Preparation of Scenarios for the Performance Optimization of a Content-based Remote Sensing Image Mining System

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Background

- We talk about high resolution satellite SAR images
- Advanced satellite ground segments need tools for automated image content analysis in image archives
- Scenarios are needed for the full chain of processing steps
  - verification of all routines
  - handling of image content (semantics)
  - performance optimization
  - system monitoring and design assessment

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Scenarios and User Queries

We have to consider

- Routine queries by system operators
  - state and throughput of the image mining system

- Interactive user queries using
  - metadata
  - extracted features
  - semantic annotations
  - images (machine learning)
  - SQL queries

Scenarios and User Expectations

Our scenarios shall support

- Routine surveys (searches for known objects)
- Rapid mapping (unexpected events)
- Detection of (gradual) changes

Our scenarios shall comprise

- A defined workflow
- Selection of images
- Data ingestion and feature extraction
- Semantic annotation
- Inclusion of external information
- Interactive data exploration

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TerraSAR-X Images

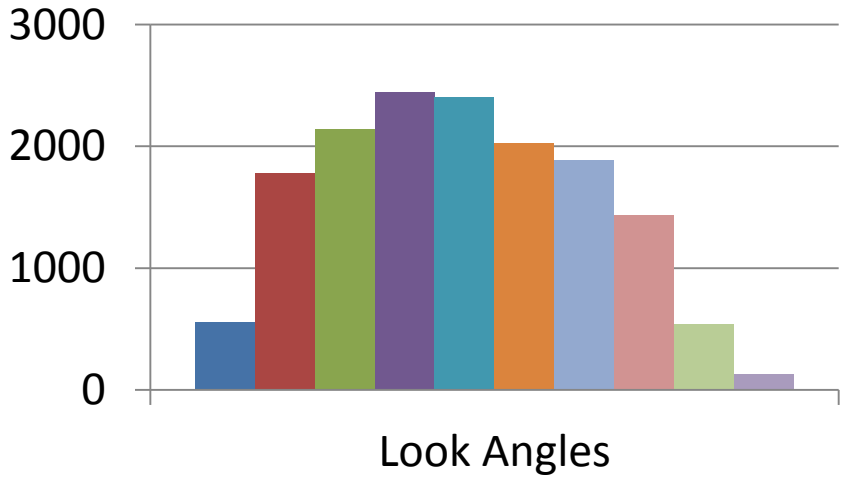
- TerraSAR-X: A German SAR satellite, 6 years of operations
- Publicly accessible catalogue with quick-look images
  http://eoweb.dlr.de:8080/index.html

Mode	ScanSAR	Stripmap	Spotlight	High Resolution Spotlight
Resolution	18 m	3 m	2 m	1 m
Typical Application	Ocean Monitoring	Global Mapping	Various Targets	Urban Areas
No. of Images	10,496*	54,297	8,156	15,331

*Up to June 30, 2013

High Resolution Spotlight Mode TerraSAR-X Images

Polarization Setting	9,962 HH 3,373 VV 1,596 HH/VV
Look Direction	Right: 15,187 Left: 144
Pass Direction	Ascending: 7,611 Descending:7,720



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Geographical Image Distribution (20° Bins)

Lon Lat	-160	-140	-120	-100	-80	-60	-40	-20	0	20	40	60	80	100	120	140	160	180
80	13	7	9	5	17	9	14	3	2	25	7	7	3	5	2	1	2	0
60	36	101	72	52	7	12	17	6	956	1708	252	82	88	72	50	52	62	2
40	0	0	743	161	469	120	0	4	1344	1977	672	425	130	331	875	604	34	0
20	27	0	3	102	110	25	0	20	57	101	273	294	107	223	283	29	1	0
0	0	0	0	0	149	148	39	3	84	155	111	4	61	195	135	30	4	1
-20	0	0	0	0	170	63	46	0	0	173	67	1	0	0	21	39	11	10
-40	0	0	0	0	39	23	0	0	0	37	0	2	0	0	2	35	9	7
-60	0	0	0	0	10	152	0	0	19	0	7	2	8	3	7	5	0	0
-80	0	2	0	8	15	1	0	6	16	4	2	1	3	2	2	2	17	0

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Geographical Image Distribution (0.2° Bins)

Lat Lon	11.0	11.2	11.4	11.6	11.8	12.0	12.2	12.4	12.6	12.8	13.0
48.8	0	0	5	5	0	1	1	0	0	3	4
48.6	0	0	5	13	0	0	0	0	0	2	2
48.4	0	0	1	3	7	5	0	1	1	0	0
48.2	3	10	242	346	1	1	0	4	1	0	1
48.0	6	13	18	7	1	0	0	3	1	1	0
47.8	1	3	1	0	0	1	1	3	2	8	6
47.6	3	2	1	1	0	96	96	0	0	4	9
47.4	3	1	0	1	1	4	3	0	0	0	0
47.2	0	1	5	0	0	0	0	0	0	0	0
47.0	0	0	2	0	0	0	0	0	0	0	2
46.8	0	0	2	0	0	0	0	0	0	0	0

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Image Characteristics

- We have individually selected high resolution scenes:
  - Single images as well as image time series

- The prime target types are
  - Urban areas and settlements
  - Infrastructure (e.g., airports, harbours, …, barrier lakes)
  - Geography images (e.g., mountains, shorelines)
  - Industrial sites, military facilities, mines
  - Vegetation and agriculture
  - …
  - Others: polar ice, ocean water

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Consequences for our Scenarios

- Our scenarios should follow the target types and the suspected applications
- Shall we cover all target types?
- Labeling support needed from domain experts?
- How to express dynamic changes semantically

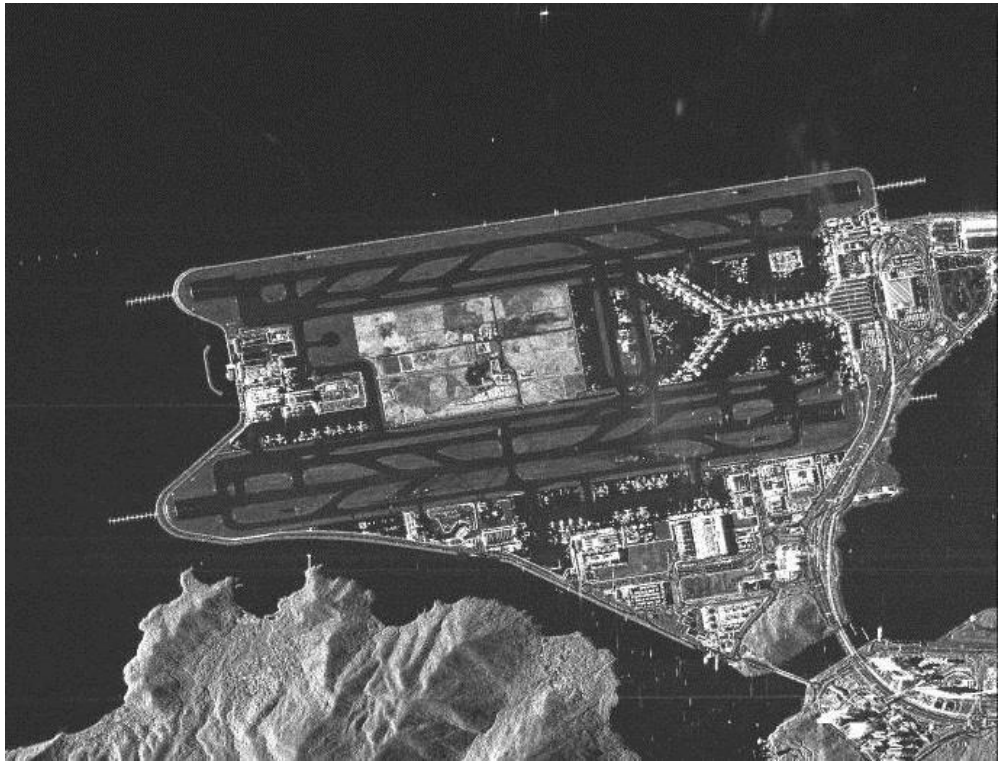
Example: Urban Scene

Tijuana, Mexico and the US Border:

Labeling support e.g. by Google Earth

Different architectural styles

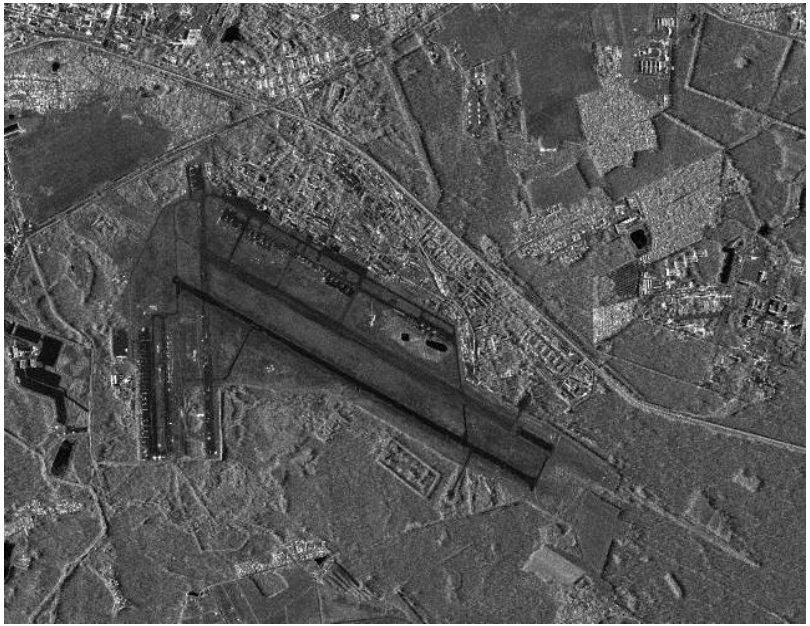
Example: Hong Kong Airport



Does the reclaimed land subside? (Typical time series issue)

Labeling support by civil aviation experts?

Example: Chkalovsky Airport (near Moscow)



Airport in Summer

Airport in Winter

Do we need a label "*Snow-covered runway*"?

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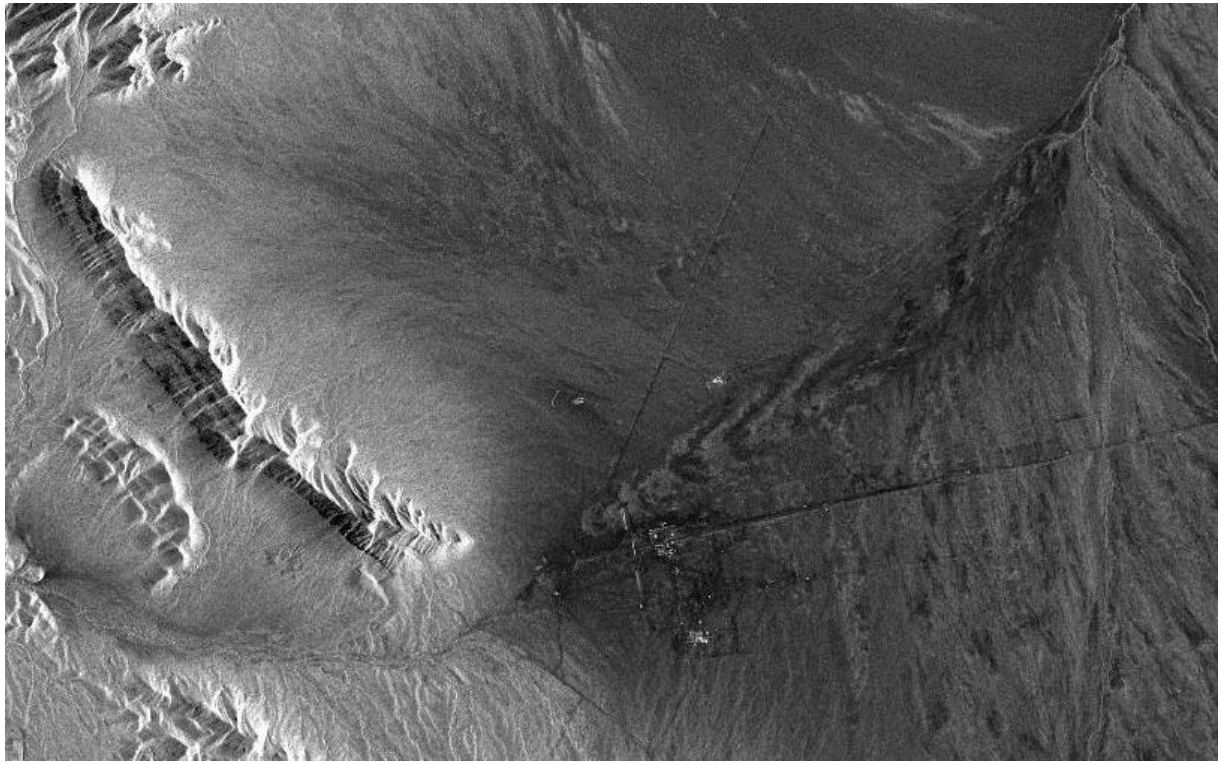
Example: Long Beach Harbor

How many ships can we count? Support by image time series?

Labeling support by shipping experts?

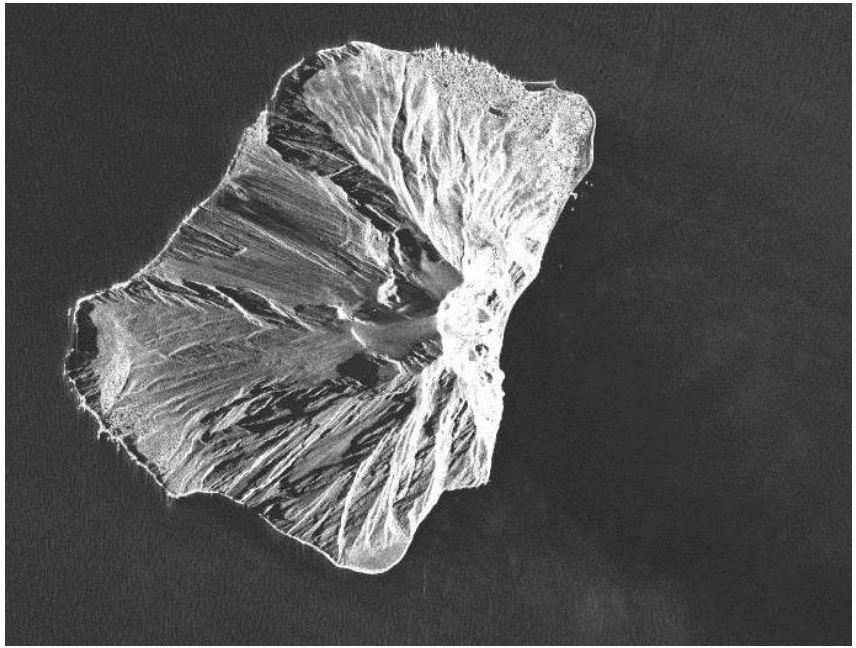
Example: Mining near Quartzside, USA

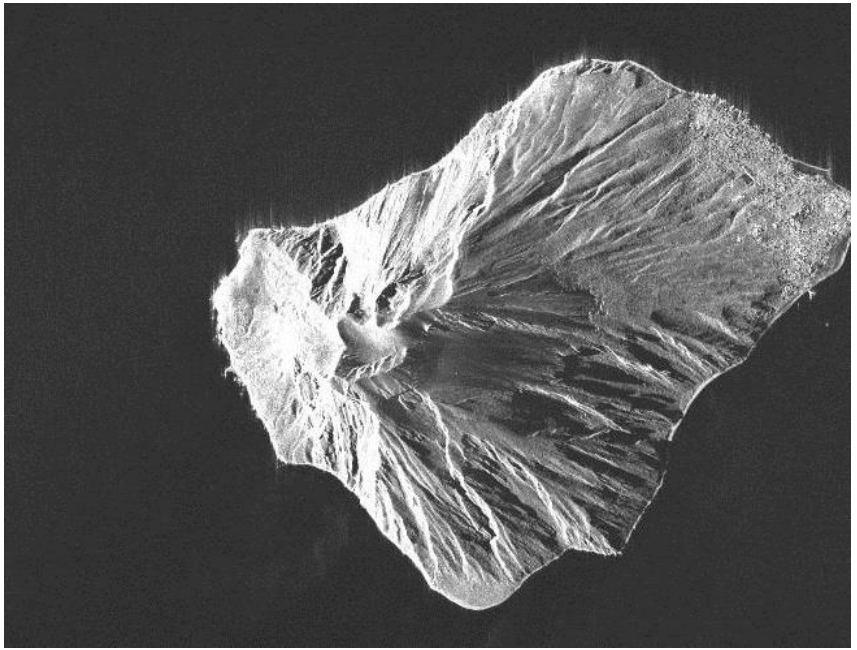


What is our labeling concept?

Labeling support by geology and mining experts?

Example: Mt. Stromboli (Italy)





How many classes of lava can we discern?

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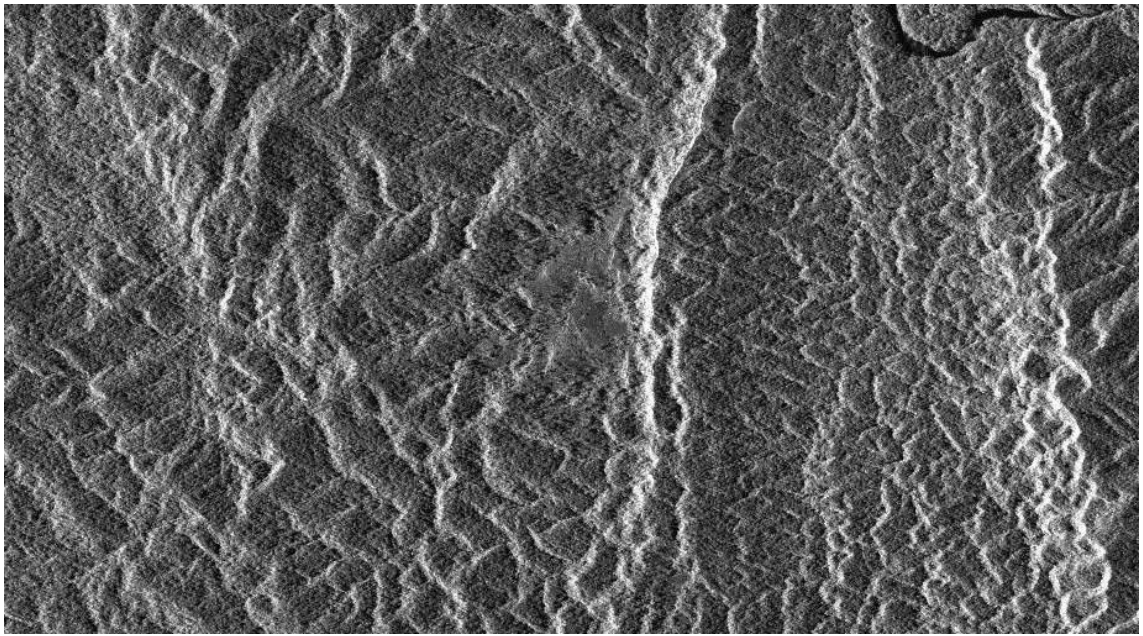
Example: Agriculture in Japan

Do we see rice paddies?

Labeling support by agriculture experts?

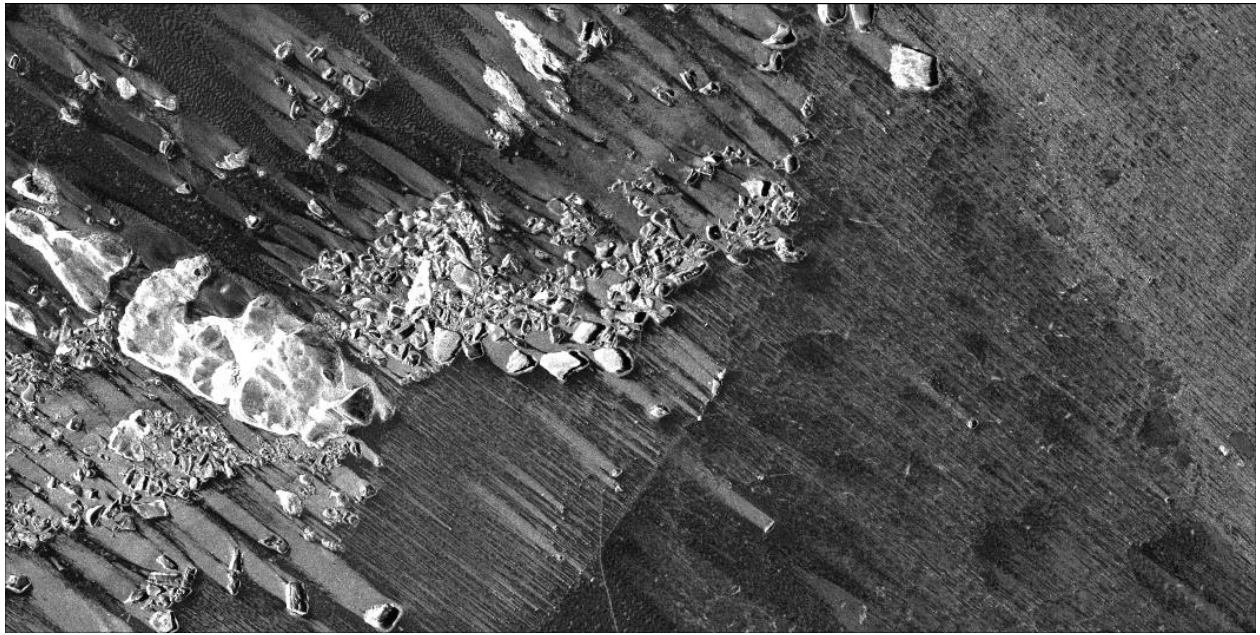
Example: Jungle in Congo



What do we see?

Labeling support by forestry experts?

Example: Ice in Antarctica

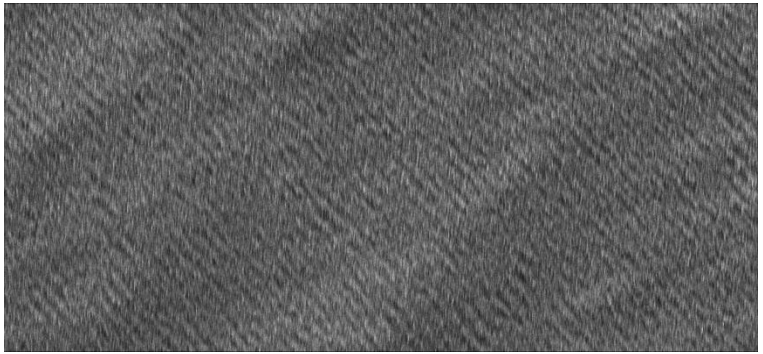


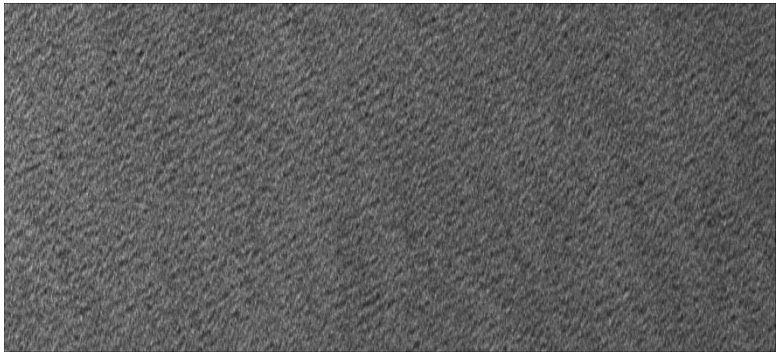
What do we see?

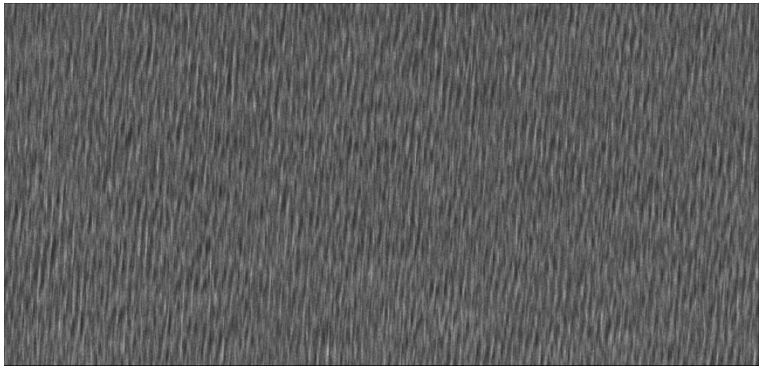
Labeling support by glaciology experts?

Shall we include wind direction?

Example: Ocean Waves







… a new semantic treasure chest

Labeling by derived quantities (e.g., wave height and wind speed)?

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Conclusions

- We need a correct and useful labeling of target area characteristics
- The selection and understanding of target areas determines the capabilities of our scenarios; however, we can leave out some topics
- Support by experts is often helpful