Long-term Monitoring of Atmospheric Trace Gases by using ground-based FTIR spectrometry at the Izaña Atmospheric Observatory

Omaira García

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SPARC Regional Workshop, 12-13 January, 2015

Agencia Estatal de Meteorología

Karlsruhe Institute of Technology

da-en.congresoseci.com/sparc2015

- **Welcome**
- Workshop Venue and Location
- Workshop Programme
- Abstract Submission
- Abstract book
- Accommodation
- Workshop Registration & Hotel Booking
- City Information

Welcome

Dear Colleagues,

We are pleased to announce the SPARC regional workshop on the "Role of the stratosphere in climate variability and prediction" which will be held on 12-13 January 2015 in the Palacio de la Madraza, Granada, Spain, back-to-back with the SPARC SSG meeting (13-16 January 2015).

SPARC (Stratosphere-troposphere Processes And their Role in Climate) is a core project of the World Climate Research Program (WCRP) that coordinates international efforts to bring knowledge of the stratosphere to bear on relevant issues in climate variability and prediction. SPARC provides expertise in several key areas related to climate variability and climate change, such as dynamical variability, ozone, stratosphere-troposphere dynamical coupling, gravity waves, temperature trends, data assimilation, etc.

Holding a "local workshop" in combination with the annual SPARC Scientific Steering Group (SSG)

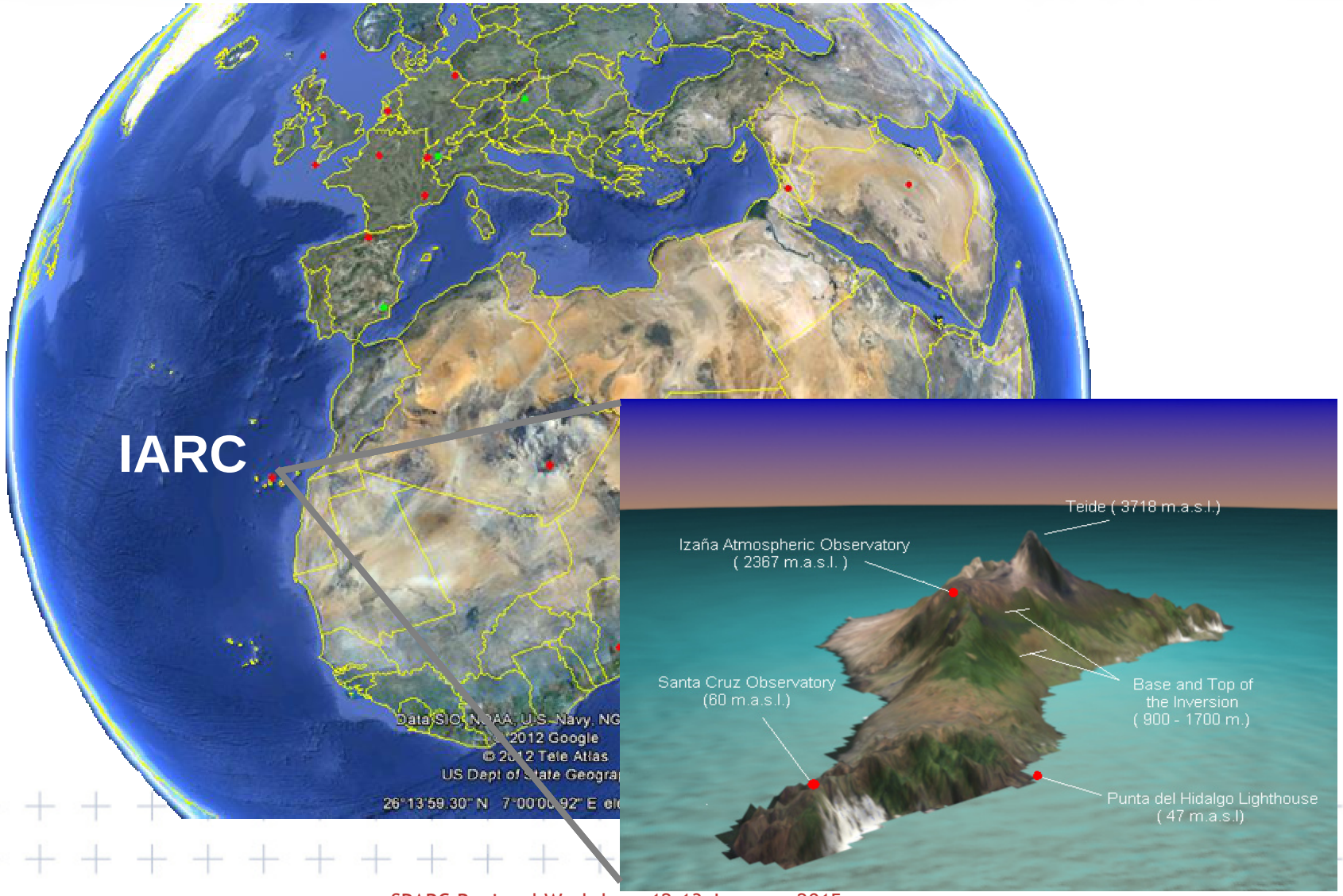
t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CCEQFjAA&url=http%3A%2F%2Fgranada-en.congresoseci.com%2Fsparc2015&ei=K98RVfD6B4e7Ua-WgdgP&usg=AFQjCNHdVeYJHaoyenp

Outline

1. Izaña Atmospheric Research Center (IARC) – Izaña Atmospheric Observatory (IAO)
   - Where we are, Who we are, and What we do
2. Monitoring of Atmospheric Composition using Fourier Transform Infrared Spectrometry (FTS)
   - FTS Technique
   - Potential of FTS observations through some examples:
     Is the Ozone Layer recovering? What happens at Tropics-Subtropics?
     Can FTIR spectra be used to detect tropospheric/stratospheric regional scale GHGs variations?
     Validation of space-based observations?
3. Summary+Conclusions

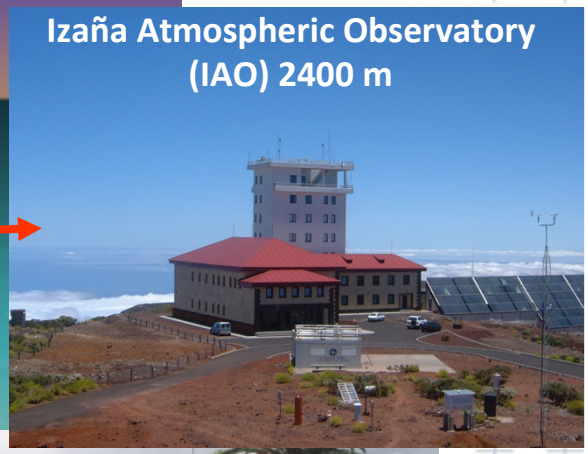
Izaña Atmospheric Research Center (IARC)- Izaña Atmospheric Observatory (IAO)

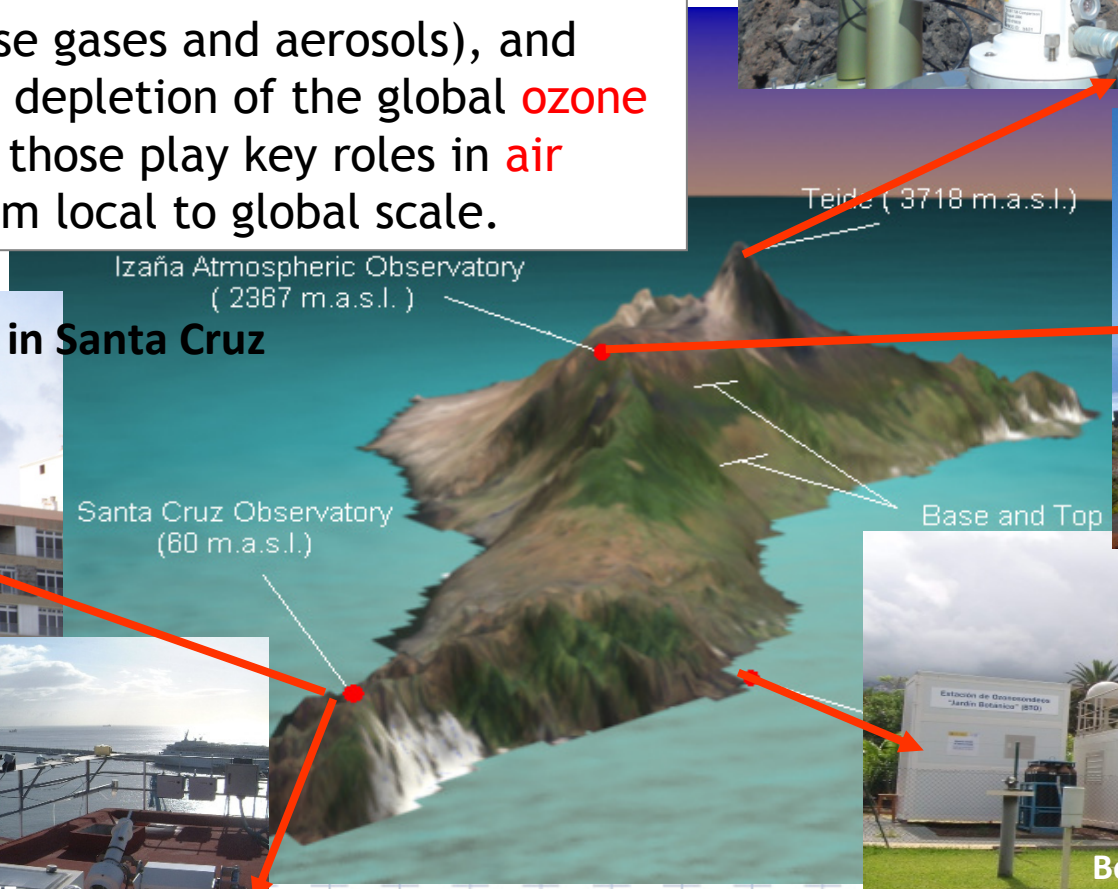
Strategic Geographic Location

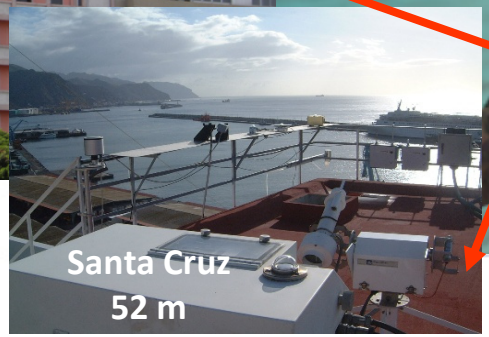


The IARC's Mission

The IARC-AEMET conducts monitoring and research related to atmospheric constituents that are capable of forcing change in the climate of the Earth (greenhouse gases and aerosols), and may cause depletion of the global ozone layer, and those play key roles in air quality from local to global scale.





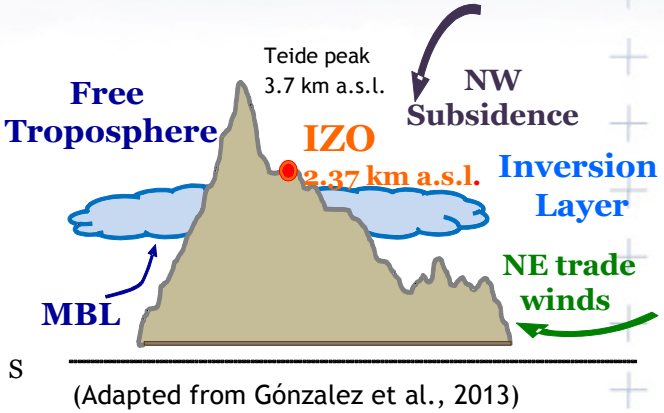


Why the Izaña Atmospheric Observatory (IAO)?

Above a strong subtropical temperature inversion layer

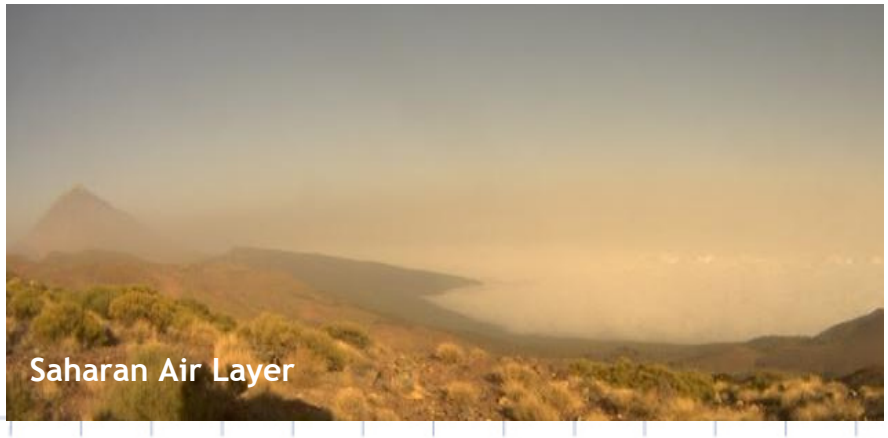
Quasi-permanent subsidence regime

Representative of the background free-troposphere



(Adapted from Gónzalez et al., 2013)

Excellent conditions for in-situ and remote sensing observations



(Rodríguez et al., 2014)

Why the Izaña Atmospheric Observatory (IAO)?

Comprehensive programme for the atmospheric composition monitoring.

2015

Chemical and Physcical Atmospheric Observations

In **March 1985** the Spanish-German BAPMoN station was inaugurated and in **1990** the Izaña Observatory was part of the Global Atmosheric Watch Programme (WMO).

1970-1990

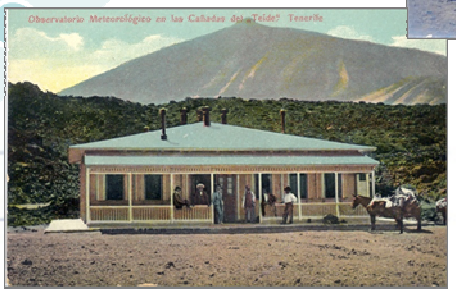
Meteorogical and Atmospheric Observations

1916

Only Meteorological Observations

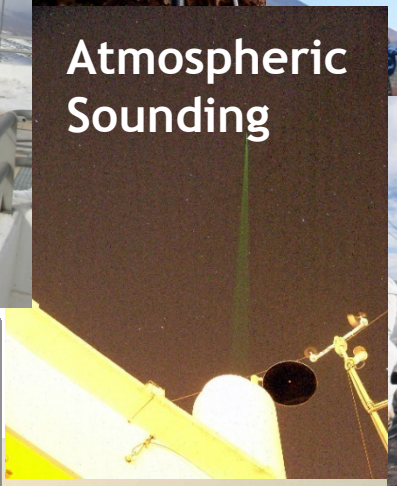
In **January 1916** the Izaña Meteorological Observatory was inaugurated.

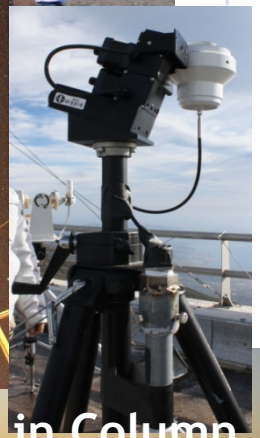
1909

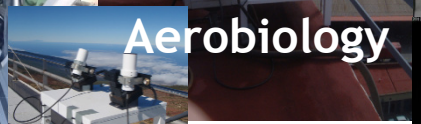


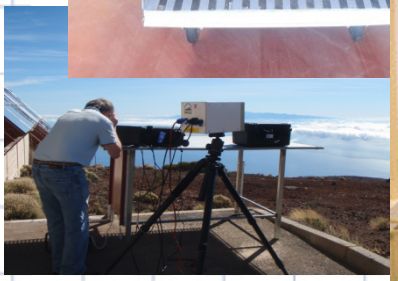
In **November 1909** the first observations of winds in the upper atmosphere of Canarias were performed in La Cañada de la Grieta-Teide.

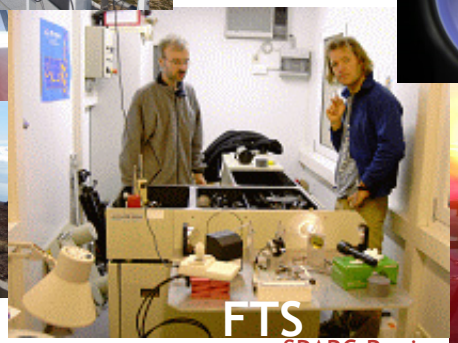
Comprehensive Programme for Atmospheric Composition Monitoring

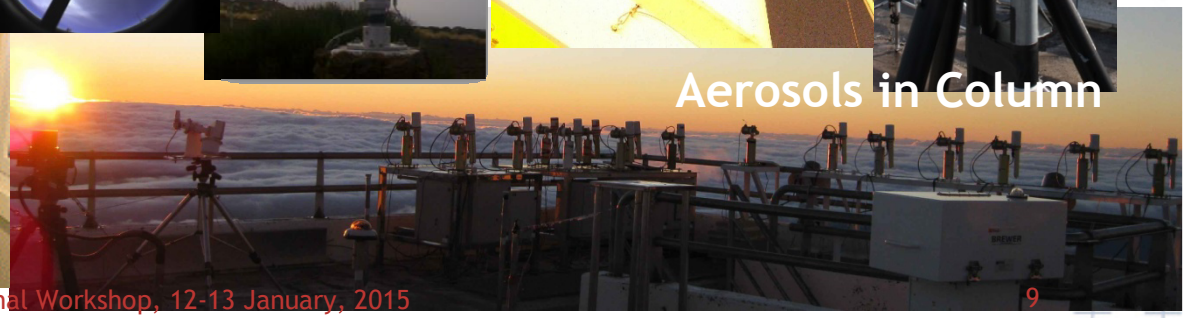










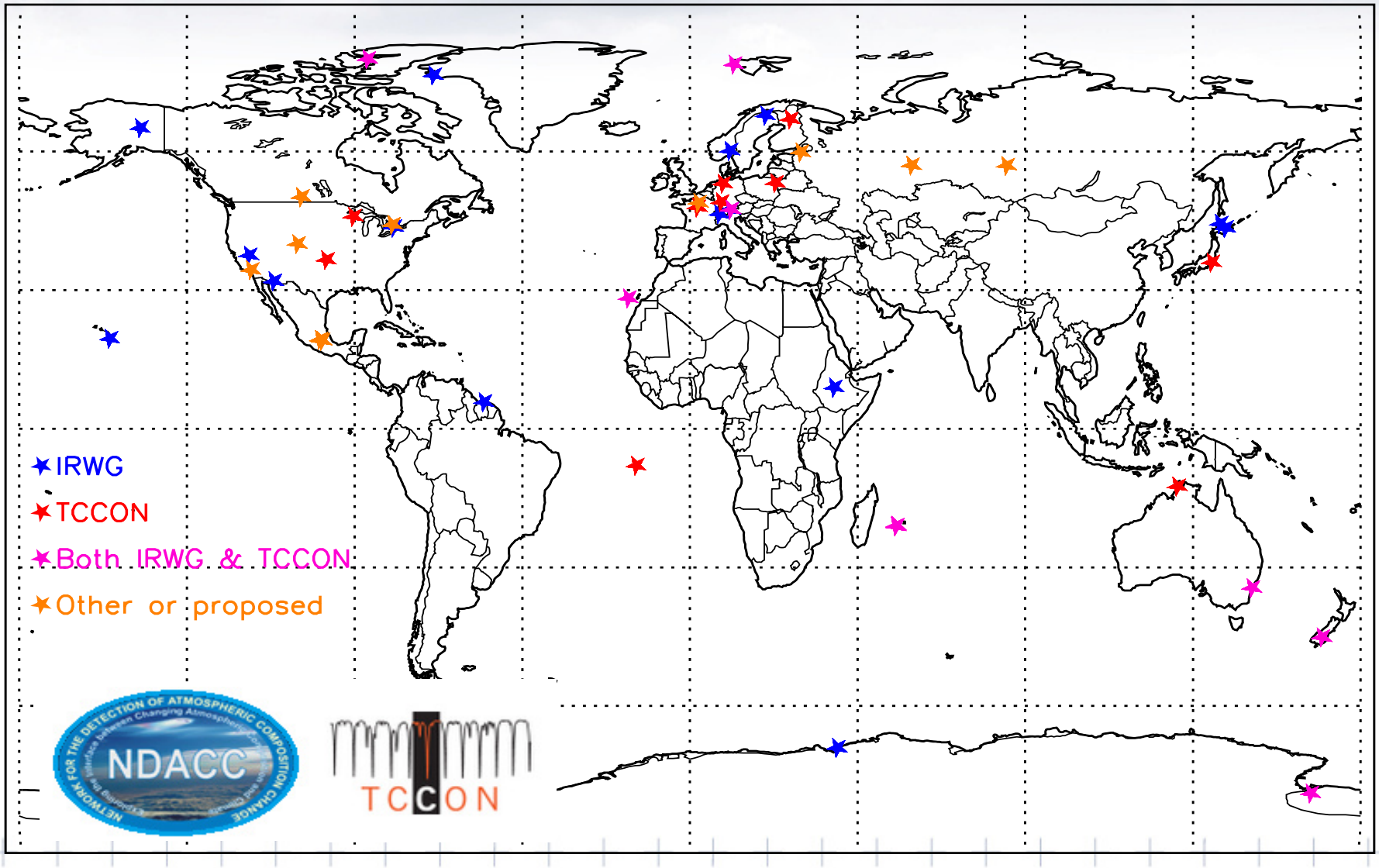


Reference Station at a global scale

Participation in many international networks and research initiatives

Monitoring of Atmospheric Composition using Fourier Transform Infrared Spectrometry

Global Ground-Based FTIR Spectrometers



NDACC/IRWG: Network for the Detection of Atmospheric Composition Change/Infrared Working Group
TCCON: Total Carbon Column Observation Network

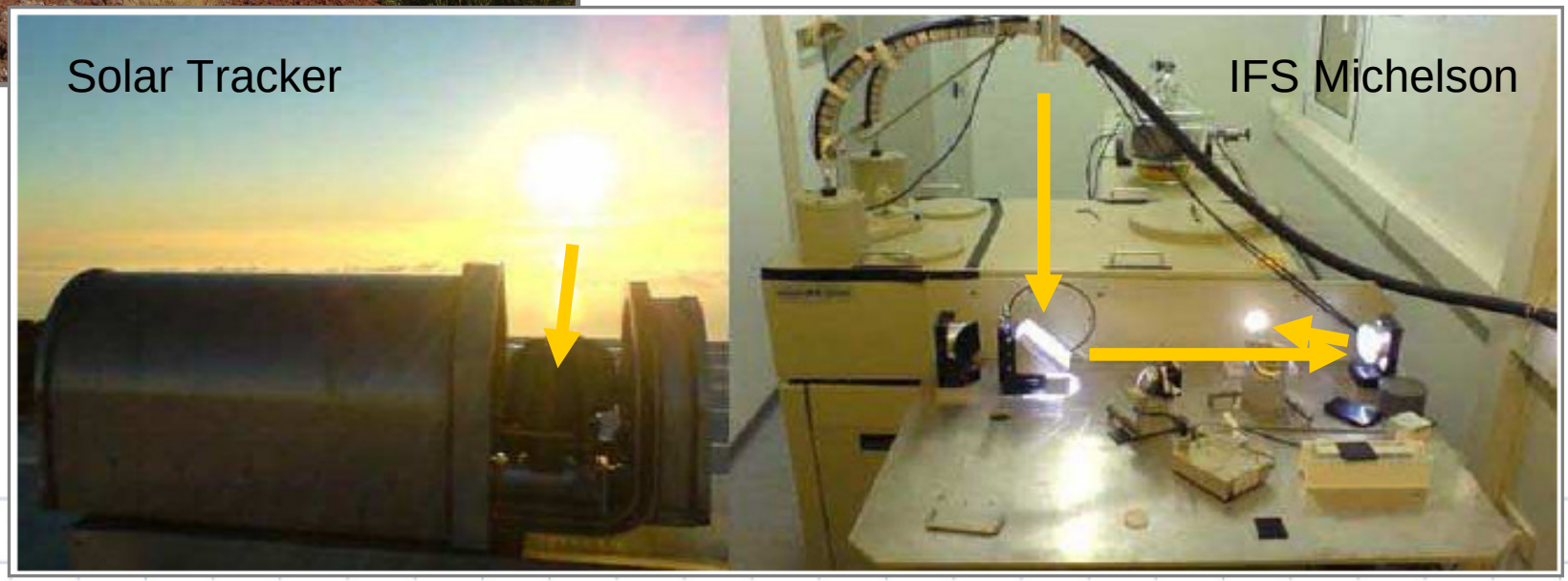
Fourier Transform Sprectrometry (FTS) Technique

FTS measurements at Izaña since 1999 as a result of the close collaboration between:

AEMet Agencia Estatal de Meteorología

KIT Karlsruhe Institute of Technology

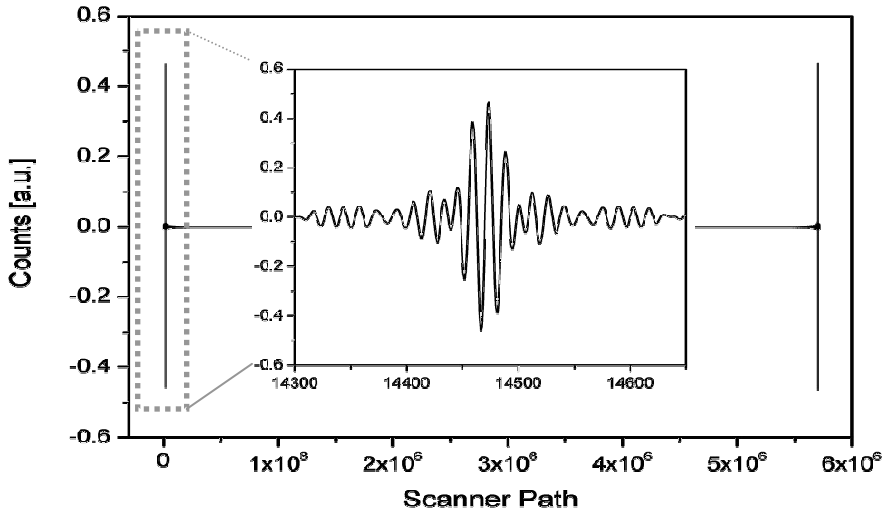
BOD (KIT-Germany)
Ground-based remote-sensing using Fourier-transform interferometers (BOD)

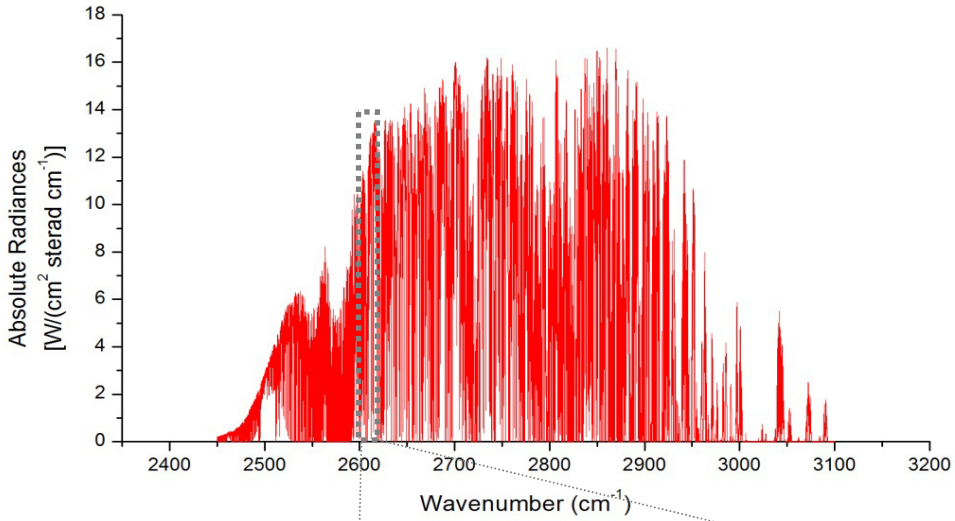


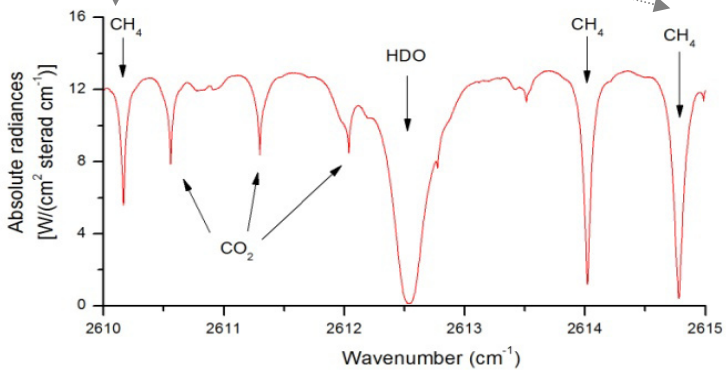
Adquisition and Processing

$$S(K) = \Im(I(x)) = \int_{-\infty}^{\infty} e^{-i2\pi Kx} I(x)dx$$

Interferogram → **Solar Absorption Spectrum**







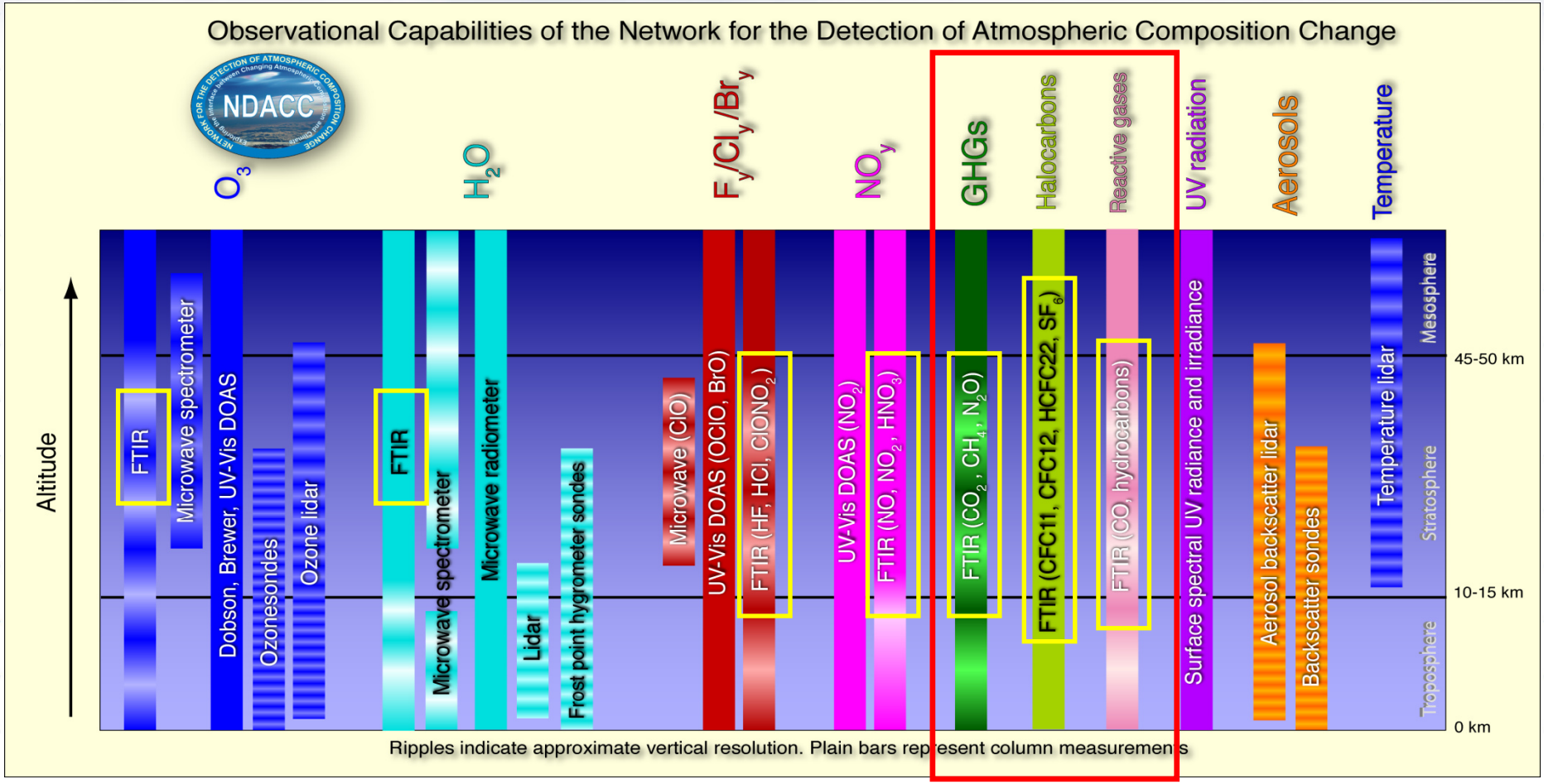
PROFFIT (Hase et al., 2004)

Line position → Which gas is absorbing

Line depths/area → The amount of the absorbing gas

Line shape → Altitude distribution of the absorbing gas

>25 Absorbing Gases in NIR-MIR (Total Column and Vertical Profile)



In **yellow** all trace gases observed by FTS technique
In **red** those trace gases observed **ONLY** by FTS technique

Our current goal "Observing Earth Climate System and its Changes"

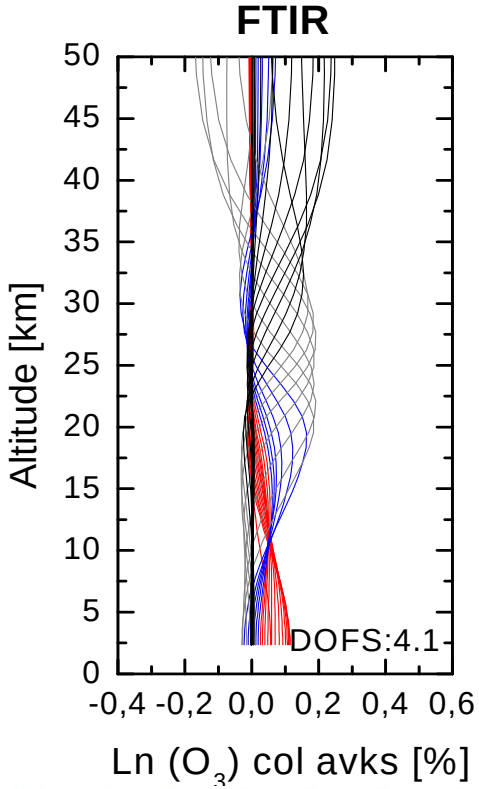
1) Long-term monitoring of Ozone Related Species, Greenhouse Gases, Water Vapour (including isotopologues)
   - Optimisation and Development of New Observation Strategies
   - Continuous Documentation of Quality
   - Global Representativeness
2) Validation of Satellite data and Climate Models

Connect the long-term monitoring to "Researching the Changes and its Causes"

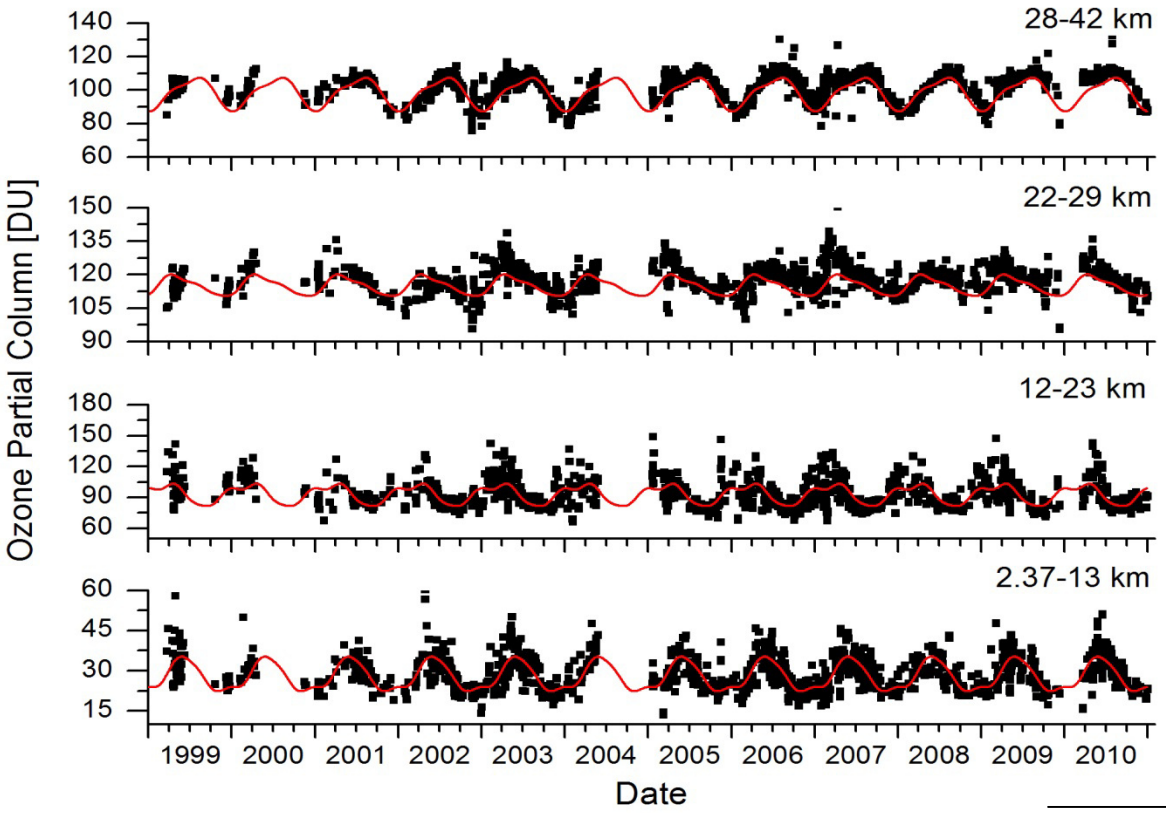
Potential of FTS Observations through Examples

Is the ozone layer recovering? What happens at Tropics-Subtropics?

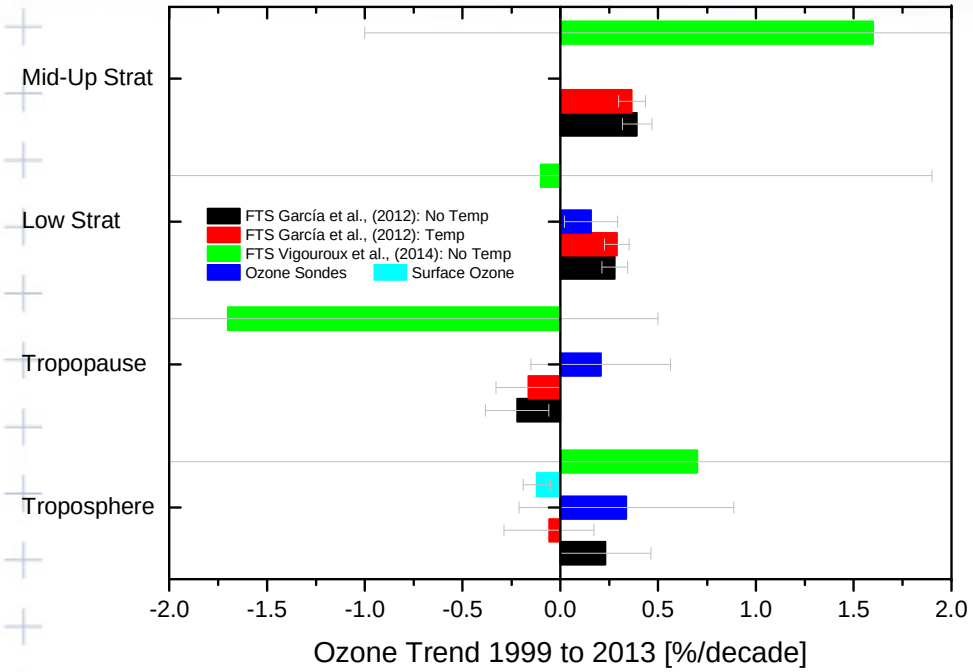
Lack of Observations at Subtropics!!
Strategic Location of Izaña: Transition between Tropics and Mid-latitudes



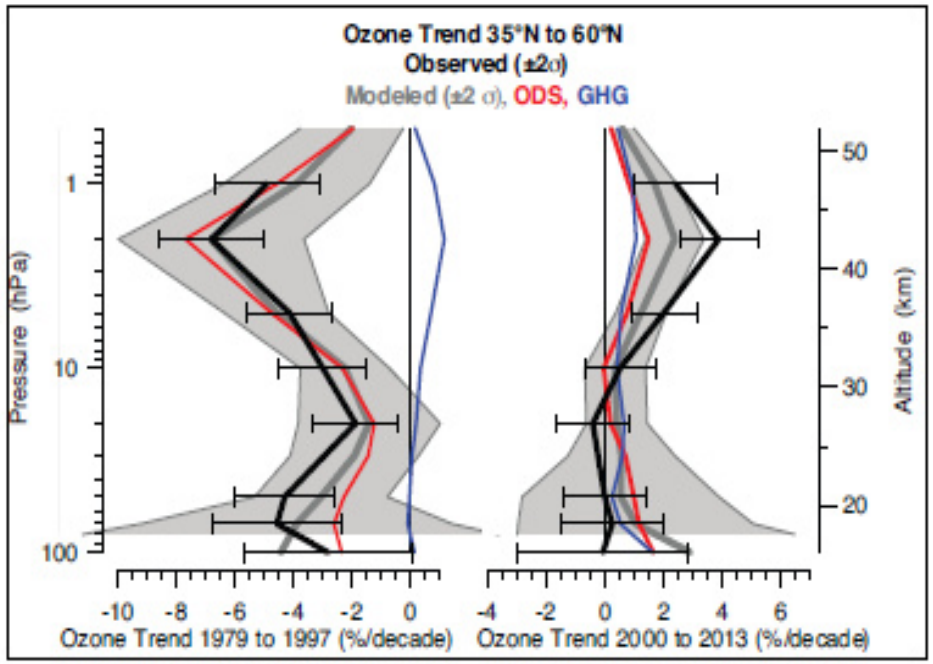
troposphere, tropopause, lower stratosphere, middle/upper stratosphere



Izaña FTS



WMO (2014)



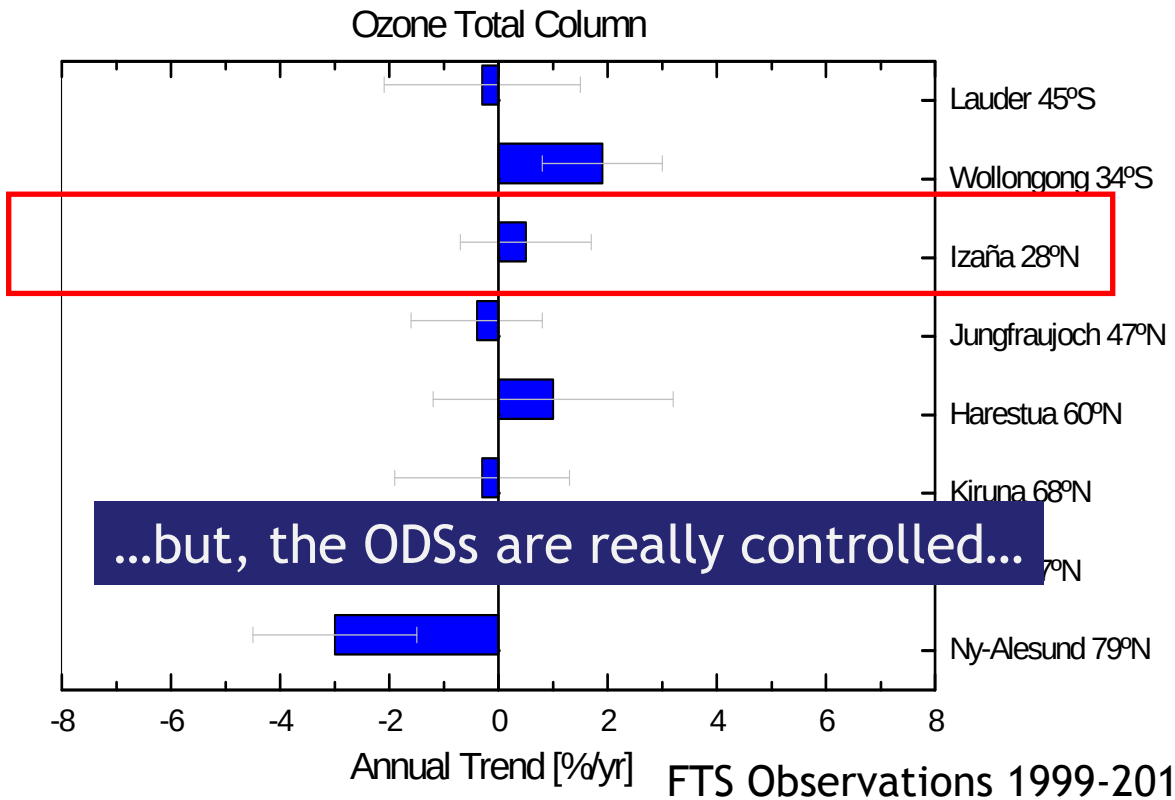
Izaña FTS ozone profile observations are within the SPARC/IO3C/IGACO-O3/NDACC (SI2N) Initiative

WMO (2014)

The decline in ODS abundances and the cooling by increased CO2 are estimated to have contributed roughly equally to the observed upper stratospheric ozone increases.

Stratification of Ozone Recovery, but…

… Non significant Recovery of Ozone Total Columns (in agreement with WMO 2010)



…but, the ODSs are really controlled…

FTS Observations 1999-2013 (Vigouroux et al., 2014)

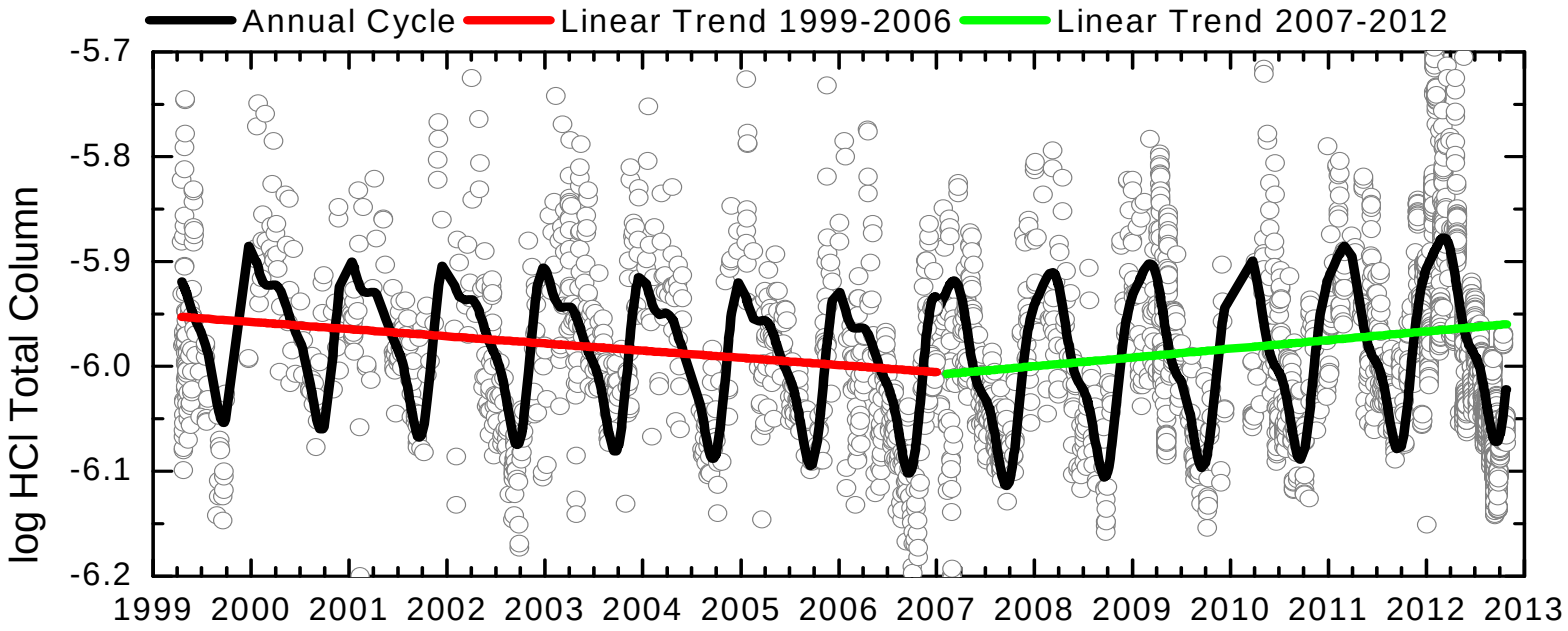
WMO (2014)

As controlled ozone-depleting substances decline, the evolution of the ozone layer in the second half of the 21st century will largely depend on the atmospheric abundances of CO_2, N_2O, and CH_4.

Are Ozone Concentrations at risk in Northern Hemisphere?

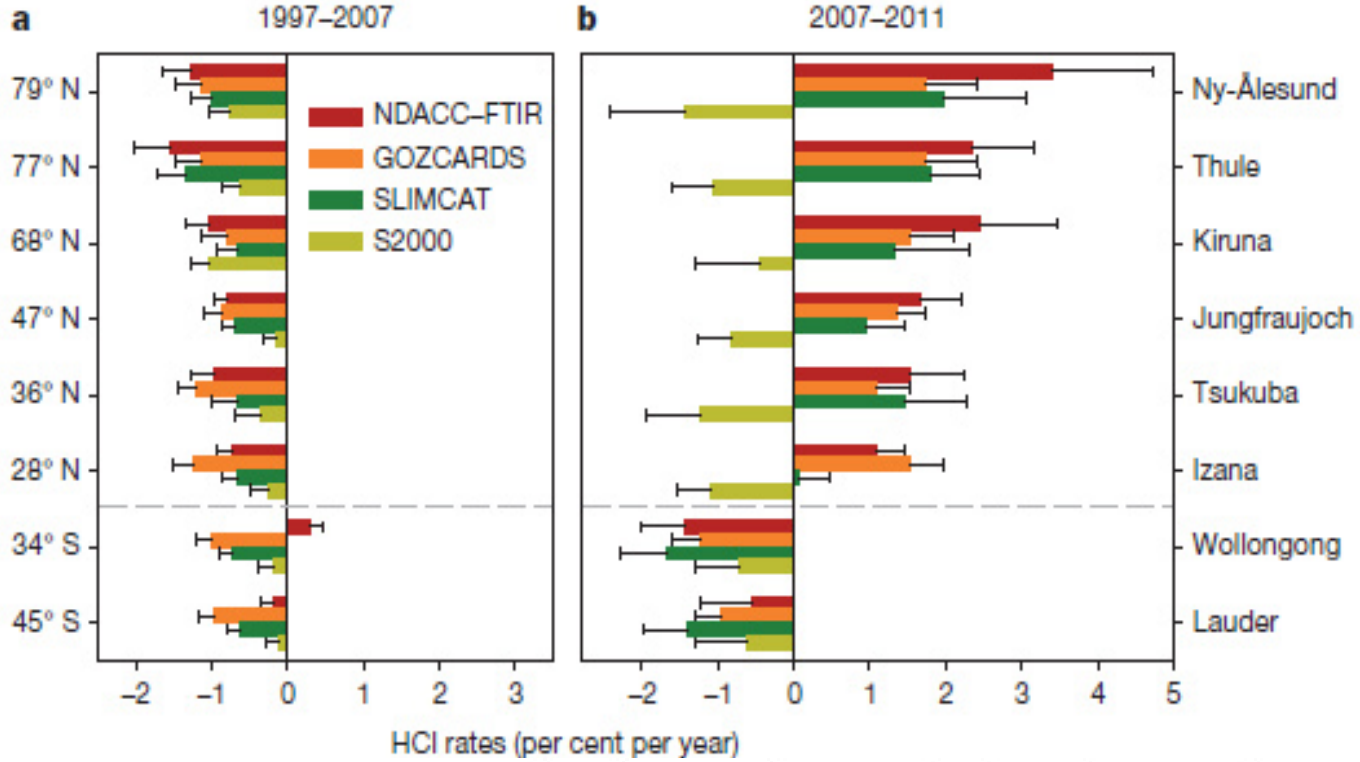
Unexpectedly, stratospheric HCl is increasing again after a decade of gradual decline

Izaña FTS

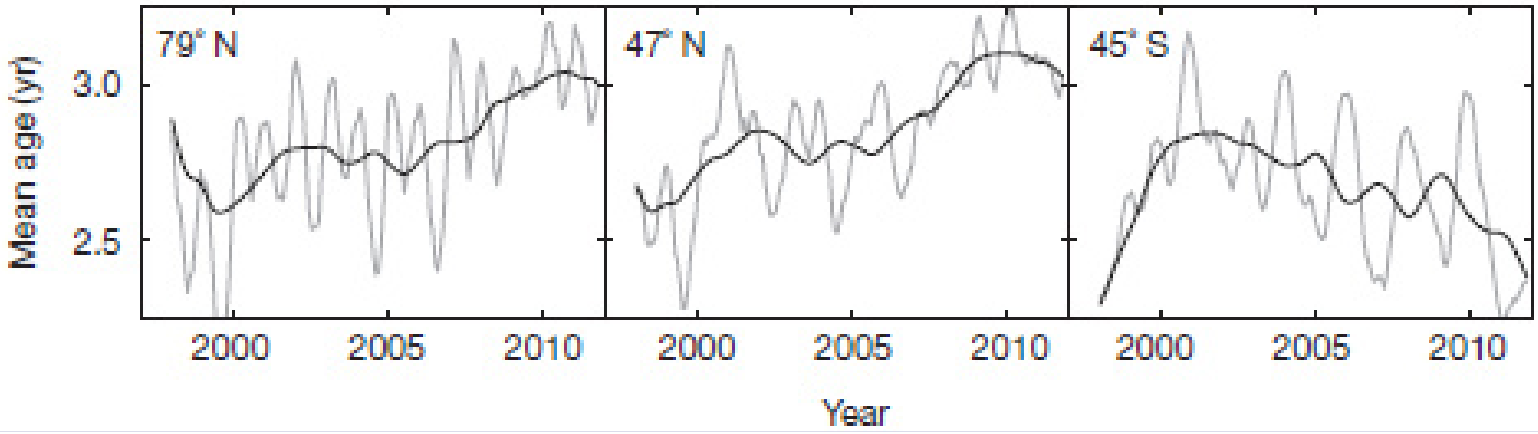


(Mahieu et al., 2014, Nature)

Are Ozone Concentrations at risk in Northern Hemisphere?



Slowdown in the Northern Hemisphere atmospheric circulation

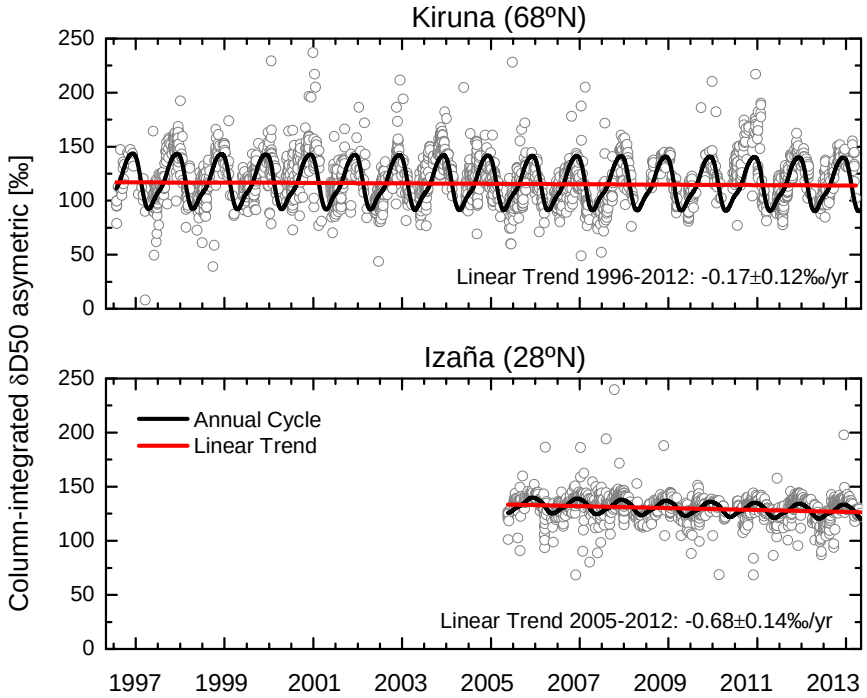


Role played by O_3 isotope ratios: additional information regarding their sources, sinks, and transport

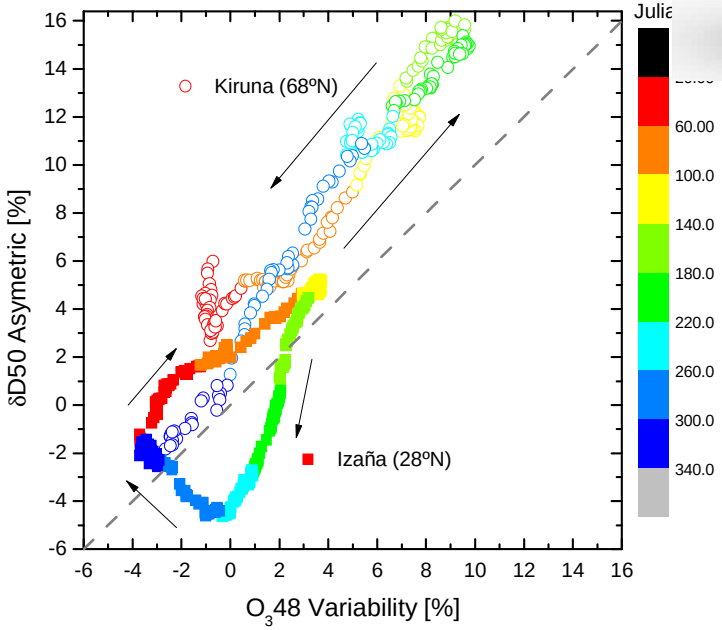
$$\delta D50\ \text{Asymetric}\ [‰] = \left(\frac{^{48}O_3}{^{50}O_3} - 1 \right) \cdot 1000$$

$^{48}O_3$= Total Column of $^{48}O_3$
$^{50}O_3$ = Total Column of $^{50}O_3$ Asymetric

Long-term time series



Annual Cycle



Significant Decreasing Trends: Different long-term Patterns for the two main Ozone isotopes

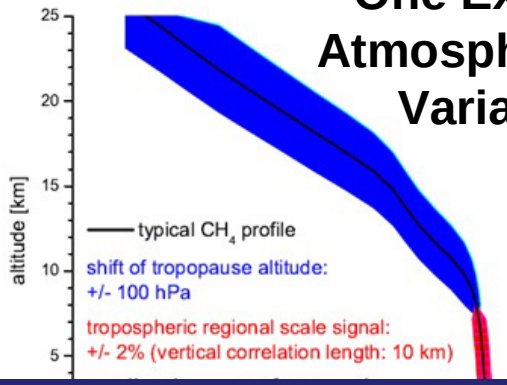
Different Inter-annual Patterns for Subtropical and Polar Latitudes

Can FTS spectra be used to detect regional-scale tropospheric/stratospheric GHGs variations?

- The tropospheric regional-scale CH_4 variations are rather small.

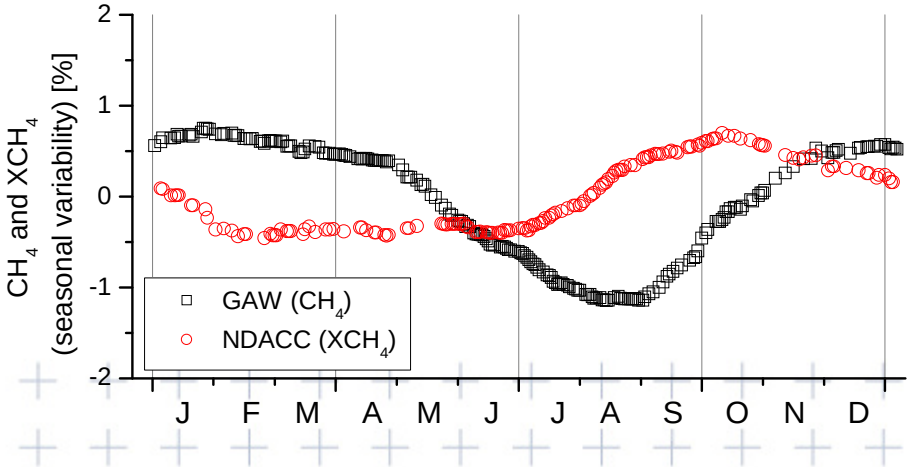
- Near-surface CH_4 variations and variations due to the tropopause altitude shifts are large and strongly affect the total column signal.

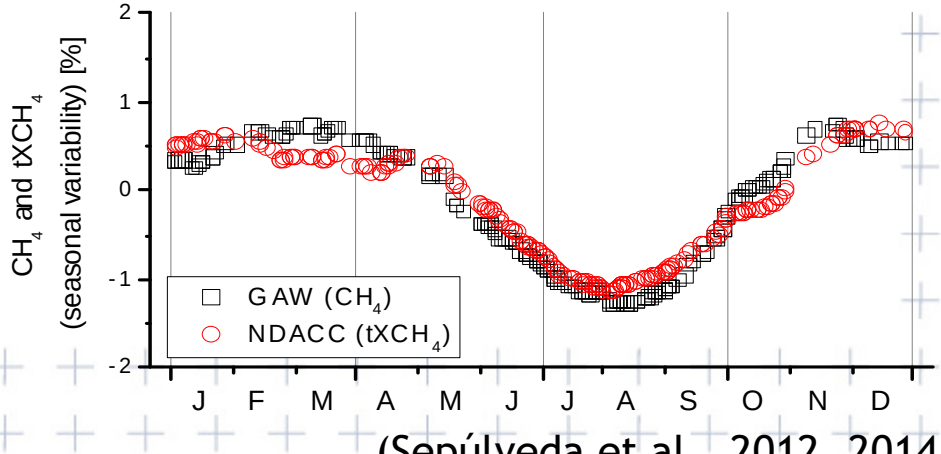
One Example: Atmospheric CH_4 Variations



Problem: Total column-averaged CH_4 is no a good proxy for the troposphere

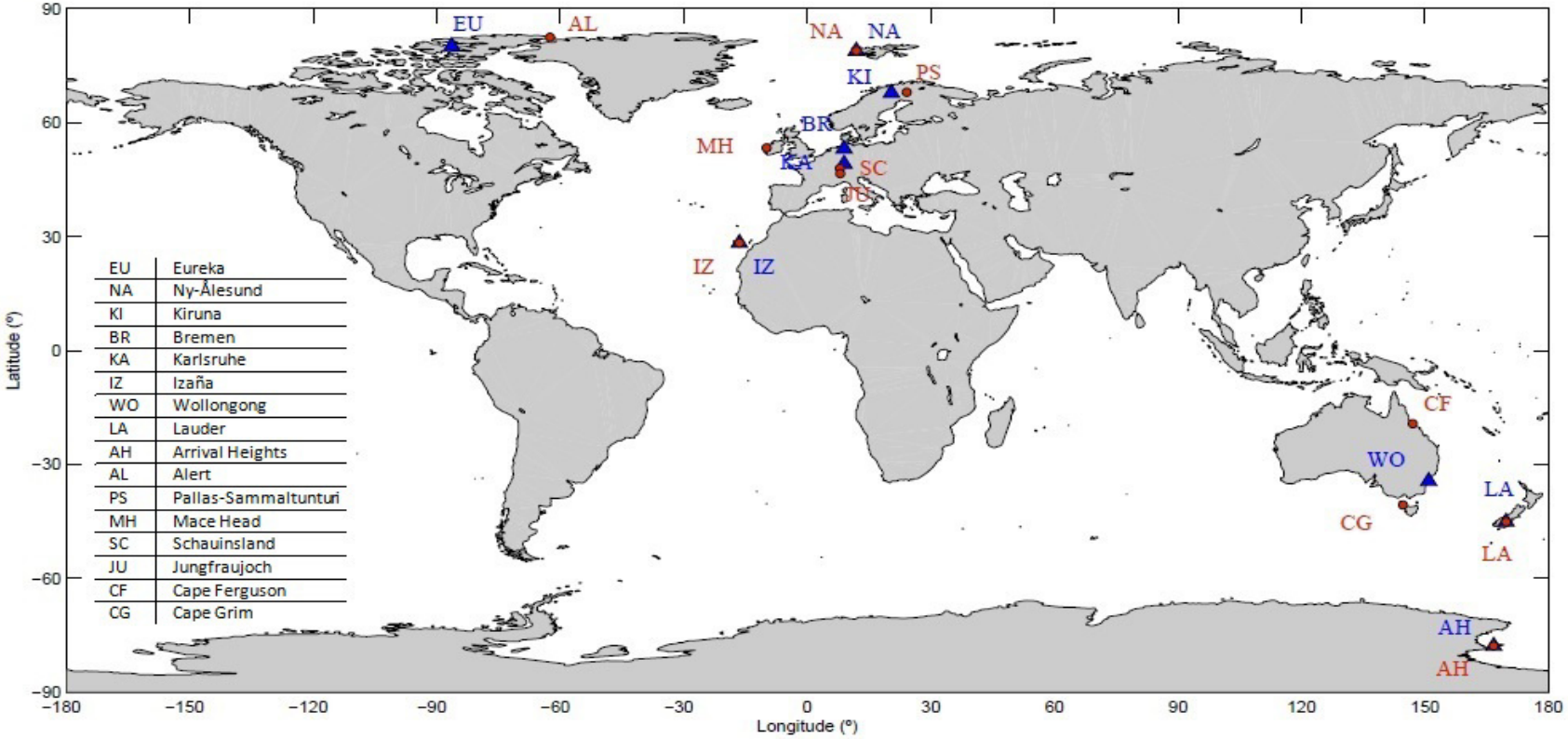
Solution: Optimisation of Inversion Strategies



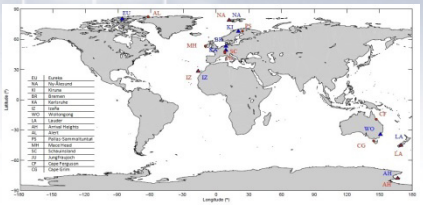


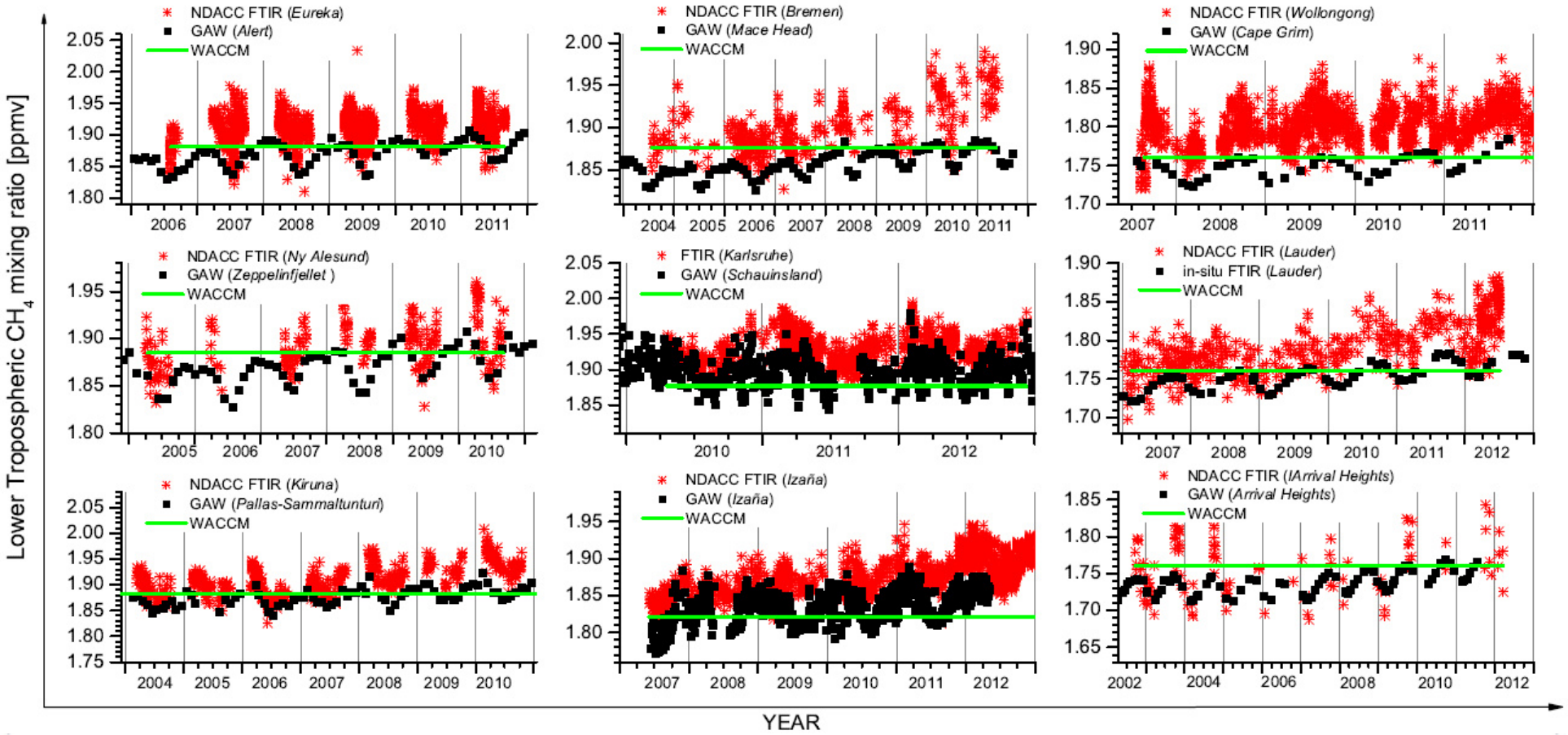
(Sepúlveda et al., 2012, 2014)

Global representativeness



Global representativeness



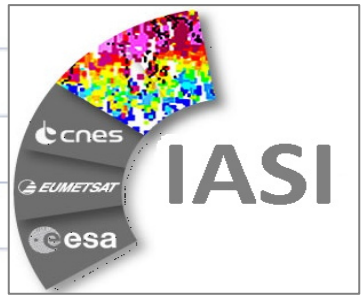


Similar results have been obtained for other GHGs, like N_2O (García et al., 2014).

Validation of Space-Based Observations

Izaña FTIR

Validation of Space-Based Observations



SCIAM
Scanning Imaging Absorpt

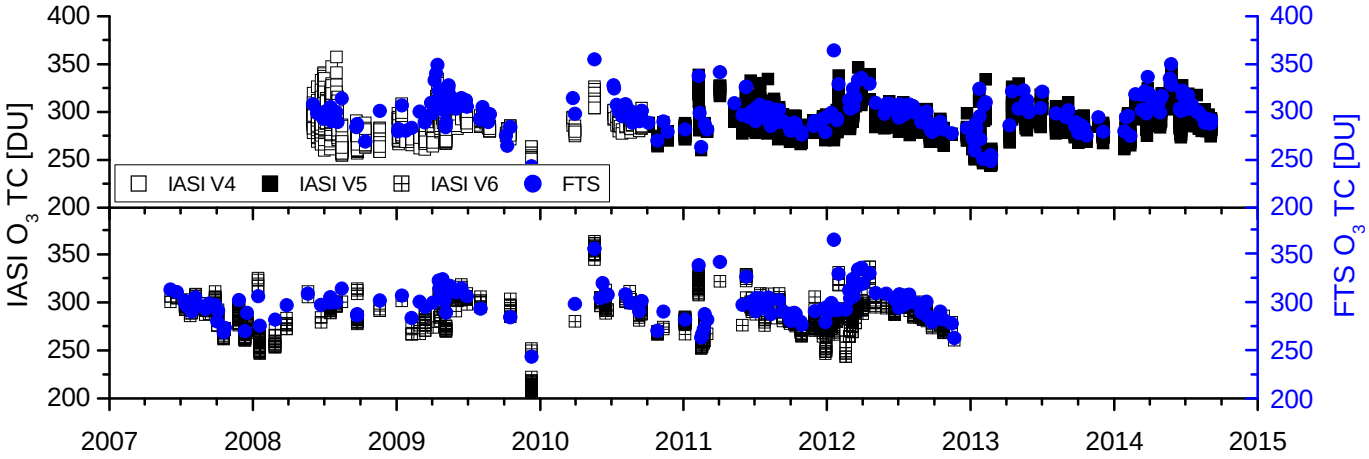
Comprehensive long-term validation of operational IASI-A and IASI-B trace gas products

VALIASI

New retrievals: tropospheric {H_2O,δD} distributions

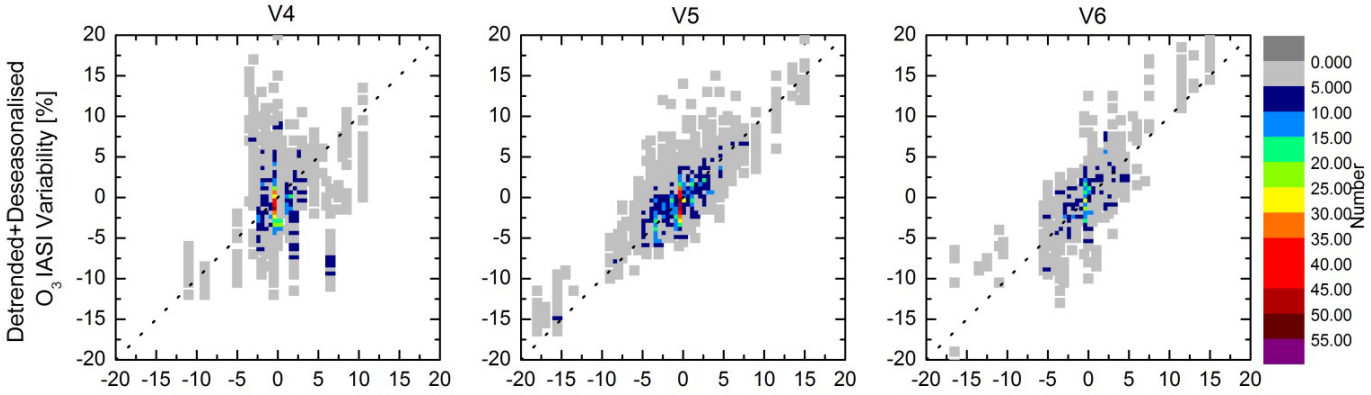
Does IASI and the ground-based FTS system observe the same anomalies? Are the different IASI versions consistent?

An Example O_3

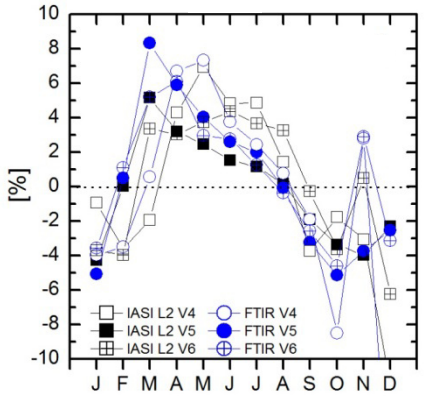


Analysis on Different Time Scales

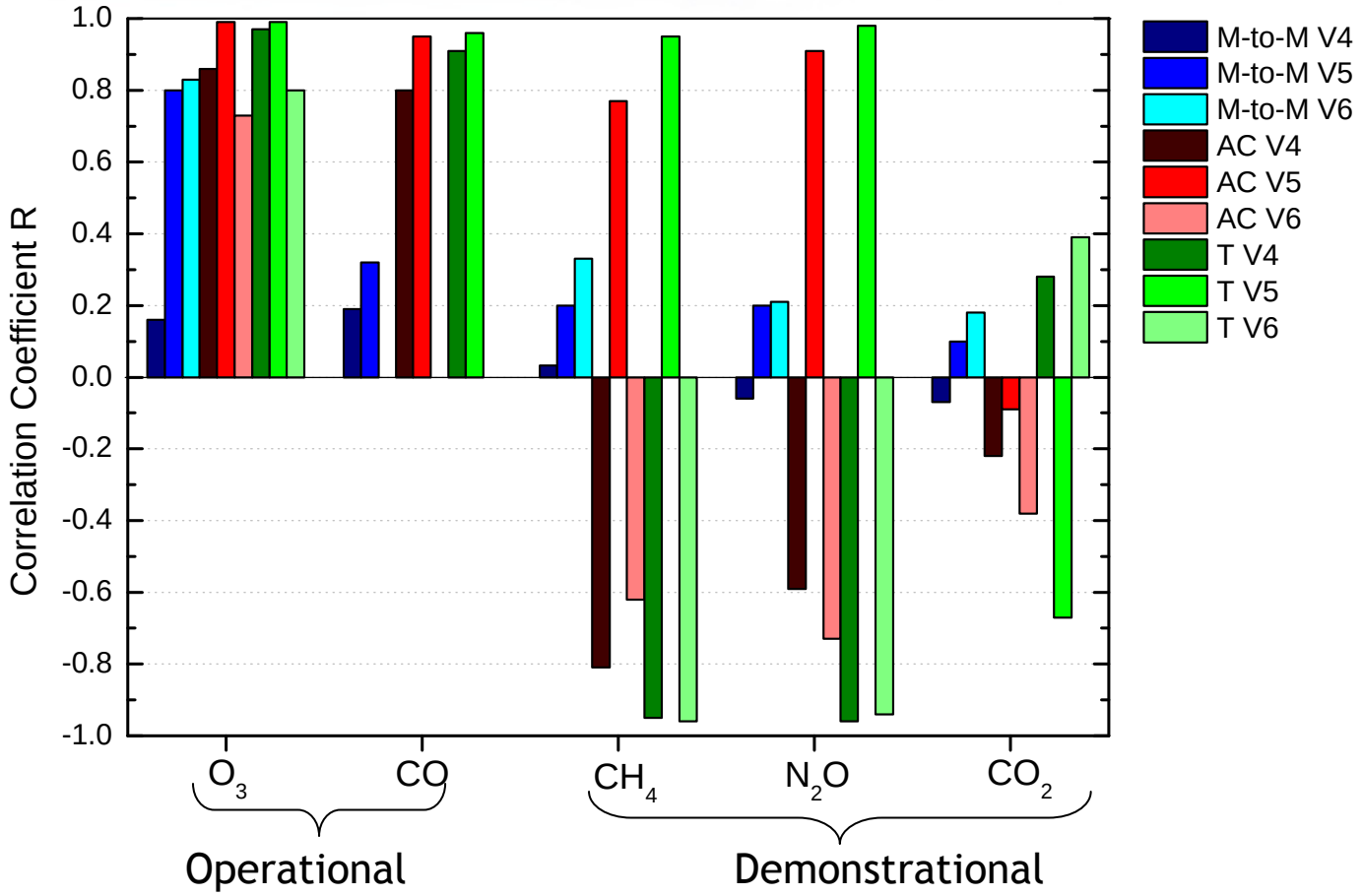
Measurement-to-Measurement



Annual Cycles



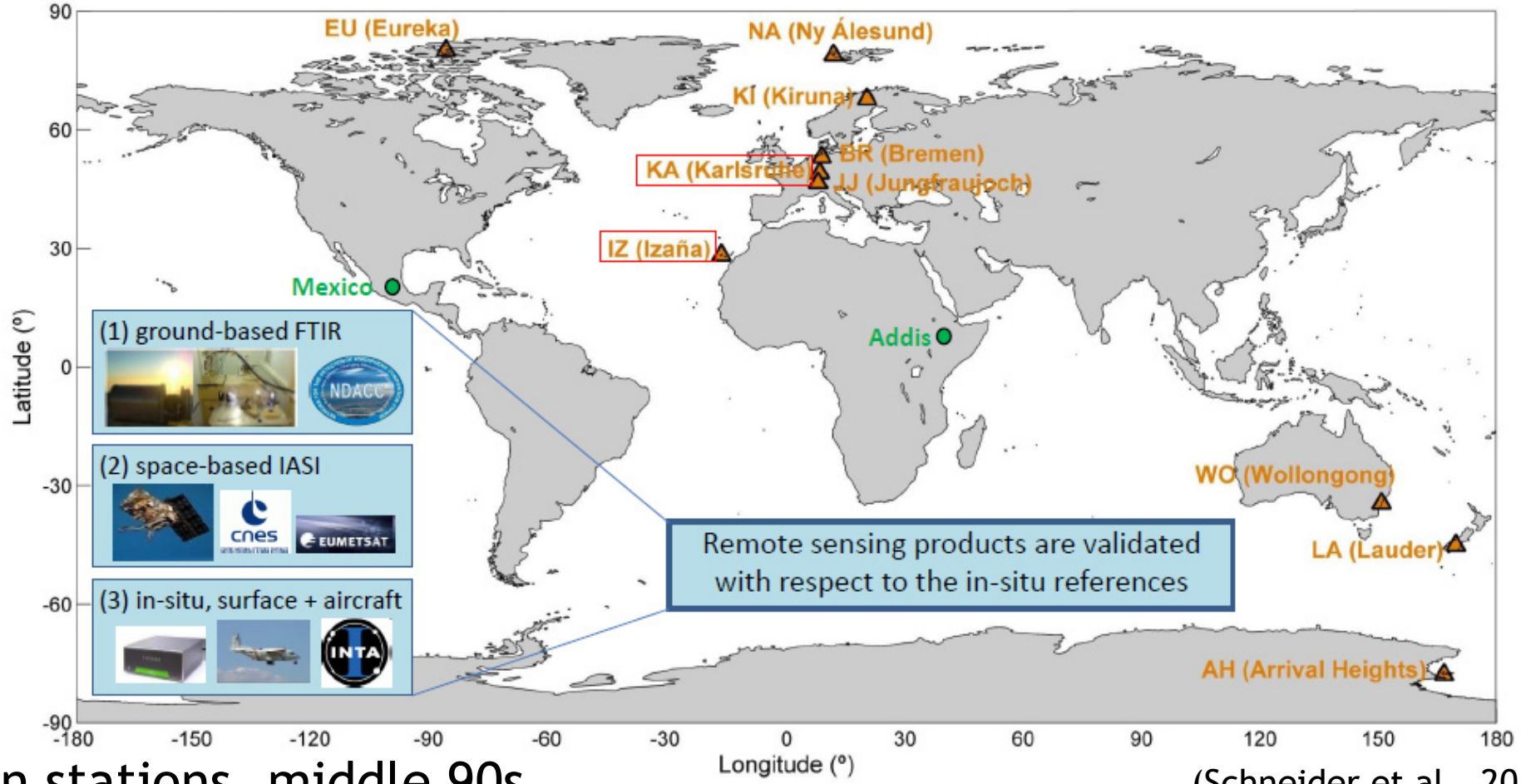
For all IASI trace gas products…



Validation on Near-Real Time (www.novia.aemet.es) ⇒ Detection of anomalies and instrumental issues!!

ERC project **MUSICA:**

MUlti-platform remote **S**ensing of **I**sotopologues for investigating the **C**ycle of **A**tmospheric water

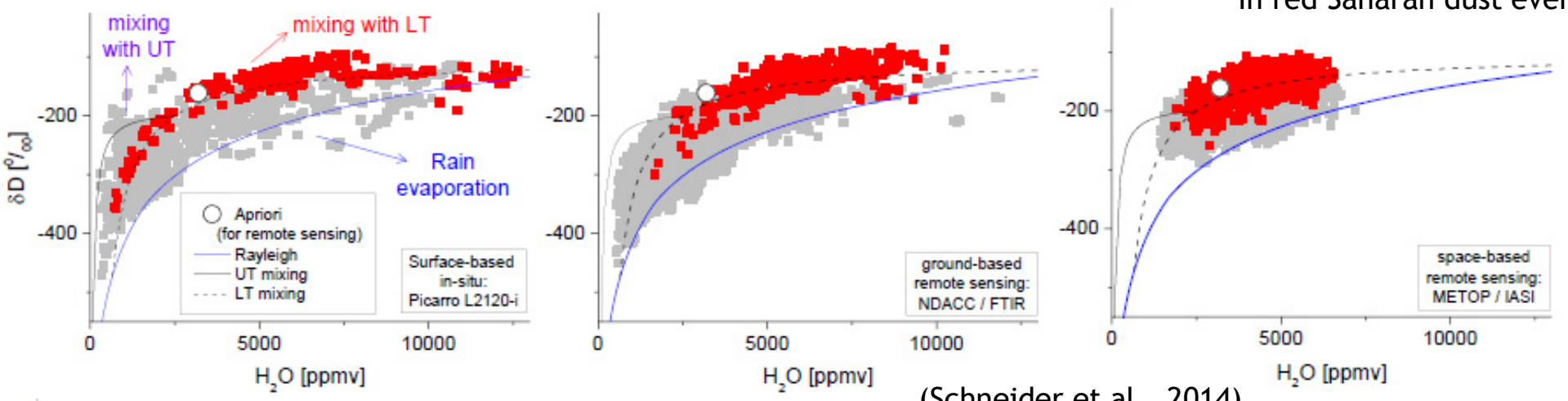


Ten stations, middle 90s

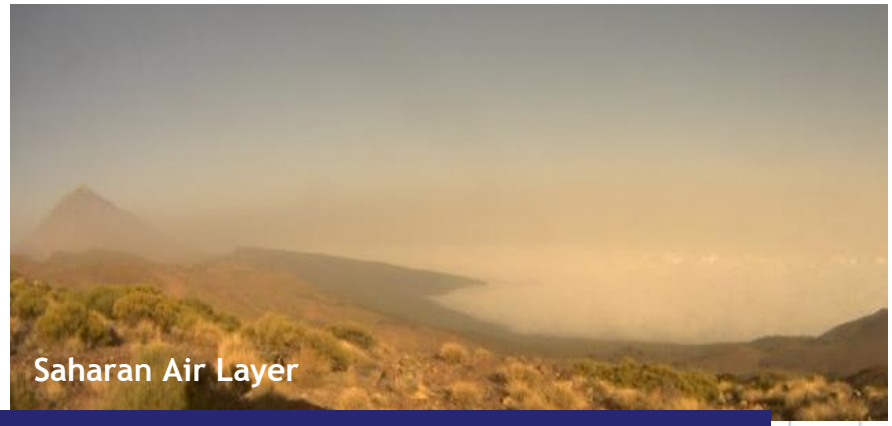
(Schneider et al., 2012)

To what extent is δD complementary to H_2O? $\delta D \sim HD^{16}O/H_2{}^{16}O$

In red Saharan dust events

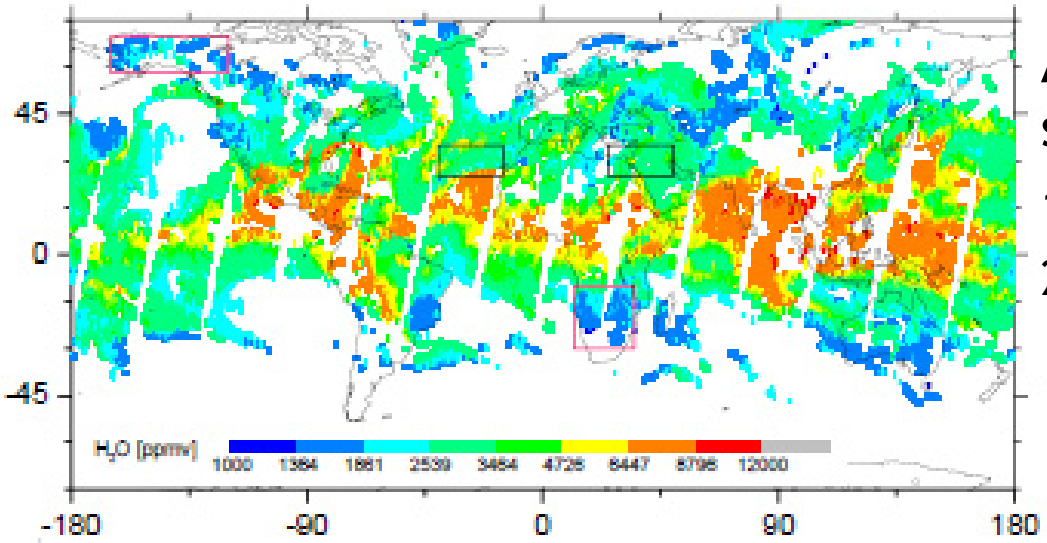


(Schneider et al., 2014)



Validation of the remote sensing isotopes products

Metop-IASI {H_2O,δD} distributions at a global scale



Areas with similar humidity, but significantly different fractionations:

1. North Atlantic-Arabia
2. Alaska -Africa

Added value of tropospheric {H_2O,δD} remote sensing distributions

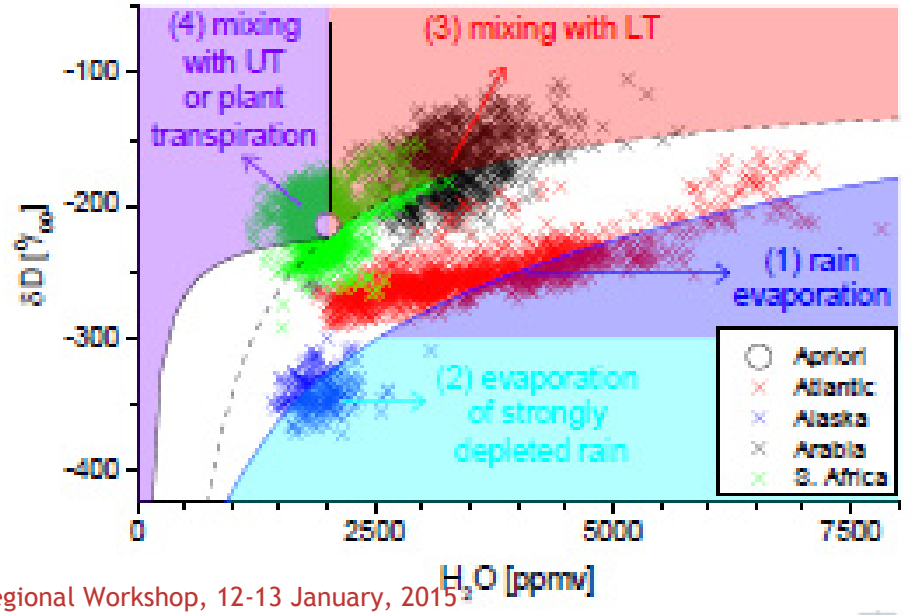
Different processes control the humidity:

1.1. Rain Evaporation

1.2. Evaporation of strongly depleted rain

2.1. Mixing with lower troposphere

2.2. Mixing with upper troposphere or plant transpiration



Summary+Conclusions

- Complex interplay among atmospheric constituents → multi-variable techniques, like the FTS experiments, are very useful.
- One single measurement technique is able to monitor many atmospheric gases → Great potential for analysing independently tropospheric and stratospheric signals.
- Many Applications: Observing and Researching the atmospheric composition and its changes, validating of space-based data and models, operational assimilation in global models (near future),…

Open door for collaborations and comments!!

To know more … http://izana.aemet.es

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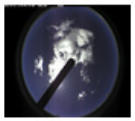
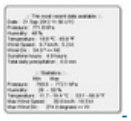


DATOS METEO



¡¡NUEVO VÍDEO !!Nubes de evolución.

Participación en la Conferencia de Satélites Meteorológicos EUMETSAT 2014

El Centro de Investigación Atmosférica de Izaña, junto al Instituto de Tecnología de Karlsruhe (KIT, Alemania), ha presentado dos TRABAJOS en la "EUMETSATMeteorologicalSatelliteConference 2014", que tuvo lugar en Ginebra (Suiza) del 22 al 26 de Septiembre de 2014. El congreso EUMETSAT es la reunión anual por excelencia de todos aquellos grupos internacionales involucrados en el desarrollo y uso de observaciones satelitales bajo los programas de observación de EUMETSAT (EuropeanOrganisationfortheExploitation of Más...


Many Thanks for
your Attention!!

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