Towards Operational Water Resources Management in South Asia Exploiting Satellite Geodetic and Remote Sensing Technologies

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OBJECTIVES

To reach ARL>7 for operational water management in South Asia for the following:

1) Satellite (GPM/TRMM) Precipitation and Model-based seasonal forecasting of water availability.
2) Satellite-based Mountain glacier and snowpack monitoring.
3) Multi-Satellite Altimetry based monthly-to-3 monthly monitoring and projection of reservoir storage changes.
4) Monthly-to-seasonal GRACE-based monitoring and projection of ground water storage anomalies.
5) Satellite Altimetry-based long-range (> 14 days) river level forecasting during non-Monsoon periods.

IN OTHER WORDS…

- ✓ To empower 8 (Govt.) water management agencies of South Asia to improve and independently manage water resources for decision making at 30-180 day timescales using the vantage of space.
- ✓ Build capacity ground up for durable and sustainable applications of satellite-based products and tools (by building synergy with NASA SERVIR program) – ***long after project ends (to get out of business)***.
- ✓ Improve the quality of life of inhabitants of Indus, Ganges and Brahmaputra river basins.

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IN OTHER WORDS…

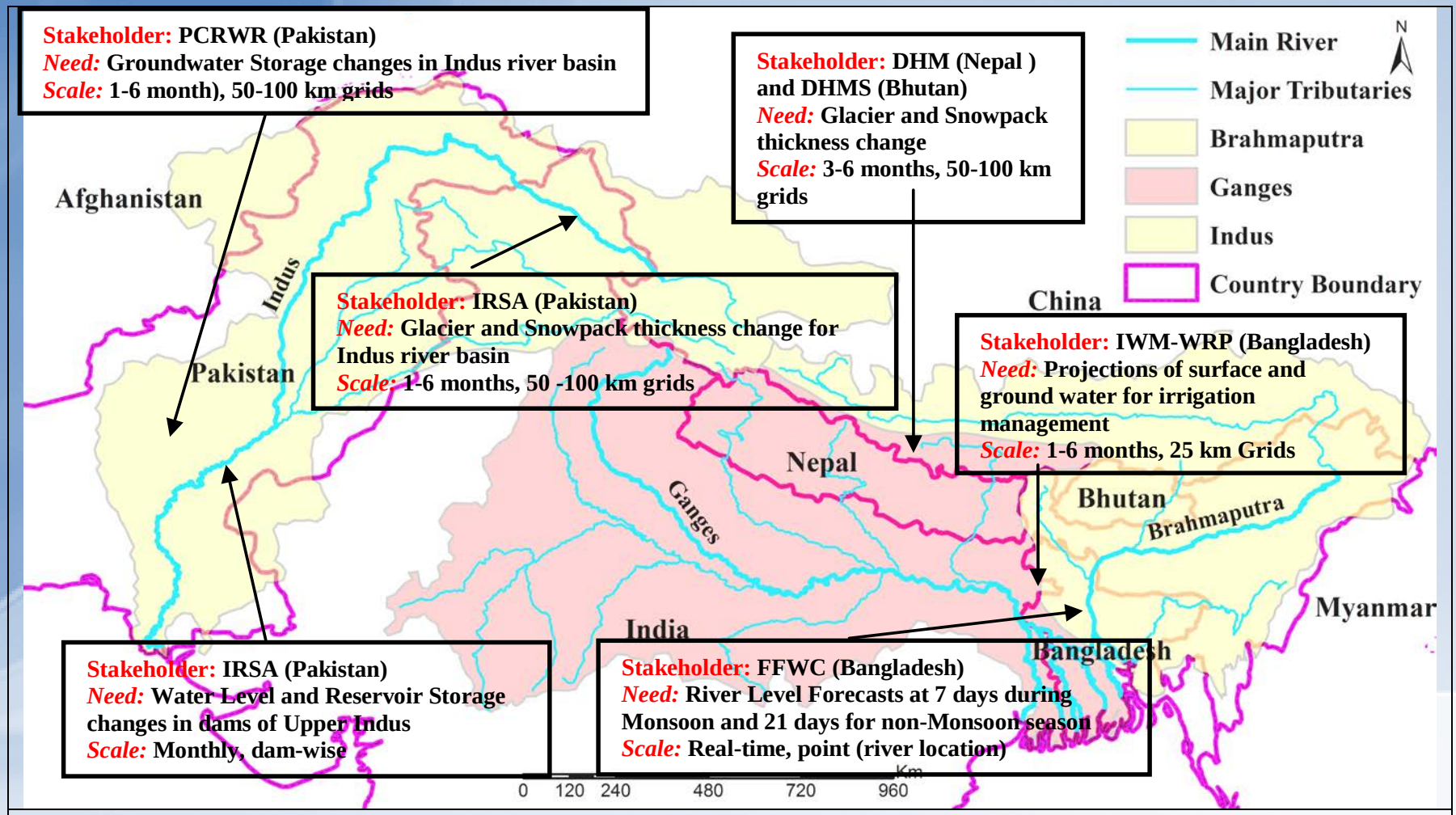

Figure 1. Map showing key water application needs of six end-user water management agencies in the Ganges-Brahmaputra and Indus River basins. FFWC – Flood Forecasting and Warning Center (FFWC-Bangladesh), IWM-WRP (Institute of Water Modeling- Water Resources & Planning-Bangladesh), IRSA (Indus River System Authority – Pakistan), PCRWR (Pakistan Council for Research on Water Resources –Pakistan) and DHM (Department of Hydrometeorology, Nepal), DHMS (Department of Hydromet Services-Bhutan).

THE STAKEHOLDER AGENCIES (TOTAL 8 GOVT. AGENCIES)

- ✓ **Indus River System Authority** – IRSA; national mandate to ensure equitable distribution among provincial stakeholders.
- ✓ **Pakistan Council for Research on Water Resources** – PCRWR; national mandate to do 'research' on water resources for policy and planning guidance.
- ✓ **Pakistan Agricultural Research Council** (PARC)-national mandate for crop management
- ✓ Nepal and Bhutan **Departments of Meteorology and Hydrology**
- ✓ Bangladesh **Institute of Water Modeling** (IWM) and **Flood Forecasting and Warning Center** (FFWC)

All agencies are Federal Govt-funded; staff salary are Federal budget lines; strong potential for opening new permanent positions and hardware infrastructure in federal budget for durable application of products/tools without external funding.

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SATELLITE SENSORS AND TOOLS

Sensors

- ✓ JASON-2; AltiKa, *JASON-3, ICESat-2, Sentinel-3*
- ✓ GRACE
- ✓ TRMM and GPM
- ✓ Various SAR, Polarimetric SAR, visible and near-infrared sensors (LANDSAT/MODIS)

Tools:

- ✓ Altimeter Tool
- ✓ GRACE Tool
- ✓ Hydrologic Model (VIC)-based web-interface with hindcast, nowcast and forecast (up to 180 days) functionality (based on TRMM/GPM and model forecast data).

MODUS OPERANDI FOR RAISING ARL

- ✓ Based capacity building workshop (thanks to SERVIR) and lessons learned along the way.
- ✓ Study agencies carefully over a year to delineate decision making needs.
- ✓ Make 'Draft' Tools as 'toys' to allow maximum interaction during training workshops.
- ✓ Redesigned Workshop delivery as follows:
  - ✓ ***Morning session*** – overview of concept, theory; interaction with toys;
  - ✓ ***Afternoon session*** – solicitation of agency-specific feedback on required design features (changes to existing or new functionalities) for operational & independent adoption
  - ✓ Summarize a 1 year action plan as a "*loosely binding*" document between supply (PI) and demand (agencies).
  - ✓ Six products 'pushed' during Feb 16-20, 2015 workshop in Pakistan. Three directly relevant to water management at timescales of 30-180 days.

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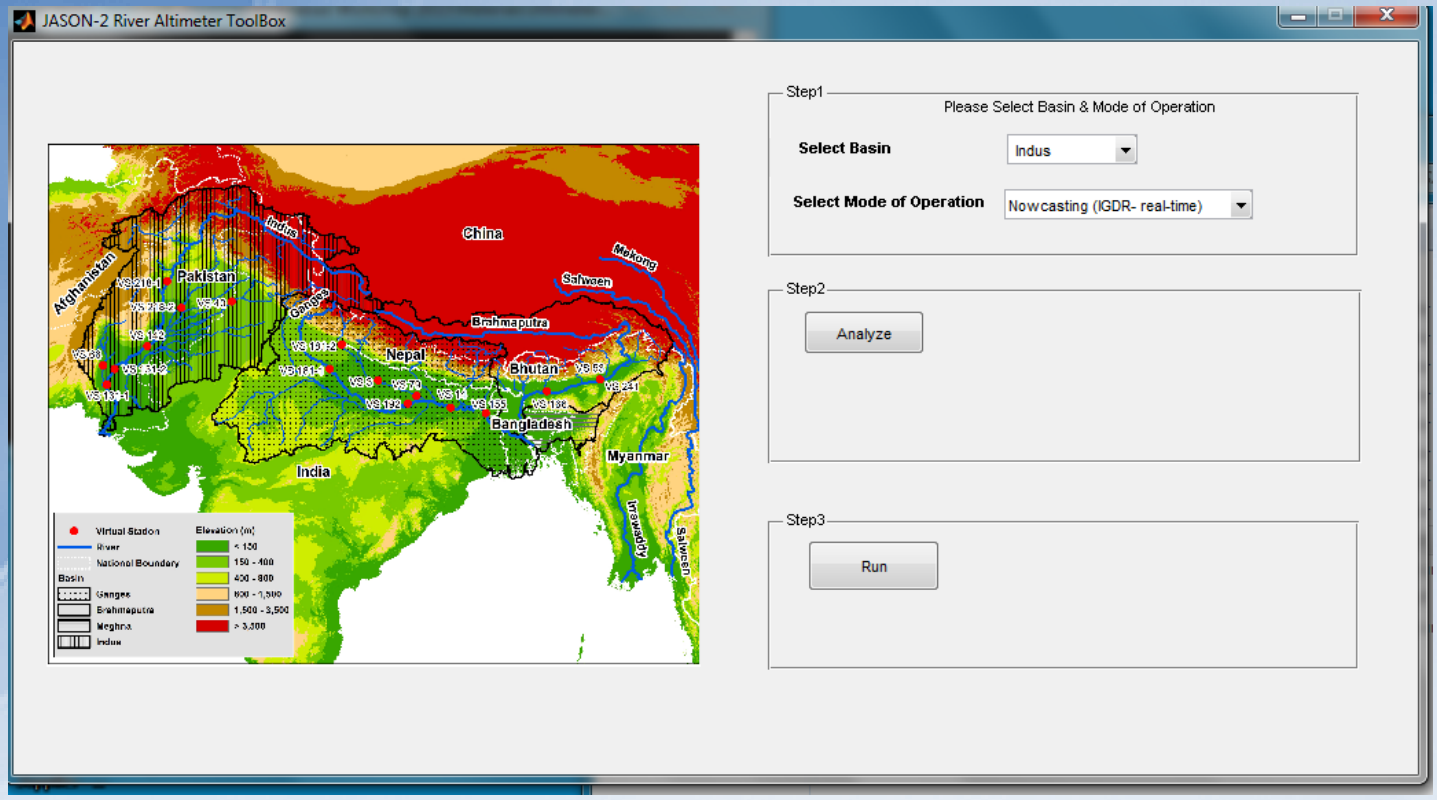
The TOOLS (Intentionally Unfinished)

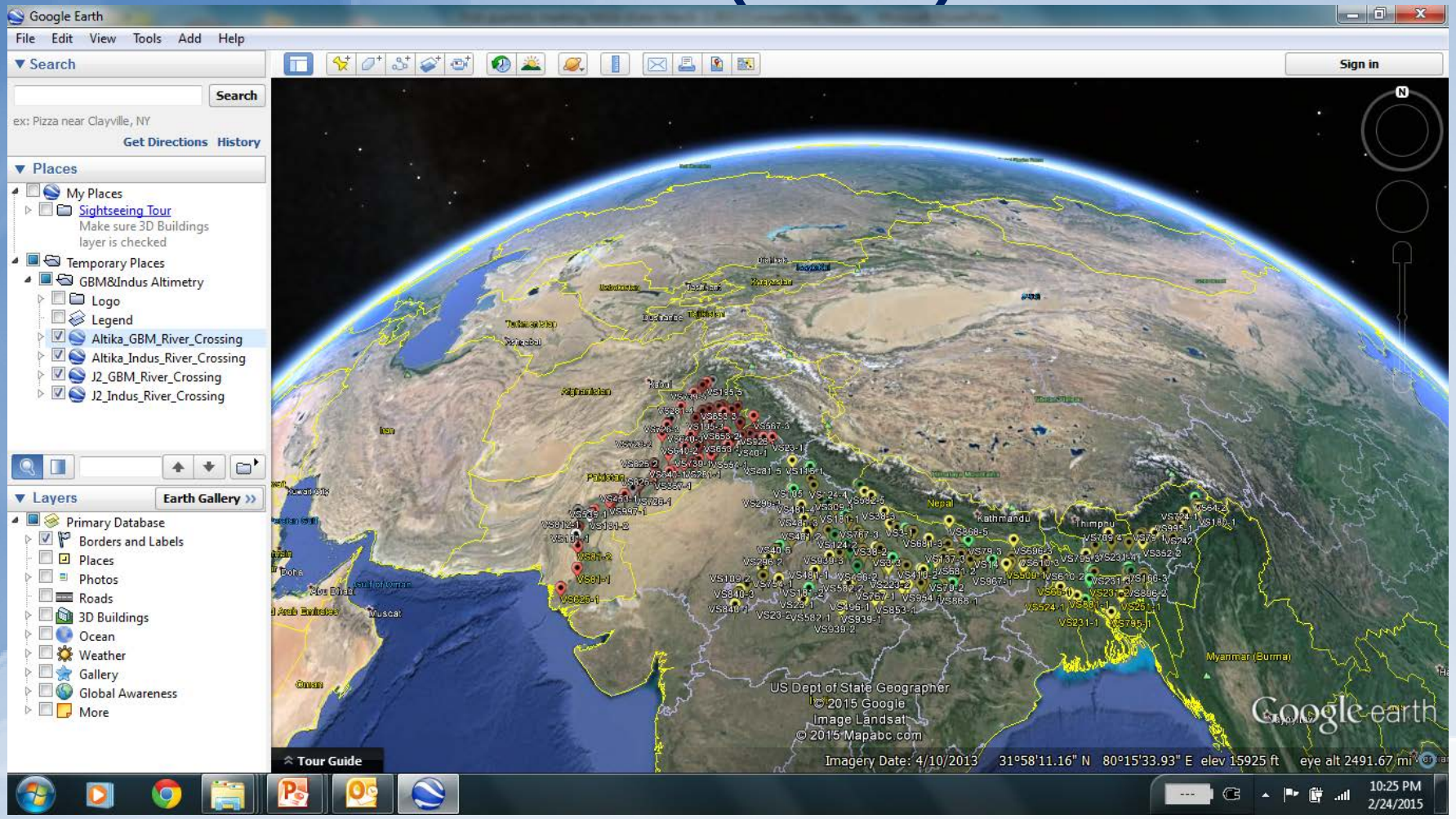


Graphical User Interface for JASON-2 and AltiKa at select virtual stations; Users have option to select specific sensor and station location.

Data download – manual

Useful for: water balance, reservoir storage change at monthly scales; irrigation diversion (for seasonal water management downstream nations); flood forecasting

TOOLS (Contd)



Google Earth (Pro) version of Altimeter Tool. Red, yellow and Green stations are crossings by JASON-2 and AltiKa.

Useful for: reservoir storage change, river level, water balance, snow depth, flood forecasting

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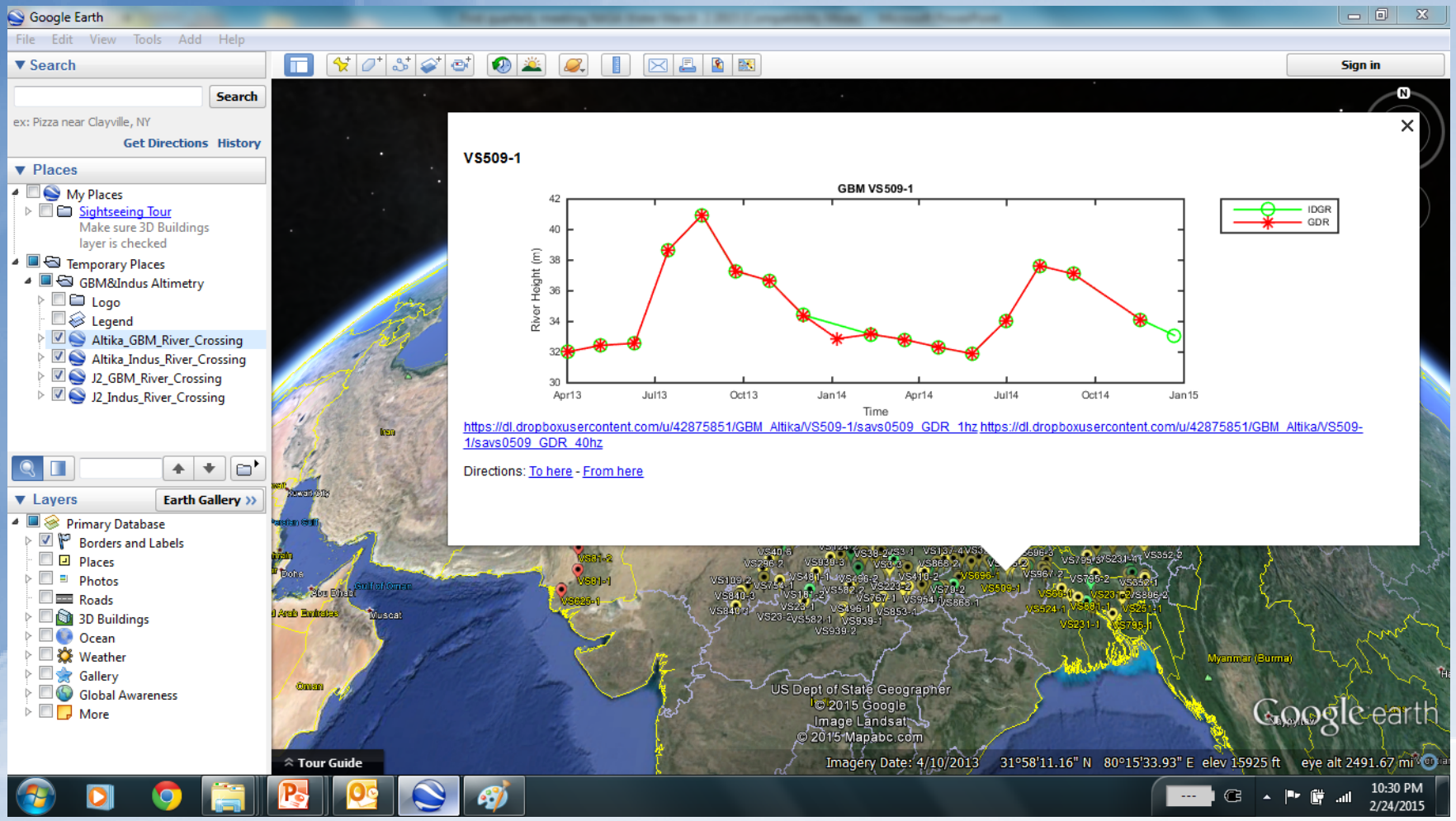

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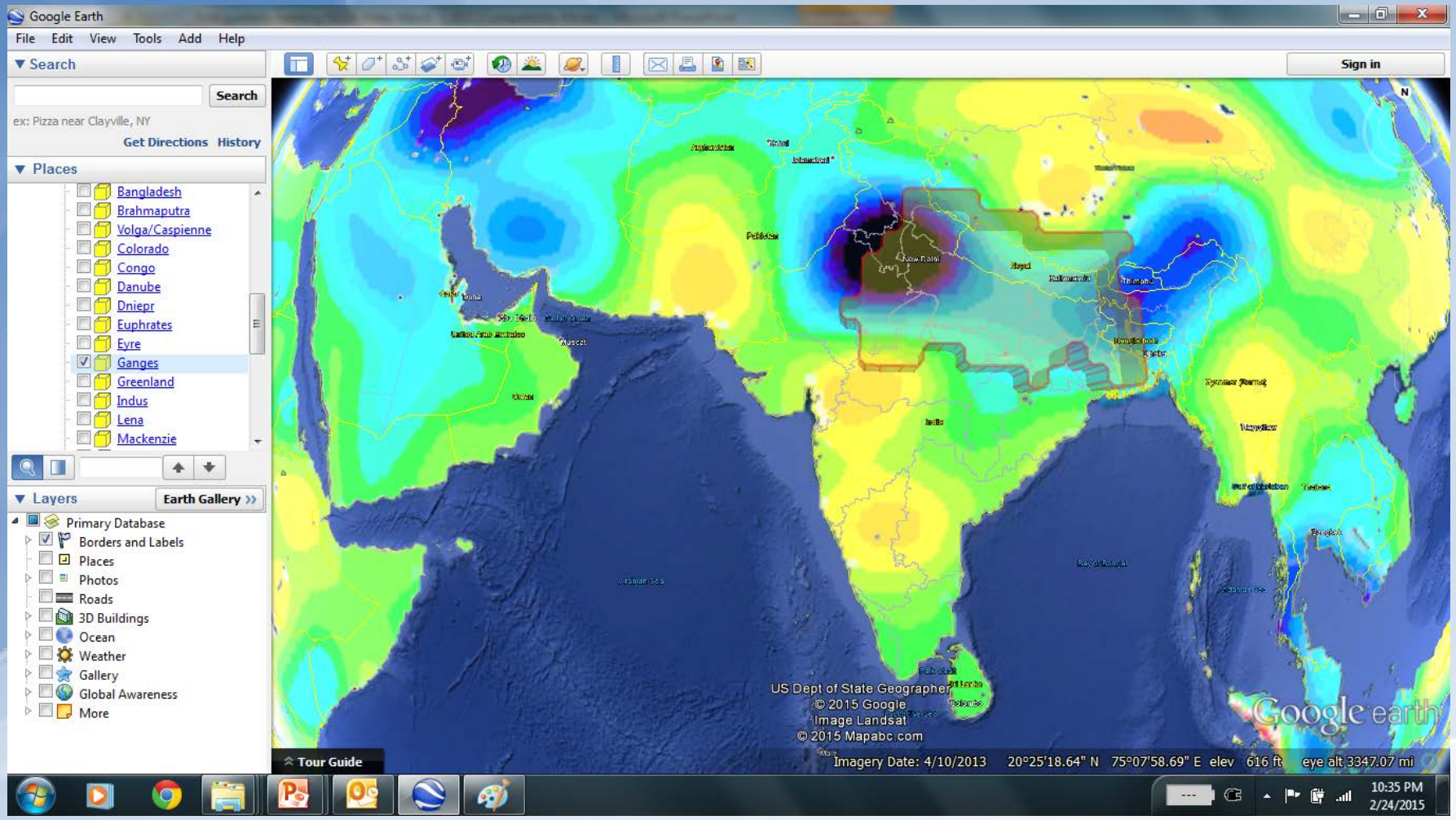
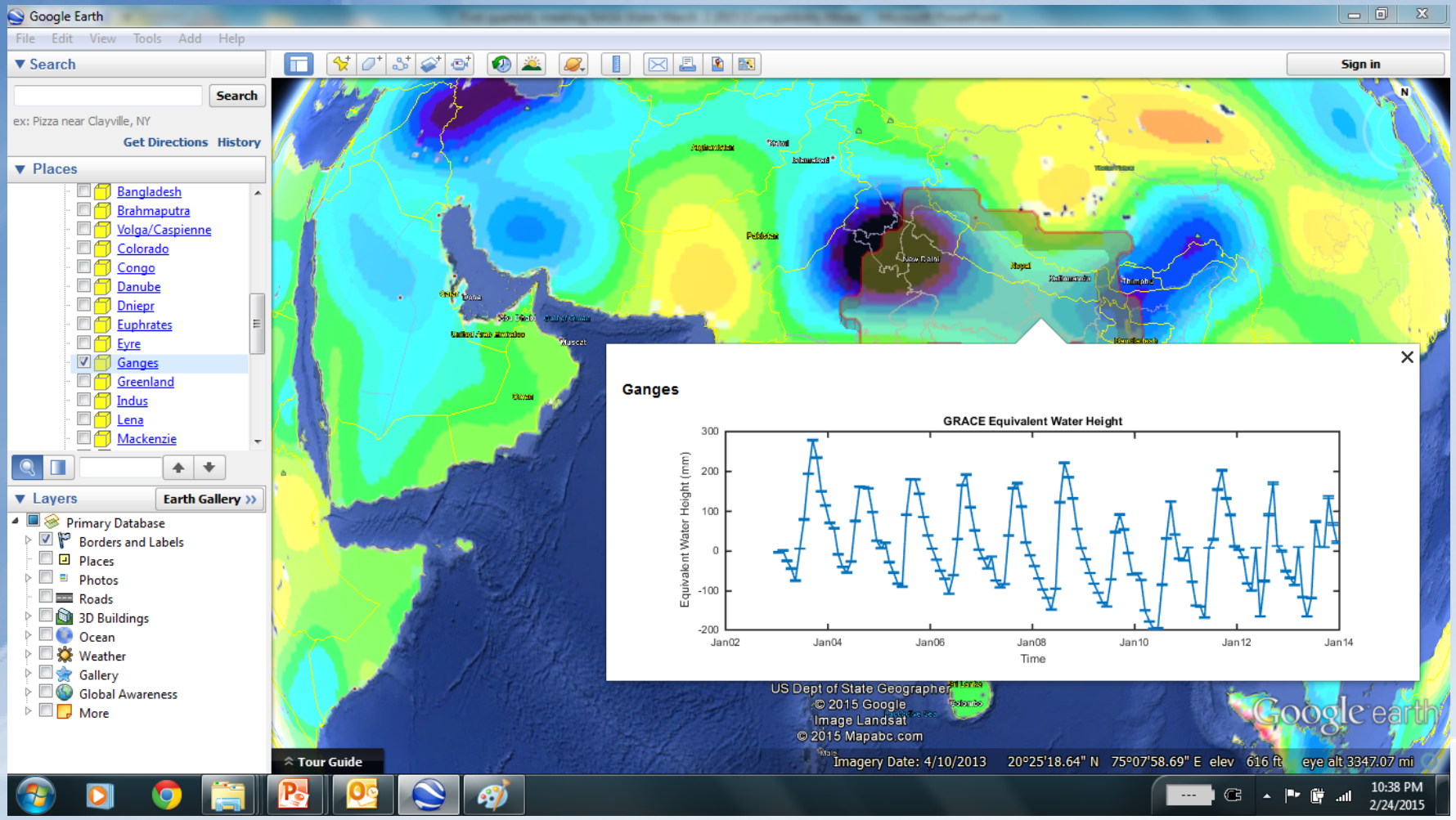


GRACE tool for equivalent water storage (monthly and daily solutions) (with downscaling) – basin-wise and spatially distributed

Useful for: Groundwater management (Monsoon recharge; pre-Monsoon synopsis); Glacier monitoring; Freshwater water balance (Indus), Discussing Indus Treaty.

TOOLS (Contd.)



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Data available from GRACE inception

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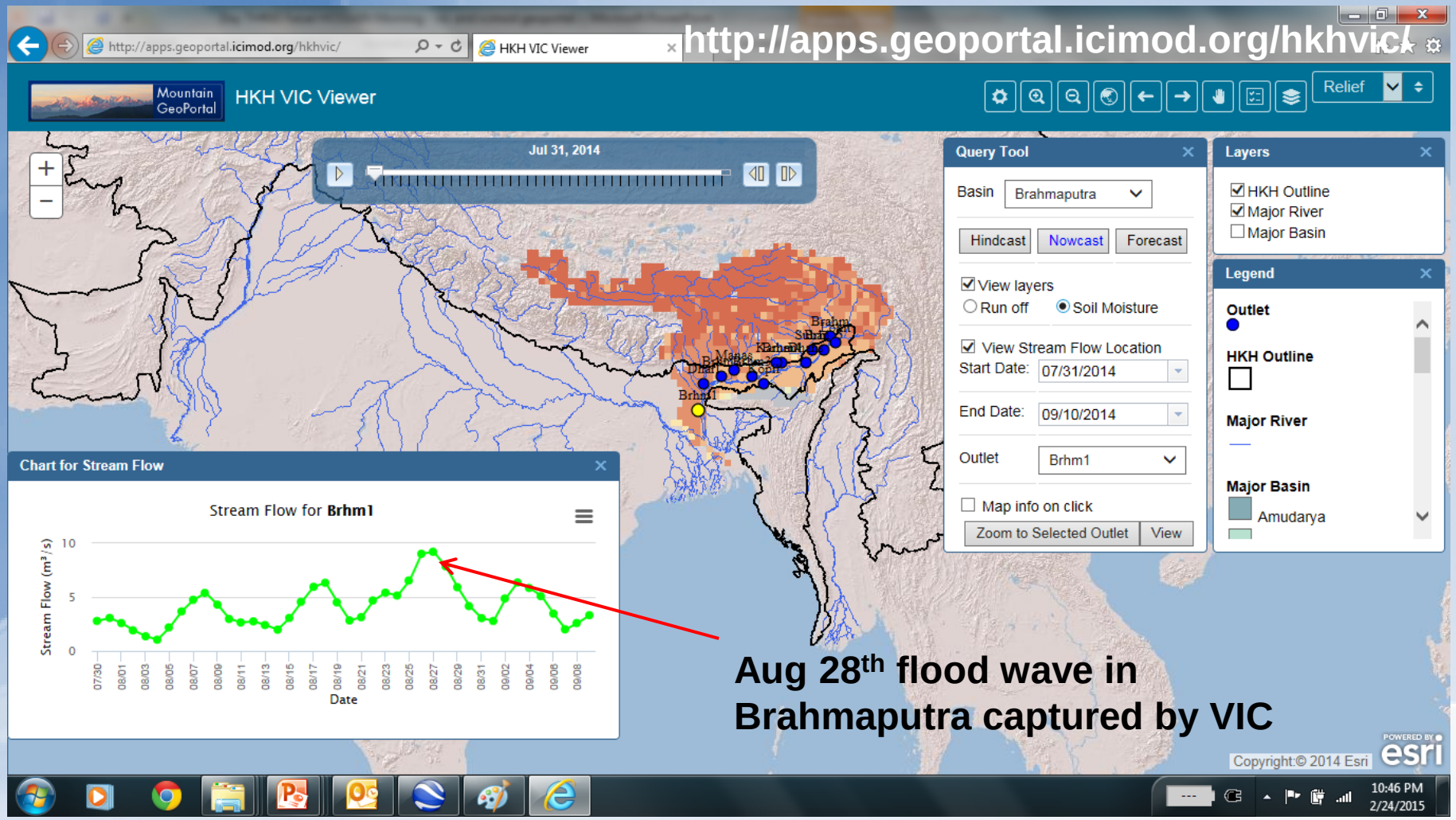


Aug 28th flood wave in Brahmaputra captured by VIC

Hydrologic Model (VIC) based hindcast, nowcast and forecast (up to 6 months) of soil moisture, runoff and stream flow.

Useful for: water management, planning, policy development, water balance studies; irrigation planning; guidance on flood forecasting. Can be combined with previous tools

AGENCY FEEDBACK ON DESIGN (1 Year Action Plan 2015-2016)

Capacity Building Workshop held Feb 16-20 2015 in Pakistan with SERVIR (ICIMOD-regional) coordination support. Total of 5 Govt. Agencies attended an intense session. Three products (and all tools) directly relevant to 30-180 day projection of water anomalies.

Findings - Key design features required are:

1) Google Earth as main template with automatic/manual data download option;
2) Functionality for compute, overlaying user-specified GIS layers, point data etc.
3) Functionality for storing numeric data (raster).
4) Functionality for calibration and user-defined forcing files for VIC model geoportal.
5) Higher spatial resolution and guidance on data quality (e.g. sigma0 for altimetry).
6) Breaking down into sub-basins.

TARGET
(1 Year Action Plan 2015-2016)

- Finalize all tools/models according to design feedback provided by agencies to make them agency-relevant.

- Conduct trial in agency environment for PARC, PCRWR and IRSA in Spring 2016 of all three tools and 3 products. Complete hand-over and adoption > mid-2016.

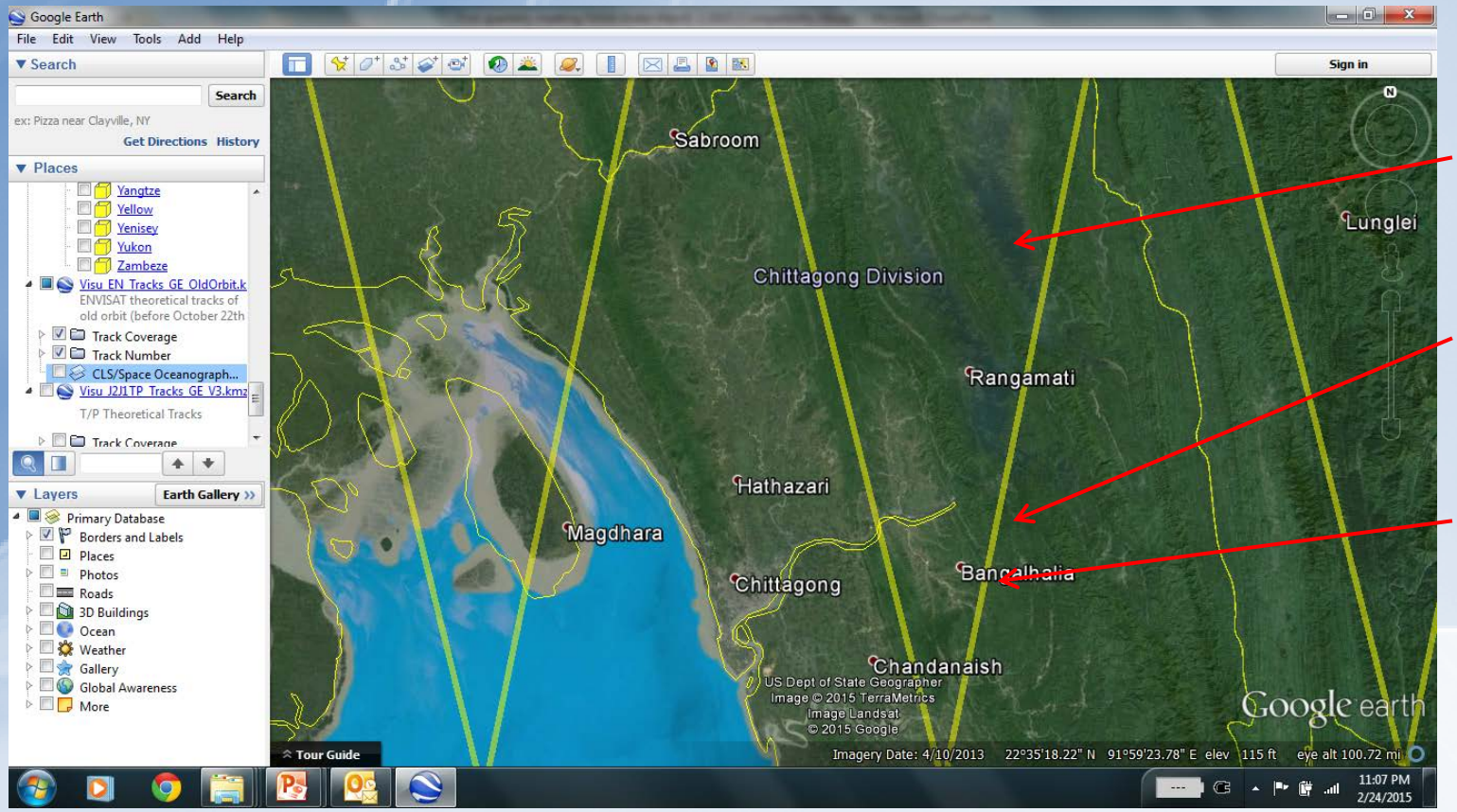
- Transboundary Reservoir Management (> mid-2016) for IWM using data from domestic reservoir storage and flow release data inside Bangladesh (*Lake Kaptai*).

- Operational Water Management (> mid-2016) for IWM Water Resources Division for April-Nov water management using hydrologic model forecast.

- Operational Flood Guidance (> mid-2015) for FFWC.

IMMEDIATE AGENCY-TRIGGERED ACTION

- Institute of Water Modeling (IWM) Water Resources and Planning Division (WRP)



Artificial Reservoir – *Kaptai Lake*

Hydropower Dam

AltiKa/Envisat tracks

IWM-WRP initiating its own 'research' to investigate altimeter-based reservoir storage changes and releases for a 'domestic reservoir' – afforded by satellite tools.
A regional altimeter tool to be used by IWM for transboundary reservoirs.

IMMEDIATE AGENCY-TRIGGERED ACTION (no training from supply-side)

- **Institute of Water Modeling (IWM) Water Resources and Planning Division (WRP):**

  GRACE tool as an additional tool/constraint for Brahmaputra sub-basin model development and application. Altimeter tool for understanding wetland connectivity in 'haors' (local name for seasonal lakes) and for water/eco- system management

- **FFWC to start using VIC geoportal** as a flood guidance based on accurate delineation of Aug 28th 2014 peak flow.
- **FFWC to start using altimeter tool** for improving sampling for flood forecasting.
- **PCRWR to investigate the use of altimeter tool** for freshwater inflow from transboundary regions of Upper Indus basin.

ACKNOWLEDGEMENTS

NASA SERVIR Program and ICIMOD for stakeholder engagement

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