Aerosol, Clouds and the Southern Ocean

From Cape Grim to the RV Investigator

Melita Keywood and Alain Protat

20 May 2015

OCEANS AND ATMOSPHERE FLAGSHIP
www.csiro.au

UNIVERSITY OF WOLLONGONG

QUT

CSIRO

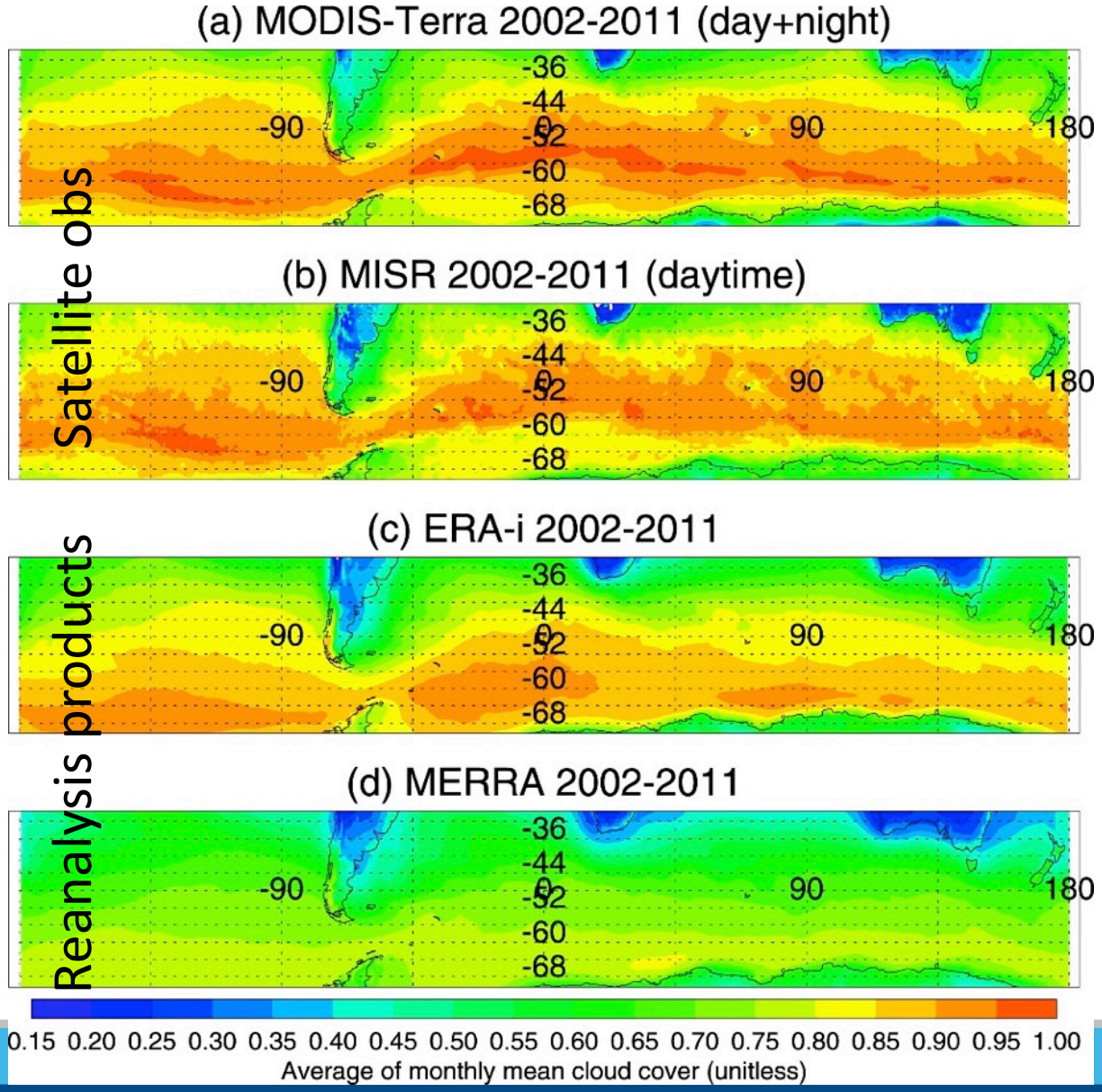
Australian Government
Bureau of Meteorology

Marine National Facility

MACQUARIE University

THE UNIVERSITY OF MELBOURNE

Poor simulation of Southern Ocean Clouds



- cloud over SO >0.8 in a band between 40° and 60°S
- reanalysis underestimates cloud cover by about 0.1-0.2

What's so important about the atmosphere over the Southern Ocean?

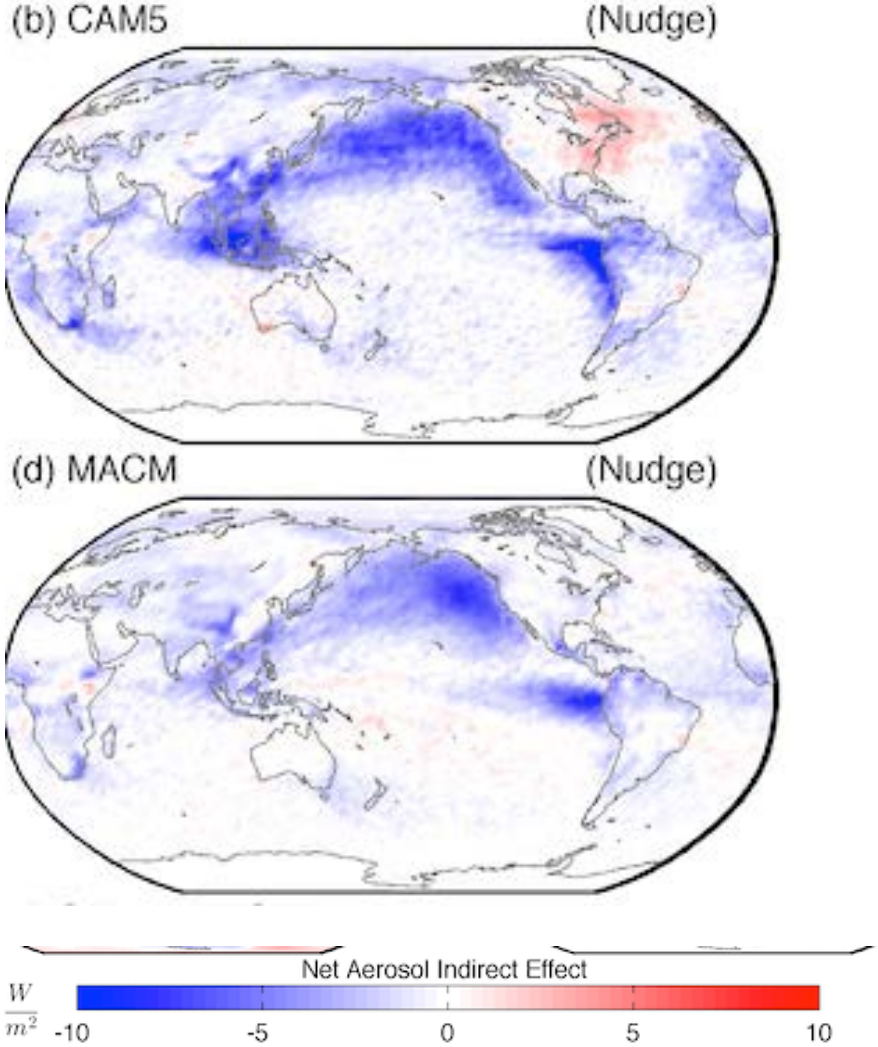
Large radiation bias for Southern Ocean (models overestimate radiation) e.g. Trenberth and Fasullo (2010)

Two main cloud regimes affecting the shortwave radiation in the SO

1) frontal clouds because they are highly reflective
2) low-level clouds because they are ubiquitous (Haynes et al. 2011)

 Photo from Dagmar

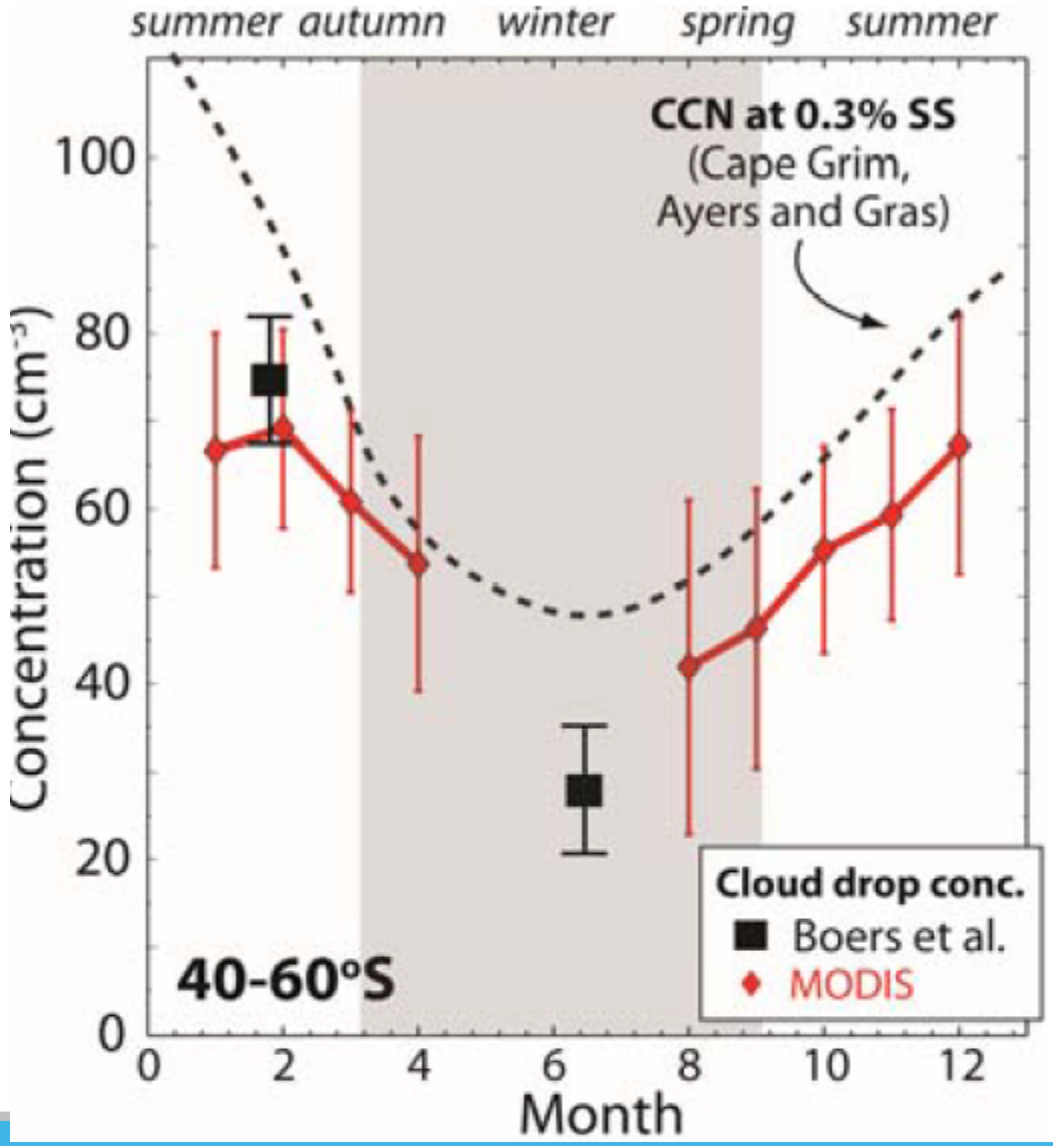
Southern Ocean- modern surrogate for pre-industrial aerosol conditions



- aerosol forcing associated with ACI over the SO is small relative to NH

Adapted from Kooperman et al. (2012)

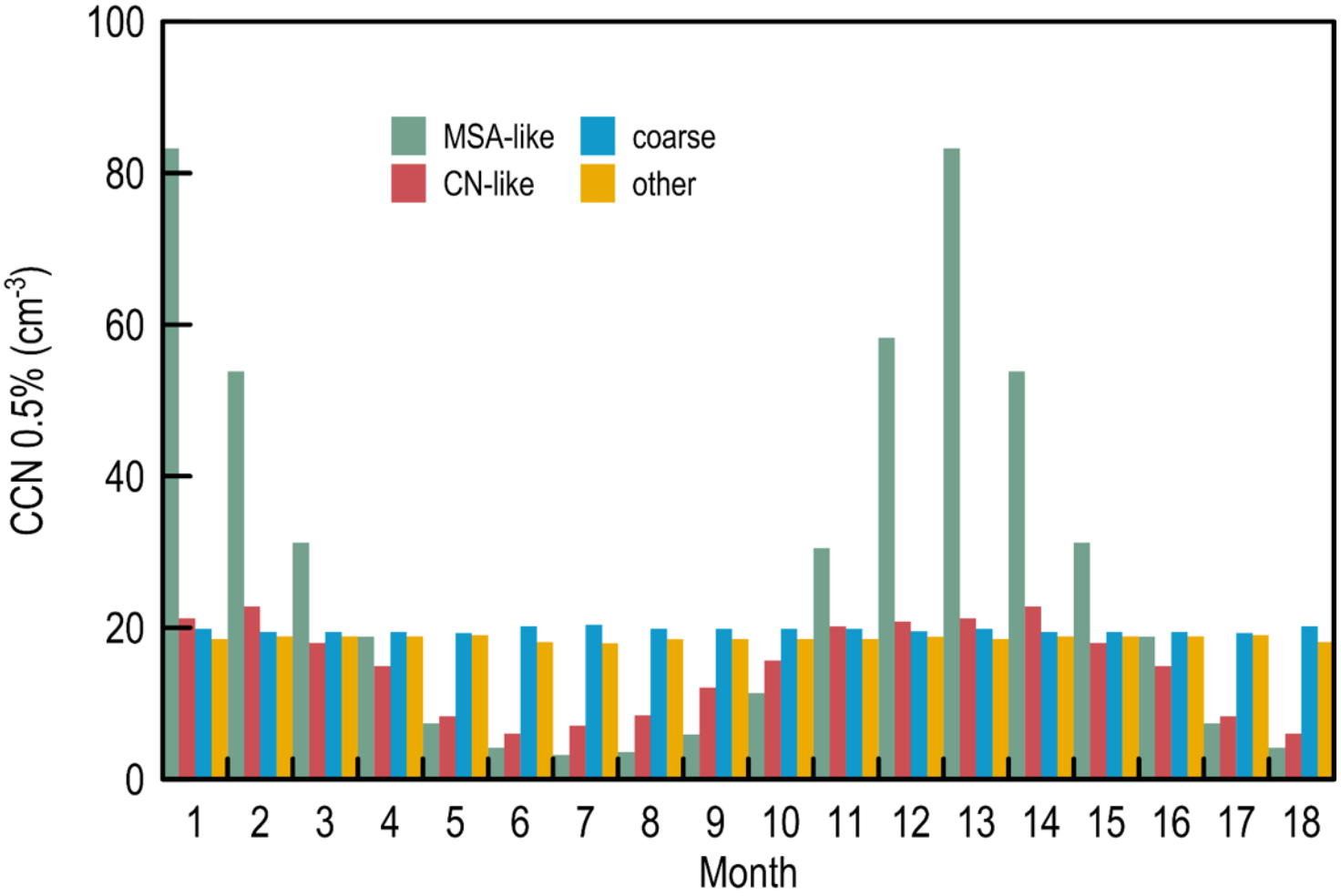
Cape Grim



The processes that influence cloud-forming aerosol properties in the remote marine atmosphere such as the SO are poorly understood (Quinn and Bates 2011)

Figure 4: Seasonal cycles of cloud drop concentration (N_d) and CCN concentration over the Southern Ocean. *N_d data are derived from passive visible/near-IR data from MODIS (red) and from limited aircraft flights during winter and summer (black squares). The seasonal cycle of CCN at 0.3% supersaturation from measurements at Cape Grim (Ayers and Gras 1991) is also shown, as are cloud droplet concentration measurements from SOCEX campaigns (Table 1).*

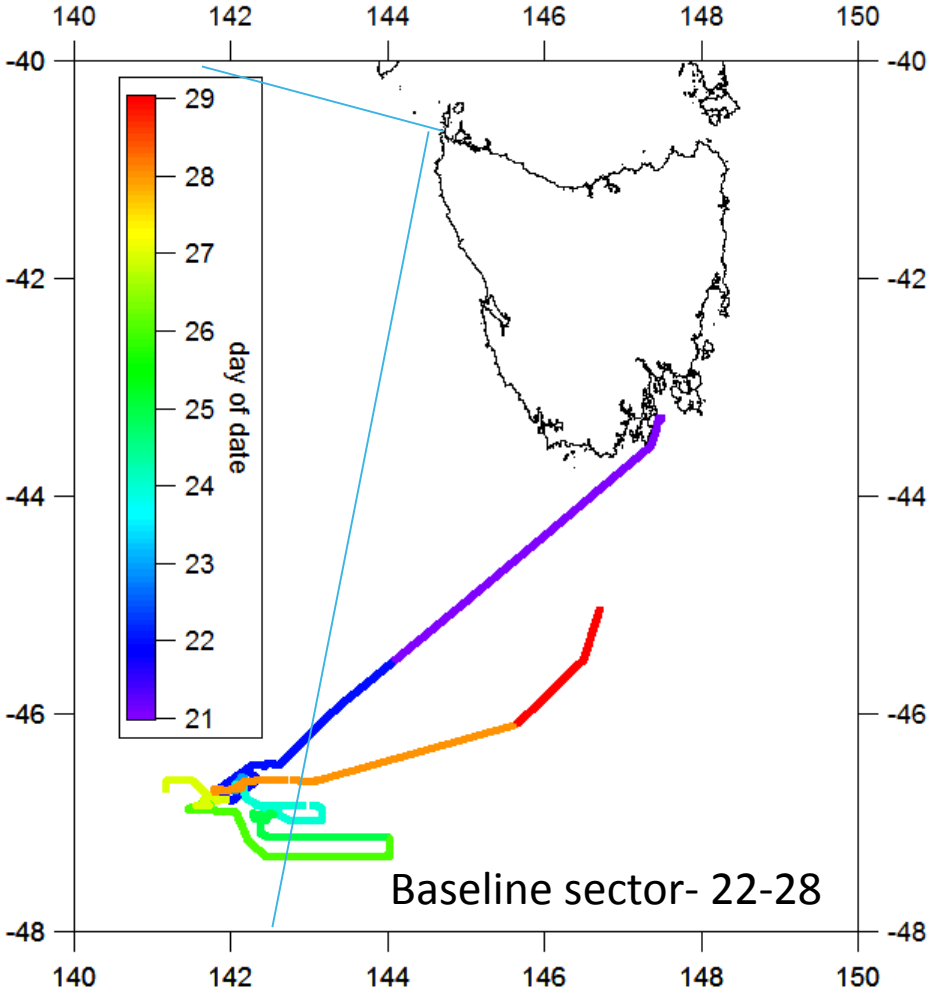
DMS only important in summer

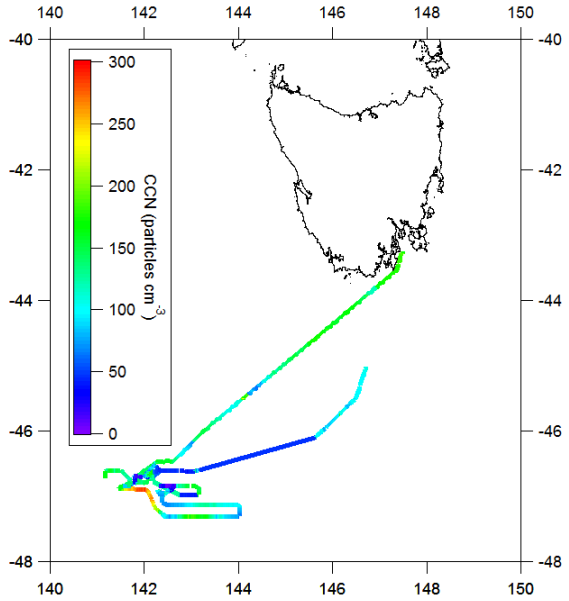


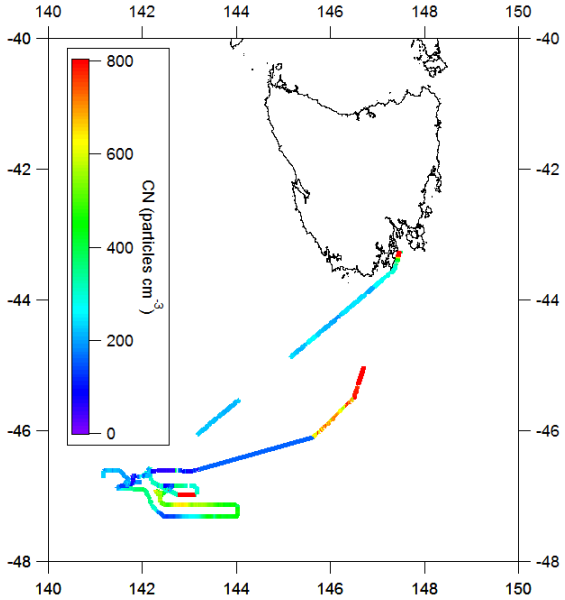
RV Investigator

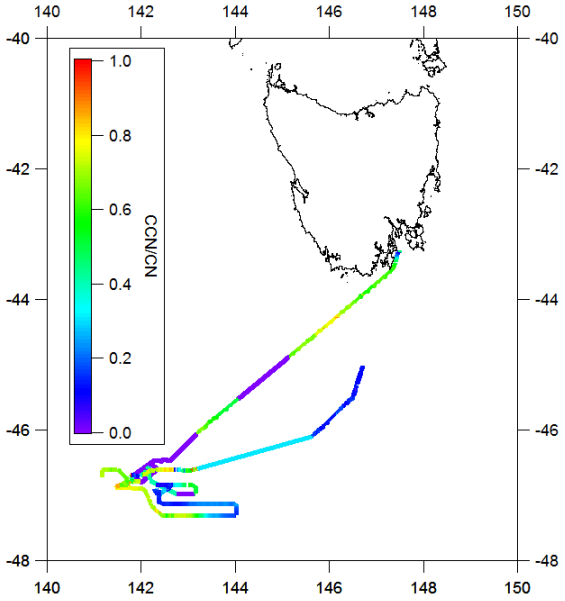
Maiden Science Voyage INV2015-v01

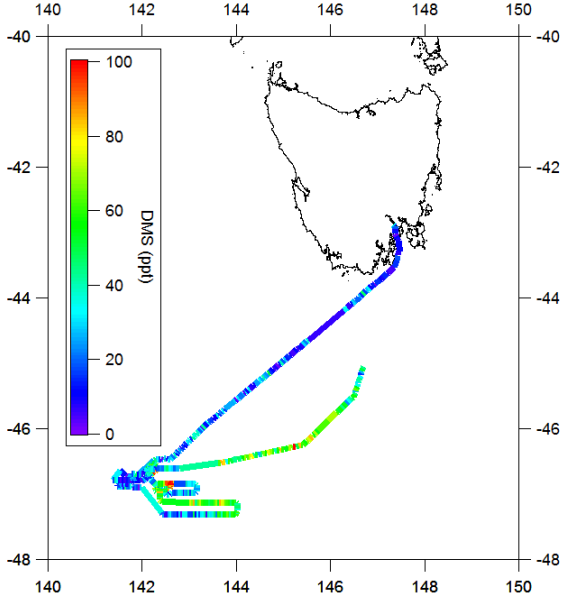
- Piggy backed onto Moorings voyage
- 21-29 March 2015



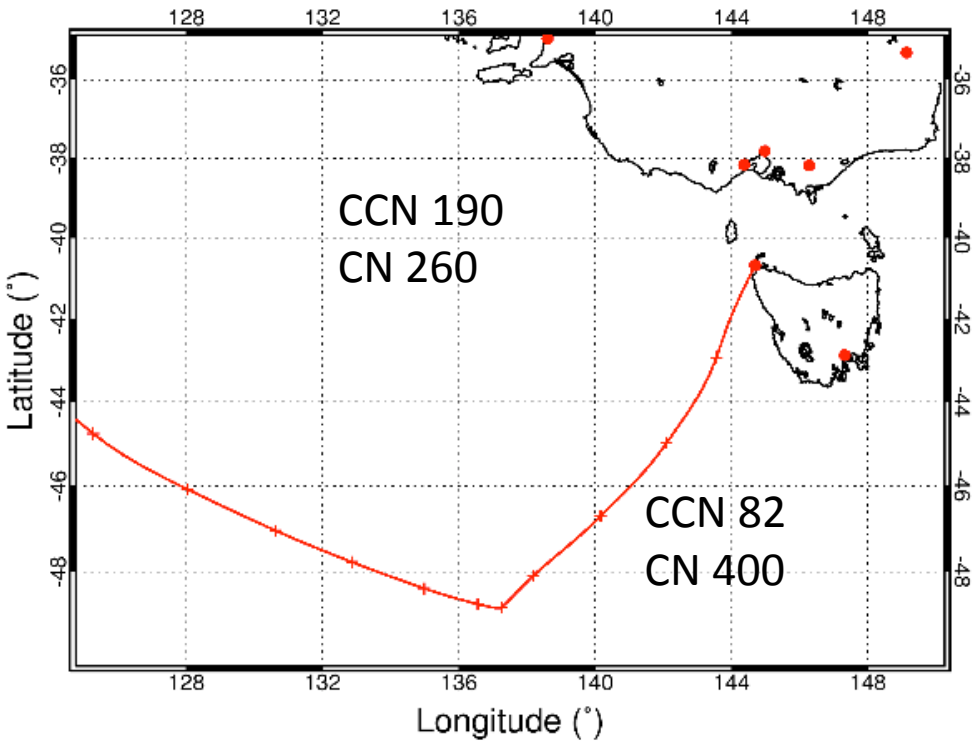

CCN (particles cm-3)
300
250
200
150
100
50
0
140
142
144
146
148
150
-40
-42
-44
-46
-48


CN (particles cm-3)
800
600
400
200
0
140
142
144
146
148
150
-40
-42
-44
-46
-48


CCN/CN
1.0
0.8
0.6
0.4
0.2
0.0
140
142
144
146
148
150
-40
-42
-44
-46
-48

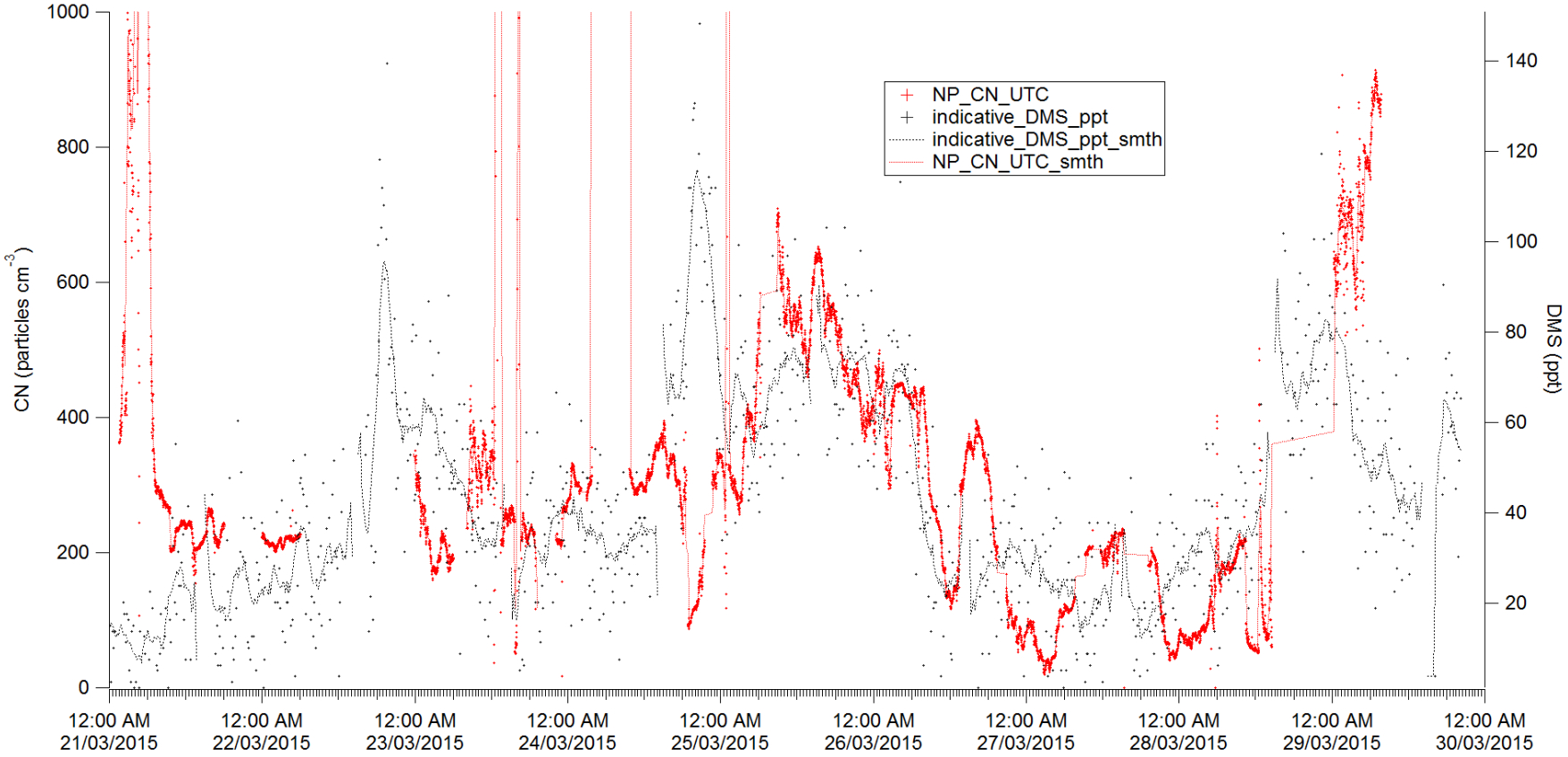

DMS (ppt)
100
80
60
40
20
0
140
142
144
146
148
150
-40
-42
-44
-46
-48

Relationship to Cape Grim

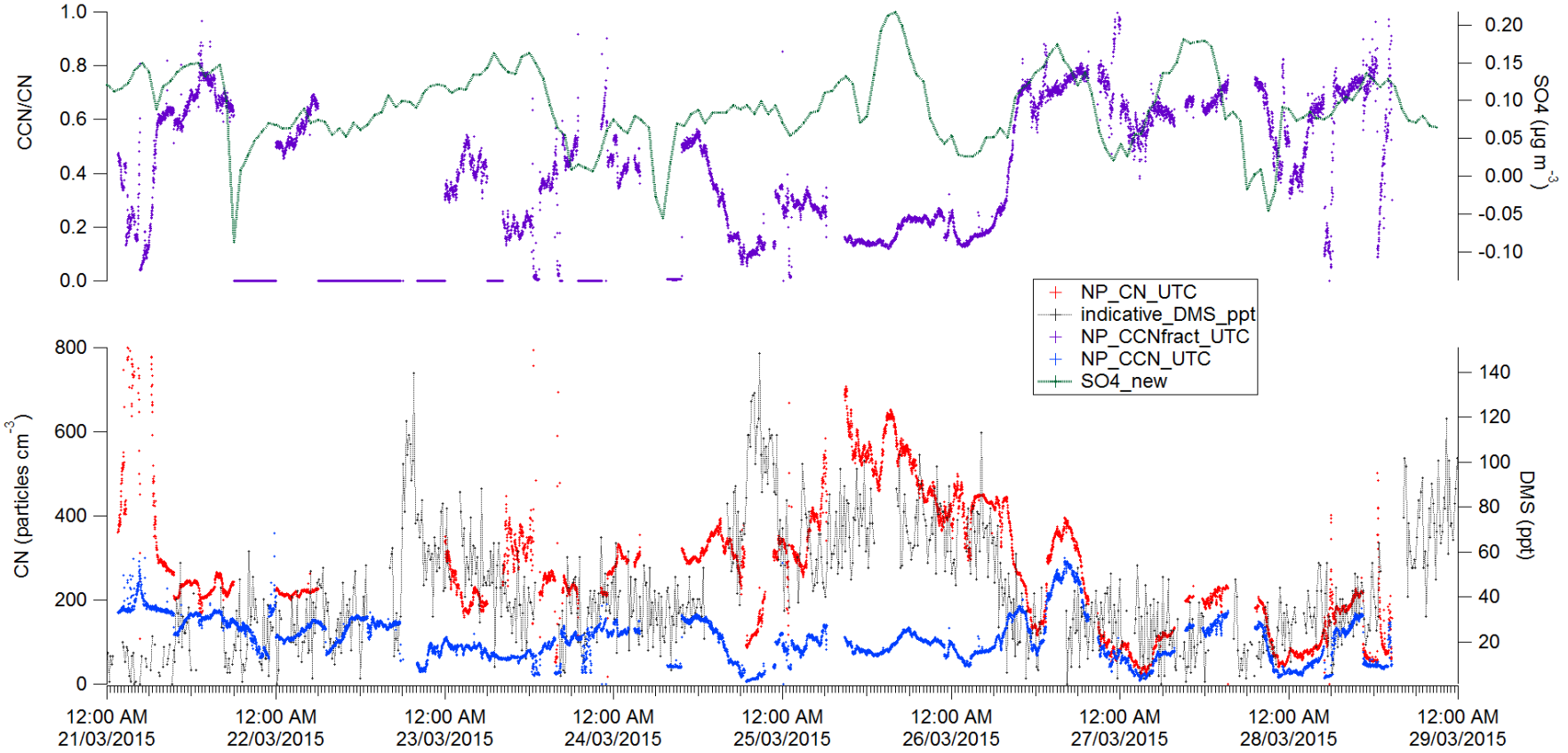


- Ship was in Baseline sector 22-28 March
- Back trajectories (96 hours) carried out every 6 hours
- 5 cases of back trajectory passing through location of ship (approx.)
- 18 hours behind
- 23 March (no CN data)
- 26 March (CCN and CN data)
- CPC colocation at Cape Grim agreed within 1%
- CCN colocation at Cape Grim agreed within 20%

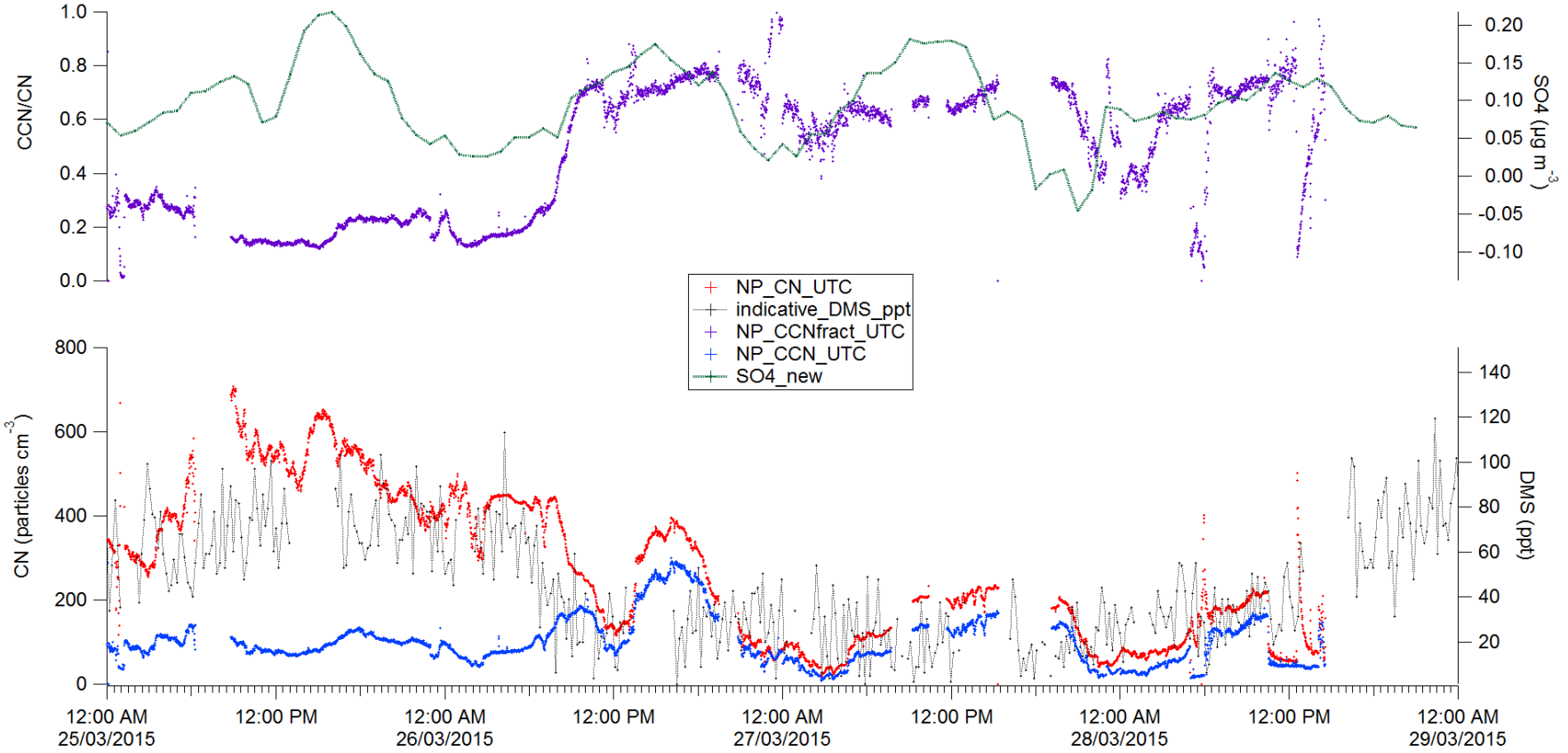
Periodical features

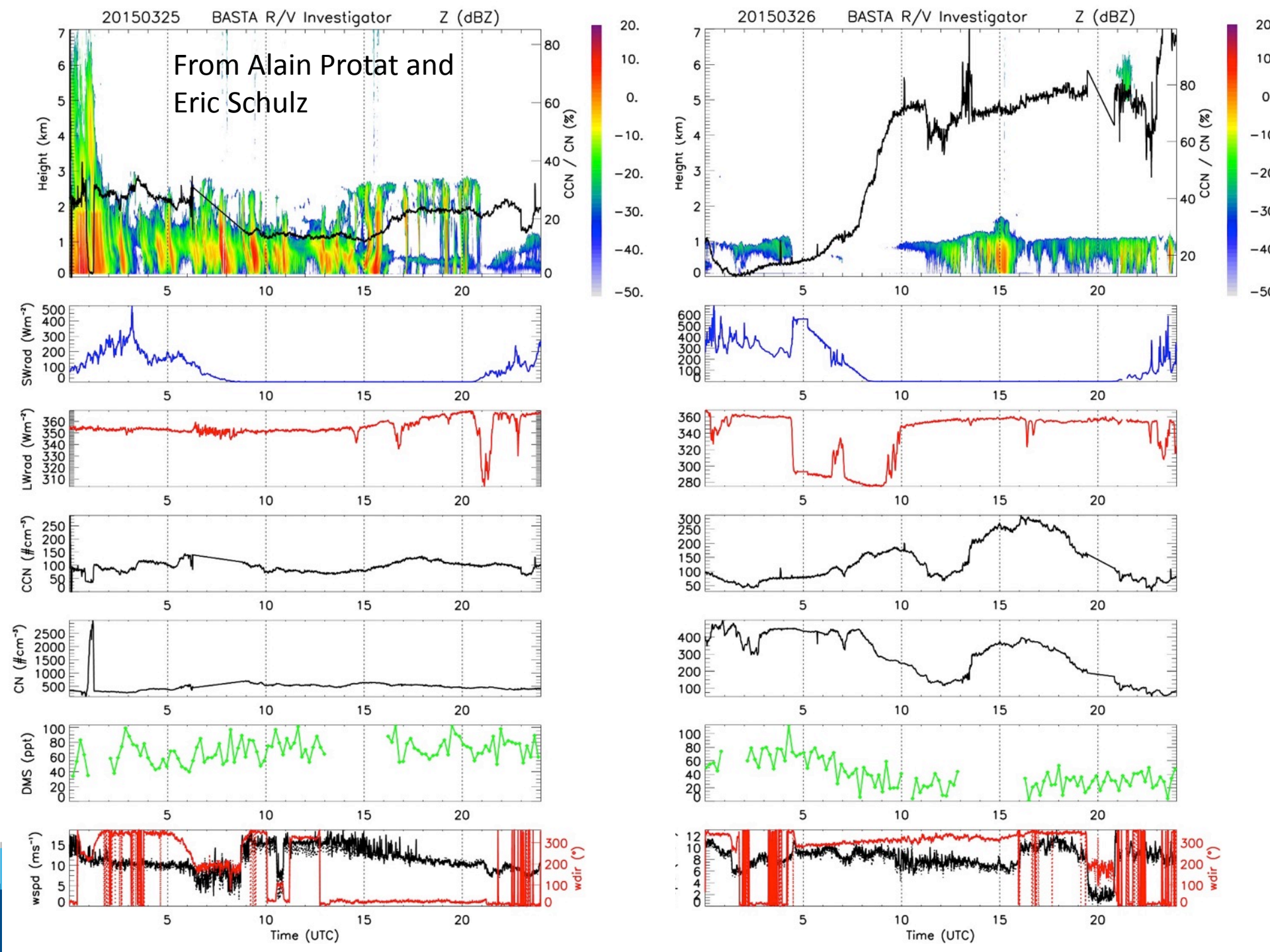


Diurnal features



Different patterns




20150325 BASTA R/V Investigator Z (dBZ)
20150326 BASTA R/V Investigator Z (dBZ)
From Alain Protat and Eric Schulz
Height (km)
CCN / CN (%)
SWrad (Wm⁻²)
LWrad (Wm⁻²)
CCN (#cm⁻³)
CN (#cm⁻³)
DMS (ppt)
wspd (ms⁻¹)
wdir (°)
Time (UTC)

Summary of quick look at data

- Remove smoke plume
- CN concentrations between 100-800 particles cm^{-3}
- CCN concentrations 20-200 particles cm^{-3}
- CN decreases from SO to Cape Grim; CCN increases
- 5 day cycle CN and DMS (clearer in 2nd half of journey when data set is more complete
- CCN/CCN ratio increases on 26th from 20% to 80% and remains at 80%- after this we see a clear diurnal cycle in CN, CCN, SO4 but not DMS
- Increase in CCN/CN followed by presence of low level clouds (less than 1km)

What next?

More voyages on RV Investigator (for instruments and others)

CAPRICORN- Clouds, Aerosols, Precipitation, Radiation, and atmospheric Composition Over the southeRn oceaN –led by Alain Protat- March 2016

ACRE -Antarctic Cloud and Radiation Experiment led by Simon Alexander (AAD)- Macquarie Island 2016

SOCRATES- proposal- US led-SO Clouds, Radiation, Aerosol Transport Experimental Study (SOCRATES)

CSIRO OCE Post Doc – being advertised now! See CSIRO Careers web site

http://csiro.nga.net.au/?jati=252ba9a8-bac7-16df-b7c4-88cea809bb90

Acknowledgements

- Alain Protat (BoM)
- Jason Ward, James Harnwell, Suzie Molloy, Marcel van der Schoot, Paul Selleck, Sarah Lawson, Ian Galbally CSIRO
- Zoran Ristovski, Luke Cravigan, Joel , Branka QUT
- Dave Griffith and Dagmar UoW
- Robyn Schofield, Dougie, Stephani Uni Melbourne
- Grant Edwards Macquarie Uni
- MNF Operations particularly Max Maguire and Lisa Woodward
- Ian McRobert, Will Ponsonby, Steve Thomas, Brett Muir CSIRO
- Leigh Roberts CSIRO
- Crew
- MNF TAG
- O&A CDF and MNF for providing operating
- Ken Glasson (BoM), Tom Trull (Voyage Leader), Eric Shultz (BoM)

Photos by Stewart Wilde