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Bundesamt für Meteorologie und Klimatologie
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Event-based forecasting and collaboration

EGOWS 2014, Oslo (Norway)

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Agenda

- Introduction
- Events and Meteorological depictions
- AWEM
- Advanced aspects
- Conclusion

Introduction – Event based forecasting

Observation

- Over the years workstation software more and more became production tools
- Shifts forecaster work away from analyzing and monitoring weather towards production
- Examples from NinJo
 - » Graphical products (LL-SigWx, SFC analysis/forecast)
 - » SIGMET/AIRMET, Gafor, TAFs
 - » MMO (modified model output)
 - » Hurricane forecasts
 - » Public warnings ... and probably many, many more



Introduction – Event based forecasting

Observation (continued)

- Many of these products describe the same weather phenomena
 - Products are “re”-created because
 - » Weather changes (adjust attributes)
 - » Different scales (synoptic, meso-/micro-scale)
 - » Different purposes (graphical vs. bulletins)
 - » Different area of responsibility (phenomenon moves out of / into the AOR of another service or forecast centre)
- Forecasters are asking for product monitoring tools
- Reason: be able to cope with the vast amount of products

Introduction – Event based forecasting

Let's try a different approach: **Event-based forecasting**

1. Let the forecaster analyze/describe/monitor the weather
2. Let the software generate/disseminate/monitor the products

Idea

Use interactive graphical editing to allow the forecaster to depict his **conceptual model of the state of the atmosphere and transfer it to an IT system** where it is saved, transmitted and kept for further modification and processing.

Meteorological depictions

- Significant instances of weather phenomena become weather events represented by met-objects
 - » Traceable representation of the phenomenon
 - » Stored in central met-object database
 - » Create/updated/retired using graphical editing
- Meteorological depictions
 - » Snap-shots that describe weather at a particular point in time
 - » Contain one or more met-objects to represent the phenomenon
 - » Depictions are updated if weather changes significantly
 - » Very much like key-frames

Meteorological depictions – Benefits

- Object-oriented forecaster workflow
 - » Forecaster analyzes/depicts/monitors weather events (not products)
- Collaboration is a given
 - » Objects can be shared easily
- First-guess met-objects can be generated easily from all types of sources
 - » VA met-objects from VA advisories
 - » Icing/turbulence from models, TS from CbTRAM/RadTRAM
- Enables single-voice across centres and services
- Objects and depictions can be used to generate products

Conclusion

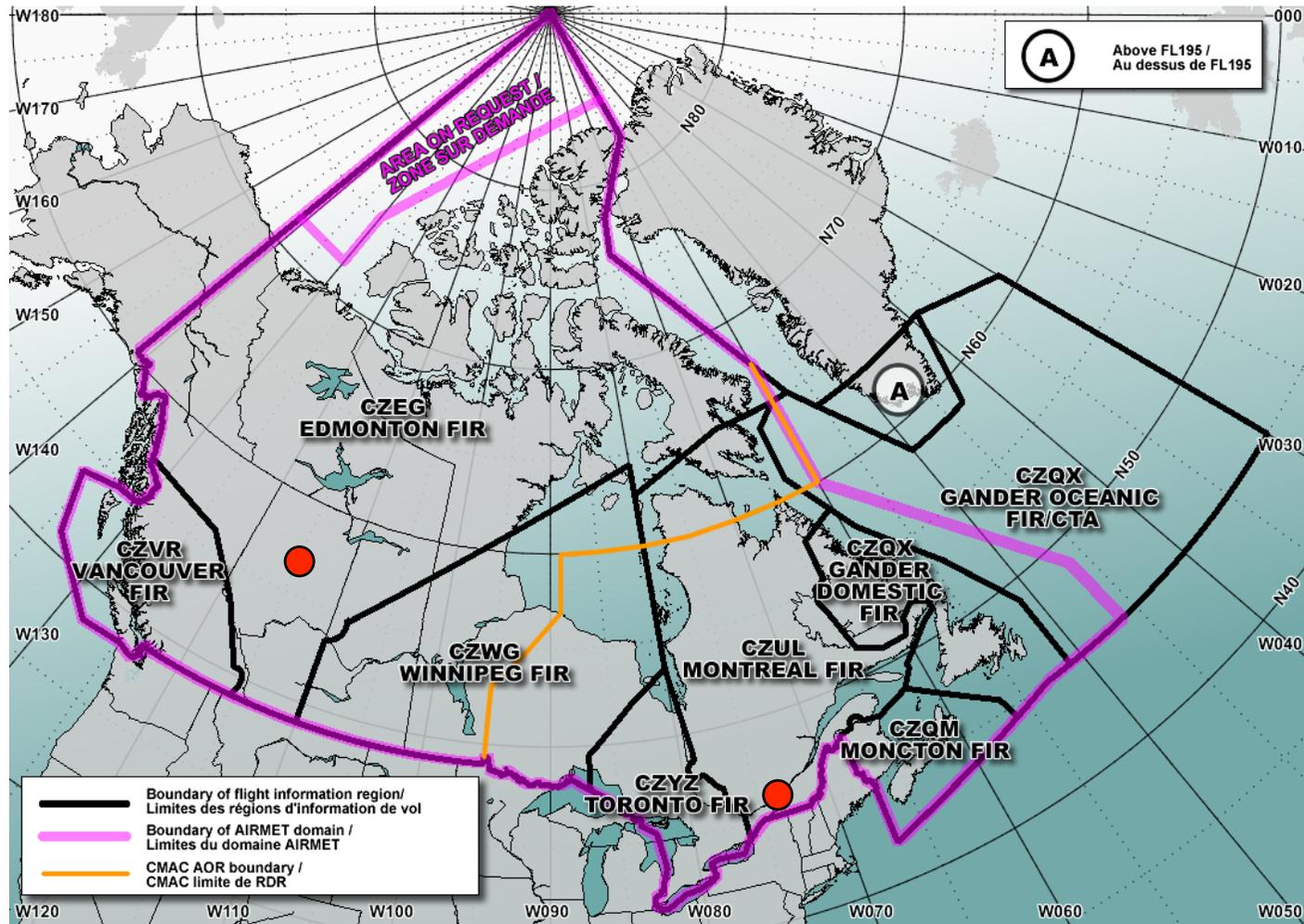
- Conceptual model becomes data itself
 - » Forecaster maintains these conceptual models
 - Analyze/document/monitor weather
 - » Dissemination systems make this data available to every other system that needs it
 - Share these models for collaboration, re-use and product generation
 - » Batch systems generate products (graphics, warnings etc.)
- Everybody involved does what he can do best 😊

AWEM – Aviation Weather Event Manager

- Operational proof-of-concept for event-based forecasting
 - » Put into operations on Nov 14th 2013 for the Meteorological Service of Canada to generate SIGMET/AIRMET warnings
 - » Used at the two aviation centres in Edmonton and Montréal
- Forecaster creates, updates, monitors SED metobjects
 - » Significant Event Descriptions
 - » Three different states: draft, active, retired
- All events are continuously synchronized among the two centres
 - » All forecasters have the same view on what is going on
 - » Collaboration typically weather moves across boundary of area of responsibility

AWEM – Aviation Weather Event Manager

- The AOR of the two Canadian aviation centres



AWEM – Concept



Forecaster depicts weather using significant event descriptions (SED)

SIGMET

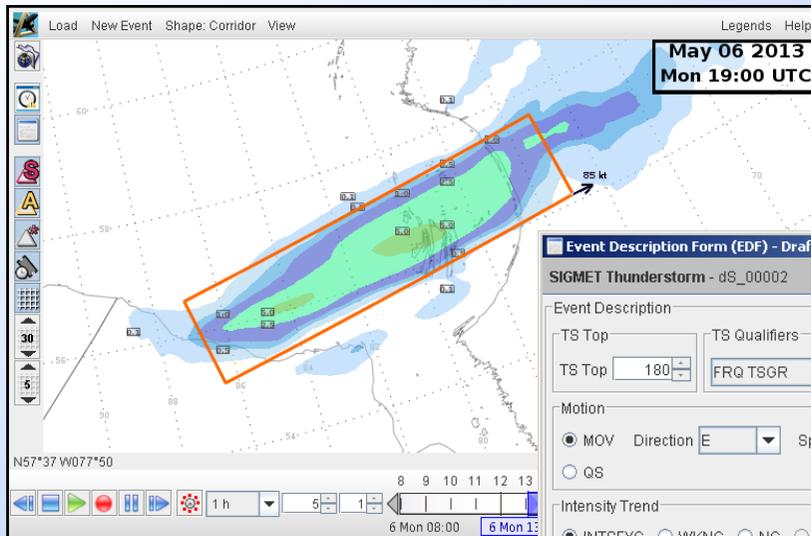
MOP



Products are generated based on SED metobjects

storage and production system

SED metobject are stored



Event Description Form (EDF) - Draft event

SIGMET Thunderstorm - ds_00002

Event Description

TS Top: 180
TS Qualifiers: FRQ TSGR

Motion: MOV Direction: E Speed: 85

Intensity Trend: INTSFYG WKNG NC UNKNOWN

Valid Period: OBS FCST 1940Z to 2340Z
AT 06/05/2013 06/05/2013

Event Area

| pt | Latitude | Longitude | Reference Site | Add | Delete |
|----|----------|-----------|----------------|-----|--------|
| 1 | N 55°50' | W 086°42' | 30 E CYER | | |
| 2 | N 56°52' | W 075°05' | 45 NE CYMU | | |

Width/Radius: 45.0 nm

Flight Information Region (FIR): Montreal Affected, Winnipeg Affected

Graphical Area Forecast (GFA): (GFACN34) Affected, (GFACN33) Affected

Buttons: Delete, Reload, Save, Preview, Send

NinJo and IGE



AWEM – Layer

The screenshot displays the AWEM (Automated Weather Event Monitoring) software interface. The main window shows a map of Canada with various weather events overlaid. Three callout boxes highlight key features:

- Attribute modification / validation:** Points to the Event Description Form (EDF) window, which contains fields for event description, motion, intensity trend, valid period, and graphical area forecast.
- Event monitoring and alerting:** Points to the Event Monitoring List (EML) window, which displays a table of active events.
- Interactive creation / modification:** Points to the map area where users can interactively create or modify event shapes and attributes.

The Event Monitoring List (EML) window shows the following data:

| Event ID | Event Type | Phenome... | State | FIR | Reason | Time R... | Time Due | Map |
|----------|---------------|------------|-------|-----------|--------------|-----------|----------|-----|
| dS_00001 | TS | Draft | CZEG | | | | | |
| A_00001 | SFC VIS / ... | Active | CZVR | GFA Check | -2 hr 0 min | 151200UTC | Go | |
| A_00001 | SFC VIS / ... | Active | CZVR | Update | -0 hr 15 min | 151345UTC | Go | |

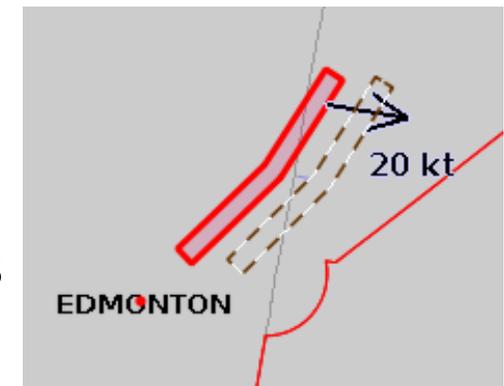
The Event Description Form (EDF) window shows the following details for a SIGMET Thunderstorm event (dS_00001):

- Event Description:** TS Top 180, TS Qualifiers SQLN TSGR.
- Motion:** MOV, Direction E, Speed 20.
- Intensity Trend:** INTSFYG.
- Valid Period:** OBS, 0955Z to 1355Z, 15/05/2014.
- Event Area:** Initial Event Area table with 3 points (Latitude, Longitude, Reference Site).
- Flight Information Region:** Edmonton Affected.
- Graphical Area Forecast:** GFACN32 Affected.

The main map shows a weather event area (orange outline) near Edmonton, with a speed of 20 kt. The map includes labels for Whitehorse, Yellowknife, Regina, and Winnipeg. A legend in the bottom right corner lists various event states and their corresponding symbols.

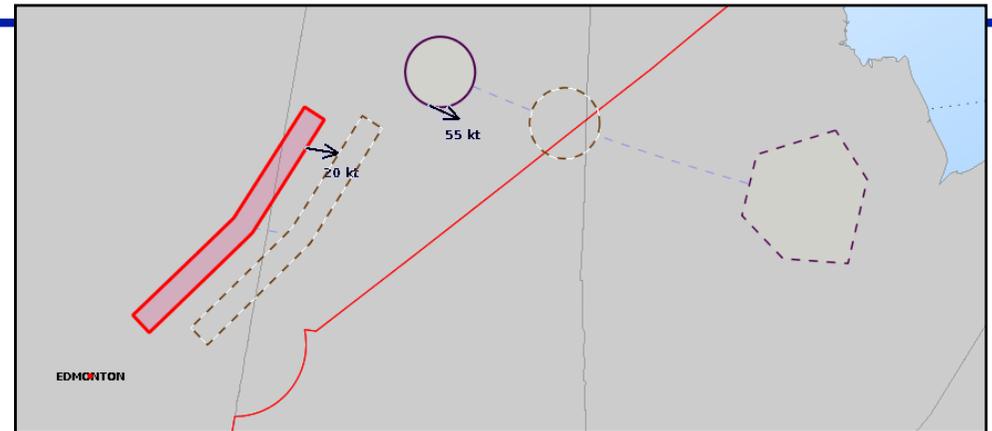
AWEM – a typical scenario

- Forecaster creates a new draft for a TS
 - » Manually or import from first-guess metobject
- Forecaster adds the defined attributes
- Forecaster saves the event
 - » A draft event version is saved and distributed to all other workstations
- Forecaster activates the event
 - » An active event version is saved and distributed to all other workstations
 - » Products get generated (Sigmet/Airmet warnings for all covered FIRs)
 - » AWEM starts monitoring the event

A screenshot of the SIGMET Thunderstorm - dS_00001 interface. The interface is divided into several sections: Event Description, Event Area, Intensity Trend, Valid Period, Forecaster Notes, and Status Messages. The Event Description section includes fields for TS Top, TS Qualifiers (SQLN TSGR), Motion (MOV, Direction E, Speed 20), Intensity Trend (INTSFYG, WKNG, NC, UNKNOWN), and Valid Period (OBS, FCST, 1140Z to 1540Z, AT 15/05/2014). The Event Area section includes an Initial Event Area table with columns for pt, Latitude, Longitude, Reference Site, Add, and Delete. The table contains three rows of data. Below the table are fields for Width/Radius (10 nm) and Manual Edit. The Flight Information Region (FIR) and Graphical Area Forecast (GFA) sections show affected areas: Edmonton and GFACN32. The Status Messages section shows a message: 2014/05/15 11:43 Z: Validation *SUCCESSFUL* - consider saving changes to server. At the bottom, there are buttons for Delete, Reload, Save, Preview, and Send.

AWEM – a typical scenario

- Event is visually advected (“drifted”) by its defined motion or the position of a final event area



- Different monitoring rules currently implemented

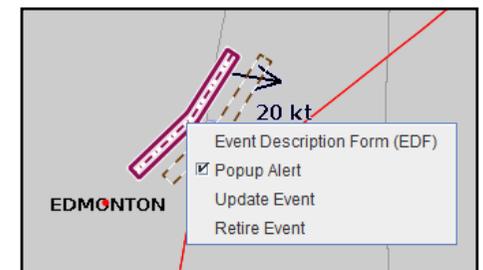
» E.g. drifting: “*Defined motion*

drifts the event out of FIR CZEG within 20mins. Consider updating”

| Event ID | Event Type | Phenome... | State | FIR | Reason | Time R... | Time Due | Map |
|----------|------------|---------------|--------|------|-----------|-------------|-----------|-----|
| A_00001 | ⚠ | SFC VIS / ... | Active | CZVR | GFA Check | 0 hr 11 min | 151200UTC | Go |
| A_00001 | ⚠ | SFC VIS / ... | Active | CZVR | Update | 1 hr 56 min | 151345UTC | Go |
| S_00002 | 🌪 | TS | Active | CZEG | Update | 3 hr 56 min | 151545UTC | Go |

- Forecaster updates the event

» Modifies shape, motion, attributes

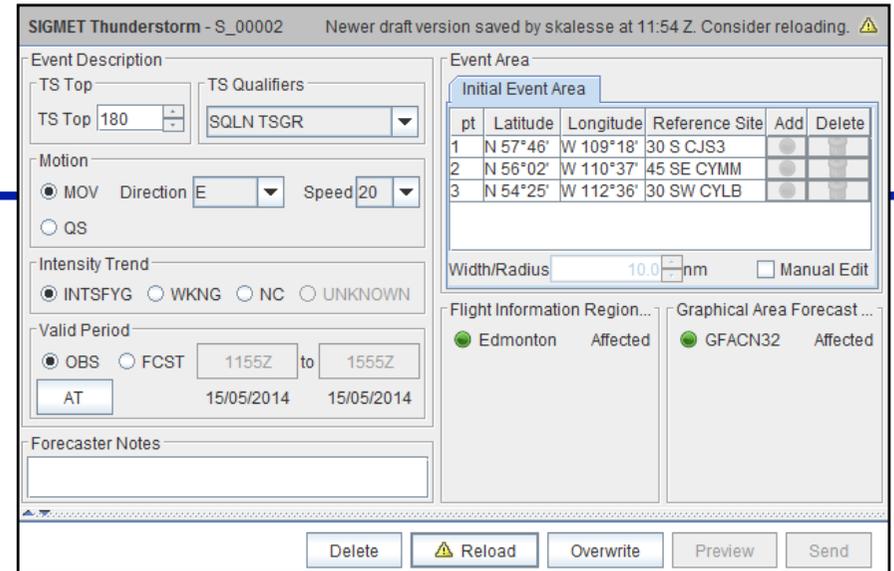


- Forecaster saves intermediate draft event version

» Event version gets distributed to all other workstations

AWEM – a typical scenario

- At CMAC AOR boundaries, forecasters will collaborate by sharing intermediate draft versions
- Forecaster publishes new active event version
 - » Cancellation products get generated for all FIRs that are not covered anymore
 - » Update products get generated for all still covered FIRs
 - » New products are generated for newly covered FIRs
- Once the phenomenon disappeared or moves out the Canadian AOR, the forecaster retires the event
 - » Cancellation products are sent for all covered FIRs



SIGMET Thunderstorm - S_00002 Newer draft version saved by skalesse at 11:54 Z. Consider reloading. ⚠

Event Description

TS Top: 180 TS Qualifiers: SQLN TSGR

Motion: MOV Direction: E Speed: 20
 QS

Intensity Trend: INTSFYG WKNG NC UNKNOWN

Valid Period: OBS FCST 1155Z to 1555Z
AT 15/05/2014 15/05/2014

Forecaster Notes

Event Area

| pt | Latitude | Longitude | Reference Site | Add | Delete |
|----|----------|-----------|----------------|--------------------------|--------------------------|
| 1 | N 57°46' | W 109°18' | 30 S CJS3 | <input type="checkbox"/> | <input type="checkbox"/> |
| 2 | N 56°02' | W 110°37' | 45 SE CYMM | <input type="checkbox"/> | <input type="checkbox"/> |
| 3 | N 54°25' | W 112°36' | 30 SW CYLB | <input type="checkbox"/> | <input type="checkbox"/> |

Width/Radius: 10.0 nm Manual Edit

Flight Information Region... Graphical Area Forecast...

Edmonton Affected GFACN32 Affected

Delete Reload Overwrite Preview Send

AWEM collaboration, allowing forecasters to share and edit draft event versions



AWEM – Notes

- Forecasting workflow is event-based
 - » Forecaster updates his depiction of the weather
 - » Configurable list of phenomena with their met. attributes
 - » Forecaster does not create products
 - » AWEM doesn't even show any products
 - » Almost no ties to products (although we are not 100% there)
 - Events still categorized SIGMET/AIRMET events
 - Event shapes according to product requirements
 - Monitoring rules exist for FIR boundary/coverage violations
 - Latest version even includes a product preview (but will be eliminated in one of next versions)

AWEM – Notes

- For dissemination purposes the metobject is a product itself
 - » MOP == “Metobject product” := metobject + meta-data
 - » Metobject: purely meteorological information
 - » Meta-data: product identification and extra data
 - SIGMET/AIRMET bulletins generated from the MOP
 - » Ideally outside of NinJo (optionally from within NinJo)
- This really makes the workstation independent of the final products
- Generate graphical products (images) using NinJo batch
 - Generate IWXXM, GML as input for external customers

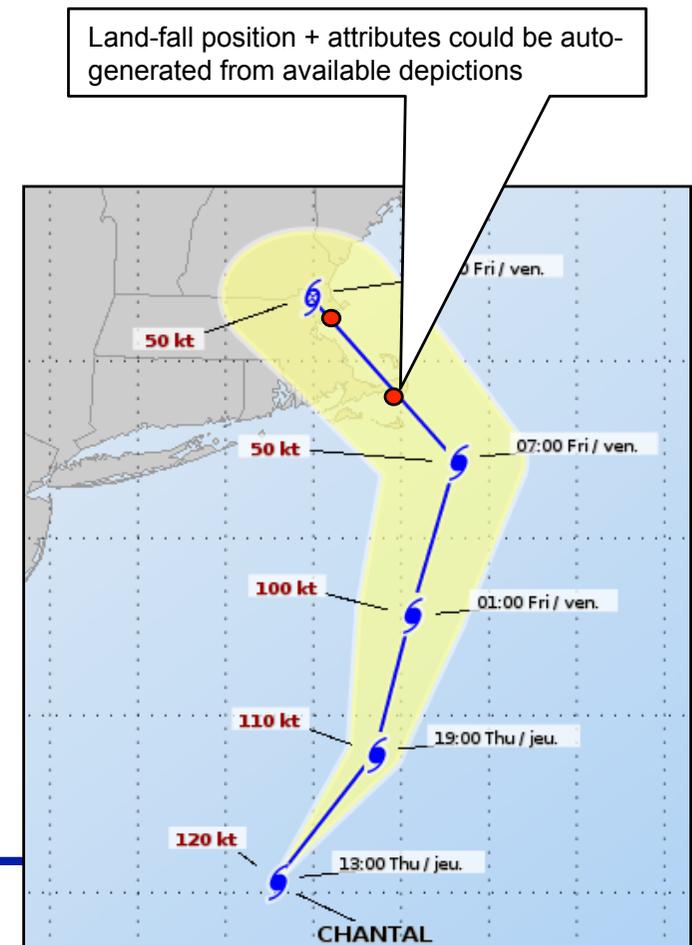
Advanced aspects

Conceptual changes:

- Event based forecasting could reduce responsibility of the forecaster from many products to one
 - » Define the metobject (or MOP) to be the one and only product the forecaster is responsible for (make him monitor that one)
 - » All other products are software generated. In the future software will need to be responsible for correctness
- Event based forecasting can improve quality of products
 - » Forecaster focusses on describing the weather, he doesn't create a great number of products
 - » E.g.: AWEM generates at least 5 products for each update in case the event covers two FIRs.
 - » Monitors one event instead of five products

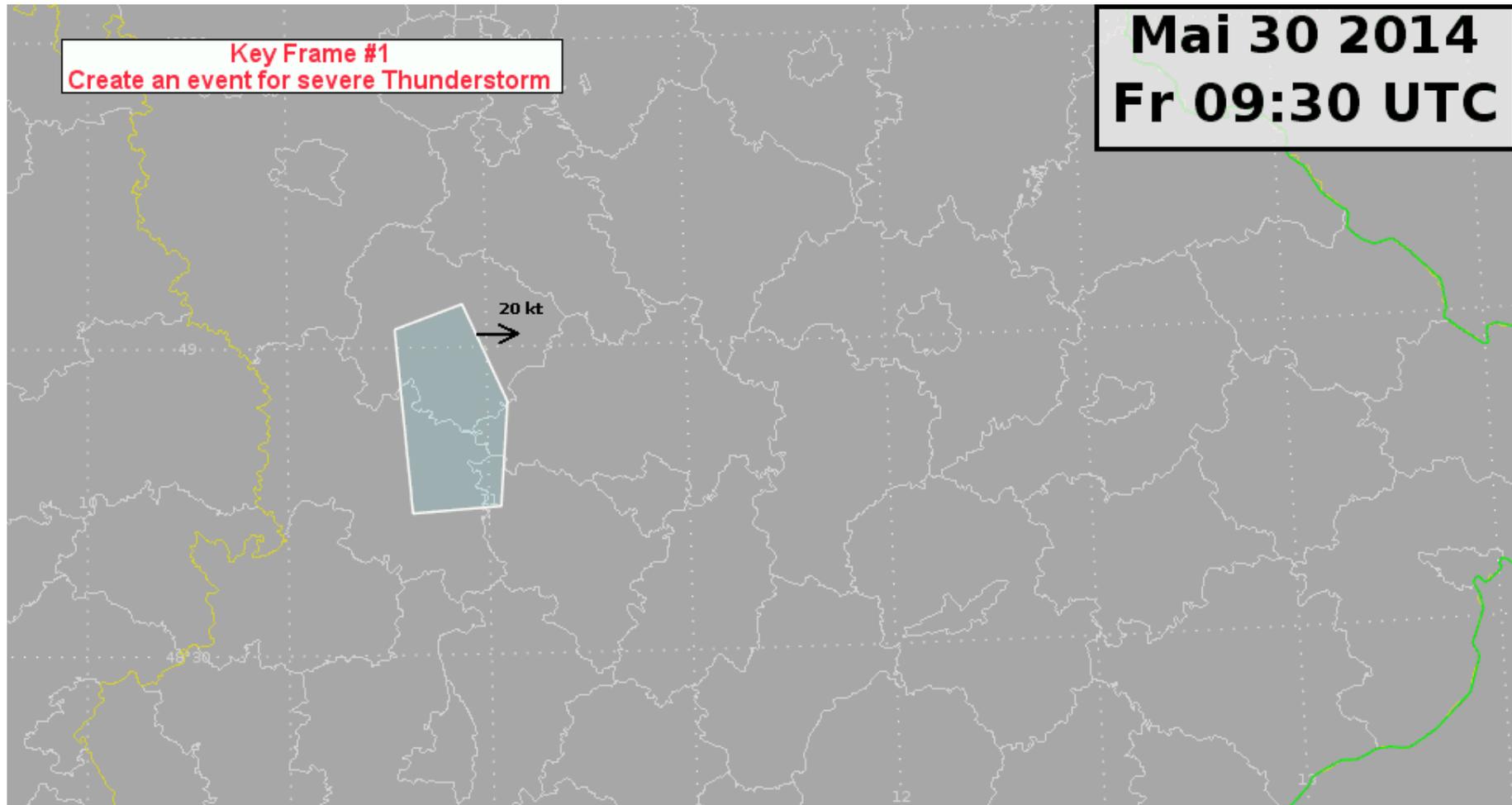
Advanced aspects

- Object-oriented meteorological depictions behave like key-frames
 - » Created and updated whenever there are significant changes
- Allows for inter-frame interpolation
 - » Apply shape morphing techniques
 - » Interpolate: Object shape, Object motion, Object attributes
- Auto-generate products
- Example: Hurricane track forecast
 - » From track forecast, interpolate land-fall
 - » Then auto-generate warnings



Key frames and automatic warning production

- Severe thunderstorm event moves over Bavaria



Conclusion

- Observation:
 - » Event-based forecasting is not so much a technical novelty
 - » It is a gigantic conceptual change in the forecasting workflow
- Challenges:
 - » How do we (re-) define responsibilities for forecasters and it systems
 - » How to coordinate collaboration between services ...
 - ... when presently we don't even collaborate within the services
 - ... when responsibilities don't cross borders even though weather usually does?

Conclusion – Benefits

- Stream-lined forecaster workflow:
 - » create, save, send, update, retire
 - » Forecaster works on weather not products
- Workflow is product independent
- Products to be auto-generated
 - » Software takes over product responsibility
- Objects to be re-used for different use-cases and products
- Object-based collaboration, post-processing, archiving built-in
 - » Why do we have to share pngs when we can share objects!