All-Sky Visualization Using the the Local Analysis and Prediction System (LAPS)

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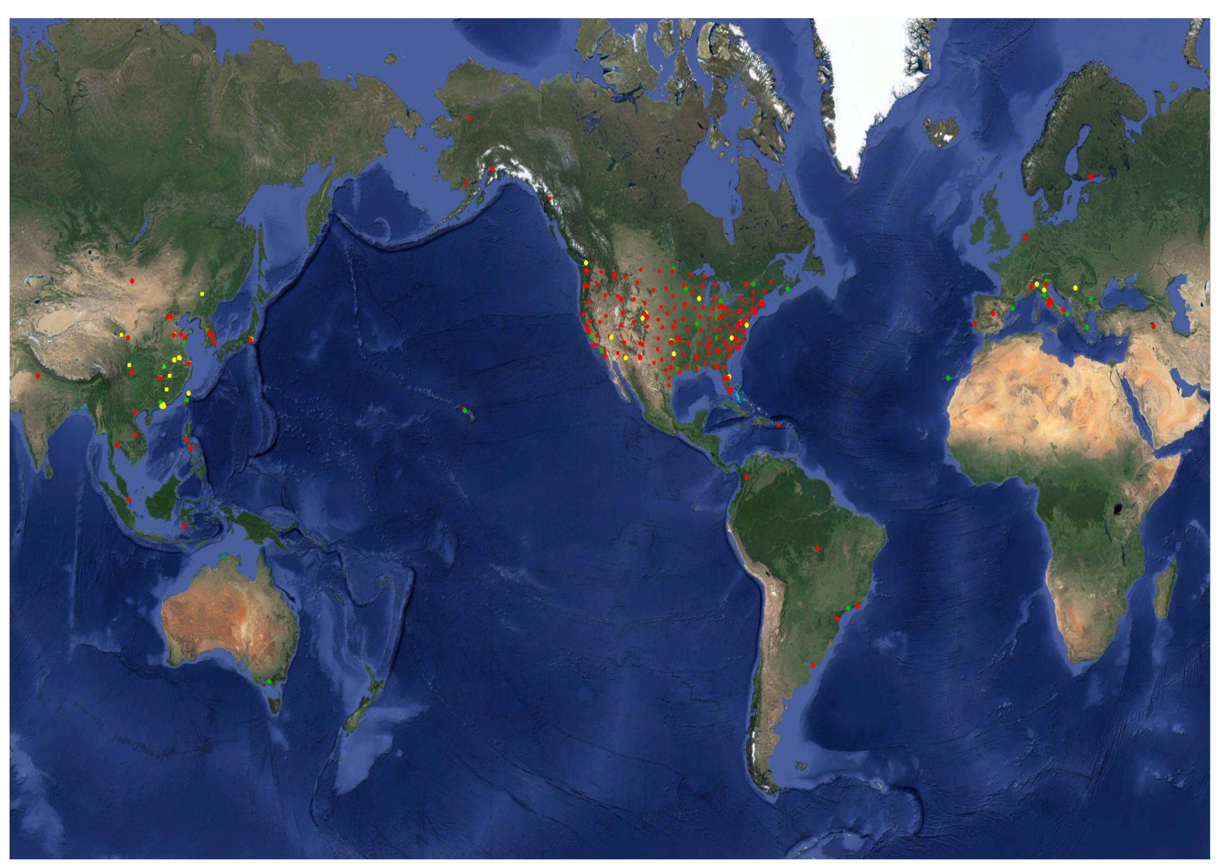
Introduction

- LAPS is used for data assimilation, nowcasting, and model initialization/post-processing
- High Resolution and Rapid Update
- Blends a wide variety of in-situ and remotely sensed data sets (e.g. METARs, mesonets, radar, satellite)
- About 150 group and individual users worldwide
- Federal, state agencies (e.g. NWS, USAF, California Dept. Water Resources)
- Private Sector (e.g. Greenpower Labs)
- Academia (e.g. University of Hawaii)
- International (e.g. Taiwan CWB, FMI)
- **System can be used to analyze and forecast clouds and related sky conditions**



Sites around the world where LAPS is being used

LAPS Attributes

- Analysis has variational and "traditional" options
- LAPS analyses (**with active clouds**) are used to initialize a meso-scale forecast model (e.g. WRF)
- Adjustable horizontal, vertical, and temporal resolution
- Highly portable and efficient software
- **Utilizes 1km, 15min visible satellite imagery along with IR for rapid updating**

For More Information

- **http://laps.noaa.gov**
- **Contact Lead Author Steve Albers**
  - **303-497-6057**
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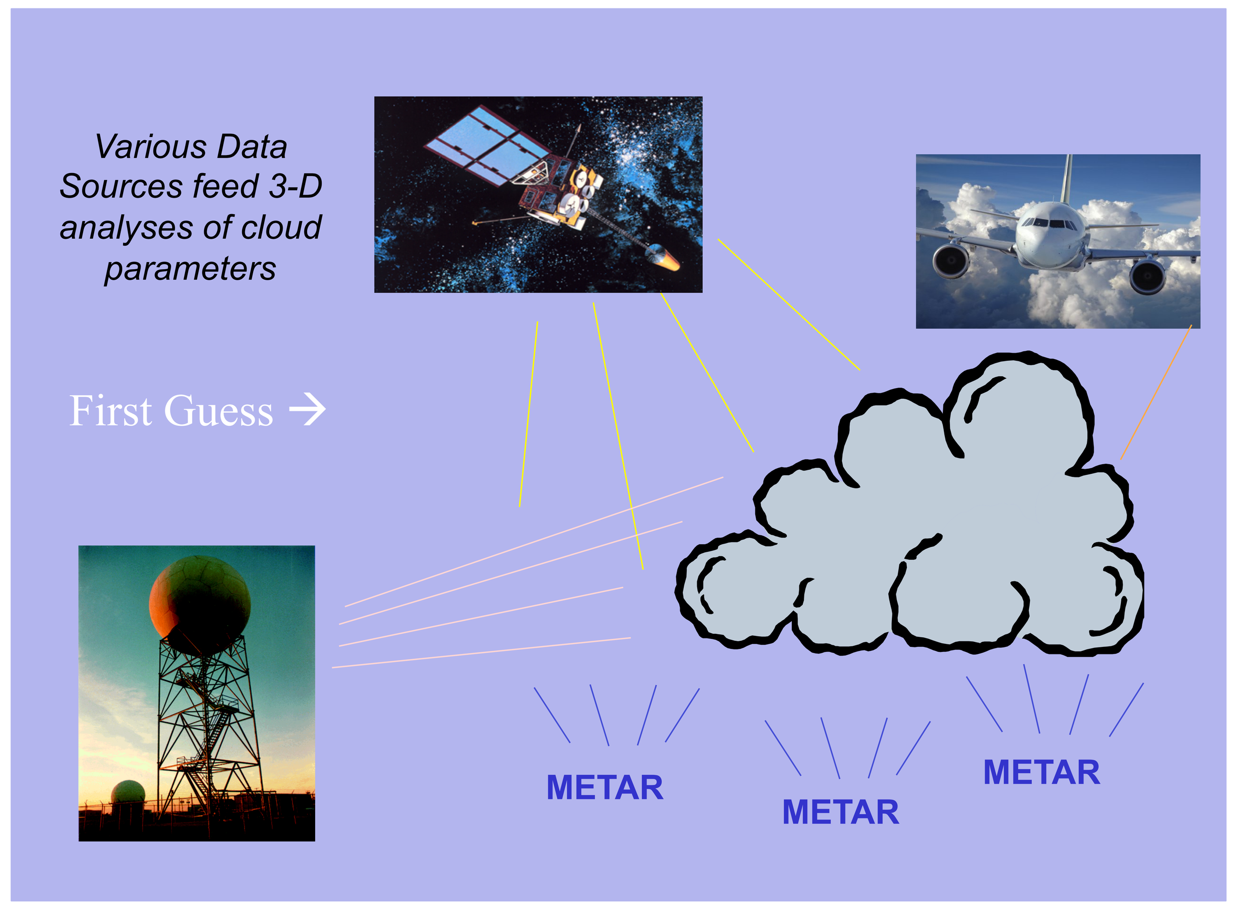
Three-Dimensional Cloud Analysis

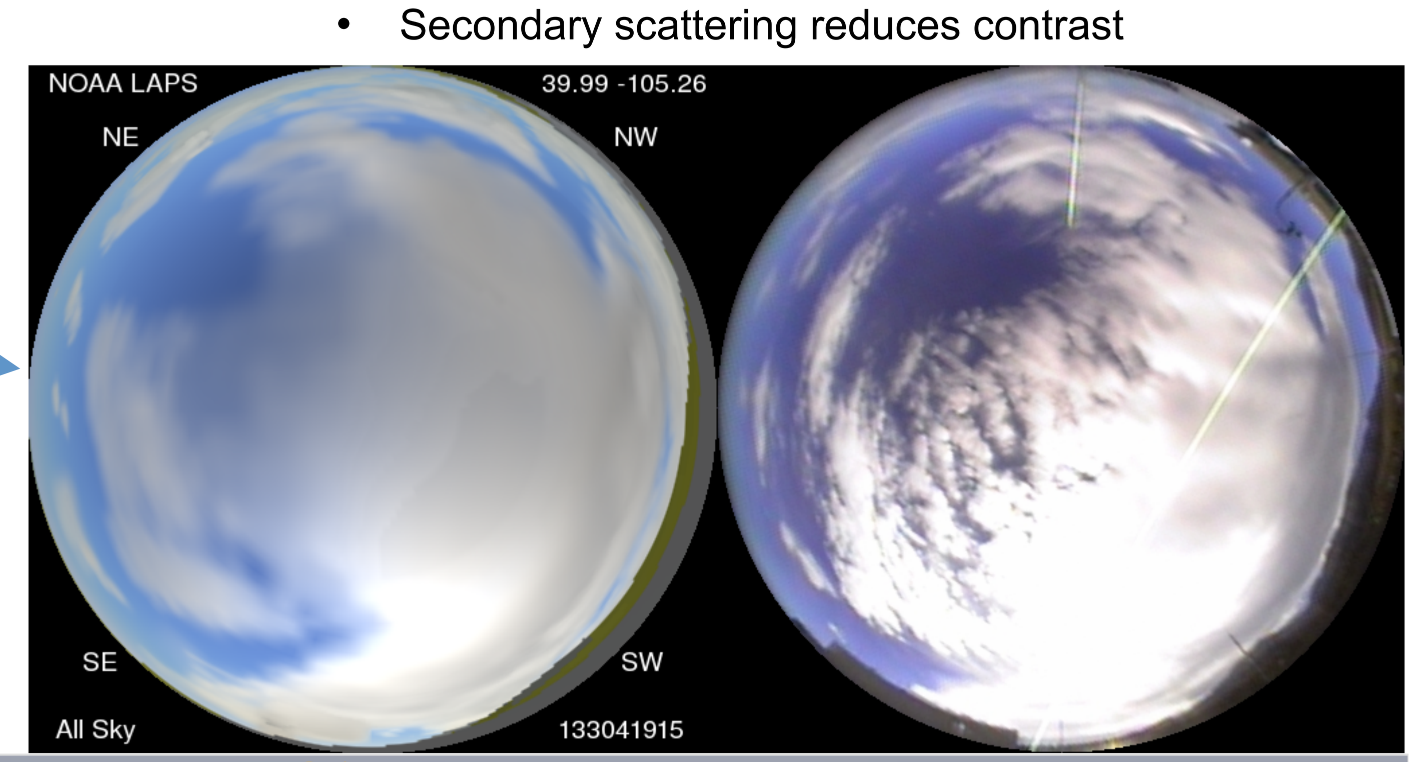


Simulation Ingredients

- 3-D LAPS 1km Resolution Gridded Cloud Analyses (Cloud liquid, ice, snow)
- Specification of Aerosols (haze)
- Chosen from same vantage point as camera
- Location of Sun and other light sources (moon, planets, stars, surface lights)

Polar "Fish-eye" Lens View

Left is LAPS analysis simulation, right is camera image (Moonglow All-Sky Camera)



Cylindrical Panoramic View

Top is re-projected LAPS analysis simulation, bottom is camera image

Visualization Technique

- Illumination of clouds, air, and terrain pre-computed
- Sky brightness based on sun and other light sources
- Ray Tracing from vantage point to each sky location
- Scattering by intervening clouds, aerosols, air molecules
- Terrain shown when along the line of sight
- Physically- and empirically-based for best efficiency

Clear Air Sky Brightness

- Source can be sun or moon
- Rayleigh Scattering by Air Molecules (blue sky)
  - Minimum brightness 90 deg from light source
  - Blue-Green sky color near the horizon far from sun
- Mie Scattering by Aerosols
  - Specified by 3 Henyey-Greenstein phase functions
  - Brightest near the light source and the horizon
- Cloud/Terrain shadows can show crepuscular rays
- Night-time sky brightness from other light sources
  - Planets, stars, airglow, surface lighting
- Earth shadow geometry considered during twilight
  - Secondary scattering reduces contrast

Cloud / Precipitation Scattering

- Mie scattering phase function means things clouds are brighter near the sun (silver lining), cloud corona
- Thick clouds are the opposite, being lit up better when opposite the sun
- Rayleigh scattering by clear air can redden distant clouds
- Future enhancement to add rainbows, halos, etc.

All-Sky Web Page

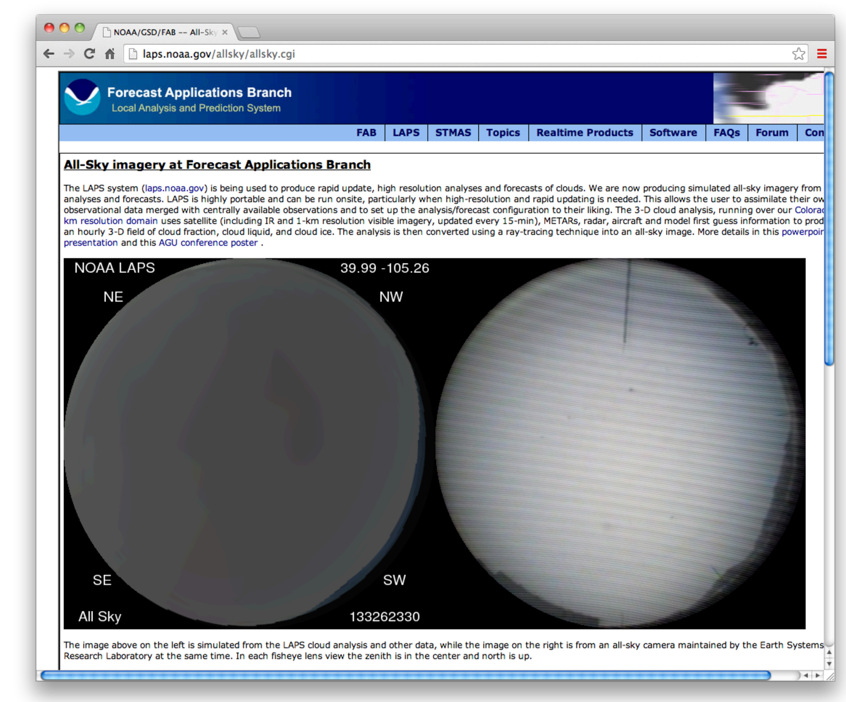
Qualitative Comparison

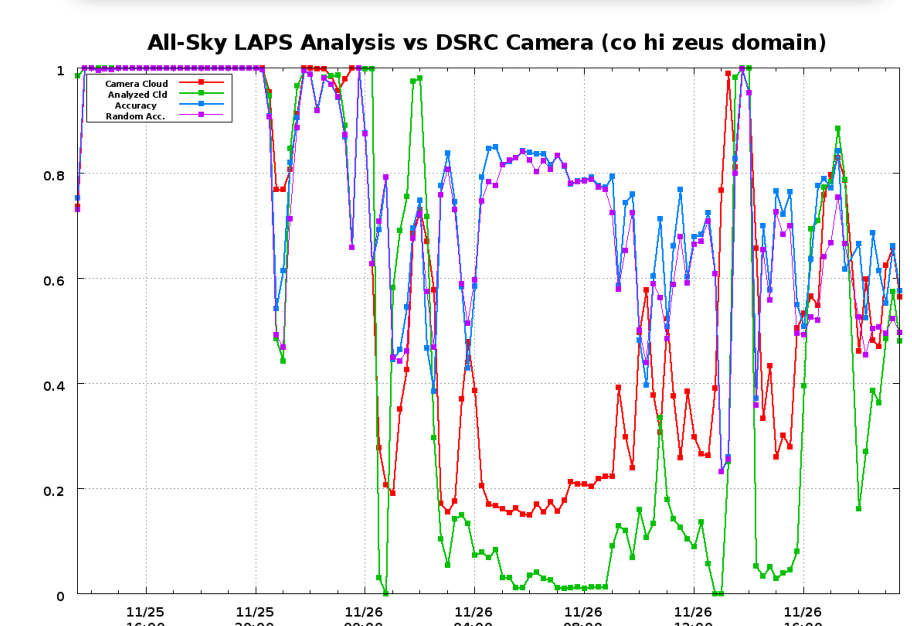
Objective Verification Under Development

Cloudy Fraction (Observed and Simulated)

Accuracy (Pct correct)

Accuracy of Random Cloud Placement (for reference)





Results

- Helps guide improvement of analyses and model initialization
- Fit is reasonable for a 1km analysis resolution
  - cloud placement better than random statistic
- Helps communicate capabilities of high-resolution real-time LAPS model, displaying output for both lay and scientific audiences

Future Modeling Improvements

- Develop improved variational cloud analysis and hot-start (e.g. with CRTM)
- Hot-start with more consistent clouds and water vapor
- Ensure analysis / model consistency with microphysics, radiation, and dynamics