



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

- 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.

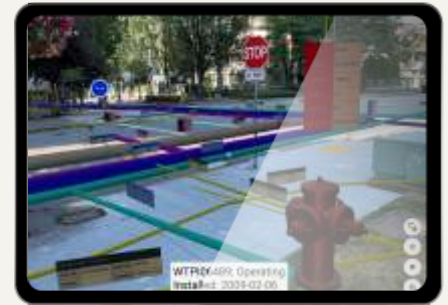


## FME Flow

Brings life to FME Form *workflows*

### FME Flow Hosted

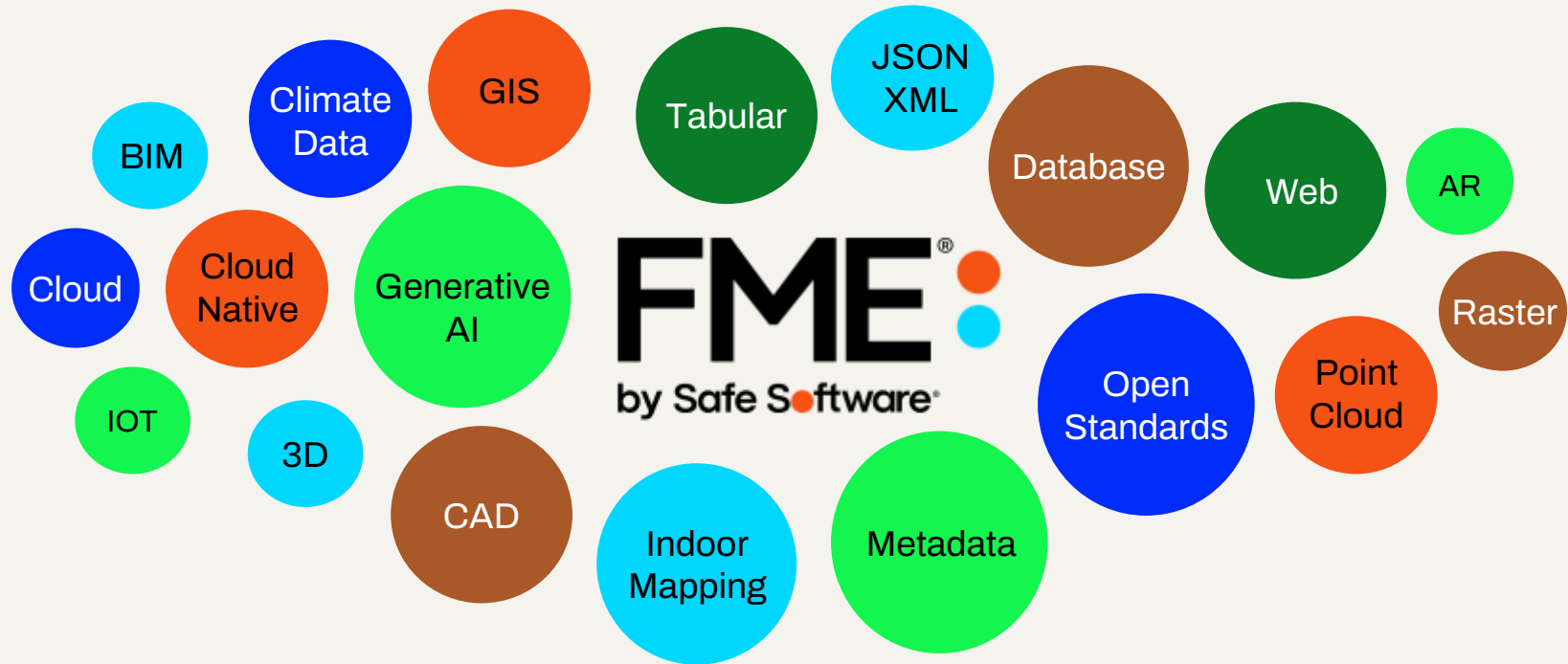
Safe Software SaaS Version of FME Flow



## FME Realize

Experience data in real world  
context, in real time.

# Unrivalled Data Support

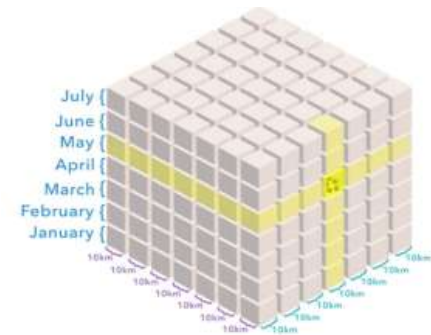


With 500+ supported data types in FME.

# 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*

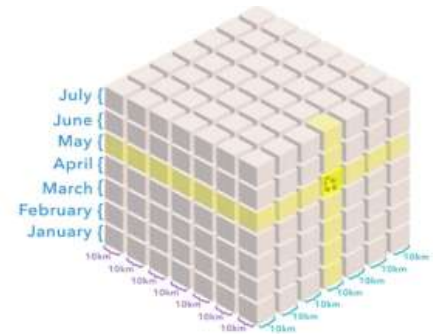


# Climate Resilience / Extreme Weather: FME Data Fusion

*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

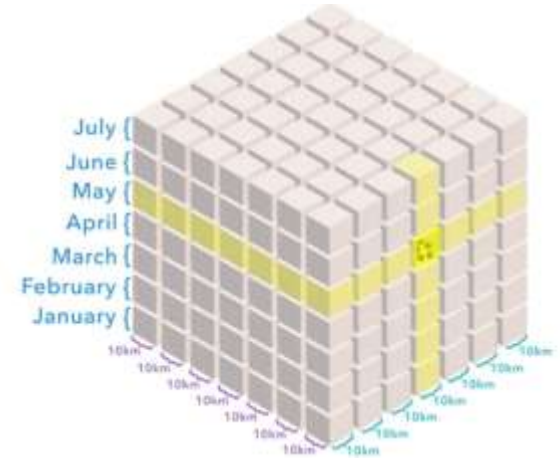
***Goal: Assess** weather and climate forecast variables to assess population and critical infrastructure impacts*



# 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

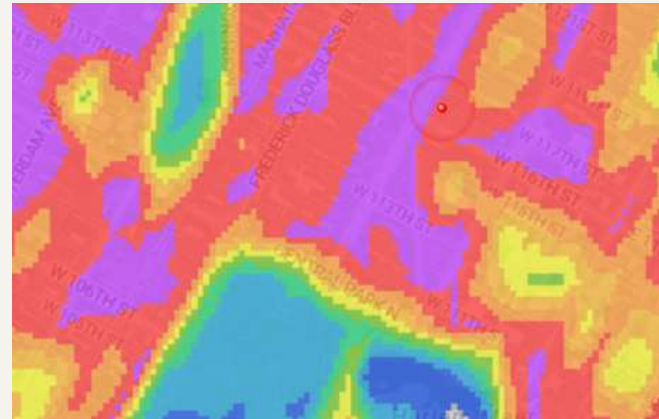
# Safe and OGC Open Standards: Vision

- 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**



# Climate Resilience Scenarios

- Drought
- Flood
- Fire
- Heat



# 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*



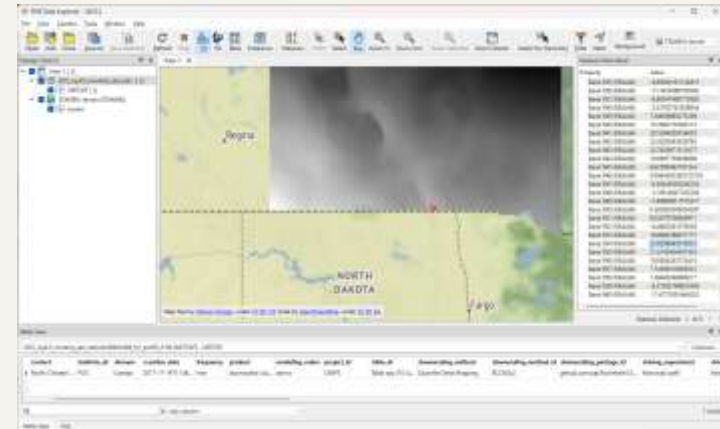
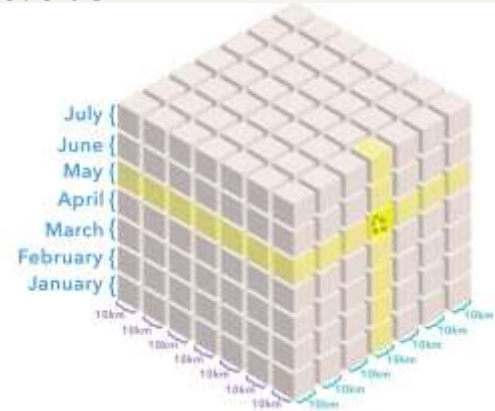
<https://www.ogc.org/initiatives/crp/>



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

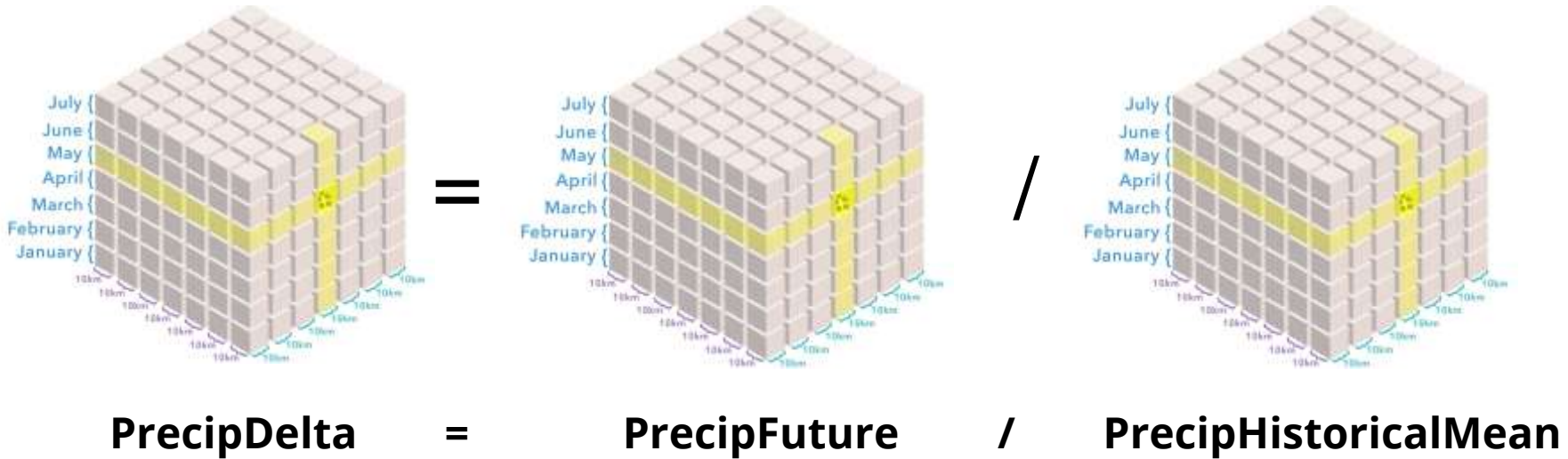
How to provide the data needed for climate impact and disaster indicators to local planners and stakeholders?

- **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

# MB Precipitation: Future Delta



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

# 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

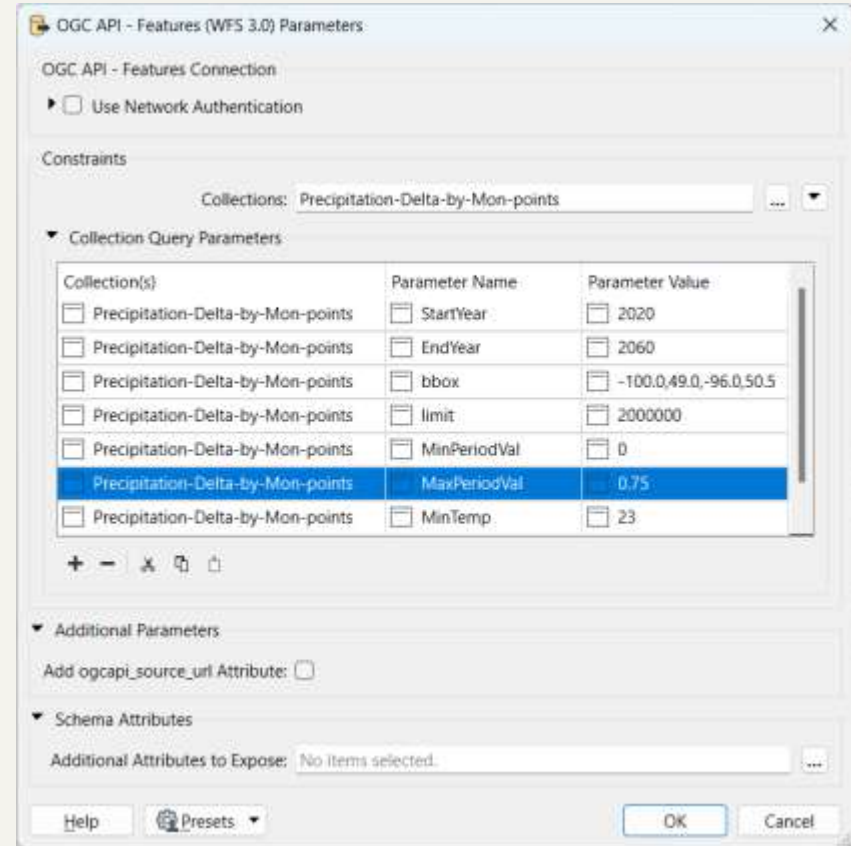
MinPeriodValue: 0 (PrecipDelta)

MaxPeriodValue: 0.75 (PrecipDelta)

MinTemp: 23C (Min Mean Monthly Temp)

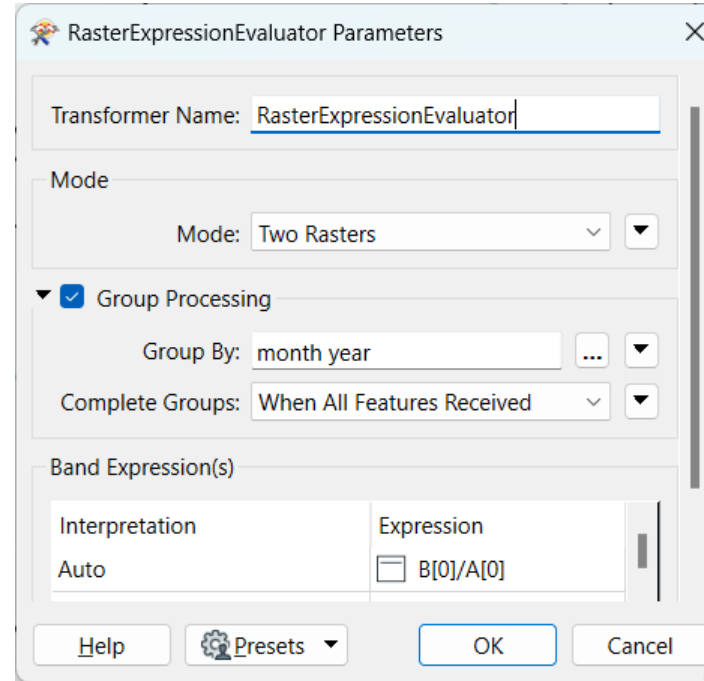
*Find all time step points over the next 40 years for southern Manitoba where projections indicate:*

- **> 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

The screenshot displays the FME Data Inspector 2022.2 interface. The main window shows a map of Manitoba, Canada, with a data layer representing precipitation and temperature. A 'Transition Parameter Values' dialog is open on the left, showing various parameters for the data layer. The 'Feature Information' panel on the right provides details for the selected feature, including its geometry, source file, and various data fields. A data table is visible at the bottom, showing the output of the data layer.

**Transition Parameter Values**

User Parameters:

- Block: -100.0, 49.0, -95.0, 52.0
- Start year: 2030
- End year: 2048
- Limit: 1000000
- Max temp: 40
- Min temp: 23
- Max precip: 100
- Min precip: 0
- Max precip index: 0.75
- Min precip index: 0
- Max period value: 9
- Min period value: 0

Save As User Parameter Default Values:  Save As User Parameter Default Values

Options: Presets: Run Cancel

**Feature Information**

Property	Value
downscaling_method (string)	Quantile Delta Mapping
driving_experiment (string)	historical/rcp45
fme_basename (string)	collection
fme_dataset (string; UTF-8)	https://disasterpilot-clean.fmecloud.co...
fme_geometry (string; UTF-8)	fme_point
fme_type (string; UTF-8)	fme_point
id (64 bit integer)	732735
json_type (string; UTF-8)	json_point
month (64 bit integer)	8
netcdf_data_variable.long_name	Precipitation.Temperature
netcdf_data_variable.name	pr_tmean
netcdf_data_variable.units	kg m-2 d-1
netcdf_title (string; UTF-8)	Bias Correction/Constructed Analogues...
ogcapi_type (string; UTF-8)	ogcapi_point
precipDeltaIndex (64 bit real)	0.53
precipTotalMon (64 bit real)	25.401
project_id (string; UTF-8)	CMIP5
source_file (string; UTF-8)	DCS_rcp4_5_monthly_abs_lation0.08x0.0...
target_institution (string)	Canadian Forest Service, Natural Resourc...
tempMeanMon (64 bit real)	23.009
year (64 bit integer)	2048
<b>IFMEPoint</b>	<b>-97.4583351, 49.0416683</b>

**collection [OGCAPI\_FEATURES] - Precipitation-Delta-by-Mon-points**

id	date	year	YY	month	source_file	precipTotalMon	precipDeltaIndex	tempMeanMon	contact	project_id	downscaling_method	driving_experiment	target_insti
1	2048-08-01	2048		8	DCS_rcp4_5_mo...	25.401	0.53	23.009	Pacific Climate L...	CMIP5	Quantile Delta Mapping	historical/rcp45	Canadian For
2	2048-08-01	2048		8	DCS_rcp4_5_mo...	25.535	0.533	23.01	Pacific Climate L...	CMIP5	Quantile Delta Mapping	historical/rcp45	Canadian For
3	2048-08-01	2048		8	DCS_rcp4_5_mo...	26.035	0.537	23.006	Pacific Climate L...	CMIP5	Quantile Delta Mapping	historical/rcp45	Canadian For

1 selected / 63 row(s)

# 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



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 km<sup>2</sup>, 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

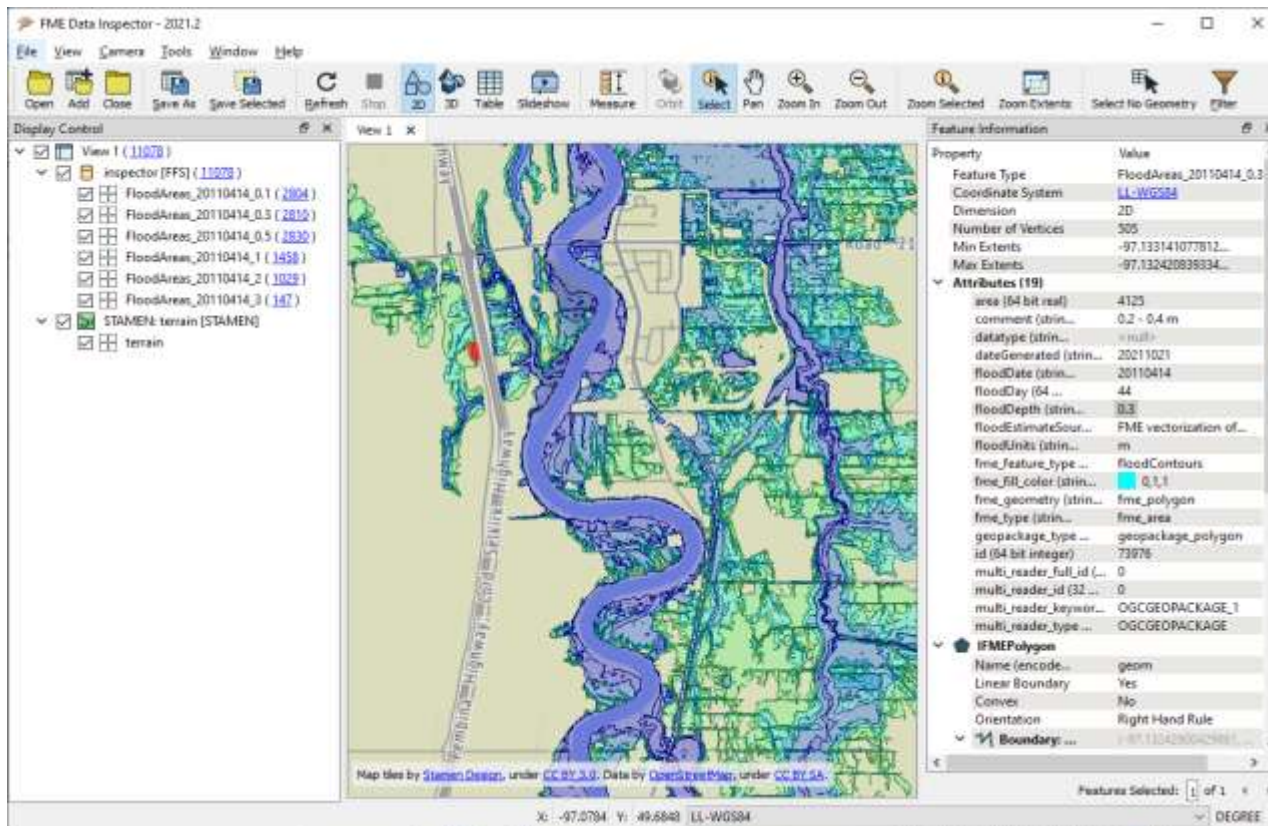
*Red River Flood 2011 - Highest water levels and flows in modern history - three million hectares*

[https://www.gov.mb.ca/mit/wms/rrf/historical\\_2011.html](https://www.gov.mb.ca/mit/wms/rrf/historical_2011.html)



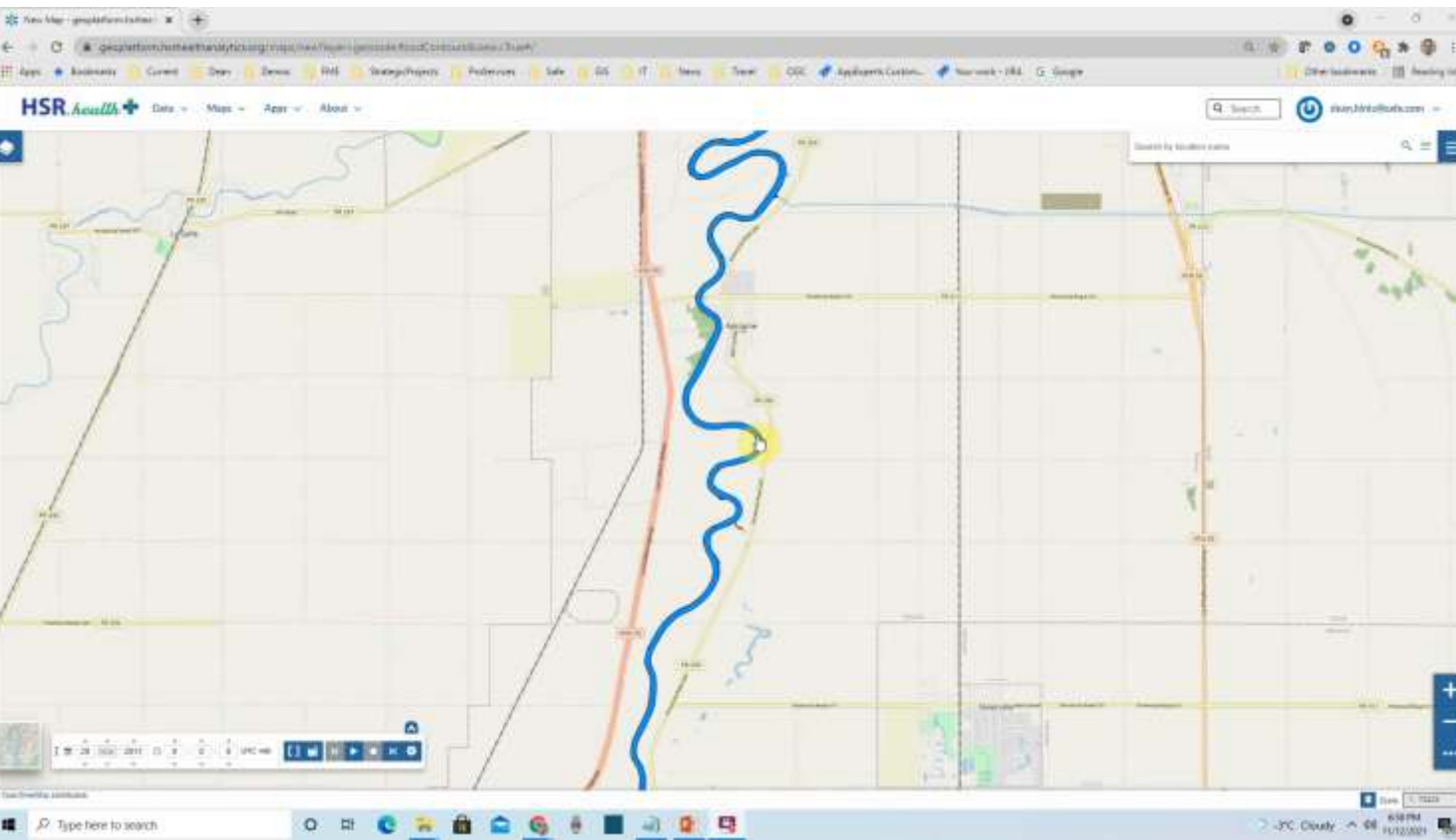


# DP2021: Flood Contour Geopackage: flooded areas south of Winnipeg



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**

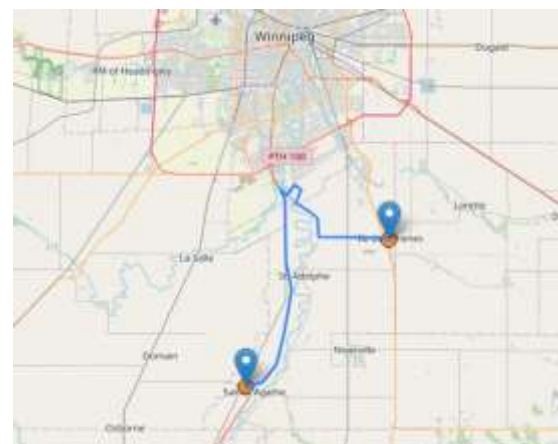
**Open Geospatial Consortium**

# 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



# 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.”*

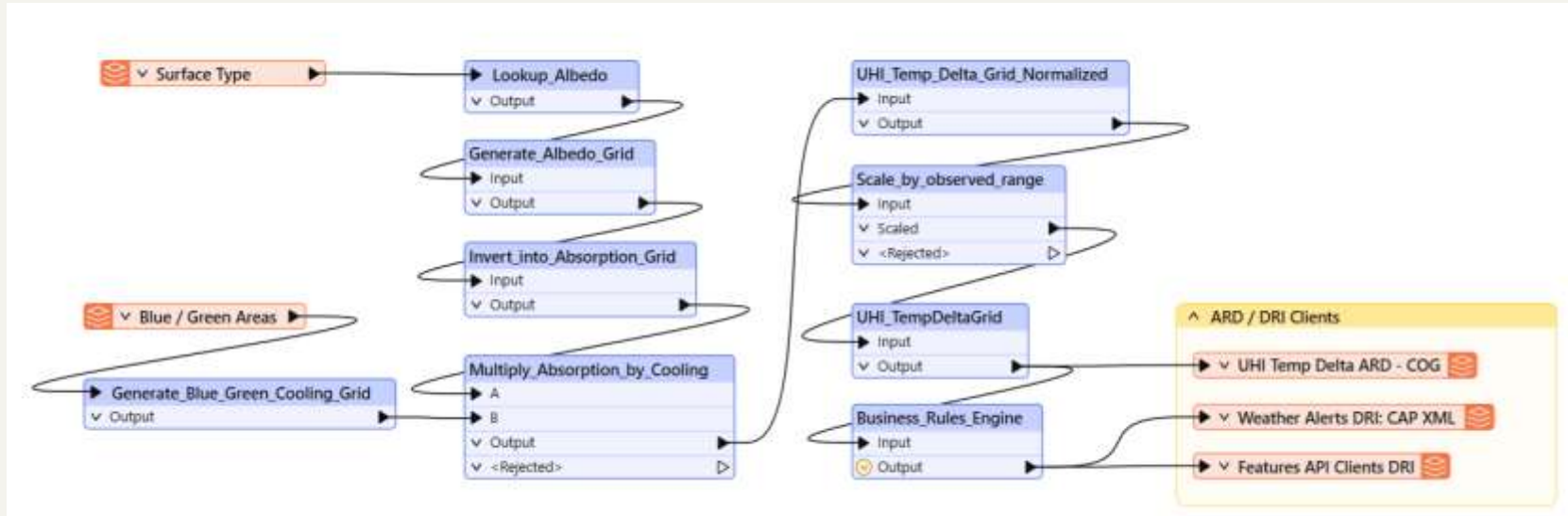
U.S. Environmental Protection Agency

<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



## 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

# Heat Grid Depiction for Central Harlem

## Input Data: NYC Open Data Surface Type

AttributeMapper Parameters

Transformer Name: **AttributeMapper**

Attribute Selection

Input Attribute: **Class**

Output Attribute: **albedo**

Value Map

Default Output Value: **0**

Mapping Direction: **Forward (Input To Output)**

Input Value	Output Value
<input type="checkbox"/> asphalt	<input type="checkbox"/> 10
<input type="checkbox"/> bare soil	<input type="checkbox"/> 30
<input type="checkbox"/> brick paver	<input type="checkbox"/> 20
<input type="checkbox"/> bush	<input type="checkbox"/> 50
<input type="checkbox"/> concrete	<input type="checkbox"/> 15
<input type="checkbox"/> grass	<input type="checkbox"/> 40
<input type="checkbox"/> gravel	<input type="checkbox"/> 25
<input type="checkbox"/> metal	<input type="checkbox"/> 30
<input type="checkbox"/> other	<input type="checkbox"/> 30
<input type="checkbox"/> rock	<input type="checkbox"/> 15
<input type="checkbox"/> roof	<input type="checkbox"/> 20
<input type="checkbox"/> synthetic turf	<input type="checkbox"/> 30
<input type="checkbox"/> tree	<input type="checkbox"/> 60
<input type="checkbox"/> water	<input type="checkbox"/> 90
<input type="checkbox"/> wood	<input type="checkbox"/> 50
<input type="checkbox"/> open water	<input type="checkbox"/> 90

Help Presets OK Cancel

Feature Information

Features Selected: 1 of 1

Property

Exposed Attributes (14)

Property	Data Type	Value
OBJECTID	int32	619027
Grade	varchar(200)	Impervious
Block	int32	1171
Lot	int16	1
CD	int16	164
Borough	varchar(2)	MT
BB	varchar(4)	101110001
Class	varchar(200)	asphalt
create_name	varchar(30)	Asp
create_date	datetime	2020011012:16:17
edit_name	varchar(30)	
edit_date	datetime	
SHAPE_Length	real64	192341.9373626854
SHAPE_Area	real64	2501842.812755376

Unexposed Attributes (4)

FMG Attributes (3)

Geometry

Coordinate System

Dimension

Number of Vertices

Min Extent

Max Extent

MultiArea (30 Parts)

X: 90888.0074 Y: 216171.1320\_NY03-UP-D

# Heat Grid Depiction for Central Harlem

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



Albedo Grid

$1 - X$



UHI Temperature Delta Grid



Absorption Grid



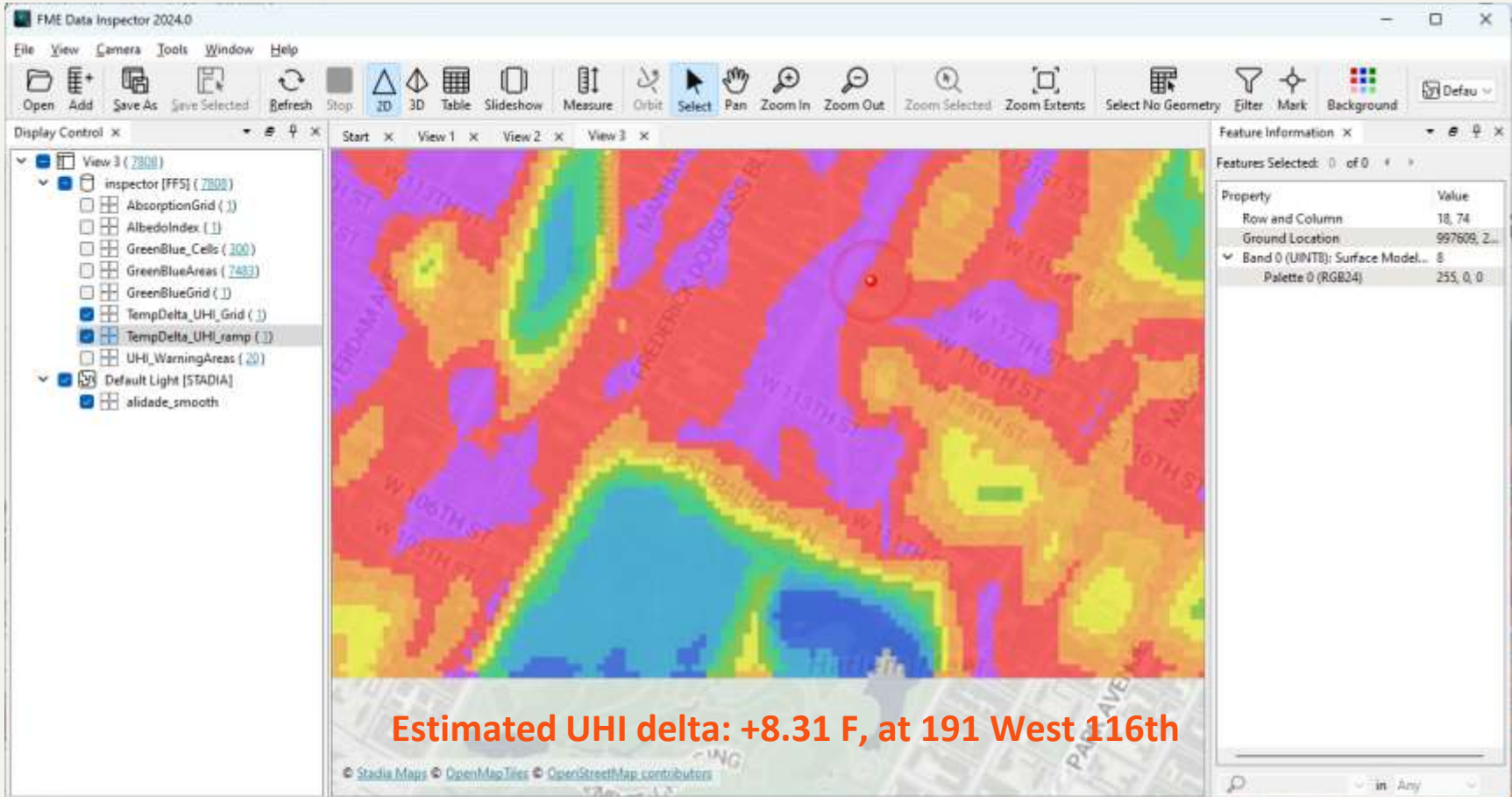
$X$



Blue / Green Cooling Grid

# Heat Grid Depiction for Central Harlem

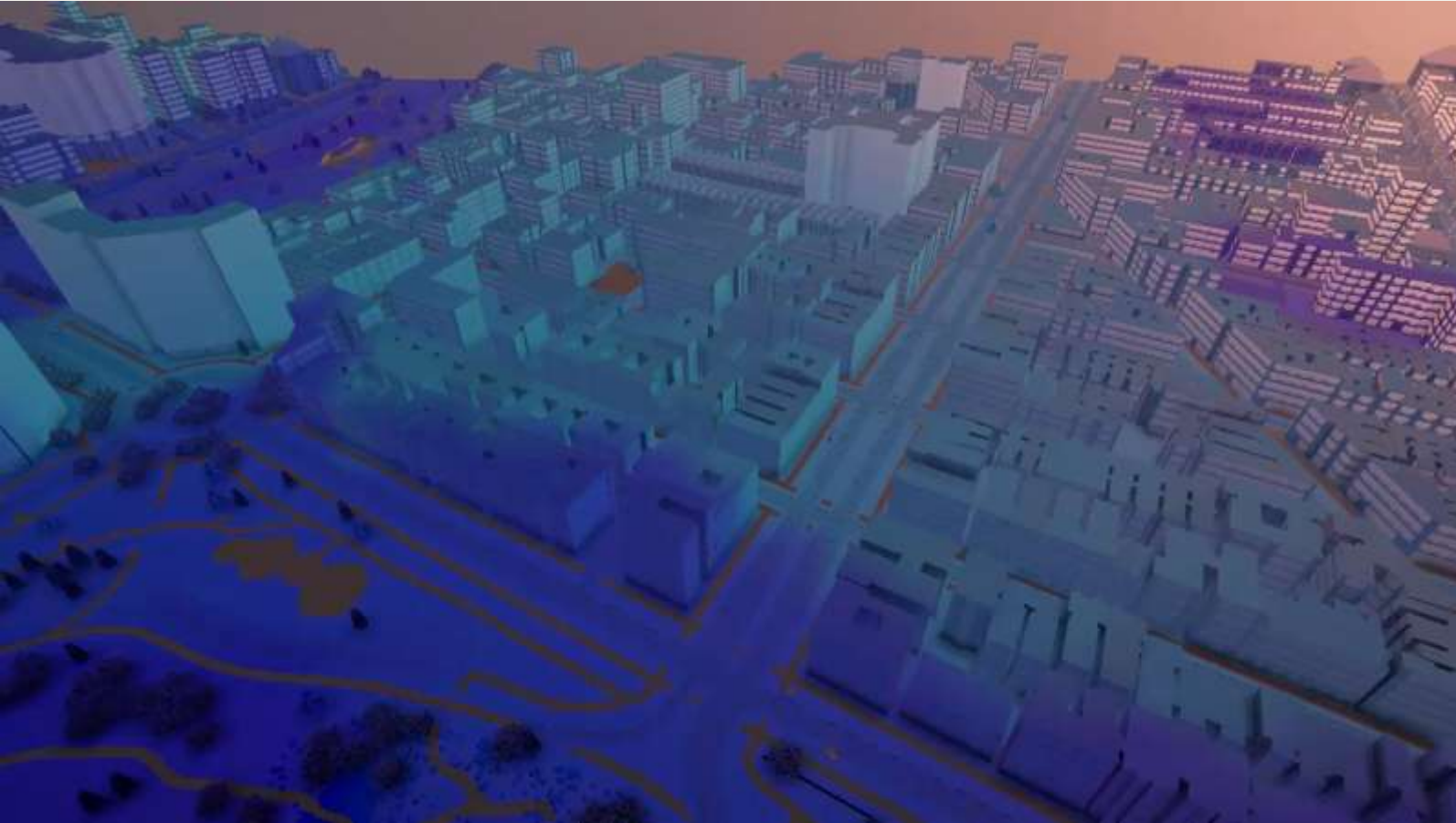
## UHI Grid ARD Scaled by Observed Heat Island Temperature Range (11 F)



# Heat Grid Depiction for Central Harlem

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

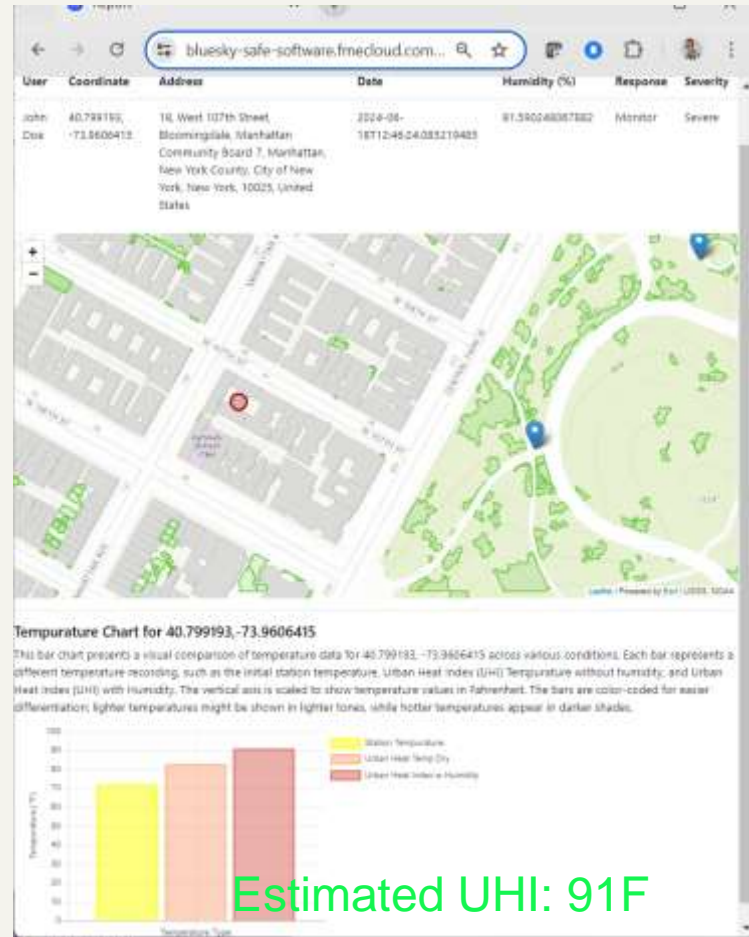
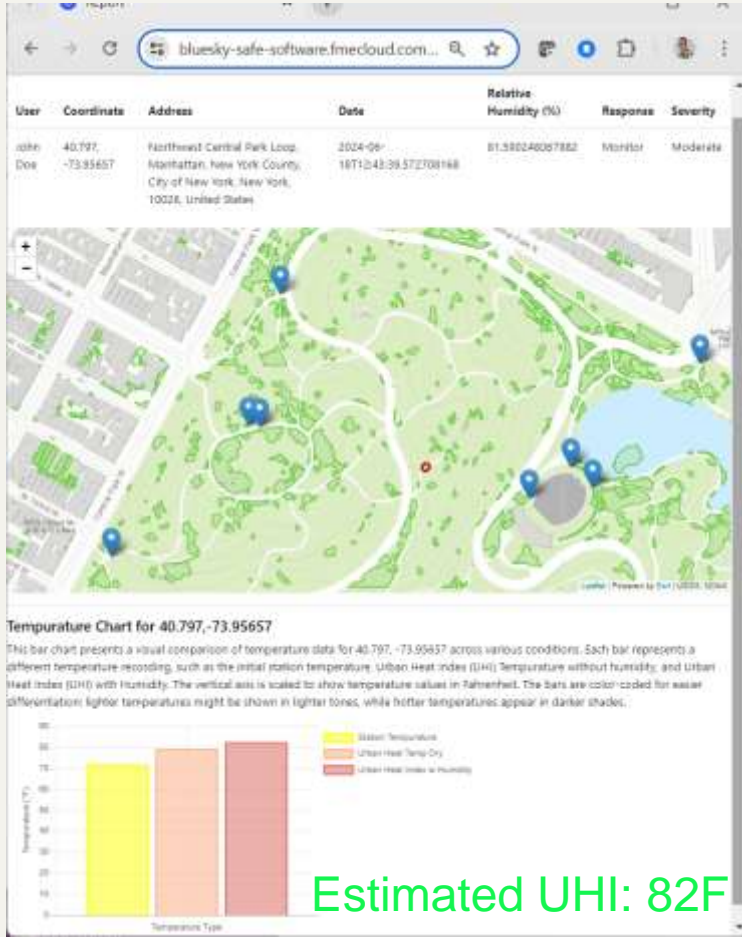
Safe Software



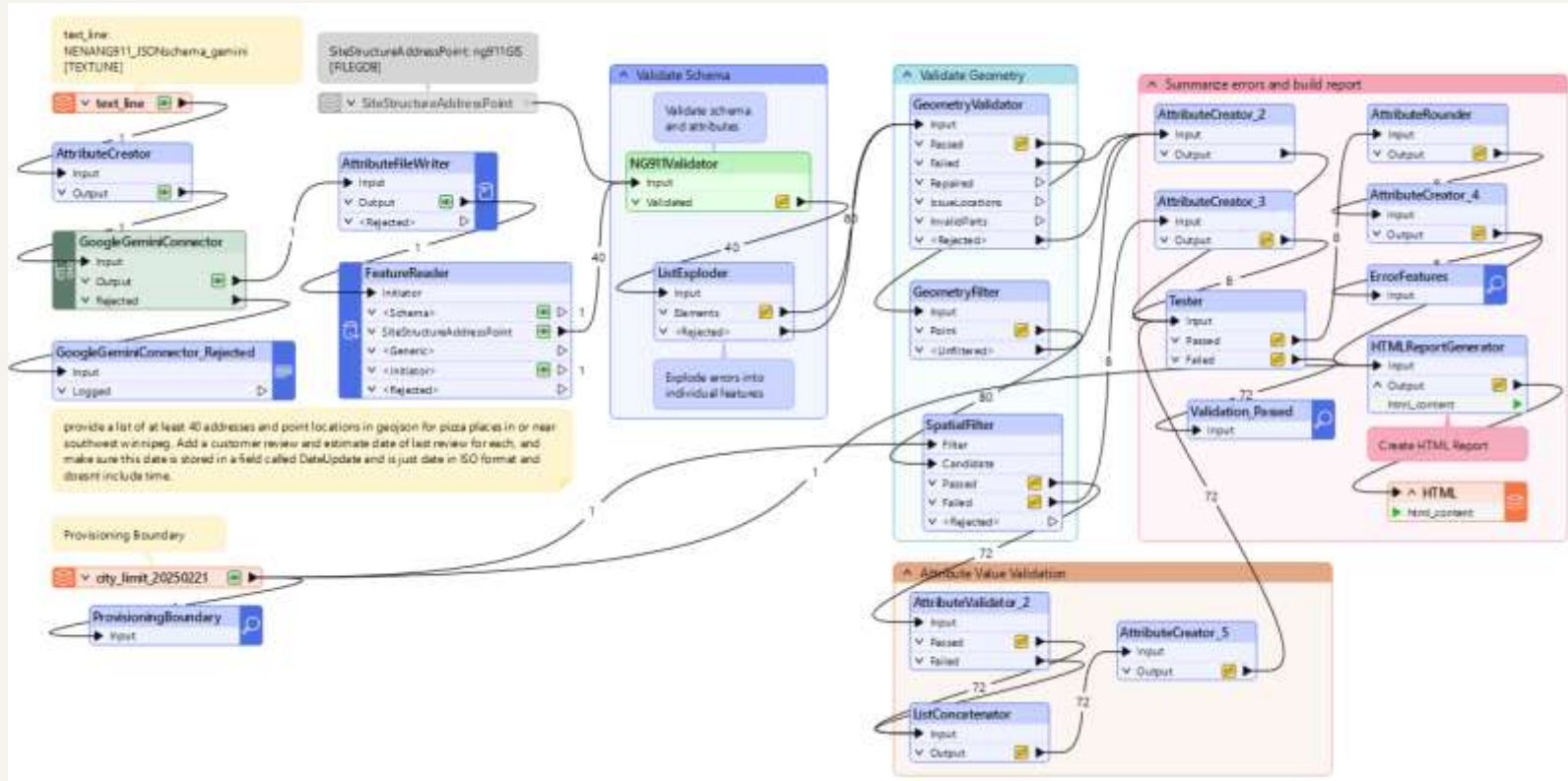
Estimated UHI  
delta: 12 hour  
daytime  
animation by  
Navteca using  
UHI ARD from  
FME



# Alerts: Urban Temperature HTML Report



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

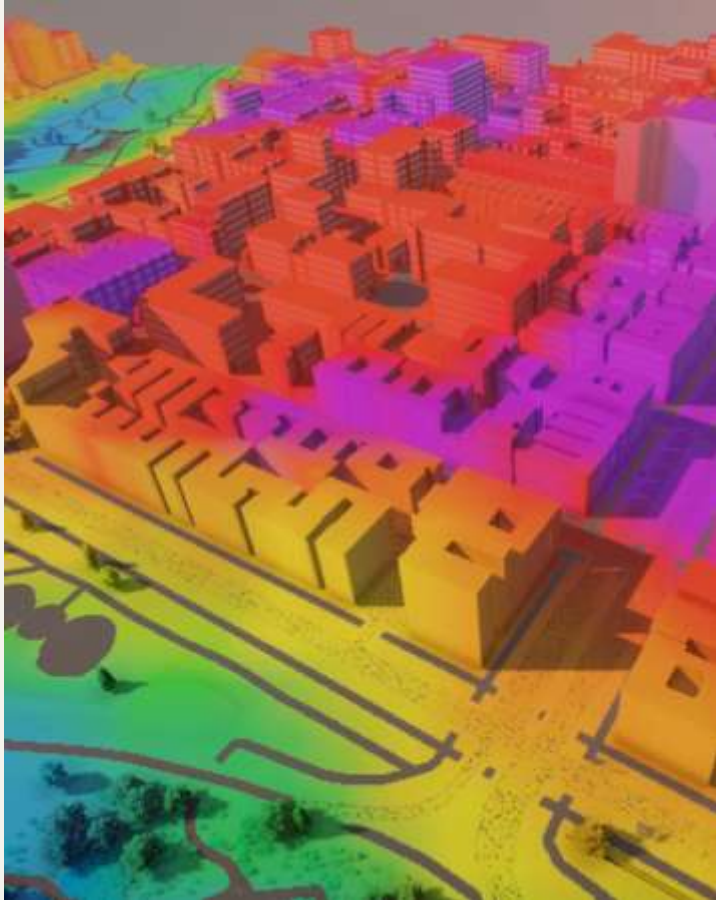


# Weather & Climate Data Integration

## Lessons Learned

- **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