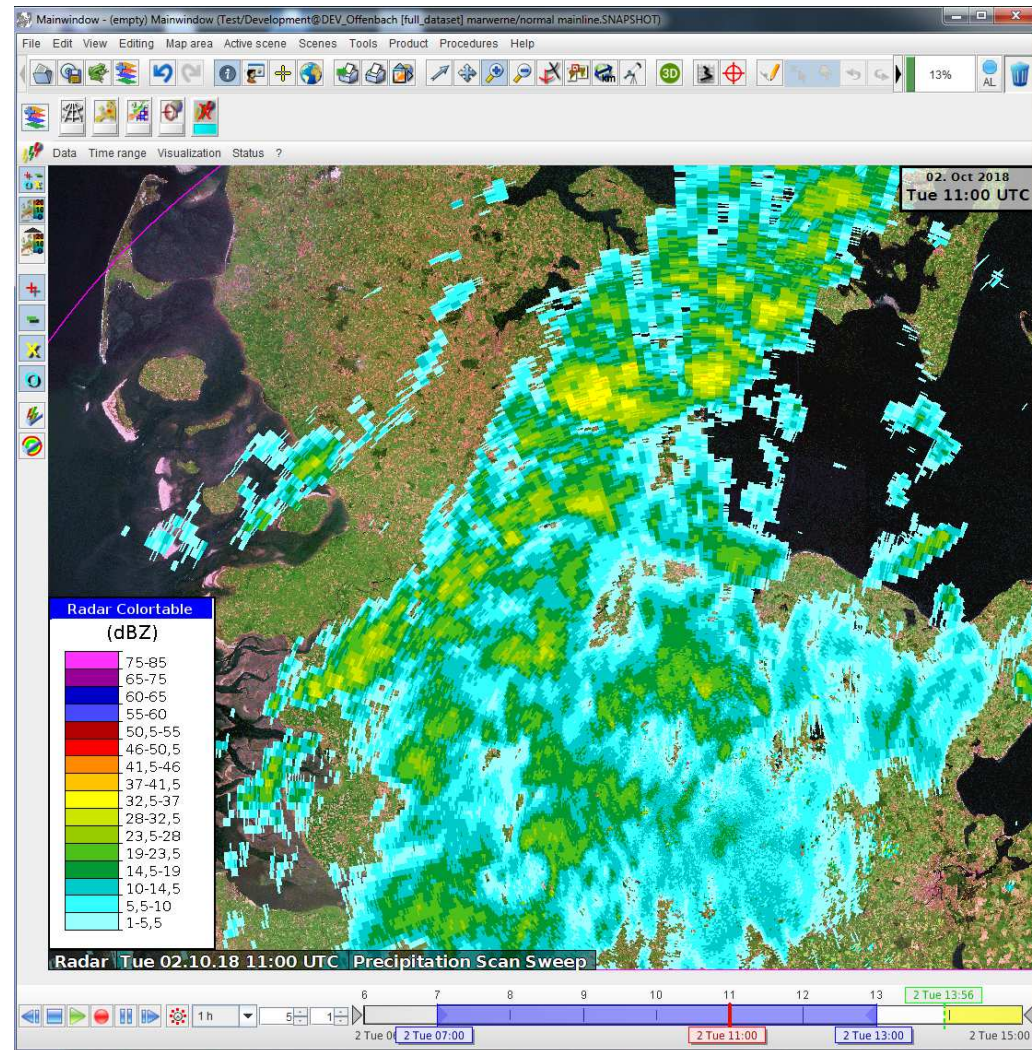
Meteorological data, geographic positioning and data formats

Past accuracy vs.
recent & future accuracy needs

EGOWS 2018, Reading
Marcus Werner (DWD & NinJo Consortium)

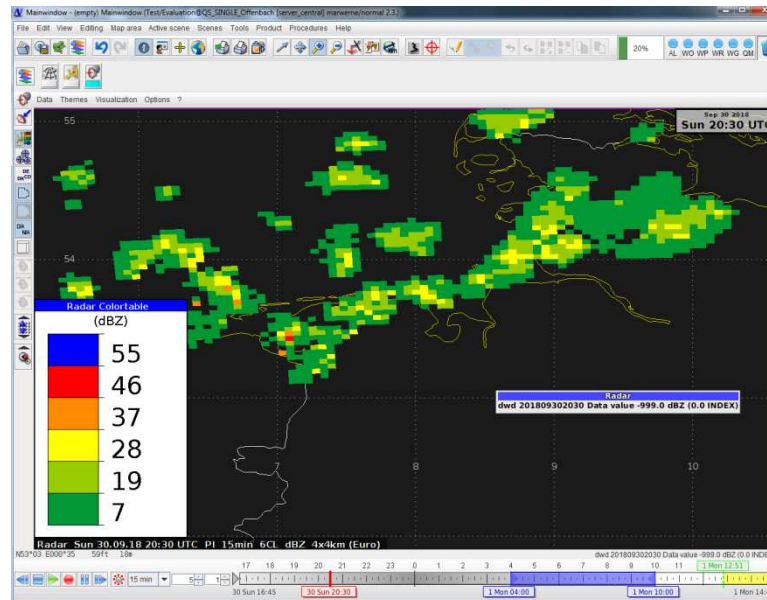
Agenda

- Past & Present
- Use-cases
- Background
- Some experiments
- Conclusion & our way forward



Past & Present

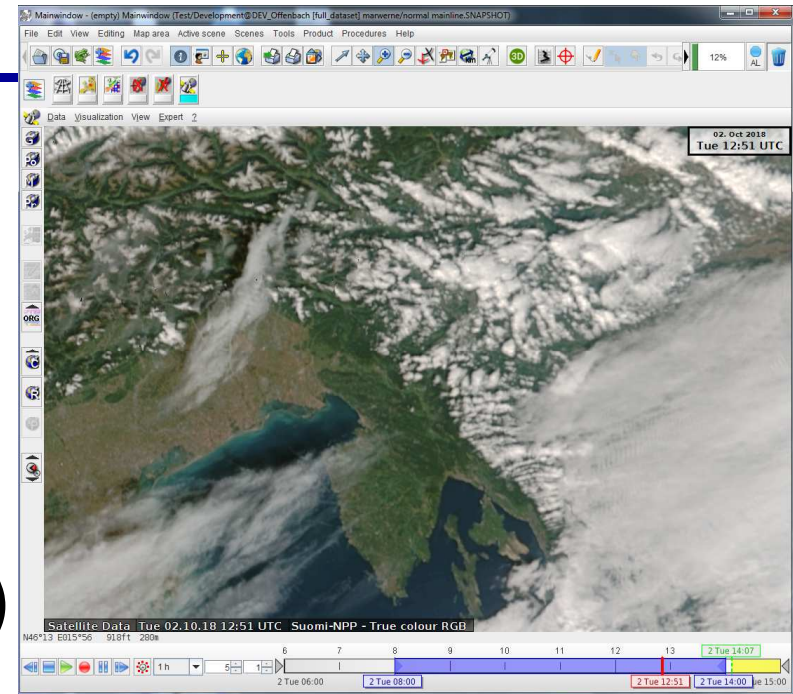
- Few years ago, exact geo-positioning was less important
 - **Radar data** (res. 4 km, 6 classes, 15 min)



- **SAT data** (MFG, res. 5 km WV+IR, res. 2.5 km VIS, 30 min)
- **NWP** (grid size 2 – 30+ km, time resolution vv = 1-3h on ~sphere)
- **Surface data** (every 1h, (λ, ϕ) or (x,y) incl. CRS “Coord. Ref. Syst.” ??)

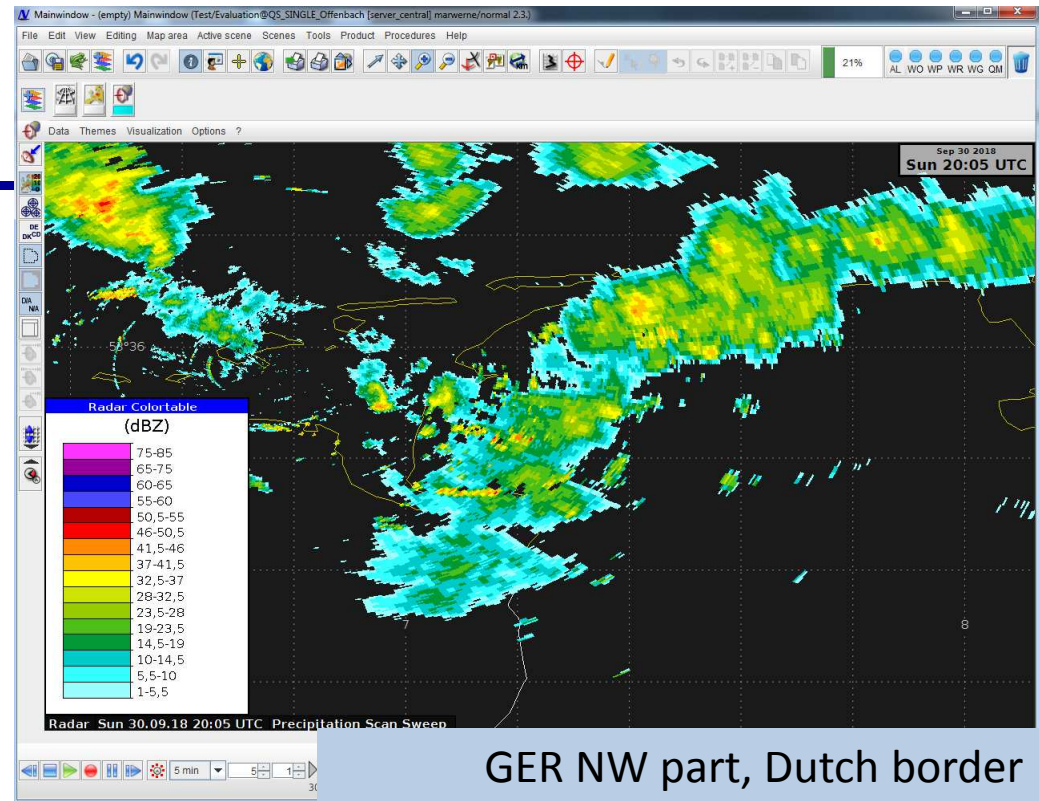
Recent data and needs 1

- **Radar Data** (res. 250 m polar data, time res. 5 min (≥ 2.5 min), 19 classes or continuous dBZ)
- **NowCasting/Model Data (SINFONY)** (grid size ≤ 1 km, 5 min)
- **Surface data** (CRS WGS 84, 1 – 10 min)
- **Lightning data** (CRS WGS 84, res. $\sim \leq 100$ m ?!?, time res. \sim ms)
- High resolution satellites (polar orbiting satellites - **Suomi-NPP**, geostationary **MTG** series)
- Semi-automated products (**warnings** on municipality level)



Recent data and needs 2

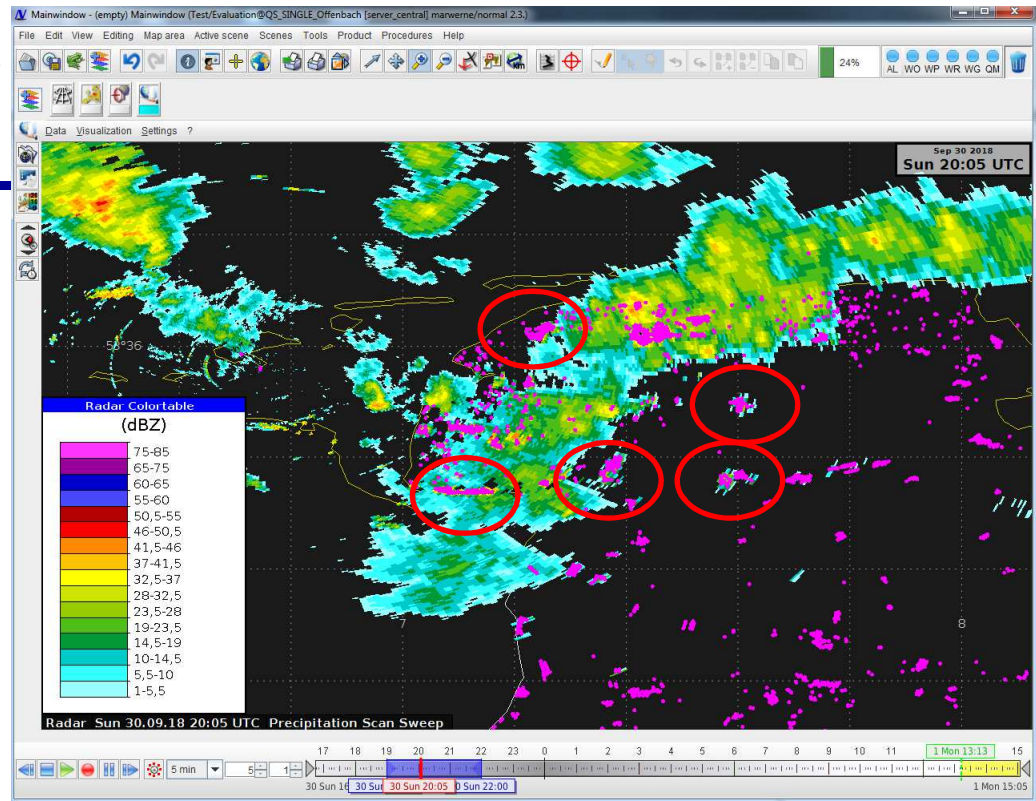
- **Wind Power Stations / Windmill-powered Plant (WEA, WGS 84)**



- Expert reports (insurance claims, aviation accidents, etc)
- Radio sounding (straight up?), AMDAR & turbulence data (GPS)
- Automated classification (e.g. cloud masks) vs. pure visual usage
- ICAO – WGS 84 (relative vague specs for SIGMETs polygons)
- City climate

Recent data and needs 2'

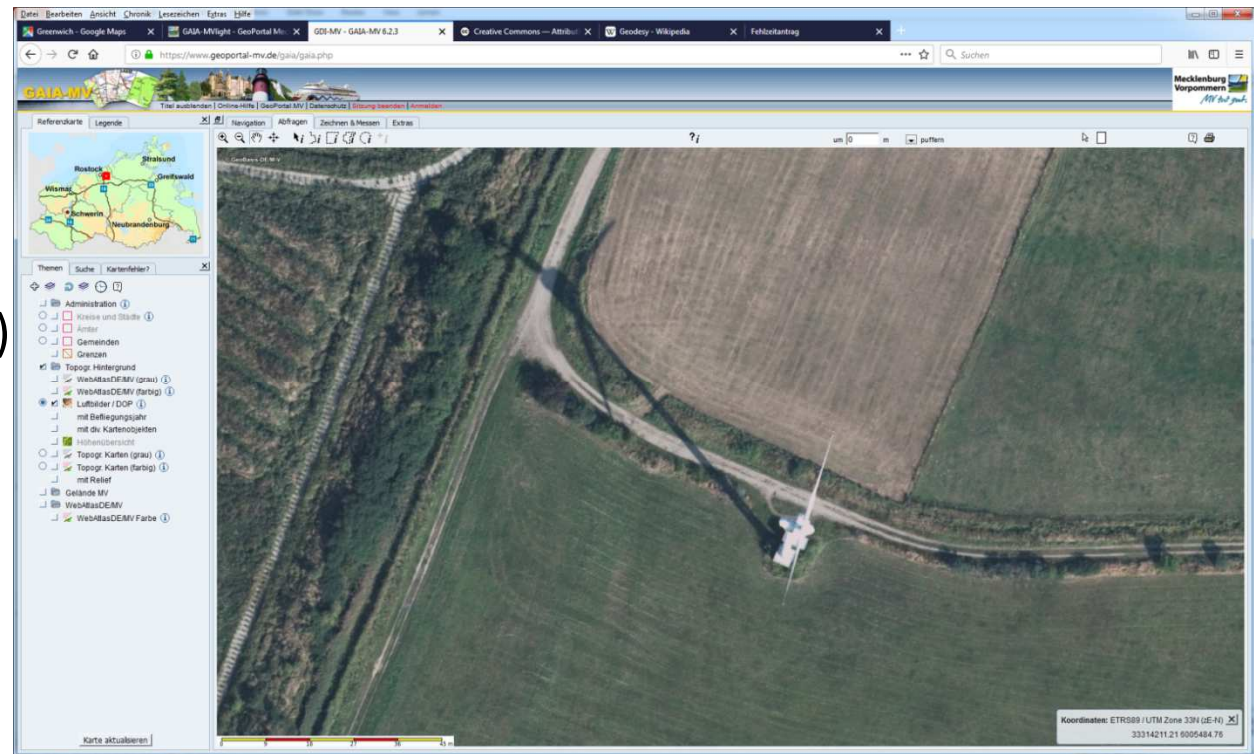
- **Wind Power Stations / Windmill-powered Plant (WEA, WGS 84 , pink dots, © Bundesamt für Kartographie und Geodäsie)**



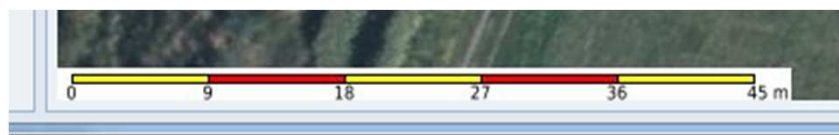
Precipitation Scan (lowest sweep)

Recent data and needs 3

- Hi-res background information, freely available (via WMS)
 - Open Street Maps
 - INSPIRE
 - BKG Maps
 - Ortho Photos (German administration)



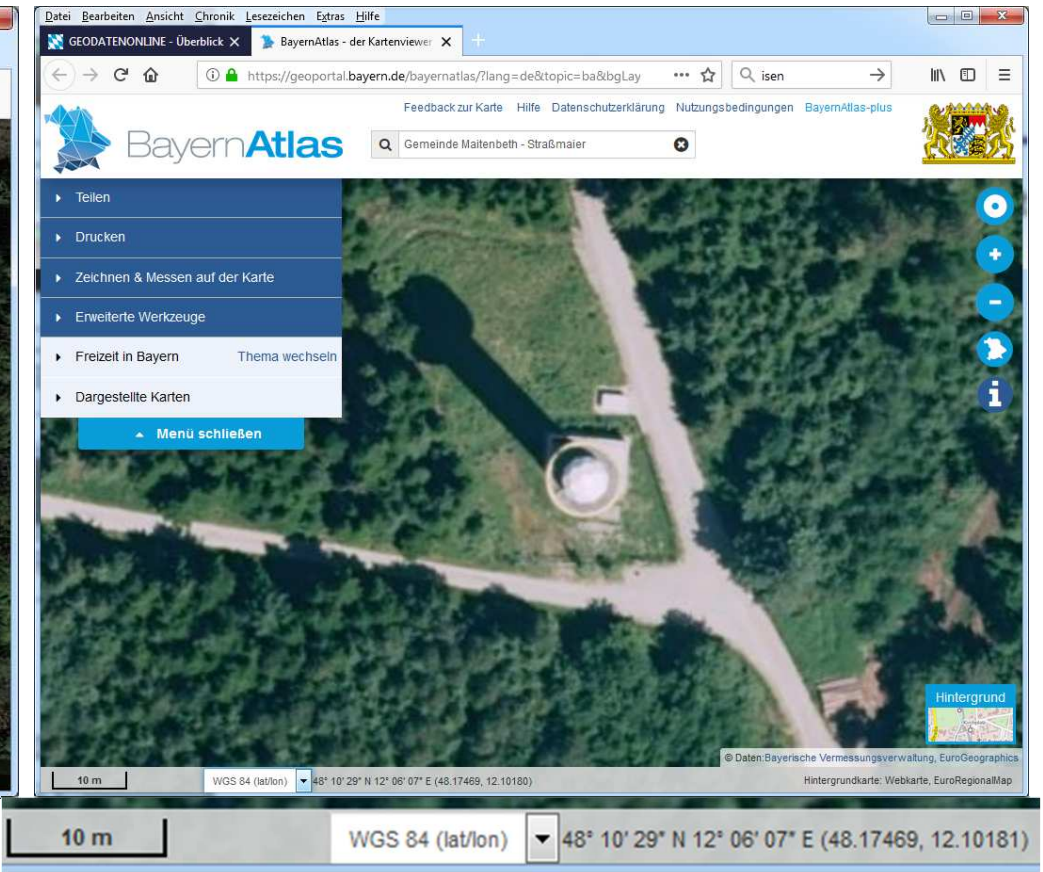
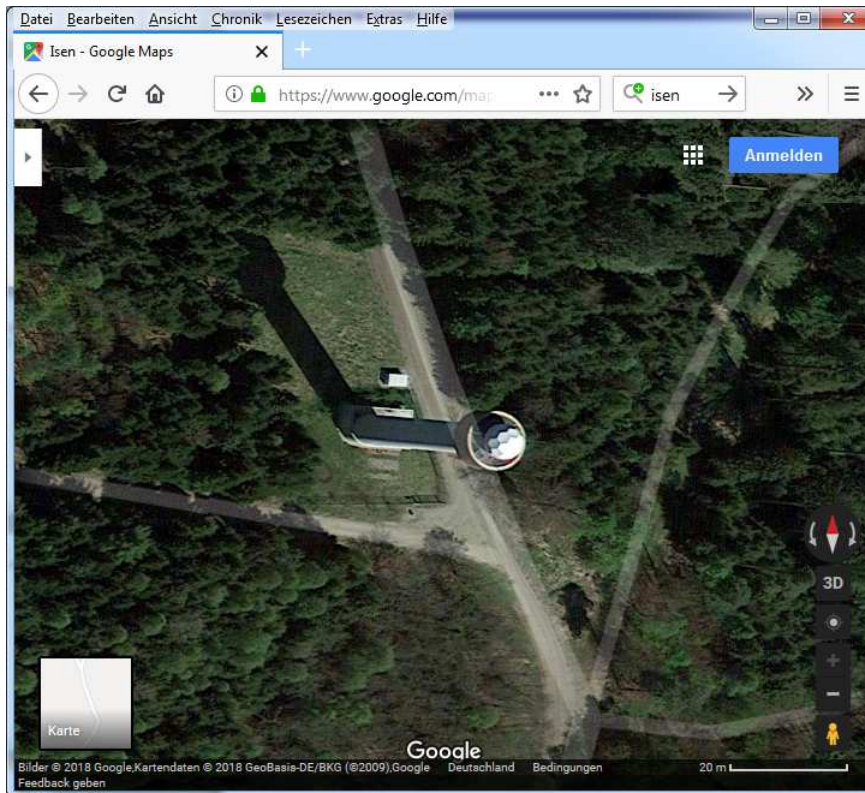
Source: GDI-MV - Digitale Orthophotos (DOP WMS) , Landesamt für innere Verwaltung M-V, Amt für Geoinformation, Vermessung und Katasterwesen, Bodenauflösung von 0,2 m, Publikation 10.04.2017, URL<https://www.geoportal-mv.de/gaia/gaia.php>, Retrieved 1-Oct-2018



Koordinaten: ETRS89 / UTM Zone 33N (zE-N) X
33314211.21 6005484.76

Recent data and needs 4 (DWD Radar “Isen / Bavaria”)

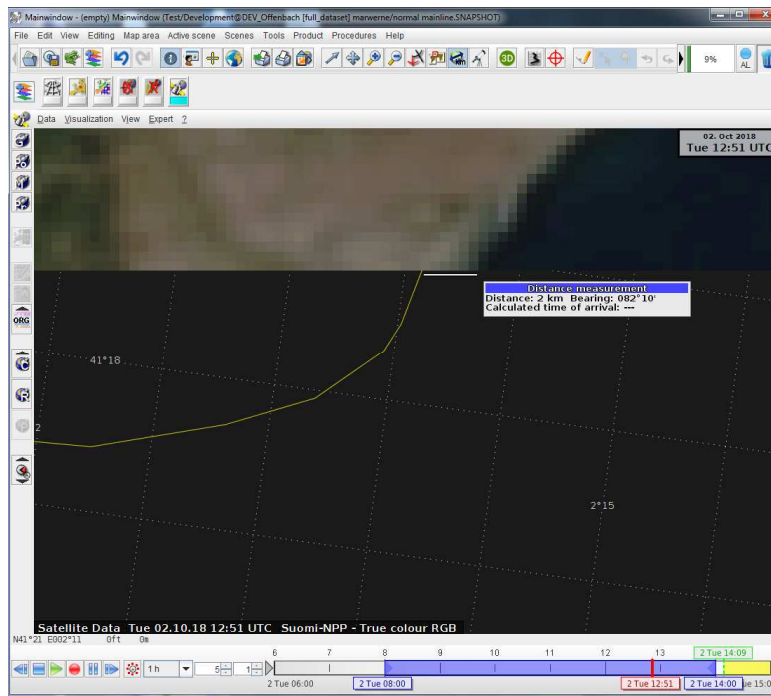
- Google Maps vs. German administration



Source: **Geoportal Bayern und den BayernAtlas**,
<https://geoportal.bayern.de/bayernatlas/?lang=de&topic=ba&bgLayer=atkis&catalogNodes=11,122&E=4507672.21&N=5337418.20&zoom=15&layers=luftbild>, Retrieved 1-Oct-2018

Recent data and needs 5

- Layer concept (Vector data + Raster data)
- Different high resolution data should **overlay correctly**



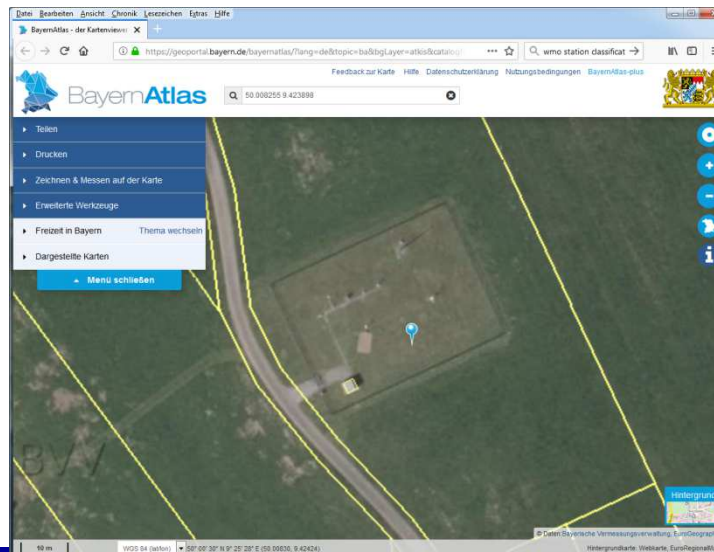
Coastline of the
Mediterranean Sea
Suomi-NPP versus
GeoGrid

→ 2 km offset (E-W)

- **SYNOP surface data, “exact time” is difficult to handle (own + other country)**

Recent data and needs 6 (Surface station classification)

- **WMO surface station classification**
(siting classification for surface observing stations on land)
<http://www.wmo.int/pages/prog/www/IMOP/SitingClassif/SitingClassif.html>
 - Ensure to minimize the influence factors for the measurement resp. the results (shadows, surrounding environment,..)
 - Check geographic coordinates...
 - Main work done within a GIS (using NinJo is possible)



DWD Station Neuhütte/Spessart, WMO #10646

Source: **Geoportal Bayern und den BayernAtlas**,
https://geoportal.bayern.de/bayernatlas/?lang=de&topic=ba&bgLayer=at&catalogNodes=11,122&E=4315444.31&N=5544510.99&zoom=15&layers=luftbild,luftbild_parz, Retrieved 1-Oct-2018

Problem

- Real Earth \leftrightarrow Model Earth
- Model base body: ellipsoid of revolution **(a, b)** \leftrightarrow sphere **(R)**
- Variations in Datum / Country specific optimizations
- (λ, ϕ) , but no exact reference CRS given
- Exact numbers ?!?! (e.g. corners of extend, low acc.)
- Old meteorological formats (try to safe every bit)
- Past: Simplification of application code (sphere vs. ellipsoid)
 - Execution time (with current CPU, still valid?)
 - Own implementation, no use of std. libraries

How accurate do we want (or need) to work?

Example – Greenwich Royal Observatory

- Position of the “historic” Prime-Meridian (vs. WGS 84)



Source: Wikipedia.de,
“Der historische Nullmeridian ist am *Transit House* in Greenwich auf dem Boden und am Gebäude markiert.”,
URL: <https://de.wikipedia.org/wiki/Nullmeridian#/media/File:Prime-meridian.jpg>,
Retrieved 1-Oct-2018



Source: Wikipedia.de,
“Ein GPS-Empfänger zeigt über dem in Greenwich markierten Nullmeridian nicht exakt die Länge Null an”,
<https://de.wikipedia.org/wiki/Nullmeridian#/media/File:Greenwich-GPS.jpg>,
Retrieved 1-Oct-2018

Example – Greenwich Royal Observatory



Source-URL: <https://www.google.de/maps>. Retrieved 1-Oct-2018

DWD data & applications

- NWP sphere R=6 371 229 m (ICON & COSMO)
- Radolan sphere R=6 370 040 m
- NinJo sphere R=6 365 831 m
- Big portion of WGS 84 data
a = 6.378.137,000 m (Equator)
b = 6.356.752,314 m (Pole axis)



Lage des 50. Breitengrades nach World Geodetic System 1984 (WGS 84) in Oestrich-Winkel im Rheingau. Nach dem für topografische Karten in Deutschland angenommenen

Potsdam Datum liegt der 50. Breitengrad hier etwa 130 Meter weiter südlich.

Source:
https://de.wikipedia.org/wiki/World_Geodetic_System_1984,
Retrieved 2-Oct-2018

Current accuracy needs....

- Recent DWD requirement for geo-position of own radar data (~res. 250 m, i.e. within 1 radar pixel)
- We do not need meter (or cm) accuracy (yet)
- Model data (DWD NWP is always on a sphere)

```
DWD COSMO-D2
===== SECTION_3 ( length=84, padding=0 ) =====
...
13-14  gridDefinitionTemplateNumber = 1 [Rotated latitude/longitude (grib2/tables/19/3.1.table) ]
15     shapeOfTheEarth = 6 [Earth assumed spherical with radius of 6 371 229.0 m (grib2/tables/19/3.2.table) ]
...
31-34  Ni = 651
35-38  Nj = 716
...
47-50  latitudeOfFirstGridPoint = -6300000
51-54  longitudeOfFirstGridPoint = 352500000
...
```

forecast error, multiple points should be taken together,....
but there is land sea mask, t_2m & v_10m at coastline

Recent experimental work...

- Platform: ArcGIS Pro, QGIS + NinJo V 2.x,3.x,4.x (using Proj4J)
- Use different maps (NinJo legacy Proj.-FWK vs. new impl. Proj4J)
- Select sample products (well documented)
 - RADOLAN / RADVOR (Radolan format and Grib1 format)
 - Work with **Radolan extend** (900x900 km) and **Radolan product area**
 - Projected data
 - Is there an official EPSG:nnn code ?
- Check WEA position against Ortho-Photos
- Position of DWD Radar Sites (Docu./DB vs. Ortho-Photo)
- Vary parameters of the CRS (sphere incl. radius ↔ WGS84)
- Mix sphere & WGS84 coordinates What happens?

Try to get a feeling for the size of error....

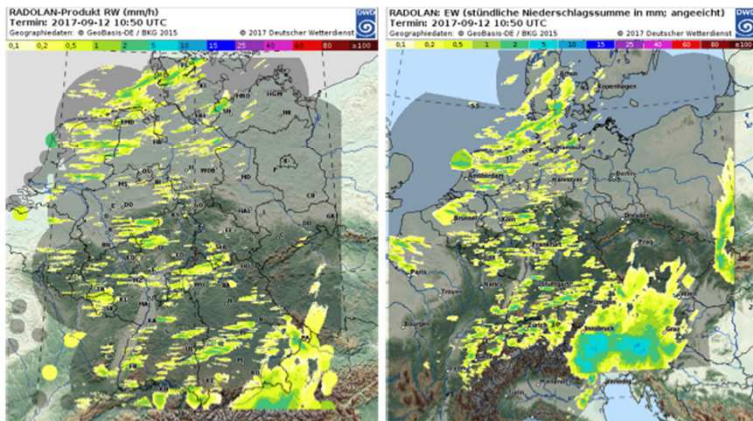
A product with good documentation... (DWD Radolan)

RADOLAN/RADVOR



Hoch aufgelöste Niederschlagsanalyse und –vorhersage auf der Basis quantitativer Radar- und Ombrometerdaten für grenzüberschreitende Fluss-Einzugsgebiete von Deutschland im Echtzeitbetrieb

Beschreibung des Kompositformats Version 2.4.4



Deutscher Wetterdienst
Abteilung Hydrometeorologie

<http://www.dwd.de/RADOLAN>

<http://www.dwd.de/radvor>

August 2018

Calibrated Quantitative Precipitation Analysis

RADOLAN und RADVOR: Beschreibung des Kompositformats

Formatbeschreibung

11

Km-Raster (RADOLAN national)

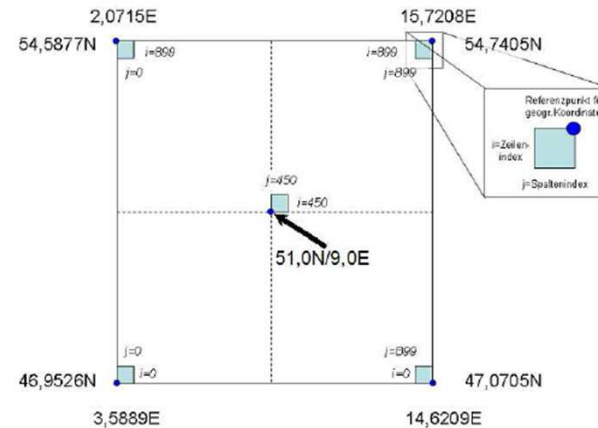
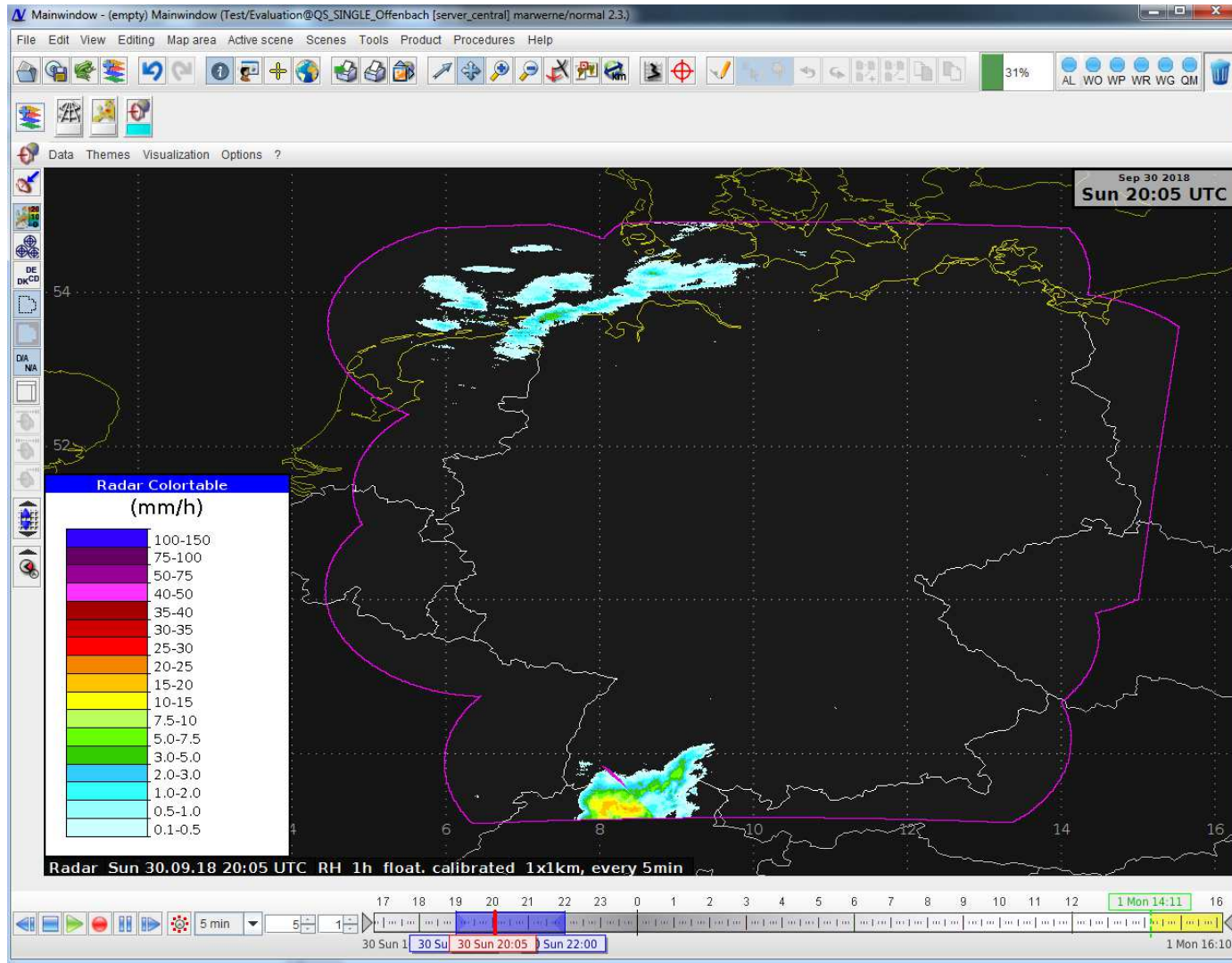


Abbildung 1: 1 x 1 km-Raster des nationalen Komposits (RADOLAN-Raster)

Ecke / Koordinate	λ	ϕ	x	y
linke untere Ecke	3,5889°E	46,9526°N	-523,4622	-4658,645
rechte untere Ecke	14,6209°E	47,0705°N	376,5378	-4658,645
rechte obere Ecke	15,7208°E	54,7405°N	376,5378	-3758,645
linke obere Ecke	2,0715°E	54,5877°N	-523,4622	-3758,645

DWD Radolan RH 1h float. calibrated 1x1km, every 5min



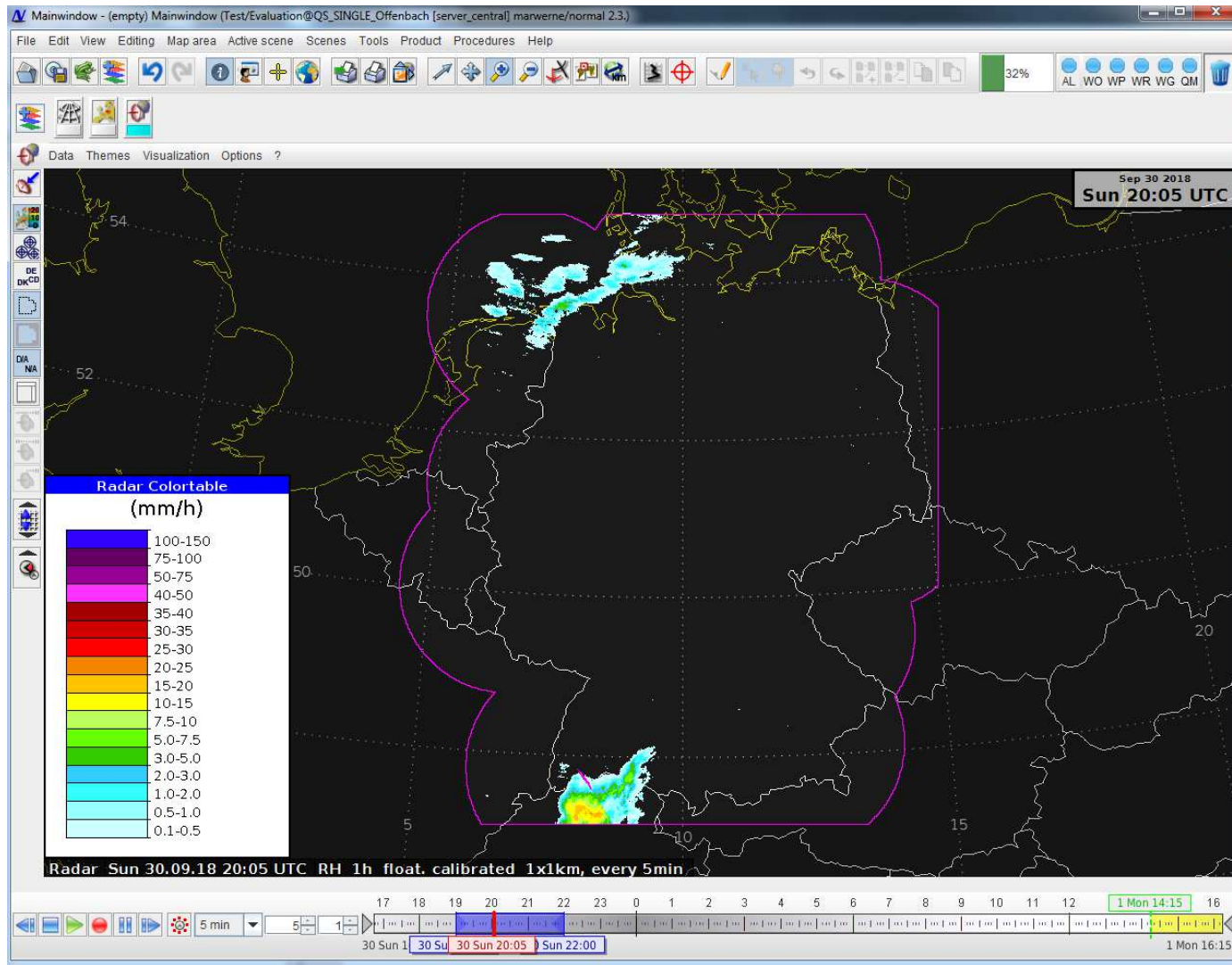
Rectangular
projection

on

WGS 84 Ellipsoid

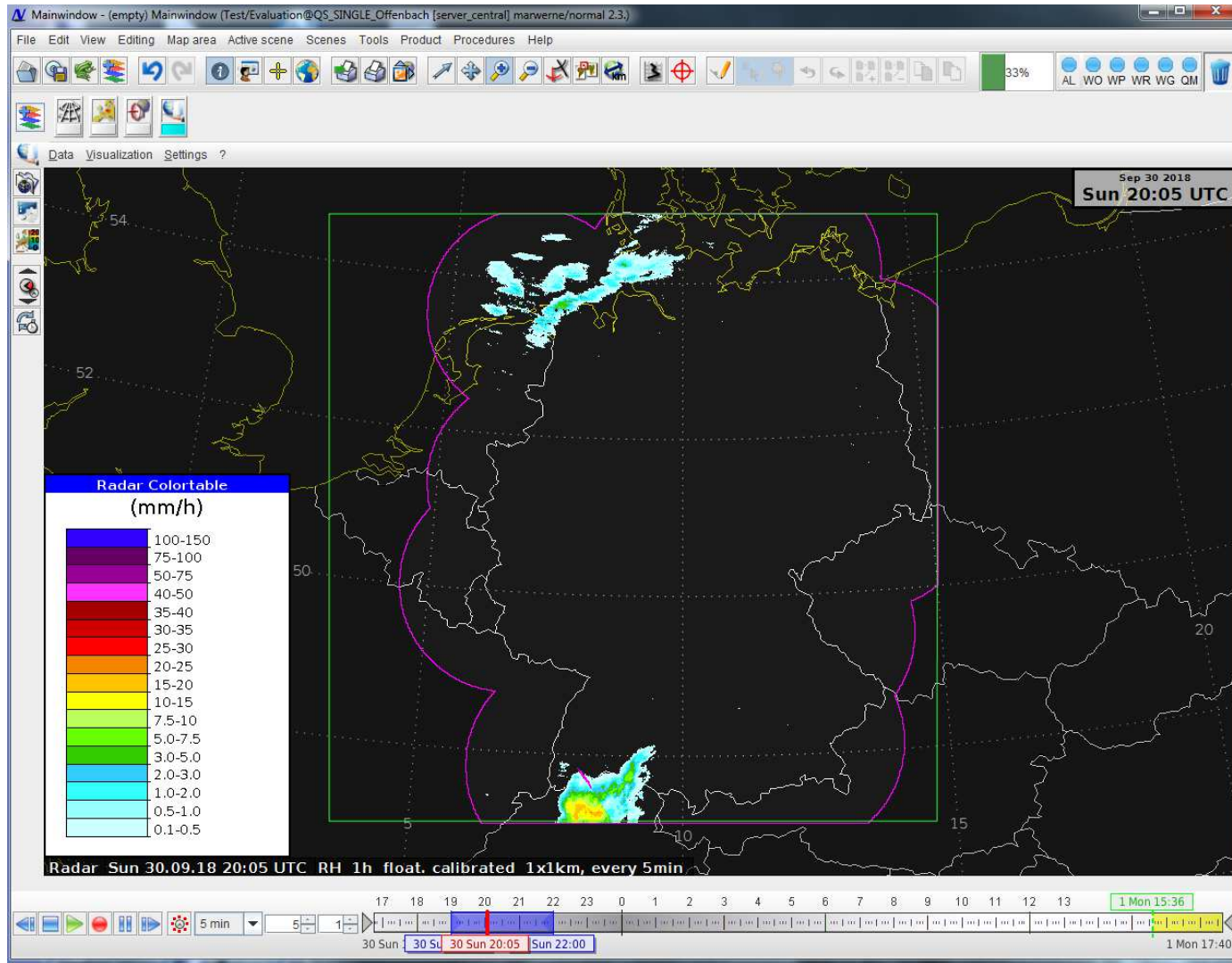
Radolan is
projected data
(NPS 60°N 10°E)

DWD Radolan RH 1h float. calibrated 1x1km, every 5min



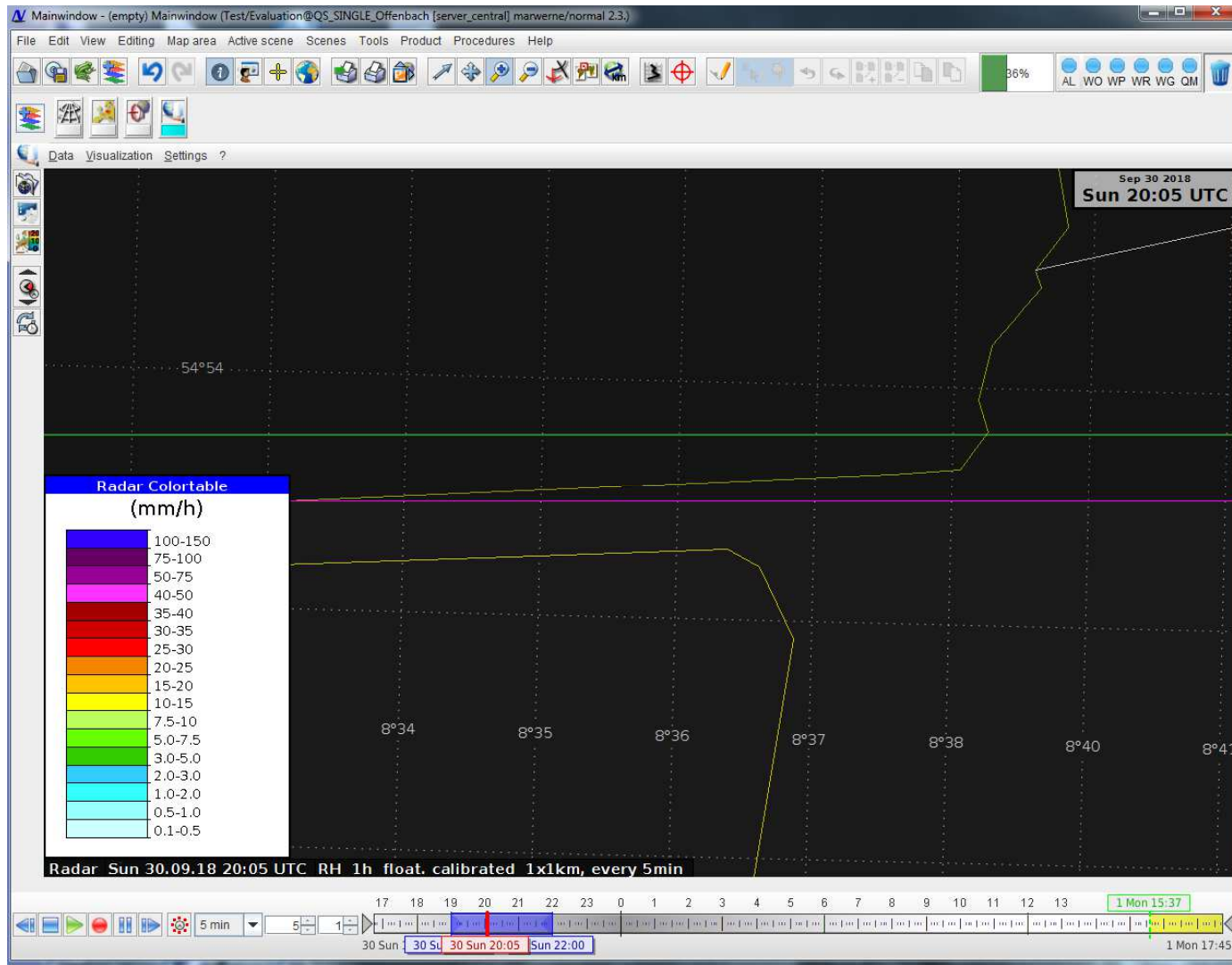
North polar
stereographic
projection
(on a NinJo sphere
with projection area
60°N and center
meridian 10°E)

DWD Radolan RH 1h float. calibrated 1x1km, every 5min



Overview

DWD Radolan RH 1h float. calibrated 1x1km, every 5min

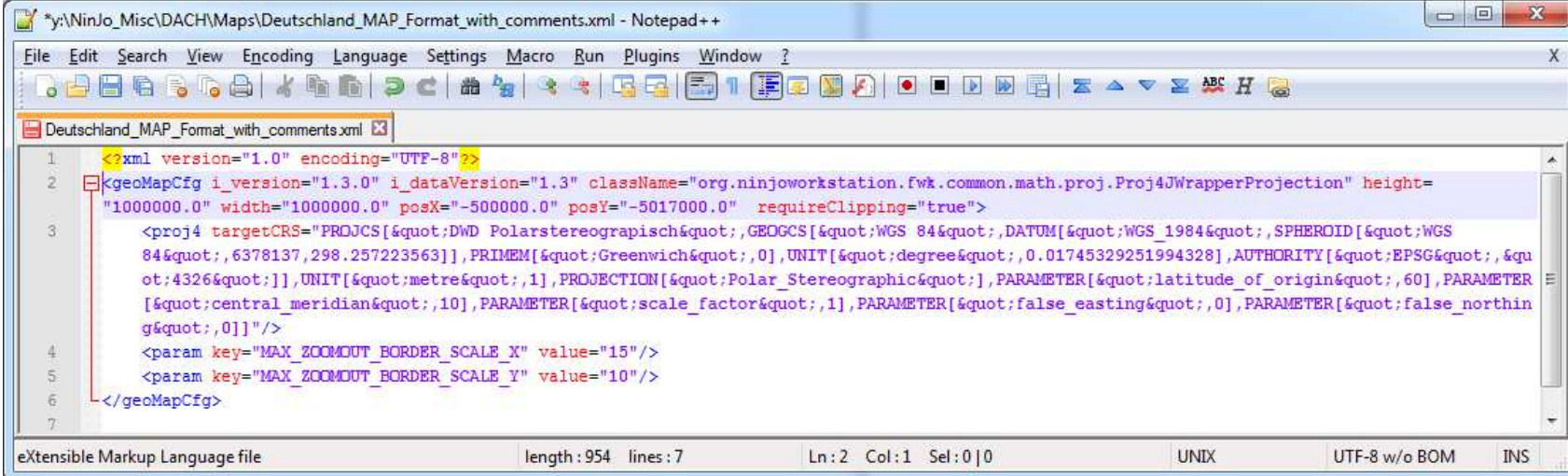


Detailed ZOOM on the dam to Sylt Island (German/Danish border)

~600 m N/S offset

Example: „Map definition“ in NinJo using Proj4J Library

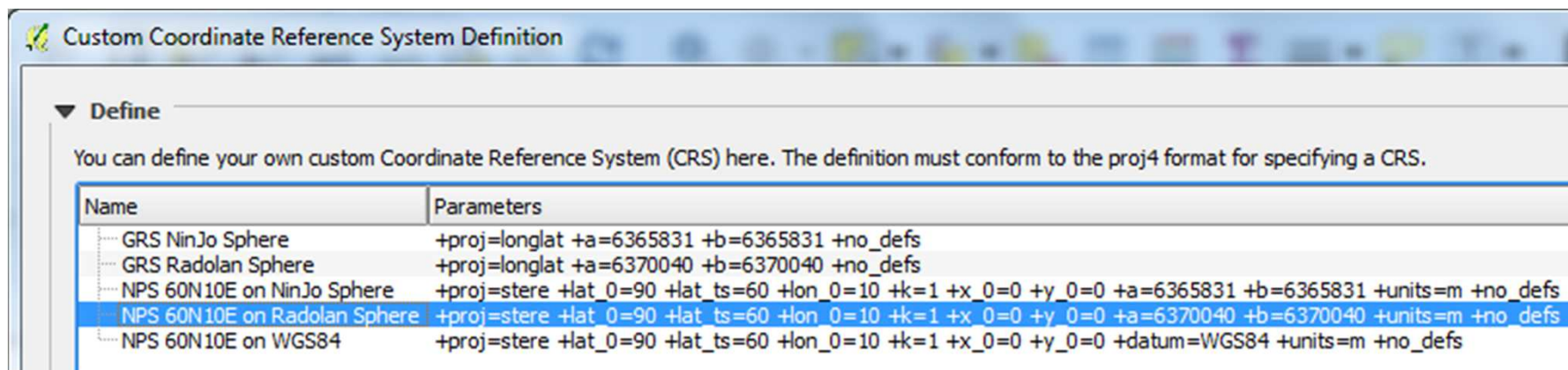
- Avoid „custom defined CRS“ (here NPS 60°N, 10°E on WGS84)



```
<?xml version="1.0" encoding="UTF-8"?>
<geoMapCfg i_version="1.3.0" i_dataVersion="1.3" className="org.ninjoworkstation.fwk.common.math.proj.Proj4JWrapperProjection" height="
1000000.0" width="1000000.0" posX="-500000.0" posY="-5017000.0" requireClipping="true">
  <proj4 targetCRS="PROJCS[&quot;DWD Polarstereografisch&quot;;GEOGCS[&quot;WGS 84&quot;;DATUM[&quot;WGS 1984&quot;;SPHEROID[&quot;WGS
84&quot;;6378137,298.257223563]],PRIMEM[&quot;Greenwich&quot;;0],UNIT[&quot;degree&quot;;0.01745329251994328],AUTHORITY[&quot;EPSG&quot;;&qu
ot;4326&quot;]],UNIT[&quot;metre&quot;;1],PROJECTION[&quot;Polar_Stereographic&quot;],PARAMETER[&quot;latitude_of_origin&quot;;60],PARAMETER
[&quot;central_meridian&quot;;10],PARAMETER[&quot;scale_factor&quot;;1],PARAMETER[&quot>false_easting&quot;;0],PARAMETER[&quot>false_northin
g&quot;;0]]"/>
  <param key="MAX_ZOOMOUT_BORDER_SCALE_X" value="15"/>
  <param key="MAX_ZOOMOUT_BORDER_SCALE_Y" value="10"/>
</geoMapCfg>
```

Length comparison in QGIS 2.18 (NPS, projected CRS)

- Measure the top 900 km Radolan extend (W-E length) via Custom CRS + CSV export
 - NPS 60°N/10°E on Radolan Sphere
--> 900 000.0 m ~ no error (by definition)
 - NPS 60°N/10°E on NinJo Sphere
--> 899 405.3 m ~ 600 m error
 - NPS 60°N/10°E on WGS 84 Datum
--> 903 108.7 m ~ 3 100 m error



Map Definition (WKT Definition – MAPS.DWD.DE)

- Radolan projection - **EPSG:1000001**

[Geometrie projizieren nach EPSG:1000001](#)

WKT

```
PROJCS["Radolan projection",  
  GEOGCS["Radolan Coordinate System",  
    DATUM["Radolan Kugel",  
      SPHEROID["Erdkugel", 6370040.0, 0.0]],  
    PRIMEM["Greenwich", 0.0, AUTHORITY["EPSG","8901"]],  
    UNIT["degree", 0.017453292519943295],  
    AXIS["Longitude", EAST],  
    AXIS["Latitude", NORTH]],  
  PROJECTION["Stereographic_North_Pole"],  
  PARAMETER["central_meridian", 10.0],  
  PARAMETER["Standard_Parallel_1", 60.0],  
  PARAMETER["scale_factor", 1.0],  
  PARAMETER["false_easting", 0.0],  
  PARAMETER["false_northing", 0.0],  
  UNIT["m*1000.0", 1000.0],  
  AXIS["X", EAST],  
  AXIS["Y", NORTH],  
  AUTHORITY["EPSG","1000001"]]
```



- Better as a custom defined CRS, but why not apply for an official EPSG ?

Conclusion & our way forward (1)

- Try to be a little bit more accurate (avoids significant support efforts & investigations going forward)
- “Old data formats” are likely to stay unchanged
- New & future data formats should incorporate
 - exact position information and reference CRS (ideally WGS 84, avoid data on spheres if possible)
 - go for standard EPSG codes (instead of custom definitions)
 - exact time reference
 - avoid saving every bit in the input data
 - contain **all necessary** information (drag-and-drop possible)

Conclusion & our way forward (2)

- Future formats should be supported by GIS (ArcMap, ArcGIS Pro, QGIS,...)
- DWD Radar data:
 - BUFRs contain proj4 string (on Sphere)
 - NEW DWD radar data is likely to use HDF5 (ODIM) with WGS84
- Data should be corrected at the producer side (e.g. parallax error for SAT data)

Questions? & Are you facing similar challenges...

