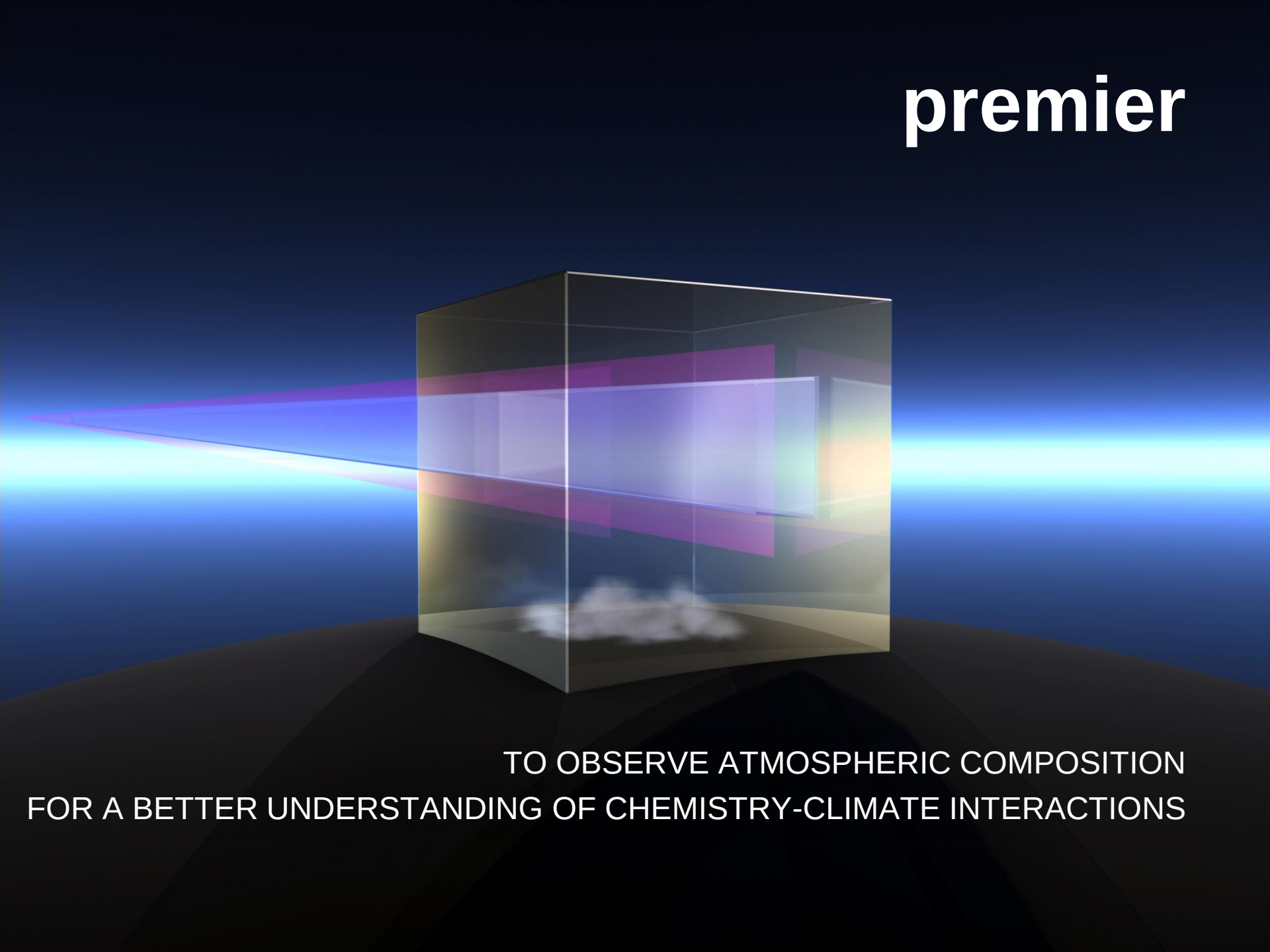
premier



TO OBSERVE ATMOSPHERIC COMPOSITION
FOR A BETTER UNDERSTANDING OF CHEMISTRY-CLIMATE INTERACTIONS

PREMIER: ESA EE-7 Candidate Mission to Sound Atmospheric Composition

Presentation by B. Kerridge (RAL, UK) on behalf of:

Mission Advisory Group

M. Hegglin (University of Reading, UK)
J. McConnell (York University, Canada)
D. Murtagh (Chalmers University, Sweden)
J. Orphal (KIT, Germany)
V-H. Peuch (ECMWF, UK)
M. Riese (FZJ, Germany)
M. van Weele (KNMI, Netherlands)

J. Langen (ESA Mission Scientist)
B.Carnicero-Dominguez (ESA Technical Co-ordinator)

and the **Science Study Teams**

Mission objectives

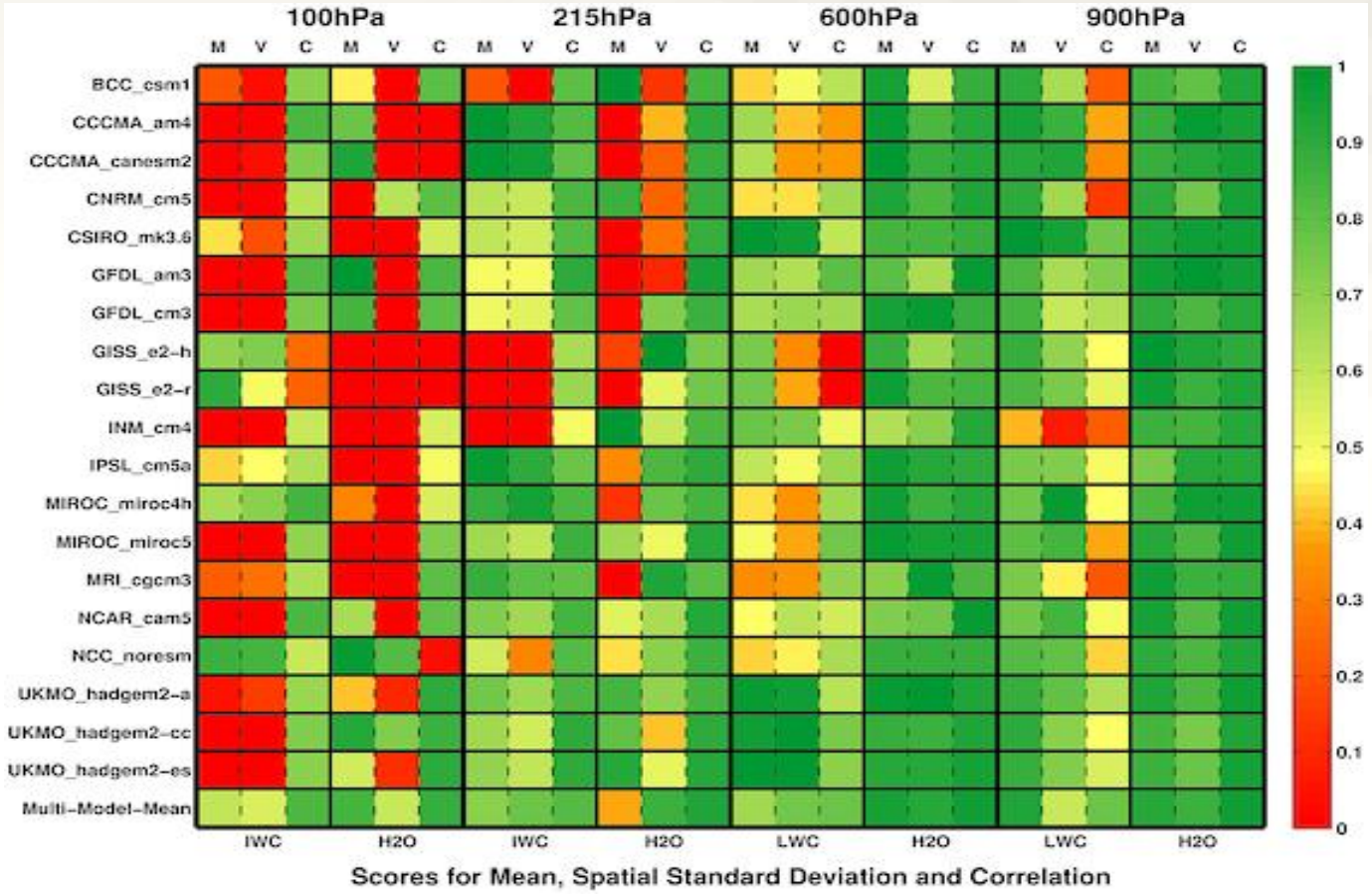
- To explore processes controlling global atmospheric composition in the mid/upper troposphere and lower stratosphere; region of particular sensitivity for surface climate.
  - *by resolving 3-D structures of trace gases, thin cirrus and temperature in this region on finer scales than previously accessible from space*
- To explore links with surface emissions and pollution
  - *by exploiting synergies with nadir-sounders on MetOp/SG*
- Scientific Objectives:

  A. Impact of UTLS variability and the general circulation on surface climate
  B. Trace gas exchange between the troposphere and stratosphere
  C. Impact of convection, pyroconvection and their outflow on UTLS composition
  D. Processes linking composition of the UTLS and lower troposphere

- In addition, to advance operational applications for satellite composition data and contribute to global, height-resolved monitoring.

→ *Observational requirements are demanding*

Climate model simulations of water vapour and cloud



Jiang, J. H., et al. Evaluation of cloud and water vapor simulations in CMIP5 climate models using NASA "A-Train" satellite observations, J. Geophys. Res., 117, D14105, doi:10.1029/2011JD017237, 2012

—Largest spread among models and largest differences from A-Train in upper trop.

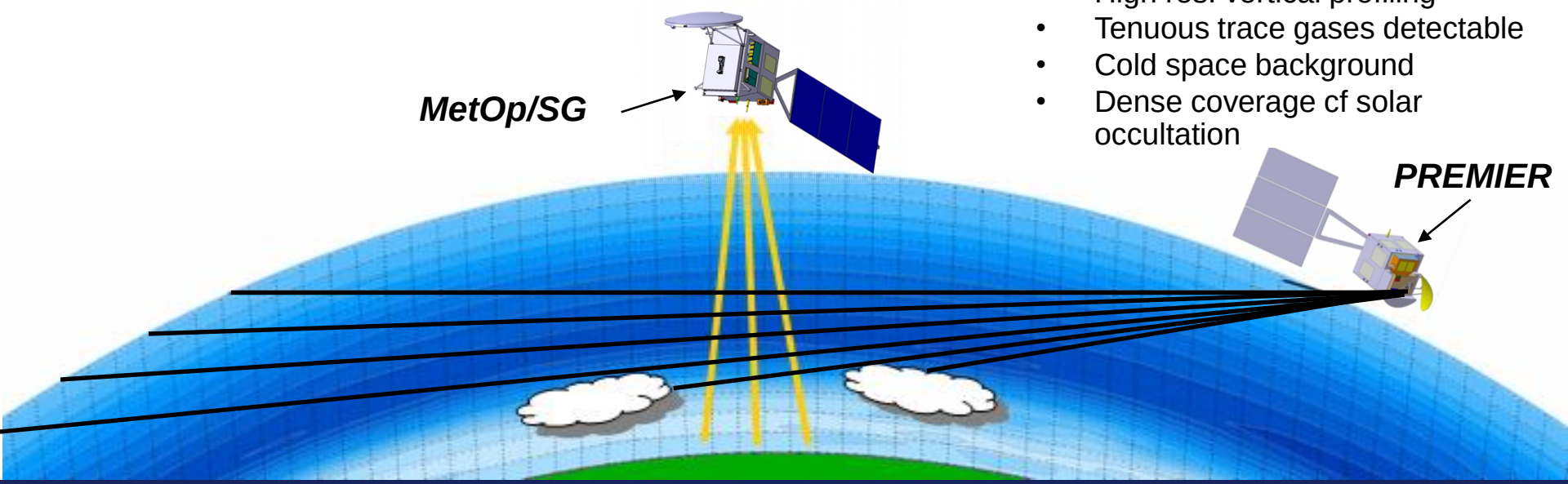
Observation techniques

Nadir-sounding

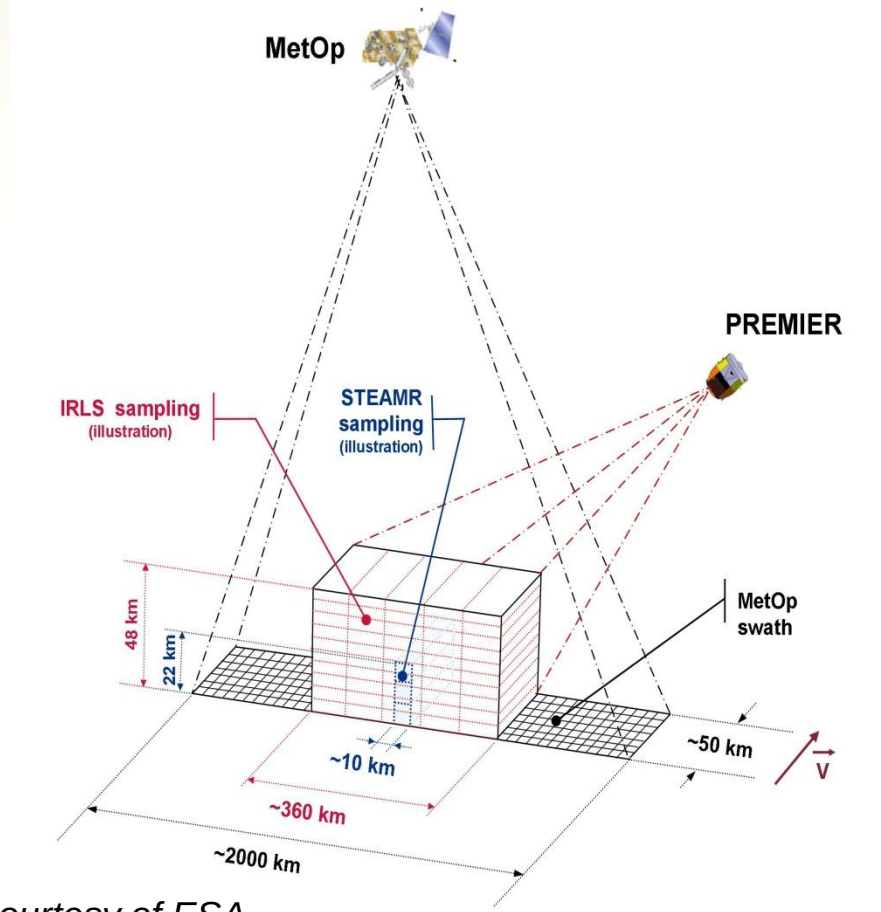
- Near-surface layer seen between clouds *but*
- Little or no vertical resolution

Limb-emission sounding

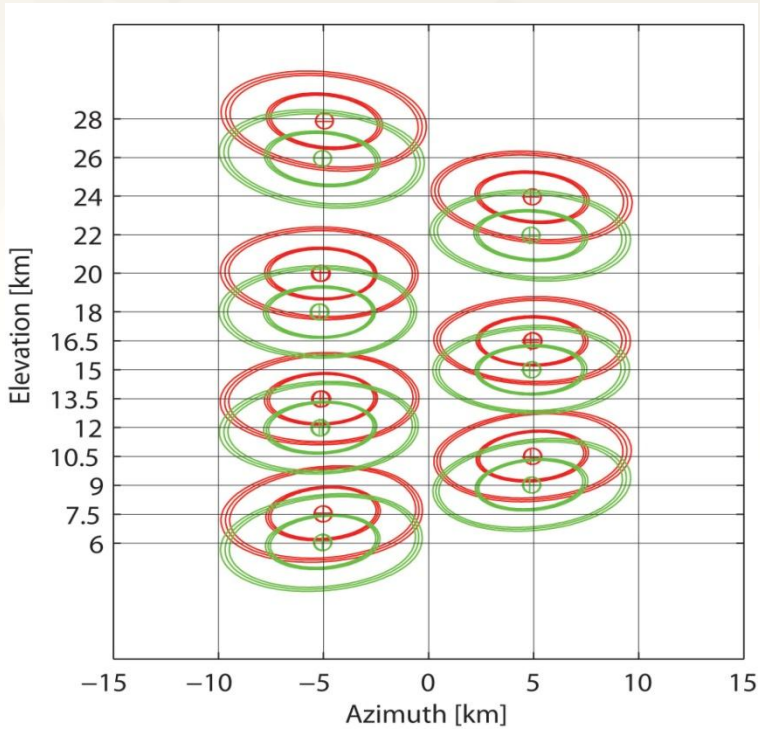
- High res. vertical profiling
- Tenuous trace gases detectable
- Cold space background
- Dense coverage cf solar occultation



Observing Geometry for Array Concepts



Courtesy of ESA



STEAMR array: 14 fixed staring receivers
7 in 2 orthogonal polarisations
− *UK concept*

Complementarity of IR and mm-wave limb sounders

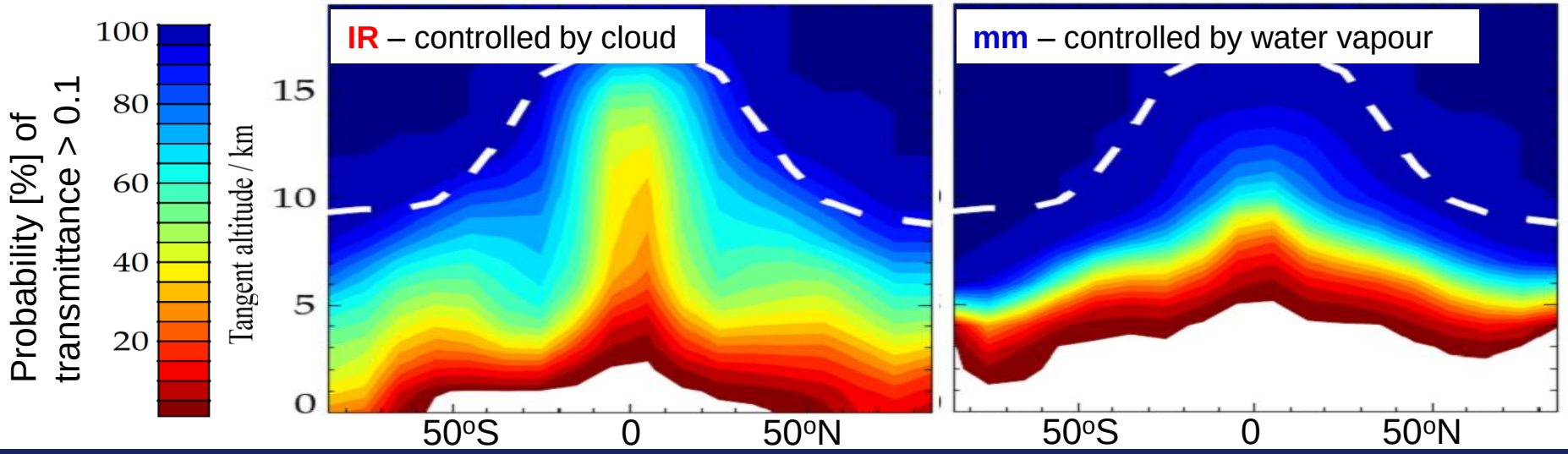
- Target trace gases:

  IR: CH_4; organic compounds; nitrogen oxides
  mm-wave: CO; biomass burning indicators; halogens

- Sensitivity to cirrus particle size

  IR: R_e < 100μm
  mm-wave: R_e >100μm

  → *Different penetration depths into troposphere for H_2O, O_3, HNO_3 & HCN*

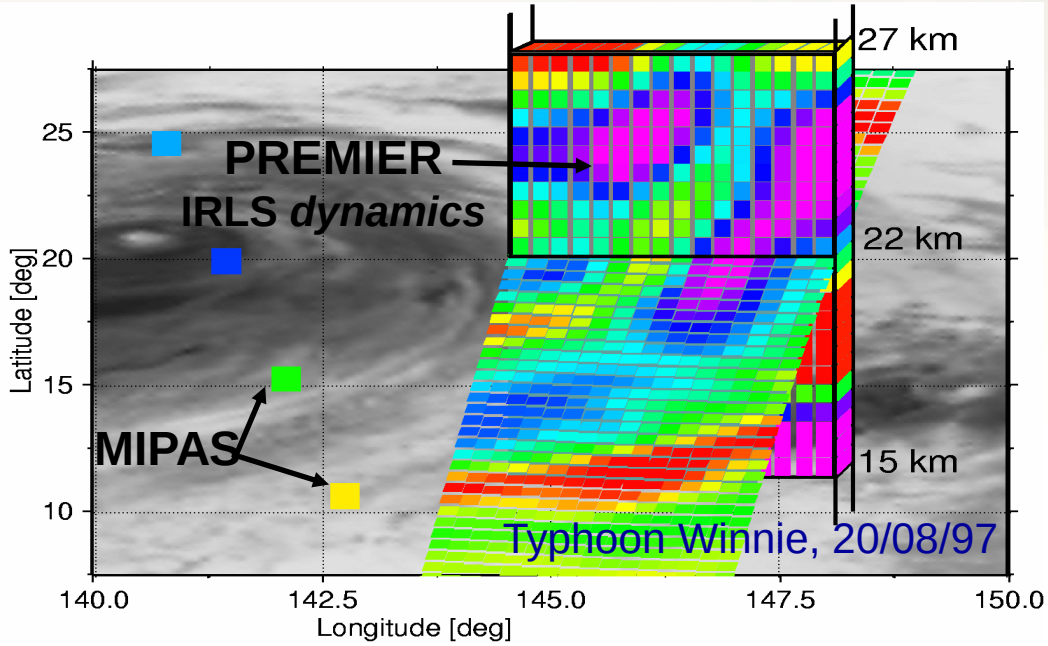


Advances over current limb-emission sounders

- Stringent requirements in the mid/upper troposphere and lower stratosphere demand
    1. Finer vertical sampling
    2. Finer along-track sampling
    3. 3rd dimension to be added by viewing across-track
- The 6 – 25km range will be sampled more densely
    - ~5 x 10^6 limb-views / day cf ~2 x 10^4 for MIPAS
    - Many more cloud-free views

→ ***Atmospheric fields will be observed in fine detail***

Sampling 3-D temperature structure generated by gravity waves



→ ***Wavelength & wavevector***
→ ***Back-tracing to sources***

- GWMF estimate for individual events

→ *accuracy improved x10*

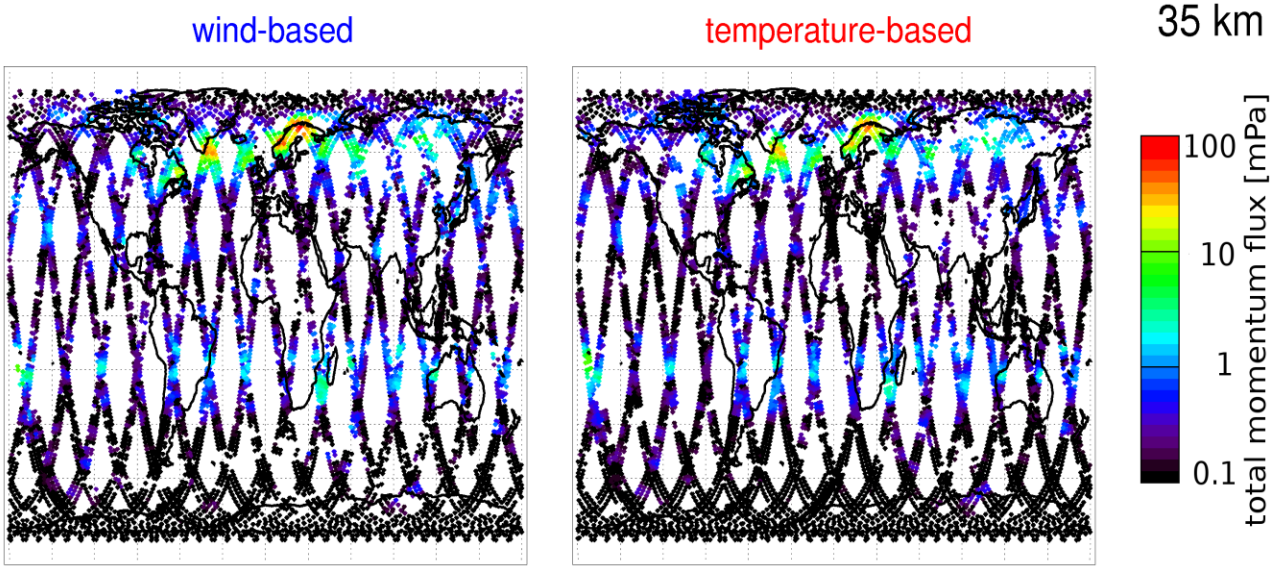
- GWMF zonal and hemispheric means require direction

→ *available for the first time*

GWMF at 35km for 1 day (29/01/08) from:

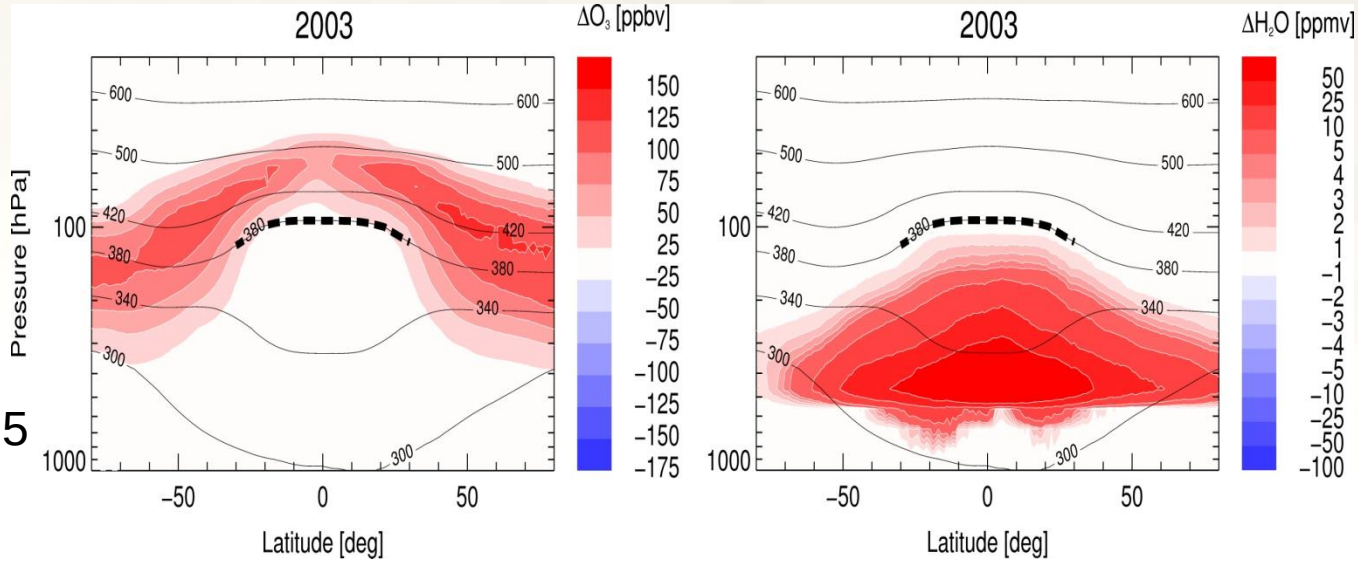
- ECMWF high-res wind
- PREMIER simulation
  - 2D T retrieval
  - Isolate mesoscale
  - 3D GW analysis

Courtesy, P. Preusse



Sensitivity to mixing of annual mean O_3 & H_2O distributions and their radiative effects

Differences between CLaMS annual zonal means for Lyapunov mixing coeff. = 1.2 or 1.5



Riese, M. et al, J. Geophys. Res., 117, D16305, doi:10.1029/2012JD017751, 2012

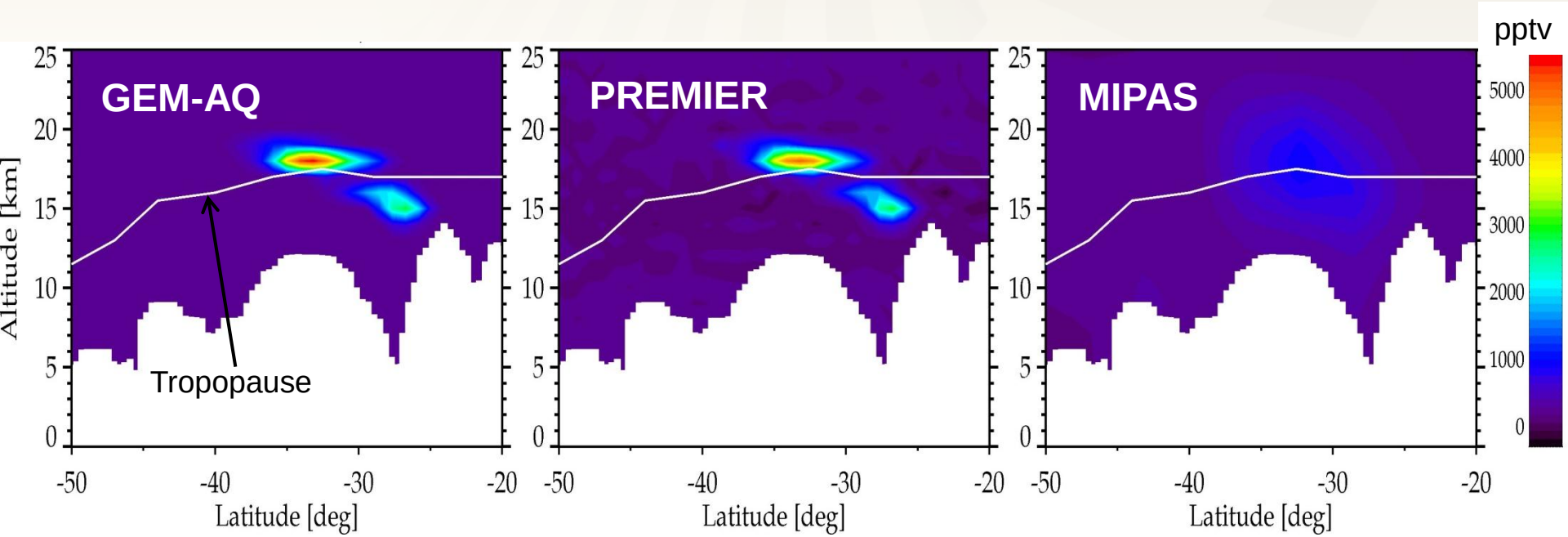
→ Differences in global mean radiative effect ΔRE:

O_3: 0.17 Wm^{-2}
H_2O: 0.72 Wm^{-2}

ΔRF since 1980 due to LLGHGs + aerosols + strat. H_2O ~0.9Wm^{-2} (Solomon et al,2010)

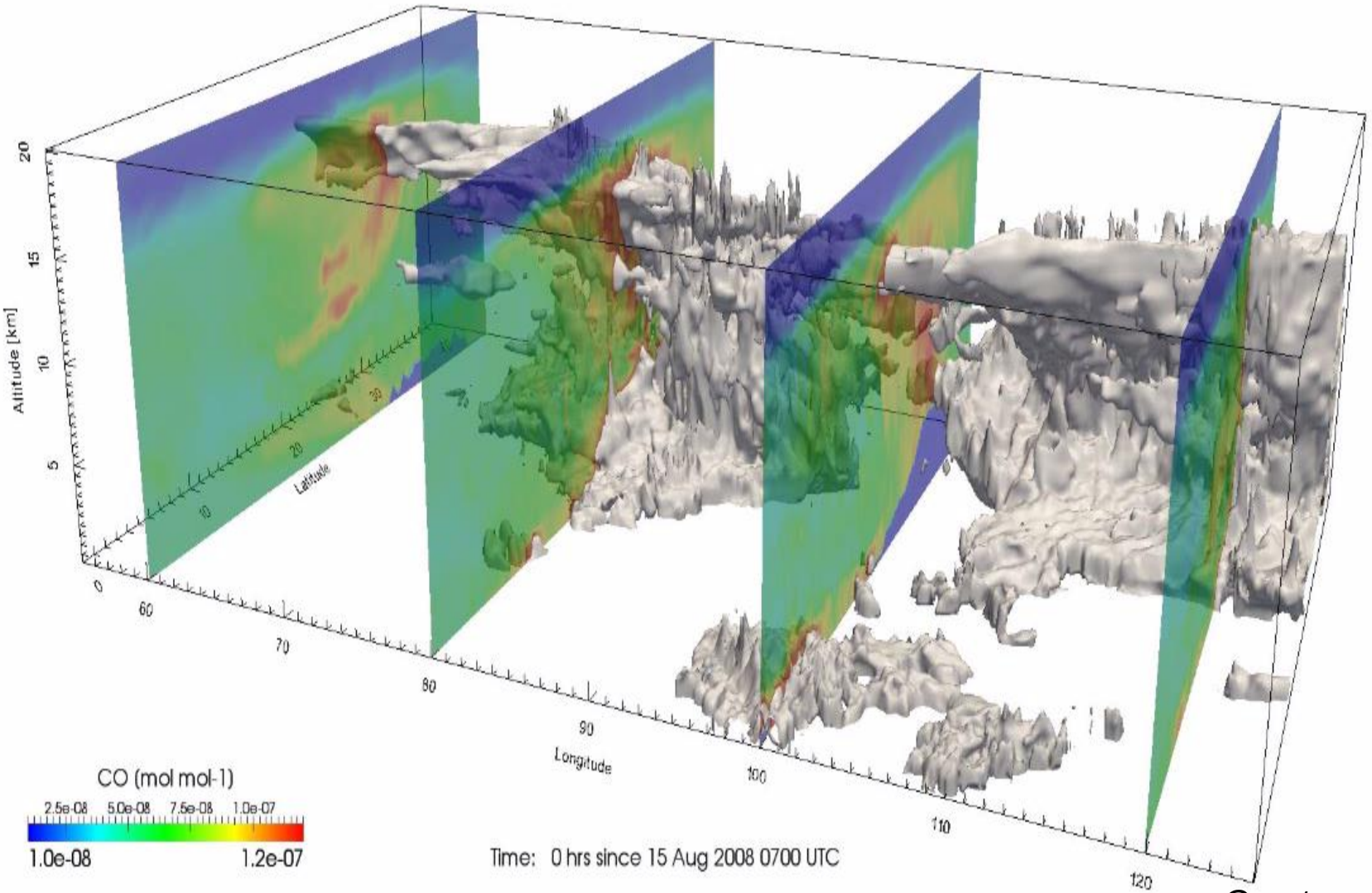
PREMIER will resolve fine-scale structure in O_3 and H_2O in the height-range of climate sensitivity and critically test model mixing schemes.

HCN in double plume from Kilmore East fires: comparison of GEM-AQ & simulated ir x-sections



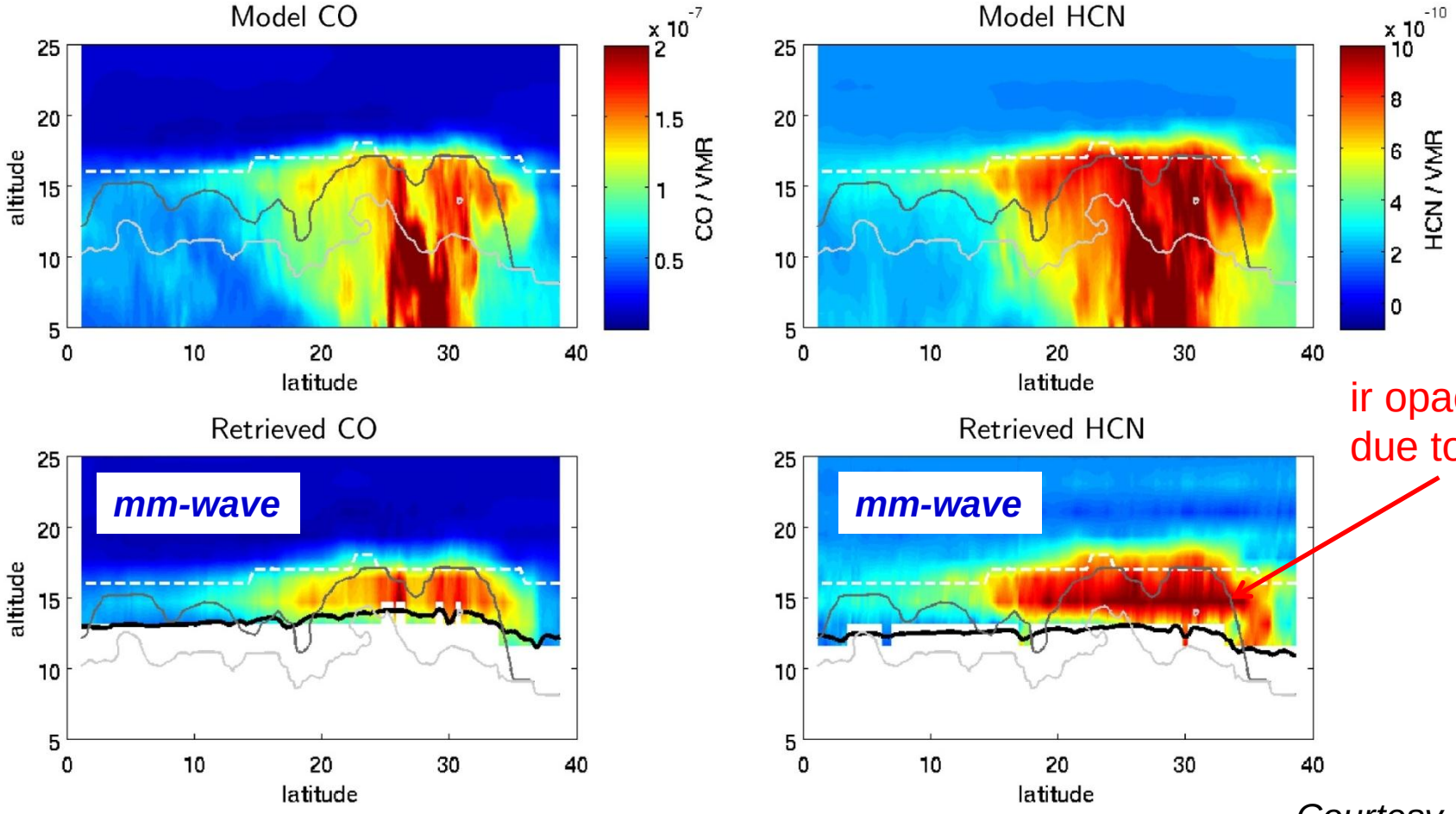
Courtesy of N.Glatthor

PREMIER will track ozone precursors and HCN in plumes to quantify ozone production and radiative forcing from pyroconvective sources



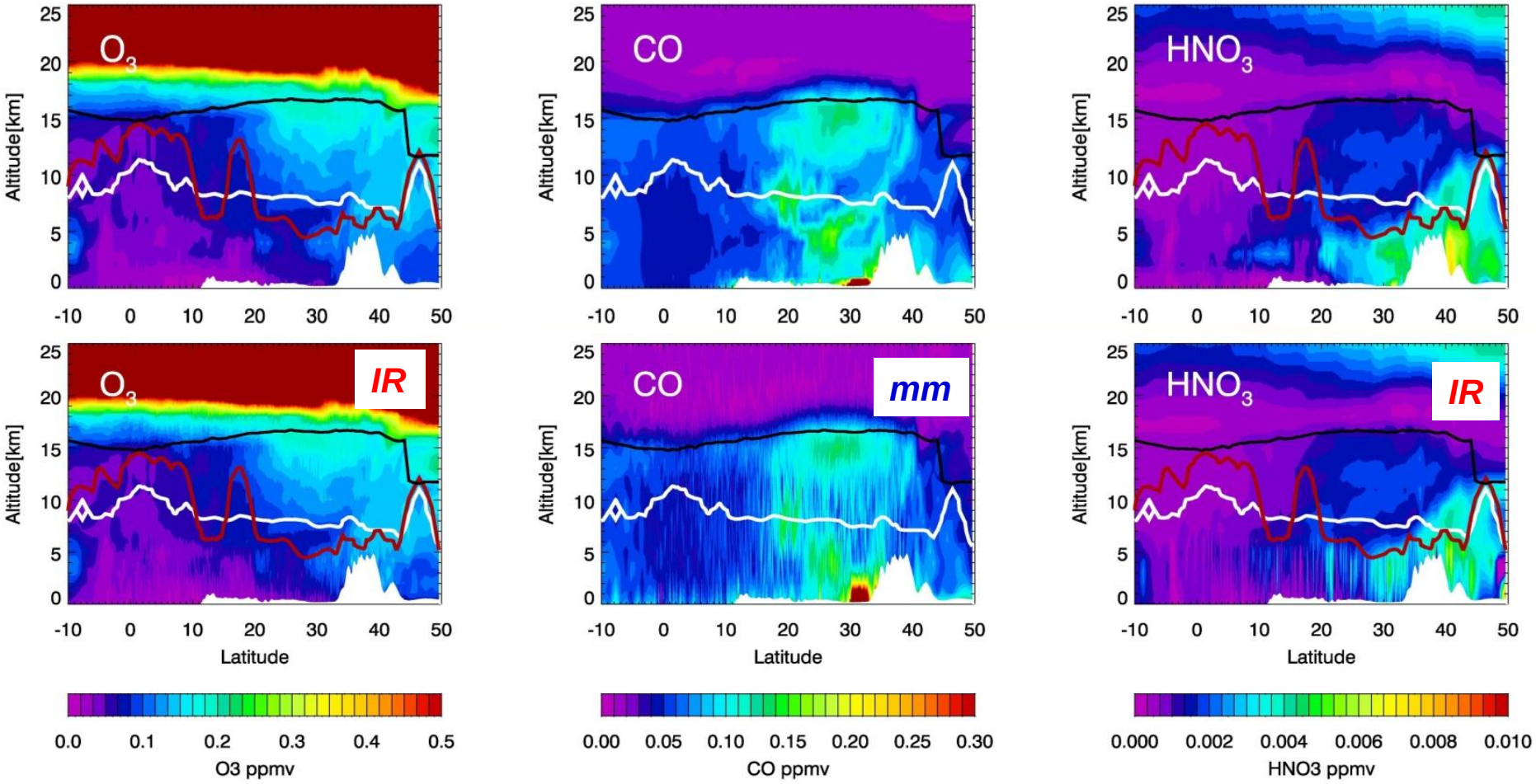
Courtesy of A.Lupu

Comparison of GEM-AQ and mm-wave retrieved CO & HCN x-sections - *monsoon core*



Courtesy of J.Urban

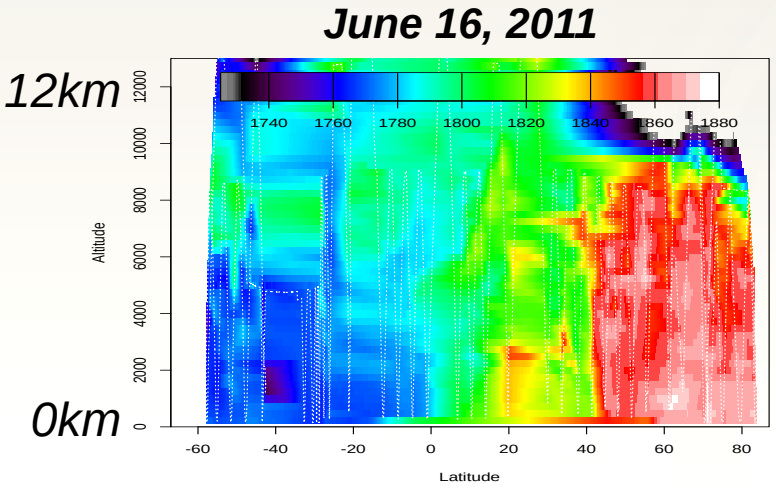
Comparison of GEM-AQ and PREMIER-MetOp/SG combined retrieved O_3, CO & HNO_3 - *monsoon periphery*

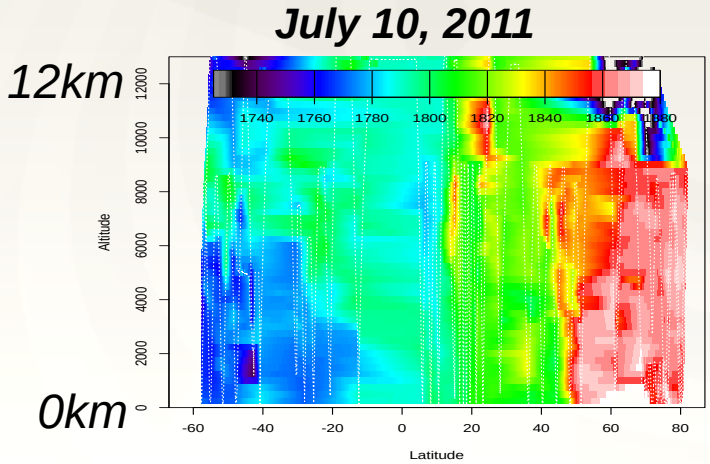


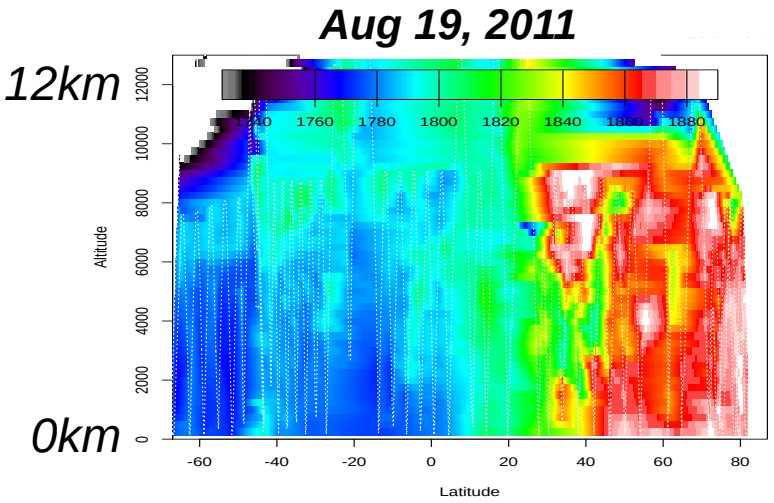
Courtesy A.Waterfall

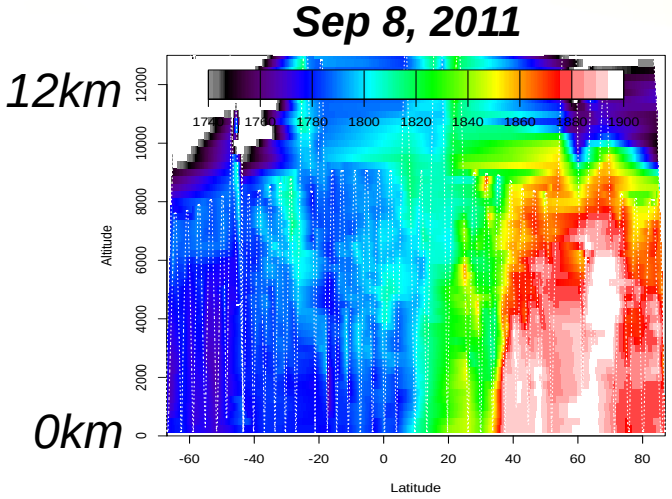
PREMIER will observe daily 3-D fields to investigate monsoon uplift in detail
In combination with MetOp/SG, fields will be extended into lower troposphere

Methane vertical structure and variability





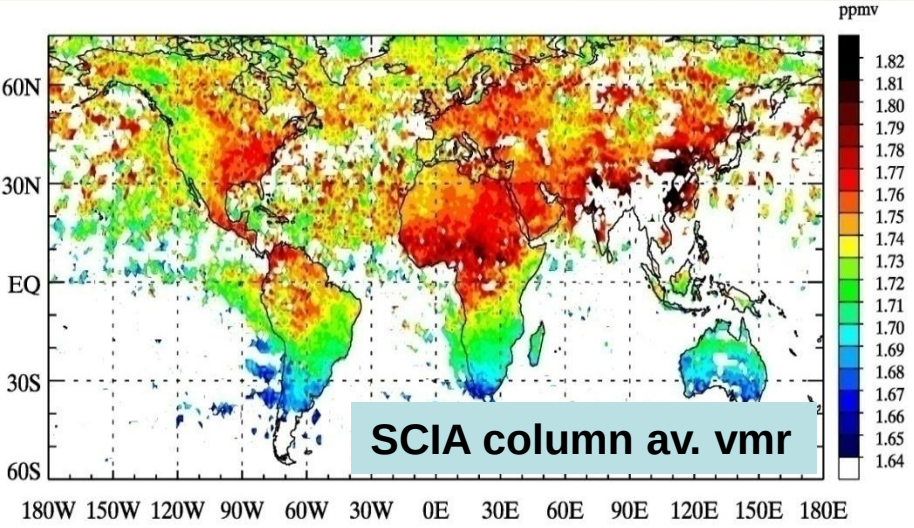


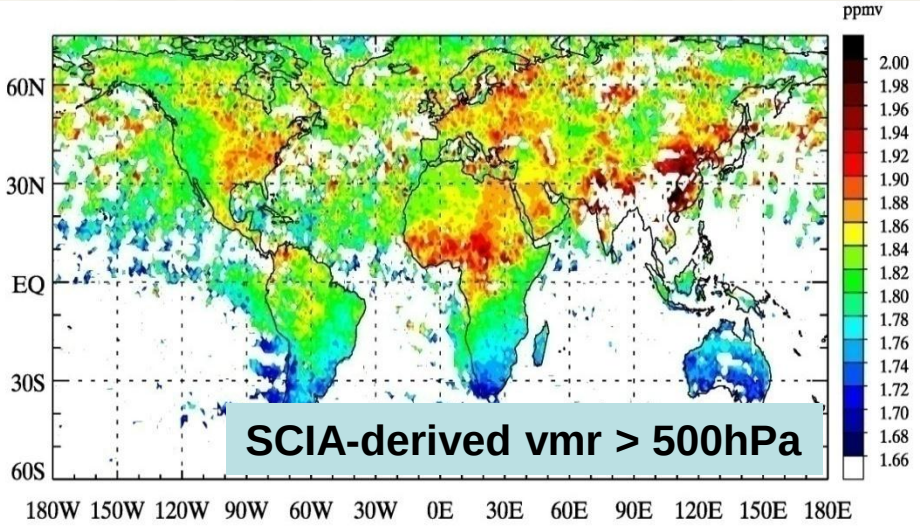


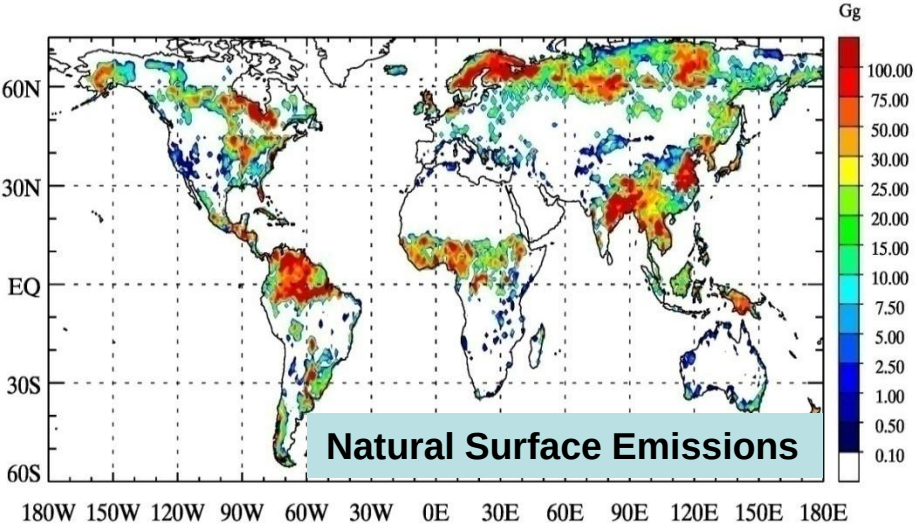
Profiles from *in situ* sensor during ascents & descents in HIPPO flights

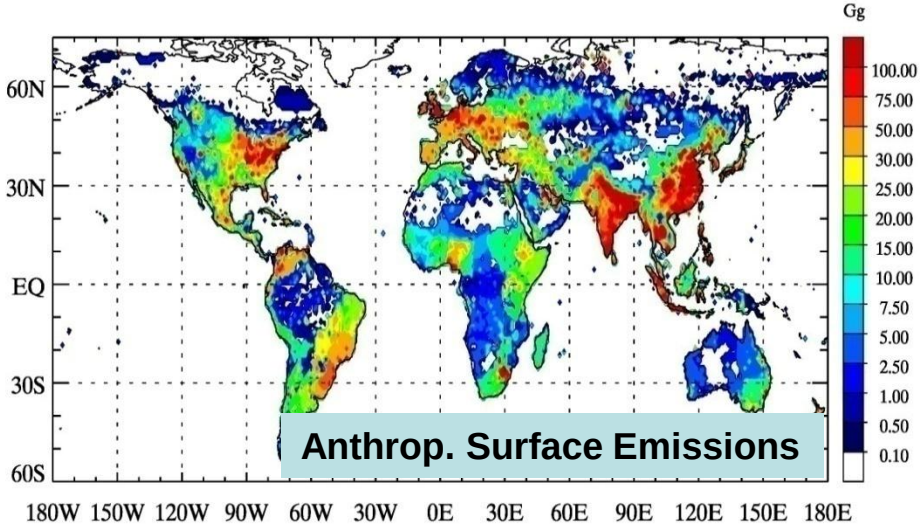
→ ***Height-resolved data to improve on column average data for surface emission estimates***

Impact on Column-Average Methane Mixing Ratios for Inverse Modelling of Surface Fluxes









BBC NEWS

SCIENCE & ENVIRONMENT

14 September 2012 Last updated at 09:47

Met Office model 'better at predicting extreme winters'

UK weather forecasters can predict cold winter weather a season ahead with more confidence, according to analysis of a new computer model.

Writing in Environmental Research Letters, scientists say the model is better at simulating phenomena known as sudden stratospheric warmings (SSWs).

These happen when the usual westerly winds at 10-50km altitude break down, causing cold weather on the surface.

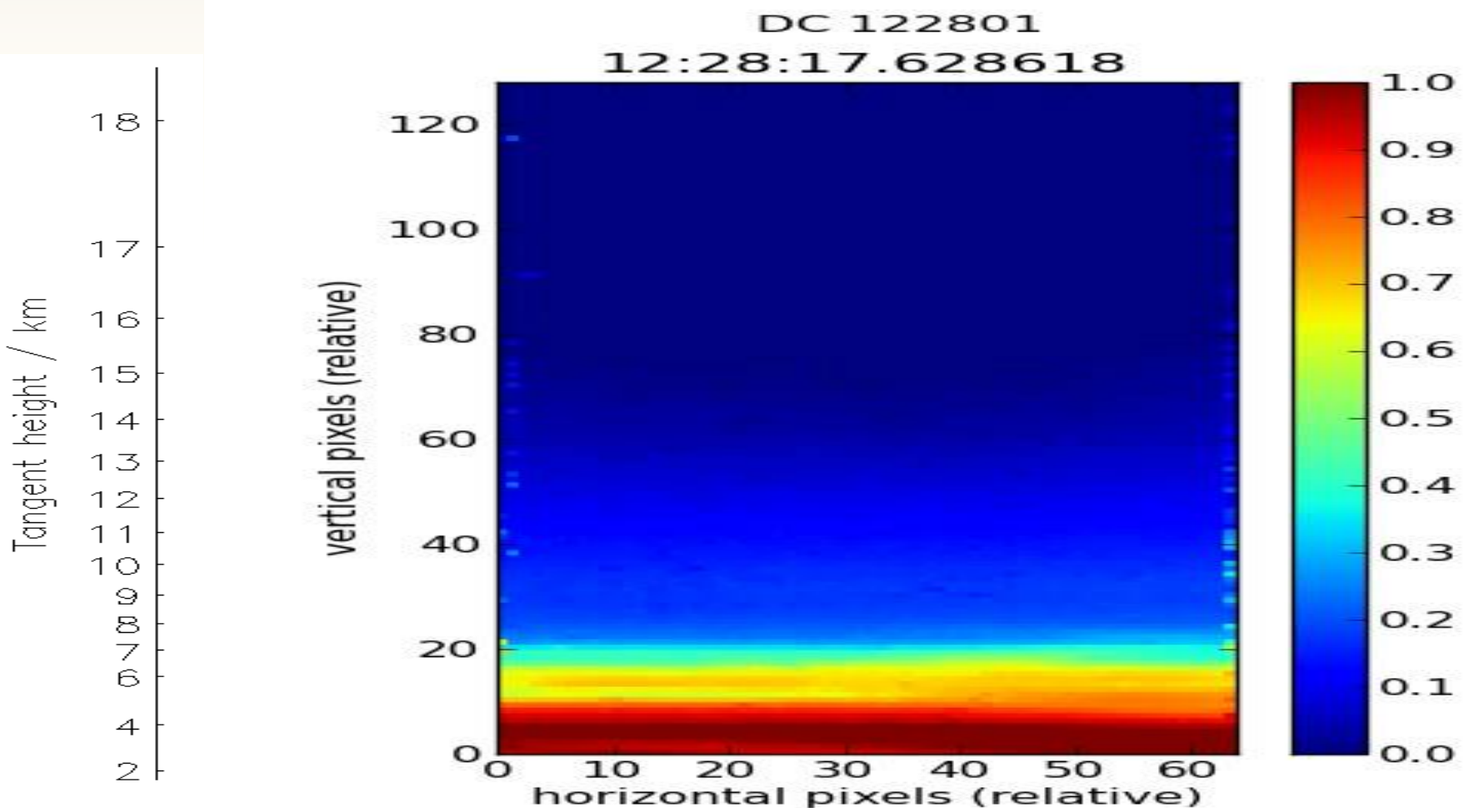
V-H. Peuch *applications paper*,
Eumetsat Satellite conference

Airborne campaigns in Mar'10, Dec'11 and Sep'12

- to demonstrate new observing capabilities

- *D.Gerber poster*

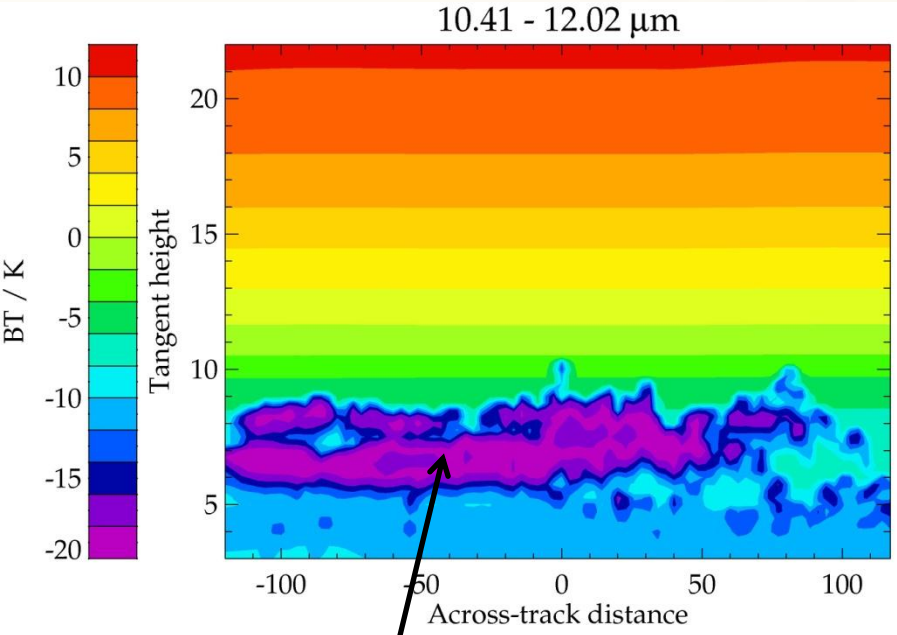
Limb-image of spectrally – integrated radiance - *interferometer DC signal*



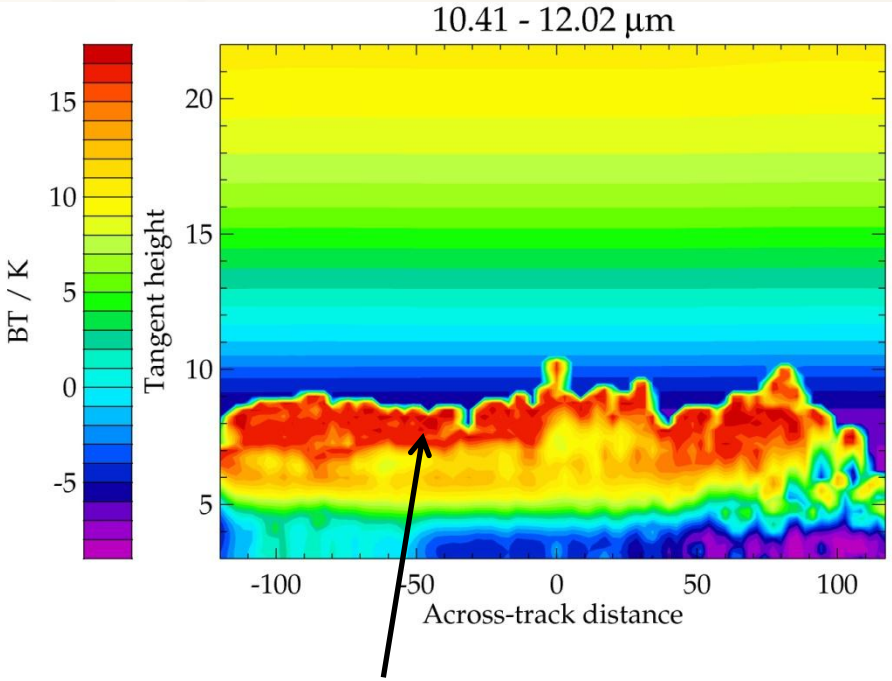
Courtesy of T.Guggenmoser

Simulated IR Limb Image – BT diff. 10.4 – 12.0 μm

Eyjafjallajokull (Iceland) plume 7th May 2010



IR signature for cirrus substituted for ash



Calipso x-section
- ***OD scaled from 0.2 to 0.02***
- ***ash IR spectral properties***

Courtesy of R.Siddans

PREMIER will detect thin ash layers and precisely determine their altitude as well as ultra thin cirrus

Summary

- *PREMIER will bring into sharp focus processes controlling atmospheric composition in the height-range most important to climate*
- *For the first time, 3-D distributions will be observed from space with the resolution needed to quantify*:
  - **Impacts on surface climate of detailed distributions & dynamical coupling**
  - **Trace gas exchange between troposphere and stratosphere**
  - **Impacts of convective and pyroconvective outflows on UTLS**
  - **Processes linking higher layers with the lower troposphere**
- *In addition, PREMIER will contribute to global height-resolved monitoring (GCOS) and advance operational applications in the GMES Atmosphere Core Service***.**
- ***Report for Mission Selection*** http://www.esa.int/esaEO/SEMUMJ8X73H_index_0.html
- ***Analyses of airborne campaign & satellite data and simulation studies ongoing for Delta Report and User Consultation (2013)***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UK scientific & technical contributions enabled through NCEO & CEOI
→ opportunity for key role in mission implementation