Disaster monitoring and risk assessment using EO and SensorWeb

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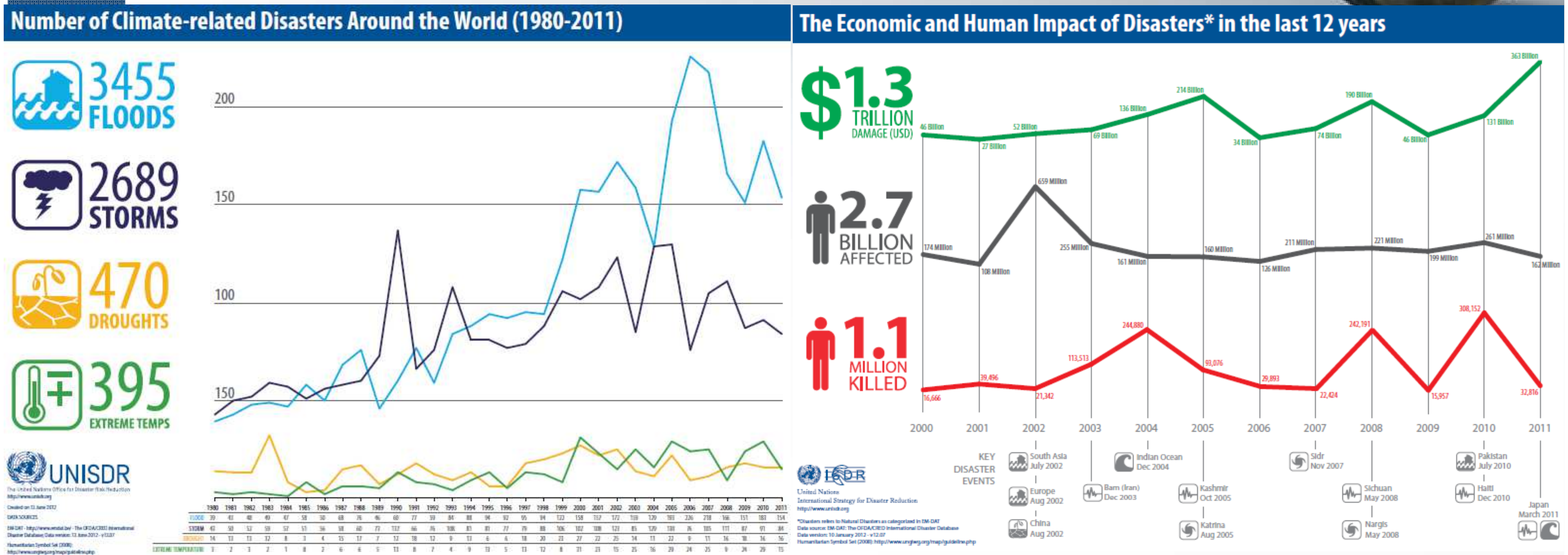
Natural Disasters



http://www.unisdr.org/we/inform/disaster-statistics

- Risk-oriented approach
  - *protection against disasters to managing the risks of disasters*
  - Ex.: European Flood Risk Directive (FRD)

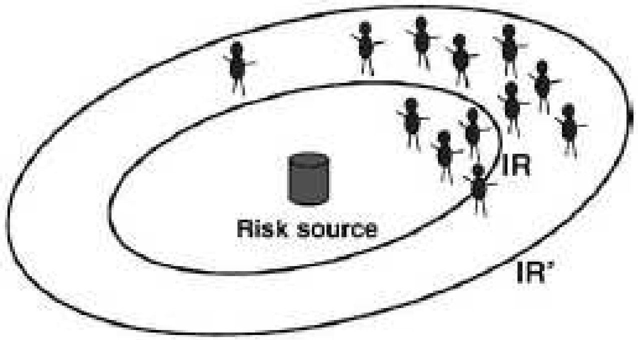
Disaster Risk Assessment

- *Risk*
  - *combination of the probability of a disaster and of the potential adverse consequences for human health, the environment, economic activity, …*

Risk = F (hazard, vulnerability)

- *Integrated risk in area A*

$$R_A(x,y) = \iint_A r(x,y)dxdy$$

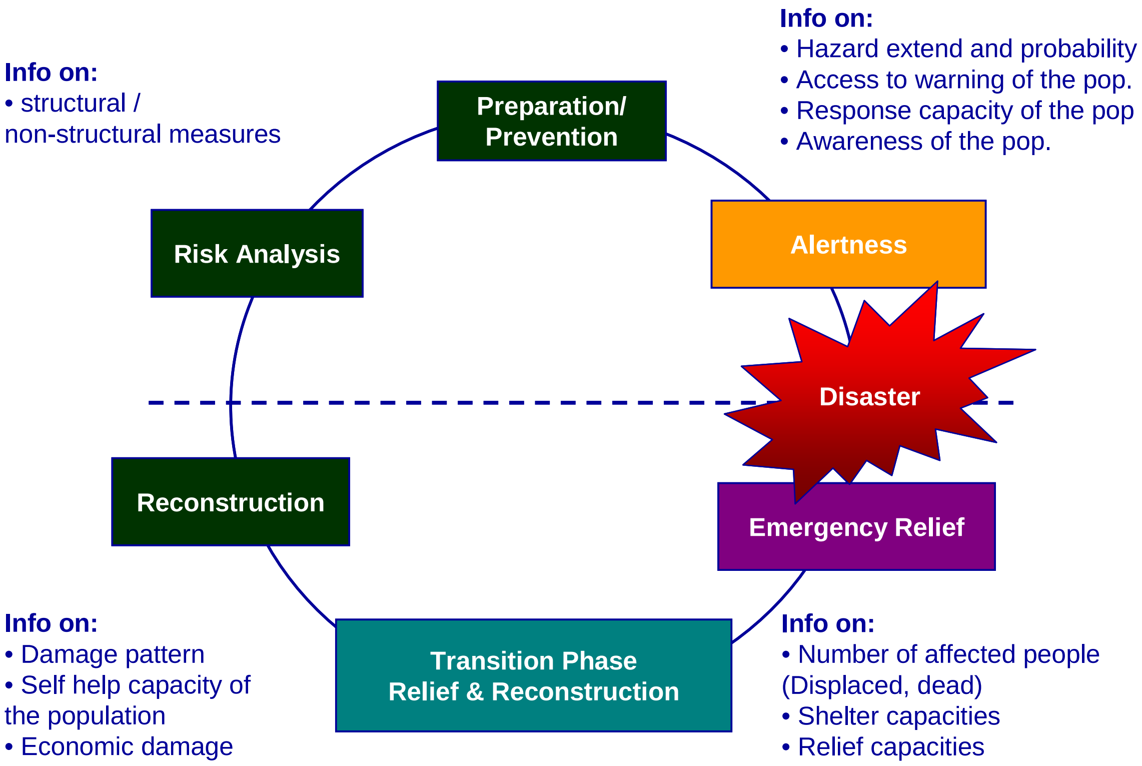


where r(x,y) is individual risk at point (x,y)

$$r(x,y) = \int_0^\infty h_{xy}(z)\, p_{xy}(z)\, dz$$

EO for Disaster Risk Assessment

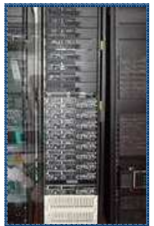
- To support the full **Disaster Management Cycle**



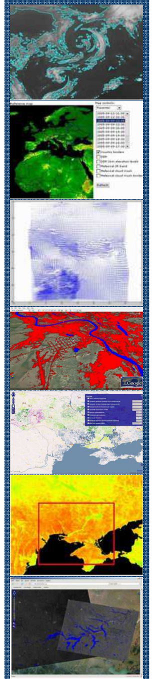
- Advantages for mapping:
  - Hazard/probability
  - Vulnerability

Sandy, USA, 29.10.2012

Floods, Ukraine, 27.07.2008



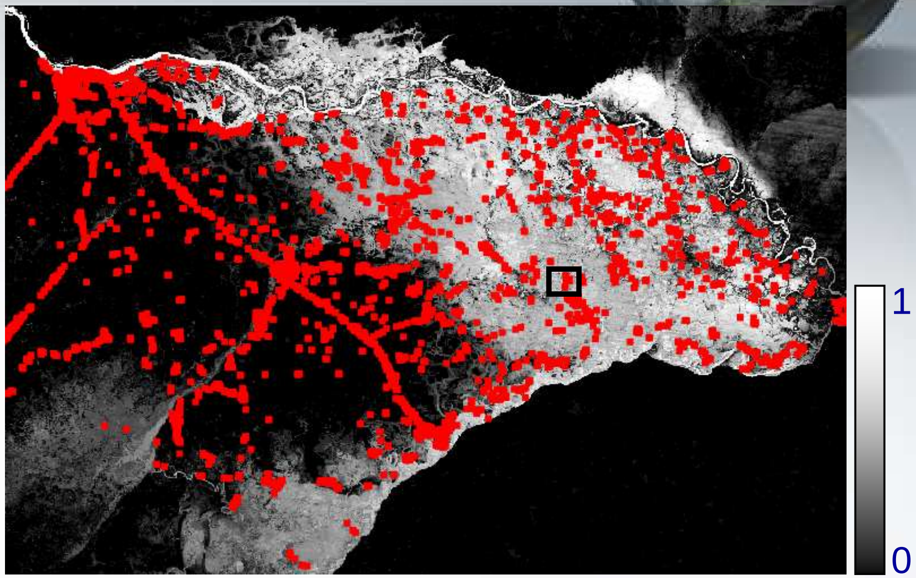
EO for Disaster Risk Assessment



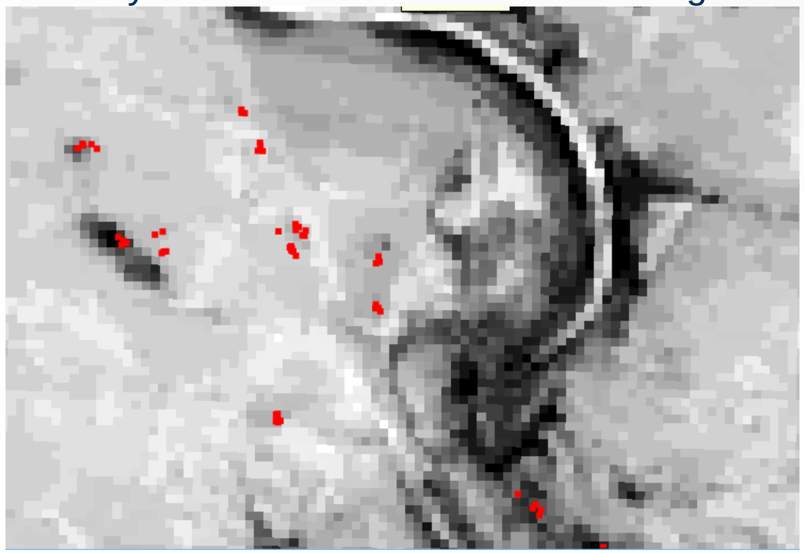
- **Natural disasters**
  - Floods
  - Droughts
  - Fires
  - Storms
  - Earthquakes, volcanoes
  - Landslides
- **Hazard mapping**
  - Disaster mapping
  - EO data time-series processing
    - E.g. using extreme-value-theory (EVT), frequency analysis
  - Data assimilation
- **Vulnerability**
  - Land cover (crop) mapping, assets mapping, …
- **Operational disaster risk assessment**
  - Integration of heterogeneous data, sensors, models, …
  - Service-oriented approach

Case study 1: Flood hazard mapping from EO data time-series

- Within Namibian SensorWeb Pilot
- Region: Katima Mulilo, Namibia
- Data
  - Satellite
    - Landsat-5/TM and Landsat-7/ETM+
      - 102 scenes
      - Time period
        - » 1989-2012
    - TRMM
      - Time period
        - » 1999-2010
  - Ground
    - Water level and water flow
    - Time period
      - 1943-1954
        1965-2010

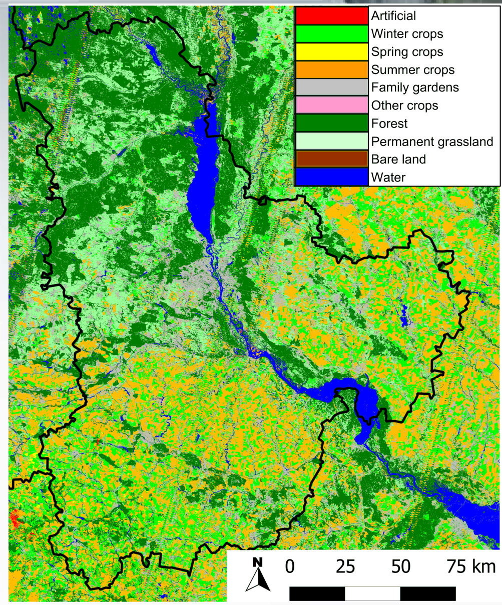


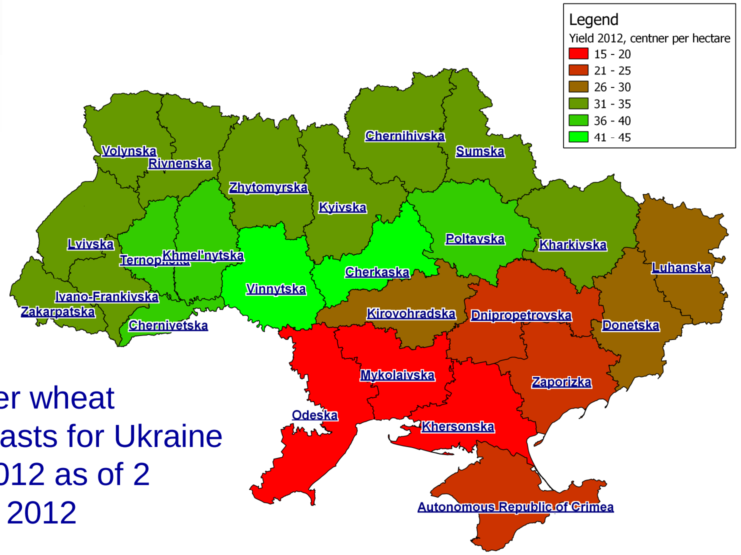
Probability of inundation overlaid on dwelling density



Case study 2: Agriculture monitoring

- Within GEO GLAM and JECAM
  - Established JECAM test sites in Ukraine
  - SOAR-JECAM
    - “SAR parameters optimization for crop classification”
  - Tasks
    - Crop mapping and area estimation
      - SAR and optical satellite images assisted by ground surveys
    - Crop yield forecasting
      - Based on MODIS data and statistics





Winter wheat forecasts for Ukraine for 2012 as of 2 June 2012

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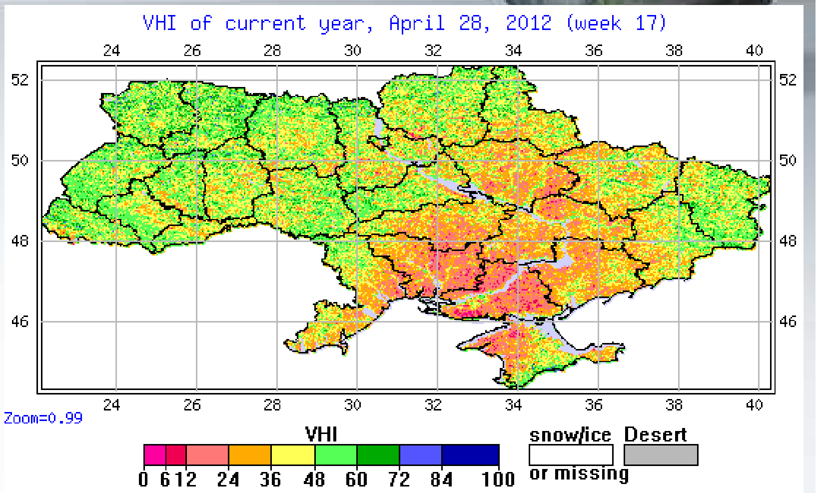
Case study 3: Drought hazard mapping from EO data time-series

- Application of the extreme value theory (EVT) to EO data
  - Vegetation Health Index (NOAA)
  - Period: 1981-2012
  - Spatial resolution 16 km or 256 km^2
    - Density of weather stations in Ukraine: ~3353 km^2

Drought level	VHI
Abnormally dry condition	35-40
Moderate	26-35
Severe	16-25
Extreme	6-15
Exceptional	0-5



Poisson process and Generalized Pareto distribution (Poisson-GP)

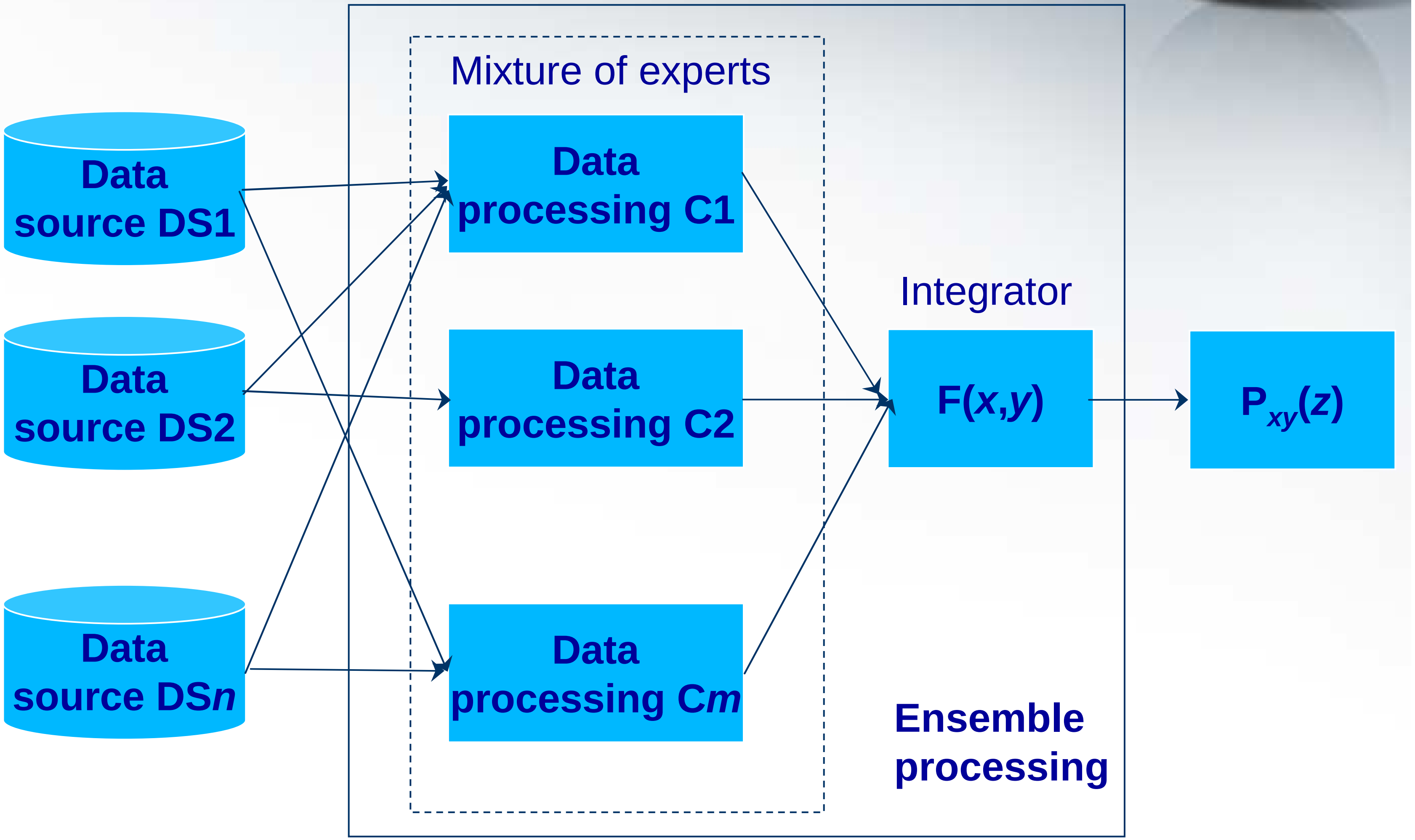
$$P(Y < y \mid \alpha, k) = 1 - \left(1 - k\frac{y}{\alpha}\right)^{1/k}, \; y = x - x_0$$

Parameters estimation – probability weighted moments (PWM)

$$\hat{k} = \left(\frac{b_0}{2b_1 - b_0}\right) - 2, \; \hat{\alpha} = (1 + k)b_0$$

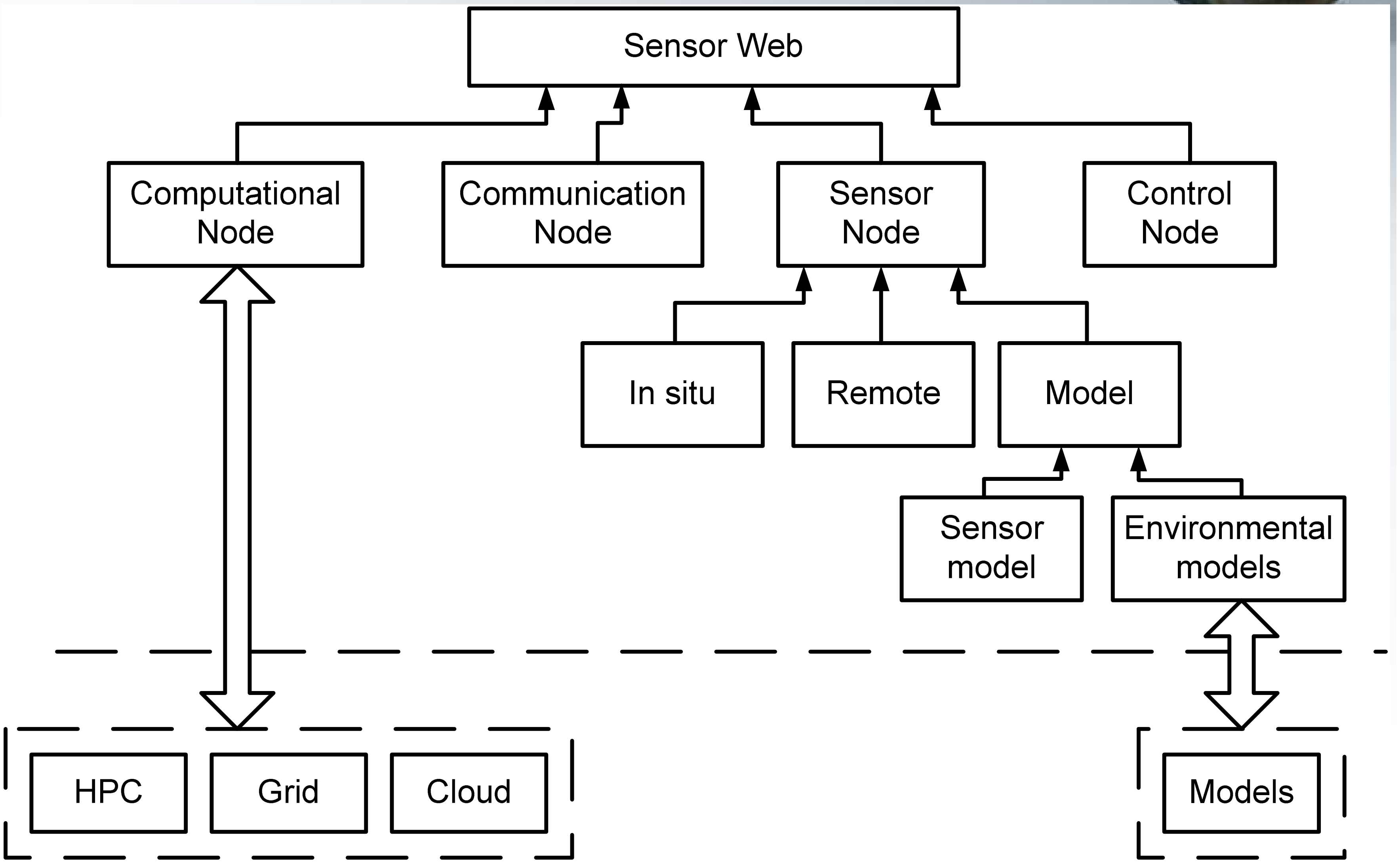
$$b_r = \frac{1}{n}\sum_{i=1}^{n}\frac{(i-1)(i-2)\ldots(i-r)}{(n-1)(n-2)\ldots(n-r)}\, y_{(i)}$$

Deriving Disaster Probability Density Function



$P_{xy}(z)$ is probability density function

Sensor Web Architecture



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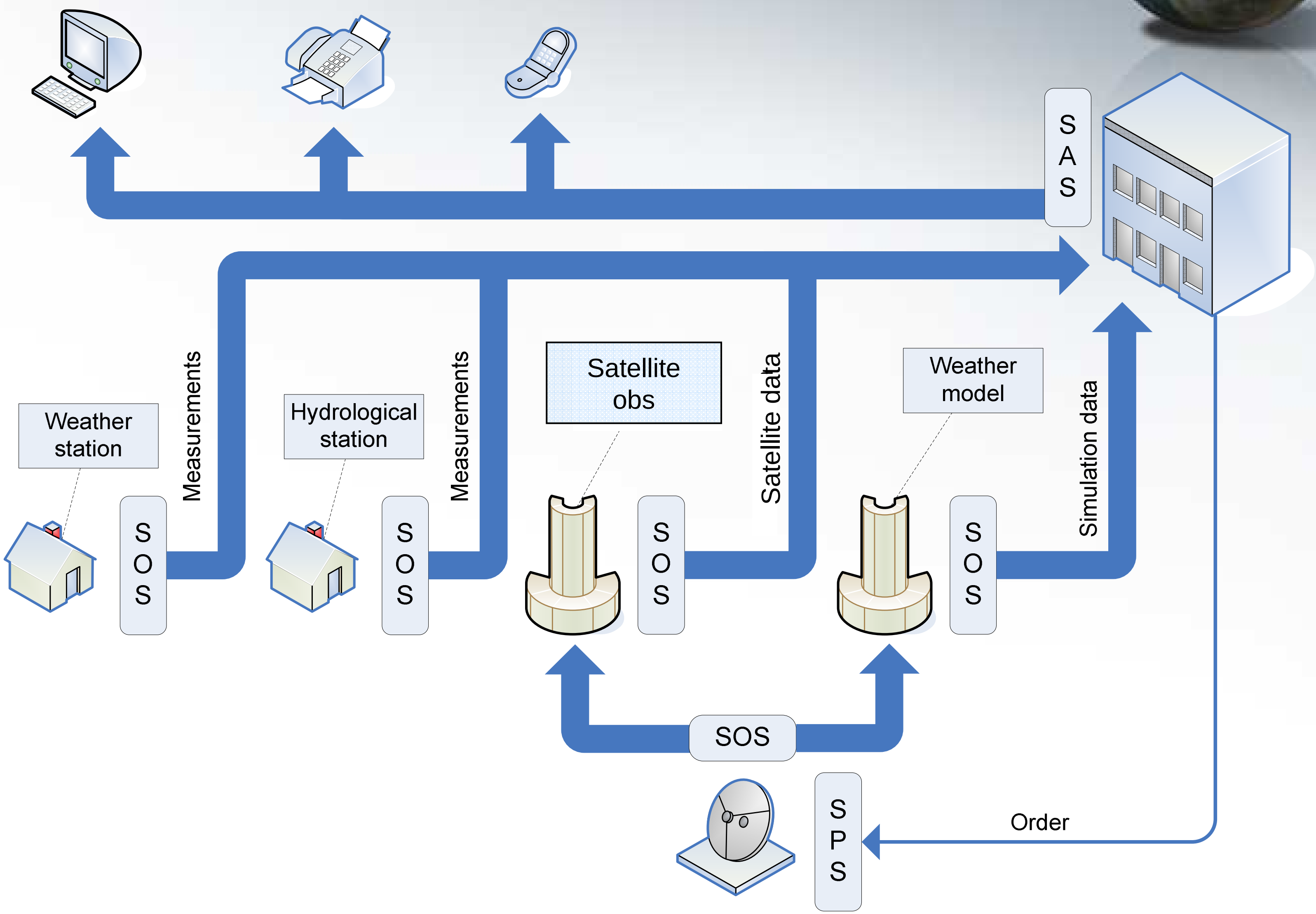
SW Architecture for Flood Application



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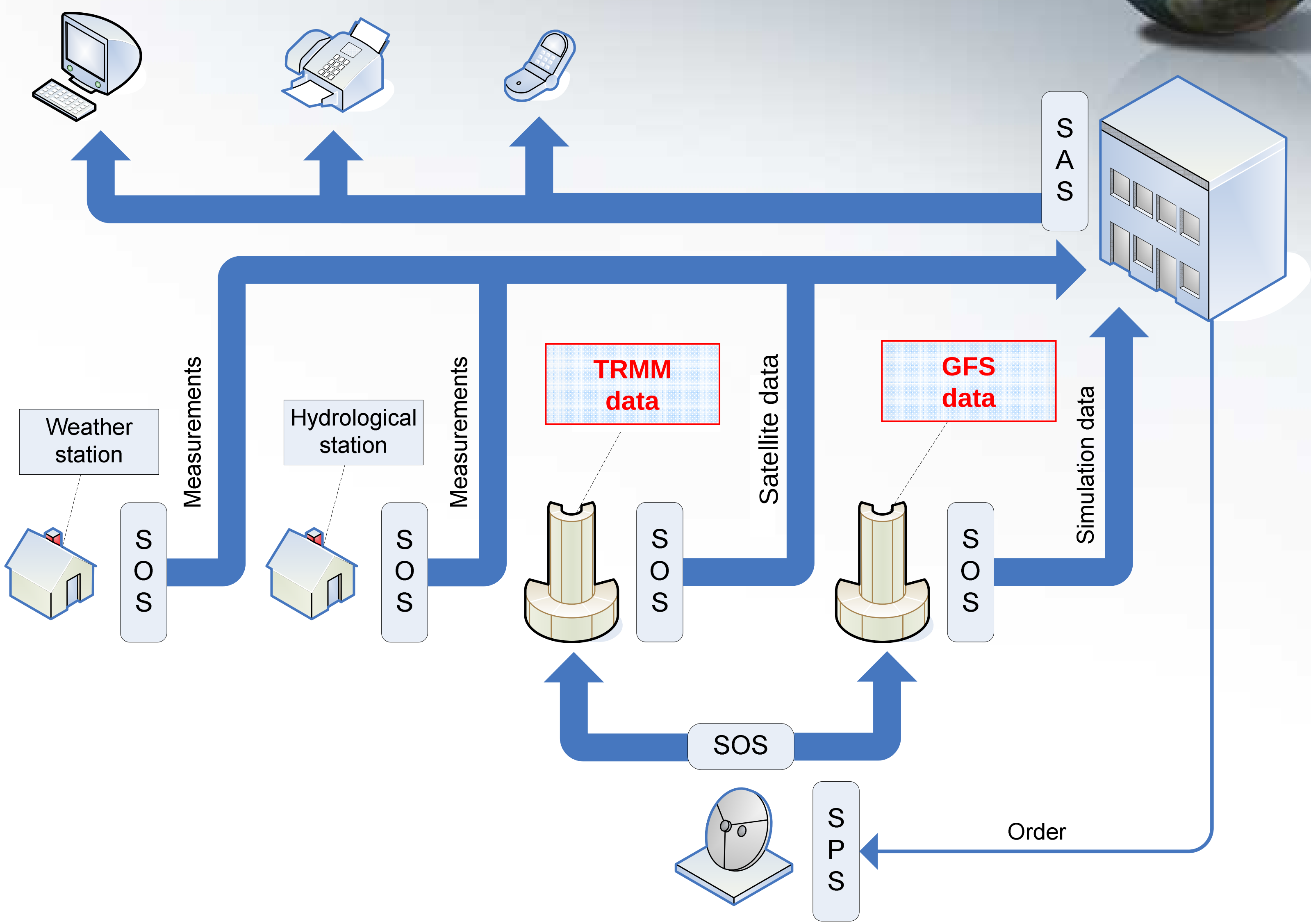
SW Architecture for Flood Application



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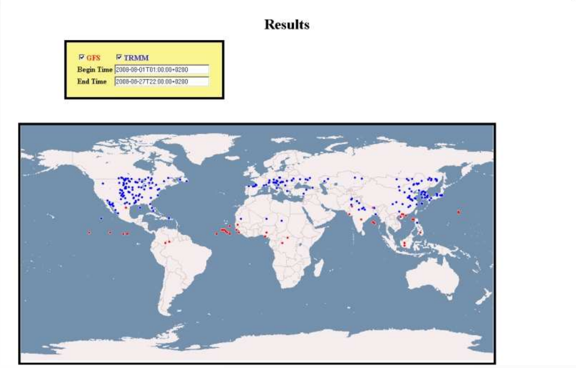
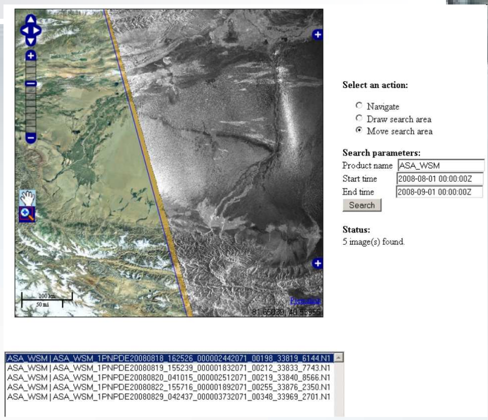
Workflow



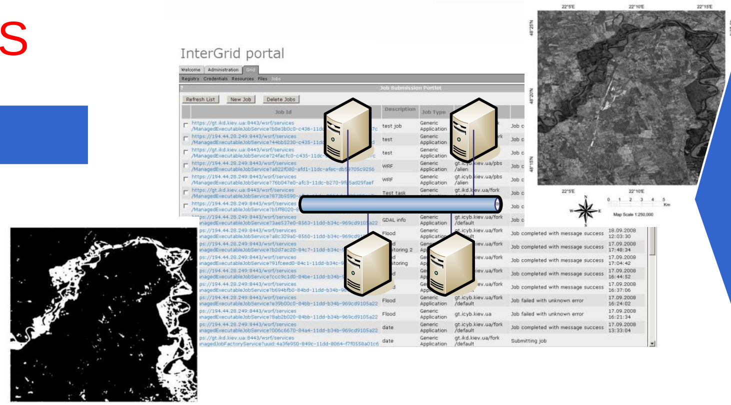
SOS Interface to GFS & TRMM data

SPS



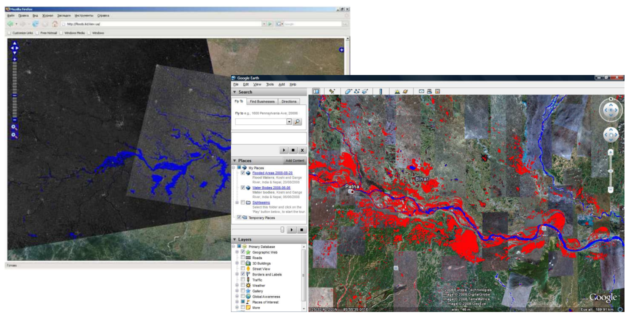
Satellite Observations

Processing services



Data Processing in Grid

WMS



Visualization of Data

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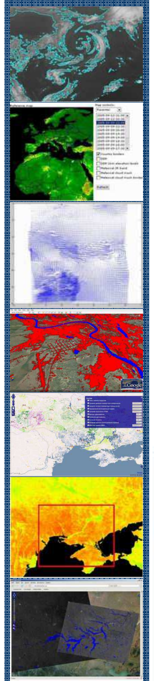
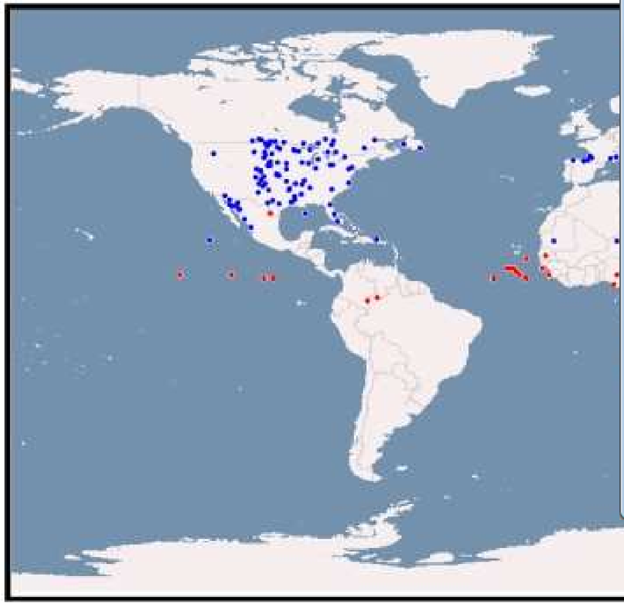
Models and observations



- Meteorological forecasts are operationally obtained from the Global Forecasting System (GFS, 1 deg.) using the Sensor Observation Service (SOS). TRMM data (0.25 deg.) using SOS are also provided.

☑ GFS ☑ TRMM
Begin Time 2008-08-01T01:00:00+0200
End Time 2008-08-27T22:00:00+0200



GFS

Date/Time	Location(lon,lat)	1 day forecast (mm)	3 day forecast (mm)	7 day forecast (mm)
2008-08-25T04:00:00+04	POINT(153 24)	68.544	81.464	92.088
2008-08-25T10:00:00+04	POINT(153 23)	84.905	94.726	103.44
2008-08-26T22:00:00+04	POINT(-70 0)	84.139	84.999	89.348
2008-08-27T10:00:00+04	POINT(-16 10)	52.160	56.789	92.678
2008-08-27T16:00:00+04	POINT(89 27)	85.226	97.822	112.34
2008-08-27T22:00:00+04	POINT(89 27)	55.850	65.271	76.813

TRMM

Date/Time	Location(lon,lat)	Observation (mm/hour)
2008-08-25T04:00:00+04	POINT(-89.50 37.25)	28
2008-08-25T07:00:00+04	POINT(-112.50 31.25)	35
2008-08-25T10:00:00+04	POINT(125.00 30.25)	20
2008-08-25T13:00:00+04	POINT(125.50 30.00)	24
2008-08-25T16:00:00+04	POINT(115.00 48.00)	20
2008-08-25T19:00:00+04	POINT(79.50 49.25)	20
2008-08-25T22:00:00+04	POINT(117.75 49.00)	24
2008-08-26T01:00:00+04	POINT(-58.75 48.50)	20
2008-08-26T04:00:00+04	POINT(-81.00 34.50)	26

Готово — Интернет | Защищенный режим: вкл.

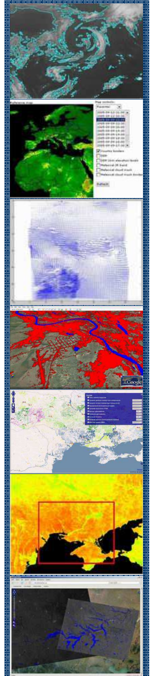
From GEOSS AIP CFP-2

SOS response for TRMM

- <?xml version=\"1.0\" encoding=\"UTF-8\"?><om:ObservationCollection xmlns:om=\"http://www.opengis.net/om/1.0\" xmlns:gml=\"http://www.opengis.net/gml\" xmlns:xsi=\"http://www.w3.org/2001/XMLSchema-instance\" xmlns:xlink=\"http://www.w3.org/1999/xlink\" xmlns:swe=\"http://www.opengis.net/swe/1.0.1\" xmlns:sa=\"http://www.opengis.net/sampling/1.0\" gml:id=\"oc1968\" xsi:schemaLocation=\"http://www.opengis.net/om/1.0 http://schemas.opengis.net/om/1.0.0/om.xsd http://www.opengis.net/sampling/1.0 http://schemas.opengis.net/sampling/1.0.0/sampling.xsd\"> <gml:boundedBy> <gml:Envelope> <gml:lowerCorner>1.0 1.0</gml:lowerCorner> <gml:upperCorner>1.0 1.0</gml:upperCorner> </gml:Envelope> </gml:boundedBy> <om:member> <om:Observation> <om:samplingTime> <gml:TimePeriod xsi:type=\"gml:TimePeriodType\"> <gml:beginPosition>2008-08-01T04:00:00+04:00</gml:beginPosition&g t; <gml:endPosition>2008-08-05T22:00:00+04:00</gml:endPosition> </gml:TimePeriod> </om:samplingTime> <om:procedure xlink:href=\"urn:ogc:object:feature:Sensor:Models:TRMM\"/> <om:observedProperty> <swe:CompositePhenomenon gml:id=\"cpid0\" dimension=\"1\"> <gml:name>resultComponents</gml:name> <swe:component xlink:href=\"urn:ogc:data:time:iso8601\"/> <swe:component xlink:href=\"urn:ogc:def:phenomenon:OGC:1.0.30:extreme-precipitation\"/> </swe:CompositePhenomenon> </om:observedProperty> <om:featureOfInterest> <gml:FeatureCollection> <gml:featureMember> <sa:SamplingPoint gml:id=\"id_1002\"> <gml:name>TRMM EXTENT</gml:name> <sa:sampledFeature xlink:href=\"\"/> <sa:position> <gml:Point> <gml:pos srsName=\"urn:ogc:def:crs:EPSG:4326\">1.0 1.0</gml:pos> </gml:Point> </sa:position> </sa:SamplingPoint> </gml:featureMember> </gml:FeatureCollection> </om:featureOfInterest> <om:result> <swe:DataArray> <swe:elementCount> <swe:Count> <swe:value>39</swe:value> </swe:Count> </swe:elementCount> <swe:elementType name=\"Components\"> <swe:SimpleDataRecord> <swe:field name=\"Time\"> <swe:Time definition=\"urn:ogc:data:time:iso8601\"/> </swe:field> <swe:field name=\"feature\"> <swe:Text definition=\"urn:ogc:data:feature\"/> </swe:field> <swe:field name=\"extreme-precipitation\"> <swe:Category definition=\"urn:ogc:def:phenomenon:OGC:1.0.30:extreme-precipitation\"/> </swe:field> </swe:SimpleDataRecord> </swe:elementType> <swe:encoding> <swe:TextBlock decimalSeparator=\".\" tokenSeparator=\",\" blockSeparator=\"@@\"/> </swe:encoding> <swe:values>**2008-08-01T04:00:00+04,id_1002,POINT(-75.75 36.50);20@@2008-08-01T07:00:00+04,id_1002,POINT(71.50 33.25);20@@2008-08-01T10:00:00+04,id_1002,POINT(71.50 29.25);22@@2008-08-01T13:00:00+04,id_1002,POINT(-89.75 48.75);39@@2008-08-01T16:00:00+04,id_1002,POINT(77.25 25.50);23@@2008-08-01T19:00:00+04,id_1002,POINT(9.00 46.50);20@@2008-08-01T22:00:00+04,id_1002,POINT(121.50 15.50);22@@2008-08-02T01:00:00+04,id_1002,POINT(8.75 46.00);23@@2008-08-02T04:00:00+04,id_1002,POINT(127.75 38.75);20@@2008-08-02T07:00:00+04,id_1002,POINT(-102.75 49.75);21@@2008-08-02T10:00:00+04,id_1002,POINT(115.75 41.50);23@@**<swe:values> </swe:DataArray> </om:result> </om:Observation> </om:member>\</om:ObservationCollection>"

Grid & Sensor Web Integration

- Benefits from integration with the Grid platform like Globus Toolkit:
  - **Sensors discovery** could be performed through the combination of Index Service and Trigger Service;
  - High-level access to XML description of the sensors and services could be made through queries to the **Index Service**;
  - Grid platform provides a convenient way for the implementation of **notifications** and **event triggering** using corresponding platform components;
  - **Reliable File Transfer** (RFT) service provides reliable data transfer for large volumes of data;
  - **Globus Security Infrastructure** provides enforcement of data and services access policies in a very flexible way allowing implementation of desired security policy



Summary

- EO provide advantages and benefits for disaster risk assessment in terms of both:
  - *Hazard mapping* (probability density function estimation)
  - *Vulnerability mapping*
- Disaster risk assessment requires integration of multi-source data => *take advantage of Sensor Web*
- Need for models => *integration with Model Web*
  - E.g. global meteorological models (GFS); frequency analysis, modeling of extremes from satellite data and products

Thank You!

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