

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

Mathematics and big data technology development to visualize, deliver and analyze IMS and ARGO data

Tyler Tucker

San Diego State University

April 23rd 2018

Table of Contents

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

① Thesis Overview

② TSM

③ Argovis

④ Conclusion

Table of Contents

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

① Thesis Overview

② TSM

③ Argovis

④ Conclusion

Thesis overview

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

- Both climate and oceanographic science disciplines are feeling a data explosion and are struggling to scale.
- Unprecedented amounts of data are made available by governmental agencies like NOAA and NASA and used by the scientific community to draw inferences about the Earth.
- The traditional visualization and delivery tools can be improved to handle the surge of big data.
- This presentation describes techniques used to create visualization and data retrieval products.
- Global data sets need modern web app technologies for professional and amateur to visualize, retrieve, and analyze data as quickly, accurately, and painlessly as possible.

Focus on two data sets

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

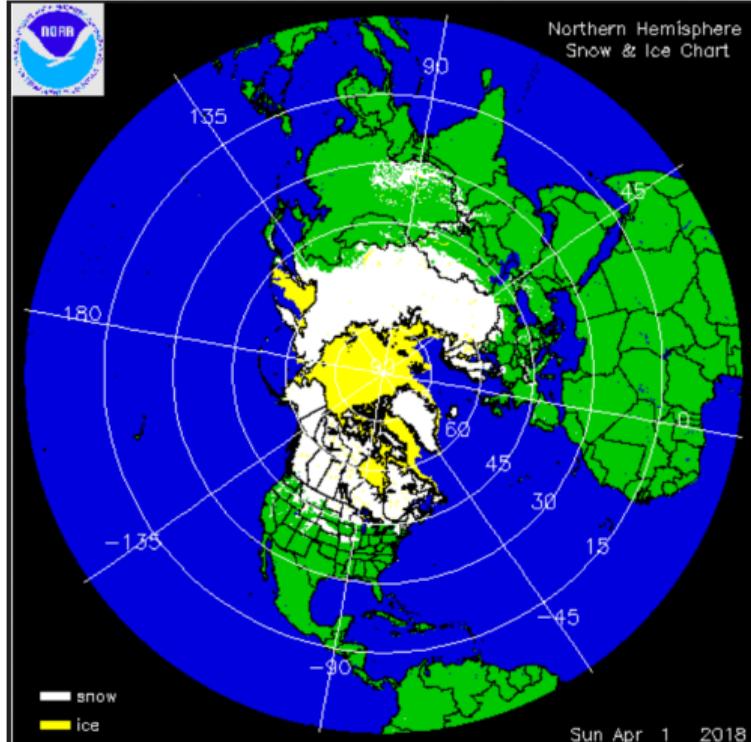


Figure: IMS snow cover, <http://www.natice.noaa.gov/ims/>

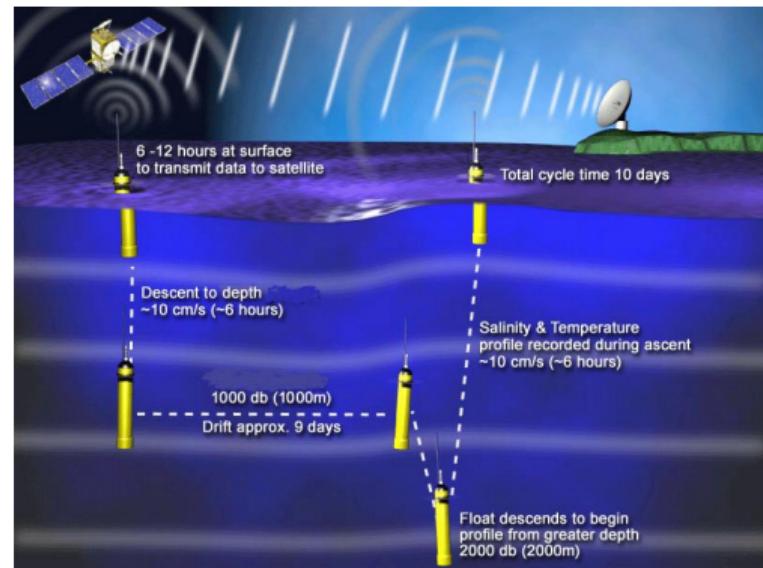


Figure: Detail of one profile cycle
http://www.argo.ucsd.edu/How_Argo_floats.html

Table of Contents

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

1 Thesis Overview

2 TSM

3 Argovis

4 Conclusion

Interactive Multisensor Snow and Ice Mapping System

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

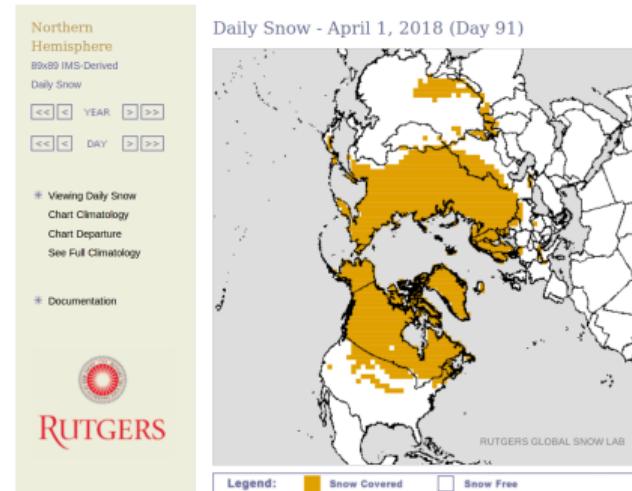


Figure: IMS snow cover,
<https://climate.rutgers.edu/snowcover/>

- Daily snow/ice coverage.
- Matrix style output on FTP site
- Current tools for visualization

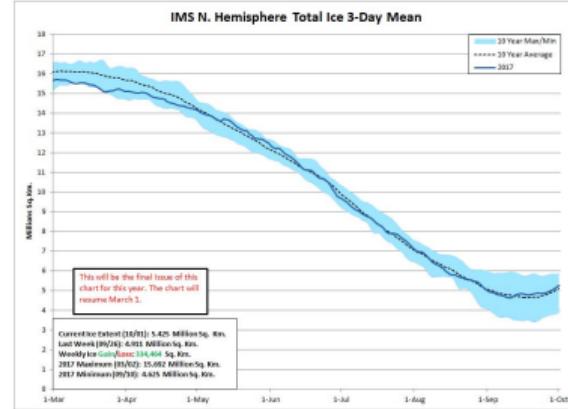


Figure: IMS snow area,
<http://www.natice.noaa.gov/ims/>
Research topics

- Calculate grid area?
- Estimate snow/ice coverage in km^2
- Estimated error vs other products?

Introducing IMS - Tibet Snow Man

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

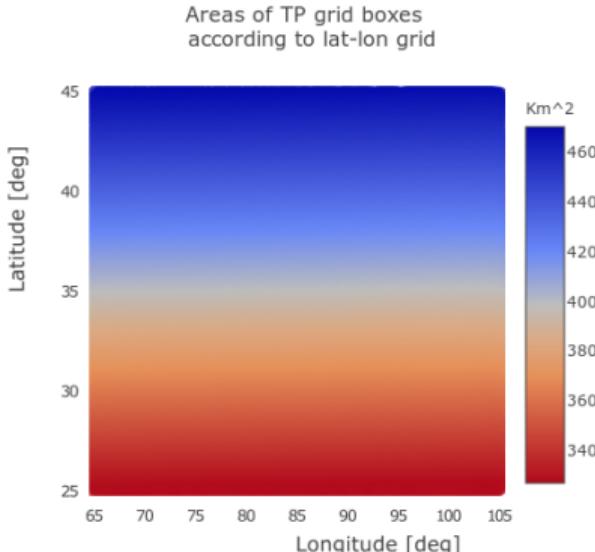


Figure: Time series comparison between $24 \times 24\text{km}^2$ assumption and area calculation via shoe-lace formula.

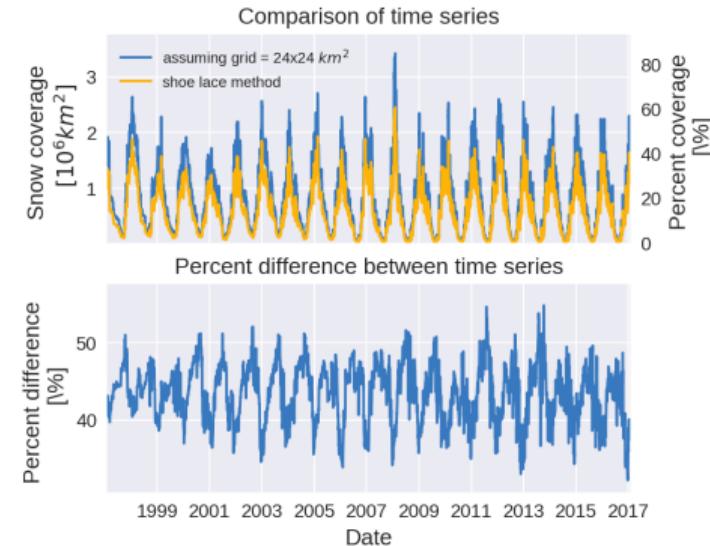


Figure: Tibetan plateau region's snow cover for 2 January 2015: The white region indicates snow cover which is overlaid on the land surface topography.

Introducing IMS - Tibet Snow Man

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

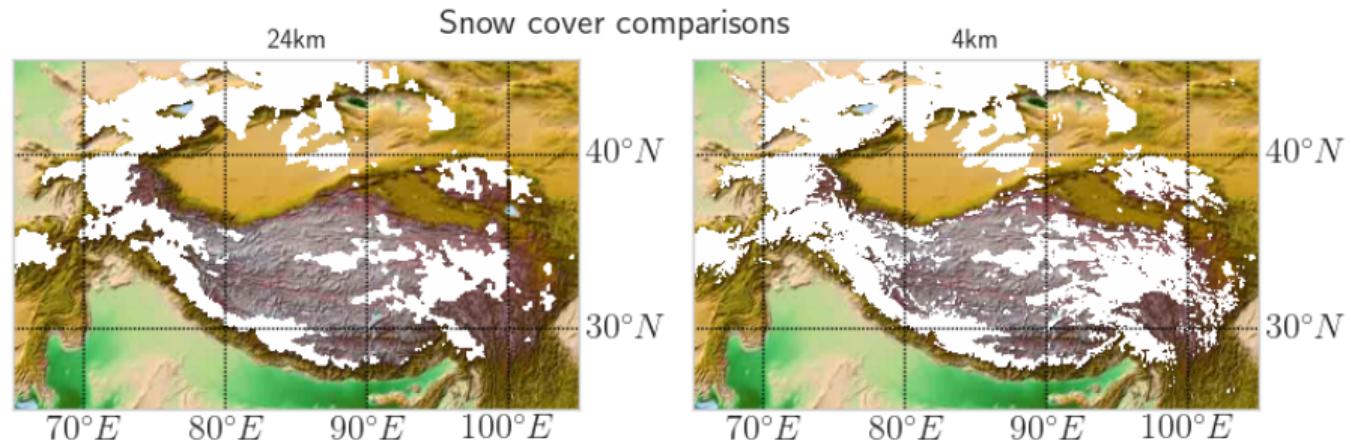


Figure: Time series comparison between $24 \times 24\text{km}$ 2 assumption and area calculation via shoe-lace formula. Time lapse is available at <https://www.youtube.com/watch?v=Kz82dwMKnLY&t=0s>

Describing the Data

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

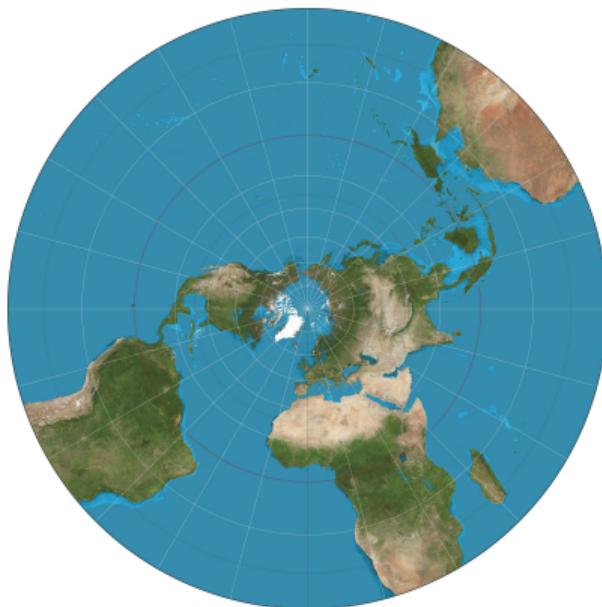


Figure: Stereographic projection. Taken from
https://en.wikipedia.org/wiki/Stereographic_projection

Stereographic Projection

Equations to map a sphere point (ϕ, λ) to a Cartesian point (x, y) are below:

$$x = 2R k_0 \tan\left(\frac{\pi}{4} - \frac{\phi}{2}\right) \sin(\lambda - \lambda_0)$$

$$y = -2R k_0 \tan\left(\frac{\pi}{4} - \frac{\phi}{2}\right) \cos(\lambda - \lambda_0)$$

The length scale factor k is

$$k = \frac{2k_0}{1 + \sin(\phi)},$$

and (ϕ_0, λ_0) is a designated center point.

Describing the Data

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

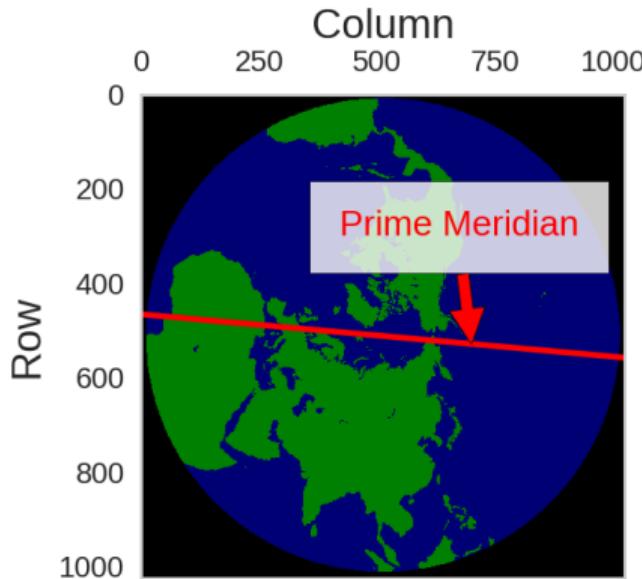


Figure: Grid coordinate ticks of NH without snow and ice cover. IMS provides daily files in an $n \times n$ format. The data is given in .asc files but mirrored to the figure shown. The file represents a stereographic projection, with the 80° meridian line pointing up. IMS rotates the prime meridian by about 10.22° clockwise to the horizontal. This figure shows the 24km resolution data, which has $n = 1024$.

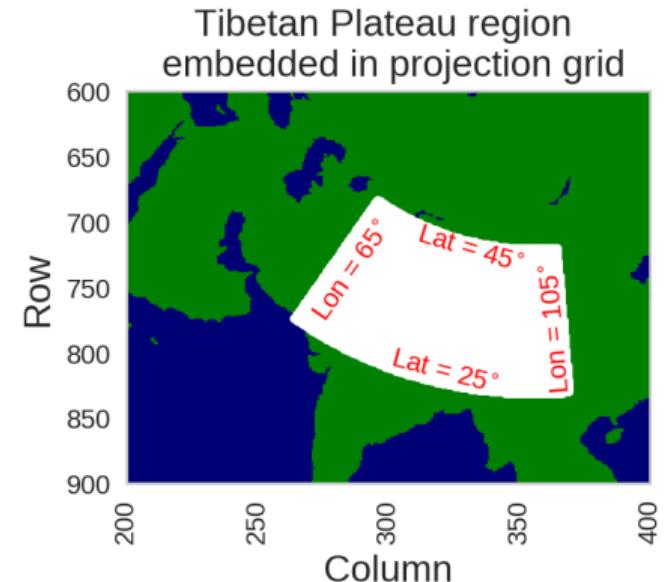


Figure: The TP region ($25^\circ - 45^\circ$ N and $65^\circ - 105^\circ$ E) shown bounded in white is shown on a stereographic projection.

Describing the Data

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

- IMS claims a 24x24, 4x4, and 1x1 km resolution products. In reality, this is true at about 60° latitudes.
- IMS is a non-uniform grid.
- Data is coarser at the pole!
- Areas along latitude vary by almost x2
- Why make equator data finer for a snow/ice product?
- What are the consequences calculating snow/ice coverage with a uniform grid assumption?

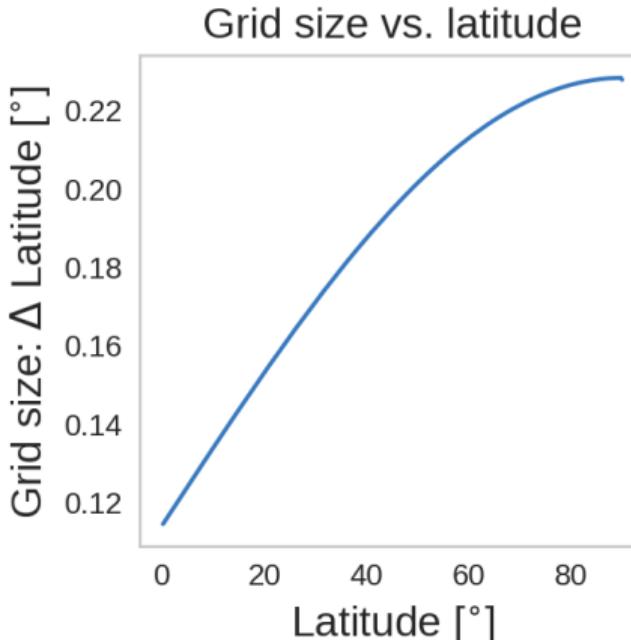


Figure: Latitude was taken from IMS latitude file: rows 0 to 512, column 512, points plotted lie approximately at $80^{\circ}E$. Grid points are distributed densely near the equator, with latitude grid spacing of $.11^{\circ}$ at the equator. The latitude grid spacing increases to $.23^{\circ}$ at the north pole.

Describing the Data

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion



Figure: Latitude was taken from IMS latitude file: rows 0 to 512, column 512, points plotted lie approximately at $80^{\circ} E$.

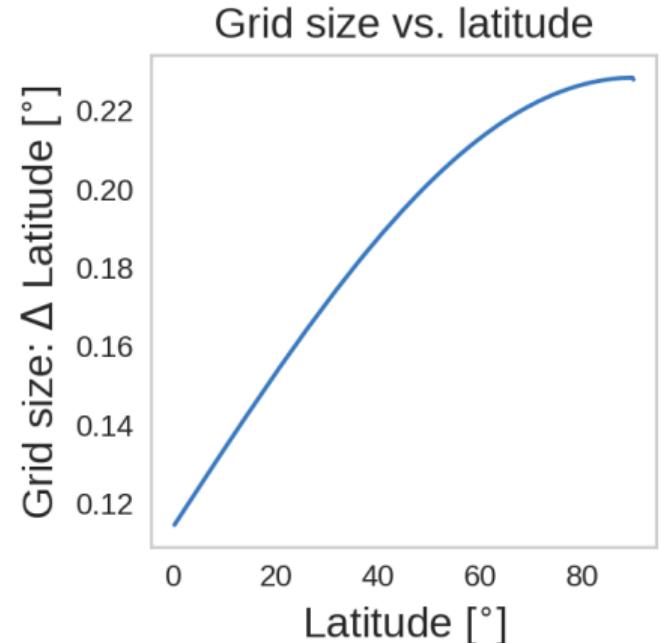


Figure: Grid points are distributed densely near the equator, with latitude grid spacing of $.11^{\circ}$ at the equator. The latitude grid spacing increases to $.23^{\circ}$ at the north pole.

Calculating Areas

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

- Question: Given a latitude-longitude grid, how can we estimate areas?
- Answer: Assume each point is a center of a 4-point polygon on a 2d equal-area projection. We can estimate the corners and find the areas of each cell using Green's theorem.

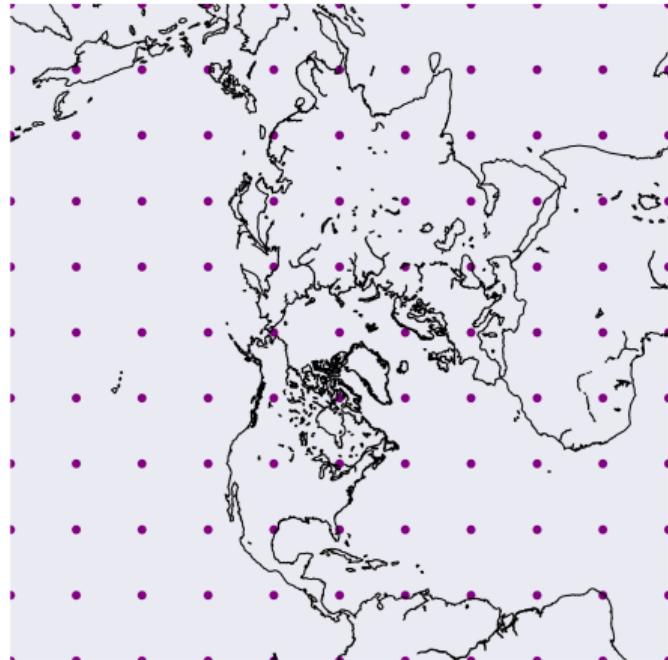


Figure: Sample grid

Calculating Areas: Use an Equal Area Projection

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion



Figure: Lambert azimuthal equal area projection.
Taken from https://en.wikipedia.org/wiki/Lambert_azimuthal_equal-area_projection

Lambert Azimuthal Equal Area Pprojection

Equations to map a sphere point (ϕ, λ) to a Cartesian point (x, y) are below:

$$x = Rk' \cos \phi_1 \sin(\lambda - \lambda_0)$$

$$y = Rk' [\cos \phi_1 \sin \phi - \sin \phi_1 \cos \phi \cos(\lambda - \lambda_0)]$$

$$k' = \frac{\sqrt{2}}{\sqrt{1 + \sin \phi_1 \sin \phi + \cos \phi_1 \cos \phi \cos(\lambda - \lambda_0)}}$$

Where $R = 6,371\text{km}$ is the Earth's radius. For the TP, $\phi_1 = 35^\circ$, $\lambda_0 = 85^\circ$

Calculating Areas: Estimate Grid Cell Area

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

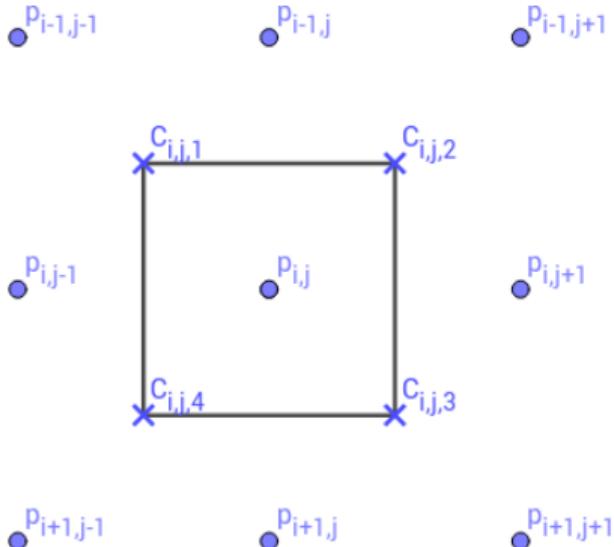


Figure: Grid box showing grid box corners $C_{i,j,k}$ for lat-lon point $p_{i,j}$ calculated using shoe-lace formula.

Corner/Centroids

A grid point $p_{i,j}$ has four corners $C_{i,j,k}$. Corners are the centroids of the bounding square.

$$C_{ij1} = \frac{1}{4}(p_{i-1,j-1} + p_{i,j-1} + p_{i,j} + p_{i-1,j})$$

$$C_{ij2} = \frac{1}{4}(p_{i-1,j} + p_{i-1,j+1} + p_{i,j+1} + p_{i,j})$$

$$C_{ij3} = \frac{1}{4}(p_{i,j} + p_{i,j+1} + p_{i+1,j+1} + p_{i+1,j})$$

$$C_{ij4} = \frac{1}{4}(p_{i-1,j} + p_{i,j} + p_{i+1,j} + p_{i-1,j+1})$$

Calculating Areas: Estimate Grid Cell Area

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

Shoelace/Surveyor's Formula

Discrete Green's Theorem estimates area on a 2D surface. Given a set of vectors x_k, y_k of the four corners of point $p_{i,j}$, area $A_{i,j}$ is computed to be

$$A_{ij} = \frac{1}{2} \left| \sum_{k=1}^3 x_k y_{i+1} + x_n y_1 - \sum_{k=1}^3 x_{k+1} y_k - x_1 y_n \right|$$

Calculating Areas: Estimate Grid Cell Area

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

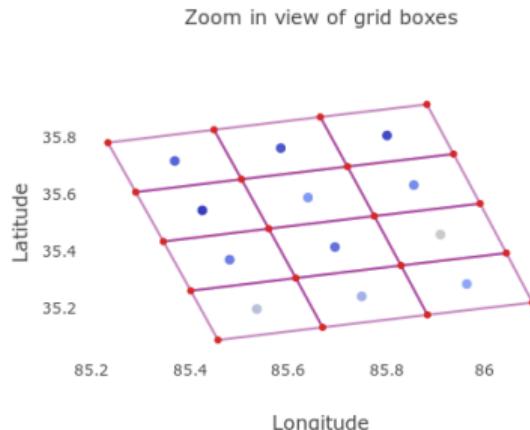


Figure: A zoom-in display of grid boxes and their centroid points provided a detailed view on how areas are estimated. Each central circle represents a lat-lon point provided by IMS. TSM calculates the red corner points followed by the bounding boxes' area.

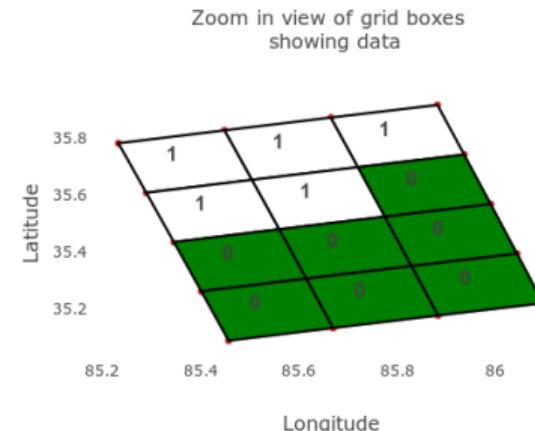


Figure: A zoom-in view of the IMS data with snow/no snow illustrations. Cells covered in snow are in white and cells with no snow are shown in green.

LEAP Areas Over TP of '24km²' Resolution

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

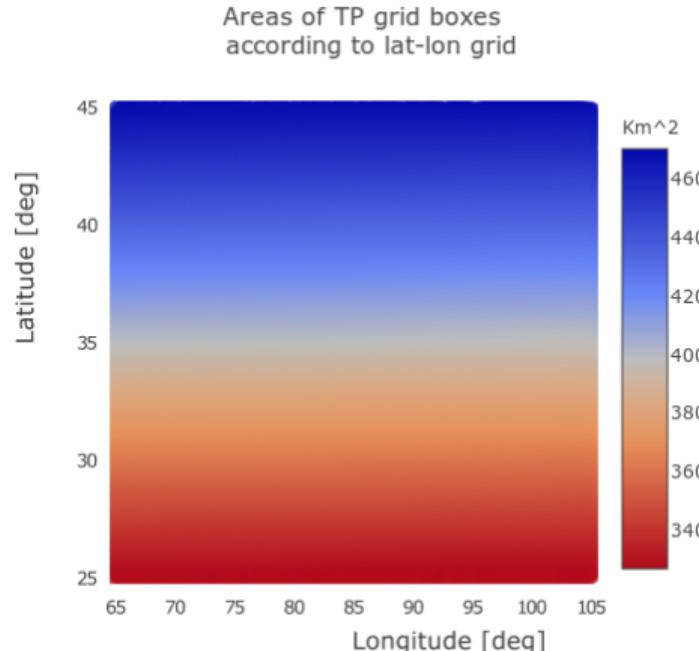


Figure: The area of a grid box varies according to latitude.

Comparing LEAP Areas With Uniform Assumption

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

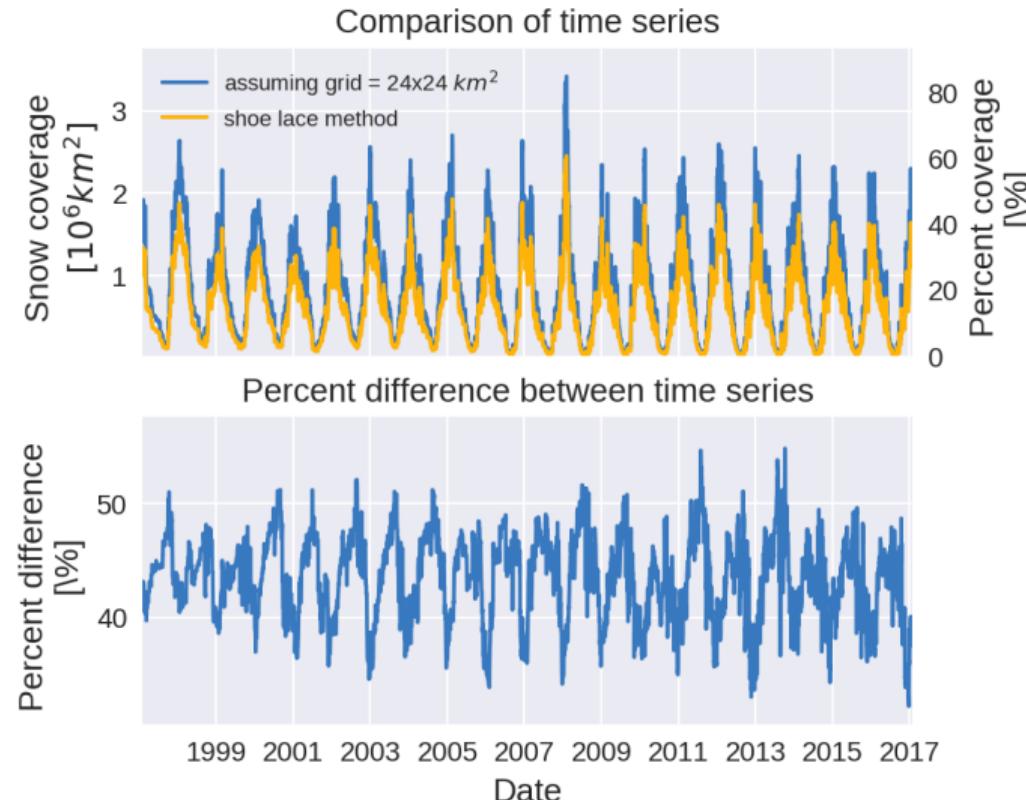


Figure: Time series comparison between $24 \times 24 \text{ km}^2$ assumption and area calculation via shoe-lace formula.

Comparing '24km²' with '4km²' Resolutions

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

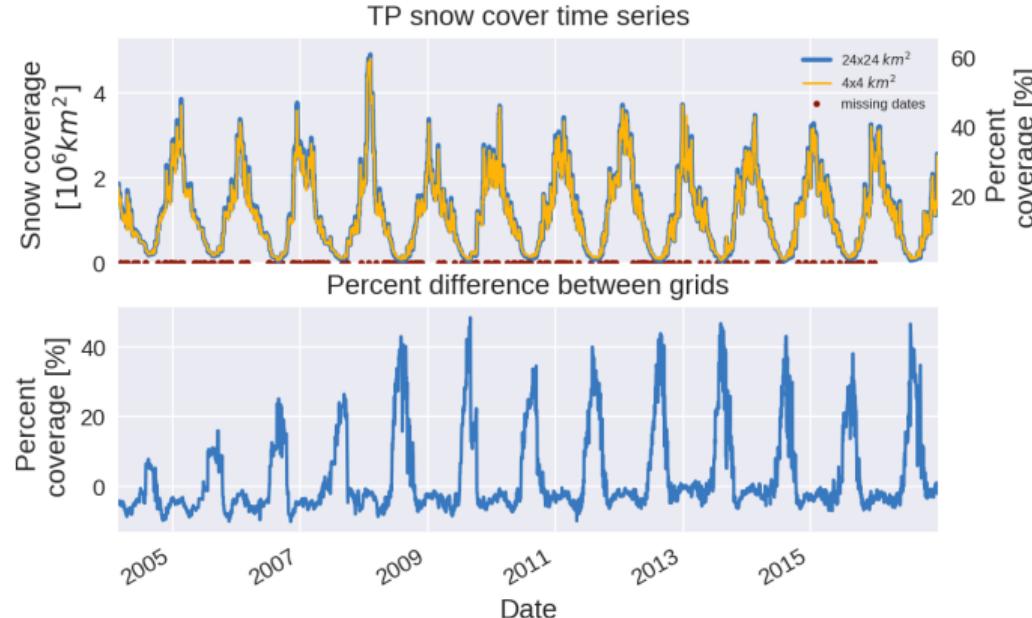


Figure: The snow cover area time series comparison between two resolutions: 4 km and 24 km. Percent difference calculated using percent difference $100 * \left(\frac{ts_{24_km} - ts_{4_km}}{ts_{4_km}} \right)$.

Climatology: 5 Day Binning

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

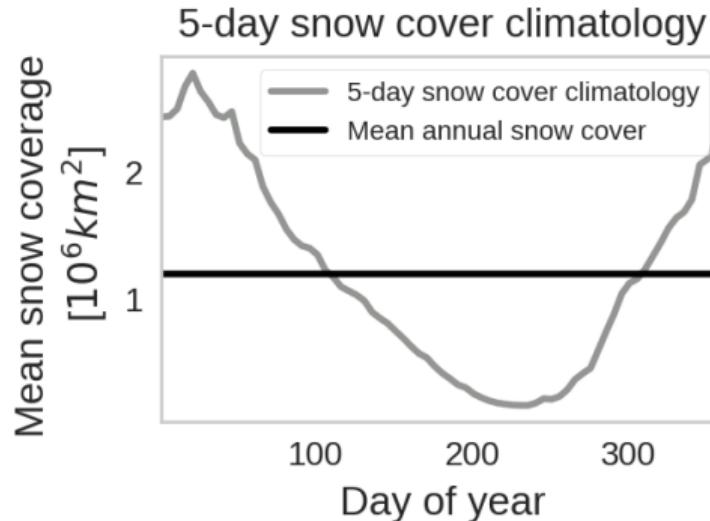


Figure: 5 day climate averages of the 24x24 km annual snow cycle.

Climatology: STL via LOESS Regression

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

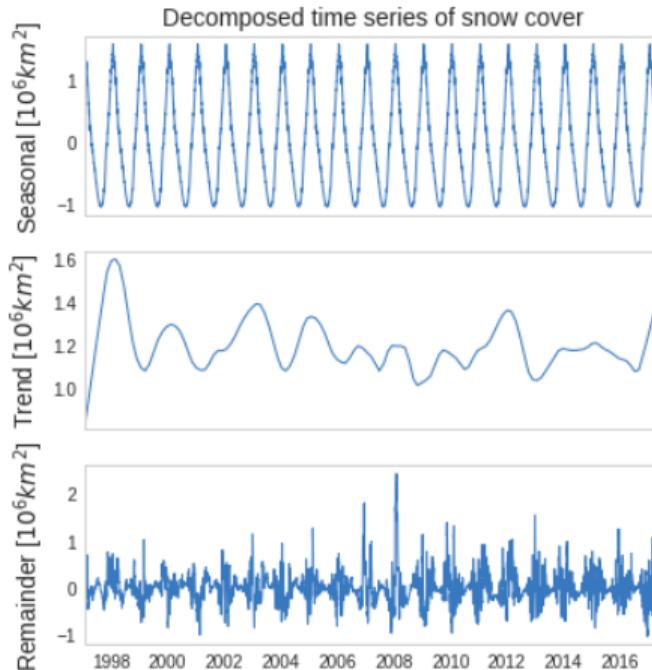


Figure: Deseasonalized using STL algorithm described in Appendix.

STL

Seasonal Decomposition Based on LOESS by Cleveland et al 1990 allows a non stationary time series with a seasonal trend to be decomposed into three parts: The trend T_t , season S_t , and the residual R_t . Where the original signal Z_t is combination of all three.

$$Z_t = T_t + S_t + R_t$$

Implementation is done using the `stl()` function in R.

Anomalies

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

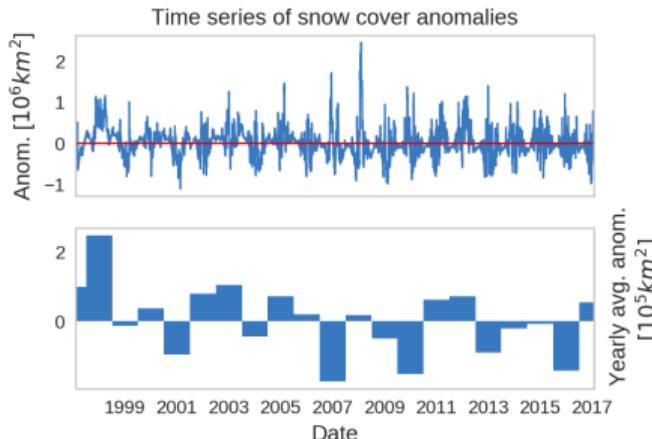


Figure: Time series of Snow coverage anomalies with included trend line, in addition to yearly averaged anomalies, shown by the bar chart.

Anomalies

5-day average climate model $\text{clim}(t)_5$ is subtracted from the time series, $\text{Snow}(t)$.

$$\text{Anomalies}(t) = \text{Snow}(t) - \text{clim}(t)_5$$

Note that anomalies and STL remainder are attempting to deseasonalize the signal. Both are not variance stationary.

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

Table: Anomaly Distribution Properties

Statistic	Value
Mean	-309.9 km^2
Median	-30992 km^2
Min	$-1.112 \cdot 10^6 \text{ km}^2$
Max	$2.446 \cdot 10^6 \text{ km}^2$
Standard Deviation	$.34259971 \cdot 10^6 \text{ km}^2$
Skew	1.0006
Kurtosis (Pearson's)	4.351

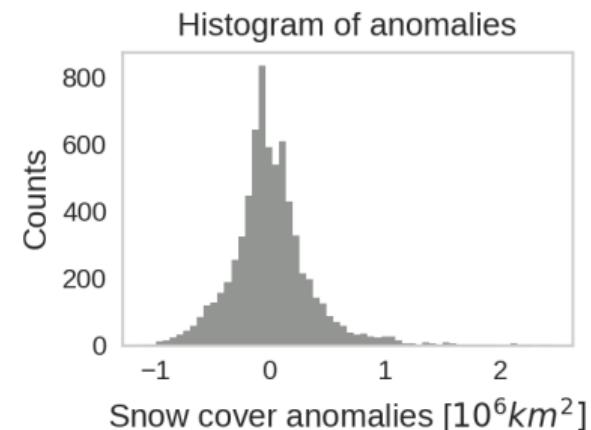


Figure: Histogram of the 24×24 anomalies.

TSM as a Product

IMS and ARGO
data
visualization
and delivery

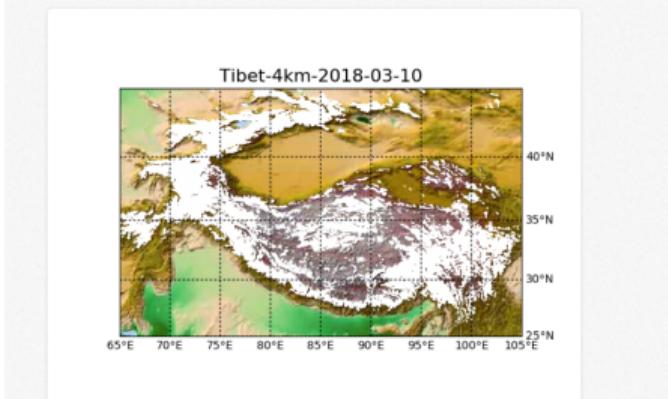
Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion



None of this could be done without the help of the National Snow and Ice Data Center
<https://nsidc.org/>

[National Ice Center. 2008, updated daily. IMS daily Northern Hemisphere snow and ice analysis at 1 km, 4 km, and 24 km resolutions. Boulder, CO: National Snow and Ice Data Center. Digital media.]

Posted by Tyler Tucker • Wed 12 April 2017 • [IMS](#) • [climate](#), [timeseries](#)

Figure: TSM is currently used to generate daily snow mapping at <http://www.itsonlyamodel.us/daily-snow.html>

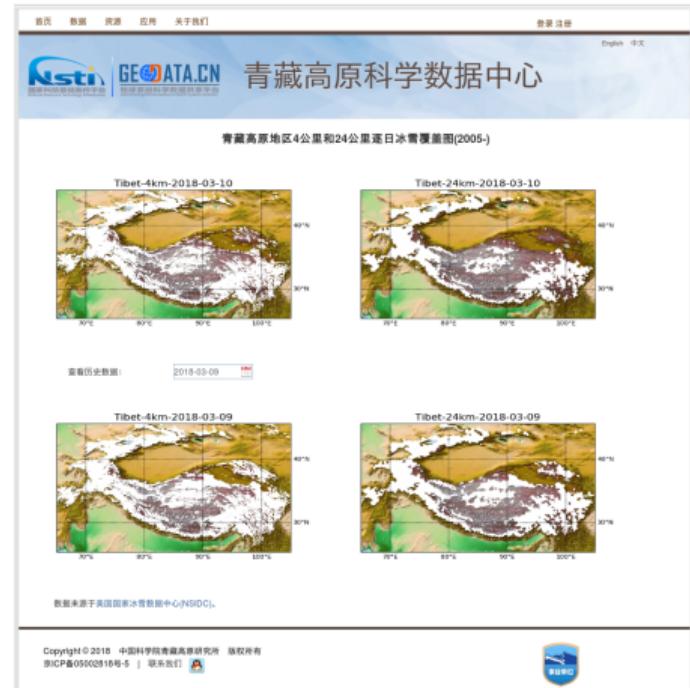


Figure: Screenshot of <http://www.tpedatabase.cn/tibetSnow.jsp> showing daily snow plot at archives at 24 and 4 km resolution.

TSM as a Product

IMS and ARGO
data
visualization
and delivery

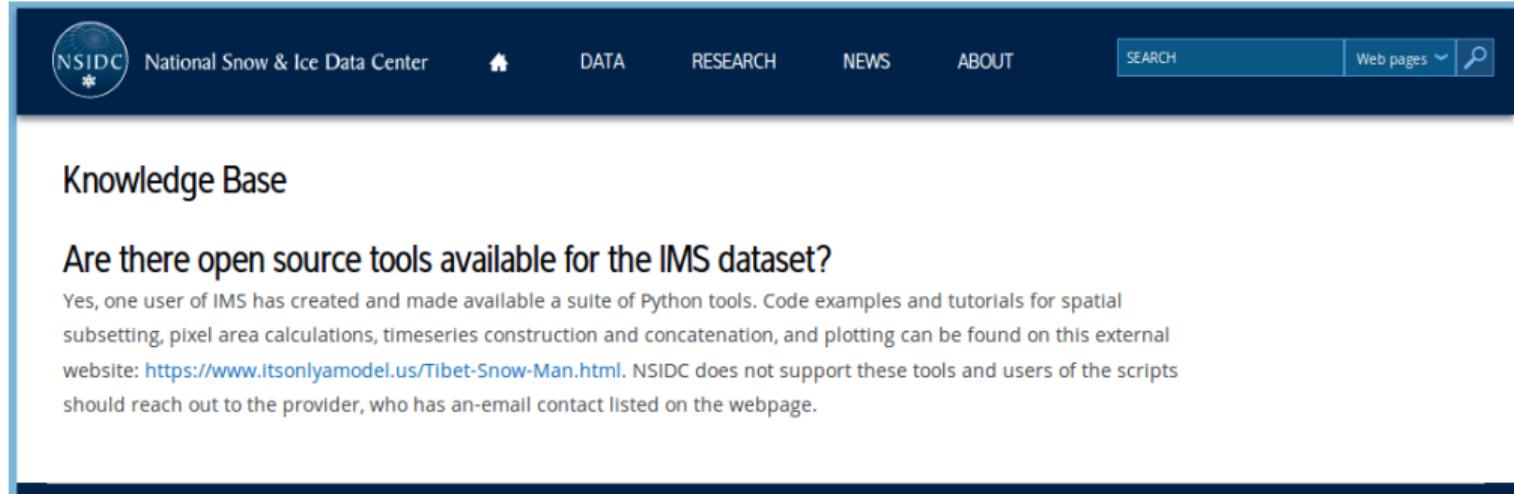
Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion



The screenshot shows the NSIDC website's header with links for DATA, RESEARCH, NEWS, and ABOUT. A search bar at the top right includes options for "SEARCH" and "Web pages". Below the header, the page title is "Knowledge Base". A main question is displayed: "Are there open source tools available for the IMS dataset?". The answer below states: "Yes, one user of IMS has created and made available a suite of Python tools. Code examples and tutorials for spatial subsetting, pixel area calculations, timeseries construction and concatenation, and plotting can be found on this external website: <https://www.itsonlyamodel.us/Tibet-Snow-Man.html>. NSIDC does not support these tools and users of the scripts should reach out to the provider, who has an-email contact listed on the webpage."

Figure: TSM is cited by NSIDC at
<http://nsidc.org/support/faq/are-there-open-source-tools-available-ims-dataset>

Next Steps and Conclusion

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion



- Build code into a web app instead of a python library. Interactive web apps attract more users and researchers.
- IMS error is difficult to characterize. How can we estimate error, reduce bias? Can we trust these products?
- Apply this when they release a Southern Hemisphere Product

Table of Contents

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

1 Thesis Overview

2 TSM

3 Argovis

4 Conclusion

IMS and ARGO data visualization and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

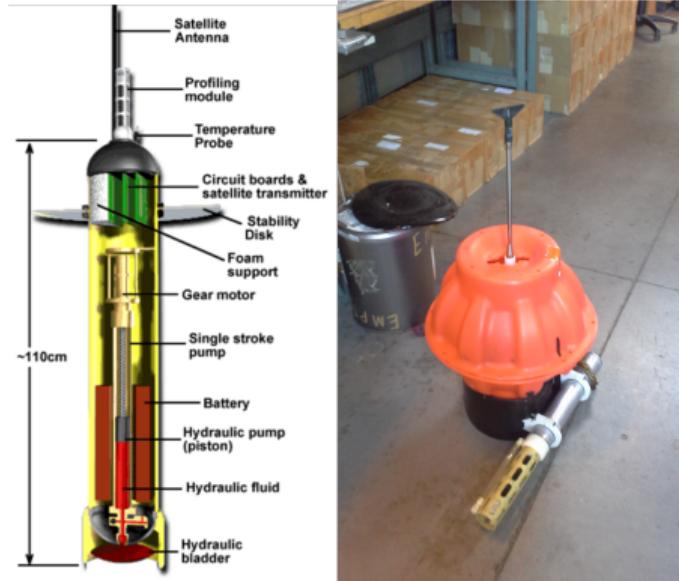


Figure: APEX float (left). Image taken from <http://argofloats.wikispaces.com/home> Deep Solo prototype (right) Taken by me at SIO.



Figure: Image taken from <http://argofloats.wikispaces.com/home>

Research topics

- How to access data?
- How to visualize data set?
- How to handle errors?

Argo Terminology

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

- Profile: Prray of measurements taken by float/platform.
- Platform: Device that takes profiles. Platform \equiv Float.
- Selection: Profiles grouped by area, date, depth, etc.

Coriolis Visualization Application

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion



Figure: Argo Active network map (left)

<http://www.argo-france.fr/en/argo-active-network-map>/Showing argo profiles owned by the Coriolis (French) DAC. Yellow dots represent floats operated by the Coriolis project. Selecting a dot reveals a side panel with additional information (right). Velocity field animations overlay the profile dots showing currents generated via ANDRO. Screenshot taken from <http://map.argo-france.fr/>

Pros:

- Fast
- Intuitive
- Interactive

Cons:

- Can't select regions
- Can't select platforms
- Limited to recent profiles
- Highcharts aren't FOSS

NASA Sea Level Change Data Analysis Tool

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion



Figure: DAT web app format with Data tab displayed on the side bar. Argo derived gridded salinity and temperature products from January 2004 to January 2017 are available to plot. Screenshot taken from <https://sealevel.nasa.gov/data-analysis-tool/>

Pros:

- Regional selection
- Offers several data sets
- Time series
- Contour images overlay

Cons:

- Cuts off in middle of ocean
- Slow
- Non-intuitive
- Beta product (includes bugs)
- Limited to gridded products

4D Visual Delivery of Big Climate Data: MrSharky

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

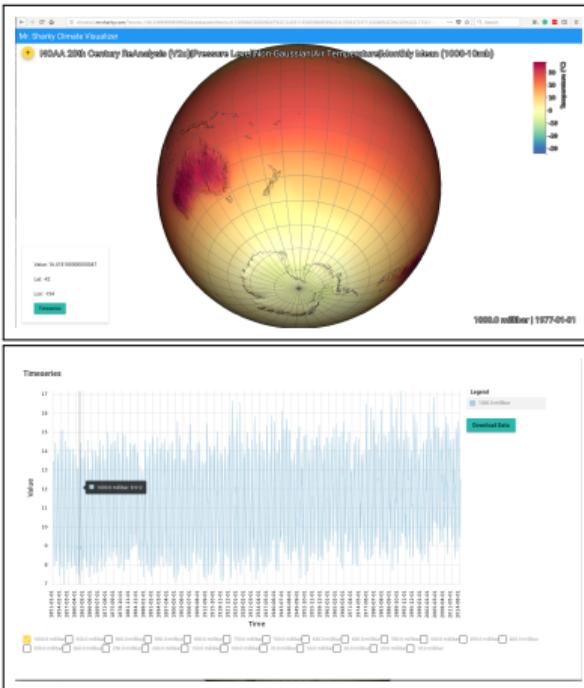


Figure: Clicking a point on the globe will generate a box element showing the point's value and latitude-longitude coordinates, shown in the lower left corner of the (top) subfigure. Clicking the teal button will generate a time series (bottom) that can be downloaded as a .csv file. Screenshots taken from <http://climate2.mrsharky.com/>

Pros:

- Rich with custom viewing features
 - View in several projections
 - Provides time series
 - Uses several products

Cons:

- Resource heavy
 - Little documentation on how to use
 - Limited chart capability
 - Limited to gridded products

Visualization and Data Retrieval Tool: Argovis

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

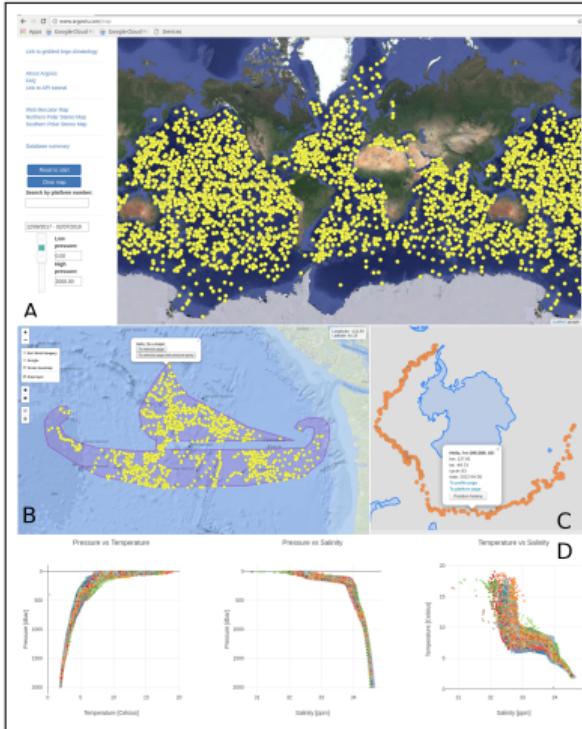


Figure: Argovis features: interactive map (top) Selection(mid right),
stereo projection (left), data charts (bottom)

Pros:

- Custom viewing features
- Includes stereographic projection
- Interactive map
- API included
- Video tutorials! <https://www.youtube.com/watch?v=I1NJ0owuTHM>

Cons:

- No time series
- Only Argo data
- No gridded products

Argo Data

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

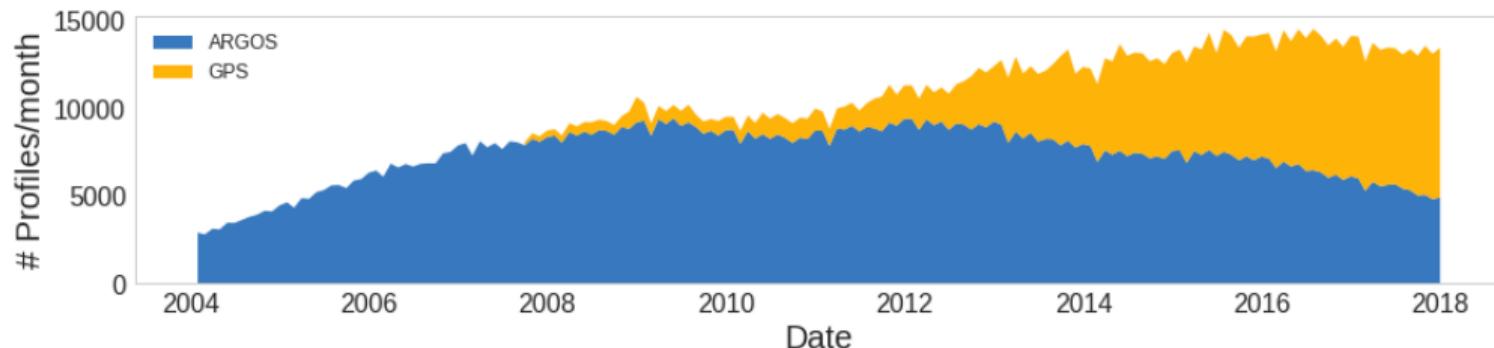


Figure: History of Argo profiles reported each month since the programs inception. Trends towards GPS measurements indicate a need for a data retrieval service. Argo data generation is increasing in the number of profiles reported and by the amount of data reported by each profile.

Index of ftp://usgodaе.org/pub/outgoing/argo/latest_data/[Up to higher level directory](#)

Name	Size	Last Modified
File: D20180112_prof.nc	88595 KB	1/13/18 12:01:00 AM PST
File: D20180113_prof.nc	53831 KB	1/13/18 3:00:00 AM PST
File: D20180115_prof.nc	55136 KB	1/15/18 11:00:00 PM PST
File: D20180116_prof.nc	31304 KB	1/16/18 10:02:00 PM PST
File: D20180117_prof.nc	53875 KB	1/18/18 12:00:00 AM PST
File: D20180118_prof.nc	31498 KB	1/18/18 9:00:00 PM PST
File: D20180118_prof_0.nc	99863 KB	1/18/18 4:03:00 AM PST
File: D20180119_prof.nc	1928 KB	1/20/18 12:00:00 AM PST
File: D20180120_prof.nc	1367 KB	1/20/18 3:00:00 AM PST
File: D20180122_prof.nc	2035 KB	1/22/18 8:00:00 PM PST
File: D20180123_prof.nc	31686 KB	1/23/18 5:00:00 PM PST
File: D20180124_prof.nc	22981 KB	1/24/18 6:00:00 PM PST
File: D20180125_prof.nc	79559 KB	1/25/18 3:00:00 PM PST
File: D20180125_prof_0.nc	100842 KB	1/25/18 2:00:00 PM PST
File: D20180127_prof.nc	696 KB	1/27/18 3:00:00 AM PST
File: D20180129_prof.nc	81714 KB	1/30/18 12:00:00 AM PST
File: D20180130_prof.nc	25430 KB	1/30/18 1:00:00 PM PST
File: D20180131_prof.nc	76379 KB	1/31/18 8:00:00 PM PST
File: D20180201_prof.nc	96713 KB	2/1/18 4:00:00 PM PST
File: D20180201_prof_0.nc	99828 KB	2/1/18 5:00:00 PM PST

Argovis JSON output

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

Listing 1: JSON schema of mongoDB profile.

```
{  
    "_id": <String>,  
    "max_pres": <Int>,  
    "measurements": <List[{"temp": <Number>,  
                           psal: <Number>,  
                           pres: <Number>,  
                           ...}]]>,  
    "date": <ISODate>,  
    "POSITIONING_SYSTEM": <String>,  
    "PLATFORM_TYPE": <String>,  
    "DATA_MODE": <String>,  
    "PI_NAME": <String>,  
    "cycle_number": <Int>,  
    "lat": <Number>,  
    "lon": <Number>,  
    "geoLocation", {"type": "Point",  
                   "coordinates": [<Number[2]>]},  
    "dac": <String>,  
    "platform_number": <String>,  
    "station_parameters": <List[String]>,  
    "nc_url": <String>  
}
```

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

Listing 2: Python function to retrieve profile data. Uses 'requests' library

```
def get_profile (profile_number):
    resp = requests.get('http://www.argovis.com/catalog/profiles /'+profile_number)
    # Consider any status other than 2xx an error
    if not resp.status_code // 100 == 2:
        return "Error: Unexpected response {}".format(resp)
    profile = resp.json()
    return profile
```

API: Platform function

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

Listing 3: Python function to retrieve platform data

```
def get_platform_profiles (platform_number):
    resp = requests.get('http://www.argovis.com/catalog/platforms/' + platform_number)
    # Consider any status other than 2xx an error
    if not resp.status_code // 100 == 2:
        return "Error: Unexpected response {}".format(resp)
    if resp.status_code == 500:
        return "Error: 500 status {}".format(resp)
    platformProfiles = resp.json()
    return platformProfiles
```

API: Selection function

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

Listing 4: Python function to retrieve selection data

```
def get_selection_profiles (startDate, endDate, shape, presRange=None):
    baseURL = 'http://www.argo-vis.com/selection/profiles'
    startDateQuery = '?startDate=' + startDate
    endDateQuery = '&endDate=' + endDate
    shapeQuery = '&shape=' + shape.replace(' ', '')
    if not presRange == None:
        pressRangeQuery = '&presRange=' + presRange
        url = baseURL + startDateQuery + endDateQuery + pressRangeQuery + shapeQuery
    else :
        url = baseURL + startDateQuery + endDateQuery + shapeQuery
    resp = requests.get(url)
    # Consider any status other than 2xx an error
    if not resp.status_code // 100 == 2:
        return "Error: Unexpected response {}".format(resp)
    if resp.status_code == 500:
        pdb.set_trace()
        return "Error: 500 status {}".format(resp)
    selectionProfiles = resp.json()
    return selectionProfiles
```

API: Time Series Applications

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

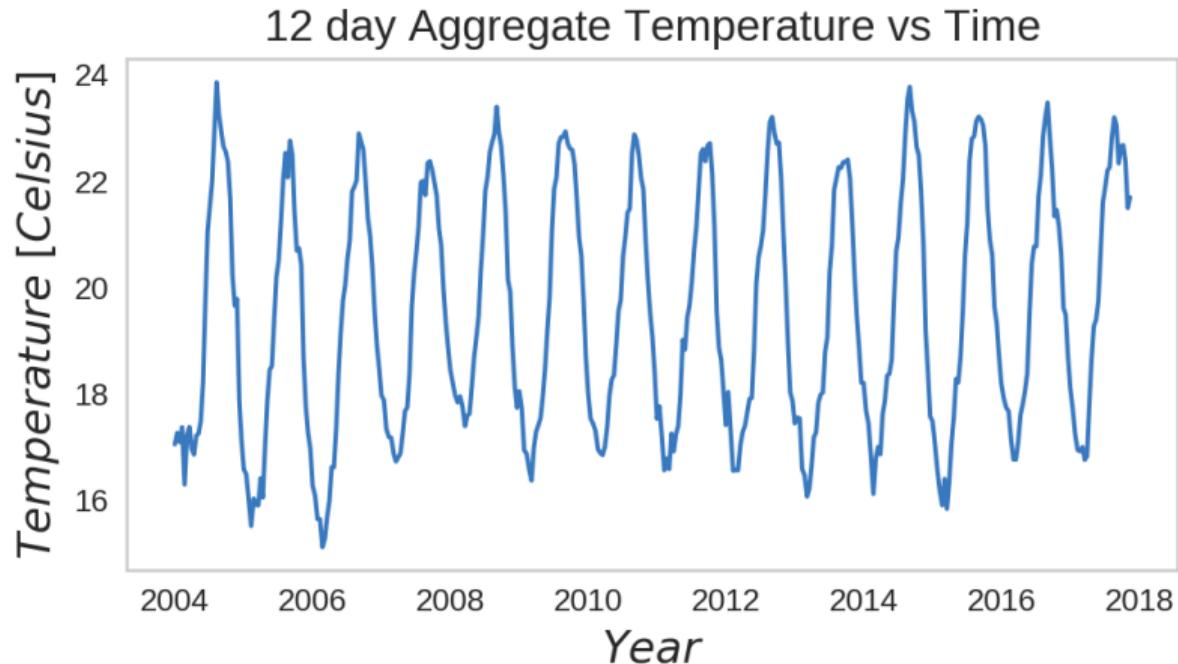


Figure: API includes a special time series generator for a selection.

API: Time Series Applications

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

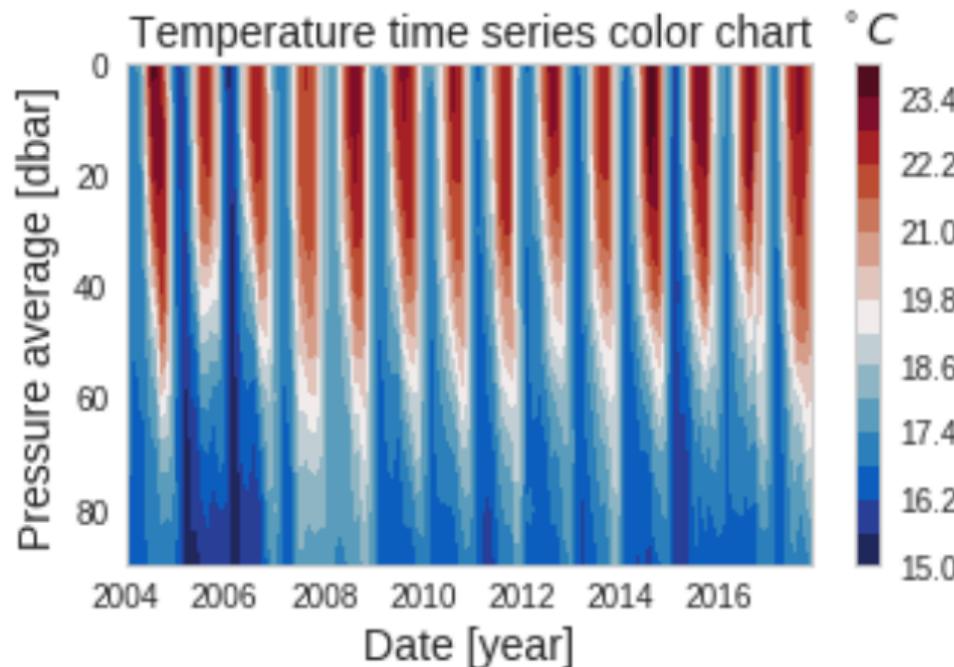


Figure: Time series at ten equally spaced partitions along the first 100 meters of the water column (10 meters/partition). Temperature is displayed as color and the y-axis is plotted as pressure (depth).

API: Histogram on Basemap

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

Argo profiles during January, 2018

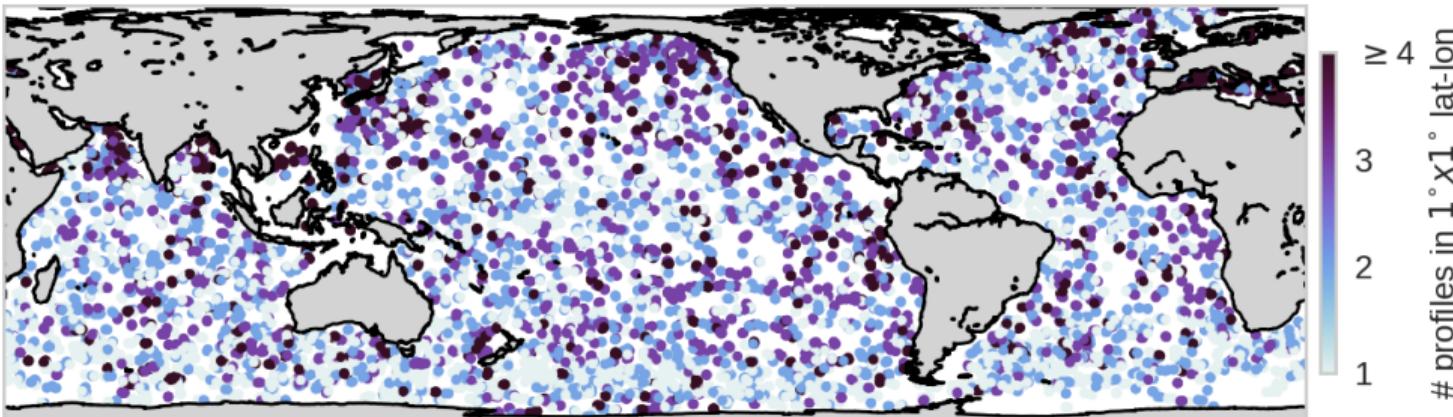


Figure: SST time series of selection. Color chart was made using a cubic interpolation of 10 different depths aggregated every 10 dbar.

API: View Float Types

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

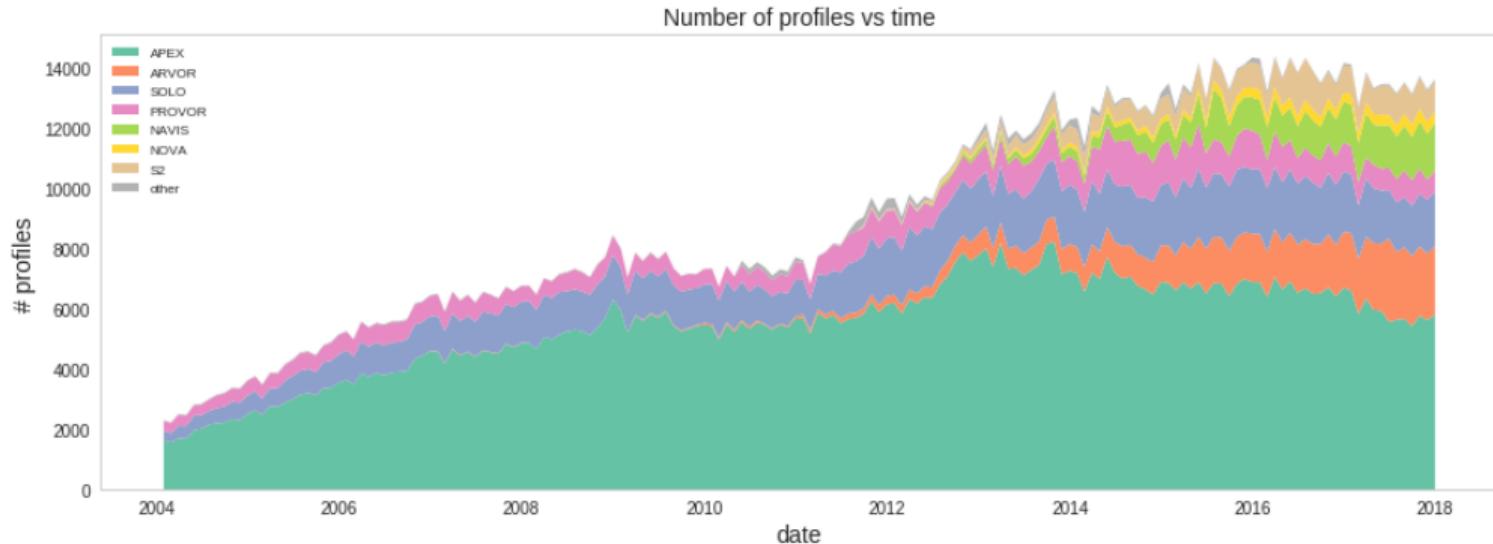


Figure: Number of profiles reported per month vs Time.

Next Steps

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

- Create Kaggle.com competition using Argovis.com's database
- Include API in other languages, (R, MATLAB, Julia, etc.)
- Publish website release in a scientific journal
- Apply for a research grant for further development/testing.
- Included a gridded product section to the website.

Table of Contents

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

1 Thesis Overview

2 TSM

3 Argovis

4 Conclusion

Conclusion

IMS and ARGO
data
visualization
and delivery

Tyler Tucker

Thesis Overview

TSM

Argovis

Conclusion

- It is possible to create websites, blogs, videos, apps with open source materials
- The methods and approaches in this thesis serves the public, specifically the next generation of scientist
- Web-based toolkits serve the user community.
- Agencies are actively pursuing similar websites (NASA, NOAA, Argo France). This thesis applies to them.