Estimating methane emissions from point sources using airborne in-situ and airborne remote sensing observations

Thomas Krings[1],Konstantin Gerilowski[1], Bruno Neininger[2], Sven Krautwurst[1], Michael Buchwitz[1], Carsten Lindemann[3], Dirk Schüttemeyer[4], Richard Kolyer[5], David R.Thompson[6], Michael L. Eastwood[6], Daniel C. Nunes[6], Haflidi Jonsson[7], Markus Horstjann[1], Ira Leifer[8], Robert O. Green[6], Matthew M Fladeland[5], John P. Burrows[1], Heinrich Bovensmann[1]

[1] Institute of Environmental Physics, University of Bremen, Germany,
[2] METAIR AG, Switzerland,
[3] Free University of Berlin, Germany,
[4] ESA / ESTEC, The Netherlands,
[5]NASA Ames Research Center, Moffett Field, CA, United States,
[6]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, United States,
[7]Center for Interdisciplinary Remotely-Piloted Aircraft Studies, Marina, CA, United States,
[8]University of California Santa Barbara, Santa Barbara, CA, United States

Thomas.Krings@iup.physik.uni-bremen.de

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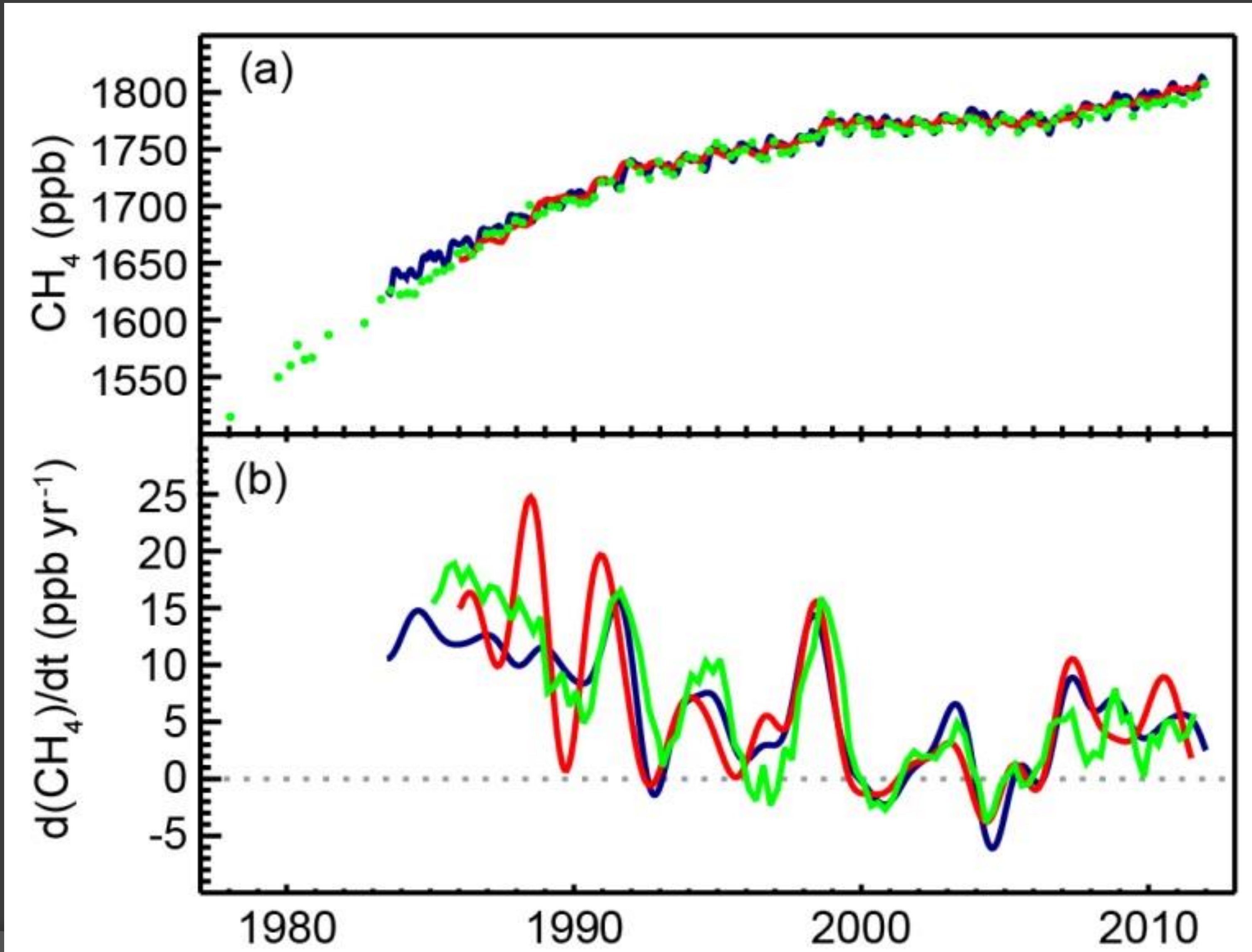
Methane in the atmosphere

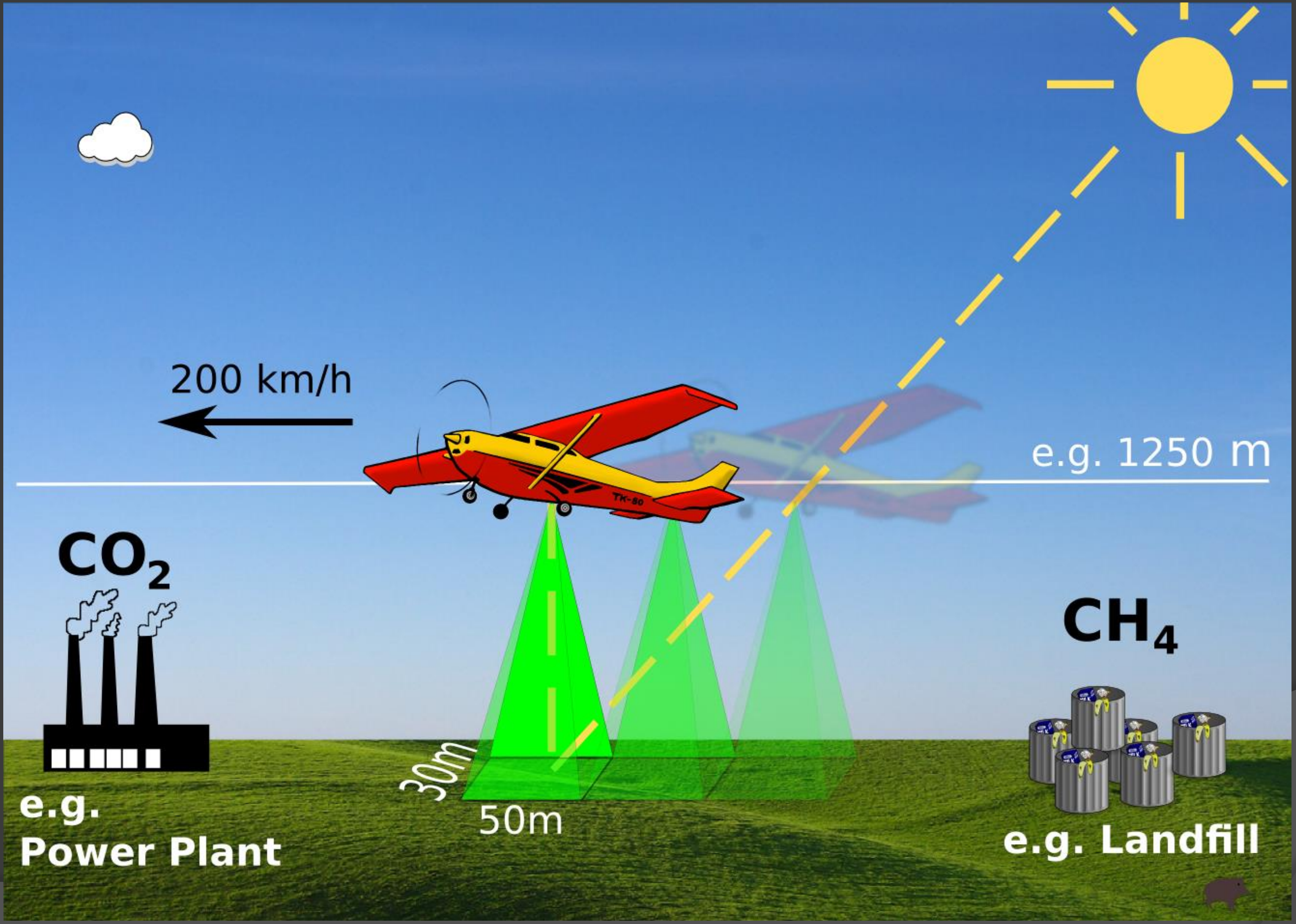


IPCC (2013)

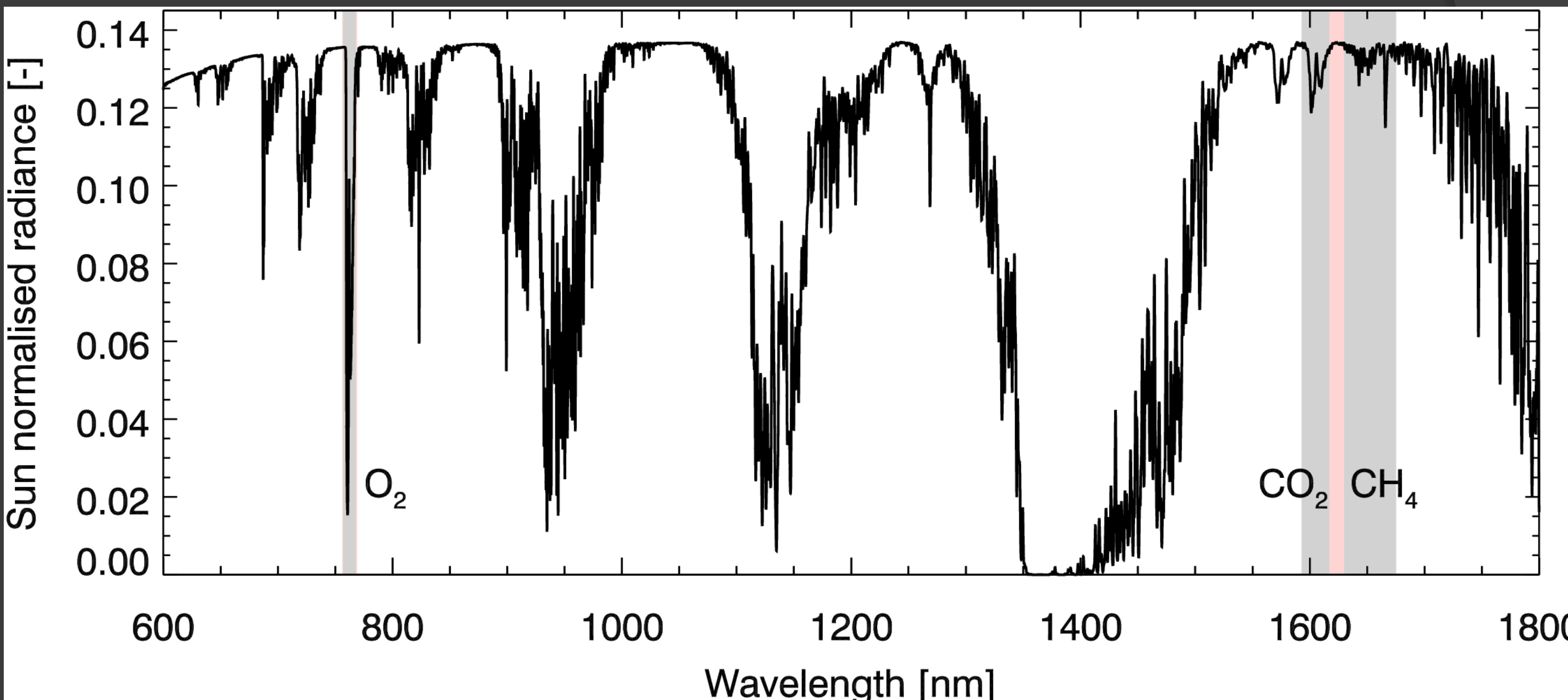
Point sources

- Approximately 40% of methane sources are rather localized

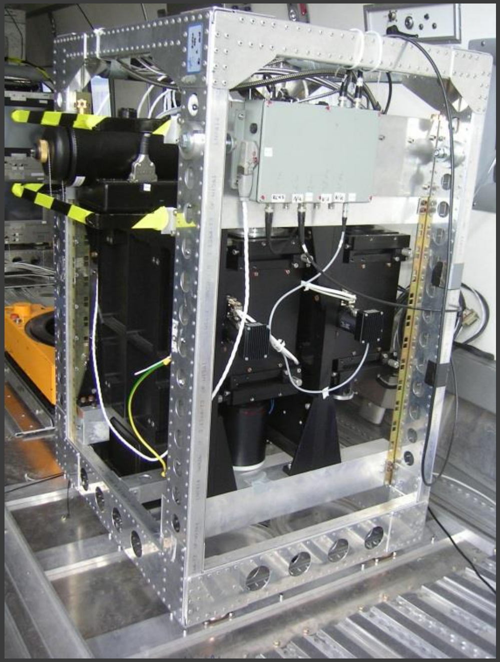
Remote Sensing instrument MAMAP: Measurement geometry



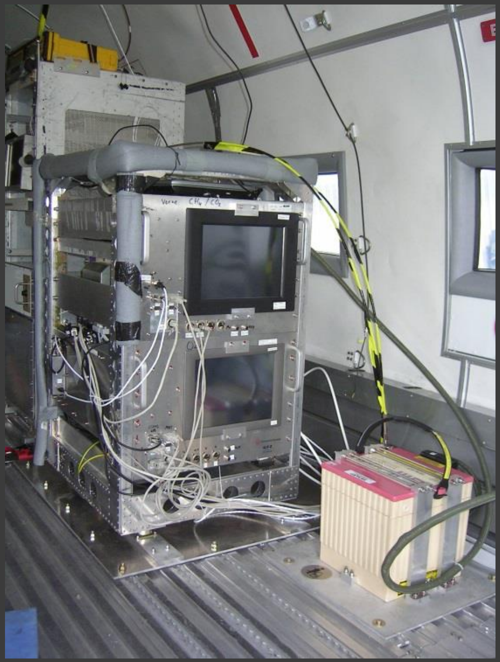
Spectral range



Remote Sensing instrument MAMAP: airplane integration



Spectrometer



Control unit

Integration in Cessna 207T

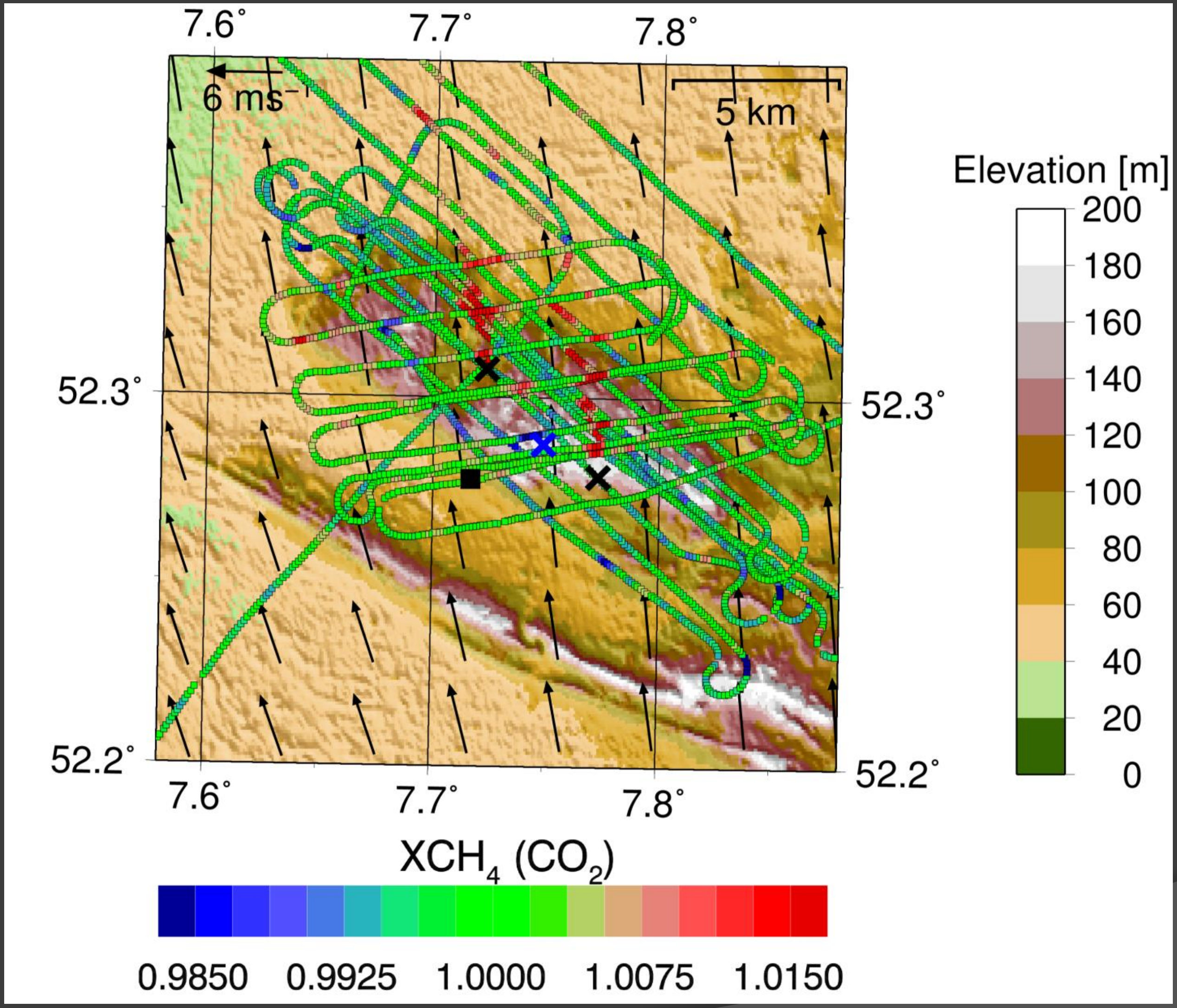
Campaign setup – August 2012

- Survey of localised CO_2 and CH_4 targets with remote sensing (IUP - University of Bremen) and in-situ techniques (METAIR)
- Testing of synergistic inversion approaches

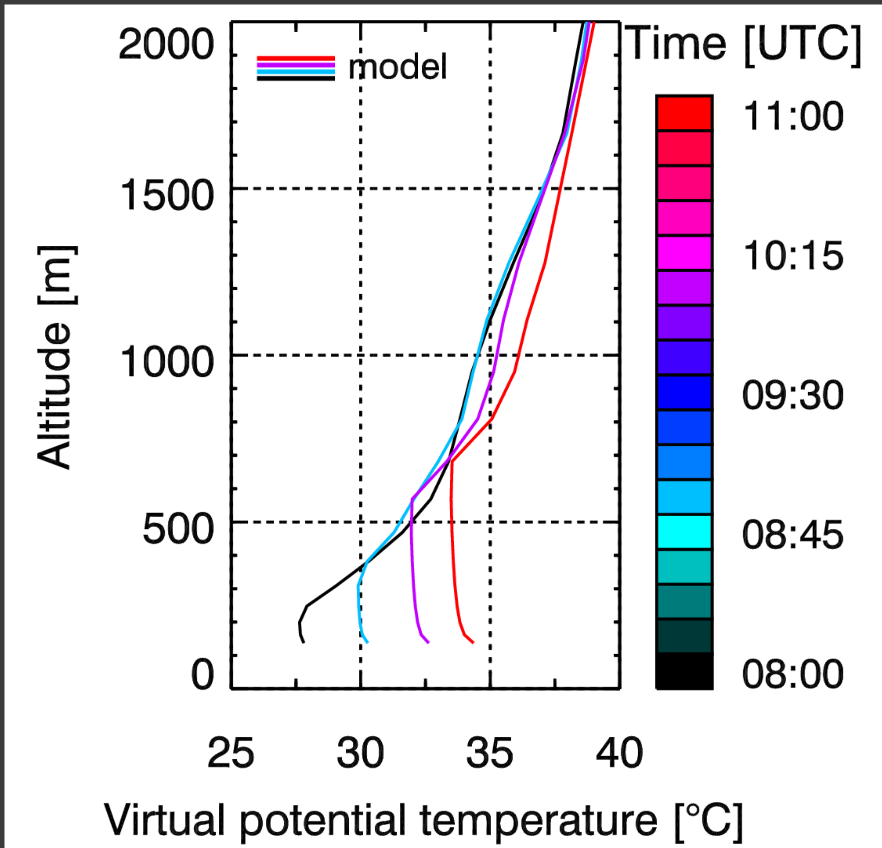
Coal mine Ibbenbüren

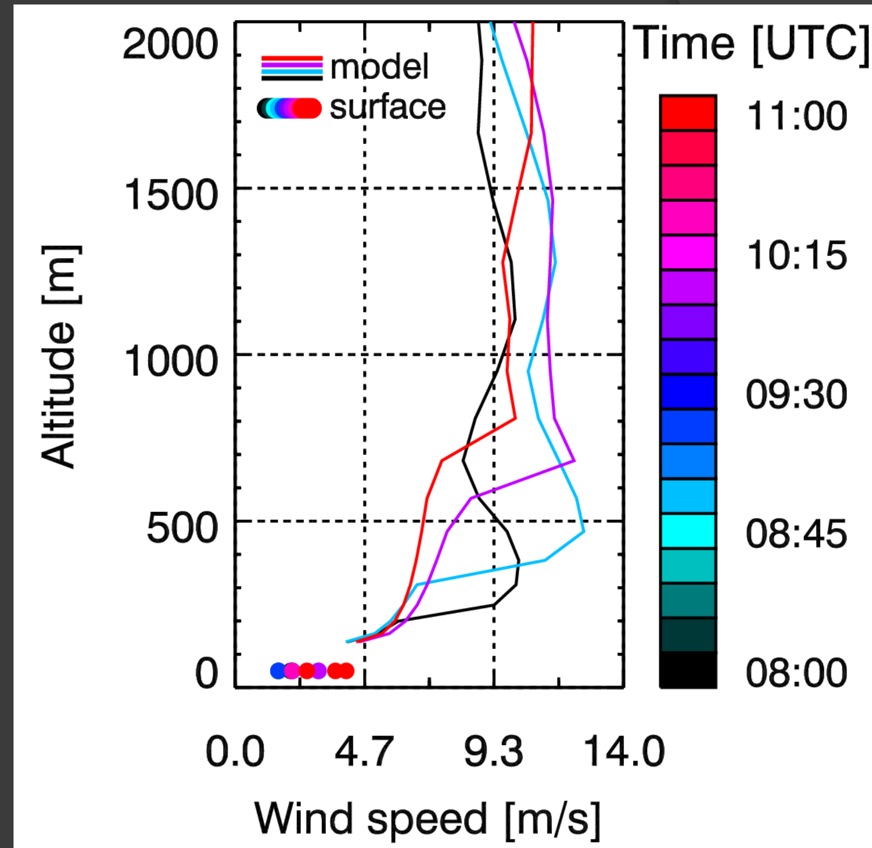
- Coal mine ventilation shafts (DSK Anthrazit Ibbenbüren GmbH)

Ibbenbüren MAMAP data



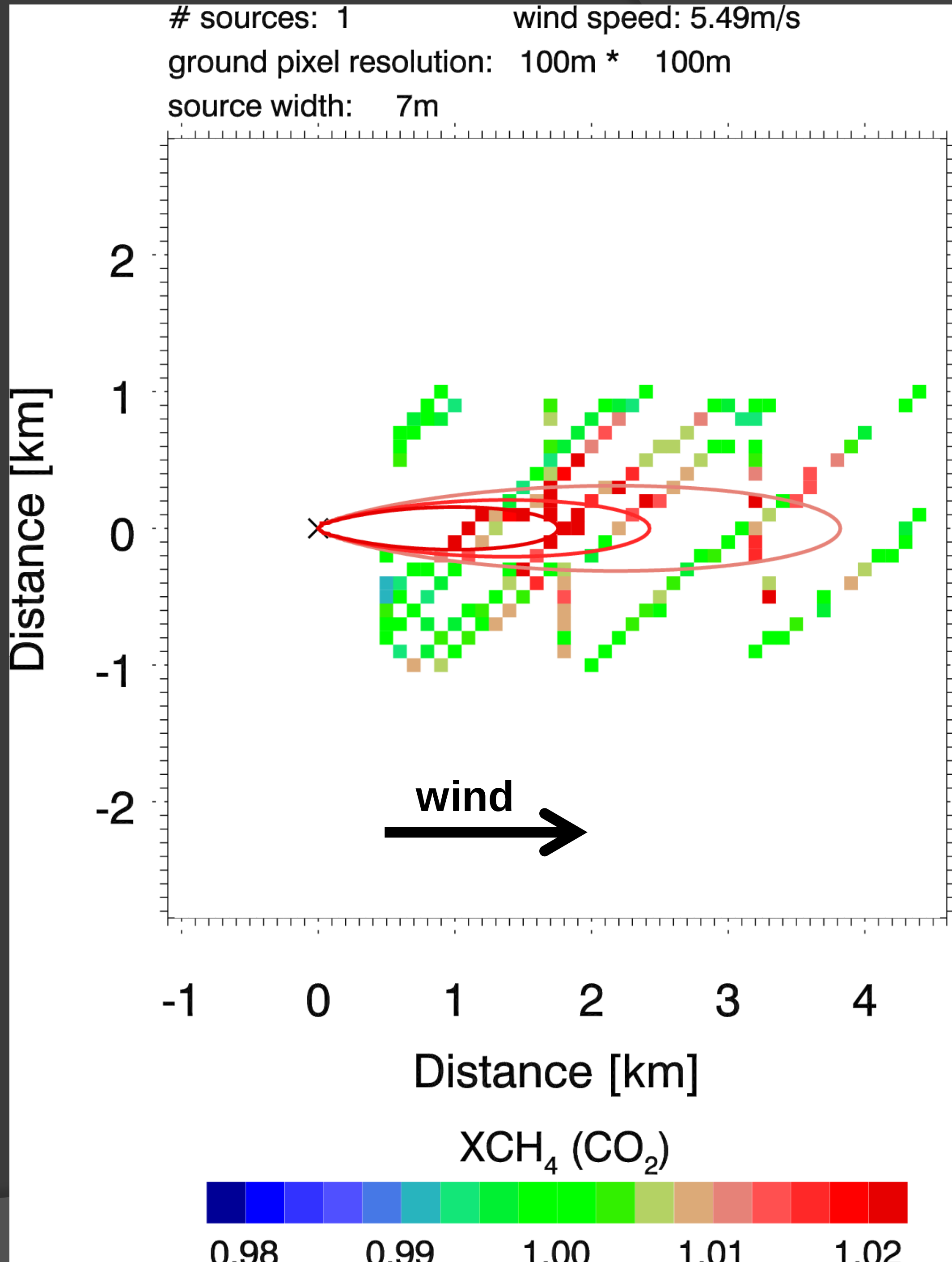
Model data (COSMO-DE): Wind and stability



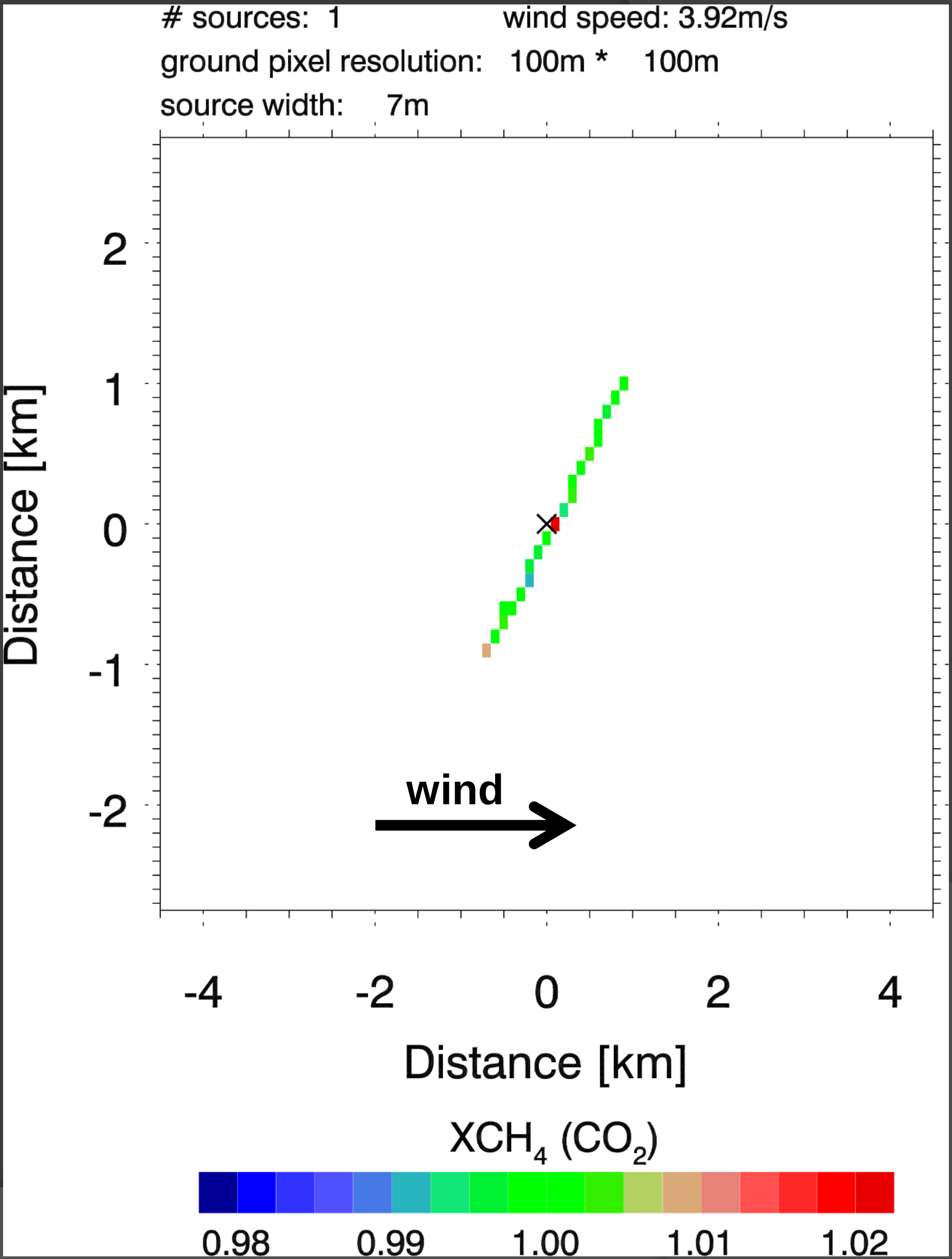


- Virtual potential temperature can be taken as an indicator for vertical stability and boundary layer height
- Wind speed ranges from about 4m/s to 12.5m/s

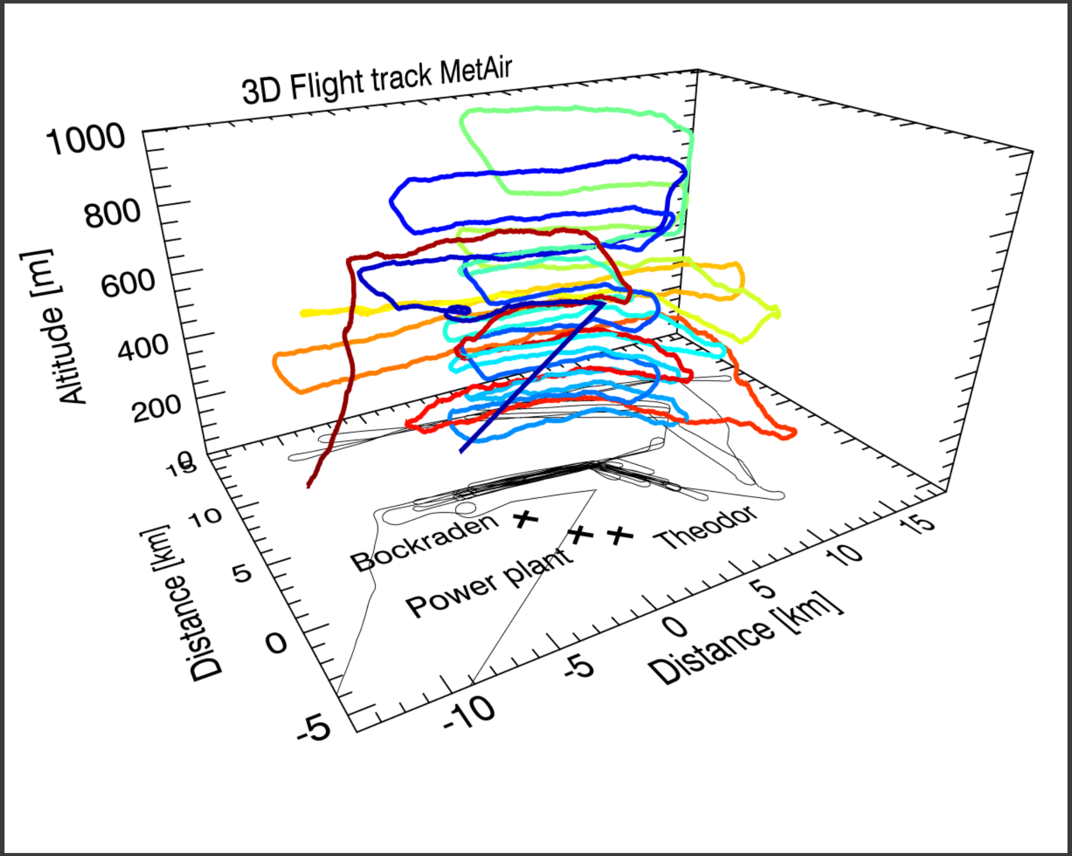
Ibbenbüren Bockraden Shaft – plume Inversion

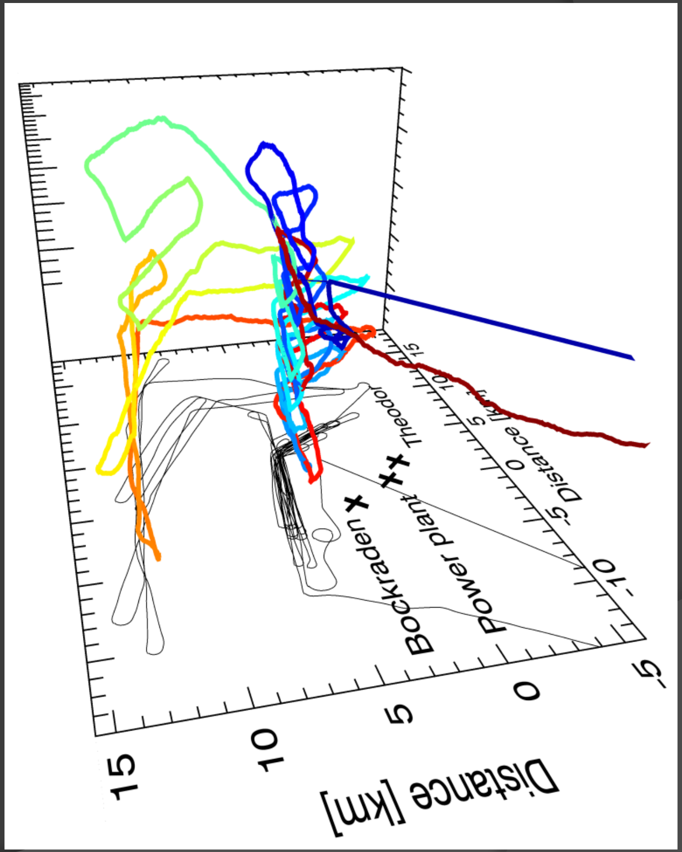


Ibbenbüren Bockraden Shaft – mass balance approach

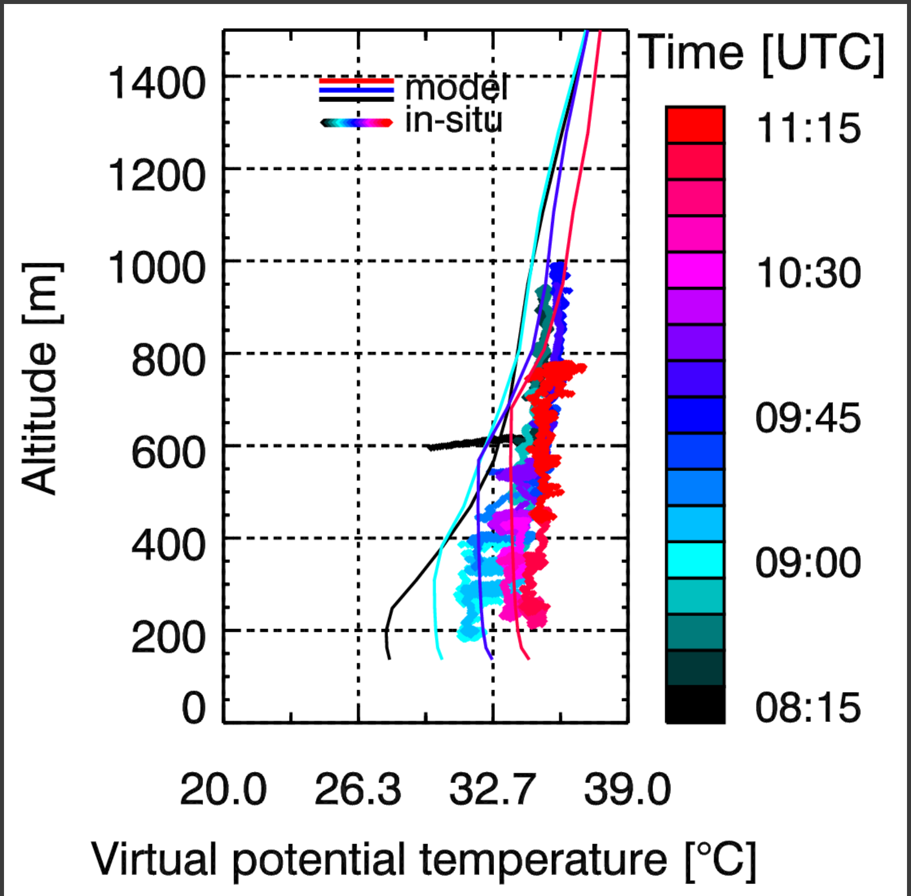


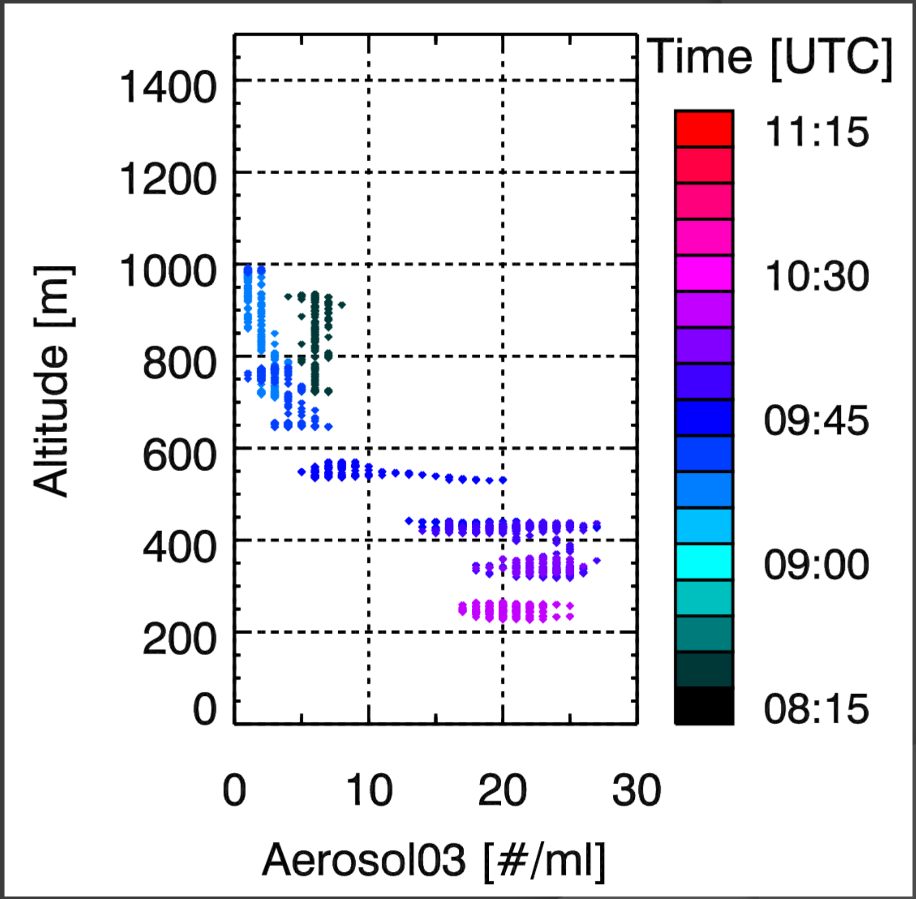
In-situ flight track: Ibbenbüren coal mine



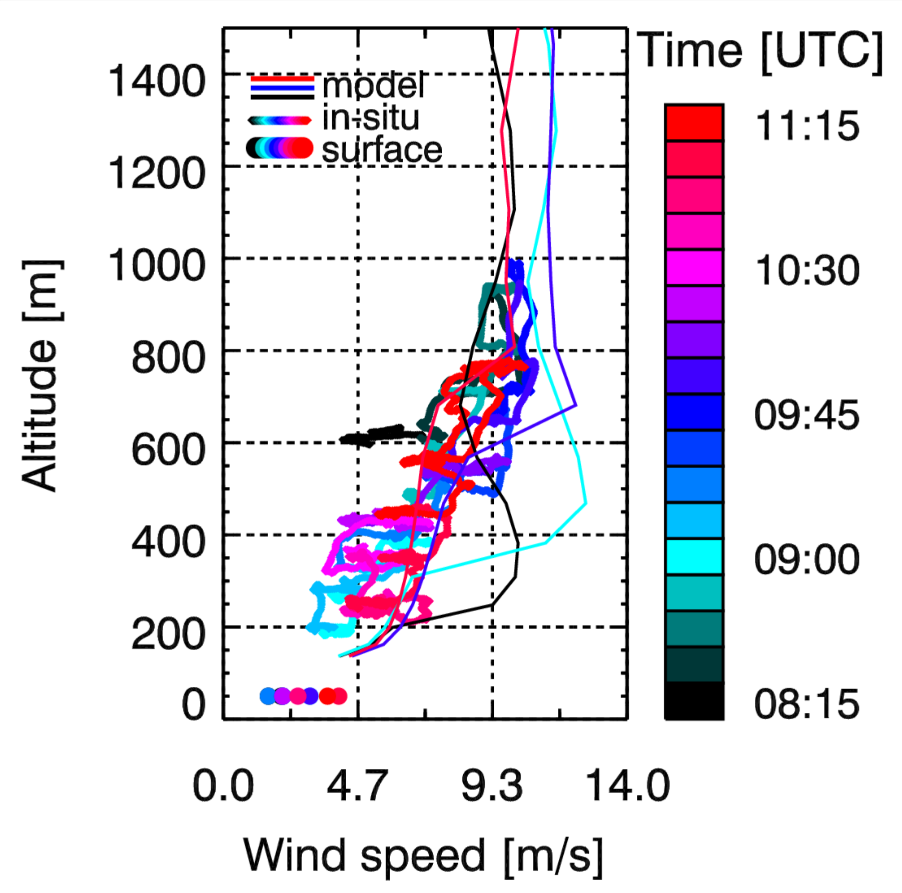


Virtual potential temperature and aerosol



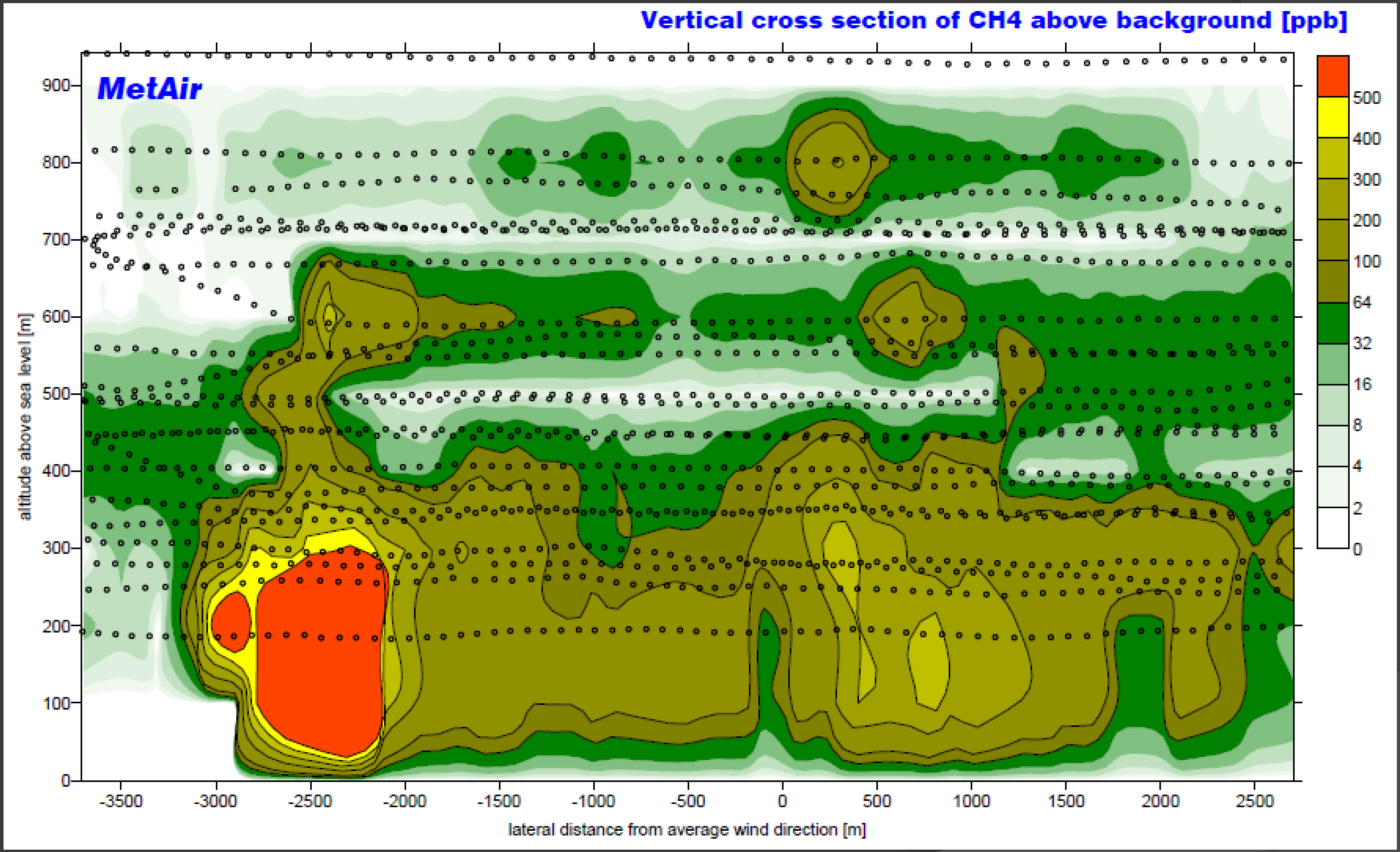


Model vs in-situ wind speed per layer

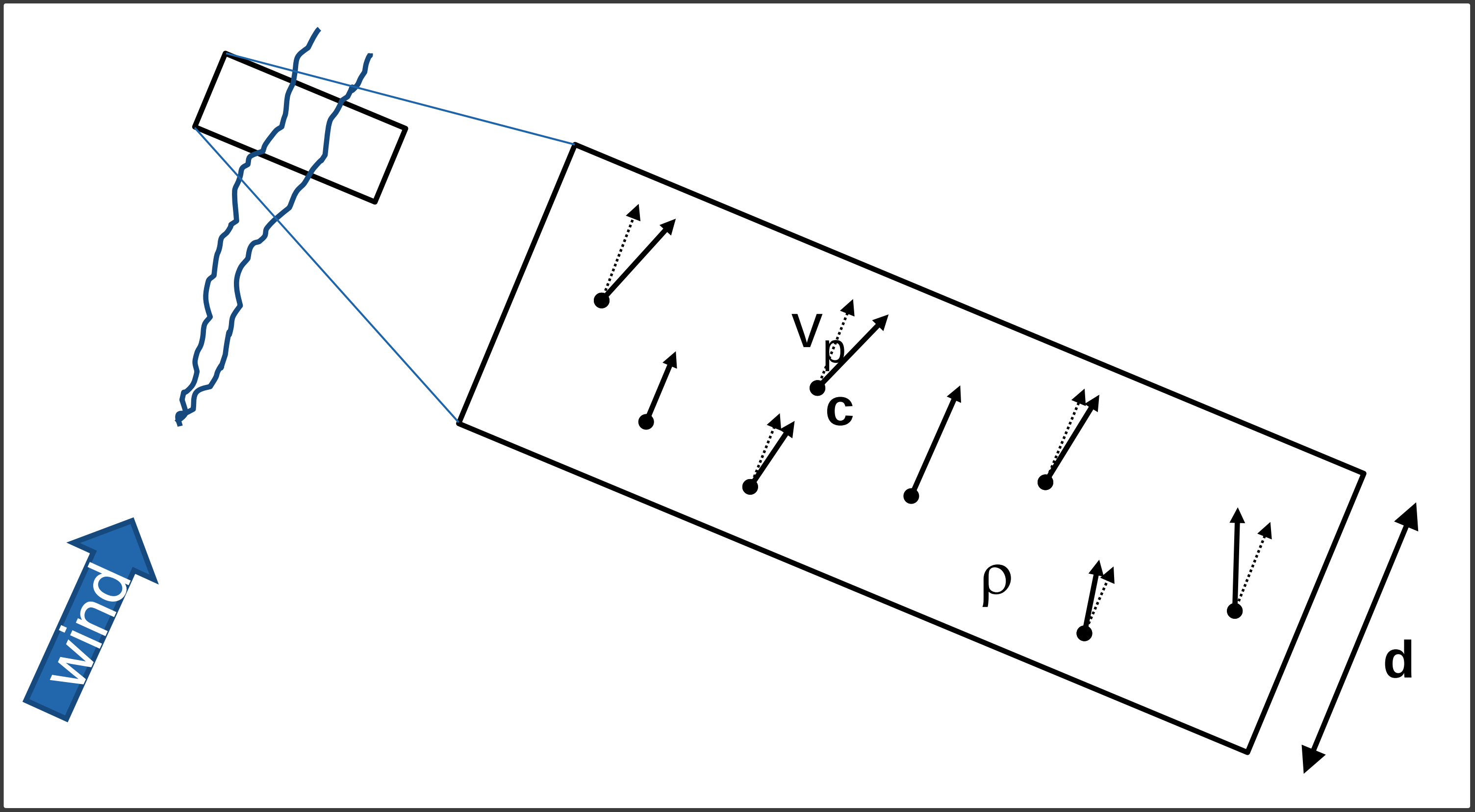


Altitude range a.s.l. [m]	Model wind speed [m/s]	In-situ wind speed [m/s]	Wind speed difference [m/s]
830 – 992	11.21	9.91	-1.31
668 – 830	11.88	9.45	-2.43
507 – 668	12.61	8.40	-4.21
345 – 507	11.52	6.17	-5.35
183 – 345	6.68	4.82	-1.85

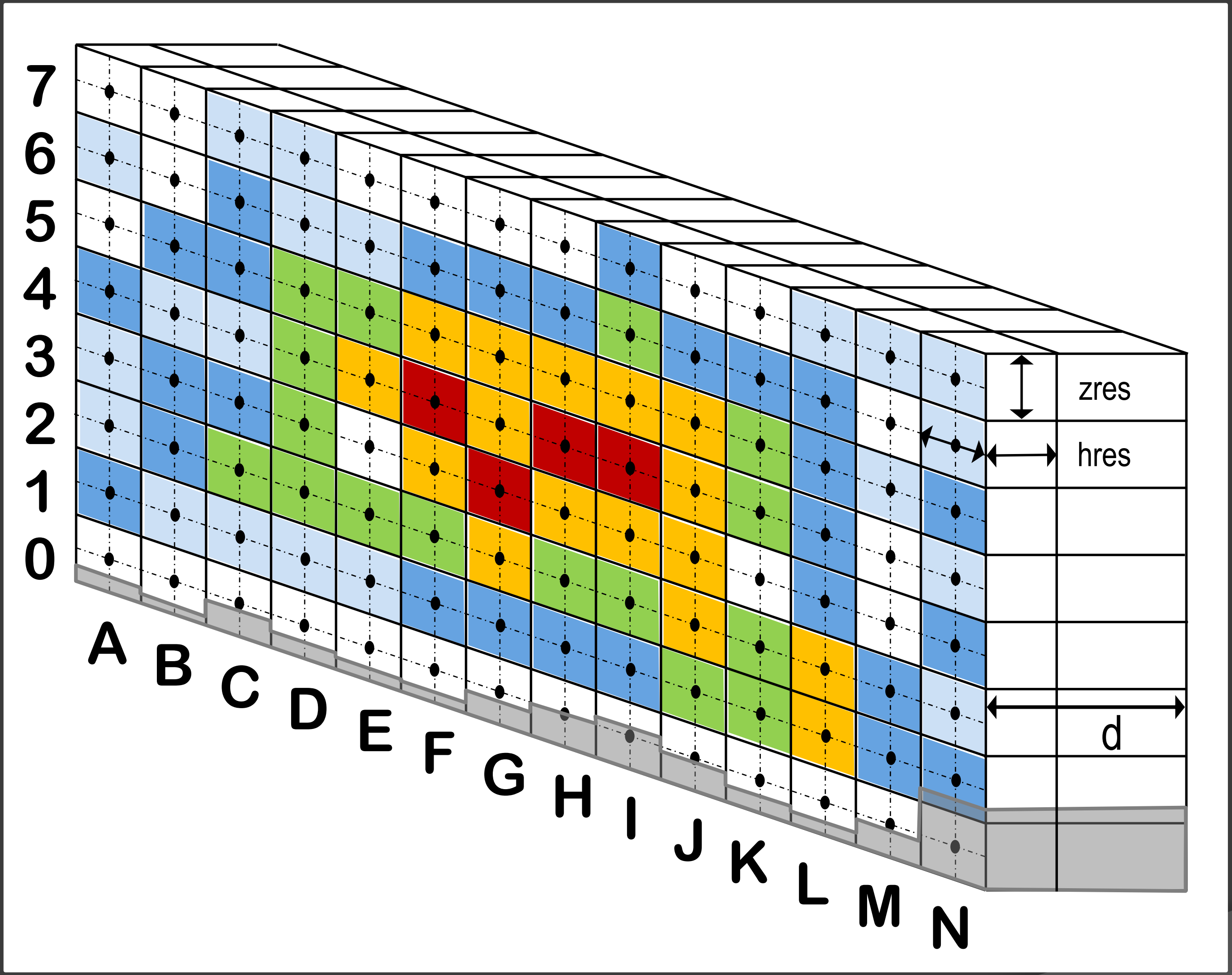
In situ CH_4 cross section



In situ emission rate estimate I



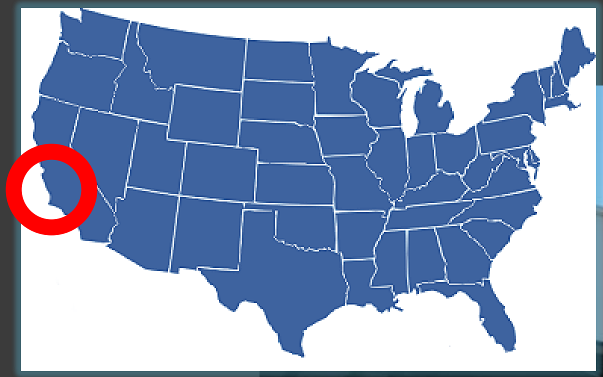
In situ emission rate estimate II



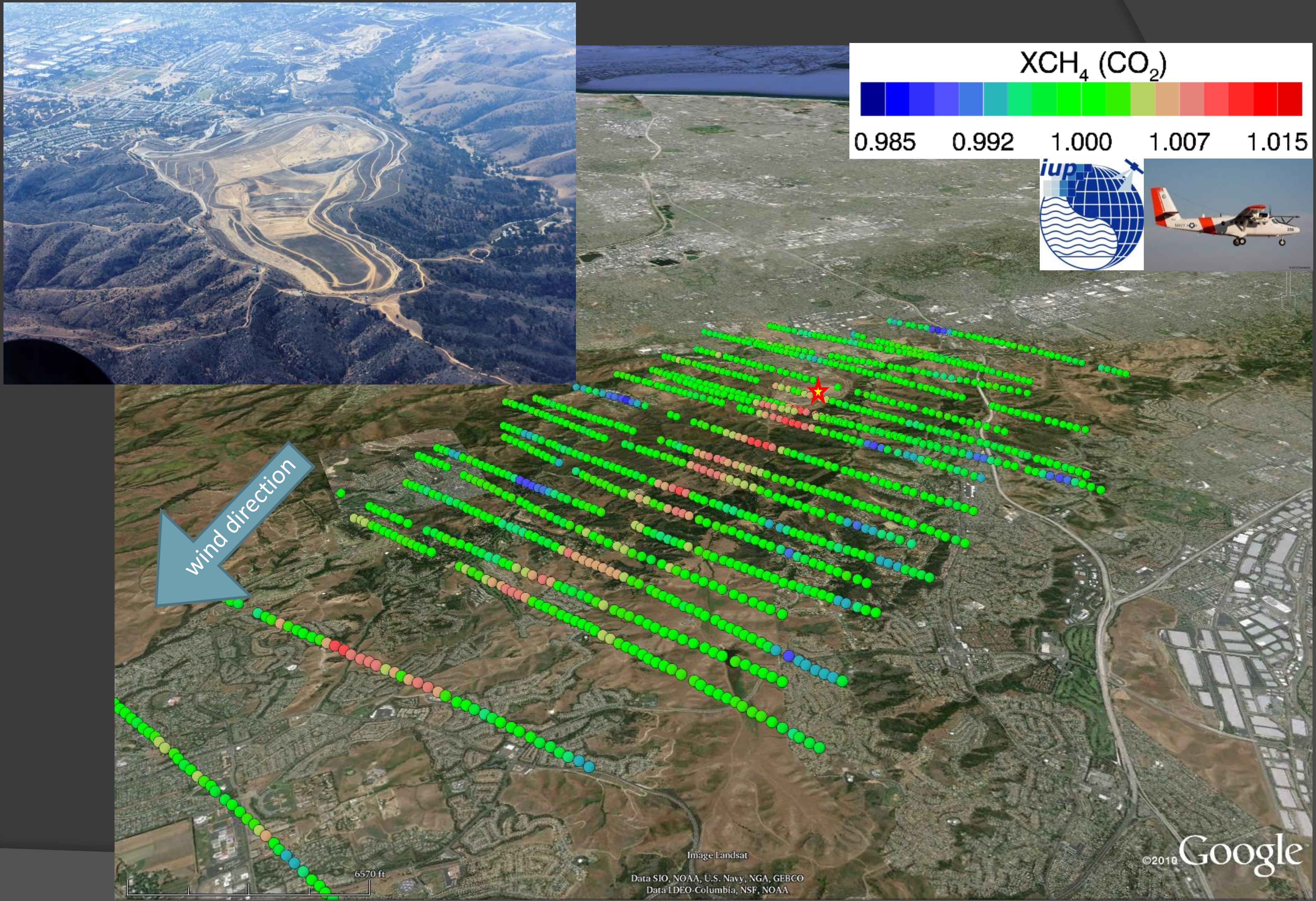
Results

Data basis	MAMAP, COSMO-DE and meteorology from airborne in-situ			In-situ (Metair)			Reported
Target	Gaussian plume	Mass balance	Approx. accuracy	Near field inversion	Far field inversion	Approx. accuracy	
Theodor Shaft	12.30 $ktCH_4/yr$ (+/-4.9%)	14.76 $ktCH_4/yr$	25%	19.44 $ktCH_4/yr$	89.9 $ktCH_4/yr$ (+/-31%)	47%	16.4 $ktCH_4/yr$
Bockraden Shaft	16.05 $ktCH_4/yr$ (+/-4.9%)	15.30 $ktCH_4/yr$	25%	22.69 $ktCH_4/yr$		45%	18.2 $ktCH_4/yr$

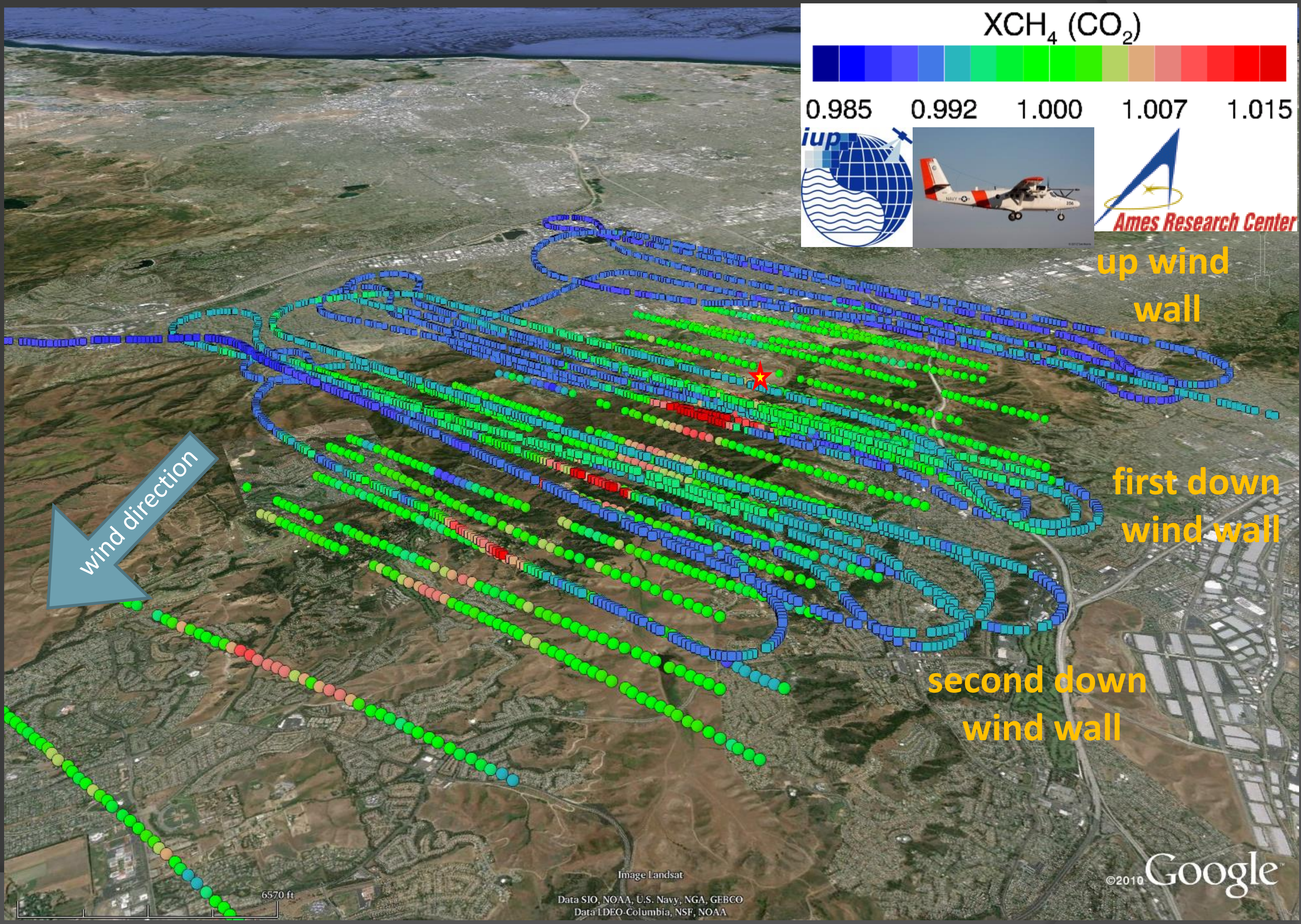
The CO_2 and Methane experiment (COMEX)



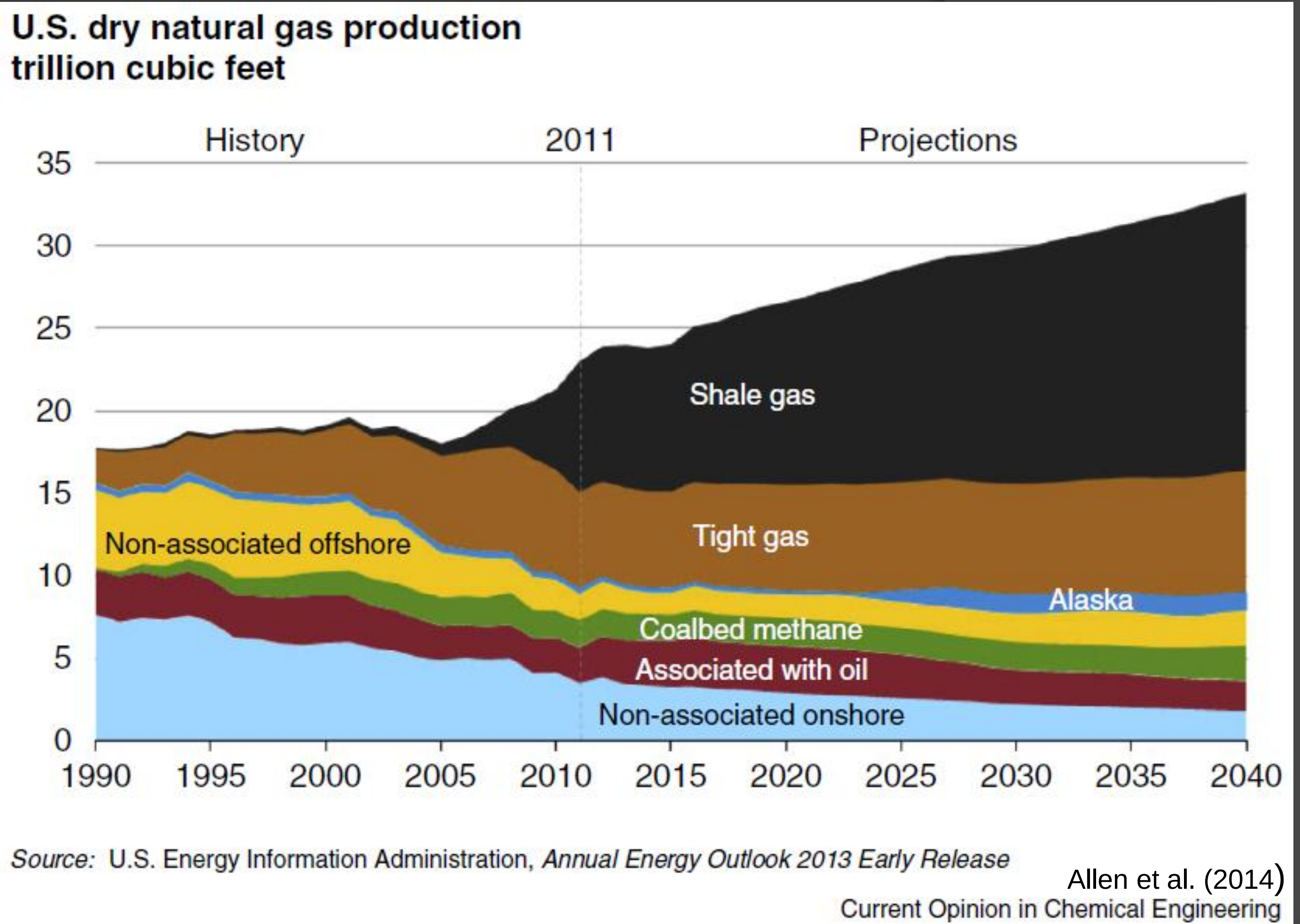
MAMAP CH_4 from Olinda Alpha landfill (L.A. basin, CA)



MAMAP CH_4 from Olinda Alpha landfill and in-situ Picarro



Methane from oil and gas production

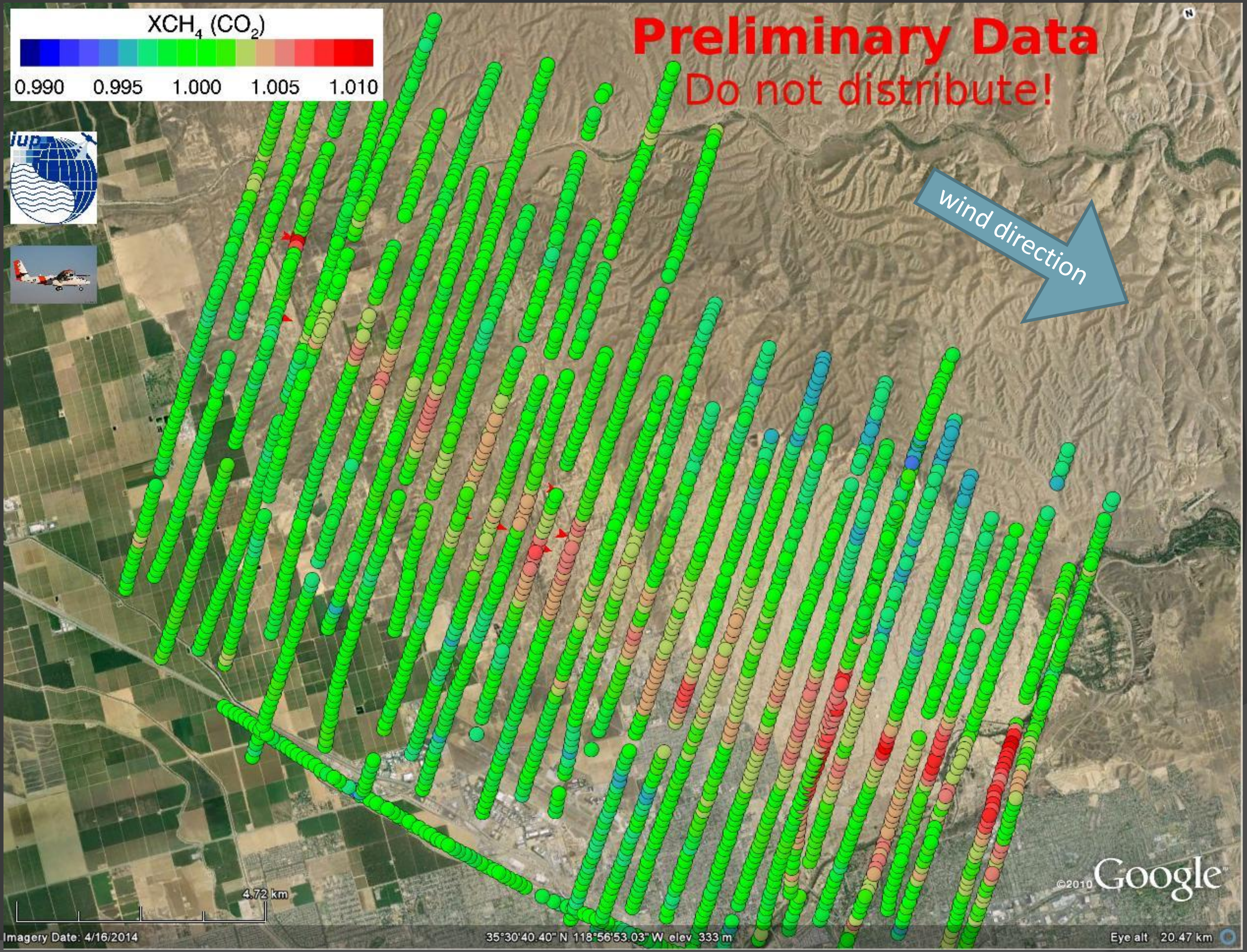


Allen et al. (2014)

- Huge uncertainties and discrepancies between bottom up and top down estimates
  - Schneising et al (2014), Allen et al. (2014), Kort et al. (2014), …
- Leakage rate vs. climate benefit (w.r.t. coal)
  - < 3.2% (Alvarez et al., 2012)

Kern River Oil Field (CA)

MAMAP XCH_4 measurements over the Kern Oil Fields (04.09.2014)



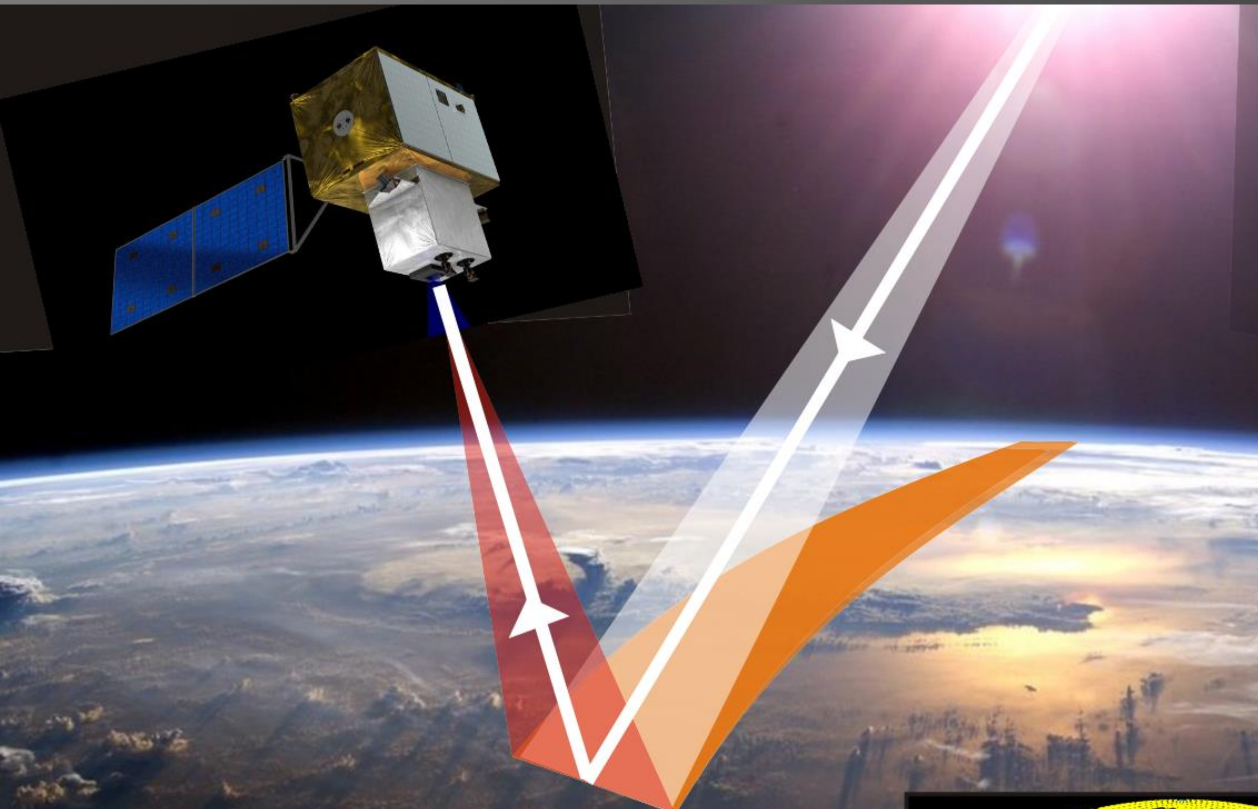
MAMAP XCH_4 data compared to AVIRISng remote sensing (JPL) retrieved CH_4 maps

[MAMAP and AVIRISng data overlay removed for this version]

MAMAP XCH_4 data compared to AVIRISng remote sensing (JPL) retrieved CH_4 maps

[MAMAP and AVIRISng data overlay zoom removed for this version]

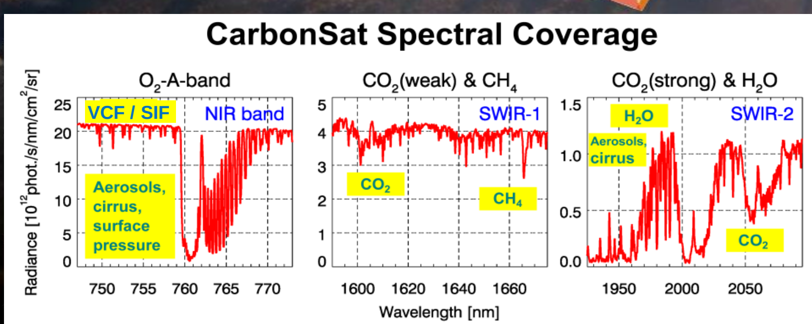
Carbon monitoring satellite (CarbonSat)

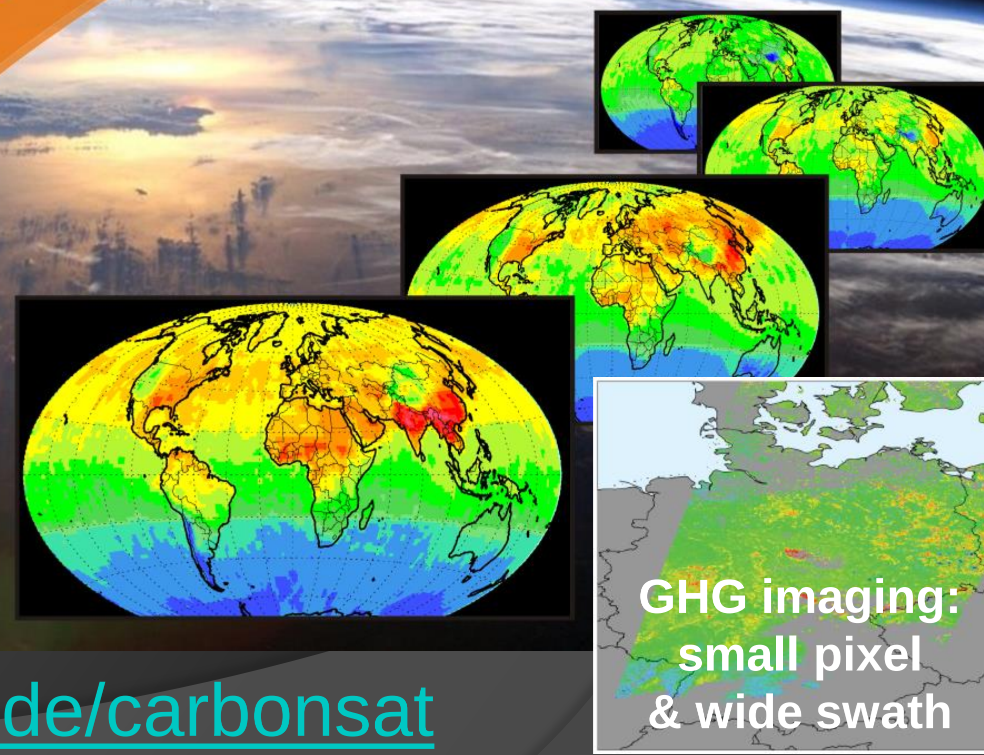


CarbonSat

Global CO_2 & CH_4 from space

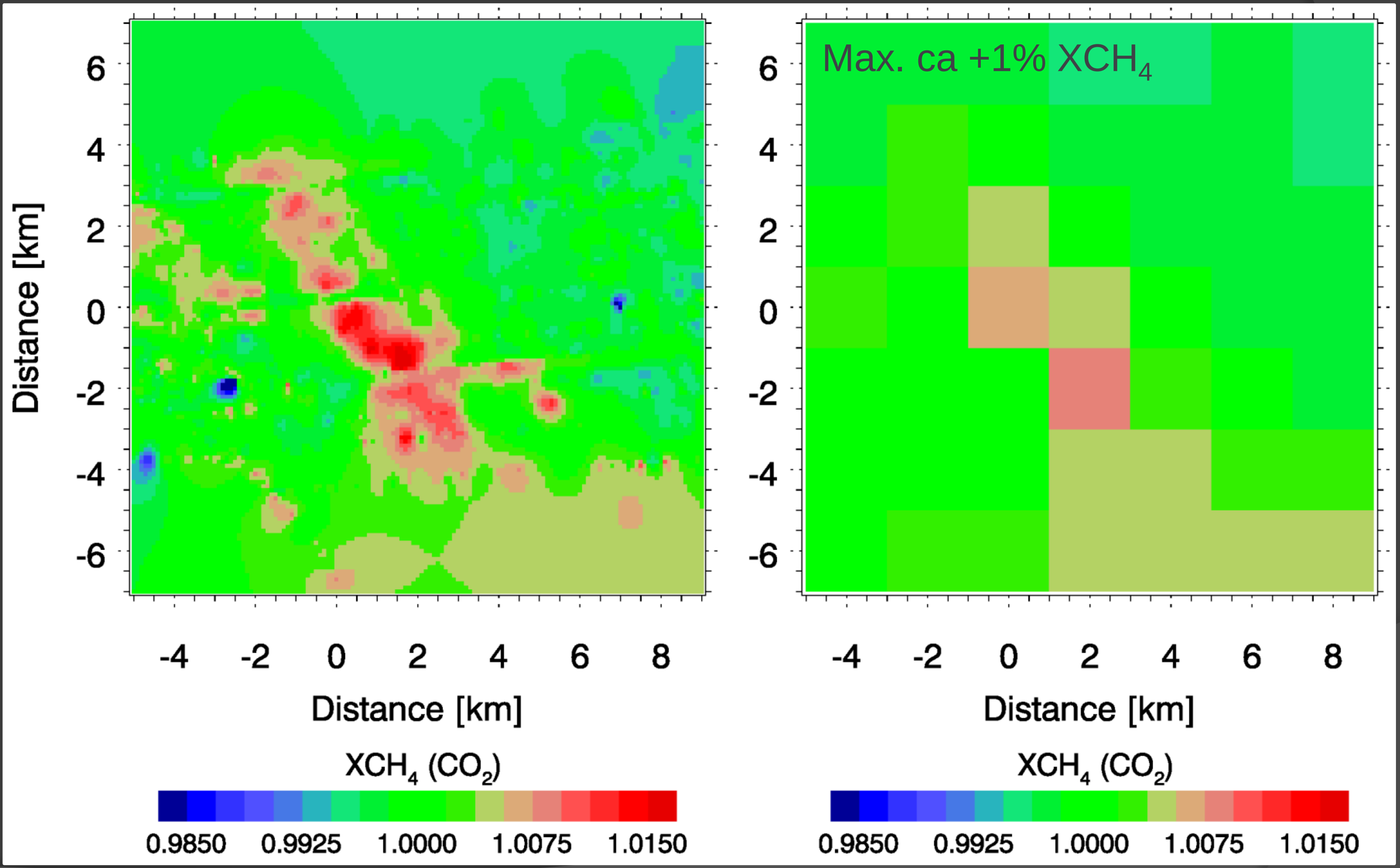
Earth Explorer 8 (EE8) Candidate Mission





www.iup.uni-bremen.de/carbonsat

Kern River at CarbonSat resolution



Conclusions

- Combination of remote sensing and in-situ offers the possibility to improve the emission estimates and validate them
- Experiences gained with this approach can help to assess unknown or uncertain emissions
- Combination of remote sensing with high spectral and low spatial on the one hand and low spectral and high spatial resolution on the other hand can help to quantify and pinpoint sources
- The future satellite mission CarbonSat could contribute in regularly monitoring large point sources from space

Thomas.Krings@iup.physik.uni-bremen.de