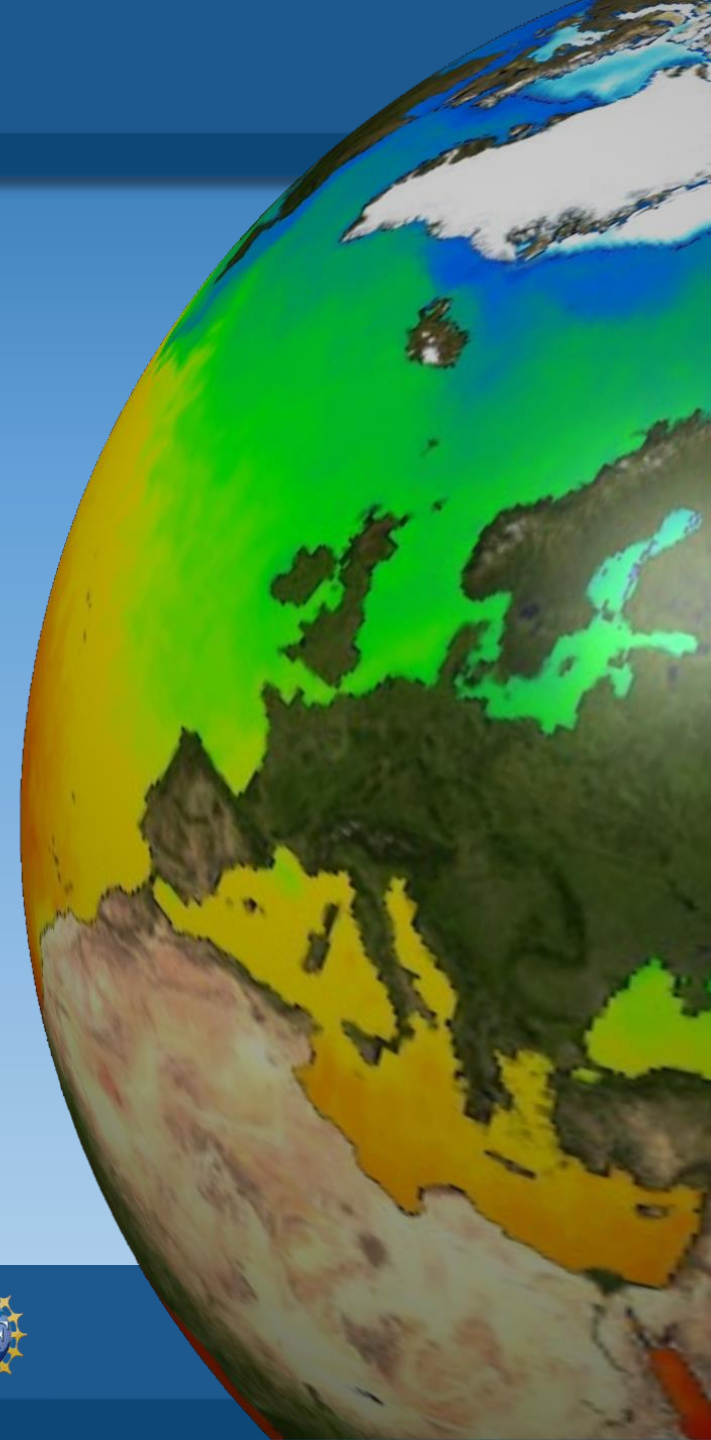


Exploring Geoscience with AR/VR Technologies

Tim Scheitlin

*Computational & Information Systems Laboratory (CISL),
National Center for Atmospheric Research (NCAR),
Boulder, Colorado, USA*

Using ECMWF's Forecasts (UEF2018)
Reading, UK
5-8 June 2018



Presentation Overview



Meteo AR



Meteo VR

- Brief Introduction to NCAR
- Project Motivation
- Summer SIParCS Program
- Meteo AR/VR Apps
- Adding ECMWF Data to the Apps
- Future Directions and Interests
- Try it for yourself!

Brief Introduction to NCAR

- National Center for Atmospheric Research, Boulder, CO
- Mission: Understand...atmosphere and geospace systems...and to **foster the transfer of knowledge and technology** for the betterment of life on Earth.

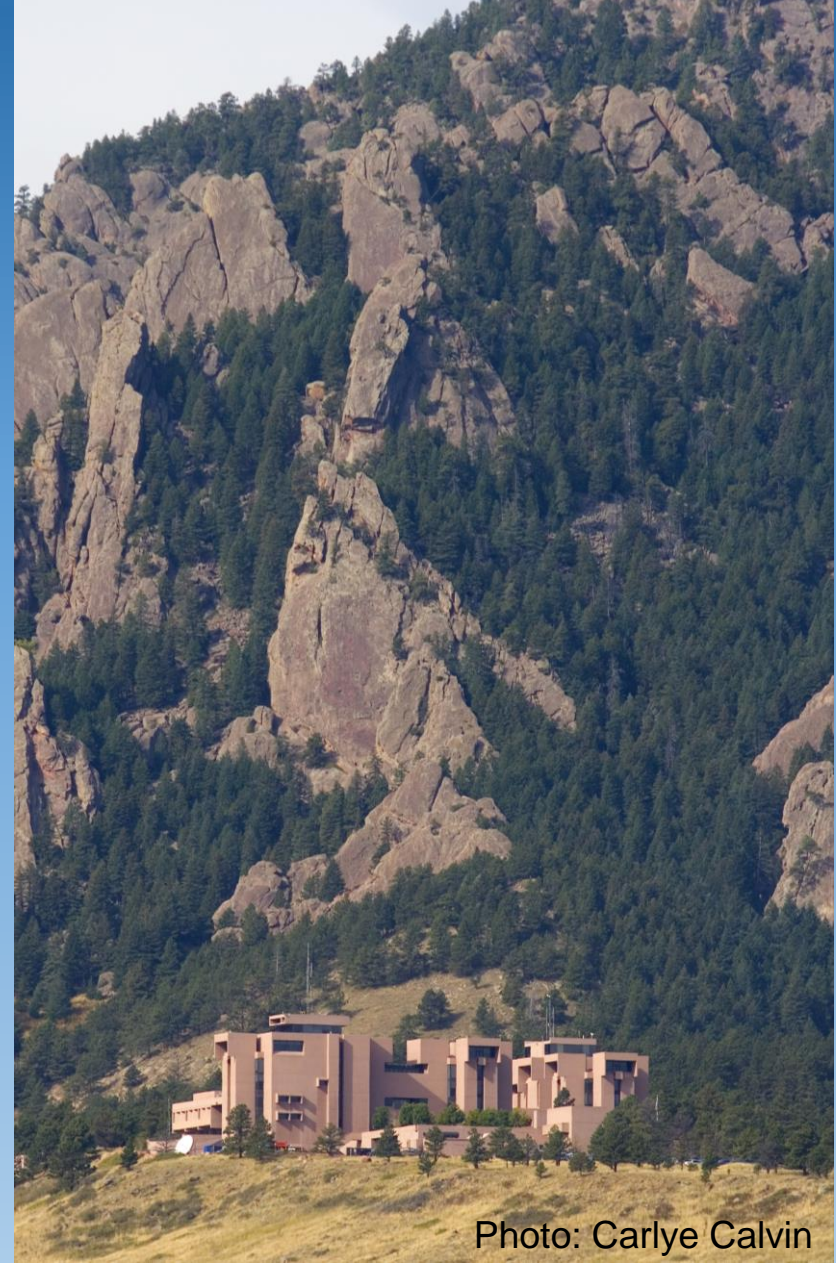


Photo: Carlye Calvin

Data center and computing resources

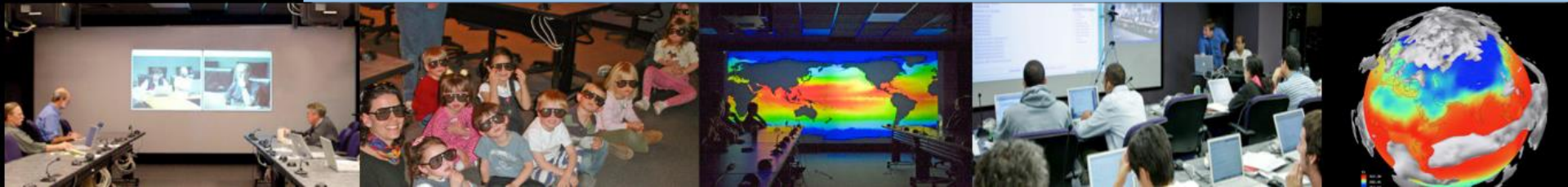
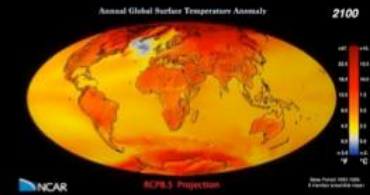
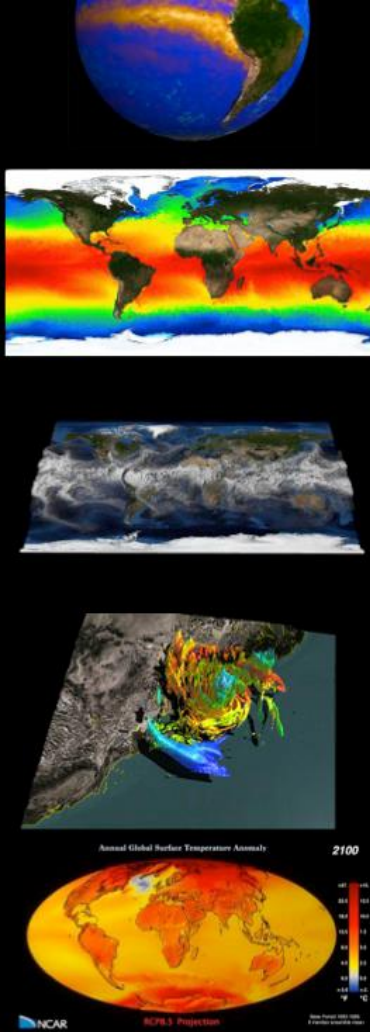
Computational and Information Systems Laboratory (CISL) supports the computing resources for NCAR.

- Yellowstone (retired) – 1.54 petaflops
- Cheyenne: 5.34 petaflops
- Glade: 53 PB rotating disk
- HPSS: 320 PB tape archive



Visualization Lab

- Organizational resource for collaborative meetings, 3D presentations, and classroom instruction.
- Used for Training, Education, and Outreach to diverse audiences including K-12, post-secondary, adult students, and the general public, as well as scientific, governmental, and corporate visitors.
- Provides support to scientists for developing compelling visualizations suitable for presentation, communication, and publication.
- Supports 3D rendering of large datasets to foster awareness and understanding of NCAR science and research.



Project Motivation

How can we educate, engage, and make our data and visualizations more accessible to a wider and more diverse audience?

- In the Virtual Reality (VR) world, a large flat screen or a 3D projection is used to display data and visualizations.
- We want to make our data and visualizations more accessible to a wider and more diverse audience's smartphones and tablets.
- Users should be able to interact with the data and visualizations.



<https://blog.davemdavis.net/2015/01/23/virtual-reality-vs-augmented-reality-vs-holograms/>

What is Virtual Reality (VR) ?

- VR is an environment in which the user is fully immersed in a virtual/ synthesized environment
- Can be achieved with a smartphone and Google Cardboard or head mounted displays (HMDs) (E.g. Oculus rift, OSVR ...)
- The phone displays a split screen image/video

OSVR headset



Google Cardboard



Split screen view



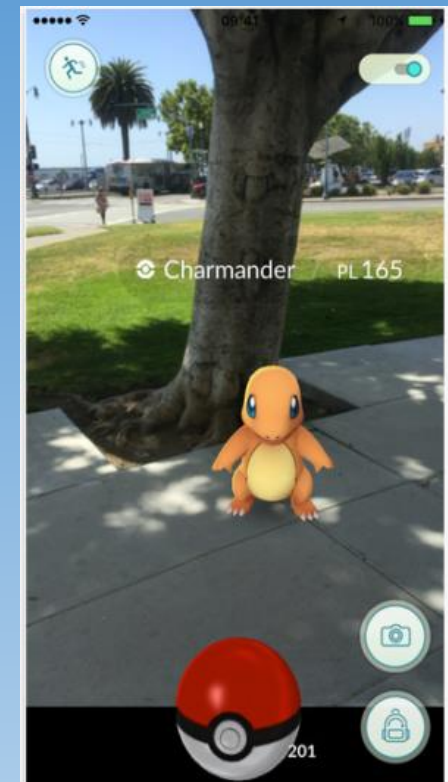
What is Augmented Reality (AR) ?

- Augmented reality allows the user to see the real world with virtual objects superimposed on it
- Can be achieved with smartphones, tablet computer or head mounted displays (HMD)

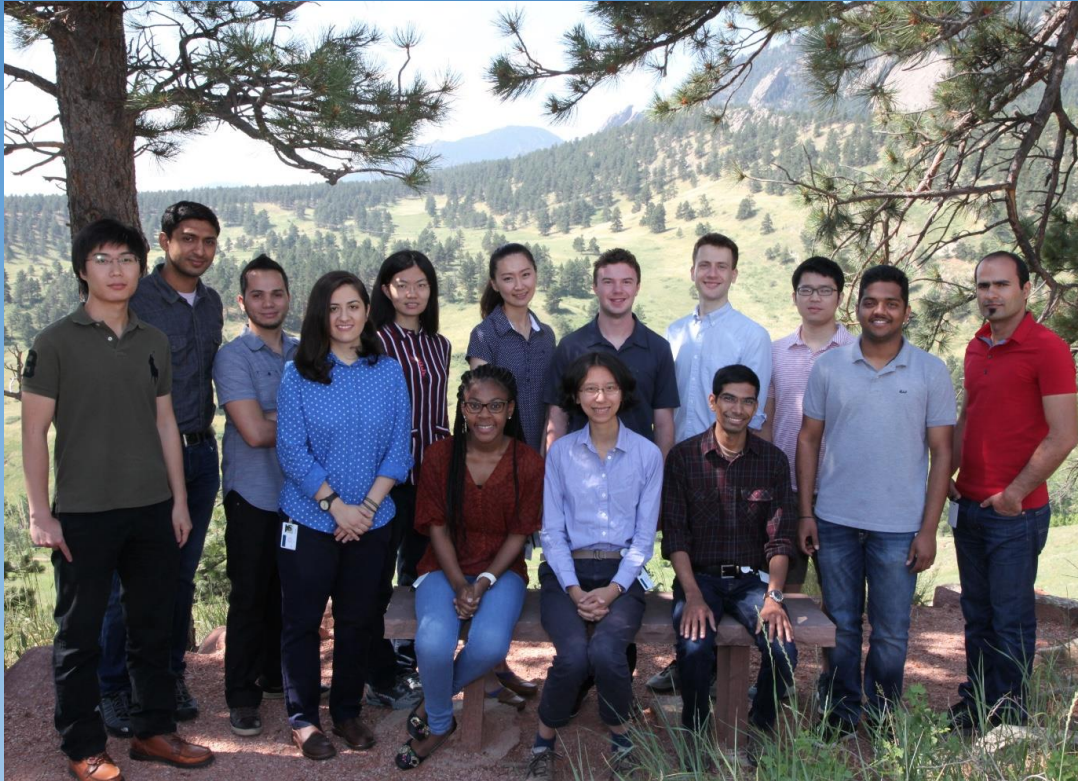
* Microsoft's HoloLens



Pokémon Go



2016 SIParCS Interns



- Makes a long-term, positive impact on the quality and diversity of the workforce needed to use and operate 21st century supercomputers.
- Offers undergraduate and graduate students hands-on R&D opportunities in High performance computing (HPC).
- Embeds students as interns in CISL for an 11-week session.

SIParCS Summer Project in Virtual Reality



Summer Project Proposal: Develop a Google Cardboard VR app for exploring and manipulating Earth science data by displaying 3D scenes on a smart phone.

Nihanth Cherukuru: Lead Developer and AR/VR expert
Matt Rehme: Content Developer and viz expert



<https://dzone.com/>

Meteo VR and Meteo AR

Interactive, Educational, & Free



Meteo VR



Meteo AR



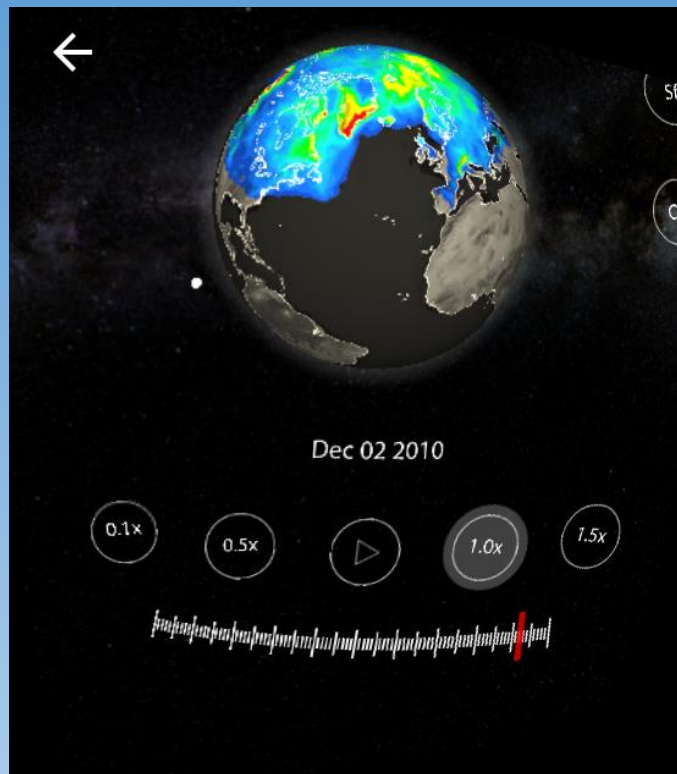
Downloads in the last 12 months

Application	iOS	Android
Meteo AR	1235	764
Meteo VR	148	41
Total = 2188	1383	805

Meteo VR (Virtual Reality)



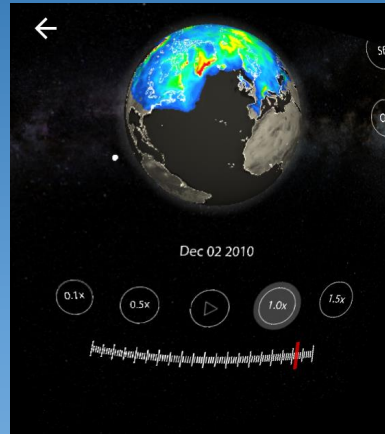
Meteo VR



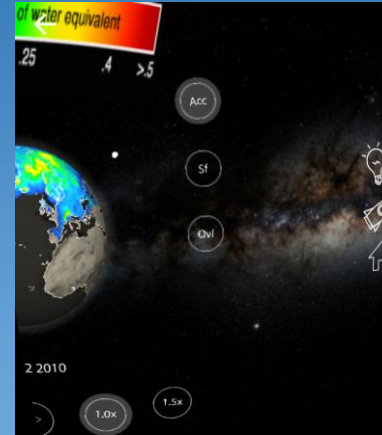
Meteo VR user interface



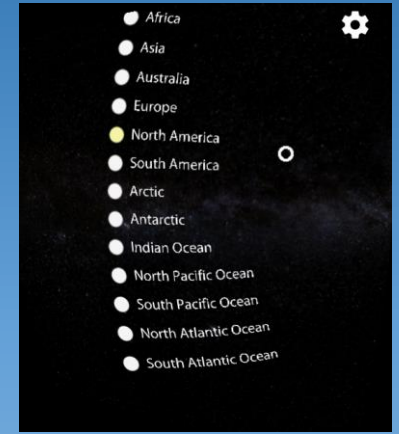
Choose a dataset



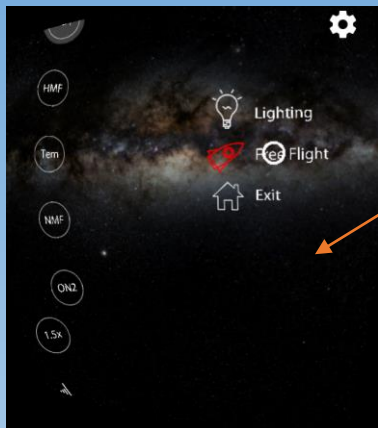
Animate



Choose a variable



Choose a view



Navigate

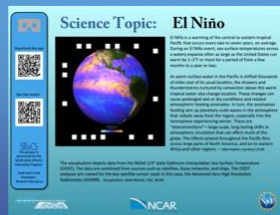
Double-click
to get out



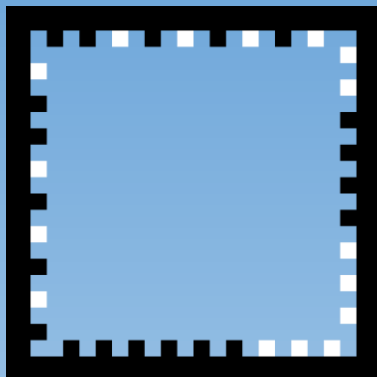
Meteo AR (Augmented Reality)



Meteo AR



AR Marker



Science Topic: Surface Wind Speed



The magnitude of surface wind speed during a one year period is shown in this visualization using data from a high resolution (1/4 degree) simulation of present day climate using the Community Earth System Model (CESM).

Bright, rotating, areas represent storm systems that move through the mid-latitudes in both hemispheres, and sharp lines in the wind field are weather fronts tied to these storms.

Things to look for:

- Wind speeds are higher over the ocean and are reduced by surface friction after storms make landfall. Land masses in the Northern Hemisphere slow storm propagation in the mid-latitudes. Whereas in the Southern Hemisphere, strong westerly winds are unhindered between 40-50 degrees south, giving rise to the term "the roaring 40s."
- The Hawaiian Islands sit in the path of the Trade Winds, creating a wind shadow on the leeward (downwind) side of the islands.
- Tropical storms that stray out of the tropics can be captured by synoptic storms, curving them eastward and transporting large amounts of heat, moisture, and energy to higher latitudes

This visualization shows surface wind speed across the planet over the course of one year. Brighter areas represent higher wind speeds.

- Visualization: Matt Rehme, CISL, NCAR.
- Computational Modeling: Susan Bates and Nan Rosenbloom, NCAR.

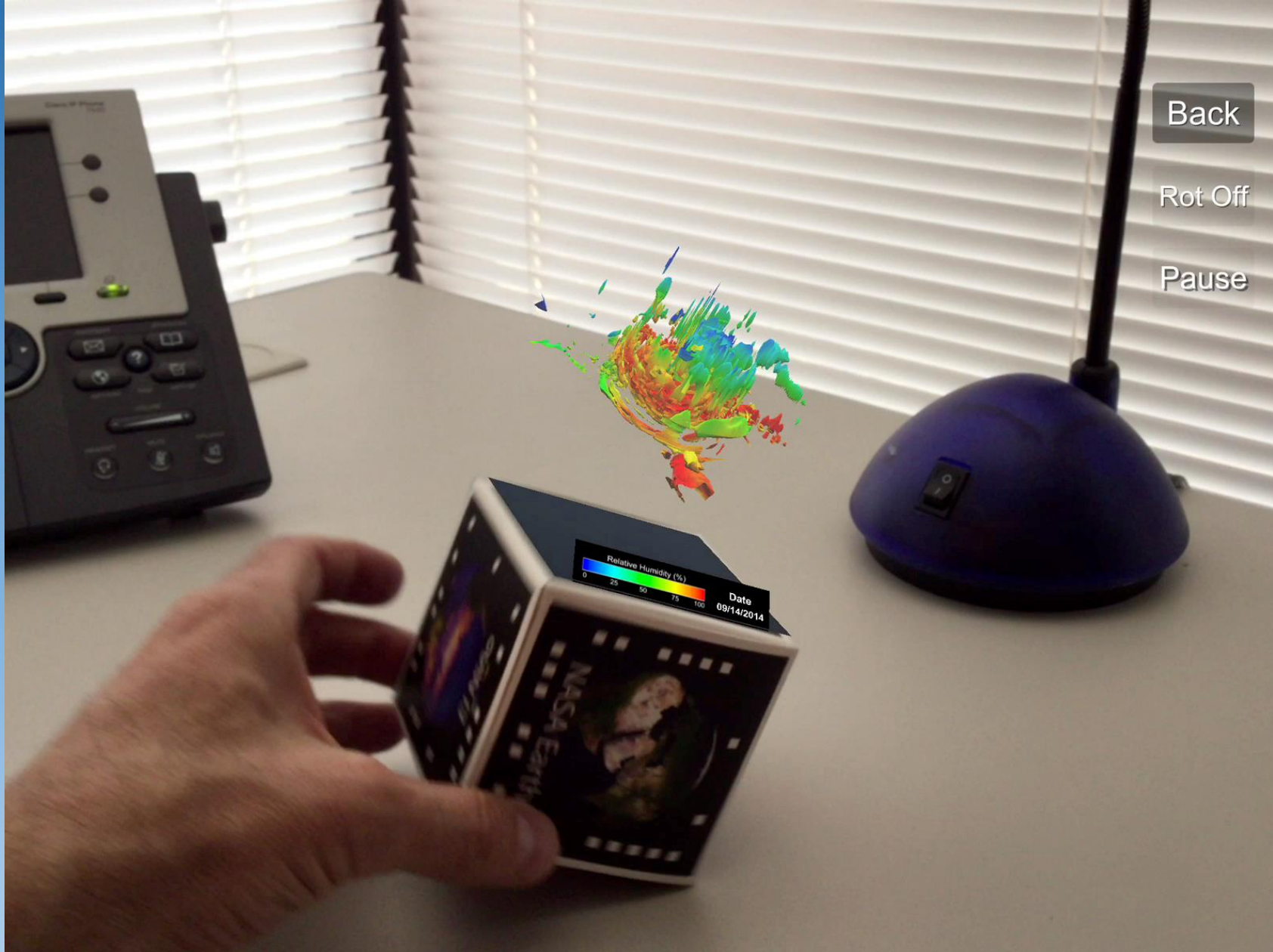


Meteo AR

An Augmented Reality interface for exploring 3D earth science datasets

Meteo AR Cube





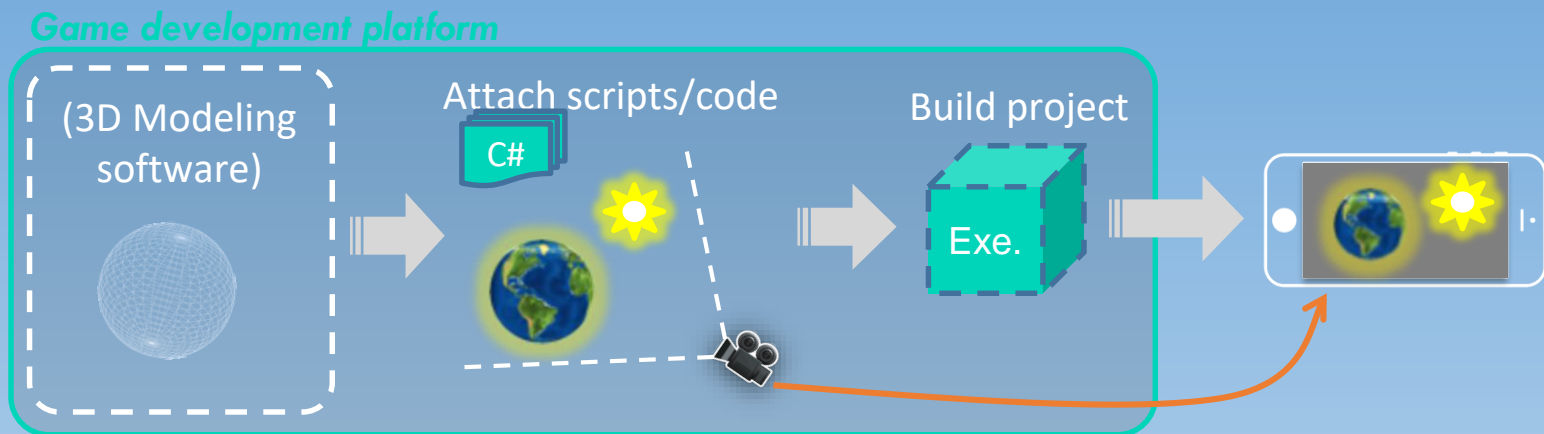
Back

Rot Off

Pause

Game development platforms

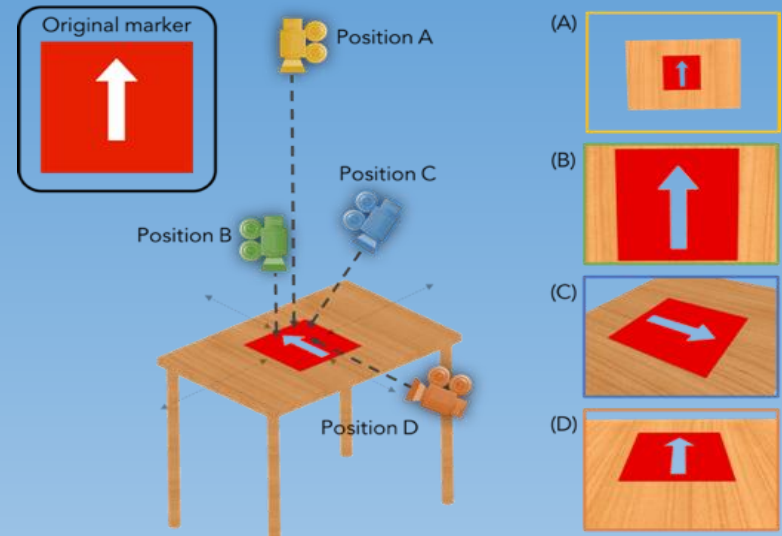
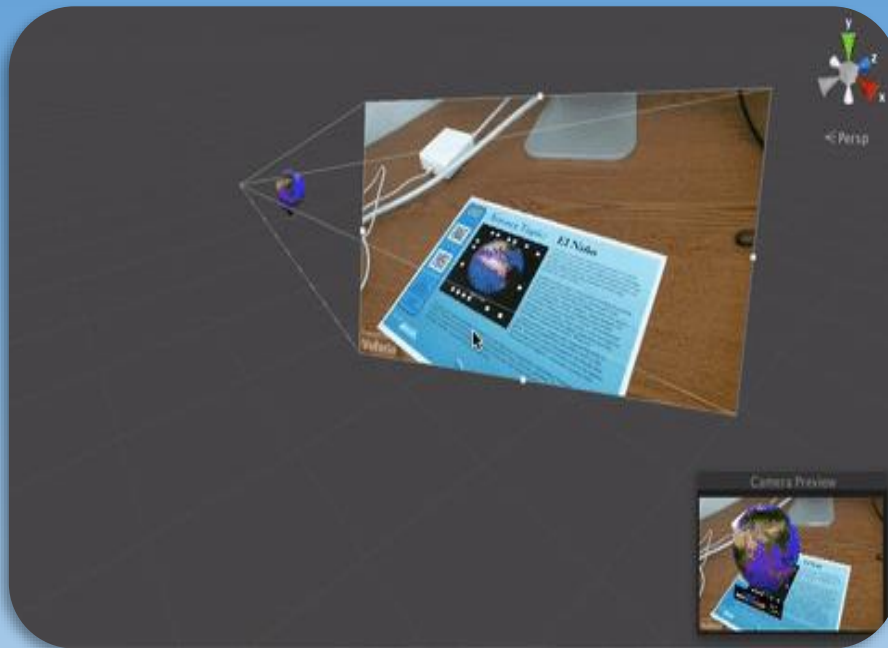
- They are tools to create computer games
- E.g. Unity, Unreal, Cryengine ...
- Unity was chosen based on its popularity and extensive documentation
- Typical workflow:
 - a) Create or import computer models
 - b) Attach scripts (computer code) to specify mechanics and the logic
 - c) Package and create an executable version of the game



Computer Vision Techniques (AR Version)

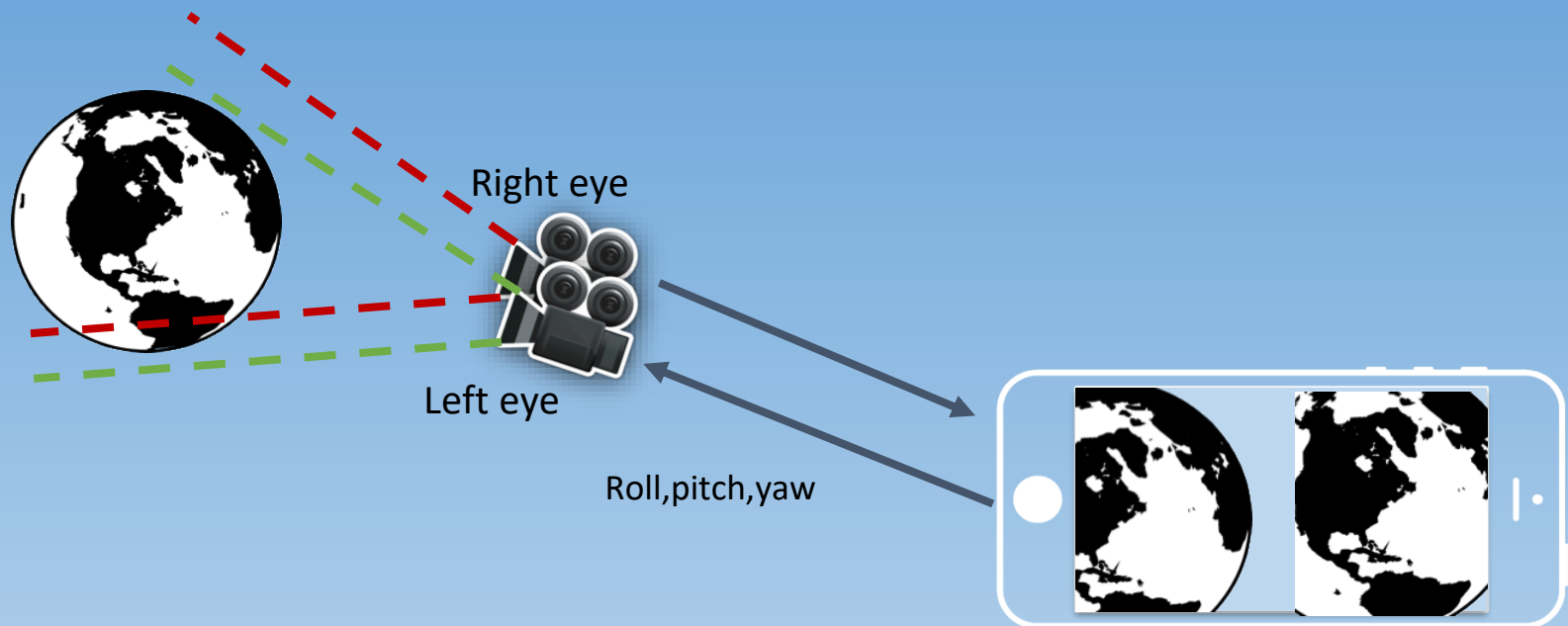
Marker on the science sheet is used to:

- 1) Identify the dataset
- 2) Track the device in 3D space

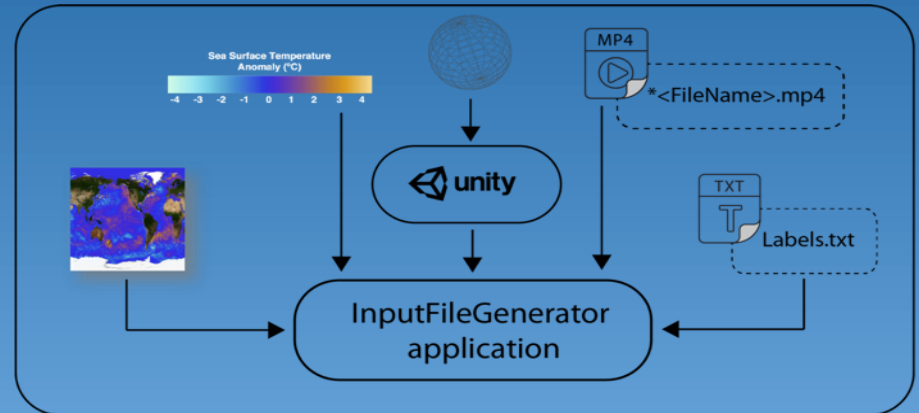


VR version

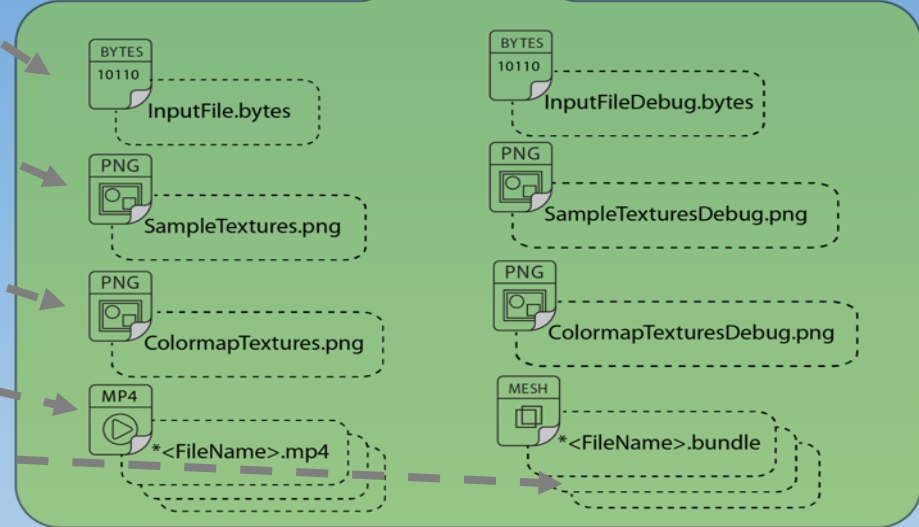
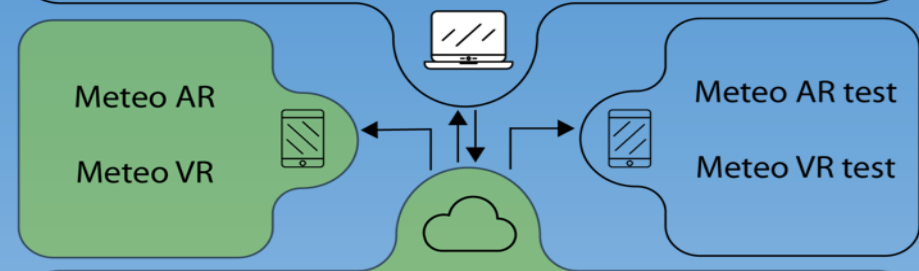
- One image per eye is captured by two virtual cameras to obtain the image to be displayed on the screen
- The virtual cameras mimic the orientation of the device by obtaining the attitude information of the physical device



Server Side

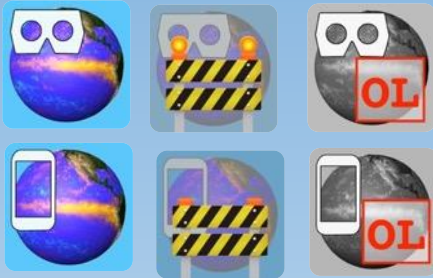
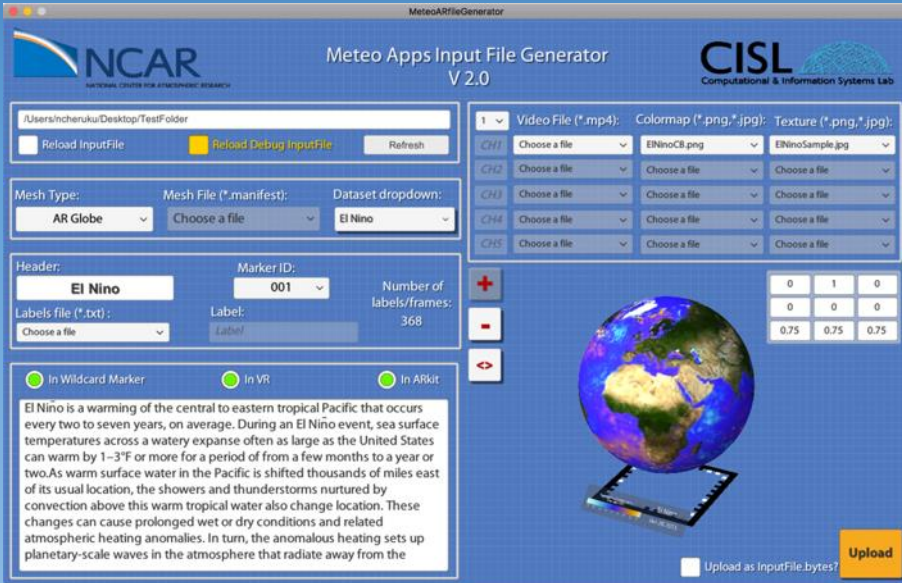


- Stores dependencies
- Texture atlas to display startup image
- Texture atlas of colormaps
- Video file for each dataset
- Mesh file for generic datasets

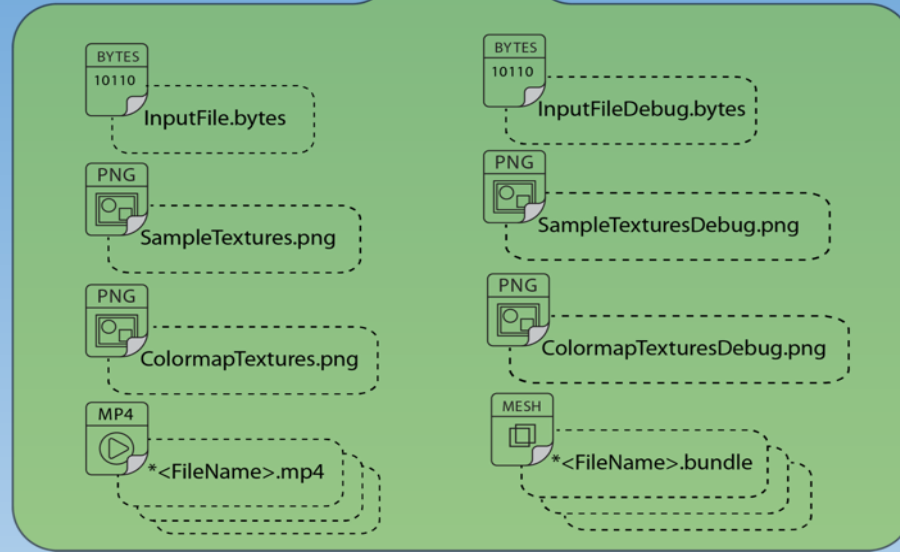
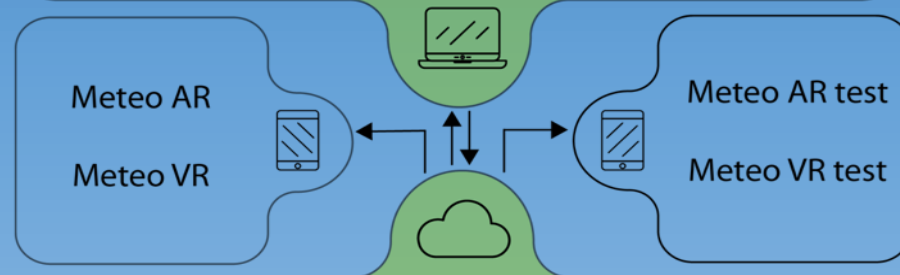
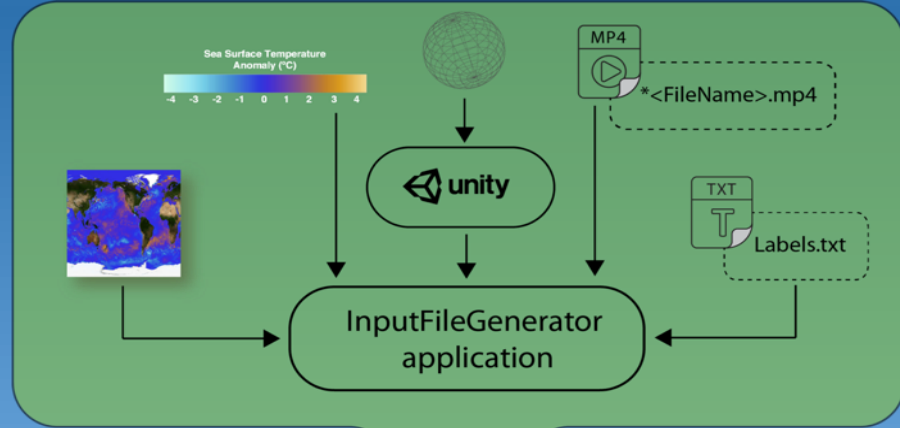


Data Providers

- Desktop app built in Unity and seamlessly integrates with AWS



Production, Test, and Offline Versions

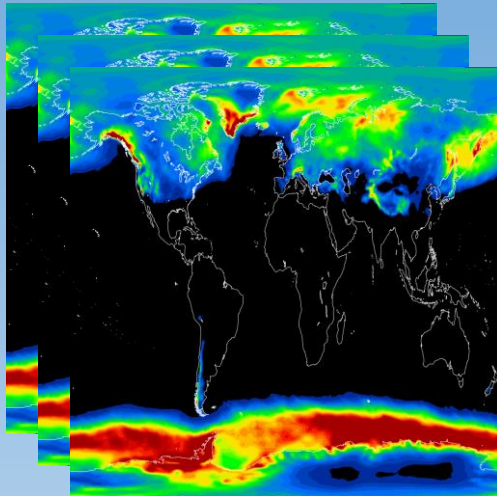


Adding ECMWF Data to Meteo Apps

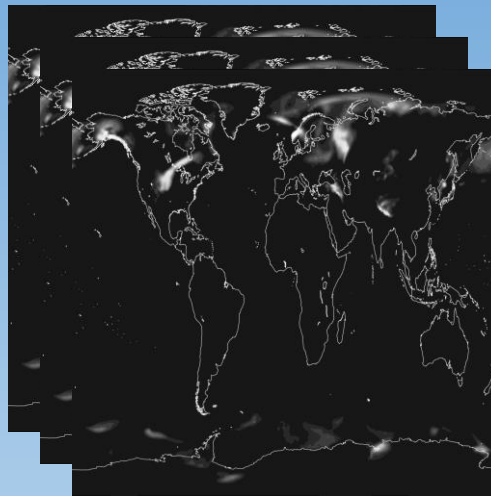


- Downloaded snowfall data from MARS System
 - ERA-Interim/LAND Global Climate Reanalysis
 - Variable: 2010 Snowfall, 480x241, netCDF, ~500 MB
- NCAR Command Language (NCL) generates CE contour plots:
 - ~200 LOC in the NCL script
 - Daily Snowfall
 - Accumulated Snowfall

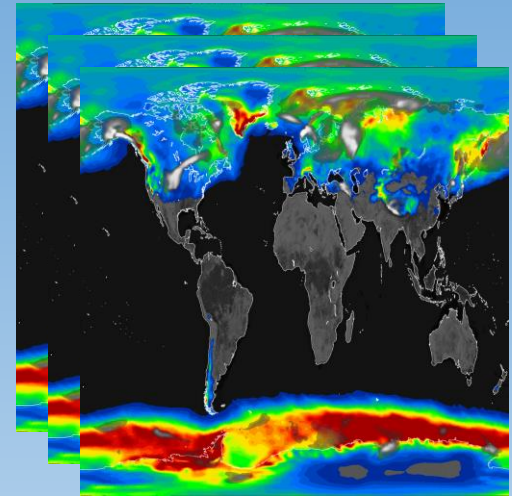
Snowfall Accumulation



Snowfall



Overlay

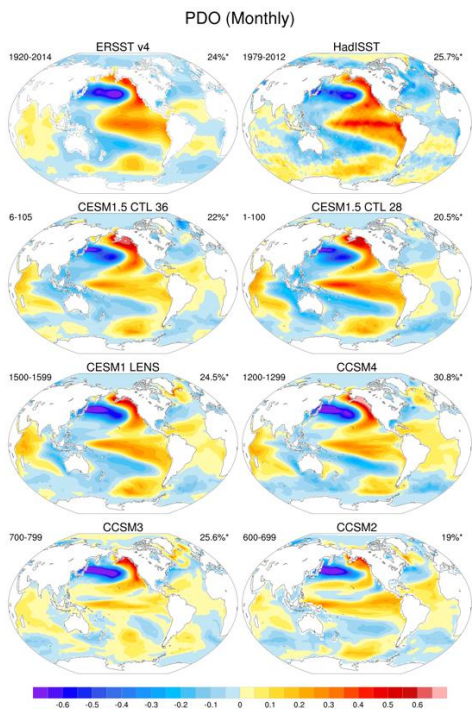


NCAR Command Language

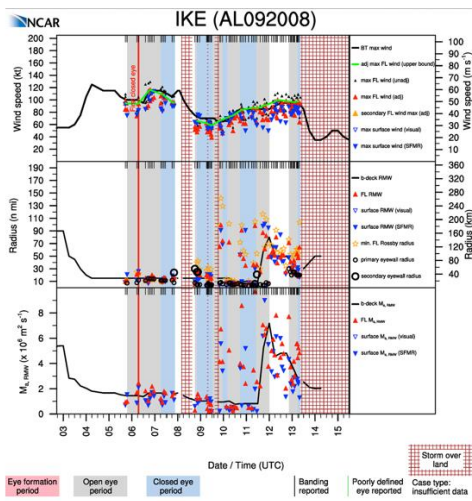
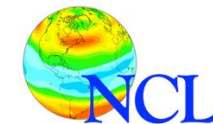
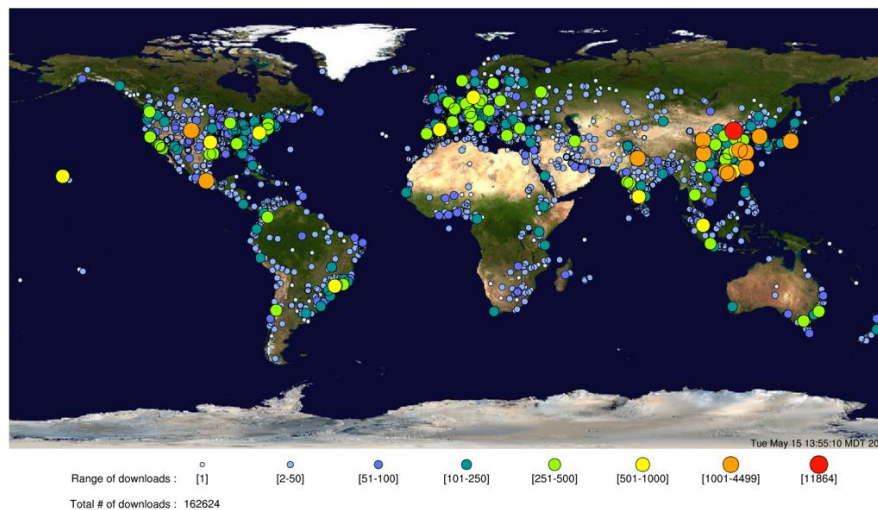
<https://www.ncl.ucar.edu/>

Scripting language tailored for the analysis of geoscientific data

- robust file I/O
- specialized computational routines
- publication-quality visualizations
- intensive training workshops
- well-supported
- hundreds of examples

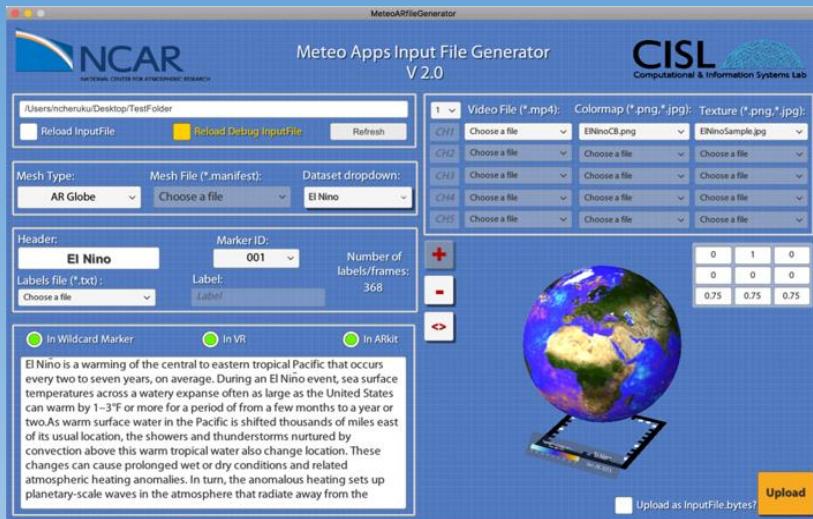



Location and number of NCL downloads : March 2010 to May 2018



Adding ECMWF Data to Meteo Apps


- MP4 files generated with Quicktime Pro
- Meteo Apps InputFileGenerator application used to ingest imagery
- Tested and published to AWS.
- Science sheet added








Download the app
Download on the App Store
GET IT ON Google play

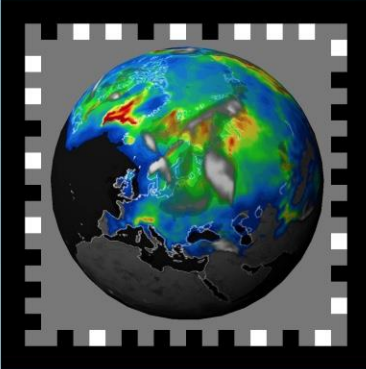
To learn more about this science topic visit the ECMWF website at <https://www.ecmwf.int>



This project is sponsored by the NCAR 2016 SIParCS Internship Program.
Lead Developer: Nihanth Cherukuru



Science Topic: ECMWF Snowfall



Scientists and researchers combine data from many sources to create global datasets that describe the recent history of the atmosphere, land surface, and oceans. Data from computer models and observations are combined to produce “reanalysis” datasets, which were used to create this animation of annual (2010) snowfall across the globe.

Three buttons labeled Sf, Acc, and Ovl, let you toggle between the daily Snowfall (Sf), Annual Accumulation (Acc), and an Overlay (Ovl) of the two together.

A climate reanalysis gives estimates of atmospheric parameters such as air temperature, pressure and wind at different altitudes, and surface parameters such as rainfall, soil moisture content, and sea-surface temperature. Reanalysis data are used for monitoring climate change, for research and education, and for commercial applications.

The data shown here were provided by the European Centre for Medium-Range Weather Forecasts (ECMWF) using their meteorological data archive (MARS) system. MARS is the largest of its kind in the world and continues to grow. As of January 2018, it contains around 200 petabytes of operational and research data, with about 200 terabytes being added daily. More than 400 billion meteorological fields are stored in MARS. - Information provided by the ECMWF web page.

Data description: Daily time steps from the ECMWF ERA-Interim/LAND Global Climate Reanalyses dataset. The Grid size is .75 deg x .75 deg and the variable (snowfall) is measured in meters of water equivalent.
Visualization: Tim Scheitlin, CISL, NCAR.

iPad Demo



Photo courtesy Jenna Preston and Elliott Foust

Future Directions and Interests

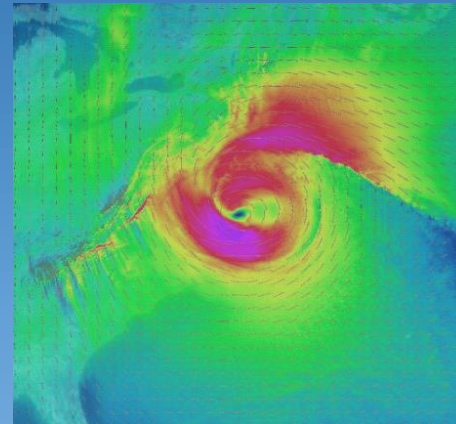
- Markerless AR (ARkit)
- Adding real time weather forecasts
- Work with a partner to develop a curriculum around AR/VR
- Release a version for content developers (to host on their own site)
- 3D printed models with AR overlays



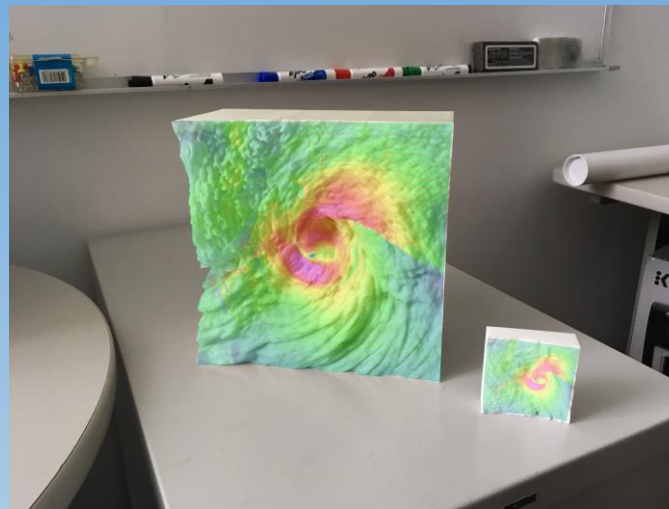
Future Directions: 3D printing with AR overlay



3D Hurricane courtesy
Scott Pearse (NCAR)



Hurricane windspeed
visualization



Thank you! & Questions?

Download the Meteo Apps to your device.



Meteo VR



Meteo AR



Extra Slides



Meteo AR

Exploring Geoscience with Augmented Reality

Meteo AR (bit.ly/NcarMeteoApp case sensitive) is a free Augmented Reality (AR) application that runs on iOS and Android devices. It displays interactive virtual objects, like an animated globe or a hurricane, over real world imagery that is captured by your mobile device's camera. The app works with downloadable "science sheets" that include background information about science topics like El Niño, Hurricanes, Climate Change, and more.

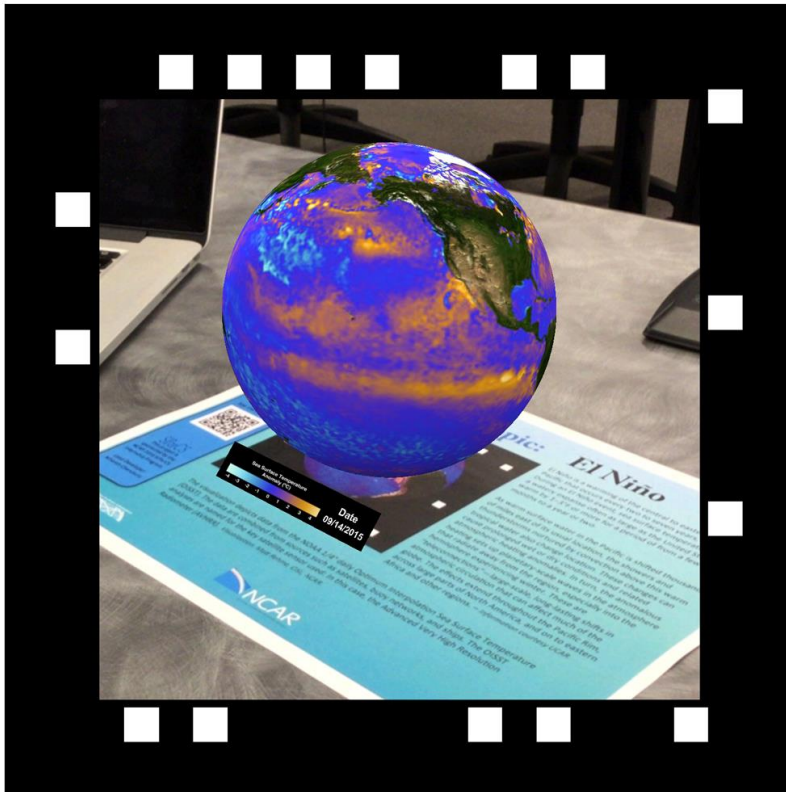
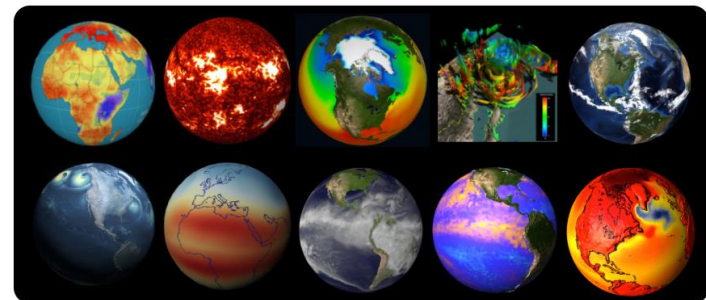
Two Simple Steps

1. Download the Meteo AR app from the Google Play (Android Devices) or the Apple Store (iOS devices).



2. Run the app and point your mobile device's camera at the image to the left. A virtual object will soon appear!

The image is interactive. Rotate the object with a finger swipe across the screen or explore many other science topics like those shown here!



Science Topic: Hurricane Odile
Print out (in color or black and white) a collection of science sheets to explore more topics:
<http://bit.ly/NcarMeteoApp-ScienceSheets>
(Case Sensitive)



AR

Mobile devices (\$200-1000)



<http://www.augmentedrealitytrends.com/ar-app/top-augmented-reality-apps-for-ipad.html>

Vuzix Smart Glass (\$1500 est.) + phone



<https://www.vuzix.com/Products/m3000-smart-glasses>

Microsoft HoloLens (\$4000) + PC



<https://www.microsoft.com/en-us/holoLens/hardware>

VR

Google Cardboard (\$15) + phone



https://store.google.com/product/google_cardboard

Samsung Gear VR (\$99) + phone



<https://consumermediallc.files.wordpress.com/2015/01/samsungvr.jpg>

HTC Vive (\$500) + PC



<http://heavy.com/tech/2016/11/top-best-vr-headset-virtual-reality-oculus-rift-htc-vive-christmas-gifts-gaming-guide-review>