Trident Warrior 2013: Demonstrating the Use of Unmanned Aerial Vehicles for Characterizing the Marine Electromagnetic Propagation Environment

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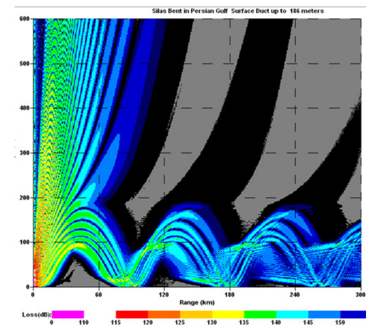
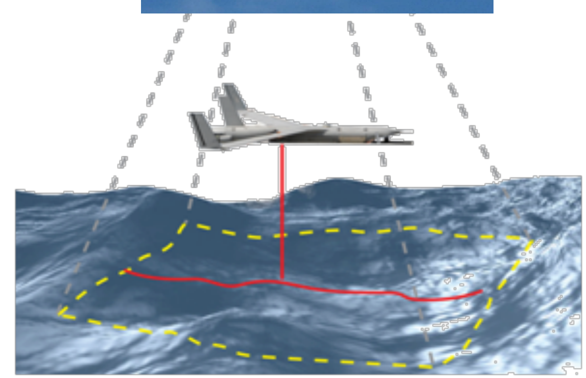
This presentation is **UNCLASSIFIED.**

Outline

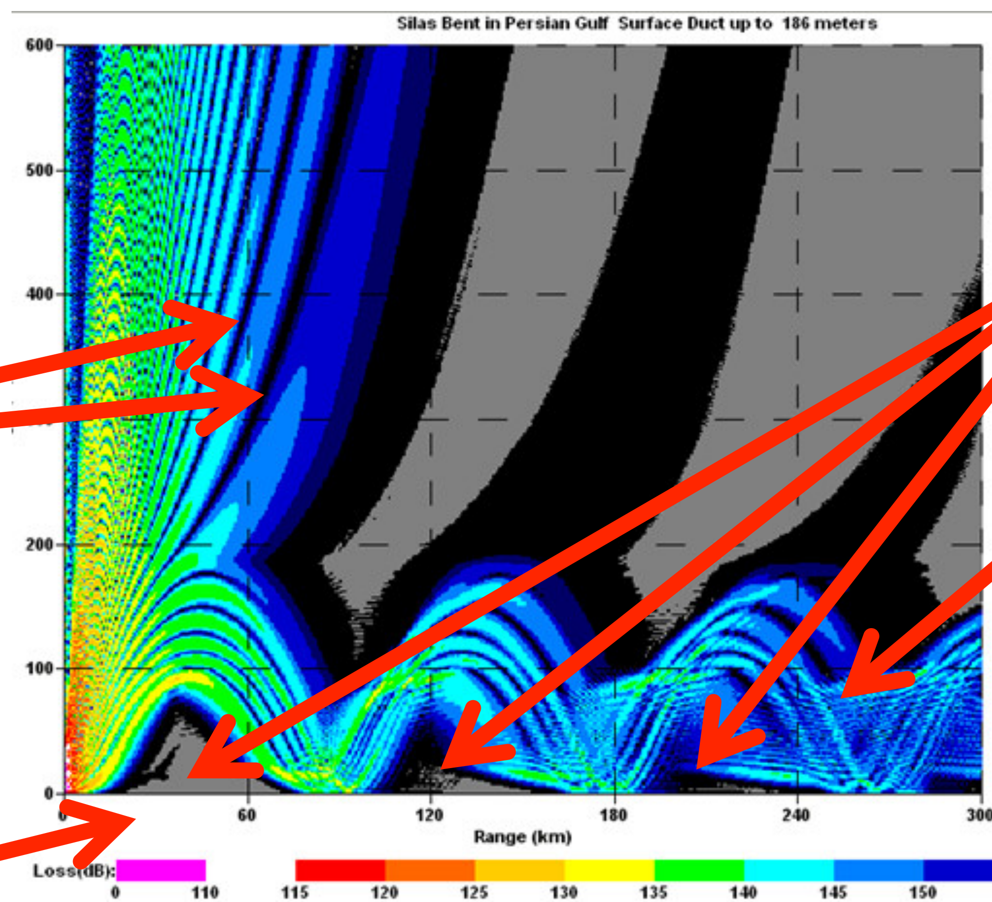


- EM Radiation Background
- InstantEye
- Trident Warrior 2013
- Summary
- Future Work

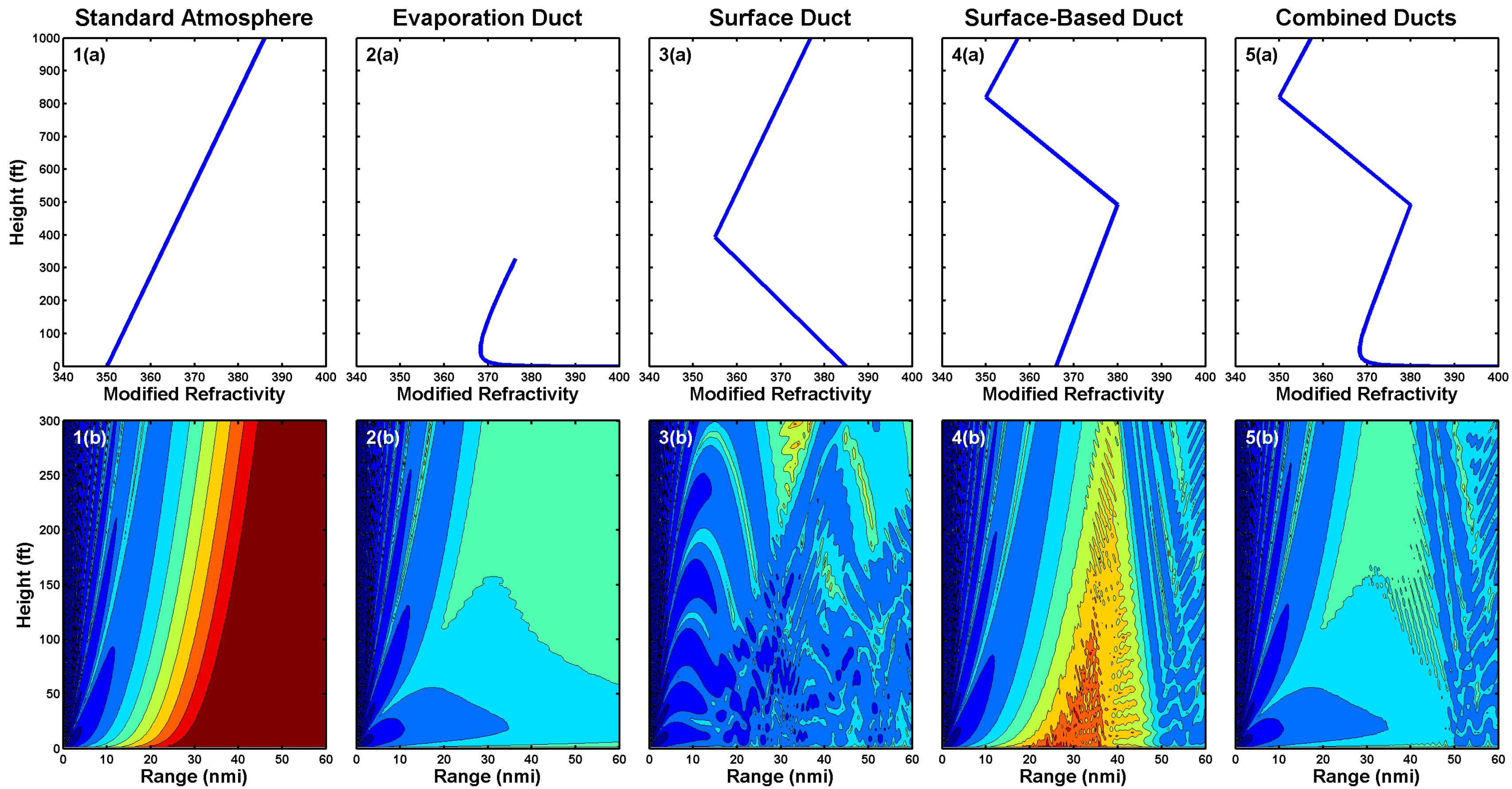


EM Radiation

The atmosphere can have a big effect on EM radiation propagation. For example *refraction* (bending of EM rays) controls



Types of Ducts



Measuring and Predicting Refractive Conditions

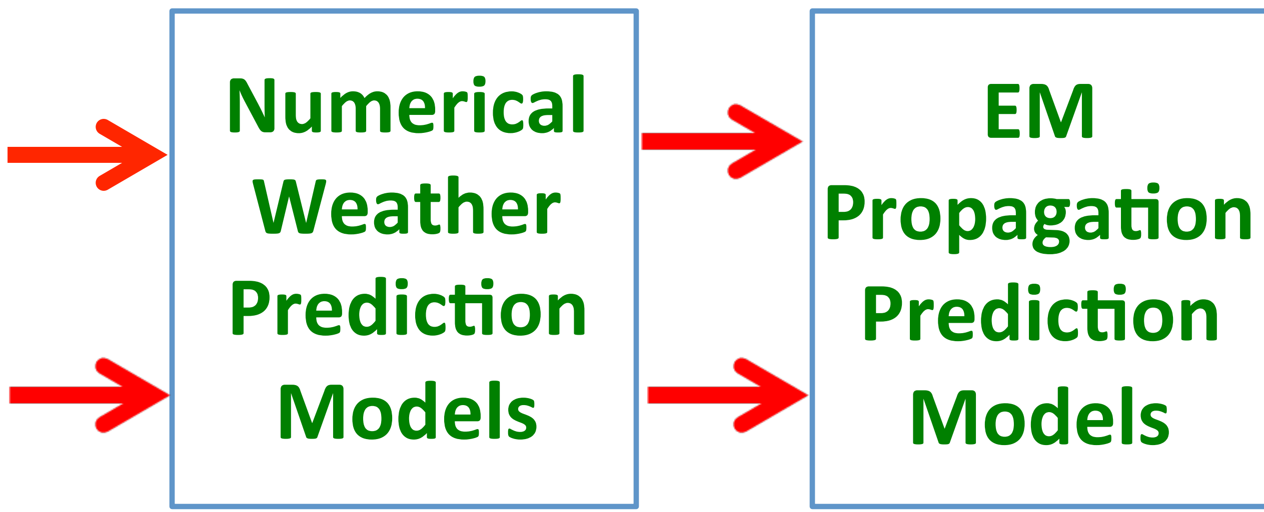
Old Navy

Radiosondes

Numerical Weather Prediction Models → EM Propagation Prediction Models

Measuring and Predicting Refractive Conditions

Current Navy



Measuring and Predicting Refractive Conditions

Current Navy

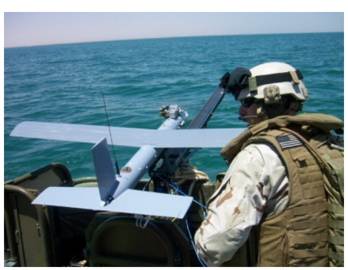
- Routine Weather Obs
  - Surface
  - Upper Air
  - Buoys
- Satellite
- Onboard Instruments

→ Numerical Weather Prediction Models → EM Propagation Prediction Models

Problems: Inadequate spatial and temporal resolution
May not have data for immediate operating area

Measuring and Predicting Refractive Conditions

Future Navy



Small UAS

→ **Numerical Weather Prediction Models** → **EM Propagation Prediction Models**

InstantEye

InstantEye with radiosonde attached at McMillan Field during JIFX13-4

JIFX13-2

Trident Warrior 2013

Objective

- ***Do on scene meteorological and oceanographic observations from UAVs provide increased, tactically significant skill for EM propagation prediction over a model-only solution from COAMPS/AREPS (as compared to the Navy Metoc rawinsonde program cancelled in FY11)?***

- **To answer this we need:**

  UAV Met observations to input into models

  Validating EM propagation observations

  Validating Met observations (for attributing performance shortfalls to the various parts of the processing chain)

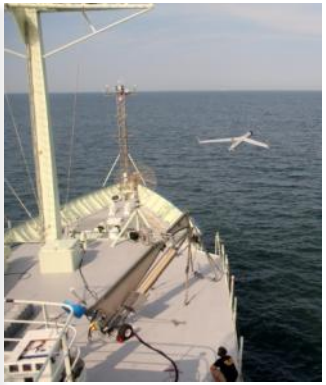
- **Coincident integrated Met and Ocean observations (for understanding conditions as they change and improving coupled model fidelity in the future)**

Trident Warrior 2013

Overview

- Demonstrate UxS METOC collection, data assimilation and high resolution weather modeling to support EW, ISR, and USW mission planning using a reach-back CONOPS
- Assess the value of in-situ boundary layer information on EW/ISR sensor performance assessments compared to model-only scenarios

- 5 days on-station R/V Knorr (AGOR-15) July 13-17, 2013
- 48 ScanEagle UAV Flight Hours (Day/Night, Nearshore, Offshore, 3 payloads)
- Numerous Daily Rawinsondes (4x synoptic, up/downs, tethersondes coincident with UAV observations)
- UHF/VHF, X, C, S Band Signal Strength Measurements
- 3 Waveglider USVs with Met and Ocean Payloads
- 5 Scripps drifting wave buoys
- 2 NPS Flux Buoys
- 8 SLOCUM and Seaglider UUVs
- 4 P-3 Flights/250 AXBTs



Trident Warrior 2013
Kite and Tethersonde Measurements
(surrogate for InstantEye)

Purpose: Characterization of evaporation duct and other low level refractive features

Method: Attach radiosonde to kite or tethered balloon. Perform several profiles from the surface to 150 – 300 m elevation. Use small boat to avoid large ship contamination effects.

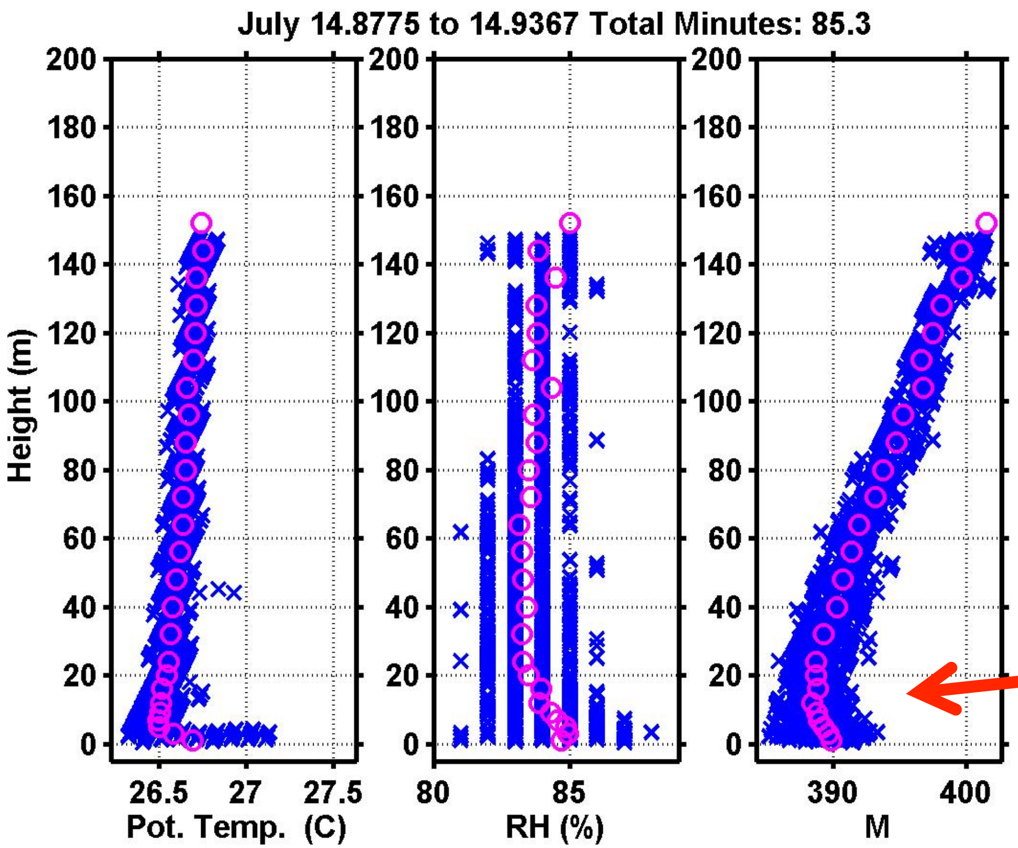
Measurements: Pressure, Temperature, Humidity, Modified Refractivity (derived)

Timing: 3 – 8 profiles performed during Scan Eagle flights each day. Starting at:

July 13 2020Z (kitesonde)
July 14 1420Z (tethersonde)
July 15 1514Z (tethersonde)
July 16 1620Z (tethersonde)
July 17 1719Z (tethersonde)

Kite and Tethersonde Measurements

Example Profiles



July 14 case

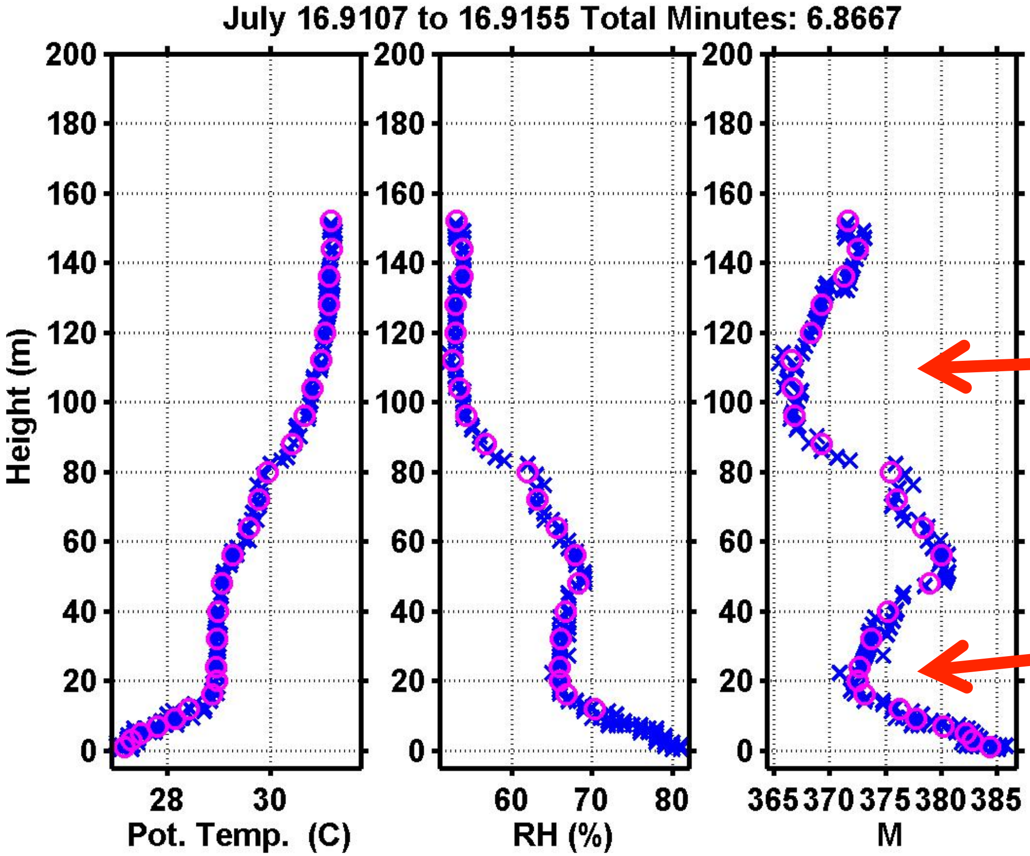
Winds 7-9 kts

All data from 10 profiles (X)
Height bin averages (O)

"Classic" Evaporation Duct
17 m height

Kite and Tethersonde Measurements

Example Profiles



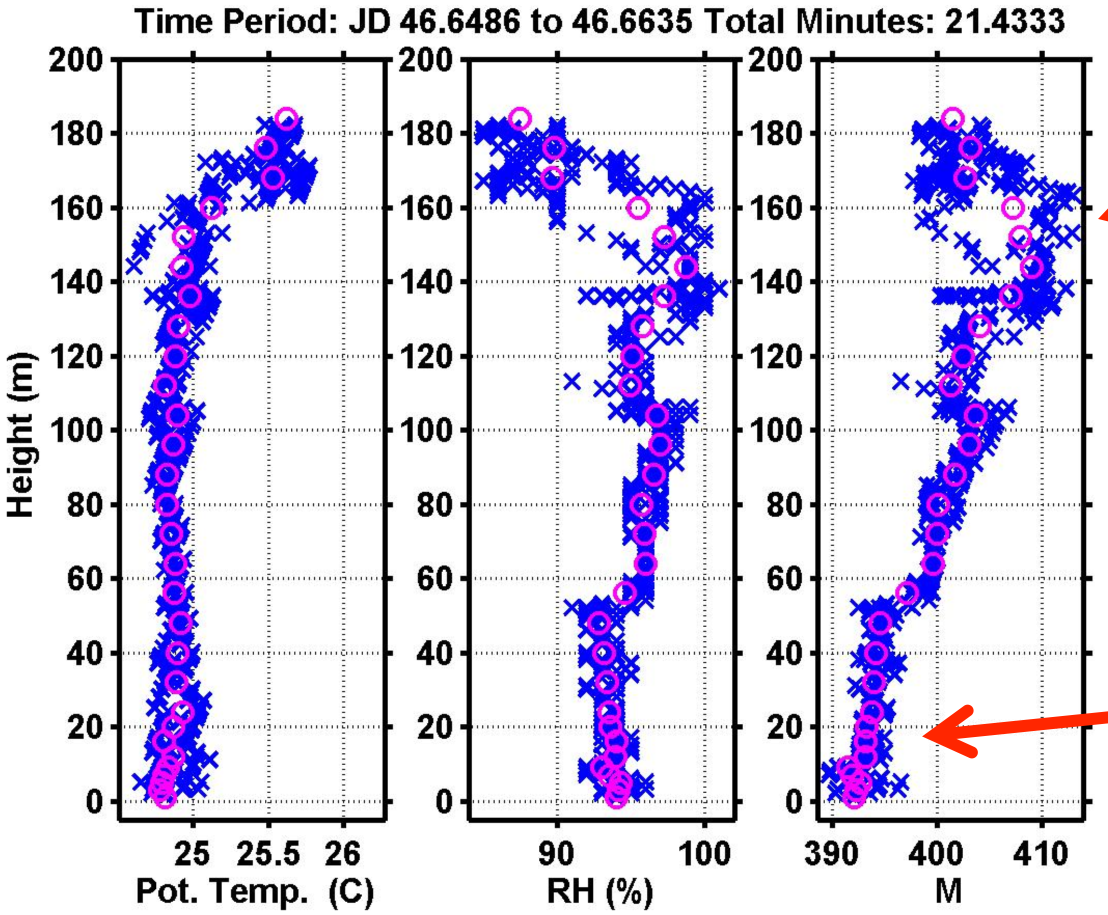
July 16 case
Winds 4 - 6 kts
Single Profile Shown

Surface-Based Duct
110 m height

Evaporation Duct
20 m height

Kite and Tethersonde Measurements

Example Profiles



July 15 case
Winds 1 - 3 kts
Two profiles shown

Shallow elevated duct

No Evaporation Duct

Overall Trident Warrior 2013 Summary

"Official"

- **Successfully demonstrated integration of various technologies**
- **Very lucky weather – several good ducting cases**
- **Several "firsts" in technology demonstrations**
- **Clear deviations from assumptions used in current EM propagation predictions were observed.**
- **Ocean and atmospheric forecast models missed many of the refractive features**
- **In situ observations did improve the forecast relative to these shortfalls in most of the initial analysis.**

Overall Trident Warrior 2013 Summary

My Take

- Scan Eagle represents a mature, sophisticated technology
- Scan Eagle provided accurate temperature and humidity profiles (winds need work)

- Scan Eagle provided areal coverage
- However, Scan Eagle is expensive ($80K?)
- Requires large launch and recovery hardware and trailer
- 12 people required to operate Scan Eagle during TW13
- Won’t fly < 50 m ASL
- Number of people required to perform InstantEye measurements: 1

- Much cheaper, basically expendable
- Could fly within 1 m of surface

Future Research Efforts

- Get NAVAIR flight approval so I can fly InstantEye
- Perform more calibration tests at Camp Roberts
- Perform at-sea tests
- Develop organic met sensor system
- Convince Navy of utility
- Attract student interest