Wind turning in the boundary layer
- observations and comparison with CMIP5 models

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Introduction

- We do not have any direct global measurements of surface drag
- Look at parameters that can constrain what the models should be doing – the wind turning in the boundary layer is one of them
- The angle of wind turning is closely related to the cross-isobaric flow which is important for cyclone development and the large-scale flow

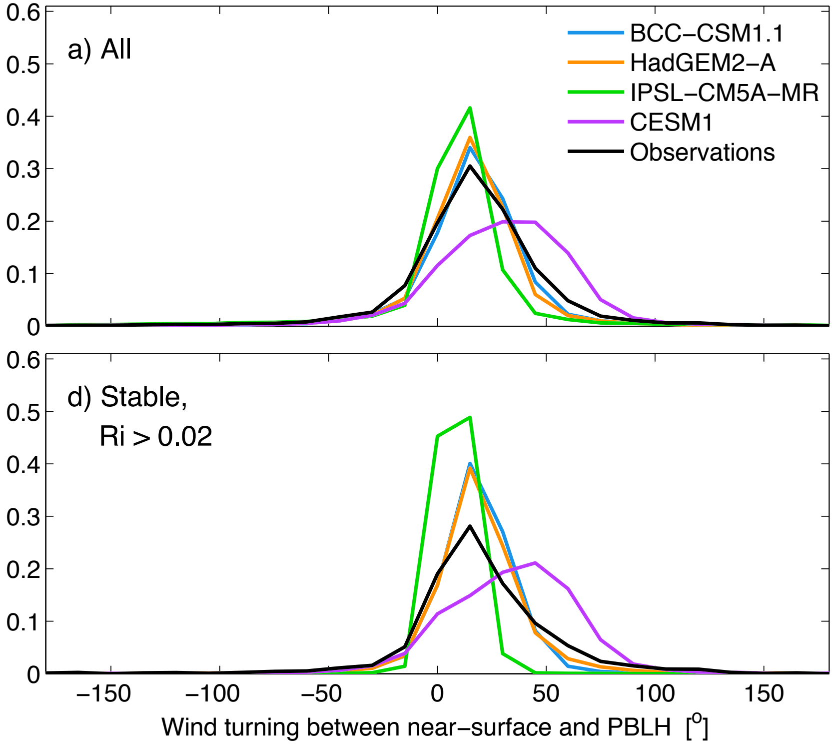
Introduction

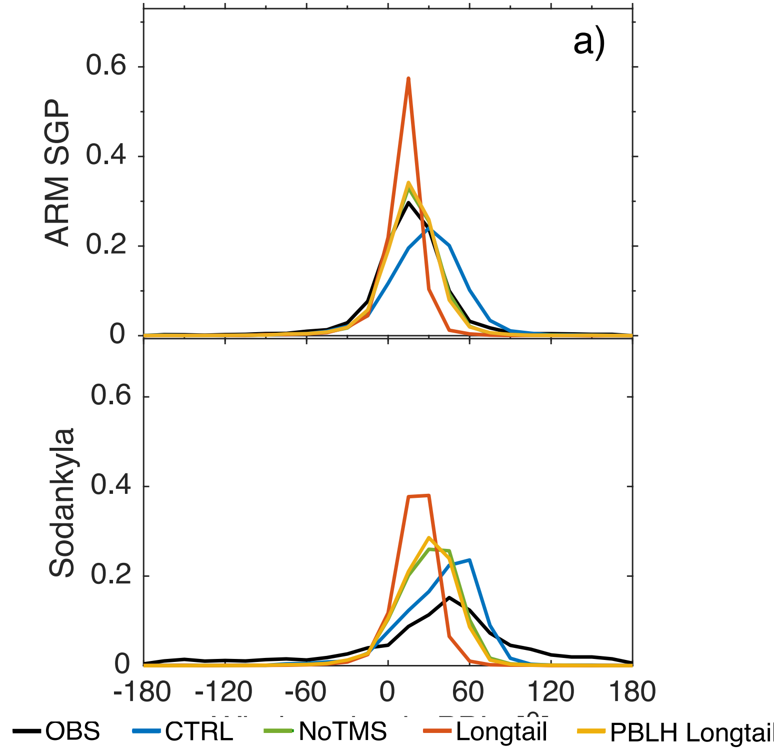
Known modeling problems:

- Too large cross-isobaric flow
- Too deep stable PBLs
- The angle between the near-surface and geostrophic wind is too small

The evaluations are generally based on a few point studies (Cabauw ~32^{o}) or LES comparisons

- Recently climatologies of PBLH has emerged





Studied the angle of windturning at one (two) locations in CMIP5 models and in several versions of CAM with different surface drag and vertical diffusion

Large differences between the models/model versions

Lindvall, J., Svensson, G., and Caballero, R. (2016). The impact of changes in parameterizations of surface drag and vertical diusion on the large-scale circulation in the Community Atmosphere Model (CAM5). Accepted in Climate Dynamics

Svensson, G. and Lindvall, J. (2015). Evaluation of Near-Surface Variables and the Vertical Structure of the Boundary Layer in CMIP5 Models. Journal of Climate, 28(13):5233–5253

Data

IGRA

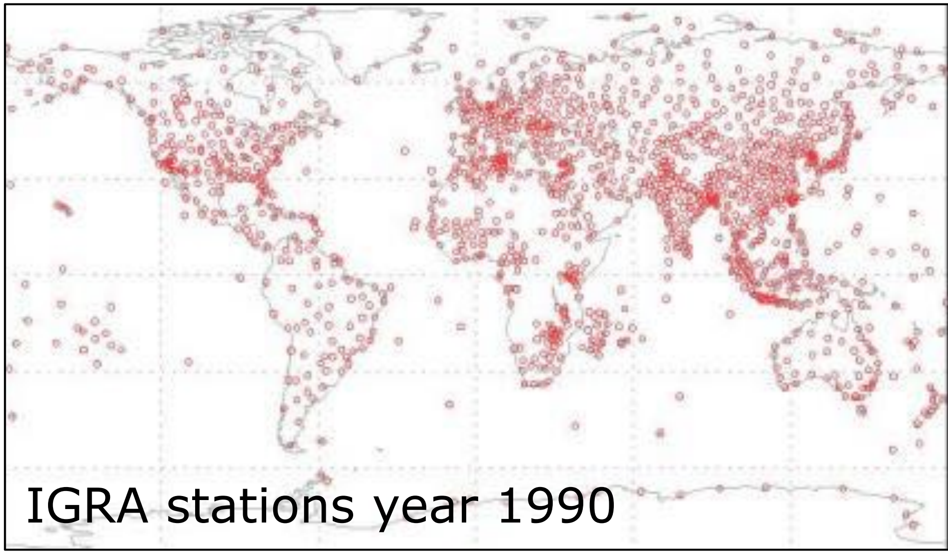
- Soundings at over 1000 locations (681 included)
- Limited vertical resolution
- PBLH from Seidel et al, 2010 (1971-2010)

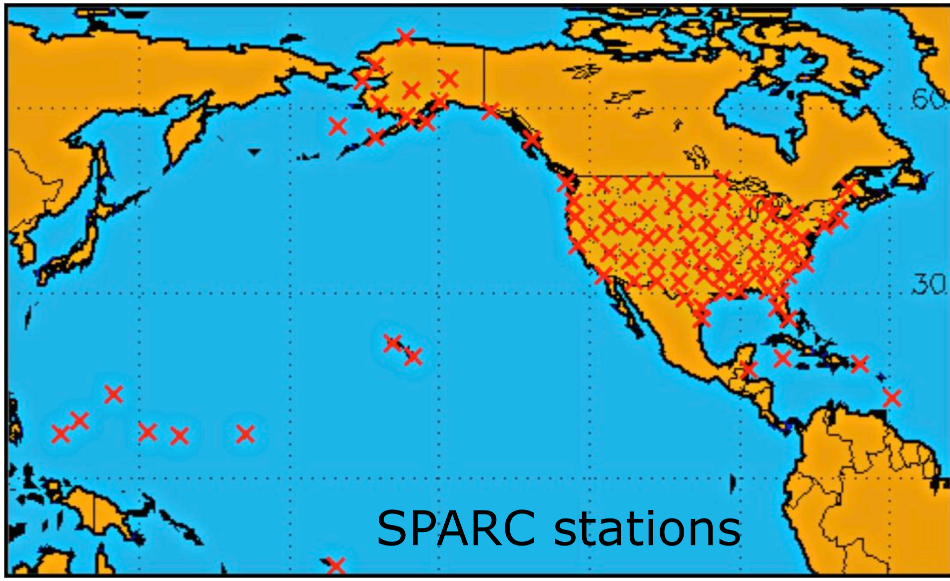
SPARC

- High vertical resolution (6 or 1 s)
- Fewer points (US only)
- 1998-2011

Models

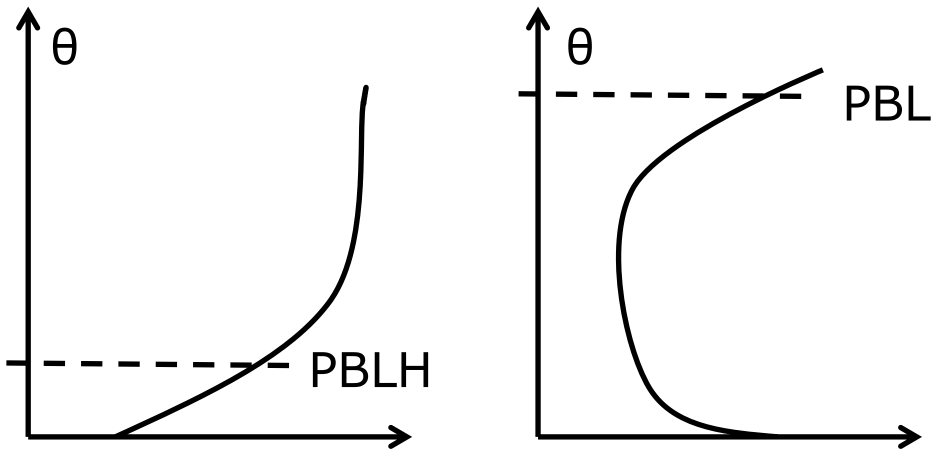
- 6-hourly, global data
- 5 years and 5 models (for now)
- CMIP5 data + CESM(CLUBB)





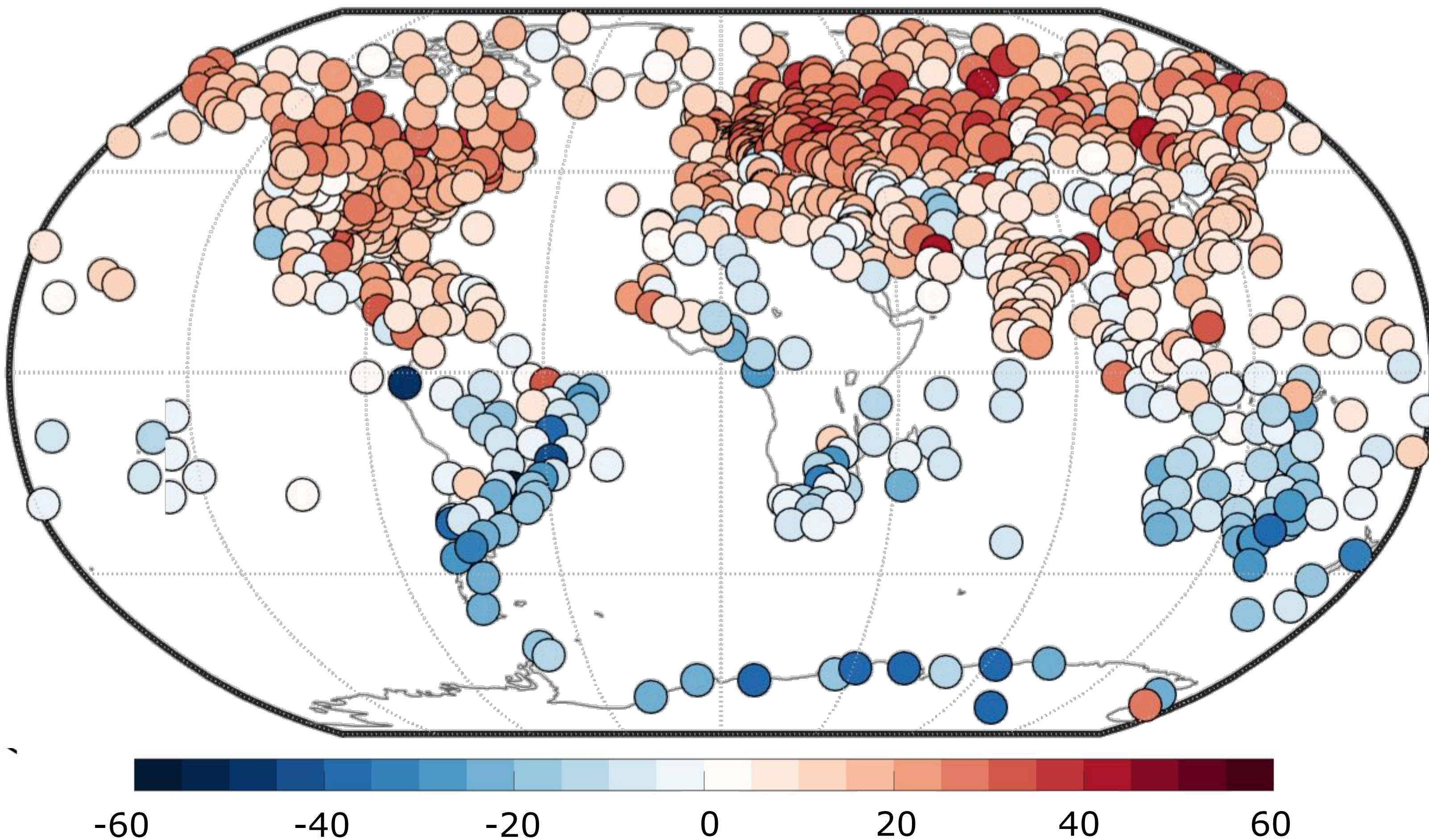
Data

- The turning of the wind with height is calculated between the first level above the PBLH and 10 m wind (the lowest height in the sounding data set)

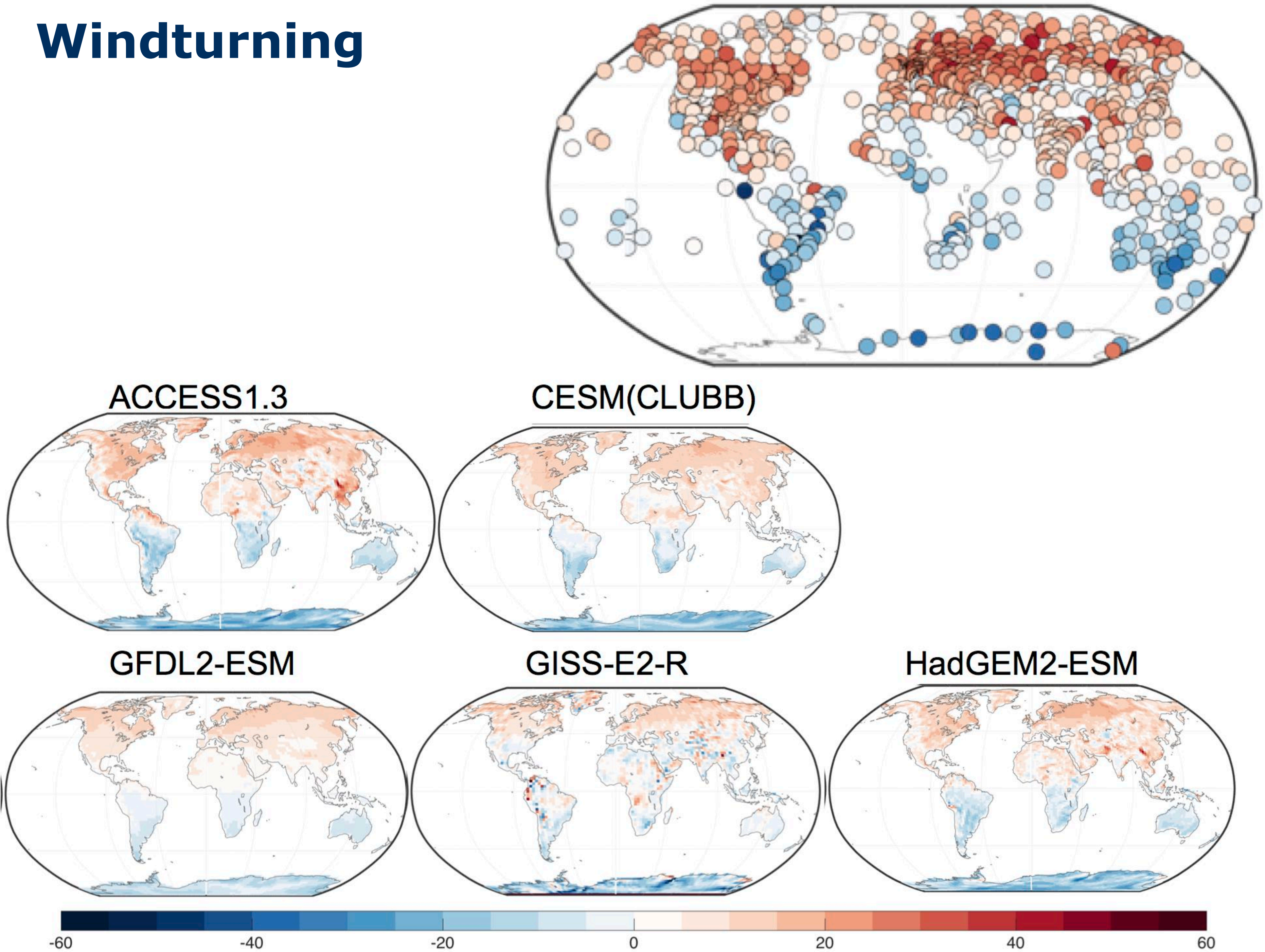


- The PBLH is from a dataset by Seidel et al (2010)
- Diagnosed using a bulk Richardson number (finding first level where $Ri_{bulk} > 0.25$)
- For a fair comparison, the same method is used to calculate the PBLH in the models

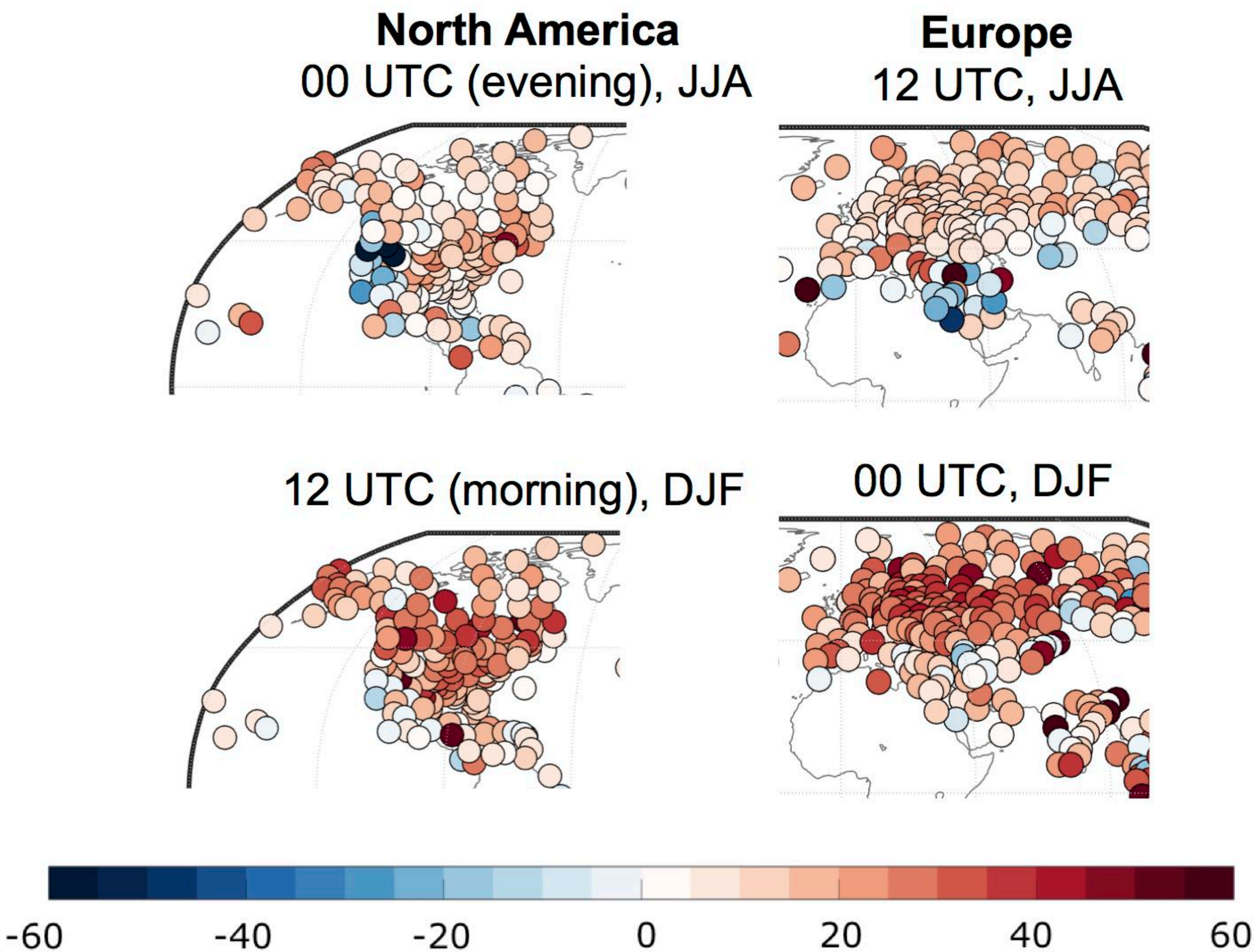
The angle of wind turning - observations



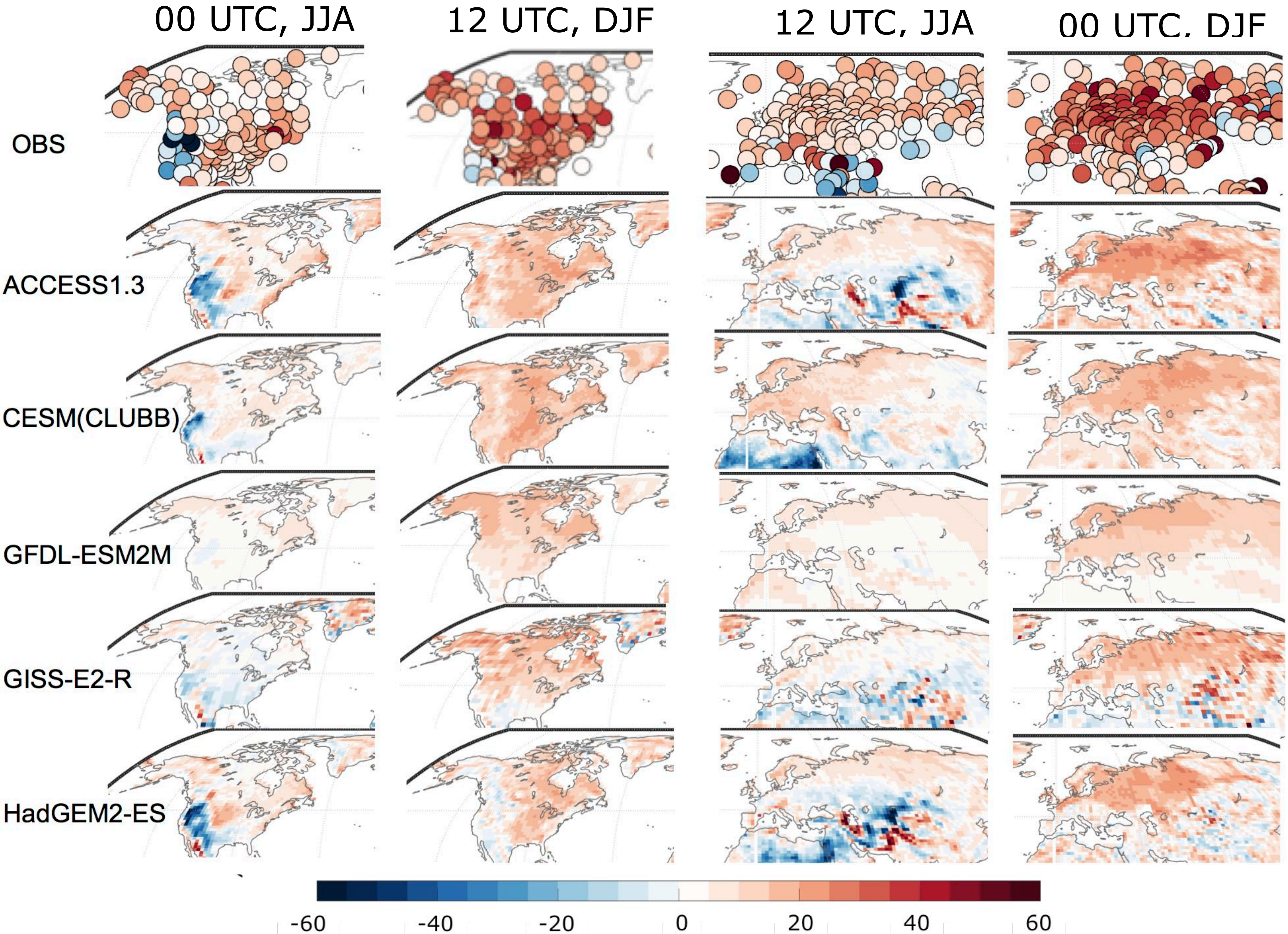
Windturning



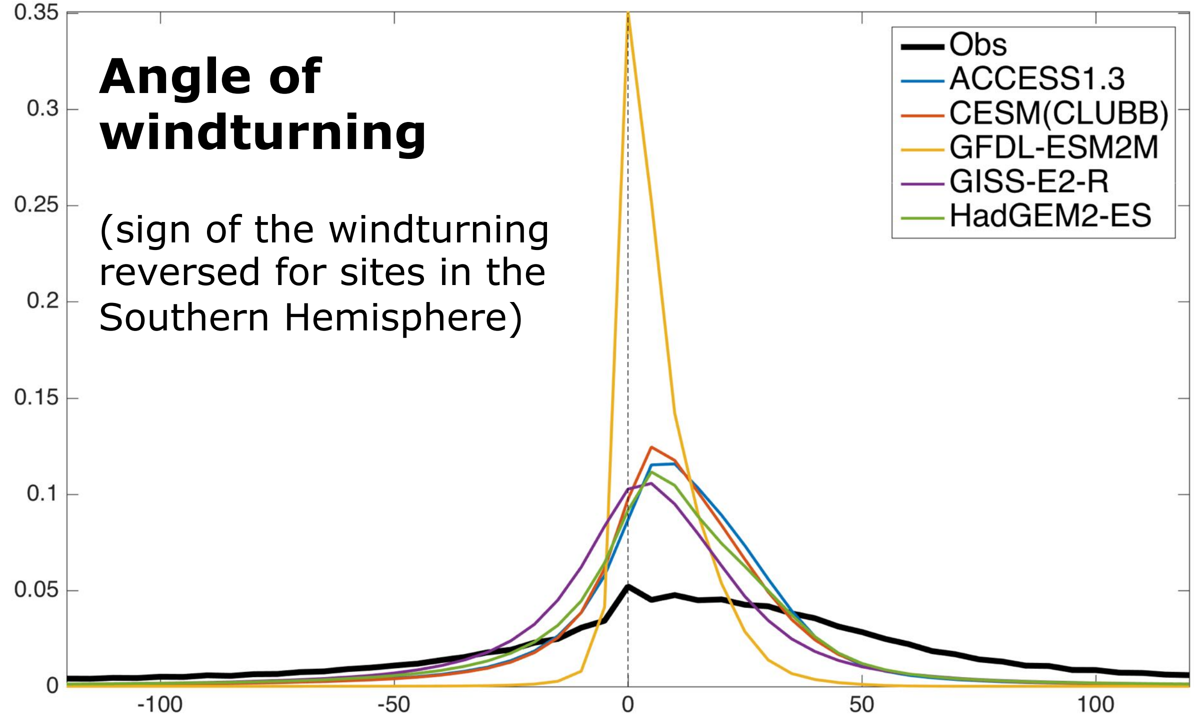
Windturning - seasons



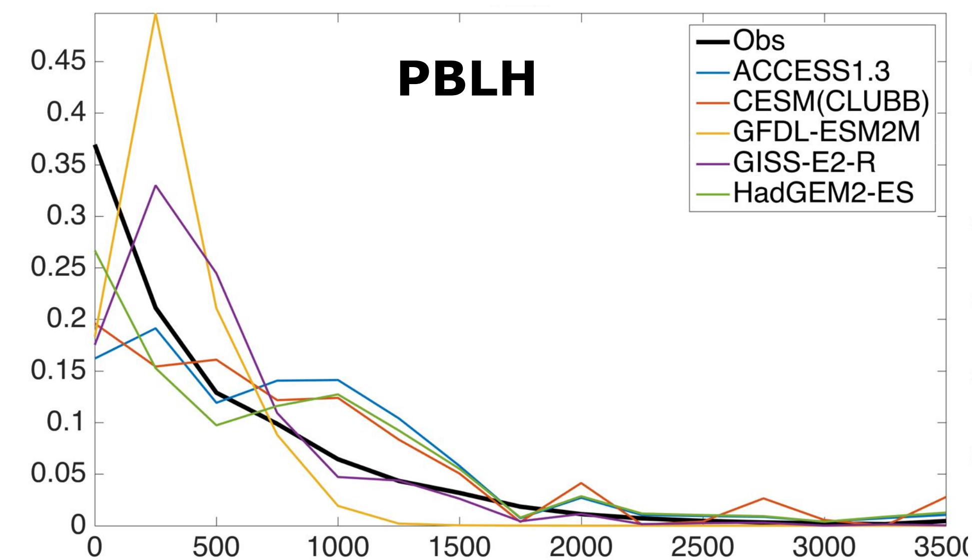
Windturning - seasons

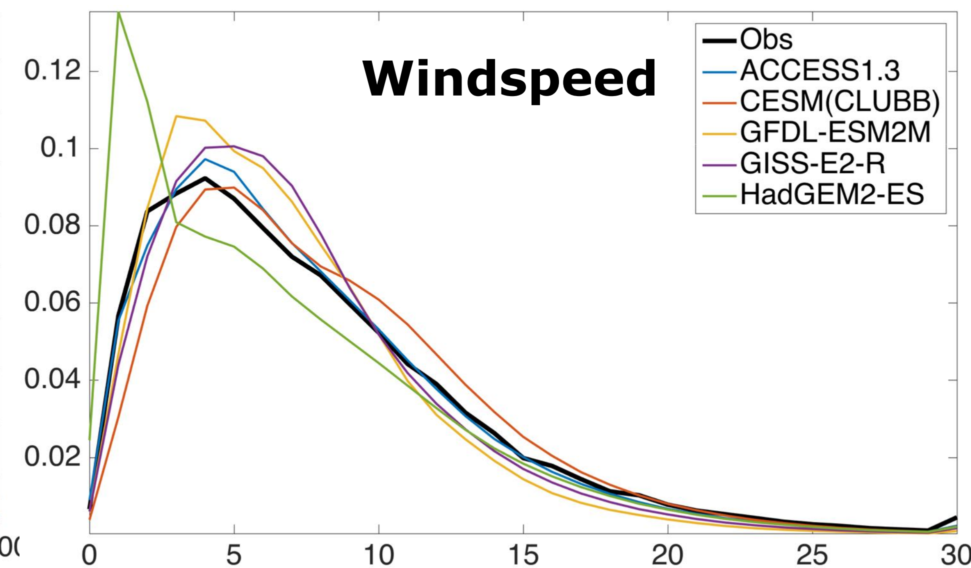


PDFs for all observation sites



- Observations show a wider PDF and larger angles of windturning
- Models are similar except GFDL



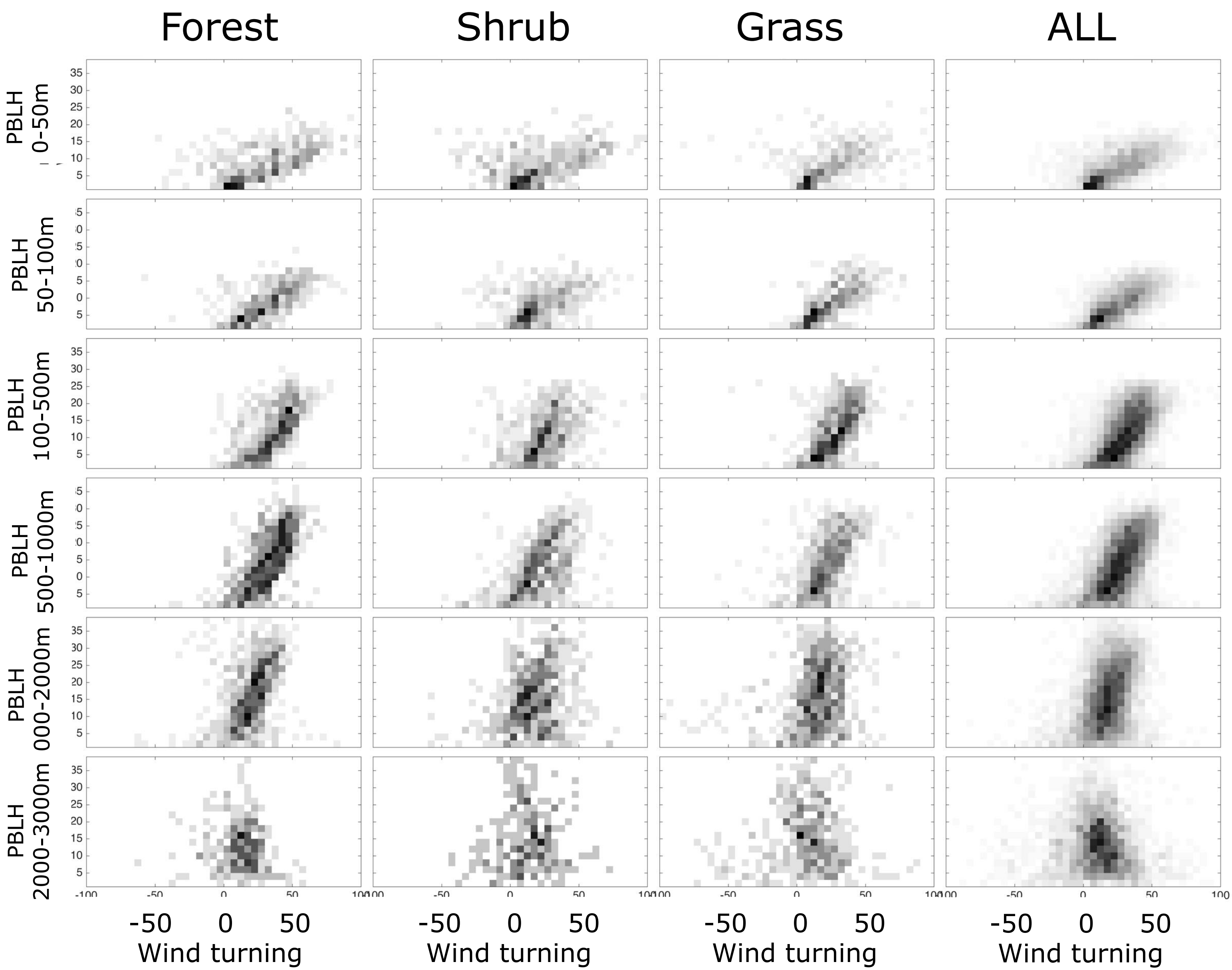


Angle of windturning vs wind speed - Observations

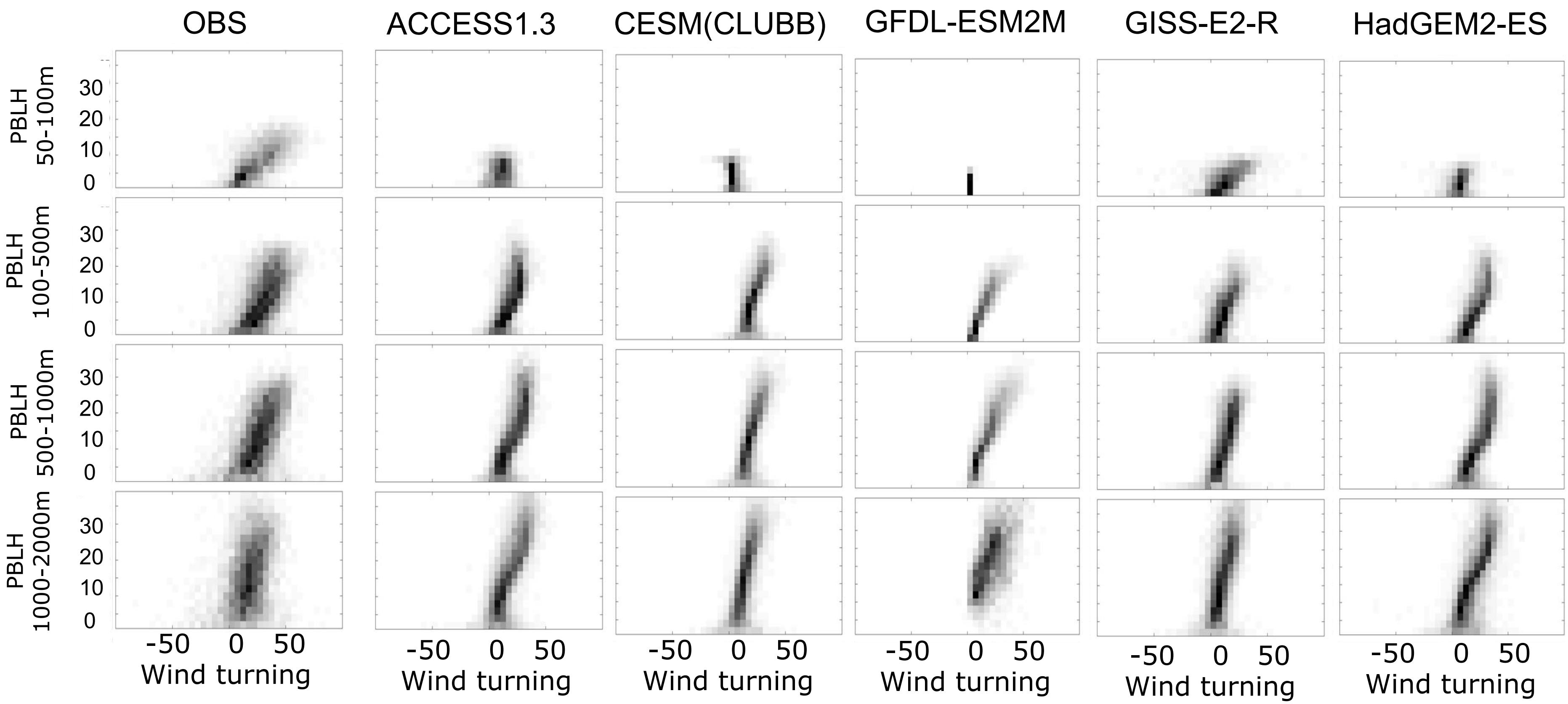
The turning of the wind increases with wind speed.

The increase is faster for lower PBLHs

Different surface types (from MODIS data) show the same behavior



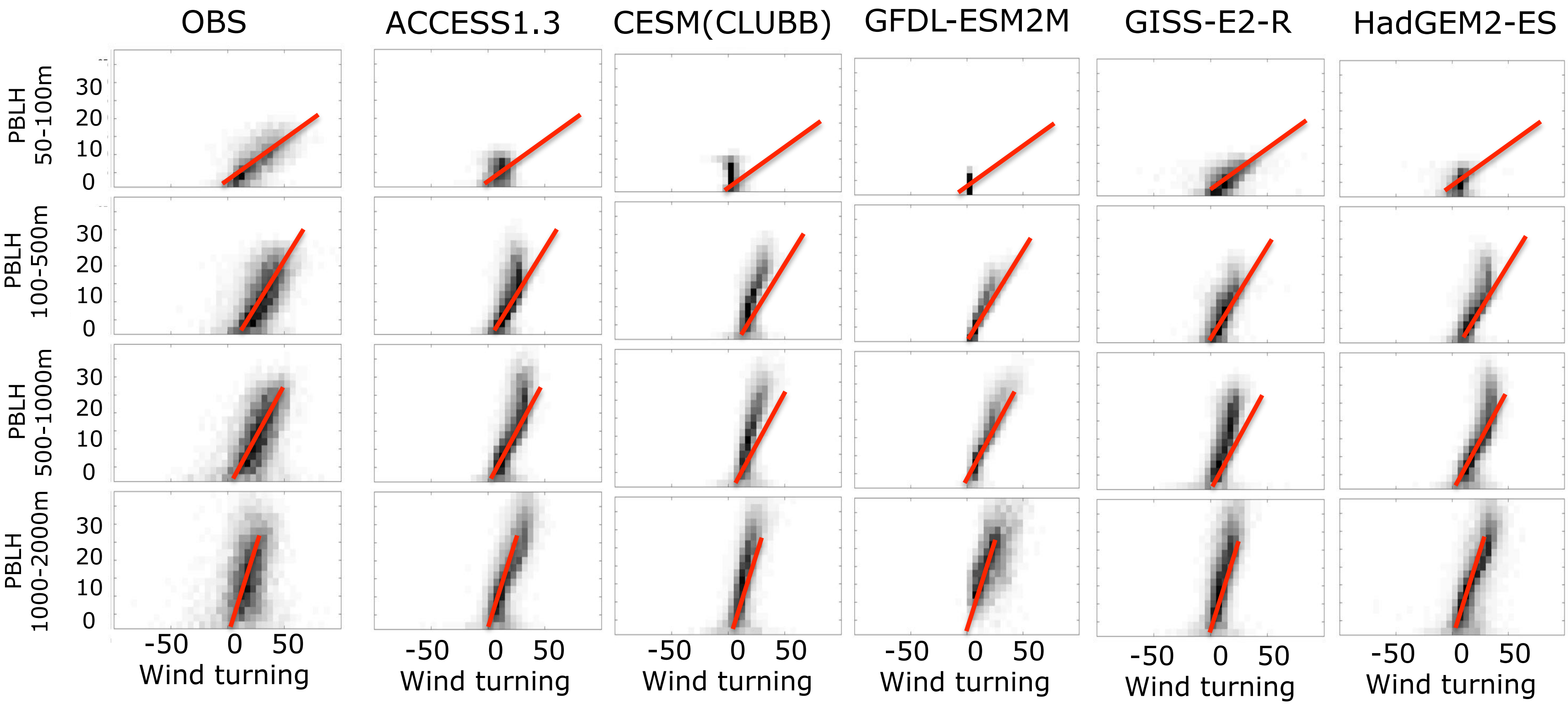
Angle of windturning vs wind speed



The models also show an increase of the wind turning with wind speed.

The differences in the slope between difference PBLH regimes is less in the models

Angle of windturning vs wind speed



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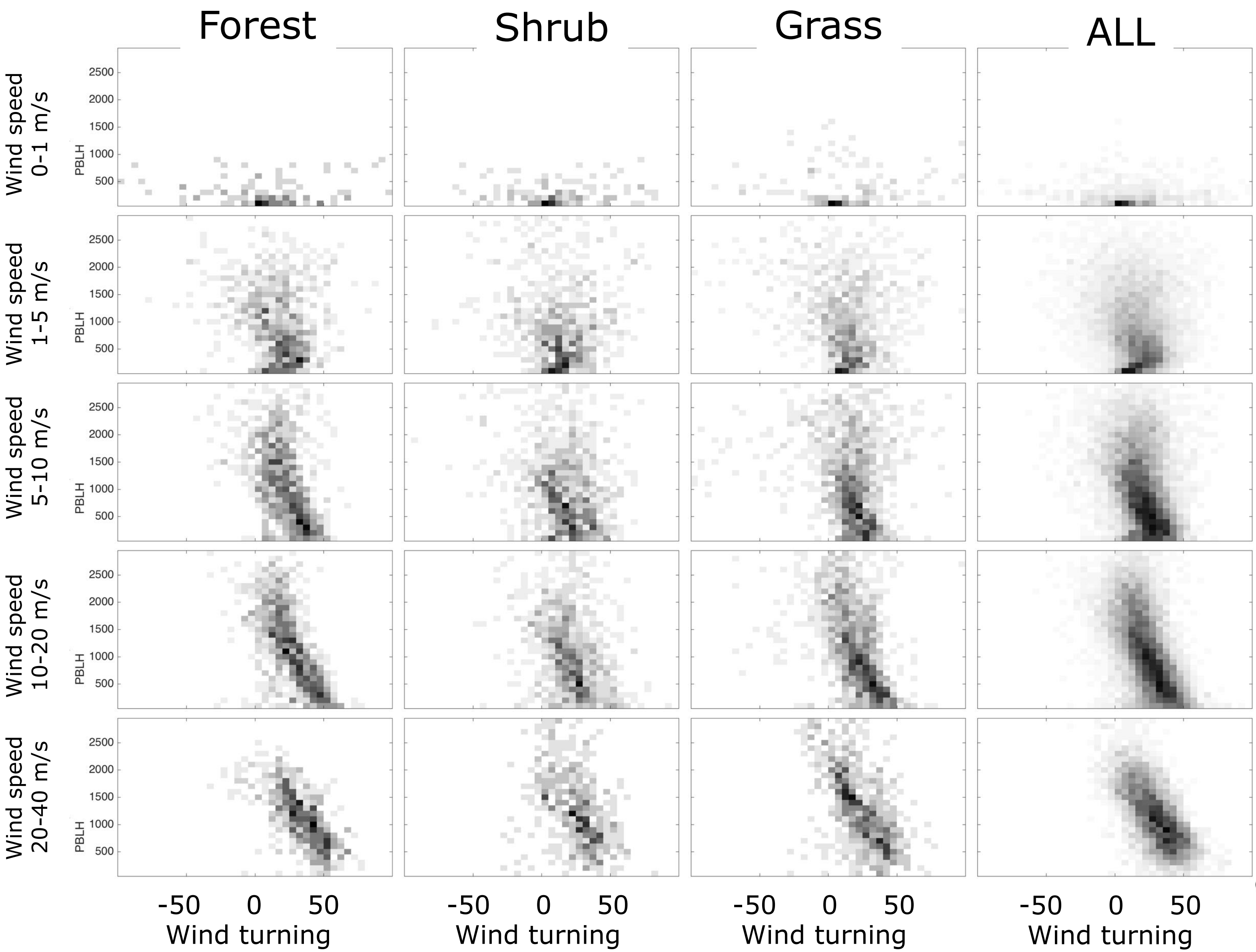
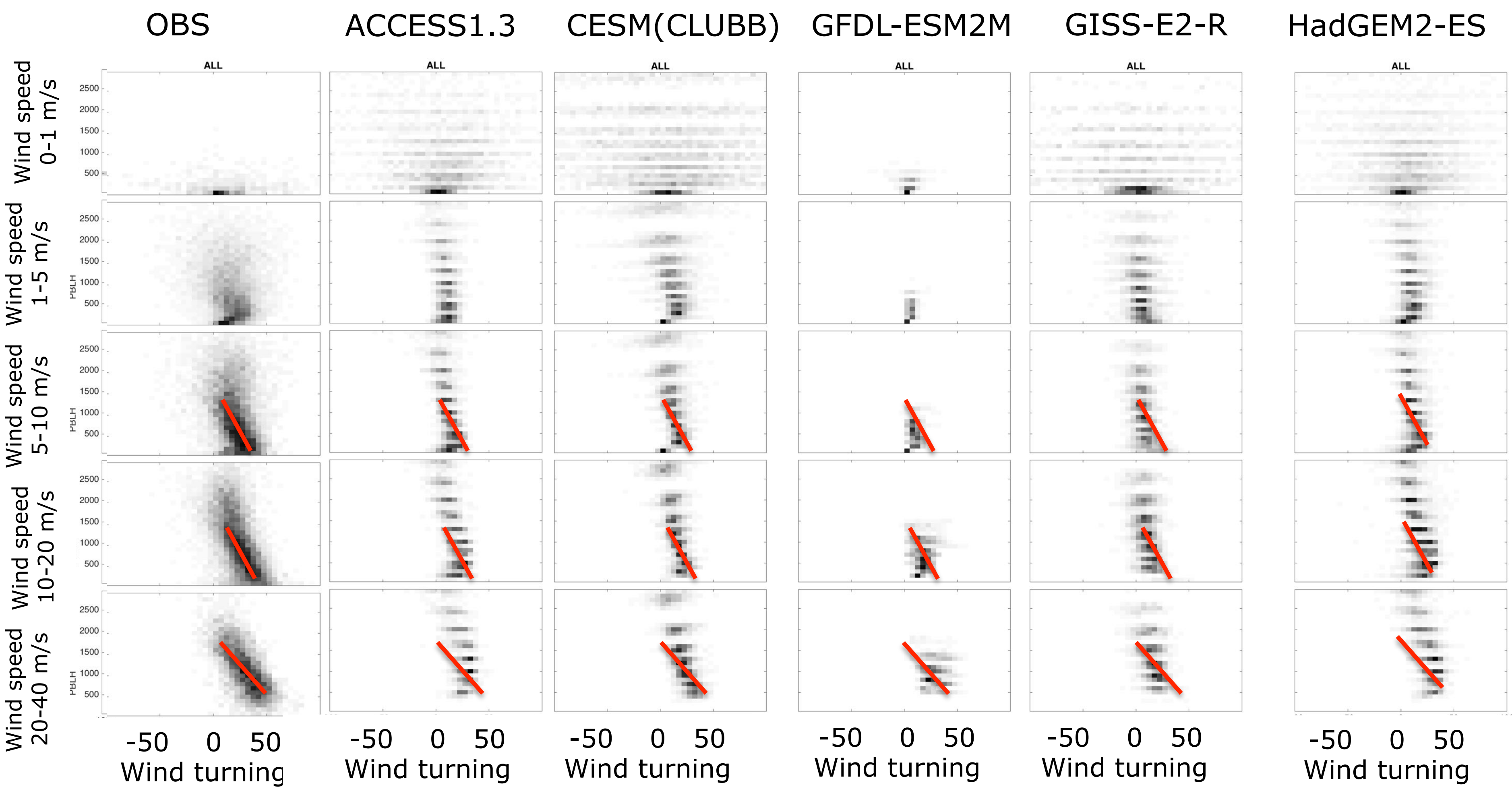
Angle of windturning vs PBLH - Observations



The turning of the wind decreases with PBLH

Different surface types (from MODIS data) show the same behavior

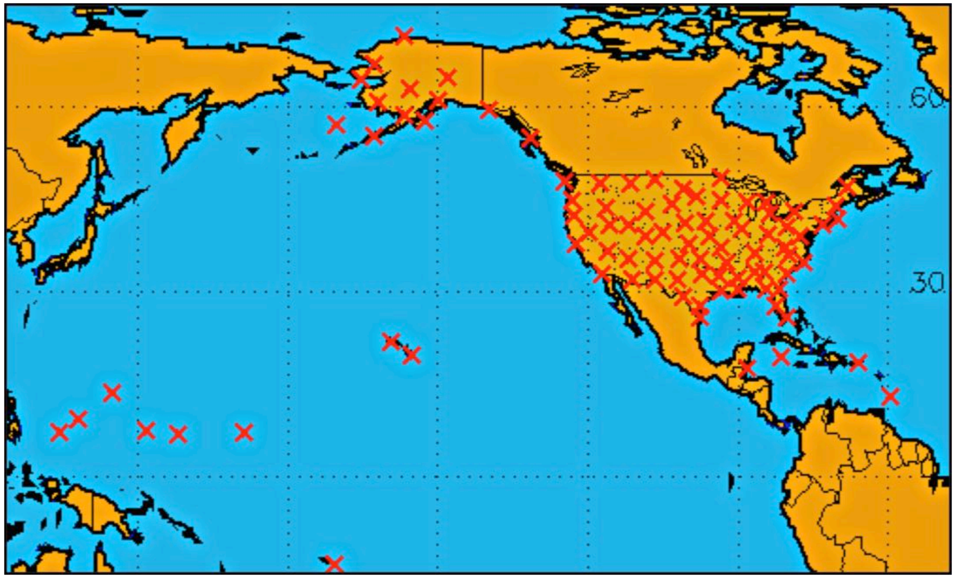
Angle of windturning vs PBLH



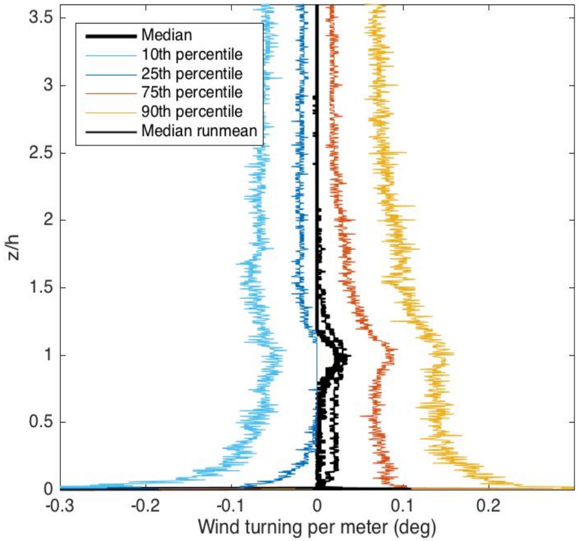
The models also show the decrease of the wind turning with PBLH.

The spread is smaller in the models.

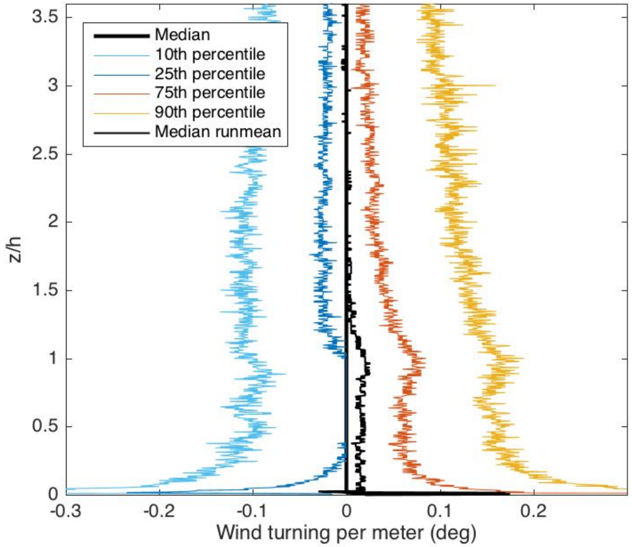
SPARC - examples



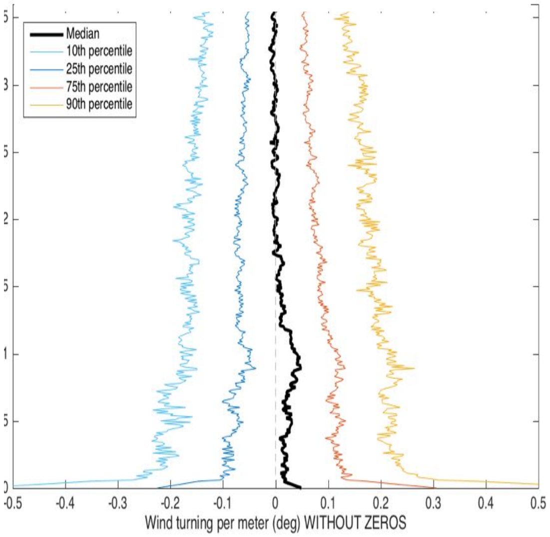
International Falls, Minnesota



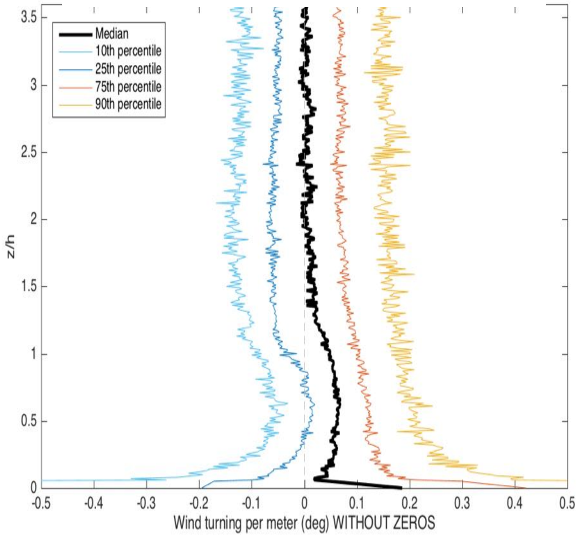
Birmingham, Alabama



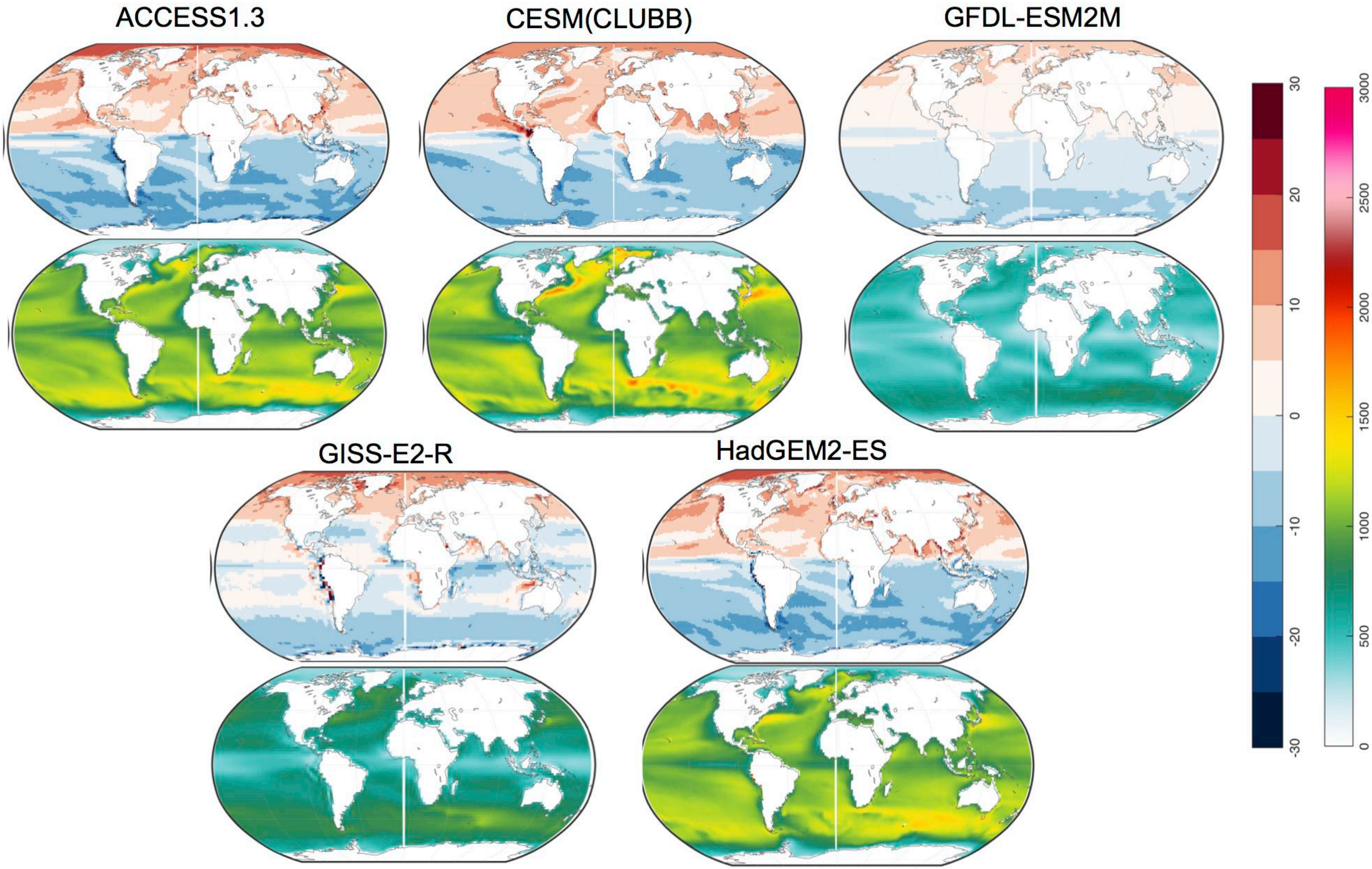
00 UTC (afternoon)



12 UTC (morning)



Wind turning and PBLH over oceans – model differences



Outlook

- Continue the analysis and include more models
- Use SPARC data to estimate uncertainties in the IGRA data and study what goes on in the vertical
- Compare the observations with reanalyses
- Look more closely at polar areas

Summary

- We have used radiosondes to attempt to get a climatology of the wind turning in the PBL

- Both the angles of windturning and the variations in windturning are smaller in the models than in the observations.
- The angle of windturning increases with wind speed and decreases with PBLH and this is to some extent captured by the observations

Stockholm University

Thank you!