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Parameterizing background snow-free soil albedo in CABLE

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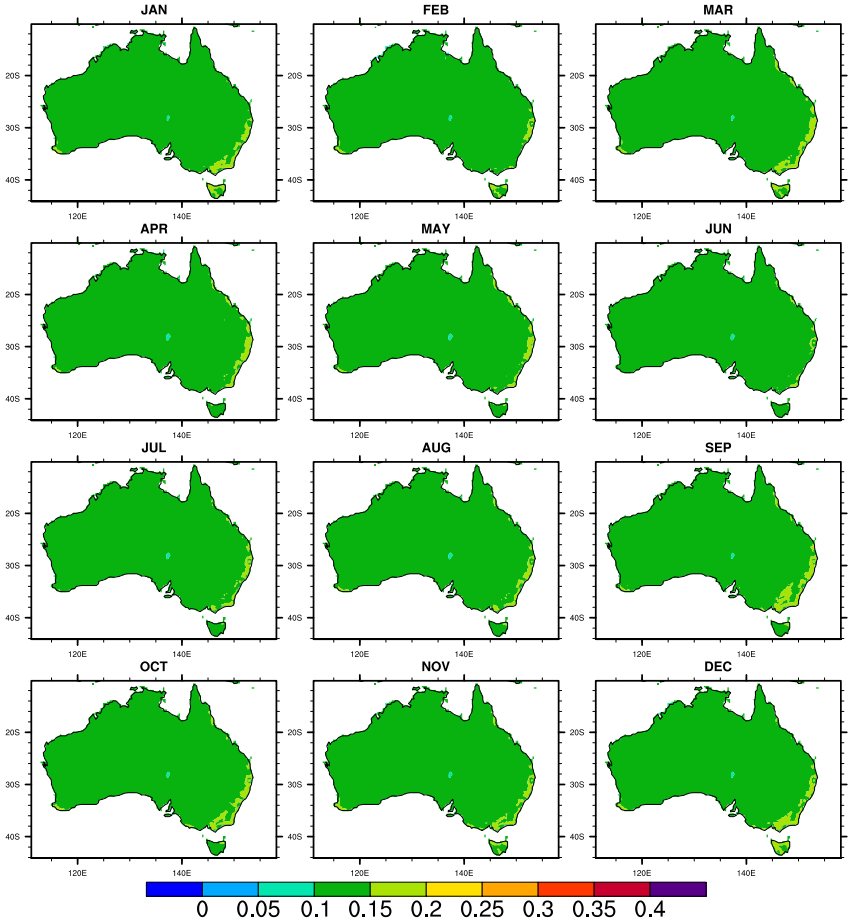
Motivation

- Albedo is critical in getting surface energy balance right:
  - Can have a strong influence on precipitation, evapotranspiration, surface air temperatures etc.
  - Errors in albedo will invariably result in serious model biases

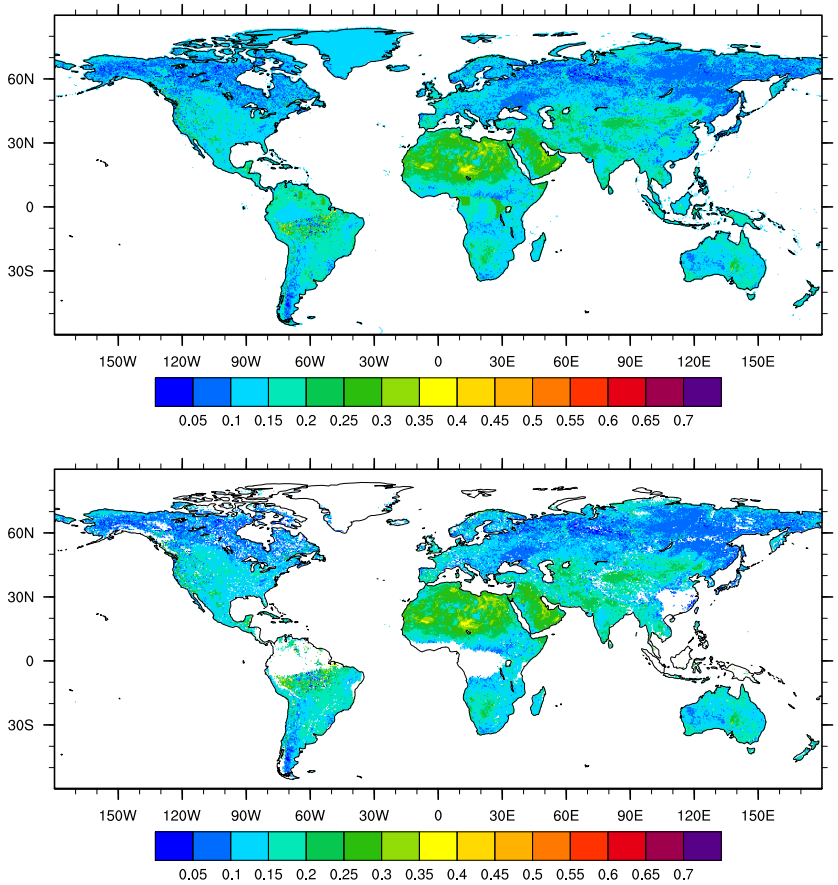
- Albedo in CABLE is a function of:
  - Vegetation albedo - parameterized
  - Background snow-free soil albedo- prescribed or held constant
  - Snow albedo - parameterized

- Background soil albedo has a strong influence on overall Albedo:

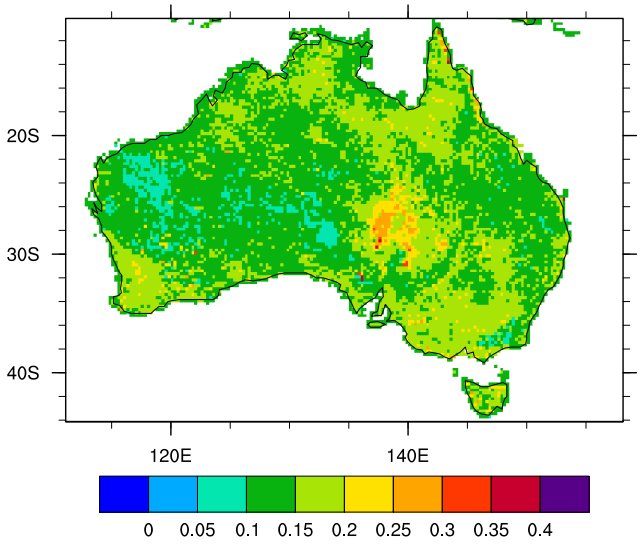
Overall 2002 monthly albedo when using default constant soil albedo (0.1)



- We can prescribe spatially varying background snow-free soil albedo (e.g., Houldcroft et al. 2009 – derived from MODIS):



- Gaps filled with values from Wilson and Henderson-Sellers (1985) (based on soil-color).



- Most LSMs parameterize background snow-free soil albedo based on soil color and upper soil moisture:

$$\alpha_s = \min[\{\alpha_{sat} + \max(0.11-0.4\theta\ ,\ 0)\}\ ,\ \{\alpha_{dry}\}]$$

- α_{sat} and α_{dry} are the soil albedos for a saturated and dry soil of particular color in VIS and NIR (Zhou et al. 2003):

Table 2a. CLM Parameters for Albedo for Different Colored Soils in Visible (0.3–0.7 μm) and Near-Infrared (0.7–5.0 μm)

Soil Color Type	Saturated Soil Albedo		Dry Soil Albedo	
	Visible	Near-Infrared	Visible	Near-Infrared
1	0.12	0.24	0.24	0.48
2	0.11	0.22	0.22	0.44
3	0.10	0.20	0.20	0.40
4	0.09	0.18	0.18	0.36
5	0.08	0.16	0.16	0.32
6	0.07	0.14	0.14	0.28
7	0.06	0.12	0.12	0.24
8	0.05	0.10	0.10	0.20

- θ is volumetric soil water content of first soil layer

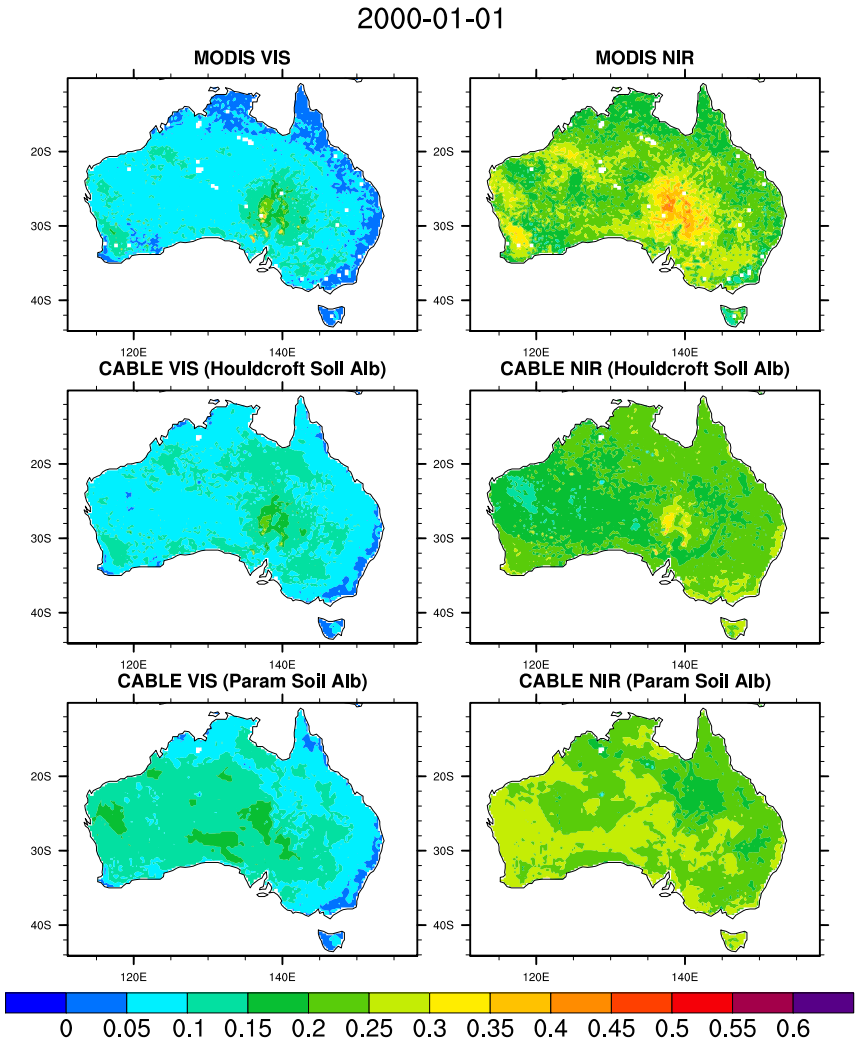
Simulations

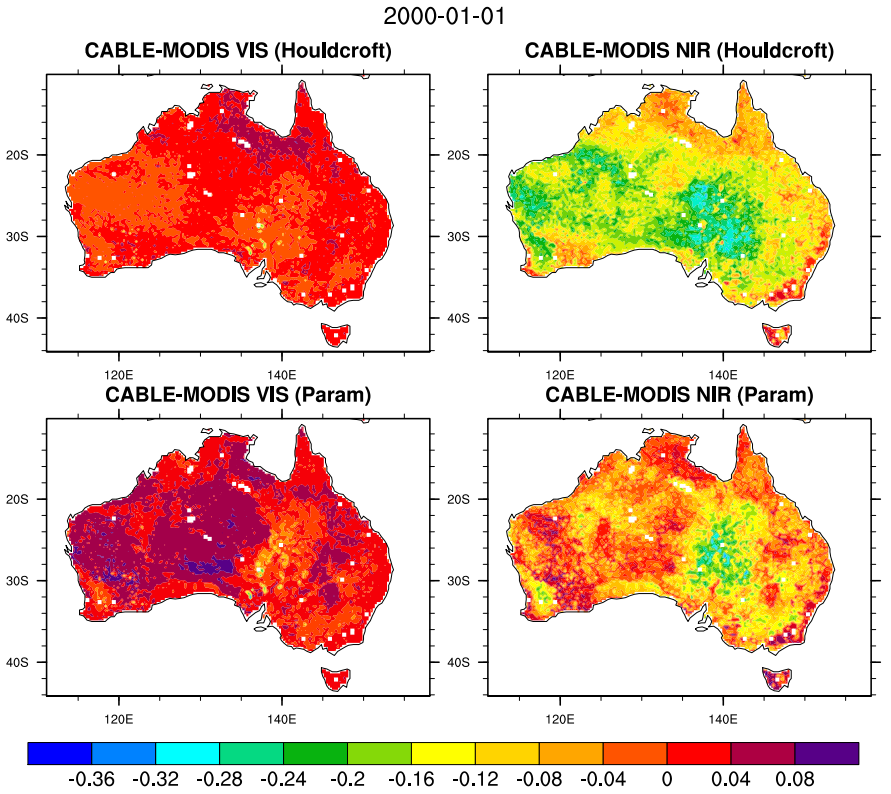
- 30-Year CABLE-LIS "offline" 0.25 Deg simulations over Australia:
  - Driven with bias-corrected MERRA data (1979-2009)
  - Two simulations:
    - Snow-free soil albedo prescribed from Houldcroft et al. (2009)
    - Snow-free soil albedo parameterized based on soil color and moisture (Code adapted from CLM2.0)
  - Leaf and transmittance and reflectance vary with PFT, and based on Francia Avilla's PhD thesis.
  - Monthly LAI prescribed from MODIS climatology

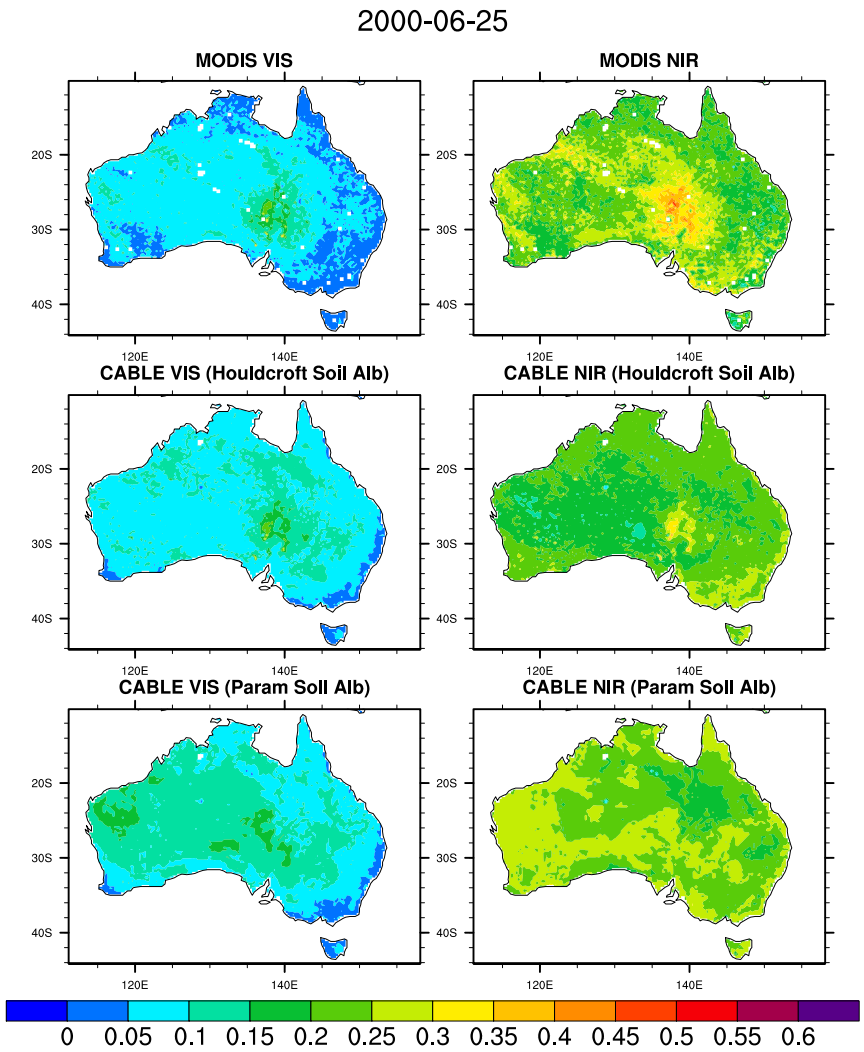
Simulations

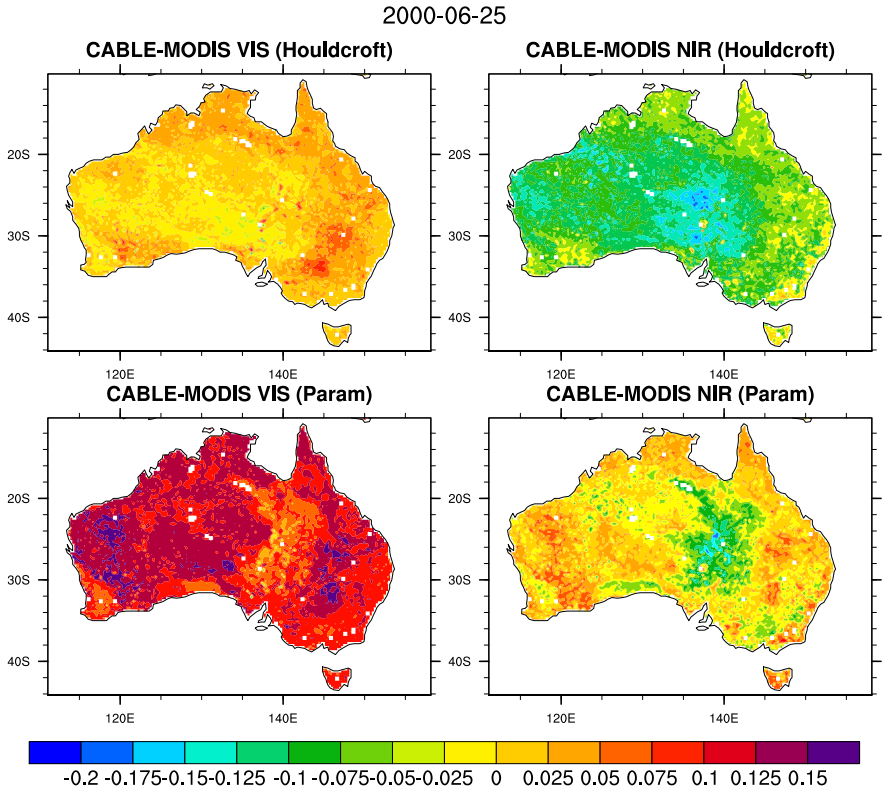
- Results compared against the MODIS NIR and VIS black-sky Albedo product (MOD43B3):
  - Spatially gap-filled albedo product (2000-2004 available)
  - 1 arc-minute spatial resolution, 16-day temporal resolution
  - Only looked at year 2000 data for now

- Planning to use other satellite products in the future:
  - VITO Albedo from geoland2 data-portal
  - 1Km spatial resolution
  - 10-day temporal resolution
  - 2 versions: 1999 to present, or 2009 to present
- Any others?

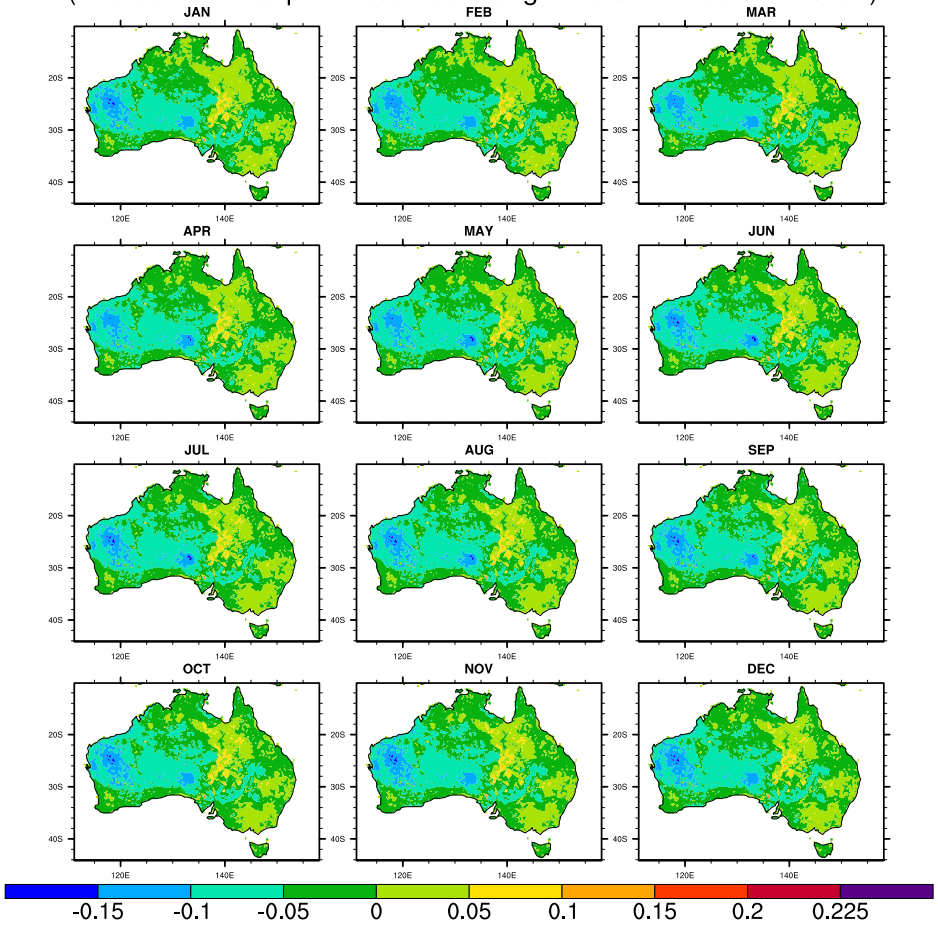

2000-01-01
MODIS VIS
MODIS NIR
CABLE VIS (Houldcroft Soil Alb)
CABLE NIR (Houldcroft Soil Alb)
CABLE VIS (Param Soil Alb)
CABLE NIR (Param Soil Alb)
20S
30S
40S
120E
140E
0 0.05 0.1 0.15 0.2 0.25 0.3 0.35 0.4 0.45 0.5 0.55 0.6


2000-01-01
CABLE-MODIS VIS (Houldcroft)
CABLE-MODIS NIR (Houldcroft)
CABLE-MODIS VIS (Param)
CABLE-MODIS NIR (Param)
20S
30S
40S
120E
140E
-0.36 -0.32 -0.28 -0.24 -0.2 -0.16 -0.12 -0.08 -0.04 0 0.04 0.08

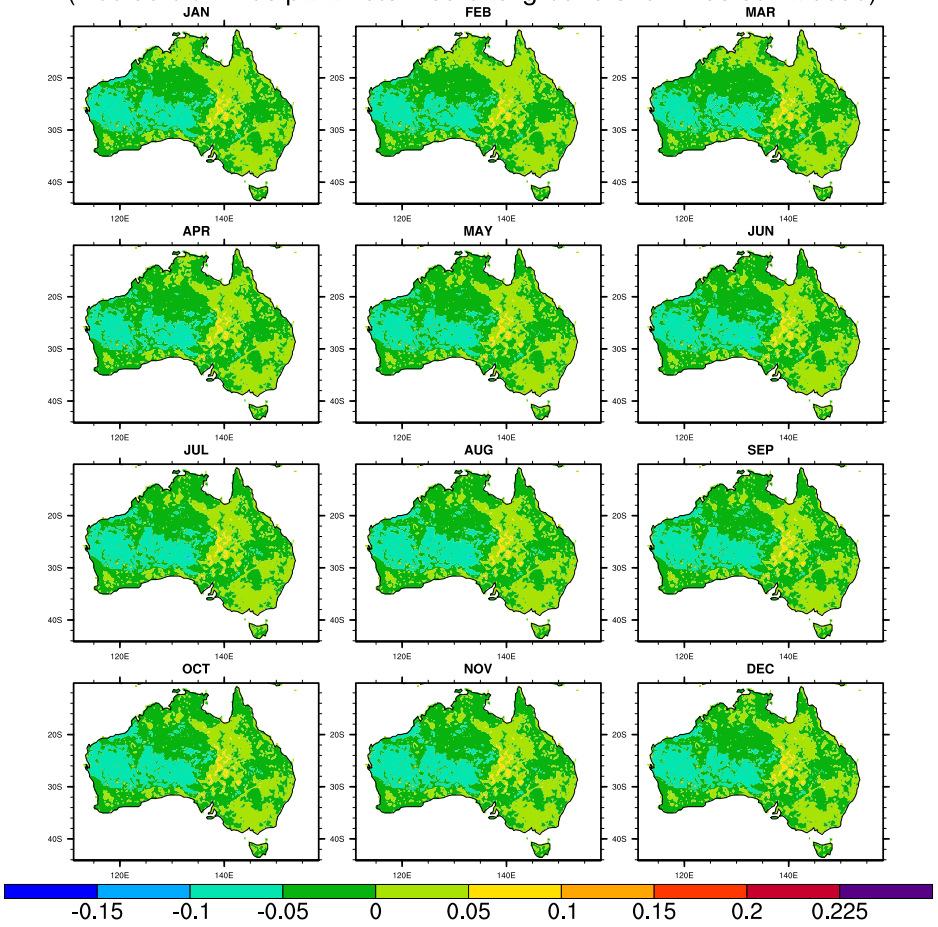

2000-06-25
MODIS VIS
MODIS NIR
CABLE VIS (Houldcroft Soil Alb)
CABLE NIR (Houldcroft Soil Alb)
CABLE VIS (Param Soil Alb)
CABLE NIR (Param Soil Alb)
20S
30S
40S
120E
140E
0 0.05 0.1 0.15 0.2 0.25 0.3 0.35 0.4 0.45 0.5 0.55 0.6


2000-06-25
CABLE-MODIS VIS (Houldcroft)
CABLE-MODIS NIR (Houldcroft)
CABLE-MODIS VIS (Param)
CABLE-MODIS NIR (Param)
20S
30S
40S
120E
140E
-0.2 -0.175 -0.15 -0.125 -0.1 -0.075 -0.05 -0.025 0 0.025 0.05 0.075 0.1 0.125 0.15

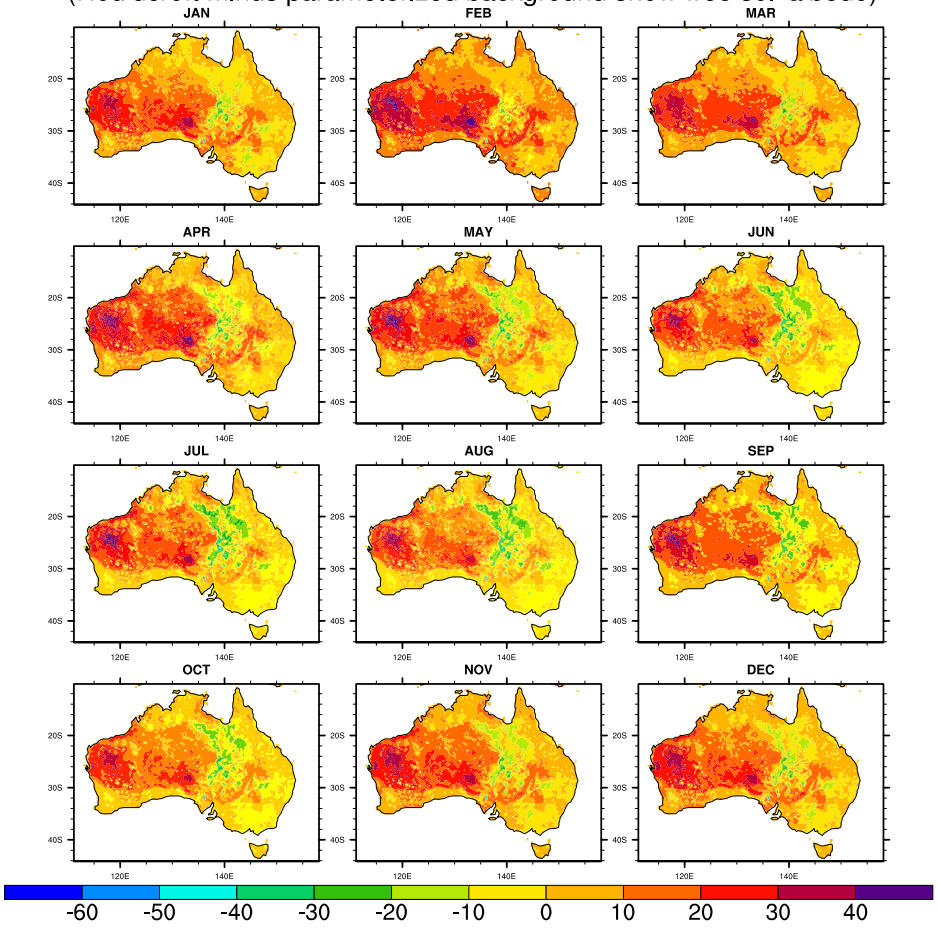
Monthly mean difference in Albedo_NIR from 2000-2009
(Houldcroft minus parameterized background snow-free soil albedo)



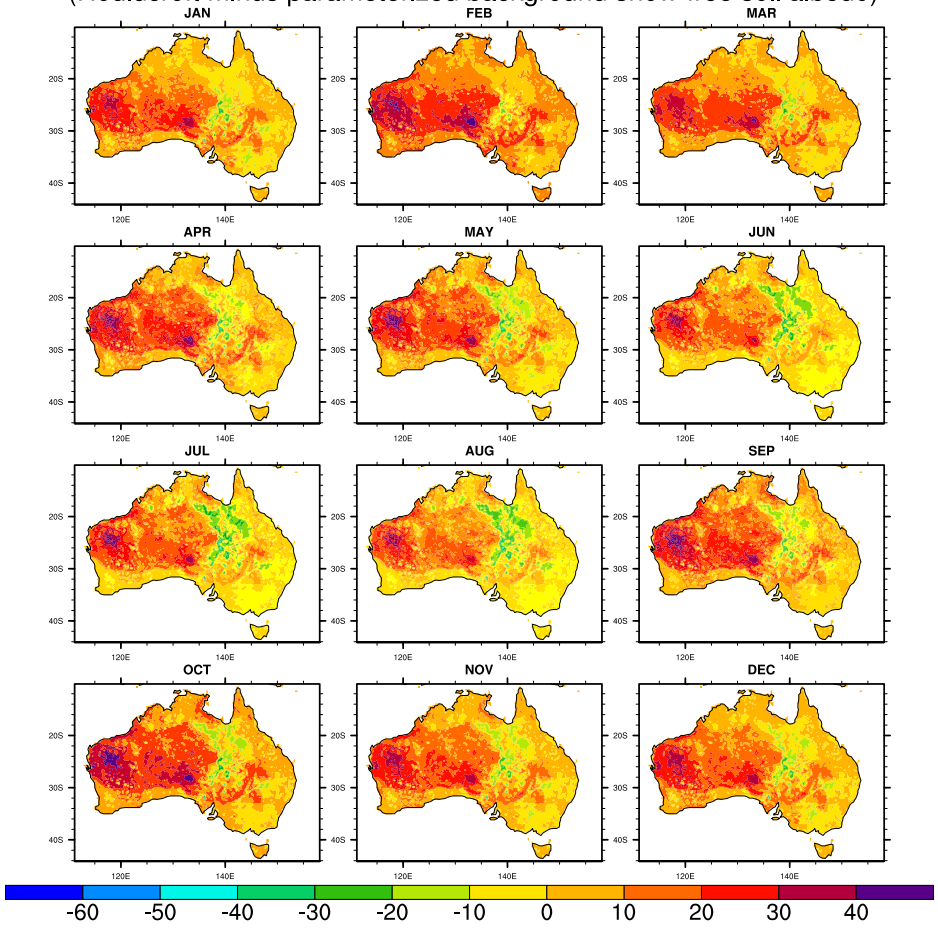
Monthly mean difference in Albedo_VIS from 2000-2009
(Houldcroft minus parameterized background snow-free soil albedo)



Monthly mean difference in Rnet from 2000-2009
(Houldcroft minus parameterized background snow-free soil albedo)



Monthly mean difference in Qh from 2000-2009
(Houldcroft minus parameterized background snow-free soil albedo)



Future plans:

- Need to carefully assess CABLE albedo simulations
  - This is very preliminary work….
    - Only looked at "snap-shots"
  - Need to analyze Albedo over each PFT separately – work in progress…..
  - Parameter optimization for leaf transmittance and reflectance of PFTs?
  - Albedo simulations in CABLE-SLI ? (Will soon be in LIS-WRF)
  - Global simulations? Look at snow albedo as well?
  - The LIS platform is ideal to carry out this sort of work!
  - Happy to collaborate! Drop me an email (J.Kala@unsw.edu.au)

Future plans:

- Some studies suggest that bare soil albedo is strongly dependent on Solar Zenith Angle (SZA), especially in desert regions (Wang et al. 2005, GRL):

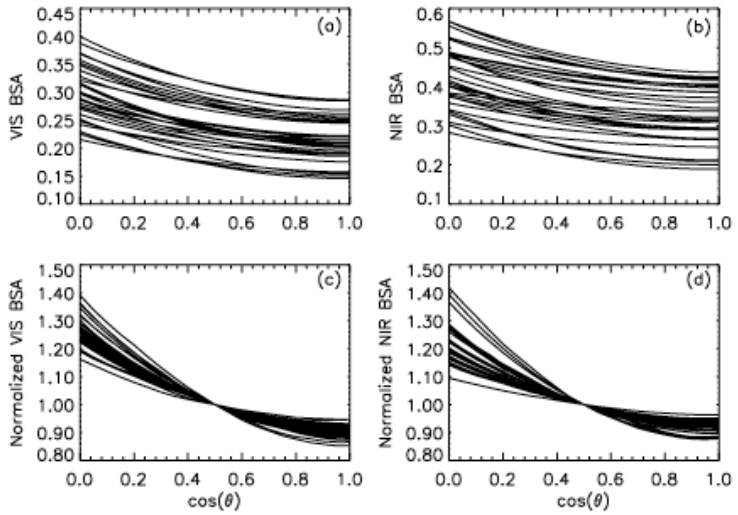


Figure 1. The median curves of the MODIS black-sky albedos in (a) VIS band and (b) NIR band versus the cosine of SZA at 30 desert locations. The normalized curves with respect to their albedo values at 60° SZA are shown in (c) VIS band and (d) NIR band.

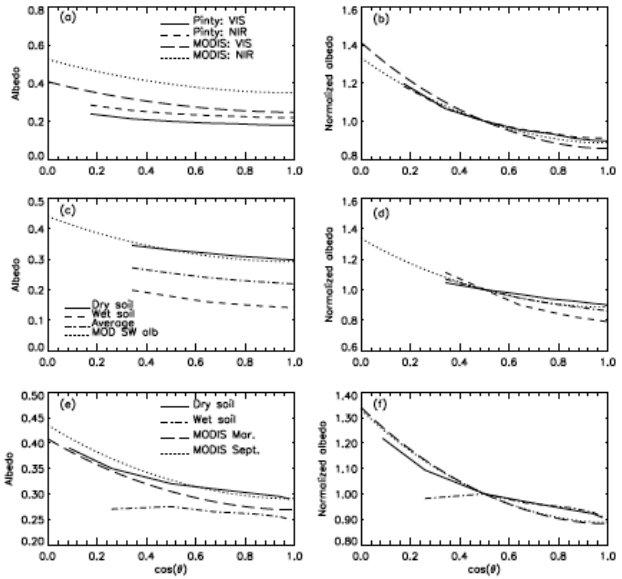


Figure 2. Comparison of MODIS data with in situ measurements. (a) The bare soil albedo in VIS and NIR bands versus cosine SZA in Tunisia, Africa in April 1983 [*Pinty et al.*, 1989]; (b) Same as (a) except for normalized black-sky albedos with respect to the albedo at 60° SZA; (c) The bare soil albedo in the SW band in Phoenix, Arizona in May, July, September, and December 1973 [*Idso et al.*, 1975]; (d) Same as (c) except for normalized black-sky albedos; (e) The bare soil albedo in the SW band over the Sahel desert in March and September 1990 [*Allen et al.*, 1994]; (f) Same as (e) except for normalized black-sky albedos.

Questions?

Email: J.Kala@unsw.edu.au or Jatin.Kala.JK@gmail.com

- In the code:

```
DO ib = 1,2 ! Number of wavebands (vis, nir)
      inc = MAX(0.11-0.40*ssoil%wb(:,1), 0.)
      albsod(:,ib) = MIN(albsat(soil%soilcol,ib)+inc, albdry(soil%soilcol,ib))
      albsoi(:,ib) = albsod(:,ib)
END DO

   ! alb. soil is the mean of direct and indirect albedo
   if (soil%compalbsoil(1) == 1) then
     ssoil%calc_albsoil = 0.5*(albsod + albsoi)
   else
     ssoil%calc_albsoil = SPREAD(soil%albsoil,2,nrb)
   end if
```