第11回CEReS環境リモートセンシングシンポジウム，千葉大学，2009.2.23

# 大気エアロゾルと火山ガスの光学観測と大気拡散解析

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T. Bouquet（鹿児島大学 理学部）

## 報告内容

A. 東アジアにおける2008年黄砂の映像定点観測
With 王寧・張剛（長春），D.ユドゥガー・N.オトジャガル(UB)
B. 火山噴煙・黄砂と視程の可視・近赤外映像観測
霧島新燃岳噴煙の50km望遠観測
C. 日本火山における$SO_2$ガス放出のUVカメラ観測
With M. Watson (Univ. Bristol)
D. 三宅島における火山性SO2の大気拡散
with 藤原宏章・稲葉和弘(三宅島測候所)

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## A. 東アジアにおける2008年黄砂の映像定点観測

Asian Dust in the Spring of 2008
http://arist.edu.kagoshima-u.ac.jp/adust/ad2008/ad08top.htm

Long term camera records of Asian dust events in eastern Asia during 2005-2008

**K. Kinoshita and T. Nagamatsu** (Kagoshima Univ.), **N. Iino** (Kumamoto Univ.),
**Wang Ning and Zhang Gang** (NENU, Changchun),
**D. Jugder and N. Ogtonjargal** (IMH, Ulaanbaatar)

The CEReS Int'l Symp. & SKYNET Workshop, Nov. 2008

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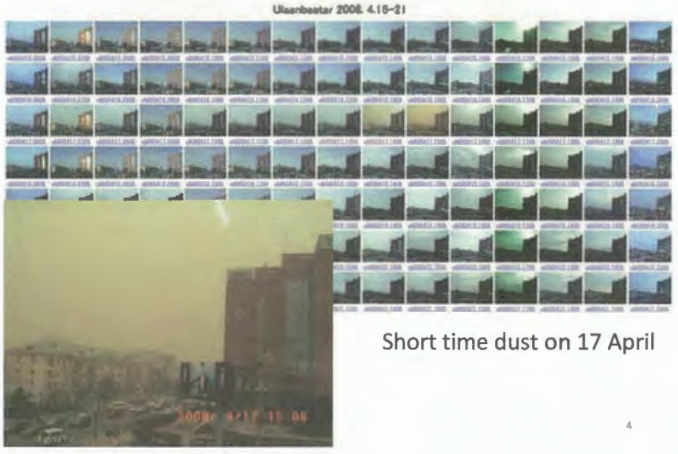
## Ulaanbaatar, Spring 2008




Short time dust on 17 April

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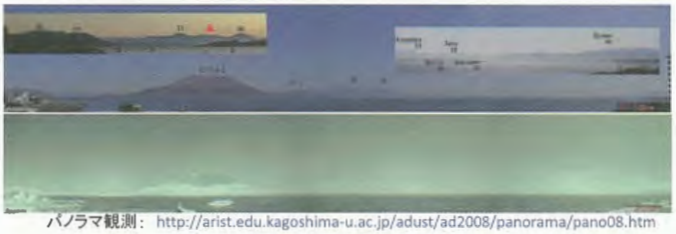
## Changchun light dust on 1-2 March 2008 3.1_13CST

1st dust in Japan over Okinawa-Tohoku on 3 Mar.,
Followed by dispersing dust on 4 March.
Kagoshima: visibility decreased to 5 km on 3 Mar.

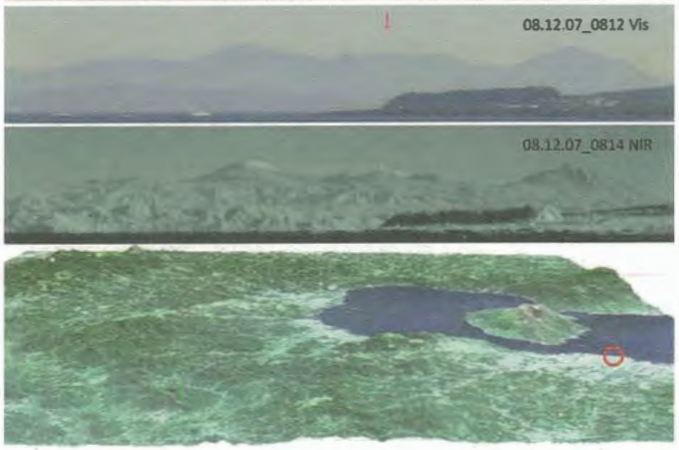
## B. 火山噴煙・黄砂と視程の可視・近赤外映像定点観測

赤潮・大陸からの汚染気塊も
インターバル撮影
（デジタルカメラ・ビデオカメラ・パソコンWebCam）
広角ー手動多方向撮影　：可視・近赤外
可視光でのコントラストの方が良い時もある　↓08.3.21_1307



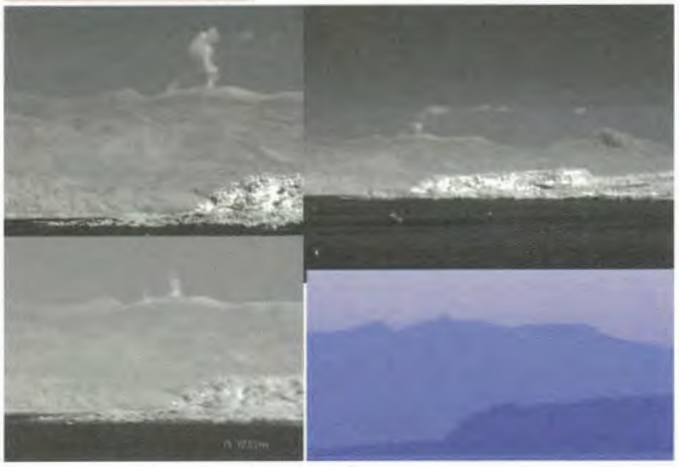
パノラマ観測：　http://arist.edu.kagoshima-u.ac.jp/adust/ad2008/panorama/pano08.htm

## 霧島新燃岳噴煙の50km望遠観測




## 霧島新燃岳噴煙　08.12.15_1015Vis, 1020NIR

## 霧島新燃岳噴煙 '09　1.3_1253, 1347 / 1.15_1251, 1.28_0730Vis

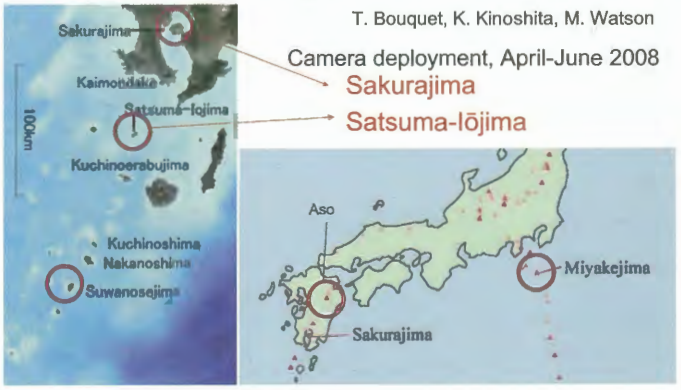


## C. 日本の火山における$SO_2$ガス放出の紫外線カメラ観測

日本火山学会秋季大会、岩手大学、2008.10, p.41

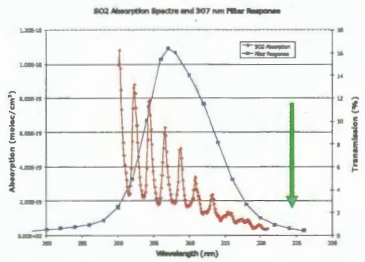
14th CEReS Int'l Symp. & SKYNET Workshop, Nov. 2008, pp.173-176,

T. Bouquet, K. Kinoshita, M. Watson




## $SO_2$ retrieval

- $SO_2$ absorbs UV light in the region 300-315 nm
- Bandpass filter centred on 307 nm




Cf. Mori & Burton (2006)

Use of a **second filter** >320 nm (outside the $SO_2$ signature)

Difference imaging by two cameras eliminates the effect of aerosols / other species in the gas plume

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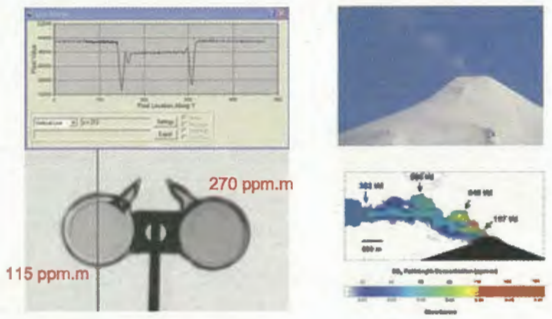
## The UV imaging camera

- Mori & Burton (2006) and Bluth et al. (2007):
  UV camera used here based on Bluth et al.
- 2-D CCD: 1024x1024 array
- Lens: 105mm focal length, field of view ~13°

Pixel resolution typically **1-3 m**

## Quantifying $SO_2$




$SO_2$ absorbance calibrated to column concentration amount using gas cells of known concentration (end and beginning of sequence)

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## Imaging at Sakurajima: 2008年4月24日

- Imaging location ~4.5 km from vent > pixel resolution = 1.51 m
- 15:40 – 16:00 (20 minute sequence)
- 5 sec. interval between images
- Exposure time (adjusted for imaging conditions) = 0.6 sec.

•○ 昭和火口 behind southern slope


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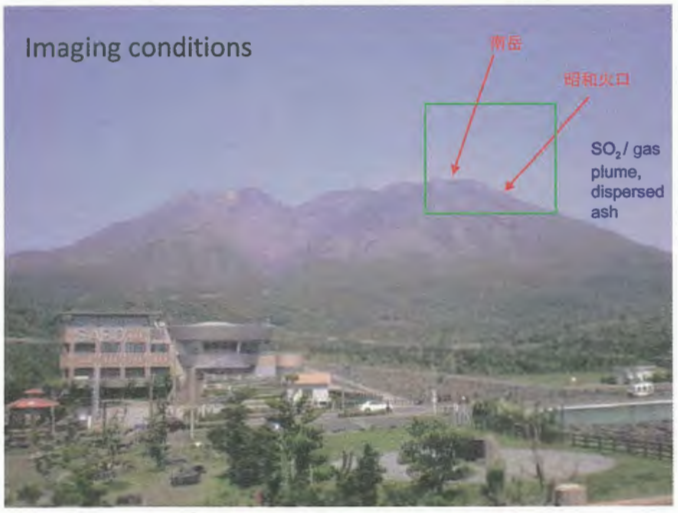
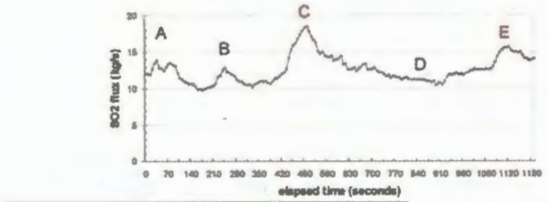
## Imaging conditions

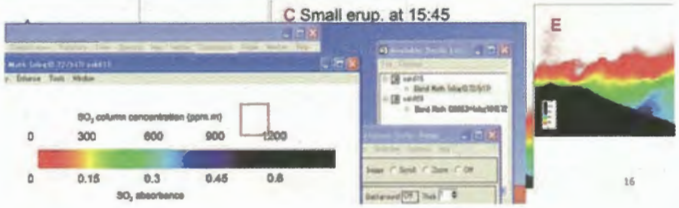



## Sakurajima $SO_2$ flux (20 mins): Average flux = 1090 t/d

Wind speed = 14.4 m/s




C Small erup. at 15:45

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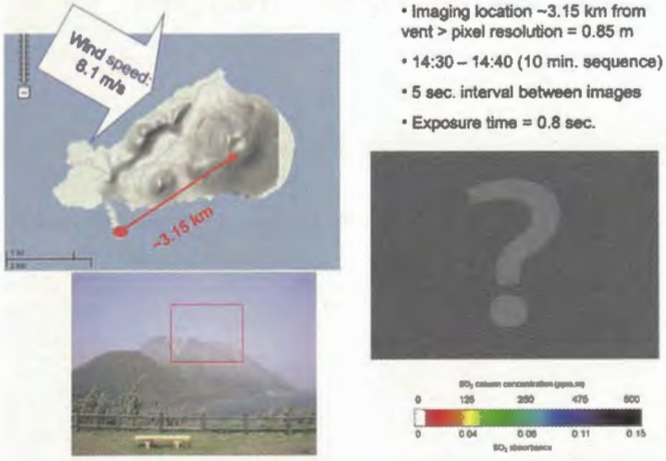
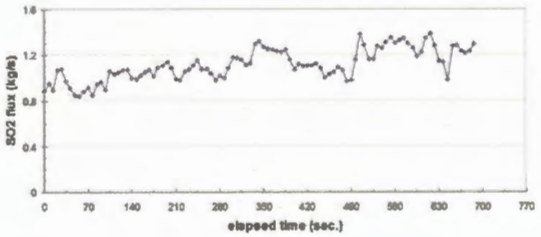
## Imaging at 薩摩硫黄島 : 2008年4月26日

- Imaging location ~3.15 km from vent > pixel resolution = 0.85 m
- 14:30 – 14:40 (10 min. sequence)
- 5 sec. interval between images
- Exposure time = 0.8 sec.




## Iojima $SO_2$ flux (~10 mins):




- Change in flux associated with pulses/puffs of $SO_2$
- Changes also likely to be controlled by wind movements
- Average flux **only 96 t/d !!** Huge underestimate compared with usual values (~300-1100 t/d)
- Due to plume moving behind the mountain, but also because of an underestimation in $SO_2$ absorbance

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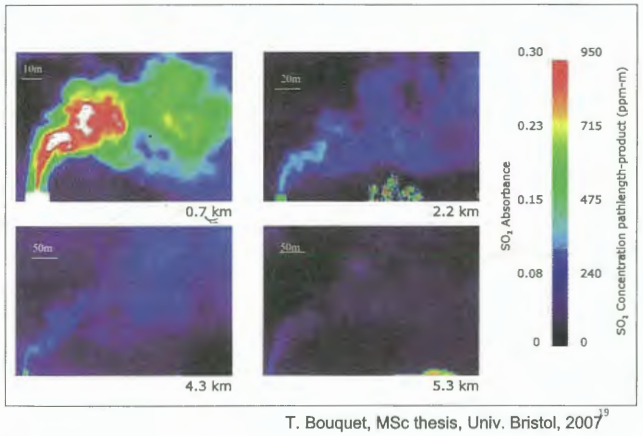
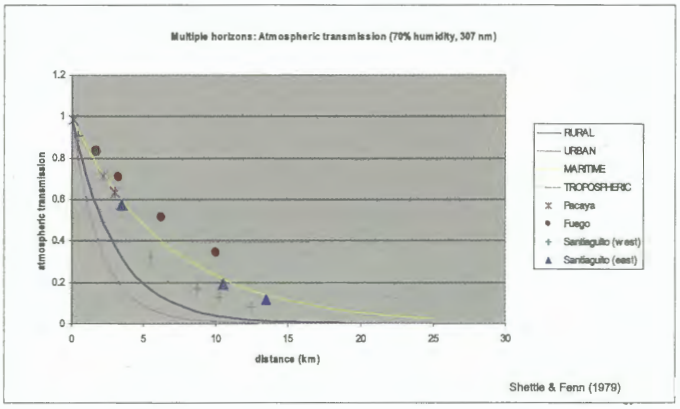
Power station plume images of $SO_2$ at 0.7-5.3 km




T. Bouquet, MSc thesis, Univ. Bristol, 2007

"Airlight": $e^{-d\beta}$ (d-distance; β-scattering coeff.)




## Conclusions of UV camera observations at Sakurajima and Satsuma-Iōjima

- Time-series derived for Sakurajima
  - change in $SO_2$ flux
  - distinction between 昭和火口 and 南岳
- However, the $SO_2$ signal is complicated by the presence of ash and UV scattering between the camera and target plume.
- Flux is heavily underestimated at Iōjima because of this.
- This study shows interesting *relative* emission rates over short time periods for preliminary images.
- Future study will concentrate on additional imagery:
  - ash images and 2nd filter
  - images from other volcanoes

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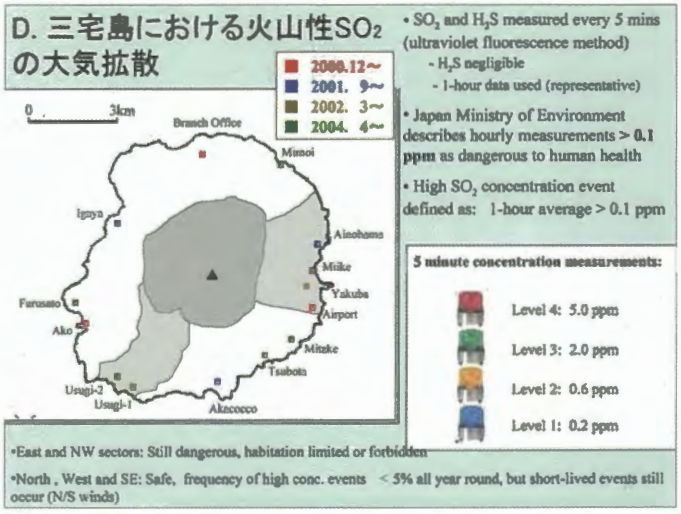
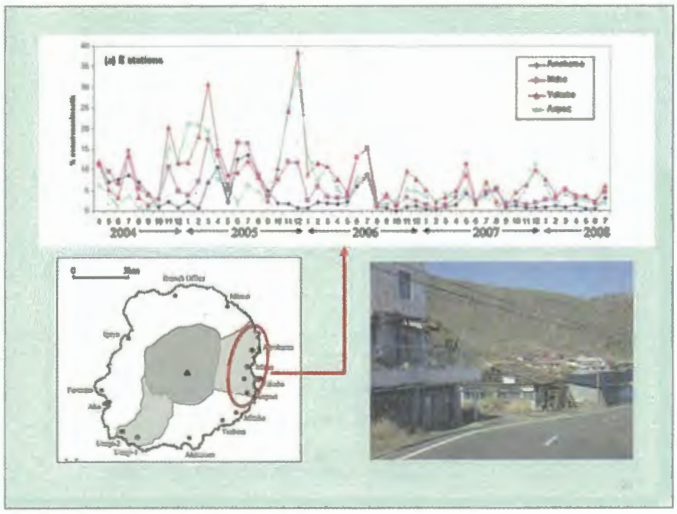
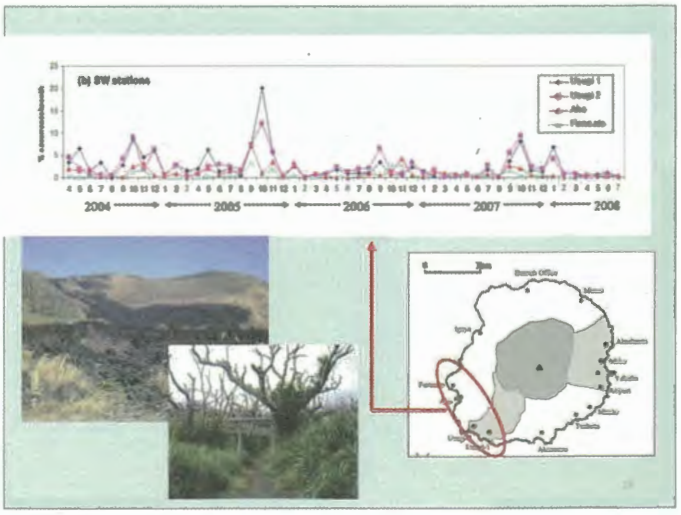
D. 三宅島における火山性$SO_2$の大気拡散

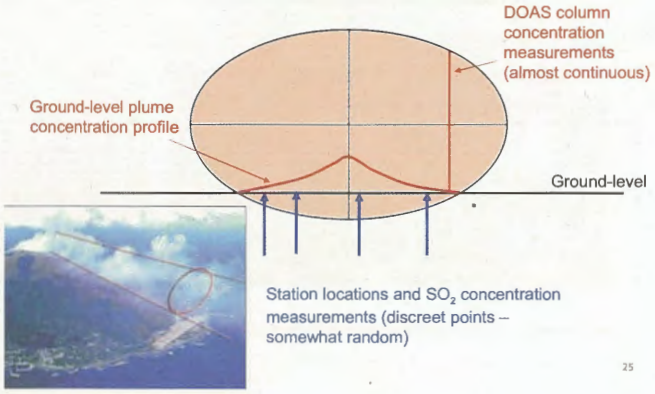


Simplified 'grounded' plume profile:

Gaussian parameterization

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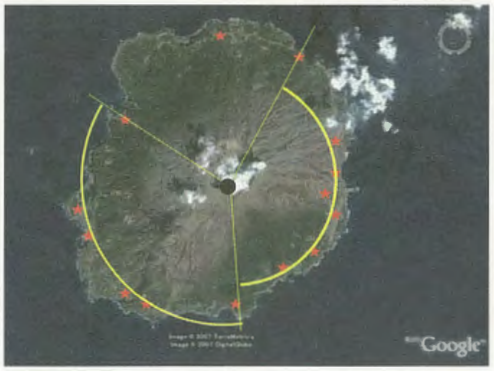
Locating plume profiles: EAST and SOUTH-WEST

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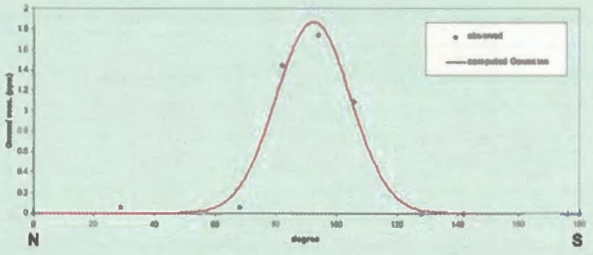
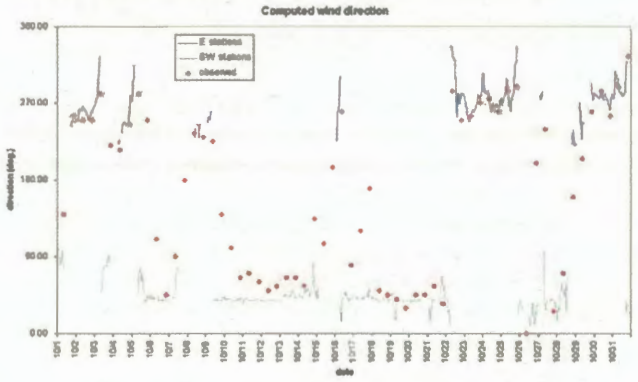
- Computed 'Gaussian' curve using least-squares technique
- Data adjusted to fit on E and SW arcs
- E.G. 1 hour's data (25 Oct. 2005, 11:00)
  - -- indication of centre of the plume (peak concentration) and **plume direction**
  - -- indication of plume boundaries (**plume width**)
- However, limitations



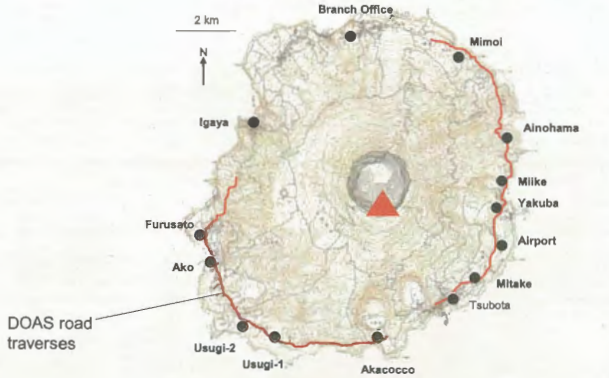

Computed **plume direction** for October 2005, compared with observed wind measurements:



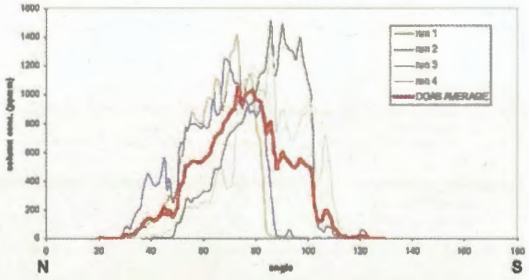

Observed: Hachijojima upper wind data (925 hPa)[25]

Comparison to UV spectrometer (DOAS) data

トーマス ブーケ・木下紀正, 藤原宏章・稲葉和弘
日本火山学会2008年度秋季大会, 岩手大, p.118

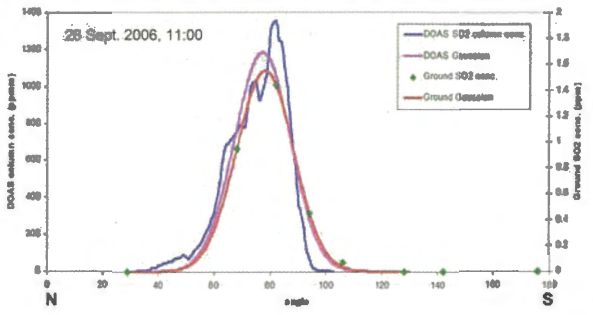



DOAS traversers




- Typically 4-5 road traverses, which take ~1 hour to complete
- Data geometrically adjusted to fit to E and SW arcs
- Simplify traverse profile by taking average of all traverses: representative of ~plume shape for 1 hour (therefore comparable to ground conc. data)

## Computed Gaussian profiles: strong wind example




- Wind speed: ~10 m/s
- Resultant plume profile: lateral dispersion of about 50°over the arc in the east
- Good correlation: plume can be modelled

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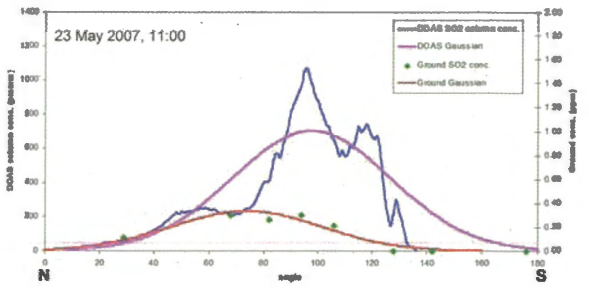
## Computed Gaussian profiles: weak wind example




- Wind speed: ~ 5 m/s
- Wide plume dispersion over eastern part of the island
- A Gaussian curve fits poorly to the DOAS data as the plume shape was very skewed (0.81) due to the low wind speed.

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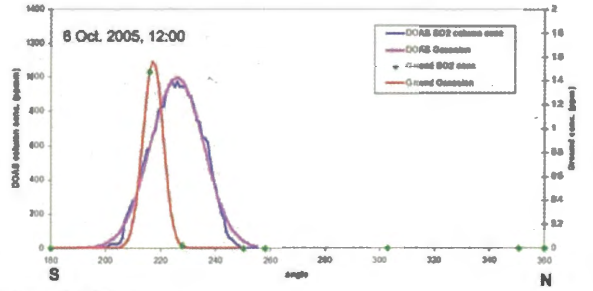
## Computed Gaussian profiles: complicated (!) example




- Wind speed: ~ 10 m/s
- Gaussian computation reasonably successful for both ground and DOAS data
- However, plume width very different: upper plume (DOAS) more dispersed
- Lower plume at ground-level inhibited due elevated land between measuring stations (topographic barrier)

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## Miyakejima $SO_2$ dispersion: conclusions

- Large data series – 14 different locations at 5 min/1 hour time resolution for last 4 years
- Correlation of 'high concentration events' with upper wind data – short and long-term trends
- We can extract plume profiles from east and south-west locations to provide information about **plume direction** and **plume width** around the coast-line of Miyakejima
  - Long time series (unique)
  - Plume dispersion highly specific
- Data comparable to DOAS profiles
  - Correlation between upper plume and ground-level dispersion
- Incorporated into detailed dispersal studies
  - Visual observations, simulation results (modelling etc.)
- UV camera images could also be linked to dispersion studies

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## まとめと今後

A. 東アジアにおける黄砂の映像定点観測

さらに継続、 RGB解析、各種データ・情報との総合的検討

B. 火山噴煙・黄砂と視程の可視・近赤外映像観測

Web公開、視程の気象台観測との比較

C+D. 火山放出$SO_2$ガスのUVカメラ観測と大気拡散解析

大量のデータ解析、防災利用、
三宅島の事態の国際的発信

We are very grateful to the support of CEReS for this project, and our co-workers for the collaborations on its sub-projects.