

OVERVIEW OF ATMOSPHERIC EFFECTS FROM OFFSHORE WIND ENERGY ACTIVITIES

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**If wind energy is removed
from the environment...**

**What effect might that have on
meteorological conditions:**

Locally?

Regionally?

Do local effects scale up to regional consequences?

Impact Assessment under NEPA



- Offshore Wind Comparison
- Wake Effects
Horns Rev
CA Example
- Ocean Circulation?
- Primary Productivity?
- Local vs. Regional Effects
- Next Steps

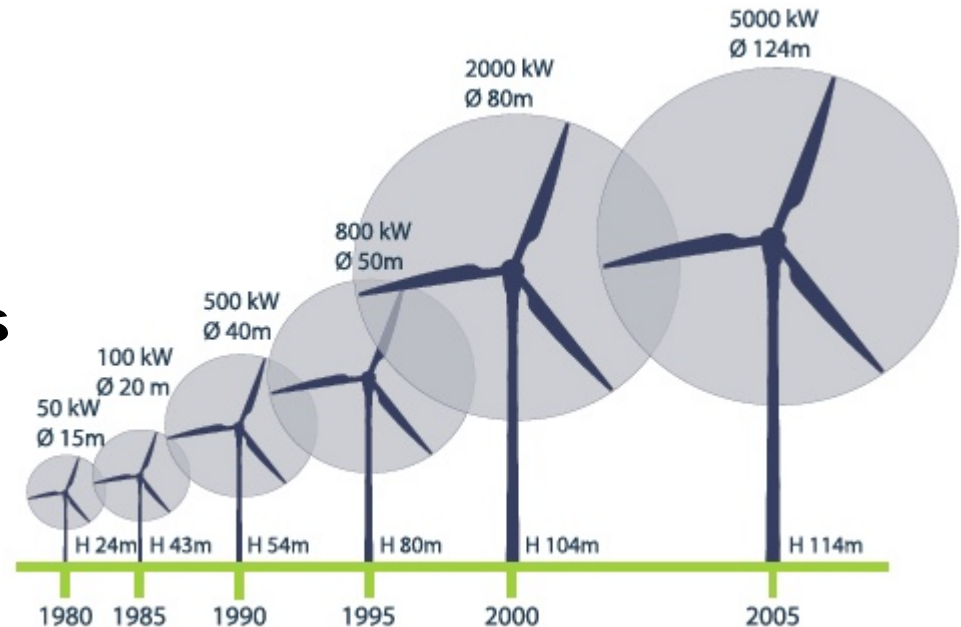
EU Currently in Operation through July 2016:
13 windfarms **3,344 turbines**

Average Depth: 25 m (fixed)
Average Distance to shore: 42 km

data: windeurope..org 2016

CA Offshore Wind Proposed:
1 windfarm **100 turbines**

Depth: 762 m (floating)
Distance to shore: 53 km



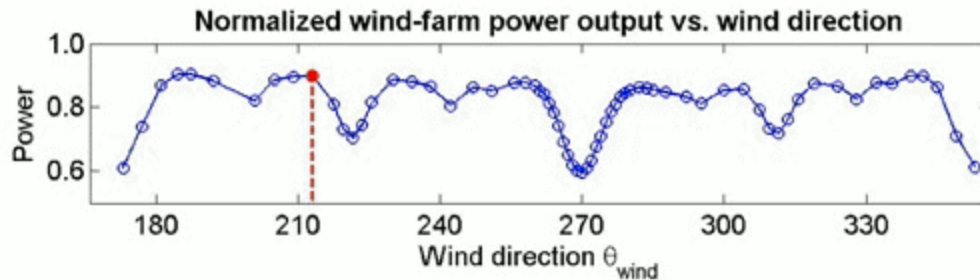


Increased turbulence

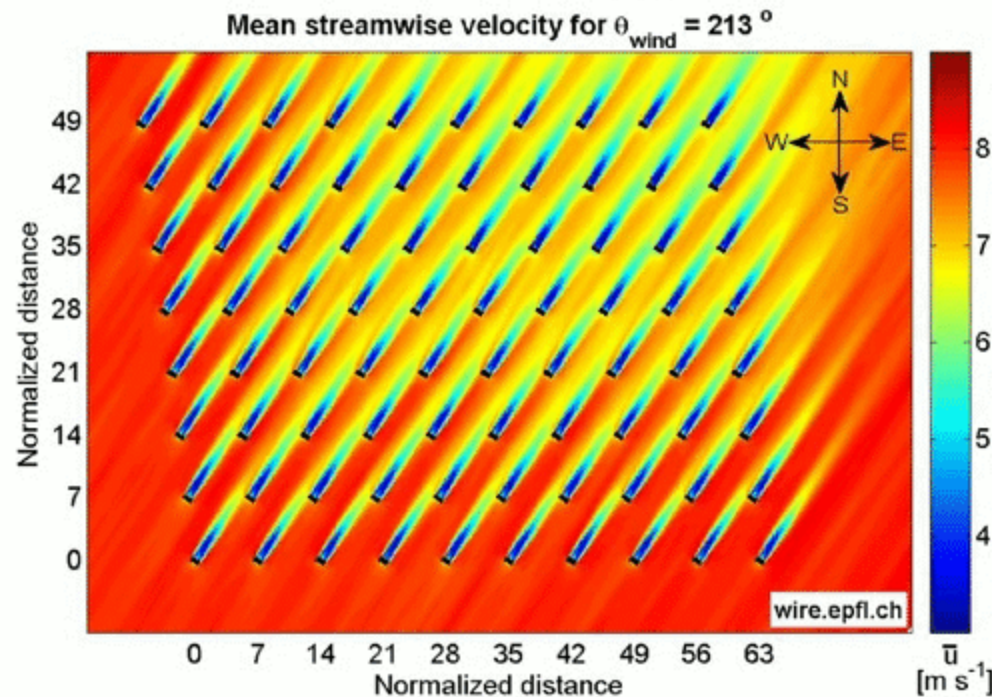
Reduction of wind speed

Localized changes in atmospheric pressure

Temperature changes (?)

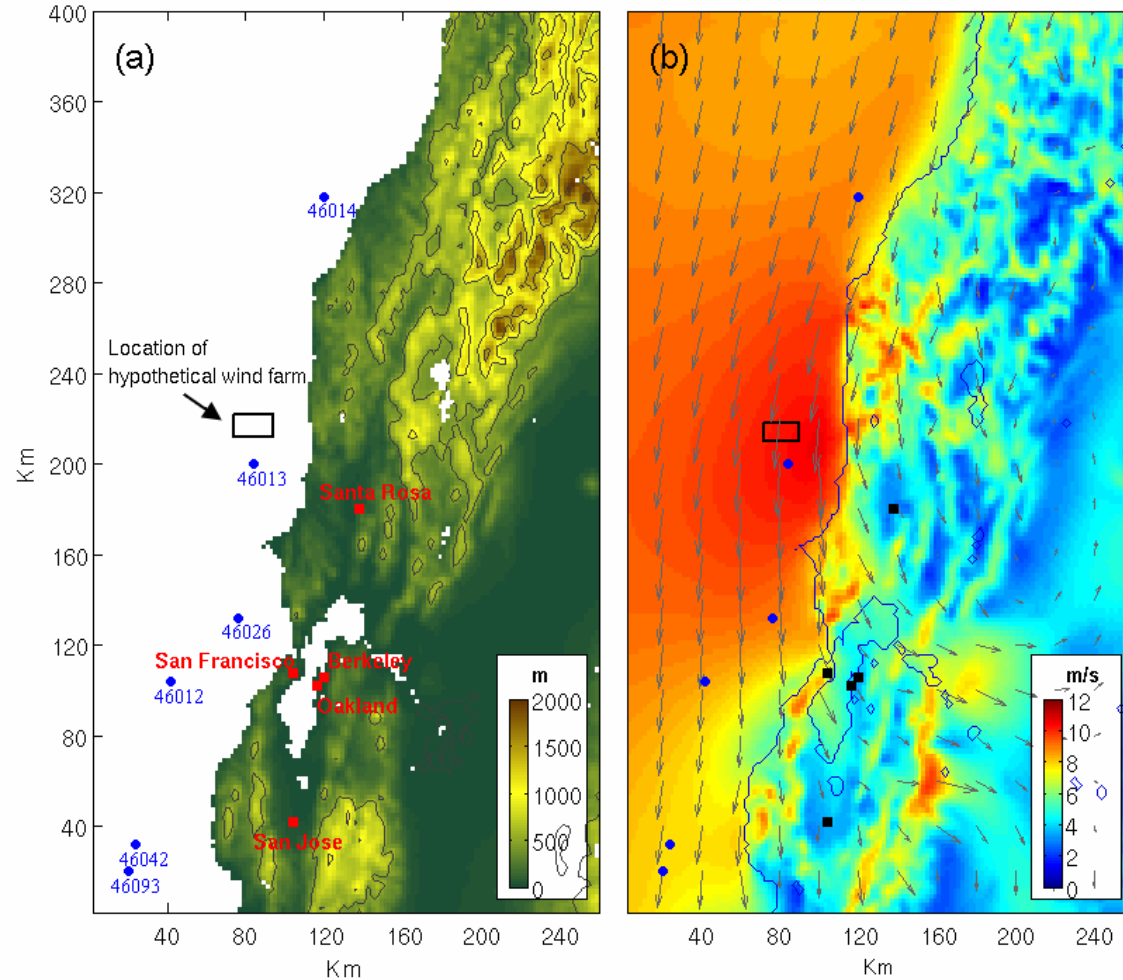


Horns Rev Offshore
Wind Farm



Large-eddy
simulations

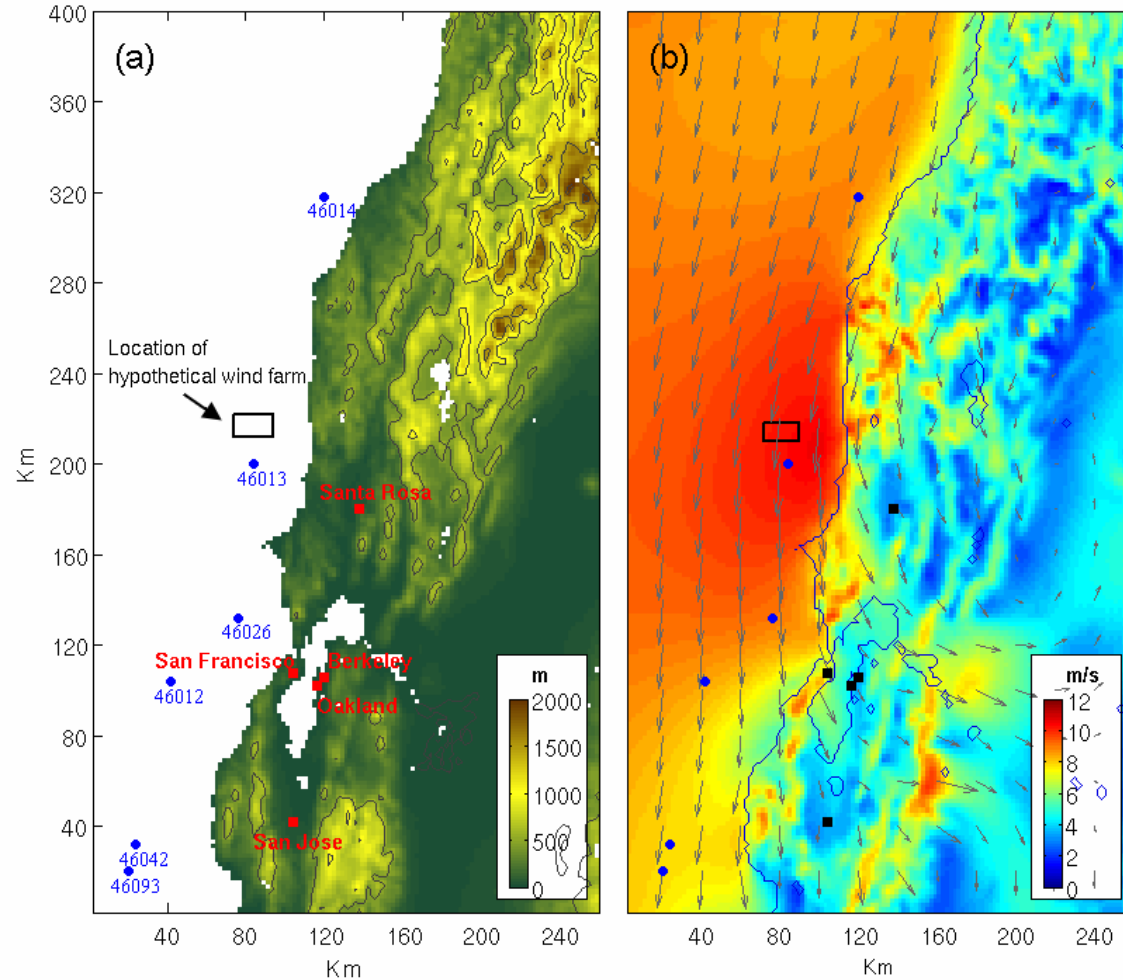
Investigate
turbine-wake
characteristics



Hypothetical Wind Farm 1 Year simulation (2009)

200 wind turbines

- 8 MW
- 125 m hub height
- 2 km spacing of turbines
- Energy extracted
- Wake created



More clouds

More moisture

Cooler temperatures

10 % decrease in wind
at center of farm

1.5 % decrease in wind
100km downstream

Results for 1 year of modeling – preliminary data

Wind forcing affects ocean current circulation

Wind exerts stress on sea surface

Wind-driven ocean circulation



Cordell Bank NMS

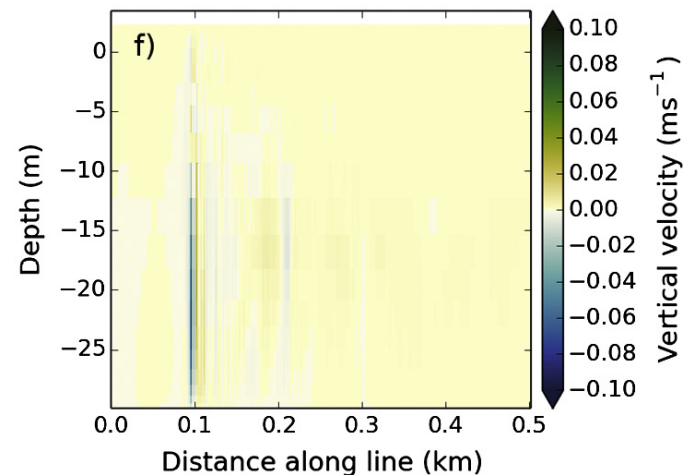
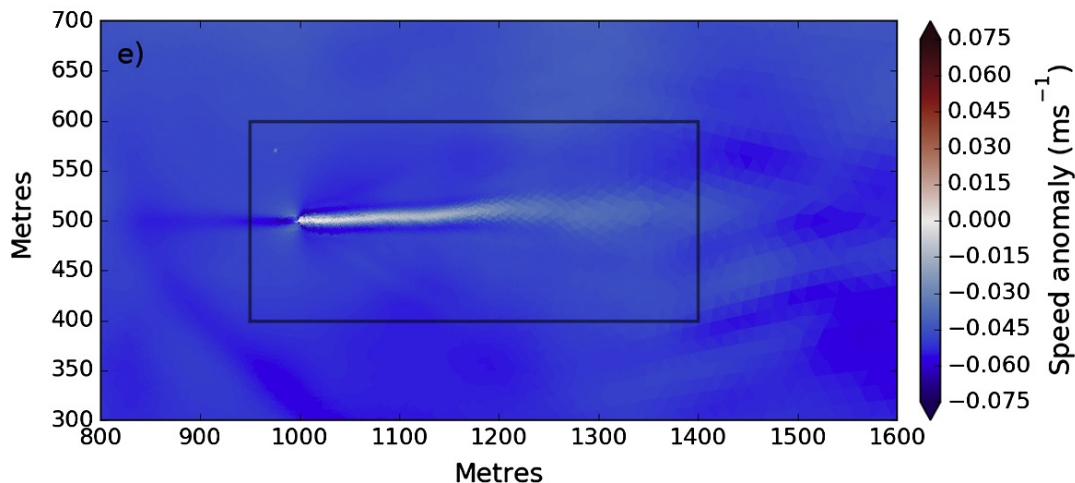
Do wind farms affect ocean circulation?

Monopiles

Wind wake

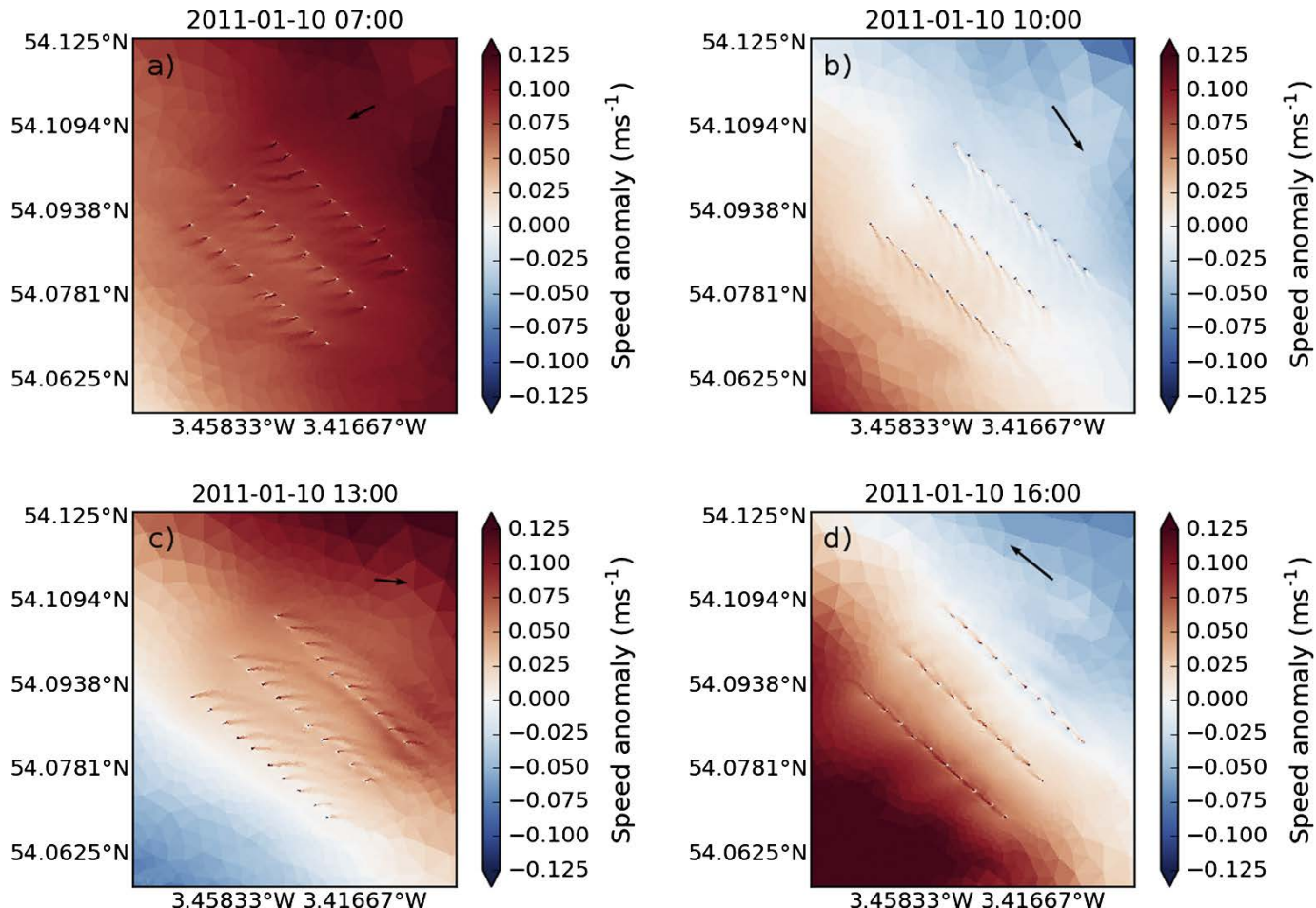
Cazenave et al. 2016

- 242 wind turbines, monopile foundations
- 3D ocean circulation model
- Turbines enhance local mixing
- May have implications for stratification and nutrient cycling
- May alter flows within a short distance (3-10 km)
- Local effects



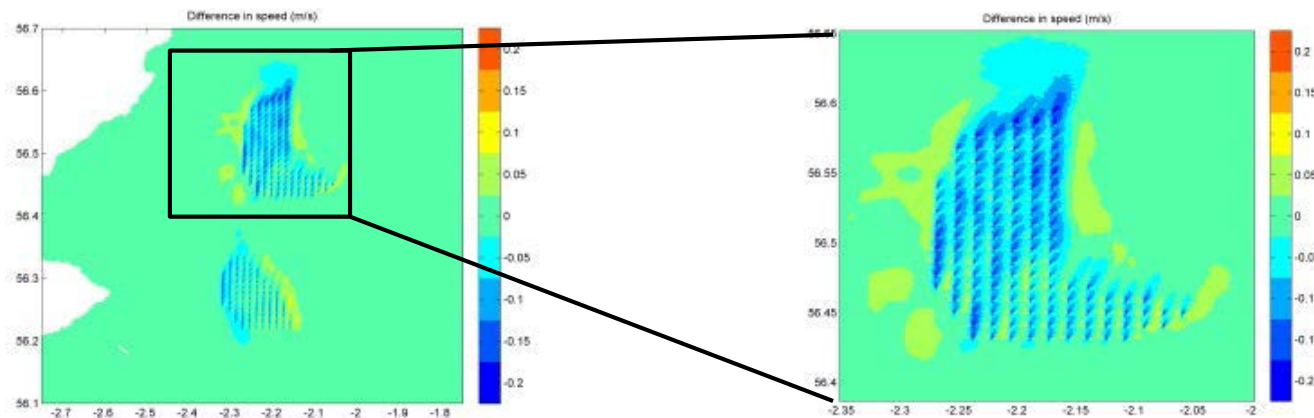
Cazenave et al. 2016

- 242 wind turbines
- Wakes surrounding monopiles – local effects



Tweedle et al. 2014

- Tight coupling of physical and biological
- Modeled impact of wind turbines on current velocities and primary production (Chl a)
- Changes in current speed influence mixing of nutrients; may affect phytoplankton
- Preliminary data – local effects



Difference in current speed with and without wind farms



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data: windeurope.org 2016

Meteorological Conditions

- local effects

Ocean Circulation & Primary Production

- preliminary results: local effects

Do local effects scale up to regional consequences?

Unlikely

- studies have not shown regional effects

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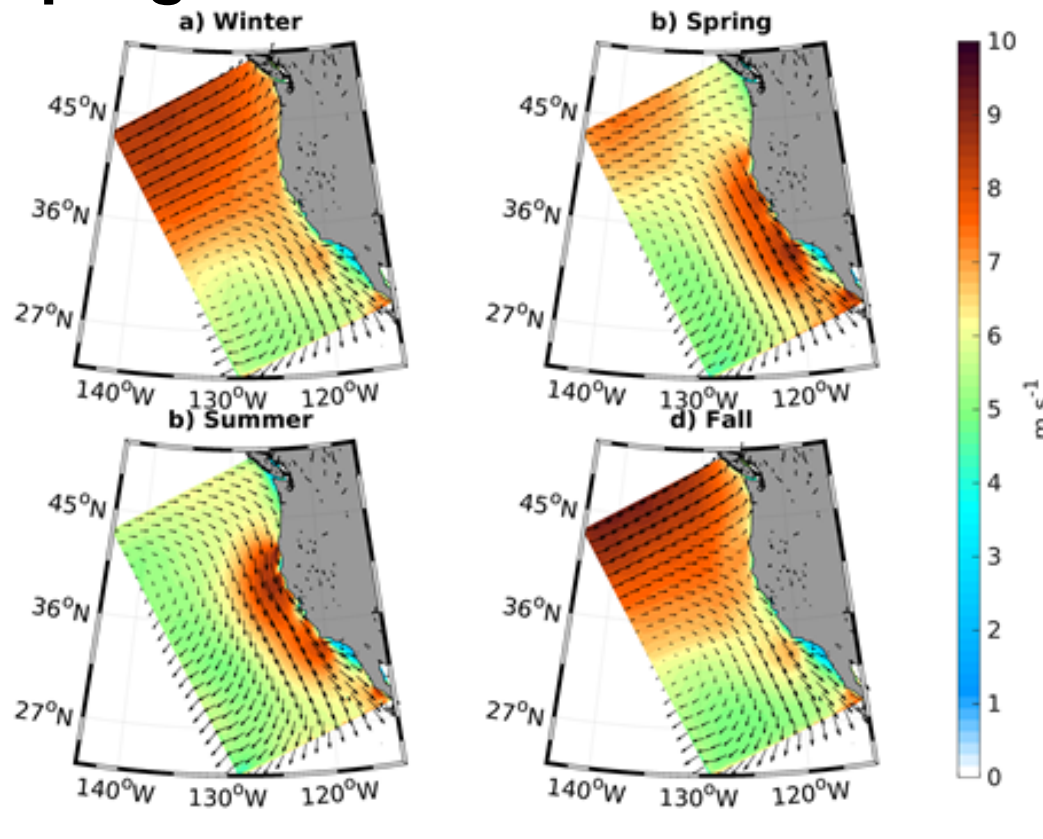
Locally?

Regionally?

Do local effects scale up to regional consequences?

Impact Assessment under NEPA

Dong et al. in progress



Modeled wind for the four seasons

- 10 year hindcast: central to southern CA
- 6 km resolution
- Available August 2017 for future modeling



- Model atmospheric effects
 - Central CA Coast
 - Multiple Years
- Scale analysis
 - Small wind farm
 - Up to full build out
 - Spacing of wind turbines



- Couple Atmospheric & Ocean Circulation Models
 - Ocean circulation effects?
(UCLA ROMS 10 yr Hindcast - August 2017)
 - Upwelling effects?
 - Primary productivity effects?

Thank You

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