# GLIMS: Progress in Mapping the World's Glaciers

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- GLIMS project description
- GLIMS glacier database and its interfaces
- Successes
- Challenges
- Summary and Call for Submissions

# Why GLIMS?

- Glaciers are key indicators of climate change and significant contributors to global sea level rise
- Only a small number of the Earth's estimated 160,000 glaciers are being monitored through field measurements
- Some inventories have been compiled
  - most of them encompassing no more than regional scales
  - WGI does not store glacier outlines or hypsometry
- GLIMS was initiated to take advantage of plentiful satellite imagery, sophisticated image processing software, and inexpensive computers with large amounts of data storage in order to to build on and improve the world inventory of glacier data.

# Overview of GLIMS

- Involves over 60 institutions in 27 countries
- Goal is to inventory a majority of the Earth's glaciers
- Each GLIMS participant (or "Regional Center") oversees the analysis of satellite imagery for a particular region
- Data received by NSIDC are inserted into a geospatial database and made available via the World Wide Web

# GLIMS Data Flows


Browse, search, and download GLIMS analyses

REGIONAL CENTERS

Search for ASTER scenes

Submit Analyses

Order ASTER data

Land Processes DAAC

ASTER metadata & browse feed

MapServer

Text-based Interface

Data Formatting

Data Submission Interface

Ingest and QA

PostGIS

PostgreSQL DBMS

GLIMS Glacier Database

Components at NSIDC

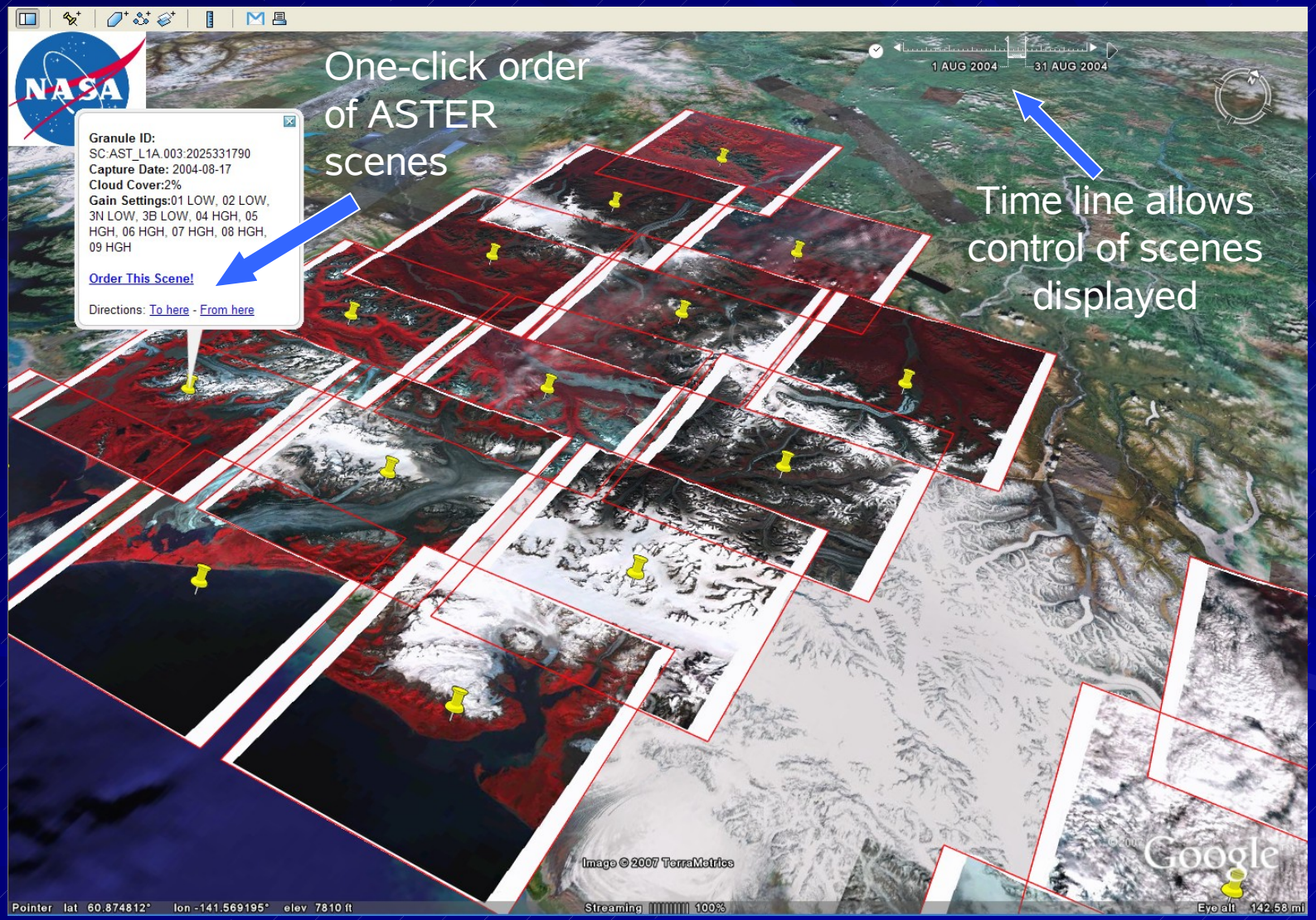
# Access to ASTER Scenes

- ASTER imagery, archived at the LP-DAAC, is the primary data source for GLIMS analyses
- A challenge for RCs is identifying scenes that
  - Were acquired over their region of interest
  - Are at the end of the ablation season
  - Are largely cloud-free
  - Have GLIMS-specified gains
- NSIDC ingests ASTER scene metadata and browse imagery from LP-DAAC, and does spatial intersection with regions of known glaciers
- Users can search for and browse ASTER scenes from within the GLIMS Glacier viewer
  - Requires copying the granule IDs of the desired scenes and using them in an ordering tool that accesses the LP-DAAC

# ASTER Scene Metadata and Browse in Google Earth

- A KML file linking GE to the entire GLIMS inventory ASTER metadata and browse is available on the GLIMS.org website
- This gives RCs another option for viewing browse and ordering granules
  - Time-line useful for isolating scenes of interest
  - One-click ordering places granules in shopping cart of LP-DAAC's GLOVis

# Example


One-click order of ASTER scenes
Time line allows control of scenes displayed
Granule ID:
SC:AST_L1A.003:2025331790
Capture Date: 2004-08-17
Cloud Cover:2%
Gain Settings:01 LOW, 02 LOW, 3N LOW, 3B LOW, 04 HGH, 05 HGH, 06 HGH, 07 HGH, 08 HGH, 09 HGH
Order This Scene!
Directions: To here - From here
1 AUG 2004
31 AUG 2004
Image © 2007 TerraMetrics
Google
Pointer lat 60.874812° lon -141.569195° elev 7810 ft
Streaming 100%
Eye alt 142.58 mi

View Help View Legend

Database Layers:

- [x] [x] GLIMS Glaciers
- [ ] [ ] ASTER Footprints
  - [x] Day Images Only
- [ ] [ ] Regional Center Outlines
- [ ] [ ] GLIMS Participants
- [ ] Glaciers from DCW
- [ ] [ ] World Glacier Inventory
- [ ] STAR Polygons
- [x] [ ] Countries

Background Imagery

- [ ] MODIS Blue Marble
- [x] Source Images

Temporally Constrain Data

- [ ] GLIMS Glaciers
- [ ] ASTER Footprints

**Start Date:**1910-01-01

Year | Month | Day

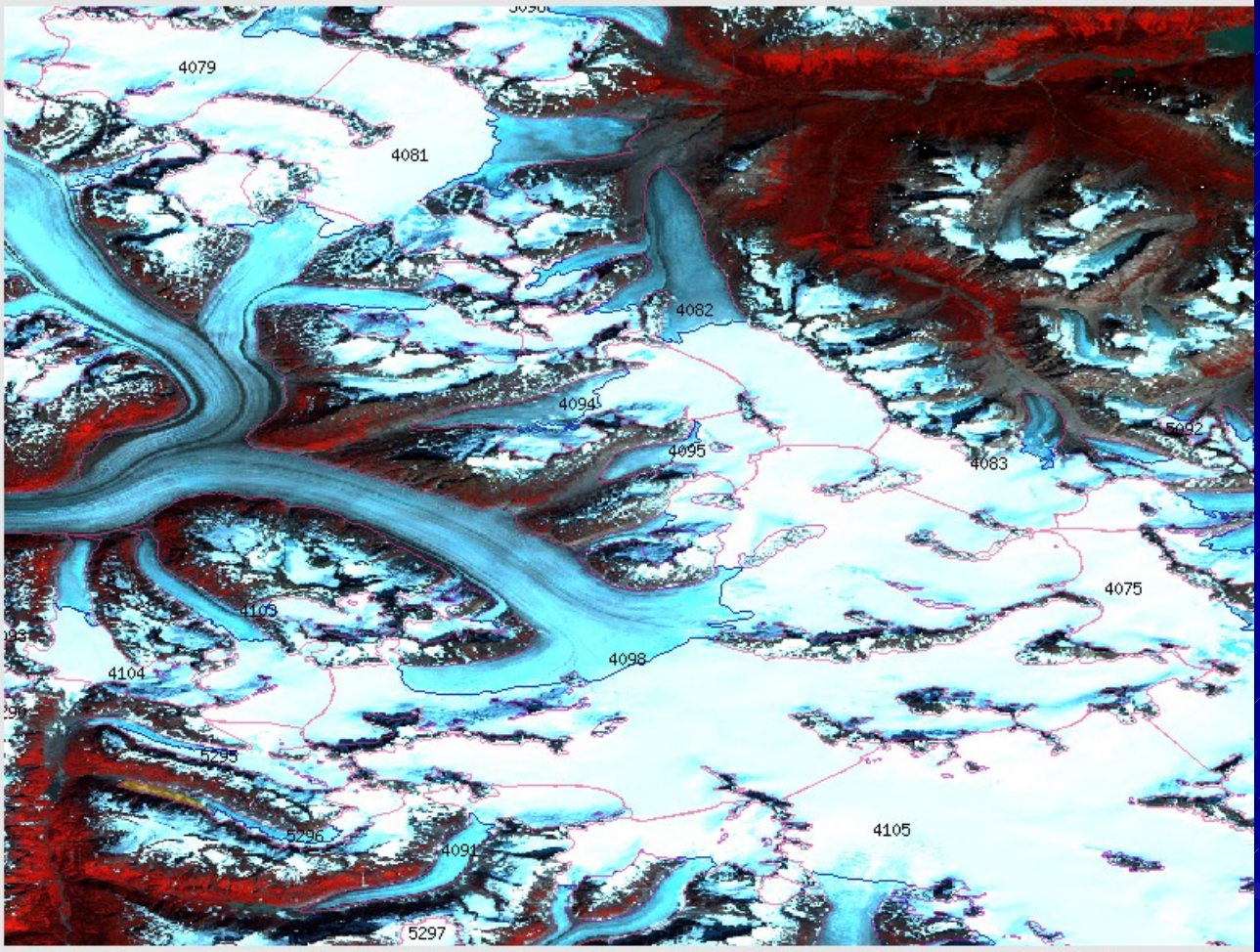
**End Date:**2007-12-31

Year | Month | Day

Refresh Map

GLIMS Glacier Database

Zoom to... | Map Size...




0 7 14 21 28 km

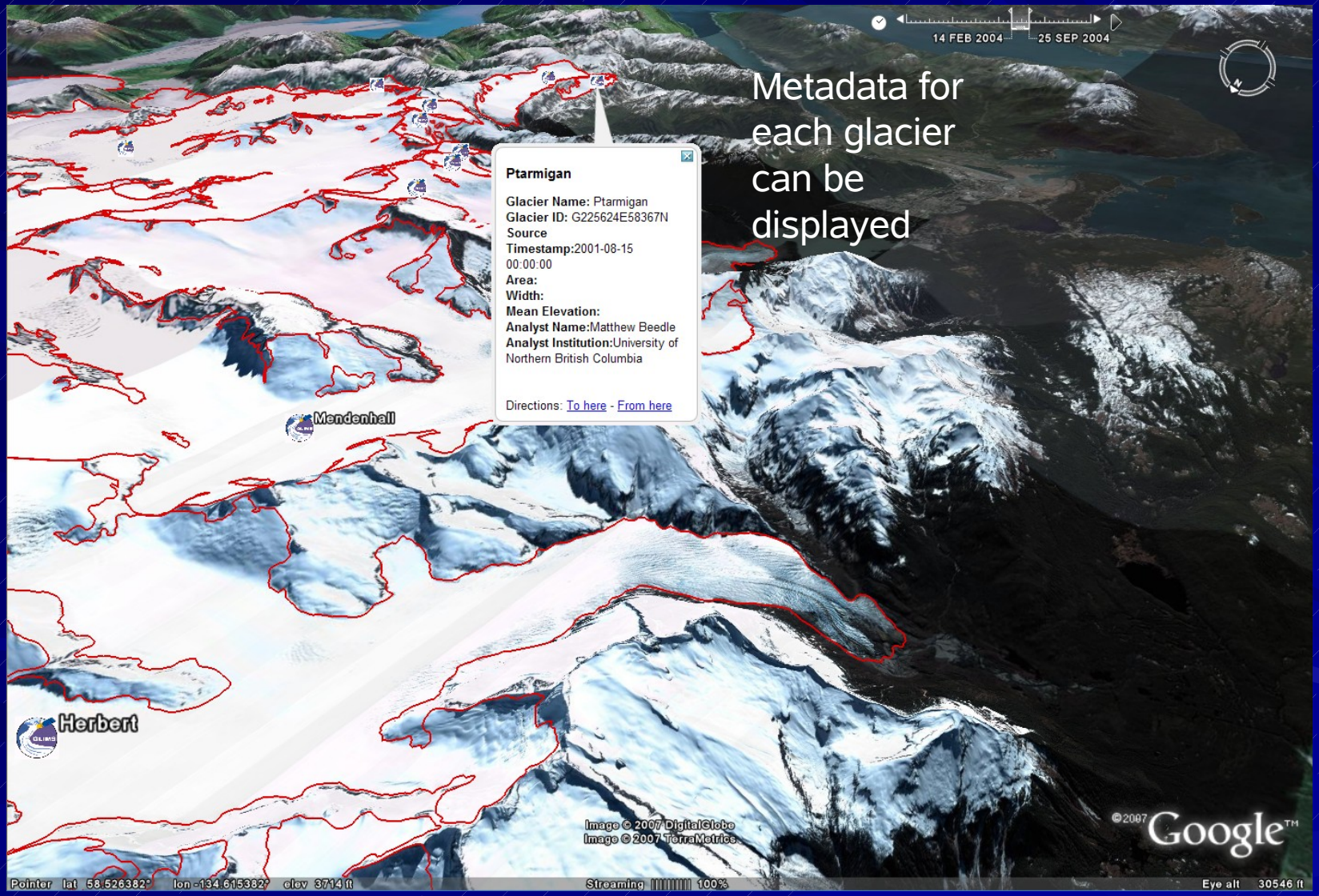
Download Data in Current View

Latitude: 59.428
Longitude: -134.885

# GLIMS Analyses in GE

- Analyses selected by users can be downloaded in a variety of formats, including KML
  - Allows users to see glacier outlines and analysis metadata within Google Earth
  - Draping of outlines over topography is especially useful
  - At global view only icons for each glacier in database are displayed

# Example


14 FEB 2004
25 SEP 2004
Metadata for each glacier can be displayed
Ptarmigan
Glacier Name: Ptarmigan
Glacier ID: G225624E58367N
Source
Timestamp:2001-08-15 00:00:00
Area:
Width:
Mean Elevation:
Analyst Name:Matthew Beedle
Analyst Institution:University of Northern British Columbia
Directions: To here - From here
Mendenhall
Herbert
Image © 2007 DigitalGlobe
Image © 2007 TerraMetrics
©2007 Google™
Pointer lat 58.526382° lon -134.615382° elev 3714 ft
Streaming 100%
Eye alt 30546 ft

# Progress

- The GLIMS Glacier Database now contains outlines of over 58 000 glaciers submitted by multiple RCs
- The database is being increasingly accessed and publications derived from it are beginning to appear

# Challenges

- As submissions to the database from around the world increase, we find that we must accommodate a greater diversity in the character and quality of the data submitted than was originally anticipated.
- Analysts use different data sources, employ different software tools and methods, and bring different understanding
- Issues that have required attention in order to achieve a high-quality glacier database have to do with metadata, georegistration and definition of where glacier boundaries are

# Problems Preventing Ingest

- Lack of required metadata, or failure in some other way to fully conform to the GLIMS data transfer specification
  - Solution:  GLIMSView exports results of glacier analysis into a format that is suitable for direct ingest into the database.
- Gross georegistration errors (outlines far removed from any glaciers)
  - Solution:  Ask submitter to correct

# Problems Affecting Quality after Ingest

- Varying interpretations of what constitutes a glacier.
  - Solution:  GLIMS Analysis tutorial
- Subtle georegistration errors
  - Difficult to identify with automated procedures
  - Typically arise from misregistration of the images or maps used, or from reprojection operations
  - Solution:  ask submitter to fix

# GLIMS Analysis Tutorial

GLIMS Analysis Tutorial

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3 Acquiring ASTER
4 Input Image(s) .....
5 Definition of a Gla
6 Defining glacier ou
7 Definition of "left"
8 Assigning GLIMS
Background .....
Definition .....
Choosing the Loc
9 Population of Othe
Null values .....
As-of time (sourc
10 Creating a "mugsl
11 Measurement unc
12 Using GLIMSVie
13 Working with mul
14 How the Ingest Pr


## 1 Introduction

This document contai
insertion into the GLI
of the database design
the process of doing a
configured for ingest
existing data set, such

A GLIMS Analysis S
outlines, together with
Analysis (without the
Glacier_Dynamic tabl
contributes several ne

## 2 Tools

A variety of tools are
for GLIMS. For exan
ArcGIS or ENVI. In

2007-04-12

defined in the observing strategy of the Global Terrestrial Network for Glaciers (GTN-G). This definition is also not intended to be used in any sort of legal context. Given the limitations of current remote sensing technology, we recognize that this definition may lead to the inclusion, in certain cases, of what would generally be considered "perennial snow masses". Definitions of "glacier" for other purposes outside of GLIMS exist elsewhere.

*A glacier or perenni*
*consists of a body of*
*season, or, in the ca*
*includes, at a minim*
*ice to the main glaci*
*ground, including n*
*considered as a sepa*

The following consequenc

1. Bodies of ice abov
considered part of
and ice (through cr
2. A tributary in a gla
separate glacier sh
glacier into which
with all relevant na
3. Any steep rock wal
themselves are NO
4. A stagnant ice mas
supports an old-gr
5. If no flow takes pla
should, in general,
divide. However,
unit at the analyst's
impractical. If the
same glacier ID, a
detail later by breal
IDs (ID of system
of those pieces, if
6. All debris-covered
7. It is possible that a
mass to the latter t
practically impossi
Therefore, within
considered as diffe

2007-04-12




*Figure 1: Landsat Thematic Mapper band 5,4,3 (red, green, blue) composite image of Unteraarglacier and surroundings, acquired 1998-08-31, with edited glacier outlines (black) and glacier basins (yellow) overlaid. The latter define ice divides and include all glacier parts that are related to a former glacier. Red dots mark basins that have been included in the new Swiss glacier inventory. Arrows denote: 1: Medial moraine outcrop (to be removed), 2: now disconnected glaciers, but included in the same basin for consistency, 3: a small cloud that hides a part of the glacier area (to be removed), 4: the ice divide is used here to correct for misclassified seasonal snow. Image and caption courtesy of Frank Paul.*

## 6 Defining glacier outlines and their attributes

Two important considerations for producing a set of glacier outlines and metadata for GLIMS are 1) the data model, and 2) the file formats. The discussion below touches on both these aspects. For details on the GLIMS Data Transfer Format, see the specification at http://glims.org/MapsAndDocs/datatransfer/data_transfer_specification.html. That file describes the shapefiles and their attributes that form the basis for transferring data to the GLIMS Glacier Database.

To create an outline that conforms to the above definition, one should create one polygon (or series of segments) that circumscribes the entire glacier. Internal rock outcrops are excluded by producing outlines around them and labeling those outlines as internal rock. This can be done simply in GLIMSView, or can be done with other tools. In the resulting "segments" shapefile, the "category" attribute should be "intrnl_rock" for internal rock

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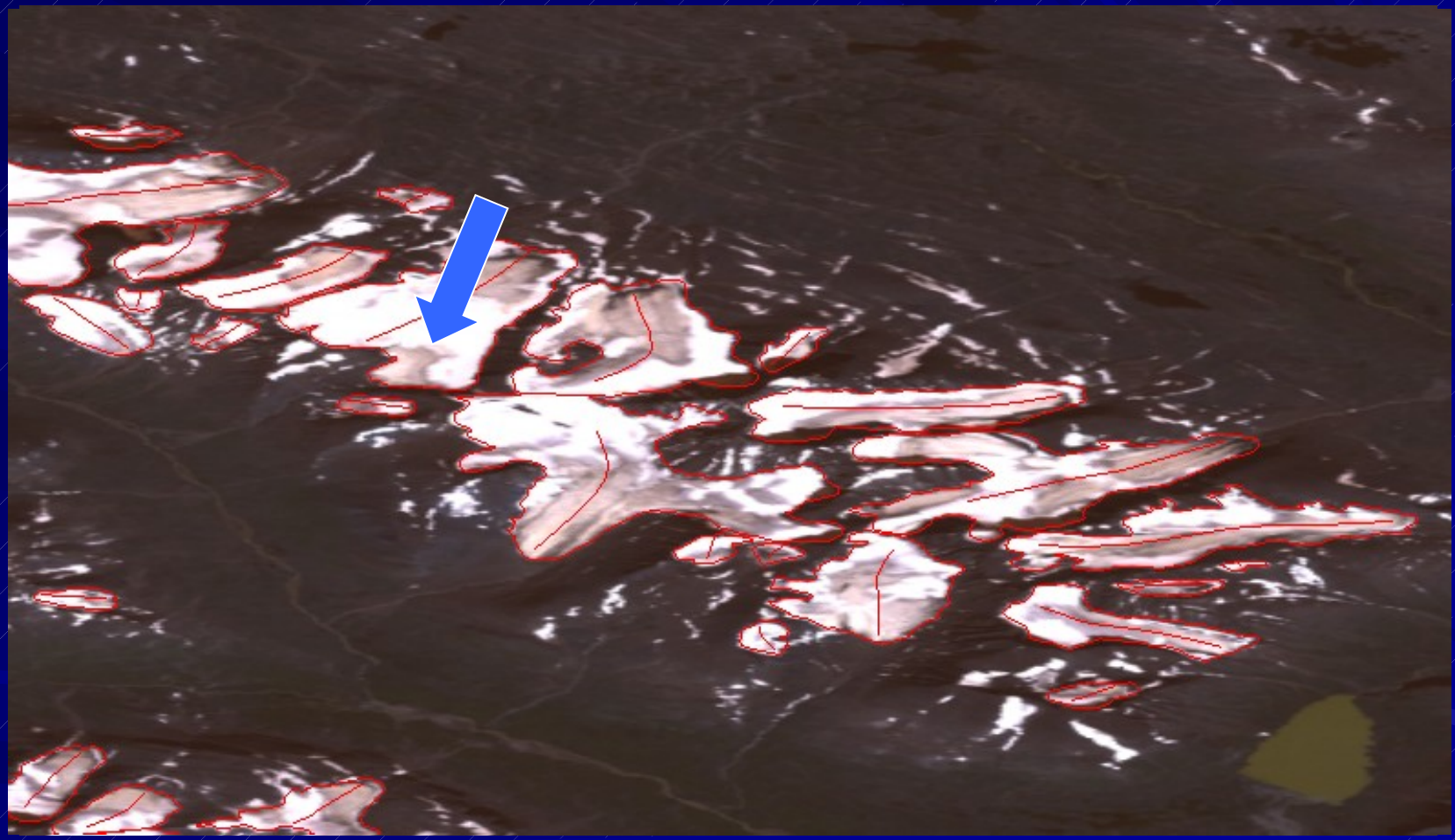
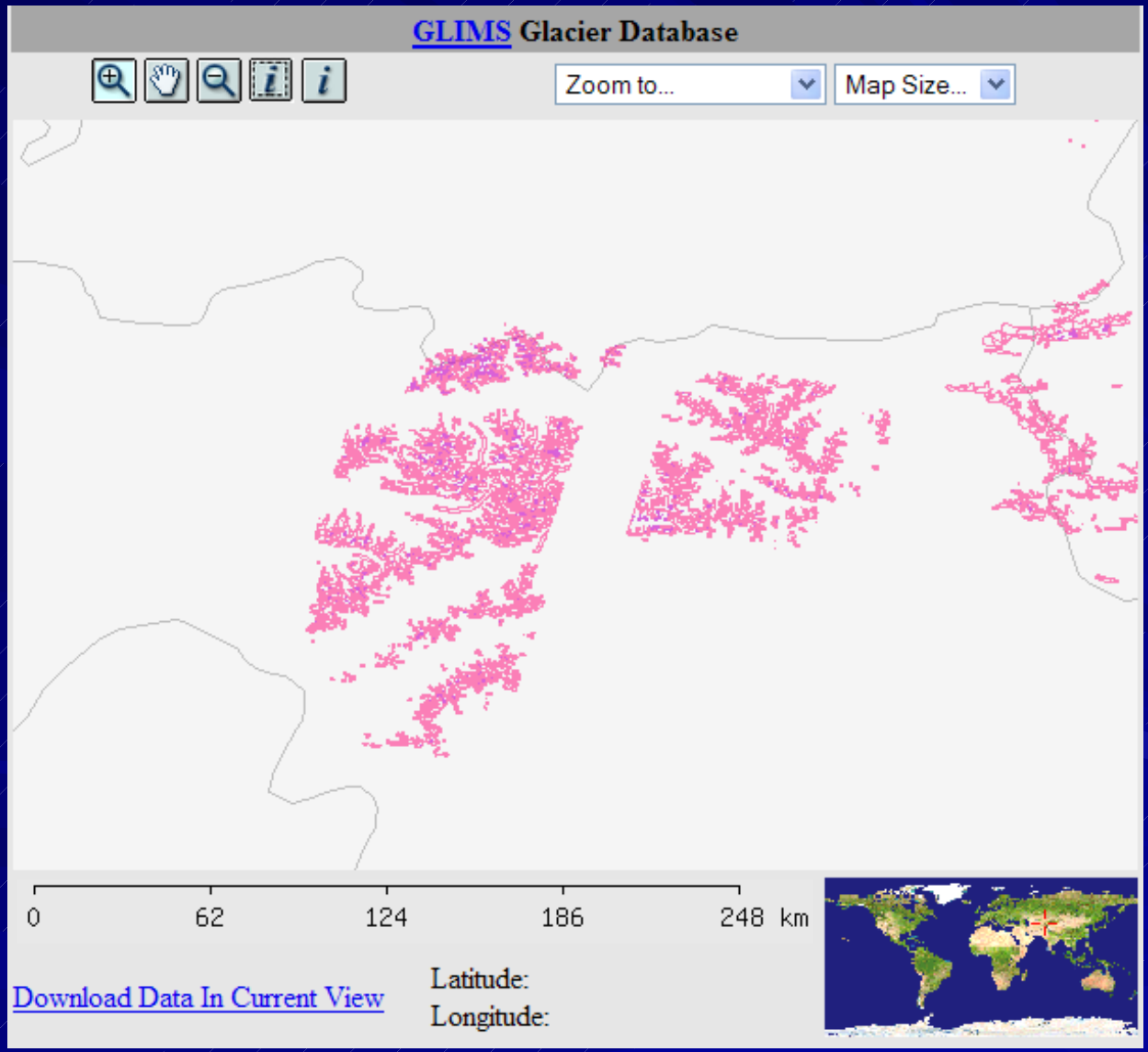
# Georegistration QC w/ GE



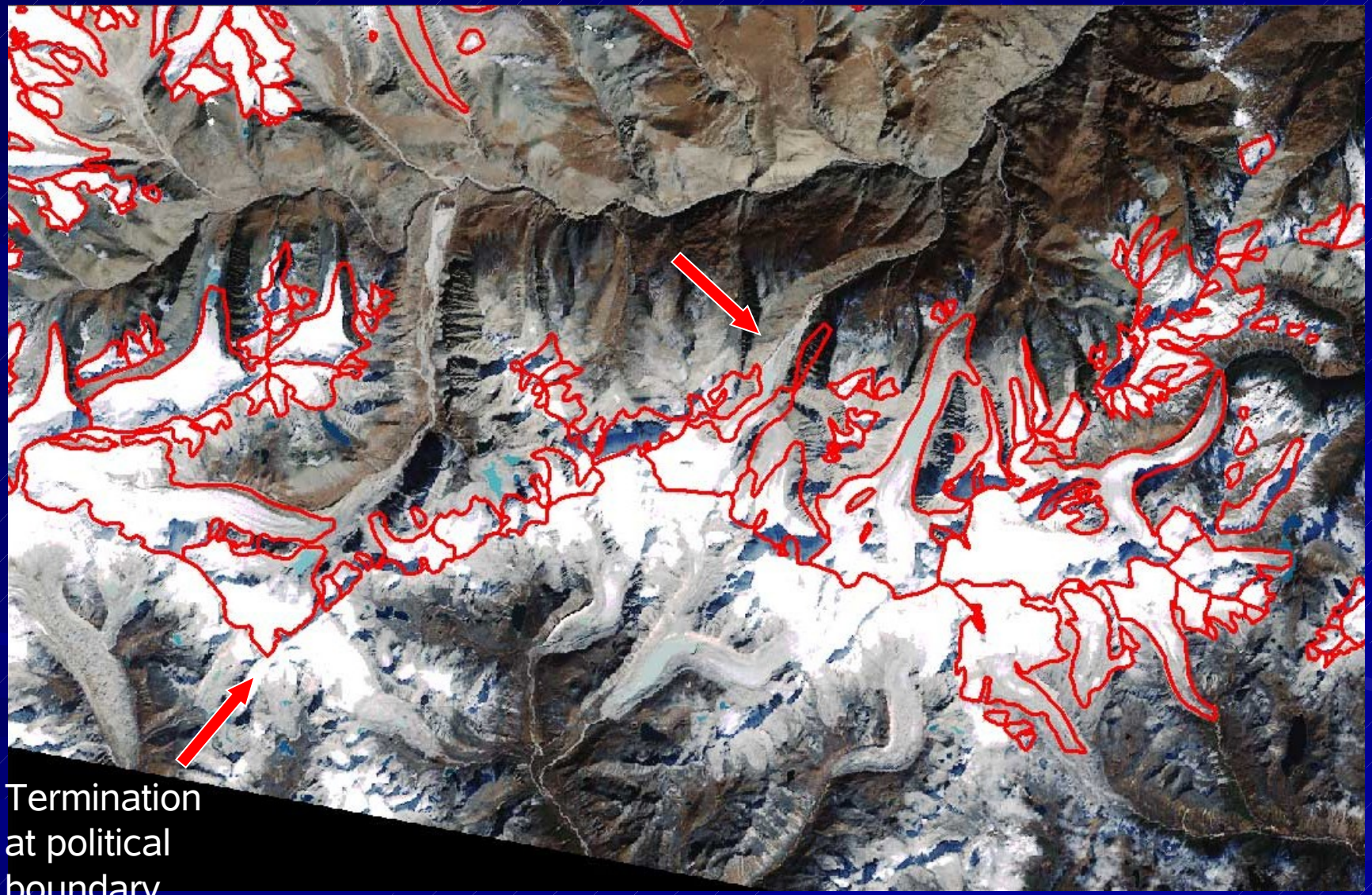
# Other Issues

- Arbitrary termination of glacier boundaries at political boundaries
- Termination of glacier boundaries at edges of available satellite images.
- Disagreement between analyses of glaciers submitted by different RCs

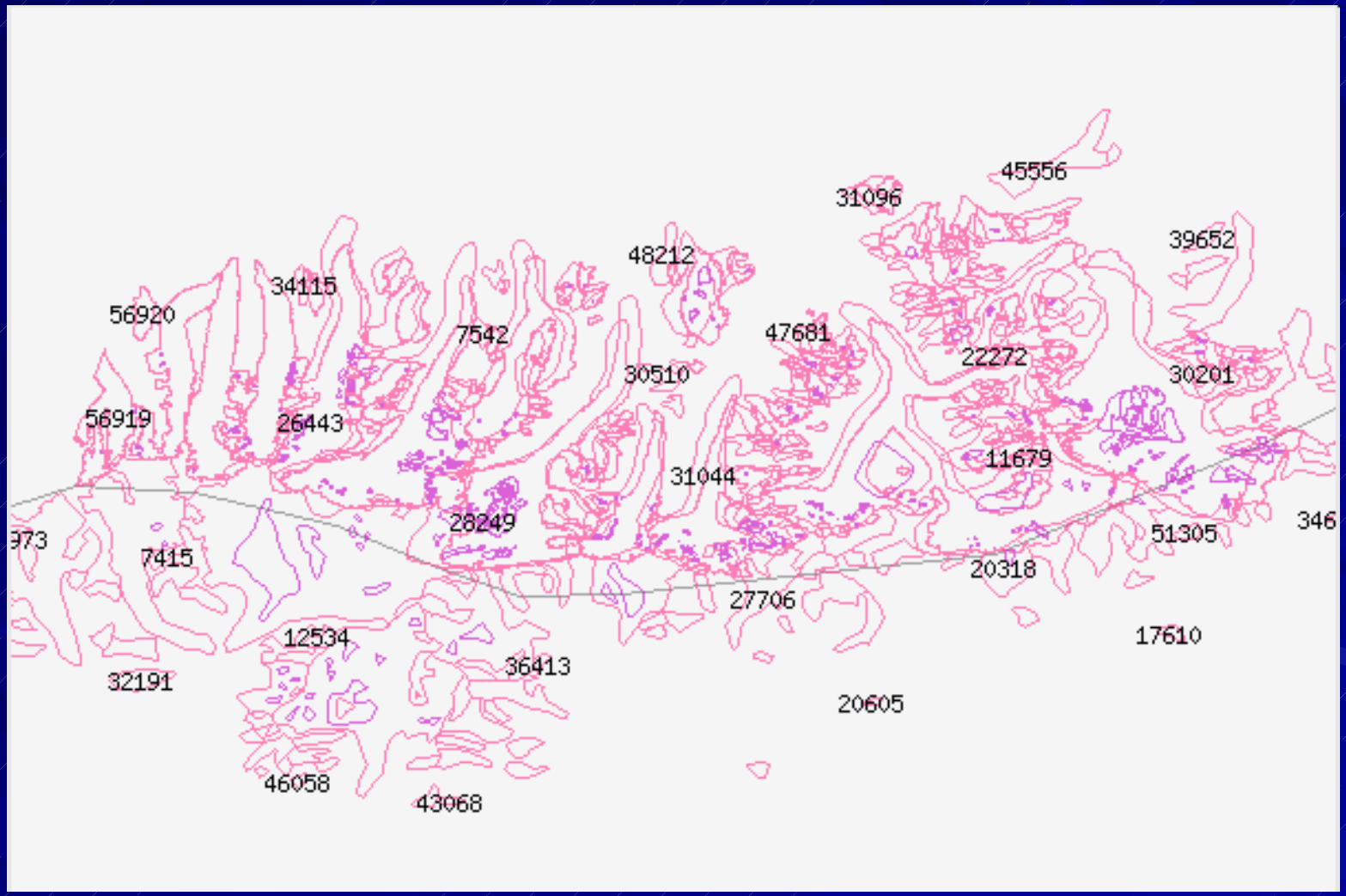
# Limitations of Scene Coverage



# Inconsistent Geolocation

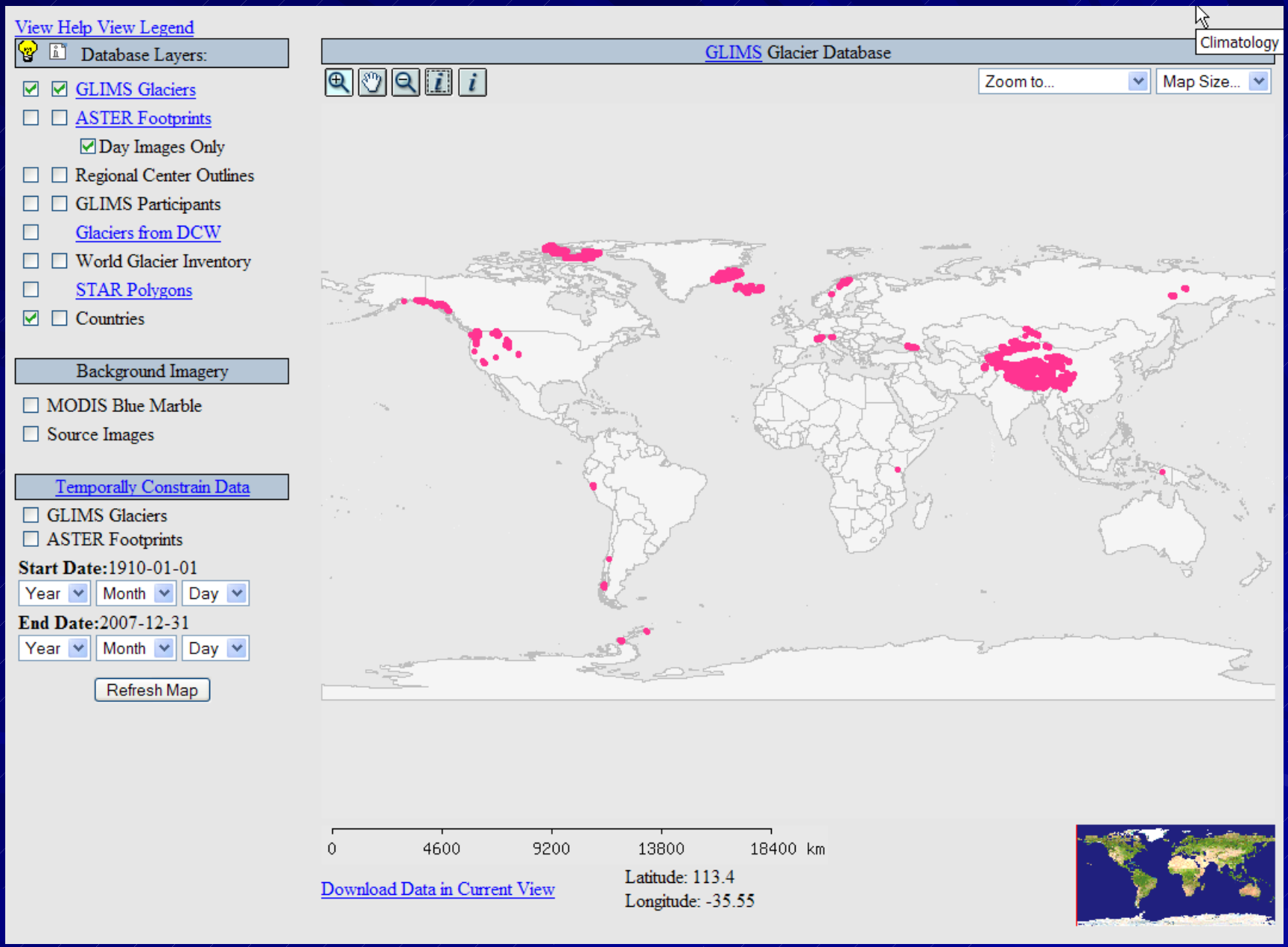


# Inconsistent Outlines from Different Analysts



# Conclusions

- The GLIMS project, through the collaboration of some 60 institutions throughout the world, is creating a database of glacier outlines and other information and making it accessible in a variety of ways.
- We are addressing issues of data coverage and data quality through a system of protocols and quality checks.
- Submissions to the database are encouraged.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Background Imagery
MODIS Blue Marble
Source Images
Temporally Constrain Data
GLIMS Glaciers
ASTER Footprints
Start Date:1910-01-01
Year
Month
Day
End Date:2007-12-31
Year
Month
Day
Refresh Map
GLIMS Glacier Database
Zoom to...
Map Size...
Climatology
0
4600
9200
13800
18400 km
Download Data in Current View
Latitude: 113.4
Longitude: -35.55