ASR Science Meeting, 18-21 March 2013
CAPI session

Why should we care about the Southern Ocean ?
Proposal for an International Field Campaign : SOCRATES

Alain Protat, ***Australian Bureau of Meteorology***

On behalf of a larger working group (listed at the end)

Australian Government
Bureau of Meteorology

The Centre for Australian Weather and Climate Research
A partnership between CSIRO and the Bureau of Meteorology

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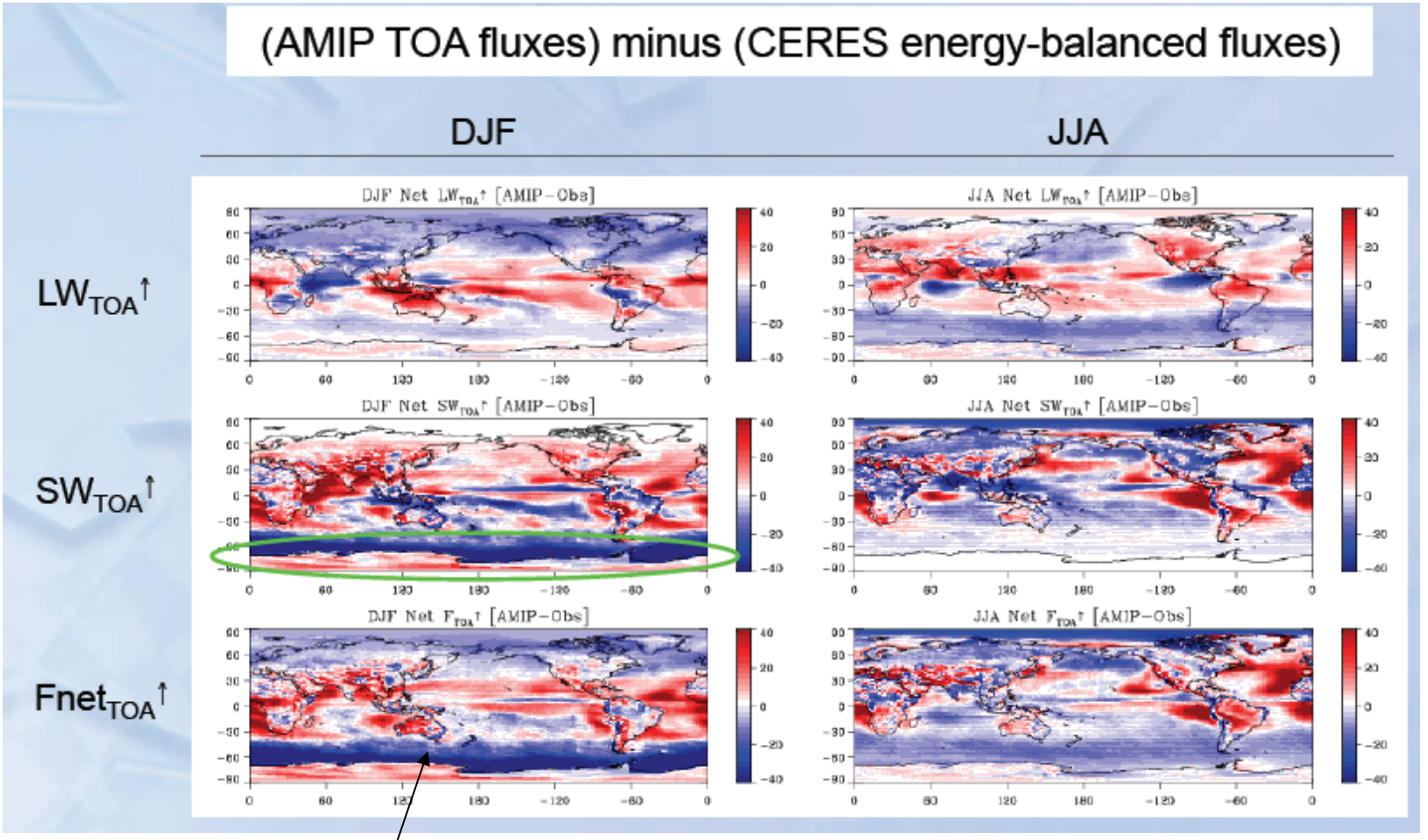
Why do we care ?
Climate model radiation biases

(AMIP TOA fluxes) minus (CERES energy-balanced fluxes)



Courtesy of J. Haynes

40-60 W m^{-2} lower than observed

Why do we care ?
Climate model radiation biases

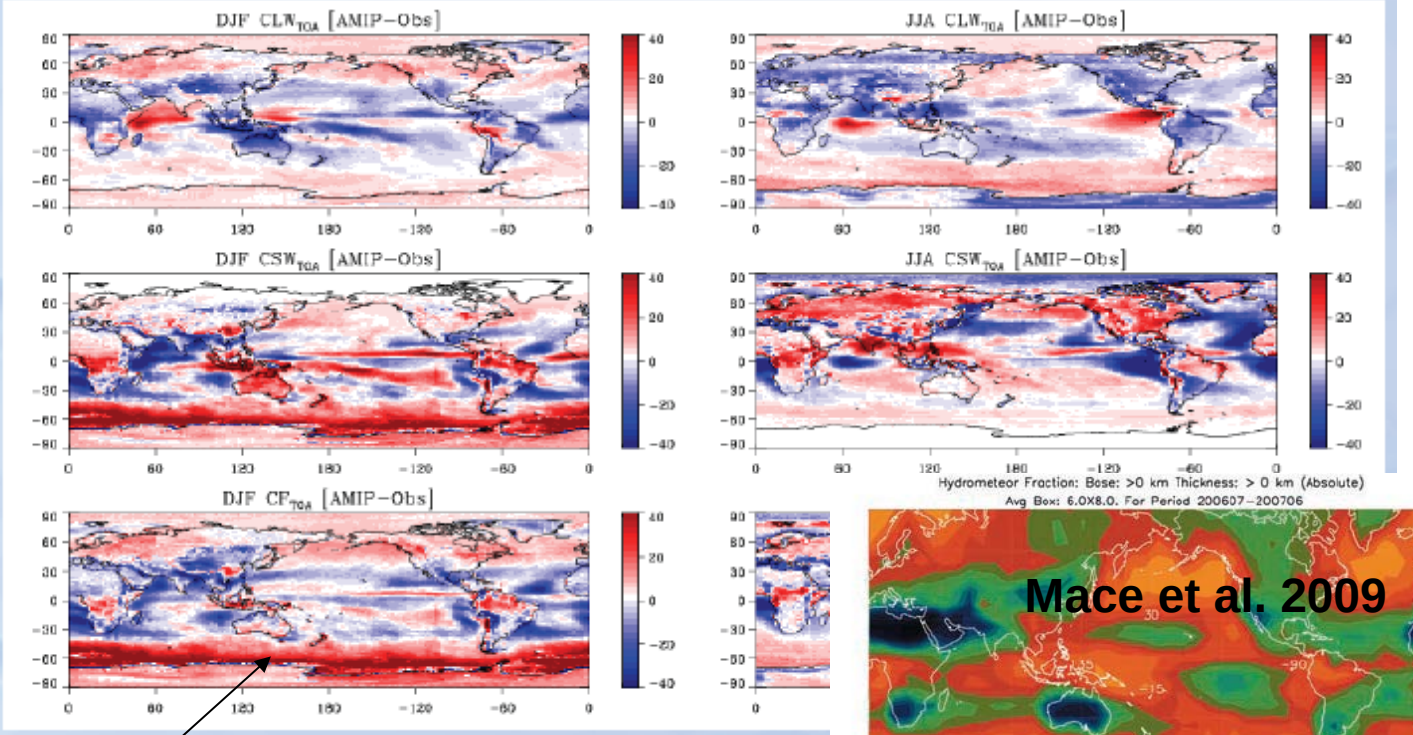
Cloud Radiative Forcing: AMIP minus Obs

DJF JJA

$CLW_{TOA}^{\uparrow}$

$CSW_{TOA}^{\uparrow}$

$CF_{TOA}^{\uparrow}$

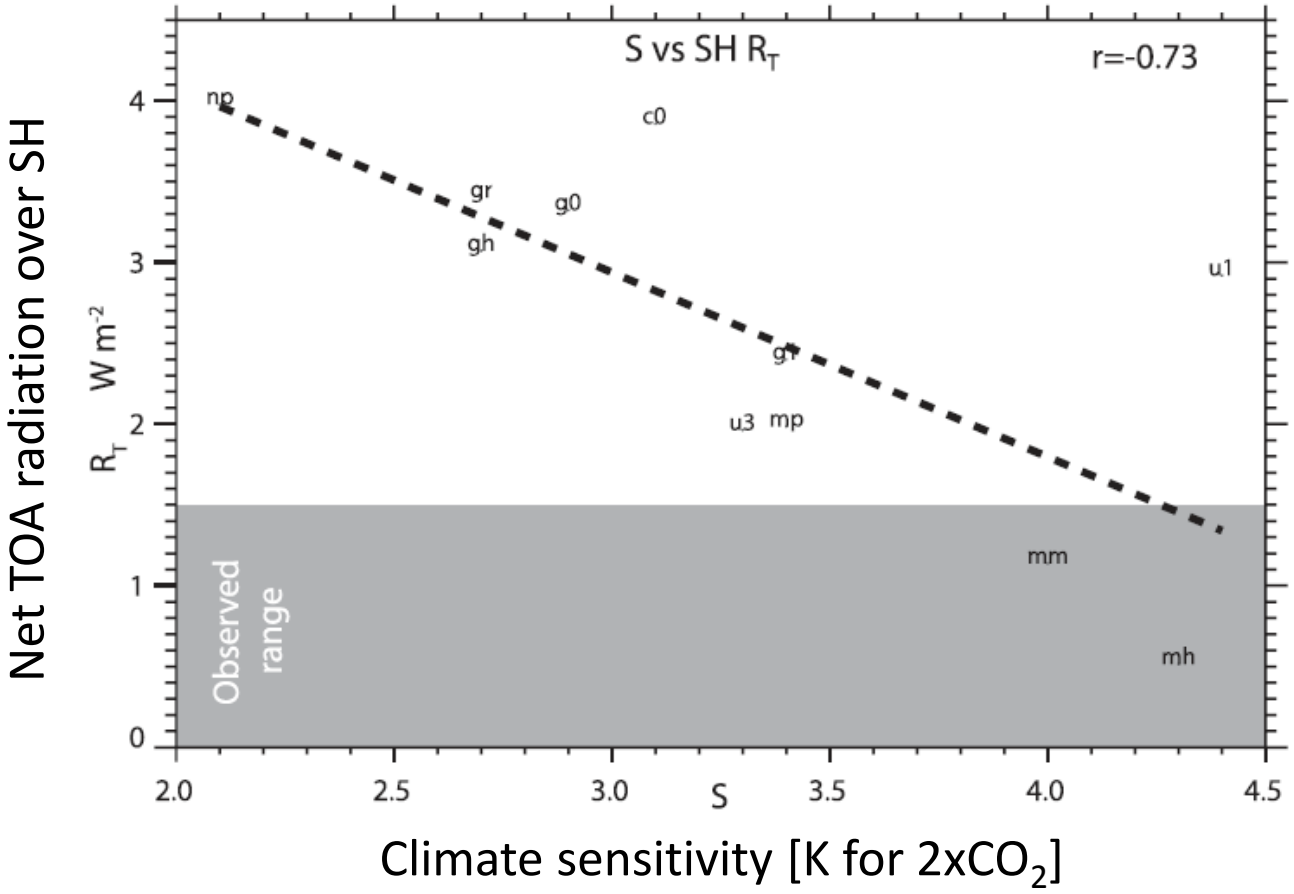


Hypothesis : Not enough low-level clouds in models and / or inaccurate microphysics ?

90-95% !

Why do we care ?
Radiation biases correlate with global climate sensitivity

Trenberth and Fasullo (*J. Climate*, 2010)



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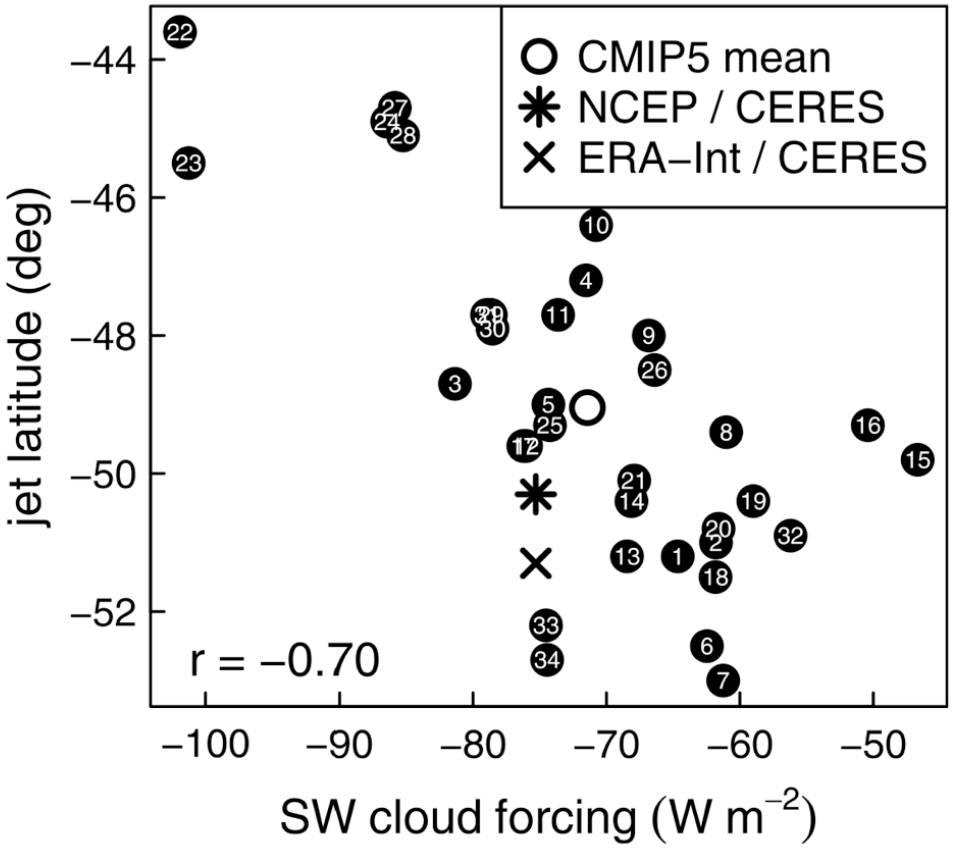
Why do we care ?
Link between SW cloud forcing and bias in dynamics



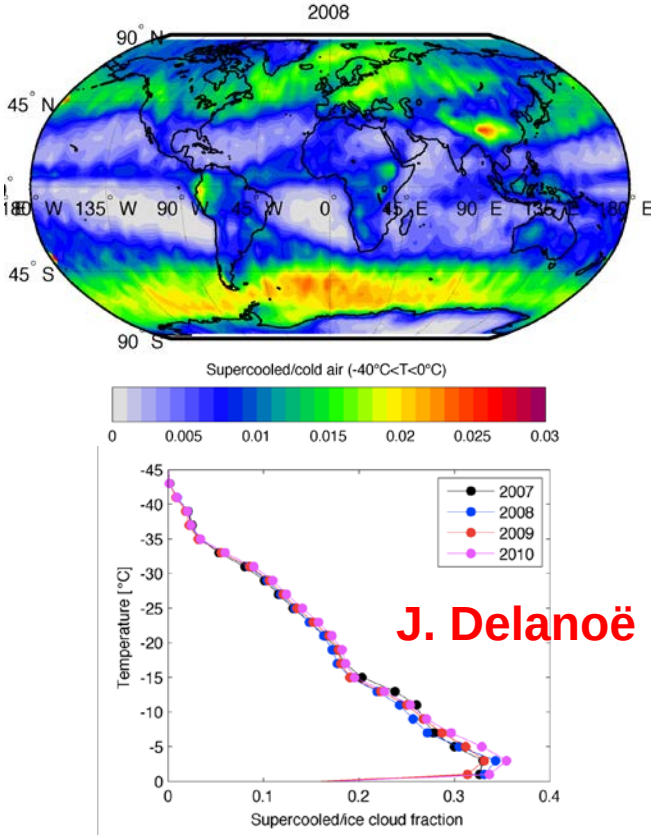
- Ceppi et al., GRL 2012: Southern Hemisphere jet latitude biases in CMIP5 models linked to shortwave cloud forcing
- Show some possible causal connection of the cloud bias to SH dynamics

Why do we care ?
Mixed phase processes and satellite validation

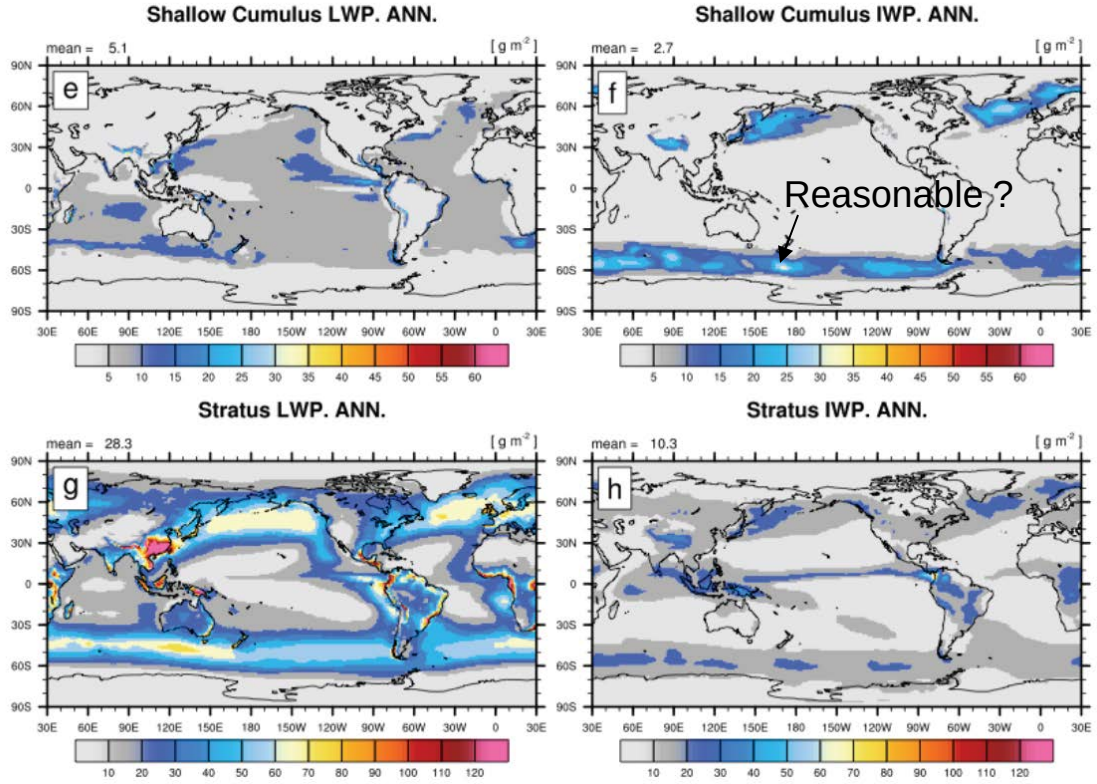


CloudSat-CALIPSO cloud phase (Delanoë and Hogan 2010, Hu et al. 2009)

The Southern Ocean hosts the largest amount (by far) of supercooled liquid water in the world
25 % of clouds have SLW at -10°C, still 10% at -30°C according to DARDAR.



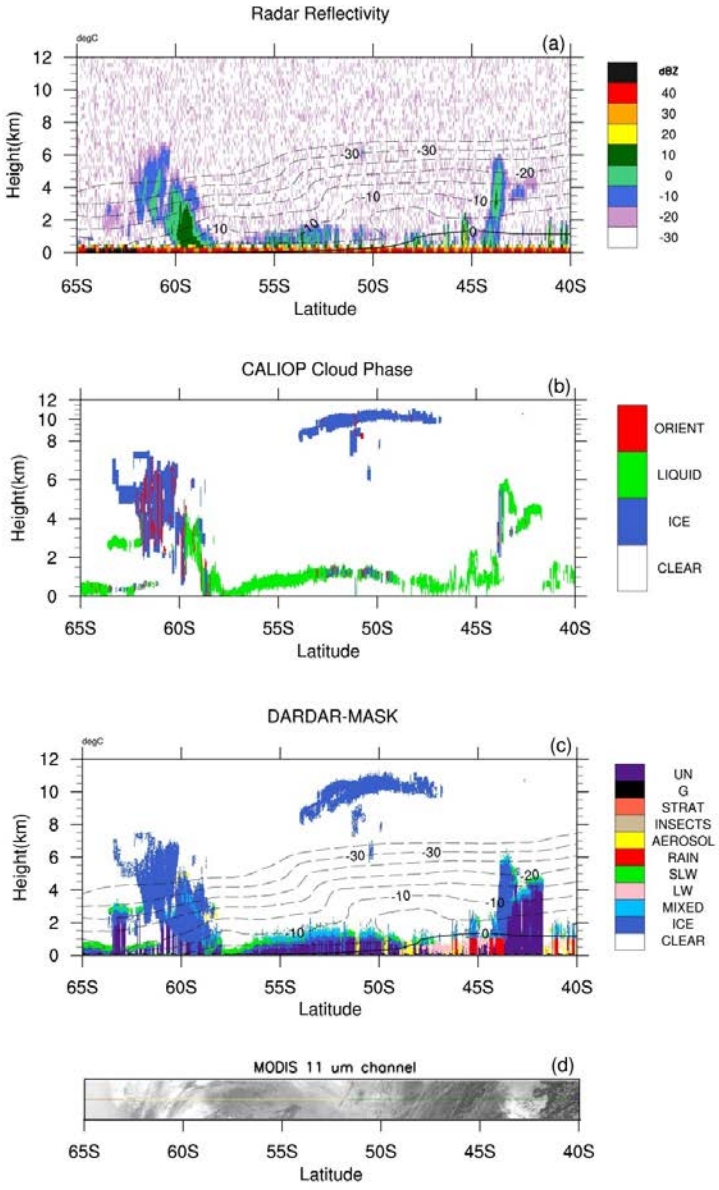
R. Wood / C. Bretherton (CAM5)

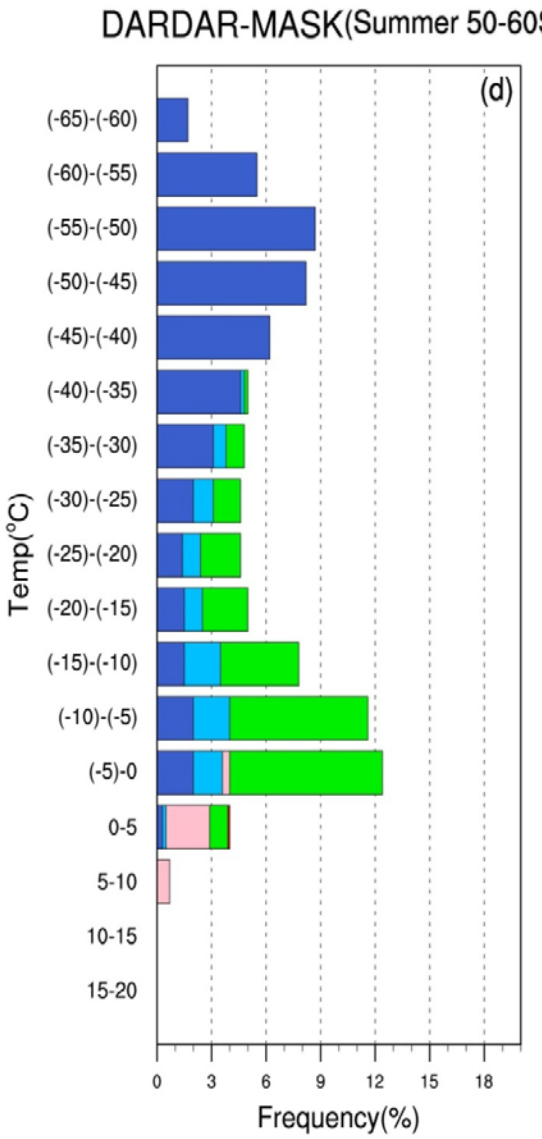


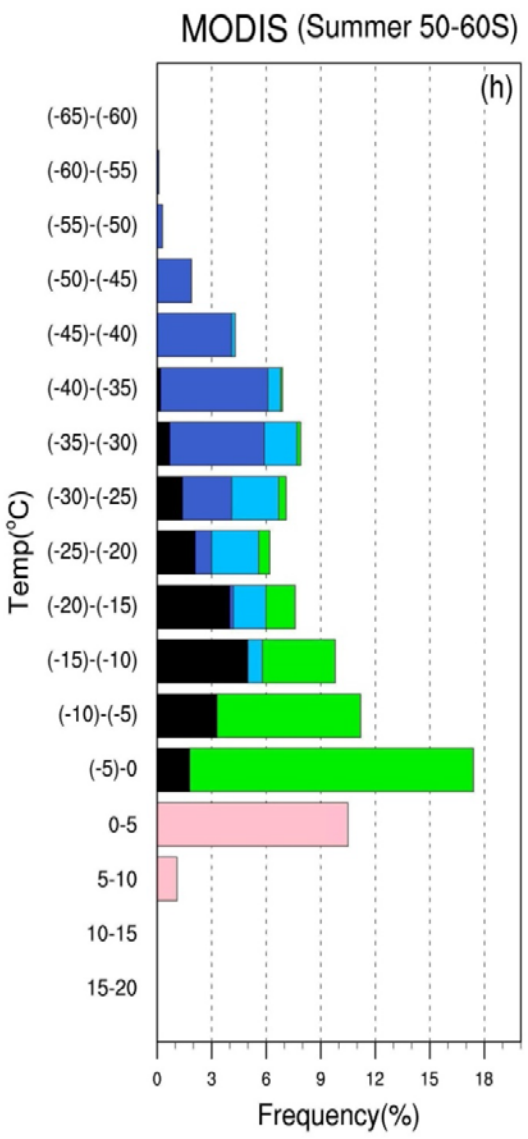
These products / model features need validation over the Southern Ocean !
Then you can use them for regional cloud-radiation process studies

Why do we care ?
Mixed phase processes and satellite validation

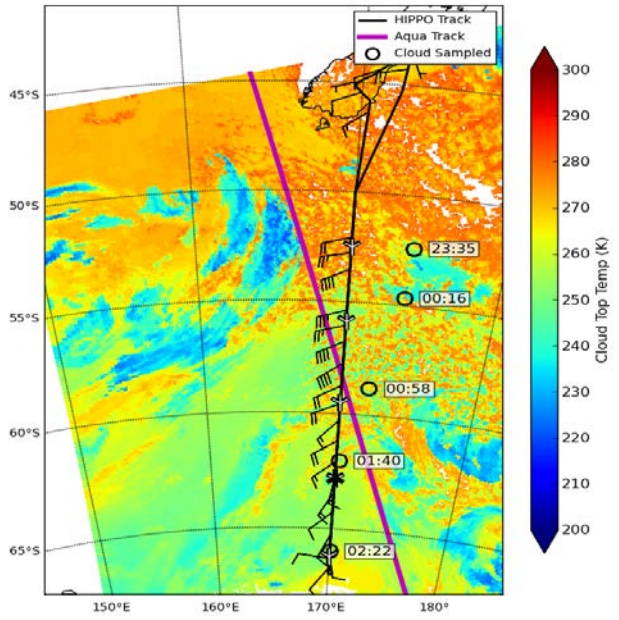
Y. Huang, S. Siems







Why do we care ?
Mixed phase processes and satellite validation

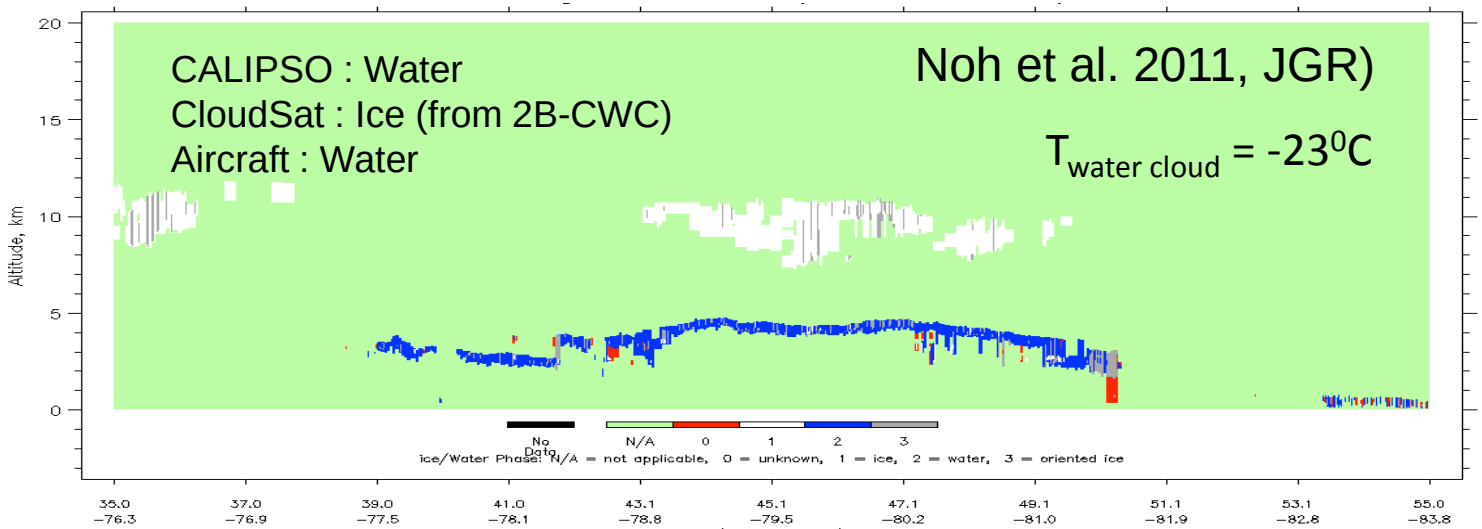


HIAPER Pole-to-Pole Observations (HIPPO)

T. Chubb, S. Siems

	23:35 ascent	00:16 descent	00:58 descent	00:58 ascent	01:40 descent[a]	01:40 ascent	02:22 ascent
Cloud top T (°C)	−11	−13	−18	−22	−18	−17	−18
Cloud depth (m)	225	500	300	900	600	500	500
LWC_{max} ($g\,m^{-3}$)	0.11	0.21	0.45	0.22	0.47	0.47	0.25
CDP modal dia. (μm)	25	20	27	23	29	25	20
2DC Identifiable ice	trace	abundant, large	present	trace	present	nil	trace
2DC Drops > 100 μm	nil	abundant	present	abundant	–	abundant	trace
Liquid precip.	trace drizzle	rain	drizzle	drizzle	–	rain	nil
Frozen precip.	nil	dend./aggr.	dend./aggr.	trace aggr.	–	trace aggr.	trace dend.
Comments	multi-layered	multi-layered	heavy snow	–	–	–	–

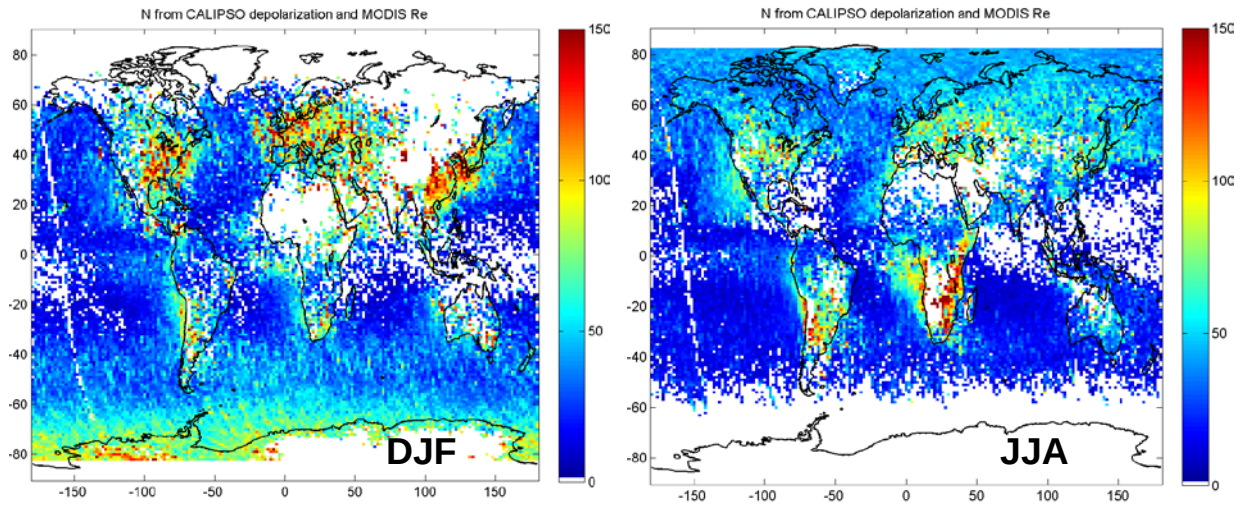
SLW observations over the SO, virtually no ice !



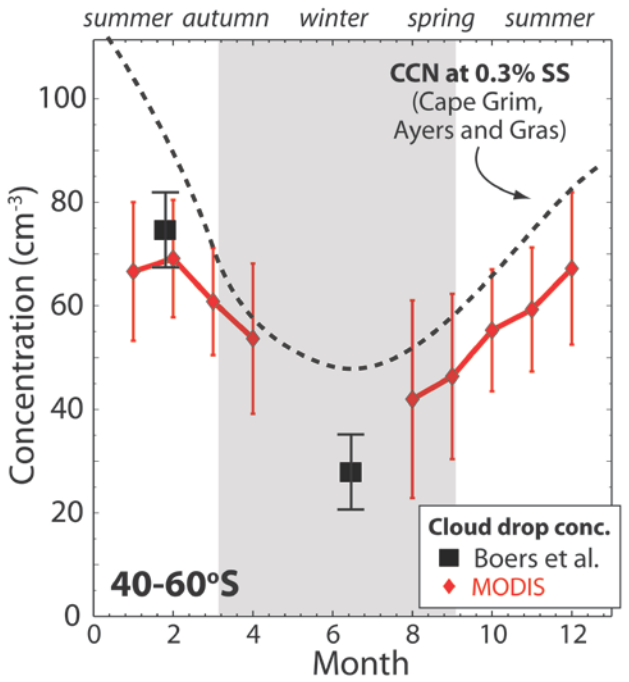
Yong Hu

Why do we care ?
Liquid cloud processes and Aerosol Indirect Effect

Large seasonal variability of cloud droplet concentration …



Y. Hu et al. 2007, ACP



R. Wood et al. 2013

Summer maximum likely biogenic (DMS, organics)
Low values, esp. in winter, have implications for strength of AIEs (e.g. Hoose et al. 2009)
In-situ and satellite observations consistent
Would lead to summertime albedo enhancement (Twomey) of ~25%

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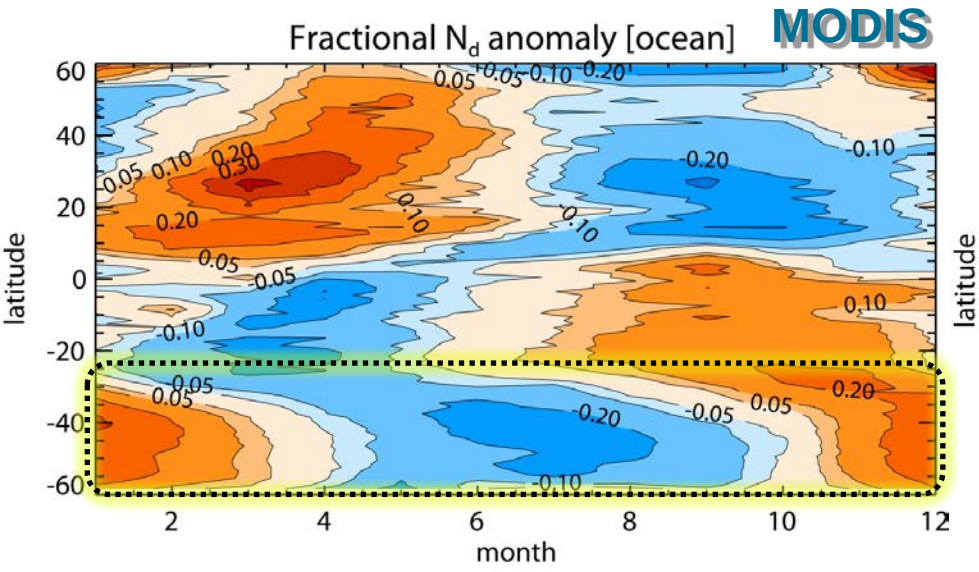
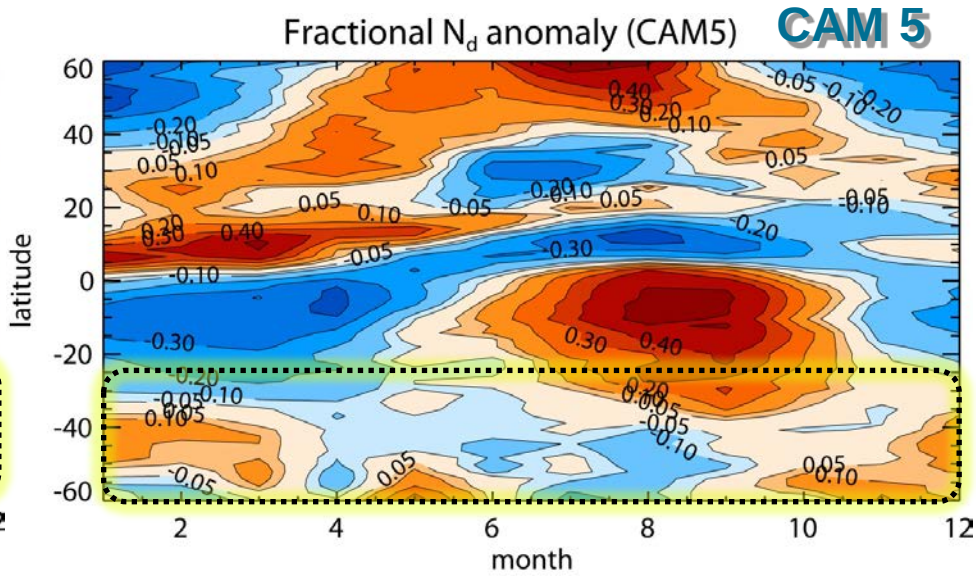
Why do we care ?
Liquid cloud processes and Aerosol Indirect Effect

GCMs don't get that annual cycle of droplet concentration right.





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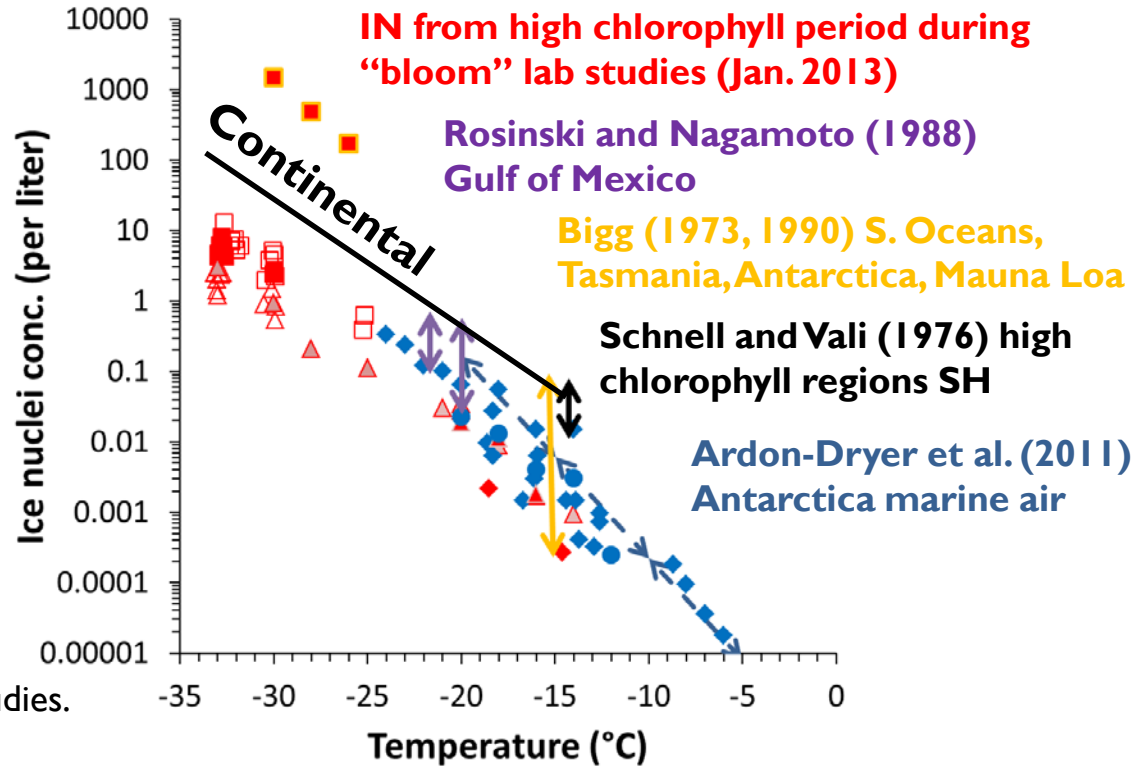
Why do we care ?
5. Sea Spray → IN → cloud microphysics in obs & GCMs

- **Hypotheses (tentative)** – (**Paul DeMott, CSU**)
  - Ice nuclei (IN) from sea spray differ strongly from land sources and their variability is tied to ocean microbiological processes.
  - Differences in microphysical properties and radiative forcing of cold clouds over remote mid-high latitude oceans reflect the influence of these varied IN properties
- **Supporting information**: - recent online and offline IN data collected in realistic sea spray experiments in the laboratory, and collected from aircraft, ground sites and cruises to polar regions.

Seaspray IN
lab = red
ICE-T (blue diamond)
Korean cruise (blue circle)

vs. historical (arrows) marine IN

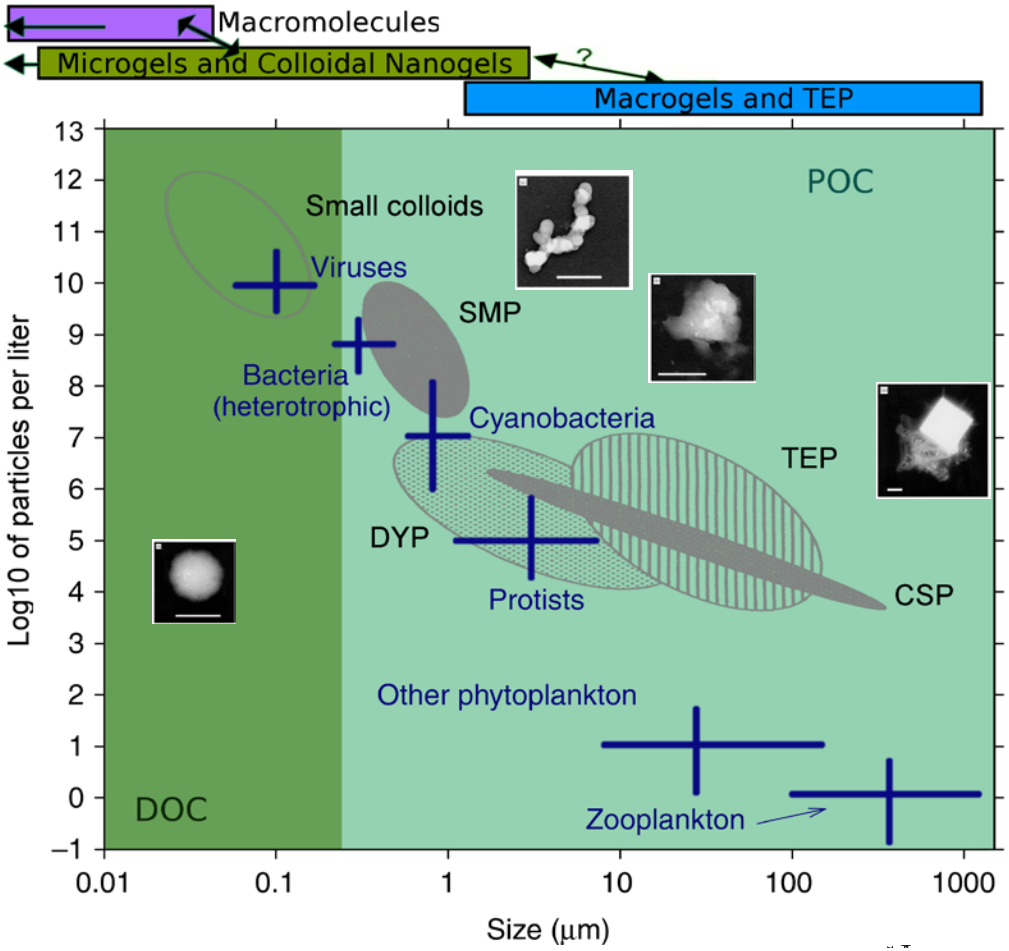


Need surface and aircraft measurements to validate lower average IN sources over oceans, high IN at bloom times, identify nuclei source

Seeks collaboration for numerical modeling studies.

Why do we care ?
Sea Spray → IN → cloud microphysics in obs & GCMs

Motivation: Improve representation of marine organic aerosol in GCMs link to ocean microbiological processes (Liu, Burrows, Elliott, Rasch)



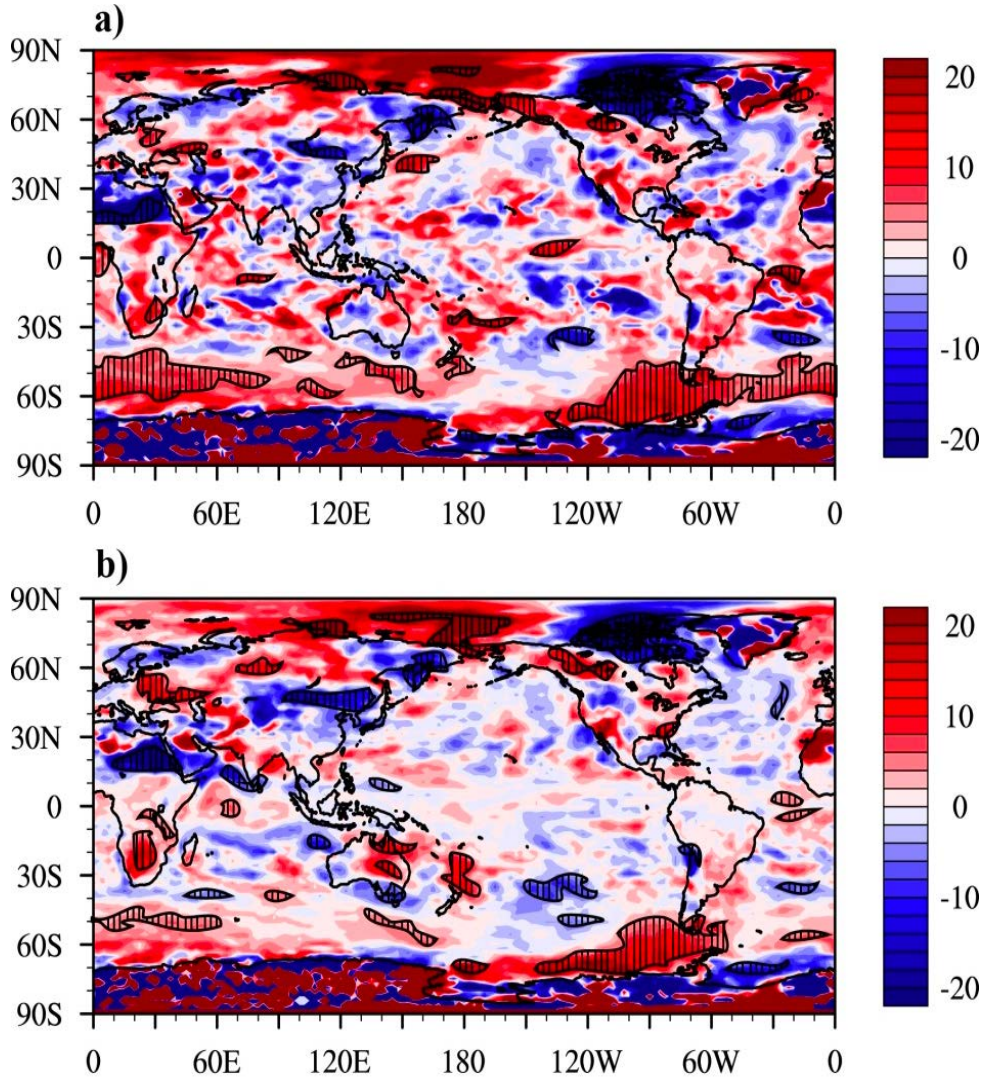
Composition of sea spray aerosol as a function of size. Organic matter is an important contributor to the submicron aerosol mass, especially in the blooming period (O'Dowd et al. 2002)

Wells and Goldberg, 1991; Alldredge et al., 1993; Long and Azam, 1996; Mostajir et al., 1995; Yamasaki et al., 1998; Verdugo et al., 2004; Kirchman, 2008; Bigg, 2007

POC: particulate organic carbon; DOC: dissolved organic carbon; SMP: submicrometer particles;
DYP: DAPI-positive yellow particles; TEP: transparent exopolymers stained by Alcian Blue;
CSP: proteinaceous particles stained by Coomassie Brilliant Blue

Why do we care ?
Model evaluation and improvement

Study the effect of marine organic aerosol on cloud properties as CCN and IN (Liu, Burrows, Elliott, Rasch, Ghan)



Percentage change in (a) **cloud droplet number** and (b**) cloud liquid water path** by marine organic emission predicted by the CAM5 model (from Gantt et al. 2012, which link marine organic emission to the ocean surface chlorophyll-a concentration)

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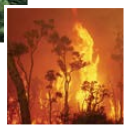
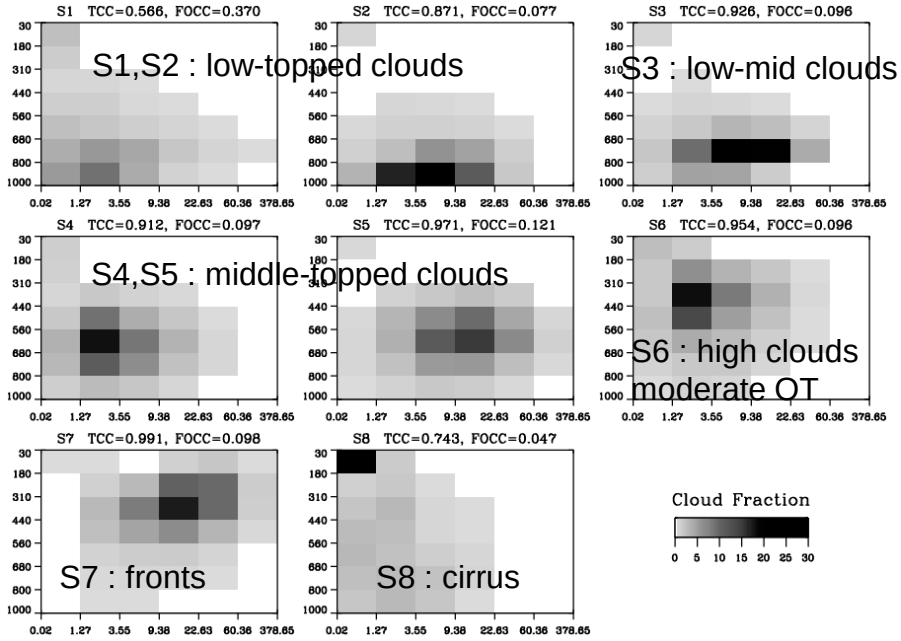
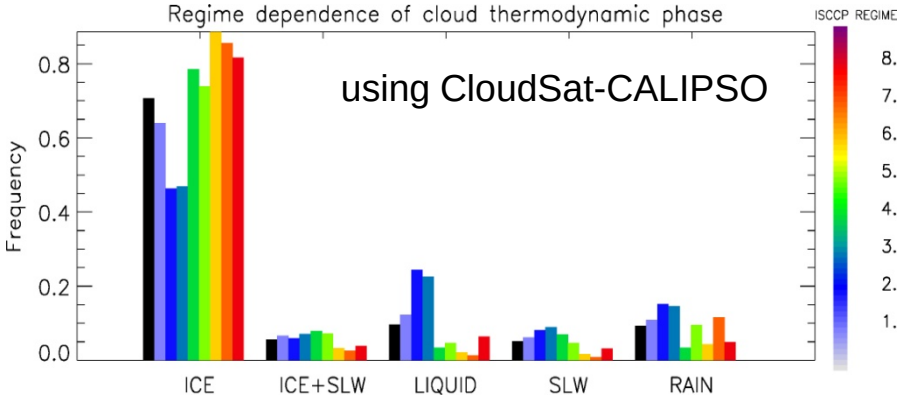
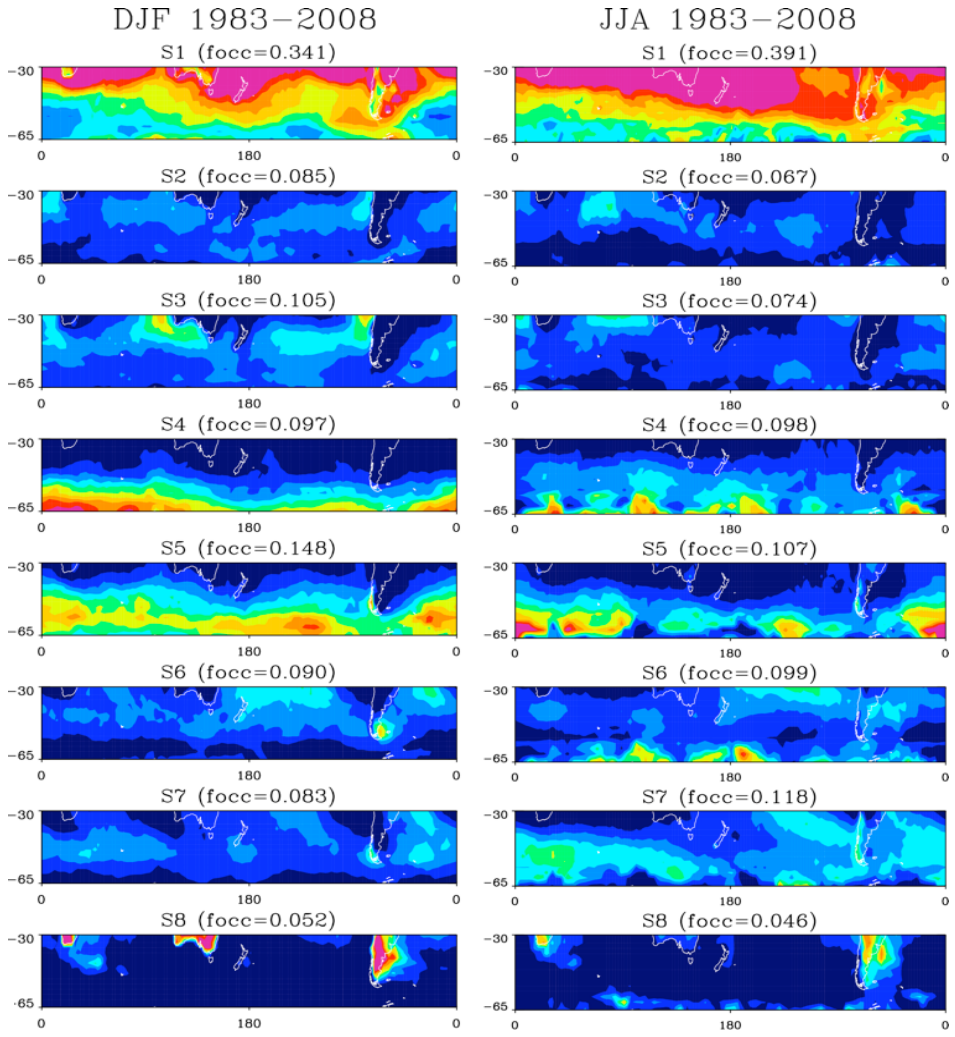
Why do we care ?
Model evaluation and improvement (possible framework)


Haynes et al. (JCLIM 2010) : 8 ISCCP cloud regimes identified







North part of SHB : S1, S2

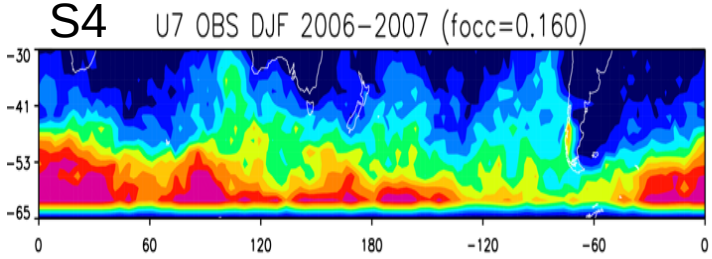
South part of SHB : S4, S5

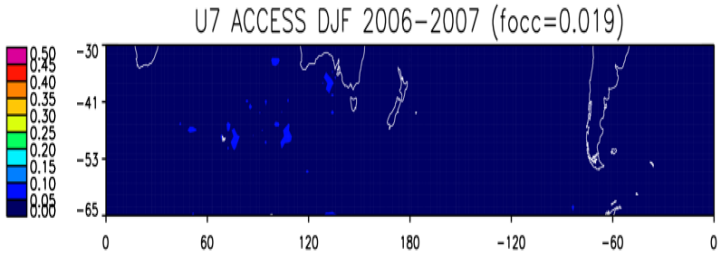
Regime dependence of model skills in the SO

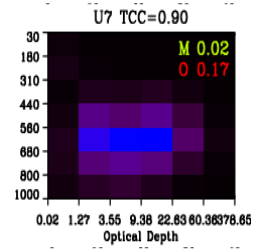
The ACCESS climate model doesn't produce any S4 and S5 clouds !
But loves his fronts and cirrus a bit too much …

C. Jakob

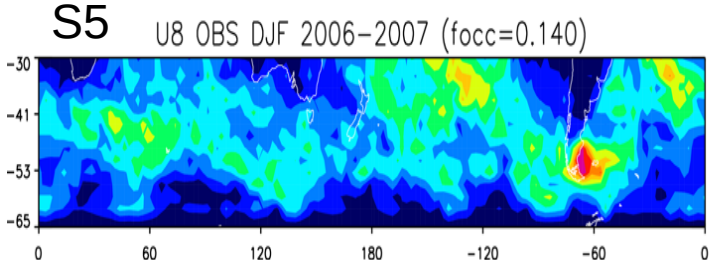
S4

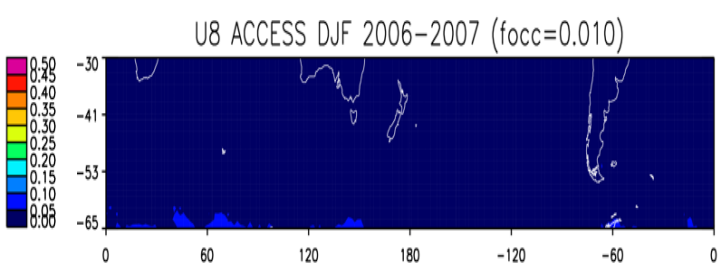


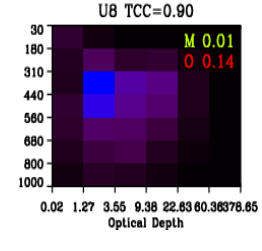




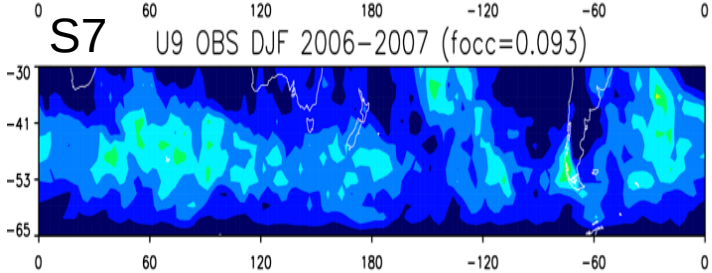
S5

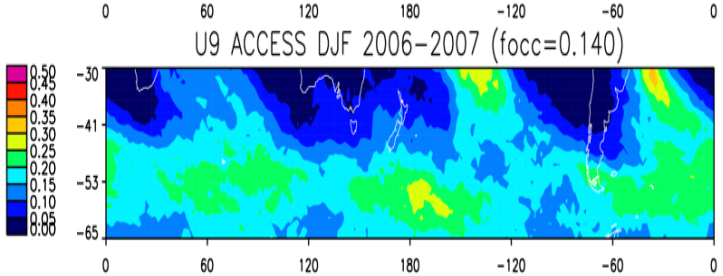


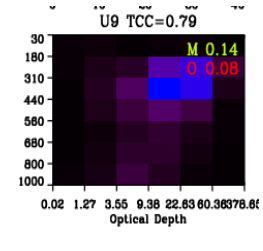




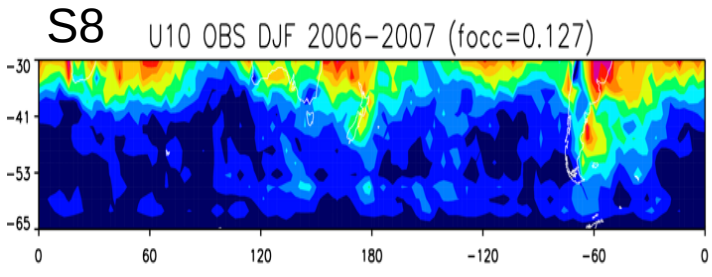
S7

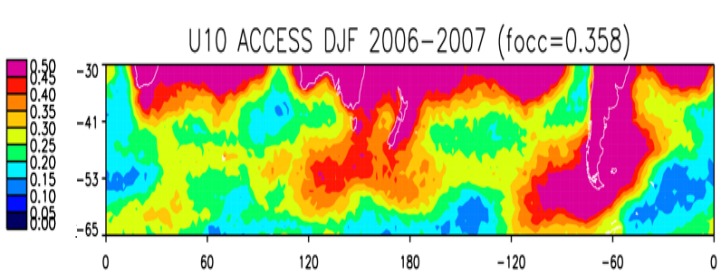


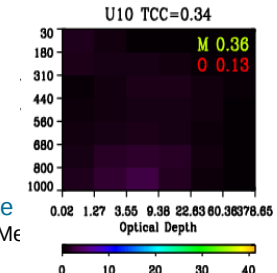




S8







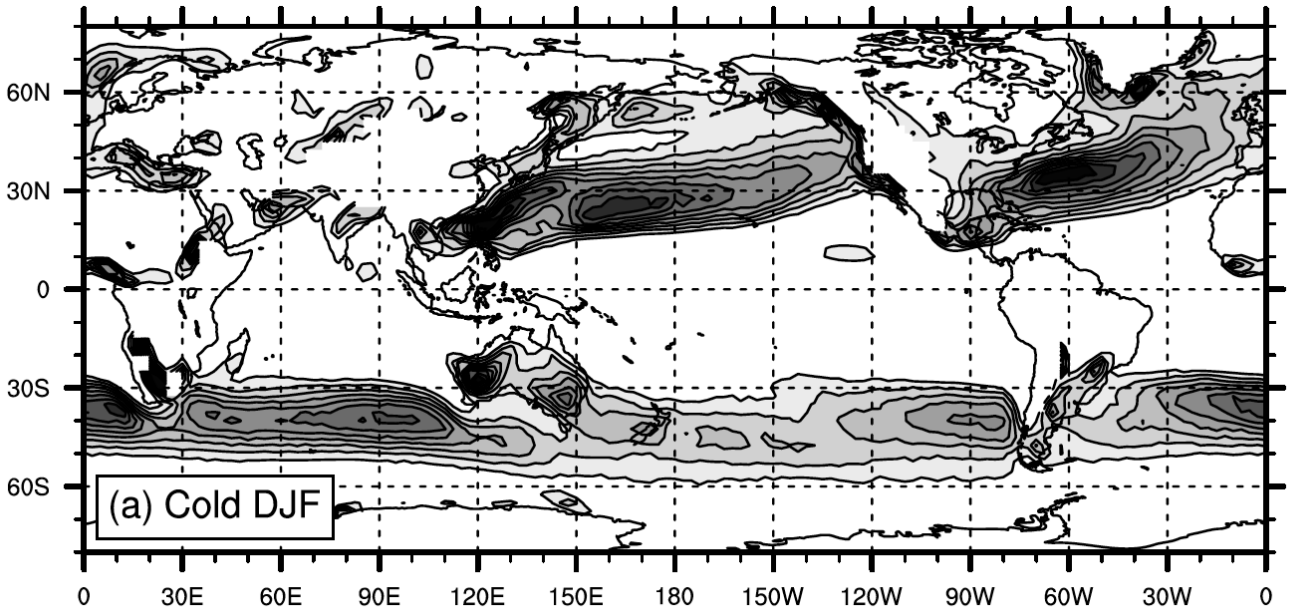
Why do we care ?
SO Frontal processes and representation in models

Fronts over the SO are important to Australia's weather and climate
Most of significant weather and fire hazard over Australia comes from fronts.
Frontal cloud systems occurrence largely overestimated in the ACCESS NWP

Some aspects of fronts are well known (frontogenesis), some still to be studied

The interaction between boundary layer processes and frontal dynamics
The role of clouds and convection on the life cycle of fronts

Berry et al. (GRL 2011): climatology of fronts in DJF



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Questions

Why do large-scale models fail to reproduce cloud processes over the SO ?

Is it just cloud occurrence (i.e., underprediction of cloud cover)?
How important are mixed-phase vs liquid cloud processes?
Statistical overlap assumption in models in this area ?
Details in the cloud microphysical properties ?
Supercooled liquid water / radiation interactions ?
Different IN from sea spray producing different cloud properties ?
Missing/misrepresenting sea spray aerosols and their effect on clouds in models?
Different precipitation susceptibility of warm clouds over the SO ?

We have documented a seasonal and regime dependence of model skills

Does the variability in some of cloud properties listed above explain this ?

Apart from satellite products (not validated much in that very special region), no available remote sensing and state-of-the-art aircraft in-situ cloud microphysical observations : we need an international field experiment !

SOCRATES

Rob Wood's contribution to the project so far ;-) – a great name !
SOCRATES : Southern Ocean Cloud Rainfall and Aerosol Transport Experimental Study

Sounds like a good start: The Socratic method is a form of inquiry and debate between individuals with opposing viewpoints based on asking and answering questions to stimulate critical thinking and to illuminate ideas – ***let's have a Socratic Lunch after this breakout !***

We would need involvement from multiple countries and agencies around :

- **The new Australian Facility Research Vessel** equipped with the first dual-pol C-band radar and a poor man's AMF (95 GHz FMCW cloud radar, lidar, microwave radiometer / profiler, radiation)

  Status : A. Protat's proposal granted for sea time in SH summer 2014, 2015, 2016, piggy-back mode
  A full 60 days deployment will be requested for SOCRATES (2016-2017 or 2017-2018 ?)

- **A full year of AMF observations**, ideally in the 50-60S latitude band – initial discussions discarded some options (Macquarie Island, Kerguelen Island) but recent discussions around "Tierra Del Fuego" – Need to check cloud regimes and impact of land but has air field … Other ideas ?

  Status : no formal proposal has been made – we need to discuss options and try to secure the AMF

- **Aircraft active remote sensing (cloud radar-lidar) and in-situ CCN / IN / cloud microphysics**
  Possible support from NCAR / NSF (HIAPER or C-130, R. Wood, G. McFarquhar), and / or the French Falcon (J. Delanoë, EarthCARE) for active remote sensing – needs discussion.

  Status : no formal proposal has been made

Current involvement and next steps

Australia : A. Protat, P. May (BOM), C. Jakob, S. Siems, M. Reeder (Monash Uni.), S. Young, C. Franklin, M. Keywood (CSIRO)

US : R. Wood, C. Bretherton (Univ. Washington), J. Mace (Univ. Utah), Y. Hu (NASA), P. DeMott (CSU), X. Liu, S. Ghan (PNNL)

France : J. Delanoë (LATMOS), A. Schwarzenboeck (LAMP)

There has also been earlier expressions of interest (to be followed up) from
G. Heymsfield (NASA), T. Ackerman, and R. Marchand (Univ. Washington)

Next steps:

One-on-one discussions between interested groups (and link with GOAMAZON & CORMORANT)
AGU session on SO clouds and meteorology to get an overview over interests
and an evening discussion on the experiment itself.

Interested ? Contacts :

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Christian Jakob (christian.jakob@monash.edu);
Rob Wood (robwood2@u.washington.edu)

Alain Protat

Why should we care about the Southern Ocean ?
Proposal for an International Effort : SOCRATES

Email: a.protat@bom.gov.au

Thank you

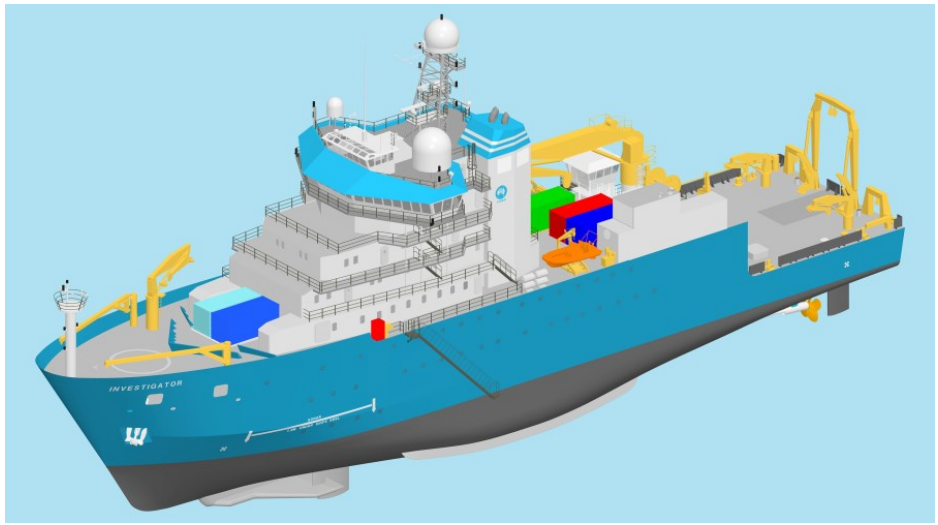
The Marine National Facility (MNF)

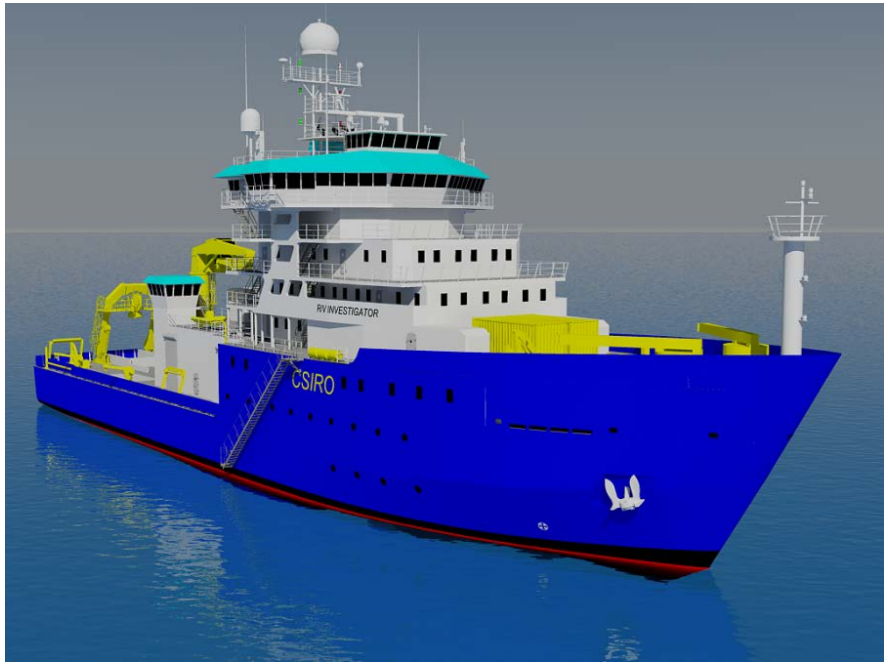
New research vessel : the RV *Investigator*

Some numbers : 93.9 m long, up to 300 days at sea per year (60 days max per voyage), can accommodate 40 scientists onboard

It is being constructed in Singapore – commissioning should start by 09 / 2013

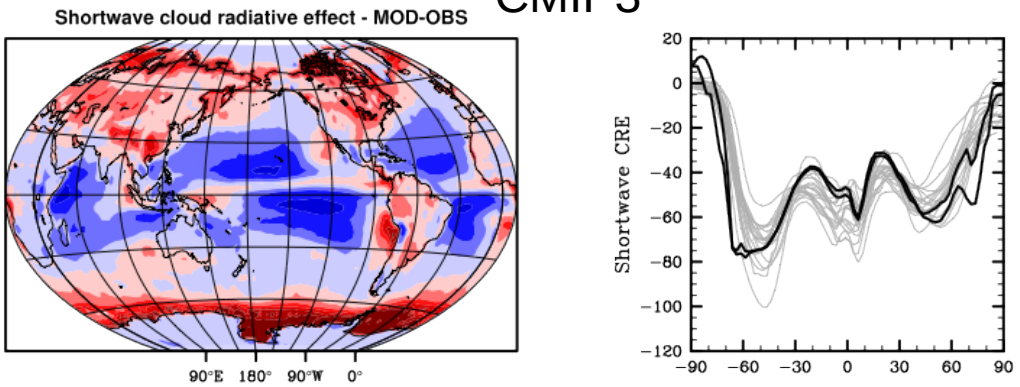
Relevant instrumentation : dual-pol C-band Doppler radar (owned by MNF), soundings, lidar (CAWCR), radiative fluxes, air-sea fluxes – looking for a cloud radar to complement that.



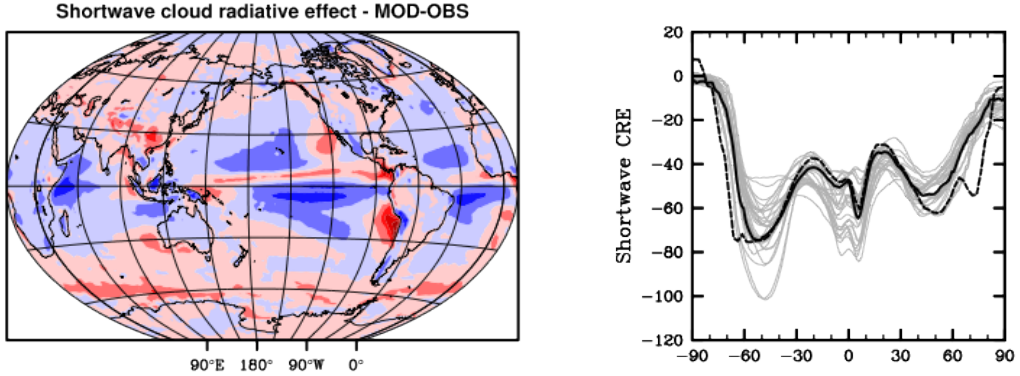


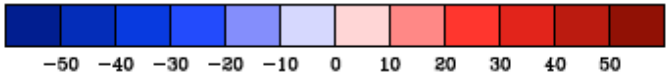
The CMIP 5 surprise (from C. Jakob)

CMIP3



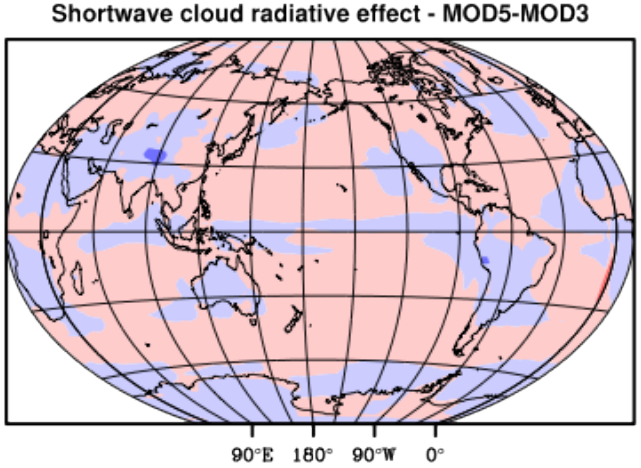
CMIP5



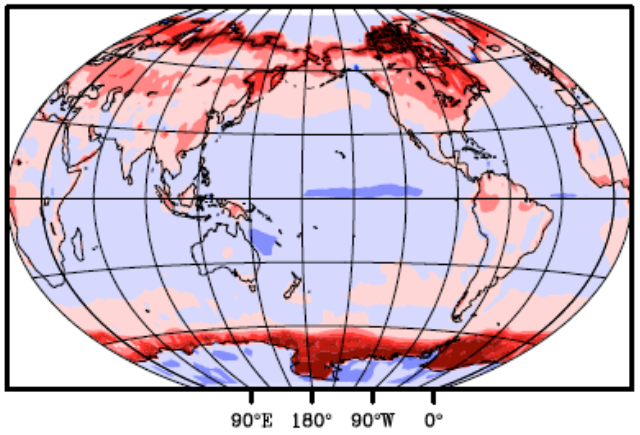


Not due to model improvement !

CMIP5-CMIP3



CERES_new-CERES_old



Biases are still among the largest

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