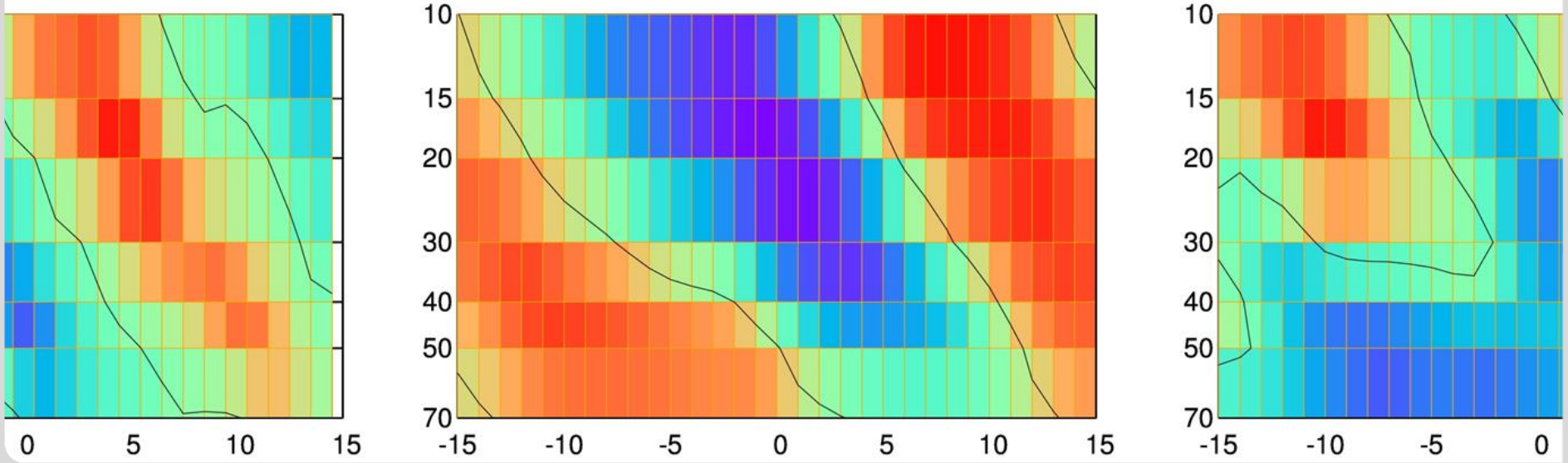
Karlsruher Institut für Technologie

National Centre for Atmospheric Science
NATURAL ENVIRONMENT RESEARCH COUNCIL

Topic 1: Atmosphere and Climate

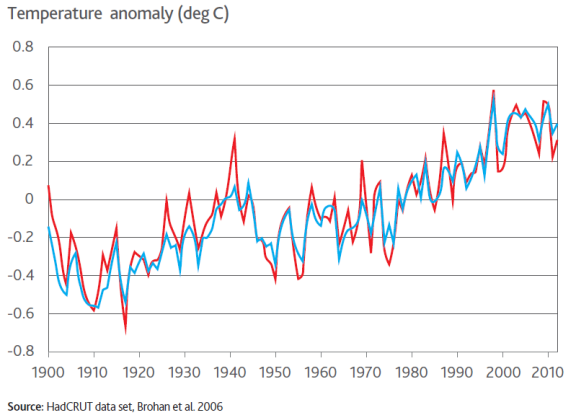
Peter Braesicke

IMK-ASF



“LAUDATO SI’, mi’ Signore”
“Praise be to you, my Lord”

Climate as a common good



23. The climate is a common good, belonging to all and meant for all. At the global level, it is a complex system linked to many of the essential conditions for human life. A very solid scientific consensus indicates that we are presently witnessing a disturbing warming of the climatic system.

THE HOLY FATHER

FRANCIS

ON CARE FOR OUR COMMON HOME

One in five Australians don...

www.independent.co.uk/environment/climate-change/one-in-five-australians-dont-b

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News > Environment > Climate Change

One in five Australians don't believe in climate change

17 per cent of Australians disbelieved in climate change, followed by 15 per cent of people in Norway, 13 per cent in New Zealand and 12 per cent of Americans

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i100 NOW TRENDING

1 Do you see faces in everything? This might be why

2 Liz Kendall had the best response when a journalist asked how much she weighed

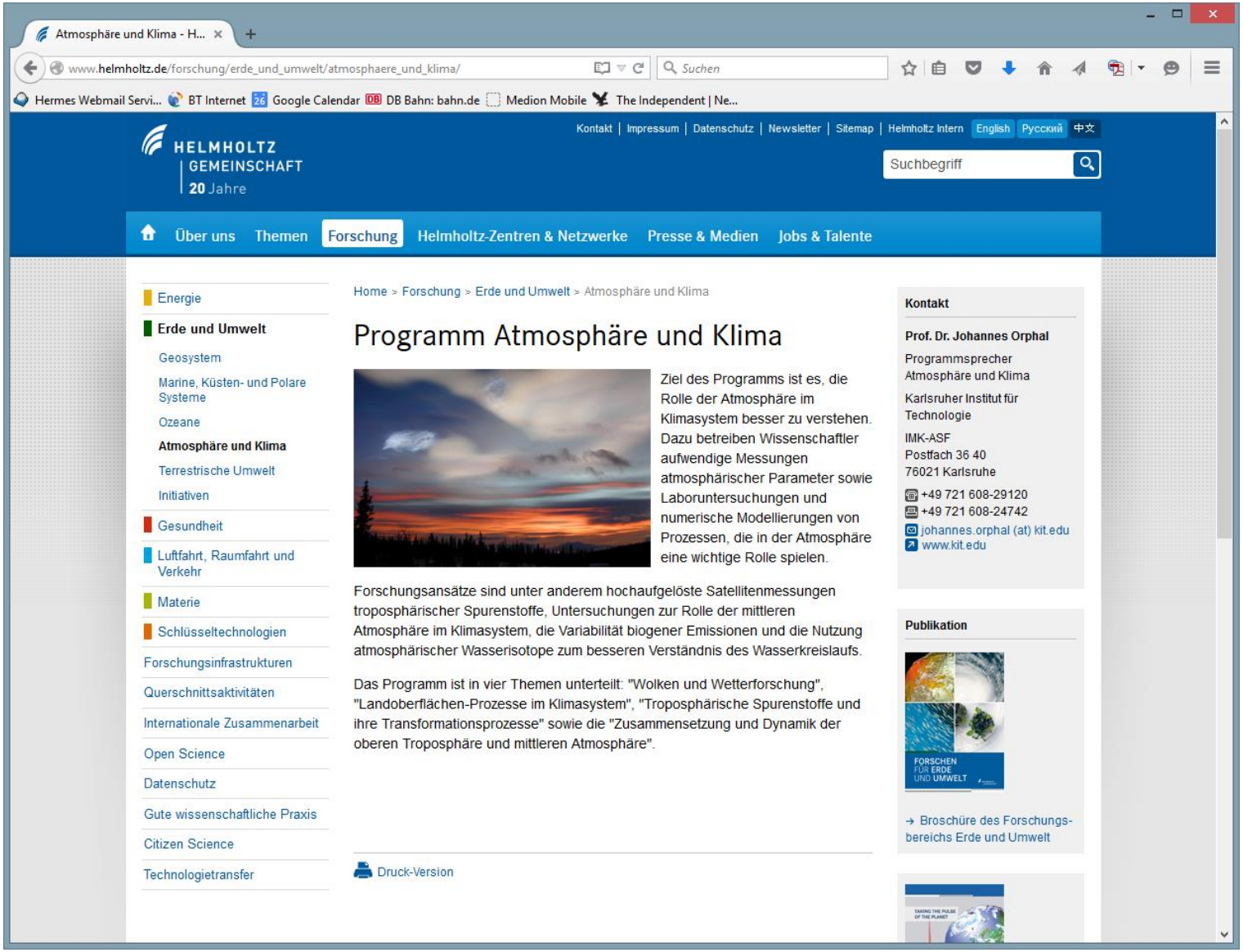
3 Donald Trump actually said this about John McCain

4 This is the best age to get married if you don't want to get divorced

5 The Express has the perfect explanation for the Queen's 'Nazi salute'

Climate matters:
Living with environmental change

- How is our research organised?
- The structure and elements of the atmosphere
- Observing the state of the atmosphere
- Modelling the atmosphere and its time evolution
  - The ozone hole as an example ….
- Concluding remarks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Programm Atmosphäre und Klima
Ziel des Programms ist es, die Rolle der Atmosphäre im Klimasystem besser zu verstehen. Dazu betreiben Wissenschaftler aufwendige Messungen atmosphärischer Parameter sowie Laboruntersuchungen und numerische Modellierungen von Prozessen, die in der Atmosphäre eine wichtige Rolle spielen.
Forschungsansätze sind unter anderem hochaufgelöste Satellitenmessungen troposphärischer Spurenstoffe, Untersuchungen zur Rolle der mittleren Atmosphäre im Klimasystem, die Variabilität biogener Emissionen und die Nutzung atmosphärischer Wasserisotope zum besseren Verständnis des Wasserkreislaufs.
Das Programm ist in vier Themen unterteilt: "Wolken und Wetterforschung", "Landoberflächen-Prozesse im Klimasystem", "Troposphärische Spurenstoffe und ihre Transformationsprozesse" sowie die "Zusammensetzung und Dynamik der oberen Troposphäre und mittleren Atmosphäre".
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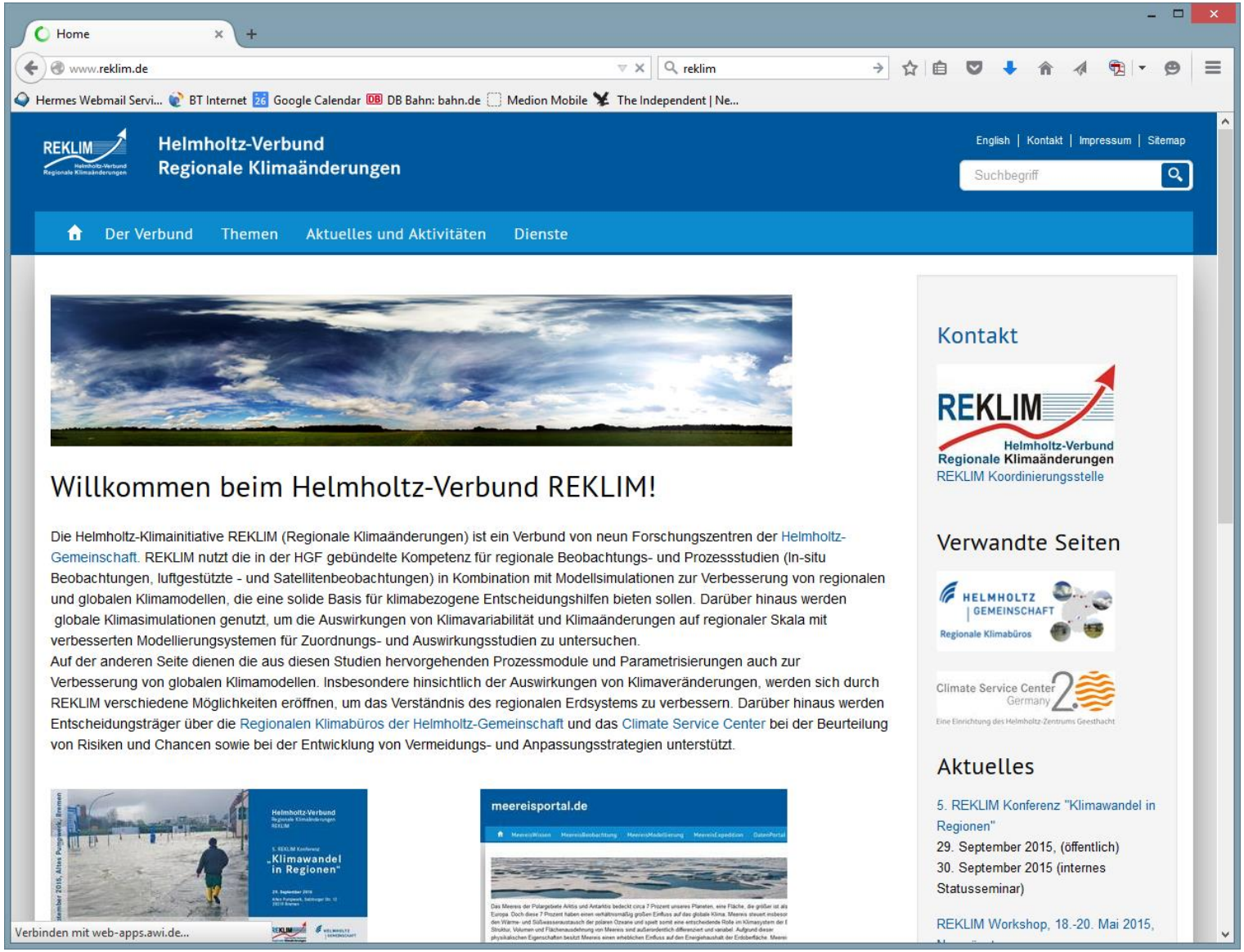
Publikation
FORSCHEN FÜR ERDE UND UMWELT
→ Broschüre des Forschungs-bereichs Erde und Umwelt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REKLIM
Helmholtz-Verbund
Regionale Klimaänderungen
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Suchbegriff
Der Verbund Themen Aktuelles und Aktivitäten Dienste
Willkommen beim Helmholtz-Verbund REKLIM!
Die Helmholtz-Klimainitiative REKLIM (Regionale Klimaänderungen) ist ein Verbund von neun Forschungszentren der Helmholtz-Gemeinschaft. REKLIM nutzt die in der HGF gebündelte Kompetenz für regionale Beobachtungs- und Prozessstudien (In-situ Beobachtungen, luftgestützte - und Satellitenbeobachtungen) in Kombination mit Modellsimulationen zur Verbesserung von regionalen und globalen Klimamodellen, die eine solide Basis für klimabezogene Entscheidungshilfen bieten sollen. Darüber hinaus werden globale Klimasimulationen genutzt, um die Auswirkungen von Klimavariabilität und Klimaänderungen auf regionaler Skala mit verbesserten Modellierungsystemen für Zuordnungs- und Auswirkungsstudien zu untersuchen.
Auf der anderen Seite dienen die aus diesen Studien hervorgehenden Prozessmodule und Parametrisierungen auch zur Verbesserung von globalen Klimamodellen. Insbesondere hinsichtlich der Auswirkungen von Klimaveränderungen, werden sich durch REKLIM verschiedene Möglichkeiten eröffnen, um das Verständnis des regionalen Erdsystems zu verbessern. Darüber hinaus werden Entscheidungsträger über die Regionalen Klimabüros der Helmholtz-Gemeinschaft und das Climate Service Center bei der Beurteilung von Risiken und Chancen sowie bei der Entwicklung von Vermeidungs- und Anpassungsstrategien unterstützt.
Kontakt
REKLIM Koordinierungsstelle
Verwandte Seiten
Regionale Klimabüros
Climate Service Center Germany
Aktuelles
5. REKLIM Konferenz "Klimawandel in Regionen"
29. September 2015, (öffentlich)
30. September 2015 (internes Statusseminar)
REKLIM Workshop, 18.-20. Mai 2015,
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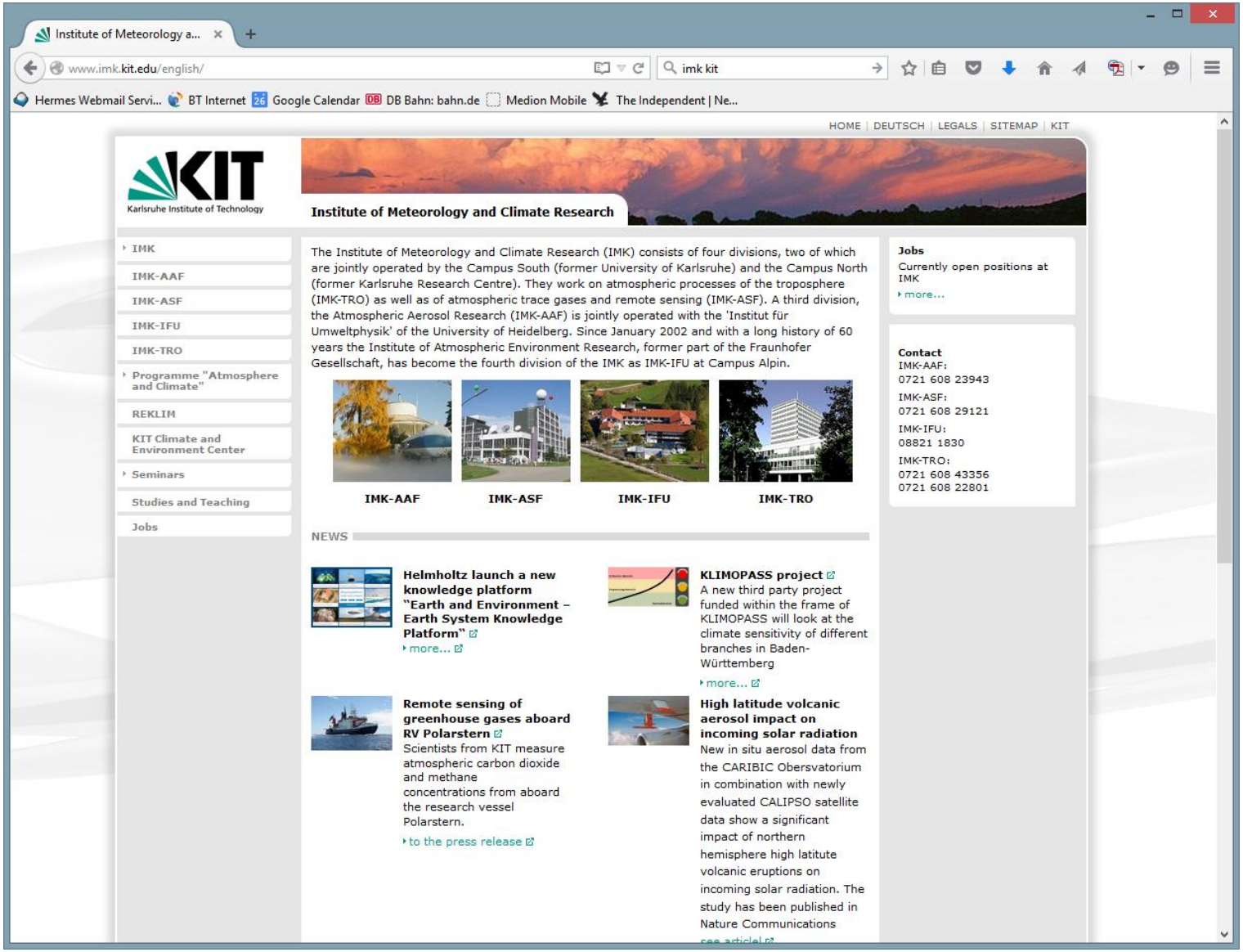
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Seminars
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Jobs
The Institute of Meteorology and Climate Research (IMK) consists of four divisions, two of which are jointly operated by the Campus South (former University of Karlsruhe) and the Campus North (former Karlsruhe Research Centre). They work on atmospheric processes of the troposphere (IMK-TRO) as well as of atmospheric trace gases and remote sensing (IMK-ASF). A third division, the Atmospheric Aerosol Research (IMK-AAF) is jointly operated with the 'Institut für Umweltphysik' of the University of Heidelberg. Since January 2002 and with a long history of 60 years the Institute of Atmospheric Environment Research, former part of the Fraunhofer Gesellschaft, has become the fourth division of the IMK as IMK-IFU at Campus Alpin.
IMK-AAF
IMK-ASF
IMK-IFU
IMK-TRO
NEWS
Helmholtz launch a new knowledge platform "Earth and Environment – Earth System Knowledge Platform"
more...
KLIMOPASS project
A new third party project funded within the frame of KLIMOPASS will look at the climate sensitivity of different branches in Baden-Württemberg
more...
Remote sensing of greenhouse gases aboard RV Polarstern
Scientists from KIT measure atmospheric carbon dioxide and methane concentrations from aboard the research vessel Polarstern.
to the press release
High latitude volcanic aerosol impact on incoming solar radiation
New in situ aerosol data from the CARIBIC Obersvatorium in combination with newly evaluated CALIPSO satellite data show a significant impact of northern hemisphere high latitute volcanic eruptions on incoming solar radiation. The study has been published in Nature Communications
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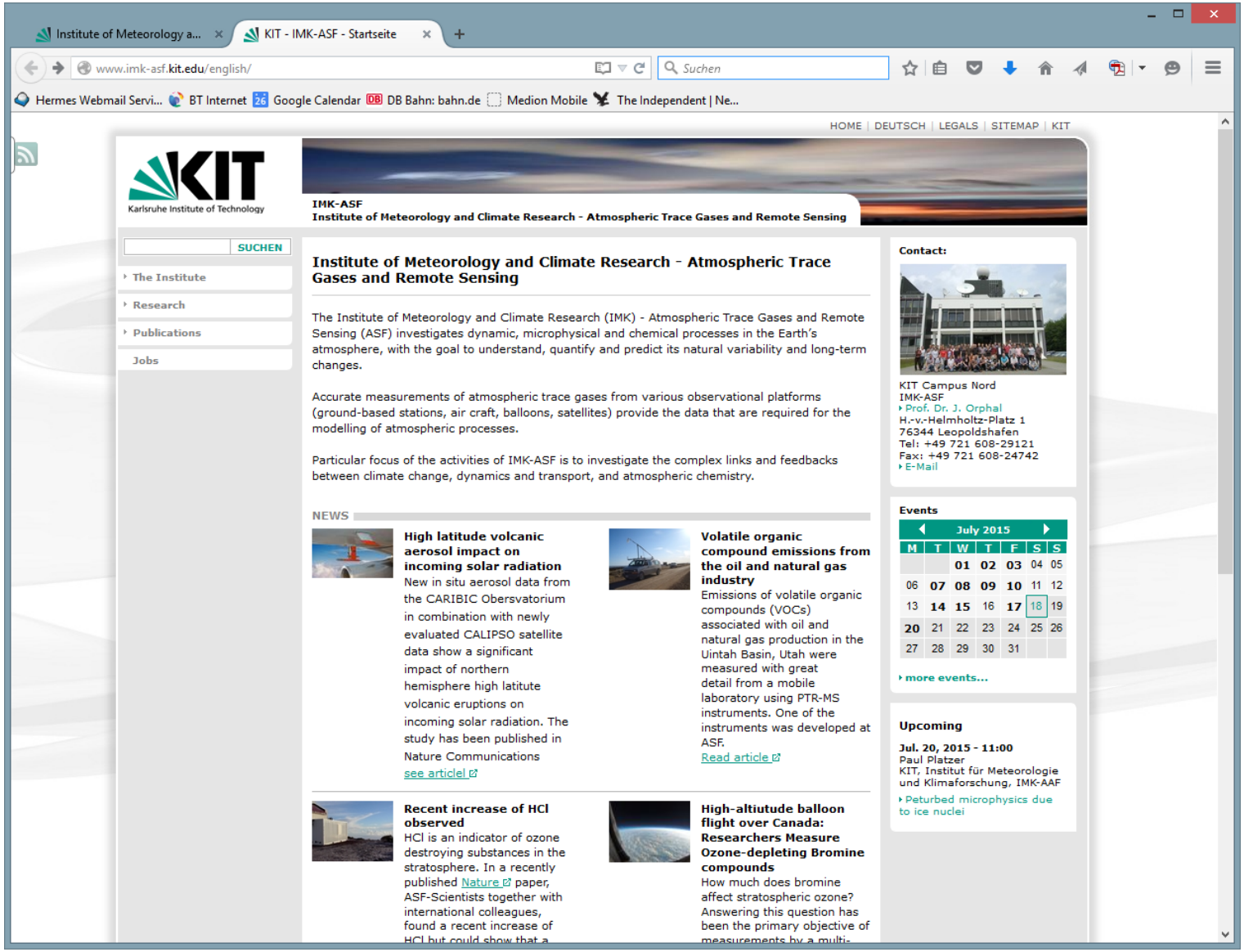
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Institute of Meteorology and Climate Research - Atmospheric Trace Gases and Remote Sensing
The Institute of Meteorology and Climate Research (IMK) - Atmospheric Trace Gases and Remote Sensing (ASF) investigates dynamic, microphysical and chemical processes in the Earth's atmosphere, with the goal to understand, quantify and predict its natural variability and long-term changes.
Accurate measurements of atmospheric trace gases from various observational platforms (ground-based stations, air craft, balloons, satellites) provide the data that are required for the modelling of atmospheric processes.
Particular focus of the activities of IMK-ASF is to investigate the complex links and feedbacks between climate change, dynamics and transport, and atmospheric chemistry.
NEWS
High latitude volcanic aerosol impact on incoming solar radiation
New in situ aerosol data from the CARIBIC Obersvatorium in combination with newly evaluated CALIPSO satellite data show a significant impact of northern hemisphere high latitute volcanic eruptions on incoming solar radiation. The study has been published in Nature Communications
see article!
Volatile organic compound emissions from the oil and natural gas industry
Emissions of volatile organic compounds (VOCs) associated with oil and natural gas production in the Uintah Basin, Utah were measured with great detail from a mobile laboratory using PTR-MS instruments. One of the instruments was developed at ASF.
Read article
Recent increase of HCl observed
HCl is an indicator of ozone destroying substances in the stratosphere. In a recently published Nature paper, ASF-Scientists together with international colleagues, found a recent increase of
High-altiutude balloon flight over Canada: Researchers Measure Ozone-depleting Bromine compounds
How much does bromine affect stratospheric ozone? Answering this question has been the primary objective of
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KIT Campus Nord
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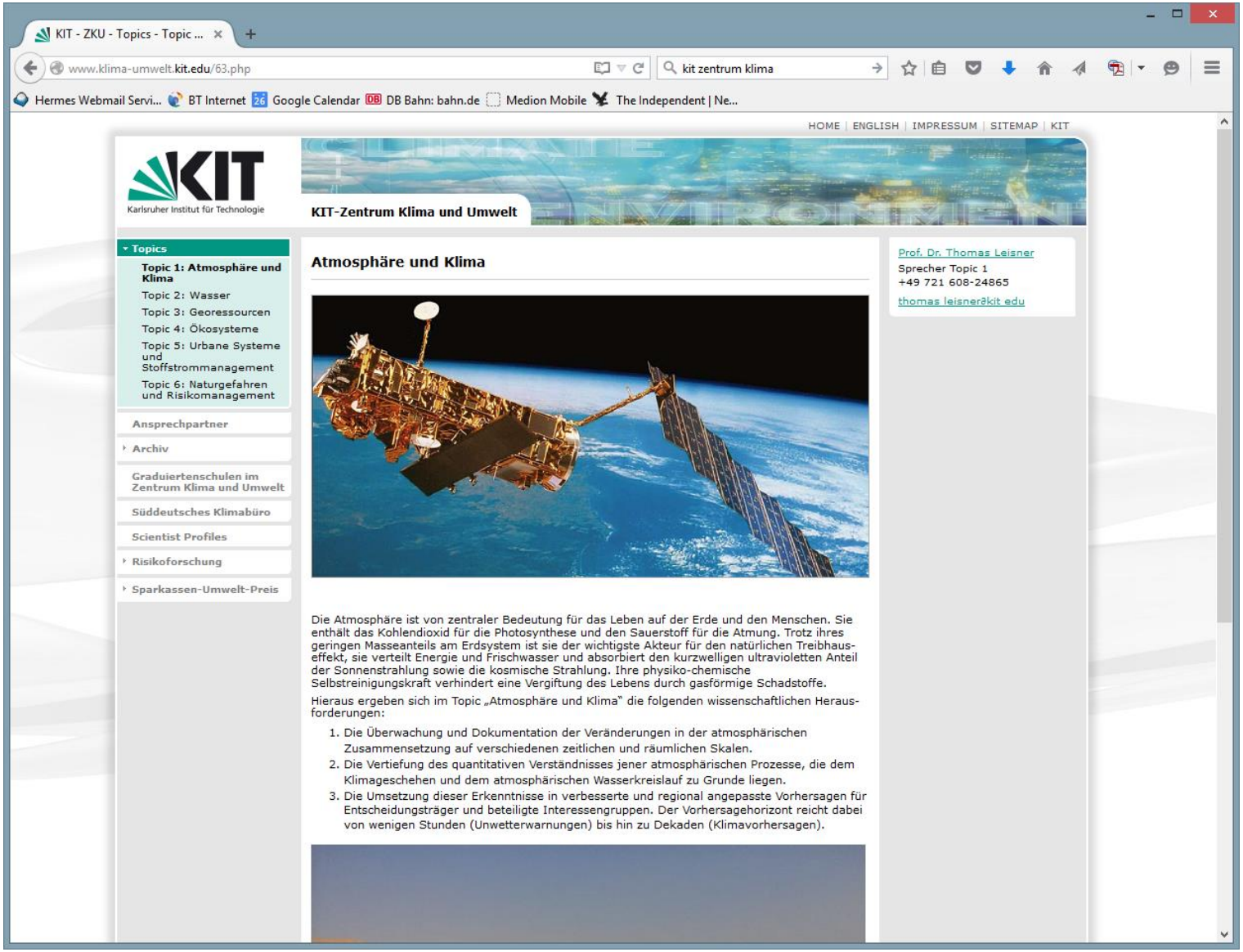
Jul. 20, 2015 - 11:00
Paul Platzer
KIT, Institut für Meteorologie und Klimaforschung, IMK-AAF
Peturbed microphysics due to ice nuclei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Atmosphäre und Klima
Die Atmosphäre ist von zentraler Bedeutung für das Leben auf der Erde und den Menschen. Sie enthält das Kohlendioxid für die Photosynthese und den Sauerstoff für die Atmung. Trotz ihres geringen Masseanteils am Erdsystem ist sie der wichtigste Akteur für den natürlichen Treibhauseffekt, sie verteilt Energie und Frischwasser und absorbiert den kurzwelligen ultravioletten Anteil der Sonnenstrahlung sowie die kosmische Strahlung. Ihre physiko-chemische Selbstreinigungskraft verhindert eine Vergiftung des Lebens durch gasförmige Schadstoffe.
Hieraus ergeben sich im Topic „Atmosphäre und Klima" die folgenden wissenschaftlichen Herausforderungen:
1. Die Überwachung und Dokumentation der Veränderungen in der atmosphärischen Zusammensetzung auf verschiedenen zeitlichen und räumlichen Skalen.
2. Die Vertiefung des quantitativen Verständnisses jener atmosphärischen Prozesse, die dem Klimageschehen und dem atmosphärischen Wasserkreislauf zu Grunde liegen.
3. Die Umsetzung dieser Erkenntnisse in verbesserte und regional angepasste Vorhersagen für Entscheidungsträger und beteiligte Interessengruppen. Der Vorhersagehorizont reicht dabei von wenigen Stunden (Unwetterwarnungen) bis hin zu Dekaden (Klimavorhersagen).
Prof. Dr. Thomas Leisner
Sprecher Topic 1
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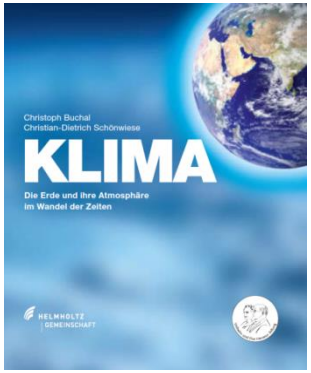
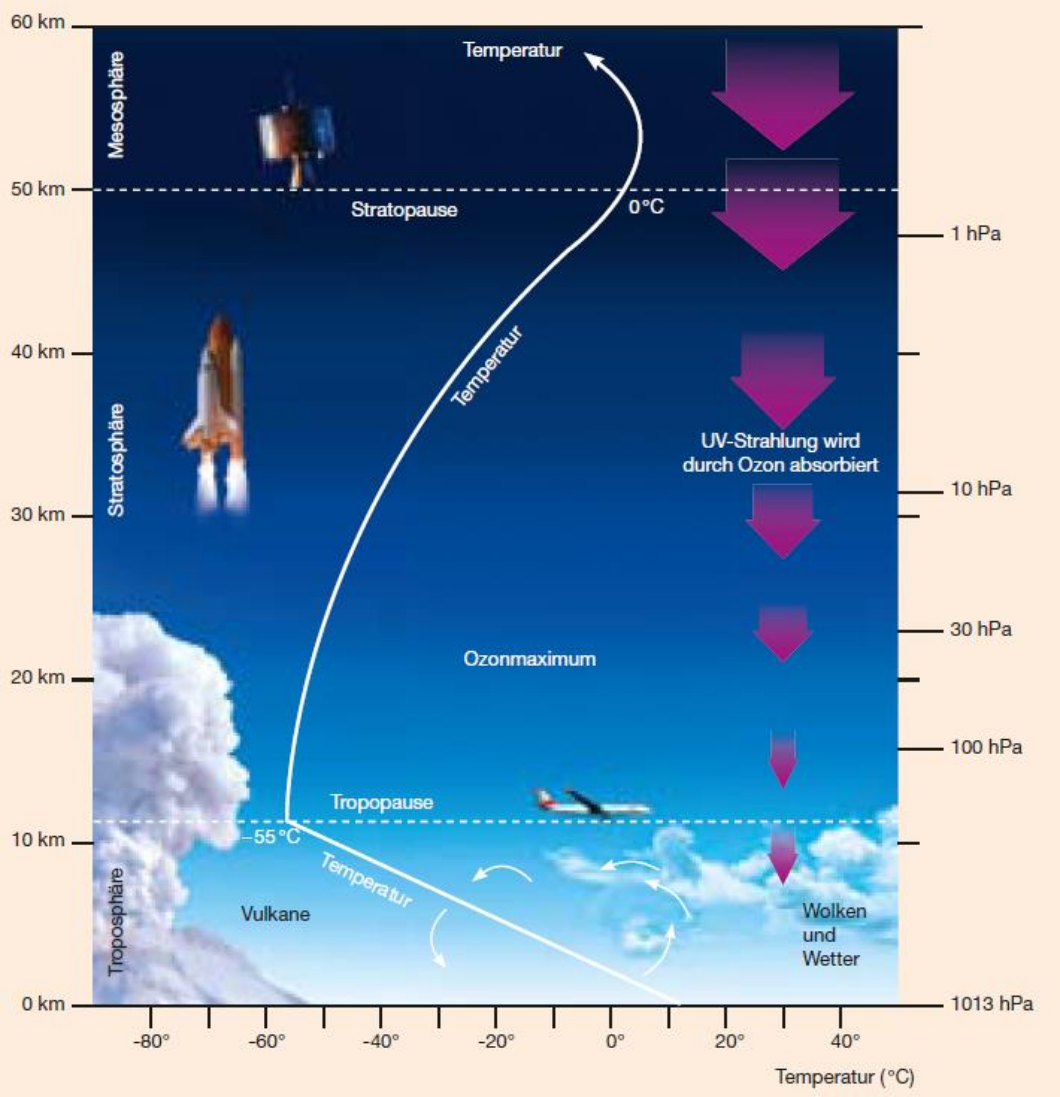
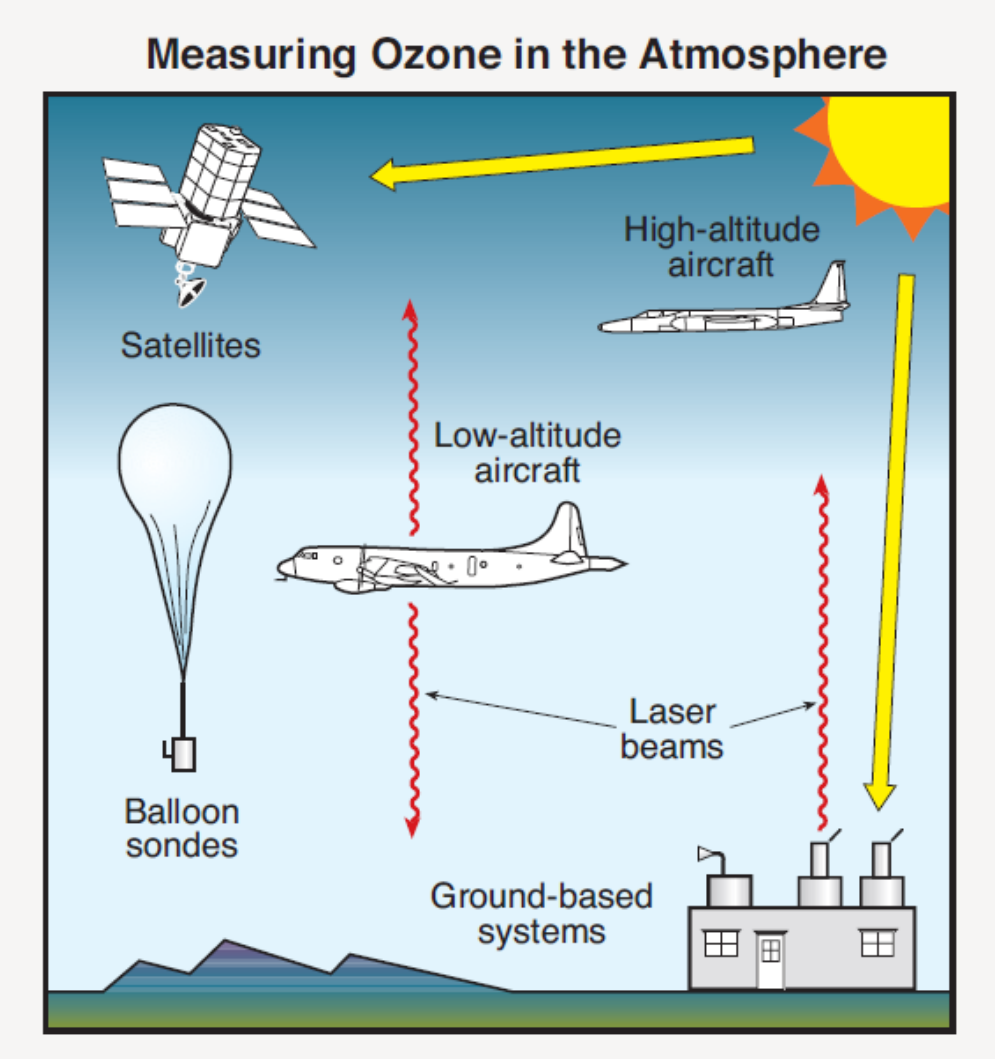
thomas leisner@kit edu

Vertical Structure of the Atmosphere





How do we measure the atmospheric state?



Satellite:
e.g. MIPAS on ENVISAT (2002-2012)

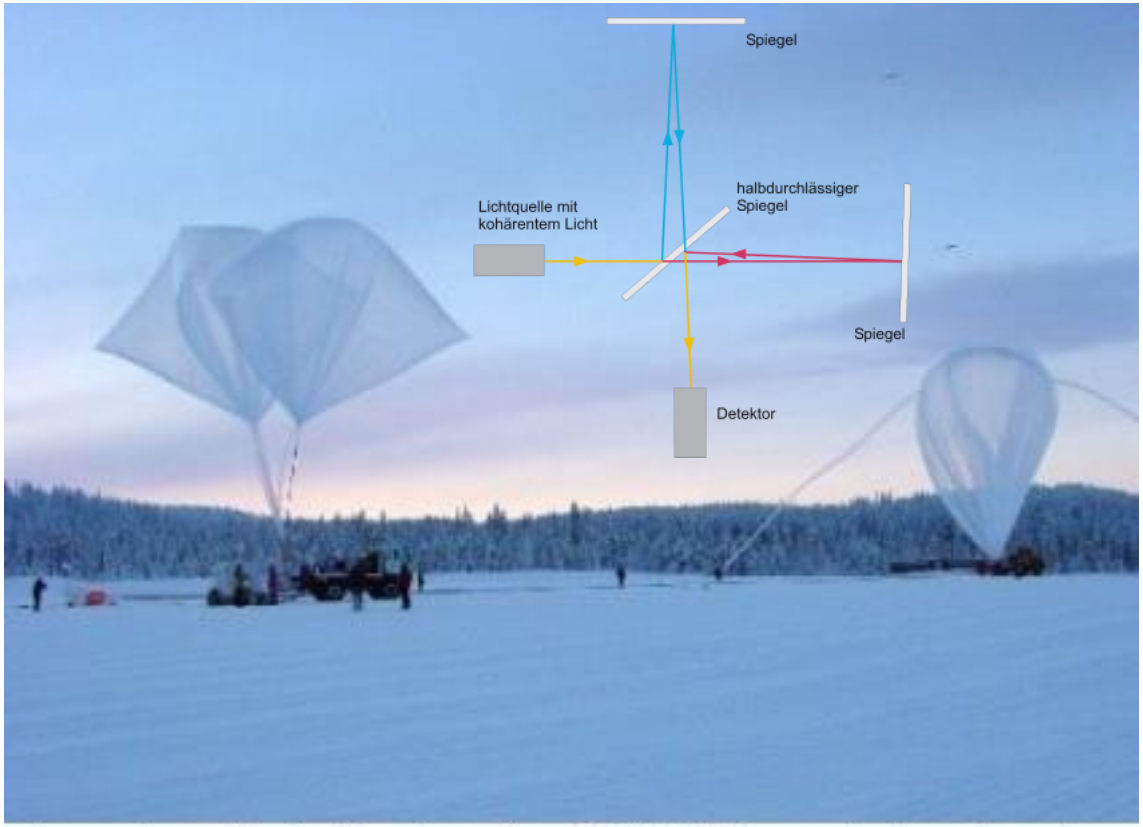
Balloon:
e.g. MIPAS-B

Aircraft:
e.g. GLORIA on HALO

Ground-based:
e.g. KITcube

ENVISAT 2002 – 2012 (KA: MIPAS)

MIPAS Balloon

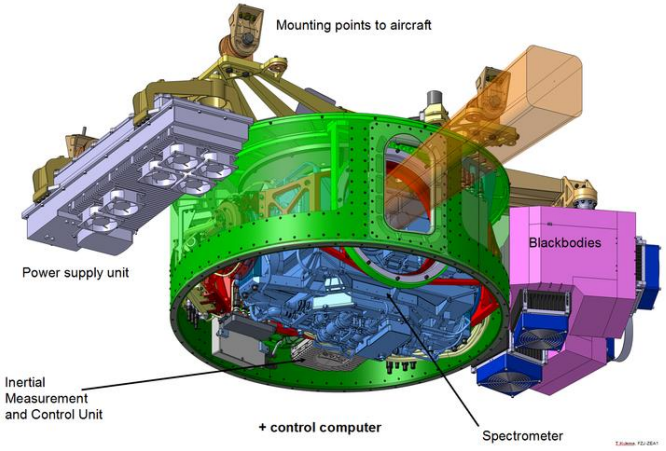


Preparation of a balloon launch of MIPAS-B2 on the launch pad at Esrange in the polar winter. At float the volume of the main balloon is typically 100.000 to 400.000 cubic meters (altitudes between 30 and 40 km). The main balloon is being inflated by helium flowing through flexible tubes. Two auxiliary balloons hold the gondola in balance to prevent dragging of the payload along the ground when the main balloon has been released.

MIPAS: Michelson Interferometer for Passive Atmospheric Sounding

GLORIA (on GEOPHYSICA and HALO)

Gimballed **L**imb **O**bserver for **R**adiance **I**maging of the **A**tmosphere (GLORIA)



Eine Entwicklung des KIT und des FZK

Karlsruher Institut für Technologie

Institut für Meteorologie und Klimaforschung - Forschungsbereich Troposphäre

SUCHEN

- Über IMK-TRO
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  - testgeräte
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KITcube: Gesamtbeobachtungssystem zur Sondierung der Atmosphäre

Ansprechpartner: Dr. Norbert Kalthoff, Dr. Andreas Wieser, Dr. Ulrich Corsmeier

Links:
- Pressemitteilung: Messbetrieb aufgenommen
- Broschüre KITcube
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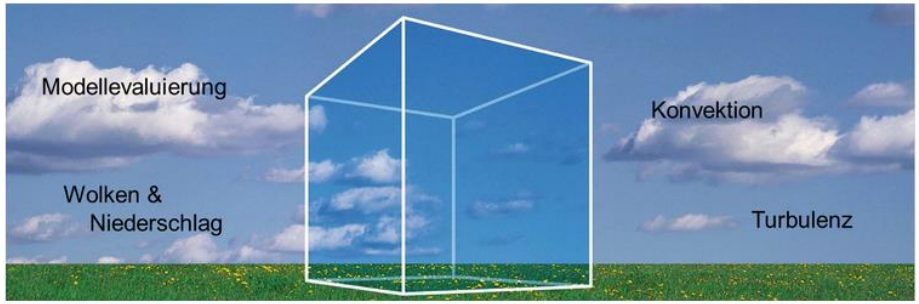
KITcube

integriertes atmosphärisches Beobachtungssystem

Mit dem KITcube verfügt das Institut für Meteorologie und Klimaforschung über ein mobiles integriertes Messsystem, das zeitlich und räumlich hochaufgelöste Messungen in der Troposphäre durchführen kann. Durch den gleichzeitigen Einsatz verschiedenster Messgeräte kann eine Vielzahl an Messgrößen in einem würfelförmigen Messvolumen von 10 x 10 x 10 km^3 bestimmt werden. Auf diese Weise ist es möglich alle relevanten atmosphärischen Prozesse detailiert zu untersuchen und letztlich neue Erkenntisse zur modellbasierten Vorhersage der untersuchten Wettererscheinungen zu gewinnen. Der KITcube zeichnet sich durch seine hohe Einsatzflexibilität aus. Er kann sowohl als mobile Einrichtung an beliebigen Messorten betrieben werden als auch im Dauerbetrieb für atmosphärisches Monitoring eingesetzt werden.

Forschungsschwerpunkte



Karlsruher Institut für Technologie

How do we model the atmosphere?

Observations

Mathematical Model

$$\frac{du}{dt} - \left(f + \frac{u\tan\phi}{a}\right)v = -\frac{1}{\rho a\cos\phi}\frac{\partial p}{\partial\lambda} - D_\lambda$$

$$\frac{dv}{dt} + \left(f + \frac{u\tan\phi}{a}\right)u = -\frac{1}{\rho a}\frac{\partial p}{\partial\phi} - D_\phi$$

$$\frac{\partial p}{\partial z} = -\rho g$$

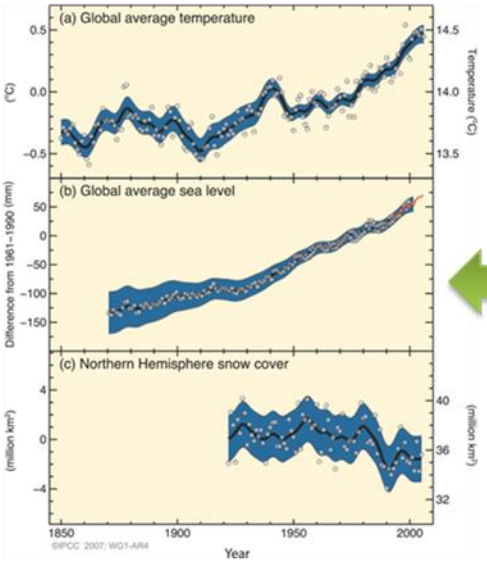
$$\frac{d\rho}{dt} + \rho\nabla\cdot\vec{v} = 0$$

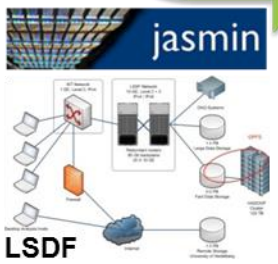
$$\rho c_v\frac{dT}{dt} + p\nabla\cdot\vec{v} = \dot{q}_{net}$$

BVs

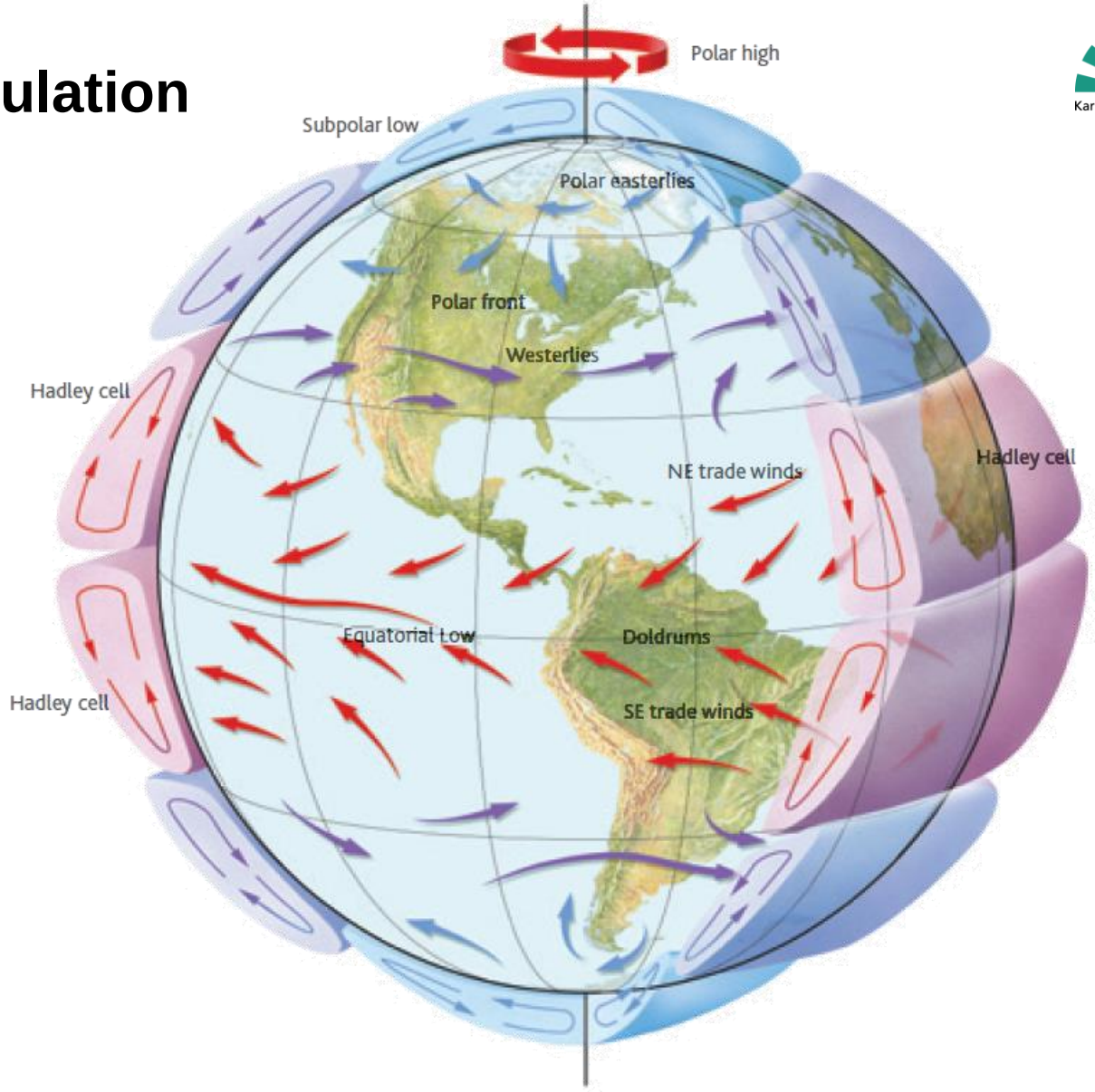
Numerical Model

Processed observations



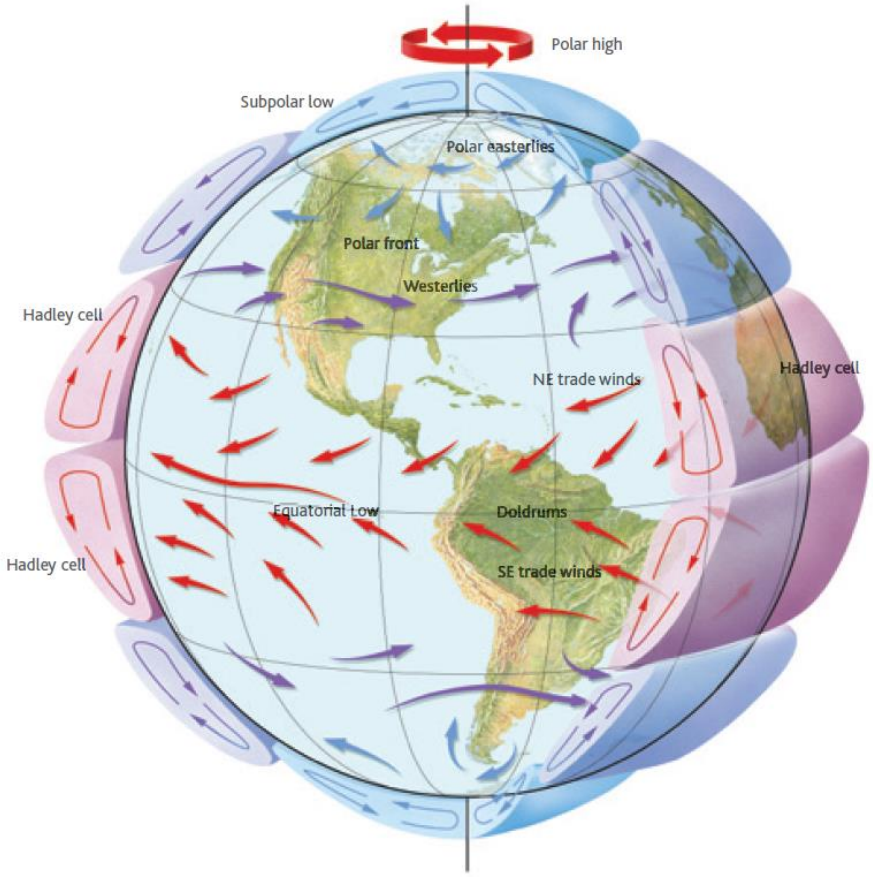


Global Circulation



Source: Gary Hicks, Science Photo Library

Global Circulation (above)



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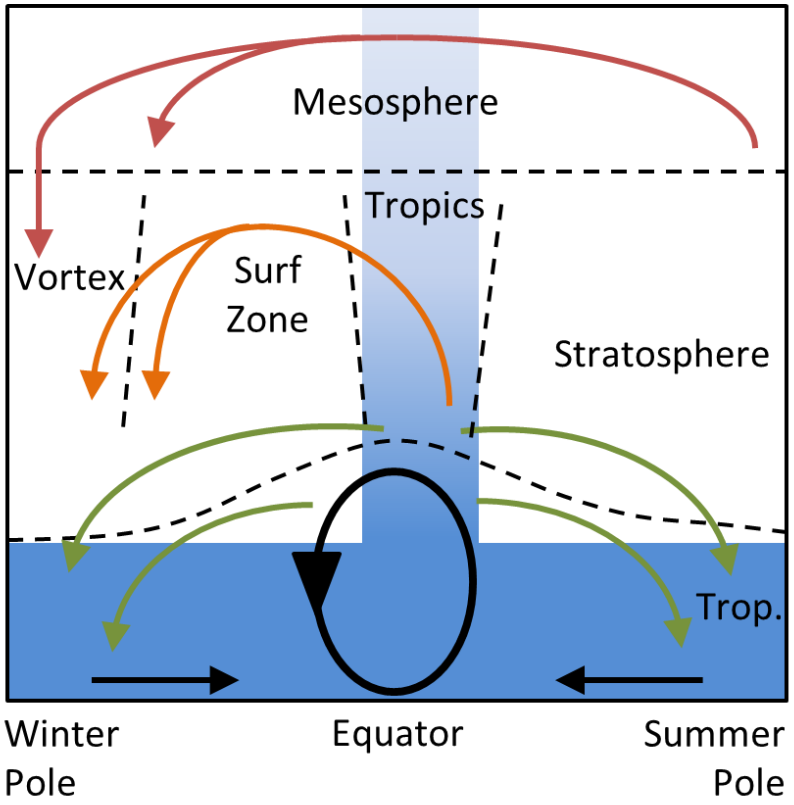
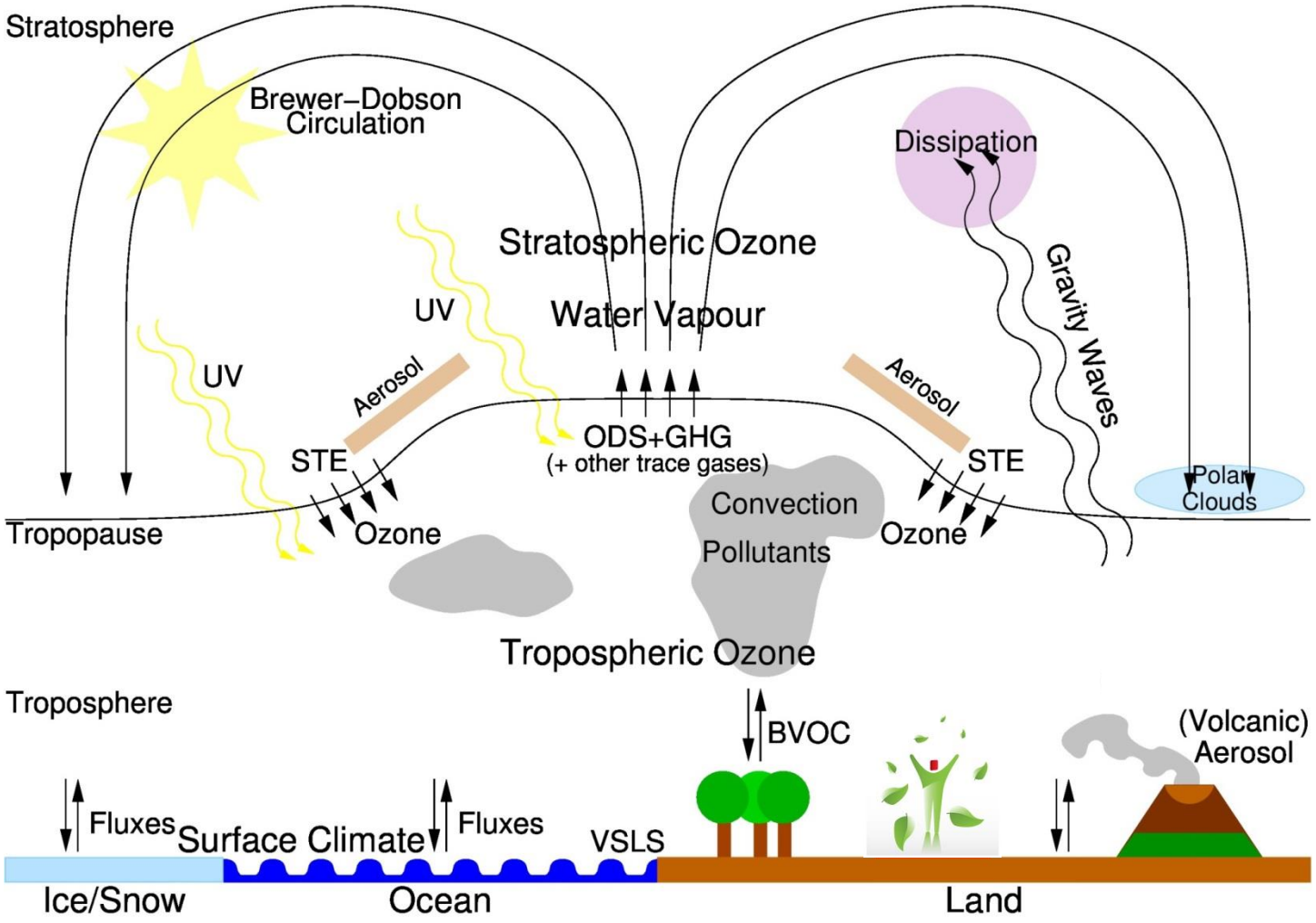


A complex system …



… and we are right in the middle!

The other anthropogenic climate change …

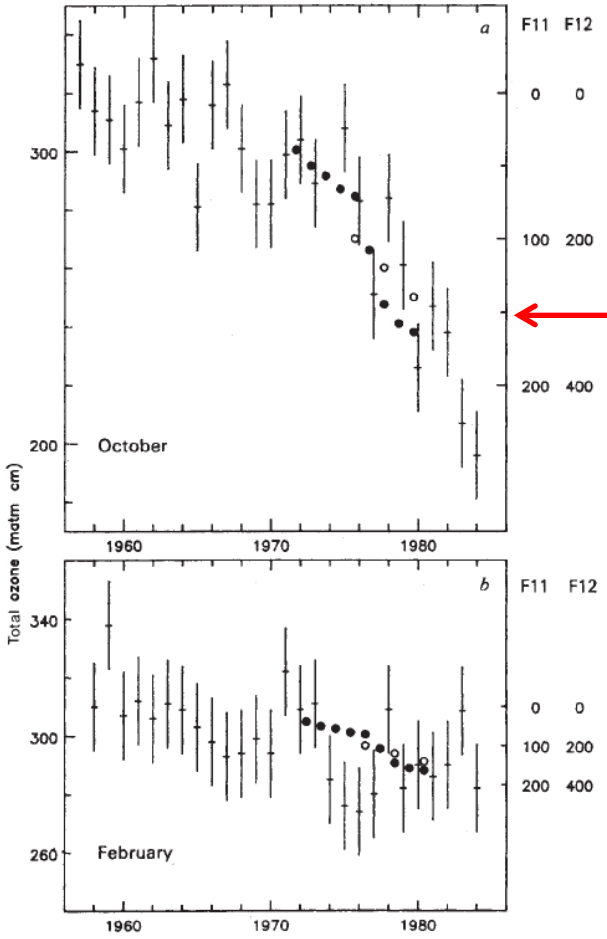


Fig. 2 Monthly means of total O_3 at Halley Bay, and Southern Hemisphere measurements of F-11 (●, p.p.t.v. (parts per thousand by volume) $CFCl_3$) and F-12 (○, p.p.t.v. CF_2Cl_2). *a*, October, 1957–84. *b*, February, 1958–84. Note that F-11 and F-12 amounts increase down the figure.

Nature, 1985

Large losses of total ozone in Antarctica reveal seasonal ClO_x/NO_x interaction

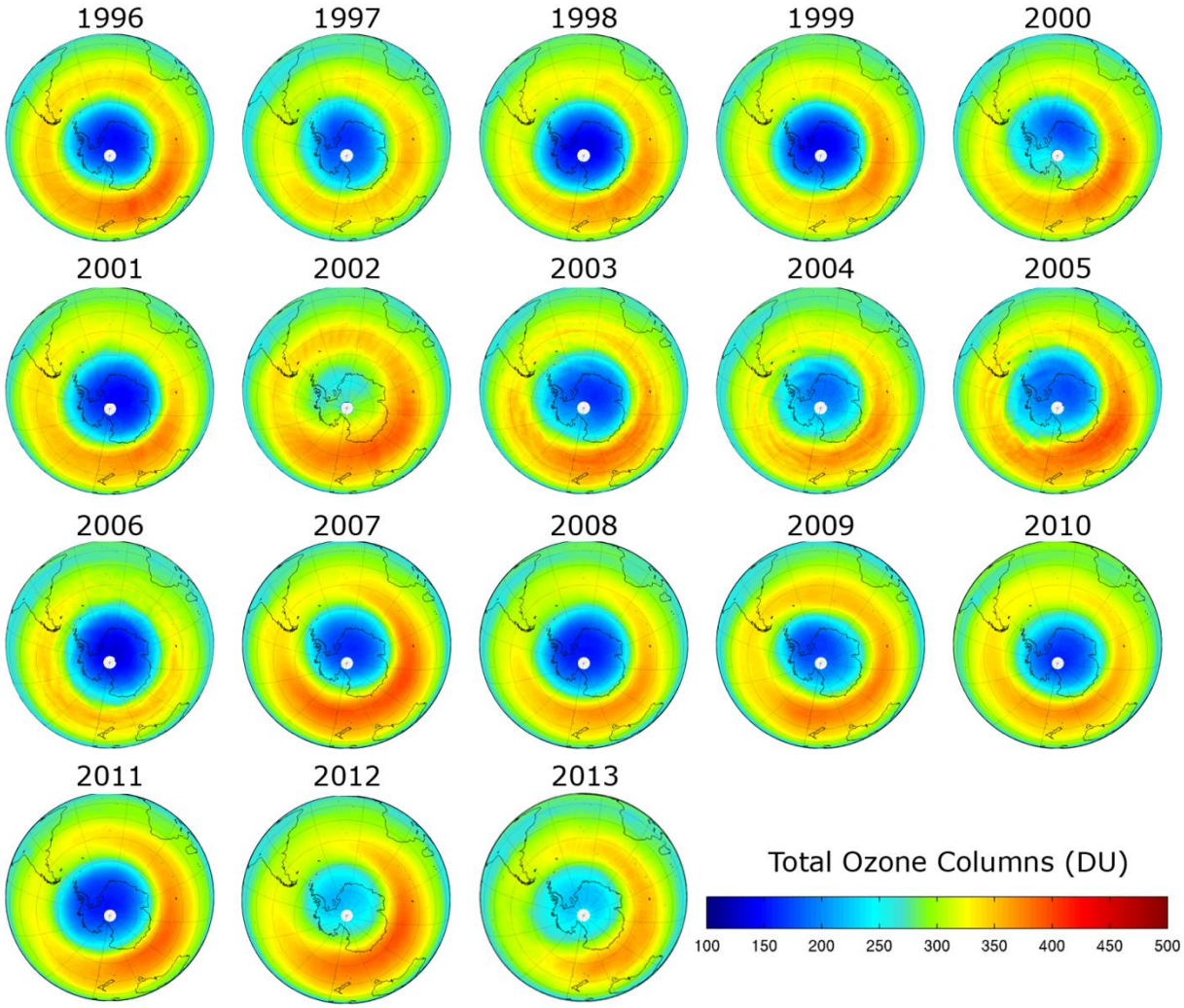
J. C. Farman, B. G. Gardiner & J. D. Shanklin

British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, UK

From the left, Farman, Brian Gardiner and Jon Shanklin, who made the initial dramatic discovery concerning the damage done to the ozone layer above Antarctica

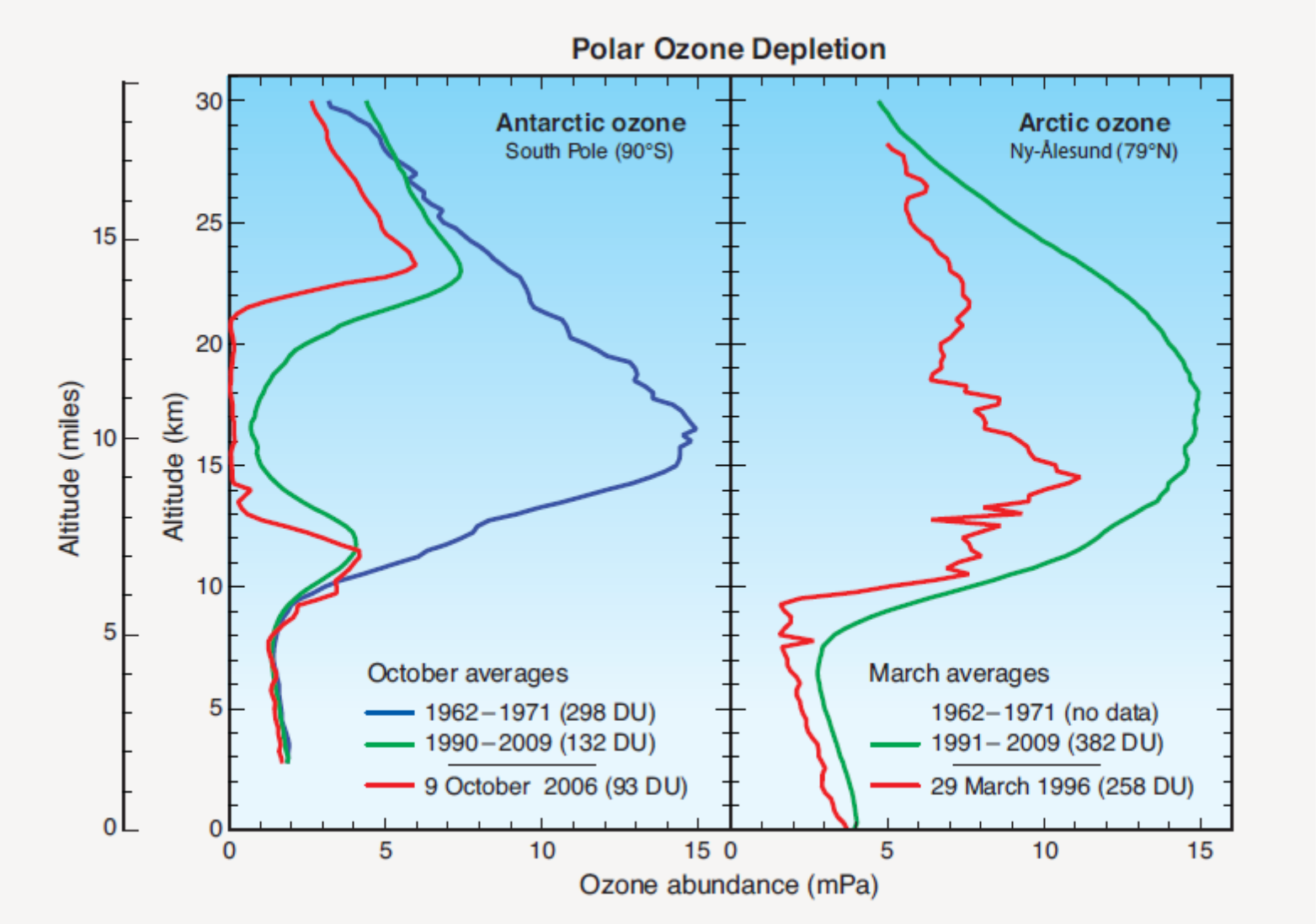
Joseph Charles Farman CBE (7 August 1930 – 11 May 2013)

The ozone hole (in colour) …



BIRA/IASB

… and in profiles



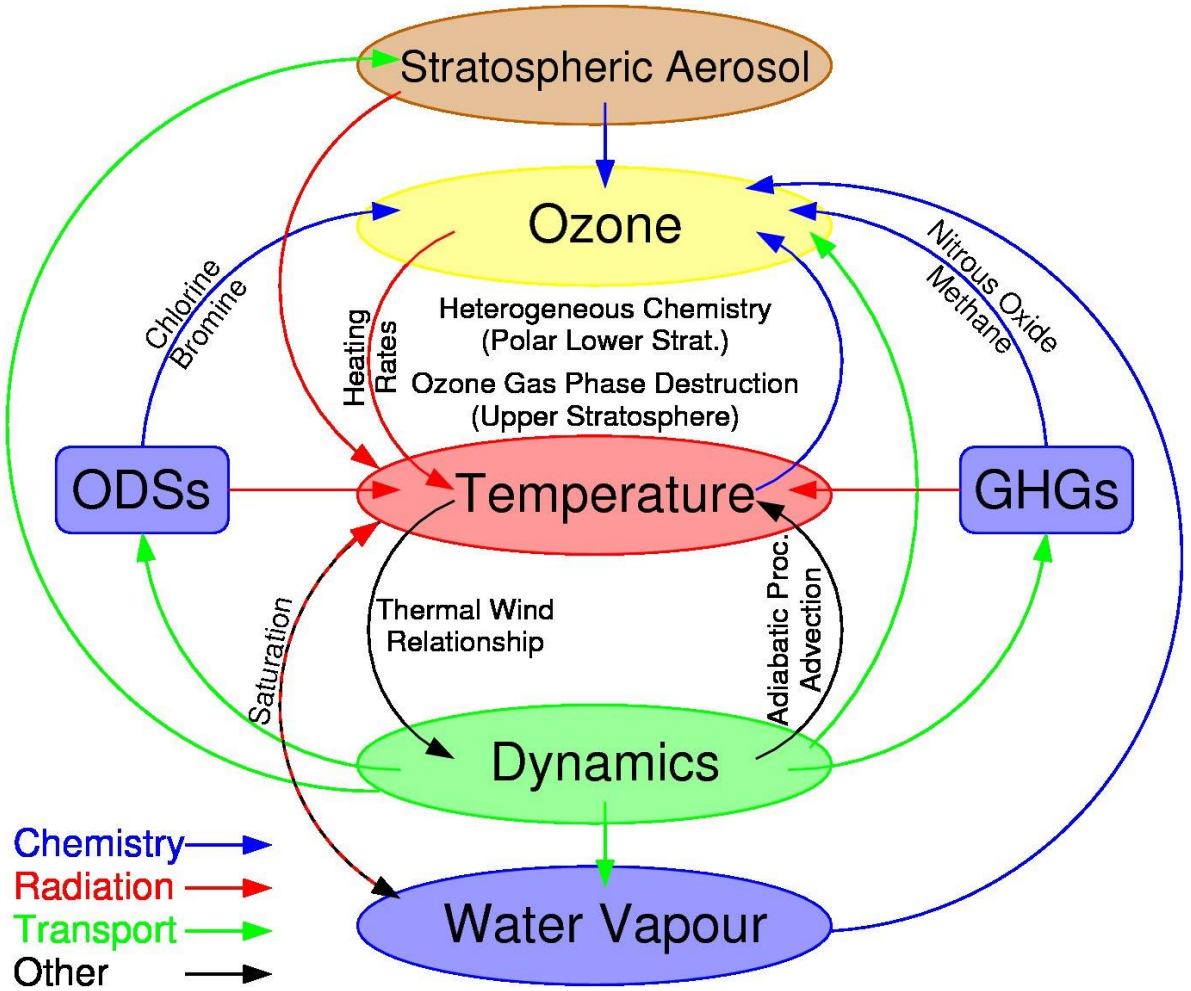
Example Science

- Do chemistry-climate interactions matter?
  - “Observed” ozone and circulation changes in the SH
  - Do they affect regions at the surface?

- How can we understand the interactions between composition (stratospheric ozone) and meteorology?
  - Tool: Chemistry-climate model (UMUKCA, …)
  - Strategy: Well defined numerical experiments to study sensitivities

- How does the ozone hole …
  - … affect seasonality in the stratosphere?
  - … affect (regional) surface climate (temperatures)?

Does the ozone hole matter?



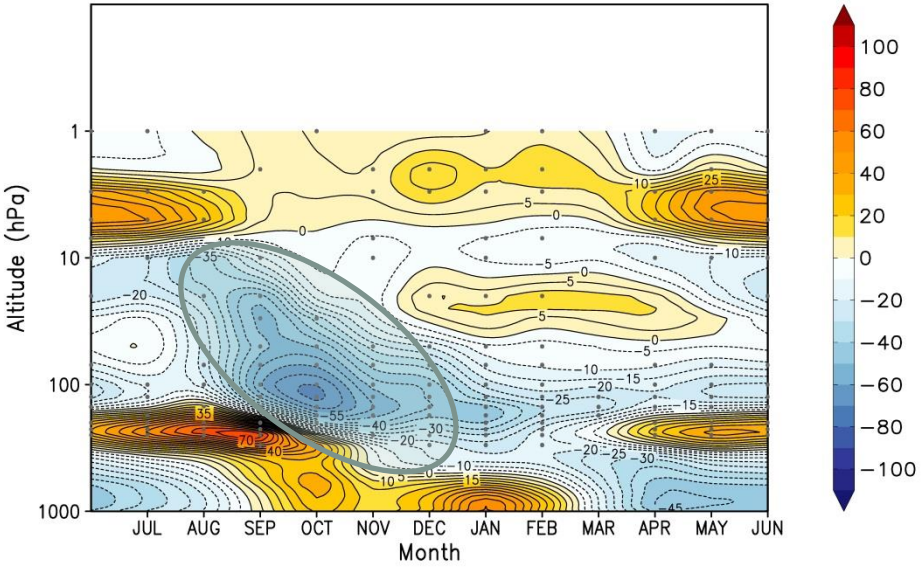
WMO, 2011

Yes!

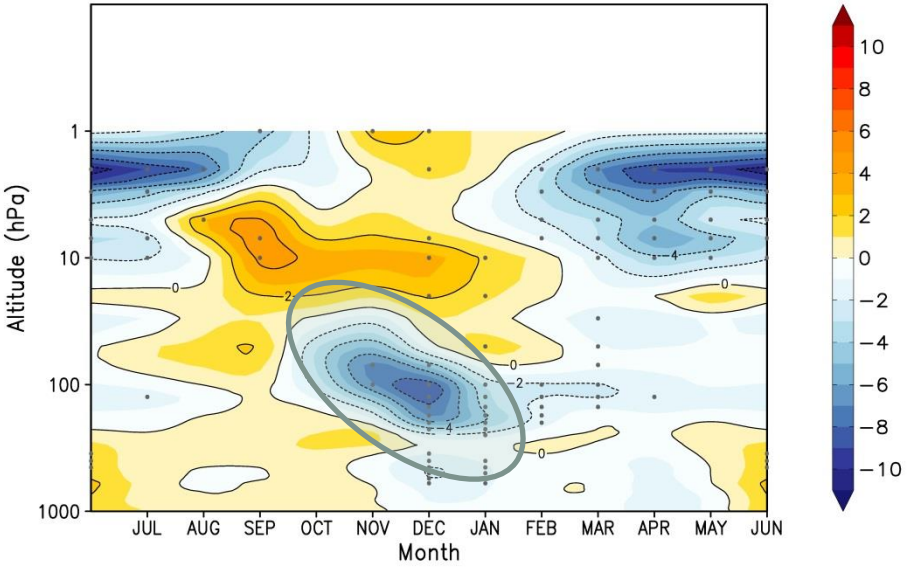
“Observed” ozone and temperature changes

ERA-Interim Reality: Mean(1998 to 2002) - Mean(1979 to 1983)

Ozone Difference [%] – 90º-75ºS



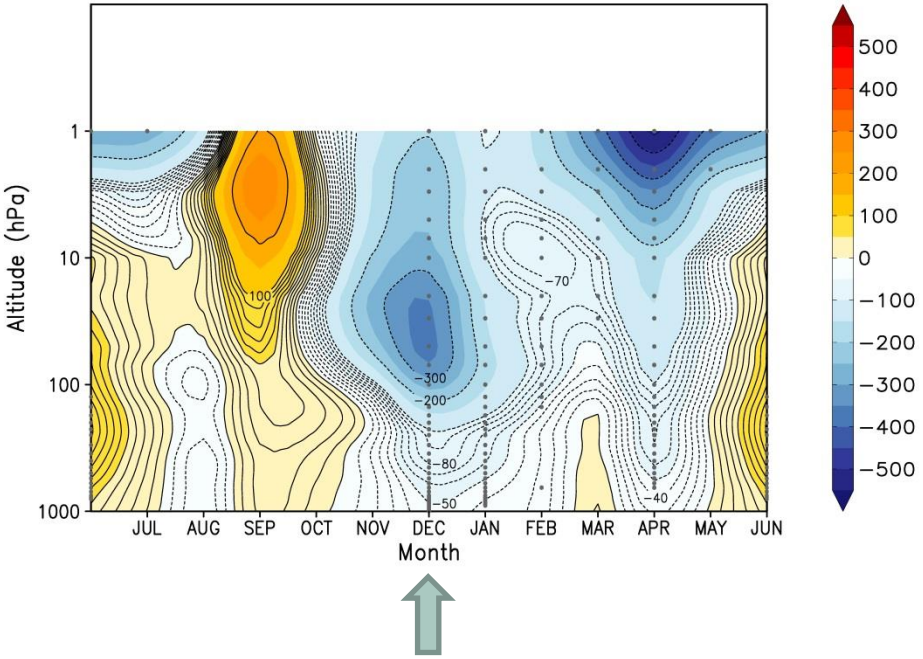
Temp. Difference [K] – 90º-75ºS



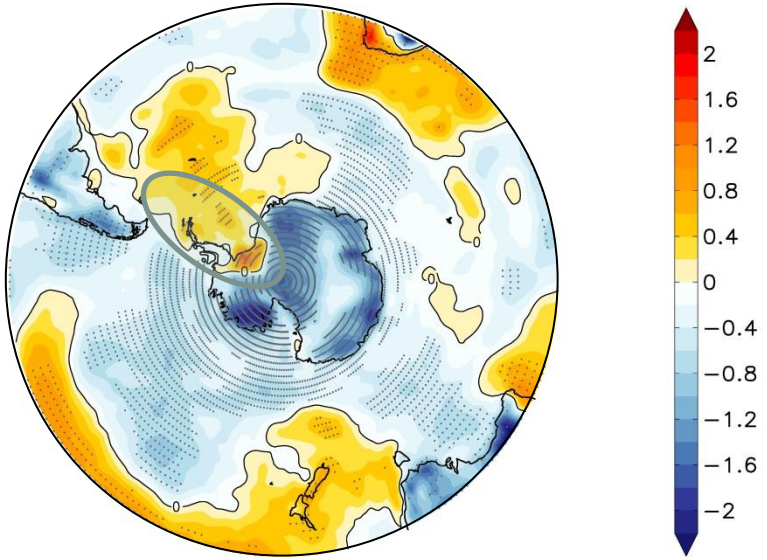
“Observed” circulation and surface changes

ERA-Interim Reality: Mean(1998 to 2002) - Mean(1979 to 1983)

Height Difference [m] – 90º-75ºS



Surface Temp. Difference [K]

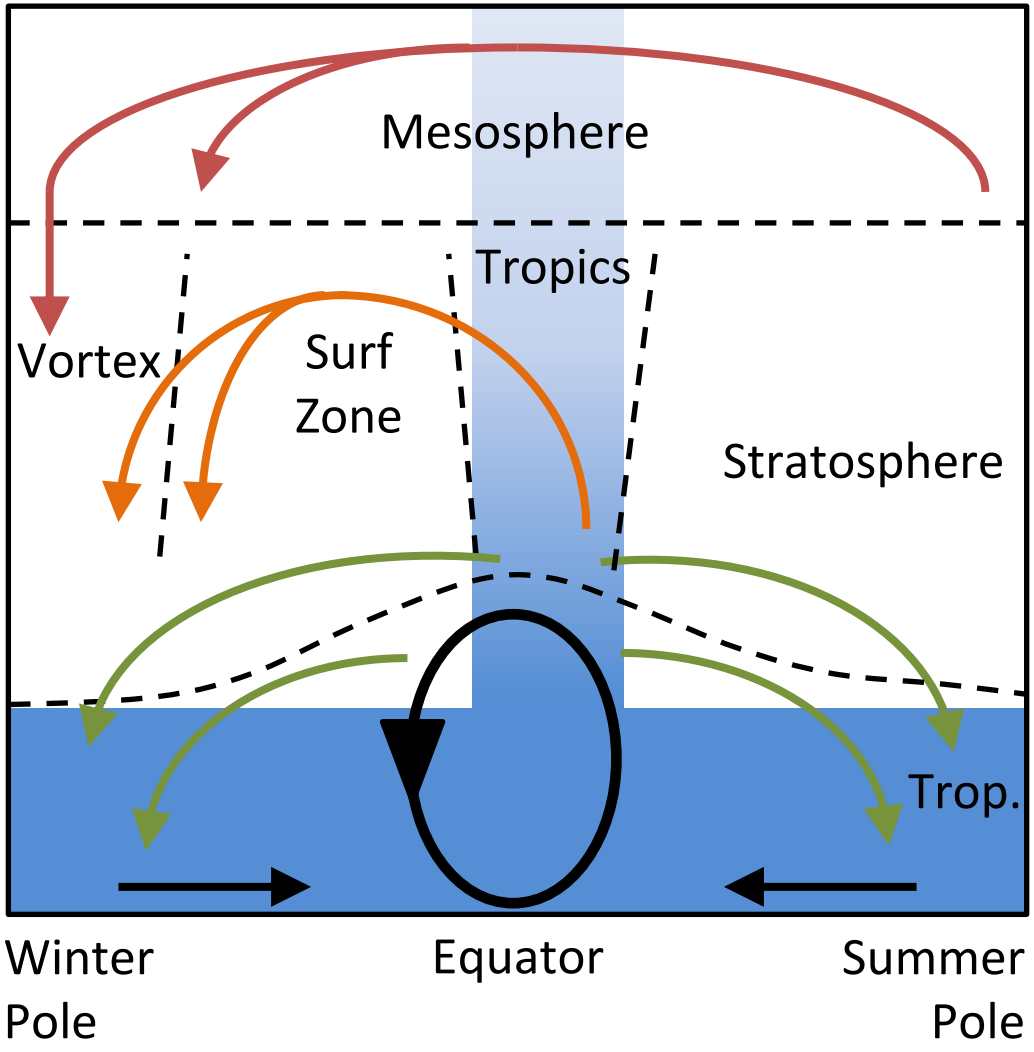


December

Brewer-Dobson Circulation

Focus: How is the seasonal progression in the Southern Hemisphere changed by ozone loss?

Does this affect the troposphere?



Conceptual structure of the Brewer-Dobson Circulation (BDC) following Plumb (2002).

Understanding: The CCM as a tool

http://www.ukca.ac.uk/wiki/index.php/UKCA

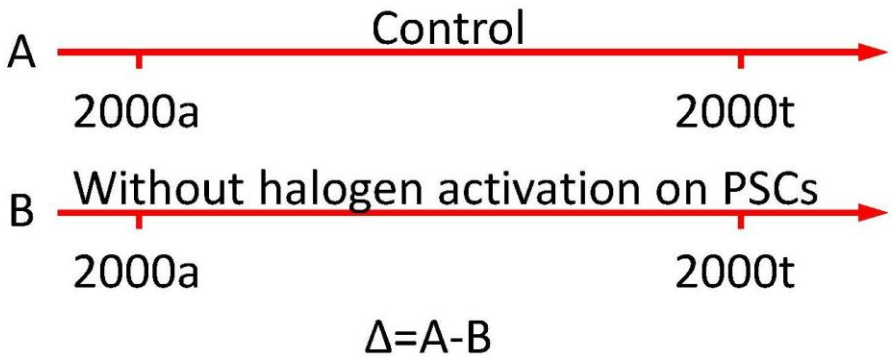
Model:
UMUKCA @ N48L60
3.75°x2.5°, 0 – 84km
CheS Chemistry (Look-up J)
CheST+ Chemistry (Fast-Jx)
Boundary conditions:
Hadley Centre SSTs/SI

Time slices for 2000 conditions

Understanding: Designing experiments

http://www.ukca.ac.uk/wiki/index.php/UKCA

Pair A: UMUKCA CheS

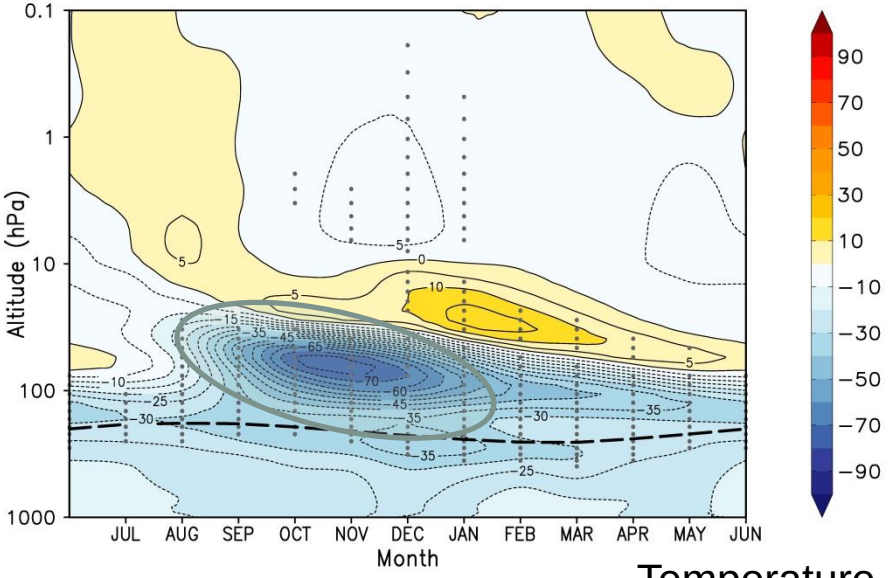


Model:
UMUKCA @ N48L60
3.75°x2.5°, 0 – 84km
CheS Chemistry (Look-up J)
CheST+ Chemistry (Fast-Jx)
Boundary conditions:
Hadley Centre SSTs/SI

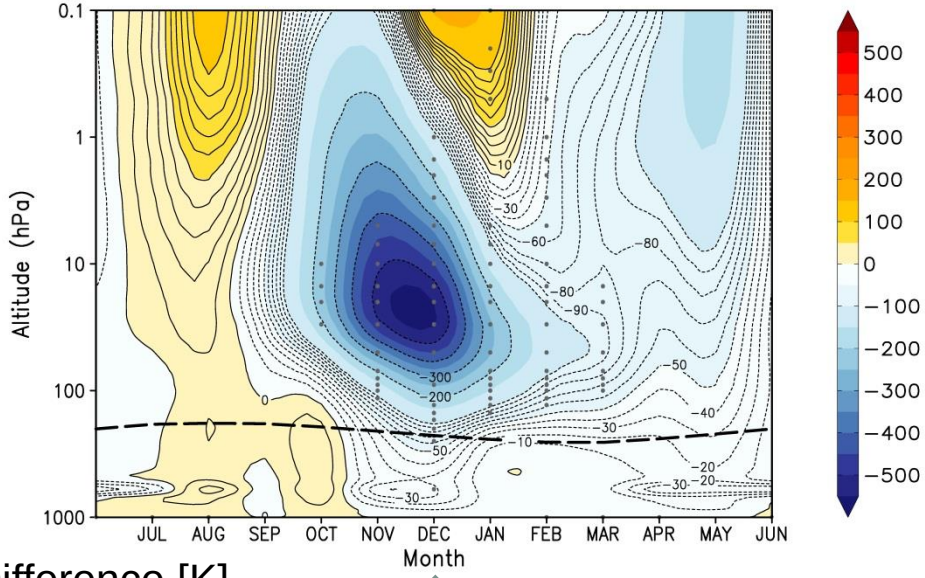
Time slices for 2000 conditions

Modelled ozone loss and response

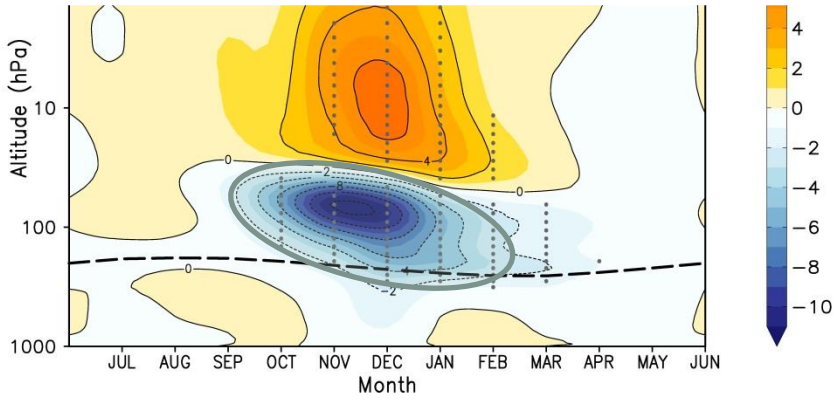
Ozone Difference [%] – 90º-75ºS



Height Difference [m] – 90º-75ºS

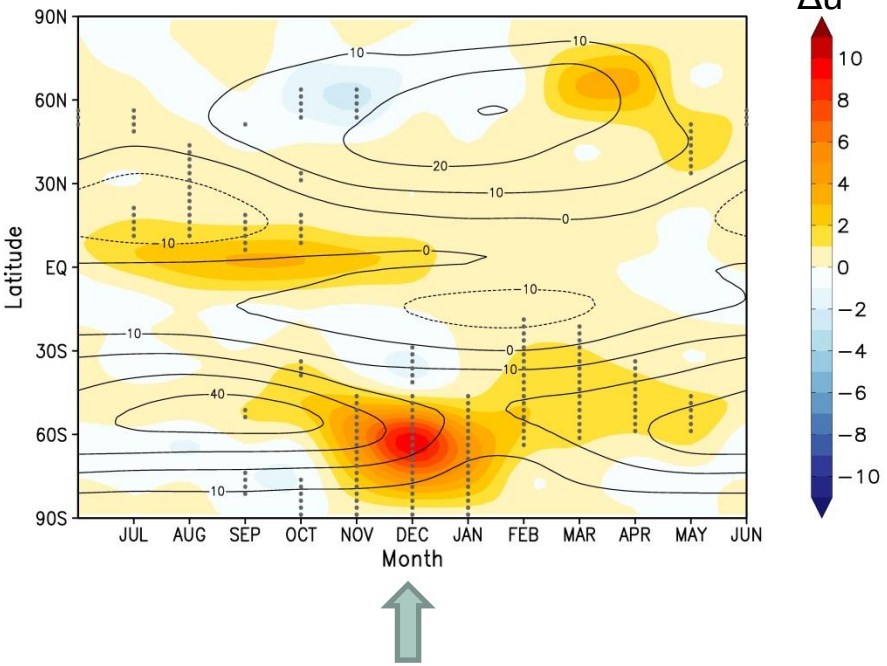


Temperature Difference [K]

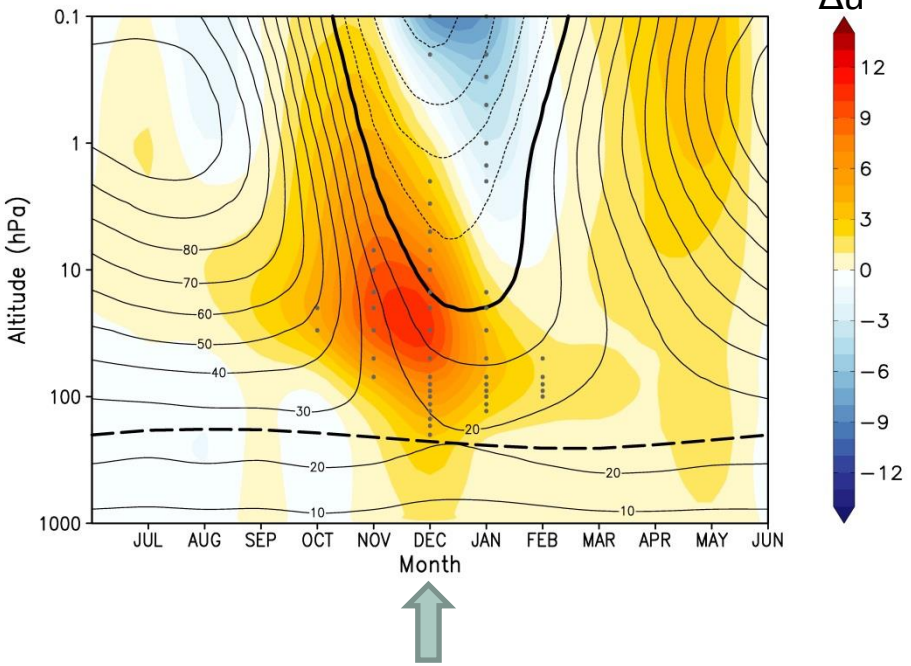


Stratospheric wind/circulation change

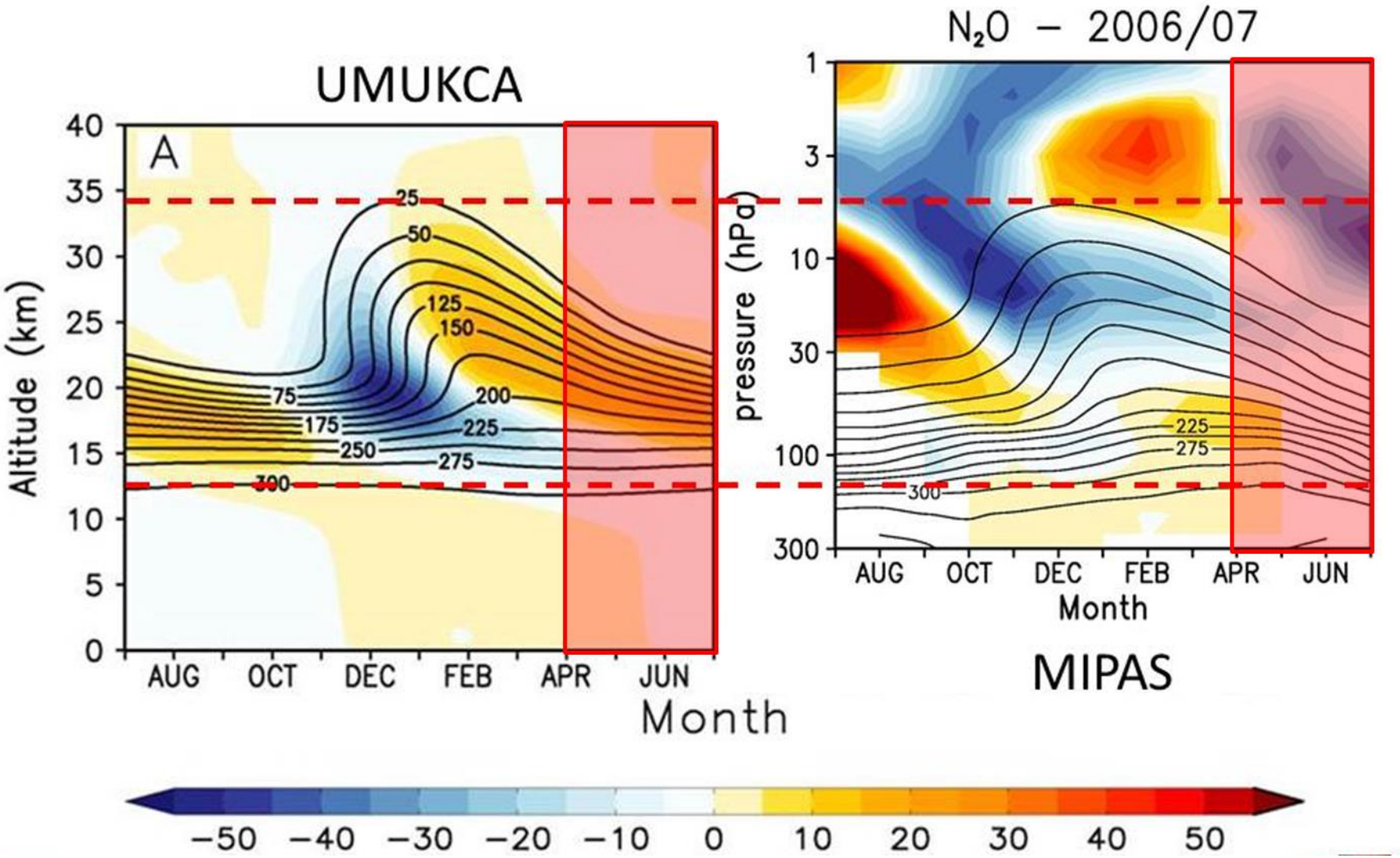
70hPa Zonal Wind [m/s] – 90º-75ºS



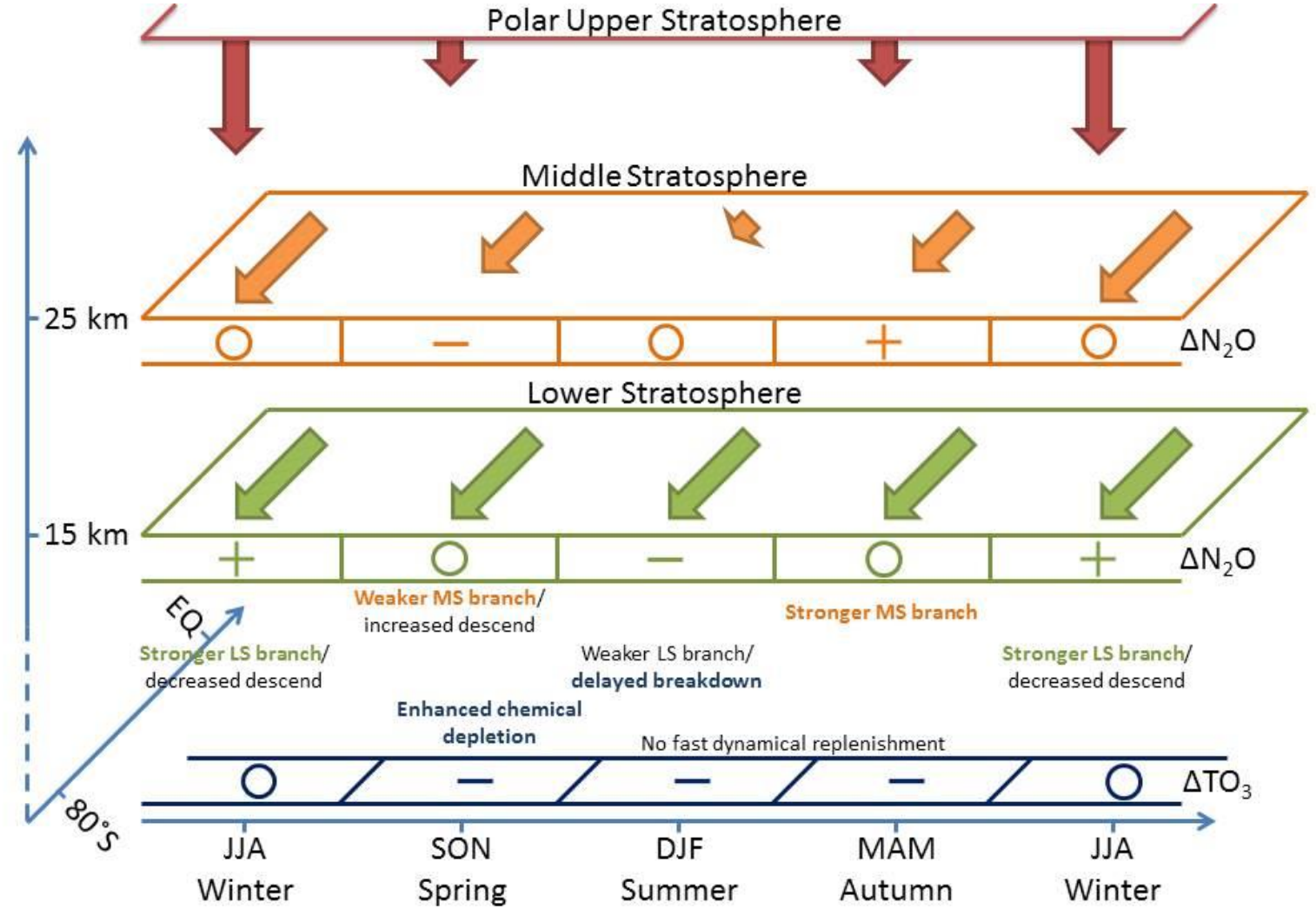
Zonal Wind [m/s] – 90º-75ºS



Stratospheric circulation/transport change

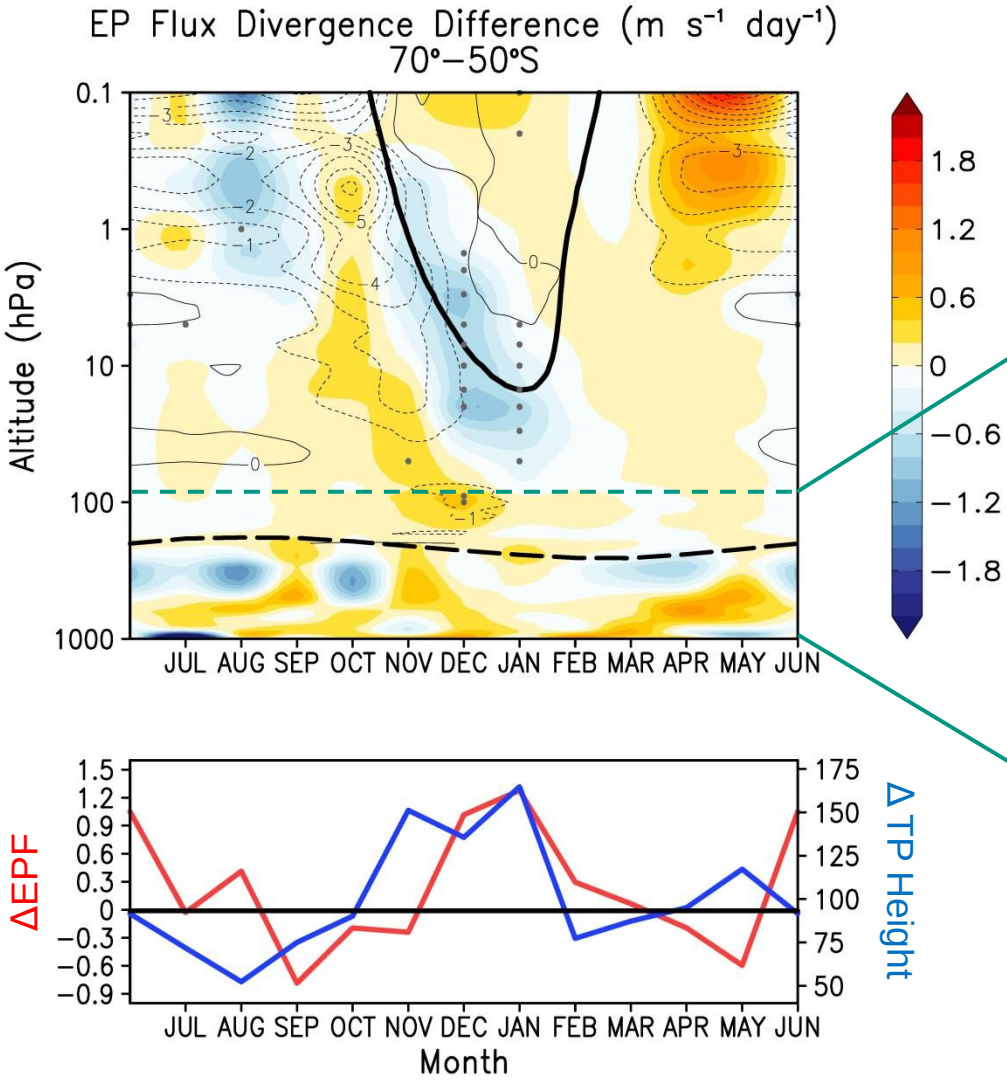


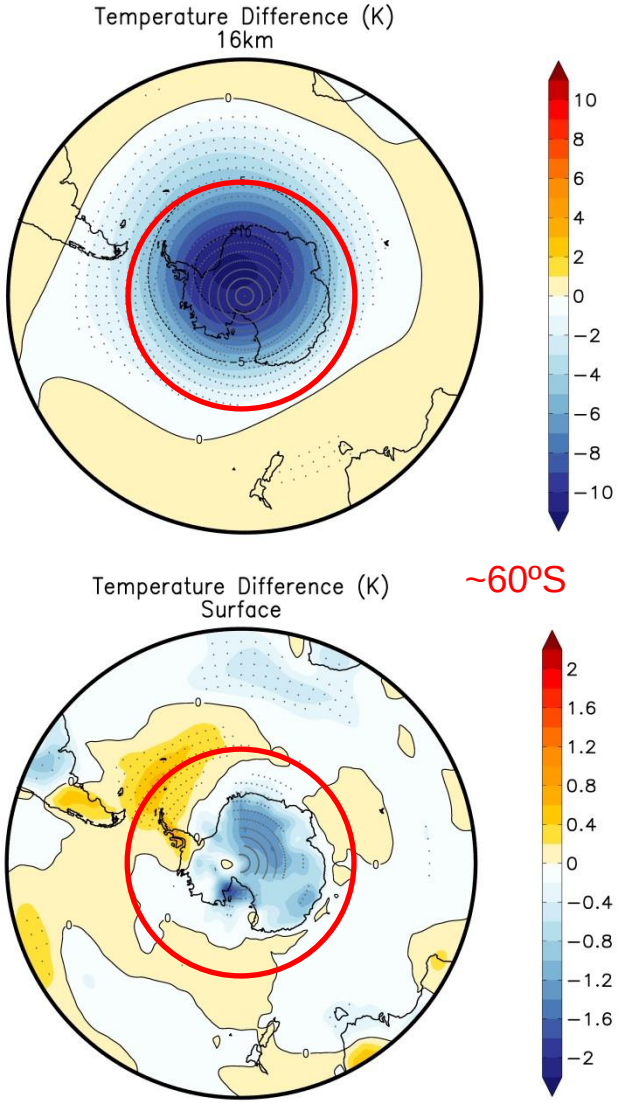
Changes in seasonality due to O_3 loss



Braesicke et al., ACP, 2013

Effects on surface climate

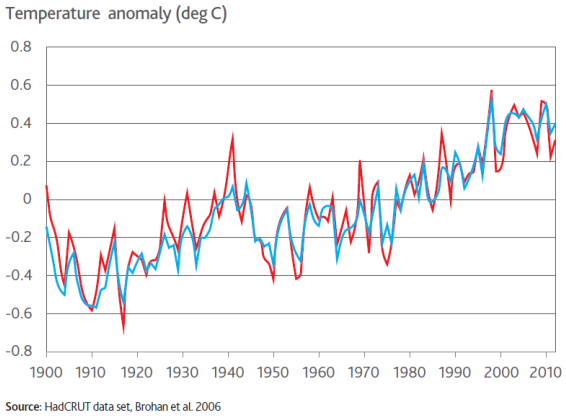




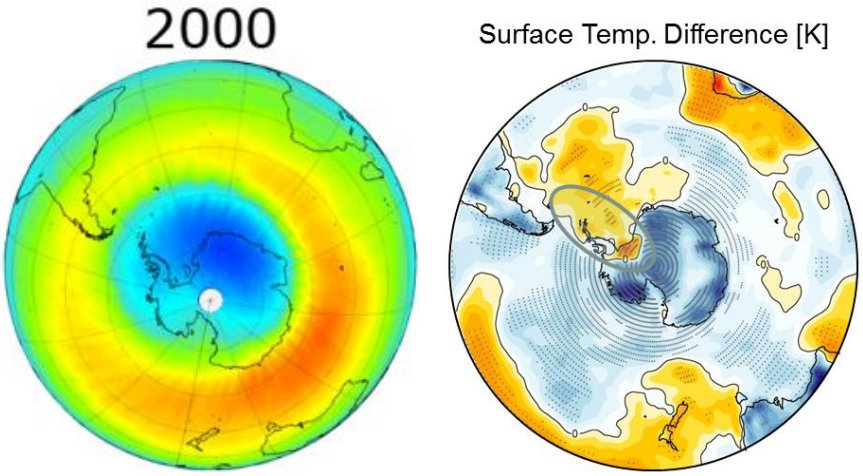
Keeble et al., ACP, 2014

“LAUDATO SI’, mi’ Signore”
“Praise be to you, my Lord”

Climate as a common good



23. The climate is a common good, belonging to all and meant for all. At the global level, it is a complex system linked to many of the essential conditions for human life. A very solid scientific consensus indicates that we are presently witnessing a disturbing warming of the climatic system.



THE HOLY FATHER

FRANCIS

ON CARE FOR OUR COMMON HOME

The End

Karlsruher Institut für Technologie

Thank you!

Summary

- **Do chemistry-climate interactions matter?**
  - **The ozone hole modifies stratospheric circulation**
  - **Stratosphere-Troposphere coupling influences regional surface climate**

- **How does the ozone hole …**
  - **… affect seasonality in the stratosphere?**
    - **Longer lasting/stronger stratospheric vortex,**
    - **Seasonal shift in the Brewer-Dobson Circulation**
  - **… affect (regional) surface climate (temperatures)?**
    - **Elevated tropopause in high latitudes,**
    - **Lagged increase in heat-flux,**
    - **Cold barotropic vortex in the lower stratosphere,**
    - **Off-pole warming and polar cooling**

- **Climate equilibrium! Does not necessarily imply causality!**