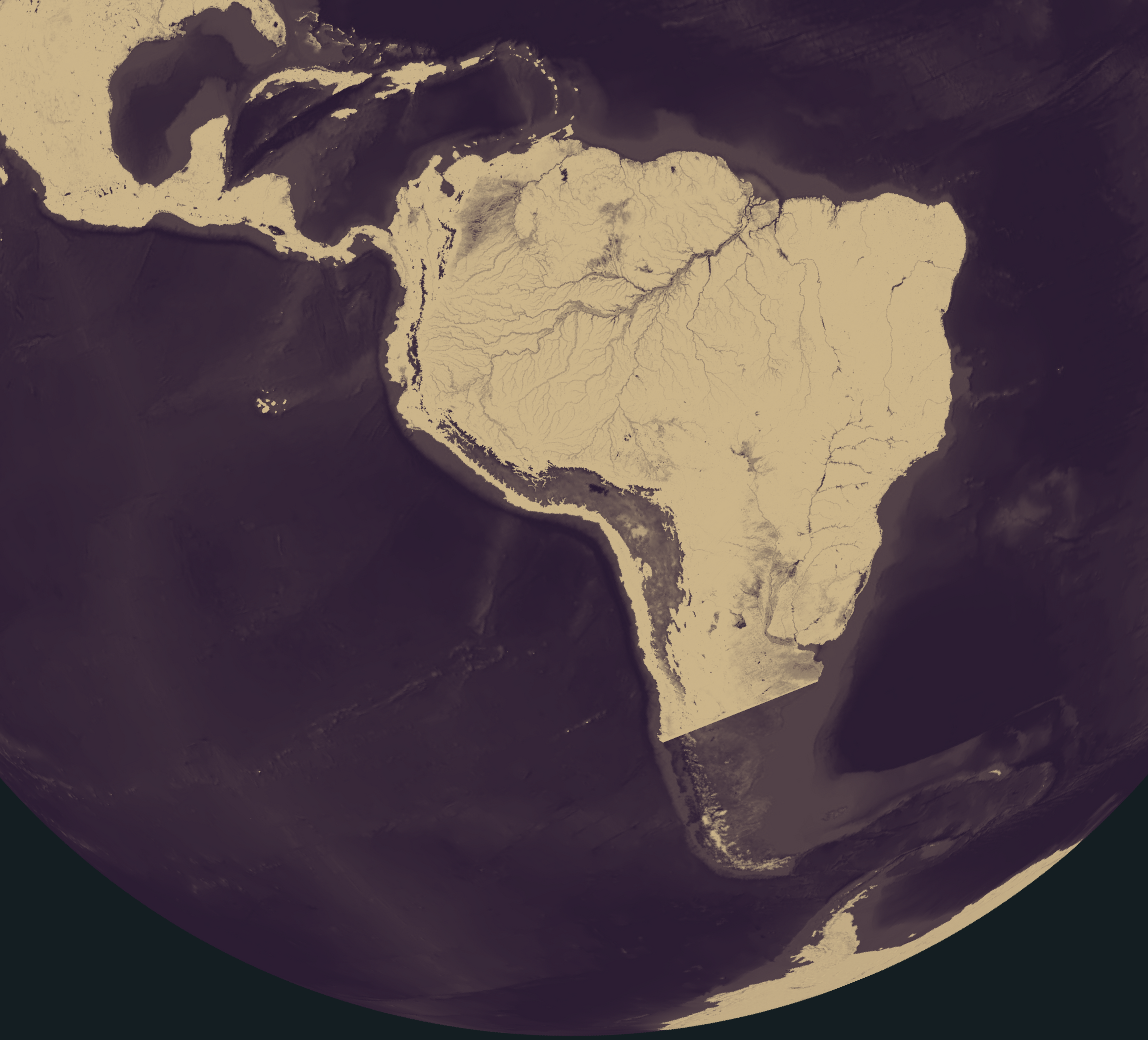


WWW.DATA.COSMIC.UCAR.EDU

# UCAR/CU CYGNSS INUNDATION MAPS

VERSION 1.0 (LAST UPDATED 08/25/22)

# INTRODUCTION

Thanks for your interest in our inundation maps! This guide will give a brief overview of the data files. For a detailed description of the algorithm, please see the citation at the bottom of this page. Note that this product should be considered "research grade," and we do not make any guarantees with regards to their quality and are subject to change without notice. This project was generously funded by the NASA Terrestrial Hydrology Program 80NSSC19K0046.

We welcome feedback. A large part of the reason for publishing these initial maps is to improve them for future versions. If you have questions, comments, or would like to collaborate, you can e-mail Clara Chew: clarac@ucar.edu

Chew, C.C. and Small, E.E., "Flooding and Inundation Maps Using Interpolated CYGNSS Reflectivity Observations," *in review at Remote Sensing of Environment.*

# FILE OVERVIEW:

File naming convention: ucar_cu_FI_v1_YYYY_DDD.nc
YYYY: 4 digit year
DDD: 3 digit day of year. Each file contains inundation fraction retrieved between DDD and DDD - 2
To geolocate the data, you will also need the geogrid.nc file.

Each netCDF file contains the following variables:
**inundation:** Refers to the inundation fraction of any 3 x 3 km grid cell.
**inundation_high:** Refers to the upper-estimate of the inundation fraction.
**inundation_low:** Refers to the lower-estimate of the inundation fraction.
**interpolation_flag:** Binary flag indicating whether the grid cell was observed or interpolated.

The upper- and lower-estimates of inundation fraction stem from an assumption of the typical uncertainty in any given CYGNSS reflectivity observation (+/-1.74 dB).

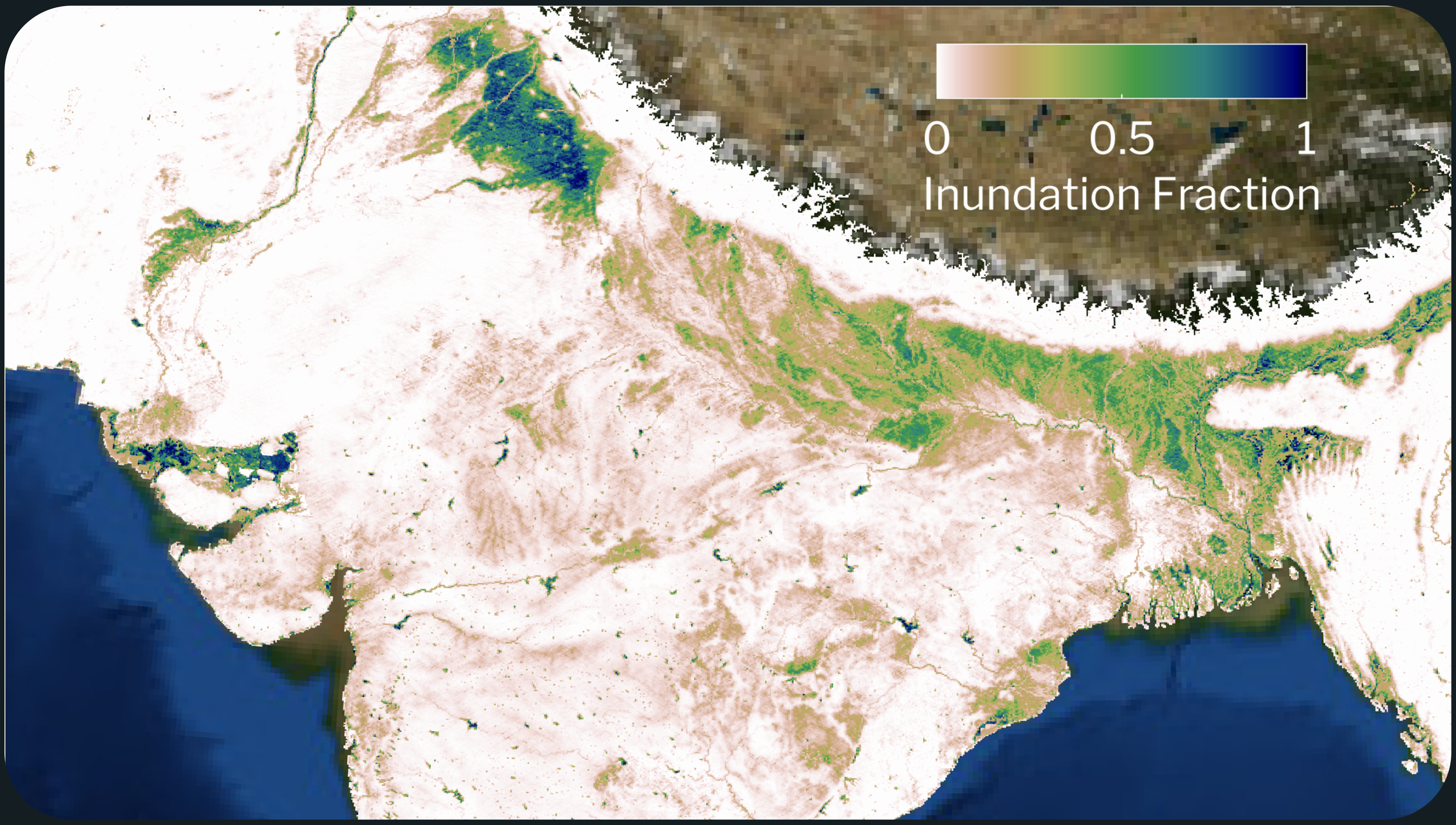
The geogrid.nc file contains the following variables necessary for geolocation:
**latitude:** Refers to the latitude of the center of the grid cell derived from the EASE grid 2.0.
**longitude:** Refers to the longitude of the center of the grid cell derived from the EASE grid 2.0.

| | | | |
|---|---|---|---|
| **Spatial coverage:** | N: 38, S: -38<br>E: 180, W: -180 | **Data format:** | netCDF4 |
| **Spatial resolution:** | 3 x 3 km | **Platform:** | CYGNSS |
| **Temporal coverage:** | March 20, 2017 - June 30, 2022 | **Sensor:** | CYGNSS GNSS-R receivers |
| **Temporal resolution:** | 3-days | **Version:** | 1.0 |
| **Data contributors:** | Chew, C.C.<br>Small, E.E. | | |

# HOW TO VIEW THE DATA:

One of our goals for the future is to have a data viewer such that users do not have to download the data themselves. Until this happens, we have written some MATLAB functions that will hopefully help users visualize the data after download. If you do not have MATLAB, there are many free and commercial software packages that can open netcdf files. For a comprehensive list, we recommend visiting the following link:
https://www.unidata.ucar.edu/software/netcdf/software.html

Included MATLAB functions:
(All functions assume the user has downloaded the desired inundation files to a directory on their personal computer.)
**Load_Plot_CYG_Inundation**: This function will make a plot of one of the three-day composite inundation files, given user inputs of desired date and latitude/longitude limits. There is an option for only viewing observed data with no spatial interpolation.
**Avg_and_Plot_CYG_Inundation**: This function is very similar to Load_Plot_CYG_Inundation, except the user can specify a range of dates from which to average inundation fraction before plotting.



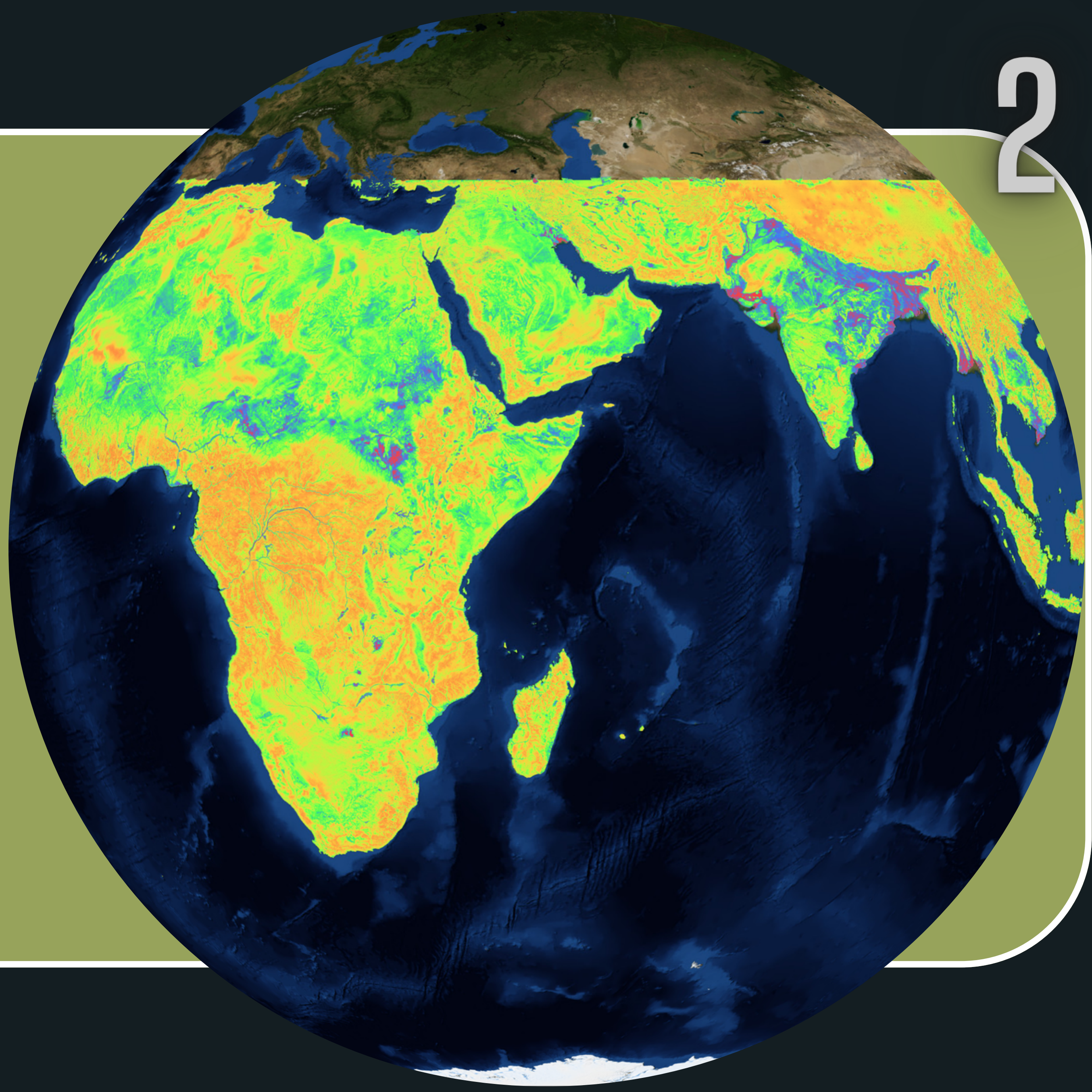
# ALGORITHM FLOWCHART:

1

Reflectivity observations are aggregated over a 3-day time interval and gridded to 3 km, using the EASE grid 2.0. Observations are corrected for antenna gain, range, and incidence angle, assuming coherent reflections. We currently use v2.1 CYGNSS data.

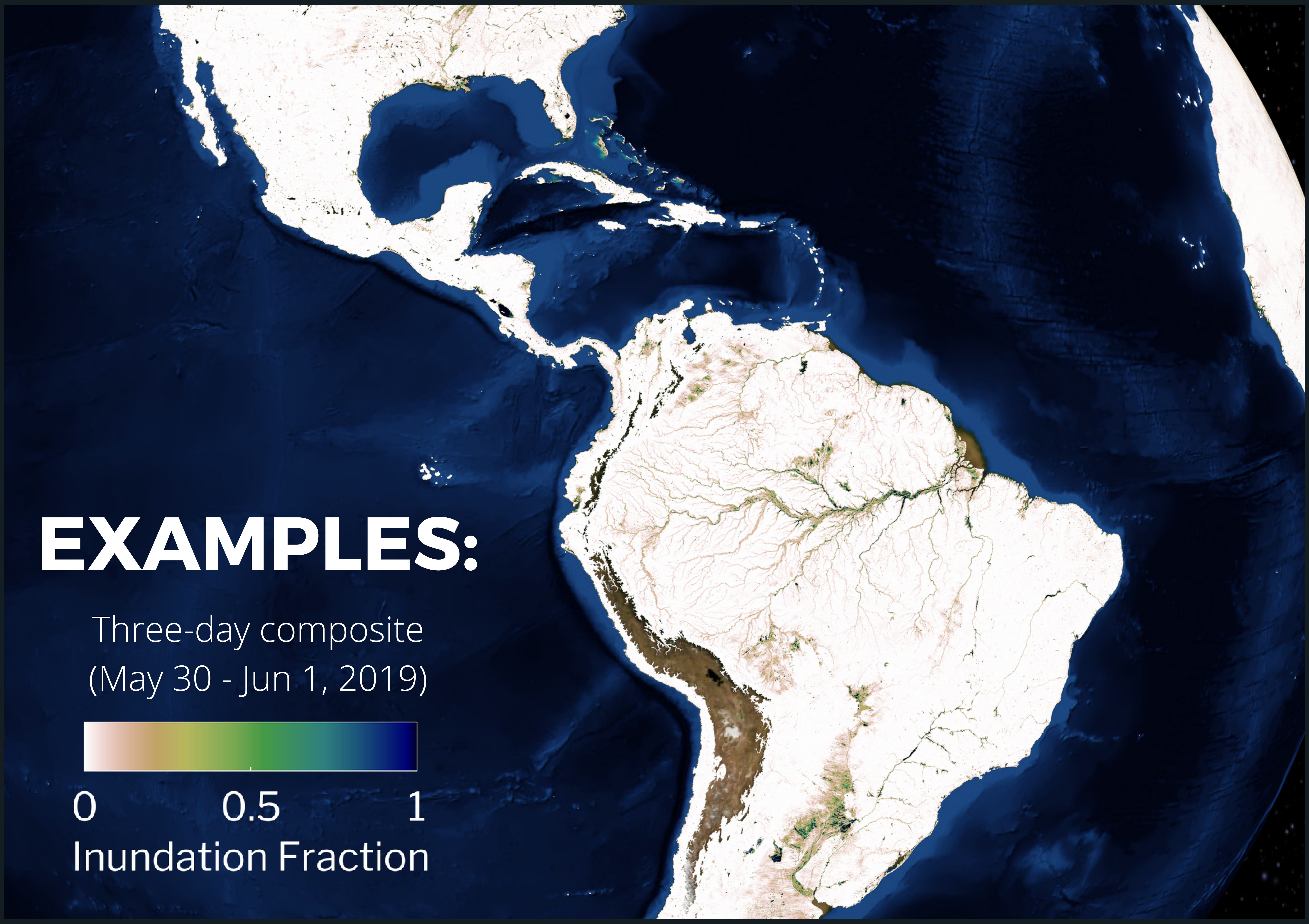
2

The gridded reflectivity observations are spatially interpolated using the POBI method (Chew, 2021). Since POBI is an exact interpolator, users have the choice whether or not to use the interpolated grid cells.

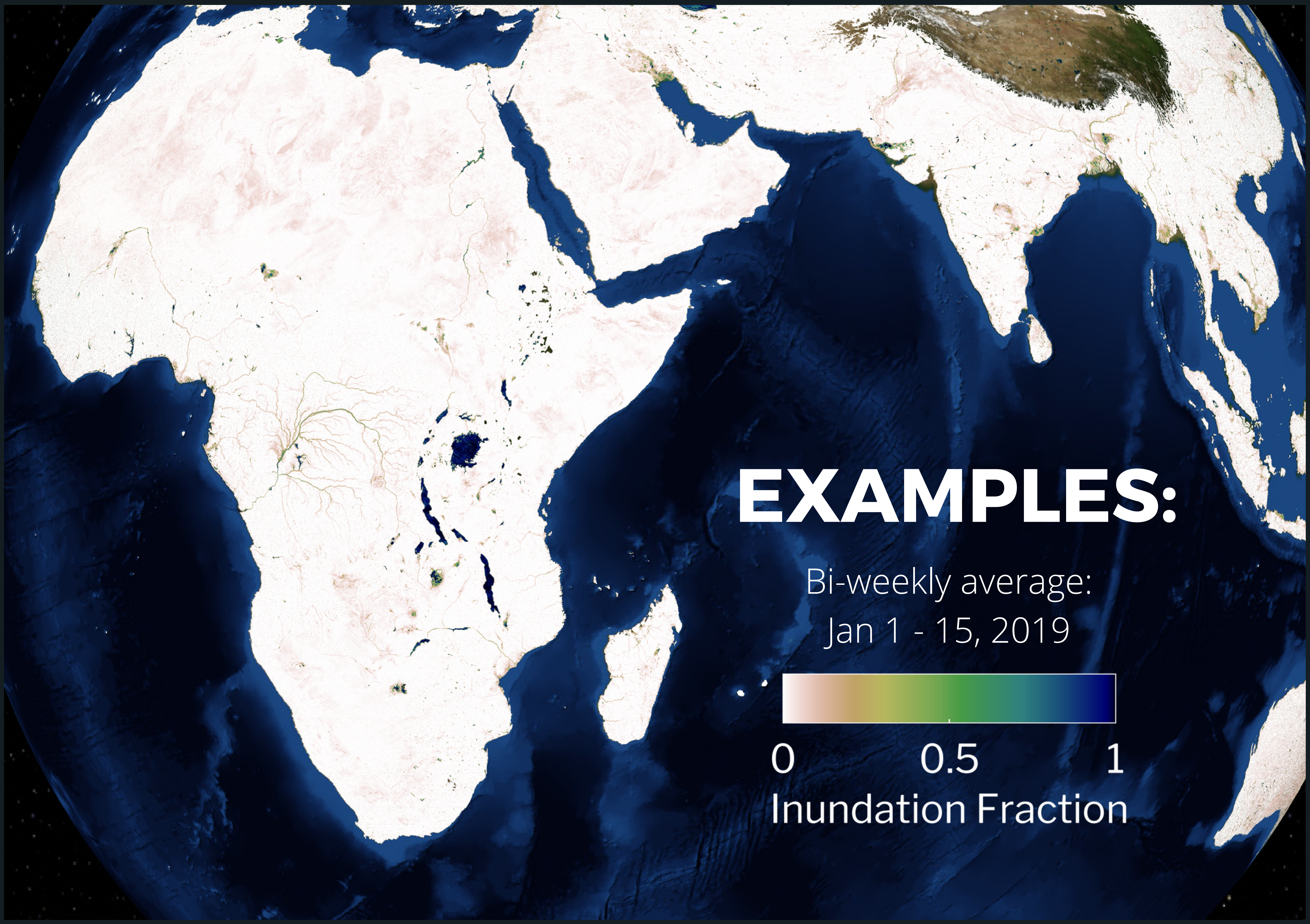


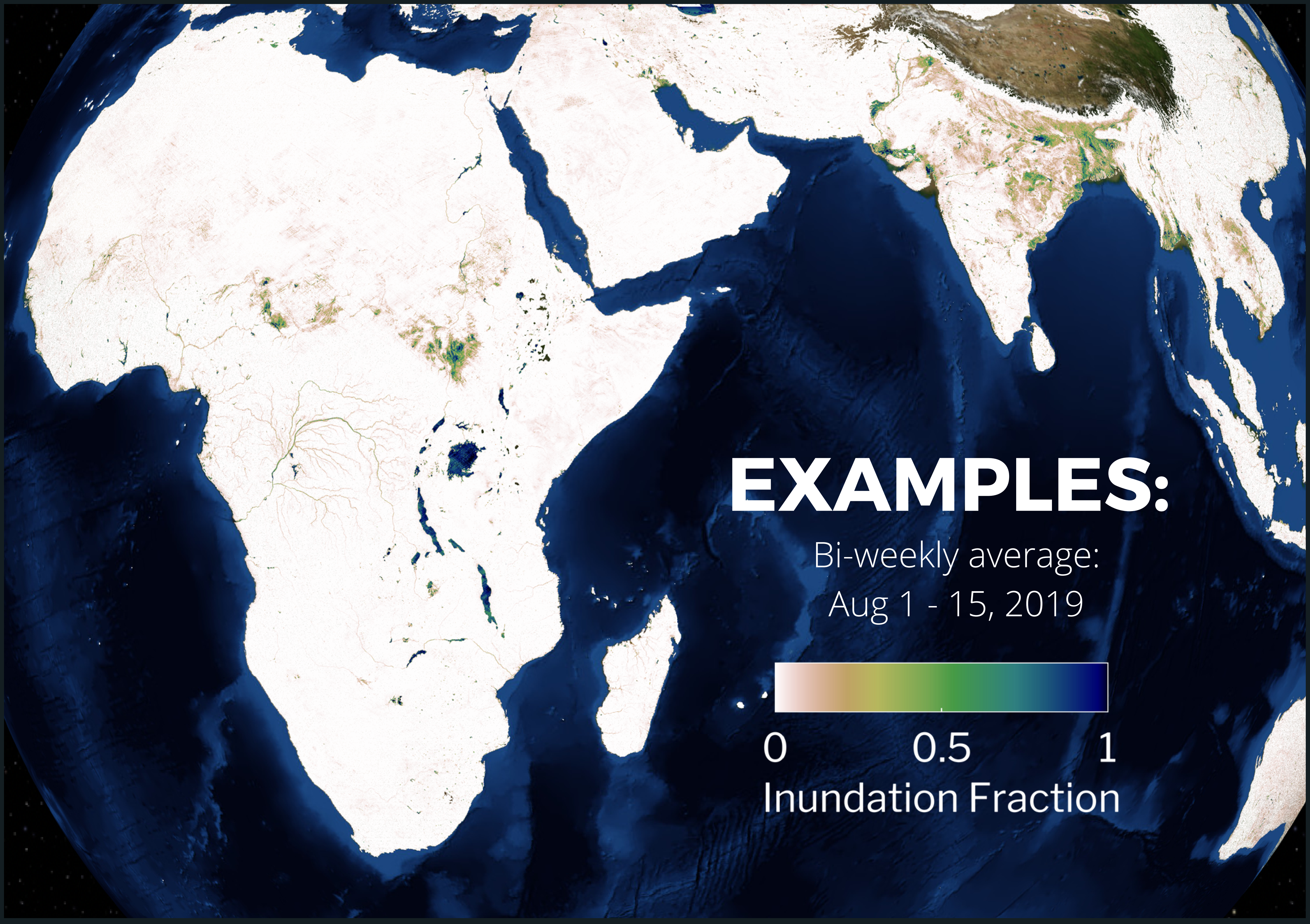
3

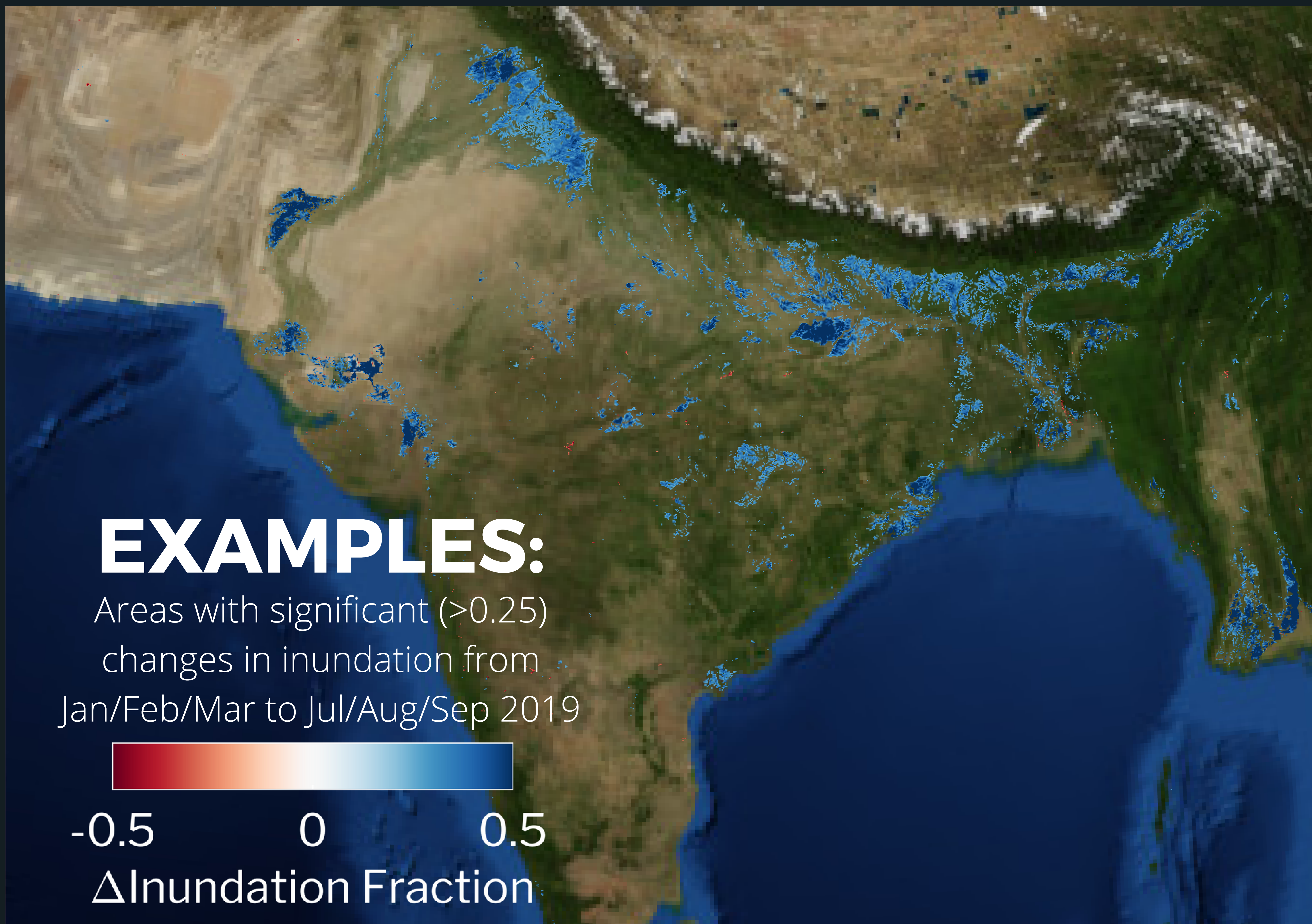
The interpolated reflectivity observations are converted into fractional inundation using a model presented in Chew and Small (2020). The model parameterization and validation are described in Chew and Small (2022, in review). A value of 1 indicates a fully inundated grid cell, and a value of 0 indicates no water presence.


EXAMPLES:
Three-day composite
(May 30 - Jun 1, 2019)
0
0.5
1
Inundation Fraction


EXAMPLES:
Three-day composite
(May 30 - Jun 1, 2019)
0
0.5
1
Inundation Fraction


EXAMPLES:
Bi-weekly average:
Jan 1 - 15, 2019
0
0.5
1
Inundation Fraction


EXAMPLES:
Bi-weekly average:
Aug 1 - 15, 2019
0
0.5
1
Inundation Fraction


EXAMPLES:
Areas with significant (>0.25)
changes in inundation from
Jan/Feb/Mar to Jul/Aug/Sep 2019
-0.5
0
0.5
ΔInundation Fraction


EXAMPLES:
Areas with significant (>0.25)
changes in inundation from
Jan/Feb/Mar to Jul/Aug/Sep 2019
-0.5
0
0.5
ΔInundation Fraction

# SOURCES OF UNCERTAINTY:

These inundation maps can often contain significant uncertainty. As with all remote sensing products, we advise users to familiarize themselves with sources of uncertainty such that they can properly interpret the output. This is just a brief overview--a detailed description of uncertainty can be found in Chew and Small (2022, in review).

**Uncertainty in reflectivity observations**
CYGNSS was not designed to map surface inundation, and the data are not calibrated for remote sensing of the land surface. We estimate an average uncertainty in the reflectivity observation itself to be +/-1.74 dB. Because the relationship between reflectivity and inundation fraction is not linear, this introduces uncertainty into our inundation estimates that varies depending on inundation extent. Larger values of fractional inundation have larger uncertainty ranges, and vice versa. This is reflected in the upper- and lower- inundation bounds contained in the data files. Averaging inundation maps over time beyond their posted 3-day files smooths out some of this uncertainty.

**Uncertainty due to spatial interpolation**
The spatial interpolation method we use from Chew (2021) assumes that current reflectivity observations vary spatially according to previous spatial behavior. By definition, floods do not follow expected behavior! The interpolation method can, and does, fail for some very anomalous events. The interpolation method performs better in regions that flood regularly.

**Uncertainty due to inaccurate model parameterization and ancillary data**
Our inundation retrieval algorithm requires ancillary knowledge of soil moisture, soil surface roughness, and water roughness. There can be significant uncertainty in all of these inputs. *In particular, the loss of SMAP soil moisture data for the latter half of June - July, 2019, will lead to an overestimation of inundation during this time period.*

**Overall, Chew and Small (2022, in review) found that the root mean square difference (RMSD) between our CYGNSS fractional inundation maps and independent maps of surface inundation tends to be between 0.05 and 0.2. Higher RMSDs were more common during flooding events relative to 'dry' time periods without significant flooding, with CYGNSS tending to underestimate flood extent during severe events.**