Frequency of lake breeze at Lake Taihu

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u Outline

- **Literature Reading**
- **Recent Work**
- **Discussion and suppose**

A METHOD FOR FINDING SEA BREEZE DAYS UNDER STABLE SYNOPTIC CONDITIONS AND ITS APPLICATION TO THE SWEDISH WEST COAST

K. BORNE , D. CHEN and M. NUNEZ

u OUTLINE

- Introduction
- Method
- Application of the method
- Evaluation of the method
- Discussion

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u Introduction

- The work represented here is part of a programme to study the characteristics, onset and physical mechanisms of sea breezes in the archipelago area of south-western Sweden. Deriving a purely observational data set in **an archipelago environment** is a difficult task for the reasons already outlined.

- In this paper we present an easy and practical method for selection of sea breeze days in this **complex environment**.

- -The produced data set is also suitable for model validation. In addition, the method can with **some minor modifications** easily be applied to different environments.

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u Traditional method

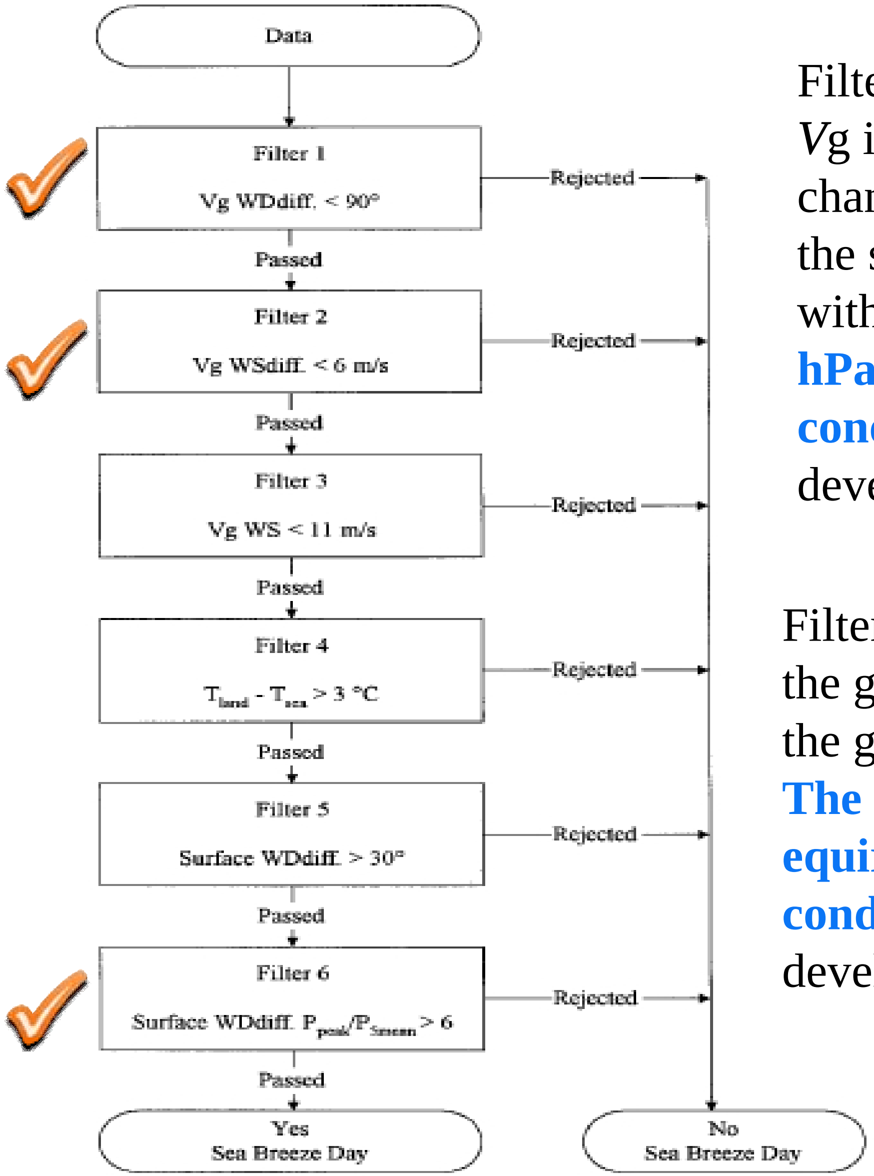
Cesar 2008:

- An abrupt shift in WD which cannot be attributed to synoptic flow and a secondary increase in WS.
- An abrupt decrease in the diurnal air temperature curve
- an abrupt increase in the diurnal vapour pressure curve

Sills 2011:

- Satellite (visible channel **)**:·line of cumulus clouds or sharp gradient in cumulus cloudiness quasi-parallel to shore.
- Radar (reflectivity, radial velocity): fine line or sharp gradient in clear-air echoes quasi-parallel to shore and shift in radial velocity along fine line
- Surface (station plots, time series):rapid shift in wind direction to onshore wind (may be accompanied by rapid change in wind speed, sharp decrease in temperature and dew point within 20 km of shore

u The method



Filter 1: *V*g: WD diff <90° during 24 h where *V*g is the geostrophic wind and WD diff. is the change in the geostrophic wind direction during the specified time. The first filter excludes days with large change sin wind direction **at the 700 hPa level** during 24 h. **Stable synoptic conditions** are a criterion for the sea breeze development

Filter 2: *V*g: WS diff.<6 m/s during 12 h where *V*g is the geostrophic wind and WS diff. is the change in the geostrophic wind speed during the specified time. **The filters 1、2 reject all days where the equirement of the stable synoptic circulation conditions**, which is a first criterion for the development of a sea breeze, is not met.

u The method

- Filter 3: Vg: WS<11 m/ s where Vg is the geostrophic wind and WS is the 700 hPa wind speed at the specified time. The third filter is there to exclude days **with a too strong synoptic wind speed.**

- Filter 4: $T_{land} - T_{sea}$>3° C,during 24 h where T_{land} is the daily maximum temperature at an inland station and T_{sea} is the sea surface temperature from a coastal station.

- Filter 5: Surface: WD diff. >30° during the hours from (sunrise+1h) to (sunset-5h). A quick change in the surface wind direction **is the most distinct characteristic feature of the sea breeze**.

- Filter 6: Surface WD diff.: P_{peak}:P_{5mean}>6 during the hours from (sunrise+1h) to (sunset-5h) where $\mathrm{P_{peak}}$:$\mathrm{P_{5mean}}$ is the ratio between a sharp change in wind direction (P_{peak}) and P_{5mean} which is the average of the hourly changes in wind direction in the 5 h following the P_{peak}. This will exclude days with **strong veering conditions not connected to the sea breeze, and also sea breeze days with very short duration time**.

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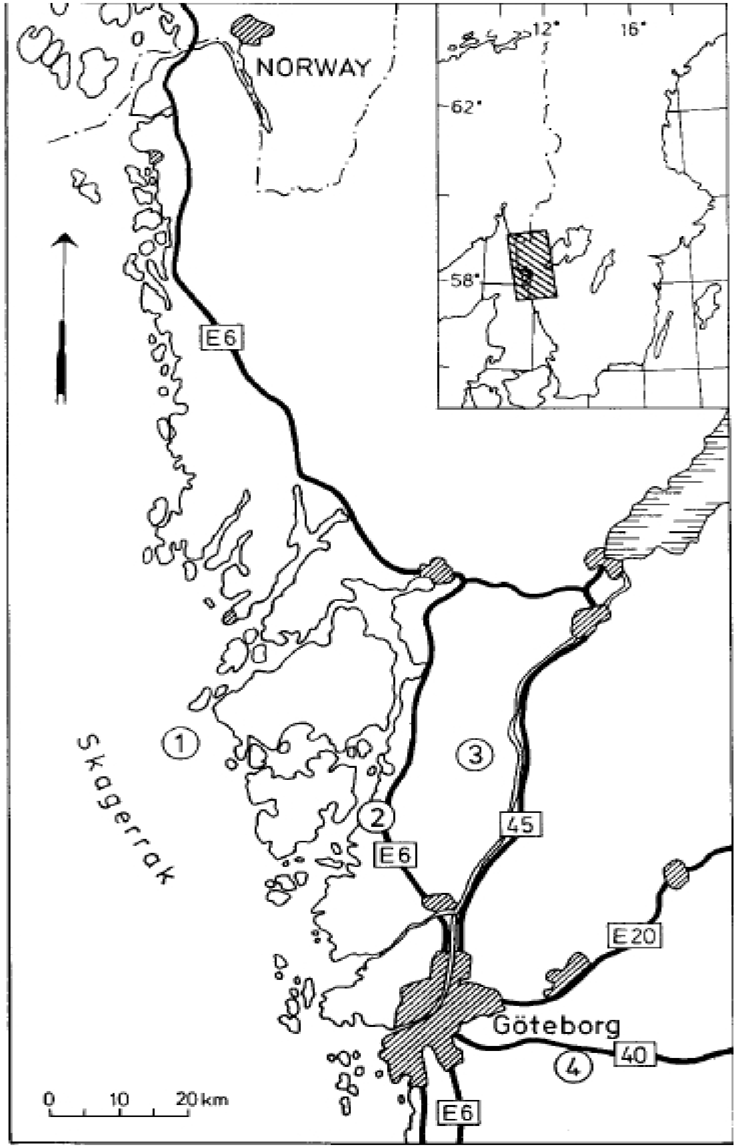
3. Application of the method



- The method uses 1 h mean surface wind speed and wind direction at 10 m height from field station 2 located near the coast.
- The temperature difference was calculated using the sea surface temperature measured approximately every third day at a meteorological station (field station 1), and the 1 h mean maximum temperature measured at the inland field station 3 approximately 20 km from the coastline.
- The synoptic conditions were represented by radiosonde data of wind speed and direction from the 700 hPa level measured every 12 h at field station 4.

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u 3. Application of the method

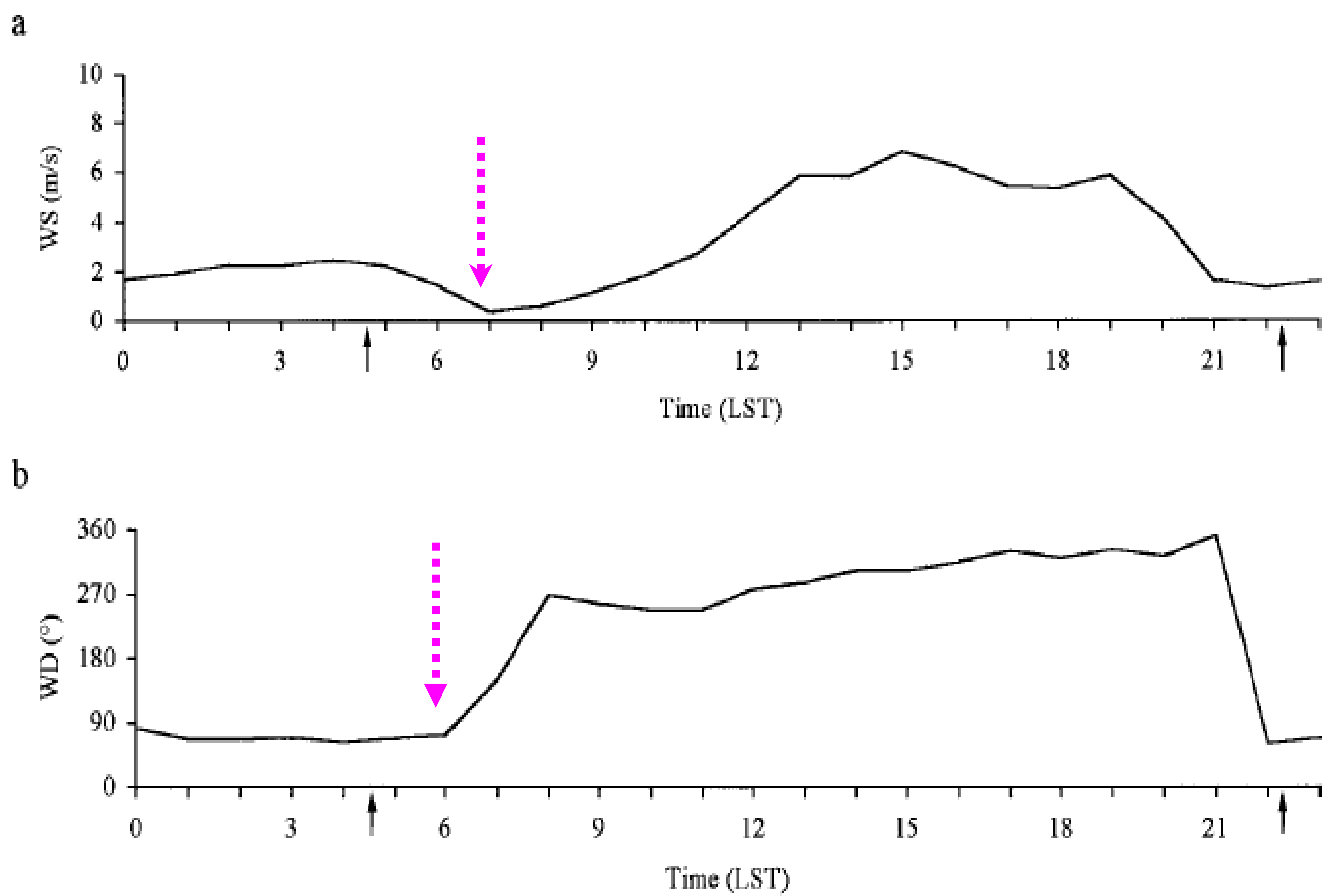

Figure 3. Characteristics of wind speed and wind direction for a day that was selected as a sea breeze day by the filter method. Data was collected on 19 July 1994 at field station 3.

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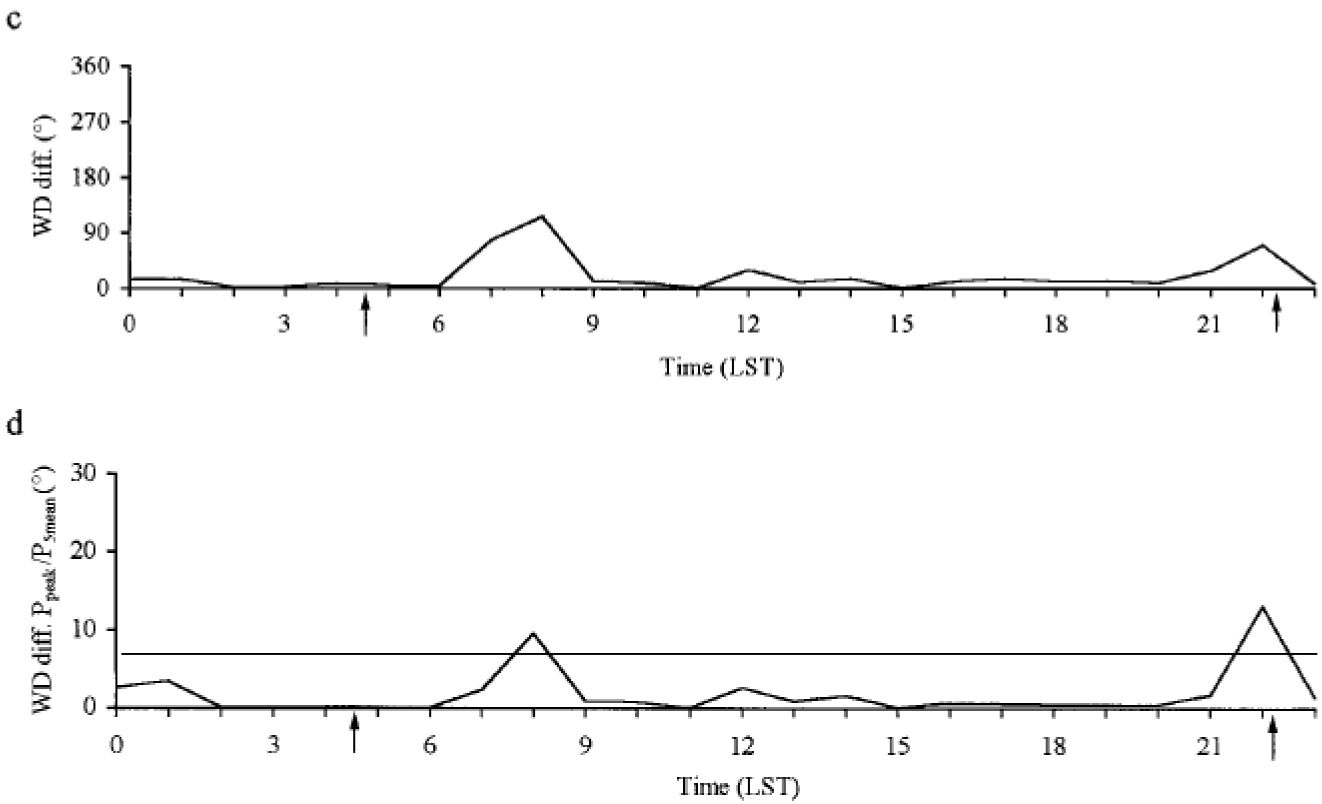

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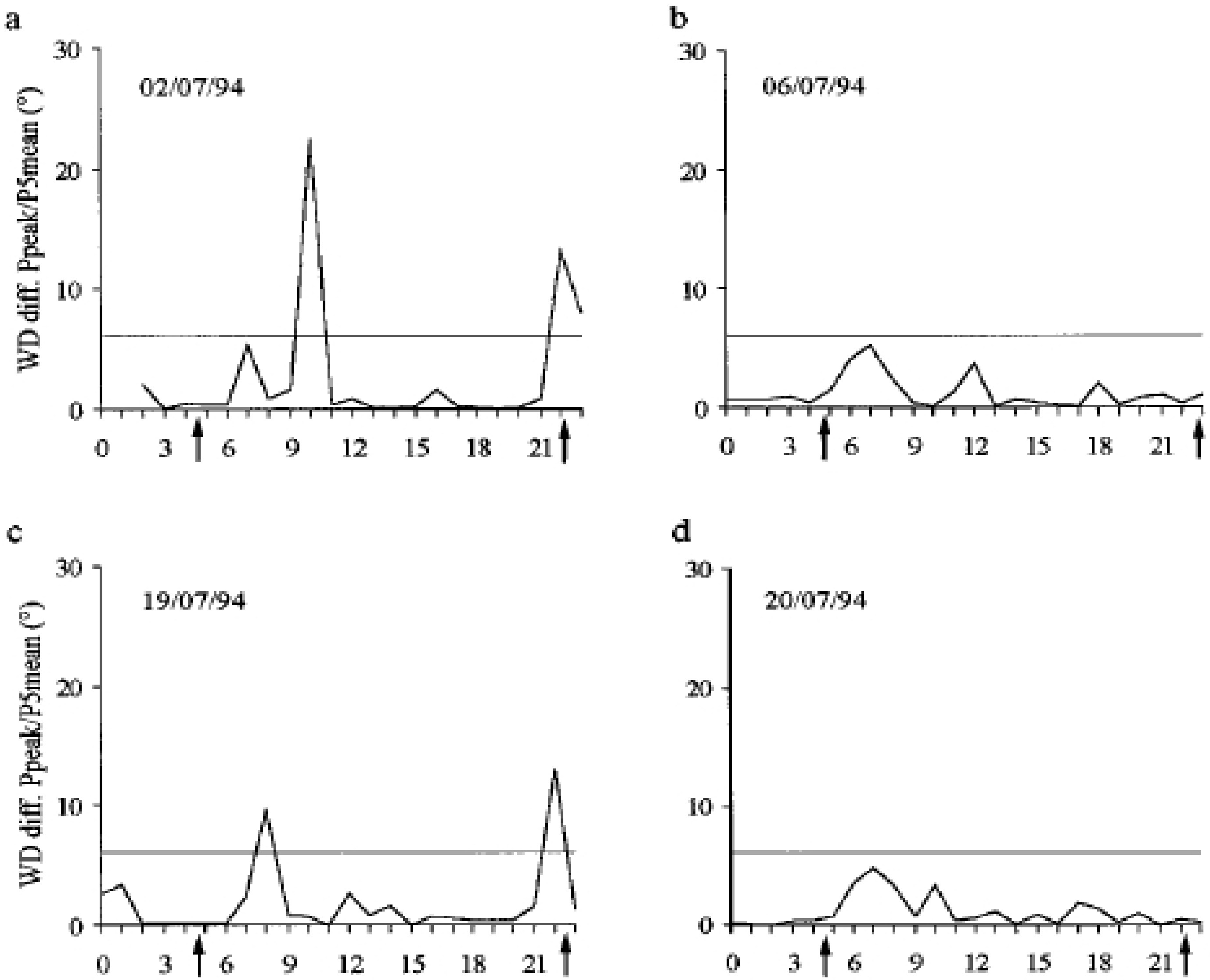
u WD diff.: P_{peak}:P_{5mean}>6



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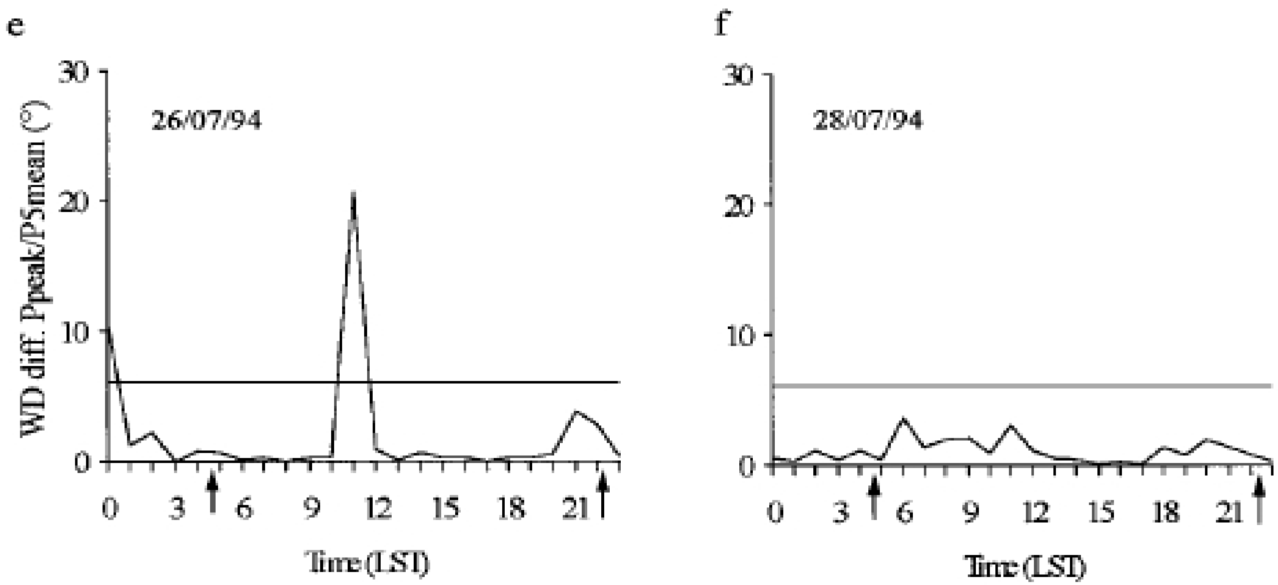
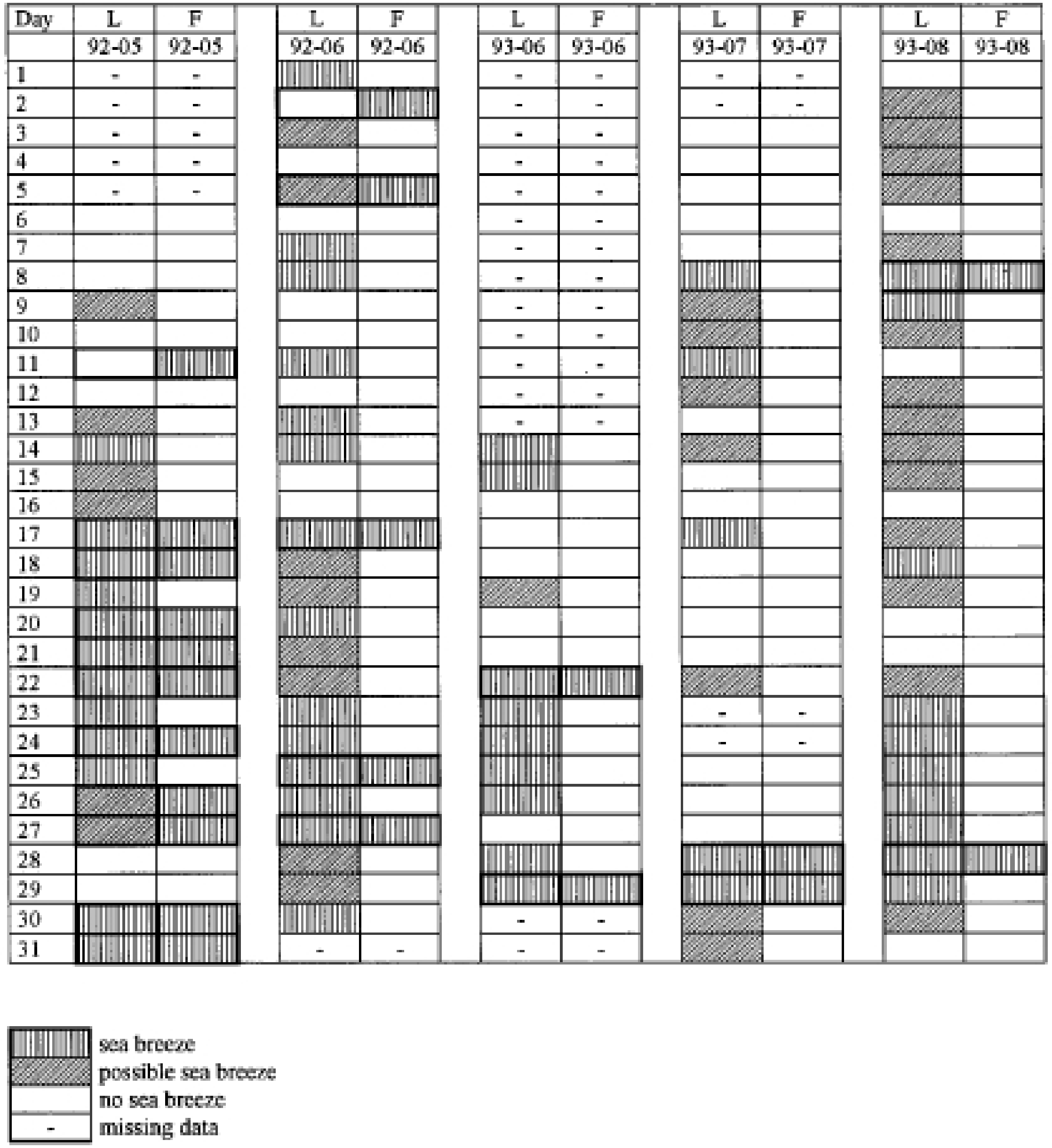


Figure 5. Sea breeze days (a) 2 July; (b) 6 July; (c) 19 July; (d) 20 July; (e) 26 July and (f) 28 July 1994 with varying wind ratio(WD diff.: *P*peak:*P*5mean). Only 3 days pass filter 6.

Figure 5 shows the wind ratio P_{peak}:P_{5mean} for six different sea breeze days. Filter 6 allows days with a peak ratio higher than six to pass the filter. In Figure 5 it can be seen that here, 3 days will be rejected (6 July, 20 July and 28 July).

u Evaluation of the method



- Table I. Summary showing how the filter method (F) compared with the Lund method (L) for the 5 months covered by this study.
- Vertical hatched lines represent prediction of a sea breeze event, and possible sea breezes are tilted lines. No sea breeze predictions are blank.
- Only 17 days were simultaneously classified as sea breezes by both methods

u Evaluation of the method

Table II. Flow diagram showing how the filter method processed the 50 days classified as sea breezes by the Lund method. Filters 1 and 4 have the highest number of rejections

Filter	Input	F1	F2	F3	F4	F5	F6	Output
Selected	50	⇒ ↓	⇒ ↓	⇒ ↓	⇒ ↓	⇒ ↓	⇒ ↓	⇒ 17
Rejected		−10	−4	−6	−10	−2	−1	

Table II shows the successive process of rejection for these 50 sea breeze days. Filters 1 and 4 are effective in the rejection process, while filters 5 and 6 only reject one or two days.

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u Comparison between the F.method and L.method

Filter	Filter method		Lund method	
	Total days selected as sea breeze by the method	Sea breeze	Possible sea breeze	Non sea breeze
1	109	41	30	38
2	109	43	28	38
3	85	42	20	23
4	64	35	14	15
5	70	47	15	8
6	75	38	16	21

Filter	Filter method		Lund method	
	Total days selected as sea breeze by the method	Sea breeze	Possible sea breeze	Non-sea breeze
1	21	9	6	6
2	21	7	8	6
3	45	8	16	21
4	66	15	22	29
5	60	3	21	36
6	55	12	20	23

Table III. Comparison of sea breeze days as selected by each filter versus the evaluation of the Lund method. For example at filter 1, 109 days passed as sea breeze days. These 109 days were partitioned as sea breeze days (41);possible sea breeze days (30); and no sea breeze days (38) by the Lund method. Table IV is of non sea breeze days and Format is the same as Table III

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u Summary

- The expected accuracy is **more than 75%** in the process of selecting sea breeze days. The six filters included in the method are **individually important**, especially filter 5 which represents the change in surface wind direction connected to the onset of the sea breeze

- The method also **normalises the data**, which enables comparisons between different areas and during different time periods to be accomplished

- Because the method is as independent as possible from the physical processes responsible for the sea breeze development, the data set can be produced **for validation** of already existing sea breeze models.

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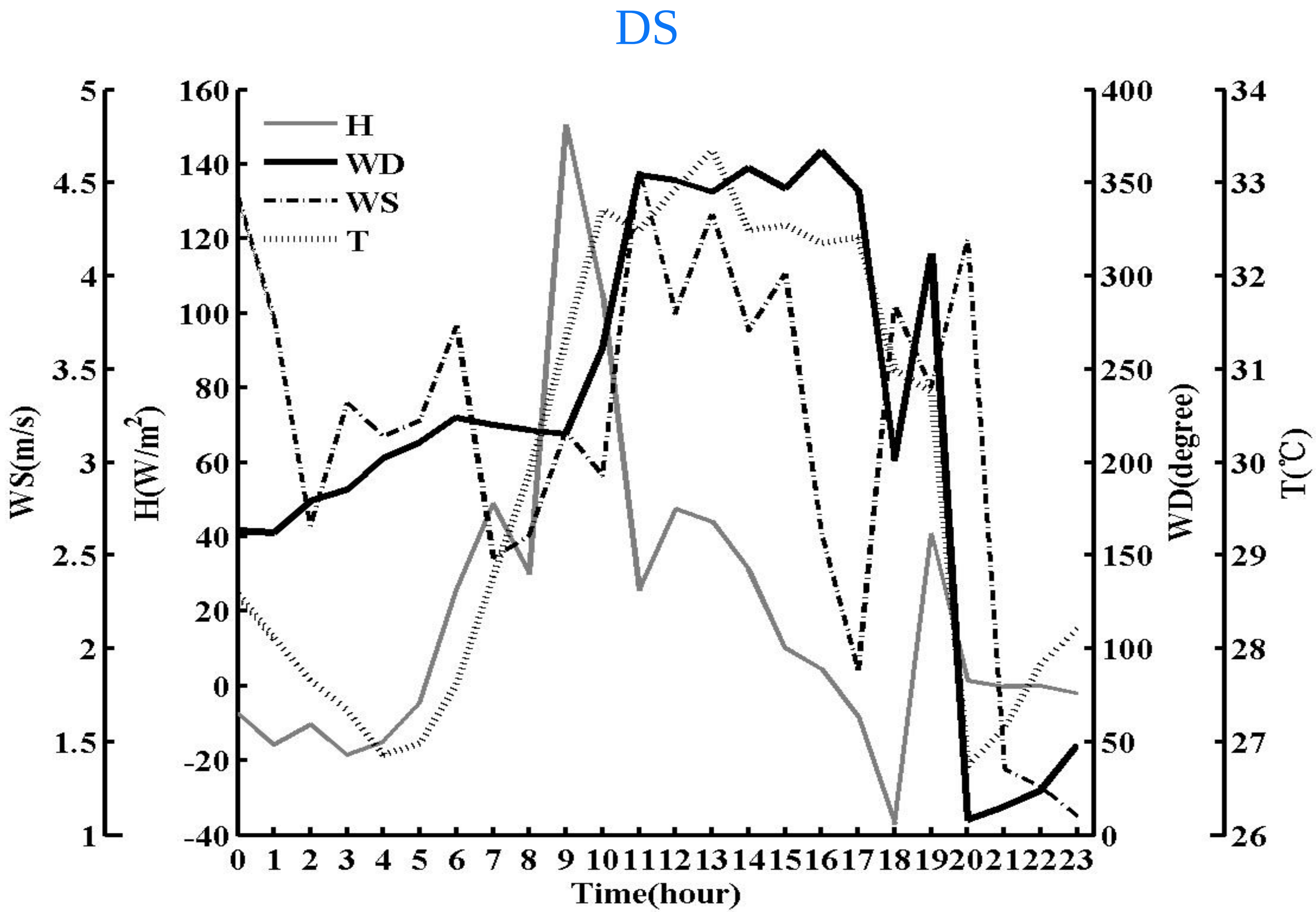
u Recent work

	Jun-2012		Jul-2012		Aug-2012		Total	
	Days	%	Days	%	Days	%	Days	%
East	8	26.7%	4	12.9%	7	22.6%	19	20.65%
West	10	32.3%	3	9.7%	8	25.8%	21	22.83%
North	9	30.0%	4	12.9%	8	25.8%	20	19.56%
South	12	40.0%	3	9.7%	9	29.0%	24	27.17%
Total	8	26.67%	3	9.67%	6	19.35%	18	19.56%

u Recent Work



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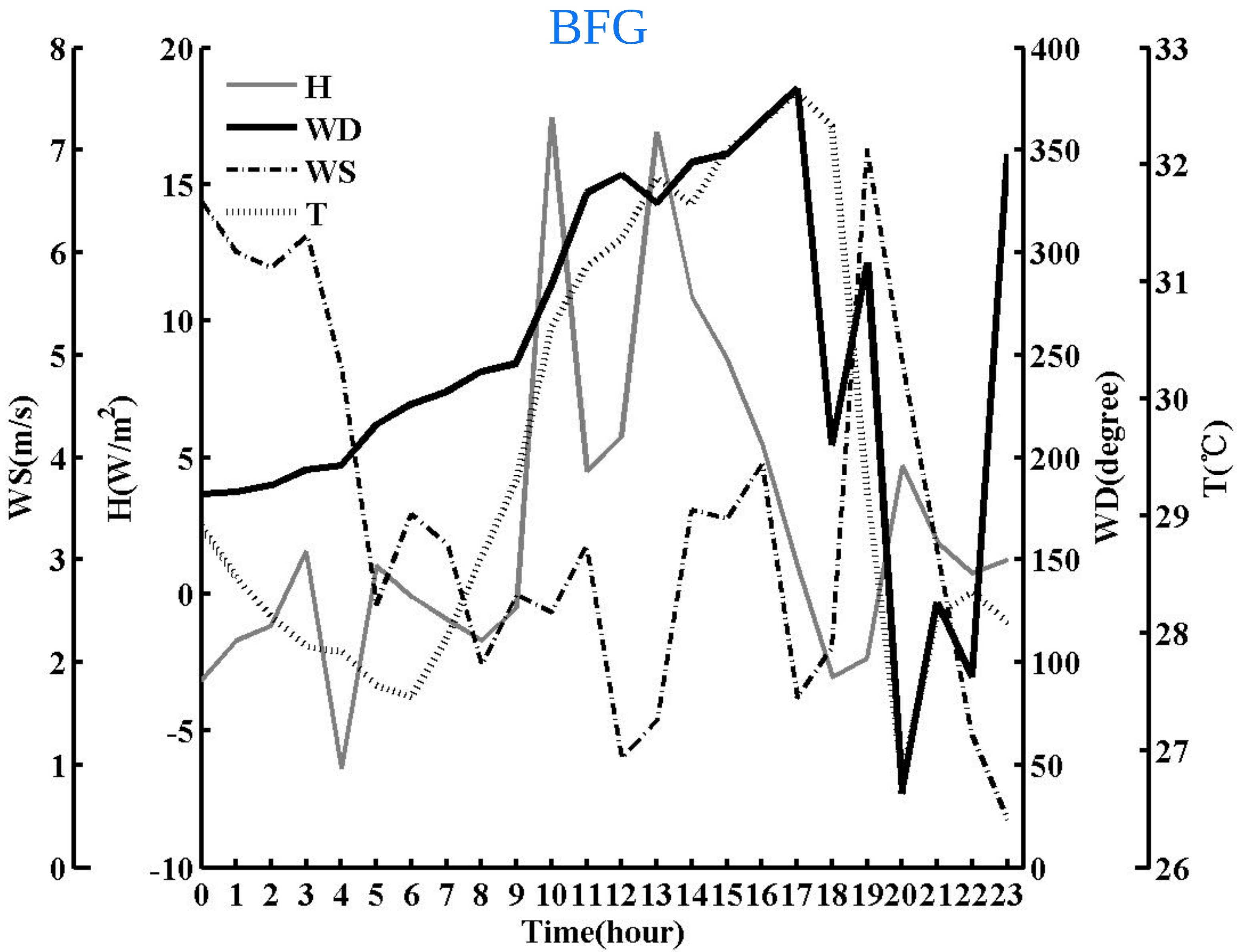

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u Discussion and suppose

Why is the lake Taihu breeze so small?

1、Explain from the formulation：

Author	Vertical length	Horizontal velocity	Horizontal length	Pressure
Niino (1987)	$\left(\frac{K_H}{\omega}\right)^{1/2}$	$\frac{g\Delta T}{T_0}\frac{1}{N}$	$\frac{N}{\omega}\left(\frac{K_H}{\omega}\right)^{1/2}$	$\rho\frac{g\Delta T}{T_0}\left(\frac{K_H}{\omega}\right)^{1/2}$
Steyn	$\frac{H}{\omega\Delta T}$	$\frac{g\Delta T}{T_0}\frac{1}{N}$	$\frac{NH}{\omega^2\Delta T}$	$\rho\frac{g}{T_0}\frac{H}{\omega}$

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u Discussion and suppose

2、The Cities in Yangtze Delta around the Taihu lake restrict the extent of the lake breeze.

- Yoshikado and Kondo (1989) found that sea breezes tended to move inland more slowly in urban Tokyo areas than in more rural areas. This is similar to the findings of Barbato (1978), who analyzed surface observations of 40 sea breezes in the Boston area. But he also suggested that the initial inland propagation of the sea-breeze front was faster **because of the high temperature gradient** between the downtown and the shore.

- Keeler(2011) the observed daytime UHI magnitude did not have a significant relationship with lake-breeze frontal movement through Chicago while the **maximum magnitude of the nighttime UHI** preceding lake-breeze development was found to be strongly related to a **decrease in speed** of LBF movement through Chicago's southwest (inland) suburbs.

Thank you