Offshore Wind Farms for Clean and Renewable Energy – Towards a Systematic Framework to Evaluate their Environmental and Societal Impact

Team 3, CCNY CRV Proposal, 6/29/22

Faculty Name	Expertise critical in project
Hansong Tang (Team Lead, civil eng.)	Fluid mechanics and simulation
Vasil Diyamandoglu (civil eng.)	Water quality
Naresh Devineni (civil eng.)	Data science
Kyle McDonald (earth and atmospheric sciences)	Remote sensing
Akira Kawaguchi (computer sciences)	Gaming and networking
Alexandar Tzanov (CUNY high performance computing center)	Computing techniques
Grace Chang (Integral Consulting)	Ocean environmental modeling
Branko Glisic (Princeton Univ., eng.)	Structure health monitoring

Background

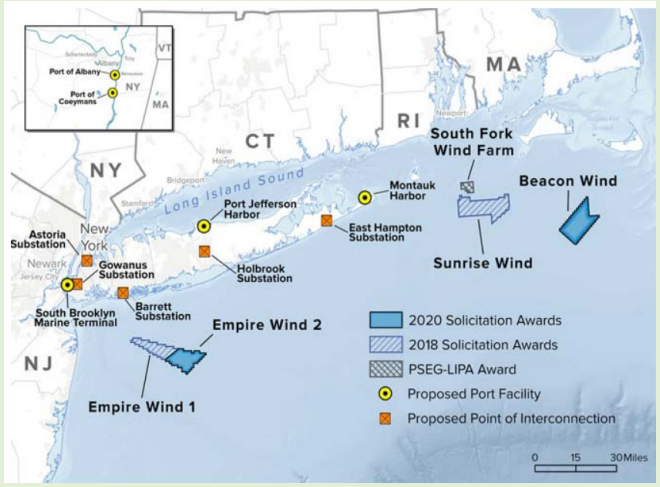
Offshore wind (OSW) energy

- Green, renewable energy
- US resource: four times the generating capacity of electric grid

Recent examples of OSW Investment (as of today)

- Federal --- 7 OSW farms, built by 2025, announced by Biden administration in Oct. 2021.
- NYS --- 2022 NYS OSW investment: $500M
- NYC --- In Sept. 2021: a 15-year, $ 191M OSW plan.
- CUNY --- 2021 $10M RFI - Offshore wind power/green energy. $3M student training on OSW energy at KCC.

Block Island Wind Farm, R.I., the 1st and only US wind farm



NY ongoing OSW projects (NYSERDA)

Problem and framing question

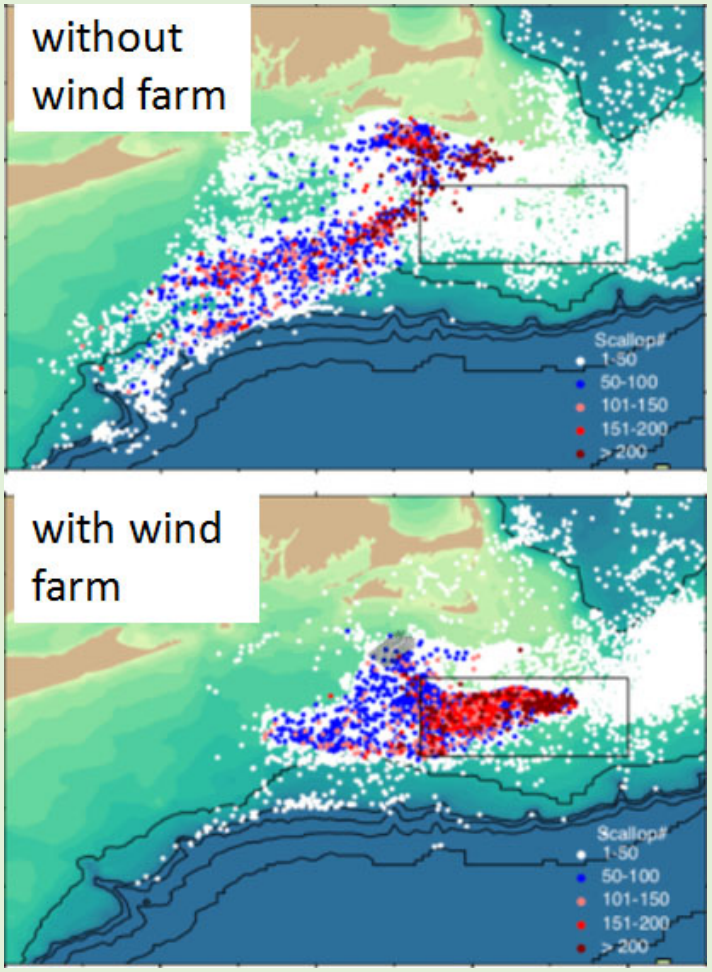
OSW farm problems

- where to allocate a farm, how?
- how to design supporting foundation and power transmission cable?
- Impact to environmental, ecological systems (larval, coral reef, …. ?
- wind farm vulnerability to ocean wave?
- ……

Framing question:

Imagine if we had the knowledge to inform the planning and building of offshore wind (OSW) farms

-- What would that look like?



Example of OSW impact (concentration of scallop), 100 turbines, in Rhode Island water (Chen et. al 2021)

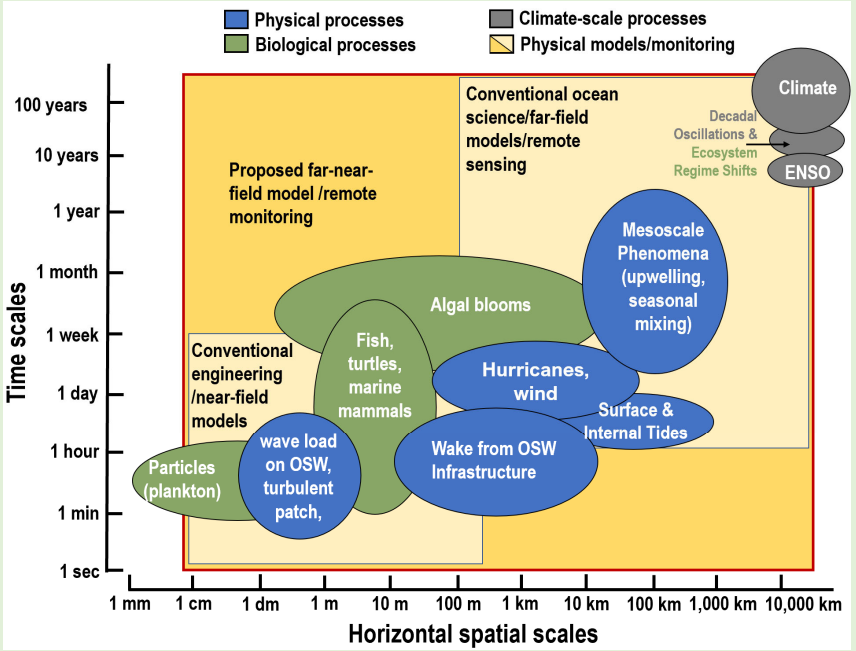
Challenge and objective

Challenge

- Multidisciplinary: coastal/civil/electric engineering, environmental sciences, oceanography, marine ecology, atmospheric science, social science, ….
- Multi-processes at drastically different scales.
- Status: no modeling methods/packages to reliably and directly evaluate the impacts.

Objective

- A high-fidelity, modeling-monitoring-data framework for the OSW impact on environments and vice versa.
- A prototype study of an OSW farm, fundamental processes, scales and magnitudes.



Complexity of the processes.

Innovations

Intellectual Merits

- The modeling-monitoring-data system built on our unique, newly developed capabilities
- The first of its kind, highly desired breakthrough for OSW farm problems
- Revealing various processes unavailable before due to technical limitations

Broader Impacts

- An unprecedented platform to study OSW problems, aid planning, permitting, installation, and operation, …
- Co-existence of OSW farms with community, ecosystems, navigation, recreation, etc.
- Promote renewable, green energy for communities at the local, regional, national levels

Making difference

- Topic --- a) timely, b) multidisciplinary, basic/applied research, c) broad impacts on science/engineering, on national, regional, and local stakeholders
- Technique --- built on unique, new capabilities of the team members, 1+1 >> 2 technically
- Funding --- growing quickly at federal, state, and city levels, from various agencies
- Benefit --- new research at CCNY: in OSW, and team members' own fields

Technical approach

Theme 1 Hydrodynamic and environmental processes

- Modelling of ocean hydrodynamics
- Remote sensing ocean hydrodynamics and environments
- Water quality valuation

Theme 2 Impacts between OSW farm and the ocean

- OSW impact on aquatic environment, awareness of the community
- Vulnerability of OSW infrastructure

Theme 3 Data-driven modeling and computer integration

- Data-driven modeling
- Computer integration, an OSW “gamebox” to educate community/society

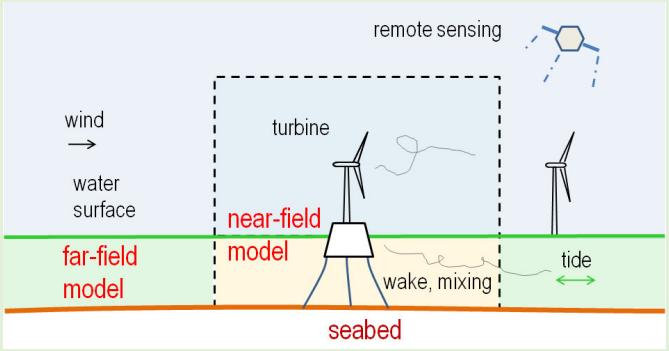
Site of study

Location:	New York Bight, or Block Island Wind Farm (RI), or Coastal Virginia Offshore Wind (VA).
OSW infrastructure:	bottom mounted or floating OSW foundation, power transmission cables, …
Other:	ocean tides, wind, bathymetry, …

Technical approach

Built on our capabilities

- A unique ocean hydrodynamics modeling system
- Near-surface meteorology and ocean surface environ.
- Data-driven modeling techniques
- Gaming techniques
- …



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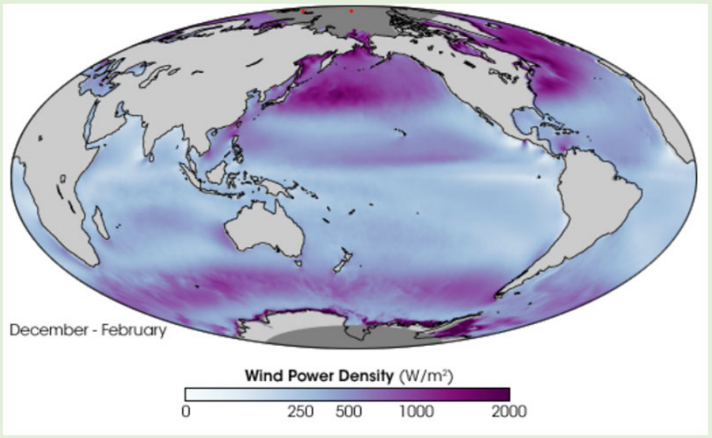

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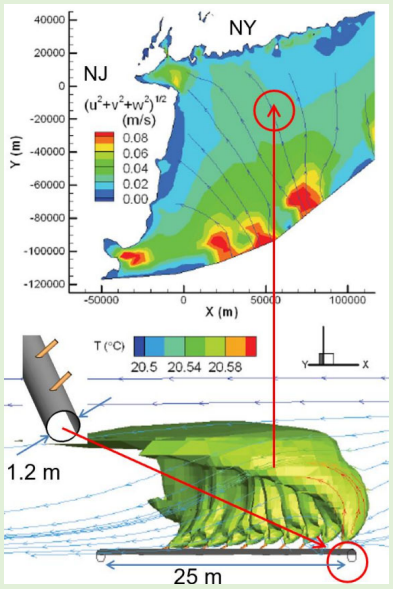

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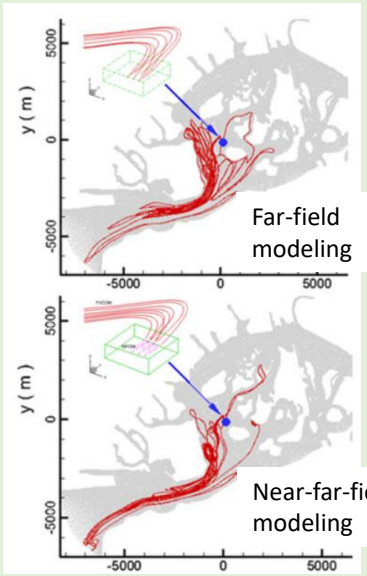

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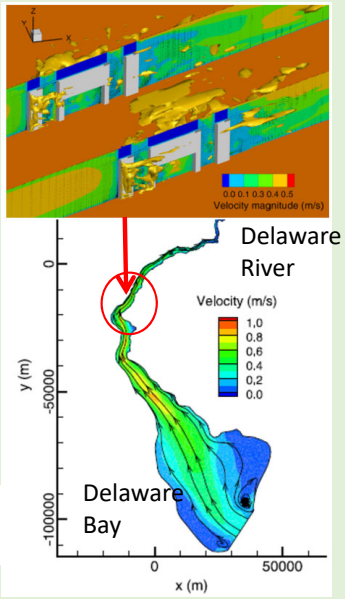


(e)

Wind power distribution over the ocean. Liu, et al. (2008)

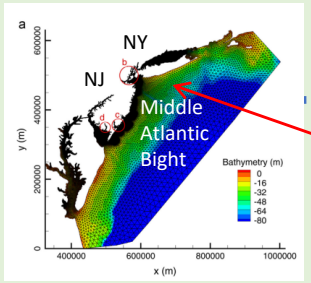
Sample simulation by our CCNY modeling system

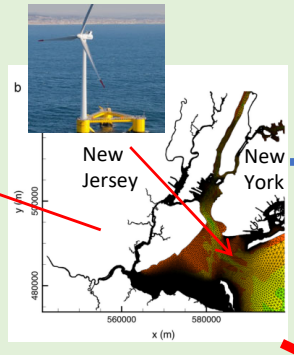
Team/task integration

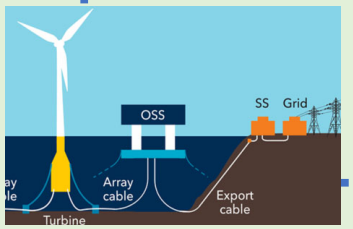
1. Tang /Tzanov –
modeling ocean hydrodynamics:
flow field, salinity, temperature, . ..

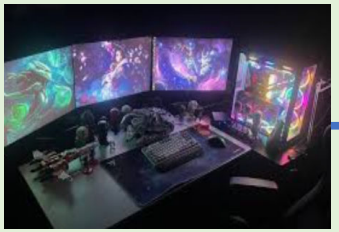
2. McDonald – satellite monitoring:
wind speed/direction, ocean temperature,
Chlorophyll, …

3. Diyamandoglu
-- water quality:
hazardous release,
OSW structural materials









4. Tang/Glisic-- Infrastructure/
power transmission cable:
forces, damage, vulnerability.

6. Devineni –
Data-driven modeling:
ML models, data flow

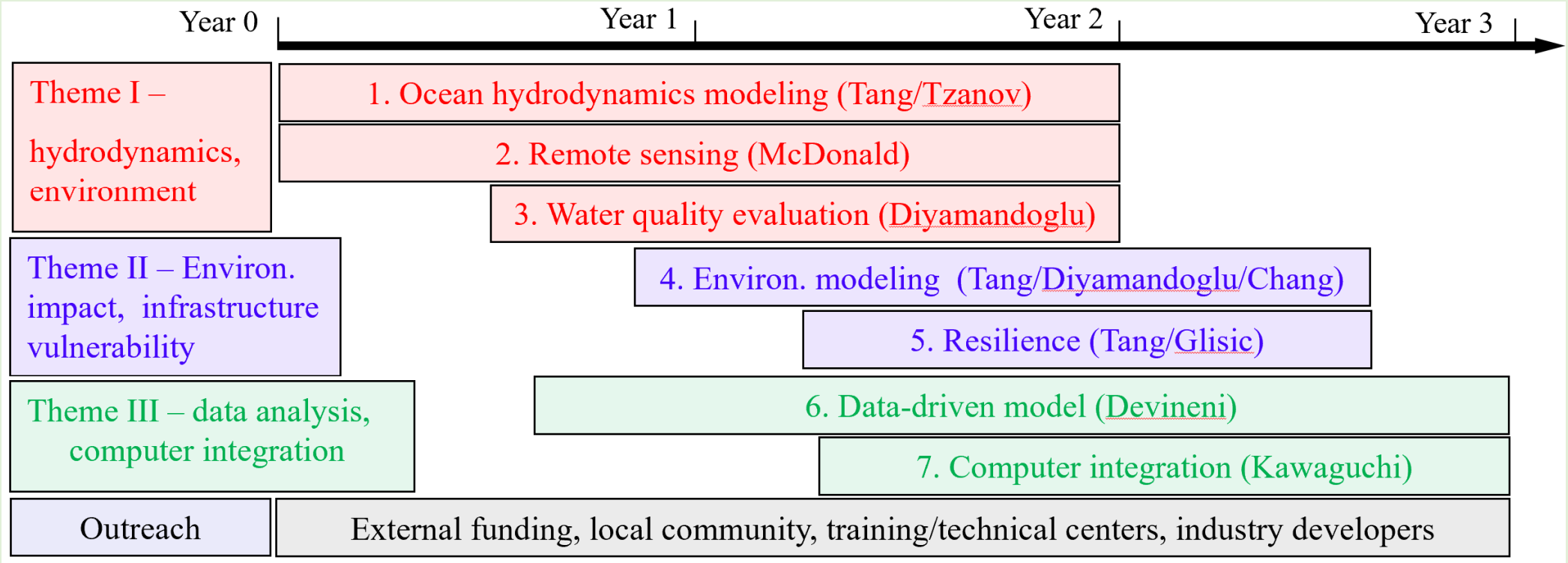
7. Kawaguchi –
computer integration:
OSW learning interface, a
“gamebox”

5. Tang/Chang/Tzanov –
environmental modeling:
pollutants dispersion, nutrient,
phytoplankton, …

Expertise

Theme #	Task #	Name	Experience
I. Hydrodynamic and environmental processes	1, 4, 5	Tang	> 30 years on modeling flows in ocean, river, aerospace, etc., developer of the project's hydrodynamics model
	2	McDonald	> 35 years on remote sensing of the earth system surface processes (ocean and terrestrial environments)
	3, 4	Diyamandoglu	First-hand experience with water quality analysis, ocean water sampling, and interpretation of water contamination
	1, 4	Tzanov	Parallel computation, large-scale scientific simulations in various backgrounds including environments
II. Impacts between OSW farm and the ocean	4	Chang	25 years of experience on ocean and OSW energy, resource assessment and environmental impact
	5	Glisic	Structure health, sensing technologies, and prognostics and decision-making theory
III. Data-driven modeling and computer visualization	6, 7	Devineni	Data-driven modeling, especially climate-hydro-systems for northeast regions, Bayesian models for extreme precipitation
	7	Kawaguchi	Database and transaction processing systems, techniques in game advancement and industry networking

Milestone and management



Management ---- Meetings (kickoff meeting, technical meeting, annual progress/plan meeting)
Presentation, annual report, publication
Activities for outreach/external funding
A part-time secretary for team members and task coordination.

Future funding prospects and self-sustaining plan

Targeted funding sources

- NSF, Convergence Program, CoPe (Coastlines and People), Fluid Dynamics program
- National Offshore Wind Research and Development Consortium (NOWRDC)
- New York State Energy Research and Development Authority (NYSERDA)
- DOE, NOAA, ……

OSW Preparation

- A proposal on OSW ocean hydrodynamics, NSF, submitted, April 2022.
- A proposal on OSW energy effects on ecosystems (preliminary proposal selected, full proposal submitted), NOWDRC, in collaboration with CRV team members. May 2022.
- Oral presentation selected, the State of Science Workshop on Wildlife and Offshore Wind Energy, New York, 26-28, July 2022.

Collaboration 1) Collin Powell Center, Sch of Education for education to explore awareness of community and society. 2) CCNY/CUNY ecology, CUNY KCC Marine Technology, Stony Brook Offshore Wind Education, NY Offshore Wind Innovation Hub.

Outreach to industry Orsted, Equinor, and Aker Offshore Wind, primary OSW industry developers (e.g., Orsted is the builder of the Block Island Wind Farm, the first US OSW farm), for collaboration and projects.

A remark: given the current crisis of gas price and energy due to the geopolitical conflicts, OSW energy is becoming more necessary and urgent.

Thanks to you all

Questions?