

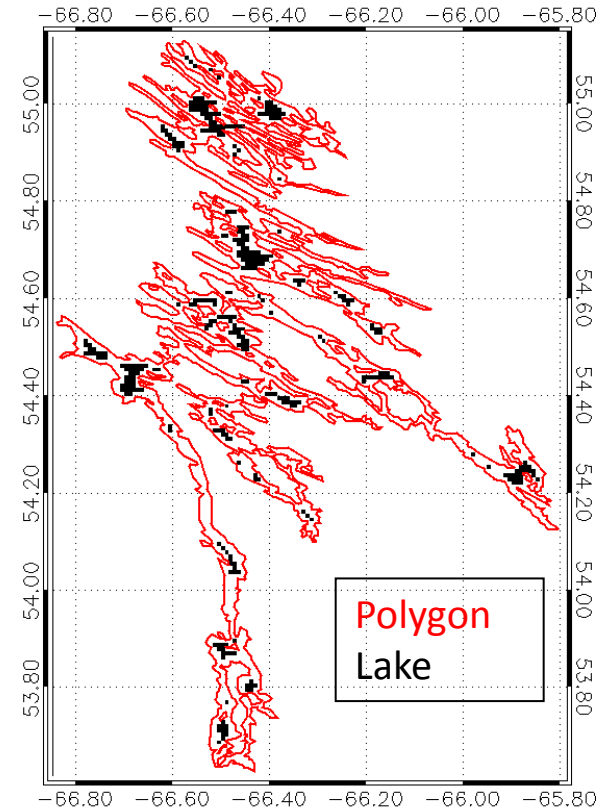
Global Lake Surface Water Temperatures from ARC-Lake

Chris Merchant, Stuart MacCallum,
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	Phases 1 and 2	Phase 3
Target size	Mostly > 500 km ²	Minimum ~50 km ²
Target type	Mostly natural lakes with stable surface area	Natural lakes, reservoirs, lakes with highly variable surface area
Number of targets	263	1628
Time range	1991-2011 (1995-2009 for v1)	1995-2012
Database	Global Lakes and Wetlands Database (GLWD), Herdendorft (1982), ILEC, LakeNet, and literature	Limited information added for new phase-3 targets
Target definition	GLWD polygons combined with binary mask	Water detection: active tests and used to derive new masks
Data products	Lake Surface Water Temperature (LSWT) and Lake Ice Cover (LIC)	LSWT and LIC
Data availability	http://hdl.handle.net/10283/88	http://www.geos.ed.ac.uk/arclake/

- Lake mask from combination of NAVOCEANO mask and GLWD polygons
- Lakes given unique IDs
 - Associate non-connected cells to a single ID
 - Enabled per-lake products
- Limitations
 - Static in time
 - Excluded lakes known to have large seasonal or long-term variations in surface area
 - Some targets poorly represented in GLWD/NAVOCEANO

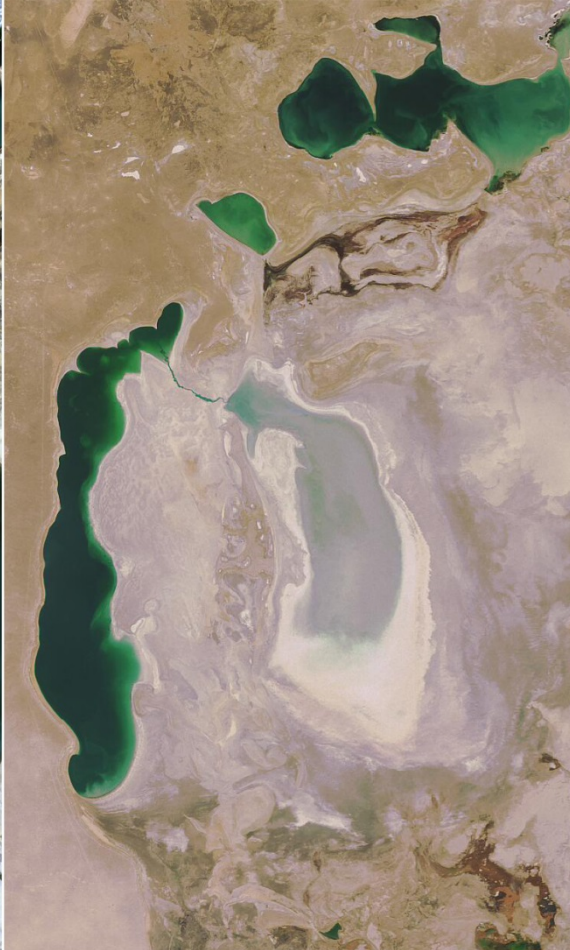


Lake Astray

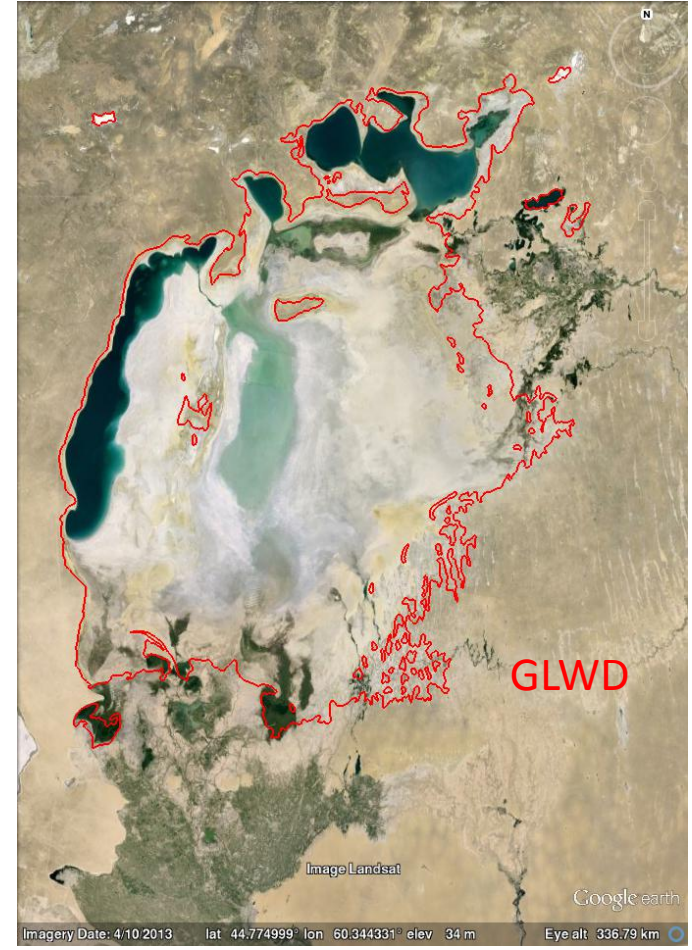
1989



2008



GLWD



earthobservatory.nasa.gov

Lake Chad



Kara-bogaz-gol



ID=238

GLWD does not provide a good representation of lake area in some cases

ID=447



- Aim to overcome earlier limitations
 - Enable targets with variable area to be included
 - Minimize problems of land contamination
 - More significant for smaller targets
- Maintain unique lake IDs
- No available global lake mask with adequate temporal resolution
- Use ATSR channels for water detection
 - visible, near-infrared (NIR) and short-wave-infrared (SWIR)
 - Only available for ATSR-2 and AATSR

Active tests:

- MNDWI – Modified Normalised Difference Water Index (> 0.1)
 - Hanqiu Xu (2006) Modification of normalised difference water index (NDWI) to enhance open water features in remotely sensed imagery. International Journal of Remote Sensing, Vol. 27, Iss. 14
 - $$\frac{(0.55 \mu\text{m} - 1.6 \mu\text{m})}{(0.55 \mu\text{m} + 1.6 \mu\text{m})}$$
- NDVI – Normalised Difference Vegetation Index (< 0.0)
 - $$\frac{(0.87 \mu\text{m} - 0.67 \mu\text{m})}{(0.87 \mu\text{m} + 0.67 \mu\text{m})}$$
- Threshold tests on vis., NIR, SWIR and $11 \mu\text{m}$ channels

Applied to ATSR-2/AATSR

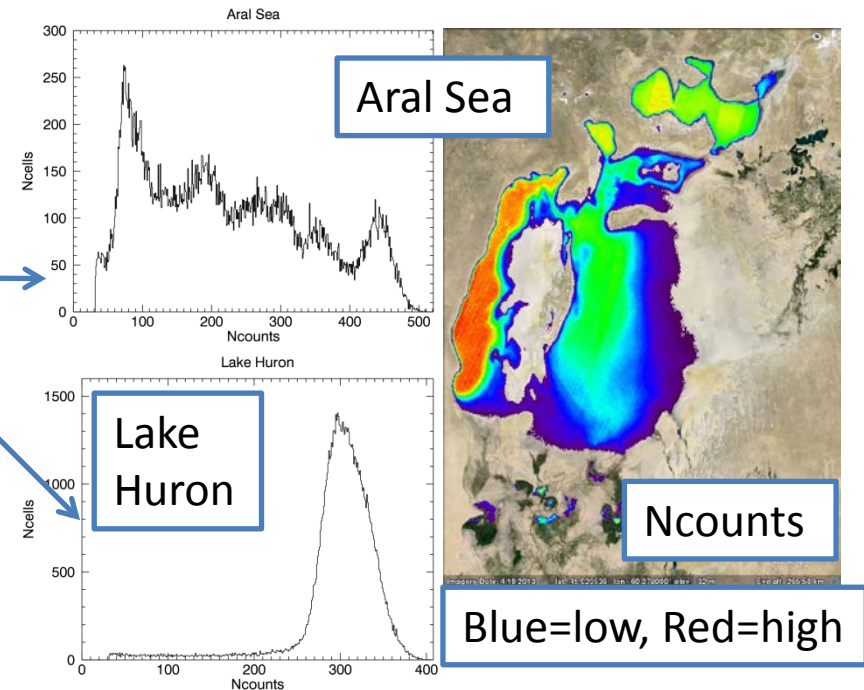
- Pre-LSWT processing
- Match water regions to GLWD IDs
- Determine night-time lake mask

Pre-LSWT processing:

- Count water detection events (Ncounts)
 - ATSR-2/AATSR period
 - 1/120° grid
- Filter false positives (cloud/terrain shadow)
 - Ncounts/DEM filters
- Match regions to GLWD IDs
 - Allow matching outside GLWD polygons
 - Do not consider regions not in GLWD
- Apply per-lake Ncounts thresholds
 - Minimise land contamination
 - Geolocation, mixed surface type
- Filter targets with smallest region < 5x5 cells
- Maximum area mask
- Apply annual per-lake Ncounts thresholds
 - Annual minimum area masks

Implementation

- Day: Active water detection for max. area mask
- Night: Annual min. area mask

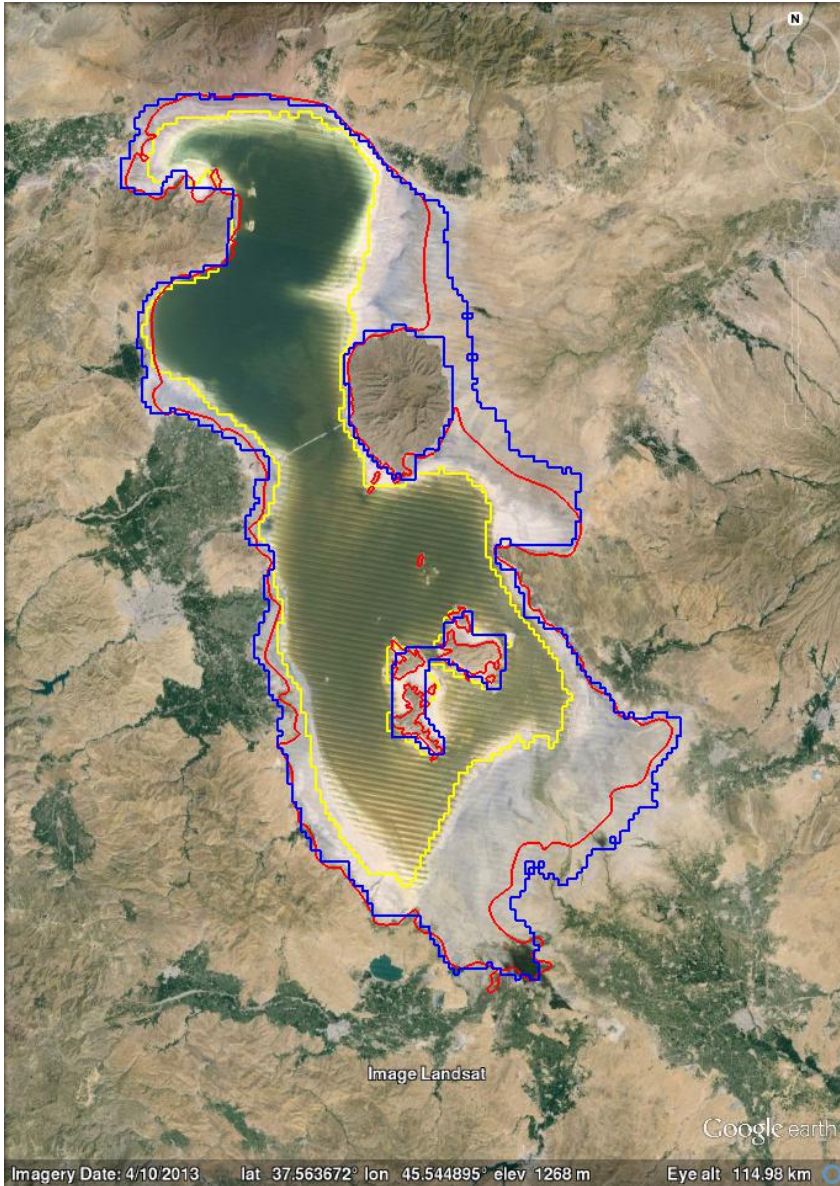




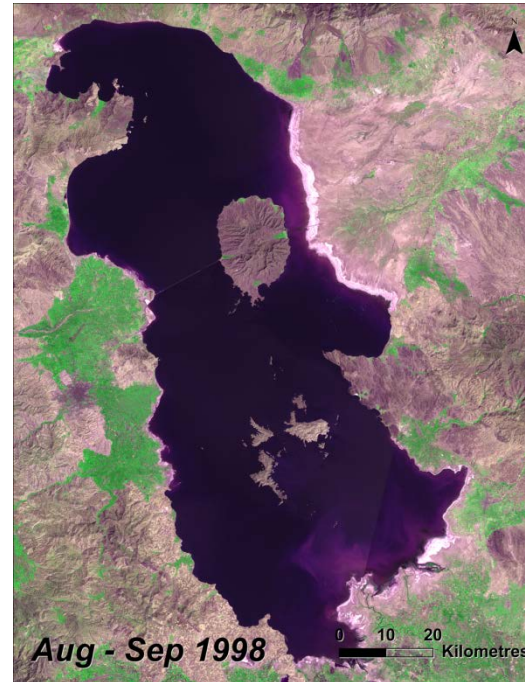
- In phase 1 and 2 but excluded from trend analysis
- Comparison of lake masks
 - Red = GLWD
 - Blue = ARC-Lake max.
 - Yellow = ARC-Lake min. (2008)



- MODIS**
- August 2008



- New addition to phase 3
- Comparison of lake masks
 - Red = GLWD
 - Blue = ARC-Lake max.
 - Yellow = ARC-Lake min. (2008)

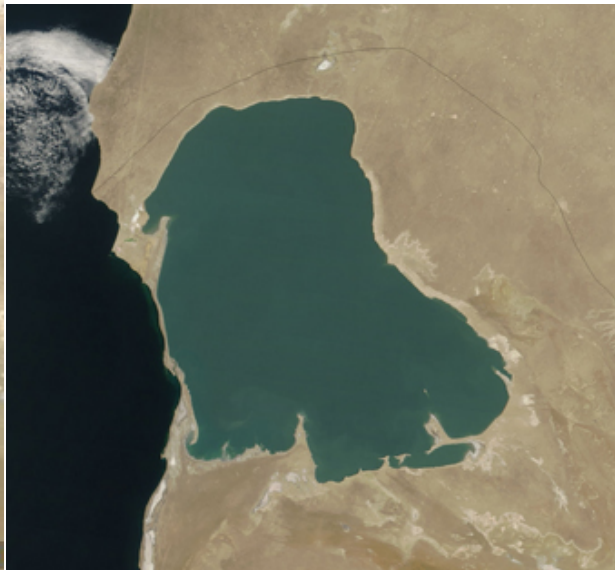


Landsat

- Aug-Sep 1998
- Source: UNEP
- <http://na.unep.net/>



- In phase 1 & 2 but poorly represented by GLWD
- Comparison of lake masks
 - Red = GLWD
 - Blue = ARC-Lake max.

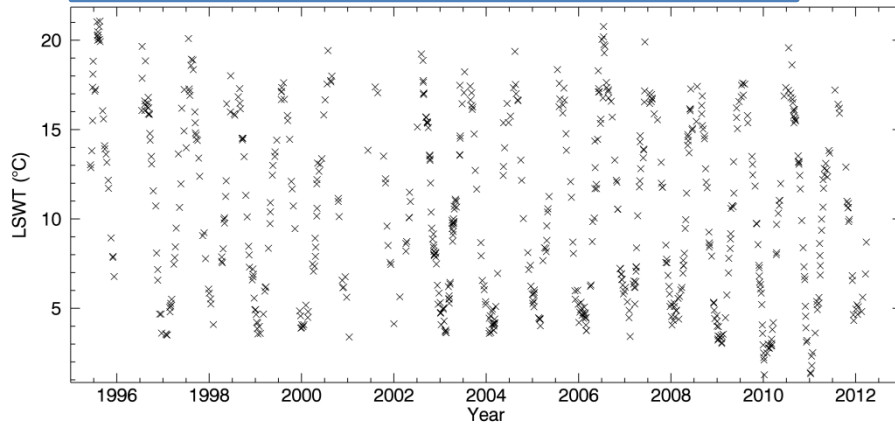


MODIS

- June 2006
- <http://visibleearth.nasa.gov/>

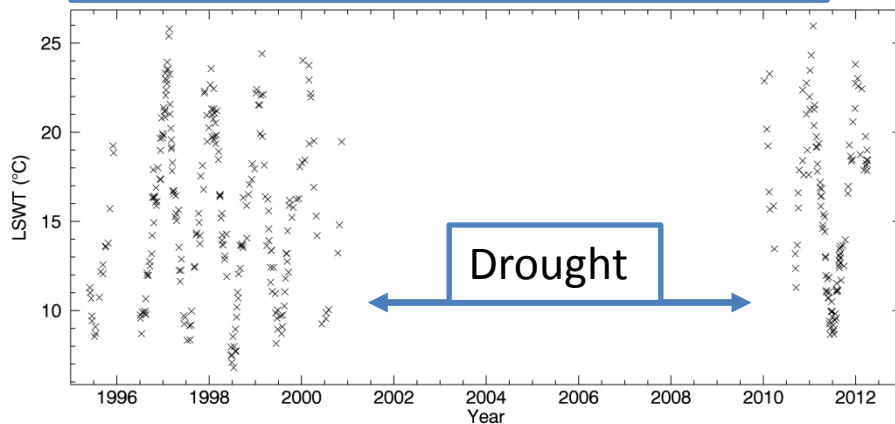
Imagery Date: 4/10/2013 lat 41.201006° lon 53.719581° elev -30 m Eye alt 161.27 km

Lough Neagh, N. Ireland (392 km²)

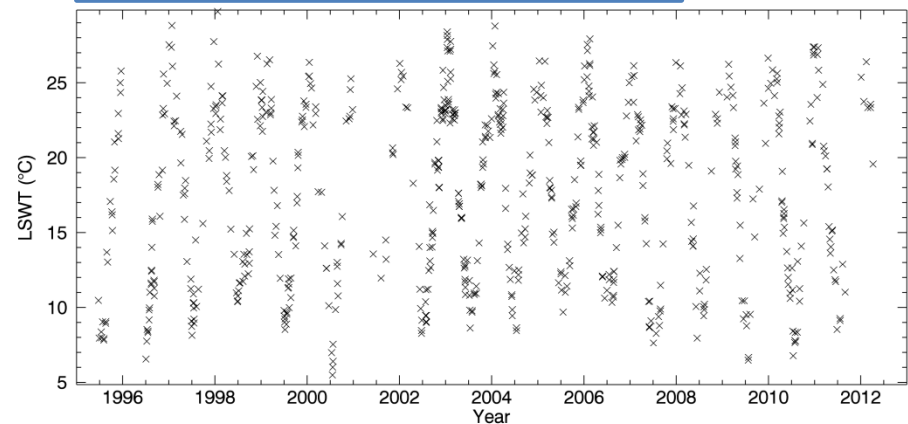


- Examples of combined ATSR-2/AATSR time-series
- LSWT for lakes as small as ~50 km²
- Monitor intermittent lakes

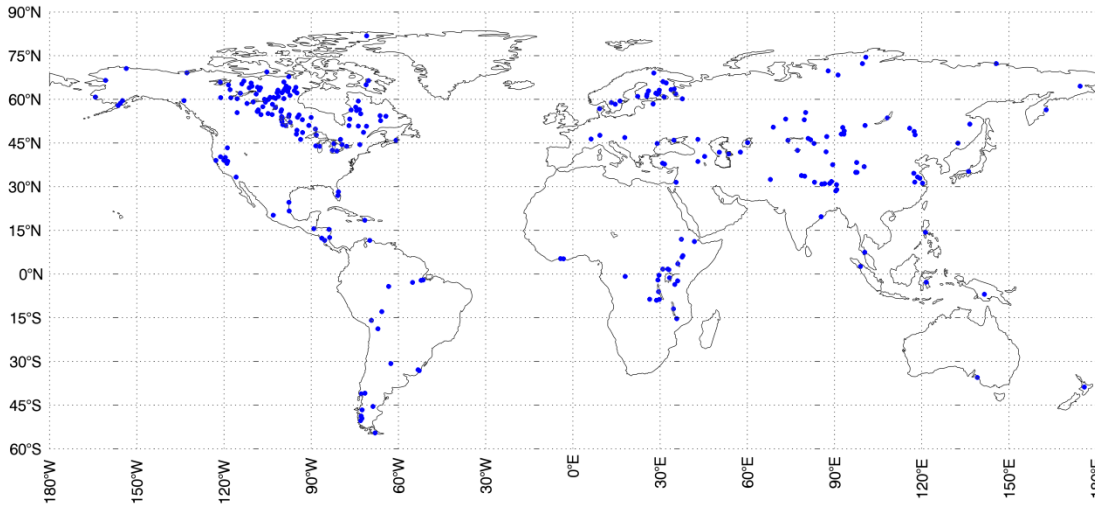
Lake Hindmarsh, Australia (130 km²)



ID=3218, Argentina (55 km²)

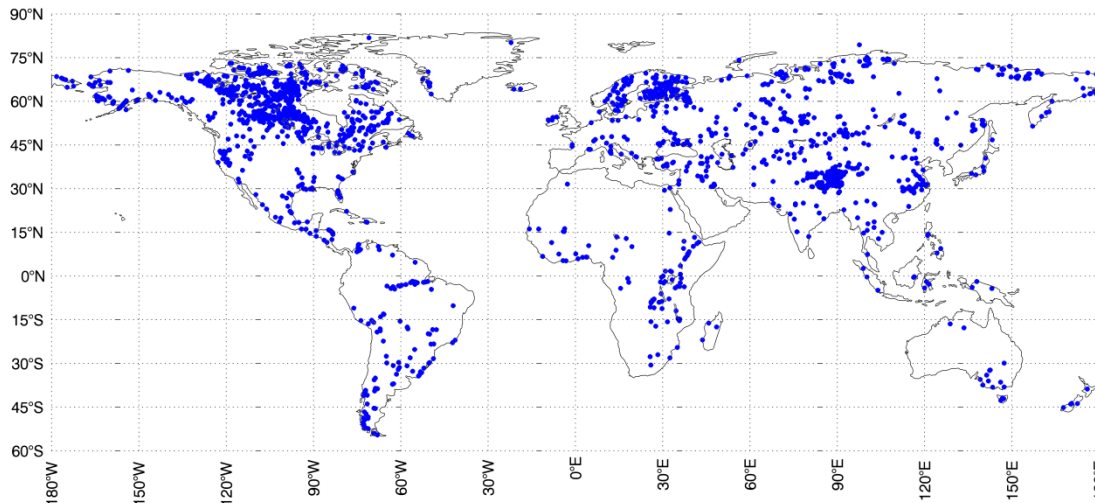


Phase-2 Targets: Initial (263)



Phase 1 and 2: 263 targets

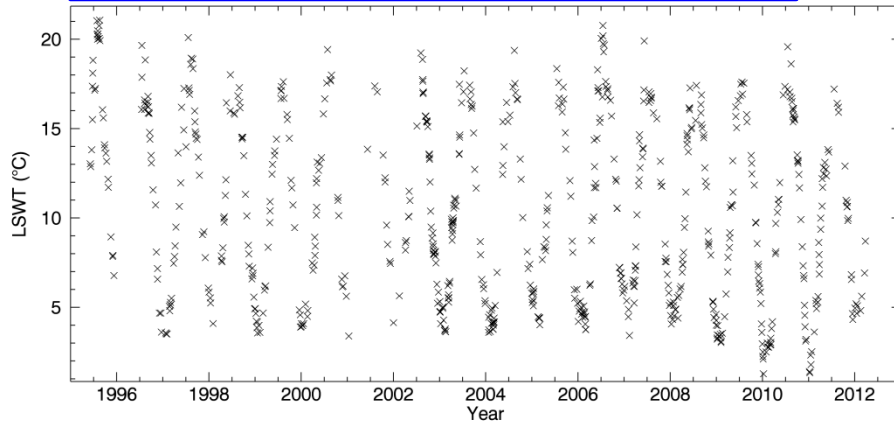
Phase-3 Targets: Initial (1628)



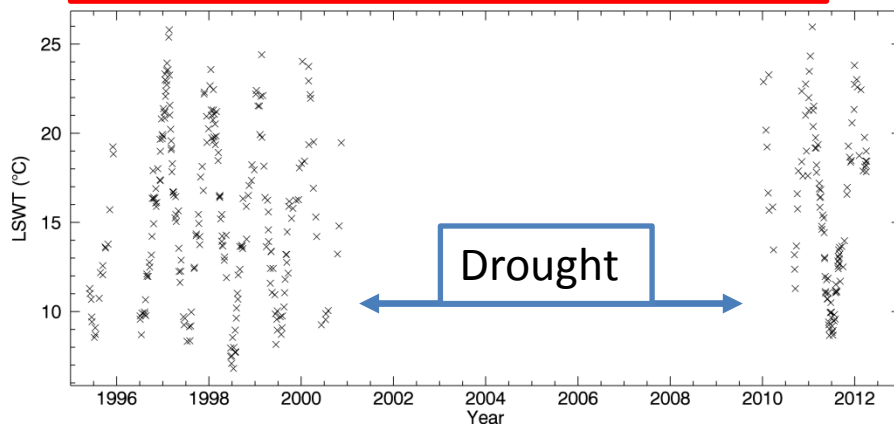
Phase 3: 1628 targets

- Improved global coverage
- Wider range of targets
 - Intermittent
 - Long term area trends
 - Reservoirs

Lough Neagh, N. Ireland (392 km²)

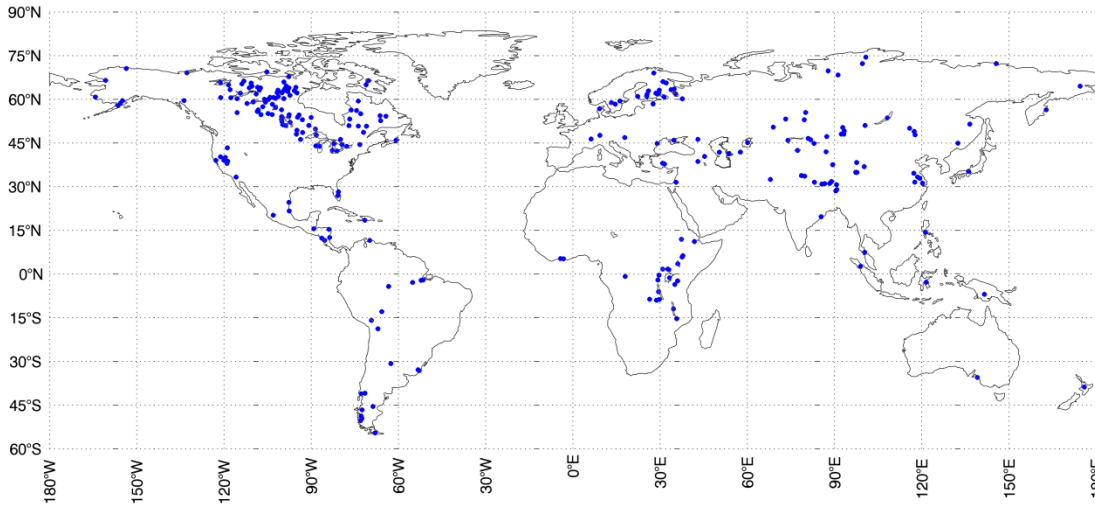


Lake Hindmarsh, Australia (130 km²)

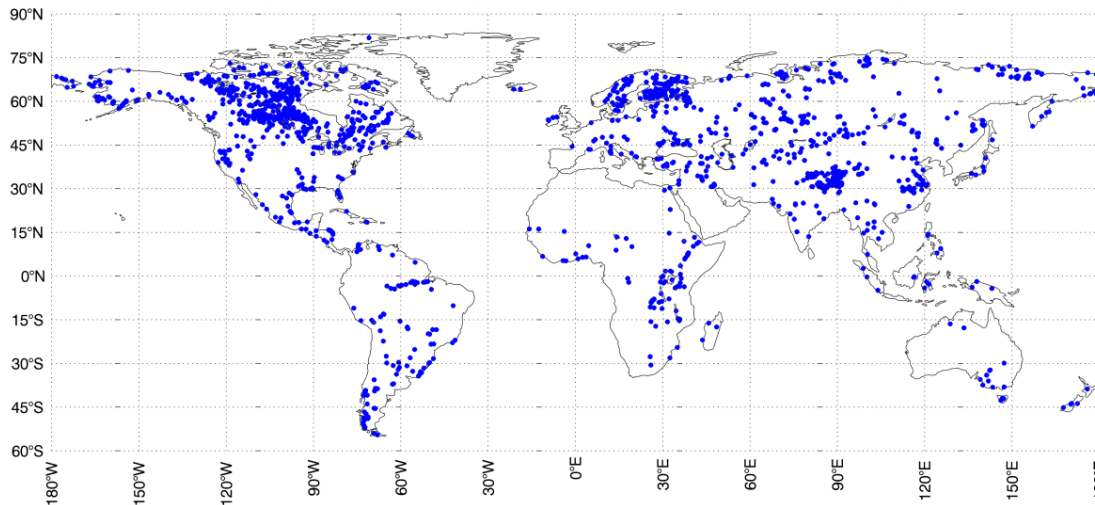


- 3 Classes
 - Time-series
 - Climatology
 - Excluded
- From temporal and spatial coverage criteria
 - Part of EOF-based reconstruction process
- Climatology class may still contain periods of “time-series” quality
 - e.g. Lake Hindmarsh

Phase-2 Targets: Time-series or climatology for at least one of ATSR2/AATSR and at least one of day/night (259)

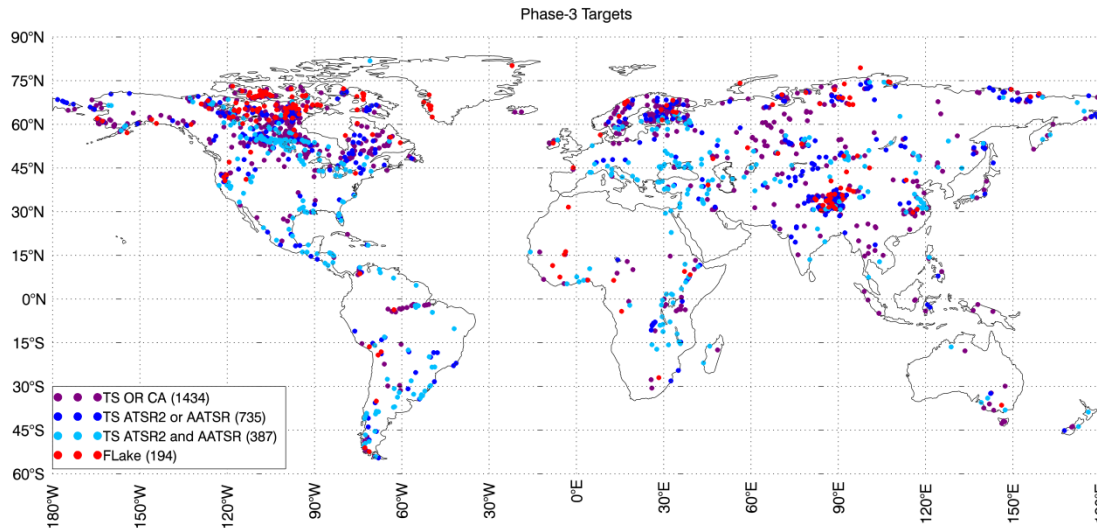
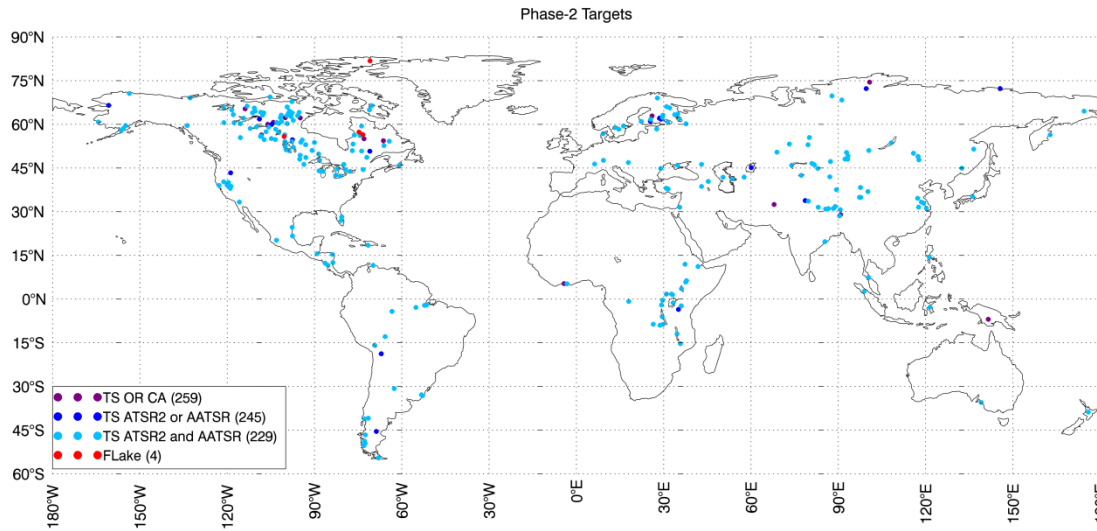


Phase-3 Targets: Time-series or climatology for at least one of ATSR2/AATSR and at least one of day/night (1434)



- Subset of targets where useful retrievals can be made
 - Phase-2 = 259
 - Phase-3 = 1434
- Minimum requirements of at least:
 - Climatology
 - One instrument
 - Day or night

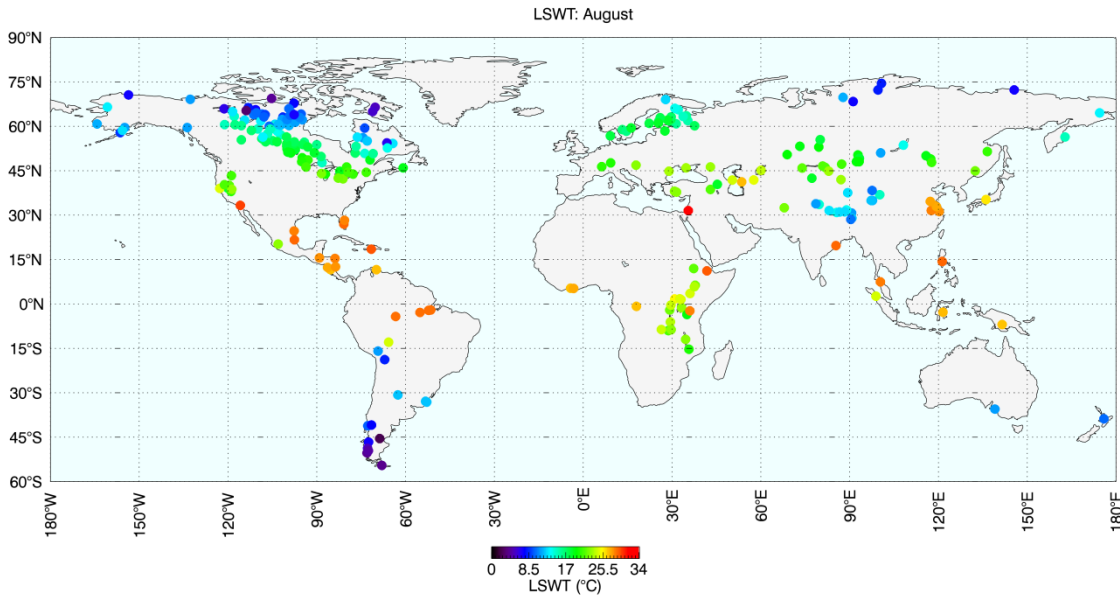
Targets



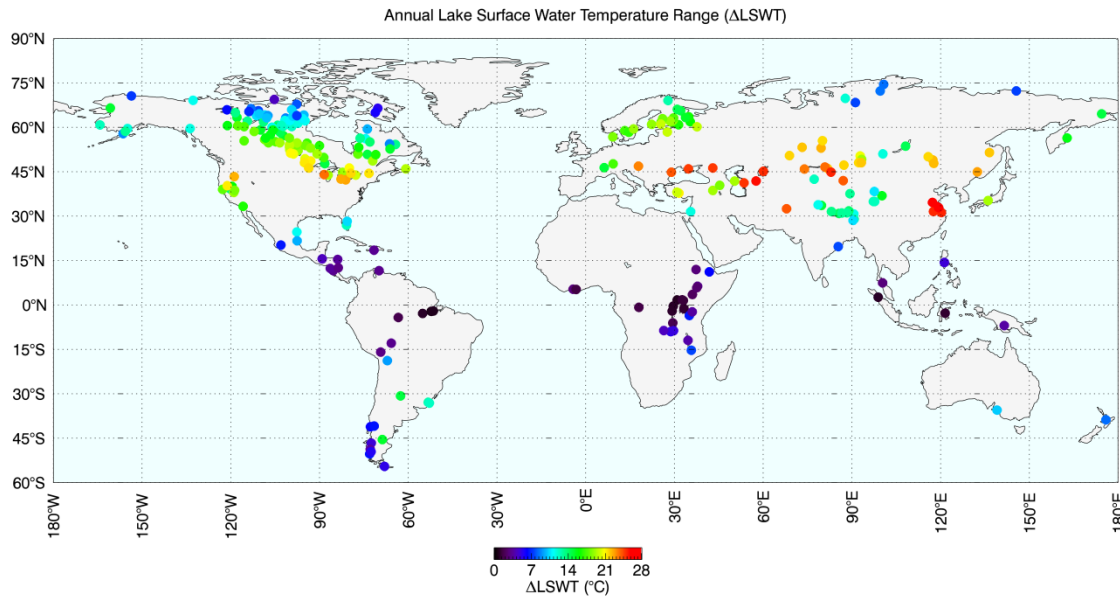
	ATSR2	AATSR
Ntimeseries	266	551
Nclimatology	828	686
Nmixed	132	173
NFlake	402	218

ATSR2/ AATSR	Day/ Night	Ntargets
TS Both	Both	253
TS Both	Either	387
TS Either	Either	735
TS/CA Both	Either	1202
TS/CA Either	Either	1434

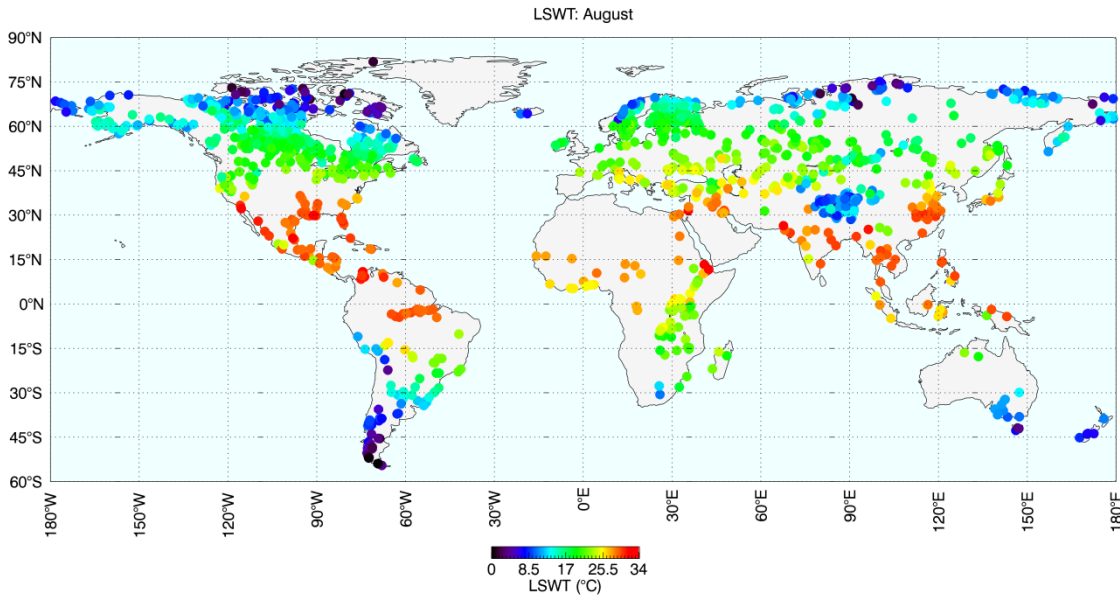
TS = Time-series
CA = Climatology



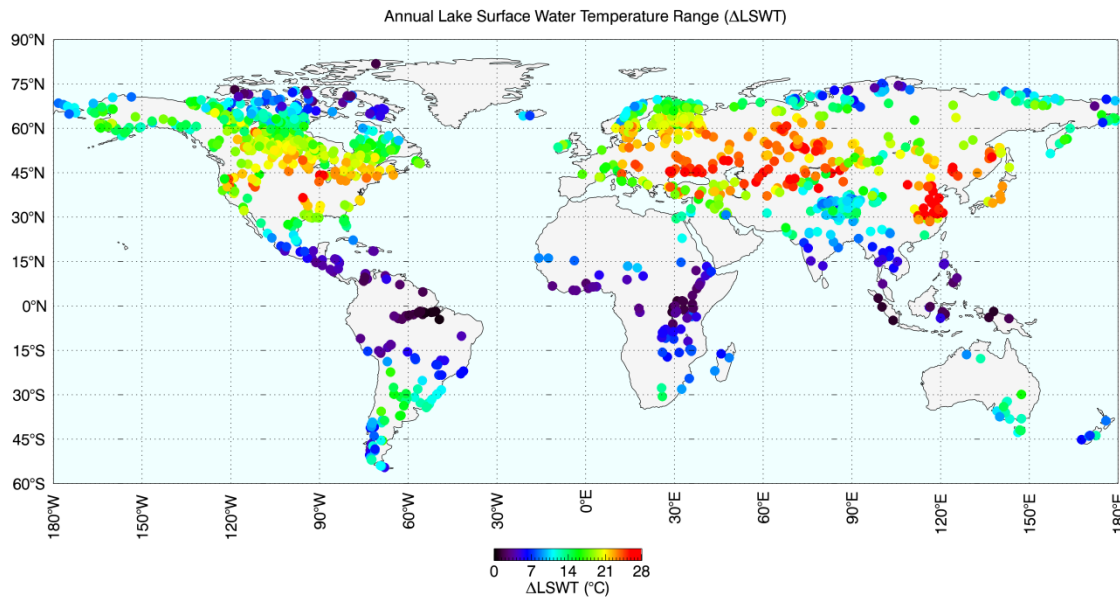
Mean August LSWT



Annual LSWT Range

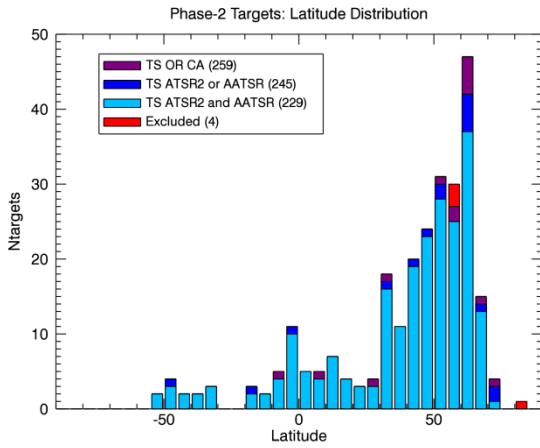


Mean August LSWT

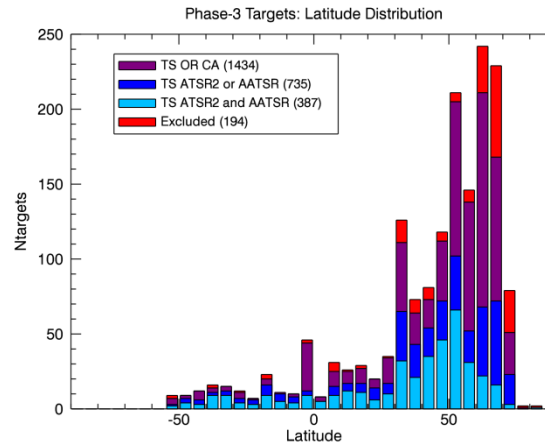


Annual LSWT Range

Phase-2

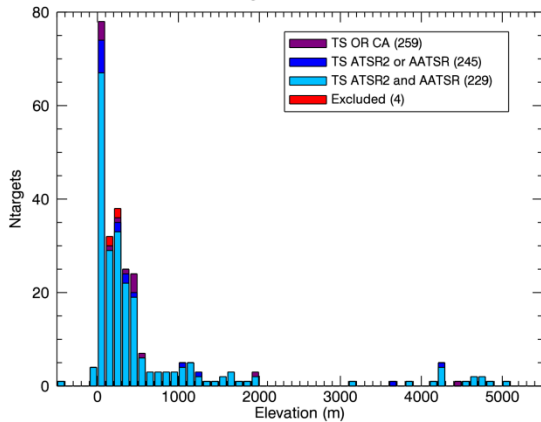


Phase-3

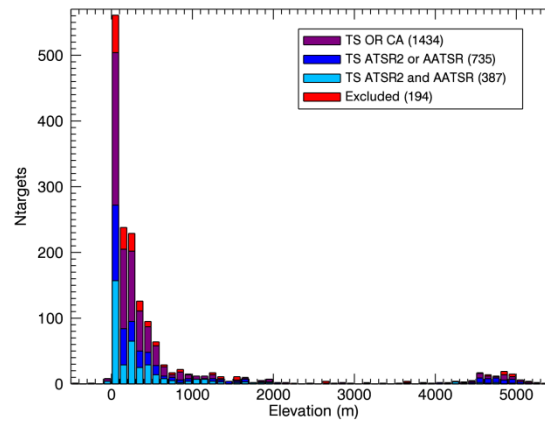


Latitude

Phase-2 Targets: Elevation Distribution

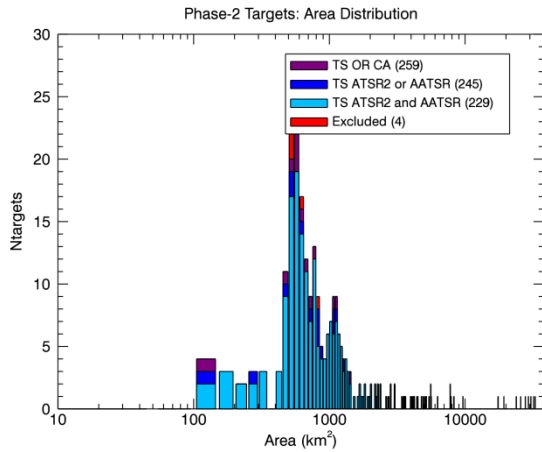


Phase-3 Targets: Elevation Distribution

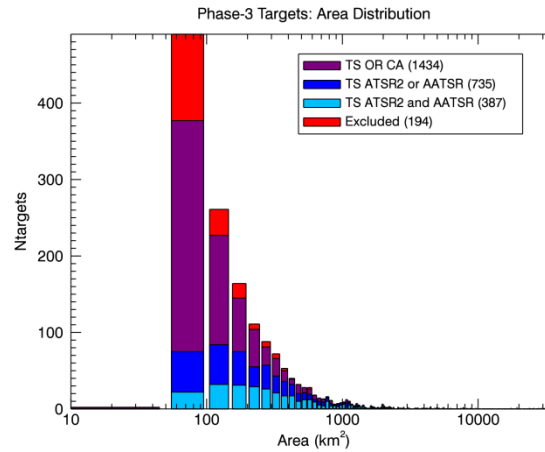


Elevation

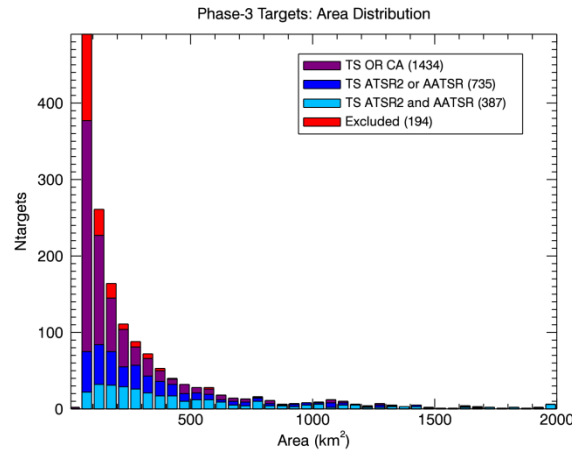
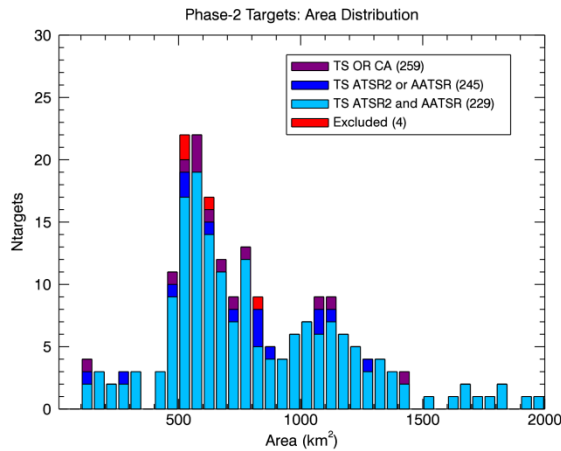
Phase-2



Phase-3



Area (all)



Area ($< 2000 \text{ km}^2$)

- v3.0 released on 23rd Oct 2013
- <http://www.geos.ed.ac.uk/arclake/>
- **1995-2012**
- **1628 targets**
- NetCDF
- LSWT + uncertainty, number of cloud, ice, water pixels in cell, etc
- **Max. area and annual min. area lake masks**
- **Limited database info for new lakes**

Attribute	Possible variants
Coverage	Per-lake / Global
Source	Observations / Reconstructions
Time	Day / Night
Spatial Resolution	0.05 degree grid / Lake-mean
Temporal Averaging	None / Climatology / Timeseries
Temporal Averaging Period	Seasonal / Monthly / Twice-monthly / Daily



- ARC-Lake methodology used to provide LSWT component
 - Extend time-series forward
 - Metop-AVHRR
 - Continuity from overlap with AATSR
 - PDRA position at the University of Reading
 - Starting March 2014
- New website coming...
 - www.laketemp.net
 - Replaces <http://www.geos.ed.ac.uk/arclake/>