Atmospheric Monitoring and Assessment - Geospatial Data and Models

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What do we Observe

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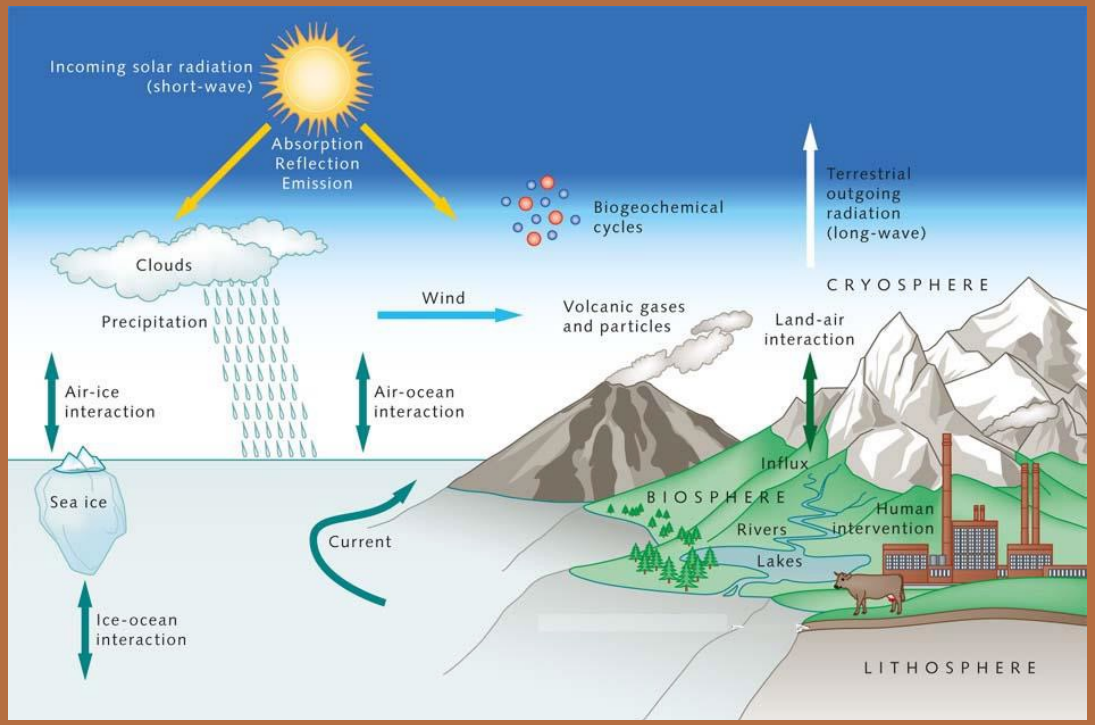
The spatio-temporal states and processes of the climate system



Source: Yang et al. , Nature Climate Change, 15 Sep, 2013

Scales

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- Microscale: kilometers
- Mesoscale: tens of kilometers
- Synoptic: hundreds or thousands of kilometers
  - Weather Maps
- Global
  - Wind belts
  - El Nino and other oscillations

Tools for Observation

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- Surface Network
- Ground based Radar
- Upper air
- Space based

Ground based monitoring

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- **Strengths:**
- Accurate, precise measurements
- Provide near surface condition

- **Limitations:**
- Measurements only in location of the instrument. Needs interpolation.
- Expensive to cover large region

Satellite data

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- **Strengths:**
- Provide seamless coverage at various scale and from places where ground based monitoring is difficult
- Provide routine measurement at various temporal scale
- Many of the data are in public domain

- **Limitations:**

- Optical sensor care blocked by cloud
- Measure entire vertical column not specific to near surface.
- Temporal and spatial resolution can limit data availability.

Integration of Satellite and Ground based data

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- Satellite provide data from area where ground coverage aren't available
- Ground based data are used to validate satellite measurement
- Correlation between satellite and ground data are used to improve satellite measurement

Model forecast data

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- **Strengths:**
- Provide future conditions
- Helpful for decision making for future

- **Limitations:**
- Uncertainty in forecast
- Difficult to interpret

Importance of Satellite based observation

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- The Global Climate Observing System (GCOS) declared **26** out of **50** essential climate variables (ECVs) as significantly dependent upon satellite observations
- **Observing the climate system at multiple spatio-temporal scales**
- Improvement of meteorological reanalysis data

Essential Climate Variables (ECVs) for which satellite observations make a significant contribution

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Domain	Essential Climate variables
Atmospheric (over land, sea and ice)	Surface: Air temperature, Wind speed and direction, Water vapour, Pressure, Precipitation, Surface radiation budget. Upper-air : Temperature, Wind speed and direction, Water vapour, Cloud properties, Earth radiation budget (including solar irradiance). Composition: Carbon dioxide, Methane, and other long-lived greenhouse gases, Ozone and Aerosol, supported by their precursors
Oceanic	Surface: Sea-surface temperature, Sea-surface salinity, Sea level, Sea state, Sea ice, Surface current, Ocean colour, Carbon dioxide partial pressure, Ocean acidity, Phytoplankton. Sub-surface: Temperature, Salinity, Current, Nutrients, Carbon dioxide partial pressure, Ocean acidity, Oxygen, Tracers.
Terrestrial	River discharge, Water use, Groundwater, Lakes, Snow cover, Glaciers and ice caps, Ice sheets, Permafrost, Albedo, Land cover (including vegetation type), Fraction of absorbed photo synthetically active radiation (FAPAR), Leaf area index (LAI), Above-ground biomass, Soil carbon, Fire disturbance, Soil moisture.

GCOS 2011: SYSTEMATIC OBSERVATION REQUIREMENTS FOR SATELLITE-BASED DATA PRODUCTS FOR CLIMATE , GCOS 154

Atmospheric remote sensing - History

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- 1960: TIROS – 1 proved that satellite can observe weather pattern
- 1964-78: Nimbus series – seven satellites launched during that period.
- 1962: Defense Meteorological Satellite Program (DMSP) launched
- 1966: ESSA –I , II, first US global weather satellite
- 1972: LandSAT series launched
- 1974: Geostationary Operational Environmental Satellite (GOES) series launched
- 1975: SMS-A, SMS-B, first spacecraft with geosynchronous orbit. Started providing cloud cover every 30 minutes
- 1984: The earth radiation budget (ERBE) satellite began
- 1986: SPOT-1 satellite launched
- 1992: US-French TOPEX Poseidon Satellite began, JERS
- 1997: TRMM launced including precipitation RADAR
- 1999: LandSAT 7, ASTER, MODIS-Terra, IKONOS
- 2002: SPOT-5, ENVISAT, MODIS Aqua
- 2003: GEOSS system launched, RadarSAT-2 launched

Access to a **variety** of remote sensing platforms

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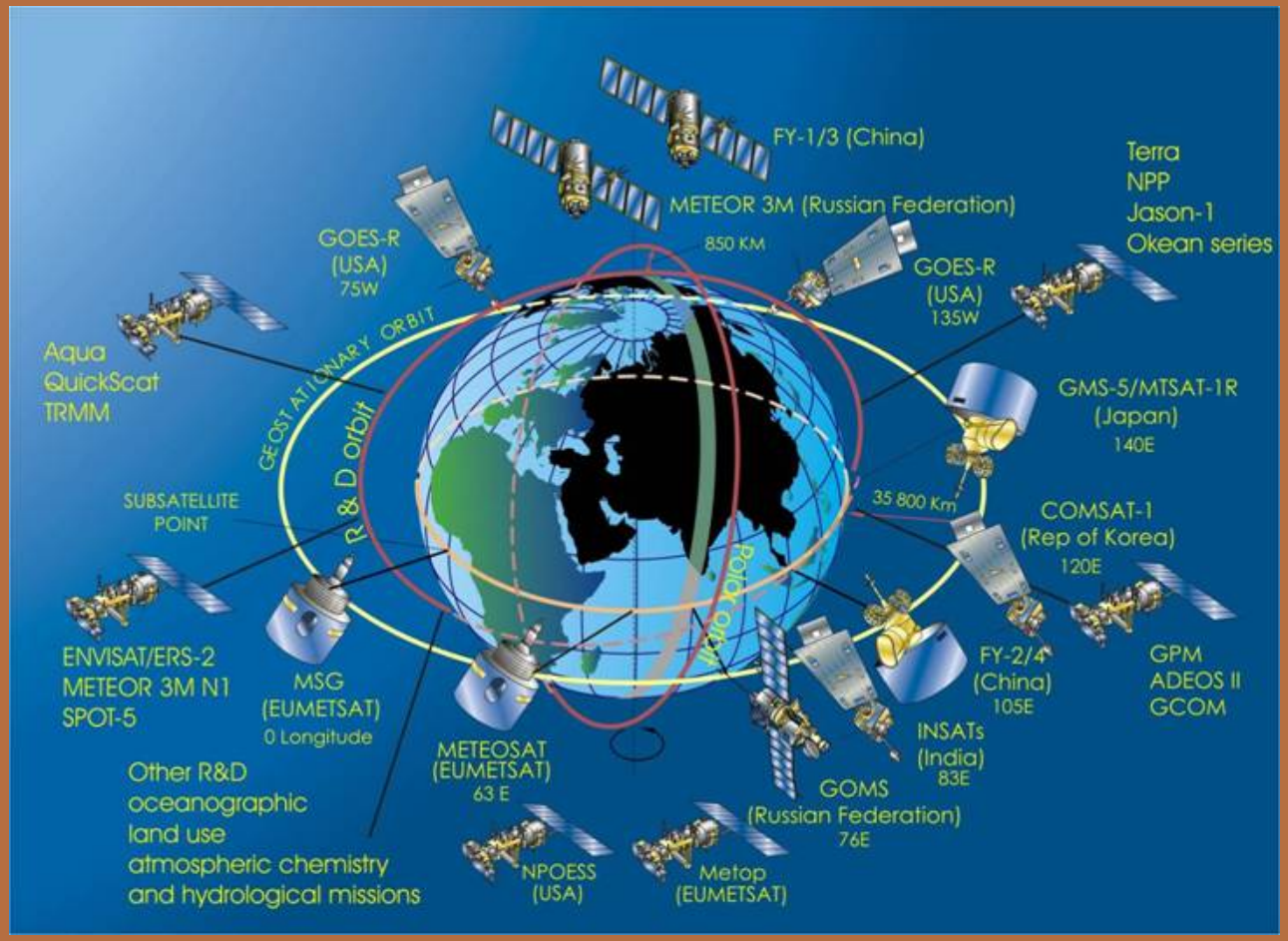

Integration across: Platforms, Sensors, Products, DAACs *is non-trivial*

Observation of ECVs - ICIMOD

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- MODIS ground station. MODIS level 2 and level 3 products
  - Near real time data delivery of selected Level-II products (within 30 minutes of satellite overpass)
  - Improved Level-III data products calibrated and customized to regional context

Observation of ECVs - ICIMOD

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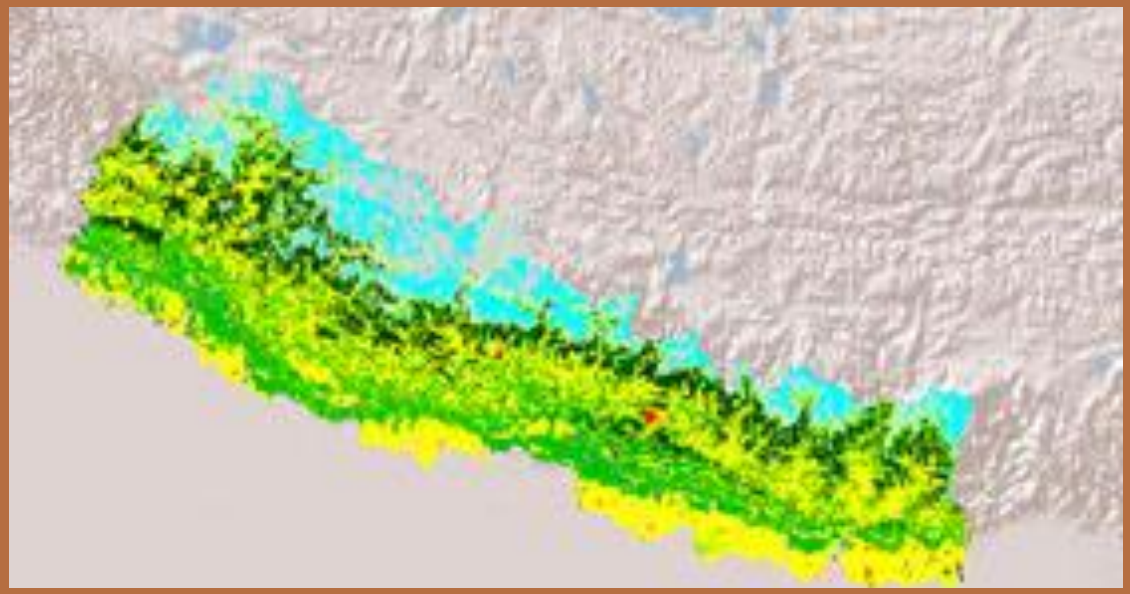
- Land Cover Dynamics
  - Decadal Land cover maps of HKH region



Nepal Land cover 2010

Observation of ECVs - ICIMOD

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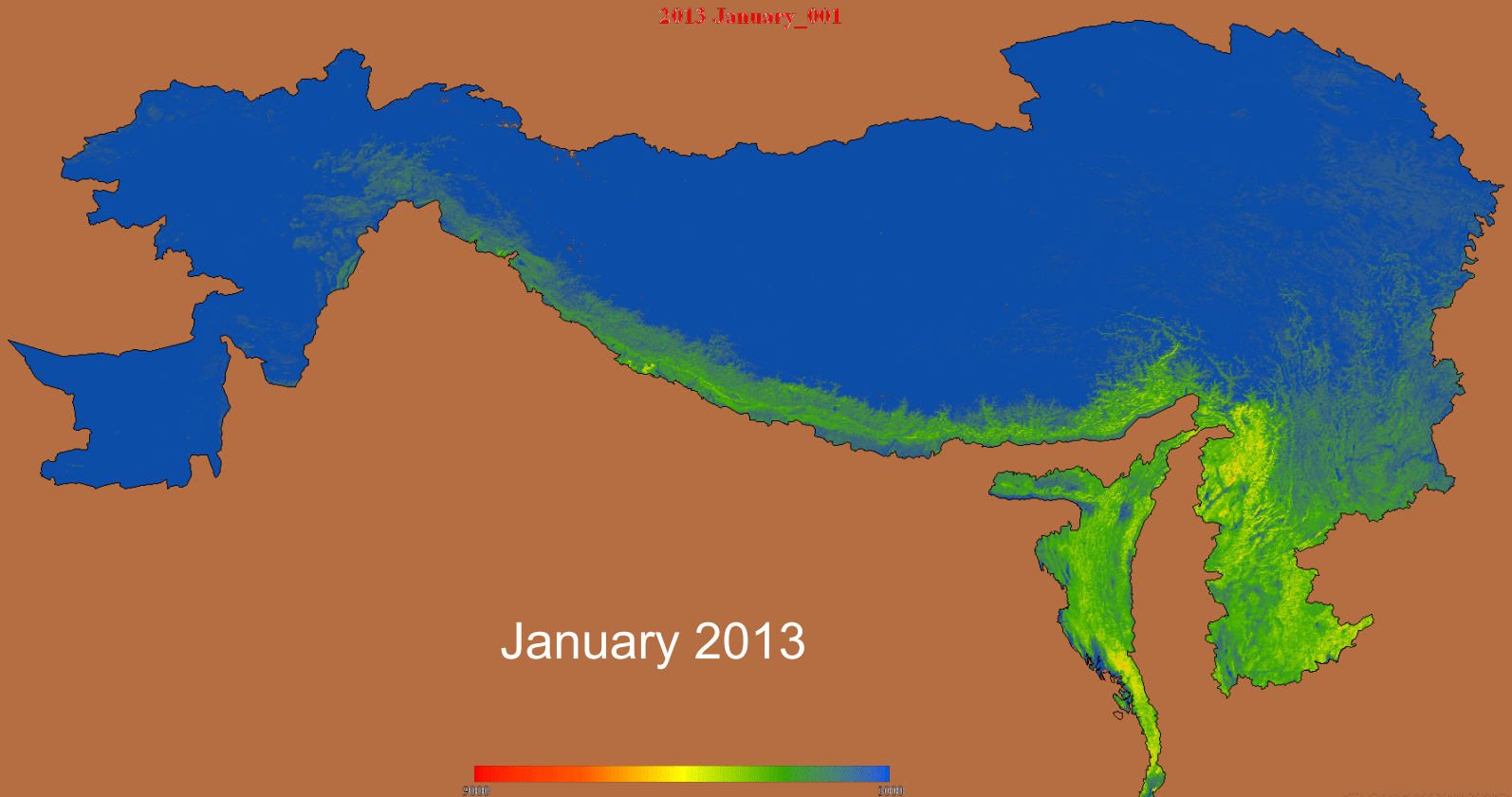
- Land Cover Dynamics
  - Annual/Seasonal vegetation dynamics (in process)



January 2013

Observation of ECVs - ICIMOD

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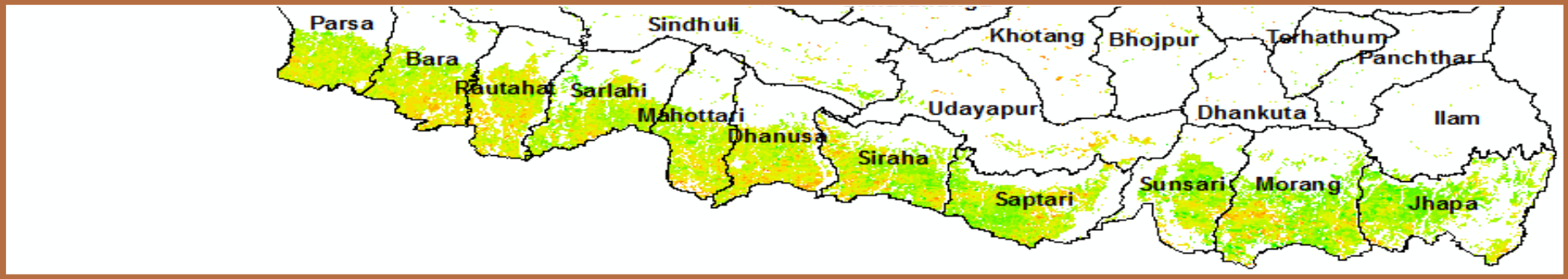
- Land Cover Dynamics
  - Crop area and growth

12 August 2013

Temopral Patterns of Rice



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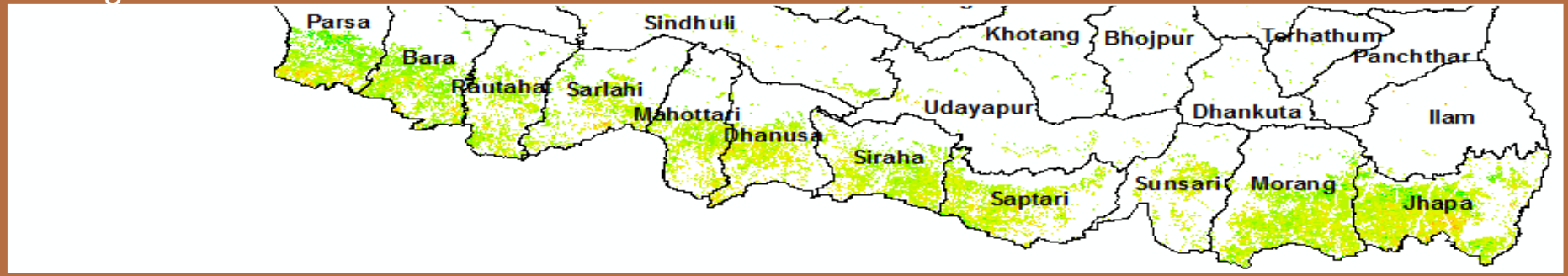

Observation of ECVs - ICIMOD

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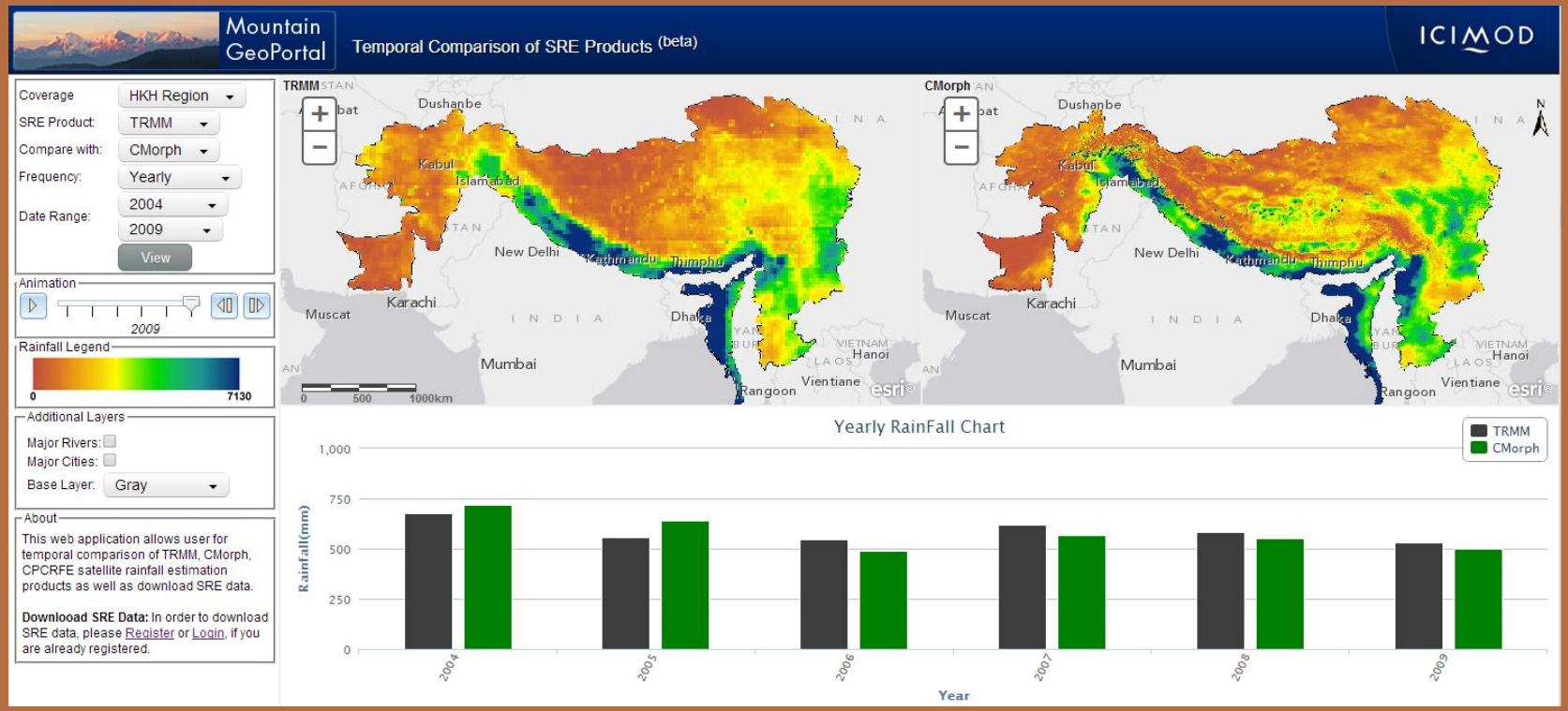
- Rainfall
  - TRMM based rainfall



Observation of ECVs - ICIMOD

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- Cryosphere
  - Baseline data on Glaciers of the HKH region
  - Decadal glacier inventory – Nepal, Bhutan
  - MODIS snow cover data (500m, 8-day composite)

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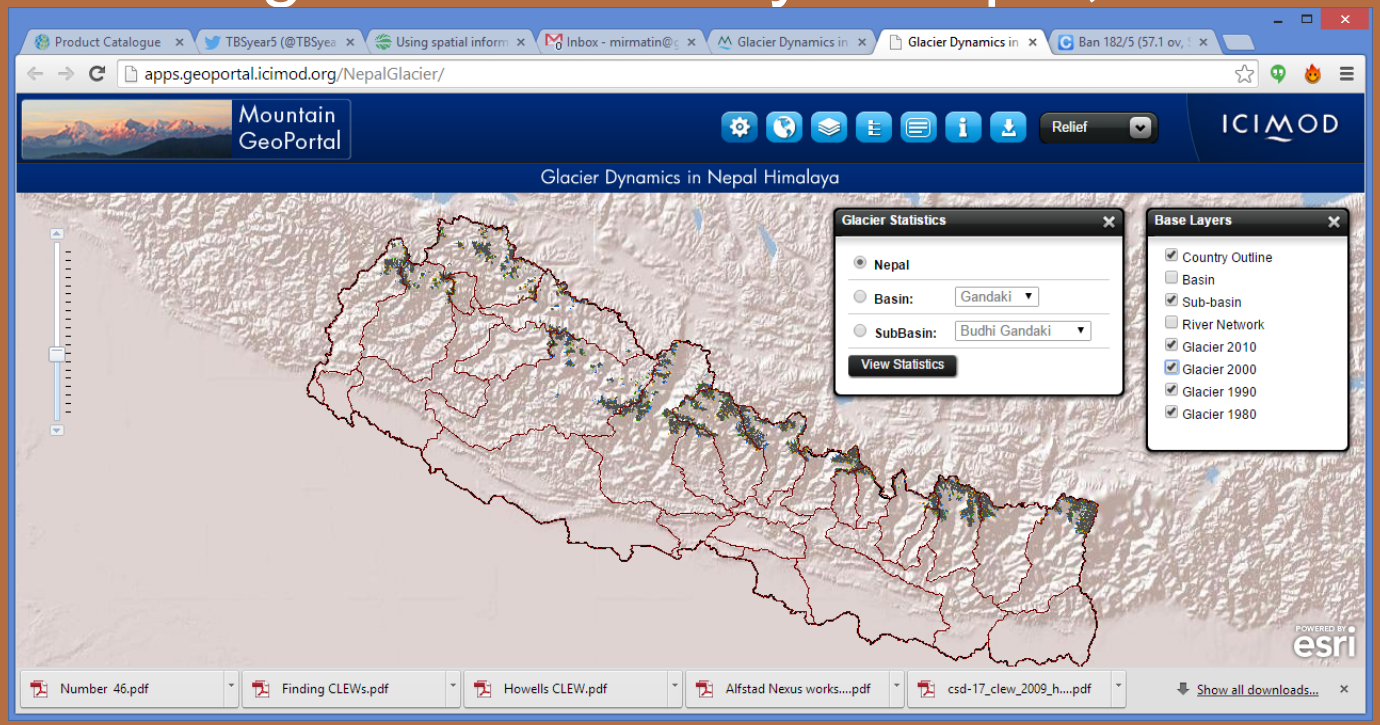

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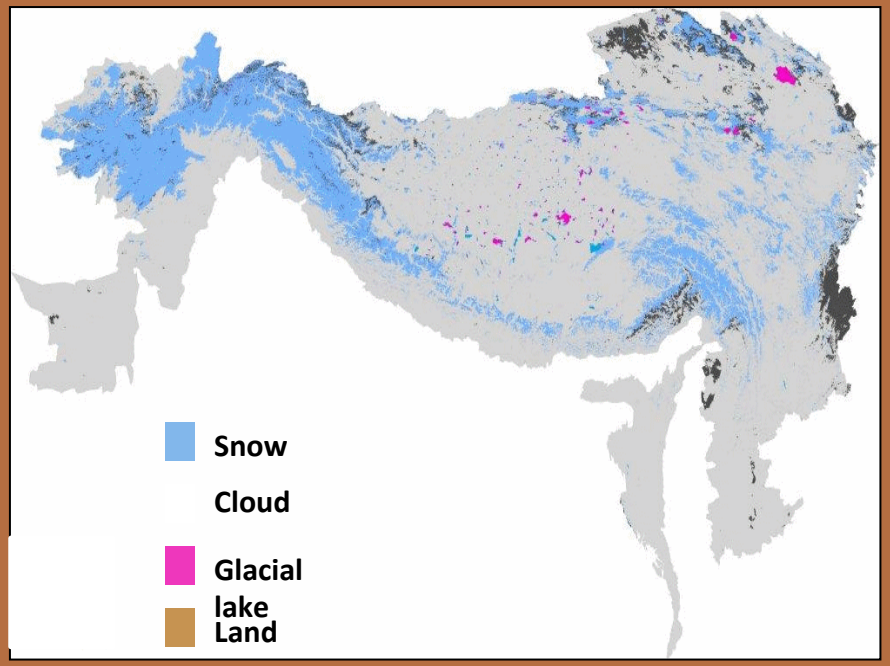

HKH Annual Snow Map (2011)

Observation of ECVs - ICIMOD

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- Active Forest fire
  - Based on MODIS active fire data
  - Filtered based on local context and fire probability
  - Overlaid with administrative, topographic and land cover information

Observation of ECVs - ICIMOD

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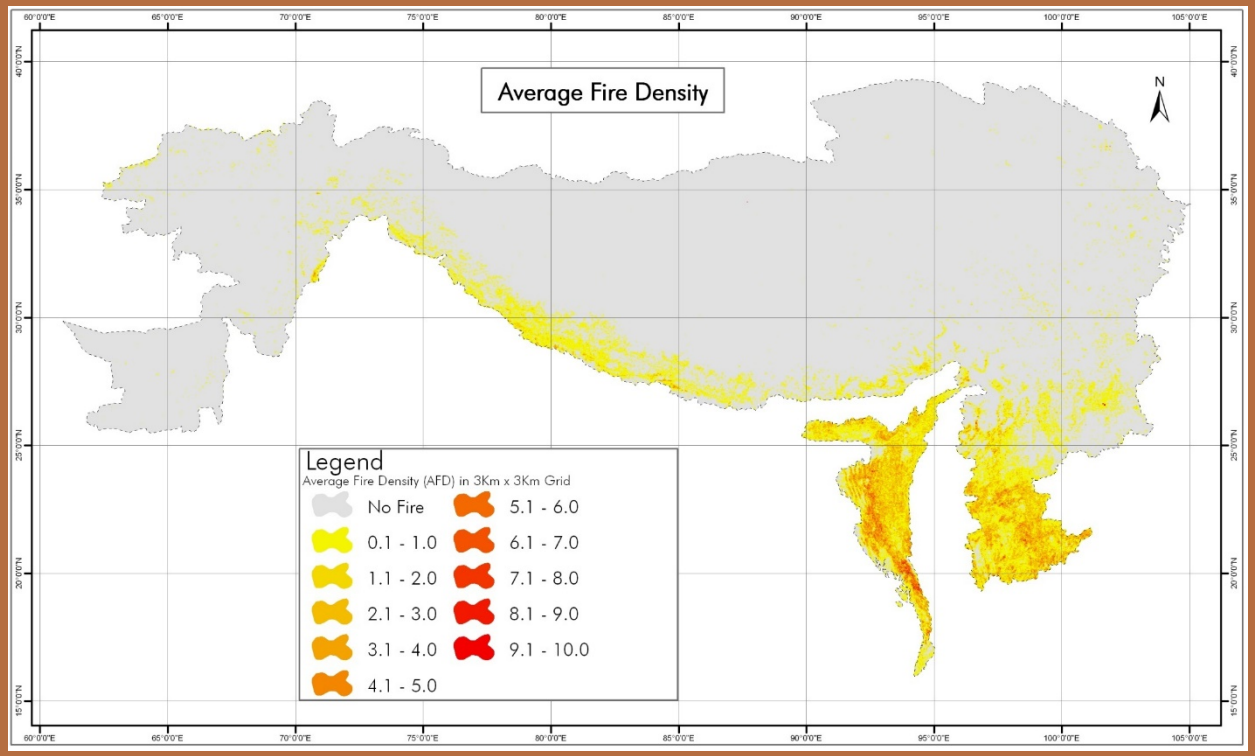

Mean Fire Density (Based on 10 Years MODIS based daily Fire occurrence data

Integration with Climate Model

- **Input of climate models**
  - Provide boundary conditions
  - Reinitialize models
  - Update the state variables
  - Provide constrains
    - Net cloud forcing
    - Short-term cloud feedback
- **Validate/calibrate climate models**
- **Improve Climate model**

Limitations

- **Short time span of data**
- **Biases associated with instrument**
  - Inadequate spatial resolution and temporal frequency
  - Poor calibrations
  - Merging data from different systems
- **Uncertainties in retrieval algorithms**
  - Radiative transfer models
  - Uncertainties in common inputs

Prospect for Future

- Future improvement in satellite
- Further calibration of additional data layers for HKH region
- Develop validation network within HKH region for critical variables
- Downscale ECVs for application at local and national scale

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