JSTO Chemical and Biological Defense Physics-Based Modeling Program

Measurement of Coastal & Littoral Toxic Material Tracer Dispersion

Dr. Robert E. Marshall

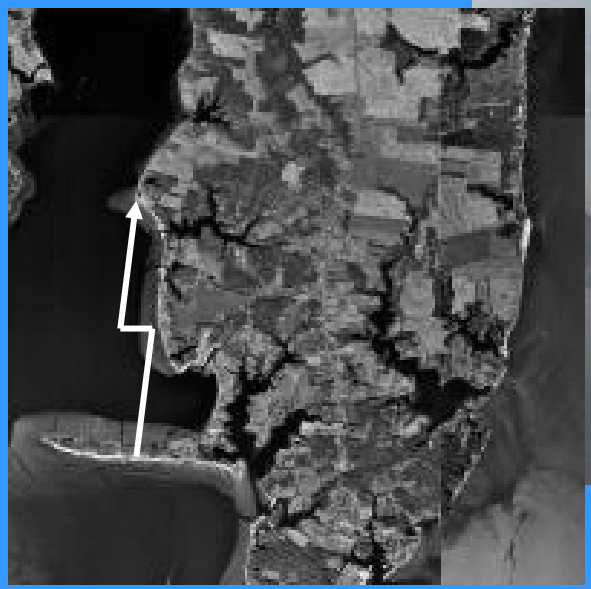
robert.e.marshall@navy.mil

T41 NSWCDD

JSTO Chemical and Biological Defense Physics-Based Modeling Program

NAVSEA WARFARE CENTERS DAHLGREN

Mouth of the Piankatank River Chesapeake Bay



Model this for CB defense?

Ground level Biomass Burn January, 2001

What validated technologies exist?

What technologies must be developed and/or validated?

Coastal and Littoral

Objectives

- Focus on the land/sea interface
- Atmospheric releases
- Accurate modeling capability to predict hazard
- Model development → empirical → coupled NWP
- Model Validation → data → field program

Coastal and Littoral

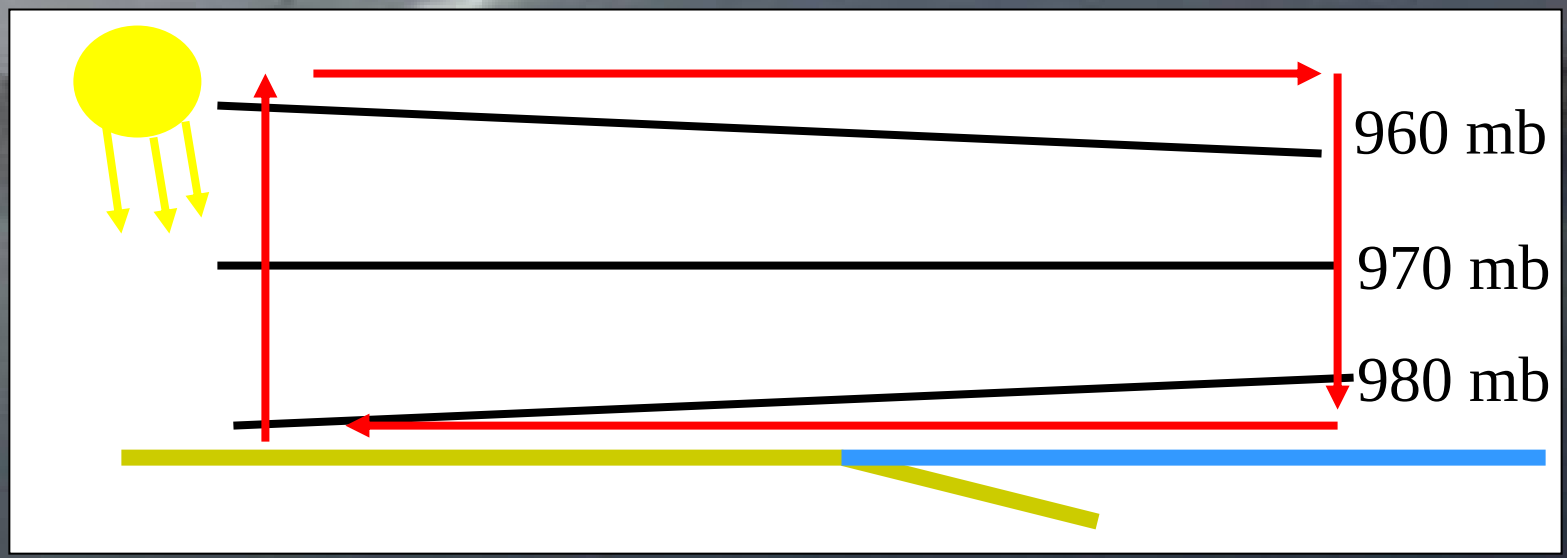
Coastal Circulations

- True child of the sun
- Thermal circulation in the presence of contrast between the heat capacity and thermal conductivity of the land and adjacent water
- Basic unit is the sea breeze

Coastal and Littoral

Sea Breeze

- Sun heats the land
- Land heats the surface air by conduction
- Convective turbulence heats the upper air



Coastal and Littoral

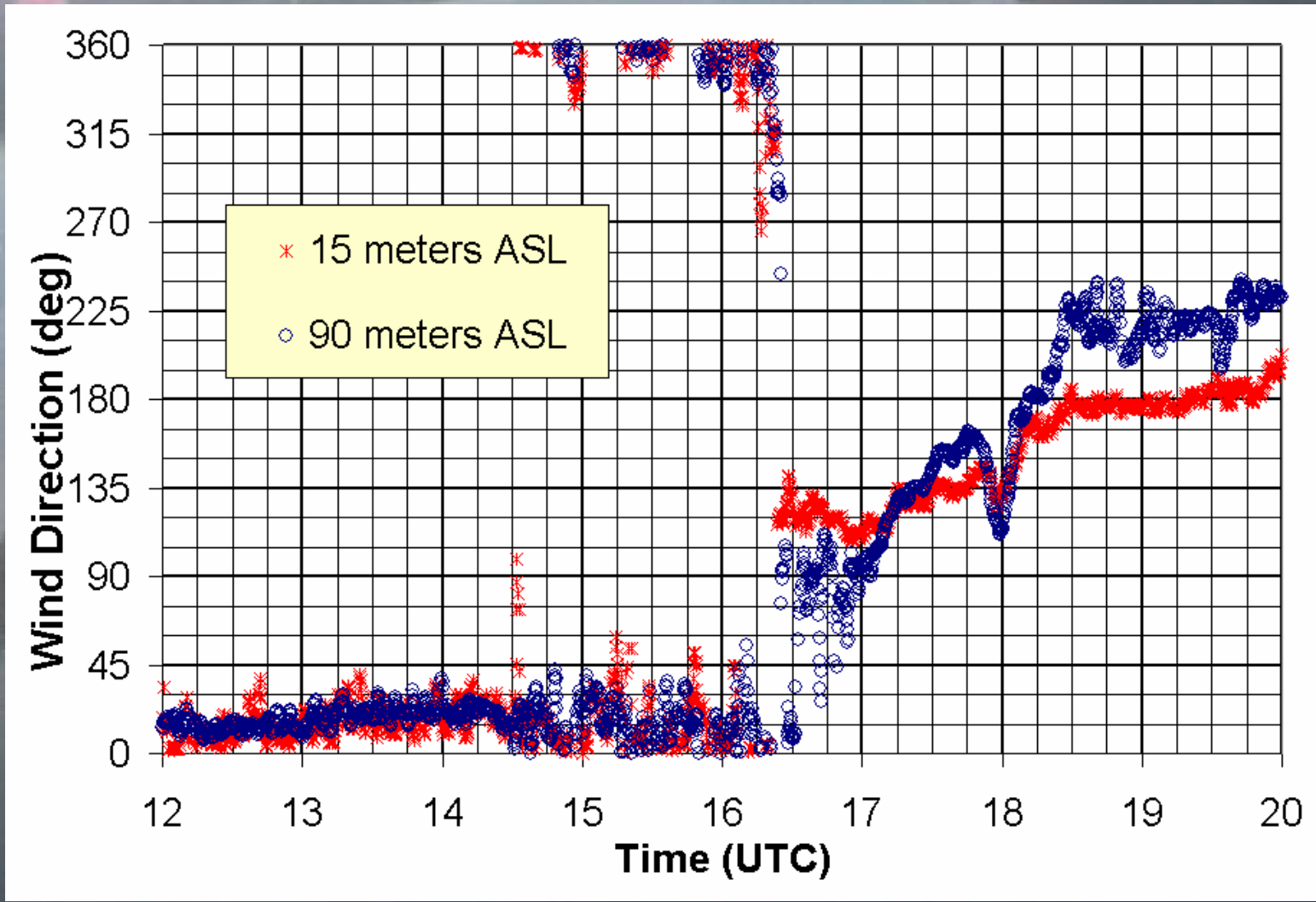
Sea Breeze Circulation

- 25 km inshore
- 50 km offshore
- 500-1000m deep
- 10-20 kt winds surface up to 100m

Sea Breeze Circulation

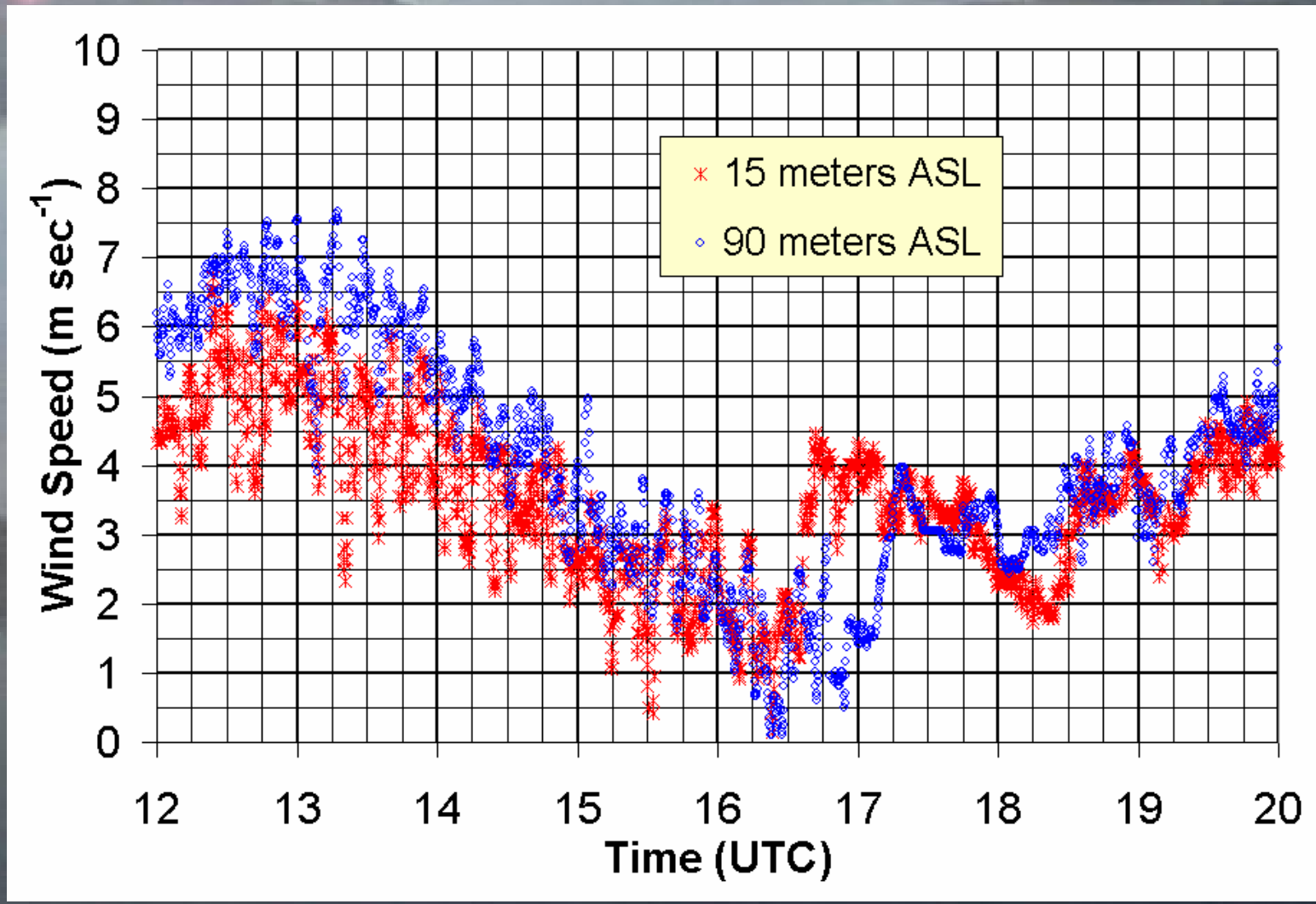
- Sea breeze front begins to move towards shore when ΔT is 3-6deg C
- Convection can appear along sea breeze front
- Sea breeze dies out 1-2 hours after sunset
- Weaker land breeze may form as land cools below temperature of water

Coastal and Littoral



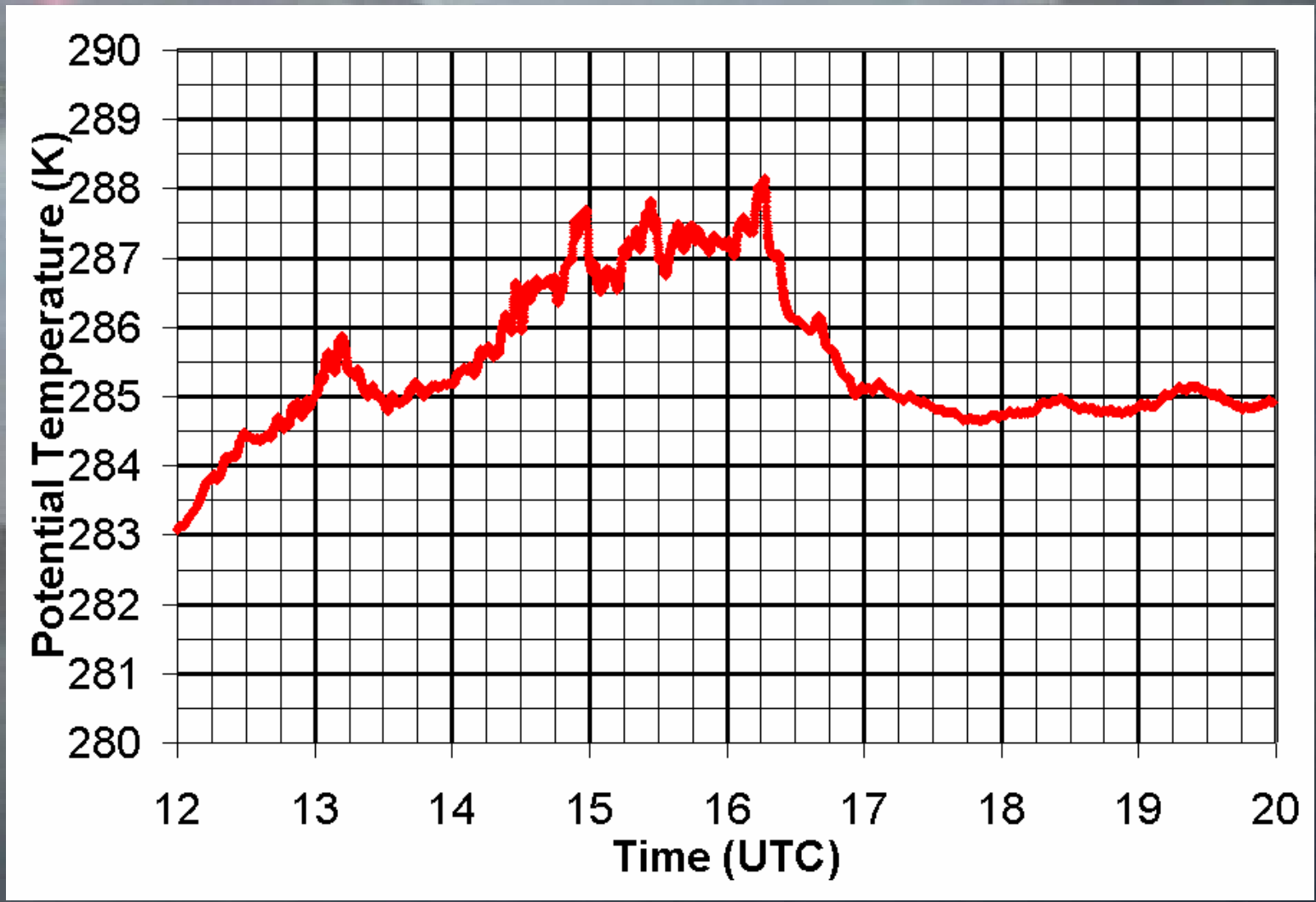
Wallops Island, VA 29 April 2000

Coastal and Littoral



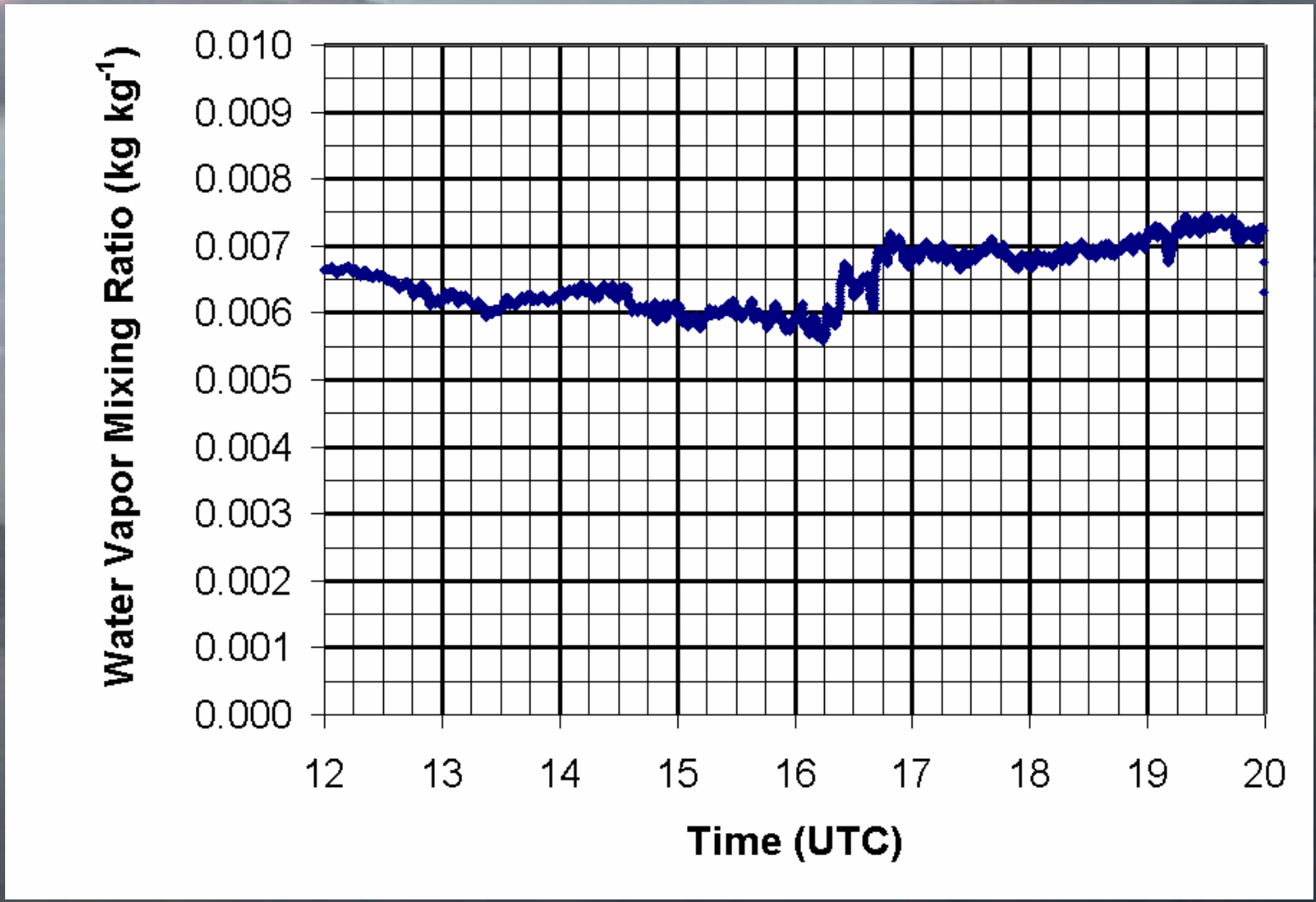
Wallops Island, VA 29 April 2000

Coastal and Littoral



Wallops Island, VA 29 April 2000

Coastal and Littoral



Wallops Island, VA 29 April 2000

Modifications to Sea Breeze

- Coastline shape: convergence/divergence
- Coastal terrain: mountain or valley winds may enhance or inhibit sea breeze circulations
- Low level inversions over land: limit vertical extent of heating and weaken sea breeze
- Coriolis induces late afternoon veering

Coastal and Littoral

Similar Circulations

- Lake breeze: Great Lakes, Lake Okeechobee
- River breeze: Landing at National Airport
- Desert breeze: differential heating-contrasting albedo of types of sand- Dugway Proving Ground

Coastal and Littoral

Components

- Literature search for data/models/theory
- Empirical model development
- Leverage meteorological data
  - **improvements in mesoscale NWP**
  - **remote and in situ sensor data assimilation**
  - **coupled ocean/atmospheric modeling**
- Field testing
- Improved coupled met and T&D model

Coastal and Littoral

Literature Search for Data/Models/Theory

- **Investigation of Data and Remote Sensing Needed for Supporting Transport and Dispersion Forecasts for Chem/Bio Threat Mitigation In Coastal and Littoral Regions**
  NOAA/ATDD

- **Measurement of Coastal & Littoral Toxic Material Tracer Dispersion**
  NSWCDD

Coastal and Littoral

Empirical Model Development

- Land Sea Temperature Difference
- Offshore wind speed
- Coastline shape
- Surface heat flux
- Dstl, Porton Down

Coastal and Littoral

Leverage Meteorological Data

- Investigation of Data and Remote Sensing Needed for Supporting Transport and Dispersion Forecasts for Chem/Bio Threat Mitigation In Coastal and Littoral Regions
  - NOAA/ATDD
- Coupled Air-Sea Modeling for Improved Coastal Dispersion Prediction
  - NRL-MRY
- Measurement of Coastal & Littoral Toxic Material Tracer Dispersion
  - Weatherflow
  - NRL-MRY

Coastal and Littoral

Field Testing

- Measurement of Coastal & Littoral Toxic Material
  - Tracer Dispersion
    - NSWCDD
    - Weatherflow
    - NRL-MRY
    - NPS
    - JHU/APL
    - NASA/WFF

- October 2004 Sea Breeze Workshop

Coastal and Littoral

Improved Coupled Met and T&D Model

- DTRA/TDOC/HPAC
  - Meteorological Research Team
    - PSU
    - NOAA
    - NCAR/RAL
- DTRO-L
  - Workshop on Uncertainty in Transport and Dispersion of CBRN Materials

Coastal and Littoral

Measurement of Coastal & Littoral Toxic Material Tracer Dispersion

Two week met and T&D sea breeze measurement program

- **NSWCDD**
  Program management, met measurements, chaff release, experiment control center
- **NRL-MRY**
  High resolution COAMPS modeling and data assimilation
- **Weatherflow**
  Meteorological measurements, high resolution RAMS modeling and data assimilation
- **JHU/APL**
  Meteorological measurements
- **Naval Postgraduate School**
  Meteorological measurements
- **NASA/WFF**
  SPANDAR

Coastal and Littoral

Measurement of Coastal & Littoral Toxic Material Tracer Dispersion

NSWCDD

- Program Management
- Boat based chaff release
- Boat based surface and GPS upper air met, SST-5 to 65km offshore
- Shoreline surface met measurements
- Land mobile GPS radiosonde system
- Experiment control center-real time telemetered met data

Coastal and Littoral

Measurement of Coastal & Littoral Toxic Material Tracer Dispersion

NRL-MRY

- Literature Search
- Wallops Island Sea Breeze Climatological Study
- 3km horizontal resolution COAMPS modeling
- Data assimilation
- Forecast team member

Coastal and Littoral

Measurement of Coastal & Littoral Toxic Material Tracer Dispersion

Weatherflow

- Literature Search
- Wallops Island Sea Breeze Climatological Study
- 2km horizontal resolution RAMS modeling
- Along coast surface met sites
- Data assimilation
- Forecast team member

Coastal and Littoral

Measurement of Coastal & Littoral Toxic Material Tracer Dispersion

JHU/APL

- Literature Search
- Helicopter MABL soundings 5 to 65 km offshore
- Rocketsonde soundings 0-5 km offshore
- Surface met measurements and SST 0-5km offshore

Coastal and Littoral

Measurement of Coastal & Littoral Toxic Material Tracer Dispersion

Naval Postgraduate School

- Literature Search
- Offshore Reynolds fluxes
- Offshore wave heights

Coastal and Littoral

Measurement of Coastal & Littoral Toxic Material Tracer Dispersion

NASA Wallops Flight Facility

- SPANDAR
- 00UTC and 12UTC synoptic soundings
- 3 surface met sites
- Shoreline wind tower (15,30,45,60,75,90m ASL)
- WFF climatological sea breeze study

Coastal and Littoral

Measurement of Coastal & Littoral Toxic Material

Tracer Dispersion

CHAFF ???

- Flow dimensions on the order of 100km
- Chaff concentration proportional to measured radar reflectivity (no chemistry or biology)
- 25 micron diameter aluminum coated mylar cut to $\lambda/2$ (5cm)
- 1 cm sec^{-1} terminal velocity
- variance of Doppler spectrum related to turbulence intensity

Coastal and Littoral

Measurement of Coastal & Littoral Toxic Material

Tracer Dispersion

SPANDAR

- Space Range Radar
- Range resolution = 75 meters
- Azimuth resolutiom = 340 meters at 50km
- 1 chaff filament per range bin at 50km provides a > 10dB signal to noise
- Data analysis and display tools well exercised at NSWCDD

Coastal and Littoral

Measurement of Coastal & Littoral Toxic Material Tracer Dispersion

FY06

- Develop WFF sea breeze climatology
- Fabricate, mount and test chaff release system
- Maintain and calibrate land and sea based meteorological hardware
- WFF environmental assessment
- Test site preparations
- Engage empirical model developers
- NWP model development
- Develop a test plan

Coastal and Littoral

Measurement of Coastal & Littoral Toxic Material Tracer Dispersion

FY07

- Obtain expendables
- Establish forecast team
- Install auxiliary surface meteorological sites
- Move hardware to WFF
- Install control center
- Two week field program
- Remove hardware from WFF
- Archive data
- Experiment first look

Coastal and Littoral

Measurement of Coastal & Littoral Toxic Material Tracer Dispersion

FY08

- Data Analysis
- NWP model testing
- Empirical model testing
- Workshop

Coastal and Littoral

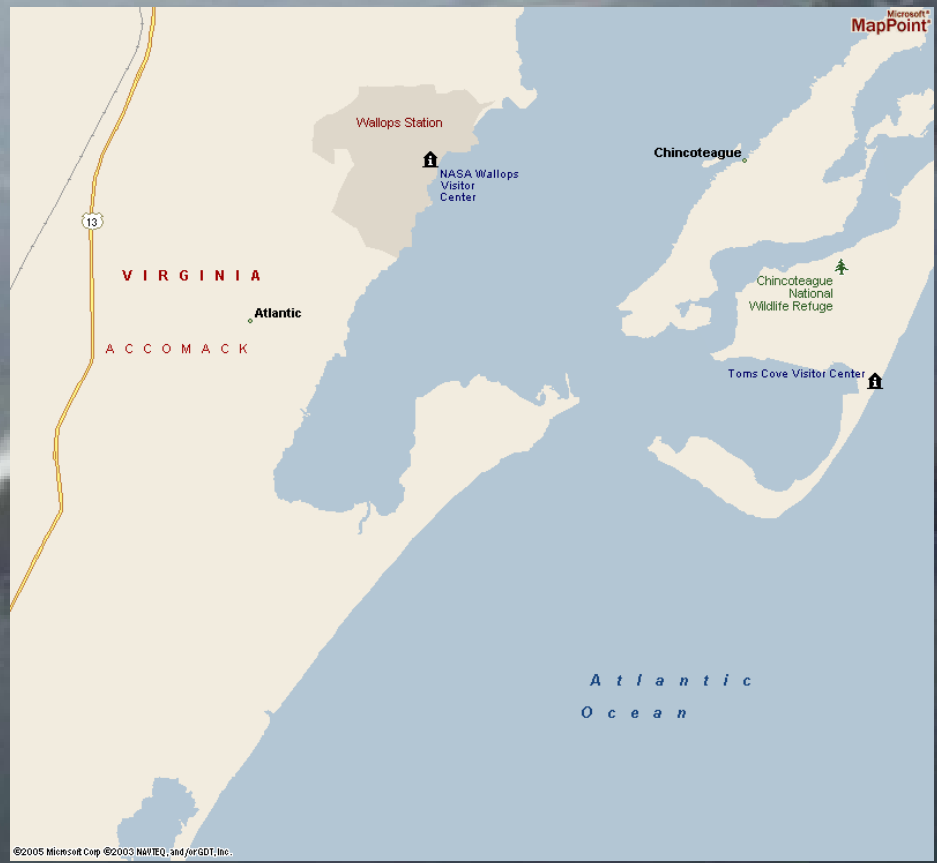
Measurement of Coastal & Littoral Toxic Material

Tracer Dispersion

Experiment Holes

- Land based Reynolds flux measurements
- Doppler Lidar technology (winds)
- Raman Lidar (temperature and humidity profiles)
  Some NAVSEA interest
- We invite participation

Coastal and Littoral



Coastal and Littoral

Coastal and Littoral

Coastal and Littoral