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NinJo
Meteorological Workstation
Station de travail météorologique

Canvas-Grid

A new approach to NWP data visualization in NinJo

16th Workshop on Meteorological Operational Systems (MOS)

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Outline

- Motivation for Canvas-Grid
- Idea
- Concepts
- Grib-lookup
- Sampling
- Calculation-FWK

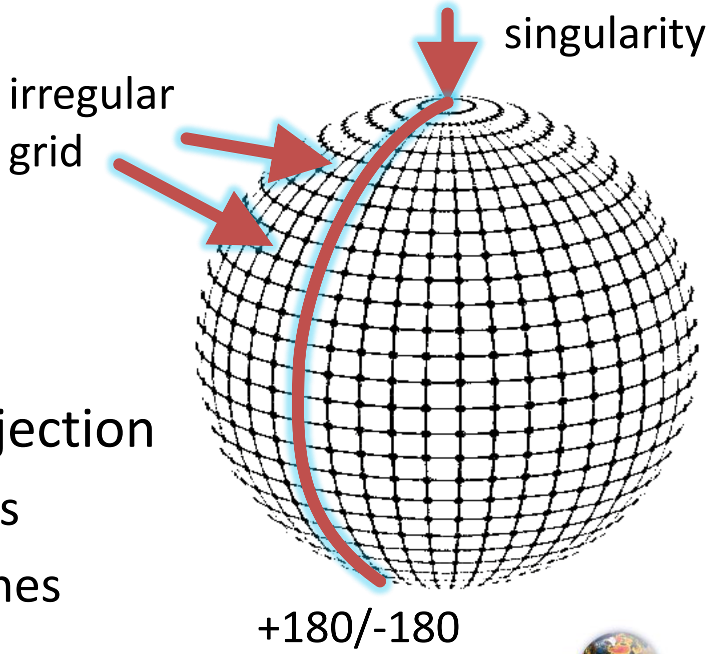
Motivation for Canvas-Grid

Visualization based directly on the globe is complicated

- Projection of GRIB-field differs from scene projection
  - How to check which part of the GRIB-field is currently visible?
  - The GRIB-field is irregular when projected onto the globe

- Special cases on dateline and poles
  - Wrap around dateline
  - Ambiguous pole representation

- Contour generation not on target projection
  - can cause self-intersections in polygons
  - can cause intersection of splined iso-lines

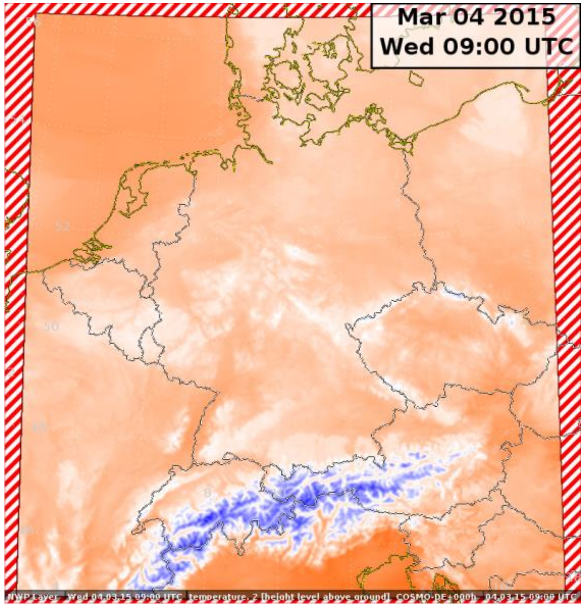


Motivation for Canvas-Grid

Work in display coordinate system is much simpler

- A simple 2D Cartesian coordinate system
- (almost) no special cases
- Simple iso-area and iso-line generation
- Simple accuracy estimation based on pixels

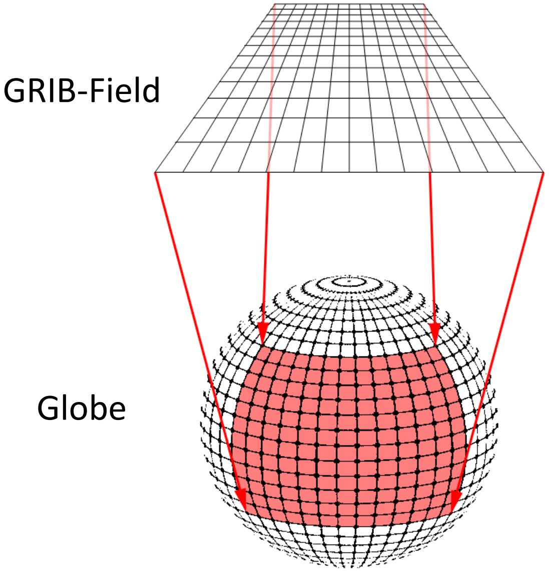
- Added benefit: new visualizations possible
  - e.g. per-pixel-coloring

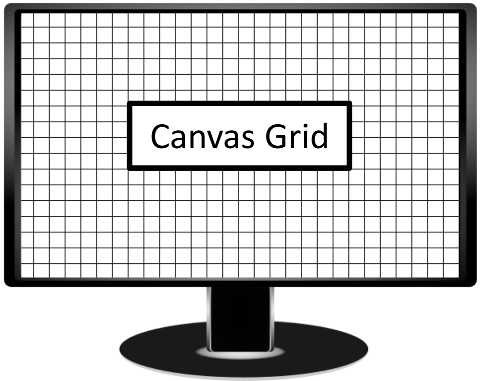


Pixel coloring example, combined with no-data visualization

Idea – Canvas-Grid

- Create an equidistant grid reflecting the display (“canvas-grid”)
- Lookup values from GRIB-field for each canvas-grid point
  - Canvas-grid points correspond to pixels
  - lower resolution is possible as well
    - Well suitable for iso-lines/-areas visualizations
- Use canvas-grid as a basis for visualization
  - Multiple visualizations on the same canvas-grid possible (lines, area, pixel, …)

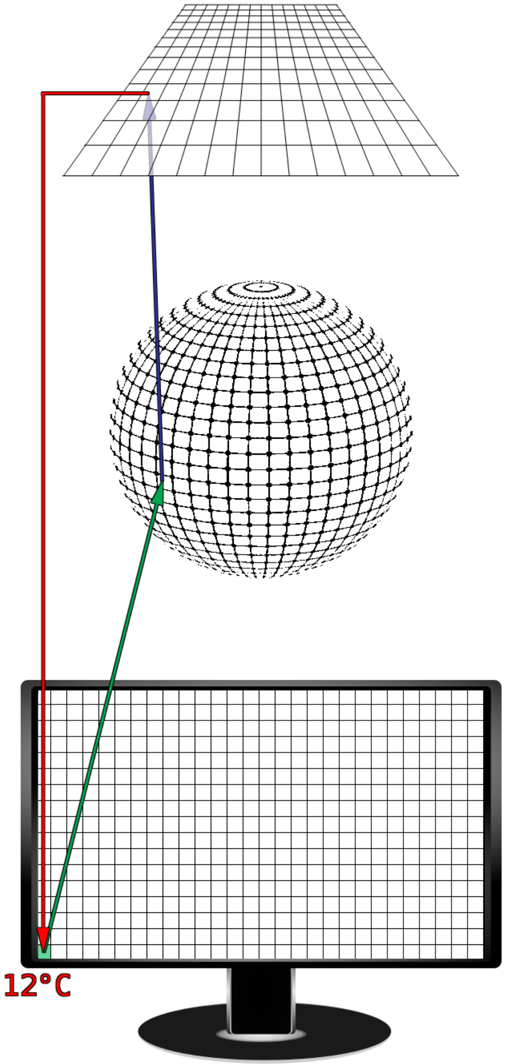




Concepts

Generation of the canvas-grid

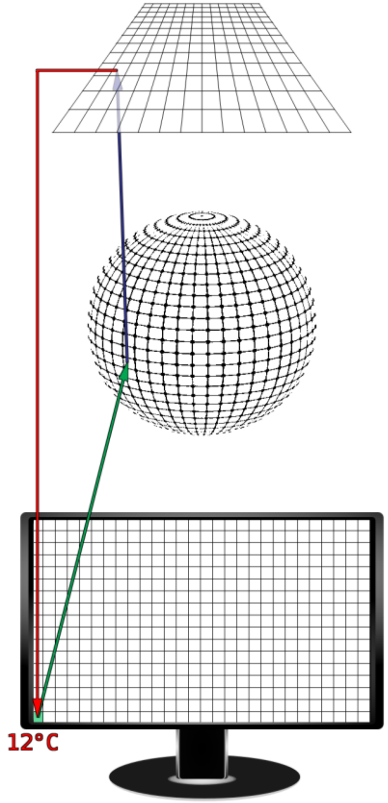
1. Compute long/lats for each canvas-pixel
   - Performed using target map projection
2. Compute GRIB-indices for each long/lat
   - Done by GRIB-containers projection
   - Result: GRIB-indices for each pixel
   - GRIB-indices are floating-points, as the long/lats are positioned in between GRIB-points
3. Lookup values from GRIB-field for each pixel
   - Use the precomputed GRIB-indices
   - **This is the new part!**



Detailed look into step 3: GRIB-lookup

Goal: for each canvas-pixel, lookup the GRIB-value

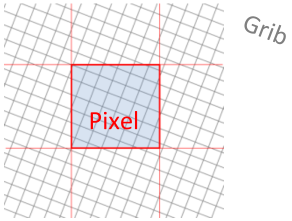
- **Input**:
  - GRIB-index (x,y) for a given pixel
    - The index is floating-point,
      i.e. points in between GRIB-points
- **Output**:
  - GRIB-value at (x,y)
    - Not necessarily the value at a given GRIB-point
    - Could be interpolated between GRIB-points
    - Could cover/span multiple GRIB-points



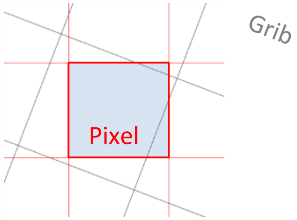
GRIB-lookup – Variants

Depends on canvas- vs. GRIB-resolution:

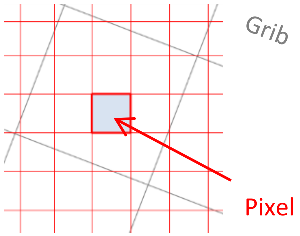
- canvas-resolution **<** GRIB-resolution
  - Aggregate all GRIB-points covered by a canvas-pixel



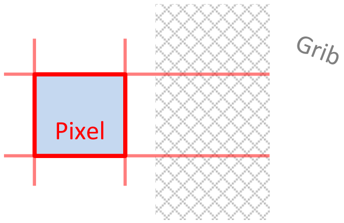
- canvas-resolution ≈ GRIB-resolution
  - Interpolate *bilinear* between GRIB-points



- canvas-resolution **>** GRIB-resolution
  - Interpolate *monotone-bicubic* between GRIB-points

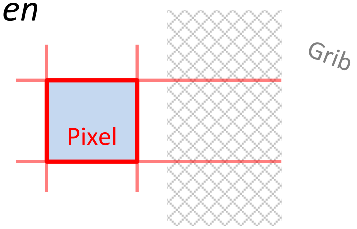


- Not enough surrounding GRIB-points
  - Nearest neighbor or NaN



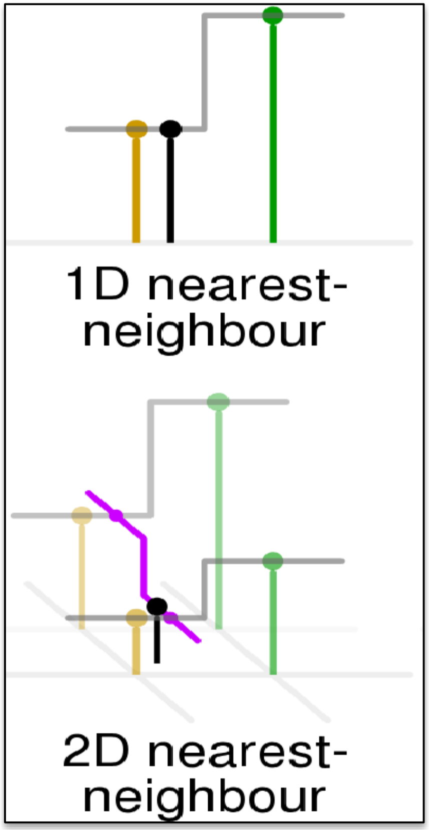
Note that, for each canvas pixel, a different option might have to be chosen

Used when

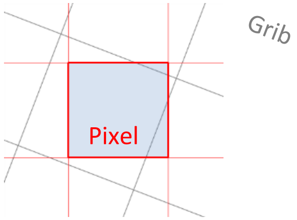


Nearest Neighbor

- The simplest form of interpolation
- Just use the nearest GRIB-point
- Used when not enough neighbors for applying other sampling methods



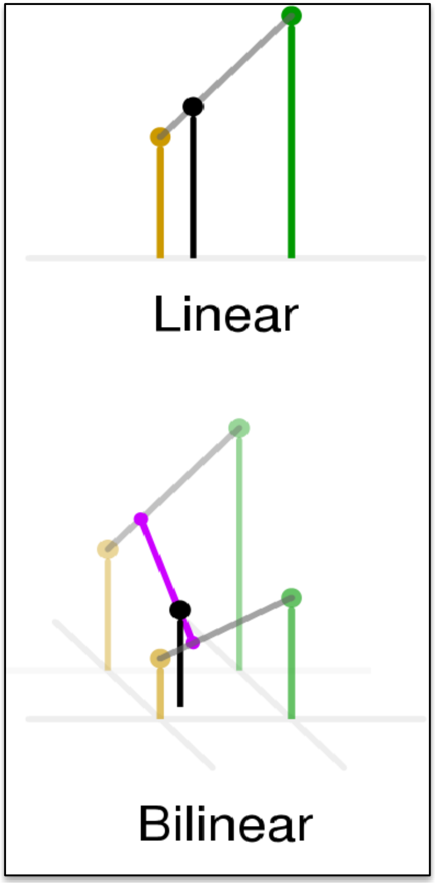
Used when

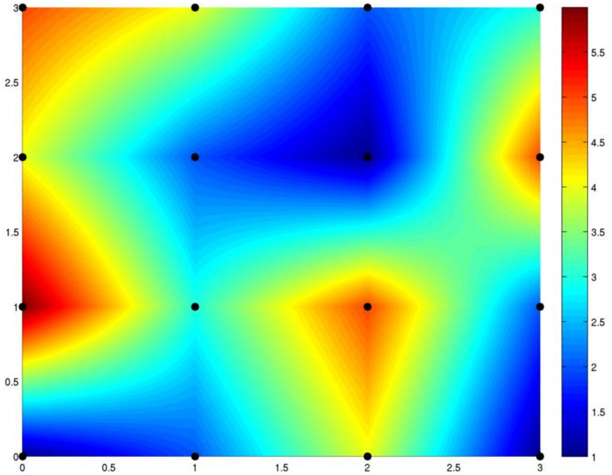


Bi-linear Interpolation

- Performs well when GRIB and display are of similar resolution

- Produces artifacts when both resolutions differ to much

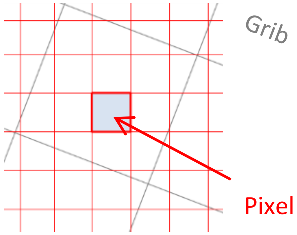




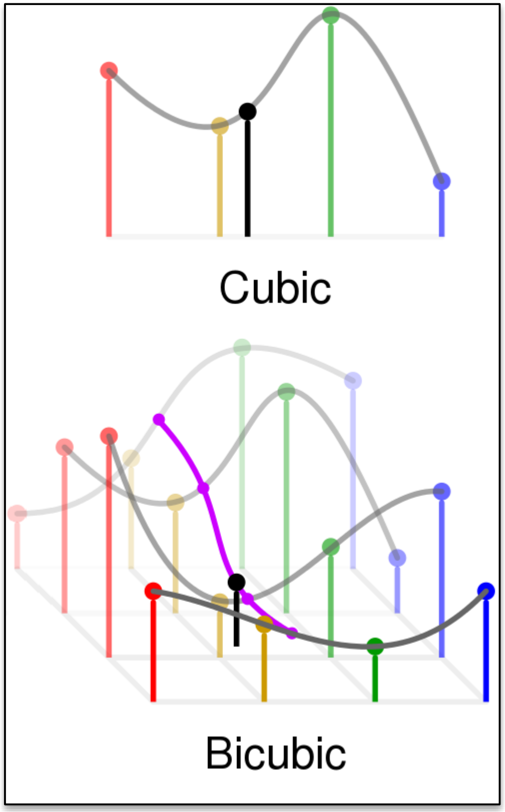
Result of bi-linear interpolation

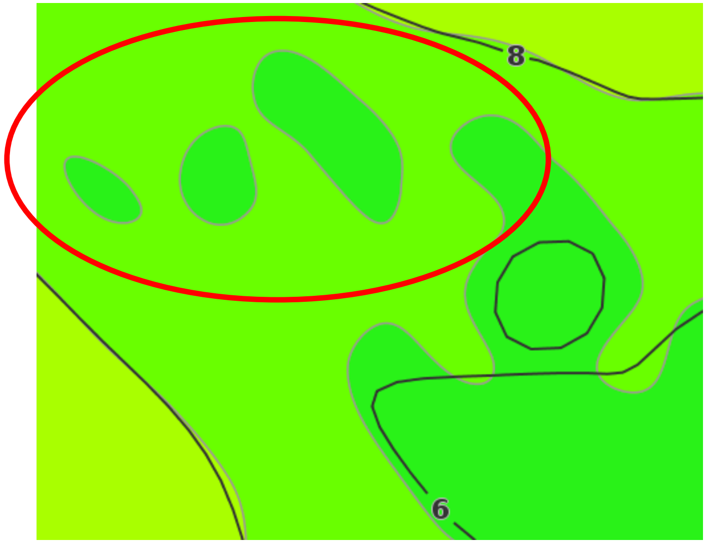
Monotone bi-cubic

Used when



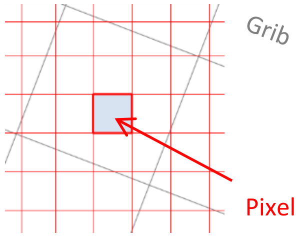
- Bi-cubic is much smoother than bilinear
- can produce artifacts
  → not used
- Use monotone bi-cubic instead





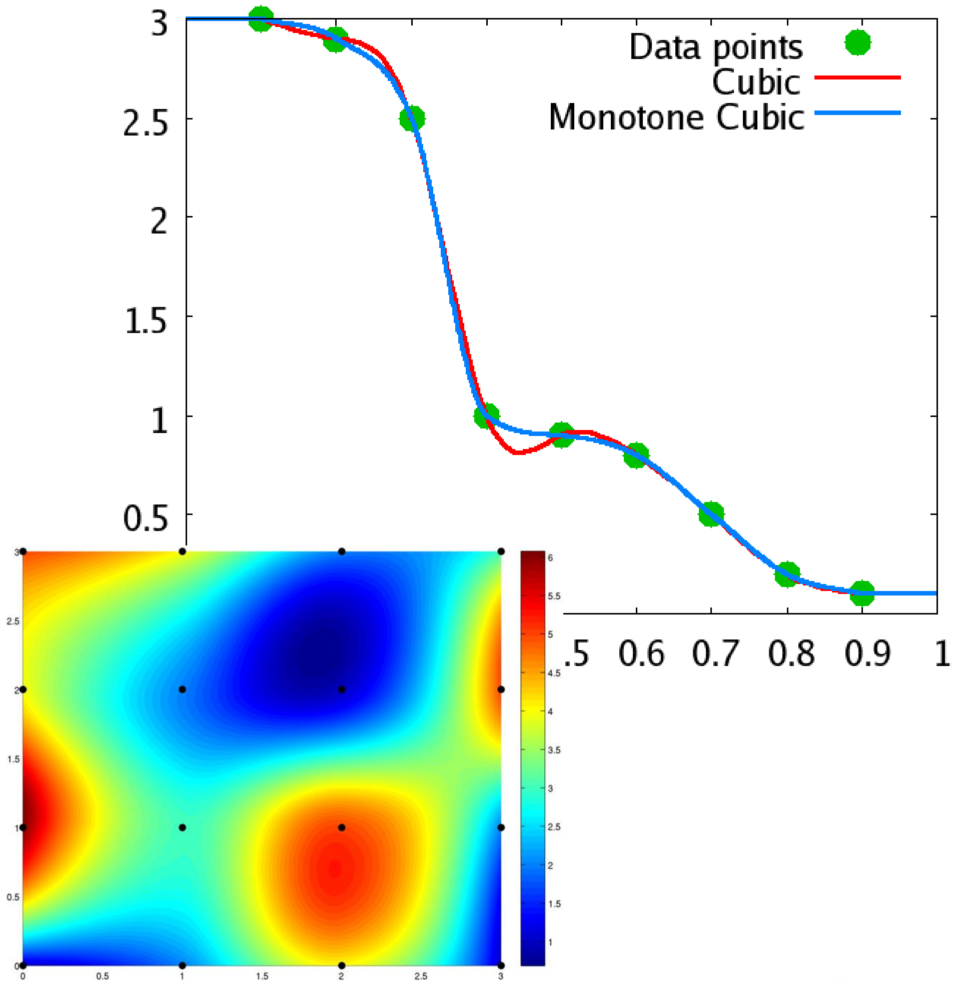
Overshoot artifacts of cubic interpolation

Used when



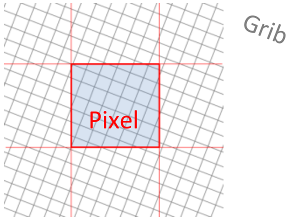
Monotone bi-cubic

- Same as bi-cubic
  - But uses harmonic-means instead of slopes/differentials
- Smooth transitions
  - But not as smooth as bicubic
- No overshoots
- Well suitable for high-resolution display



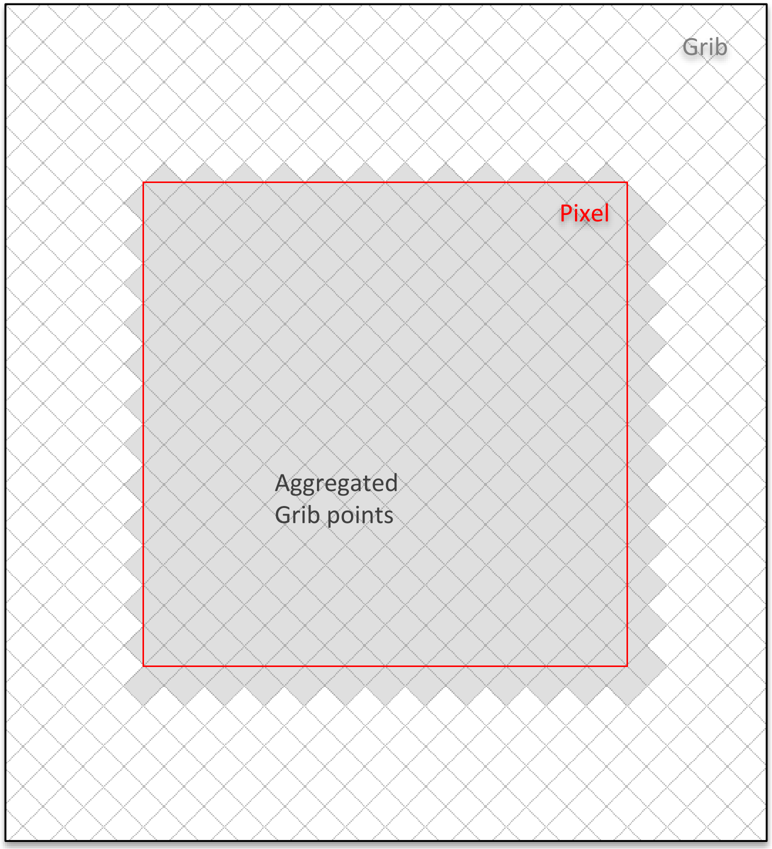
“Down-sampling”

Used when



Method of aggregation

- single canvas-pixel covers more than one GRIB-point
- Different methods for aggregating values
  - Minimum
  - Average
  - Maximum
- Implemented as a scanline algorithm



Use scan-line to aggregate covered GRIB-values

Canvas-Grid – Result

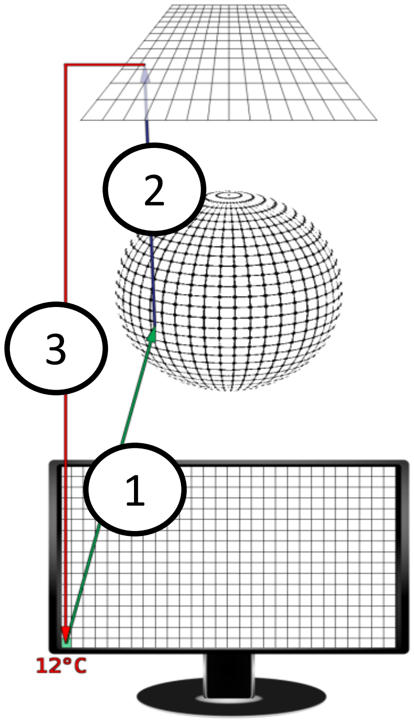
- The result of the canvas grid computation is called canvas-data
  - 2D array of float values in screen dimensions
- Canvas-data is input for Canvas-Grid visualizations
  - Not limited to GRIB-data
  - It is possible to transform other data (radar, sat, point, …) into Canvas-Data and thereby reuse visualization
- Downside: canvas-grid generation is expensive
  - *esp. lat/lon → grib-idx for unstructured gribs such as ICON*
- Performance optimizations required

Calculation-FWK – Introduction

- software framework for all sorts of computations in NinJo
  - allows nested computations
  - includes a global caching mechanism for results

- Computation of Canvas-data using Calculation Framework yields reusability and improved performance

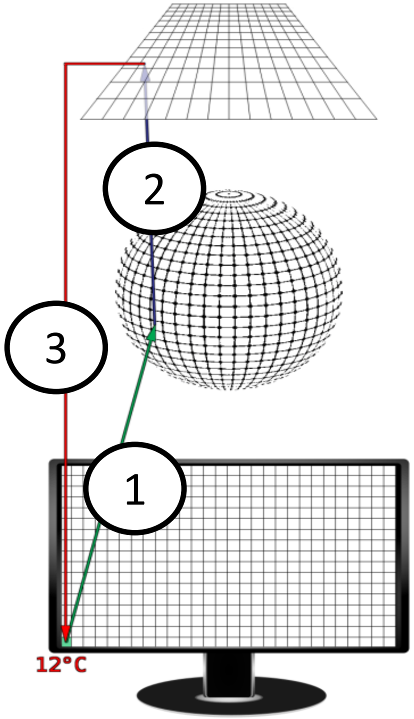
- Implemented as **three nested** calculations that mimic the “computation flow” (see slide 6):
  1. Compute lon/lats for each pixel
  2. Compute GRIB-indices for each lon/lat
  3. Lookup values from GRIB-field for each pixel



Canvas Calculation – Reusability

1. **Compute lat/lon for each pixel**
   - re-use as long as map projection is unchanged
     - all NinJo layers in one scene can share this data
2. **Compute GRIB-indices for each lat/lon**
   - re-use for all visualizations of the same model i.e. model geometry unchanged
3. **Lookup values from GRIB-field for each pixel**
   - not very re-usable
   - can only be shared for different visualizations of the same data

- **best case:** "simply" stepping through time
- **worst-case:** zoom/pan



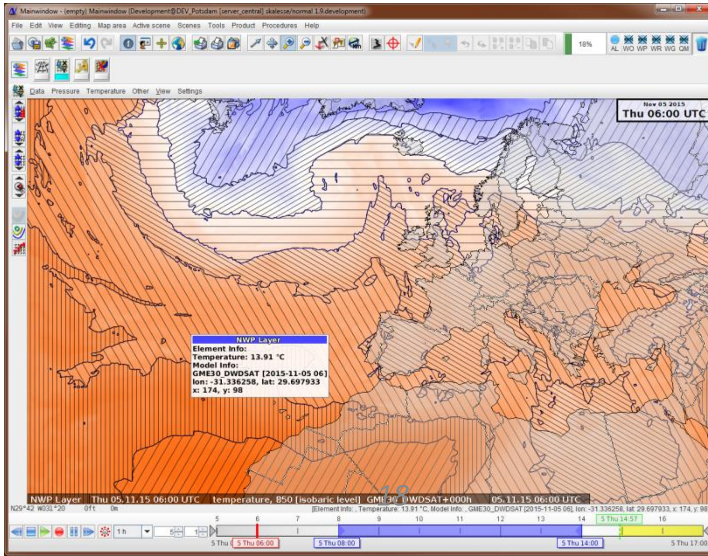
Canvas Calculation – performance

```
Convert    1770954 coords from scene to long/lat took:       137ms
Convert    1770954 coords from long/lat to grid took:         22ms
Lookup of  1770954 points from grid-field took:               92ms
    Nearest-neighbor: looked up     2824 pixels
    Downsample:       looked up        0 pixels
    Bilinear:         looked up  1768130 pixels
    Monotone-bicubic: looked up        0 pixels
```

- Numbers taken during development, they are not “final”
- First two lines (137ms + 22ms) can be saved when stepping through time
- accounts for approx. 60% of canvas grid calculation time

Canvas-Grid – Summary

- new met. data visualization for NinJo
  - based on a virtual Cartesian grid in the screen coordinate system
  - applicable for all sorts of data that can be transformed onto that virtual grid (Radar, SAT, …)
- idea:
  - estimate/look up values for each pixel of the canvas-grid
  - then visualize data on canvas-grid rather than GRIB or lat/lon coordinate system.
- iso-line/iso-area generation straight forward
- depending on the data projection, transformation might be expensive but can be optimized


Mainwindow - (empty) Mainwindow [Development@DEV_Potsdam [server_central] skalesse/normal 1.9.development]
File Edit View Editing Map area Active scene Scenes Tools Product Procedures Help
18%
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Nov 05 2015
Thu 06:00 UTC
N29°42 W031°20 0ft 0m
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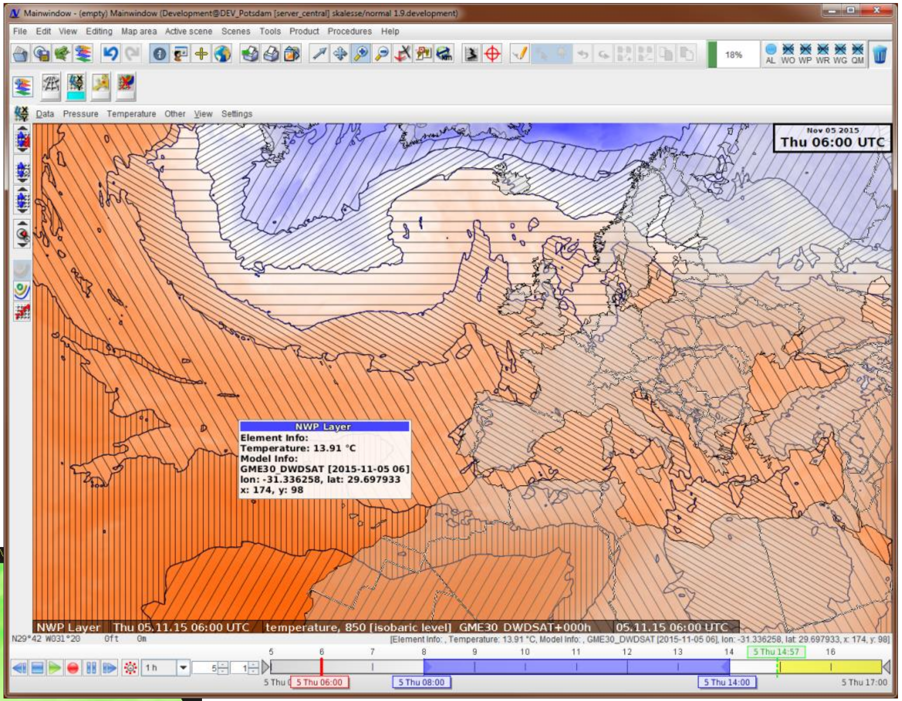
NWP Layer
Element Info:
Temperature: 13.91 °C
Model Info:
GME30_DWDSAT [2015-11-05 06]
lon: -31.336258, lat: 29.697933
x: 174, y: 98

NWP Layer Thu 05.11.15 06:00 UTC temperature, 850 [isobaric level] GME30_DWDSAT+000h 05.11.15 06:00 UTC

[Element Info: , Temperature: 13.91 °C, Model Info: , GME30_DWDSAT [2015-11-05 06], lon: -31.336258, lat: 29.697933, x: 174, y: 98

Canvas-Grid visualization

- **Thank You for the attention!**
- Credits
  - Waldemar Busiakiewicz
  - Oliver Eggert
  - Jan Schröter



Mainwindow - (empty) Mainwindow (Development@DEV_Potsdam [server_central] skalesse/normal 1.9.development)

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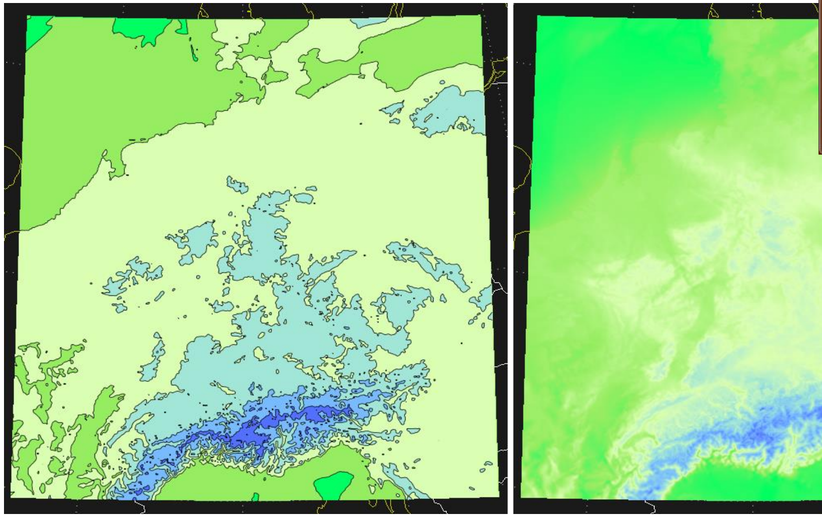
N29°42 W031°20 0ft 0m

[Element Info: , Temperature: 13.91 °C, Model Info: , GME30_DWDSAT [2015-11-05 06], lon: -31.336258, lat: 29.697933, x: 174, y: 98]

Pixel-coloring and hatch-filled iso-areas



Two types of visualizations on the canvas-grid for a German local model