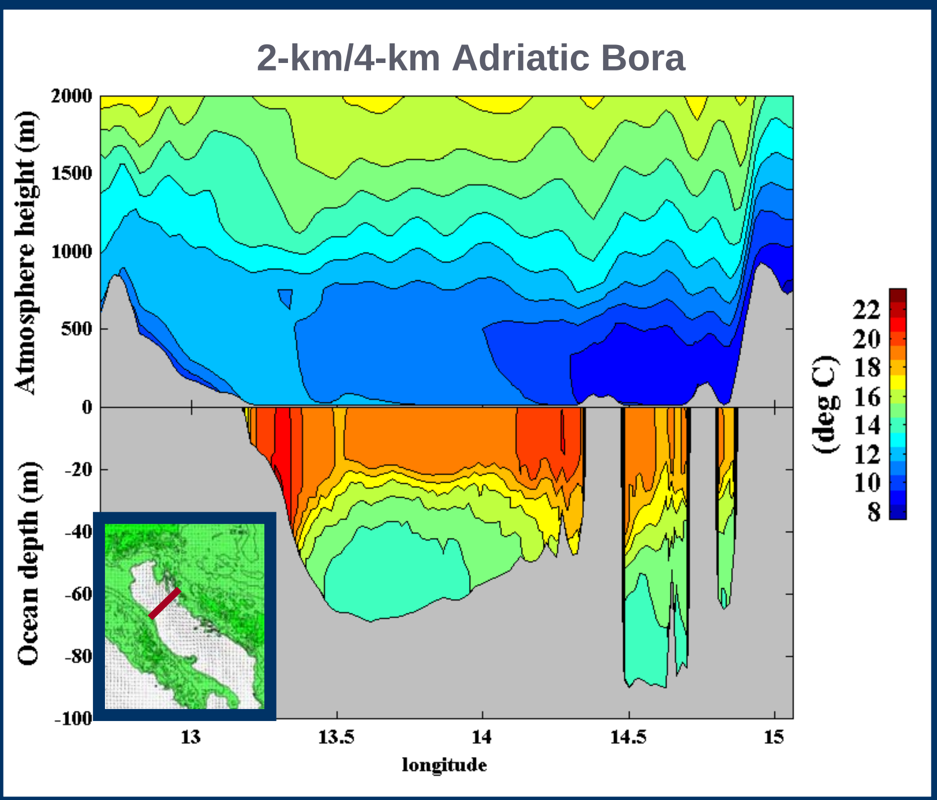
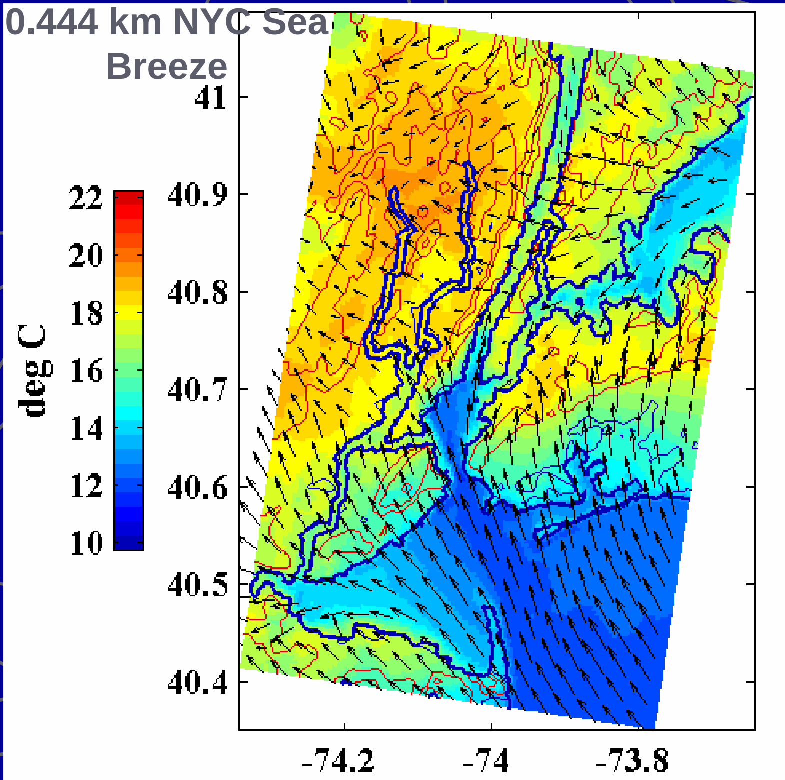
Coupled Air-Sea Modeling for Improved Coastal Dispersion Prediction

Julie Pullen

& Marine Meteorology Division,

Naval Research Laboratory





Outline

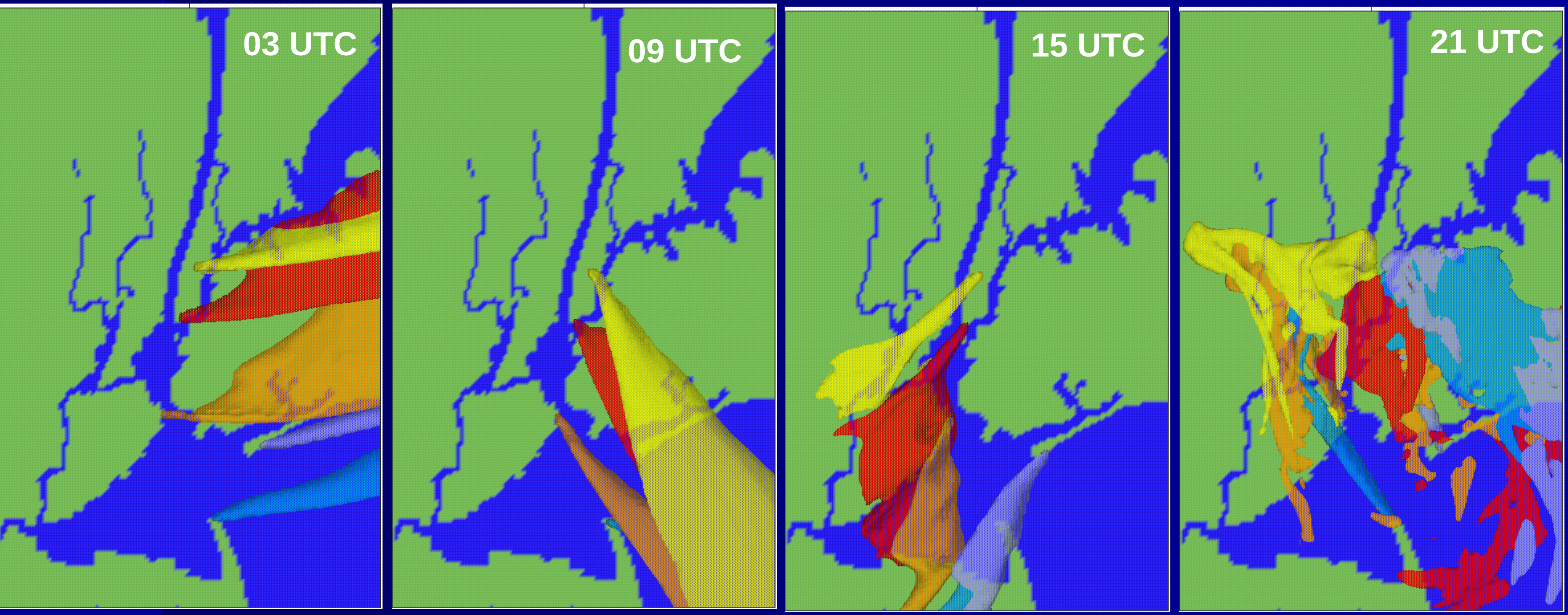
- SST impacts on NYC region during sea breezes

- 2-way air/sea feedback in the Adriatic during strong wind events

Air-Sea Interaction in NYC:
Mesoscale Modeling for CB Threats

Julie Pullen & Teddy Holt
Naval Research Laboratory
Monterey, CA

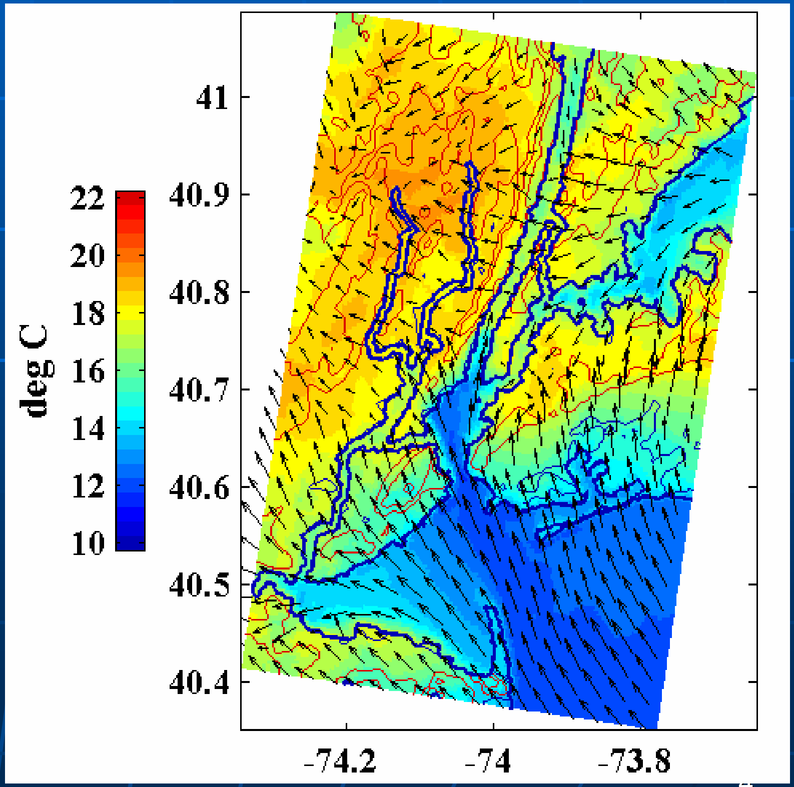
with Alan Blumberg, SIT
Brian Colle, SUNY-Stony Brook
& Marty Leach, LLNL



Mesoscale Overview

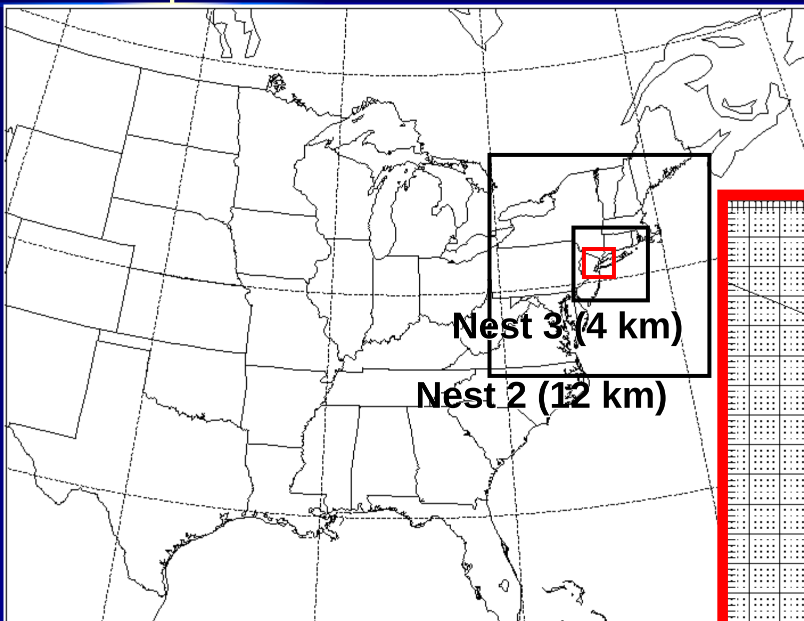
- COAMPS®: data-assimilation modeling system
- 5 nests (36 km to 0.444 km)
- urbanization and time-varying (hourly) realistic SSTs on nests 4 (1.33 km) & 5 (0.444 km)

sea breeze forecast (nest 5)

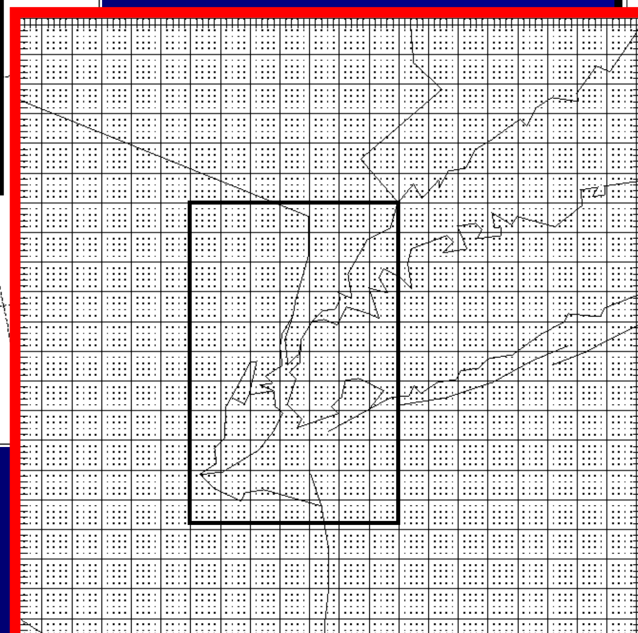


NYC Mesoscale Modeling

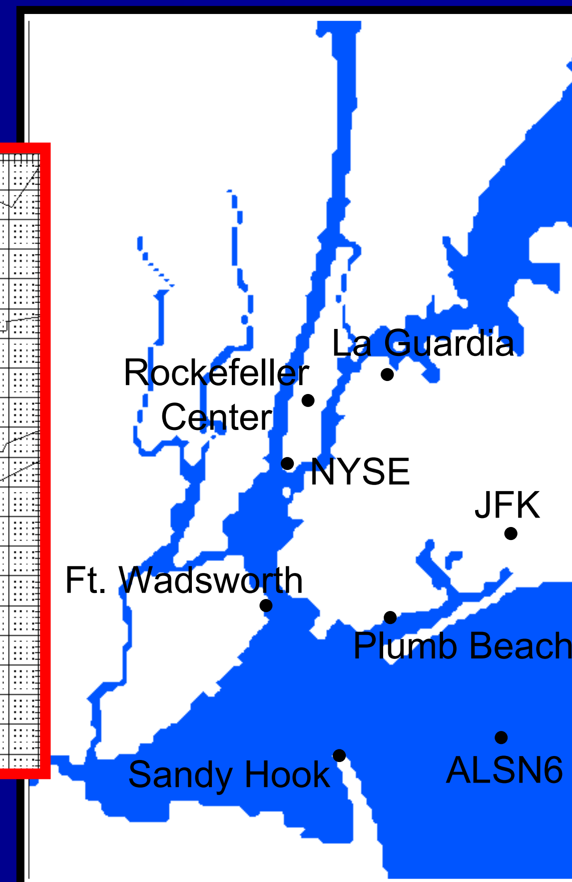
- Common horizontal grid configuration among modeling groups (NRL, LLNL, SUNY-Stony Brook, SJSU)



Nest 1 (36 km)



Nest 4 (1.33 km)

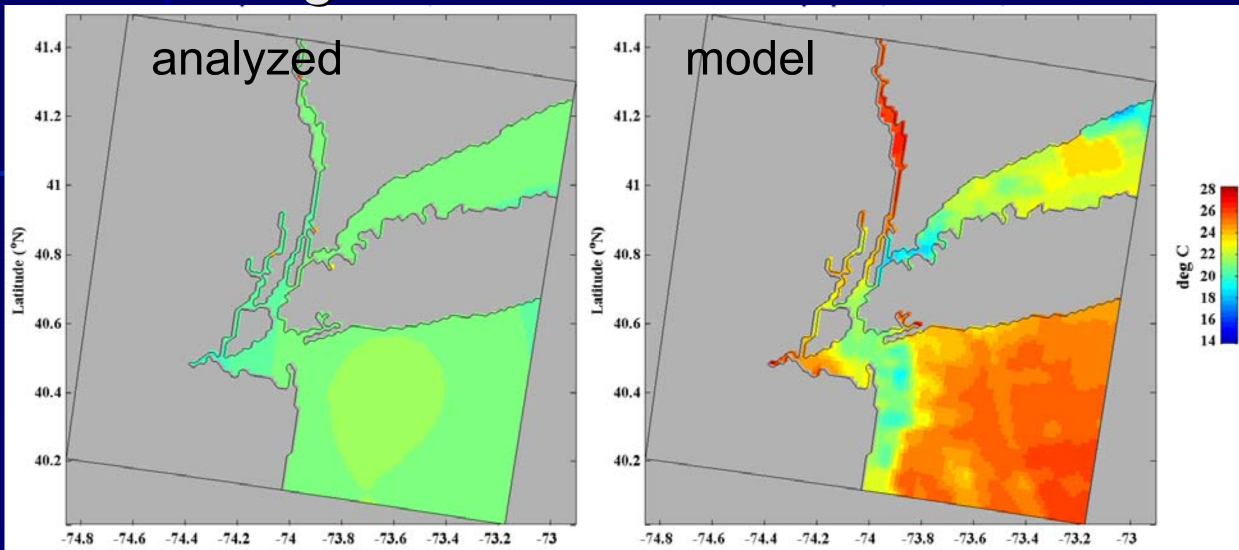


Nest 5 (0.444 km)

(5 nests: 36 km to 0.444 km)

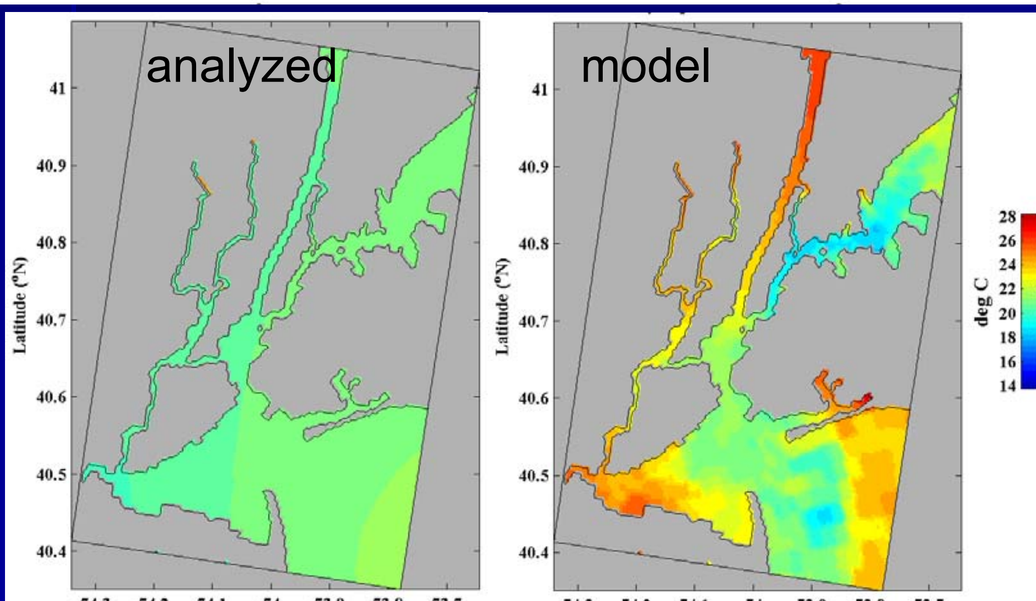
NYC Mesoscale Modeling

Realistic High-Resolution SST's

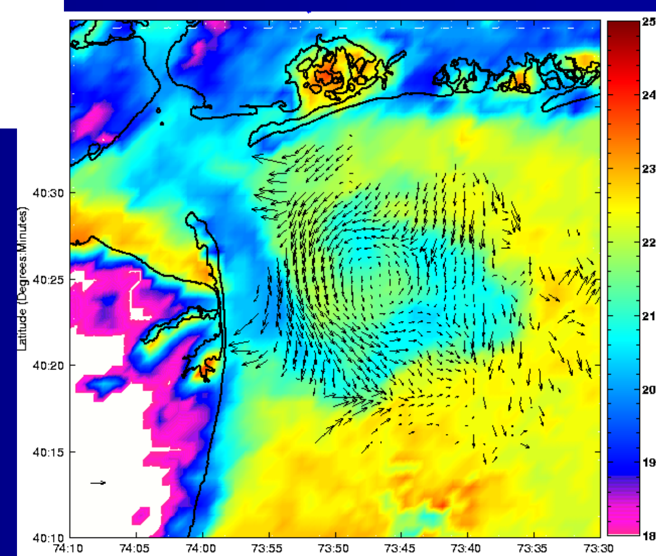


COAMPS nest 4 (1.33 km)

00 UTC 5 July 2004

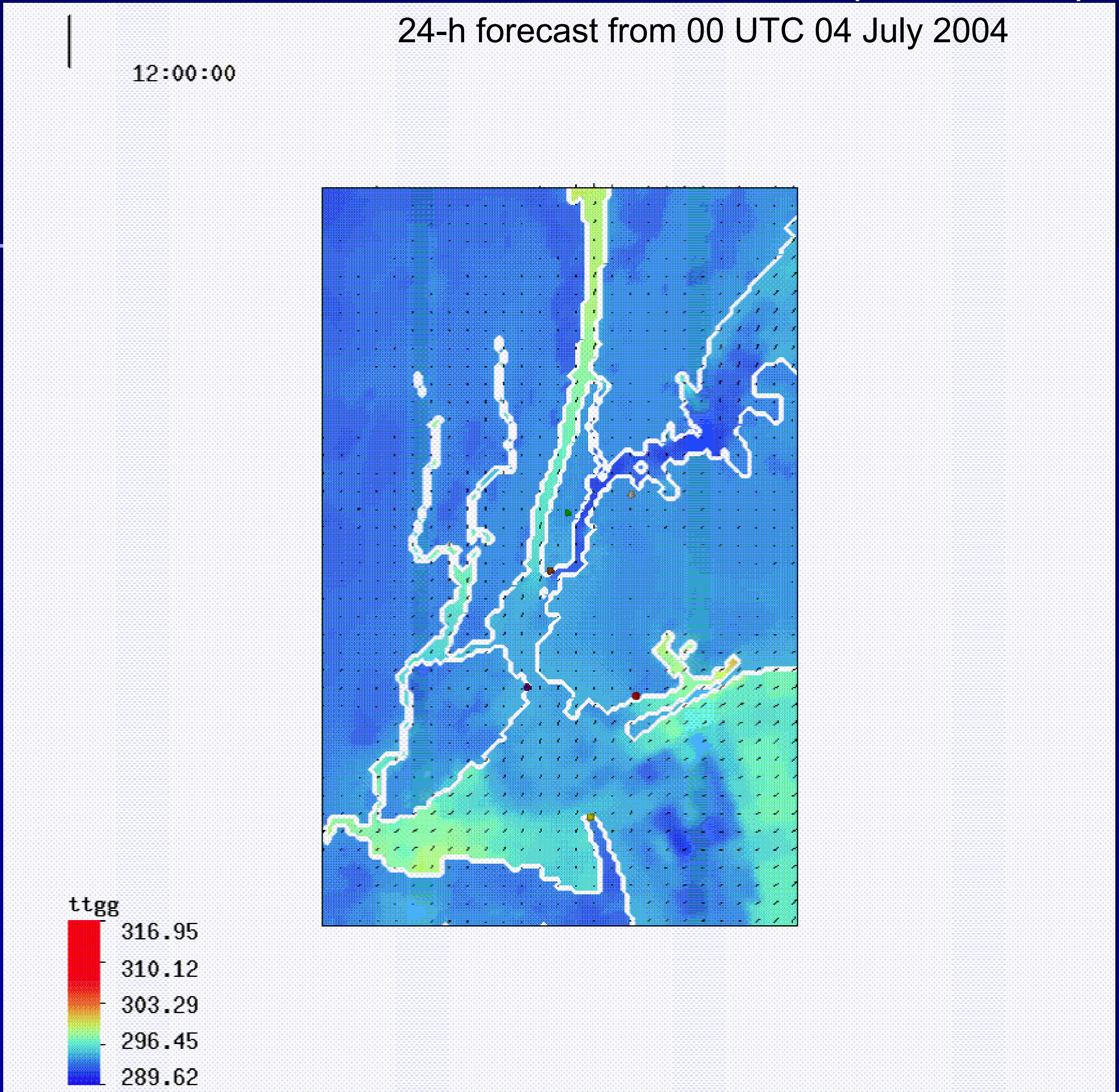


COAMPS® nest 5 (0.444 km)



Observed SST

COAMPS® NYC Nest 5 (0.444 km)



Output shown every 15 min 12 UTC 4 July to 00 UTC 5 July

Continuous 2-m release of 200 kg s^{-1} starting at 12 UTC 4 July 2004 at 6 sites

Concentration (1 mg m^{-3} isosurface)

Surface temperature (color shading, K)

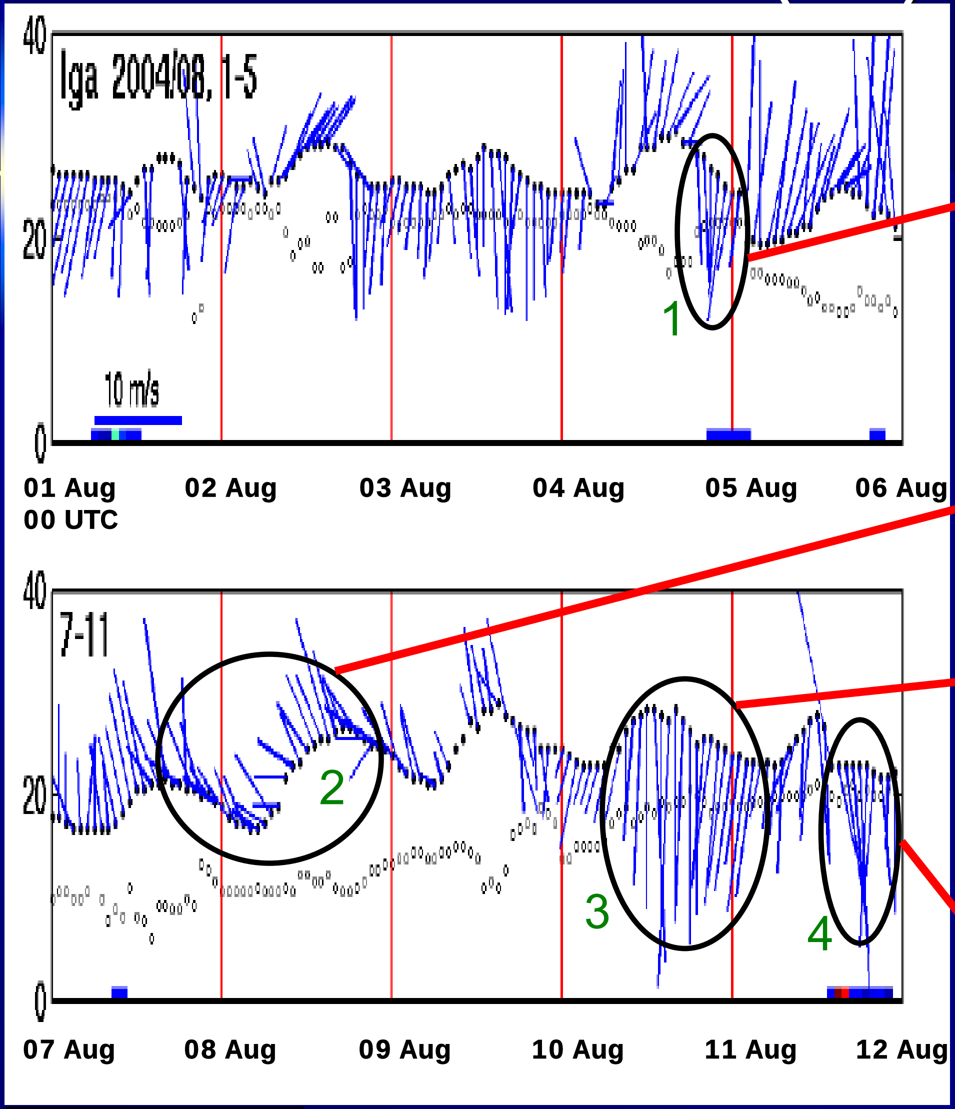
model SST (varied hourly)

10-m wind arrows

UCP

NYC Mesoscale Modeling

LaGuardia (LGA) 1-12 Aug 2004



Classic sea breeze
Northerly to southerly wind shift
Temperature decrease
Dew point increase

Sea breeze-NW wind interaction

Southerly synoptic flow with sea breeze enhancement

Sea breeze with afternoon and evening precipitation

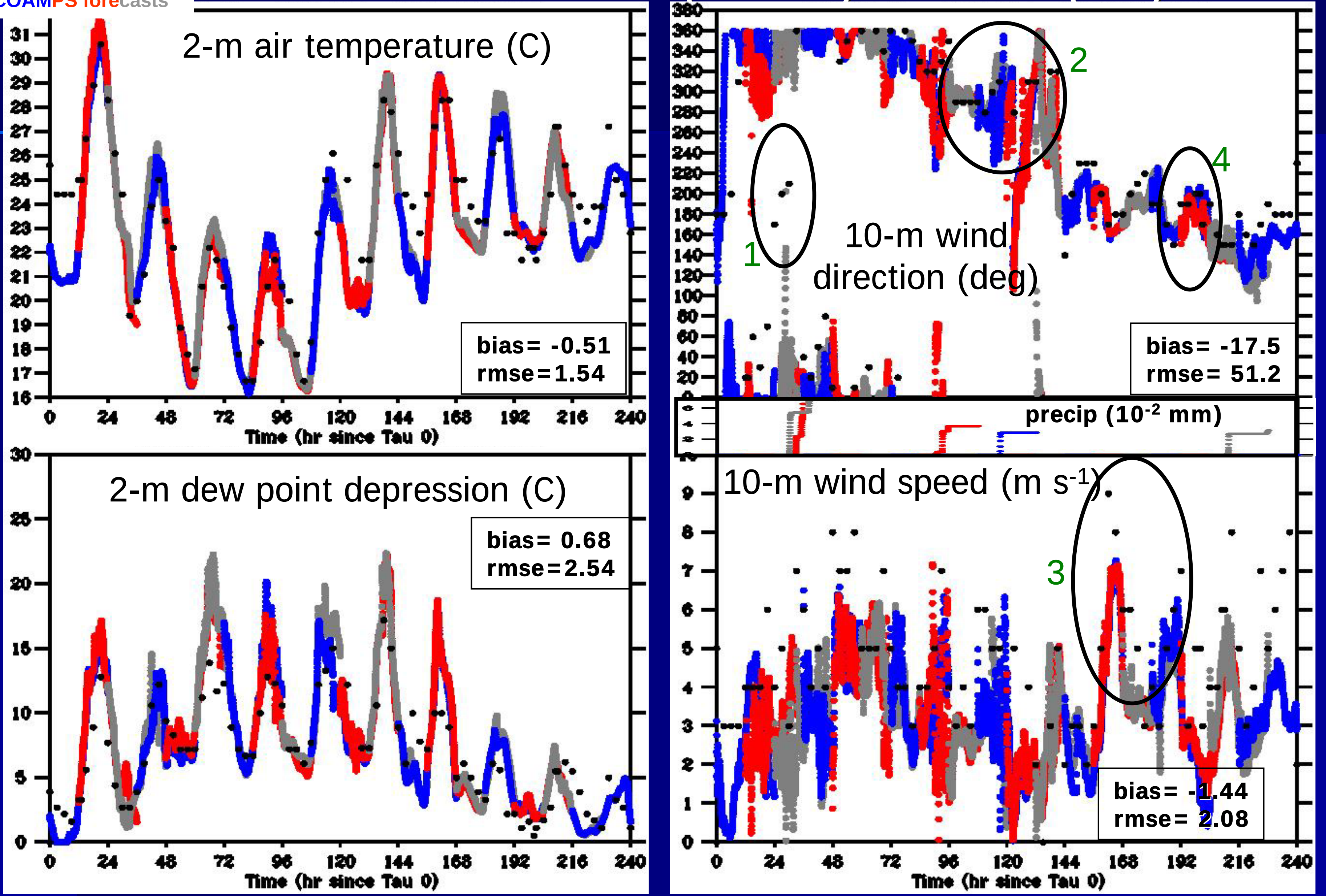
Courtesy of Michael Reynolds, BNL

NYC Mesoscale Modeling

Hourly model SST
UCP

Observations
COAMPS forecasts

COAMPS® NYC Nest 5 (0.444 km): LaGuardia (LGA)

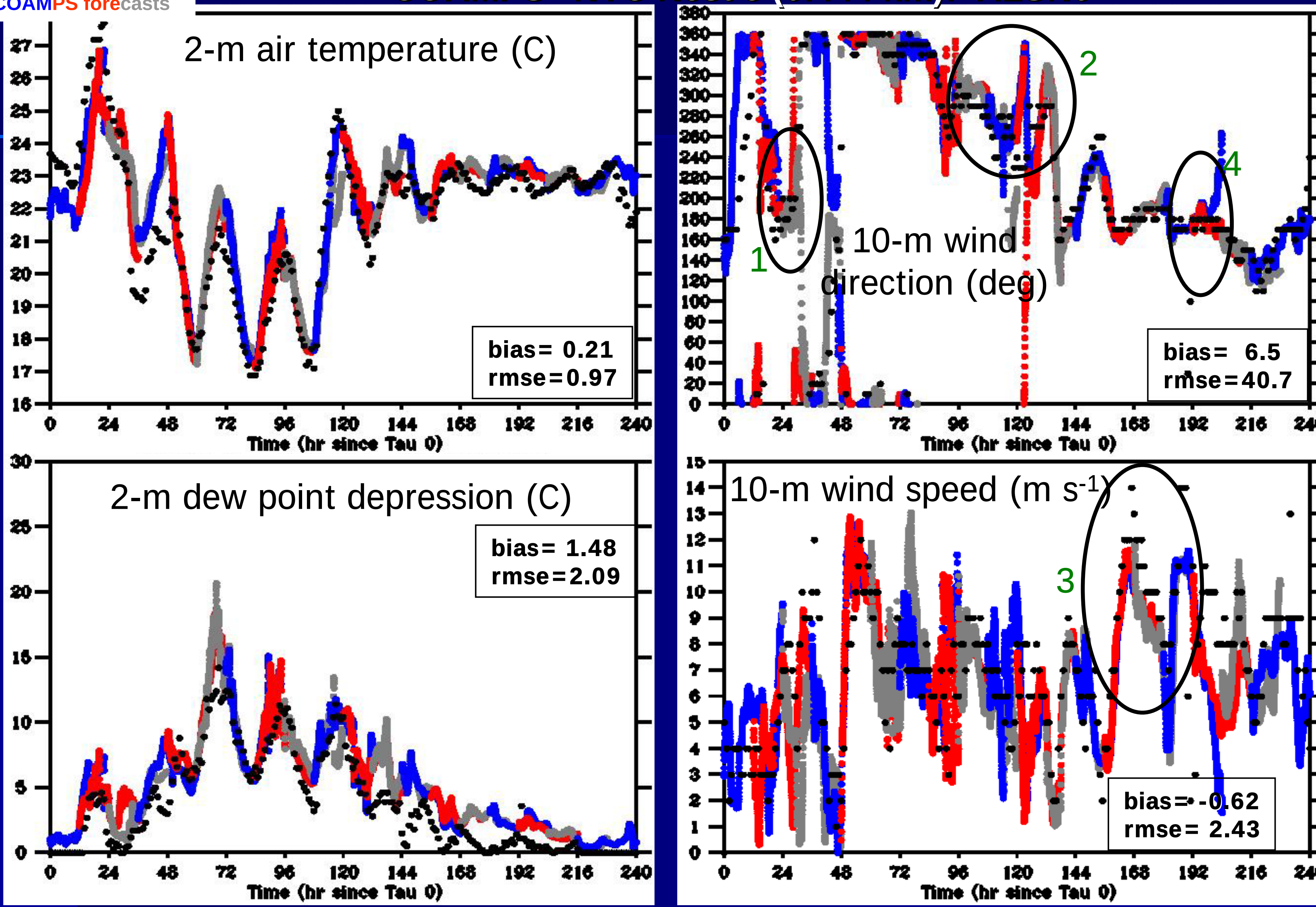


NYC Mesoscale Modeling

Hourly model SST
UCP

Observations
COAMPS forecasts

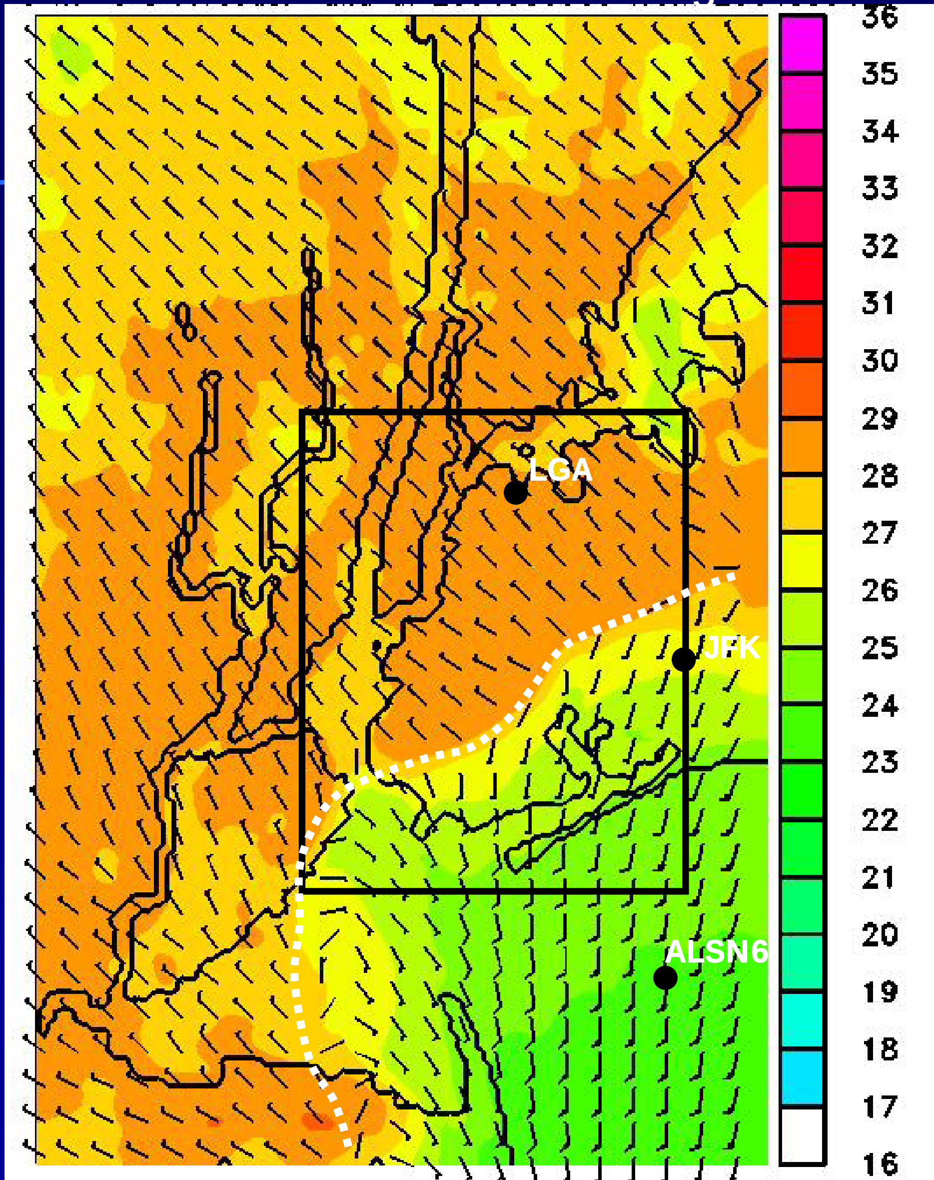
COAMPS® NYC Nest 5 (0.444 km): ALSN6



NYC Mesoscale Modeling

12-h forecast valid 00 UTC 5 Aug 2004

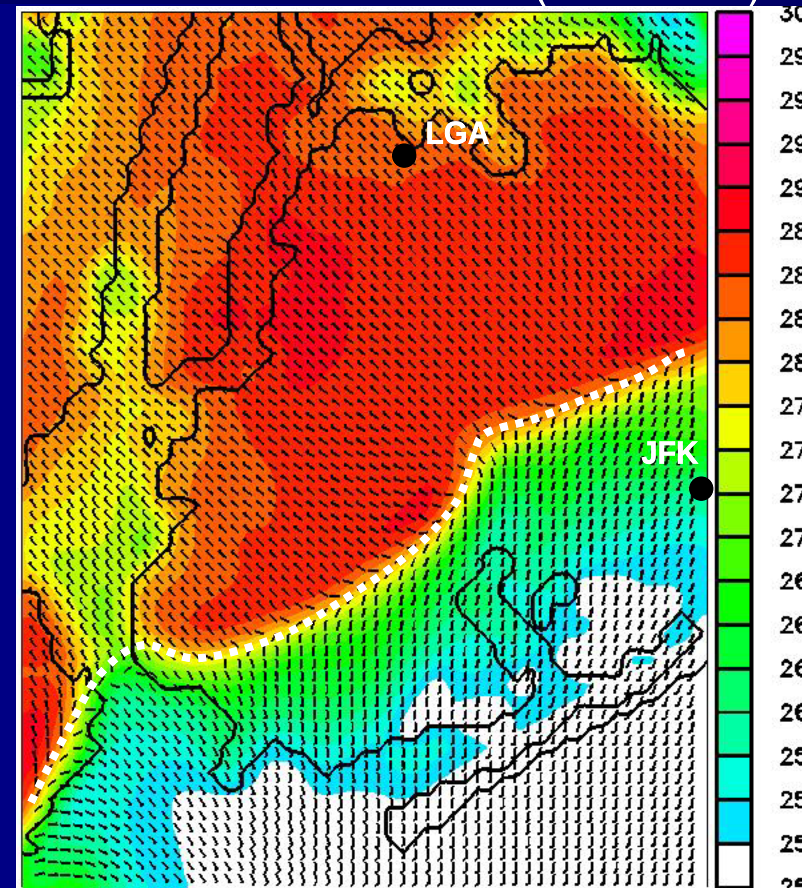
10-m winds; 2-m air temperature (C)



Winds every 5th grid point

Hourly
NYHOPS
UCP

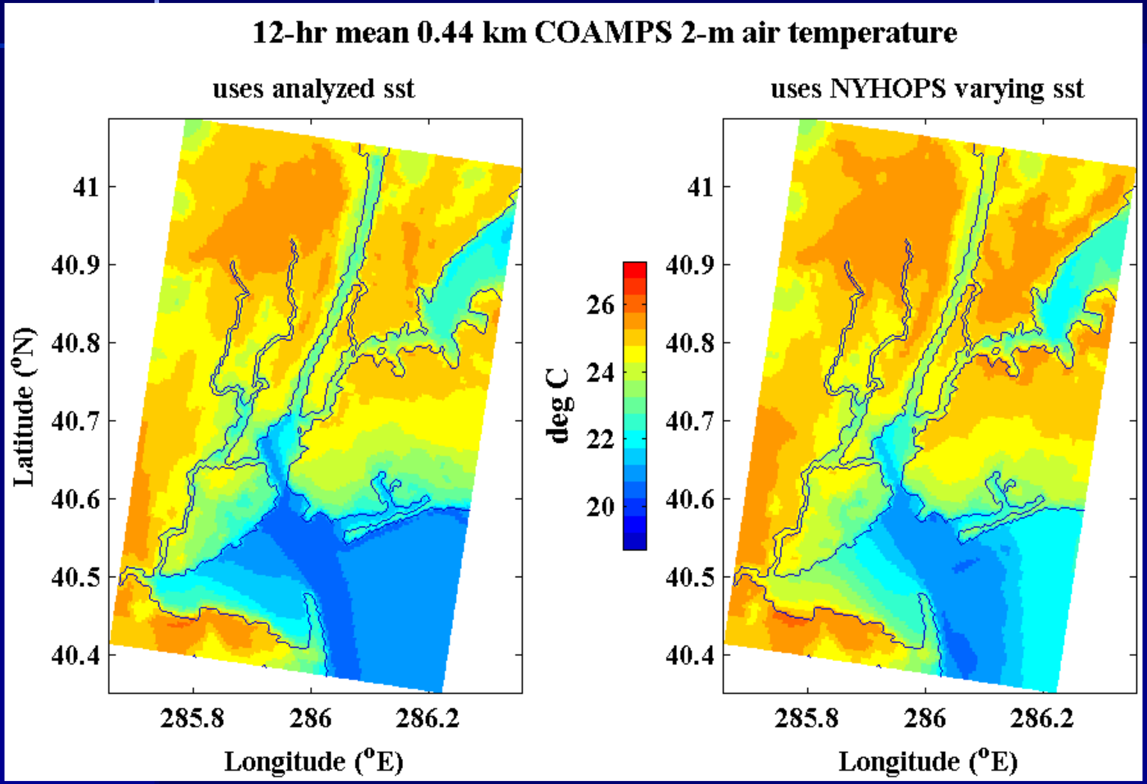
COAMPS® NYC Nest 5 (0.444 km)

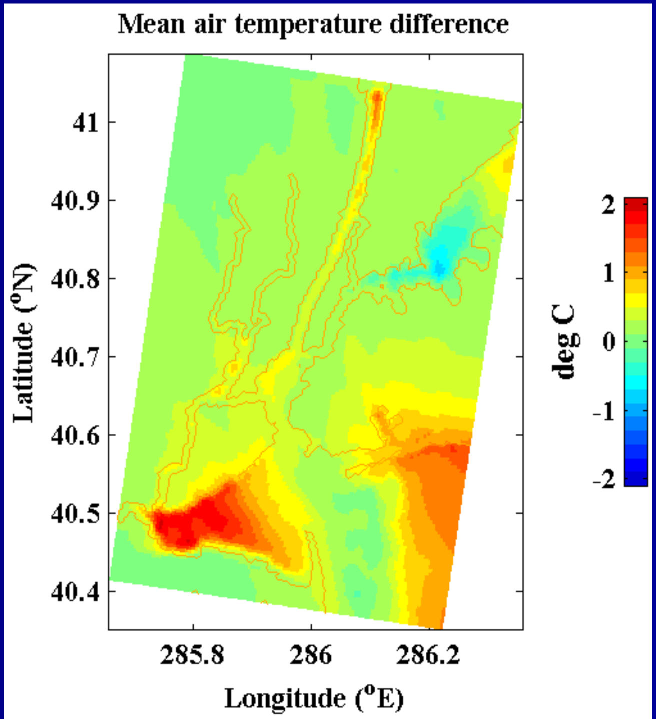


Subset: Winds every grid point

COAMPS® NYC

Hourly model SST versus analyzed SST



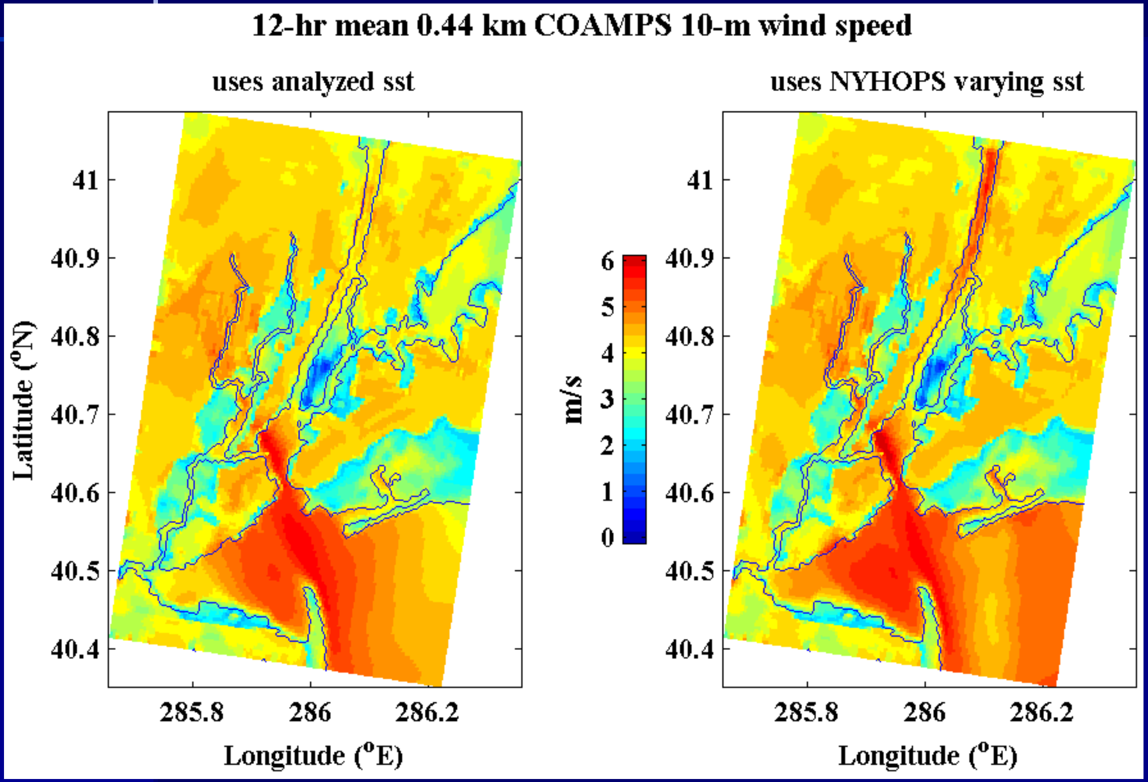


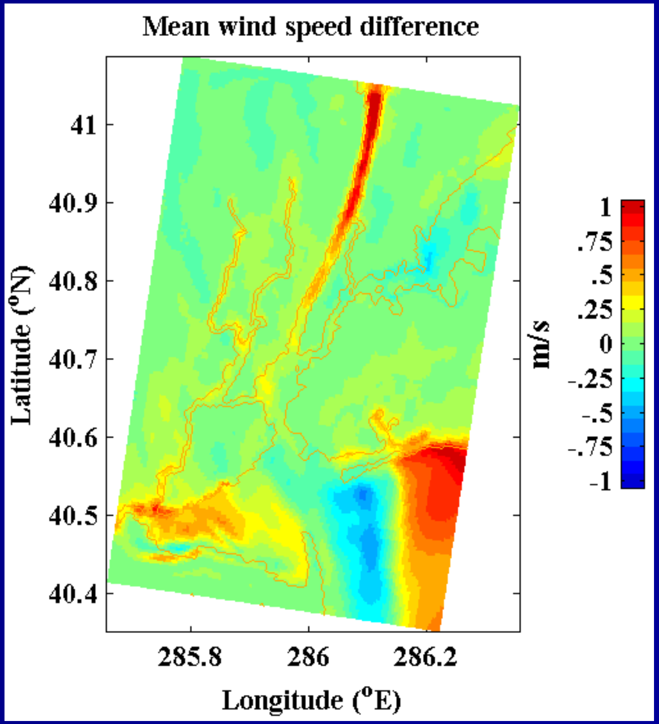
24-h forecast from 2004070400

12-h daytime period from 2004070412 to 2004070500

COAMPS® NYC

Hourly model SST versus analyzed SST



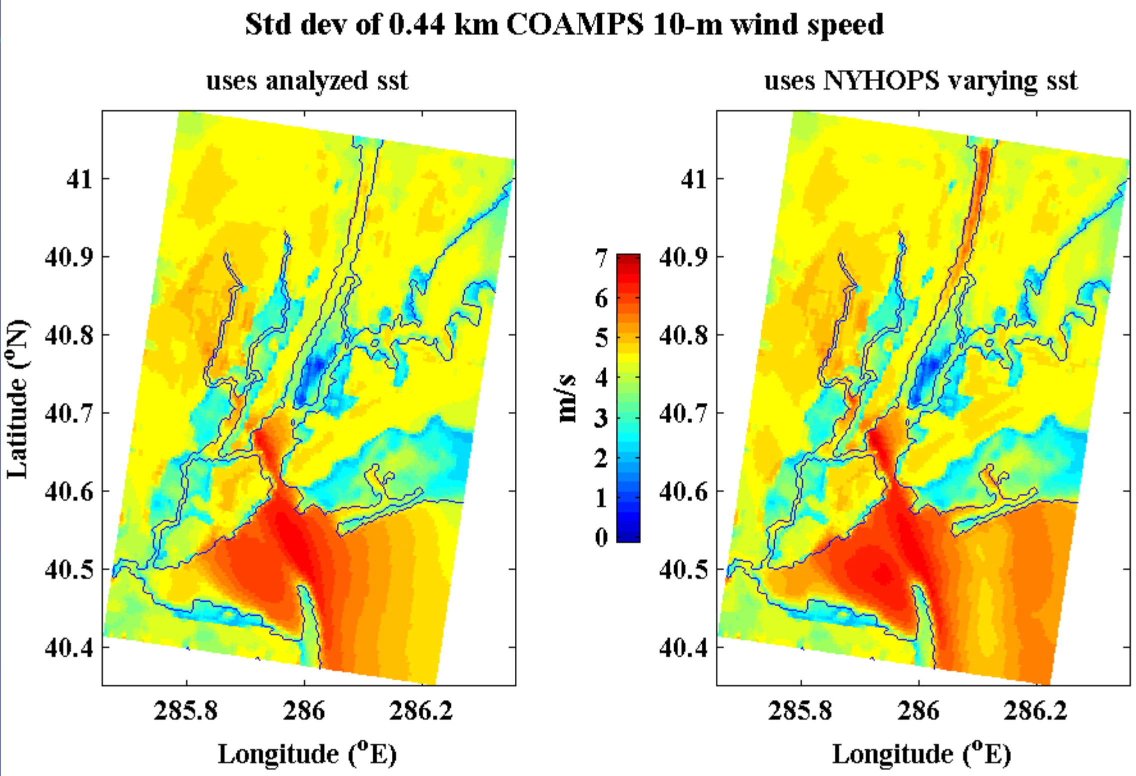


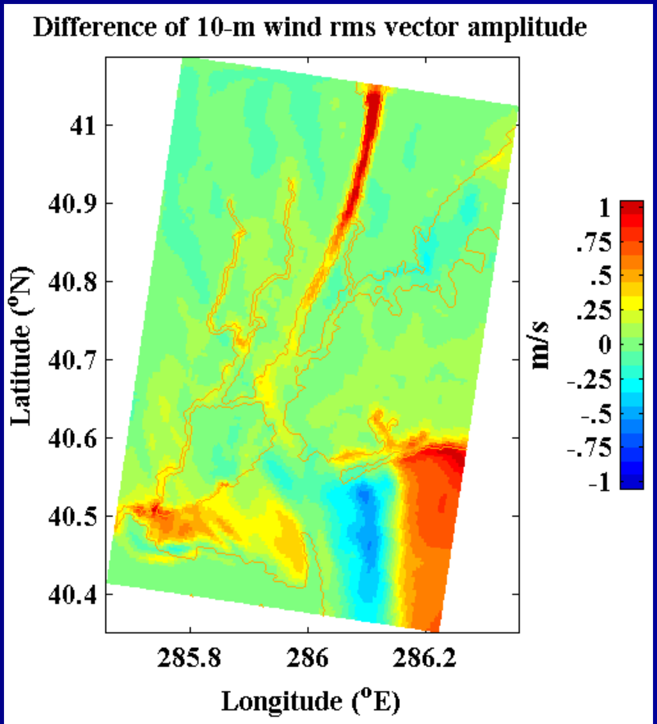
24-h forecast from 2004070400

12-h daytime period from 2004070412 to 2004070500

COAMPS® NYC

Hourly model SST versus analyzed SST





24-h forecast from 2004070400
12-h daytime period from 2004070412 to 2004070500

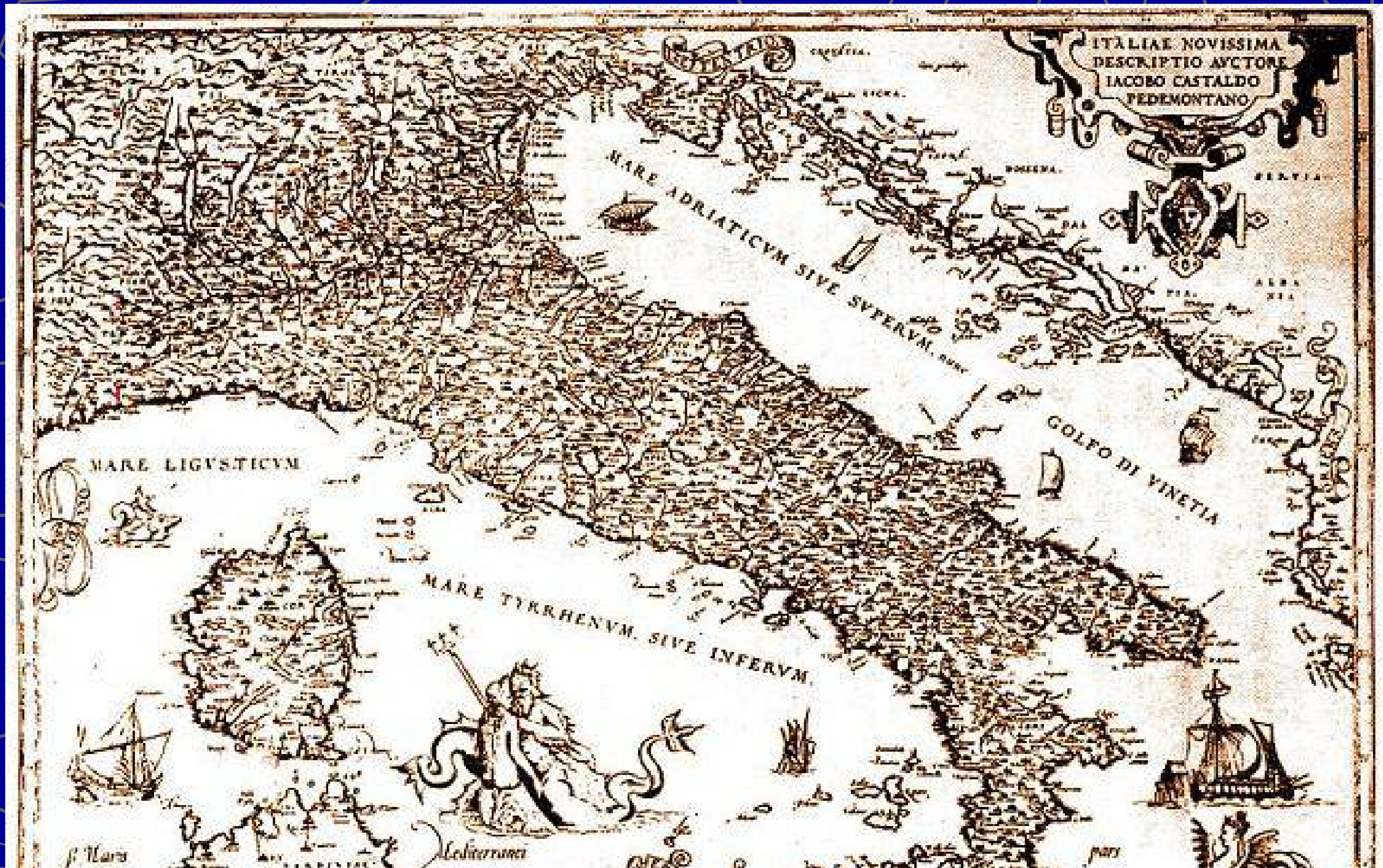
Two-Way Air-Sea Coupling: Studies of the Adriatic

Julie Pullen and James Doyle

Naval Research Laboratory–Monterey

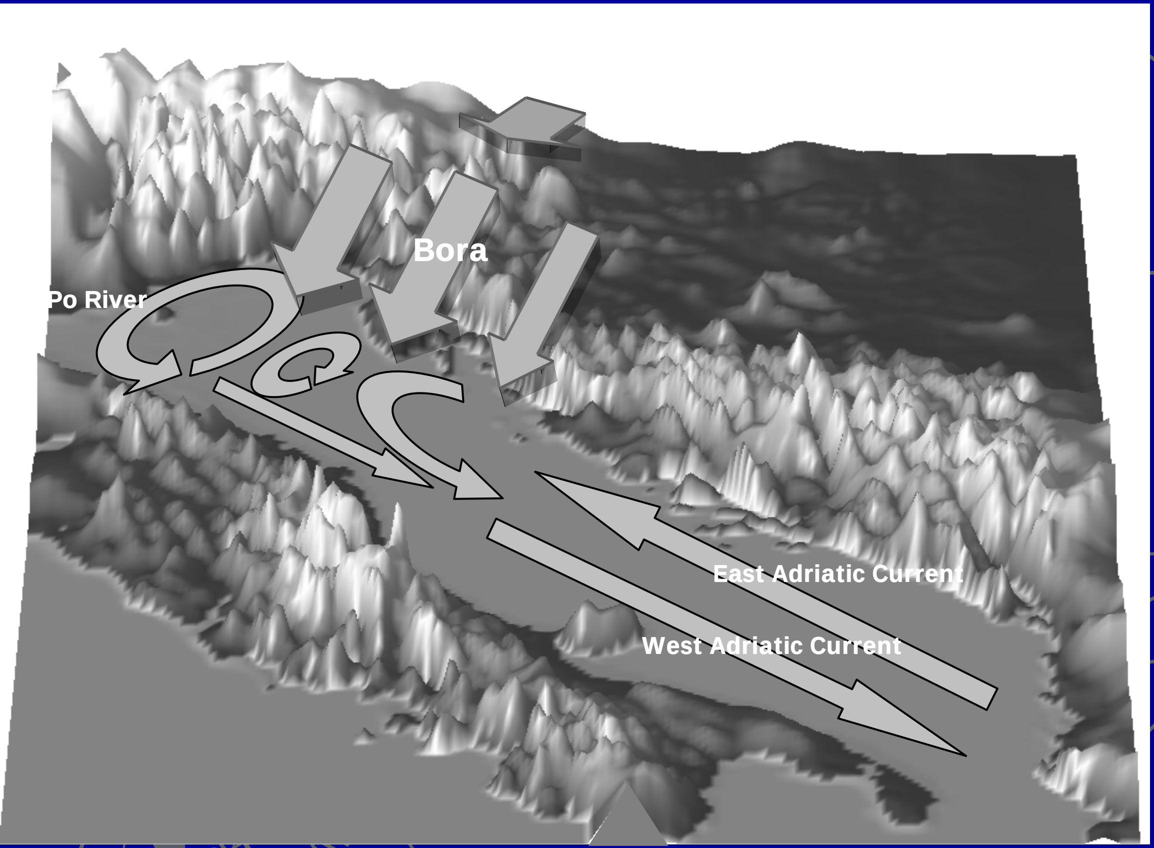
Richard Signell

NATO Undersea Research Center, ITALY



(in press, MWR)

Adriatic Circulation Patterns

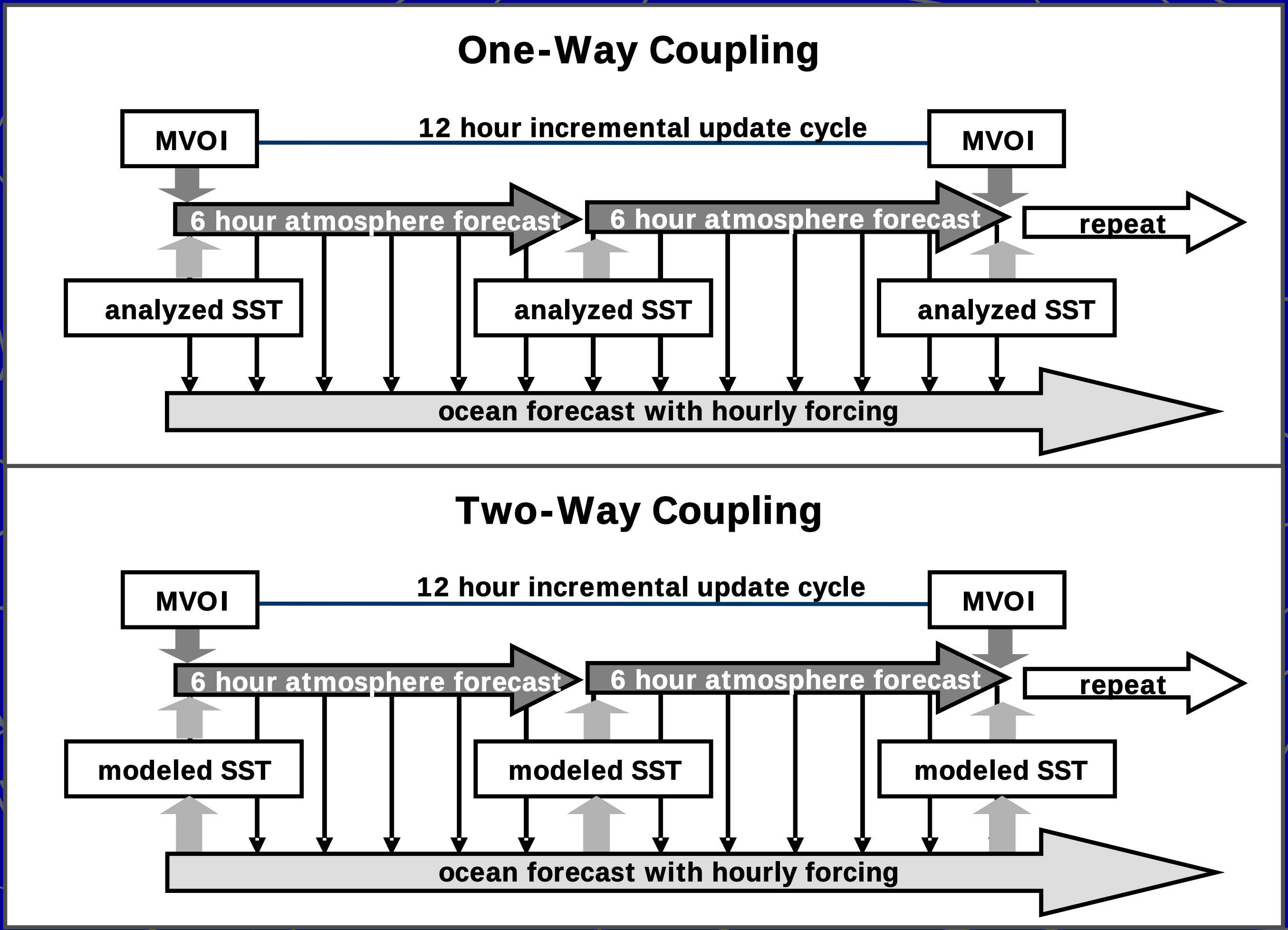


Pullen et al. (JGR-oceans, 2003):

- documented the bora-induced generic double gyre in the ocean
- evaluated one-way coupled model using ocean and atmosphere velocity observations
- quantified the importance of high-resolution atmospheric fields for forcing ocean models

Model Set-up

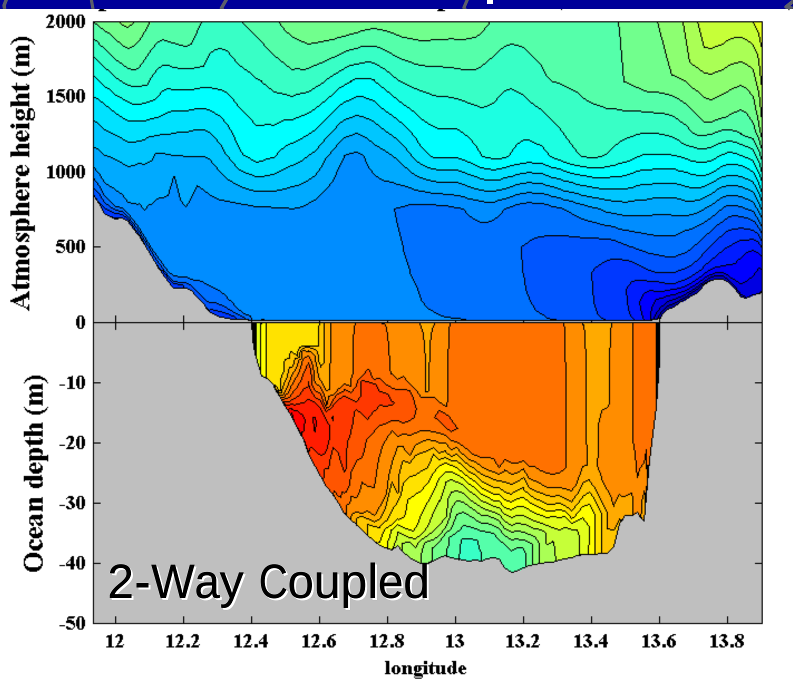
- 2-km resolution ocean model (NCOM)
- 4-km resolution atmosphere model system (COAMPS)

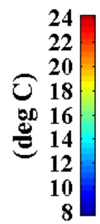


Boundary Layer & Surface Fluxes During a Bora Event

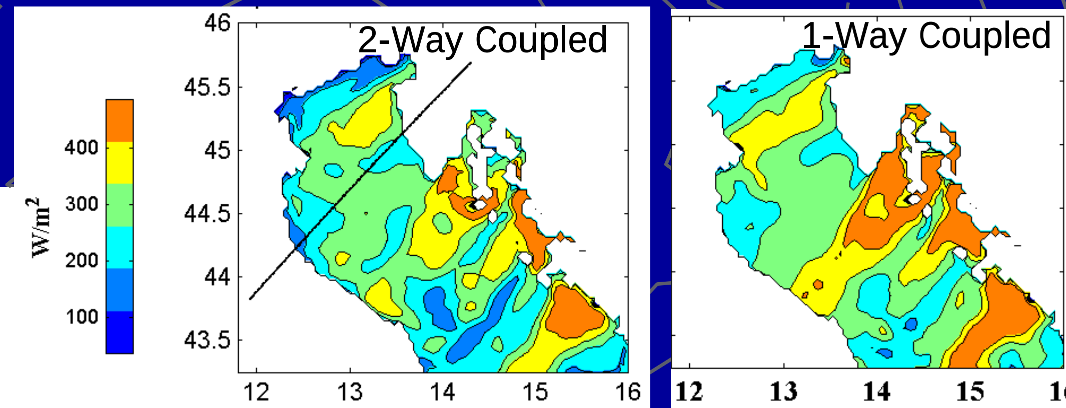
(29 September 2002 6Z)

Potential Temperature

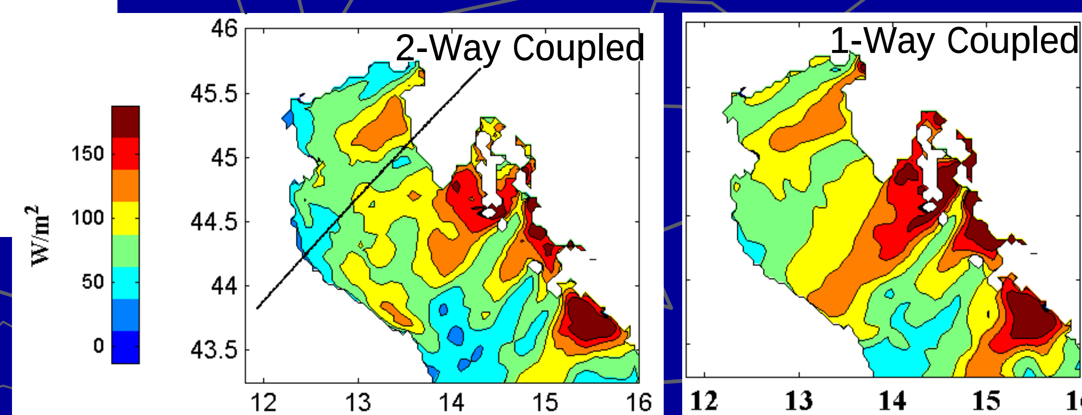




Latent Heat Flux

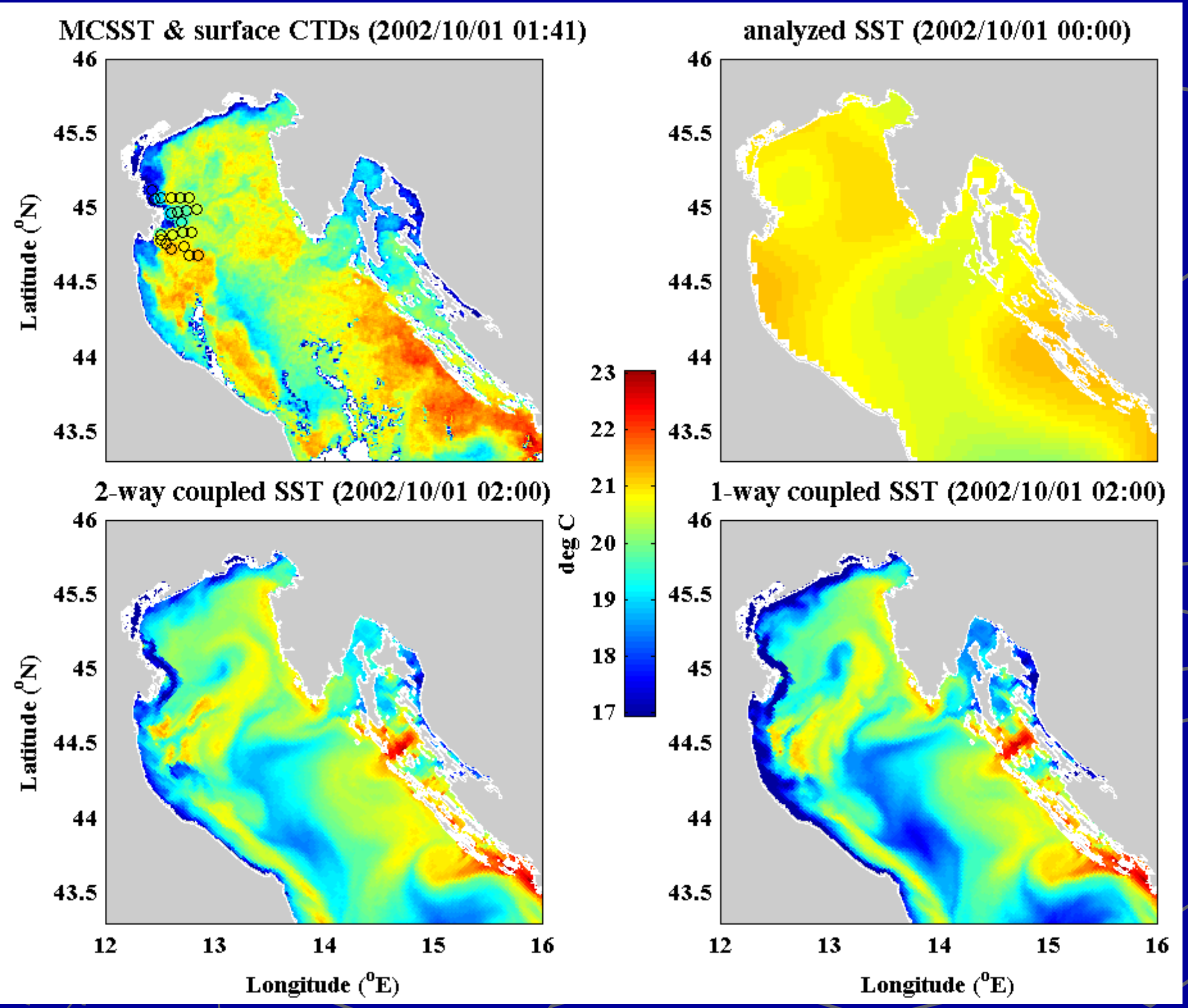


Sensible Heat Flux



Post-Bora SST Evaluation

(1 October 2002)



Basic Statistics

(in deg C)	*N*	*mean*	*Standard dev*
observed	39,217	20.06	1.19
analysis	37,214	20.80	0.21
1-way coupled	37,319	19.48	1.26
2-way coupled	37,319	19.81	0.88

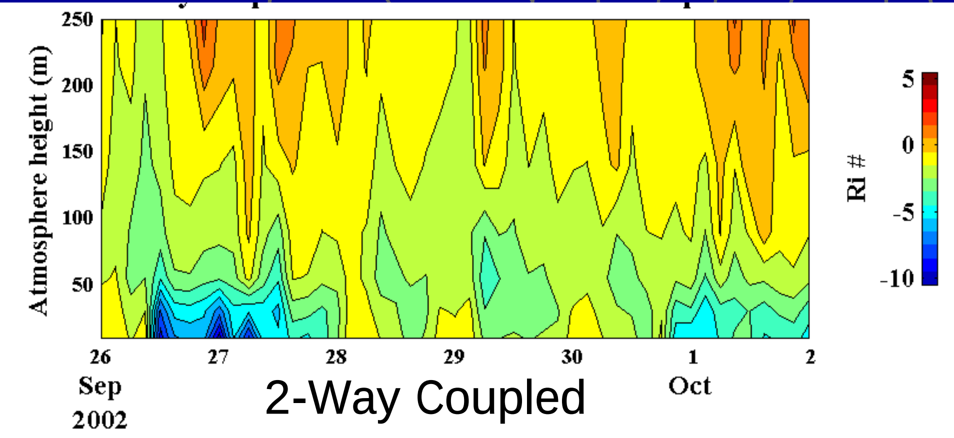
Comparison Statistics

	N	*MB*	*RMSE*	*CC*
analysis	35,977	0.59	1.16	0.23
1-way coupled	36,295	-0.69	1.22	0.60
2-way coupled	36,295	**-0.38**	**0.97**	0.57

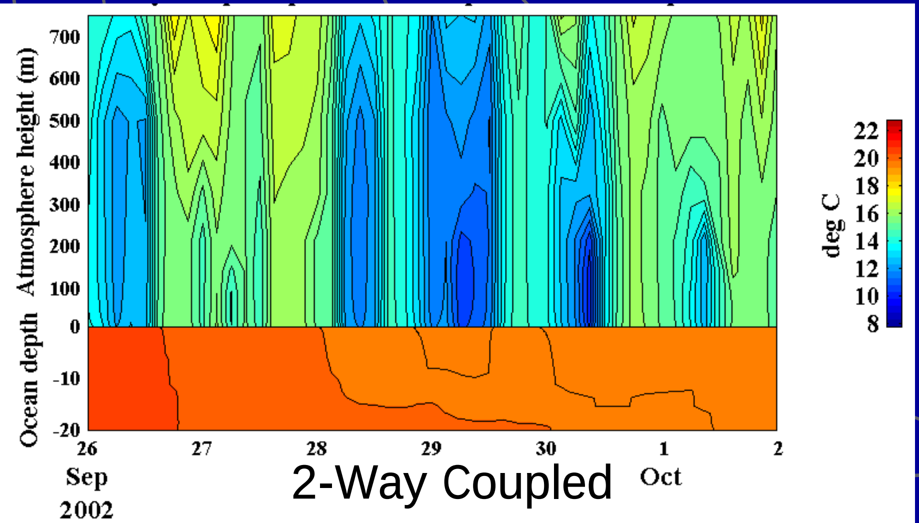
Boundary Layer Evolution During a Bora Event

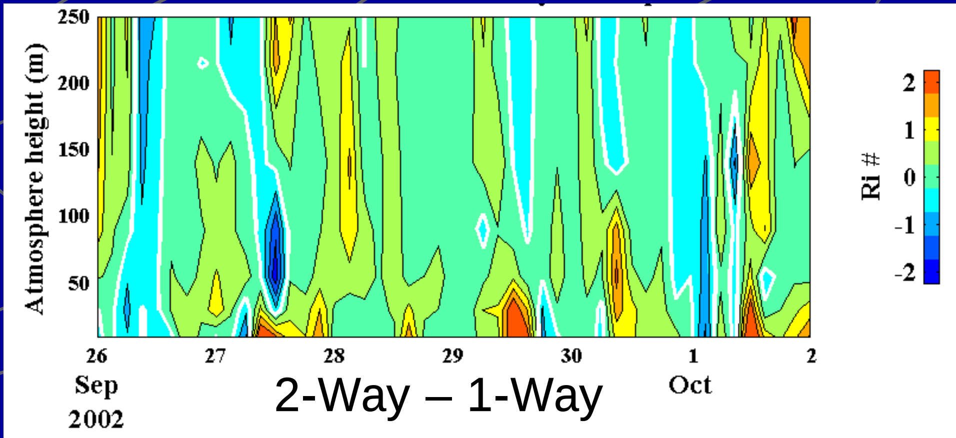
Acqua Alta (over-water site near Venice)

Richardson Number



Potential Temperature

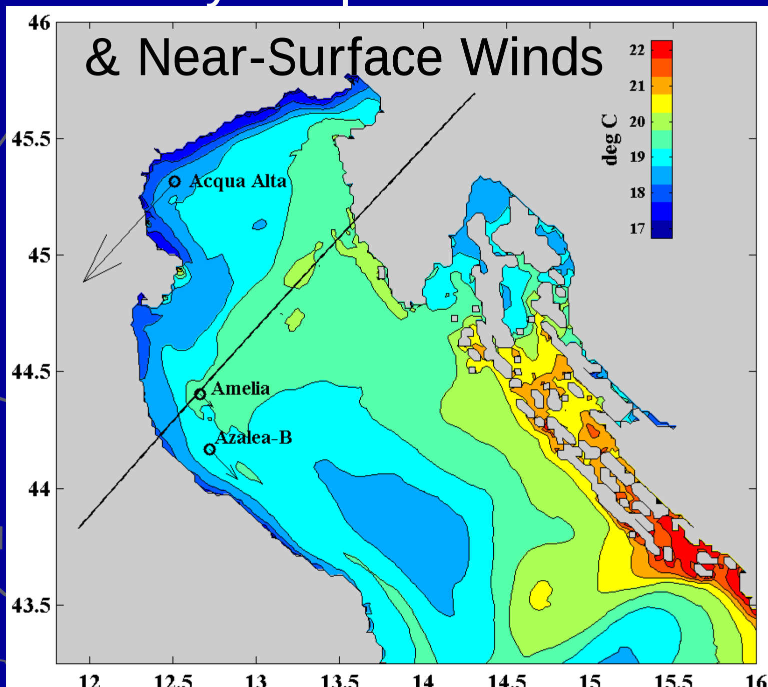




Wind & Temperature Evaluation

(23 September – 23 October 2002)

2-Way Coupled Mean SST

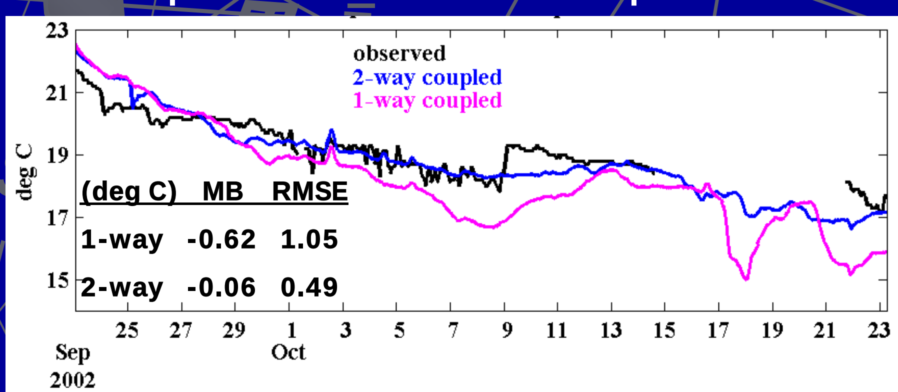


Wind Speed Statistics

(in m/s)	*N*	*mean*	*Standard dev*
Acqua Alta			
observed	726	5.36	3.76
1-way coupled	726	5.59	3.27
2-way coupled	726	5.35	3.13
Amelia			
observed	722	4.76	3.21
1-way coupled	722	5.44	2.93
2-way coupled	722	5.32	2.85
Azalea-B			
observed	655	5.05	2.94
1-way coupled	655	5.74	2.76
2-way coupled	655	5.51	2.67

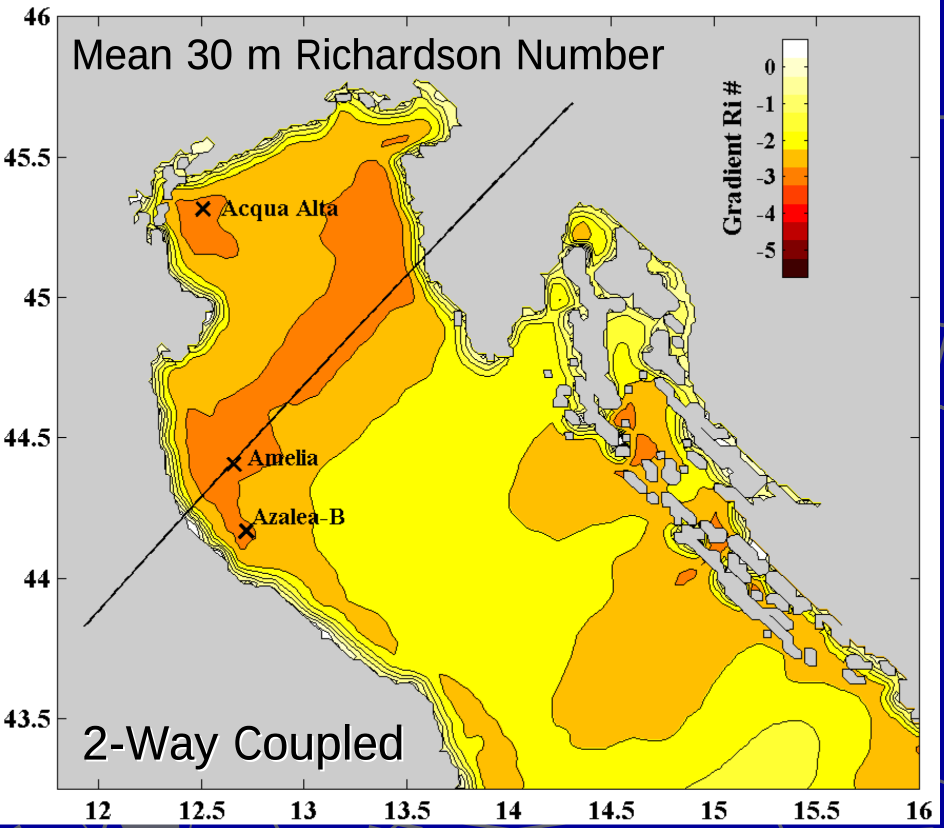
	MB	*RMSE*	*CC*
Acqua Alta			
1-way coupled	-0.23	2.81	0.69
2-way coupled	**0.01**	2.82	0.68
Amelia			
1-way coupled	-0.67	3.20	0.48
2-way coupled	**-0.56**	3.12	0.49
Azalea-B			
1-way coupled	-0.69	2.97	0.49
2-way coupled	**-0.46**	2.98	0.45

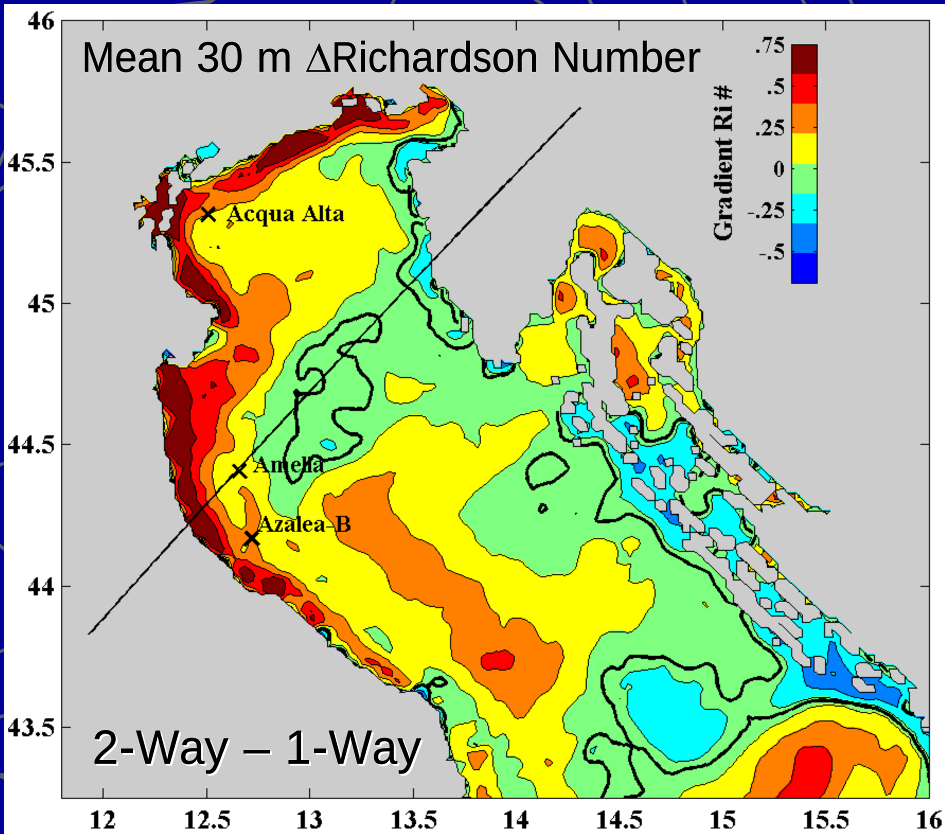
Acqua Alta Ocean Temperature



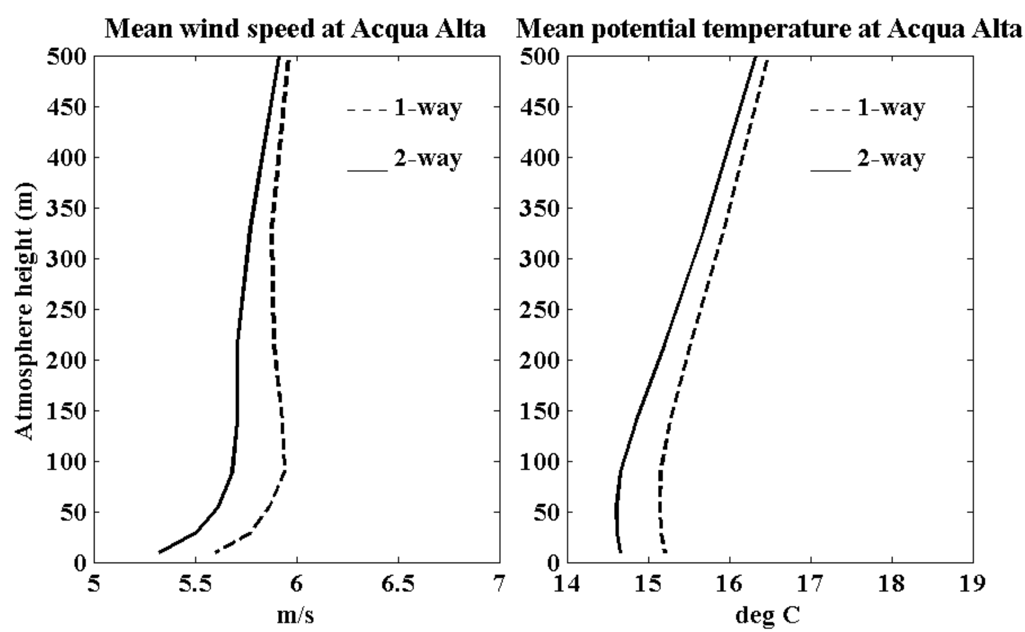
Atmospheric Stability Difference

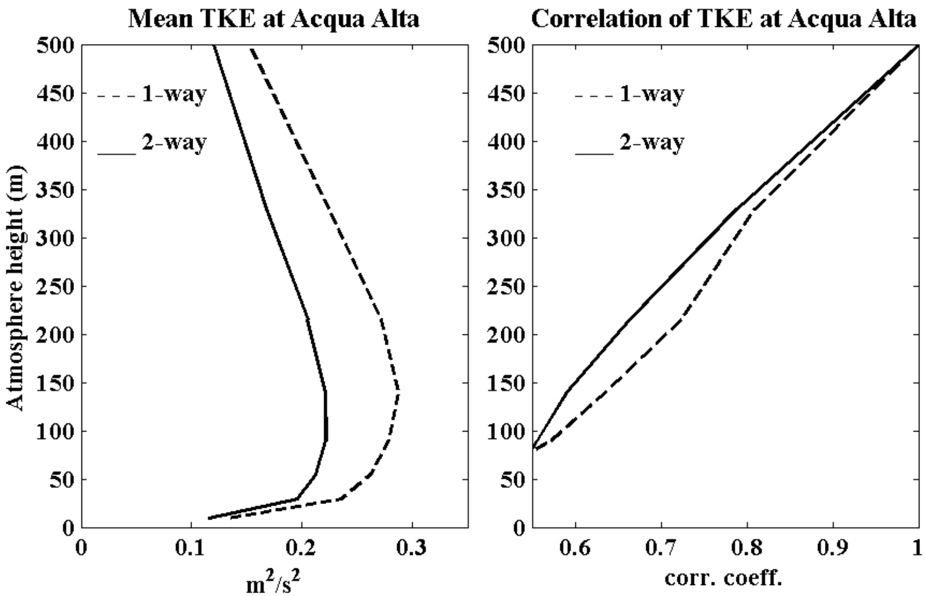
(23 September – 23 October 2002)





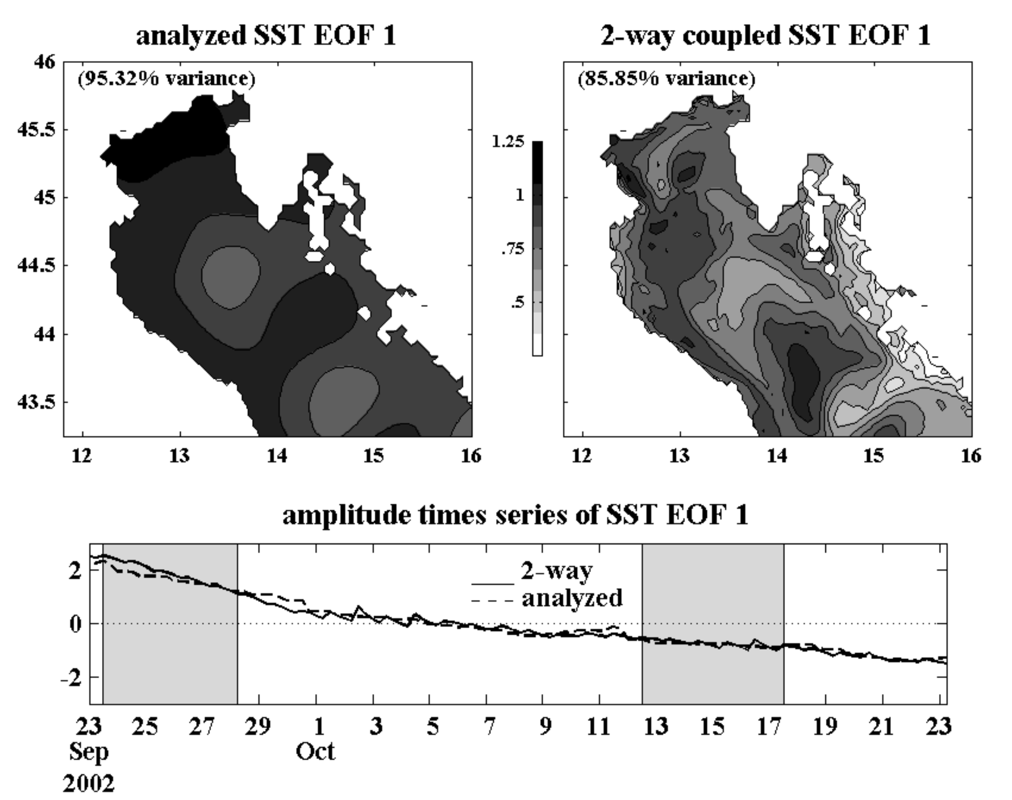
Point Statistics

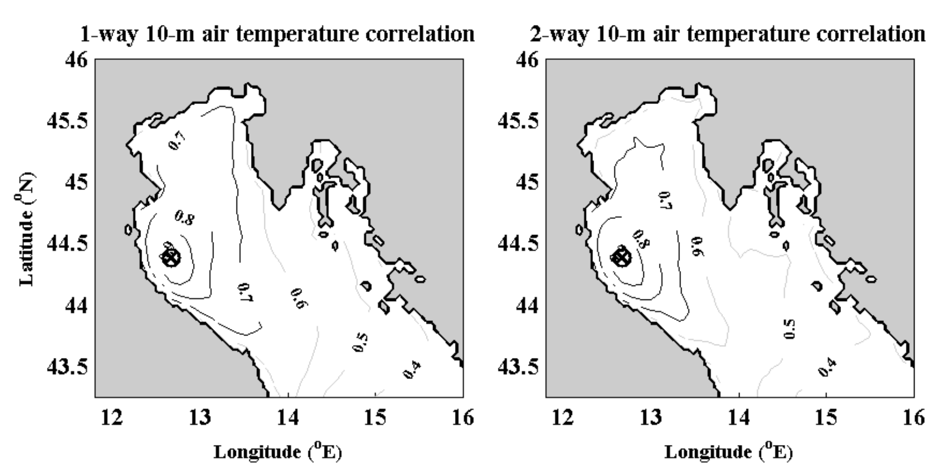




- 2-way TKE is reduced by 20% in the lower ABL
- 2-way TKE is less vertically coherent

EOFs & Correlations





Summary

- Using satellite MCSST data and in situ ocean temperature observations to evaluate model-derived SST, the 2-way coupled simulation had lower mean bias and RMSE error compared to the 1-way coupled simulation.
- At gas platforms in the northern Adriatic, the 2-way coupled model produced lower mean wind speeds that accorded better with measurements than did the values from the 1-way coupled model.
- Cooler SSTs represented in the 2-way coupled simulation stabilize the atmosphere relative to the 1-way coupled simulation, leading to reduced (more realistic) wind speeds in the 2-way coupled simulation.
- 2-way coupling impacts the correlation structure of atmospheric variables such as TKE and air temperature.

Back-Up Slides

COAMPS® Nest 5 (0.44-km) Sea-breeze simulation: 18 April 2005 (24-h fcst from 00 UTC)