Is it time for interactivity and 3D?

New approaches to analysing NWP data for observational campaigns using 3D and ensemble visualization

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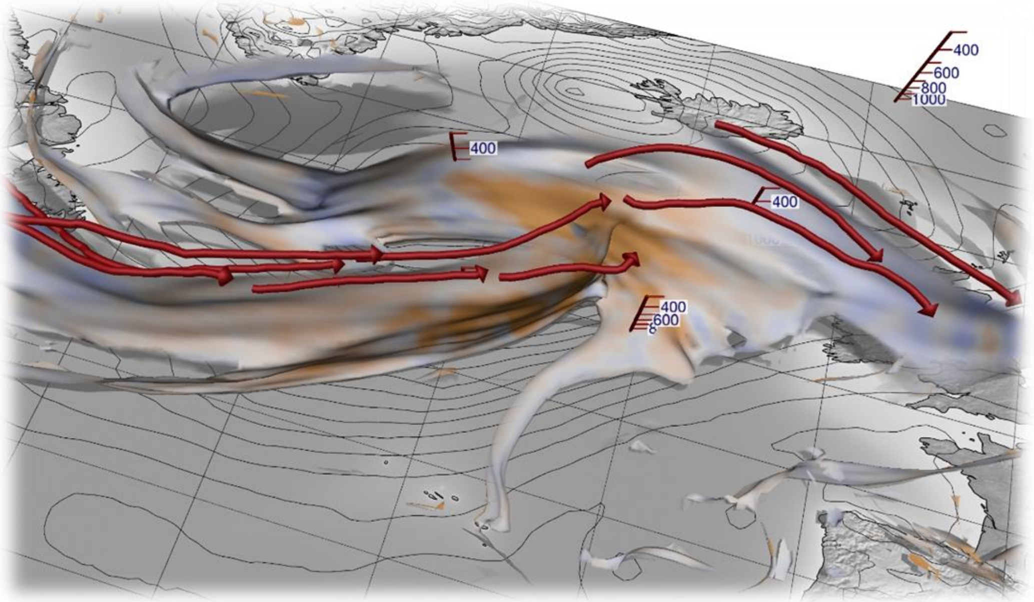
Credit to: Michael Kern, Alexander Kumpf, Bianca Tost, Rüdiger Westermann (TU München); Tim Hewson (ECMWF); Andreas Schäfler (DLR); Michael Riemer (JGU Mainz) and others

Met.3D

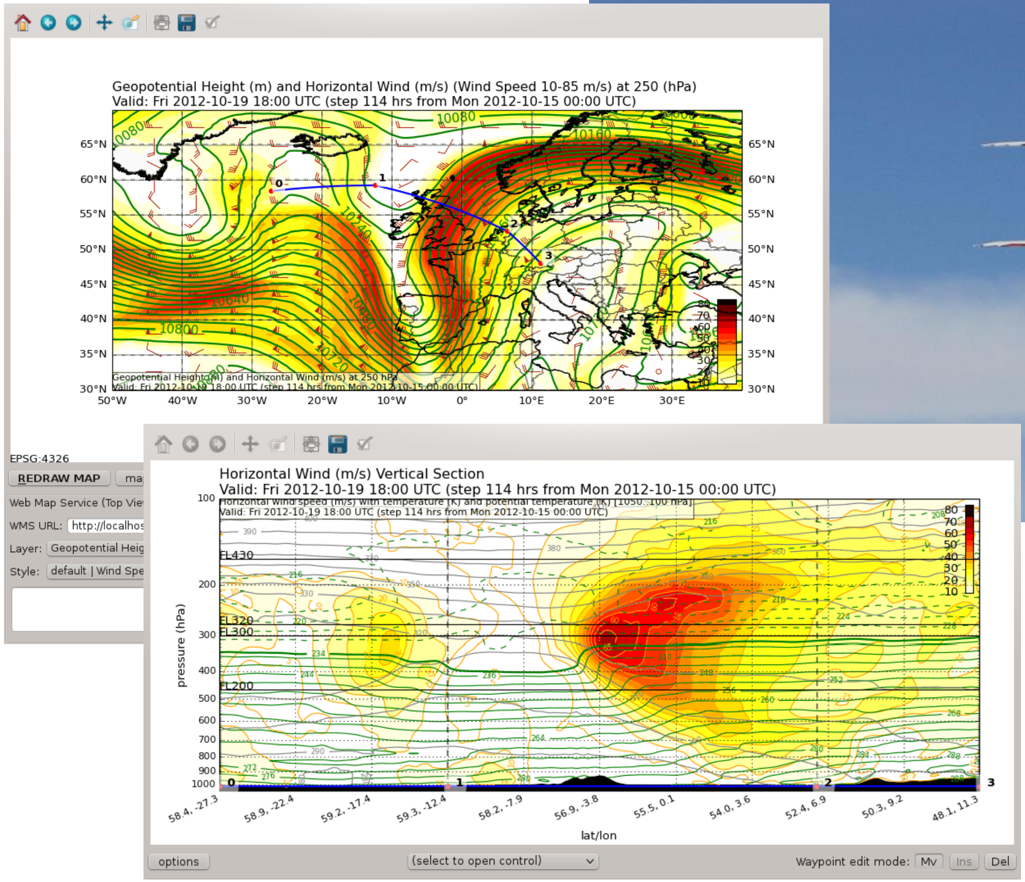
WAVES TO WEATHER



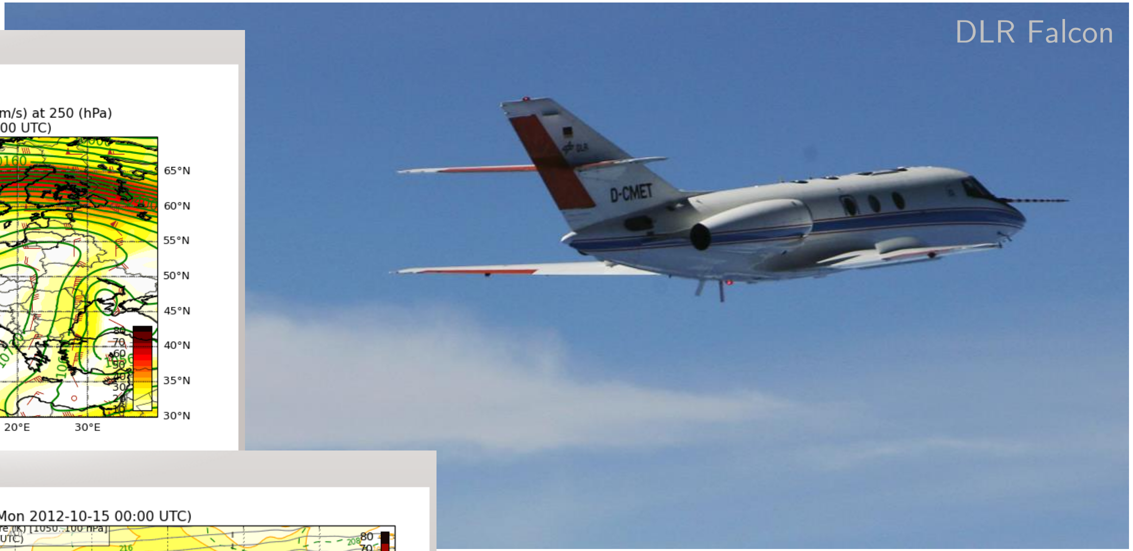
ECMWF, 11 June 2019

How do we get straightforward access to the information that is contained in NWP data?

Planning research flights: the Mission Support System

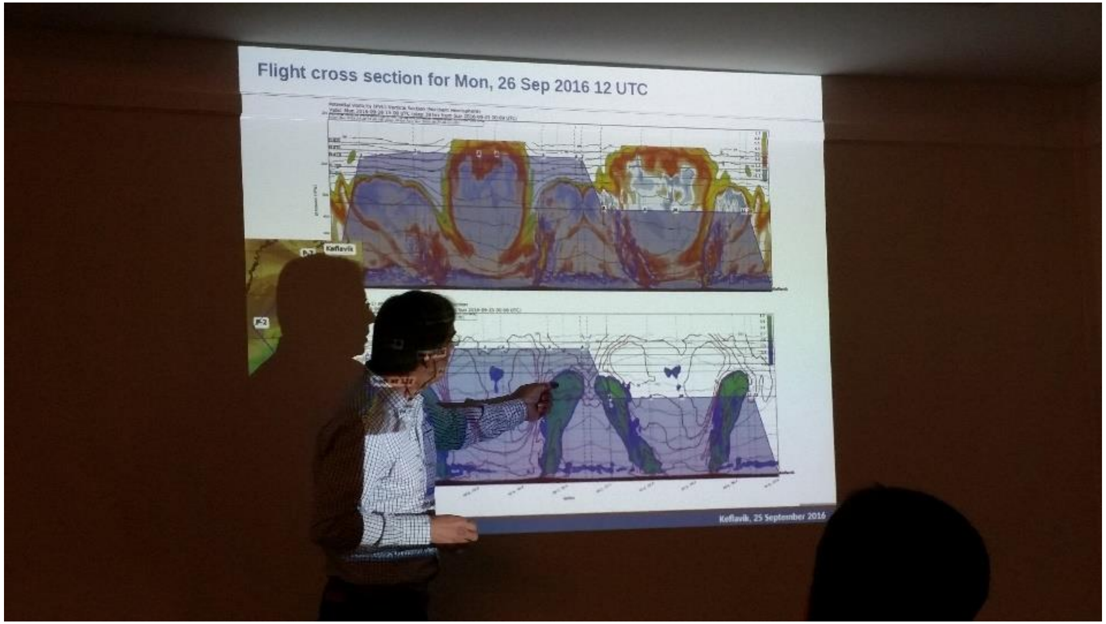


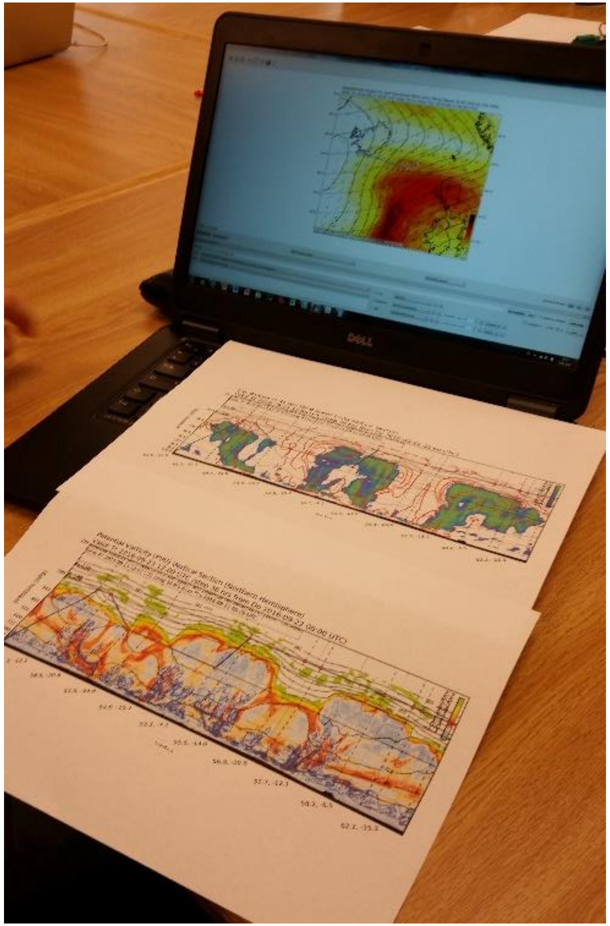
Rautenhaus, Bauer, Dörnbrack (Geosci. Model Dev. 2012)



Mission Support System (MSS): approach to introduce interactivity into forecast exploration and flight planning.

MSS has become an open-source community project

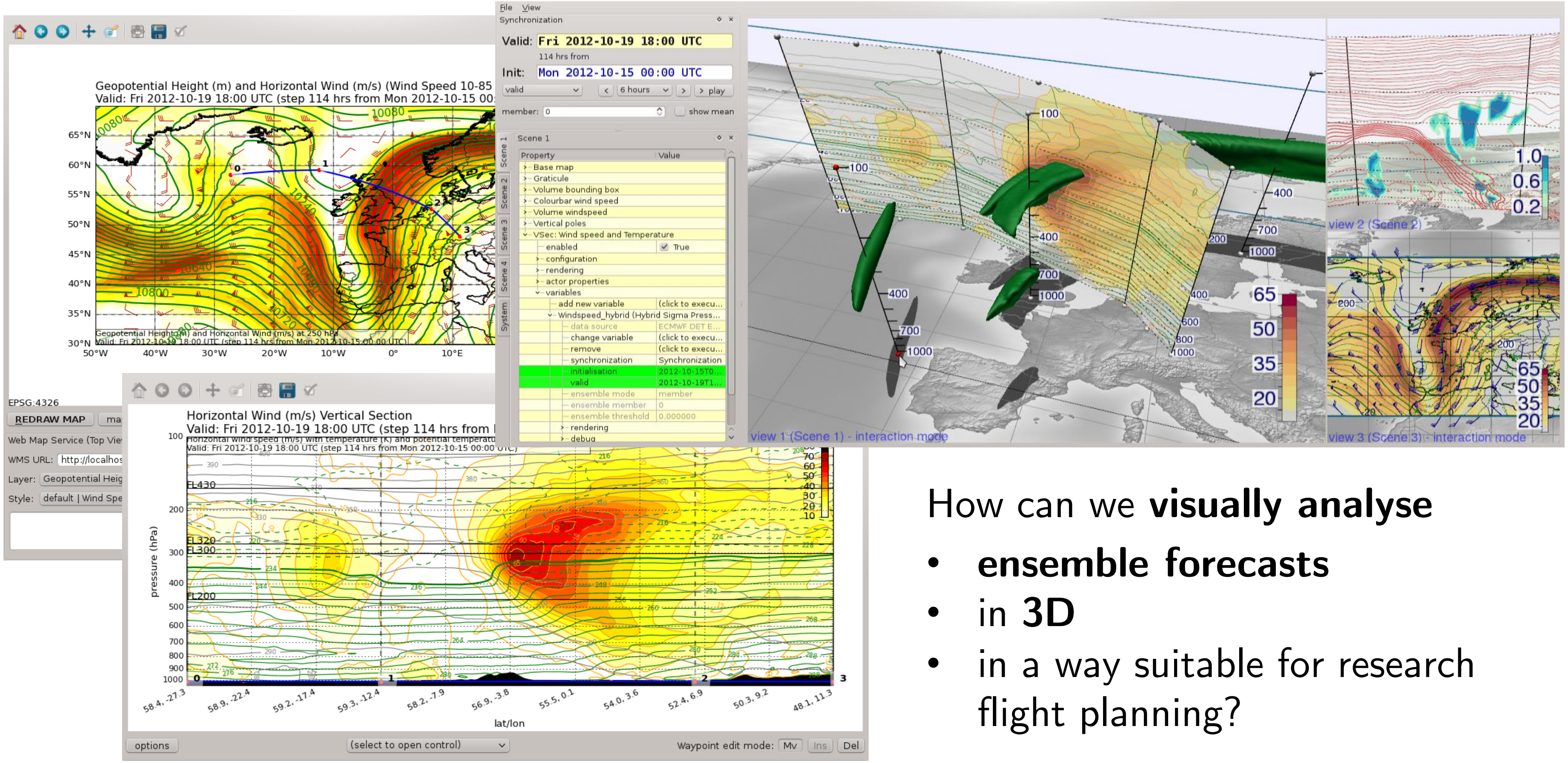




MSS development today driven by FZ Jülich;
available at: bitbucket.org/wxmetvis/mss

Here: Deployment during NAWDEX, 2016

3D and ensembles: the “birth” of Met.3D in 2012

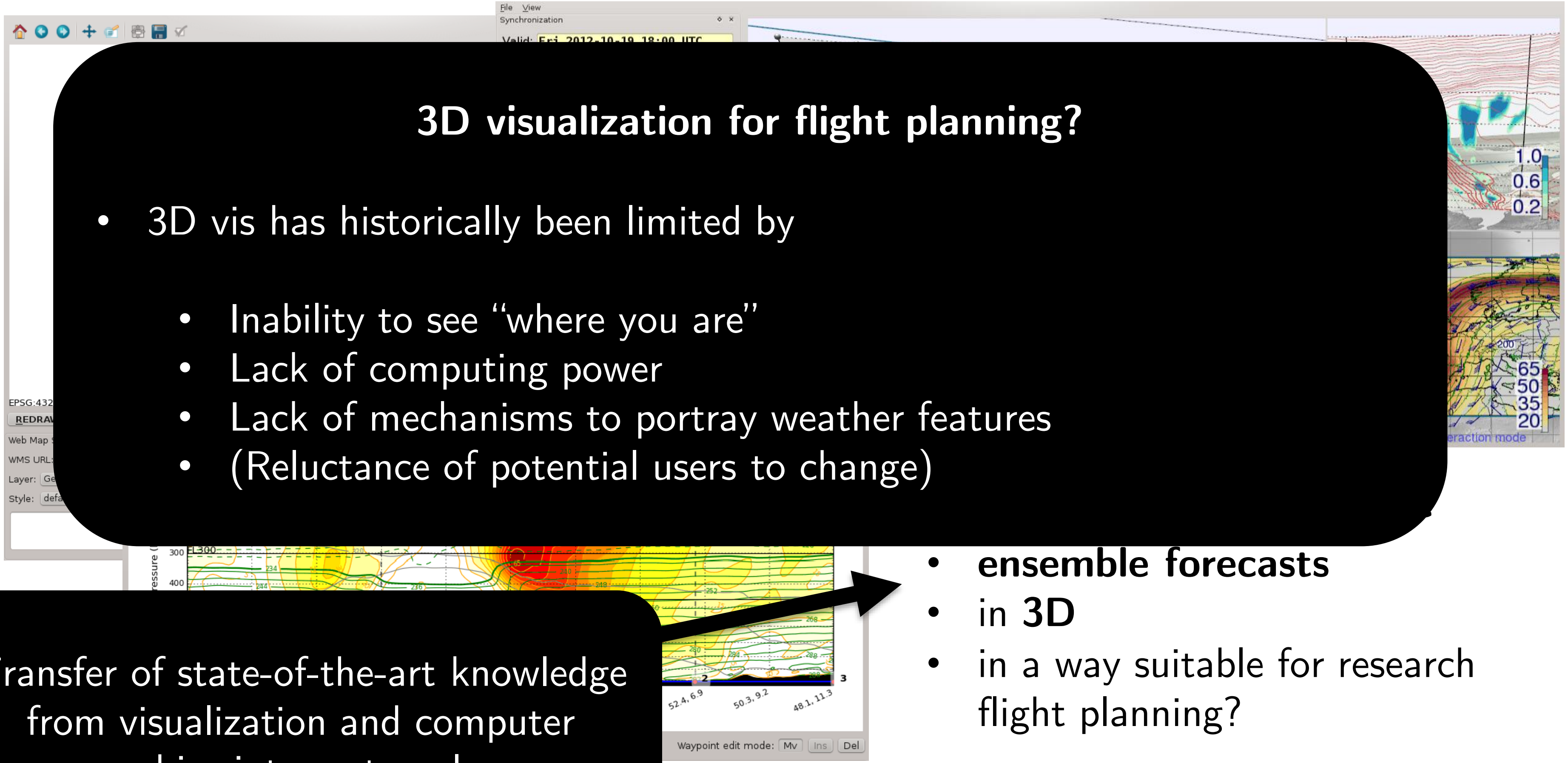


Rautenhaus, Bauer, Dörnbrack (Geosci. Model Dev. 2012)

How can we **visually analyse**

- **ensemble forecasts**
- in **3D**
- in a way suitable for research flight planning?

3D and ensembles: the "birth" of Met.3D in 2012



3D visualization for flight planning?

- 3D vis has historically been limited by
  - Inability to see "where you are"
  - Lack of computing power
  - Lack of mechanisms to portray weather features
  - (Reluctance of potential users to change)

- **ensemble forecasts**
- **in 3D**
- in a way suitable for research flight planning?

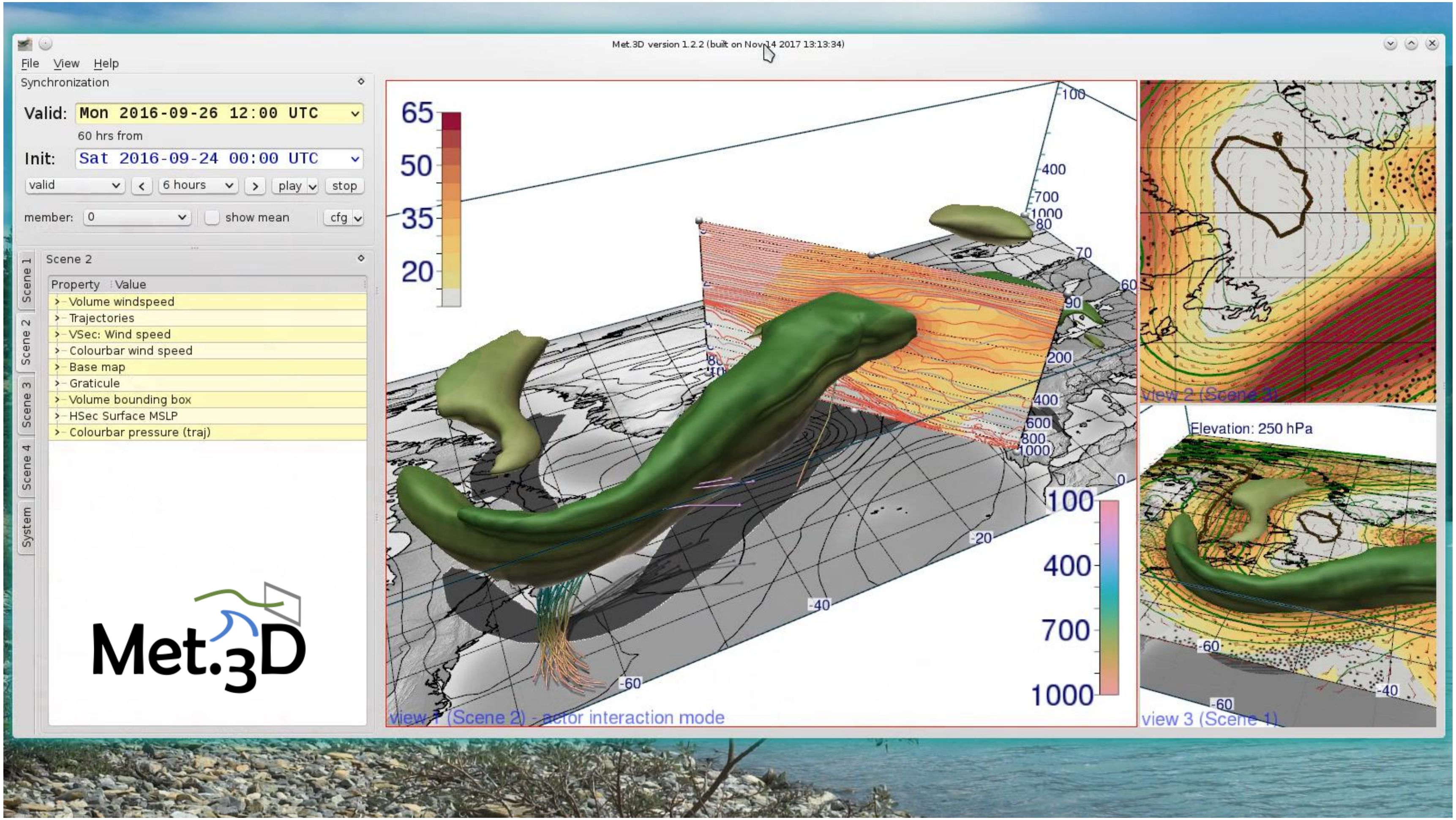
del Dev. 2012)

Transfer of state-of-the-art knowledge from visualization and computer graphics into meteorology

Ease transition by building a bridge from 2D to 3D

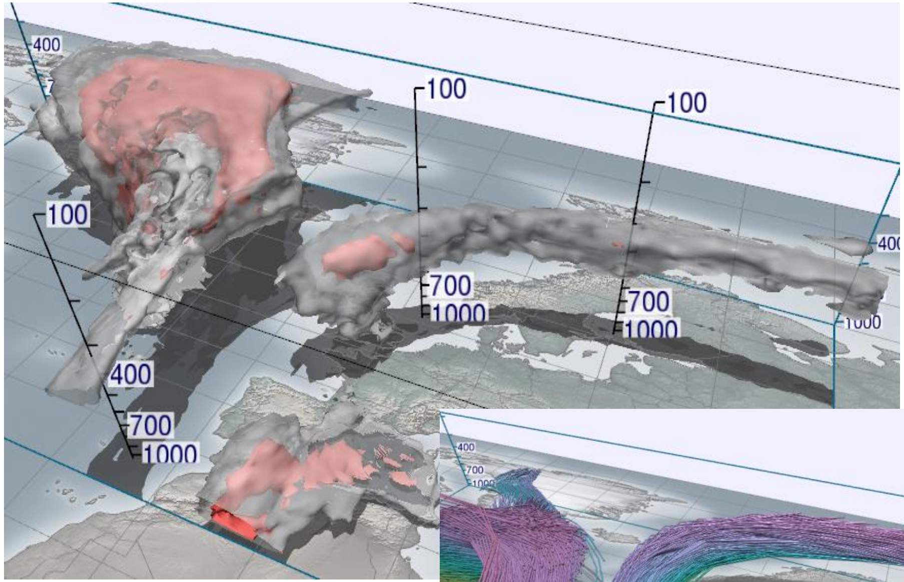
Do **not replace proven 2D techniques** but put them into a **3D context** and use 3D elements to add value.

Intuitive interaction and spatial perception are key elements.

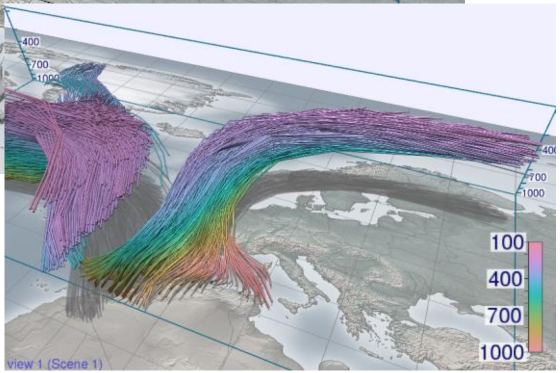


“Overview first, zoom and filter, then details on demand”

-- Shneiderman (1996)



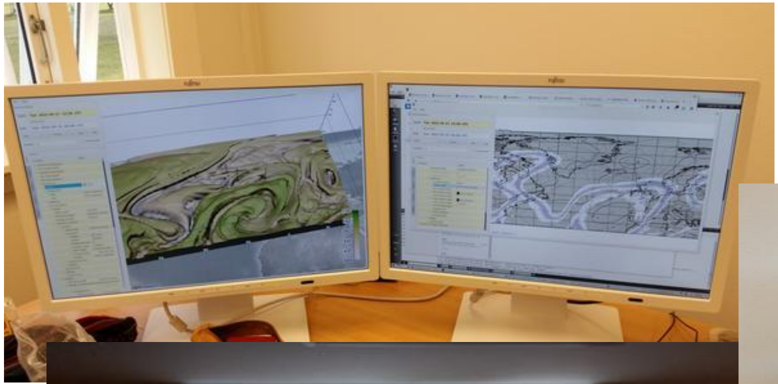
Example ensemble overview product for flight planning: probability of WCB occurrence as a summary measure to quickly find “interesting” regions.

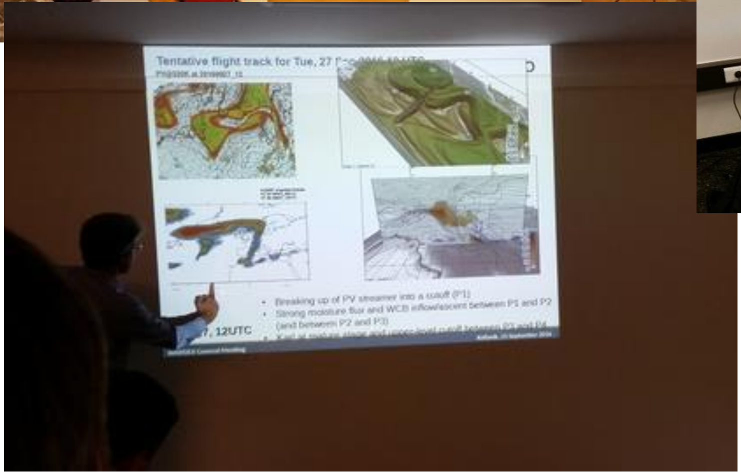


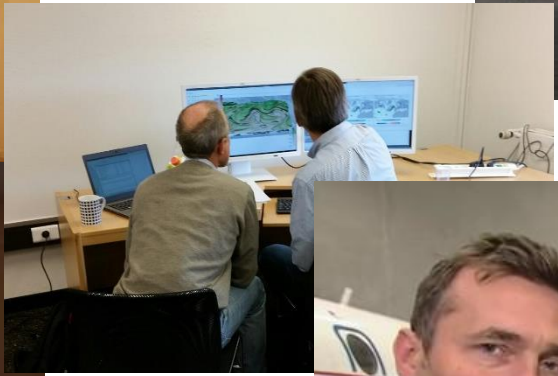
Feature detection per ensemble member with Lagrangian particle trajectories.

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

Met.3D in campaign practice: NAWDEX 2016







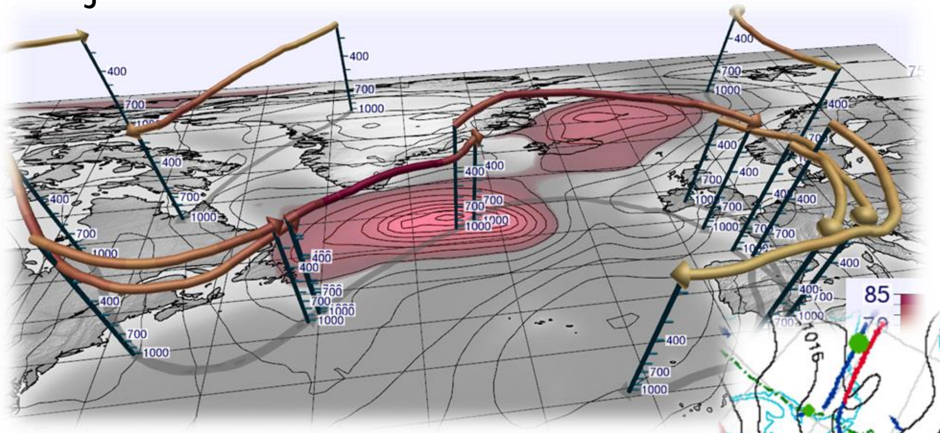
Met.3D workstations with ECMWF ENS on Iceland

3D on TV

NAWDEX motivated vis research and development

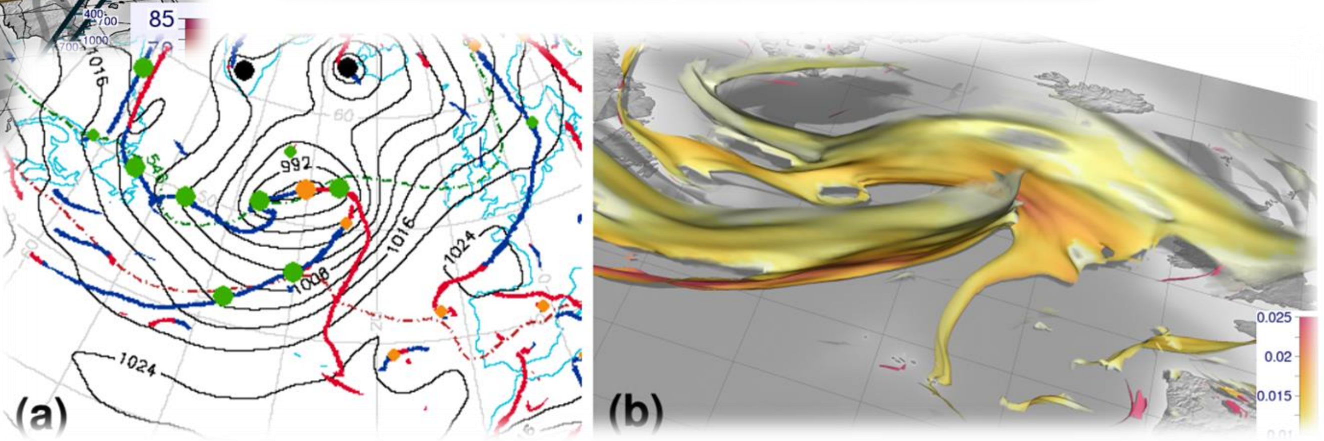
How to examine 3D meteorological features? (Michael Kern, TU Munich)

3D jet-stream core lines



Kern, Hewson, Sadlo,
Westermann, Rautenhaus (2018)

Compression of huge amounts of information into meaningful, focussed entities.

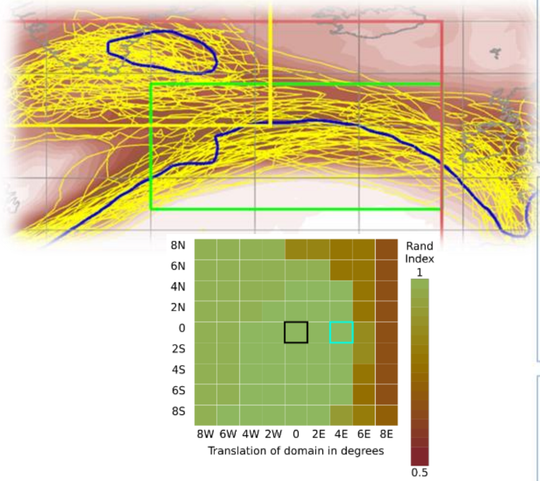


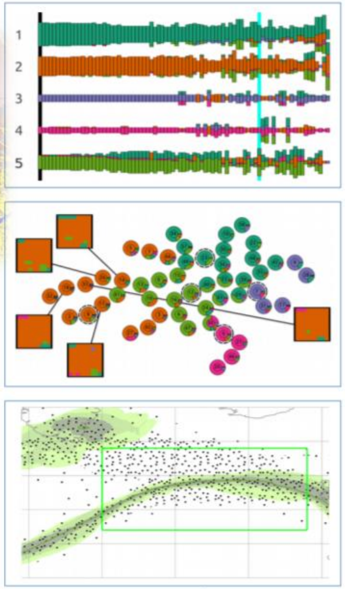
3D frontal structures

Kern, Hewson, Schäfler, Westermann, Rautenhaus (2019)

NAWDEX motivated vis research and development

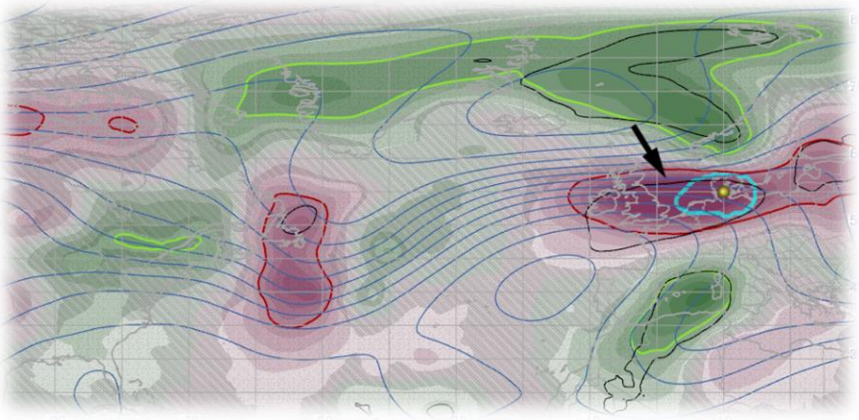
How to examine ensemble member similarity? (Alexander Kumpf, TU Munich)





Interactive ensemble clustering analysis

Kumpf, Tost, Baumgart, Riemer, Westermann, Rautenhaus (2018)



Interactive ensemble sensitivity analysis

Kumpf, Rautenhaus, Riemer, Westermann (2019)

Examples

NAWDEX Sequence A
(case "Karl")

ECMWF ensemble forecast
IT: 2016 Sept 22 00Z

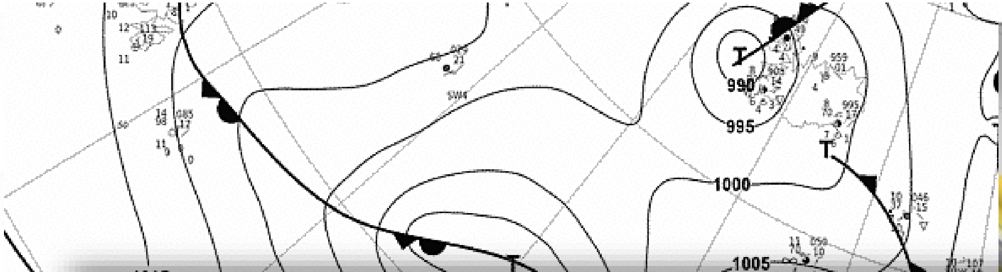
overview (control run)

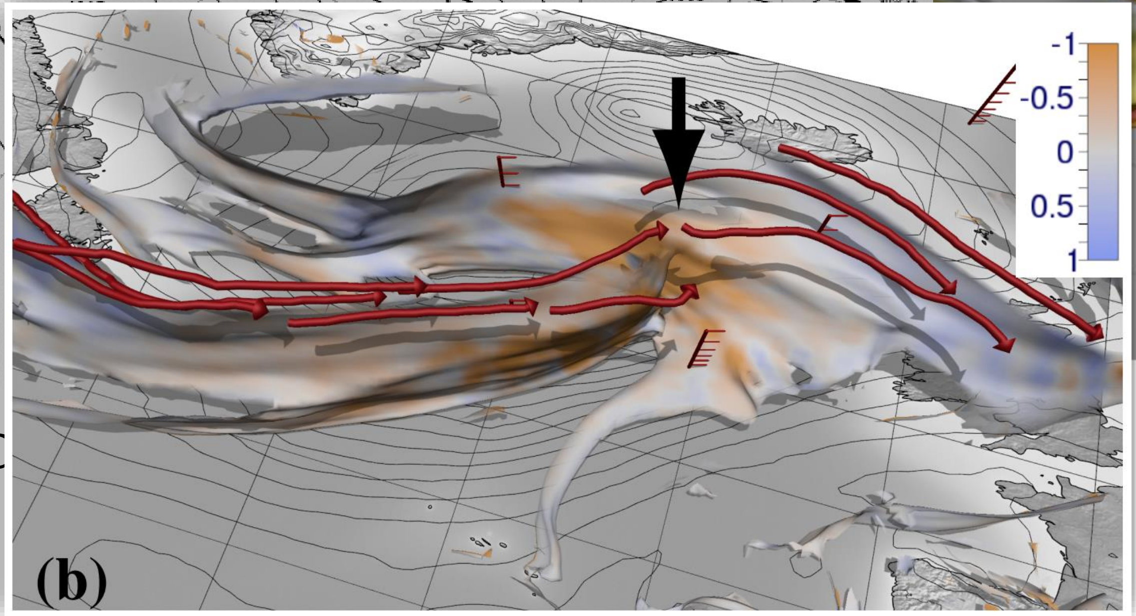
NAWDEX Sequence A
(case "Karl")

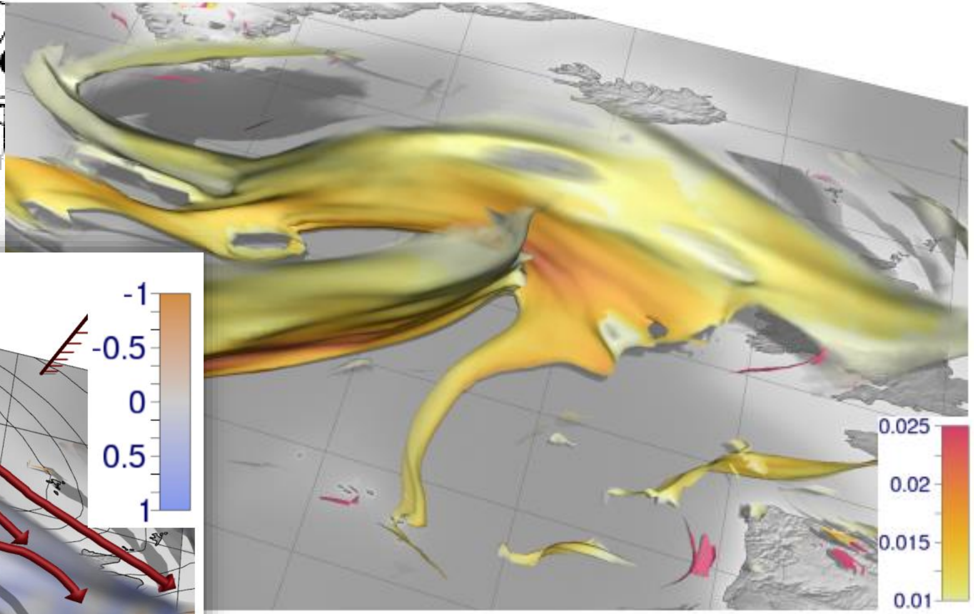
ECMWF ensemble forecast
IT: 2016 Sept 22 00Z

analysis of member 13

Analysis of frontal structure







Combine with jet-stream core lines

Kern, Hewson, Schäfler, Westermann, Rautenhaus (2019)

Interactive 3D Visual Analysis of Atmospheric Fronts

Submission ID: 1075

Clustering analysis of ridge region

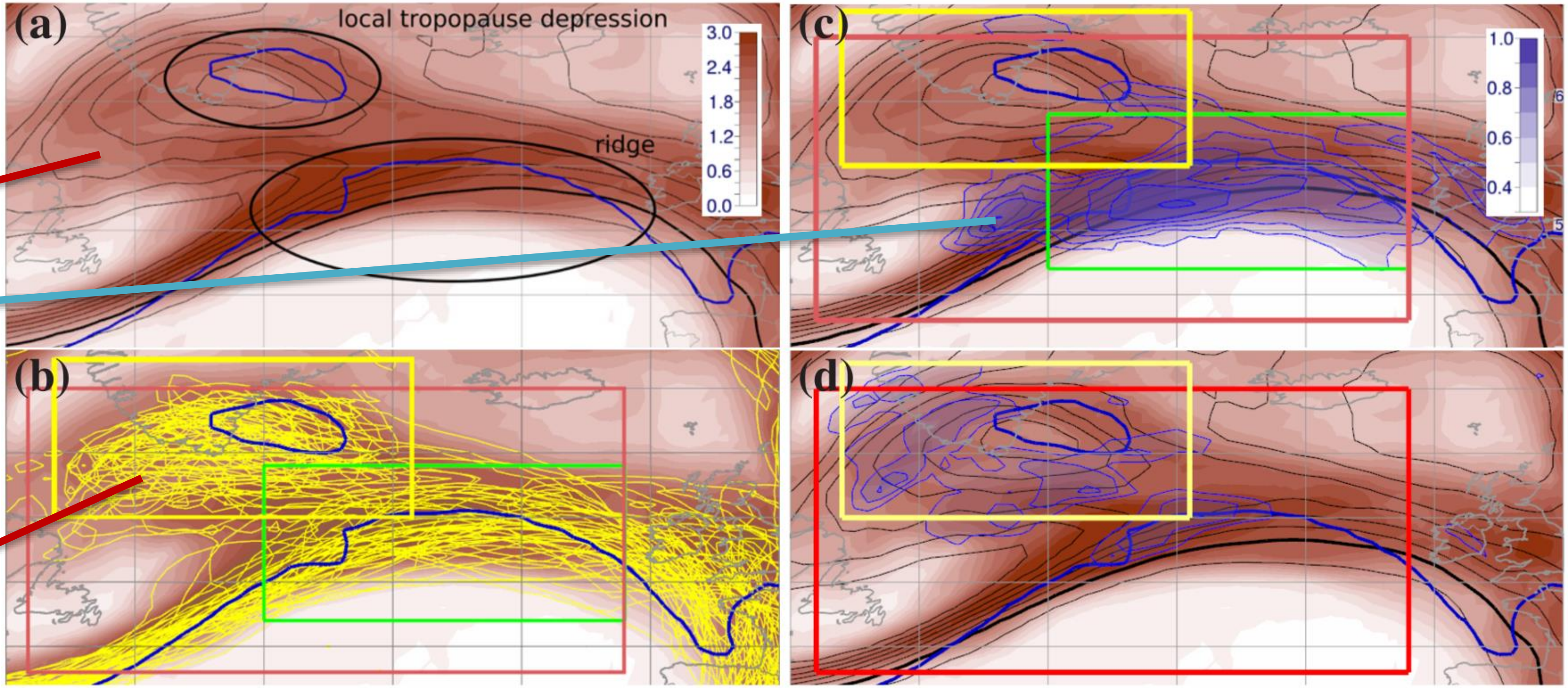
Case "KARL", IT 00Z 22 Sept 2016, VT 00Z 26 Sept 2016

PV at 250 hPa

STDEV

STDEV reduction

2 PVU



Kumpf, Tost, Baumgart, Riemer, Westermann, Rautenhaus (2018)

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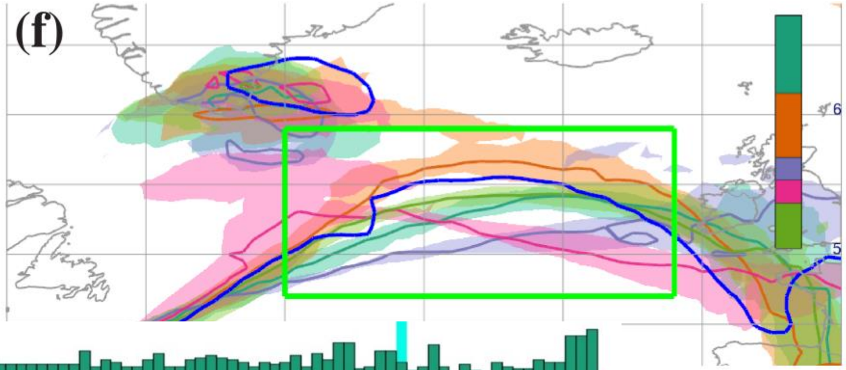
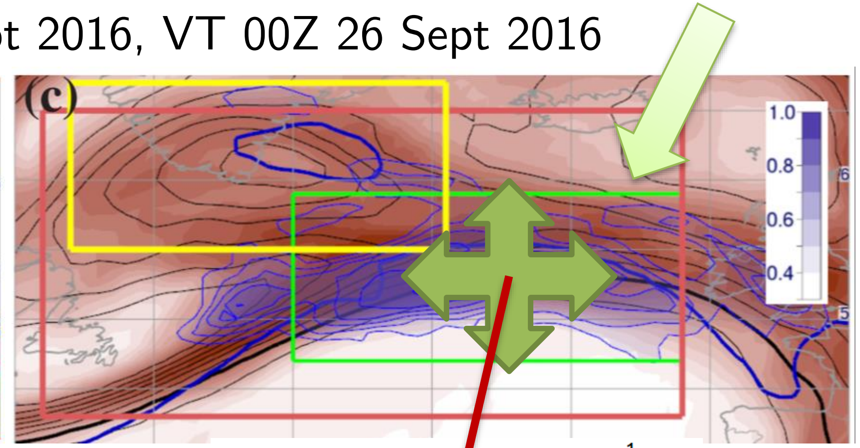
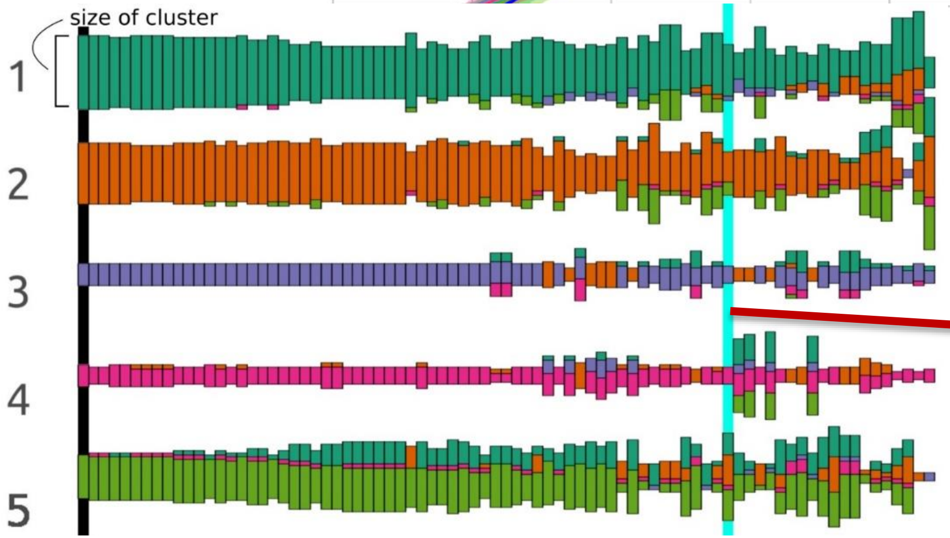
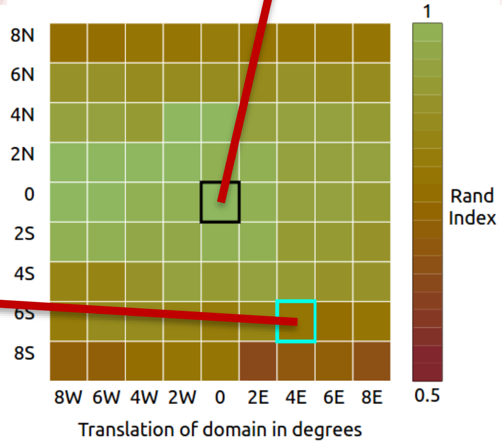


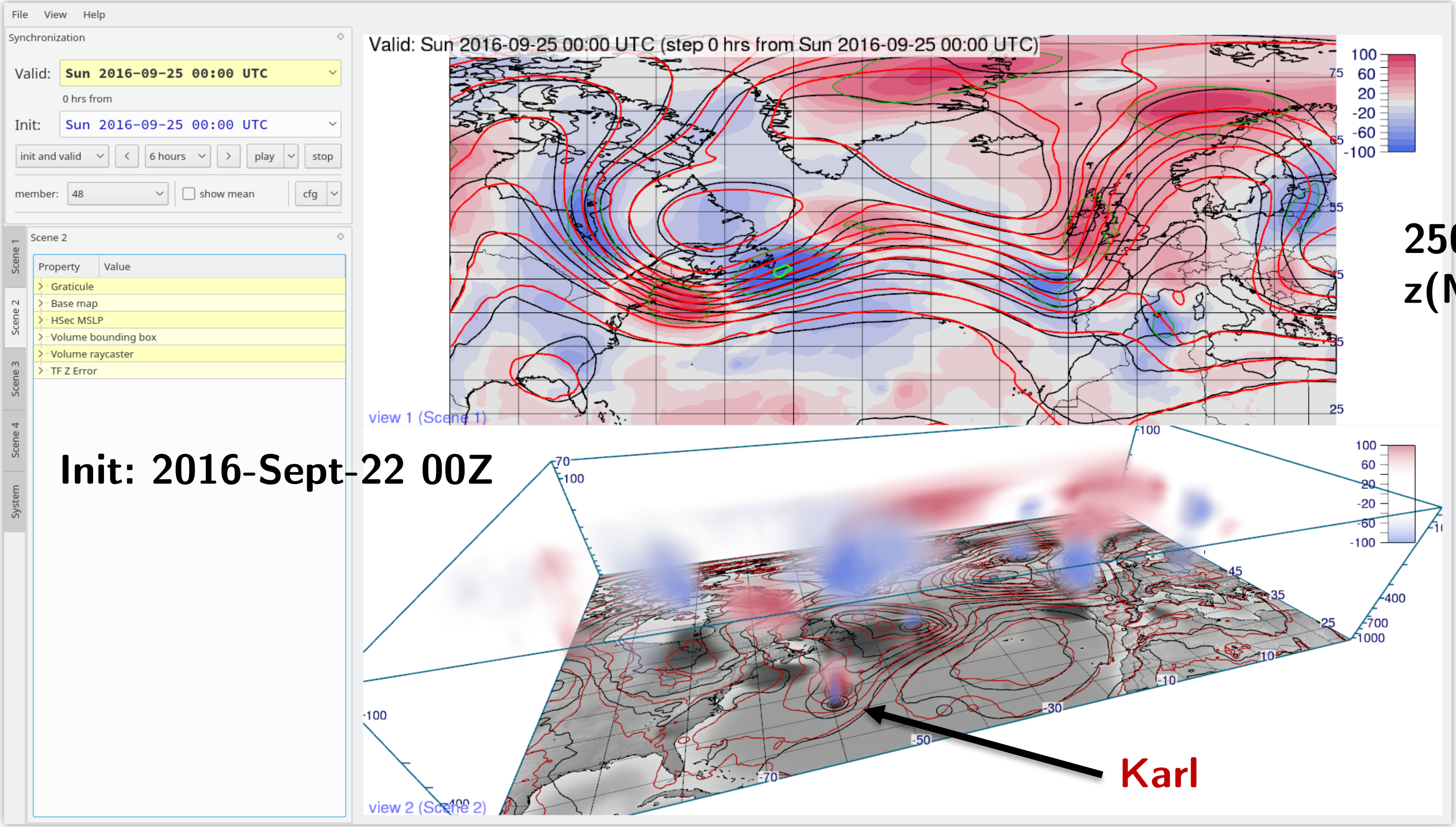






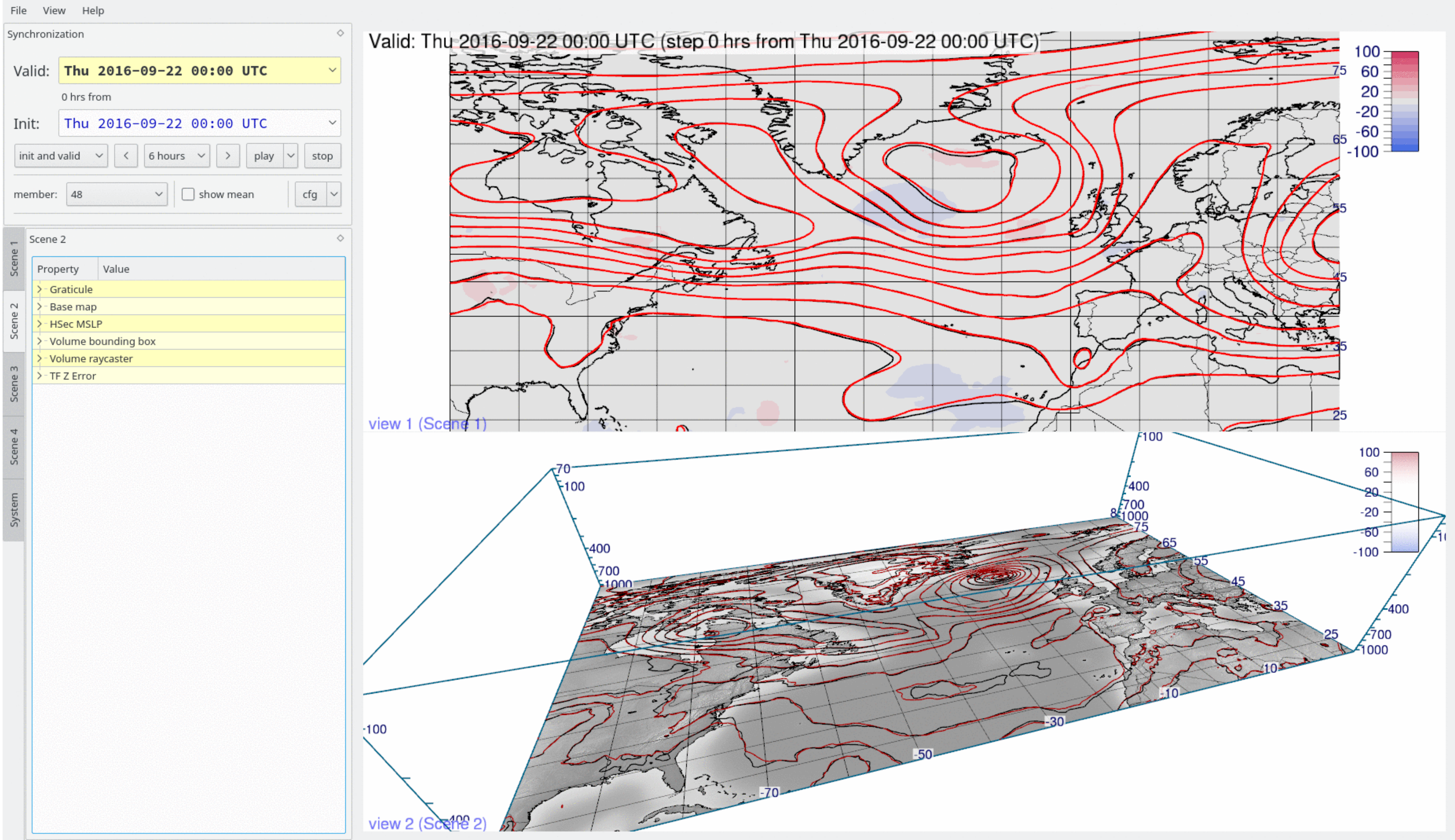
Kumpf, Tost, Baumgart, Riemer, Westermann, Rautenhaus (2018)

Forecast error: 2D + 3D views to not miss any structure



+72h M48

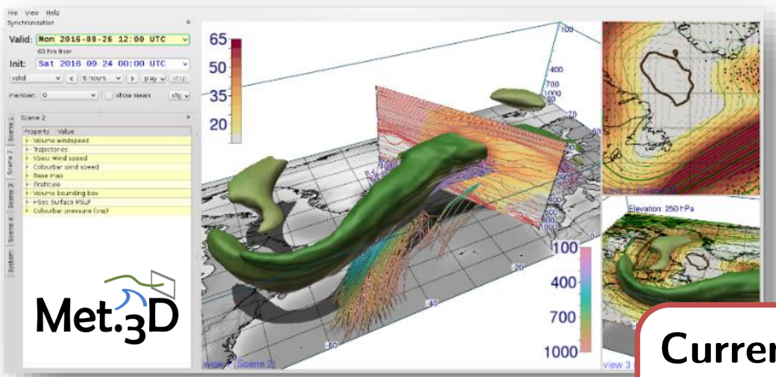
250 hPa
z(M48) – z(an)


File
View
Help
Synchronization
Valid:
Thu 2016-09-22 00:00 UTC
0 hrs from
Init:
Thu 2016-09-22 00:00 UTC
init and valid
6 hours
play
stop
member:
48
show mean
cfg
Scene 1
Scene 2
Scene 3
Scene 4
System
Scene 2
Property
Value
Graticule
Base map
HSec MSLP
Volume bounding box
Volume raycaster
TF Z Error
Valid: Thu 2016-09-22 00:00 UTC (step 0 hrs from Thu 2016-09-22 00:00 UTC)
view 1 (Scene 1)
view 2 (Scene 2)

How do we get straightforward access to the information that is contained in NWP data?

Wrap-up: How can future campaigns benefit from Met.3D?

3D visual analysis can benefit **flight planning** and **case analysis** to examine 3D structures and uncertainty.



Open-source community tool:
met3d.wavestoweather.de

I'm happy to discuss use for future campaigns.

**Currently three open positions:
1 PhD (W2W), 1 SciProg (W2W),
1 PostDoc (CLICCS)**

Experience shows:

- 3D interactive = fast exploration.
- Minimizes chance to miss structures, enhances understanding.
- Attractive in particular for students and younger scientists.

Method-centred work: I'm much interested in adapting and applying to wider range of cases.

More (experimental) code exists, e.g. to visualize observational data. It would be great to collaborate w.r.t. to using some of this.

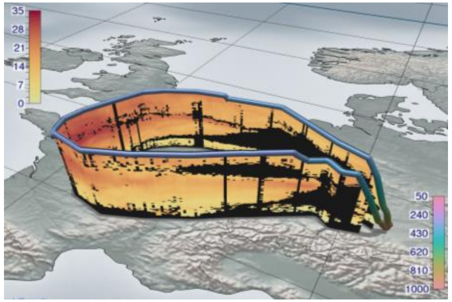


Image: Fabian Schöttl

Contact: marc.rautenhaus@uni-hamburg.de