Schintilometer measurements of Regional Sensible Heat Flux at Kherlen Bayan-Ulaan

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Scintillometer

- Optical device to measure sensible heat flux, H.
- Transmitting the infrared light from the transmitter
- The receiver measures scintillation (fluctuation) of the light intensity.

Transmitter

Receiver

Principle of Scintillometers

- Light scintillation is due to the refraction of the light in the air.
- Light refraction in the air is caused by the spatial fluctuation of the air density .
- (strong scintillation) =

  (strong density fluctuation) = (strong H)

This can be used to measure “path-averaged” heat flux

Large Aperture Scintillometer: BLS900

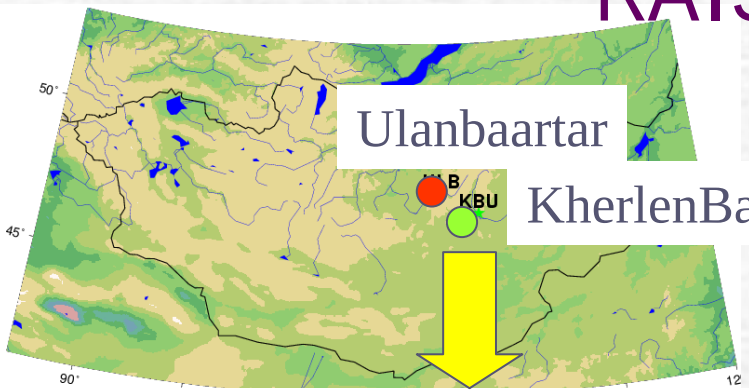
- Make: Scintec (Germany)
- Transmitter: LED disk
- Distance: 500-5000m
- Output: every 1min
- Pulse: 125Hz

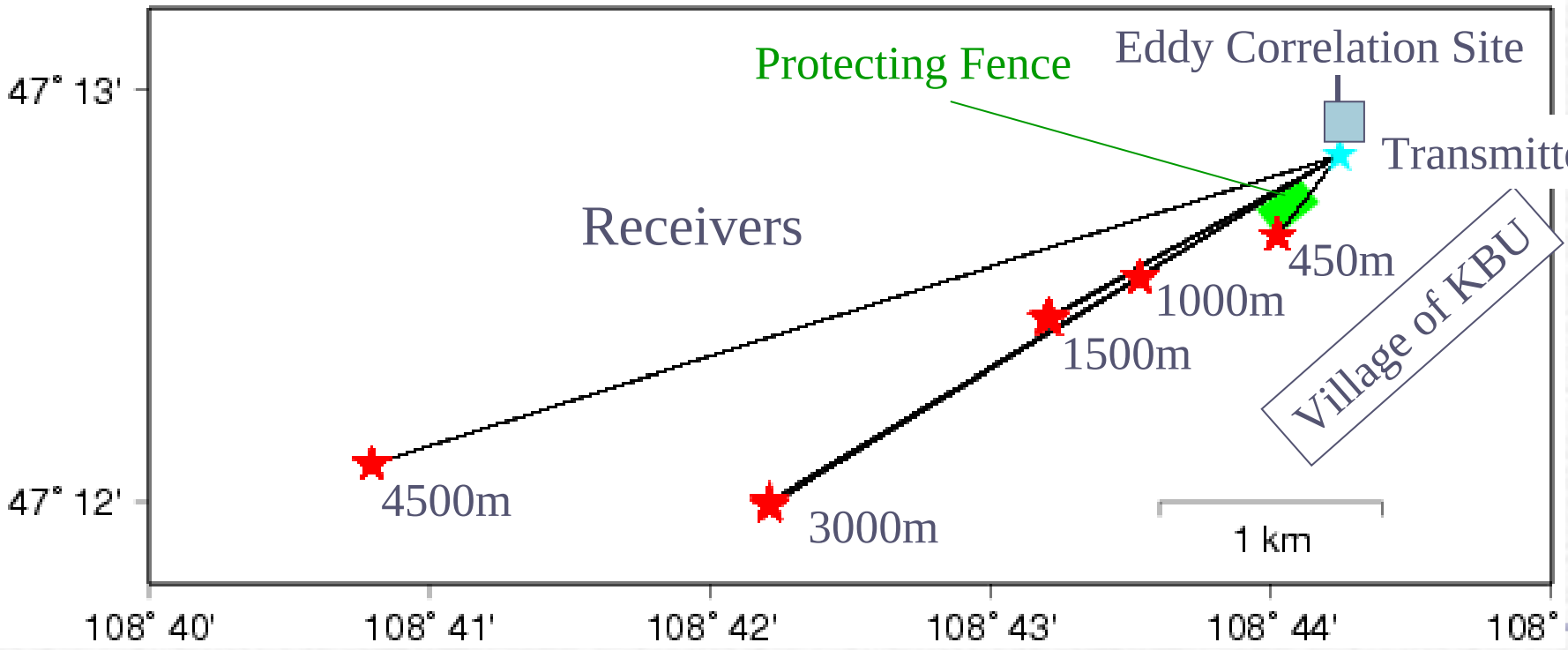
- area averaged H at the scale of few kilometers.

Scintec BLS900 transmitter

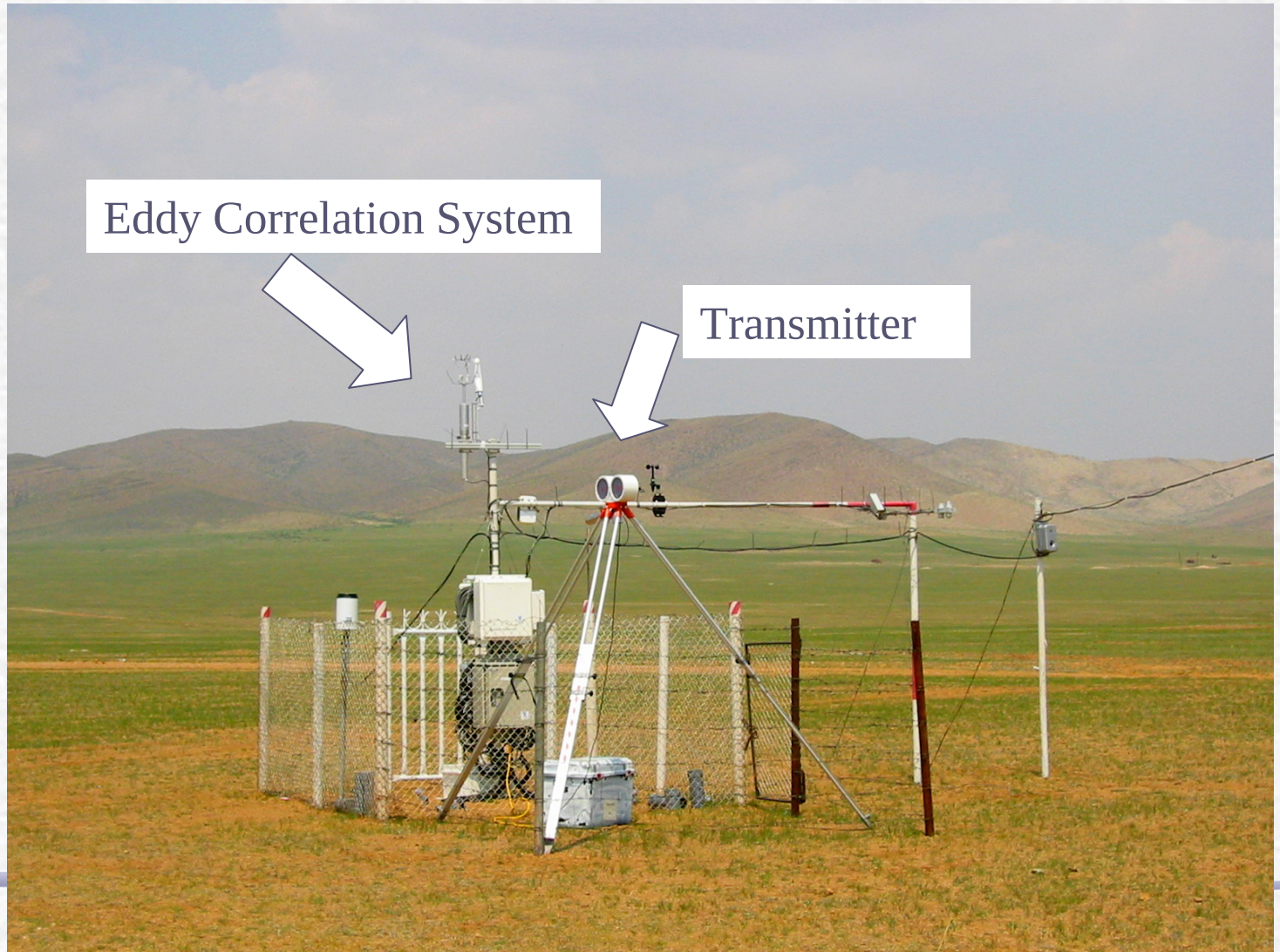
Scintec BLS900 receiver

Scintillometer operation at KBU during RAISE IOP 2003





Scintillometer operation at KBU during RAISE IOP 2003



Scintillometer operation at KBU during RAISE IOP 2003

Date	Path(m)	Duration (hrs)
2003/7/20	453	7.0
2003/7/22	4570	2.5
2003/7/26	4570	2.5
2003/7/27	3001	1.5
2003/7/28	1505	6.0
2003/7/30	453	9.0
2003/7/31	3006	8.5
2003/8/1	1505	9.0
2003/8/2	1050	10.0

Date	Path(m)	Duration (hrs)
2003/8/18	4570	6.5
2003/8/19	3008	9.0
2003/8/22	1495	8.5
2003/8/23	3008	9.0
2003/8/24	452	4.5
2003/9/30	1490	3.0
2003/10/1	3004	8.5
2003/10/2	1490	7.0
2003/10/3	453	8.0
2003/10/4	3004	2.5

19days of operations

Computation of H from Scintillometer Measurements

- Output: structure parameter of refractive index, C_n^2 (spatial heterogeneity of n).

$$C_n^{\ 2} = \frac{\overline{\{n(x+r)-n(x)\}^2}}{r^{2/3}}$$

- C_n^2 is converted to C_T^2 (spatial heterogeneity of T)

$$C_T^{\ 2} = \frac{\overline{\{T(x+r)-T(x)\}^2}}{r^{2/3}}$$

Computation of H from Scintillometer Measurements

- Use Monin-Obukhov similarity to compute H.

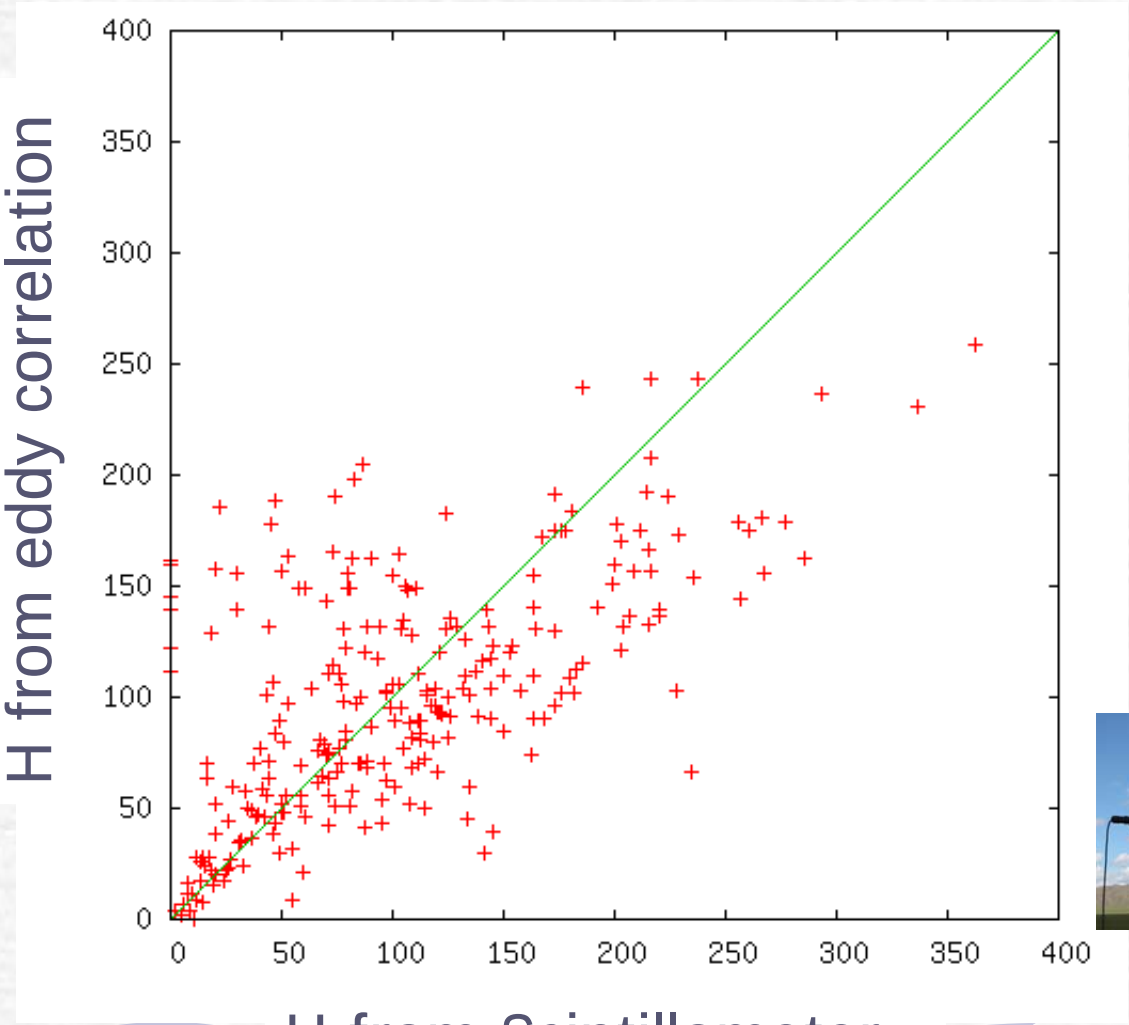
$$\Phi_{CT}\left(\frac{z}{L}\right) = \frac{z^{2/3} C_T^{\,2} u_*^{\,2}}{\{H/(\rho C_p)\}^2}$$

- with empirical formula by Thiermann & Grassl (1992) and measured u_*

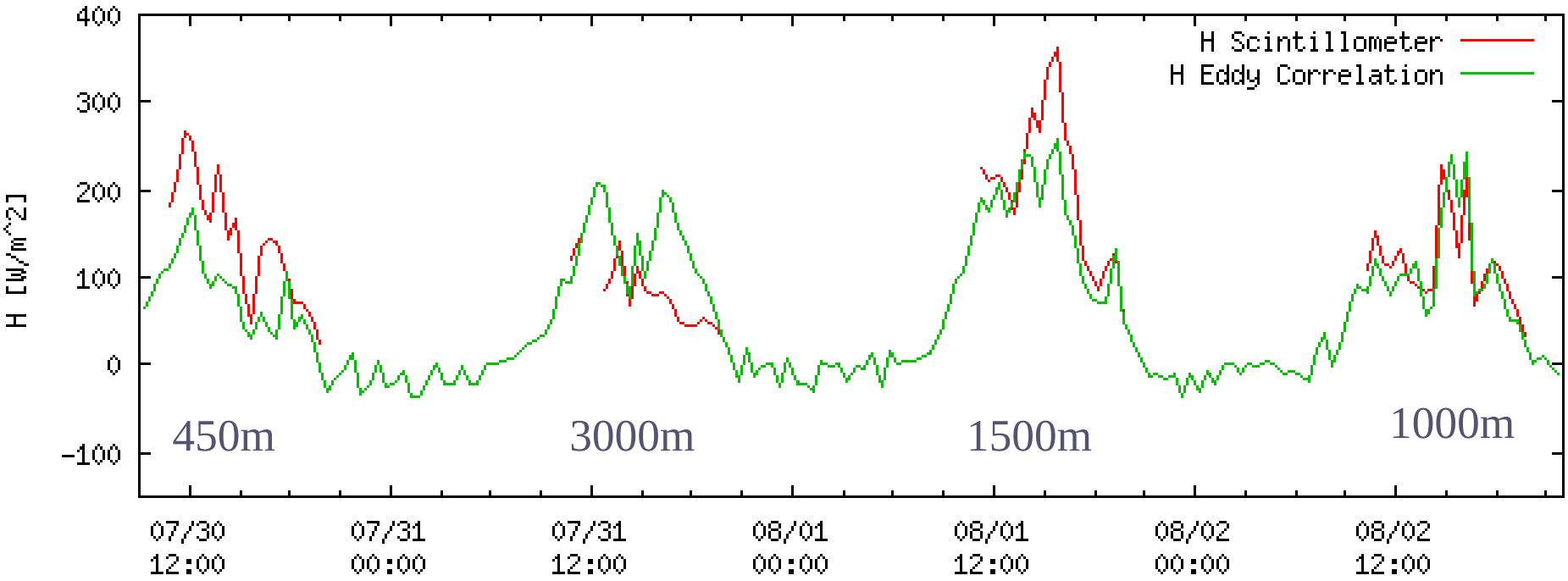
$$\Phi_{CT}\left(\frac{z}{L}\right) = 6.3\left[1 - 7\frac{z}{L} + 75\left(\frac{z}{L}\right)^2\right]^{1/3}$$

$$\frac{z}{L} = -\frac{kgzH}{\rho Cp T u_*^{\,3}}$$

Comparison with eddy correlation

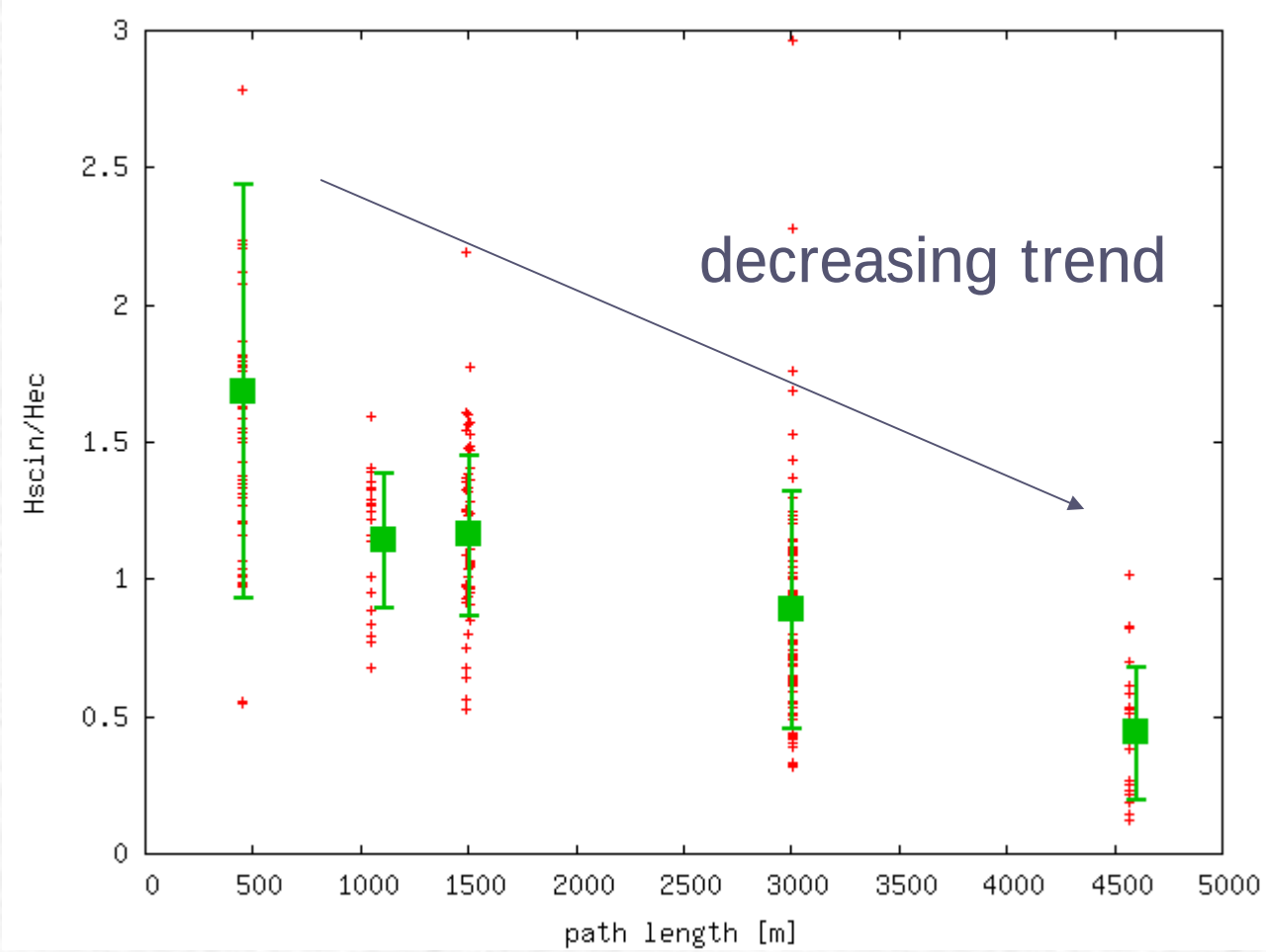


The results


H [W/m^2]
400
300
200
100
0
-100
H Scintillometer
H Eddy Correlation
450m
3000m
1500m
1000m
07/30 12:00
07/31 00:00
07/31 12:00
08/01 00:00
08/01 12:00
08/02 00:00
08/02 12:00

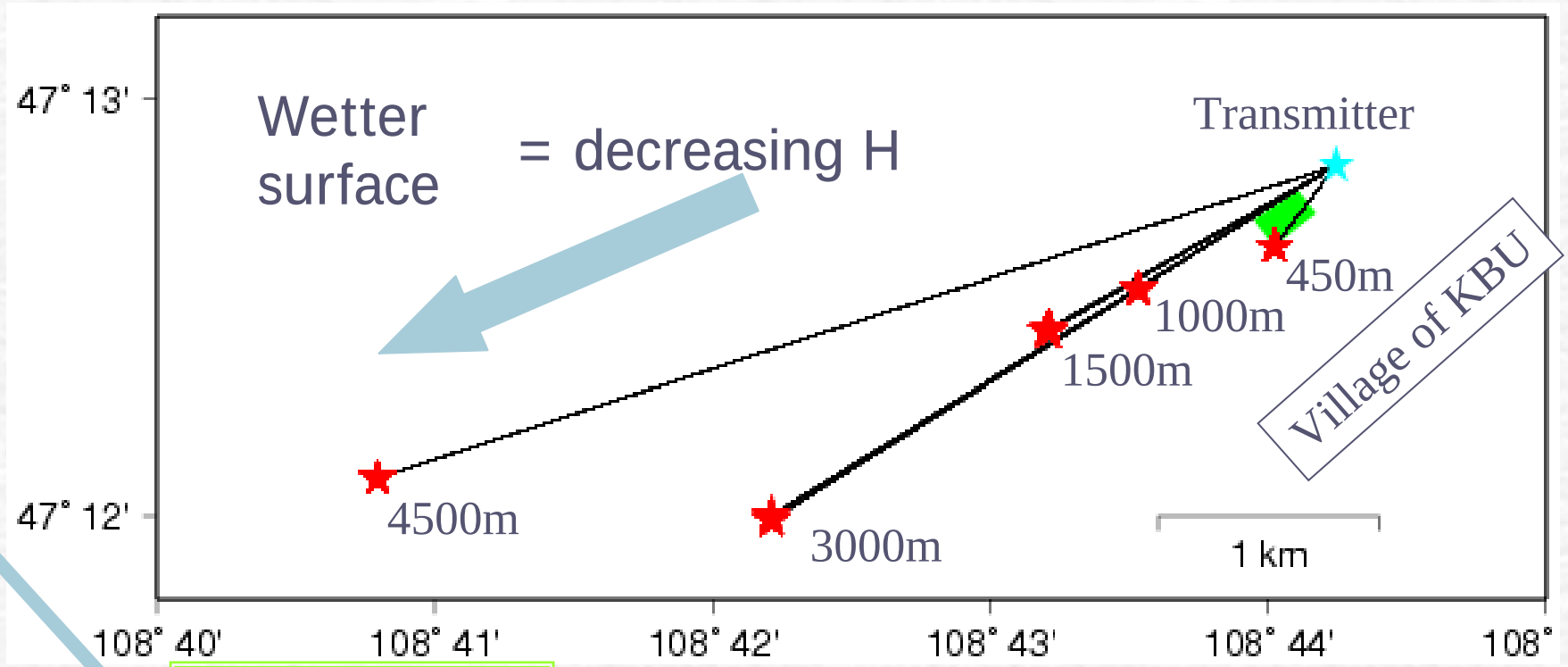
Comparison with Eddy Correlation --- dependence on the path length

H(scintillometer) / H(eddy correlation)



Path length (m)

Real surface flux distribution?



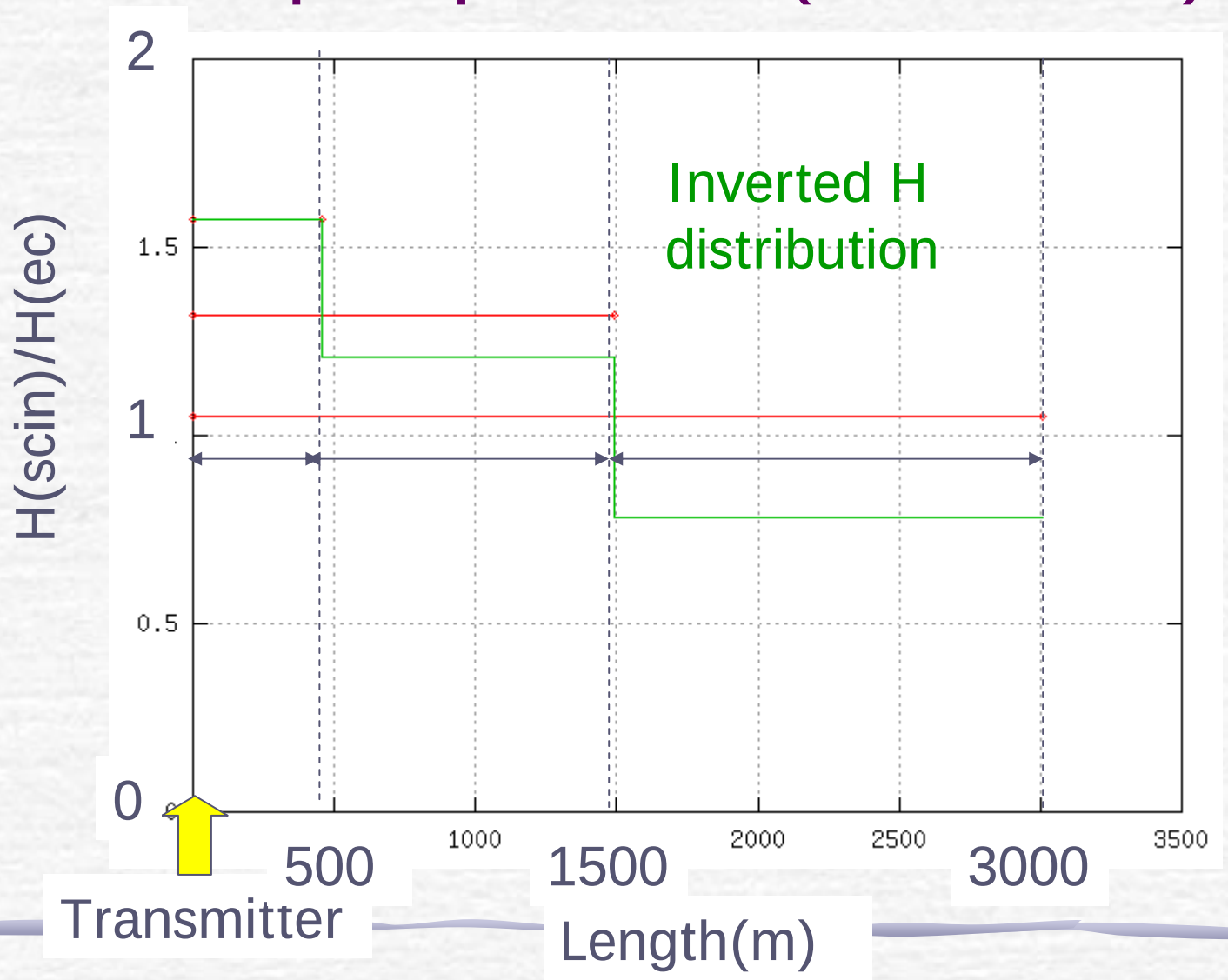
Estimating Spatial Variation of H by using Inversion Method

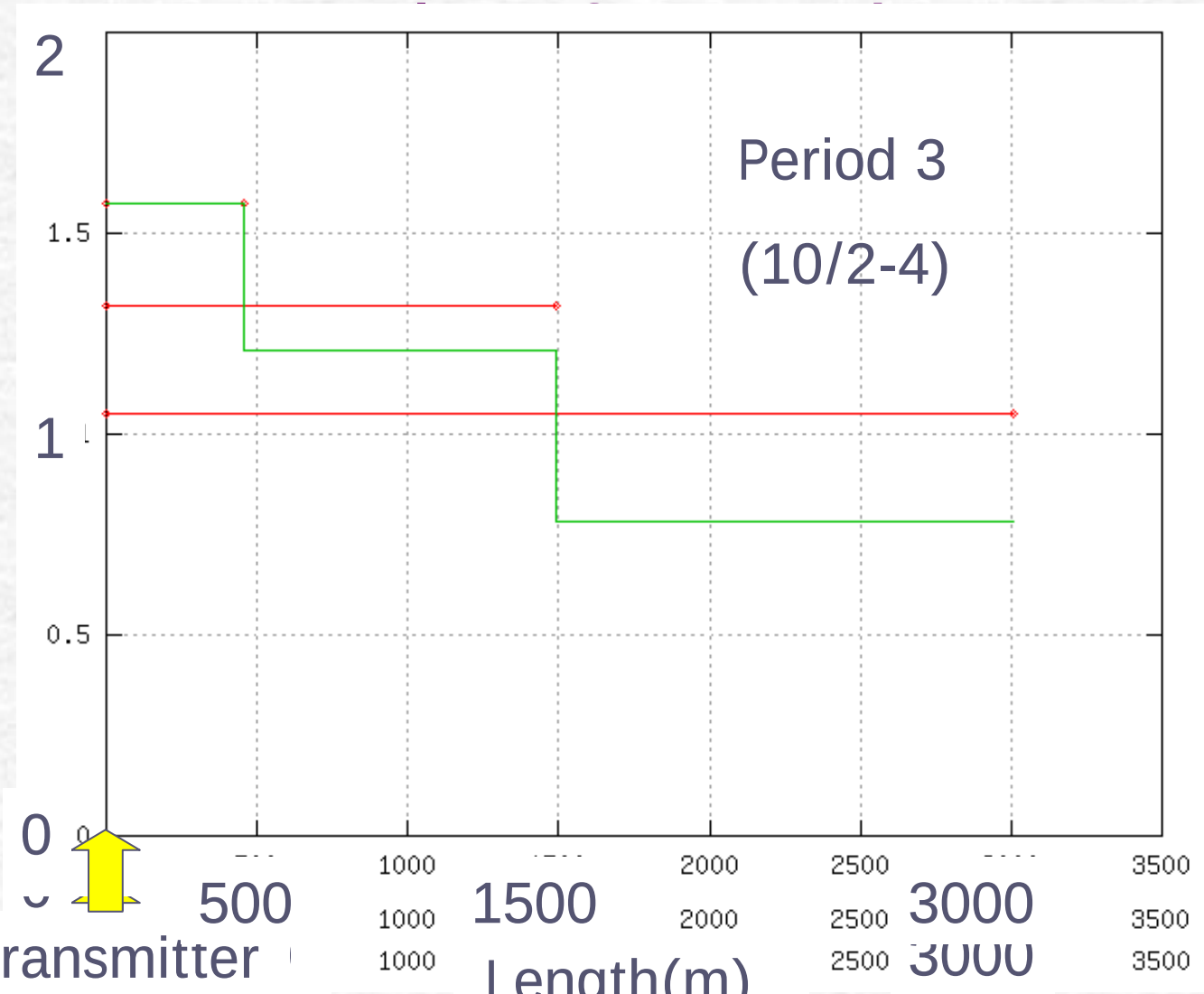
Daily average of H(scin)/H(ec)

Date	Path(m)	H(scin)/H(ec)
Period 1		
2003/07/31	3000	0.63
2003/08/01	1500	1.25
2003/08/02	1100	1.06
Period 2		
2003/08/22	1500	1.20
2003/08/23	3000	0.77
2003/08/24	45	1.09
Period 3		
2003/10/02	1500	1.32
2003/10/03	450	1.58
2003/10/04	3000	1.05

1. Choose period with consecutive days
2. calculate daily average of H(scin)/H(ec) for each period
3. Assume that difference of the ratio is due to the spatial distribution of H (stationarity)
4. Invert them to derive spatial variation of H

Example: period 3 (10/2-10/4)




Period 3
(10/2-4)
2
1.5
1
0.5
0
0
500
1000
1500
2000
2500
3000
3500
Transmitter
Length(m)

Summary

- Scintillometer operation was performed during 2003 RAISE IOP.
- H measured by scintillometer is “comparable” with the eddy correlation measurements
- Inversion method was used in an attemt to retrieve spatial distribution of H
- Need verification with the aircraft measurements, and satellite remote sensing.

Possible Explanation for decrease with the path length

- Systematic error in the device
- Effect of the mirage
  - Strong refraction of the light.
  - At 4500m of path length, light intensity was extremely weak.
- “Real” flux distribution
  - Strong capability of the

Comparison of C_T^2