Global River and Lake Monitoring from Multi-Mission Altimetry: Capability, Potential and Mission Requirements

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Overview

- Introduction
- What altimeter datasets are available?
- Why ‘retrack’ the echoes?
- With full retracking, how do different instruments perform globally over inland water?
- Applications of these data
- Future possibilities - what do we really need?

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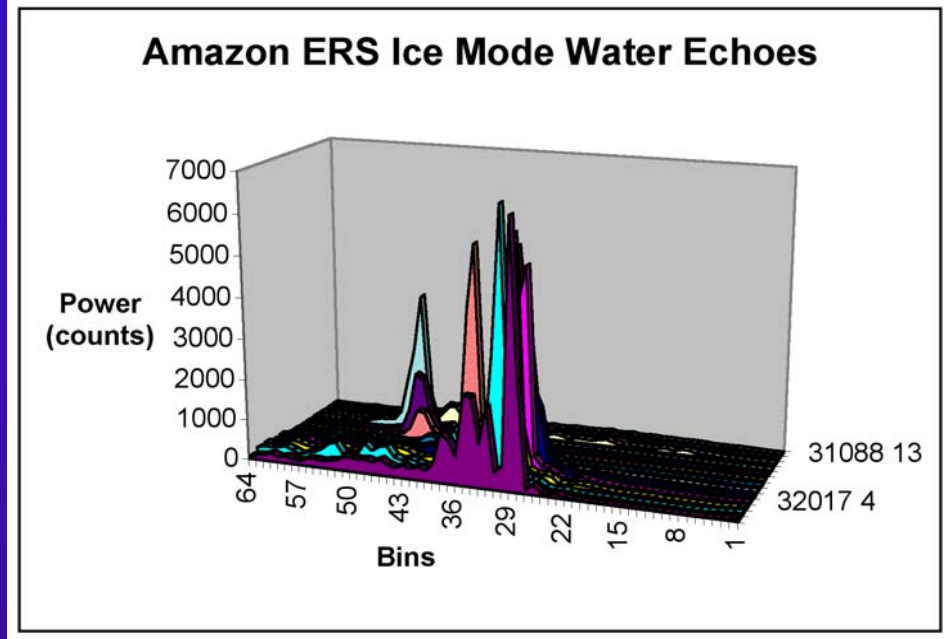
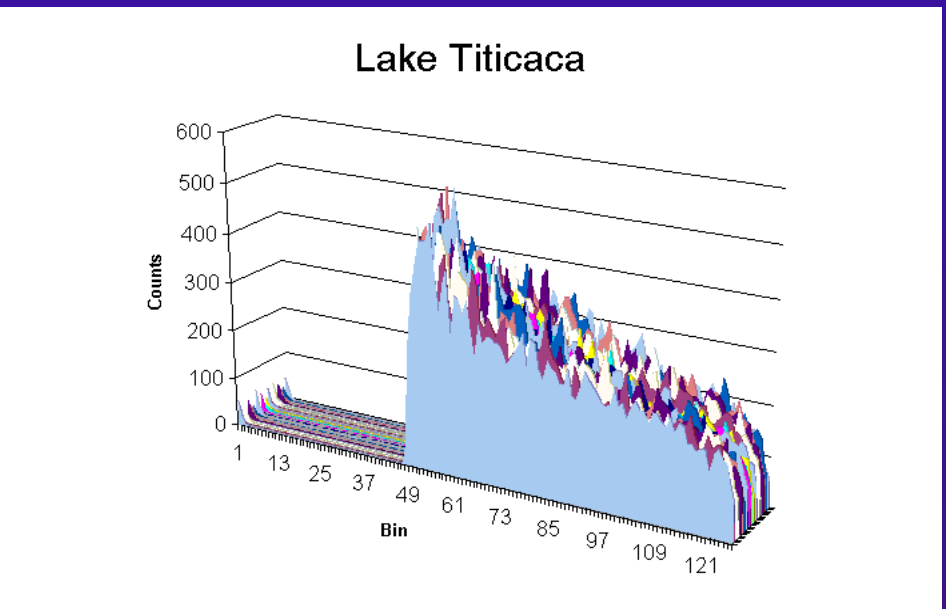
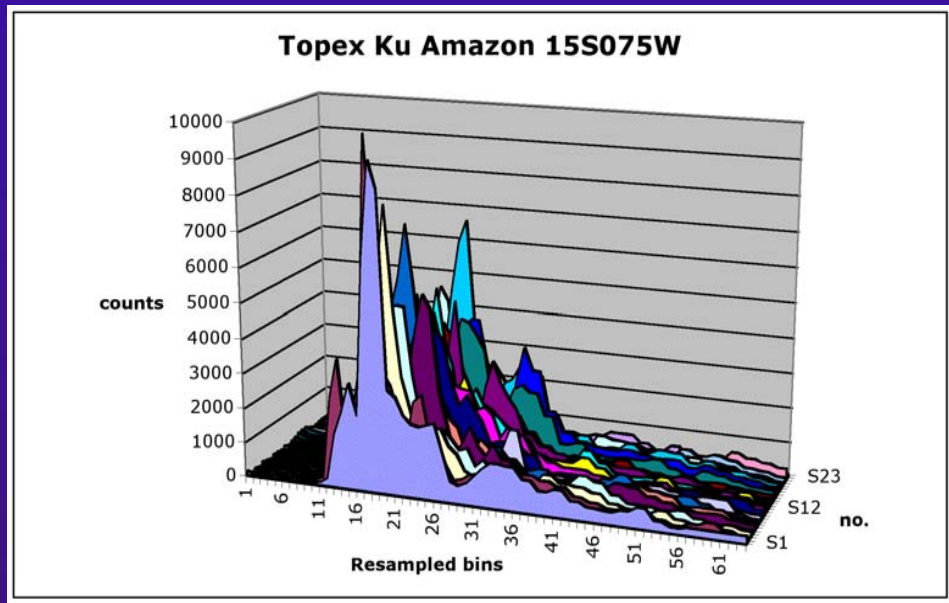
Introduction

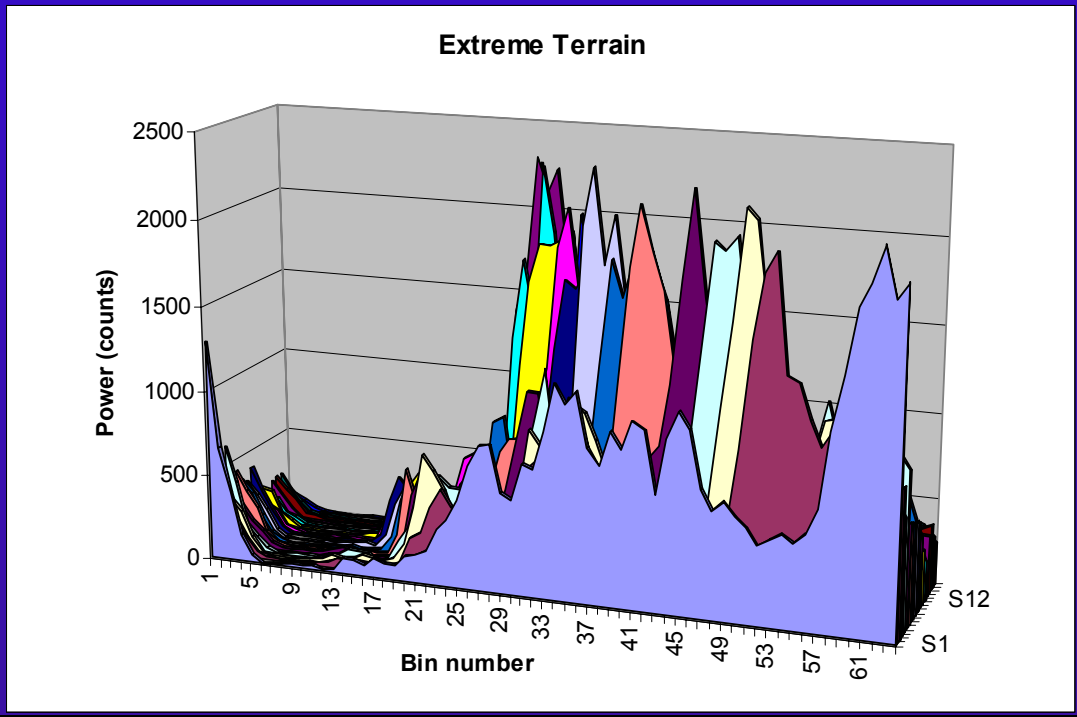
- Decadal time series now exist from ERS-1/2 and Topex/Poseidon missions.
- New missions Envisat and Jason-1 continue the time series. Other altimeters e.g. GFO also flying.
- Although prioritised for ocean operation, data collected also over land and ice surfaces.
- Some work has been done for many years over major inland water bodies.
- But constraints on pre-processed data limited scope.
- Next slide shows well-behaved ocean (Topex) and lake (Envisat) echoes, then echoes from inland water (Topex, ERS-2). Following slide shows complex echoes over land/water margins

Why ‘retrack’ the echoes?









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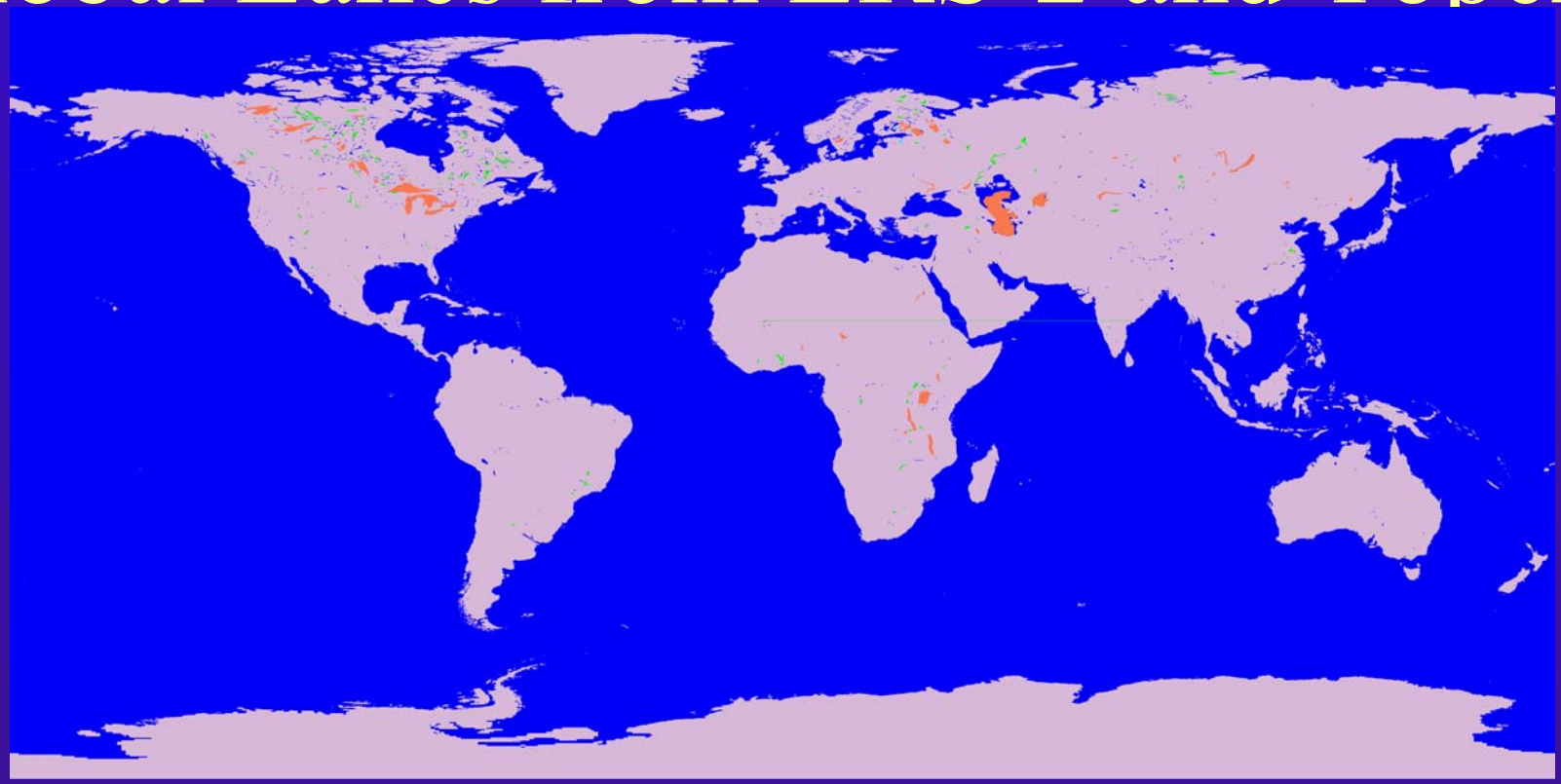
Retracking

- By reprocessing the individual echoes from Topex, ERS-1/2, Jason-1, heights can be determined over land, ice and inland water. For example, over 100 million datapoints per year are obtained over land by retracking ERS-1/2 data.
- This allows a range of applications to be addressed. Whilst the orbit repeat patterns, other than the ERS-1 Geodetic Mission, are not favourable for topographic mapping, inland water monitoring can be addressed.
- How many inland water targets have been observed by ERS-2 and Topex?

Global Lakes from ERS-2 and Topex



Overflying the CIA lakes network with retracked Topex and ERS-2 data shows about 378 lake systems seen by Topex, 672 by ERS-2 of 842. Consequence of orbit patterns & Ice tracking mode on ERS RA-1.

Key: Lakes overflown by Topex & ERS, ERS only, Topex only, lakes not seen by any satellite are coloured blue.

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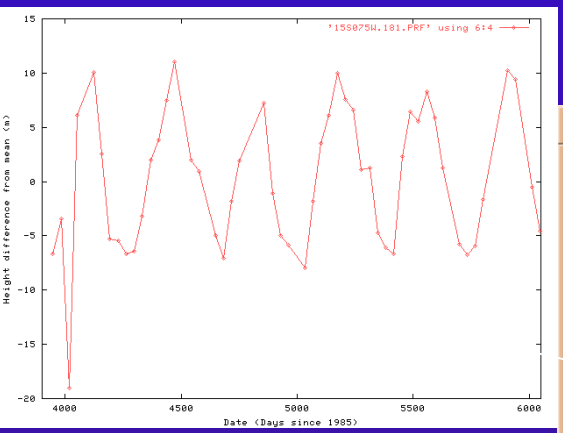
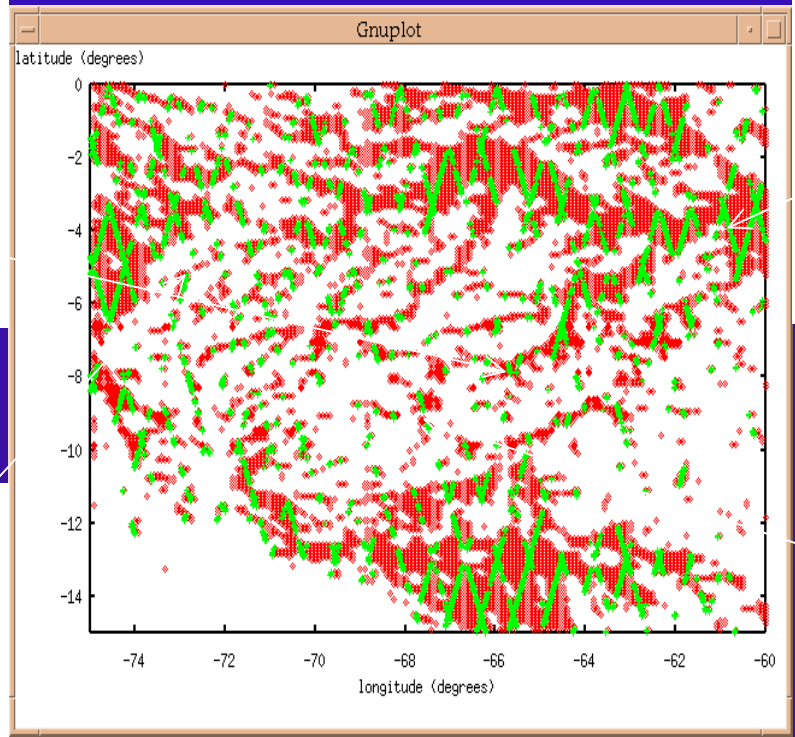
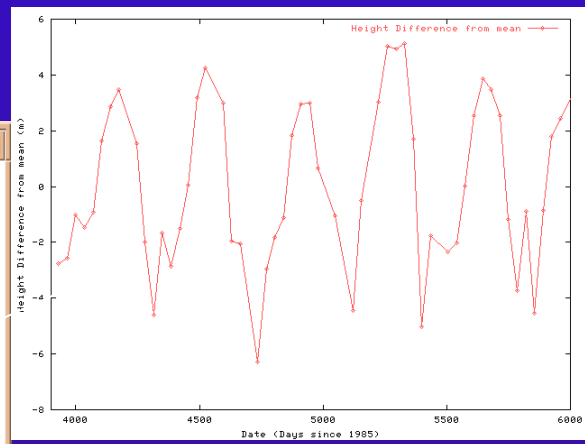
Rivers

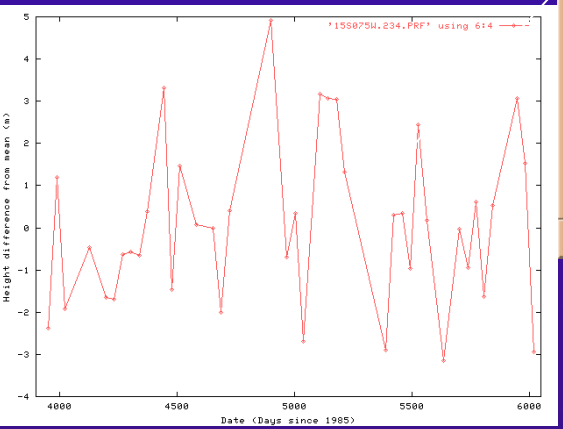
- So majority of earth's major lake systems have decadal time series of echoes already collected by ERS and Topex. Temporal sampling is poor: 10 days for Topex, 35 days for ERS-2.
- Lakes integrate the surface water flow over the catchment area, so change slowly; therefore sampling of Topex is just sufficient for some applications. BUT ERS is much better at acquiring targets in rough terrain.
- What about rivers? How do existing systems perform over rivers?
- Next slides show performance over the Amazon basin of Topex(Ku), ERS-2 and ERS--1 3 day mission. Mask used was created from ERS-1 GM.
- Note that ERS-2 shows a 7 year time series: Topex 1 year, ERS-1 3 day just 3 months are available.

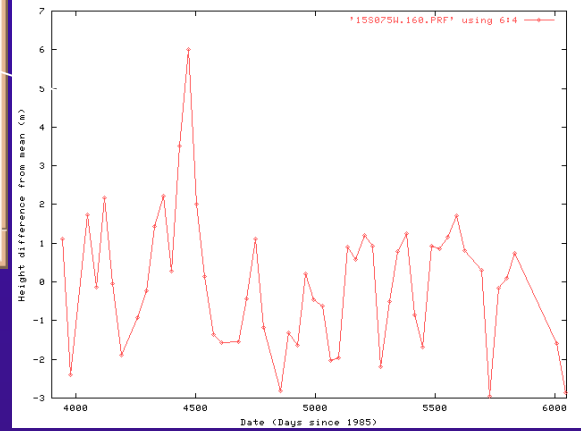
Amazon basin - ERS-2 Coverage











ERS-2 Crossings (green) over Amazon basin bright targets (274 valid crossings out of theoretical maximum of 516). 4 typical crossings .

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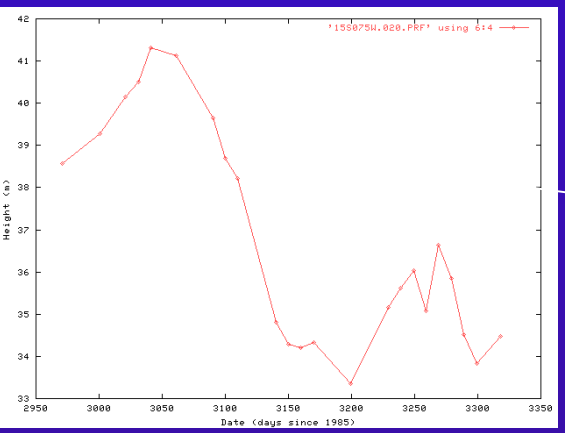
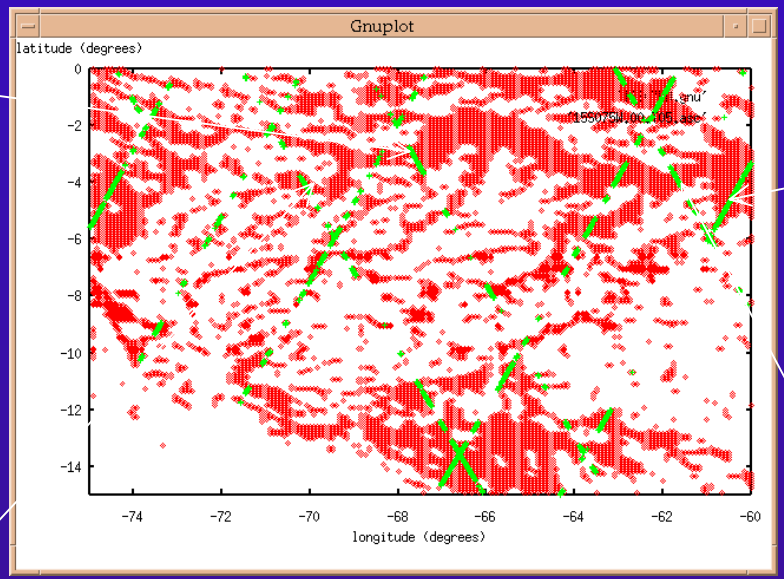
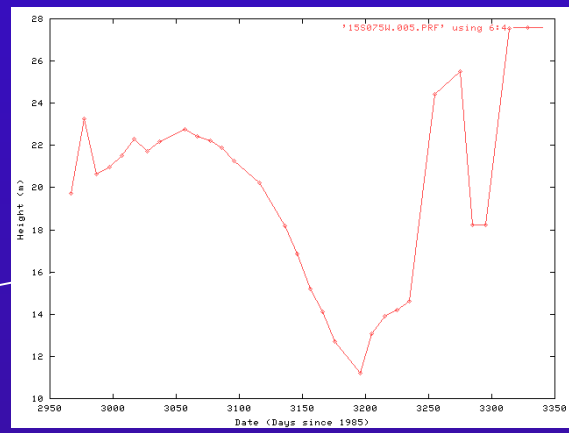
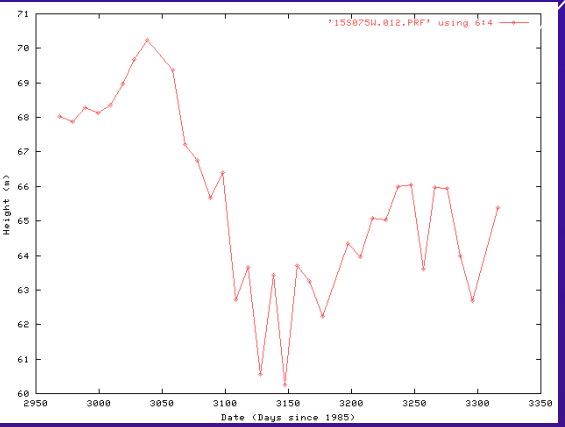
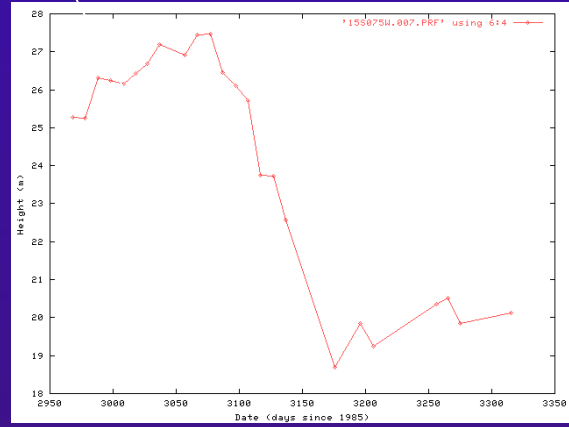
Amazon basin - Topex Coverage











Topex Crossings (green) over Amazon basin bright targets (35 valid crossings this cycle out of theoretical maximum of 147). Note that only 1 year of data shown.

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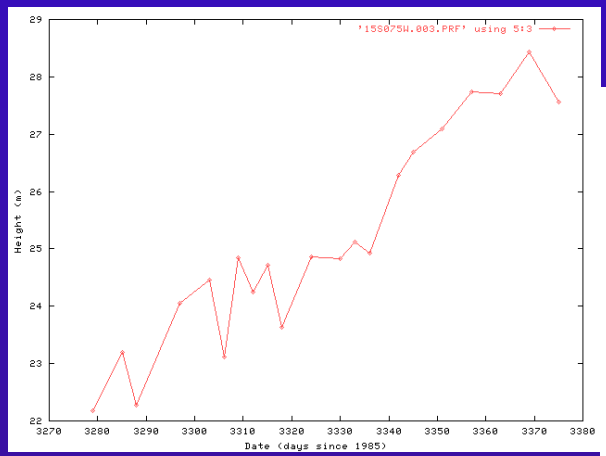
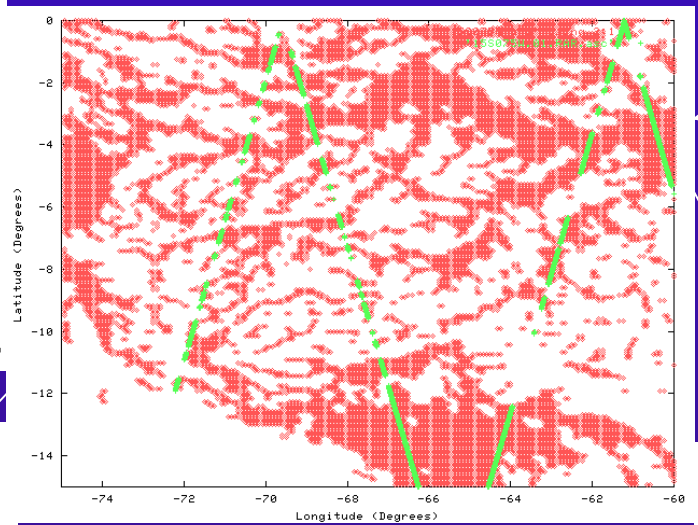
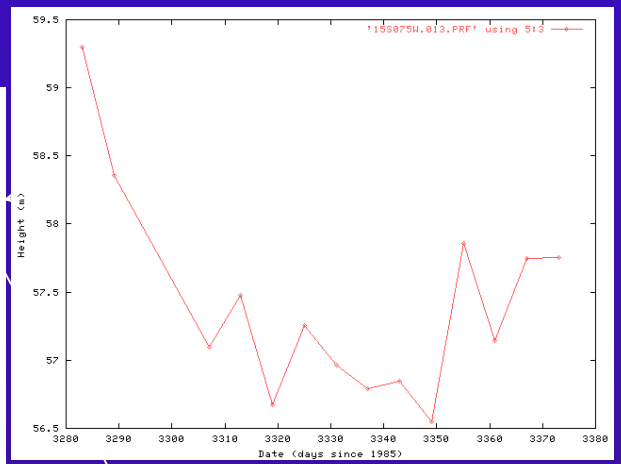
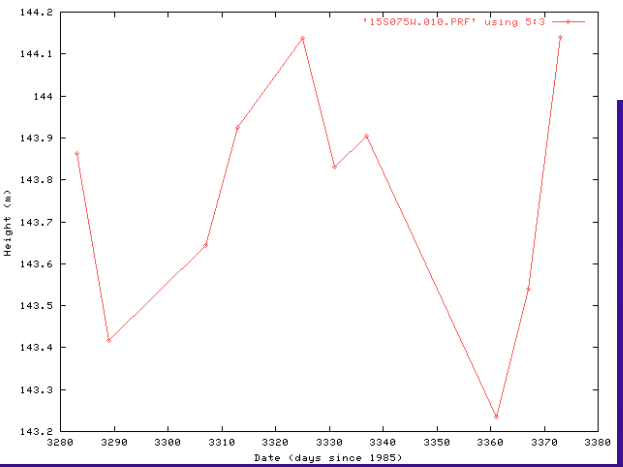
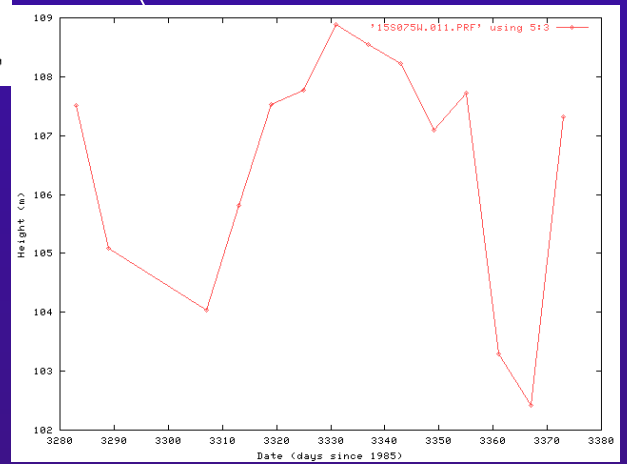
Amazon basin - ERS-1 3 Day Coverage











ERS-2 3 day crossings (green) over Amazon basin bright targets (total of 49 theoretical maximum crossings)

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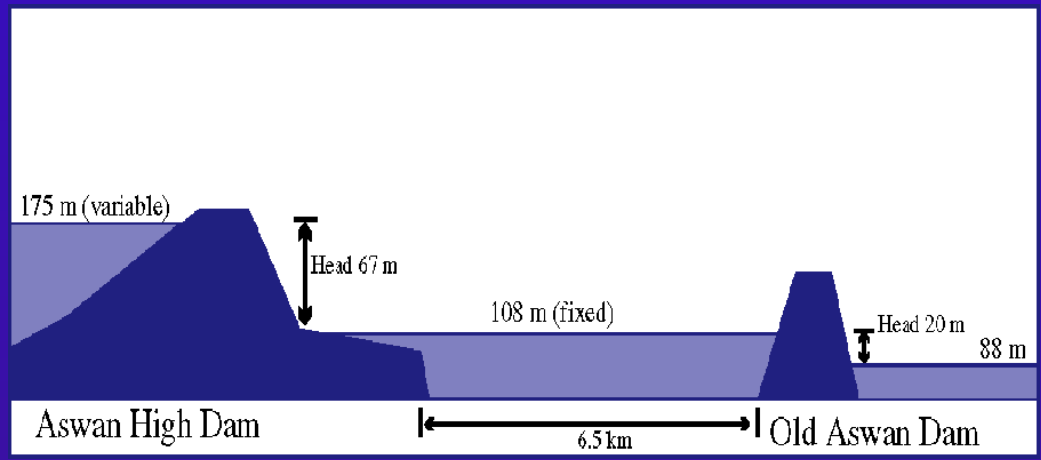
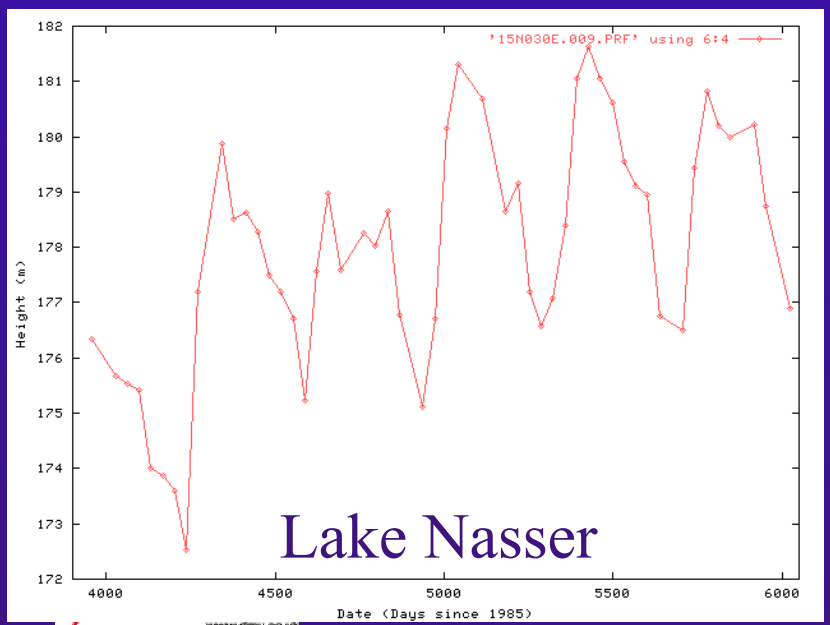
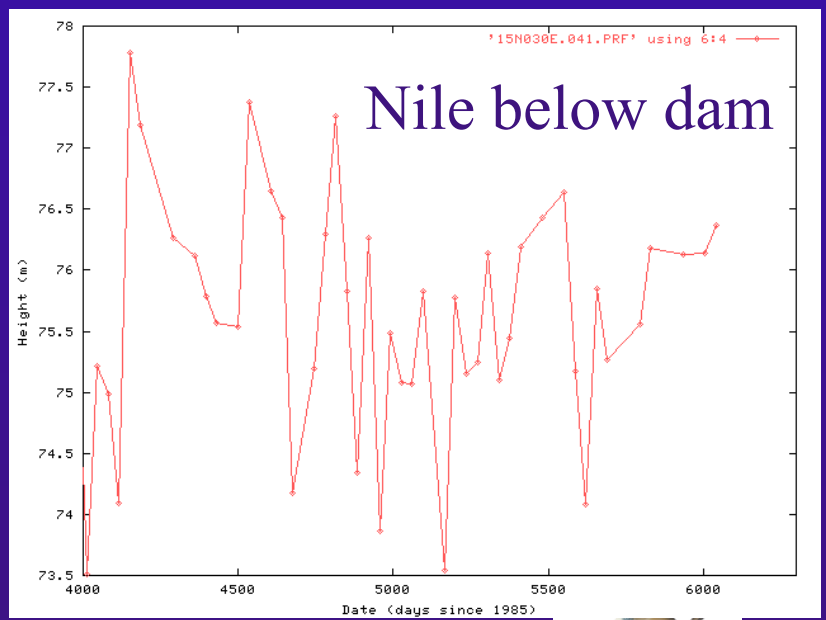
Sampling Issues

- The 3 day sampling of ERS-1 shows near-optimal sampling of the Amazon basin: but only a small time series is available. And the spatial sampling is terrible: the number of targets acquired is drastically reduced. So one satellite cannot fulfill the monitoring requirement, but could provide temporally adequate sampling over rivers for a small subset of crossing points over the world's river systems.
- To show the effectiveness of close spatial sampling, the next slide shows ERS-2 35 day data above and below the Aswan High Dam. The seasonal variation in lake Nasser is well captured, but the river variation is too rapid to be observed with a 35 day repeat.

Applications - Aswan Dam







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Future possibilities

- What have we got in the medium term?
  - Cryosat (maybe some data over land tbd)
  - Jason -2 (we hope)
- What do we really need?
- Options:
  - One dedicated mission
  - Constellation of ‘cheapsats’
- This work suggests that quantity and timeliness of data outweighs all other considerations especially for human-oriented applications. This suggests a constellation solution as the best way forward
- High sampling rate is essential for rivers: ice mode tracker is preferred especially for rivers.

Conclusion

- With Envisat and Jason-1, near-real-time recovery of data is possible. This opens up a new range of hydrology applications such as flood monitoring, surge tracking, hydropower optimisation. But not enough coverage.
- With a constellation which gave ERS-2 type spatial sampling, and a temporal sampling of 3 days or better , global monitoring of the earth's surface water resources would really be possible. Since the next generation of wars are likely to be fought over scarce water resources, the ability to quantify and monitor these resources globally and independently is of great importance.