Early Flood Warning Pilot Project in Namibia

for CEOS Disaster SBA

Dan Mandl – NASA/GSFC

February 13, 2012

Where is Namibia

2

Namibia Use Case: 2009 Flood Disaster

- *In February and March 2009, torrential rains increased water levels in Zambezi, Okavango, Cunene and Chobe Rivers*
- *This led to a 40-year flood in Caprivi, Kavango and Cuvelai basins, affecting some 750,000 people (37.5% of population of Namibia)*
- *Whole villages were cut off and had to be relocated into camps. Some 50,000 people were displaced*
- *Livestock were stranded and died of hunger*
- *102 people died*

Flood Related Impacts

- Health
  - Malaria
  - Cholera
  - Schistosomiasis
- Infrastructure damage
  - Roads
  - Schools
  - Clinics
- Food security
  - Crop and wildlife loss
- Human wildlife conflict
  - Encroachment of wildlife on human settlements

4

Stakeholders

- Namibia Department of Hydrology
- University of Namibia
  - Department of Geography
  - Multidisciplinary Research Center
- Namibia Ministry of Health
- NASA/GSFC
- University of Maryland, Department of Geography
- University of Oklahoma
- University of Chicago
- Open Cloud Consortium
- Committee on Earth Observing Satellites (CEOS)
  - Disaster Societal Benefit Area
  - Working Group on Information Systems and Services (WGISS)

Project Objectives

- Define & facilitate implementation of a sensor web-based architecture for risk management from a multi-hazard perspective
- Address scope of GEOSS Task (Disaster Management DI-09-02b-3)
- Expected Impact:
  - Reduce the time to acquire and improve the use of relevant satellite data for flood assessment and forecasting
  - Increase the usefulness of derived satellite flood data products for local populations
- Approach:
  - Coordinate with WGISS to document and prototype a disaster management architecture to demonstrate improved decision support capability and access to remote sensing assets
  - Conduct socioeconomic surveys in flood prone areas
    - Identify local concerns/cultural barriers which prevent use of local flood forecasts
    - Explore methods to incorporate local observations into decision support systems and social networking technology (e.g crowd sourcing)

Objectives Illustrated

Satellite Observation

In-Situ Gauge

$$E = 1 - \frac{\sum_{t=1}^{T} (Q_o^t - Q_m^t)^2}{\sum_{t=1}^{T} (Q_o^t - \overline{Q_o})^2}$$

Predictive Flood Model

Household Surveys

SensorWeb Processing

Decision Support System

Economic Impacts

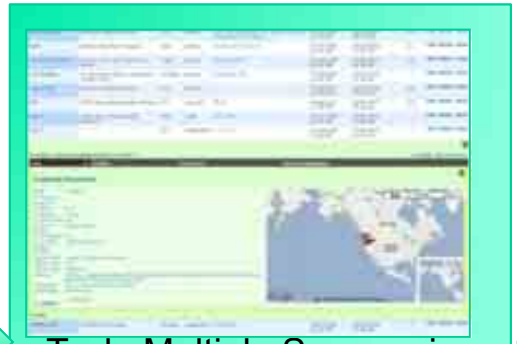
Namibia Flood Dashboard

Local Notification

NASA Flood SensorWeb Concept

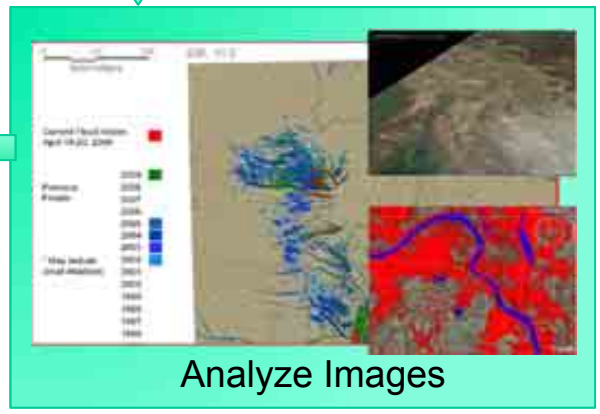
Detect Heavy Rains and Floods Upstream at a coarse level

Trigger automatic high resolution satellite data acquisition

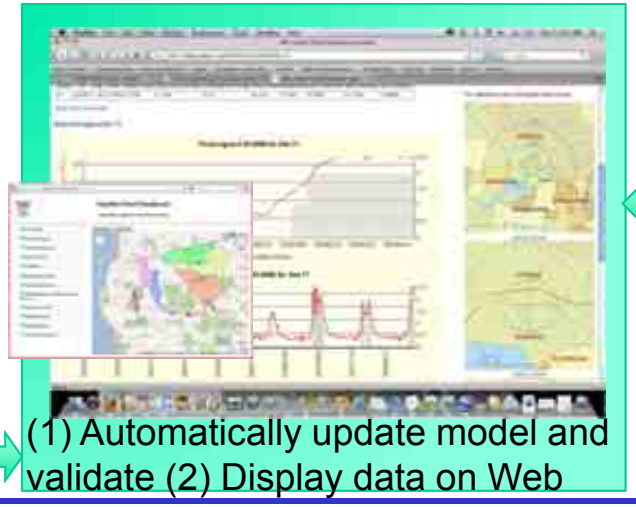


Task Multiple Sensors in Area of Interest

Acquire Satellite Data (Images)

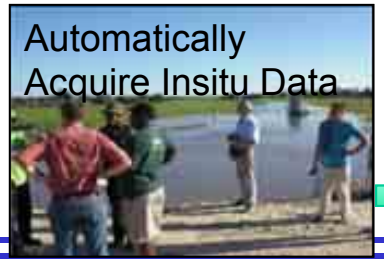


Analyze Images



(1) Automatically update model and validate (2) Display data on Web

Analyze Risks



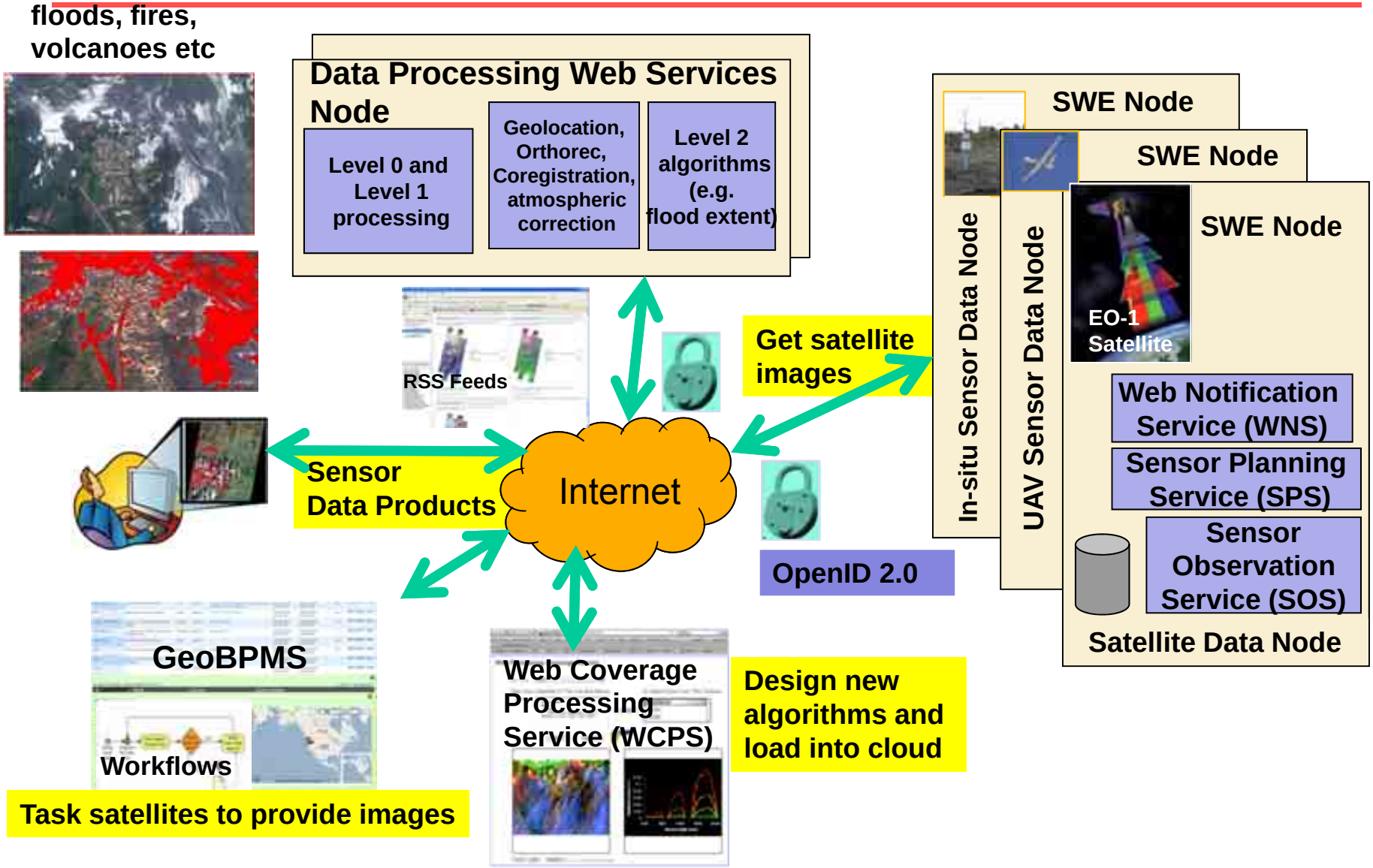
Automatically Acquire Insitu Data

Approach

- Namibia Department of Hydrology, Namibia Ministry of Health
  - In-country equipment, personnel and other resources
  - Logistics support
  - Direct technology development of other stakeholders
  - Local conditions expertise
- NASA, Univ. of Maryland, Univ. of Chicago, Univ. of Oklahoma, Open Cloud Consortium
  - Satellite imagery
  - Training on how to process the imagery to extract salient flood information
  - Preliminary flood models
  - Training on further refinement of flood models
  - Computation cloud and web interface to host data, models and displays
- Univ. of Namibia and Univ. of Maryland
  - In country survey development and design
  - Conduct case study surveys in flood prone areas
  - Culturally informed data analysis

SensorWeb High Level Architecture

Sensors, Algorithms and Models Wrapped in Web Services Provide Easy Access to Sensor Data and Sensor Data Products



Cloud Configuration for Flood Dashboard

CREST Hydrological Model

TRMM based Global Rainfall Estimates

Radarsat Images & flood extent maps

MODIS Daily Flood Extent Map

Global Disaster and Alert and Coordination System (GDACS)

Namibian River Gauge Stations - Daily Measurements

Storage – 1 year Hyperion & ALI Level 1R

Storage – 1 year Hyperion & ALI Level 1G

Storage – 1 years Hyperion & ALI Level 1R and Level 1G AC

Storage – 1 year User Defined L2 Products e.g. EO-1 Flood Mask

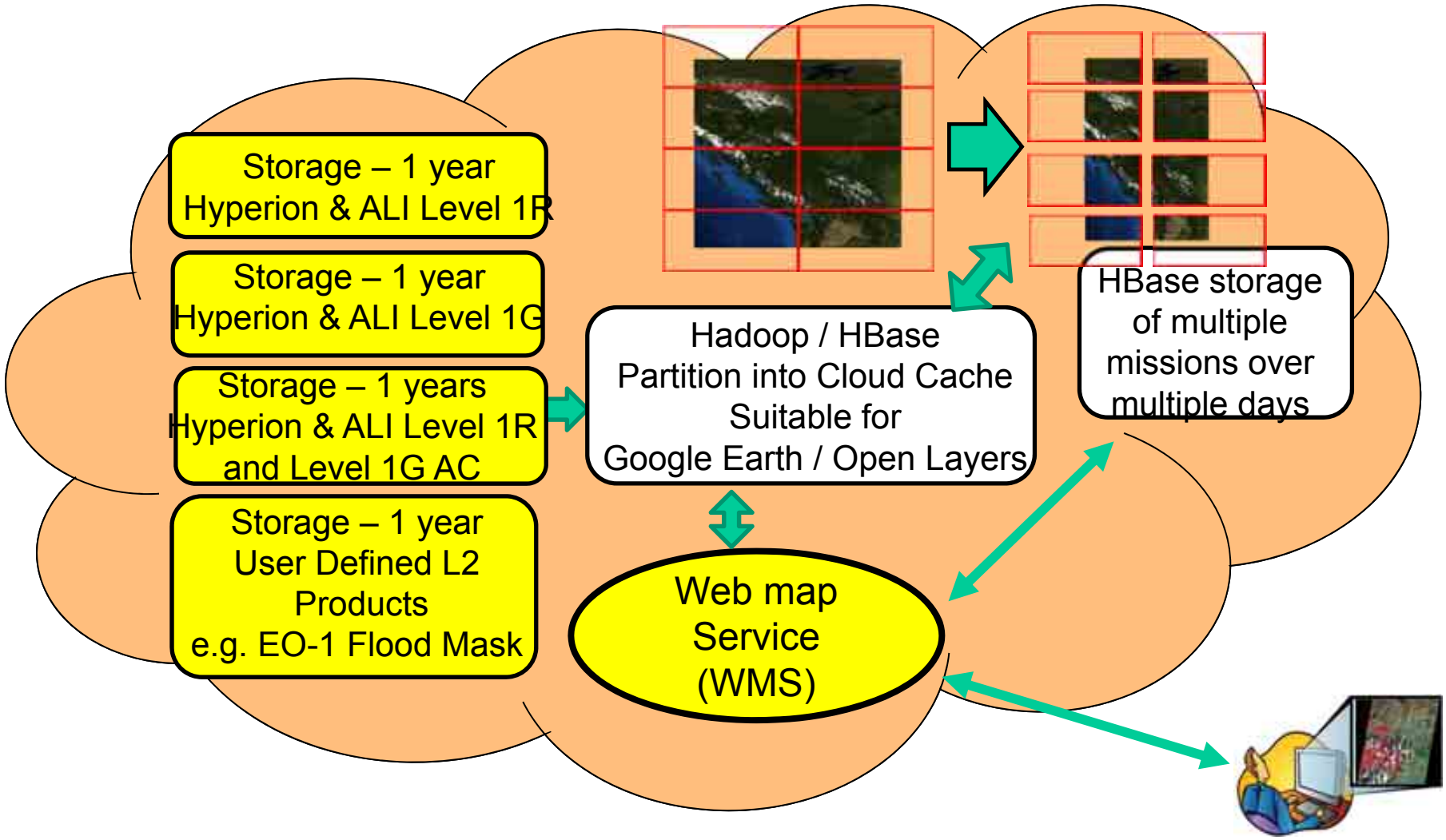
Namibia River Gauge Data base

Flood Dashboard Display Service
- Mashup
- Google Maps Inset
- Plot Package

http server

•Eucalyptus/Open Stack-based Elastic Cloud SW
•300+ core processors
•40 x 2 Tbytes of storage
•10 Gbps connection to GSFC
- being upgraded to 80 Gbps (Part of OCC)
•Hadoop/Tiling
•Supplied by Open Cloud Consortium
•Open Science Data Cloud Virtual Machines & HTTP server to VM's

Hadoop and Tiling Handles Large Dataset Displays

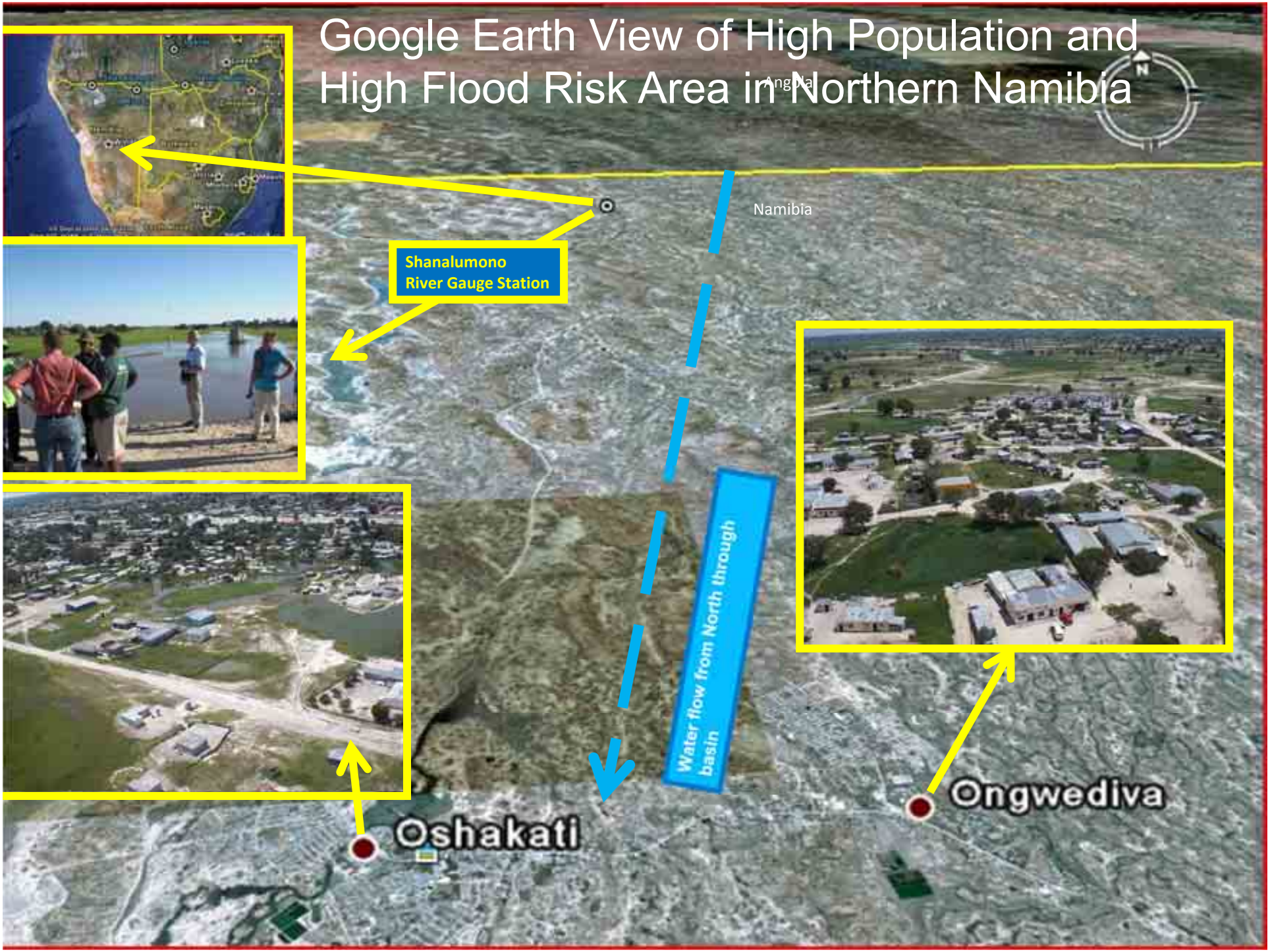


Potential Case Study, Cuvelai Basin - Oshana Formations

- Seasonally inundated depressions.
- Undulating landscape with topographic relief of approximately 1 meter at 1 km ASL.
- Characteristic landscape for a large area of northern Namibia and southern Angola, ca. 150 km northwest of the Etosha Pan.
- Characterized by small scale agriculture and grazing, with seasonal harvest of fish which breed in the oshanas.
- Over 50% of country's population lives in this area
- This area experiences the most flood damage in the country

Oshakati in Northern Namibia
flood picture in 2009

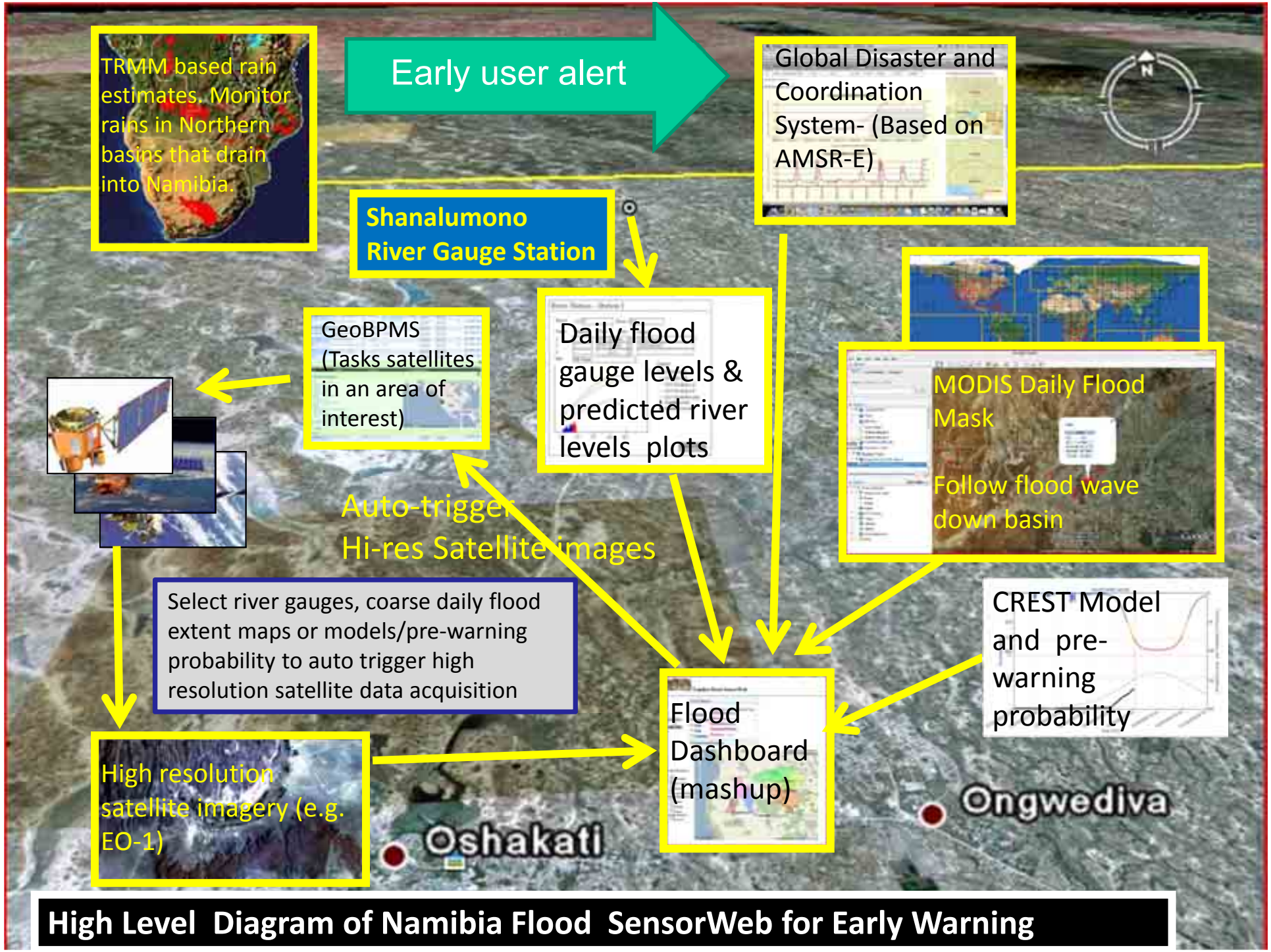
13


Google Earth View of High Population and High Flood Risk Area in Northern Namibia
Angola
Namibia
Shanalumono River Gauge Station
Water flow from North through basin
Oshakati
Ongwediva

EO-1 Satellite Image of High Risk Flood Area in Northern Namibia

Shanalumono river gauge station taken From helicopter Dan Mandl, Jan 29, 2011

Earth Observing 1 (EO-1)Advanced Land Image (ALI)
Pan sharpened to 10 meter resolution, Oshakati area Oct 10, 2010
Processing by WCPS, Pat Cappelaere and Antonio Scari Techgraf/PUC Rio



High Level Diagram of Namibia Flood SensorWeb for Early Warning

Training for Data Capture

Georeferenced photos to enable Rob Sohlberg from Univ. of Maryland to train classifier to detect presence of water in grassy marsh lands via from satellite data.

McCloud Katjizeu (orange) Dept of Hydrology compares GPS readings of control point with UNAM students for mapping exercise

Project Augmentation: Socioeconomic Assessment

Left to Right: Matt Handy (NASA), Reinhold Kambuli (NDH), Village Resident, Dr. Julie Silva(UMD), John Moyo(Local Guide)

Preliminary visits to flood prone villages to gauge community interest in participating in socioeconomic surveys and assess familiarity and perceptions of radio flood forecasts.

Flooding and Impacts on Local Livelihoods

Villager shows flood damage and impact during team site assessment

Flood Impact on Wild Life and Subsequently on Humans Nearby

Hippo tracks near villager Crop fields. Hippo crop destruction is big impact to villagers.

Request from Namibia Hydrological Services

- Monitor flooding in near-real time
- Create classification products
  - partition floodwaters by turbidity
  - presence of grasses, etc.
- Demonstrate rapid prototyping utilizing Web Coverage Process Services (WCPS)
  - To be used to both inform civil managers and – more importantly – to developed and validate predictive models.
- Improved hydrological model based on CREST
  - Model developed by University of Oklahoma
- Improved data products pipeline (more automation)

21

Contributions of Namibian Partners

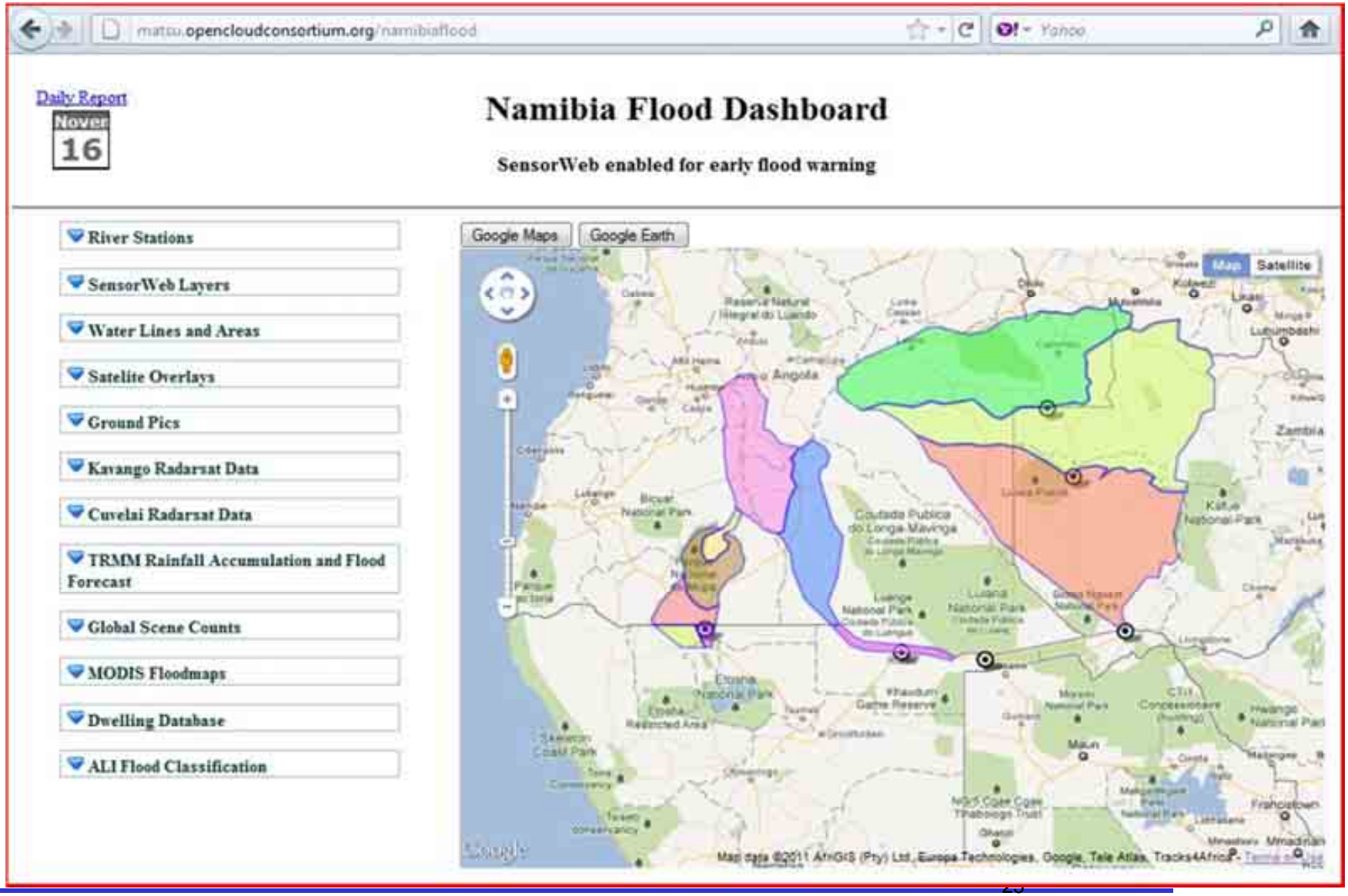
- Local terrain expertise to improve modeling
- Knowledge of local populations
- Expertise on conducting local surveys
- Develop new techniques and products useful to decision makers
- Namibian model will be extended to other countries and applications.

Hydrology team begins river validation exercise

Dan Mandl/NASA, Alphons Mosimane/UNAM, Selma Lendevlo//UNAM, Dr. Julie Silva/UMD, Dan Mandl/NASA, Victoria Shifidi/Dept Hydrology , Dr. Simon Angombe/UNAM, Margaret Angula/UNAM

Socioeconomic team discusses desired outcomes, timeline and next steps to develop a village level study which is integrated with Hydrology Dept. effort.

Planned Technical Enhancements to Flood Dashboard
Current Flood Dashboard on Computation Cloud



Planned Technical Enhancements to Flood Dashboard

- Partnership with Canadian Space Agency to simultaneously task EO-1 and Radarsat and deliver products from both automatically to Flood Dashbaoad
- Color code river stations to indicate underlying states and click for details
- More options on hydrographs
  - Min
  - Max
  - Average
  - Rainfall plots overlay
- Daily excel file download from FTP site and which provides underlying status and color codes of river gauges
- Track visitors to site
- Prototype pre-early flood warning which shows probability of flooding for next two weeks (via a plot) and is updated daily by model (see next slide)
  - Developed by University of Oklahoma (Yang Hong and Zac Flamig)

24

Probability of Flooding
(Univ. of Oklahoma, Zac Flamig)

Obs flow

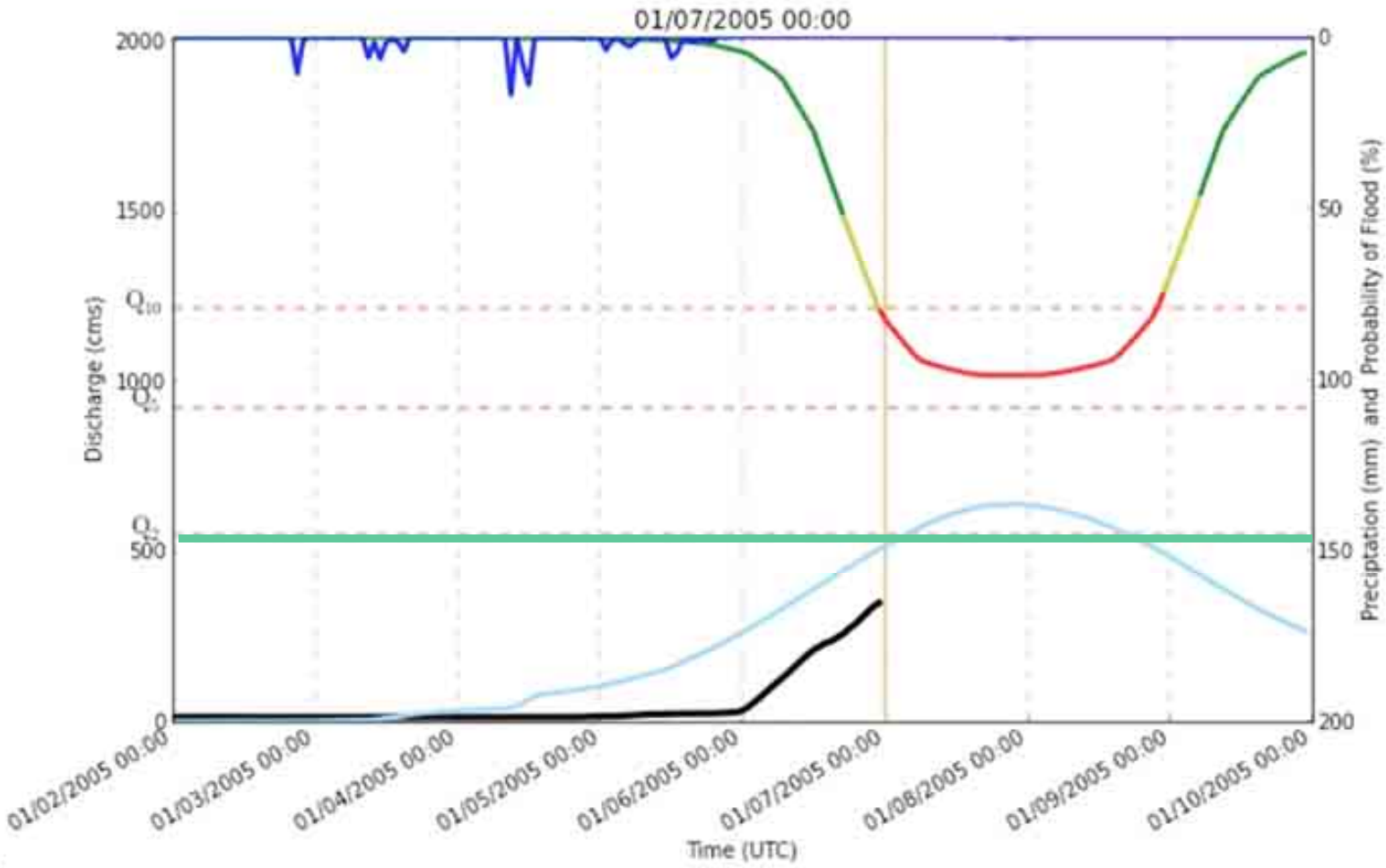
Sim flow

Precip

p(f) ≥ 0%

p(f) ≥ 50%

p(f) ≥ 75%



Planned Technical Enhancements to Flood Dashboard

- Obtained data from Central Bureau of statistics on this trip. Put on dashboard
  - New dwelling unit data base with schools, roads, commercial buildings, hospitals etc. geolocated and identified by class
  - Begin to evaluate how to use flood data with this data base (e.g. roads blocked due to floods)
- Collected hundreds of GPS encoded photos to enhance /calibrate flood classification algorithm for EO-1
- Met with Ministry of Health, National Vector Borne Disease Control Program, personnel to discuss adding water-borne disease risk maps as layer on Flood Dashboard
  - Dr. Petrina Uusikia, Chief Medical Officer, National Vector-borne Disease Control Program, Ministry of Health
  - Closhilde Narib,
- Met with Dr. Martin Hipondoka, head of Remote Sensing at Univ. of Namibia
  - Trying to arrange training on classification for floods using EO-1 optical imagery and Radarsat imagery

26

Planned Social Enhancements to Flood Dashboard

- Conduct data reconnaissance on social/cultural perceptions and usage of flood forecasts
  - E.g. track radio alerts which are in different languages and determine how message changed from original message provided by Dept of Hydrology
  - Investigate indicators the local villagers pay attention to because of cultural forces
- Conduct case studies in rural Namibian villages (e.g., socio-economic surveys and in-depth interviews) in order to

  –Identify ways to enhance effective use of flood forecasts by villagers

  –Assess value of local ecosystem services in order to develop flood prevention scenarios that reflect local preferences for goods and service