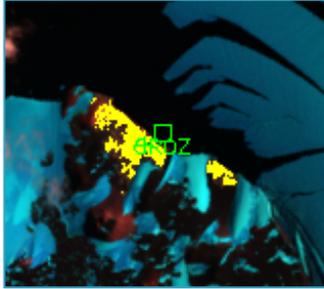
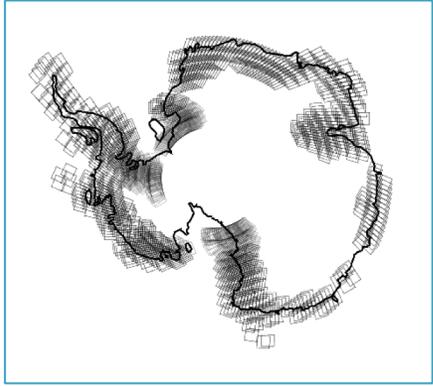




Bayesian data-model synthesis for
biological conservation and management
in Antarctica

Heather J. Lynch, Mathew Schwaller
Christian Che-Castaldo

Stony Brook University Ecology & Evolution



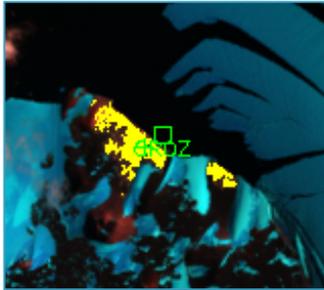
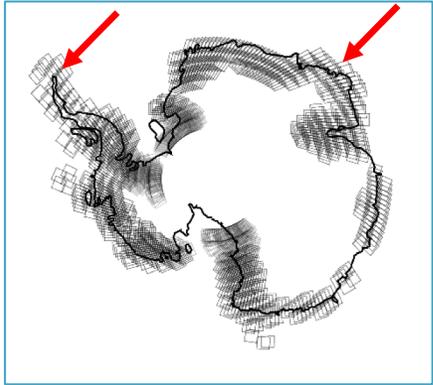
1 – Algorithm development & improvement:

Develop algorithms to identify penguins and seabirds over the entire continent of Antarctica.

(Landsat & Sub-meter commercial)

Danger Islands

Mt. Biscoe



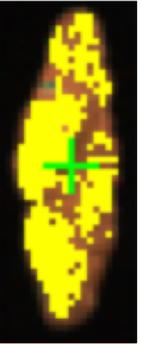
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Image redacted

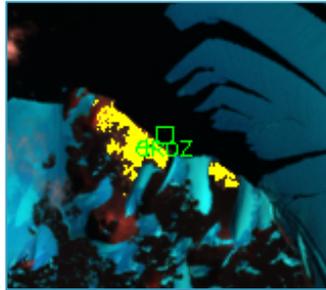
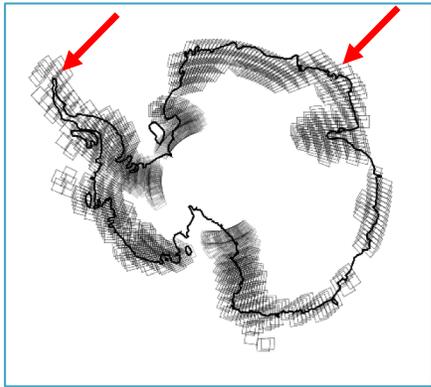


Brash Island
(Danger Islands)

2 – Discovery: Discovered several penguin and petrel “mega-colonies” from Landsat images revealing their pinkish guano. Reshaping our understanding of seabird biogeography.

> 1 million penguins discovered by Landsat

Danger Islands Mt. Bischoe



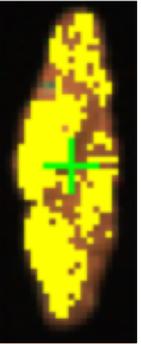
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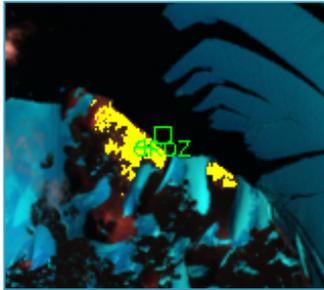
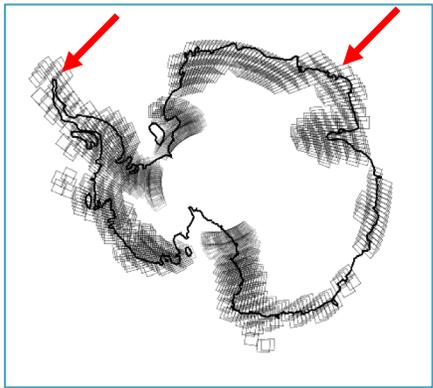
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Credit: NBC

Danger Islands Mt. Biscoe



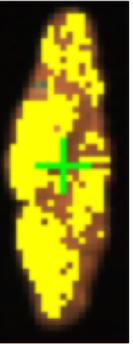
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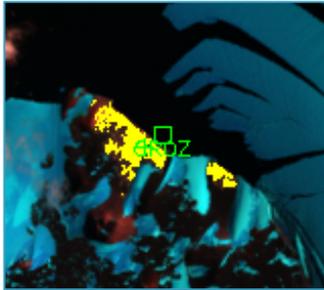
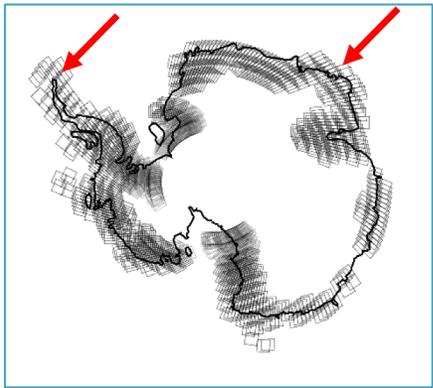
BEFORE DISCOVERY



AFTER DISCOVERY

3 – Influencing management: Danger Islands colonies were not considered high priority (blue shading) for conservation but proposed MPA has been expanded (pink polygons) by ~ 2 million ha as a direct result of discoveries made using Landsat imagery under NASA funding. *Maps taken from actual policy document being prepared by Argentina for the Antarctic Treaty Consultative Meeting.*

Danger Islands Mt. Biscoe



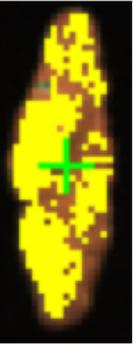
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Brash Island (Danger Islands)

> 1 million penguins discovered by Landsat



4 – Ground validation:

Landsat-enabled exploration of previously unsurveyed territory.



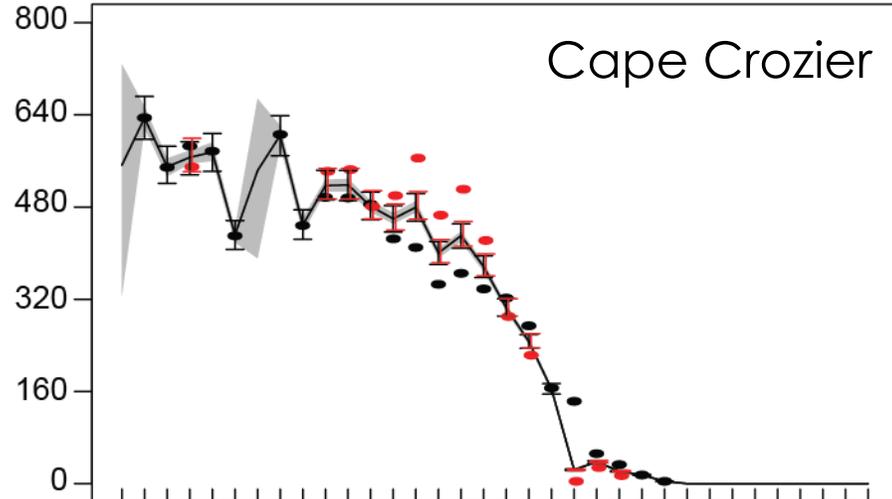
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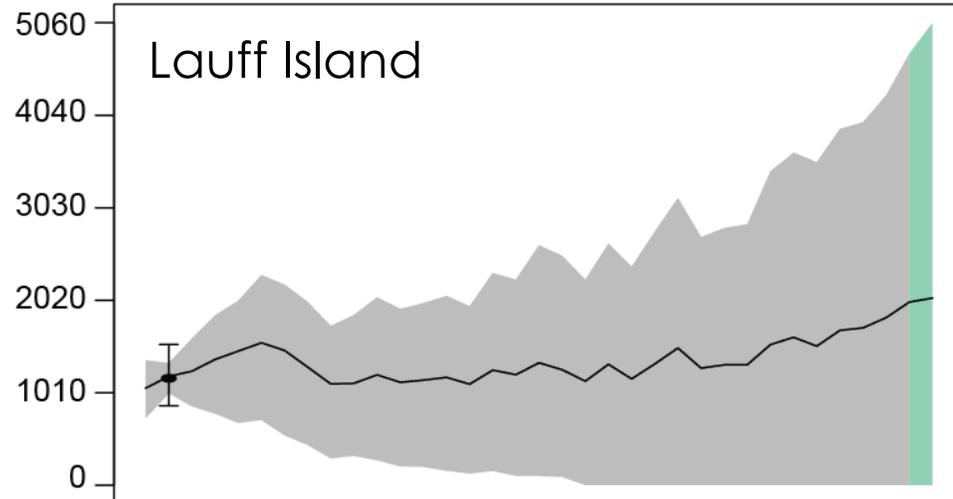
Credit: Thomas Sayre-McCord (WHOI)

At the site level

Data-rich sites



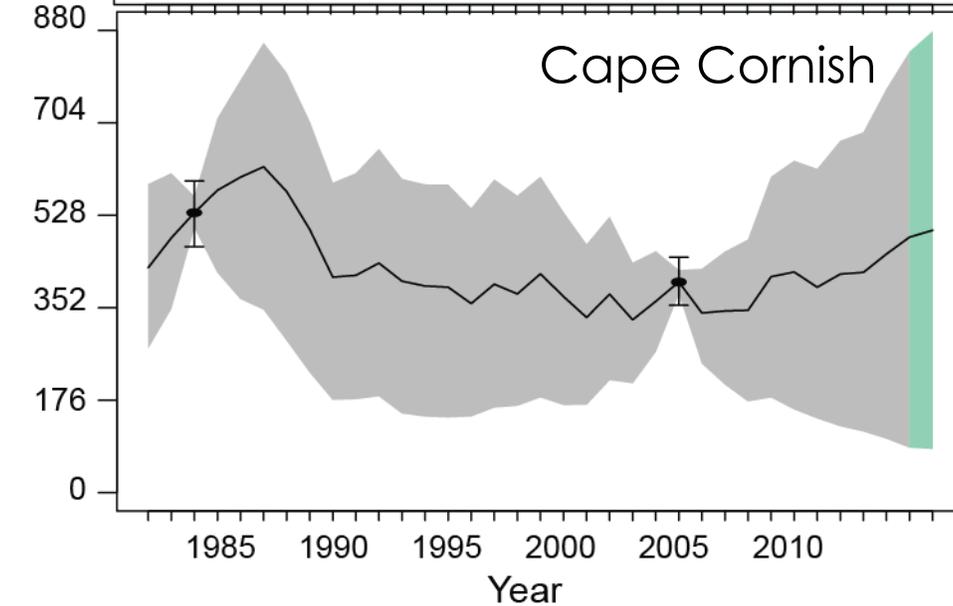
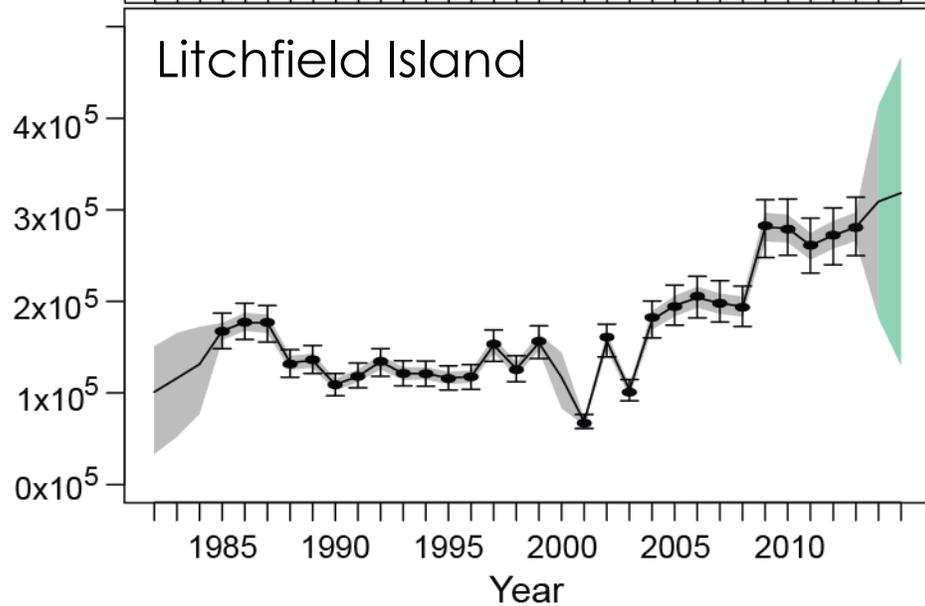
Data-poor sites



How does the model infer abundance when there is no data?

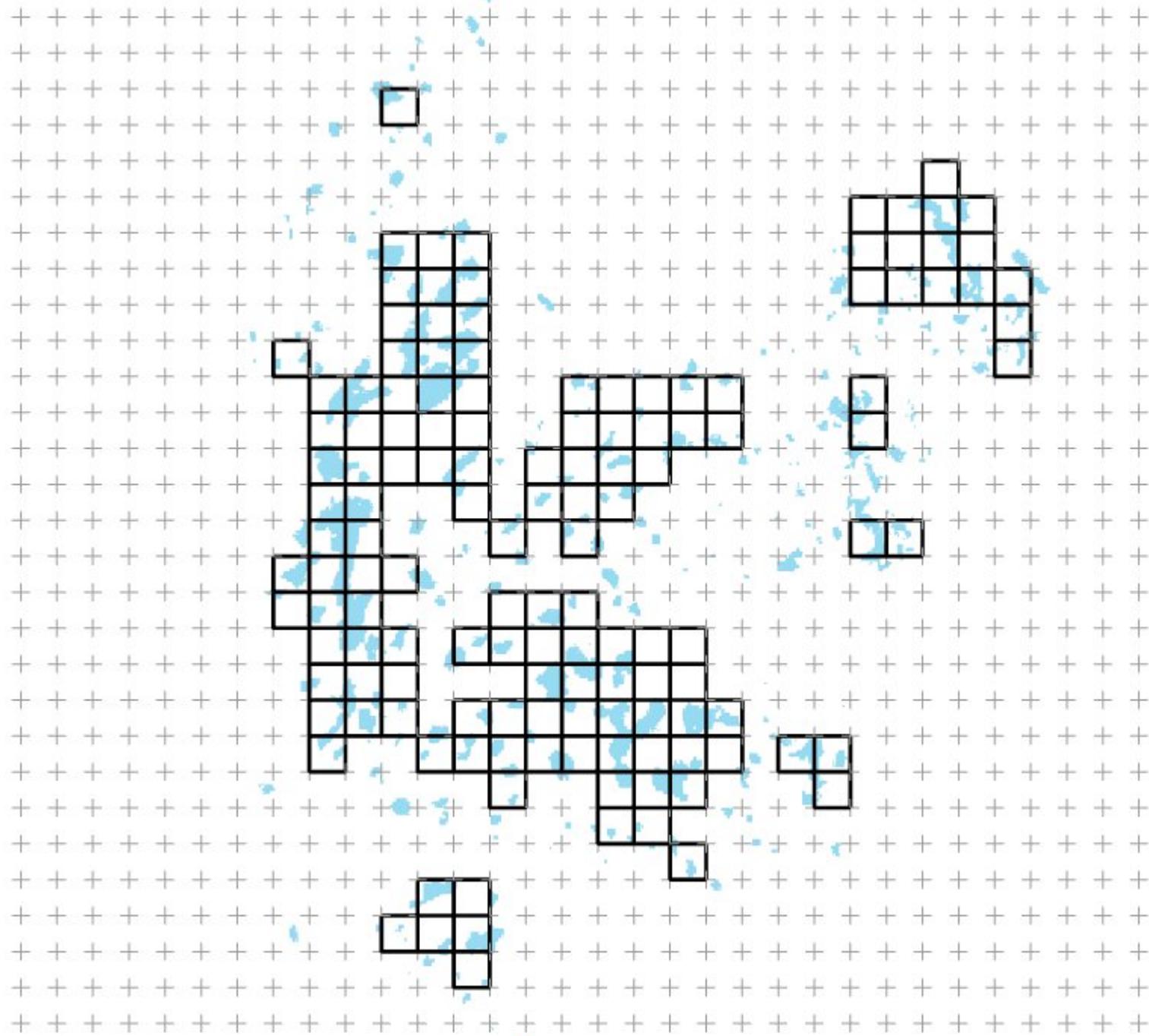
Shared covariates allow for a 'best-guess' in years with missing data.

...but still, uncertainty is huge between surveys



Est. from nest counts in black

Est. from chick counts in red



□ Landsat pixel identified as “guano” class

High-res guano patch

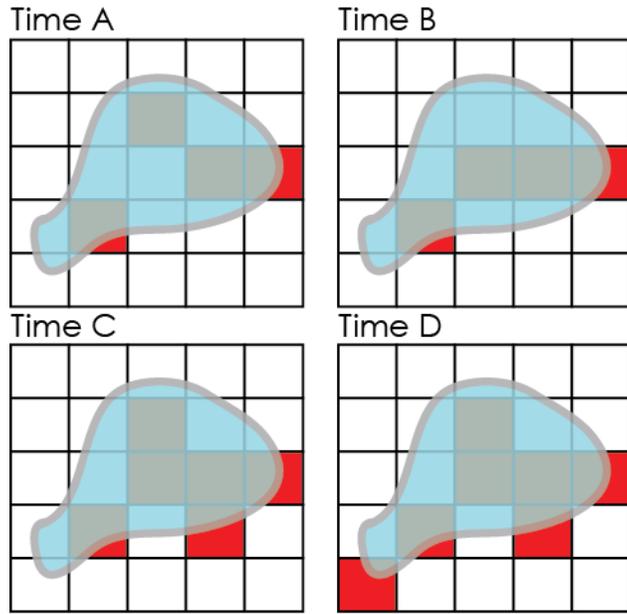
↕ 30 m

Using:

- Landsat-4
- Landsat-5
- Landsat-7 (incl. SLC error era)
- Landsat-8

Using the guano stain to georegister imagery but this will not be required starting with Landsat-8.

High-res guano patch



number of times a pixel is flagged as "guano" class

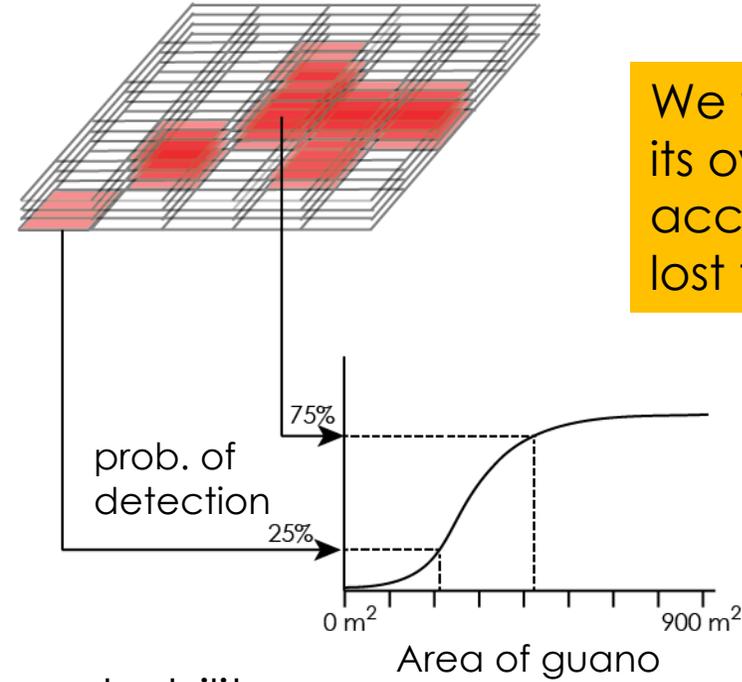
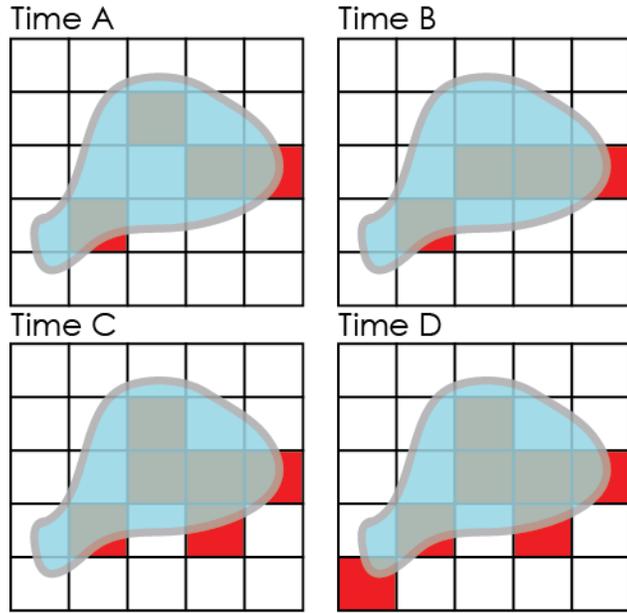
number of cloud-free Landsat repeats

probability of detection

$$Y_i \sim \text{Binom}(n_i, p(\text{fraction covered}_i))$$

$$\text{logit}(p(\text{fraction covered}_i)) = \beta_0 + \beta_1 * \text{fraction covered}$$

High-res guano patch

We treat each pixel as its own stack; easily accommodates pixels lost to SLC error

number of times a pixel is flagged as "guano" class

number of cloud-free Landsat repeats

probability of detection

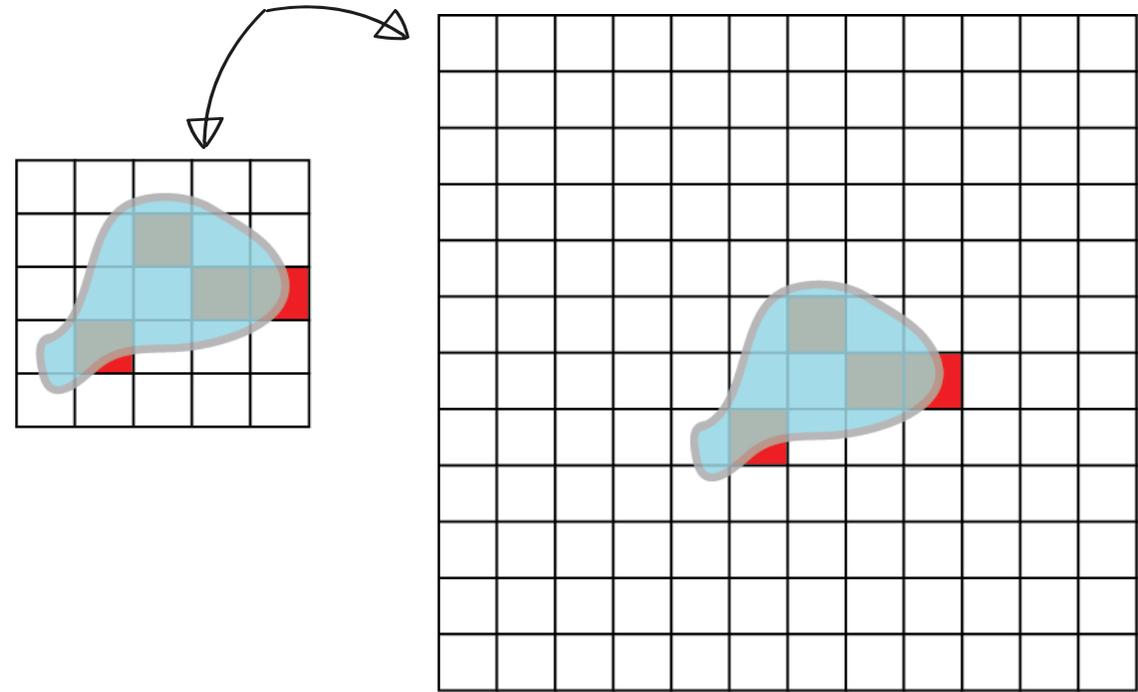
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these two scenarios yield different abundance estimates

One caveat: Total estimated abundance depends on the area of interest

Why? Because even areas that have never been classified as guano will have some non-zero detection probability



To the rescue:
A new Landsat-8
based bare rock layer

An automated methodology for differentiating rock from snow, clouds and sea in Antarctica from Landsat 8 imagery: a new rock outcrop map and area estimation for the entire Antarctic continent

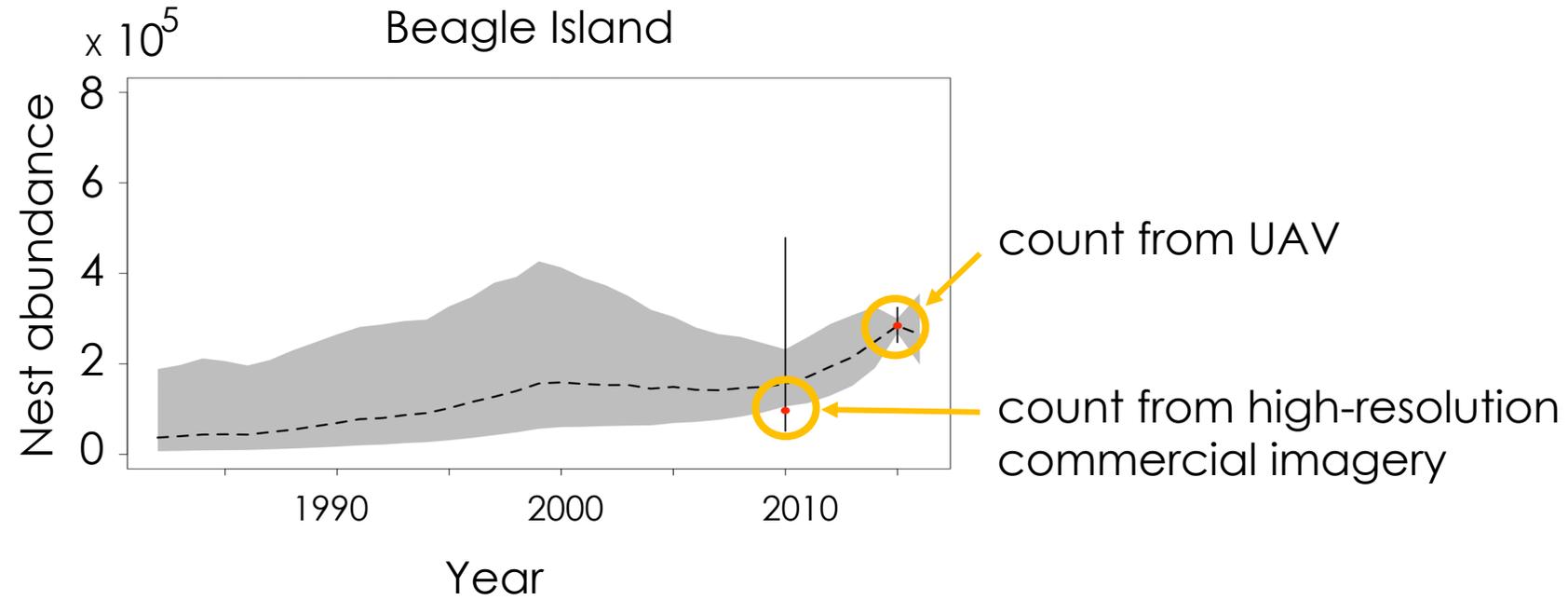
Alex Burton-Johnson¹, Martin Black^{1,2}, Peter T. Fretwell¹, and Joseph Kaluza-Gilbert³

¹British Antarctic Survey, Cambridge, CB3 0ET, UK

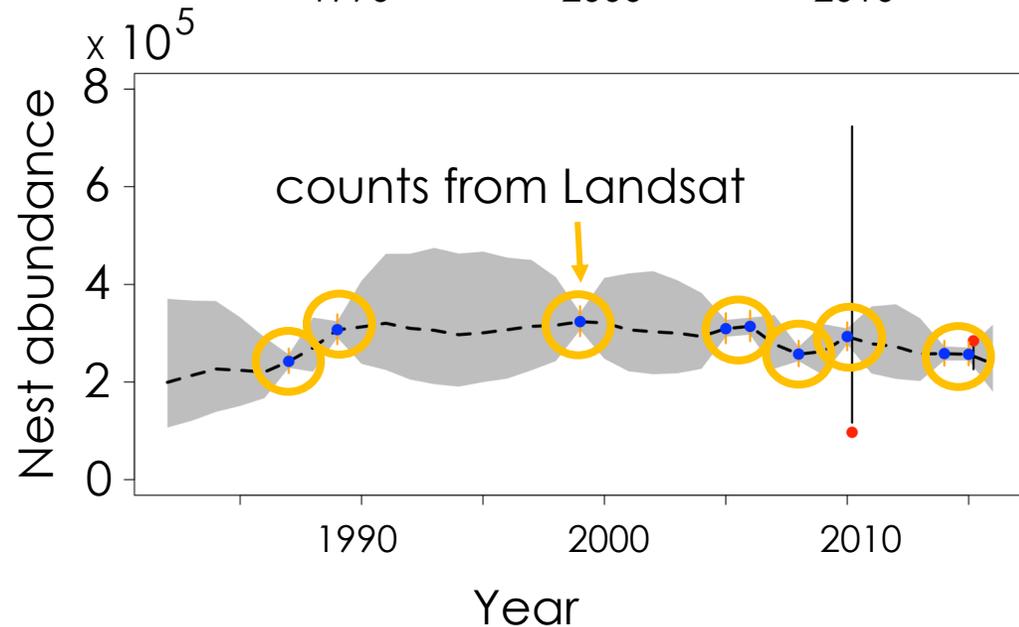
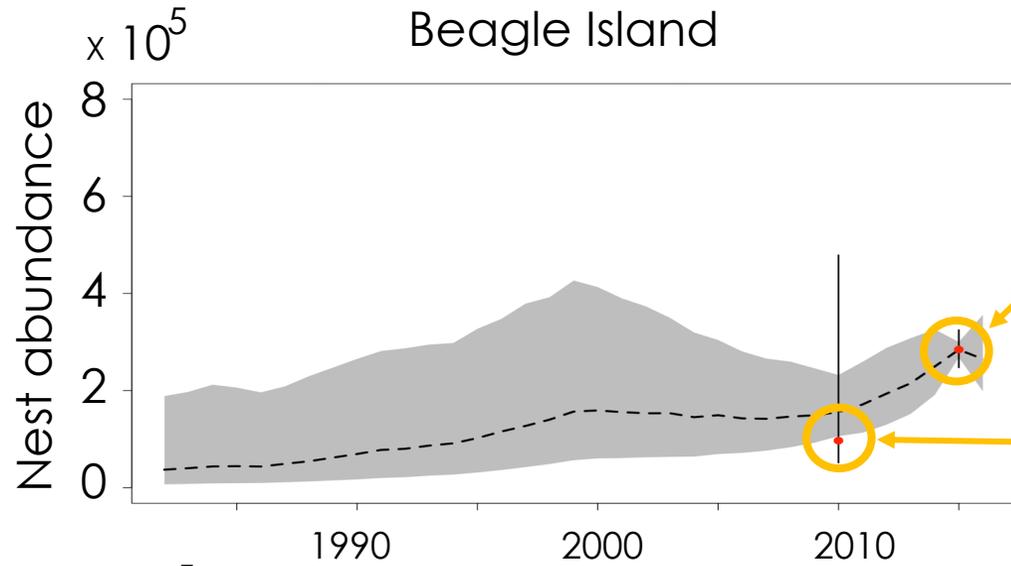
²Department of Geography, Environment and Earth Sciences, University of Hull, Hull, HU6 7RX, UK

³School of Geography, Earth and Environmental Sciences, University of Birmingham, Birmingham, B15 2TT, UK

Does the integration of Landsat-based estimates improve model results? Yes!



Does the integration of Landsat-based estimates improve model results? Yes!



Our integration of the (statistically-downscaled) Landsat-derived abundance estimates radically changes our understanding of long-term trend and narrows our uncertainty on historical abundance.

* High resolution commercial satellite imagery not always better

MAPPPD retrospective

Successes:

- Created **reproducible workflows** for Landsat imagery interpretation
- Developed time series models that **incorporate multiple data types**
- Moved towards **open-source community development** of models that can be incorporated into ensemble model forecasts of abundance
- Created a decision support tool that is actively being used within the stakeholder community

MAPPPD retrospective

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Challenges/Open questions/Future directions:

- Automated image interpretation of high-resolution satellite imagery

Convolutional Neural Networks

Image
redacted



Input Image

Image
redacted

Ground Truth

Image
redacted

Prediction

Image
redacted



MAPPPD retrospective

Successes:

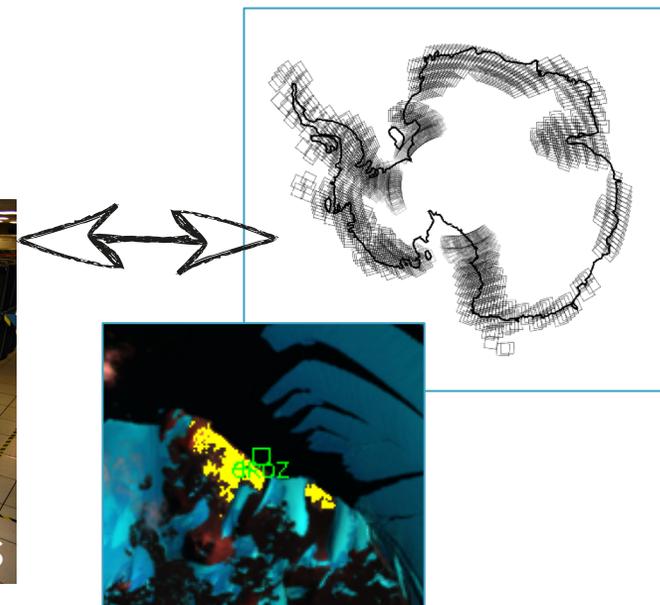
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Challenges/Open questions/Future directions:

- Automated image interpretation of high-resolution satellite imagery
- High-performance and high-throughput computing bottlenecks

↑
CNNs require GPUs

↑
Required to scale



ICEBERG: Imagery Cyberinfrastructure and Extensible Building Blocks to Enhance Research in the Geosciences

Heather Lynch (Stony Brook University)

Shantenu Jha (Department of Electrical and Computer Engineering, Rutgers University)

Vena Chu (Department of Geography, University of California Santa Barbara)

Mike Willis (Department of Geological Sciences, University of Colorado Boulder)

Mark Salvatore (Department of Physics and Astronomy, Northern Arizona University)



Stony Brook University

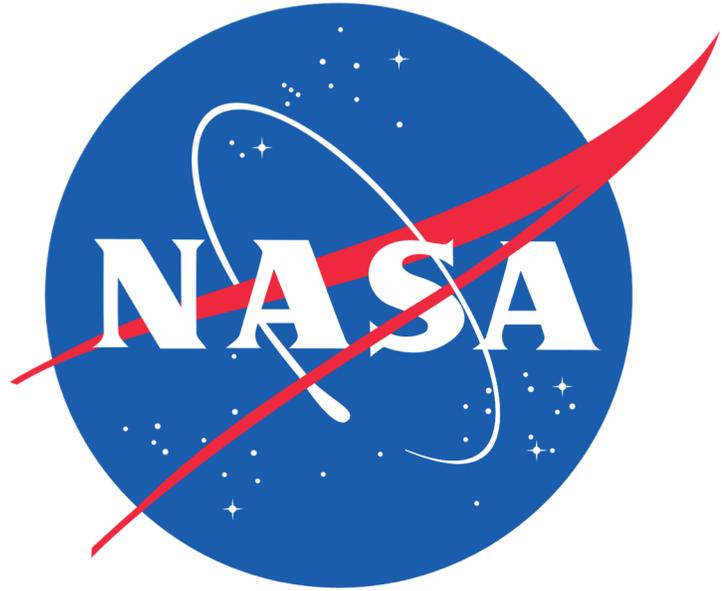


**University of Colorado
Boulder**



**UNIVERSITY OF CALIFORNIA
SANTA BARBARA**





Huge thanks to Woody Turner and Cindy Schmidt for all the help over the life cycle of the MAPPD project!