Dean Hintz, Safe Software

Integration of climate scenario impact models with standards based analytic data pipelines and GeoAI to support improved resilience for urban systems

Agenda

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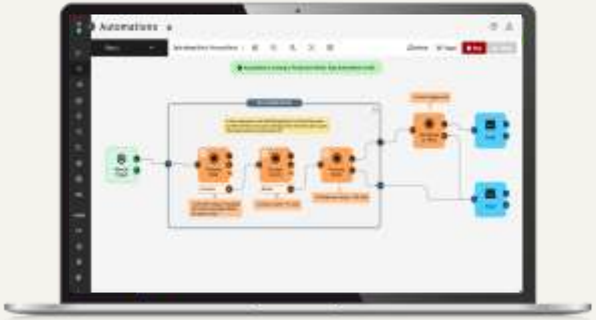
- Introduction: Climate Resilience Data Challenge
- Climate Resilience Challenges:
  - Flood, Fire, Drought, Extreme Heat
- FME Data Fusion Approach
  - Climate model results, open standards, transformation tools, analytic pipelines, scalable architecture & GeoAI
  - OGC disaster & climate resilience pilots
- Lessons learned

Mitigating Extreme Weather Impacts Leveraging Open Standards & Model Based Integration Pipelines

FME Enterprise Integration Platform

The only All-Data, Any-AI Platform.



FME Form

Data Movement and transformations *workflows* are built here.

FME Flow

Brings life to FME Form *workflows*

FME Flow Hosted

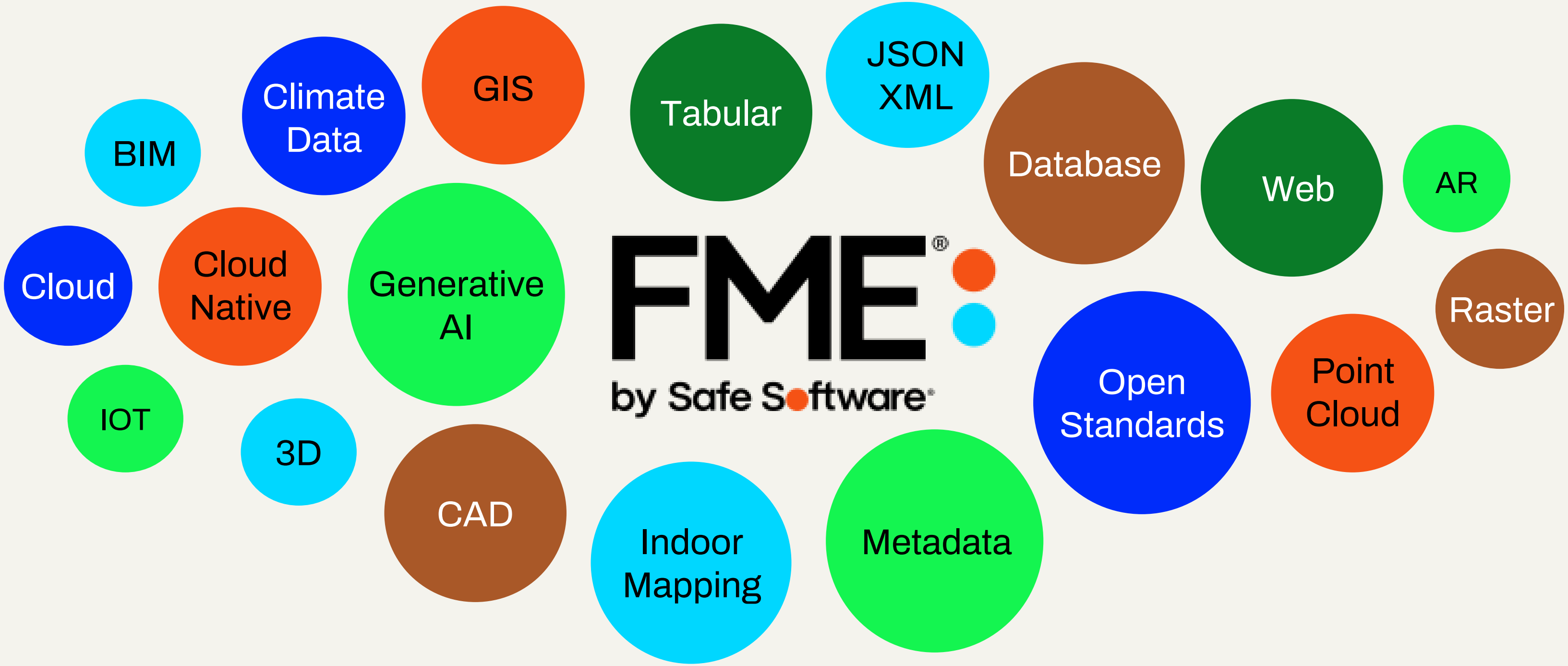
Safe Software SaaS Version of FME Flow

FME Realize

Experience data in real world context, in real time.

fme.safe.com/platform

Unrivalled Data Support

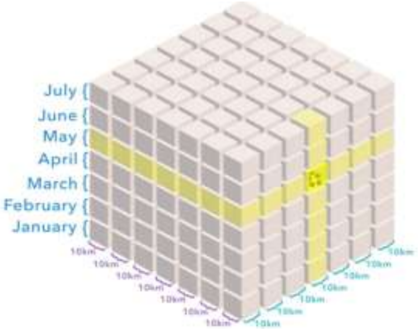


With 500+ supported data types in FME.

Climate Resilience / Extreme Weather: Data Challenge

- **Complex, diverse data structures**
  - Model outputs - time series data cubes
  - Multi - dimensional: Spatial, temporal, environmental variable
  - Variable: temperature, precipitation, soil moisture, wind
  - Multi-scalar (global to downscaled local)
- **Massive data volumes**
  - 1000 steps, monthly: 80 years, daily: 2.75
- **Rapid update frequency – real time weather forecasts**

***Goal: Assess** weather and climate forecast variables to assess population and critical infrastructure impacts*

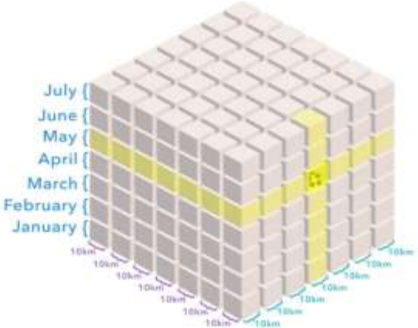


Climate Resilience / Extreme Weather: FME Data Fusion

Rapid data integration leveraging open standards via FME's integration and automation platform

- **Open standards**
  - Comprehensive support for weather & climate standards allows modular interchange between weather & climate models & downstream analytics
- FME's flexible **data transform platform** supports rapid development of data structure extraction and integration workflows
- **Scalable FME architecture** enables automation of massive data volume pipelines

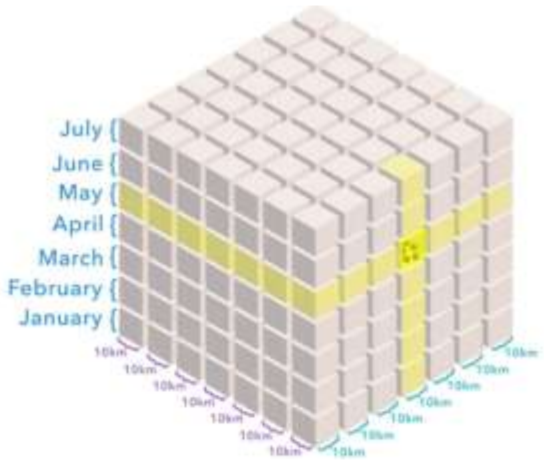
Goal: Assess *weather and climate forecast variables to assess population and critical infrastructure impacts*



Disaster and Climate Data Sources to Impact Risk

How can data for climate impact and disaster indicators be provided to a decision makers?

- **Past & present data:** Situational awareness - base map, hazards, imagery, sensors.
- **Future data:** Change awareness - risk scenarios due to climate change - climate variables: e.g. precipitation, temperature.
- ***Challenge:*** *Climate services not well known or utilized within the communities likely to be affected by impacts.*



Data cube - example data structure

Safe and OGC Open Standards: Vision

- Improved data sharing helps us address both global and local challenges

- Community based open standards supports collaboration & rapid data integration

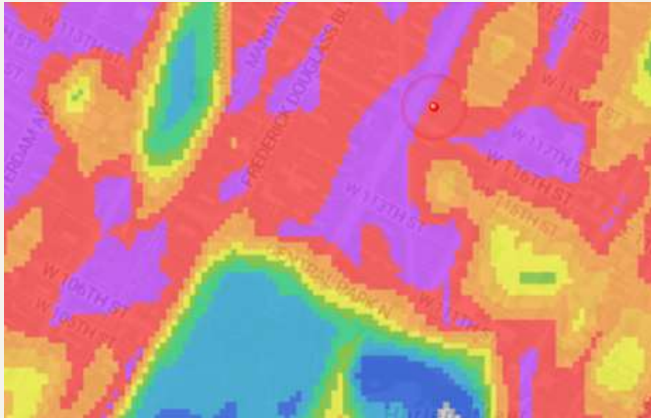
- FAIR: Findable, Accessible, Interoperable, Reusable

- **Open Data standards**
  - Fosters data **democratization**
  - Fuels data flow **automation**
  - Foundational to **governance, analytics & AI**
  - Furthers **adaptability, agility & modularity**

Safe Software buildingSMART International CNG Open Geospatial Consortium

Climate Resilience Scenarios

- Drought
- Flood
- Fire
- Heat



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Drought: OGC Climate Resilience Pilot 2023

Pilot Goals:

- **Build climate resilience**
- **Expand audience** for climate services
- Demonstrate the value of OGC **standards** and **SDI**'s (FAIR)
- Show how OGC can support international **climate change goals**
- Build a **community of stakeholders**

better understand the range of possible impacts - allows us to better prepare and compensate for them

https://www.ogc.org/initiatives/crp/

Natural Resources Canada | Ressources naturelles Canada
Canada

Homeland Security

NOAA

Open Geospatial Consortium

Disaster Pilot 2023:
Disaster and Climate Data Sources to ARD & Impacts

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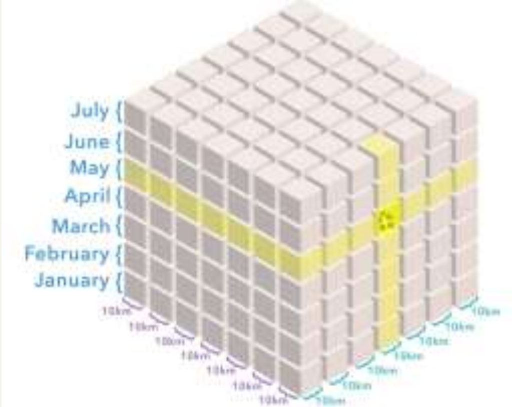
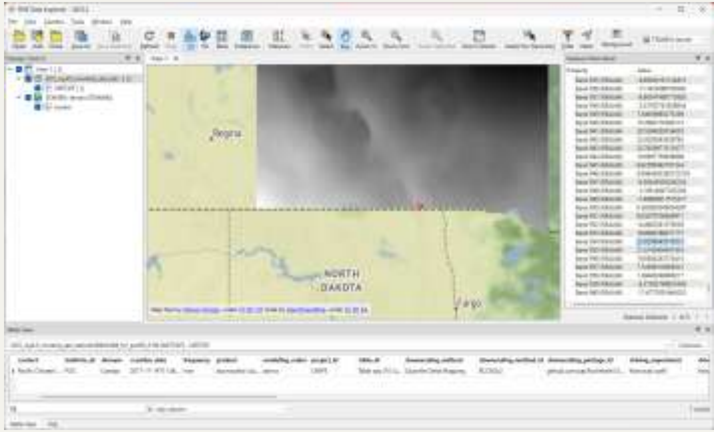


How to provide the data needed for climate impact and disaster indicators to local planners and stakeholders?

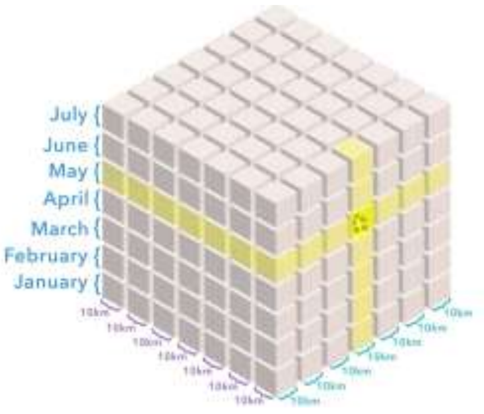
- **Goal: Connect Climate and Disaster Pilots**
- **Data: Current situational awareness**
  - Base map: physical, land use, infrastructure, pop
  - EO data: hazards and impacts
  - Drought & hydrologic monitoring
- **Data: Future change awareness - risk scenarios due to climate change**
  - Climate model outputs - **time series data cubes**
  - Temperature, precipitation and moisture projections
  - **Analysis Ready Data** (ARD) **model results summary**
  - **Climate services** known in climate community but **not well known or utilized** across affected impact domains



NetCDF from Environment Canada

Open Geospatial Consortium

MB Precipitation: Future Delta



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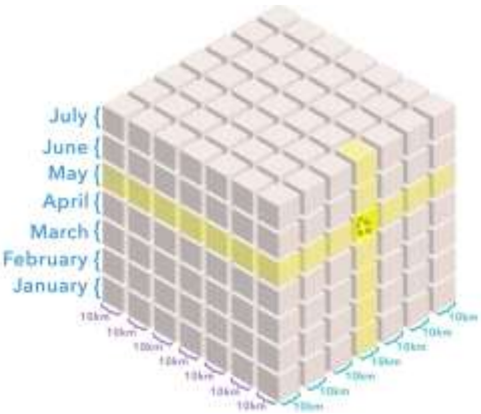

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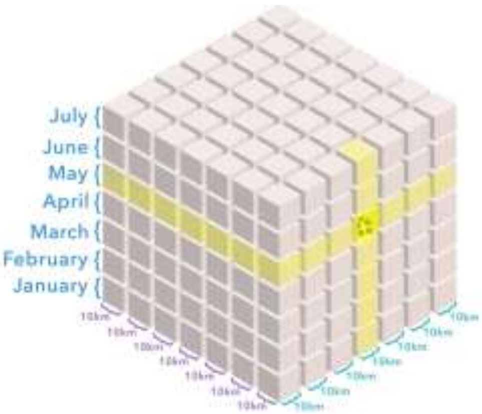

PrecipDelta = PrecipFuture / PrecipHistoricalMean

Yields a value from 0 to N where 0 = no precipitation and 1.0 = 100% of historical mean precipitation

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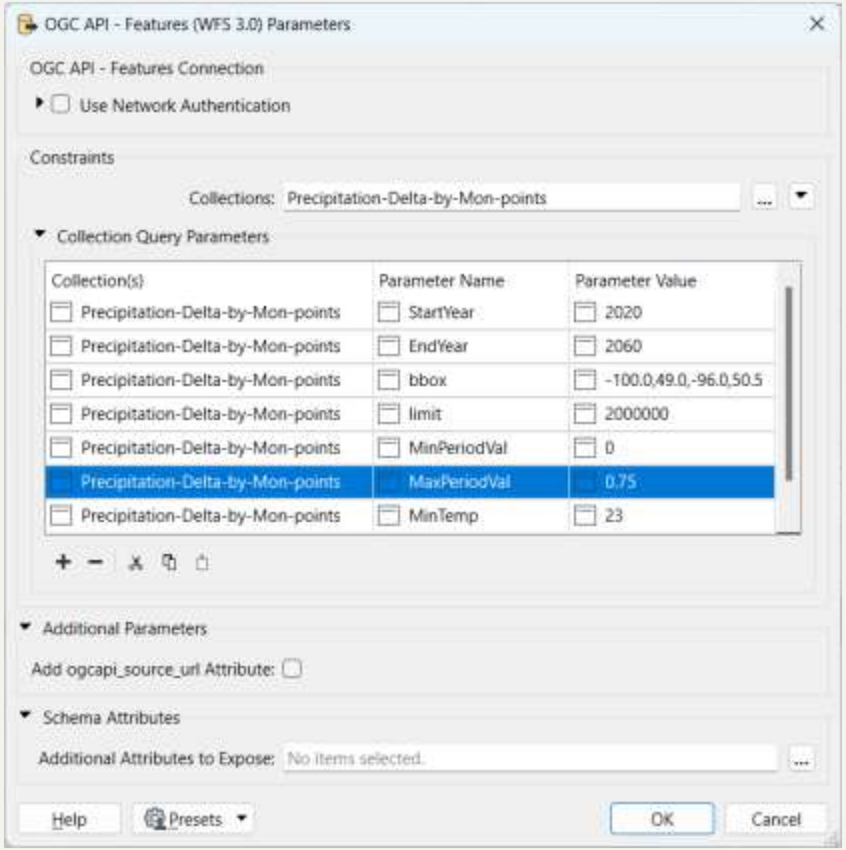
MB Drought Risk: Combined Precip Temp Query

OGC API Features Query Parameters:

Start Year: 2020
End Year: 2060
BBox: -100.0,49.0,-96.0,50.5
Limit: 2,000,000
MinPeriodValue: 0 (PrecipDelta)
MaxPeriodValue: 0.75 (PrecipDelta)
MinTemp: 23C (Min Mean Monthly Temp)

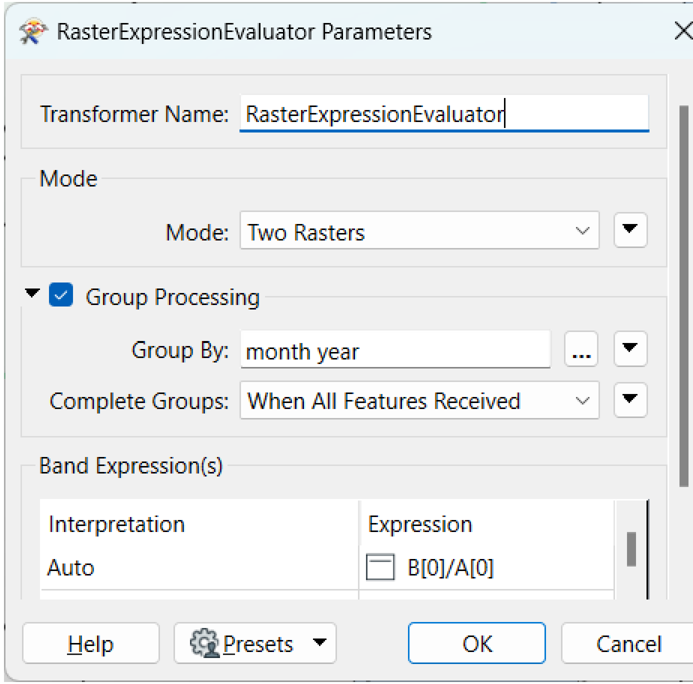
Find all time step points over the next 40 years for southern Manitoba where projections indicate:

- ***> 25% dryer than historical mean*** *AND*
- ***mean monthly temperature > 23C***

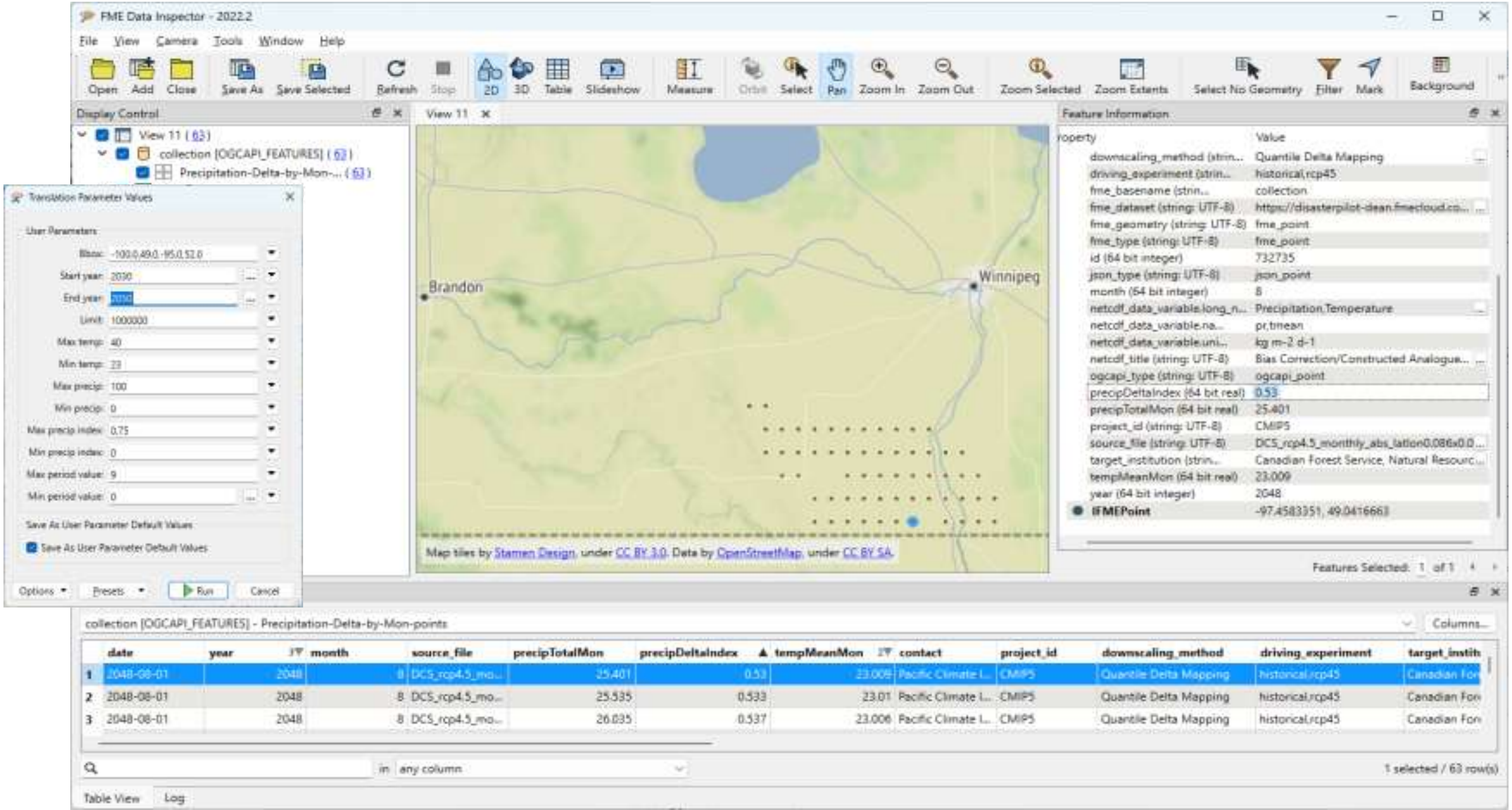


MB: Precipitation Delta

- Calculate **historical mean** precipitation per month across 30 years of time series using grid algebra (by cell, **1950 -1980**)
- Read **future precipitation** time series per month
- **PrecipDelta_ts = PrecipFuture_ts / PrecipHistoricalMean_ts**
- Replaces 2 step difference and normalization process
- **Raster to vector** convert delta grid to points
- Apply PrecipDelta properties to points, and write to **Geopackage, GeoJSON**
- Visualization component feeds this to their vegetation model



MB Drought Risk: Combined Precip Temp Output



LA (CRP): Precipitation Delta > Visualization

1. Compute Precipitation Delta (Future – Historical)
2. Export to format suitable for Laubwerk's visualization platform: GeoJSON
3. Vegetation is modelled based on combination of growth model and environmental conditions over time
4. First visualization based on current climate
5. Second visualization incorporates climate variables from FME

FME by Safe Software

Corner Hollywood Blvd And Camino Palmero St Looking Looking North (Status Quo)

Visualizations provided courtesy of **Timm Dapper, Laubwerk**

LAUBWERK

LA Visualization: Landscape Impact


2020


2040a


2060a


2040b

2060b

OGC Disaster Pilot 2021: Red River Flood Scenario

- The **Red River** flows north from South Dakota and Minnesota into Manitoba Canada & Hudson Bay (287,500 km2, 890 km)
- The flat slope of the Red River Basin means flow is slow, allowing runoff to backfill
- Ice jams and ground frost in spring impede flow and infiltration

Red River Flood 2011 - Highest water levels and flows in modern history - three million hectares

https://www.gov.mb.ca/mit/wms/rrf/historical_2011.html

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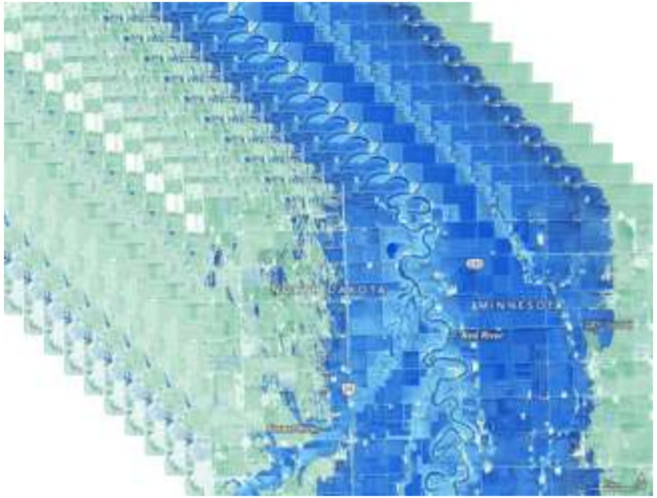
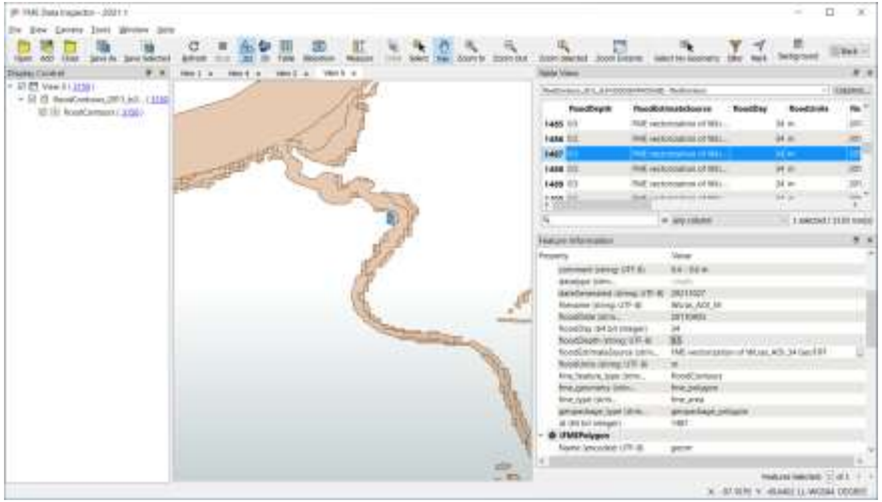
Disaster Pilot 2021:
Red River Flood Routing Recipe

Open Geospatial Consortium





RSS-Hydro

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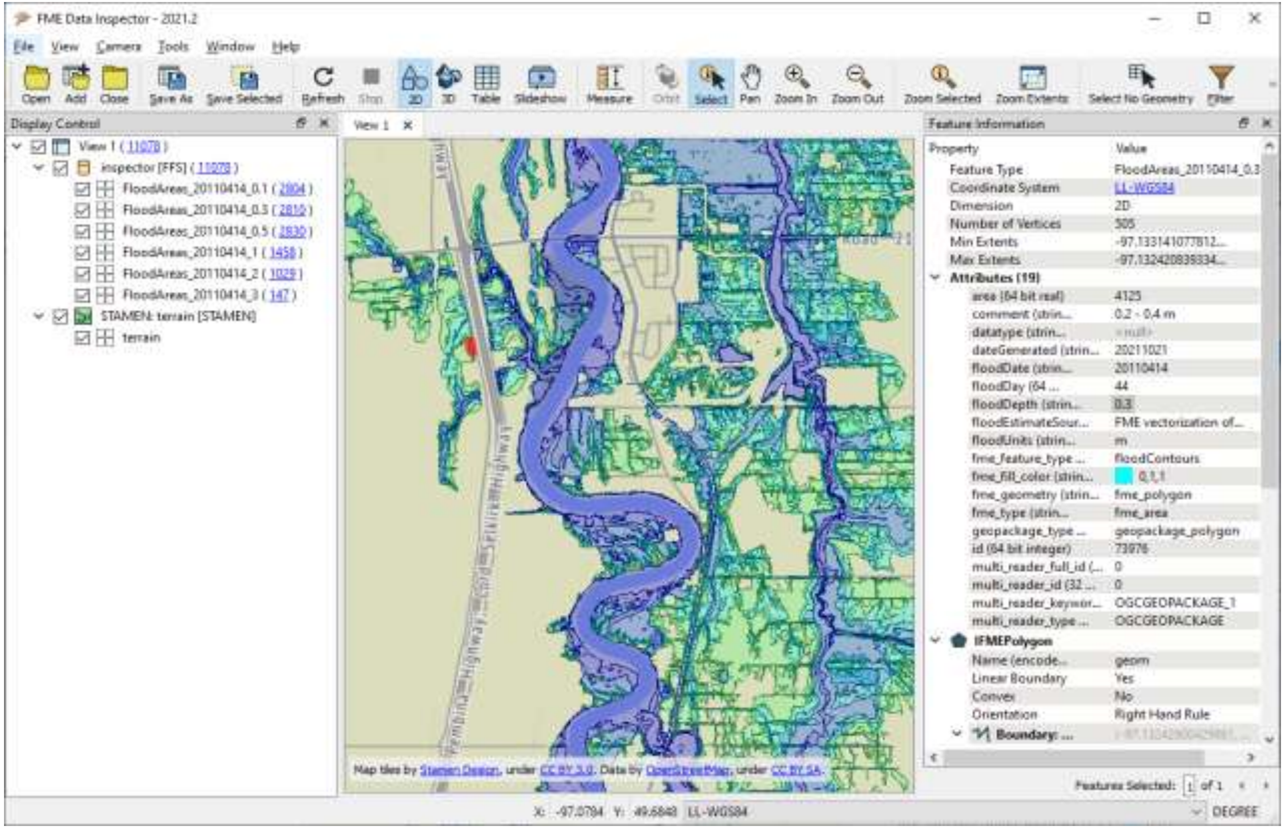
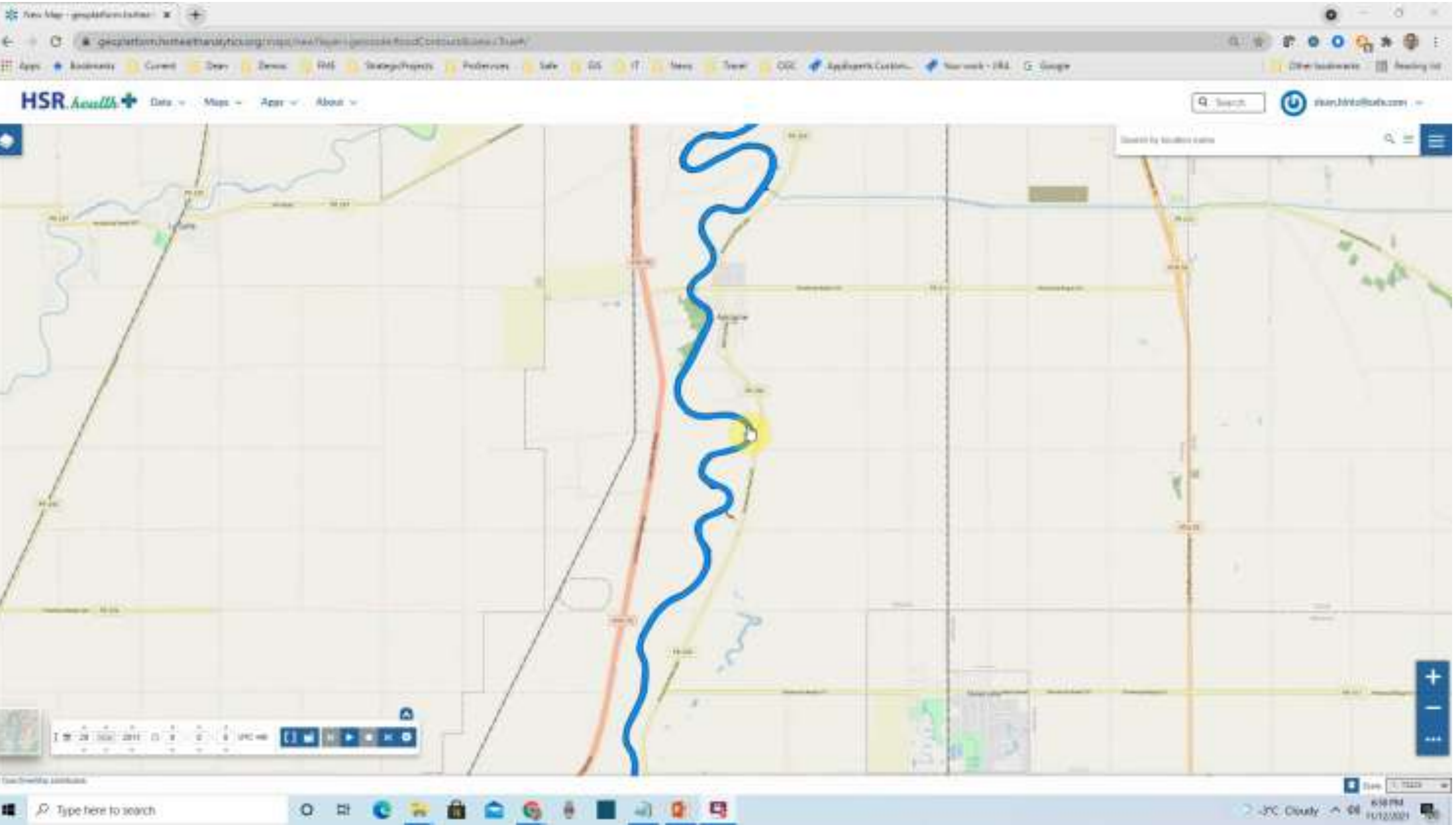
skymantics

DP2021: Flood Contour Geopackage: flooded areas south of Winnipeg



RSS Hydro flood model run for Apr 14 2011 timestep, classified by flood depths in meters (0.1, 0.3, 0.5, 1,2)

Flood Routing Recipe:
Flood Contours Published to Pilot GeoNode/GeoServer



DP21 Pilot GeoNode

- Layer search
- Metadata
- Styling
- Interactive web map interface
- Time Series
- Data download
- OGC web services: WMS / WFS

HSR.health

GeoSolutions

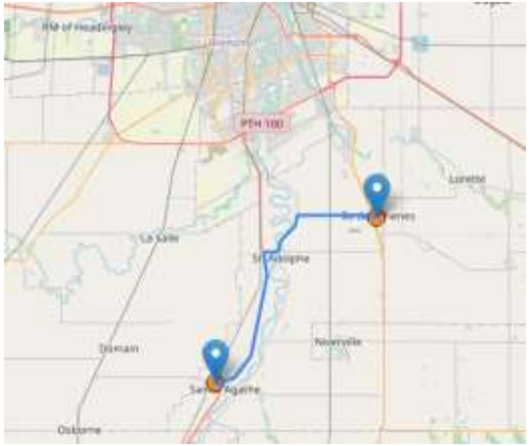
Open Geospatial Consortium

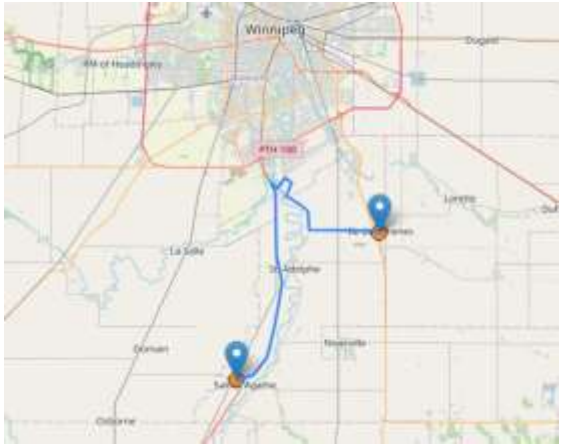
Routing Client for Exploring Decision Ready Indicators

Optimal route

Select flood levels for
Road restrictions

New optimal route





OGC Climate & Disaster Resilience Pilot 2024

- The Climate and Disaster Resilience pilot: Jan-Sep 2024
- 18 participating organizations

- **Main motivation**: Need for new methods, tools, and systems to better understand, predict, and address (natural) phenomena, including
  - intensification and changing patterns of typhoons
  - landslides
  - flooding
  - extreme heat events

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Urban Heat Island Effect - Challenge

- **Heat is the deadliest natural disaster**
- **Urban areas experience greater heat extremes** due to the heat absorbent artificial landscapes, lack of cooling vegetation and water
- Cities experience temperature increases > 7C
- 80% of US population lives in cities
- **No current real time warnings exist that incorporate localized UHI effect information**

“The urban heat island effect is a measurable increase in ambient urban air temperatures resulting primarily from the replacement of vegetation with buildings, roads, and other heat-absorbing infrastructure.”

U.S. Environmental Protection Agency

https://www.climatecentral.org/climate-matters/urban-heat-islands-2023

Heat Grid Depiction for Central Harlem

Input Data: NYC Open Data Surface Type & Impervious surfaces

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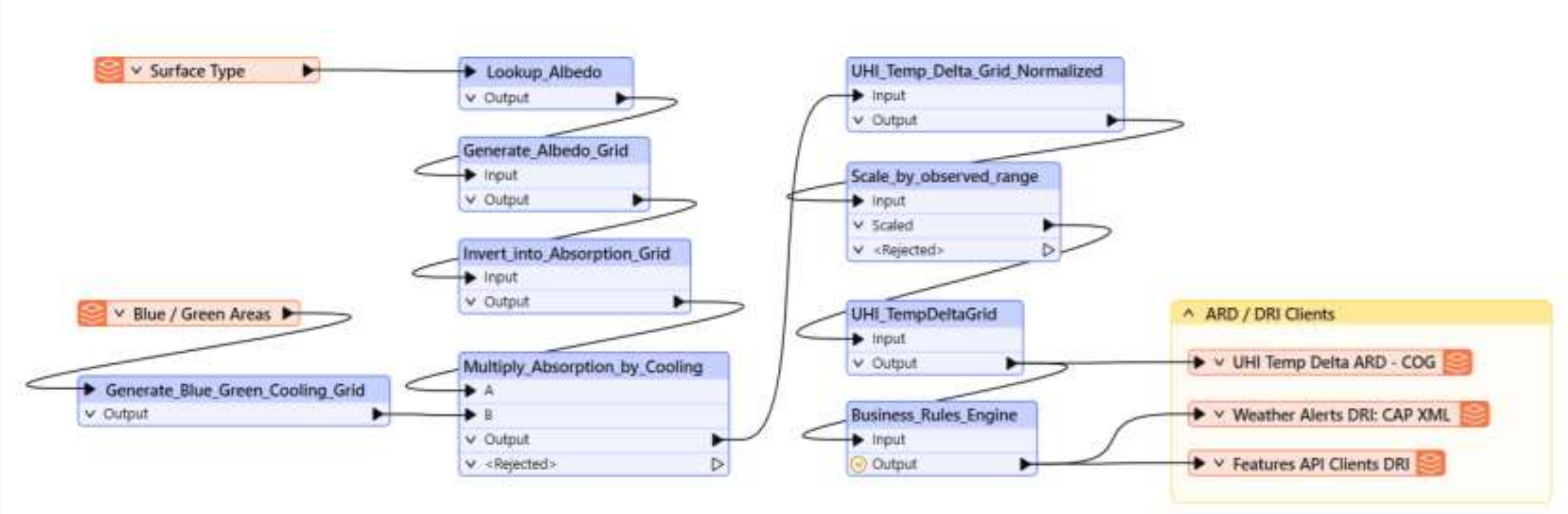
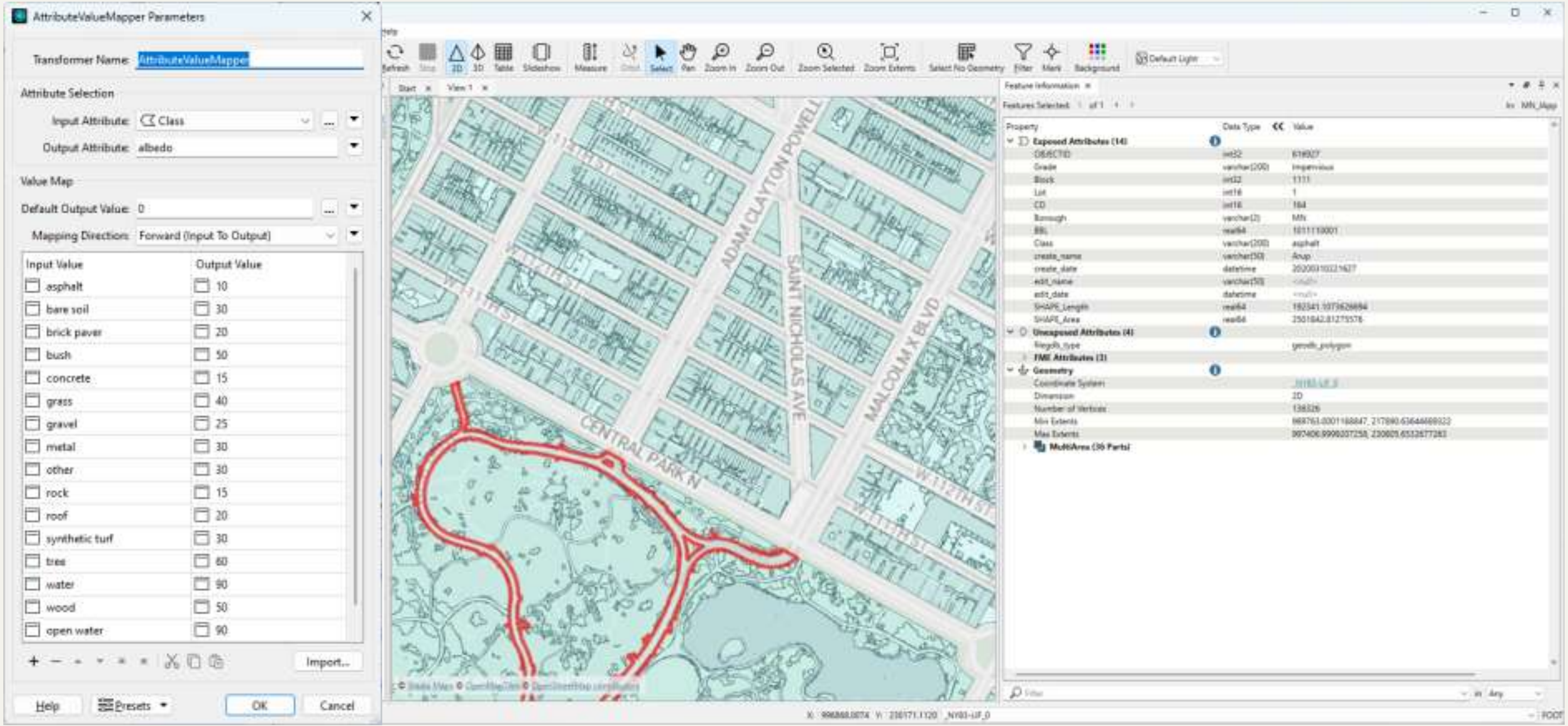


Urban Heat Island Delta Grid FME Workflow:

1. Generate albedo grid
2. Invert to absorption grid
3. Multiply by cooling grid
4. Normalize grid
5. Scale by observed UHI temp range
6. Generate outputs: UHI ARD - COG

FME by Safe Software

Heat Grid Depiction for Central Harlem
Input Data: NYC Open Data Surface Type



Heat Grid Depiction for Central Harlem

Raster Algebra Workflow to generate normalized UHI Temperature Delta Grid from Absorption and Cooling Grids

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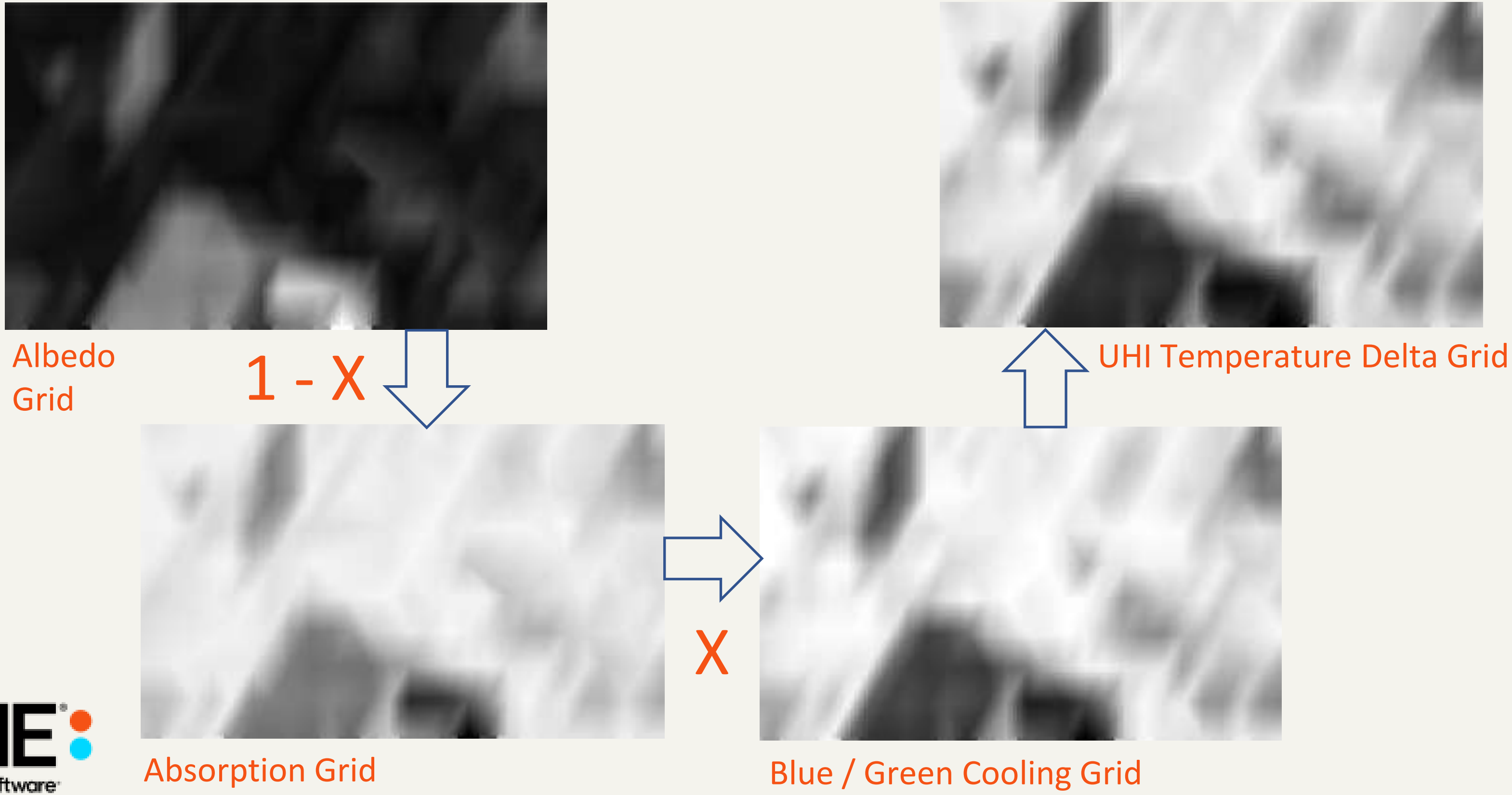

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Heat Grid Depiction for Central Harlem

UHI Grid ARD Scaled by Observed Heat Island Temperature Range (11 F)

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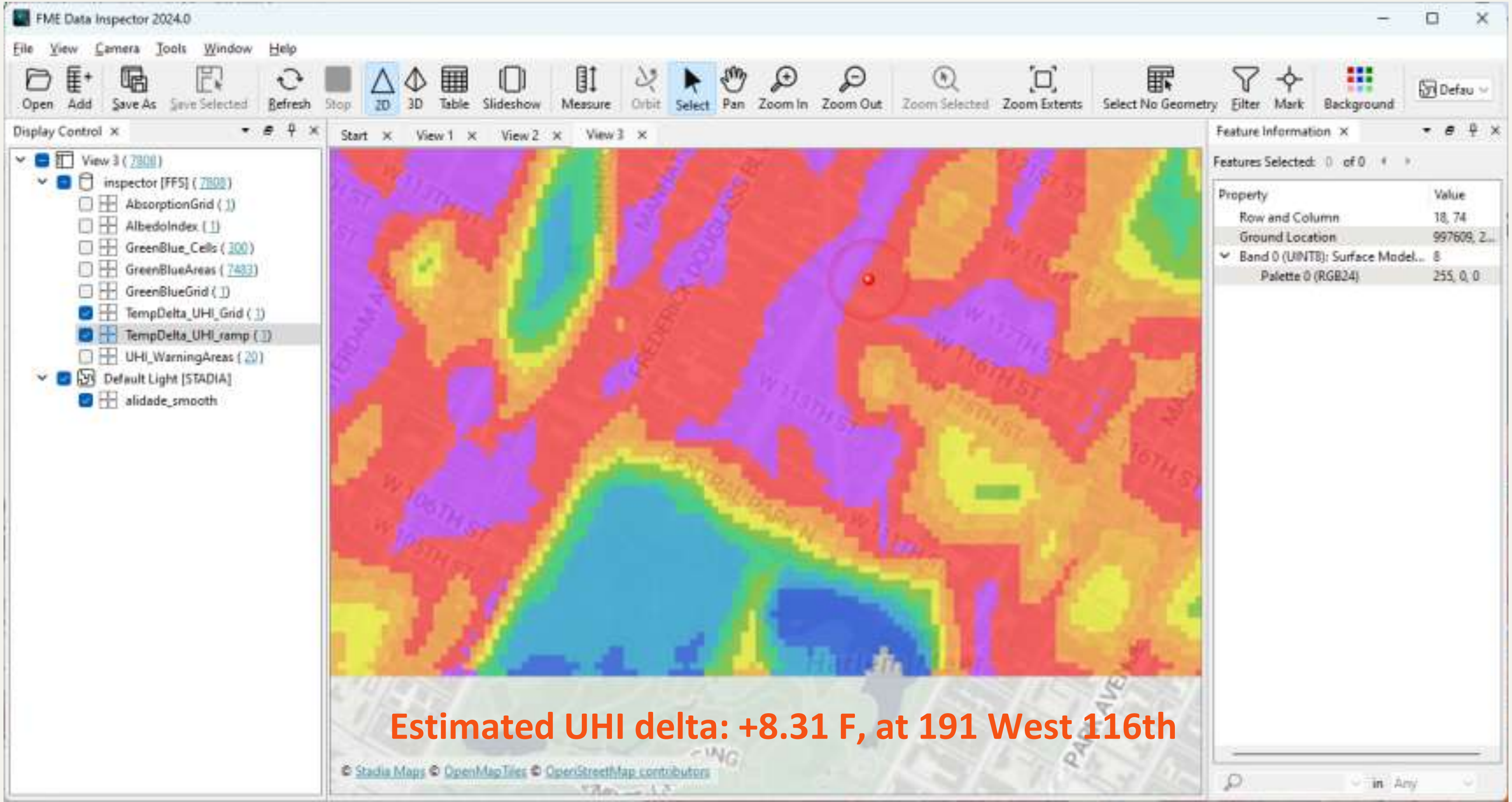

Heat Grid Depiction for Central Harlem

UHI Grid ARD Scaled by Observed Heat Island Temperature Range (11 F)

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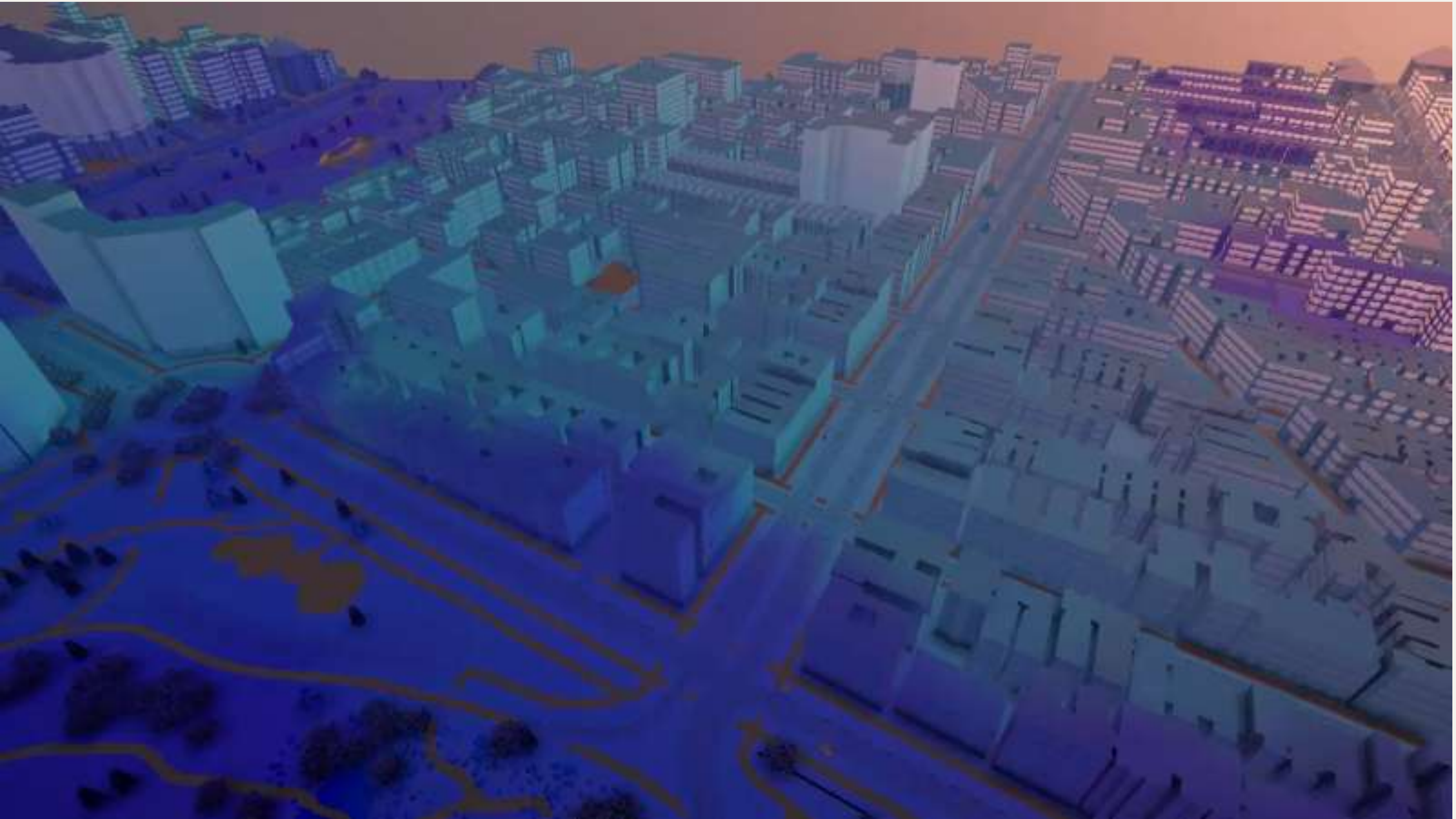

Estimated UHI delta: 12 hour daytime animation by Navteca using UHI ARD from FME

Navteca

FME by Safe Software

Alerts: Urban Temperature HTML Report

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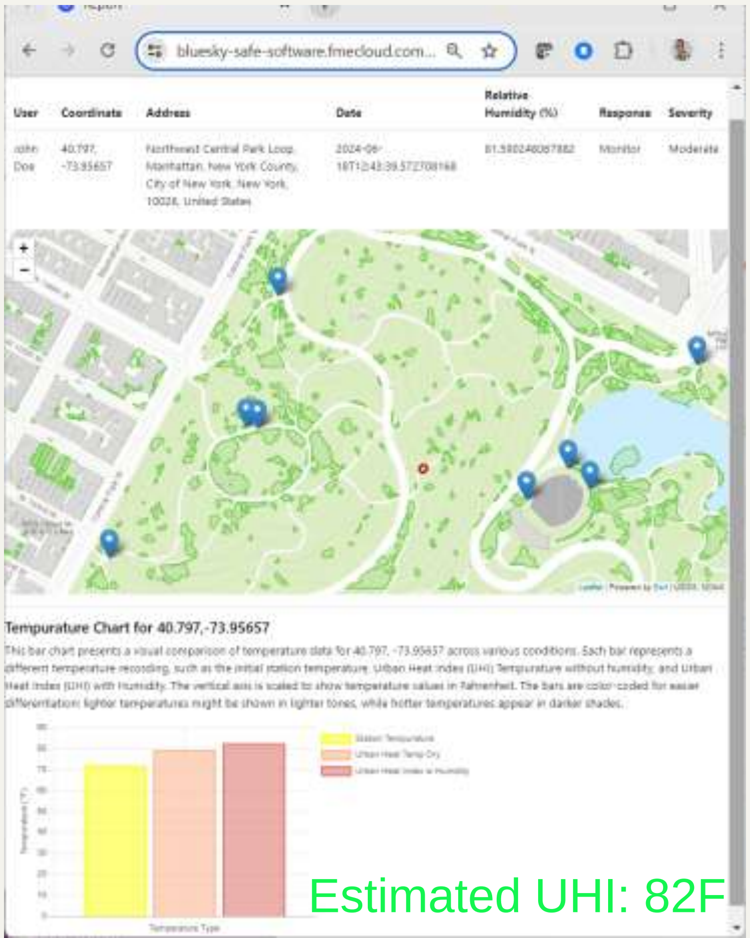
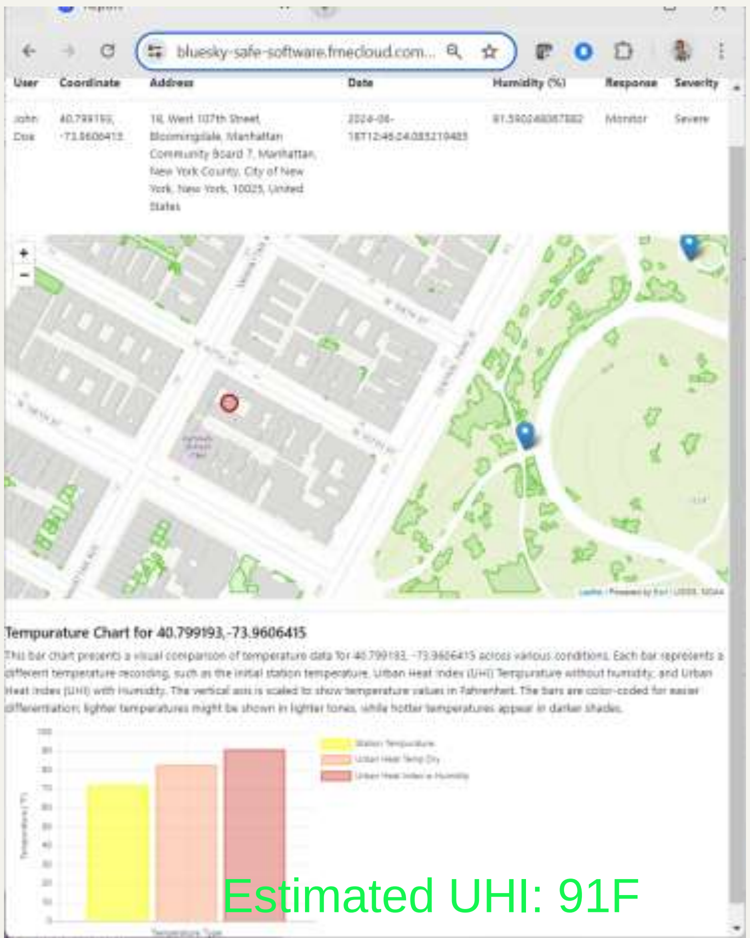
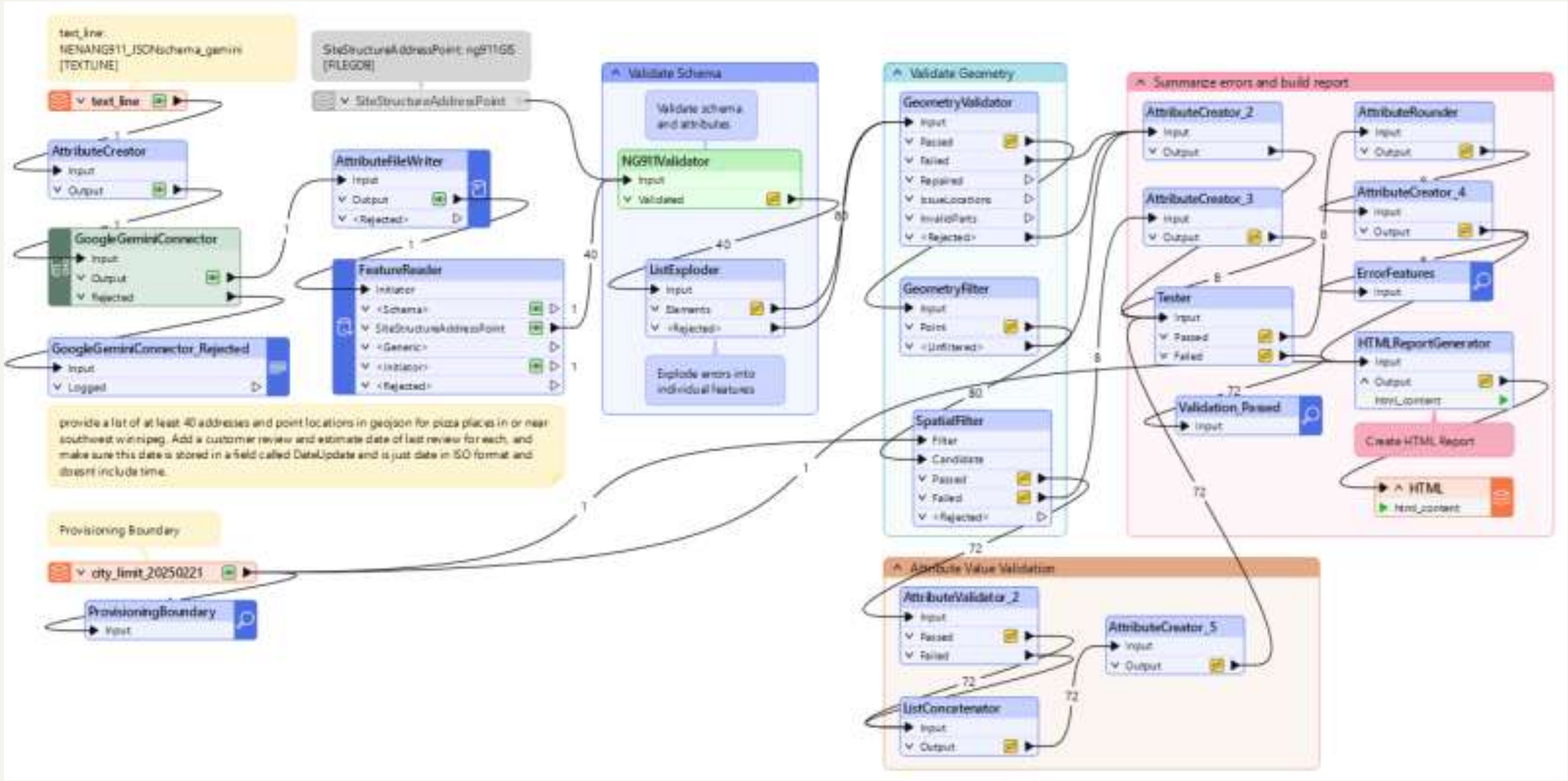




Leverage AI to generate and validate NG911 address data:
Structured Response Query using JSON Schema and GeoJSON



Weather & Climate Data Integration

Lessons Learned

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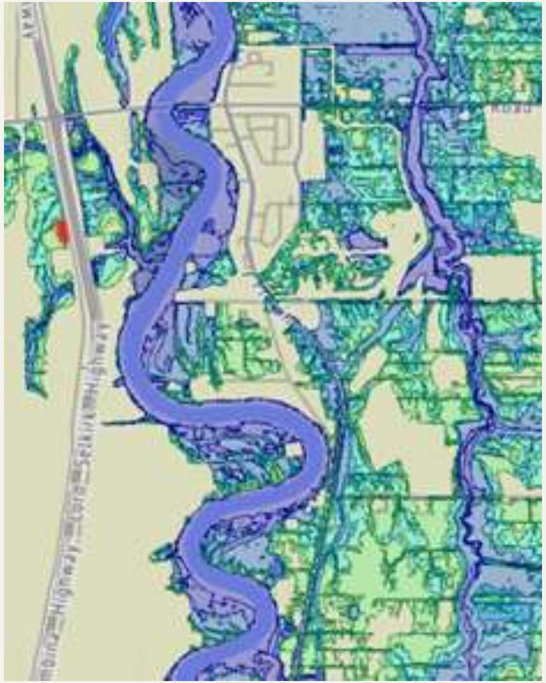
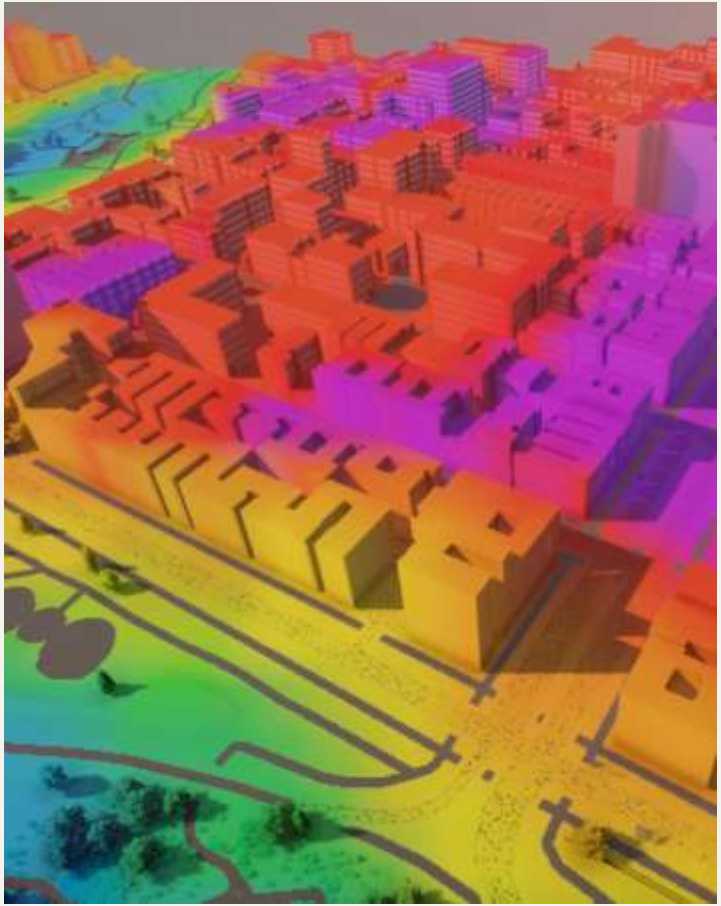
- **Start simple - most critical, influential data sources**
- **Open standards support** key for integration of complex data streams from diverse weather and climate models
- **Real time integration** from existing weather services
- Use higher resolution local data (e.g. DEMs, surface type) to increase effective resolution of forecast services
- **FME's support for** cloud native formats: read what you need - enhances scalability and cloud computing: COPC, ZARR
- **Optimization strategy**: evaluate requirements related to transactions volume vs data volume, response time requirements
- **Test scenarios** Develop realistic scenarios informed by experts & stakeholders





Summary

- Climate is changing, weather becoming more extreme
- Improving resilience is key. The right data is essential to supporting resilience workflows.
- The complexity, volume and speed of weather and climate and weather data can present challenges to building decision support applications
- FME provides a path forward with its support for no-code data transformation, open standards and scalable platform