Modeling the planetary boundary layer at Dome C using Polar WRF

Atelier – Dome C
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Motivation

- Develop better understanding of the atmospheric boundary layer at Dome C
  - Evaluate Polar WRF using observations at Dome C
  - Compare output to other models (e.g. AROME, MesoNH, MAR)
  - Explore modifications of PolarWRF

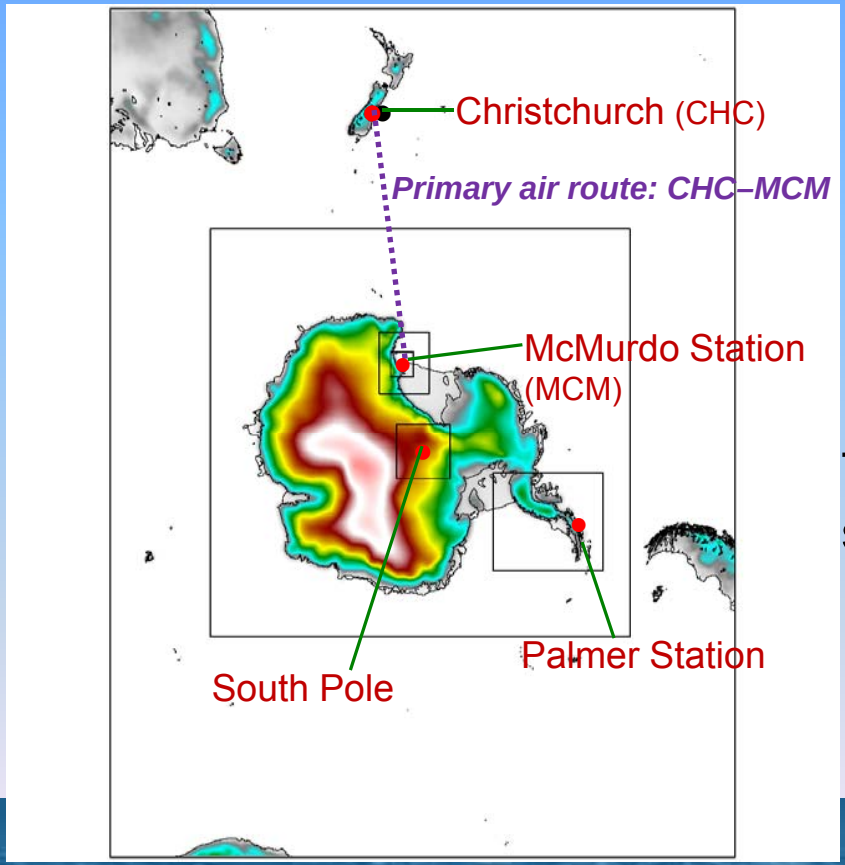
Polar WRF

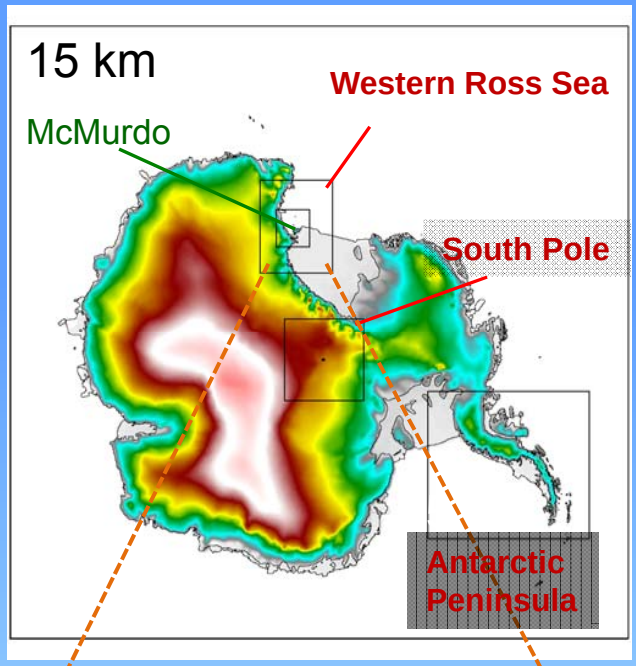
- Polar version of WRF 3.4, the US next-generation mesoscale model
  - Developed by several groups in collaboration
- Direct “relation” of PolarMM5
- Previously used predominantly for the Arctic
- Now being employed for Antarctic
  - AMPS
  - Looking for model to be tested, especially in the boundary layer

Antarctic Mesoscale Predication System

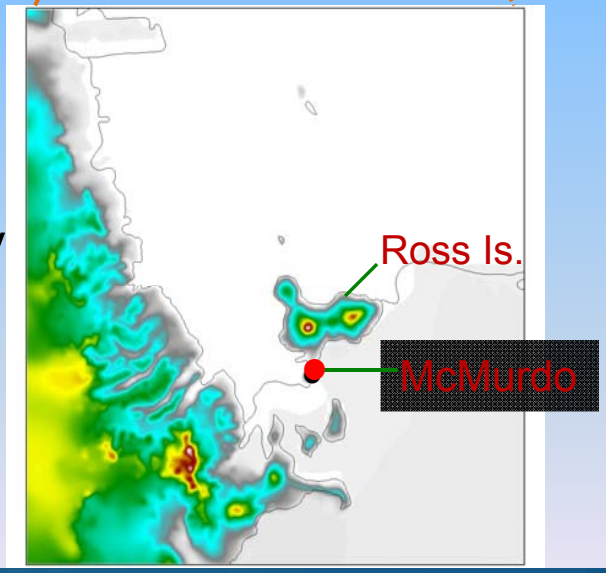
AMPS WRF (Nov. 2011

6 Grids: 45-, 15-, 5-, 1.67-km





Topography shaded



Details in *Bromwich et al. 2010*

Slide from Powers and Manning 2011

Polar WRF in Antarctica

- Boundary layer
  - YSU PBL does not give good results
  - MYNN and QNSE PBL may be better than MYJ
- May need to edit LANDUSE.TBL and VEGPARM.TBL to get *seasonal albedo* and *emissivity*
- Known issues
  - Dry-bias in near-surface temperature (*Bromwich et al. 2011*)
  - Possible (+) surface wind bias (but (-) bias from old version is gone) (*Bromwich and Otieno 2013*)
  - RRTMG is good (*Bromwich and Otieno 2013*)
  - Should employ Morrison double moment and Grell3d

Polar WRF Setup

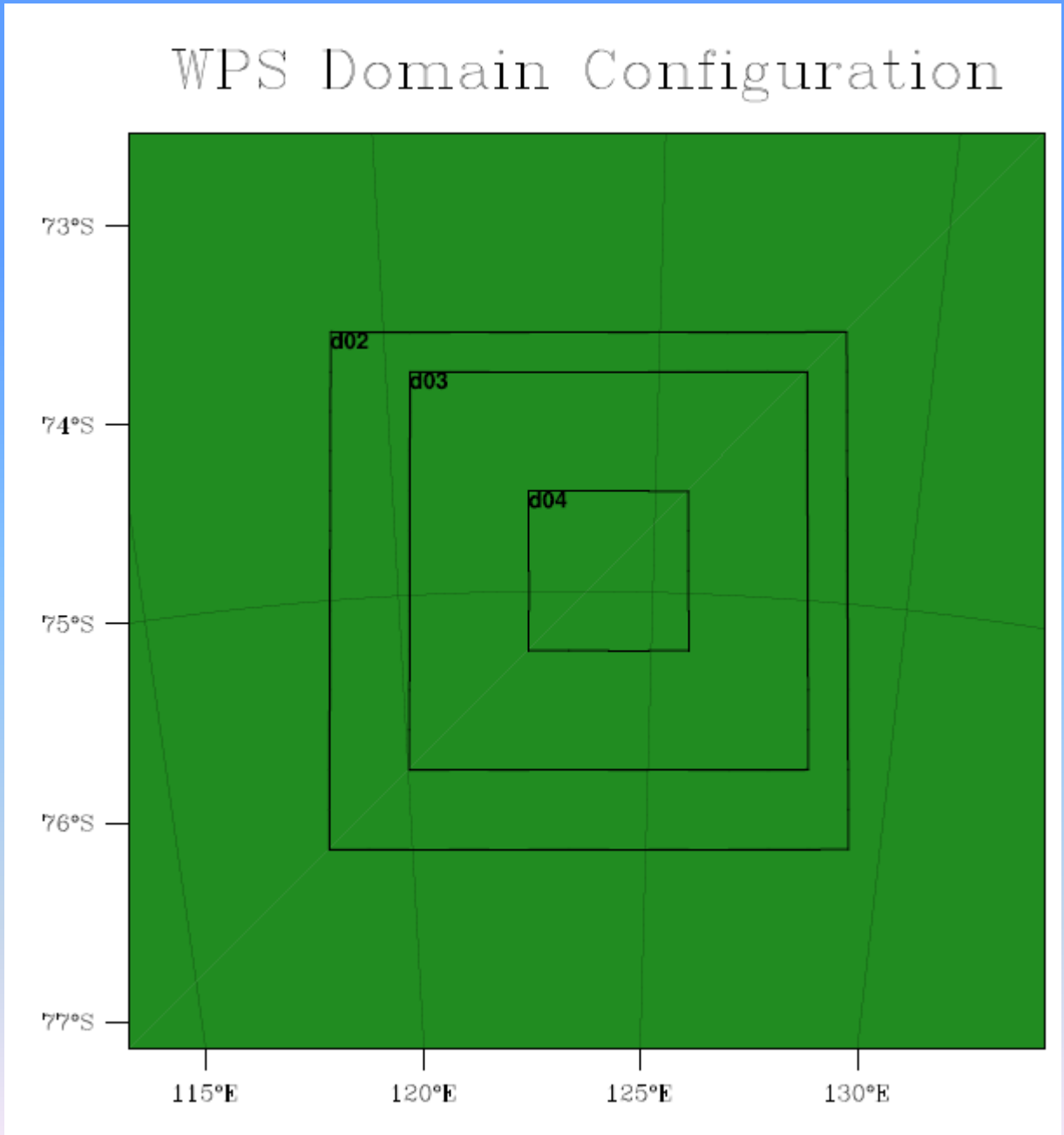
Period: December 2-5, 2009

Domain	Resolution (km)	Points	Size (km^2)
1	22.5	24 x 24	540 x 540
2	7.5	40 x 40	300 x 300
3	2.5	88 x 88	220 x 220
4	0.83	94 x 94	78.3 x 78.3

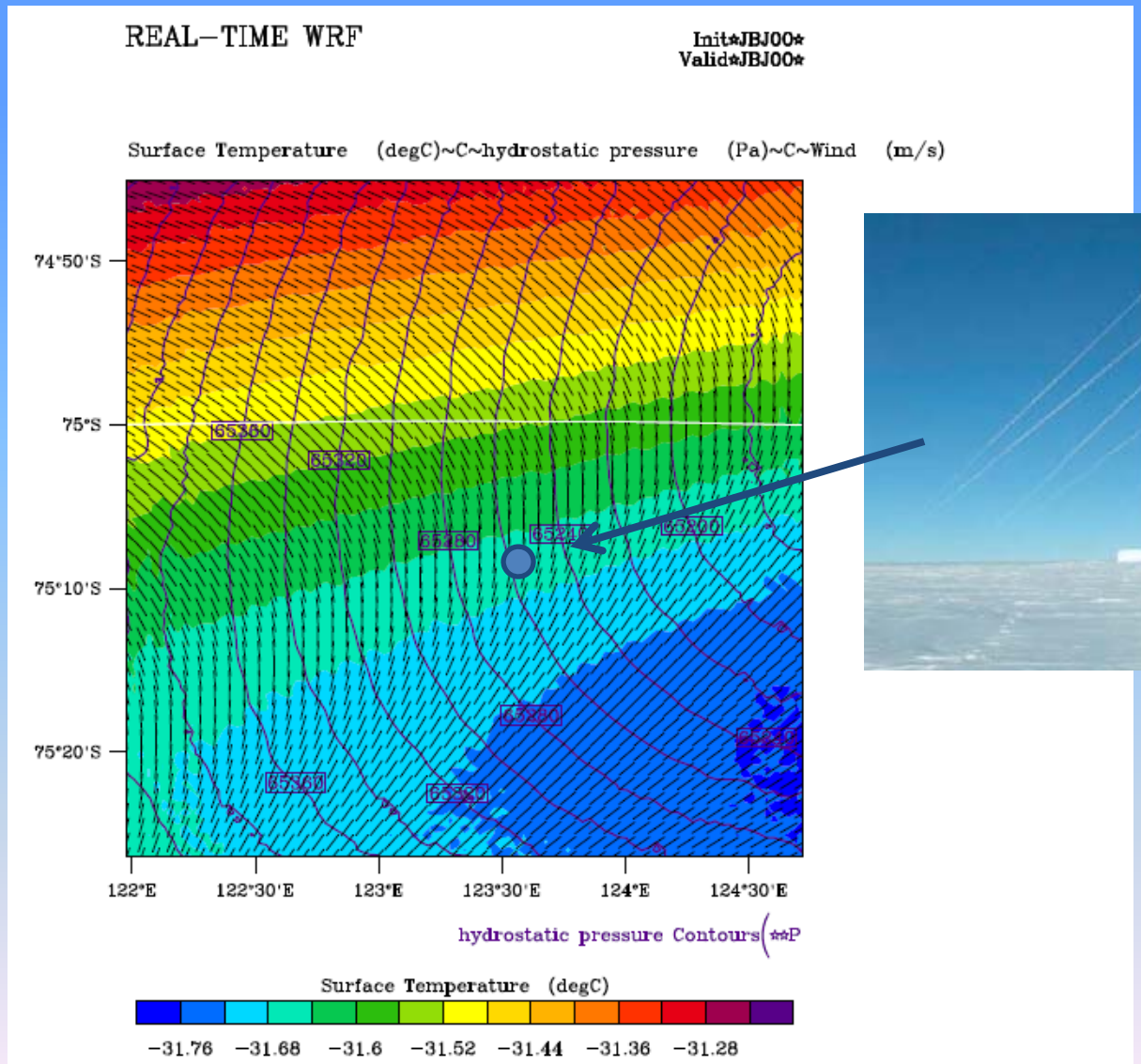
Levels (η): 60 (matched to AROME)
Forcing : ERA-Interim (~80 km, 6 hours)

Model Physics

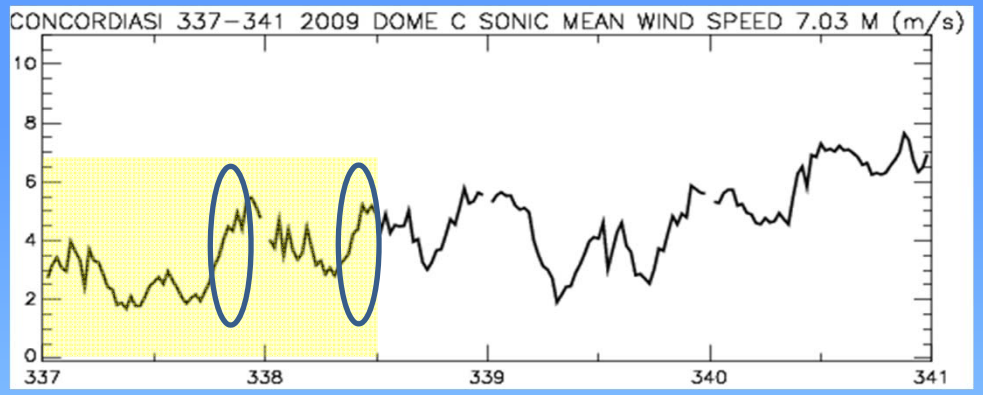
LSM: Noah (w/ latest polar mods) **PBL**: MYJ (TKE) scheme
Microphysics: Morrison 2-moment **Sfc layer**: Eta scheme
Clouds: New Grell scheme (G3): *22.5-km,7.5-km* ;
Fully-explicit: *2.5-km, 0.83-km*
LW radiation: RRTM **SW radiation**: Dudhia scheme


WPS Domain Configuration
73°S
74°S
75°S
76°S
77°S
115°E
120°E
125°E
130°E
d02
d03
d04

Preliminary results



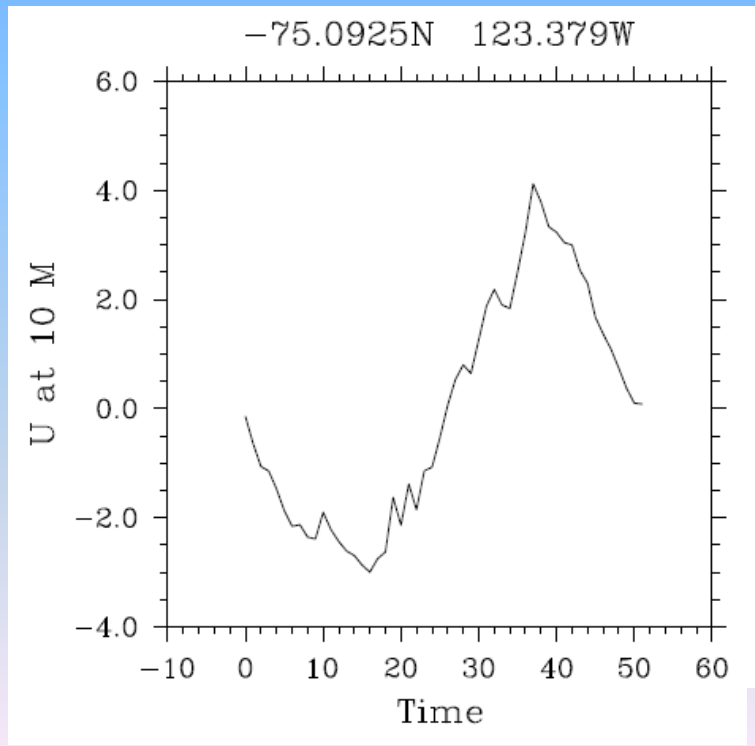
Mean wind speed (from sonic anemometers) m/s



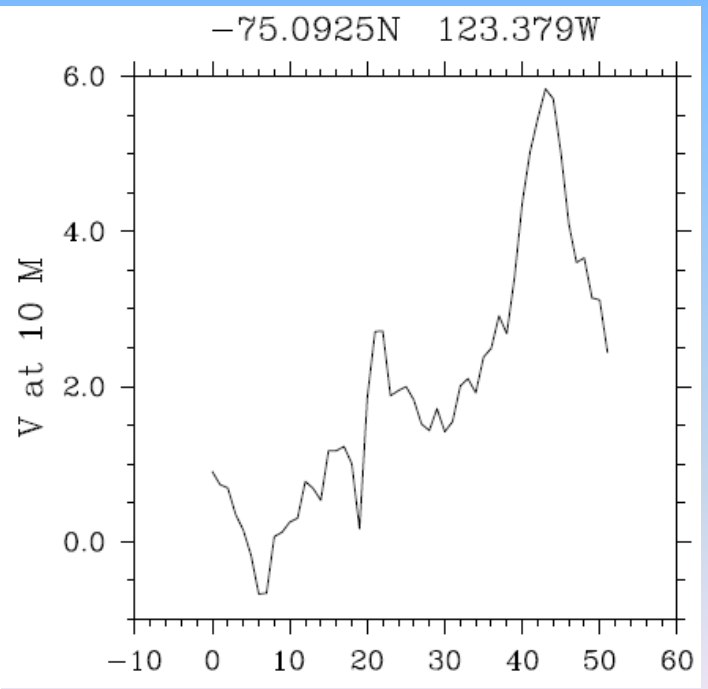
From Olivier

At Concordia PWRF wind speed bias of + 2m/s in Jan 2007

Bromwich & Otieno 2013

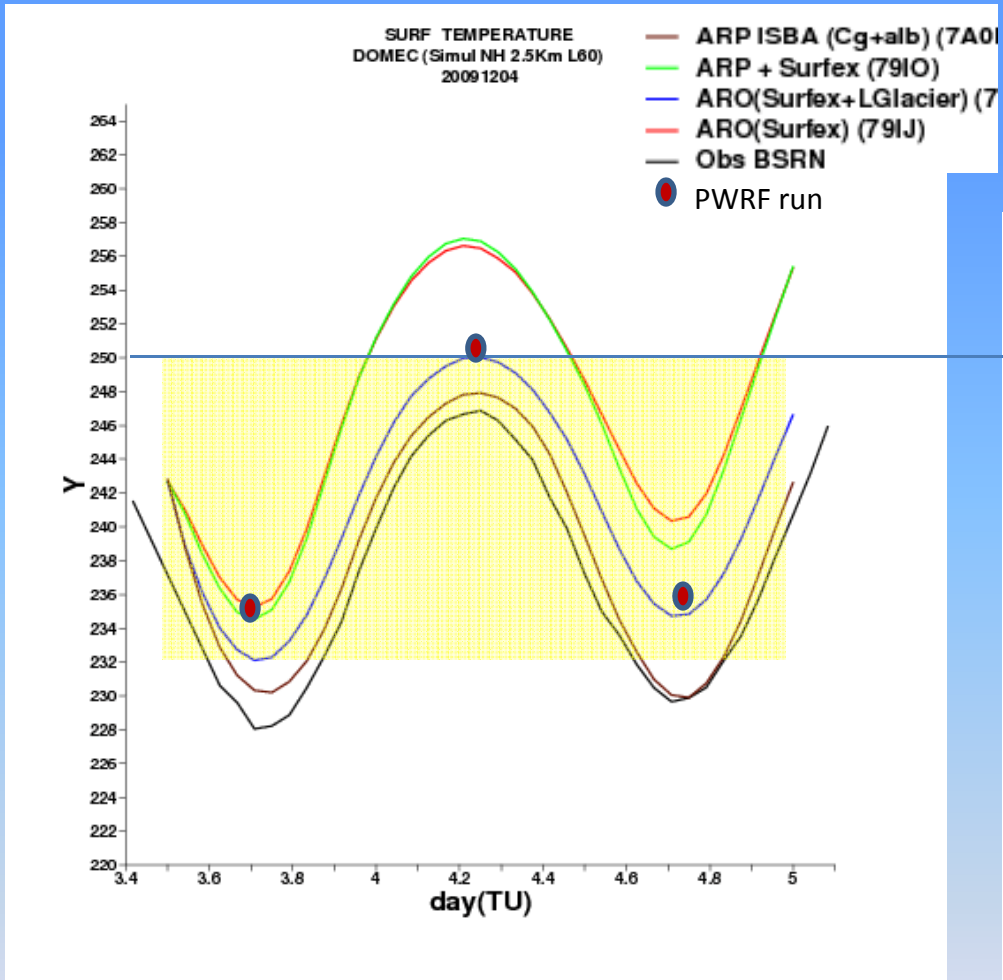


hours since 12/02/2009 12UTC

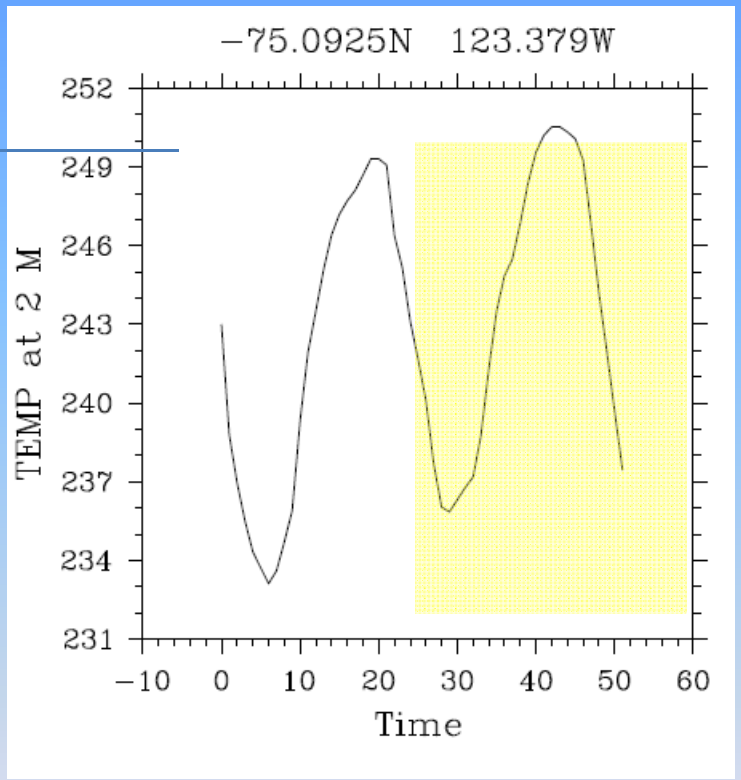


hours since 12/02/2009 12UTC

December, 4th 2009 (Case1) Init:03/12/09 at 12UTC

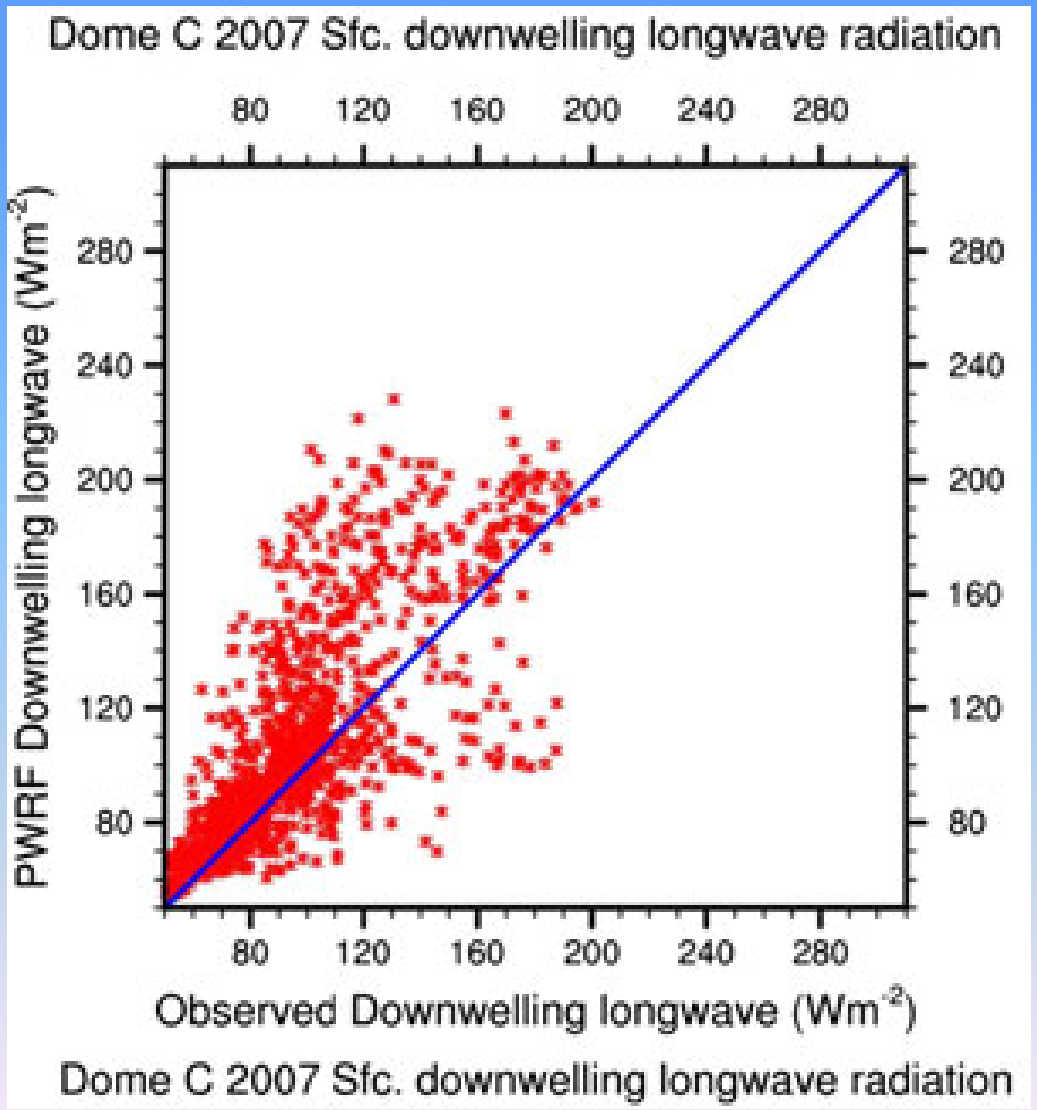


Polar WRF – 2-4 December

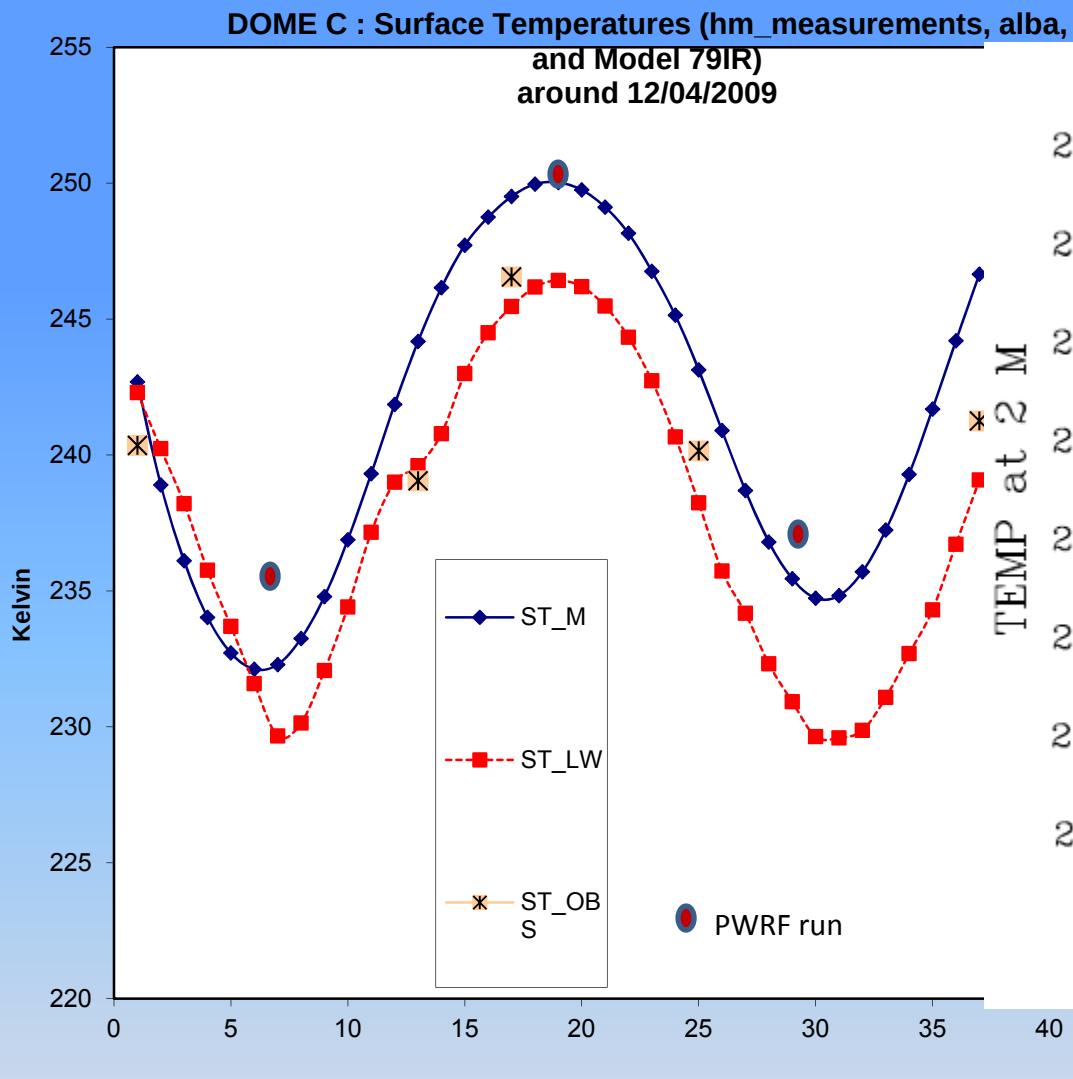


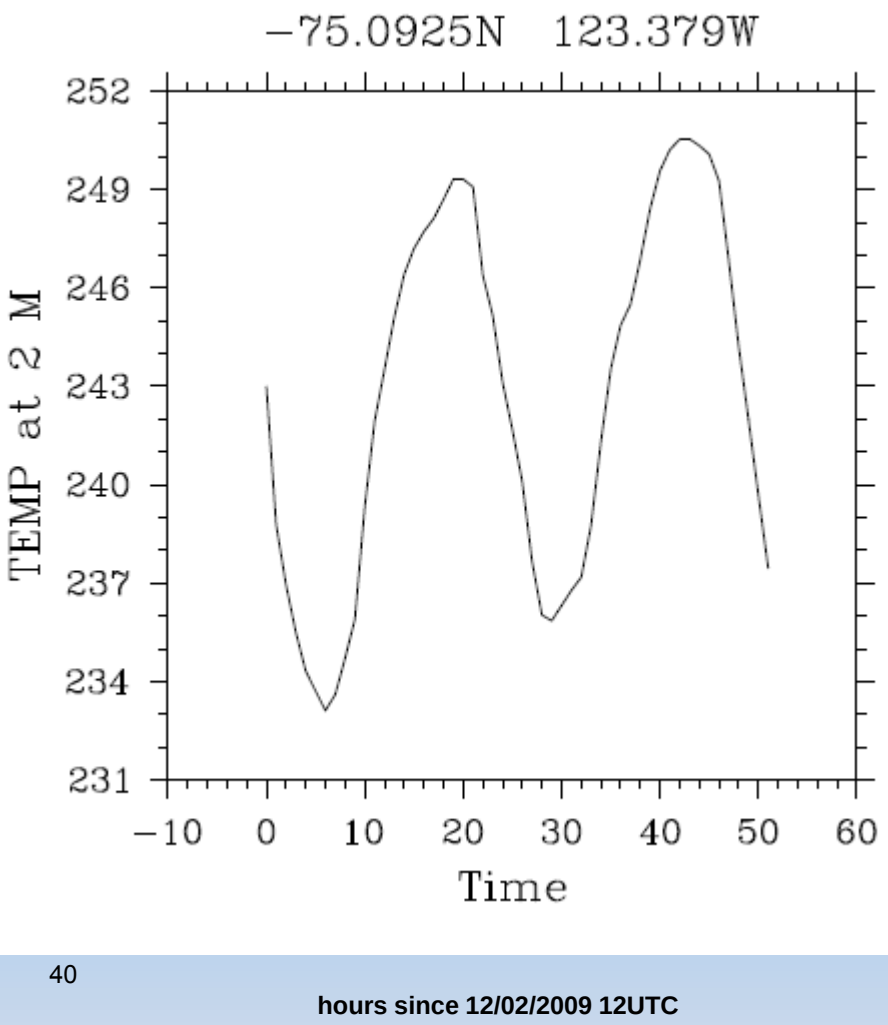
hours since 12/02/2009 12UTC

Bromwich & Otieno 2013

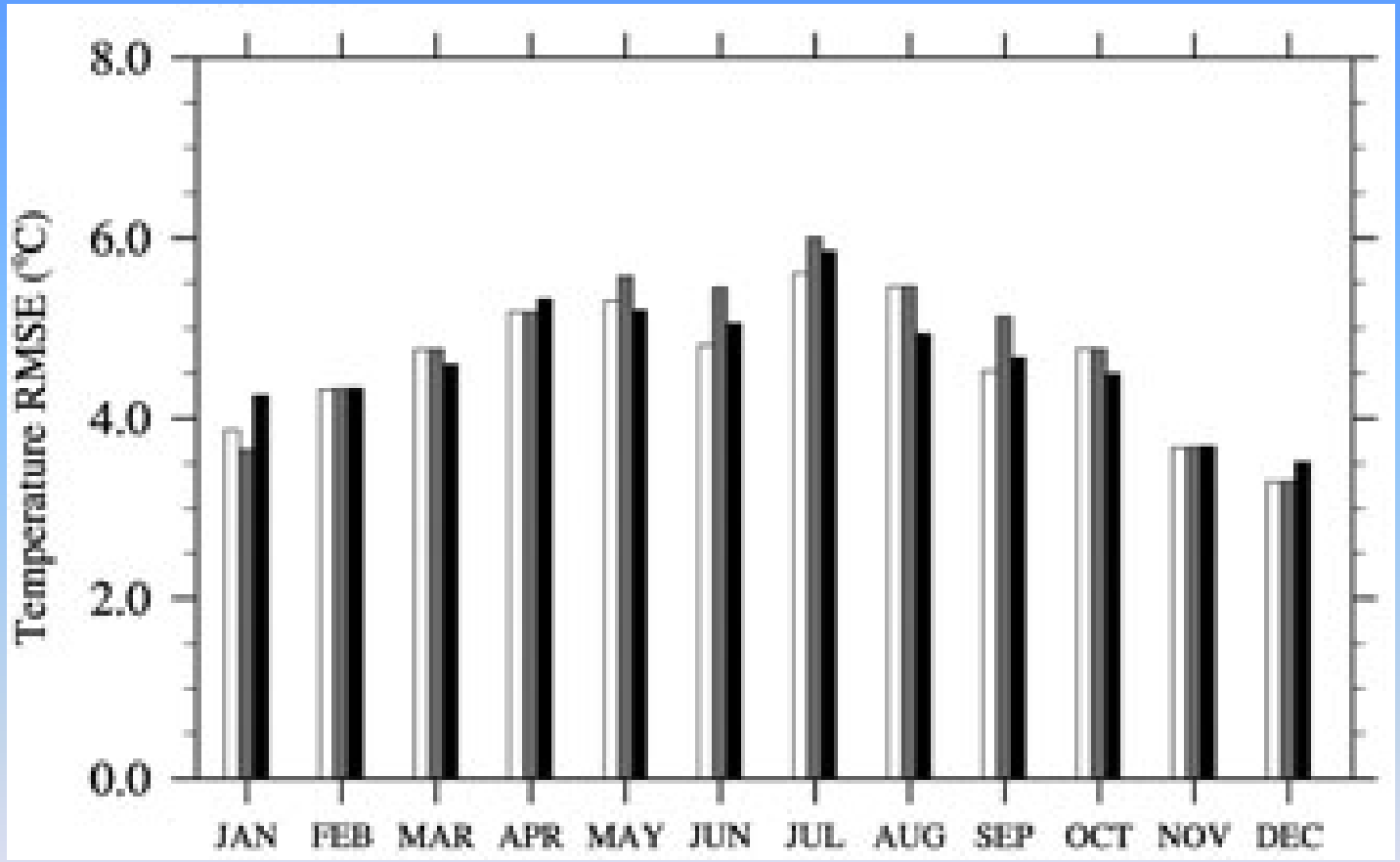


Polar WRF overestimates DW LW at sfc


DOME C : Surface Temperatures (hm_measurements, alba, and Model 79lR) around 12/04/2009
Kelvin
255
250
245
240
235
230
225
220
0
5
10
15
20
25
30
35
40
ST_M
ST_LW
ST_OBS
PWRF run
hours since 12/03/2009 12UTC


−75.0925N 123.379W
TEMP at 2 M
252
249
246
243
240
237
234
231
−10
0
10
20
30
40
50
60
Time
hours since 12/02/2009 12UTC

Bromwich & Otieno 2013



Lowest RMSE and lowest correlation with observations in Dec/Jan

Ongoing Work

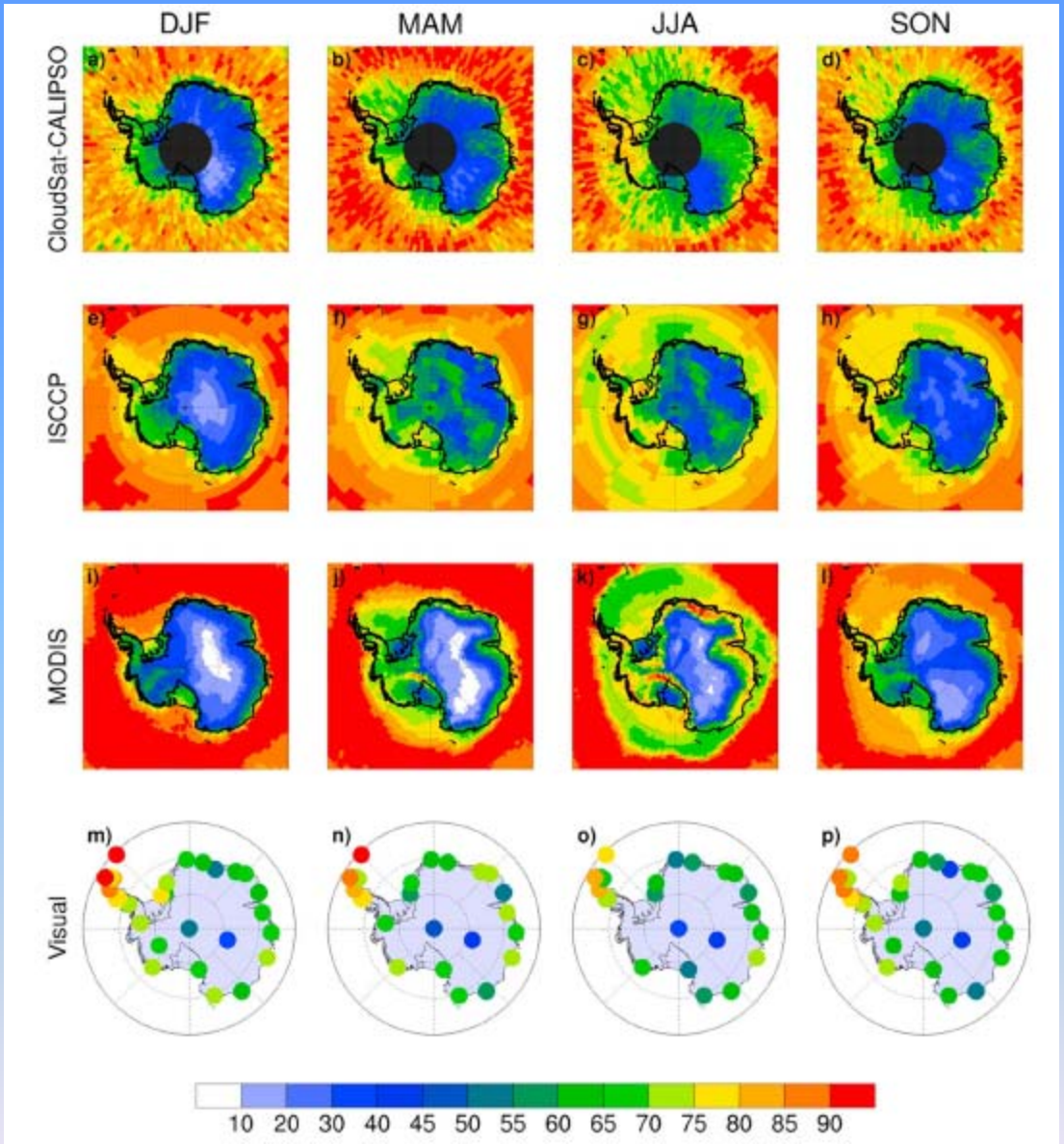
- Compare with Observations and Models in detail
  - Surface radiative budget
    - Change the surface albedo and emissivity?
    - RRTMG – probably doesn't matter
- Change boundary layer and surface parameterization
  - Try QNSE or MYNN
- Clouds – Satellites vary, few ground observations
  - MODIS too few near South Pole, CloudSat/ISCCP too many (Bronwich and Nicholas 2012),
- AMPS data as forcing data
  - Record is spotty

2006-2010

2000-2009

2000-2011

1971-1996

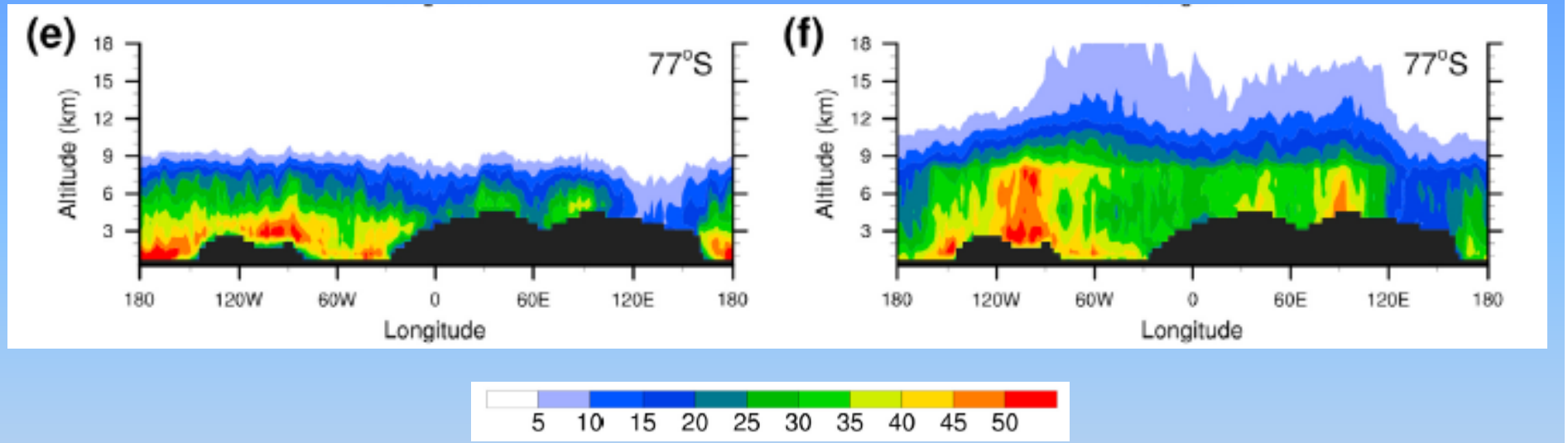


Bromwich and Nicholas 2012

Seasonal Variability in Cloud Amount

Summer (DJF)

Winter (JJA)



**Profiles from CloudSat-Calipso*

Bromwich and Nicholas 2012