Data Science at DLR

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Data Science at DLR

- Data science ∈ DLR's new cross cutting initiative on digitization
- Foundation of DLR Institute "Data Science" in Jena
- Current and future use cases:
    - Space Debris
    - Digital Aircraft
    - Distributed Post-Processing
    - Interactive Planetary Science Data Exploration
    - Earth Observation
    - …

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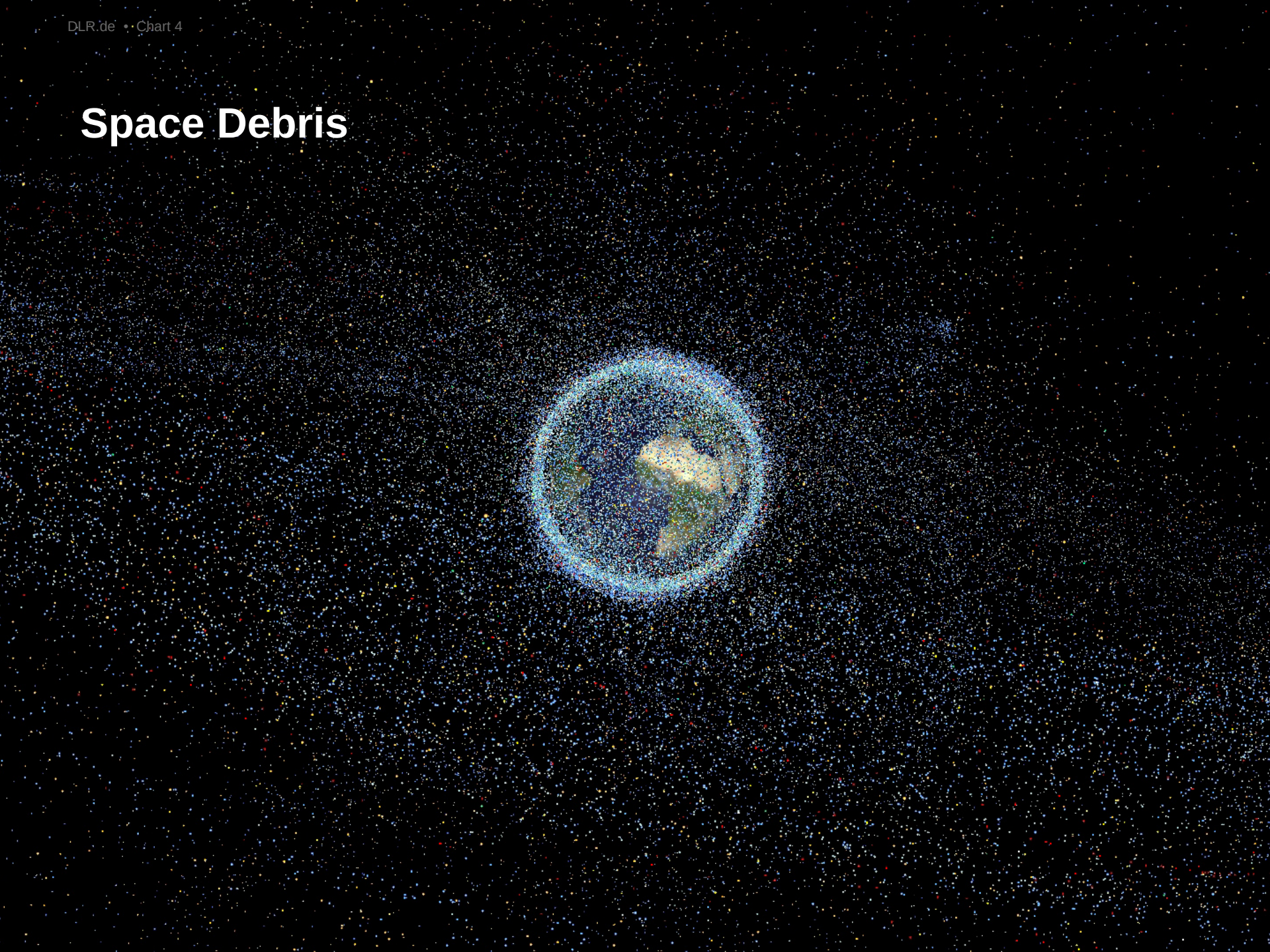
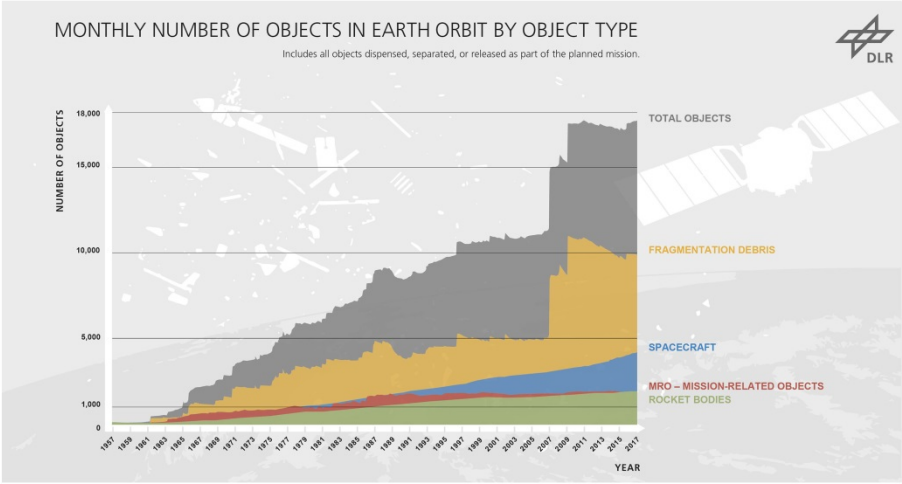
Space Debris



Data Science at DLR
Space Debris

- Human made objects in space without function
  - Rocket bodies (upper stages)
  - Mission related debris
  - Decommissioned satellites
  - Fragmentation debris
- Debris Catalogues
  - Managed and hosted by U.S. Space Surveillance Network
    - ~18 k parts > 10cm, 2016
  - Weltraumlagezentrum WLZ Uedem merges catalogues with own data
- Simulations estimate much higher number of objects
  - 750 k objects in orbit (>1cm)
  - ~ 150 M objects (>1mm)
  - Space debris speed: roughly 8 km/s
- Most debris between 800 and 900 kilometers



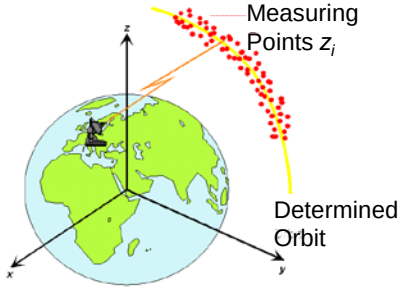
Source: NASA

Fig.: Impact of object on aluminum

Data Science at DLR
Space Debris

Backbone Catalogue of Relational Debris Information (BACARDI)

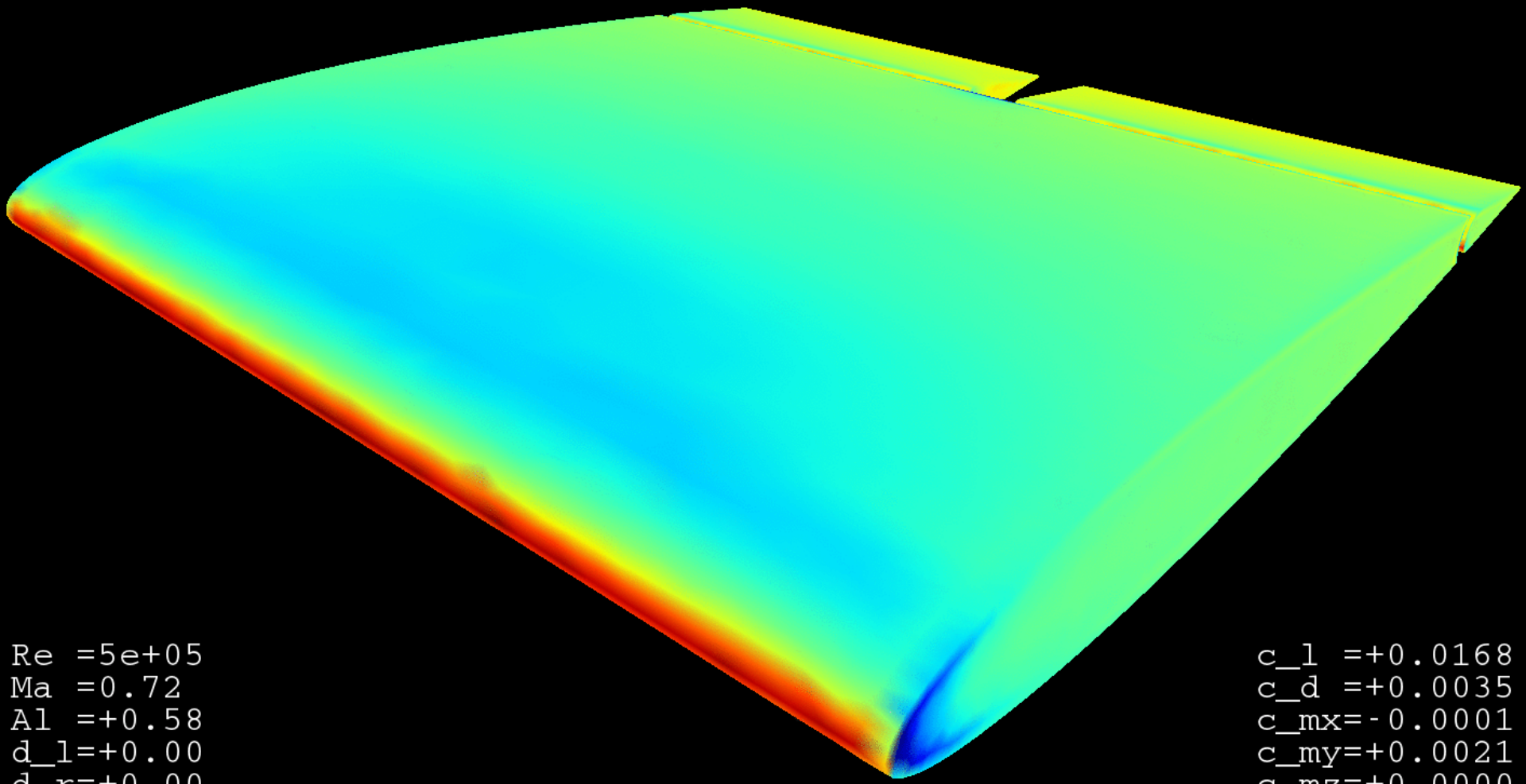
- Goals
  - Development of database for debris trajectories
    - Nearly complete (as far as possible)
    - High precision
  - Primary Sources: Sensors and operational data
  - Secondary Sources: Externally generated data
- Research and Development
  - Database for up to 1 M objects
  - Fast computation for trajectory determination, propagation, object identification, detection of maneuvers and fragmentations, …
- Mission Support
  - Trajectory information
  - Collision prediction
  - Re-entry prediction
  - …



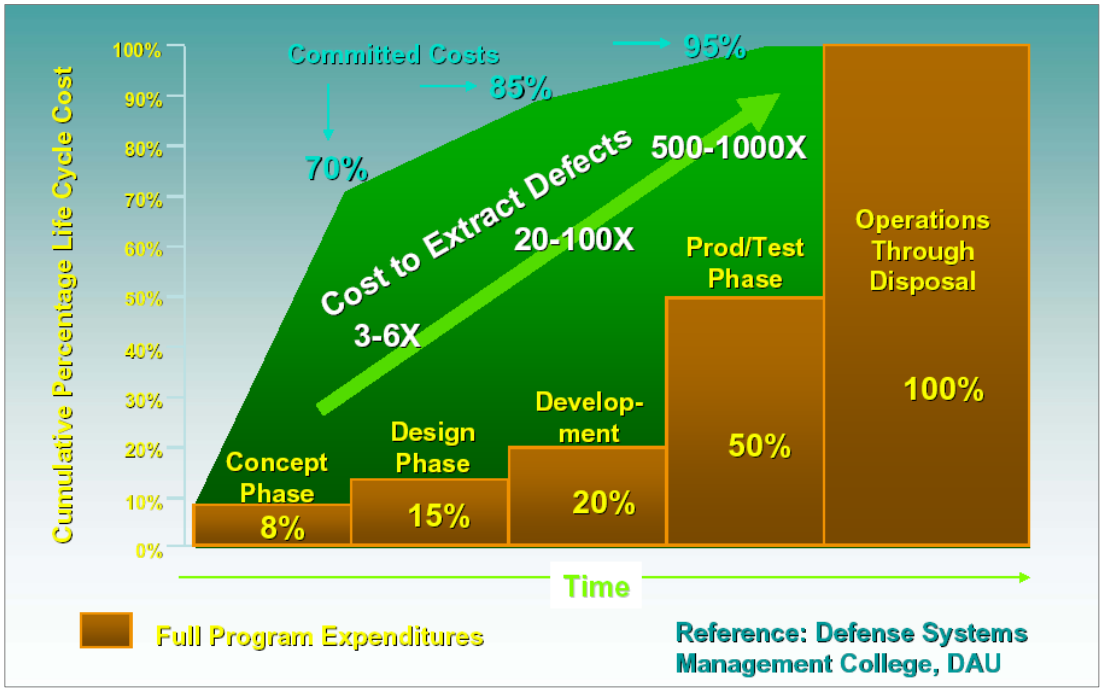
Orbit Prediction by Averaging:

$$\sum_i [z_i - f_i(\mathbf{r}, v)]^2 = Min$$

Digital Aircraft



Data Science at DLR
Digital Aircraft



- Concept and design phase commit 80% of total cost
- Cost to extract/correct defects increase by:
  - Factor 3-6 at project start
  - Factor 500-1000 towards project end

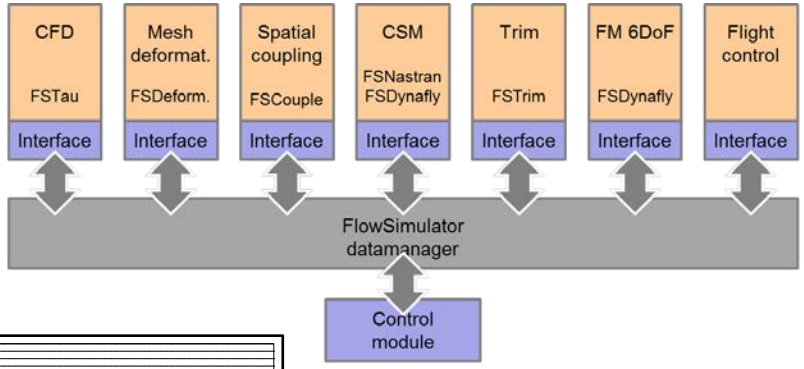
➔ Virtual Aircraft – Representation of all important properties driving aircraft design in one model

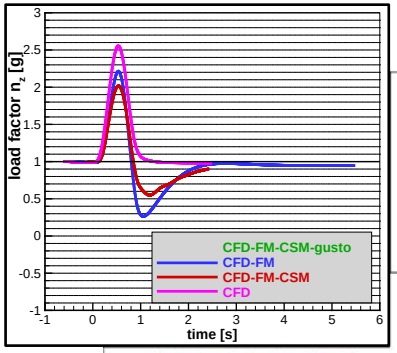
Data Science at DLR
Digital Aircraft

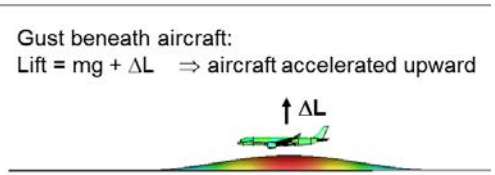
Flying the Equations

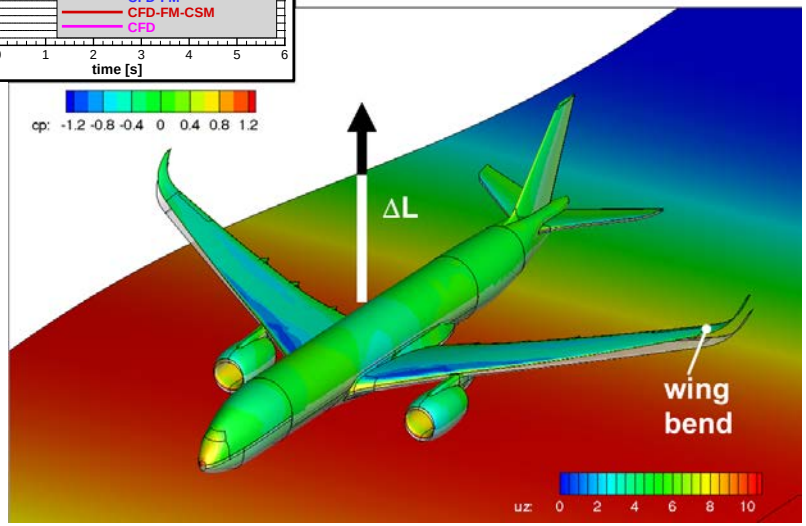
- Gust Load Prediction (Example)
  - M = 0.836
  - m = 150t
  - Re = 77 x 10^6
  - H = 8.2 km
  - Vertical gust, v_{gust} = 10.52 m/s

- Approach
  - Compute aircraft in aero-elastic equilibrium
  - Fulfill trim conditions
  - Perform unsteady coupled simulation







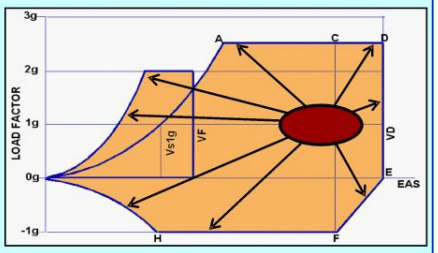


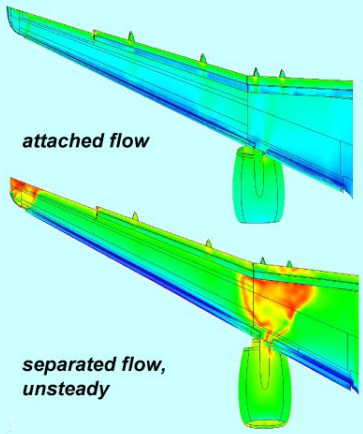
Data Science at DLR
Digital Aircraft

Flying through the Database

Full flight envelope coverage:

CFD mostly done near cruise point





configurations:

clean

airbrakes deployed

high lift

- 50 flight points
- 100 mass cases
- 10 a/c configurations
- 5 maneuvers
- 20 gusts (gradient lengths)
- 4 control laws

~ 20,000,000 simulations

Engineering experience for **current** configurations and technologies

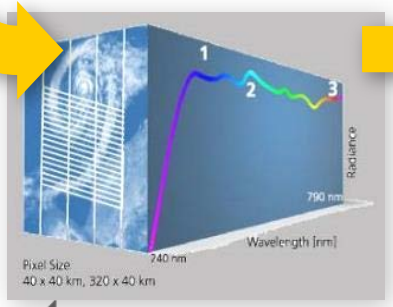
~ 100,000 simulations

Earth Observation – End-to-End Production Chain

Data reception

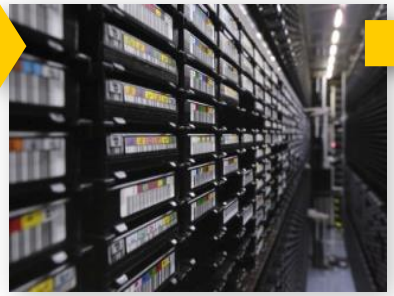
Science & Application

Calibration

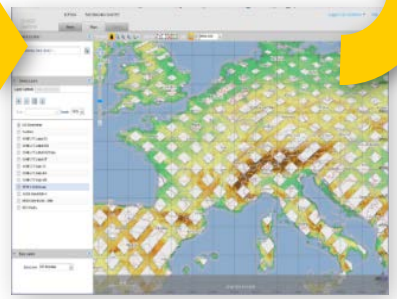


Product generation

Archiving



Access

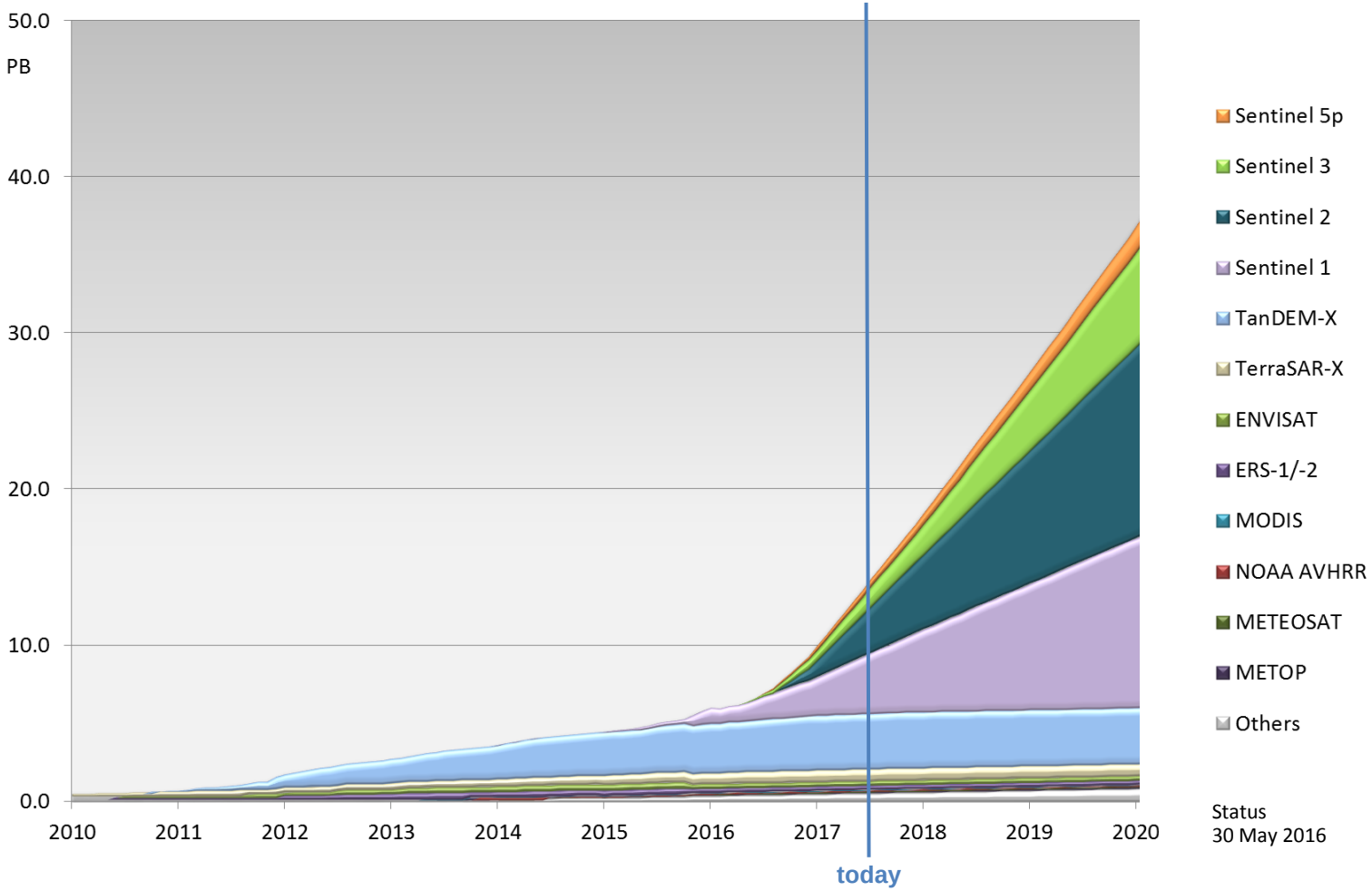


DLR

Data Cubes – Decadal Time Series for Climate Research

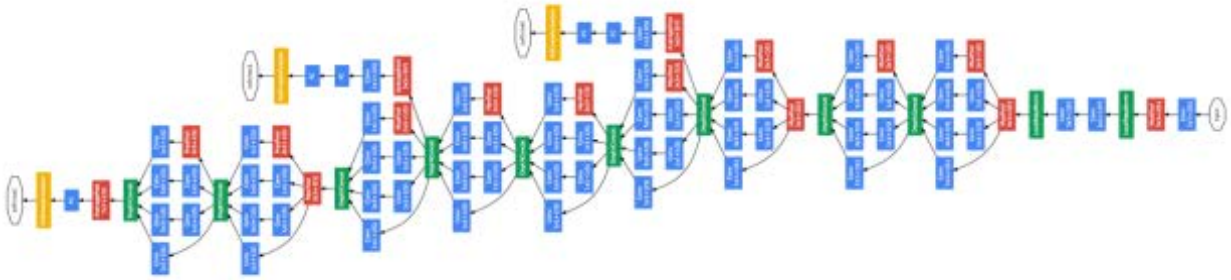
Evolution of Arctic Sea Ice

German Satellite EO Data Archive at DLR



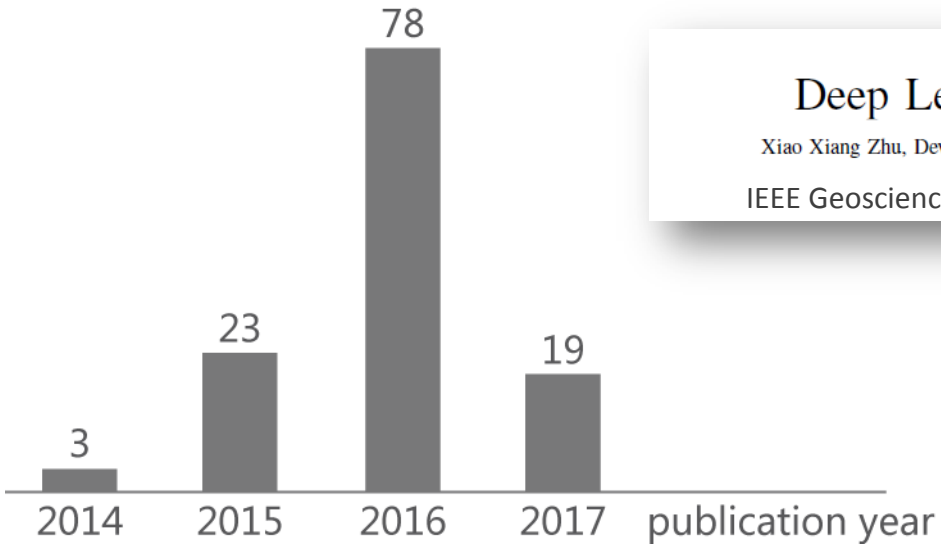
Deep Learning in Remote Sensing

A New and Exciting Field



number of papers

[source: ISI web of science]



Deep Learning in Remote Sensing: A Review

Xiao Xiang Zhu, Devis Tuia, Lichao Mou, Gui-Song Xia, Liangpei Zhang, Feng Xu, Friedrich Fraundorfer

IEEE Geoscience and Remote Sensing Magazine, invited submission, 2017.

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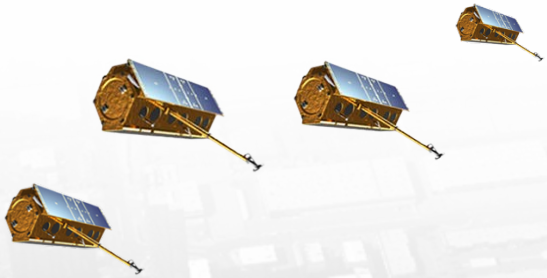
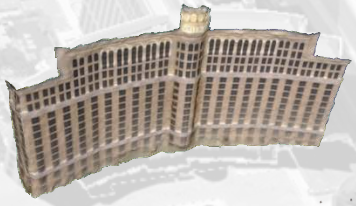
What makes Deep Learning in Remote Sensing Special?

- Retrieval of physical or bio-chemical quantities:
  High accuracy requirements
  Expert knowledge necessary using existing (traditional) models
- Multi-modal data: SAR, multi-/super-/hyperspectral, GIS, etc.
- Geodetic measurements with error bars → Instance- and significance-dependent learning
- Geo-located → Data and information fusion with non-conventional complementary sources, e.g. social media
- Data can be 5-dimensional (x-y-z-t-λ):
  Novel Deep Learning strategies for image time-series, high dimensional spectral images and complex valued data

Fusion of InSAR and Social Media Data





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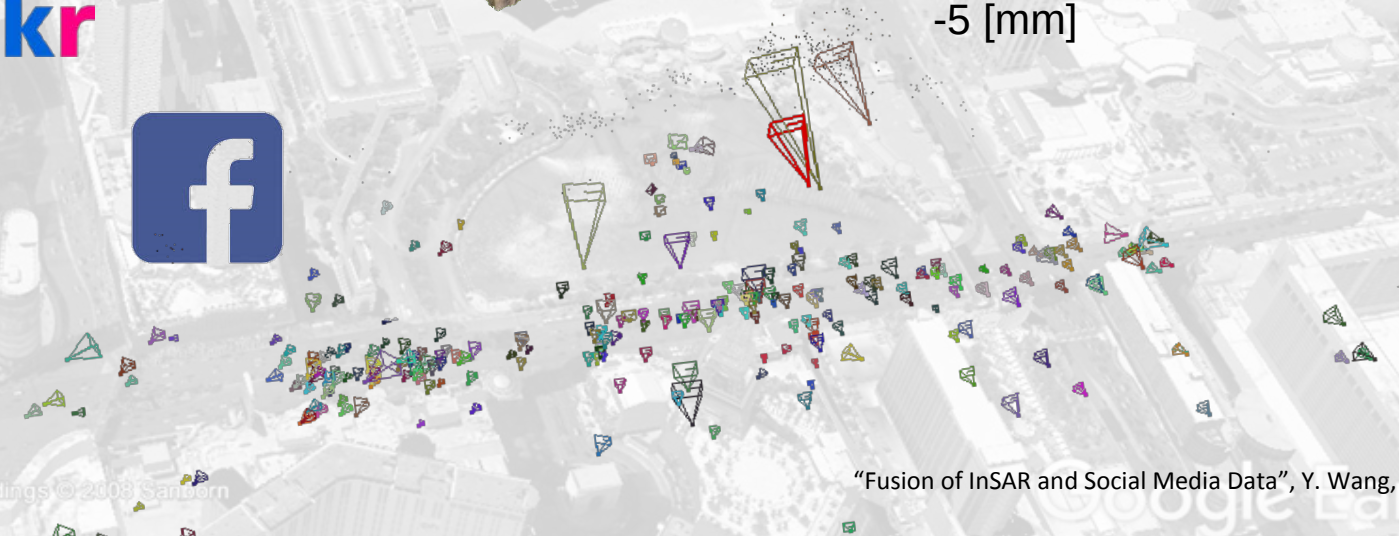
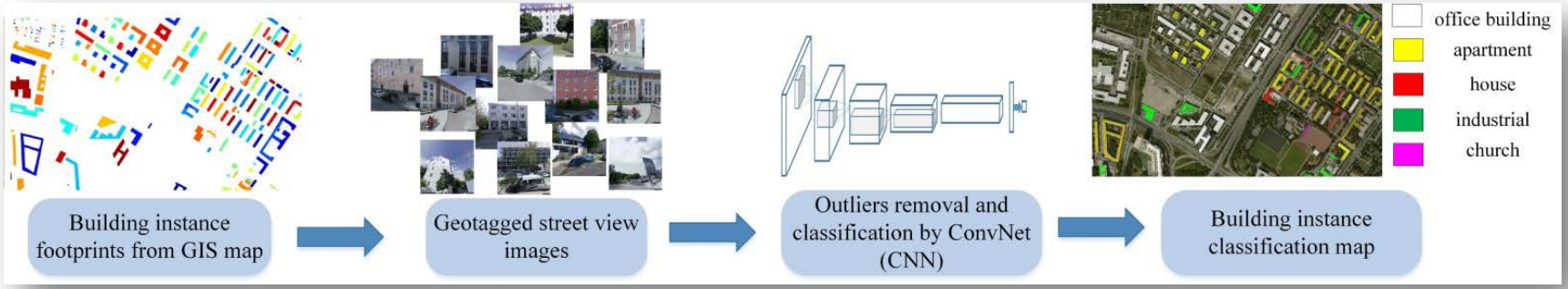


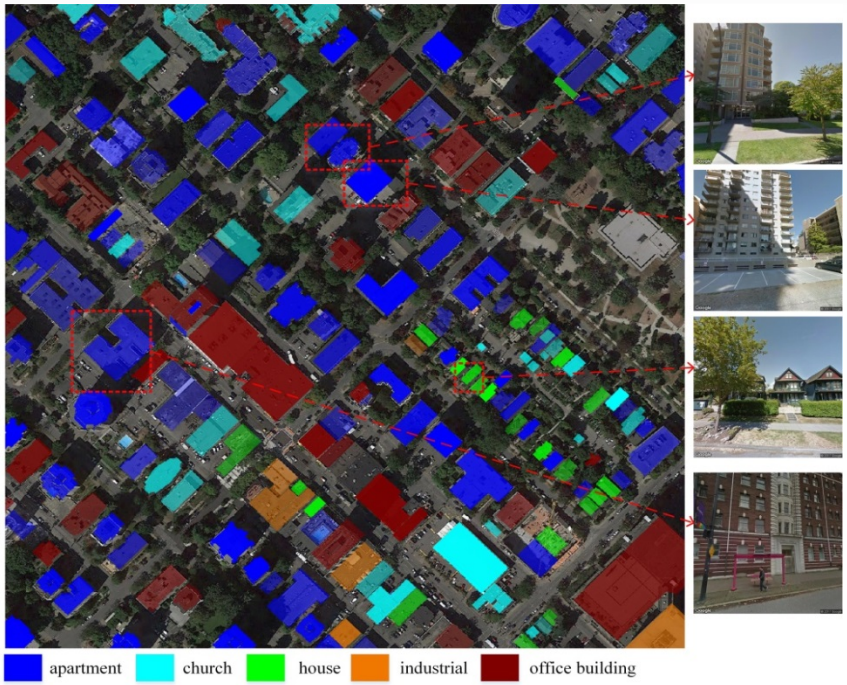
"Fusion of InSAR and Social Media Data", Y. Wang, X. Zhu

Building Instance Classification Using Street View Images



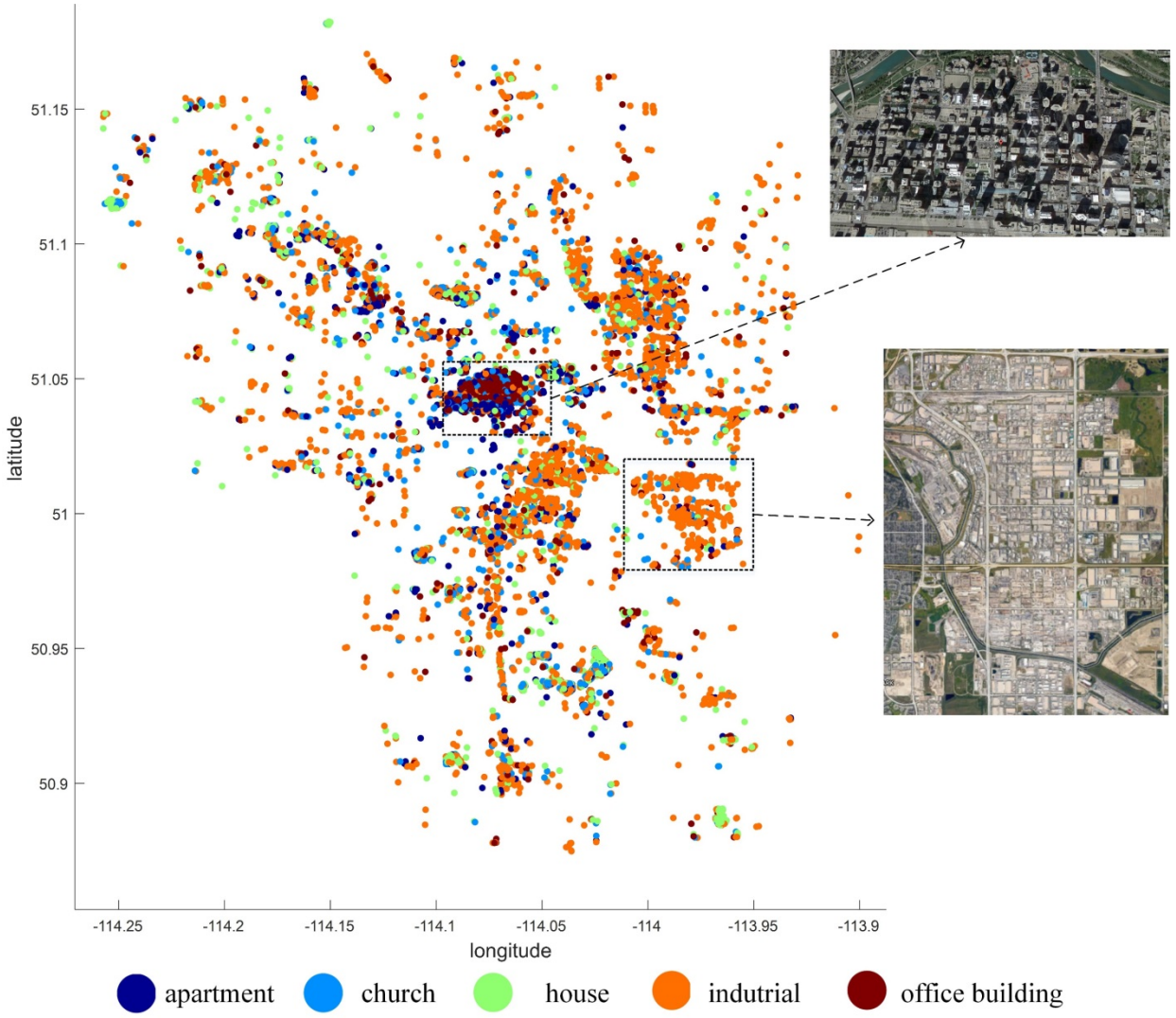
Building instances

An area in Vancouver

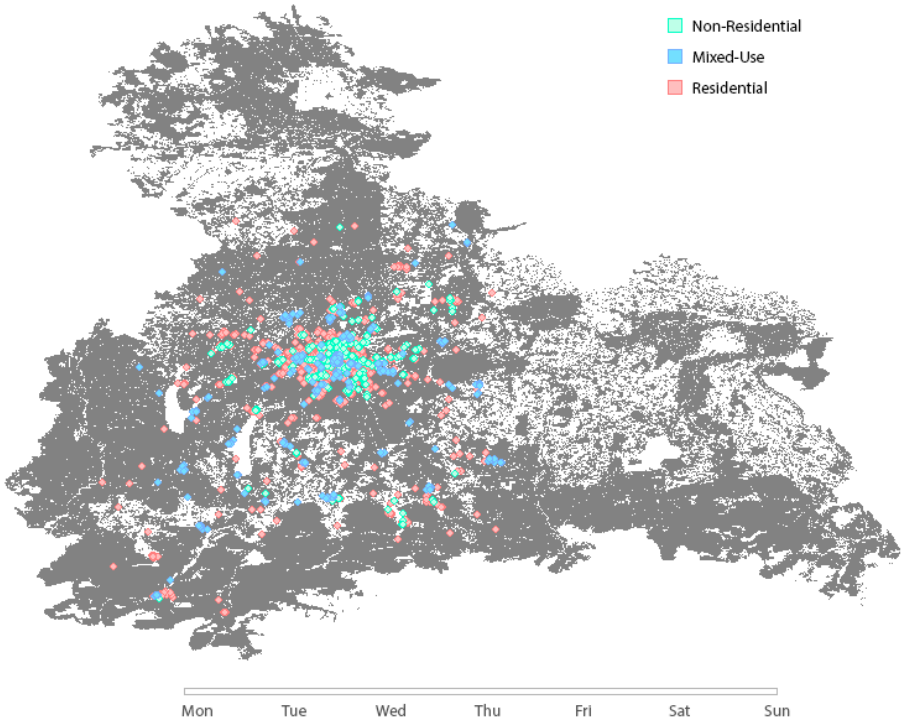


"Building instance classification based on façade information of street view images", J. Kang, M. Körner, Y. Wang, X. Zhu

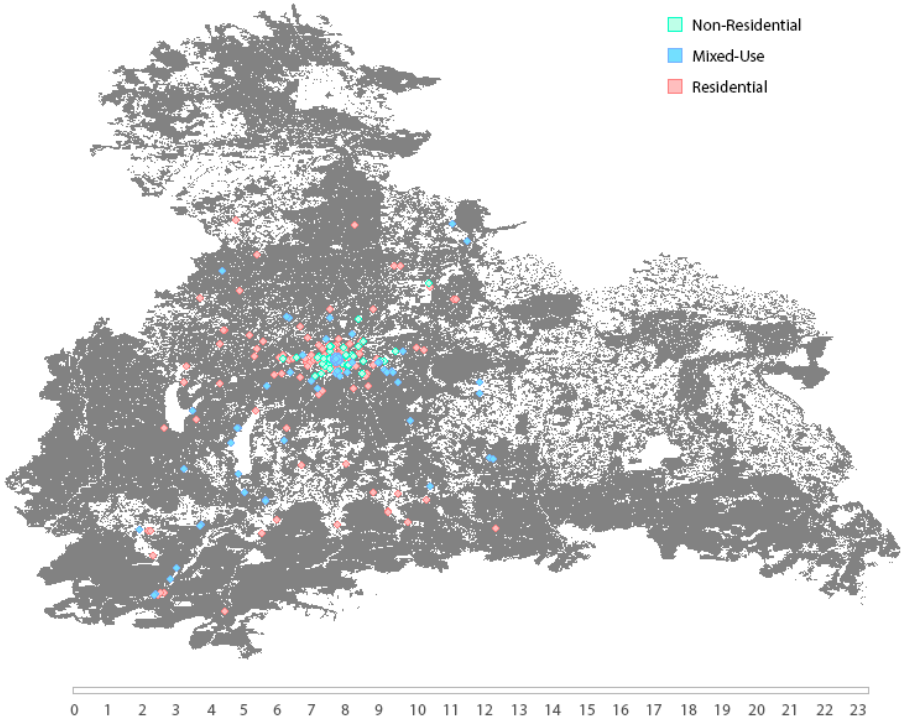
The whole city of Calgary



Building Settlement Types from Tweets?



Week days



Hour in a day

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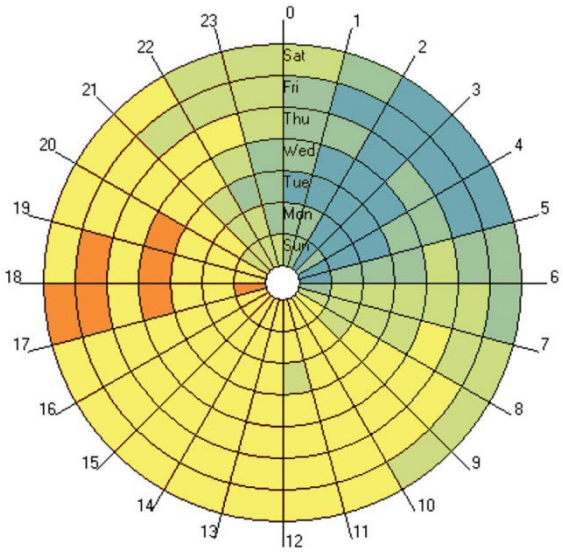
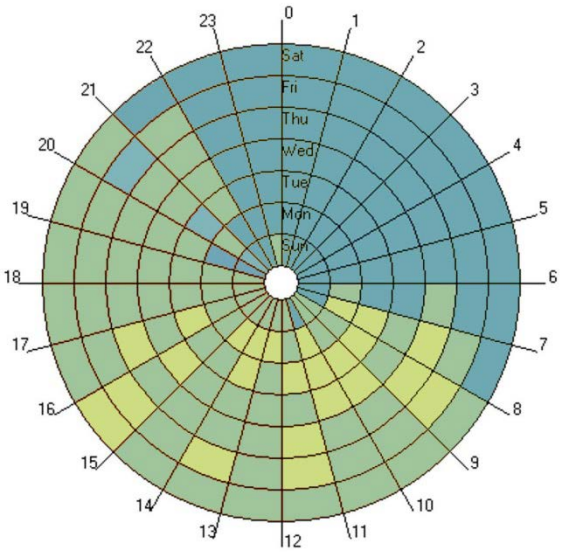
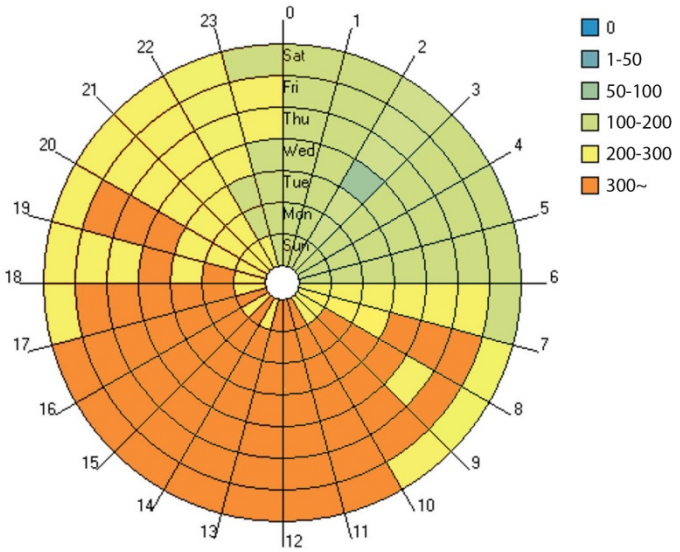
Time Chart for Geo-referenced Tweets



Residential



Non-Residential

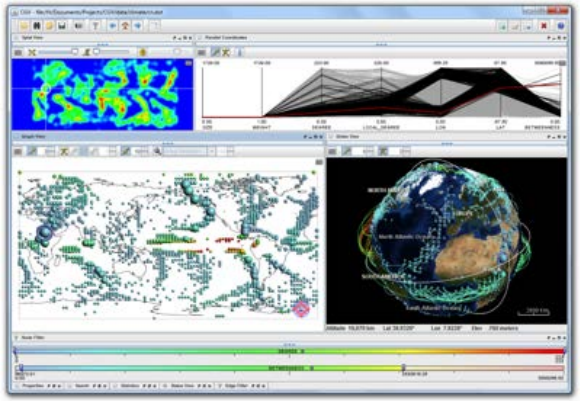


Mixed-Use

DLR Institute for Data Science in Jena

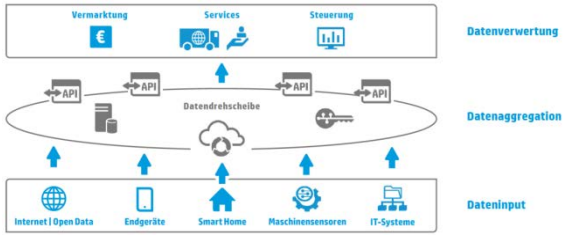
Foundig director: Dr. Robert Axmann
Planned Staff: 65 (incl. 3rd party funding)

DLR Institute for Data Science
Departments



Management and Analysis of Big Data

- Database concepts and semantic design
- Machine Learning and Data Mining
- Visual Analytics



Smart Systems

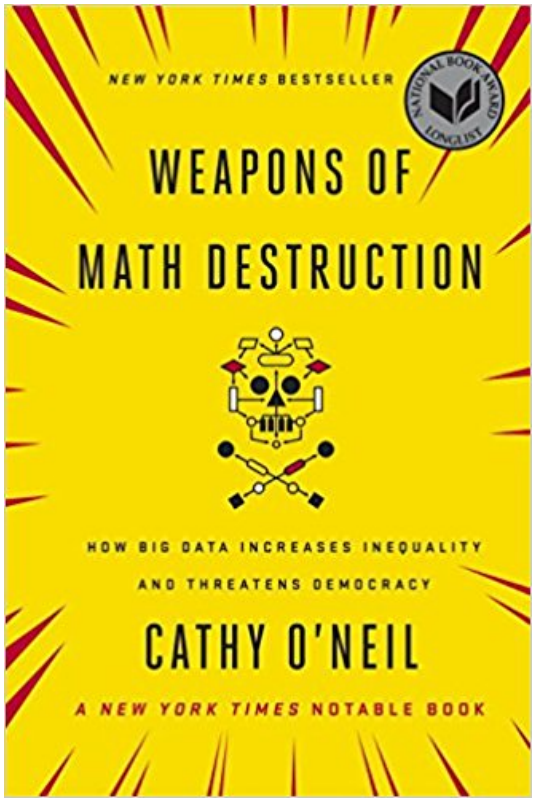
- Digital platforms for space research (Space 4.0)
- Internet of Things (IoT) and Semantic Web

IT Security

- Secure networked systems
- Encryption technologies
- Data protection strategies for the digital society

Citizen Science

Don‘t Forget: The Social and Ethic Dimension of Big Data and Data Science!



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