Ship-based remote sensing observations of clouds and aerosol over the Atlantic Ocean

Bernhard Pospichal (1)
Veronika Wolf (1), Alexandra Pietsch (1), Ronny Engelmann (2), and Andreas Macke (2)
(1) University of Leipzig, Institute for Meteorology
(2) Leibniz-Institute for Tropospheric Research

Introduction

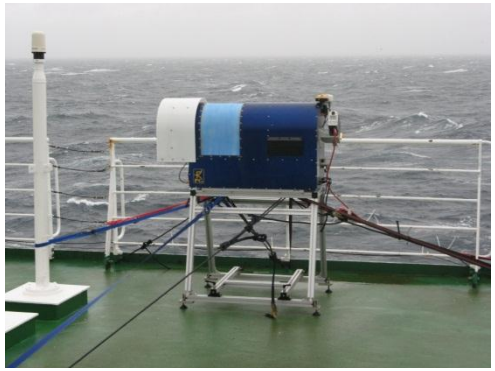
- The number of ship-based remote sensing observations of the lower troposphere over the oceans is very small, although > 70 % of the Earth's surface is covered by water
- Remote sensing observations of the atmosphere (esp. water vapor, clouds) by satellites are in some cases better feasible over oceans because of the relatively homogeneous properties of the sea surface
- However, for detailed studies of the lower troposphere, ship-based observations can give more insight into the exchange processes between ocean surface and atmosphere
- Remote sensing observations of cloud, aerosol and radiation properties over the Atlantic have been performed. Some results and first statistical evaluations will be presented here

Project OCEANET

- The OCEANET project has been launched in 2007 jointly by several German institutions (IFM-GEOMAR, GKSS, AWI, and TROPOS)
- The goal was to use the Atlantic transects of Polarstern to perform atmospheric remote sensing observations over different climate zones
- Since 2007, on a total of 13 cruises measurements of cloud, aerosol and radiation properties were performed.

Instrumentation

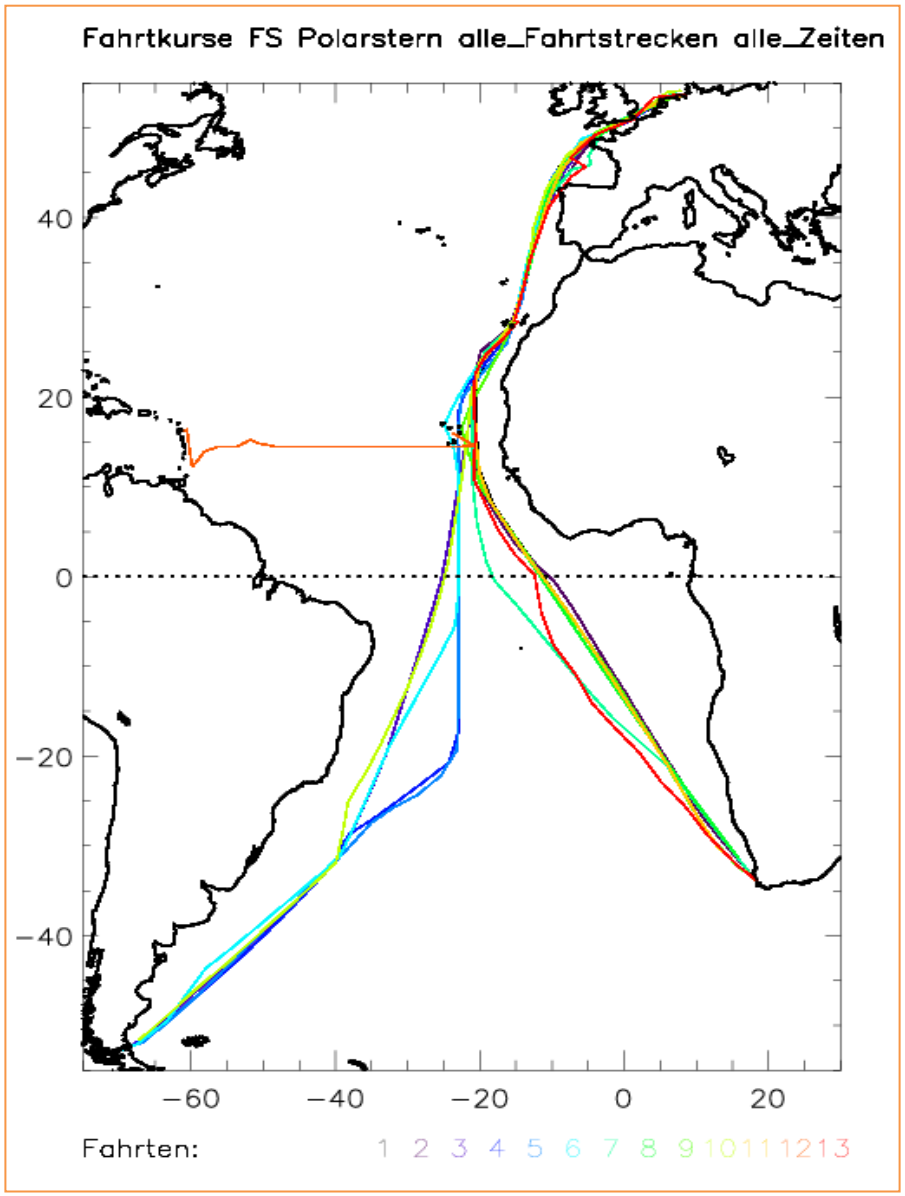
The instrumentation consisted of:



- a passive microwave radiometer HATPRO
- a lidar ceilometer (installed permanently on the ship)
- a full-sky camera
- full radiation balance
- Sun photometer
- the Raman lidar POLLY^{XT} (only on seven cruises)
- spectral solar irradiances (three cruises)
- radiosoundings (1x per day, sometimes 2x)
- standard meteorological observations on the ship
- turbulence measurements
- 95 GHz cloud radar (only cruise 13)

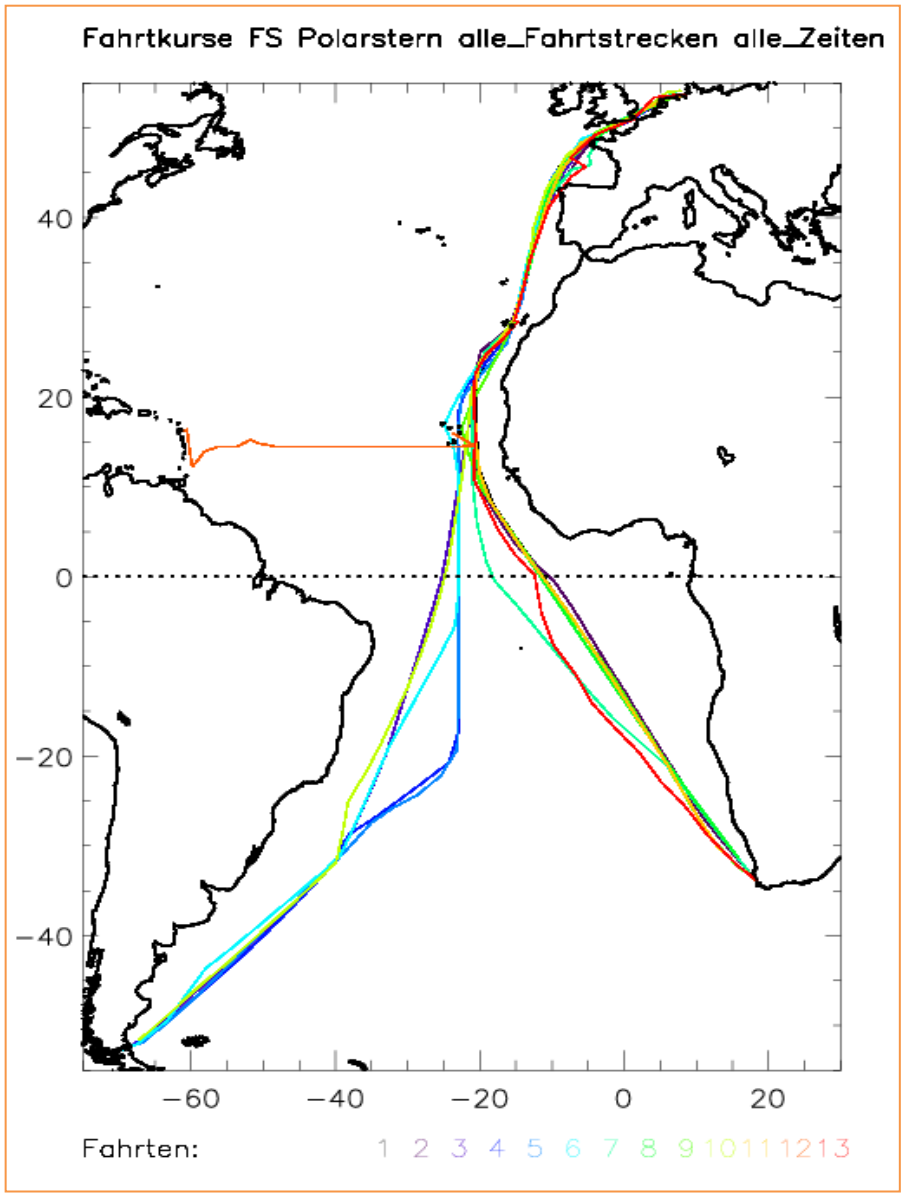
- in-situ aerosol observations

Cruise tracks

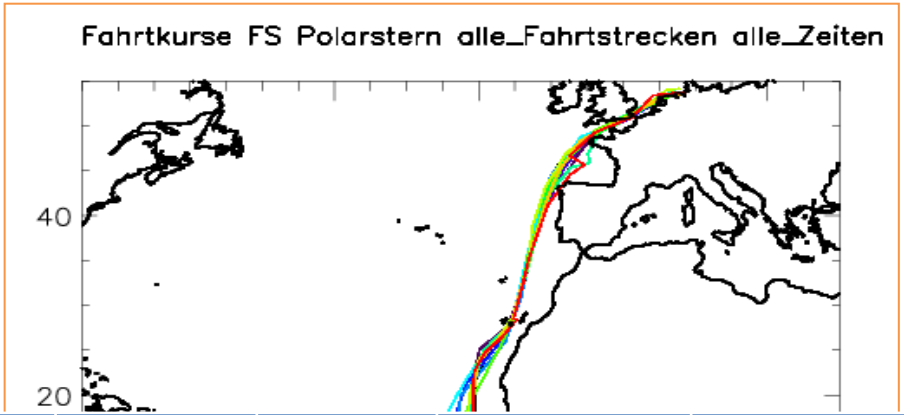


- Bremerhaven – Cape Town or Punta Arenas
- Northward cruises in April/May
- Southward cruises in October/November
- One cruise on METEOR with zonal cross-section from Caribbean to Cape Verde

Cruise tracks

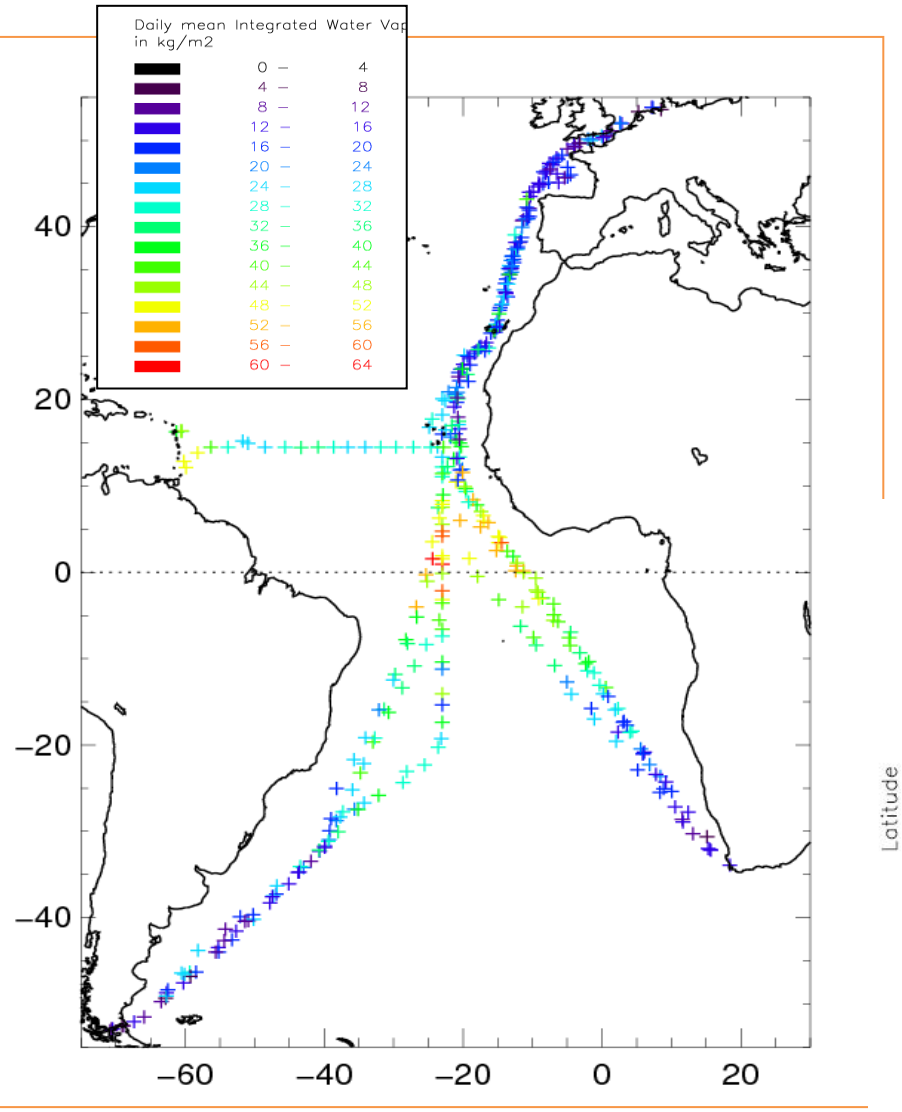


Cruise tracks

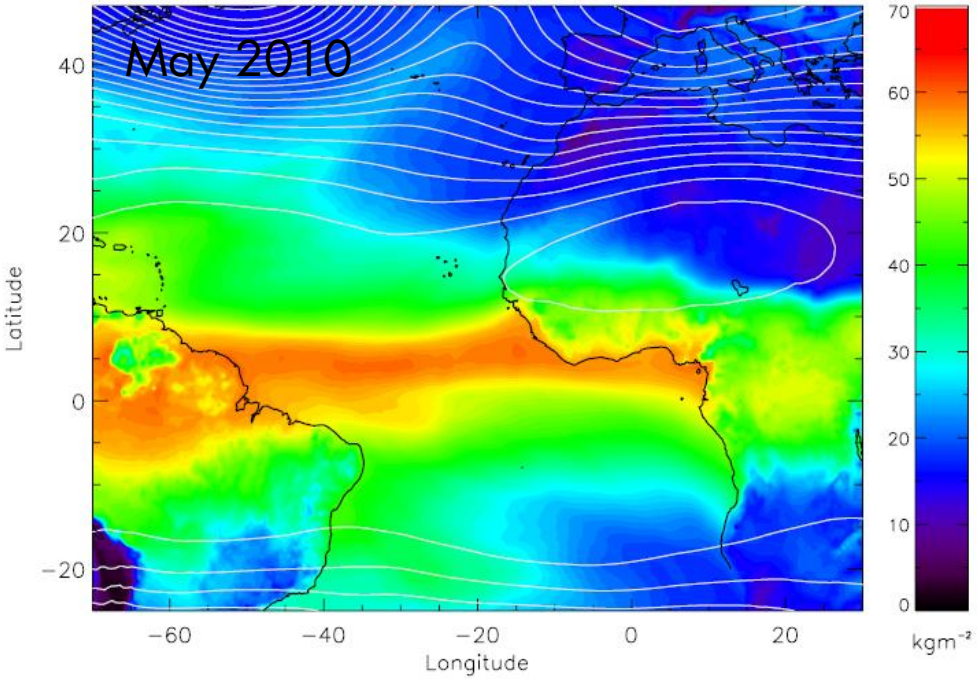


Nr	Cruise name	Start day	End day	Season	Start	End	Trade wind zone	
1	ANT-XXIII/10	12.04.2007	04.05.2007	Spring	Cape Town	Bremerhaven	8	32
2	ANT-XXIV/1	26.10.2007	26.11.2007	Autumn	Bremerhaven	Cape Town	10	23
3	ANT-XXIV/4	18.04.2008	20.05.2008	Spring	Punta Arenas	Bremerhaven	8	28
4	ANT-XXV/5	11.04.2009	24.05.2009	Spring	Punta Arenas	Bremerhaven	9	34
5	ANT-XXVI/1	16.10.2009	25.10.2009	Autumn	Bremerhaven	Punta Arenas	10	25
6	ANT-XXVI/4	07.04.2010	17.05.2010	Spring	Punta Arenas	Bremerhaven	5	27
7	ANT-XXVII/1	25.10.2010	26.11.2010	Autumn	Bremerhaven	Cape Town	21	28
8	ANT-XXVII/4	20.04.2011	20.05.2011	Spring	Cape Town	Bremerhaven	8	30
9	ANT-XXVIII/1	28.10.2011	30.11.2011	Autumn	Bremerhaven	Cape Town	10	30
10	ANT-XXVIII/5	11.04.2012	15.05.2012	Spring	Punta Arenas	Bremerhaven	10	26
11	ANT-XXIX/1	27.10.2012	27.11.2012	Autumn	Bremerhaven	Cape Town	14	21
12	M96	28.04.2013	22.05.2013	Spring	Pointe-à-Pitre	Mindelo	-	-
13	ANT-XXIX/10	08.03.2014	13.04.2014	Spring	Cape Town	Bremerhaven	10	26

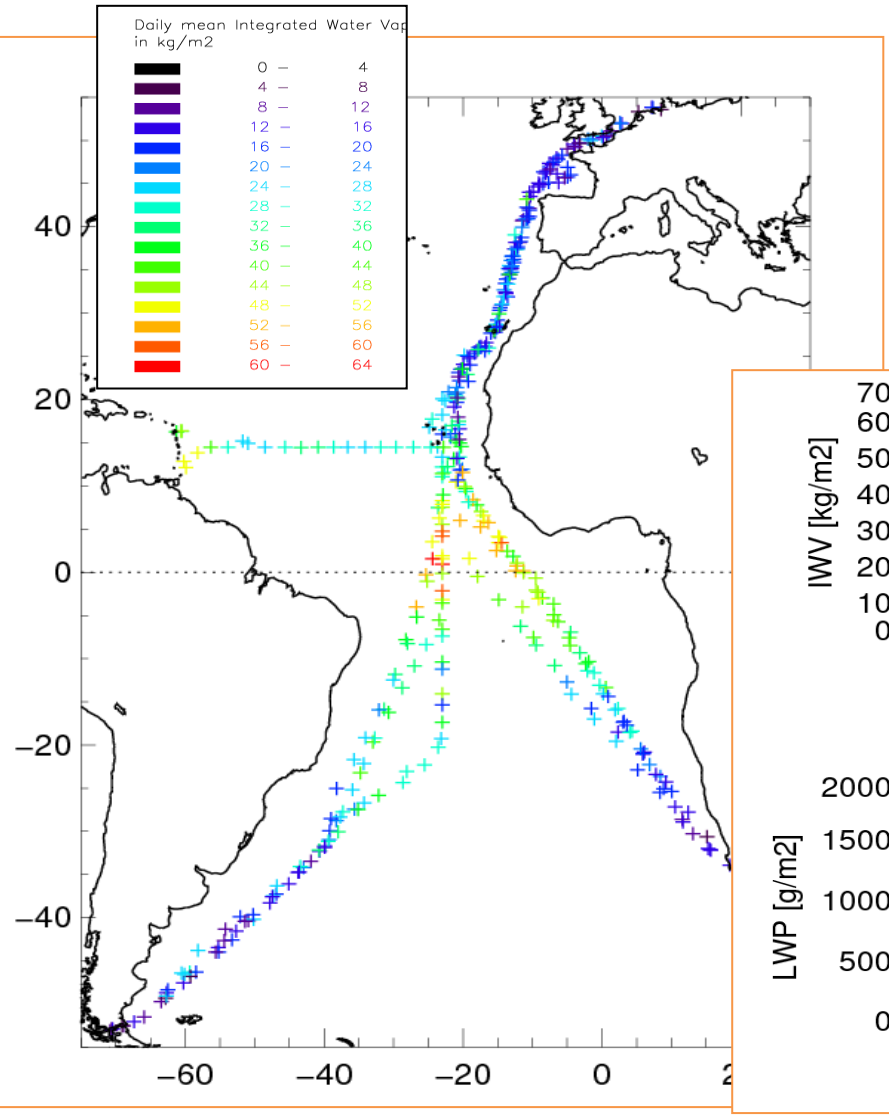
Water vapor distribution



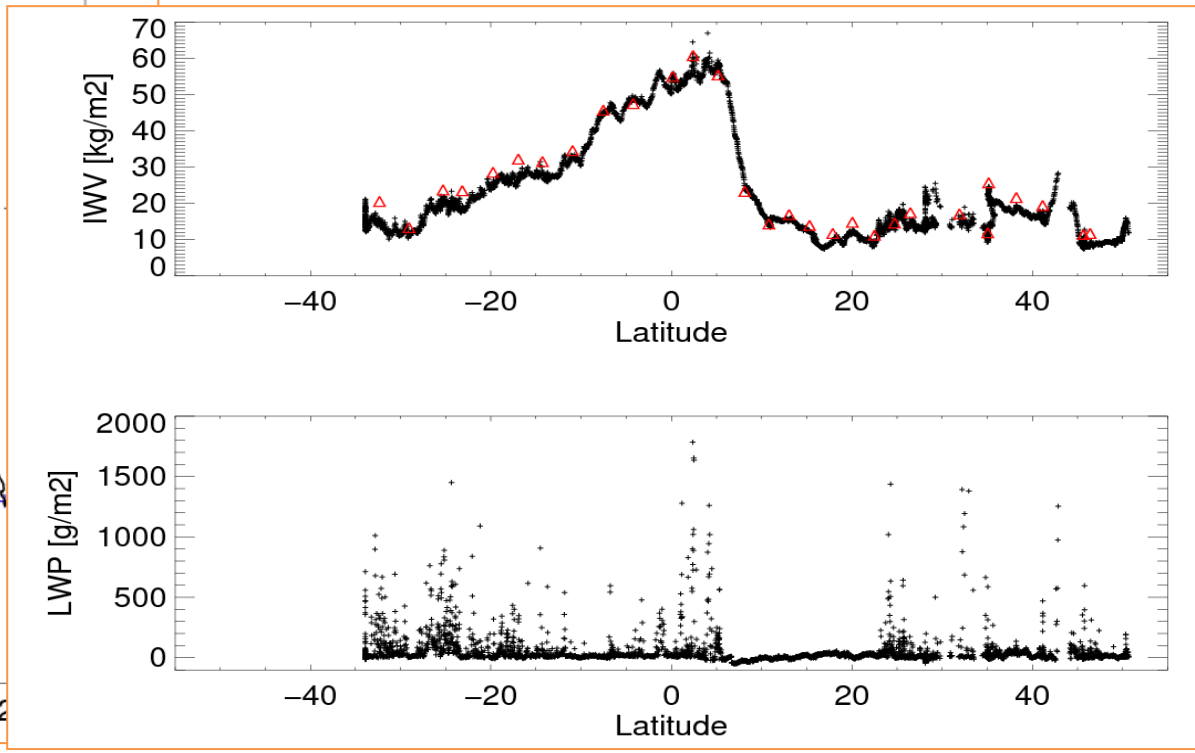
- IWV (integrated water vapor) for all cruises, ITCZ well detected
- mean IWV from May 2010 ECMWF analyses



Water vapor distribution

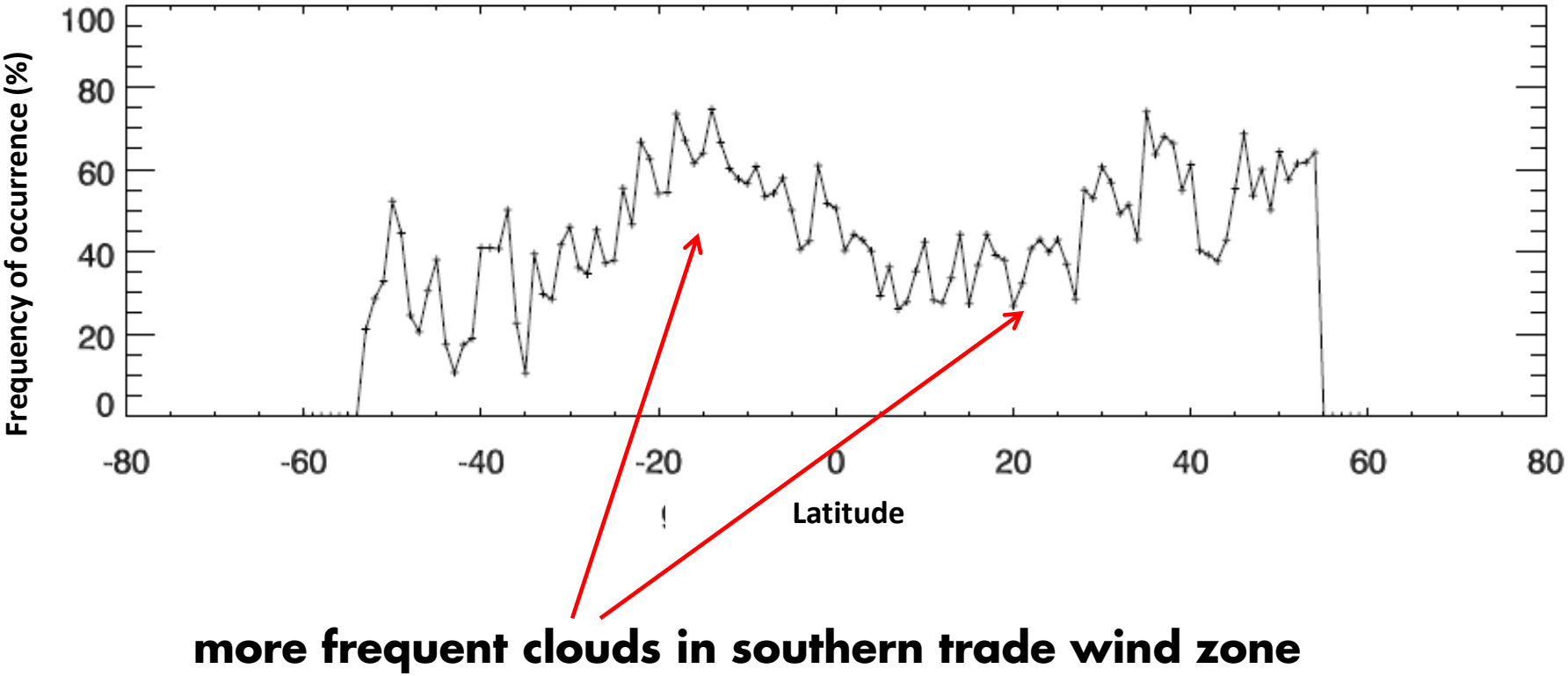


Cross-section of IWV and LWP for one cruise (ANT-29/10), red: radiosonde



Cloud distribution

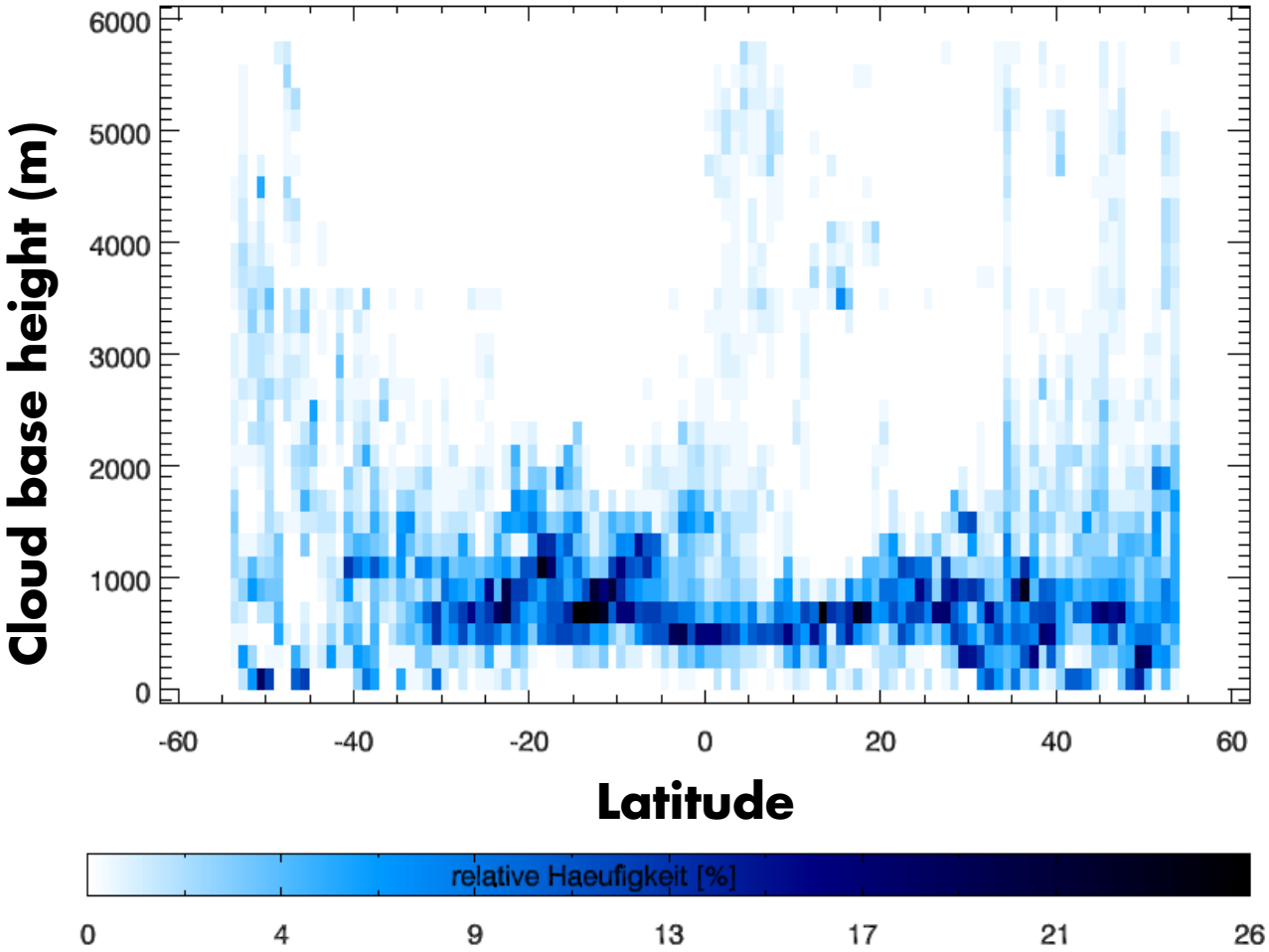
- Frequency of clouds observed by ceilometer (all cruises)



more frequent clouds in southern trade wind zone

Cloud distribution

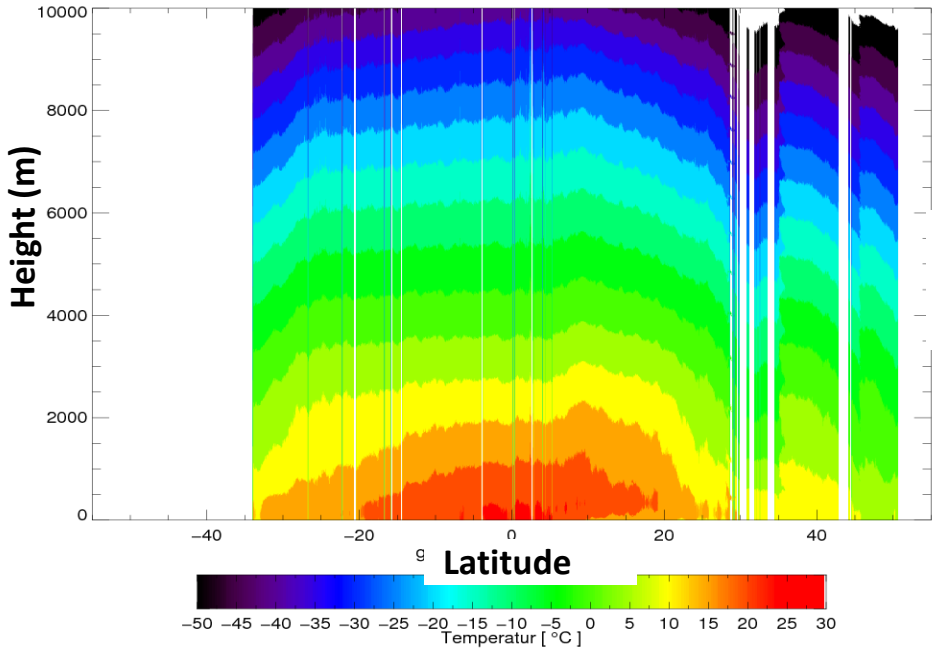
Frequency of clouds observed by ceilometer (all cruises), separation by (lowest) cloud base height



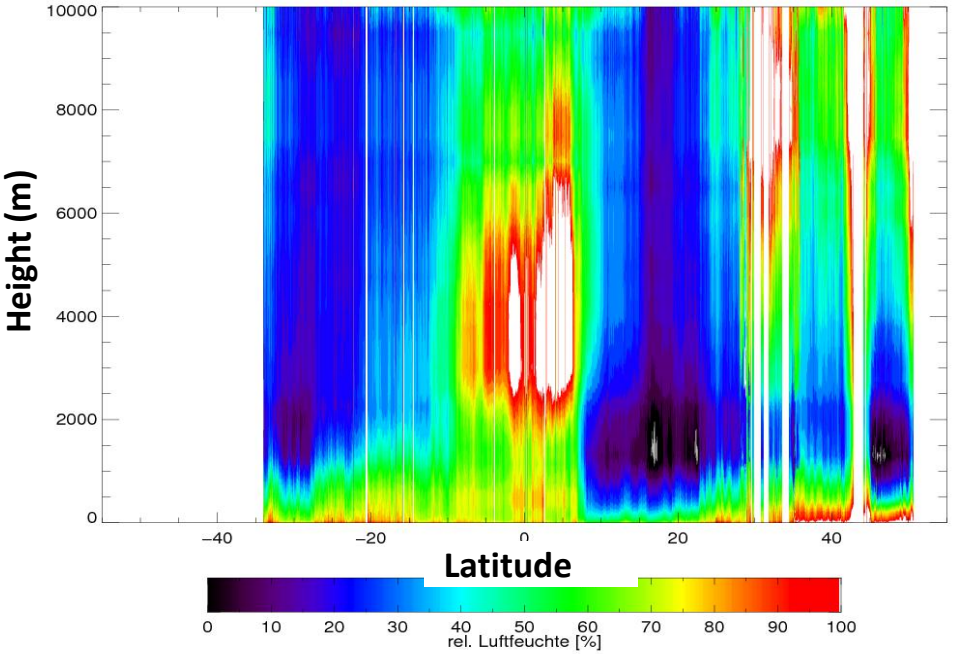
Temperature/humidity profiles

- Microwave radiometer profiles along ship track (ANT-29/10, March/April 2014)

Temperature profile



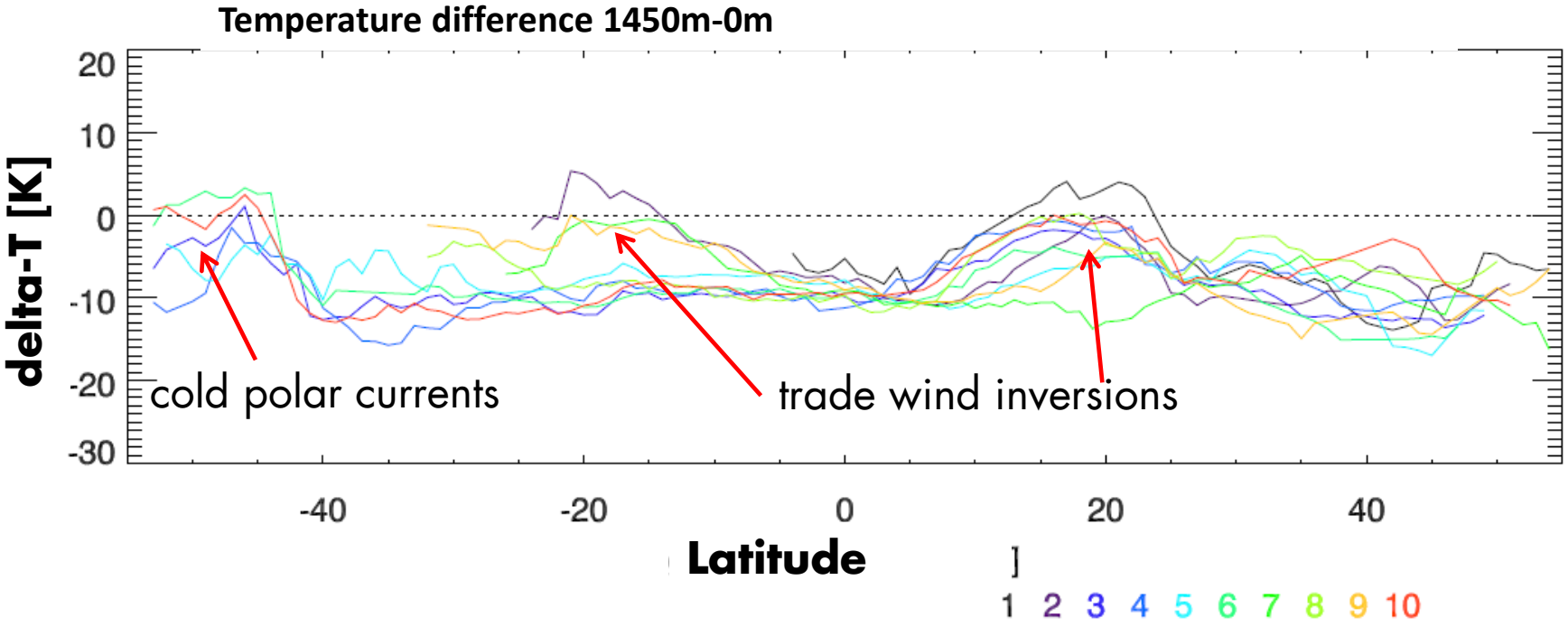
Rel. humidity profile



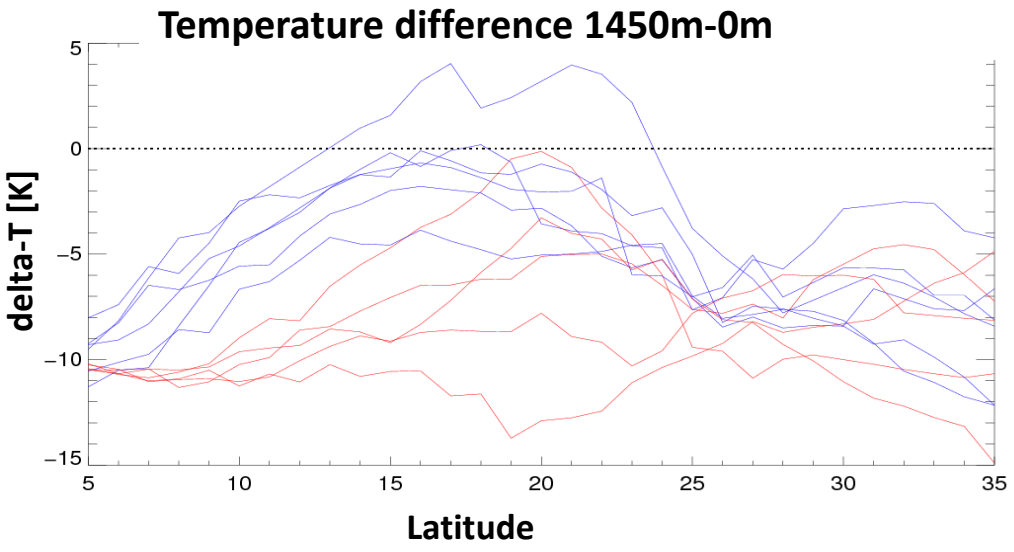
Atmospheric stability

From HATPRO temperature profiles, information on inversions are provided

Trade wind inversions appear very well at nearly every cruise



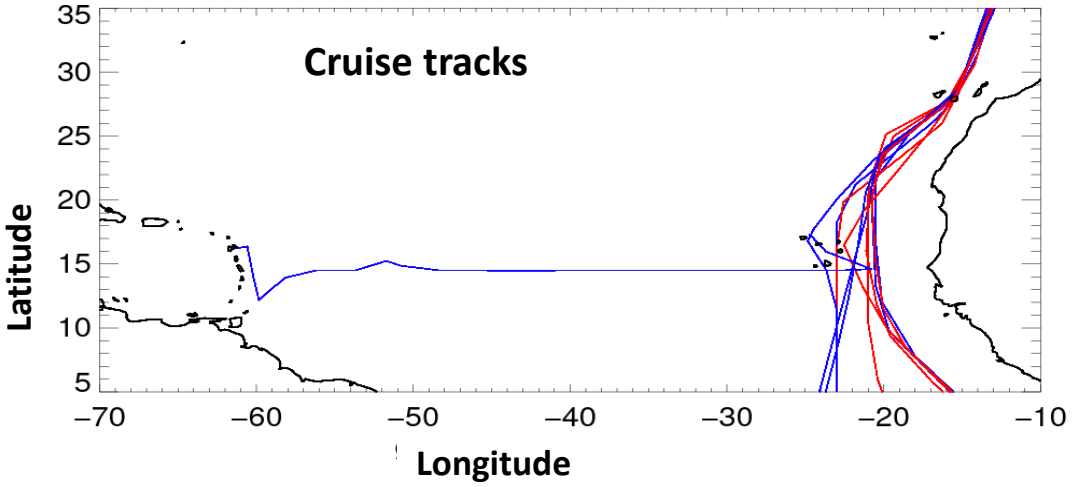
Zoom into northern trade wind zone



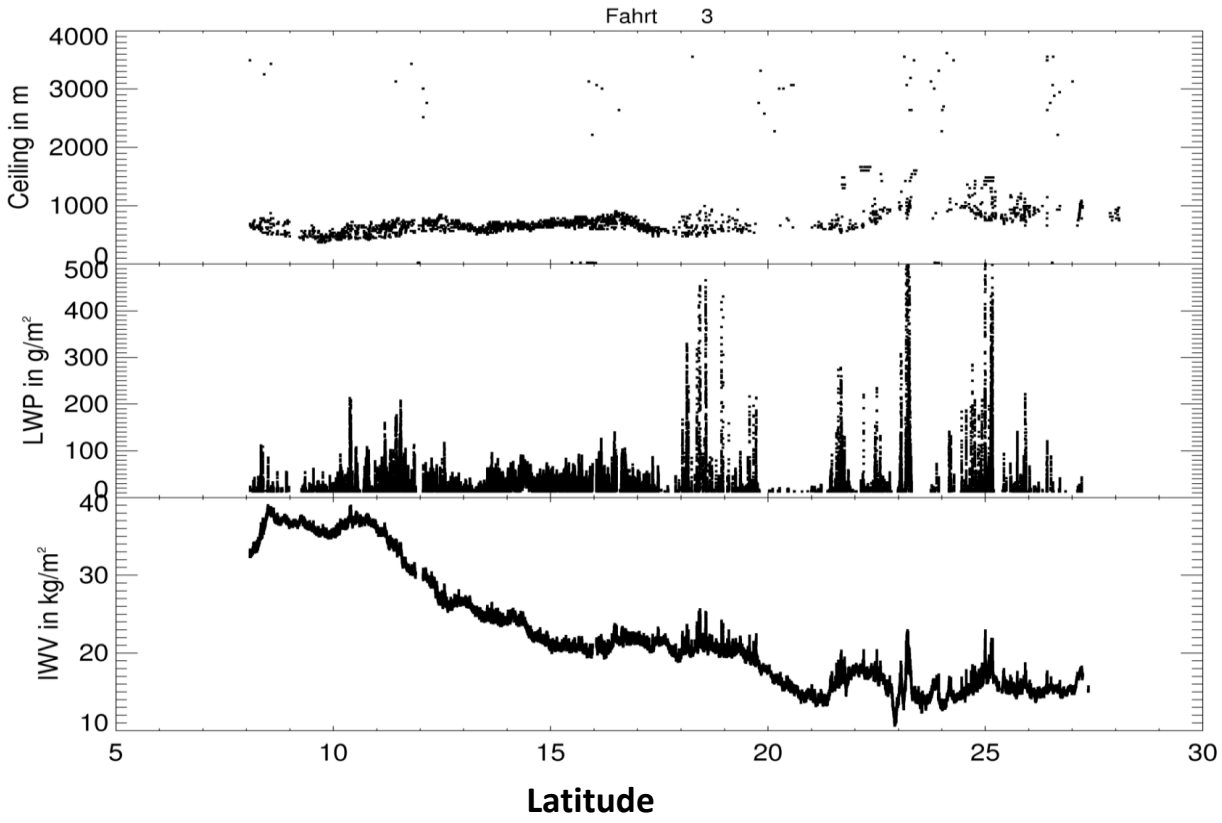
Northern trade wind zone properties

red: October/November
blue: April/May

> stronger inversions in northern spring season



Trade wind zone



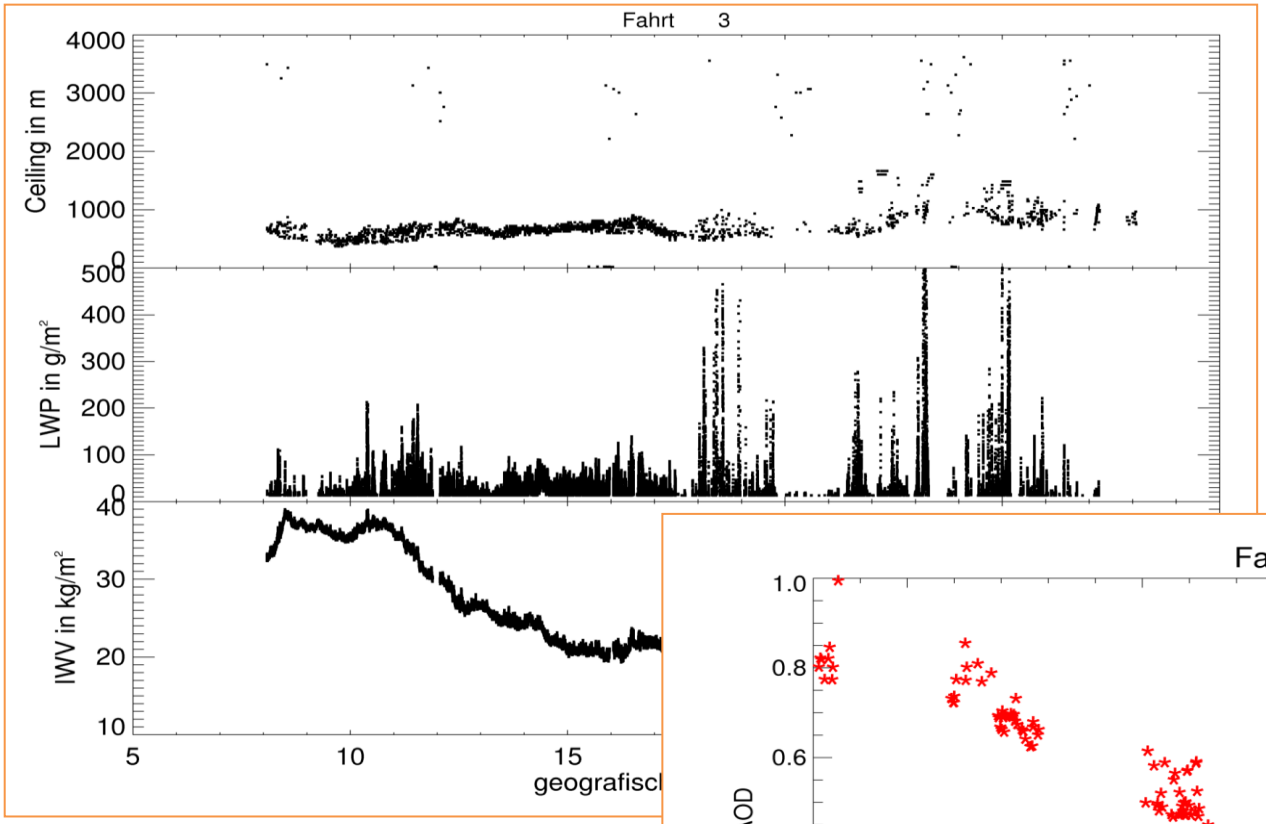
Cruise ANT-24/4 (April/May 2008)

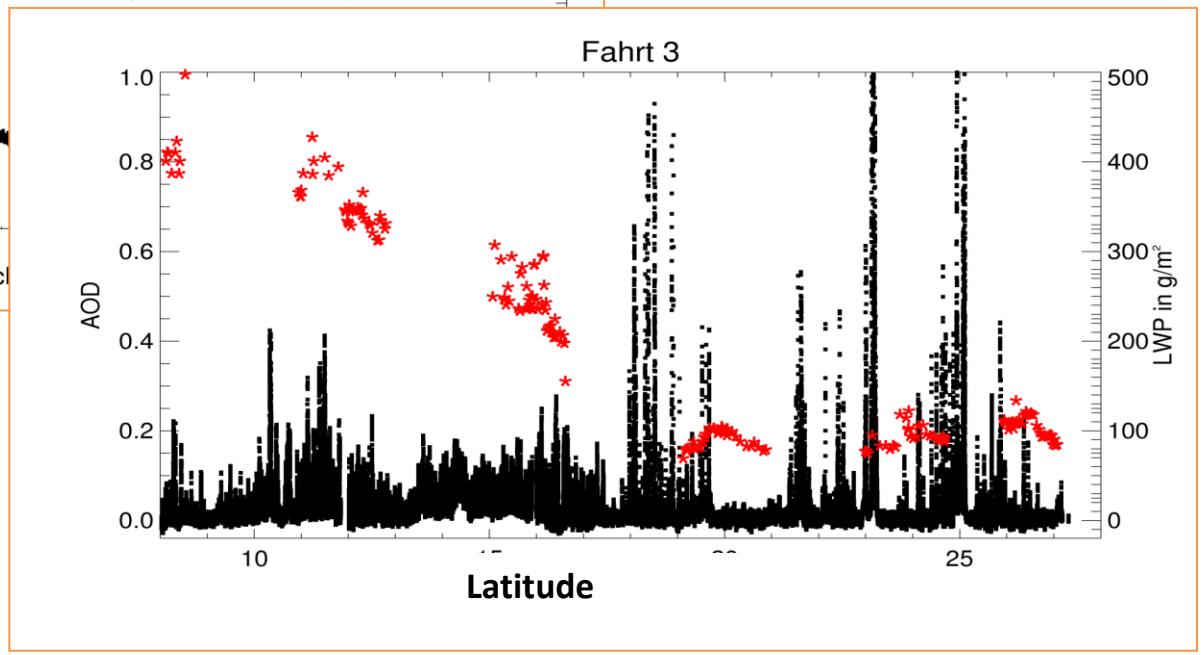
Cloudbase height (m)

Liquid water path (g/m²)

Integrated water vapor (kg/m²)

Trade wind zone

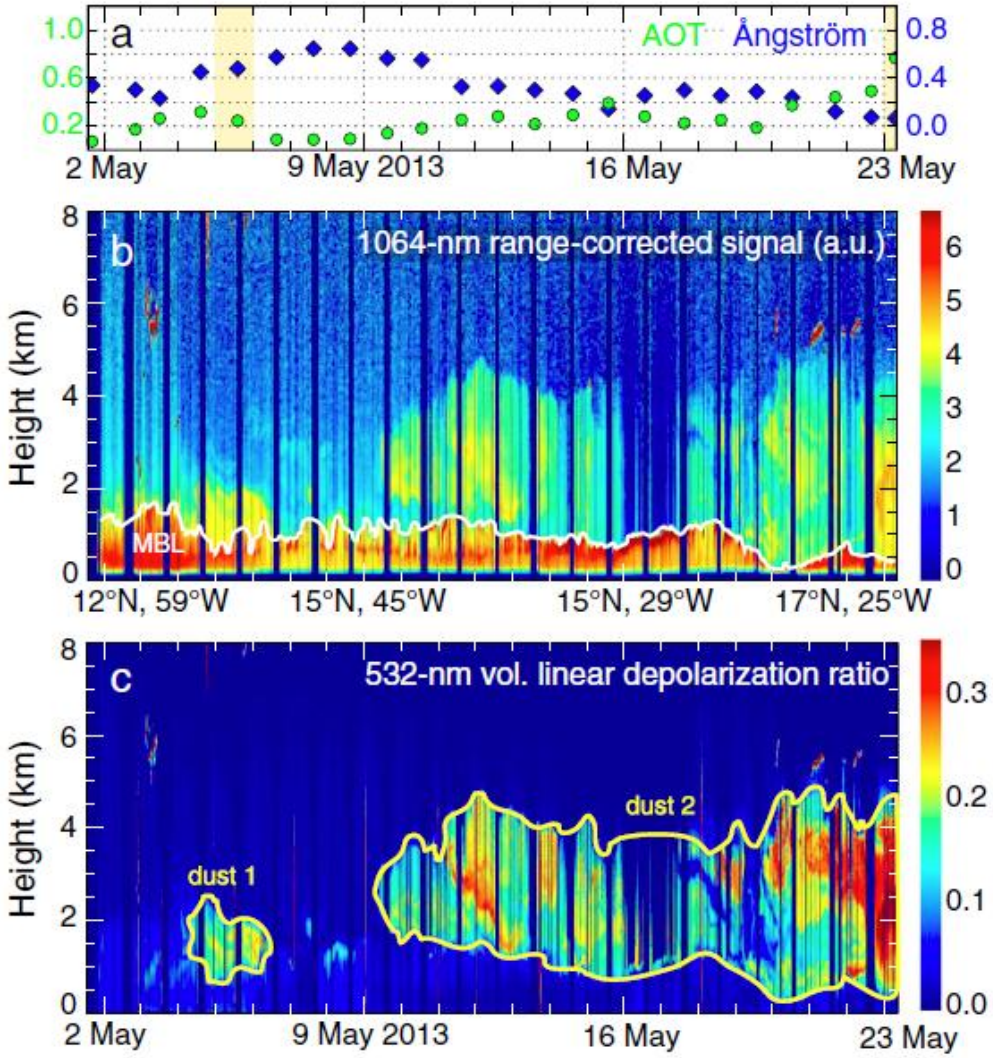


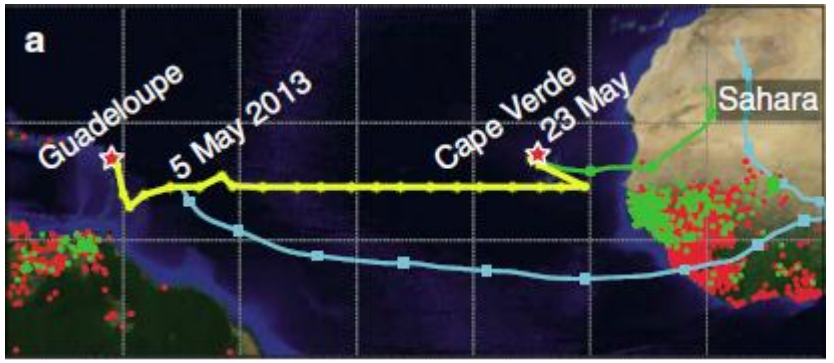


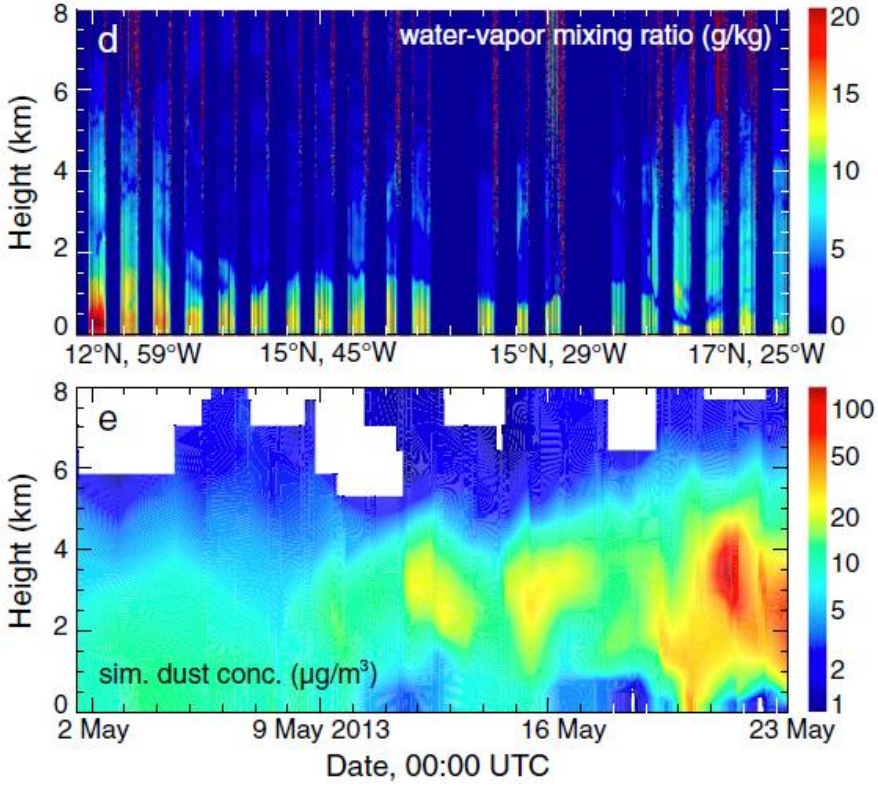
Cruise ANT-24/4
(April/May 2008)

- Liquid water path (g/m²)
- Aerosol optical depth

Aerosol distribution

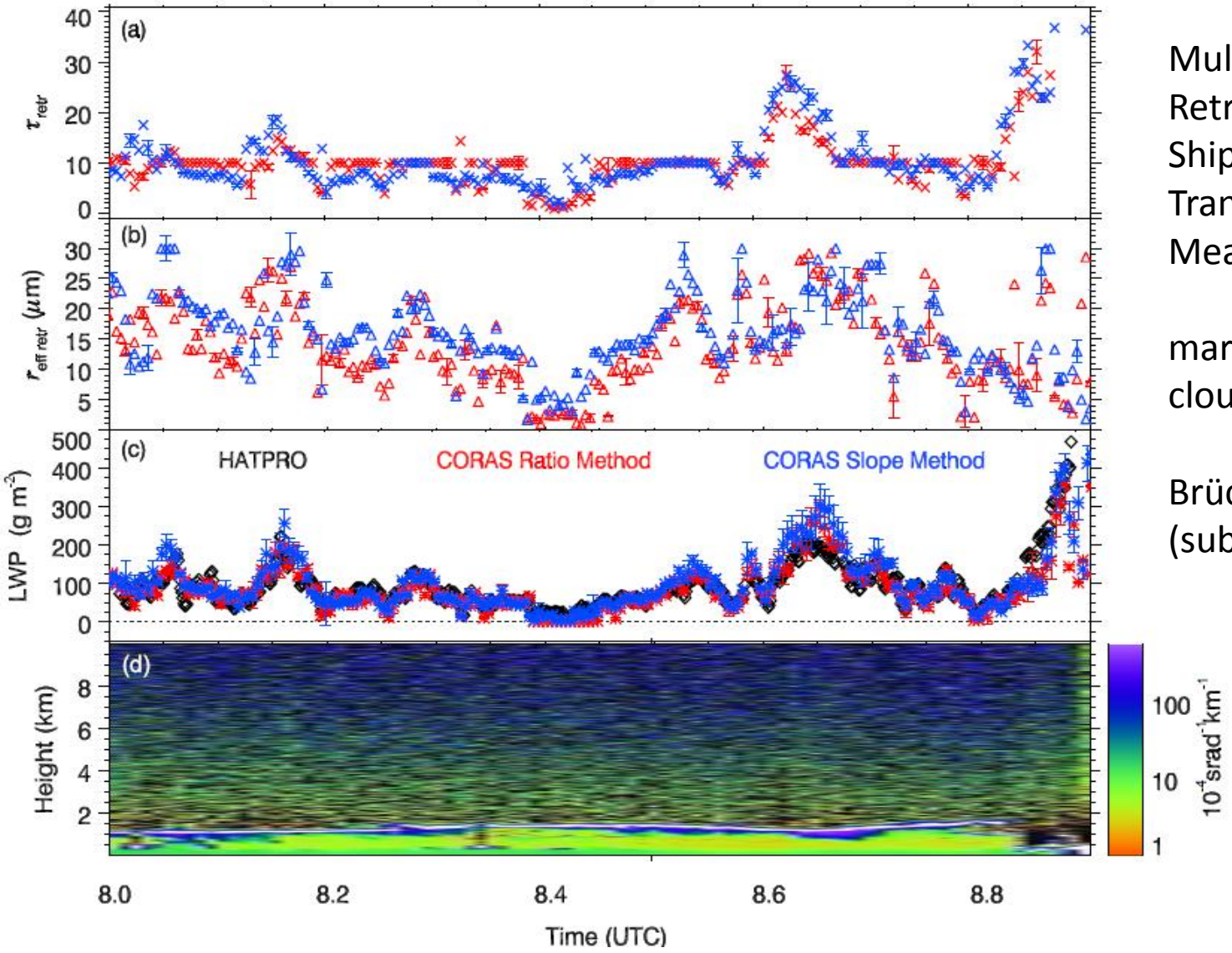






Kanitz et al. 2014

Spectral cloud retrieval



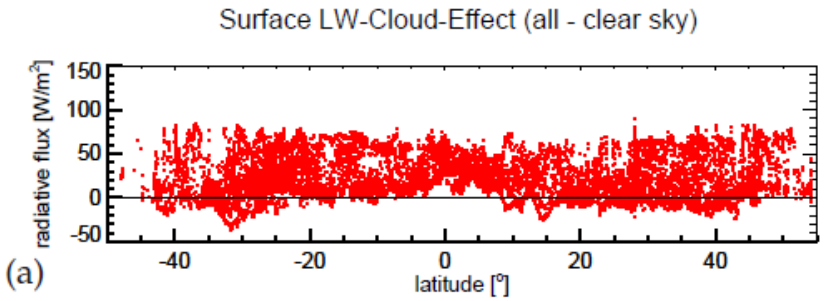
Multi–Spectral Cloud Retrieval Method for Ship–based Solar Transmissivity Measurements

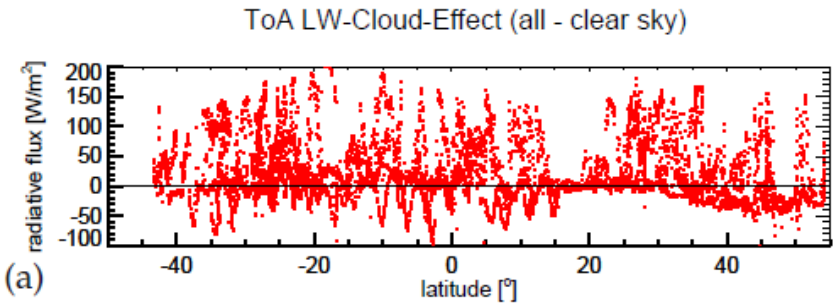
marine stratocumulus clouds in SE Atlantic

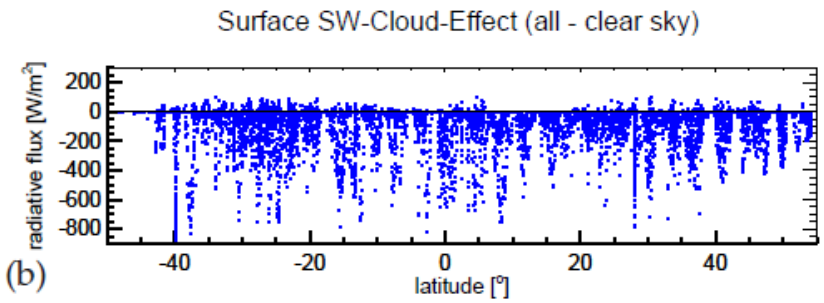
Brückner et al. 2014 (submitted to JGR)

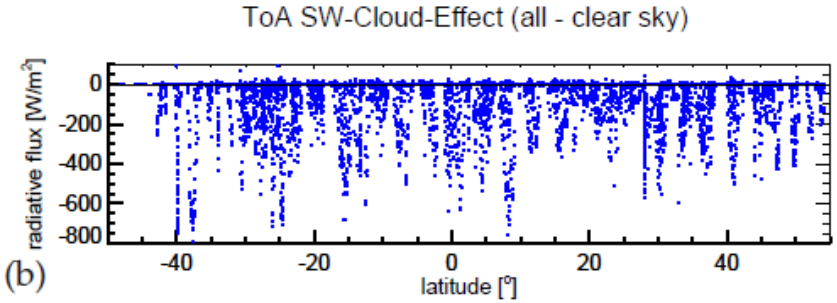
Cloud radiative effects

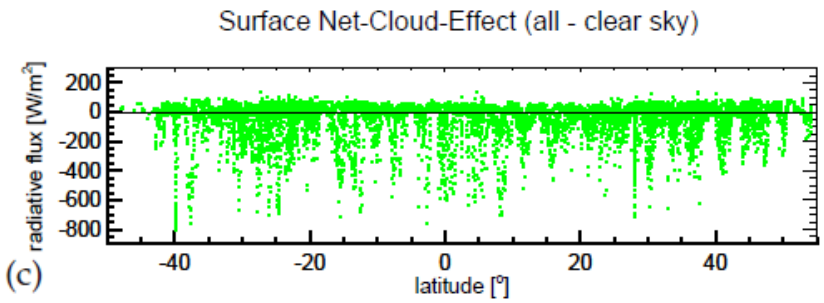
Radiative effects from SW and LW radiation observations

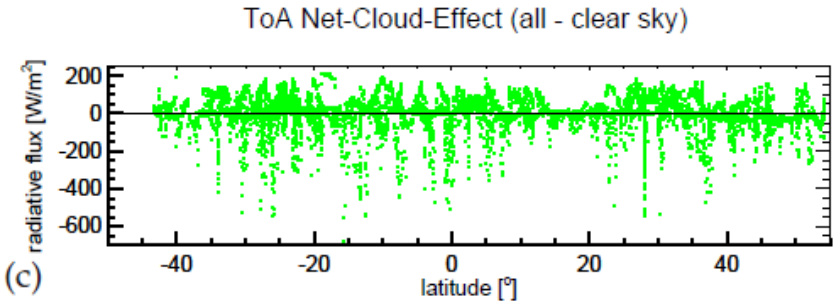








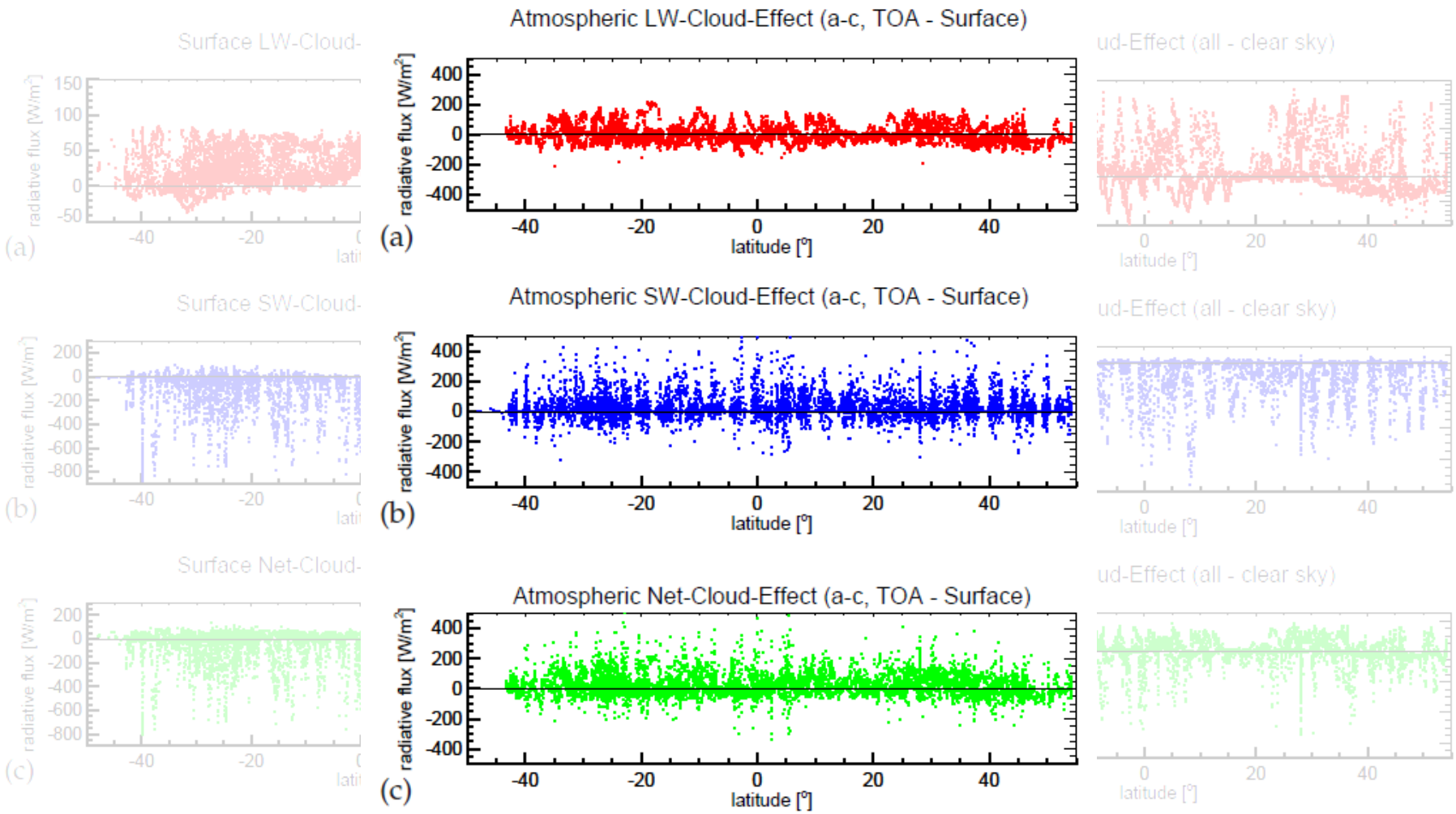




Kalisch, 2011

Cloud radiative effects

Radiative effects from SW and LW radiation observations



Kalisch, 2011

Summary/Outlook

- Ship-based observations of tropospheric properties (clouds, water vapor, aerosol, radiation) on 13 cruises of Polarstern,
- Statistics for different climatic zones possible
- Continuation of measurements (next cruise in March/April 2015)
- Further investigation of cloud properties by adding information from cloud radar measurements (only cruise 13)
- Evaluation of satellite overpasses (Cloudsat, Calipso)
- Combination with MSG-SEVIRI cloud products

Thank you for your attention!