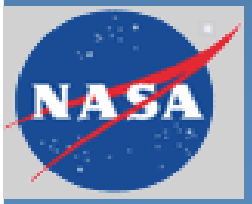
Altimetry for Oceans and Hydrology
Applications Workshop
Lisbon, 21-22nd October 2010

Satellite Altimetry Measurements over Lakes and Reservoirs

Charon M. Birkett, ESSIC/UMD
Brian Beckley, Jairo Santana, Annette Conger, Thomas Ferrolo,
SGT at NASA/GSFC, Greenbelt MD
Michelle Hofton, Yuanjie Li, Ralph Dubayah, Geography/UMD
Martina Ricko, AOSC/UMD
Curt Reynolds, USDA/FAS/OGA, Washington DC
Christa Peters-Lidard, Hydrological Sciences Branch, NASA/GSFC



Research:
NASA Decision Support through Earth Science Research Results NNX08AM72G
NASA Ocean Surface Topography Team NNX08AT88G
NASA ICESat and CRYOSAT NNX06AH40G

Operations: USDA/FAS/OGA (PECAD) Reservoir Monitoring Program

USDA Decision Support System Requirements and Expectations

USDA Requirements

Long-term: Quantitative determination of irrigation potential in agriculture-sensitive regions

Short-term: Qualitative indication of hydrological drought or high-water situations

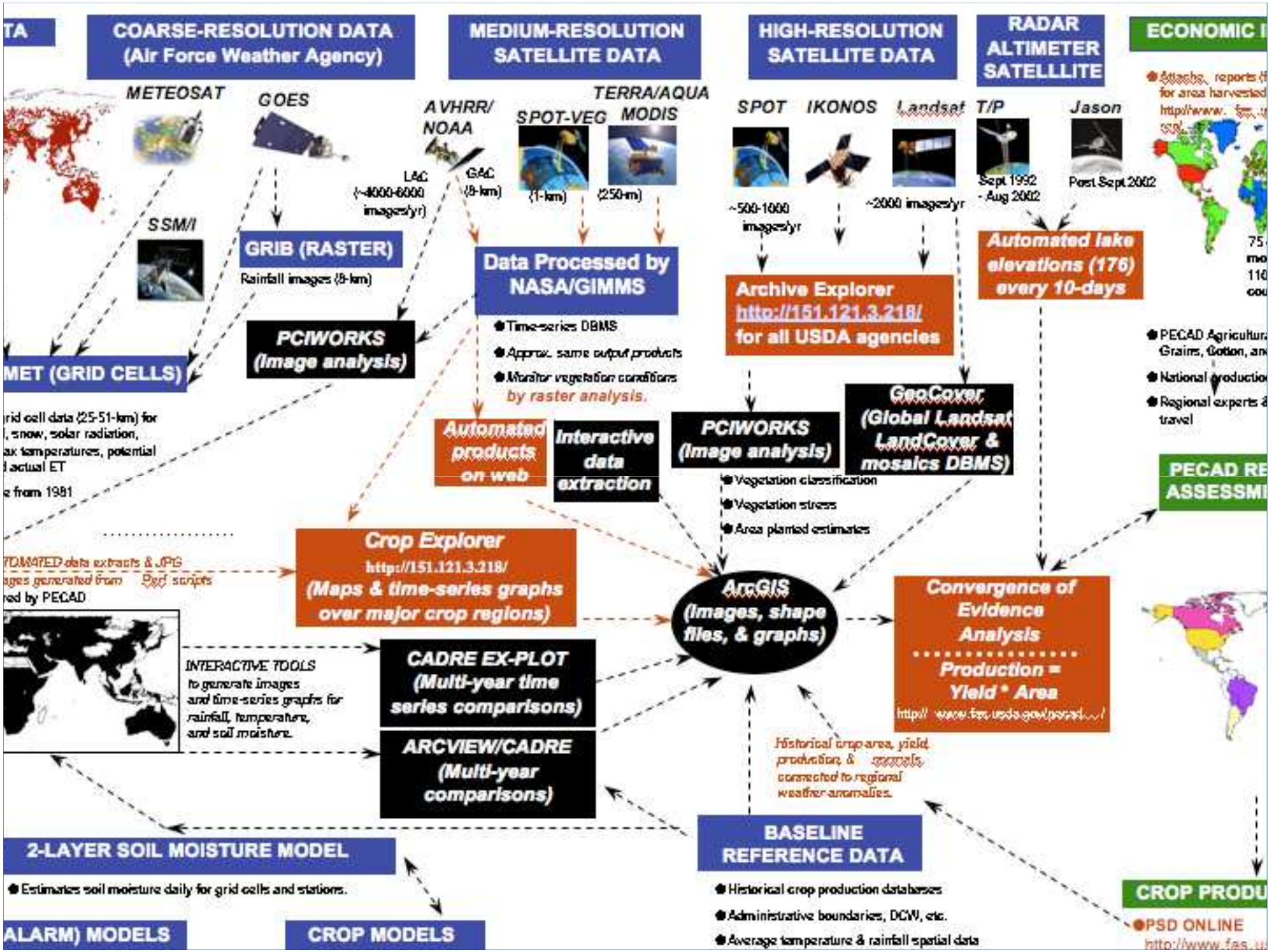
INPUT TO BE USED WITHIN MONTHLY "LOCK-UP"

Project Requirements

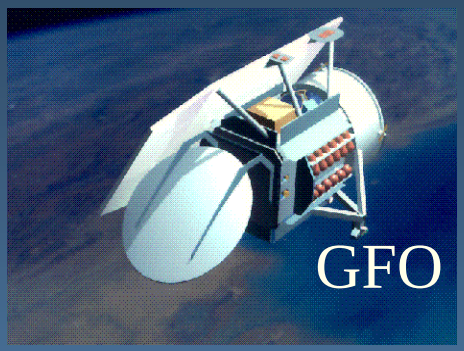
- Near Real Time lake-level variations/weekly update
- Historical Perspective - Archive data post 1992
- Designated set of lakes and reservoirs > 500

Expectations

- Elevation Accuracy = 10% of seasonal amplitude
- Free and Easily Accessible Products = web html based formats


TA
COARSE-RESOLUTION DATA (Air Force Weather Agency)
MEDIUM-RESOLUTION SATELLITE DATA
HIGH-RESOLUTION SATELLITE DATA
RADAR ALTIMETER SATELLLITE
ECONOMIC I
METEOSAT
GOES
AVHRR/ NOAA
SPOT-VEG
TERRA/AQUA MODIS
SPOT
IKONOS
Landsat
T/P
Jason
SSM/I
LAC (~4000-6000 images/yr)
GAC (8-km)
(1-km)
(250-m)
~500-1000 images/yr
~2000 images/yr
Sept 1992 - Aug 2002
Post Sept 2002
GRIB (RASTER)
Rainfall images (8-km)
Data Processed by NASA/GIMMS
Time-series DBMS
Approx. same output products
Monitor vegetation conditions by raster analysis.
Archive Explorer http://151.121.3.218/ for all USDA agencies
Automated lake elevations (176) every 10-days
PCIWORKS (Image analysis)
MET (GRID CELLS)
rid cell data (25-51-km) for , snow, solar radiation, ax temperatures, potential actual ET
e from 1981
Automated products on web
Interactive data extraction
PCIWORKS (Image analysis)
GeoCover (Global Landsat LandCover & mosaics DBMS)
Vegetation classification
Vegetation stress
Area planted estimates
PECAD Agricultur Grains, Cotton, an
National productio
Regional experts & travel
PECAD RE ASSESSMI
Crop Explorer
http://151.121.3.218/
(Maps & time-series graphs over major crop regions)
ArcGIS (Images, shape files, & graphs)
Convergence of Evidence Analysis
Production = Yield * Area
http// www.fas.usda.gov/pecad.../
ges generated from
ed by PECAD
INTERACTIVE TOOLS to generate images and time-series graphs for rainfall, temperature, and soil moisture.
CADRE EX-PLOT (Multi-year time series comparisons)
ARCVIEW/CADRE (Multi-year comparisons)
Historical crop area, yield, production & anomalies connected to regional weather anomalies.
2-LAYER SOIL MOISTURE MODEL
Estimates soil moisture daily for grid cells and stations.
BASELINE REFERENCE DATA
Historical crop production databases
Administrative boundaries, DCW, etc.
Average temperature & rainfall spatial data
CROP PRODU
PSD ONLINE
http://www.fas.u
ALARM) MODELS
CROP MODELS

Satellite Radar Altimeters - USDA GRLM/Current



Naval Research Lab

USDA United States Department of Agriculture
Foreign Agricultural Service

Linking U.S. Agriculture FAS to the World

Crop Explorer

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Switch to CE Google Maps

Explore by Region

North America
United States
Canada

Central America
Mexico
Central America and Caribbean

South America
Brazil
Northern South America
Southern South America

Site Index

Former Soviet Union
Kazakstan
Russia, Azerbaijan, Armenia and Georgia
Ukraine, Moldova, and Belarus

Africa
North Africa
Southern Africa
East Africa
West Africa

Asia
Eastern China
South Asia
Southeast Asia
Central Asia
Korea

Europe
Europe

Middle East
Iran, Iraq, Syria and Turkey

Oceania
Australia

Africa | Asia | Europe | Middle East | North America | South America | World

Explore by Crop

Select a Commodity Submit

Commodity Intelligence Articles and Reports

Pakistan: Rice and Cotton Production Regions Damaged by Floods.
(Sep 13, 2010)

From late July through August, Pakistan received abundant to excessive monsoon rainfall across the country including many of the major rice and cotton growing areas. The excessive precipitation triggered severe overland and river flooding. The impact of the floodwater is most severe in Khyber Pakhtunkhwa (N.W.F.P), Baluchistan, Punjab, and the northern districts of Sindh. These provinces have experienced significant loss of cropland and damage to agricultural infrastructure. The major kharif season (June-November) crops are rice and cotton, but a substantial amount of corn, millet, and sorghum is grown during the kharif season as well. The floodwaters are receding in the mid- and upper-reaches of the Indus Valley but continue to expand in the southern district of Sindh. The final extent of the floodwaters and the resulting damage to crops is still uncertain. The USDA's preliminary assessment, based primarily on satellite imagery, indicates significant crop damage in major rice and cotton areas along the Indus River in Punjab and Sindh provinces. The USDA forecasts 2010/11 Pakistan rice production at 5.3 million tons, down

News & Events

- Tropical Cyclone Monitor
- Google Gadgets
- Iraq Operational Agricultural Monitoring Project
- RSS News Feeds
- Speaker Presentations on Global Food Security Challenges

Related Sites

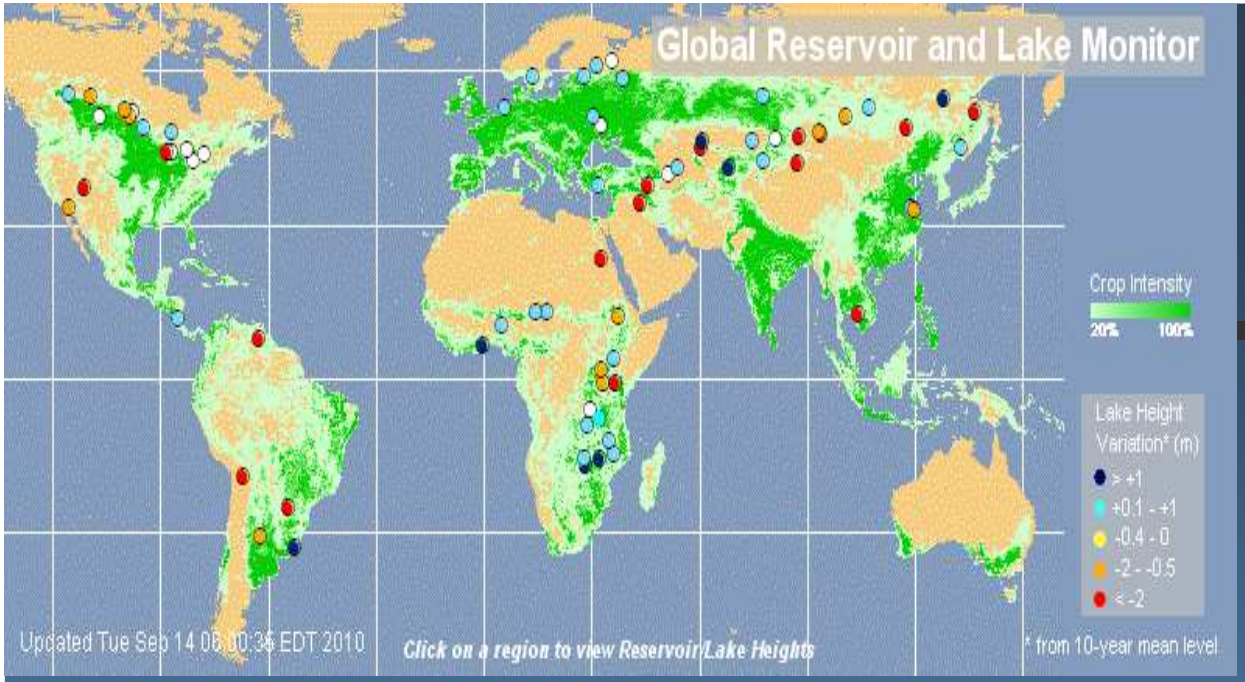
- Agricultural Production
- Articles and Reports
- Explore by Crop
- Future of Land Imaging
- Geographic Search
- Global Climate Change
- Global Crop Production
- Global Reservoirs/Lakes
- Landsat GloVis
- MODIS Image Gallery
- MODIS Image Archive
- MODIS NDVI Gallery
- MODIS NDVI Time Series
- MPA Rainfall Maps
- Photo Gallery
- USDA Satellite Imagery Archive

Metadata

- Live Data and Maps
- GeoSpatial One-Stop

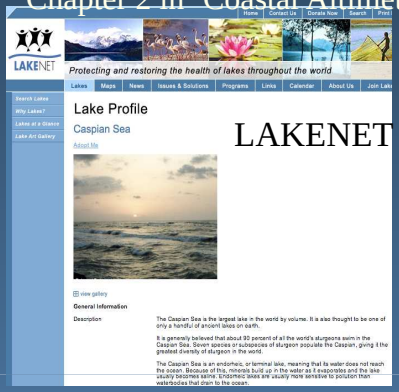
USDA/FAS
Crop Explorer

Portal for
data sets



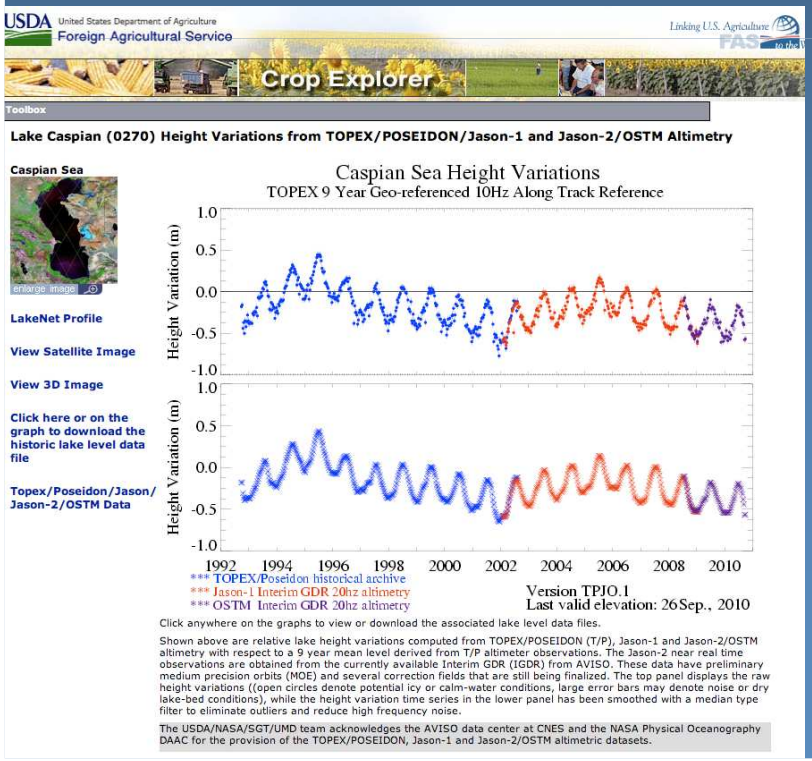
The Global Reservoir and Lake Monitor

2009, Birkett, C.M., Reynolds, C., Beckley, B and B. Doorn, From Research to Operations: The USDA Global Reservoir and Lake Monitor,
Chapter 2 in 'Coastal Altimetry', Springer.



LAKENET

databases, Web links, etc

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TPJO.1                                :
0270 Caspian                          :
 40.00   51.00                        :
 45.54   47.40                        :
 36.96   53.95                        :
 37.50   44.00                        :
    92     46                         :
 0.07                                 :
 0.18                                 :
Column 1: Calendar year +
Column 2: filtered lake he
19920926 17   7      -0.180
19921006 15   5      -0.180
19921016 13   4      -0.308
19921026 11   3      -0.356
19921105  9   1      -0.392
19921115  7   0      -0.390
19921125  4  58      -0.372
19921205  2  57      -0.368
19921215  0  55      -0.360
19921224 22  54      -0.364
19930103 20  52      -0.368
19930113 18  51      -0.372
19930123 16  49      -0.358
19930202 14  48     999.990
19930212 12  46      -0.334
19930222 10  45      -0.306
19930304  8  43      -0.278
19930314  6  42      -0.252
19930324  4  40      -0.246
19930403  2  39      -0.232
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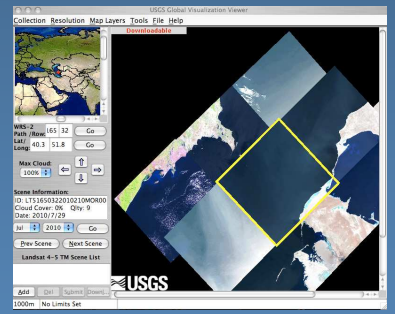
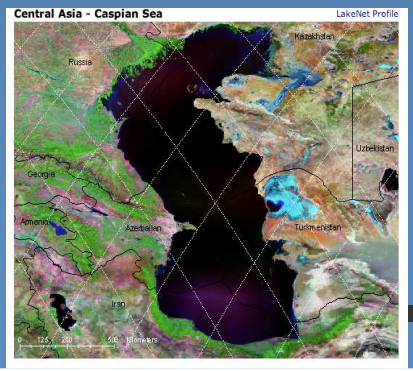


USGS Global Visualization Viewer

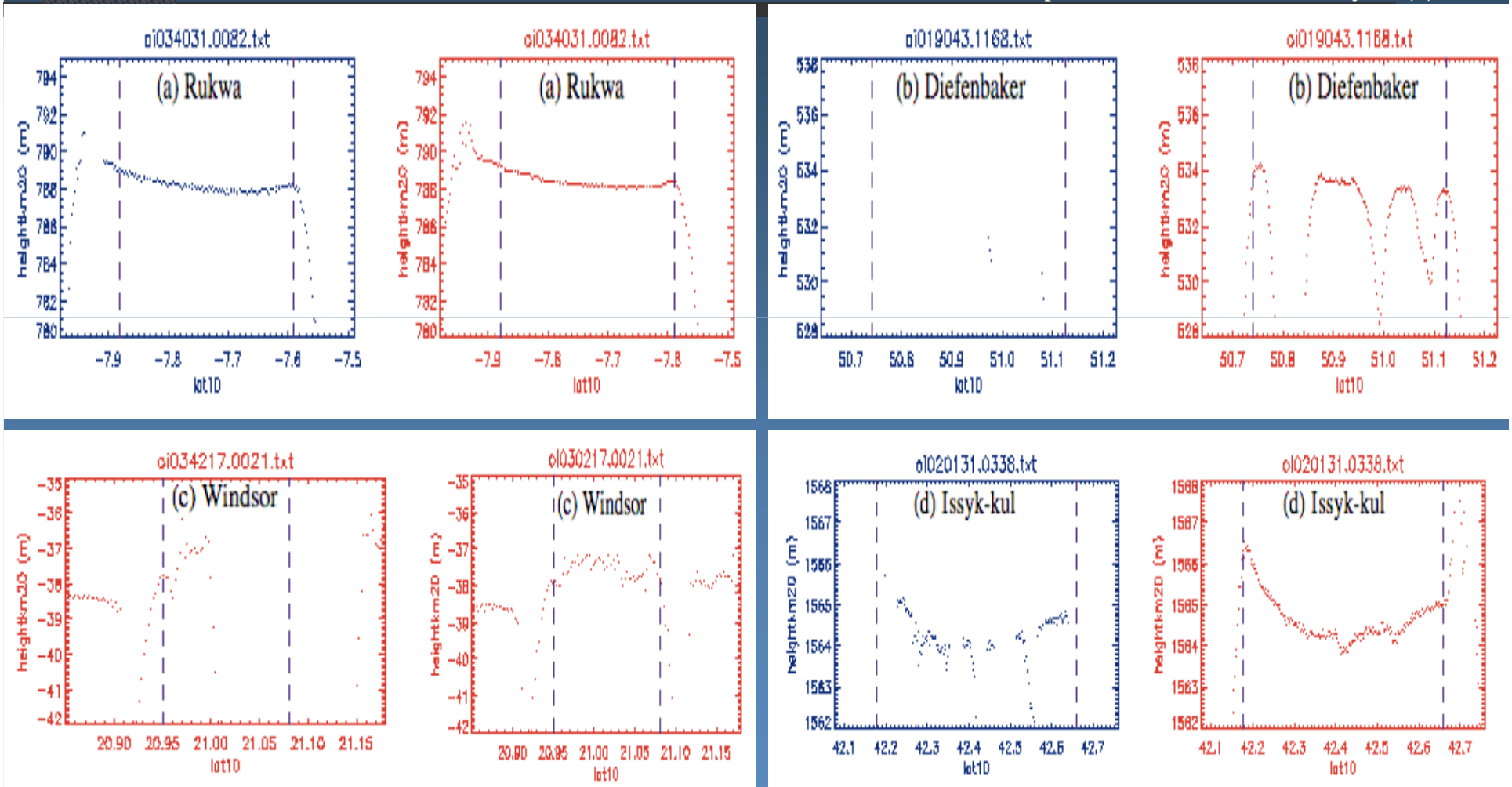


Satellite Imagery

Instrument Performance - Jason-3/OSTM

Tests on parameters, trackers, atmospheric and ice effects

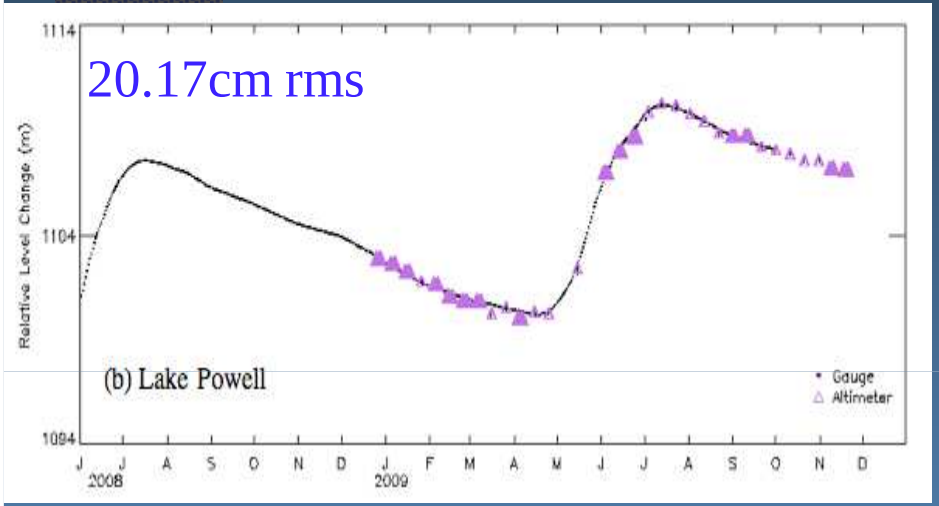
2010, Birkett, C.M., Beckley, B., Investigating the Performance of the Jason-2/OSTM radar altimeter over Lakes and Reservoirs, Jason-2/OSTM Special Issue, Marine Geodesy, 33(1), 204

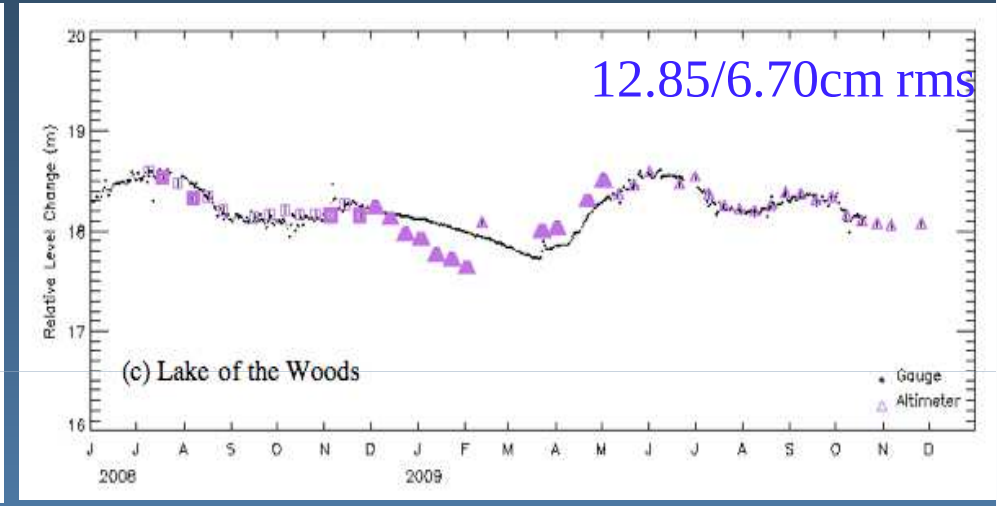


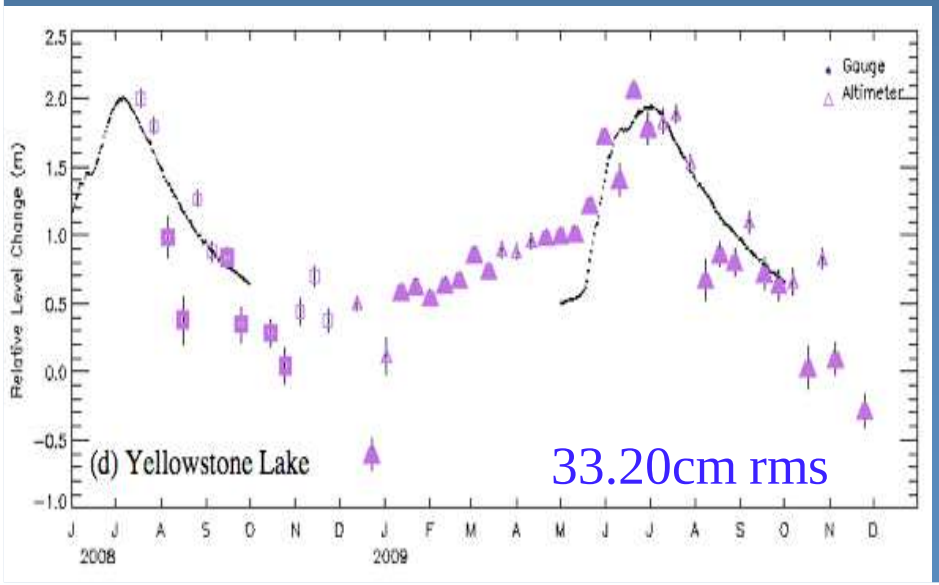
Surface water height profiles, ocean retracker(blue), ice retracker (red). Windsor example shows cycle034 DIODE/DEM mode loss. May/June for Windsor/Rukwa, Dec/Jan for Issyk-kul/Diefenbaker.

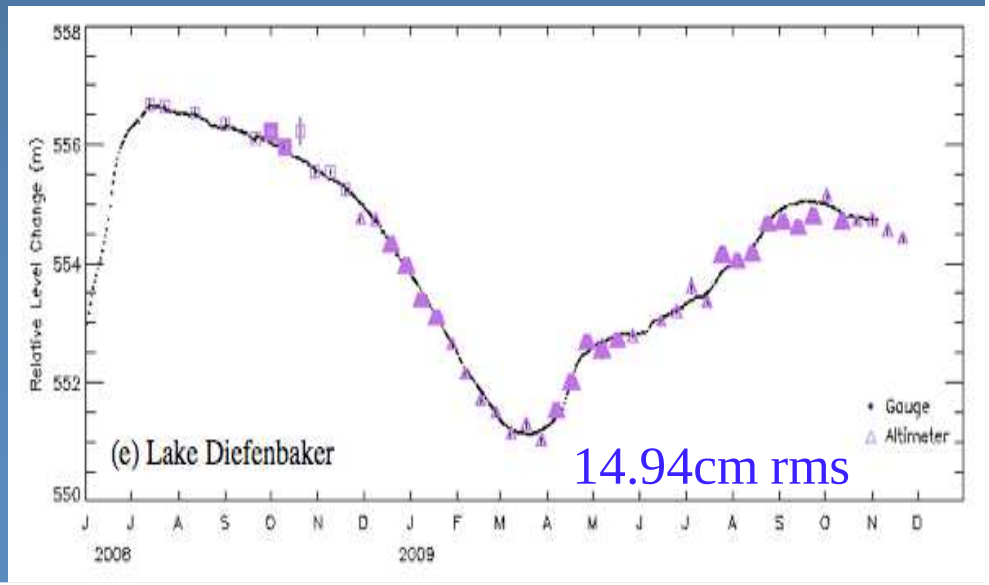
Product Validation - Jason-3/OSTM

For each mission - tests on altimetric parameters, range trackers, atmospheric and ice effects

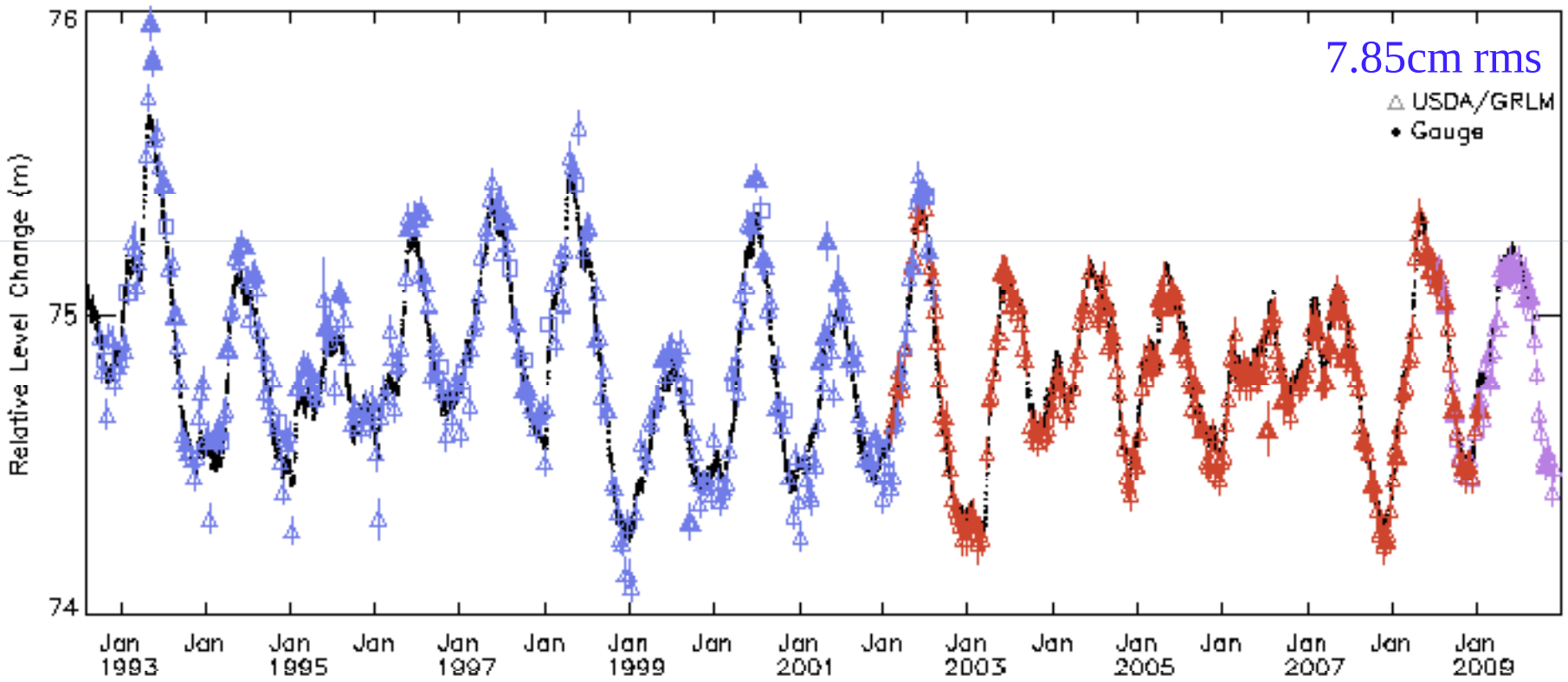








Product Validation - Combined missions
e.g. Lake Ontario TPJO.1
(OSTM 2.95cm rms)



Venezuela to Ration Water Because of Low El Nino Rainfall

October 22, 2009

Venezuelan President Hugo Chavez urged citizens to cutback on showering time as the country's electric and water supply problems mount.

Venezuela will enact n
methods, including red
until May, because of l
Hugo Chavez announc

The drier cycle has cau
the country's hydroelec
water reserves, includi
the world's largest dam
located on the Caroni F
percent of Venezuela's
River, located in the Or
discharge rate, but it ha
itself lately.

This drought has aggra
fragile situation. Growing demand for and under-investment in water lead to se
Venezuela earlier this year.

Power cut of 2,000 MW if Guri dam level reach meters

The largest power reduction must be made in ce
Venezuelan Guayana's Corporation (CVG)

ENERGY

Government authorities believe that the water level of the Guri reservoir will reach the critical level of 240 meters above sea level by June, and at point additional power rationing will be required.

The Executive branch of government has already outlined two scenarios for operating the Guri hydroelectric plant if the reservoir drops level. According to a report prepared by National Electric Corporation (Corpoelec two options: operating the electricity gr without the addition of the new generat

Higher water level in Guri Dam fails to solve power crisis

The water level of the reservoir is growing but thermoelectric generation has not expanded

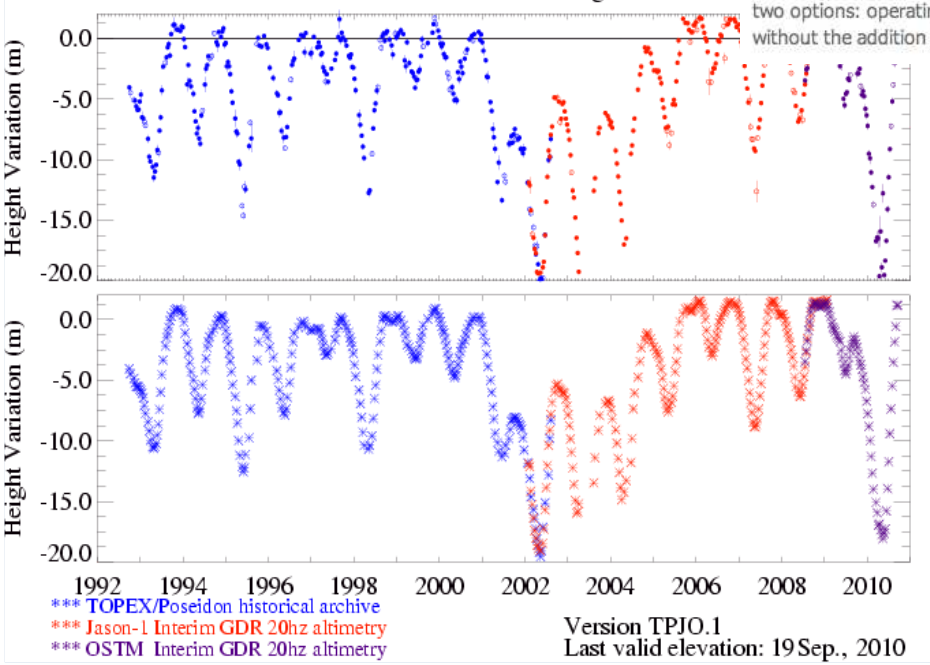
ENERGY

The rainy season is arriving in Venezuela and the water level of the Guri reservoir is starting to increase, but concerns about the serious power crisis facing the country remain.

Following rains, the water level of the Guri Dam has increased by 13 centimeters in two days (File photo)

In fact, the National Electricity Corporation (Corpoelec) informed the authorities of state-run steelmaker Siderúrgica del Orinoco (Sidor) that electricity rationing in the main Venezuelan mill would be implemented throughout the year. This means that the steelmaker company will have to maintain its current production level. That is, a maximum power consumption of 300 megawatts, which allows for operation of one furnace only.

The level of the Guri reservoir is declining over



The peak oil crisis: countdown at the Guri

by Tom Whipple

☆☆☆☆☆

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Most Americans have never heard of Venezuela's great Guri dam. Completed in 1978 with 20 generators and 10,200 MW of generating capacity, at one time it had the most generating capacity of any hydro dam in the world.

By way of comparison, the Three Gorges dam in China is to produce 22,500 MW when completed next year and the U.S.'s Grande Coulee which dates back to 1942 can produce 6,800 MW. If you disregard the ecological damage caused by great dams, they can be wonderful things for they produce prodigious amounts of emissions-free energy at very low cost --- provided, of course, it keeps raining in the dam's watershed. Until recently nobody gave this much thought until last summer when El Niño, and perhaps a touch of global warming, started doing funny things to Venezuela's weather.

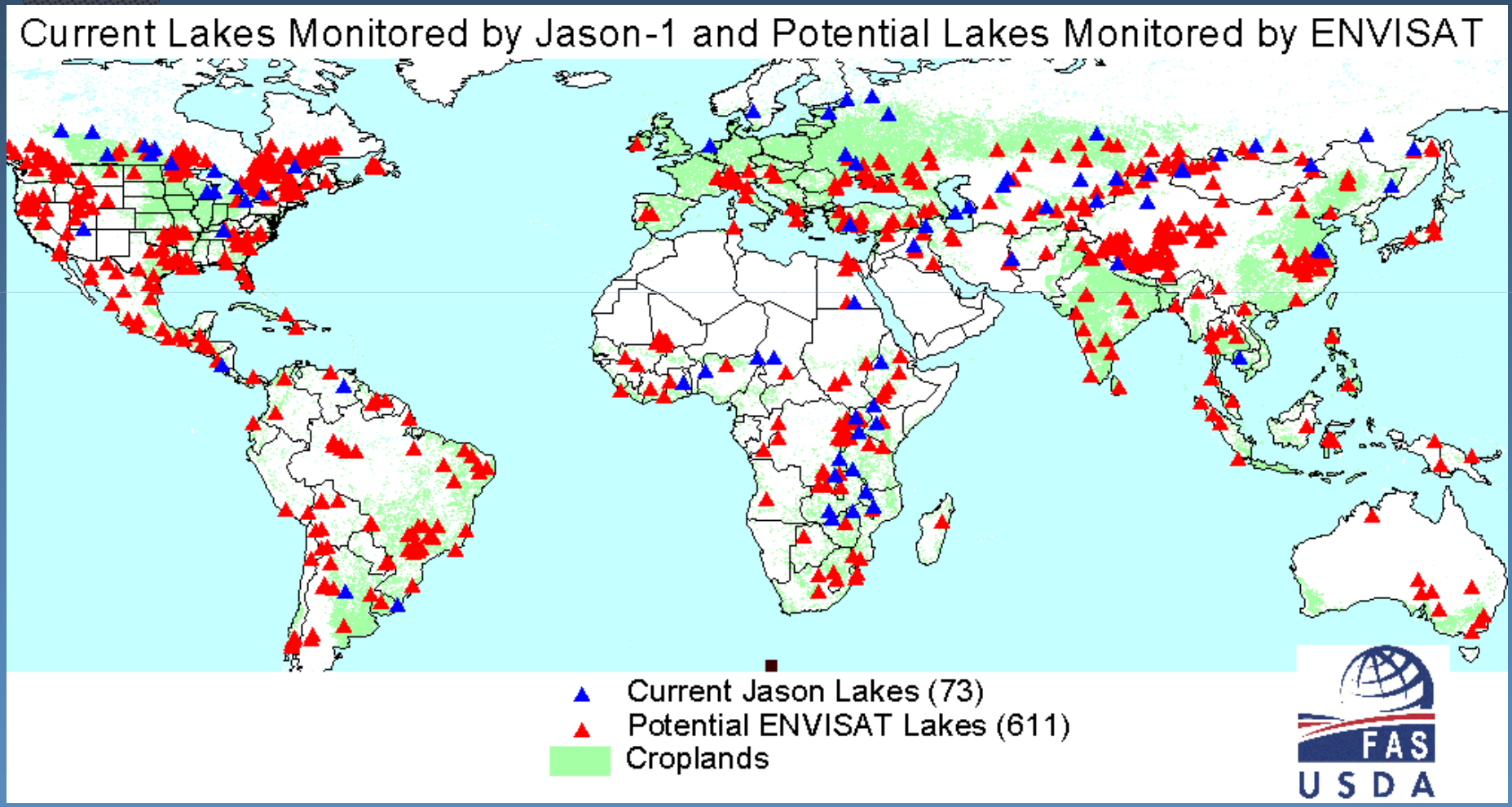
The rainy season in Venezuela which refills the reservoirs runs from June to October. The summer of 2009 it was a catastrophe. Rainfall was only about one third of normal so that by last fall alarm bells began sounding as it looked as if the water could fall to the level where the dam would have to shut down most of its generating capacity. The Guri dam has a lower and older generating hall with much less capacity than the main hall and there are two smaller dams located downstream from the Guri. The problem is that if they have to stop letting water through to the turbines in the main Guri dam, the water is no longer available to the downstream plants so their output drops markedly too.

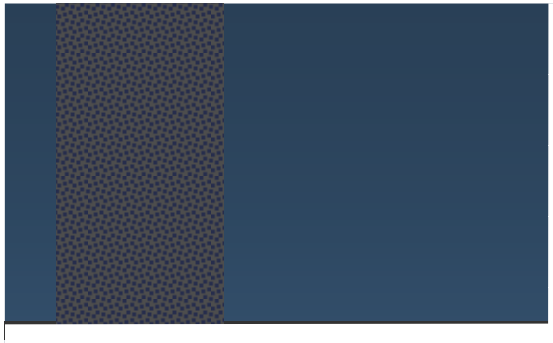
Case Studies

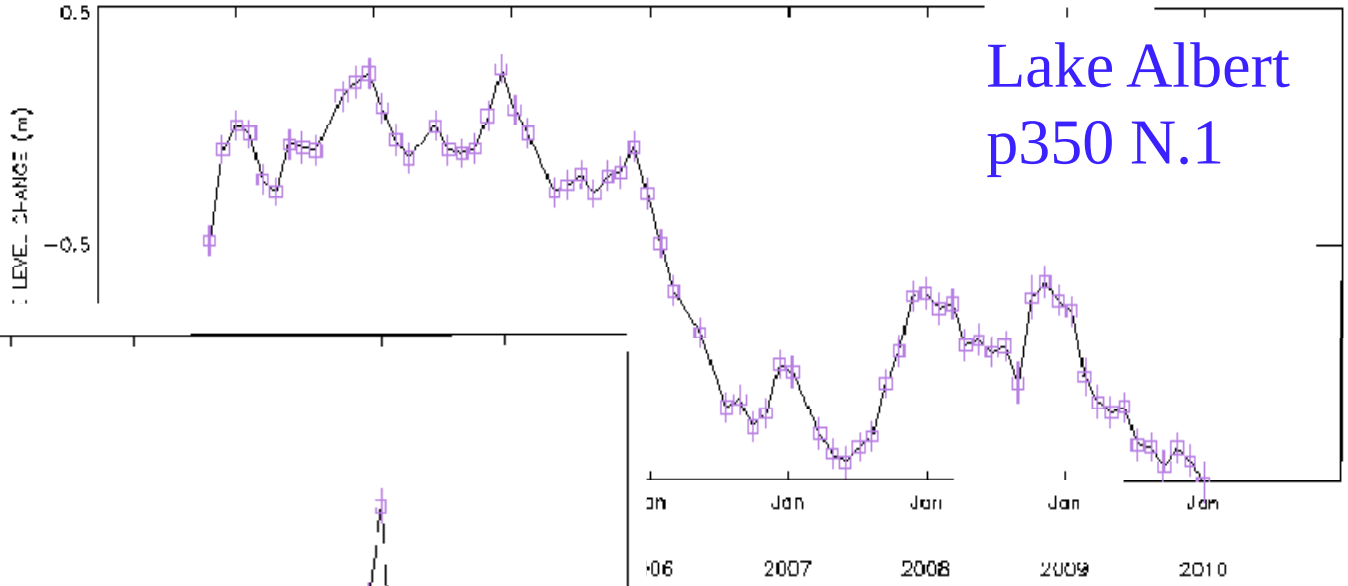
Reservoirs in the News

Current: Product expansion, 35-day Target Coverage

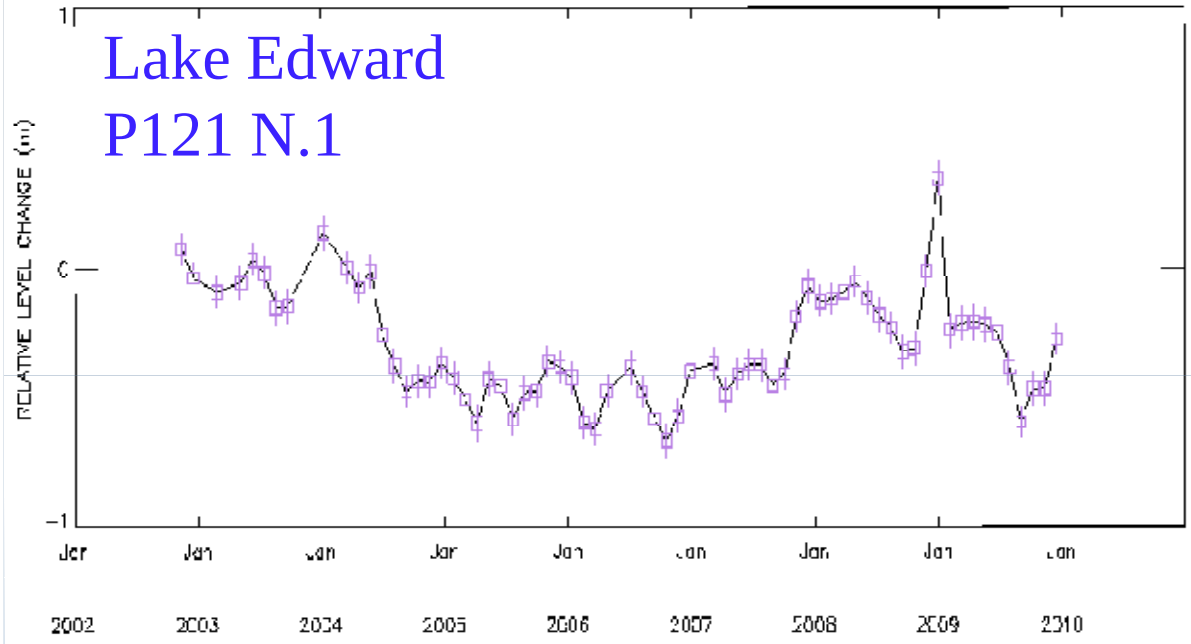
Phase IV





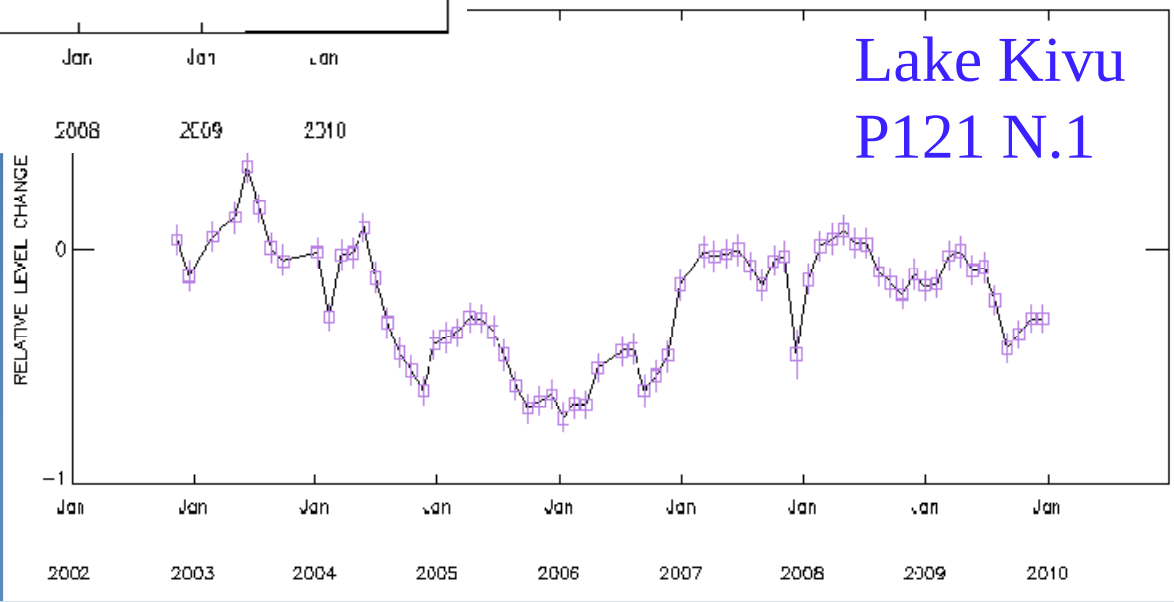


Lake Albert
p350 N.1



Lake Edward
P121 N.1

ENVISAT
Preliminary N.1 Products



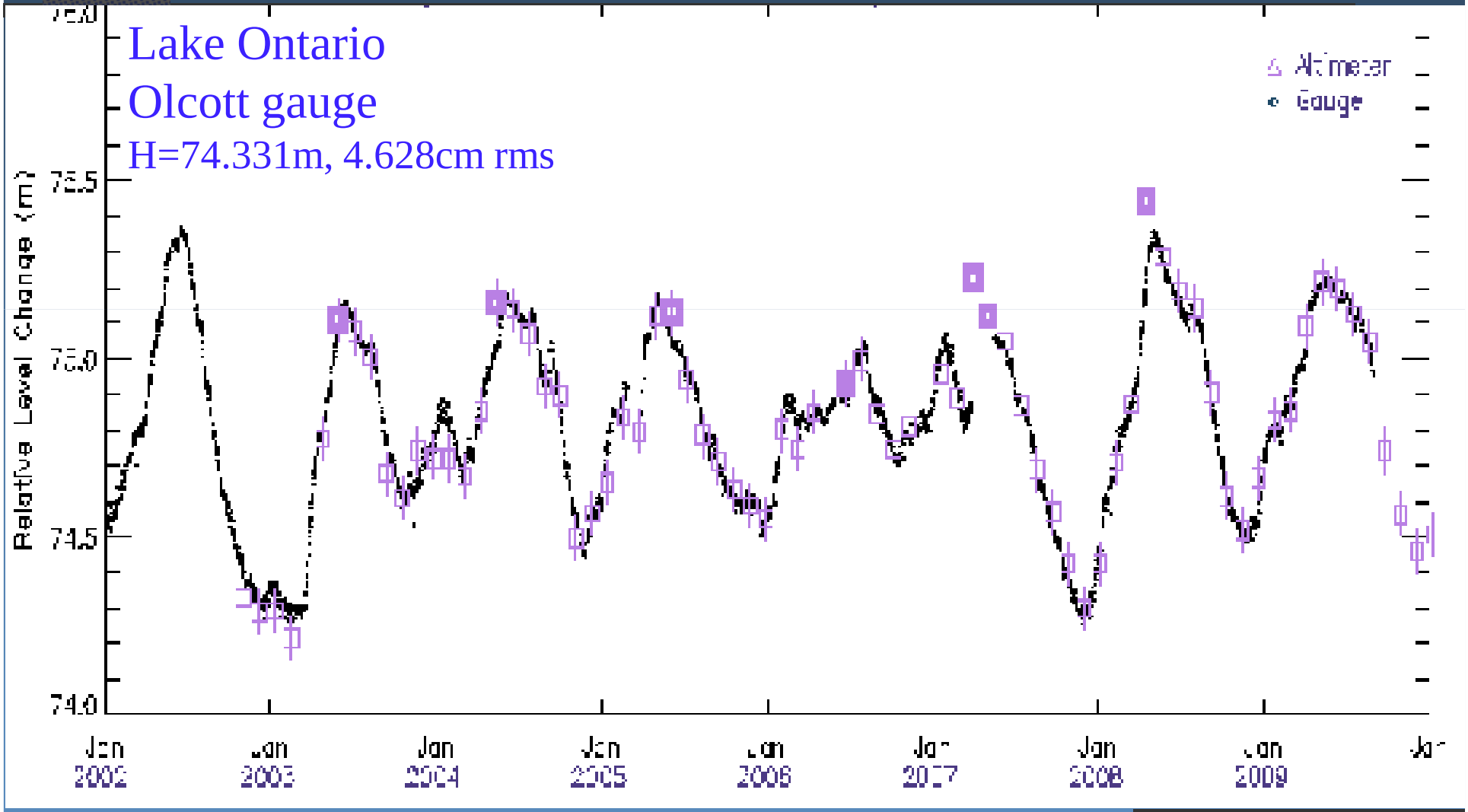
Lake Kivu
P121 N.1

New products - lakes not observed by the NASA/CNES suite of instruments

ENVISAT product validation

Use of gauge data for “absolute” checks

Testing of tracker and altimeter parameter options



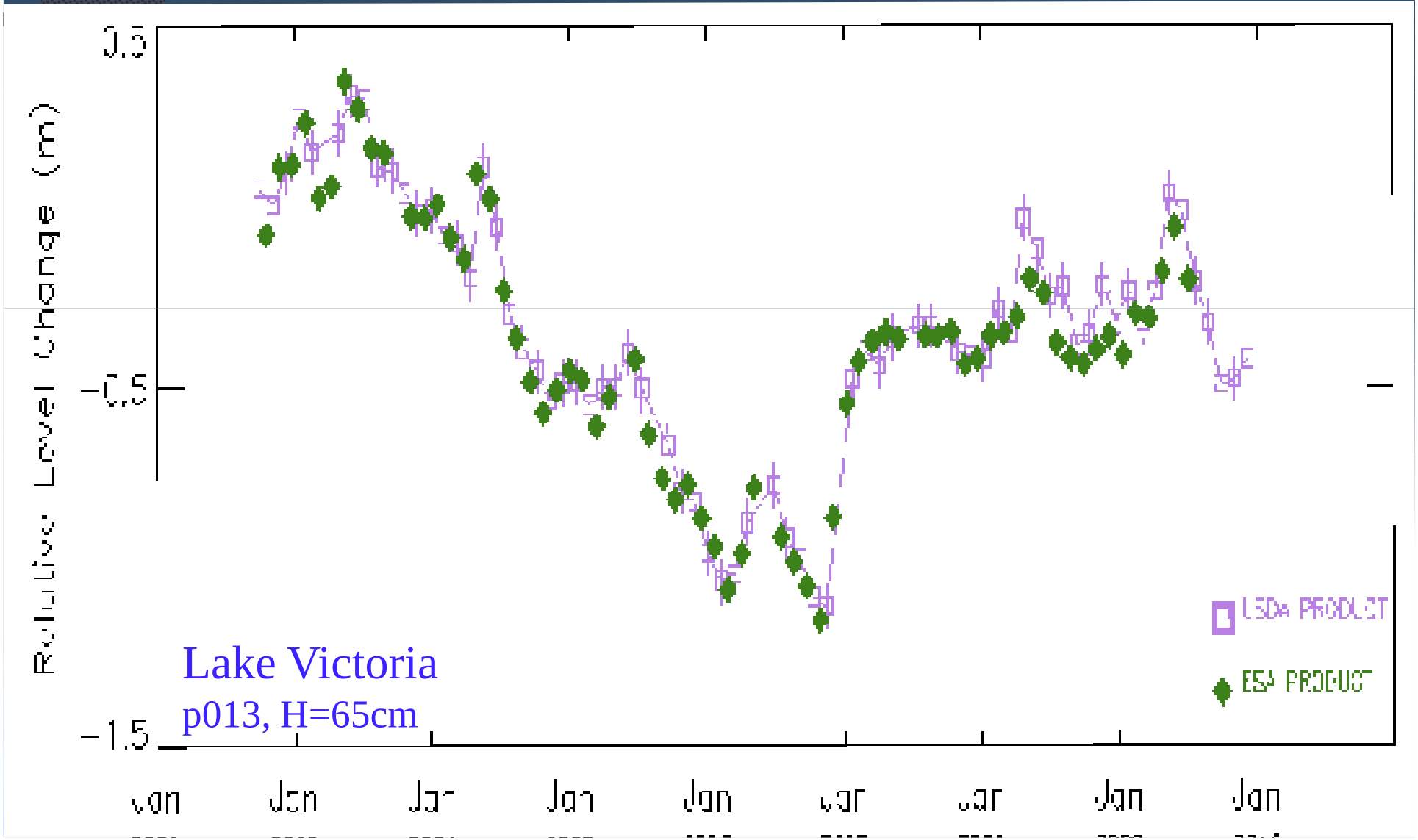
ECMWF, DORIS, ssbias, ocean-retracker

Current: ENVISAT product validation

Same Platform.

Versus ESA lake products for relative checks.

Tracks and overpass dates may differ.

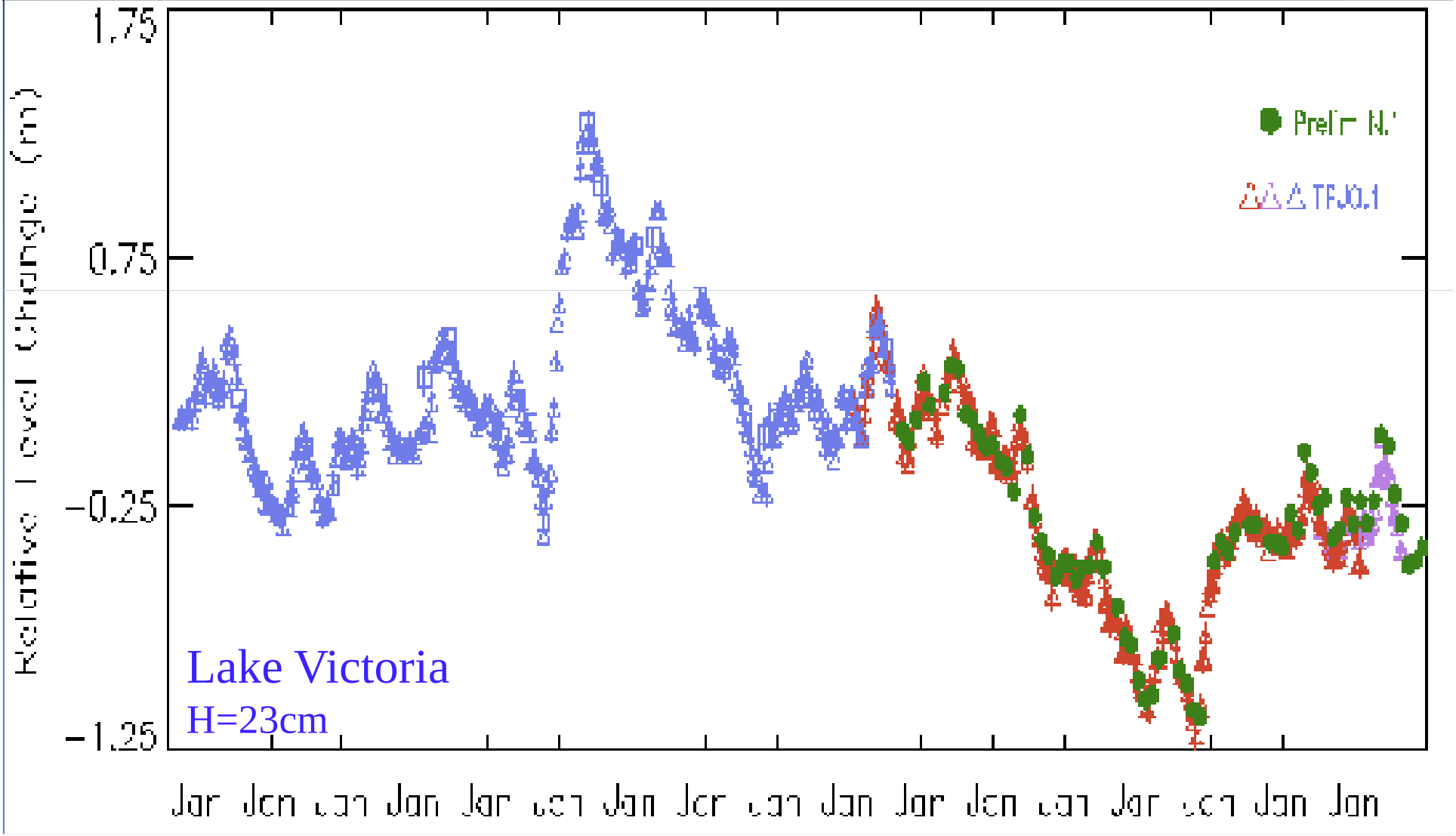


ENVISAT product validation

Cross-Platform Tests.

Versus Jason-2/OSTM for relative checks

Track locations/dates will differ.



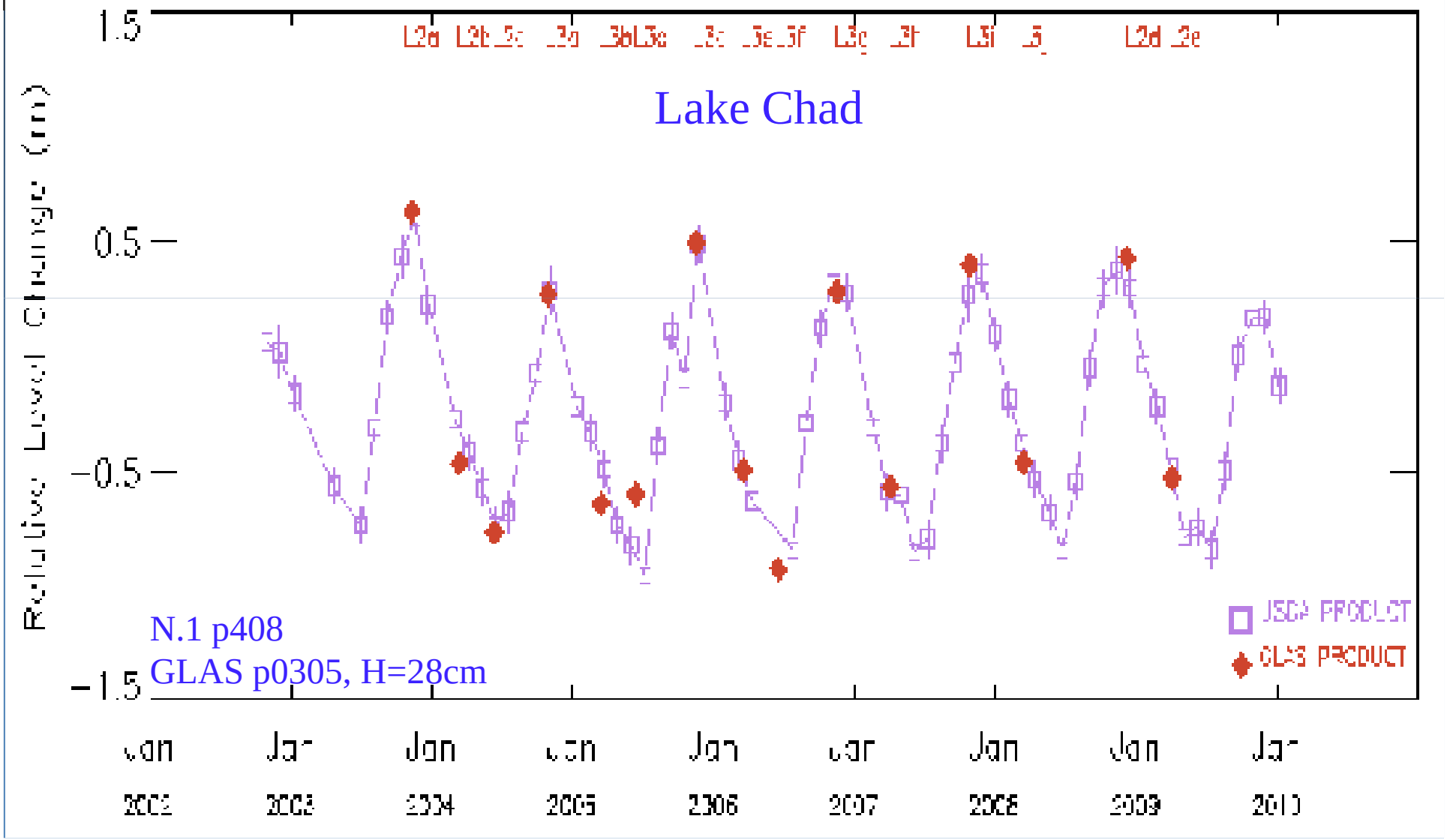
3 lasers,
1064 and 532nm,
1-10ns pulse, ~70m footprint, 175m along-track spacing

Current: ENVISAT product validation

Cross-Platform tests.

Versus ICESat/GLAS laser altimeter for relative checks.

Track locations/dates will differ.



N.1 p408

GLAS p0305, H=28cm

Product Status and Continuity

Prelim ENVISAT N.1 products - by December 2010
(archive 2002-2010, ranked)
ERS+ENVISAT products E1E2N1.1 by mid 2011
(1994-2002)
SARAL to extend 35-day repeat timeline from 2011
[Sentinel-3 to extend 35-day repeat timeline from 2013]

Jason-2/OSTM to continue current NRT
[Jason-3 to extend 10-day repeat timeline from 2013]

Benchmarking-I:

Assessment - product validation, user response and interaction, and feedbacks to the system

- USDA CropExplorer receives 40,00 hits and 2,000 visits per day
  - Global Reservoir Lake Monitor is the 9th most popular link page
- Users are *.edu, *.mil, *.com, *.gov, *.org
  - FAS foreign resource analysts, international governments, lake development agencies and networks, humanitarian organizations, conservation groups….
- Diverse applications
  - lake surveys, impoundment effects, water resources, drought effects, energy supply, fish productivity, water security, vegetation and surveillance ecology, basin or continental-scale hydrological modeling, climate change, validation tool for GRACE…..

System Updates for USDA Global Reservoir and Lake Monitor

NRT
weekly

OSTM/SARAL - greater system automation

Archive

Move from IGDR to GDR for Jason-1

Further investigation of target recognition, retracking, and range retrieval.

Enhancements to range corrections - wet trop, iono corr

Change of reference datum - single date, 20Hz, interpolated

System Updates for other End Users ?

NRT

Daily product updates
Refined quality assurance

Input to other NRT systems
Freeze or drought period?
Last entry warning flag?
Demonstrated validation set

Archive

Reference Datum
1-click global download
Selective track locations
More+Smaller Targets → SWOT, ICESAT-2, DESDynI

Ability to transform to msl
Global assessments
Highly varying extent

MODIS, Landsat, GRACE
Lidars and Passive Microwave
Central archive?

Additional basin products - lake area+volume, salinity+temp, soil moisture, precip, inflows, wetland storage effects, winter status (freeze/thaw period, snow depth, elevation)….

Lidar Considerations - GLAS Performance/Data Quantity

Cloud limitations, but penetration through optically thin clouds and availability of multiple passes allow good coverage. Acquisition of smaller <100km2 lake targets.

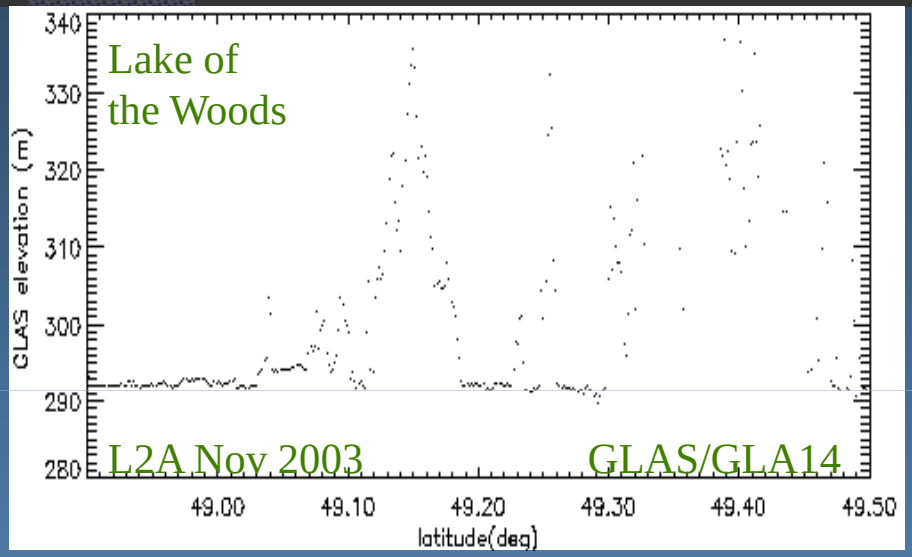
% Campaigns Present f(campaign data availability)

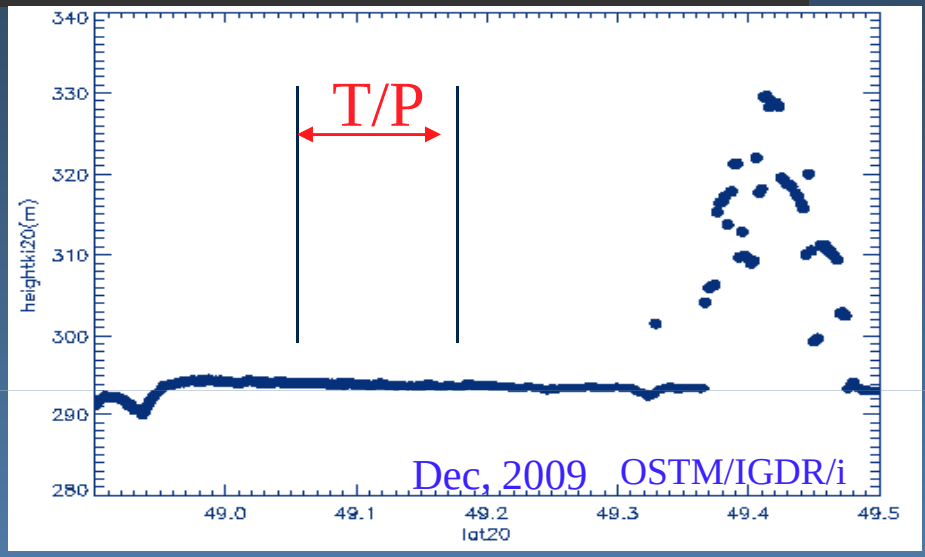
0012.Winnipeg	57-100%	(*ice)
0068.Chad	93-100%	
0266.Woods	85%	(*ice)
0319.Tonle	71-93%	
0314.Victoria	87-100%	
0334.Ontario	70-90%	(*ice)
0666.Klamath	100%	
0837.Ness	77%	(50-100km^2)
0839.Erne	46-92%	(50-100km^2)
1168.Diefenbaker	79-93%	

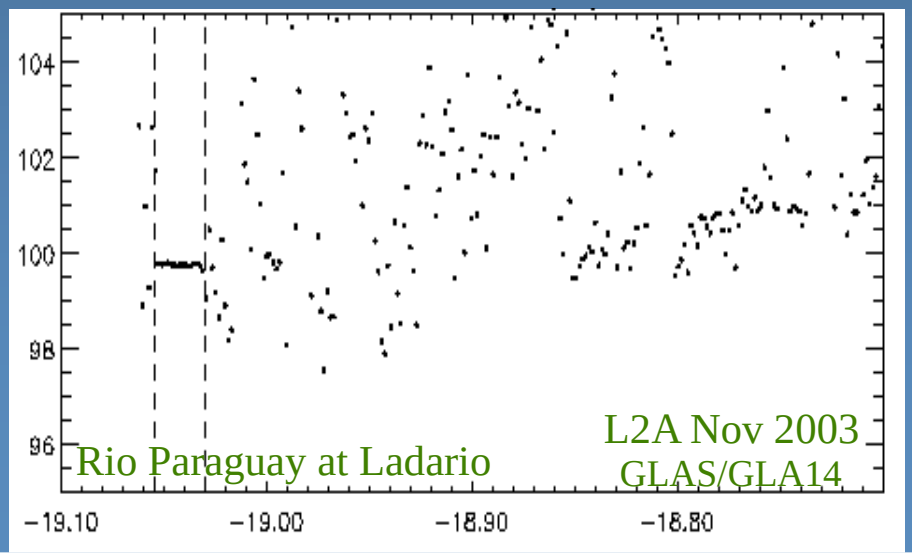
Laser energy probs - 17 campaigns (spring, summer, winter) 2003-2009, GLA14, V428/V531

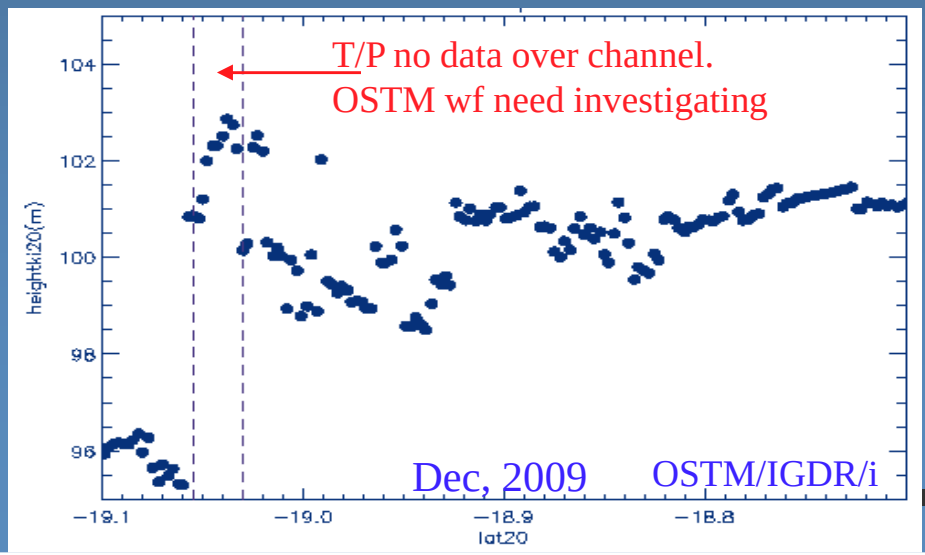
Lidar Considerations - GLAS Performance/Target Acquisition

Good, despite rapid changes in topography. Narrower channels also acquired (70m footprint, 175ATS). GLAS data already being utilized for river/discharge studies. Both radar and lidar require waveform observation in certain cases.





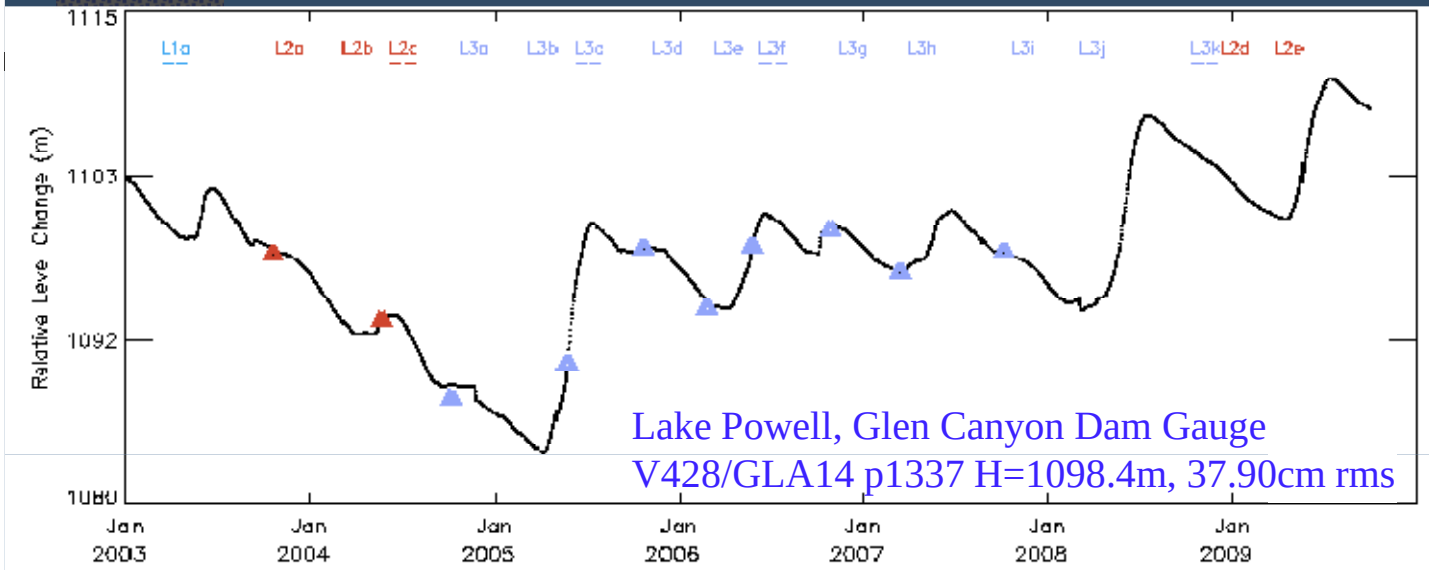


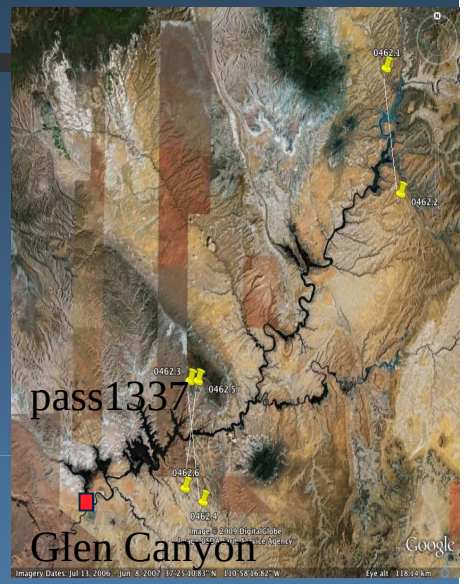


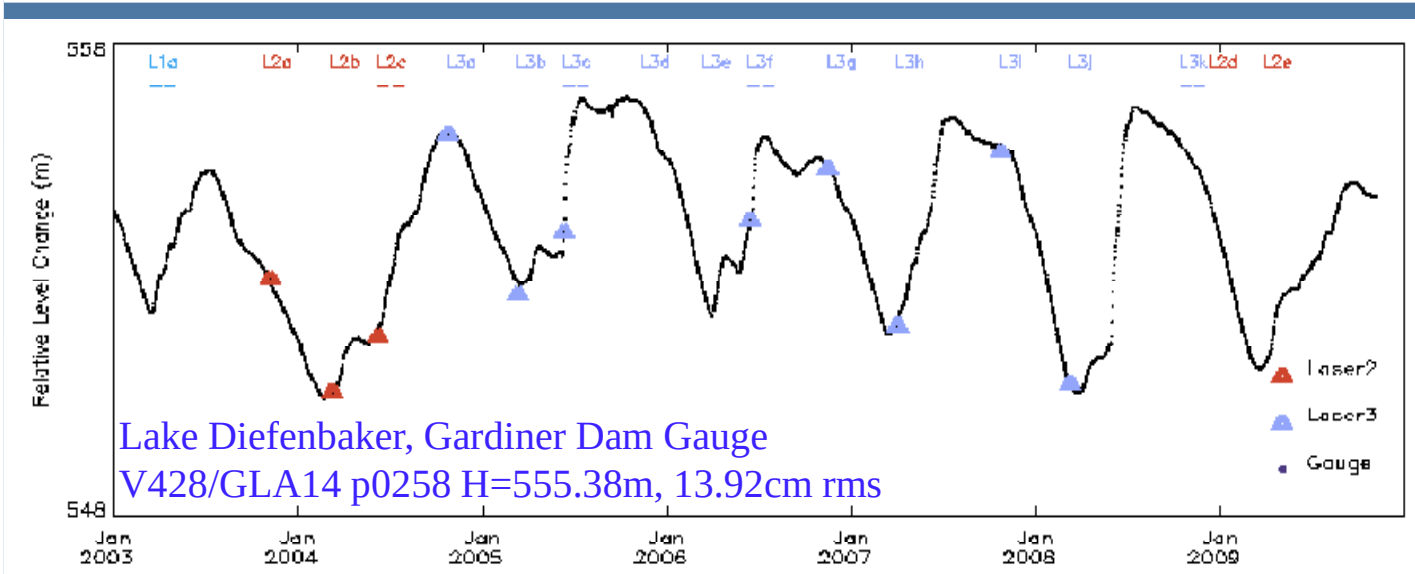
Lidar V Radar - GLAS Data quality

Validation exercises over large lakes.

Rms cf radar (OSTM/Powell =20cm, OSTM/Diefenbaker=15cm) but 10-20% of seasonal amplitude, which qualifies for USDA Lake Monitor Program for example.







Lidar V radar - Data Validity during Freeze Periods

GLAS data limited, but looks promising.
Future - ICESat-2 and DESDynI likely to be multi-beam.
Considerations as secondary validation sources, winter status measurements.