

Wind-related projects and measurements at IMK-IFU of KIT

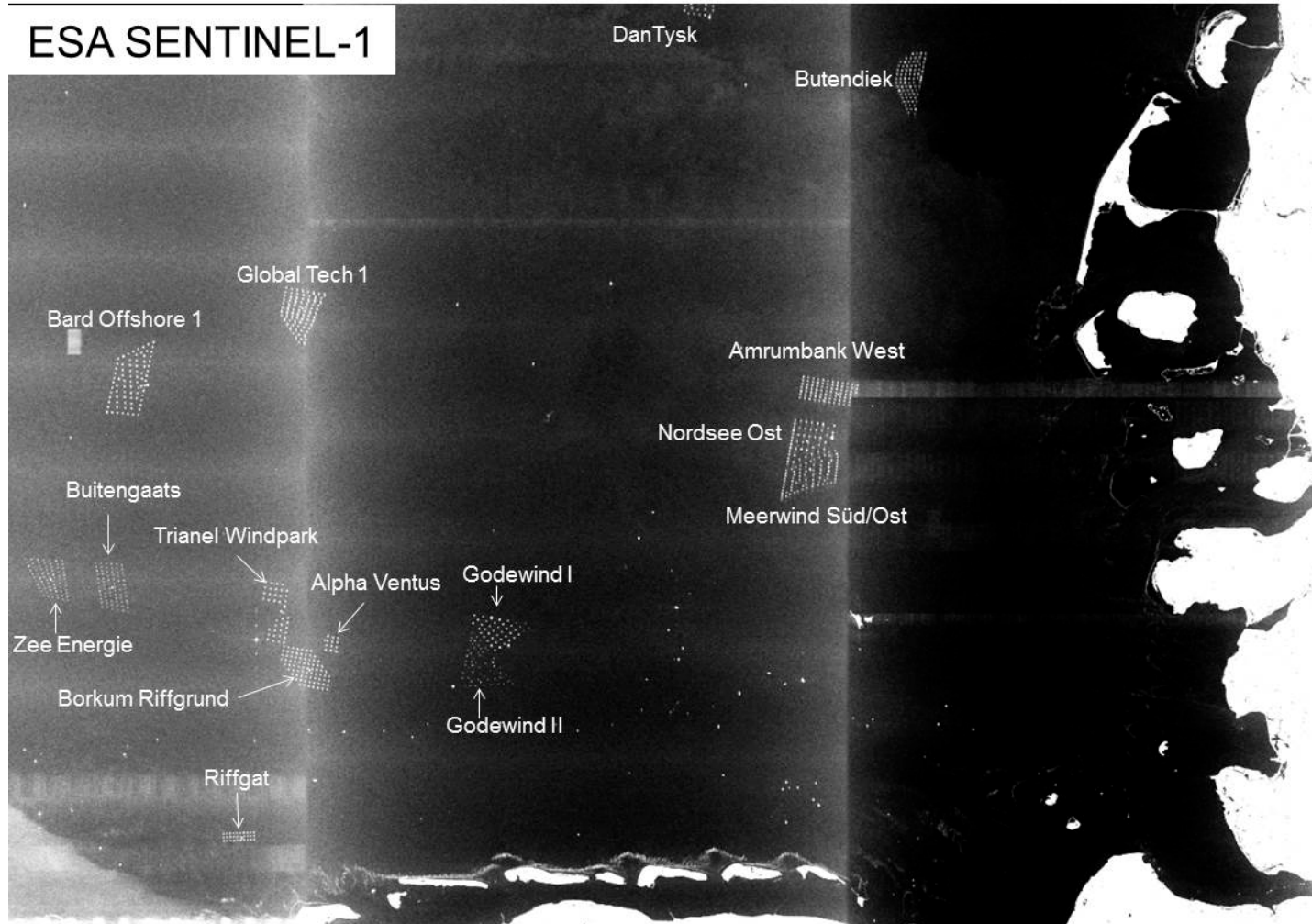
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Three running projects

WIPAFF

Wind farms in the North Sea (SAR satellite image, Dec 2015)



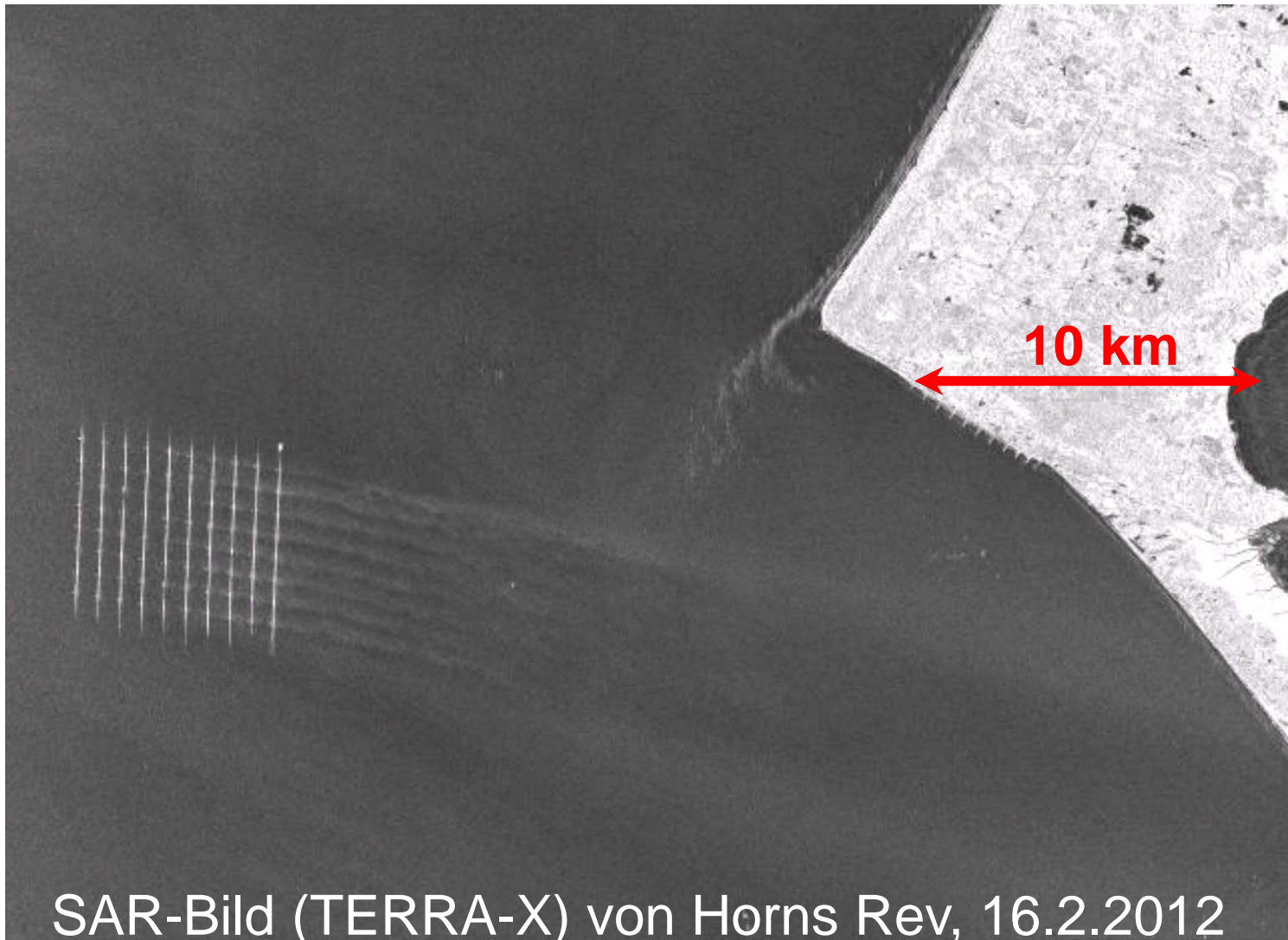
Dez. 2015 ,
 produced from
 ESA remote
 sensing data
 (@) European
 Space Agency –
 ESA

Wakes: of turbines and entire farms

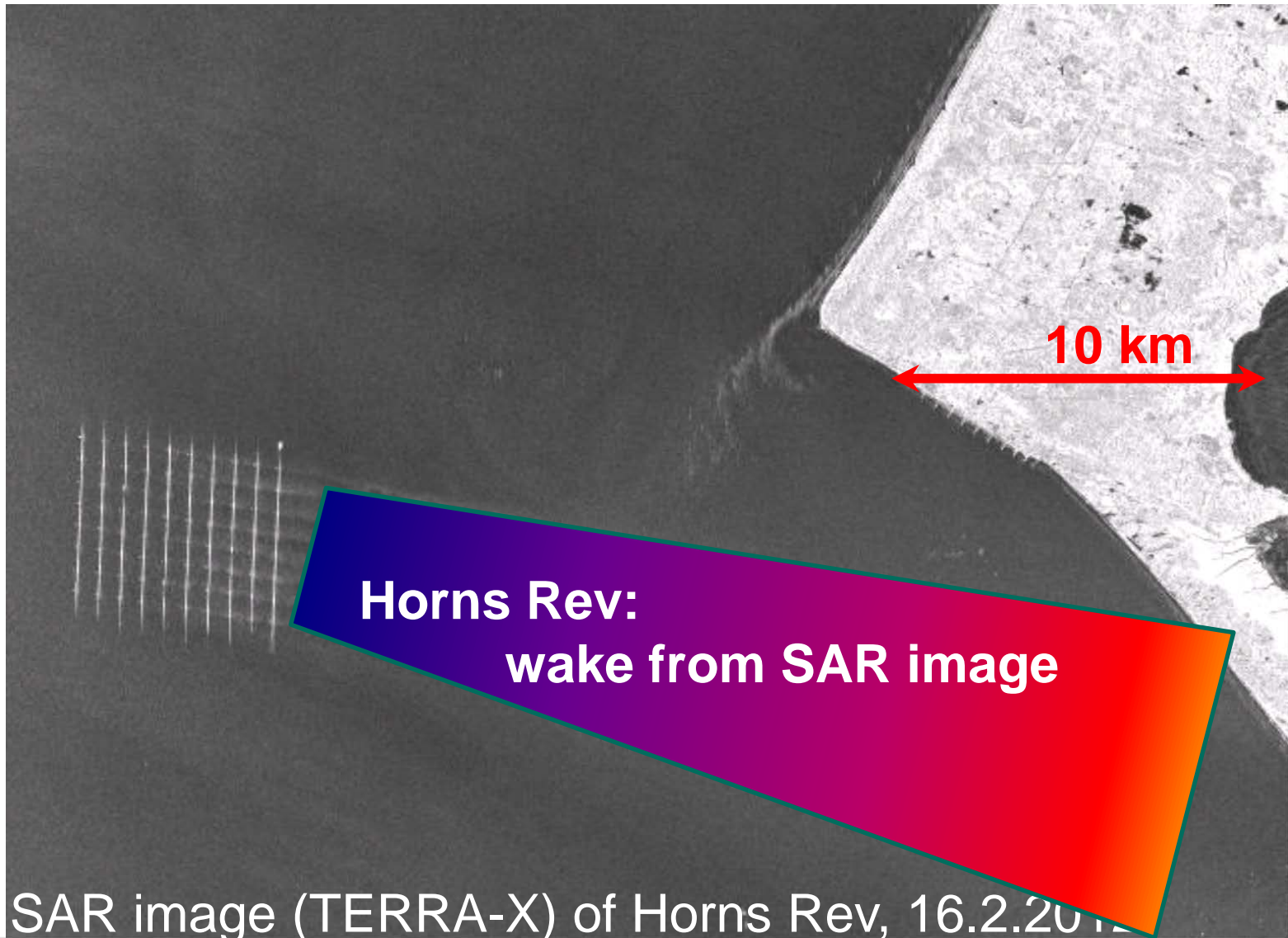


Horns Rev, 12 February 2008, Photographer: Christian Steiness, Vattenfall

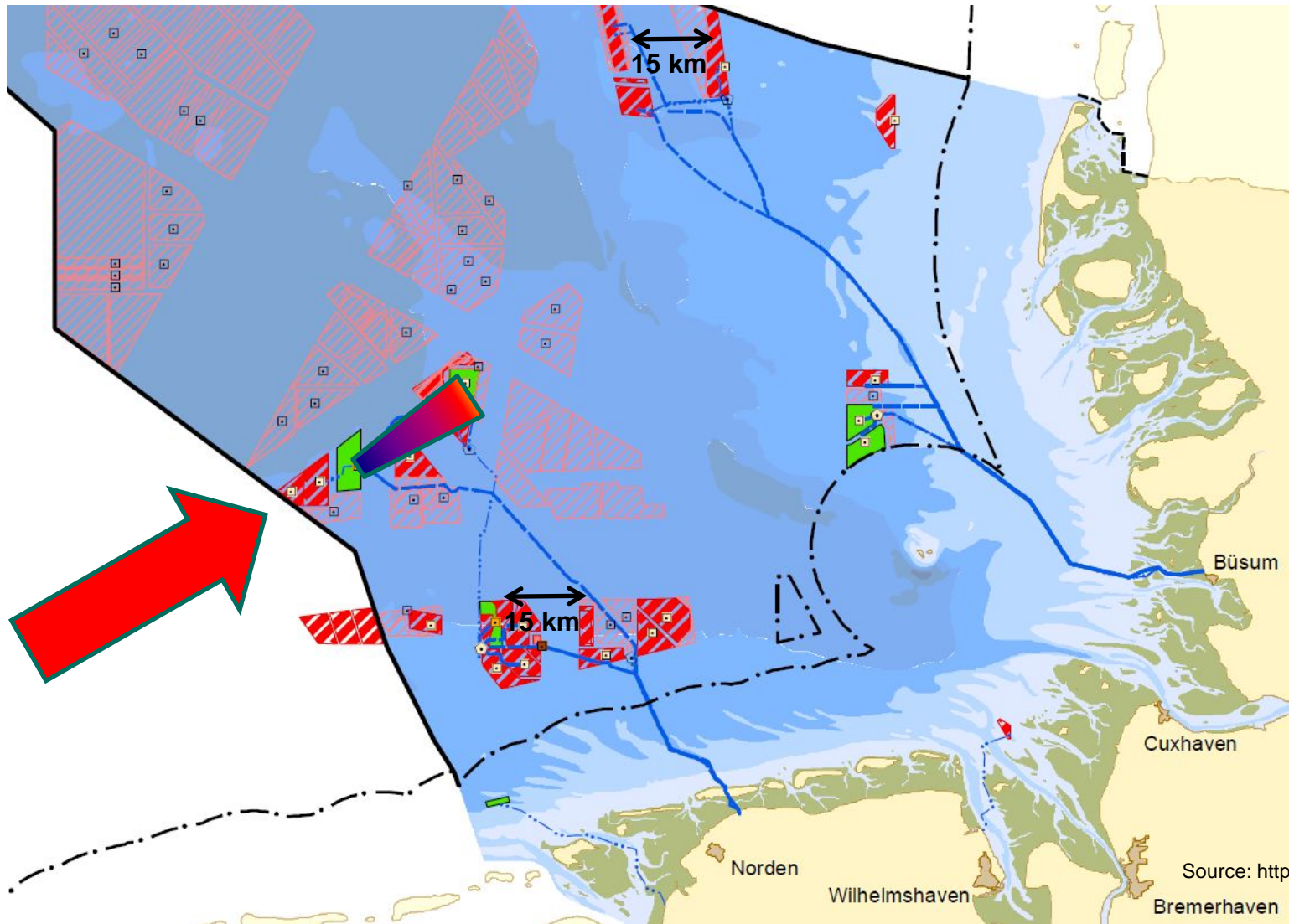
this turbine was out of service!



(c) DLR 2012
TerraSar-X



(c) DLR 2012
TerraSar-X





Recently started: WIPAFF (Wind Park Far Fields)

11.2015 – 02.2019

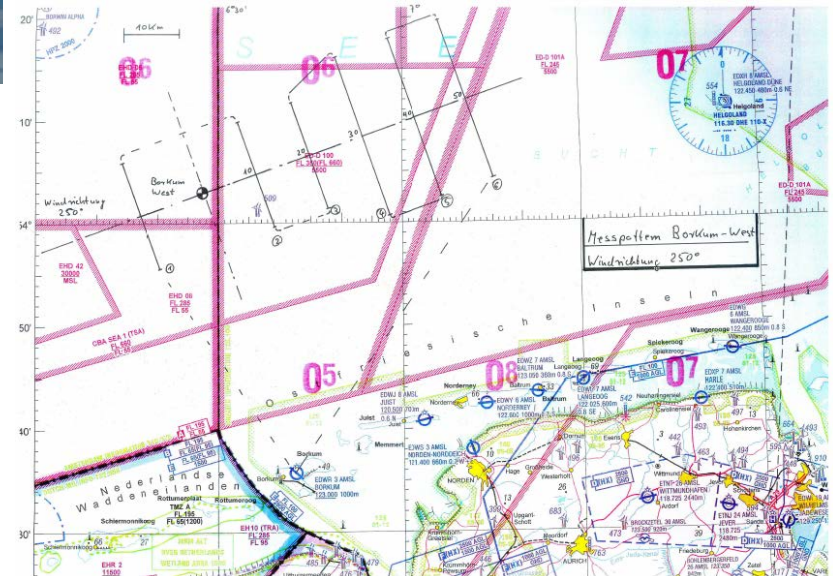
5 partners: **KIT, Institute of Meteorology and Climate Research
Technical University Braunschweig (Astrid Lampert)
Helmholtz Centre Geesthacht (Johannes Schultz-Stellenfleth)
UL International GmbH (ex: DEWI) (Thomas Neumann)
University Tübingen (Jens Bange)**

- aircraft observations (Do 128) of wakes**
- analysis of SAR satellite images of wakes**
- simulation of wind fields with WRF (wave model, farm parameterisation)**
- adaptation of analytic and industrial wind farm models**
- impact on local and regional climate**

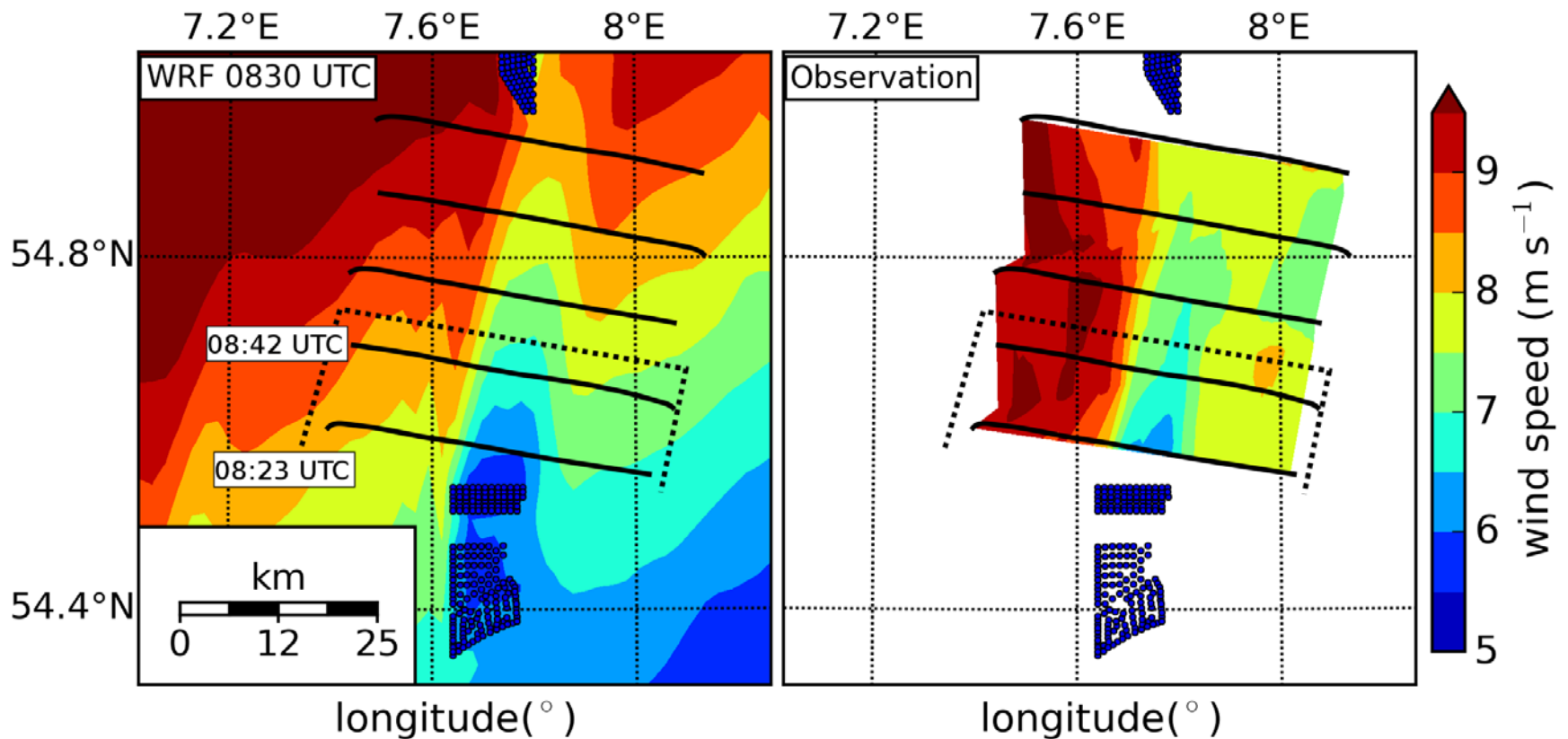


Do 128 of TU Braunschweig

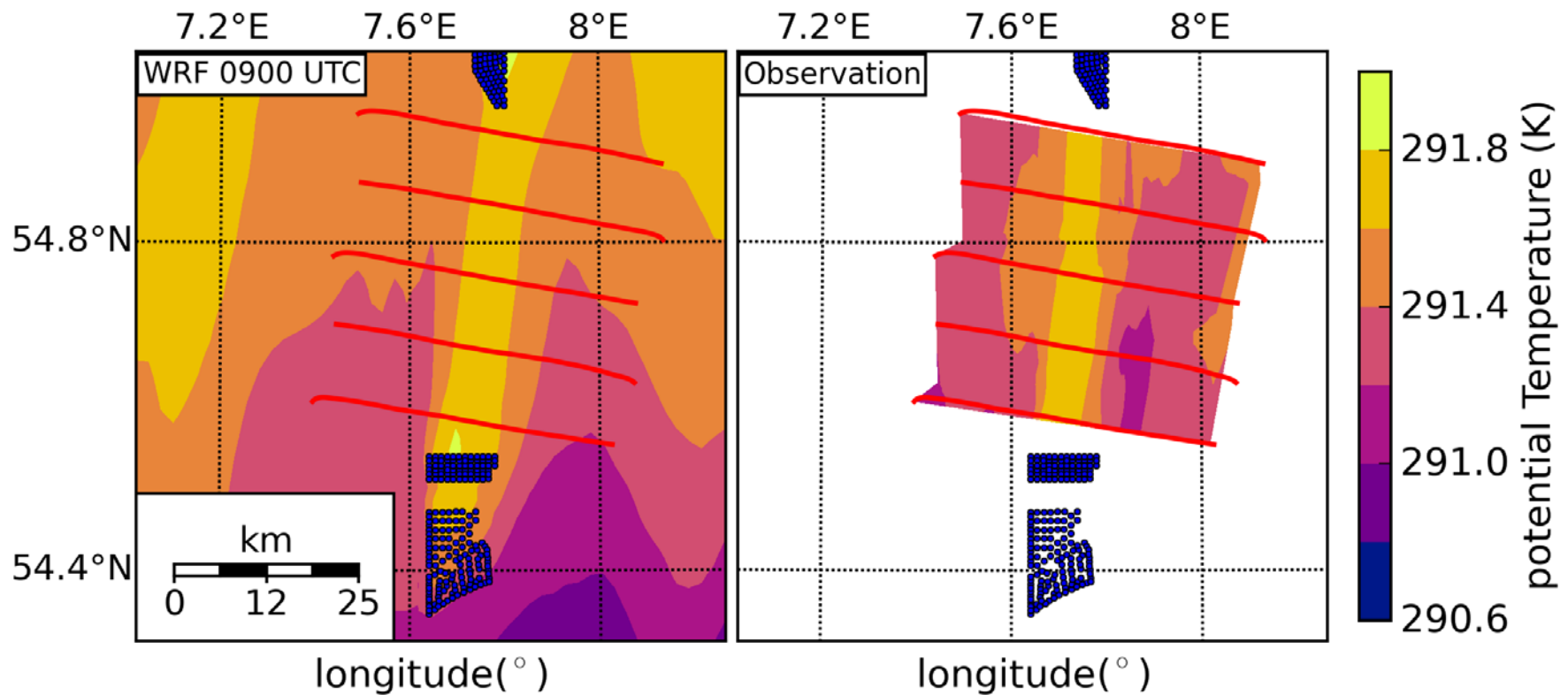
(source for these images: IFF, TU Braunschweig)



Wind: simulation (WRF) and observation (Do 128)



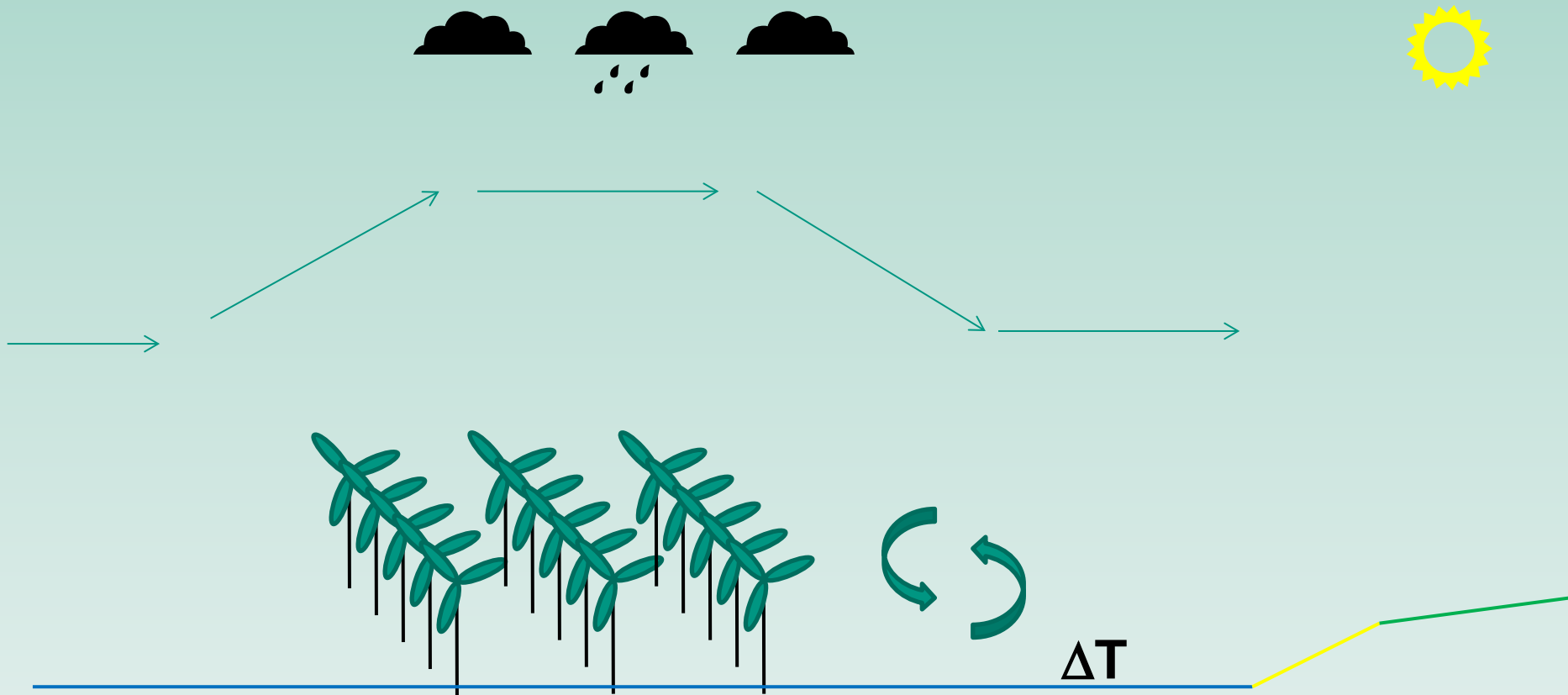
Temperature: simulation (WRF) and observation (Do 128)



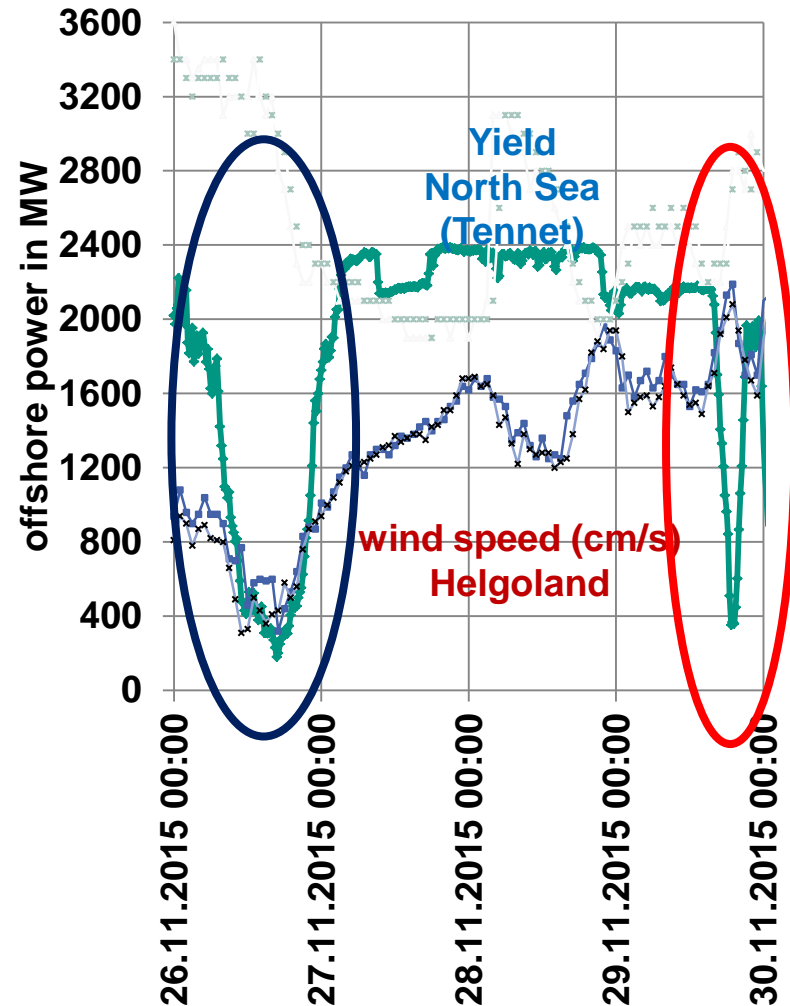
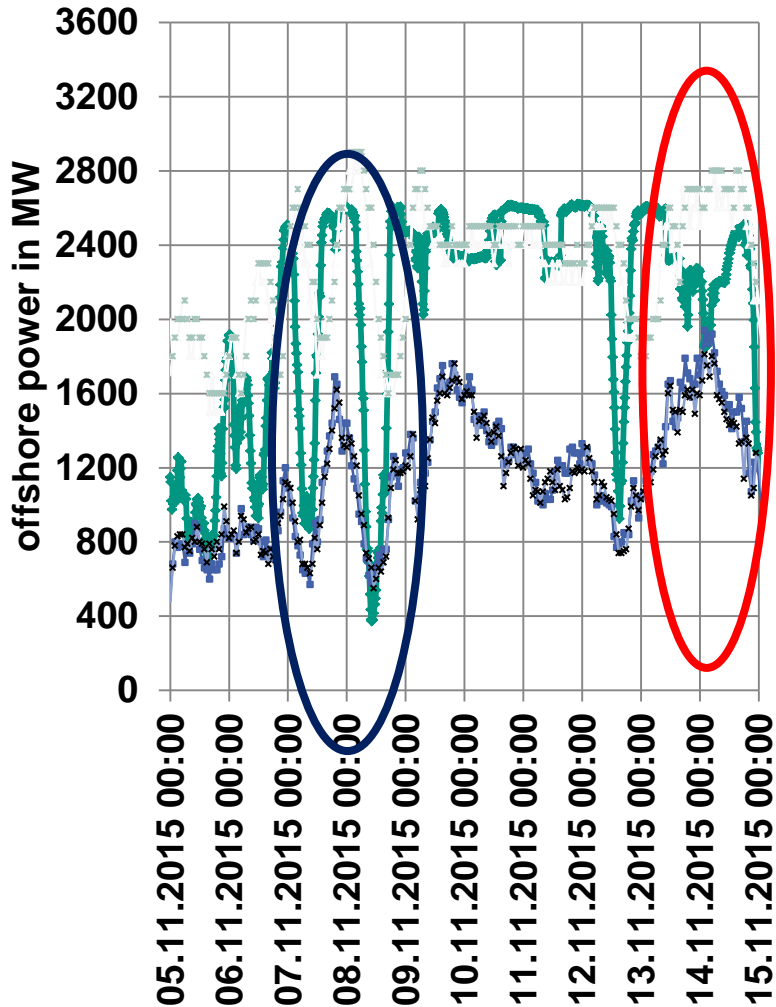
impact on the regional climate

cloud formation,
modification of precipitation
modification of sun shine duration
modification of wind field

...



impact of cut-in (blue) and cut-off (red) Windgeschw. (own graphics, data source: Tennet, DWD)



WINSENT

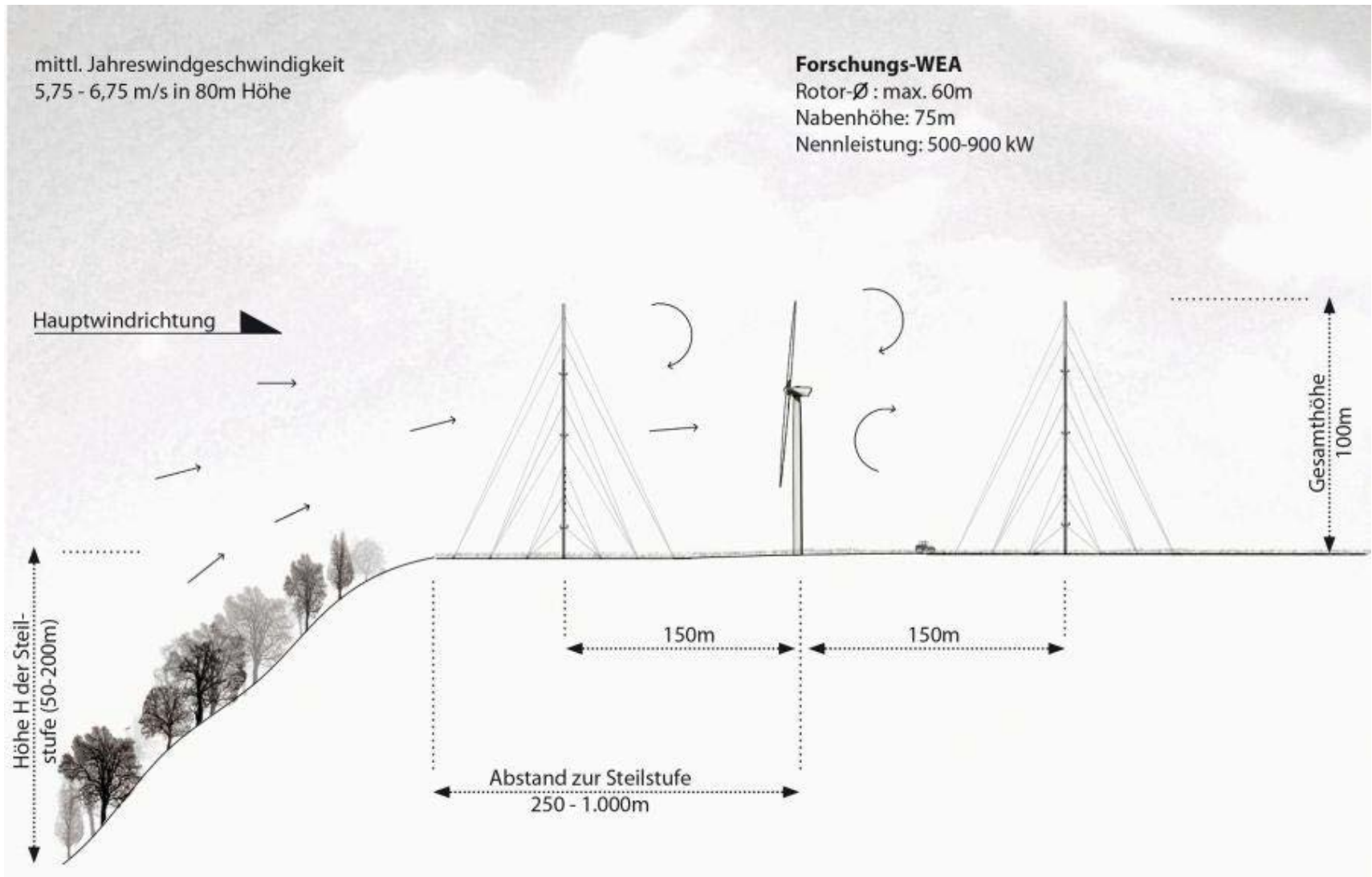
Recently started: WINSENT (WIND Science and ENGINEERING in complex Terrain)

12.2016 – 06.2020

5 partners: **Center for Solar Energy and Hydrogen Research, ZSW**
University Stuttgart
Technical University Munich
IMK-IFU, IBF and GPI of KIT
University Tübingen
Univ. of Appl. Sci. Esslingen

- creating and instrumenting a test site for wind turbines in complex terrain**
- two turbines, four met masts**
- simulation of wind fields with WRF-LES**
- putting together a model chain (from regional climate to blade flow)**

set up of the WINSSENT test site



[UC]²

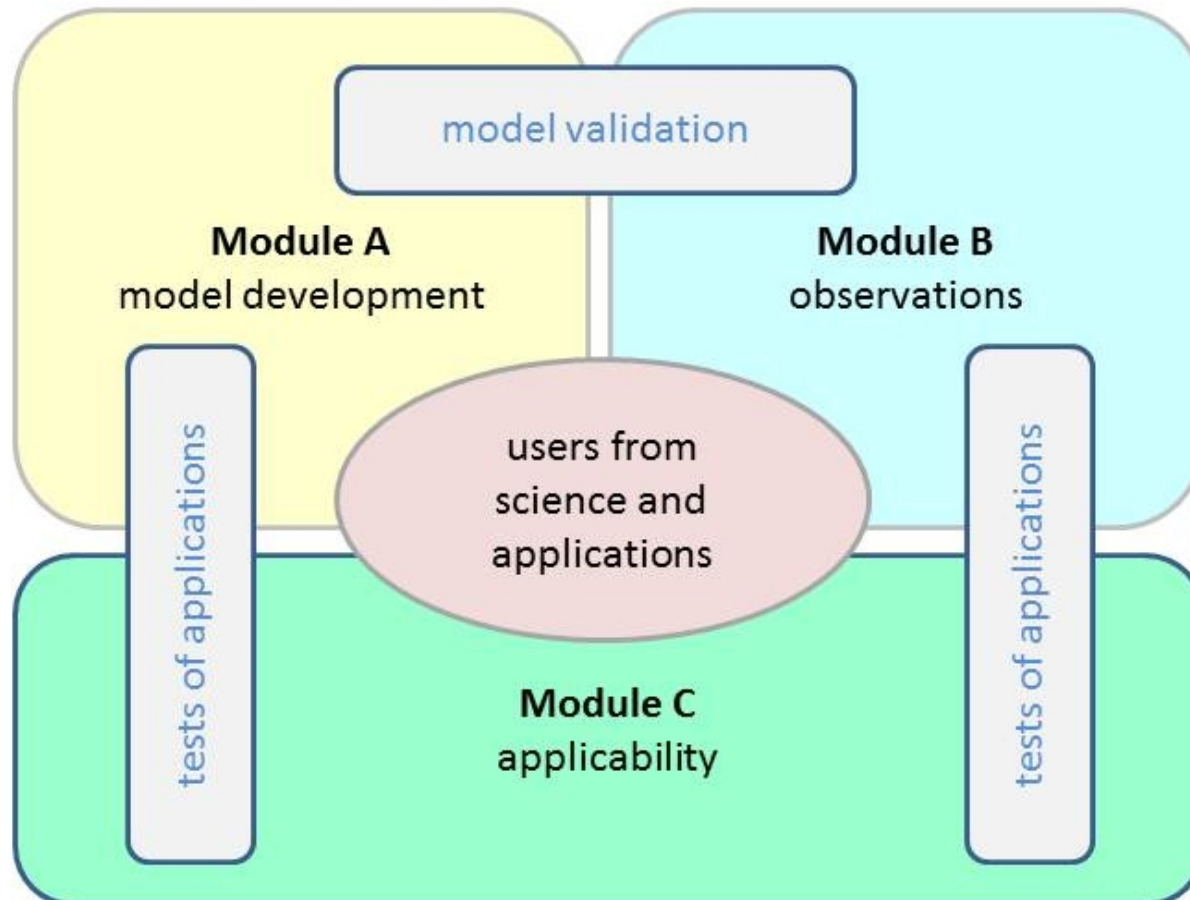
Recently started: [UC]² (Urban Climate under Climate Change)

6.2016 –5.2019

23 partners from Germany plus sub-contractors plus three cities

- creating a model chain across scales (street canyon to regional climate)
- evaluating the model chain
- testing the model chain

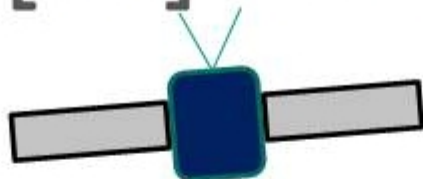
urban climate model



[UC]²: B-3DO



14



14 14 14

- 1 TU Berlin
- 2 HU Berlin
- 3 FU Berlin
- 4 TU Braunschweig
- 5 IASS Potsdam
- 6 FZJ Jülich
- 7 KIT IMK IFU+TRO

- 8 U Stuttgart
- 9 TU Dresden
- 10 U Hamburg
- 11 DWD
- 12 U Hannover
- 13 Geo-NET
- 14 DLR

blau: Hamburg rot: Berlin

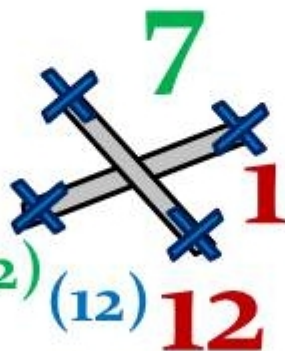
grün: Stuttgart



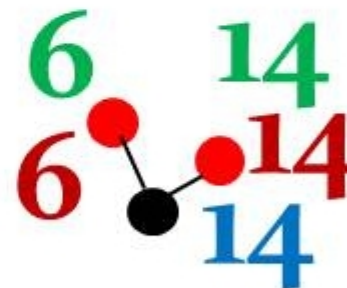
8 9
11 9
11 11



3 11
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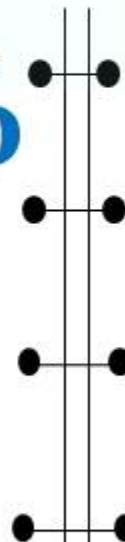


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12



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6 14
14

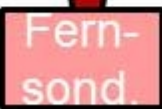
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11 8 3
6 4



8



Fern-sond.

5

statio
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2



8 9



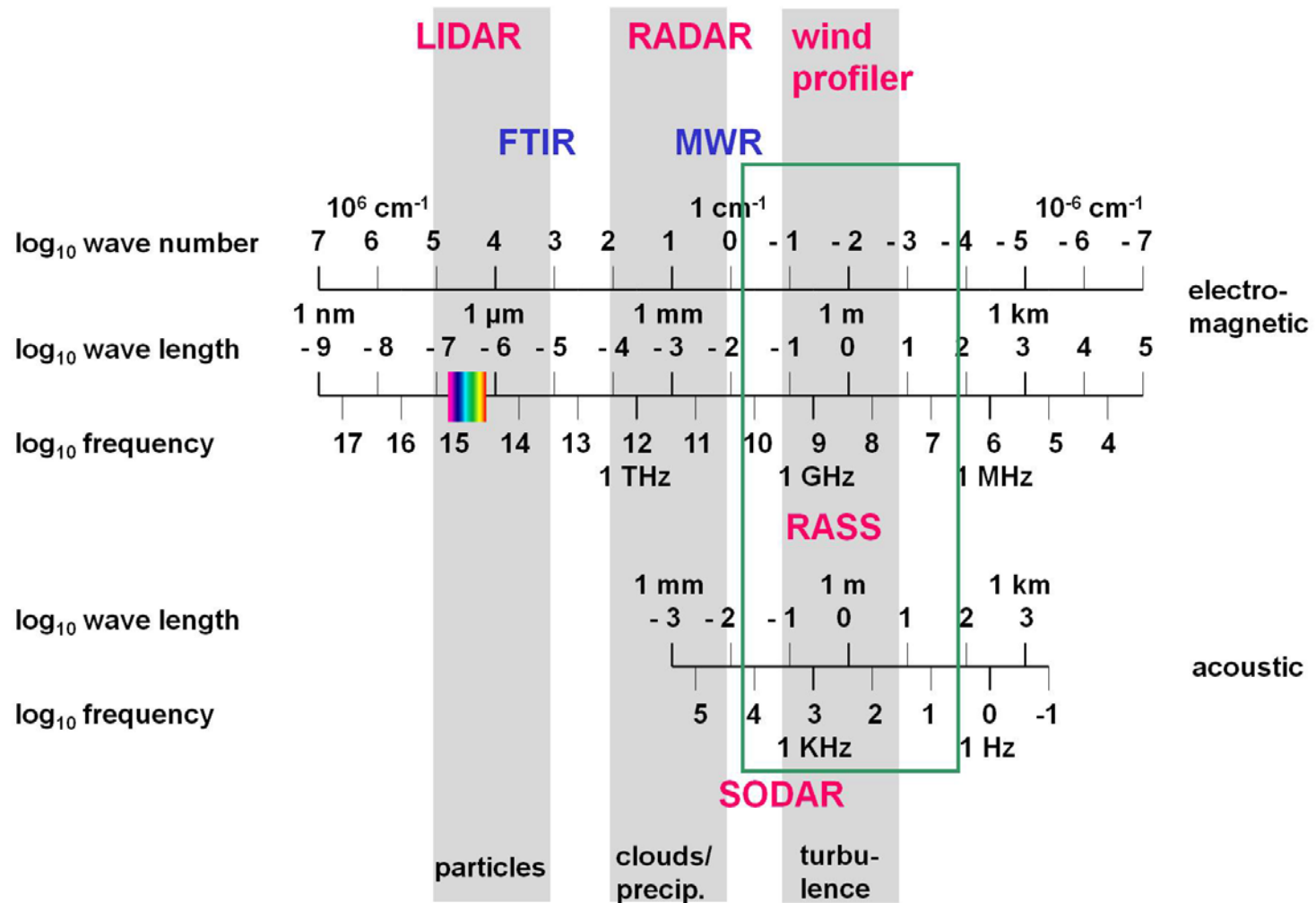
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2 1

measurement techniques

Frequencies for atmospheric remote sensing



Emeis, S., 2010: Measurement Methods in Atmospheric Sciences - In situ and remote. Borntraeger, Stuttgart, 272 pp., 103 figs, 28 tables, ISBN 978-3-443-01066-9.

surface-based remote sensing devices at IMK-IFU

miniSODAR,
acoustic backscatter, Doppler
Analysis → wind, turbulence



SODAR-RASS (Doppler-RASS), acoustic and
electro-magnetic backscatter, determines sound
speed → wind and temperature profiles



windlidar, optical backscatter, Doppler Analysis,
wave length $\sim 1.5 \mu\text{m}$ → wind and aerosol profiles



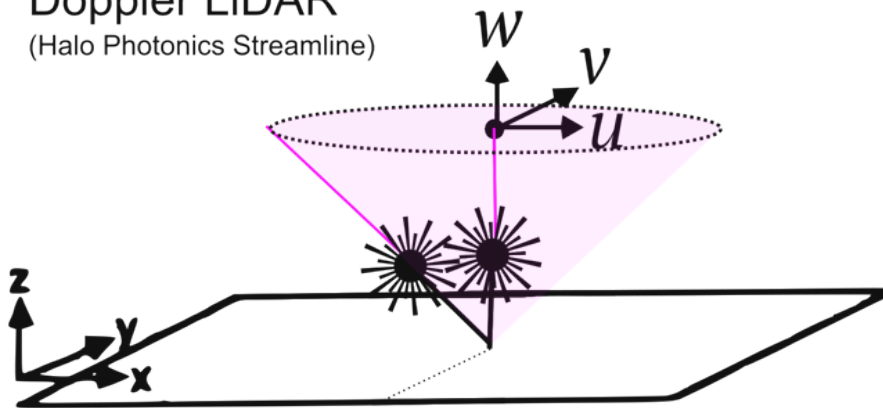
ceilometer, optical
backscatter, pulsed,
wave length $\sim 0.9 \mu\text{m}$
→ aerosol profiles



image:
Halo Photonics

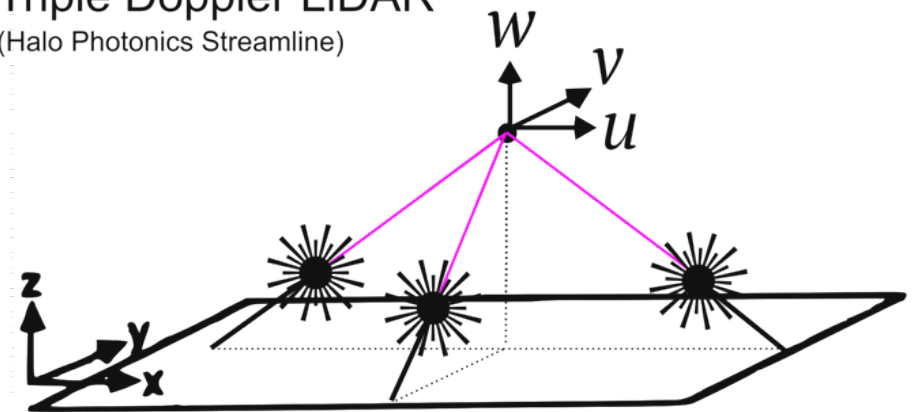
Windlidar - virtual tower

Doppler LiDAR
(Halo Photonics Streamline)



profiles of mean wind and
variance of vertical velocity component

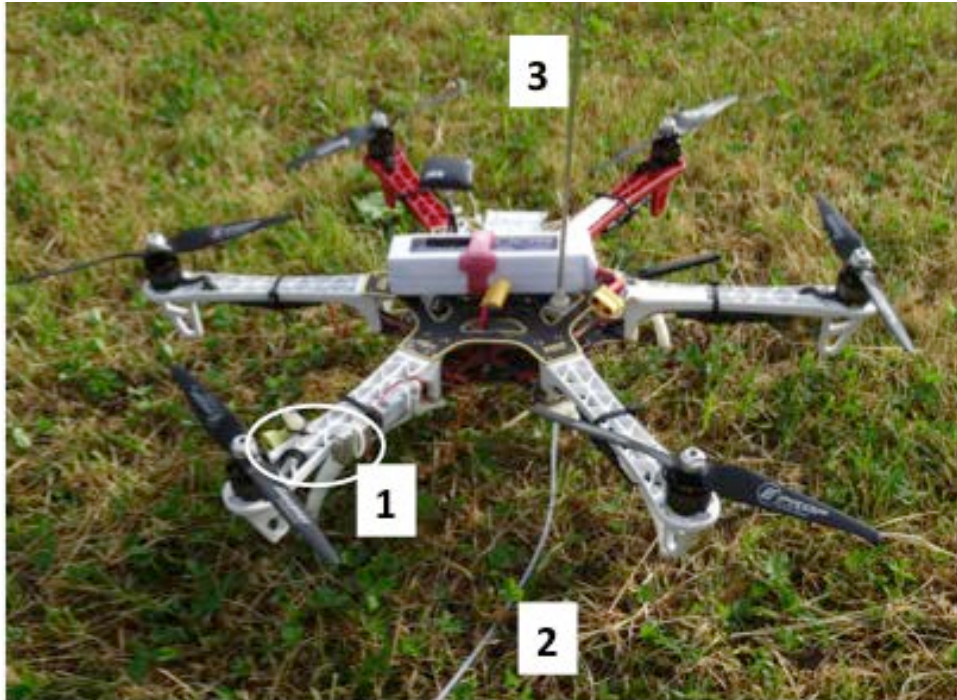
Triple Doppler LiDAR
(Halo Photonics Streamline)



profiles of mean wind and
variance of all velocity components

airborne in situ measurements at IMK-IFU

drone (hexacopter)



- 1 Air temperature and humidity sensors
- 2 Teflon tube
- 3 Tube extension above hexacopter

Summary

- **wind and turbulence fields in different environments (urban, complex terrain, offshore)**
- **observations and model simulations across scales**
- **remote sensing techniques (surface-based, airborne, space-borne)**
- **drones**
- **urban living conditions (wind climate, thermal comfort, air quality)**
- **renewable energies (wind, solar, hydro)**
- **energy meteorology new subject at universities**



**Thank You
for your
attention**

