Geophysical Institute, Faculty of Mathematics and
Natural Sciences

Offshore wind energy research at GFI and UiB

16. February 2016

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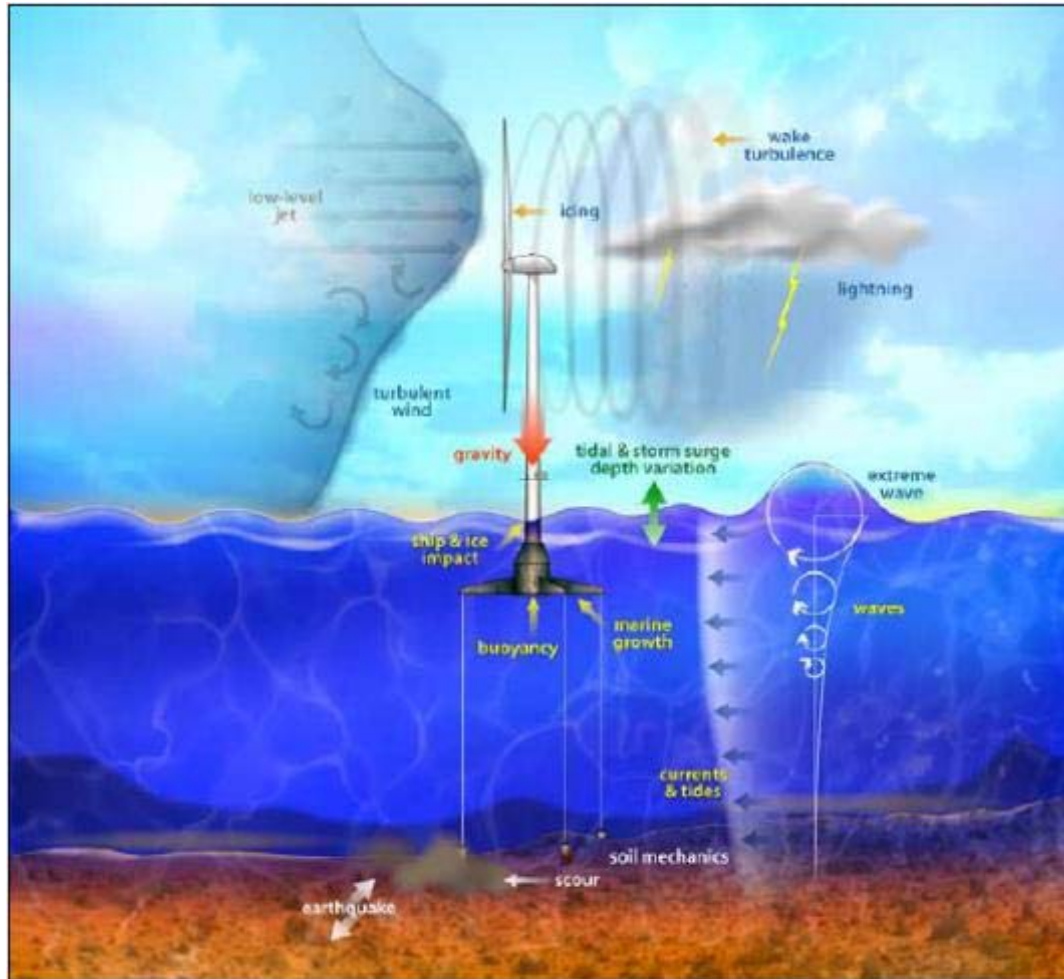
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Outline

- Importance of met-ocean conditions for offshore wind energy
- Short history of wind energy research at GFI
- Related research and infrastructure at GFI
- Relevant expertise and competence at UiB

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Importance of met-ocean conditions

Of interest atmosphere:
– Average wind speed
– Wind shear over the rotor disk
– Turbulence intensity

Of interest ocean:
– Average current
– Wave conditions (slamming, breaking)
– Turbulence intensity

The main problem:
– Massive lack of observational data

Source: http://www.ieawind.org/GWEC_PDF/GWEC%20Annex23.pdf

Importance of met-ocean conditions

MABL (Marine Atmospheric Boundary Layer)

- planning phase: wind resource assessment; design criteria for structural loads (e.g. occurrence of extreme winds)
- construction phase: weather windows favorable for marine operations (e.g. heavy lift operations)
- operation phase:
  - actual flow conditions (wind speed, turbulence intensity)
  - accessibility for O&M

OML (Oceanic mixed layer)

- planning phase: design criteria for structural loads (e.g. extreme waves)
- construction and operation phase: max. wave height for marine operations and WT accessibility; static and dynamic loads by currents, waves and wave breaking

offshore wind energy research at GFI

2008: preparation of FME application for NORCOWE

2009: establishment of NORCOWE (240 MNOK over 8 years)

- GFI ca. 3 MNOK/year, including ca. 1 MNOK in-kind
- 2 reward PhD positions from Mat-Nat faculty
- 1 PhD project funded by BKK stipend on renewable energy
- associated industrial PhD project with StormGEO

GFI involvement (until end of NORCOWE in 2017):

- 3 Professors (P. Haugan, I. Fer, J. Reuder)
- 2 Post-Docs
- 5 Phd projects
- ca. 10 master projects

related projects initiated/triggered by NORCOWE (e.g. DECOFF, Statoil SUMO)

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ongoing offshore wind related activities at GFI

- EFOWI (Equipment for Offshore Wind Energy Infrastructure); 4 static wind lidar systems and 2 met-ocean buoys; NFR infrastructure 2010-2013, now mostly integrated in OBLO (15 MNOK)

- OBLO (Offshore Boundary Layer Observatory); advanced mobile equipment for offshore wind related measurements in the atmospheric and oceanic boundary layer; NFR infrastructure, 2012-2020 (21 MNOK)

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actual hot topics addressed by GFI

- ❑ single turbine wakes
  - ▪ extension, 3d-structure and dynamics, dependent on stability

- ❑ wind farm wakes
  - ▪ strength and extension, dependent on stability

- ❑ characterization of the turbine/wind park inflow
  - ▪ production optimalization and load/fatigue reduction

- ❑ improvement of BL parameterization schemes in numerical models for better wind forecast
  - ▪ process understanding of turbulent exchange processes
  - ▪ added complexity by air-sea interaction and wave effects

- ❑ reliable offshore site assessment
  - ▪ e.g. floating lidars, MWTP
- ❑ air-sea interaction

OBLEX-F1 offshore measurement campaign at FINO1

Martin Flügge (CMR),
Benny Svardal (CMR),
Mostafa Bakhoday Paskyabi (UiB)
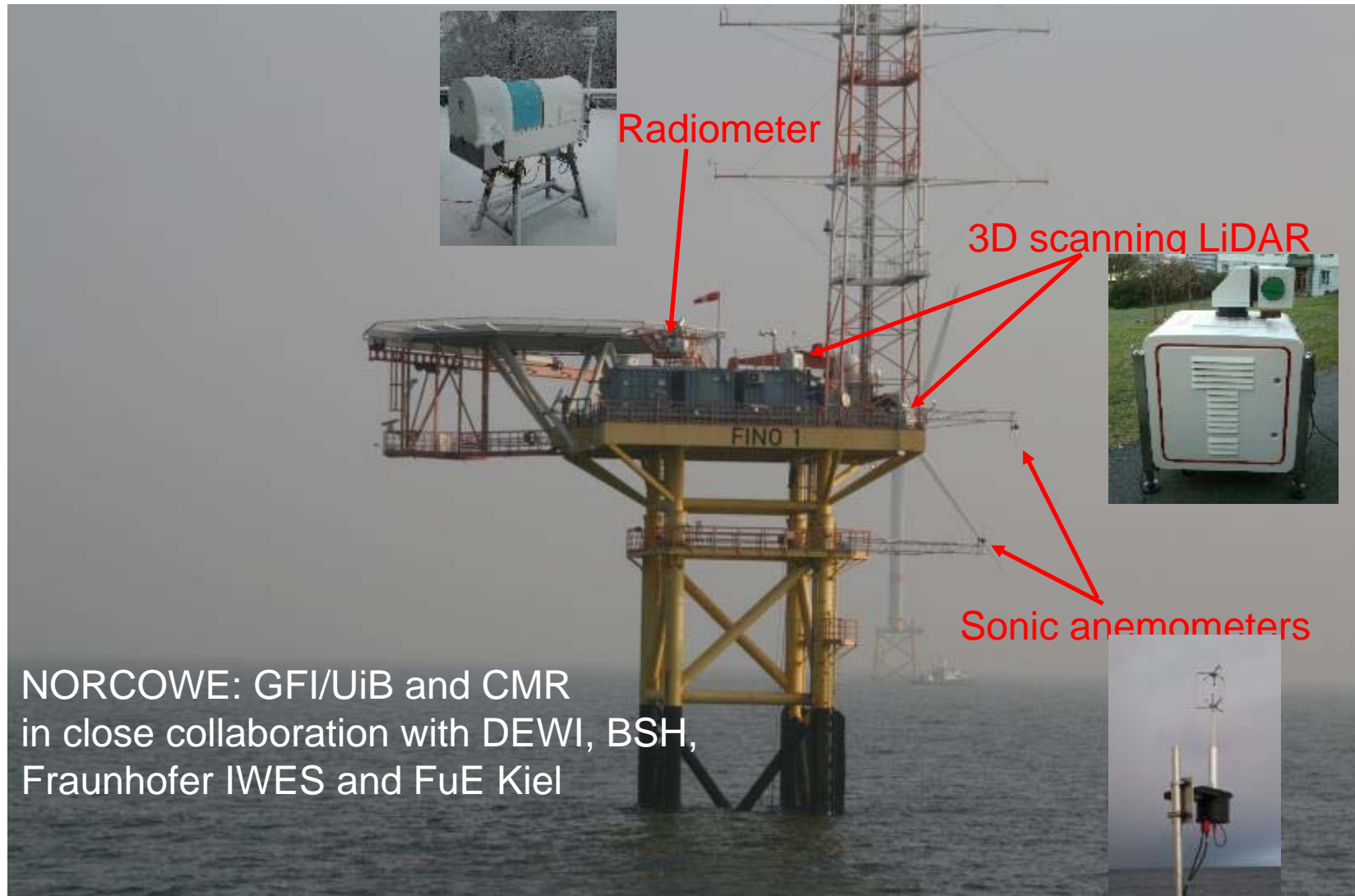and Stephan Kral (UiB)

May 2015-September 2016
(atmospheric measurements)
June-October 2015
(oceanographic measurements)

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OBLEX-F1 offshore measurement campaign at FINO1

Radiometer

3D scanning LiDAR

Sonic anemometers

NORCOWE: GFI/UiB and CMR
in close collaboration with DEWI, BSH,
Fraunhofer IWES and FuE Kiel

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Axys *CMR Sailbuoy*
WindSentinel *Wave sensor,*
LIDAR buoy *temperature*

BSH
Wave buoy
Accelerometers,
compass

UIB/OBLO
Bottom frame
- ADCP, Aquadopp, ADV

FINO 1

UIB/OBLO
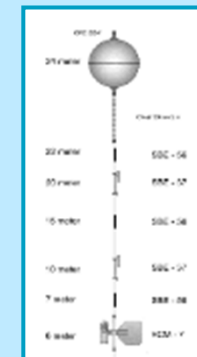**Bottom frame**
- ADCP, Aquadopp, ADV
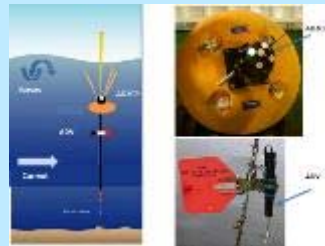
UIB/OBLO
Submerged buoy
- ADCP

UIB/OBLO MATS
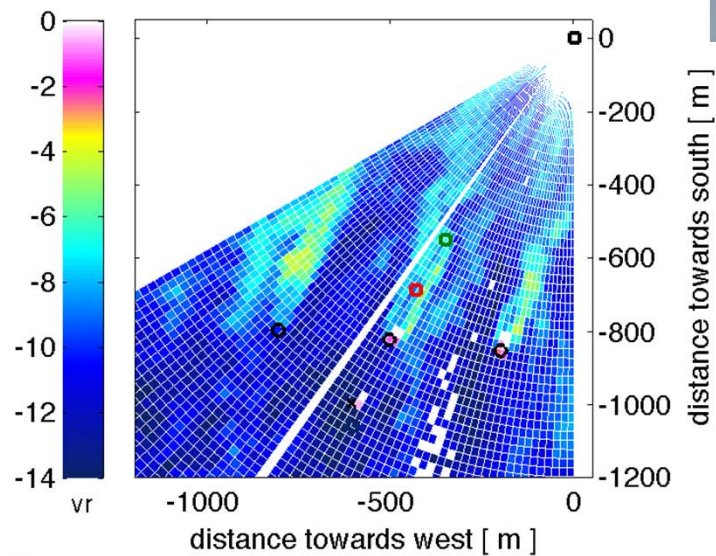**Submerged buoy**
- Microrider shear probes, Aquadopp

Novel measurement strategies for wake investigations

masts
e.g. FINO1

http://www.dewi.de/dewi/index
.php?id=152

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scanning wind lidar

RPAS

ongoing offshore wind related activities at GFI

- participation in the application for the Centre for Offshore Wind Energy Research (COWIND); follow on and extension of the two former offshore wind related FMEs NORCOWE and NOWITECH (funding decision 26.05.2016.)

- participation in Windscanner.no; preparing an application for a national Norwegian infrastructure for coordinated long- and short range lidar wind scanners (ca. 8 M€);

- GFI has initiated a SFF proposal (Prof. Ilker Fer) on air-sea interaction processes that will also have beneficial side-effects for basic research related to offshore wind (review of stage 1)

- broad international collaborations
  - universities and research institutes
  - EERA (European Energy Research Alliance)
  - IEA (International Energy Agency) Wind Task 32 (lidar)

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Wind energy relevant competence at UiB

- **Geophysics: Met-Ocean conditions**
  - advanced met-ocean measurements and data analysis under the aspect of offshore wind applications with existing measurement infrastructure
  - development, test and application of novel measurement methods and strategies
  - in-depth analysis of relevant met-ocean data sets (both own measurements and existing other data sets, e.g. FINO, DTU, ECN)
  - modelling and model validation activities related to the improved representation of turbulence and air-sea interaction in the coupled atmosphere-ocean boundary layer in the presence of waves

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Wind energy relevant competence at UiB

- **Mathematics/Informatics: Optimization**
  - Localization of wind turbines in offshore wind parks
  - Wiring between turbines and and against electricity network on land
  - Optimization of floating turbines

- **Geology/Seismology:**
  - Characterization of seabed properties (high resolution shallow seismic and drilling); in particular to reduce total initial survey costs when wind energy, waves and weather conditions as well as seabed properties need to be characterized in planning for new areas

Wind energy relevant competence at UiB

- **Biology:**
  - investigation of environmental impacts including marine ecological effects of large wind farms;
  - early phase studies to underpin Environmental Impact Assessments of new areas
- **Social Sciences:**
  - societal aspects of offshore wind integration and innovation
  - effects of regional, national and international policies and regulations on development of Norwegian offshore wind industry
  - acceptance of offshore wind (e.g. fishery in Japan)
- **Law?,**
- **Material technology?,**
- ......

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Geophysical Institute – strategy 2015-2019

	Meteorology	Physical Oceanography	Biogeo-chemistry	Climate Dynamics
Atmosphere–ocean–ice interactions				
Climate and marine ecosystems				
Polar research				
Renewable energy resources				
	Process understanding Observations Theory Modelling	Process understanding Observations Theory Modelling	Process understanding Observations Theory Lab Modelling	Process understanding Observations Theory Modelling