

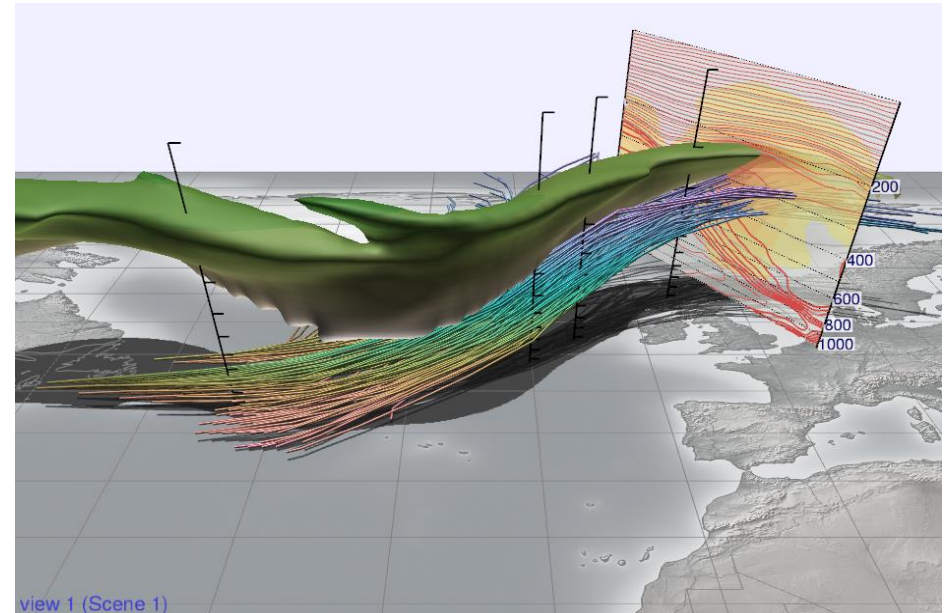
Ensemble and 3D visualisation with Met.3D – recent research and software updates

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Florian Ferstl⁽¹⁾, Bianca Tost⁽¹⁾, Michael Kern⁽¹⁾, Alexander Kumpf⁽¹⁾,
Christoph Heidelmann⁽¹⁾, Fabian Schöttl⁽¹⁾, Mathias Kanzler⁽¹⁾,
Rüdiger Westermann⁽¹⁾

(1) Computer Graphics and Visualization Group, Technische Universität München

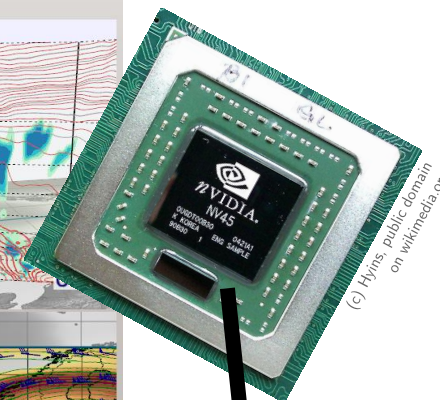
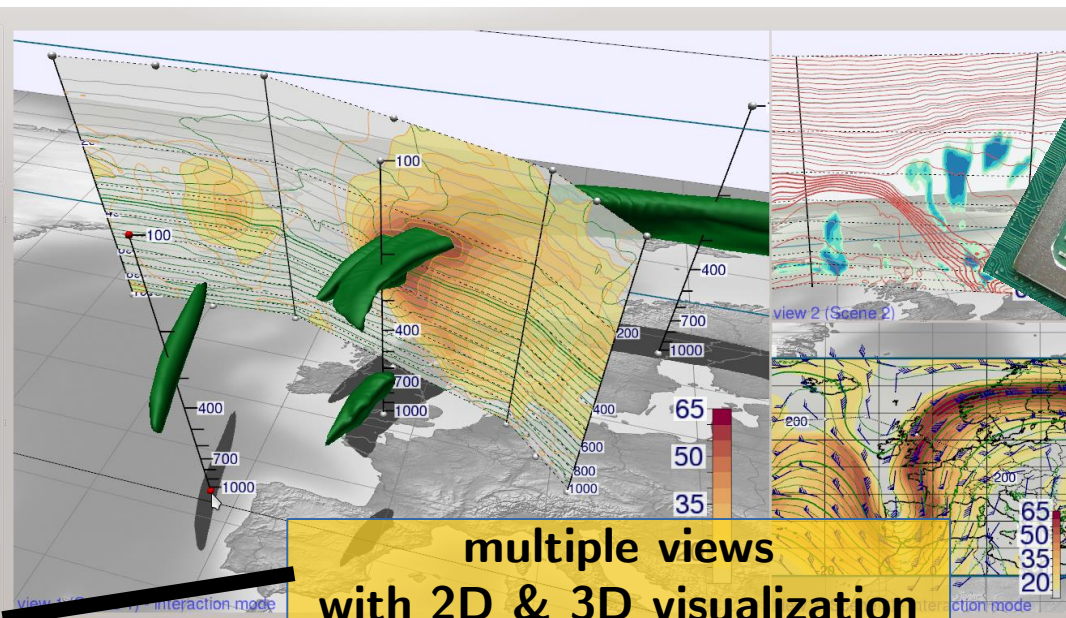
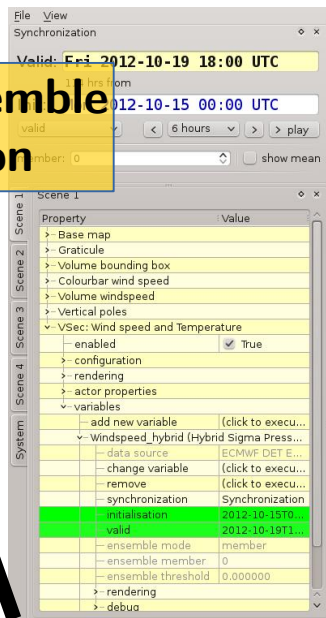
*Meteorological Operational Systems Workshop
ECMWF, Reading – 02 March 2017*



Met.3D is an interactive 3D ensemble analysis tool

Developed in university/research context at the Technical University of Munich, in collaboration with meteorological institutes and institutions. Goal: advance meteorological visualization.

time & ensemble navigation



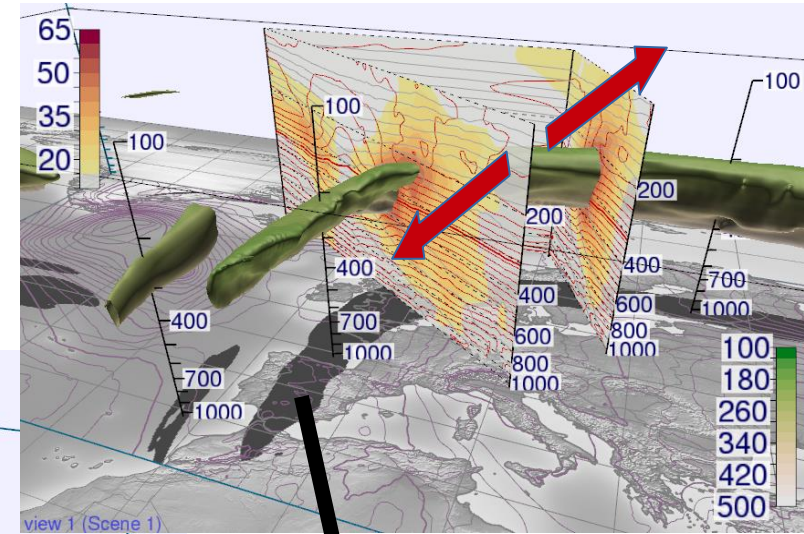
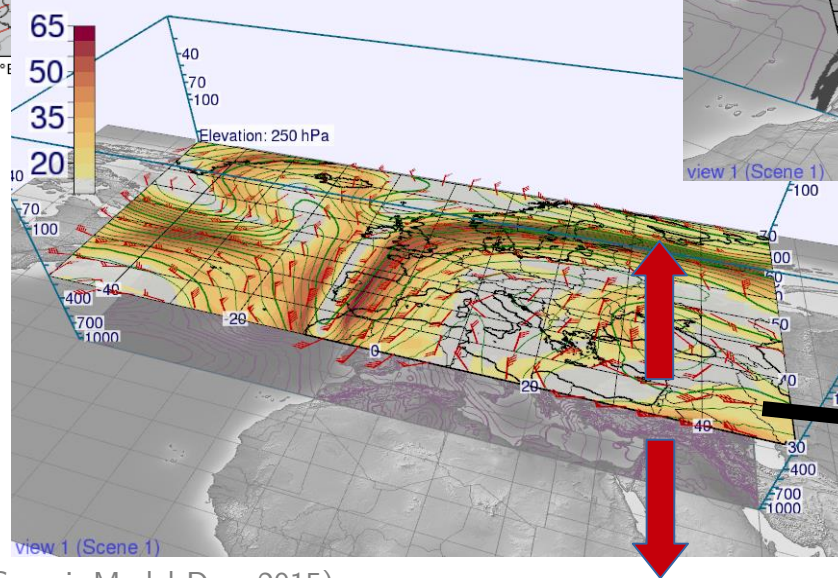
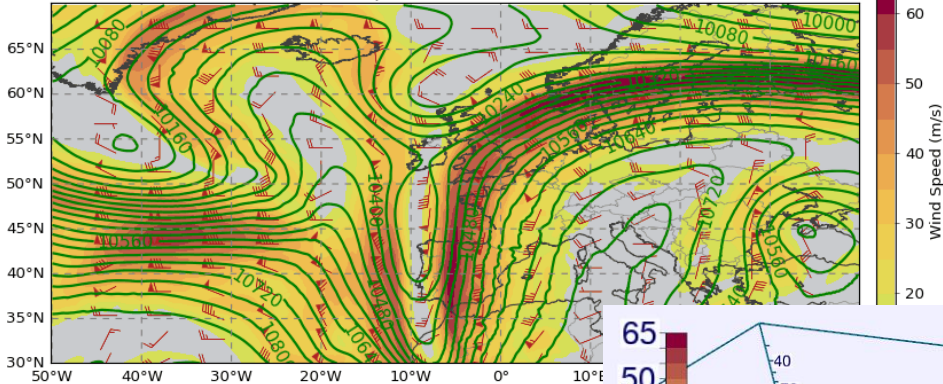
(c) Hybris public domain on Wikimedia.org

User interface elements required for exploration of numerical simulations (e.g. forecast data).

GPU based.

Focus 1: interactive, combined 2D/3D visualization

Geopotential Height (m) and Horizontal Wind (m/s) at 250 hPa
Valid: Fri 2012-10-19 18:00 UTC (step 66 hrs from Wed 2012-10-17 00:00 UTC)

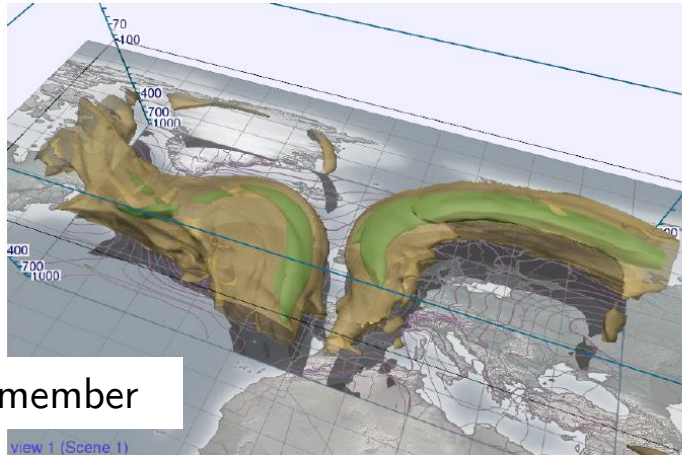


Do not replace proven 2D techniques but put them into a 3D context and use 3D elements to add value.

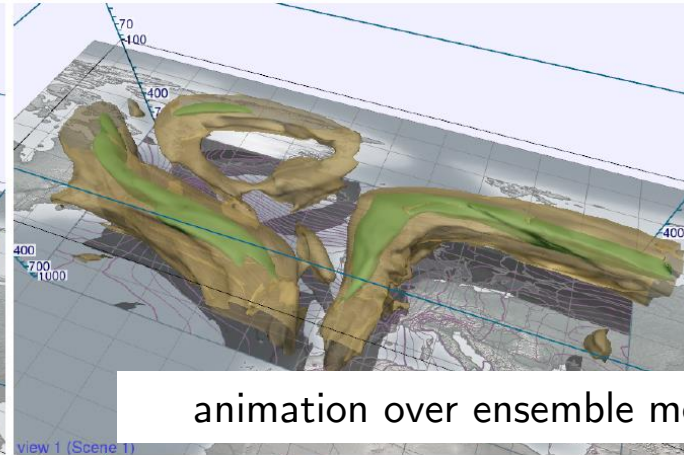
Shadows and vertical axes for spatial perception.

Interactively move section: fast means to explore vertical structure.

Focus 2: interactive ensemble analysis

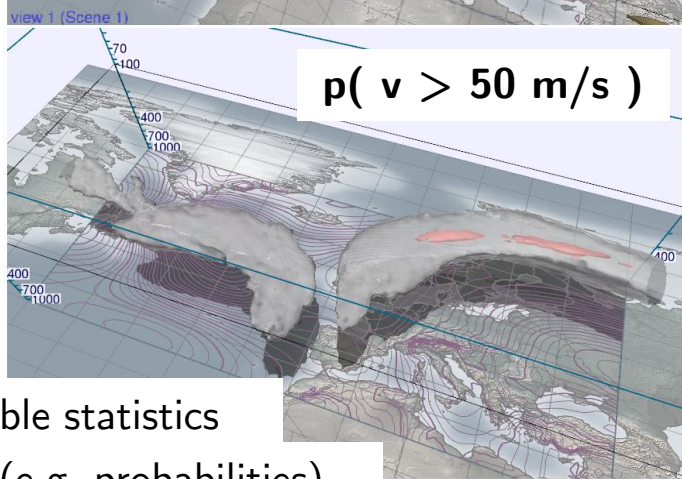


single member

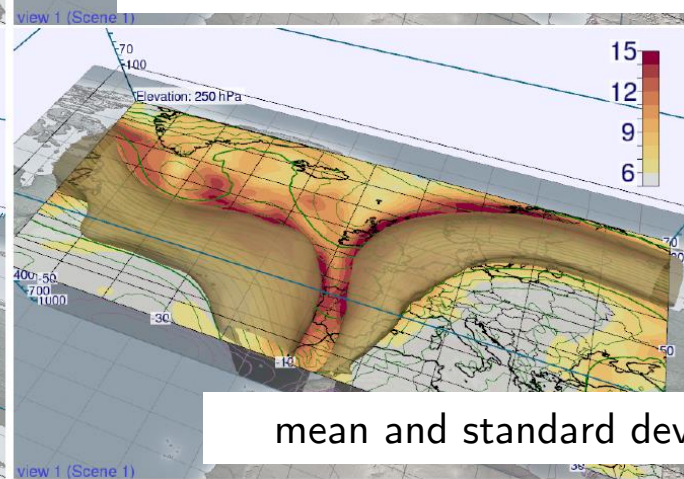


animation over ensemble members

jetstream – 3D isosurfaces
50 m/s and 30 m/s



ensemble statistics
(e.g. probabilities)



mean and standard deviation

Rautenhaus, Kern, Schäfler, Westermann (Geosci. Model Dev. 2015)

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The image displays the Met.3D software interface. On the left, a 'Synchronization' panel shows a timeline for 'Valid: Fri 2012-10-19 18:00 UTC' and '2012-10-15 00:00 UTC' with navigation controls. Below it, a 'Property' panel lists settings for 'VSec: Wind speed and Temperature' and 'windspeed_hybrid'. The main area features a 3D visualization of a meteorological model with a vertical axis from 100 to 1000 and a horizontal axis from 400 to 1000. A color scale on the right ranges from 35 to 65. A 'view 2 (Scene 2)' inset shows a 2D map view. A GPU chip is shown on the right, with a callout indicating it is GPU based.

time & ensemble navigation

multiple views with 2D & 3D visualization

GPU based.

User interface elements required for exploration of numerical simulations (e.g. forecast data).

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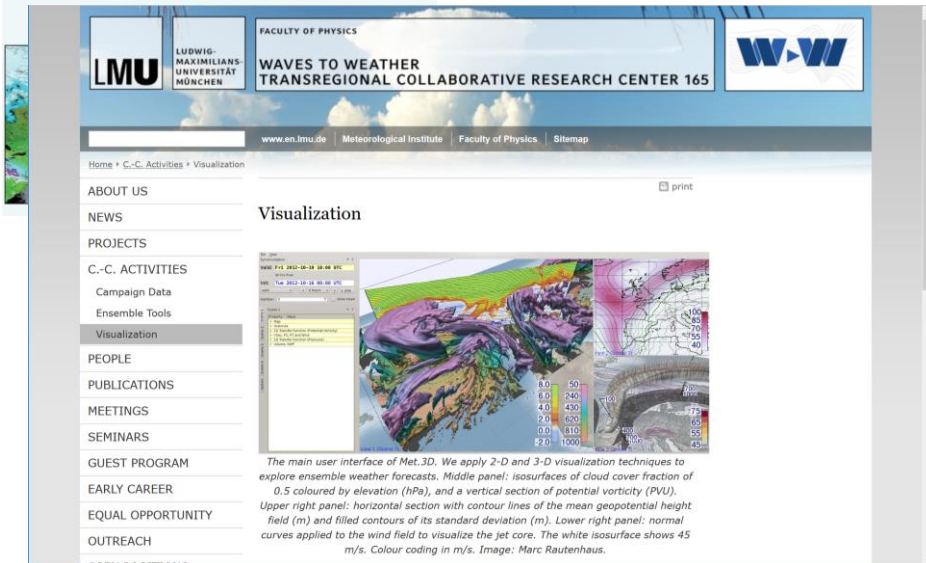
Collaborative research centre in Munich, Mainz, Karlsruhe on issues of predictability (www.wavestoweather.de).

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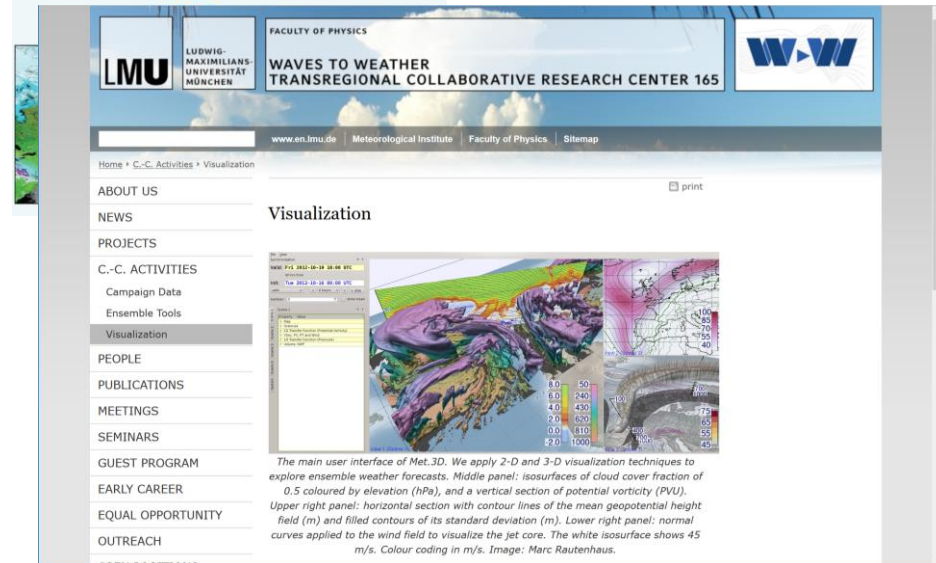
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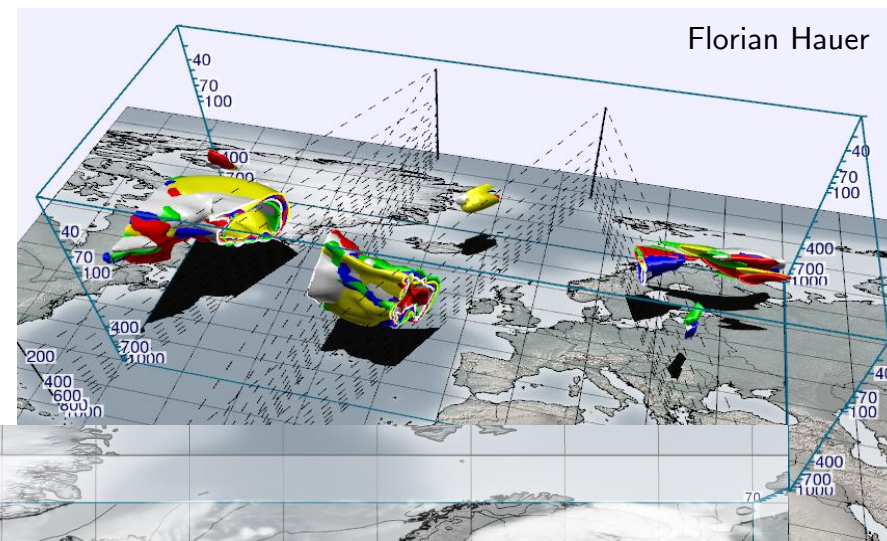
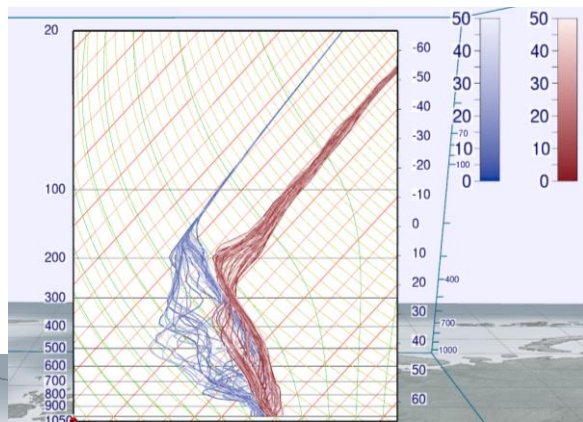
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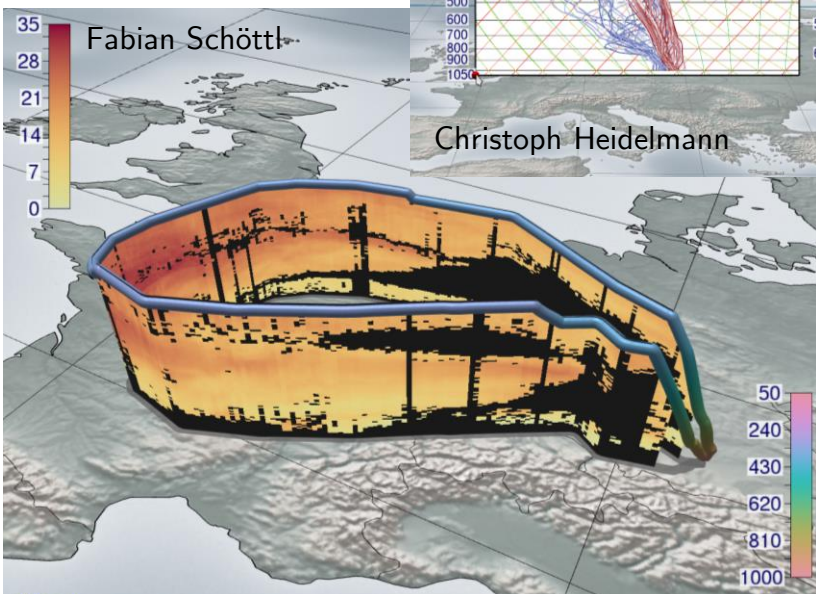
At TU Munich: 2 PhD projects on uncertainty visualization (Alexander Kumpf and Michael Kern); varying number of student projects.

Objective: develop novel visual data analysis techniques for ensemble datasets; use Met.3D with these techniques to investigate ensemble behaviour.

Examples of recent student projects

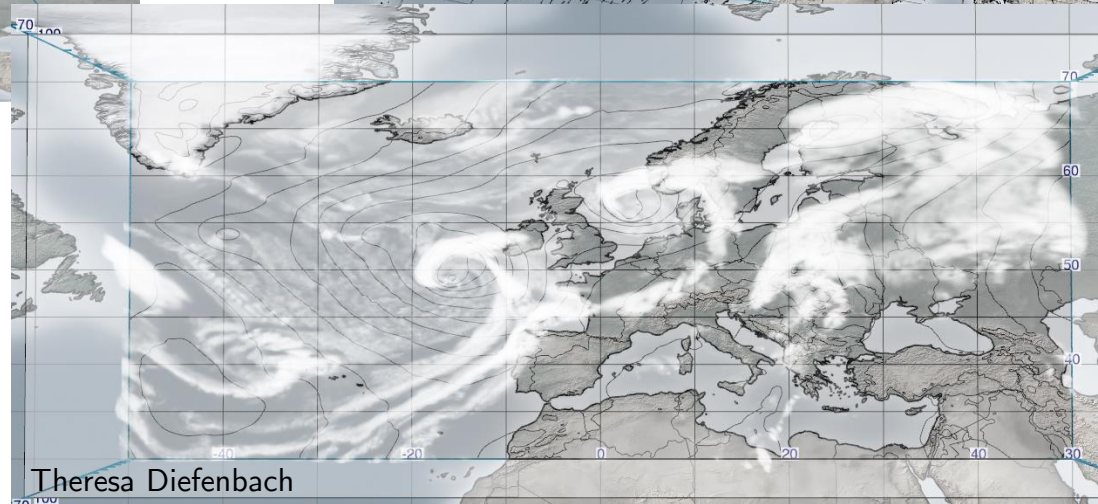


Florian Hauer



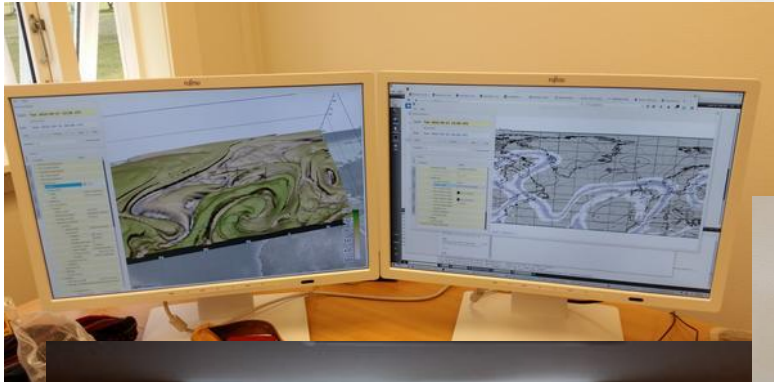
Fabian Schöttl

Christoph Heidelmann

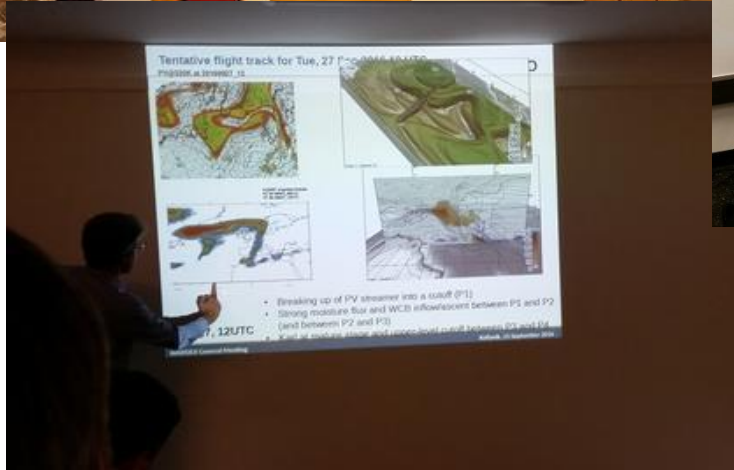


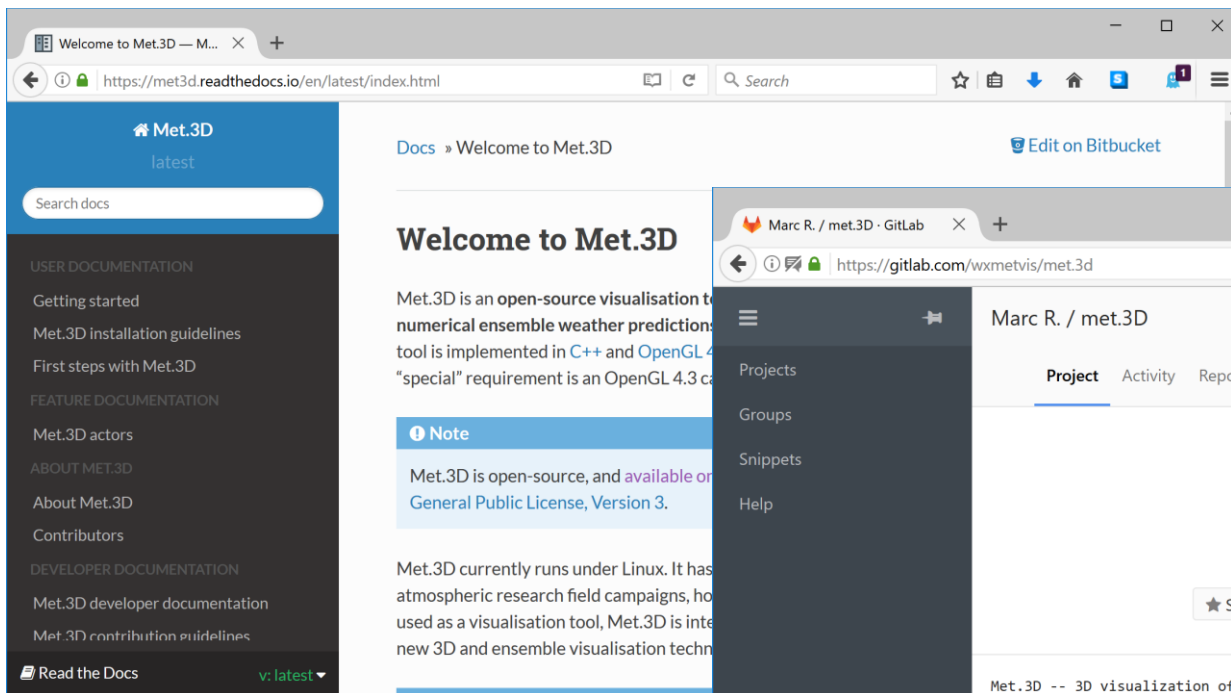
Theresa Diefenbach

Met.3D workstations
on Iceland

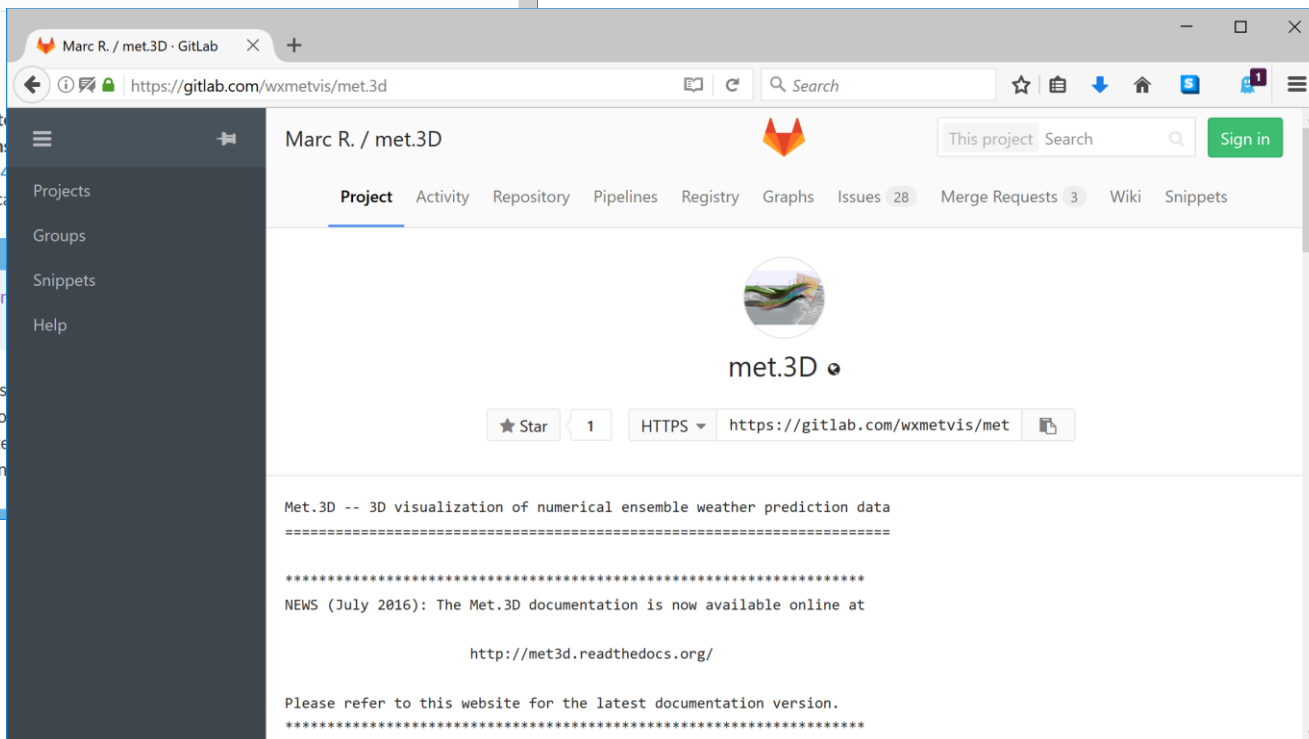


Met.3D on TV





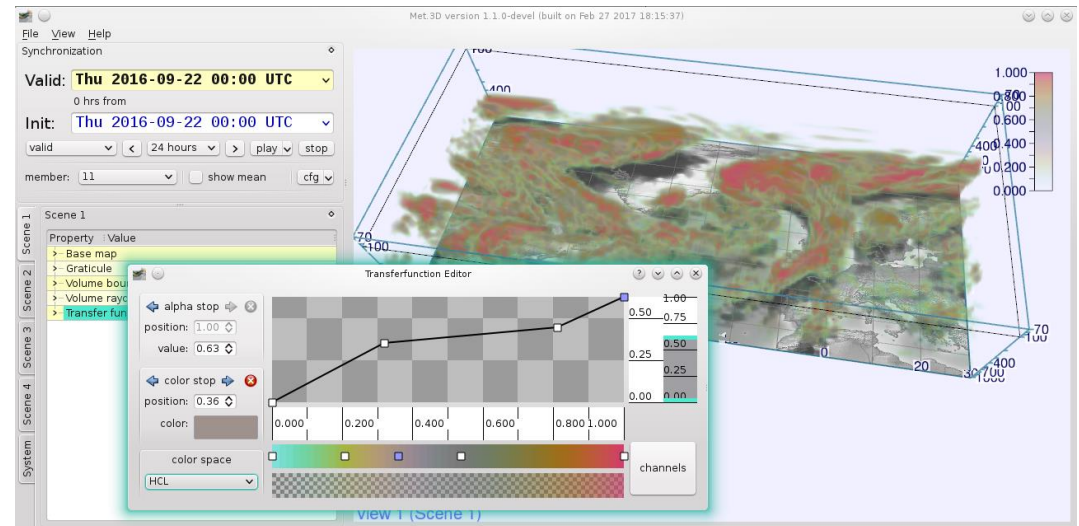
Documentation:
met3d.readthedocs.org



Repository:
gitlab.com/wxmetvis/met.3d

Roadmap:

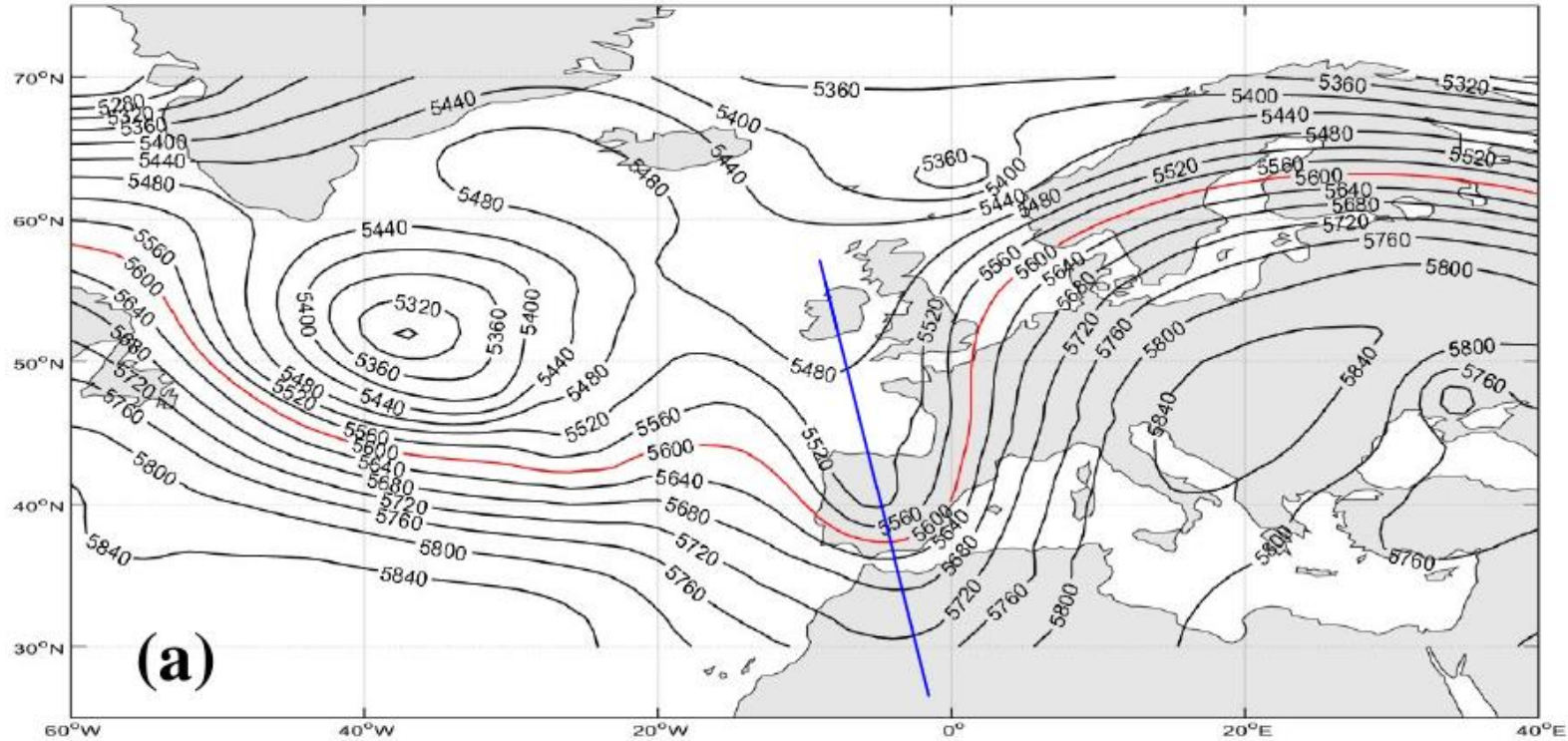
- March 2017 – **Version 1.1** – bugfixes, usability improvements
 - Volume rendering, HCL colour bar editor, stippling, cmake
- June 2017 – Version 1.2 – RPMs, Windows version, COSMO support
- Later in 2017/18
 - Uncertainty visualization methods
 - Support for aircraft observations
 - Metview and Python interfaces
 - ICON support



Roadmap:

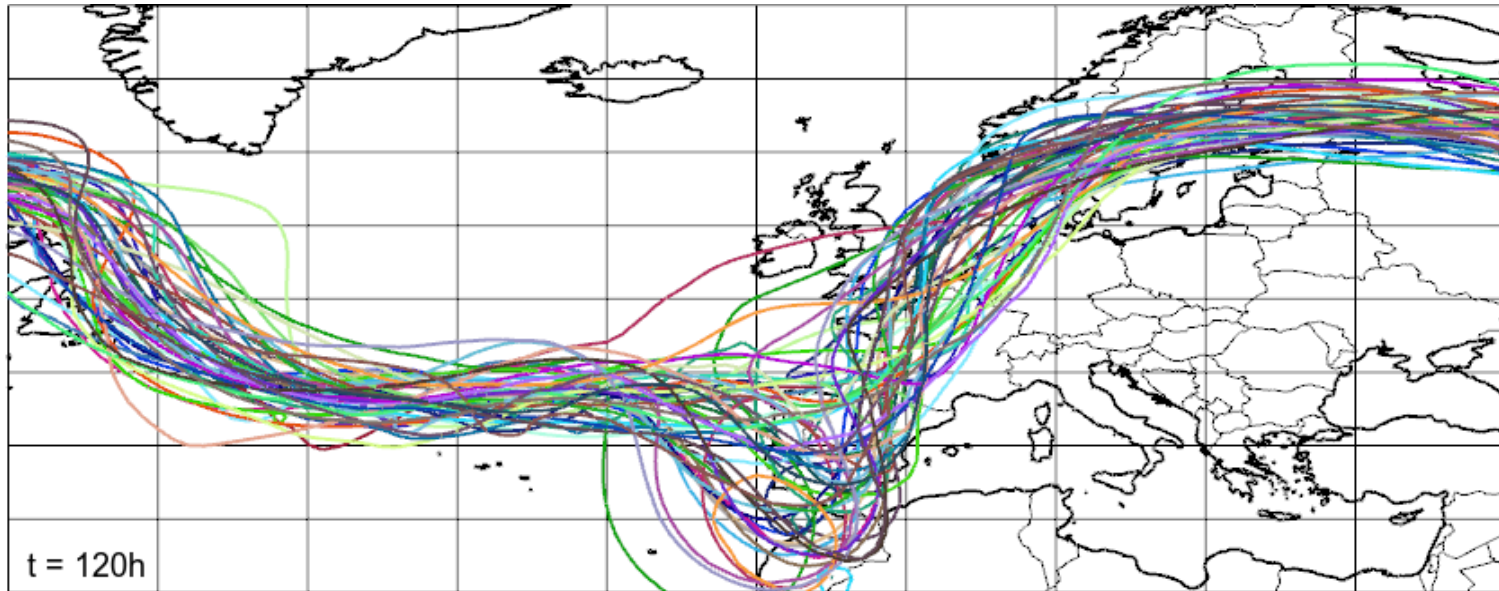
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How can we improve spaghetti plots?



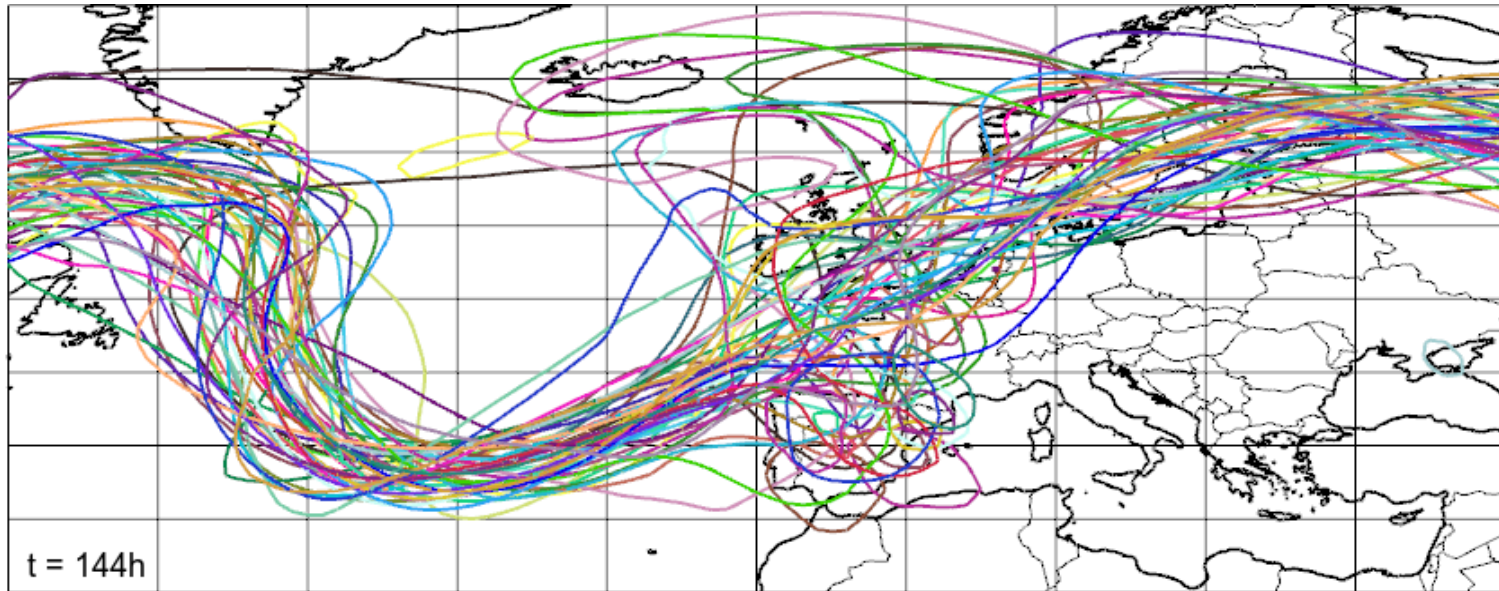
Ferstl, Kanzler, Rautenhaus, Westermann (Comput. Graphics Forum 2016)

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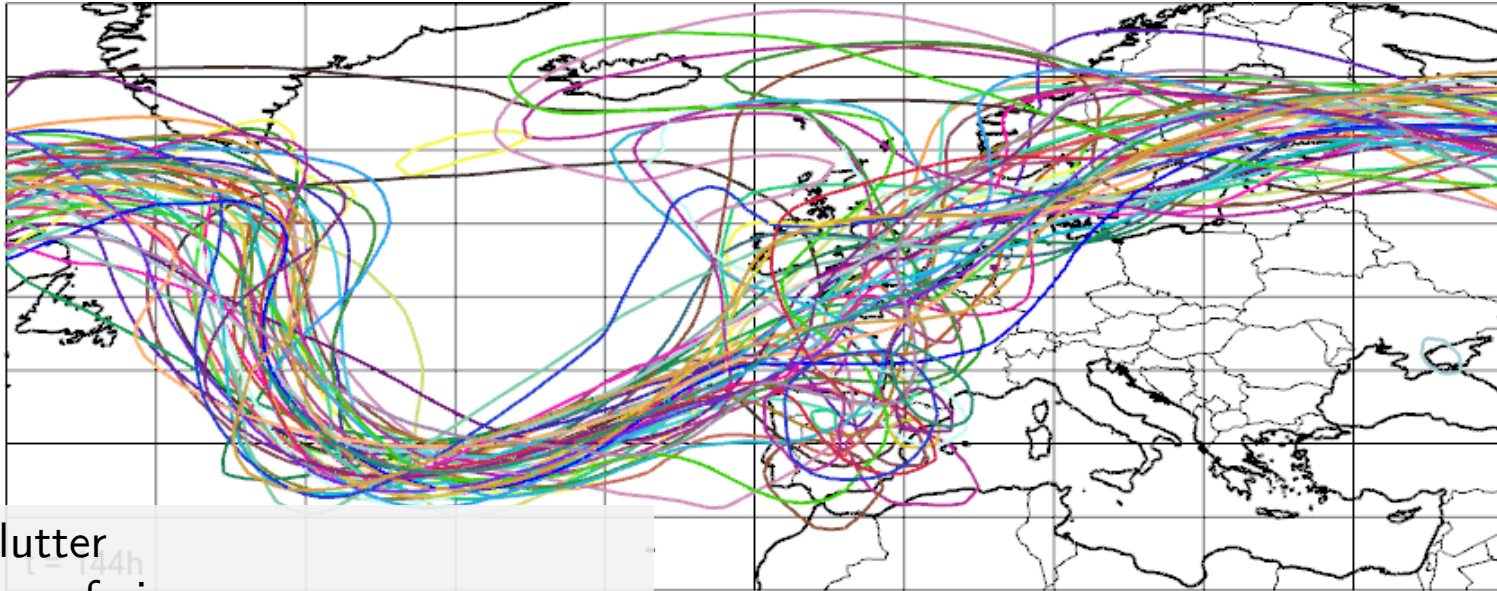


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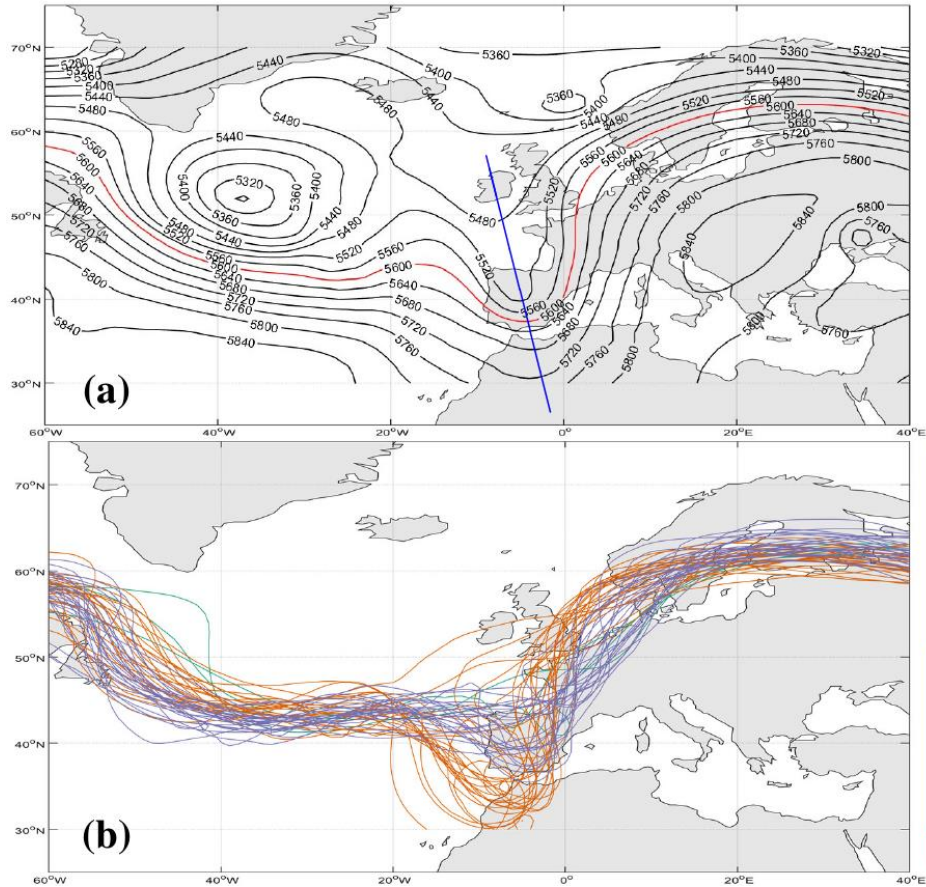


- Visual clutter
- Heavy use of viewers memory

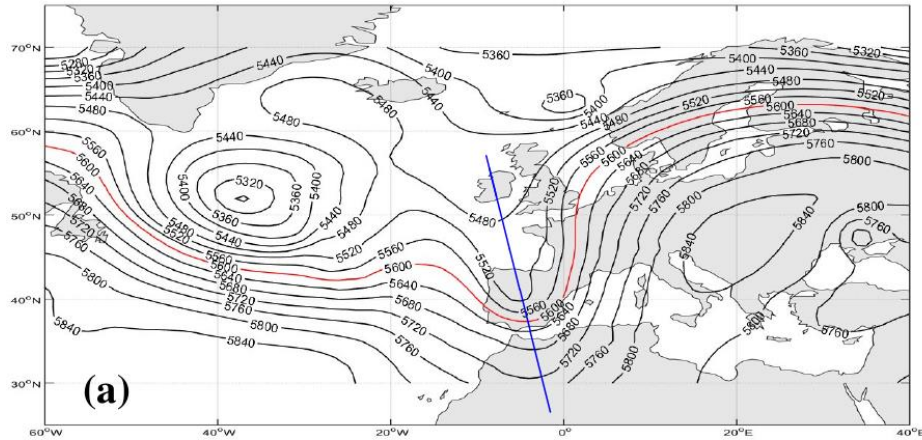
How to show forecast scenarios?

Ferstl, Kanzler, Rautenhaus, Westermann (Comput. Graphics Forum 2016)

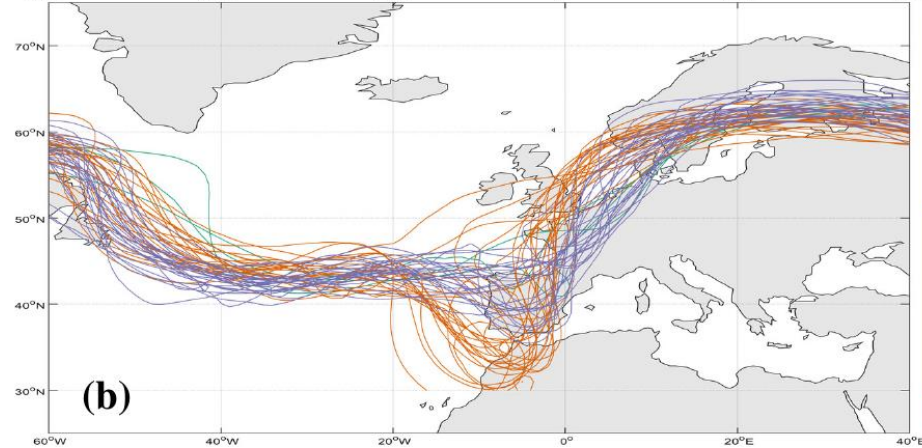
Our alternative: “variability plots”



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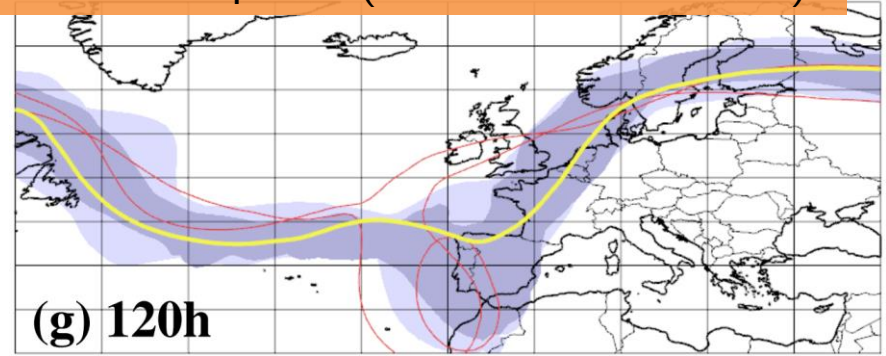


(a)



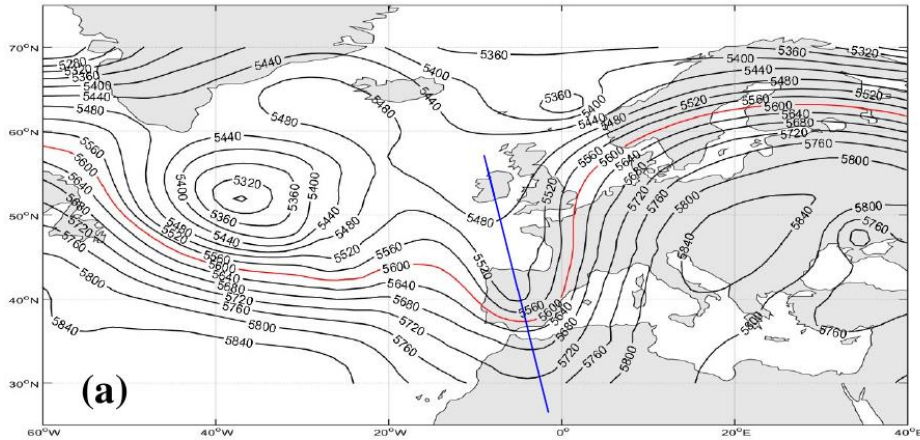
(b)

“Contour boxplots” (Whitaker et al. 2013)

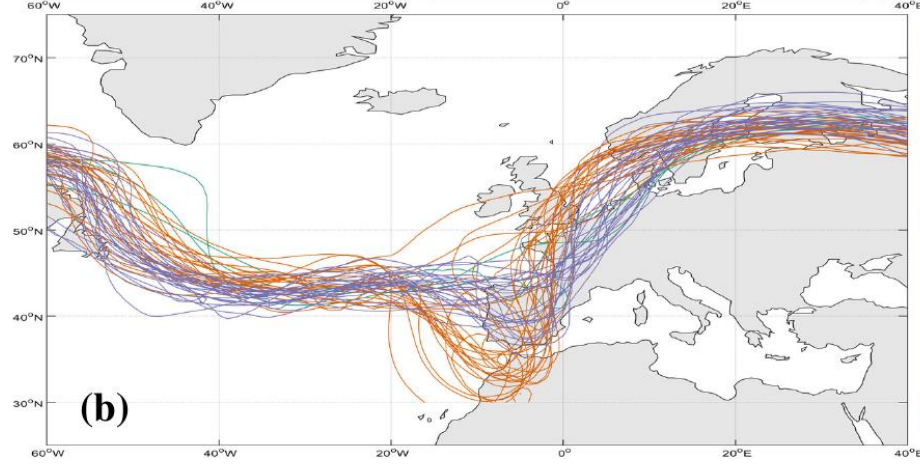


(g) 120h

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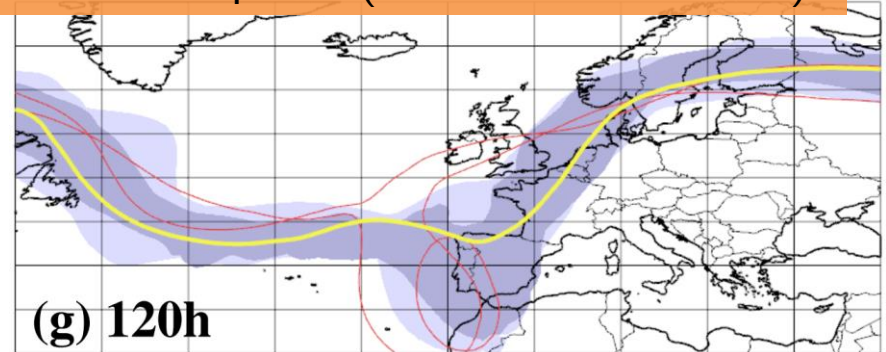


(a)



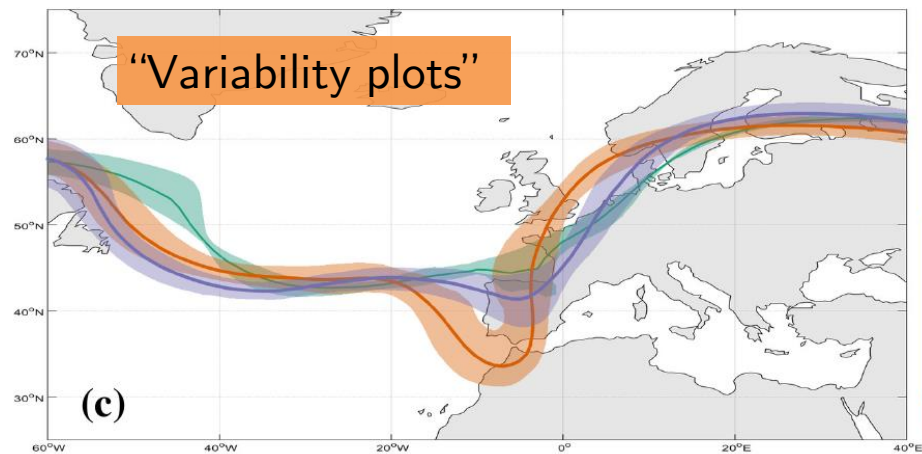
(b)

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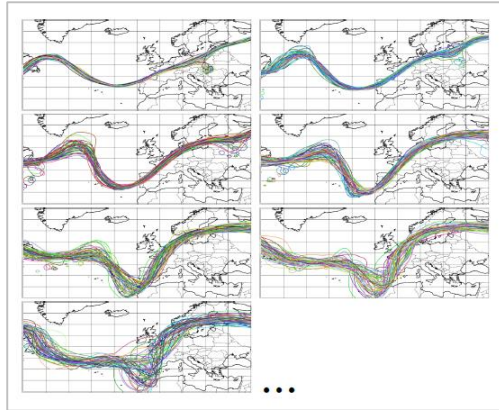
“Variability plots”



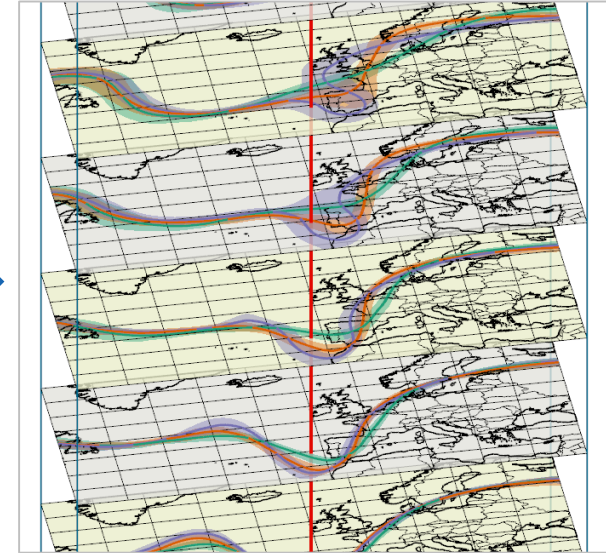
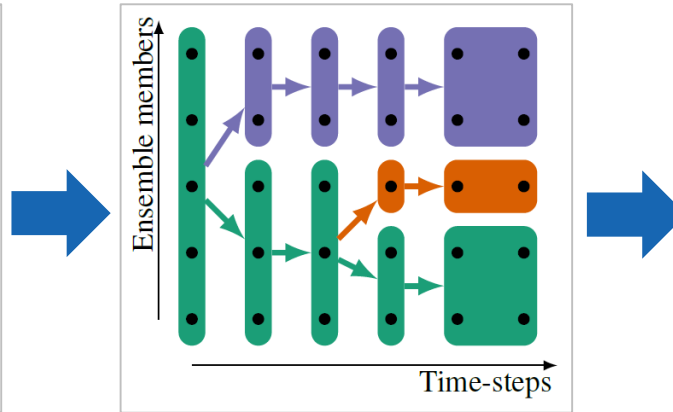
(c)

Ferstl, Kanzler, Rautenhaus, Westermann (Comput. Graphics Forum 2016)

Time-dependent ensemble of iso-contours

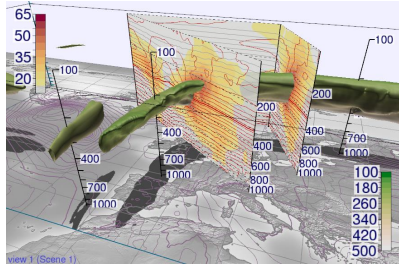


Time-hierarchical clustering

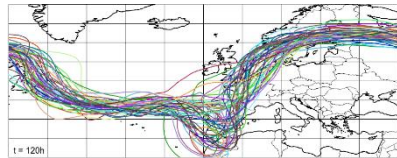


– video –

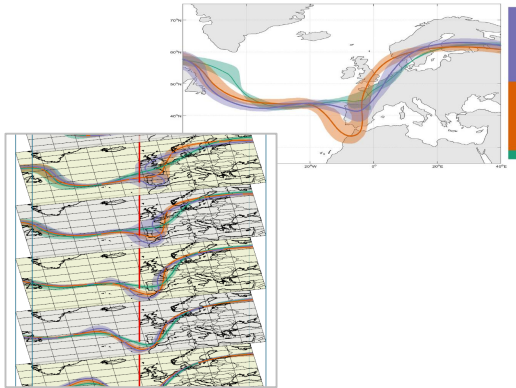
Ferstl, Kanzler, Rautenhaus, Westermann (Trans. Visual. Comput. Graphics 2017)



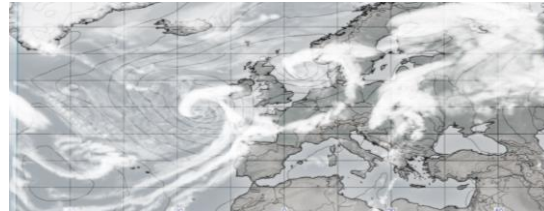
Met.3D combines 2D plots with 3D elements;
GPU facilitates interactive usage.



Research on new techniques to explore ensemble forecasts.



Research in “Waves to Weather” on new visual data analysis techniques.



Met.3D is open-source (mostly).

It runs under **Linux** (soon also Windows).

Online manual is available at

<https://met3d.readthedocs.org>

GIT repository is available on Bitbucket:

<https://gitlab.com/wxmetvis/met.3d>

Try **Met.3D** at the **exhibition** this afternoon!

Acknowledgements:

- Parts of the presented work were supported by the European Union under the ERC Advanced Grant 291372 – SaferVis – Uncertainty Visualization for Reliable Data Discovery.
- Parts of the presented work were supported by the Transregional Collaborative Research Center SFB/TRR 165 “Waves to Weather” funded by the German Science Foundation (DFG).
- ECMWF data were kindly provided by ECMWF special project “Support Tool for HALO Missions”.