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Impact of NEXRAD Derived Winds on NARAC Dispersion Modeling

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Outline

1. Background on IMAAC
2. Discuss objective / motivation of the project
3. Background on radar derived winds
4. Results from ongoing projects tasks
5. Preliminary Results

IMAAC Provides Federal Dispersion Modeling During Events Requiring Federal Coordination

- Created by Homeland Security Council (2004)
- Eight-agency Memorandum of Understanding: DHS, DoD, DOE, EPA, HHS, NASA, NOAA, NRC
- IMAAC roles codified in National Response Framework
- National deployment plan via federal operations centers and federal agency regional assets
- Support of National Exercise Program and National Security Special Events
- NARAC is the primary provider of IMAAC products

"The IMAAC provides a single point for the coordination and dissemination of Federal dispersion modeling and hazard prediction products that represent the Federal position" during actual or potential incidents requiring federal coordination" (*National Response Framework*)

Research Objective / Motivation

- **Objective:** Evaluate the potential benefit of assimilating NEXRAD radar derived winds to dispersion modeling capabilities / emergency response

- **Motivation:** Radar derived winds provide valuable data for dispersion modeling applications for the following reasons:

1. Radar wind observations are at height levels that are typically absent in traditional sources of weather observations
2. NEXRAD wind observations are made every hour as opposed to every 12 hours for National Weather Service upper air (balloon) soundings
3. Radar derived winds cover a large volume versus a single point by balloon soundings

These advantages could result in improved dispersion modeling results

Research Methodology

- **Method:** To evaluate the potential benefits / costs associated with using NEXRAD derived wind profiles, the following tasks will be completed:

TASK 1 - Quantify percentage of time NEXRAD winds are available

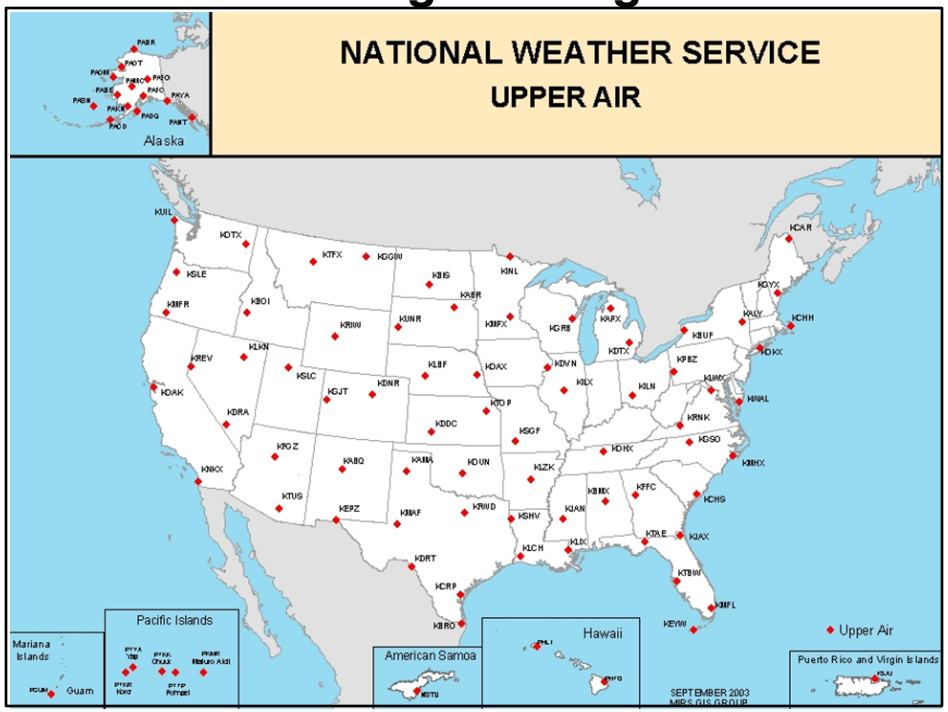
TASK 2 - Validate NEXRAD winds against traditional sources of weather observations

TASK 3 - Statistical analysis of assimilating NEXRAD winds into IMAAC's diagnostic meteorological model for three study sites (Phoenix, Chicago, and Kennedy Space Center)

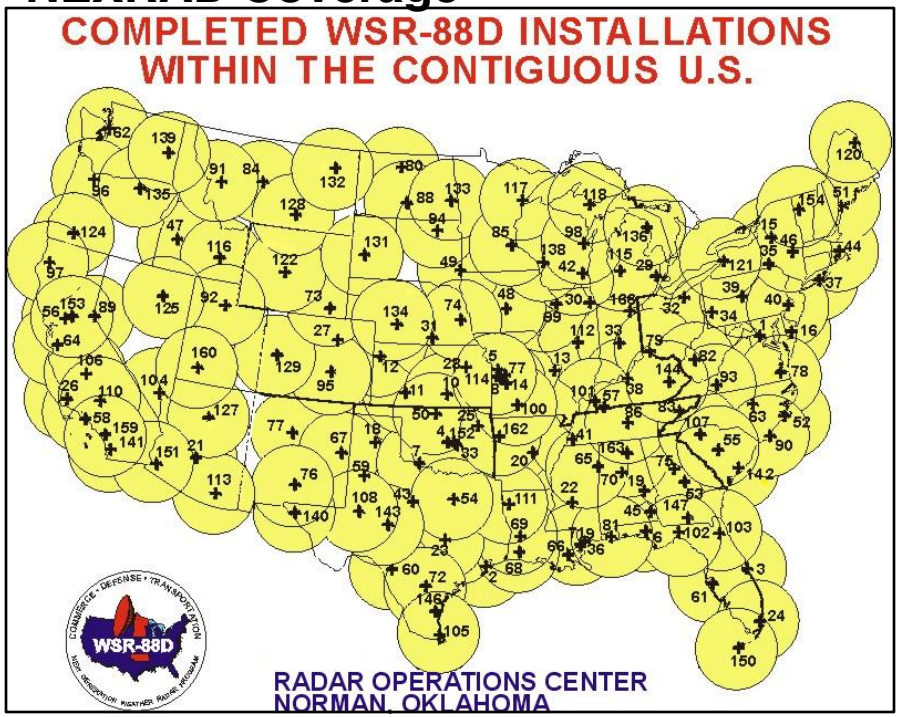
TASK 4 - Evaluate impact of incorporating NEXRAD data into a weather prediction model

NEXRAD data provides superior upper air data coverage compared to balloon soundings

Balloon Sounding Coverage



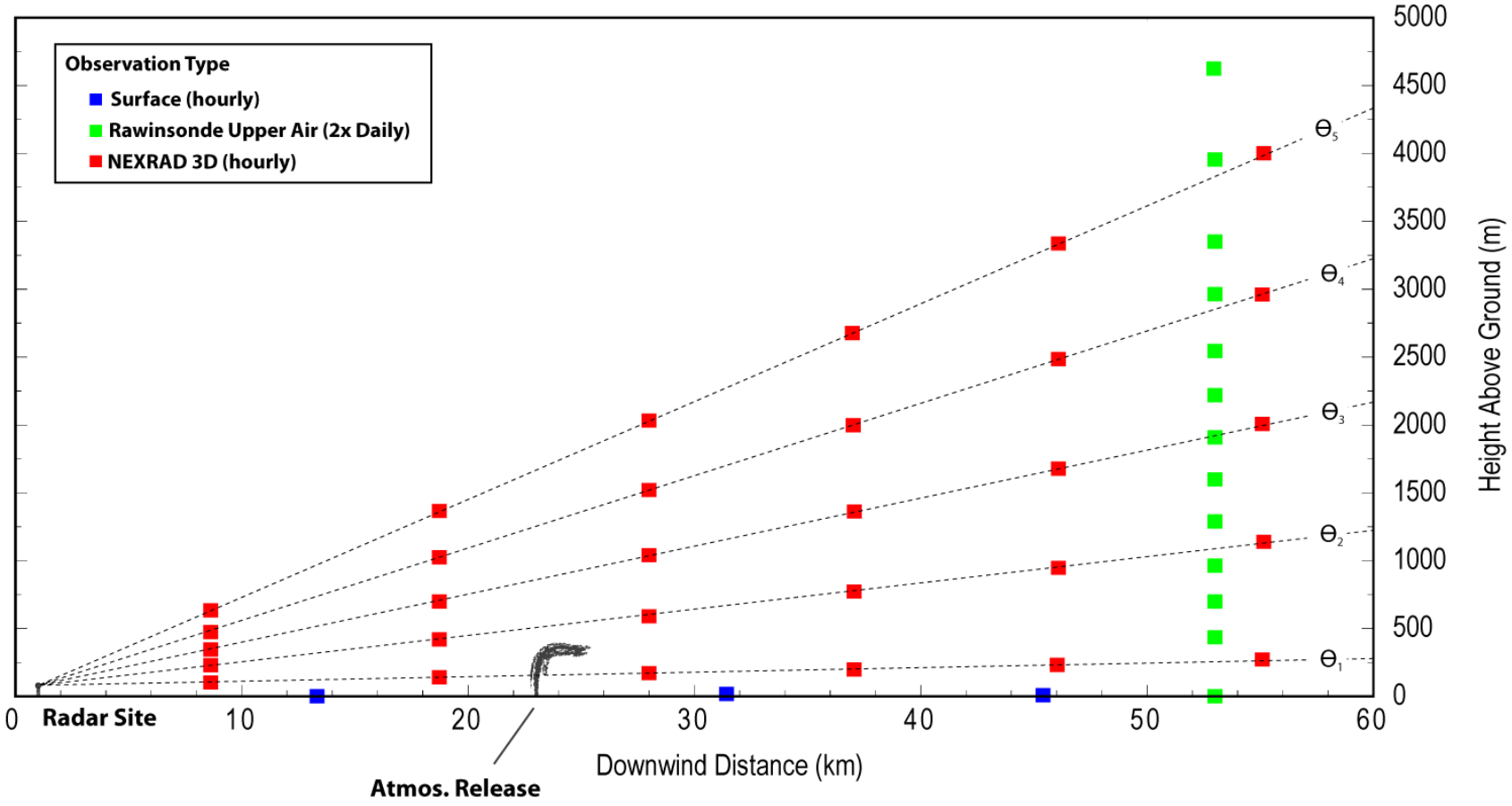
NEXRAD Coverage



Temporal resolution: Rawinsonde is 12 hrs, NEXRAD is hourly

Background on radar derived wind profiles

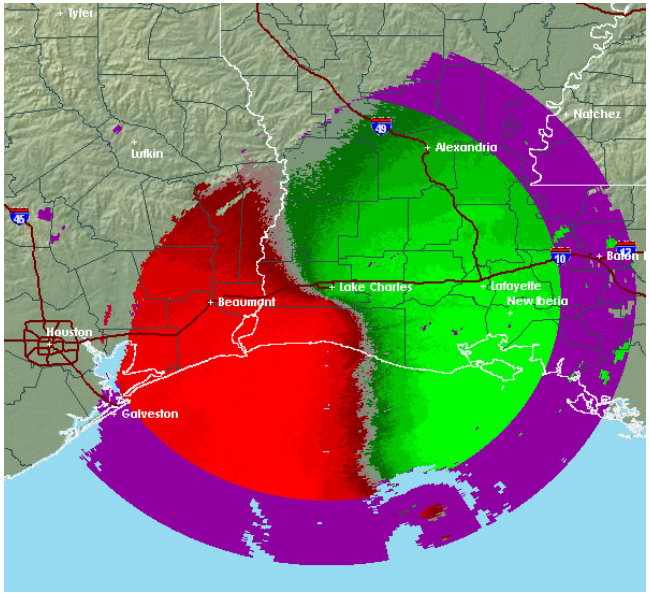
- NEXRAD radar data has the potential to provide quality upper air observations much closer to an atmospheric release than traditional sources of upper air data. Using RADAR derived winds for dispersion modeling is a new application.



NEXRAD data provided by PNNL

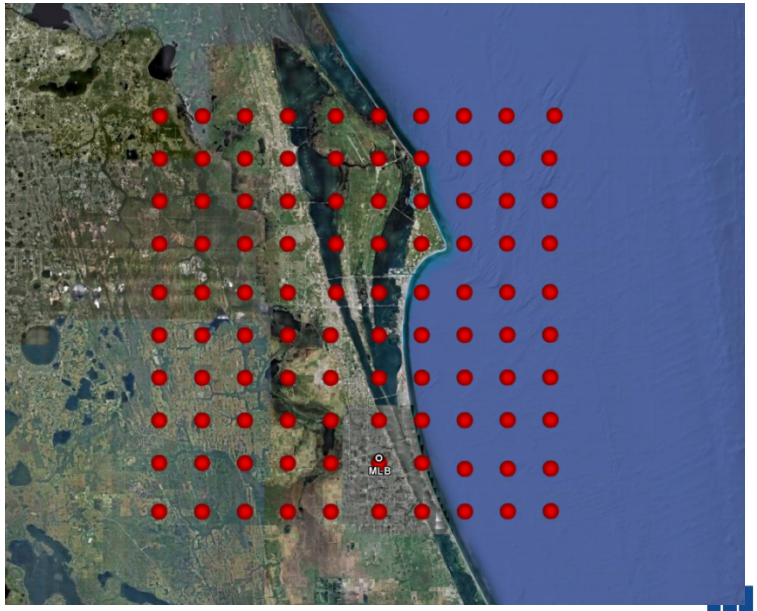
- For this project, we are getting NEXRAD data from the Pacific Northwest National Laboratory (PNNL). PNNL is using algorithms they developed to convert raw radar data to gridded profiles. NEXRAD winds are provided every hour.

Raw radar data (polar coordinates)



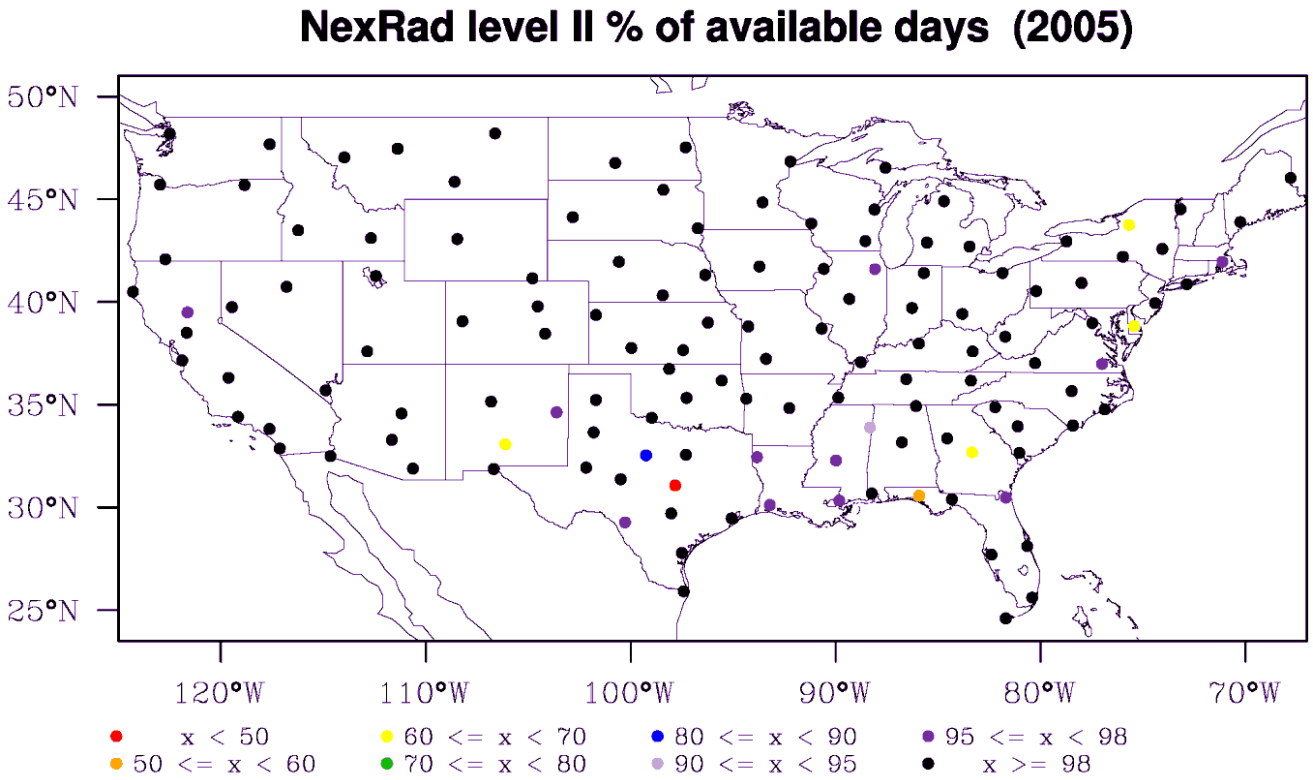
PNNL algorithm

Gridded wind profiles



Task 1. NEXRAD Data Availability

- The goal is to answer (1.) what is the upper limit of raw NEXRAD data availability and (2.) how often can quality controlled wind profiles be derived from the raw data.



Task 1. NEXRAD data availability

- We are currently performing a statistical analysis on NEXRAD wind profiles provided by PNNL for the 3 study sites (Phoenix, Chicago, and Kennedy Space Center).

Preliminary Statistics

Study Site	Data Availability	Total data feed hours
Phoenix	54%	15337
Chicago	59%	8281
Kennedy Space	71%	8281

- Preliminary results reveal data is available less of the time for the Chicago and Phoenix study sites. Reasons for fewer observations over these two sites will be investigated further. Seasonal and diurnal variations in data availability will also be studied.

Task 2. Validate NEXRAD derived winds with observations from traditional platforms

- To have confidence in the NEXRAD winds, they need to be compared with upper air observations from traditional data sources such as balloon soundings and profilers.

- NEXRAD data will be compared with observations from Kennedy Space Center (KSC). KSC was selected as the validation site due to its dense network of upper air data and IMAAC's access to these special (non-public) data.

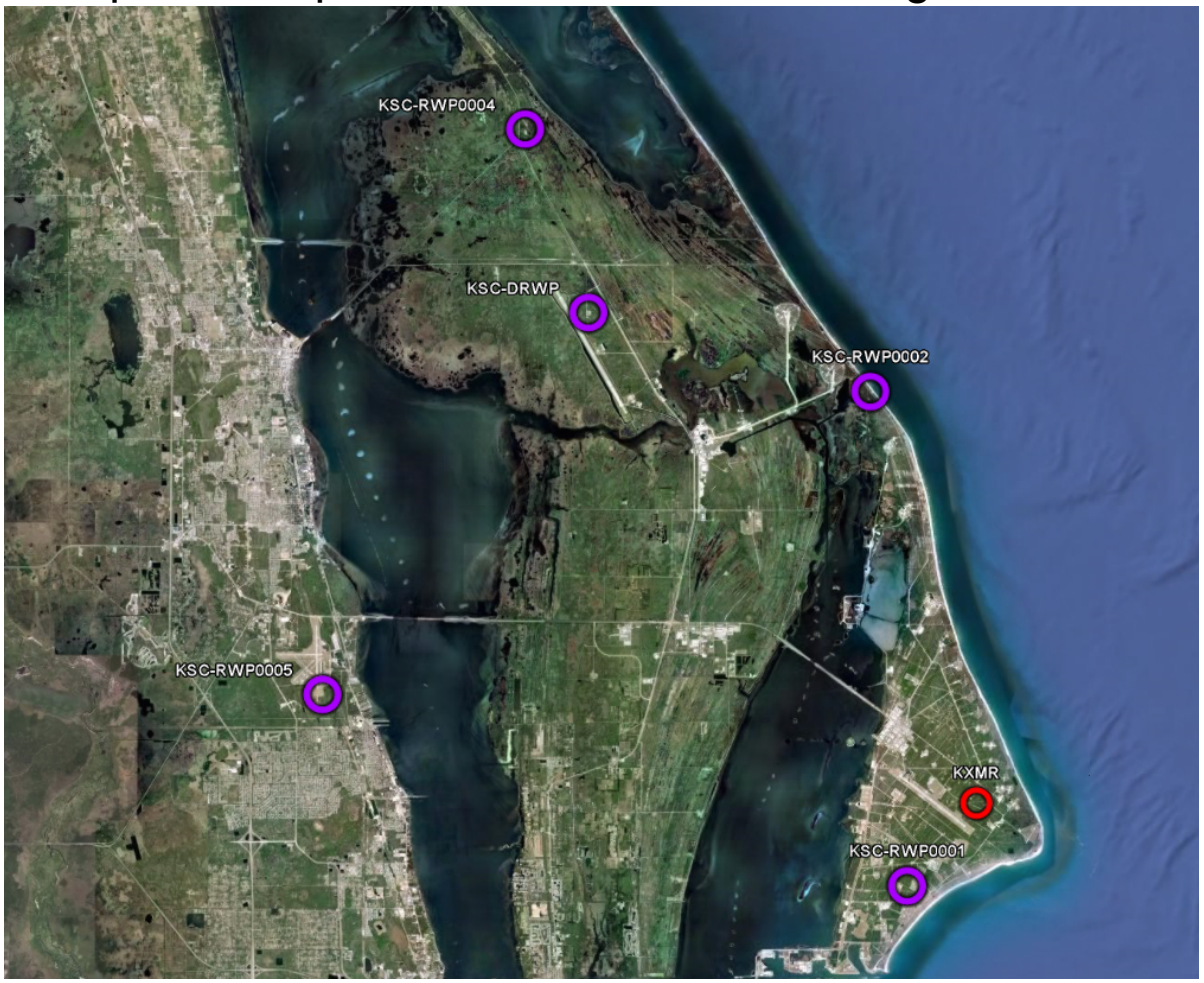
Task 2. Kennedy Space Center has dense network of upper air observations

The dense network of upper air observation locations at Kennedy Space Center provides an excellent evaluation case.

5 Profilers

1 Balloon sounding site

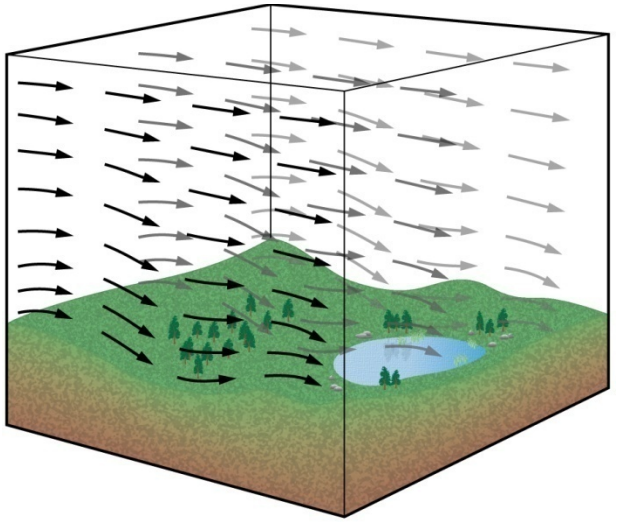
Map of KSC profiler and balloon sounding locations



Task 3. Statistical analysis of impacts of NEXRAD data on NARAC dispersion calculations

- To test the impact of radar derived winds on IMAAC dispersion modeling results, a statistical evaluation with data from Phoenix, Chicago, and Kennedy Space Center is being performed.
- 20 dispersion runs with and without NEXRAD data are being made at each study site.
- A statistical comparison of concentration fields from the runs with and without assimilating NEXRAD data will be made.

Task 3. IMAAC Diagnostic meteorological model (ADAPT) background



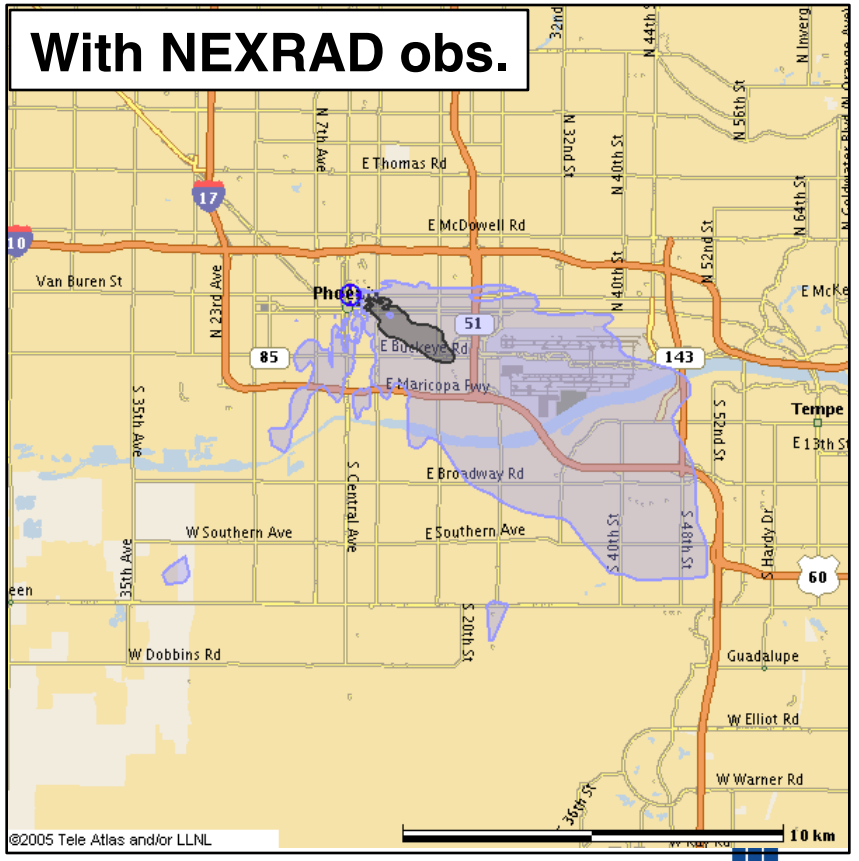
- Input data:
  - Multiple surface and upper air meteorological observations
  - Spatially-varying land surface characteristics and terrain elevation

- Methods:
  - Spatial interpolation (using inverse-distance-squared weighting or other methods) of wind observations to generate initial 3-D gridded wind field, as well as temperature, pressure and humidity fields

Task 3. NEXRAD data resulted in different deposition plots over Phoenix on 1-2 July 2008

Scenario: 300 m Release Height, Generic Particulate, 4 hour continuous release

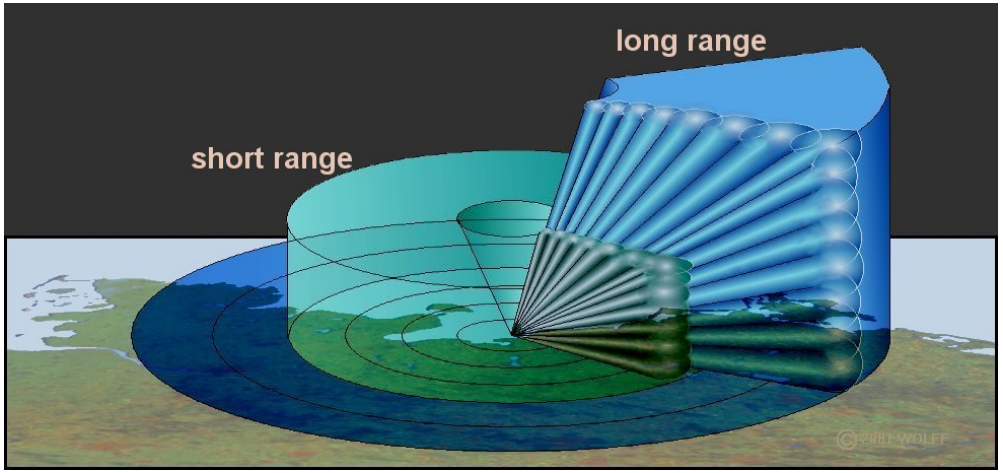
Cause of Differences: Hourly NEXRAD data was able to resolve upper air wind shift that the NWS balloon sounding in Phoenix did not. This is an example of more extreme difference.



Task 3. Evaluate impacts of assimilating NEXRAD winds into a prognostic weather forecast model

- Dispersion runs for Phoenix have been completed and the statistical analysis started. Dispersion runs for Chicago and KSC are ongoing.

- Our statistical analysis of the effects of assimilating NEXRAD data will include investigating changes in peak concentration, spatial coverage of deposition, and others.



Task 4. Evaluate impacts of assimilating NEXRAD winds into a prognostic weather forecast model

- In addition to running a diagnostic atmospheric model with NEXRAD, the impact of radar winds on a prognostic model is also being investigated.

- The Weather Research and Forecast (WRF) model was selected as the study prognostic model due to its unique ability to assimilate height level observations. Other models require an associated pressure level with observations that radar can not provide.

- The impact of assimilating NEXRAD data on the strength and timing of a sea breeze front over Kennedy Space Center was selected as the first WRF simulation case study. Due to the limited number of WRF simulation that can be run, the simulations will not be for a statistical analysis.

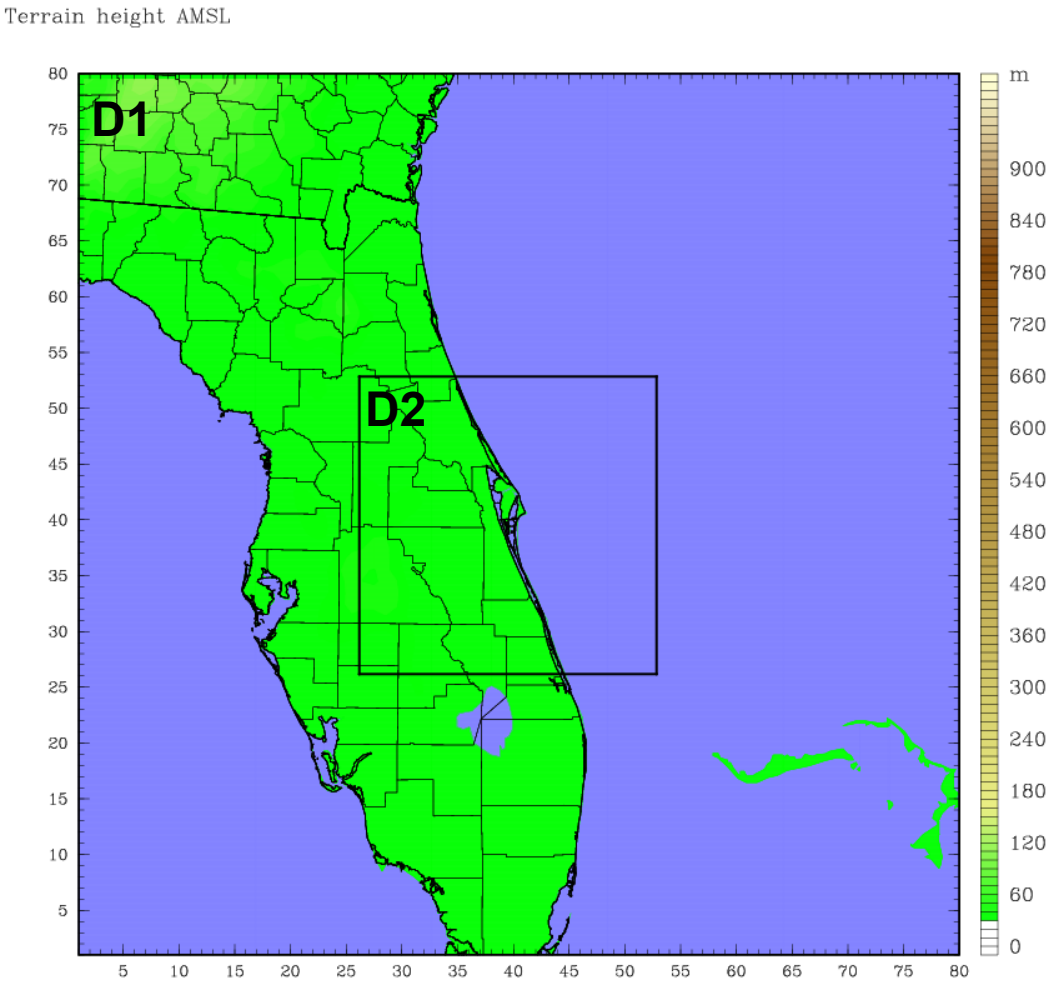
Task 4. WRF Model Domains for Kennedy Space Center Case Study

2 model domains were used to sufficiently resolve a sea breeze circulation observed on 12 June 2009

Horizontal grid spacing is 9 and 3 km

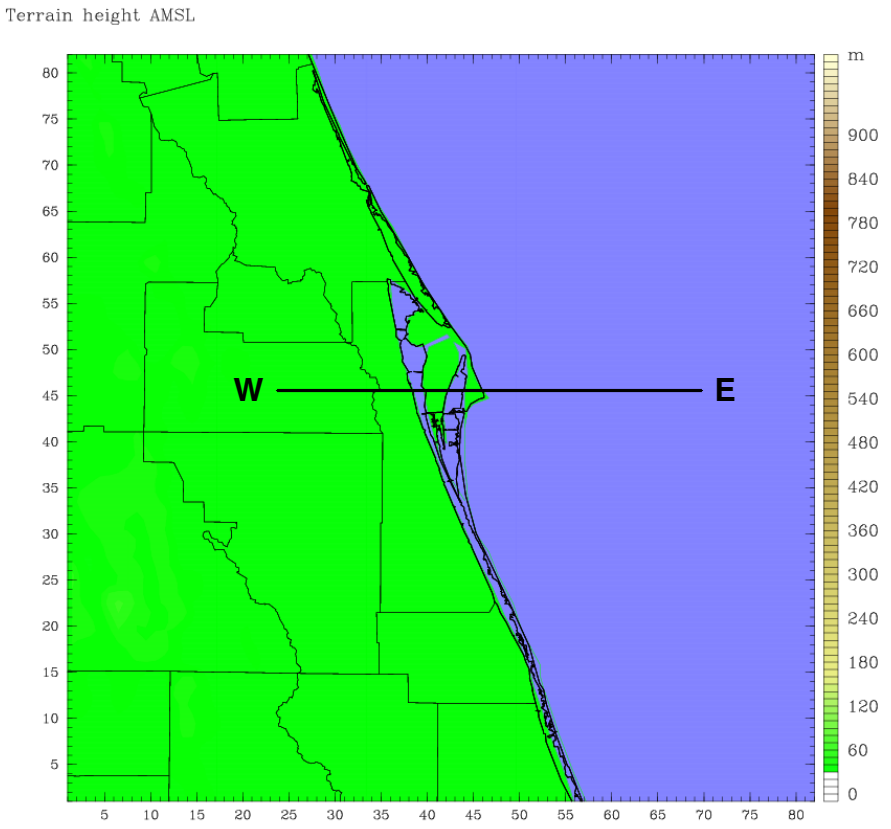
<u>Control Run</u>: Analysis nudging for outer domain

<u>Experimental Run</u>: Analysis nudging for outer domain and observational nudging of NEXRAD winds for inner domain

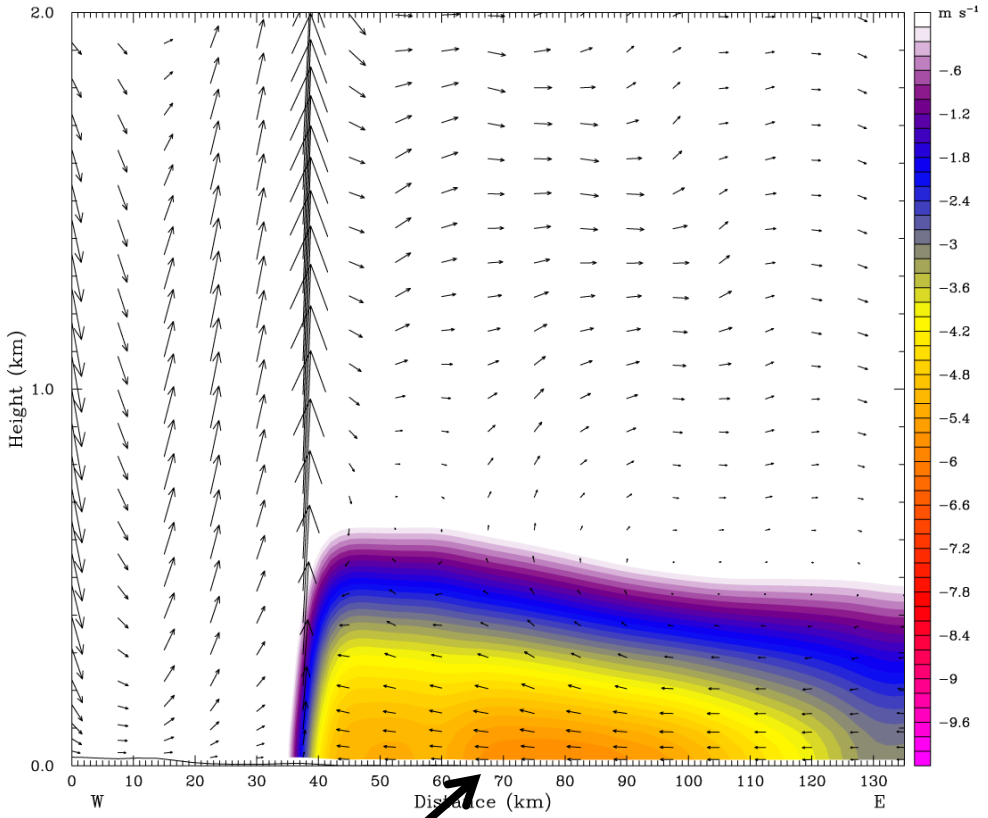


Task 4. Cross section of WRF simulated sea breeze circulation (Control Run)

Map of cross section location

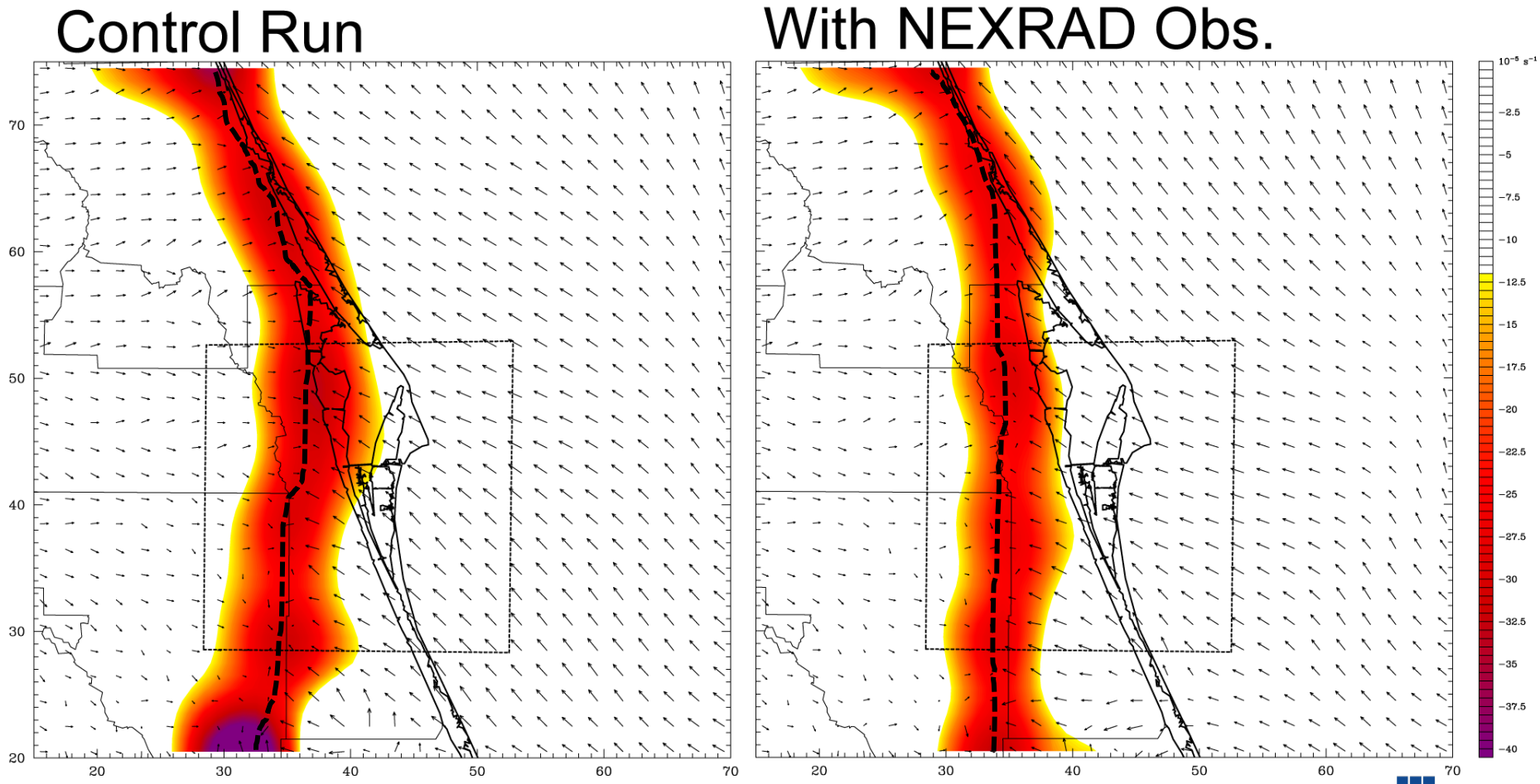


Onshore wind (color contours) valid 12 June 2009 at 17:00 LST



Task 4. Location of sea breeze front was shifted when NEXRAD observations are assimilated

Simulated 10m wind vectors and convergence valid 12 June 2009 at 17:00 LST



Task 4. Next steps

- Compare WRF simulations to observations to test if assimilating NEXRAD data improved the timing and strength of the sea breeze.

- Run another test case over Chicago to study the impact of NEXRAD data on forecasting a lake breeze.

PRELIMINARY RESULTS

1. Some occasional QA / QC issues with the PNNL provided data set have been encountered and will be addressed

2. The percentage of NEXRAD data availability from Chicago and Phoenix was lower than for the Kennedy Space Center and requires further investigation

3. Assimilating NEXRAD data into the IMAAC suite of models has resulted in differences in concentration fields for preliminary dispersion calculations

4. The timing of a sea breeze front was slightly modified for a case study over the Kennedy Space Center when NEXRAD data were assimilated into the WRF atmospheric model

5. Preliminary results show using NEXRAD winds results in different dispersion results. However, enough data issues still exist that a recommendation on the value of NEXRAD winds can not yet be made.