Met Office

An operational analysis of lake surface water temperature (LSWT)

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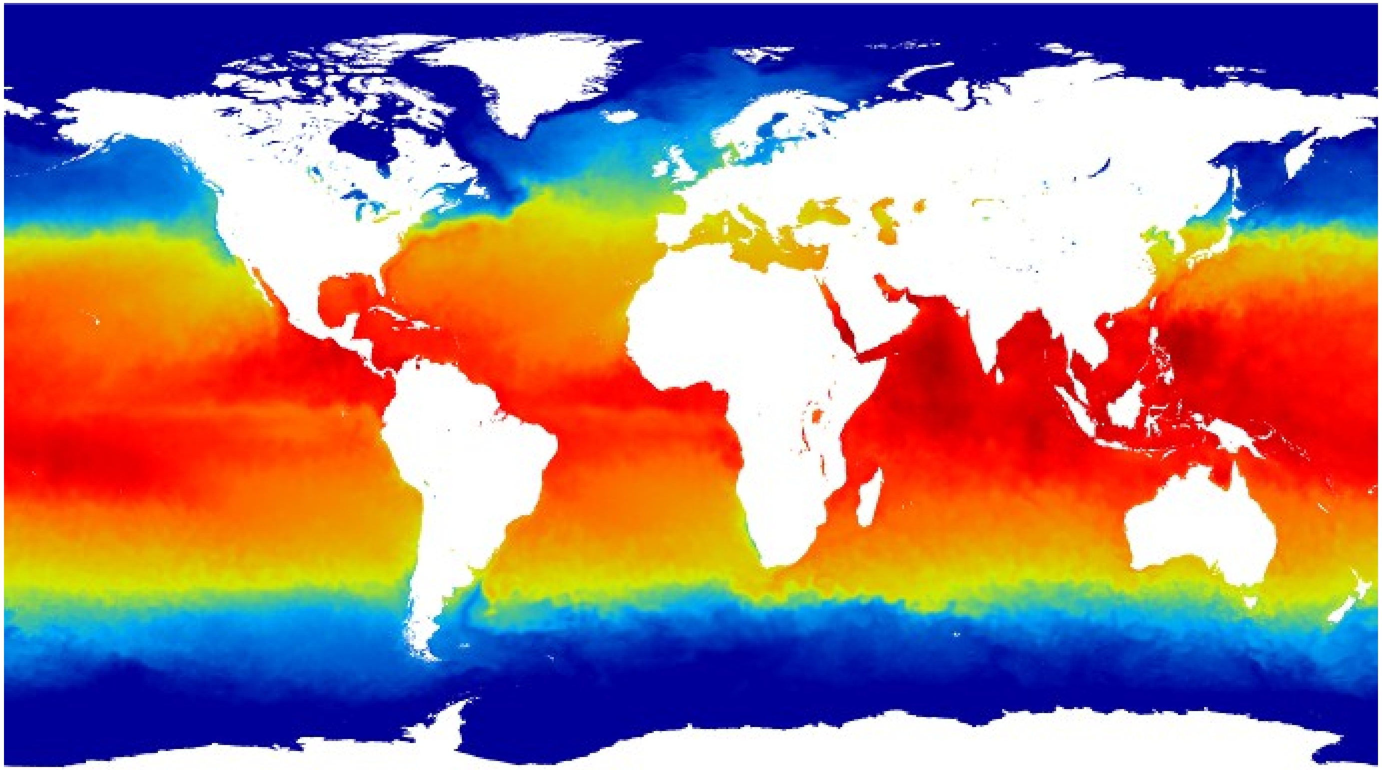
Overview

- Introduction
- LSWT observation types
- LSWT analysis method
- Operational output
- Validation of LSWT analysis
- Summary and future plans

Introduction

OSTIA: Operational Sea surface Temperature and sea Ice Analysis



24 May 2012

- Lake Surface Water Temperature (LSWT) was included in OSTIA in November 2011
- Part of daily SST field
- 1/20^{o}, foundation temperature
- Prior to this, Caspian Sea was only lake in OSTIA

Introduction

- Now have 248 lakes, >500 km^2 area, plus 10 extra
- Main users are NWP (boundary conditions)
- Important for regional models, e.g. Lake Victoria project

LSWT observations

LSWT data routinely available as part of IR satellite SST products used in OSTIA (MetOp and NOAA AVHRR, IASI, AATSR until recently)

LSWT data based on SST retrieval algorithms, no lake-specific processing

Cloud cover means number of observations over lakes is variable

Also in-situ data available through GTS, (Global Telecommunication System) mostly from North American Great Lakes (> 80%)

LSWT observations

Use of SST algorithms for LSWT introduces errors owing to:

- Cloud-clearing schemes optimised for oceans
- Elevation and continental location of lakes affects atmospheric thickness, water vapour column and aerosol corrections
- Surface emissivity (salinity dependent)

Also other errors:

- Sparse observations, especially in cloudy regions
- Coastal contamination

Currently the only NRT observations of lakes available

Background check performed before assimilation

LSWT analysis method

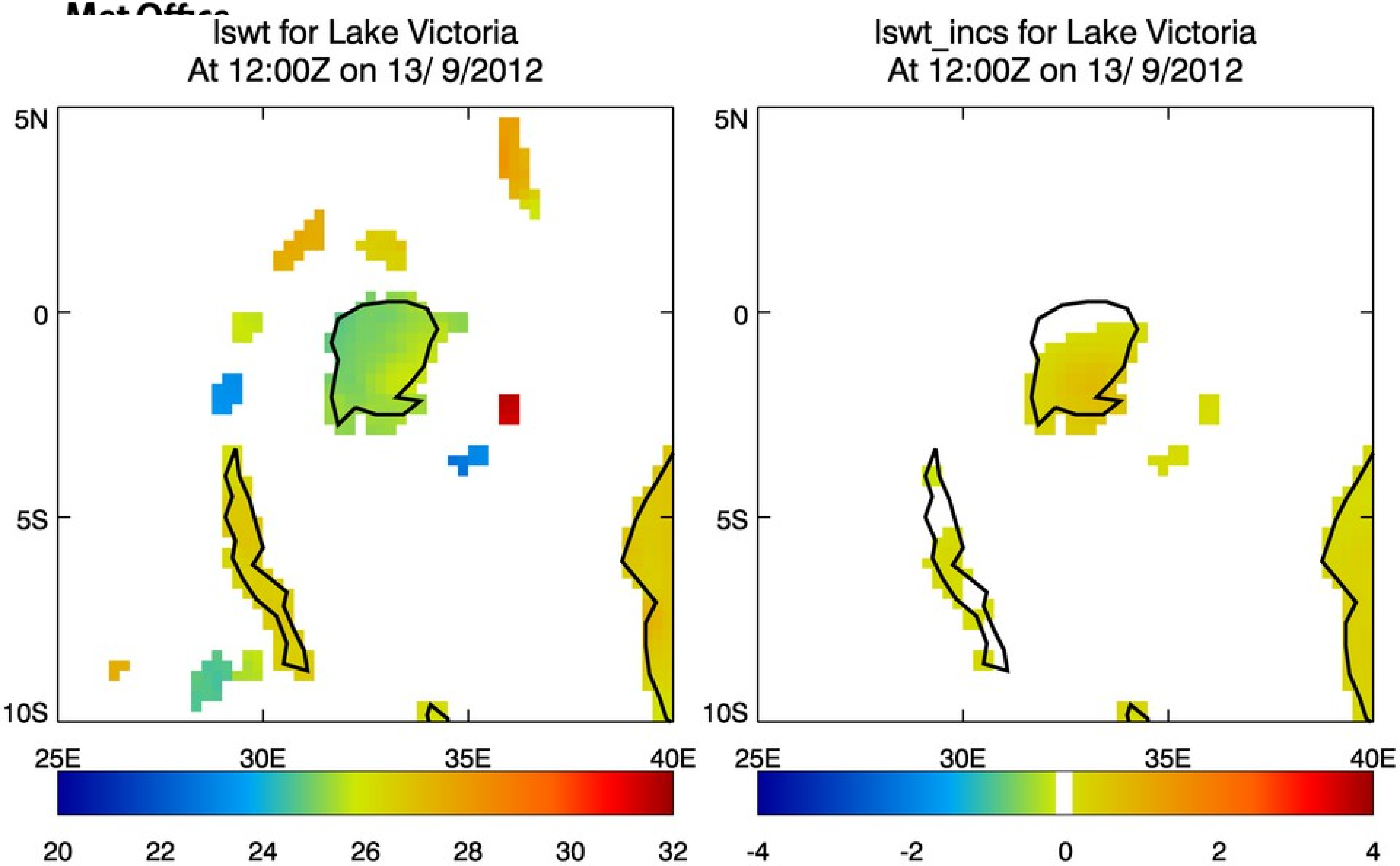
Same as SST analysis method:

- Optimal interpolation type scheme
- Background field is previous day's analysis with slight relaxation to climatology
- OSTIA reanalysis v1.0 climatology for SSTs, ARCLake nighttime climatology for lakes
- Bias correction to in-situ and soon MetOp AVHRR (was AATSR)

LSWT analysis method

- GHRSST observation errors supplied
- Error covariances, length scales not specific to lakes
- For foundation temperature, nighttime satellite data or ws > 6 m s^{-1} (skin effect)
- OSTIA analysis method not optimised for lakes
  – but produces reasonable results and is starting point for future development work

Operational output



Validation

ESA ARCLake LSWT retrievals (Univ. Edinburgh, MacCallum and Merchant, 2011) are best global satellite lake surface temperature observations available (we also use their land/lake mask)

- Lake-specific coefficients
- Cloud clearing scheme designed for lakes
- Salinity-dependent emissivity

Used as independent data to validate OSTIA LSWT

- OSTIA LSWT JJA 2009, using in situ, AATSR, MetOp AVHRR, NOAA-18 AVHRR LSWT observations
- Validation against nighttime ARCLake observations (AATSR)
- Independent from AATSR assimilated into OSTIA as different retrieval algorithm
- Note ARCLake is skin temp, OSTIA is foundation

Validation

Observation type	OSTIA-ARCobs Mean Error	OSTIA-ARCobs RMS Error	ARCclim-ARCobs Mean Error	ARCclim-ARCobs RMS Error	Mean Daily No. ARCobs
Global	0.65	1.31	0.00	1.78	4453
Great Lakes	1.41	1.78	0.45	2.13	822
Lake Victoria	0.40	0.44	0.08	0.29	137
Lake Baikal	1.83	2.76	1.21	2.11	140
Salton Sea	-0.13	1.45	-0.15	1.44	7
Lake Geneva	-0.06	0.63	1.00	1.67	2
Lake Constance	-0.06	1.02	0.95	1.87	1
Lake Tahoe	-0.46	0.83	0.28	0.82	2

Global accuracy 1.31 K

Bias includes cool skin effect of 0.2 K, but could still be improved

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Generally, RMS error for OSTIA – ARCLake obs better (lower) than ARCLake climatology – ARCLake obs

Demonstrates OSTIA more accurate than climatology overall

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Threshold global accuracy requirement of LSWT analysis 0.8 K RMS (target 0.5 K), same as SST. 1.31 K does not meet this, but use of analysis improvement over climatology

Use of retrieval algorithms and analysis techniques optimised for SST means accuracy of LSWT analysis poorer than for SST (0.55 K), as expected

Relationships to lake parameters

Lake metadata collated by ARCLake project (thanks to Stuart MacCallum for providing data)

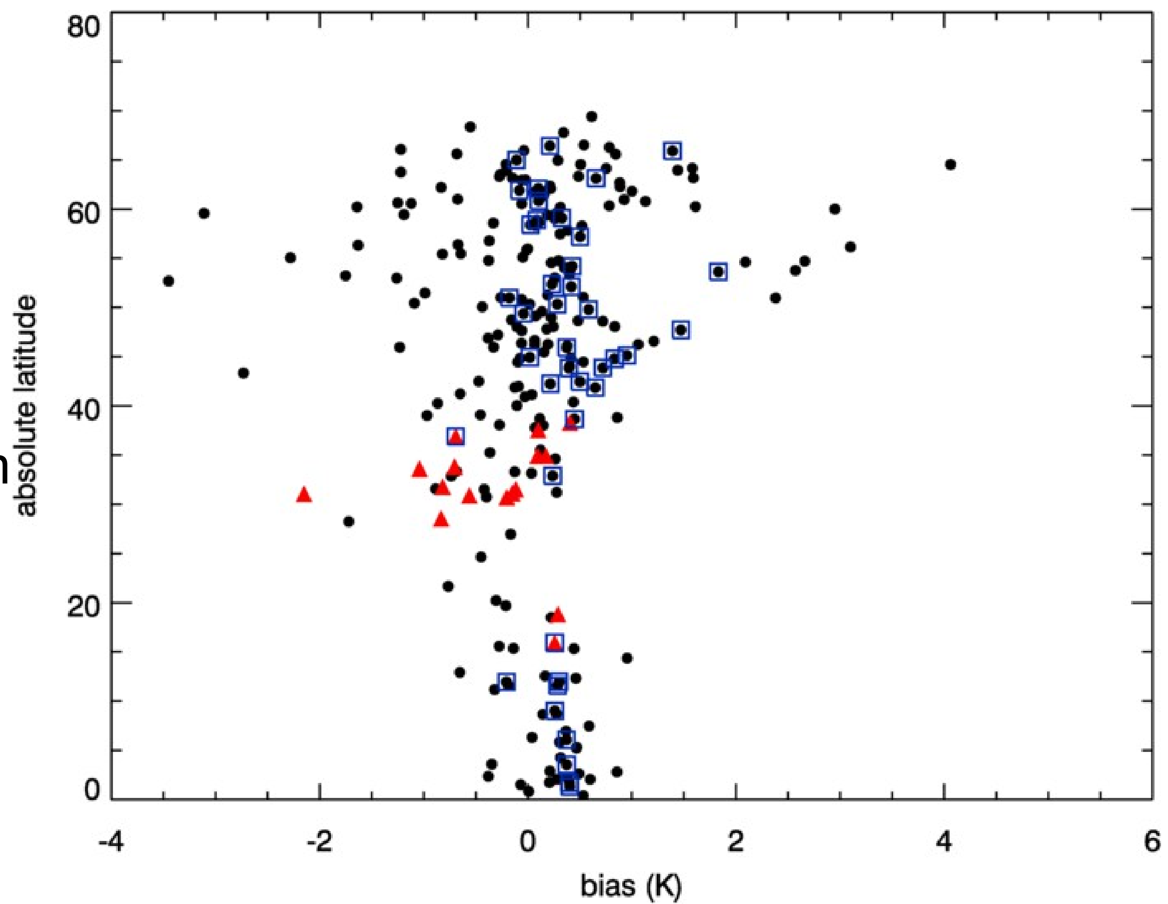
OSTIA LSWT analysis minus ARCLake nighttime observations, JJA 2009 average, with absolute latitude (disregarding hemisphere)

Each point represents a lake

red triangle=elevation >2500 m

black dot=elevation<=2500 m

blue square=surface area also >3000 km^2



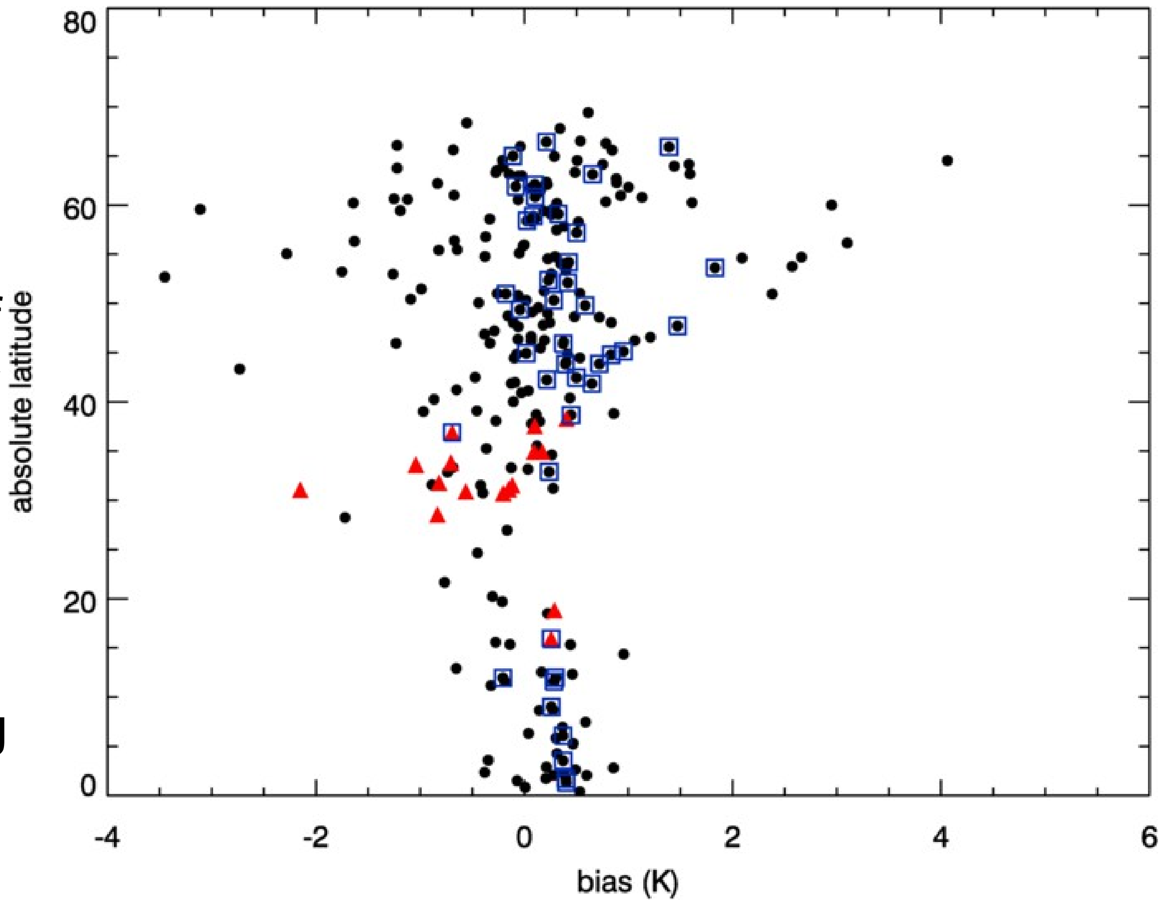
Relationships to lake parameters

Large lakes at elevations closer to sea level expected to give best results

Here they have a positive bias

Higher altitude lakes likely to have a negative bias (mean of bias is statistically significantly different to low elevations at 0.05 level)

LSWT for higher altitude, smaller lakes may have compensating errors, reducing the bias



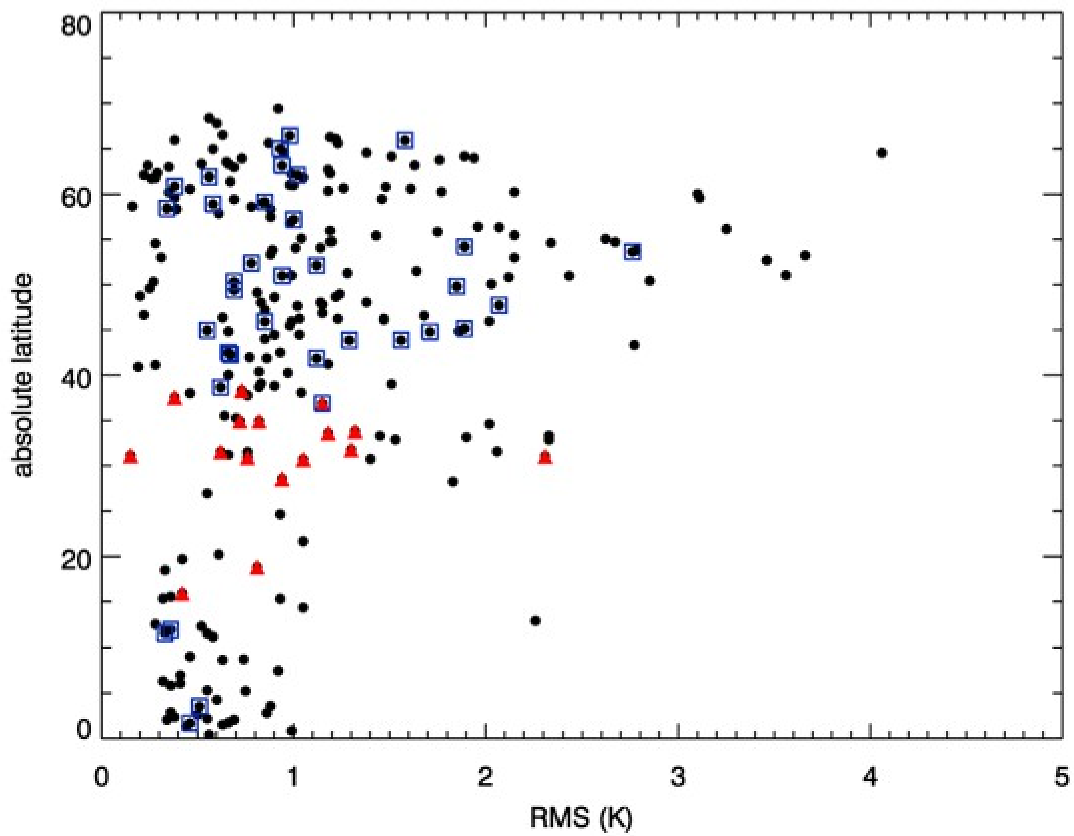
Relationships to lake parameters

Statistically significant difference between RMS of lakes with latitudes above 30° (1.41 K) and below 30° (0.74 K) (not found for bias)

Lakes at latitudes below 30° have smaller annual temperature cycle, easier to capture variability in analysis

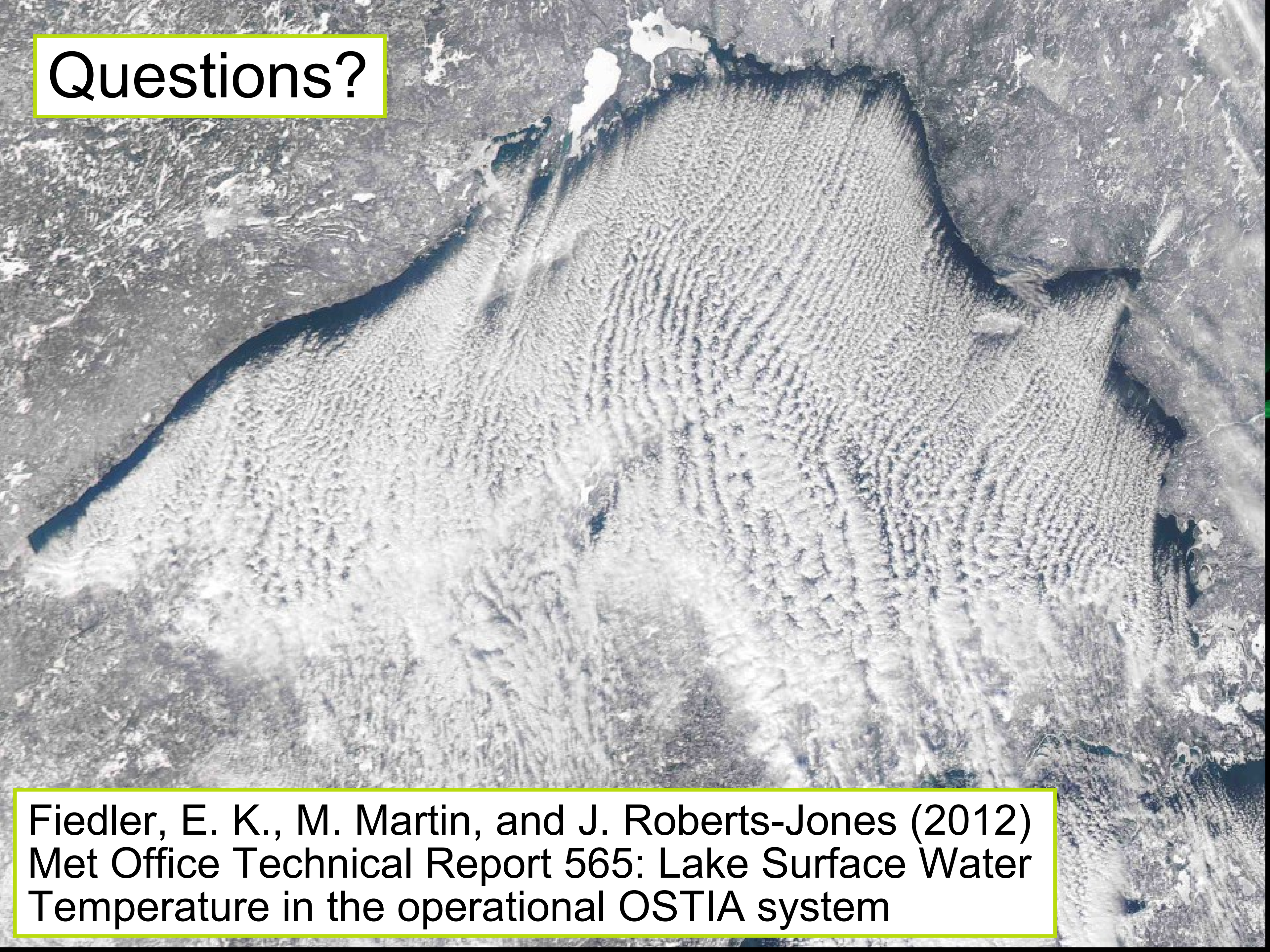
Little obvious relationship between RMS error with lake area and elevation

No relationships found with lake depth and volume



Summary and Future Plans

- LSWT included in operational OSTIA product for 248 lakes
- LSWT analysis produced in same way as SST analysis
- Bias in OSTIA LSWT can depend on lake area and elevation, RMS on latitude
- Global accuracy of OSTIA LSWT for JJA 2009 against independent observations (ARCLake), RMS error 1.31 K, bias 0.65 K (OSTIA minus ARCLake, including skin-bulk error of ~0.2 K)
- OSTIA LSWT improvement over use of climatology to capture day-to-day variation in global lake temperatures
- Plans for lake ice to be operational in March 2013 as part of OSTIA
    - ice mask and relaxation to freezing
    - combination of NCEP ice concentration product and LSWT thresholds


Questions?
Fiedler, E. K., M. Martin, and J. Roberts-Jones (2012)
Met Office Technical Report 565: Lake Surface Water
Temperature in the operational OSTIA system